Chinese VLBI Network - New 40m Dishes

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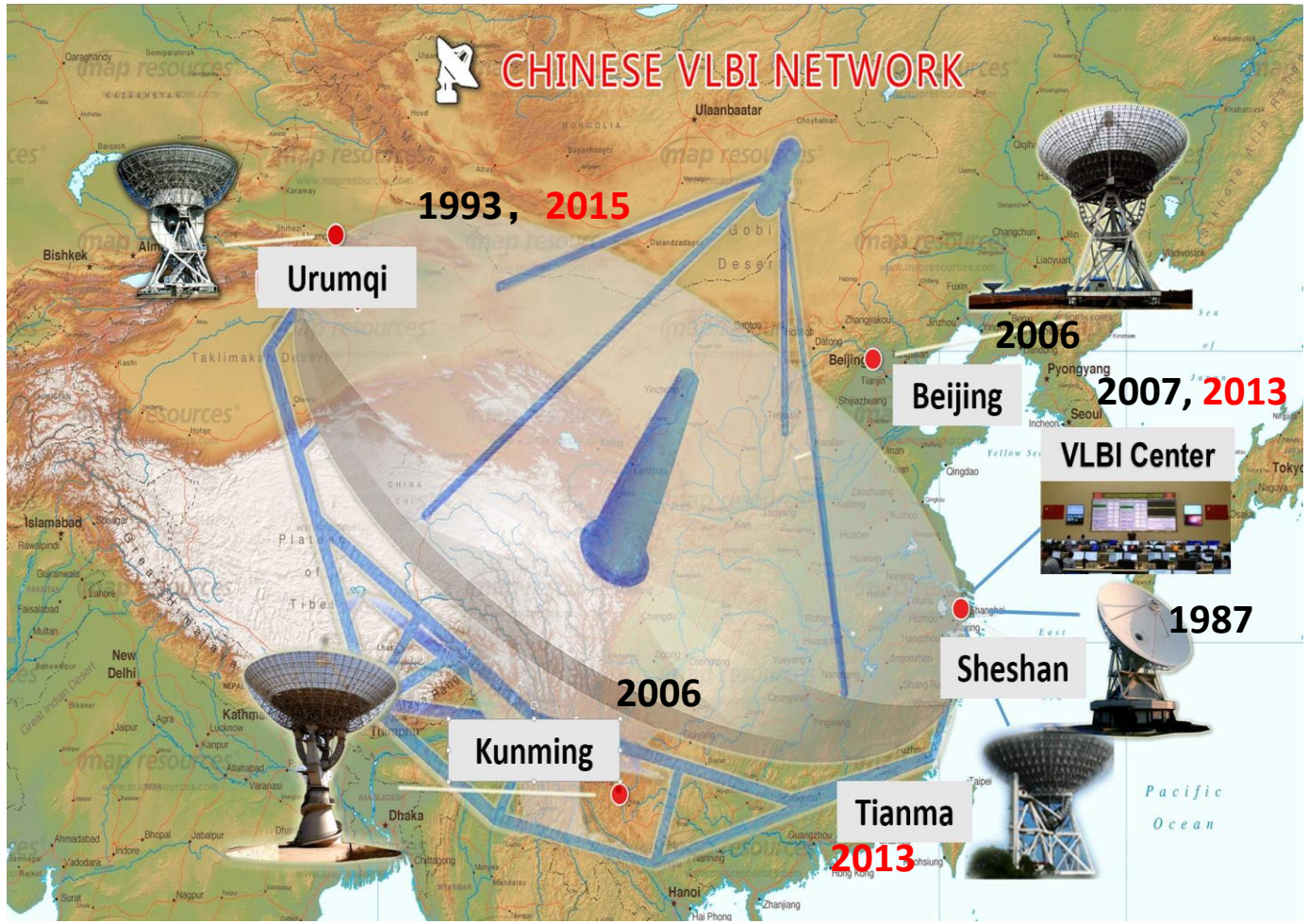
Outline

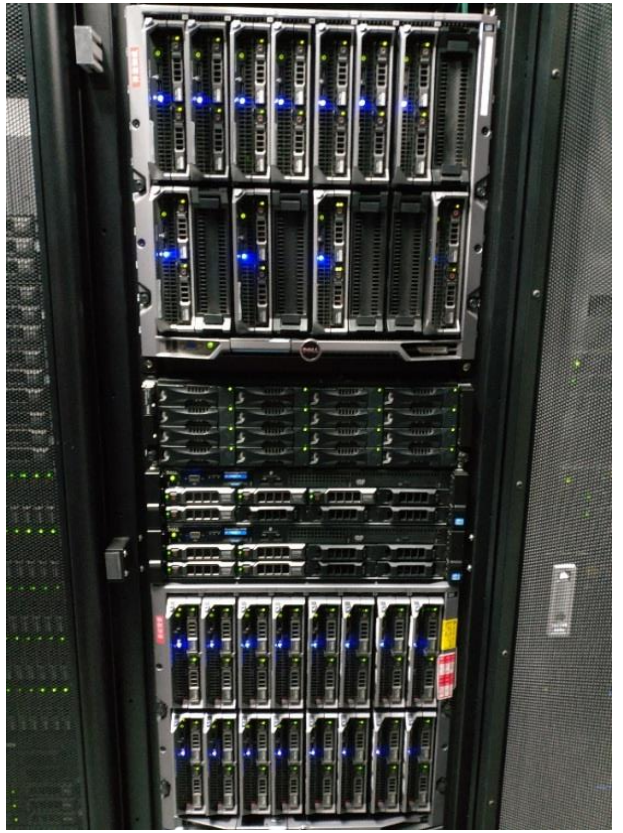
1. Current Chinese VLBI Network (CVN) status
2. Site selections for the new antennas
3. Technical Specifications
4. Construction Progress
5. Summary

1. Current Chinese VLBI Network (CVN) status



- The Chinese VLBI Network (CVN) consists of 4 radio telescopes (Shanghai Tianma:65m, Shanghai Sheshan:25m, Urumqi:26m, Kunming:40m) and one data processing center in Shanghai Observatory.
- Since August, Beijing station has left CVN and will focus on deep space mission data reception.
- Kunming and Sheshan stations have updated the servo systems recently.

Two Correlators (Astronomy and deep-space)



Shanghai Correlator (DiFX) :

For IVS, EAVN observations.

864 CPU cores, 3.6PB storage, 2~4Gbps international fiber link.

CVN correlator (developed by SHAO) for lunar & deep-space missions

SW correlator(CPU+GPU): 1048 CPU cores, 4 Nvidia K80 GPU, Networking: 40Gb Infiniband, 10Gb Ethernet, 730TB storage

Frequency coverage and backends of CVN antennas

Antennas	L	S/X	C	X/Ka	K	Q	Backend
Tianma65	√	√	√	√	√	√	DBBC2/CDAS2
Seshan25		√					
Urumqi	√	√	√		√	√	DBBC2/CDAS2
Kunming		√	√				CDAS2/DBBC
	EVN	EVN	EVN		EVN		
			EAVN		EAVN	EAVN	
		IVS					
		CVN					

CVN operation for astronomy and deep-space missions

- Astronomy
  - Tianma65, Seshan25, Kunming and Urumqi take part in EVN/EAVN observations.
  - CVN regular astronomical sessions is under coordination.
- Space geodesy & absolute astrometry
  - Tianma65, Seshan25, Kunming and Urumqi join IVS observations.
  - SHAO operates Seshan25, Kunming and Urumqi under the project CMONOC (Crustal Movement Observation Network Of China).
  - Shanghai correlator supports IVS/AOV/APSG scheduling/correlation.
- Deep-space mission
  - CVN is a powerful tracking and navigation tool in China's deep-space mission.
  - Used in lunar missions of CE1-CE6, and Tianwen1 Mars mission.

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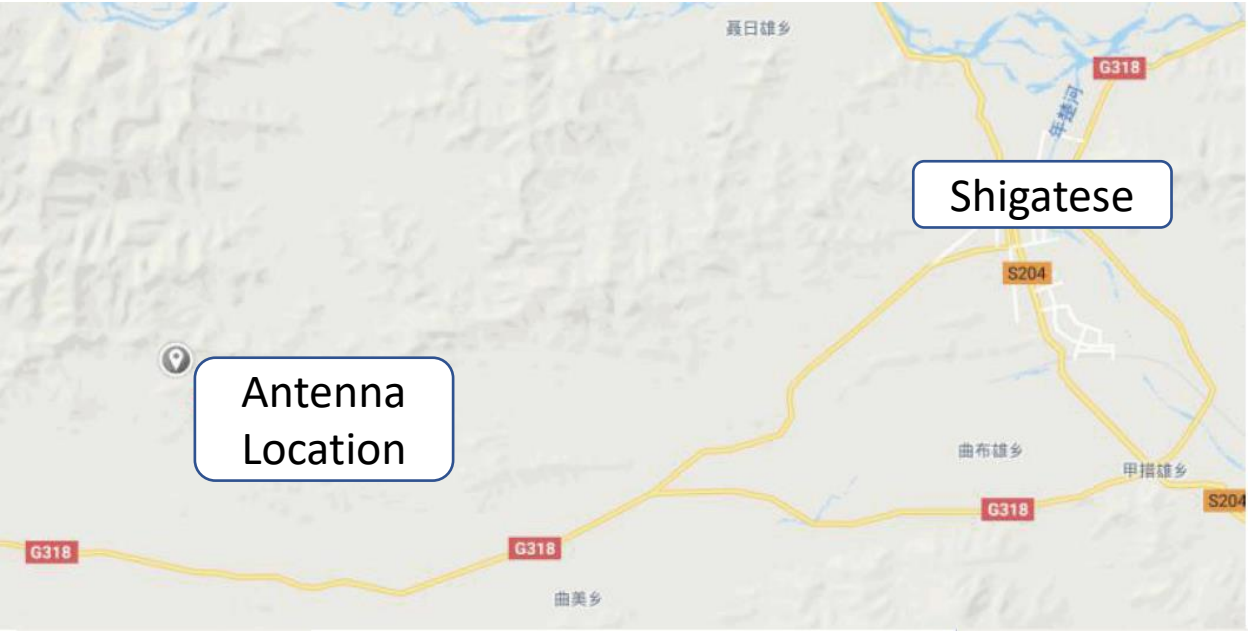
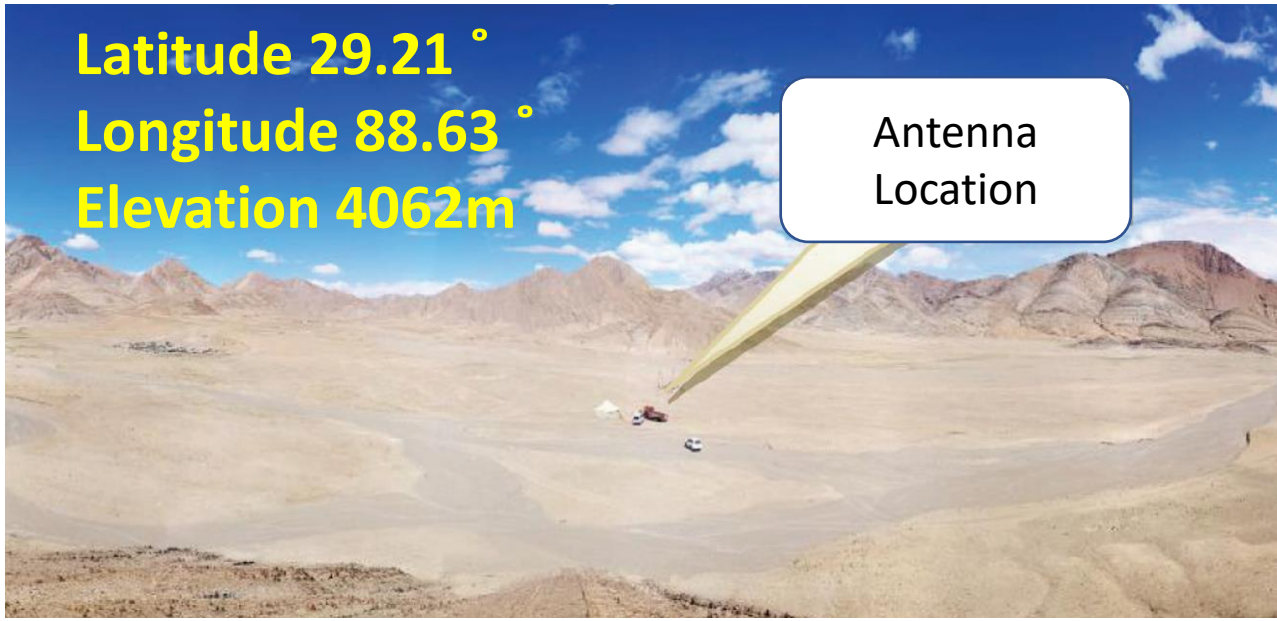
2. Site selection of Shigatse and Changbai Mountain

- Seshan25, Kunming, and Urumqi stations are in extended service.
- CVN needs new antennas.
- The site selection work began before 2017.
- Several areas had been considered, and the final focus was on Jilin province(northeast region) and Tibet(southwest region).

Site of the Shigatse station

- The Shigatse Radio Telescope is located at the border of Sangzhuzi District and Saga County.
- It is approximately 35 kilometers west of the Shigatse urban area, Gobi with little vegetation.
- The coordinates are 29.21° North latitude, 88.63° East longitude, at an altitude of 4,062 meters.
- High altitude area, lack of oxygen (60% of Shanghai), breathing problem.
- Low precipitation level, good for high frequency observation.



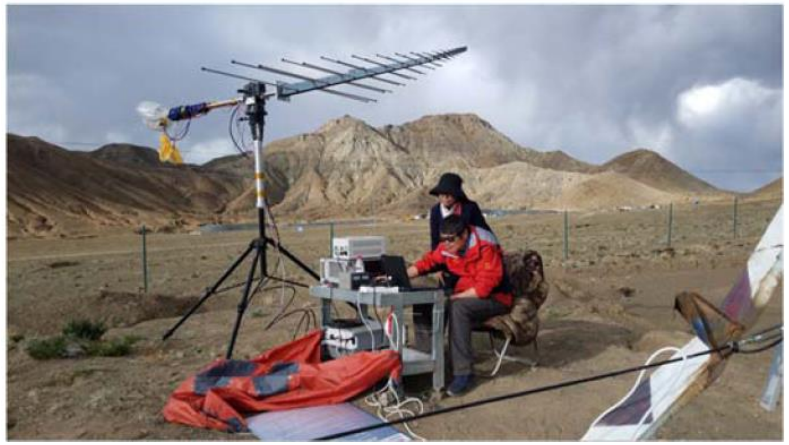


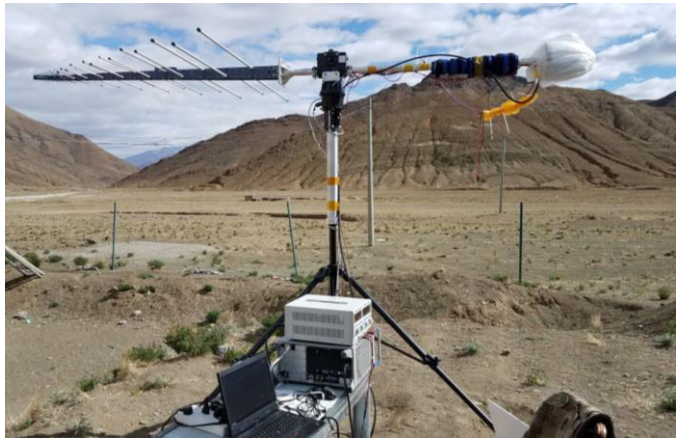
Photographs taken during the site selection process

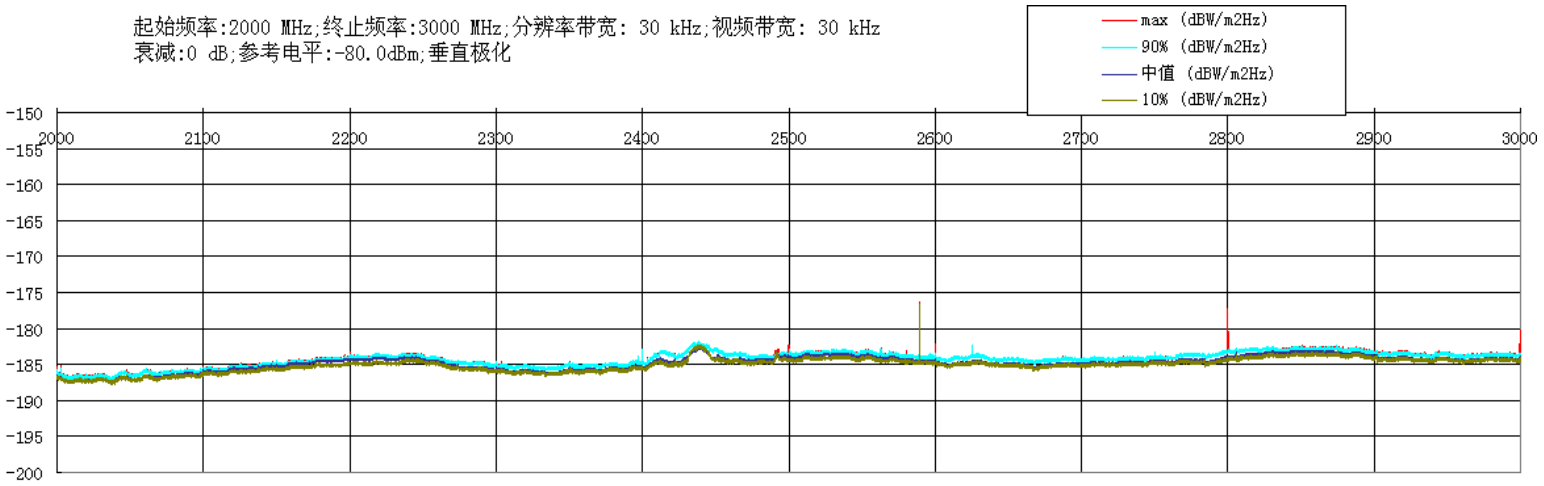
The local government is very supportive of the new antenna.

Radio environmental test

- From May 28th to June 4th, 2019, the local radio environment was measured;
- Good radio environment, less electromagnetic interference.





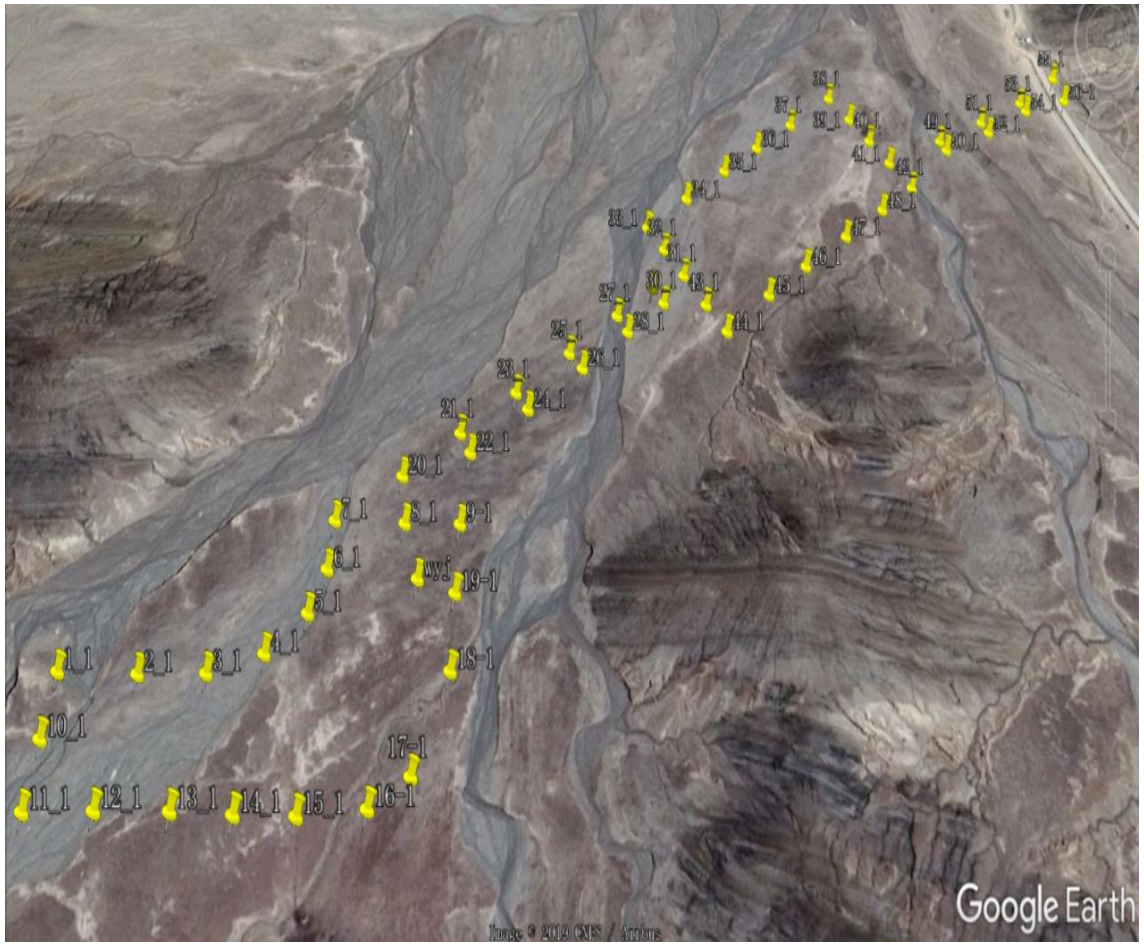


Geological Survey

Soil was being sampled through drilling methods.

There is a rock layer at approximately 25 meters deep.

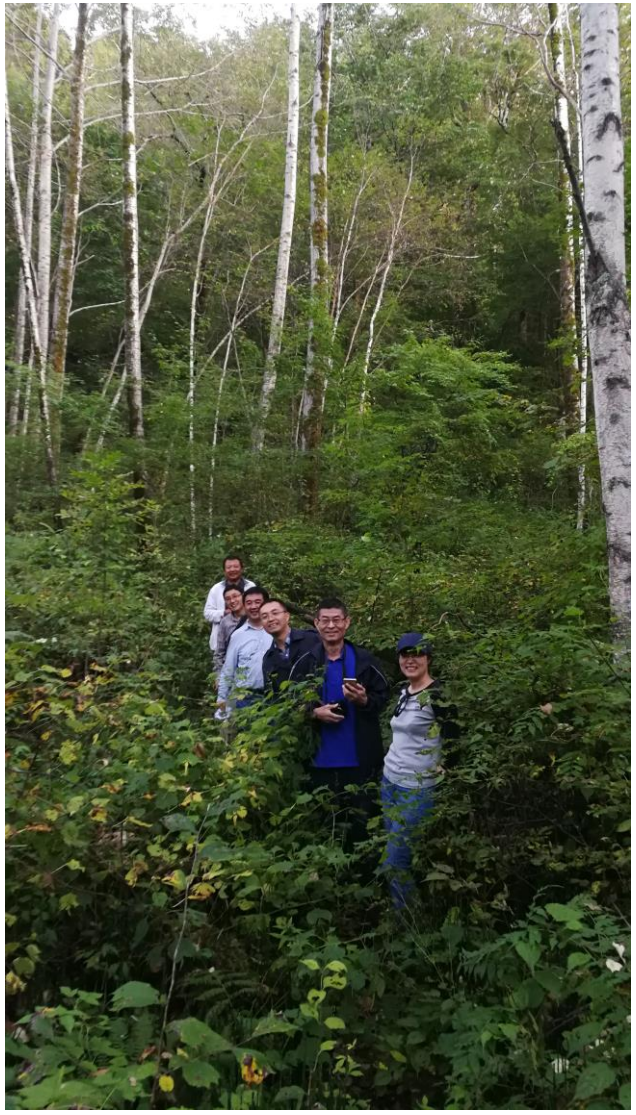
Land Surveying and Demarcation



Changbai Mountain station site selection

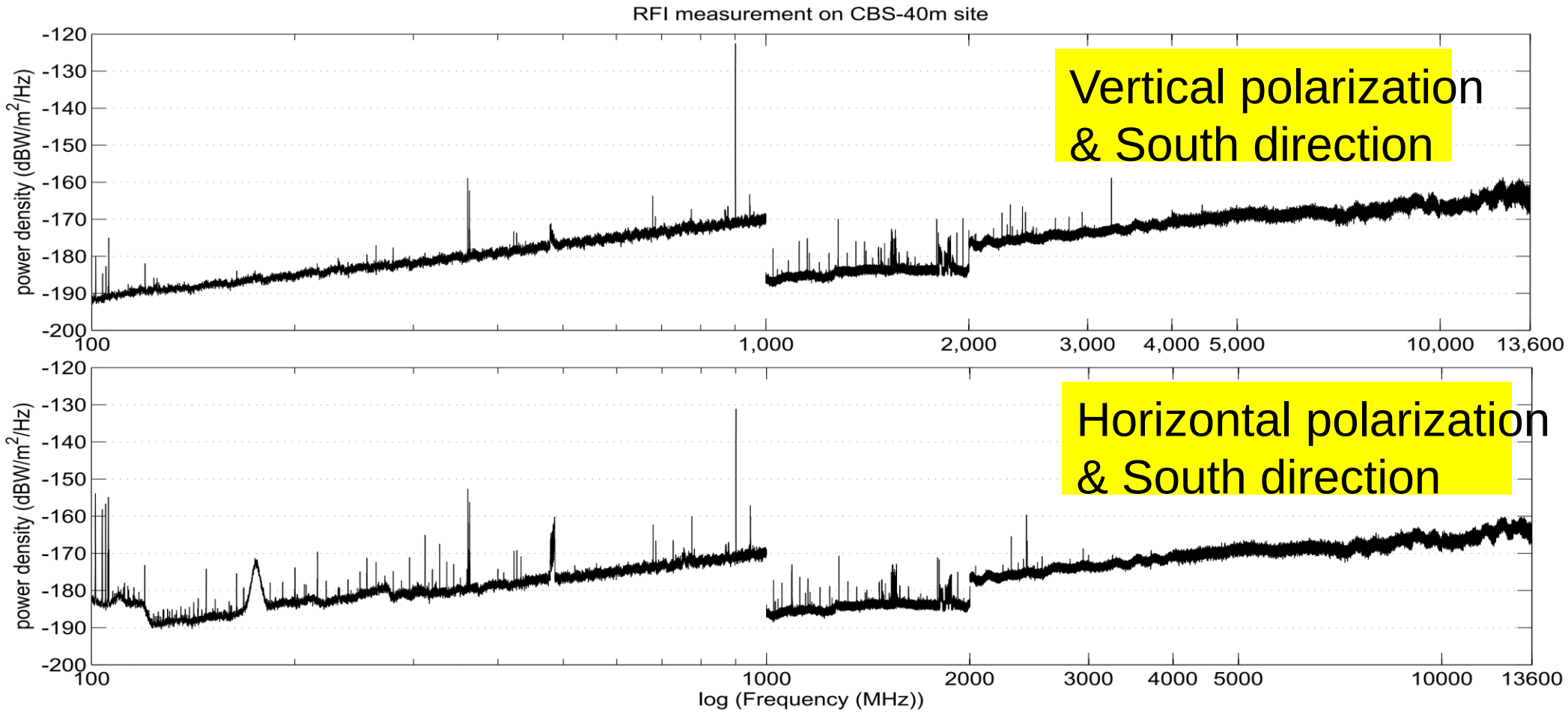
- Extensive site selection have been conducted early than 2018.
- Changbai Mountain Station is located near Changbai Mountain National Forest Park, not far from the famous Tianchi volcanic crater lake.
- Lowest temperature is -41.5 ℃(Record low temperature).

Site selection of Changbai Mountain



RFI situations on site

- Good radio environment, less electromagnetic interference.



Geological Survey

Sampling soil through drilling

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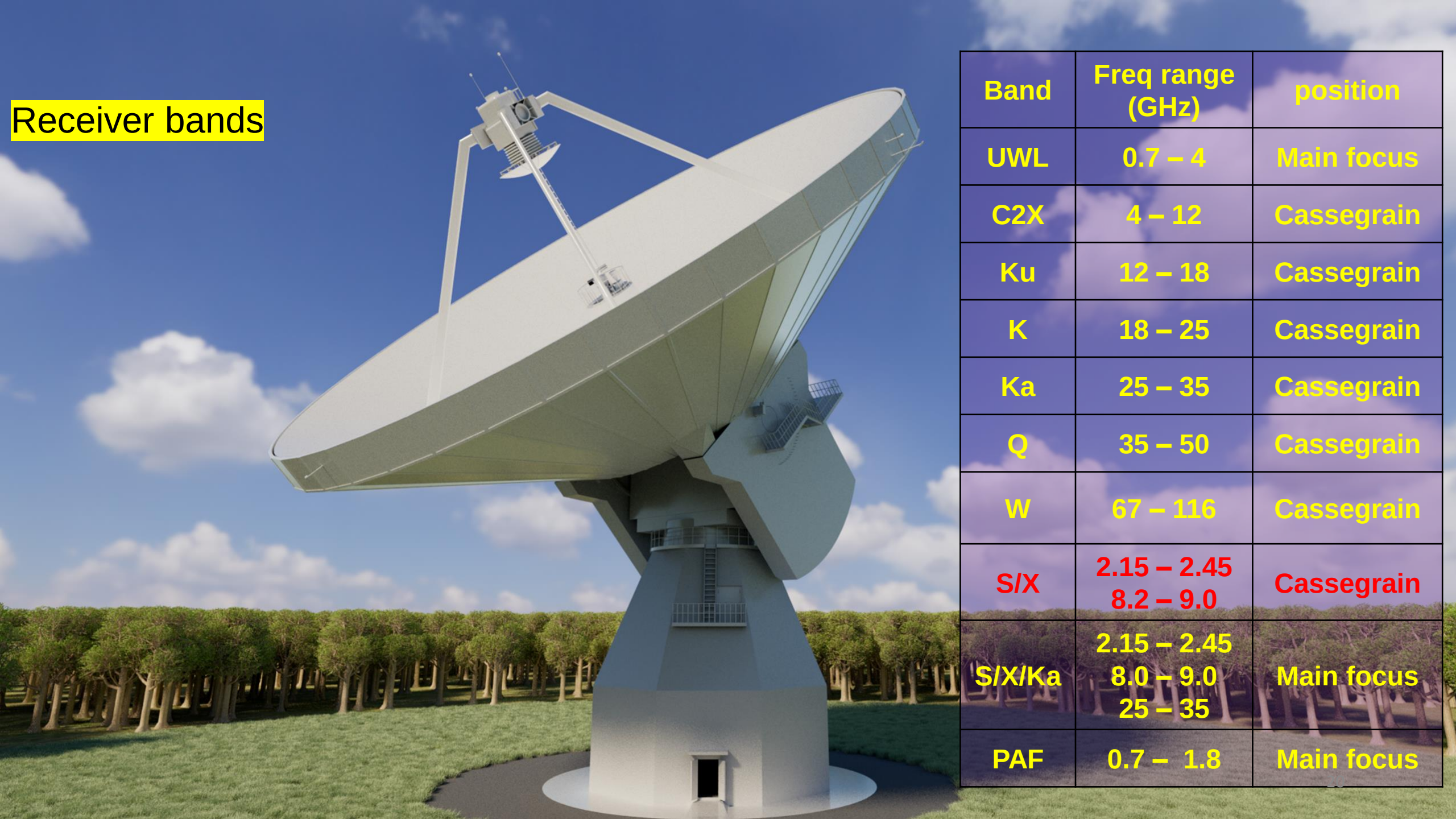
3. Telescope Specifications

- Configuration: Cassegrain & main focus
- Main reflector: 40 m
- Sub reflector: 3.5 m(CBM)/4.2m(Shigatse)
- Primary focal ratio (F/D): 0.35
- Band switching time: 1 minute
- Frequency coverage: 1-50 GHz,
- Surface accuracy: 0.3 mm RMS
- Pointing accuracy: 5 arcsec
- Slew rates: 2 degree/s azimuth, 1 degree/s elevation
- Weight: ~ 850 tons

Receiver bands

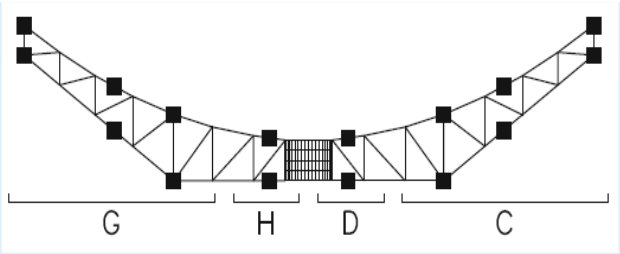


Band	Freq range (GHz)	position
UWL	0.7 – 4	Main focus
C2X	4 – 12	Cassegrain
Ku	12 – 18	Cassegrain
K	18 – 25	Cassegrain
Ka	25 – 35	Cassegrain
Q	35 – 50	Cassegrain
W	67 – 116	Cassegrain
S/X	2.15 – 2.45 8.2 – 9.0	Cassegrain
S/X/Ka	2.15 – 2.45 8.0 – 9.0 25 – 35	Main focus
PAF	0.7 – 1.8	Main focus

Shigatse 40m Radio telescope

1. Adjustable, reversible carbon fiber sub-reflector, and L-band feed installed on the primary focus.

2. Multi band feed switch mechanism, feed frequency covered from L band (1GHz) to W band(87GHz).



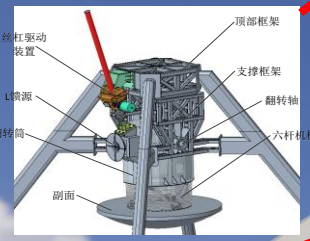
3. Structural shape preservation design; The backup is fully insulated and equipped with temperature sensors and air circulation。

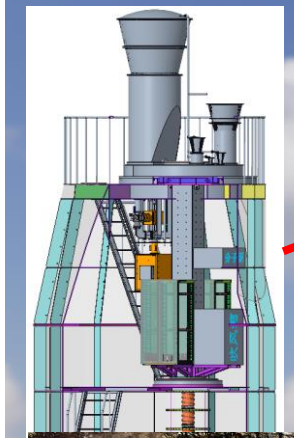
4. Both azimuth and elevation are driven by four motors to ensure reliability and overcome wind disturbances.

5. The tower base and antenna are fully insulated to improve pointing errors caused by temperature differences.

Changbai Mountain 40m Radio telescope

Feature 2: Cassegrain & main focus. Frequency coverage 0.7-50GHz, and could be extended to W-band.





Feature 5: very strong antenna foundation roots in basalt of Changbai Mountain.

Feature 1: Aperture efficiency > 65% @ X-band with 15°<EL<80 °. Pointing accuracy 5"

Feature 3: 468 pieces panels of main reflector, with 80 micron RMS of each panel, and total error 0.3mm RMS

Feature 4: antenna is completely enveloped by thermal insulation material to avoid cold weather effect and thermal deformation from solar.

Feature 5: LQG technology will be adopted in servo system.

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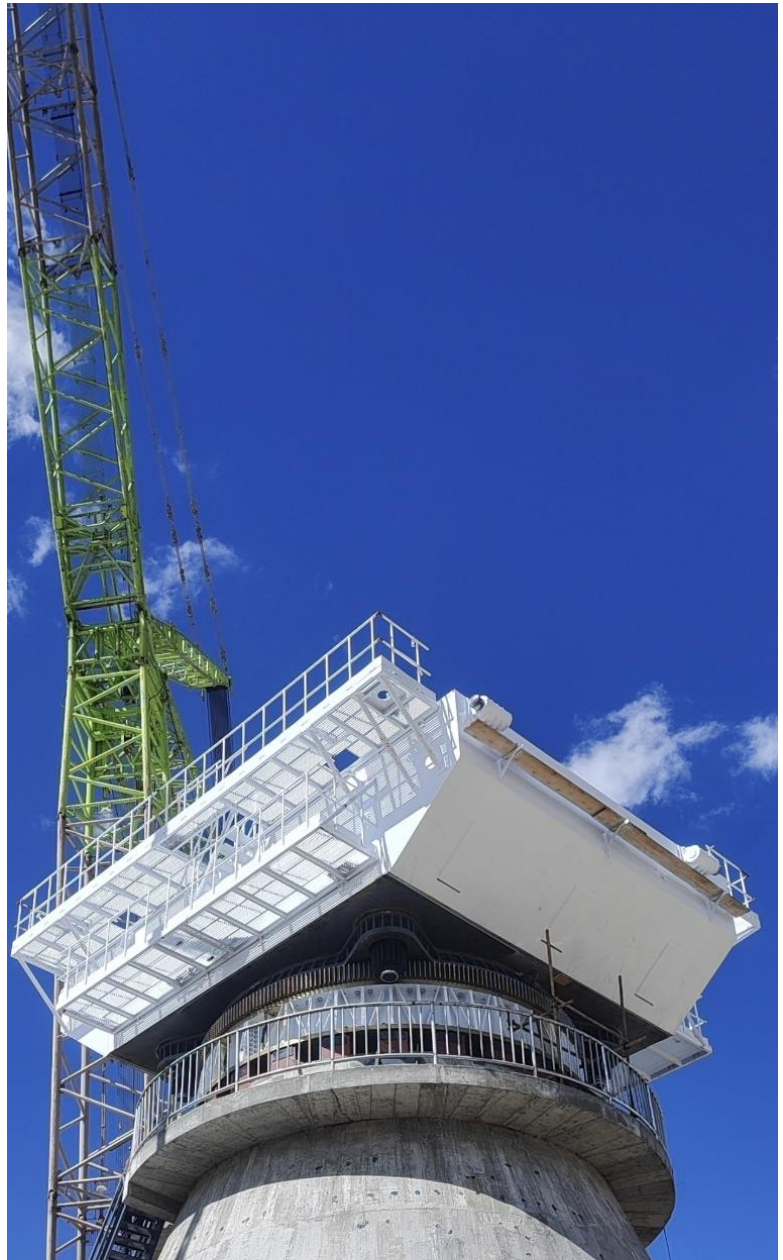
Shigatse 40m Radio Telescope construction schedule

No.	Time	Key events
1	2023/7	Contract Signing
2	2023/8	Design and implementation plan review, start drawing processing, Start infrastructure construction.
3	2023/9/15	Project Kick-Off Meeting
4	2023/12	Complete the development of each unit for acceptance and review.
5	2024/4/10	Complete the maintenance, processing, and assembly of various components
6	2024/6/30	The antenna foundation construction has been completed.
7	2024/9/30	The maintenance of the foundation has been completed
8	2024/10/10	The lifting of antenna surface, pedestal, and reflector units has been completed.
9	2024/10/20	Antenna system servo electrical installation, installing S/X feed.
10	2024/10/25	Accuracy measurement and adjustment of primary reflector and sub-reflector.
11	2024/11/15	Debugging of servo control performance and receiver performance.
12	2024/11/30	The main performance self-test of the antenna.
13	2024/12/30	Complete on-site testing, acceptance pre review.

Shigatse 40m Radio Telescope Kick-Off Meeting Sep 15, 2023

Sep 20, 2024

Azimuth platform lifted
Reflector construction completed



Sep 26,2024

S/X receiver installation complete

Oct 6,2024

Preparation for reflector lifting

Oct 7,2024

Main reflector lifting

Oct 7,2024

Completed the construction of observation and auxiliary buildings.

Changbai Mountain telescope schedule

2019 – site selection
2022 – project funded
2023 – Critical Design Review
2024 – antenna construction finished
2025 – commissioning

Main reflector lifting

Aug 27,2024

The main reflector has been lifted

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- Shigatse and Changbai Mountain 40m antennas will join CVN before March 2025.
- They will be opened to international observations, like EVN, EAVN, IVS.
- These two antennas will upgrade CVN performance in the future.

✓ These telescopes will extend CVN's longest baseline from 3,200 to 3,800 kilometers.

✓ They will enhance CVN's capabilities in studying supermassive black holes, rapid transient phenomena, the Milky Way's dynamics, and high-precision Earth-space reference frameworks.

✓ They will also support space VLBI and deep space exploration missions.

Thank you!

谢谢！