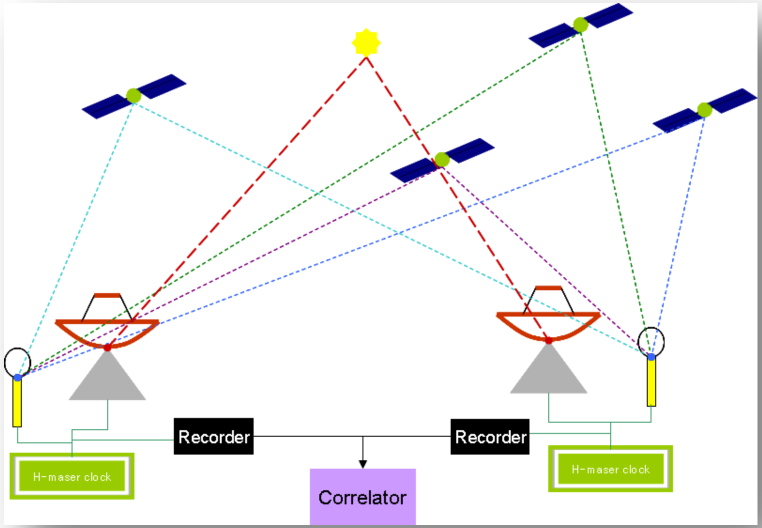
VALIDATION EXPERIMENT OF THE GPS-VLBI HYBRID SYSTEM



Kwak, Younghee[1]

Tetsuro Kondo[2], Tadahiro Gotoh[2], Jun Amagai[2], Hiroshi Takiguchi[2], Mamoru Sekido[2], Ryuichi Ichikawa[2], Tetsuo Sasao[4], Junghe Cho[1], Tuhwan Kim[3]

[1]*Korea Astronomy and Space Science Institute*
[2]*National Institute of Information and Communications Technology*
[3]*Ajou University*
[4]*Yaeyama Star Club*

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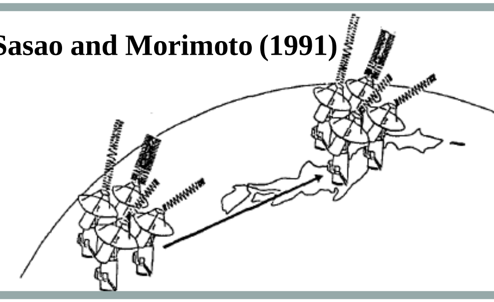
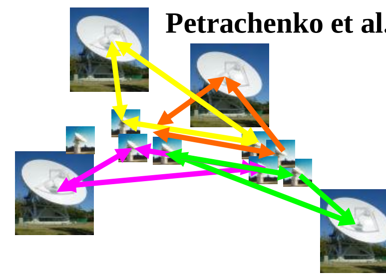
Motivation

Multiple Antennas or Beams

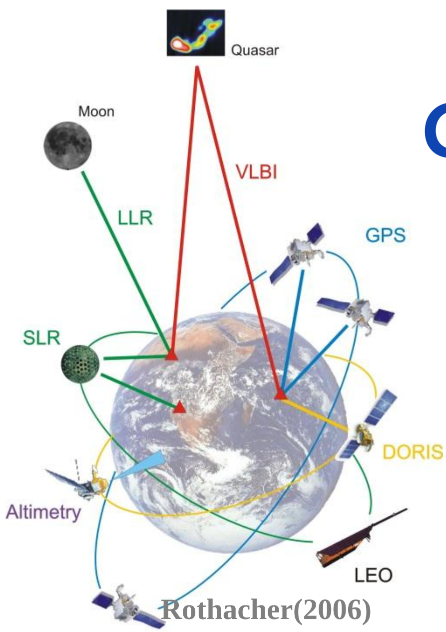

Sasao and Morimoto (1991)

+


Petrachenko et al.,(2002)

Hase et al.(2009)

Combination of Space Geodetic techniques



Rothacher(2006)

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Parameters determined by space geodetic techniques

Techniques	ICRF	EOP				ITRF	Center of Earth mass
		Nutation	Polar motion	UT1	LOD		
VLBI	O	O	O	O	O	O	
GNSS			O		O	O	O
SLR			O		O	O	O
DORIS			O		O	O	O

ITRF : International Terrestrial Reference Frame

ICRF : International Celestial Reference Frame

EOP : Earth Orientation Parameters

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How can we combine space geodetic techniques effectively?

Approach in terms of
observation level combination

Ideal partner of VLBI

- Radio wave for co-observation with VLBI
- Many sources and various direction

(multi-beam) at one time

- Cheaper than others and easier to install (commercial product)

Global Positioning System

➔Combination of VLBI and GPS

Enabling technology

that made GPS-VLBI Hybrid system realizable

- Development of Digital Processing technique
  - High speed VLBI Sampler e.g. VSSP32
  - Large data volume of recording system
  - S/W correlator with high performance processor e.g. K5 correlator

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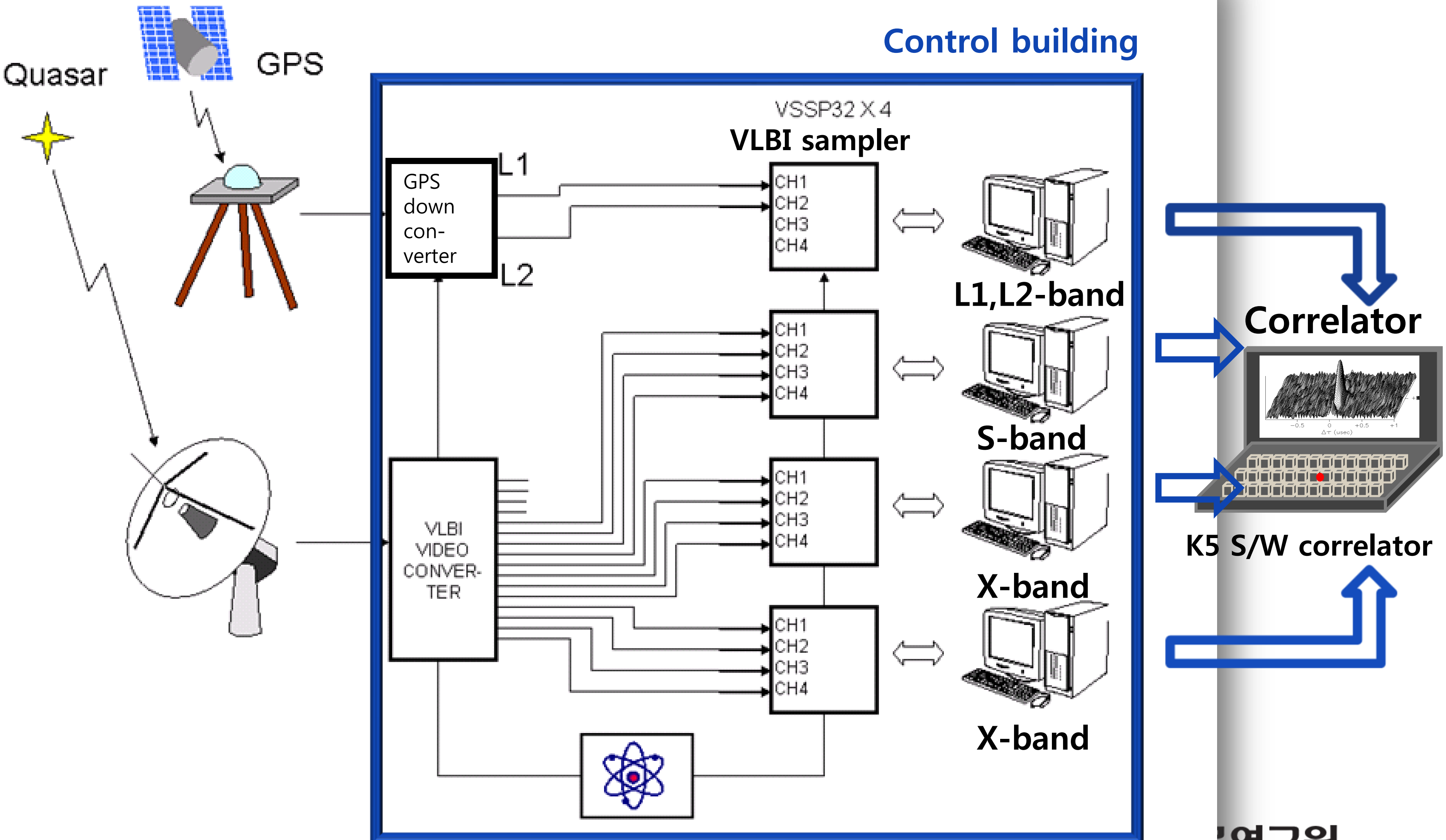
GPS-VLBI hybrid system

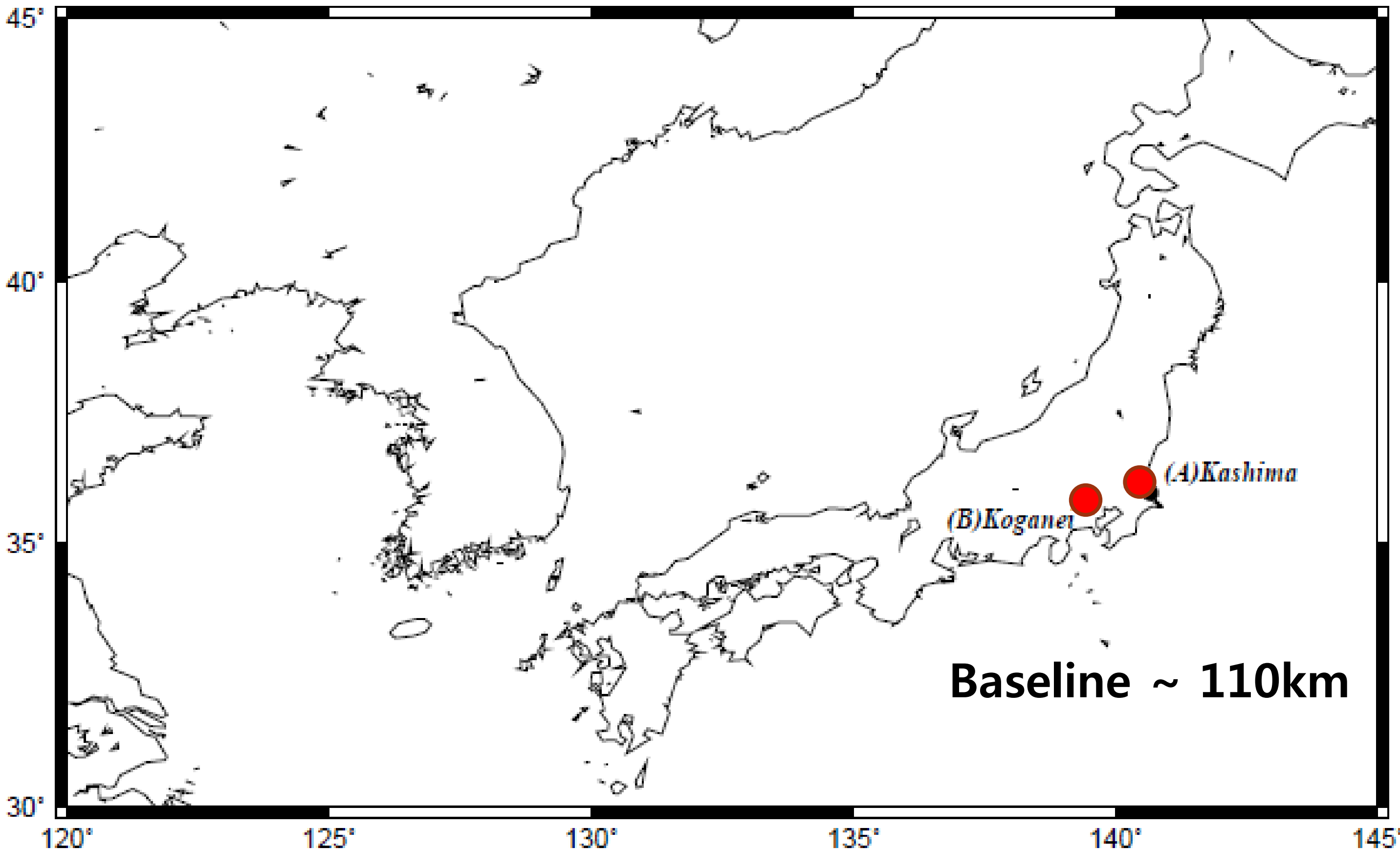


Revised from T. Kondo's diagram

ce Science Institute

24-hour GV Hybrid Observation

- On 25th – 26th Dec. 2009



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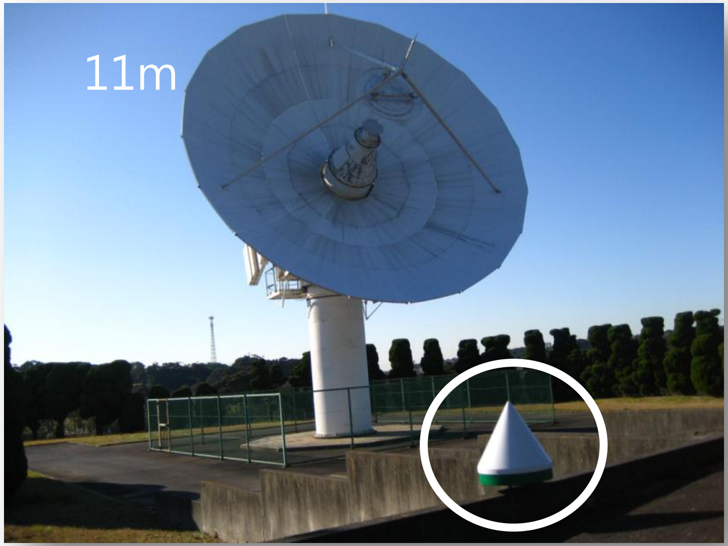
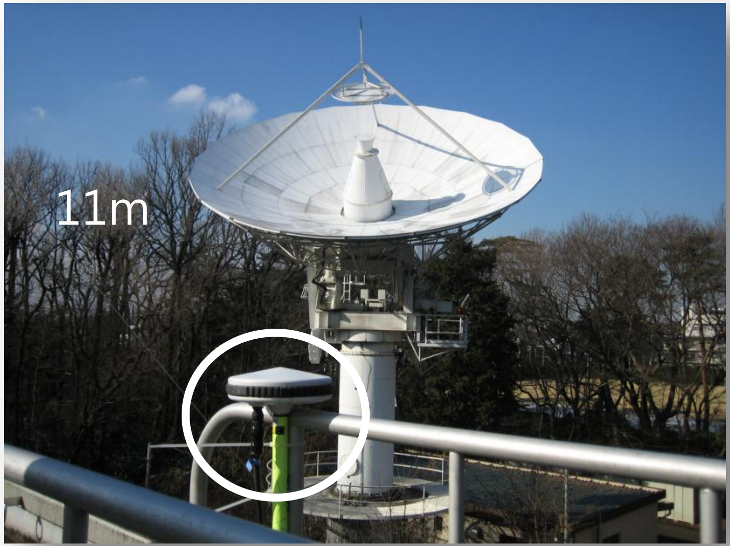
Antennas for the 24-hour experiment with GV Hybrid System

Kashima



Koganei



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GPS-VLBI Hybrid Observation

- VLBI

  Normal VLBI 24hr session

- GPS

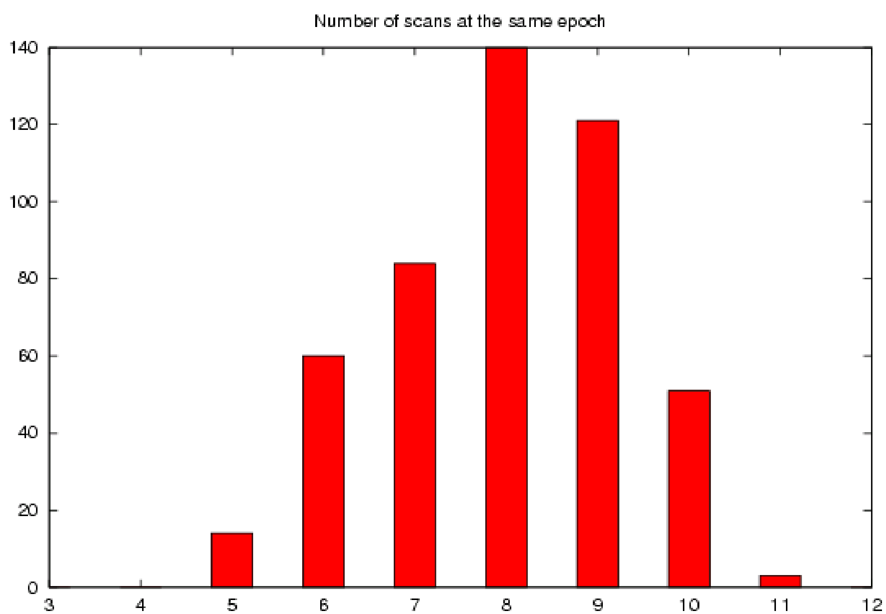
  To reduce GPS data volume to 1/3

  1min. on + 2 min. off GPS 24hr session

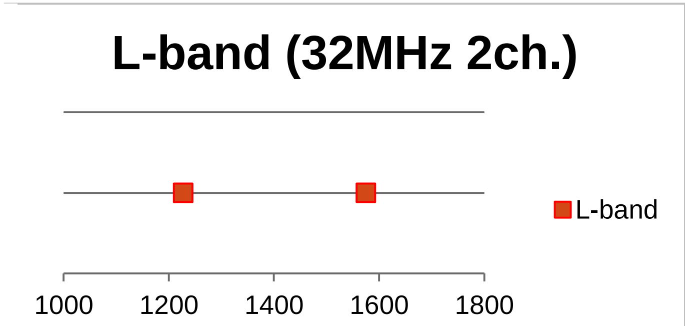
Correlation Processing

Freq. band	S	X	L1	L2
# of channels	4	8	1	1
Bandwidth synthesis	**O**	**O**	**X**	**X**
Integration time	Scan duration	Scan duration	60s	60s
# of targets at one scan	**1**	**1**	**5~11**	**5~11**

Number of scans



Number of simultaneously observed GPS satellites



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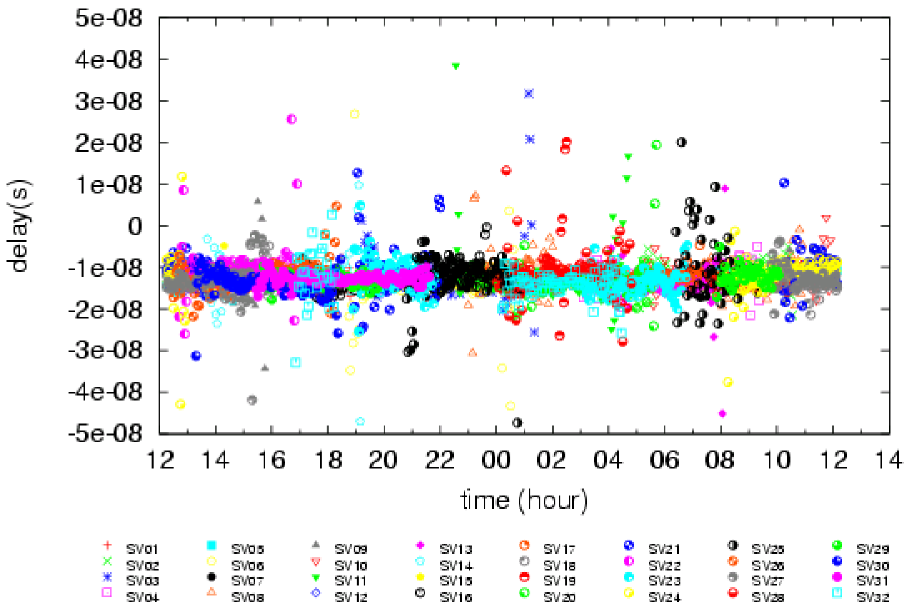
Results

GPS Group delay

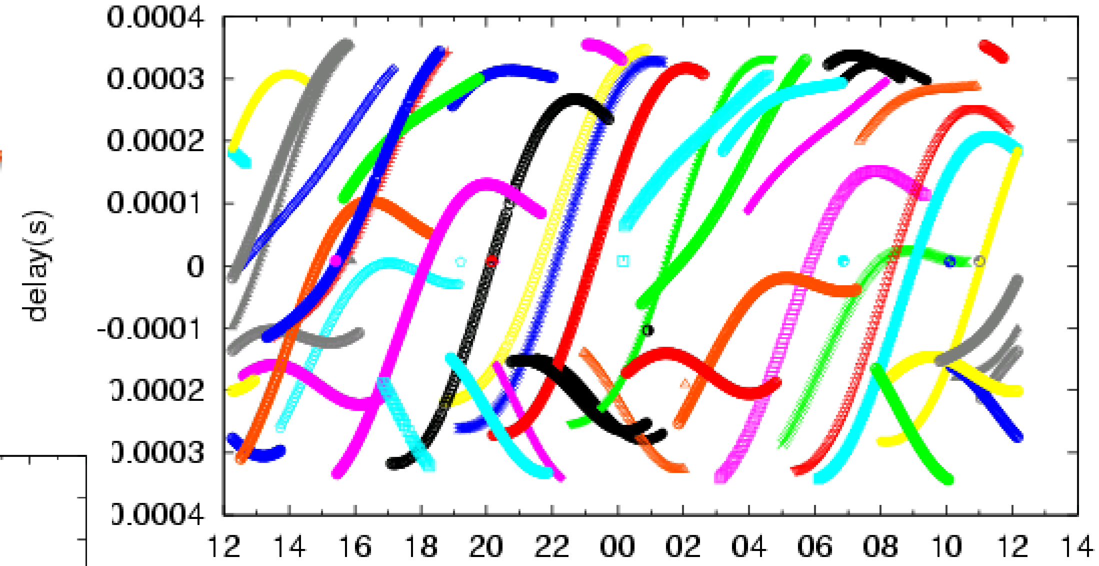
Results :

GPS L1-band

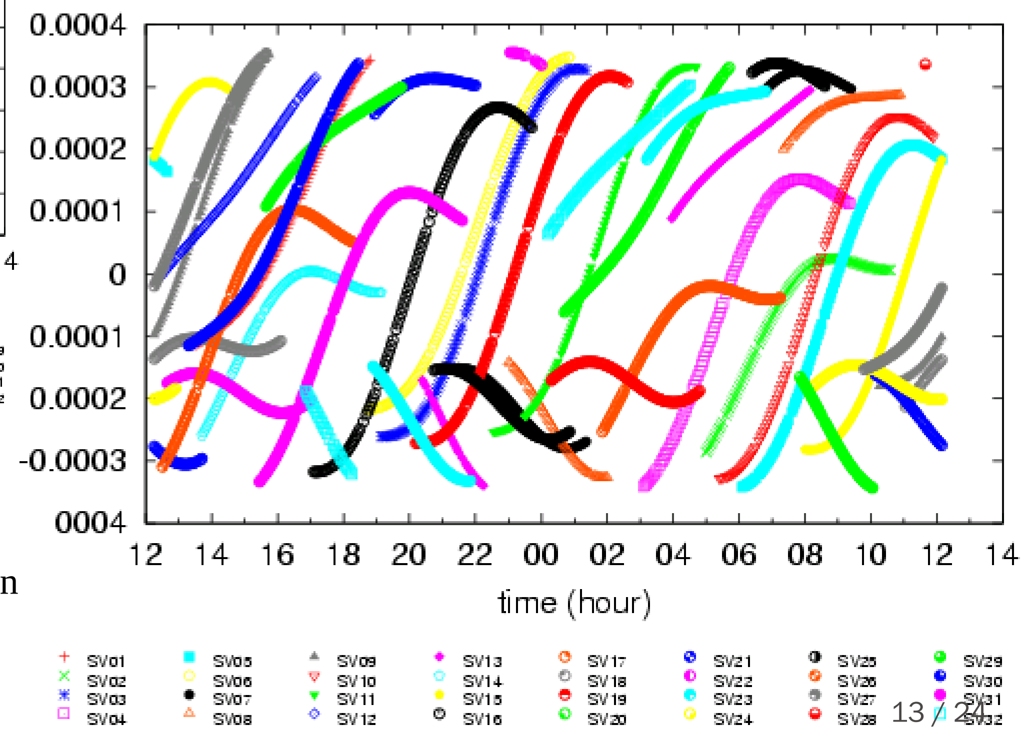
Observed L1 delay - VIRGO calculated delay



Observed L1 delay



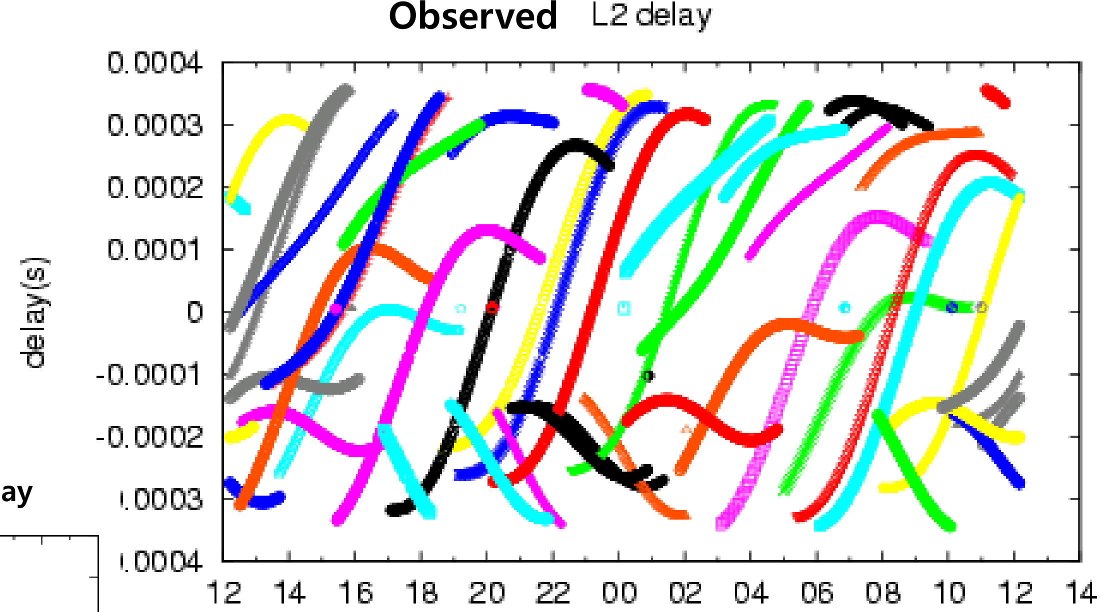
VIRGO calculated delay

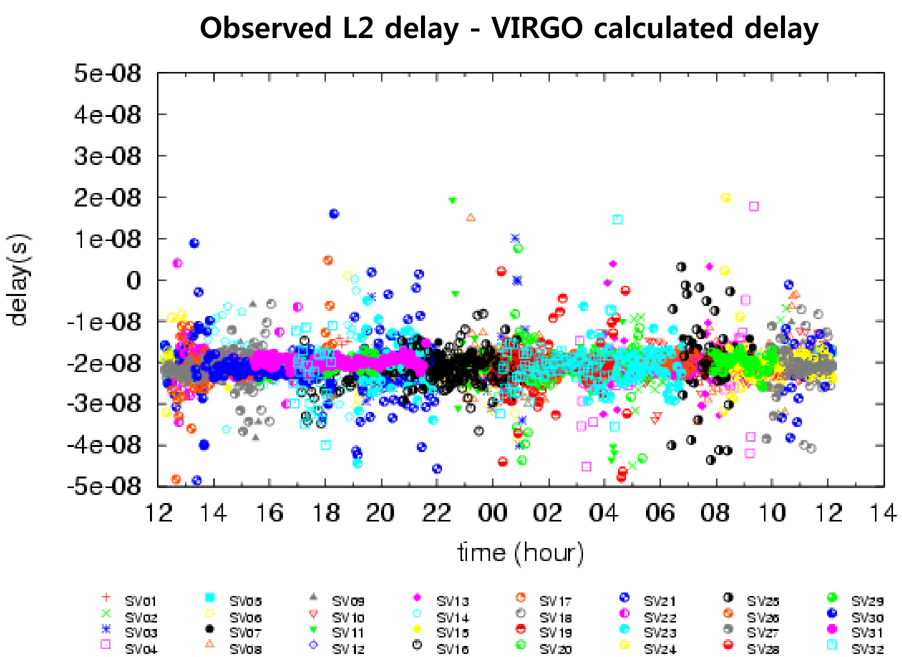


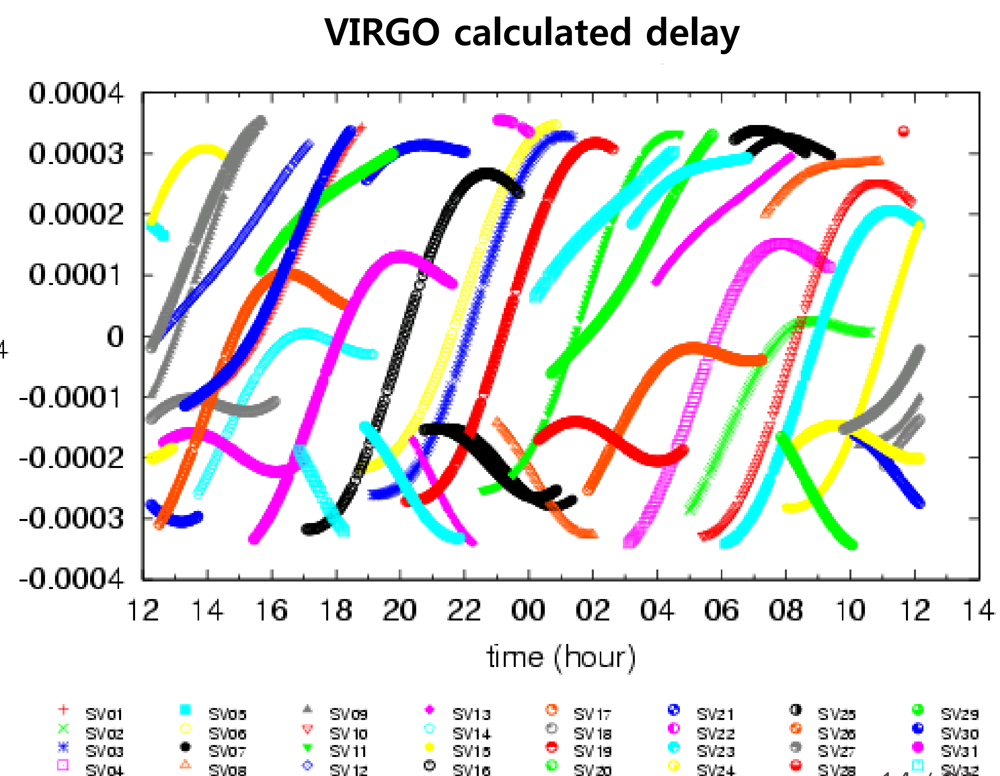
VIRGO : Analysis software for
VLBI-GPS **I**nterconnected **R**adio **G**eodetic **O**bservation

Results :

GPS L2-band

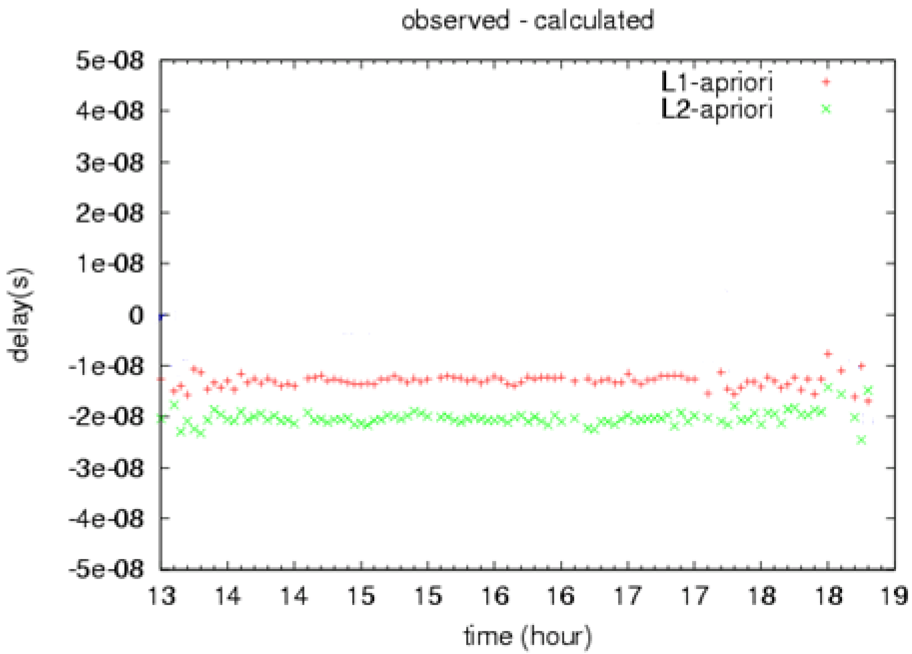






Results : Difference in L1 and L2 cables

e.g. SV01



- ✓ Difference in L1 and L2 cables

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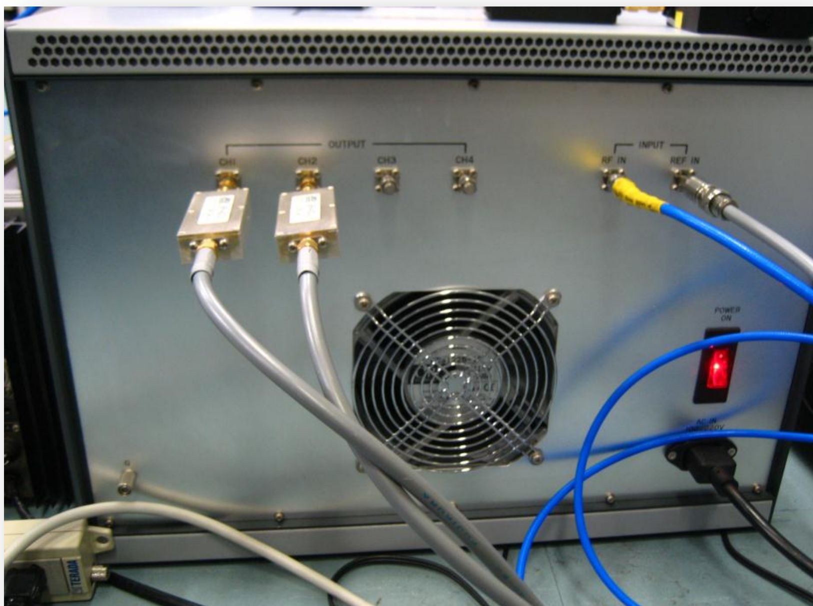
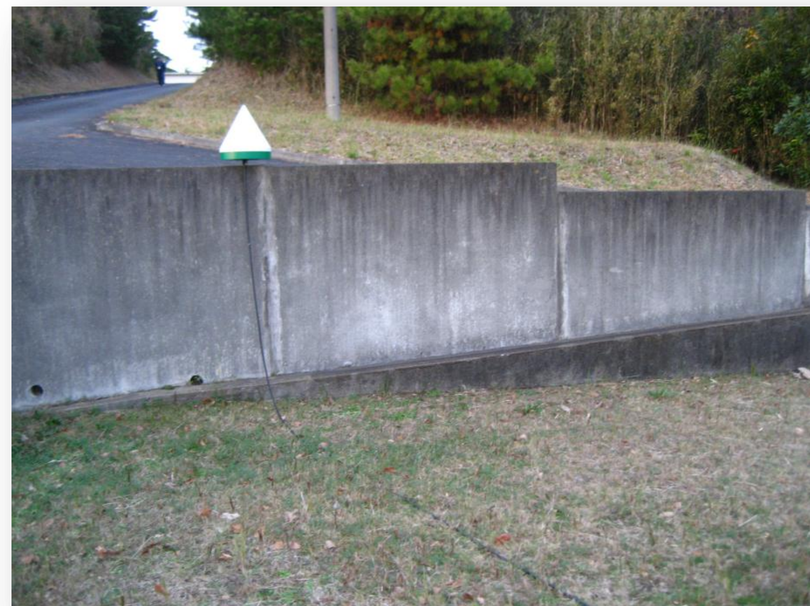
Cables for the experiment with GV Hybrid System

- No phase/cable calibrator for GPS
- GPS cables on the air





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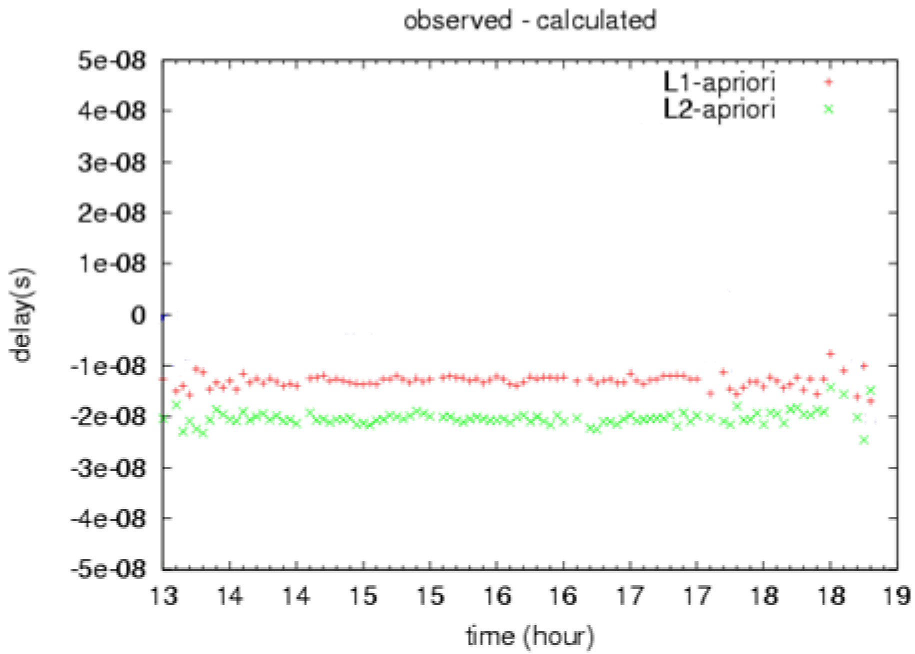
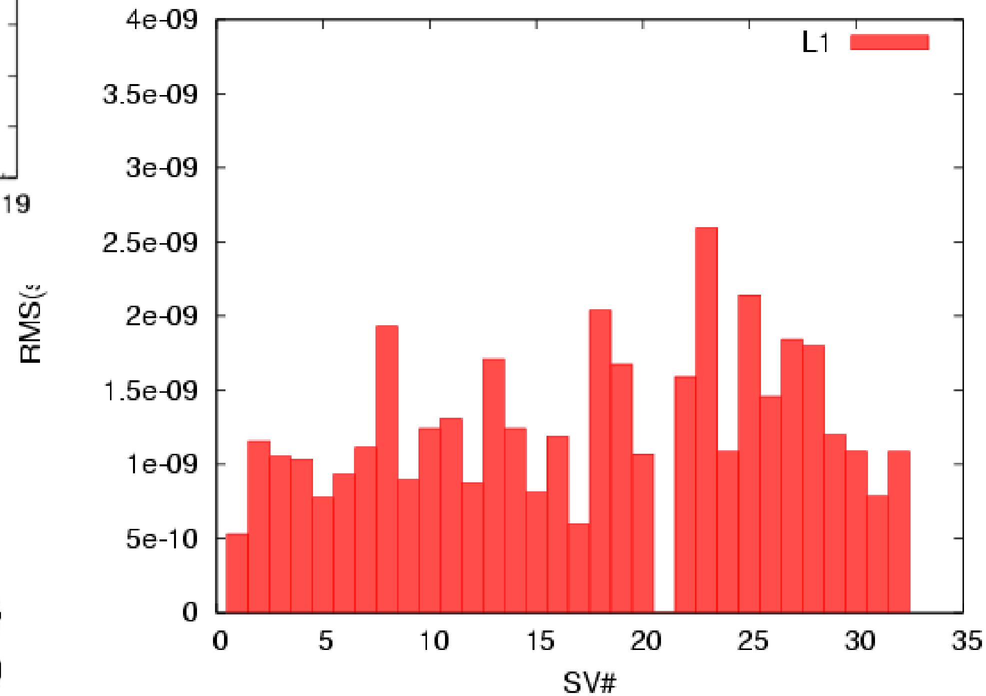
Results : Low cut filtered L1 O-C

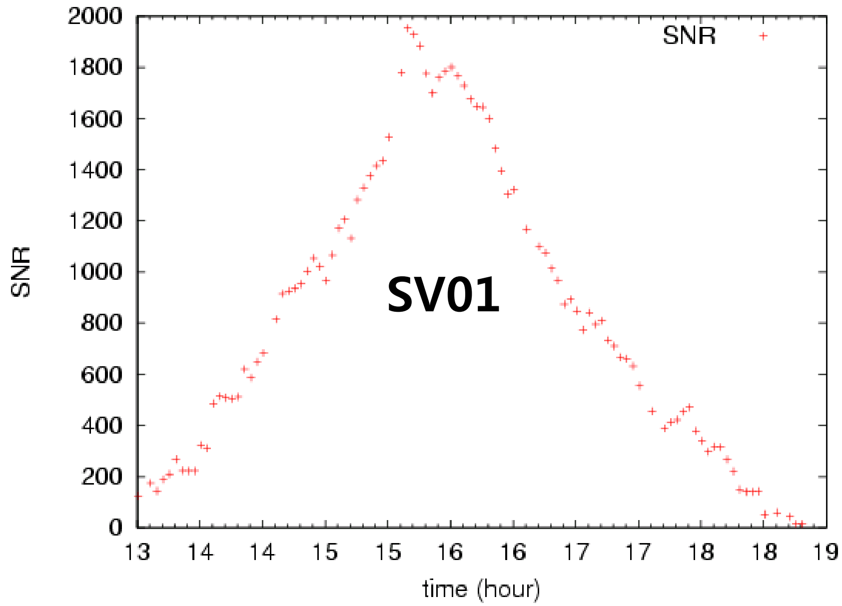
e.g. SV01

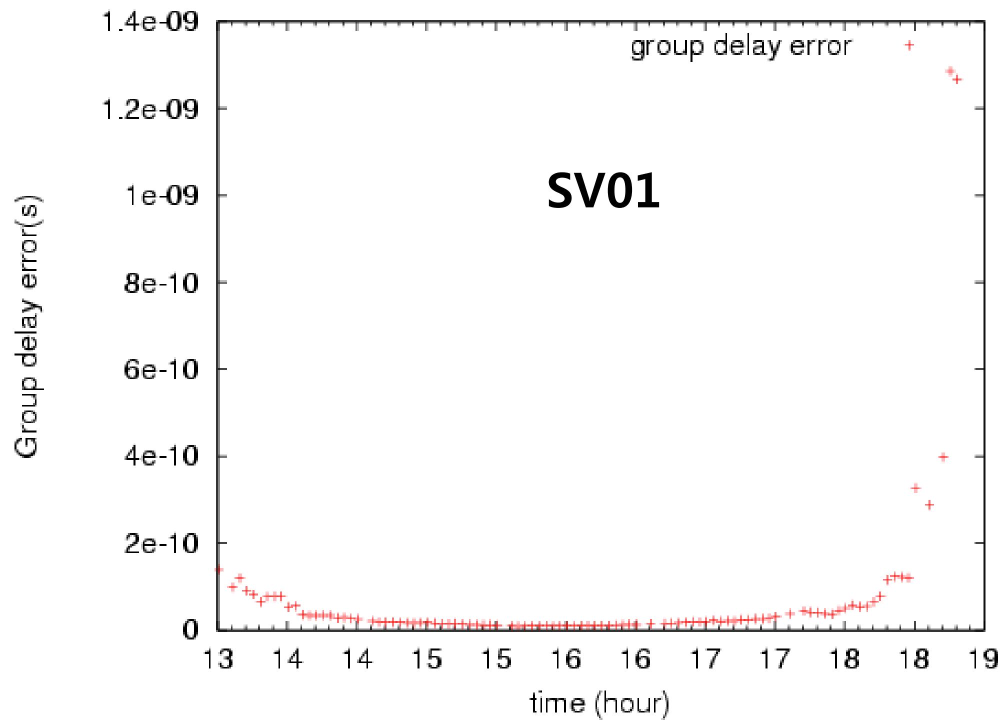




- ✓ Systematic variation

SNR & white noise assumed Group delay error (SV01)





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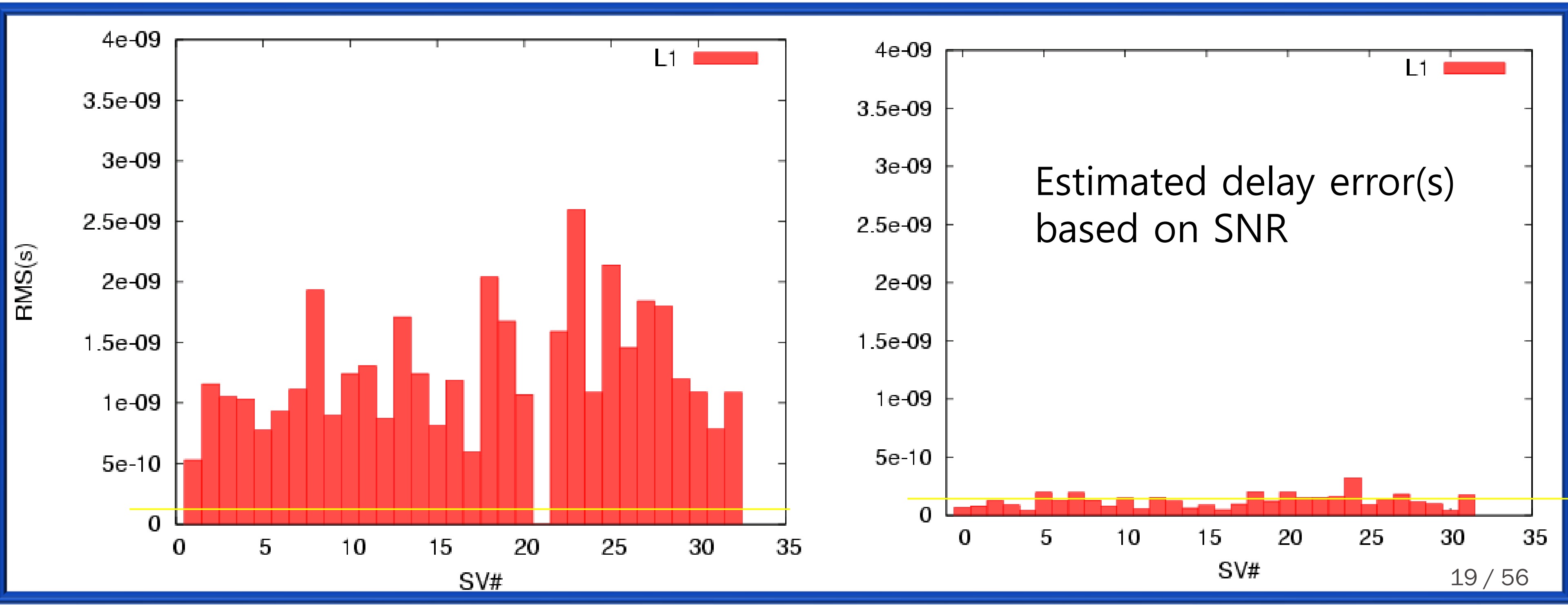
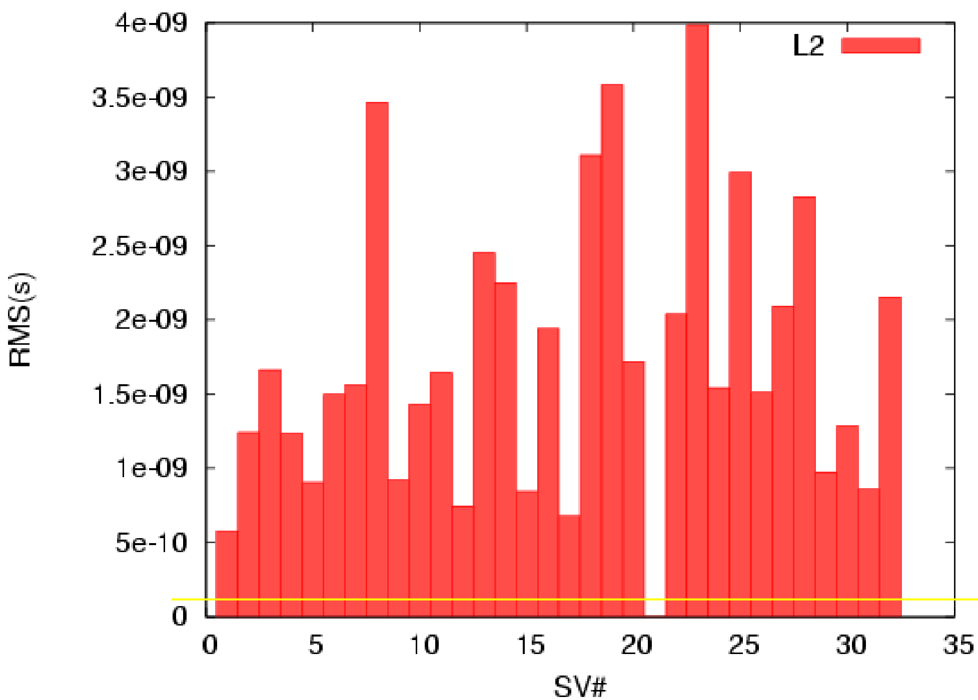
Results : L1

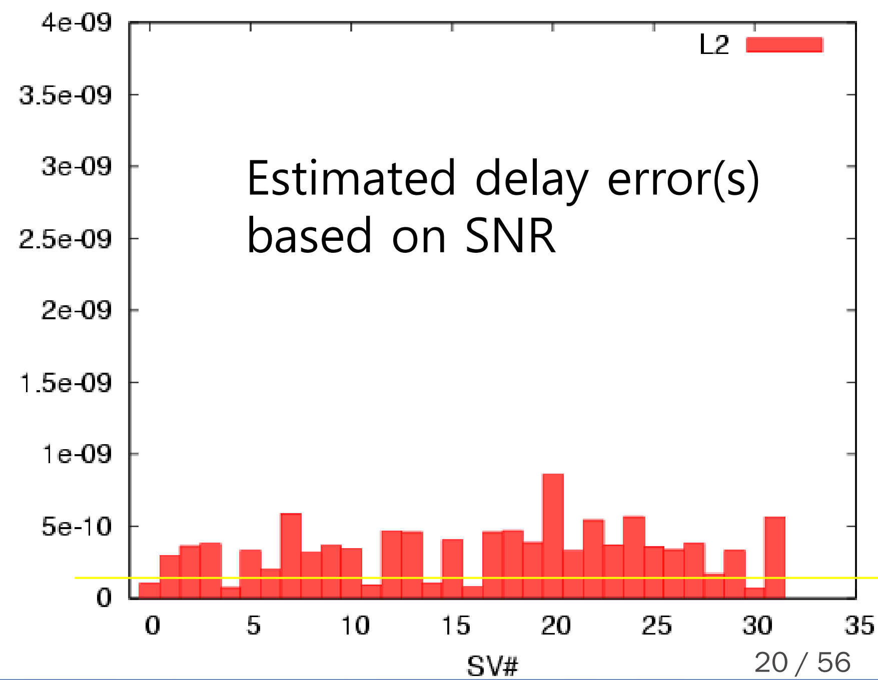
Low cut filtered L1 O-C VS White noise assumed Group delay error(SV01)



Results : L2

Low cut filtered L1 O-C VS White noise assumed Group delay error(SV01)





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Possible Causes of Large Scatters in GPS O-C

Known Things

- A prioris
  - We used IGS broadcast ephemeris in calculating geometric delay
  - Wet delay not included
- Measurements
  - No phase/cable calibrator

Other Things can be considered

✓ Spectral characteristic of GPS signal was not considered in correlation model

✓ Phase center problems were not took into account

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Conclusion

- GPS-VLBI hybrid system was successfully developed and GPS signals were reliably sampled, recorded, and correlated in VLBI system during 24-hour experiment

- Many GPS satellites showed high SNR which would yield 0.1 nsec level of thermal noise error assuming white noise.

- However, actual O-C of GPS group delays show nanosecond level scatter

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Conclusion

We need further investigation in

- ✓ better delay model (use of precise ephemeris)
- ✓ better correlation model (proper account of characteristics of GPS signals such as real spectrum, code nature)
- ✓ consideration of GPS specific problems such as multi-path and phase center
- ✓ better instrumentation (use of phase and delay calibrator, cable duct).

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Future Works

- Baseline analysis
- New down converter unit
- New L5 band added
- Lager network in global scale

Thank you for your attention!!!

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