User Manual
of SWAE Software

Version: 3.0.0

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Qingcheng AE Institute (Guangzhou) Co., Ltd / QAWRUMS Ltd.

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Content

Part 1 Function Introduction

1. Basic Information

SWAE acoustic emission system software is a collection of real-time acquisition / analysis software and post analysis software. It is designed based on Windows operating system and can run normally in 64-bit Windows 7/8/10/11. The operating system is suitable for the acoustic emission detector of SAEU3H series, SAEW series, SAEI series and RAEM1 series of our company. It can sample and play back the data of the equipment. At the same time, it supports the installation and use of multiple computers. The number of users is unlimited, which is convenient for joint analysis and research after the event.

The main features of the software are as follows:

1) It is suitable for windows 64-bit operating system;
2) Multiple client end installation without encryption is convenient for multiple computers to use at the same time;
3) Similar to Windows Office operation style, easy to use;
4) The shortcut tool menu can be customized manually to operate the software conveniently and quickly;
5) Various 2D and 3D graphics display;
6) A software built-in all Location modules;
7) Software is upgraded free of charge for life;

If there are any problems or other special needs in the use of the software, we hope you can put forward your valuable opinions, so that we can provide you with free upgrade service after improving the version of the software.

As the software is constantly updated, the software interface or settings may change slightly.

1.1. Computer Hardware Requirements

Acoustic emission software and driver must be used in Windows operating system with 64-bit hardware. In order to improve the efficiency of data acquisition and transmission, it is recommended to use high-frequency multi-core processor and high-speed and large-capacity memory as far as possible; and the selection of large-capacity hard disk can provide convenience for data storage; when there are high requirements for acoustic emission waveform acquisition or the number of acoustic emission host channel is greater than 48.

The following Table 1.1 can be referred to when selecting a computer for the acoustic emission host.

Table 1-1 Recommended Computer Configuration

Application	AE Channel	Minimum computer configuration
Scientific research experiment	4 Channel	I5 processor, 8G memory, 500G mechanical hard disk, 1024x768 resolution
Scientific research experiment	4<Channel≤16	I5 processor, 8G memory, 500G mechanical / 128G SSD, USB3.0 interface, 1024x768 resolution
Scientific research experiment	Channel>16	I7 processor, 16G memory, 1TB mechanical / 256G SSD, USB3.0 interface, 1280 x1024 resolution
Engineering inspection	16≤Channel	I5 processor, 4G memory, 500G mechanical hard disk, 1024x768 resolution
Engineering inspection	Channel≥16	I5 processor, 8G memory, 1TB mechanical hard disk, 1280 x1024 resolution

1.2. Software Upgrade

QingCheng promises to upgrade permanently free of charge for all SWAE series acoustic emission software. The installation method of the upgrade software is automatic coverage installation. Users can consult or visit Qingcheng website to view the relevant software upgrade information.

1.3. Document Types

SWAE AE file type includes configuration file and data file. The configuration file suffix is .AEC, and the latter includes parameter file (.PRA) and waveform file (.AED).

1.3.1. Configuration File

The configuration file suffix is [.AEC]. Users can quickly complete the parameter settings and view settings by transferring the existing configuration files in the software. If no file is available, the system will default the initial settings stored in the root directory of the program installation, and the hardware and view settings will revert to the default value of the program.

The general settings file contains the following file contents:

- Save all the setting data related to the acoustic emission acquisition instrument hardware to the file;
- Save the type and use rules of parameter filter;
- View setting and view group setting;
- Save statistics settings;
- Storage and Location related settings

1.3.2. Parameter File

The parameter file is an independent data file with suffix of .pra. The data is presented in the form of "parameter table" in the software. The parameter types include: arrival time, amplitude, counts, duration, absolute energy, rise counts, rise time, RMS, ASL, 12 external parameters, centroid frequency, peak frequency, 5 partial power spectrum, etc.

The parameter file name can be named in the file storage path. If it is not named manually, the program uses the default name and the tag generated by the computer system time to automatically generate, and automatically changes the time tag after a file end to ensure that the file is stored and not covered;

The encoding format of parameter file is described in detail in SWAE software secondary development package provided by QingCheng.

1.3.3. Waveform File

Waveform file generally refers to time domain waveform file with suffix of **.aed**, which takes up more storage space than parameter file, and is affected by many conditions such as sampling rate and sampling accuracy. The data is presented in the form of "waveform" in the software. Waveform file is not only limited to the original waveform file, but also includes the following post-processing waveform: time-domain waveform, frequency-domain waveform, wavelet, etc.

The waveform file is generated together with the parameter file after the waveform collection function is turned on. The file name and storage path are also consistent with the parameter file and do not need to be specified manually; only in full waveform mode, it needs to be set manually. **Automatic file naming method: name + "_" + sample time**, for example: CJ2(70dB) _220630153540436.aed, so as to ensure the uninterrupted data collection process.

The coding format of waveform file is described in detail in the secondary development package of SWAE software provided by QingCheng.

2. Interface and Functions

2.1. Main Interface Menu

The first step in the process of using SWAE is to start the program. Double click the **[SWAE]** icon on the windows desktop to load the default configuration after the software starts. If the default configuration is not saved, you need to set the required view in the View menu. The main interface of the software is shown in Figure 2-1, which generally includes four parts: main menu area, secondary menu area, view area and statistics bar.

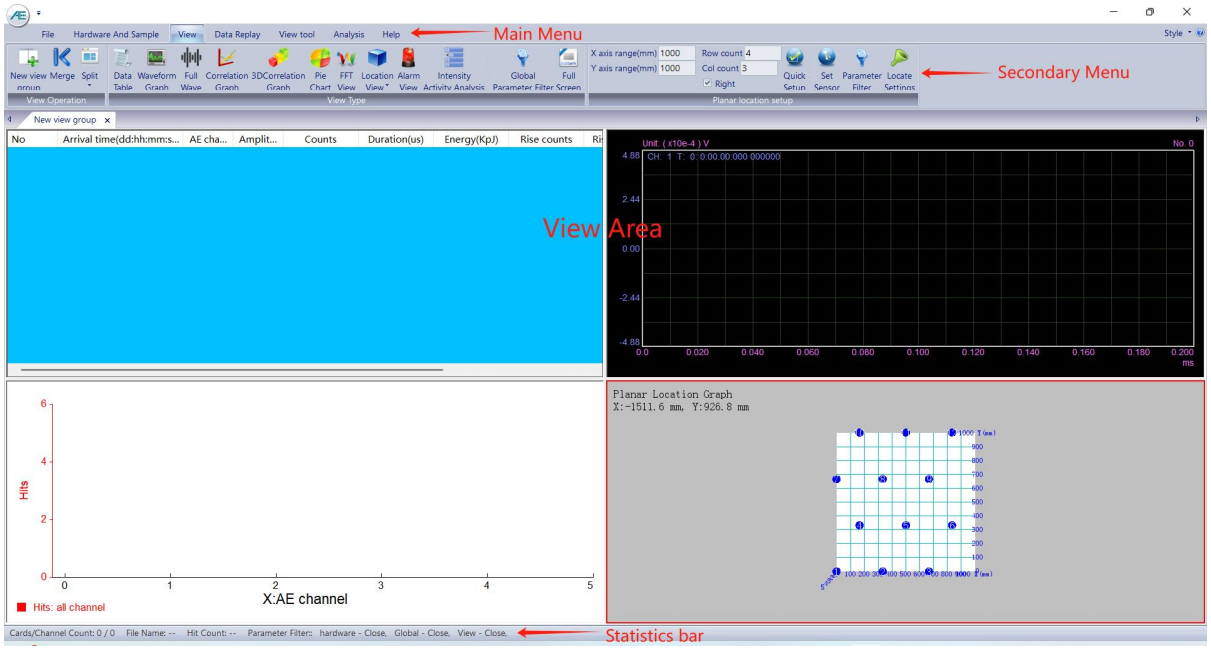


Fig. 2-1 Software Main Interface View

The main display areas of the software interface include:

1) The software title bar is the windows standard title bar, with Qingcheng AE institute logo on the left. The minimize, maximize and close buttons are the triangles next to the logo. The main menu bar beside is the level-1 menu option.
2) The secondary menu bar is below the main menu and it's the next level operation after the main menu selection.
3) View group: SWAE software can create multiple view groups, and each view group can be set with up to 80 views. Each view group can be named and arranged in parallel with the view group title bar. Click on each view group to switch the view display.

4) The view area is the display area of each view under the view group.

5) The views can be copied and pasted by right clicking or ctrl + C/V.

6) Statistics bar area, located at the bottom of the software interface, can manually set different equipment real-time statistical information.

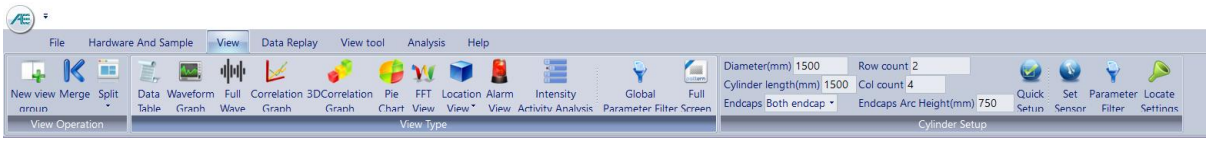


Fig. 2-2 Main Menu of the Software

2.2. Menu Function

The menu area includes the main menu area and the secondary menu area. The main menu includes seven parts: **[File], [Hardware and Sample], [View], [Data Replay], [View Tool], [Analysis]** and **[Help]**. Each sub-menu contains menus with different functions. There is a convenient menu setting window in the upper left corner of the software. The operator can customize the display of common shortcut keys and display methods in the lower area according to the usage habits.

2.2.1. View/ Switch Devices Supported by the Software

Software supported devices include SAEU3H and RAEM1 and RAEM1-6. During acquisition, the current software supported devices must correspond to the connected acoustic emission devices. Data replay, data analysis and other operations are consistent of both two modes.

You can click the "AE" icon in the upper left corner to view the current supported devices. To switch, click the "AE" icon in the upper left corner, then click the "Yes" button in the popup window, and wait for the software to start.

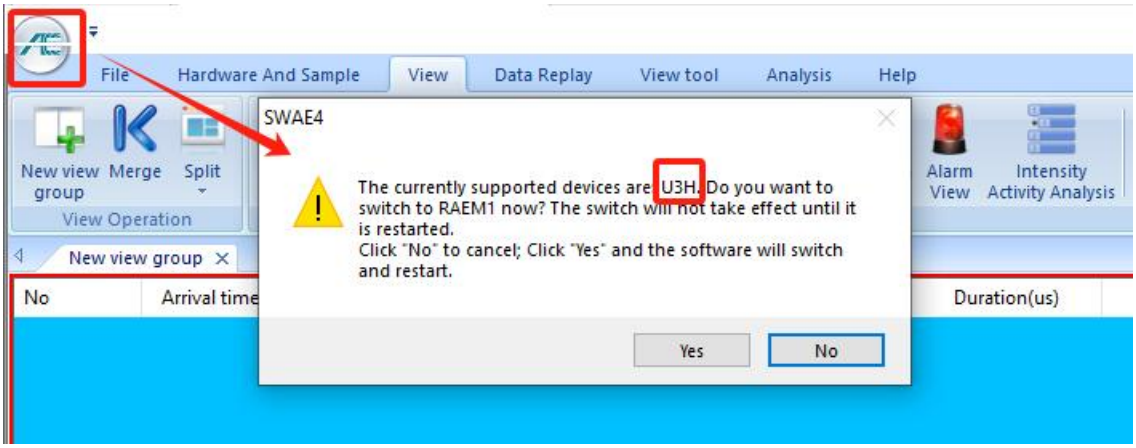


Fig. 2-3 AE software supported device interface

2.2.2. Shortcut Key Settings

Click the drop-down button on the right side of the "AE" icon to pop up the **[Custom Quick Access Toolbar]**. After selecting **[More Commands]**, the interface shown in Figure 2-5 appears. Select the function keys to be added under various menus on the left side, and click **[Add]** in the middle to add the function keys to the display area on the right side. Click **[OK]** to see the newly set functions on the shortcut toolbar on the main page Button. The deletion method is similar. Select the item to be deleted in the right display area and click **[Remove]**.

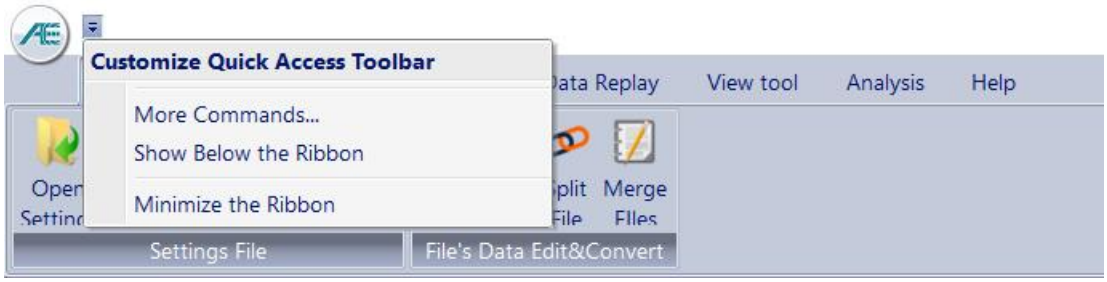


Fig. 2-4 Quick Access Toolbar

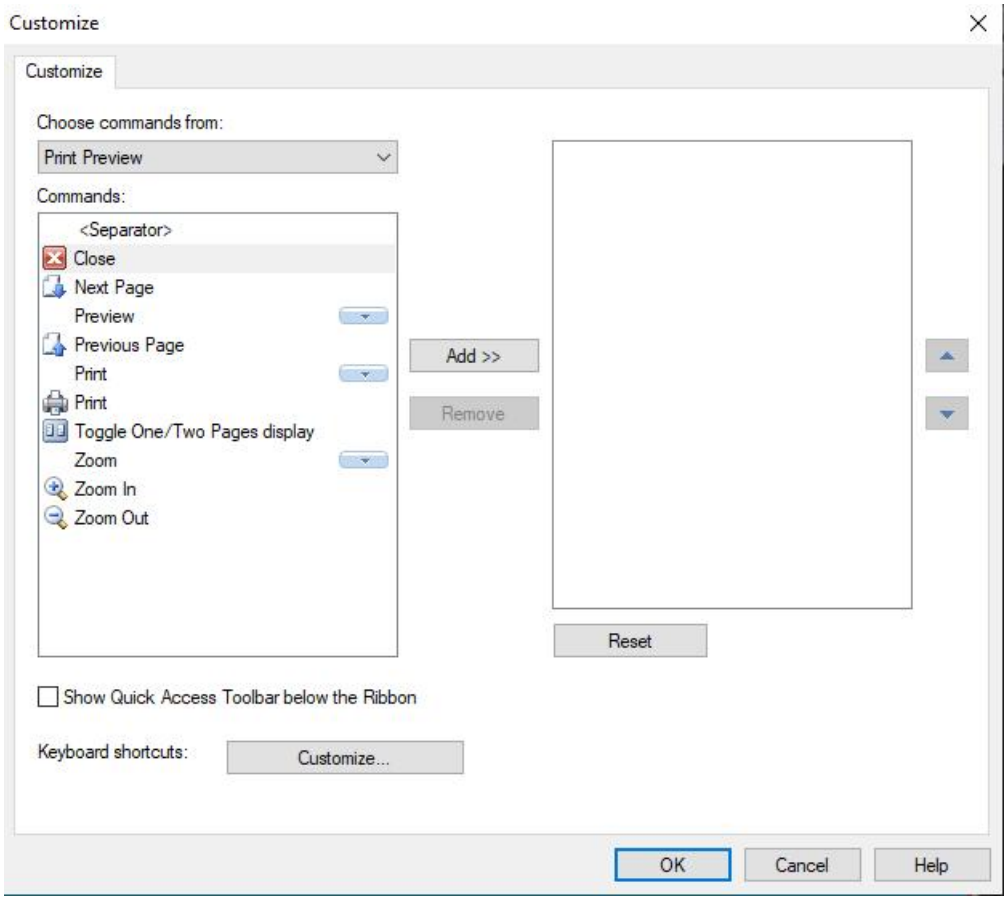


Fig. 2-5 Shortcut toolbar setting interface

In the user-defined Quick Access Toolbar menu, there is "display below the ribbon", which affects the display position of shortcut buttons on the software status bar.

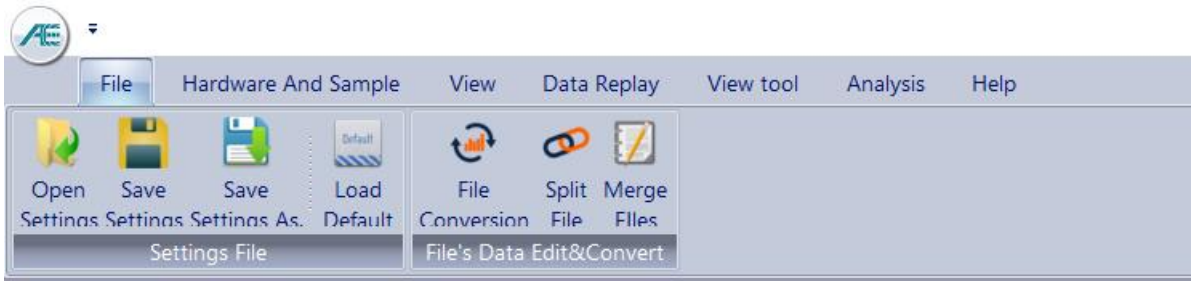


Fig. 2-6 Display interface at the bottom of the function area

2.2.3. Hide Secondary Menu

Click the drop-down button on the right side of the "AE" icon to pop up the "custom Quick Access Toolbar", and select **[Minimize the Ribbon]**. The secondary menu will be hidden to display the view area in a larger area.

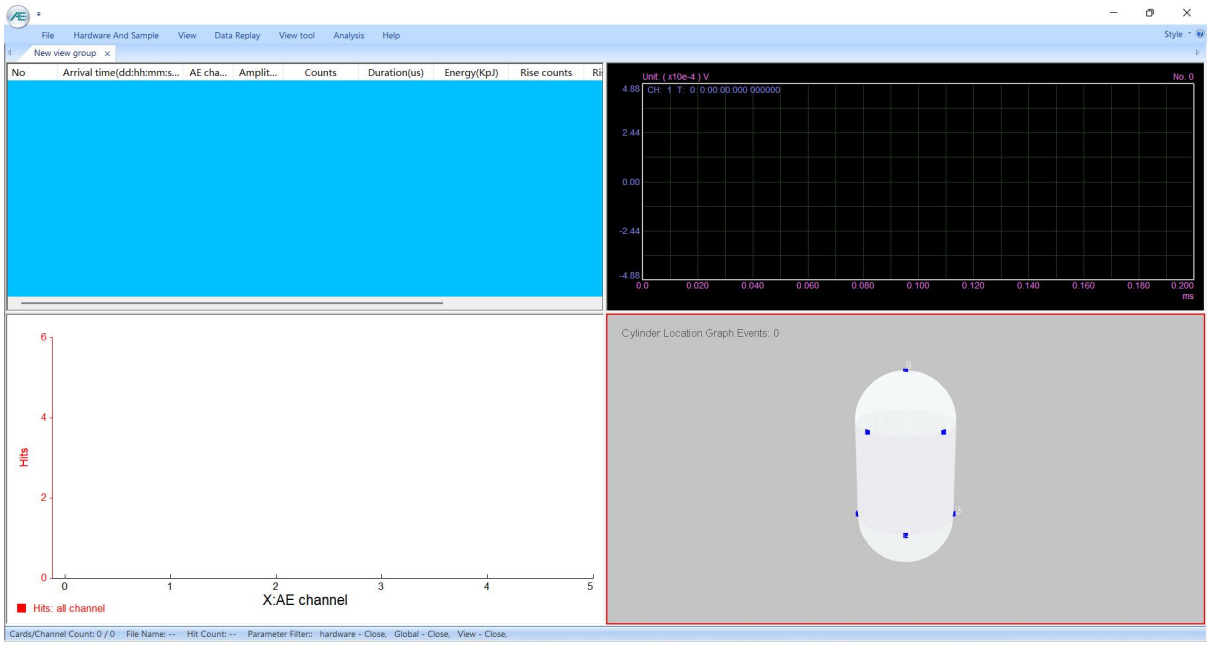


Fig. 2-7 View Display After Minimizing the Ribbon

2.2.4. File Menu

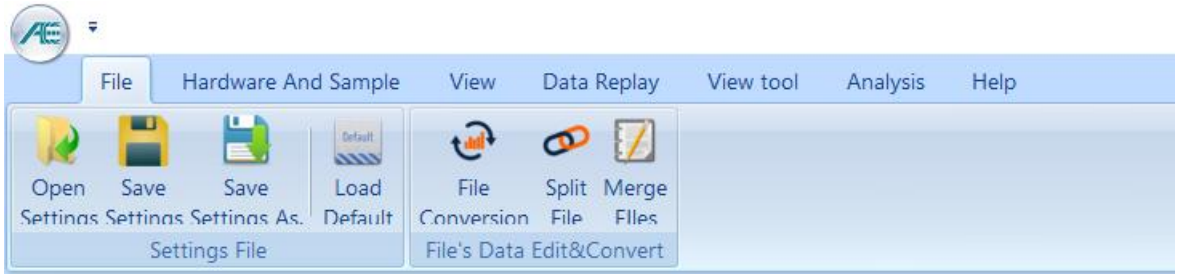


Fig. 2-8 File menu

2.2.4.1. Settings File

Open Settings: open and load one of the saved setting (configuration) files. Click [Open Settings] and a dialog box will pop up. Locate the file path, and select the corresponding name and the suffix is *.AEC* file, and then [Open].

Save Settings: save the current configurations including the hardware and sample settings, views and view settings. This setting file will be opened and loaded automatically when the software starts in the future. It is generally used for continuous testing under the same conditions, which is convenient for debugging. But it will be overwritten by the most current configuration settings when pressing the button again.

Save Settings As: save the current completed configurations as an independent file, and it can be retried and loaded without being overwritten; click [Save Settings As.] to set the storage path and file name; when typing the file name, the * needs to be removed, but the suffix ".aec" must be reserved.

Load Default: click [Load Default] to automatically load the default ".aec" file in the default storage of the software.

2.2.4.2. File Conversion and Edition

2.2.4.2.1. File Conversion

The file convert function can batch convert AE parameter file (.PRA) and AE waveform file (.AED) generated by software into common file format .TXT or .CSV. Users can use other drawing or analysis software for post processing of data. In "Open Data Files", you can batch select the original data to be converted and check the file type to be.

Note: You can convert the file during data replaying; do not operate during conversion.

Conversion of acoustic emission parameter file:

1) Click "Open data files " to select the AE parameter file to be converted; Multiple files can be selected for batch conversion. At the same time, you can choose whether to open the associated file.

2) In the upper setting area, you can choose to export the specified channel file, time range for exporting the file, arrival time setting of exporting parameters, and parameter type of exporting the file.

3) Click "Select Target Files Path" to select the location where the converted file needs to be saved.

4) Select the .TXT file or .CSV file, click "Convert". The software will automatically

display the conversion progress. After the conversion is completed, the software will pop up a prompt box, and the converted new file will be displayed in the right file box.

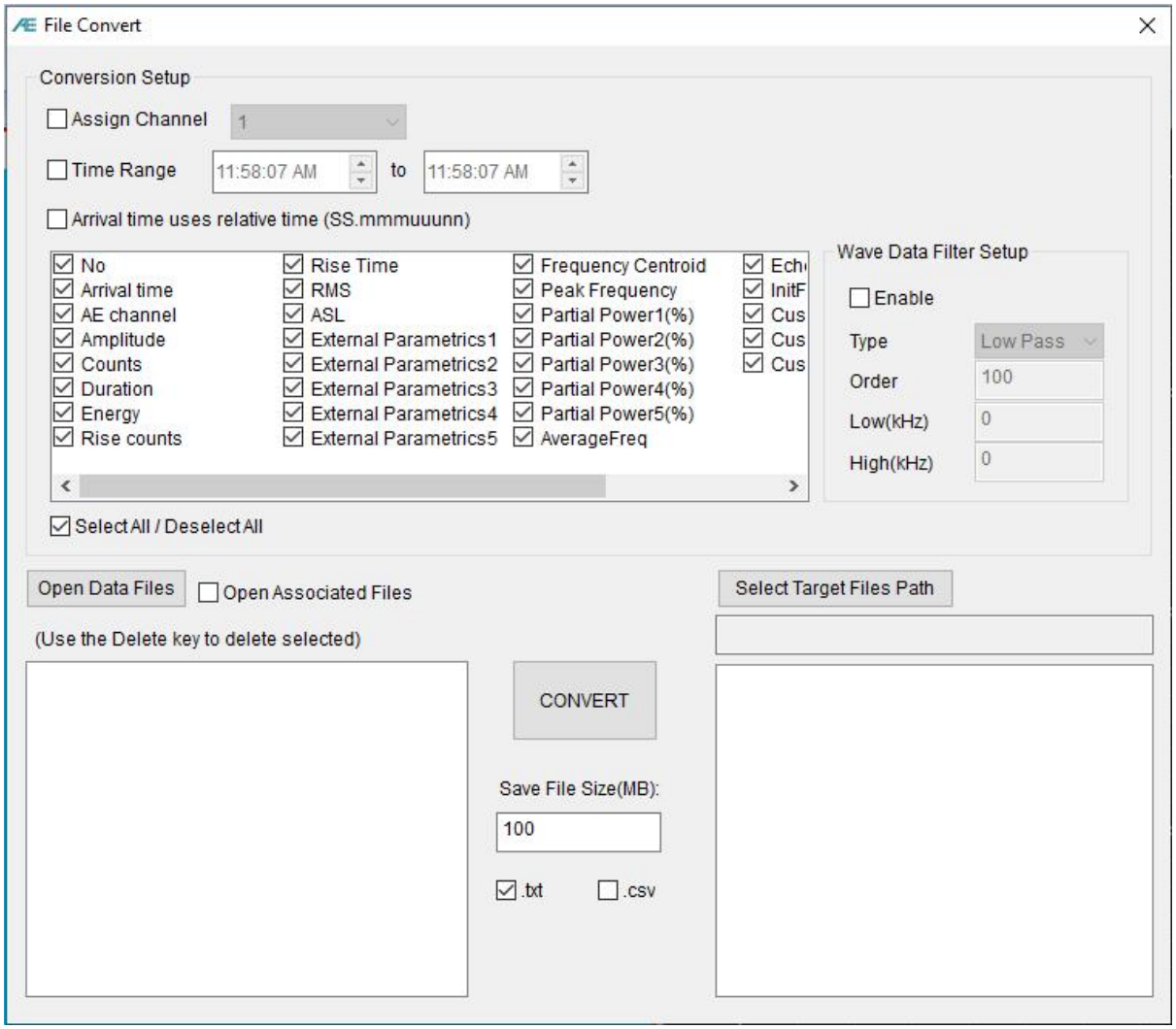


Fig. 2-9 File Conversion Set up Interface

2.2.4.2.2. Split Files

The file splitting function can extract and generate a new waveform file (.aed) or a new parameter file (.pra) according to the time range, data frame range or channel range in the larger waveform file (.aed) or the parameter file (.pra) generated by the software. The naming method of the new file is: “to” + the original file name and time tag.

After selecting the original data, the software automatically identifies the time and data frame range, and users can modify it according to their needs. You can check the channel number to

determine whether the data of the channel needs to be split. If not, there is no data of the channel in the newly generated file.

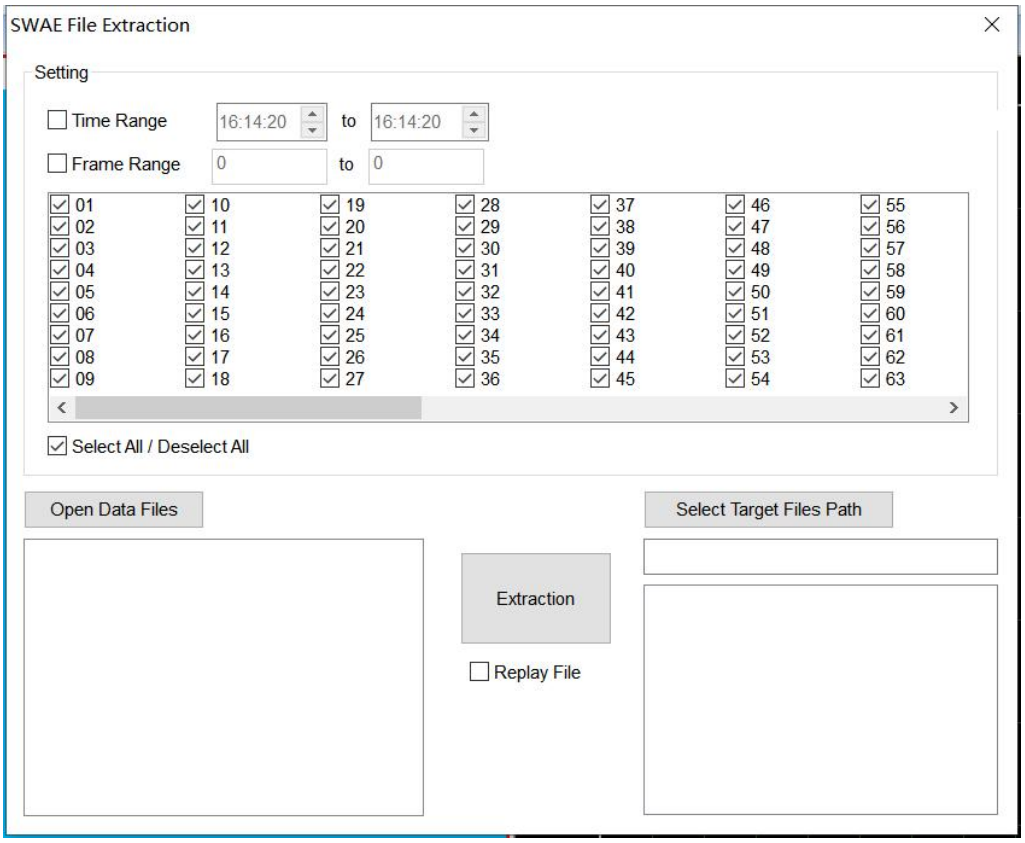


Fig. 2-10 File Splitting Interface

2.2.4.2.3. Merge Files

The file merge function can combine several AE parameters files (.pra) or AE waveform files (.aed) generated by the software to produce a new AE parameter file (.pra) or AE waveform file (.aed).

As shown in Figure 2-11, merge the file name by adding "Merge-" before the file # "1". It should be noted that in addition to the same type of merged files, the parameter settings during data collection must also be consistent.

Click [Add Merge Files] to select the files to be merged. You can choose whether to replay it after the merge, and then click [Start Merge].

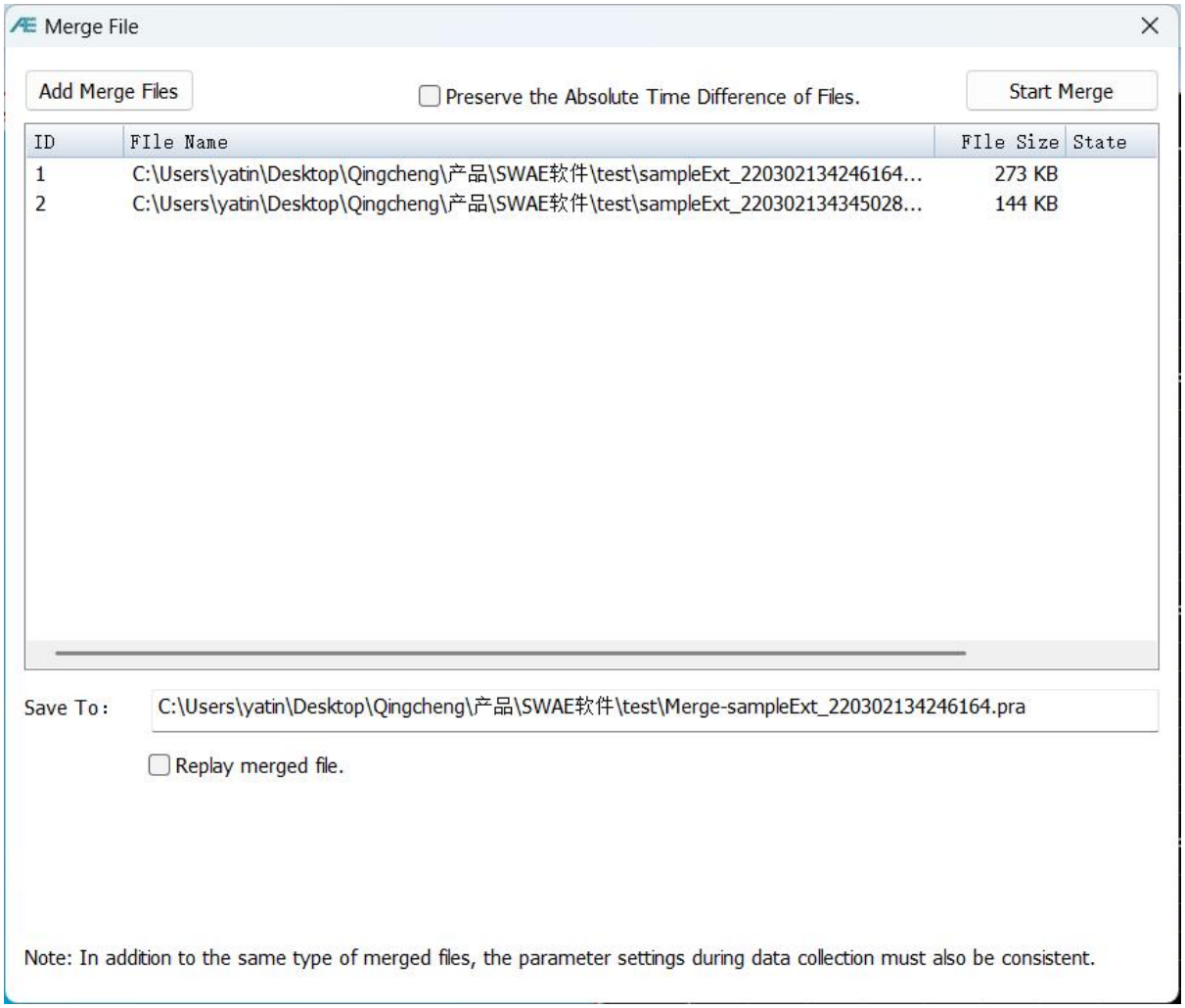


Fig. 2-11 File Merge Interface

2.2.5. Hardware and Sample Menu

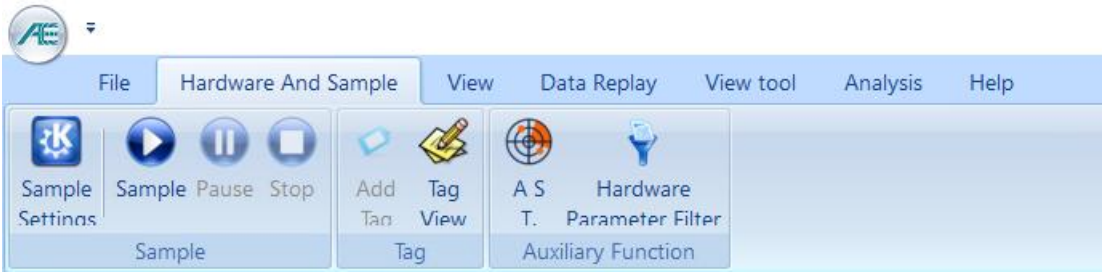


Fig. 2-12 Hardware and Sample

The hardware samples are different for different devices. The following are divided into for U3H series and for RAEM1 series.

2.2.5.1. Sample

2.2.5.1.1. Sample Settings for U3H

Below are the introduction of “Sample Settings” pages for **SAEU3H** instrument only. The “Sample Settings” for RAEM1 series is totally different. So if RAEM1 series is used, please go to Section 2.2.5.1.2.

The "Sample settings" includes the following function setting interfaces: **[Hardware Setup], [Hit Feature], [Waveform], [Saving], [FFT Setup], [Ex-Parameter Setup], [Others setup]**. The first four items are common settings in the process of acoustic emission test, and the last three items are optional settings in some tests, which can be called auxiliary settings.

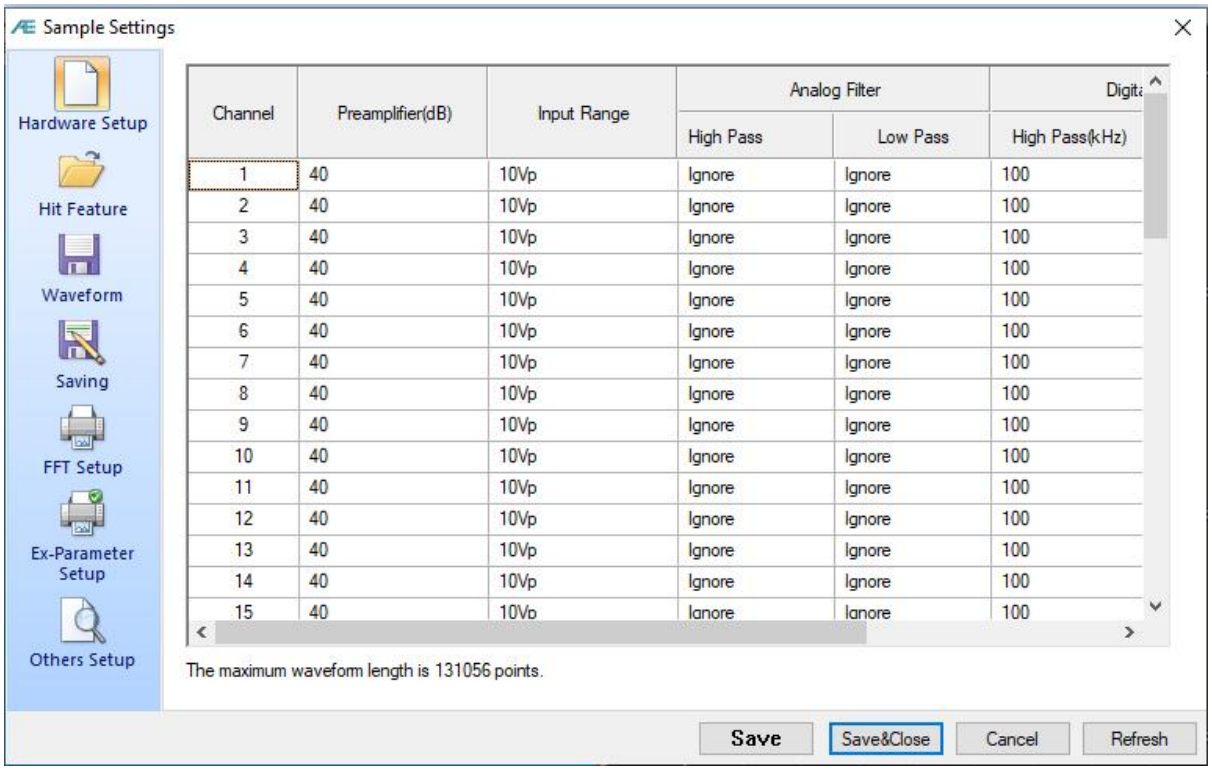


Fig. 2-13 Sample Setting Interface

2.2.5.1.1.1. Hardware Setup

Click **[Hardware Setup]** on the left side of "Sample Settings" interface, and the interface as shown in Fig. 2-13 appears. In this interface, it is necessary to set "Preamplifier (dB)", "Input range", "Analog filter", "Digital filter" and "Preamplifier power".

Definition and setting rules of nouns:

- **Channel**: The number of the channel correctly identified by the hardware corresponds to the channel number of the AE system chassis panel;
- **Preamplifier gain:** it is the actual calculated gain. In order to keep the signal traceable, generally set it same as the actually applied “preamplifier" gain, and the default 40dB is the common gain. The user can input the gain value according to the actual situation;
- **Input range**: it refers to maximum single side amplitude voltage input range accepted by acquisition board, default value is 10V; according to the application needs, there are five options for selection: "10Vp", "5Vp", "2Vp", "1Vp", "0.1Vp". In acoustic emission system, the maximum output voltage of preamplifier is generally referred to. If the actual input voltage exceeds the set value, the signal will be clipped.
- **Analog filter:** an analog circuit fixed on the acquisition board to process the analog voltage signal. The appropriate filter combination can be selected according to the actual site. There are four high pass (allow to pass if higher than) filters: Ignore (0) / 20kHz / 100kHz / 400kHz, and four low-pass (allowed to pass if lower than) filters: 100kHz / 400kHz / 1.2MHz / Ignore (infinite).

Table 2-1 Example of analog filter type

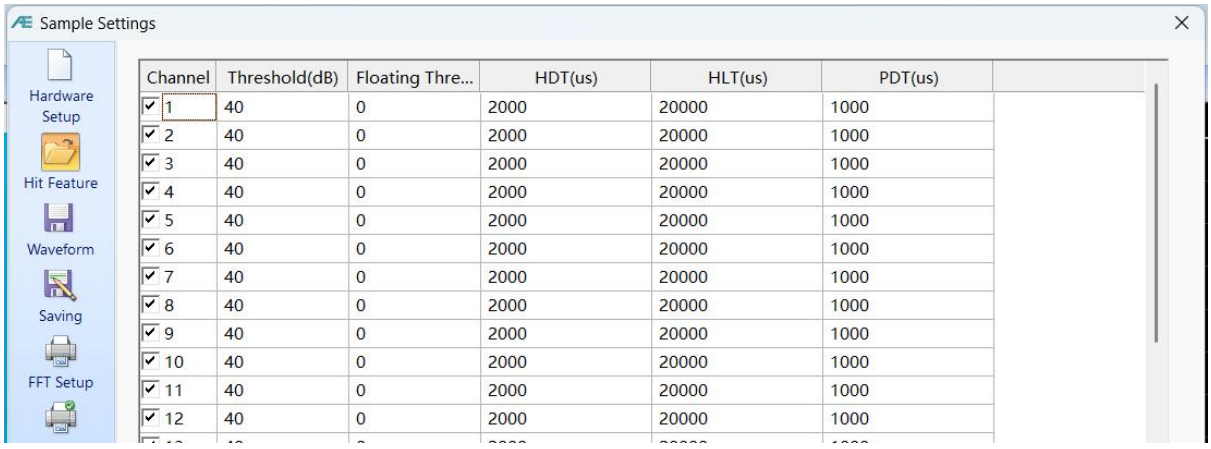
Analog Filter		Analog Filter		Analog Filter		Analog Filter	
High Pass	Low Pass	High Pass	Low Pass	High Pass	Low Pass	High Pass	Low Pass
100kHz	400kHz	400kHz	100kHz	100kHz	Ignore	Ignore	100kHz
100kHz	400kHz	400kHz	100kHz	100kHz	Ignore	Ignore	100kHz
100 ~ 400kHz Band Pass Filter		100 ~ 400kHz Band Stop Filter		> 100kHz High Pass Filter		< 100kHz Low Pass Filter	

Note: Low-passed filter allows the signal lower than the reference frequency to pass through; while the high-passed filter filters out the signal lower than the reference frequency to pass through, but allows the signal higher than the reference frequency to pass through. The "High Pass" column sets the lower limit of frequency domain, while the "Low Pass" column sets the upper limit of frequency domain. The selection of frequency band should be considered comprehensively with the frequency response of the sensor used and the expected signal frequency band.

- **Digital filter**: carrying out frequency filtering on the digitized signal, which can be activated or not according to the actual situation. The setting rules can refer to "analog filter". The lower limit of frequency domain is set in the high pass column, and the upper limit of frequency domain is set in the low-pass column. When the "digital filter" is not enabled, the values can be set as follows: high pass: 0, low-pass: 2500;
- **Preamplifier power supply**: with the driving voltage of the preamplifier, the acquisition board supports two kinds of external power supply voltage, which are 28V and 5V DC power supply respectively, and the selection is consistent with the voltage of the preamplifier, the default value is 28V; when it is set to 0V, it is an oscilloscope mode and can be directly connected to a third-party signal generator. **Note** that it cannot be modified directly. You need to click the table header and then click the pop-up menu "Allow power before modification" to click the edit box to modify.

2.2.5.1.1.2. Hit Parameter

Click [Hit Feature] on the left side of "sample setting" interface, and the following interface will appear. This interface mainly introduces the settings related to the extraction of acoustic emission parameters, including "Channel", "Parameter Threshold", "Floating threshold (under development)", "**HDT** (Hit Definition Time"), "**HLT** (Hit Lock Time)" and "**PDT** (Peak Definition Time)". The last three items are also called timing parameters. Whether the settings are correct or not is correct, it is very important to analyze the characteristic parameters of acoustic emission.



Channel	Threshold(dB)	Floating Thre...	HDT(us)	HLT(us)	PDT(us)
1	40	0	2000	20000	1000
2	40	0	2000	20000	1000
3	40	0	2000	20000	1000
4	40	0	2000	20000	1000
5	40	0	2000	20000	1000
6	40	0	2000	20000	1000
7	40	0	2000	20000	1000
8	40	0	2000	20000	1000
9	40	0	2000	20000	1000
10	40	0	2000	20000	1000
11	40	0	2000	20000	1000
12	40	0	2000	20000	1000

Fig. 2-14 Hit parameter setting interface

Definition and setting rules of nouns:

Channel: the default "√" selection number under the channel corresponds to the channel number that has been correctly identified, and corresponds to the hardware number of the chassis panel interface. The "√" in the selection box represents that the current channel enables the function of extracting acoustic emission parameters. If it is canceled the parameters will not be generated; after selecting, the parameter file with suffix of. pra will be generated.

Threshold: determine the voltage level of acoustic emission parameter data to be recorded. When the channel is in standby state and the voltage level exceeds the set value, the record will be triggered, and then controlled by timing parameters. According to the application environment setting of acoustic emission system, the noise level is generally higher than dB, and the setting range is 1-100 (integer). Generally speaking, 40dB is the common threshold;

Floating threshold (under development): it is suitable for working conditions with complicated noise environment. Generally, the floating range of 0-6dB is set. Most working sites do not need to enable this function, that is, it is set to "0"; after start-up, when the "parameter threshold" set is lower than the current "ASL" for a period of time, the actual threshold will increase the value within the "floating threshold", and the updated threshold value will be consistent with the original fixed "parameter gate". The maximum value of the two is taken as the final threshold.

HIT Definition Time: unit of microseconds (us), abbreviation HDT, the setting range is 1 ~ + ∞ (positive integer), can be directly input in the text box. It refers to the waiting time interval of hit signal set to correctly determine the end point of a hit signal. When the set HDT value is greater than the time interval T between two adjacent wave packets passing the threshold, the two wave packets will be classified as one acoustic emission hit signal; if the set HDT value is less than the time interval T when the two wave packets cross the threshold, the two wave packets are divided into two acoustic emission hit signals. For the same signal, the larger the HDT is, the less the AE parameters are extracted, and the smaller the setting is, the more AE parameters are extracted.

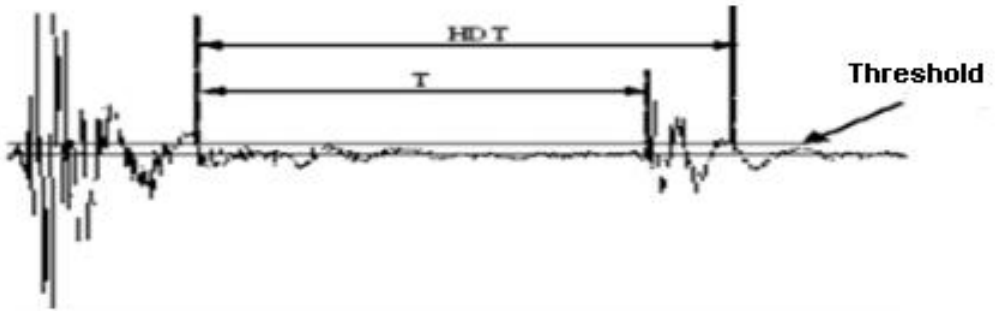


Fig. 2-15 Diagram of HDT

HIT Lock time: unit of microseconds (us), abbreviation HLT, the setting range is 1 ~ + ∞ (positive integer), can be directly input in the text box. In order to avoid receiving the reflected wave or late wave, the time window for closing the measurement circuit is set. After a HDT time after the end of the current acoustic emission event, there is a period of time (HLT) signal being ignored. This window is called hit look time. The value set is affected by signal attenuation, structure size, etc. If the setting value is too large, the subsequent AE signal will be missed. As shown in the figure below, the next AE signal T period has passed the threshold, but the HLT has not finished, and the signal in T period will not be sampled.

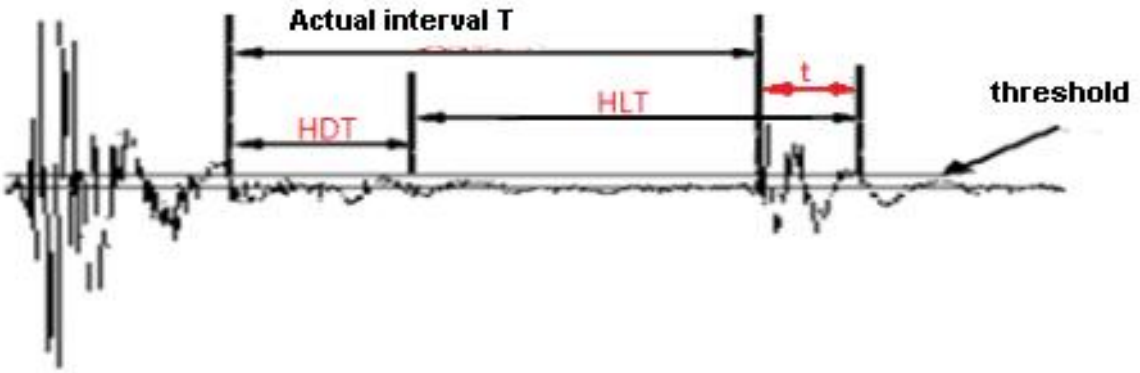


Fig. 2-16 Diagram of HDT

Peak definition time: unit of microseconds (us), abbreviated as PDT, the setting range is 1 ~ + ∞ (positive integer) theoretically, which can be input directly in the text box. The new maximum peak waiting time interval set to correctly determine the rise time of the hit signal. If it is too short, the high-speed and low amplitude precursor wave will be mistaken as the main wave, which is generally taken as **20-50%** of the hit definition time (HDT).

Convenient operation:

Modify single column parameters: first, complete the setting of "channel 1", and then click the column name, such as "Threshold dB", and the [Set Current Column] pop-up box appears, select and click;

Modify all channel parameters: first complete the setting of "channel 1", then click [Channel] in the project name to open the [Set All Columns] pop-up box, select and click;

2.2.5.1.1.3. Waveform

Click [**Waveform**] on the left side of "Sample setting" interface to display the following interface. This interface is mainly related to acoustic emission waveform and is the basis of acoustic emission waveform analysis method in later stage, such as FFT analysis, wavelet analysis, waveform generation parameters, etc. It includes **"Channel", "Trigger", "Synchronous mode", "Threshold", "Sampling rate", "Sampling length", "Sampling mode", "Pre-sample length", "Streaming"**.

Note: To ensure that the Settings of each channel in the same acquisition board are consistent, when the waveform sampling rate and sampling length of a channel are changed, other channels in the same sampling card with the channel will also be modified.

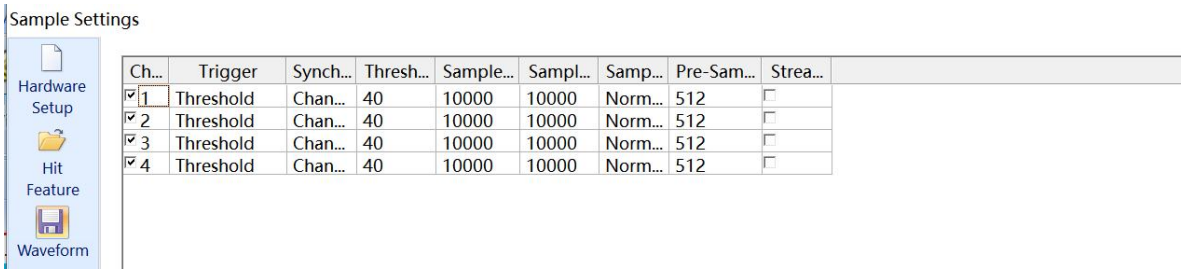


Fig. 2-17 Waveform Setup Interface

Definition and setting rules of nouns:

- **Channel**: the default "√" option number under the channel corresponds to the channel number that has been correctly identified, and corresponds to the hardware number of the chassis panel interface. The "√" in the check box represents that the current channel

enables the waveform sample and recording function. If it is canceled, the record will not be sampled; after selecting, the file with suffix (.AED) will be generated.

- **Trigger mode**

Double click any **"Trigger"** box under the **[Trigger]** column to open a drop-down window, including five modes: **"Threshold", "Parameter Trigger", "External Parameters", "Manual " and "Switch"**; each channel can be set independently.

For the application of non-oscilloscope mode or full waveform, select threshold trigger and channel independent; for the occasion of sampling full waveform function or using it as oscilloscope function, select channel synchronous trigger;

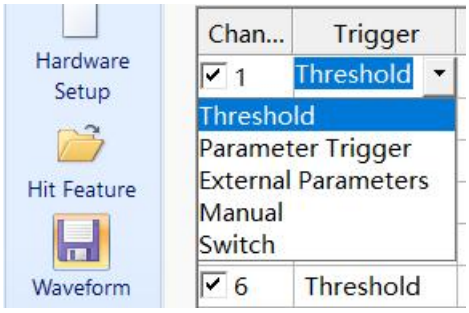


Fig. 2-18 Trigger mode

1) **Threshold trigger:** it is generally applicable to the acquisition of burst acoustic emission signal, and it is used to determine the voltage level at which AE waveform data begins to be recorded. When the channel is in standby state and the voltage level exceeds the set value, the recording will be triggered, and the end time is controlled by the "sampling length". According to the application environment setting of acoustic emission system, it is generally dB higher than the noise level, and the setting range is 1-100 (integer). Generally speaking, 40dB is the commonly used threshold in engineering;
2) **Parameter trigger:** when any AE channel receives the recorded parameters, the AE starts to enter the sample state; the waveform threshold is invalid and controlled by the HIT DATA threshold, and the waveform corresponding to the parameters is generated. The channel selection is independent and the others are invalid.
3) **External Parameters trigger:** External Parameters input controls waveform acquisition. Select "**External Parameters**" in sample settings / **External Parameters set up**, set "threshold", whose input range is 5-100% of **External Parameters** range, and the

out-parameter range is - 10V ~ + 10V. When the effective external parameter is sampled and the waveform is higher than the set threshold, the corresponding channel starts to collect waveform.

4) **Manual trigger:** Manually control the start and stop of the sampling process.

5) **Switch trigger:** select trigger level in sampling setting / other settings / trigger switch, then external switch input control waveform sampling.

- **Synchronization mode**: set the subordinate relationship between the current channel and other channels, double-click any "Channel Independent" box under the [Synchronization mode] column to open a drop-down window, including three items: "Channel Independent", "Master" and "Slave"; the default is "Channel Independent", which needs to be selected in combination with the "trigger mode" type.

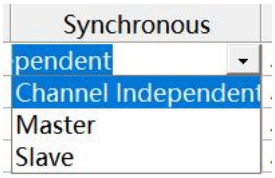


Fig. 2-19 Synchronization mode

1) **Channel Independent:** default setting, no subordination relationship with other channels, only controlled by "trigger mode" and "waveform threshold", and can be used with any trigger mode.

2) **Master channel**: it can be defined as trigger channel, and one or more can be set. When any master channel receives acoustic emission signal, other slave channels can sample acoustic emission signal synchronously.

3) **Slave channel**: it is subordinate to the "Master". When the master channel is triggered, data will be sampled together with the master channel. If both are set to "Slave", no data will be sampled.

- **Threshold**: it refers to the voltage level at which AE waveform data is recorded. When the channel is in standby state and the voltage level exceeds the set value, recording will be triggered. According to the application environment setting of acoustic emission

system, generally its setting dB is higher than the noise level, and the setting range is 1-100 (integer). Generally speaking, 40dB is the commonly used threshold in engineering; if "Streaming sampling" is ticked, the "Threshold" can be set to 1.

- **Sample rate:** its unit is kHz, and the **range is integer from 1000 to 10,000**. The value represents the maximum number of points per second that can be sampled by the current channel in the process of sampling acoustic emission signal. The larger the setting value, the higher the accuracy of the acquisition signal, and the larger the amount of data. Generally, it is recommended to set it to about 10 times of the upper limit of the frequency domain concerned. If it is set to 1000 (in kHz), it means that up to 1000K points can be sampled per second.
- **Sample length**: its unit is the number of points, which refers to the length of a single frame waveform that can be recorded and stored. If 4000 is set, it means that only the first 4000 points are stored in each frame waveform. This setting is only valid for generating waveform and does not affect parameter generation.
- **Sample mode**: double click any "normal" box under the [sample mode] column to open a drop-down window, including "Normal", "Pre-sampling" and "Post- sampling". The default value is "Normal".

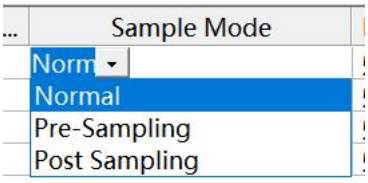


Fig. 2-20 Sampling modes

① **Normal:** start sampling once the signal exceeds the threshold. The data starts at the time when the acoustic emission signal passes the threshold and ends at the sample length.

② **Pre-sampling:** a section of data is sampled before the acoustic emission signal exceeds the threshold. The data length of this section is determined by the value set in the column "pre-sampling and post-sampling length", and the data is composed of "pre- sampling section data" and "normal- sampling section data".

③ **Post-sampling:** after the AE signal is officially lower than the threshold, a section of data is sampled. The data length of this section is determined by the value set in the column of "pre-sampling and posting sampling length", and the data is composed of "normal sampling section data" and "post sampling section data".

- **Pre/Post sampling length:** sample length points, only applied to "pre-sampling" and "post -sampling". If the combination of "pre-sampling" mode and "pre-sampling length 512" is set, it means 512 points of pre-sampling data; if it is calculated in time, it is to set the number of points / sample rate. This setting is only effective for generating waveform and does not affect parameter generation.

- **Streaming sampling:** "if" √ "is selected, it takes effect. The original threshold is triggered. The threshold is only valid when the trigger is triggered for the first time. After the channel is triggered for the first time, the waveform data will be continuously sampled, which can be understood as the full waveform mode, which is affected by the sampling rate, waveform threshold (only for the first trigger) and synchronization mode. It is suitable for the situation where ultra-long wave needs to be sampled. It is usually used in combination with spectrum research or waveform re generation parameter function.

Note: It is necessary to consider the relationship between the actual bandwidth of computer communication, the remaining space of hard disk partition and the amount of AE data. The actual communication bandwidth should be much larger than the waveform data per second; the remaining space of hard disk partition should not be less than [the waveform data per second] × [acquisition time(s)], and the acoustic emission [waveform data per second] = [the sampling rate] × 2 × [channel number used], in unit of MB.

Configuration combination list: in view of the combination relationship between the items in the interface, the following table is listed for reference only:

Table 2-2 Combination List of Waveform Acquisition Project

Trigger mode	Synchronize	Threshold	Sampling rate	Sampling length	Sampling mode	Length of pre &post sampling
Threshold	Channel Independent	O	O	O	O	O
	Master	O	O	O	O	O
Parameter	X	X	X	X	X	X
External Parameters	Channel Independent	O	O	O	O	O
	Master	O	O	O	O	O
Manual	X	X	X	X	X	X
Switch (high) trigger	X	X	X	X	X	X
Streaming sampling	Channel Independent	O first	O	X	X	X
	Master	O first	O	X	X	X
"O" is on behalf of the item is valid, "X" represents that the item is invalid.						

2.2.5.1.1.4. Saving

Click **[Saving]** on the left side of "Sample settings" interface to display the following interface. This interface is mainly related to the settings of acoustic emission data storage. Acoustic emission data files are generally divided into two categories: acoustic emission parameter data (.pra) and acoustic emission waveform data (.aed). **Automatic file naming method: file name + "_" + sample time**, for example: CJ2(70dB) _220630153540436.aed

Definition and setting rules of nouns:

- **Browse...:** Find a valid file path for file saving. If not, it needs to create a destination folder in advance. Click this button to select a path for storing data files.
- **File name**: letters, numbers and characters can be input directly in the text box, but special characters such as _ \ / : * ? " < > | etc. cannot be included, except for the "_" before the time label.
- **Save Acquired Data**: if "√" is selected, the data file will be saved to the computer,

otherwise the data will not be saved.

- **Notice Before Acquisition**: it is only used to notice whether to save data or not. If "√" is selected, it will prompt to notify every time after clicking **[Sample]**.
- **Maximum file size (MB):** setting this item can make the data sampled after the data file reaches the specified capacity be stored in a new file. The setting range is 1-4000 (positive integer, unit: MB), which can be input directly in the text box.
- **Maximum file number:** setting this item can make the data no longer be saved after the number of data files reaches a certain number (stop in the collection state) or continue to store after covering the previously stored data. The product of this value and the setting value of "maximum storage amount of sampling file" shall not exceed half of the available capacity of the storage disk. The setting range is 1-1000 (positive integer), can be entered in tot the text box.
- **Autosave setup:** Files are stored in cycles and automatically overwritten, which is enabled when "√" is selected. After checked, when the "**Maximum file number**" is reached, the software will write the previous stored files with the same name to the disk in turn, and only record the acoustic emission data of the relative time before the end.

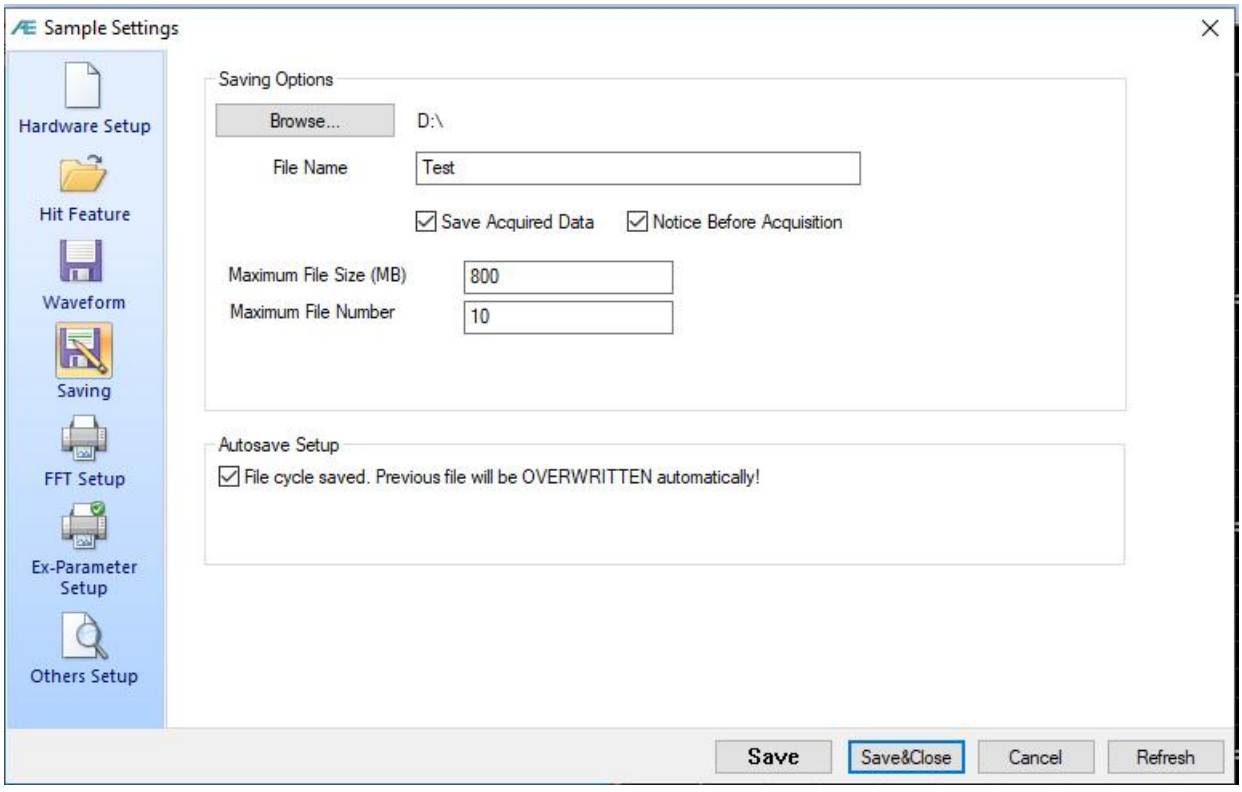


Fig. 2-21 Data Saving Interface

2.2.5.1.1.5. FFT settings

Click **[FFT setup]** on the left side of the "Sample Settings" interface to display the following interface. This interface introduces the settings related to the extraction of acoustic emission frequency domain parameters, including "Window Function", "FFT Sampling Decimation Ratio" and "Partial Power Setup". The output results related to the waveform are displayed in the "FFT View"; the results related to the parameters are displayed in the "Data Table" .

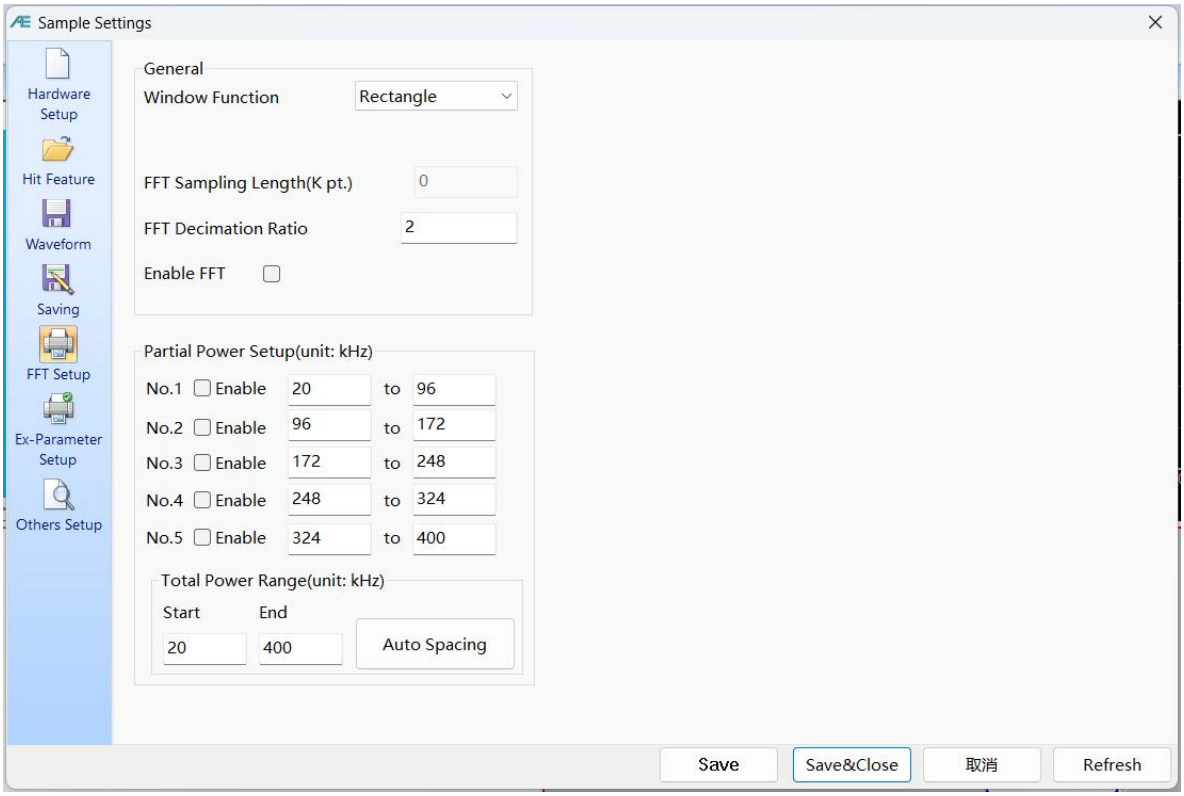


Fig. 2-22 FFT Setup Interface

Window function: the drop-down menu contains five window options: rectangle/Gauss/Hanning/Hamming/Blackman. Users can select the window type according to the actual needs. Generally, rectangle window and Gaussian window are commonly used.

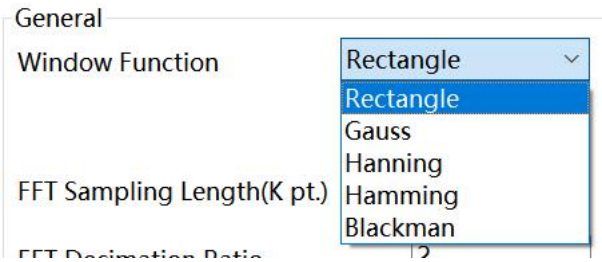


Fig. 2-23 FFT window function Interface

FFT sampling length: this position is displayed as 0 by default, the sampling length in "frequency domain waveform diagram" = FFT sampling rate / FFT Sampling decimation ratio;

FFT Sampling decimation ratio: the decimation ratio means that one of every few original sampling point (the sampling rate of waveform sampling) is taken for FFT calculation, which "2" means that one sample is extracted from every two original sampling points for FFT calculation, which is equivalent to that the FFT sampling rate is reduced to half of the original sampling rate;

Enable FFT: "if" √ "is selected, the" **Partial Power** "will be calculated;

Partial Power Setup: this part is used to set the requirements for generating local power spectrum parameters, including 5 frequency bands, namely "No.1" ~ "No.5". The box after the parameter name of "√" will enable the current parameter. It can be checked as required, and 5 parameters can be set at most. After selecting a certain parameter, the upper and lower limits of the frequency band can be set directly, and the unit is kHz. The frequency domain distribution of AE signals is generally below 500KHz.

Total power range: input positive integer directly in the text box, set the start frequency and end frequency, and click the "Auto Spacing" button, and the set value range will be automatically evenly divided according to the number of selected local power spectrum parameters. The value after automatic distribution allows users to modify it again.

2.2.5.1.1.6. Ex-Parameter Setup

Click **[Ex-Parameter Setup]** on the left side of "Sample settings" interface to display the following interface, which is related to external parameters. For specific wiring method, please refer to hardware part of **Chapter 3.7.7** of the SAEU3H user manual or contact our technicians. For synchronous acquisition of external parameters and acoustic emission signal, please refer to Chapter 2.2.5.1.1.3 Waveform < "External parameters trigger" in "trigger mode".

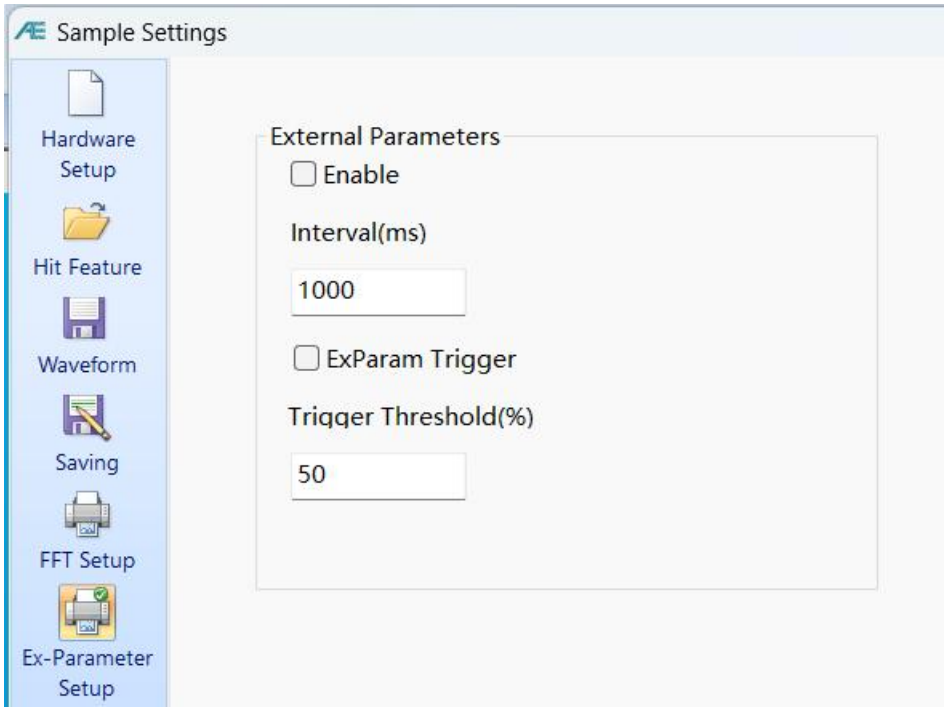


Fig. 2-24 External Parameters setting interface

External Parameters: if “Enable” check-box "√" is selected, the function of "timing sampling" will be turned on after it is enabled, and the value setting range of the latter is 5-1000 (positive integer), which can be directly input in the text box; this moment, the collected external parameter variables (analog voltage - 10V ~ + 10V) will be displayed in the same step with the acoustic emission signal; the interval value is the external parameter variable updating cycle, for example 1000ms, that is, the voltage value is collected every 1000ms, which is synchronized with the acoustic emission hit parameters. If there is no acoustic emission signal in this period, only the external parameter voltage is collected.

Ex-Param trigger: "if" √ "is selected, it is enabled, and must be used together with" External Parameters ". Waveform acquisition of control channel is controlled by external parameter input. Set" Trigger Threshold "in" Sample settings "/ Waveform sampling "/" Trigger mode ". The input external parameter range is 5-100%, and 5-100 (positive integer) can be directly input into the text box; the external parameter range is - 10V ~ + 10V, when effective external parameters are collected and the waveform is higher than the set threshold, the corresponding channel starts to collect waveform.

2.2.5.1.1.7. Others Setup

Click **[Others Setup]** on the left side of the "Sample settings" interface to display the following interface, including "max parameter time" and " trigger switch".

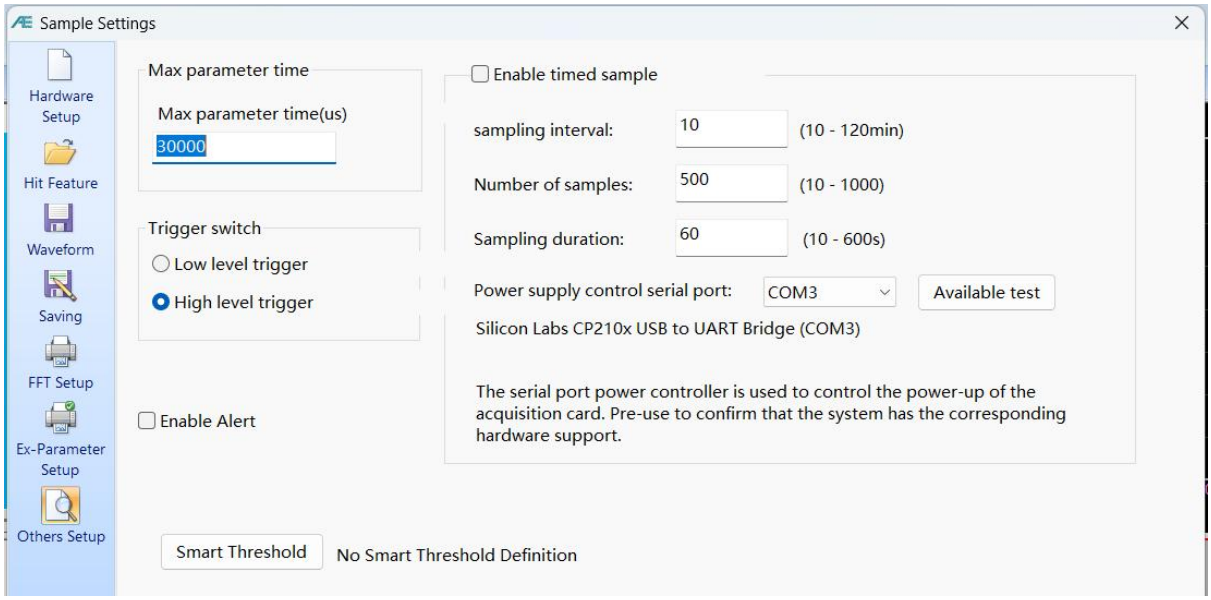


Fig. 2-25 Others setup interface

Max parameter time(us): when the acoustic emission signal is continuously higher than the threshold value, and the stated HDT cannot determine the intercepted acoustic emission parameters, the **max parameter time** takes effect, that is, the rest of the parameter futures are all calculated in the unit of the "duration" in the current generation parameter line.

Trigger switch: the AE system is controlled by external hardware input of high and low levels for signal acquisition. The setting here corresponds to the "trigger mode" in waveform sampling. When using, it needs to select "**High/low level trigger**", and the input interface is the “Din” connection port in the acoustic emission external parametric box. When the level signal received by the hardware is the same as the software setting, the AE system will get into sampling state.

Enable timed sample: After checking, the timed acquisition function can be used.

Sampling interval: the time interval between two samples.

Number of samples: how many number of samples should be collected before stopping sampling.

Sampling duration: the length of time of one sample.

Power supply control serial port: used to control the power on of the acquisition card.

Enable Alert: after enabling, the alarm output can be sent.

Smart threshold: customize thresholds, define the sample time and threshold according to the specific situation.

2.2.5.1.2. Sample Settings for RAEM1

The configuration settings of RAEM1 should be done in "RAEM1 Configuration" software. Please refer to the users manual of RAEM1.

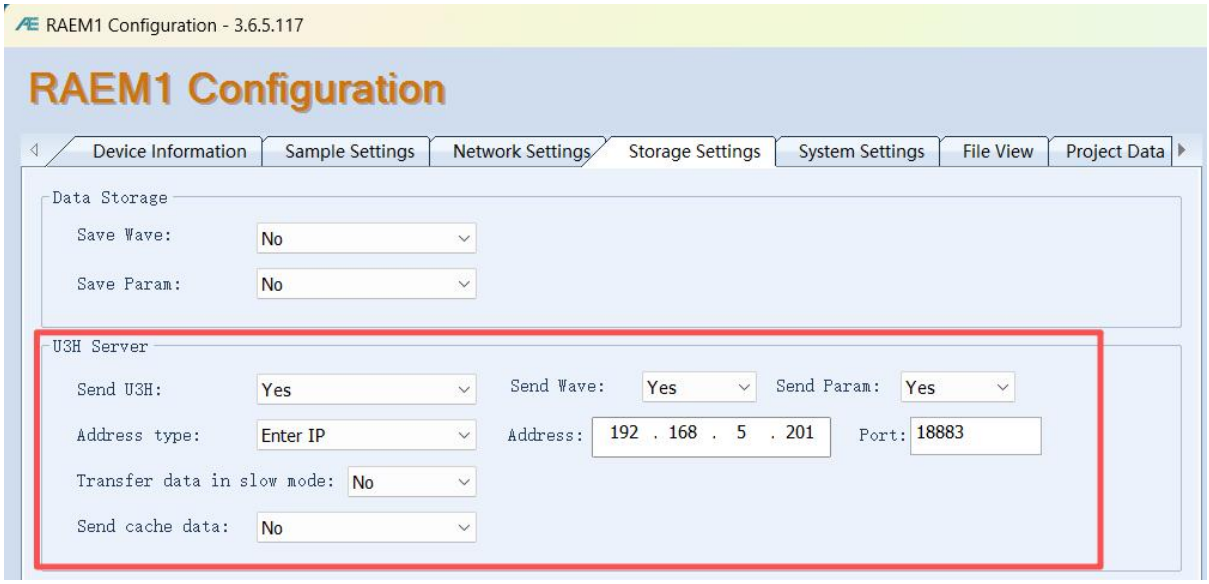


Fig. 2-26 RAEM1 Configuration software settings to "U3H server"

In the "RAEM1 Configuration" software, in the "Storage Settings":

① Enable the "**Send U3H**", "**Send Wave**" and "**Send Param**". So that the RAEM1 will send waveform and AE parameters to SWAE software (considered as the "U3H server").

② Then let RAEM1 know where to send SWAE data to. Select "Enter IP" in "**Address type**". The "Address" is the IP address of the SWAE computer receiving data from RAEM1. The IP address of the receiving computer can be found in the IPv4 address in **"Network & Internet" > "View your network properties"** of your computer. Depending

on the communication method between RAEM1 and your computer, select the right IPv4 address of the connection. Refer to the user manual of RAEM1 for details.

③ Keep the default port number as “18883”.

Only after the acquisition settings and the transmission to SWAE (“U3H server”) in “RAEM1 Configuration” software, as in the Figure 2-26, it can move on to SWAE software.

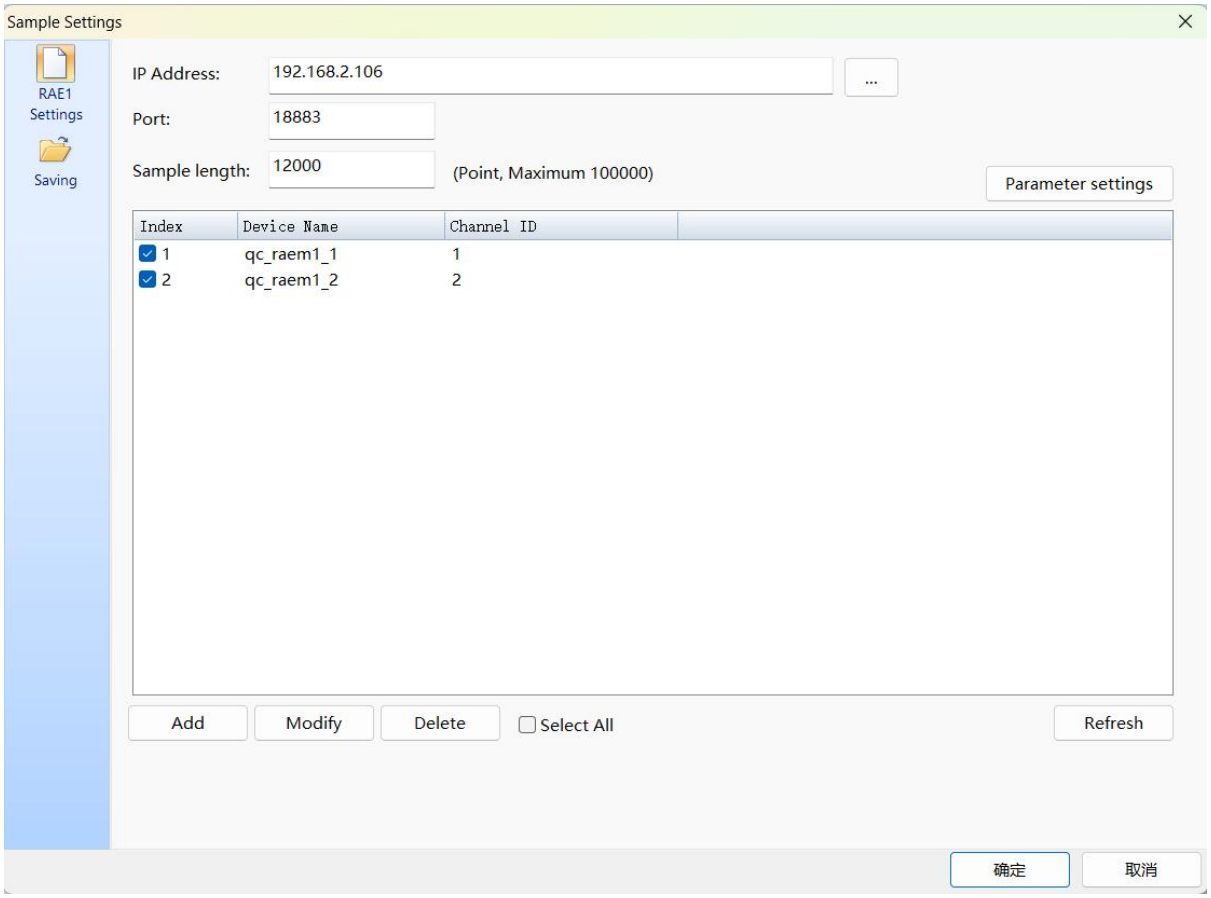


Fig. 2-27 Sample Settings for RAEM1 series

The "Sample settings" page for **RAEM1** series (RAEM1 & RAEM1-6 instruments) is shown in Figure 2-27.

The “**IP Address**” here should be the computer IP address receiving the data from RAEM1 series. (The same IP address as in the “RAEM1 Configuration” software above). Click the ... button to see what the current IP address are in the available communication methods. If it’s through Ethernet cable, the IP address is normally 192.168.0.xxx.

The “**Port**” number should be consistent with the port number in RAEM1 Configuration software, i.e. 18883.

The “**Sample length**” is only related to the waveform view display in the SWAE software, not effects on the performance of RAEM1. The sample length here means the number of sample points display in each section of the waveform view. The maximum number is 100,000 (points). It’s also related to the sample speed in RAEM1. For example, you set 2000 (kS/s) sample speed in the RAEM1 Configuration, and the sample length is 1000 (points) in the SWAE software, the length in the waveform view will be 1000/2000kS/s = 0.5ms.

The table below is the device list. Although SWAE will automatically display the data when it receives data from any available devices or channels and it will automatically number the channels based on the receive time. In case of random channel assignments by the software, **it’s better to assign the channels in advance in the list.** Click “**Refresh**” button at the right below the table, and the software will display all available devices in the network. If the device list is not correct, use the “**Add**”, “**Modify**” and “**Delete**” buttons below to correct it. The “Device Name” should be the same as the device name in the RAEM1 Configuration software. Start with Channel #1. **The checkbox next to the “Index” must be enabled** so that the SWAE will display the checked channels. Otherwise, there will be no channel to display.

The “**Saving**” sub-menu is the same as Chapter 2.2.5.1.1.4.

Click “**OK**” to save and close the settings.

2.2.5.1.3. Recommended Inspection Setup on Site

Acoustic emission technology is widely used in various industries and covers a wide range of fields. The settings of "Hardware Settings", "Hit Feature" and "Waveform” are provided for reference only.

2.2.5.1.3.1. Testing of Pressure Vessels

Table 2-3 Hardware Settings of Pressure Vessel

Hardware setup	Channel	Preamplifier gain (dB)	Input range	Analog filter		Digital filter		Preamplifier power	
				High Pass	Low pass	High pass (kHz)	Low pass (kHz)		
	Default	40	10Vp	100kHz	400KHz	100	400	28V	
Hit feature	**Channel**	**Threshold (dB)**	**Floating threshold(dB)**	**HDT(us)**		**HLT(us)**		**PDT(us)**	
	All selected	Between 35~45	0	2000		20000		1000	
Waveform	**Channel**	**Trigger**	**Synchronous**	**Threshold (dB)**	**Sample rate**	**Sample length**	**Sample mode**	**Pre sampling length**	**Streaming Sampling**
	Depends (normally not √)	Threshold	Channel Independent	Between 35~45	>3000	>20000	Normal	Default	Disable

2.2.5.1.3.2. Inspection of Atmospheric tank floor corrosion / leakage detection / high attenuation metal components

Table 2-4 Hardware settings for corrosion / leakage detection of atmospheric tank bottom plate/high attenuation metal components

Hardware setup	Channel	Preamplifier gain (dB)	Input range	Analog filter		Digital filter		Preamplifier power
				High Pass	Low pass	High pass (kHz)	Low pass (kHz)	
	Default	40	10Vp	20kHz	100KHz	20	80	28V
Hit feature	**Channel**	**Threshold (dB)**	**Floating threshold(dB)**	**HDT(us)**		**HLT(us)**		**PDT(us)**
	All selected	Between 30~45	0	1000		2000		400

	Channel	Trigger	Synchronous	Threshold (dB)	Sample rate	Sample length	Sample mode	Pre sampling length	Streaming Sampling
Waveform	Depends (normally not √)	Threshold	Channel Independent	Between 30~45	>1000	2000	Normal	Default	Disable

2.2.5.1.3.3. Small metal specimens / metal matrix composites

Table 2-5 Hardware settings of metal small specimen / metal matrix composite

Hardware setup	Channel	Preamplifier gain (dB)	Input range	Analog filter		Digital filter		Preamplifier power
				High Pass	Low pass	High pass (kHz)	Low pass (kHz)	
	Default	40	10Vp	100kHz	400KHz	100	300	28V

Hit feature	Channel	Threshold (dB)	Floating threshold(dB)	HDT(us)	HLT(us)	PDT(us)
	All selected	Between 40~45	0	600	1000	300

Waveform	Channel	Trigger	Synchronous	Threshold (dB)	Sample rate	Sample length	Sample mode	Pre sampling length	Streaming Sampling
	Depends	Threshold	Channel Independent	Between 40~45	>4000	>20000	Normal	Default	Disable

2.2.5.1.3.4. Non-metallic matrix composites (except ceramics)

Table 2-6 Hardware settings for inspection of nonmetallic matrix composites

Hardware setup	Channel	Preamplifier gain (dB)	Input range	Analog filter		Digital filter		Preamplifier power
				High Pass	Low pass	High pass (kHz)	Low pass (kHz)	
	Default	40	10Vp	20kHz	400KHz	20	300	28V

Hit feature	**Channel**	**Threshold (dB)**	**Floating threshold(dB)**	**HDT(us)**		**HLT(us)**		**PDT(us)**	
	All selected	Between 45~65	0	150		300		50	
Waveform	**Channel**	**Trigger**	**Synchronous**	**Threshold (dB)**	**Sample rate**	**Sample length**	**Sample mode**	**Pre sampling length**	**Streaming Sampling**
	Depends	Threshold	Channel Independent	Between 45~65	>4000	>20000	Normal	Default	Disable

2.2.5.1.3.5. Filament wound Composites

Table 2-7 Hardware Settings for inspection of Filament wound Composites

Hardware setup	**Channel**	**Preamplifier gain (dB)**	**Input range**	**Analog filter**		**Digital filter**		**Preamplifier power**
				High Pass	**Low pass**	**High pass (kHz)**	**Low pass (kHz)**	
	Default	40	10Vp	20kHz	400KHz	20	300	28V
Hit feature	**Channel**	**Threshold (dB)**	**Floating threshold(dB)**	**HDT(us)**		**HLT(us)**		**PDT(us)**	
	All selected	Between 55~65	0	150		300		50	
Waveform	**Channel**	**Trigger**	**Synchronous**	**Threshold (dB)**	**Sample rate**	**Sample length**	**Sample mode**	**Pre sampling length**	**Streaming Sampling**
	Depends	Threshold	Channel Independent	Between 55~65	>4000	>20000	Normal	Default	Disable

2.2.5.1.3.6. Rock mechanical test (hard rock)

Table 2-8 Hardware settings for Inspection of rock mechanical test

Hardware setup	**Channel**	**Preamplifier gain (dB)**	**Input range**	**Analog filter**		**Digital filter**		**Preamplifier power**
				High Pass	**Low pass**	**High pass (kHz)**	**Low pass (kHz)**	
	Default	40	10Vp	10kHz	400KHz	100	400	28V

Hit feature	**Channel**	**Threshold (dB)**	**Floating threshold(dB)**	**HDT(us)**		**HLT(us)**		**PDT(us)**	
	All selected	Between 40~55	0	600		1000		300	
Waveform	**Channel**	**Trigger**	**Synchronous**	**Threshold (dB)**	**Sample rate**	**Sample length**	**Sample mode**	**Pre sampling length**	**Streaming Sampling**
	Depends	Threshold	Channel Independent	Between 40~55	>4000	>20000	Normal	Default	Disable

2.2.5.1.3.7. Concrete / synthetic / sandstone mechanical tests

Table 2-9 Hardware settings for inspection of concrete / synthetic / sandstone mechanical test

Hardware setup	**Channel**	**Preamplifier gain (dB)**	**Input range**	**Analog filter**		**Digital filter**		**Preamplifier power**	
				High Pass	**Low pass**	**High pass (kHz)**	**Low pass (kHz)**		
	Default	40/60	10Vp	20kHz	100KHz	20	100	28V	
Hit feature	**Channel**	**Threshold (dB)**	**Floating threshold(dB)**	**HDT(us)**		**HLT(us)**		**PDT(us)**	
	All selected	Between 35~50	0	150		300		50	
Waveform	**Channel**	**Trigger**	**Synchronous**	**Threshold (dB)**	**Sample rate**	**Sample length**	**Sample mode**	**Pre sampling length**	**Streaming Sampling**
	Depends	Threshold	Channel Independent	Between 25~50	>2000	>10000	Normal	Default	Disable

2.2.5.1.4. Sample Control

The three buttons **[Sample], [Pause]/[Continue] and [Stop]** are only effective in the process of acoustic emission data acquisition. When the color is dark blue, it means that the button operation can be performed.

Fig. 2-28 Sample control interface

- **Start Sampling**

When the system hardware is set correctly and the sensor is connected right with preamplifier, press [Sample] to start sampling. If the system is not installed or the acoustic emission acquisition board is not selected in the "Hardware Setup", the system will have an error prompt when doing this operation;

- **Pause sampling**

Click [Pause] once take effect, and continue to perform preset operation on the data uploaded to the computer. The AE host will no longer transmit data and enter into the stage of sampling waiting state, and the button will turn into **[Continue]**;

- **Continue Sampling**

Click [Continue] to resume data acquisition and transmission. The button will turn into [Pause].

- **Stop sampling**

When the stop command takes effect, the acquisition board stops generating new data, data uploading and upper computer processing continue until all data are processed to generate data files.

2.2.5.2. Tags

It can be used in the data collection and replay period of time. The annotation content of the tag is bound with the data file, and the time point is the effective time of the tag; users are allowed to add, modify and delete at any time;

- **Add tags**

In the process of signal acquisition or data replay, if there is interference or special waveform, you can choose to add tag function. Operation: in the “Tag” menu, select "**Add Tag**" sub-menu, and the dialog box will pop up. Users can add notes in the note’s information.

- **View tag**

During data replaying, you can browse through the tags. Operation: in the “Tag” menu item, select the "**Tag View**" sub-menu to pop up the dialog box. Users can double-click a label randomly to view its corresponding waveform and parameters for analysis; modify the label content, delete the label, and select the tag to jump to the view position of the corresponding time tag. The label corresponds to the first frame of the data segment.

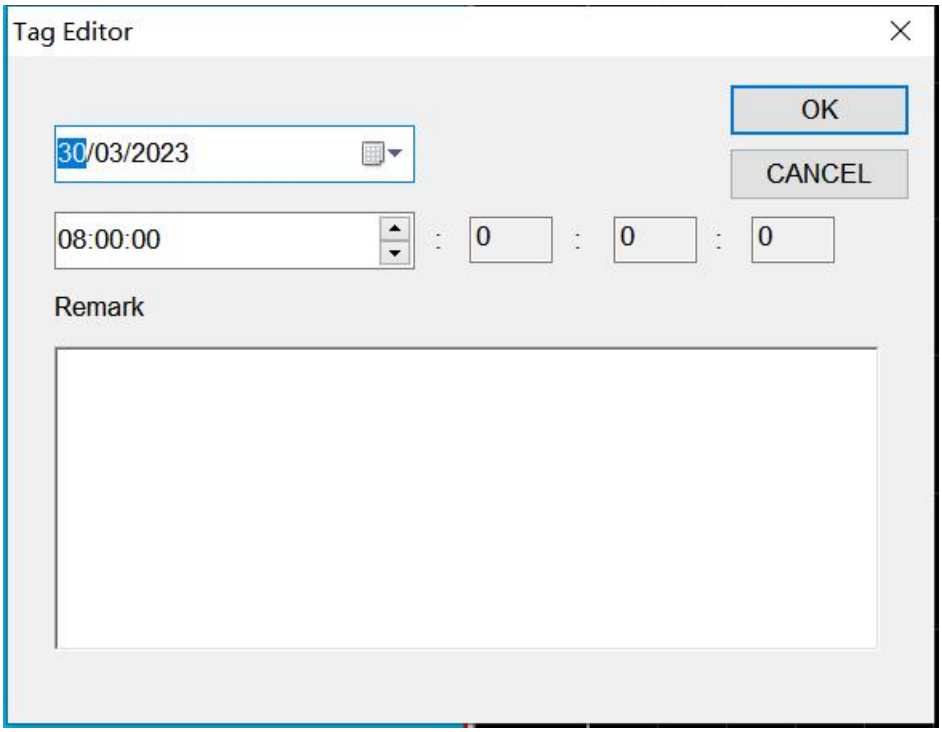


Fig. 2-29 Label editing interface

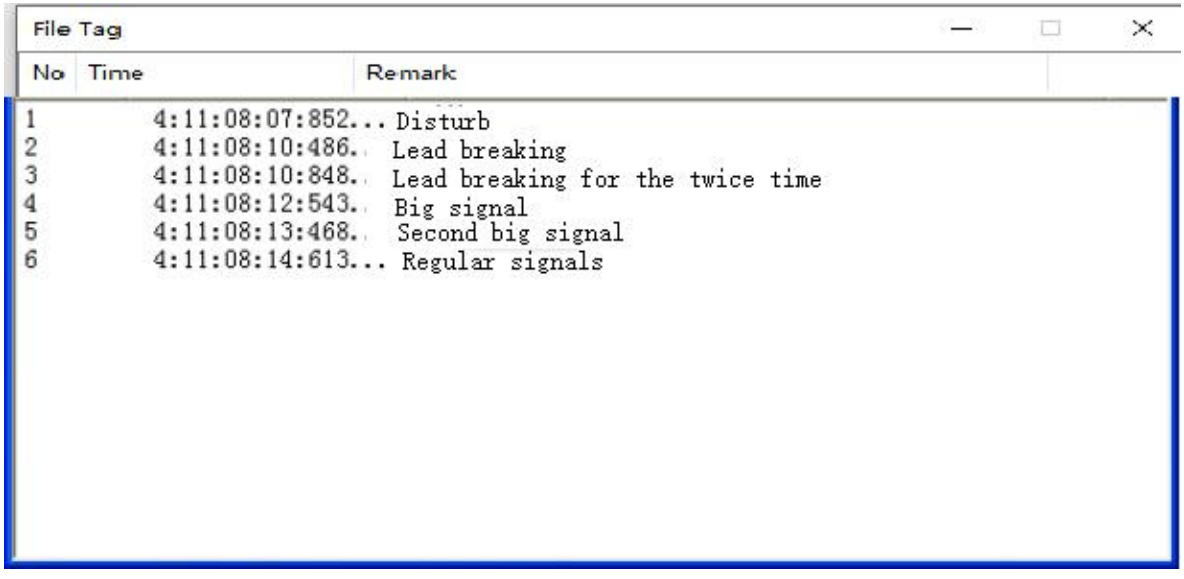


Fig. 2-30 Tab view interface

2.2.5.3. Auxiliary functions

2.2.5.3.1. Auto Sensor Testing

Through the pulse transmission function of the sensor automatic calibration (AST, Auto Sensor Testing), that is, after transmitting a pulse signal through a certain channel, observe the signal reception of all channels to check the connection of each channel, the coupling of the sensor and the sensitivity.

But please note that RAEM1 cannot perform AST well because it only has one sensor. SAEU3H and RAEM1-6 can use AST function.

Click **[Hardware and Sample]** → **[A.S.T.]** to open the AST test page. Set **[Pulse Width]** **[Pulse Interval]** **[Channel Selection]** as needed, and then click **[Start Emission]**.

Note: The AST test only takes effect when the system starts acquisition (**[Hardware and Sample]** > **[Sample]**). It is recommended that there is a certain distance between sensors. And the threshold is appropriately set higher to avoid noise reception that affects statistics. For example, for steel materials, the distance between sensors is >30cm.

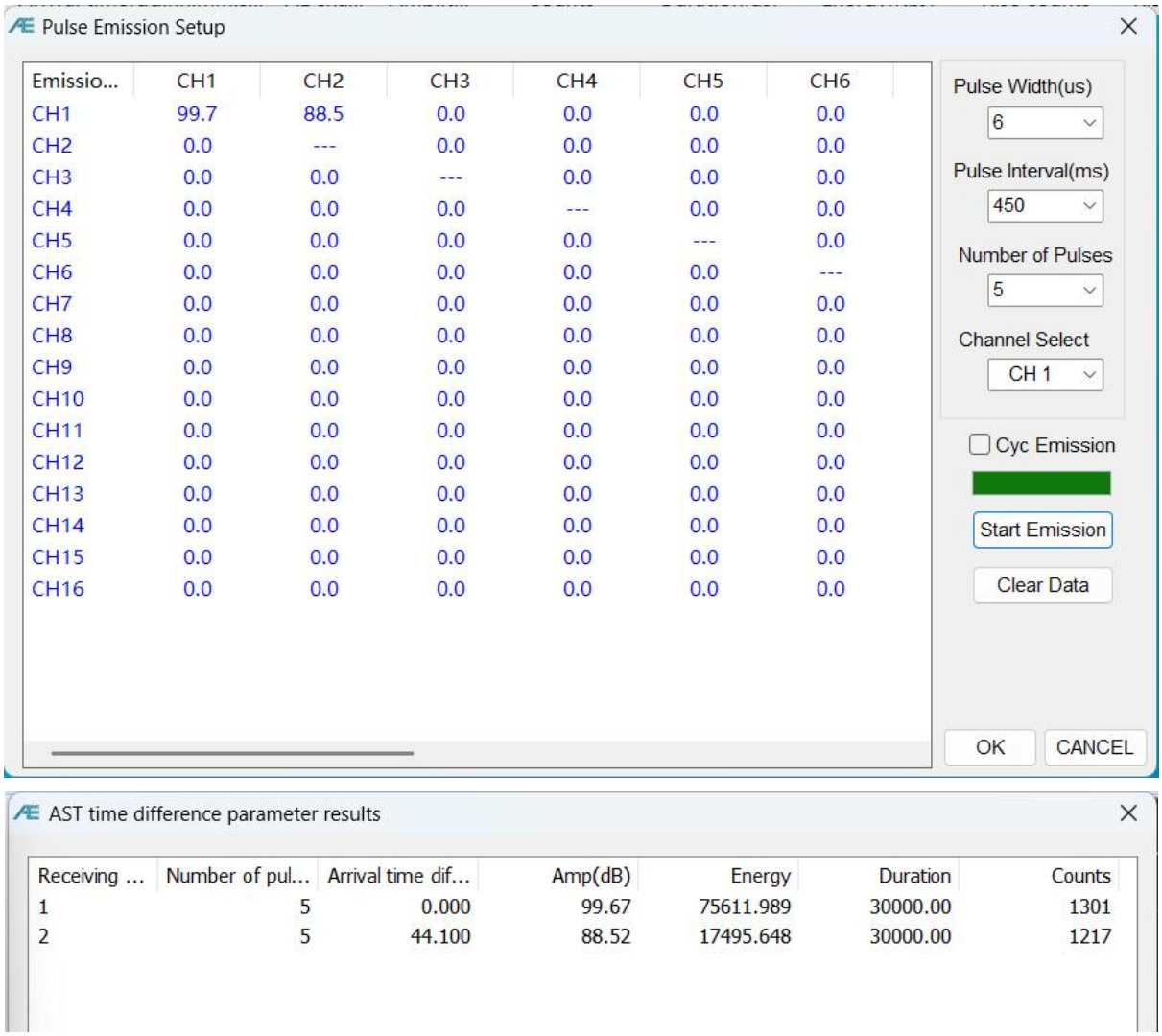


Fig. 2-31 Pulse Emission Setup Interface

Setup Description:

Pulse width: refers to the duration of a single pulse, which can be selected from 1 to 20, unit: microsecond (μs);

Pulse interval: Refers to the interval between two adjacent pulses (if there are more than 1 pulse per channel to emit). The purpose of setting the pulse interval is to prevent the influence of echoes. There are twenty options from 50 to 1000ms;

Number of pulses: The total number of pulses from the start of transmission to the end of transmission per channel according to the set interval time;

Channel selection: select the channel to transmit pulse signal. The selected channel and other channels will receive the pulse signal. Selecting "all channels" means that all channels

transmit pulse signals one by one in turns. The drop-down setting shows how many channels are available here;

Cycle Emission: It refers to that the pulse signal is continuously emitted in cycles. If a single channel is selected to emit, that single channel will emit pulse signals periodically (the number of pulses will be ignored in that case); if all channels are selected, every channel will emit the pulse signals one by one in turns until the last channel completes and it will cycle back and restart from Channel 1 again. Click this button if needed;

Start Emission: Click this button to start the pulse transmission;

Clear data: click this button to clear the completed self-calibration data for the next self-calibration task;

Cancel: click this button to close the window;

OK: click this button to indicate that the task is complete and close the window.

In the "AST time difference parameter result" window:

Receiving channel: the channels that actually receive the pulse signals.

Number of pulses: the total number of pulses actually received by specific channels from the start till the end of the emission according to the set interval time.

Arrival time difference: Arrival time difference = receiving channel arrival time - transmitting channel arrival time, unit: microsecond.

2.2.5.3.2. Hardware Parameter Filter

Click "**Hardware Parameter Filter**" button to pop up the interface as shown in the figure. This function sets the filters at the hardware level of the AE boards when sampling, and the data after the filter will be displayed and stored in the software.

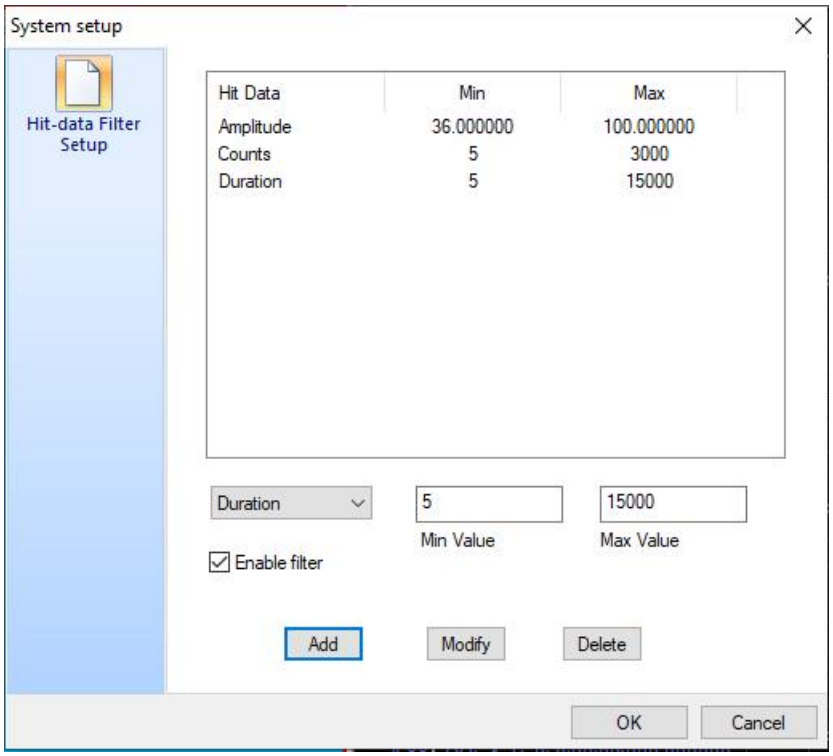


Fig. 2-32 Hardware HIT-Data Filter setup

Parameter selection: select a parameter as a filter. The arrival time, channel number, amplitude, counts, duration, energy, rise counts, rise time, RMS and ASL parameters can be selected from the drop-down menu. The parameter within the minimum and maximum value range will be retained. When multiple filters are set, only the data meeting all filters range will be recorded and displayed.

Add: to add a new parameter filter, select the corresponding AE characteristic parameters from the drop-down menu, then input the minimum value and maximum value in the text box, and click the **"Add"** button to add the parameter filter to the list.

Modify: to modify the set parameter filter, click the set parameter filter row in the list (the line turns blue after selection), and then re-enter the minimum value and maximum value in the text box, and then click the "**Modify**" button.

Delete: to delete the set parameter filter, click the parameter filter row in the selected list (the line turns blue after selection), and then click [Delete].

Enable filter: if this option is clicked, all parameter filters in the list will be effective during data replay analysis, otherwise they will not work.

2.2.6. View Menu

The view is a visual window of AE data. Selecting a certain type of view in the process of sampling and analysis will make the result display more intuitive and easier to understand and analyze. The View menu function is mainly used to set the view area, mainly including "view operation" and "view type". The view operation function is to set the frames of the display view window area, and the view type is to specify the data representation form in each view area.

Fig. 2-33 View Menu Interface

2.2.6.1. View Operation

2.2.6.1.1. New view group

A view belongs to a view group. Multiple view groups can be established at the same time. Each view group can contain one or multiple view window. Different view types can be assigned to each window according to the actual needs.

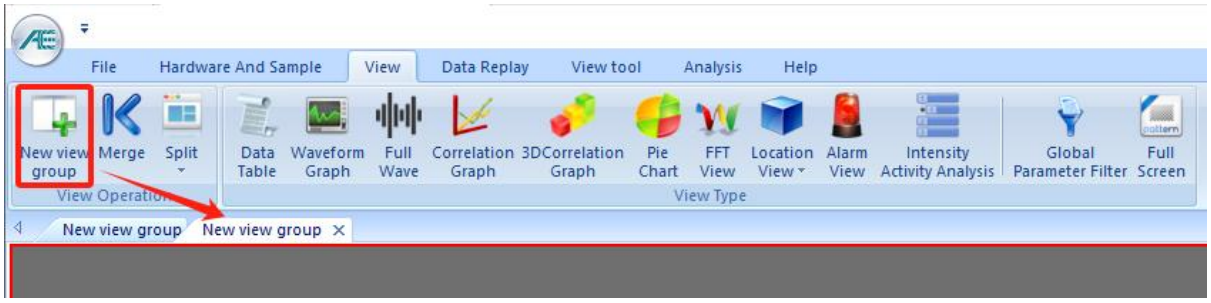


Fig. 2-34 Creating a new view group

Click **[View]** in the main menu to switch to the view setting interface. Select and click **[New View Group]**, and a complete gray area named "new view group" will appear, double click

the title location to rename it; repeat this operation to create multiple new view groups.

2.2.6.1.2. View Split

Select a new/blank view group in the graphic display area (after selection the window frame turns red), click **[Split]**, and select the array size (such as 2 rows x 3 columns) according to the demand, as shown in the figure. Click the left button again to complete the view group segmentation and generate a multiple views window. In the same way, any single existing view can be divided and split again.

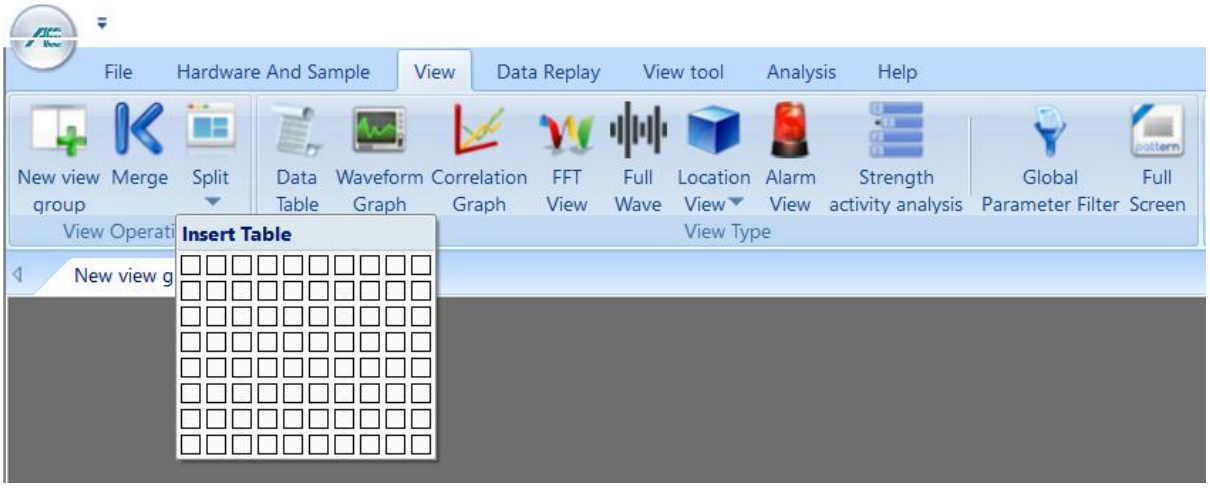


Fig. 2-35 View Split

Window attribute: any window can be split again; each window can be defined as any view type; double clicking any window can be used to maximize and minimize the display of the current view.

2.2.6.1.3. View Merging

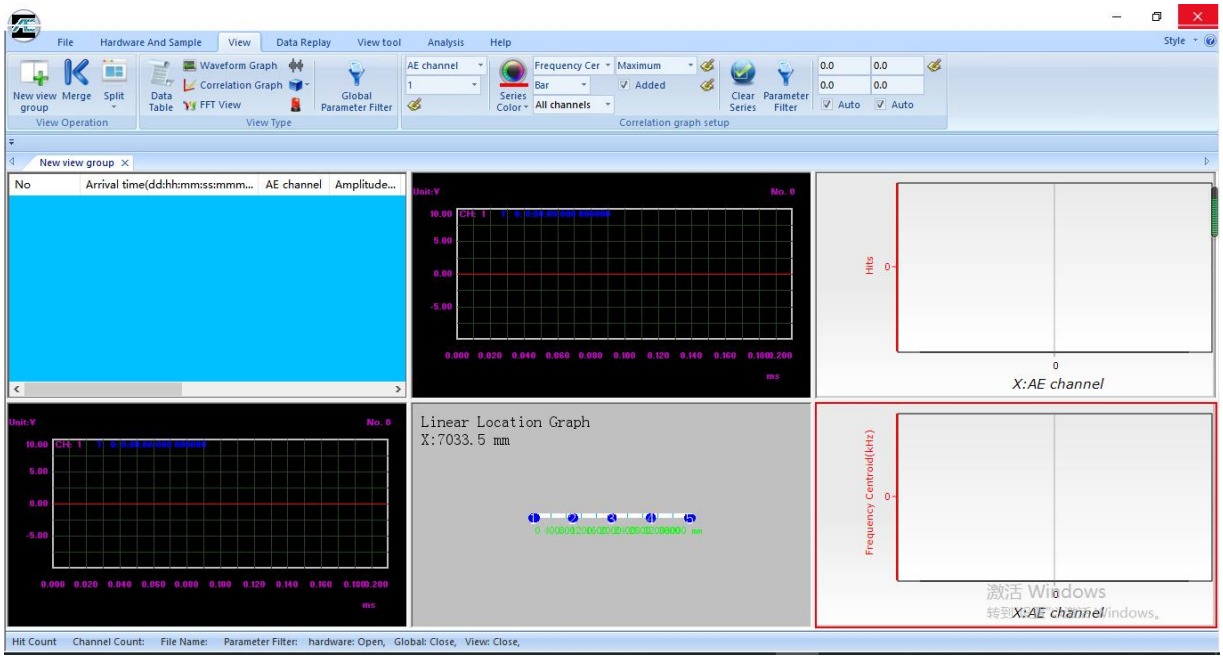


Fig. 2-36 Before View merge (selected)

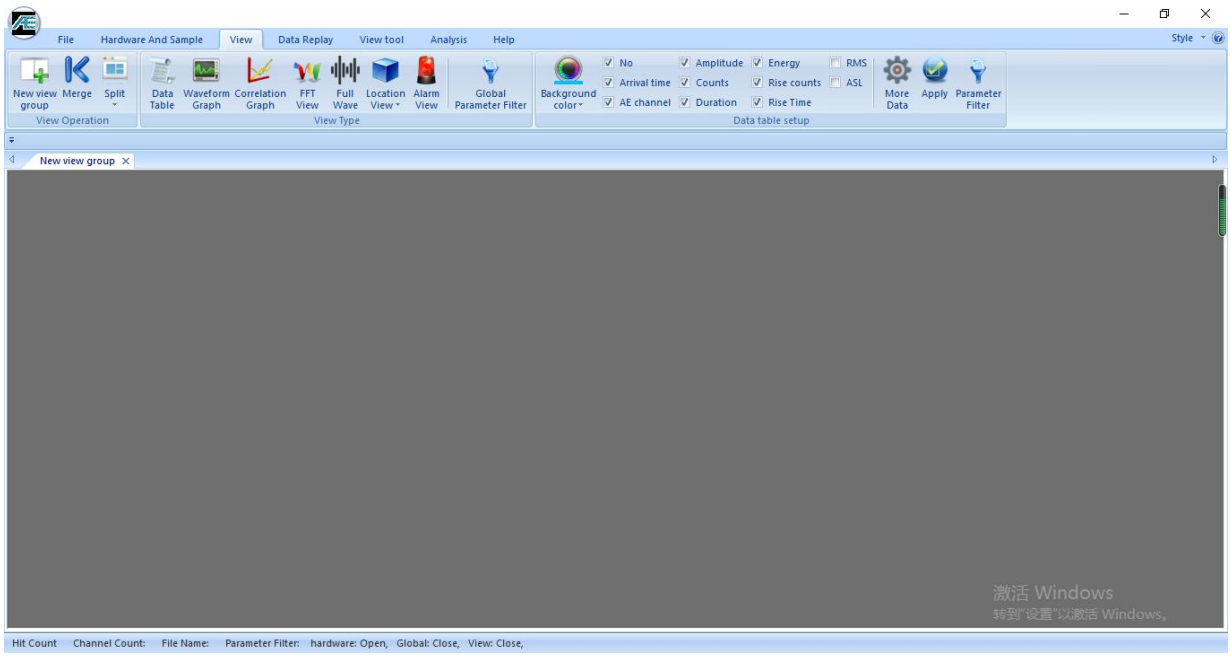


Fig. 2-37 After View Merge

Only two or more views of the same view group can be merged. After merging, these areas can be set again. After merging, no view information will be retained in this view area.

Select any view in the area to be merged (red border appears after selection). For example: as shown in Figure 2-36, the six small views are in the same view group. Select one of the small view; click **[Merge]** to complete the view merging, and the completed view interface is

shown in Figure 2-37: (After merging, no view info will be retained at this level.)

2.2.6.2. View Types

The view types can be customized for each window area, and each view has different settings. The view types include: data table, waveform graph, correlation graph, 3D correlation graph, pie chart, FFT view, full wave, location view, alarm view, intensity activity analysis, etc. This function can be used before data sampling and during data analysis. According to the usage of view data, it can be roughly divided into "Basic view" and "Derivative graph". Among them, "Data Table" and "Waveform Graph" are the basic views, while "Correlation graph", “3D Correlation graph”, “Pie chart”, "Location view", “Alarm View” and “Intensity Activity Analysis” are derivative graphs of "Data Table" and share the parameter files with suffix of .PRA; "FFT View" is the derivative diagram of "Waveform Graph", with the suffix of .AED. Only when the basic view is established in the process of AE data acquisition, can the data processing and analysis be carried out later.

2.2.6.2.1. Data Table View

2.2.6.2.1.1. Set up of data table

Select a blank view (with red border) and click “**Data Table**” in view type of the View menu to add the default data table view. The default data table includes the following parameter information: serial number, arrival time, AE channel number, amplitude, counts, duration, energy, rise counts, rise time, RMS, ASL, etc. For most applications, the default parameters are enough. For other applications, it is also needed to add more parameters. Click **[More...]** below ASL and check other parameters in the list, and click **[OK]** and then click **[Apply]** button to complete and activate the parameter adding.

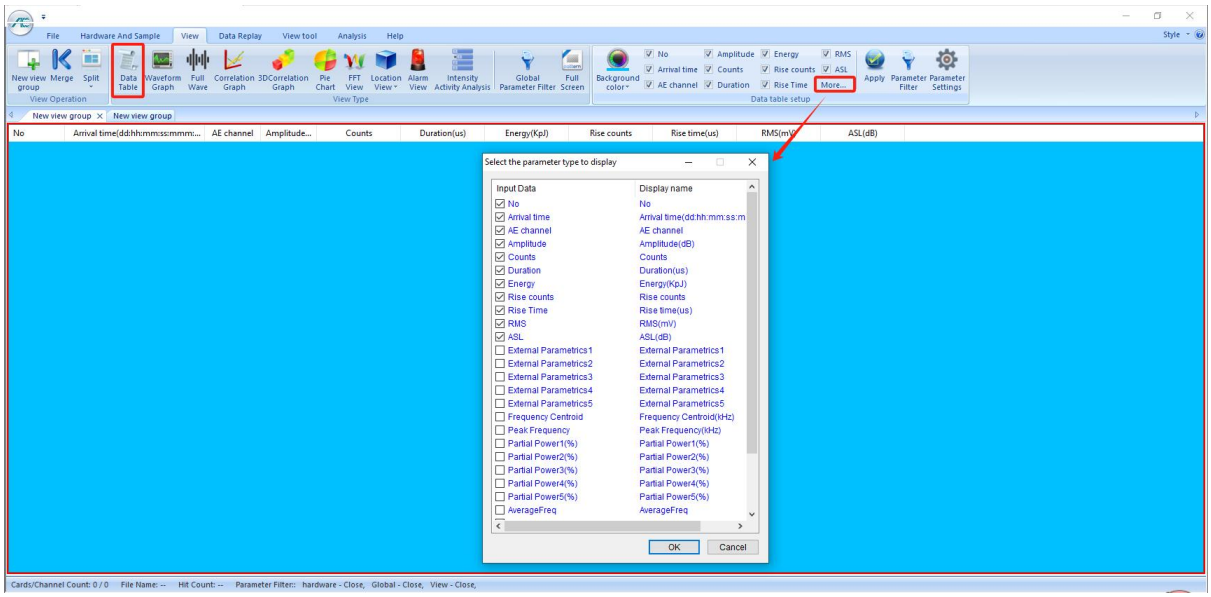


Fig. 2-38 Default parameters and optional parameters interface

2.2.6.2.1.2. Data table settings

1) **[More...]:** if the default AE parameter type cannot meet the actual needs, click the **[More...]** button below "ASL" to enter the full parameter list and check the required parameters to enable it in the "Data Table". But after changing the parameter selections, it must click **[Apply]** button on the right of the secondary menu to make the new changes take effect. In the parameter list, there are "No.", "arrival time", "channel", "amplitude", "counts", "duration", "energy", "rise counts" "rise time", "RMS", "ASL", "external parameters 1-5", "frequency centroid ", "peak frequency", "partial power 1-5", "Average Frequency", "Echo Frequency", "Initial Frequency", and "Customized value 0-2" available for selection.

2) **Parameter Settings:** the display name of the external parametric and customized values can be modified in the **[Parameter Settings]** button. Click [Parameter Settings] button to open the pop-up window. Double click the "Alias" of the external parametrics and type the name you want to display in the data table. The display value of external parametrics is the result of a linear calculation: Y = KX + B, where X is the original input voltage, Y is the display value. The coefficient [K] is the proportion of the external parameter display value and its actual input value; the coefficient [B] is the offset value, similar to

zero point calibration, that is, when there is no voltage input for an external reference channel, the voltage display of the channel in the parameter table should be zero by adjusting [B]. In the actual acquisition process, it is necessary to calibrate the set coefficient K, that is to adjust the coefficient K by comparing the measured value of the external parameter system with the actual value until the measured value of the external parameter system is close to or consistent with the actual value. Refer to figure 2-39.

3) **Custom formula alias and expression settings**: The display name of the custom value can be modified at will. Double-click the corresponding position in the "**Alias**" column to enter it directly as needed; double-click "**Expression**" to modify the equation. In the pop-up window, select the parameter variable in the left column, and modify the formula. After the calculation formula is modified, click "**Check Formula**" to confirm it is correct and click "OK" to save and exit.

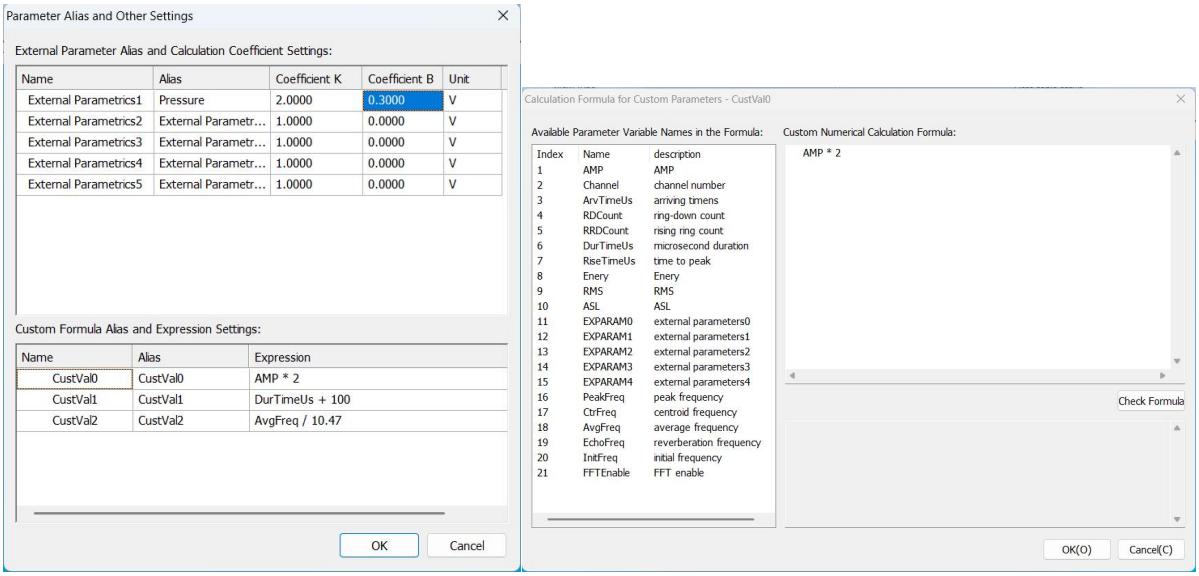


Fig. 2-39 Parameter Settings Window

4) **Frequency Centroid:** represents the frequency corresponding to the mass center of the power spectrum.

5) Peak frequency: refers to the frequency corresponding to the maximum value of power spectrum.

6) **Partial power 1 / 2 / 3 / 4 / 5:** i.e. partial power spectrum segments. When "partial power 1-5" is clicked, it is necessary to cooperate with **[FFT setup]** in the “Sample Settings”.

For specific setting method, see related FFT sections of user manual of specific devices.

The partial power 1-5 are shown in the "Data Table" in the form of percentage, indicating the percentage weight of the parameter spectrum corresponding to the set frequency range in the overall signal frequency domain. For example, the sampling rate set in the "Waveform" interface is 4000kHz, the current "FFT decimation rate" is 2, "Partial power No.2" is enabled, and the frequency band setting is 96-172kHz. If the value of "Partial power2 (%)" is 25 in the Data Table, it means that the 96-172kHz frequency spectrum power of this hit signal accounts for 25% of the total signal bandwidth 2000kHz (4000/2) spectrum.

7) **Background color:** select Data Table view and click "Background color" button to select different colors. The default color is blue.

8) **Apply:** after modifications, the modified settings will take effect after clicking **[Apply].**

2.2.6.2.1.3. Parameter Filter

Click **[Parameter filter]** to pop up "Hit Data Filter setup" interface. The filter is a view specific filter, which is only effective for the current view. Refer to Chapter "2.2.5.3.2 Hardware parameter filter" for setting methods. After the function is enabled, the parameter data conforming to the setting rules will be displayed in the "Data Table" view window. The rejected data will not be displayed and the stored data files will not be changed.

2.2.6.2.1.4. View attribute function

In the Data Table view, all groups of parameters are arranged in the order of "arrival time" by default. By clicking on the title of the parameters, all data are sorted in the ascending or descending order of that parameters. For example, clicking on "Amplitude" in the top row of the Data Table, the data will be sorted in ascending or descending order of the amplitudes.

No matter what the current setting of "Data Table" is, the right-click menu on its view interface is the same. Through this menu, you can perform operations such as "Prior page", "Next page", "Locate to", "Hit to Wave", "Output to excel", "Number of list records" and

"Sound velocity calculation".

Prior page: click "Prior page" to turn to the previous page.

Next page: click "Next page" to turn to the next page.

Locate to: when the data replay operation is paused or finished, select this option and the following window will appear. The number behind the "Parameter number" is the range of all parameters available to enter. For example, No. 458 is the last row number, and No.100 is the parameter row to locate. After clicking [OK], the cursor will be located to the 100th line.

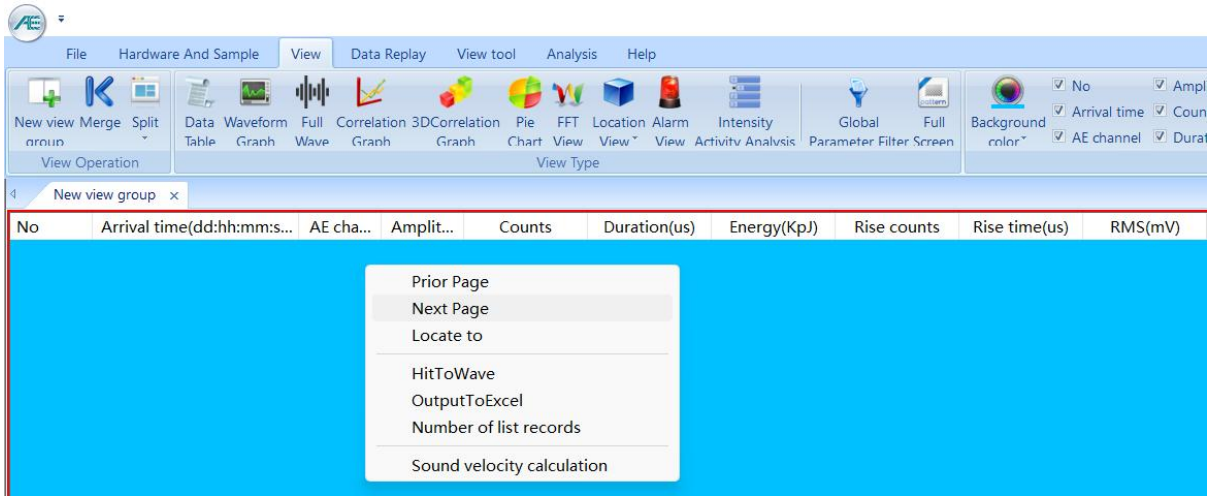


Fig. 2-40 Parameter Filter interface

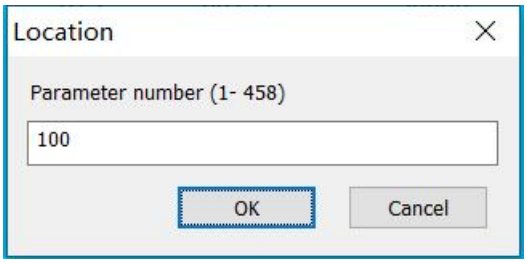


Fig. 2-41 Locate to the Specified Line Parameter

HitToWave: select a row of parameters in the "Data Table". Right click to select "HitToWave" function. This function is to find the corresponding waveform that generated this row of parameter. If the waveform file is found, it will be displayed in the waveform diagram, including channel information and time information. If there is no corresponding waveform found, the waveform will not update. To use this function, you need to pay attention to the following:

1) Parameter data (.pra) and waveform data (.aed) must have the same file name and time tag, and in the same storage path;
2) The priority of parameter format data uploading to the computer is higher than that of waveform. So the maximum instantaneous data is far less than the actual communication bandwidth;
3) The current channel must enable the saving function for both waveform file and parameter file at the same time;

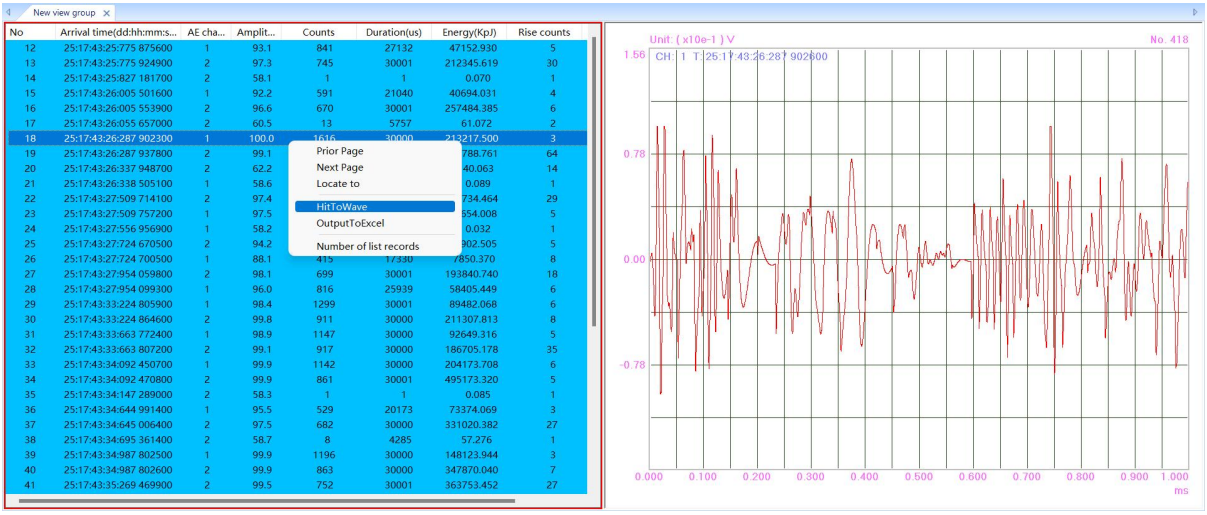


Fig. 2-42 Prompt info of Hit to Wave

Output to Excel: after selection, export all the parameter data that are displayed in the current table to the Excel format. If you need to convert all parameter data to the Excel format, please refer to Chapter "2.2.4.2.1 File Conversion".

Number of list records: Specifies the maximum number of parameters that can be displayed in the Data Table. A maximum of 80,000 records can be set.

Sound Velocity Calculation: To calculate the sound velocity using two channels, first determine the sensors to be used, and measure the physical distance between the event source and the sensors.

In the parameter table, left-click the parameter for channel 2 and press <Ctrl> to select the parameter for channel 1 (Note: The selected parameters must meet the requirements for the first arrival of the signal generated by the same event at both channels). Right-click the menu,

and click [Sound Velocity Calculation]. Select Layout 1 or Layout 2 based on the actual sensor and event source layout. “E” represents the signal source. For example, select [Layout 2], enter “110” for the A-E distance and “215” for the B-E distance, and click [Calculate] to calculate the arrival time difference and sound speed for sensors A and B.

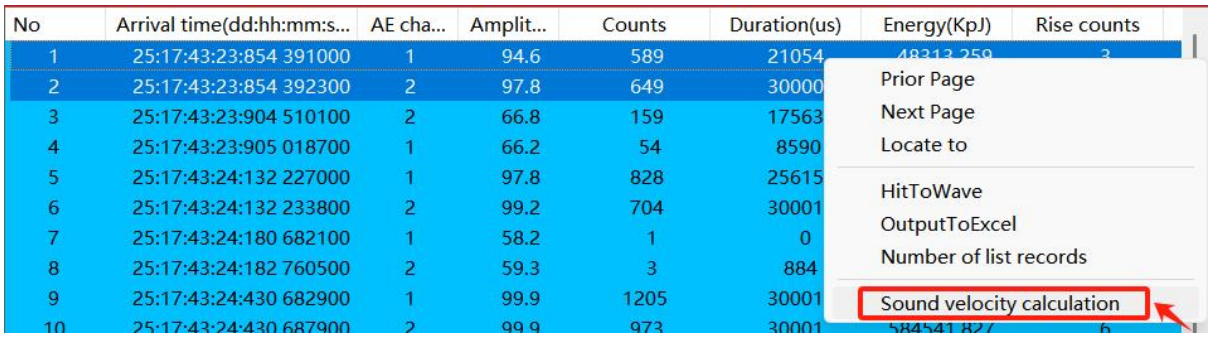


Fig. 2-43 Sound velocity test selection

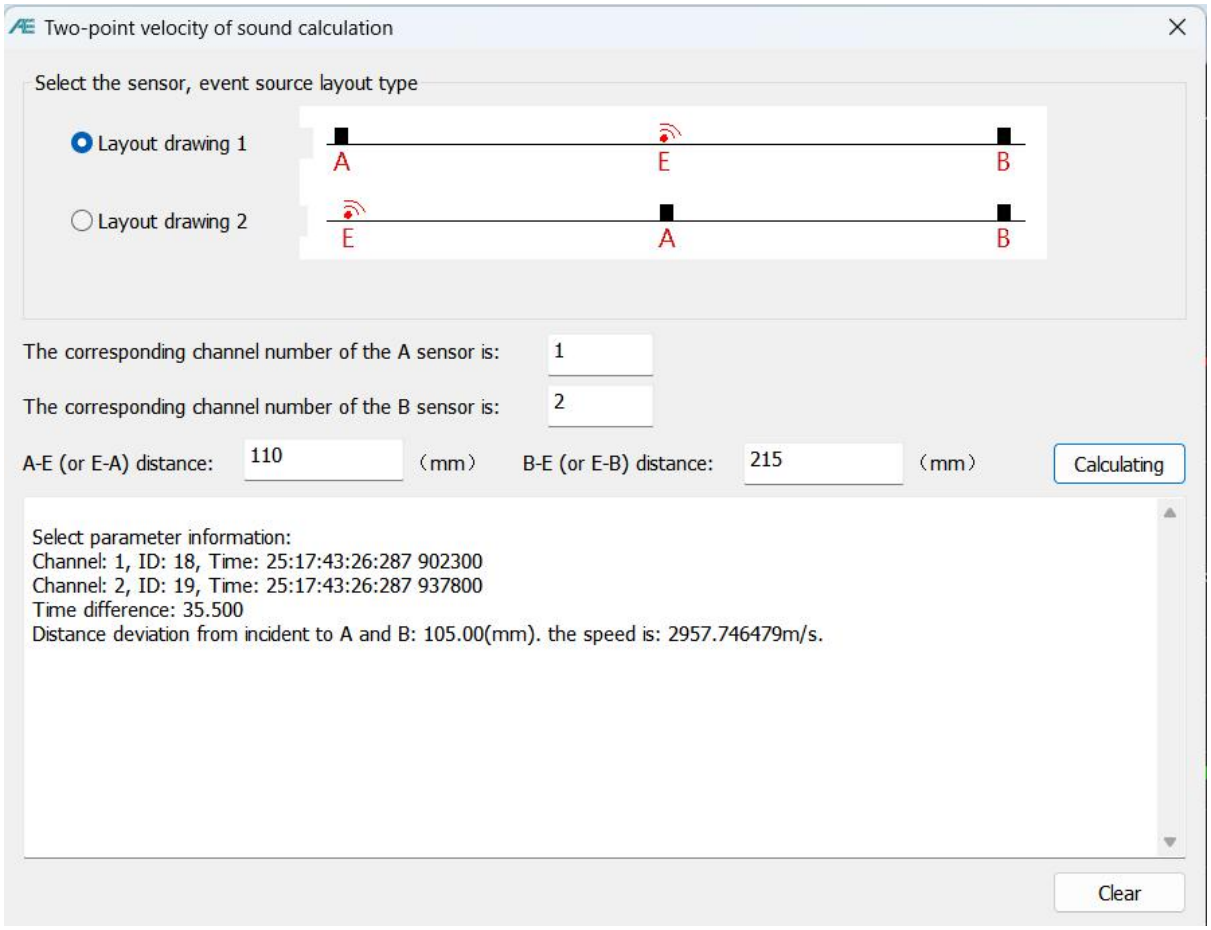


Fig. 2-44 Sound velocity calculation

2.2.6.2.2. Waveform View

The waveform view is a time domain diagram, whose X-axis is time and Y-axis is voltage

(sensor output, before the preamplifier) with the ordinate unit is initially set to Volt (also can be modified to dB). It takes the sampling length of waveform as the display time. The waveform display length of time: is equal to (=) sampling length (points) / sampling rate (points per second).

2.2.6.2.2.1. Establishment of Waveform View

Select a blank view (red border appears), and click **[View]**, then click **[Waveform Graph]** to complete the addition of default waveform.

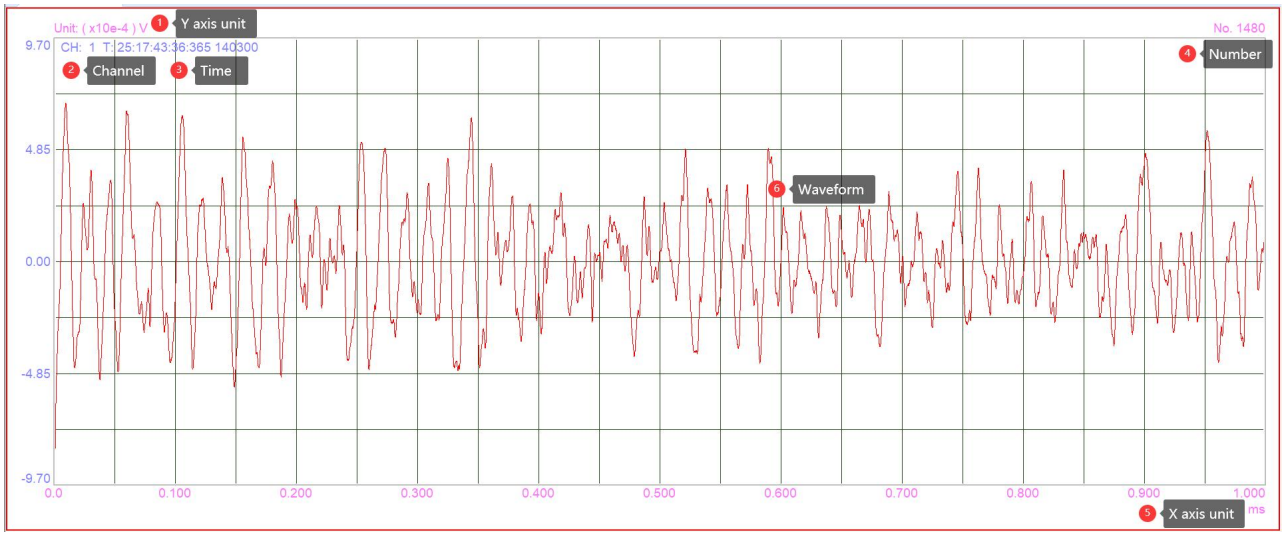


Fig. 2-45 Waveform View Interface Introduction

The waveform view interface introductions:

① Y axis unit: the default Y axis unit of the waveform is in ($x10^{-4}$) volts in the upper left corner of the view. The unit of the Y axis can be changed to dB. If the waveform is too big or small to fit in the frame vertically, **press the key <UP> or <DOWN> to zoom in or out in Y axis**.

② Channel Number: "CH:1" means it is displaying Channel #1 waveform. By default, it starts from Channel #1. If you want to see Channel #2, when the waveform view is selected *(red frame in the view area),* **scroll the mouse wheel down to change to the next channel (higher channel number). Scroll the wheel up to change to the lower channel number.**

③ Time: The time "*T: dd:hh:mm:ss:mmm uuunnn*" next to the channel number is the

waveform arrival time. It may be different from the parameter arrival time. Because the collection of the parameters and the waveform sections are independent. There are many factors such as acquisition unit models, the parameter threshold and waveform threshold differences, the sample length, HDT, HTL and EET settings and more.

④ Serial Number: the “No. xxx” at the upper right corner of the waveform view is the serial number of current waveform section. The serial number of the waveform doesn’t correspond to the serial number of the parameters. Because the collection of the parameters and the waveform sections are independent. There are many factors such as acquisition unit models, the parameter threshold and waveform threshold differences, the sample length, HDT, HTL and EET settings and more. **Press the key <LEFT> or <RIGHT> to change to the previous or next serial number (frame) of the waveform**.

⑤ X axis unit: The unit of the X axis is usually in milliseconds (ms). But it depends on the sample rate and sample length in the settings.

⑥ Waveform specs: The waveform is the digitized waveform of the sensor output (before preamplifier).

There are more settings and functions of the waveform to show.

2.2.6.2.2.2. Waveform Setup

Background color: select the waveform view and click **[Background Color]** in the sub-menu to select different background view colors. The default color is black;

Single channel / Double channels / Four channels: select the number of channels displayed in a single waveform view window. After the waveform view is selected, choose in the checkbox.

2.2.6.2.2.3. View Attribute Function

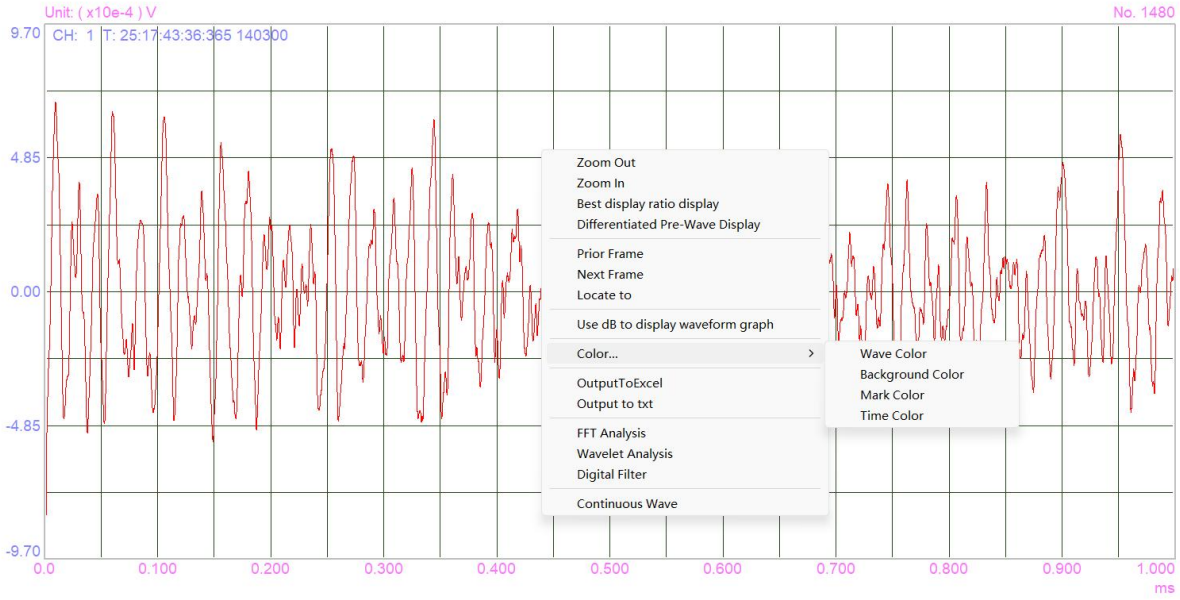


Fig. 2-46 Right click interface of Waveform

- **Zoom In:** enlarge the voltage value (Y-axis direction) of all channels in the window, which is equivalent to keyboard **UP** key **[PgUp]**;
- **Zoom Out:** reduce the voltage value (Y-axis direction) of all channels in the window, which is equivalent to keyboard **DOWN** key **[PgDn]**;
- **Best display ratio display:** displays waveform at the optimal aspect ratio..
- **Differentiated Pre-Wave Display:** displays pre-sampled waveform separately from normal sampling waveform.
- **Prior Frame:** if the current sequence number of the current waveform diagram is "**No. K**" in the upper right corner, the No. **"K-1"** waveform is filtered out from the waveform file and displayed, including the channel number and arrival time, equivalent to the keyboard **LEFT** key. The data may not be in the current channel and need to be queried by switching channel number via scrolling the mouse wheel;
- **Next Frame:** if the current sequence number of the current waveform diagram is "**No. K**" in the upper right corner, the No. **"K+1"** waveform is filtered out from the waveform file and displayed, including the channel number and arrival time, equivalent to the keyboard **RIGHT** key. The data may not be in the current channel and need to be queried by switching channel number via scrolling the mouse wheel;
- **Locate to**: when the data replay operation is suspended or finished, select this option and

the following window will appear. The number range in the bracket is the frame range available to be located in. For example, (1 - 1480) is the waveform frame range available, and No. “800” is the sequence number of the waveform frame to be located. After clicking [OK], the No.800 frame of the waveform will be displayed in the window.

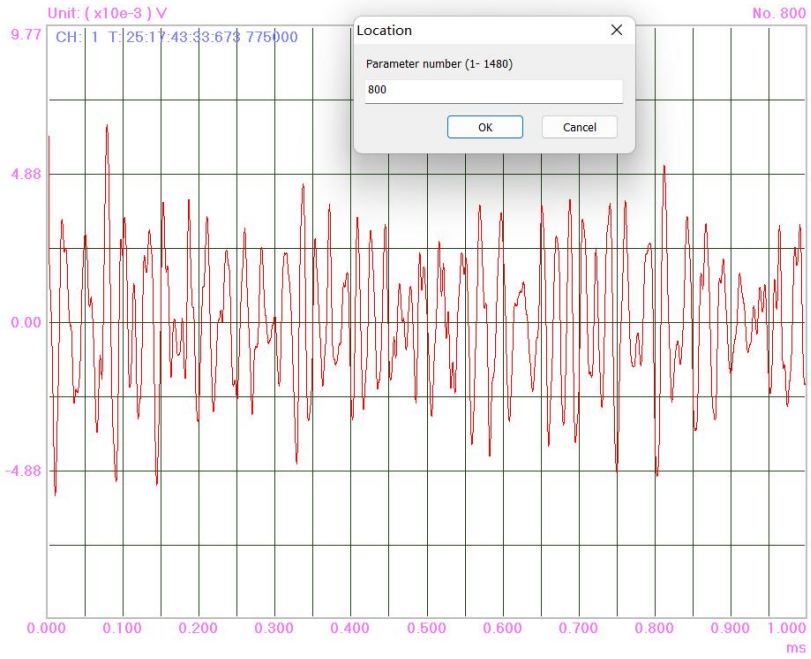


Fig. 2-47 Locate to the specified frame waveform

- **Use dB to display waveform graph:** If [Use dB to display waveform graph] option is selected, there is a dB value displaying in the upper center of the view showing the mouse point value in dB. when the mouse is moved to the waveform, the dB value is corresponding to the current point of the mouse.
- **Color:** You can choose to modify waveform color, background color, mark color, and time color. Click to enter the color table and modify the color in the channel window where the cursor stays;
- **Output to Excel:** export the current display waveform section of the channel where the cursor stopped, to the .CSV format, including the channel number, arrival time, voltage values of the waveform points and other information; the time interval T = 1 / sampling rate;
- **Output to TXT:** export the current display waveform section of the channel where the cursor stopped to .TXT format, and the information included is equivalent to exporting to the Excel format;

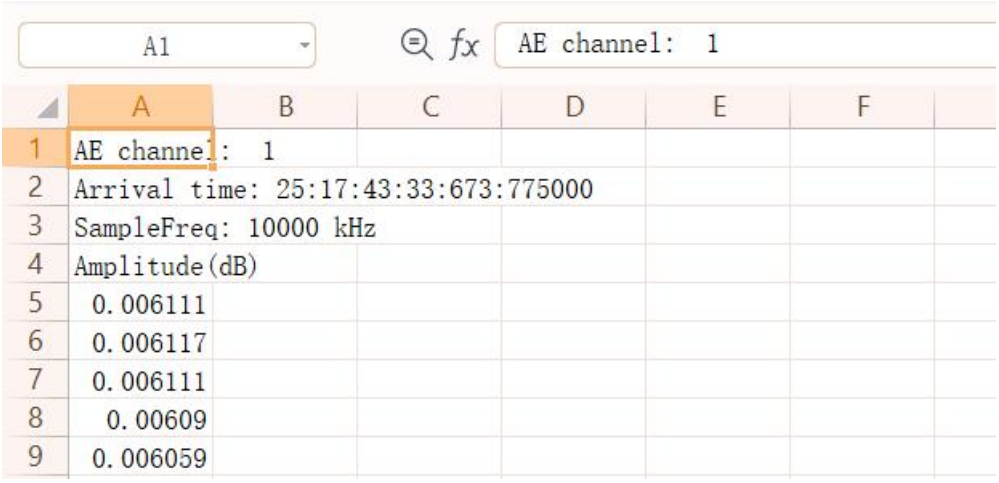


Fig. 2-48 Waveform output to excel File fragment capture

- **FFT Analysis:** converts the current time-domain waveform data into the corresponding frequency domain according to the extraction rate ([Sample Settings] > FFT Setup > FFT Decimation Ratio). For details, see Chapter “2.2.9.2 FFT Analysis”.
- **Wavelet Analysis:** The current time-domain waveform data is processed in different layers according to different frequencies and displayed in several waveform of different frequencies at the same time. For details, see Chapter “2.2.9.3 Wavelet Analysis”.
- **Digital Filter:** Set the type and frequency range of the digital filter, and then filter the current time domain waveform data. For details, see Chapter “2.2.9.4 Digital Filter”.
- **Continuous Wave:** Displays multiple waveform frames of the current waveform file in a single window. You can view a maximum of 80 consecutive frames. At the same time, the channel can be switched and the wave frame number can be located. After relocation, the wave frame on the left of the window is the located wave frame.
- **View mouse operation**: The scaling of the waveform can be accomplished with the help of the mouse operation by drawing the rectangle on top of the waveform view. The scaling area is the area within the rectangle, as illustrated below.

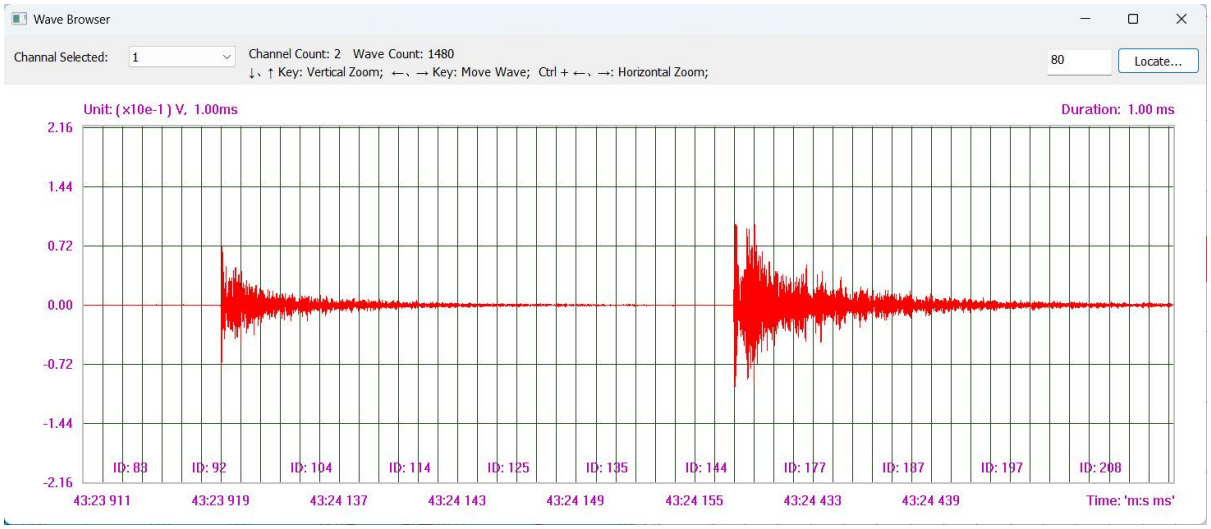


Fig. 2-49 Screen for viewing continuous waveform

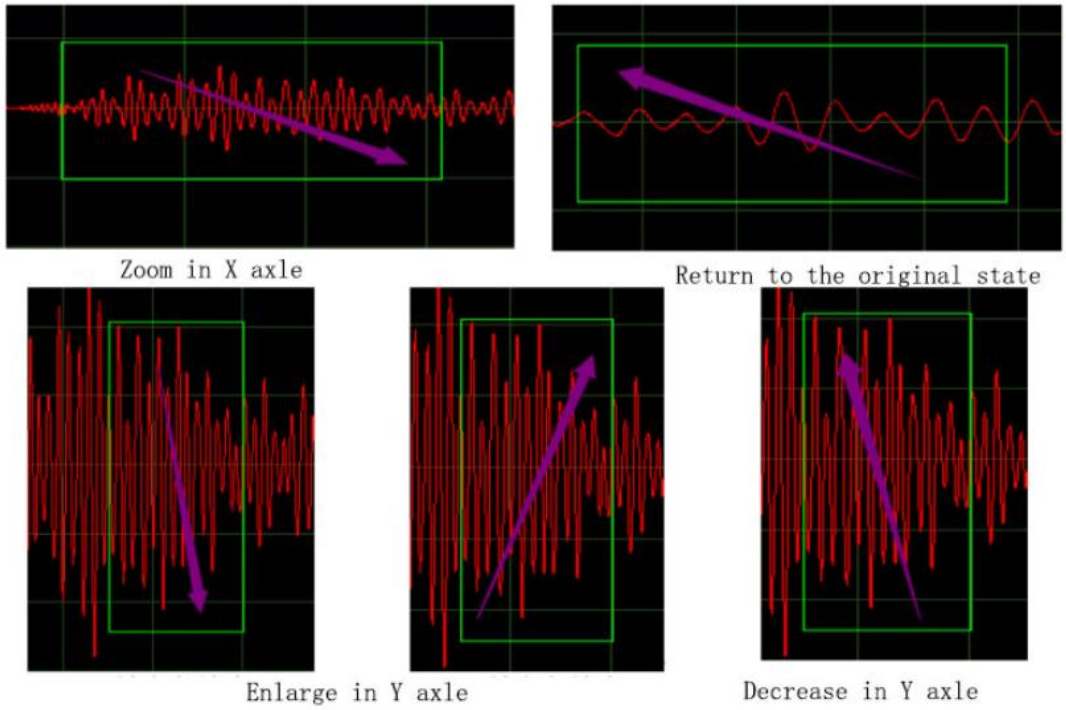


Fig. 2-50 Mouse Operation Diagram of Waveform

2.2.6.2.3. Correlation Graph

Correlation Graph is a kind of relationship diagram that uses two or more AE parameters in data table as the horizontal and vertical coordinates to draw the correlation curve, distribution point diagram, or line diagram, etc., which is used to characterize the acoustic emission signals and is a common tool for the analysis of the data table.

2.2.6.2.3.1. Establishment of correlation diagram

Select a blank view (with a red border), and click **[View]**, then click **[Correlation Graph]** to complete the addition of default correlation graph. The default channels v.s. hits correlation graph is a commonly used view.

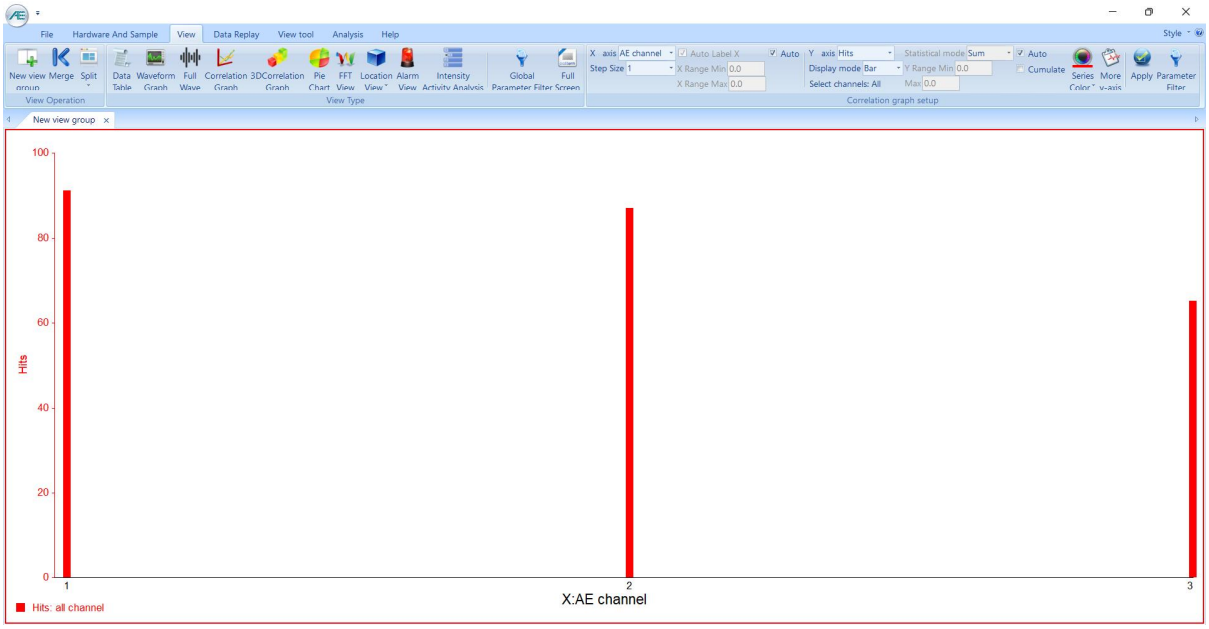


Fig. 2-51 Default Correlation Graph

2.2.6.2.3.2. Modification of Correlation Graph

After the correlation graph is selected, you can modify the settings of the correlation graph.

Note: After modifying the settings, you must click the **[Apply]** button on the right side of the view menu to update the modified settings in the graph.

- **X-axis:** click the drop-down button on the right side of [AE channel], and it contains multiple parameters for selection, including "arrival time", "AE channel ", "amplitude", "counts", "duration", "energy", "rise counts", "rise time", “RMS”, “ASL”, "External Parametrics1-5", “Hits”, "Frequency centroid(kHz)", "peak frequency(kHz)", partial power(%)1-5, Average Freq, Echo Freq, Initial Freq, and customized value 0-2;
- **(X-axis) Step Size:** The interval value between the two adjacent points on the X-axis. When the X-axis parameter is modified (not “AE channel”), there will be multiple corresponding optional values available to choose;
- ☐**Auto Label X:** When the X-axis displays the arrival time, it can adaptively change the

X-axis unit. If this option is selected, right-clicking in the relevant graph will display the absolute time.

- **X Range Min:** Sets the minimum value to be filtered on the X-axis.
- **X Range Max:** Sets the maximum value to be filtered on the X-axis. For example, a minimum of 0 and a maximum of 100 will filter out data exceeding the minimum and maximum limits on the X-axis.
- ☐ **Auto (X axis):** automatically set the X axis range. When it's enabled, the X range MIN and MAX will be disabled.
- **Y axis:** click the drop-down button on the right side of [Hits], and there are "Amplitude", "Counts", "Duration", "Energy", "Rise Count", "Rise time", "RMS", "ASL", "External Parametric 1-5", "Hits", "Frequency Centroid(kHz)", "Peak Frequency(kHz)" and "Partial power 1(%)-5(%)", Average Freq, Echo Freq, Initial Freq, and customized value 0-2 to be selected;
- **Display mode:** there are three kinds of display modes: "Dot", "Line", and "Bar". When the parameters of X and Y axes are determined, the software will automatically match the available display modes;
- **Select channels:** including "all channels" and single channel number from 1 to 128. When a channel is specified, the current correlation graph will only count the data of the specified channel;
- **Statistical mode:** "Maximum", "Average" and "Sum" or "Real" are options. When the X-axis parameter is set as "Arrival Time", the step size set in X-axis will be taken as the statistical time;
- **Y Range Min:** the maximum and minimum values of the axis range, which can be customized by the user according to the data distribution;
- **Y Range Max:** the maximum and minimum values of the axis range, which can be customized by the user according to the data distribution;

- ☐ **Auto (Y axis)**: after ☑Auto selected, the Y axis display range of the correlation graph will be automatically adjusted according to the data distribution, the Y range min and max will be disabled;

- ☐ **Cumulate:** if "☐ Cumulate" is not selected, values displayed in the graph are calculated based on each step size of X axis. When "☑Cumulate" is selected, the values are accumulated.

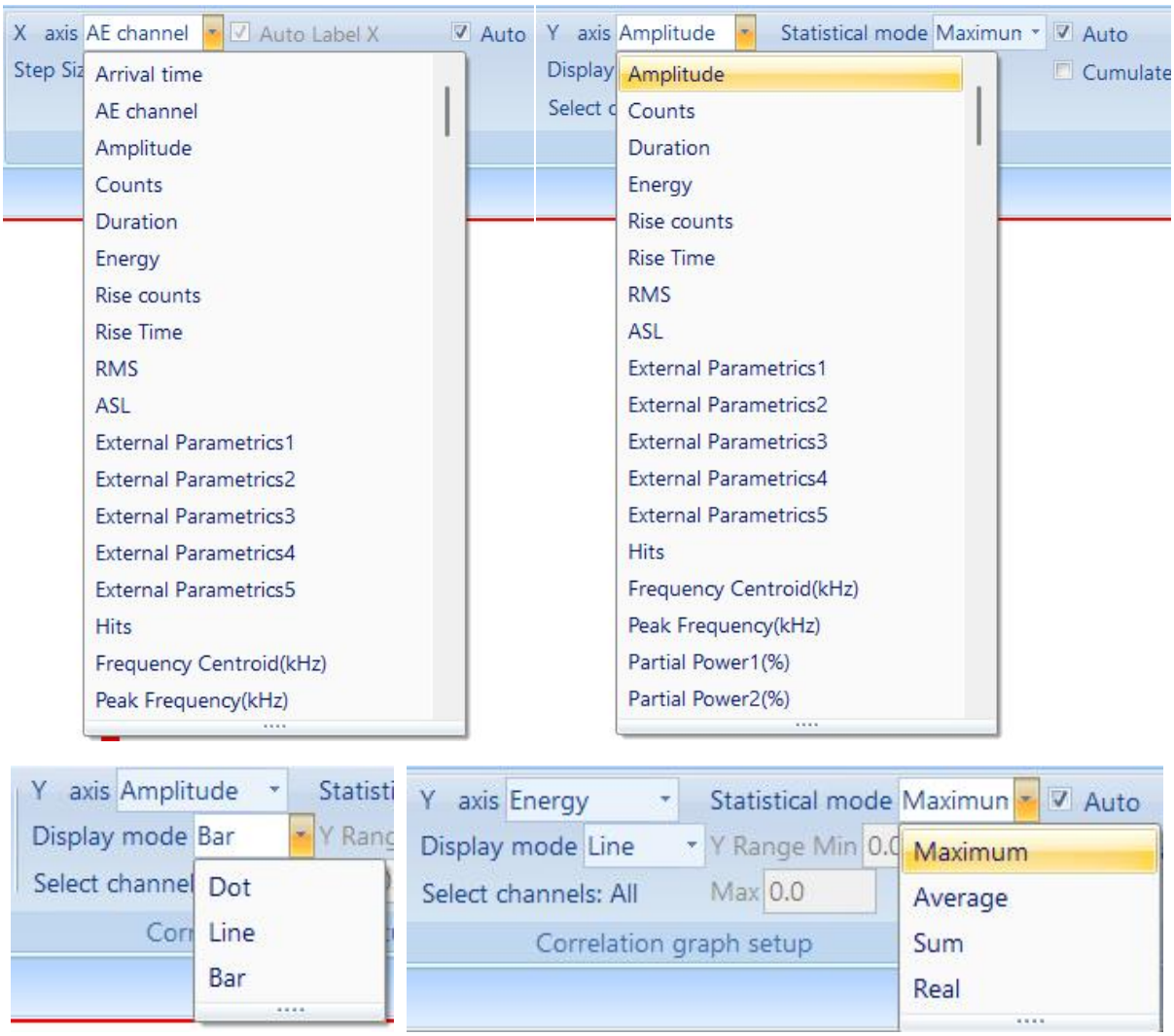


Fig. 2-52 Sub menu of Correlation Graph

For example: take the "arrival time - (hits + energy + counts)" Correlation Graph as an example:

1) Select a blank view (red border appears) and click "Correlation Graph" in "View" menu to complete adding the default correlation graph.

2) **Modify X-axis:** first, click "AE Channel", select **"Arrival time"**. Then select "step size" in the drop-down menu in the next line, such as **"100ms"**; if the current relevant graph setting is completed, but you need to modify the X-axis again, and you can repeat Step 2) without modifying the subsequent Y-axis.

3) **Modify Y-axis:**

a. First, select **"Hits"** in the Y-axis drop-down menu, then select "Display mode" >> **"Line"**, and then select "Select channels" >> **"All"**;

b. In the "Statistical mode", select **"Sum"**, combined with X-axis info, that is, the hit number is accumulated every 100ms;

c. ☐ Cumulate: when ☑ **Cumulate**, the Y-axis value is accumulated, that is to say, the statistical value obtained from step b is superimposed step by step according to the step size as the the Y-axis display value.

d. Click **"More y-axis"** button to pop up the window. Refer to Step 3) > a ~ c to complete the settings of "total **energy** accumulation" and "total **counts** accumulation" in the pop-up window, and click **"OK"**;

e. Click the **[Apply]** button on the right side of the menu to update the graph. At this point, the correlation graph **"Arrival Time - (Hits + Energy + Counts)"** view is complete.

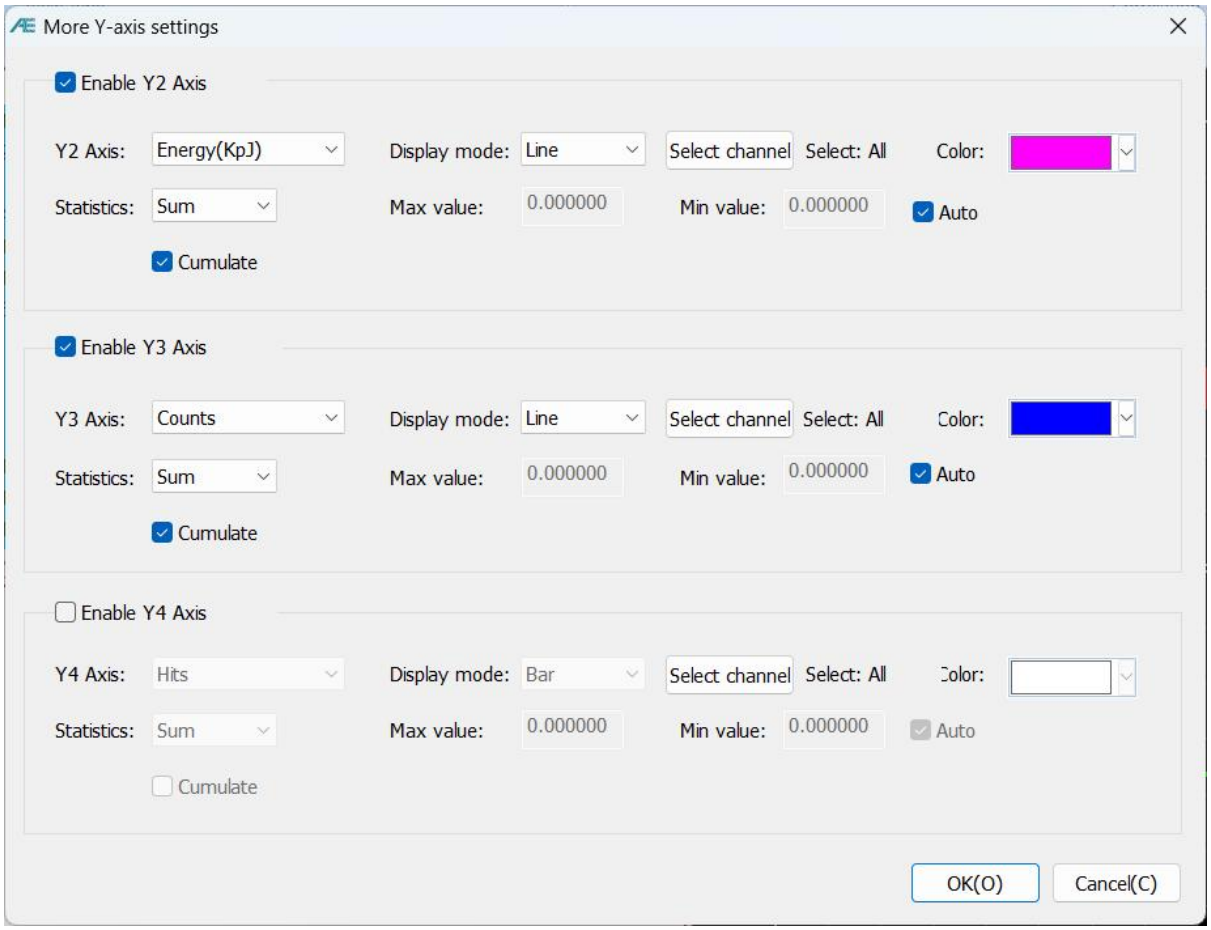


Fig. 2-53 More Y-axis Settings page

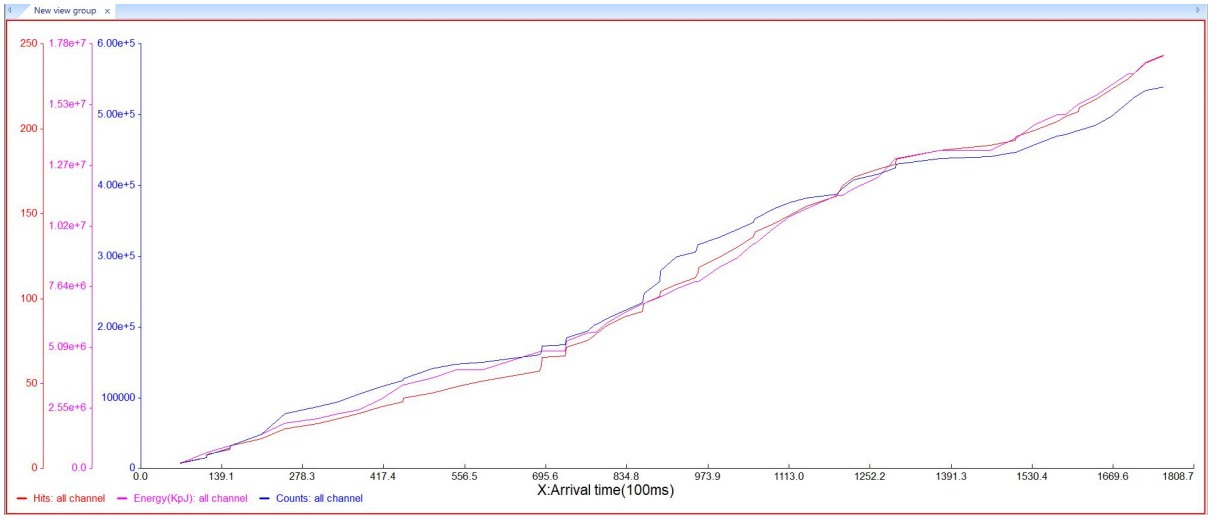


Fig. 2-54 Data Display of Multi-Y-axis Correlation Graph

2.2.6.2.3.3. View Attribute Function

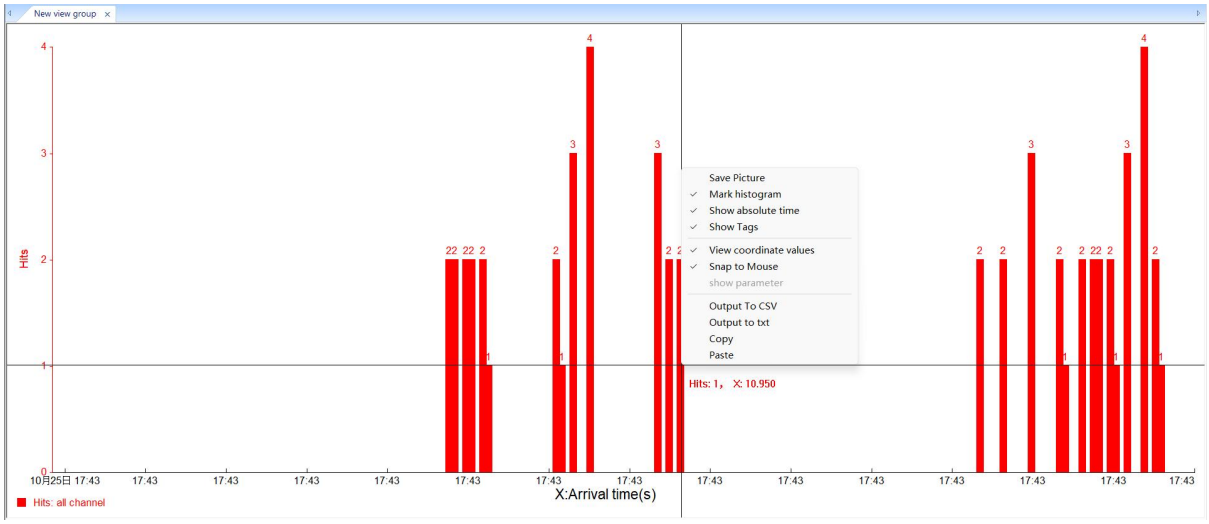


Fig. 2-55 Correlation Graph Attributes

- **Save picture:** save the current correlation graph in the form of a picture;
- **Mark histogram:** it is only showing the histogram in bar charts. After selection, the corresponding value of the bar chart will be marked;
- **Show absolute time:** After selection, when the X axis is the arrival time (relative time by default) and "Auto Label X" is selected, it will be changed to show the absolute time.
- **Show tags:** if there are tags marked in the correlation graph during the acquisition, after enabling, the tags will be displayed in the correlation graphs. To add tags during the acquisition, in the ""Hardware and Sample" >> "Add Tag".
- **View coordinate values:** After the acquisition or data replay, you can view the values of the graph where the cursor points to;
- **Magnetic function:** The display mode is "Dot" graph. When you get close to a point, the magnet will be attracted to the point, and you can quickly view the coordinate value of the point in the diagram;
- **Show parameter:** When the display mode is "Dot", the Y axis is not "Hits", the statistical mode is not "SUM", and Y value "Cumulate" is not checked, it can quickly query the selected dot's parameters in the Data Table.
- **Output to CSV**: select to export the current correlation chart data to CSV format;
- **Output to TXT:** select to export the current correlation chart data to TXT format.

2.2.6.2.3.4. Recommendation of Correlation Graph

Signal Distribution Graph

The signal distribution Graph generally establishes a two-dimensional coordinate system by comparing the number of the acoustic emission hits or events with other acoustic emission characteristic parameters for distribution statistics. The vertical axis generally selects the number of hits or events, while the horizontal axis selects any acoustic emission parameter. The distribution graph is defined by the (X-axis) parameter name, such as amplitude distribution graph, energy distribution graph, counts distribution graph, duration distribution graph, rise time distribution graph, etc., among which the amplitude distribution is the most widely used. Distribution analysis can be used to find the characteristics of AE sources, so as to identify the types of AE sources, such as crack propagation and plastic deformation of metal materials, fiber fracture and substrate cracking of composite materials, etc. This method is also often used to evaluate the intensity of AE sources. For example, the channel hits distribution graph, showing the activity of the signals received by channels. If the number of AE hits is high, the activity is strong.

Table 2-10 Recommended Settings of Common Distribution Graphs

X-axis parameters	X-axis step	Y-axis parameters	Display Mode	Name or application
AE channel	Default or 1	Hits	Bar	AE Channel- HIT distribution, used for area location
Amplitude	1	Hits	Bar, Line	Amplitude distribution Graph
Counts	1/10/100	Hits	Bar, Line	Counts distribution Graph
Energy	0.1 /1/10	Hits	Bar, Line	Energy distribution Graph
Duration	10/100	Hits	Bar, Line	Duration distribution Graph
Rise time	10/100	Hits	Bar, Line	Rise time distribution Graph
Arrival time	1/10/100	Hits (Accumulation, maximum, average)	Line	HIT histogram, for signal stages and trends

Time history chart

The X-axis is the "arrival time", and the Y-axis is the other parameters of acoustic emission, which is also known as experience diagram or time history diagram. The experience diagram can directly reflect the change of acoustic emission signal with time, and can be used to evaluate the activity of acoustic emission source or analyze the signal characteristics of a certain experimental stage combined with other external data. It is generally used for the evaluation of Felicity Ratio, Kaiser Effect, transverse load evaluation of acoustic emission and crack initiation monitoring. According to the different signal types, different AE parameters can be used to make a variety of history diagrams.

Y-axis Cumulate: once this option is clicked, the data will be accumulated and displayed as step-up status, which can be used according to the actual application.

Table 2-11 Recommended settings of common histogram

X-axis parameters	X-axis Step	Y-axis parameters	Y-axis Statistical mode	Display Mode	Name or application
Arrival time	1/10/100ms	HITS	Sum	Line	Determination of signal hit rate, stage and degree
Arrival time	1/10/100ms	Counts	Maximum/Sum		
Arrival time	1/10/100ms	Amplitude	Maximum/Average		
Arrival time	1/10/100ms	ASL	Maximum		
Arrival time	1/10/100ms	Energy	Maximum/Sum		
Arrival time	1/10/100ms	Duration	Maximum		

Correlation Graph

Correlation analysis method is also the most commonly used method in acoustic emission signal analysis. For any two acoustic emission characteristic parameters, the correlation diagram can be analyzed between them. Each of the two-dimensional coordinate axis represents a parameter, and each display point corresponds to an AE signal hit or event. Therefore, the correlation diagram in acoustic emission generally adopts the dot display mode.

The characteristics of different AE sources can be analyzed by making the correlation diagram between different parameters, so as to identify AE sources.

Table 2-12 Recommended settings of common Correlation Graph

X-axis parameters	Y-axis parameters	Name or application
Amplitude	Energy	Signal type, identification of electrical noise
Duration	Amplitude	Distinguish leakages
Duration	Energy	Distinguish leakages
Duration	Rise time	Distinguish crack and friction signal
Duration	Counts	Distinguish crack, friction and leakage signals
Rise time	Amplitude	Identification of electrical noise

2.2.6.2.3.5. Parameter filter Settings

Click **[Parameter Filter]** to pop up "Hit-data Filter Setup" interface. The filter is a view specific filter, which is only effective for the current view. Refer to Chapter "2.2.5.3.2 Hardware Parameter Filter" for setting methods. After the function is enabled, the parameter data conforming to the setting rules will participate in the drawing of relevant graphs, and the stored data files will not be changed.

2.2.6.2.4. FFT View

It is frequency domain distribution graph. Its X-axis is the frequency (kHz), and the Y-axis is voltage (after amplified by preamplifier). It is the data restoration view of waveform data after "Fast Fourier transform". The corresponding frame of time-domain waveform is transformed by "Fast Fourier transform" into a frequency domain graph. The use of this view needs to be combined with "Waveform Graph", that is, the "Waveform Graph" needs to be established at the same time when the "FFT View" is established. The two views do not have to be in the same view interface, but can be in different view groups.

2.2.6.2.4.1. Establishment of frequency domain waveform

Select a blank view (red border appears), click **[View]**, then click **[FFT View]** to complete the default frequency domain waveform. Frequency domain waveform display is the most important tool of Fourier transform (spectrum analysis) in advanced waveform analysis tools, and is one of the most commonly used means of waveform spectrum characteristics analysis.

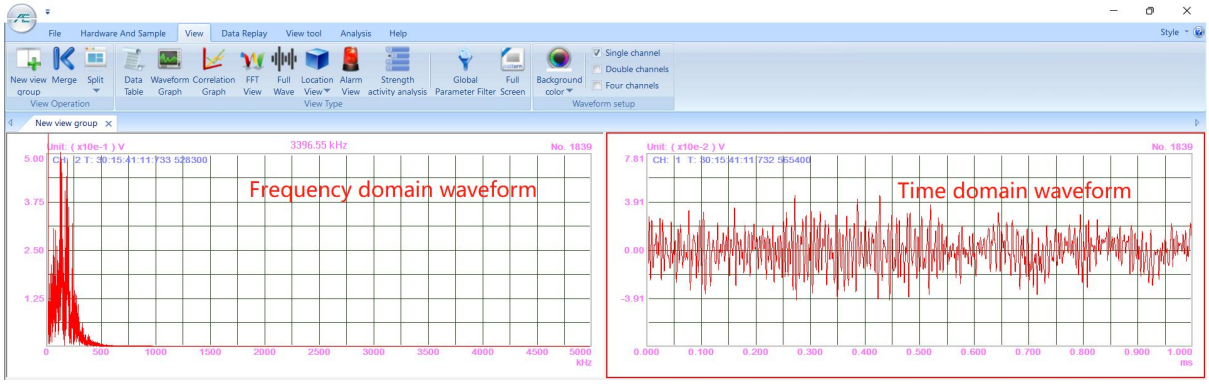


Fig. 2-56 Interface of frequency domain and time domain waveform

2.2.6.2.4.2. FFT Setup

Background color: select the FFT view area, then click [Background Color] to select different background colors. The default is black color;

Single channel / Double channels / Four channels: select the number of channels displayed in a single view window, and check it after the view is selected; the channel where the cursor is located can be switched by scrolling the mouse wheel;

Original frequency domain range: maximum frequency range of original frequency domain graph = time domain waveform sampling rate / FFT decimation ratio;

Waveform zooming: The mouse operation is similar to that in Waveform View.

Keyboard operation: After the window is selected, the [UP] key (or [DN] key) can zoom in (or zoom out) the voltage value (in the Y-axis direction) of all channels in the window.

2.2.6.2.5. Full Waveform

The "Full Waveform" is set up to cooperate with the full waveform data acquisition. During

the acquisition process, the user can observe the waveform changes in the whole process of acoustic emission. In the replay phase, by resetting configurations such as the threshold and hit definition time (HDT), the full waveform data will be selected by the new configuration filter and be replayed. After replaying, the new HIT parameters are generated according to the new parameters generation conditions.

2.2.6.2.5.1. Establishment of Full Waveform

Select a blank view (red border appears), and click **[View]**, then click **[Full Wave]** to complete the default full waveform graph addition. The full waveform view is a display of waveform for the whole acquisition period, instead of displaying the waveform in a single frame. The starting time of the time coordinate is fixed and the collected waveform data is compressed to the left.

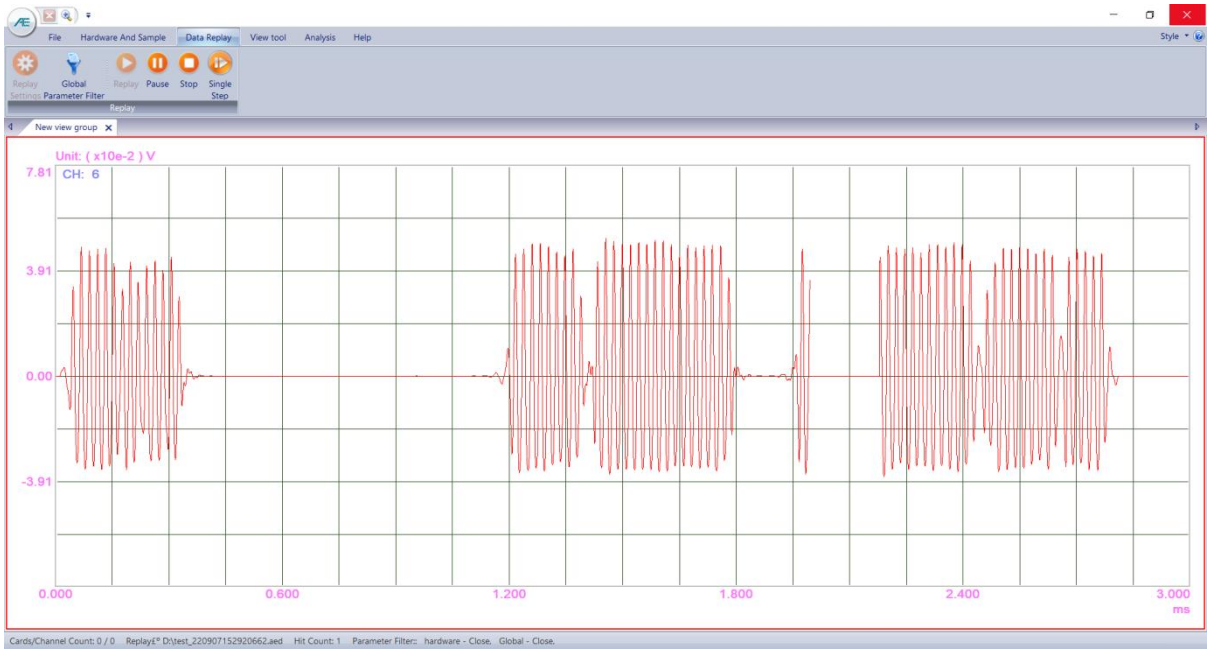


Fig. 2-57 Full Waveform setting interface

2.2.6.2.5.2. Full Waveform Analysis Function

Independent full waveform analysis has the following functions:

1) After opening the file, the static wave panorama can be displayed directly, and the current position of waves can be displayed in the panorama during replay; Synchronous waveform display of all channels;

2) Static waveform is the main part of full waveform analysis, and dynamic play is an extended function of static analysis.
3) Zoom in any waveform interval and zoom out to the panorama of waveform with one key. The processing method of waveform zooming is similar to that of "Waveform Graph". The mouse wheel can switch the channels. Keyboard operation: select the window, press [UP] key (or [DN] key) to zoom in (or out) the Y axis; [Ctrl] + [right] key ([left] key) to enlarge (or reduce) the X-axis of the window; Move the waveform with the [left] and [right] keys.
4) Any number of channels can be selected for full waveform acquisition and synchronous acquisition.

2.2.6.2.6. 3D Correlation Graph

A 3D correlogram uses the three acoustic emission parameters listed in the Data Table as X, Y, and Z coordinates to plot a distribution plot, representing the acoustic emission signal.

Select a blank view (one with a red border), select **[3D Correlation Graph]** in the **[View]** menu, select the X, Y, and Z axis types in the 3D Correlation graph setup, select the channels, and click **[Apply]**.

2.2.6.2.7. Pie Chart

A pie chart uses a circle to represent the total (the total amount) and then divides the circle into different sectors. The size of each sector represents the proportion of the whole. This method allows you to intuitively display the relationship between each sector and the whole, as well as the relative sizes of each sector.

Select a blank view (one with a red border) and select [Pie Chart] from the [View] menu's "View Type" to add a pie chart.

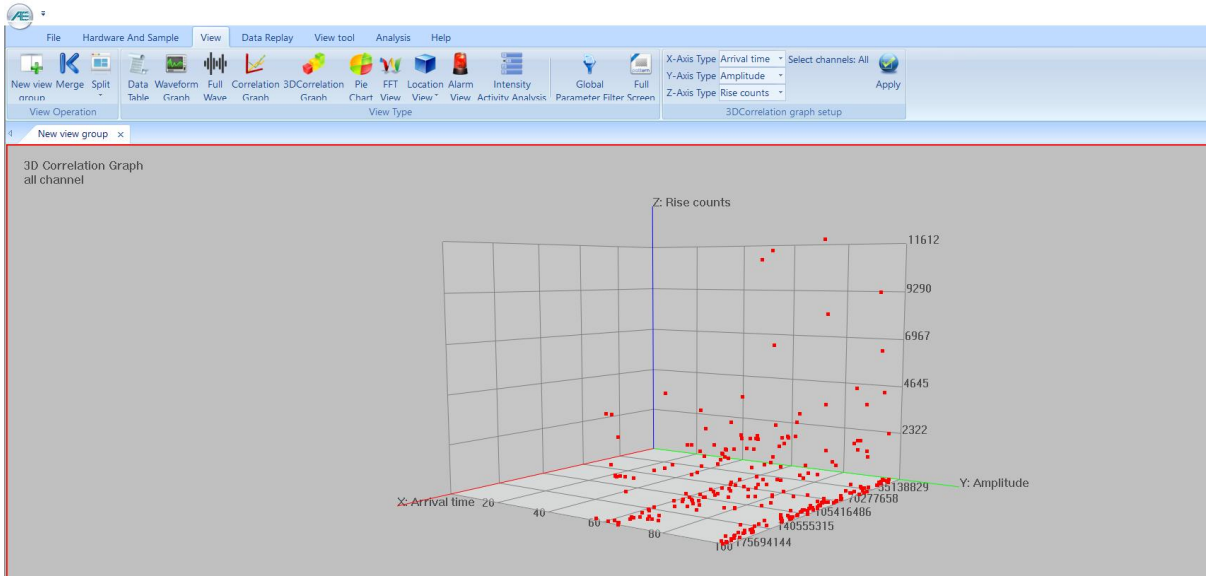


Fig. 2-58 3D Correlation graph

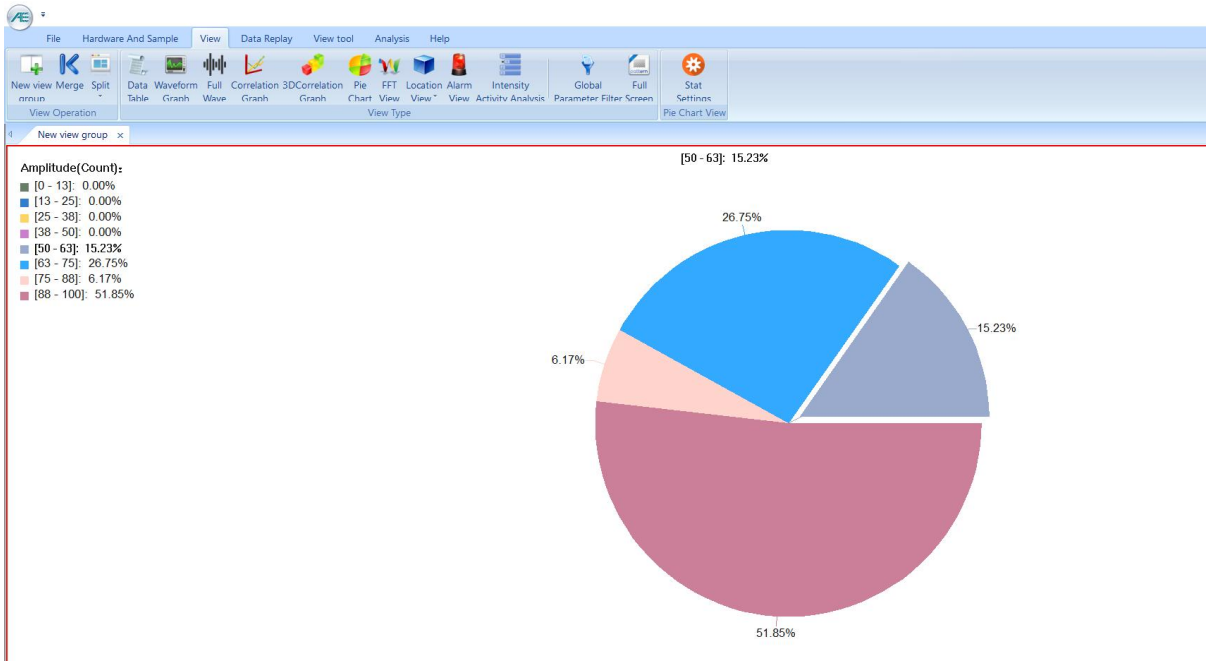


Fig. 2-59 Pie Chart View

2.2.6.2.8. Location View

Location view analysis is a means of acoustic emission data analysis, which can more directly show the location of acoustic source signal, and more intuitively evaluate the severity of damage combined with physical structures. Firstly, build the approximate model based on the sensor array layout on the measured object. Then the acoustic emission data are visually

displayed on the location view model. The location view types in SWAE includes: Linear Graph, Planar Location Graph, Cube Location Graph, Tank bottom (circular surface) Location Graph, Cylinder/Solid Cylinder Location Graph, Sphere Location Graph, etc.

Each location Graph can be set with independent parameter filters and location event parameters, which supports the simultaneous calculation and display function of multiple location graphs. The view can be zoomed in and zoomed out through the mouse wheel. The [Ctrl]+"R" button can restore the original view under any condition.

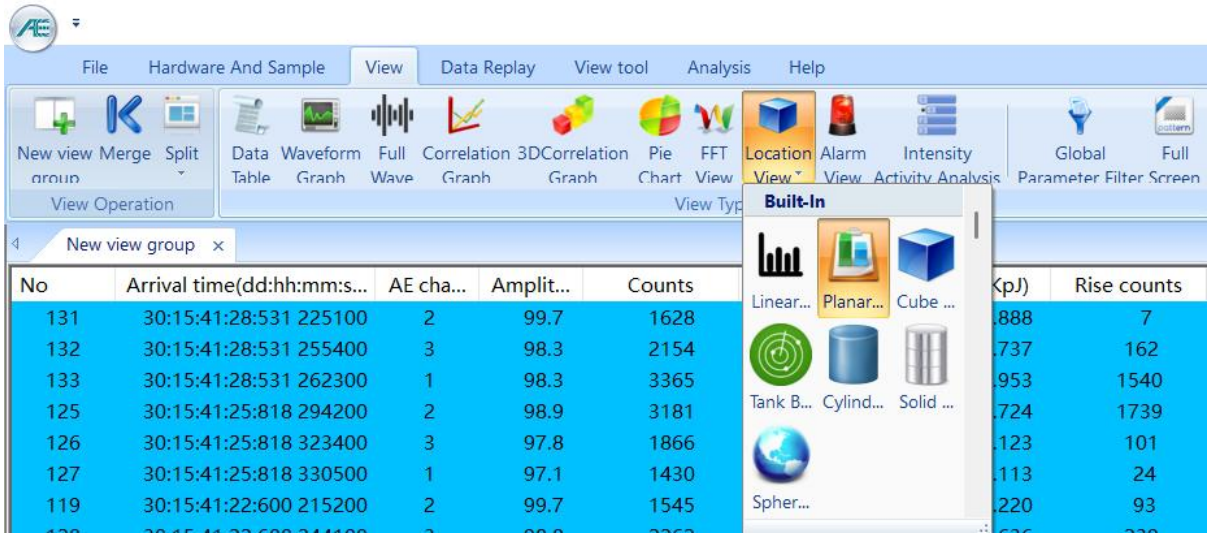


Fig. 2-60 Location view types

2.2.6.2.8.1. Linear Location Graph

Linear Location is generally applicable to pressure pipes, trailer cylinders or pressure equipment and vessels with an aspect ratio of length and width greater than 3; and it is suitable for location requirements limited to one-dimensional structural or material mechanics experiments.

1) **View creation:** select a blank view (with red border), click **[View]**, then click **[Location View]**, then choose **[Linear Location Graph]** to create the default line Location view;

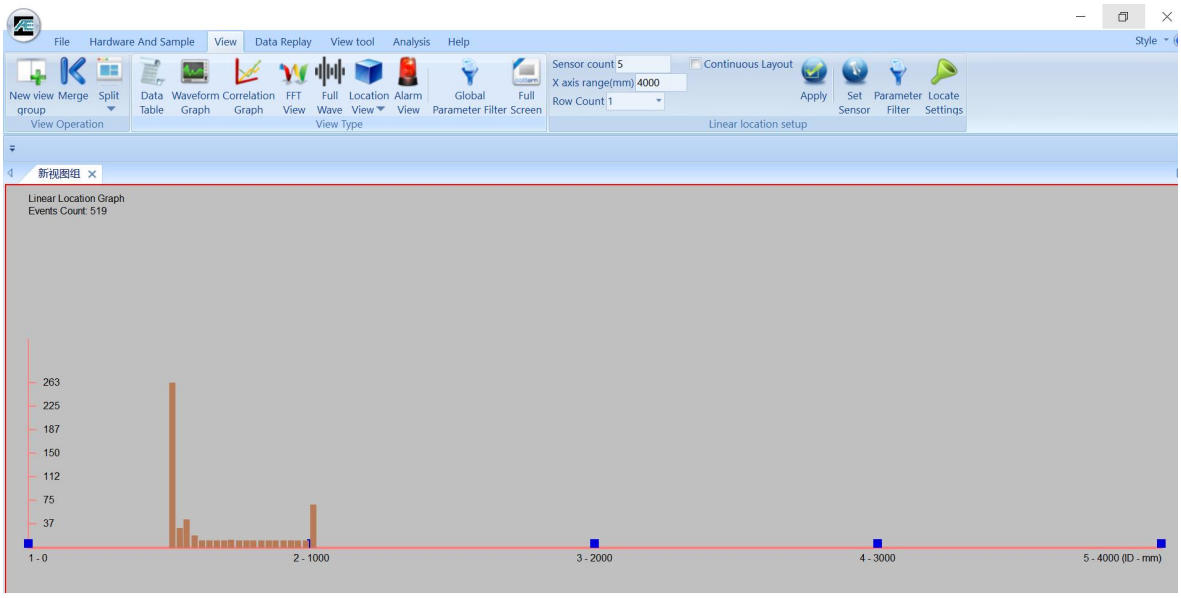


Fig. 2-61 Default view of Linear Location Graph

2) View Modification

The modification of linear Location Graph only involves the coordinate settings of sensors. The software supports quick modification, that is, input the total length and the number of sensors, and then the software will distribute them with the equal spacing; or it can manually set the number and coordinates of sensors according to the actual situation.

Quick Setup: select the default location view (red border appears), and then modify the "X-axis range" (total length of measurement) and the actual number of sensors, and click **[Apply]**; then the software will distribute them with the equal spacing. Refer to the coordinates given by the software to install the sensors.

Manual Setting: first, you need to know the distances between all sensors to Sensor#1. After the quick modification, click the **[Set Sensor]** button to pop up the dialog box as Fig. 6-61. The number under the "channel" column is the sensor number, which is generally consistent with the channel number to the AE host, or can also be changed to the user's desired number. Select the number under the channel directly for modification (note that the modified number should not be repeated with the existing number). The column “X(mm)” is the distance of each sensor away from sensor#1. Modify it according to the actual situation. After modification, click the **[OK]** button to update the view.

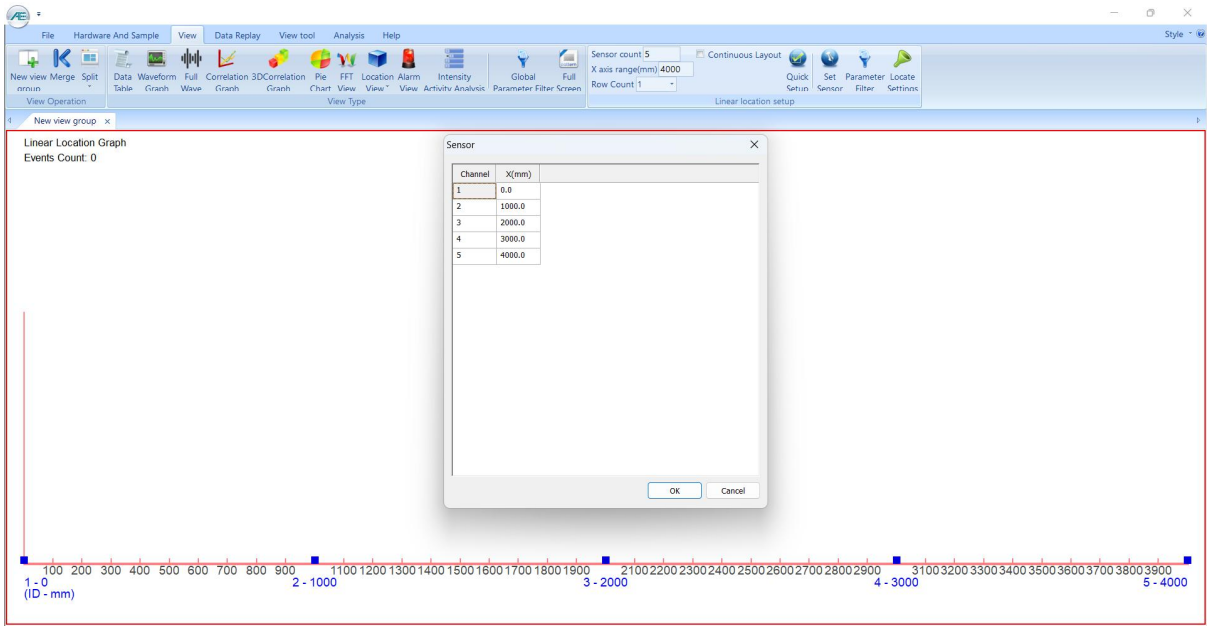


Fig. 2-62 Manual modification coordinate position

3) Explanation of interface terms

Sensor count: it refers to the total number of sensors to be arranged in the linear location, which can be input directly in the text box;

X axis range(mm): when the sensors are equally divided, it refers to the total length to be detected. When the sensor is used to set and modify the coordinates, this value is not less than the detection length, which can be input directly in the text box;

Row Count: the row numbers of linear arrays in the linear location view. It will require the sensor number is at least 3 or more to be valid.

Continuous Layout: when there is more than 1 row, it determines if the last sensor of the current row should also be the first sensor in the next row. There are four sensors and two rows. If the “Continuous Layout” is not enabled, the first row has Sensor#1 and #2, and the second row has Sensor#3 and #4. But when the “Continuous Layout” is enabled, the first row has Sensor#1, #2 and #3, and the second row has Sensor#3 and #4.

Events Count: at the upper left corner of the location graph, there is the “Events Count” representing the number of valid location events generated on the current location Graph;

X: 500 mm: the current horizontal (x axis) coordinate where the mouse cursor stays on the

view, which is shown at the upper left corner of the view under the “Events count”.

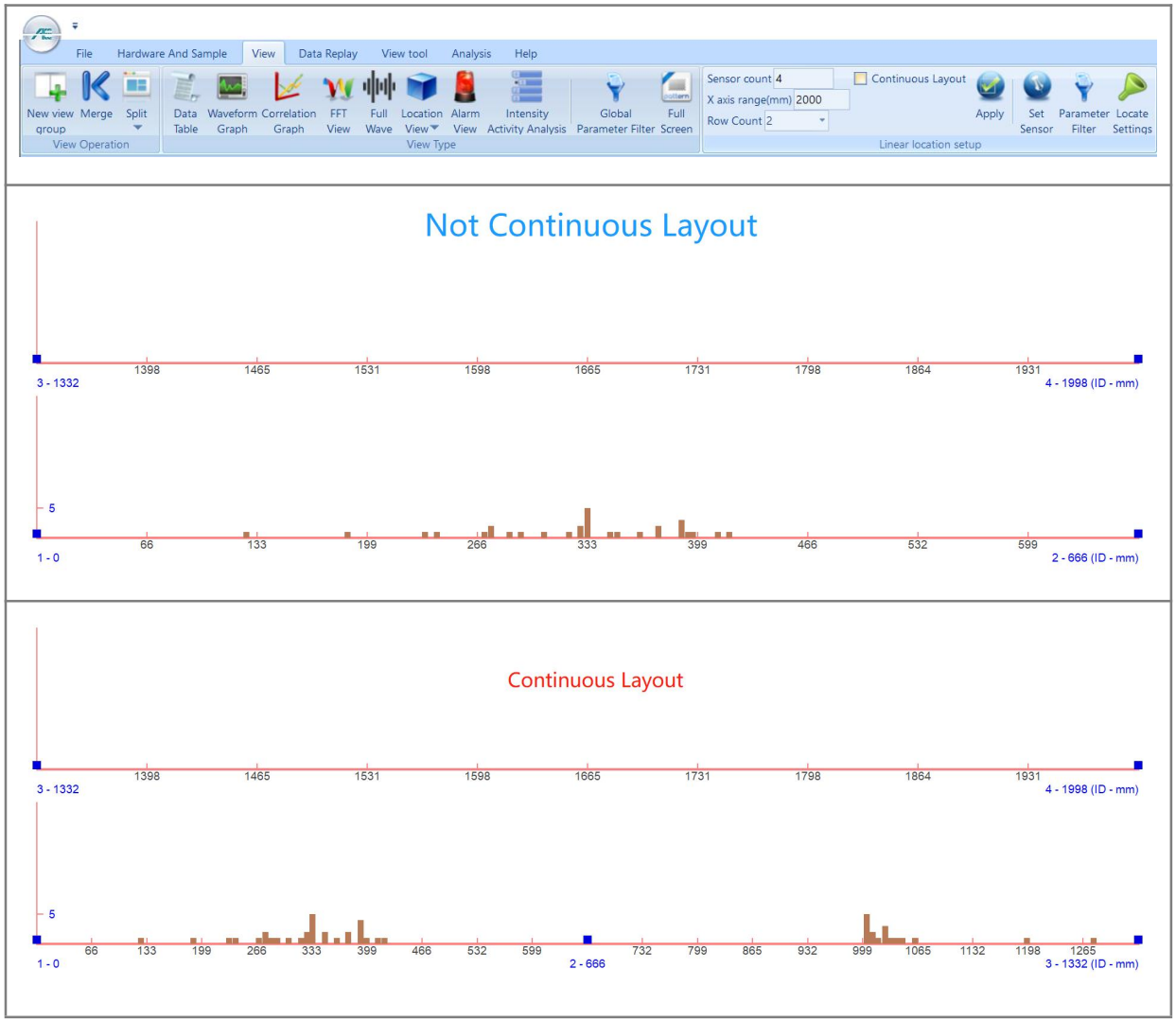


Fig. 2-63 Linear Location Graph Continuous layout difference

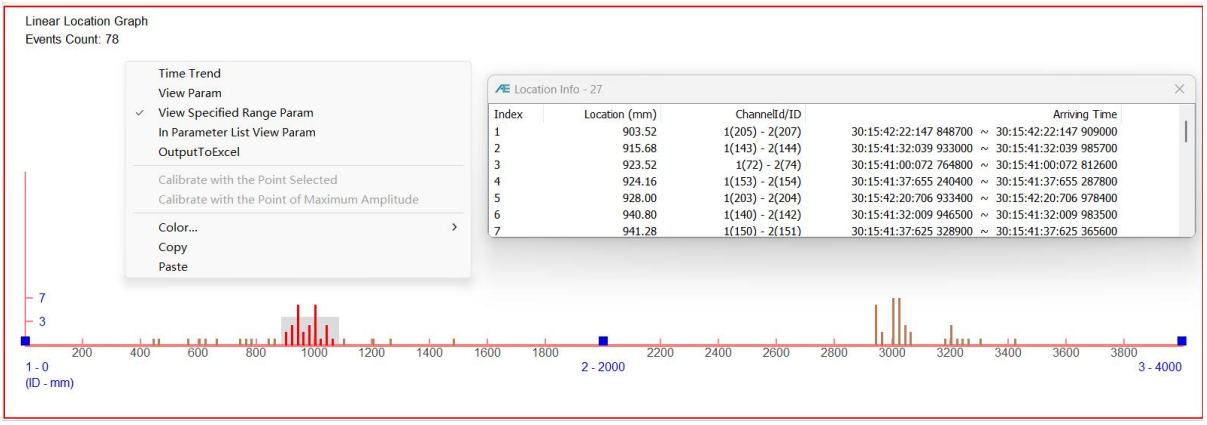


Fig. 2-64 Linear Location Graph View property menu

4) View property function

Right click on the location view to open the view property menu.

Time Trend: Draw a time trend graph of the parameters of the location points, with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click again to switch the Y-axis parameters.

View Param: after enabling, click on any valid data points on the location view. Parameter information of the position point will be displayed including the location coordinates, channel ID and the arrival time.

View Specified Range Param: after enabling, enter the covering range width (mm) from the interested position, by default 200mm of range. Then click on any valid data points on the location view. Parameter information of the position point and the nearby 200mm area points will be displayed including the location coordinates, channel ID and the arrival time. The points are calculated based on the channel parameters in the location parameter table.

In Parameter List View Param: after enabling, click the location points, and it filters out the parameters of the selected points and shows in the Data Table.

Output to Excel: export the location info, including coordinate info and parameter info to excel format;

Color...: to modify the background color and modify the selected range background color.

2.2.6.2.8.2. Planar Location Graph

Planar Location Graph is generally suitable for planar structure detection and local detection of large curved surface radius.

1) **View creation:** select a blank view (with red border), click **[View]**, then click **[Location View]**, then select **[Planar Location Graph]** to create the default planar location view;

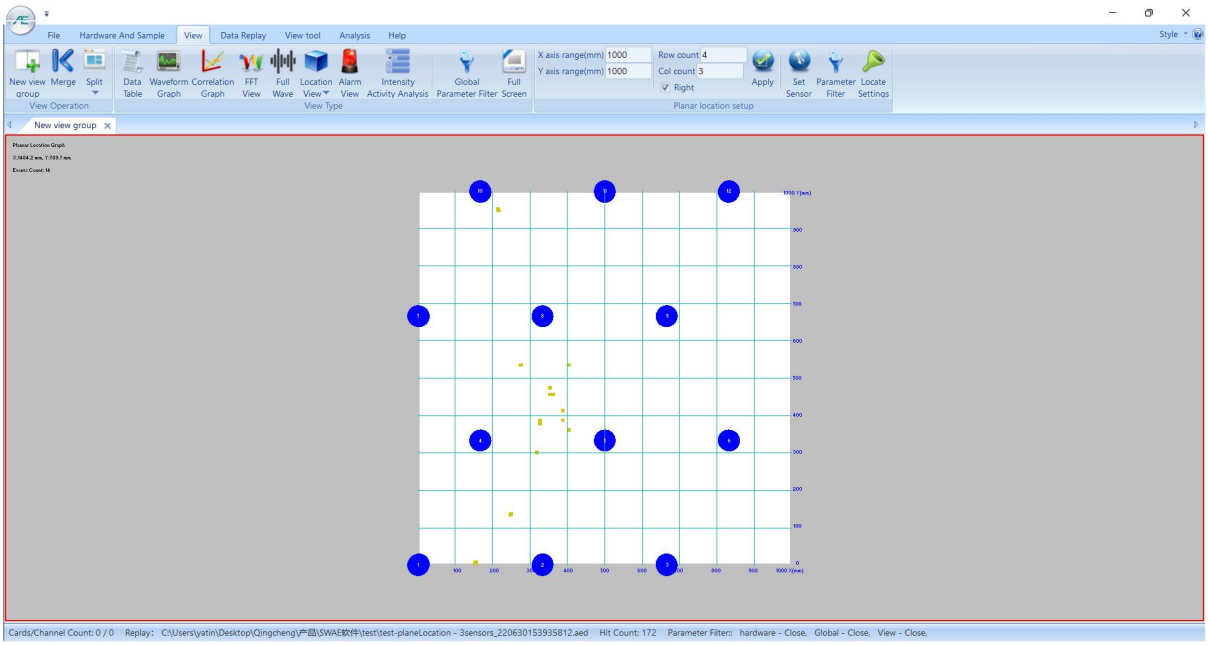


Fig. 2-65 Default Planar Location Graph

2) View Modification

The modification of Planar Location Graph involves the number of sensors, coordinates and detection area. The software supports simple setup mode, which is, entering the range of area and the number of sensors, and it automatically distributes the sensors with equal sensor spacing. The number and relative distance of sensors can also be manually set according to the actual situation.

Simple Setup:

a. Select the default location view (red border appears), and then modify "X-axis range" and "Y-axis range". The maximum range can be up to 500 meters.

b. Input the number of rows and columns of the sensor array. This function can only be arranged in horizontal and vertical straight lines. The horizontal sensor spacing between the adjacent sensors = X-axis range / column number; the vertical sensor spacing = Y-axis range / (number of rows - 1).

c. Select whether to click "☐**Right**" and click **[Apply]**; if it is selected, the first sensor in the second row is to the right side of Sensor #1, in the middle between Sensor #1 and #2, and Sensor #1 is located at the coordinate origin; if it is not selected, the first sensor in the second row is to the left side of Sensor #1, and the horizontal coordinate of Sensor #1

and the coordinate origin is half of the distance between Sensor #1 and #2;

d. When there is a difference between the actual sensor number/positions and the sensor in the software, click **[Set Sensor]** and select "Add" or "Delete" to adjust the sensor number, and modify the sensor coordinates.

e. Click **[Apply]** to update the settings.

Manual setup

a. First, confirm the the X-axis and Y-axis coordinates of all sensors relative to Sensor #1. Click the **[Set sensor]** button to pop up the dialog box, and then make some modifications if needed.

b. The number under the "Channel" column is the sensor number, which is generally consistent with the channel number connecting to the AE host. Change it to the user's desired number. Note that the modified number should not be repeated with the existing number.

c. The value below the “X(mm)” column is the horizontal distance from the coordinate origin, and the value under the “Y(mm)” column is the vertical distance from the coordinate origin, which can be directly input according to the actual situation.

d. After modification, click the **[OK]** button to update.

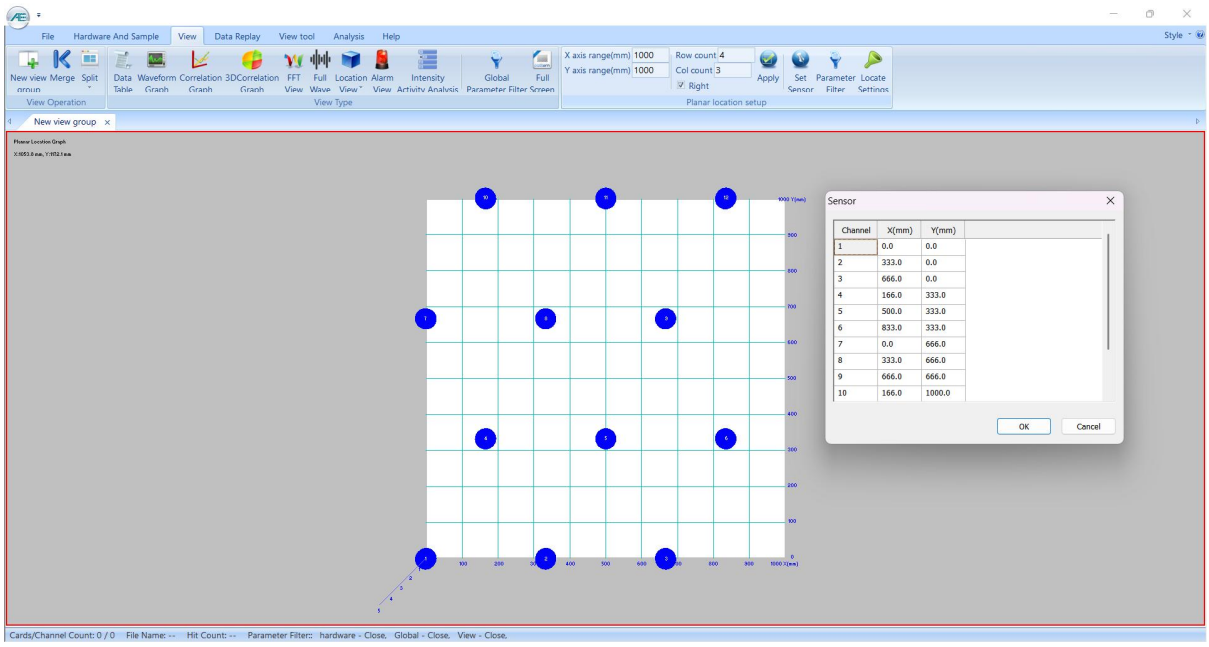


Fig. 2-66 View coordinate modification of Planar Location Graph

3) **Explanation of Interface terms**

- **X-axis range / Y-axis range (mm):** "X-axis range" and "Y-axis range" refer to the length and width of the detected area, which can be input directly in the text box, the maximum value is 500m(500000mm).
- **Number of rows / columns:** "Row count" and "Col count" refer to the number of horizontal rows and vertical columns of the sensor array respectively. The horizontal distance between adjacent sensors = X-axis range / column count; vertical spacing = Y-axis range / (number of rows-1).
- ☐ **Right:** if it is selected, the first sensor in the second row is to the right side of Sensor #1, in the middle between Sensor #1 and #2, and Sensor #1 is located at the coordinate origin; if it is not selected, the first sensor in the second row is to the left side of Sensor #1, and the horizontal coordinate of Sensor #1 and the coordinate origin is half of the distance between Sensor #1 and #2.
- **Events count:** the number of valid location events generated on the current location Graph.
- **X/Y coordinates:** the current X and Y coordinates where the mouse cursor stays on the view, which is shown at the upper left corner of the view under the “Events count”.

4) **View Attribute function**

- **Time Trend:** Draw a time trend graph of the parameters of the location points, with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click again to switch the Y-axis parameters.
- **View Param**: enable it to call out the red circle used to filter out the parameters within the circle area. Move the red circle to the interested area, if there are location points, the parameters of the circled location points will be filtered and displayed in the "Data Table".
- **Output to Excel:** to export the location info, including coordinate info and parameter info to Excel format.
- **Calibrate with the Point Selected**: when there is any point selected by the red circle,

select this option to open the calibration window. The selected point location is calculated in the software and it should be same coordinates as the actual source position. If they are different, by adjusting the X or Y coordinates of the point as well as the sound velocity to make it closer to the actual source location coordinates.

- **Calibrate with the Point of Maximum Amplitude:** similar to “Calibrate with the Point Selected”, but the select point is with the maximum amplitude.
- **Color:** click "Color" to modify the background color.
- **View Coordinate:** open the window to show all the location points coordinates.
- **3D Coordinates:** change the planner view in 3D dimensions.

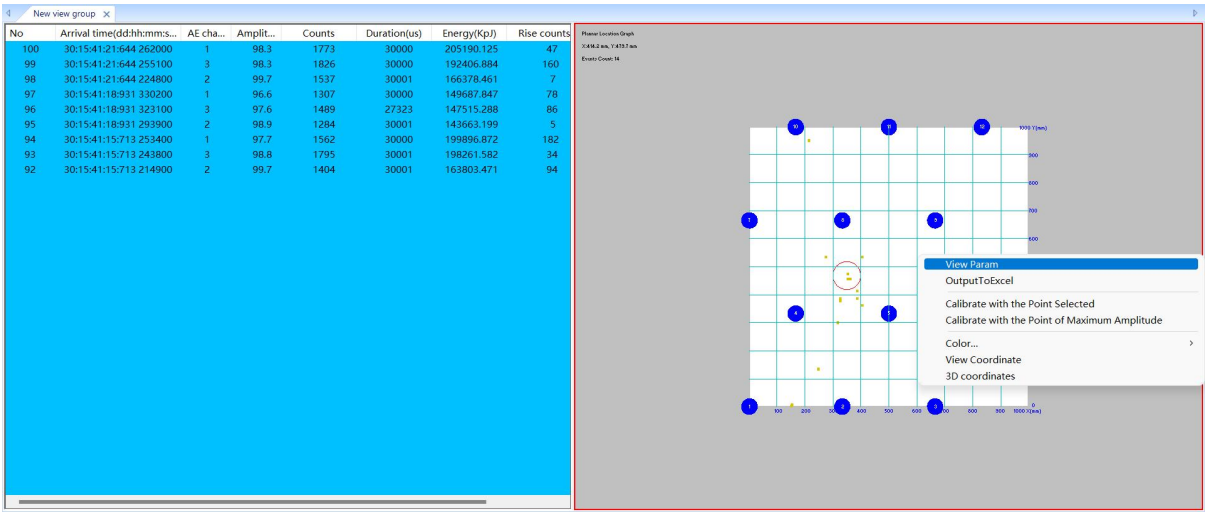


Fig. 2-67 View Para of Planar Location Graph

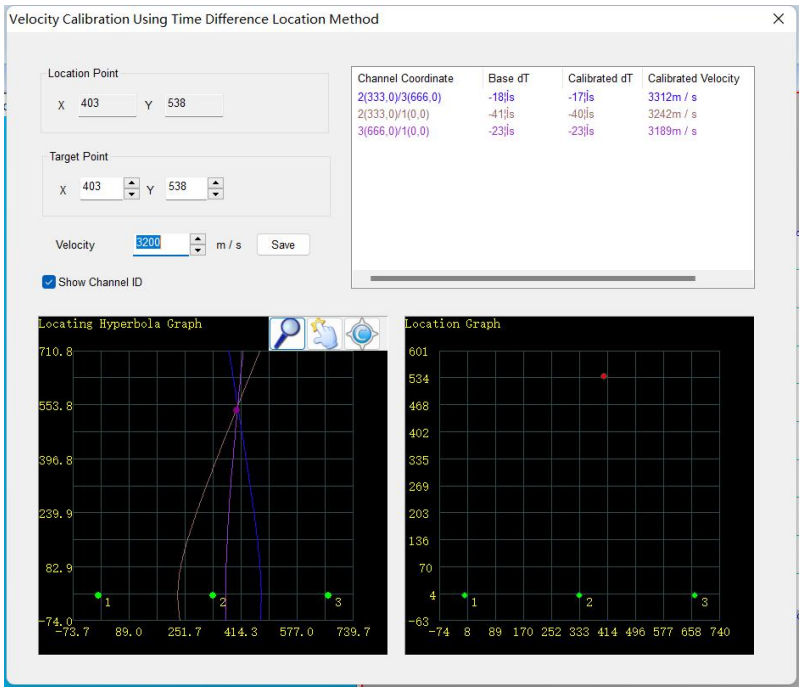


Fig. 2-68 Planar Location Graph Point Calibration

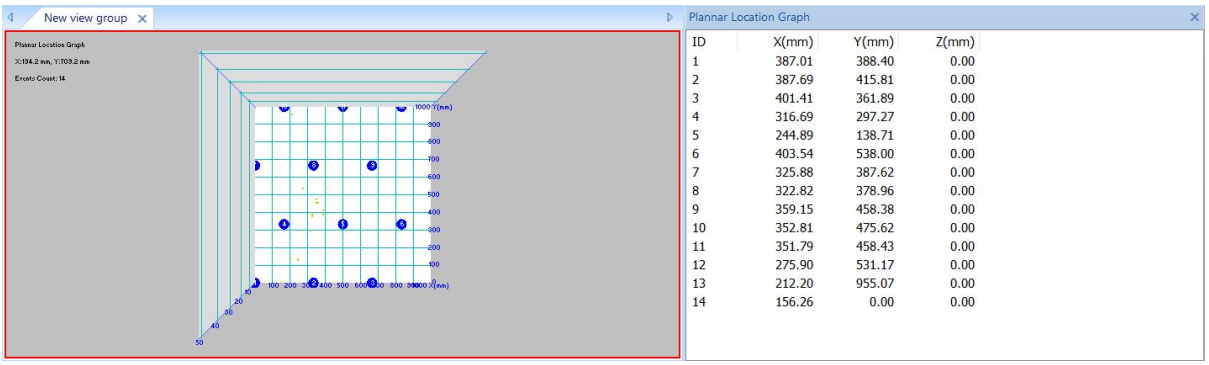


Fig. 2-69 View Coordinates and 3D dimension of Planar Location Graph

2.2.6.2.8.3. Cube Location Graph

Cube Location is generally applicable to the detection of solid cube like cubic structure, and is widely used in laboratory research direction, such as mechanical experiment process, rock block mechanical experiment, etc. The average density of the measured object and the installation position of the sensors have great influence on the location results.

1) **View creation:** select a blank view (with red border), click **[View]**, then **[Location view]**, and then select **[Cube Location Graph]** to create the default cube Location view.

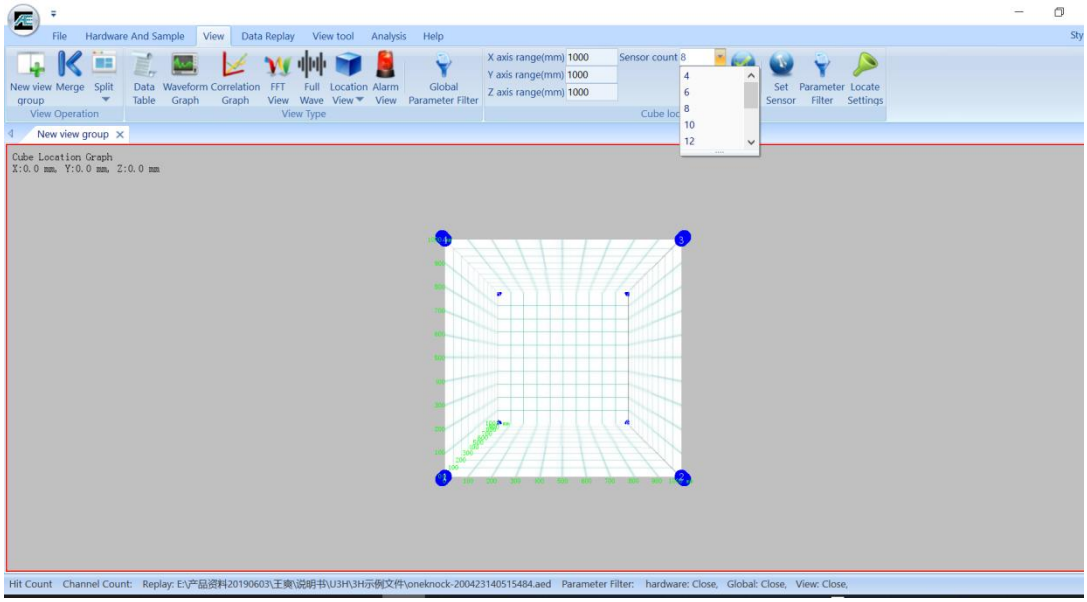


Fig. 2-70 Default view of Cube Location Graph

2) View modification

The modification of Cube Location Graph involves the number of sensors, coordinates and detection size. The software supports quick modification mode, that is, after inputting the size of detection area and selecting the number of sensors, the software automatically allocates the sensors; or the number of sensors and relative distances can also be modified manually according to the actual situation. The optional number of sensors is 4, 6, 8, 10, 12, 14, etc. If the actual number of sensors is not available, you can manually adjust in the **[Set Sensor]** to add or delete.

Simple modification

a) Select the default Location view (red border appears), and then modify "X / Y / Z axis range", where the X, Y, Z ranges are the actual measured object size;

b) Select the number of sensors. If there is no corresponding number available, select the closest number; then, refer to the "Manual setup" method for adjustment;

c) Click **[Apply]** to update the setting. Then the sensors are arranged automatically according to the coordinate positions given by the software.

Manual setup

a. First, know that all sensors X / Y / Z axis coordinates related to Sensor#1, and after the simple modification steps, click the **[Set Sensor]** button to modify the sensor numbers and coordinates.

b. The number under the "channel" column is the sensor number, which is generally consistent with the channel numbers to the AE host. Or change to the user's desired number. Note that the modified number should not be repeated with the existing number.

c. The value under column X is the horizontal distance from the coordinate origin, the value under column Y is the vertical upward distance from the coordinate origin, and the value under column Z is the vertical outward distance from the coordinate origin, which can be directly input according to the actual situation.

d. When there is a difference between the actual sensor number or coordinates and that of the software setup, right-click in the “Set Sensor" table and select "Add" or "delete" to adjust, as well as modifying the coordinates according to the actual position.

e. Click **[OK]** to modify the current interface.

3) Explanation of interface terms

- **X-axis range / Y-axis range / Z-axis range:** "X-axis range", "Y-axis range" and "Z-axis range" refer to the length, height and width of the detected area;
- **Number of sensors:** the total number of sensors to be used, which can be 4, 6, 8, 10, 12, 14, etc.;
- **Events count:** the number of valid location events generated on the current location Graph;
- **X/Y/Z coordinates:** the current X, Y and Z coordinates where the mouse cursor stays on the view, which is shown at the upper left corner of the view under the “Events count”.

4) View property function

- **Time Trend:** Draw a time trend graph of the parameters of the location points, with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click again to switch the Y-axis parameters.
- **View Param**: enable it to call out the red circle used to filter out the parameters within the circle area. Move the red circle to the interested area, if there are location points, the parameters of the circled location points will be filtered and displayed in the "Data Table".
- **Output to Excel:** to export the location info, including coordinate info and parameter info to Excel format.
- **Calibrate with the Point Selected**: when there is any point selected by the red circle, select this option to open the calibration window. The selected point location is calculated in the software and it should be same coordinates as the actual source position. If they are different, by adjusting the coordinates of the point as well as the sound velocity to make it closer to the actual source location coordinates.
- **Calibrate with the Point of Maximum Amplitude:** similar to “Calibrate with the Point Selected”, but the select point is with the maximum amplitude.
- **Color:** click "Color" to modify the background color.
- **View Coordinate:** open the window to show all the location points coordinates.

2.2.6.2.8.4. Tank Bottom Location Graph

Tank bottom location is generally suitable for flat disk or disk structure with large radius of curved surface. In engineering inspection, it is often used for bottom plate corrosion of atmospheric tank and source location of pressure vessel end caps.

1) **View creation:** select a blank view (red border appears), click **[View]**, then click **[Location view]**, and select **[Tankbottom Location Graph]** to create the default tank bottom location graph.

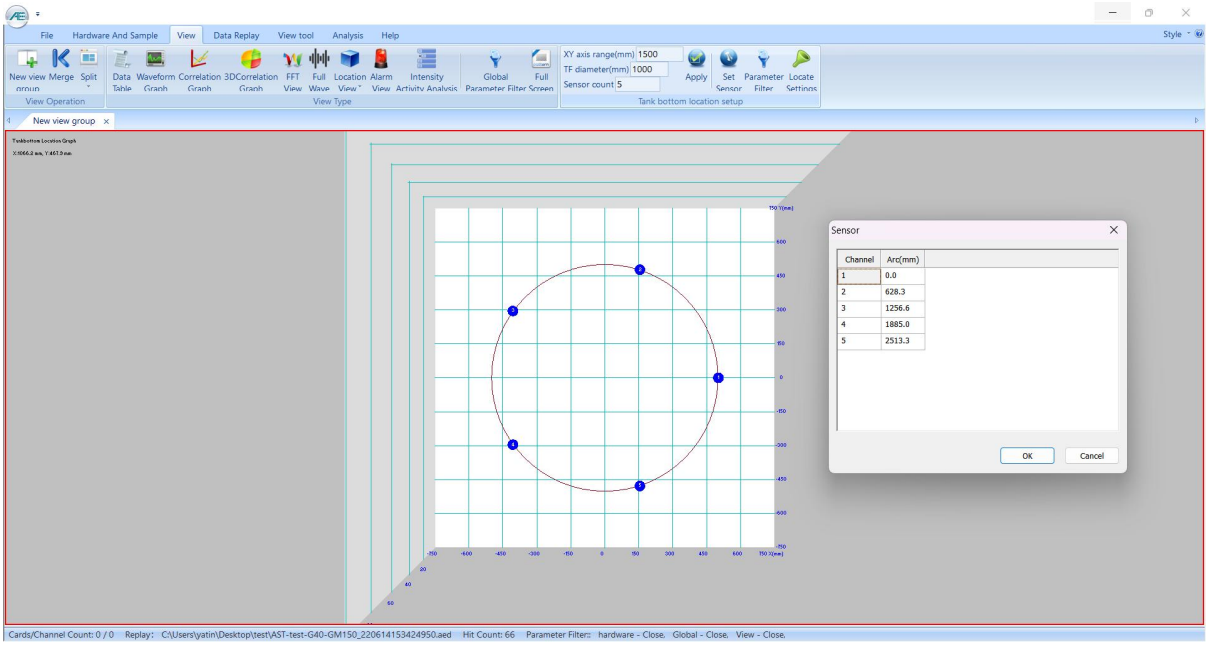


Fig. 2-71 Default view of Tank Bottom Location Graph

2) View modification

The modification of tank bottom location graph involves the setting of the number of sensors, the diameter of detection area and the size of display area. The software supports the quick modification mode, that is, with the number of sensors, the diameter of detection area and the size of display area, the software automatically arranges the sensor locations with equal spacing; on the other hand the number of sensors and the arc length can be modified according to the actual situation for manual setting.

Simple modification

a. Select the default location view (red border appears), and then directly modify "X/Y range", "TF (tank floor/bottom) diameter" (up to 120m) and "Sensor count" in the "View" interface.

b. Click **[Apply]** to update the settings. Then the sensors are arranged according to the coordinate position given by the software.

Manual Setup

a. Firstly, confirm the counter clockwise arc length distance of all sensors relative to Sensor

#1, and then on the basis of simple modification, click the **[Set Sensor]** button to pop up the dialog box.

b. The number under the "channel" column is the sensor number, which is generally consistent with the host channel number, and can also be changed to the user's desired number. Note that the modified number should not be repeated with the existing number;

c. The value under "**Arc (mm) length**" is the counter clockwise axial arc length of the distance from Sensor #1, which can be directly entered according to the actual situation.

d. After modification, directly click the **[OK]** button.

3) Explanation of View Setup Functions

- **X/Y axis range(mm):** it refers to the display range of the horizontal and vertical coordinates of the sensor layout.
- **TF diameter(mm):** refers to the diameter of the actual tank bottom inspected area. In order to make the location view fully display the distribution of tank bottom location sensors, it is recommended to set "XY axis range" slightly larger than "TF diameter".
- **Sensor count**: the number of sensors to be used, which can be determined by referring to the distance equally divided by the circumference length. The more sensors are used, the smaller the blind edge detection area is;
- **Events count:** the number of valid location events generated on the current location Graph;
- **X/Y coordinates:** the current X and Y coordinates where the mouse cursor stays on the view, which is shown at the upper left corner of the view under the “Events count”.

4) View property function

- **Time Trend:** Draw a time trend graph of the parameters of the location points, with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click again to switch the Y-axis parameters.
- **View Param**: enable it to call out the red circle used to filter out the parameters within

the circle area. Move the red circle to the interested area, if there are location points, the parameters of the circled location points will be filtered and displayed in the "Data Table".

- **Output to Excel:** to export the location info, including coordinate info and parameter info to Excel format.
- **Calibrate with the Point Selected**: when there is any point selected by the red circle, select this option to open the calibration window. The selected point location is calculated in the software and it should be same coordinates as the actual source position. If they are different, by adjusting the X or Y coordinates of the point as well as the sound velocity to make it closer to the actual source location coordinates.
- **Calibrate with the Point of Maximum Amplitude:** similar to “Calibrate with the Point Selected”, but the select point is with the maximum amplitude.
- **Color:** click "Color" to modify the background color.
- **View Coordinate:** open the window to show all the location points coordinates.
- **3D Coordinates:** change the planner view in 3D dimensions.

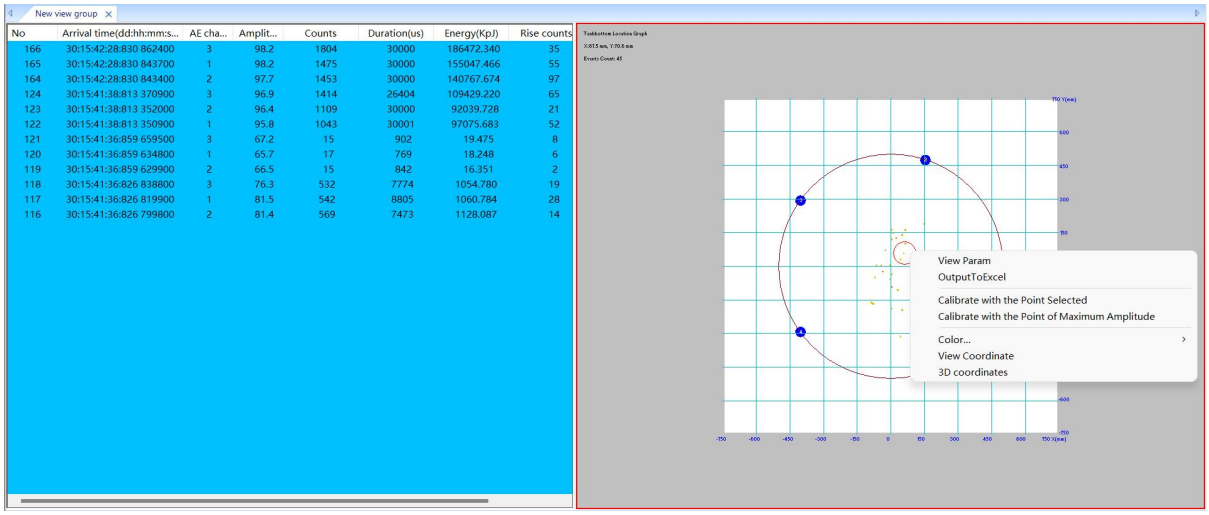


Fig. 2-72 Tank Bottom Location Graph View Parameters

2.2.6.2.8.5. Cylinder Location Graph

Cylinder Location is generally applicable to the detection of cylindrical containers/pressure vessels, including with or without end caps (heads). It is generally applicable to tank type pressure vessels with or without end caps in industrial field, such as various chemical reactors, gas cylinders, horizontal tanks, column tanks, towers, etc., as well as ring barrel components in the laboratory.

1) **View creation:** select a blank view (with red border), click **[View]**, and click **[Location Graph]**, then click **[Cylinder Location Graph]** to create the default cylinder location graph.

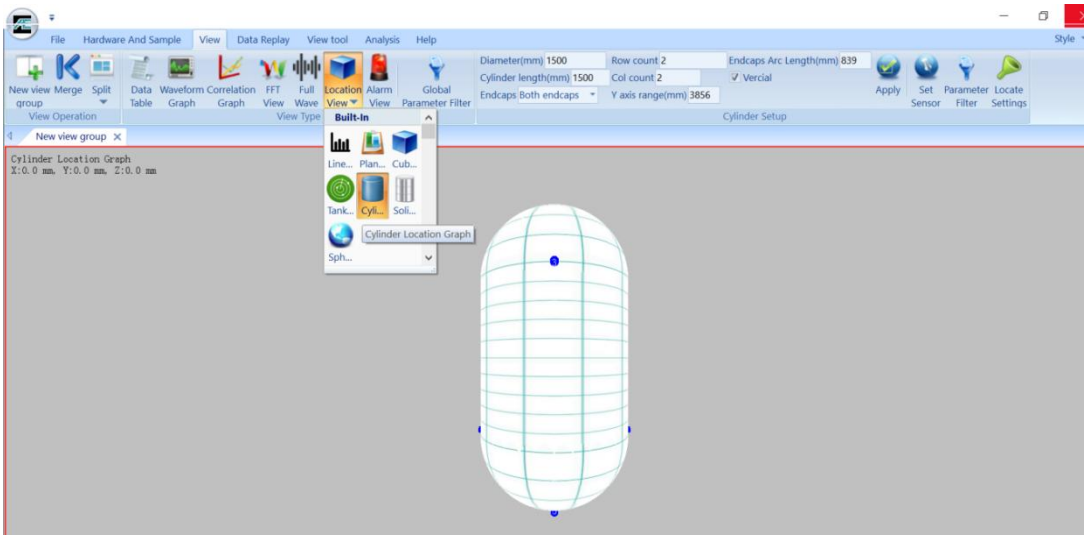


Fig. 2-73 Default Cylinder Location Graph

2) View modification

The Cylinder Location Graph supports simple modification, which can be done by setting the diameter, cylinder length, sensor numbers and other information, and then the software automatically distributes sensors with the equal spacing; or can manually set the number of sensors and relative distances according to the actual situation.

Simple modification

a. Select the default location view (red border appears), and then modify "Diameter", "Cylinder length", "Endcaps, "Row count", "Col count", and "Endcaps Arc Height" in the "View" interface;

b. Click **[Apply]** to update the settings. Then the sensors are automatically arranged

according to the coordinate positions given by the software.

Manual Setup

a. Firstly, confirm the X and Y coordinates info of all sensors relative to Sensor #1, and then on the basis of simple modification, click the **[Set Sensor]** button to directly modify the value in the interface;

b. The number under the "channel" column is the sensor number, which is generally consistent with the host channel number, and can also be changed to the user's desired number. Note that the modified number should not be repeated with the existing number;

c. The value below the “X(mm)” column is the horizontal distance from the coordinate origin, and the value under the “Y(mm)” column is the vertical distance from the coordinate origin, which can be directly input according to the actual situation.

d. After modification, directly click the **[OK]** button in the current interface.

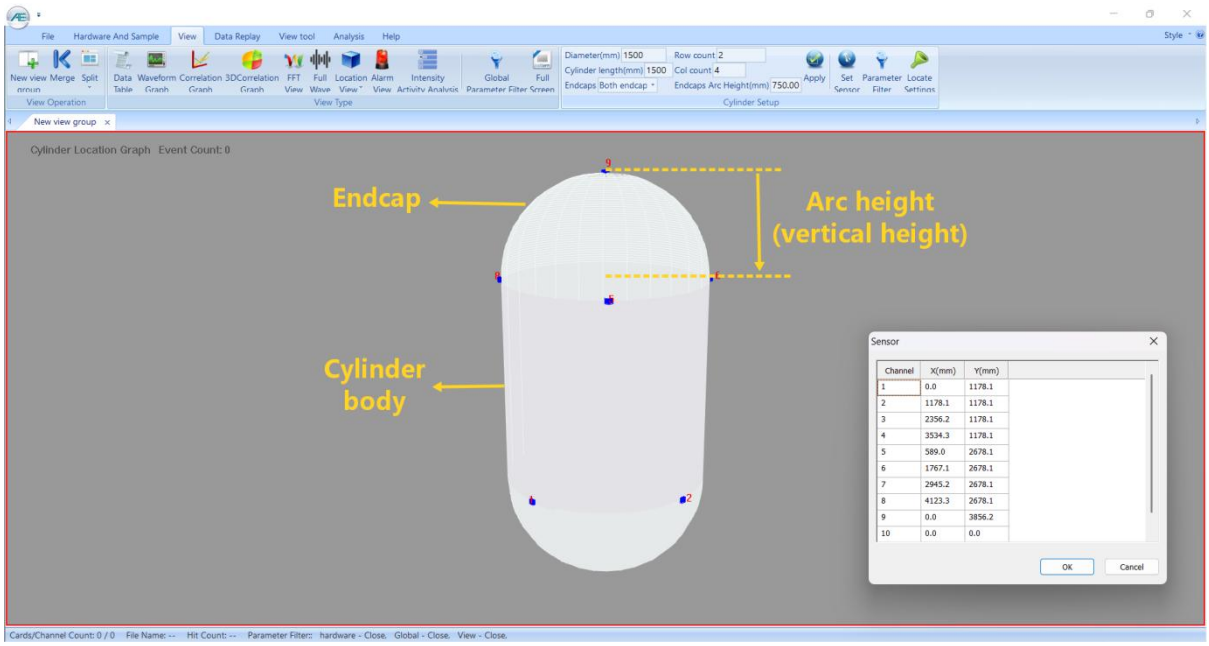


Fig. 2-74 Cylinder Location Graph Introduction

3) Explanation of Interface Terms

- **Diameter:** it is the outer diameter of the cylinder part, unit of mm;
- **Cylinder length(mm):** generally, refers to the height/ length of the cylindrical section

without the end caps (cylinder heads);

- **Endcaps:** the “endcaps” here refer to the cylinder headers, on the top or bottom parts of the cylinder block, including "no endcaps", "only top endcaps", "only bottom endcaps" and "both endcaps";
- **Row count:** refers to the number of circles (rows) of sensors arranged along the cylinder height direction (excluding the sensors on the cylinder heads). The setting range is 1-50 (integer);
- **Col count:** the number of sensors arranged in each circle (row) (excluding the sensors on the cylinder heads), the setting range is 1-50 (integer);
- **Endcaps Arc Height (mm)**: refers to the vertical height between the highest point of the header and the body of the cylinder.
- **Event count:** the number of valid location events generated on the current graph.

4) View property function

- **Time Trend:** Draw a time trend graph of the parameters of the location points, with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click again to switch the Y-axis parameters.
- **View Param**: enable it to call out the red circle (the cluster) used to filter out the parameters within the circle area. Move the red circle to the interested area, if there are location points (events), the parameters of the circled location points will be filtered and displayed in the "Data Table";
- **Delete event points in the viewing area**: to delete the location points in the view.
- **Output to Excel:** to export the location info, including coordinate info and parameter info to Excel format;
- **Calibrate with the Point of Maximum Amplitude:** when there are some points selected by the red circle, select this option to open the calibration window. The point with the maximum amplitude among the selected circle is used for calibration. The selected point

location is calculated in the software and it should be same coordinates as the actual source position. If they are different, by adjusting the X or Y coordinates of the point as well as the sound velocity to make it closer to the actual source location coordinates.

- **Event point intensity analysis**: The severity of defects in the area is determined based on the source amplitude of the positioning points in the area and the number of different stages, mainly used for result rating (classification).
- **Planar display:** convert 3D modeling to a 2D planar display.

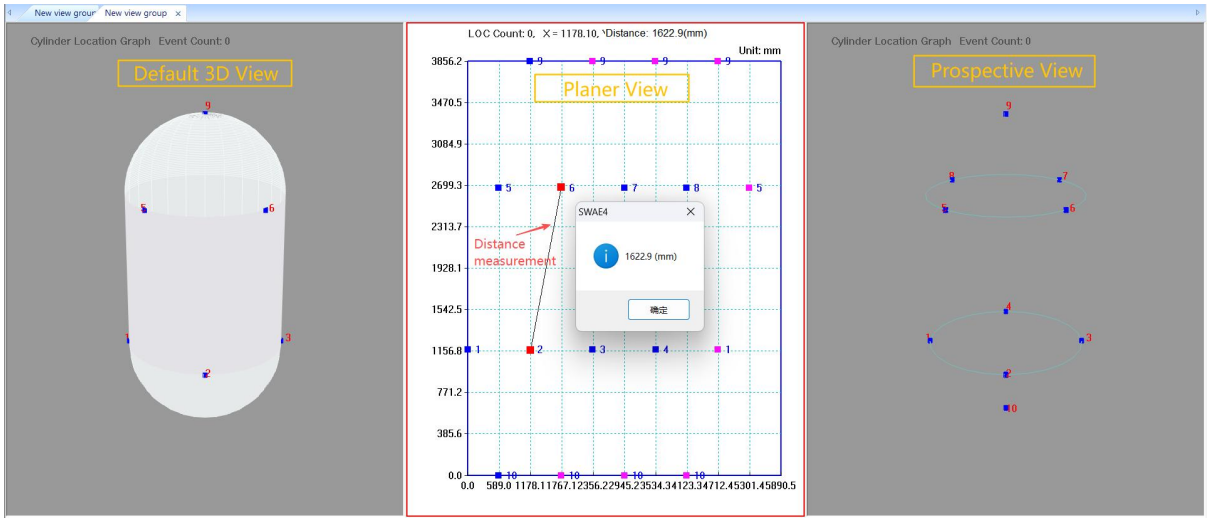


Fig. 2-75 Cylinder view 3D mode, planar and prospective view

- **Distance measurement**: in the planar view, in the right-click menu, check “Distance measurement” to enable the measuring. Left click on starting point on the view and drag to the end point. When releasing the mouse, the pop-up window will display the distance between these two points.
- **Perspective view**: in the 3D view mode, right-click menu and select “Prospective view” and it will display only the sensors without the cylinder surface.

2.2.6.2.8.6. Solid Cylinder Graph

Solid cylinder location is generally applicable to the detection of solid cylinder structure, and is widely used in laboratory research direction, such as mechanical experiment process, rock

block mechanical experiment, etc. The average material density of the measured object has a great influence on the Location results.

(1) View creation: select a blank view (with red border), click **[View]**, click **[Location View]**, then select **[Solid Cylinder Graph]** to create the default Solid Cylinder Graph;

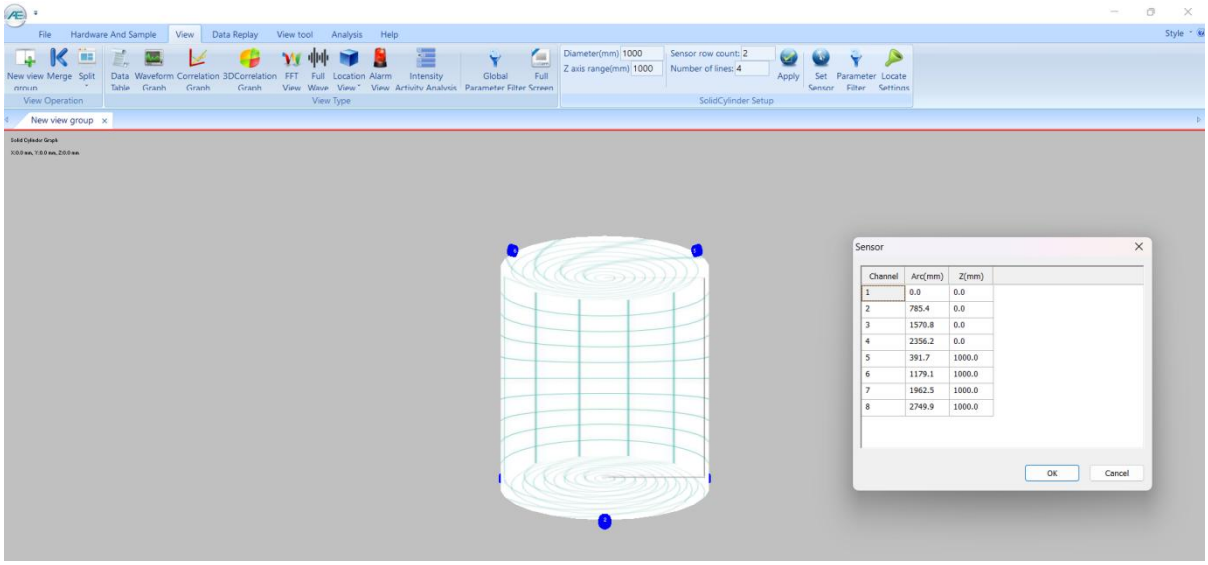


Fig. 2-76 Axis Setting interface of Solid Cylinder Graph

(2) View modification

The modification of **Solid Cylinder Graph** involves the number of sensors, coordinates and the size of the measured area. The software supports simple setup mode, i.e. after entering the size of the detection area and the number of sensors, the software automatically allocates the sensors. But the number of sensors and the relative distance can be modified manually.

Simple modification

1) Select the default location view (red border appears), and then modify the "Diameter" of the cylinder block and the "Z-axis range" as the cylinder block height.

2) Enter the number of sensors in the "Sensor row count" and "Number of lines"; then refer to the "Manual setting" method to adjust.

3) Click **[Apply]** to update the settings of simple modification. Then the sensors are arranged according to the coordinate positions given by the software.

Manual setup

a. Firstly, the horizontal arc length and vertical height from all sensors referring to Sensor #1 should be known;

b. Then, on the basis of simple modification, click the **[Set Sensor]** button;

c. The number under the "channel" column is the sensor number, which is generally consistent with the host channel number, and can also be changed to the user's desired number. Note that the modified number should not be repeated with the existing number;

d. The value under the "Arc(mm)" column is the clockwise arc length of the distance from Sensor #1, and the value below the “Z(mm)” column is the vertical distance from the coordinate origin;

e. To add or delete sensors, right-click on the "Set Sensor" window and select "Add" or "Delete". If adding sensors, enter the sensor number, arc length and Z axis values. To delete a sensor, click on the sensor number row and when the row background color turns blue, right click and select “Delete”;

f. After modification, click the **[OK]** button in the current interface to update the view.

(3) Explanation of interface terms

- **Diameter / Z-axis range:** "Diameter" and "Z-axis range" refer to the diameter and height of the detected area, which can be input directly in the text box;
- **Sensor Row Count:** the number of rows on the cylinder.
- **Number of lines**: refers to the number of sensor per row.
- **X/Y/Z coordinates:** the current X, Y and Z coordinates where the mouse cursor stays on the view, which is shown at the upper left corner of the view.
- **Events count:** the number of valid location events generated on the location Graph.

(4) View property function

- **Time Trend:** Draw a time trend graph of the parameters of the location points, with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click again to switch the Y-axis parameters.
- **Time Trend:** Draw a time trend graph of the location point parameters with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click to switch the Y-axis parameters.
- **View Param**: enable it to call out the red circle used to filter out the parameters within the circle area. Move the red circle to the interested area, if there are location points, the parameters of the circled location points will be displayed in the "Data Table".
- **Output to Excel:** to export the location info, including coordinate info and parameter info to Excel format;
- **Calibrate with the Point Selected**: when there is any point selected by the red circle, select this option to open the calibration window. The selected point location is calculated in the software and it should be same coordinates as the actual source position. If they are different, by adjusting the X or Y coordinates of the point as well as the sound velocity to make it closer to the actual source location coordinates.
- **Calibrate with the Point of Maximum Amplitude:** similar to “Calibrate with the Point Selected”, but the select point is with the maximum amplitude.
- **Planar**: Convert 3D modeling into 2D modeling display.
- **Color:** click "Color" to modify the background color.
- **Edit Event Point Color**: choose to display the event points color based in quantity or time.
- **View Coordinate:** open the window to show all the location points coordinates.
- **Distance measurement**: in the planar view, in the right-click menu, check “Distance measurement” to enable the measuring. Left click on starting point on the view and drag to the end point. When releasing the mouse, the pop-up window will display the distance

between these two points.

2.2.6.2.8.7. Spherical Location Graph

Spherical Location is generally applicable to the detection of spherical hollow shell structures. It is generally applicable to the detection of spherical vessel or hemispherical end caps in industrial field.

1) **View setup**:

select a blank view (with red border), click **[View]**, then click type in view menu, and select **[Spherical Location Graph]** in the pop-up location graph type to create the default spherical location view.

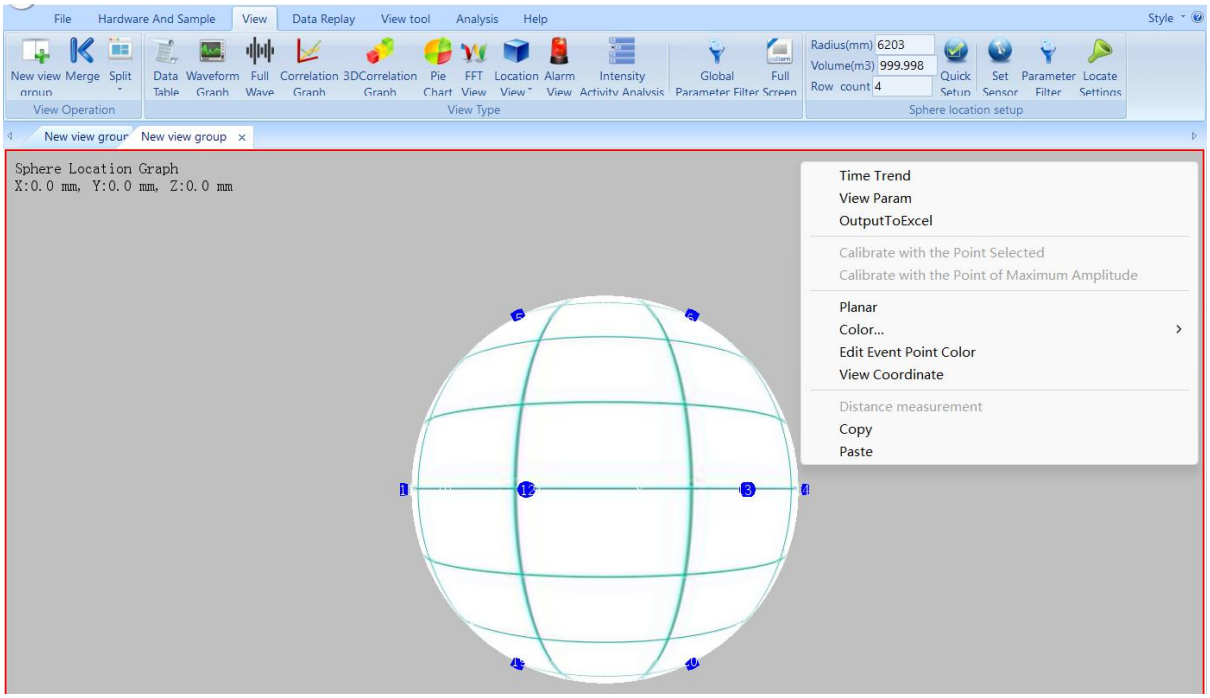


Fig. 2-77 Spherical Location Default Graph

2) View modification

After entering the sphere radius and the number of layers to be set, and then the software will assign the sensors based on standards. The sensor number and their relative positions can also be manually set according to the actual situation. It is recommended to adopt the default setup of software, and then adjust the position of individual sensors appropriately.

Setting method

a. Select the default location view (red border appears), and then modify the information of "Radius", "Volume" and “Row count” in the "View" interface. The volume and radius are related parameters, the modification of radius will affect volume, and the modification of volume will also affect the value of radius. The number of rows exclude the two sensors on the top and bottom of the sphere;

b. Click **[Apply]** to update the settings. Then the sensors are arranged according to the coordinate positions given by the software.

c. If the recommended sensor placement for a particular channel fails, you can manually adjust it by clicking [**Set Sensor]**.

- **Number of Layers**: how many layers of sensors are there on the sphere surface.
- **Automatic Layout**: after entering the layer number, click “Automatic layout” and the system will automatically get the sensor positions including the spacing and offsets.
- **3D/Plane**: click to convert the sphere location view between the 3D mode and the planar view.
- **Layer ID**: the layer numbers.
- **Number**: refers to the total number of sensors placed in each layer.
- **Vertical Spacing**: The vertical surface spacing between the two layers.
- **Horizontal Spacing**: The horizontal spacing between sensors in the same layer.
- **Longitude Offset:** The longitudinal offset (in degrees) of the first sensor of the layer from the 0° longitude.
- **Sensors Nos.**: the sensor serial numbers in the layer.

d. After modification, click the **[OK]** button in the current interface to update the settings.

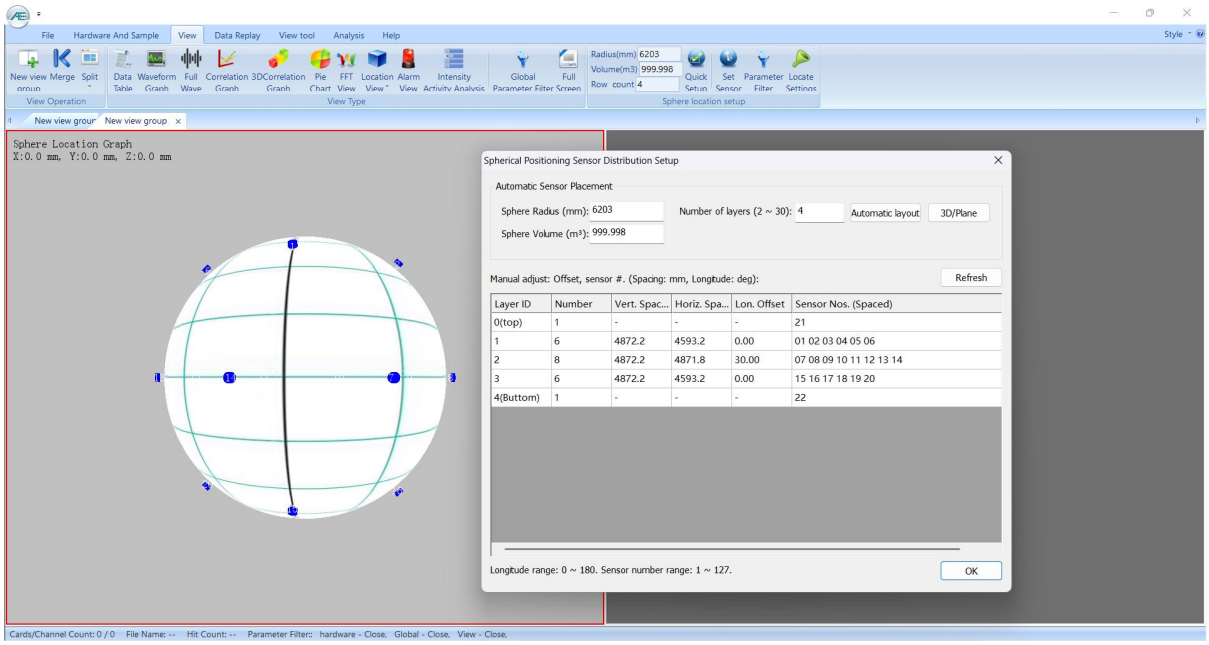


Fig. 2-78 Sensor settings of Spherical Location Graph

3) Explanation of interface terms

- **Radius**: the calculation formula of the radius of sphere: $R = \sqrt[3]{\frac{3V}{4\pi}}$, where V is the nominal volume, and π = 3.14; "R" is the radius in unit of millimeters;
- **Volume:** The formula for calculating the volume of a sphere is $V= (4/3)\ \pi R^3$, where π is 3.14 and R is the radius of the sphere; The unit of V is m^3;
- **Row count:** refers to the number of circles of sensors arranged on the sphere. The actual number of layers is the set number + 1. the reference row number can be: row#=π×radius(mm)÷5000mm, by rounding up the result as integer.
- **X/Y/Z coordinates:** the current X, Y and Z coordinates where the mouse cursor stays on the view, which is shown at the upper left corner of the view.
- **Events count:** the number of valid location events generated on the current location Graph.
- **Total Events**: Equivalent to the number of event counts, representing the number of time difference location events generated on the current location map.
- **Related Sensors**: The channel number of the parameter row involved in the time

difference positioning of the current positioning point.

- **Current Position Point X/Y**: The coordinates of the location point in the planar display, with the reference point being the origin of a rectangle with the arc length of the hemisphere as the side length.

4) View property function

- **Time Trend:** Draw a time trend graph of the parameters of the location points, with the arrival time as the X-axis and the acoustic emission characteristic parameters as the Y-axis. Right-click again to switch the Y-axis parameters.
- **View Param**: enable it to call out the red circle used to filter out the parameters within the circle area. Move the red circle to the interested area, if there are location points, the parameters of the circled location points will be filtered and displayed in the "Data Table"; as shown in Figure 6-69;
- **Output to Excel:** to export the location info, including coordinate info and parameter info to Excel format;
- **Calibrate with the Point Selected**: when there is any point selected by the red circle, select this option to open the calibration window as Figure 6-65. The selected point location is calculated in the software and it should be same coordinates as the actual source position. If they are different, by adjusting the X or Y coordinates of the point as well as the sound velocity to make it closer to the actual source location coordinates.
- **Calibrate with the Point of Maximum Amplitude:** similar to “Calibrate with the Point Selected”, but the select point is with the maximum amplitude.
- **Planar display:** convert 3D modeling to a 2D planner display. The numbers in yellow orange color are the repeated sensor numbers which is also the first sensor in the row. So that it can round up in the 3D dimension.
- **Color:** click "Color" to modify the background color.
- **View Coordinate:** open the window to show all the location points coordinates.

- **Distance measurement**: in the planar view, in the right-click menu, check “Distance measurement” to enable the measuring. Left click on starting point on the view and drag to the end point. When releasing the mouse, the pop-up window will display the distance between these two points.

2.2.6.2.8.8. Parametric Filter

After selecting any location view, click **[Parameter filter]** to pop up "HIT-Data Filter Setup" interface. The filter is a view specific filter, which is only effective for the current view. Refer to Chapter "2.2.5.3.2 Hardware Parameter Filter" for setting method. After the function is enabled, the parameter data conforming to the setting rules will participate in the TDOA location calculation of the location graph, and the stored data files will not be changed.

2.2.6.2.8.9. Locate Settings

2.2.6.2.8.9.1. Event Setting

After selecting any location view, click **[Locate Settings]** to open the **“Event Setting”** window. All parameter settings in this window are valid only for the current location graph.

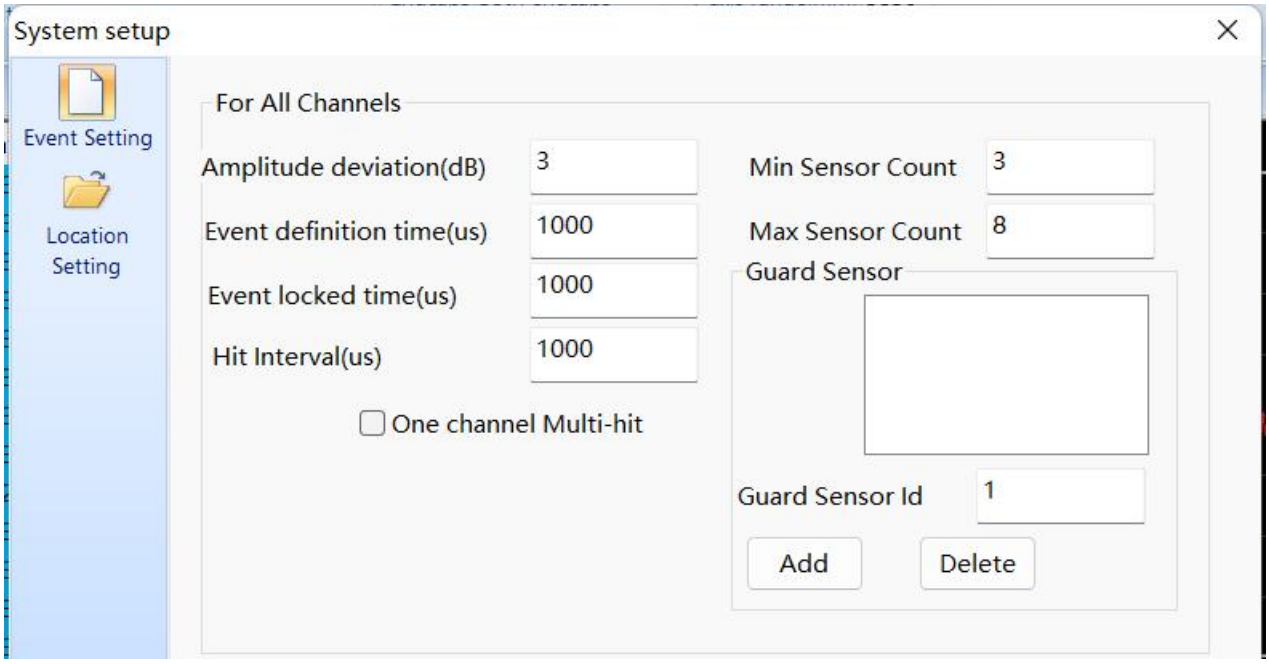


Fig. 2-79 Event Generation Settings

For the convenience of understanding, we give an example of rectangular sensor array to illustrate: *S1-S4* are sensors, **[*a, b, d*]** are distance values, the proposed sound speed is ***C***, and four sensors are used to participate in the positioning calculation.

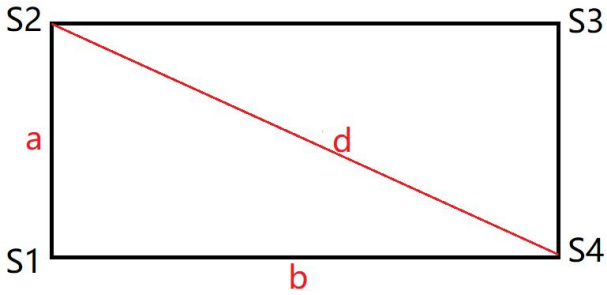


Fig. 2-80 Schematic diagram of sensor arrangement array

- **Amplitude deviation:** Set the amplitude deviation to eliminate the pseudo events. For example, if the first hit is smaller than the second hit and the difference exceeds the deviation, the event group is invalid and the first hit should be selected again. If the hit amplitude in the event group is smaller than its subsequent hits and the difference exceeds the deviation, that hit should be eliminated. **The amplitude deviation should be a reasonable value, which depends on the difference between the maximum sensor sensitivity and the minimum sensitivity among all sensors (i.e. S1-S4 in the array) during the sensor sensitivity test**. The amplitude deviation should be slightly larger than the difference. If the maximum sensitivity difference of all sensors in the array is 4dB, the amplitude deviation setting should be slightly greater than 4dB, maybe 6dB. But it should not be too large, otherwise there will be too many pseudo-events;

- **Event definition time:** the time is started from the first hit. When the set event definition time is up, even if there is no other hits received from all the relevant channels, the event will be forced to end. It can be considered as the time within which all signals received by the location sensor group are considered from the same acoustic emission source. Therefore, when setting this time value, the critical case of the sensor group is considered, such as polygonal shape sensor array arrangement. Select the maximum distance between two sensors, which is the boundary generated by the location event. **Divide the maximum distance by the sound speed**, which will obtain the maximum definition time of a location event. It can also include some the error range, **such as 20%**. In

summary, the event definition time can be

[(Maximum sensor spacing / measured sound velocity)×1.2]

In the example rectangular array, the value is *[(d/C)×1.2]*;

- **Event locked time**: starting from the last hit of the previous event. Any hit received within this set duration will not be regarded as the first hit of the next event group. If the 3-probe plane location algorithm is used, the event locked time can be set to 0. If the multi-probes plane location algorithm is used, the locked time can be set to be the same as the hit definition time (HDT).

- **Hit Interval**: the timing starts from the first hit. Before the end of this set duration, the event group will continue to execute if there is any hit data received from other channels in the array. If no other channel hit is received, the event group will be forced to cut off and re-select the first hit. **Select the maximum distance between two adjacent sensors in the same array, and divide it by the sound speed**, which is the maximum defined value of a location event. When the error range is set appropriately, such as 20%. The event hit interval can be

  [(Maximum adjacent sensor spacing / measured sound velocity)×1.2]

  In the rectangular array, the value to be input is *[(b/C)×1.2]*.

- **Min / Max Sensor Counts:** the Min / Max sensors counts refers to the number of hits used for location event calculations. If the number of hits received are below the minimum counts, the event is invalid, while if the hit number is greater than the maximum number, the exceeded hits upon reception are abandoned and the event will be forced to end but still valid. The larger the maximum sensors counts, the more hits are used for TDOA (Time difference of Arrival) location calculations.

In the process of multiple regression calculation, more source locations will be involved in verification and averaging, which can theoretically increase the accuracy of positioning. However, for different sensor arrangements and different sensor spacing, it should also set a

more reasonable number of sensor counts to calculate source locations.

For the general surface location, the number of sensors (hits) should be set according to the material attenuation curve and sensor layout spacing, as well as the noise threshold on site. For example, in the 6-sensor position array, if the maximum sensor spacing is 6 meters, the signal attenuation of such distance is 58 dB and the threshold is set to 45 dB, the standard pencil lead breaking signal cannot be detected. So that the position of the location source cannot be calculated or other random noise is mixed in during this period, which will lead to inaccurate location calculation results. Therefore, for this case, the minimum sensor counts cannot be set to 6. In general, in the linear location view, the minimum and maximum sensor counts involving in the source location calculation are both 2. For other types of location views, the default minimum sensors counts are 3, because the triangle positioning array is normally used for general surface source location. The maximum sensor counts are 8 by default. For example, when 10 sensor parameters in the array meet the positioning conditions, the first 8 calculations are directly selected.

- **Guard sensor:** it is used to eliminate the false location calculation caused by remote noises. When the channel is defined as the guard sensor and it receives the first hit, the event group will not take effect and the location point will not be calculated within the event definition time. Enter the channel number in the “Guard Sensor ID” and click **[Add]**; or select the channel number in the “Guard Sensor” window and click **[Delete]** to delete from the channel list.

2.2.6.2.8.9.2. Location Setting

After selecting any location view, click **[Locate Settings]** to open the “System Setup" interface. Click the **[Location Setting]** button on the left to display the interface. This interface involves the sound velocity setting and arrival time selection.

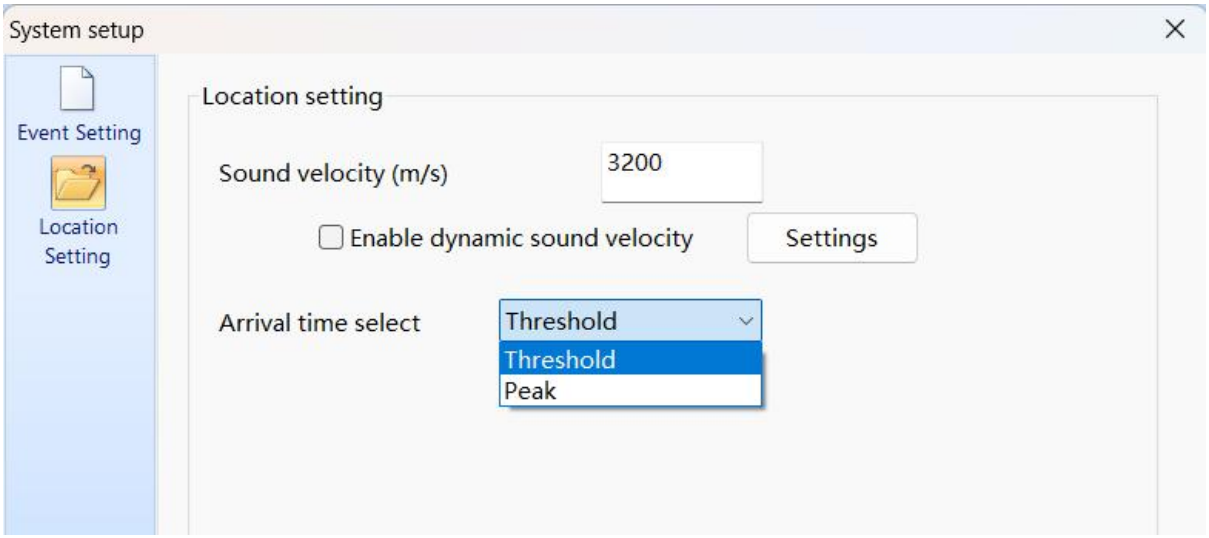


Fig. 2-81 Location settings

Sound velocity is generally obtained in measurements, and a reasonable sound velocity is very important for the location accuracy. The default sound velocity is the common metal surface wave sound velocity, which is suitable for plane plate layout with a sensor spacing of 1-5 meters.

Dynamic Sound Velocity: by enabling this function, it can set a velocity curve in time domain. It can be used in some cases of velocity changes when the temperature changes.

Arrival time selection: the default is "Threshold", that is, when calculating the positioning point, the time difference is calculated based on the time when the signal passes the threshold; while the "Peak" means the time difference is calculated based on the time when the peak amplitude is located.

There are two ways to get the sound velocity. The first method is to use the pencil lead break (PLB) test and the Data Table to measure and calculate the actual velocity in the material. The other method is to use the function of "Calibrate with the point selected /of Maximum Amplitude" in the right-click menu of the location view. But the second method is mostly for small adjustments.

1) Two-point Velocity Calculation

Install two sensors on a flat surface of the same and continuous material surface. Measure and record the distance L in advance. Start the data acquisition (signal recording) in the

software. Break the pencil leads in between the two sensors or on the extension line of the two sensors. (*Note that the threshold can be set higher, e,g. 70dB to eliminate the interference of non-valid pencil lead breaking signals.*)

In the Data Table view, find and select the two hits from the same PLB event. Right click the menu and select “Sound velocity calculation”. And the window of the “Two-point velocity of sound calculation” window pops up.

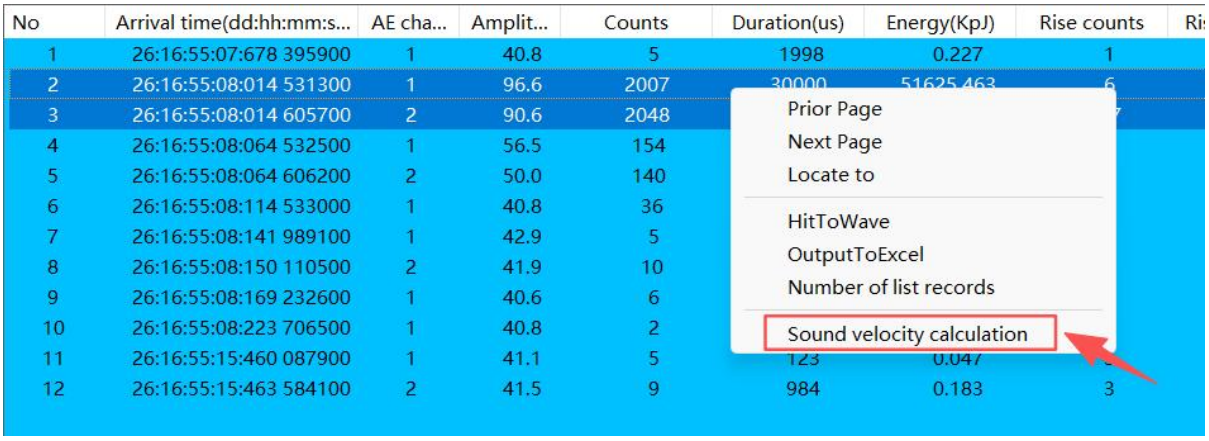


Fig. 2-82 Selecting the velocity calculation function

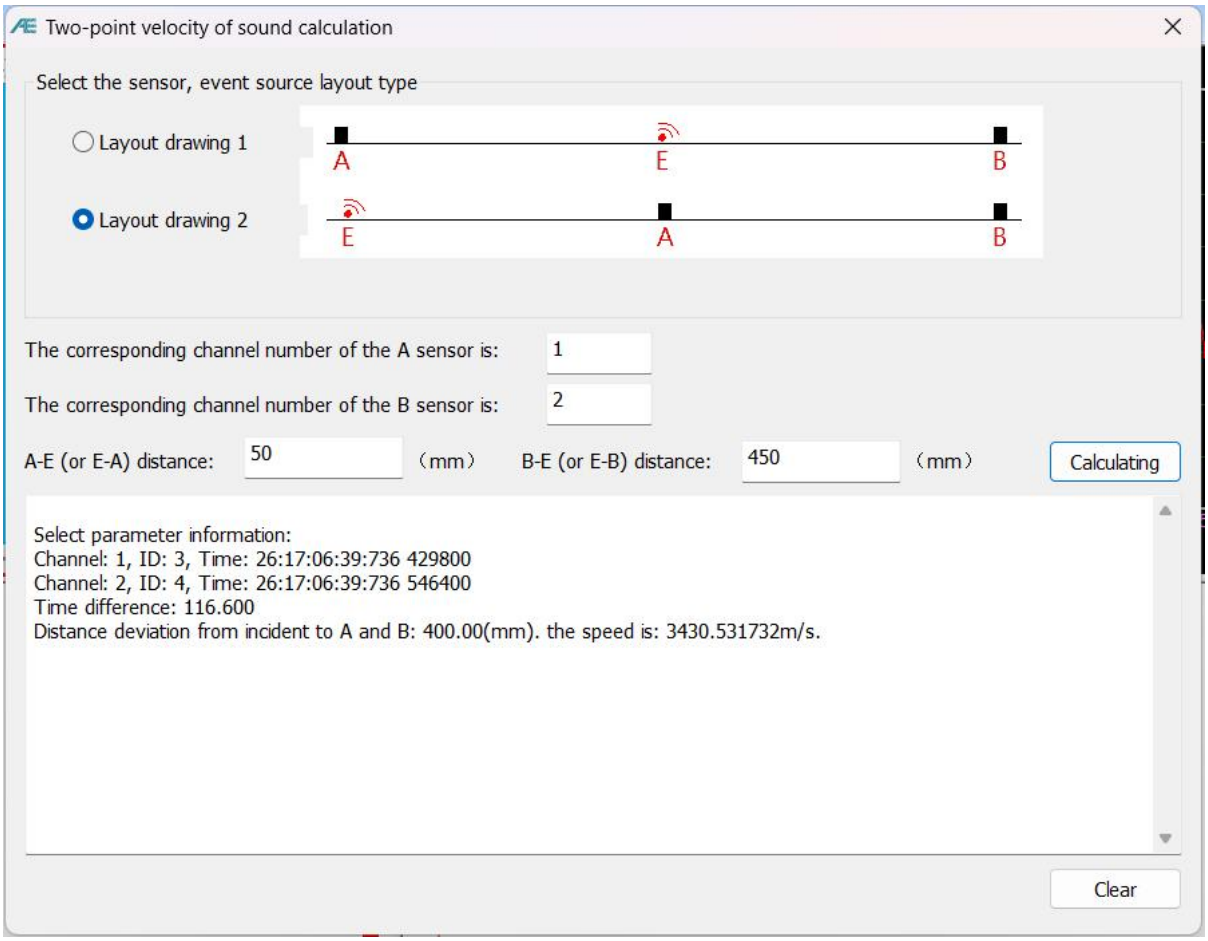


Fig. 2-83 Two-point velocity calculation window

Based on the actual pencil lead breaking positions, select Layout 1 or 2. E is the pencil breaking position (event source). Then confirm or modify the channel numbers corresponding to Sensor A or B. Then fill in the distances between A-E and B-E, positive values in unit of mm. Click “Calculating” button and get the result speed (velocity).

***Note**: the PLB position cannot be in the middle point of the two sensors.*

2) Sound velocity calibration by curve fitting

In the location views, when there are some valid event source points, right click the view and the menu has the “Calibrate with the points selected/ of Maximum amplitude”. These functions are for slightly adjusting the velocity to obtain more accuracy event points.

Calibrated with the Point Selected: except for the linear location graph, the sound velocity

is calculated according to the location position of the selected measured point and the actual acoustic emission source location;

Calibrate with the Point of Maximum Amplitude: except for the linear location graph, the software performs the hyperbolic fitting calibration of the sound velocity according to the position of the measured selected point with the maximum amplitude and the actual acoustic emission source location.

The two calibration methods are different only in the way of selecting measured points, and the calibration methods are the same, take "**Calibrated with the point selected"** for example**:**

a. Firstly, move the mouse cursor to the measured location points to be selected, and then right-click menu and select "**Calibrated with the point selected**";

b. Adjust the X-axis and Y-axis coordinates of the "Target Point". In the "Locating Hyperbolic Graph", the purple point is the target point, and the target point refers to the real AE source, such as the location of pencil lead breaks;

c. Adjust the sound velocity through the sound speed velocity button. When all hyperbolas intersect at one point and coincide with the target point, or make the target point be the center of all intersection points of hyperbola, the calibration is completed. The red point in the "Location Graph" on the right is the calculated location point;

d. Click the **[Save]** button, and then input this calibrated sound velocity to the "Sound Velocity" column.

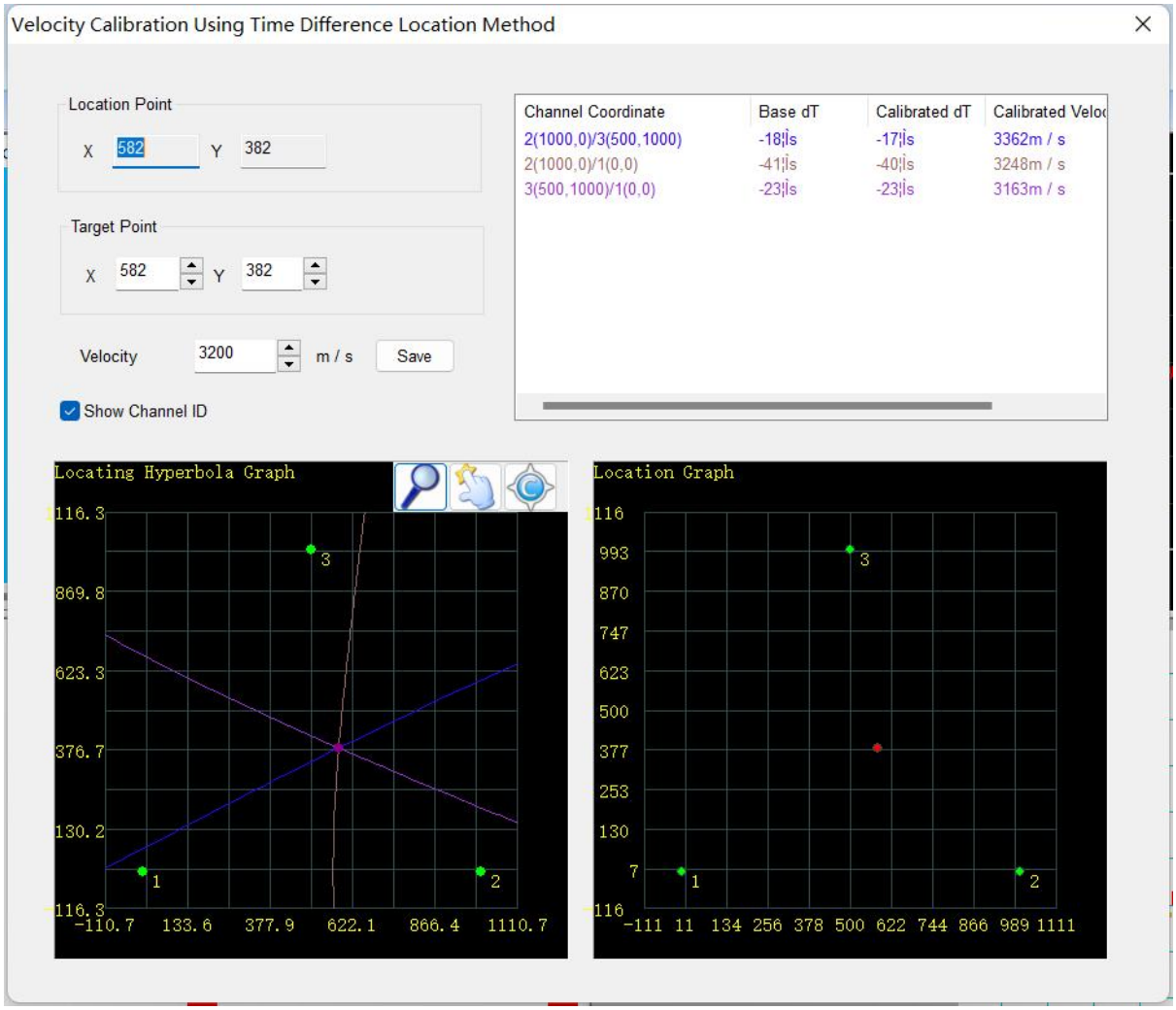


Fig. 2-84 Calculation of sound velocity interface by sound velocity fitting

2.2.6.2.9. Alarm View

The **alarm view** is the output alarm display diagram based on the alarm settings set by users. The number of alarms shown in the diagram means the corresponding triggered hits (row numbers of the parameters) in the corresponding channels.

Note: The alarm view is valid only during data acquisition, not during the data replay analysis.

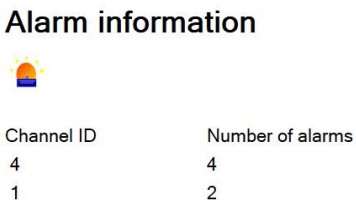


Fig. 2-85 Alarm display view

Select a blank view (red border appears) and click **[Alarm view]** in the "View" menu to complete the establishment of the alarm view.

After the alarm view is selected, click **[Alarm Settings]** on the right side of the view menu to set alarm rules in the pop-up “Hit Data Alarm Setup” interface.

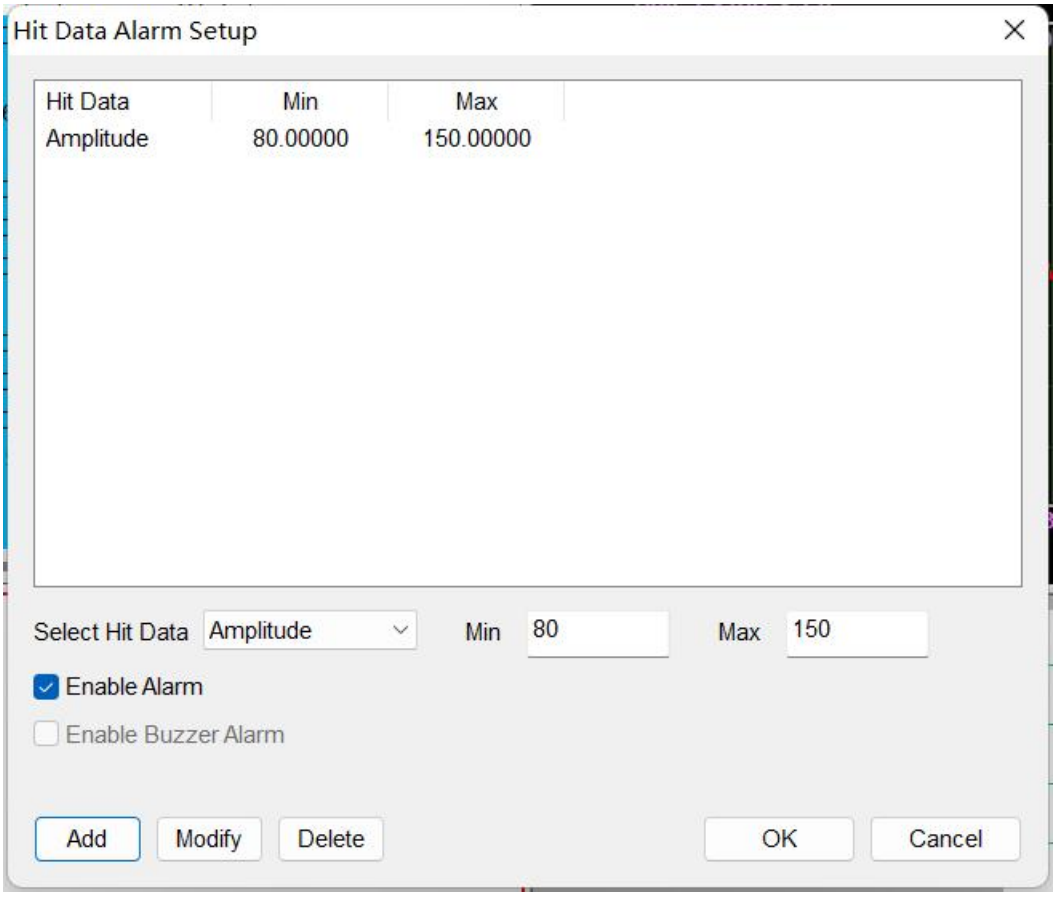


Fig. 2-86 Setting alarm parameters

Select Hit Data: You can set “Arrival Time”, “AE Channel”, “Amplitude”, “Counts”, “Duration”, “Energy”, “Rise Counts”, “Rise Time”, “RMS”, and “ASL” (select from the drop-down list) as the alarm trigger rules and modify the minimum and maximum values.

The data within the set range of those parameters is retained. When multiple rules are configured, the relationship between rules is **"and"**. That is, only the data that meets all rules can be recorded and displayed.

Add: To add a new rule, select the corresponding AE featured parameters from the drop-down menu, enter the minimum and maximum values in the text box, and click **[Add]** to add the rule to the list.

Modify: To modify an existing rule, click the corresponding rule in the selected list (the line turns blue after the rule is selected), enter the minimum and maximum values again in the text box, and click **[Modify]** to update the new value range.

Delete: To delete a rule, click the corresponding rule in the selected list (the row turns blue after the rule is selected) and then click the **[Delete]** button to remove it.

Enable Alarm: Check this to indicate that all rules in the list are in effect during data collection, otherwise they will not take effect.

2.2.6.2.10. Intensity Activity Analysis

Intensity activity analysis refers to that the user sets some rating rules according to the requirements, and the software carries out the intensity rating, activity rating and comprehensive rating analysis based on the collected parameter data.

The intensity rating is determined by the values of the selected parameters, and the activity rating is determined by the number of times when an intensity rating level triggers. If any of the collected parameters exceeds a specified level of intensity or activity, it is assessed as such level of intensity or activity.

The comprehensive rating is the highest level of intensity and activity combined over a period of time, giving the highest level of the composite rating. The comprehensive level meets the NBT47013.9-2015 standard.

Table 2-13 Comprehensive Level complying to NBT47013.9-2015 standard

Comprehensive level		Activity level			
		4	3	2	1
Statistical intensity level	3	4	4	3	2
	2	4	3	2	1
	1	3	3	2	1

Important note: the intensity levels of the comprehensive rating should not exceed 3 and the activity levels should not exceed 4. Otherwise, a comprehensive rating cannot be given.

2.2.6.2.10.1. Established intensity activity analysis view

Select a blank view (red border appears) and click **[Intensity Activity Analysis]** in the "View" menu to complete the addition of the intensity activity analysis view (the initial analysis mode is "Intensity alarm").

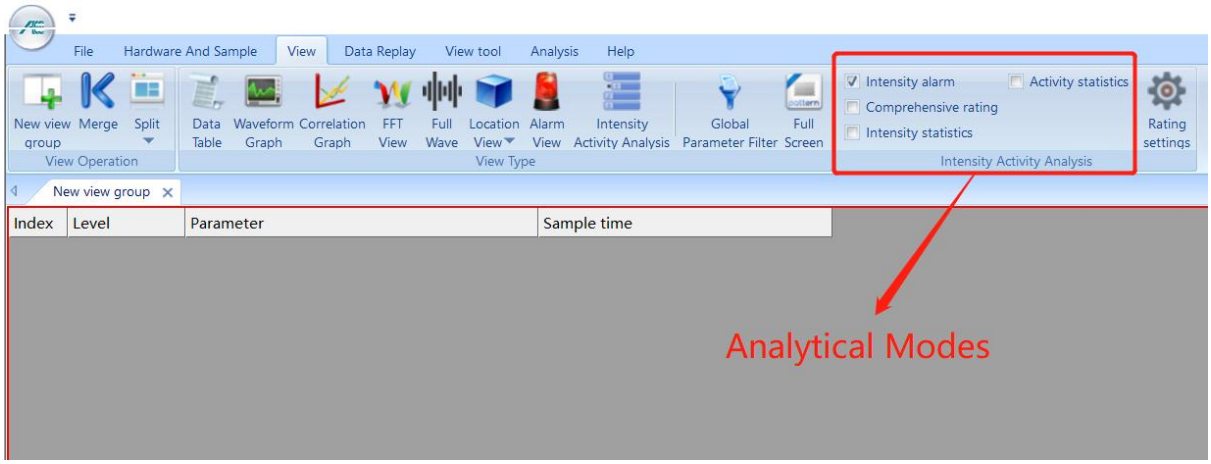


Fig. 2-87 Default view of intensity activity analysis

2.2.6.2.10.2. Analytical Modes

Select a analytical mode to display in the current window including: “Intensity alarm”, “Intensity statistics”, “Activity statistics”, “Comprehensive rating” respectively. Check to take effect.

1) **Intensity alarm:** Show the list of parameters triggering the intensity levels with their

corresponding triggered levels and sample time in the table;

2) **Intensity statistics:**

- Time-level chart: Display the highest intensity level of each statistical period and draw a statistical chart;
- Level-quantity chart: Display the number of occurrence for each intensity level over the time and draw a statistical chart;

3) **Activity statistics:**

- Time-quantity chart: display the number of occurrence of all intensity levels in each statistical period and draw a statistical chart;
- Time-level chart: displays the activity level of each statistical period and draws a statistical chart;

4) **Comprehensive rating:** it lists the highest intensity level and activity level, and the result comprehensive rating of each statistical period, with the detail intensity data, activity data, statistical length and the sample time.

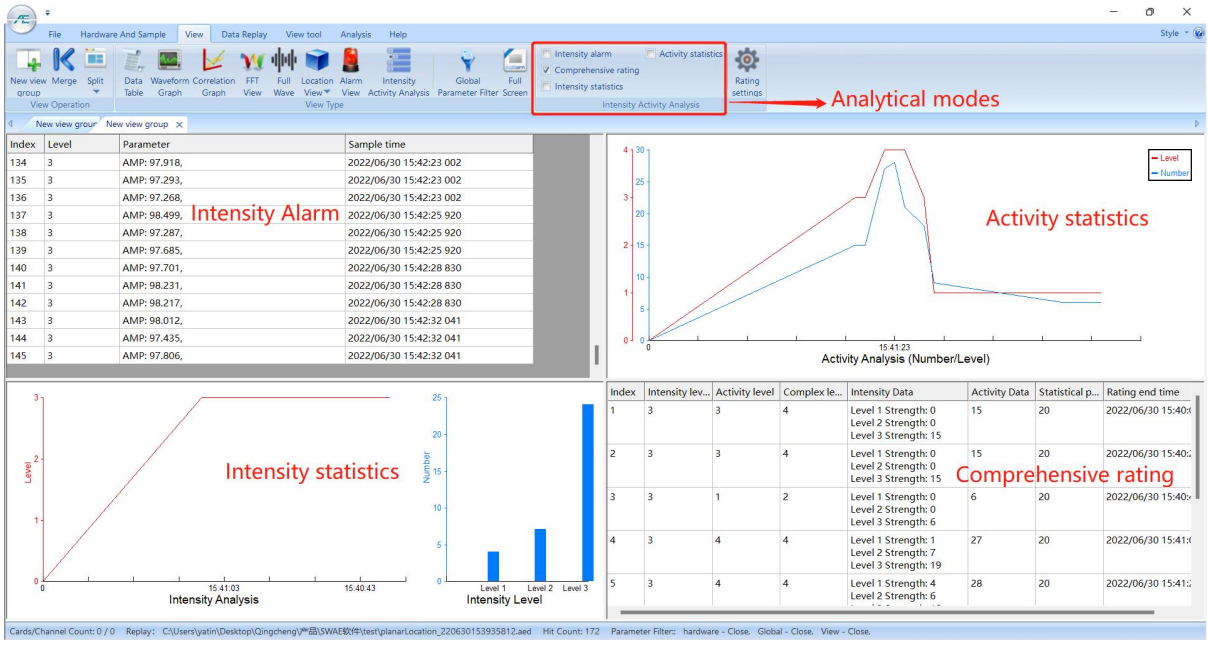


Fig. 2-88 Intensity activity analysis 4 analytical modes

2.2.6.2.10.3. Rating setting

Select the intensity activity analysis view and click the **[Rating settings]** on the right of the "View" menu to enter the intensity/activity setting interface.

Note: All the four analytical modes use the same **[Rating Settings]** as shown below, rather than each view setting being independent.

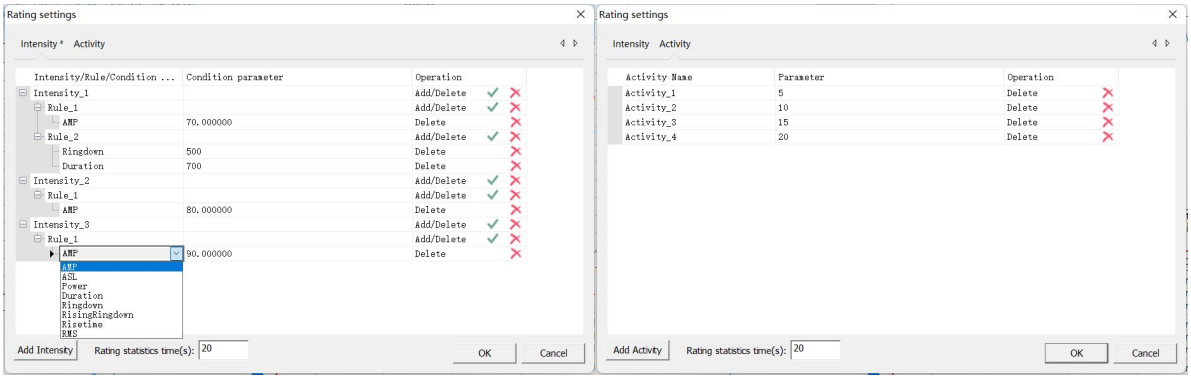


Fig. 2-89 Setting screen for intensity activity analysis

- **Rating statistics time(s):** Enter the statistical time (seconds) as the length of each statistical period in the intensity statistics mode, activity statistics mode, and comprehensive rating mode. It is 20 by default.

- **Intensity setting:**

Click the lower left corner **[Add Intensity]** to add the intensity conditions or rules; Click **[√]** to the right of "Add/Delete" to add "Rule" to the "Intensity_1" level; then click **[√]** again on the right of "Add/Delete" to add a parameter to "Rule_1".

Click on the name of the parameter to modify the parameter type. Click on the value of the parameter to modify the value.

Click **[×]** to the right of the intensity_1/rule_1/parameter name to delete the corresponding intensity/rule/parameter.

Note: There are up to a maximum of 3 "Intensity" levels and 8 "parameters" to be added.

- **Activity setting:**

Click the [Activity] at the upper left corner and then click on the lower left corner **[Add**

Activity] to add the activity rules; click on the value under the “Parameter” column to modify the activity value; click **[×]** to the right of "Activity_x" to delete the "activity".

Note: There are up to a maximum of 4 "activity" levels to be added, and the activity values must be greater than 0 and increasing level by level.

◆ **Intensity rating criteria:**

If the value of the parameter is in between Intensity_1 and Intensity_2, its intensity level is level 1; if in between Intensity_2 and Intensity_3, its intensity level is level 2; and if it is above Intensity_3, it is level 3 (up to 3 intensity levels are set).

If there are multiple rules under the same intensity, it only takes one rule to reach this intensity level. If there are multiple parameters under one rule, it needs to have all parameter conditions at the same time to meet the rule.

◆ **Activity rating criteria:**

Count the number of occurrence of the intensity level triggers for each statistical period. If the number is in between Activity_1 and Activity_2, its activity level is level 1; if in between Activity_2 and Activity_3, it is level 2; if in between Activity_3 and Activity_4, it is level 3; and if it is above Activity_4, it is level 4 (maximum 4 activity levels are set).

◆ **Comprehensive rating criterion:**

The highest level of comprehensive rating is given by synthesizing the highest level of intensity and activity in each statistical period. The comprehensive level meets the NBT47013.9-2015 standard.

Table 2-14 Comprehensive Level complying to NBT47013.9-2015 standard

Comprehensive level		Activity level			
		4	3	2	1
Statistical intensity level	3	4	4	3	2
	2	4	3	2	1
	1	3	3	2	1

2.2.6.2.11. Global Parameter Filter

The global parameter filter is effective for all views at the same time, which only affects the data display and does not affect the data storage. By setting the upper and lower limits of different AE parameters, only the parameters that are within the range will be displayed in the replay process, and the filtered parameters will be drawn in the correlation graph, location graph calculation and other processes. Refer to Chapter "2.2.5.3.2 Hardware Parameter Filter" for similar setting methods.

As shown in the figure below, the common filter settings for the metal pressure vessel inspection include increasing the amplitude threshold, filtering the parameters of small counts, and filtering the parameters with excessive rise time. The values in the figure do not have any reference value, just only for examples. These filter settings can refer to the relevant research literature of acoustic emission signal of metal materials, and the parameter filters should be based on the field noises in each working condition to determine carefully.

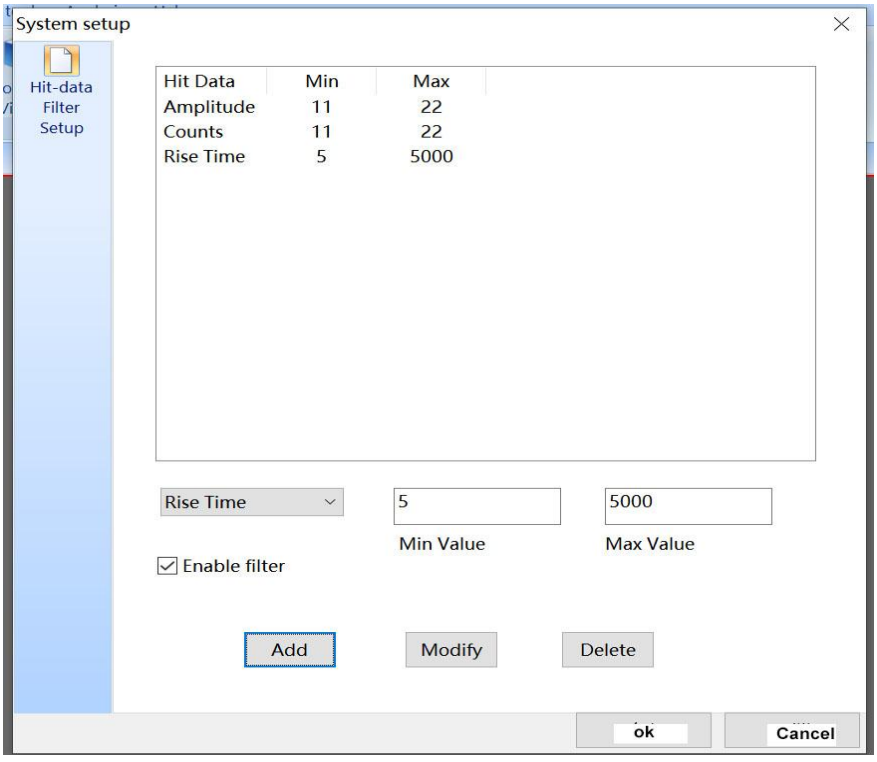


Fig. 2-90 Global Parameter Filter Setting up

2.2.6.2.12. Full Screen

Click **[Full Screen]** button to display the view in full screen for a larger view area. Click **[Exit Full screen]** to exit the full screen mode.

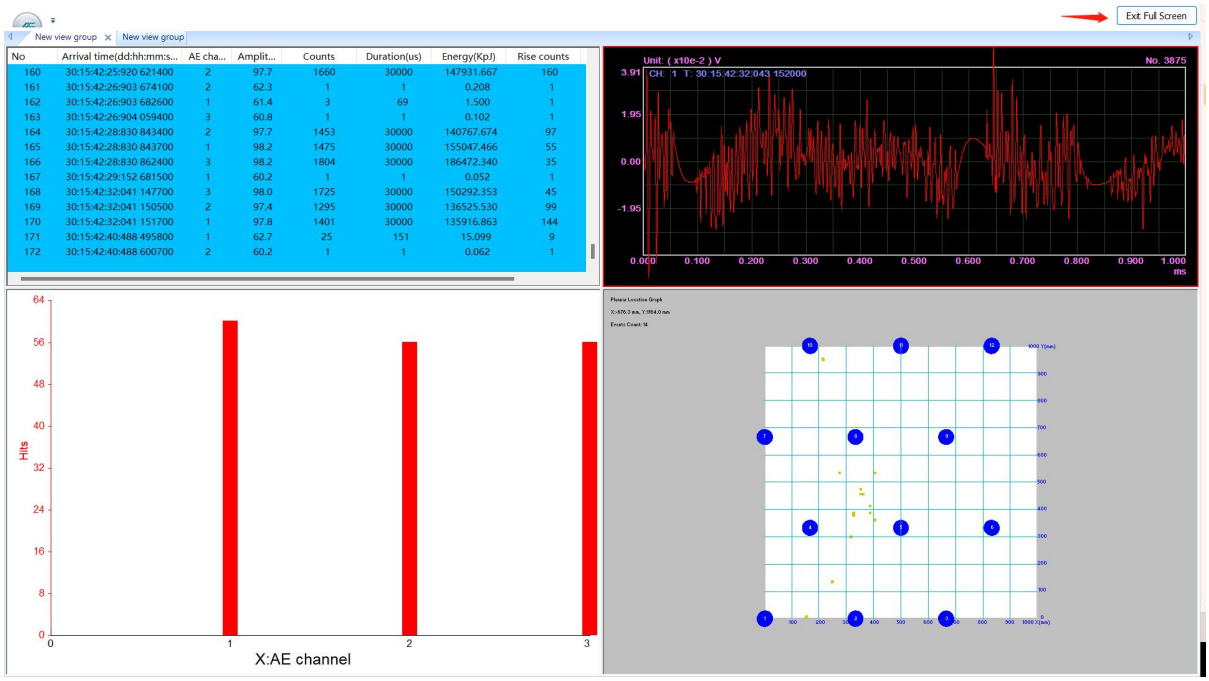


Fig. 2-91 Displays the full-screen screen

2.2.7. Data Replay Menu

After the completion of data acquisition, the main work is data analysis. Generally, the stored data are replayed. In the process of replay, data processing means are selected, and the authenticity and choice of data results are processed in order to get the correct result.

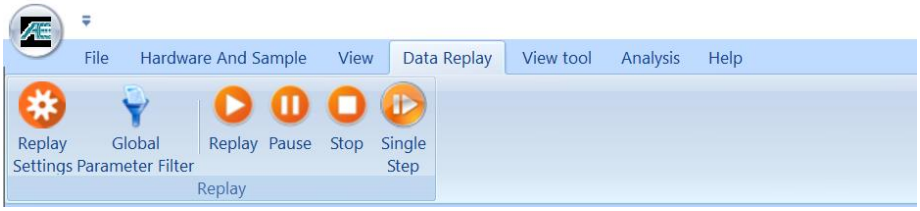


Fig. 2-92 Data Replay function

- **Replay Settings:** including the selection of replay data files and the replay mode;

- **Global parameter filter**: equivalent to global parameter filter in Chapter 2.2.6.2.9;
- **Replay:** start the continuous replay of data;
- **Pause:** pause during the data replay. Click it again to resume the data replay;
- **Stop:** force to termination during data replay;
- **Single step:** for the replay of waveform data, it is to replay the waveform frame by frame. Click once to replay one frame at a time; for the replay of parameter data, it is to replay in a batch by batch which batch value is set as the "Replay Speed" in the “Replay Settings”. Click once to replay one batch at a time.

2.2.7.1. Replay Settings

Click **[Replay Settings]** in "Data Replay", and select the data file to be played back in the pop-up file selection window. The data file has been described in the previous article, mainly including the waveform file with suffix of (.aed) or the parameter file with suffix of (.pra). For most detection cases, data processing results and analysis are based on acoustic emission characteristic parameters, so it is necessary to improve the performance of the system data replay speed and efficiency by selecting the parameter file for replaying.

2.2.7.1.1. Data Replay

- When playing a continuous data file which is automatically split into multiple files by the system, the automatic recognition sequence can be selected to play continuously;
- By default, "Replay Parameter" and "Replay Waveform" are selected, and the data replay type can be selected according to the needs. When the "Parameter" and "Waveform" are checked at the same time, the parameter files and waveform files will be replayed back at the same time;
- The replay speed (FPS) can be set, with a maximum of 100000;

Press the [Space] bar/key to replay the data step by step, and press the [Enter] key to continuously replay the waveform and parameters to the end. After the data replay, it will

automatically stop. If you need to pause or stop during the replay process, click the [Pause] or [Stop] button in the replay control bar.

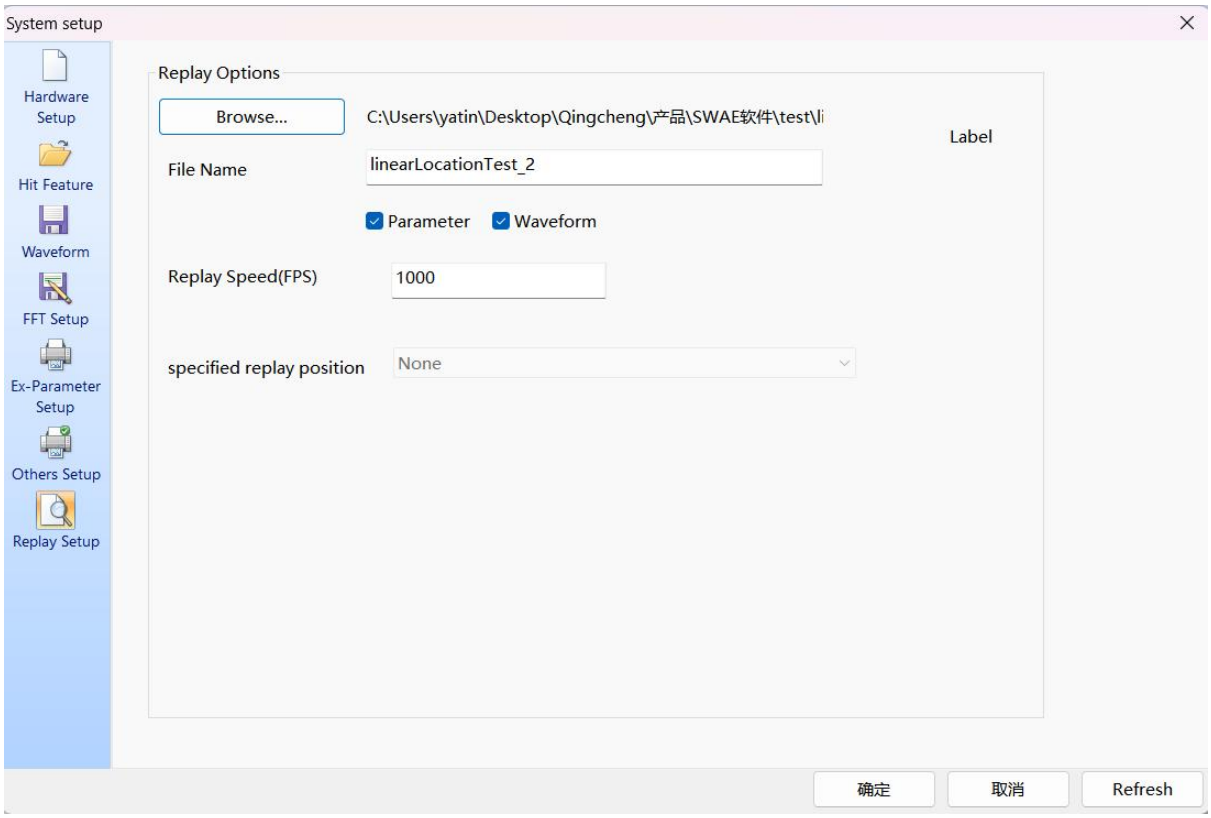


Fig. 2-93 Data Replay Settings

2.2.8. View Tools menu

Click **[View tool]** in the main menu to switch to the "View tools" page, which is divided into "Common" and special view tools such as "Data table", and "Waveform Graph".

Fig. 2-94 View tool Interface

View tools refer to some view operation tools that are commonly used and can be put into the shortcut toolbar as shortcut keys. They do not necessarily include all the tools. Some tools are

put into the right-click options of view according to usage habits. The right-click menu may not be used as a tool in the view, and it may be used as a tool in the view.

2.2.8.1. Common functions

The common view tools include "View Reset" and "Save Picture". The above two functions can be used in data acquisition phase and data replay phase.

View Reset: restore the original state of the view after zooming in, zooming out, dragging and rotating. Click the **[View Reset]** button to restore the selected view to the default initial state without changing the data content already displayed on the view;

Save Picture: the selected view will be copied to the clipboard in the form of pictures, so as to paste it into the edited document.

2.2.8.2. Function of parameter table

There are two tool buttons for special view tools for the “Data Table” view, **[Home]** and **[End]** buttons respectively. It is mainly used for the data table pointing to the beginning and end parts. For data in the middle stage of the table, you can use the function of "**Locate to**" a parameter on the right-click menu of the "Data table".

2.2.8.3. Function of Waveform

The waveform graph tool is only used to process the time domain waveform "Waveform Graph" in time domain. When the waveform view is selected, the following functions can be used by clicking the corresponding button:

- **Zoom in Y**: zoom in the Y axis by twice and display the vertical coordinates of waveform in the window, which is equivalent to the keyboard key "↑";
- **Zoom out Y**: zoom out in the Y axis by 0.5 time, which is equivalent to the keyboard key "↓";

- **Zoom In X**: stretch the X axis of the waveform in the window to both ends with the center as the reference point, and then the waveform information at both ends will not be displayed in the window;
- **Zoom out X**: compress the X axis of the waveform in the window to the center with the center as the reference point, and the waveform at both ends that cannot be observed in the current waveform graph will be recorded and displayed in the window;
- **Prior channel**: when there are many channels, a single view cannot display the waveform view of all channels. Click this button to switch to display the waveform data of the previous channel in the current view; it is equivalent to the mouse wheel scrolling up operation;
- **Next channel:** similar to the description of "previous channel", switch to display the waveform data of the next channel; it is equivalent to the mouse wheel scrolling down operation;

  The above function buttons can be used both in the data acquisition and data replay stages; the description of the function buttons below can only be used in the data replay phase.

- The **[Home Frame]** and **[End Frame]** functions can switch the waveform frame by clicking the corresponding button after the waveform data replay is finished. When [Pause] or [Stop] is executed during data replay, the [End frame] will be switched to the last frame of the waveform that has been replayed, and the data that has not been played back will not be pointed.

2.2.9. Analysis Menu

The functions in the “Analysis” menu are mainly used for the auxiliary analysis of data in the data replay stage. Click **[Analysis]** in the main menu, including the selection and operation of waveform data and data processing functions, and the setting of location and cluster analysis.

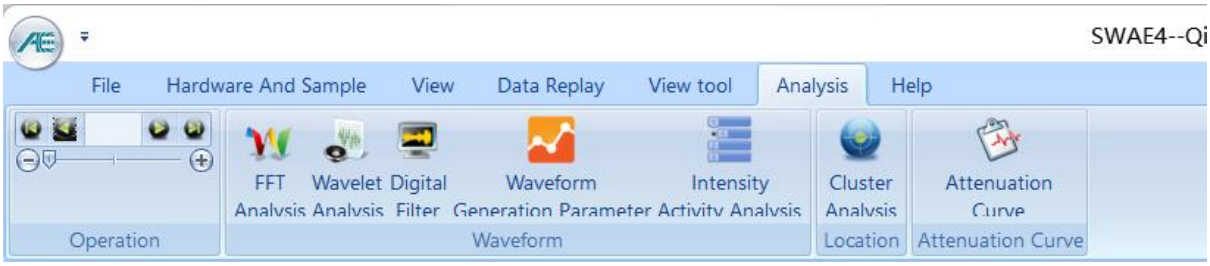


Fig. 2-95 Analysis menu interface

2.2.9.1. Operation

This function only takes effect in the waveform data replay stage. After the file is loaded, the waveform frame in the current waveform window can be switched by controlling the progress bar 

. The value in the middle represents the frame number in the whole waveform data file, and the slider position of the progress bar  indicates the approximate position of the data in the window in the whole waveform data file.

"  ", and "  ": after clicking, the current waveform frame can be switched to the "Prior frame" or "Next frame", which is equivalent to the "→" and "←" keys in the "Waveform View".

"  " and "  ": after clicking, the current waveform frame can be switched to the "Home frame" or "End frame", which is equivalent to the corresponding button in "View Tool" menu.

2.2.9.2. FFT Analysis

Convert the time domain waveform data into the corresponding frequency domain waveform according to the decimation rate ([Hardware and Sample] > [Sample Settings] > [FFT Setup]). Select [Analysis] > [FFT Analysis] or right-click menu on the "Waveform View" and select "FFT Analysis" to enter the interface. The upper window is "Time -domain waveform", and the lower window is the corresponding "FFT waveform". The dragging operations such as

zoom in and zoom out of waveform introduced in the waveform diagram are also applicable to this interface.

Right mouse button can modify the spectrum color; or export the spectrum graph data and save it as csv file. When setting the file name, the * must be removed, but the suffix must remain.

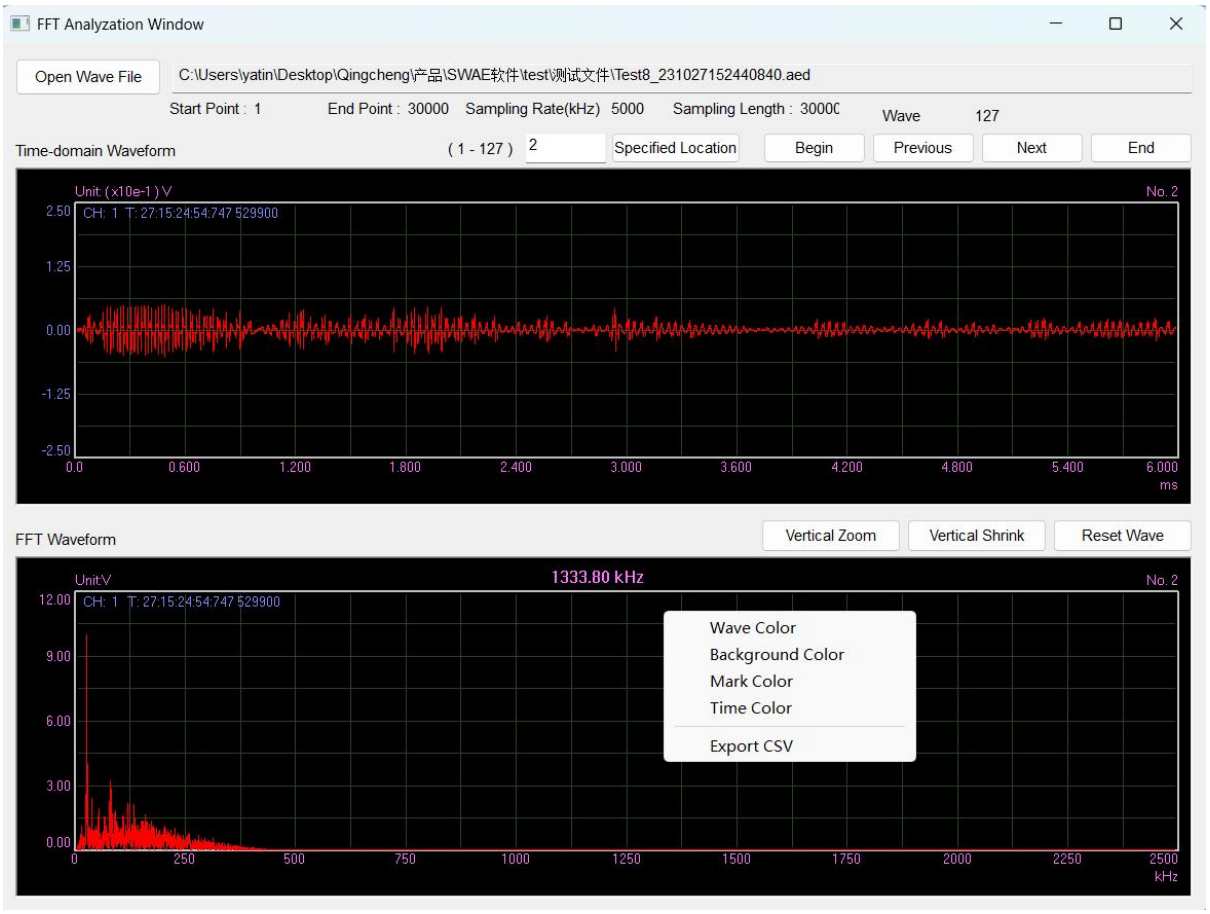


Fig. 2-96 Fast Fourier Transform

Open Wave File: select the waveform file with suffix (.aed) to be processed in the pop-up box; at this time, information related to data will be displayed below the file name, such as start point, end point, sampling length, sampling rate, waveform counts, etc. The values of “start point” and “end point “are related to the start and end points of the data contained in the "Time -domain waveform" below.

Specified location: input the corresponding frame number of the waveform in the box, and then click to display the corresponding frame in the "Time -domain waveform" graph;

Begin /End: refer to the first and last frame of the waveform;

Previous / Next: click to switch the current waveform frame to the "Prior frame" or "Next frame", which is equivalent to the "→" and "←" keys in the "Waveform View".

Vertical zoom in / Vertical Shrink: it is only effective for "FFT" view. Vertically zoom in and out of the FFT waveform, which is equivalent to the "↑" and "↓" keys in the "Waveform View";

Reset: Reset to the original waveform state after clicking;

View Mouse Operations: The mouse wheel allows you to switch channels. The operations described in the waveform area, such as zooming in and out, also apply to this screen.

2.2.9.3. Wavelet Analysis

Fig. 2-97 Setting interface of Wavelet Analysis interface

The Time-domain waveform data are processed in different frequency layers and displayed in the form of several same time domain but different frequency waveform. Click on "**Analysis**" menu or right click on the "**Waveform Graph**" view, and select the **[Wavelet Analysis]**

option to enter the interface. The first graph on the top is the original time-domain waveform, and the lower graphs are the corresponding waveform that has been "wavelet transformed". The wavelets are extracted by 1/2 frequency band.

Click the right mouse button on the graph to "**export the waveform data on the current graph**" and save it as a csv file. When setting the file name, the * must be removed, but the suffix must remain.

Open Wave File: after clicking, select the waveform file with suffix of (.aed) in the pop-up box; at this time, the information related to data will be displayed under the file name, such as data length, start point, end point, sampling rate and the wavelet settings.

Select Wavelet: select the rule of stripping from the drop-down menu, for example stripping one layer every 3dB;

- **dB**: Daubechies wavelet basis, one of the most commonly used wavelet bases, with compact support and good frequency localization. Common Daubechies wavelet bases include db2, db4, and db6.
- **sym**: Symlets wavelet basis, a symmetric Daubechies wavelet basis with similar frequency localization and phase symmetry. Common Symlets wavelet bases include sym2, sym4, and sym8.
- **coif**: Coiflets wavelet basis, with compact support and good frequency localization, offers better performance than Daubechies wavelet bases in some applications. Common Coiflets wavelet bases include coif1, coif2, and coif3.
- **bior**: Biorthogonal wavelet basis, a set of paired wavelet basis functions with variable support length and frequency response. Common Biorthogonal wavelet bases include bior2.2, bior3.3, and bior6.8.
- **rbio**: A type of biorthogonal wavelet, one of the commonly used wavelet basis functions in wavelet transforms, featuring compact support, symmetry, and linear phase.
- **dmey**: The Dmeyer wavelet, also known as the discrete Meyer wavelet, is an FIR-based approximation of the Meyer wavelet and is used for fast discrete wavelet transforms.

Level: the number of layers to be peeled off by wavelet transform, which generally needs to combine the original waveform sampling rate and the expected frequency setting of the lowest signal;

Fundamental frequency of sampling rate: lowest frequency;

Frequency division factor: the frequency of a single frequency signal is reduced to the original 1/N, called N frequency division;

Transform: After modifying the fundamental frequency and frequency division coefficients of wavelet selection, grade and sampling rate, click "transform" to apply;

Start/ End Points: directly point to the first and last frame of the waveform;

Previous / Next frame: click to switch the current waveform frame to the "Prior frame" or "Next frame", which is equivalent to the "→" and "←" keys in the "Waveform View".

Specified position: input the corresponding frame of waveform directly in the front window, and the corresponding wave frame will be directly displayed in the "time domain waveform" diagram after clicking;

View Mouse operations: The mouse wheel allows you to switch channels. The operations described in the waveform area, such as zooming in and out, also apply to this screen.

2.2.9.4. Digital Filter

By setting the digital filter type and frequency band range, and then performing a secondary filtering on the time domain waveform data. Click on "**Analysis**" menu or right click on the "**Waveform Graph**" view, and select the **[Digital Filter]** option to enter the interface. The upper left corner of the view is the "original (Ori) wave" diagram and the filtered waveform will be displayed in the lower left corner.

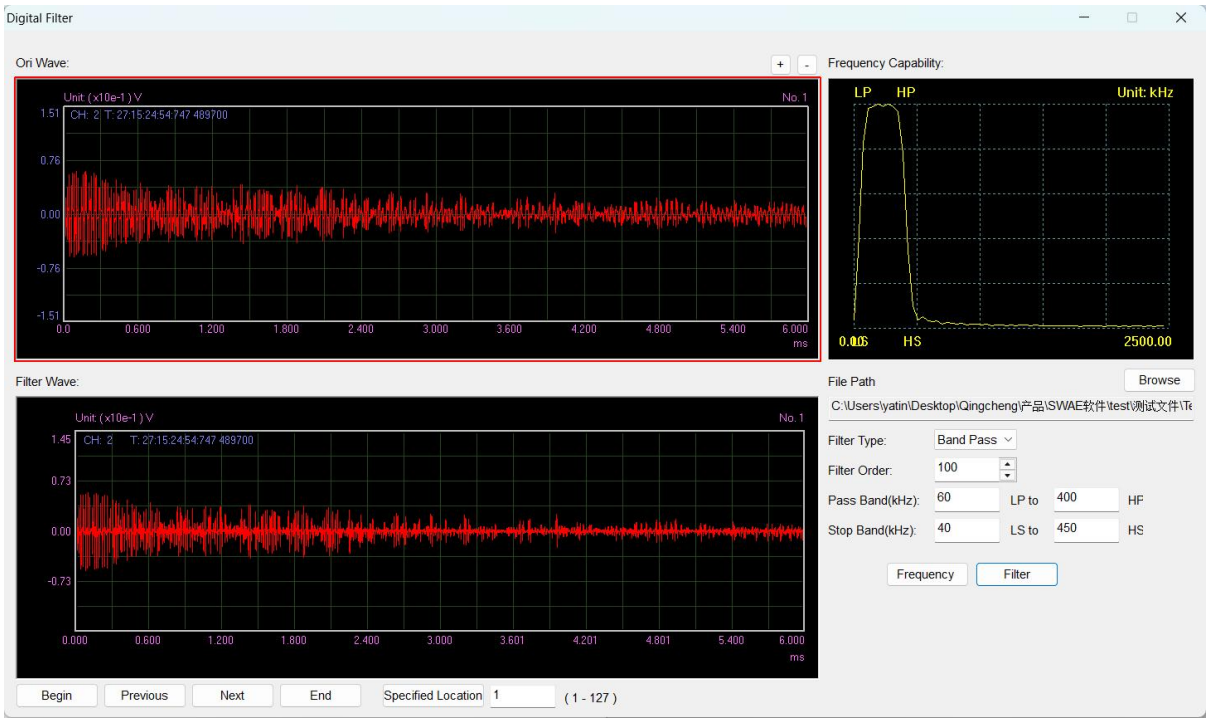


Fig. 2-98 Digital Filter Setting interface

Browse: after clicking, select the waveform data file with the suffix of (.aed) to be processed in the pop-up box. The selected waveform will be displayed in the upper left window as the “Ori Wave”.

Filter type: select the filter type from the drop-down menu, including band pass, band stop, low pass and high pass filters.

Pass band: the upper and lower limits of the signal band allowed to pass, LP corresponding to the lower limit of the pass band, HP corresponding to the upper limit of the pass band;

Stop band: the upper and lower limits of the signal band to be blocked, LS corresponding to the lower stop band limit, HS corresponding to the upper stop band limit;

When the filtering performance is not clear, click the "**Frequency**" button and the “**Frequency Capability**” in the upper right corner can display the filter diagram based on the filled information.

After the filter is setup, click the **“Filter”** button to take affect. The waveform after filtering

will be displayed in the lower left corner window as the “Filter Wave”.

+/-: above the “Ori Wave” frame, the “+/-” buttons are to vertically zoom in or out the current graph, which is equivalent to the ↑ or ↓ key of the keyboard;

Begin / End: direct to the first and last frame of the waveform;

Previous / Next: click to switch the current waveform frame to the "Prior frame" or "Next frame", which is equivalent to the “→” and “←” keys in the "Waveform View".

Specified location: input the corresponding value of waveform frame directly in the front window, and click to display the corresponding frame in the "original waveform" graph.

2.2.9.5. Waveform Generation Parameter

The waveform to parameter function can convert the AE waveform file (.aed) into a new AE parameter file (.pra).

Click **[Analysis] > [Waveform Generation Parameter] > [Open File]** button, to select the waveform file to be converted (multiple files collected in the same batch can be converted at the same time).

After the selected file is opened, the software automatically names the newly to-be generated parameter file (.pra) in the “**Save To**” path, which is consistent with the waveform file name.

The initial conversion settings is the current system setting. You can adjust the parameter threshold, HDT, HLT, PDT and EET.

You can select the time range to select the time period to be converted. The waveform frame range and channel number can be selected. Check "**Report Conversion Information**” to show the conversion information after the waveform conversion is completed. You can check “**Replay Param File**” to automatically replay the generated parameter data in the view after conversion.

By default, the generated parameter file has the same name as the waveform file. If there is a

parameter file with the same name already existing, the software uses another name to store the new parameter file. The "Replay Param File" option only replay the parameters, not the waveform.

If there is no converted parameters, the size of the converted parameter file is set to 128KB.

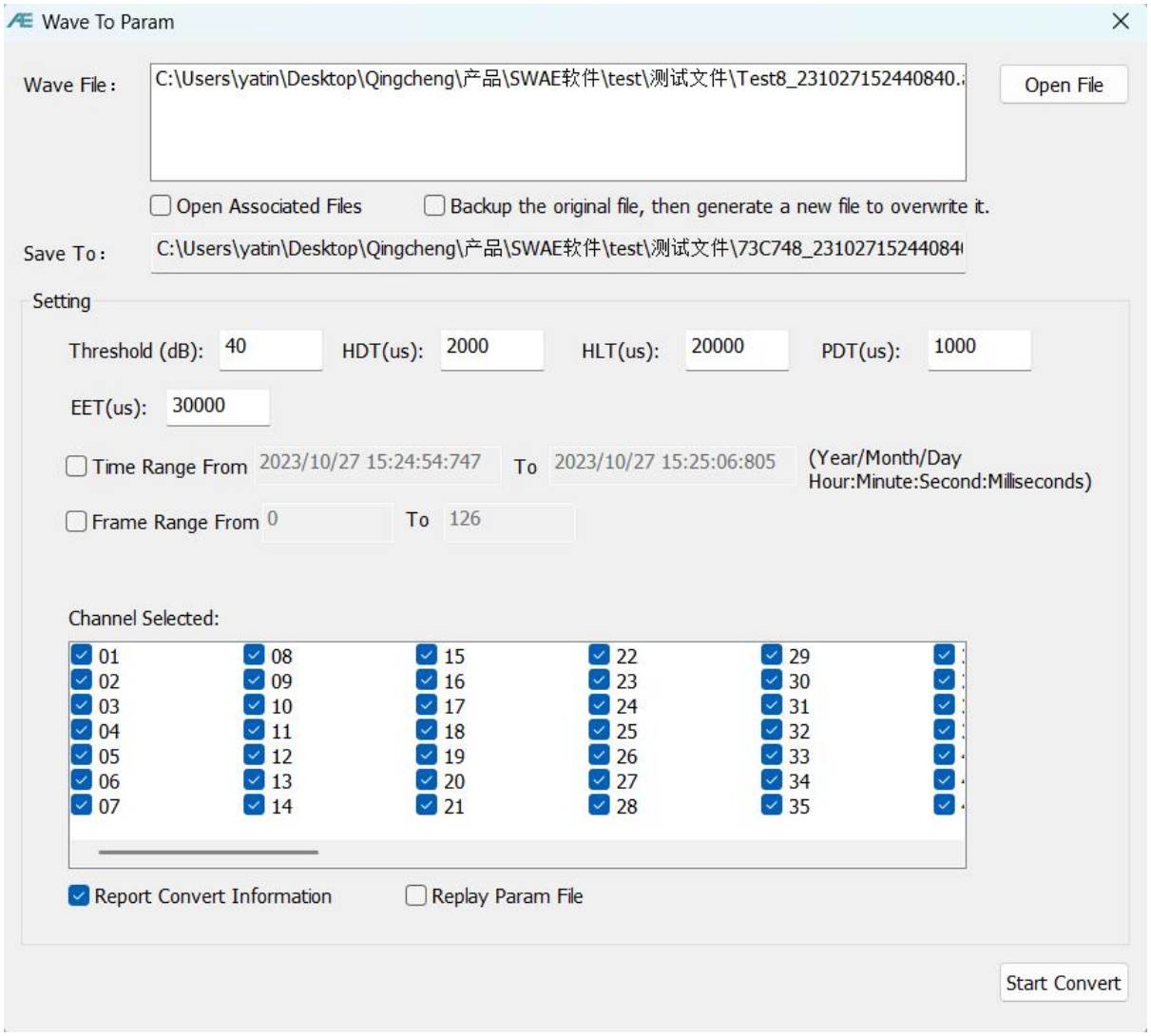


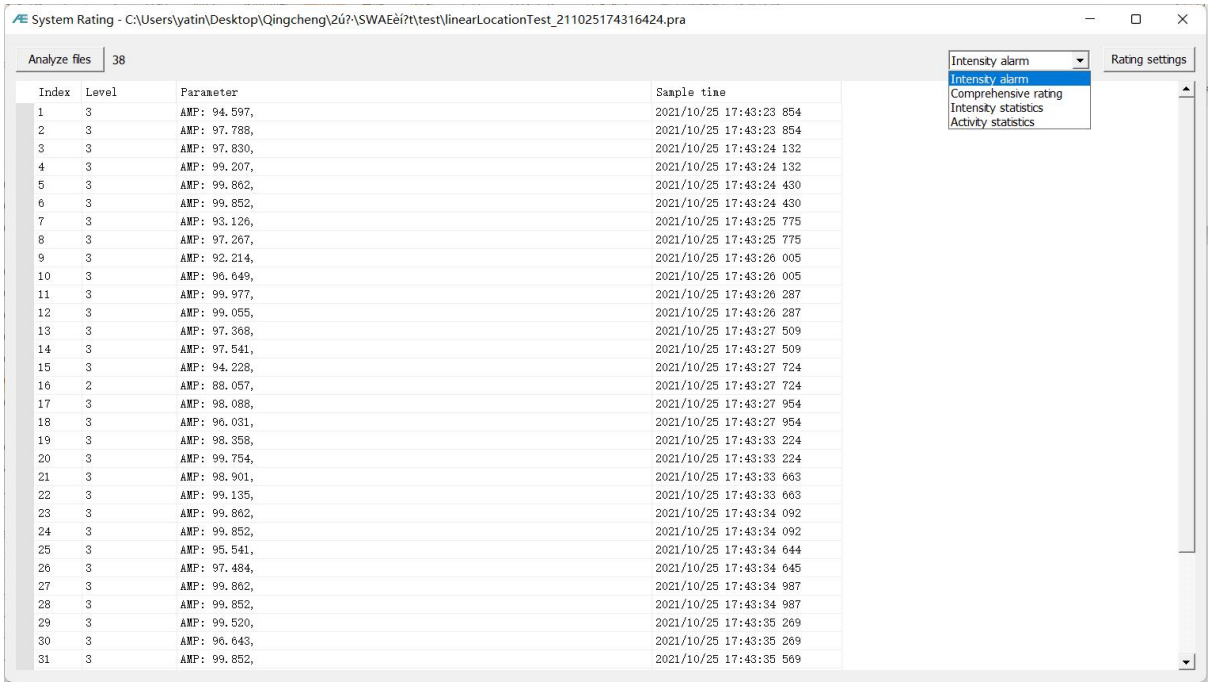
Fig. 2-99 Waveform parameters page

2.2.9.6. Intensity Activity Analysis

Intensity activity analysis refers to that the user sets some rating rules according to the requirements, and carries out intensity rating, activity rating and comprehensive rating analysis based on the collected parameter data.

The AE parameter file (.pra file) generated by the software can be rated and analyzed.

In the "Analysis", select the "Intensity Activity Analysis" option to enter the rating screen.



Index	Level	Parameter	Sample time
1	3	AMP: 94.597,	2021/10/25 17:43:23 854
2	3	AMP: 97.788,	2021/10/25 17:43:23 854
3	3	AMP: 97.830,	2021/10/25 17:43:24 132
4	3	AMP: 99.207,	2021/10/25 17:43:24 132
5	3	AMP: 99.862,	2021/10/25 17:43:24 430
6	3	AMP: 99.852,	2021/10/25 17:43:24 430
7	3	AMP: 93.126,	2021/10/25 17:43:25 775
8	3	AMP: 97.267,	2021/10/25 17:43:25 775
9	3	AMP: 92.214,	2021/10/25 17:43:26 005
10	3	AMP: 96.649,	2021/10/25 17:43:26 005
11	3	AMP: 99.977,	2021/10/25 17:43:26 287
12	3	AMP: 99.055,	2021/10/25 17:43:26 287
13	3	AMP: 97.368,	2021/10/25 17:43:27 509
14	3	AMP: 97.541,	2021/10/25 17:43:27 509
15	3	AMP: 94.228,	2021/10/25 17:43:27 724
16	2	AMP: 88.057,	2021/10/25 17:43:27 724
17	3	AMP: 98.088,	2021/10/25 17:43:27 954
18	3	AMP: 96.031,	2021/10/25 17:43:27 954
19	3	AMP: 98.358,	2021/10/25 17:43:33 224
20	3	AMP: 99.754,	2021/10/25 17:43:33 224
21	3	AMP: 98.901,	2021/10/25 17:43:33 663
22	3	AMP: 99.135,	2021/10/25 17:43:33 663
23	3	AMP: 99.862,	2021/10/25 17:43:34 092
24	3	AMP: 99.852,	2021/10/25 17:43:34 092
25	3	AMP: 95.541,	2021/10/25 17:43:34 644
26	3	AMP: 97.484,	2021/10/25 17:43:34 645
27	3	AMP: 99.862,	2021/10/25 17:43:34 987
28	3	AMP: 99.852,	2021/10/25 17:43:34 987
29	3	AMP: 99.520,	2021/10/25 17:43:35 269
30	3	AMP: 96.643,	2021/10/25 17:43:35 269
31	3	AMP: 99.852,	2021/10/25 17:43:35 569

Fig. 2-100 Default system rating page

Analyze files: Click **[Analyze files]** and select the parameter file (suffix.pra) that you want to analyze in the displayed file selection box.

Intensity alarm/ Comprehensive rating/ Intensity statistics/ Activity statistics: these are the Intensity activity analysis modes. You can click the list box to switch modes (the initial mode is "Intensity alarm"). For details about the mode, please refer to Chapter “2.2.6.2.10.2. Analytical Modes”.

Rating settings: After clicking [Rating Setting], you can set the intensity and activity rating rules in the pop-up rating setting interface. For details about the setting rules, see Chapter “2.2.6.2.10.3. Rating Setting”.

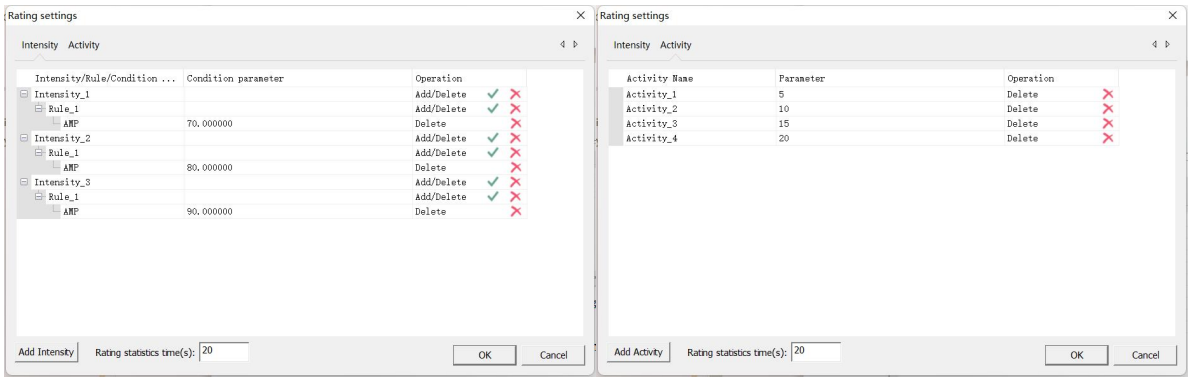


Fig. 2-101 Intensity/activity setting screen

2.2.9.7. Cluster Analysis (Location Concentrated Area)

This setting is mainly used to set the "radius" value of the circle which is used to circle out the location concentration area in the Location Graph, which can be enabled by right-click and select "View Param" on the location views. The circle is used in the location view. When "View Param" is selected, a red circle shows up in the location view and it moves along with the mouse. Left click to put down the red circle to circle out where the points are concentrated. Then the related parameters of these circled points will be filtered and displayed in the "Data Table". Modify the circle radius by pressing the "Cluster Analysis".

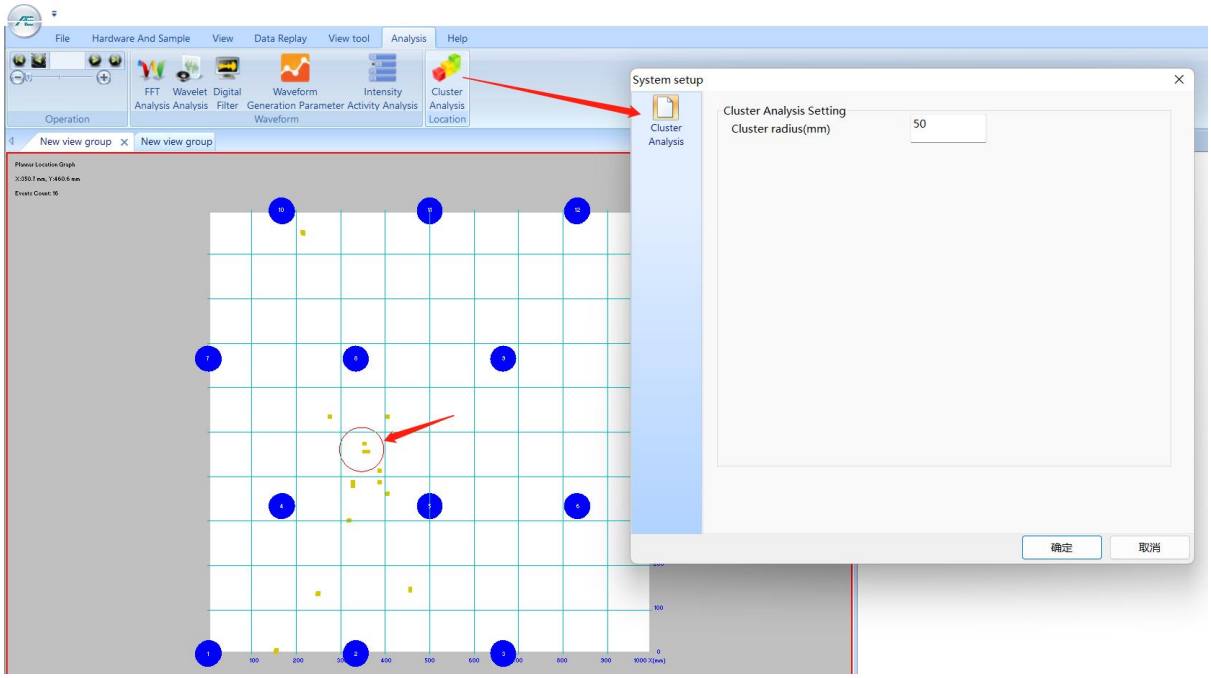


Fig. 2-102 Setting interface of Cluster analysis

2.2.9.8. Attenuation Curve

Attenuation testing has two primary purposes in acoustic emission testing: first, ensuring that the sensor array receives the expected acoustic emission signal; second, estimating the raw acoustic emission signal strength. The spacing in typical sensor placement plans is based on empirical values, and following this rule can generally capture and collect acoustic emission signals. When testing unknown materials and structures, this step should be performed before finalizing the sensor placement plan. The attenuation characteristics can be used to determine the sensor placement and quantity.

Click **[Analysis]** → **[Attenuation Curve]** to open the attenuation curve settings page.

Fig. 2-103 Attenuation curve function button

Enter the measured **[Distance]** value and the signal **[Amplitude]** detected by the sensors after transmitting a signal using an analog source at that distance, then click **[Add]**.

For example: Fix Sensor #2 and input signals at 0.5m, 1m, and 1.5m away from it, with input signals of 85dB, 70dB, and 55dB respectively. Click **[Add]** to see the attenuation curve of Sensor 2.

To modify or delete the points in the curve, first click on the row of the data, the filled values are displayed in the input boxes again. Modify the values in the input boxes and click **[Modify]** button. To delete, just click **[Delete]** button.

[Close and Save] is to save the entered data and curve and close the window.

[Cancel] will close the window without saving the new data.

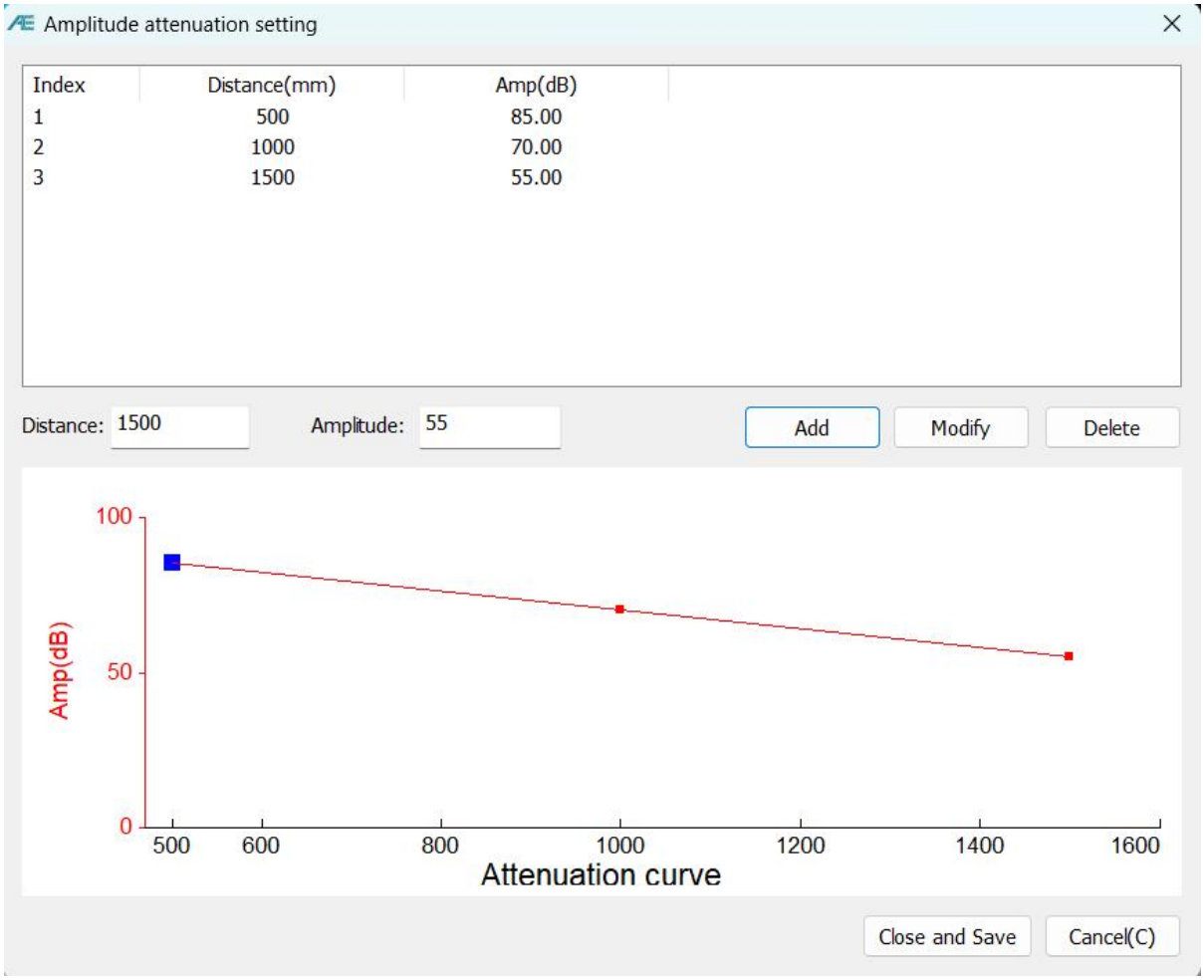


Fig. 2-104 Attenuation curve window

2.2.10. Help Menu

Click the **[Help]** button in the main menu. There are “U3H to RAEM1”, “Language” and "About" option will appear on the page.

Fig. 2-105 Help page

[U3H => RAEM1] is to convert the current supporting instrument. It is the same effect as clicking on the logo on the upper left corner of the software. “U3H” means the current

connecting instrument is SAEU3H multi-channel AE system. “RAEM1” means the RAEM1 single channel AE monitoring system and also RAEM1-6 multi-channel monitoring system. The difference of the two modes is mainly the hardware setting menu. If clicking “Yes” means to change to the other instrument mode. Then the software will restart to take affect.

Click **[Language]** to switch between Chinese and English. After you select a language, you need to manually restart the software.

Click the **[About]** button to view the version number of the current software and the firmware version number of the acquisition board in the pop-up window, as shown in the following figure:

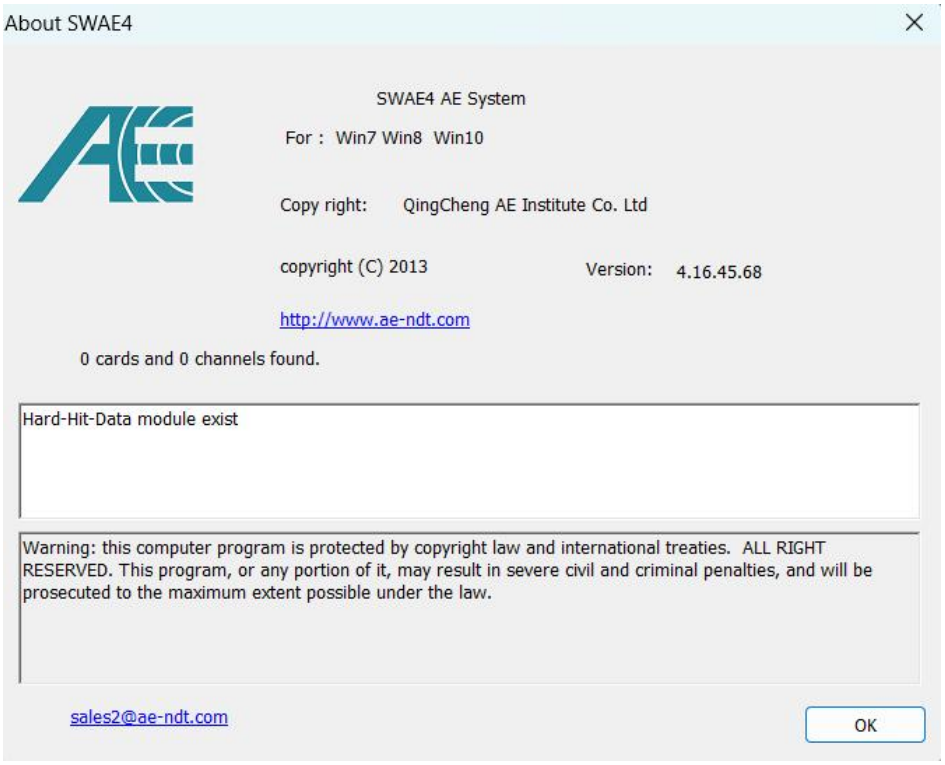


Fig. 2-106 Software / Hardware version information

2.3. View Display Area

Multiple "View groups" can be set in the view display area, and each view group can contain multiple views and types. By setting different grouping forms, data can be viewed more

effectively and intuitively

View group title bar: you can choose to view different view groups. Each view group contains multiple custom view group names;

View area: display data table, location graph, waveform graph, correlation graph, etc. You can arbitrarily drag the border between adjacent views to adjust the scale, and split and merge each view position.

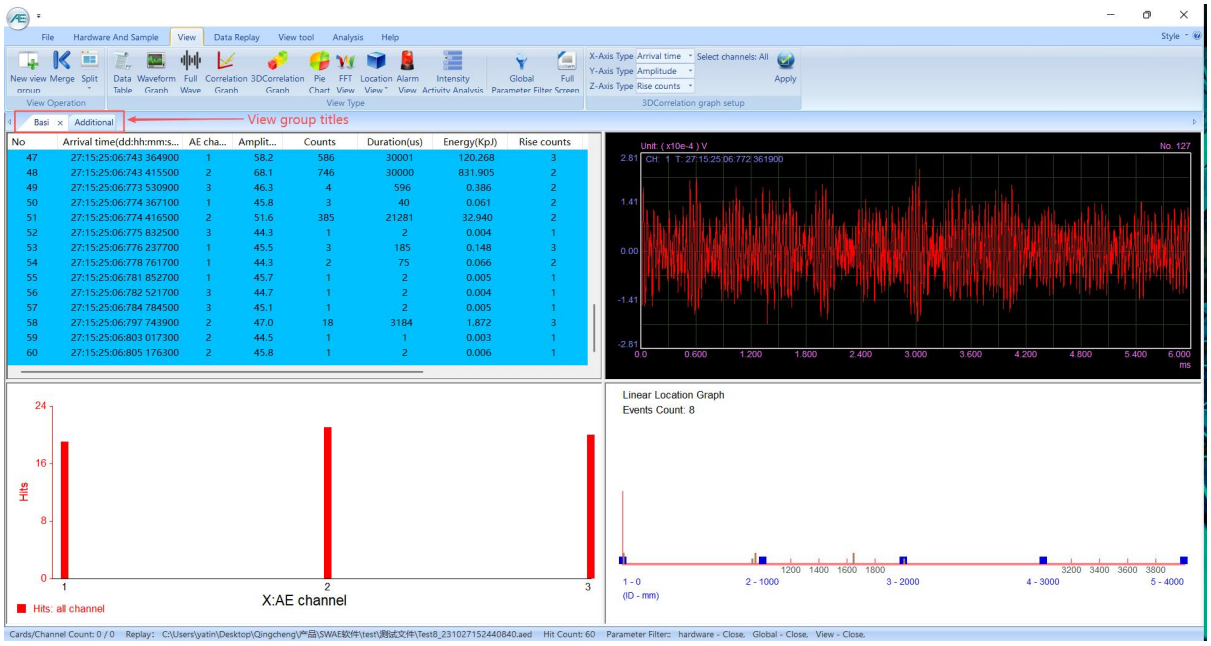


Fig. 2-107 View display area

2.4. Status Statistics Area

The statistical area can display the statistical information in the process of data acquisition or replay. Users can customize the information items displayed in the alternative types by directly checking the corresponding item name. The optional items include total number of collisions, total number of channels, acquisition / replay status, data file name, parameter filter, etc.

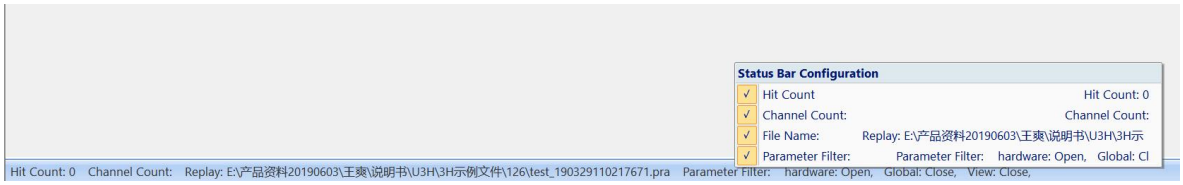


Fig. 2-108 Status statistics column and setting interface

Hit count: the parameter lines that have been recorded or displayed during data acquisition or replay are equal to the parameter lines in the Data table;

Channel Count: the number of channels used in the data acquisition process, or the number of channels receiving data during data replay;

Sample / Replay: data source, when "Sample" is displayed in the acquisition process, and "Replay" is displayed in the data replay process; the next adjacent information is the path and file name of the data;

Parameter filter: It includes hardware filter, global filter and view filter, which correspond to "Hardware", "Global" and "view" respectively. The States after "Hardware" and "Global" are unchanged in the same data sample or data replay back stage. The "view" takes effect for the selected view. If the filter states set for each view are different, the state will be "off" when switching views and "on" transformation.

Part 2 Quick Use Guide

3. Testing Cases of Acoustic Emission

The following quick use guide is for users who want do a quick AE test to obtain some acoustic emission data, not for specific AE instruments. Take the pressure vessel test in the special equipment industry as the example, and explain the acoustic emission testing or experimental process. The laboratory test can refer to this part and adjust it according to the actual situation.

3.1. General Steps of Acoustic Emission Testing /Experiment

1) **Preparation before testing:** understand the site situation, equipment operation processes and the testing conditions;
2) **Determination scheme:** location modes, sensor array layout positions, detection processes, etc.;
3) **Equipment hardware connection**: sensor installation, equipment connections, etc.;
4) **Software debugging**: determine the view type and data sample rules;
5) **Threshold determination:** the acquisition threshold is determined by testing the background noise level;
6) **Sensitivity test:** ensure the consistency of sensitivity of all sensors or meet the test standard as far as possible;
7) **Attenuation test:** after the sensor scheme is determined, the attenuation test is to verify the minimum signal can be received;
8) **Sound velocity test**: it is needed when the time difference of arrival (TDOA) locating algorithm is used. If there is no the regional location or no location requirements, it can be ignored;
9) **Location calibration test:** it is needed when the time difference of arrival (TDOA) locating algorithm is used. If there is no the regional location or no location requirements, it can be ignored;

10) **Data acquisition:** according to the proposed scheme, data acquisition can be done at each stage or experimental phases;
11) **Secondary sensitivity test:** the post sensitivity test is to determine the validity of the data especially after the long-term detection, or when the test environment is unstable or tough;
12) **Location reverse calibration test**: for large component detection, the simulation source test is carried out in the location concentration area;
13) **Data processing:** issue the experiment report or test report with the data analysis.

3.2. Example of Testing Procedure

3.2.1. Preparation Before Testing

Before the acoustic emission detection or test, it is necessary to understand and check the object to be tested. According to the size, structure, material and working conditions of the tested object, the approximate test processes of acoustic emission detection is determined. It is very important to acquire and obtain effective AE data.

3.2.1.1. Review of The Inspected Containers

1) Review the qualification certificate, quality certificate and as built drawing of the tested object to obtain the basic parameters, such as equipment diameter, height, wall thickness, material, internal structure, design pressure and working pressure, as well as the location of suspected defects in delivery acceptance;
2) Operation data review to obtain operation information, such as actual working pressure and working medium of equipment.

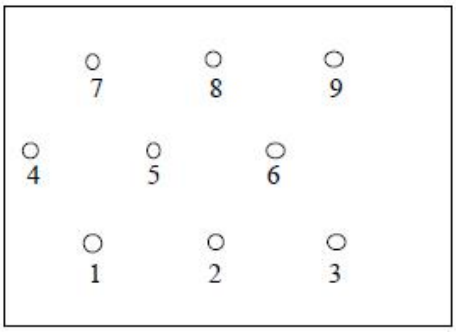
3.2.1.2. Scheme Determination

1) **Sensor layout scheme**: the number of channels and sensors of the AE instrument is

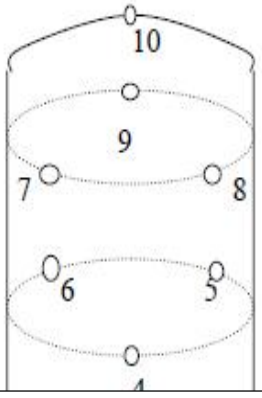
determined by the external diameter and height of the measured object (*when the attenuation curve and the sensor spacing of the similar material and structure is known*). Generally, the distance between the crack signal of metal special equipment and the sensor array is not more than 5 meters, and the location diagrams of different containers can refer to Fig. 3-1. For the tested object in the laboratory, it can be determined according to the structure, or material or the research direction of the tested object, for example using 2 sensors for the tensile strength test and using 2 or 8 sensors for rock mechanic tests.

2) **Determination of test process:** for example, the pressure and pressure rate of acoustic emission test are determined according to the working pressure of the vessel. For laboratory use, it can be the factors such as speed, temperature, load, etc.

3) Determine the approximate time of acoustic emission testing and the auxiliary conditions to be provided by the tested party. Select relatively no external interference environment for acoustic emission detection or test if possible. When the third party is required to complete, the scheme negotiation shall be conducted as early as possible.



Sensor layout of plate structure



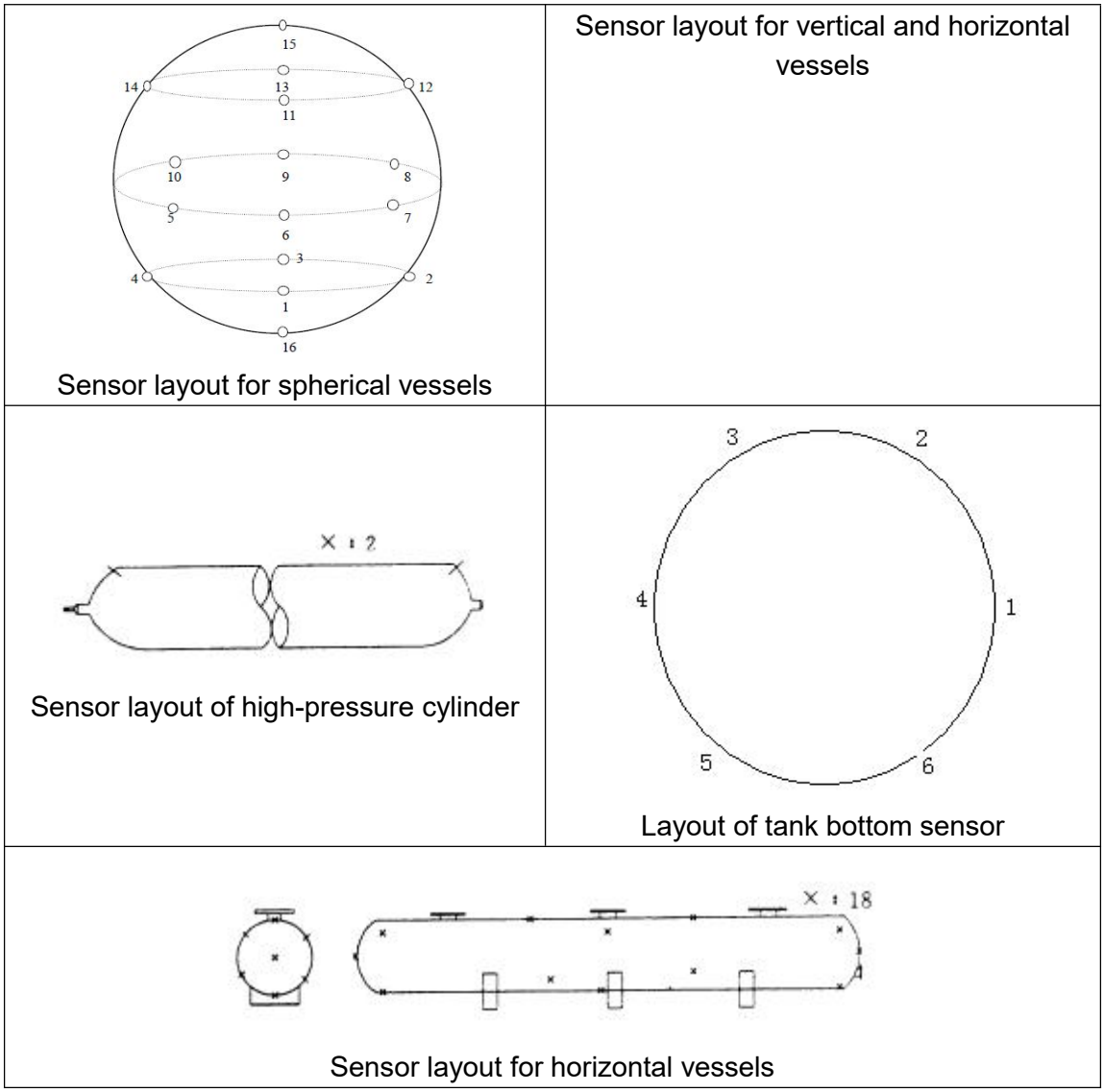


Fig. 3-1 Sensor Layout of Pressure Vessels

3.2.1.3. On Site Confirmation

1) Make sure the load requirements and auxiliary conditions to be provided for acoustic emission testing with the tested party, such as the provision of power supply, scaffolding for sensor placement or provision of crown block required for the placement of sensors.

2) Make sure the AE Host placement and sensor installation position; under the premise of ensuring the safety of the AE host position, the operator should observe the computer display and the measured object at the same time; when the existing conditions don't allow directly installing the sensors, it is necessary to consider the way of thermal insulation breaking or waveguide rods.

3) Propose the fixing method of preamplifier and coaxial cable, and estimate roughly the length of coaxial cable to the AE Host.

3.2.1.4. Instrument Preparation

1) Prepare and test the acoustic emission system and its accessories to ensure the normal operation of the whole system.

2) Prepare the safety facilities according to the safety requirements of the testing site.

3) Prepare on-site grinding tools and fixing materials, such as scraper, sandpaper, tape, etc.

3.2.2. On Site Installation

3.2.2.1. Placement of Instruments

1) Select the appropriate time for the AE detection, such as no rain, snow, breeze, and no cross-operation period.

2) Place the instruments to the allowed positions on site. Keep a safe distance between the pressure vessel and the tested vessel. Place the instruments outside the firewall for the container containing flammable and explosive media.

3) The power supply is placed near the instrument, and the ground wire of the safety protection device should be installed if possible. Ensure the continuous and stable power supply of the power supply during the acoustic emission test.

3.2.2.2. System Connection

1) **Determine the installation positions of the sensors**: select the reference starting point and determine the sensor installation position. It is recommended to mark the

corresponding sensor number near the position point, and record the reference point positions.

2) **Surface preparation of sensor installation positions**: sand the installation area to remove the thermal insulation layer, anti-corrosion coating and protective paint, and to expose the metal luster;

3) **Connect the signal cable** to the sensor, and pay attention to the interface connection tightness;

4) **Coating some coupling agent** on the receiving surface of the sensor or the sanded area. And couple the sensor to the surface of the container;

5) **Fix the sensor** with a magnetic holder or using some adhesive tapes. The method is flexible as long as it can hold the sensor tightly and well-coupled to the surface;

6) The output end of the signal line is connected with the input port of preamplifier if the sensor is not integrated with preamp. When using the PAS preamplifier, it is necessary to pay attention to the switch position of the inputs (single or differential). The cable length between the sensor and the preamp is recommended to be within 2 meters.

7) Select the appropriate length of the coaxial cable and connect it the output of the preamplifier;

8) Referring to the number marked next to the sensor installation position, connect the other end of the coaxial cable to the corresponding channel number on the acoustic emission instrument front panel;

9) Check the channel connection between the sensor position number and the channel number on the instrument one by one to make sure the channel number is not mixed up;

10) Connect the acoustic emission host instrument with the computer through the connection cable (depending on the available communication methods).

11) Open the SWAE software.

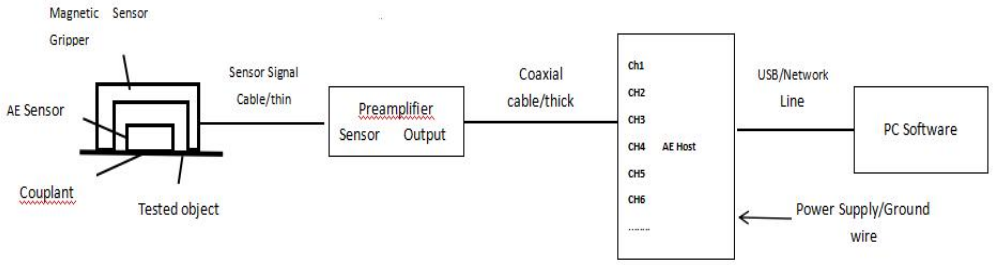


Fig. 3-2 Connection Diagram of Split Sensor

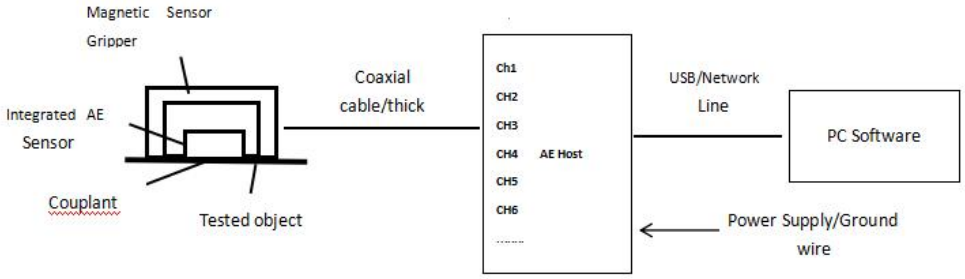


Fig. 3-3 Connection Diagram of Integrated Sensor

3.2.3. Basic Software Settings

The software setting part includes "View setup" and "Sample setting". The view setting is mainly to establish the corresponding views to display the AE data, and the sample setting is mainly to set up the hardware parameters and sample rules.

3.2.3.1. Software Startup

Double click the **[SWAE]**  icon on the desktop with the left mouse button to open the software. The default views appeared when the software opens are the Data Table and the waveform views. In order to facilitate the subsequent setting operations, click on any view, and then click the **[View]** and then **[Merge]** buttons in the menu bar, so that the view area will be restored to one gray area.

Note: the current supporting device of the software must correspond to the connected acoustic emission device; the same applies to the [Data Replay], [Analysis] and other operations. You can click the "AE" icon in the upper left corner to view the current supported

devices. To change device, click the "AE" icon in the upper left corner, then click the "Yes" button in the popup window, and wait for the software to restart.

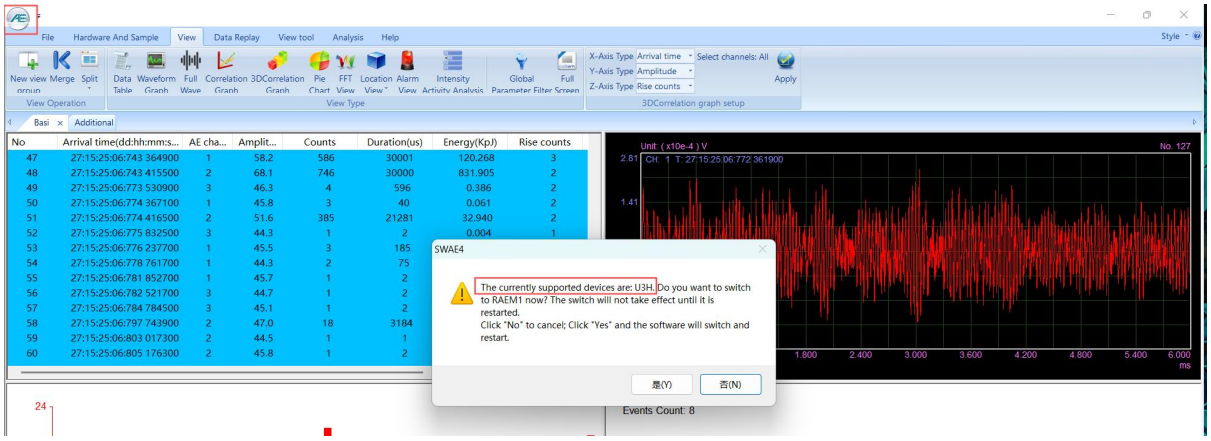


Fig. 3-4 Initial interface of SWAE software and the supported device window

3.2.3.2. View Settings

General inspections or tests need to establish four types of views, including "Waveform", "Data Table", "Correlation Graph" and "Location Graph". Users can select the types and quantity of views according to actual needs. The latter three types are the most common in industrial detection applications, and the first three types are mostly in laboratory purposes.

3.2.3.2.1. View Segmentation

Select a new view group in the graphic display area (select the frame to turn red). Click **[Split]**, and move the mouse to select the view array (such as 2 rows and 2 columns) according to the demand, as shown in the figure. Click the mouse again to complete the view group segmentation and generate multiple view windows. In the same way, any view can be divided for more than once.

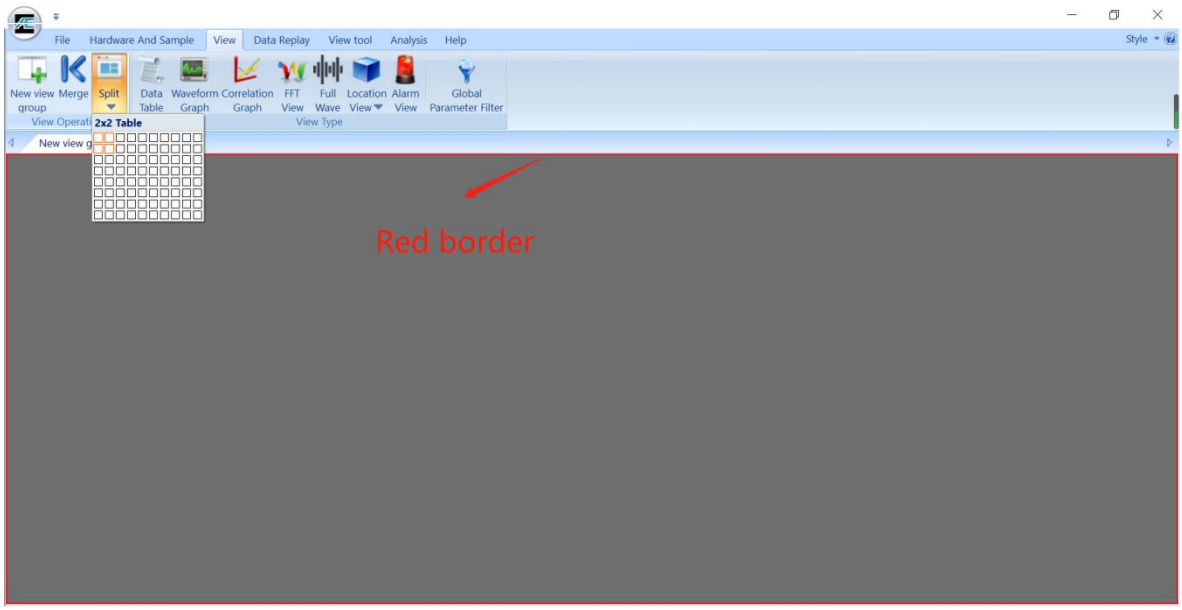


Fig. 3-5 View Splitting

3.2.3.2.2. Establishment of Waveform Graph

Select the first blank view in the upper left corner with the mouse, and click [Waveform graph] in the "View type" under the "View menu" to complete the addition of waveform view. The number of channels displayed in the view window can be selected through “Waveform setup” section next to the “View Type”.

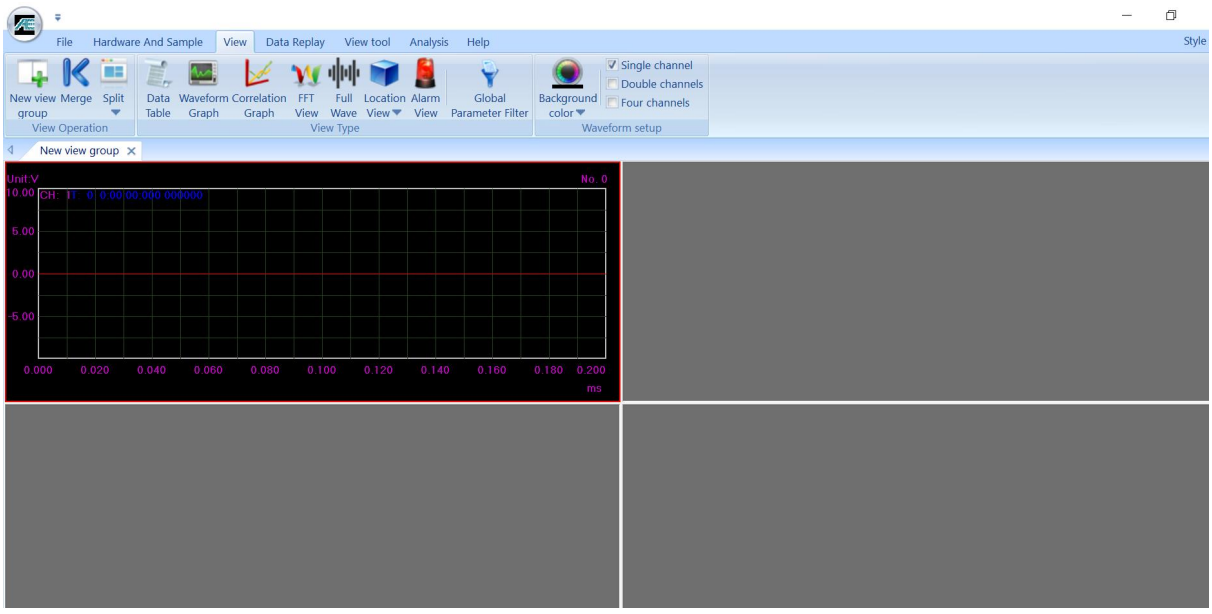


Fig. 3-6 Waveform Graph

3.2.3.2.3. Data Table Setup

Select the blank view in the upper right corner, and of select **[Data Table]** to finish adding the “Data Table View”. If the default AE parameter types cannot meet the actual needs, click **[More data]** to enter the parameter selection interface. After checking the required parameter name, click **[OK]**.

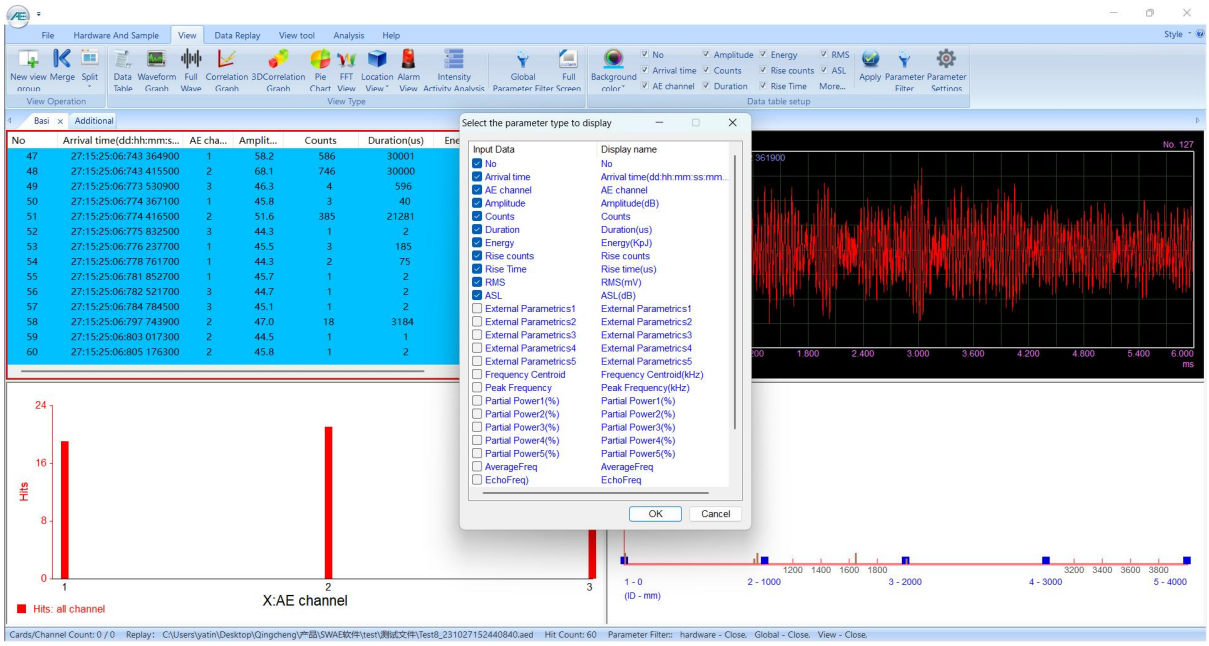


Fig. 3-7 Data table view and parameter selection

3.2.3.2.4. Correlation Graph Setup

Select the blank view in the lower left corner, click “View”, the choose **[Correlation Graph]** to complete the addition of correlation graph view. The default "Hits- AE channel" scatter diagram is a common correlation chart, which can directly observe the data received by each channel. When it is necessary to change or add multi- coordinate statistics, please refer to Chapter 2.2.6.2.3.2 “Modification of Correlation Graph”.

3.2.3.2.5. Location View Setup

1) Default Location View setup

Select the blank view in the bottom right corner, and click **[Location View]**, and a list of “the

location graph" type appears. In the industrial inspection, cylinder containers are the majority of pressure vessels. Take a cylinder location graph as an example. In the pop-up location Graph type, select **[Cylinder Location Graph]** to add the default cylinder Location view.

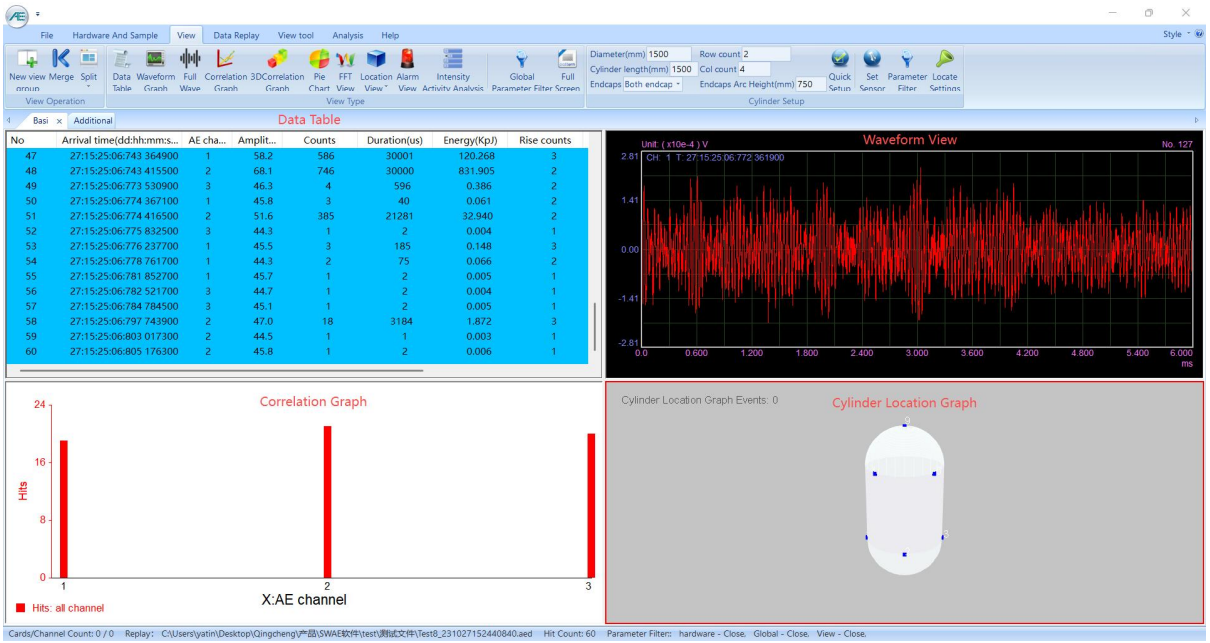


Fig. 3-8 Four Types of View Interface

2) Basic Info Modification

First, select the location graph, and modify the relevant data directly on the right side of the secondary menu of the "View" menu. For example, the diameter of the cylinder is 1500mm, the cylinder length is 1500mm. If the heads/domes/"endcaps" (in the software) of the pressure vessels are for detection as well, the "Endcaps" should be selected for "Both endcaps" . The default sensor array in the software are for 2 rows and 4 columns, excluding the sensors on the heads. Fill in the information based on the actual situation and click **[Quick Setup]** button to take affect.

- **Diameter:** it is the outer diameter of the cylinder part, unit of mm;
- **Cylinder length(mm):** generally, refers to the height/ length of the cylindrical section without the end caps (cylinder heads);
- **Endcaps:** the "endcaps" here refer to the cylinder headers, on the top or bottom parts of the cylinder block, including "no endcaps", "only top endcaps", "only bottom endcaps" and "both endcaps";

- **Row count:** refers to the number of circles (rows) of sensors arranged along the cylinder height direction (excluding the sensors on the cylinder heads). The setting range is 1-50 (integer);
- **Col count:** the number of sensors arranged in each circle (row) (excluding the sensors on the cylinder heads), the setting range is 1-50 (integer);
- **Endcaps Arc Height (mm)**: refers to the vertical height between the highest point of the header and the body of the cylinder.

3) Axis Adjustment

After the operation of the above steps, the software will give the default recommended sensor location coordinates, which basically adopts the principle of equal division. The X-axis of the coordinate origin is the sensor #1 near the circumferential seam, and the Y-axis of the origin is the center of the end caps near Sensor #1. The rest sensors are arranged clockwise from bottom to the top, following by the sensors at the end caps. Users can use this as a reference to install the sensors. When the actual installation position is different, the coordinates can be modified by clicking the **[Set Sensor]** button.

a. Firstly, confirm the X and Y coordinates info of all sensors relative to Sensor #1, and then on the basis of simple modification, click the **[Set Sensor]** button to directly modify the value in the interface;

b. The number under the "channel" column is the sensor number, which is generally consistent with the host channel number, and can also be changed to the user's desired number. Note that the modified number should not be repeated with the existing number;

c. The value below the “X(mm)” column is the horizontal distance from the coordinate origin, and the value under the “Y(mm)” column is the vertical distance from the coordinate origin, which can be directly input according to the actual situation.

d. After modification, directly click the **[OK]** button in the current interface.

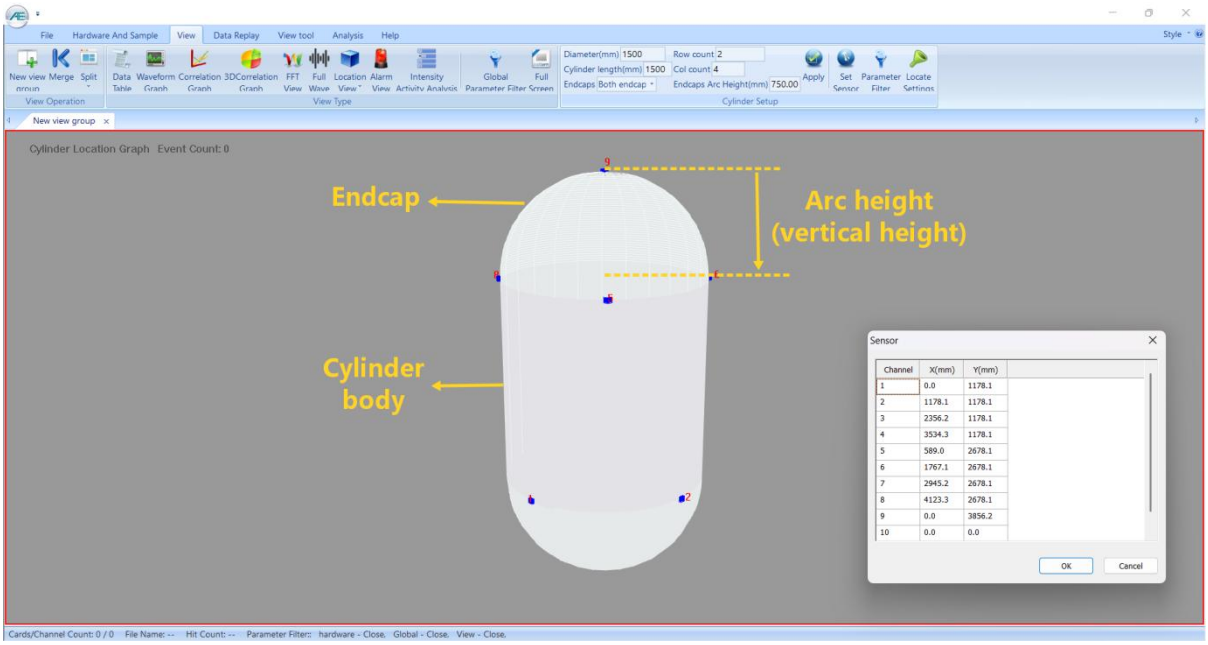


Fig. 3-9 Basic Info Modification of Cylinder Location Graph

3.2.3.3. Hardware Settings

Below are the introduction of “Sample Settings” pages for **RAEM1** instrument only. The “Sample Settings” for SAEU3H and RAEM1 series are totally different. So if SAEU3H series is used, please go to Section 2.2.5.1.1. If RAEM1 series is used, please go to Section 2.2.5.1.2.

The configuration settings of RAEM1 should be done in “RAEM1 Configuration” software. Please refer to the users manual of RAEM1.

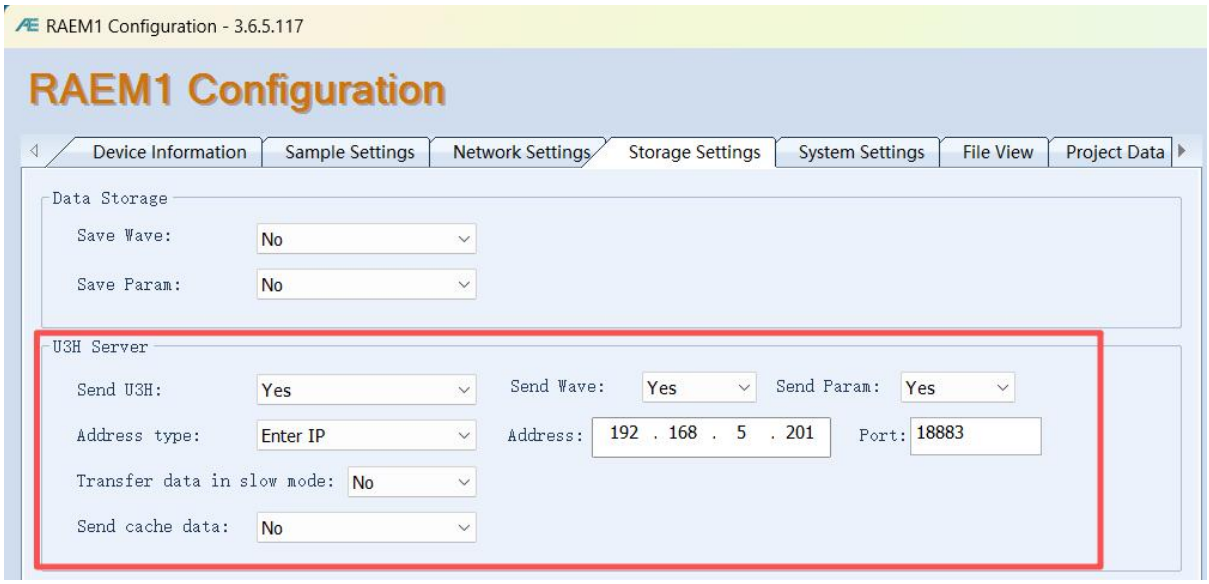


Fig. 3-10 RAEM1 Configuration software settings to "U3H server"

In the "RAEM1 Configuration" software, in the "Storage Settings":

④ Enable the "**Send U3H**", "**Send Wave**" and "**Send Param**". So that the RAEM1 will send waveform and AE parameters to SWAE software (considered as the "U3H server").

⑤ Then let RAEM1 know where to send SWAE data to. Select "Enter IP" in "**Address type**". The "Address" is the IP address of the SWAE computer receiving data from RAEM1. The IP address of the receiving computer can be found in the IPv4 address in **"Network & Internet" > "View your network properties"** of your computer. Depending on the communication method between RAEM1 and your computer, select the right IPv4 address of the connection. Refer to the user manual of RAEM1 for details.

⑥ Keep the default port number as "18883".

Only after the acquisition settings and the transmission to SWAE ("U3H server") in "RAEM1 Configuration" software, it can move on to SWAE software.

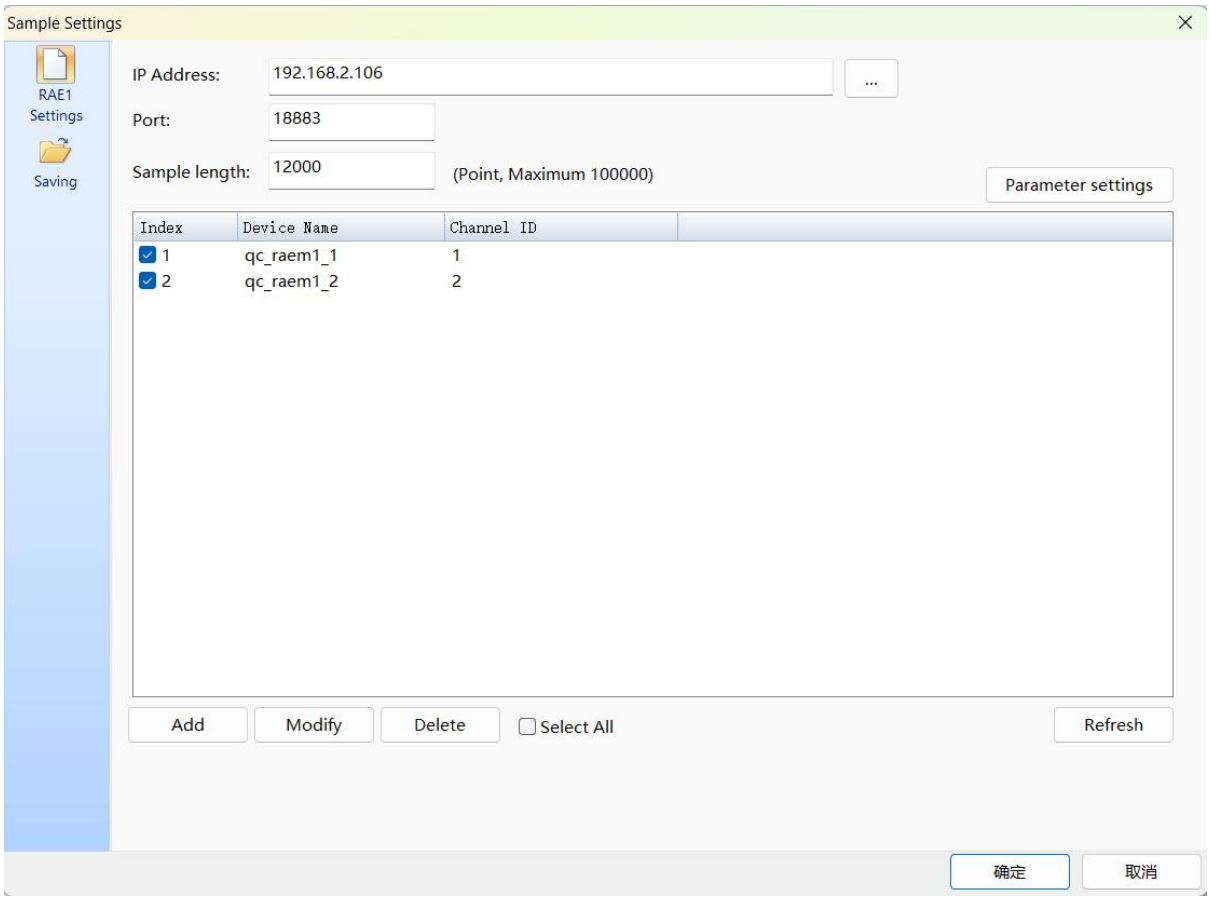


Fig. 3-11 Sample Settings for RAEM1 series

The "Sample settings" page for **RAEM1** series (RAEM1 & RAEM1-6 instruments) is shown in Figure 3-11.

The "**IP Address**" here should be the computer IP address receiving the data from RAEM1 series. (The same IP address as in the "RAEM1 Configuration" software above). Click the ... button to see what the current IP address are in the available communication methods. If it's through Ethernet cable, the IP address is normally 192.168.0.xxx.

The "**Port**" number should be consistent with the port number in RAEM1 Configuration software, i.e. 18883.

The "**Sample length**" is only related to the waveform view display in the SWAE software, not effects on the performance of RAEM1. The sample length here means the number of sample points display in each section of the waveform view. The maximum number is 100,000 (points). It's also related to the sample speed in RAEM1. For example, you set 2000

(kS/s) sample speed in the RAEM1 Configuration, and the sample length is 1000 (points) in the SWAE software, the length in the waveform view will be 1000/2000kS/s = 0.5ms.

The table below is the device list. Although SWAE will automatically display the data when it receives data from any available devices or channels and it will automatically number the channels based on the receive time. In case of random channel assignments by the software, **it's better to assign the channels in advance in the list.** Click "**Refresh**" button at the right below the table, and the software will display all available devices in the network. If the device list is not correct, use the "**Add**", "**Modify**" and "**Delete**" buttons below to correct it. The "Device Name" should be the same as the device name in the RAEM1 Configuration software. Start with Channel #1. **The checkbox next to the "Index" must be enabled** so that the SWAE will display the checked channels. Otherwise, there will be no channel to display.

Whether to save the data files, including waveform file with suffix of (.AED) and parameter file with suffix of (.PRA), the user can decide according to the actual situation. Click **[Saving]** on the left menu bar to set in the interface:

- **Data file path**: click **[Browse...]** button to locate to the target folder for the files to be saved;
- **File Name:** letters, numbers and characters can be input directly in the text box, but special characters such as _ \ / : * ? " < > | etc. cannot be included;
- **Save Acquired Data**: if it is selected, the data file will be saved, and the corresponding .aed and/or .pra files will be generated in the target folder. Otherwise the collected data will not be saved;
- **Notice Before Acquisition**: only used to prompt whether to save data or not. If it is selected, you will be prompted "save/not save data" before each acquisition starts.
- **Maximum File Size (MB)**: when the data size is larger than this set file size, it will created another new file to keep on saving the coming data until the acquisition stops. The setting range is 1-4000 integer, in MB, which can be directly input in the text box;
- **Maximum File Number**: the maximum number of files (including both the .AED and .PRA files) after reaching this value, no longer save the data (stop in the collection

state) or continue to store data by overwriting the previously stored data. The combination of this value and the setting value of "maximum file size" shall not exceed half of the available capacity of the hard disk. The setting range is 1-1000 (positive integer), which can be directly in the text box;

- **Autosave Setup**: check the box to allow files overwriting, when the maximum file number is reached.

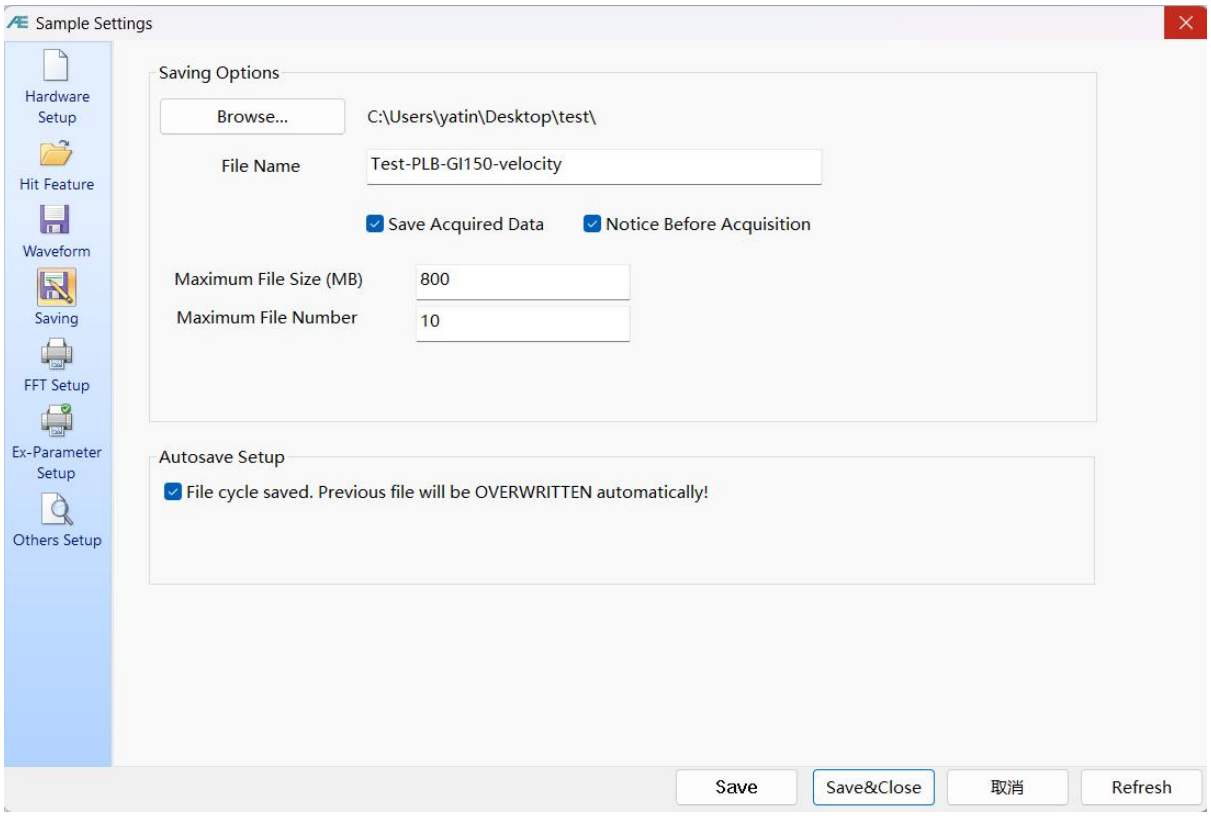


Fig. 3-12 Saving Settings

3.2.4. Threshold Determination

1) In the RAEM1 Configuration Software, **[Sample Settings] > [Sample Parameters]**, set the "**Threshold**" all selected channels to 28dB or lower;

2) In the SWAE software, click the **[Sample]** button in the **[Hardware And Sample]** interface, and stop the acquisition after about 3-5min;

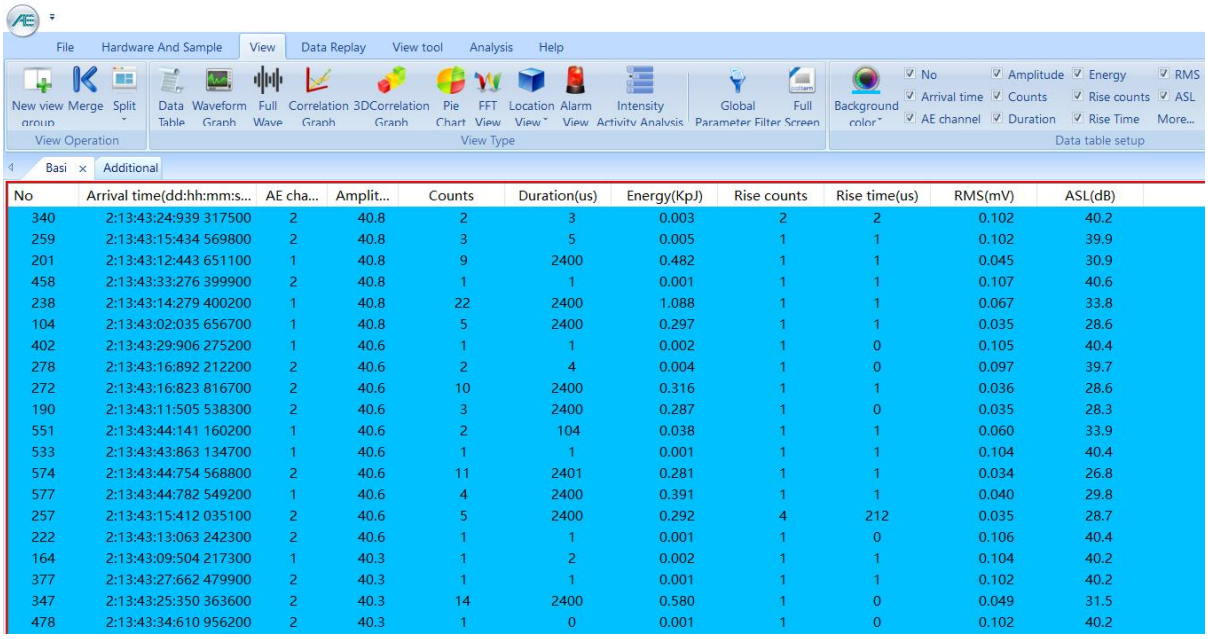
3) Click "Amplitude" column in the “Data Table” to sort the table in an ascending or descending order.

4) Find the maximum amplitude value that also appears most frequently to be the background noise level. As shown in Figure 3-13, the most frequent value (noise level) is around 40dB. But some channels have higher noise values constantly so that it is necessary to redo the coupling of those channels;

5) Repeat steps 1-4 until the amplitudes of all channels are close to 40dB;

6) The threshold value is the noise value plus some buffer space, which generally increases by 3~6dB, and 35~55dB is the commonly used threshold value. Users can control the threshold level according to the actual detection site.

Remarks: the acoustic emission test of atmospheric tank bottom plate corrosion has no way to decide on the noise level, which can be set between 35 and 50dB according to the site conditions.



No	Arrival time(dd:hh:mm:s...	AE cha...	Amplit...	Counts	Duration(us)	Energy(KpJ)	Rise counts	Rise time(us)	RMS(mV)	ASL(dB)
340	2:13:43:24:939 317500	2	40.8	2	3	0.003	2	2	0.102	40.2
259	2:13:43:15:434 569800	2	40.8	3	5	0.005	1	1	0.102	39.9
201	2:13:43:12:443 651100	1	40.8	9	2400	0.482	1	1	0.045	30.9
458	2:13:43:33:276 399900	2	40.8	1	1	0.001	1	1	0.107	40.6
238	2:13:43:14:279 400200	1	40.8	22	2400	1.088	1	1	0.067	33.8
104	2:13:43:02:035 656700	1	40.8	5	2400	0.297	1	1	0.035	28.6
402	2:13:43:29:906 275200	1	40.6	1	1	0.002	1	0	0.105	40.4
278	2:13:43:16:892 212200	2	40.6	2	4	0.004	1	0	0.097	39.7
272	2:13:43:16:823 816700	2	40.6	10	2400	0.316	1	1	0.036	28.6
190	2:13:43:11:505 538300	2	40.6	3	2400	0.287	1	0	0.035	28.3
551	2:13:43:44:141 160200	1	40.6	2	104	0.038	1	1	0.060	33.9
533	2:13:43:43:863 134700	1	40.6	1	1	0.001	1	1	0.104	40.4
574	2:13:43:44:754 568800	2	40.6	11	2401	0.281	1	1	0.034	26.8
577	2:13:43:44:782 549200	1	40.6	4	2400	0.391	1	1	0.040	29.8
257	2:13:43:15:412 035100	2	40.6	5	2400	0.292	4	212	0.035	28.7
222	2:13:43:13:063 242300	2	40.6	1	1	0.001	1	0	0.106	40.4
164	2:13:43:09:504 217300	1	40.3	1	2	0.002	1	1	0.104	40.2
377	2:13:43:27:662 479900	2	40.3	1	1	0.001	1	1	0.102	40.2
347	2:13:43:25:350 363600	2	40.3	14	2400	0.580	1	0	0.049	31.5
478	2:13:43:34:610 956200	2	40.3	1	0	0.001	1	0	0.102	40.2

Fig. 3-13 Background Noise Measurement Results

3.2.5. Channel Sensitivity

1) Only the background noise data is collected, and the "Threshold" in **the RAEM1 Configuration software** can be set to 50dB for official data acquisition.

2) The sensitivity of each channel is calibrated by breaking the pencil lead for three times at

at the same position by a certain distance from the sensor (for example, the pressure vessel is specified as 100 mm from the sensor). The pencil lead breaking angle, lead core length and pressure strength are as consistent as possible. When it is obvious that the pencil lead breaking effect is greatly different, repeat the step;

3) The first three maximum "amplitudes" received by each channel are recorded;

4) The average value of the three maximum “amplitudes” is the current channel sensitivity; when it is obvious that the sensitivity of a certain channel is abnormal, the sensor and other accessories of the channel can be replaced or re-coupled; then, repeat step 2) to 4);

5) Then average of all channels sensitivity as the system sensitivity;

6) According to the standards or combined with the test requirements, the results of step 5) and step 4) are compared one by one to evaluate whether the channel sensitivity meets the requirements, such as the difference between the channel sensitivity and the system sensitivity is generally ± 3dB or ± 4dB, which is required for the detection of special equipment.

3.2.6. Attenuation Test

Attenuation test has two basic purposes in AE detection. The first purpose is to ensure that the whole sensor array can receive the desired AE signal, and the other purpose is to calculate the original source AE signal amplitude based on the attenuation curves. In general, the spacing in the sensor layout scheme is usually based on similar test experiences. According to some known experiences, the acquisition of acoustic emission signal can be basically realized. When encountering the test of unknown materials and structures, this step should be advanced before the determination of the sensor layout scheme, so as to determine the sensor layout scheme and quantity based on the attenuation characteristics.

3.2.6.1. Attenuation Test Steps

1) The typical positions on the tested AE components, such as the curved surface diameter

change, thickness reduction, weld number and welding mode change, should be tested separately.

2) Make test points along the longest line in a sensor array, such as 0.1m, 0.5m, 1m, 2m, 3m etc. and make test distance not shorter than the maximum length of the connecting line. The above test positions need to be polished to expose the metallic luster.

3) Only enable one channel in the array for data acquisition and saving, and the "parameter threshold" of the channel is set to the determined threshold value for data acquisition, such as 50dB.

4) Break the pencil lead for three times at at the test positions from the sensor, and record the maximum amplitude received. Repeat twice.

5) Calculate the average of the three maximum amplitudes at each position, which is the attenuation measurement value at that distance from the sensor; subtracting the attenuation measurement value with 100dB is the attenuation amount of that position.

6) Repeat step 4) and 5) until all the test distance positions are complete. The distance v.s amplitude attenuation curve is obtained with all the distances and attenuation values, which can be directly used to calculate the source original acoustic emission signal.

3.2.6.2. Making Attenuation Curve

Click **[Analysis]** → **[Attenuation Curve]** to open the attenuation curve settings page.

Enter the measured **[Distance]** value and the signal **[Amplitude]** detected by the sensors after transmitting a signal using an analog source at that distance, then click **[Add]**.

To modify or delete the points in the curve, first click on the row of the data, the filled values are displayed in the input boxes again. Modify the values in the input boxes and click **[Modify]** button. To delete, just click **[Delete]** button.

[Close and Save] is to save the entered data and curve and close the window.

[Cancel] will close the window without saving the new data.

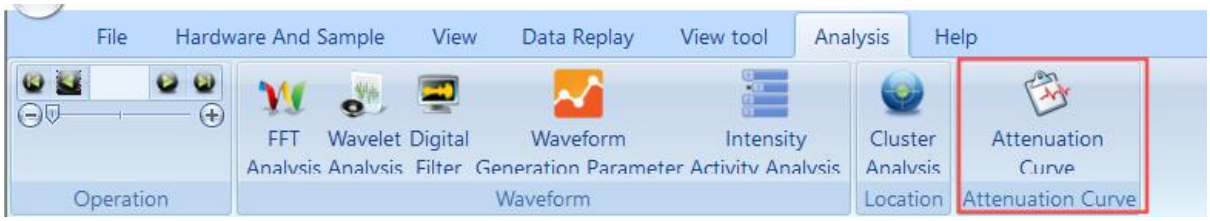


Fig. 3-14 Attenuation curve function button

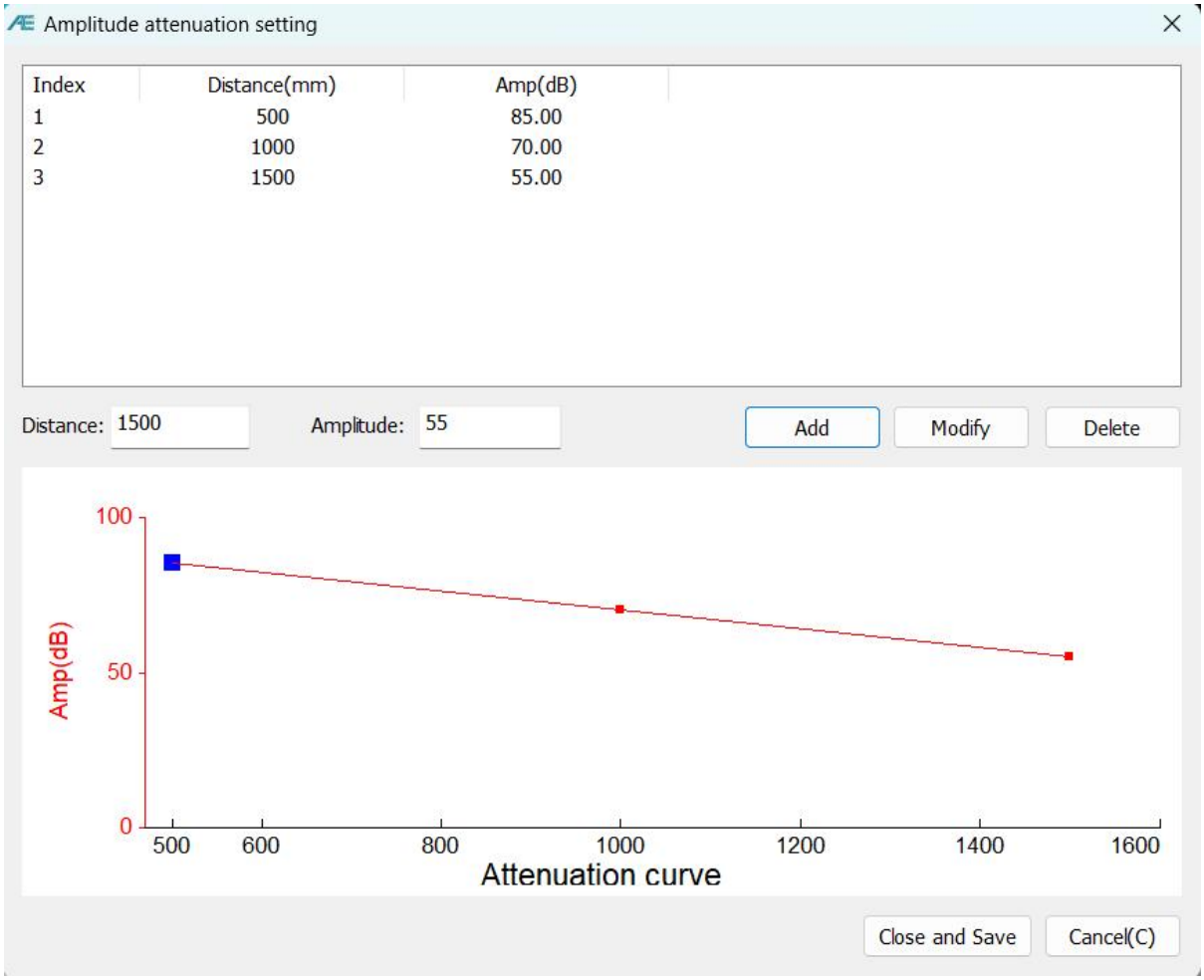


Fig. 3-15 Attenuation curve window

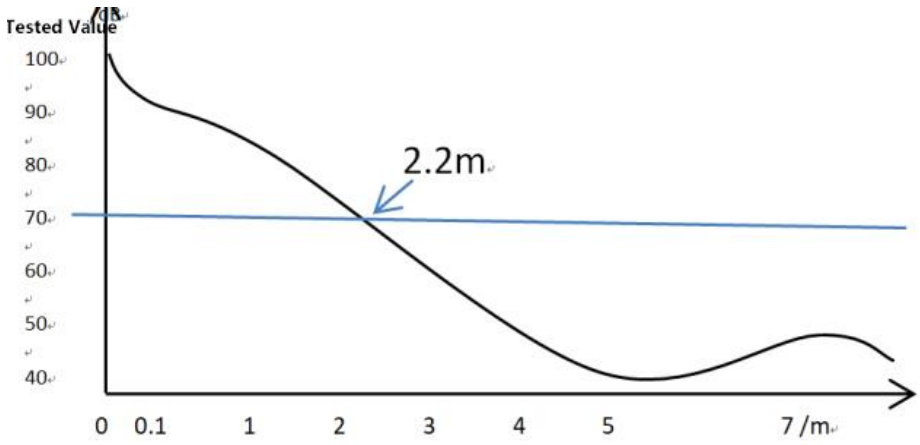


Fig. 3-16 Distance attenuation curve

3.2.7. Velocity Test

When the acoustic emission detection involves source locations, the sound velocity used is generally the compound wave velocity, which needs to be measured on site.

The method of measure the actual velocity propagating in the material is to use the pencil lead break (PLB) test and the Data Table to measure and calculate the actual velocity in the material.

Two-point Velocity Calculation

Install two sensors on a flat surface of the same and continuous material surface. Measure and record the distance *L* in advance. Start the data acquisition (signal recording) in the software. Break the pencil leads in between the two sensors or on the extension line of the two sensors.

***Note**: that the threshold can be set higher, e,g. 70dB to eliminate the interference of non-valid pencil lead breaking signals.*

***Note**: the PLB position cannot be in the middle point of the two sensors.*

In the Data Table view, find and select the two hits from the same PLB event. Right click the menu and select “Sound velocity calculation”. And the window of the “Two-point velocity of sound calculation” window pops up.

Based on the actual pencil lead breaking positions, select Layout 1 or 2. E is the pencil breaking position (event source). Then confirm or modify the channel numbers corresponding to Sensor A or B. Then fill in the distances between A-E and B-E, positive values in unit of mm. Click “Calculating” button and get the result speed (velocity).

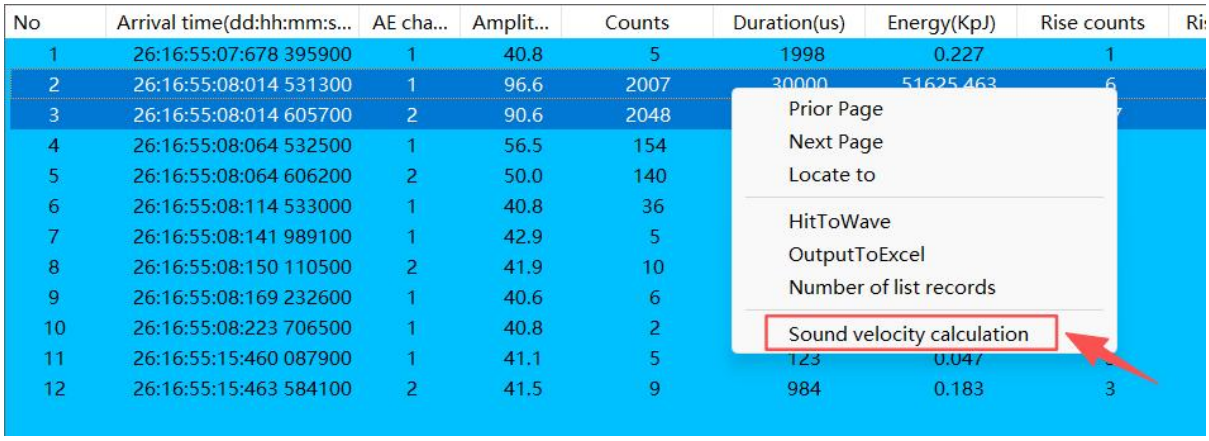


Fig. 3-17 Selecting the velocity calculation function

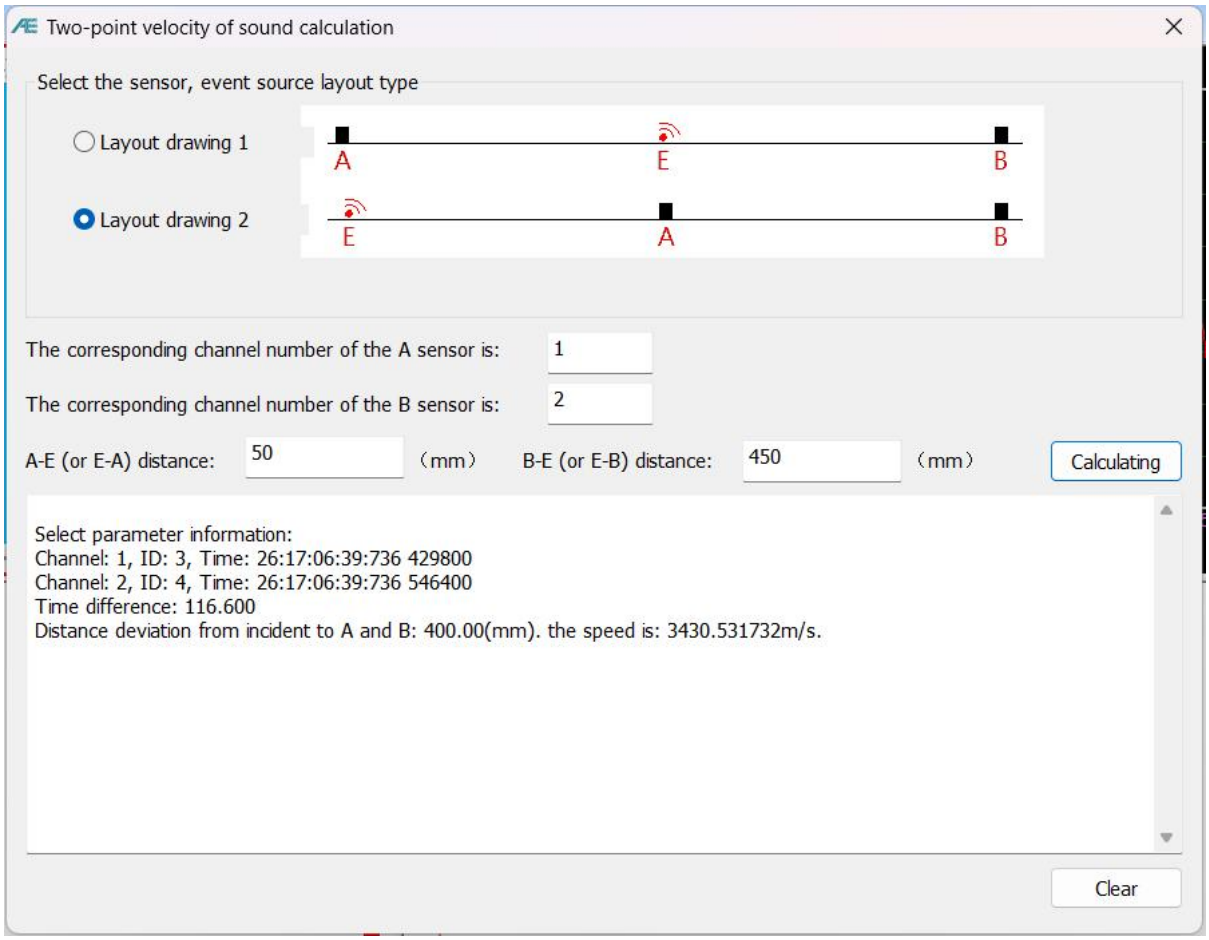


Fig. 3-18 Two-point velocity calculation window

3.2.8. Location Calibration Test

The location calibration test compares the location point generated by artificial simulation source with the actual acoustic emission source location to determine whether the two are consistent. In the industrial detection, the error range of pressure vessel is based on whether the calculated point is the unique corresponding point and whether it conforms to the location error range. The error range of the pressure vessel is within 5% of the maximum distance between sensors. The location calibration test is generally based on the approximate modeling view with location requirements and software supports, and the test in this stage should be the same as that used in the later detection. The analog stimulation source used in location calibration should be as similar as possible to the signal characteristics from the material itself, such as simulating crack propagation by breaking pencil leads or simulating corrosion signals by sandpaper grinding.

In general applications, the steps and methods related to the source locating have great differences in accuracy due to different location methods. Therefore, as a general reference, a reasonable location setting should be made for each location type according to the actual needs.

For general detection applications, the location setting steps are as follows:

1) The sensor layout scheme and location graph type are defined.

2) According to the structure and attenuation characteristics, the grouping mode of sensors is defined, and several sensors participate in the TDOA location of the current array.

3) The sound velocity used in TDOA location is defined.

4) Clearly known the sensor sensitivities.

5) Enter the "Location setting" interface corresponding to the location graph, and input the corresponding settings, such as sound speed, event settings, etc. Refer to Chapter 2.2.6.2.8.9.

6) Enable all channels to be used, set the corresponding "waveform threshold" and

"parameter threshold", and then start acquisition.

7) Then try to locate the typical position by simulating the source, to see if the location results are consistent with the expected results. Otherwise, the above steps need to be repeated until the location meets the requirements. Generally, it can be achieved by adjusting the sound speed and the "Event Settings".

3.2.9. Data Acquisition

After the location calibration is completed, the AE signal acquisition for the official AE test can be carried out. The data acquisition in this stage is the generation and capture of real AE signals, and it does not need to manually apply the analog source signals on. The acoustic emission detection of pressure vessels generally includes the data acquisition in the pressure boosting and pressure maintaining stages; the data acquisition in each stage can be carried out according to the proposed test scheme in the laboratory;

Before and after this stage of work, the set configuration file can be saved to facilitate the subsequent use of the same specification test and subsequent data analysis and processing; click **[File]** in the menu bar, and then select **[Save Settings as]** to store the configuration file in the specified folder.

3.2.10. Secondary Sensitivity Test

When the acoustic emission test is carried out continuously for a long time or the installation position of the sensor is in a harsh environment, the coupling state of the sensor may change. The method is the same as that in Chapter “3.2.5 Channel Sensitivity”. If there is a big difference between the post sensitivity and the sensitivity before detection, it is necessary to refer to the data in the process of data analysis or to develop a new detection scheme to conduct the test again.

3.2.11. Reverse Location Calibration

For the obvious source location concentrated areas indicated in the location graph, use the same detection settings and the simulation source to do the reverse location calibration. The reliability and accuracy of the acoustic emission source locations are determined by combining the actual location of the source point and the position of the tested component. The method is the same as that in Chapter "3**.2.8 Location calibration Test"**.

3.2.12. Data Analysis

After the completion of data acquisition, the main work after is the data analysis. Data analysis refers to the replay of stored data, and the selection of data processing means in the replay process. The authenticity and trade-off of data results are targeted to obtain the correct results, which can be implemented by referring to the corresponding standards or technical literature. For example, the inspection of pressure vessels can refer to <NB/T 47013.9-2012 nondestructive testing of pressure equipment Part 9: acoustic emission testing> or <GB/T 18182-2012 method for acoustic emission testing and result evaluation of metal pressure vessels>.

3.2.12.1. Parametric Filter

Parameter filter is to set the upper and lower limit values of different characteristic parameters, which will not be displayed in the replay process, and the filtered parameters will be drawn correlation graph, location graph calculation and other processes.

In metal pressure vessel detection, the common filter settings include increasing the amplitude threshold, filtering the parameters of small counts and too long of the rise time. The values in the figure do not have any significance, and are only for example. These filter settings can refer to the relevant literature on acoustic emission signal of metal materials. The

parametric filter should be analyzed according to the field noise of each working condition Be careful. When you do not select a view, click [Global Parameter Filter] in the location to add a global parameter filter, which is valid for all views related to parameters; when a view is selected, clicking [Parameter Filter] only takes effect for the current view, and attention should be paid to the specific use.

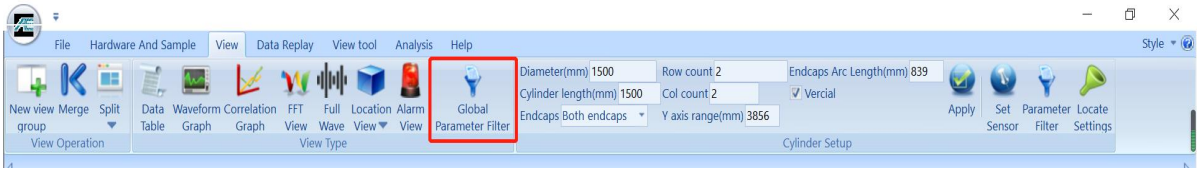


Fig. 3-19 Global Filter

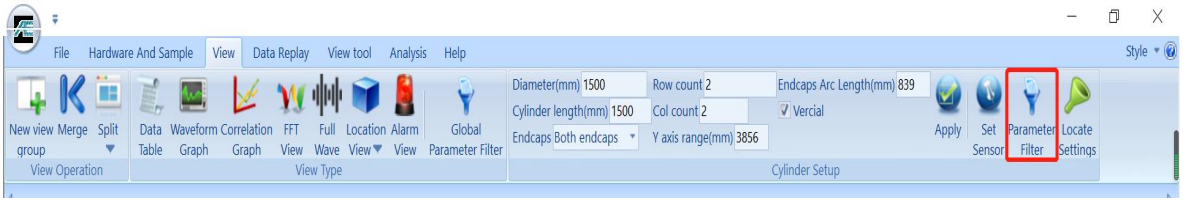


Fig. 3-20 Parameter filter setting

3.2.12.2. Location Rule Adjustment

If, after the parameter filter, the distribution of location events in the location graph is still scattered and disordered except for the location concentrated area, it can be considered to adjust the location rules appropriately to remove the scattered location points, on the premise that the scattered location points can be identified as noise interference or other meaningless signals according to the data distribution. The adjustment of location rules is mainly "event definition time" and “event lock time”. When the location points are disordered and scattered, the "event definition time" and "amplitude deviation" can be appropriately reduced, and the "event locking time" can also be appropriately increased.