Trans-pacific broadband VLBI

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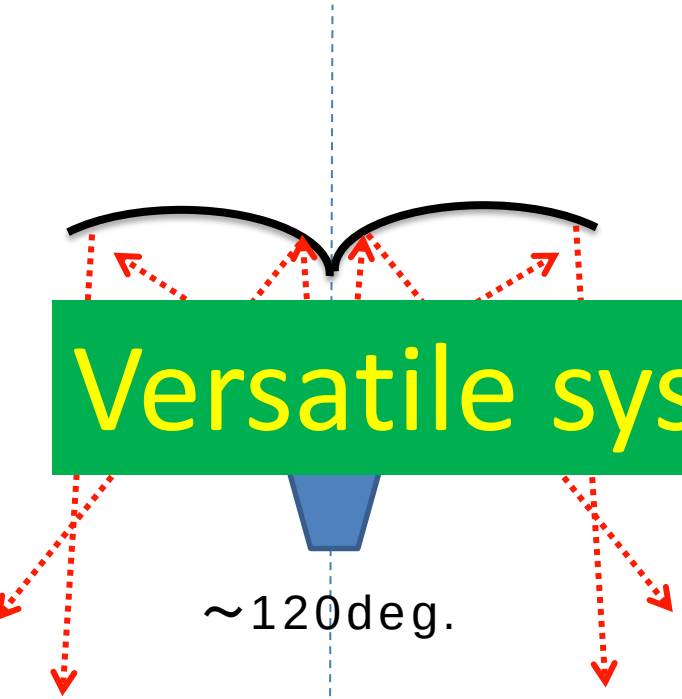
Contents

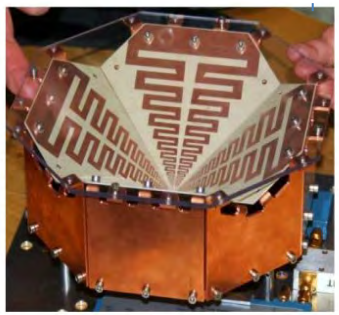
- Broadband project “GALA-V”
- First Transpacific broadband VLBI

Gala-V project

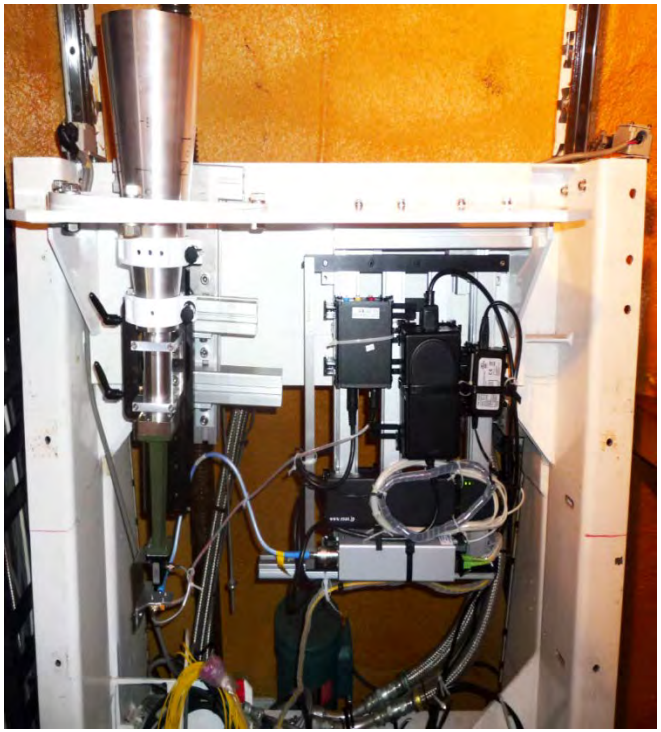
Broadband
and Narrow
beam width



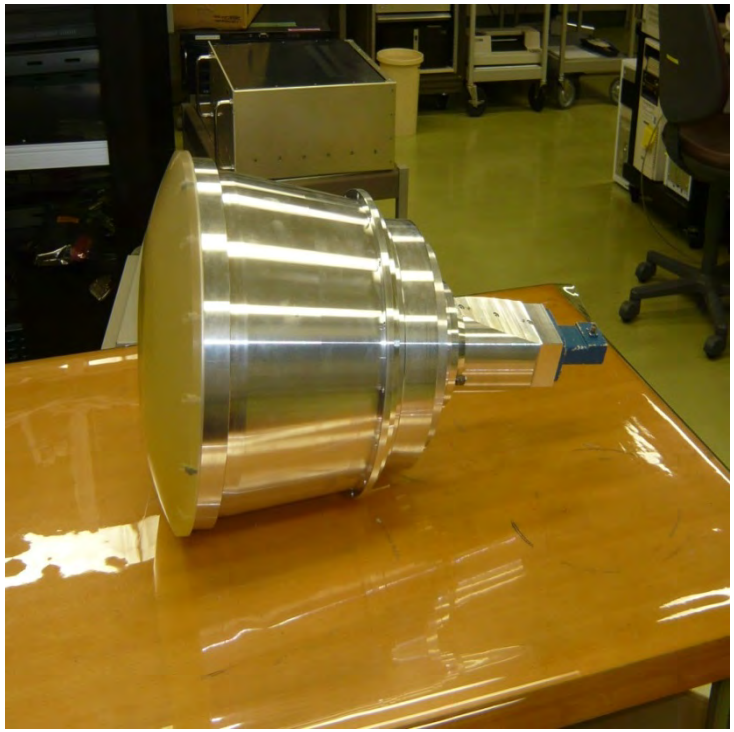
Versatile system for most antennas



Broadband Feed for Cassegrain optics in Gala-V project

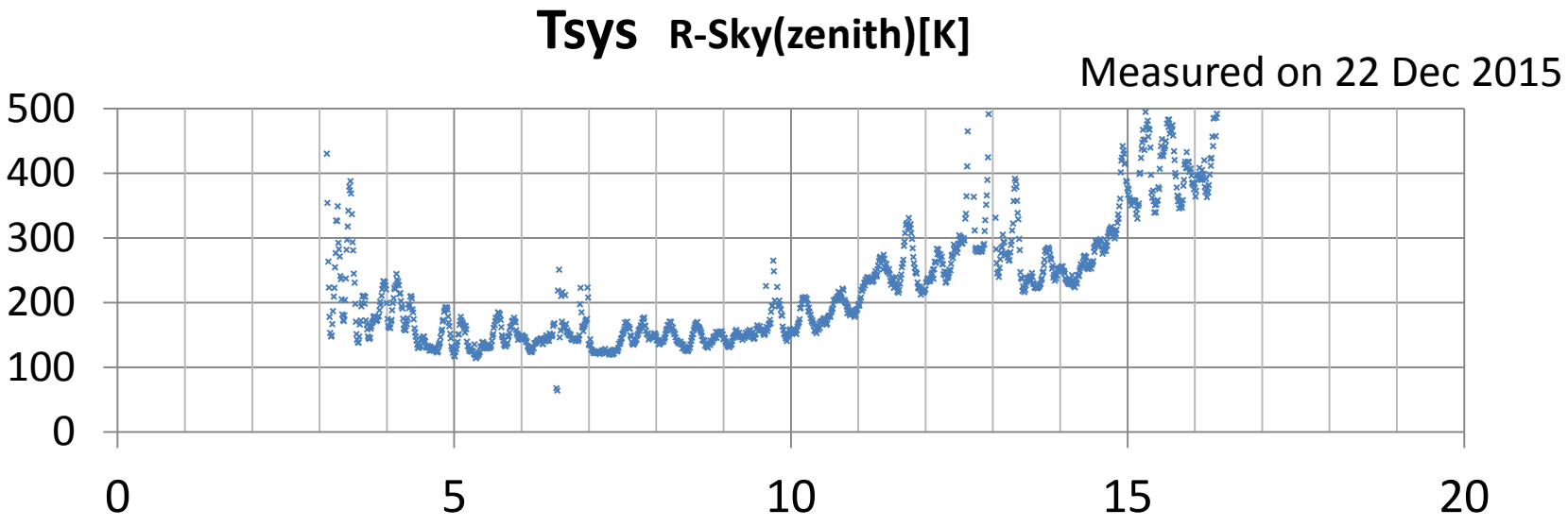


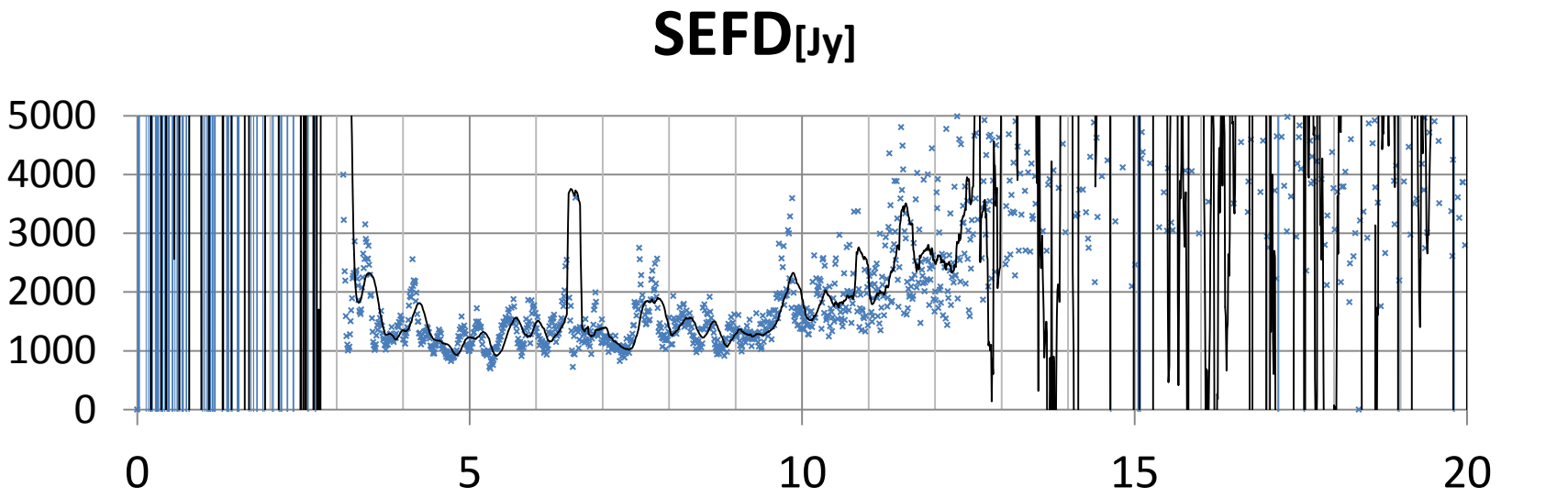
IGUANA Feed (6.5-15GHz)



NINJA Feed (3.2-14.4GHz)

NINJA feed system

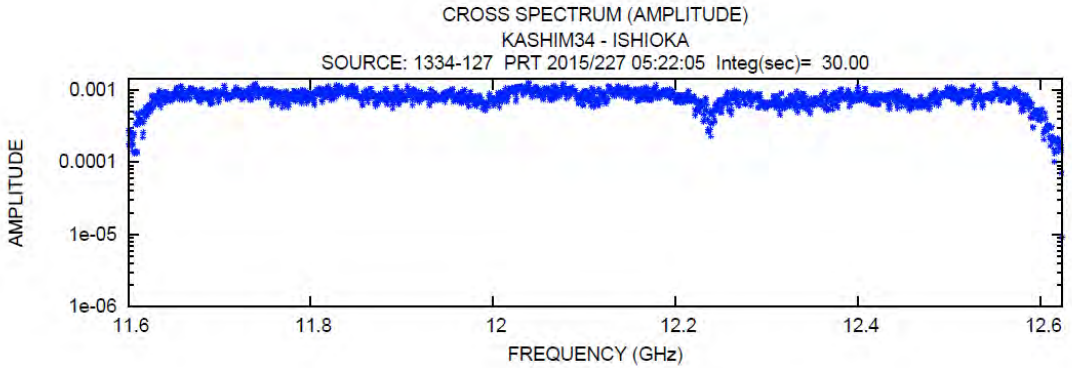


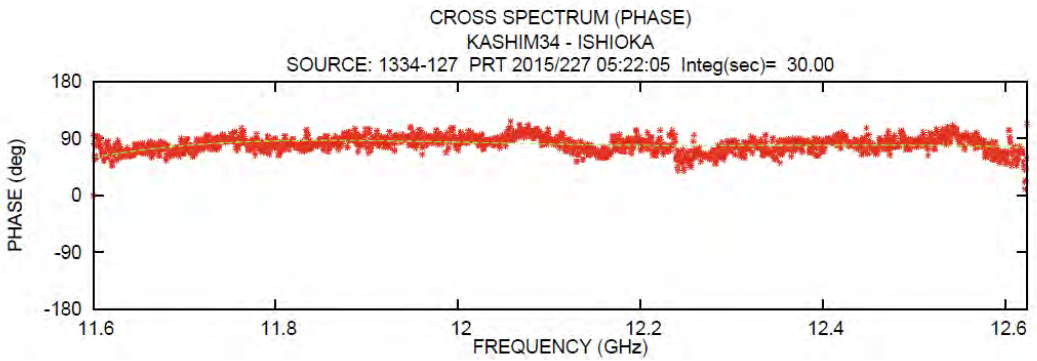


Direct sampling system

- GALAS

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

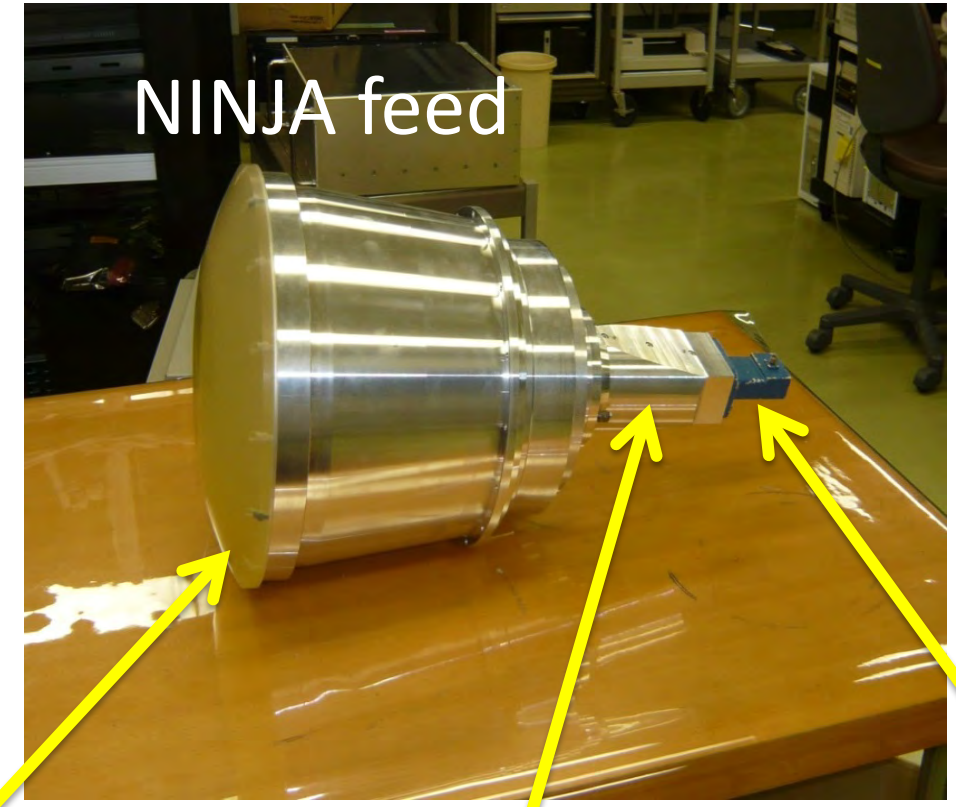




- **Phase-cal is not necessary**

How do we suppress RFI broadband system??

- Technique 1 : Suppress RFI before LNA

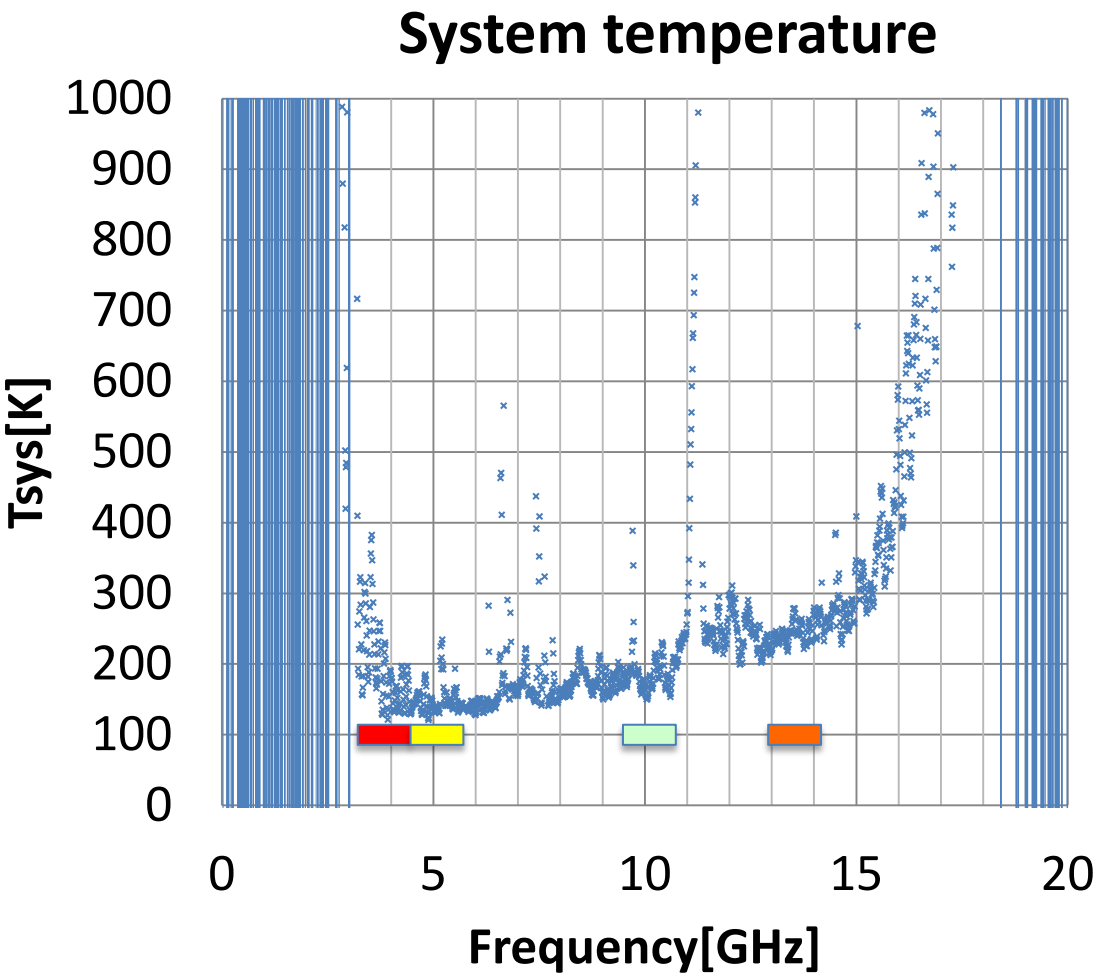


Feed
designed 2.2GHz to 14.4GHz

Waveguide
designed from **2.8GHz**

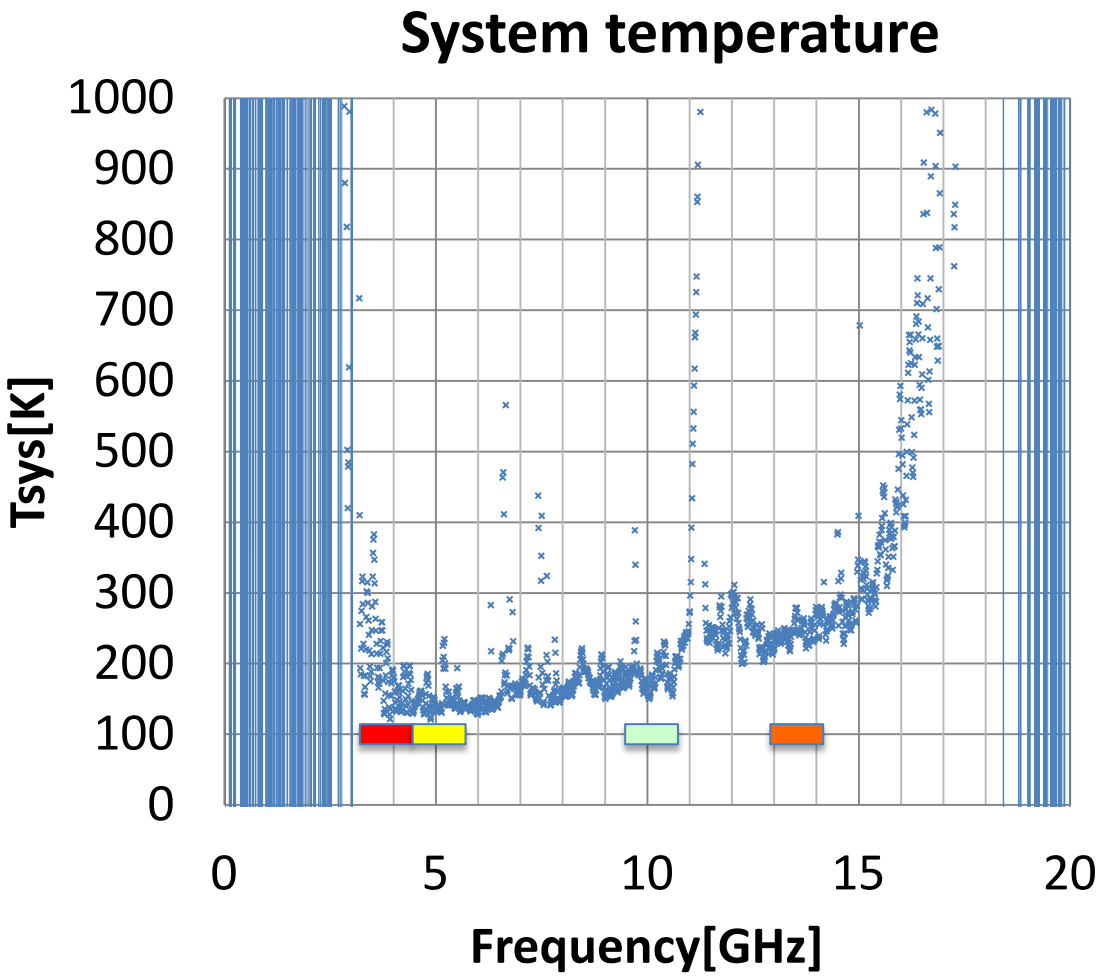
Waveguide converter
from **3.2 GHz**

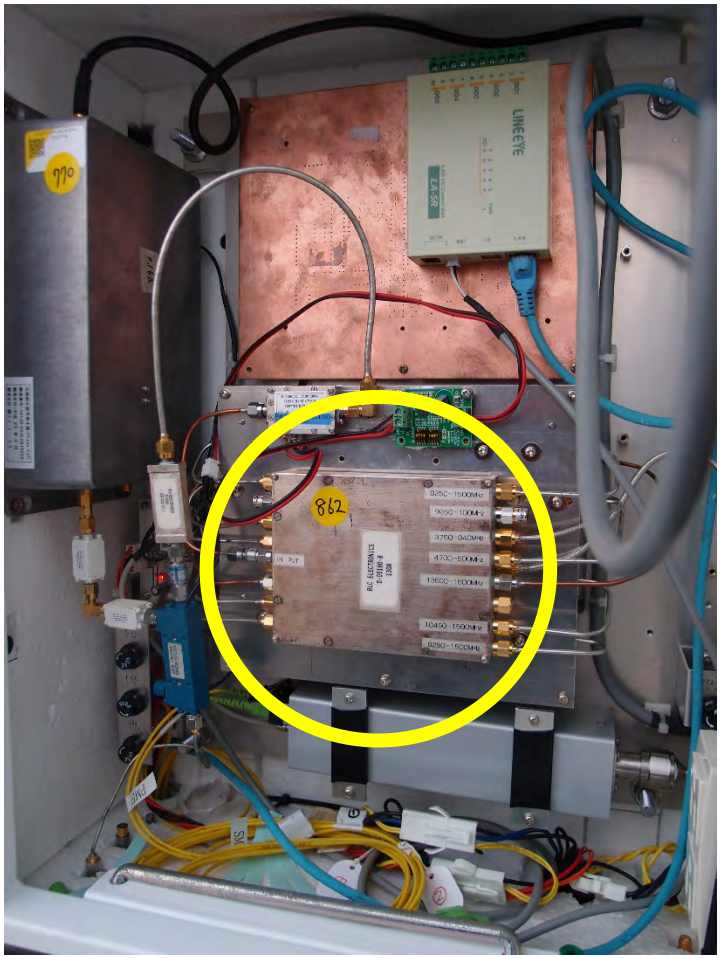
VLBI in Tokyo
The heaviest RFI site in world!!



If LNA does not saturate, everything must be OK !

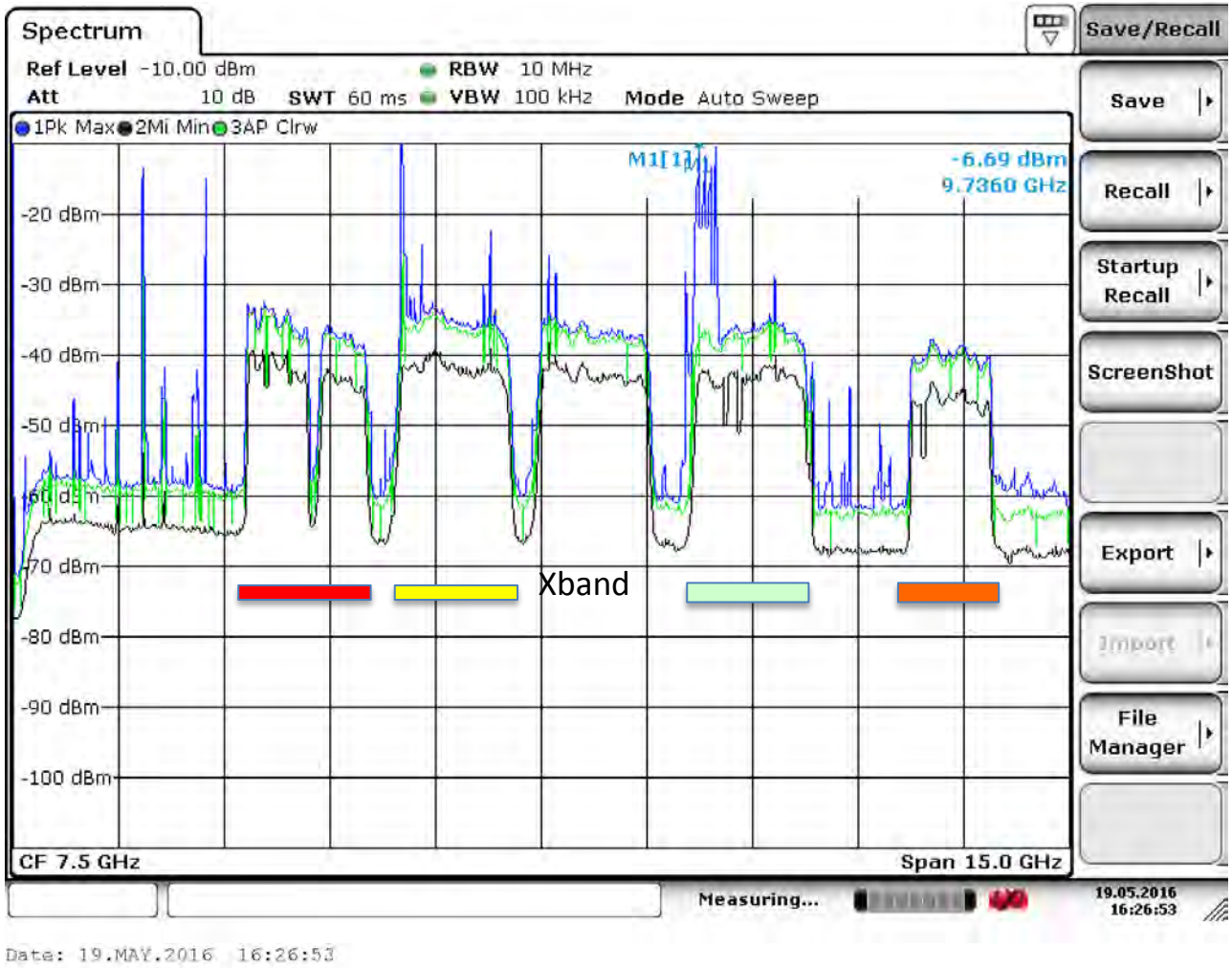
- Technique 2： Suppress RFI after LNA





Filter bank of compact antenna

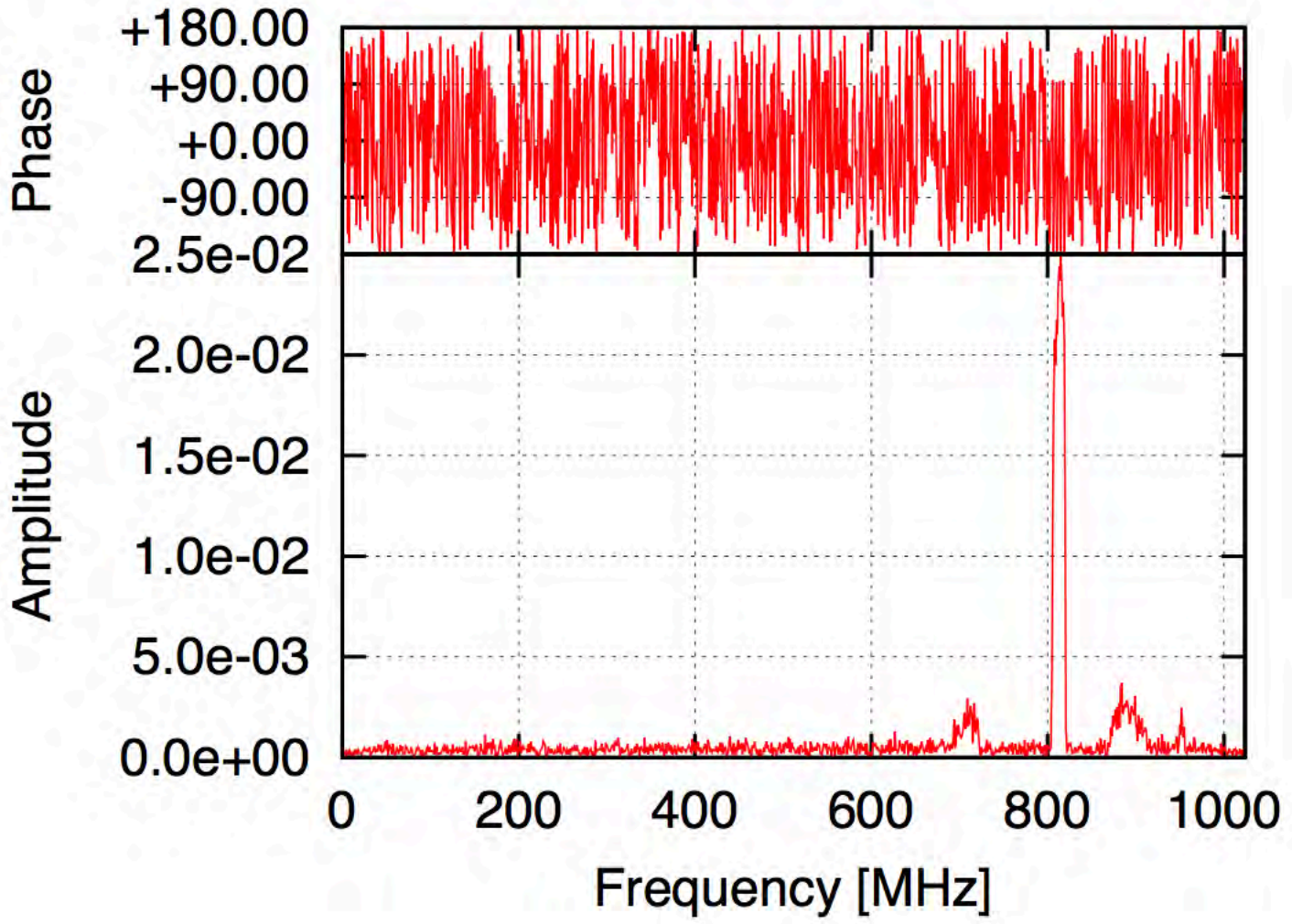
Though heavy site in Tokyo, broad-band system works well

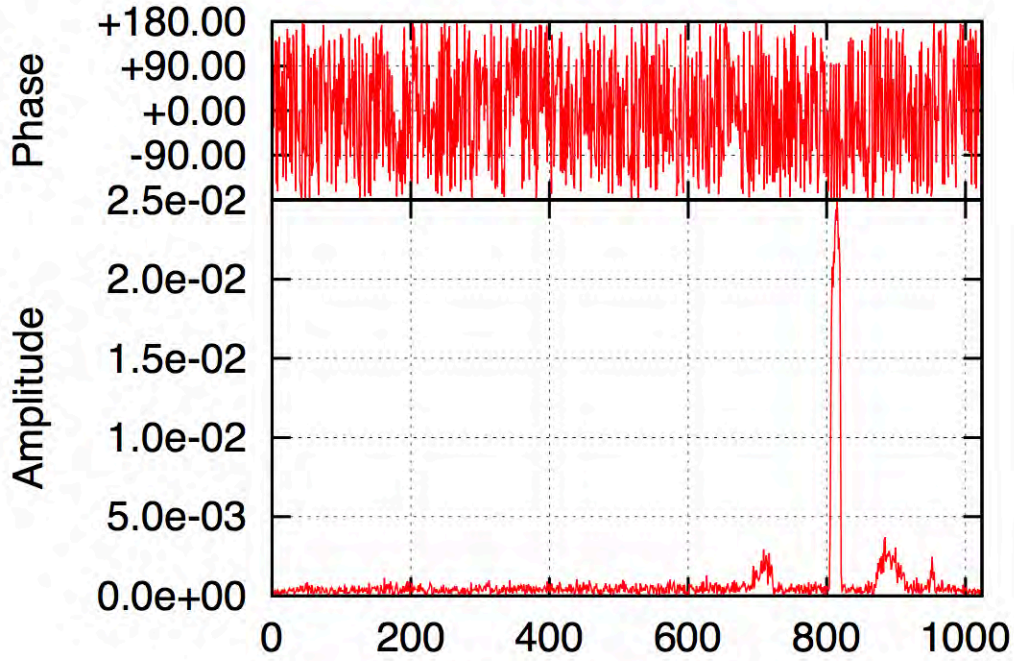


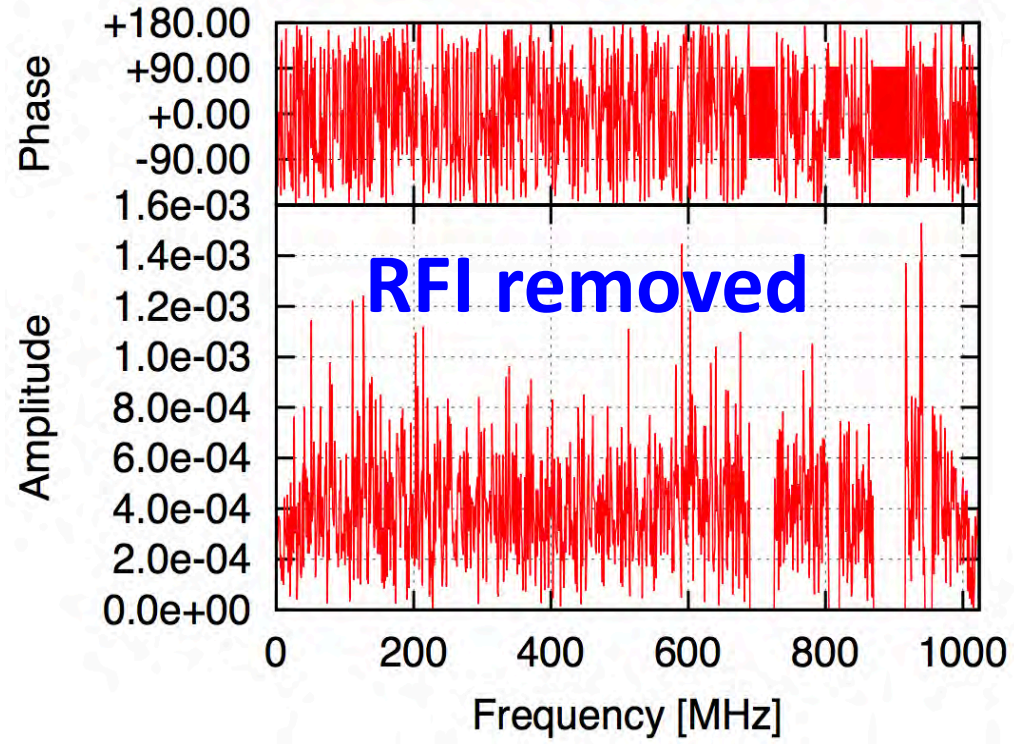
Since Kashima 34m does not install such filter bank,
Most sites in other countries must be no problem

- Technique 3 : Suppress RFI at post correlation

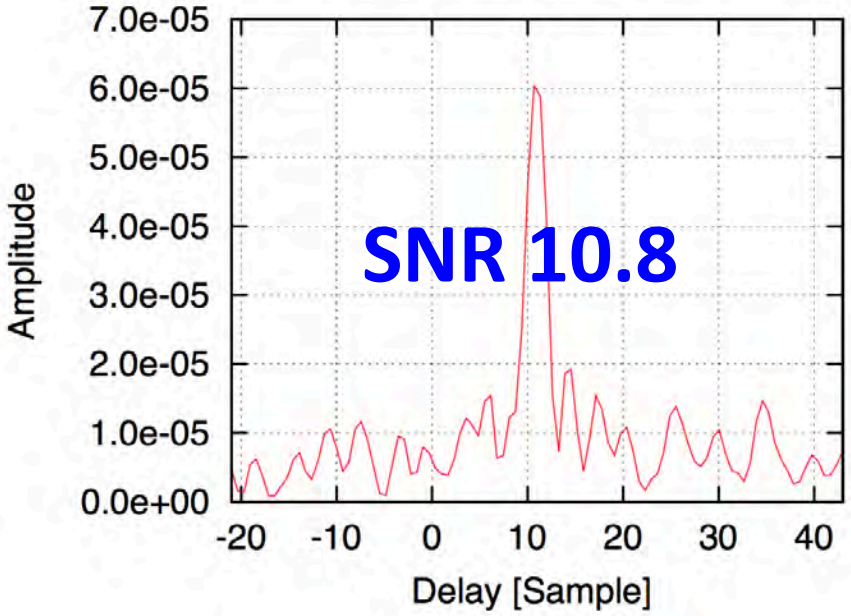
Cross spectrum in 10GHz on compact#2 – Ishioka







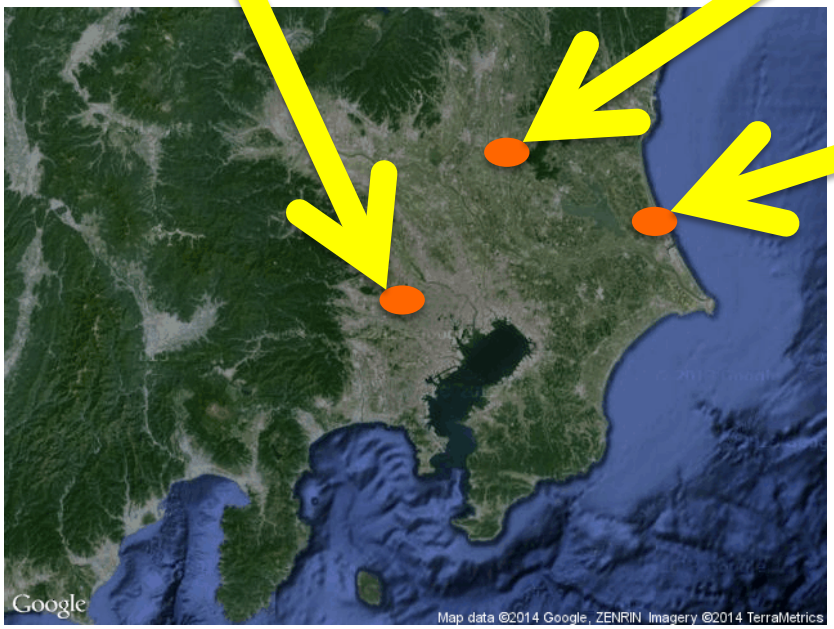
No fringe detected

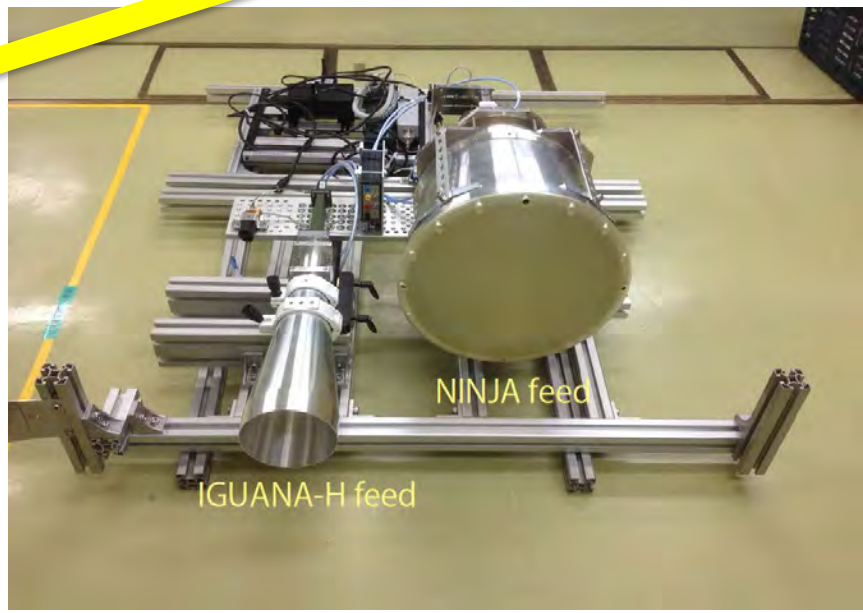


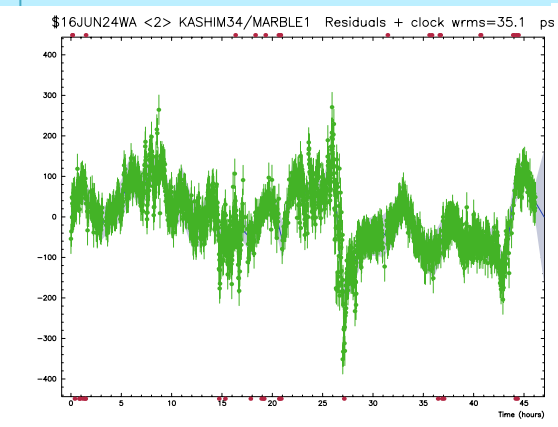
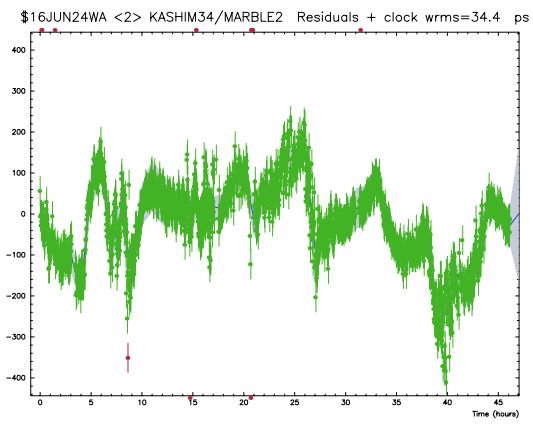
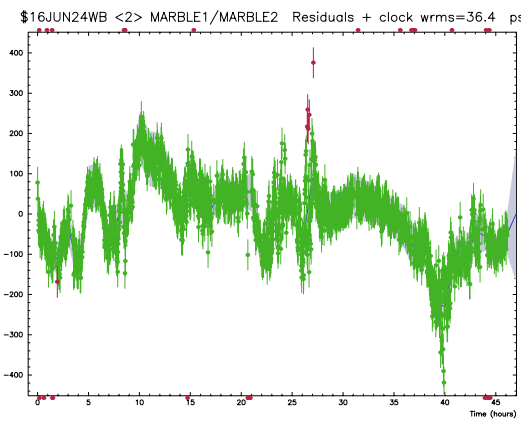
Tokyo UTC(NICT)

Tsukuba UTC(NMIJ)

34 meter RT in Kashima





code: GV16176	Kas34 - #1	Kas34 - #2	#1 - #2
RMS	35.1ps	34.4ps	36.4ps
Clock +Rsd in 24h			

Hobart – Ishioka – Kashima

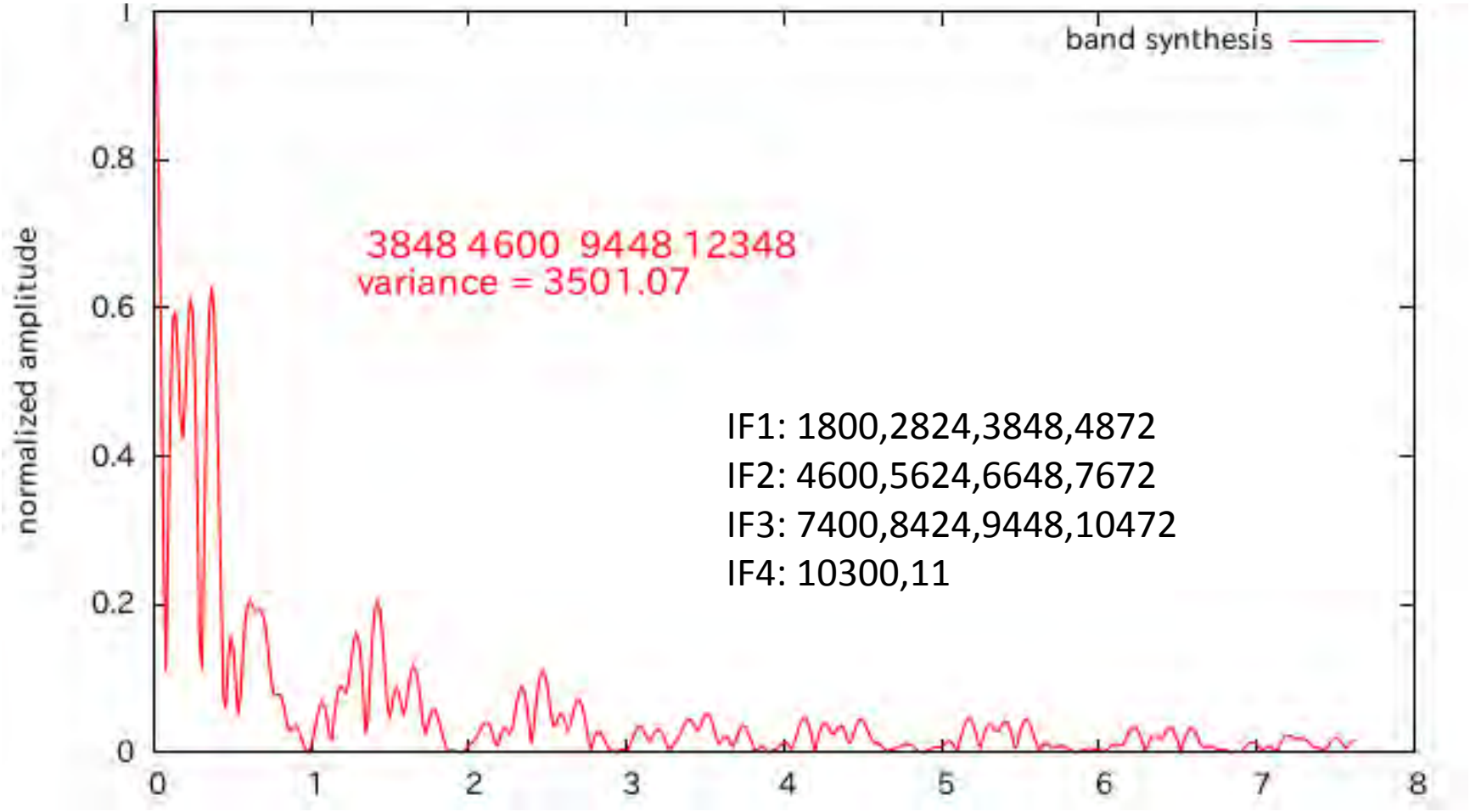
- 2016 August, four 1024MHz bands

Purpose

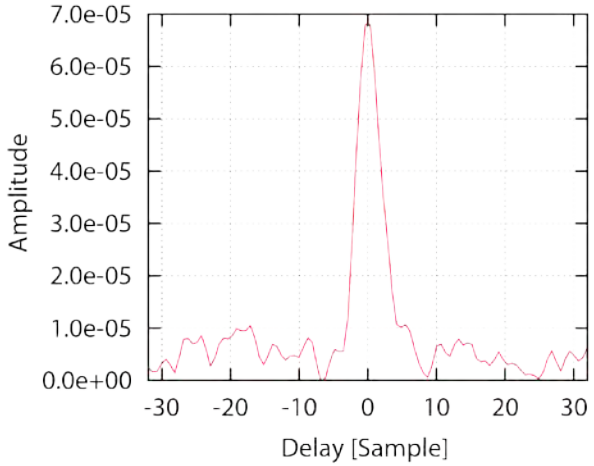
- To detect broadband fringe (at least)
- To confirm bandwidth synthesis
  on the long baseline
- To measure the ionosphere effect

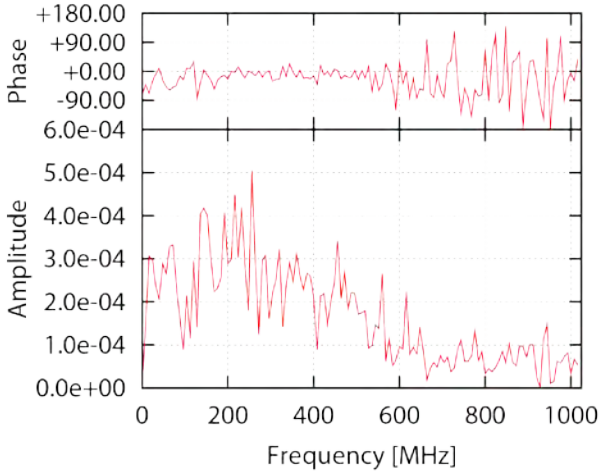
Hobart system

- The Hobart 12m antenna was equipped with a Stirling Cycle cooled Caltech QRFH feed (**2.3 – 14 GHz**) and receiver manufactured by Callisto (France).
- The system temperature **75 K** across the band.
- New broadband downconverter (made at UTAS)
- Each 4 GHz wide IF was sampled at 2GHz and 2-bit
- HAT-Lab DBBC3 and a Flexbuff

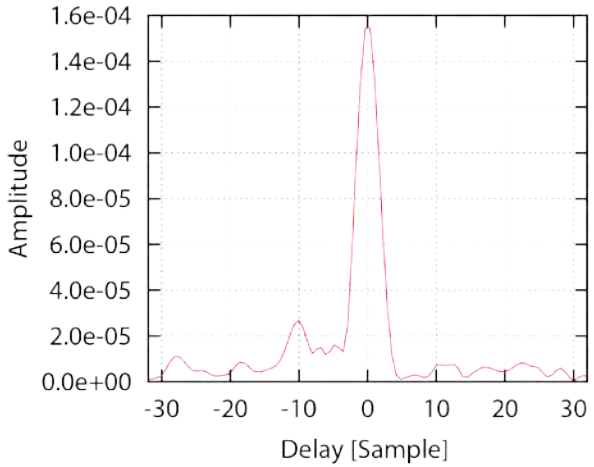

band synthesis
normalized amplitude
3848 4600 9448 12348
variance = 3501.07
IF1: 1800,2824,3848,4872
IF2: 4600,5624,6648,7672
IF3: 7400,8424,9448,10472
IF4: 10300,11
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8

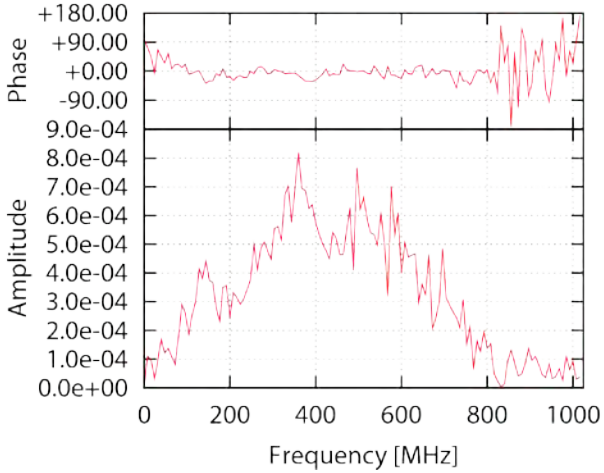
First international broadband fringe against Hobart baseline






```
Epoch      : 2016/222 11:00:00
Station-1:              Hobart
Station-2:             Ishioka
Source     :          3C279[  A]
Length     :     36.000000[sec]
Sampling   :   2048000000[sps]
Frequency: +3848.000000[MHz]
Peak Amp   :      0.006943[ % ]
Peak Phs   :    -15.615757[deg]
Delay      :     -0.000015[spl]
Rate       :   +189.298842[mHz]
SNR        :     18.788921
```






```
Epoch      : 2016/222 11:00:00
Station-1:              Hobart
Station-2:             Ishioka
Source     :          3C279[  B]
Length     :     36.000000[sec]
Sampling   :   2048000000[sps]
Frequency: +4600.000000[MHz]
Peak Amp   :      0.015756[ % ]
Peak Phs   :    -37.377534[deg]
Delay      :     +0.000000[spl]
Rate       :   +233.109792[mHz]
SNR        :     40.807740
```

fringe detection against Hobart

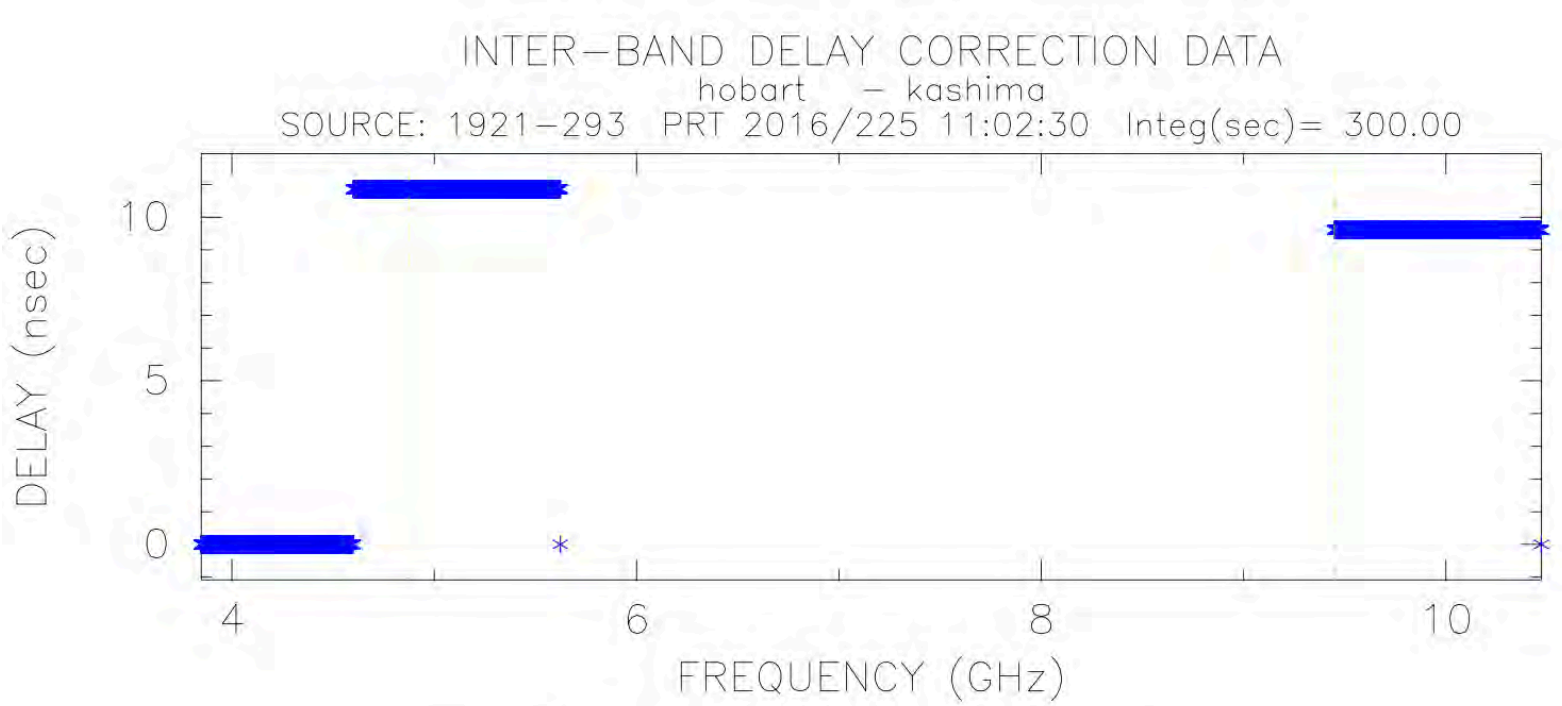
band	SNR	Note
3.8GHz	◯	OK
4.6GHz	◯	OK, 0 to 1% frame loss
9.4GHz	△	too weak than expected 0 to 1.6% frame loss
12.3GHz	×	Even 5 min integration, strange… 0 to 4.7% frame loss

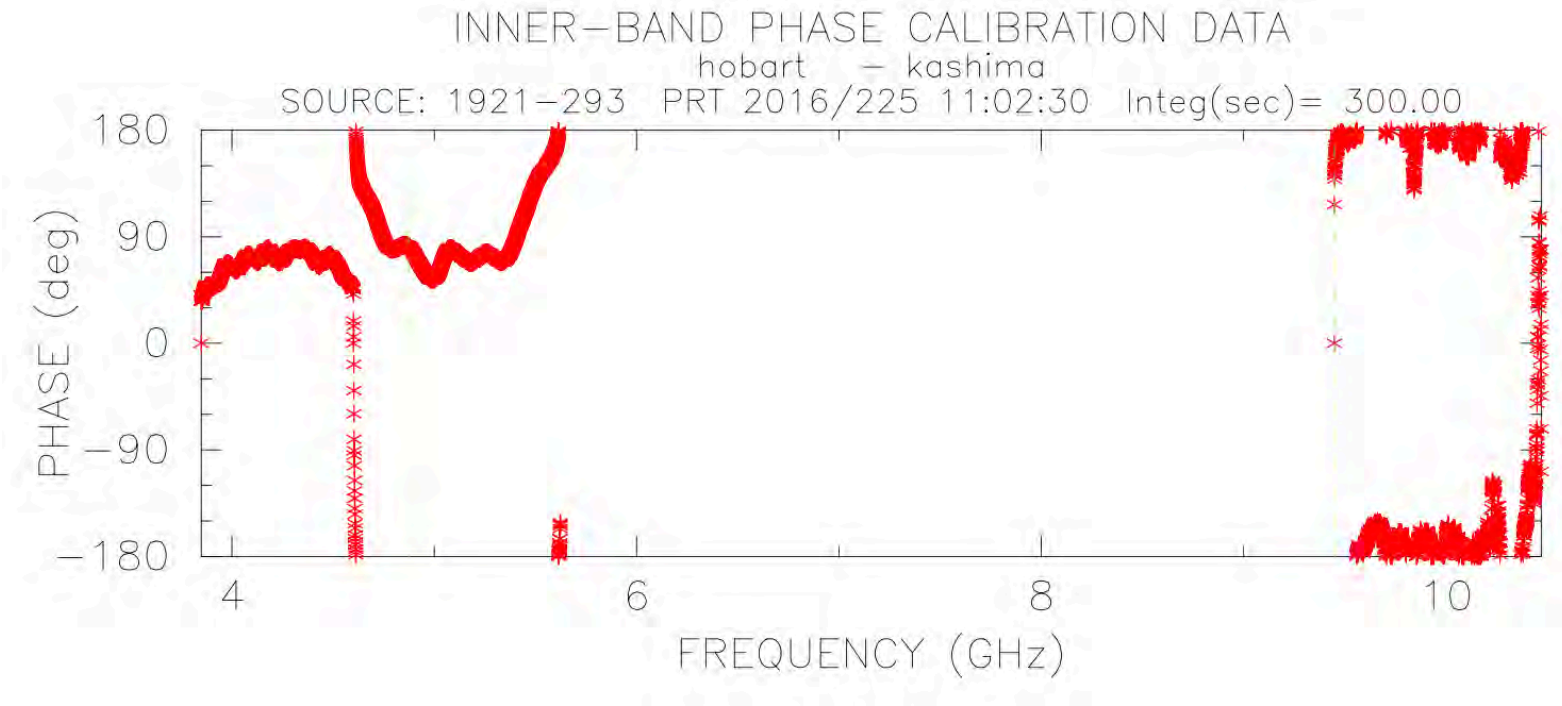
Between Kashima and Ishioka, All fringes were found on four bands.
Best performance at 7 to 8GHz for Hobart

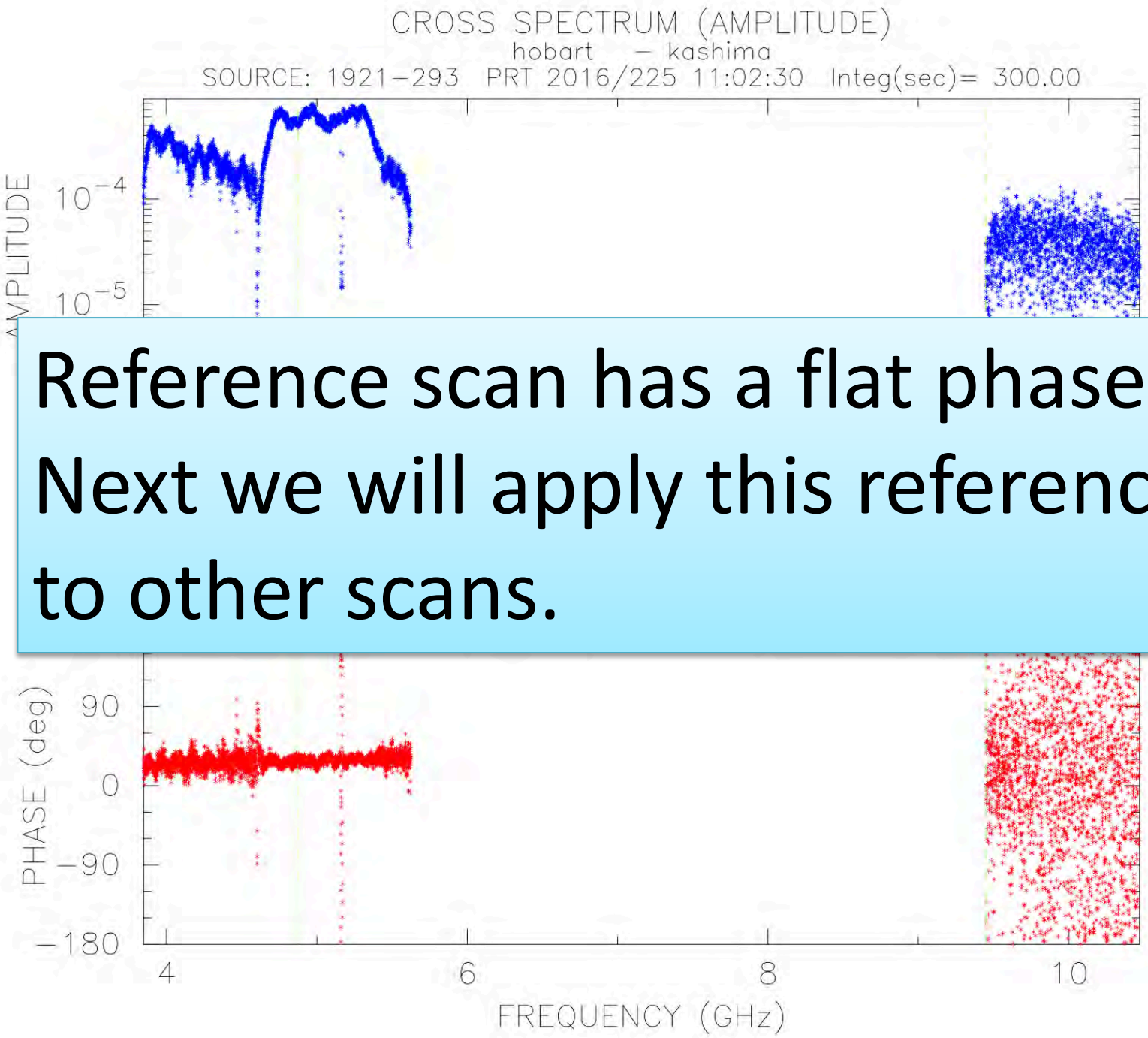
The wideband bandwidth synthesis

- Take strong radio source scan as a reference
  1. inter-band delay correction
  2. inner-band phase correction
- ionospheric delay correction.

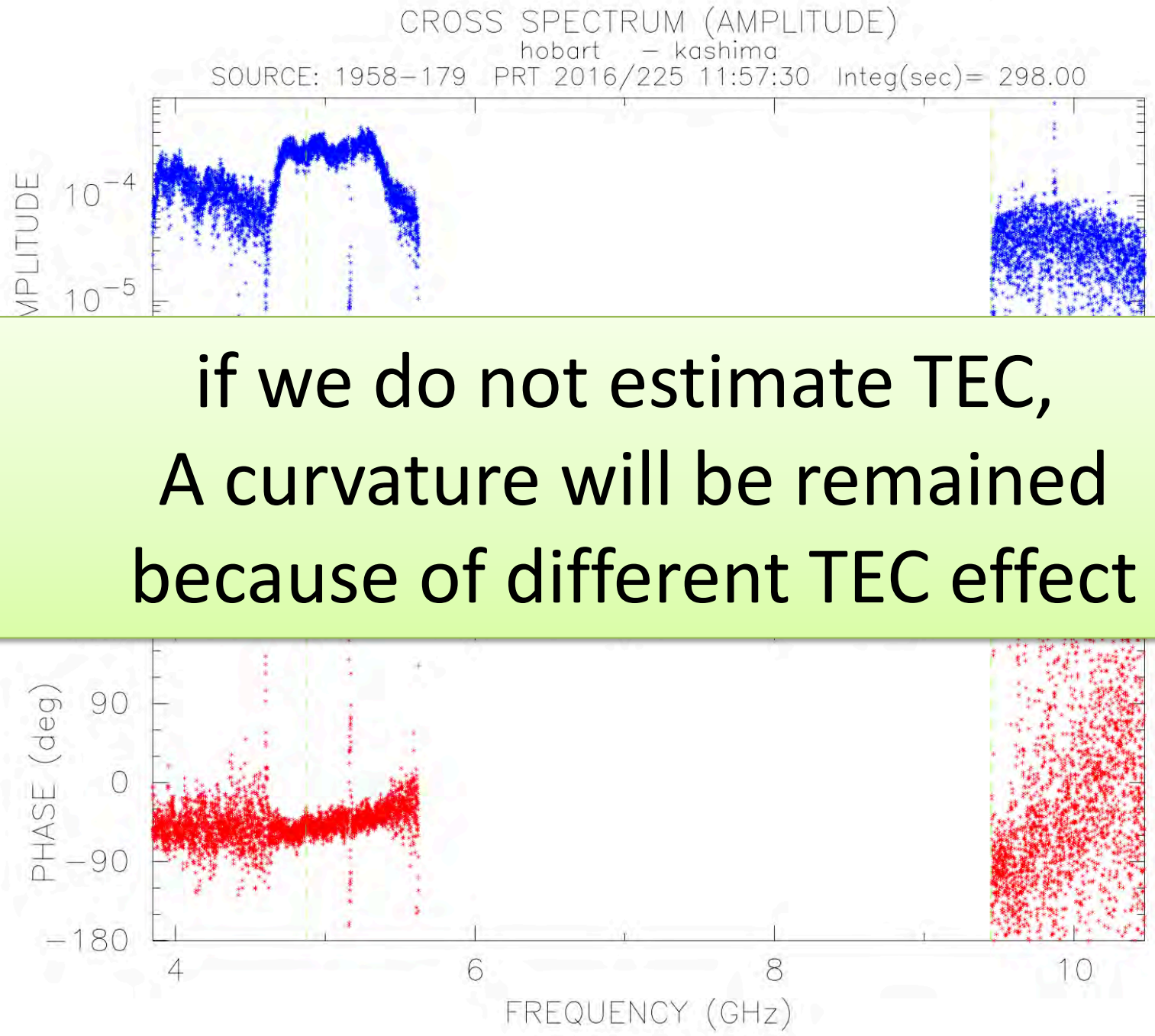
Kondo & Takefuji 2016 RadioScience in press


INTER−BAND DELAY CORRECTION DATA
hobart − kashima
SOURCE: 1921−293 PRT 2016/225 11:02:30 Integ(sec)= 300.00
DELAY (nsec)
10
5
0
4
6
8
10
FREQUENCY (GHz)

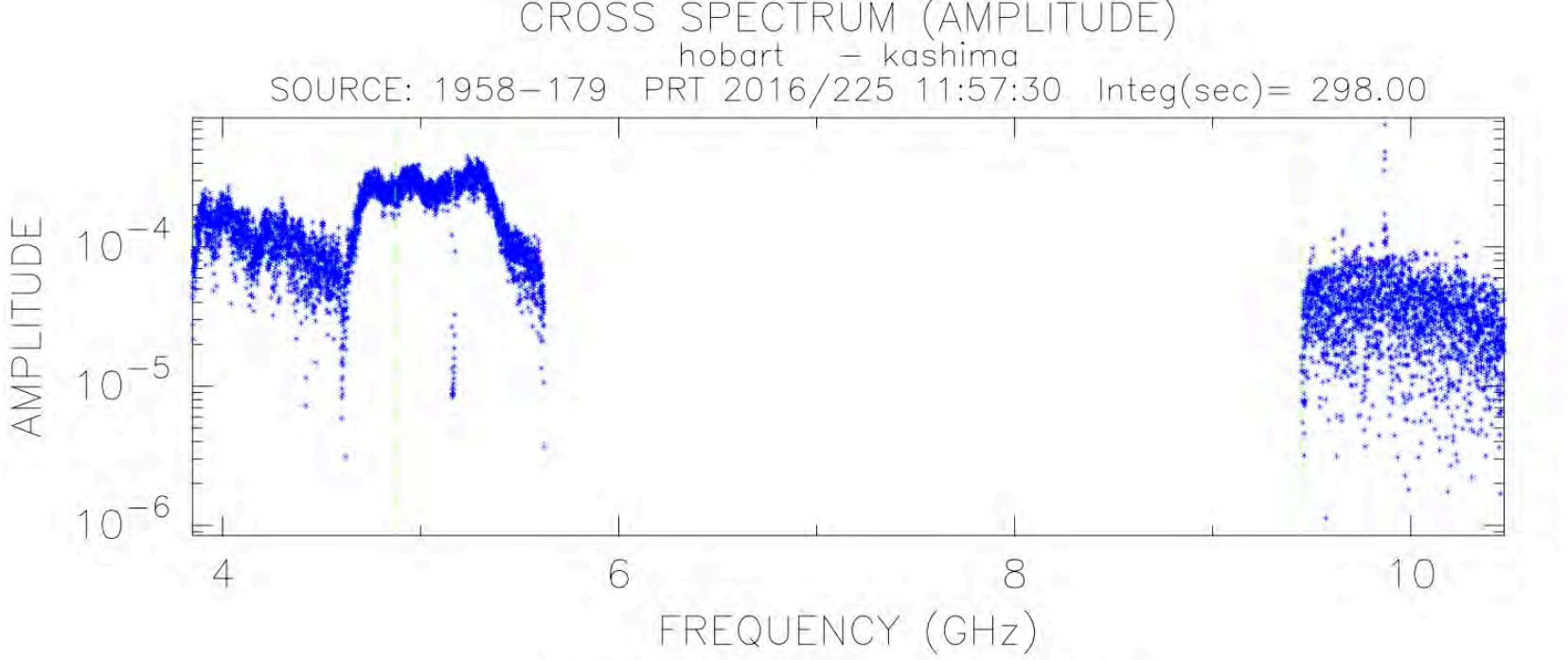

INNER−BAND PHASE CALIBRATION DATA
hobart − kashima
SOURCE: 1921−293 PRT 2016/225 11:02:30 Integ(sec)= 300.00
PHASE (deg)
180
90
0
−90
−180
4
6
8
10
FREQUENCY (GHz)

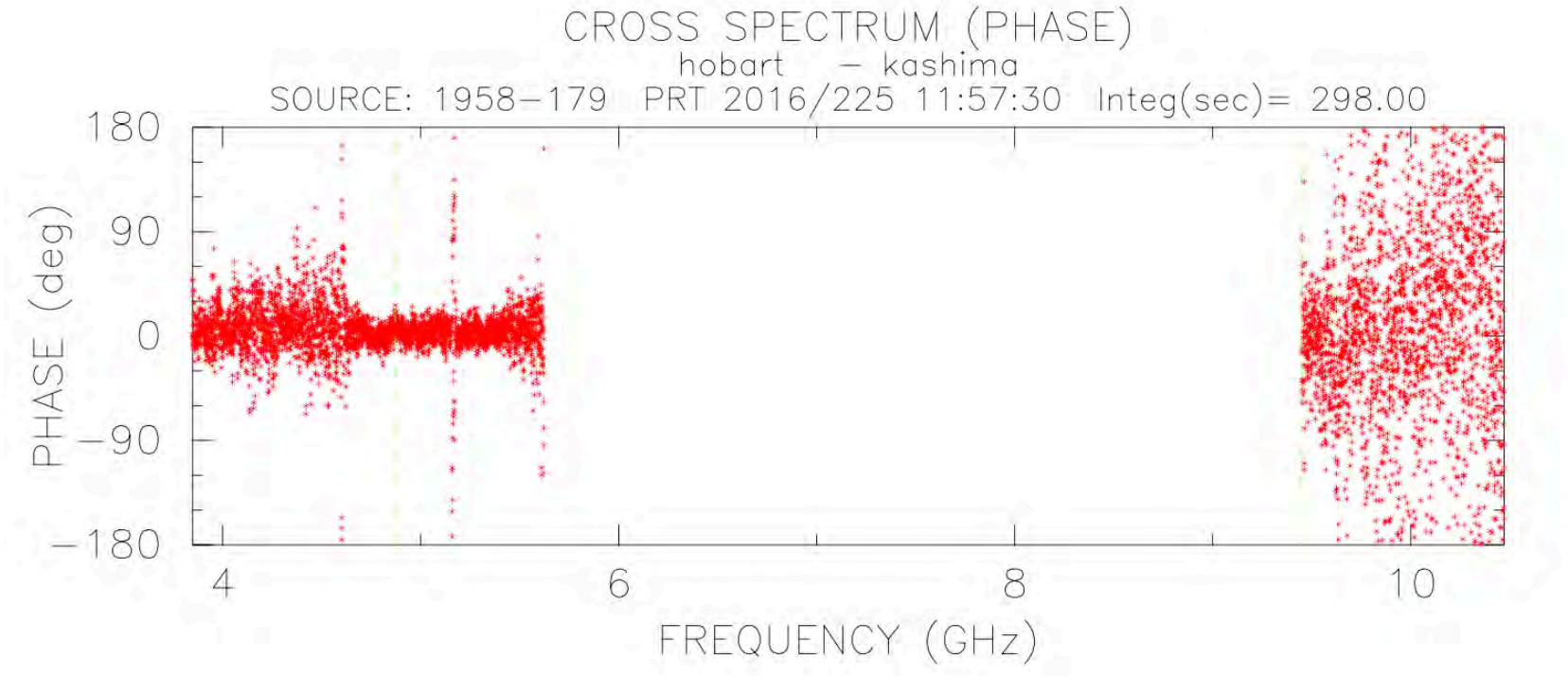


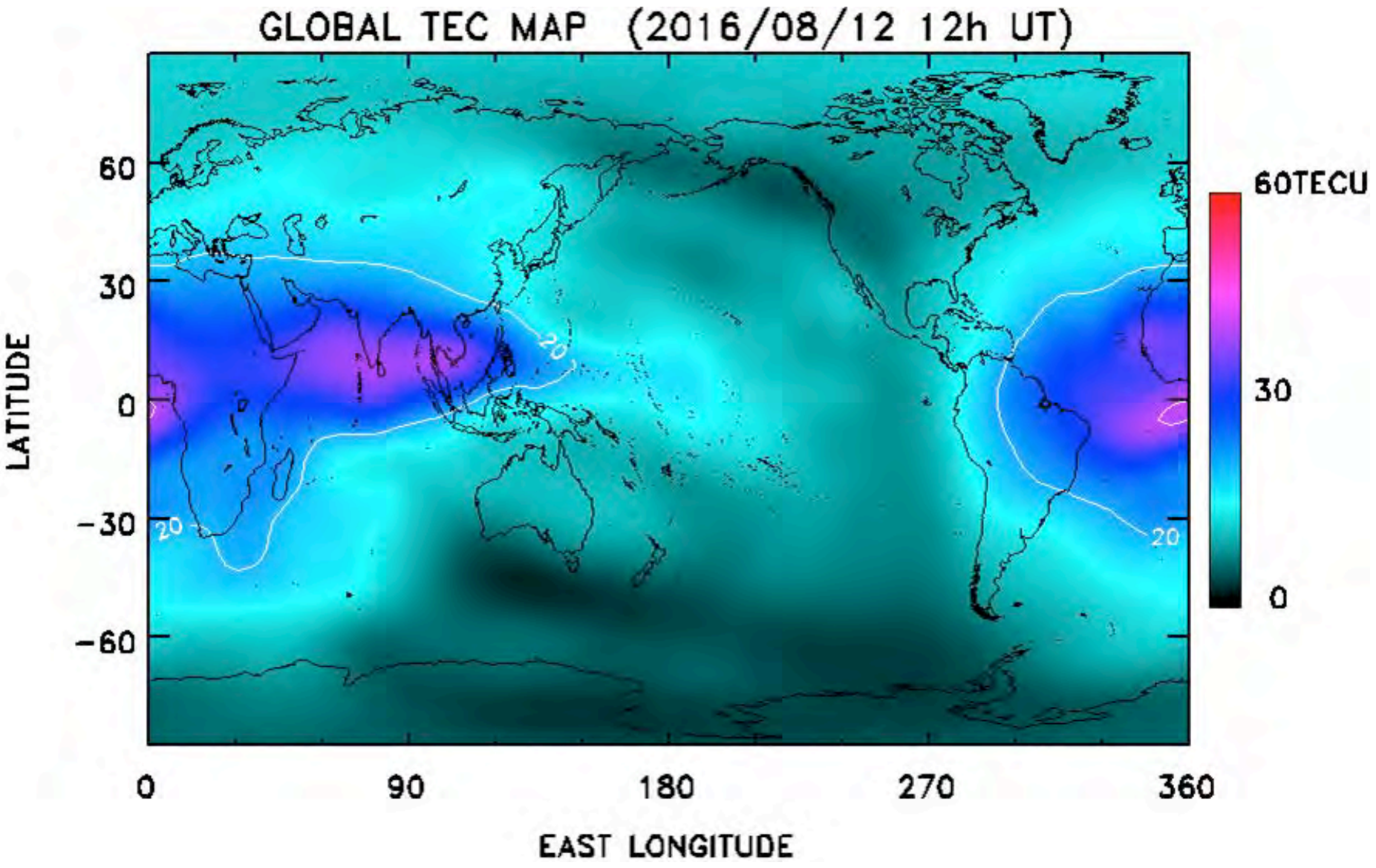
Reference scan has a flat phase
Next we will apply this reference to other scans.



if we do not estimate TEC,
A curvature will be remained
because of different TEC effect


CROSS SPECTRUM (AMPLITUDE)
hobart – kashima
SOURCE: 1958−179 PRT 2016/225 11:57:30 Integ(sec)= 298.00
AMPLITUDE
10^{-4}
10^{-5}
10^{-6}
4
6
8
10
FREQUENCY (GHz)


CROSS SPECTRUM (PHASE)
hobart – kashima
SOURCE: 1958−179 PRT 2016/225 11:57:30 Integ(sec)= 298.00
PHASE (deg)
180
90
0
−90
−180
4
6
8
10
FREQUENCY (GHz)


GLOBAL TEC MAP (2016/08/12 12h UT)
60
30
0
-30
-60
LATITUDE
0
90
180
270
360
EAST LONGITUDE
20
20
20
60TECU
30
0

Source	PRT on 2016/225	TECU(VLBI)	TECU(GPS) slant	Note
1937+21	11:10:00	0	0	As a Delay Calibrator
1908-201	11:27:30	-3.11	-7.85	
1958-179	11:57:30	-4.68	-10.36	

The make sense