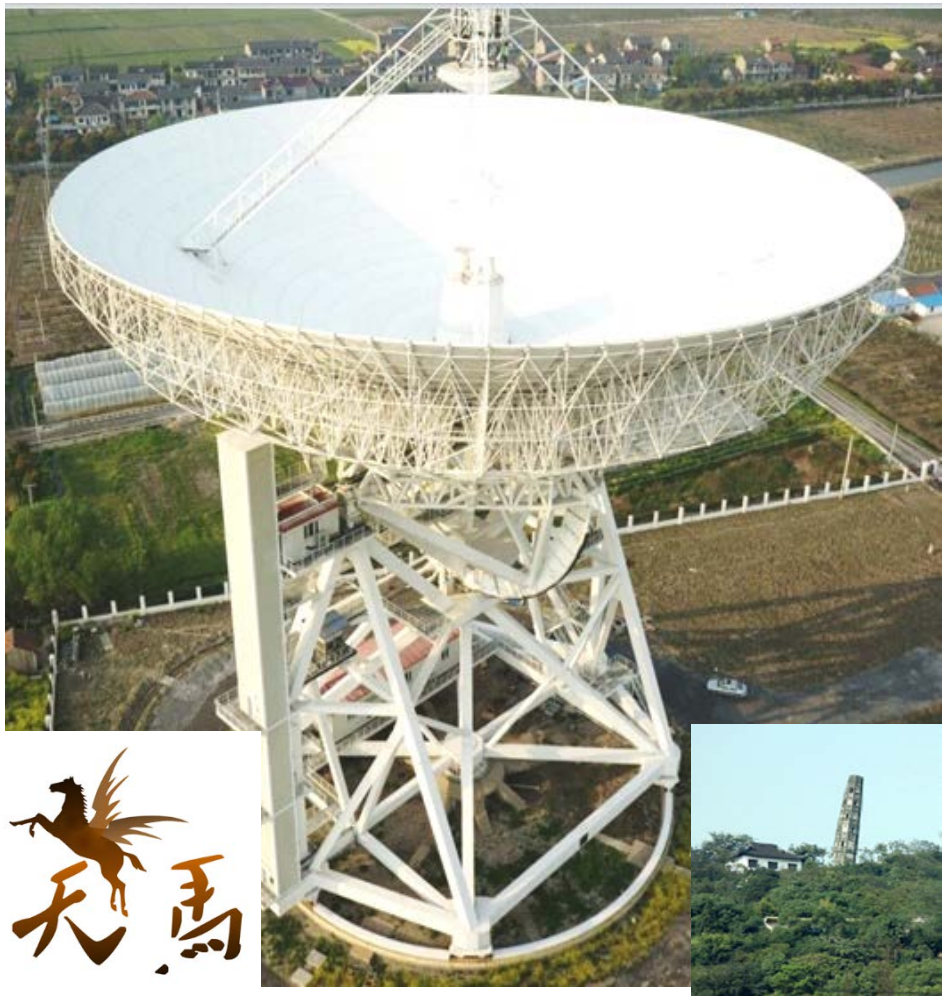
Report on TianMa Telescope (Shanghai 65m radio telescope)

Shanghai Astronomical Observatory

Liu Qinghui
Tianma telescope team



TianMa Telescope Team

No.	Name	Job
1	Shen zhiqiang	scientist/ team leader
2	Liu qinghui	technique
3	Li bin	receiver
4	Wang junzhi	scientist
5	Yan zhen	scientist
6	LI juan	scientist
7	Fan qingyuan	telescope
8	Ling quanbao	mechanical
9	Wang jinqing	telescope
10	Zhao rongbing	software
11	Fu li	mechanical
12	Zhong weiye	receiver
13	Wang lingling	Time/freq.
14	Dong jian	software

No.	Name	Job
15	Wu yajun	terminal
16	Xia bo	observation
17	Jiang yongbin	observation
18	Yu linfeng	observation
19	Gou wei	observation
20	Zuo xiuting	observation
21	Jiang yongchen	observation
22	Sun yunxia	observation
23	Chen ying	observation
24	Guo wen	observation
25	Lu xuejiang	observation
26	Chen qiang	observation
27	Shao jie	observation
28	He wenting	secretary
29	Wu fang	secretary

Content

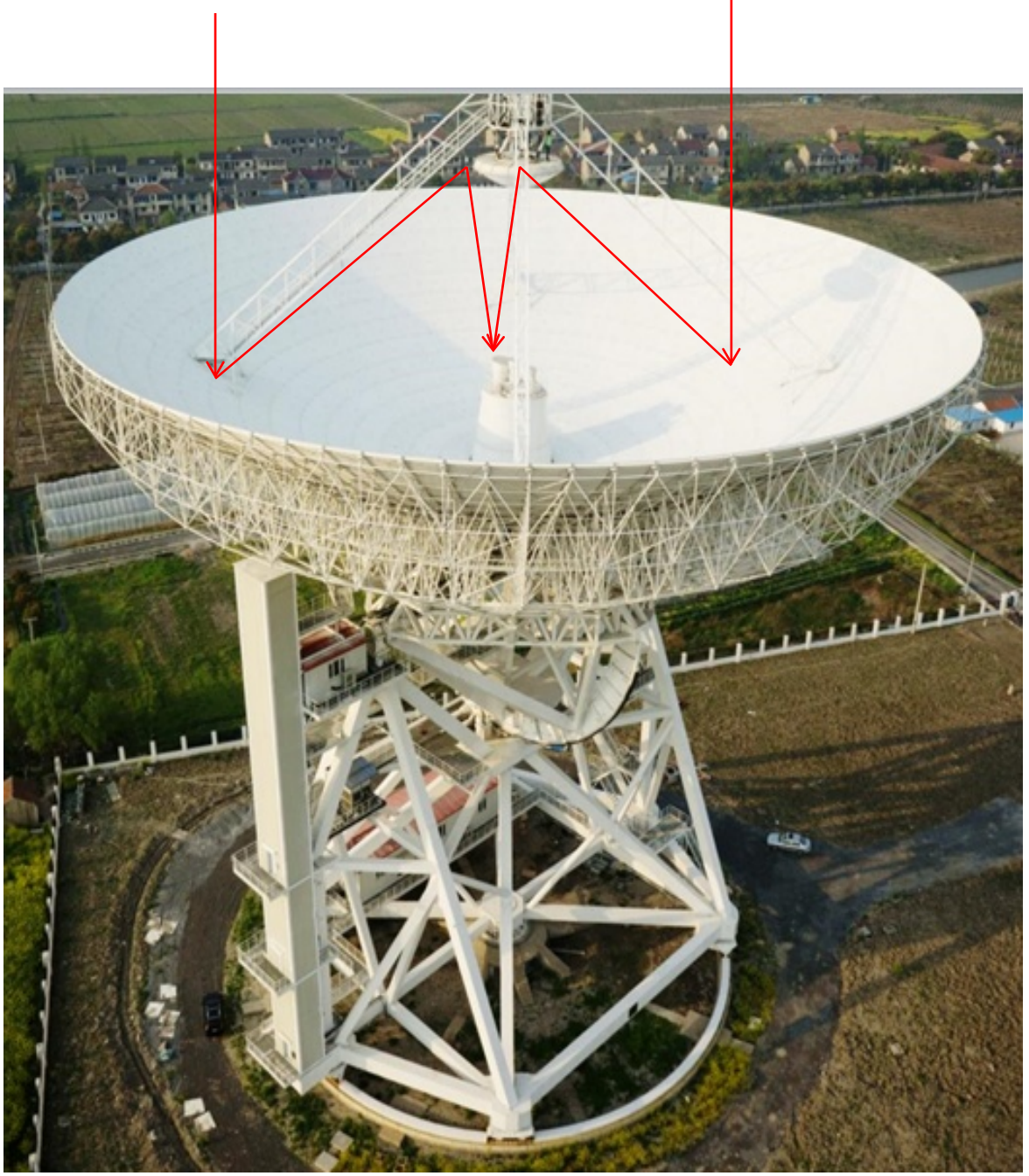
1. Construction and test

2. Radio astronomical observation

3. Applications in deep spacecraft

Brief introduction

Tianma Telescope is a steerable radio telescope with a diameter of 65 m, built during 2009-2013. Tianma Telescope greatly improves the measurement capabilities of Chinese VLBI network and plays an important role in deep space exploration and astronomy researches.

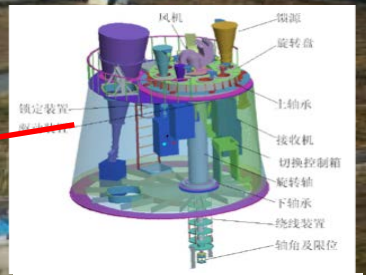


Preliminary results of Tianma telescope

- **Tianma telescope has successful tracked Chinese lunar mission ChangE-2 in 2012, Lunar soft landing mission ChangE-3 in 2013, ChangE-5 flight test mission in 2014 for VLBI orbit determination, and has made "outstanding contributions".**
- **Tianma telescope successfully carries out observations for spectra lines, pulsar and VLBI radio astronomy, and opened to the outside world.**

Tianma Telescope major innovative points

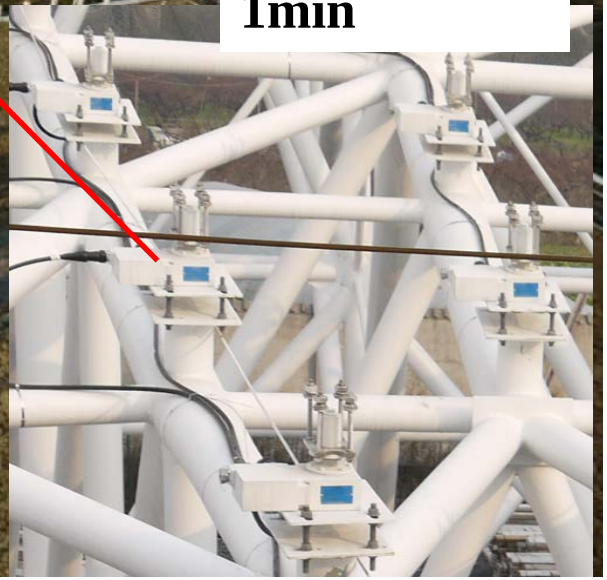
Six-link parallel adjustment of sub-reflector 0.05mm



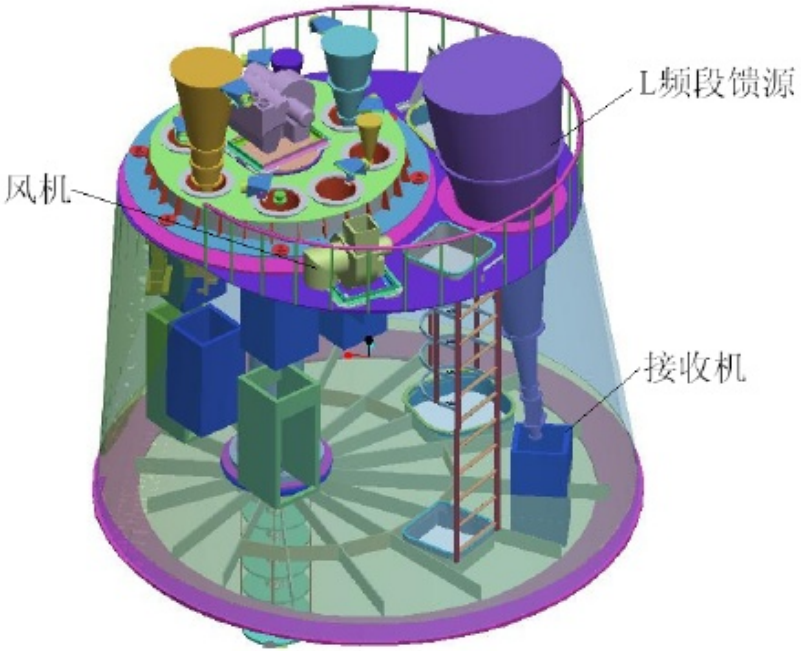
Automatic feed-rotating 1min

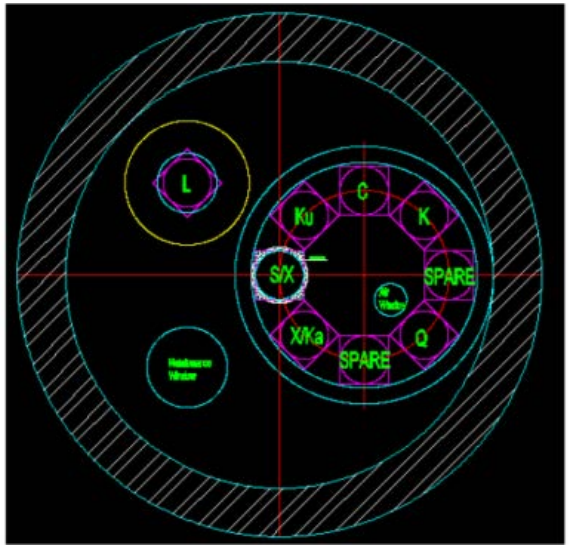
Seamless welded azimuth track 0.5mm

Active Surface System 0.015mm



Automatic feed-rotating mechanism

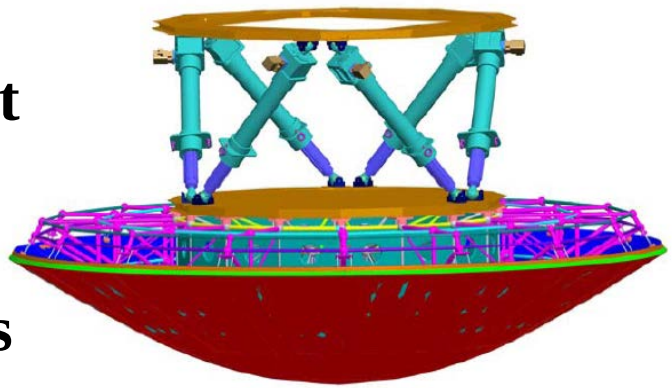


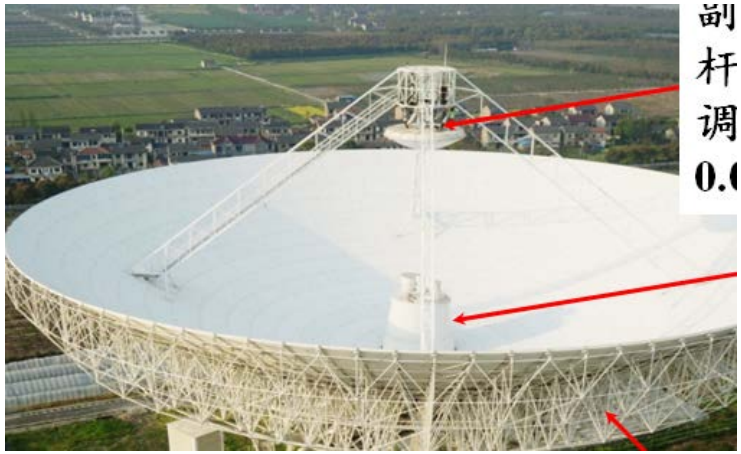


Completing observation band switching within 1 min

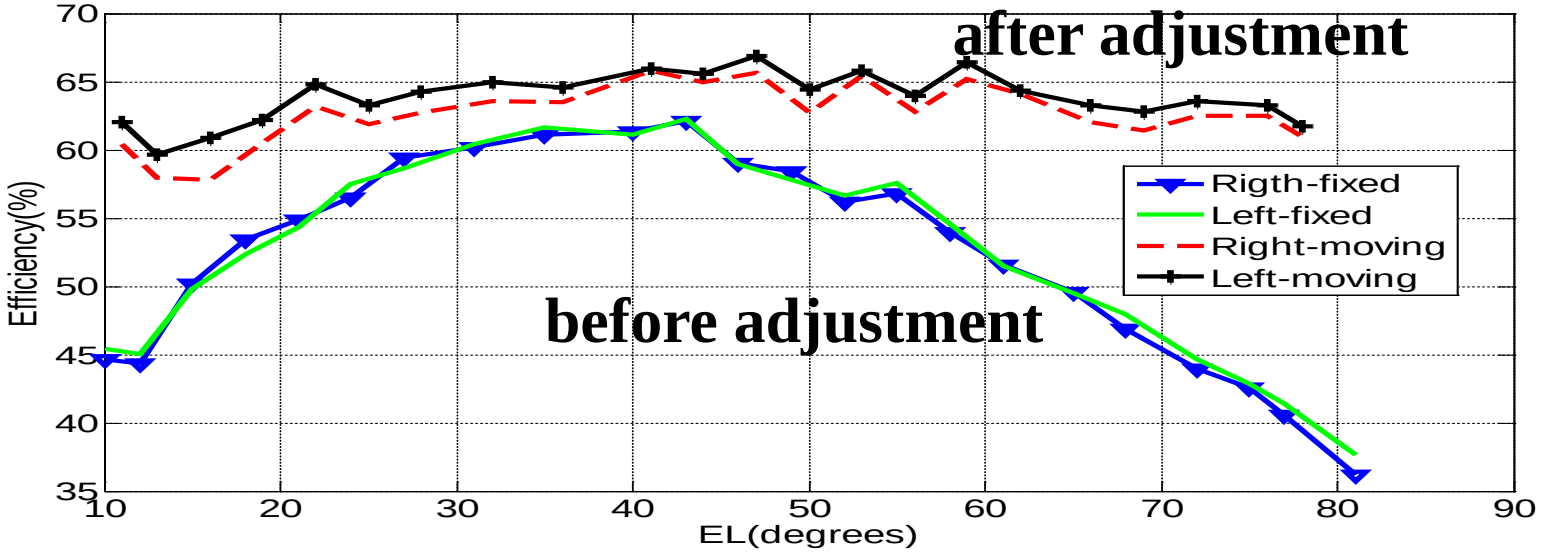
Six-link parallel adjustment of sub-reflector

X、Y、Z Adjustment amount: A few centimeters





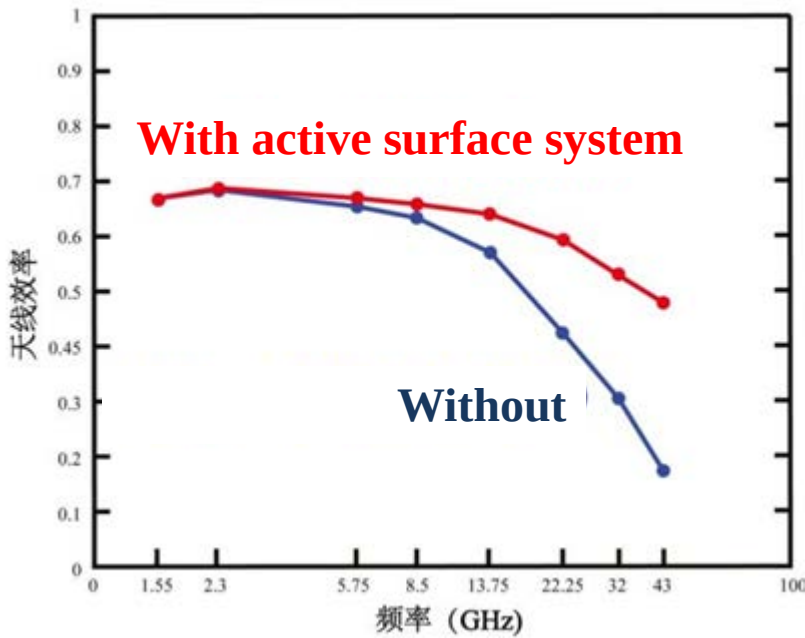
The left- and right-hand circular polarization efficiency of X band before and after adjustment of sub surface position and orientation.



Active surface system

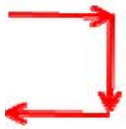
Actuators: 1104

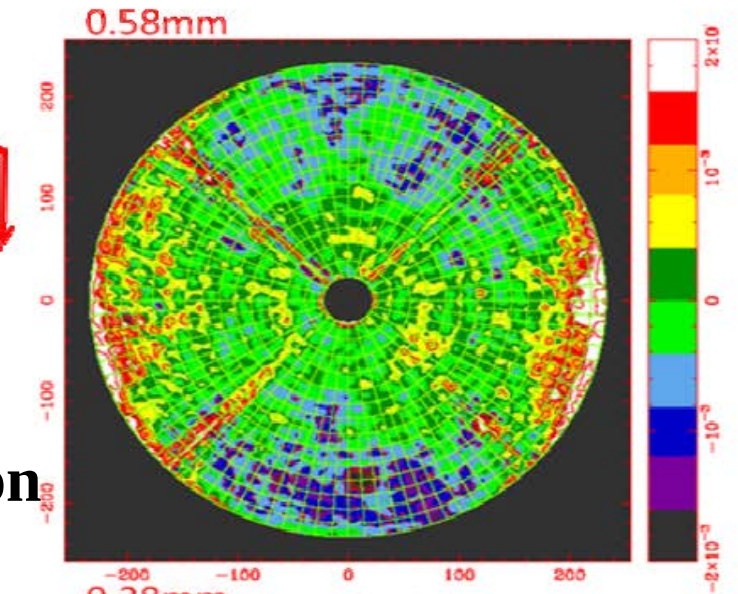
Range±15mm, accuracy 0.015mm

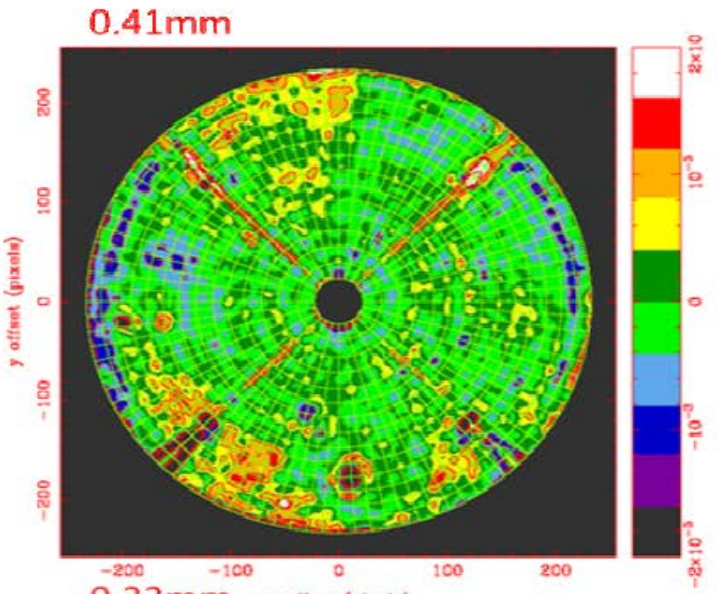


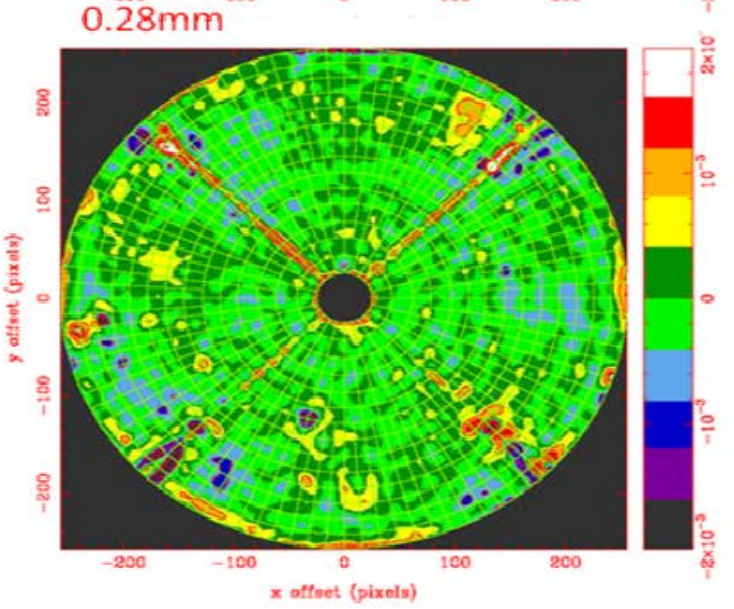
Surface accuracy of main reflector measured by using holographic technique

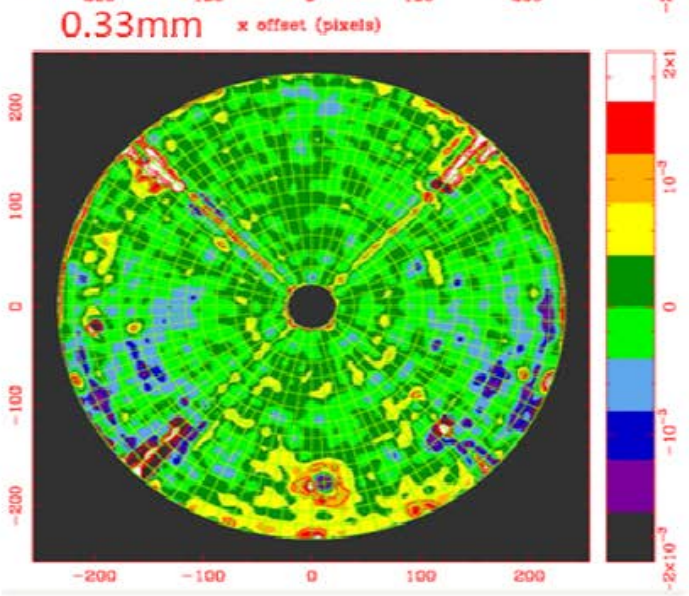
Elevation 52deg



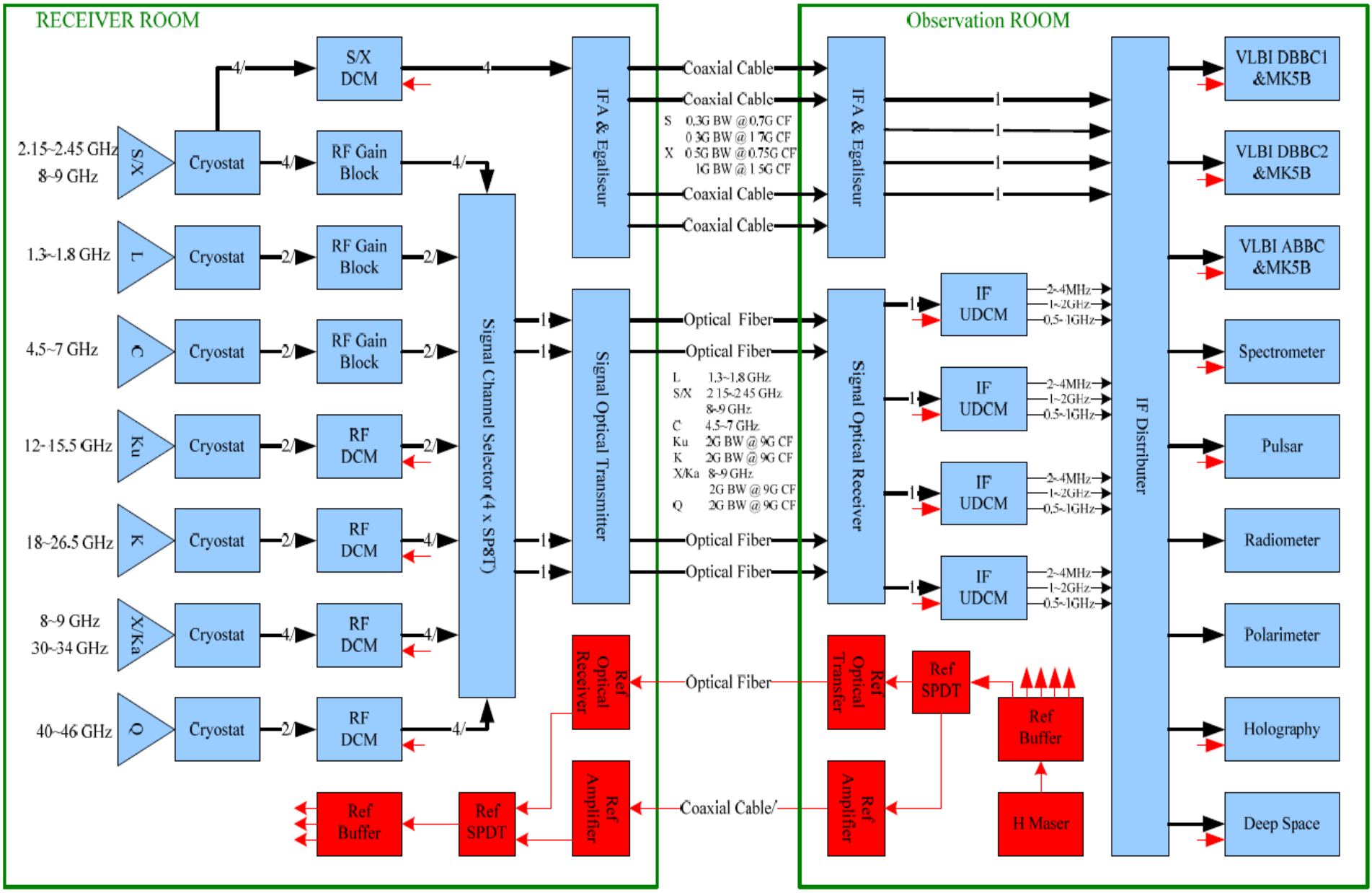




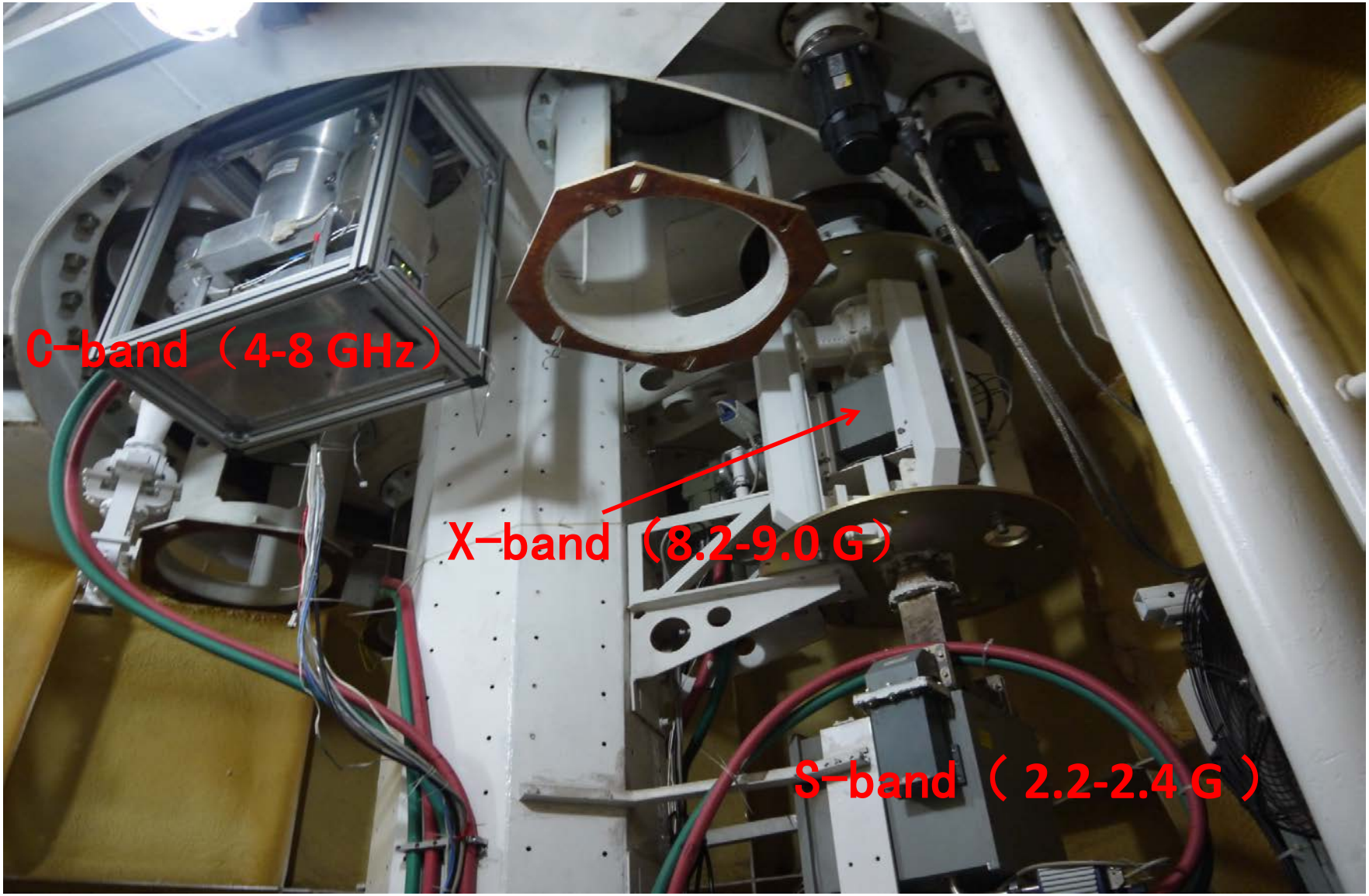




Receiving system of Tianma telescope



S/X and C-band receivers



L, K, Q-band receivers developed by SHAO

1.25-1.75

18-26.5

35-50 GHz

Receiving system

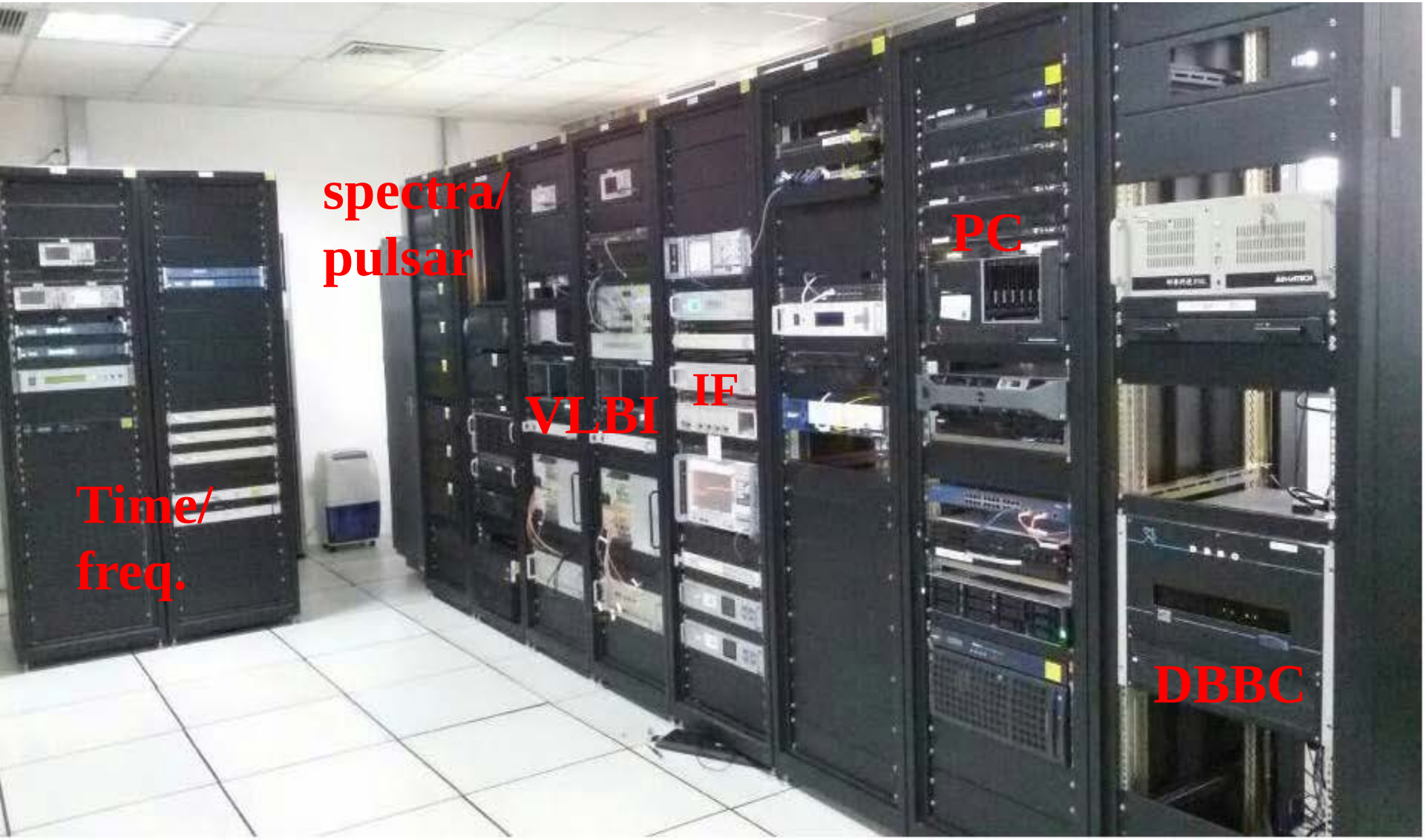
Band	L	S	C	X	Ku	K	Ka	Q
Wavelength	18&21cm	13cm	5&6cm	3.6cm	2.2cm	1.3cm	9mm	7mm
Freq(GHz)	1.25-1.75	2.2-2.4	4-8	8.2-9.0	12-18	18-26.5	30-34	35-50
BW(GHz)	0.50	0.20	4.00	0.80	6.00	8.50	4.00	15.00
BW/CF(%)	33	9	67	9	40	38	13	35
T(Sky)(k)	12	12	10	10	12	25	25	26
T(Rx)(K)	10	21	10	22	15	35	35	40
T(Sys)(K)	26	33	20	32	27	60	60	66
Feed Type	Compact	Conical	Conical	Conical	Conical	Compact	Conical	Compact
Efficiency	55%	60%	65%	55%	55%	50%	50%	45%
Polarization	Dual Circ	Dual Circ	Dual Circ	Dual Circ	Dual Circ	Dual Circ	Dual Circ	Dual Circ
Refrigerator	1020	1020	350	1020	350	408S2	408S2	1020
Status	Installed	Installed	Installed	Installed	Installed	Installed	Installed	Installed

Comparison TMRT with other telescopes

		GBT	Effelsberg	Parkes	Lovell	Tianma
L	Freq	1.15-1.73	1.27-1.45, 1.59-1.73	1.2-1.8	1.25-1.50, 1.55-1.73	1.25-1.75
	SEFD	10	20,19	31	36,65	31
S	Freq	1.73-2.6	2.20-2.30	2.2-2.5	-----	2.2-2.4
	SEFD	12	300	25	-----	≥31
C	Freq	3.95-5.85	5.75-6.75	4.5-5.1	6.0-7.0	4.0-8.0
	SEFD	10	25	61	80	28
X	Freq	8.00-10.1	7.9-9.0	8,1-8.7	-----	8.2-9.0
	SEFD	15	18	170	-----	≥38

Note: System Equivalent Flux Density (SEFD): $SEFD = \frac{2k_B T_{sys}}{A_e}$

Terminals



Terminals

VLBI（CDAS,DBBC）

Spectra line/pulsar（DIBAS）

Content

1. Construction and test

2. Radio astronomical observation

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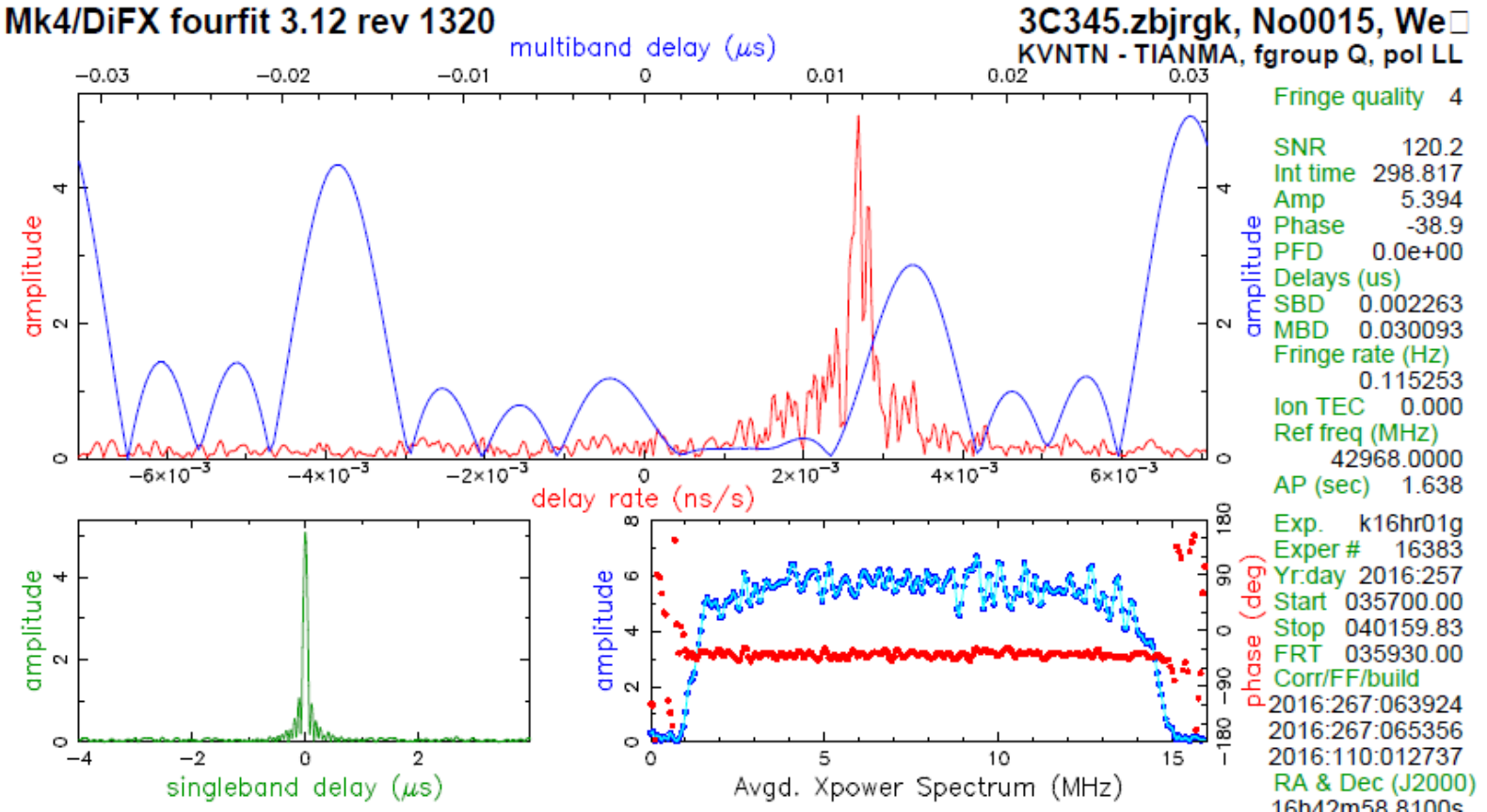
EVN and IVS VLBI observations

- **Tianma telescope has taken part in EVN VLBI observations at L , C and S/X band since 2015, and sometime was selected as the reference telescope in data processing.**
- **Tianma telescope also took part in EVN e-VLBI observations with a data transfer rate of 1 Gbps.**
- **Tianma telescope took part in IVS conventional observations for 5 times in 2015, and planning for 7 times in 2016.**

coordinate	position (mm)	Position error (mm)	velocity (mm/yr)	Velocity error (mm/yr)
X	-2826708649.89	7.305	-31.42	5.600
Y	4679237081.85	11.773	-17.47	7.517
Z	3274667547.20	8.408	-16.80	6.114

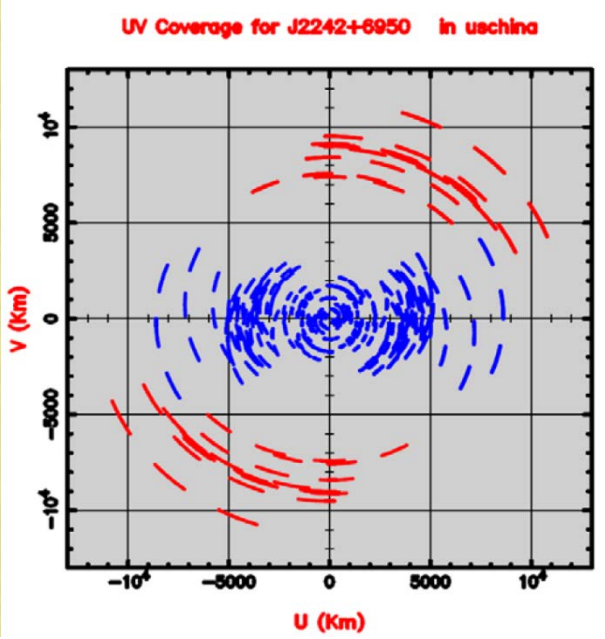
East Asia VLBI observations

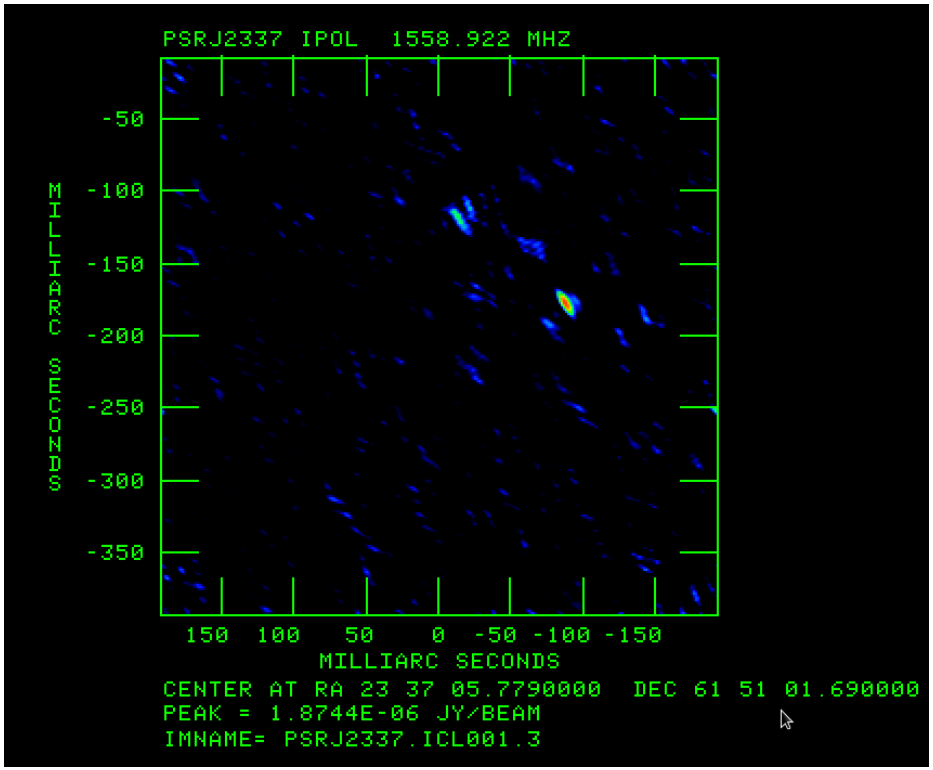
Tianma telescope successfully participates in VLBI observations with Korea 3 stations and Japan 4 stations at 43 GHz.These results show that Tianma telescope has VLBI observation ability at Q-band.

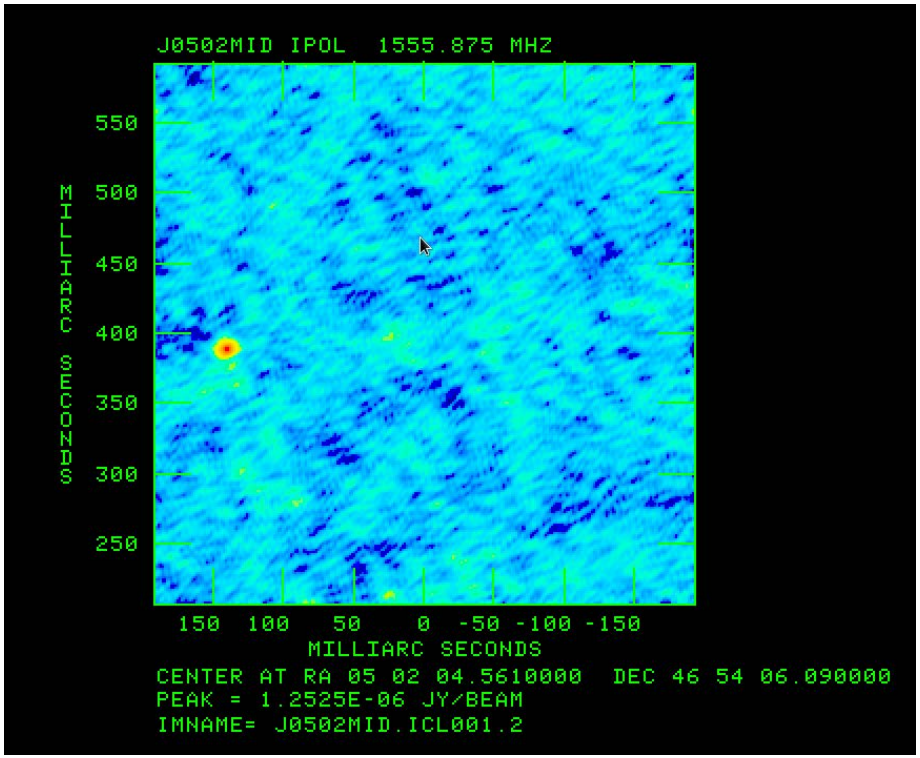


Tianma-VLBA VLBI observation

- **Mapping results for pulsar B2334 + 61 and B0458 + 46. The measuring accuracy was improved by about three times.**







Tianma pulsar observation

The DIBAS pulsar observation modules were finished and installed at Tianma telescope in June 2014. This backend supports four principal pulsar observation modes:

[1] coherent dedispersion search;

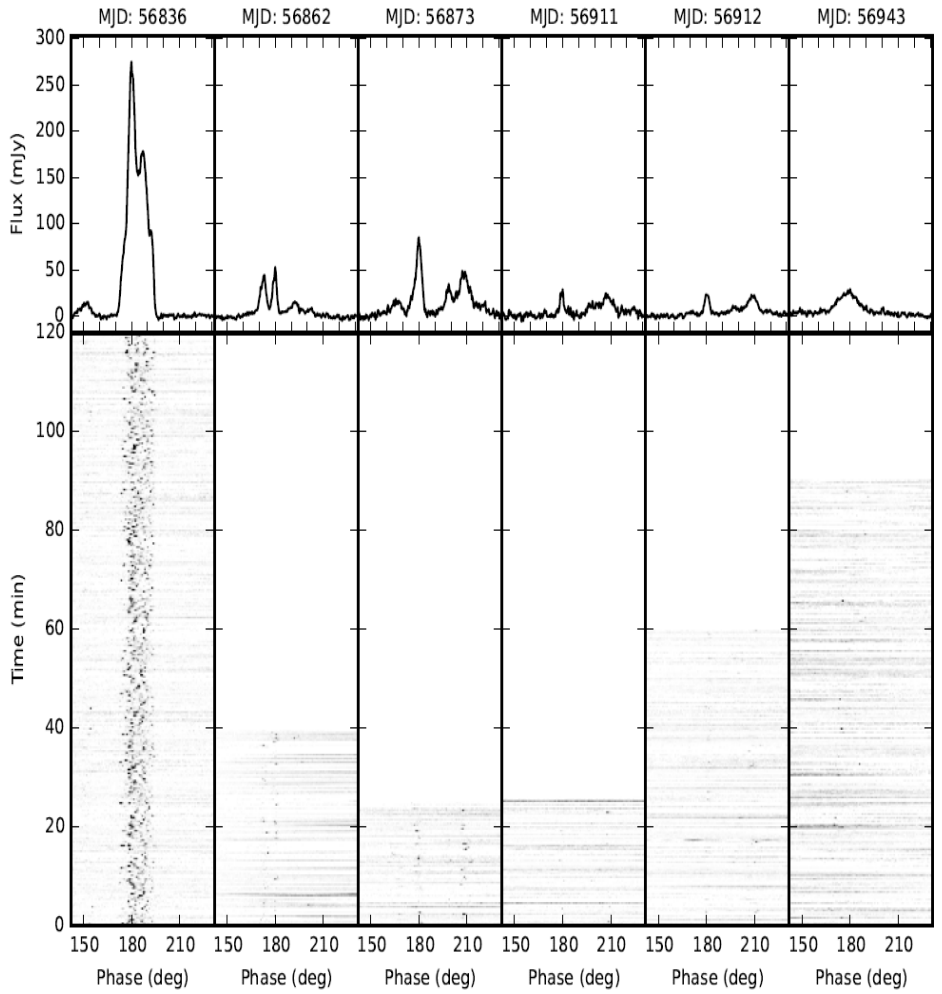
[2] incoherent dedispersion search;

[3] coherent online folding;

[4] incoherent dedispersion online folding.

Pulsar observation

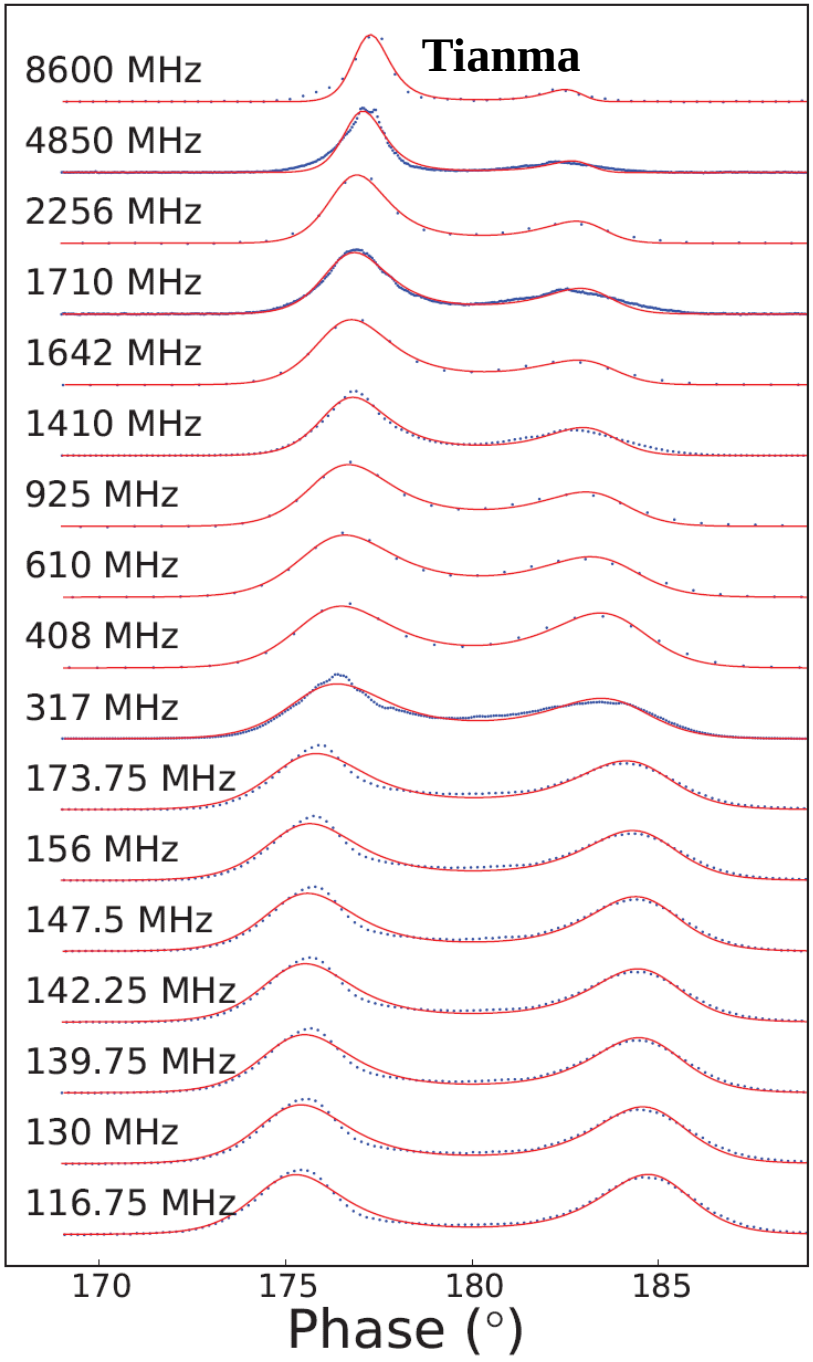
A batch of pulsars have been detected at L、S、C and X band, including the pulsar with the shortest rotational period on the northern sky and the magmetar around the Galactic center. One case of strong radio flare of the magmetar PSR J1745-2900 was detected by the TMRT at X-band.



Integrated profiles and phase–time plots of magnetar J1745–2900

Pulsar observation

The pulsar PSR B1133 + 16 multi-frequency integral profiles. The highest frequency (8600 MHz) results were obtained by using Tianma telescope.



DIBAS spectra line observation model

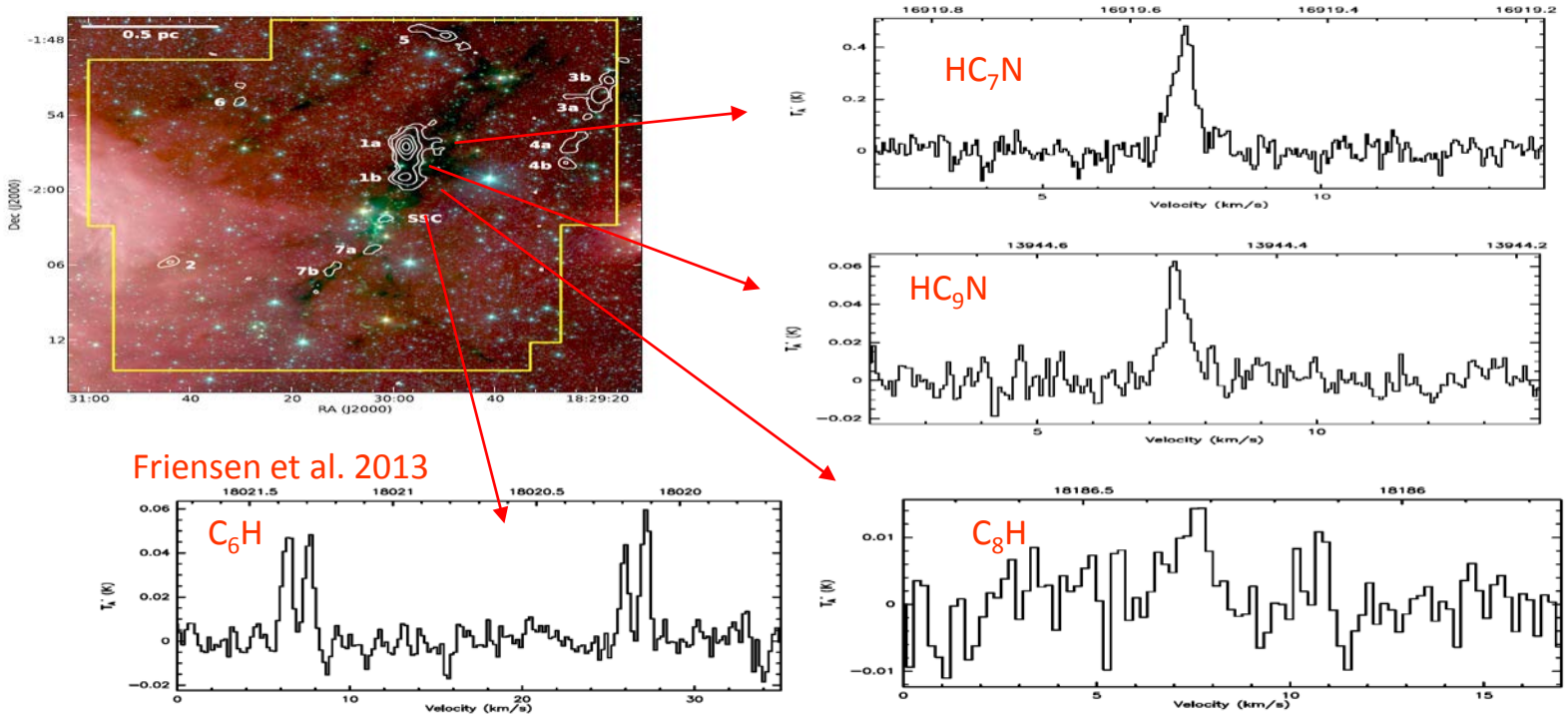
- Total support 29 observation model
- The highest resolution is 20 Hz
- The maximum bandwidth is 1.5 GHz

表2　谱线模式参数表

Table 2　The parameters of molecular line observing modes

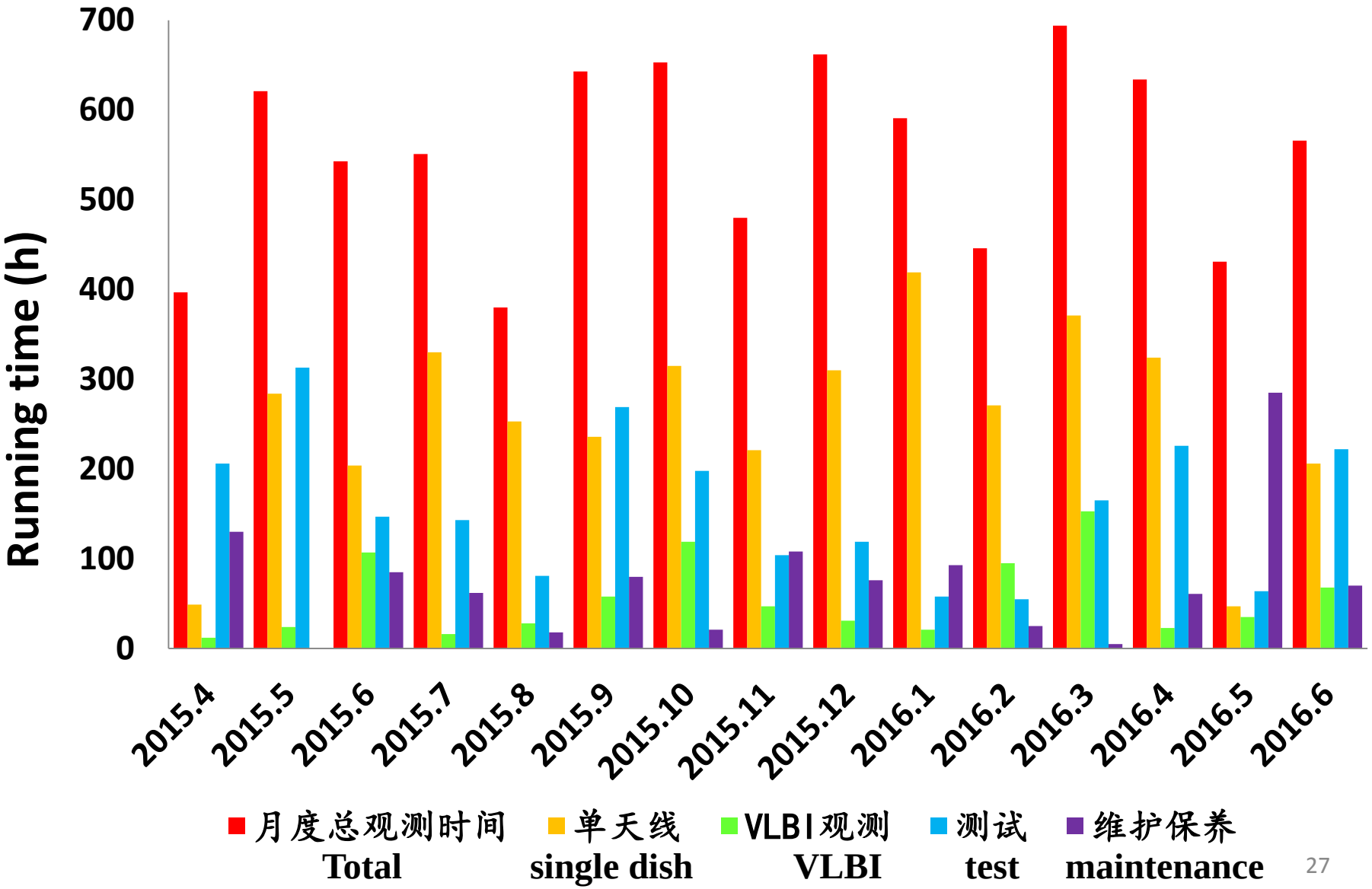
模式	N_{band}	BW (MHz)	N_{chan}	Δf (kHz)	Δv (km s^{-1}) 45GHz	22.5GHz	9GHz	6.7GHz	1.7 GHz
1	1	1500	1024	1465	9.8	19.5	49	66	259
2	1	1500	16384	92	0.6	1.2	3.1	4.1	16.2
3	1	1000	16384	61	0.4	0.8	2.0	2.7	10.8
4	1	187.5	32768	5.7	0.04	0.08	0.19	0.26	1.01
5	1	187.5	65536	2.9	0.02	0.04	0.10	0.13	0.51
6	1	187.5	131072	1.4	0.01	0.02	0.05	0.06	0.25
7	1	100	32768	3.1	0.02	0.04	0.1	0.14	0.55
8	1	100	65536	1.5	0.01	0.02	0.05	0.07	0.26
9	1	100	131072	0.8	0.005	0.01	0.03	0.036	0.14
10	1	23.44	32768	0.7	0.005	0.009	0.023	0.031	0.124
11	1	23.44	65536	0.4	0.003	0.0053	0.013	0.018	0.07
12	1	23.44	131072	0.2	0.0013	0.0026	0.0067	0.009	0.035
13	1	23.44	262144	0.1	0.0007	0.0013	0.0033	0.0045	0.018
14	1	23.44	524288	0.05	0.00035	0.00065	0.00165	0.00225	0.009
15	1	11.72	32768	0.4	0.003	0.0053	0.013	0.018	0.07
16	1	11.72	65536	0.2	0.0013	0.0026	0.0067	0.009	0.035
17	1	11.72	131072	0.1	0.0007	0.0013	0.0033	0.0045	0.018
18	1	11.72	262144	0.05	0.00035	0.00065	0.00165	0.00225	0.009
19	1	11.72	524288	0.02	0.00013	0.00026	0.00067	0.0009	0.0035
20	8	23.44	4096	5.7	0.038	0.076	0.19	0.26	1.01
21	8	23.44	8192	2.9	0.02	0.04	0.1	0.13	0.51
22	8	23.44	16384	1.4	0.01	0.02	0.05	0.06	0.25
23	8	23.44	32768	0.7	0.005	0.009	0.023	0.031	0.124
24	8	23.44	65536	0.4	0.003	0.0053	0.013	0.018	0.07
25	8	15.625	4096	3.8	0.025	0.051	0.13	0.17	0.67
26	8	15.625	8192	1.9	0.013	0.025	0.063	0.085	0.34
27	8	15.625	16384	0.95	0.006	0.013	0.032	0.043	0.17
28	8	15.625	32678	0.48	0.0032	0.0064	0.016	0.021	0.085
29	8	15.625	65536	0.24	0.0016	0.0032	0.008	0.011	0.042

Detection of long carbon-chain molecules in Serpens South with TMRT (Li et al. 2016, ApJ, 824, 136)



We detect several long carbon-chain molecules, including HC_5N, HC_7N, HC_9N, C_6H, C_8H, HC_3N and its ^{13}C isotopes toward Serpens south 1a with TMRT. We detected some new transitions and resolved some hyperfine components for the first time in the ISM. This is the third molecular cloud detected in HC_9N and C_8H. The column densities of these long carbon-chain molecules are almost comparable to those in TMC-1, and hence, like Lupus-1A, this source could also be regarded as "TMC-1 like cloud".

Tianma Running time (2015.4-2016.6)



Tianma telescope is open to researchers

Call for proposals-Spectroscopic observations with Tianma 65m telescope

2014-12-25 | 编辑： | 【大 中 小】【打印】【关闭】

Dear Colleagues,

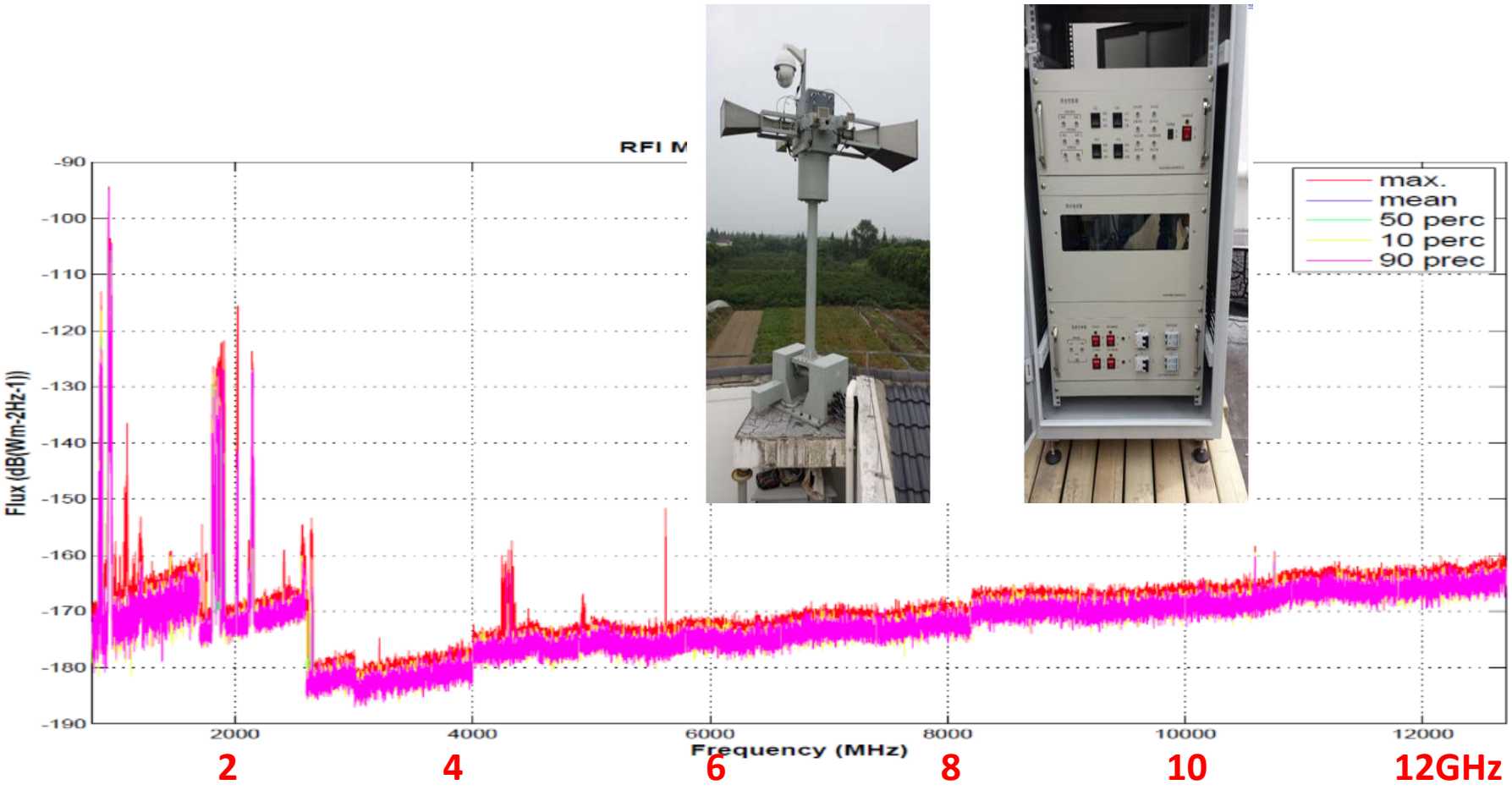
We wish to draw your attention to call for proposals of spectroscopic observations with the Tianma 65m telescope. With the hard work of technical staffs at the Tianma 65m telescope, we now have three sets of receiver on the telescope ready for spectroscopic observations as L (1.25-1.75GHz), S (2.2-2.4 GHz)/X (8.2-9.0 GHz), and C (4-8GHz) bands. The typical system temperature at these receiver bands is about 30 K, while the main beam efficiency below 10 GHz is about 60%. The DIBAS backend can provide 29 modes of different frequency resolutions, from 0.022 kHz to 1464.8 kHz. For more detailed information of the receivers and backend, please read the file in link from the website

http://www.shao.ac.cn/xwzx/kydt/201412/t20141225_4281825.html.

For each proposal, please include a cover letter and the main text part. The cover letter should have an abstract, information of PI and Co-Is (Name, Institute, email, etc.), and time requests (LST ranges, receivers, backend setups), while the main text part should include Scientific Justification and Technical Justification. The proposals should be in English with one page of cover letter and the main text should be less than 3 pages including figures, tables and references. Please use the template tex file in the website mentioned above.

The deadline will be February 10, 2015, 17:00 (Beijing time) and this call for proposals will cover the observing period from April 15, 2015 to September 30, 2015. In this call for proposal, the PI's institute should be within China. Please send the file to tac-65m@shao.ac.cn before the deadline. If you have any technical questions, please send email to help-line-65m@shao.ac.cn .

We built RFI monitoring platform at Tianma telescope. RFI is strong at L and S band, very little at X and above bands. C band has a little interference



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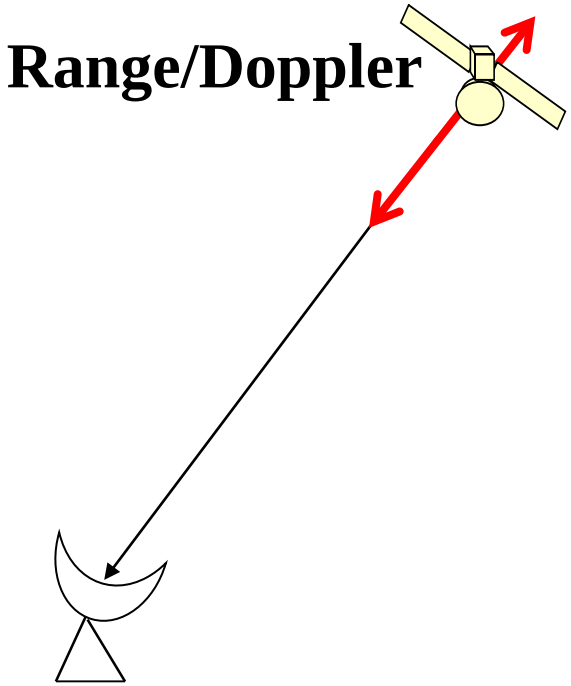
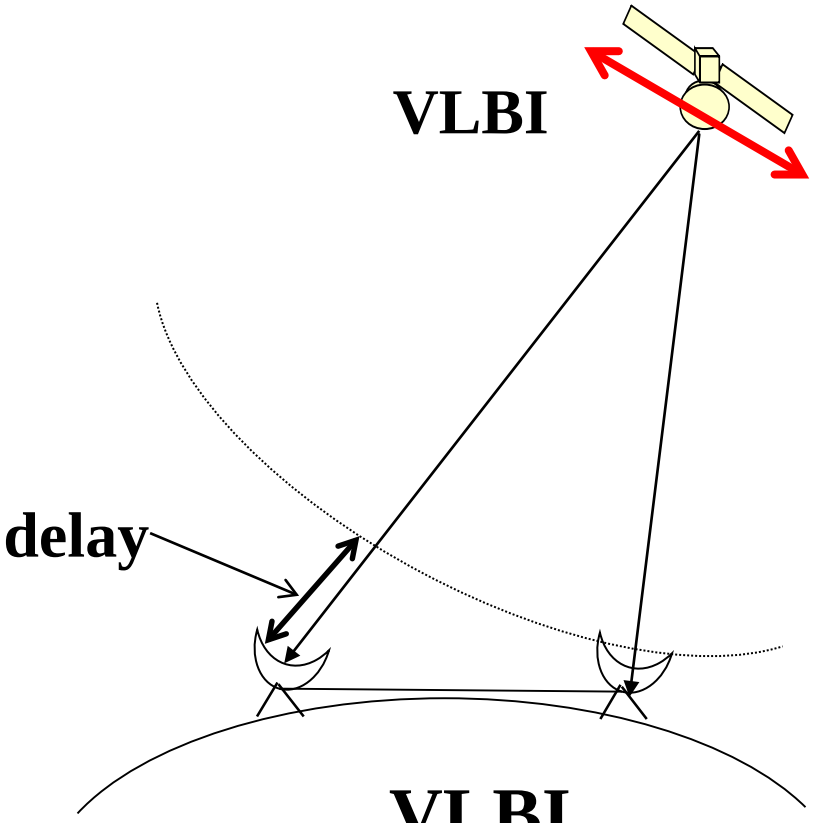
3. Applications in deep spacecraft

VLBI for tracking spacecraft

Tianma telescope has successful tracked Chinese lunar mission CE-2, CE-3 and CE-5T1



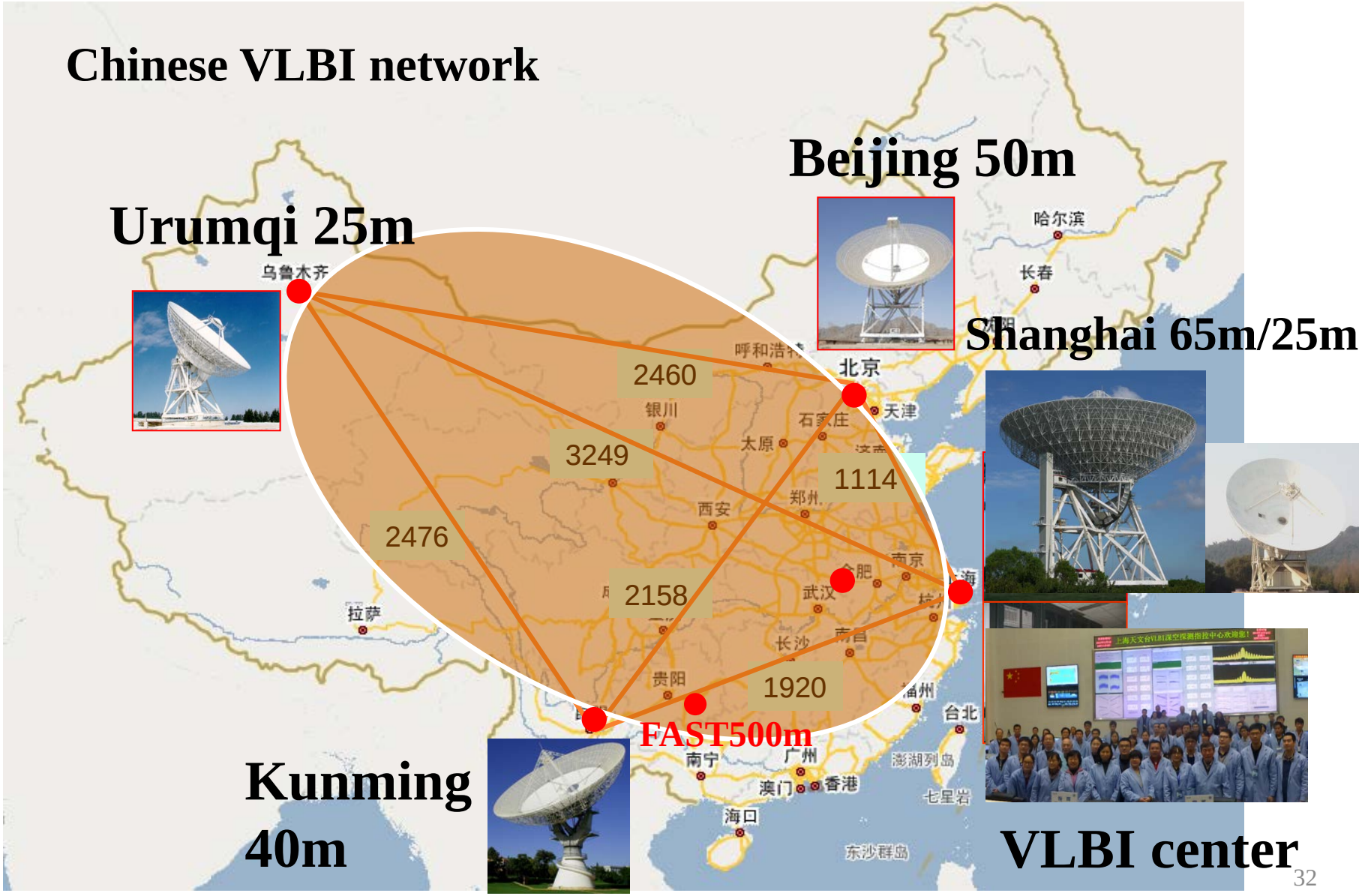
Range/ Doppler



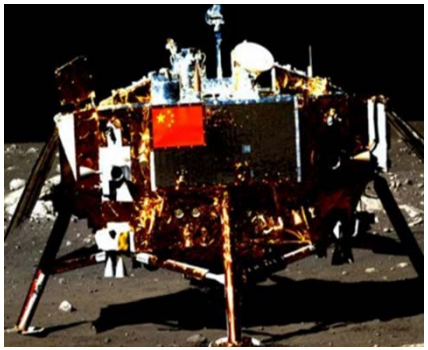
VLBI

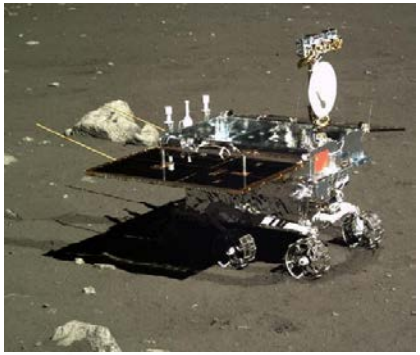
(Very Long Baseline Interferometer)

Chinese VLBI network



CE-3 Orbit

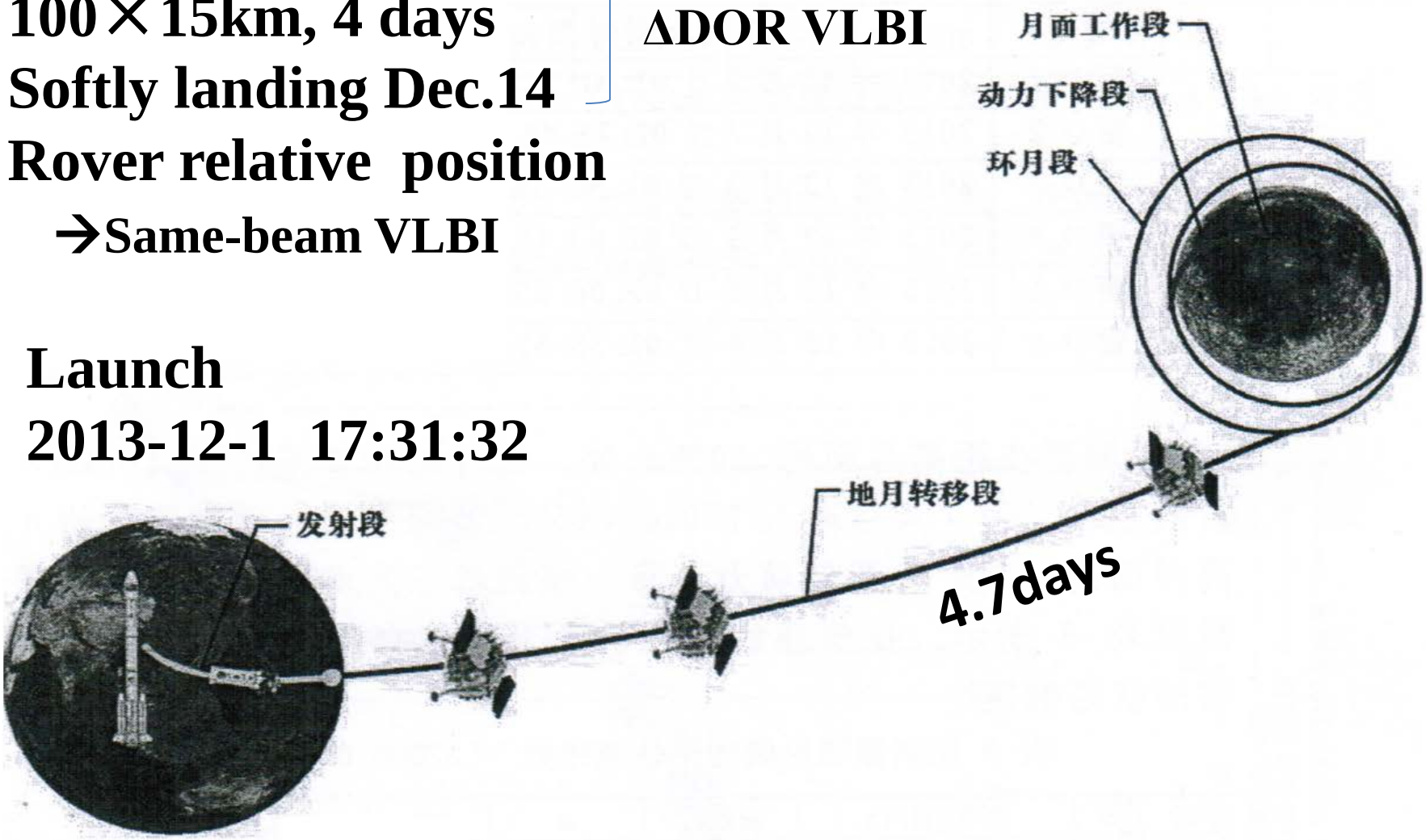




Flying to moon
100×100km, 4 days.
100×15km, 4 days
Softly landing Dec.14
Rover relative position
→Same-beam VLBI

ΔDOR VLBI

Launch
2013-12-1 17:31:32



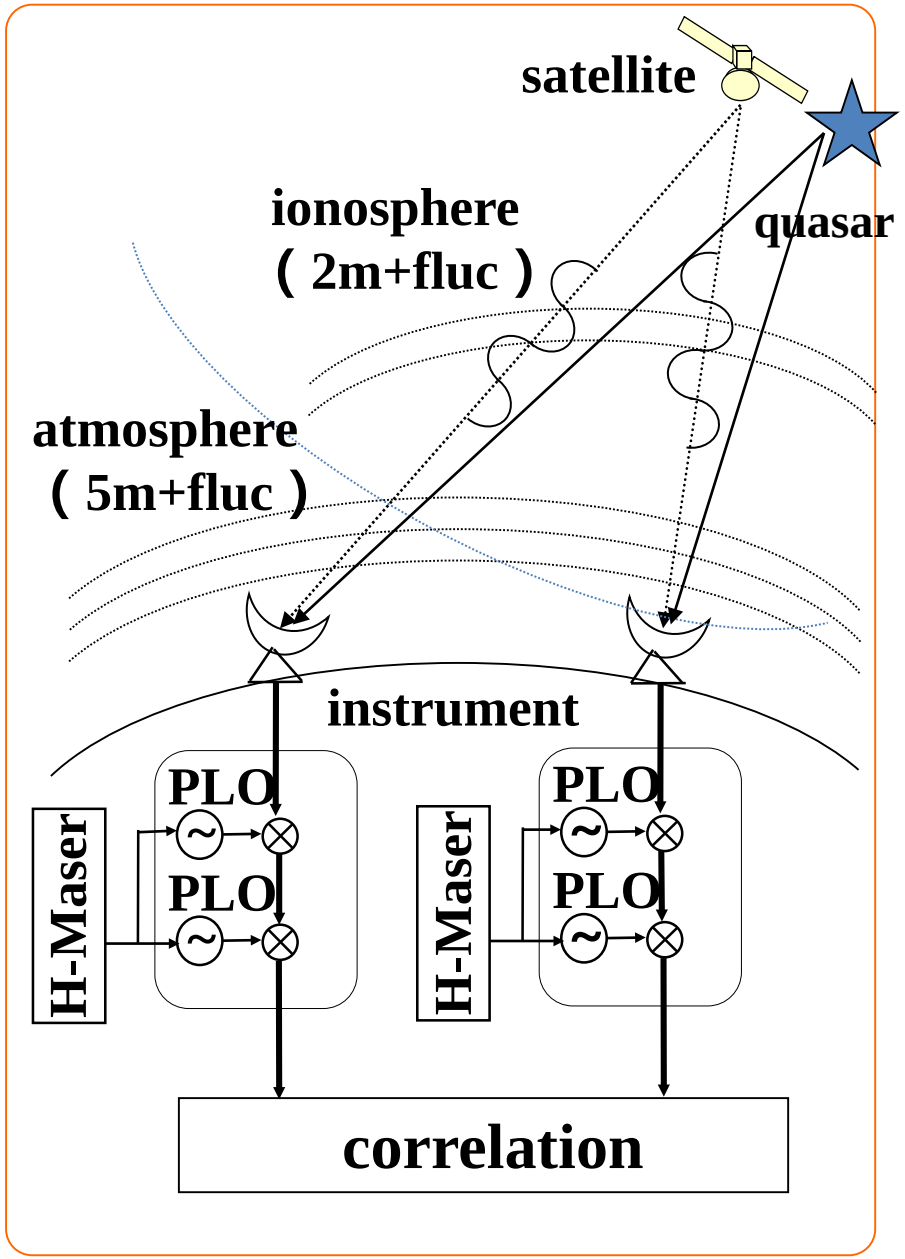
High-accuracy VLBI

Observation mode

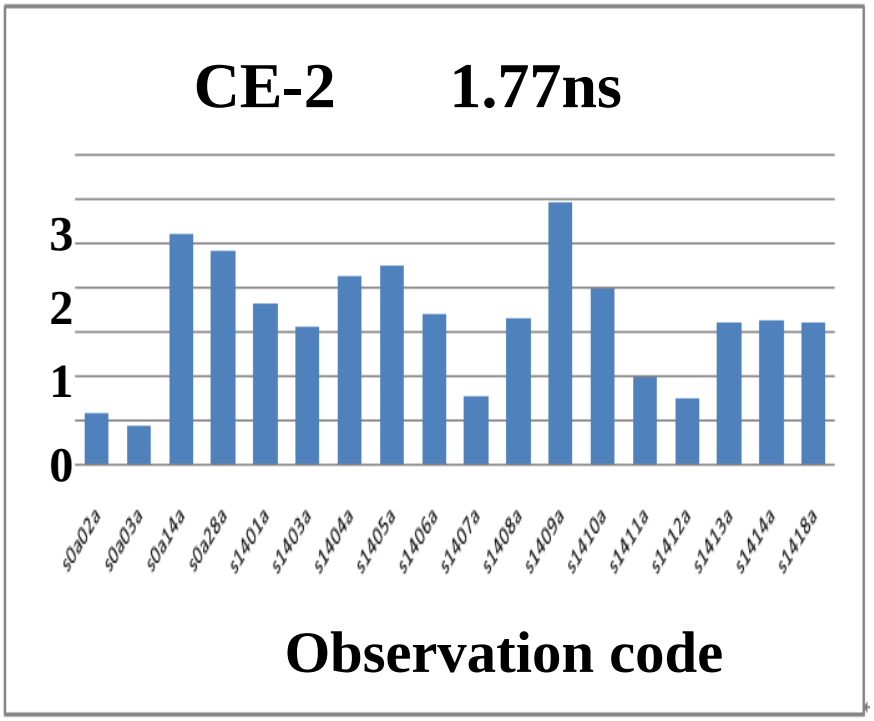
Quasar	sat	quasar	sat	quasar	sat
5m	5m	5m	5m	5m	5min

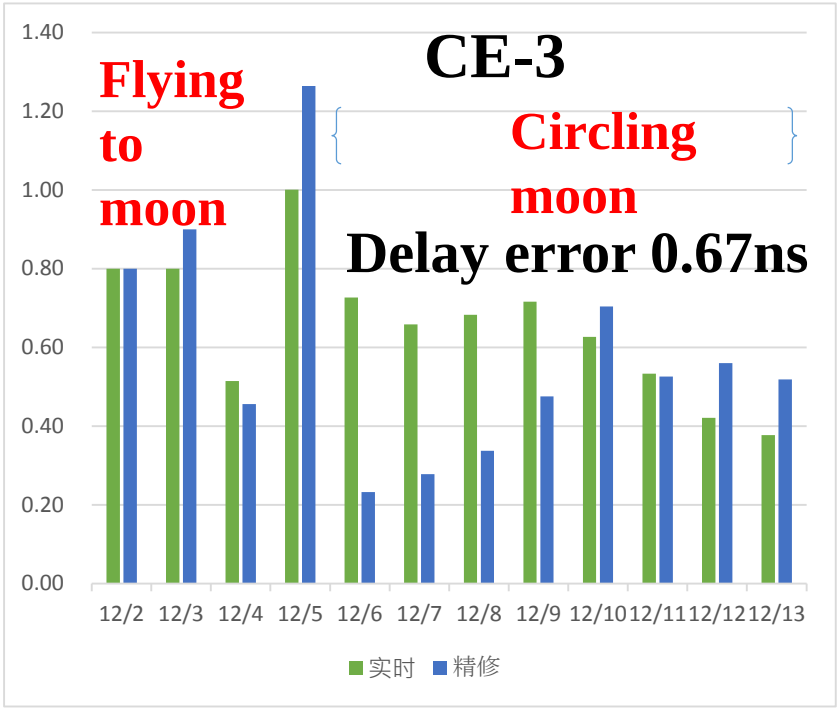
Tianma telescope contribution

- **A substantial increase in observation sensitivity.**
- **A large expansion of choice of the radio source near spacecraft, improve the accuracy of the calibration.**
- **A substantial increase in the success rate of Delta DOR VLBI delay.**
- **The above 3 points significantly improve the accuracy of the VLBI measurement system, to make a significant contribution to the lunar soft landing .**



CE-2 and CE-3 VLBI delay residual after orbit determination

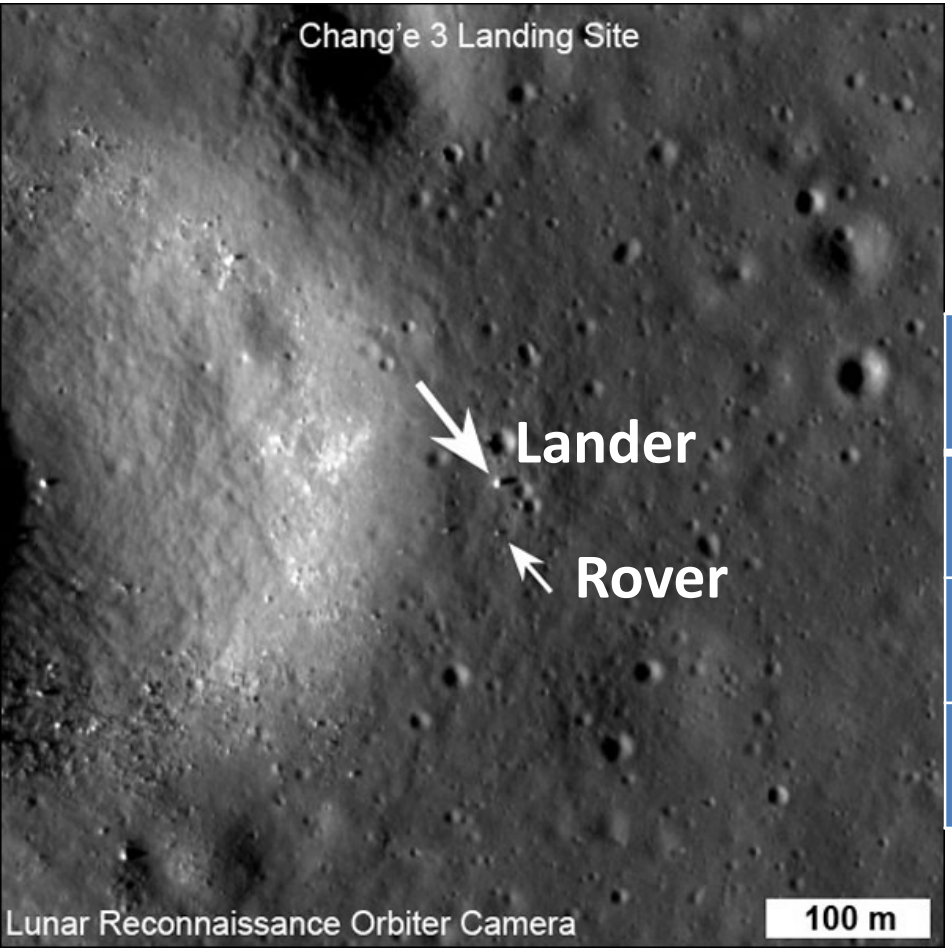




Orbit determination error (VLBI+Doppler/Range)

- **Flying to the moon: hundreds meters**
- **Circling the moon: tens meters**
- **Landing site: tens meters**

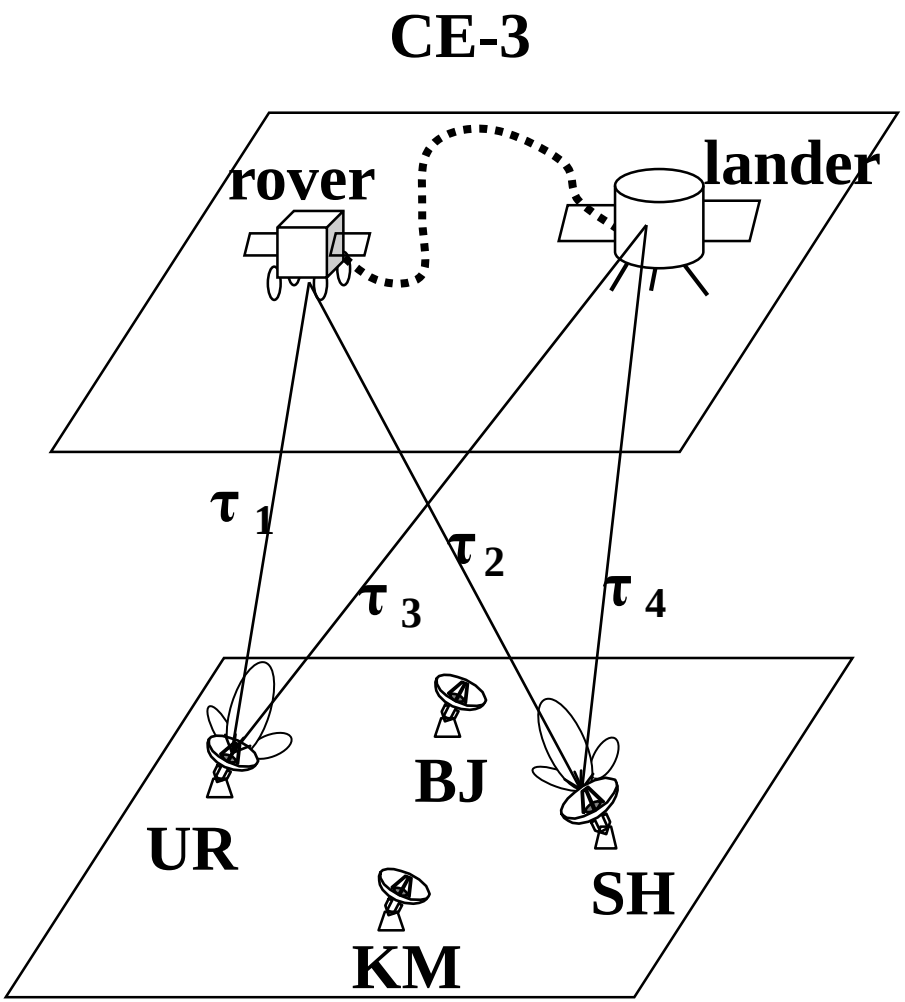
CE-3 landing site

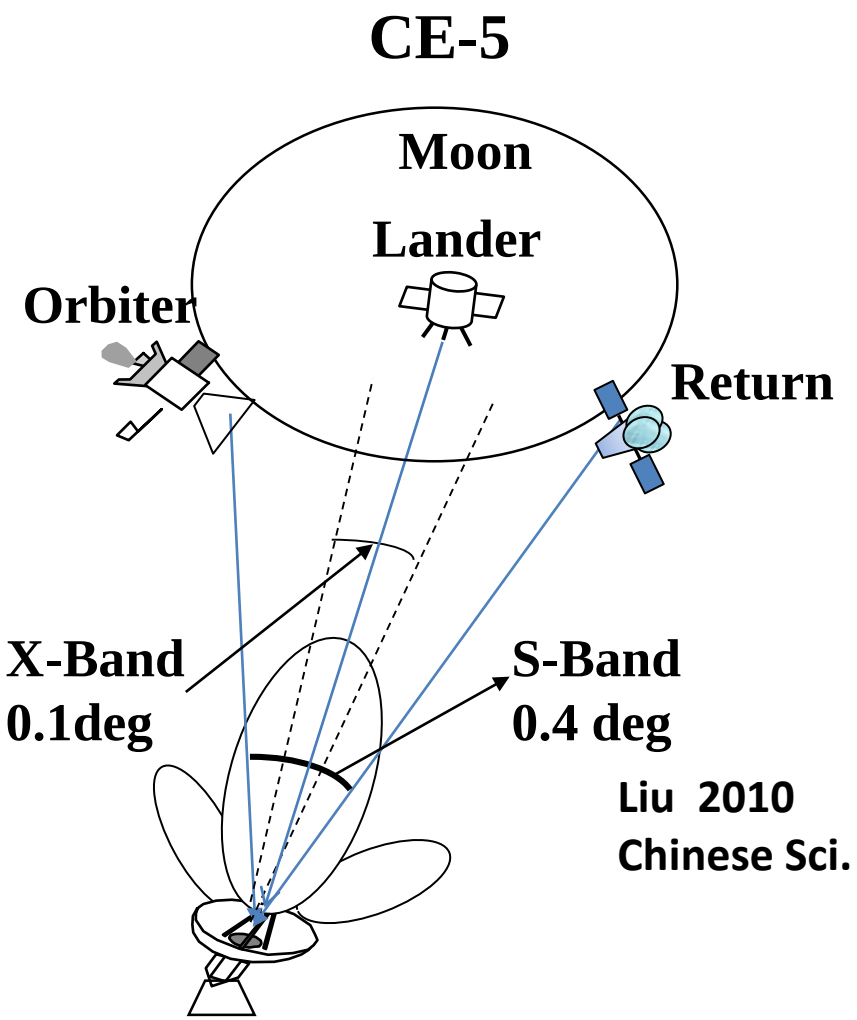


Position difference measured by SHAO and NASA was less than 50m

	longitude	latitude	height
NASA	-19.5116	44.1214	-2640.0
SHAO	-19.5124	44.1206	-2632.0
Position	17m	24m	8m

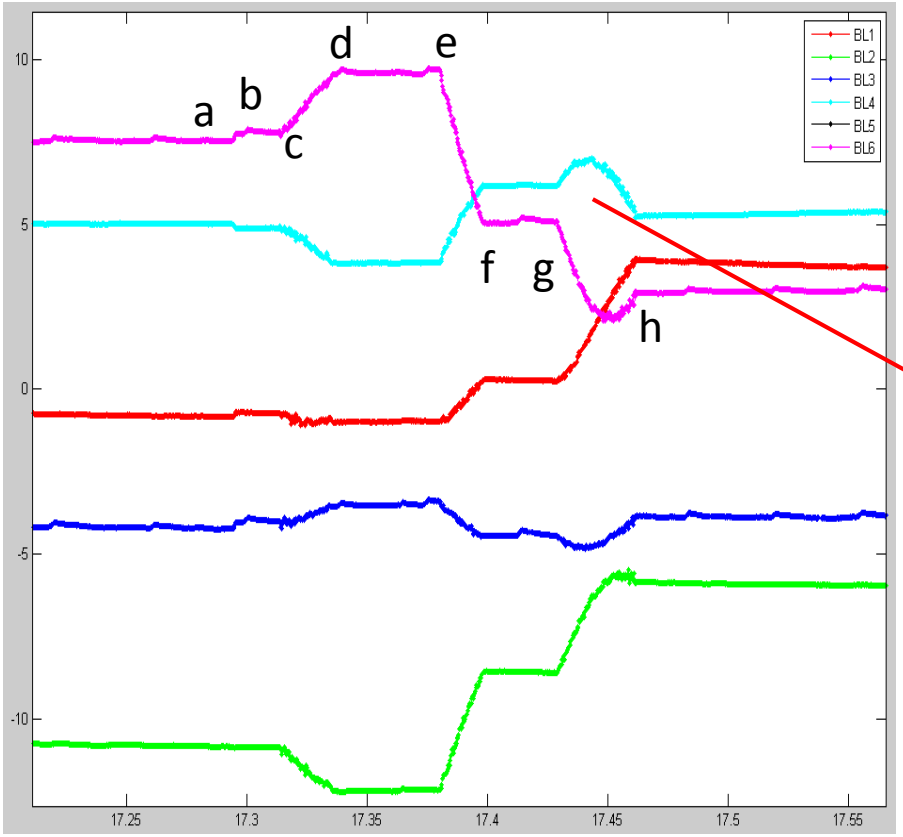
Same-beam VLBI in CE-3 and CE-5

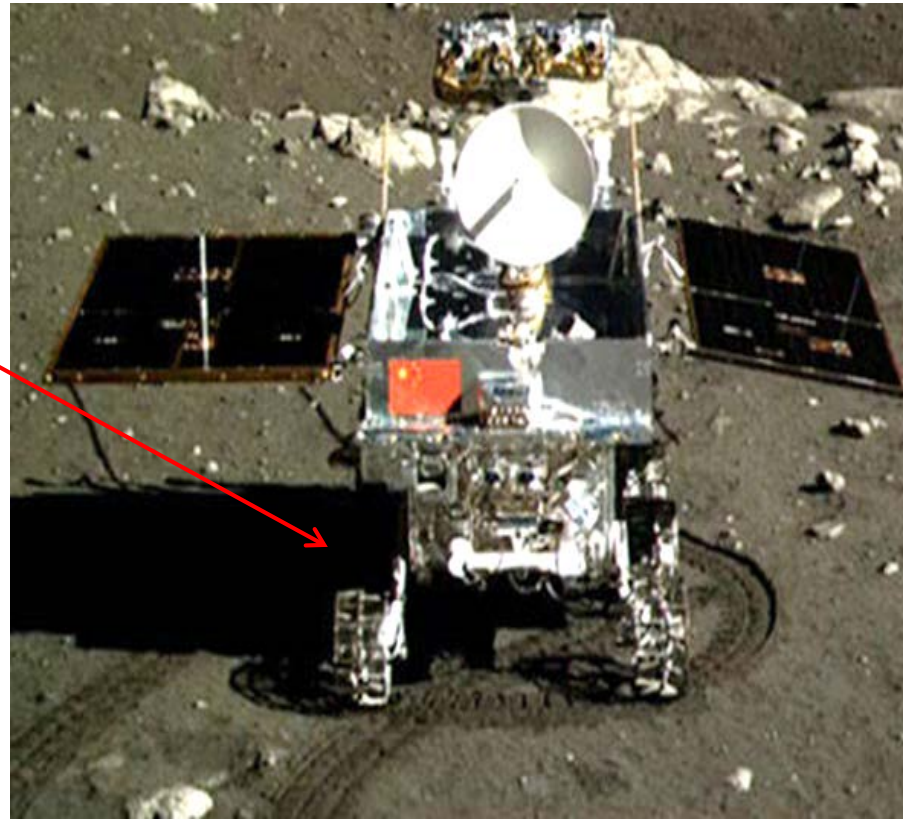




Measuring relative position/orbit by using differential phase delay of same-beam VLBI

Monitor rover movement with a sensitivity of 5 cm



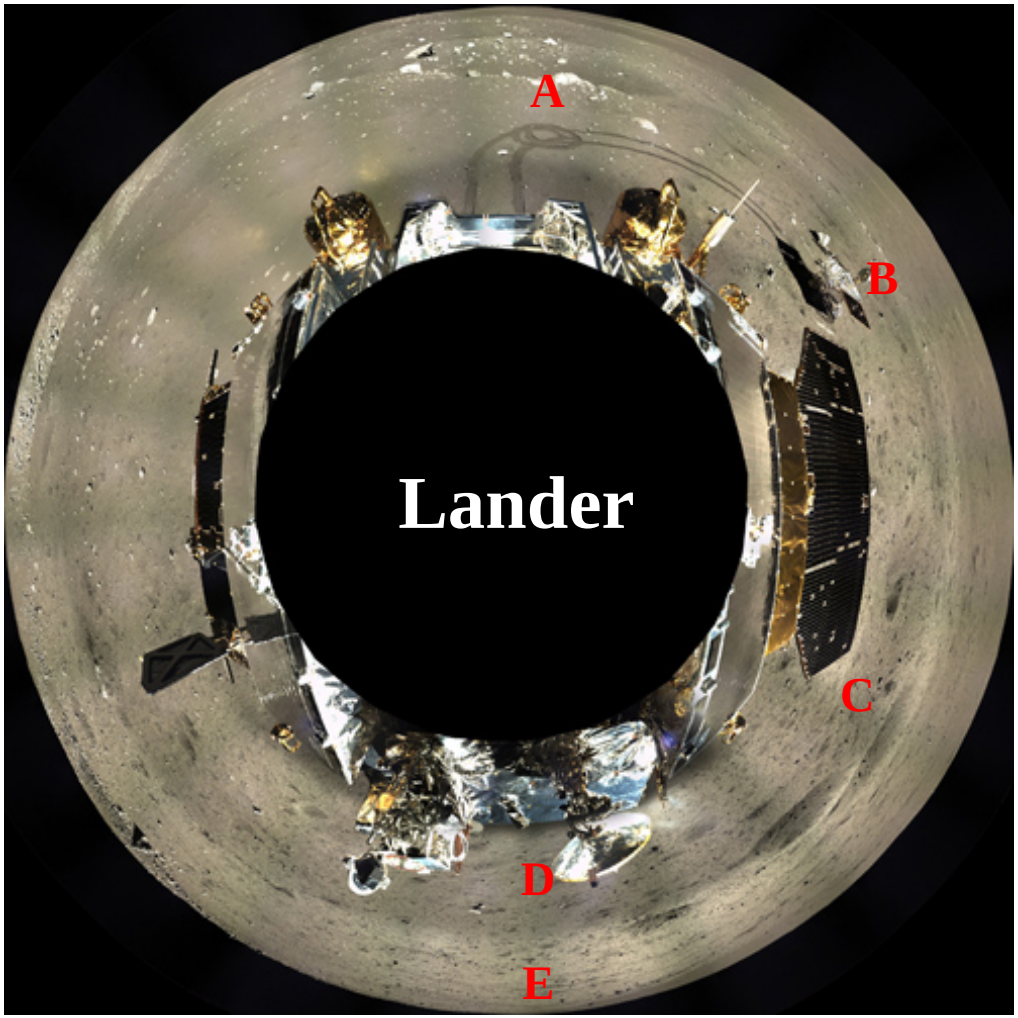


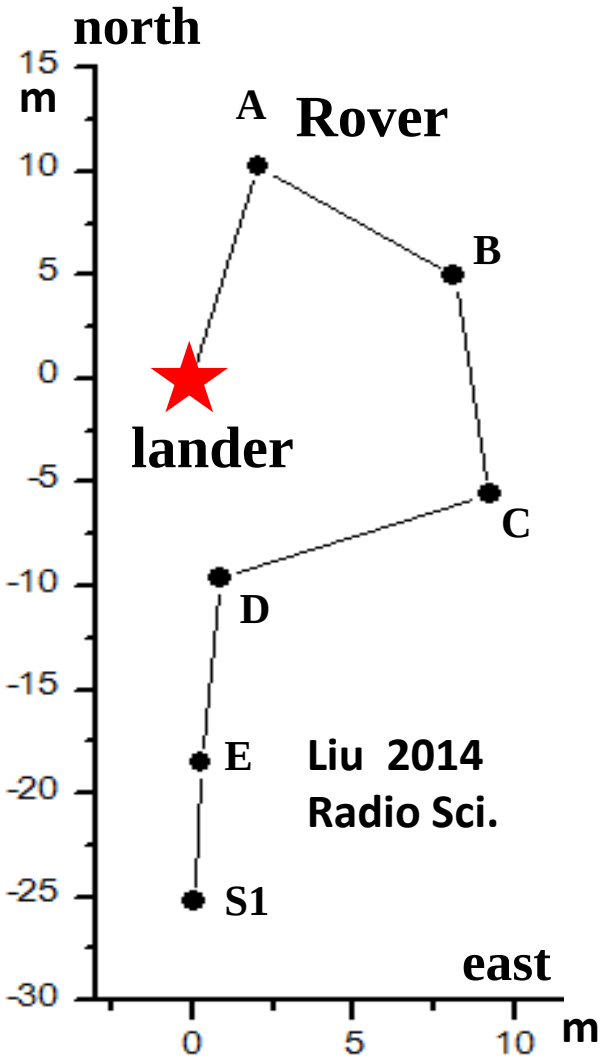
a-b: a little movement, c-d: several meter movement

e-f: several meter movement ,

g-h: make a turn

Rover relative position determination with an accuracy of 1m.






Tianma telescope team will continue to work in all aspects of radio astronomy, deep space exploration, science research and education,
Welcome to use Tianma telescope