4. Data acquisition

- Cableless seismograph and 2 Hz geophone
- General rule of thumb about active and passive surface wave measurements
- Shallow passive data acquisition using cableless seismograph
- Active data acquisition using cableless seismograph
- Deep passive data acquisition using cableless seismograph
- H/V
- Quality control

6. Data acquisition

- Cableless seismograph and 2 Hz geophone
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- Quality control

Cableless seismograph Atom : 1C and 3C

1C

3C

Simple acquisition - No laptop required

Turn on Atom

Push power button

Autonomous recording

No laptop required !

Turn off Atom

Push power button

Low energy consumption - Operates up to 70 hours in the field between charges!

1C : 70 hours with internal battery

External power from USB operates forever

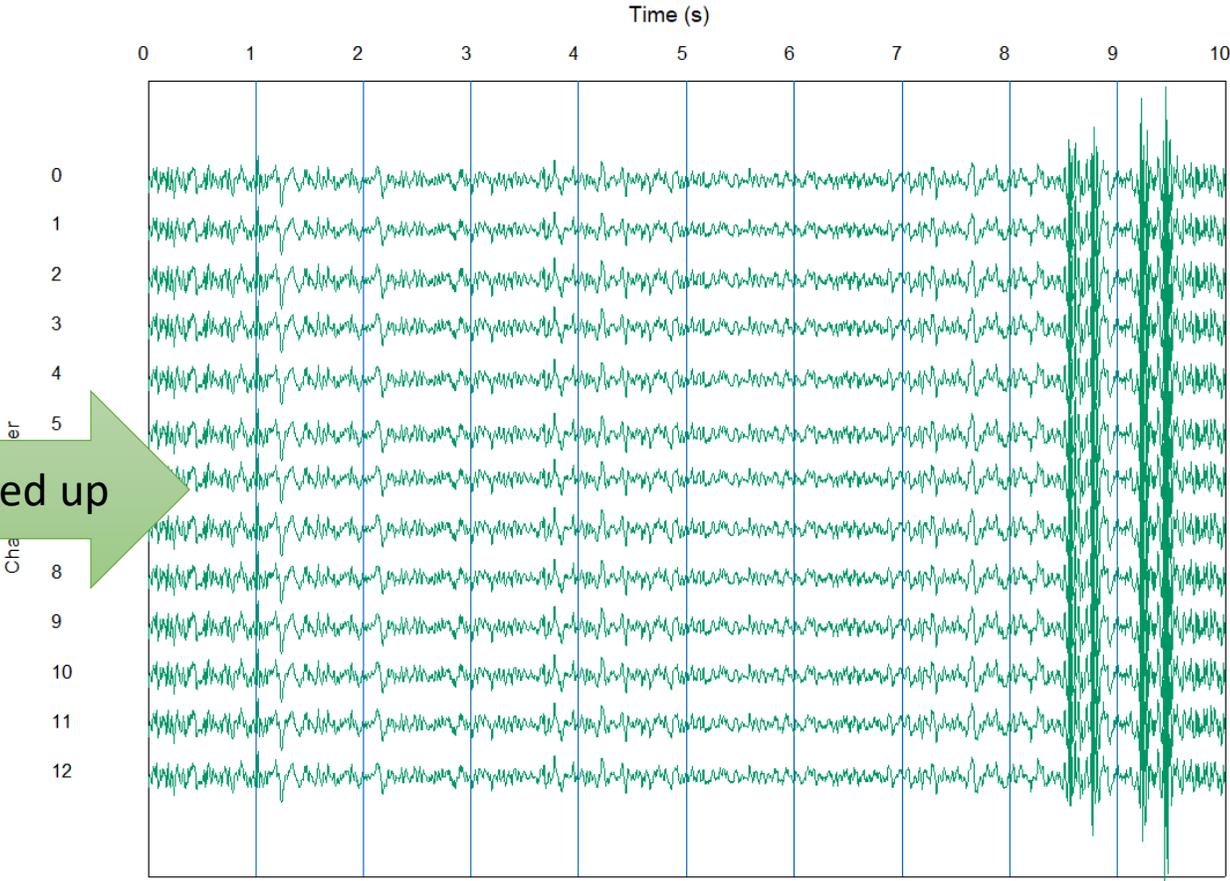3C : 45 hours with internal battery
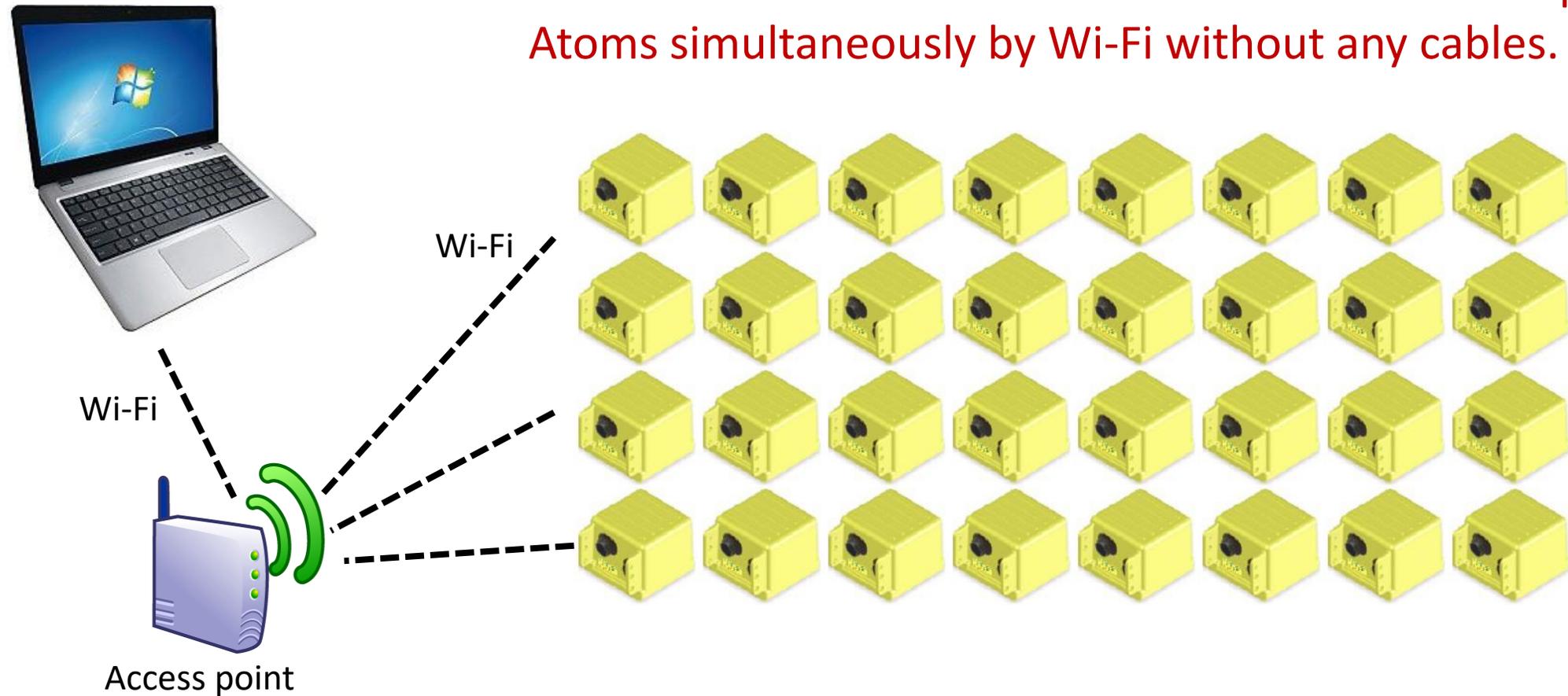
GPS time synchronization – Cable free!

Huddle test

Lined up

Wireless downloading – Cable free!

Geometrics' Atom downloader can download data from up to 50 Atoms simultaneously by Wi-Fi without any cables.
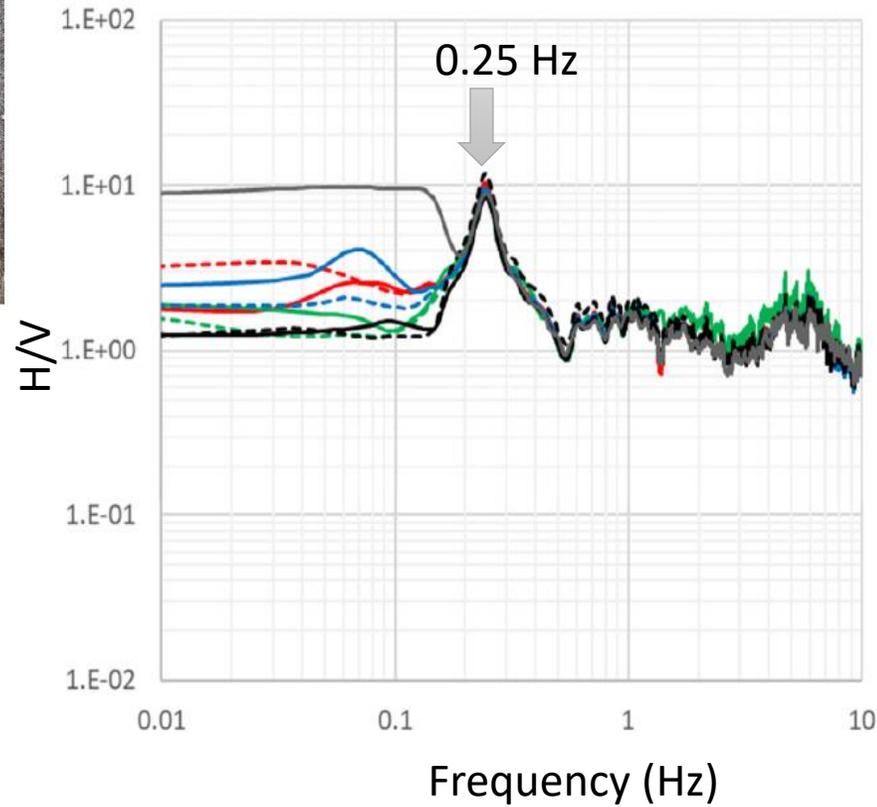
Wi-Fi

Wi-Fi

Access point

Comparison with broadband sensors
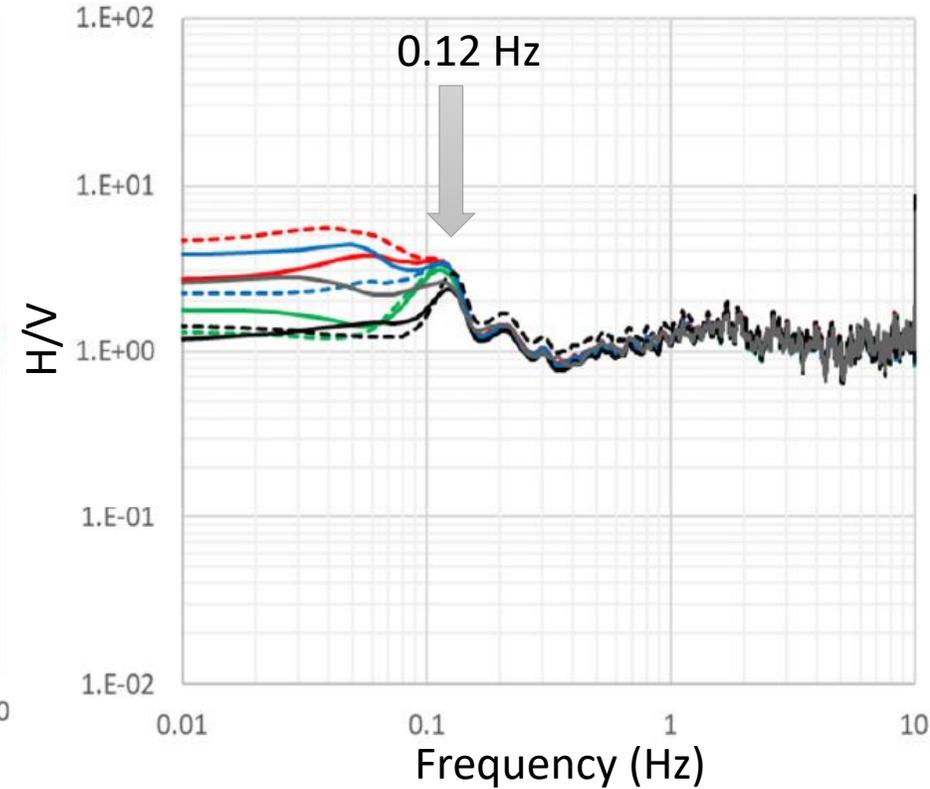
6. Data acquisition

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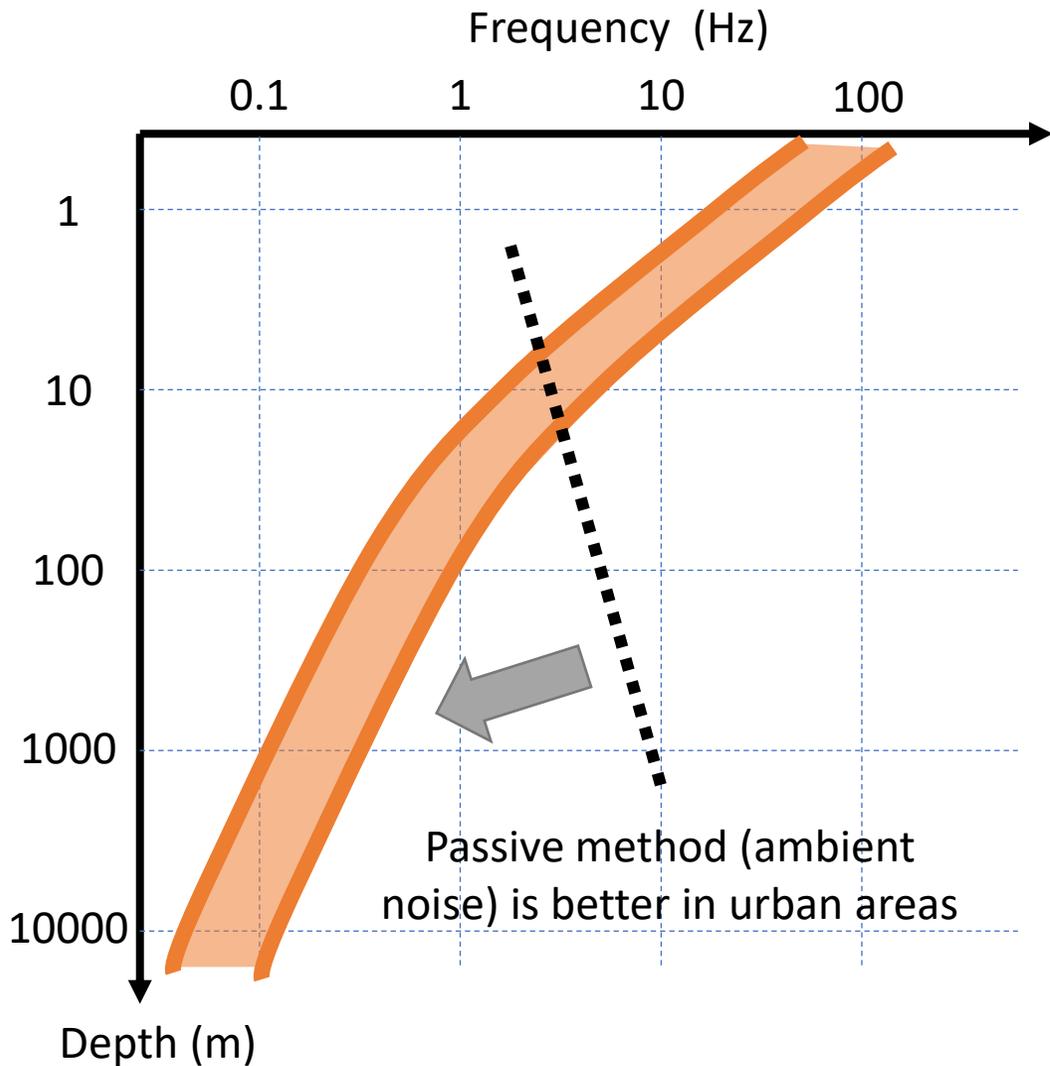Several important equations
in active and passive surface wave methods

Wavelength = Phase velocity/Frequency

Depth = Wavelength/3

Phase velocity ≃ S-wave velocity
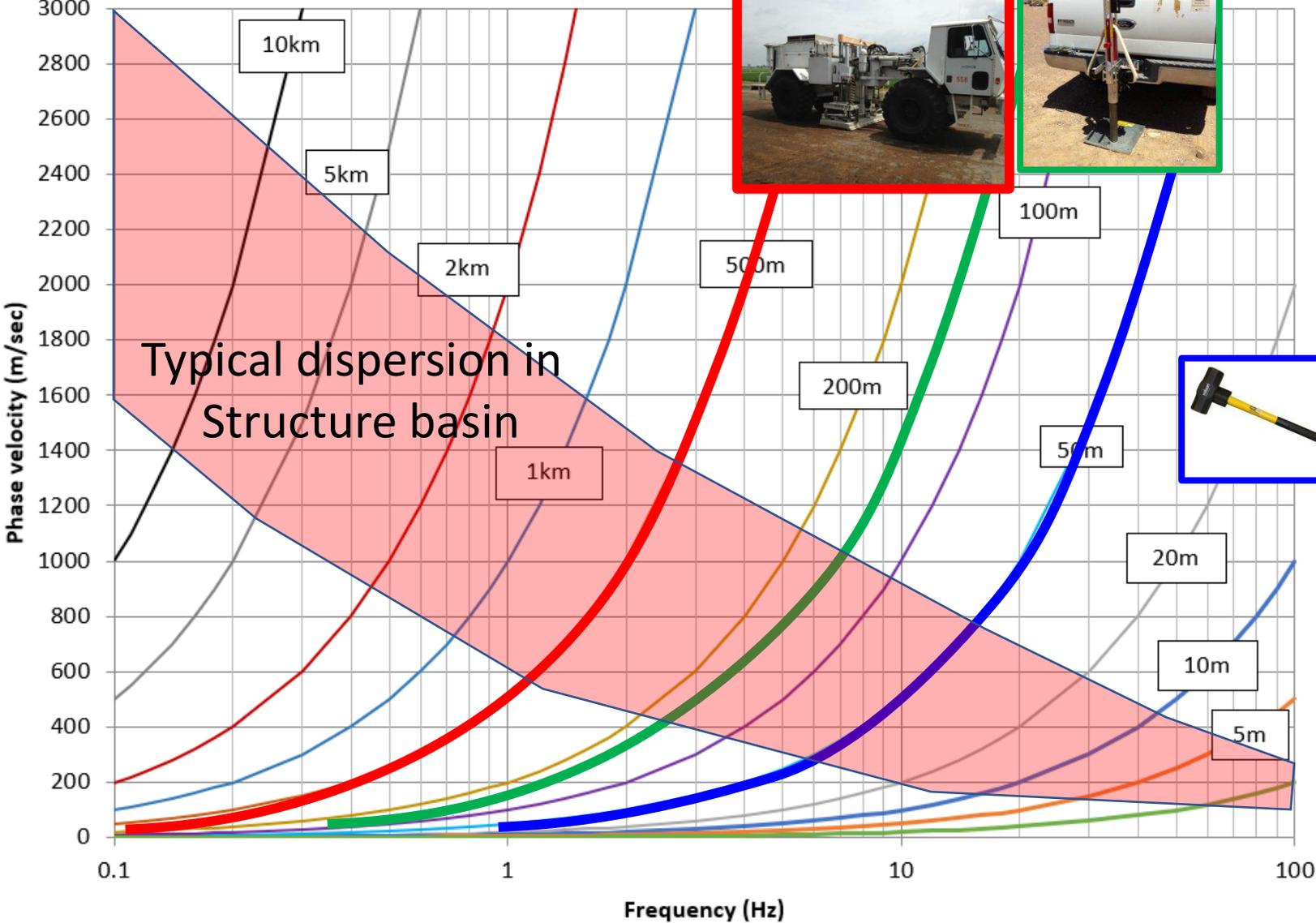
Why ambient noise ?

Penetration depth and frequency of interest in surface wave method

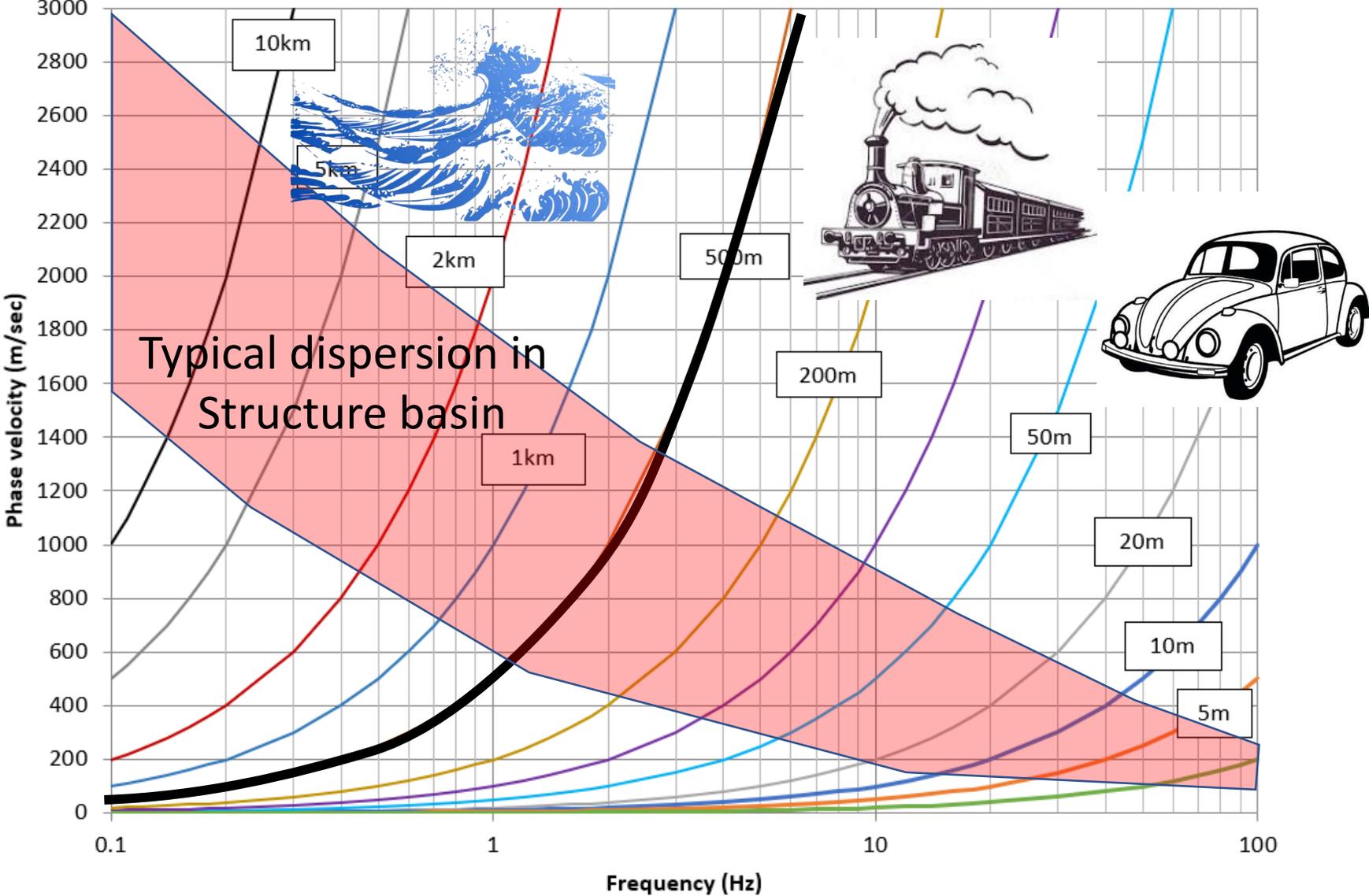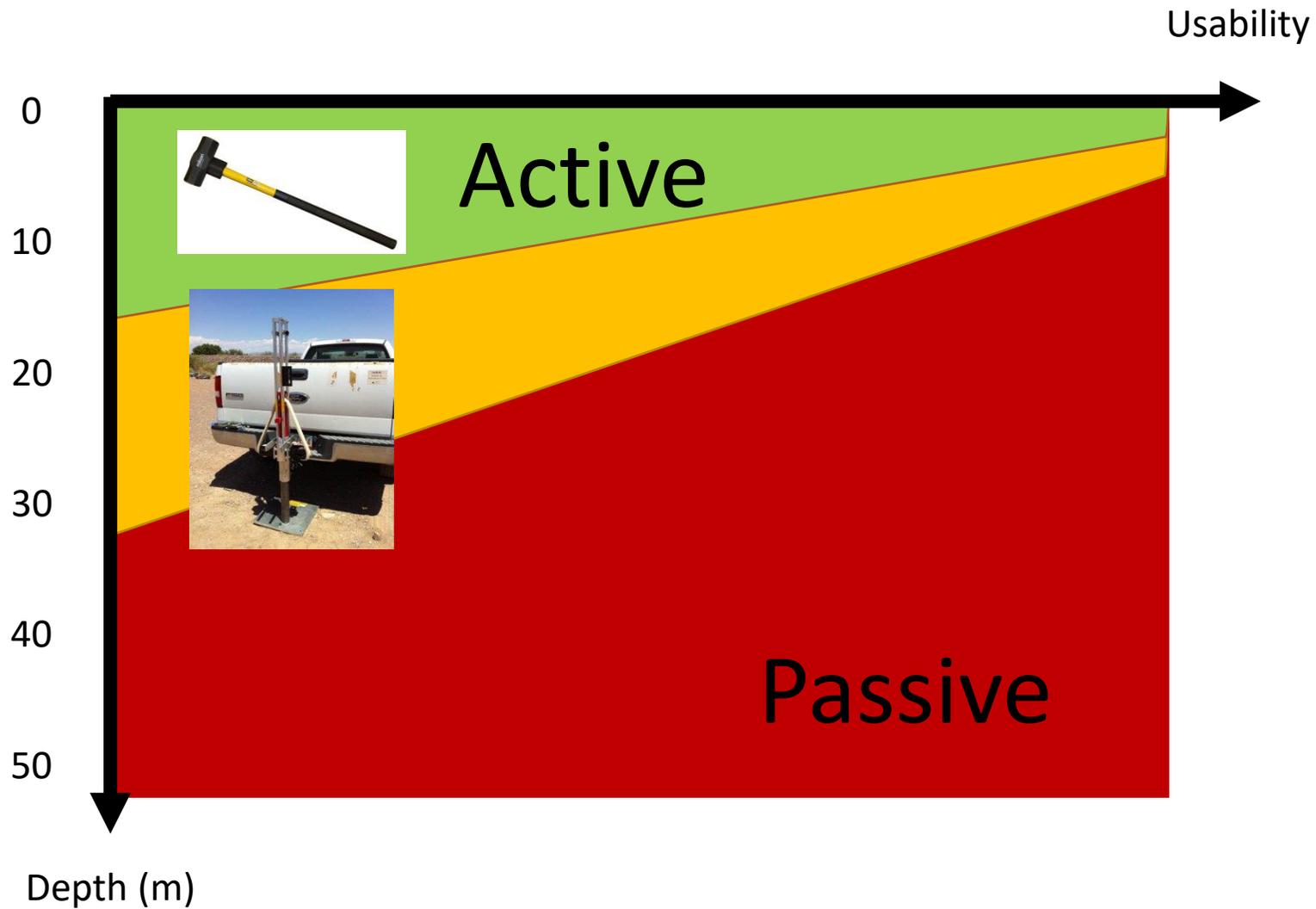*Typical frequency range of active and passive surface waves from various sources*

Passive method (ambient noise) is better in urban areas
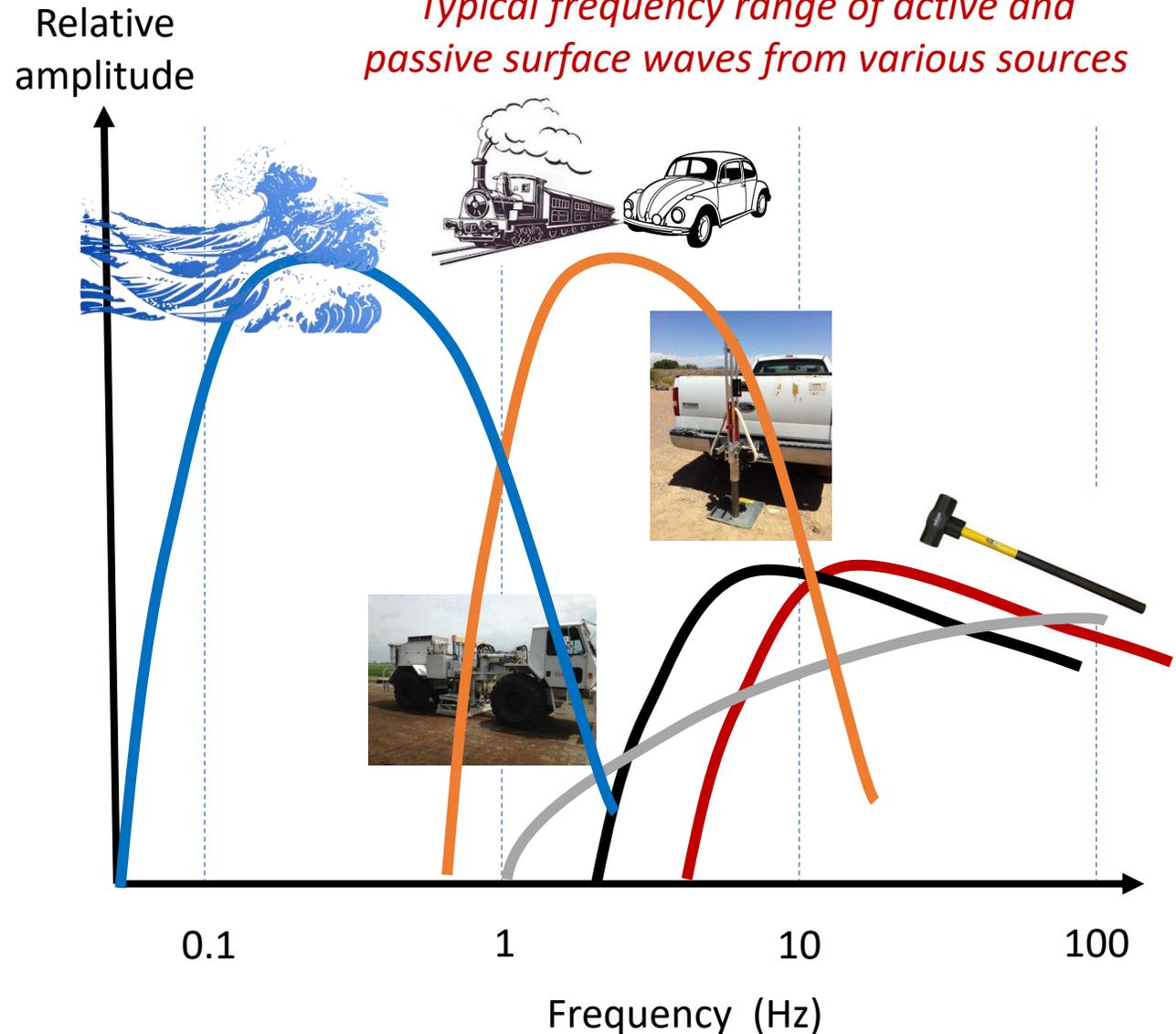
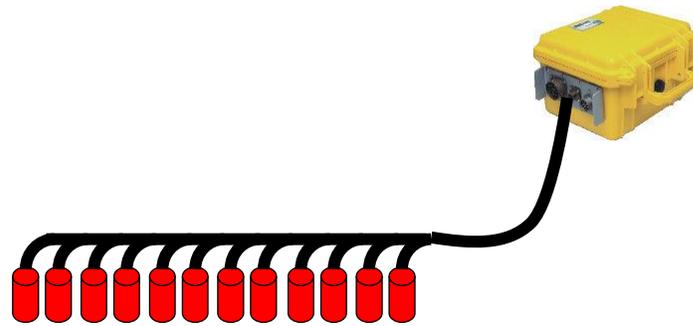# Surface wave sources : Active

Surface wave sources : Active

4. Data acquisition

Active or Passive ?

Array size

Active

Passive
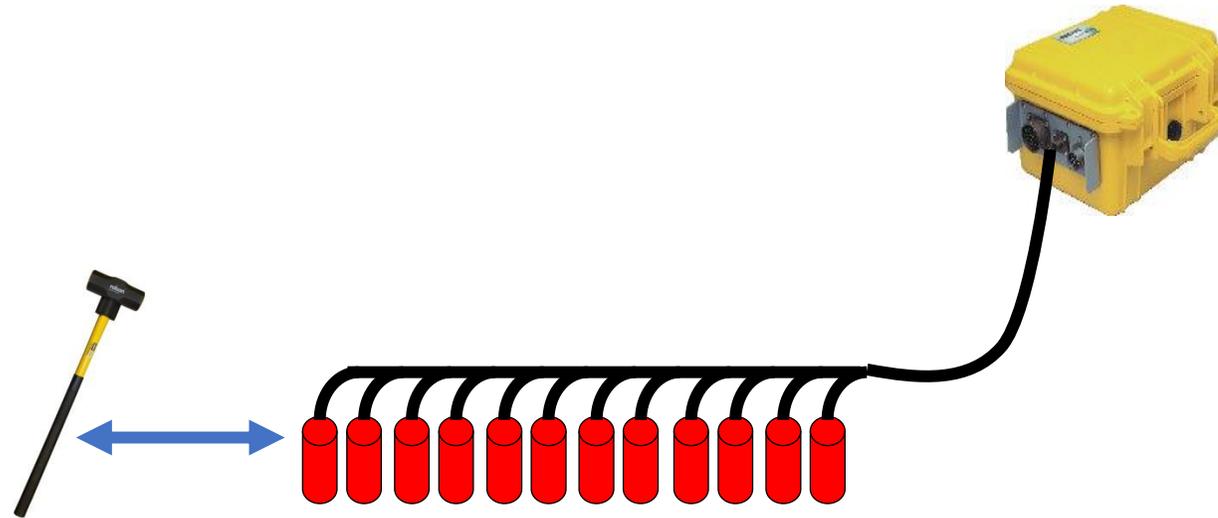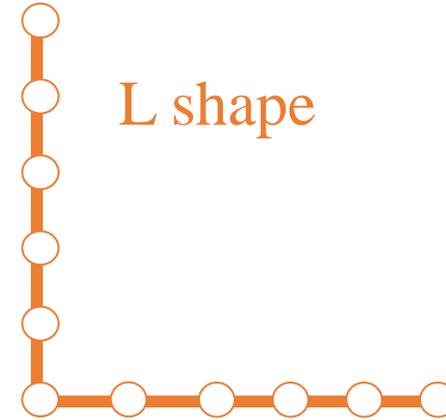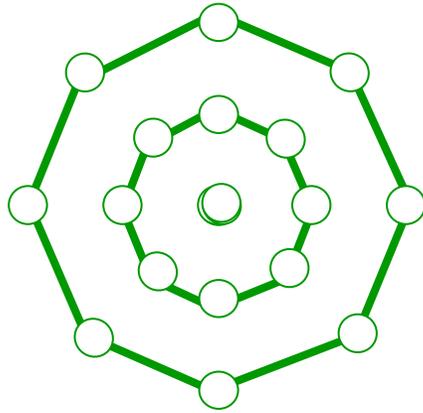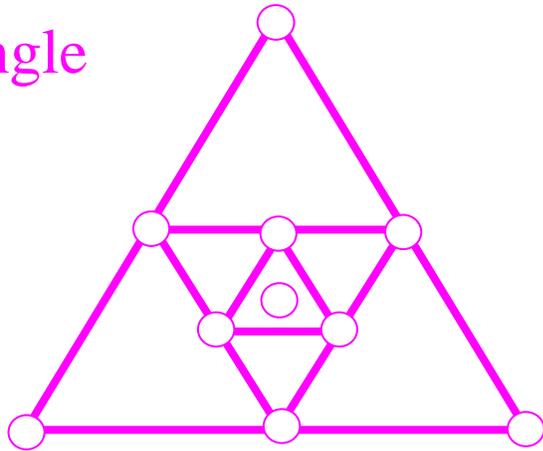

Depth=Array size/2

Depth=Array size

Active : Source offset ?
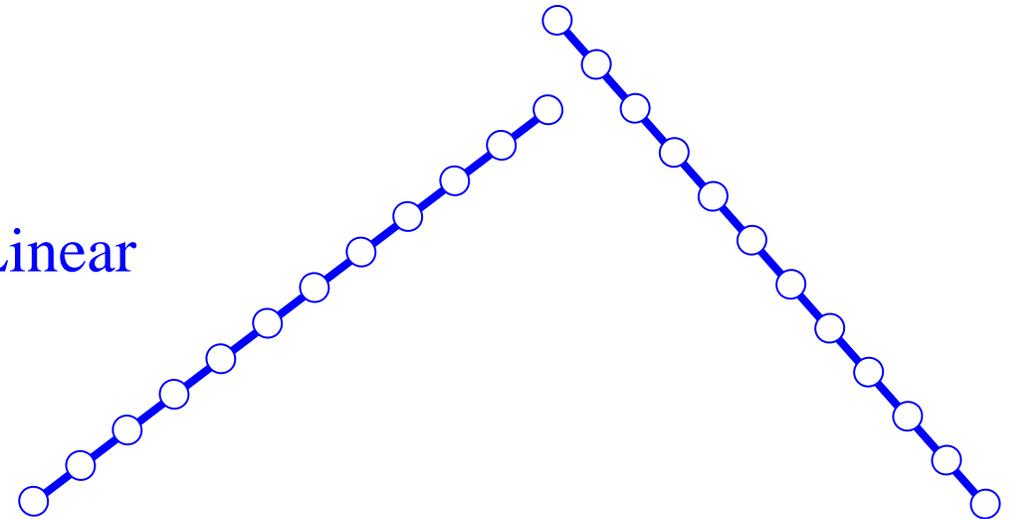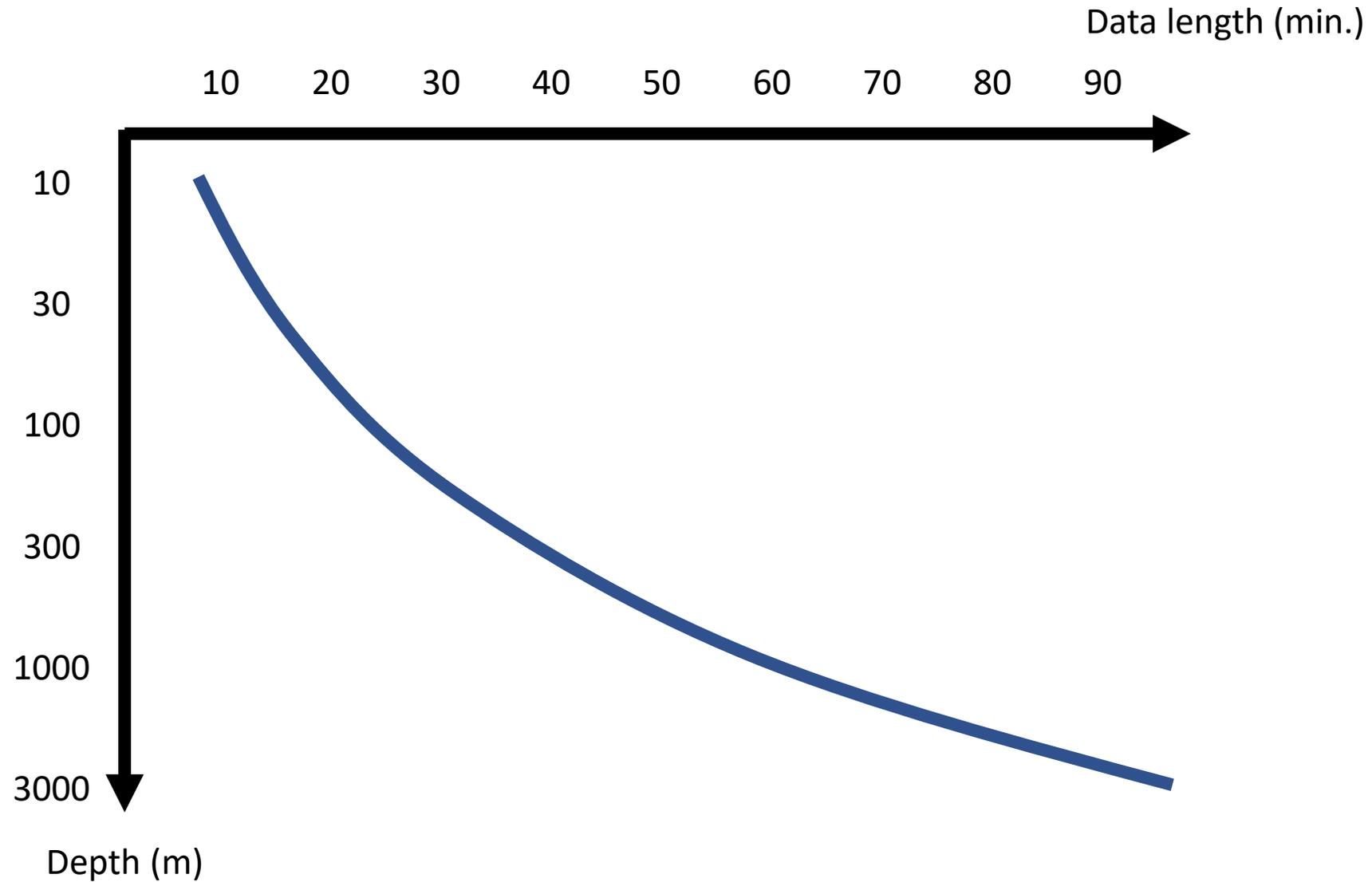
1/2 wavelength

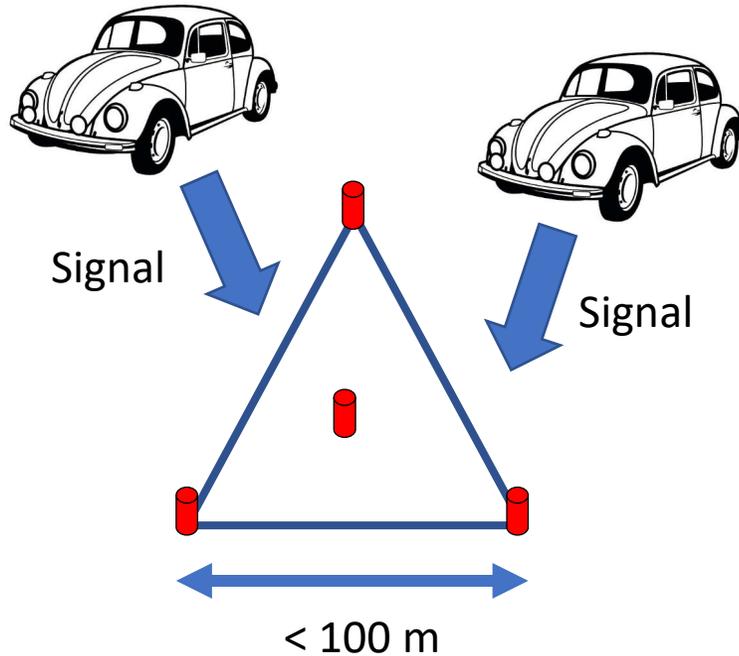# Passive : array shape

Circle

L shape

Triangle

Linear

Passive : Data length ?

Passive : day or night ?

Source must be outside of array !

Small array (< 100m)

Large array (>100m)

Signal

Signal

Noise

Noise

Noise

< 100 m

> 100 m

Traffic outside of array can be signal !
Can be done day or night.
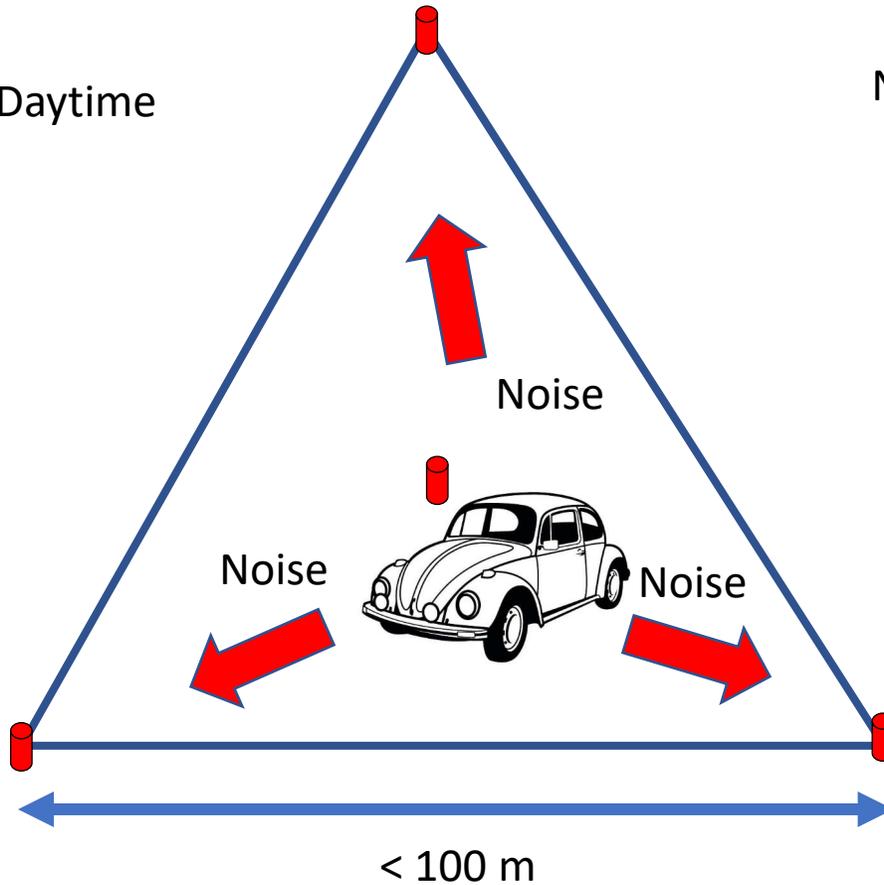
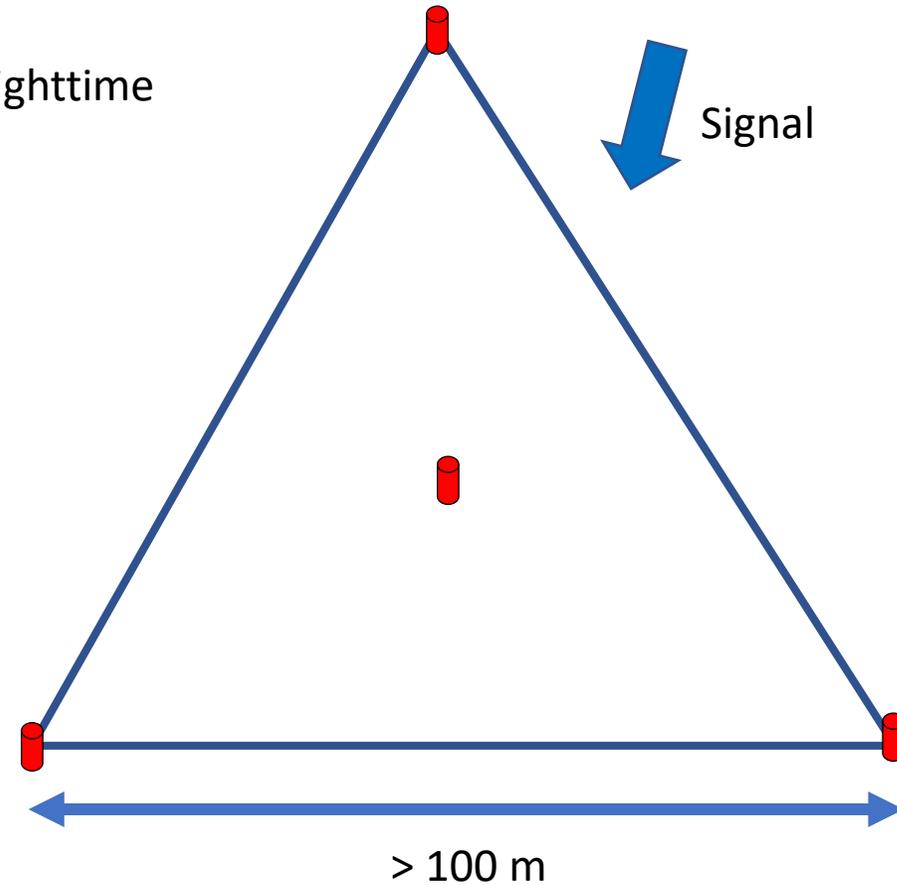Traffic inside of array is noise !

Passive : day or night ?

Large array (>100m)

Daytime

Noise

Noise

Noise

< 100 m

Nighttime

Signal

> 100 m
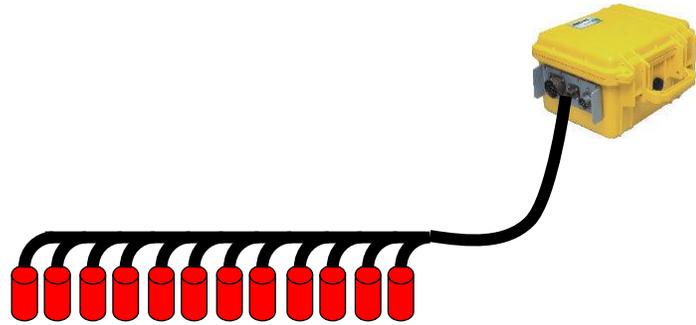
Nighttime is better for large array.

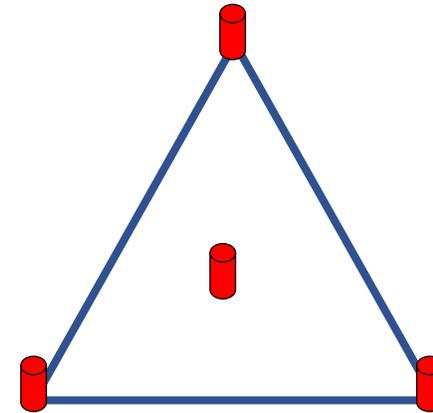# Array size (max. receiver spacing) and penetration depth

Active

Depth=Array size/2

Passive methods penetrate deeper than active method

Passive

Depth=Array size

6. Data acquisition

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- Deep passive data acquisition using cableless seismograph
- H/V
- Quality control

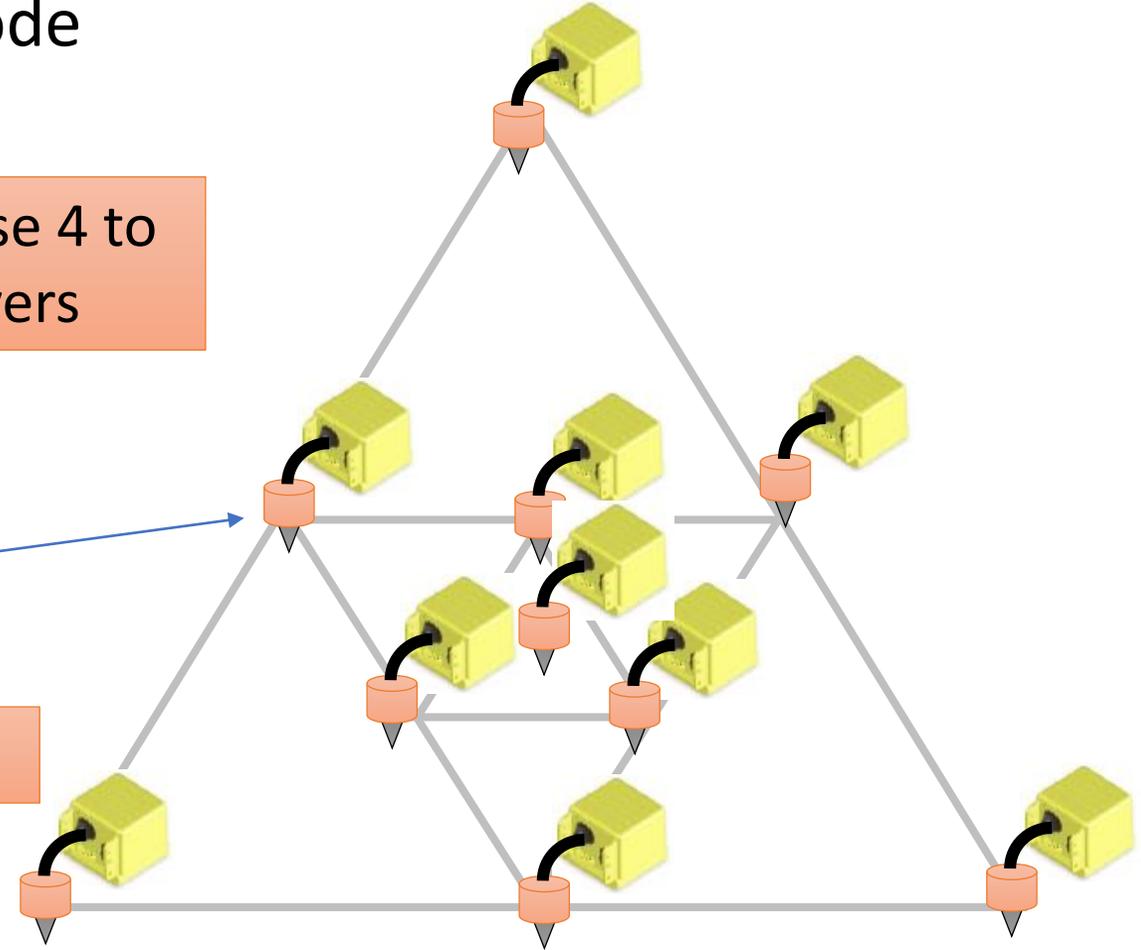# Seismograph and receiver (passive method)

Conventional seismograph
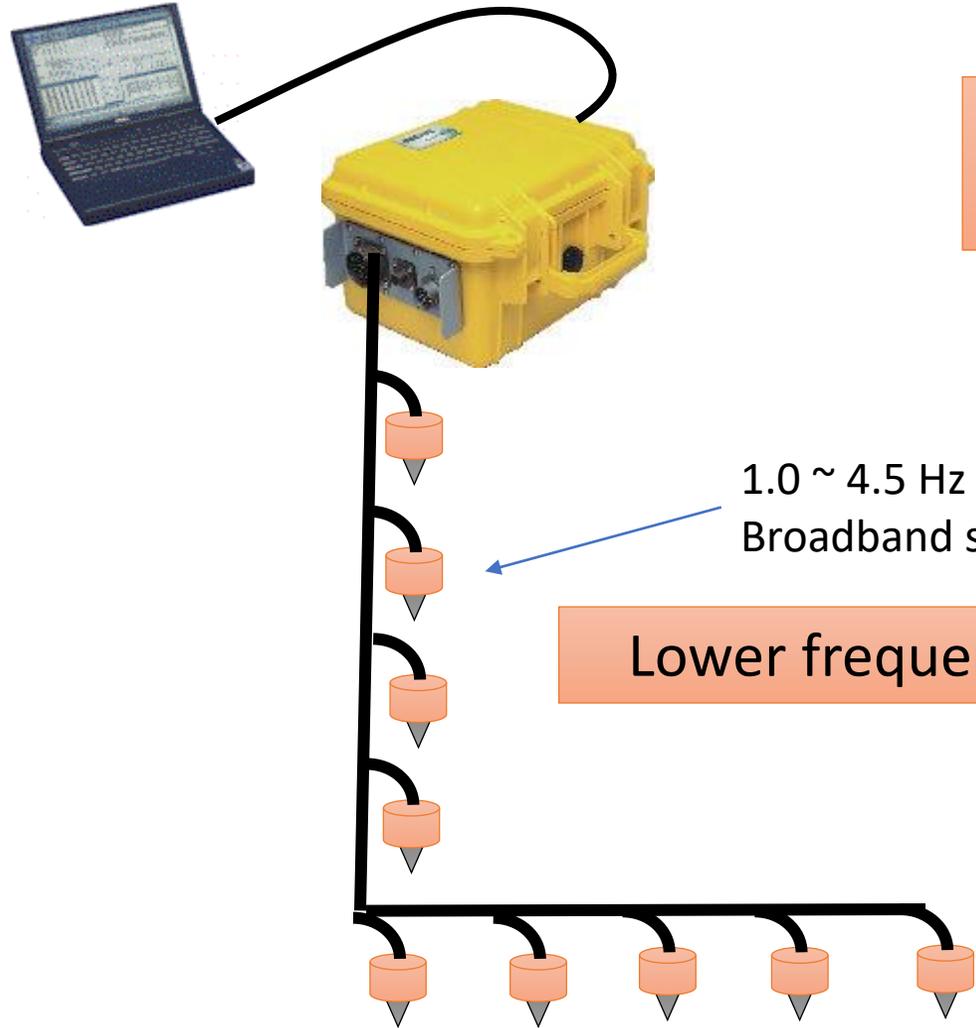
Node

Generally use 4 to 20 receivers

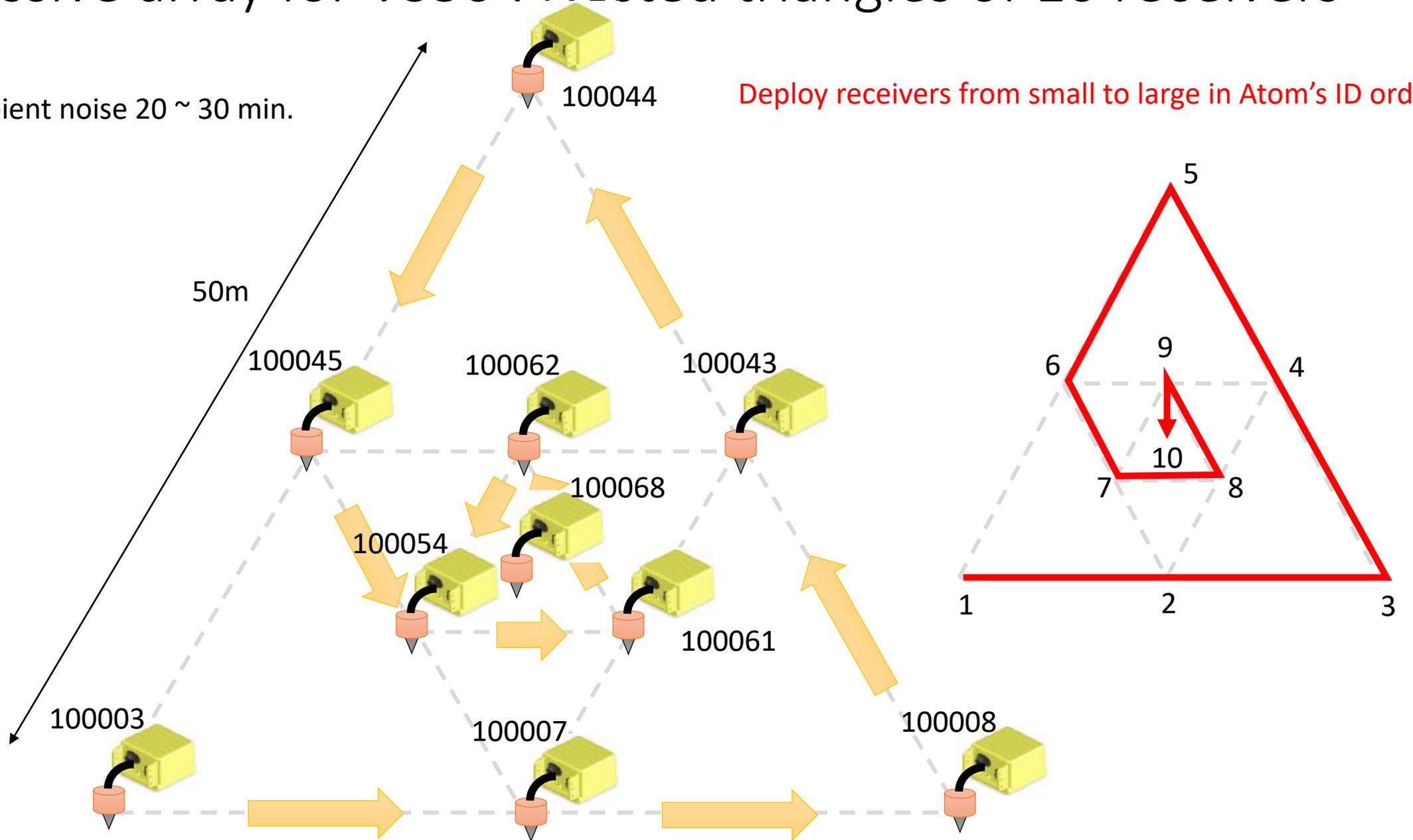1.0 ~ 4.5 Hz geophone
Broadband seismometer

Lower frequency is better

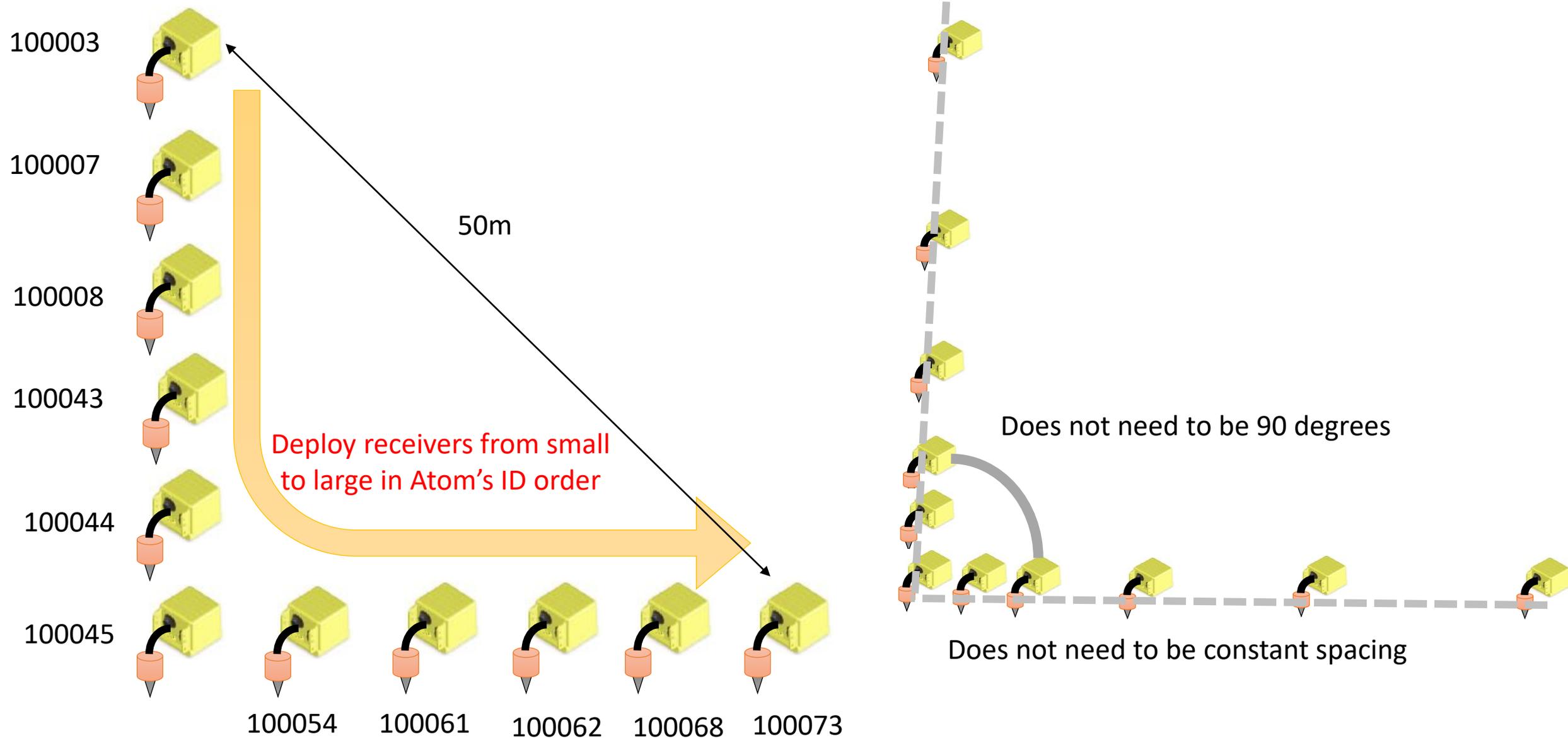# Small passive array for VS30 : Nested triangles of 10 receivers

Record ambient noise 20 ~ 30 min.

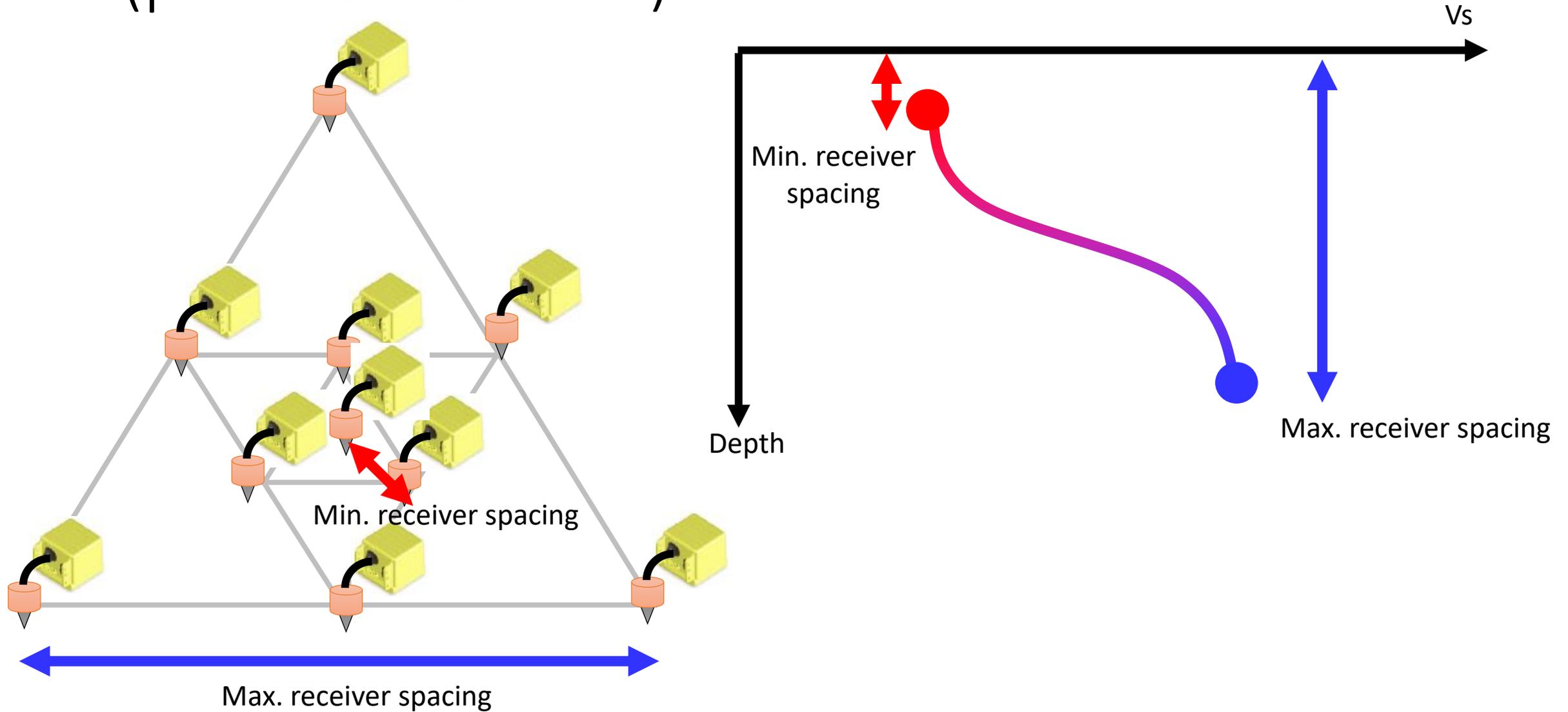Deploy receivers from small to large in Atom's ID order

50m

100044

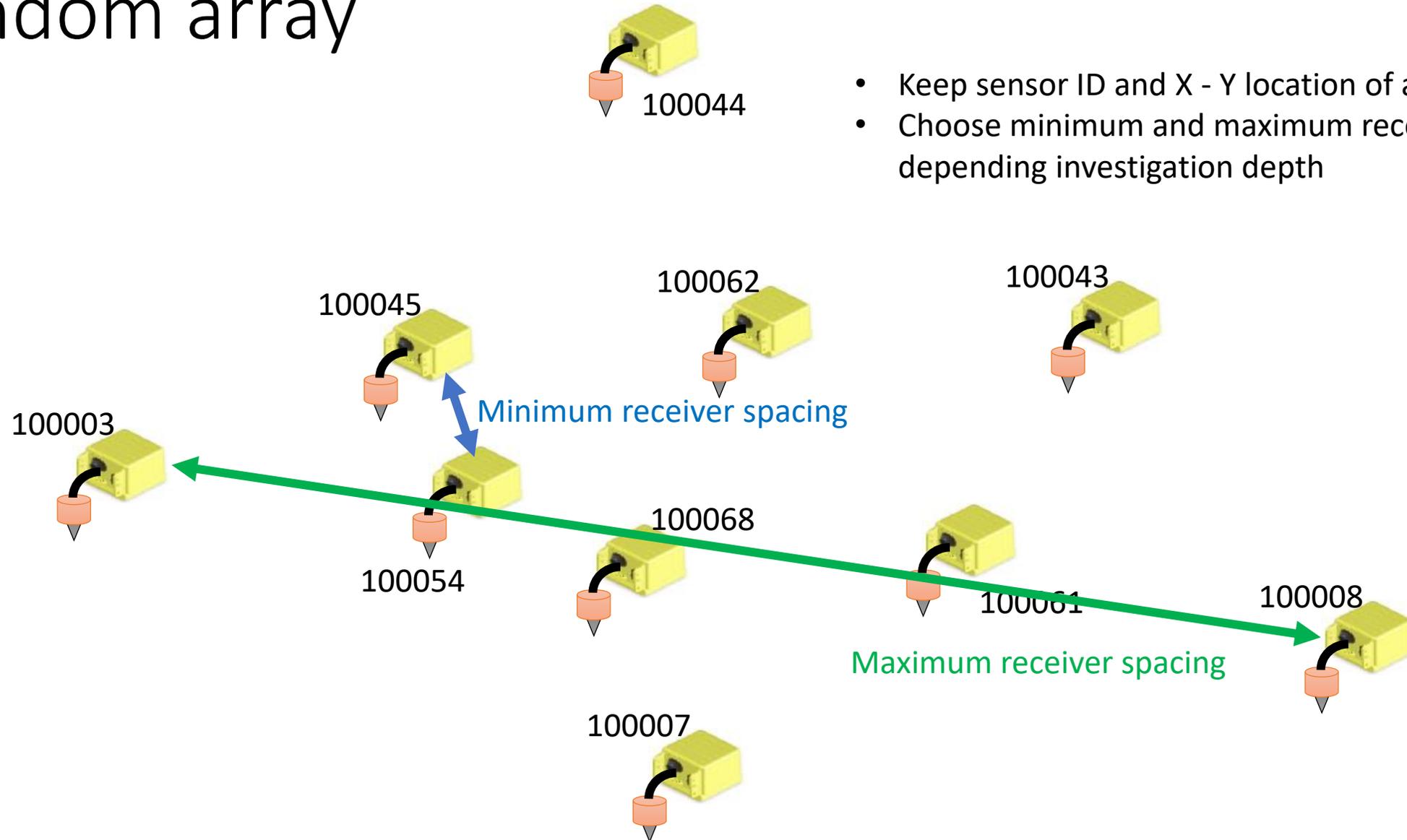100045   100062   100043

100068

100054

100061

100003   100007   100008

L-shaped array of 11 receivers

100003

100007

100008

100043

100044

100045

50m

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

100054 100061 100062 100068 100073

Does not need to be 90 degrees

Does not need to be constant spacing

Minimum and maximum receiver spacing (passive methods)

Random array

- Keep sensor ID and X - Y location of all receivers
- Choose minimum and maximum receiver spacing depending investigation depth
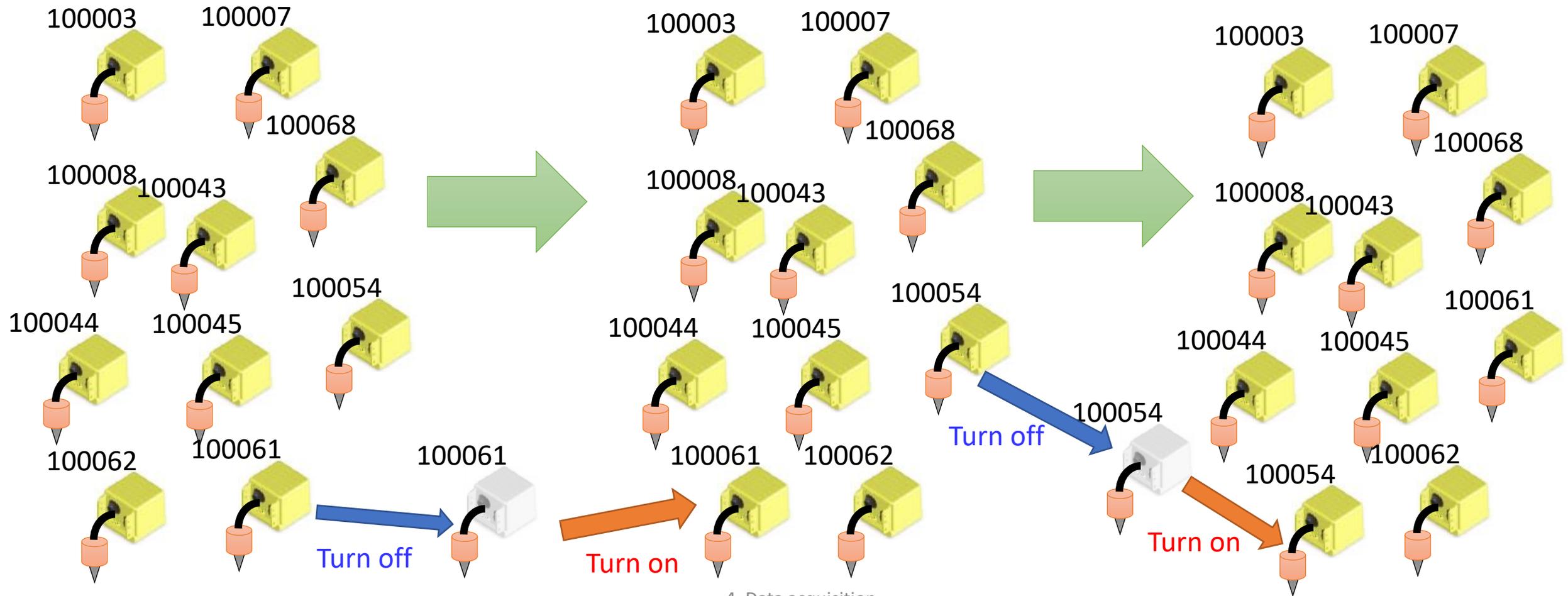
100044

100045

100062

100043

Minimum receiver spacing

100003

100068

100054

100061

100008

Maximum receiver spacing

100007

Data acquisition

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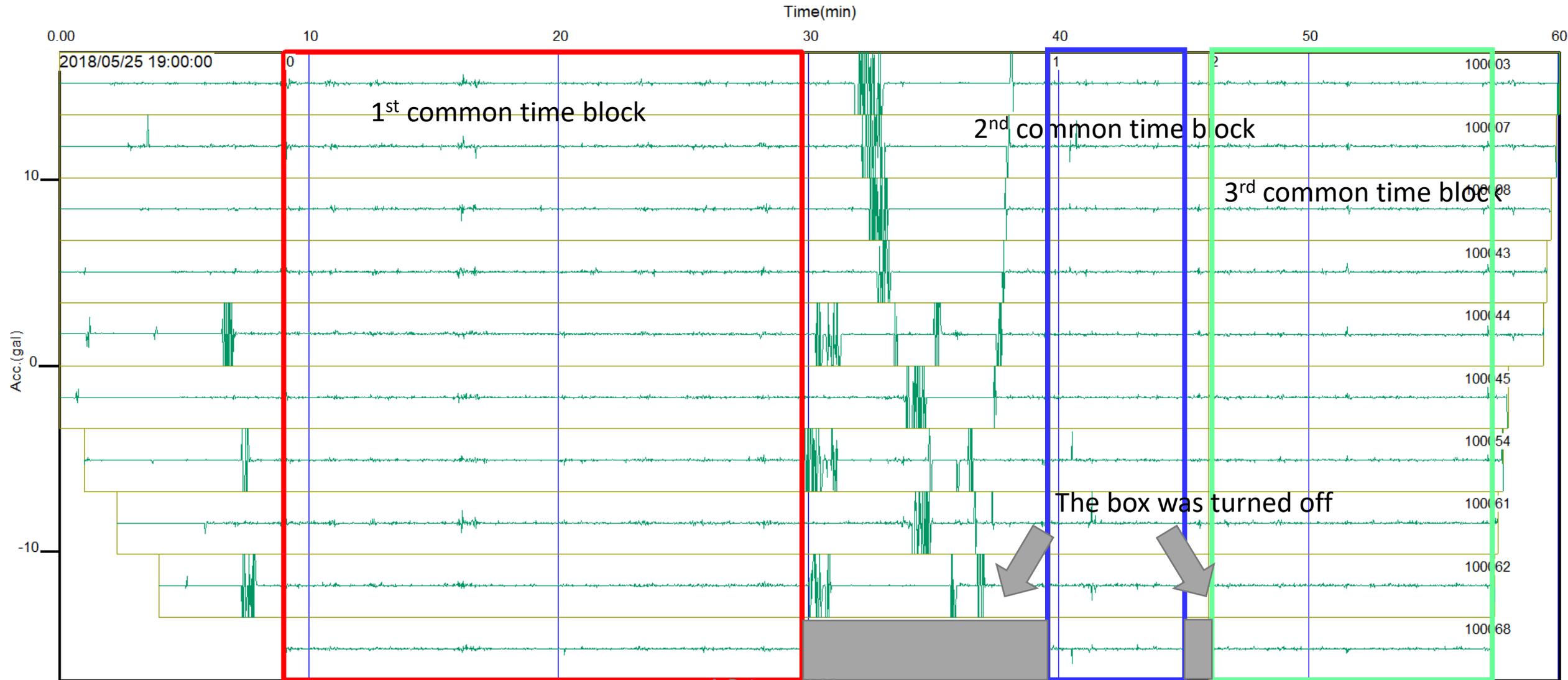
Raw data

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.
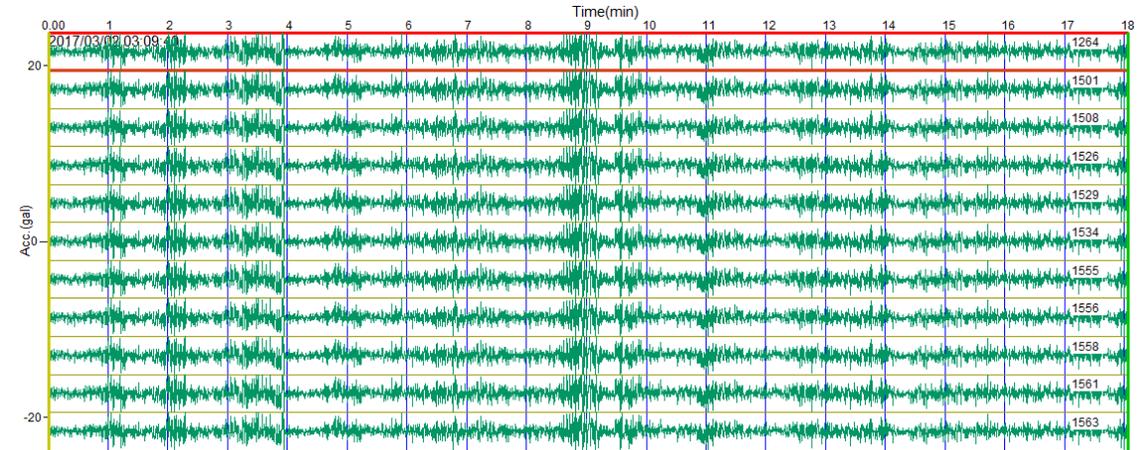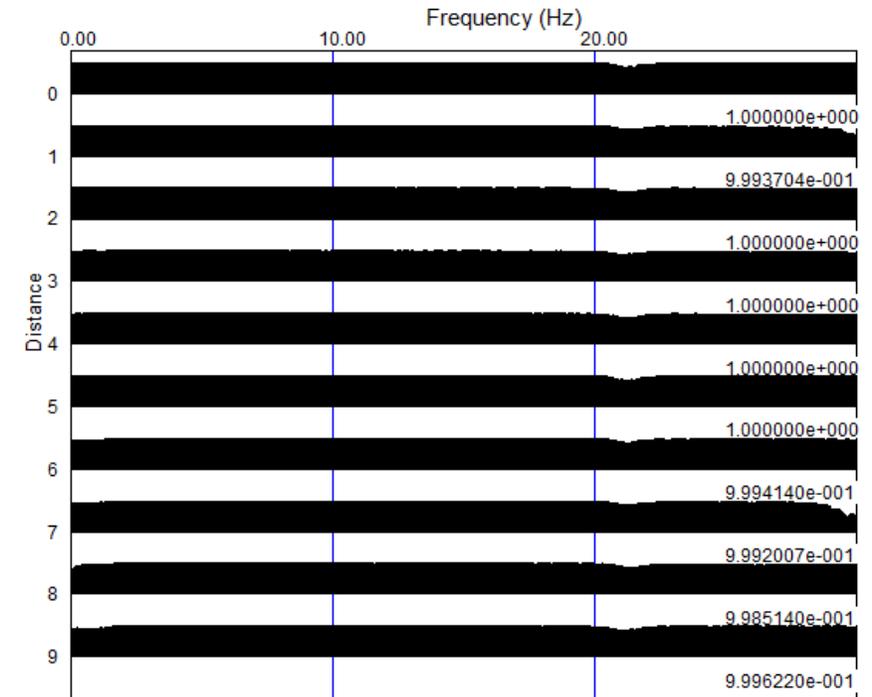
Huddle test

A huddle test is strongly recommended before starting data acquisition to make sure that the character of the sensor is identical between all of the Atom units.

Example of data obtained by huddle test

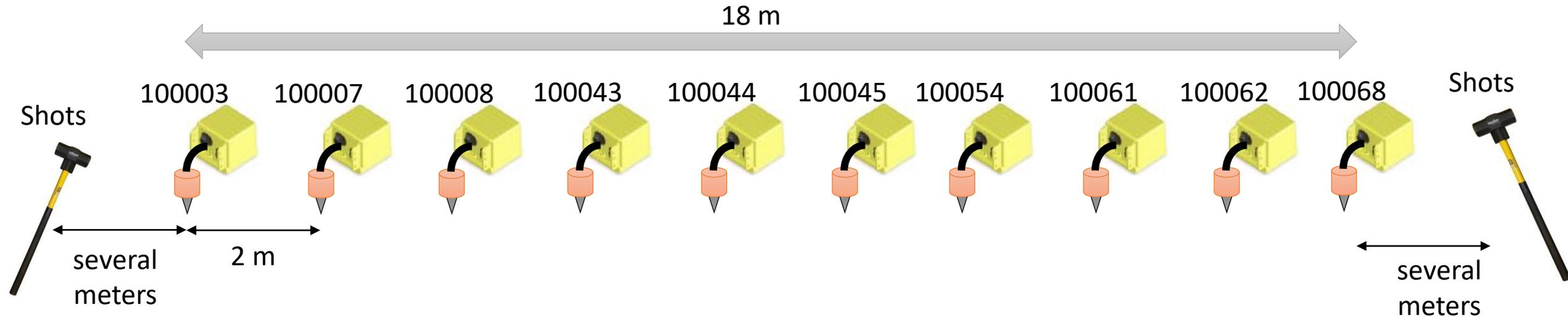Coherencies must be one throughout a frequency range of interest

6. Data acquisition

- Cableless seismograph and 2 Hz geophone
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- Shallow passive data acquisition using cableless seismograph
- Active data acquisition using cableless seismograph
- Deep passive data acquisition using cableless seismograph
- H/V
- Quality control
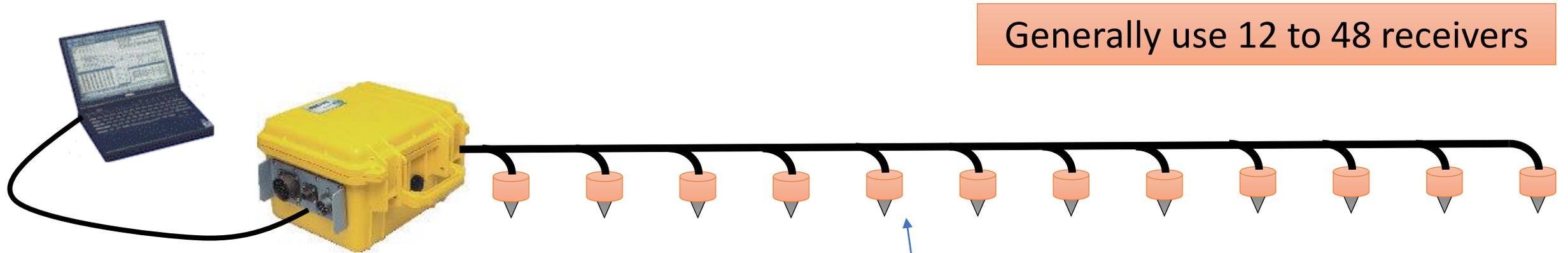
Active : linear array of 10 receivers with 2 m spacings

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

18 m

Shots   100003   100007   100008   100043   100044   100045   100054   100061   100062   100068   Shots

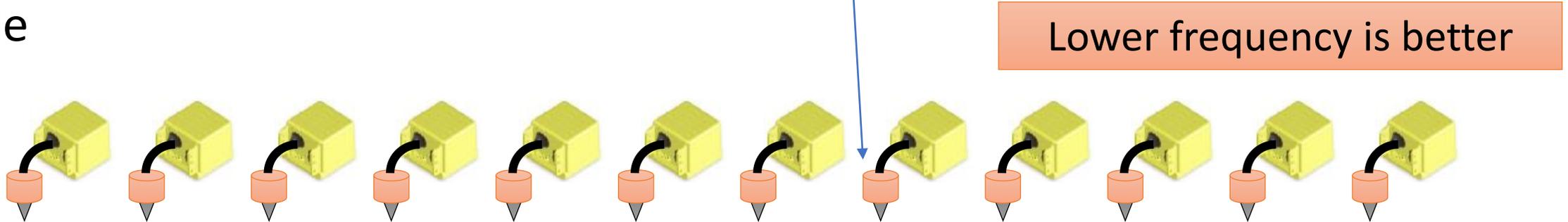several meters   2 m   several meters

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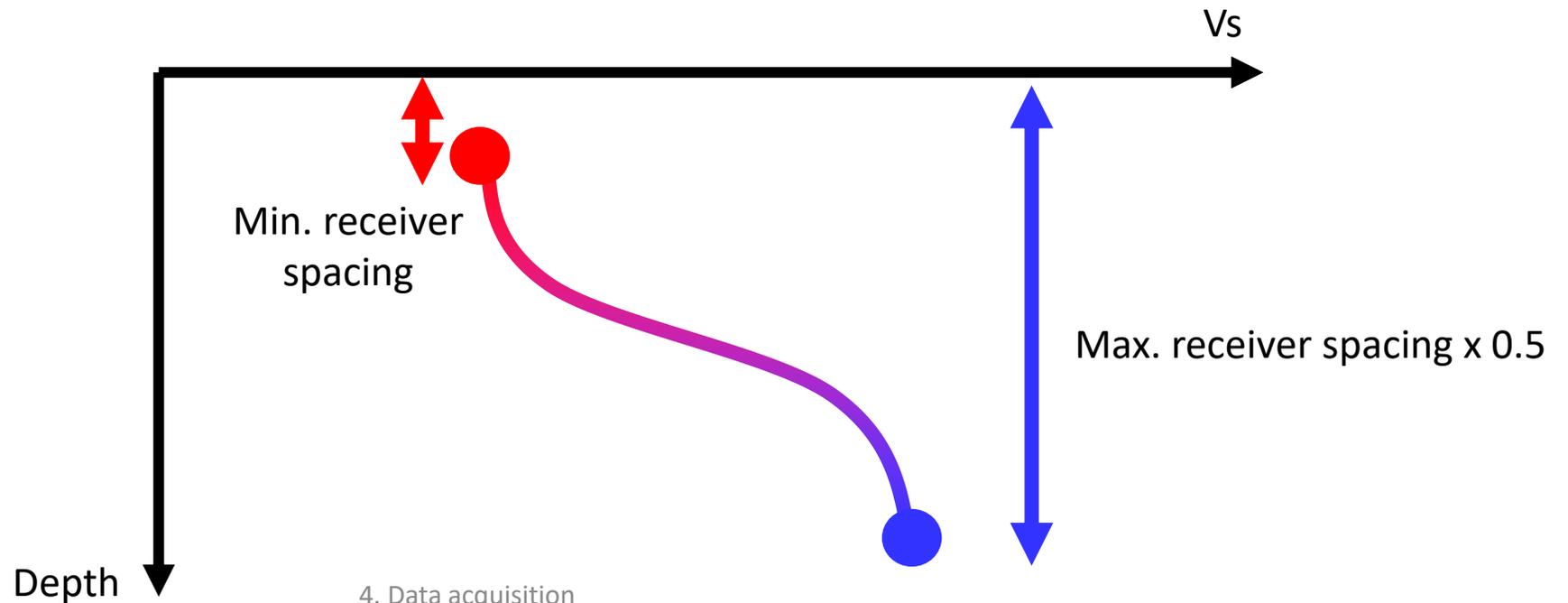
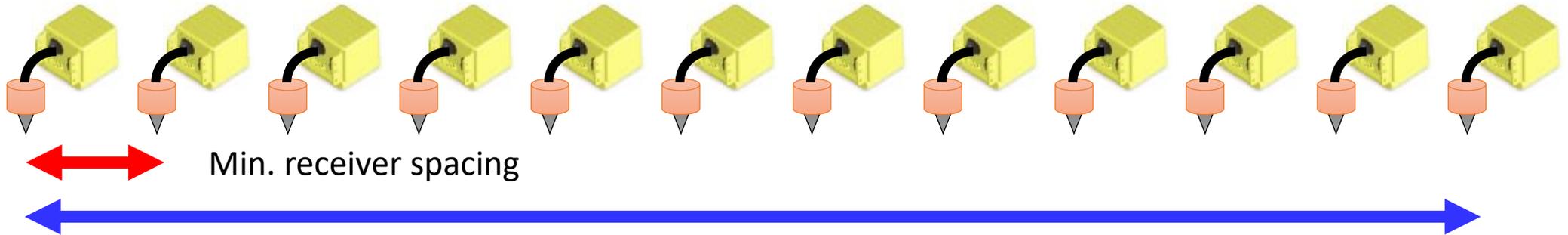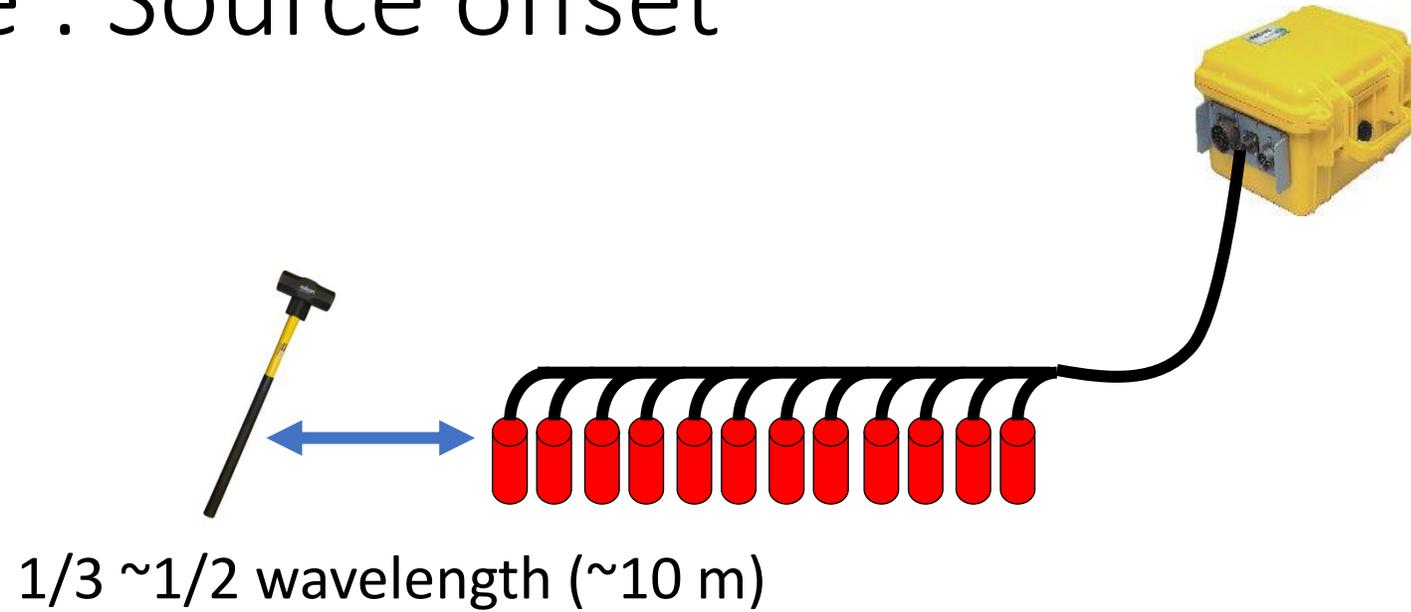# Seismograph and receiver (active method)

Conventional seismograph

Generally use 12 to 48 receivers

4.5 ~ 28 Hz geophone (or accelerometer)

Node

Lower frequency is better

Minimum and maximum receiver spacing (active methods)

Min. receiver spacing

Max. receiver spacing

Vs

Min. receiver spacing

Max. receiver spacing x 0.5

Depth

Active : Source offset

Maximum offset

1/3 ~1/2 wavelength (~10 m)

Typical source offsets
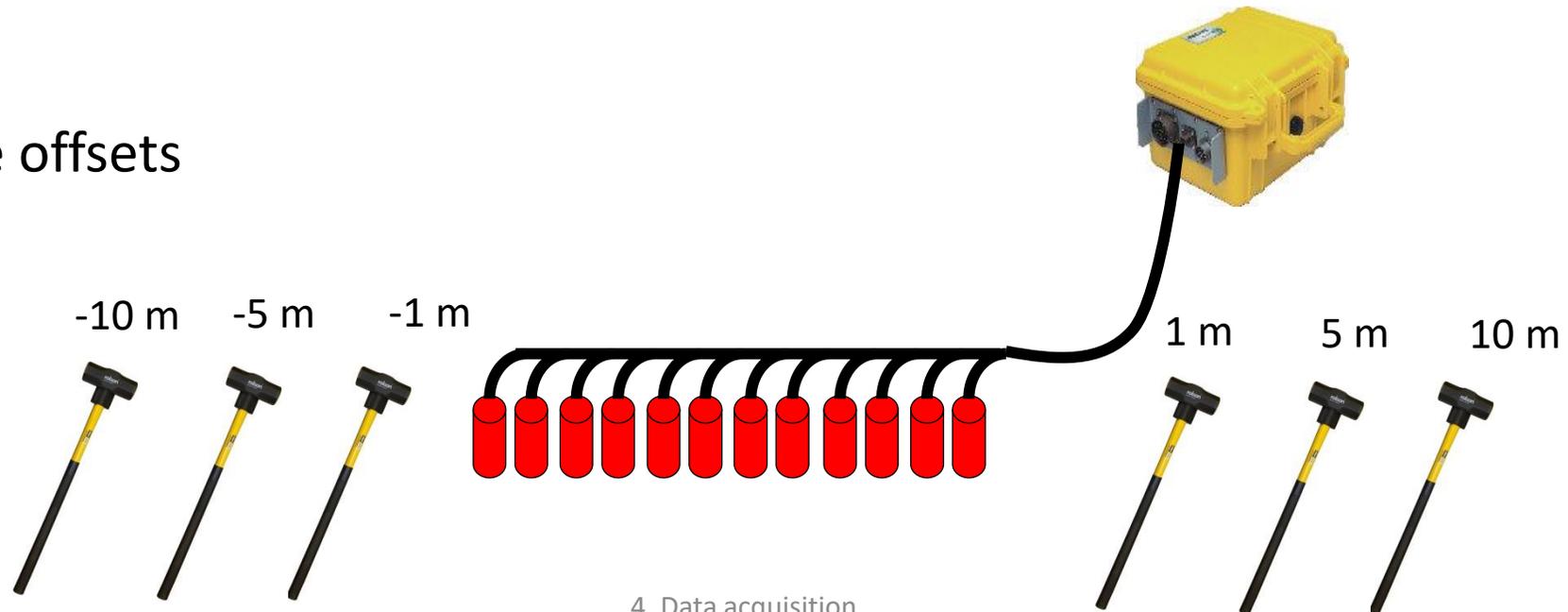
-10 m   -5 m   -1 m   1 m   5 m   10 m

6. Data acquisition

- Cableless seismograph and 2 Hz geophone
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- Shallow passive data acquisition using cableless seismograph
- Active data acquisition using cableless seismograph
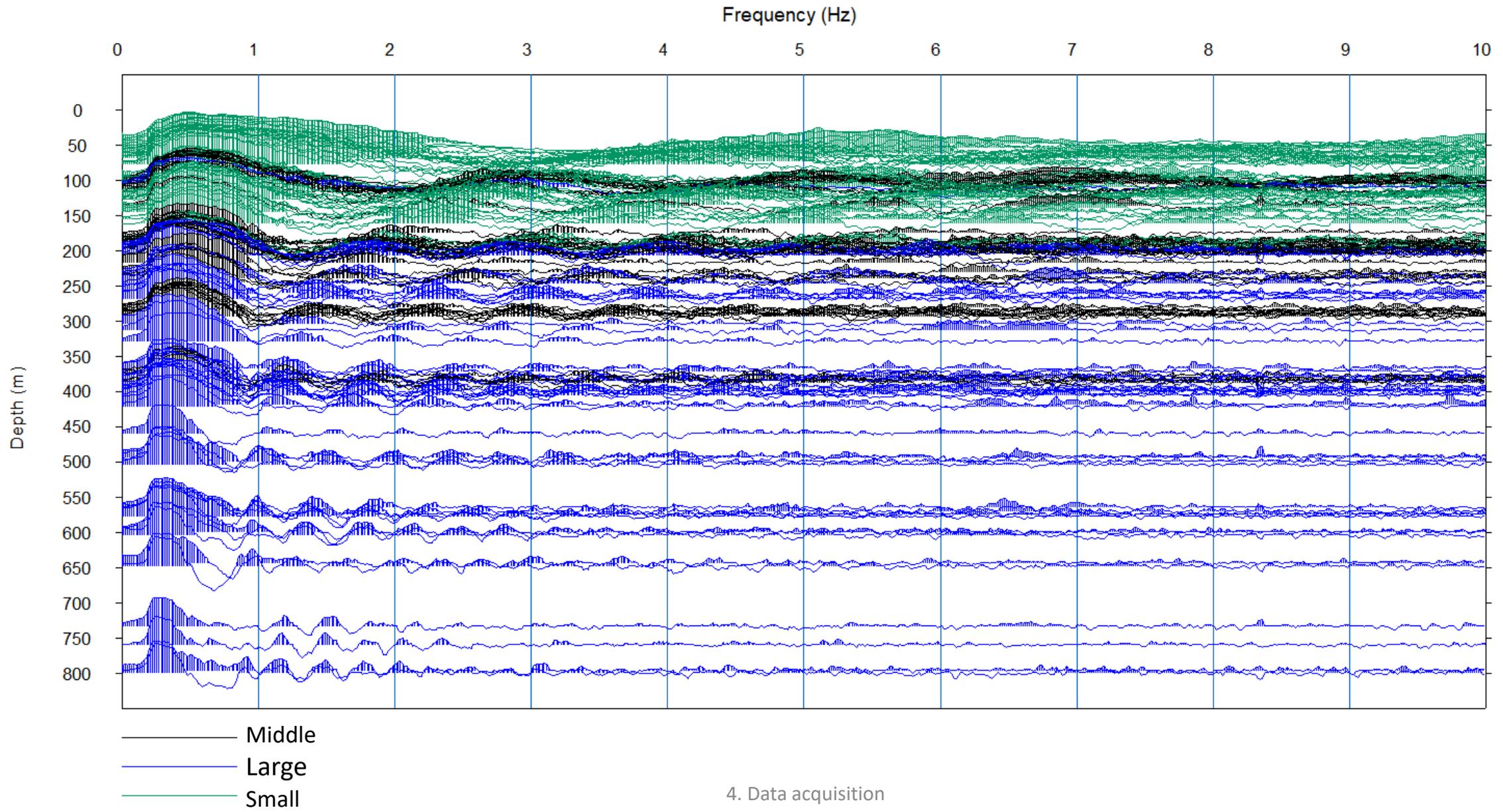- Deep passive data acquisition using cableless seismograph
- H/V
- Quality control

All sensor location
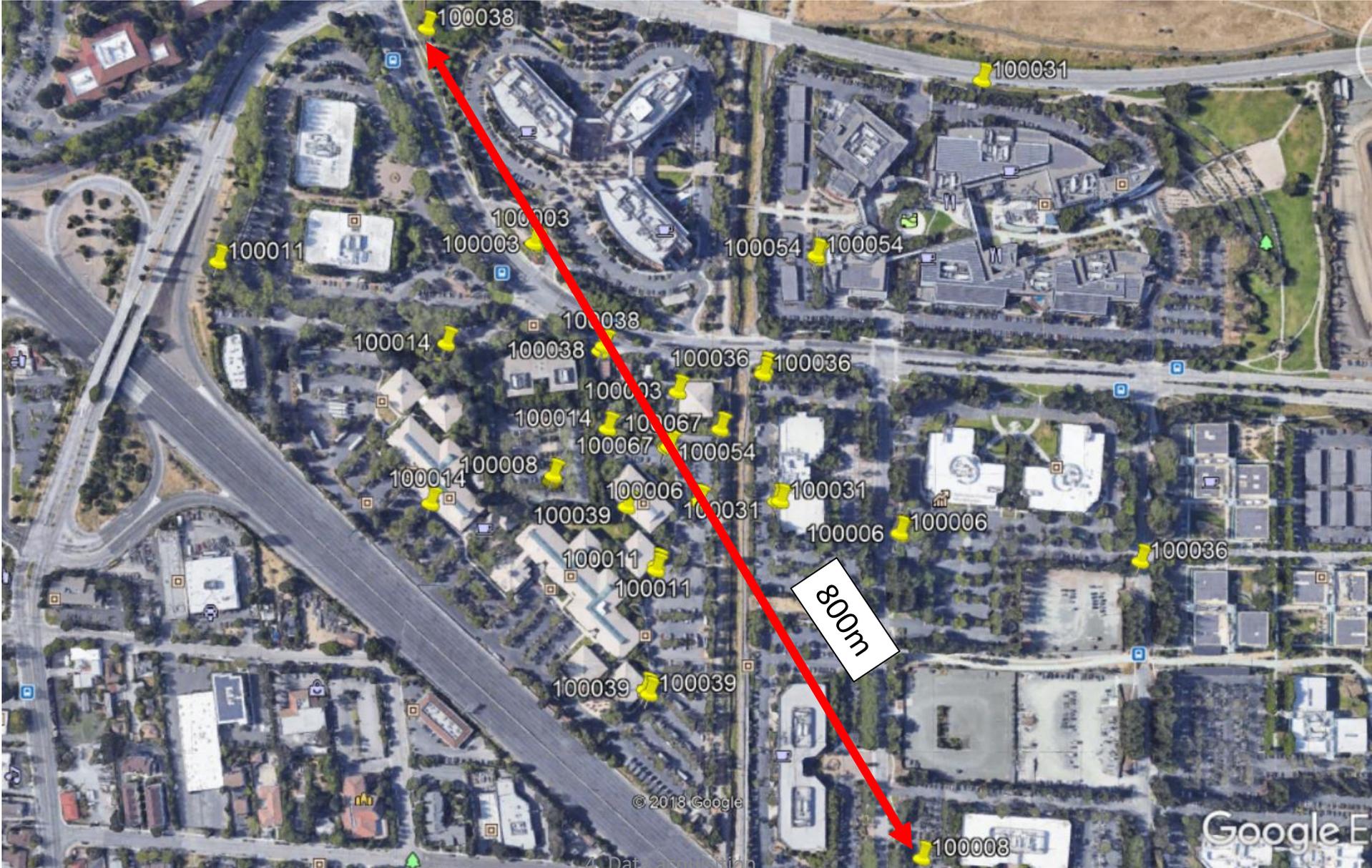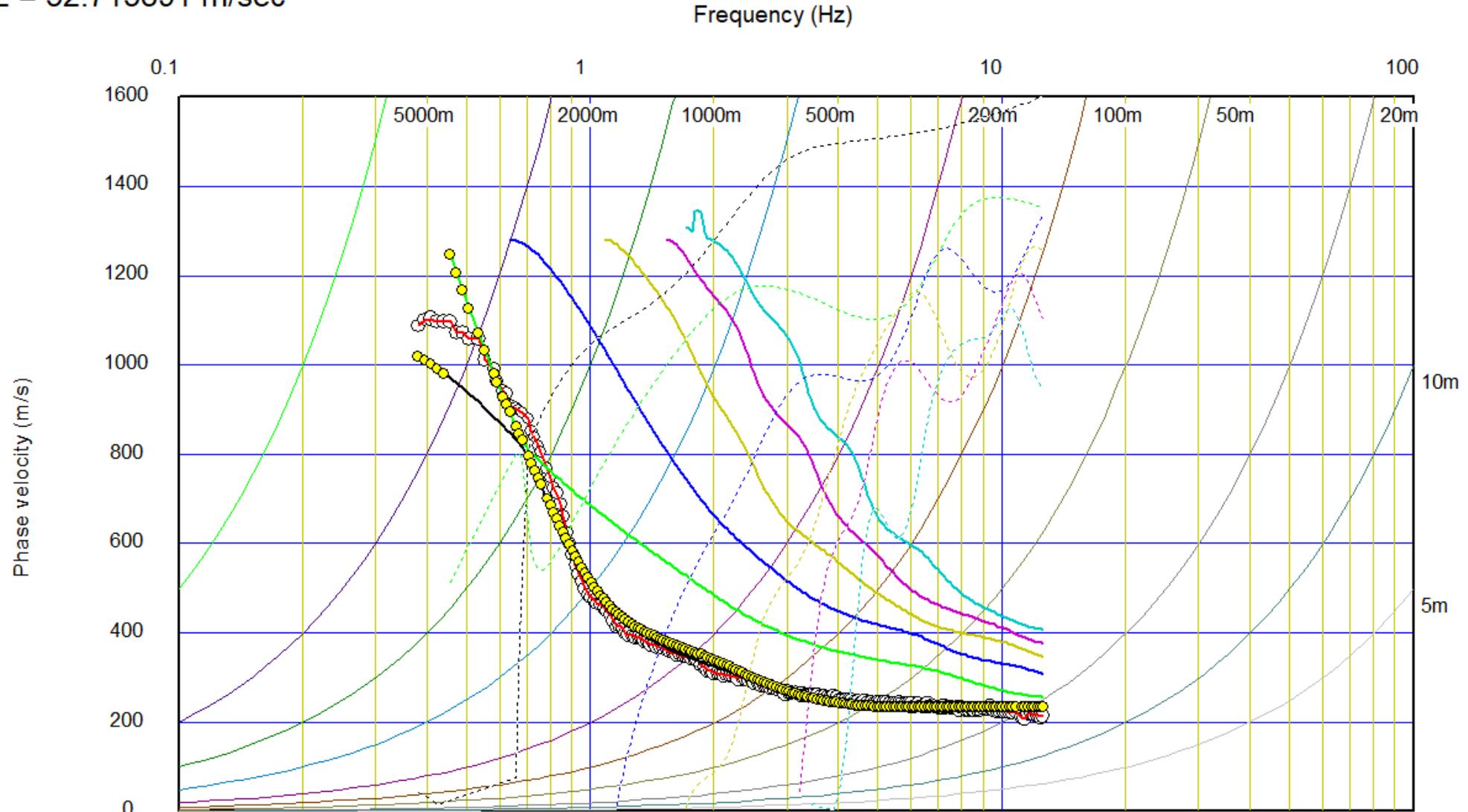
Large passive array

1000 m

Coherencies

Phase velocity image in frequency domain
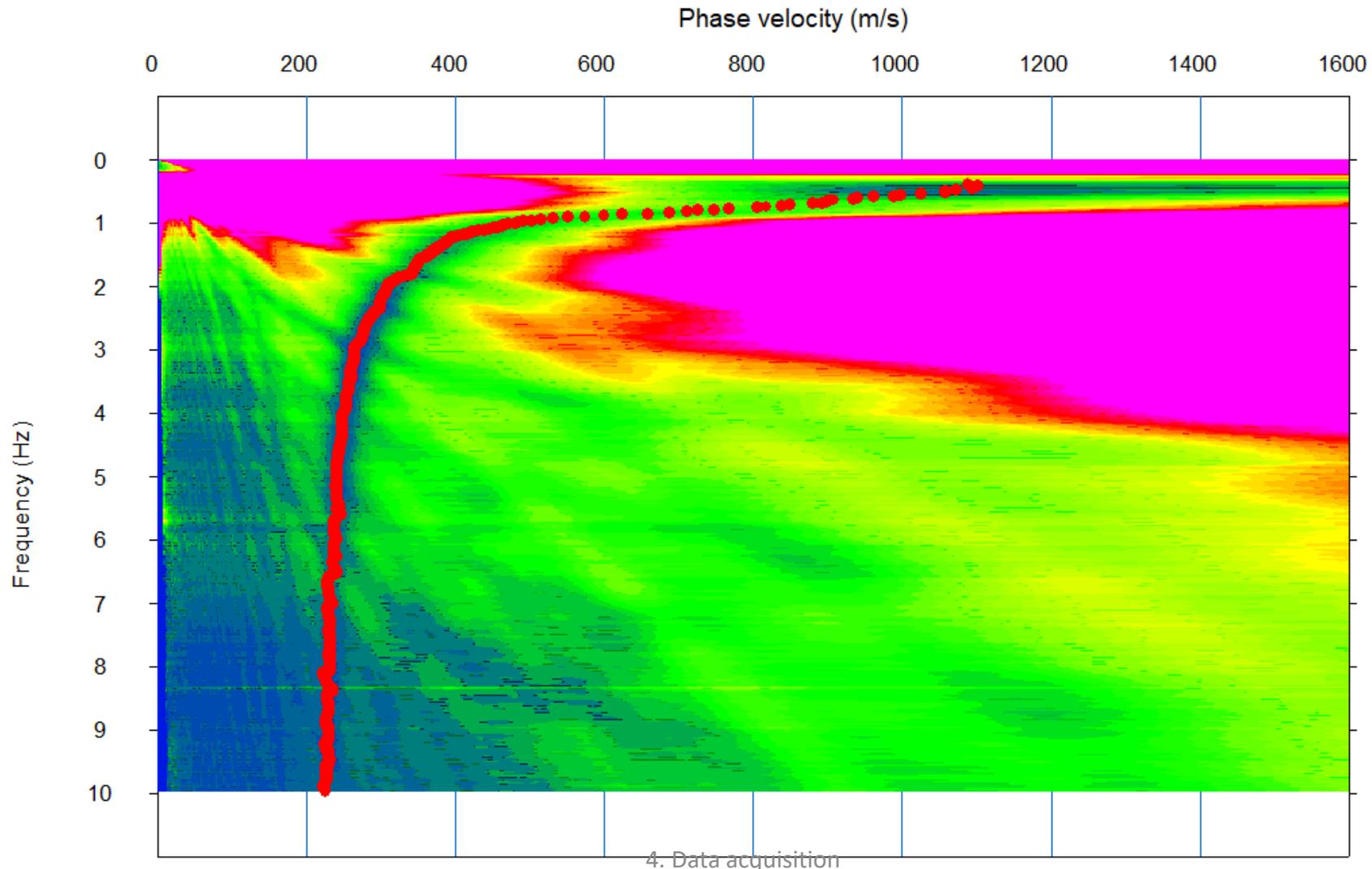
Dispersion curve
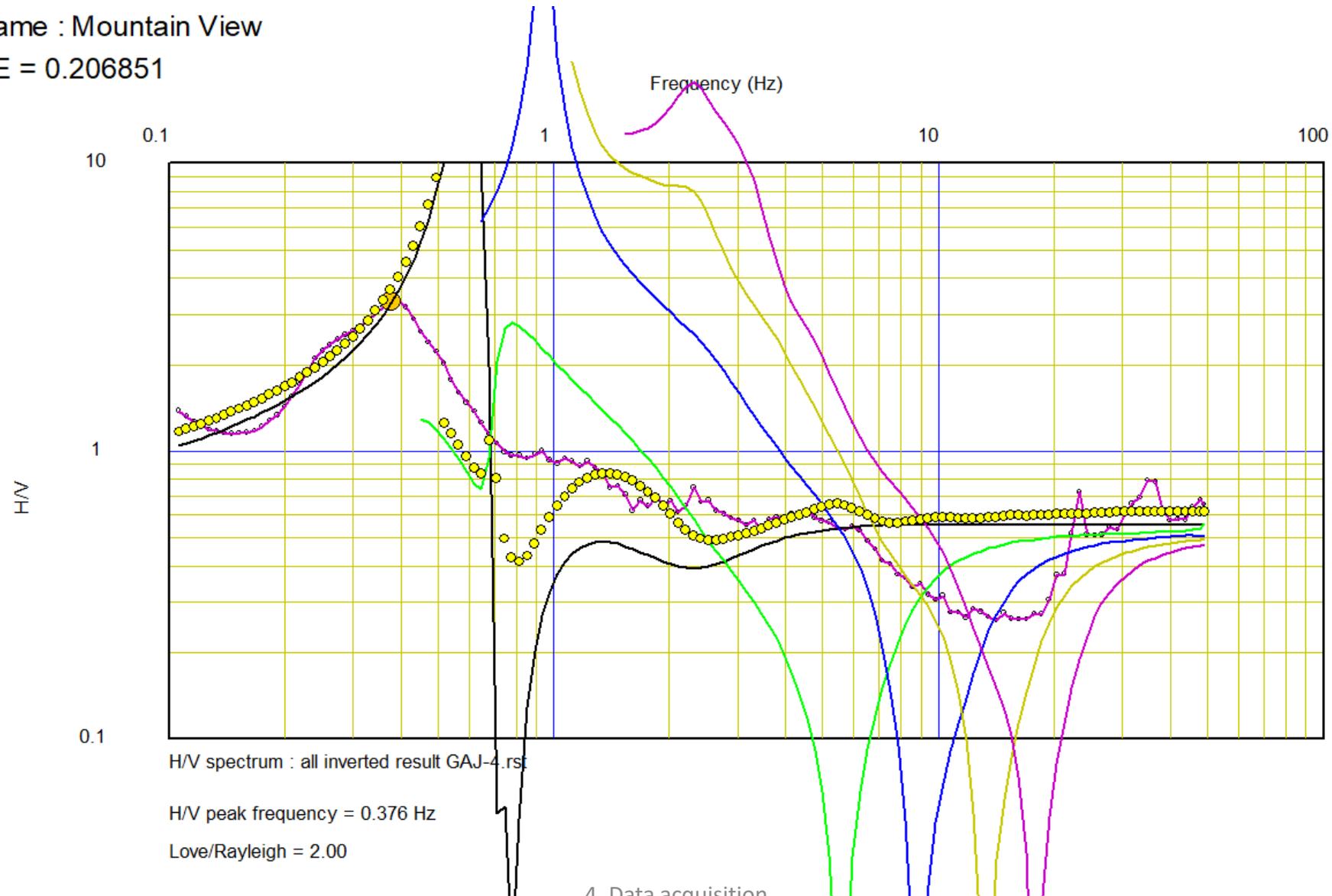
Index=0 Total error=0.030465

RMSE = 32.715891 m/sec

Dispersion curve : all inverted result GAJ-4.rst
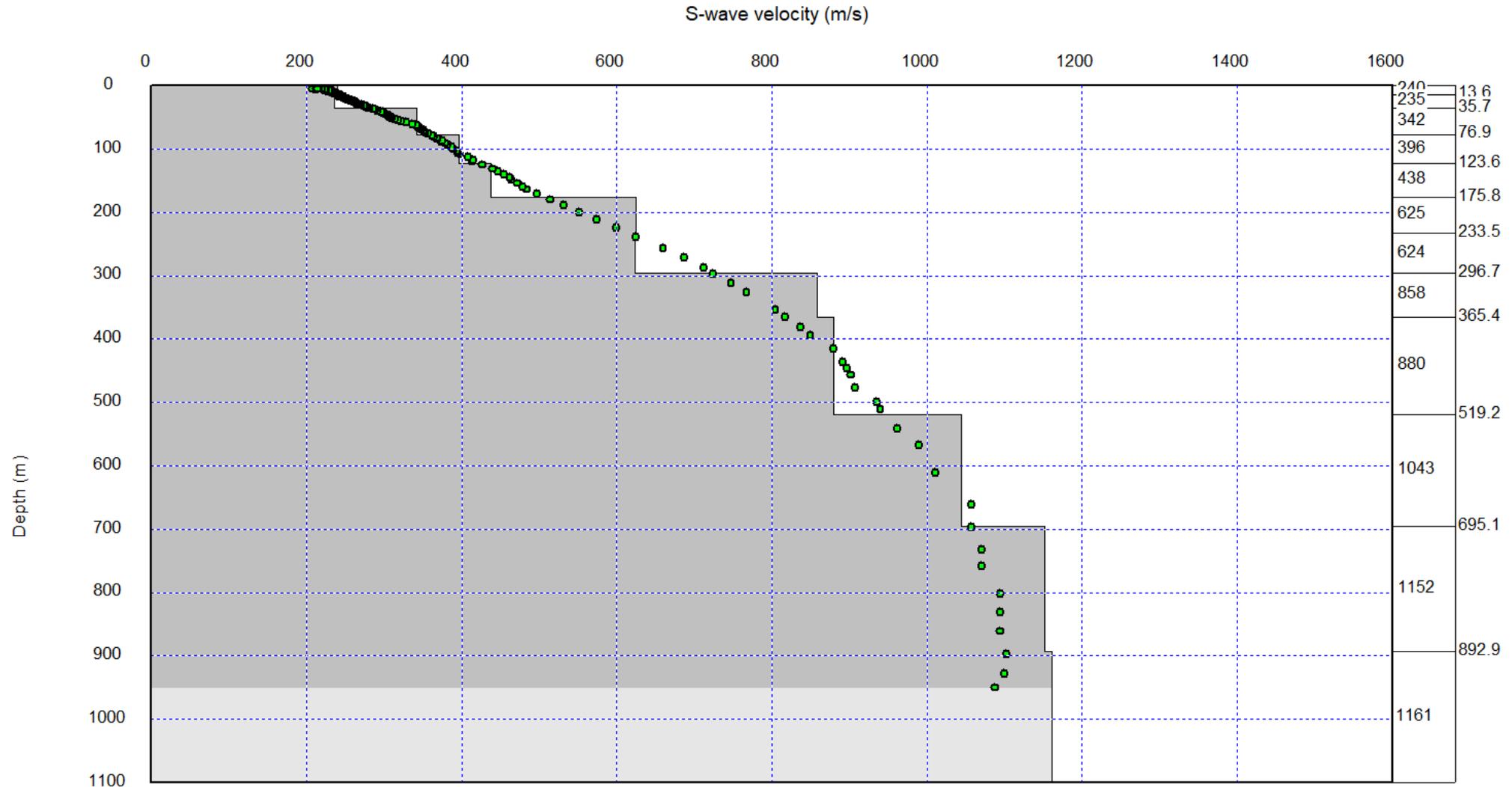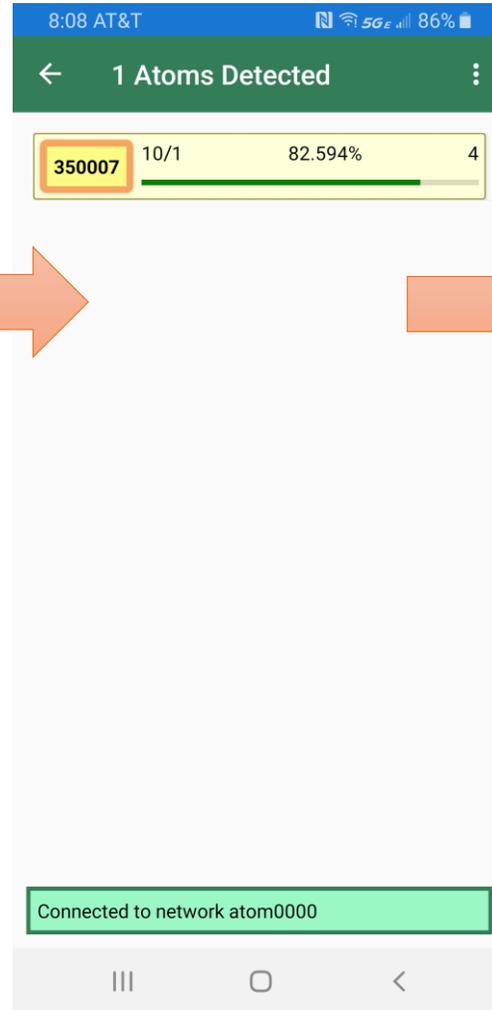
Horizontal to vertical spectra ratio

Site name : Mountain View
RMSE = 0.206851

Frequency (Hz)

H/V

H/V spectrum : all inverted result GAJ-4.rsf

H/V peak frequency = 0.376 Hz

Love/Rayleigh = 2.00

Inverted S-wave velocity model

Site name : Mountain View

S-wave velocity model : all inverted result GAJ-4.rst

6. Data acquisition

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- Shallow passive data acquisition using cableless seismograph
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- Deep passive data acquisition using cableless seismograph
- H/V
- Quality control

Data acquisition and processing using geophone and mobile devices

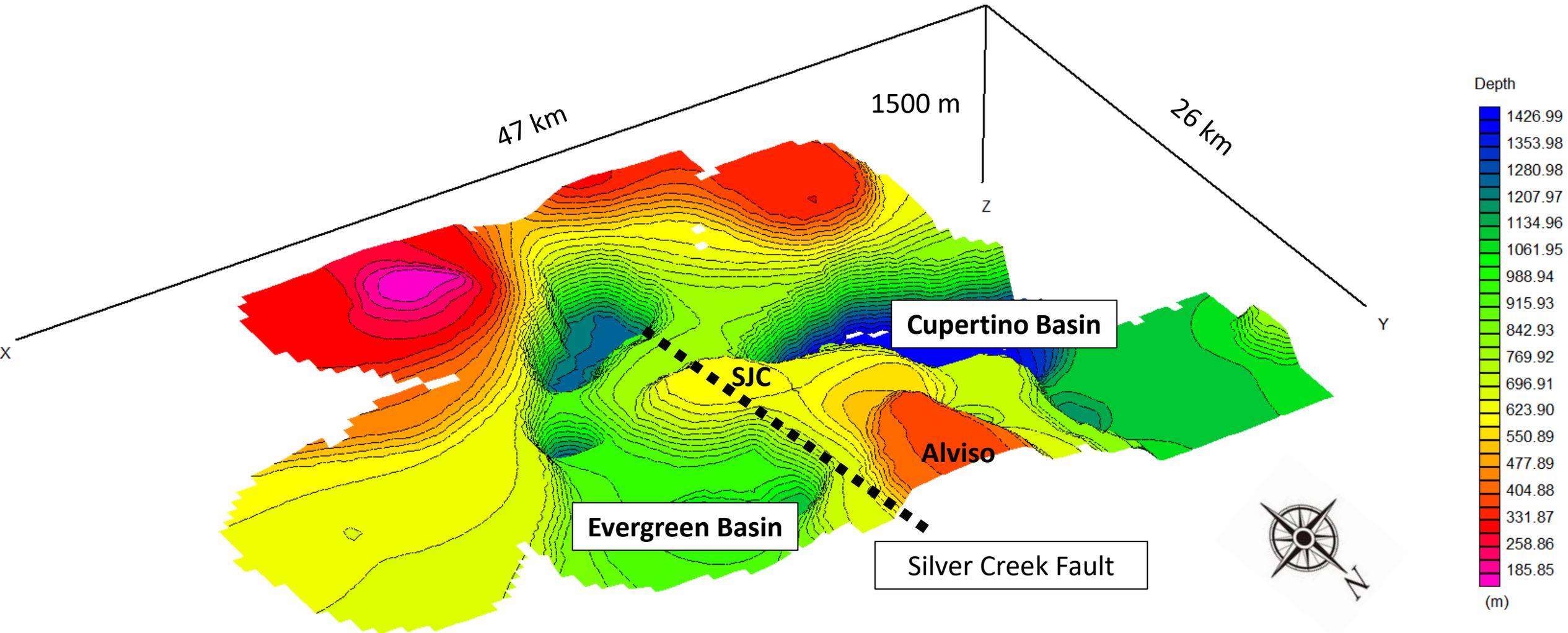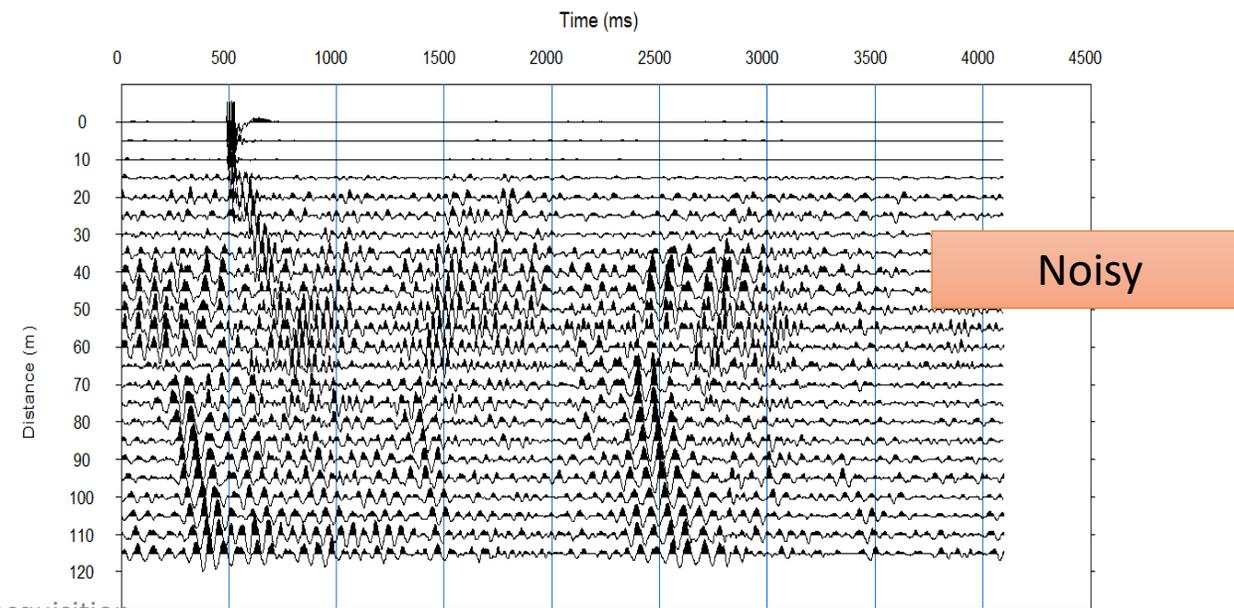Data acquisition (20 min.~ 1 hour)   Download to mobile   3C waveform traces   H/V spectrum
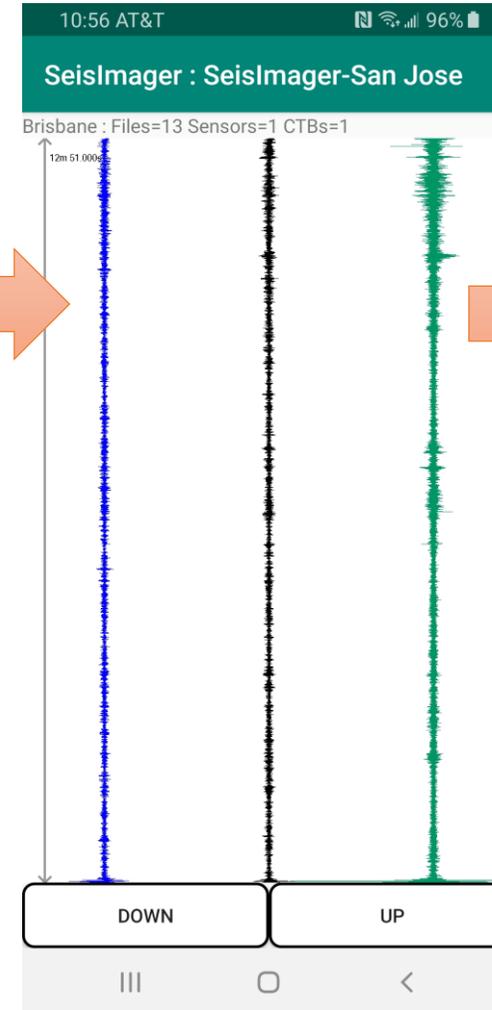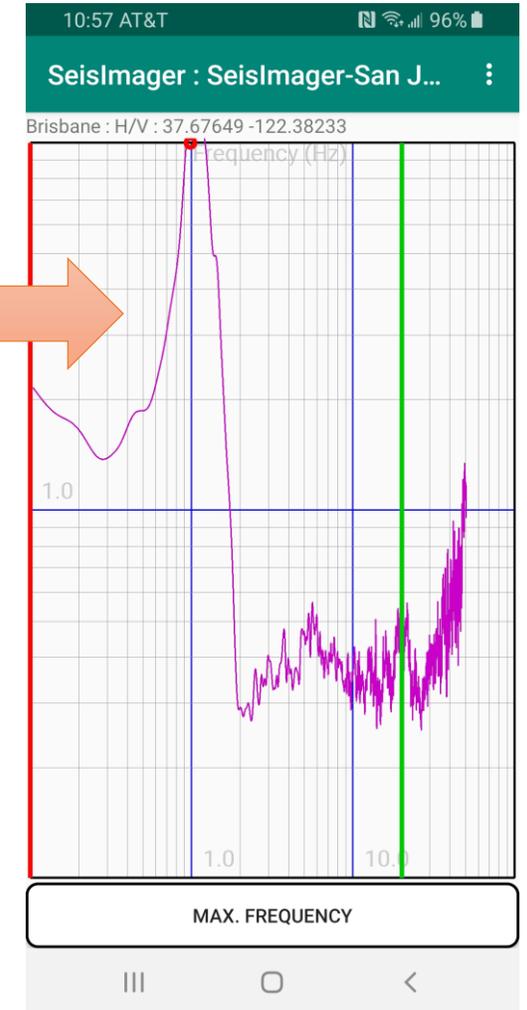
Summary of investigation results
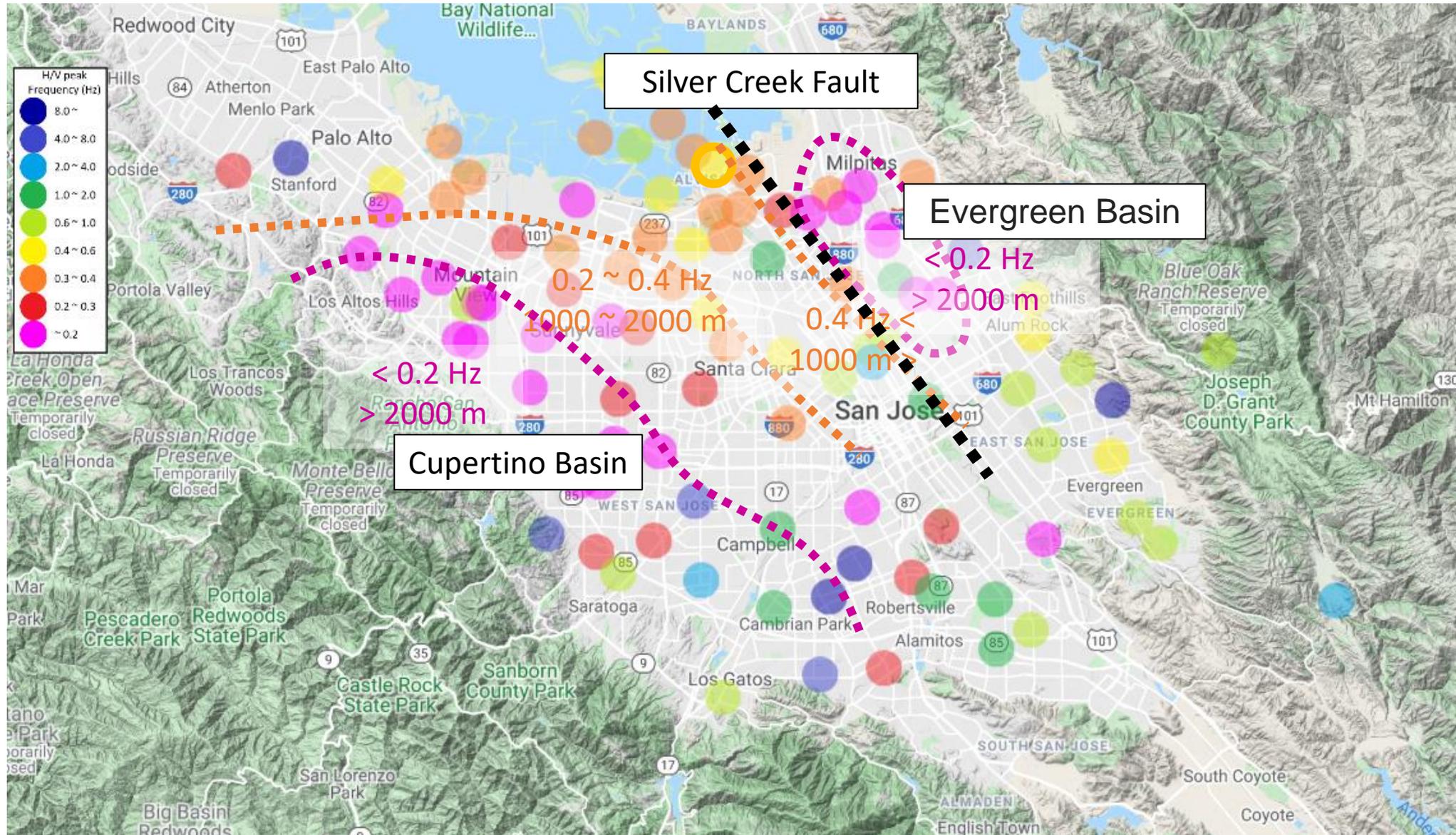
Preliminary 3D S-wave velocity model
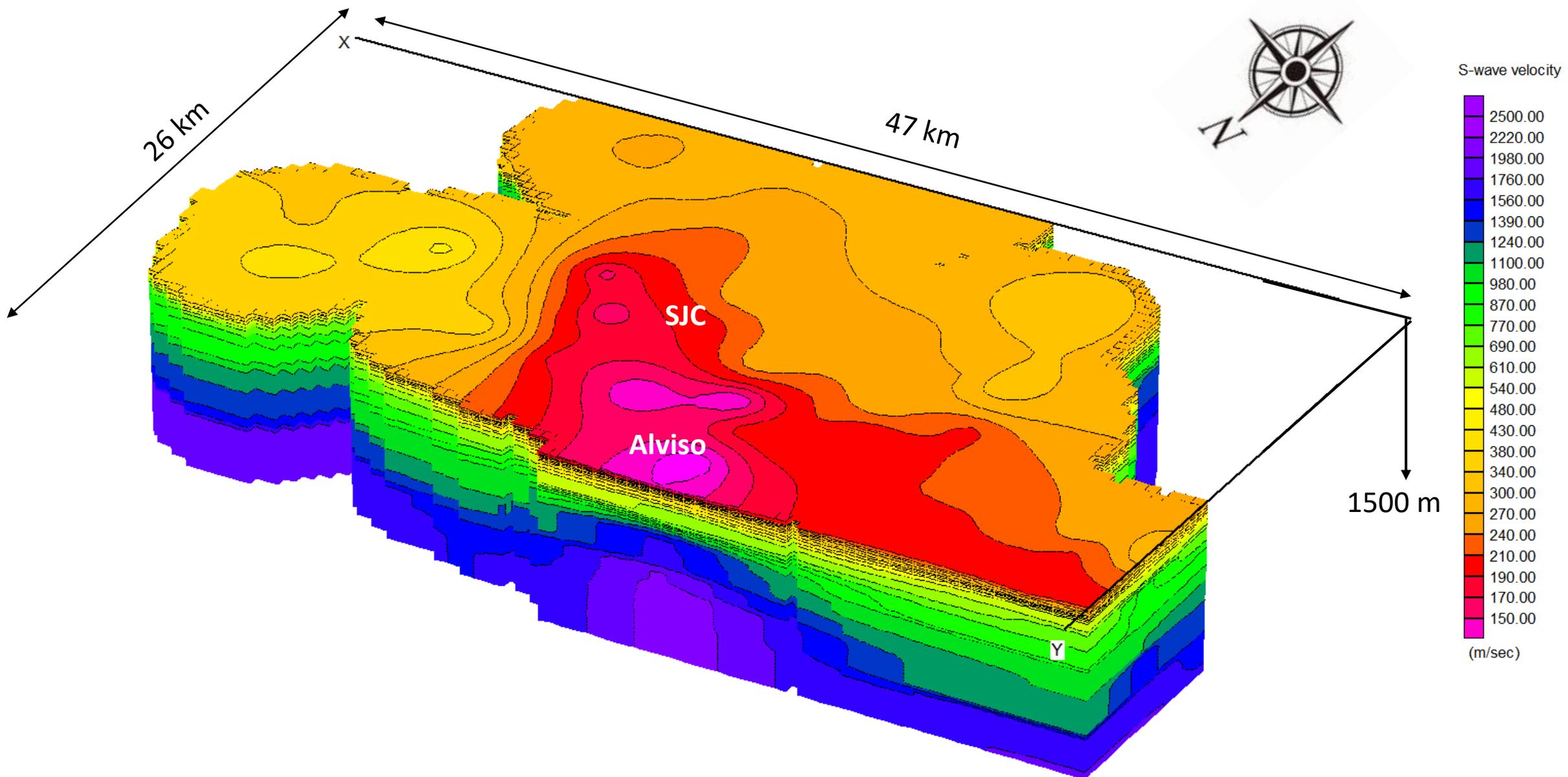
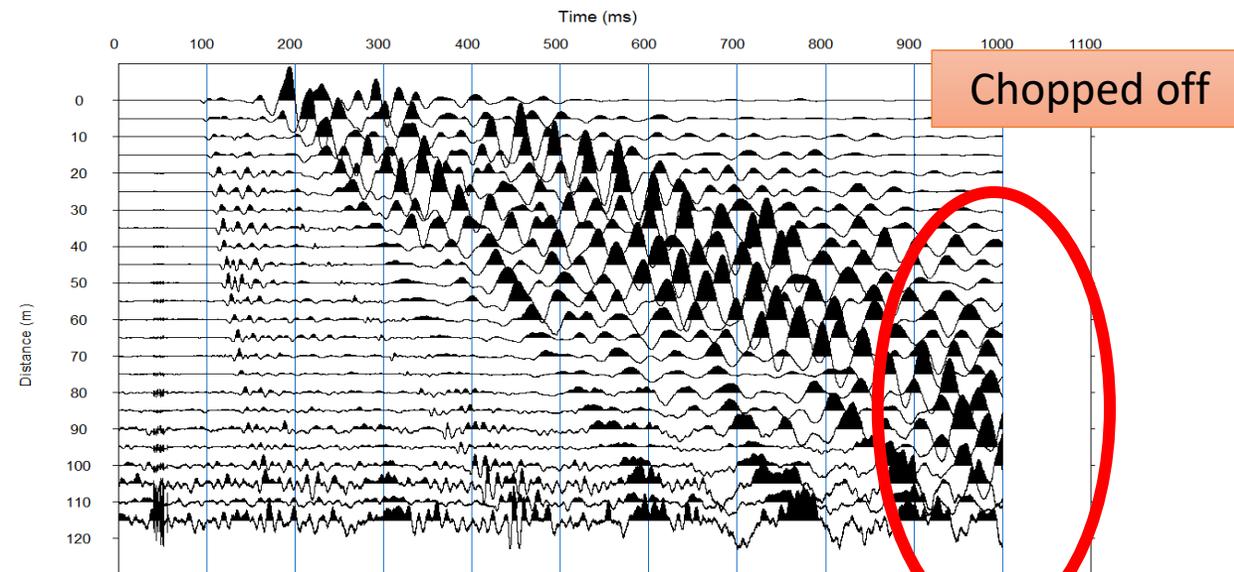# Depth to a bedrock with Vs > 1500 m/sec

6. Data acquisition

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- Shallow passive data acquisition using cableless seismograph
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- H/V
- Quality control
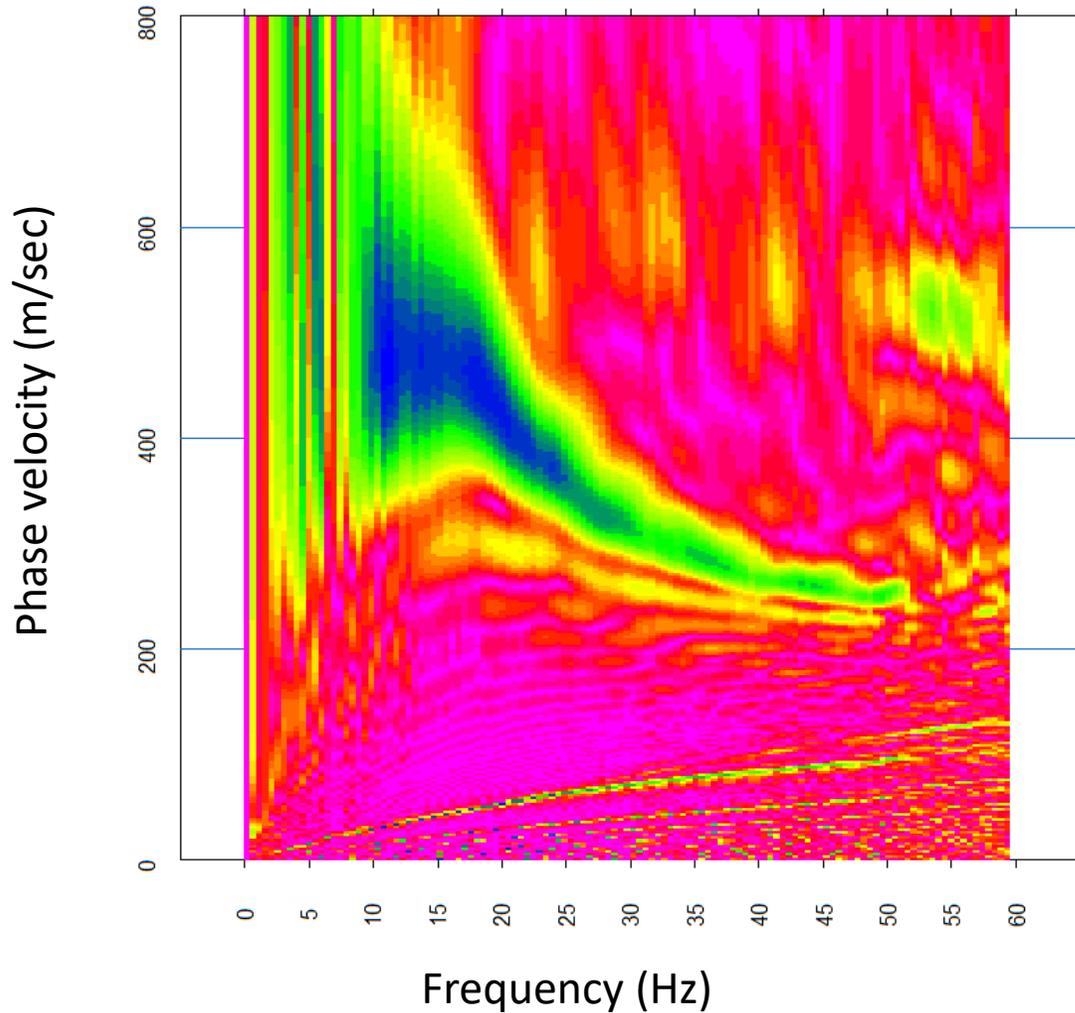
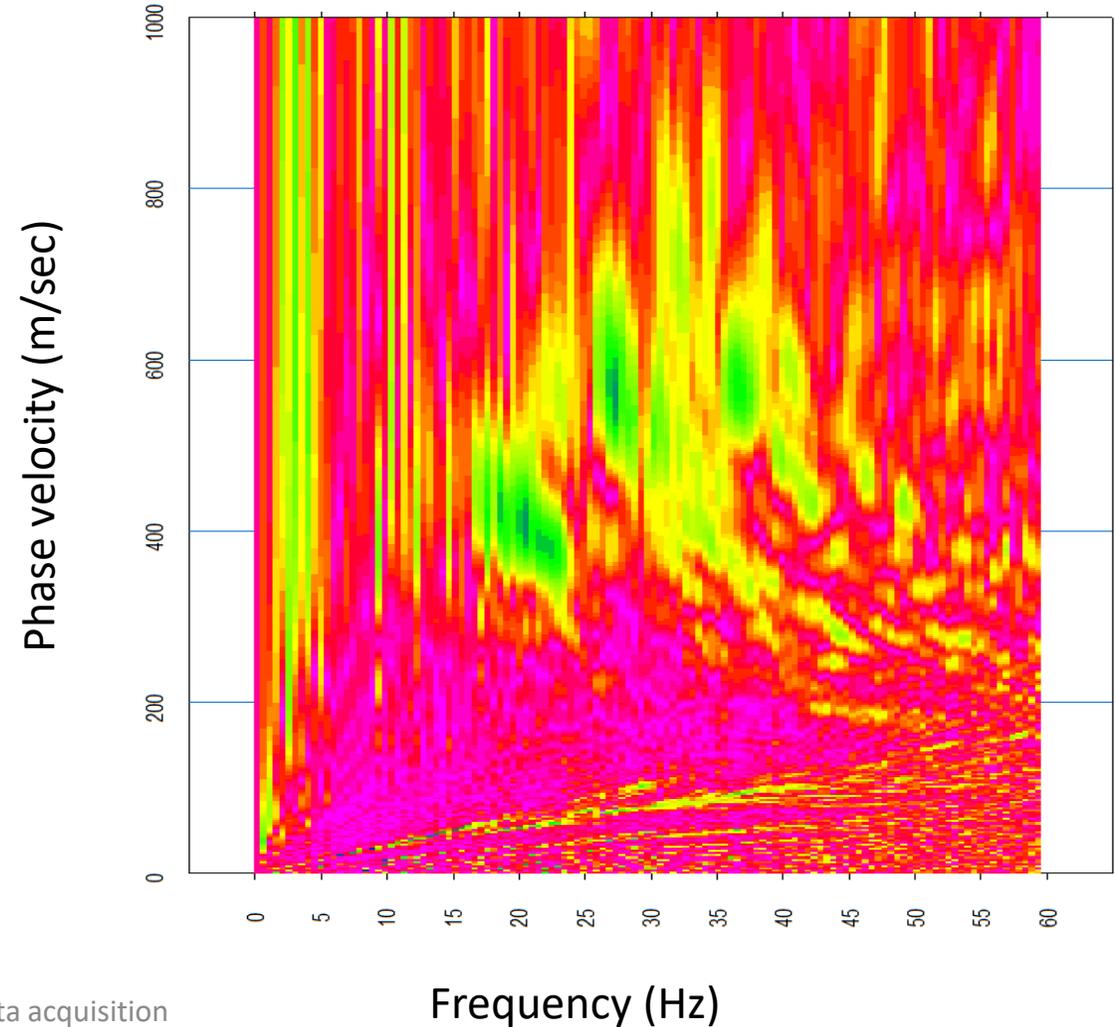# Quality control (time domain)

Good data

Chopped off

Noisy
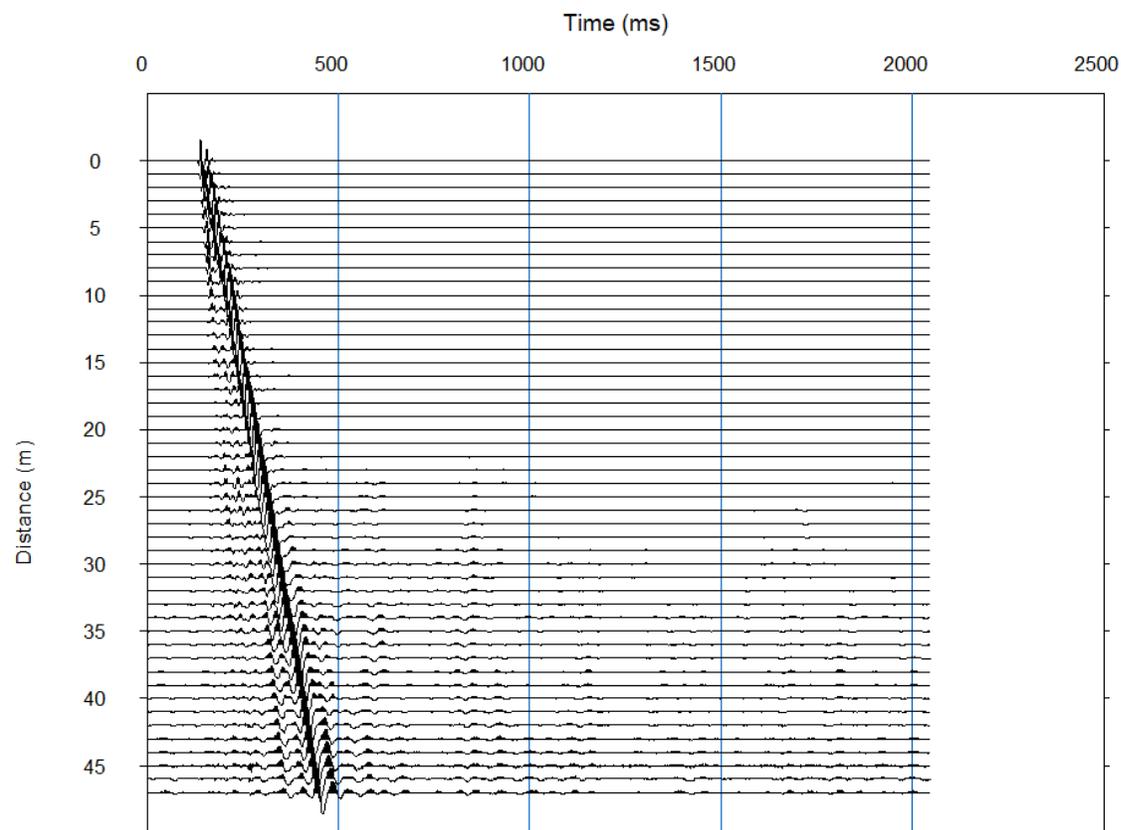
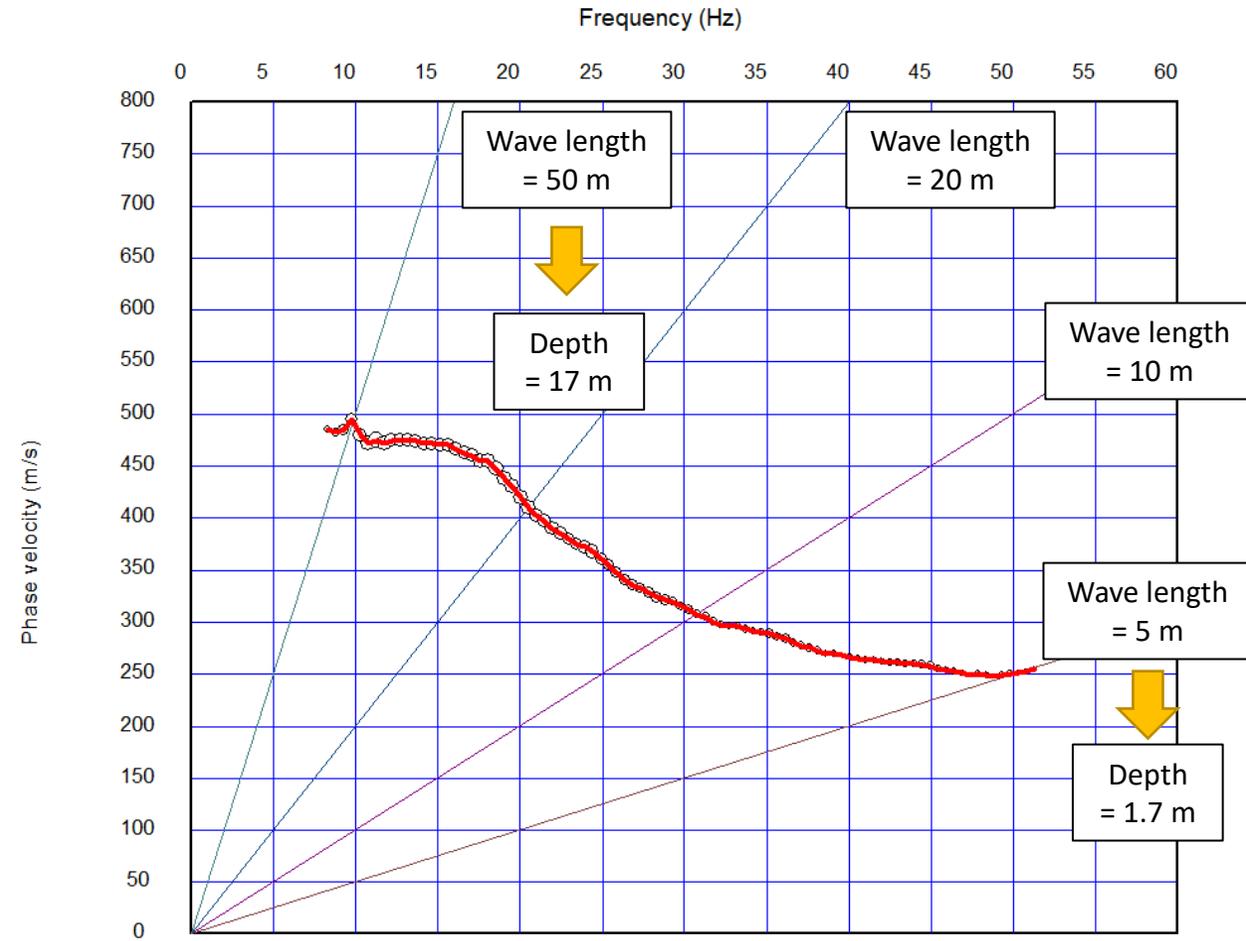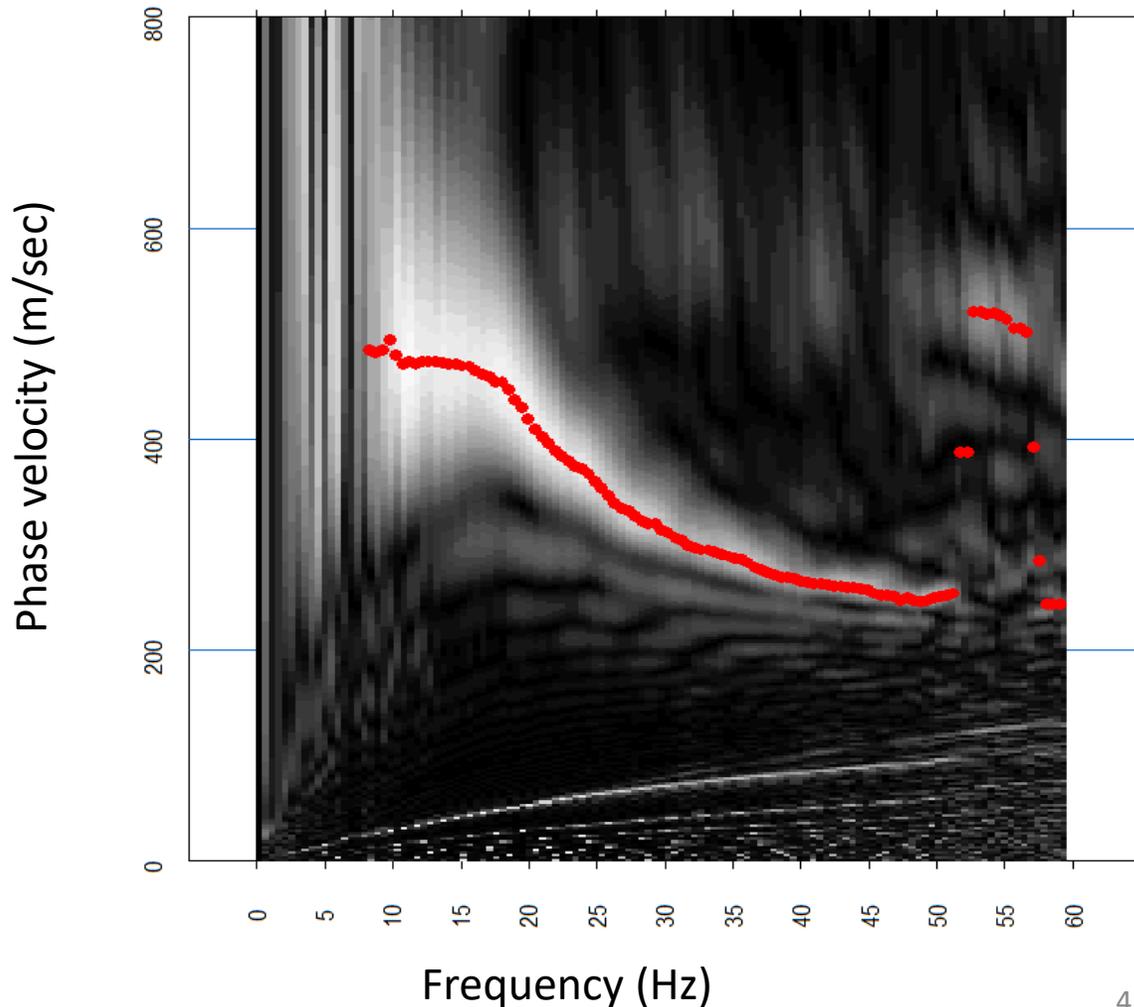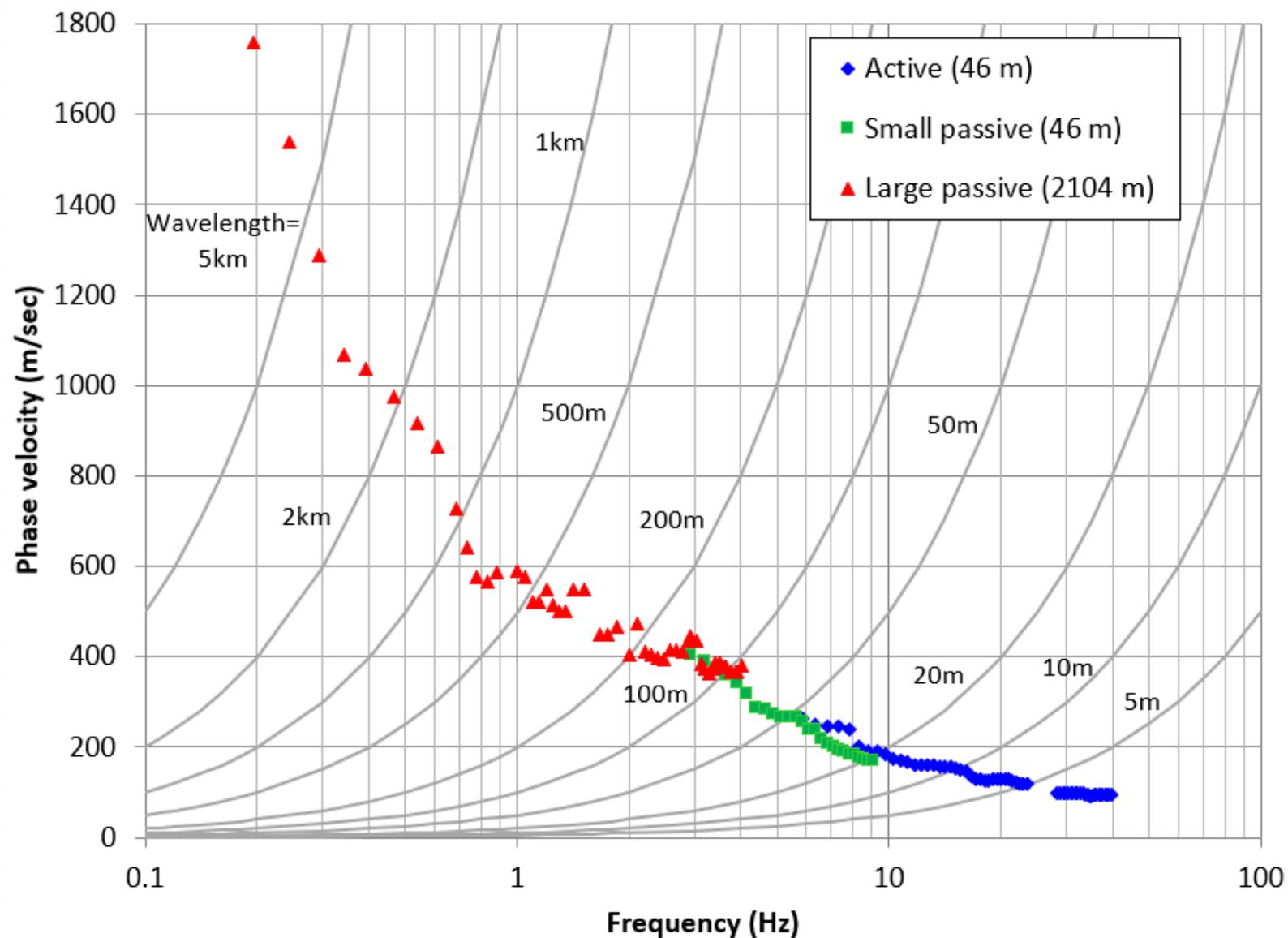# Quality control (frequency domain)

Good data

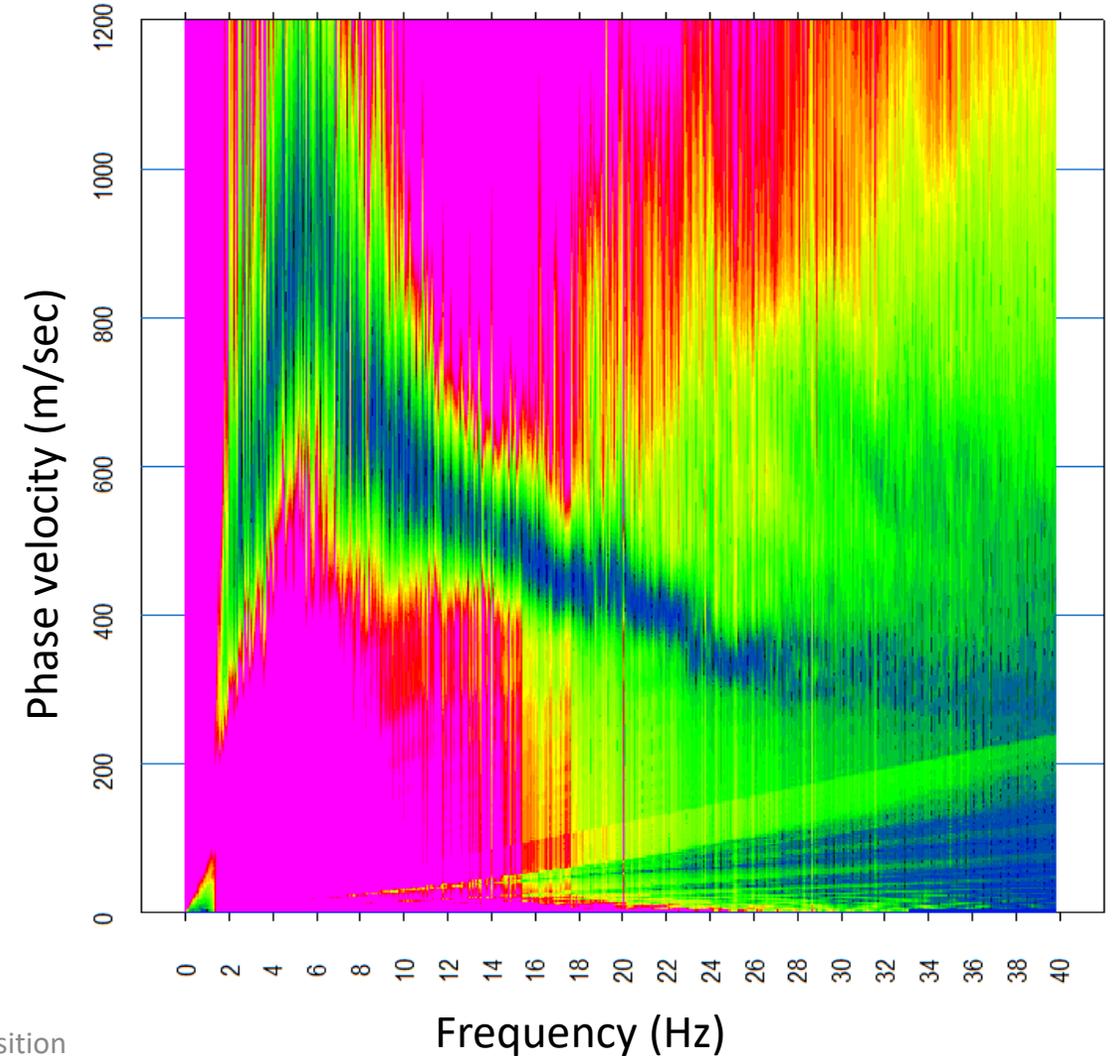Bad data

Quality control (frequency domain)
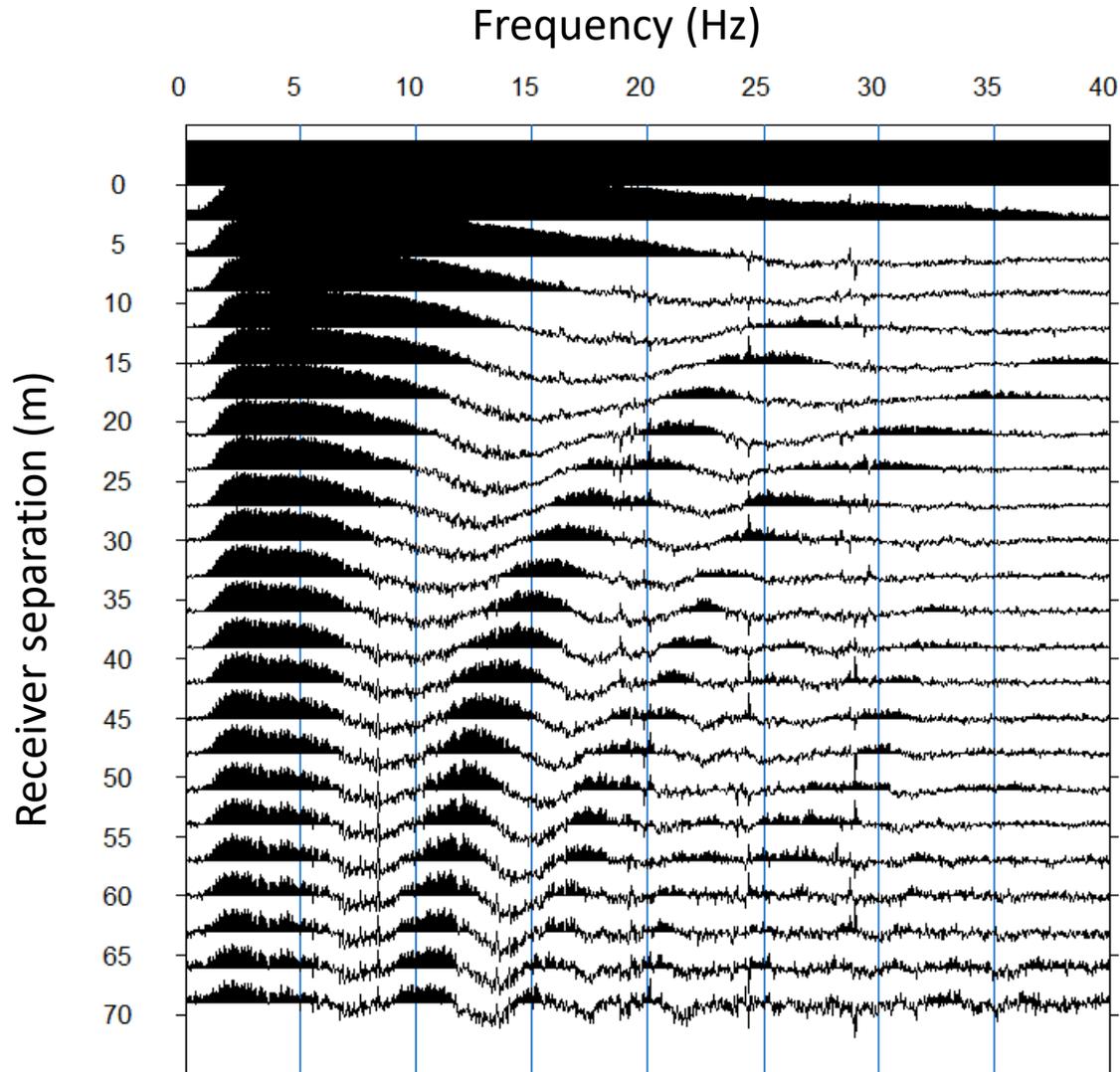
Dispersion curve

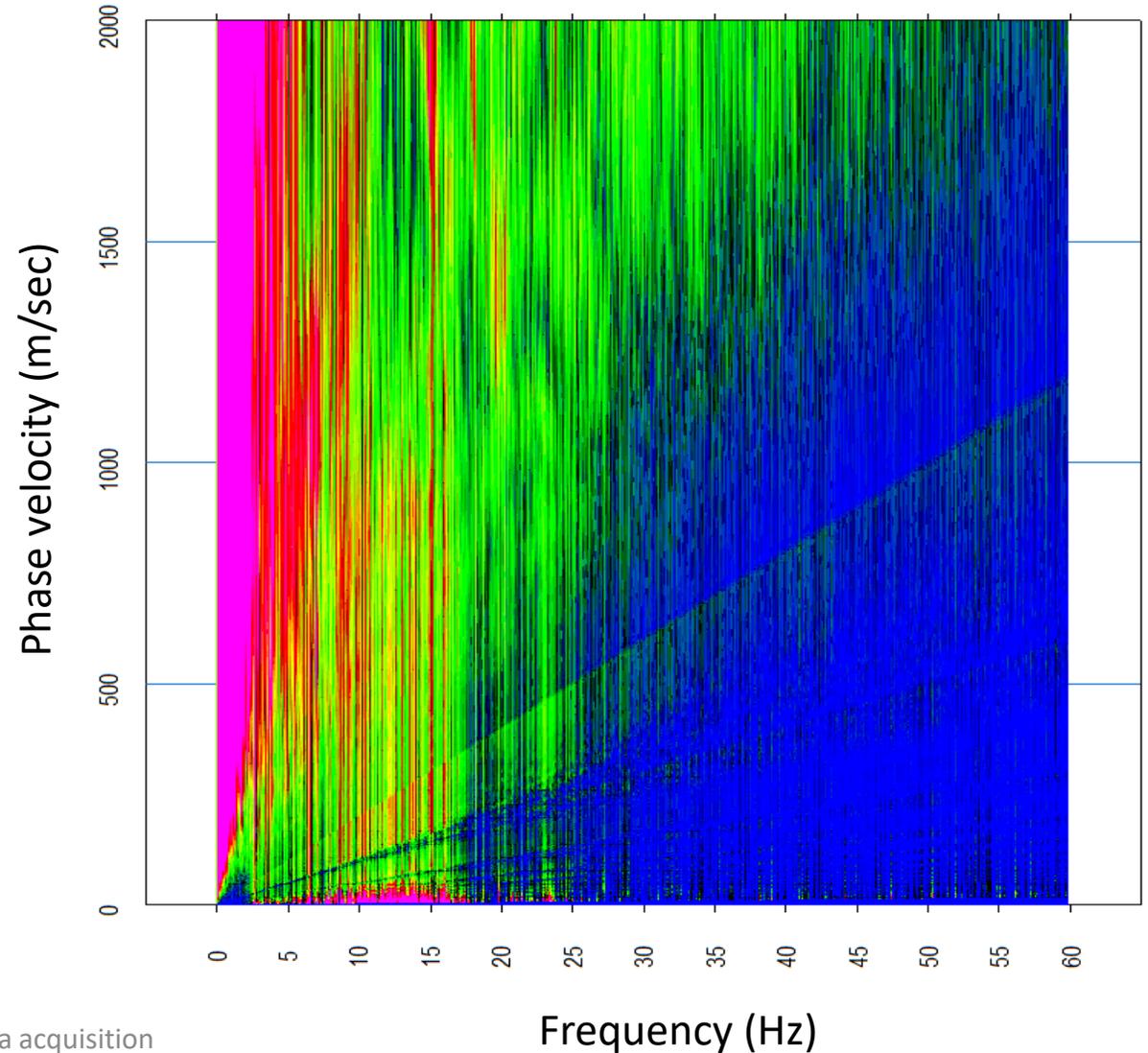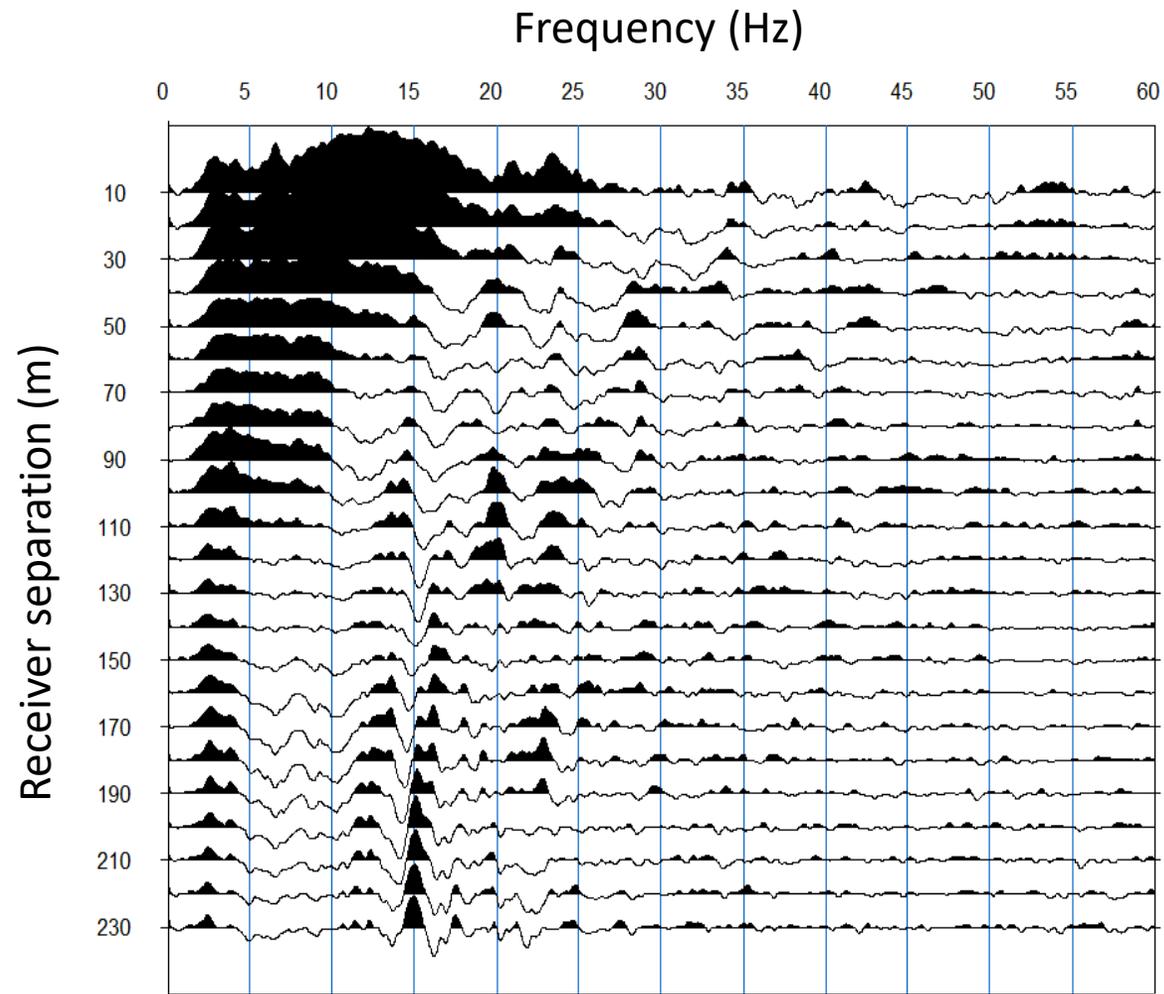# Comparison of active and passive dispersion curves

Quality control (frequency domain)

Good data

Quality control (frequency domain)

Bad data

4. Data acquisition

Coherencies obtained at day time and night time

Daytime

Nighttime

Quality has big difference

600 m

Coherencies obtained at day time and night time

Daytime

Nighttime

Arrays larger than 100 m must be measured in nighttime at urban area

It is quite important to confirm dispersion curves meet investigation purposes at field