

Receiving the SuperDARN Hokkaido East HF radar
signal at a remote station using the USRP

(and Development of Imaging receiver using USRP)

Yoshiyuki Hamaguchi,
(ISEE, Nagoya Univ.)

Coauthors: N. Nishitani and T. Hori (ISEE, Nagoya Univ.)

What's USRP?

- # USRP is a kind of SDR (Software-Defined Radio).
- # The transmission and reception functions of high frequency signals can be performed freely by software (e.g. Python).
- # Therefore, the radar function can be easily realized in comparison with the hardware designing.
- # USRP is high performance in SDR, but a little expensive.
(e.g. USRP-N210 is \$1943.)
- # We are developing remote receivers and imaging receivers using the reception function of USRP.



About remote receivers

- # We started observation with an remote receivers in December 2014 in Nagoya and Rikubetsu.
- # Rikubetsu is the site of SuperDARN Hokkaido East HF radar.
- # Rikubetsu receives HF radar directly and uses it as a reference for time and frequency measurements.
- # Rikubetsu and Nagoya data are compared, and the Doppler shift and HF wave travel time via the ionosphere are measured.

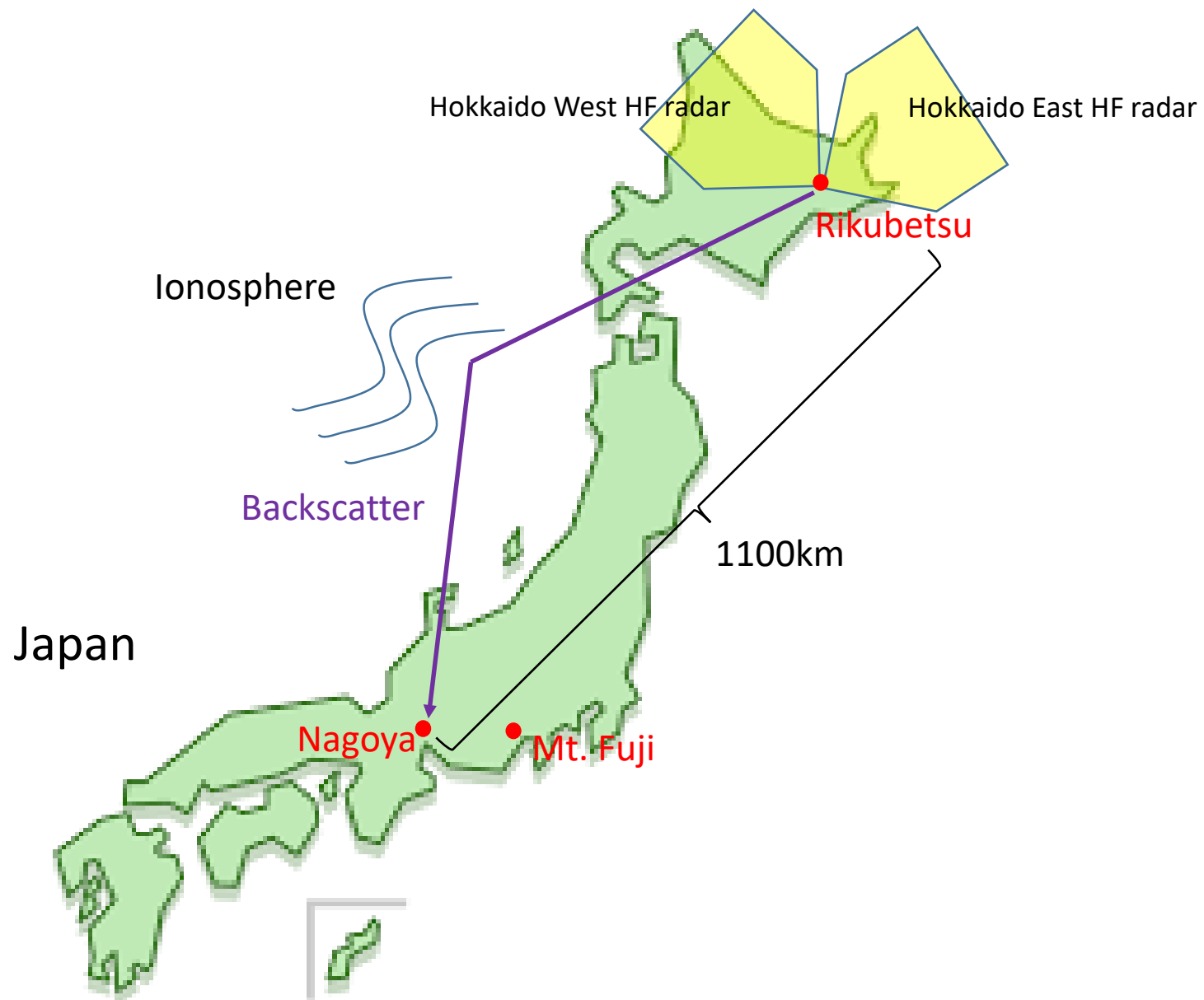
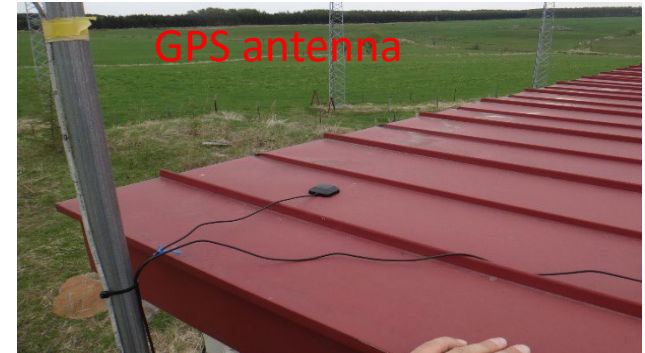
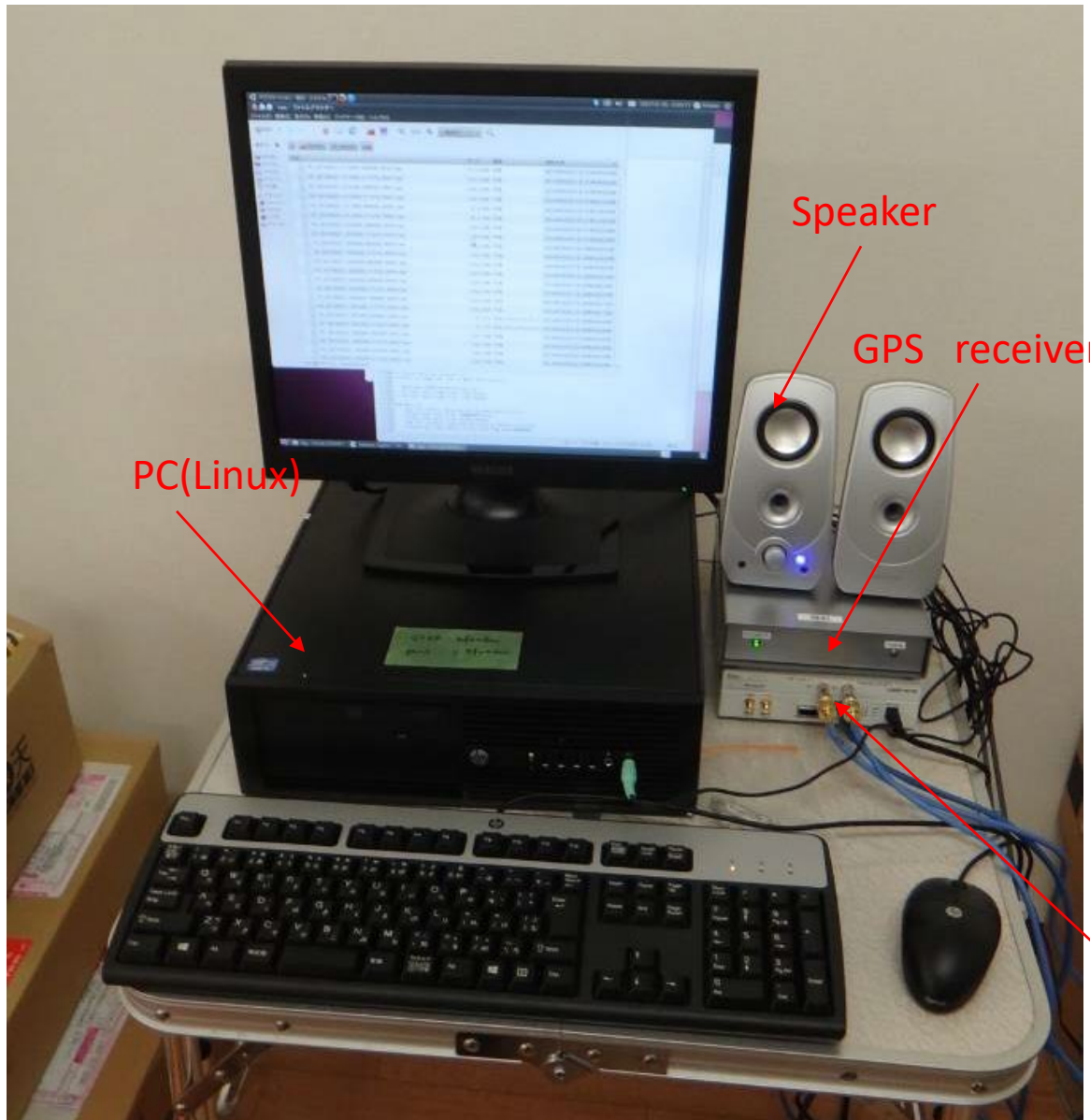


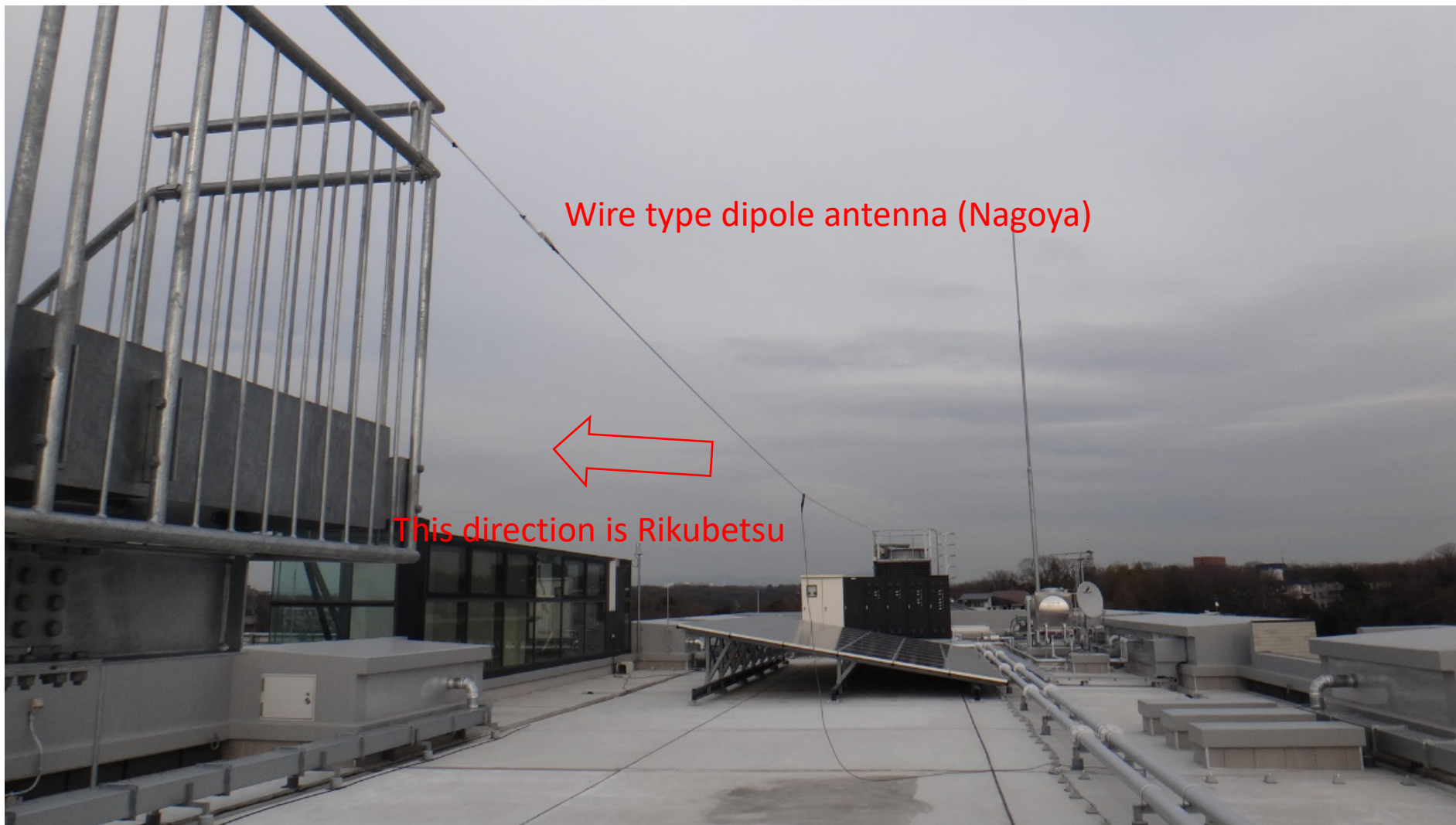
Figure 1

Observation devices

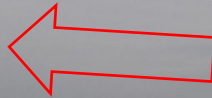


USRP-N210
(Save 2 ch of I/Q data
at 32 kSamples/sec)

Figure 2

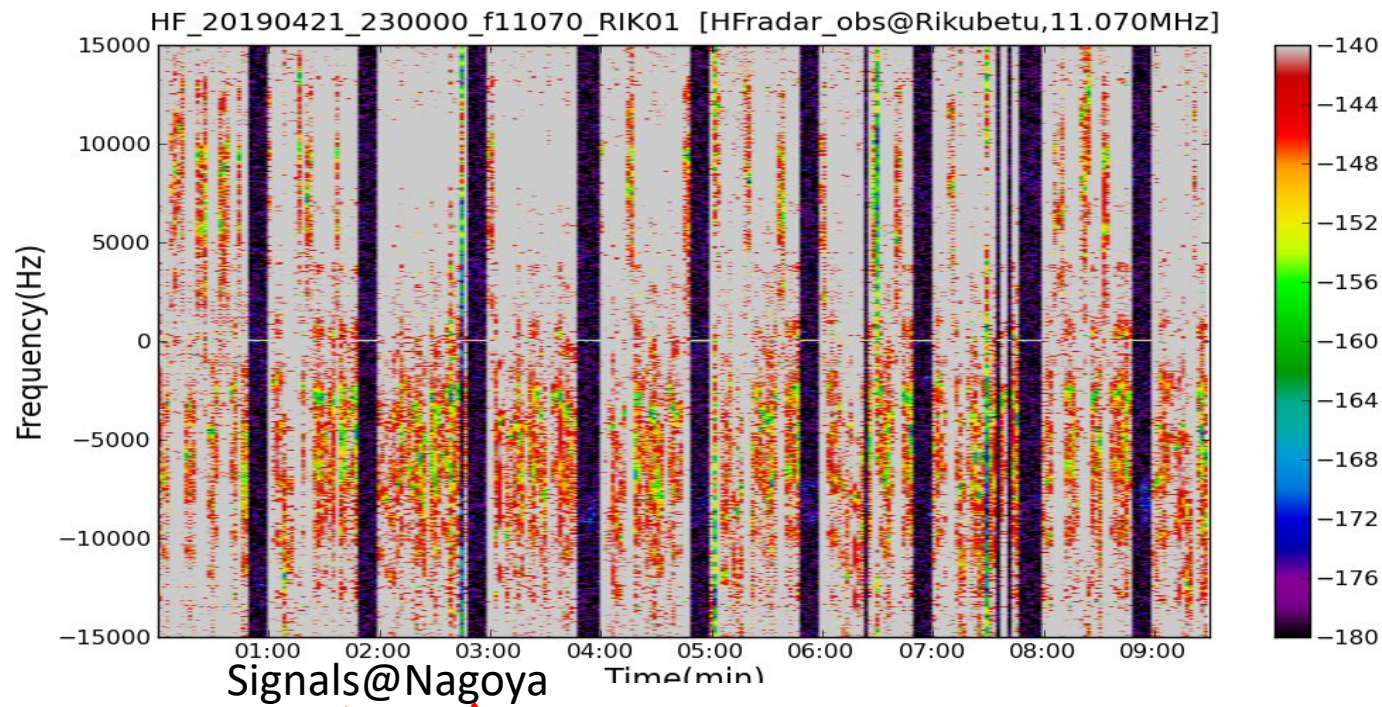


Wire type dipole antenna (Nagoya)



This direction is Rikubetsu

Figure 3



Rikubetsu and
Nagoya Spectrum
at the same time

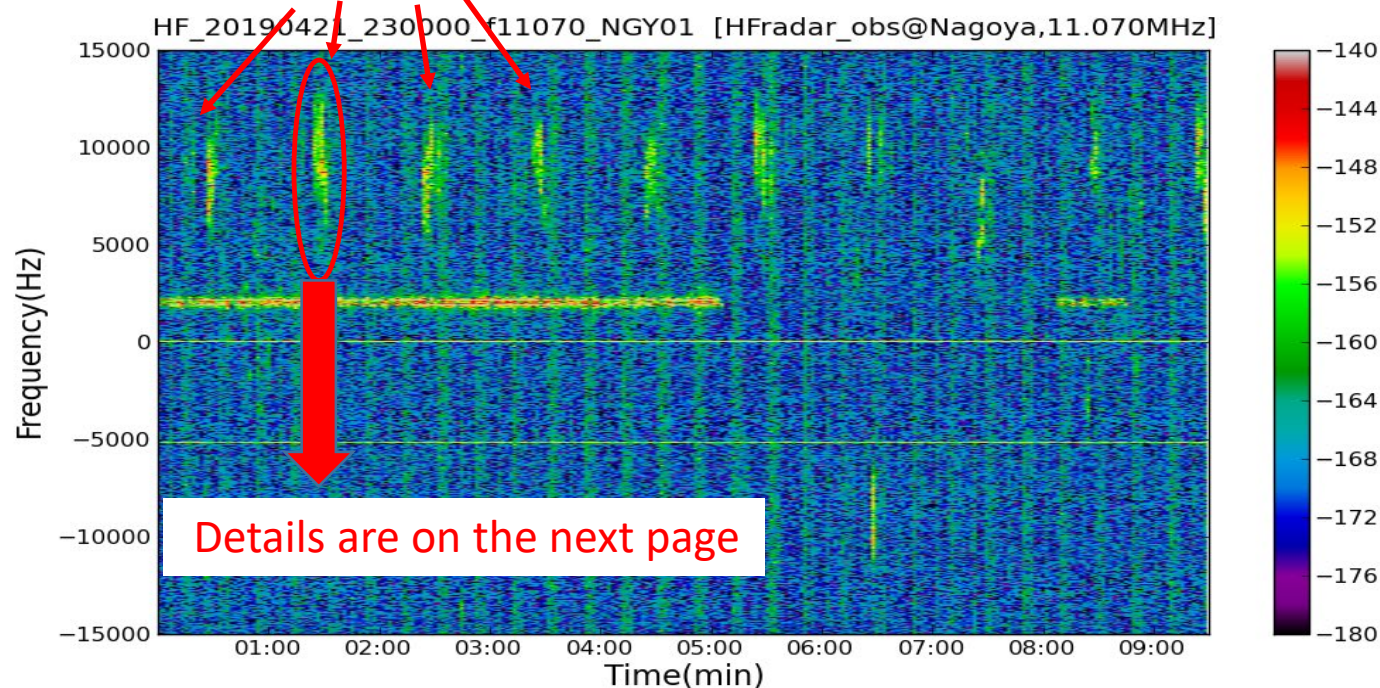
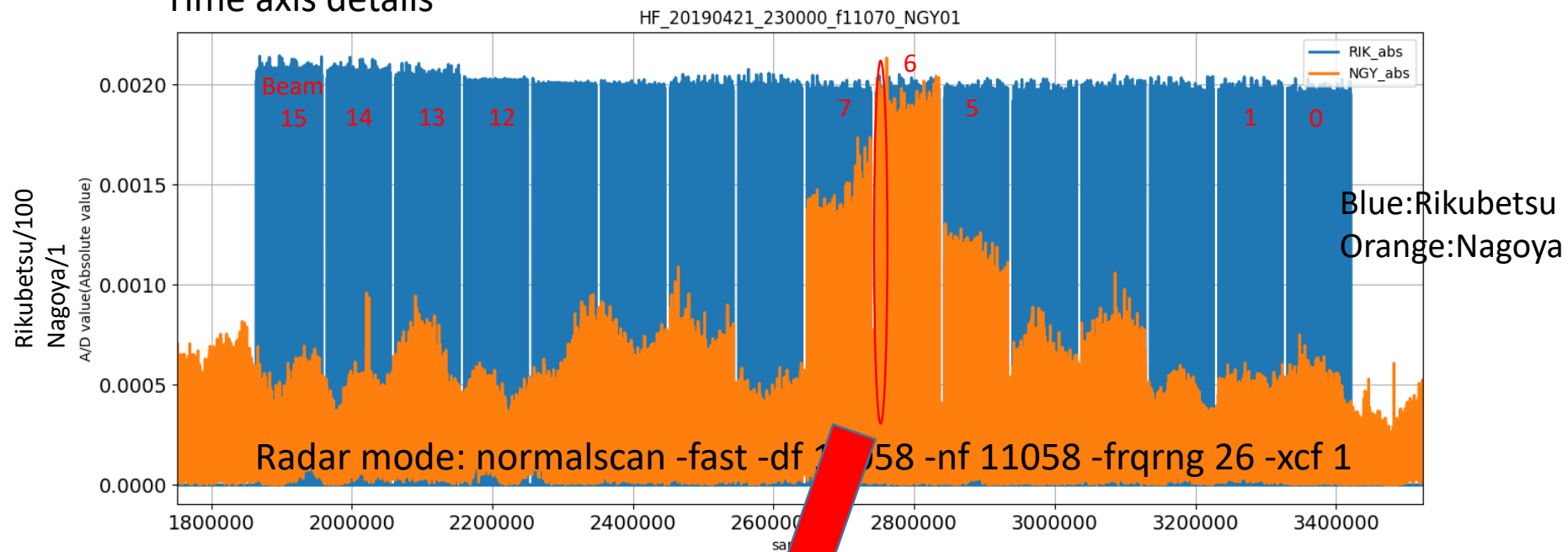


Figure 4

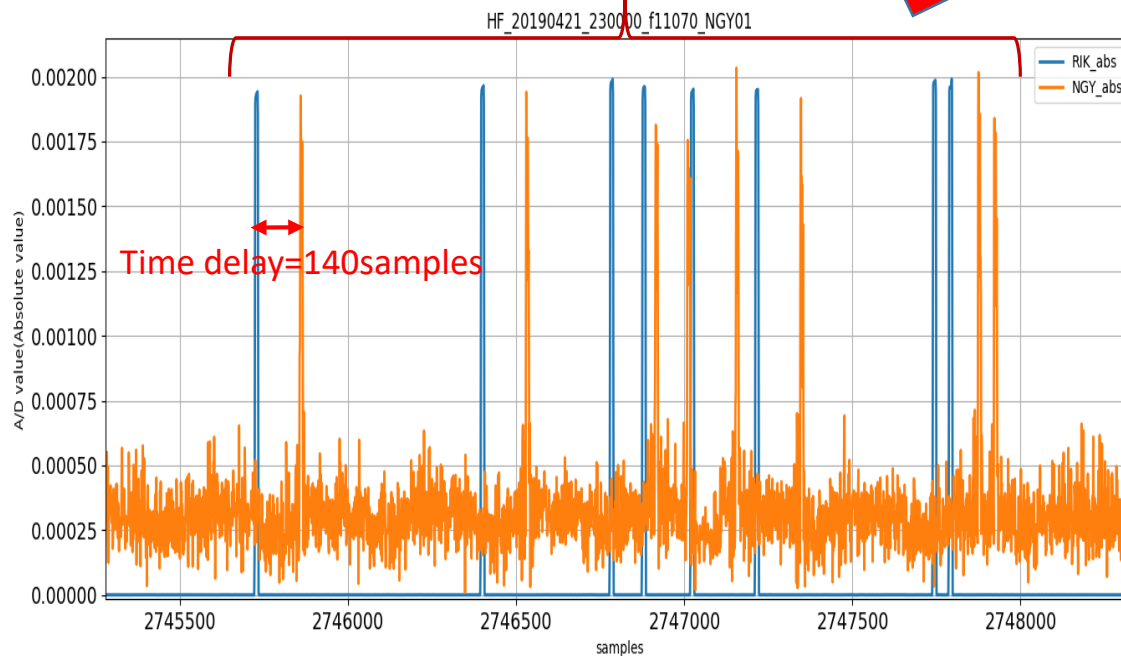
Time axis details



Kat_scan_1500

Expansion

Figure 5



$$\text{Time delay} = 140\text{samples} * 1/(32\text{kS/s}) = 4.375\text{ms}$$

$$\text{Path length} = 4.375\text{ms} * (\text{speed of light}) = 1312.5\text{km}$$

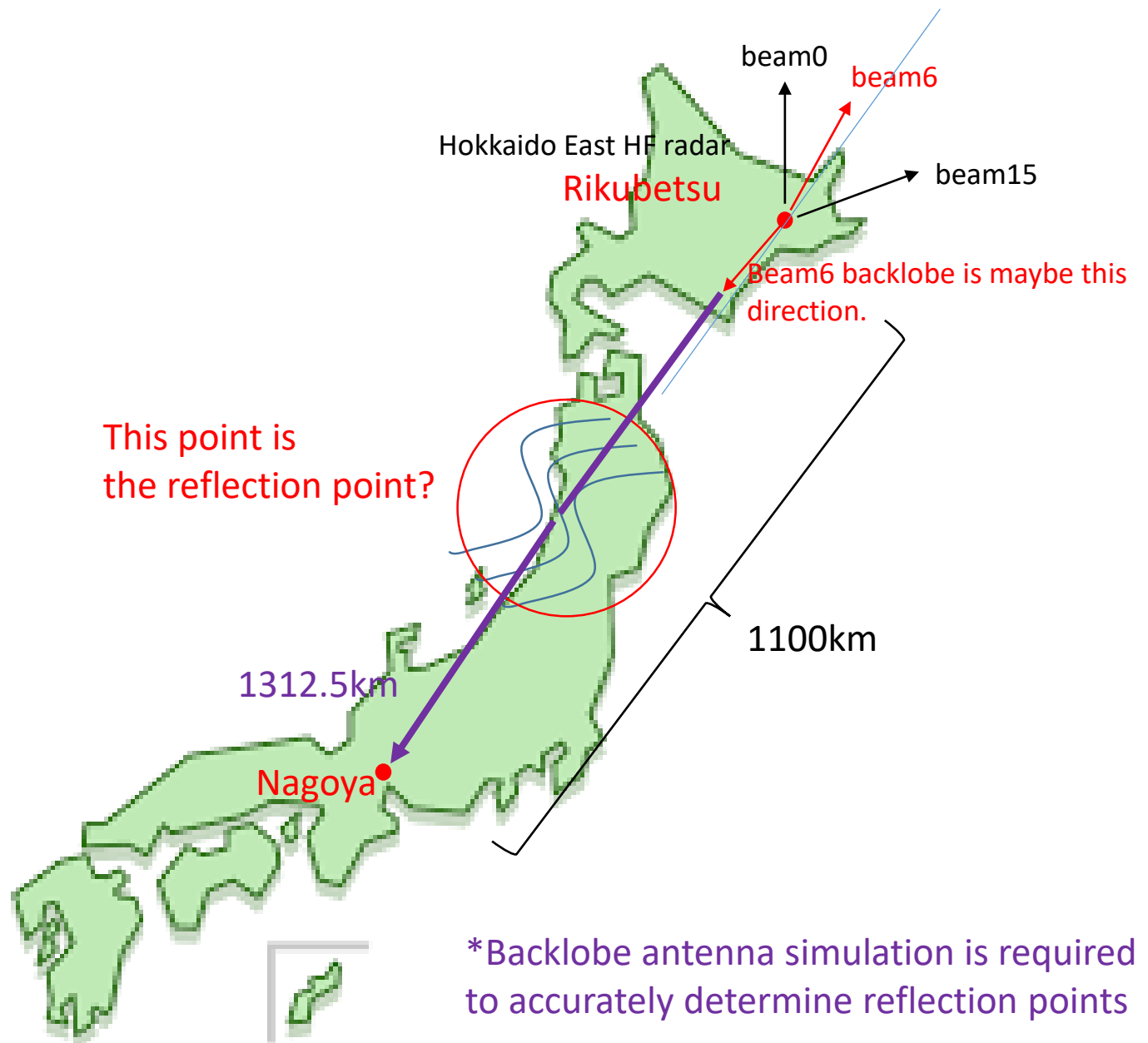
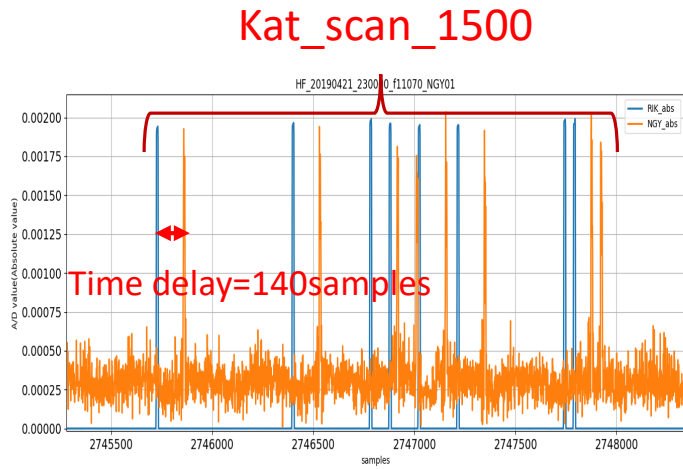


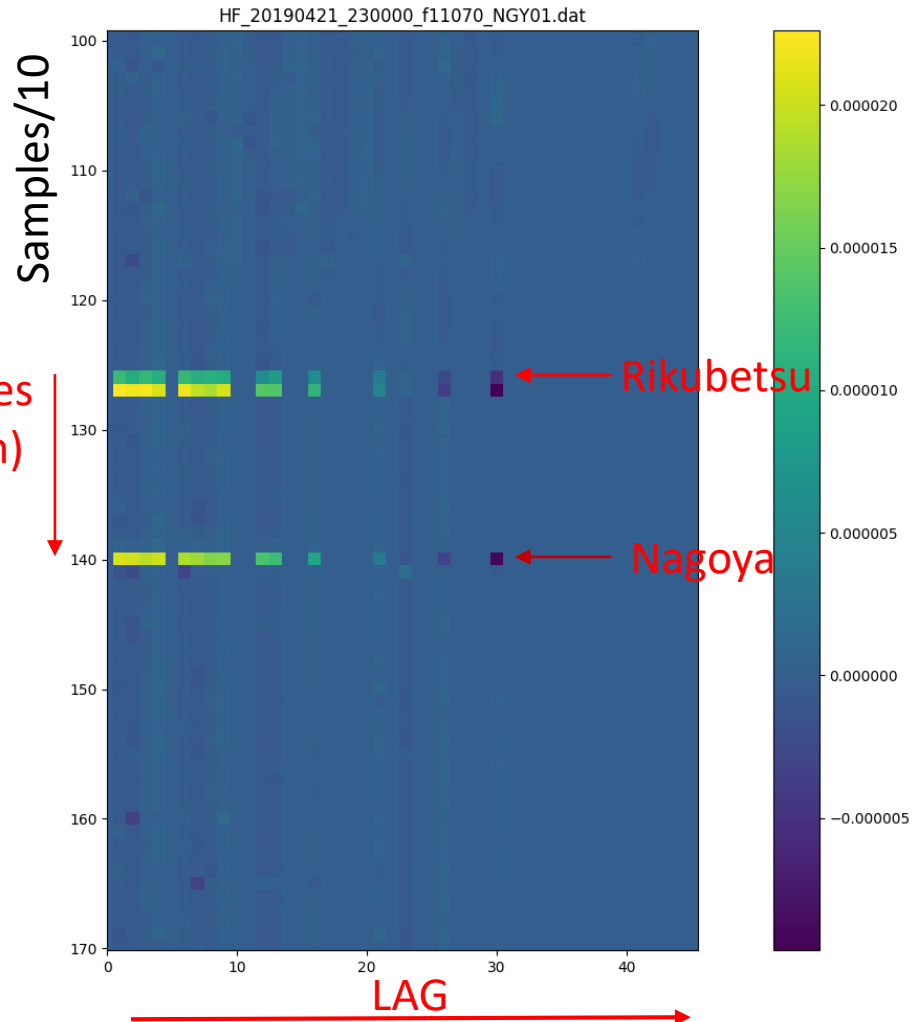
Figure 6

Autocorrelation



Autocorrelation processing

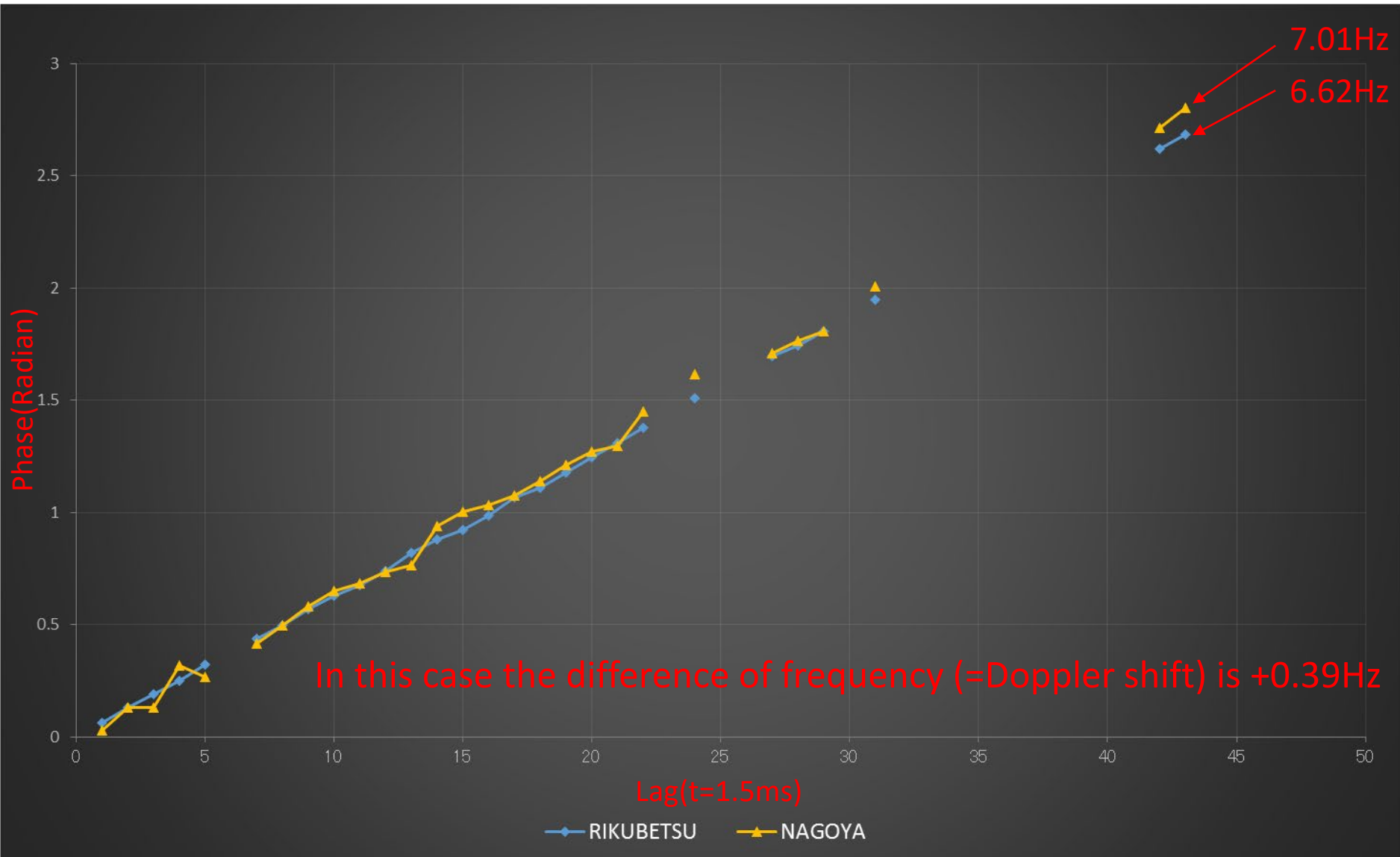
140samples
(1312.5km)



*The change of color indicates the change of phase

Figure 7

Relation between Lag and phase change



*The reason why there is a 6.62Hz offset in Rikubetsu's frequency is that the Hokkaido East radar does not use rubidium as a reference for radar.

Figure 8

Summary

- # It is possible to observe HF radar signal at remote stations using USRP.
- # By comparing the data of the remote station and the local station, the distance and the Doppler shift of the ionospheric reflection point can be determined.
- # By including the beam number in the calculation, it may be possible to estimate the reflection position.
- # Because this system is simple, production is easy.

Current technical issues and future goals

- # Nagoya observation point is very noisy, so we want to move it to a quiet place. Then we will get more small signals.
- # To increase the number of observation points. This will improve the accuracy of reflection point and the Doppler shift.
- # Because the amount of data is large(300MB/10 min@one station), We need to change the format and compress the amount of data.
- # Automate data collection and calculations are necessary.
In addition, we want to display the simple-style results on the WEB page.

Development of Imaging receiver using USRP

- # We are developing imaging receivers by developing remote receiver using USRP N210.
- # It is planned to be attached to the Hokkaido East HF radar and supposed to be able to simultaneously make observation by the HF radar and the imaging receiver.

SuperDARN
Hokkaido East HF radar

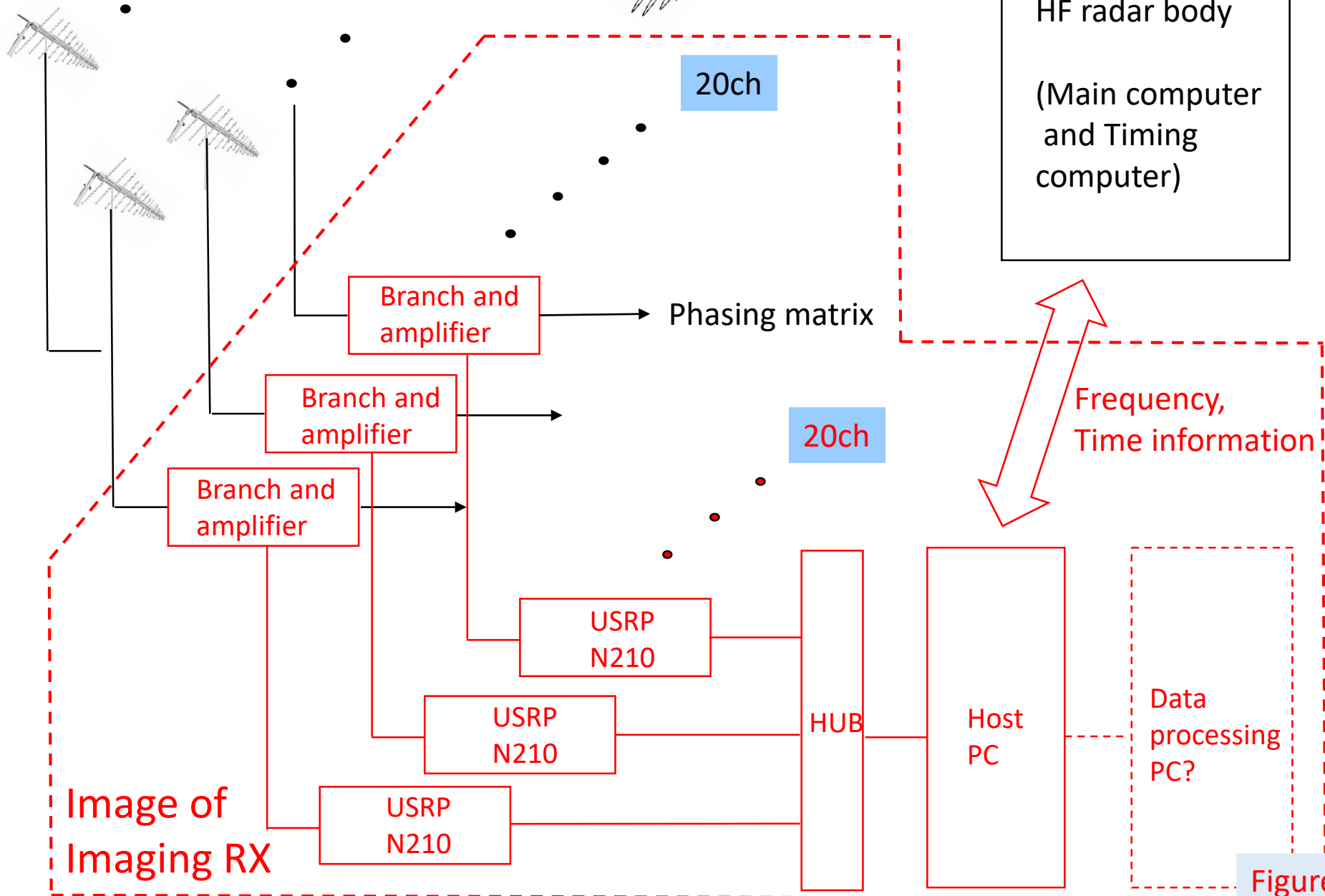


Figure 9

Big walls

There are two big walls in building a radar attached imaging receiver.

- (a) Whether frequency and time can be synchronized between the radar and the imaging receiver.
- (b) Whether we can successfully get an HF signal from the antenna without affecting the radar.

Current status

For (a), we are doing pretty well. We are able to acquire 8ch of data by synchronizing the radar simulator with 4 USRPs.

For (b), we are starting to prototype a branch and amplifier circuit. However, there is a problem with abnormal oscillation and it is not working well...

Future goals

- # After solving the problem of abnormal oscillation, we aim to install a few USRPs on Hokkaido East Radar as an imaging receiver.
- # And we aim to acquire 20 ch continuous data by adding USRPs.(This requires 10 USRPs)