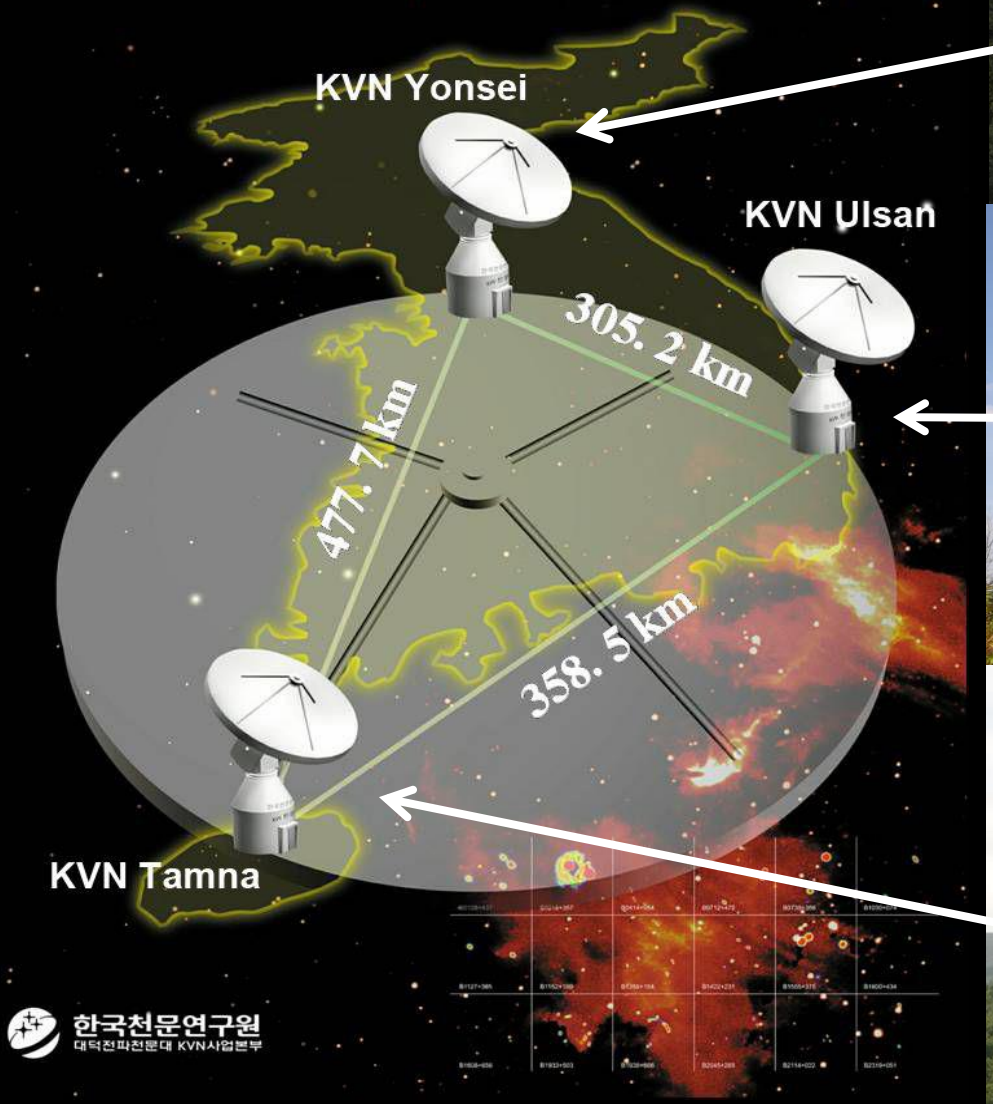
Mm-VLBI phase correction with the KVN and its recent updates

Taehyun Jung (KASI)
on be half of KVN group

3rd International VLBI Technology Workshop @ Groningen , Netherland Nov. 10–13, 2014

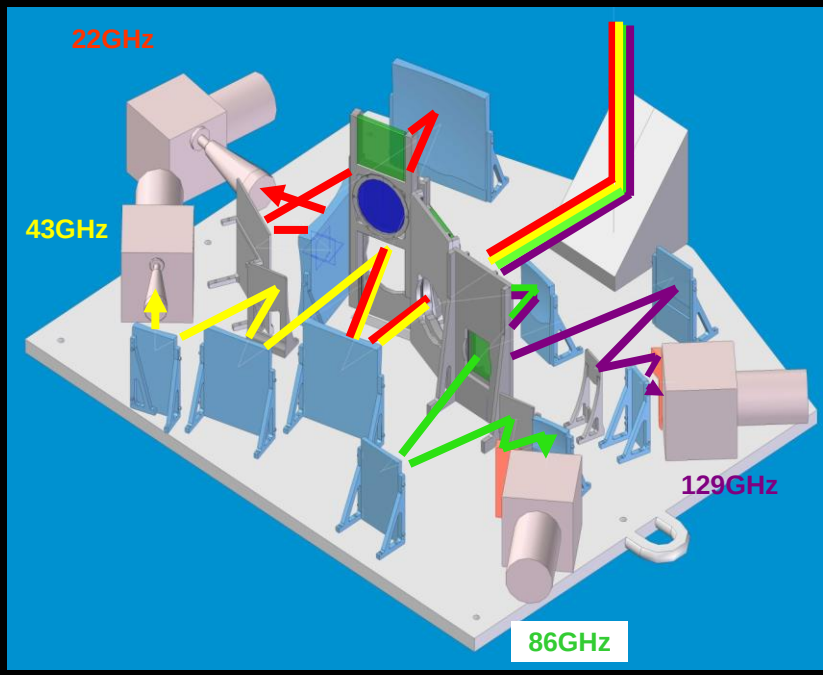
KVN 한국우주전파관측망
Korean VLBI Network



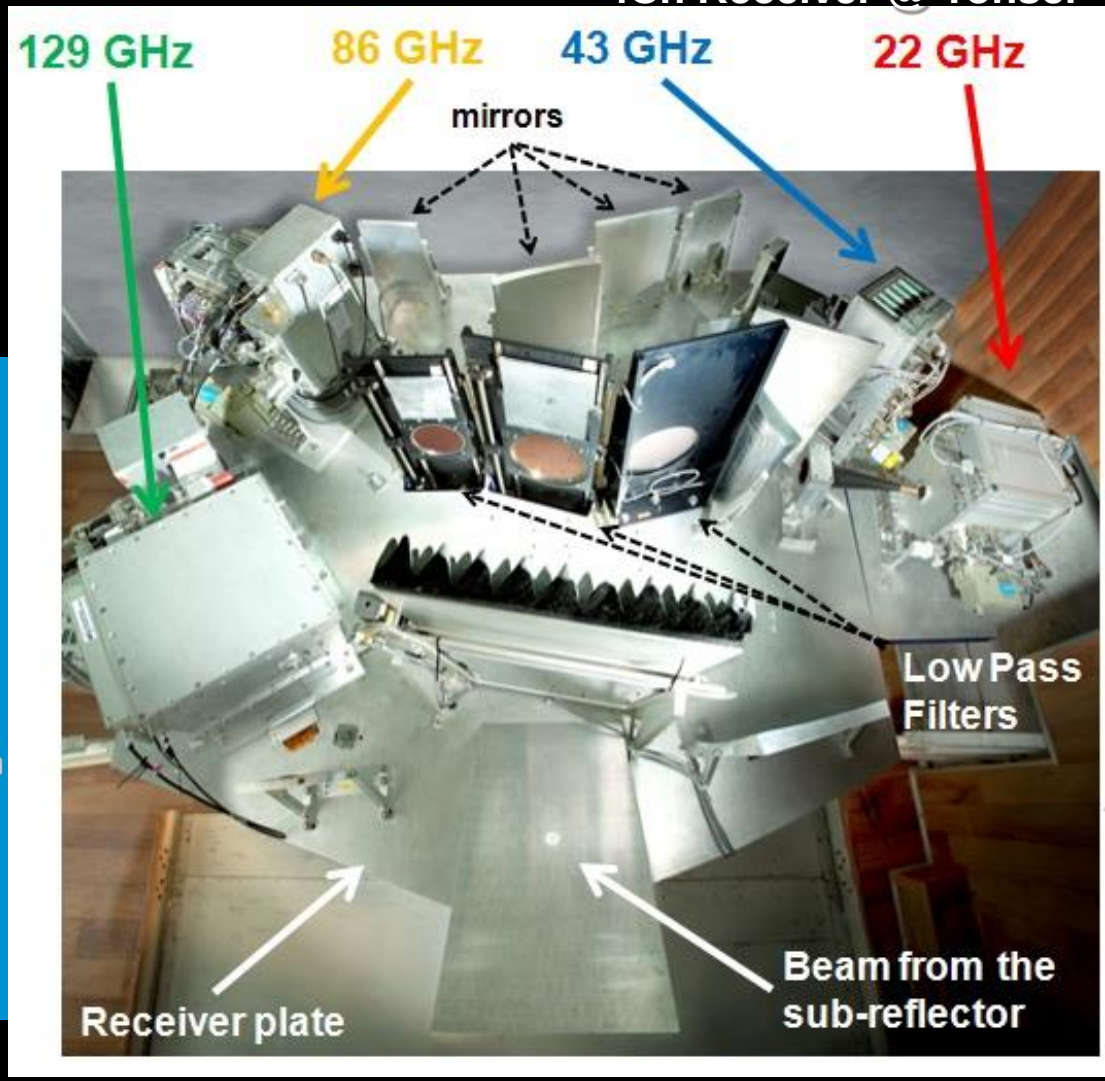
한국천문연구원
대덕전파천문대 KVN사업본부

Multi-Frequency Receiving System

Beams from antenna



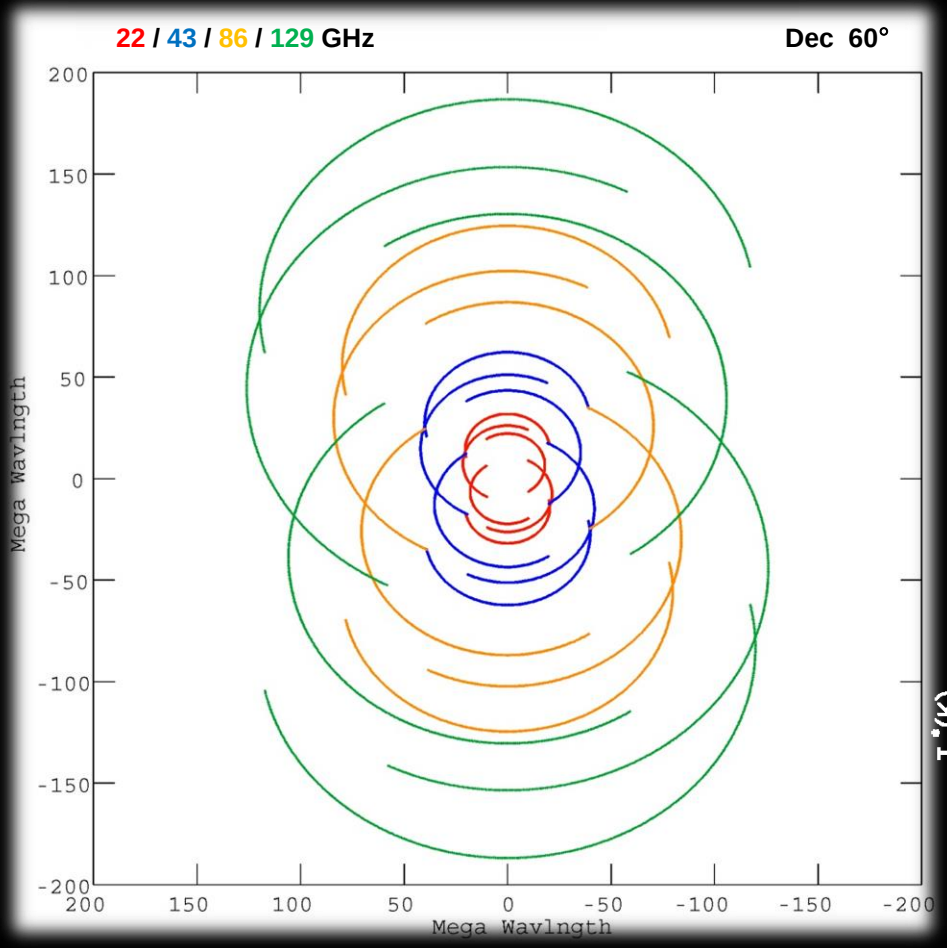
4Ch Receiver @ Yonsei



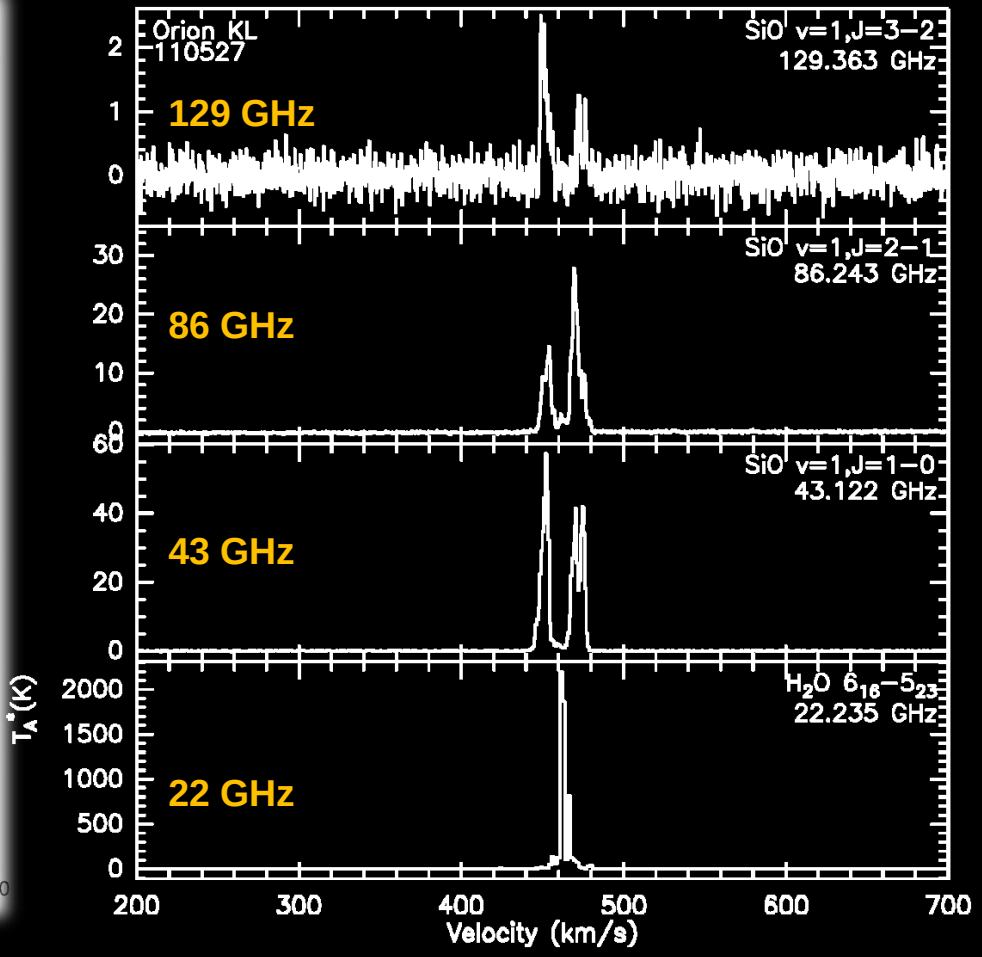
Band	K	Q	W	D
Freq. Range	21.25-23.25	42.11-44.11	85-95	125-142
Trx (K)	30-40	70-80 (40-50 KUS)	80-100	50-80

Han et al. (2008)

First Light from 22/43/86/129 GHz Simultaneous Single Dish Observation

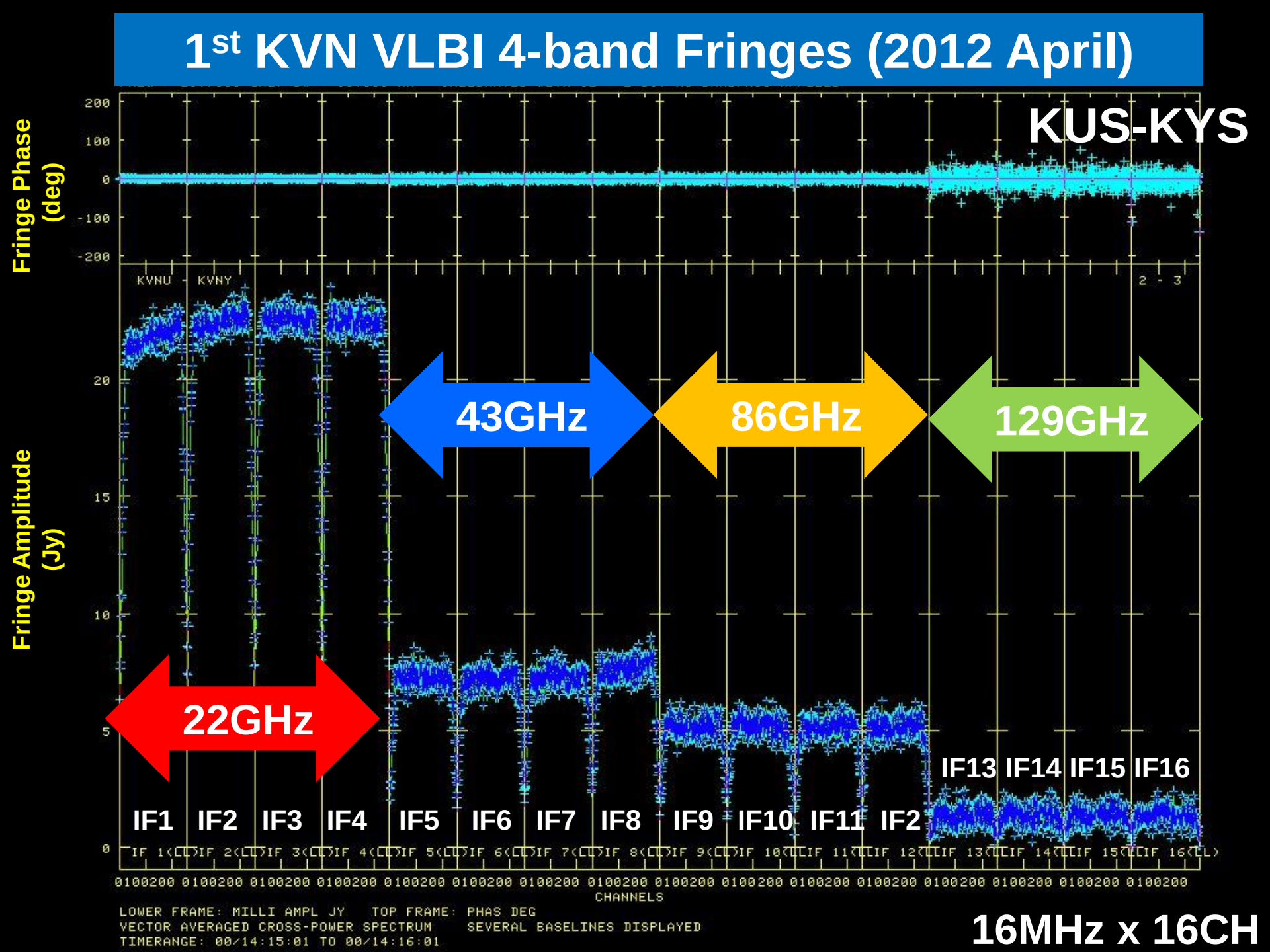


4CH UV Coverage



H20/SiO Masers in Orion KL

1st KVN VLBI 4-band Fringes (2012 April)



Multi-Frequency Phase Referencing (MFPR)

$$\Phi^h = \Phi^h{}_{str} + 2\pi\nu^h(\tau_g + \tau_C + \tau_{inst} + \tau_{trop} + \tau_{ion}) + \Phi^h{}_{LO}$$

$$\Phi^l = \Phi^l{}_{str} + 2\pi\nu^l(\tau_g + \tau_C + \tau_{inst} + \tau_{trop} + \tau_{ion}) + \Phi^l{}_{LO}$$

Self-calibration at lower frequency

$\Phi^l{}_{str}$

$2\pi\nu^l(\tau_g + \tau_C + \tau_{inst} + \tau_{trop} + \tau_{ion}) + \Phi^l{}_{LO}$

$\Delta\Phi = \Phi^h - r\Phi^l$

$r = \nu_h / \nu_l$

slow varying term

$$\Delta\Phi = \Phi_h - \frac{\nu_h}{\nu_l}\Phi_l = \Phi_h{}^{str} + 2\pi\nu_h(\tau_h{}^g - \tau^g{}_l) - 2\pi\left(1 - \frac{\nu_h^2}{\nu_l^2}\right)\frac{\nu_0^2}{\nu_h^2}\tau^{ion} + (\Phi_h{}^{LO} - \frac{\nu_h}{\nu_l}\Phi_l{}^{LO})$$

Source Structure

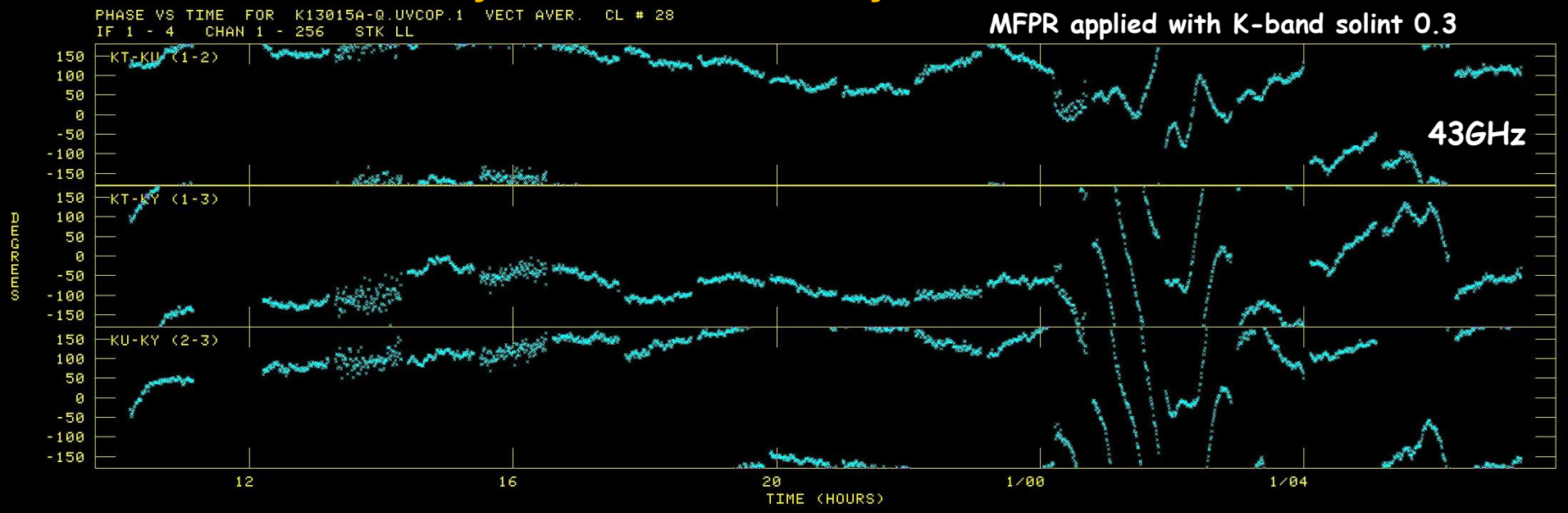
Core-shift diff in maser lines

ionosphere

instrument

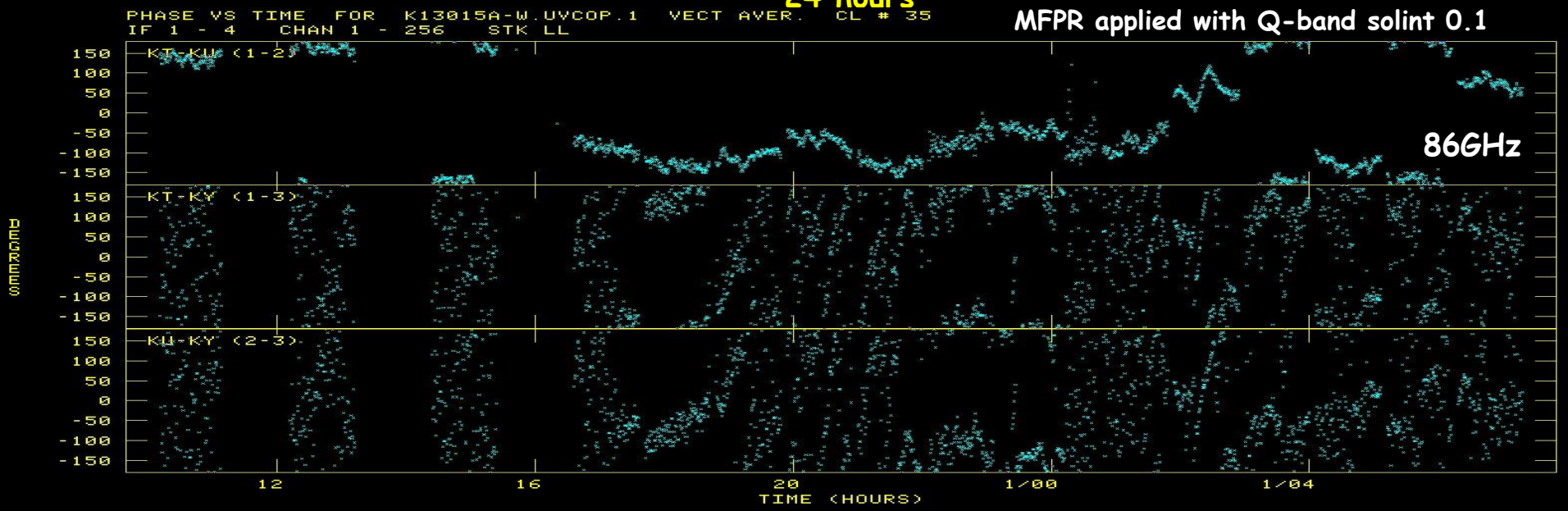
By doing Self-calibration again for longer solution interval, we can get an image at higher frequency

43GHz & 86GHz Visibility Phase referenced by 22GHz

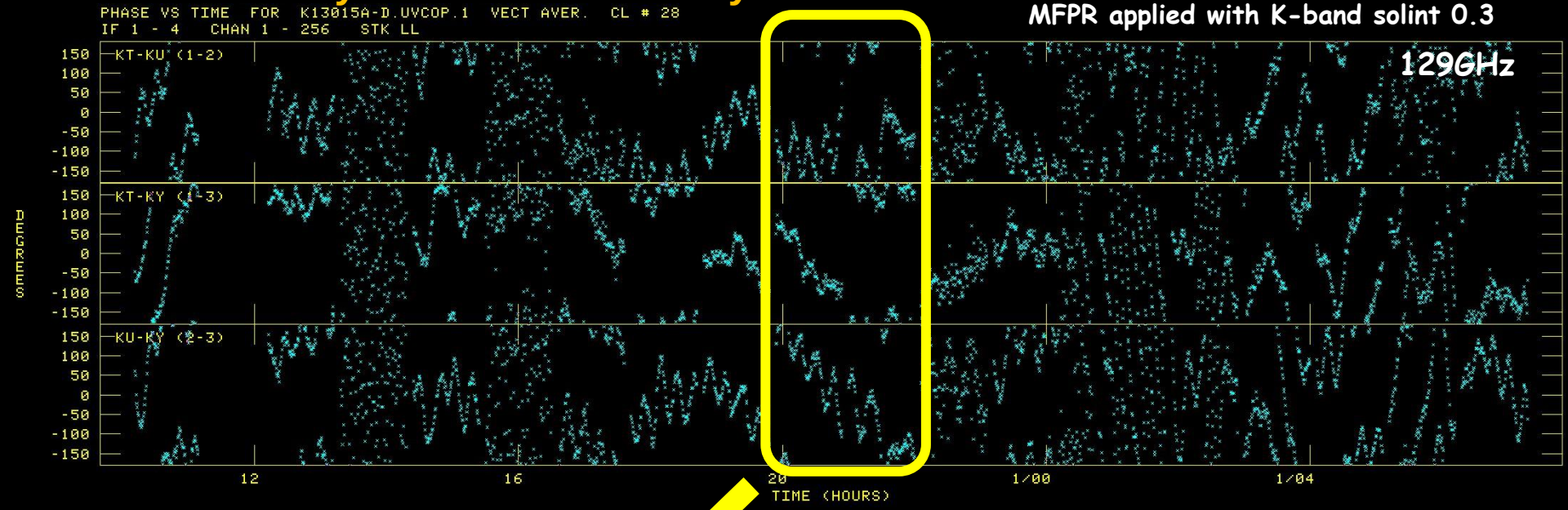


NRAO150 0133+476 3C84 1308+326 3C279 3C345 NRAO530 SGR-A 3C454.3 2255-282
0202+149 1023+131 3C273 1633+382 NRAO512 FAS 1921-293 BLLAC NRAO150

24 hours



129GHz Visibility Phase referenced by 22GHz



MFPR applied with K-band solint 0.3

129GHz

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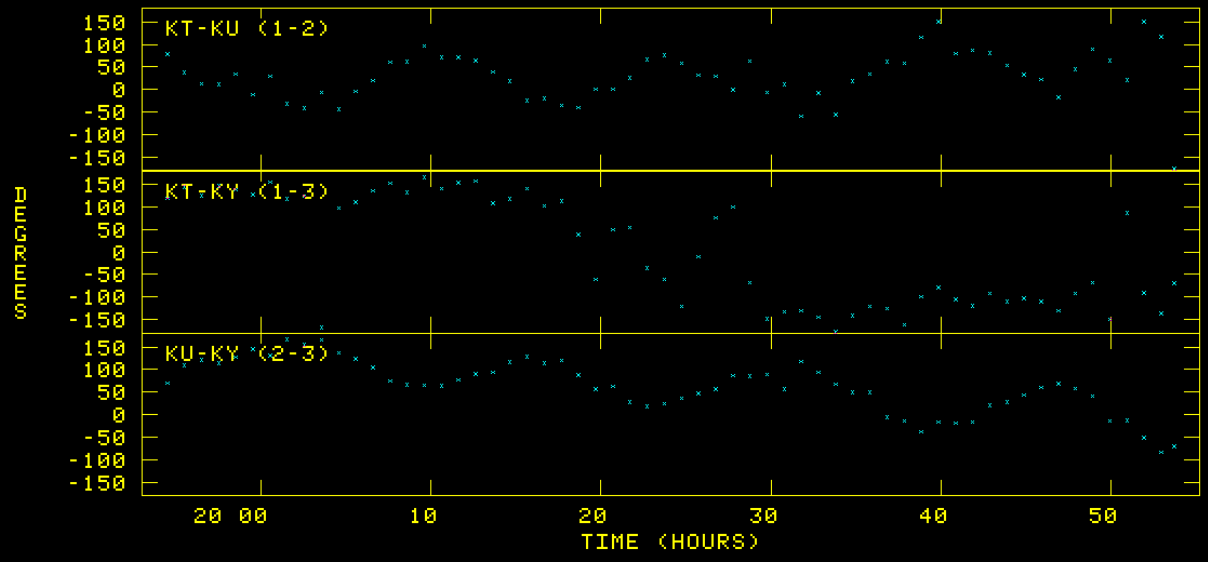
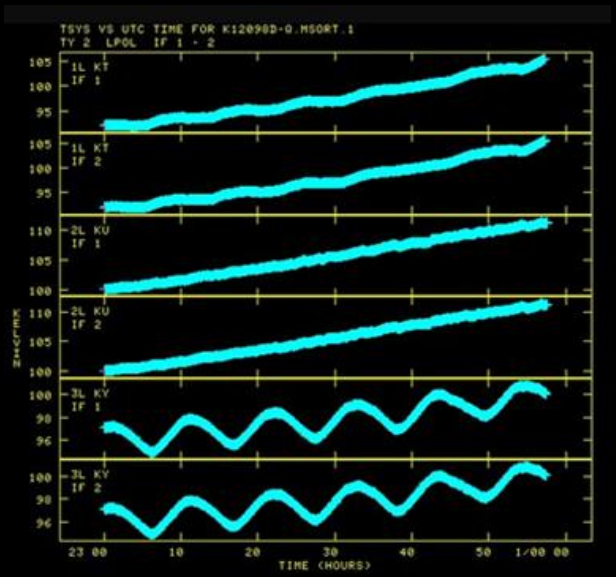
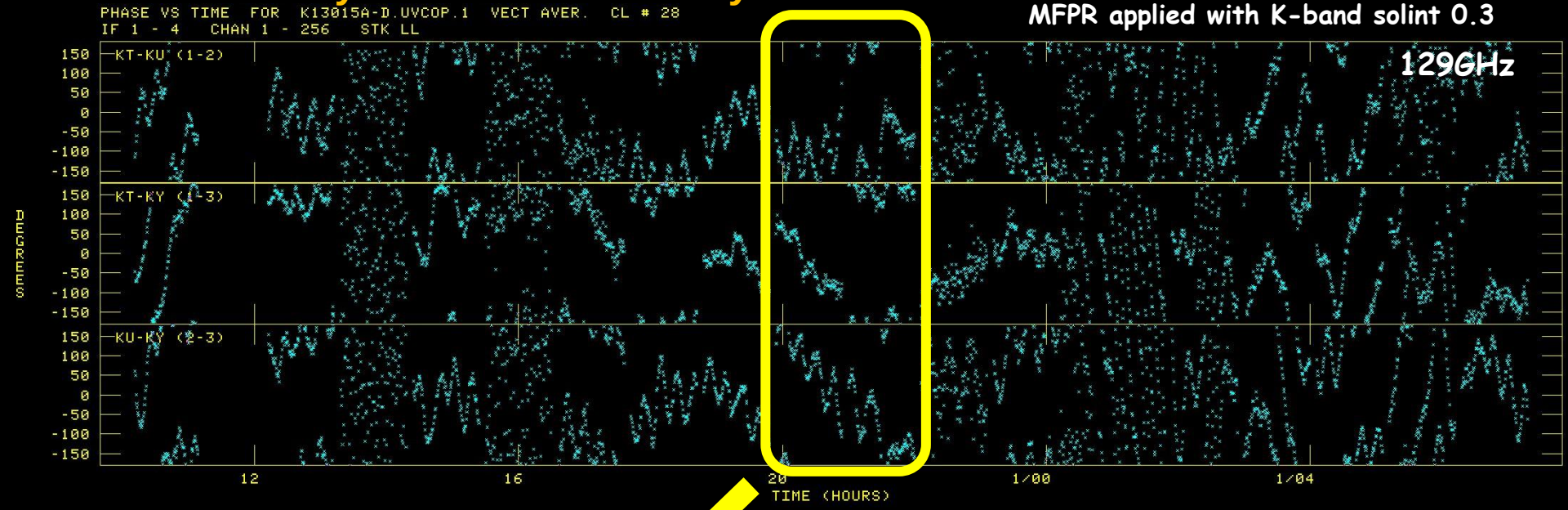




129GHz Visibility Phase referenced by 22GHz



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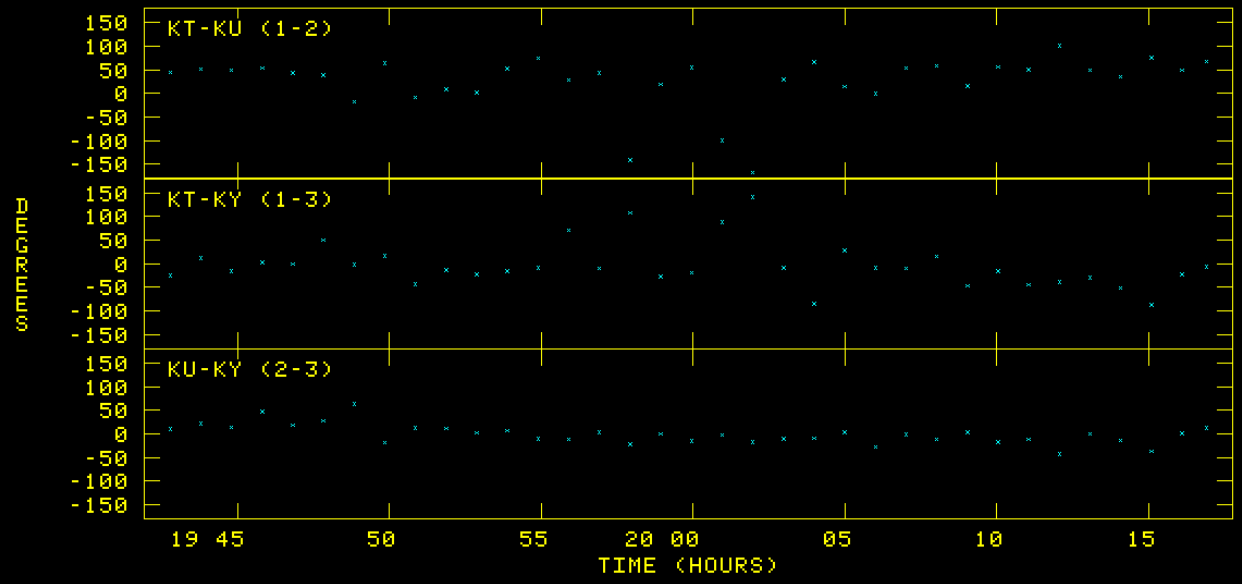
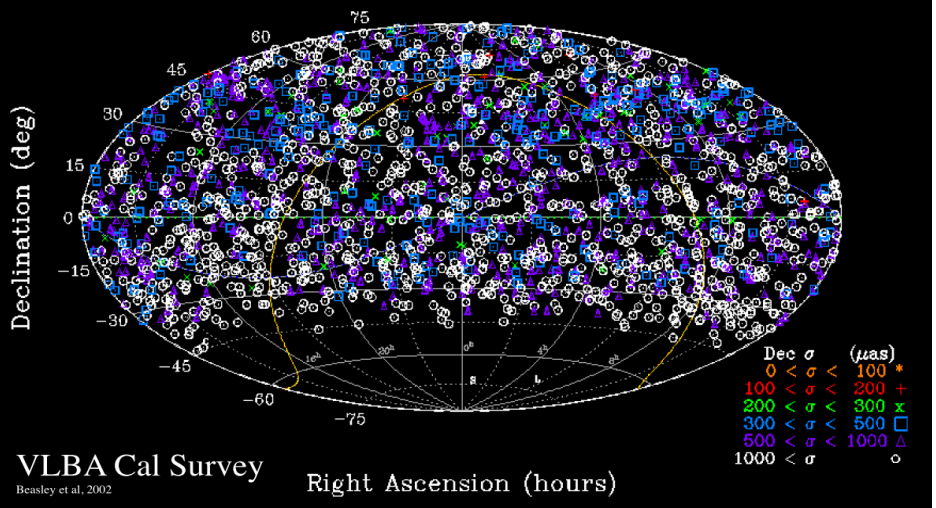
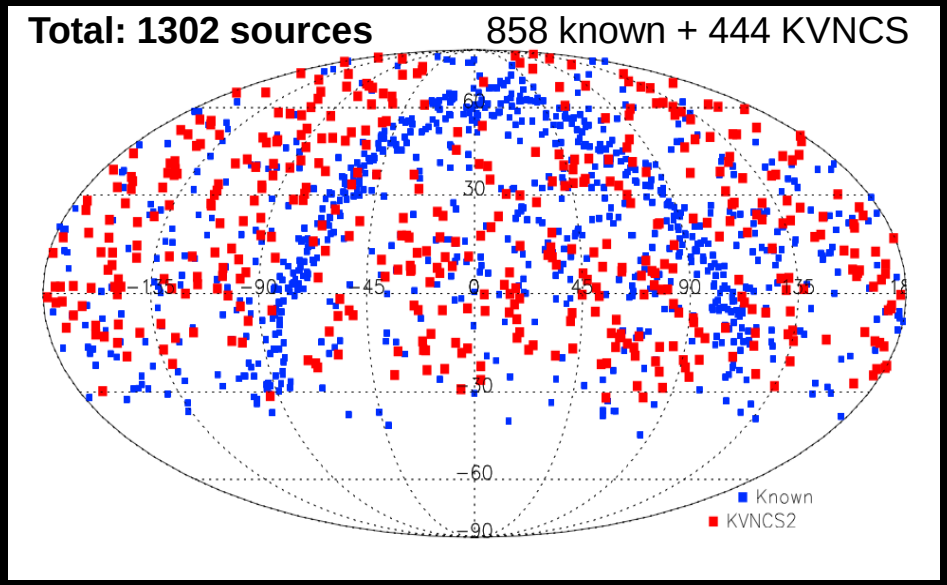


New thermal control system at KVN Yonsei Rx Room

Multifrequency AGN Survey with the KVN

Discovering high-frequency sources & Maximizing the KVN uniqueness



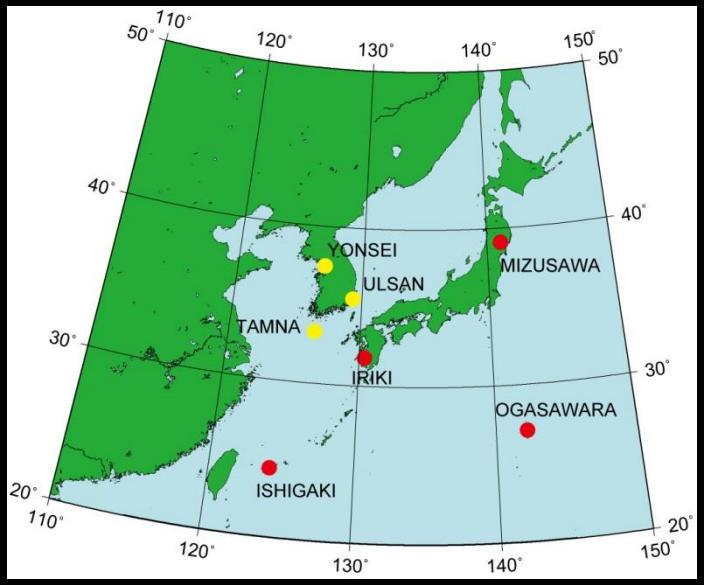


KVN Legacy Program

KVN Activities

High Precision Astrometry

KVN and VERA Array (KaVA)
http://kava.kasi.re.kr



KaVA

Register | login

KVN & VERA Array | Observation | Correlation | Contact | Wiki

Welcome to KaVA

KaVA(KVN and VERA Array) is a combined VLBI array with KVN (Korean VLBI Network) and VERA (VLBI Exploration of Radio Astrometry) operated by Korea Astronomy and Space Science Institute (KASI) and National Astronomical Observatory of Japan (NAOJ), respectively... More

Proposal 2015A

Dear Colleagues,

We invite proposals for the open use observations of the KaVA, a joint array of the KVN (Korean VLBI Network) and the VERA (VLBI exploration of Radio Astrometry). The joint array ...More

Proposal submission 2015A

Upcoming Meetings

- UST-GUAS Radio astronomy winter school : 10-13 Feb 2015, Jeju island, Korea
- 8th East Asia VLBI Workshop : 2015, Taiwan

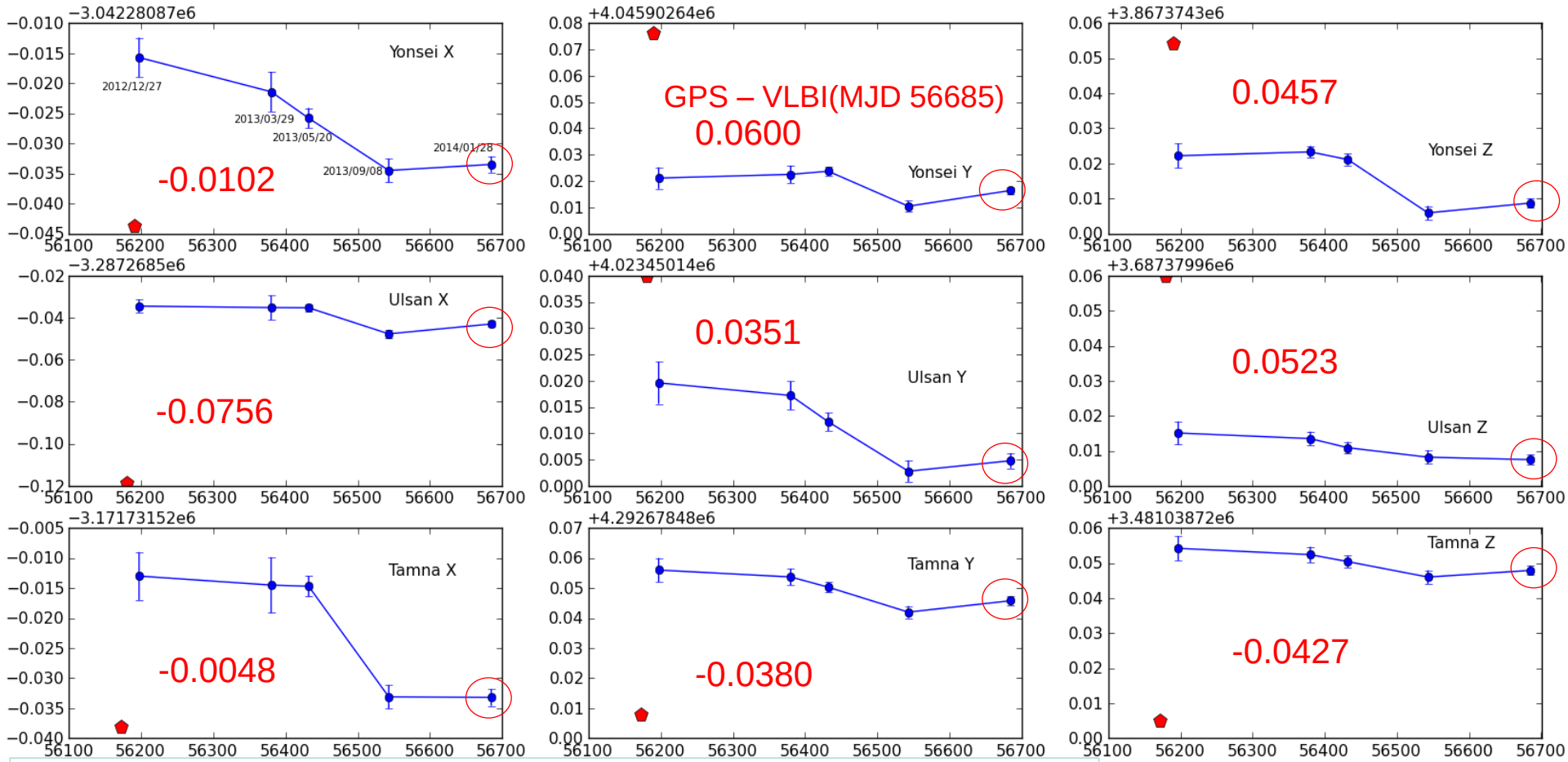
2014 Previous Meetings

- 6th KaVA Joint Science WG meeting : 20-21 Jan 2014, Kagoshima, Japan
- 7th KaVA Joint Science WG meeting : 8-9 July 2014, Yamaghchi, Japan
- 7th East Asia VLBI Workshop : 20 August 2014, Deajeon, Korea (APRIM session)
- Korea-Italy AGN Workshop : 30 Oct 2014, Korea

IVP measurements from K-band Geodesy

Observational Status

- 2011 : r11361k (2011/12/27) ** only KYS solution was obtained*
- 2012 : r12271k (2012/09/27) ** all solutions were obtained * waiting correlation & analysis*
- 2013 : r13088k (2013/03/29), r13140k (2013/05/20), r13251k (2013/09/08), r13313k (2013/11/09)
- 2014 : r14028k (2014/01/28), r14095k (2014/04/05), r14159k (2014/06/08), r14246k (2014/09/03)



Offsets: X: 0.5~7.5 cm, Y: 3.5~6.0 cm, Z: 4.3~5.2 cm

X-axis: MJD Y-axis: Position (m)

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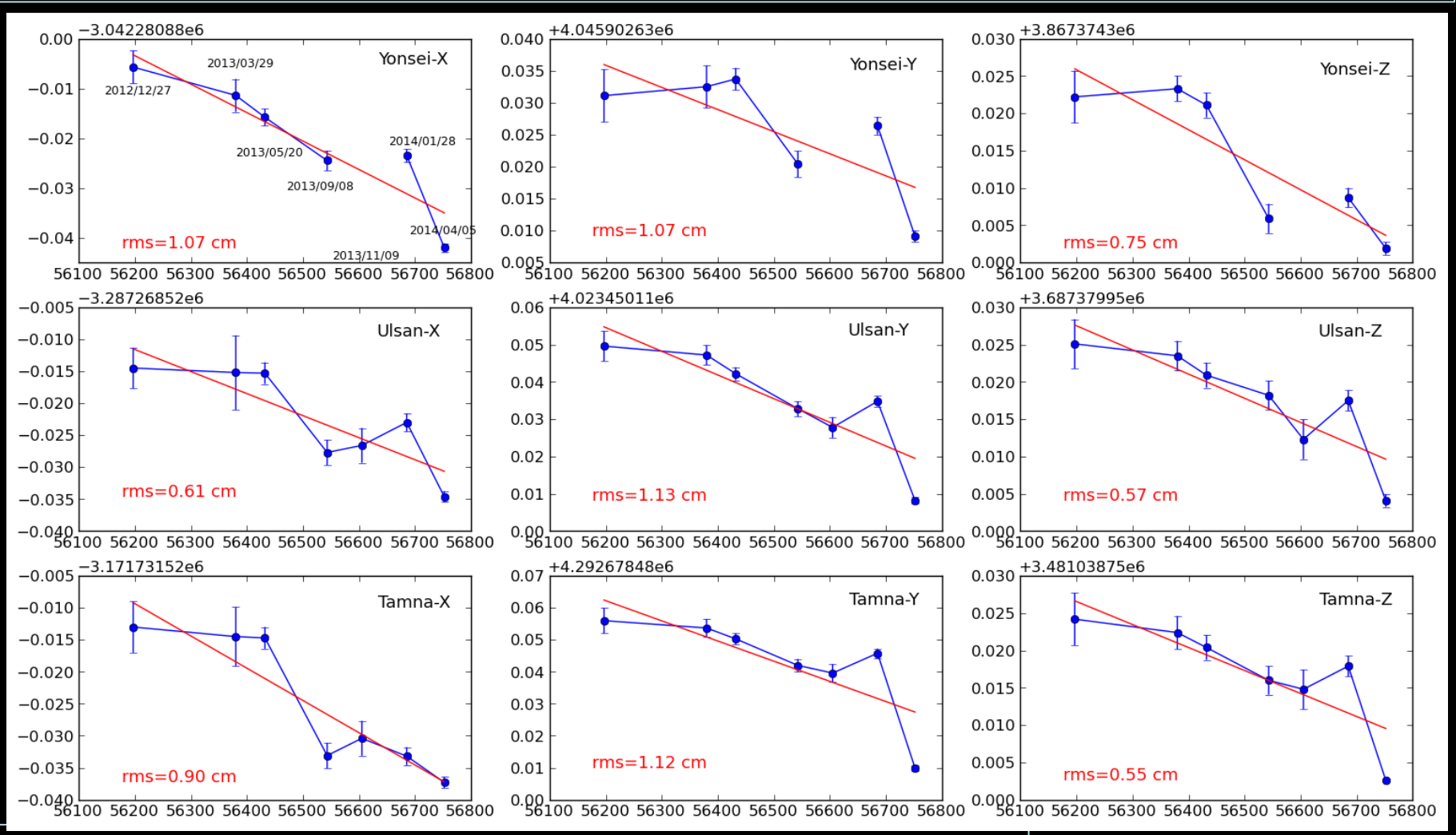
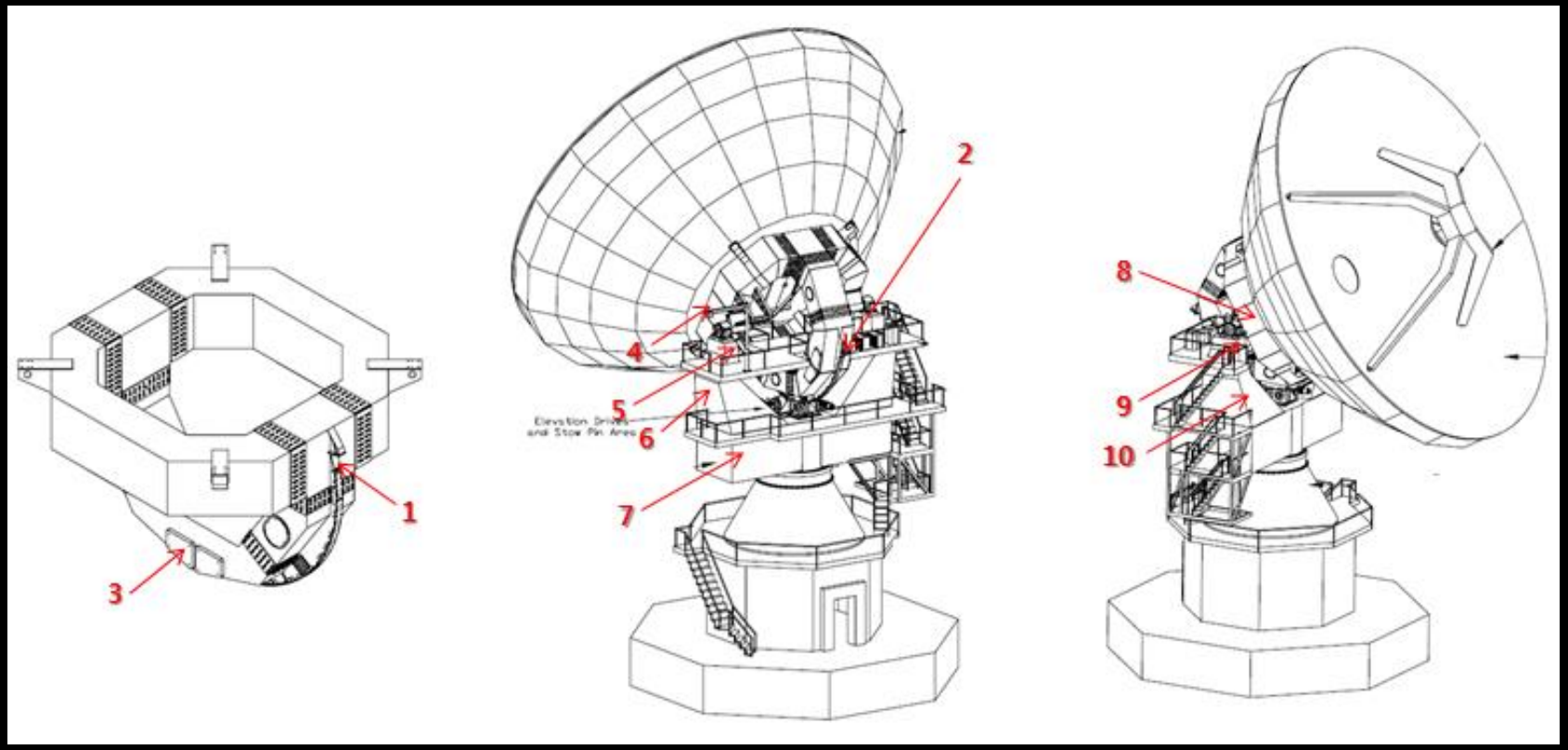


Offsets: X: 0.5~7.5 cm, Y: 3.5~6.0 cm, Z: 4.3~5.2 cm

X-axis: MJD Y-axis: Position (m)

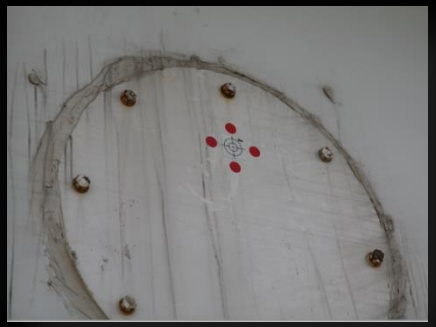
Feasibility Test of KVN Antenna Reference Position (IVP) Target & Optical Survey Matrix

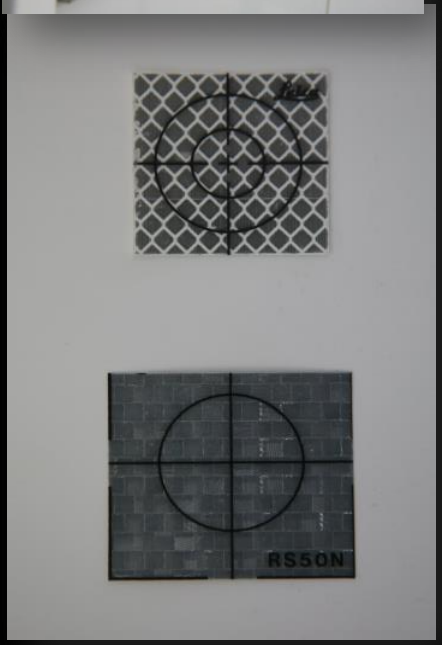
1. Define Pillar Position
2. Target Installation
3. Optical Survey
4. Analysis (GPS & Optical Tie)

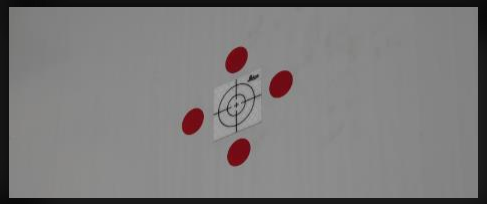


Antenna Position ID	1	2	3	4	5	6
AZ (deg)	0	60	120	180	240	300
EL (deg)	0	35	47	60	75	85

IVP measurements of KVN Tamna (2014 Sep 29-30)





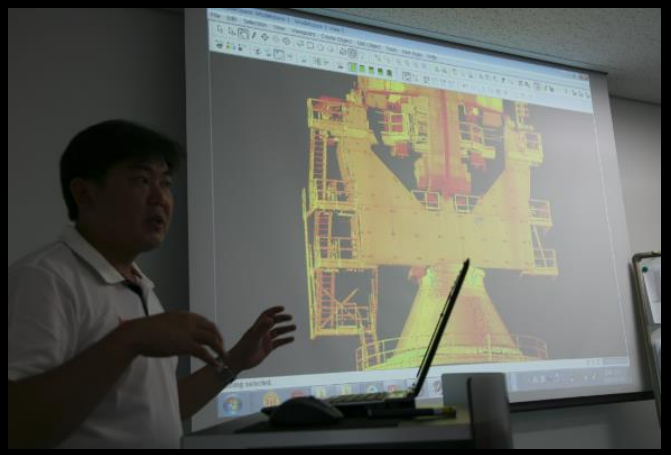


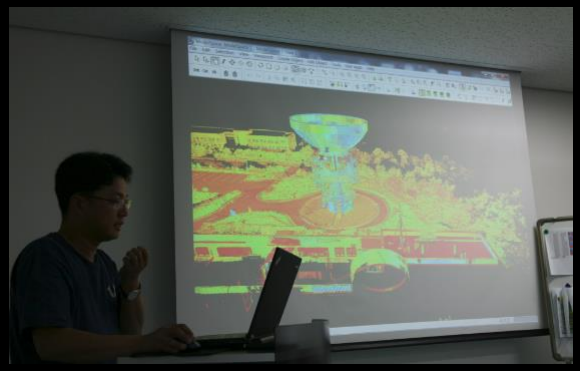
Targets for optical survey

IVP measurements of KVN Tamna (2014 Sep 29-30)

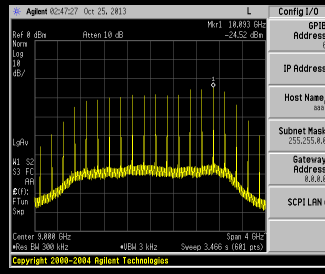
IVP Measurements Discussions

Leica Instruments

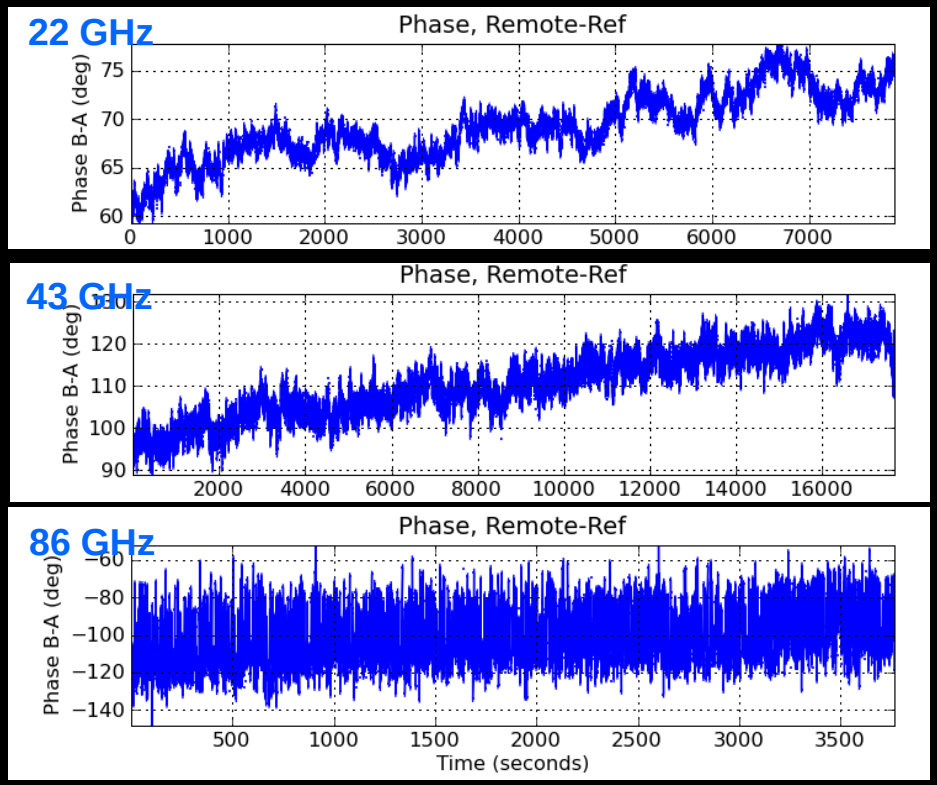


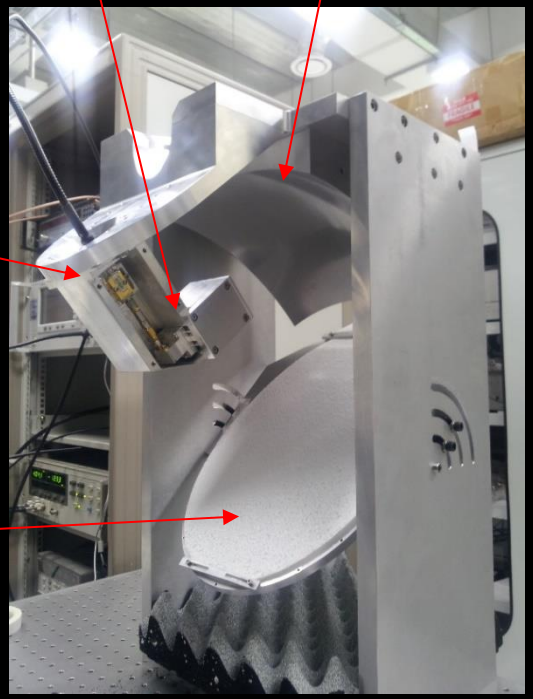


Developments of Phase Tone Calibration System



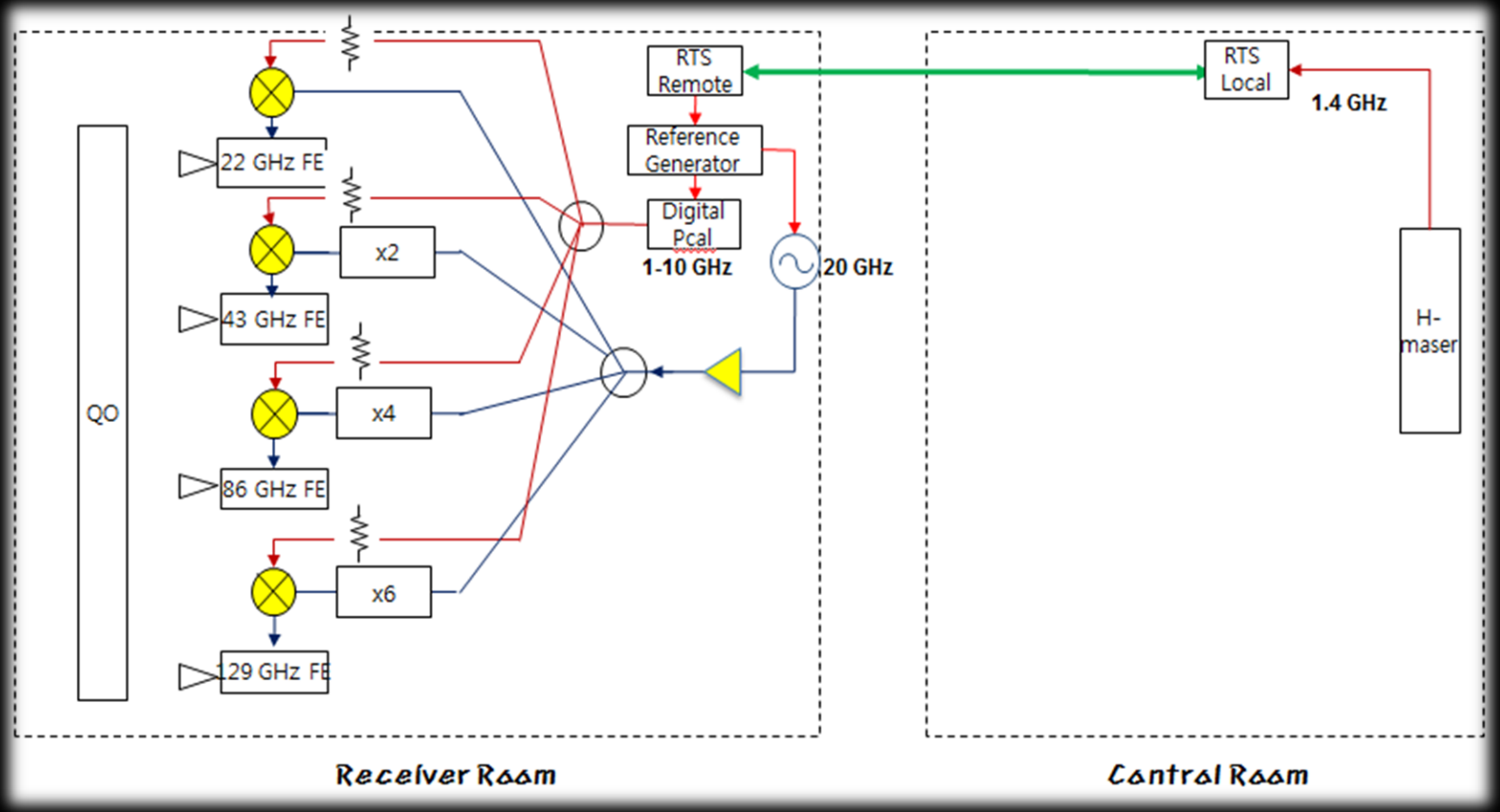
- **1st approach: Quasi-optics Injection Method**
  - Reference signal frequency : 200 MHz
  - Comb generator : commercial NLTL(2.4mm connector, spec: <50 GHz)
  - Quasi-optics injection using DRWH, ellipsoidal mirror & Mylar sheet
  - Custom designed comb needed for 129 GHz-band power generation
  - Equalization problem have to be solved





Developments of Phase Tone Calibration System

- 2nd approach: Digital P-cal Method
  - Transmission Line injection thru coupling ports using Low-frequency Phase calibrator, PDRO, and multipliers
  - Expected to be no big problem comparing to quasi-optics injection method
  - No component development needed
  - Quasi-optics components are not calibrated.



GPS Installation - close collaboration with KASI GPS group

1. KVN antenna position

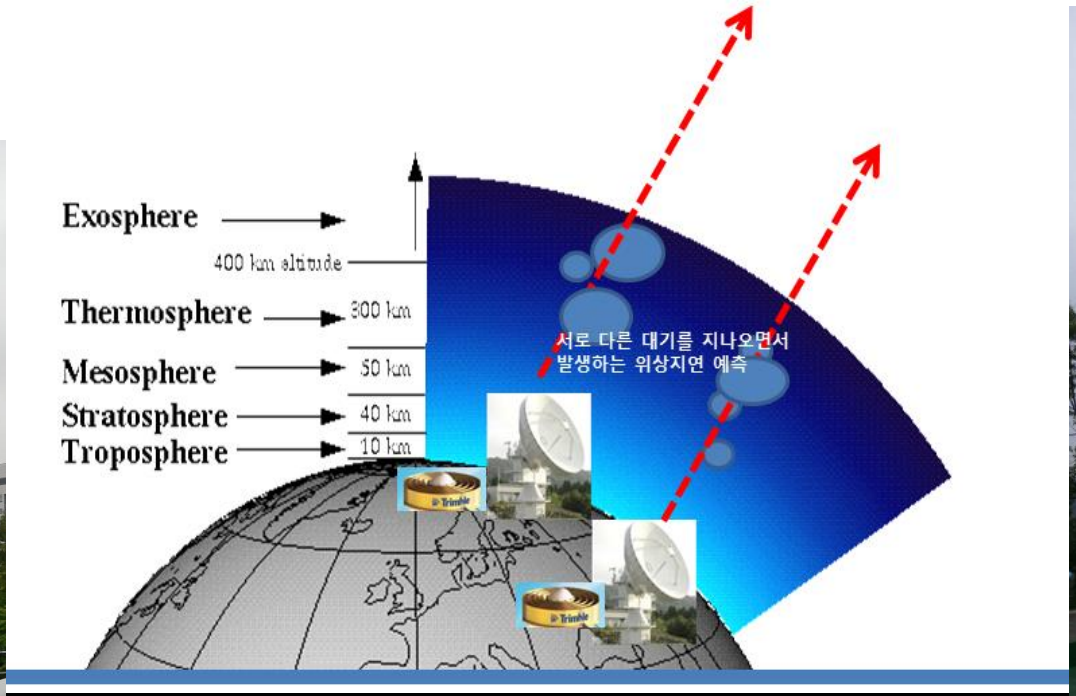
- displacement of KVN antenna position
- In-Variant Point (IVP) measurement

➔ To monitor accurate KVN antenna positions

2. Atmospheric model calculation

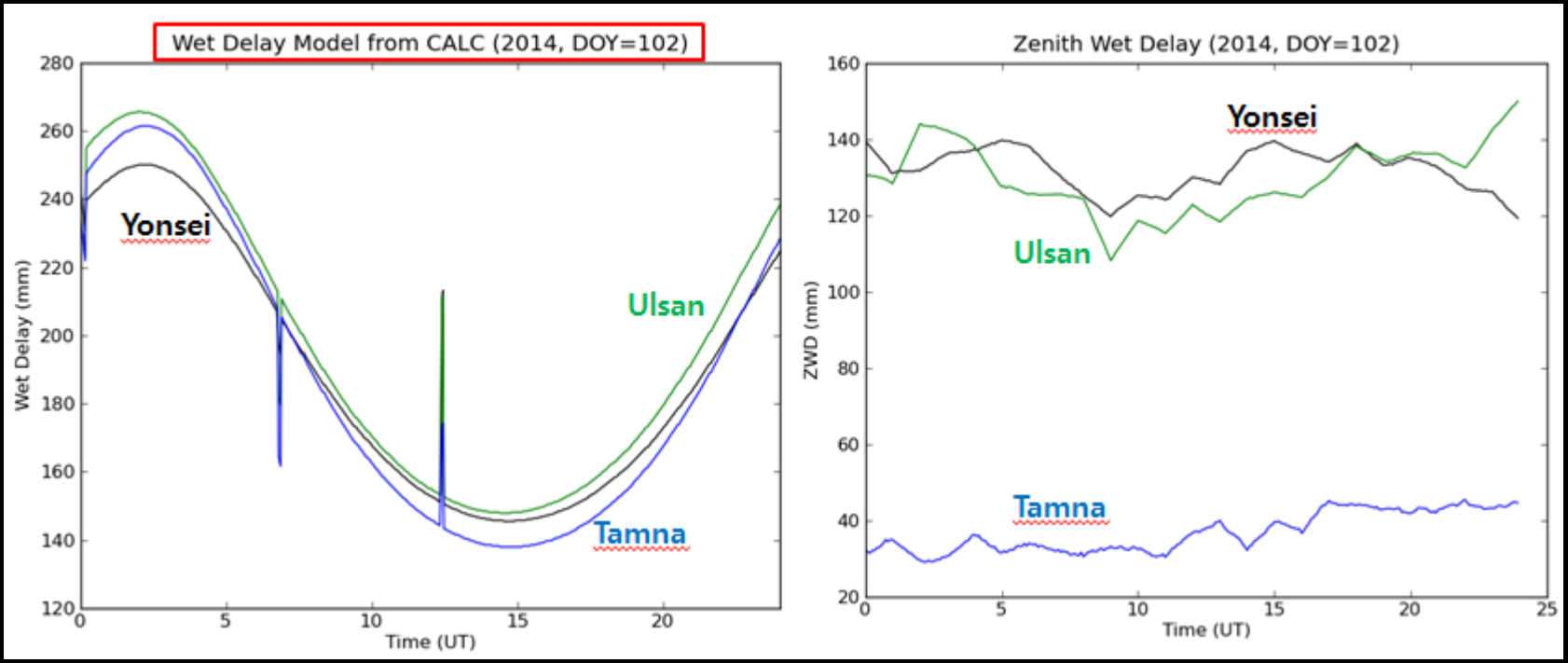
- Wet delay & TEC estimation

➔ To improve a phase referencing capability & astrometric accuracy



GPS applications towards better modeling of atmosphere

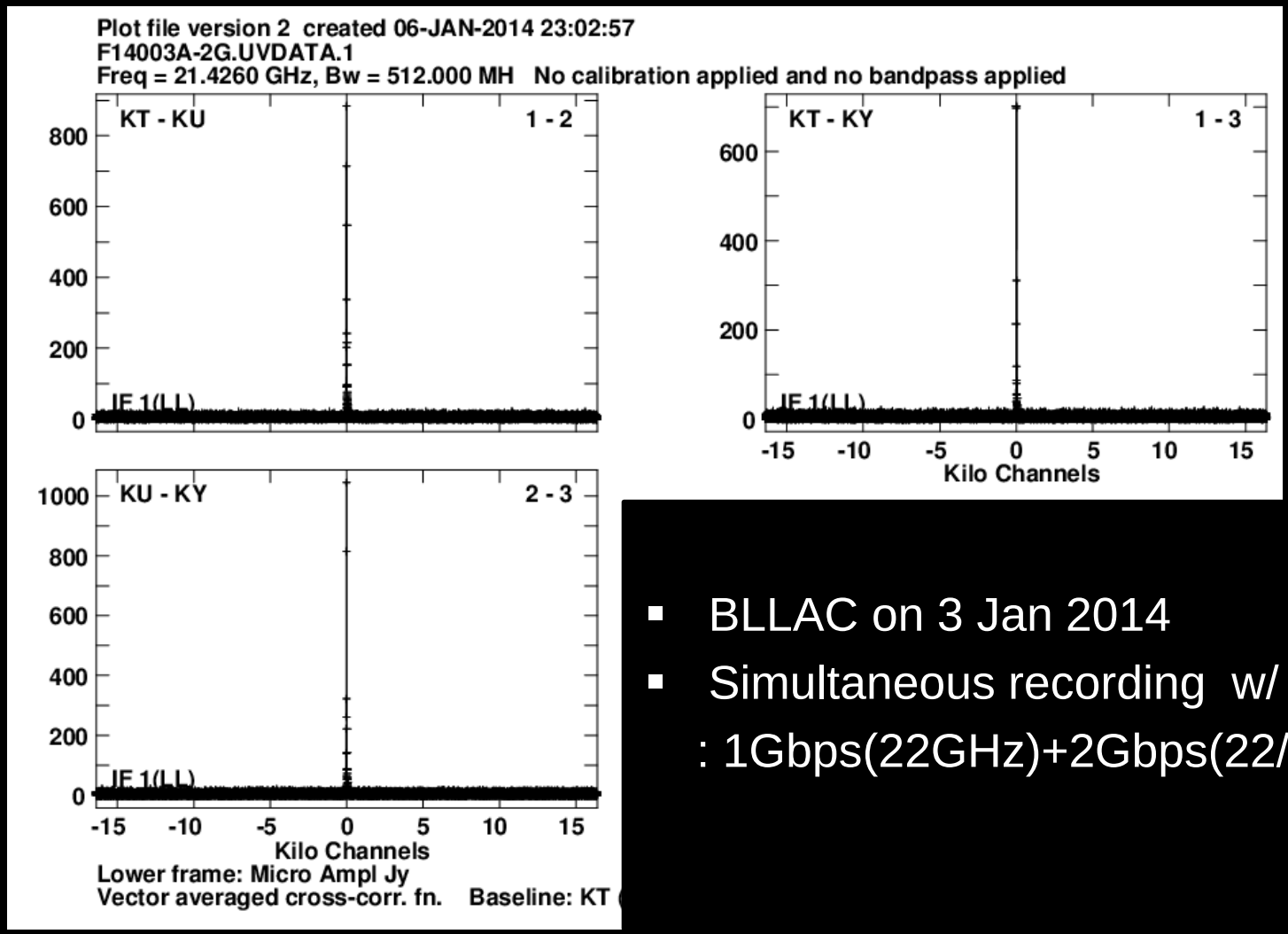
- ZTD were obtained from GPS at each KVN site
- GPS sampling period ~ 5 min
- Example: one PolarCap (1803+784), 24hr
- Correlation model of wet delay (line of sight)
  - model path = [ZWD(correlator model) + ΔZWD] / sin(elevation)
  - comparison: “true path (from GPS) – model path (from CALC)”



KVN Activities

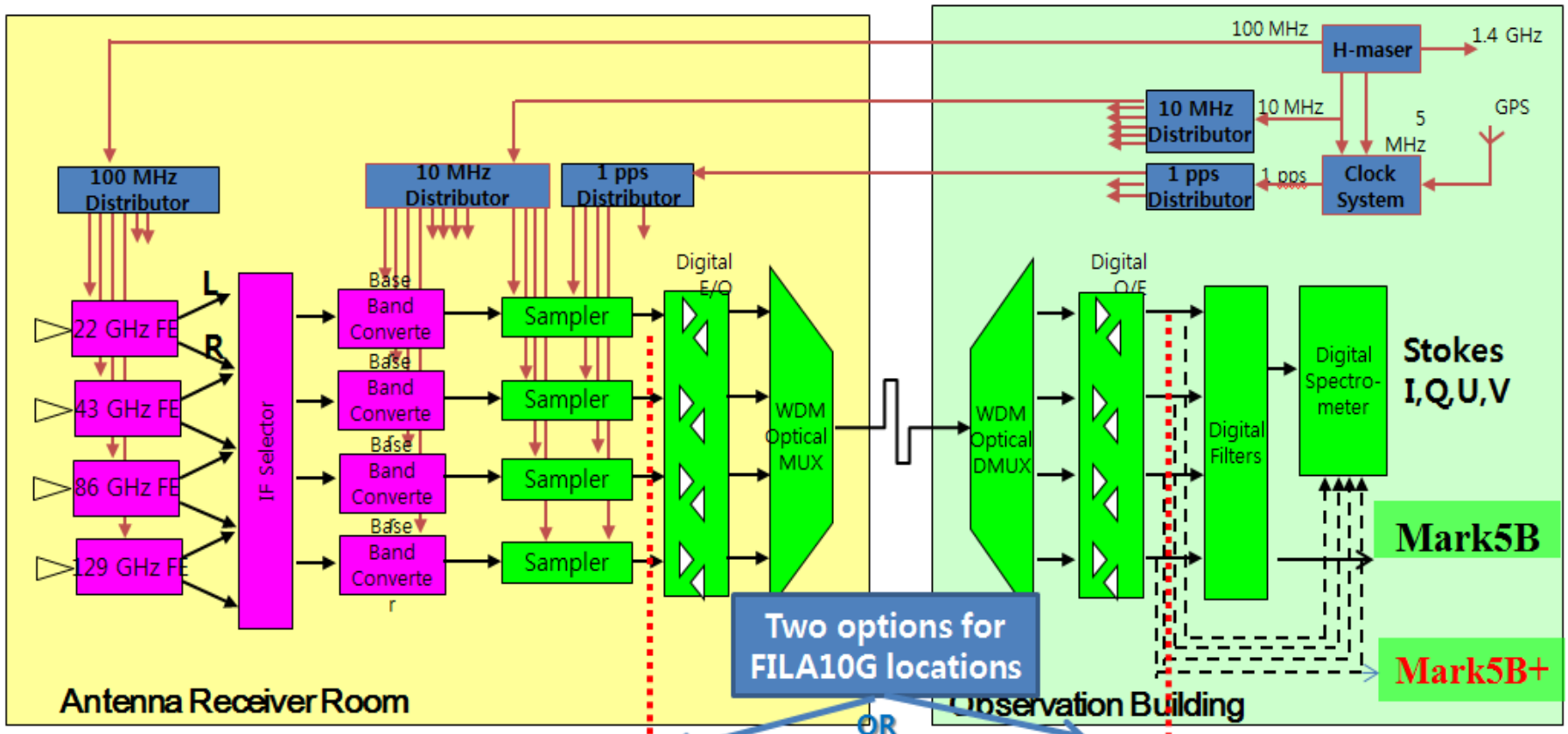
High Sensitivity

2Gbps (512MHz BW) using Mark5B+



- BLLAC on 3 Jan 2014
- Simultaneous recording w/ Mark5B+ & 5B
  : 1Gbps(22GHz)+2Gbps(22/43/86/129GHz)

KVN 8Gbps Operations with FILA10G & Mark6



- current

  Mark5B : 1Gbps (BW = 256MHz)

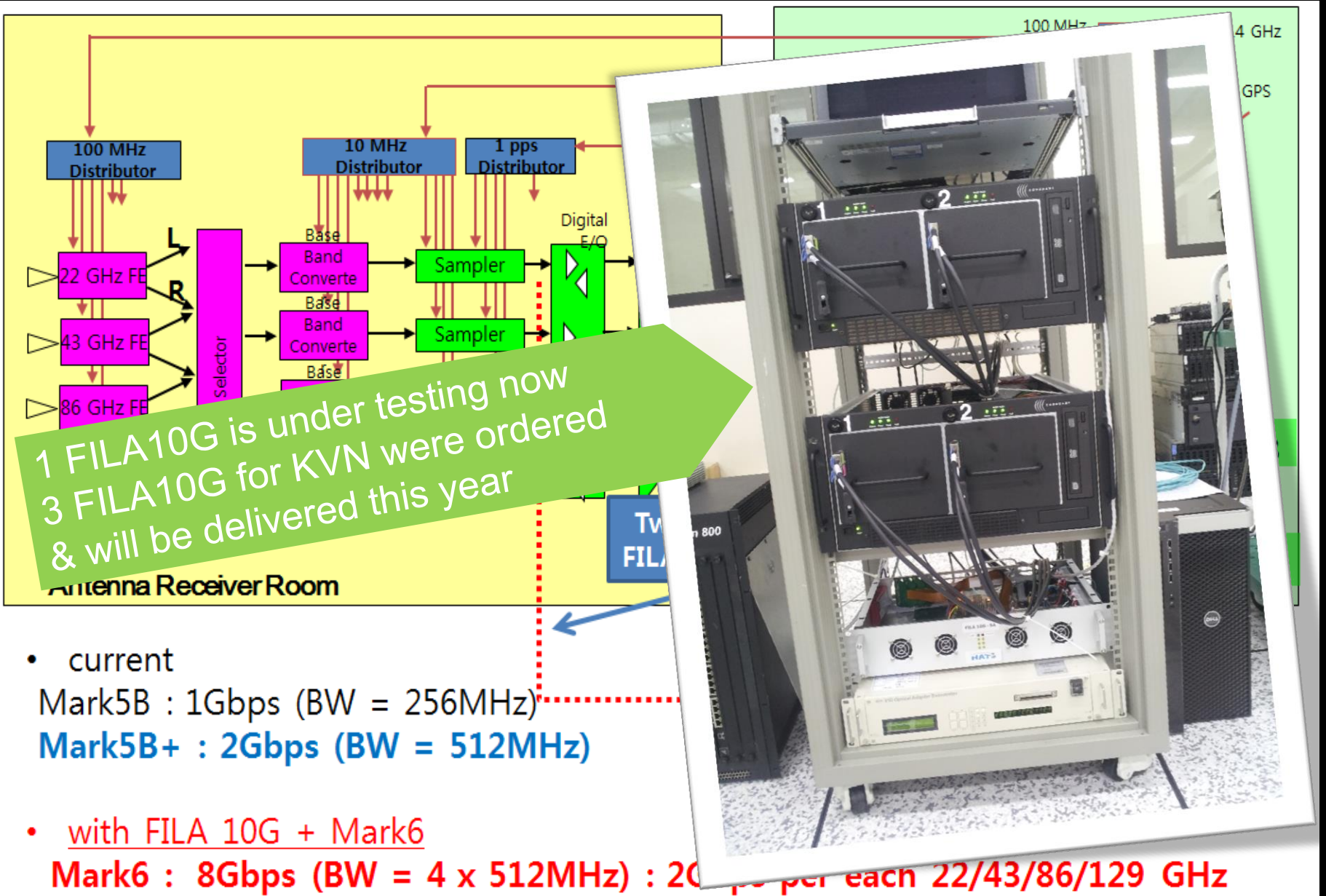
  Mark5B+ : 2Gbps (BW = 512MHz)

VIS-10GE Adapter FILA 10G — 10GE — Mark6 (or OctaDisk2)

- with FILA 10G + Mark6

  Mark6 : 8Gbps (BW = 4 x 512MHz) : 2Gbps per each 22/43/86/129 GHz

KVN 8Gbps Operations with FILA10G & Mark6



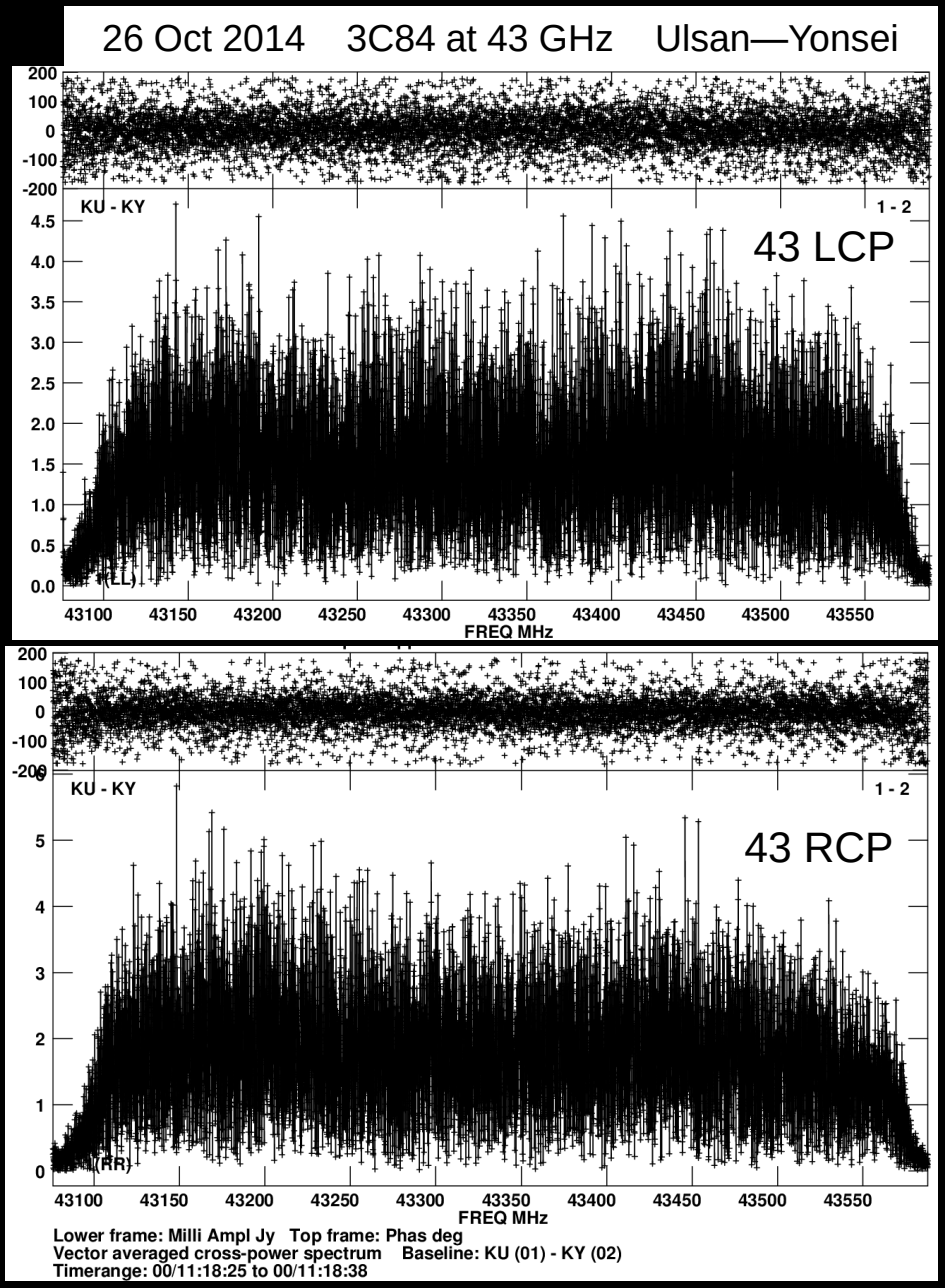
- current

  Mark5B : 1Gbps (BW = 256MHz)

  Mark5B+ : 2Gbps (BW = 512MHz)

- with FILA 10G + Mark6

  Mark6 : 8Gbps (BW = 4 x 512MHz) : 2G[illegible] per each 22/43/86/129 GHz

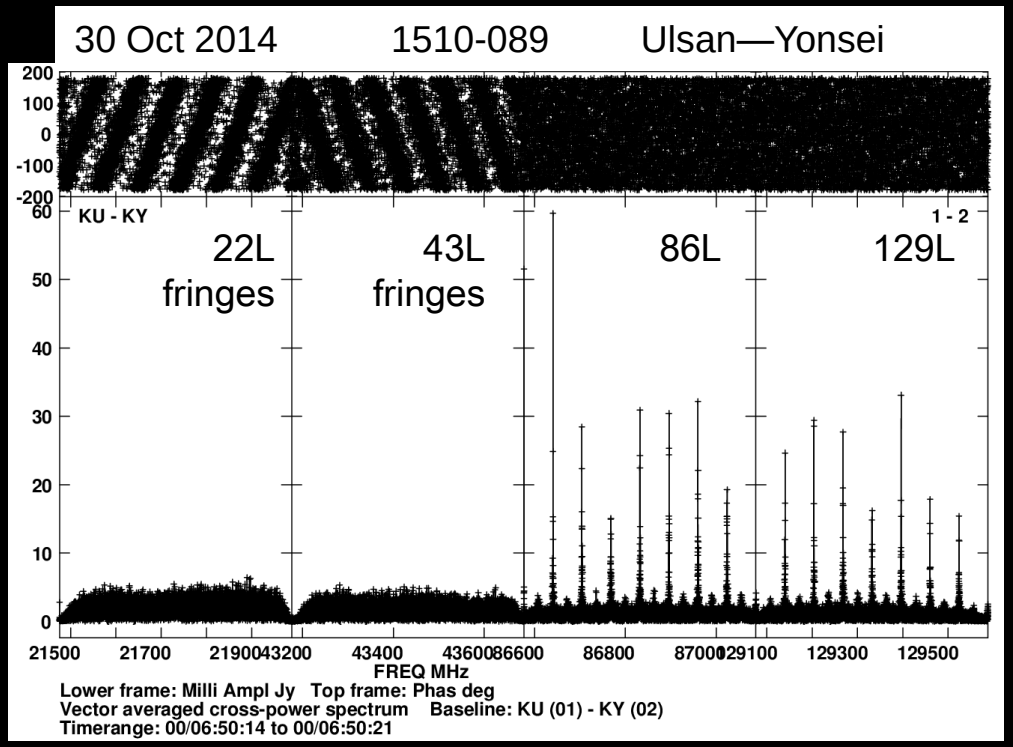


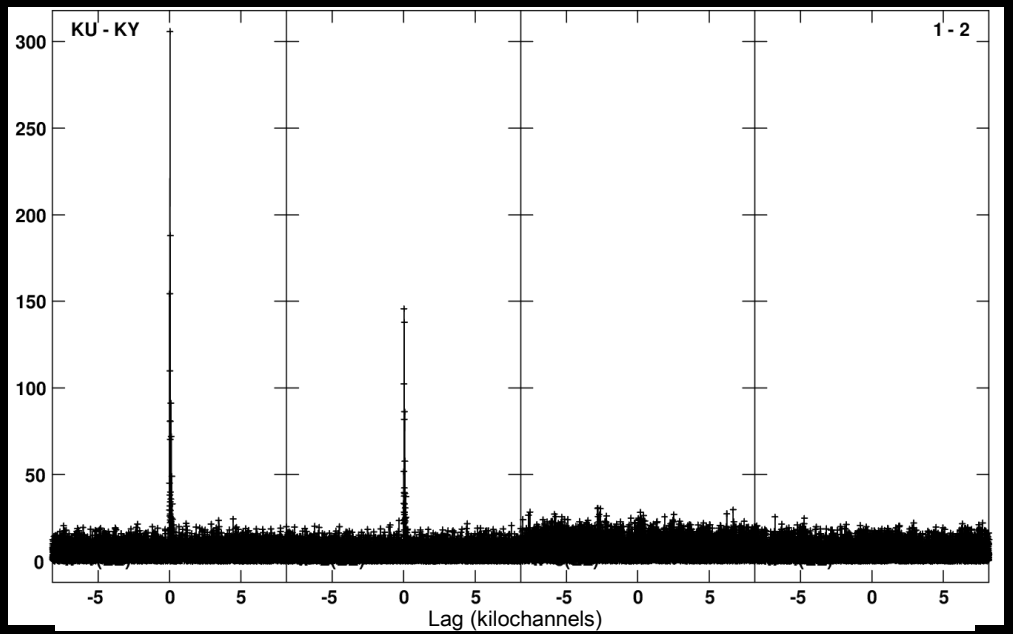
First 4 Gbps Fringes

and Almost 8 Gbps Fringes

Jan Wagner, Min-Gyu Song, Do-Young Byun

- Observations
  - 3C84, 3C345, BL Lac, …
  - 43/86 GHz dual-pol or 22/43/86/129 GHz single-pol
  - 4 IFs x 512 MHz @ 8 Gbps
  - FILA10G and VOA VSI-to-10GbE
  - Mark6 with KVN “burst mode” sw
- Fringe detection
  - DiFX software correlator
  - 4 Gbps no fringes in IF 3 and 4 due to bad spectra
  - 4 Gbps fringes in IF 1 and 2
  - Single band SNR 40 to 70 in 2 sec





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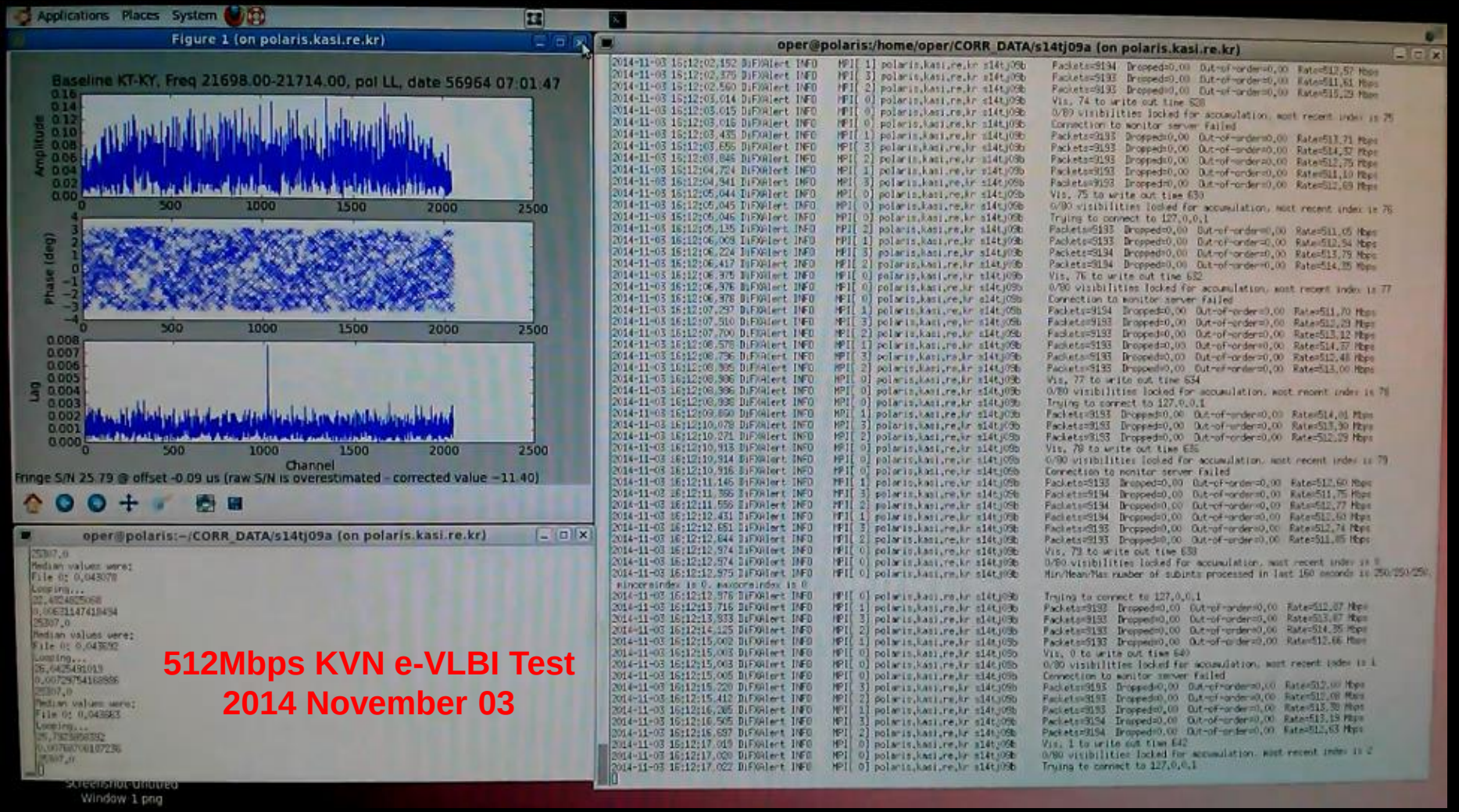
KVN e-VLBI Test



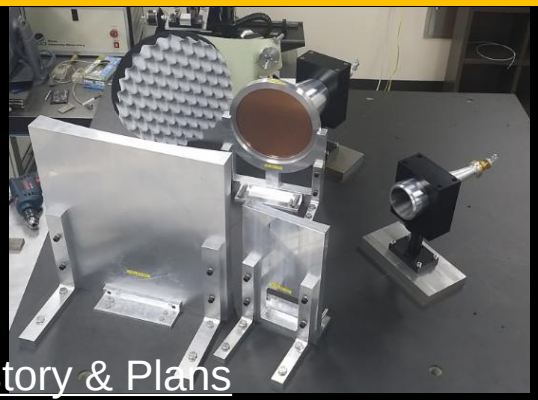
Improvement of KVN Network connection in 2014

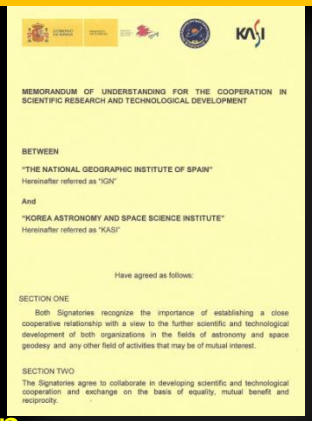
- 1Gbps ➔ 10Gbps (KYS), 5Gbps (KUS & KTN)
- Now upgrading network switches (available soon!)

KVN Activities

International Collaborations

Quasi-Optics as a Powerful Tool of mm-VLBI Collaboration with Yebes 40m & VERA Mizusawa





MEMORANDUM OF UNDERSTANDING FOR THE COOPERATION IN SCIENTIFIC RESEARCH AND TECHNOLOGICAL DEVELOPMENT

BETWEEN

"THE NATIONAL GEOGRAPHIC INSTITUTE OF SPAIN"
Hereinafter referred as "IGN"

And

"KOREA ASTRONOMY AND SPACE SCIENCE INSTITUTE"
Hereinafter referred as "KASI"

Have agreed as follows:

SECTION ONE

Both Signatories recognize the importance of establishing a close cooperative relationship with a view to the further scientific and technological development of both organizations in the fields of astronomy and space geodesy and any other field of activities that may be of mutual interest.

SECTION TWO

The Signatories agree to collaborate in developing scientific and technological cooperation and exchange on the basis of equality, mutual benefit and reciprocity.

History & Plans

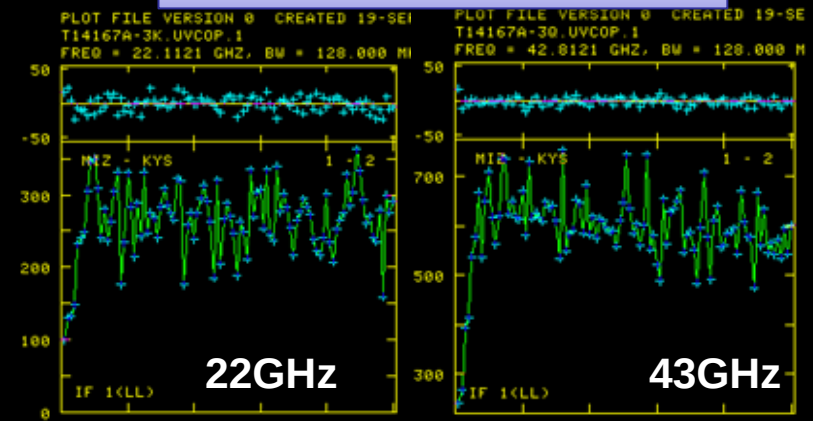
- 2011 Nov. : K/Q/W QO discussion
- 2014 Jan-Aug : QO design
- 2014 Jun : KASI-IGN MOU
- 2014 Sep : Manufacture
- 2014 Oct : Shipping to Yebes
- 2014 Nov : Installation & Initial Test
- 2015 Jan : K/Q band fringe test

History & Plans

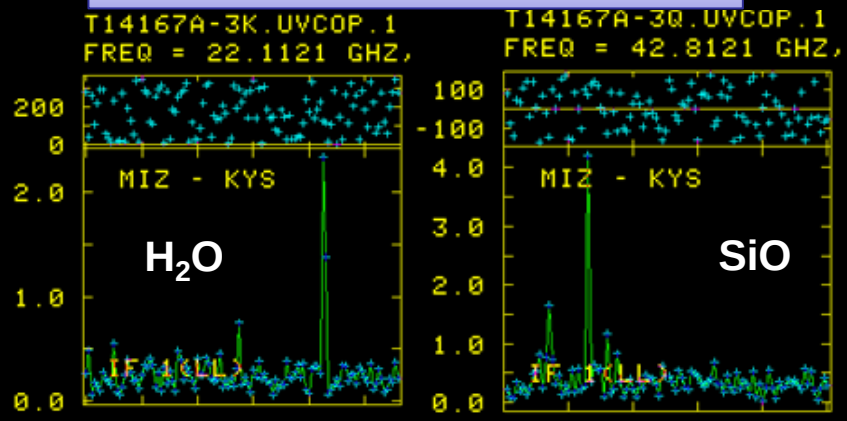
- 2013 Nov : Manufacture
- 2013 Dec. : Shipping & Installation
- 2014 Jun : K/Q VLBI fringe test
- 2014 Sep : Fringe Detection
- 2014 Dec : Science verification test

Success on QO test outside of KVN

K/Q simultaneous fringes of OJ287

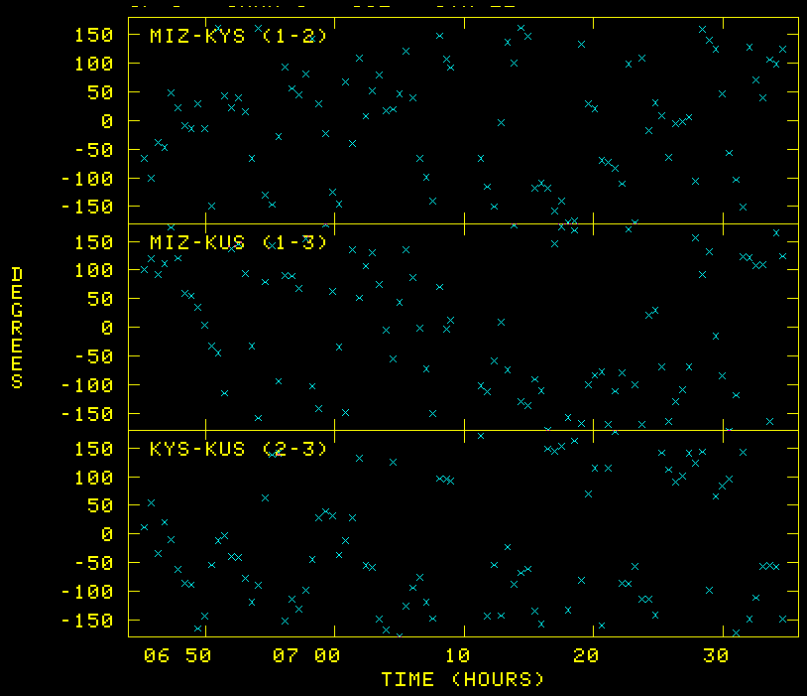


H_2O/SiO Simultaneous fringes of ORION-KL

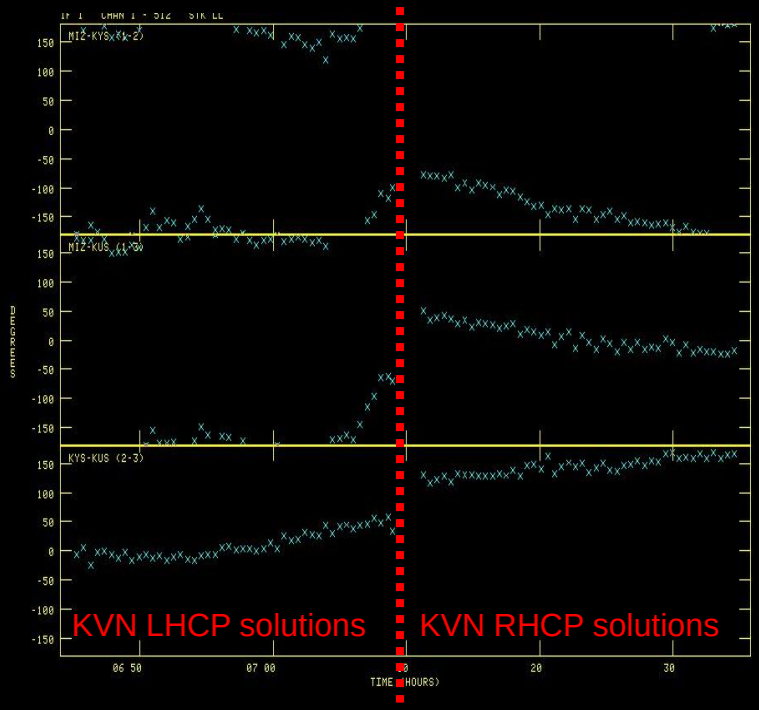


Phase Correction with QO systems (K→Q, OJ287)

Q-band Visibility Phase
No calibration applied



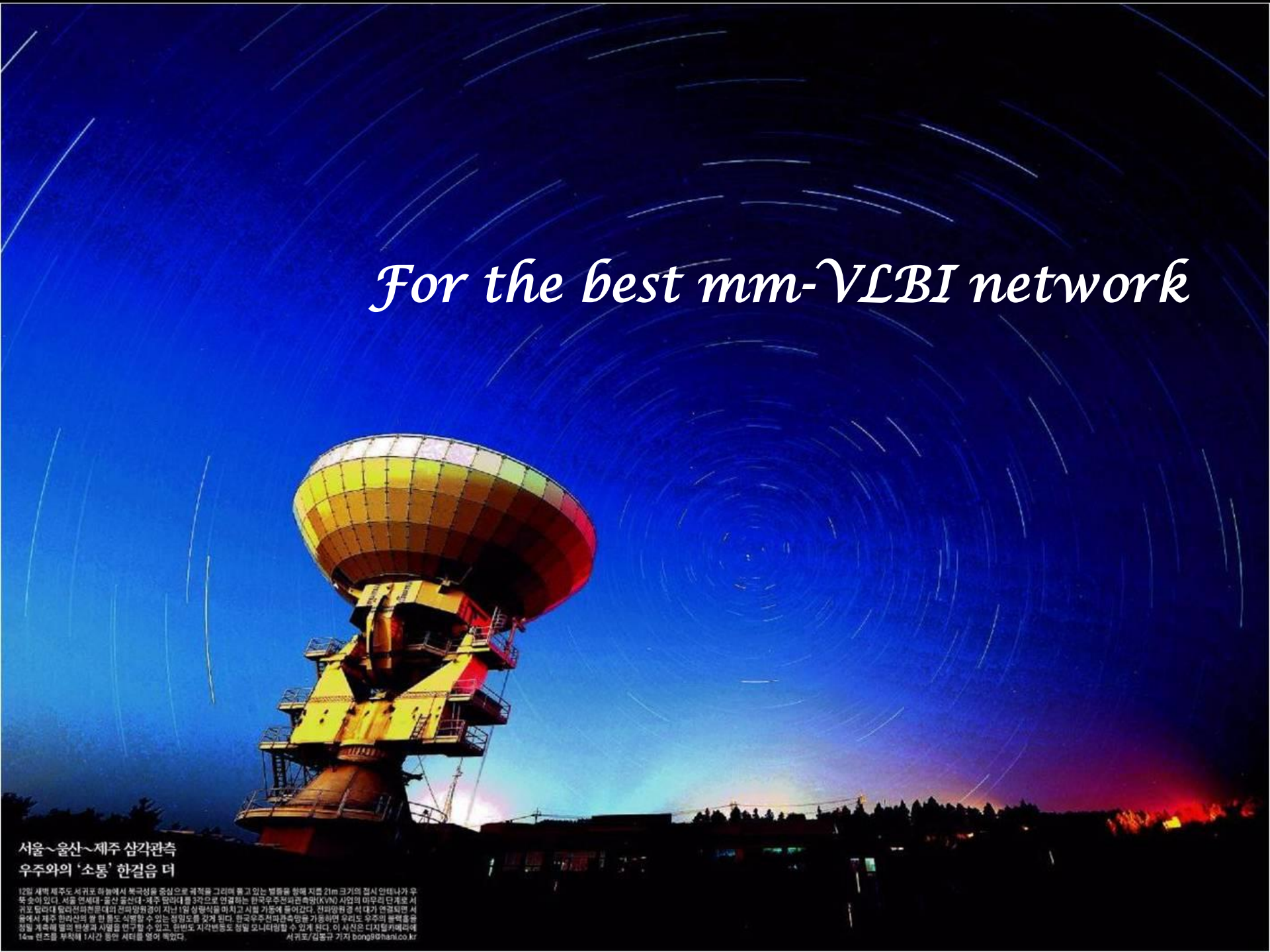
Q-band Visibility Phase
Calibrated by K-band Phase Solutions



- K-band fringe phase solutions of OJ287 were applied to calibrate Q-band data
- Visibility phase of Q-band calibrated by K-band shows more stable phase than raw data although there are high phase rates at MIZ related baselines
  ➔ The feasibility of K/Q simultaneous observing system has been demonstrated !!

- Science demonstration will be made on be half of KaVA science sub-working group

For the best mm-VLBI network



서울~울산~제주 삼각관측
우주와의 '소통' 한걸음 더

12일 새벽 제주도 서귀포 하늘에서 북극성을 중심으로 궤적을 그리며 돌고 있는 별들을 향해 지름 21m 크기의 접시 안테나가 우뚝 솟아 있다. 서울 연세대·울산 울산대·제주 탐라대를 3각으로 연결하는 한국우주전파관측망(KVN) 사업의 마무리 단계로 서귀포 탐라대 탐라전파천문대의 전파망원경이 지난 1일 상량식을 마치고 시험 가동에 들어갔다. 전파망원경 세 대가 연결되면 서울에서 제주 한라산의 쌀 한 톨도 식별할 수 있는 정밀도를 갖게 된다. 한국우주전파관측망을 가동하면 우리도 우주의 블랙홀을 정밀 계측해 별의 탄생과 사멸을 연구할 수 있고, 태풍도 지각변동도 정밀 모니터링할 수 있게 된다. 이 사진은 디지털카메라에 14㎜ 렌즈를 부착해 1시간 동안 셔터를 열어 찍었다.

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