NZ Rugby Champion in 2015

Broadband VLBI
Kick Off !!!

Kazuhiro Takefuji
on behalf of NICT/Kashima

Contents

- Broadband project “GALA-V”
- Kashima 34m and Ishioka 13m
- First Japanese sub-mm VLBI

Japan’s team beated South Africa, Samoa and the US in 2015 ！ ！

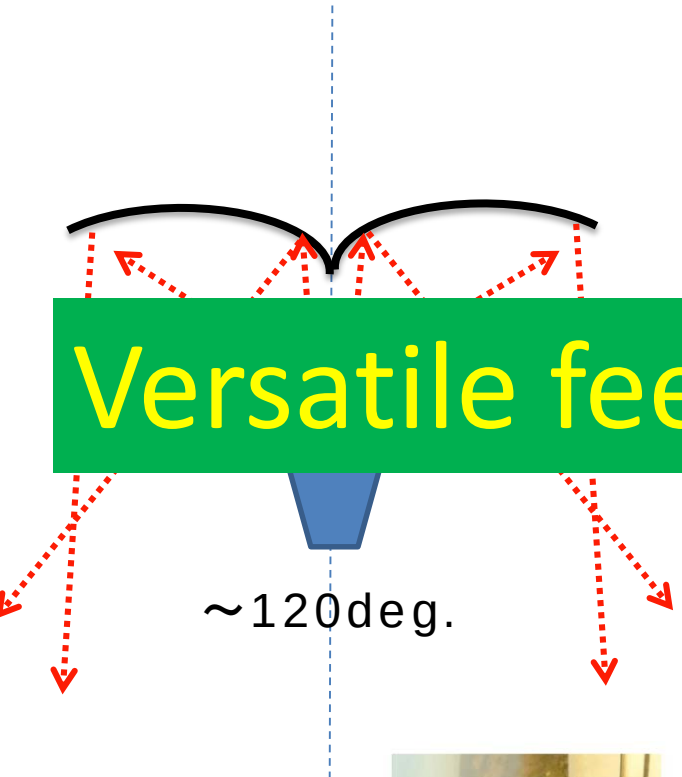
They won! why?

- Speed
- Strategy
- Their strong minds were connected in

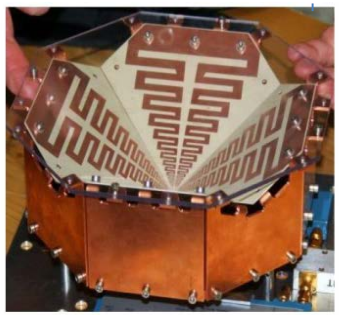
Broad-band

Gala-V Feed

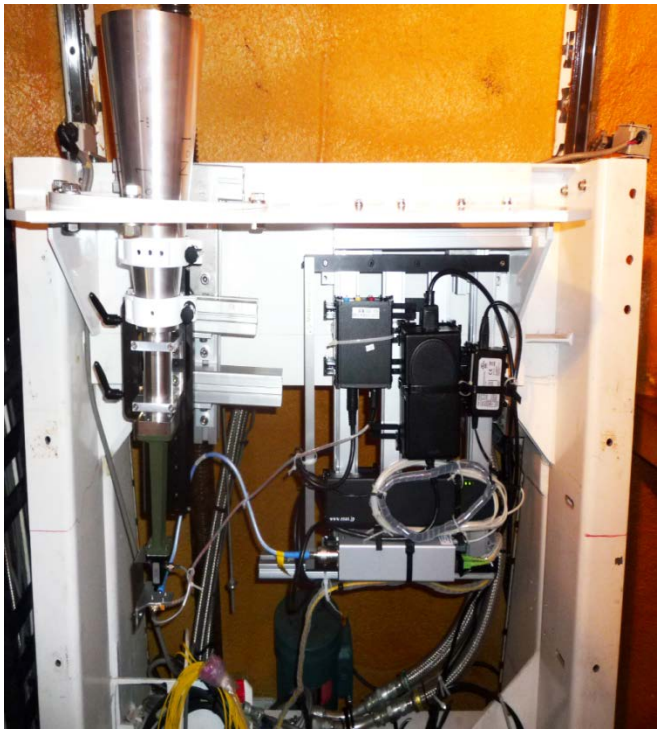
Broadband
and Narrow
beam width



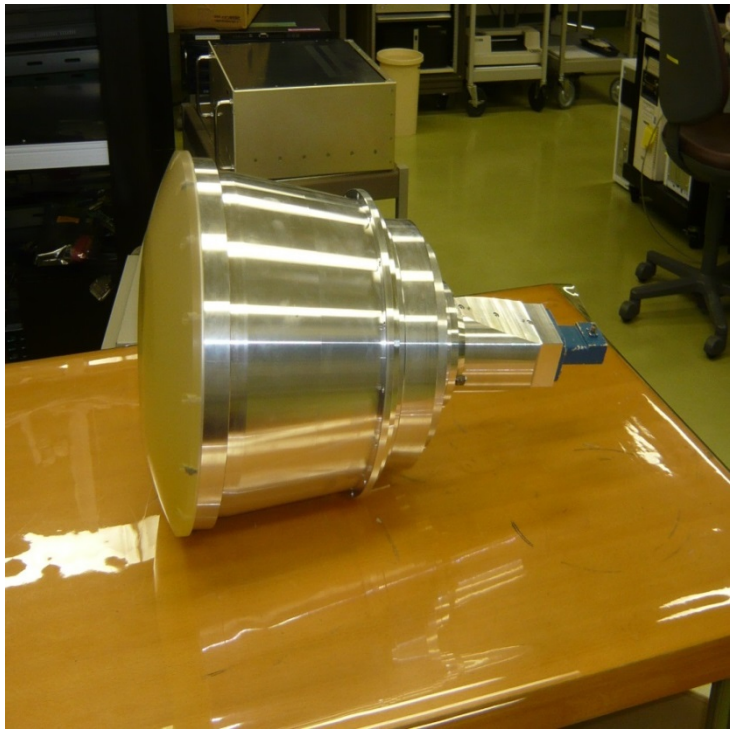
Versatile feed for most antennas



Broadband Feed for Cassegrain optics in Gala-V project

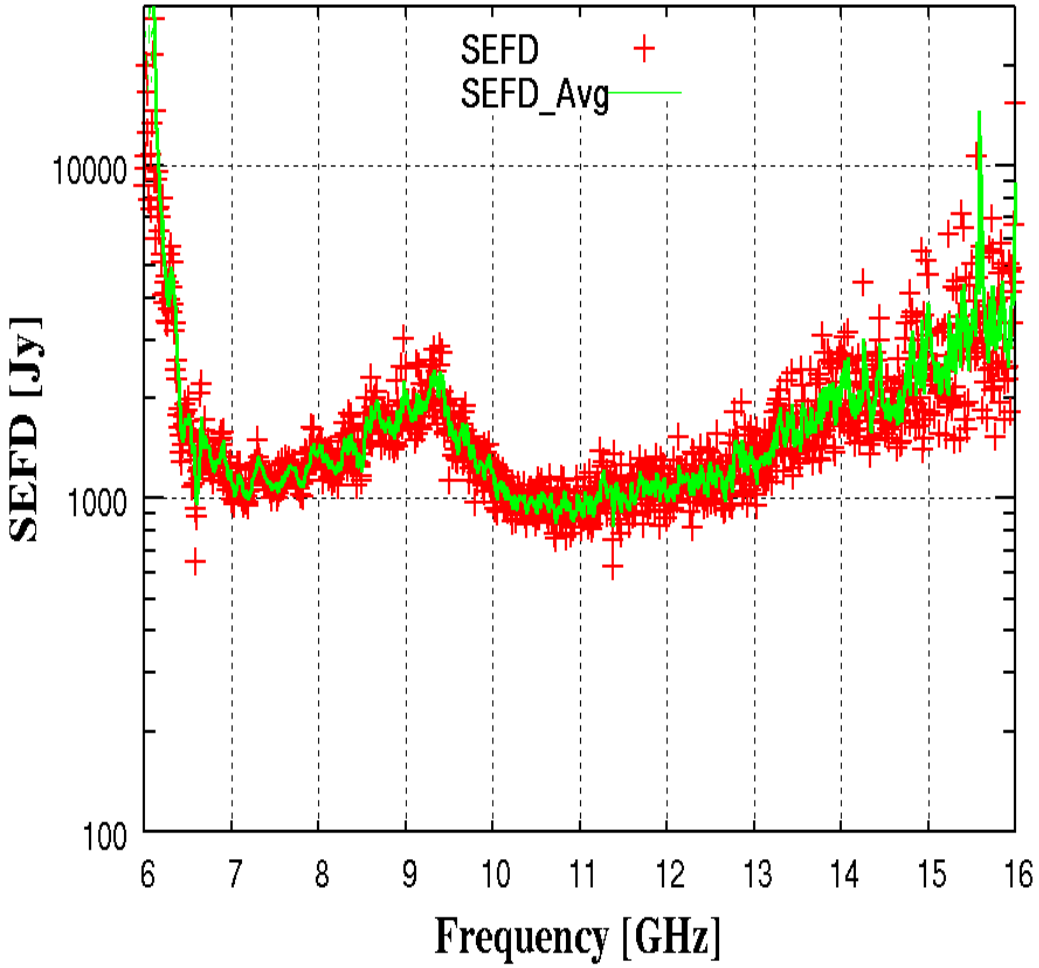


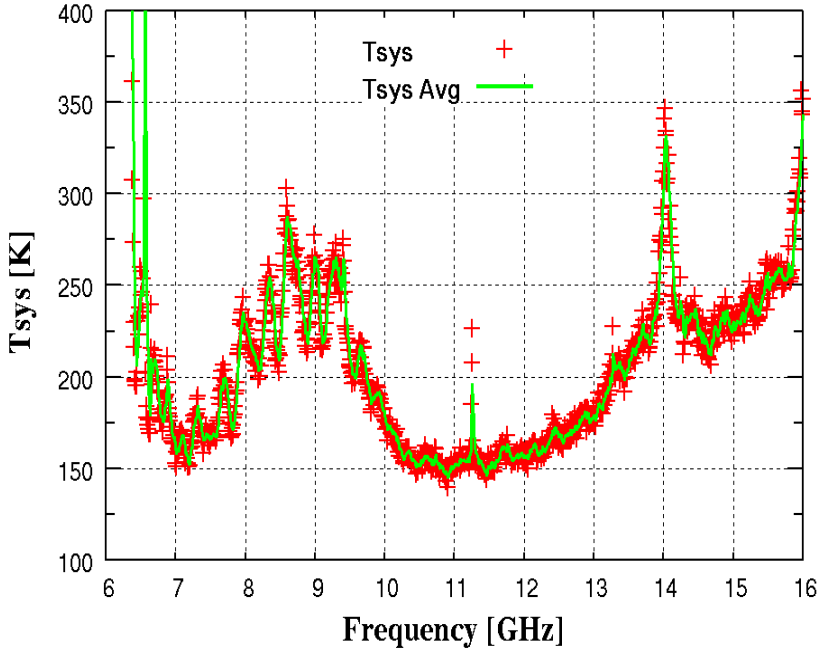
IGUANA Feed (6.5-15GHz)

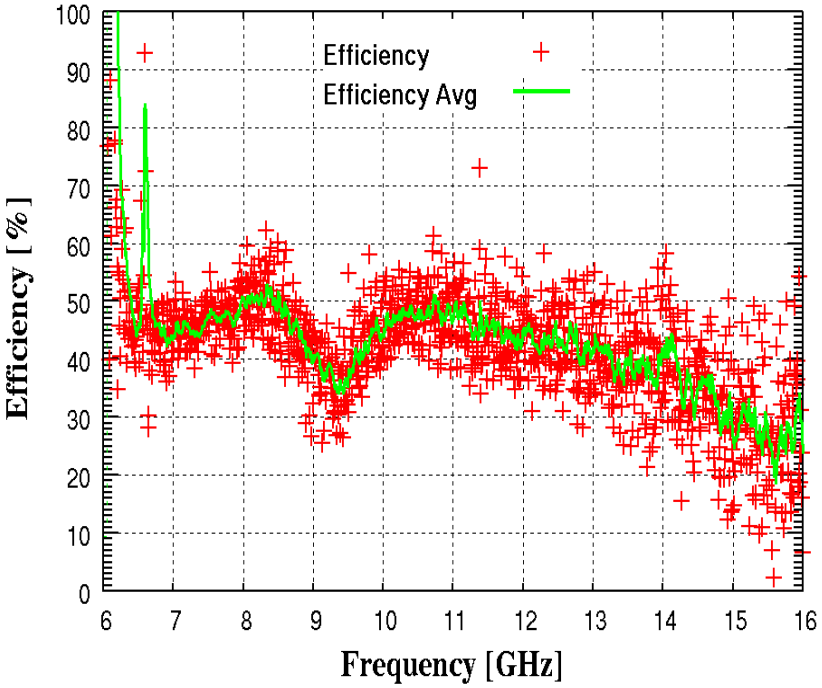


NINJA Feed (3.2-14.4GHz)

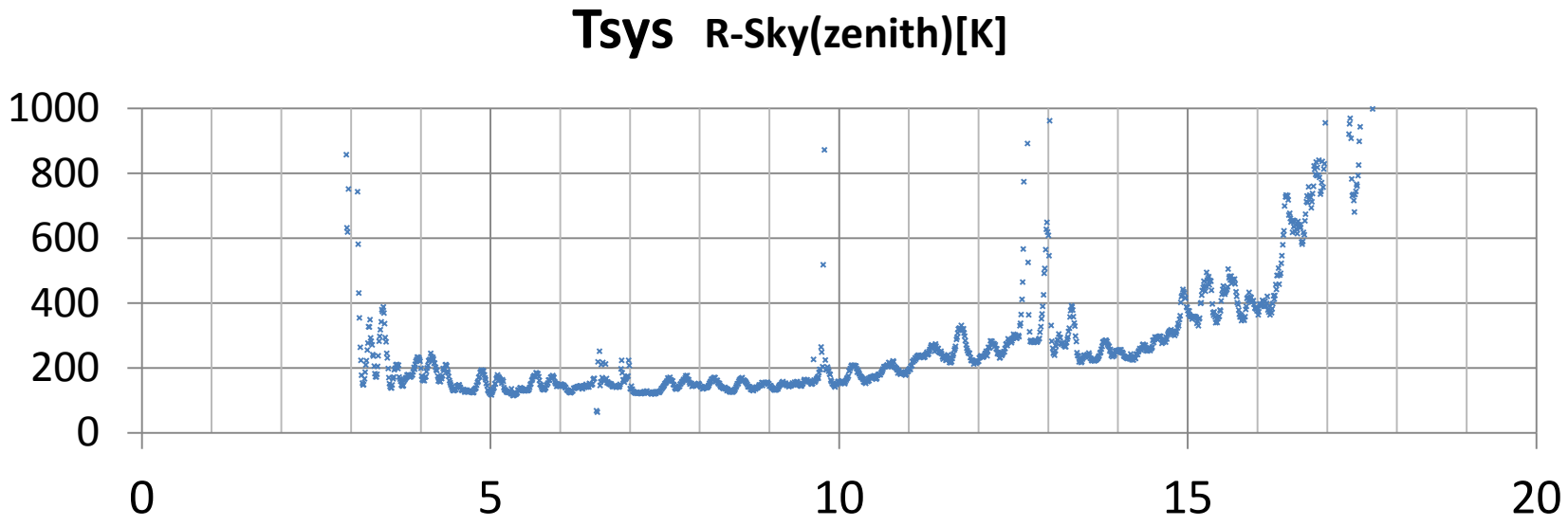
IGUANA feed system

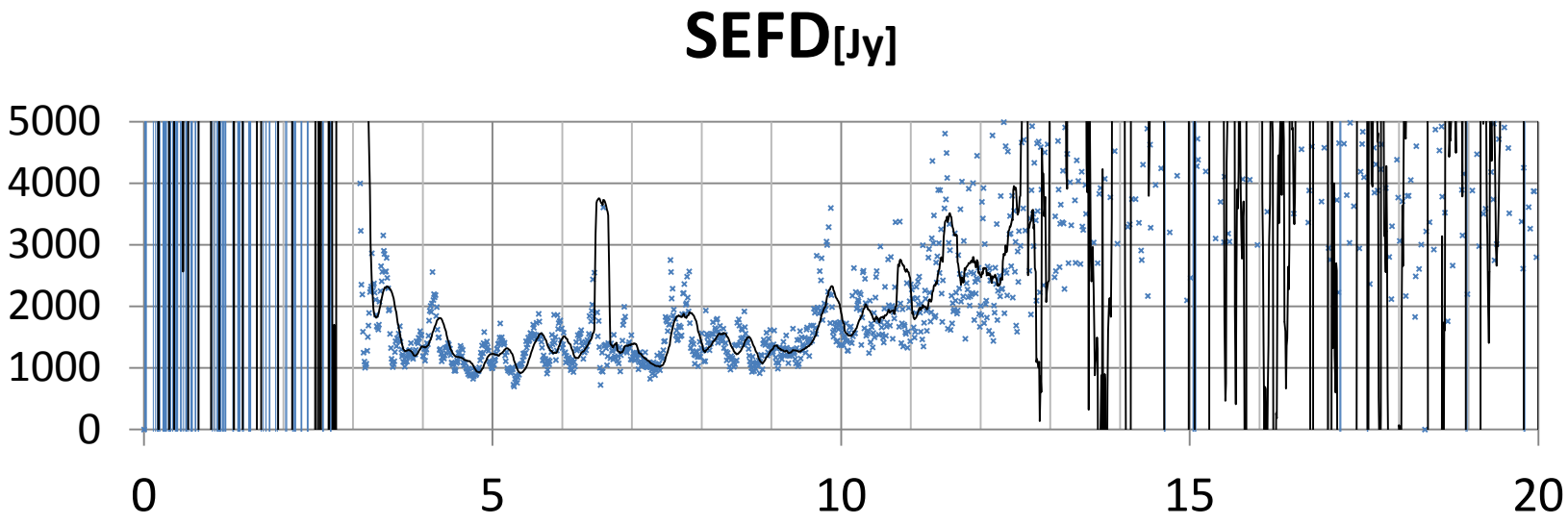






NINJA feed system



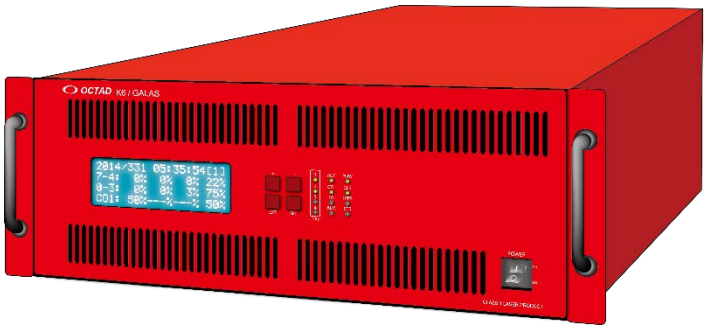


High speed sampler R&D

- ADS3000+

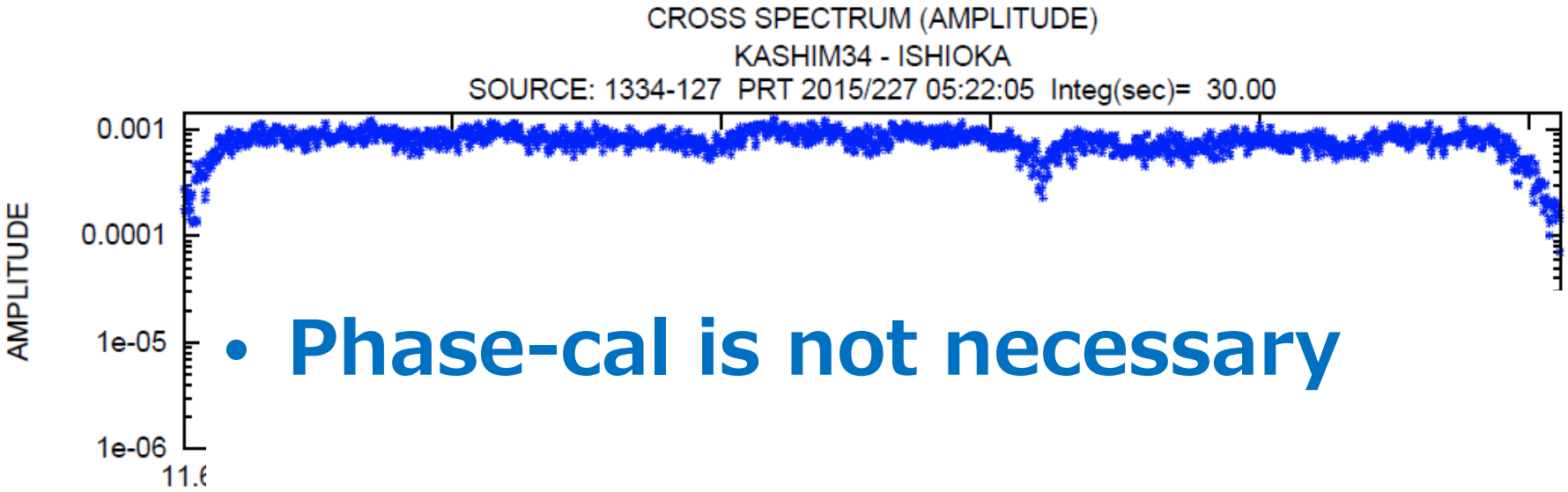
- 16ch DBBC
- All video converter can be replaced
- Installed to O'Higgins

- GALAS



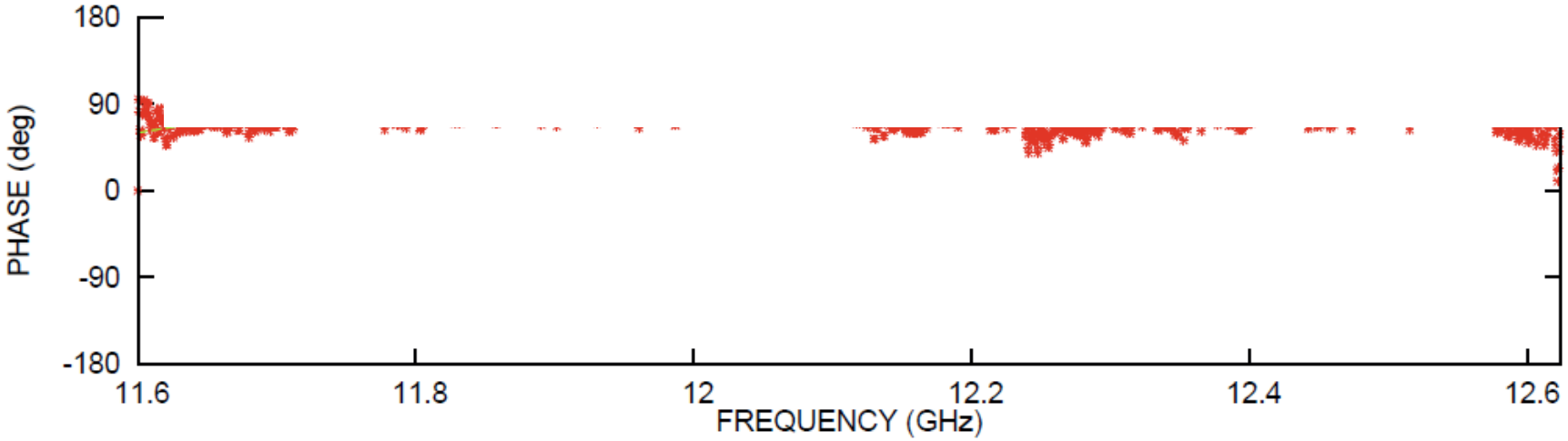
- 16Gsps 3bit
- Direct sampling ~20GHz
- 1GHz BW DBBC

Strong point of broadband



- **Phase-cal is not necessary**

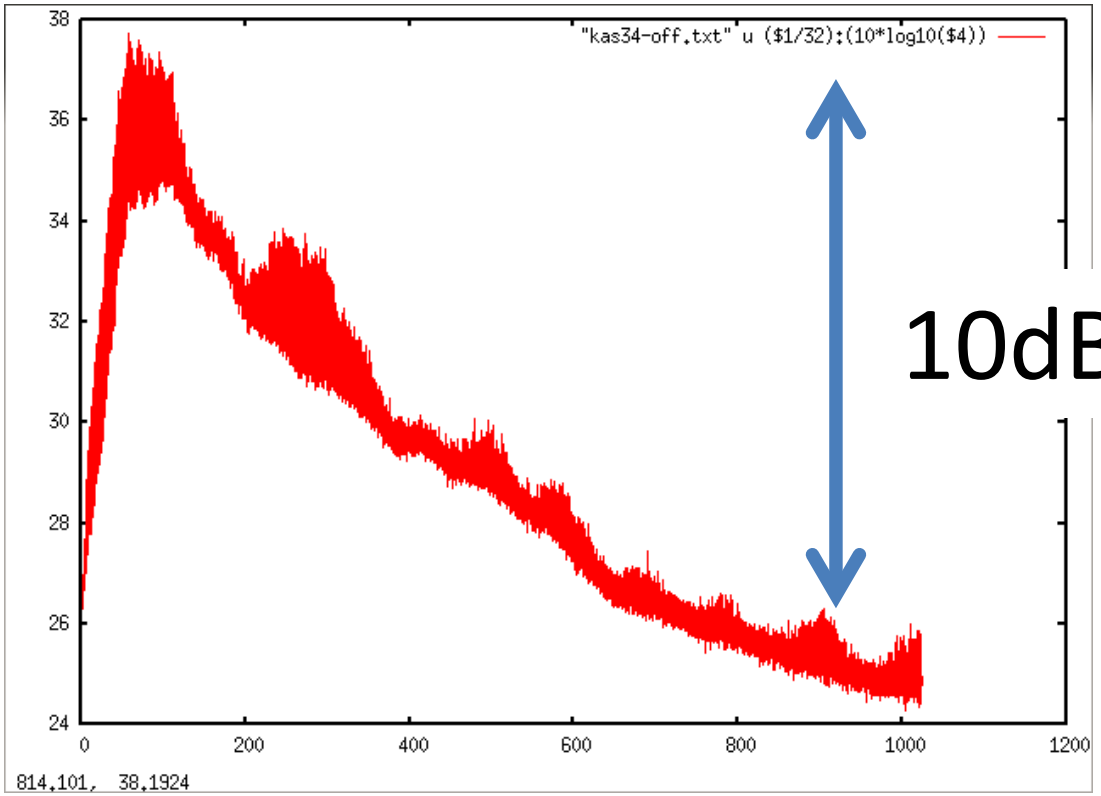
- **Even broad band also**



Weak point of broadband

$SNR \propto \sqrt{BT}$

- Do not use the relation blindly!

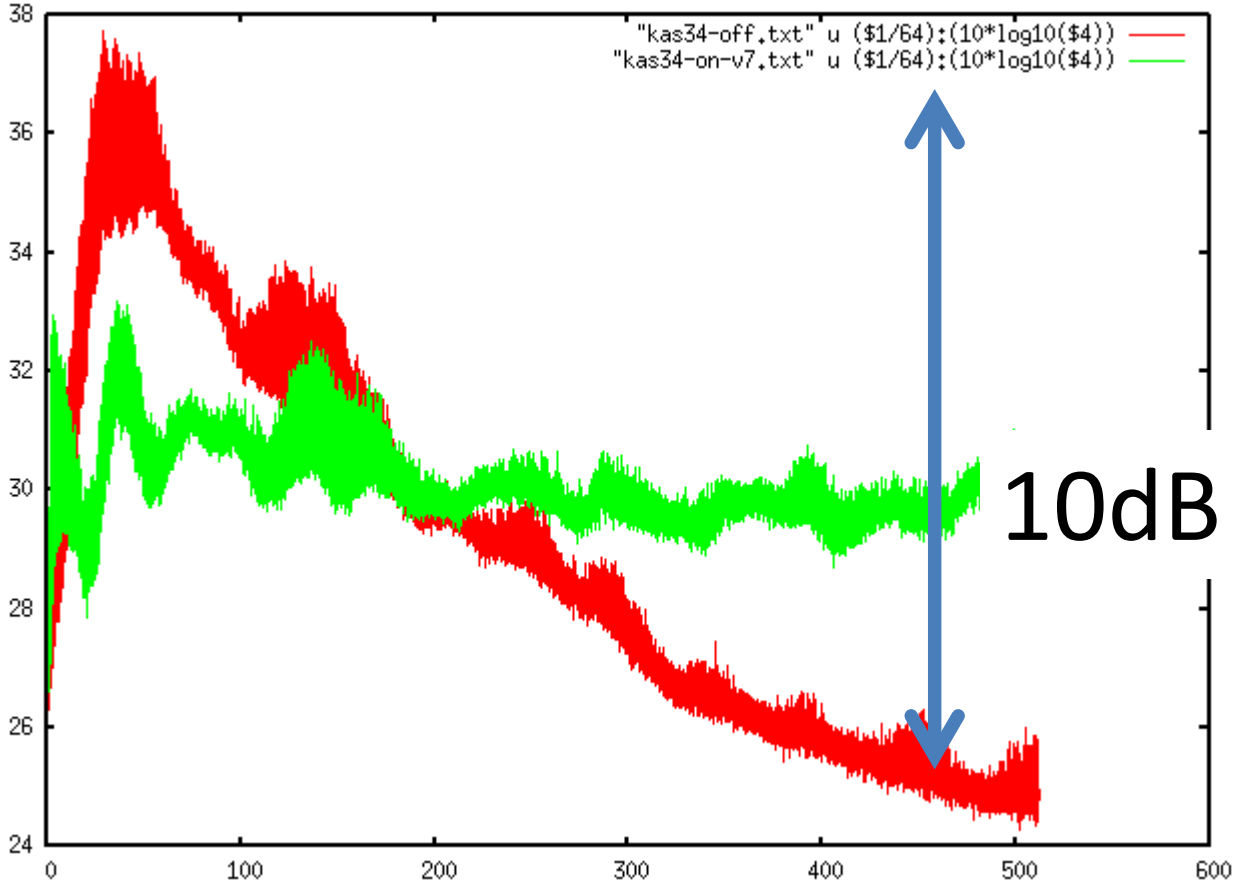


34m-Xband BW: 1GHz

Digital filter installed to **ADS3000+**

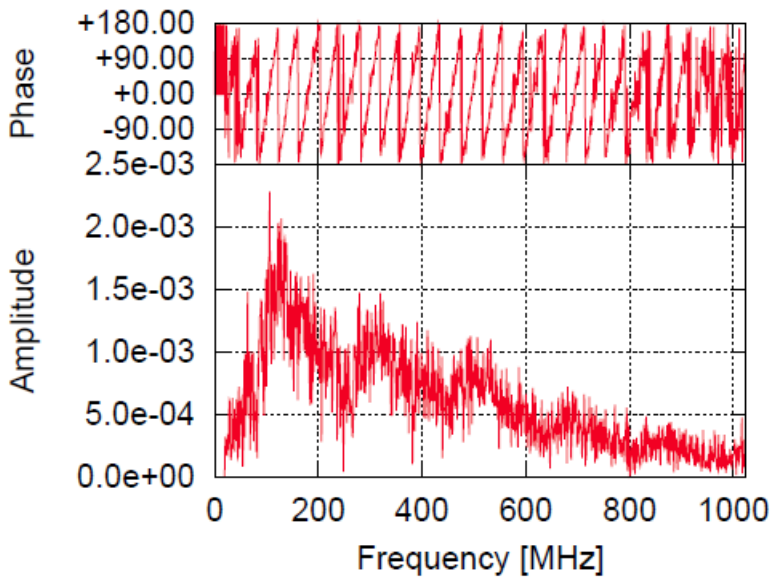
- Applied a digital filter under 2GHz, 8bit sampling in real time
- Any finite filters are available (BPF, LPF, HPF, BEF etc)

Ex Digital equalizer

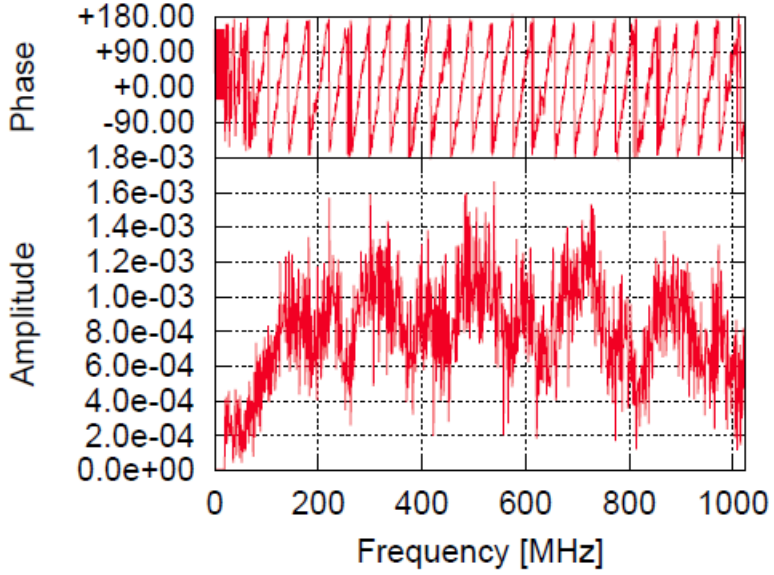


Keep flat spectrum (Takefuji, TDC report 2014)

Cross spectrum

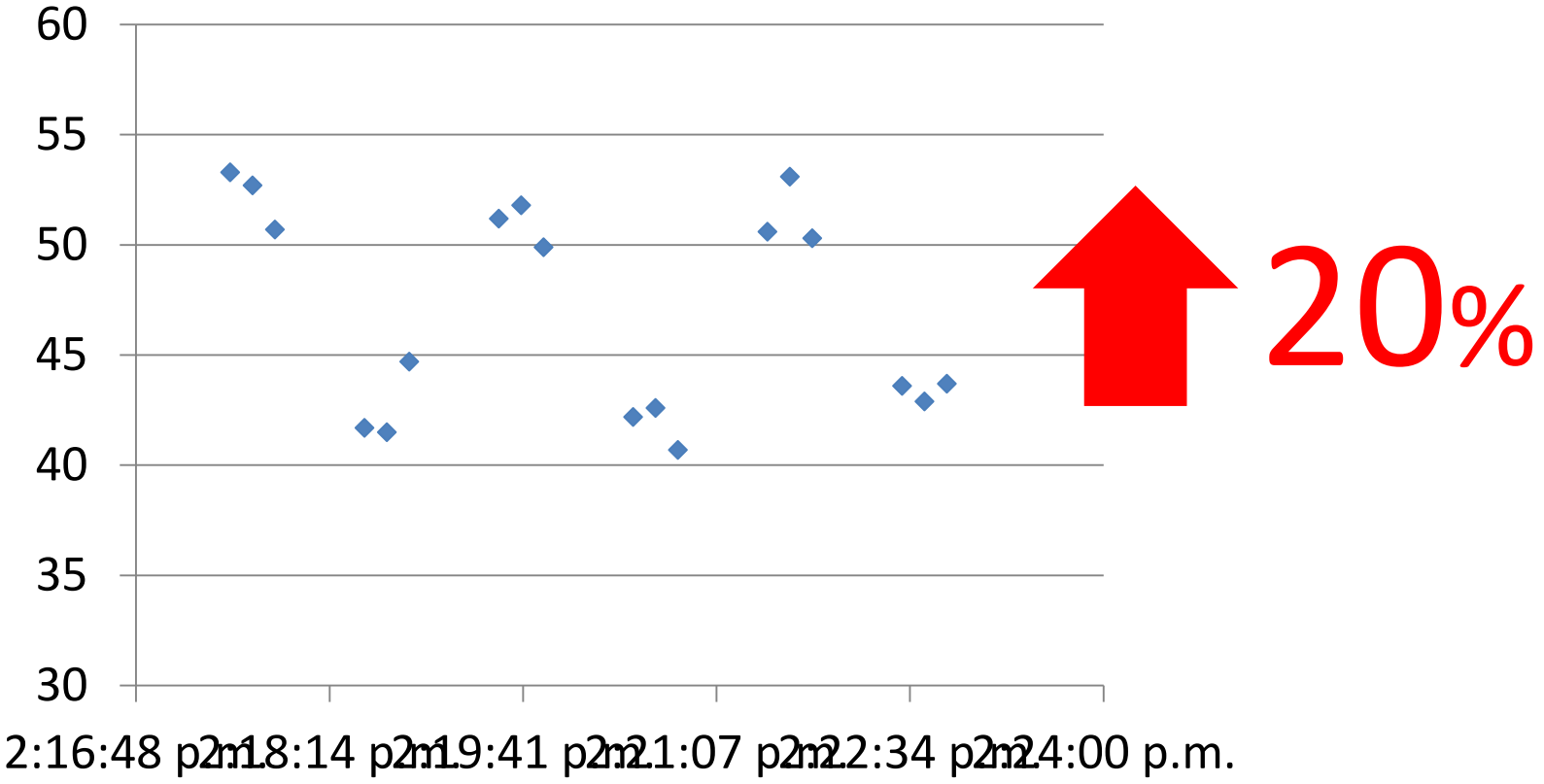


Equalizer OFF



Equalizer ON

SNR comparison

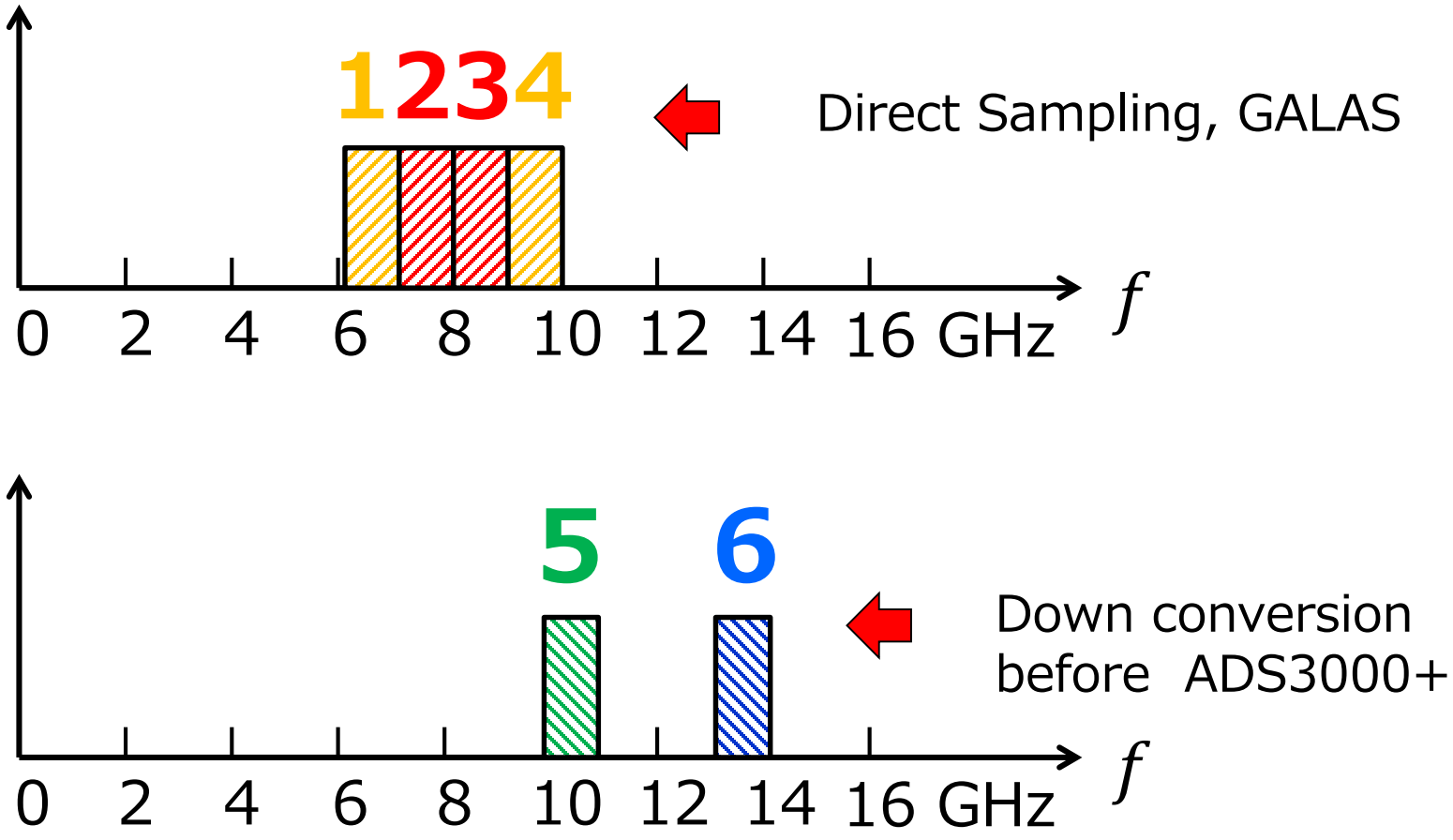


Equal to 44 % wider bandwidth

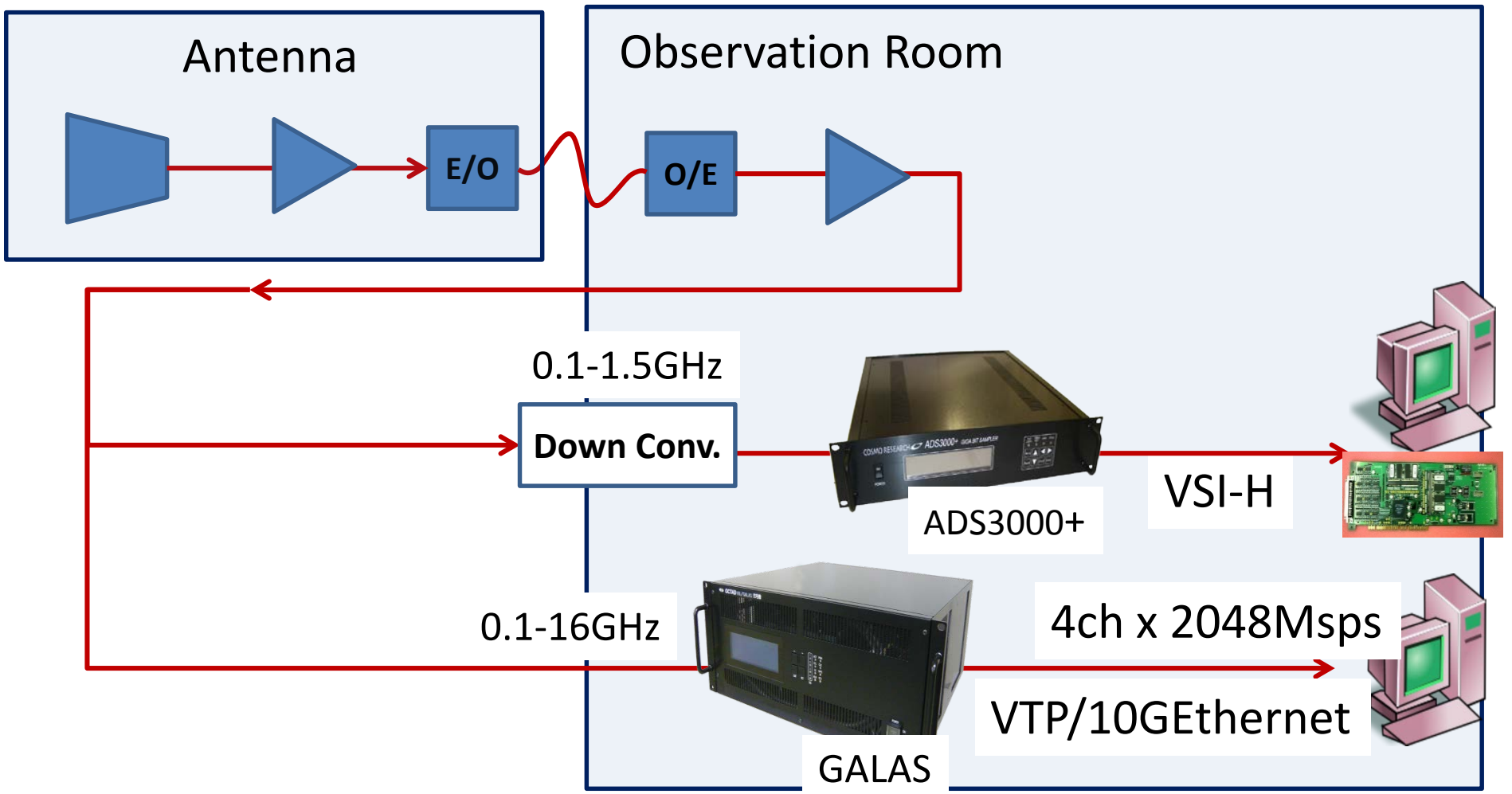
KASHIMA – ISHIOKA
Broadband Exp. Jan. 2015

Frequency allocation 6GHz to 14GHz

BW 1024MHz each

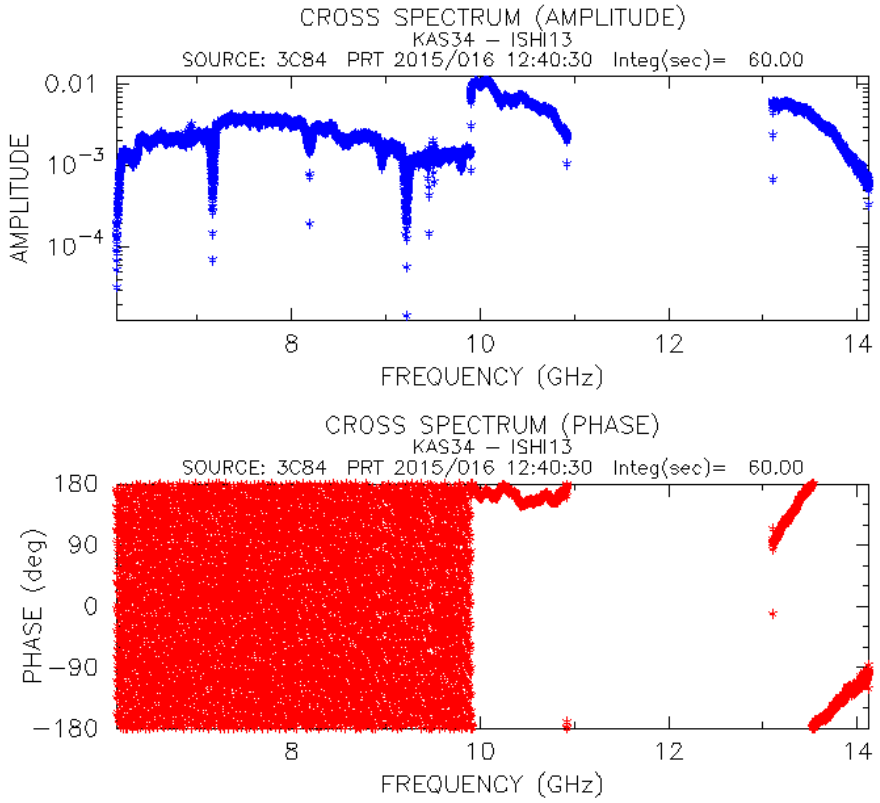


Signal Path and DAS



If we simply connected…

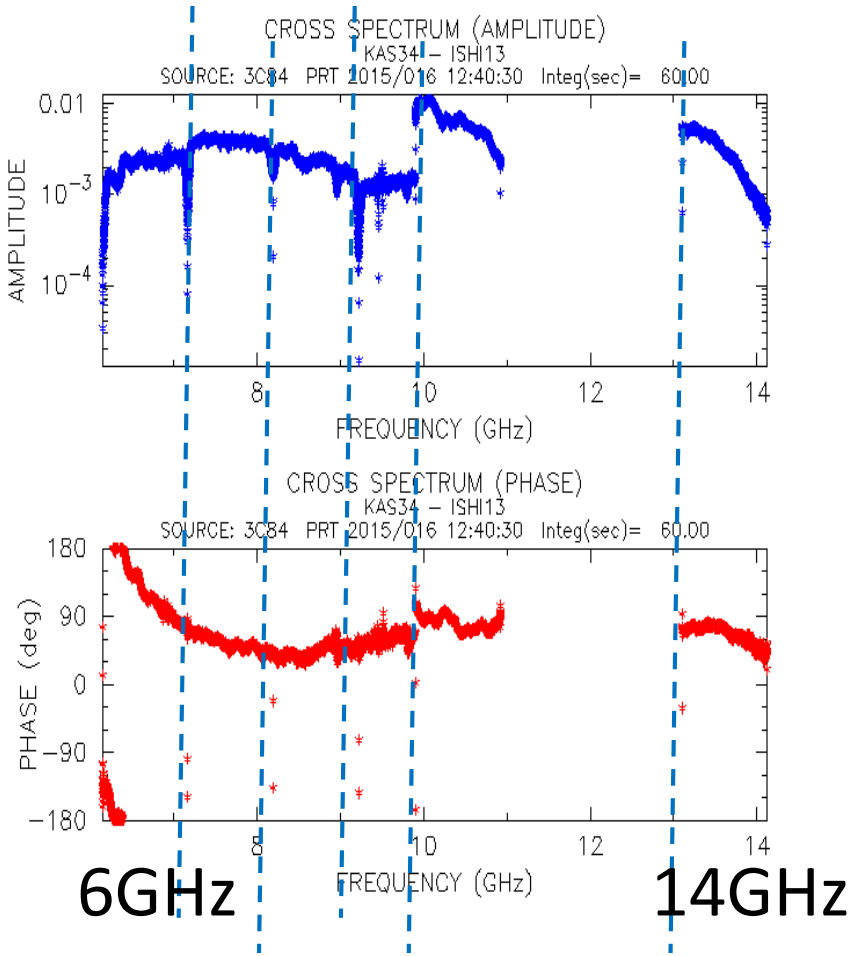
Cross spectrum



- Choose one radio source as template to be small phase error
  - Strong one
  - Small source structure
- Compensate delay from the template

Bandwidth Synthesis(#1-#6) after inter-band delay correction

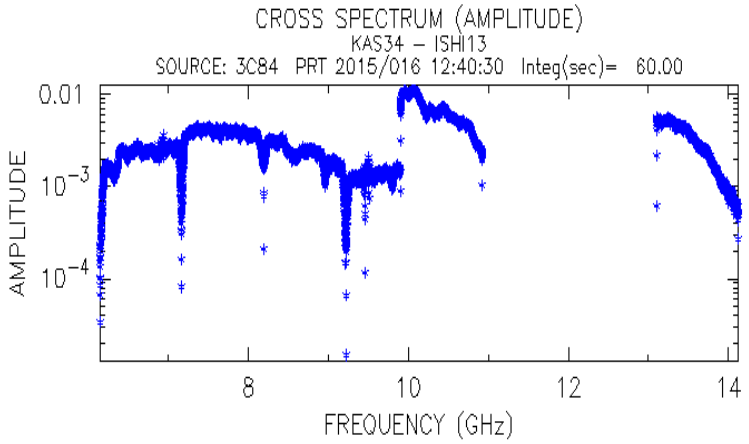
Cross Spectrum



- Polynomial curve fitting
  - fourth order is enough

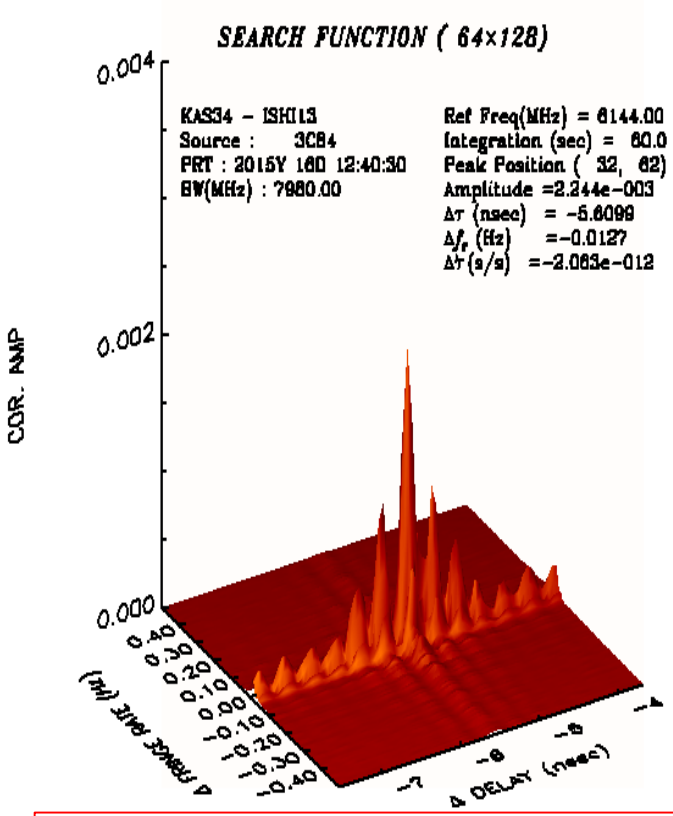
Bandwidth Synthesis(#1-#6)

Cross Spectrum



6GHz 14GHz

Delay Resolution Function



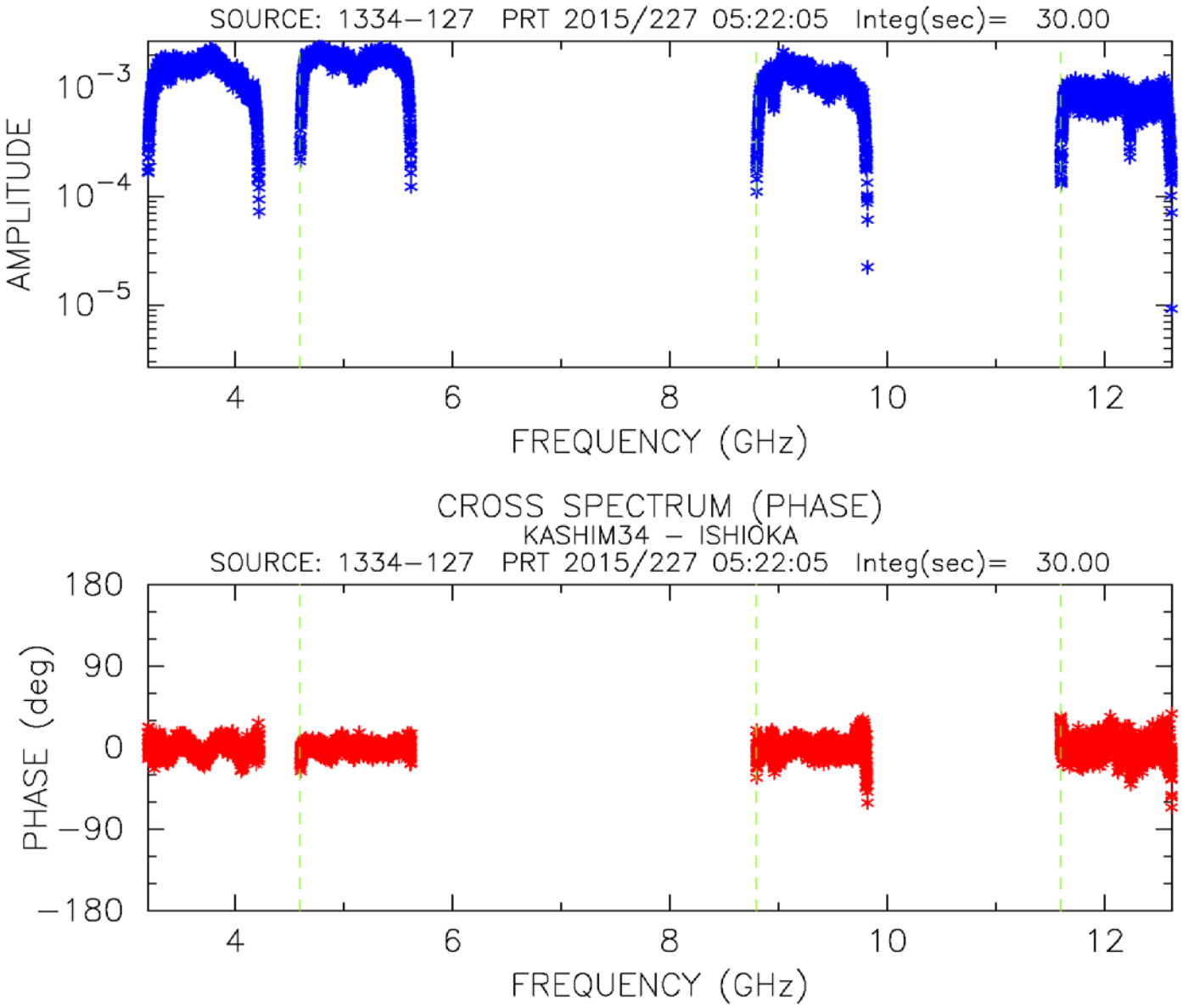
Theoretical delay precision is 27 femto sec.

KASHIMA – ISHIOKA
Second VLBI session in **summer** 2015

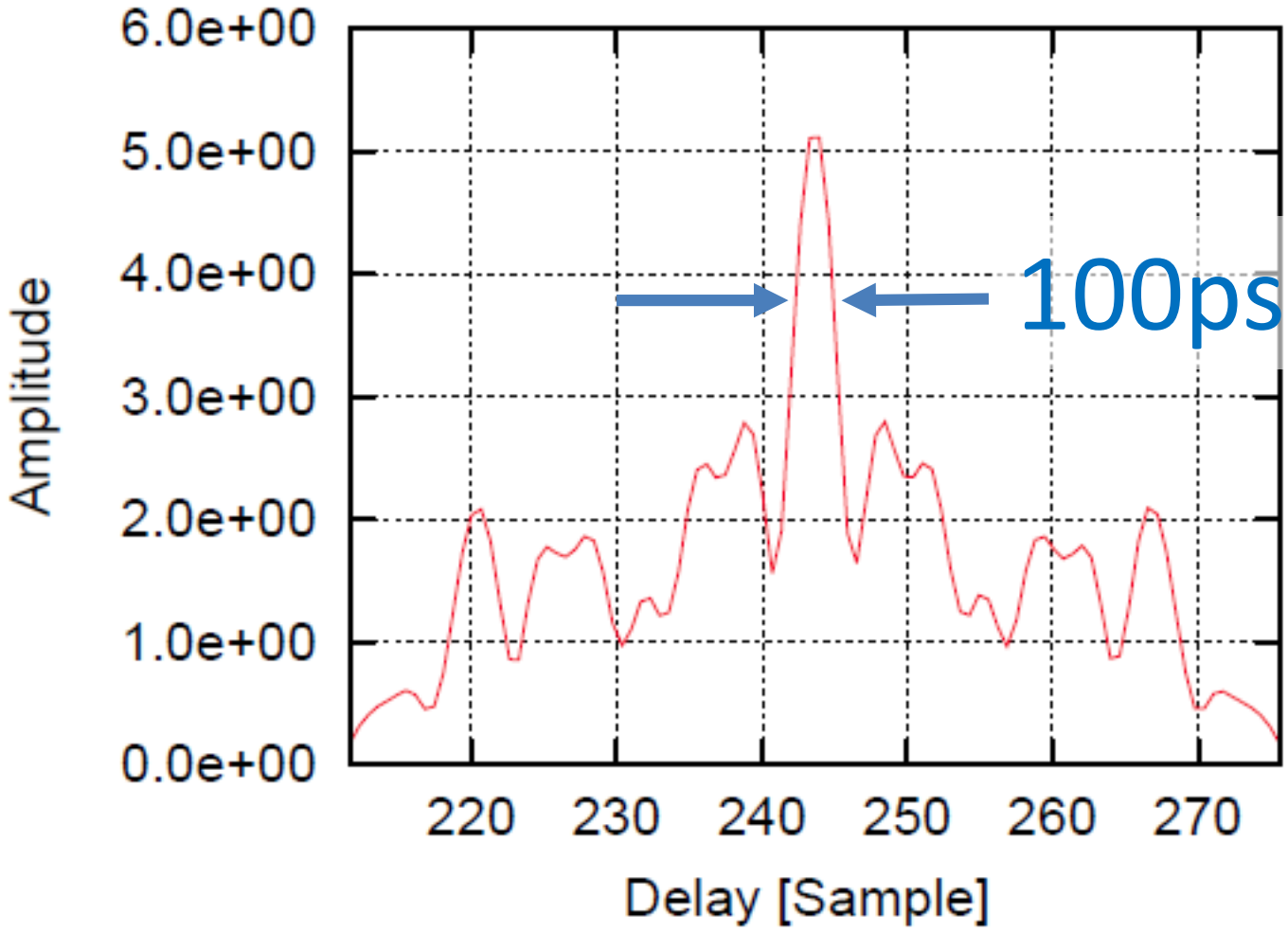
NINJA feed has installed

- 3.2 GHz to 13GHz (future 14.4GHz)
- Allocated 4 bands
  - 3.2 – 4.6 – 8.8 – 11.6 GHz
  - Almost 10GHz BW
  - Applied zero redundant array (small sidelobe)
  - Main target is to detect ionospheric delay
- Fully adopted direct sampling unit

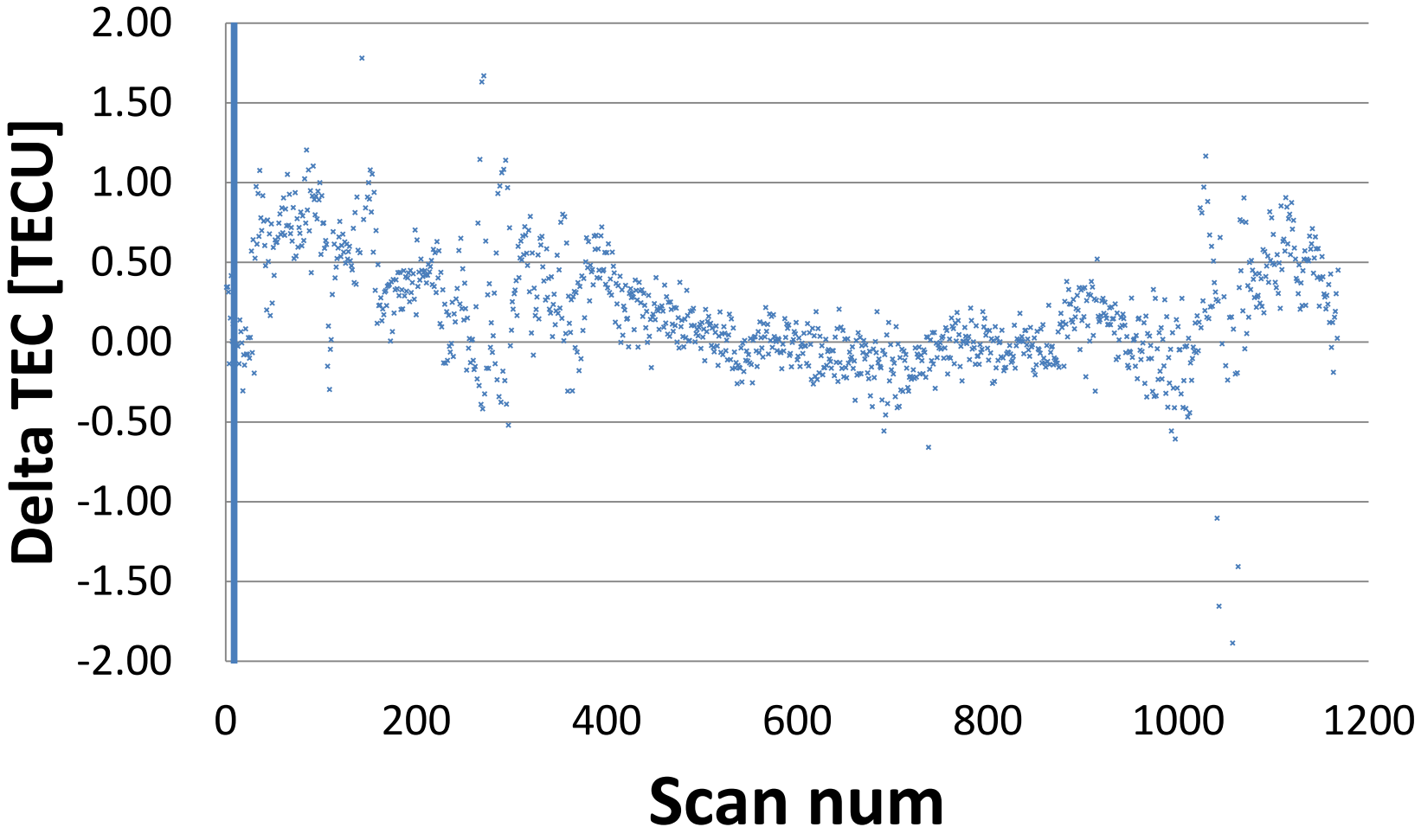
Cross spectrum



The delay resolution function



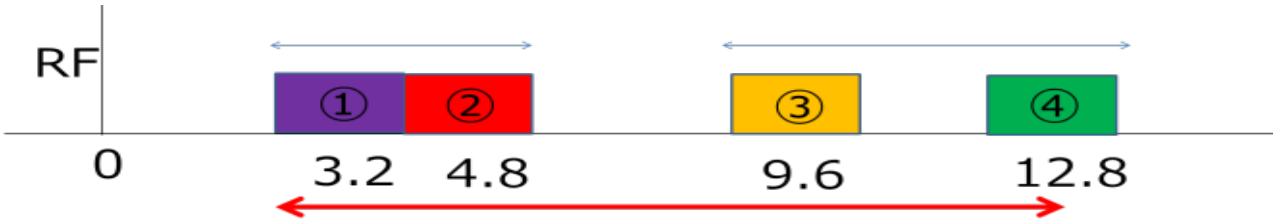
ΔTEC estimated by broadband delay



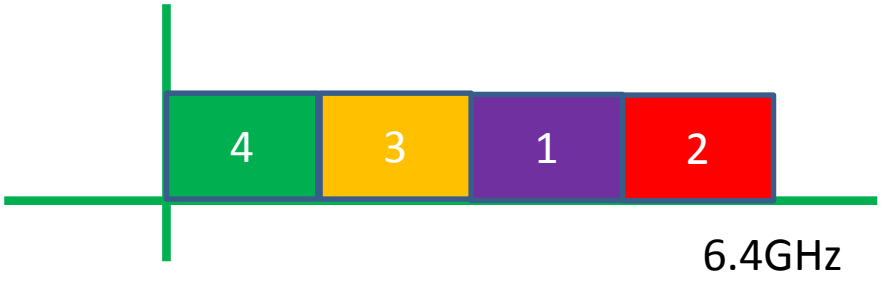
BIG problem

- 15 TB per band !
- If we perform 4 bands obs,
  - 60 TB / station
- If we use 10 stations,
  - 0.6 PB / day
- Correlation center should keep at least 2 weeks data set
  - almost 10 PB (PRETTY BAD)

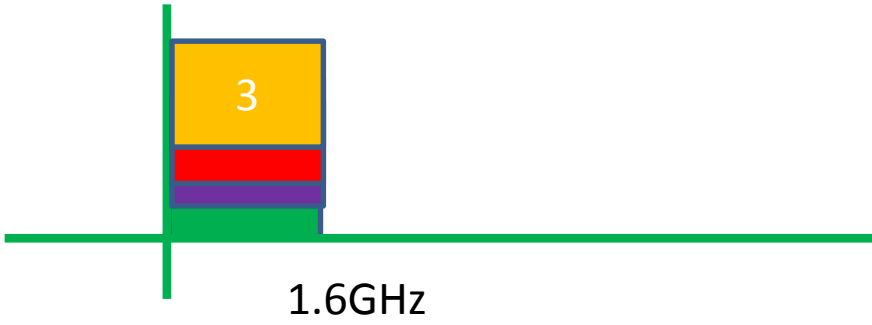
Special frequency allocation

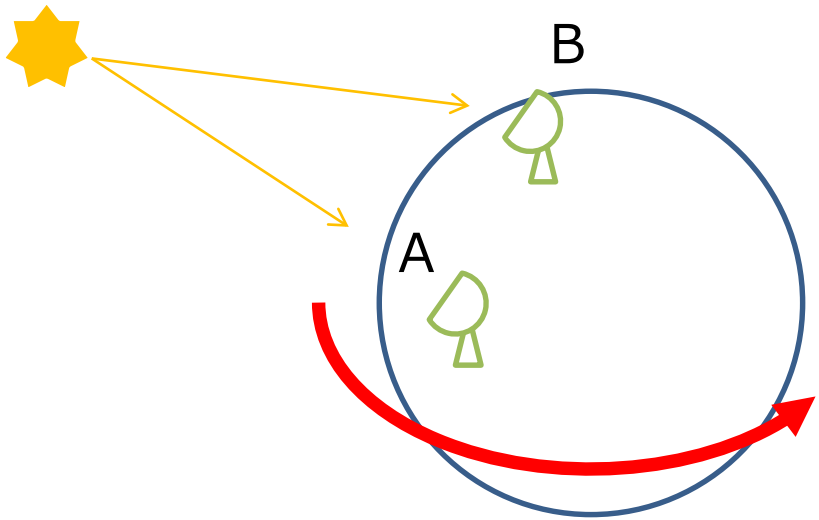


12.8GHz sampling

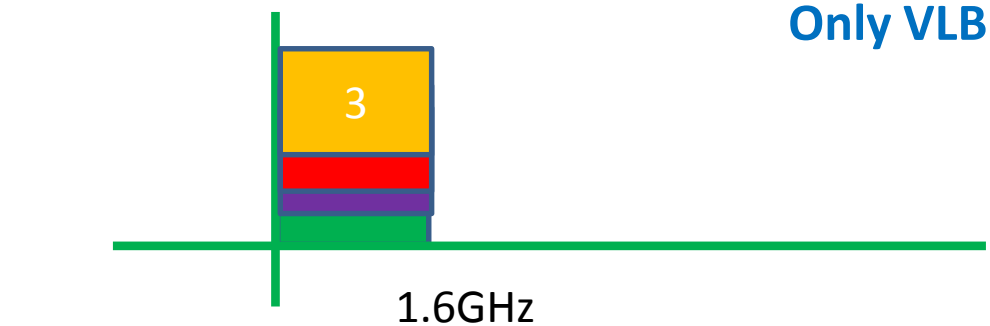


3.2GHz sampling

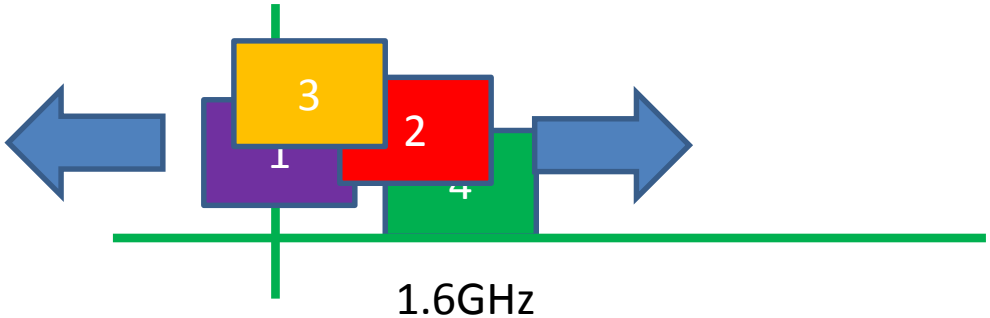




Only VLBI can distinguish folded bands



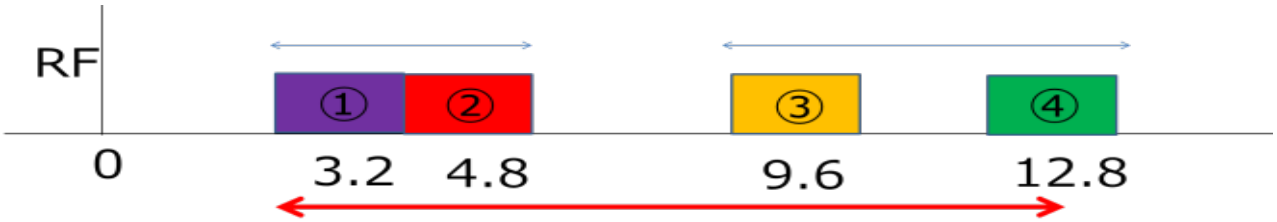
Station A



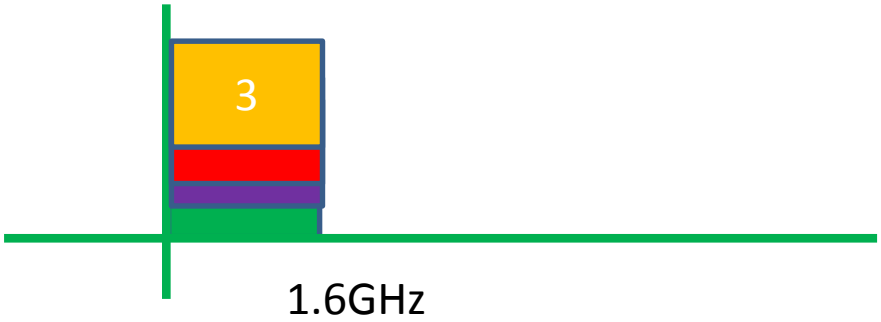
Station B

inflated image!

Special frequency allocation



3.2GHz sampling



- SNR becomes 2 times worse
- Data volume can be reduced to ¼ !

First Sub-mm VLBI in Japan

230 GHz VLBI at Nobeyama

Steady 230 GHz observation as single dishes

But

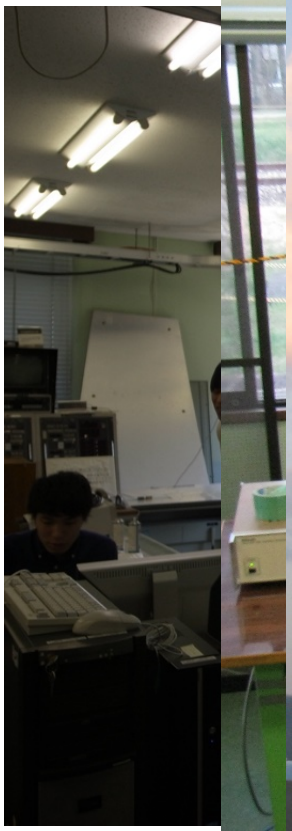
No VLBI back-ends

Need for building VLBI system temporary!

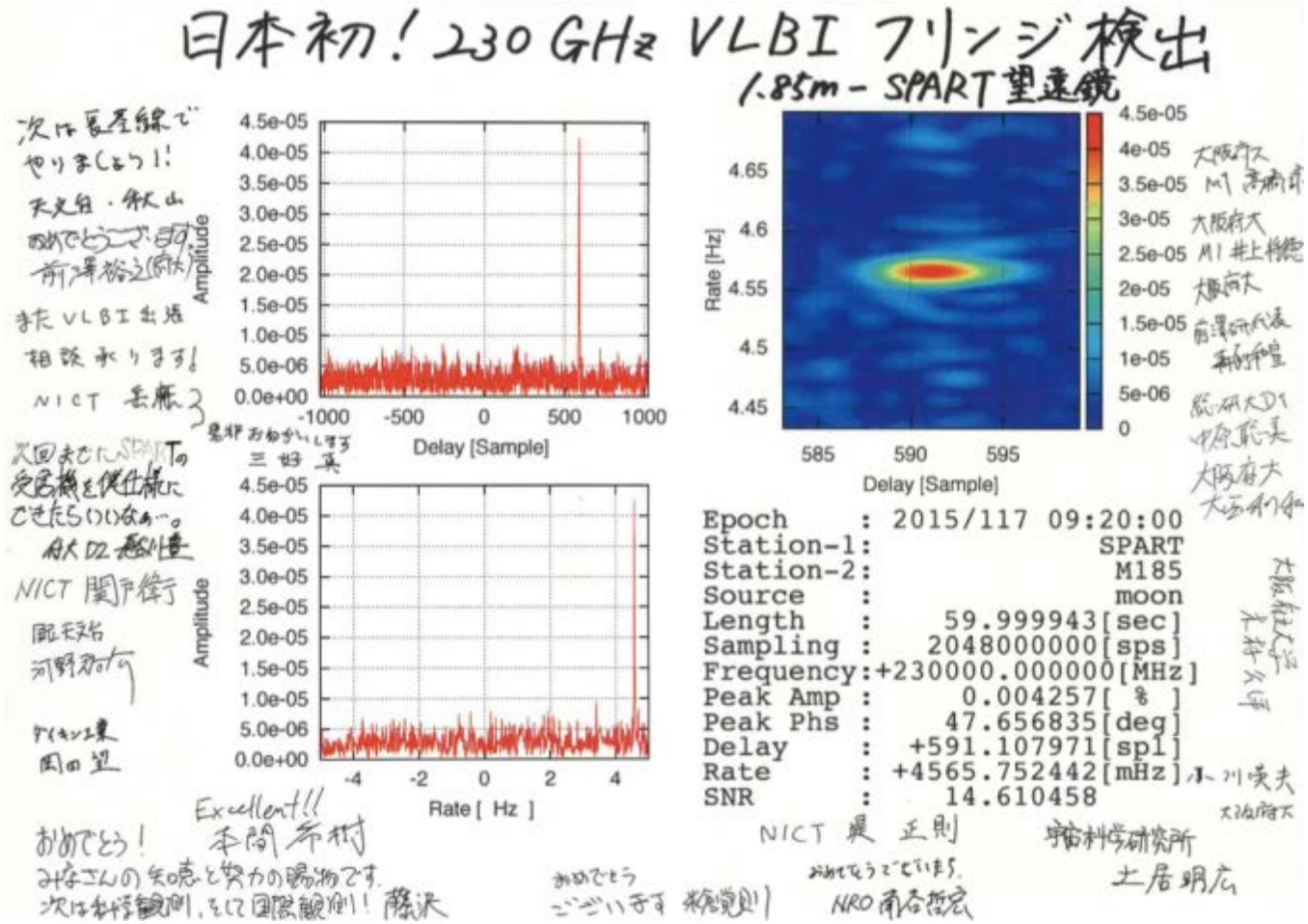
150 m
(VSBI)

Backend and Optical fiber from Kashima

- No rooms for human…



First 230 GHz fringe in Japan !



16k point / 100 Hz fringe search window

Kick off
broadband VLBI together !

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