

Measurement of environmental magnetic field

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Contents

- Calibration
- Result of Measurement
- Data quality
- Conclusion & Future Works

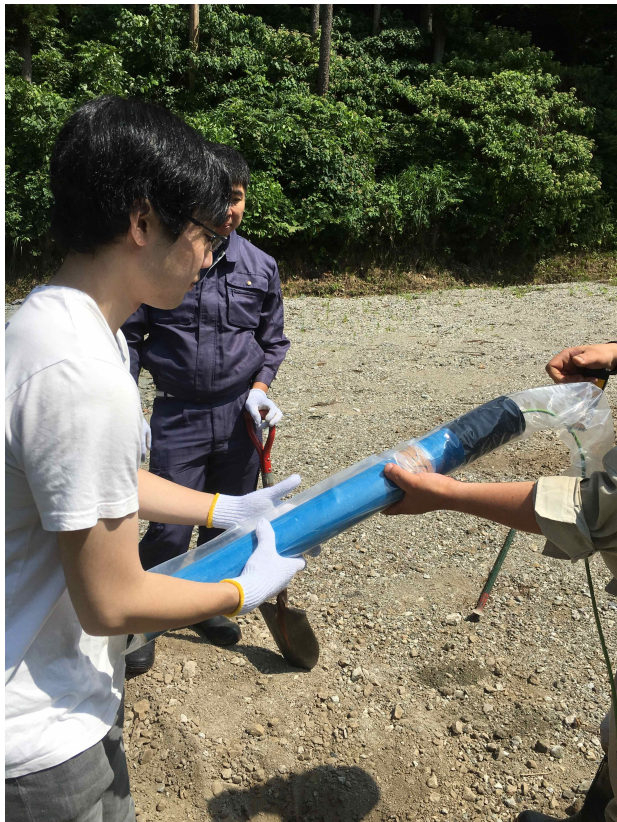
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Calibration

We used six magnetometers and two loggers and each equipment has filters

MFS-06 or 07e (metronix)



ADU-07 (metronix)

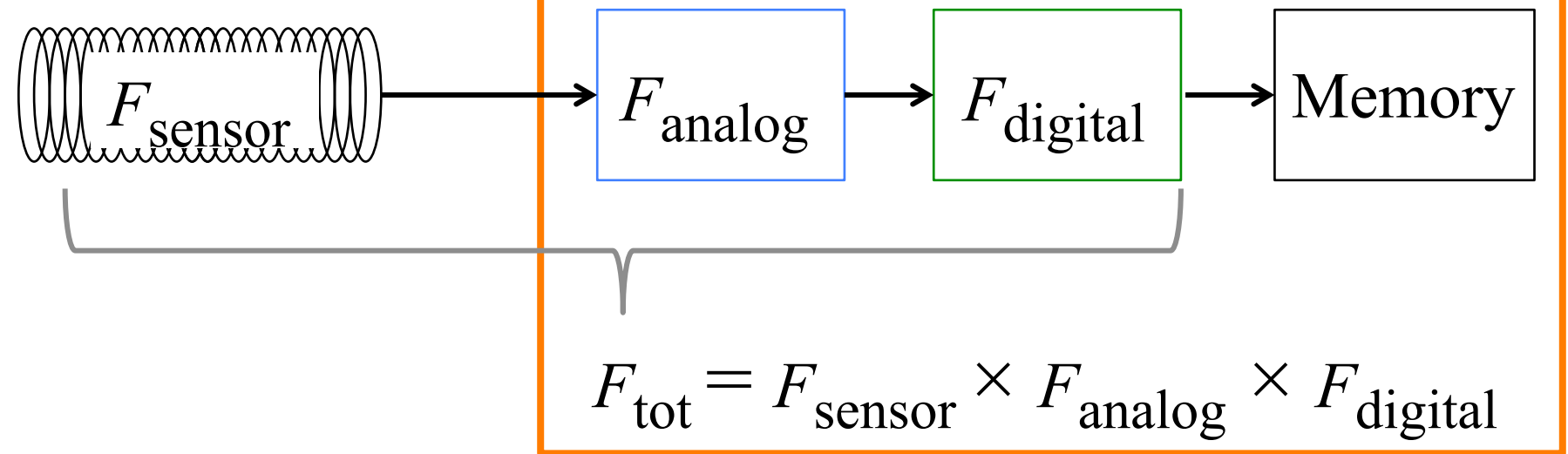


MFS-06,07e and ADU-07: under joint usage by ERI

Calibration

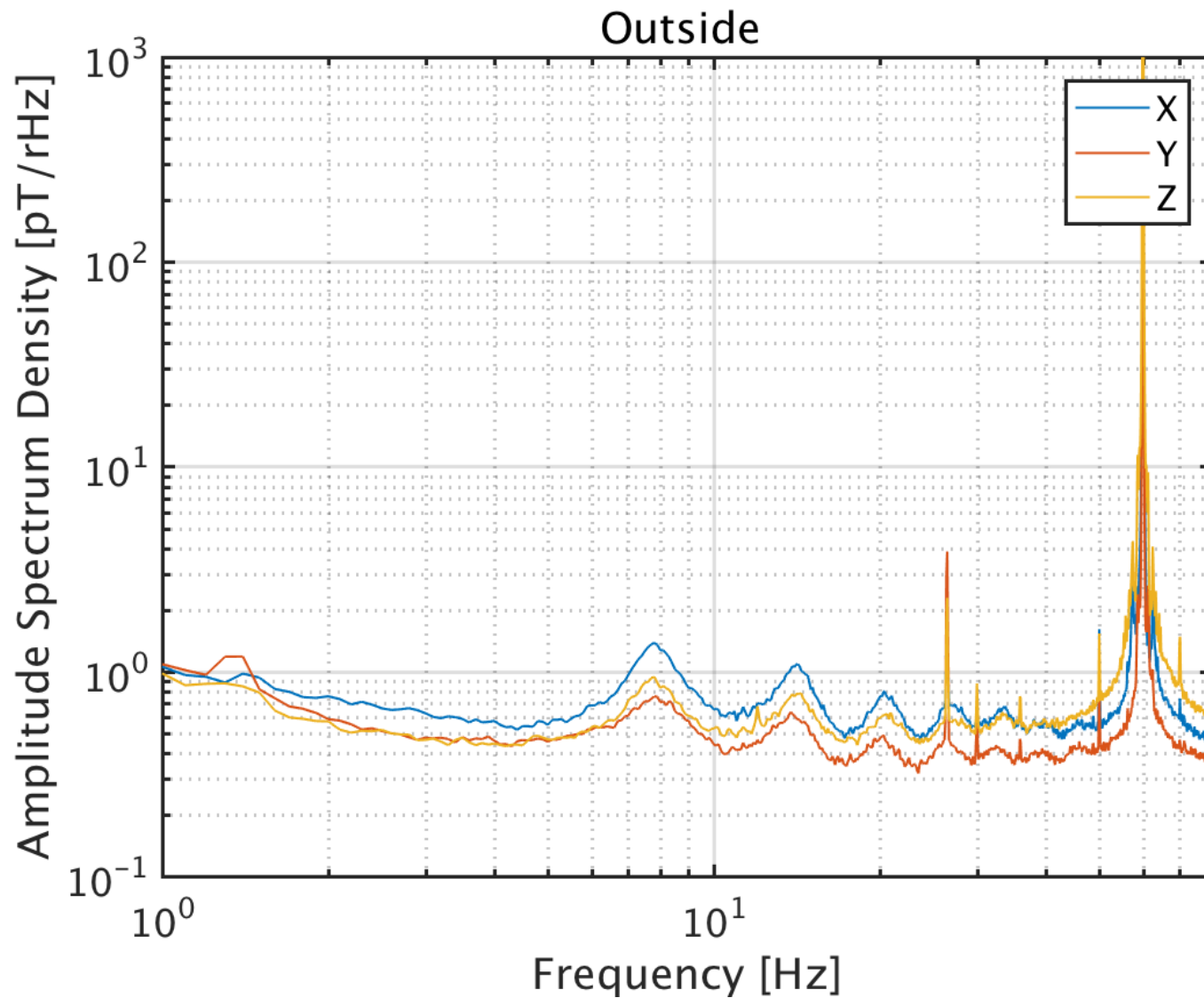
Logger (ADU-07)

Sensor
(MFS-06 or 07e)



$$X_{\text{cal}} = 1/F_{\text{tot}} \times X_{\text{raw}}$$

After calibration



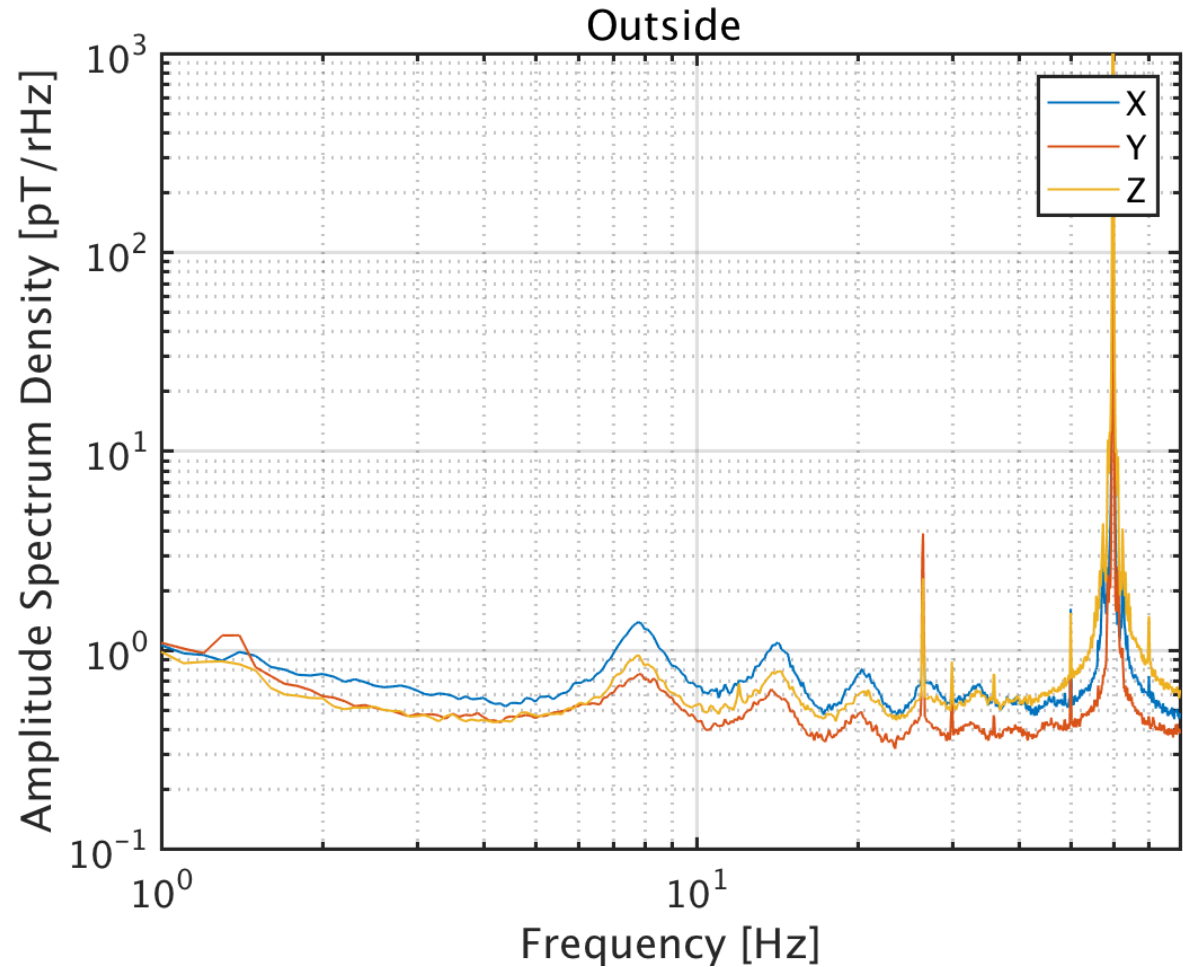
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Result of this measurement

■ Check Point

1. Amplitude
2. Frequency

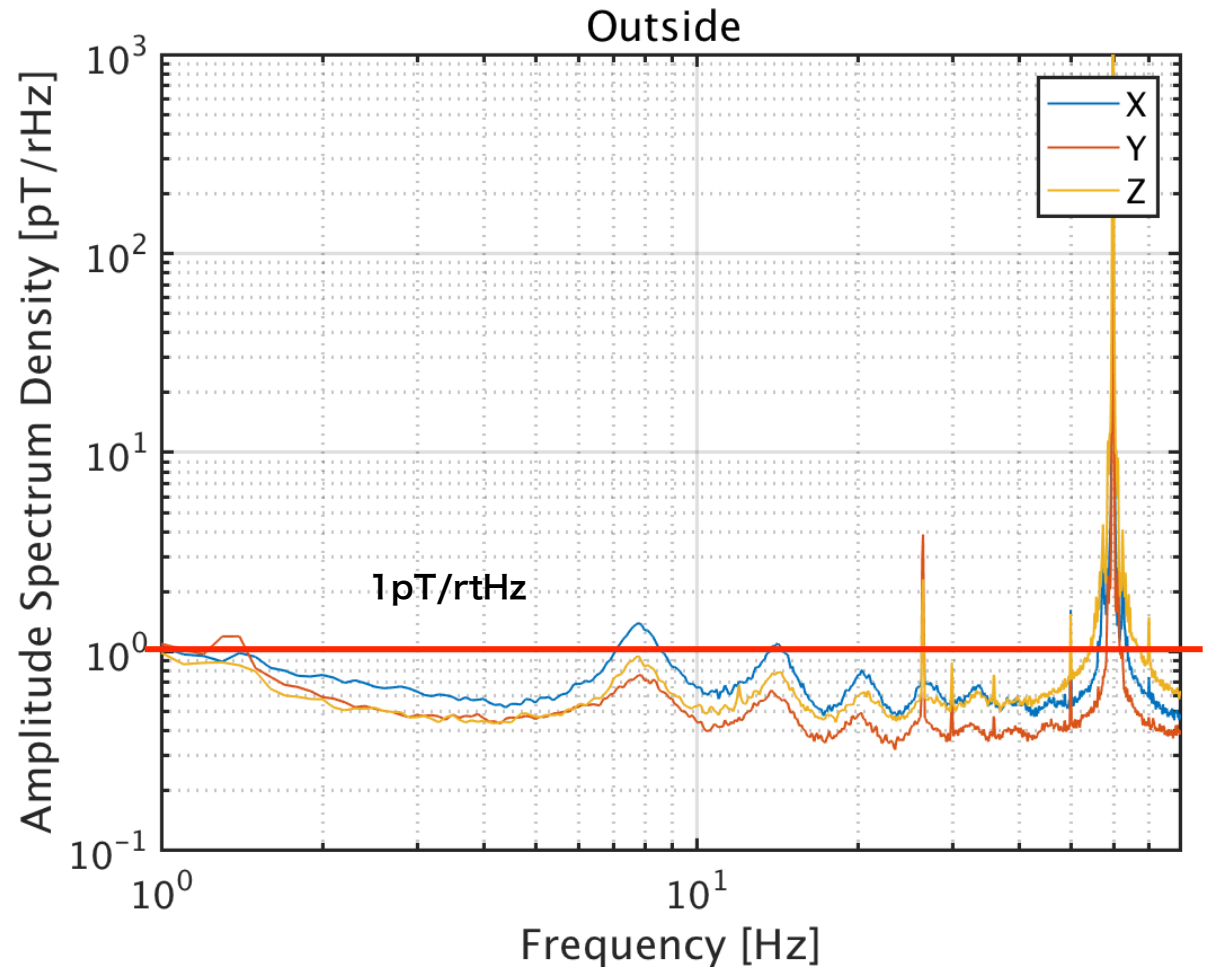


Result of this measurement

■ Check Point

1. Amplitude

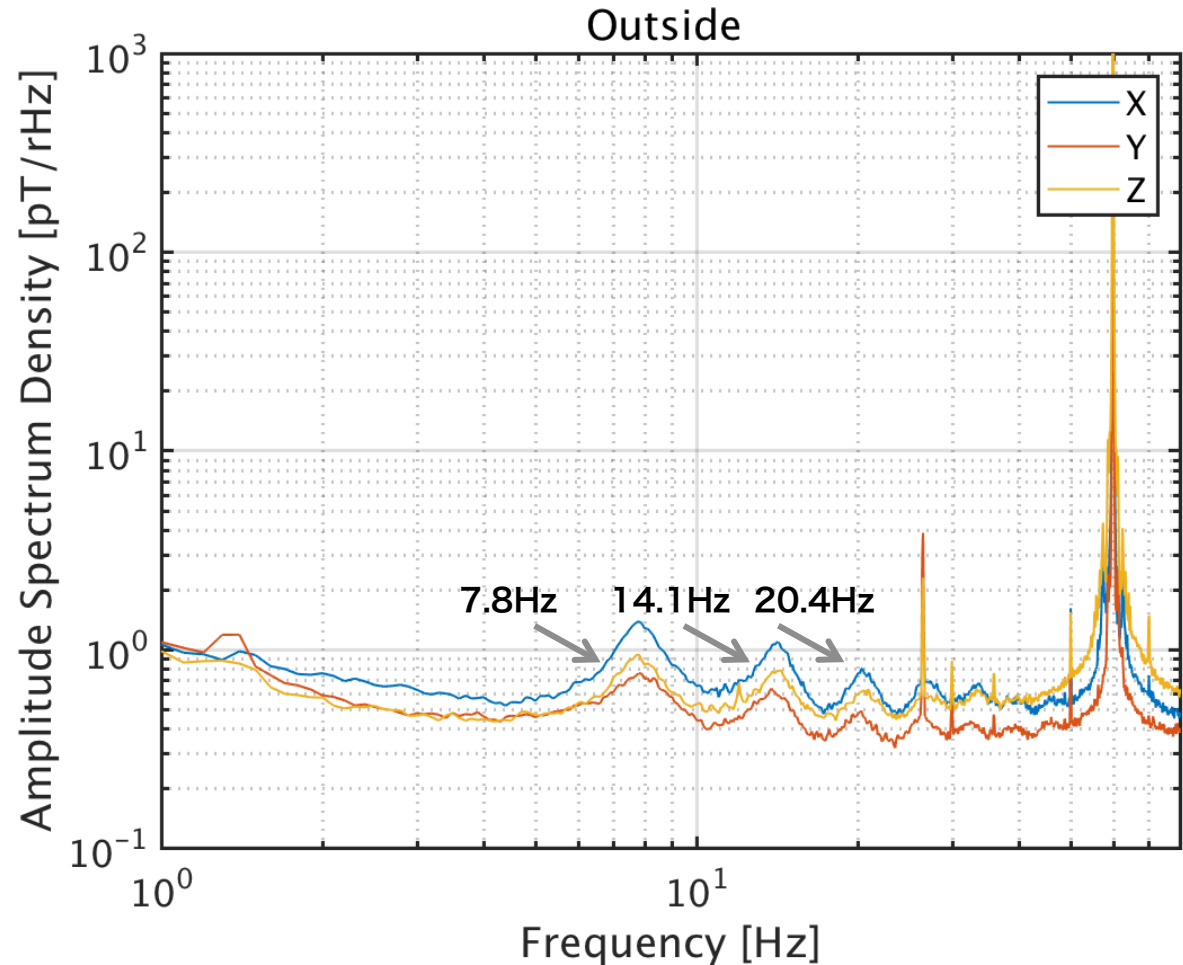
2. Frequency



Result of this measurement

■ Check Point

1. Amplitude
2. Frequency



Measurement was consistent with the prior study [1] !!

Result of this measurement

■ Compare Inside with Outside

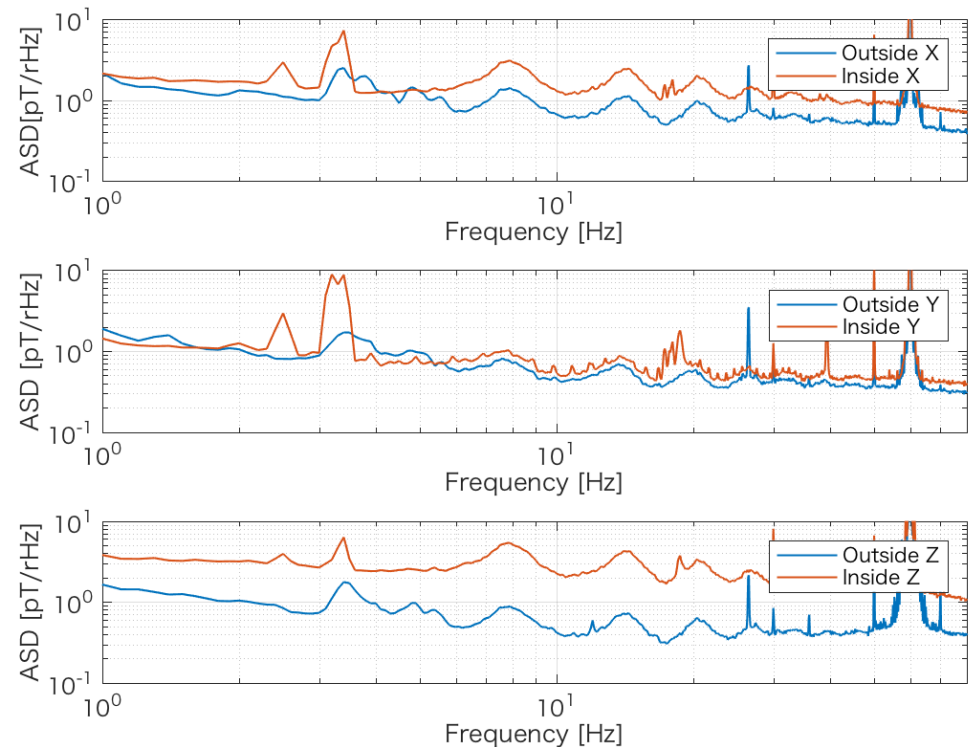
■ Result

Magnetic field inside the tunnel
is larger than outside

■ Reason

??????????

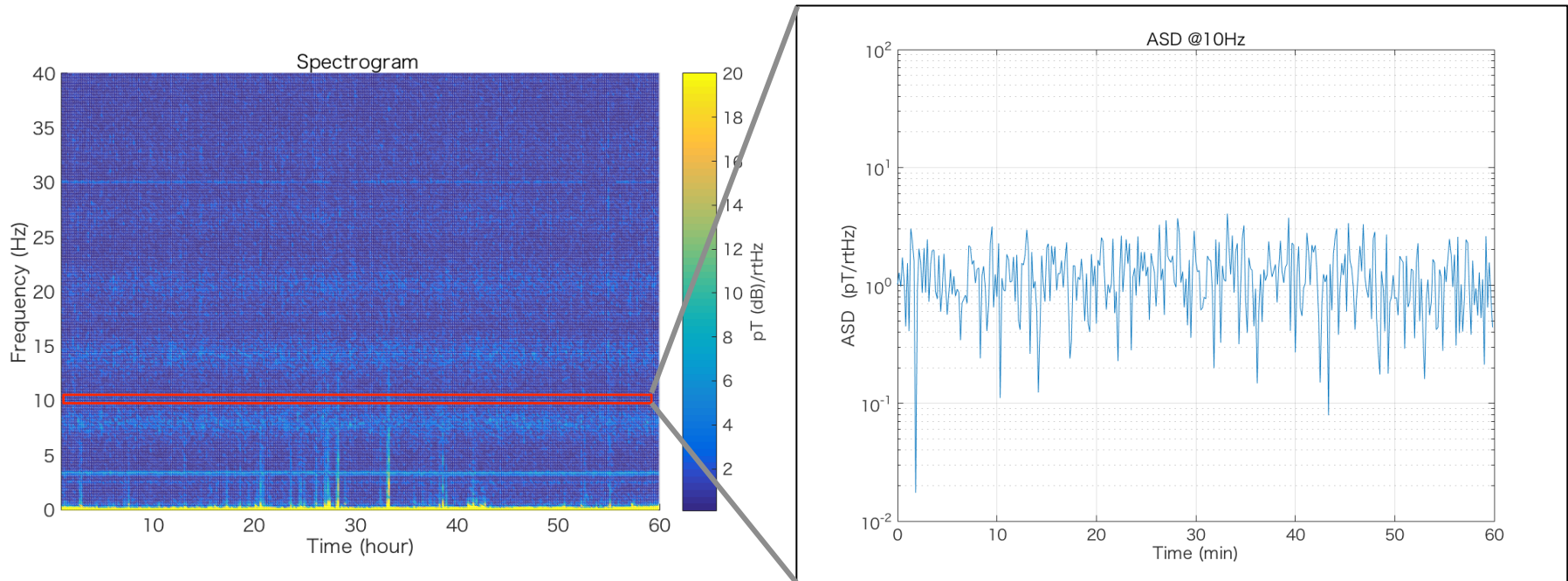
ASD Inside vs. Outside



Result of this measurement

■ Spectrogram

spectrogram of X direction outside the tunnel

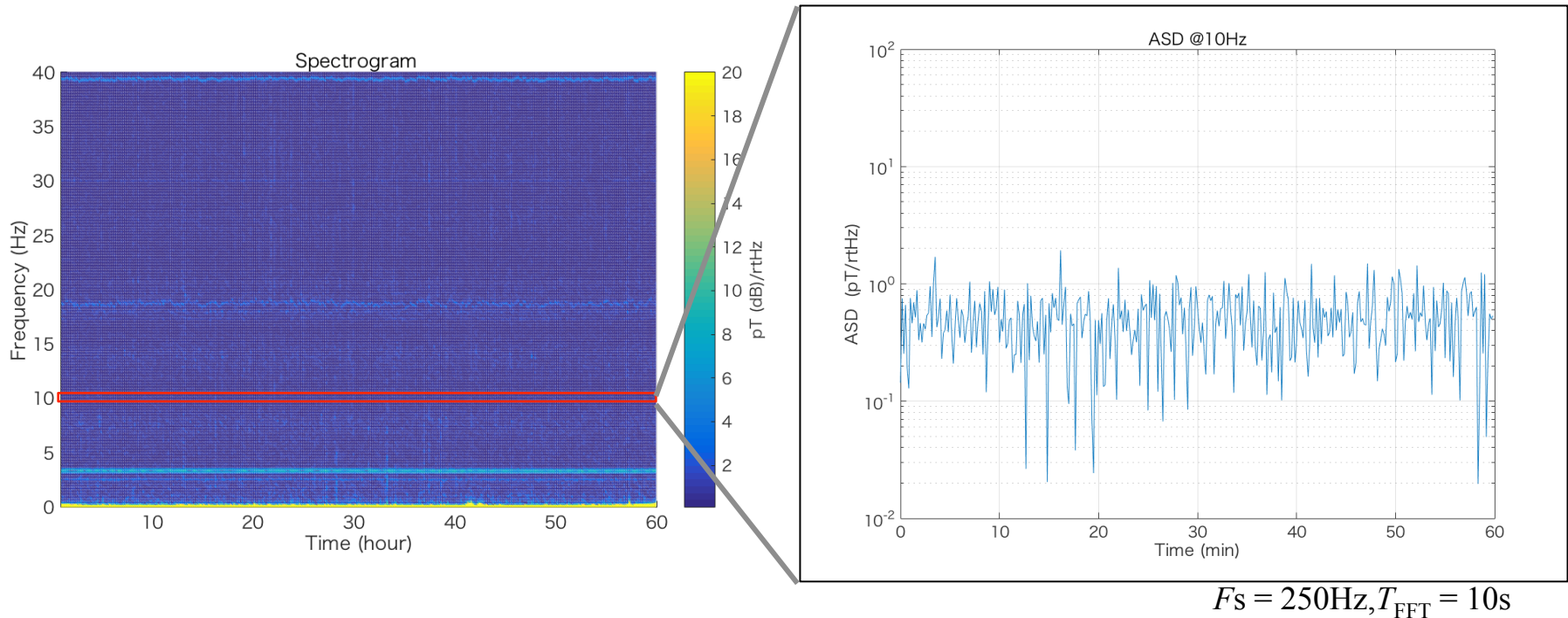


$$F_s = 250\text{Hz}, T_{\text{FFT}} = 10\text{s}$$

Result of this measurement

■ Spectrogram

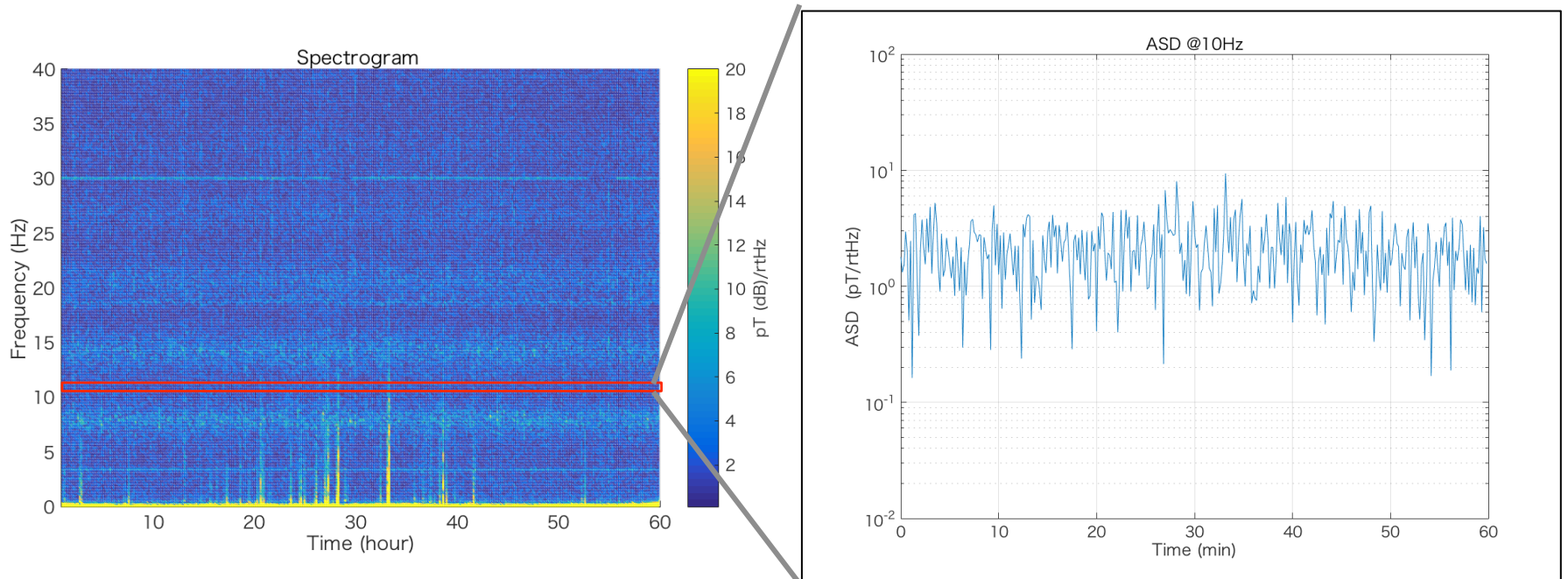
spectrogram of Y direction outside the tunnel



Result of this measurement

■ Spectrogram

spectrogram of Z direction outside the tunnel

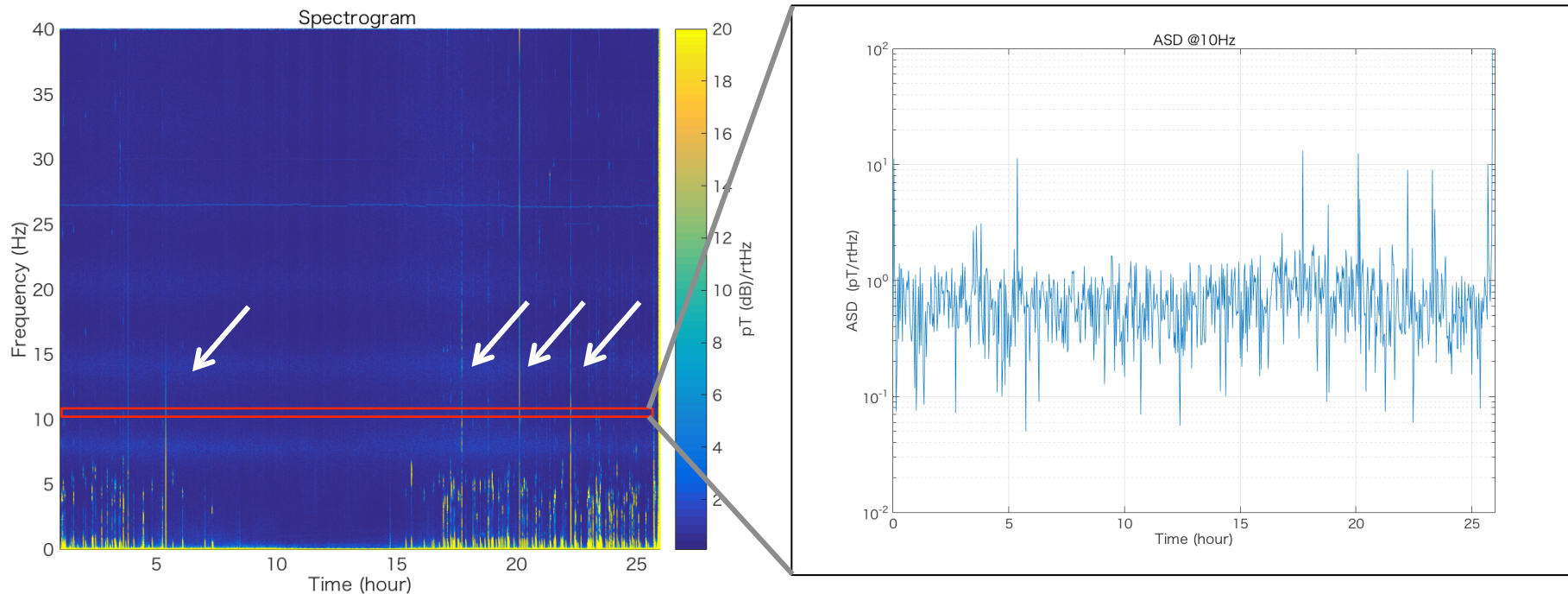


$$F_s = 250\text{Hz}, T_{\text{FFT}} = 10\text{s}$$

Result of this measurement

■ Spectrogram

spectrogram of X direction outside the tunnel



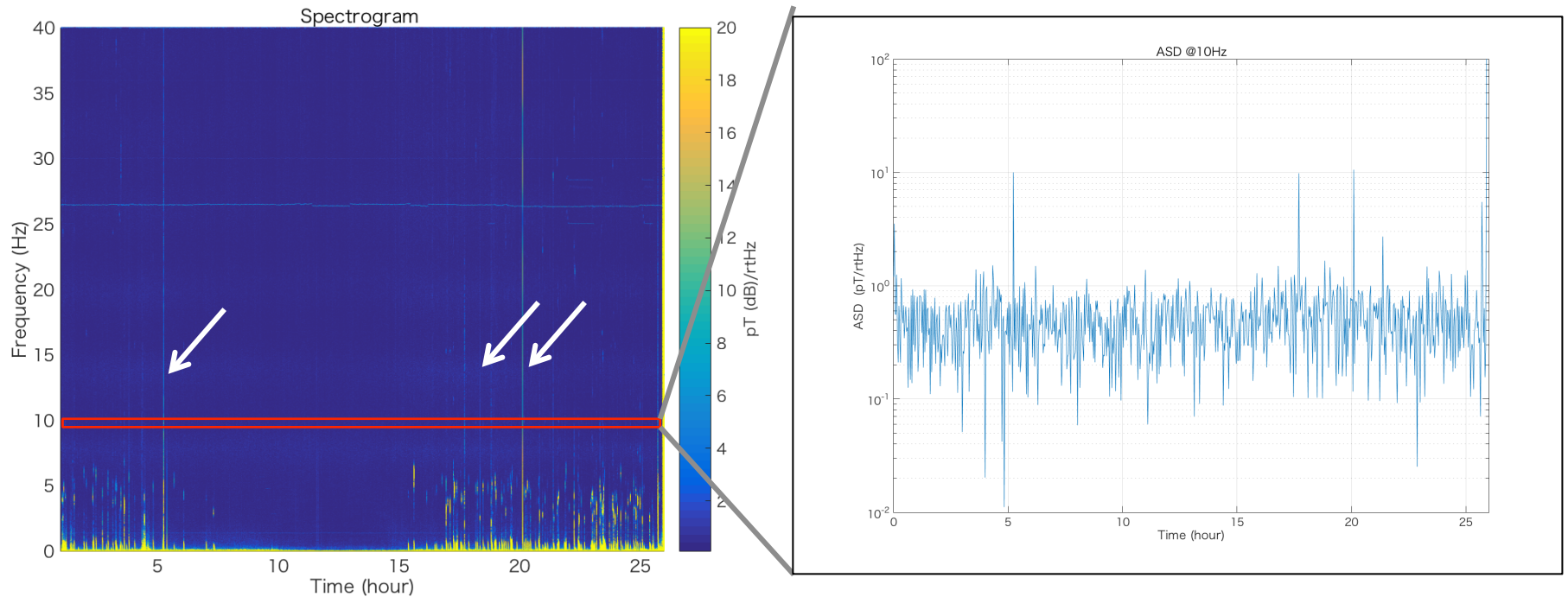
$$F_s = 100\text{Hz}, T_{\text{FFT}} = 120\text{s}$$

Some glitches caused by human activity were detected !

Result of this measurement

■ Spectrogram

spectrogram of Y direction outside the tunnel



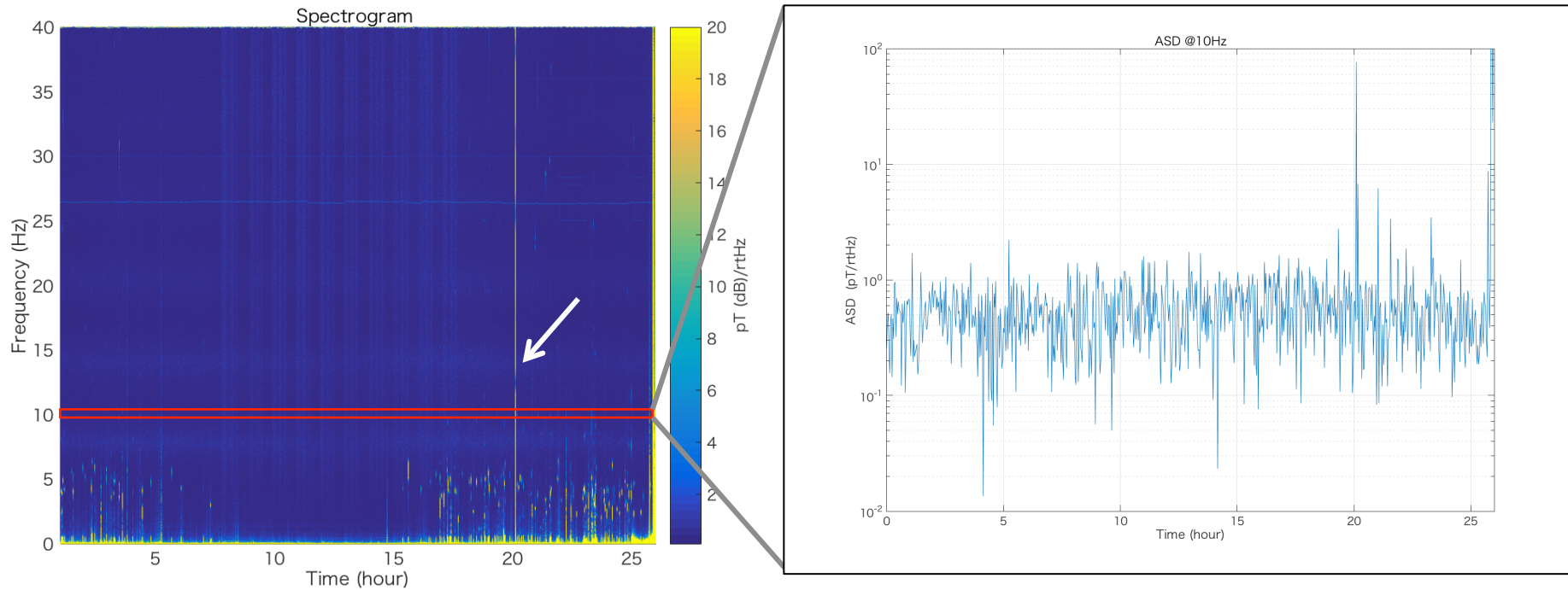
$$F_s = 100\text{Hz}, T_{\text{FFT}} = 120\text{s}$$

Some glitches caused by human activity were detected !

Result of this measurement

■ Spectrogram

spectrogram of Z direction outside the tunnel



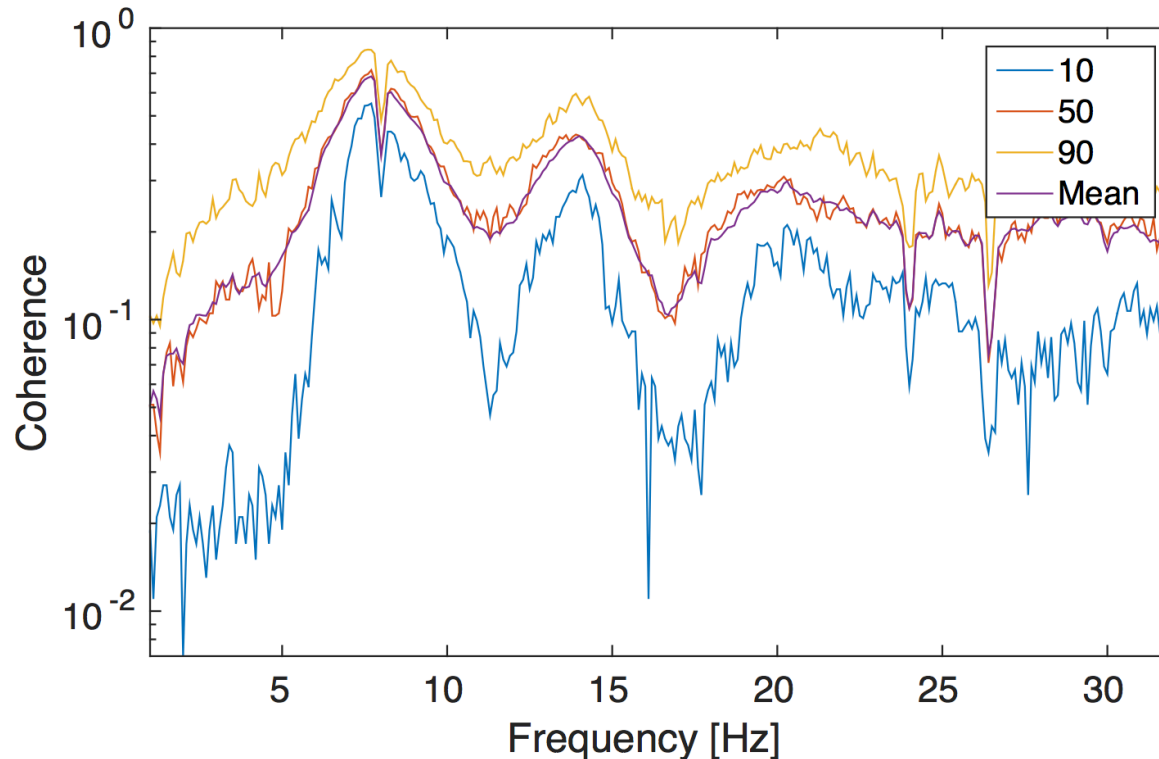
$$F_s = 100\text{Hz}, T_{\text{FFT}} = 120\text{s}$$

Some glitches caused by human activity were detected !

Result of this measurement

■ Compare KAGRA with Virgo

Virgo team calculated the coherence between KAGRA site with Virgo site



Result of this measurement

From the result of measurement :

1. Amplitude of magnetic field was few pT
2. However amplitude of magnetic field inside the tunnel was larger than outside of the tunnel
3. Some glitches caused by human activity were measured
4. Coherence of KAGRA site and Virgo site were good

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Data Quality

To evaluate the data quality we used 3 values :

1. Rayleigh Monitor
2. Spectrogram-histogram
3. Line-Tracking

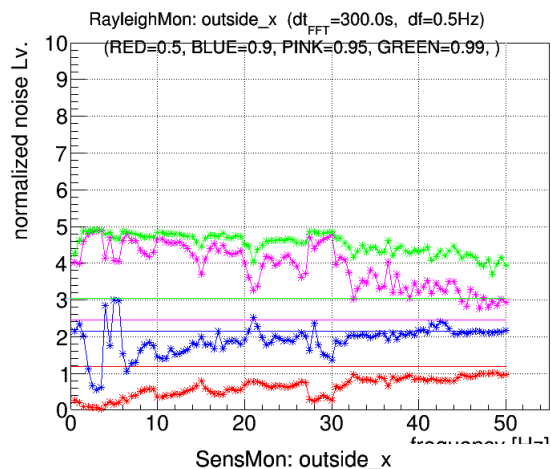
- We focus on the Gaussianity because it determines the performance of Wiener filter

We used **HasKAL** to evaluate the Data Quality
Links: <https://github.com/gw-analysis/detector-characterization>

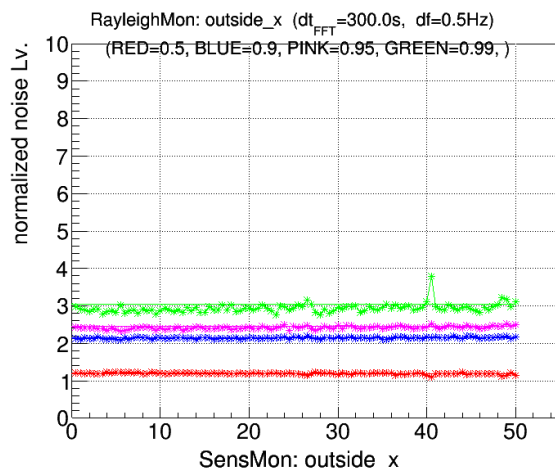
Data Quality

■ Rayleigh Monitor & Spectrogram-Histogram

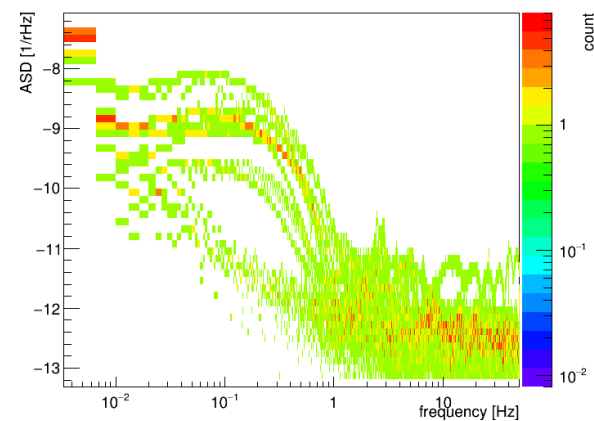
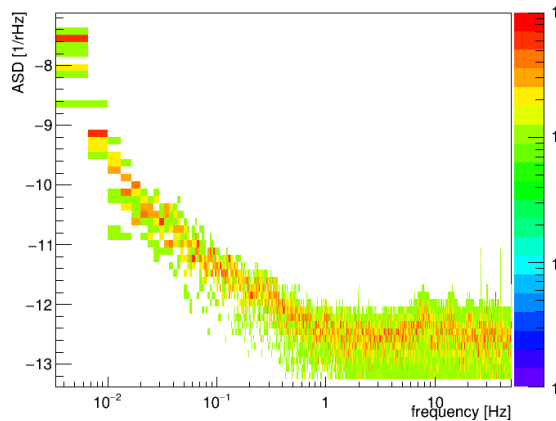
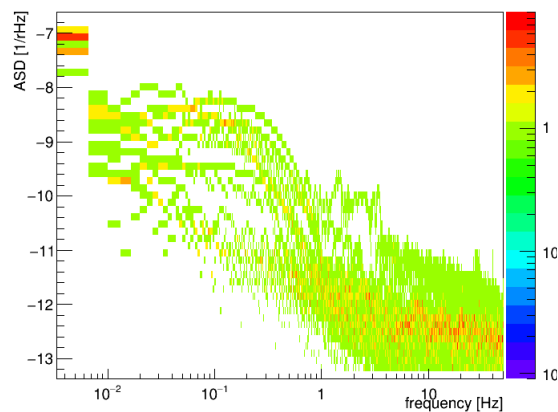
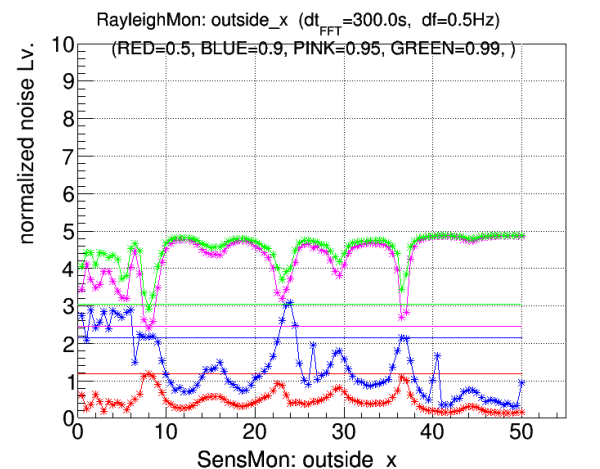
14:00-15:00(JST)



00:00-1:00(JST)



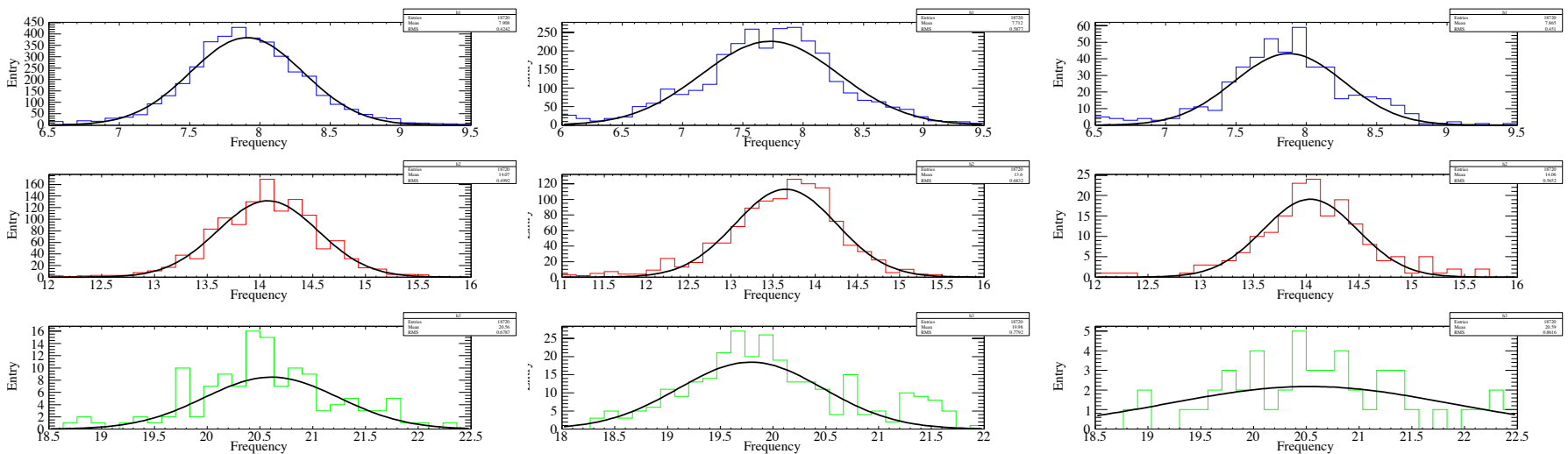
10:00-11:00(JST)



Data Quality

■ Line-Tracking (calculated by Ueno-san)

Tracking the resonant **frequency** of schumann resonance(1st 2nd 3rd)






We concluded the fluctuation of the resonant frequency showed Gaussian distribution

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Conclusion & Future works

We concluded :

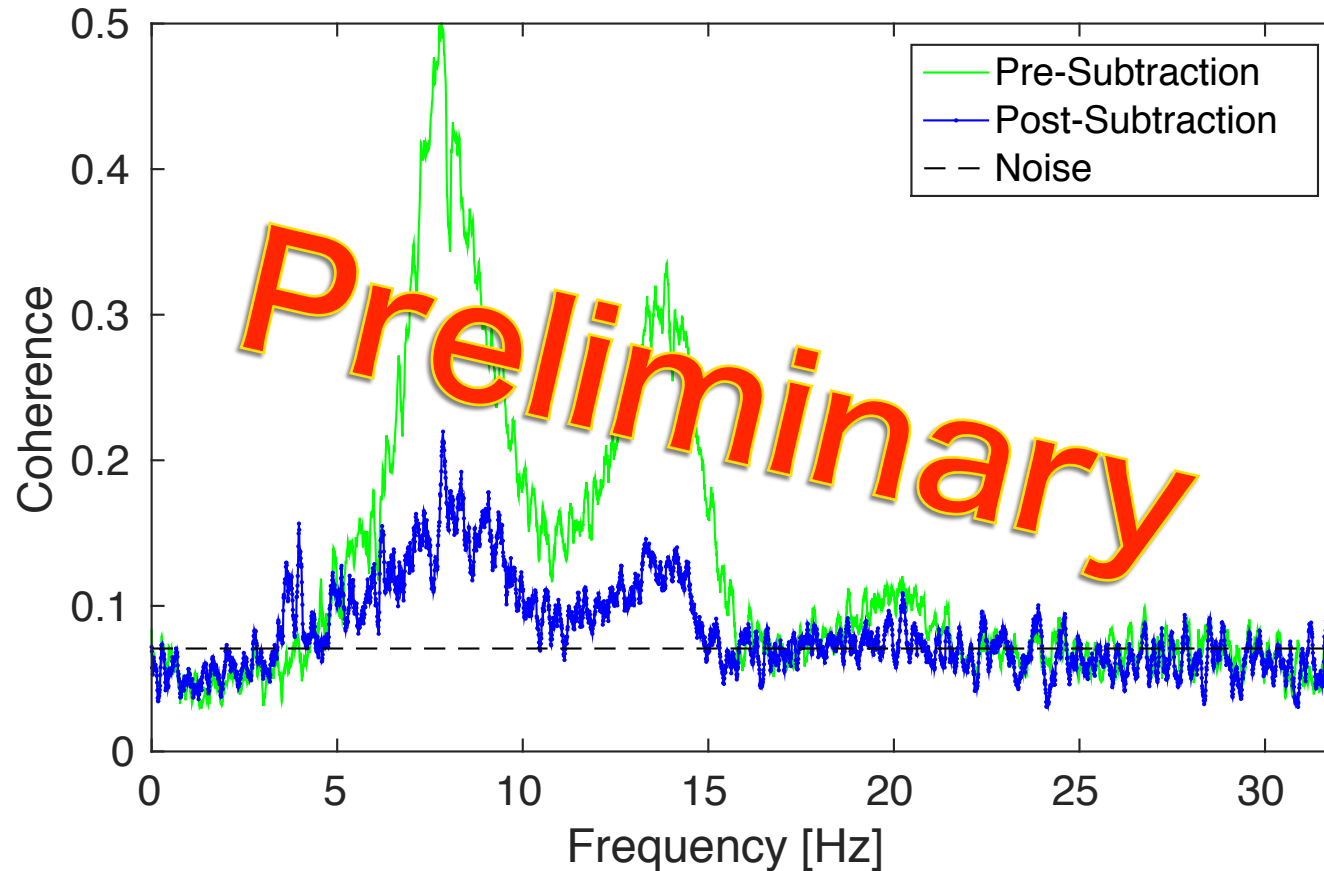
1. Measurement and calibration were successful 
2. Data quality was enough to make a Wiener filter 
3. Magnetic field inside the tunnel was larger than outside but we could not understand the true reason. 

In the future :

1. Make the wiener filter
2. Evaluate the performance of the filter
3. Understand the difference between inside and outside of tunnel

Status

Virgo team calculated the wiener filter and checked the performance



Acknowledgement

This study were supported many people and especially ,

- Koh Ueno
- Takahiro Yamamoto

Thank you very much!!

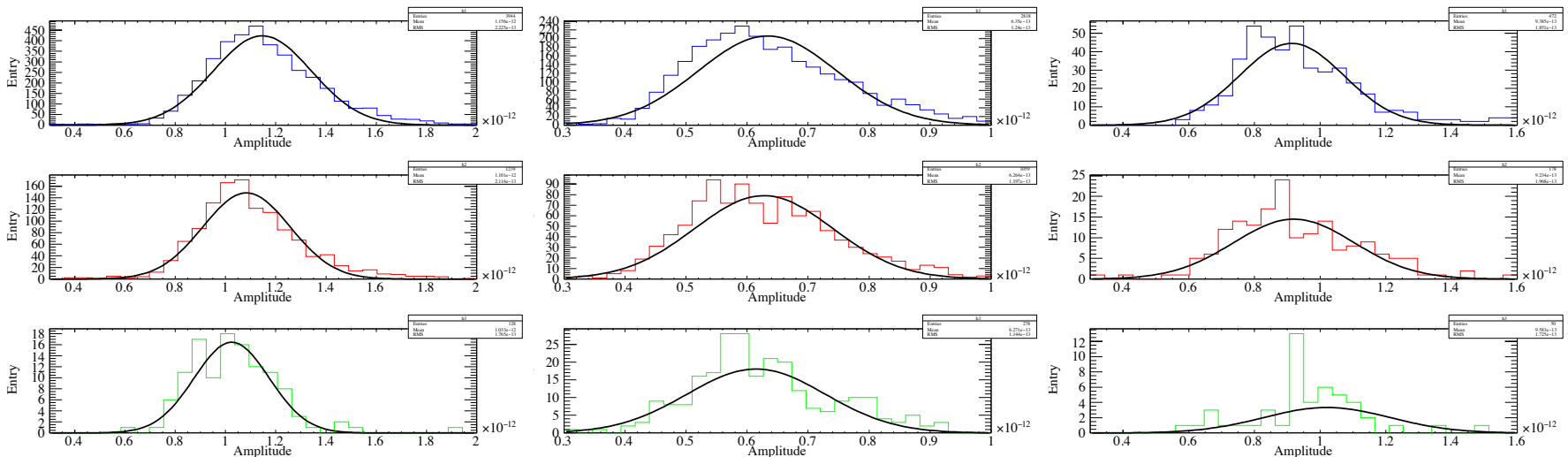
Bibliography

[1] Schumann Resonance for Tyros (Nickolaenko and Hayakawa)

Data Quality

■ Line-Tracking (calculated by Ueno-san)

Tracking the **Amplitude** of schumann resonance(1st 2nd 3rd)

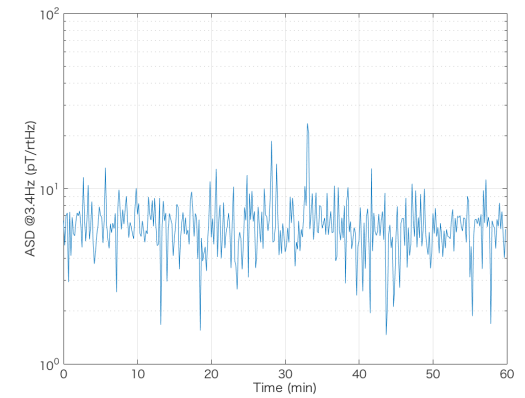
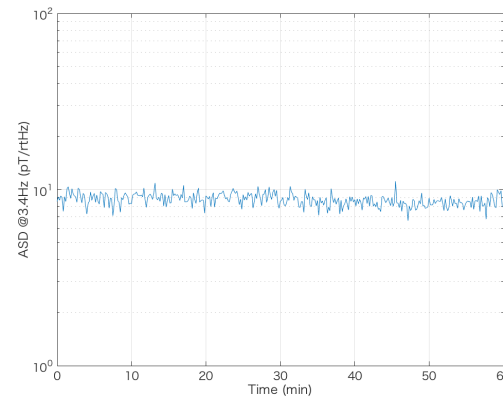
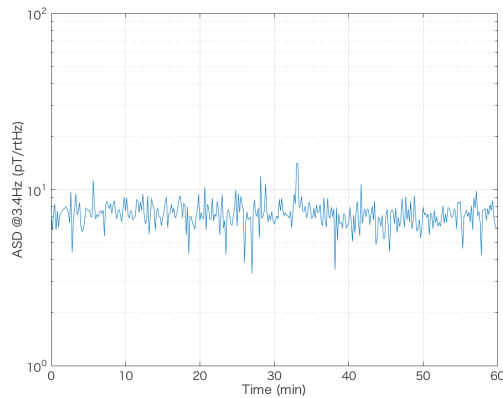
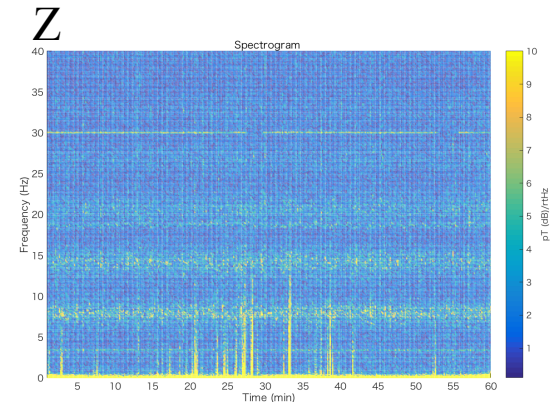
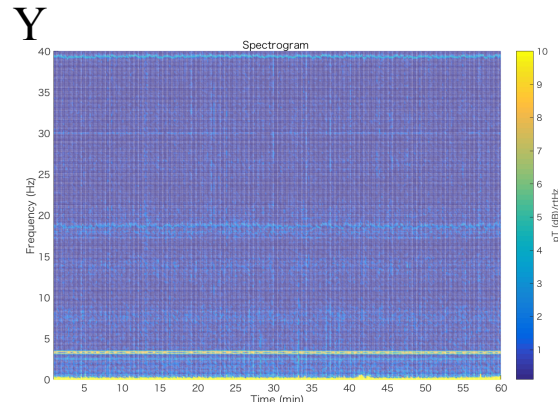
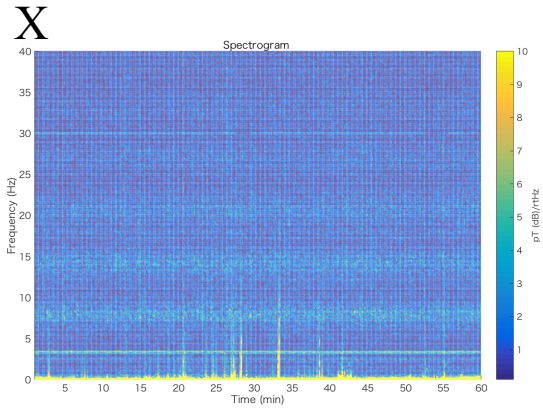


Fluctuation of resonant frequency showed χ^2 distribution

Data Quality

■ Spectrogram

Calculate the spectrogram inside the tunnel

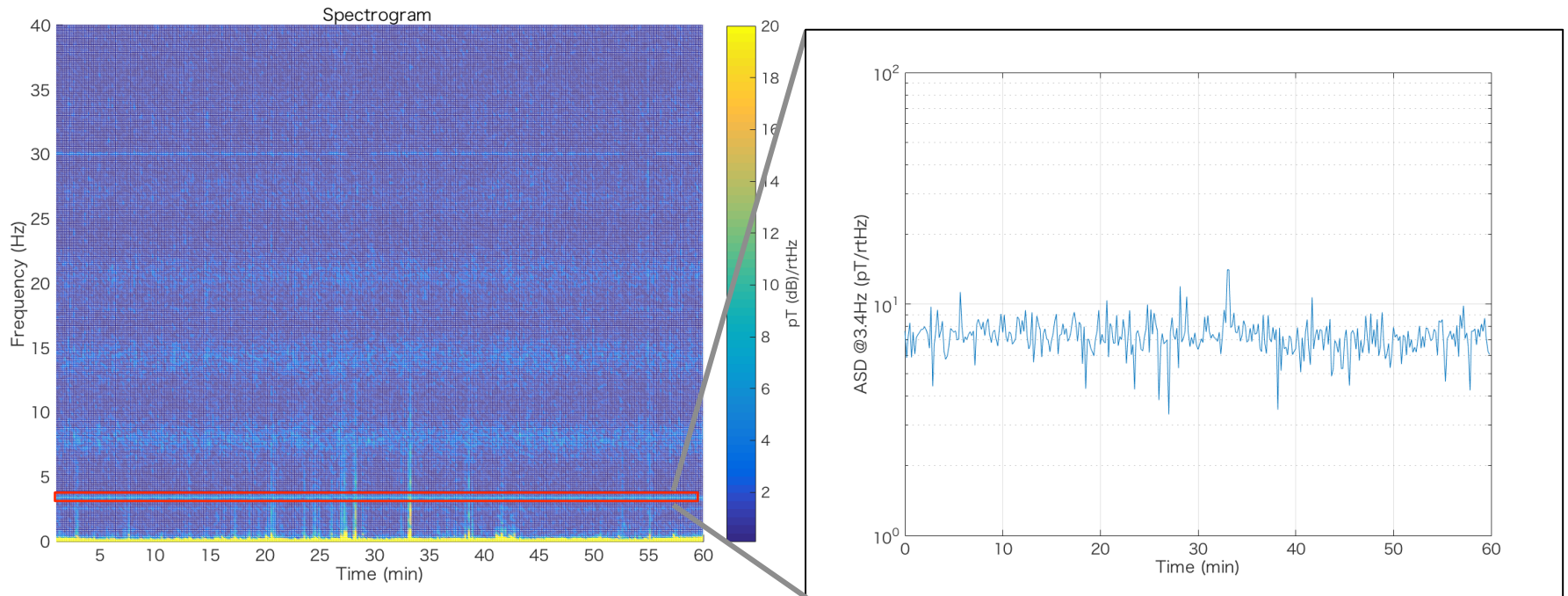


$$F_s = 250\text{Hz}, T_{\text{FFT}} = 10\text{s}$$

Data Quality

■ Spectrogram

Calculated the spectrogram of inside the tunnel

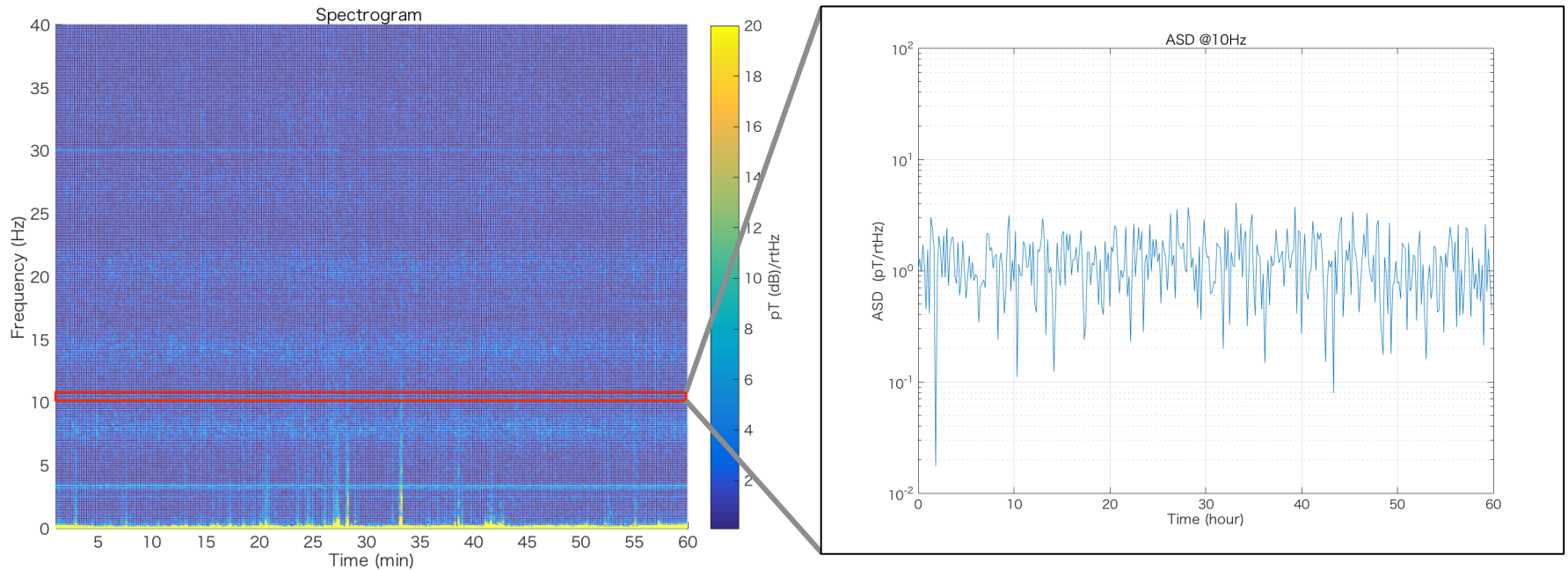


$$F_s = 250\text{Hz}, T_{\text{FFT}} = 10\text{s}$$

Data Quality

■ Spectrogram

Calculated the spectrogram of inside the tunnel



$$F_s = 250\text{Hz}, T_{\text{FFT}} = 10\text{s}$$

Data Quality

■ Outside1 vs Outside2

Almost same => Two detector were almost same

