

# Active and Passive surface wave methods using Atom for AVS30 investigation



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# Outline

- This manual summarizes data acquisition and processing flow for average S-wave velocity to a depth of 30 m (AVS30) by active and passive surface wave method using 10 Atom AUs.
- See “*Passive Surface Wave Survey using Atom and SeisImager, Quick Start*” for the details of Atom operation.
- See “*SeisImager/SWTM Manual*”, “*SeisImager/SWTM Manual Addendum (H/V)*” and “*SeisImager/SW-ProTM Manual*” for the detailed analysis of dispersion curves and/or H/V curves.
- Data example used in the manual can be downloaded from “[https://seisimager.com/GeophysicalDatabase/t10\\_50m.zip](https://seisimager.com/GeophysicalDatabase/t10_50m.zip)”.

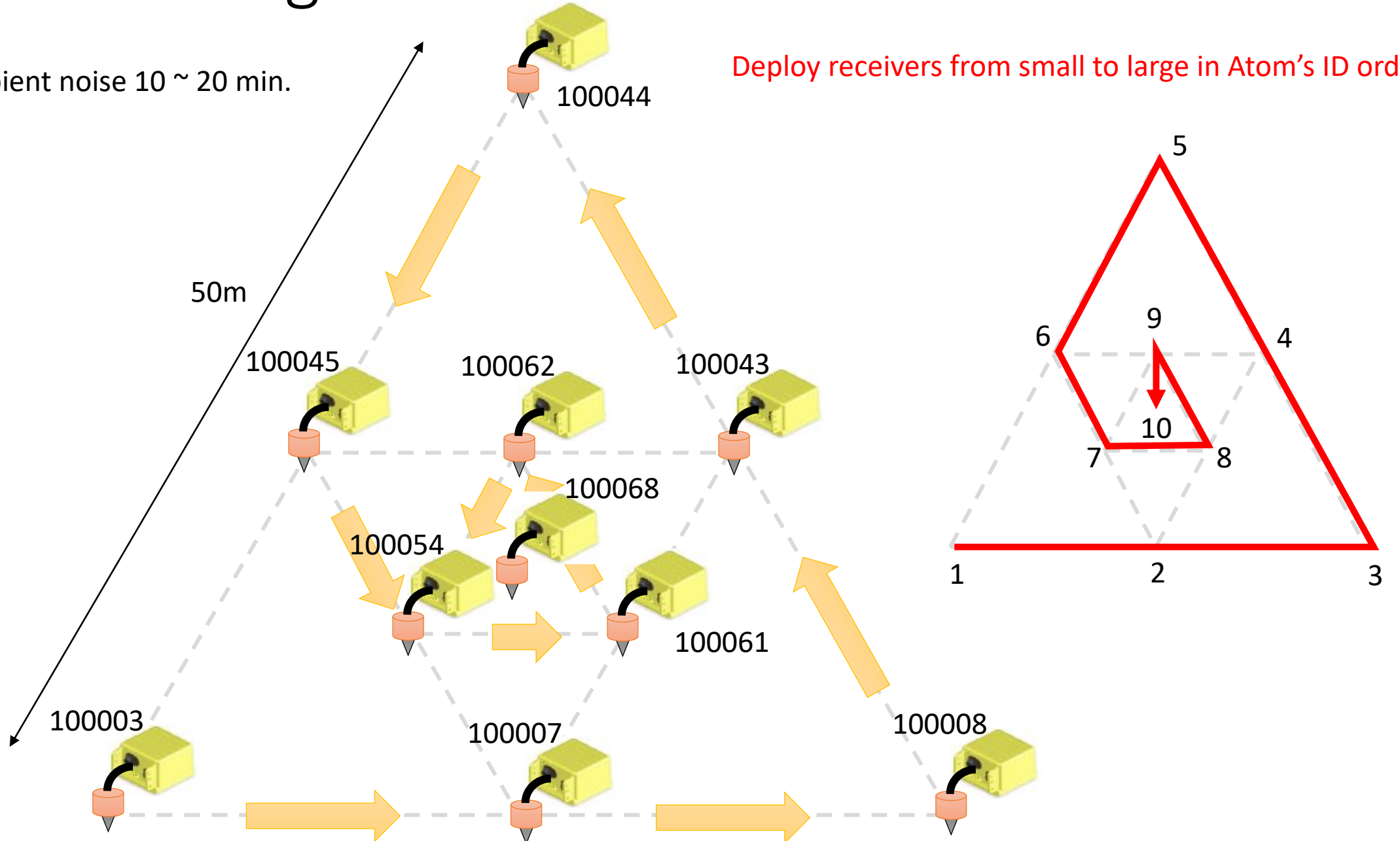
# Data acquisition using 10 Atom AUs

1. Nested triangles (L, T or crossing etc.) of 10 (7 to 20) receivers recording ambient noise (Passive). Size of array ranges 30 ~ 100 m depending on site conditions.
2. Linear array of 10 receivers with 2 m (1 ~ 5 m depending on site conditions) spacings recording active sledge hammer data (MASW).
3. Linear array of 10 receivers with 2 m (1 ~ 5 m depending on site conditions) spacings recording ambient noise (Passive). This measurement is not necessary.

# Nested triangles of 10 receivers

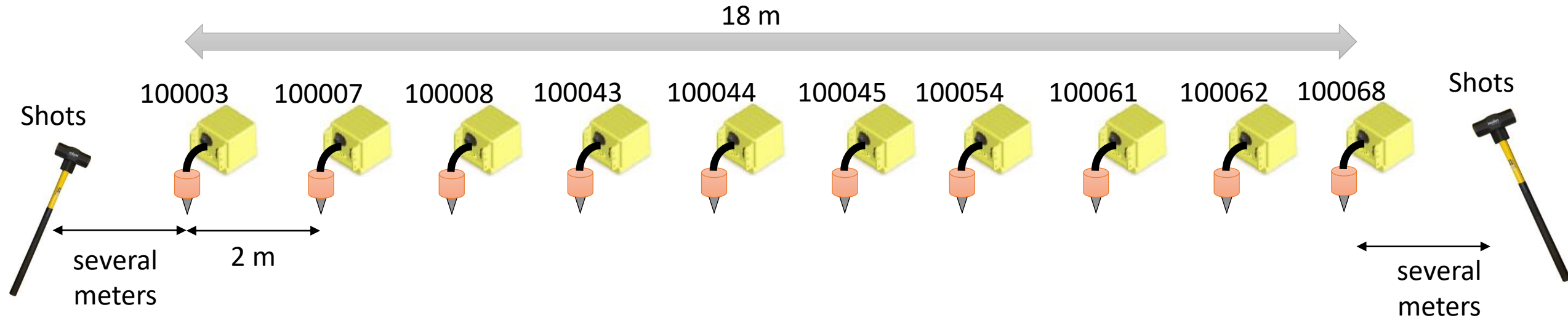
Record ambient noise 10 ~ 20 min.

Deploy receivers from small to large in Atom's ID order



# Linear array of 10 receivers with 2 m spacings

Deploy receivers from small to large in Atom's ID order.

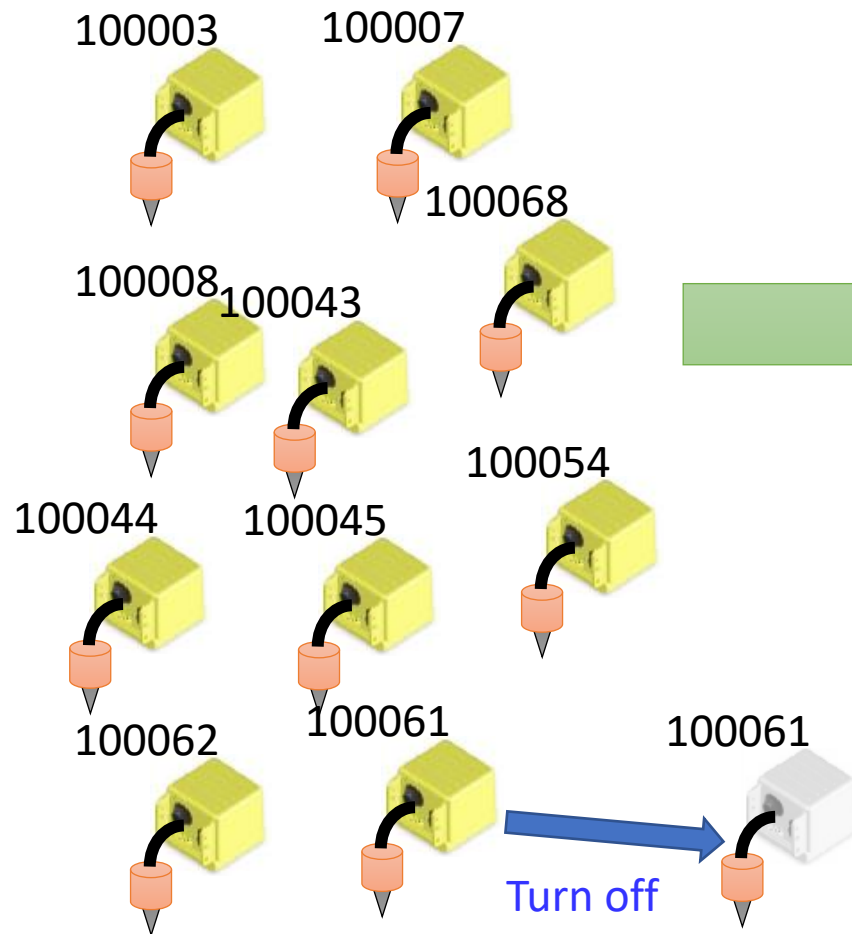


For active method (MASW), swing a sledge hammer several times at both ends.  
For passive method (linear array), record ambient noise 10 ~ 20 minutes.

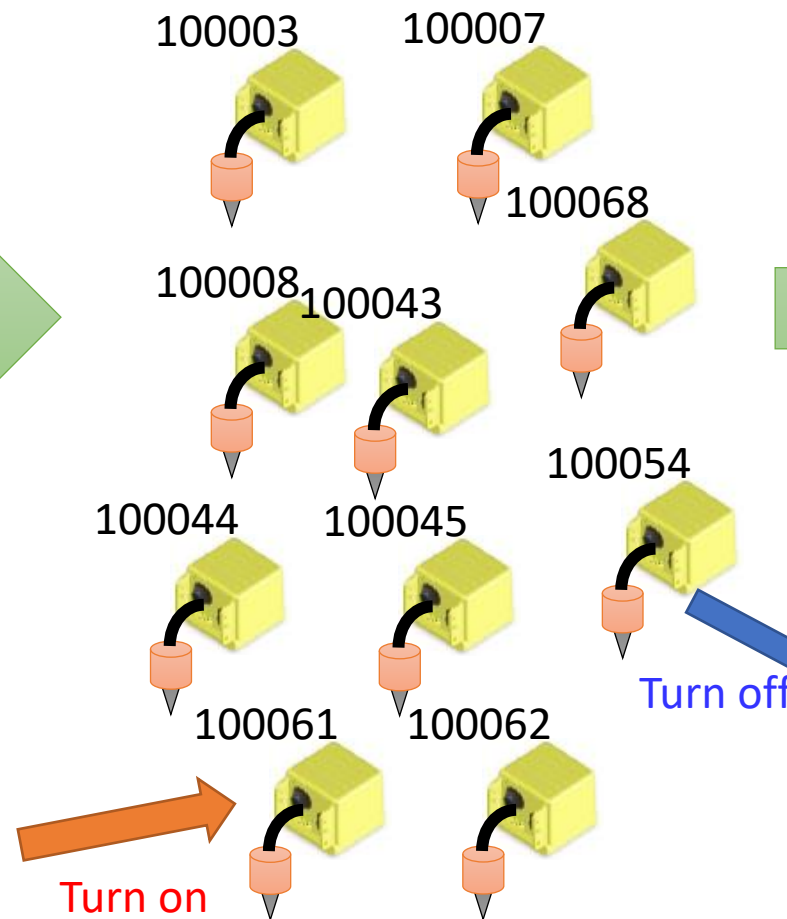
# Data acquisition

To distinguish measurements, turn off and on one box at the beginning or ending of the measurements.

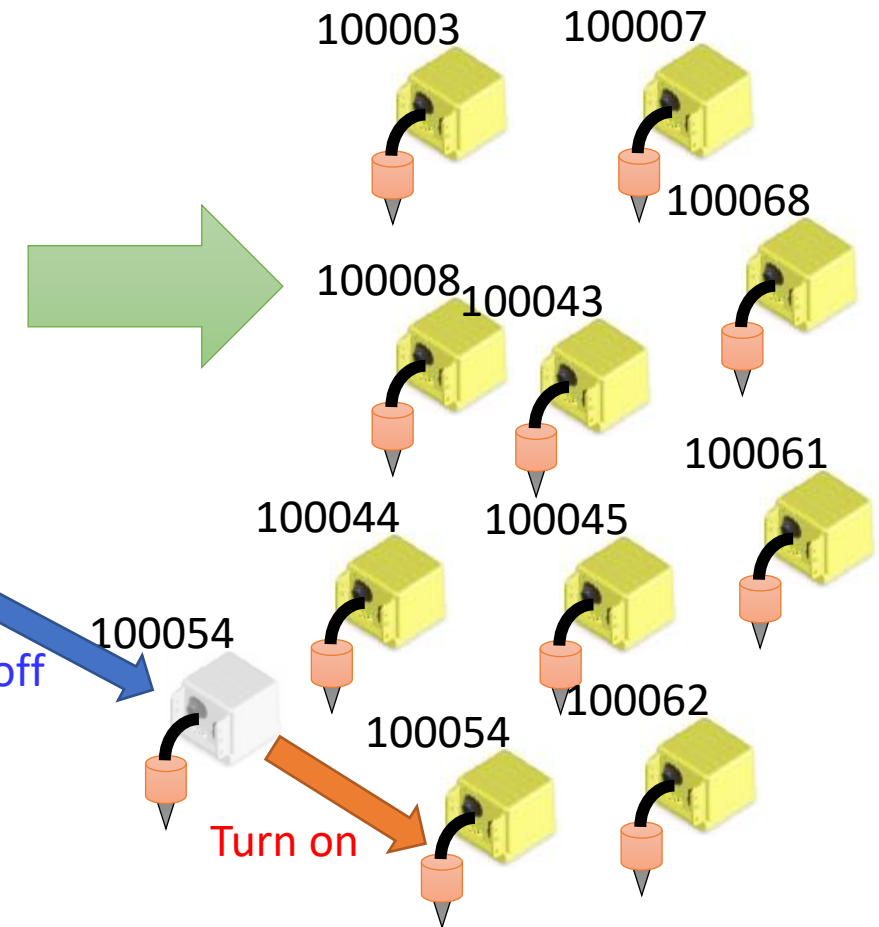
1<sup>st</sup> measurement



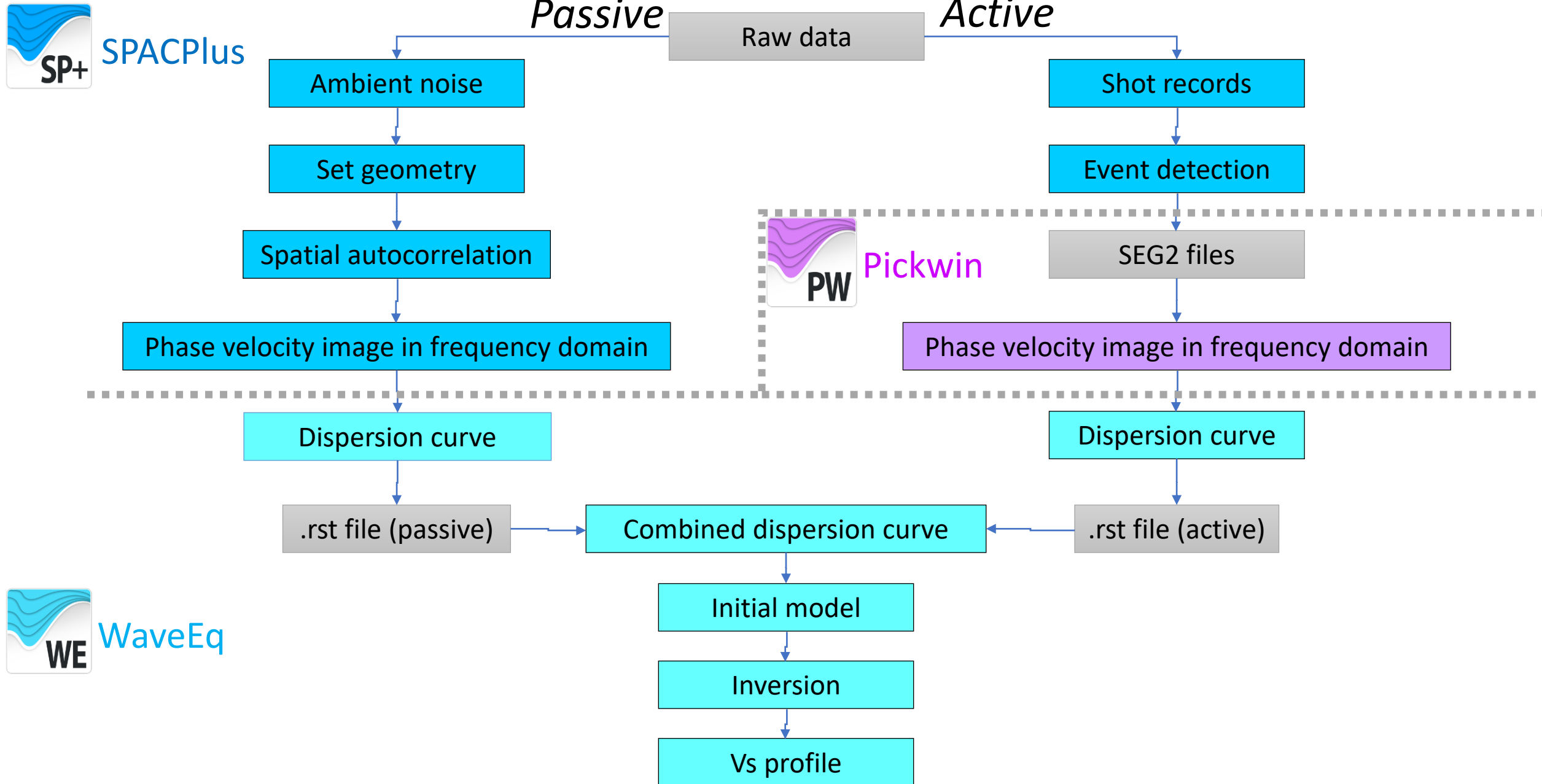
2<sup>nd</sup> measurement



3<sup>rd</sup> measurement

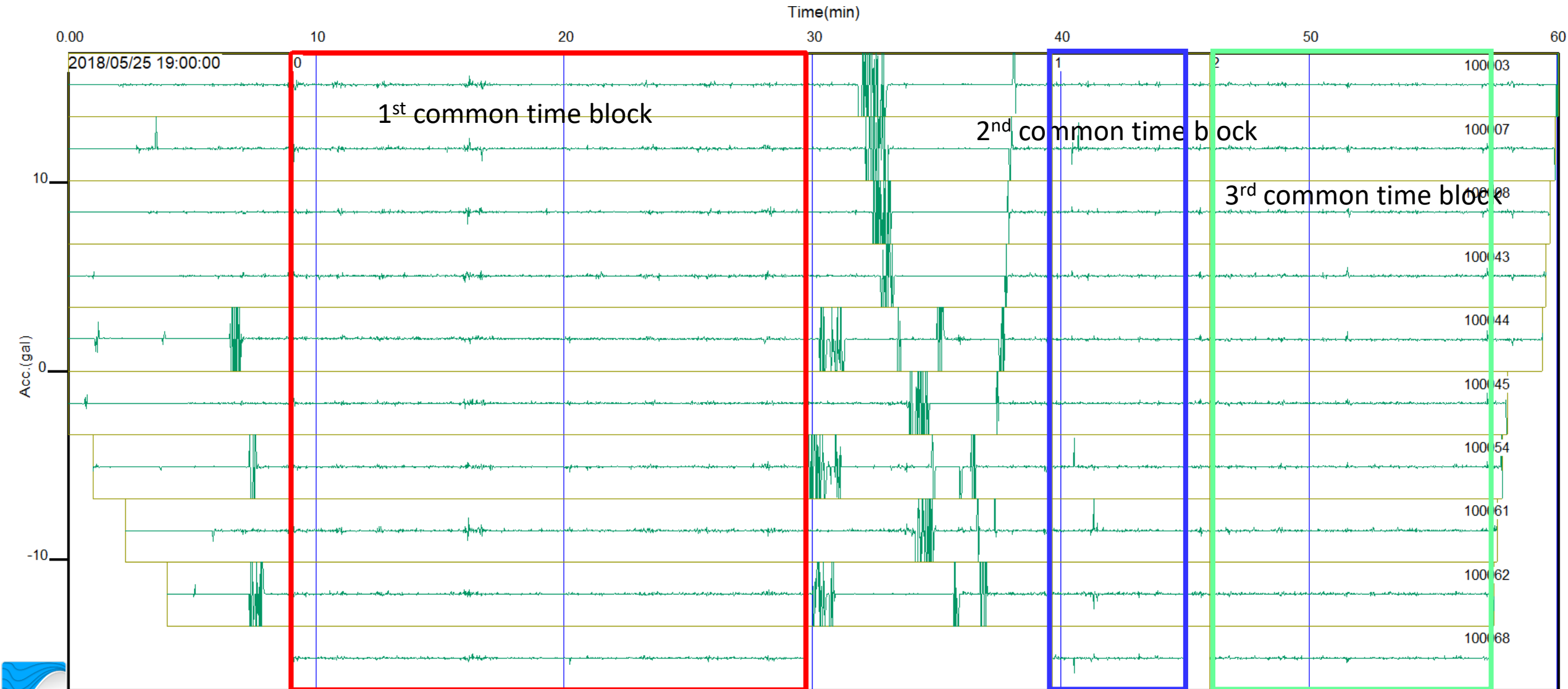


# Processing flow



# Raw data

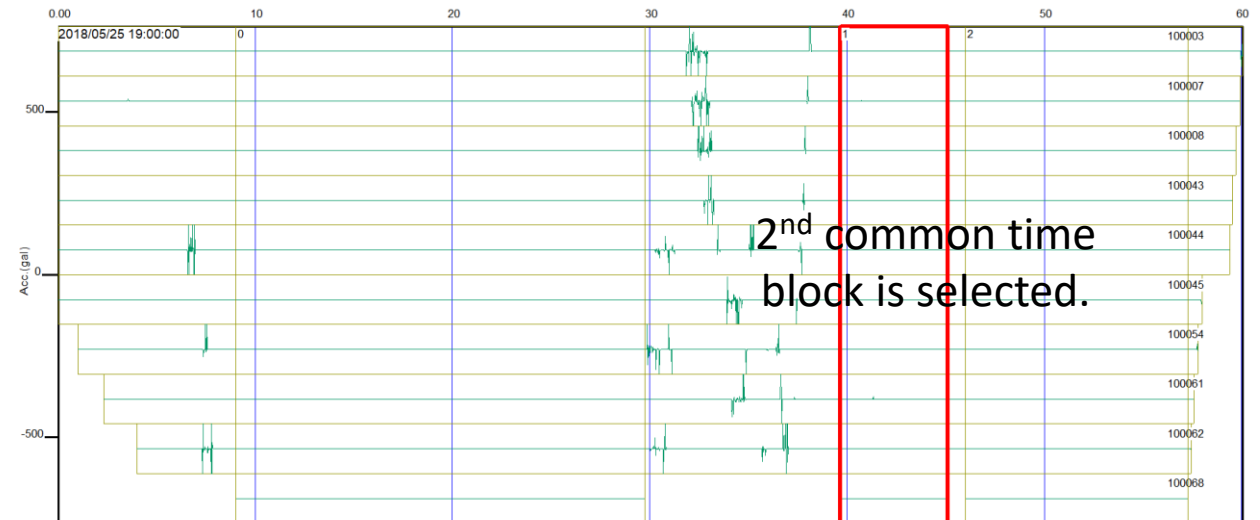
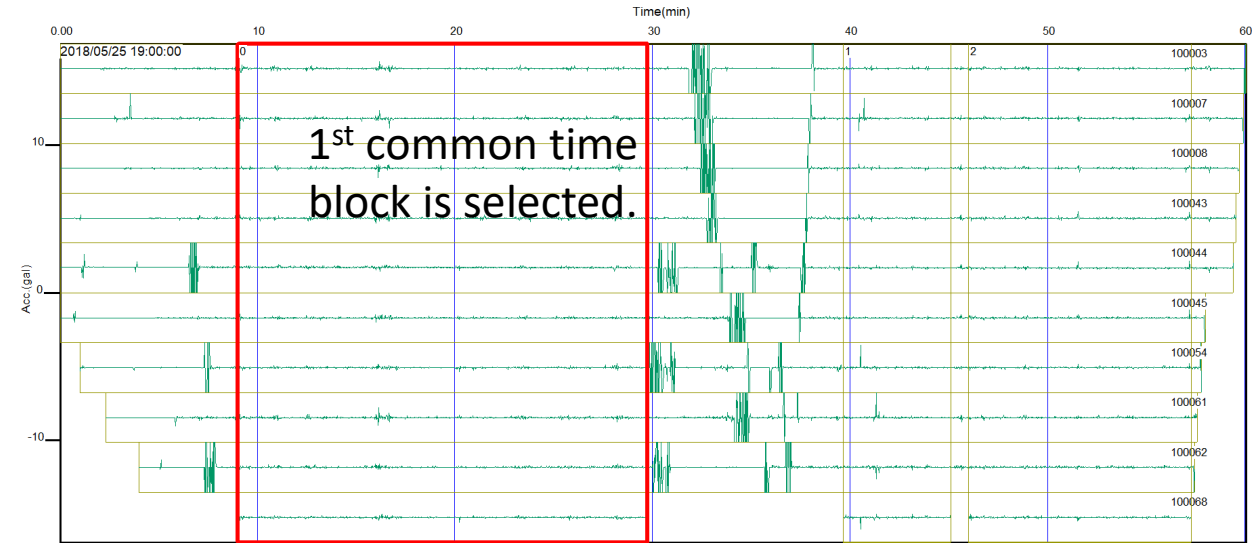
In SPACPlus, waveform traces appear in order from lower to higher Atom ID numbers. An area surrounded by a red rectangle is a “Common Time Block (CTB)” during which all Atom units were recording data.






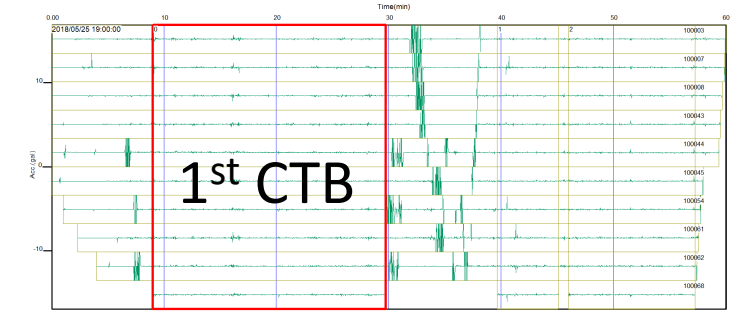
# Select a common time block to be processed

Select a common time block (CTB) to be processed, using left and right arrows if several tables are shown.

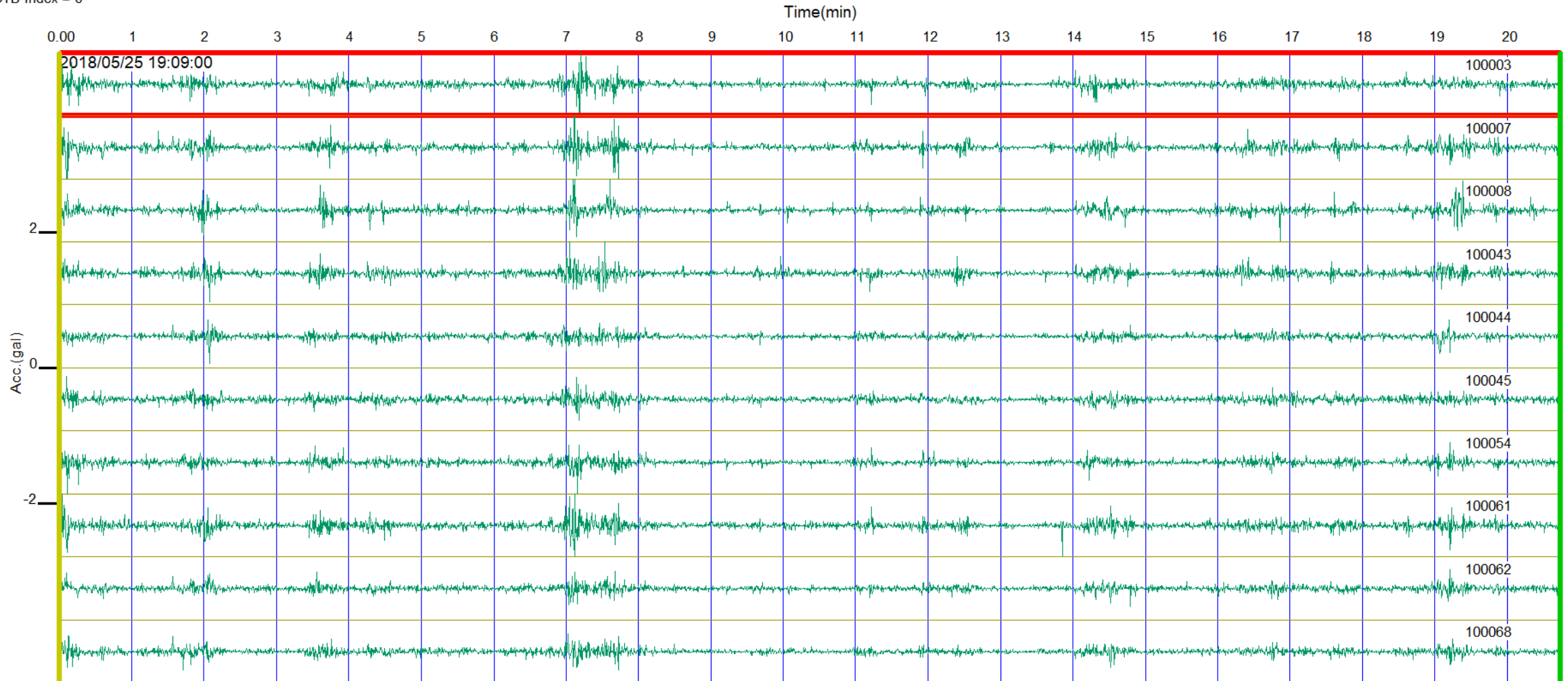


# Processing ambient noise data


Click  or select [Window]>>[Processing window] and the selected 1<sup>st</sup> CTB data (in a red rectangle) will appear in another window.

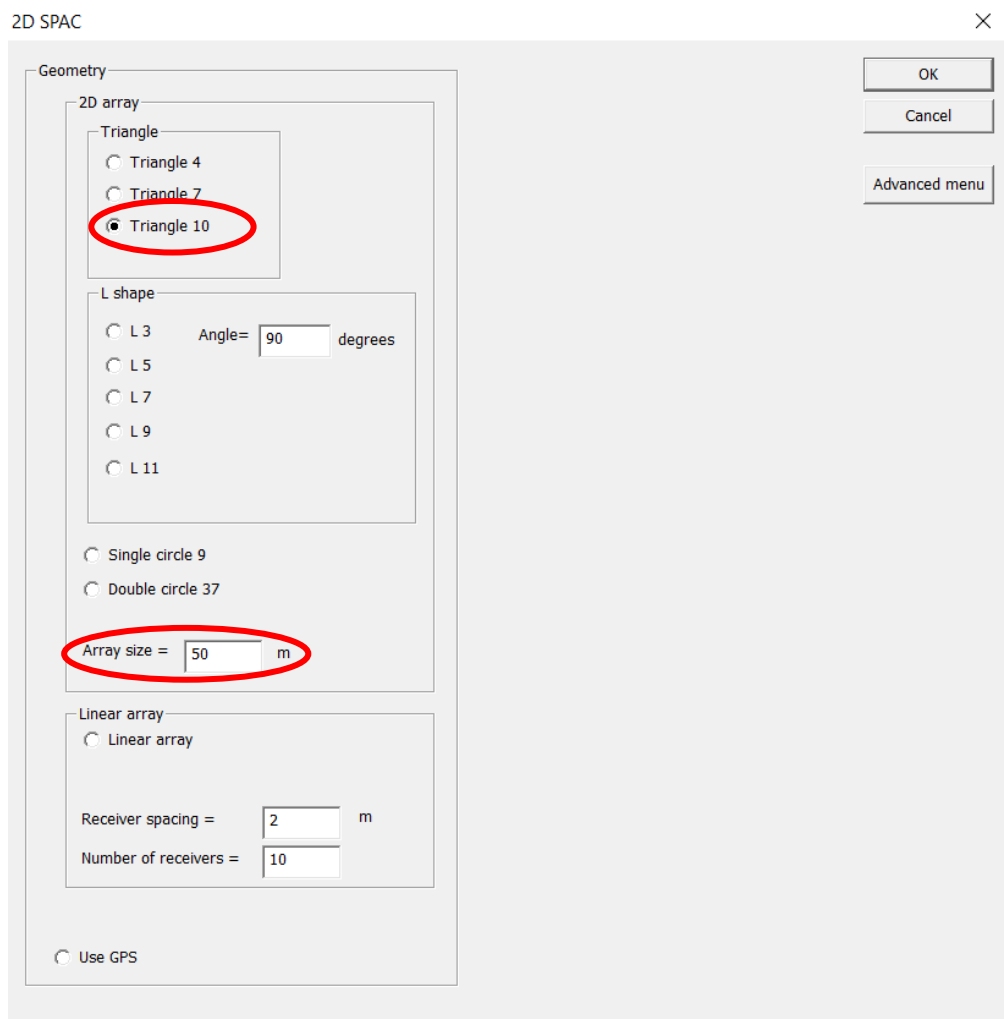


CTB Index = 0



# Set up geometry

Click  or select [Analysis]>>[SPAC analysis] to process passive surface wave data in terms of Spatial Auto Correlation (SPAC). A dialog appears for setting the shape and size of the array. Select “Triangle 10” and put “50” for “Array size”. Click “OK” to proceed.






If your geometry is not listed in default arrays, click “Advanced menu” and “Open array file” and select array file. The array file is a simple ASCII file that mentions X and Y coordinate of geophones.

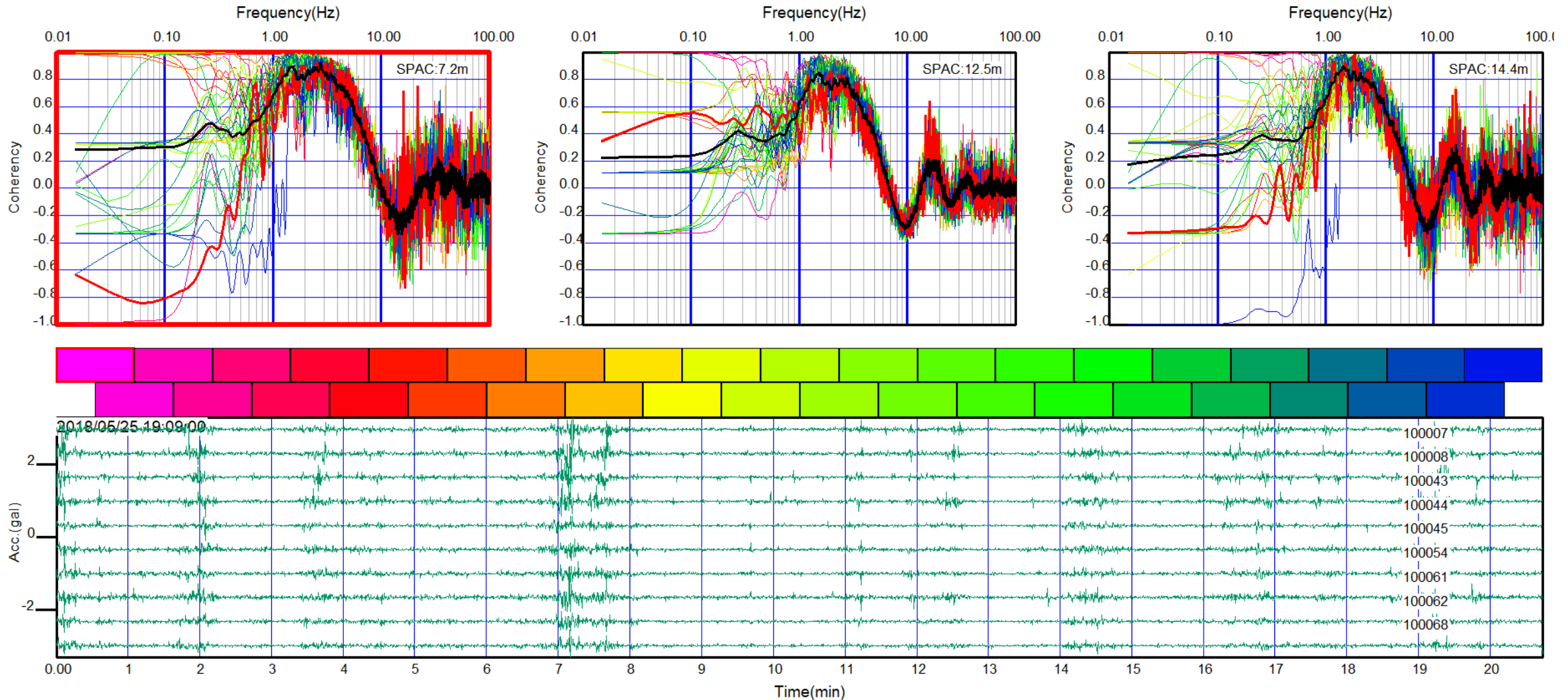


Example of array file.


```
0.000000 0.000000
25.000000 0.000000
50.000000 0.000000
37.500000 21.650635
25.000000 43.301270
12.500000 21.650635
18.750000 10.825317
31.250000 10.825317
25.000000 21.650635
25.000000 14.433757
```

# Spatial autocorrelations by frequencies

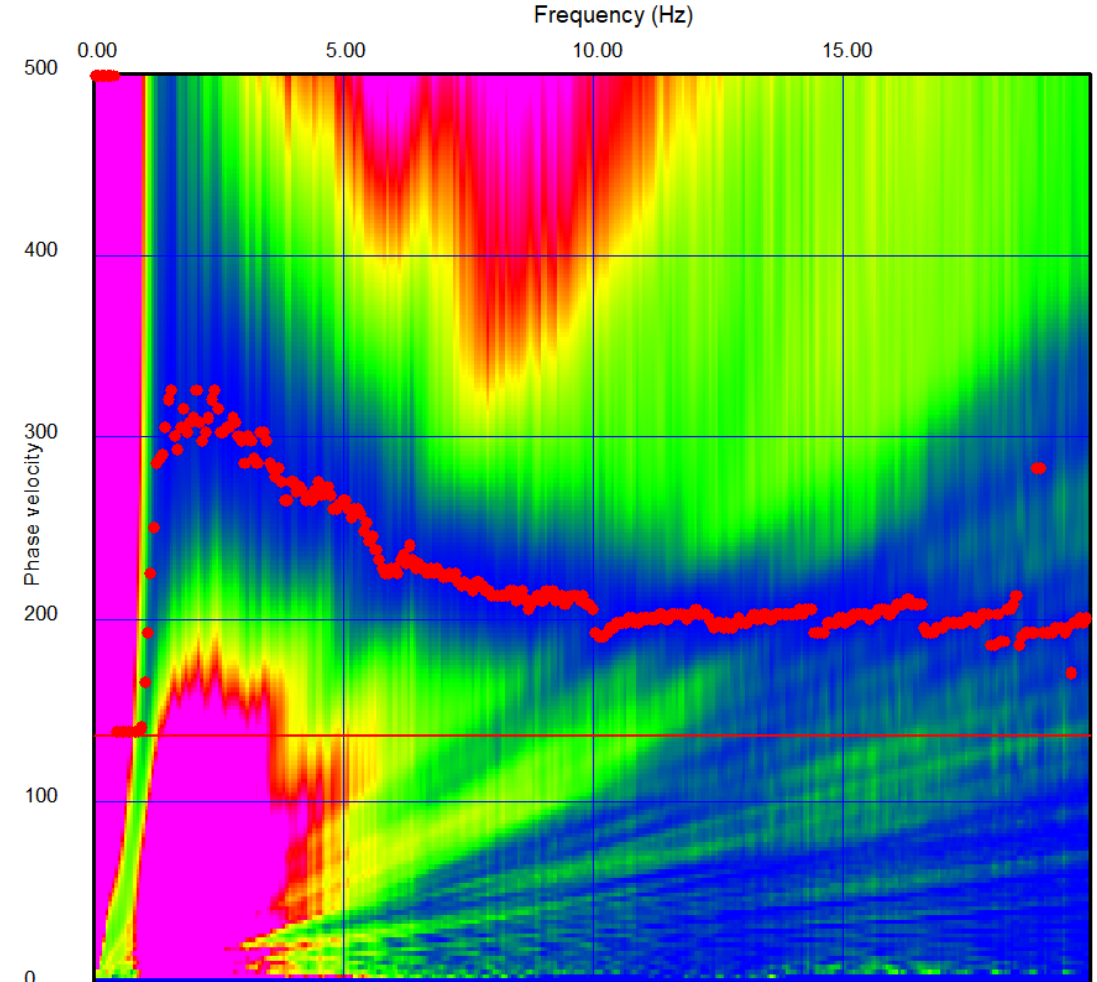
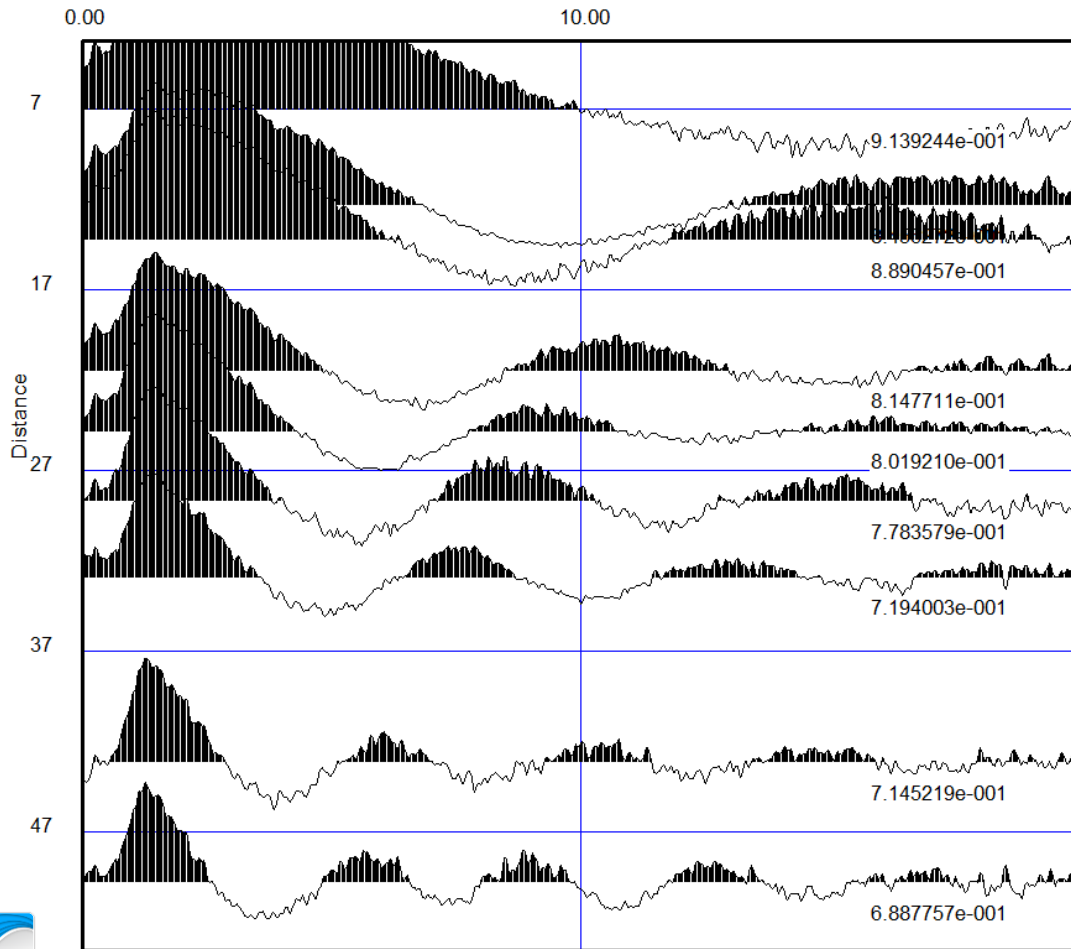
Spatial auto correlations appear. When number of receiver separation is more than three, use   buttons to scroll receiver separations to be shown. Click  or select [Phase velocity analysis]>>[Phase velocity window] and all spatial auto-correlations and a frequency domain phase velocity image appear in another window.



# All spatial autocorrelations and phase velocity image in frequency domain

To set the minimum phase velocity to be picked, adjust a red horizontal line in a phase velocity image in frequency domain by a mouse. Click  or select [Surface wave analysis]>>[Show phase velocity curve(s)] >>[Launch WaveEq].

Frequency (Hz)





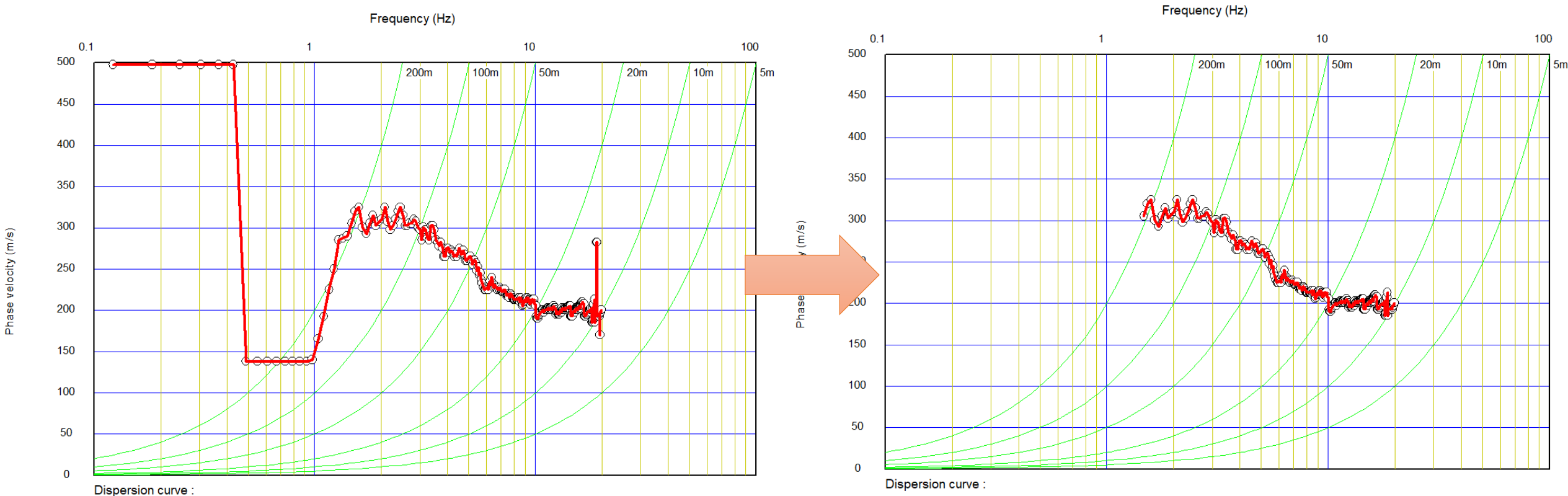
Adjust by  
a mouse



# Editing a dispersion curve in WaveEq


Delete noises or unnecessary frequency range.

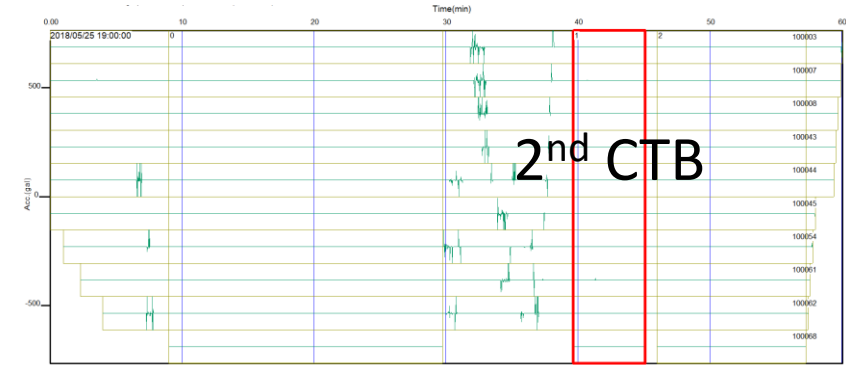
Use  or  to select phase velocities.  
Hit delete key to delete the selected phase velocities.



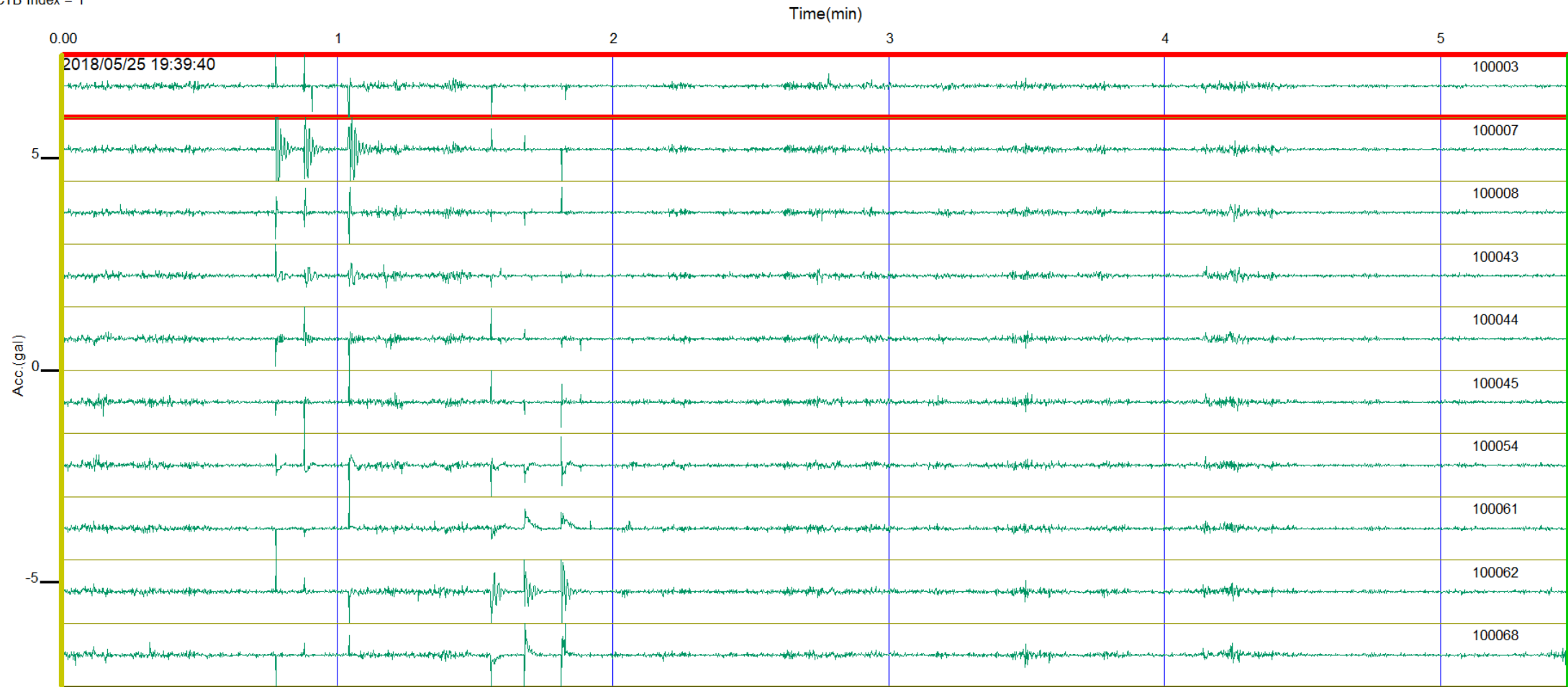
Select [File]>>[Save 1D phase velocity curve or H/V curve (.rst)] to save a dispersion curve to data file.

# Processing active data (MASW)

Click  or select [Window]>>[Processing window] and the selected 2<sup>nd</sup> CTB data (in a red rectangle) will appear in another window.



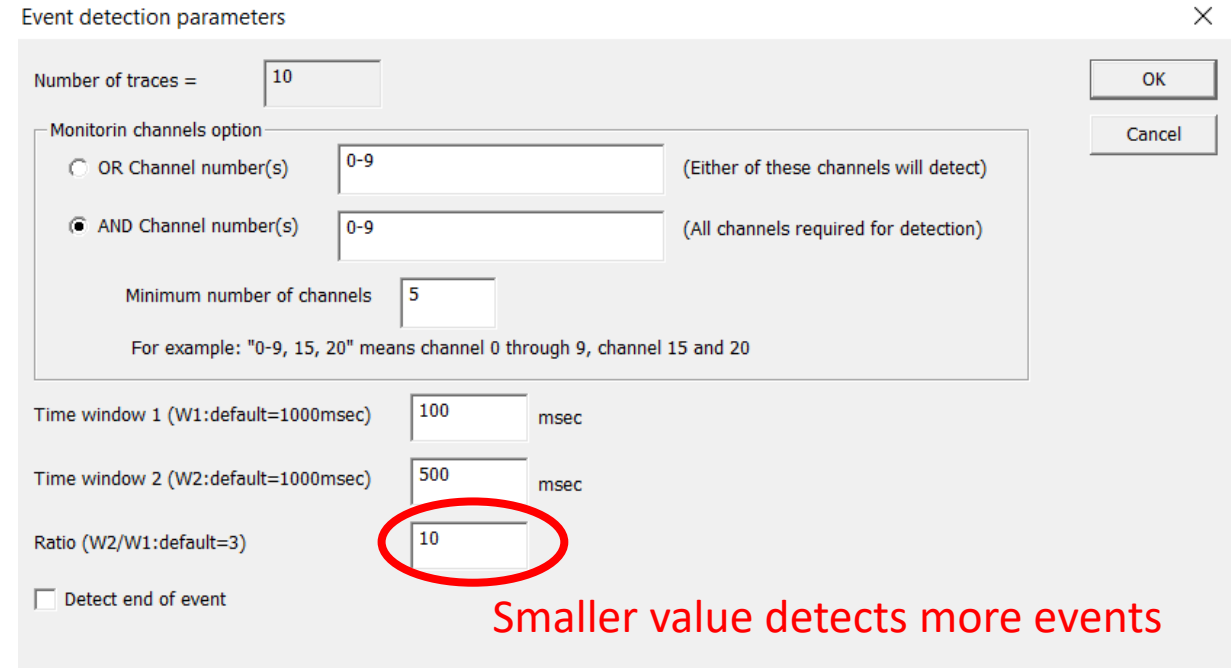
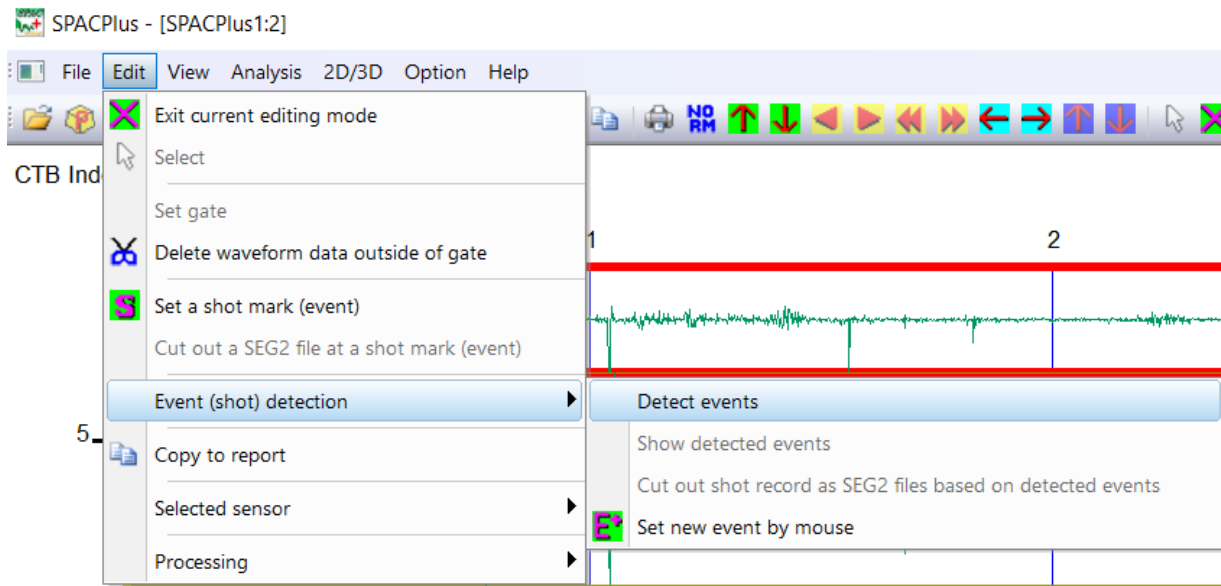
CTB Index = 1





# Detect shots by event detection

Select [Edit]>>[Event (shot) detection]>>[Detect events] and set event detection parameters.



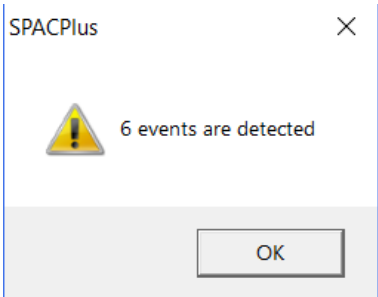
Smaller value detects more events

Click "OK" to detect events (shots).

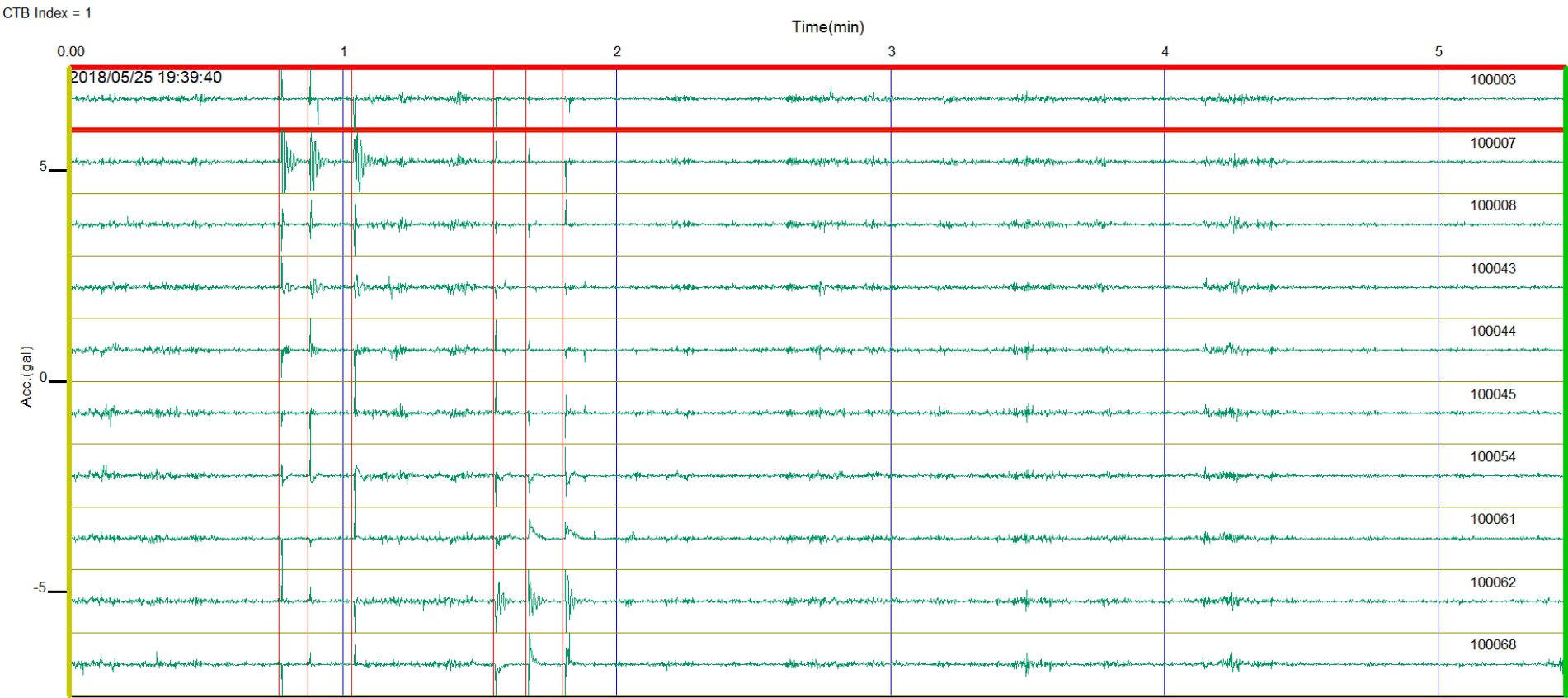


# Detect shots by event detection

Number of detected events appears.



Detected events (shots) are shown . Adjust the settings and repeat the detection until appropriate detections were obtained.

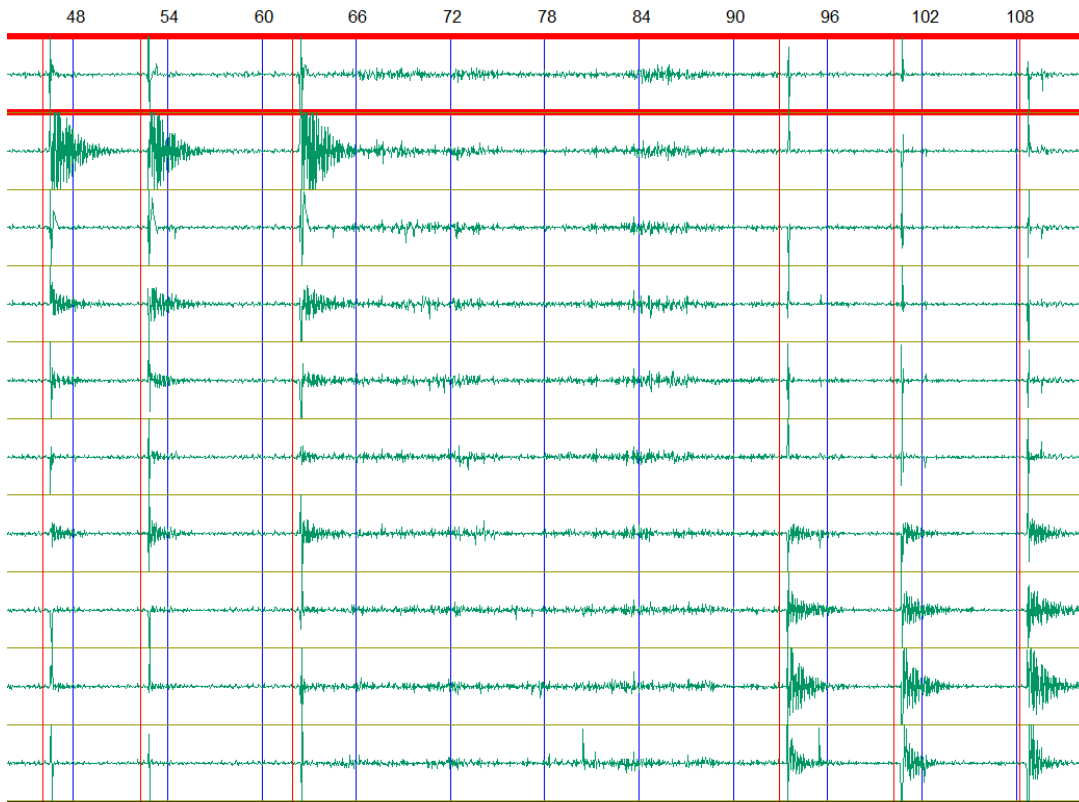


# Edit detected shots

 Change horizontal (time) scale.

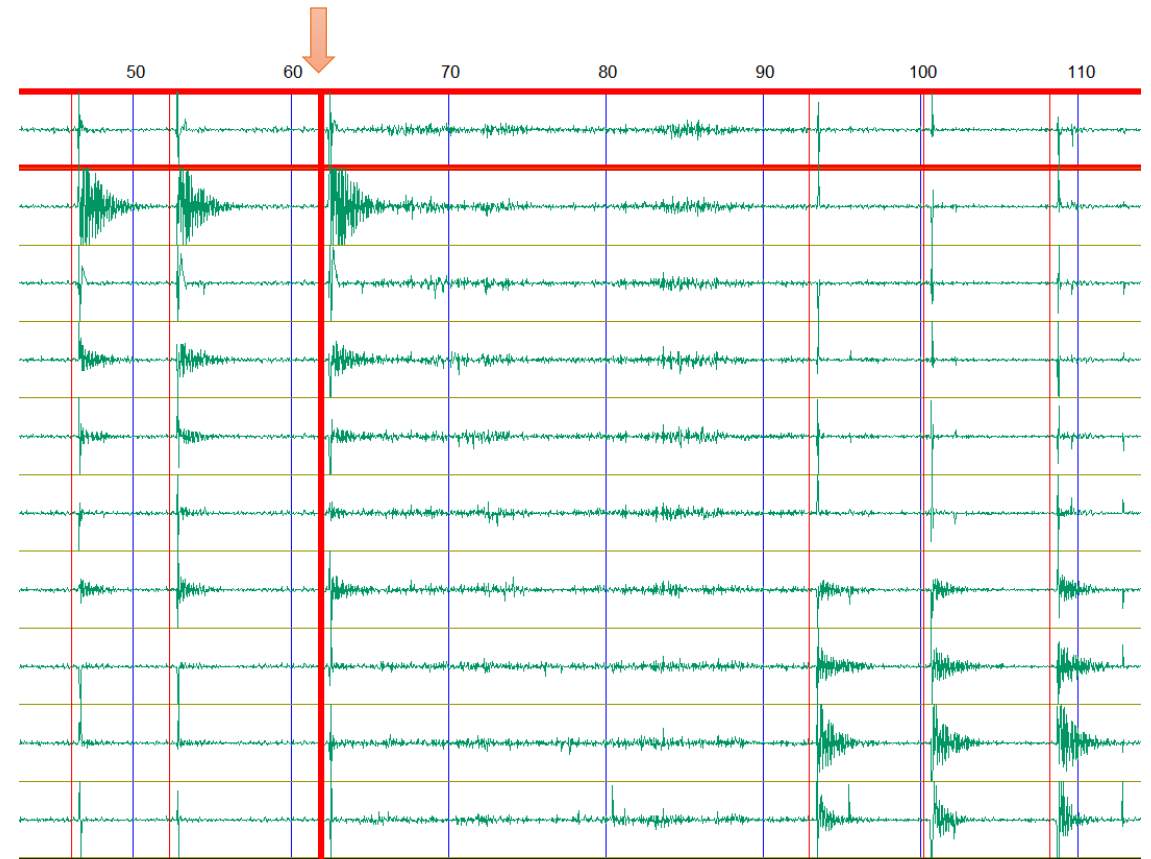
 Change amplitude.

 Add new event by clicking a left button of a mouse.



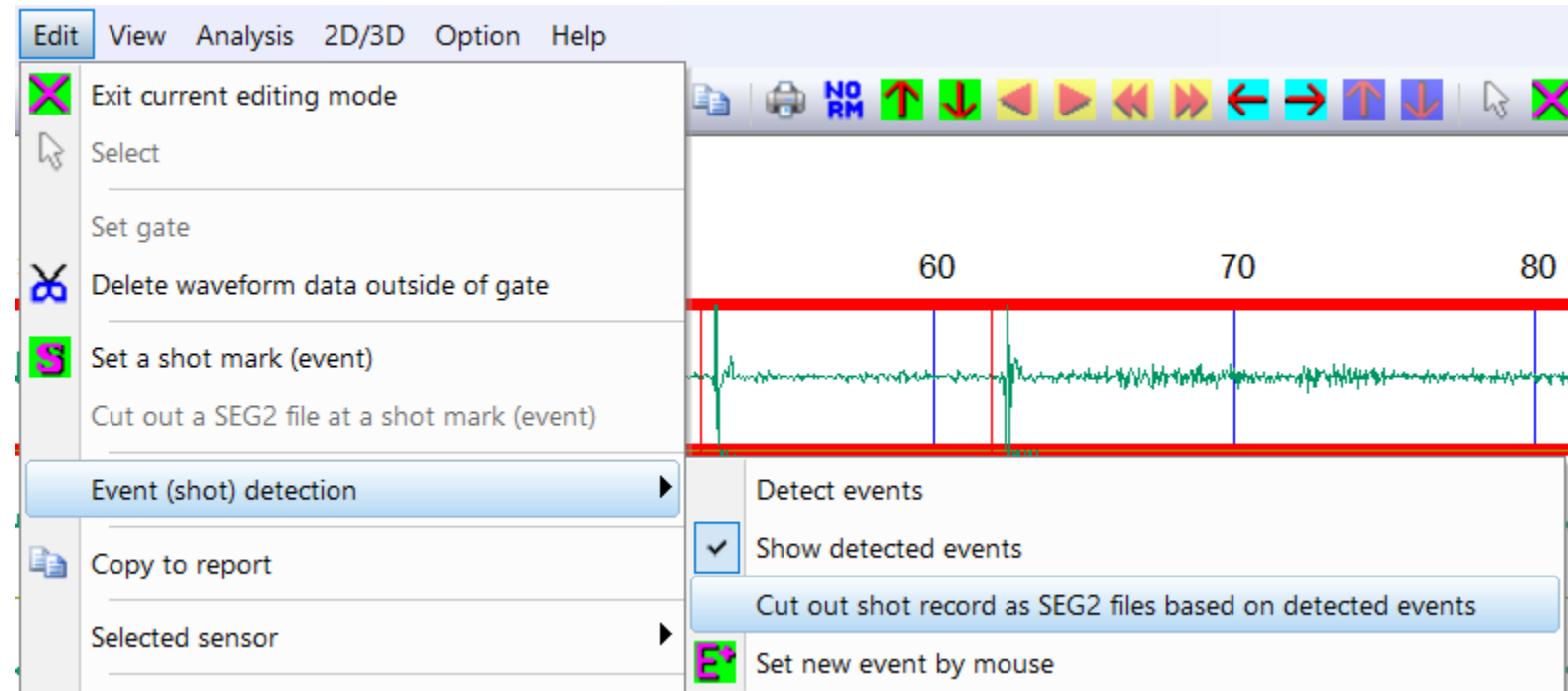
Select a detected event. Selected event is shown as a red bold line.  
Hit delete key to delete the detected event.  
Use a mouse to move the event (left button down).

Selected event

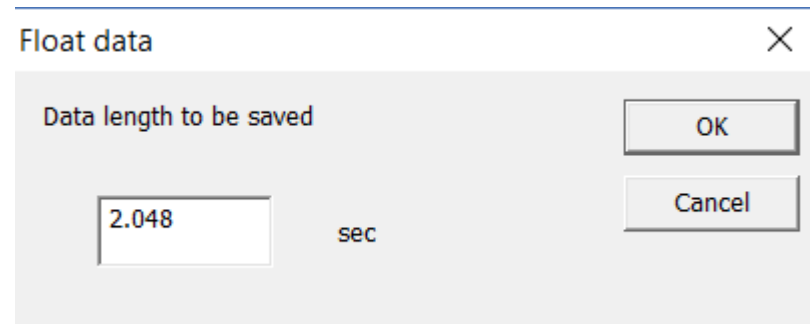


# Show detected shots by Pickwin

Select [Edit]>>[Event (shot) detection]>>[Cut out shot record as SEG2 files based on detect events].

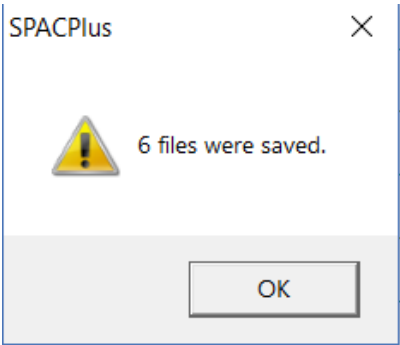


Enter data length.









# Shot records are saved as SEG2 files

Number of saved files appears.



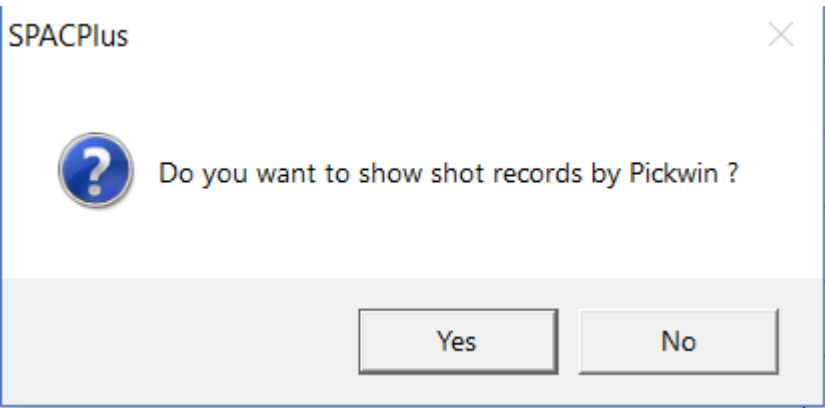
Shot records were saved as SEG2 files (.sg2) in a folder being selected.

 event_0000.sg2	5/28/2018 5:30 PM	SG2 File	30 KB
 event_0001.sg2	5/28/2018 5:30 PM	SG2 File	30 KB
 event_0002.sg2	5/28/2018 5:30 PM	SG2 File	30 KB
 event_0003.sg2	5/28/2018 5:30 PM	SG2 File	30 KB
 event_0004.sg2	5/28/2018 5:30 PM	SG2 File	30 KB
 event_0005.sg2	5/28/2018 5:30 PM	SG2 File	30 KB

A shot and file list was saved in an XML file.

 EventList.xml	5/28/2018 5:30 PM	XML Document	3 KB
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Click “Yes” to continue the processing.



```
<?xml version="1.0" encoding="SHIFT_JIS"?>
- <line>
  <line_name>line_name</line_name>
  <line_id>0</line_id>
  <sxw_menu>0</sxw_menu>
  <geometry_information>4</geometry_information>
  <data_information>0</data_information>
  <file_type>0</file_type>
  <apply_source_position>0</apply_source_position>
  <apply_receiver_position>0</apply_receiver_position>
- <file_list>
  - <file>
    <file_name>event_0000.sg2</file_name>
    <id>0</id>
    <file_type>0</file_type>
    <shot_distance>0.000000</shot_distance>
    <first_receiver>0.000000</first_receiver>
    <receiver_interval>1.000000</receiver_interval>
    <number_of_auxiliary>0</number_of_auxiliary>
    <i_source_component>2</i_source_component>
    <start_date_time>2018/5/25 19:40:26.035</start_date_time>
  </file>
  + <file>
  + <file>
  + <file>
  + <file>
  + <file>
  + <file>
  </file_list>
</line>
```

# Set up geometry

A list of shot records appear in a dialog box. Set up source location, receiver interval etc.

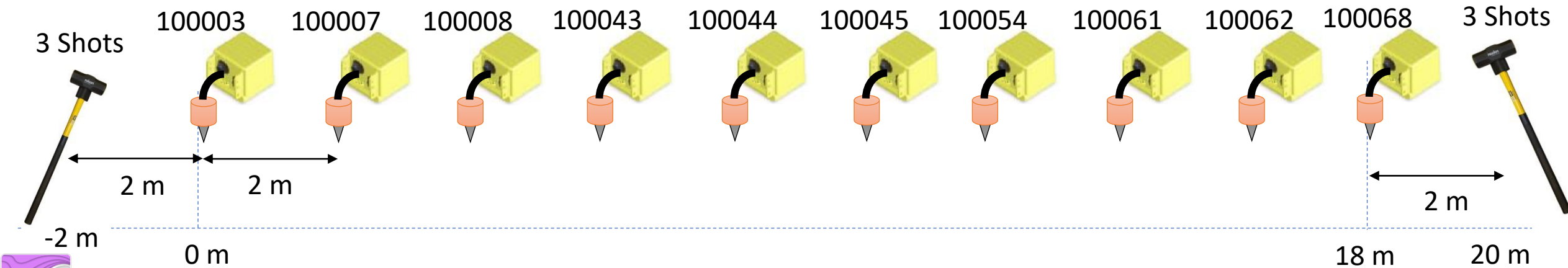
File list

Index	Edit	ID	Source (m)	1st receiver (m)	Receiver int. (m)	# of aux.	
0	<input type="checkbox"/>	0	-2	0	2	0	2018/5/25 19:40:26.035
1	<input type="checkbox"/>	1	-2	0	2	0	2018/5/25 19:40:32.268
2	<input type="checkbox"/>	2	-2	0	2	0	2018/5/25 19:40:41.967
3	<input type="checkbox"/>	3	20	0	2	0	2018/5/25 19:41:12.968
4	<input type="checkbox"/>	4	20	0	2	0	2018/5/25 19:41:20.195
5	<input type="checkbox"/>	5	20	0	2	0	2018/5/25 19:41:28.236

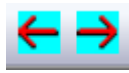
☐ Apply source coordinates from file header    ☒ Active data  
☐ Apply receiver coordinates from file header    ☐ Passive data

Number of files: 6

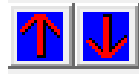
OK  
Cancel  
Next  
Back  
Set up  
Set # of aux.  
Delete  
Export  
Import



# Individual shot record shown by Pickwin



Change horizontal (time) scale.



Change distance scale.

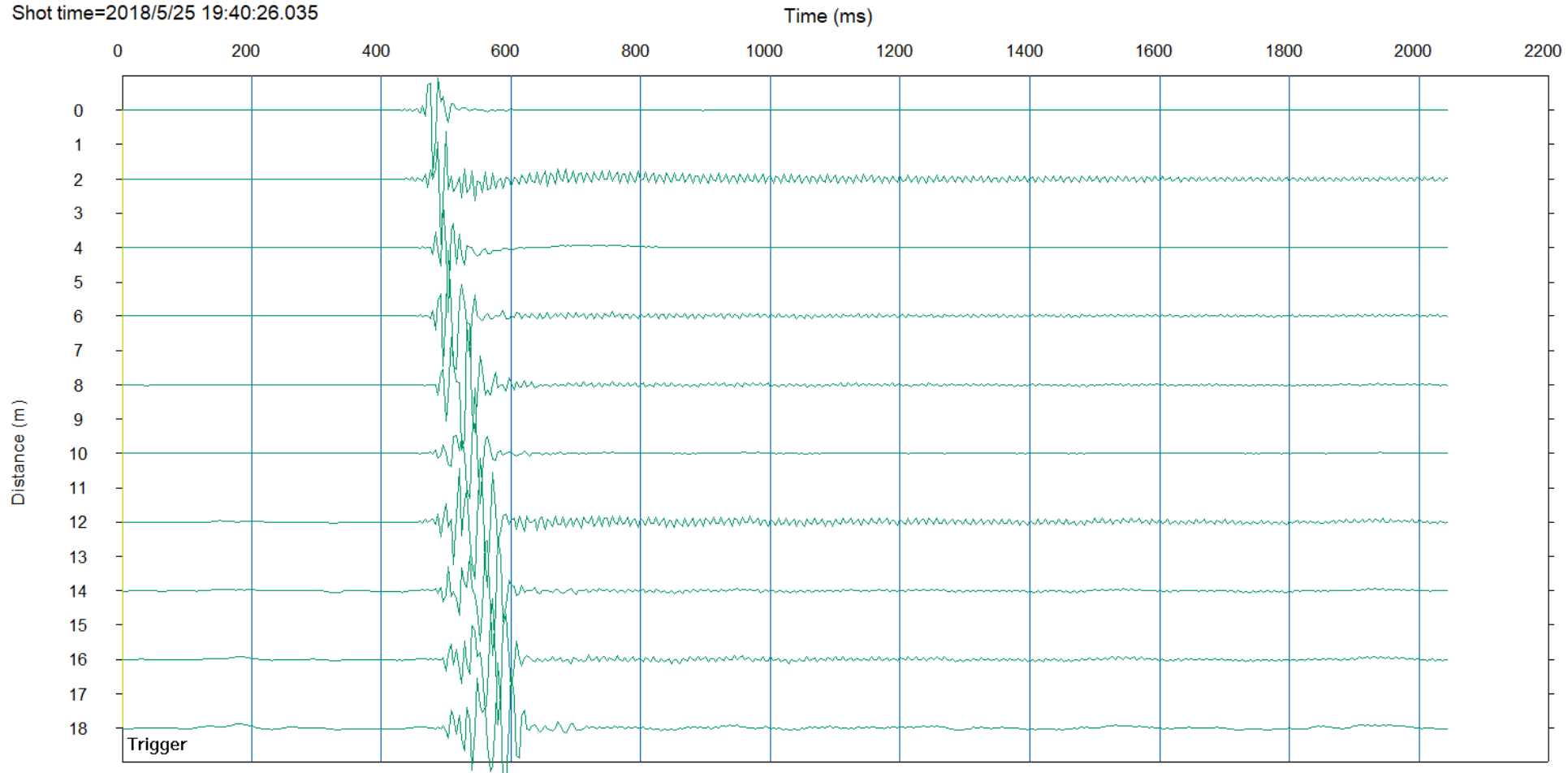


Change amplitude.



Scroll shot records.

Shot time=2018/5/25 19:40:26.035



# Transform to phase velocity image in frequency domain

Select [Surface wave analysis]>>[Phase velocity frequency transformation] or press “Ctrl+D” to transform data to a phase velocity image in frequency domain.

Set up max. phase velocity and max. frequency.

Phase velocity-frequency transformation

Phase velocity

Start  m/s

☒ End  m/s

Up

Down

OK

Cancel

Advanced menu

Frequency

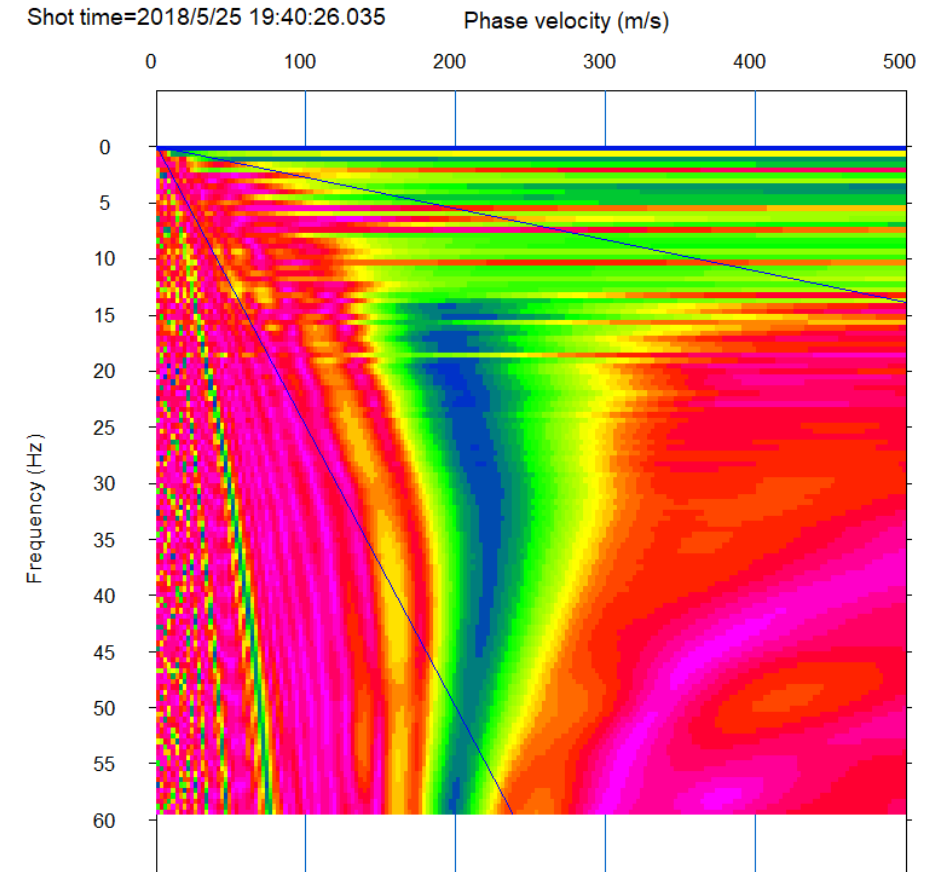
Start  Hz

☐ End  Hz

Up

Down

A phase velocity image in frequency domain appears.



# Pick phase velocities

Select [Surface wave analysis]>>[Pick phase velocity (1D)] and set up parameters.

Click “Advanced menu” to set up detailed parameters.

Min. and Max. frequency

Minimum Frequency 5 Hz

Maximum Frequency 60 Hz

☒ Use median filter

# of sample for median filter = 5

Setup

☐ Wavelength limitation

Maximum wavelength 2 times

Minimum wavelength 2 times

Setup min. and max. phase velocity

Minimum phase velocity = 35 m/s

Maximum phase velocity = 500

Setup area for phase-velocity picking

☐ Use current phase-velocity as minimum velocity for picking

Phase-velocity area 100 m/s

Check off if you want to pick all frequency range

Change minimum phase velocity to be picked depending on data

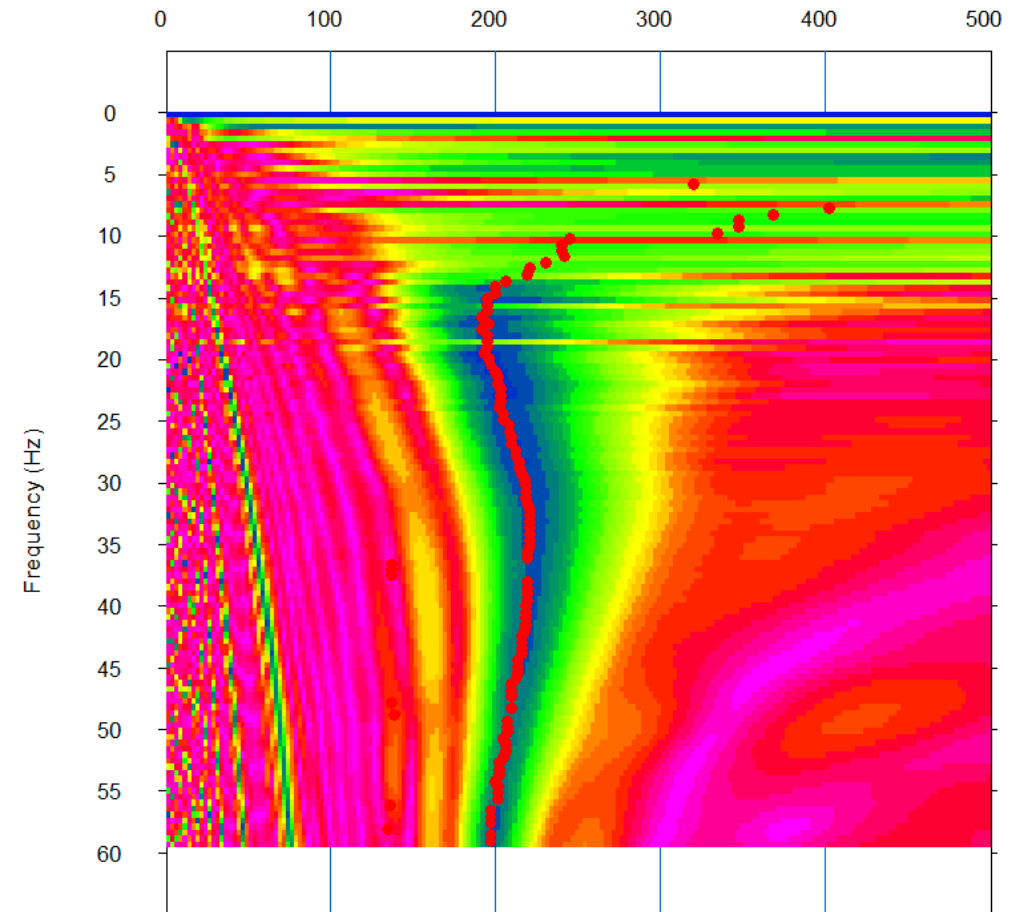
Picked phase velocities appear on a phase velocity image in frequency domain.

Click left mouse button to move one pick or drag to move a range of picks.

Click left mouse button to move one pick or drag to move a range of picks.

Shot time=2018/5/25 19:40:26.035

Phase velocity (m/s)





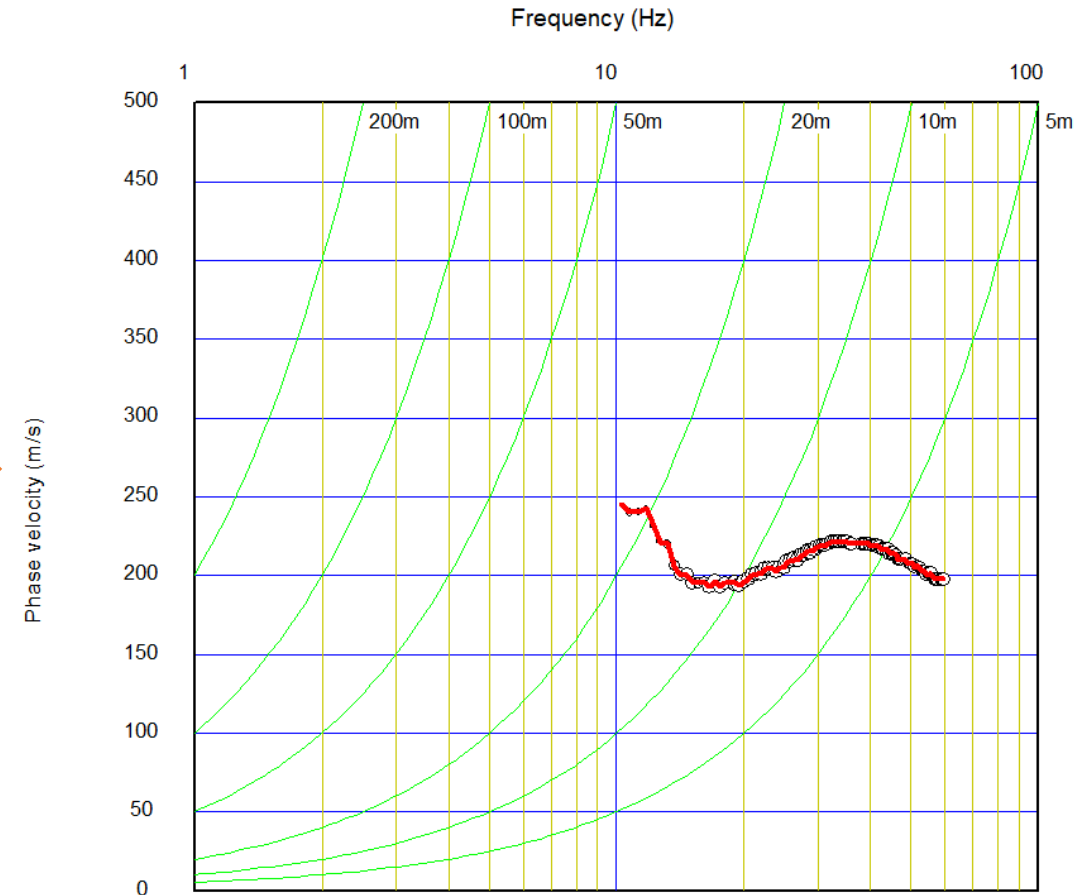
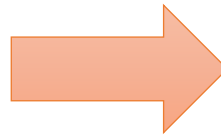
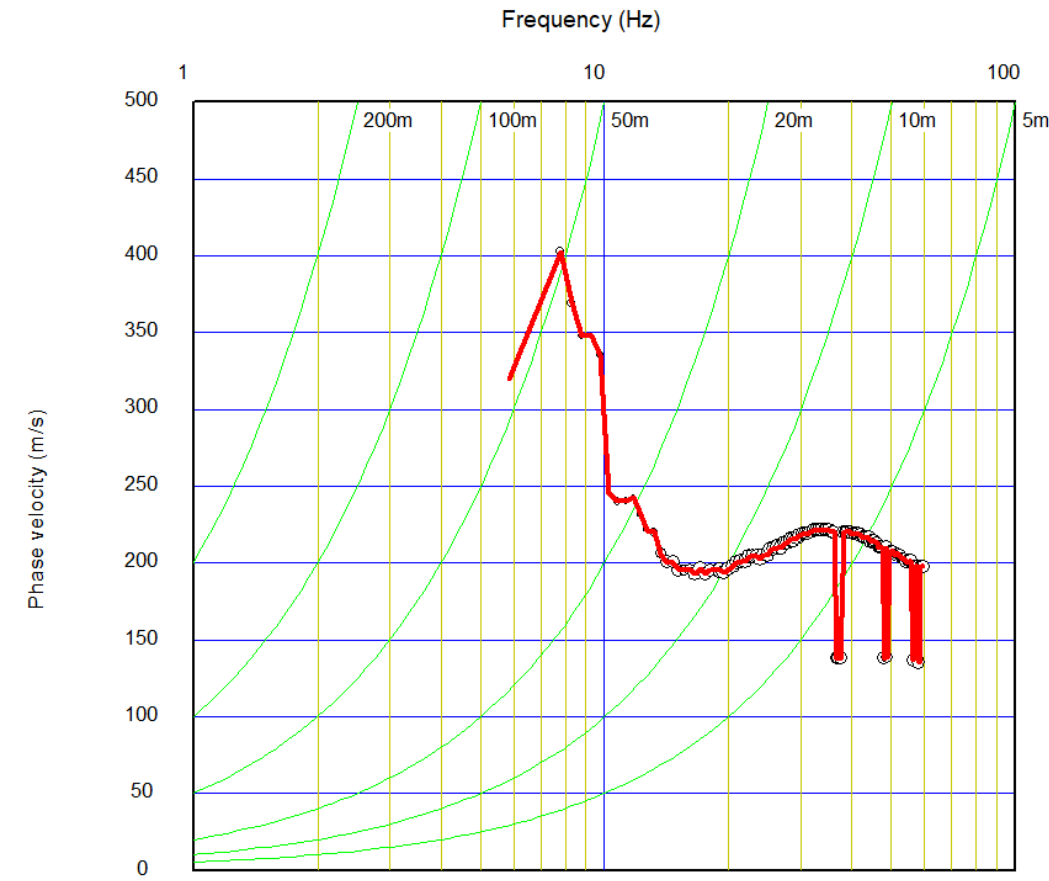
Select [Surface wave analysis]>>[Show phase velocity curve (1D) <Launch WaveEq>].



# Editing a dispersion curve in WaveEq

Delete noises or unnecessary frequency range.

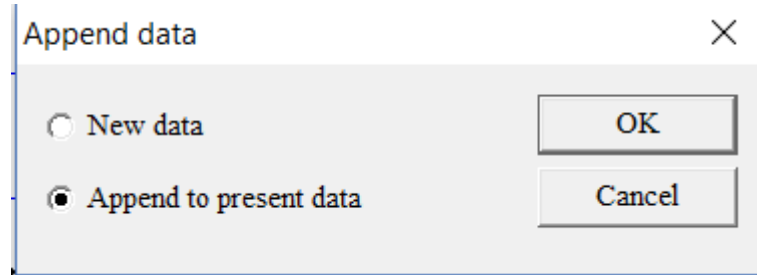
Use  or  to select phase velocities.  
Hit delete key to delete the selected phase velocities.



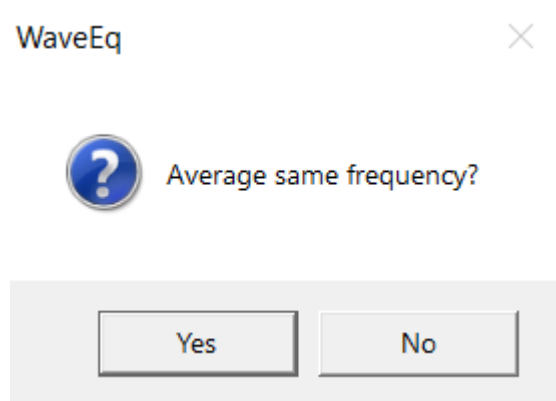
Select [File]>>[Save 1D phase velocity curve or H/V curve (.rst)] to save a dispersion curve to data file.

# Combine active and passive dispersion curves

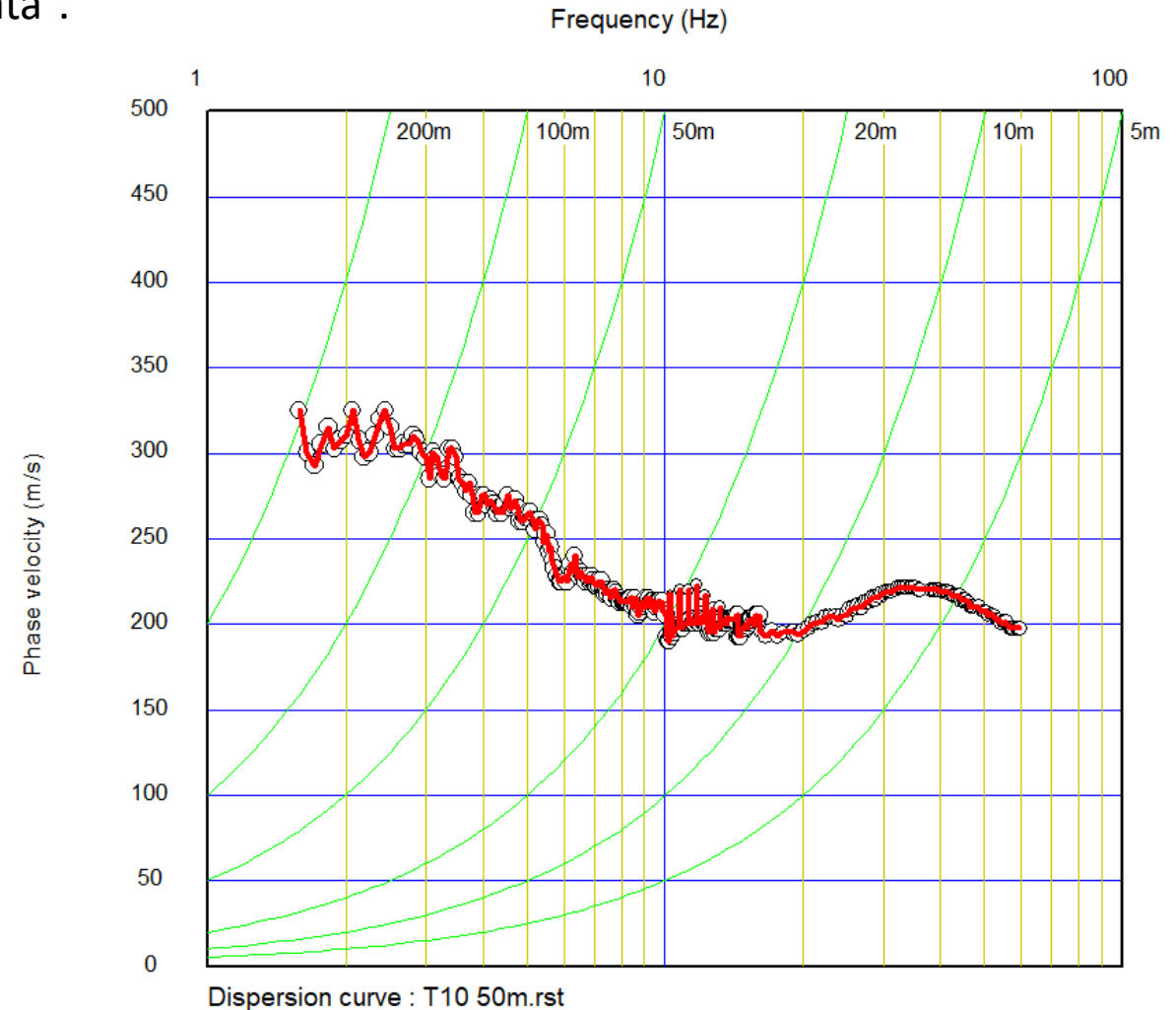
Select [File]>>[Open 1D phase velocity curve or H/V curve (.rst)].  
Select a passive data file (.rst) and choose “Append to present data”.



Data will be automatically averaged if “Yes” is chosen.  
Choose “No” if you want do not want to average automatically.




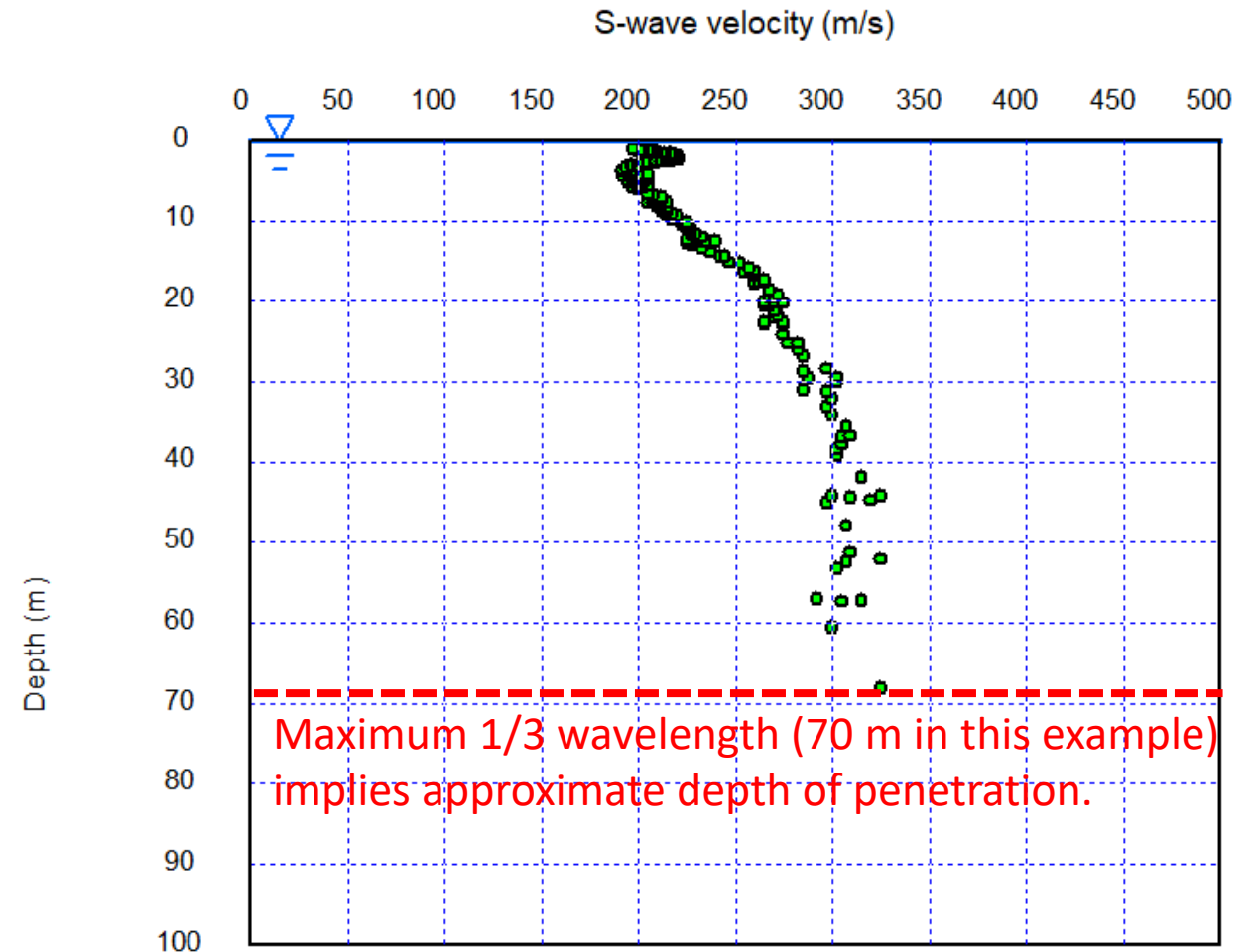
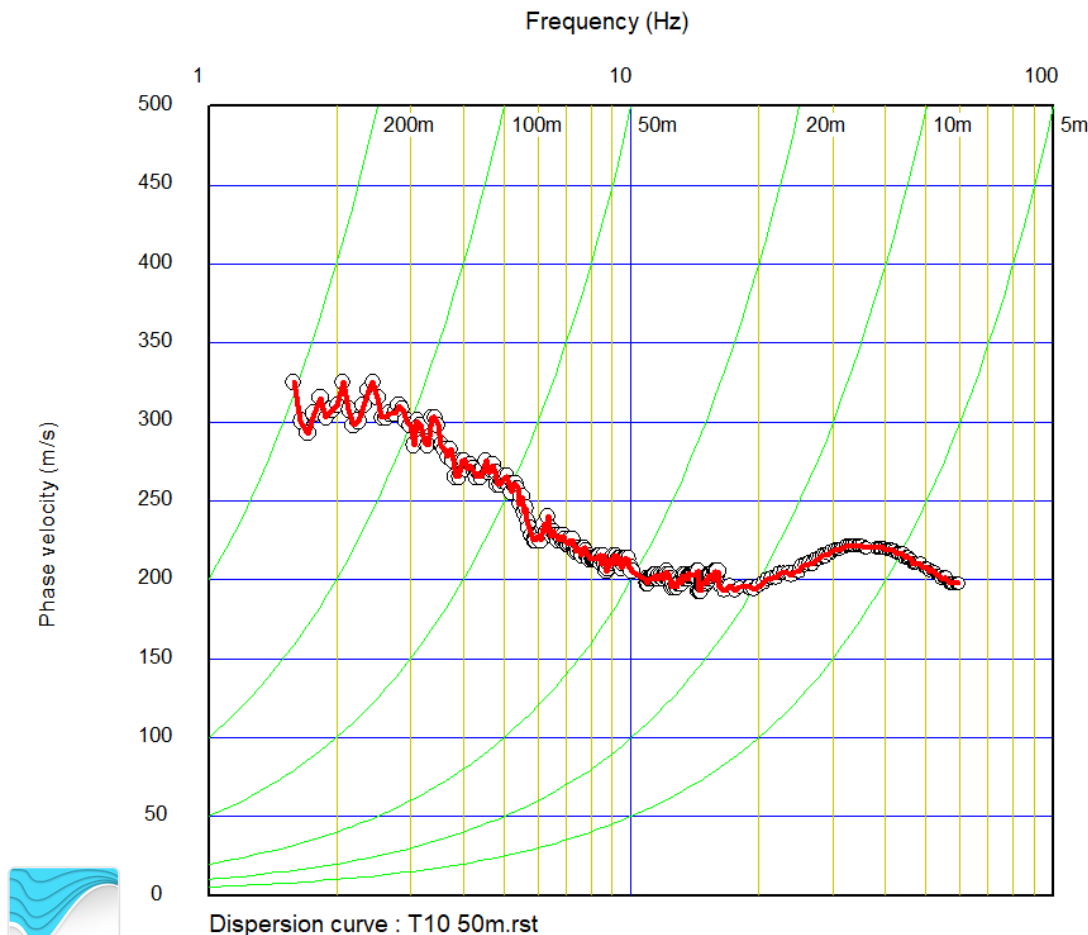
Active and passive phase velocities are shown together.



# Editing active and passive dispersion curves in WaveEq

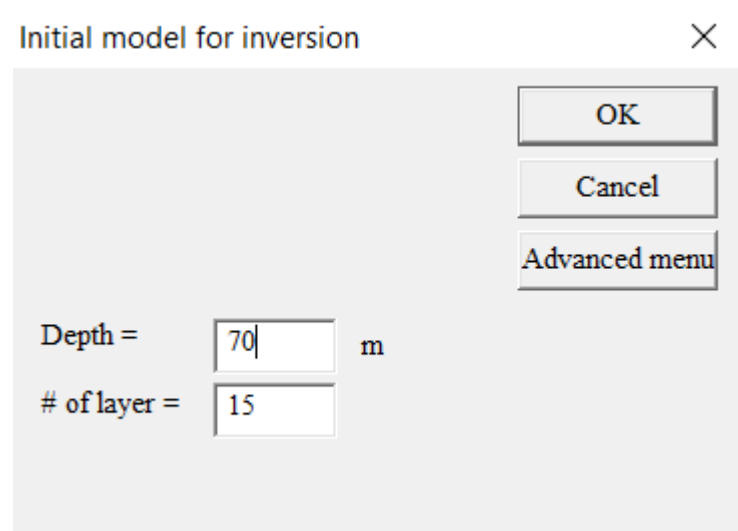
Delete noises or unnecessary frequency range.

Click  to evaluate approximate depth of penetration. Green circles indicates 1/3 wave length.



# Initial model

Select [Surface wave analysis]>>[MASW (1D)]>>[Initial model] to built an initial model.  
Set “Depth” based on a penetration depth implied by 1/3 wave length for example.



Initial model for inversion

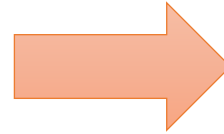
OK

Cancel

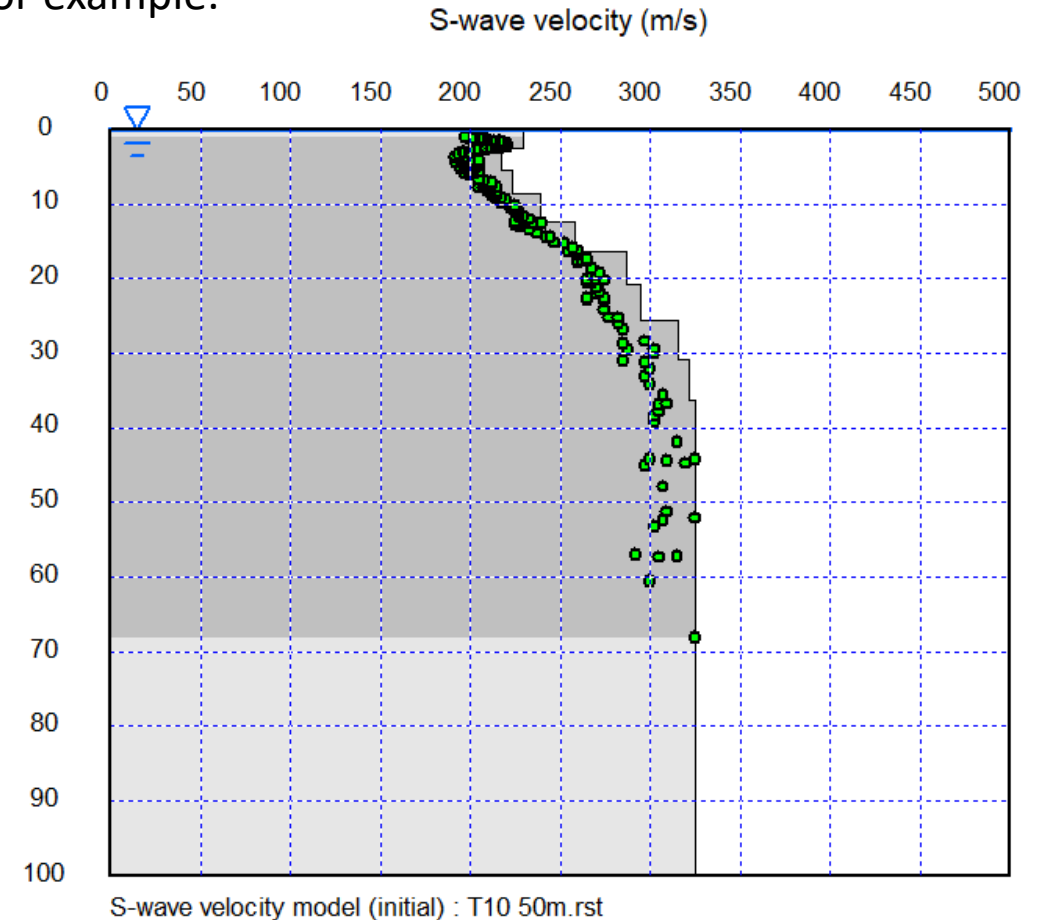
Advanced menu

Depth =  m

# of layer =



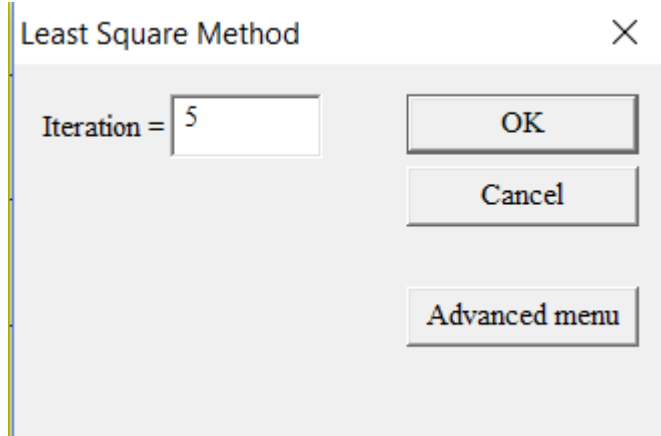
Depth (m)



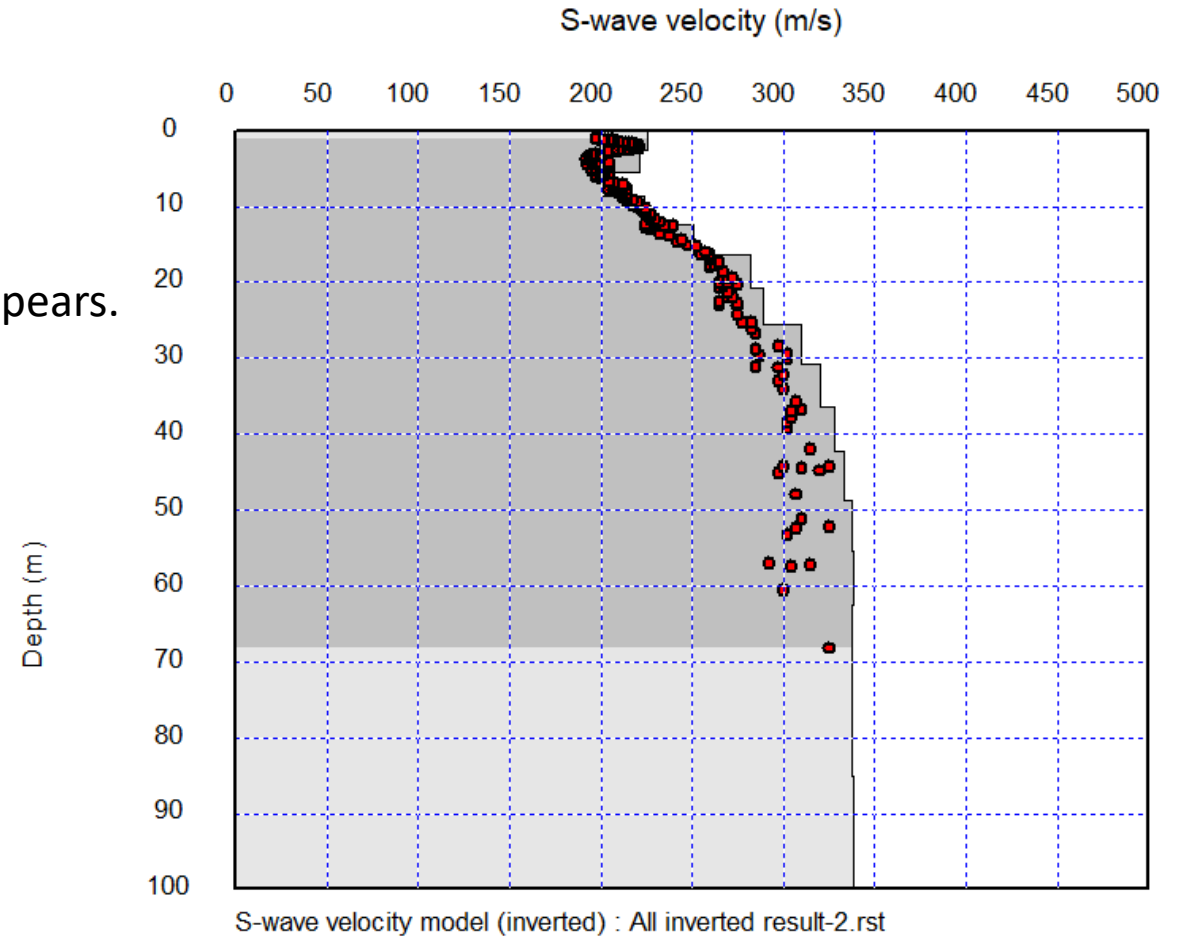
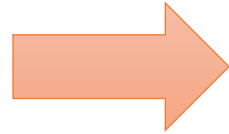
Refer “SeisImager/SW™ Manual” and “SeisImager/SW-Pro™ Manual”  
for the detaile of inversion of dispersion curves from this point.

# Inversion

Select [Surface wave analysis]>>[MASW (1D)]>>[Inversion (LSM)] to apply inversion.  
Set number of iteration and click OK.





Inverted result appears.



# Inversion

Click  to show a theoretical dispersion curve.

Observed   
Theoretical 

RMSE = 9.471599 m/sec

