March 2, 2011

Remote Observing with the FAST Telescope

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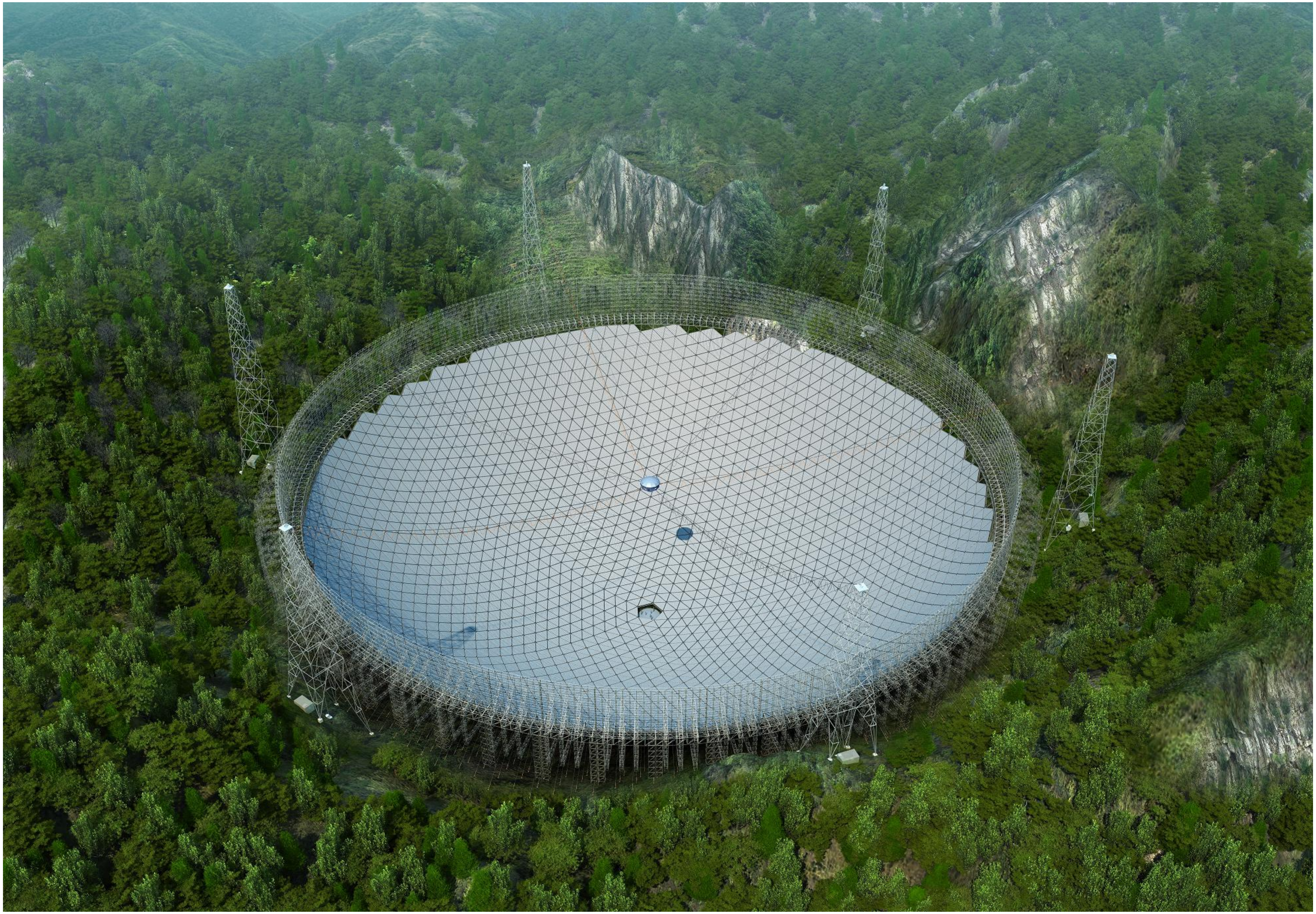
Aerial View FAST (model)



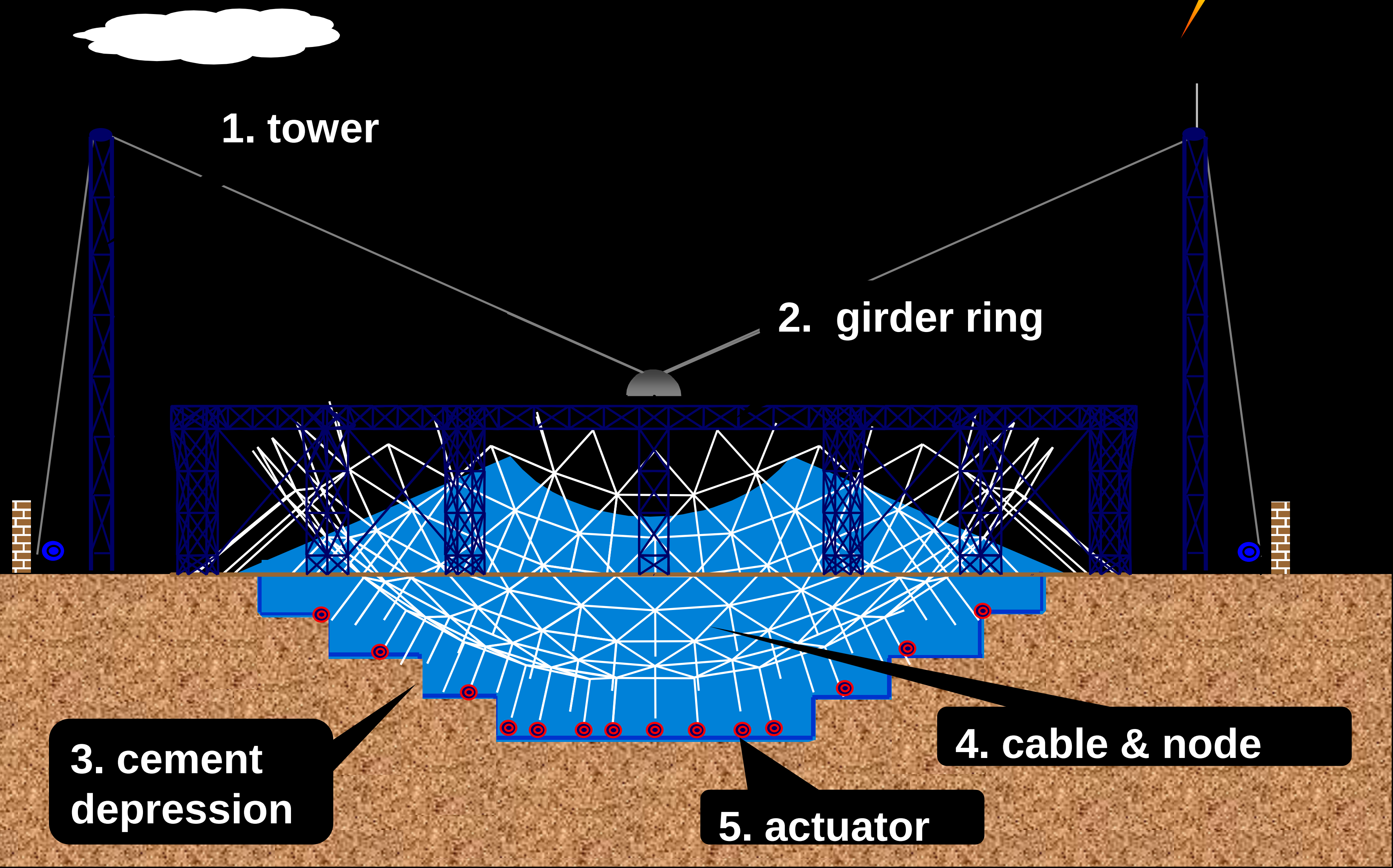
Site in Guizhou

Location: N25.647222º   E106.85583°

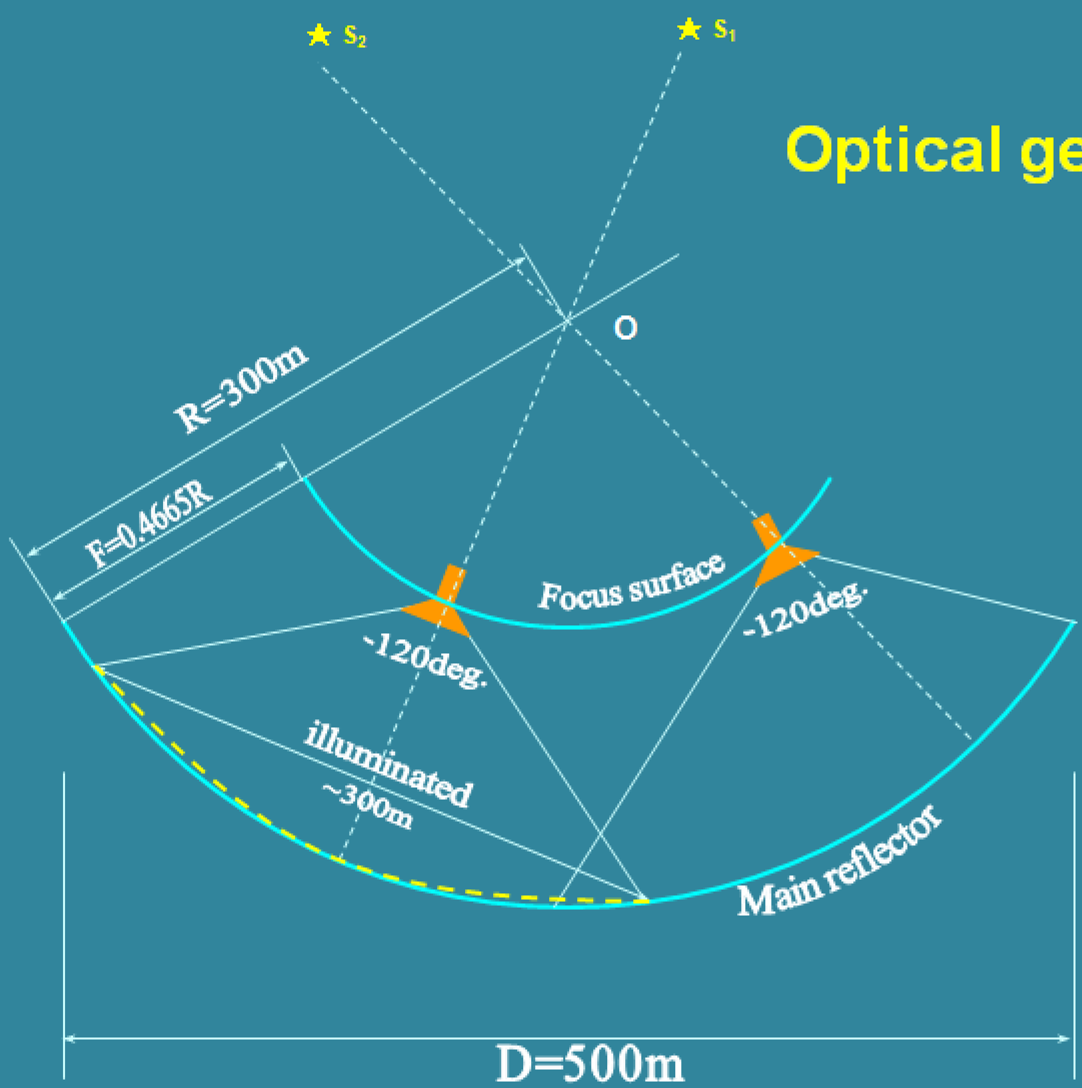
Site: the Karst region in south Guizhou Province


Quick Bird Fly Oct. 6, 2005

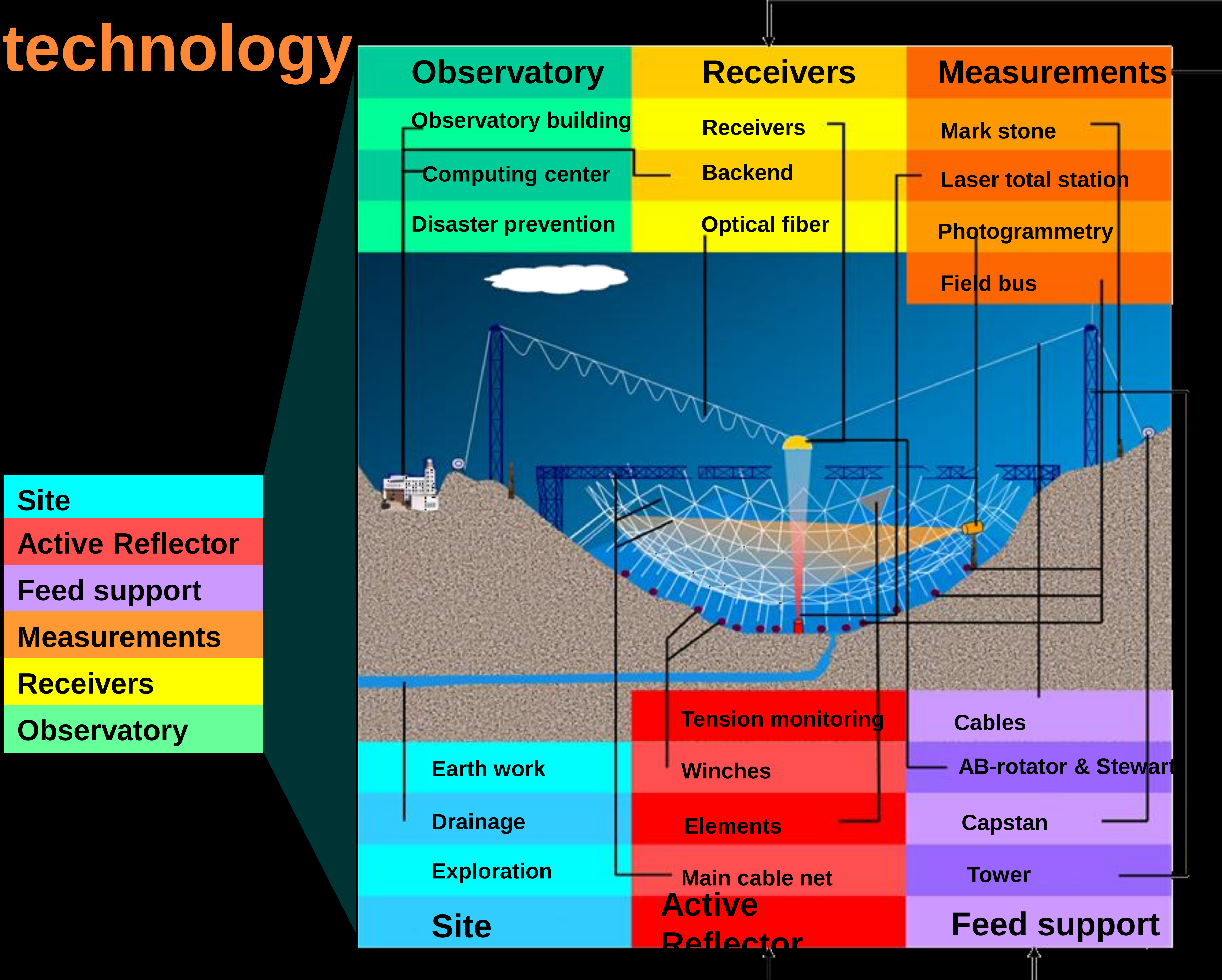
FAST model construction process

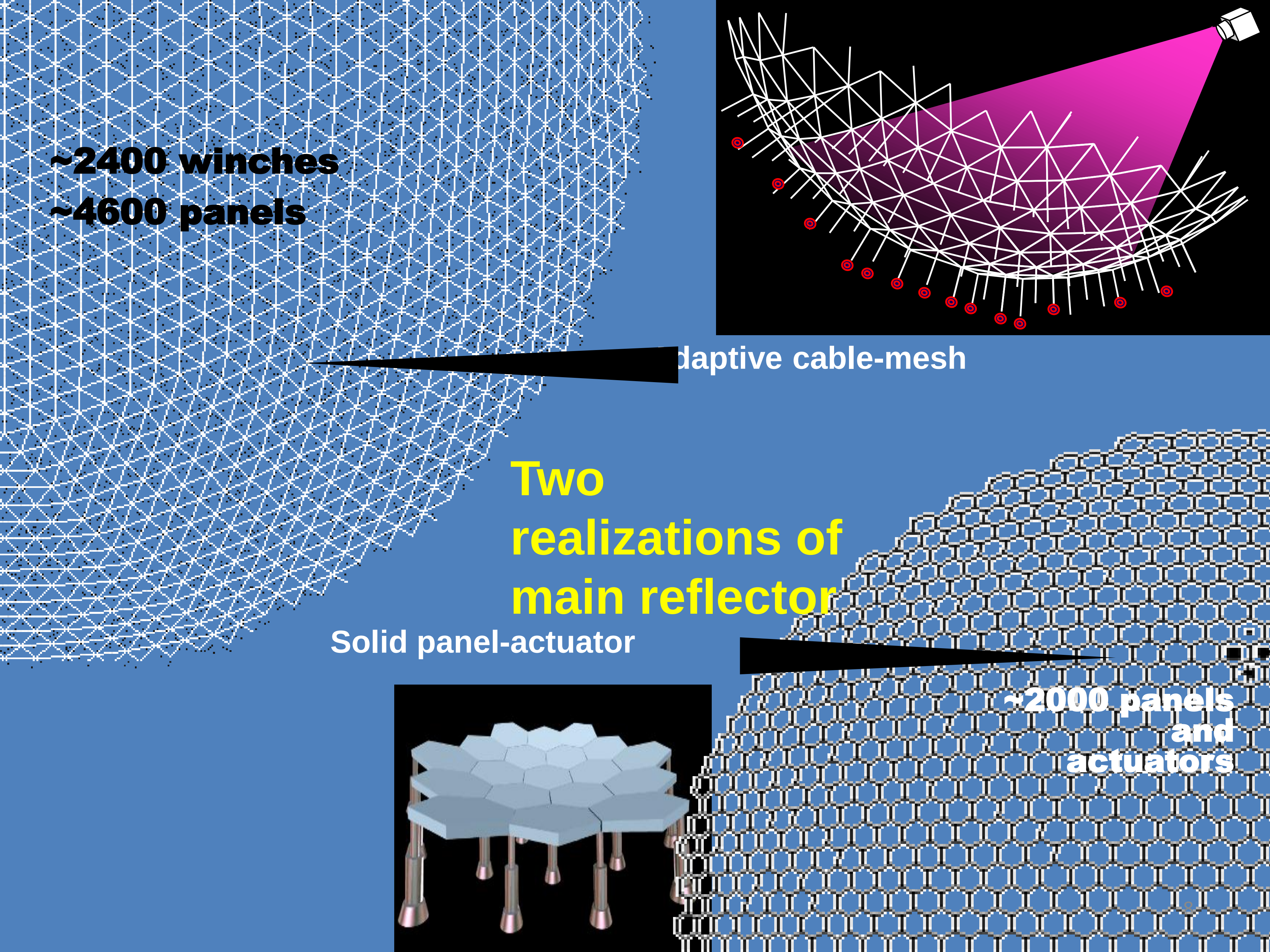


Optical geometry



3. technology

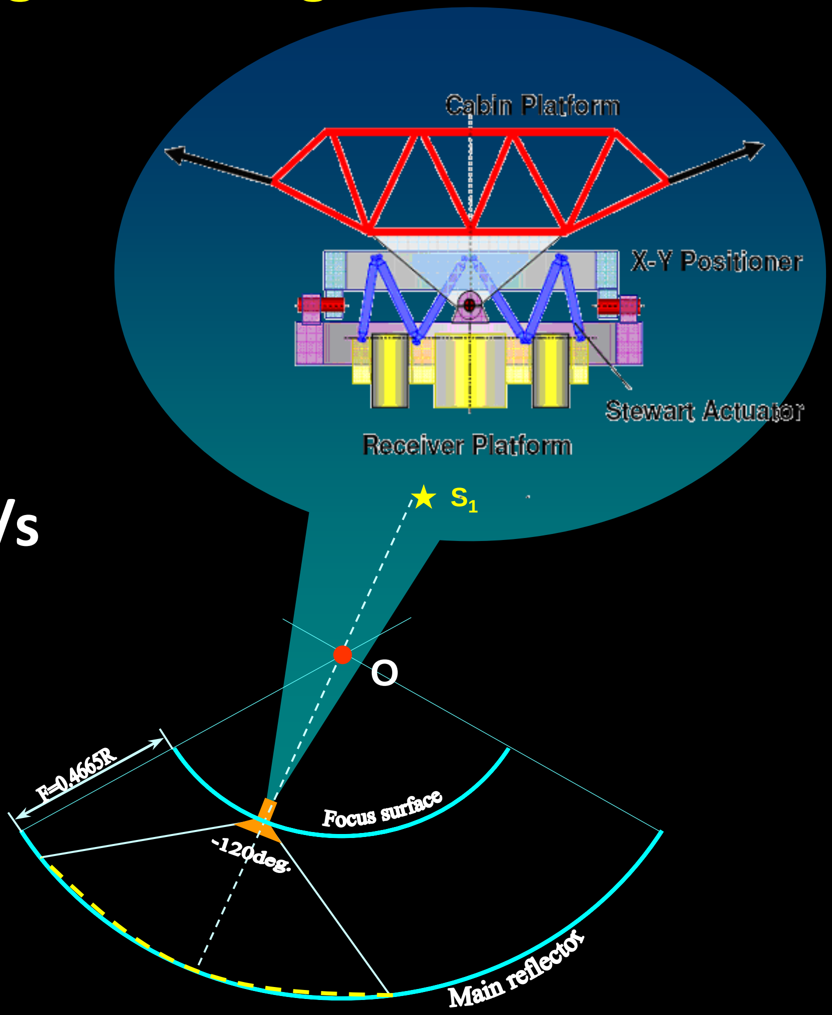



~2400 winches
~4600 panels
daptive cable-mesh
Two
realizations of
main reflector
Solid panel-actuator
~2000 panels
and
actuators

Feed support

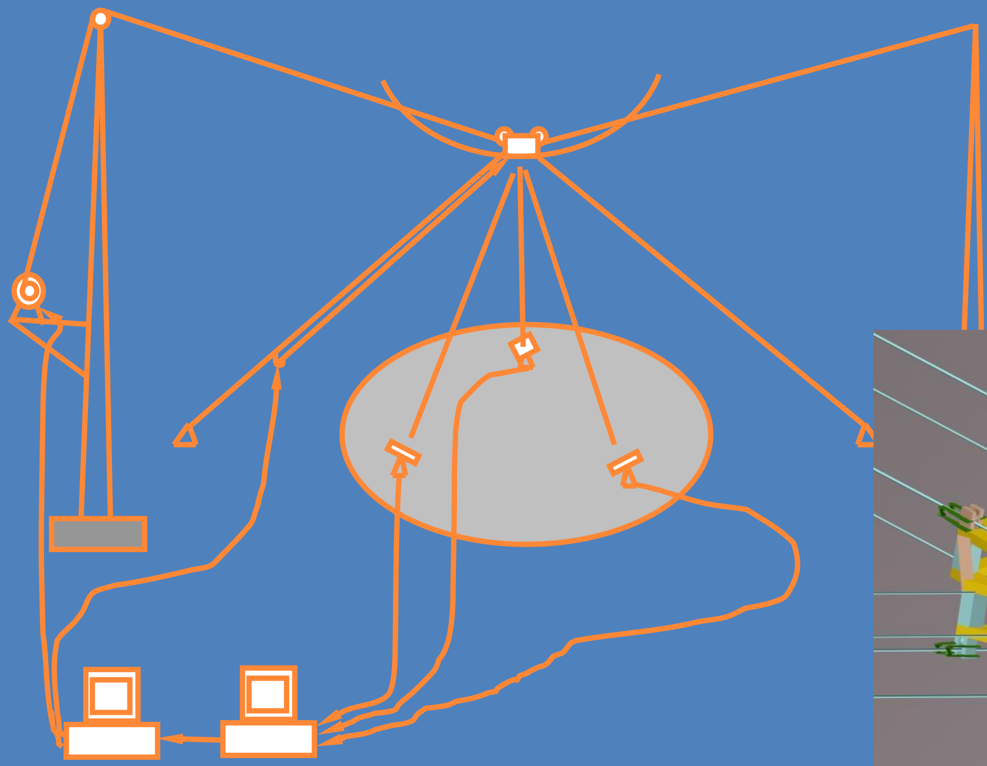
mechanical-electronic-optical integrated design

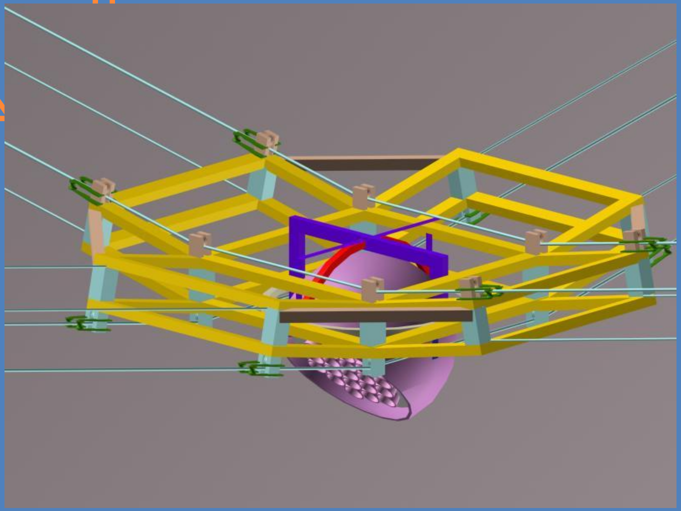
- Focal cap diameter 206m
- Cabin in total ~30t
- Load on lower plate ~3t
- Maximum tracking 11.6mm/s
- Slewing 400mm/s
- Position error <10mm
- Pointing accuracy 8''



Three main parts of cabin suspension

- **Cable network - first adjustable system**
- **Stewart - secondary adjustable system**
- **Close loop control**





2. General Technical Specification

Spherical reflector： Radius～300m, Aperture～500m, Opening angle 110~120°

Illuminated aperture： D_{ill}=300m

Focal ratio： f/D =0.467

Sky coverage： zenith angle 40° (up to 60° with efficiency loss) tracking hours 0~6h

Frequency： 70M ~ 3 GHz（up to 8GHz in future upgrading）

Sensitivity (L-Band)： A/T~2000, T~20 K

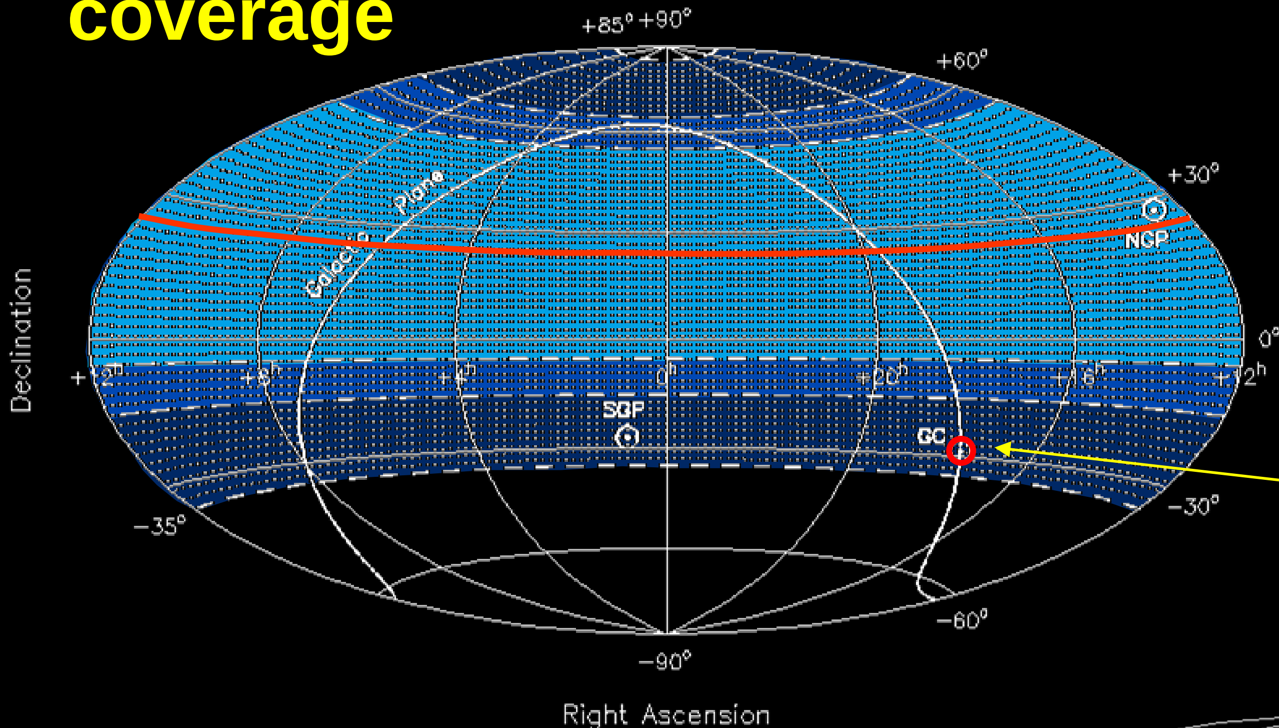
Resolution (L-Band)： 2.9′

Multi-beam (L-Band)： 19, beam number of future FPA >100

Slewing： <10min

Pointing accuracy： 8″

Opening angle - sky coverage



Sky coverage

ZA 30 deg

ZA 40 deg

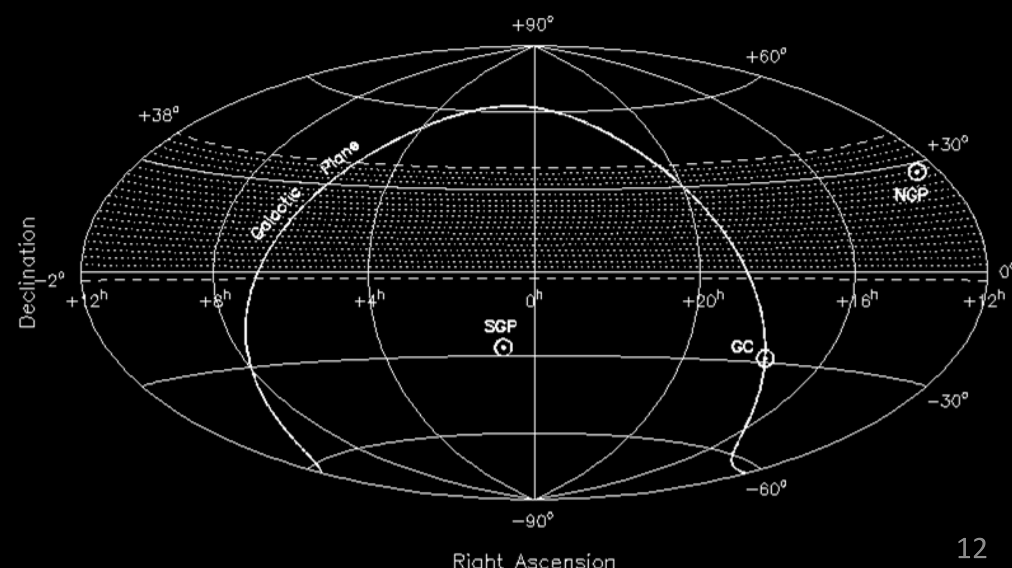
ZA 60 deg

FAST Zenith

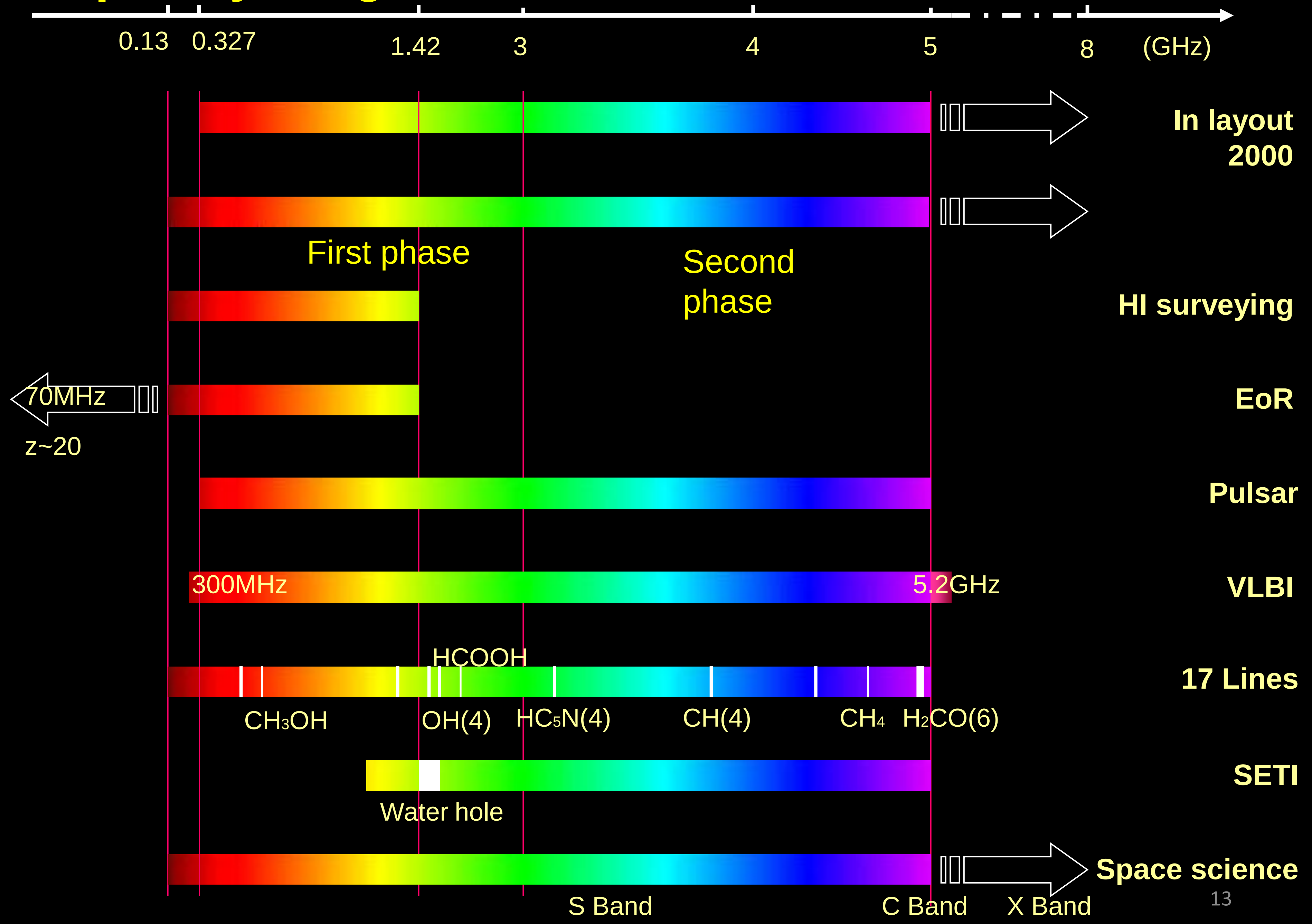
ZA 56 deg

Sky coverage

FAST vs. Arecibo



Frequency range



9 sets of FAST receivers NAOC - JBO

No	Band (GHz)	Beams	Pol.	Cryo Tsys(K)	Science
1	0.07 – 0.14	1	RCP LCP	no 1000	High-z HI(EoR),PSR, VLBI, Lines
2	0.14 – 0.28	1	RCP LCP	no 400	High-z HI(EoR),PSR, VLBI, Lines
3	0.28 – 0.56	1 or multi	RCP LCP	no 150	High-z HI(EoR),PSR, VLBI, Lines Space weather, Low frequency DSN
4	0.56 – 1.02	1 or multi	RCP LCP	yes 60	High-z HI(EoR),PSR, VLBI, Lines Exo-planet science
5	0.320 – 0.334	1	RCP LCP	no 200	HI,PSR,VLBI Early sciences
6	0.55 – 0.64	1	RCP LCP	yes 60	HI,PSR,VLBI Early Sciences
7	1.15 – 1.72	1 L wide	RCP LCP	yes 25	HI,PSR,VLBI,SETI,Lines
8	1.23 – 1.53	19 Lnarrow multibeam	RCP LCP	yes 25	HI and PSR survey, Transients
9	2.00 – 3.00	1	RCP/ LCP	yes 25	PTA, DSN, VLBI, SETI

FAST sciences

- Neutral Hydrogen line (HI) surveying
- Pulsar research
- Joining VLBI network
- Molecular lines
- Search for Extraterrestrial Intelligence (SETI)

FAST HI survey

- Extent of HI Disk, extended rotation curve to extreme large distance
- Cold Dark Matter Satellite (ΛCDM)
- HI Mass Function， BAO
- Comsmic web
- Surveying Milky Way (FV, HVC population, Magellanic Stream …)
- HI study of high redshift galaxies
- HI gas in galaxy clusters and groups
- HI absorptions from QSOs/radio sources

Neutral hydrogen (HI) survey

Blind detection of HI galaxies with 3x10^9 M_sun with an interference-free observing period of 1h, z~0.2
But, confusion will be a problem at z>0.4 …
Catinella et al. 2010 found galaxies with M(HI) ~3x 10^10 M_sun

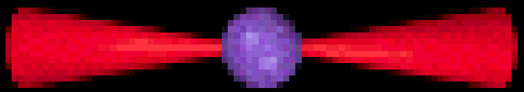
Warm HI shell around AGN, the detection range limit in a moderate integration time, z~2 or 3

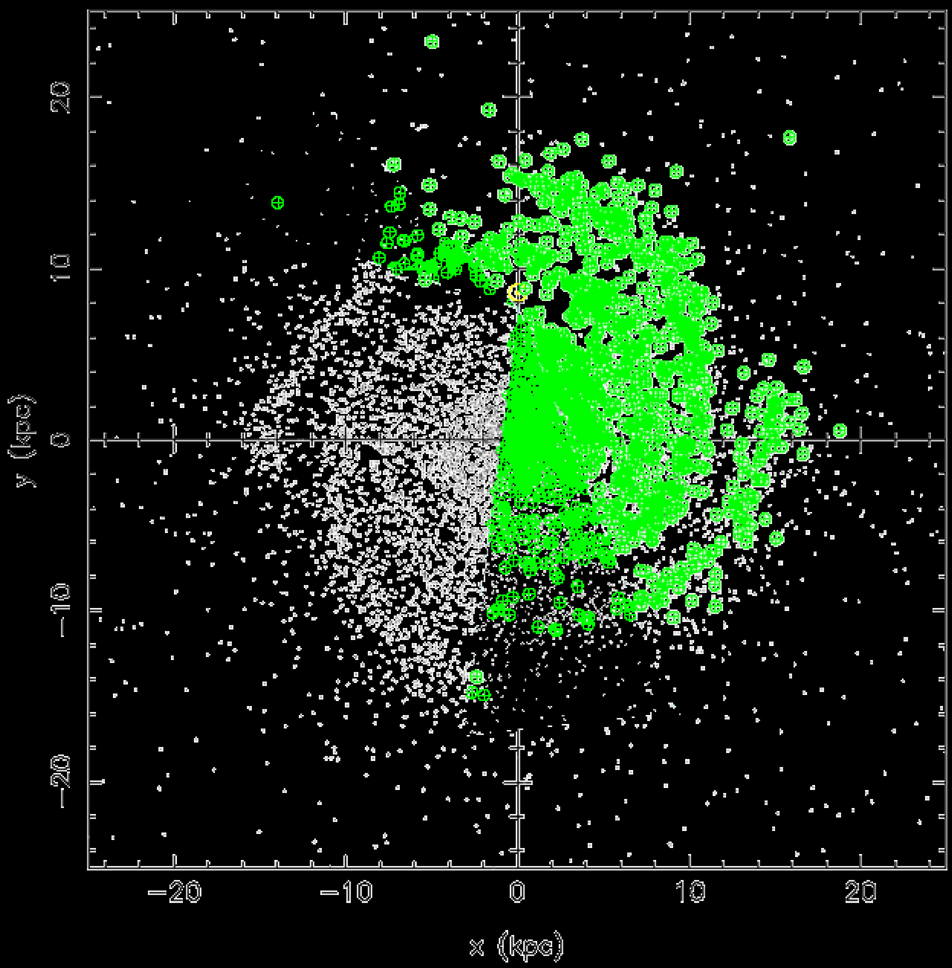
Deep integration in the neighborhood of nearby galaxies to the lowest surface density ~10^16 cm^-2

Search for dark galaxies with M(HI) ~10^-5 Msun in the local universe

FAST Pulsar Survey

There are ~ 6 X 10^4 detectable pulsars in the Galaxy, half is in FAST sky





- ~ **Thousands of new pulsars**
- **Rare objects**

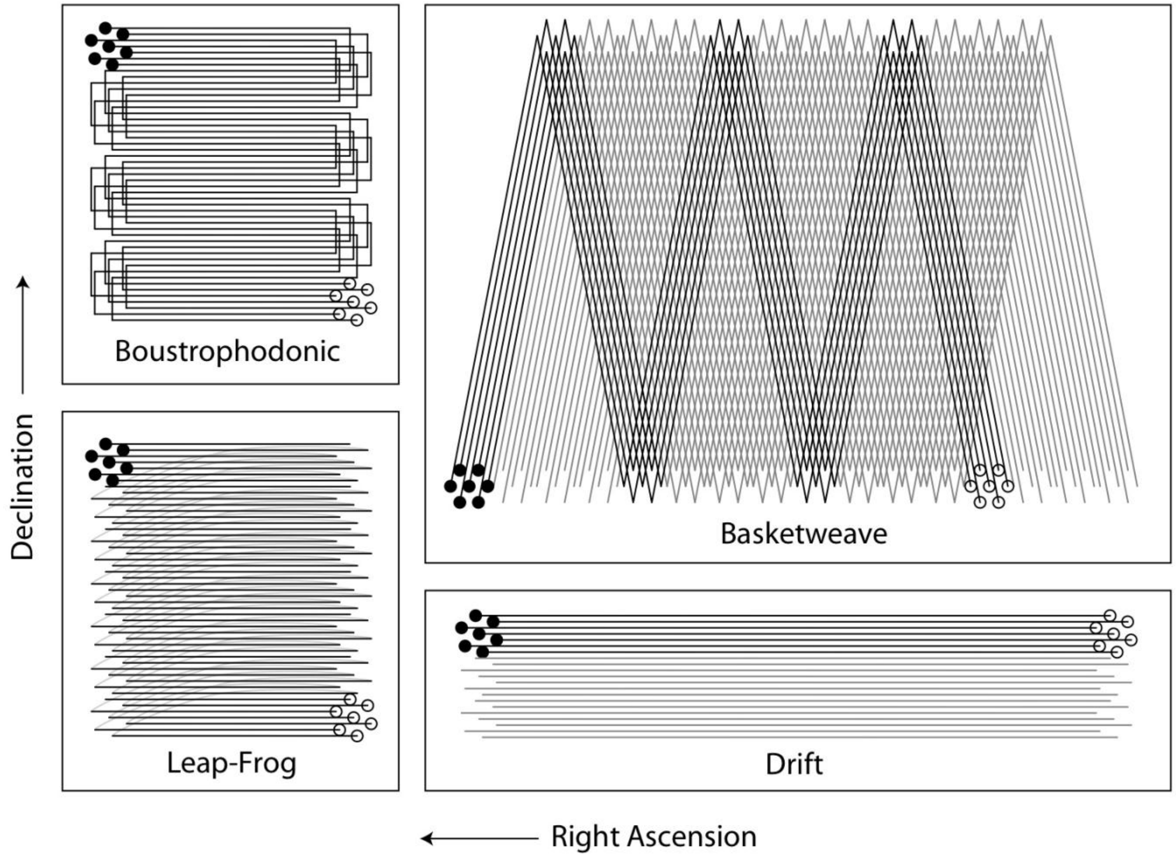
  Exotic stars – quark matter

  Pulsar-BH binary

  ….
- **Stellar evolution before SN**
- **ISM map of unprecedented details**

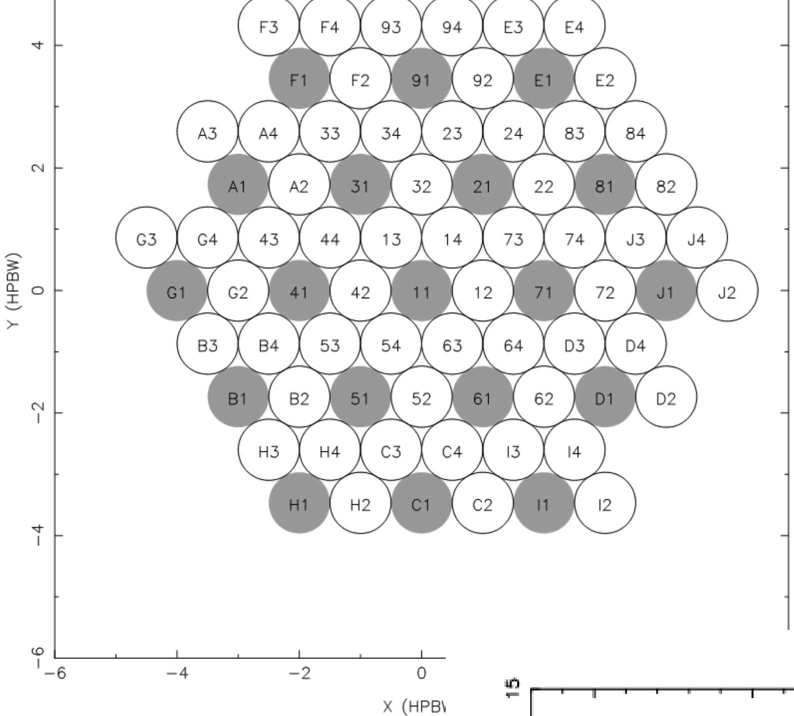
Observing Modes for FAST

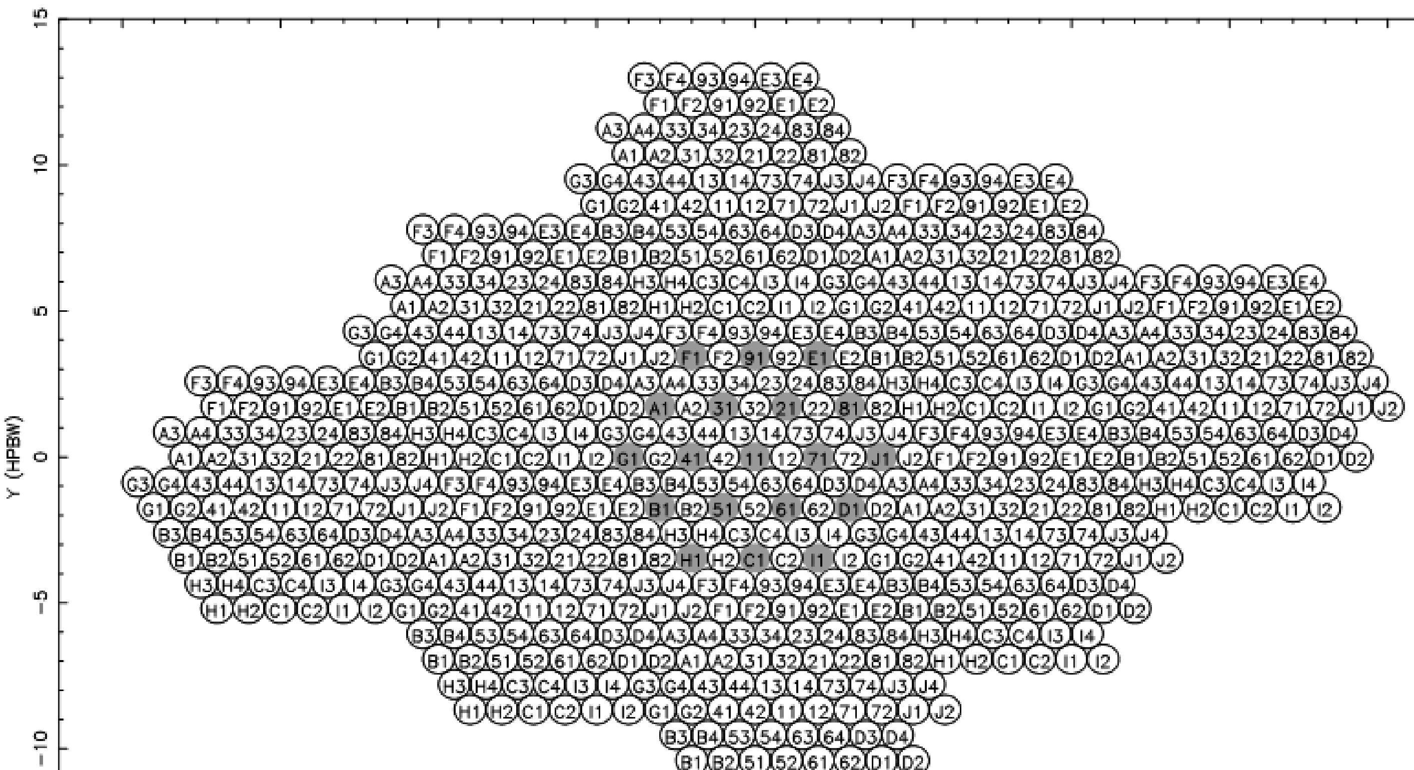
- Tracking
- Drift scan
  - Drift and chase
  - Basket-weaving
  - Drift at fixed azimuth or LST
- Position switching
- Freq switching
- Active scan (on the fly mapping)



The four modes of scanning used by GALFA-Hi. In each example, the empty circles represent the initial position of ALFA for a single day's observation and the lled circles represent the nal position of ALFA for the day's observation. In the drift and basketweave diagrams gray lines represent complementary scans taken on other days of observations. In the leap-frog diagram the gray lines represent the return slew of the telescope to the beginning of the right-ascension range to start another xed-azimuth scan.

Pulsar Survey Modes





Major Challenge: Pulsar Survey

- Large-scale surveys generate ***a lot of data***
- – 19 beams with FAST will be ~120GB per 5-min pointing, with 0.1ms sampling rate

  (assume 1K channel, if 8K channels, 1TB per 5 minutes)

  10hr per day would have 15TB data (120 TB for 8K channels)

Computing power require :more than 200 Tflops

?

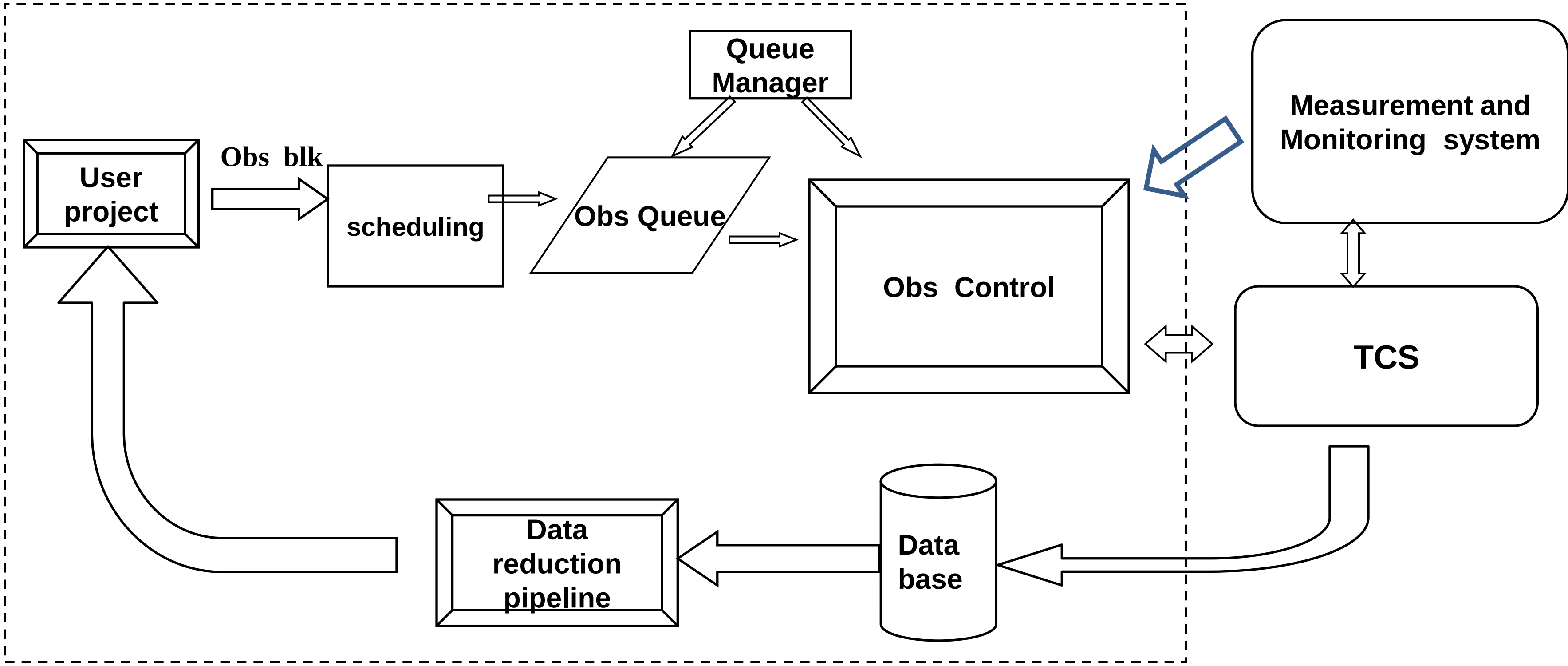
Remote observing

- Op centers: Beijing / Guiyang /FAST Site
  - Op in Guiyang, Headquarter/datacenter in Beijing
- Major computer clusters in Guiyang
- Observers want to do remote observing
  - transit modes, short observing block
- Need flex scheduling and optimization
  - Minimum movements of the dish (costly)
- Surveys dominated
- Need closely monitoring and measurements
- On site operator

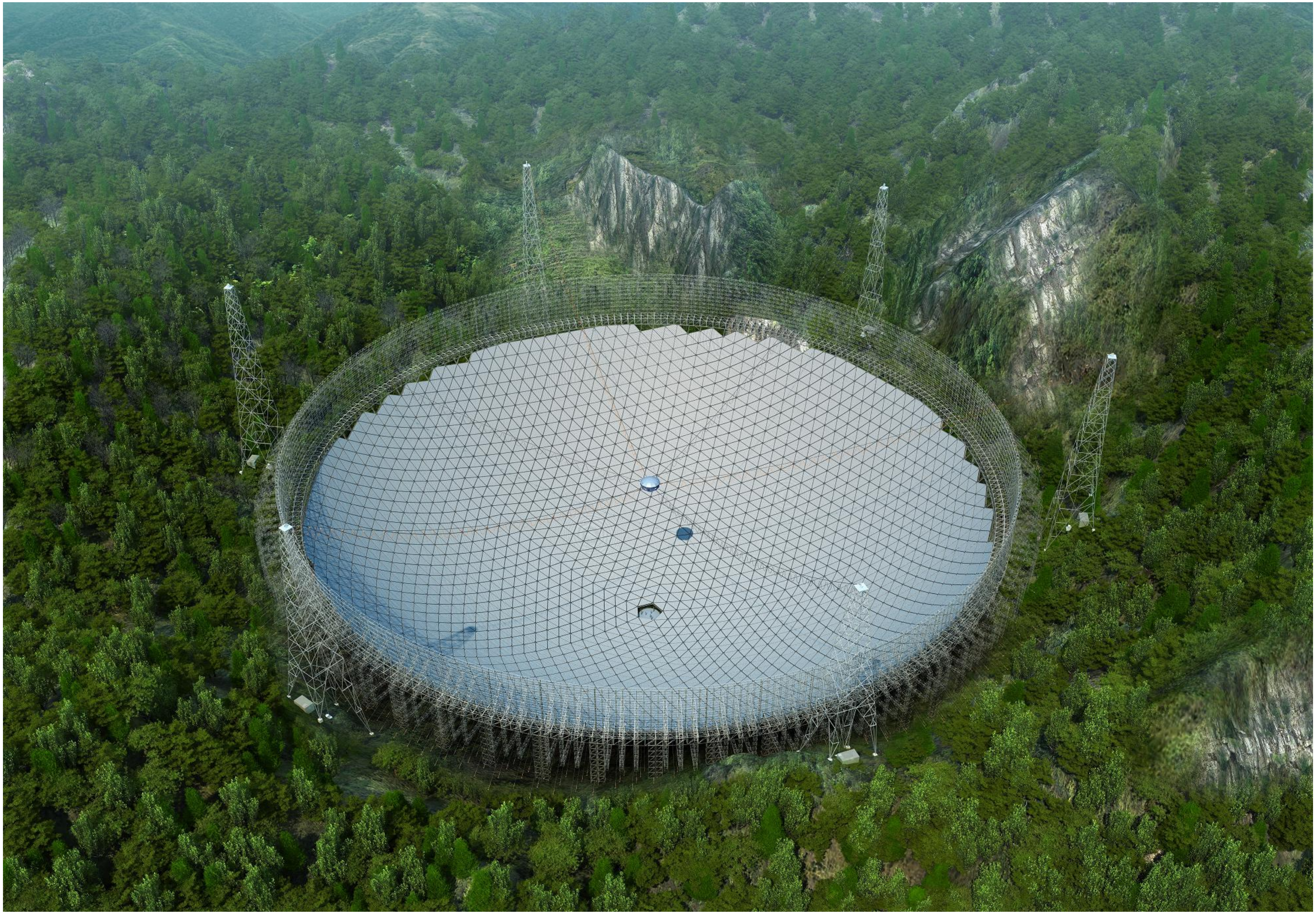
Requirements and considerations

- Computers requirements
- Network requirements
- Communication protocols
- Remote assessment, monitoring, notification, and control of subsystems
  - which part can be operated remotely?
- Data processing --pipeline
- Data management, storage, transportation, archiving

Observatory control system



FAST model



Summary

- Located at a remote, radio quite site, remote observing with the FAST telescope is highly desirable.
- Active monitoring and autonomous control of individual subsystem are needed.
- Suggestions are welcome!