中国科学院新疆天文台
XINJIANG ASTRONOMICAL OBSERVATORY, CAS

Plans for QTT
—Overall Introduction

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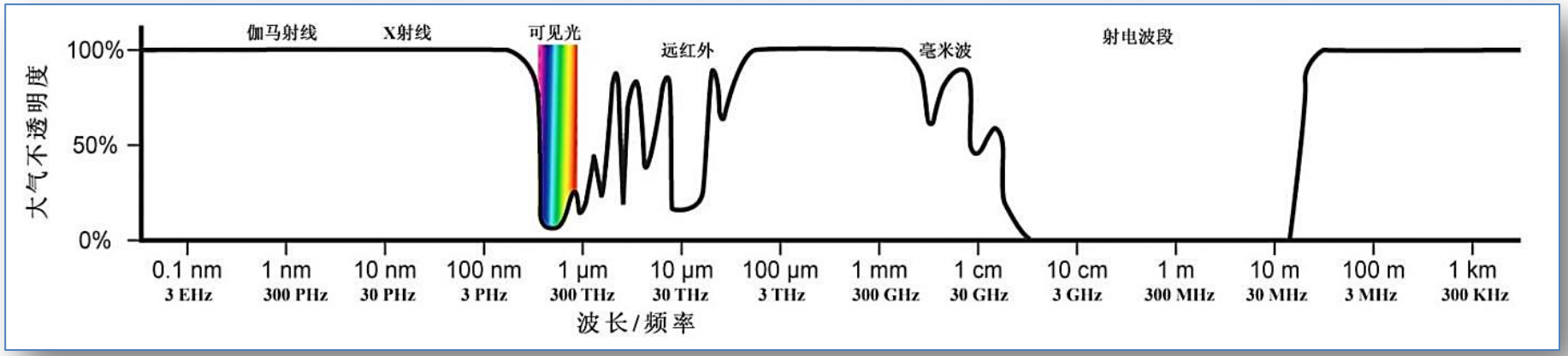
Outline

- Background
- General Plan
- QTT Site
- Science Goal
- Technique Schemes
- Progress

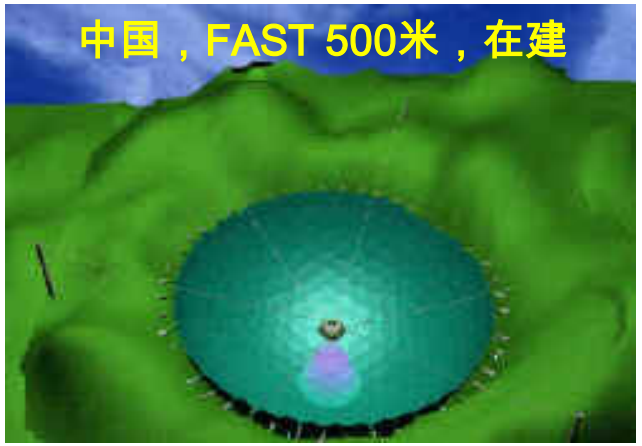
Background

- Almost all of our knowledge about the universe are based on the received electromagnetic radiation by the observer, only a small part are from real material (such as meteor)
- The transmission window of the atmosphere for radio frequency: 10MHz ~ 1THz (30m ~ 0.3mm)
- Radio wavelength spanning: $\lambda max/\lambda min \sim 3\times10^4$
- Optical: $\lambda max/\lambda min \sim 2$



Background

Giant single telescopes



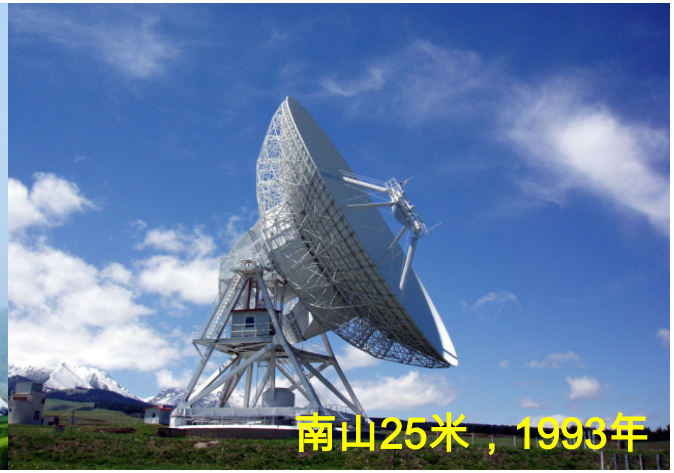
Arrays

Background

Fully steerable telescopes

Background


佘山25米，1987年


南山25米，1993年

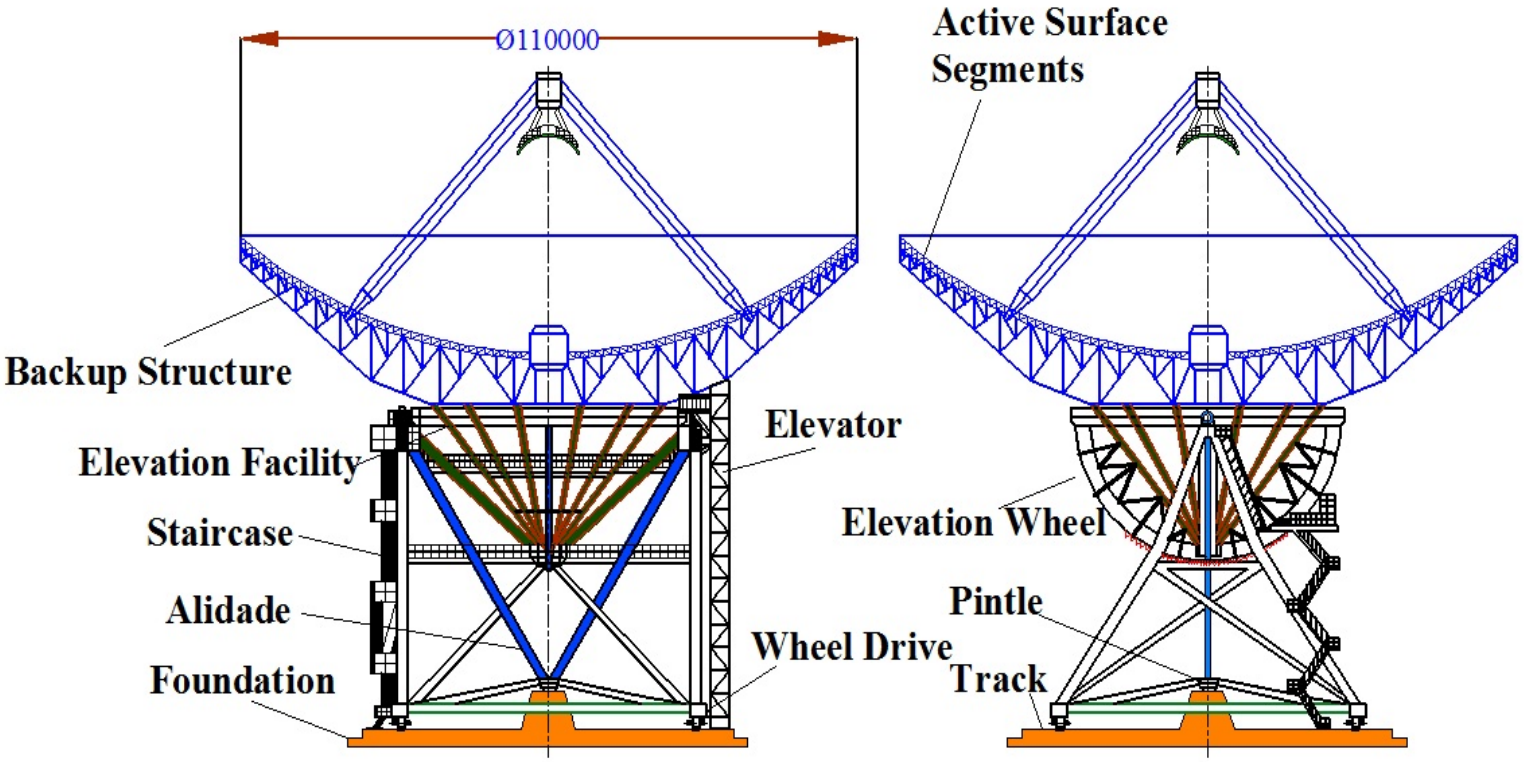

搜狐IT
密云50米，2005年


昆明40米，2006年


上海65，2012年

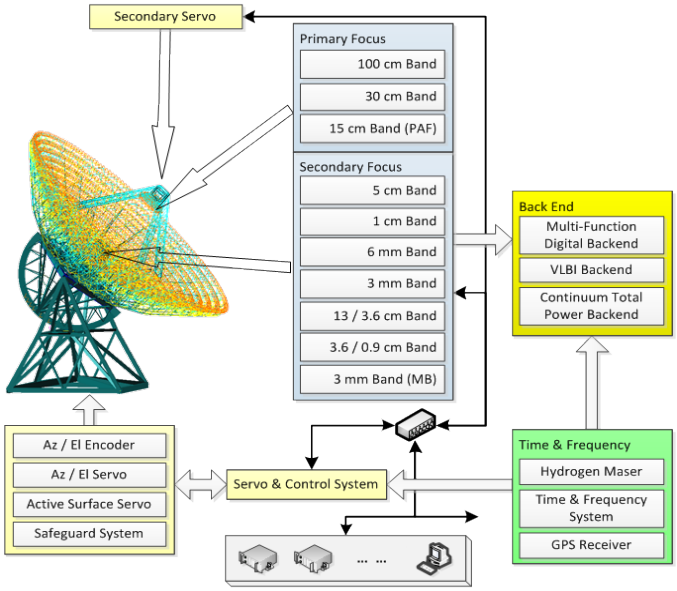
General Plan

- **QiTai radio Telescope (QTT)**
  - Steerable 110m radio telescope



General Plan

- **Features**
  - Prime/Gregorian paraboloid, Az/El
  - Aperture: 110 m
  - Fully Steerable
  - Active Surface
  - Freq Range 150 MHz – 115 GHz



General Plan

- **China VLBI (CVN):** astrometry, space exploration

  CVN+QTT: sensitivity increases 1.8 times

  CVN+QTT+65m: sensitivity increases 3 times

- **EVN**

Band (cm)	EVN Available Tele	SEFD (Jy) (NS 25m)	SEFD (Jy) (QTT)	Ratio improvement
18	10	13	9	30%
13	8	61	17	71%
6	10	14	12	16%
3.6	8	31	21	34%
1.3	6	149	101	33%

General Plan

- Surface Accuracy (rms):
  - main reflector:

    ≤0.6mm (no active surface)

    ≤0.3mm (active surface, long term ≤0.2mm)

    single panel:≤ 0.07mm
  - sub-reflector:

    ≤0.1mm

    single panel:≤0.05mm

General Plan

- Pointing Accuracy @ 6mm wave length

  with wind speed≤4m/s, temperature drift≤2℃/h, observation time: 69.5%

  – blind pointing≤5arcs

  – repeatability precision≤2.5arcs

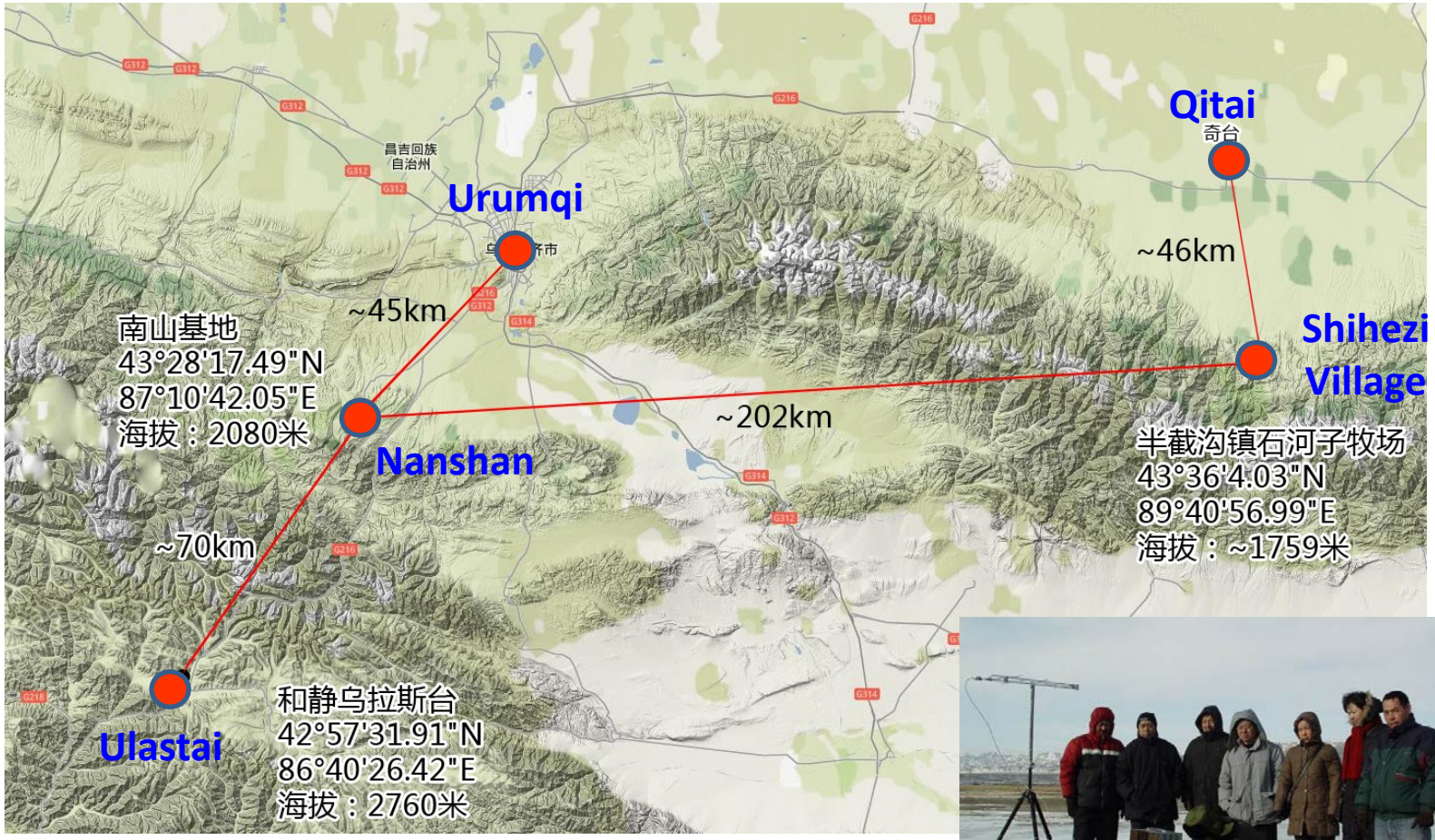
- QTT Electric Performances

Band	100cm	30cm	5cm	1cm	6mm	3mm
Efficiency (Optimum EI.)	60%	63%	63%	60% ~50%	54% ~30%	30% ~12%
System Noise (K)	30	25	20	20	45	100

General Plan

Type	Band (cm)	RF Freq (GHz)	Focus	Feed	Poln	Science Goals
Single Pixel	100	0.15 – 0.6	Primary	Kildal	Linear	Pulsar, RRT
	30	0.6 – 4	Primary	Horn	Linear	Pulsar, RRT, HI, OH, Galaxies
	5	2 – 12	Greg.	Horn	Linear	Molecular spectrum, Galaxies; VLBI
	1	12 – 36	Greg.	Horn	Linear	Pulsar, H_2O, NH_3, VLBI
	0.6	36 – 50	Greg.	Horn	Linear	Molecular spectrum, High-z CO
	0.3	72 – 115	Greg.	Horn	Linear	Molecular spectrum, Galaxies
Dual-Band	13/3.6	2.2 – 2.5 8 – 9	Greg.	Horn	Circular	VLBI, space exploration, System measurement (3.6cm)
	3.6/0.9	8 – 9 30 – 34	Greg.	Horn	Circular	VLBI, space exploration
Multi-Pixel	15	1 – 2	Primary	PAF	Linear	Pulsar, RRT, HI, OH, Galaxies
	0.6	36 – 50	Greg.	Horn (multi Beam)	Linear	Molecular spectrum, Galaxies

QTT Site

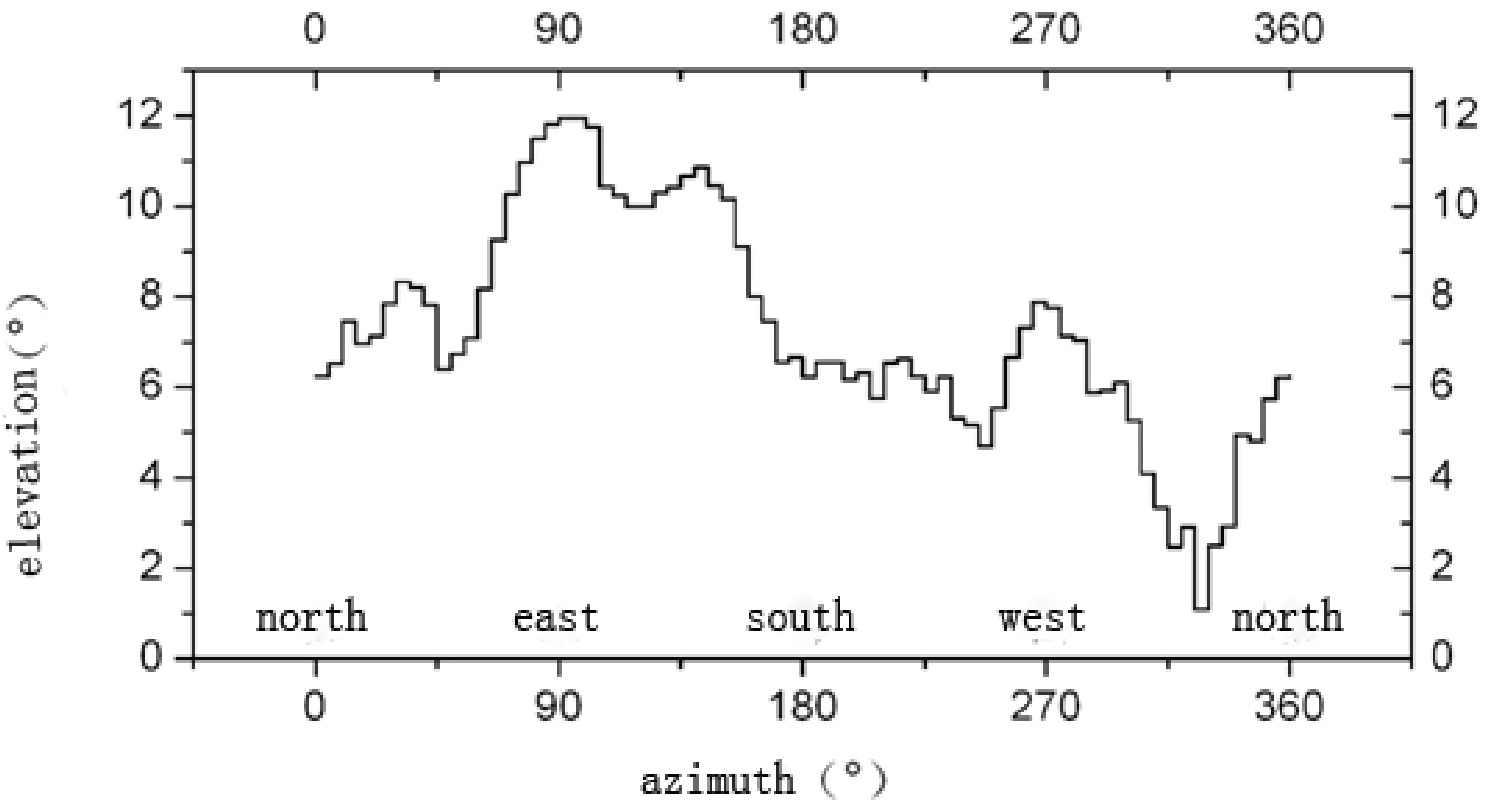

Qitai
奇台
~46km
Urumqi
~45km
南山基地
43°28'17.49"N
87°10'42.05"E
海拔：2080米
Shihezi
Village
~202km
Nanshan
半截沟镇石河子牧场
43°36'4.03"N
89°40'56.99"E
海拔：~1759米
~70km
和静乌拉斯台
42°57'31.91"N
86°40'26.42"E
海拔：2760米
Ulastai

QTT Site

- 1.5 km ×2 km basin
- Altitude range from 1730 m to 2250 m
- Surrounding ridges form an isolated layer with outside region

QTT Site

- Elevation of mountain shelter



Qitai site distribution of elevation

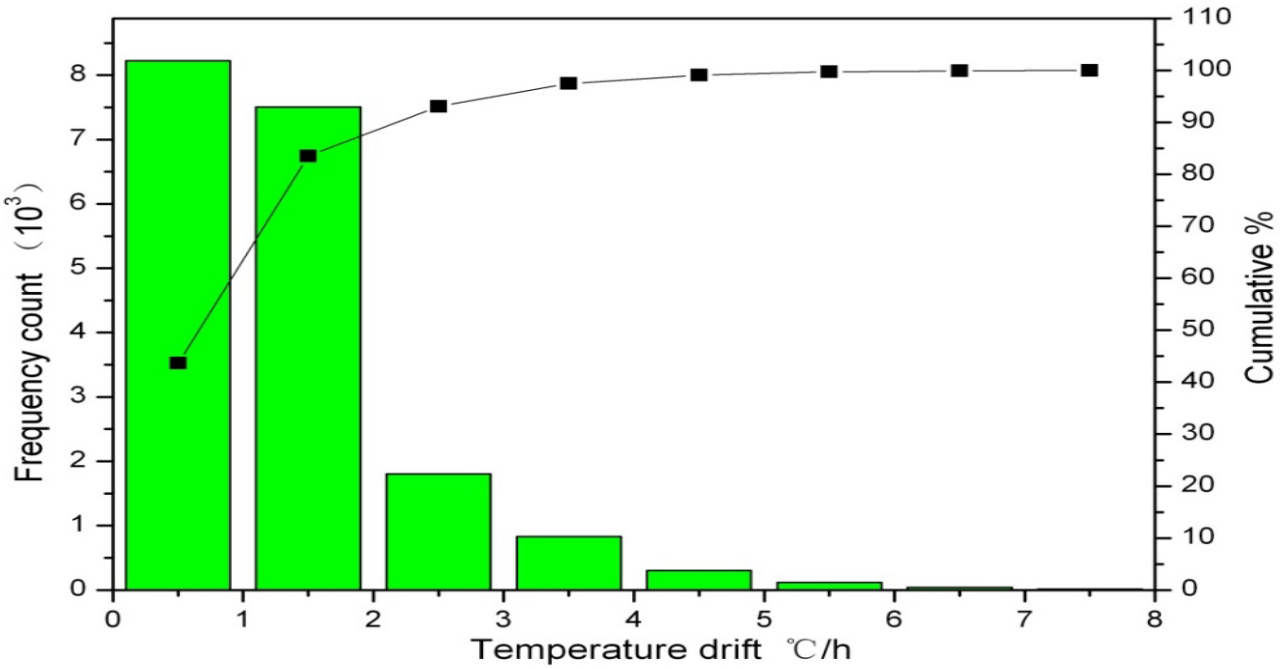
43°36'30.51"N 89°41'5.37"E H1730

QTT Site

- Average annual rainfall of area:
  - 180 to 200 mm
- Average evaporation capacity of Xinjiang area:
  - ~2000mm
- Atmospheric water vapour content:
  - Summer: ~19 mm
  - Spring and Autumn: ~9mm
  - Winter: ~3 mm

QTT Site

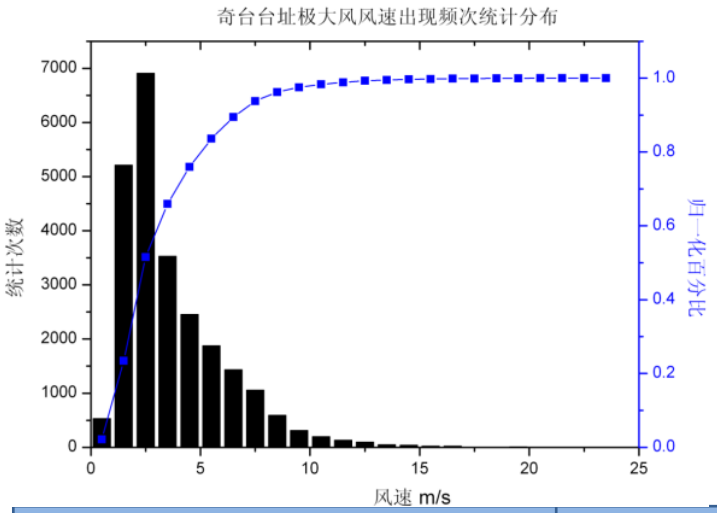
- Temperature range:
  - max +29.3 °, min－26.6 °
- Temperature drifting:

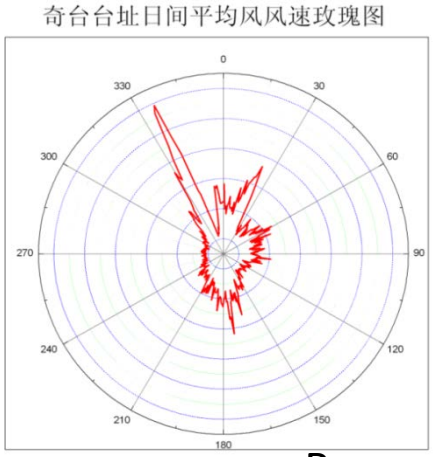


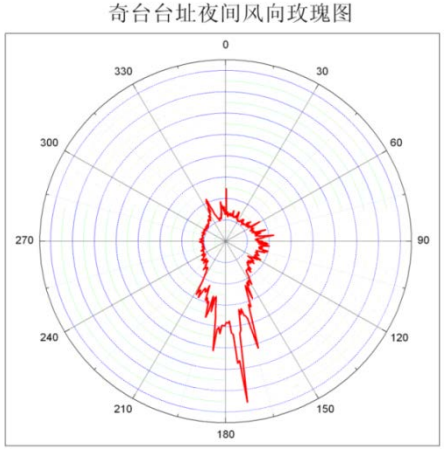
Temperature drifting	Ratio
≤ 5 ℃/hr	99.0%
≤ 3 ℃/hr	92.7%
≤ 2 ℃/hr	82.7%

QTT Site

- Frequency distribution of max. wind speed:





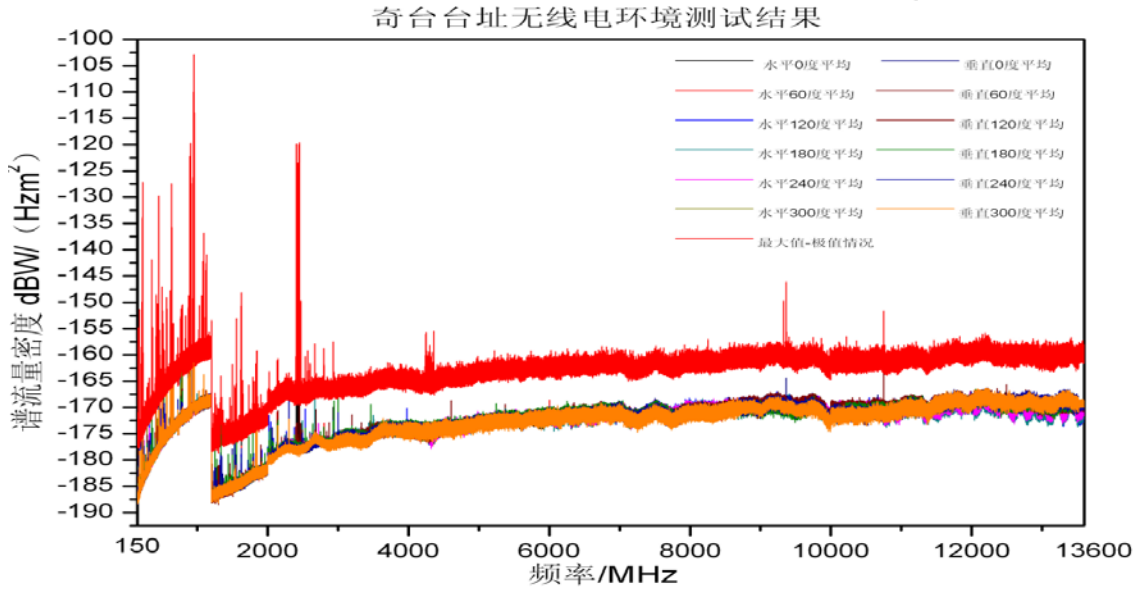


Roses diagram

Wind speed	Ratio			
	Qitai_Day	Qitai_Night	Qitai_Average	GBT
≤4m/s (3 beaufort scale)	48.9%	83.0%	65.9%	45.9%
≤6m/s (4 beaufort scale)	74.3%	92.9%	83.6%	64.5%
≤8m/s (5 beaufort scale)	91.0%	96.6%	93.7%	79.2%
≤10m/s (6 beaufort scale)	96.7%	98.3%	97.5%	88.9%
≥17m/s (8 beaufort scale)	0.21%	0.06%	0.14%	0.5%

QTT Site

- RFI: SKA-FAST measurement and processing standards

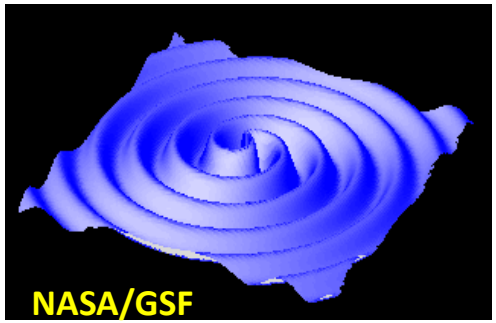


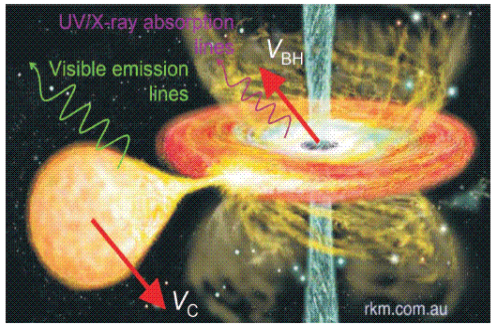
- Most interference are recognizable:
  - Measured 150 MHz — 13 GHz
  - 2 or 3-G mobile wireless communication (UHF, L, S band)
  - broadcast television (analog digital, VHF, UHF band)
  - differential rotation system of wireless satellite television (UHF, C band)
  - satellite navigations

Science Goal

Astronomy

- Molecular spectra observations
- High precision pulsar timing
- Active galactic nuclei
- Dark matter
- VLBI astrometry, astro-dynamics and space VLBI
- Sky survey: detecting organic molecule and sulphur chain molecule



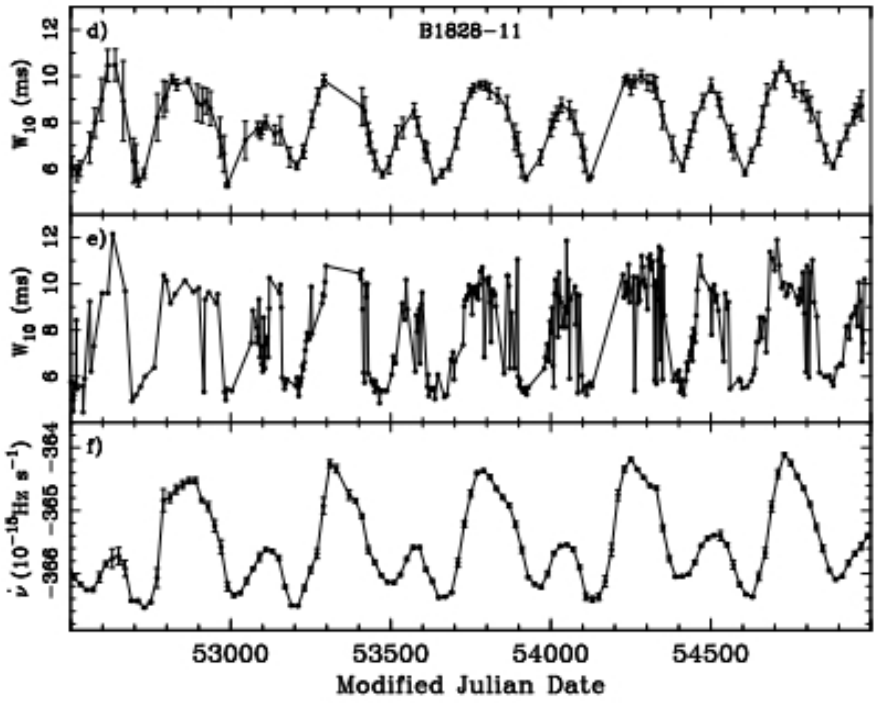


Application

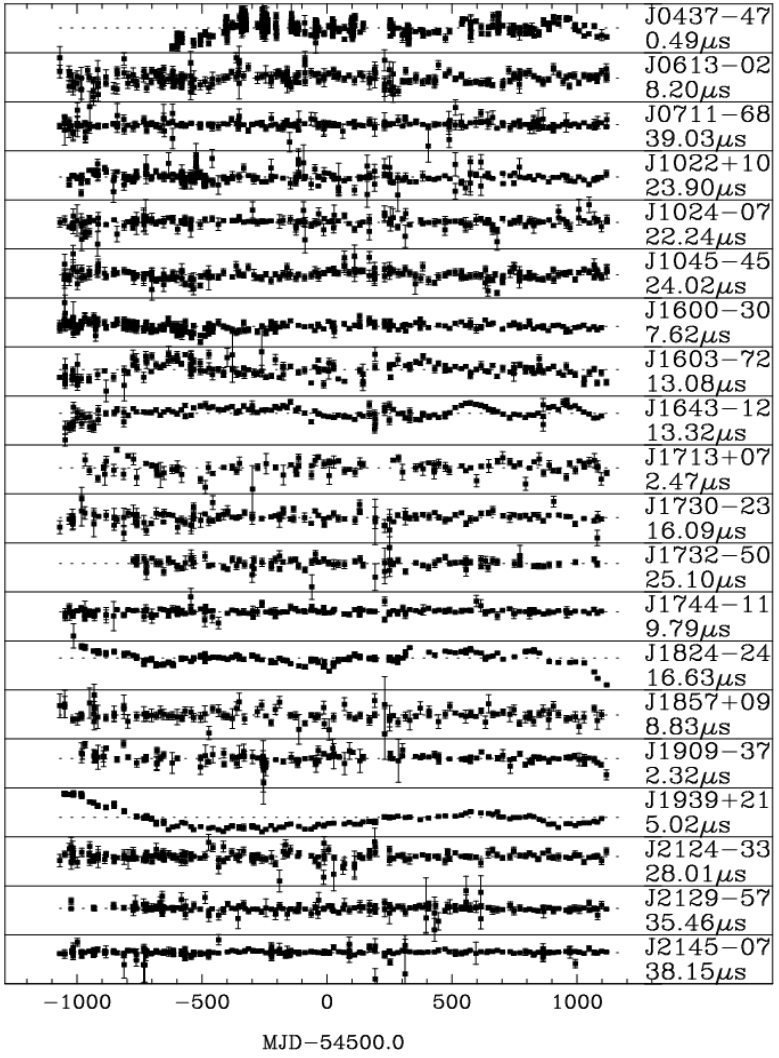
- VLBI orbit measurement for space exploration
- Pulsar time standard
- Deep space pulsar autonomous navigation

Science Goal

High precision pulsar timing



(Lyne, 2010)

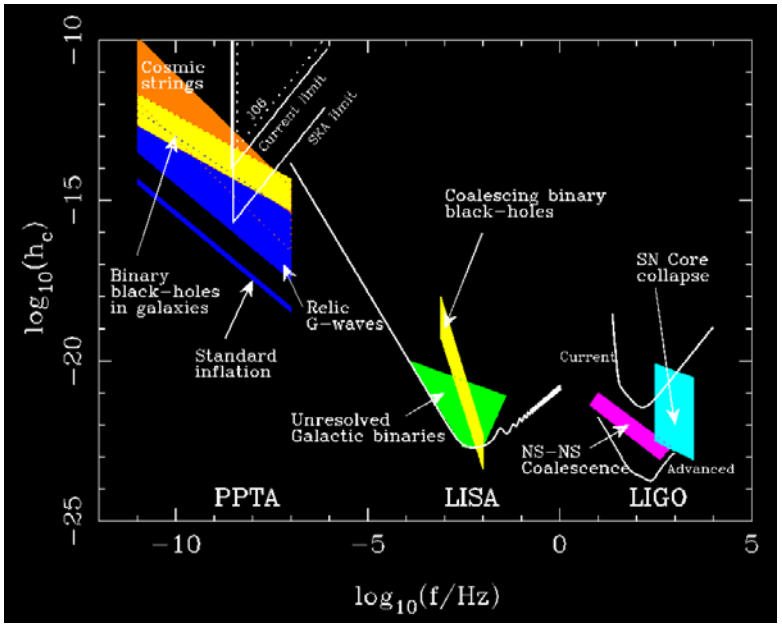


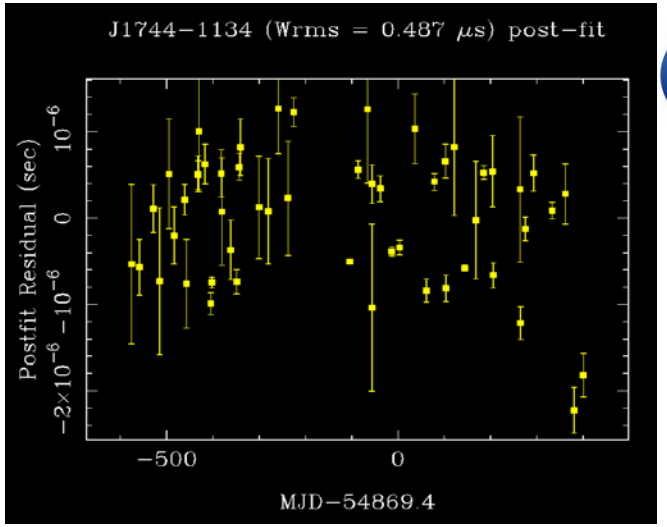
Science Goal

Gravitational wave detection

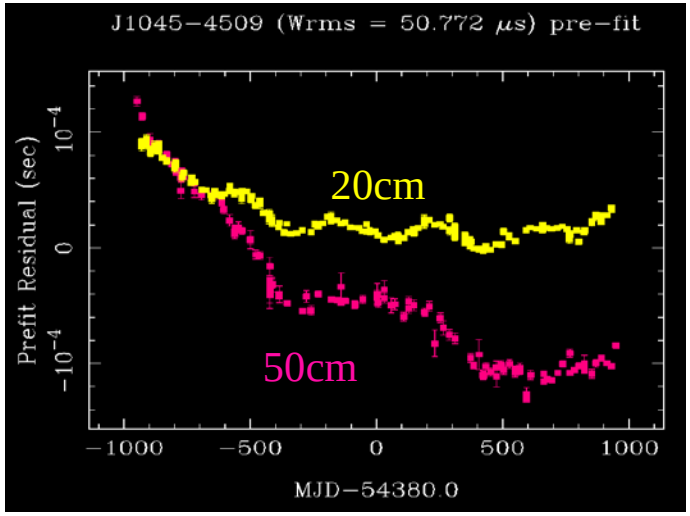
NANOGrav, IPTA, PPTA

Best: ~50 ns





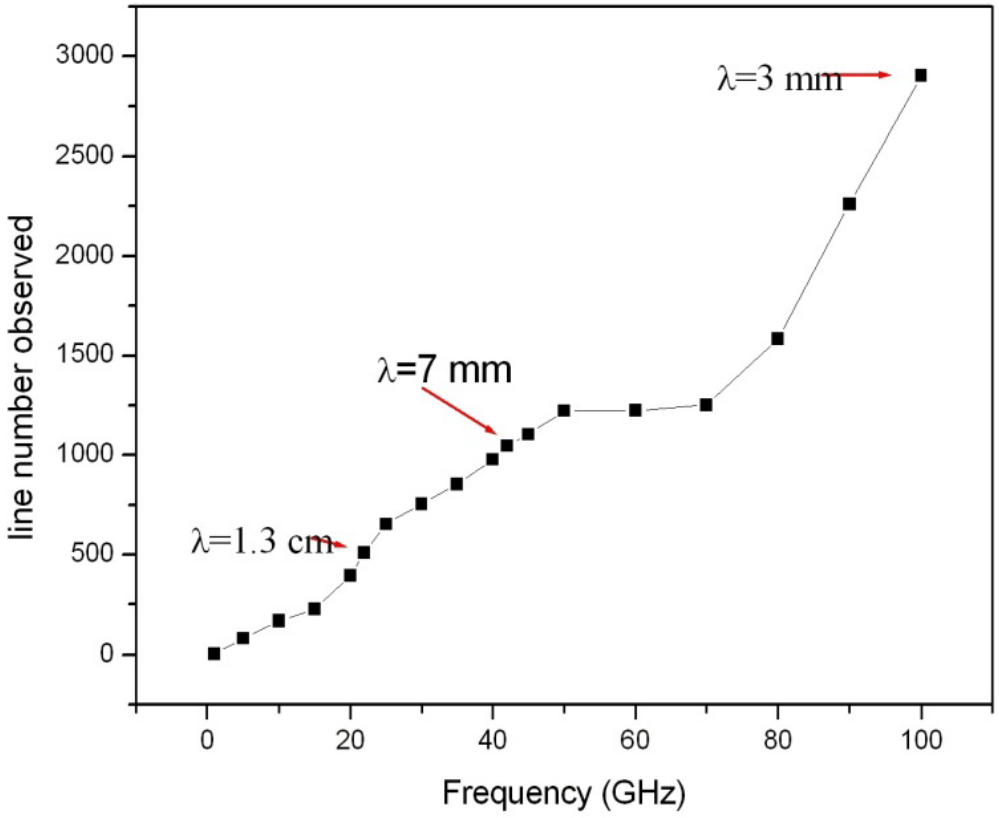
PSR J1744-1134, polarization correction, residual reduces from 487 to 195ns



PSR J1045-4509, DM correction, reduces residual by ~50%

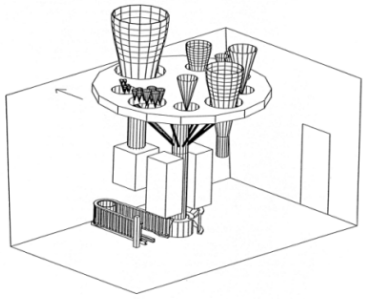
Science Goal

- Follow up obs. of FAST pulsar survey
- Spectrum survey at 6mm & 3mm

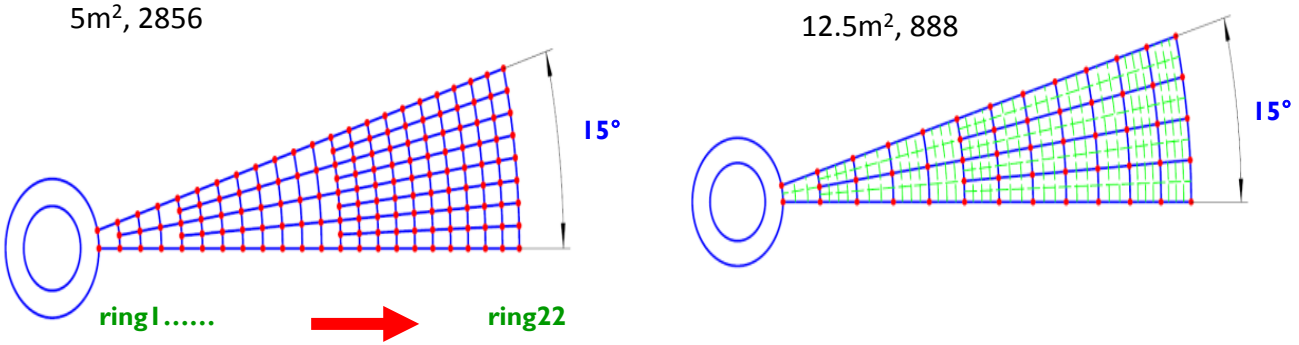


Technique Schemes

General



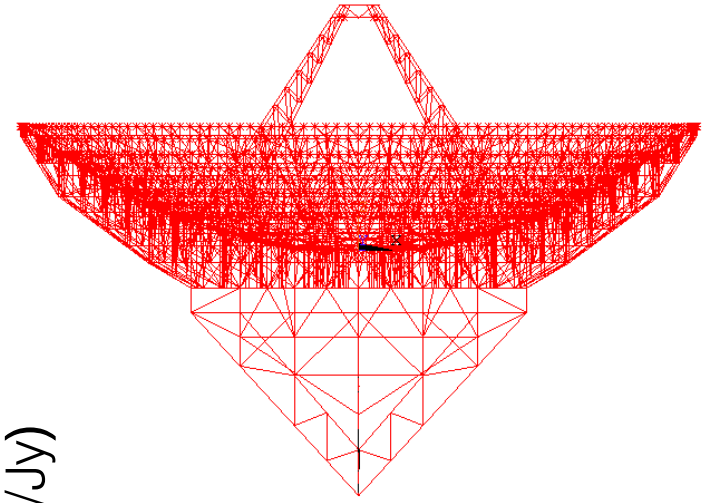
- Structure design: high antenna efficiency
- Servo control: accurate pointing
- Active surface: quasi closed-loop control
- Track: welded track + heavy load
- Structure and electronics: temp under −30℃
- Rx: wide band feed
- Multi-beam / PAF

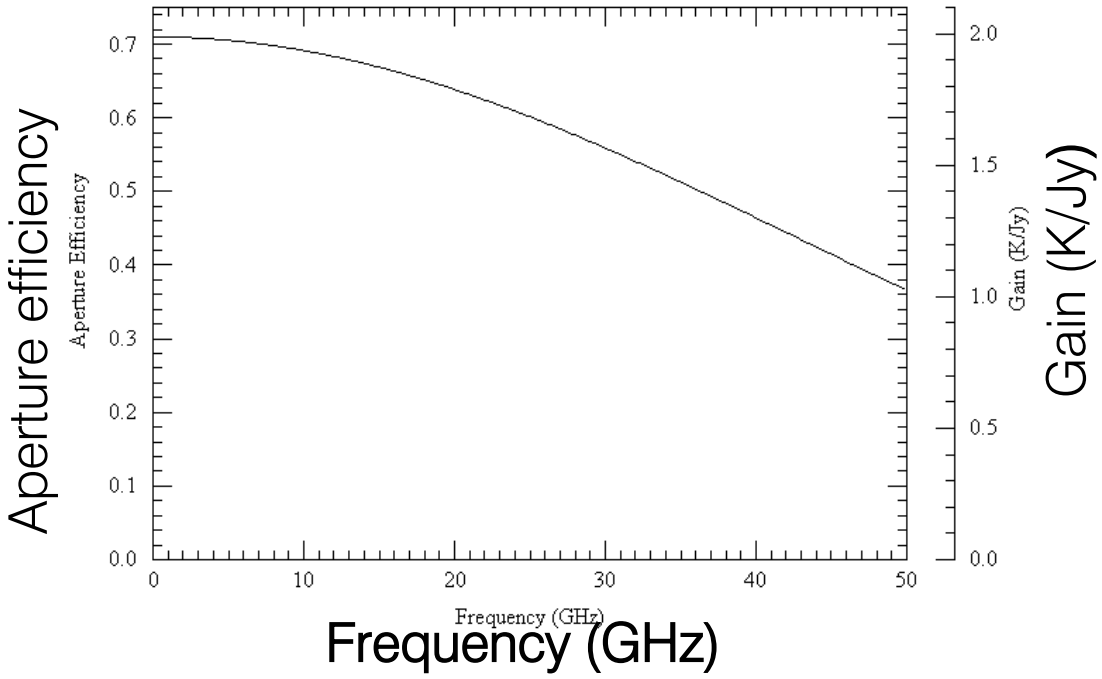


Technique Schemes

Telescope efficiency

- Conformal design
- Homology design
- Active surface

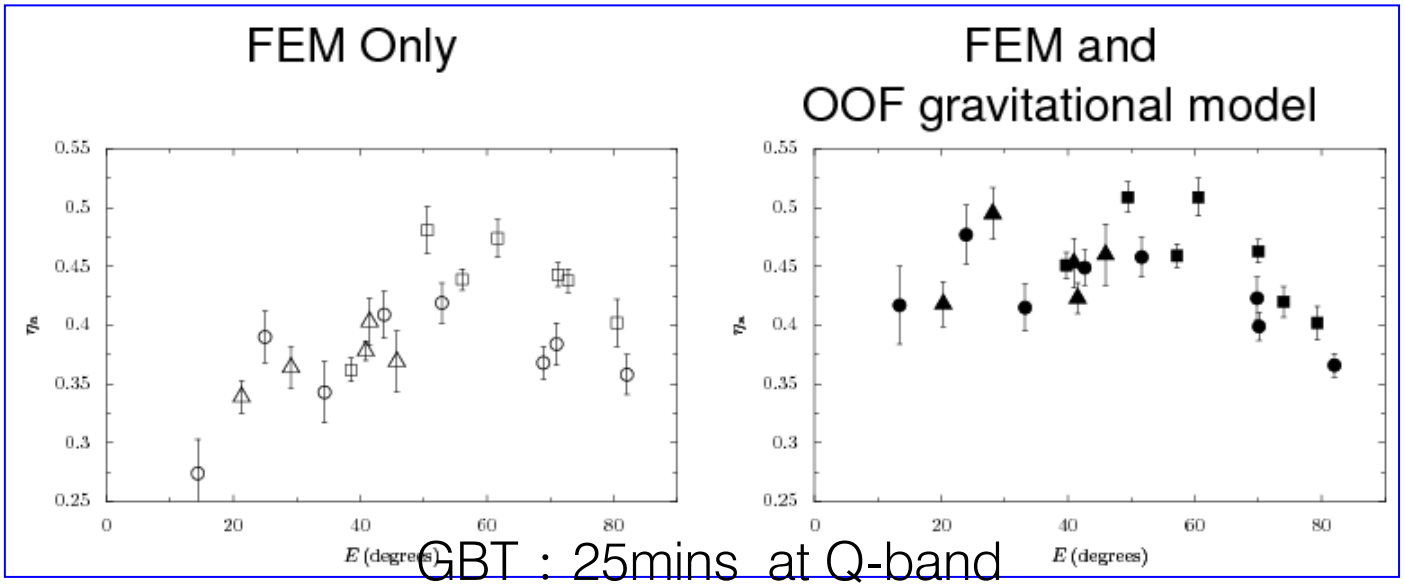




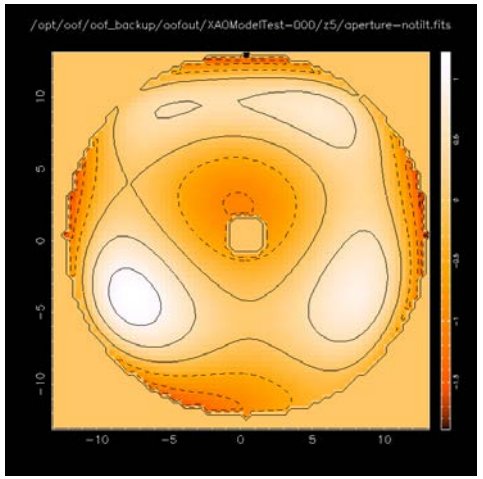
Technique Schemes

Active surface

- Deformation:
  - Gravity, thermal, temperature drifting, wind load
- FEM to Quick measurement: OOF
- Closed-loop control



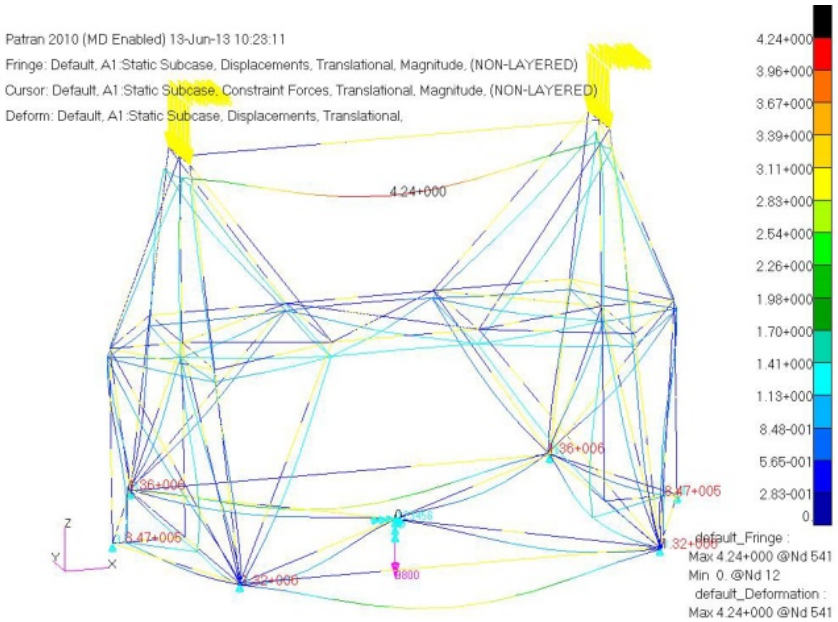
GBT : 25mins at Q-band

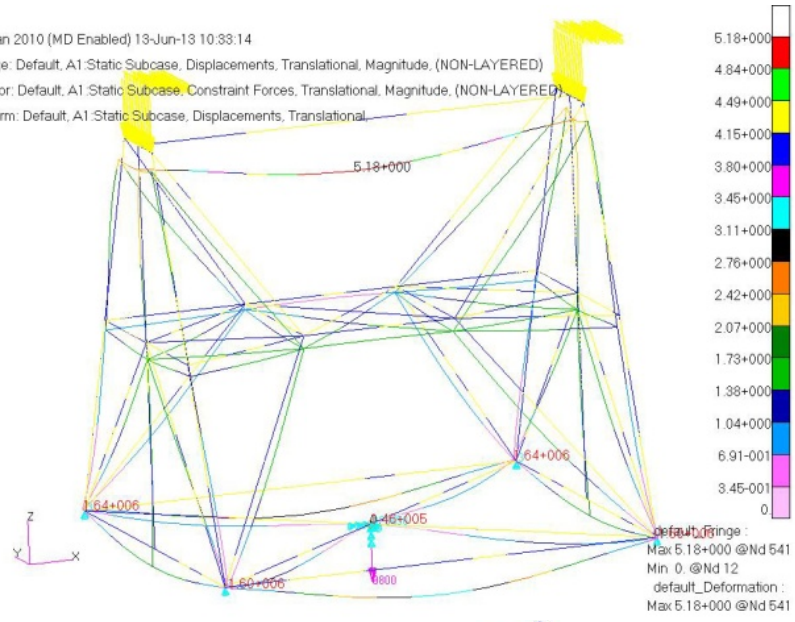


25m

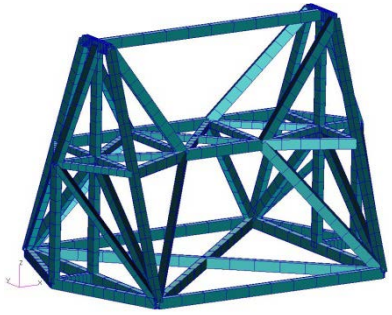
Technique Schemes

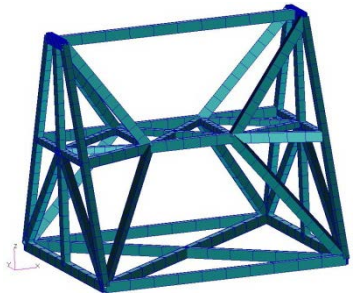
Wheel-track antenna mount: 4 or 6 feet support





Max. load

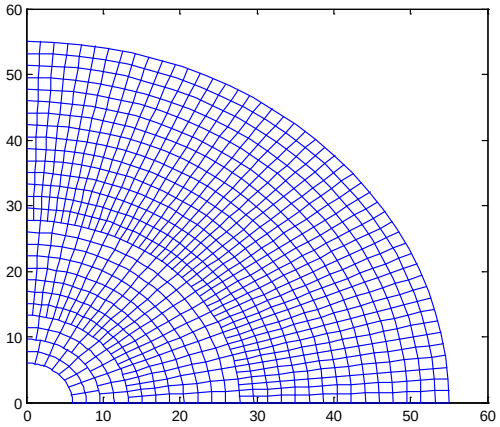


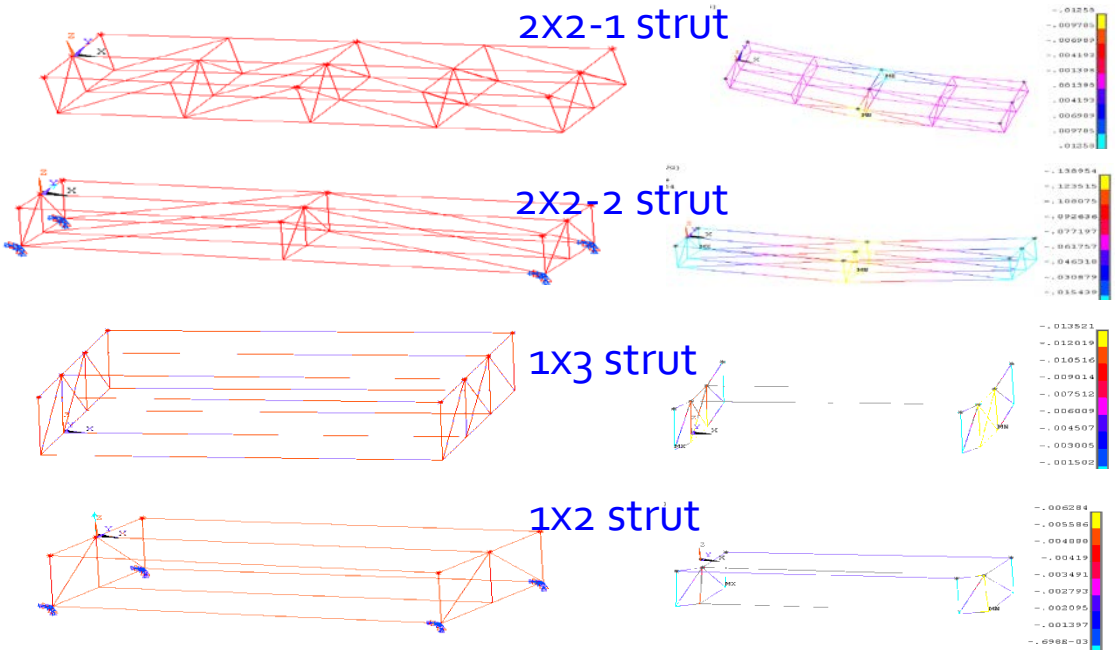


Technique Schemes

Segmented main surface

- Single joint, 27 rings, ~4000@4m²
- Secondary joint

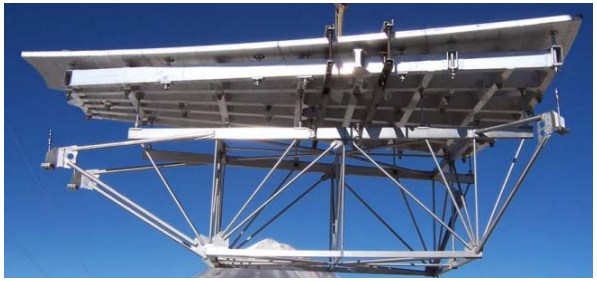




Panel : Back sub-truss

1:1.53

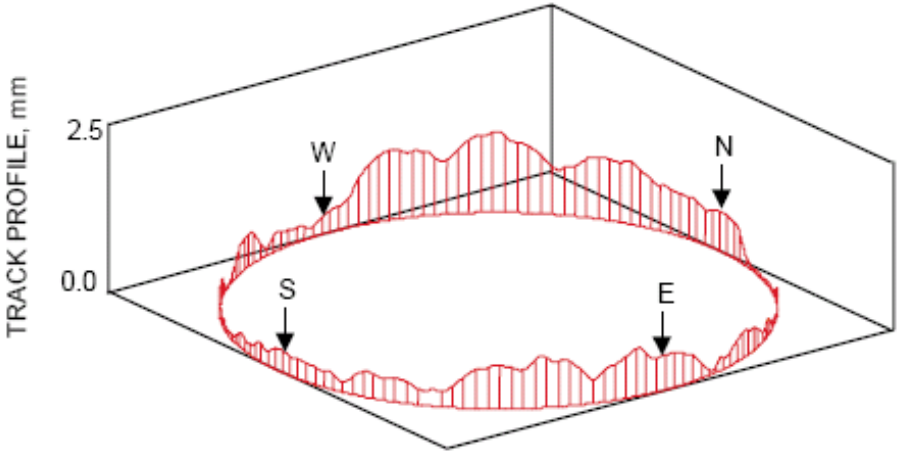
1:1.27

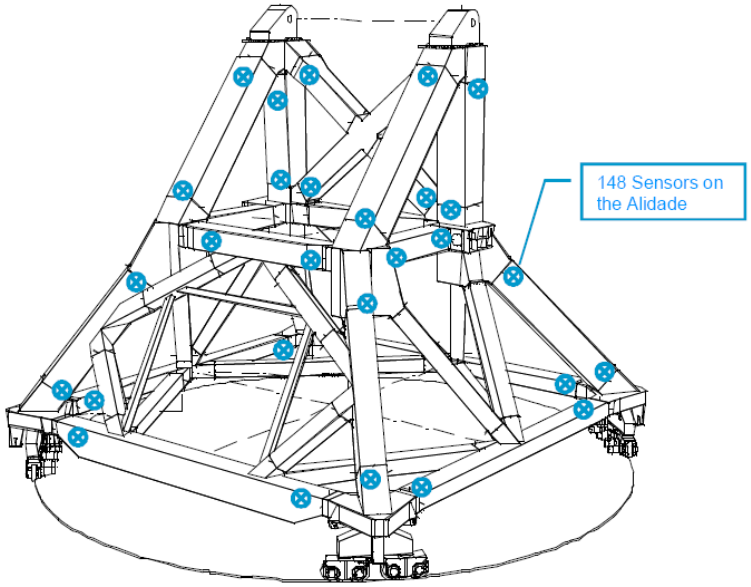


Technique Schemes

Pointing correction

- Thermal deformation
- Temperature deformation
- Wind load





Technique Schemes

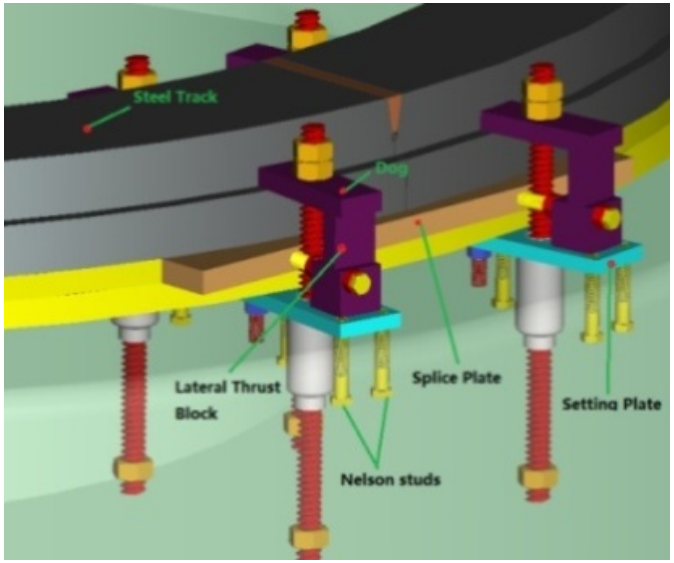
Telescope control

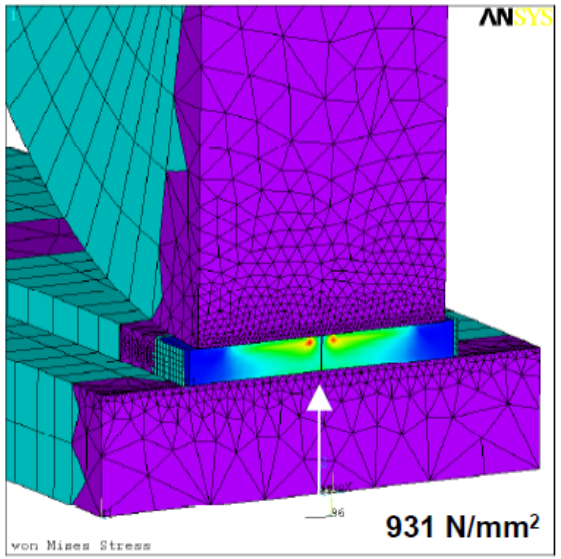
Low speed large torque drive	Increase the resonance frequency Increase the rigidity, reduce structure transmission impassable range
Digital control sys	Reduce the systematic and random error of servo system
Compound control technique	PI regulator+ Front feed compound control(FF)+ LQG

Technique schemes

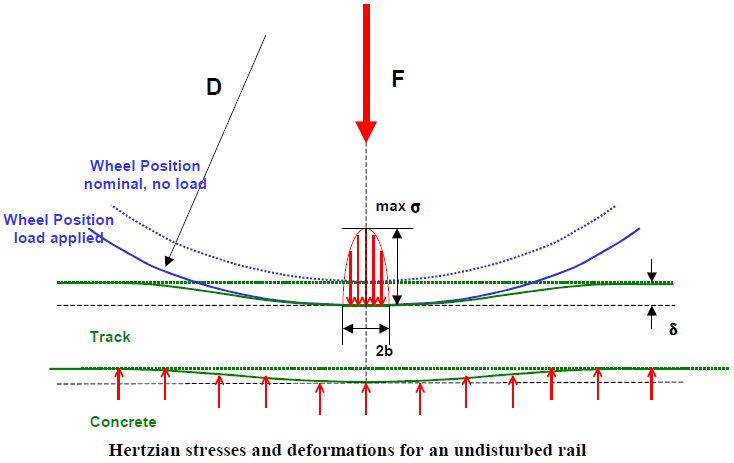
Welded wheel track

- Heavy load: ~5000 ton
- Temperature range—30—+30℃





Stress raisers at mitered gap

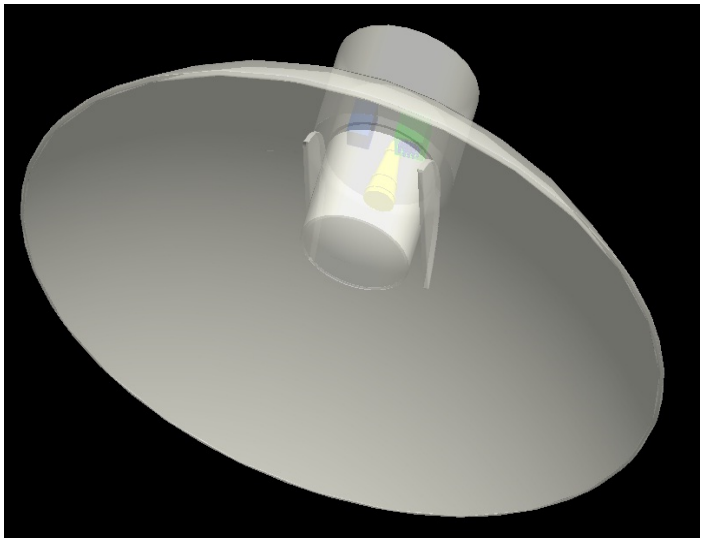


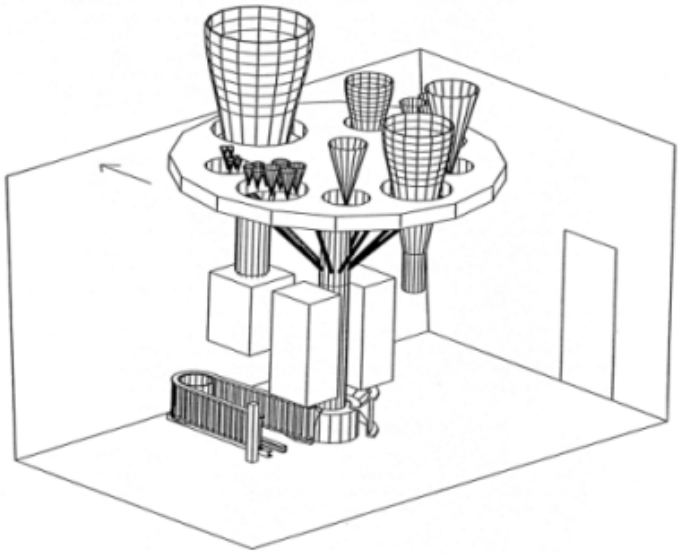
Hertzian stresses and deformations for an undisturbed rail

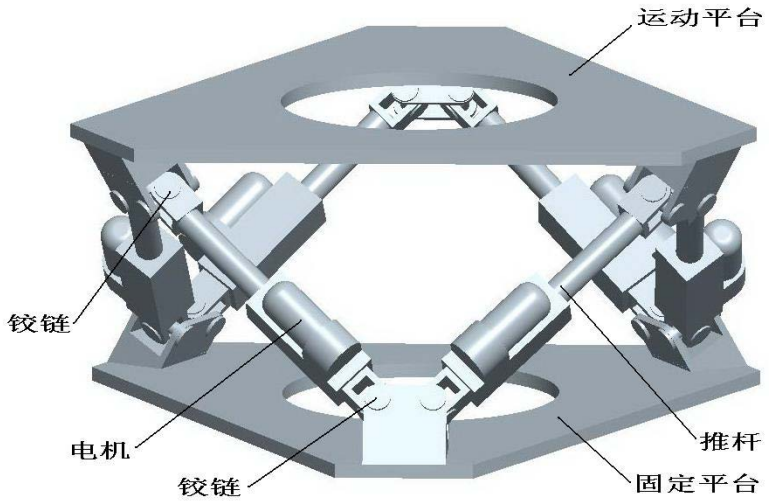
Technique Schemes

Sub-reflector

- carbon fiber
- 6-pole adjust system
- Rotate to change Rx



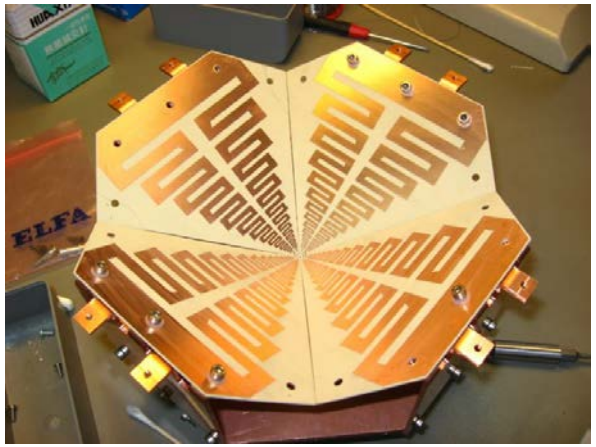




Technique schemes

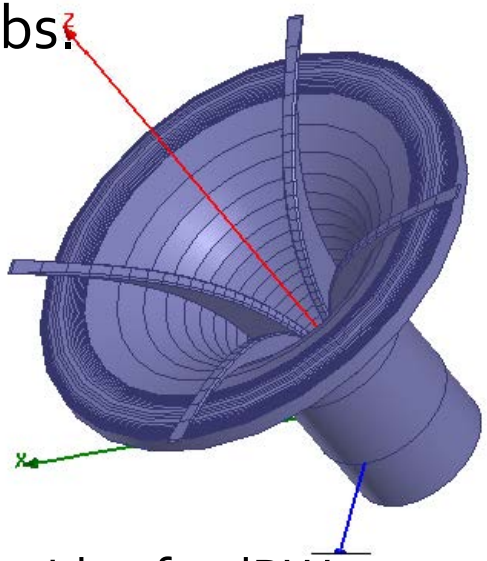
Ultra-wideband feed

- Increase S/N
- Simultaneous multi spectrum line obs.



ELEVEN feed

- Simplify structure
- Compact, low cost
- Stable phase center
- Constant beam width

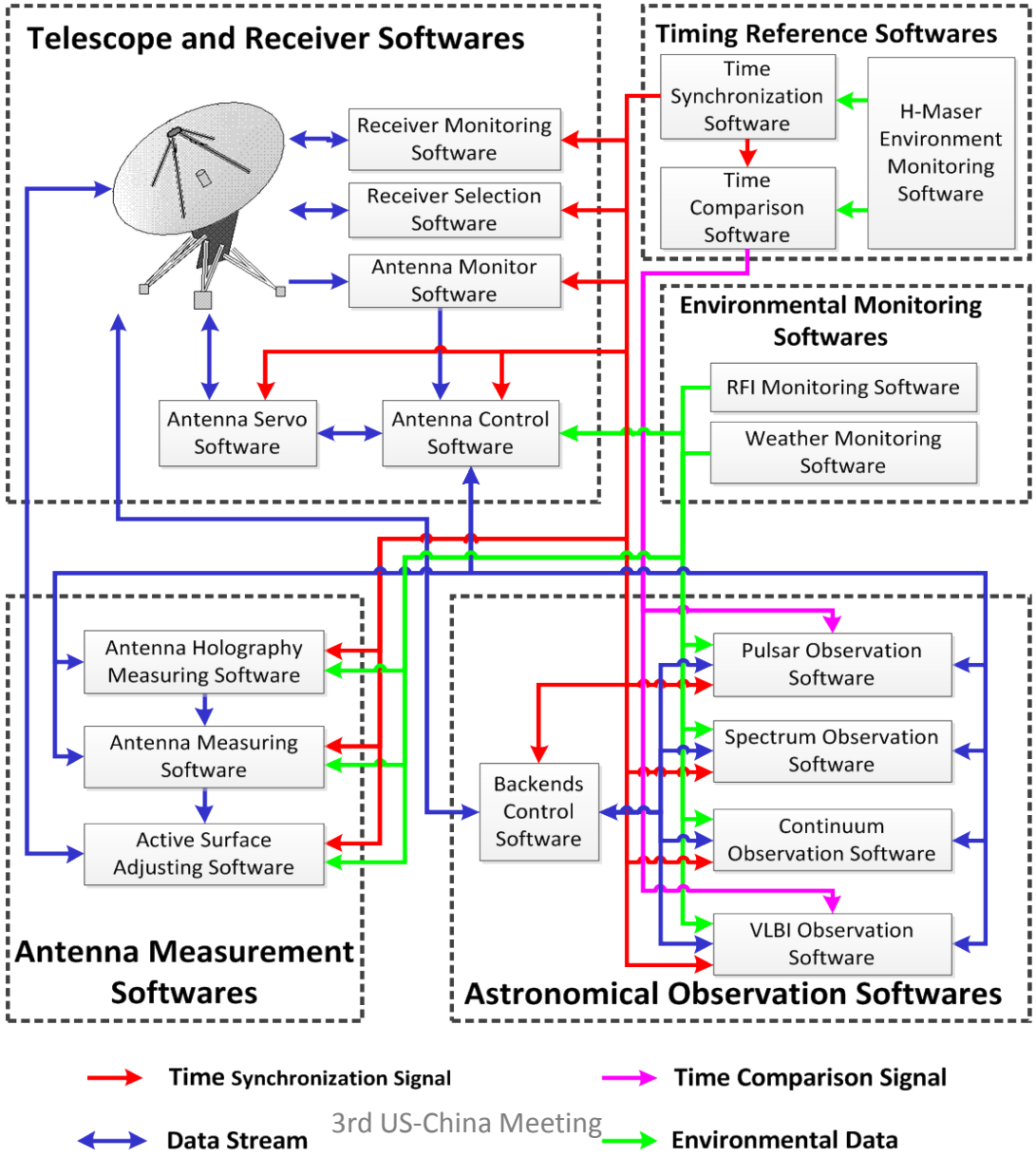


Four ridge feedBW: 10 octave band

- Better radiation pattern
- High-pass filter

Technique Scemes

Software



Progress

- Leading group by

  Nuer Baikeli (Chairman of XJ)

  Bai Chunli (President of CAS)

- Leading group office / Site headquarters

  Liu Hua (secretary of XJ government)

Progress

- Evaluations organized by CAS & NAO
- Ceremony for laying foundation
- Manufactures involved
- Design

Progress

2012 Nov. 29—Dec. 1

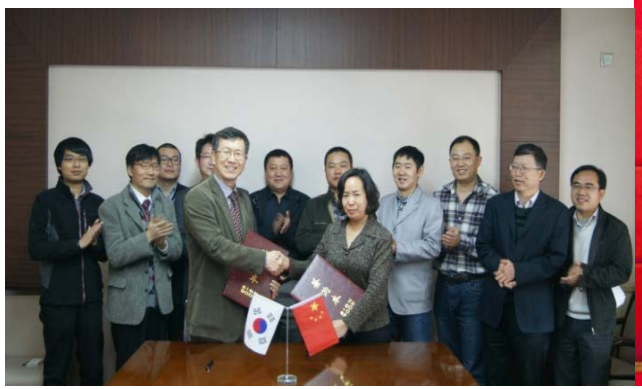
QTT International Advisory Workshop

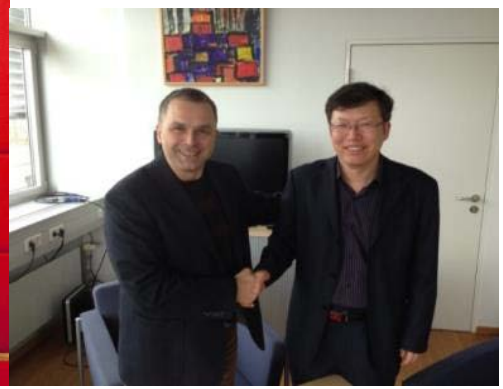
Suggestions about conceptual design, 3mm science, operating, cost

Progress

International collaboration:

- NRAO: Memorandum of Agreement for Scientific and Technical Consultation on the Planned Qi-Tai Radio Telescope (QTT)
- KASI, NAOJ, MPIfR





Progress

Infrastructure

- Land acquisition: approved
- Herdsman relocate: 130 families, move in 3 years
- Classified road: build this year
- Power: satisfy the infrastructure requirement
- Water supply plan: assessed
- Fiber connection: done for construction period
- RFI & meterological daily monitoring

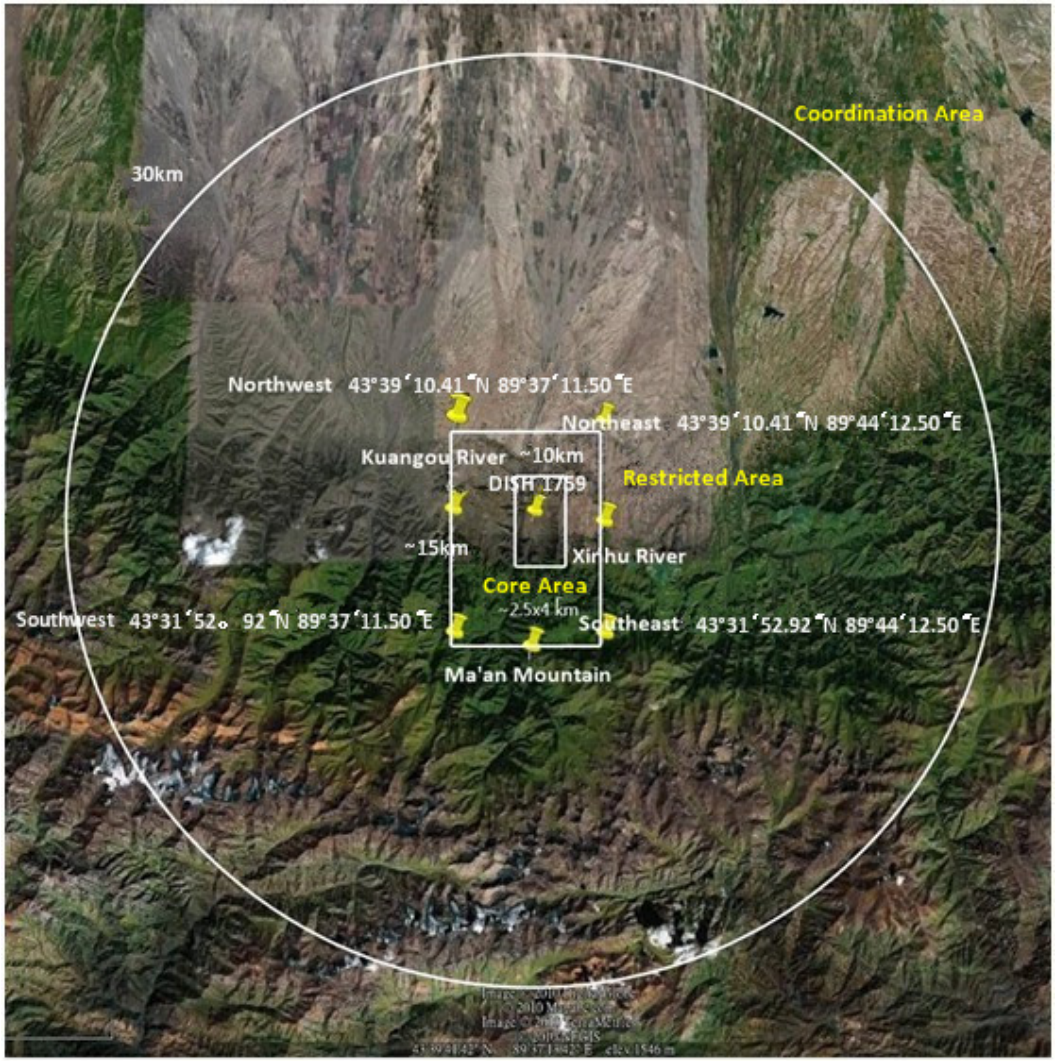
Progress

Site planning

QTT Site - Radio Protection Area

radio quiet zones @different protection levels:

- core area
- restricted area
- coordination area



Progress

Recent

- Project Approval Intension: Qitai Station for Astronomical Observation and Popular Science Education
- Funding from XJ this year

Summary

- QTT: general purpose telescope
- Site is good for 6mm and above
- Engineering specifications: 6mm
- Design aimed to 3mm
- Technique challenges: structure, pointing control, surface accuracy, active surface adjust, wideband Rx
- Science: pulsars, spectrum line, AGN, VLBI
- Present: infrastructure construction moving on
- Pursue for approving by 13^{th} 5-year plan