Efforts and attempts to develop VGOS-like station in China

Jinling Li (李金岭), SHAO
JLL@SHAO.AC.CN

EVGA, Spain, 20190318

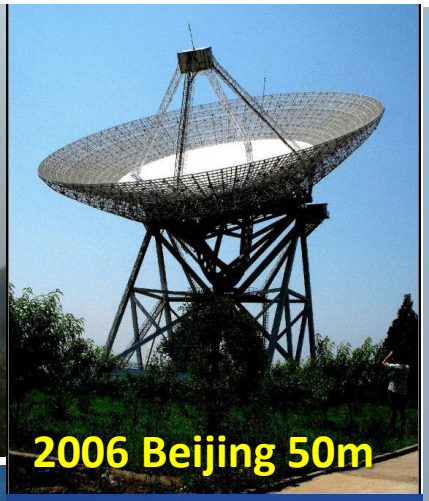
Outline

1. China VLBI Network (CVN)
2. VGOS-like station
   - 2.1 NSTC
   - 2.2 Tianma 13-m
   - 2.3 Sheshan 13-m
3. Thoughts on new VGOS station
4. A related project

1. China VLBI Network (CVN)


1974 Shanghai 6m


1987 Shanghai 25m


2006 Beijing 50m


2012 Shanghai 65m


1994 Urumqi 25m


2006 Kunming 40m

- Others, space exploration, 35-m, 64-m, etc.
- Now, VGOS-like station

2. VGOS-like station

- Type I, **NTSC13**, National Time Service Center, CAS.

  Broadband 1.2 ~ 9 GHz
- Type II, **Tianma13**, Shanghai Astronomical Observatory (SHAO), CAS.

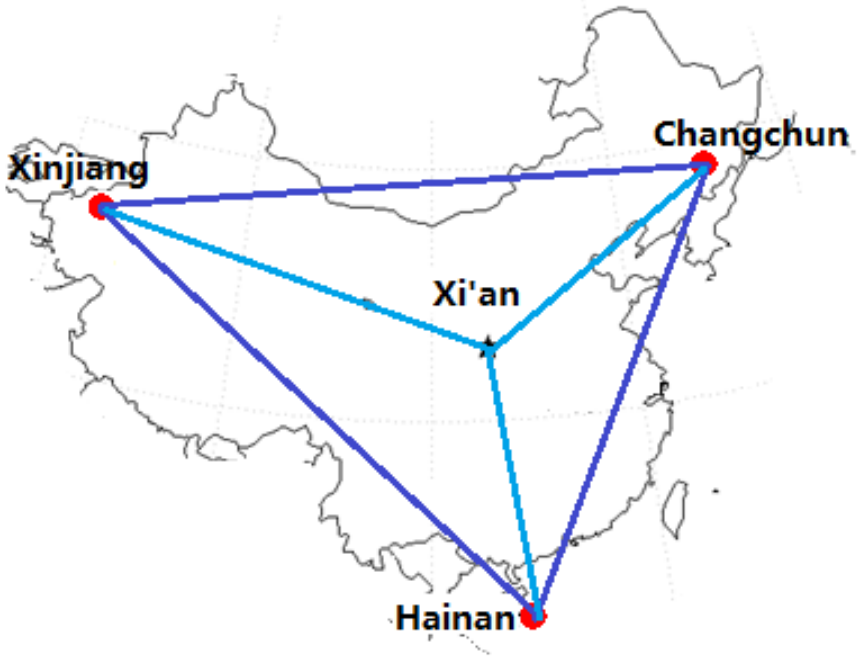
  Broadband 3 ~ 18 GHz
- Type III, **Sheshan13**, SHAO, CAS

  Broadband 2 ~ 14 GHz

  Dual band X/Ka, 7~9.5 / 28~34 GHz

2. VGOS-like station --- NTSC13

- National Time Service Center (NTSC), CAS



(1) 13-m diameter antenna

(2) high slew rate

12° /s in azimuth

6° /s in elevation

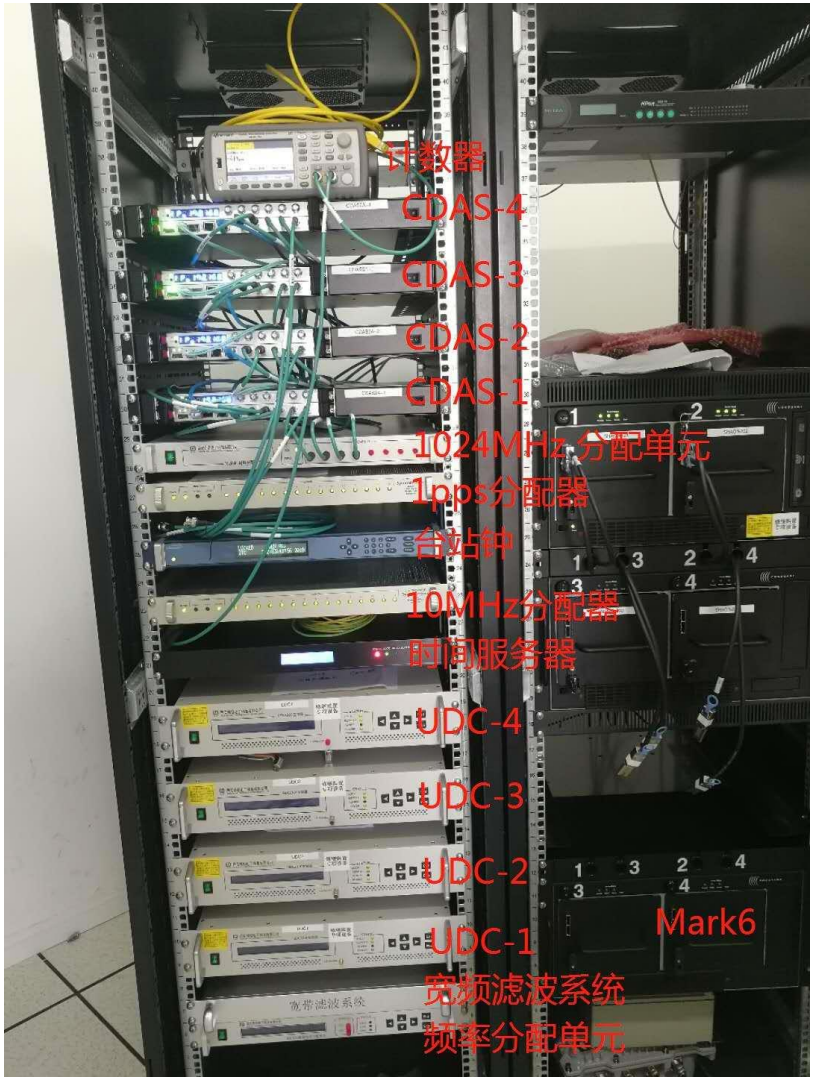
(3) freq cov 1.2 GHz ~ 9 GHz

(4) eff > 50%

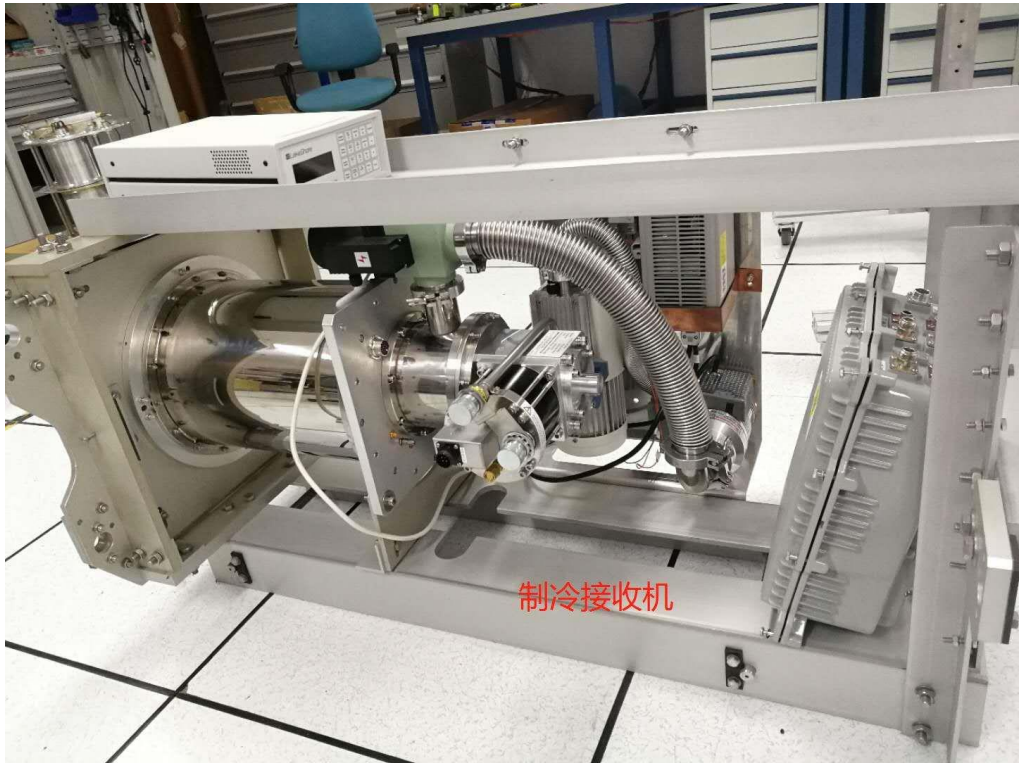
2. VGOS-like station---Tianma13

- CAS
- 13m, MTM
- 3~18 GHz
- 20 K
- 50%

2. VGOS-like station---Tianma13

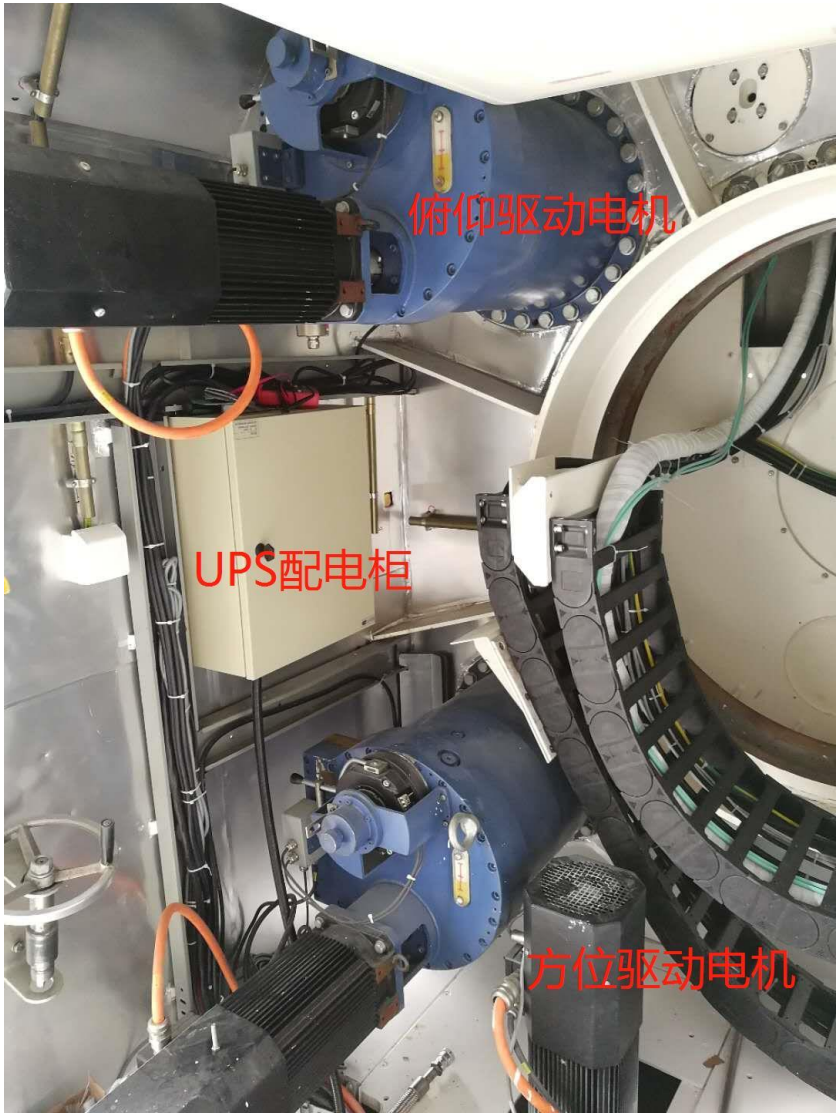


2. VGOS-like station---Tianma13

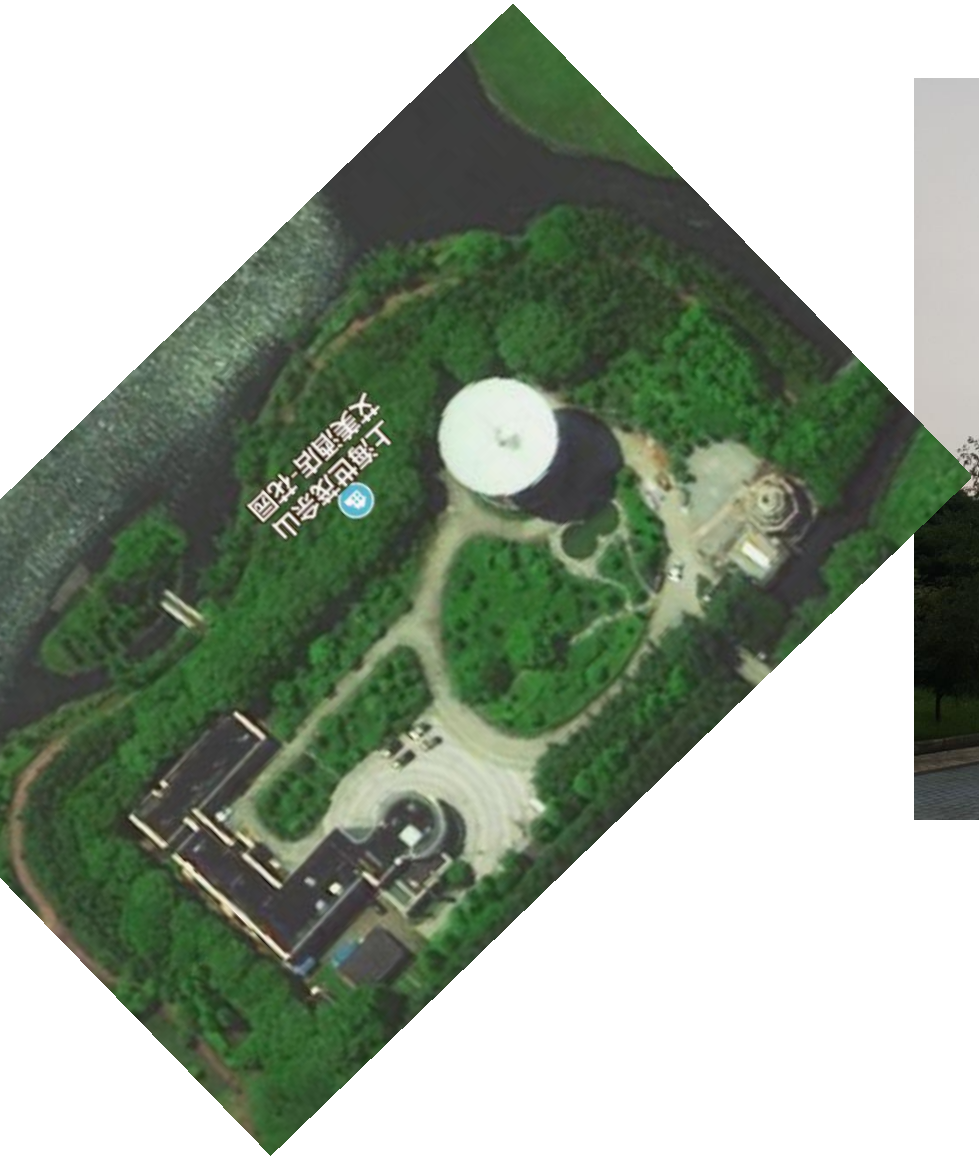


2. VGOS-like station---Tianma13

2. VGOS-like station---Tianma13



2. VGOS-like station---Sheshan13

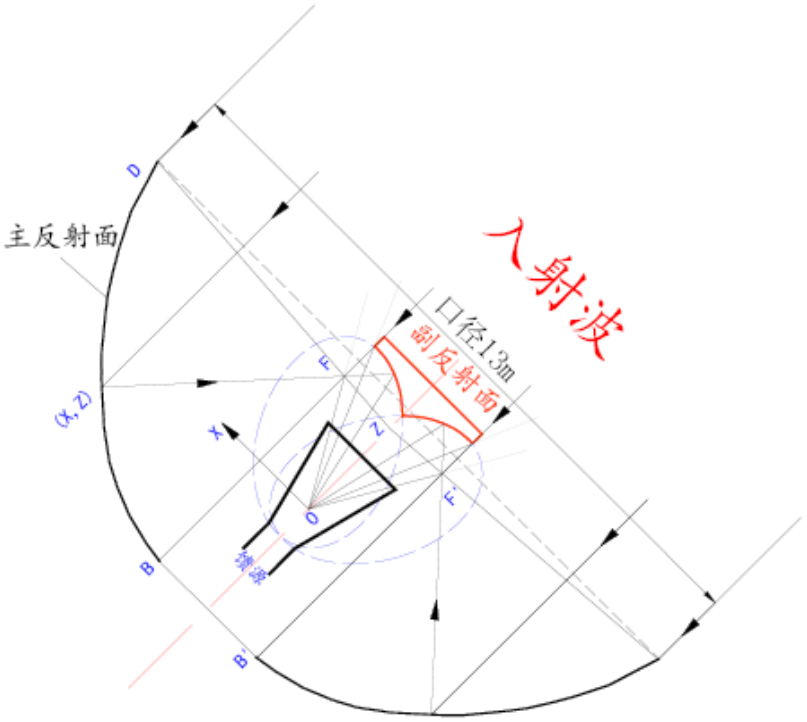


2. VGOS-like station---Sheshan13

- 13 m antenna
- Broadband 2~14 GHz, Quad ridge flared horn (QRFH) feed
- **Dual band X/Ka, 7~9.5 / 28~34 GHz**
- Cooled receiver, 20 K, 77 K
- Recoding: 4 channels of bandwidth 512 MHz, would be to 1 GHz, 2 polarizations

2. VGOS-like station---Sheshan13

- Optics



- QRFH feed

2. VGOS-like station---Sheshan13

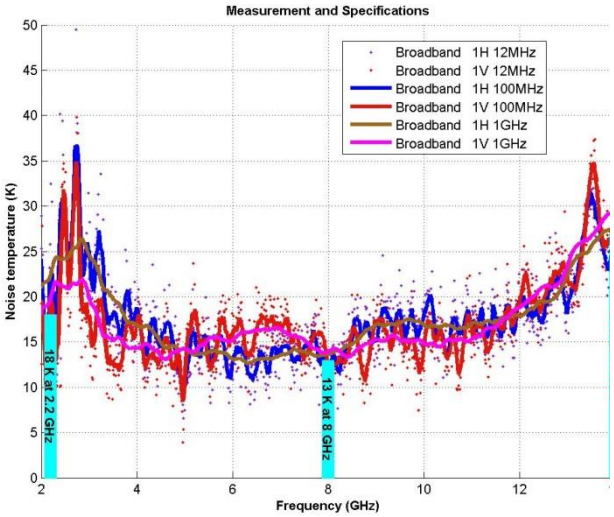
2. VGOS-like station---Sheshan13

- UDC
- Backend
- Recording
- Time & freq
- TF control
- System cntl

2. VGOS-like station---Sheshan13

- **Receivers: equivalent temperature**

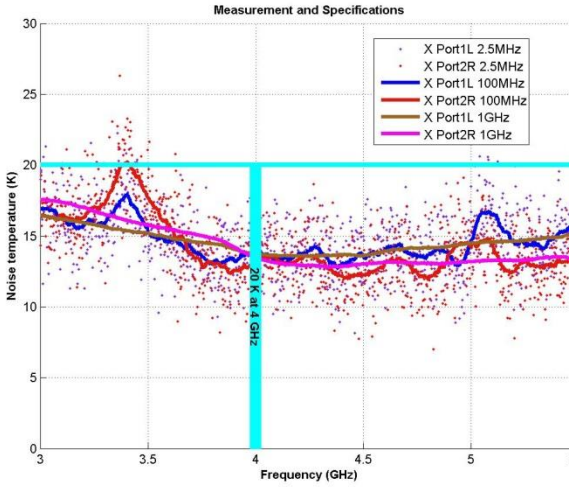
Broadband



Typical: 18 K

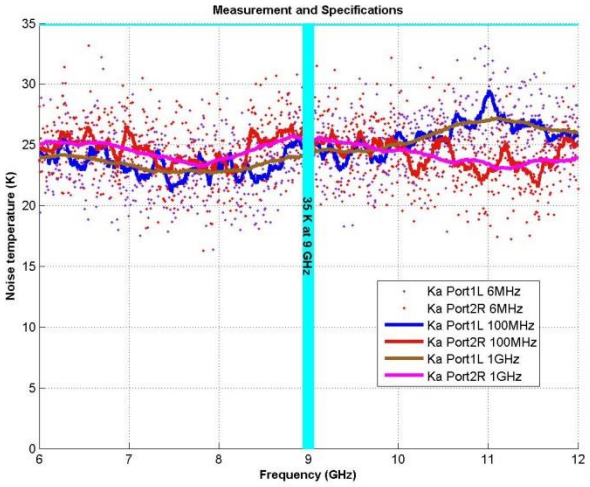
Dual-band

X-band



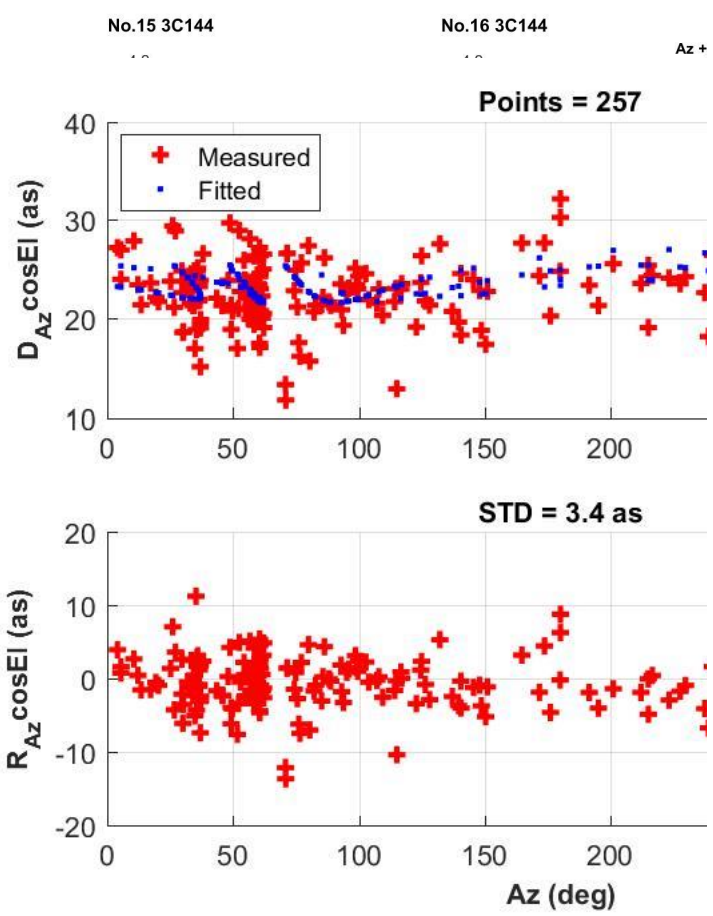
15 K

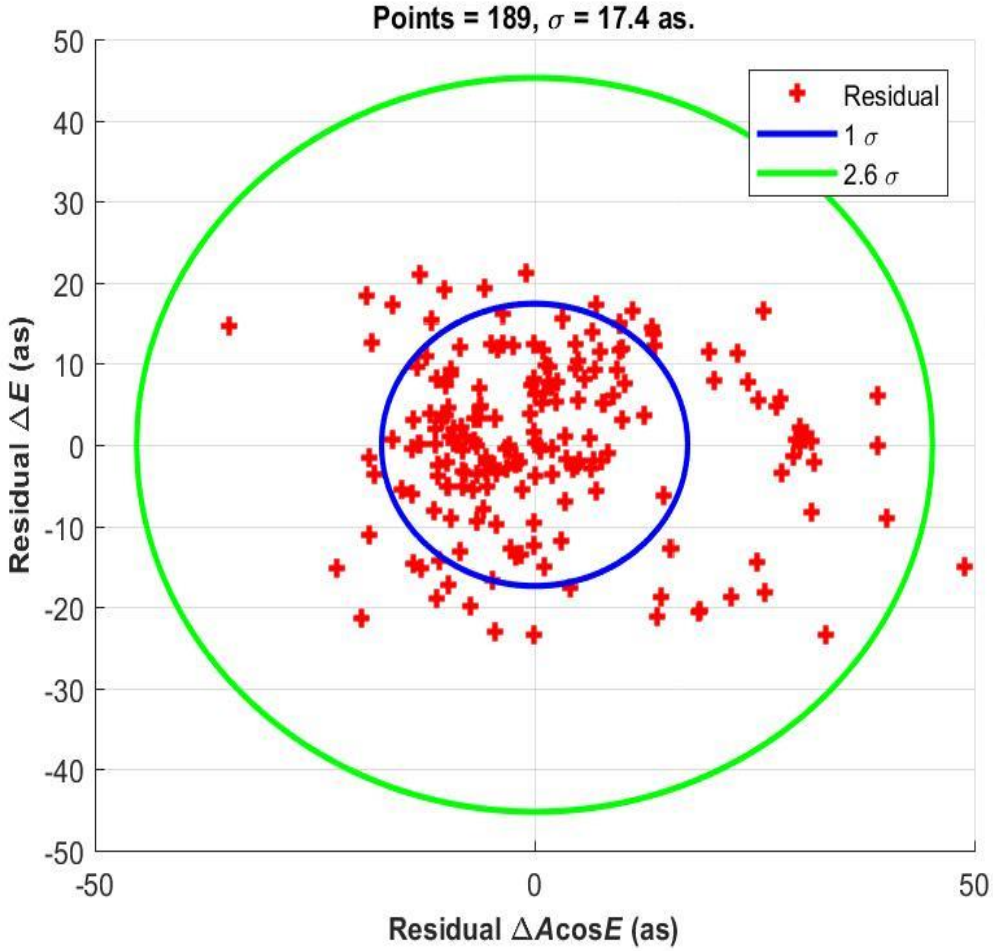
Ka-band



25 K

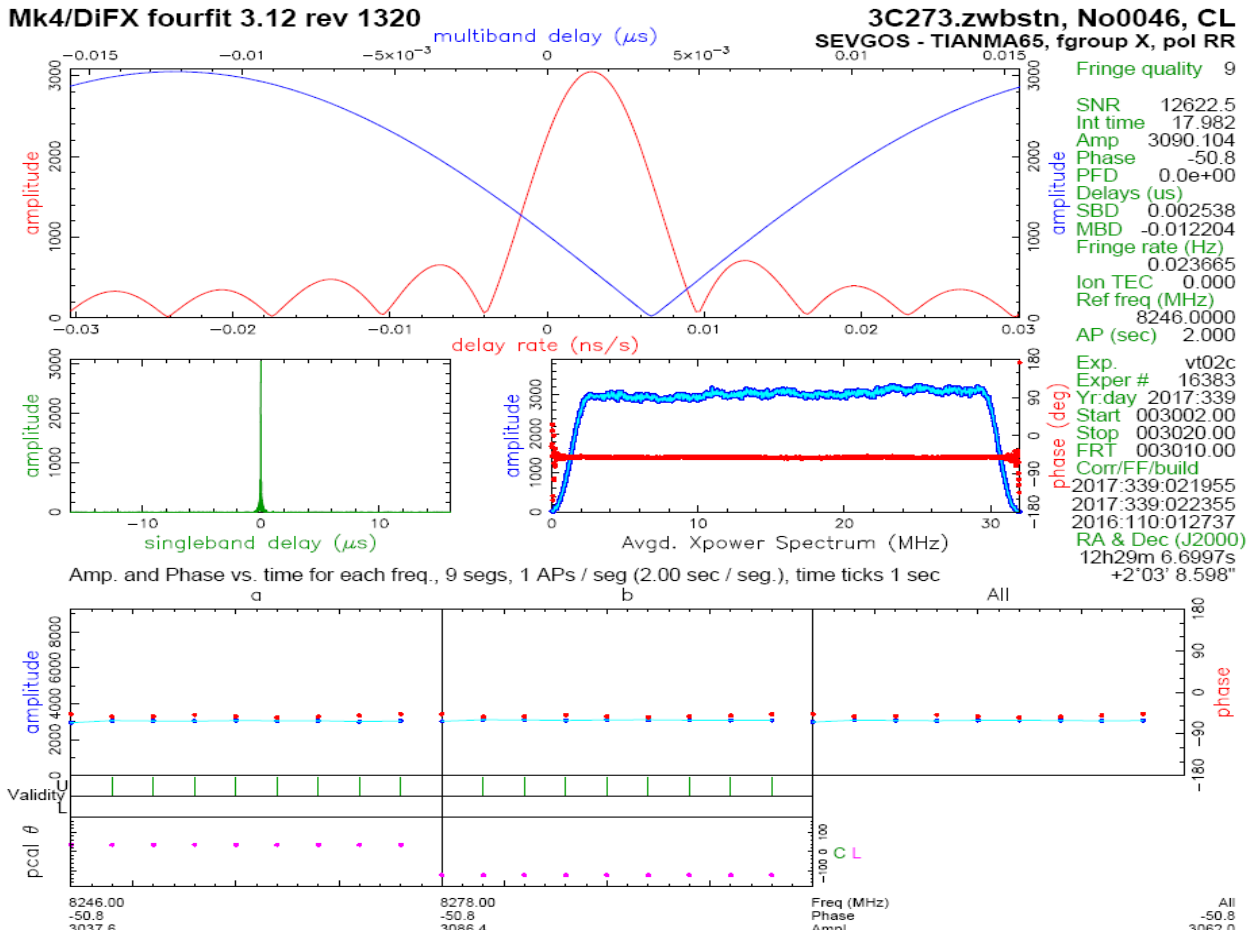
2. VGOS-like station---Sheshan13





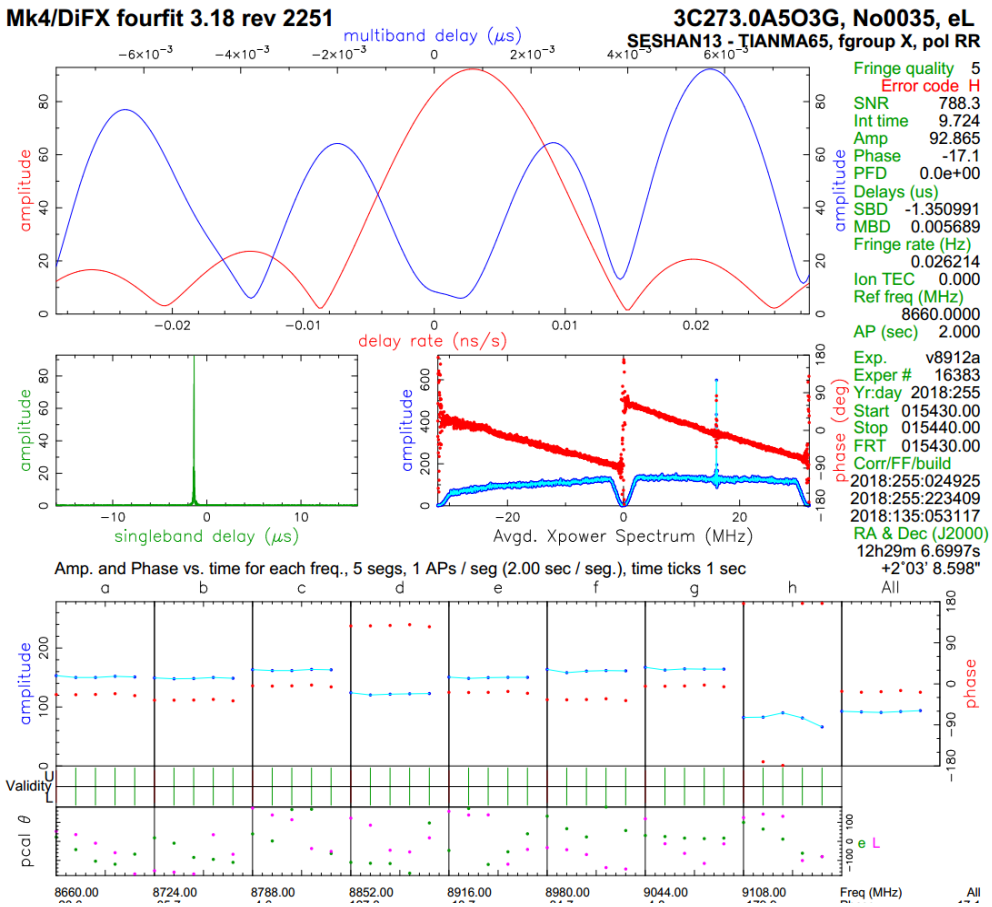
2. VGOS-like station---Sheshan13

- Dual X-band with Tianma65, Dec 05 2017



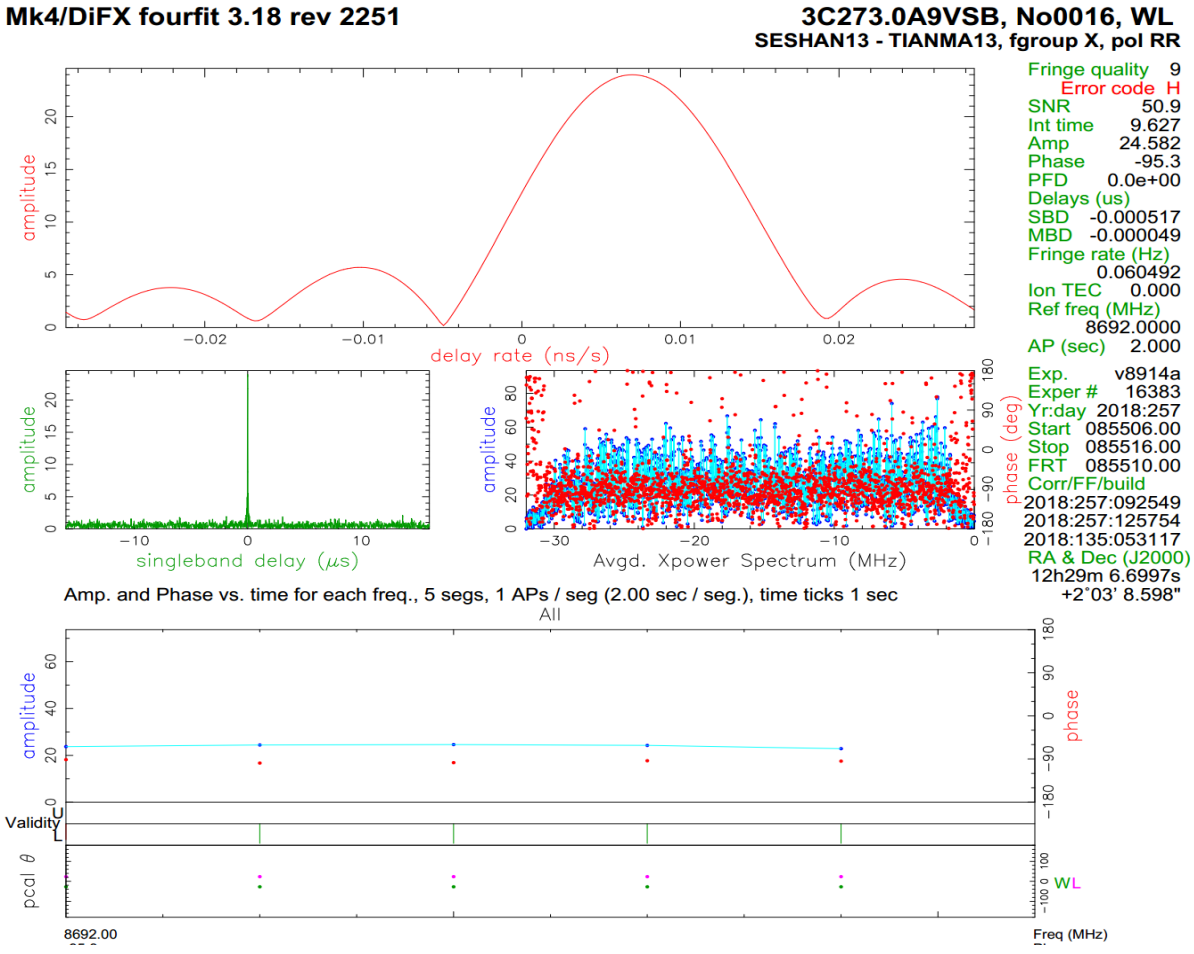
2. VGOS-like station---Sheshan13

- Broadband with Tianma65, Sept 12 2018



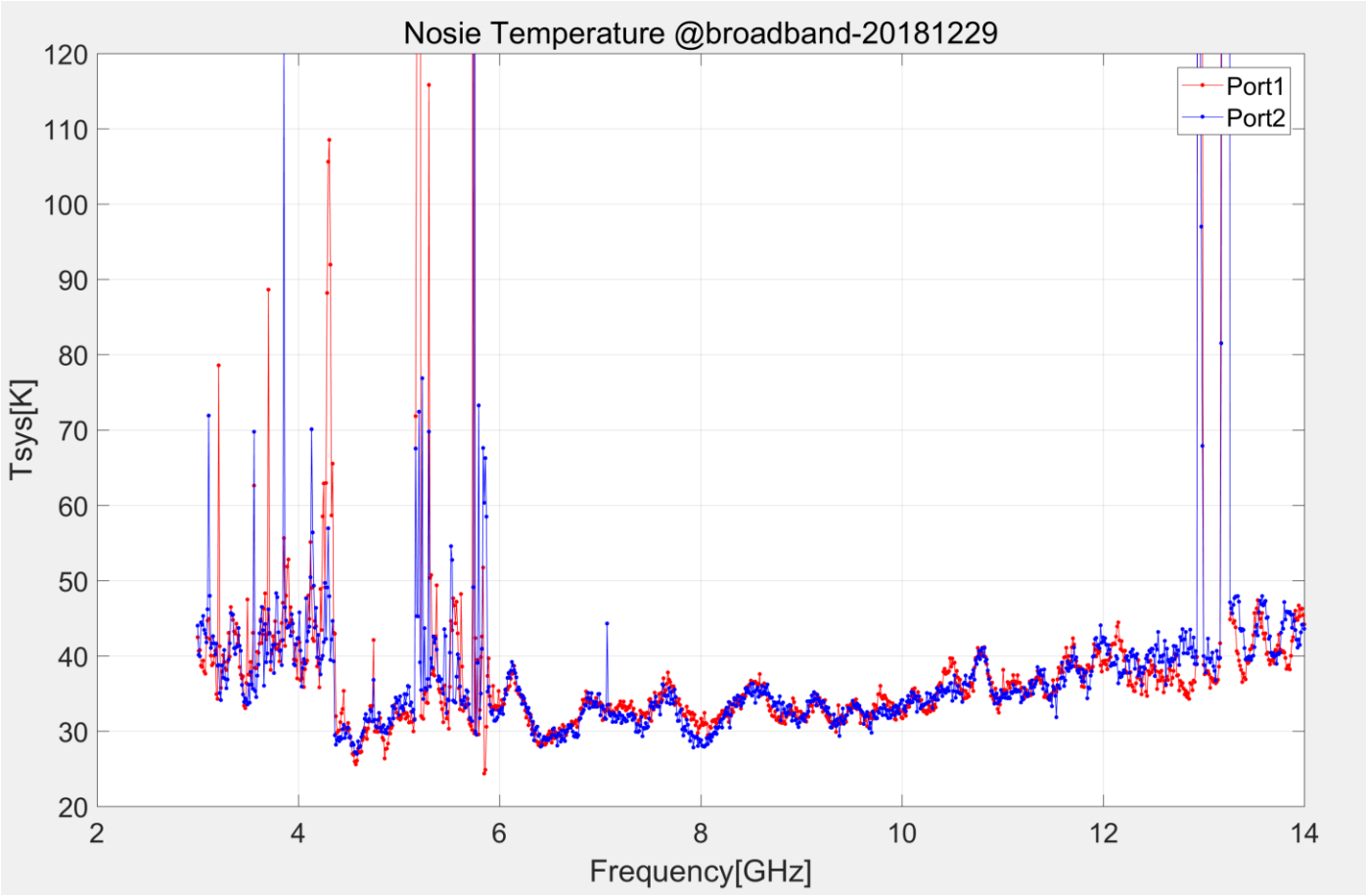
2. VGOS-like station---Sheshan13

- Broadband with Tianma13, Sept 14 2018



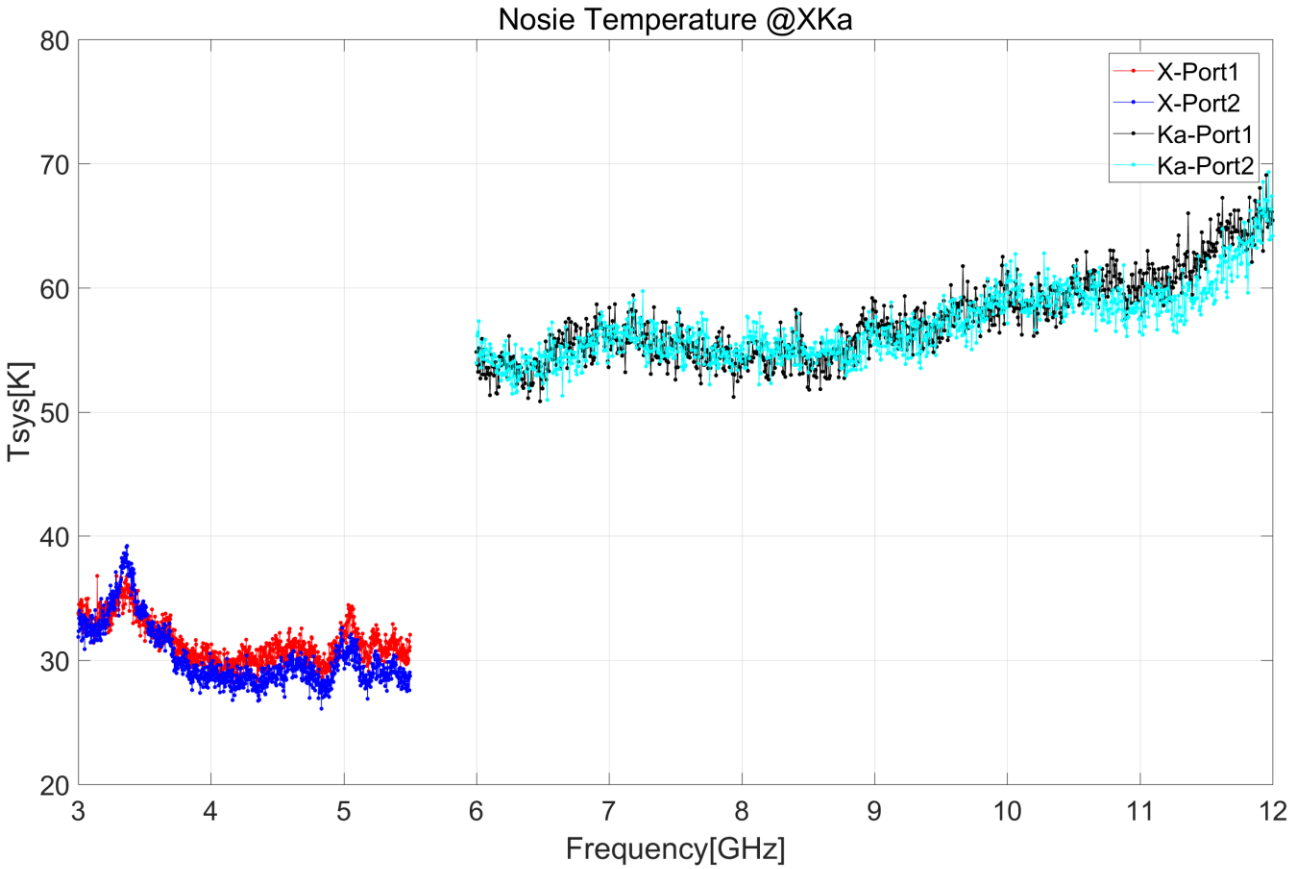
2. VGOS-like station---Sheshan13

- System temperature, broadband



2. VGOS-like station---Sheshan13

- System temperature, dual band



2. VGOS-like station---Sheshan13

Frequency (GHz)	Elevation (Deg)	Aperture Efficiency (%)	SEFD
Broadband			
4.45	56.99	52.26	2019
5.45	57.23	64.15	1522
6.45	57.48	42.74	1596
7.45	57.78	46.01	1501
8.45	58.03	53.71	1585
9.45	58.28	50.74	1669
10.45	58.53	54.71	1547
11.45	58.82	50.33	1706
Dualband X/Ka			
7.15	45.19	61.78	1268
8.65	47.27	62.26	1171
9.15	45.86	61.36	1578
30.85	51.10	49.11	2892

2. VGOS-like station---Sheshan13

- Antenna control still in adjustment
- Receiver, in adjustment, especially due to RFI
- System, many modifications required

- ***Talking is always much easier than doing***.

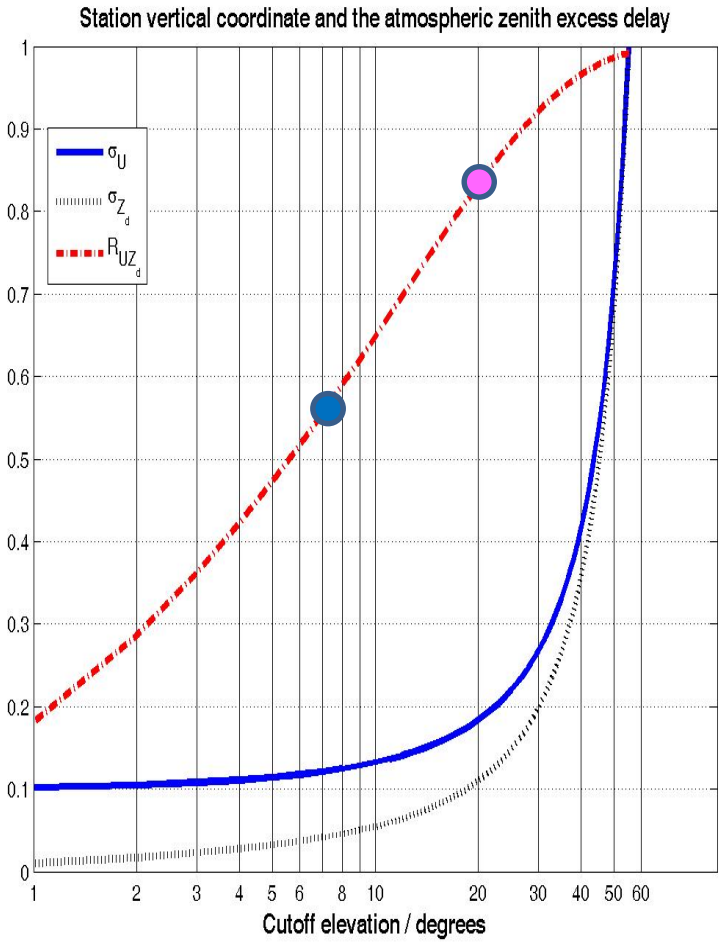
3. Thoughts on new VGOS station

To have a new site of VLBI station:

- ✓ Geological survey
- ✓ Check of historical records of climate, rainfall, snow, disastrous weather events
- ✓ Road, power, water, communication

- **3.1 Geometric shielding to a VLBI antenna**
- **3.2 Mutual shielding between two antennas**
- **3.3 Gaia celestial frame and Ka-band VLBI**
- **3.4 Supporting to deep space exploration**

3.1 Geometric shielding



Correlation coefficient between

- Vertical coordinate of station
- Excess zenith delay of atmosphere

$$R_{UZ_d} = -n \Big/ \left(\sigma_U \sigma_{Z_d} \right)$$

- **The coefficient is larger than 0.80 at elevation 20 deg.**
- **The coefficient is larger than 0.55 at elevation 7 deg.**

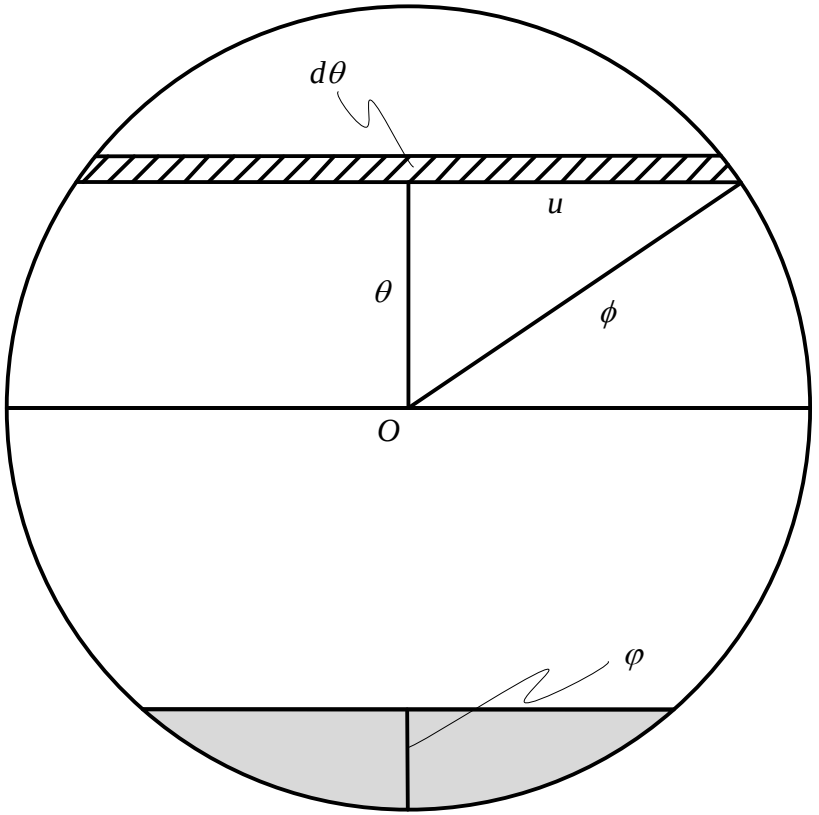
Significant geometric shielding should be avoided to get precise vertical coordinate

3.2 Mutual shielding

- The area of a crown part

$$S = 2R^2 \int_{-(\phi-\varphi)}^{\phi} \cos^{-1}\left(\frac{\cos\phi}{\cos\theta}\right)\cos\theta d\theta.$$

- The mutual shielding of two nearby antennas could be estimated.



3.3 Gaia frame and Ka-VLBI

- The Gaia project will provide a quasi-inertial optical CRF, **without EOP**
- **EOP** would be determined by terrestrial technique like VLBI
  - ➢ We need Ka-band VLBI observations to see further deep into the source

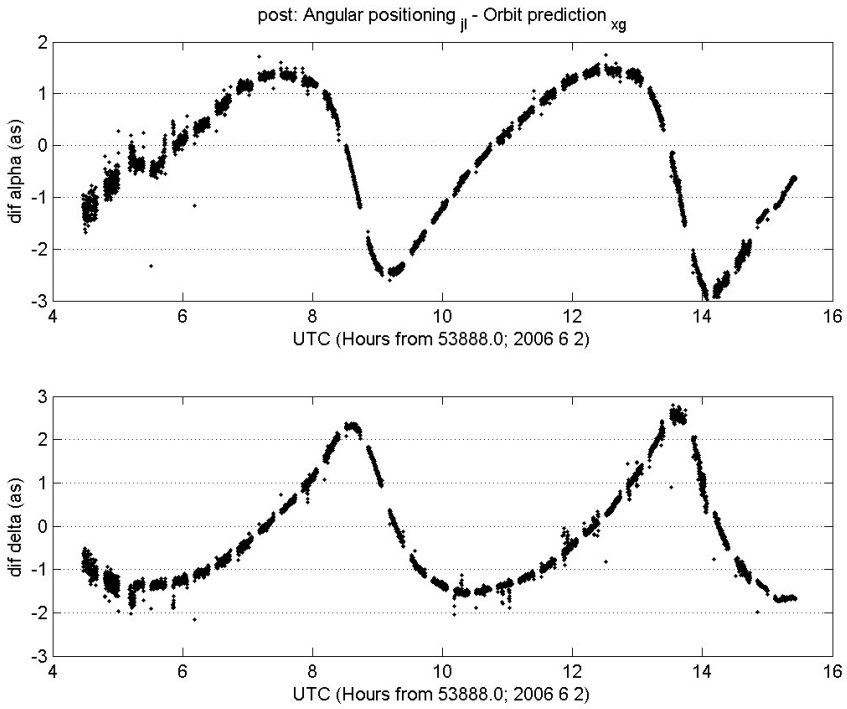
3.4 Supporting to DS exploration

- Compared to X-band, the advantages of VLBI at Ka-band, in terms of deep space exploration are:
  - ➢ high in telemetry data rate
  - ➢ high in VLBI tracking precision
  - ➢ helpful to mitigate detrimental effects of ionosphere and solar plasma on the observed time delay

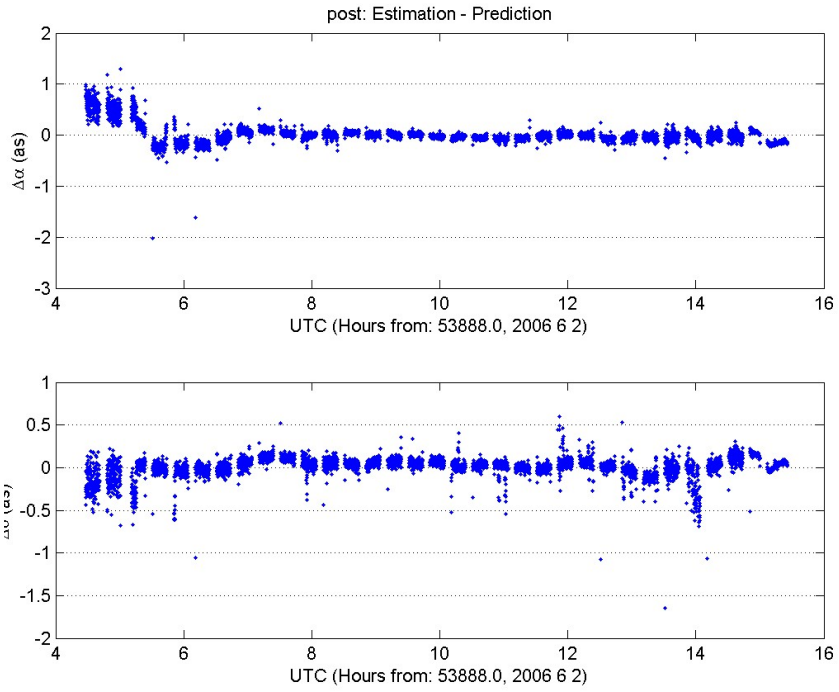
3.4 Supporting to DS exploration

Smart-1

Predicted



Reconstructed



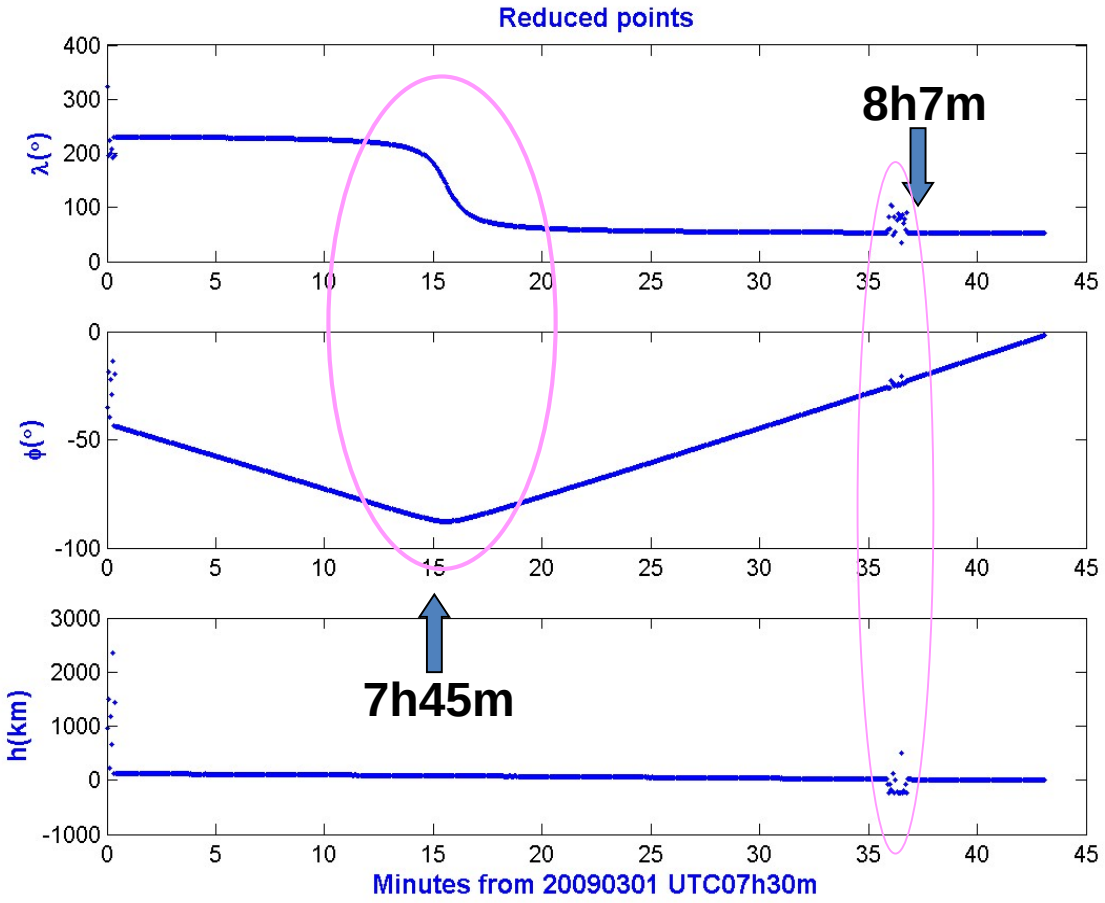
Monitoring the injection maneuver of the CE-1

--- Nov. 5, 2007

$(\vec{r}, \vec{v})$ ➔Osculating elements

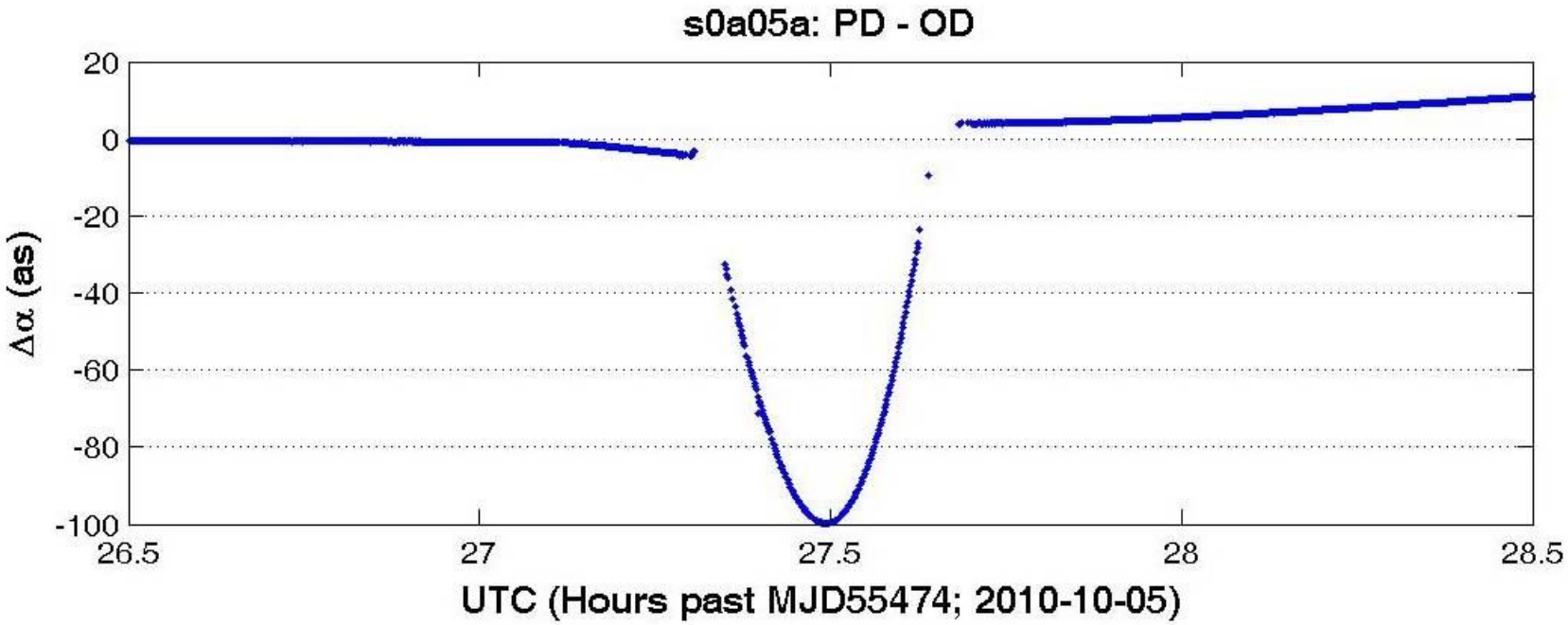
ymd	hms				
hyperbolic orbit				***Eccentricity***	
20071105	03:13:01	GC: M	a/km= 6618.708	e = 1.29441	Nb= 14
20071105	03:13:31	GC: M	a/km= 6641.511	e = 1.29340	Nb= 14
20071105	03:14:00	GC: M	a/km= 6664.319	e = 1.29238	Nb= 10
very near to a	**parabolic orbit**				
20071105	03:17:07	GC: M	a/km= 3406.991	e = 1.08194	Nb= 08
captured					
20071105	03:20:53	GC: M	a/km= 2990.028	e = 0.84911	Nb= 06
20071105	03:20:58	GC: M	a/km= 3016.474	e = 0.84918	Nb= 06
elliptic orbit					
20071105	03:42:01	GC: M	a/km= 6205.055	e = 0.68567	Nb= 12
20071105	03:42:30	GC: M	a/km= 6154.900	e = 0.68305	Nb= 12
20071105	03:43:00	GC: M	a/km= 6155.691	e = 0.68311	Nb= 12

The controlled landing of CE-1 on the Moon on 1 March 2009



The variation in the trace around UTC07h45m is corresponding to the orbit maneuver.

The tracking of the CE-2



- The curve corresponds the maneuver on 5 Oct 2010
- Before and after the curve, the results from PD and OD consistent with each other very well.
- During the maneuver the result from OD should not be reliable
- The Position Determination method could precisely monitor the trace evolution of the satellite

4. A related project

The Belt and Road Initiative

- Budget available for FOUR intern. VLBI stations
- Only TWO potential choices
  - ✓ **Chiang Mai, Thailand** **(Almost confirmed)**
  - ✓ **Matjiesfontein, South Africa** **(To be confirmed)**

- Looking for two more intern. partners
  - ✓ You, provide and prepare the site
  - ✓ SHAO provide the whole observation system
  - ✓ Both sides do the maintenance and share the data

Broad-band & X/Ka

Thank you!