

2011 June 14th

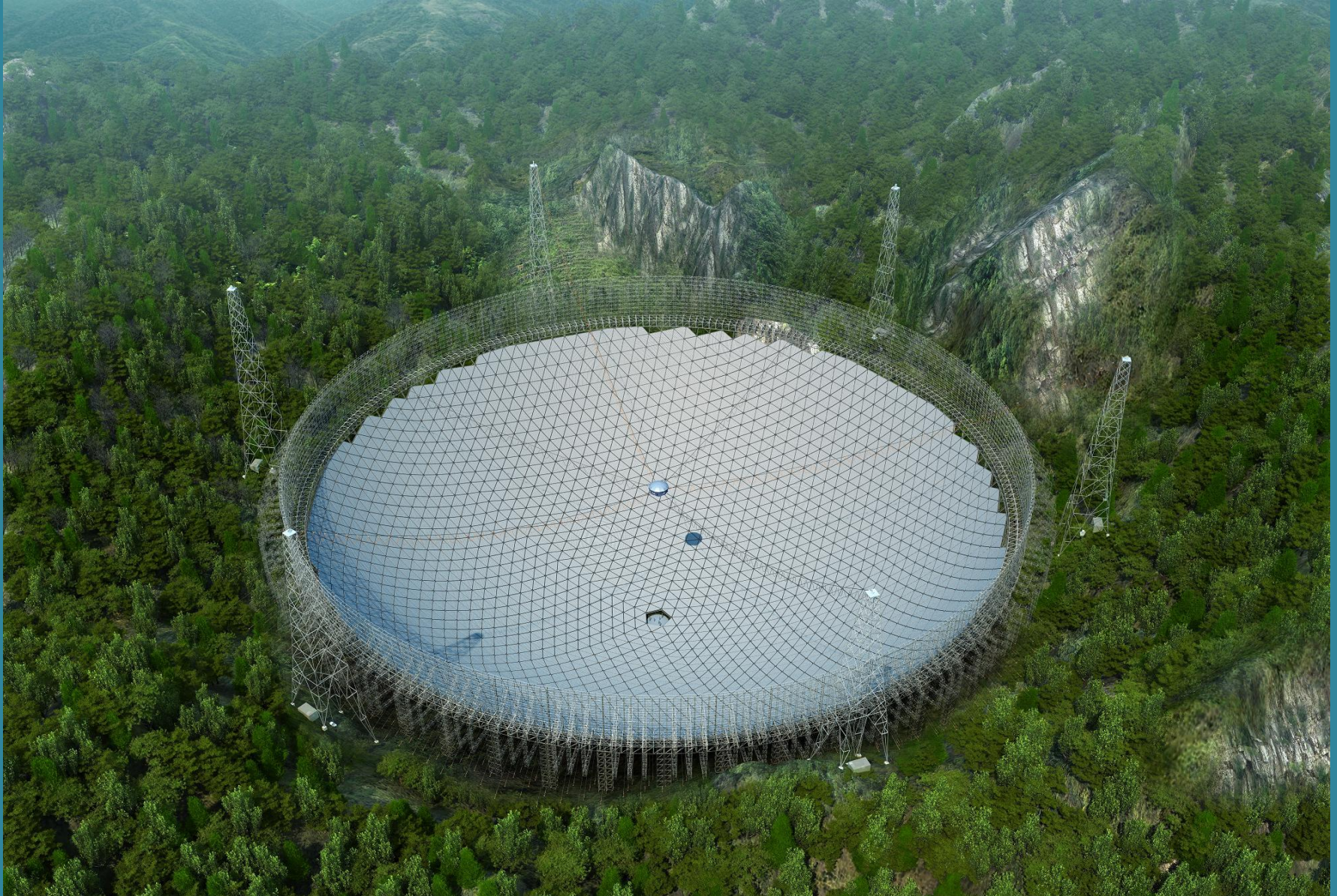
HI Survey with FAST

Five hundred meter Aperture Spherical radio Telescope



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National Astronomical Observatories
Chinese Academy of Sciences

Five hundred meter Aperture Spherical radio Telescope (FAST)



Site Surveying in Guizhou



Location: $N25.647222^{\circ}$

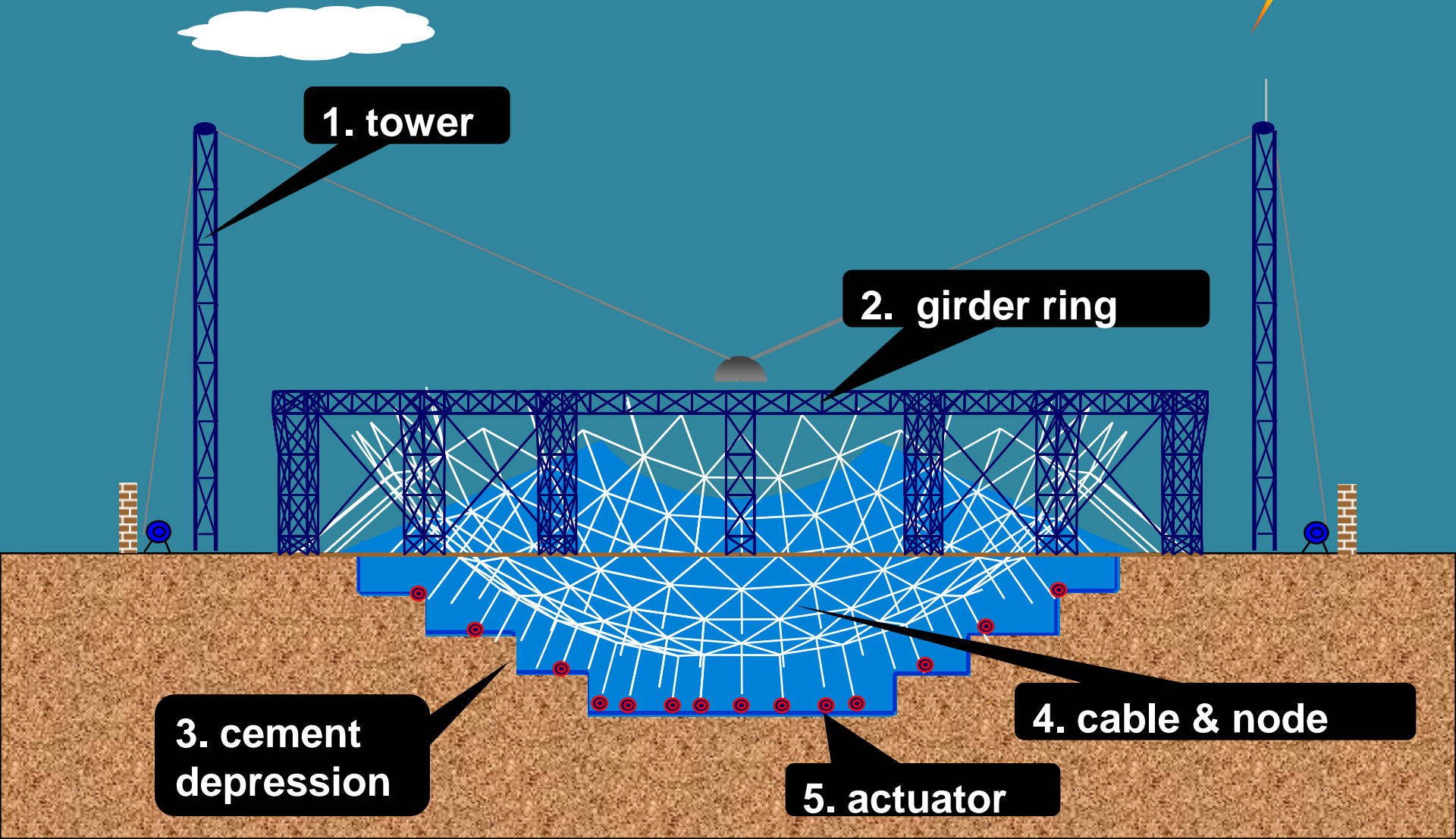
$E106.85583^{\circ}$

Site: the Karst region in south Guizhou Province

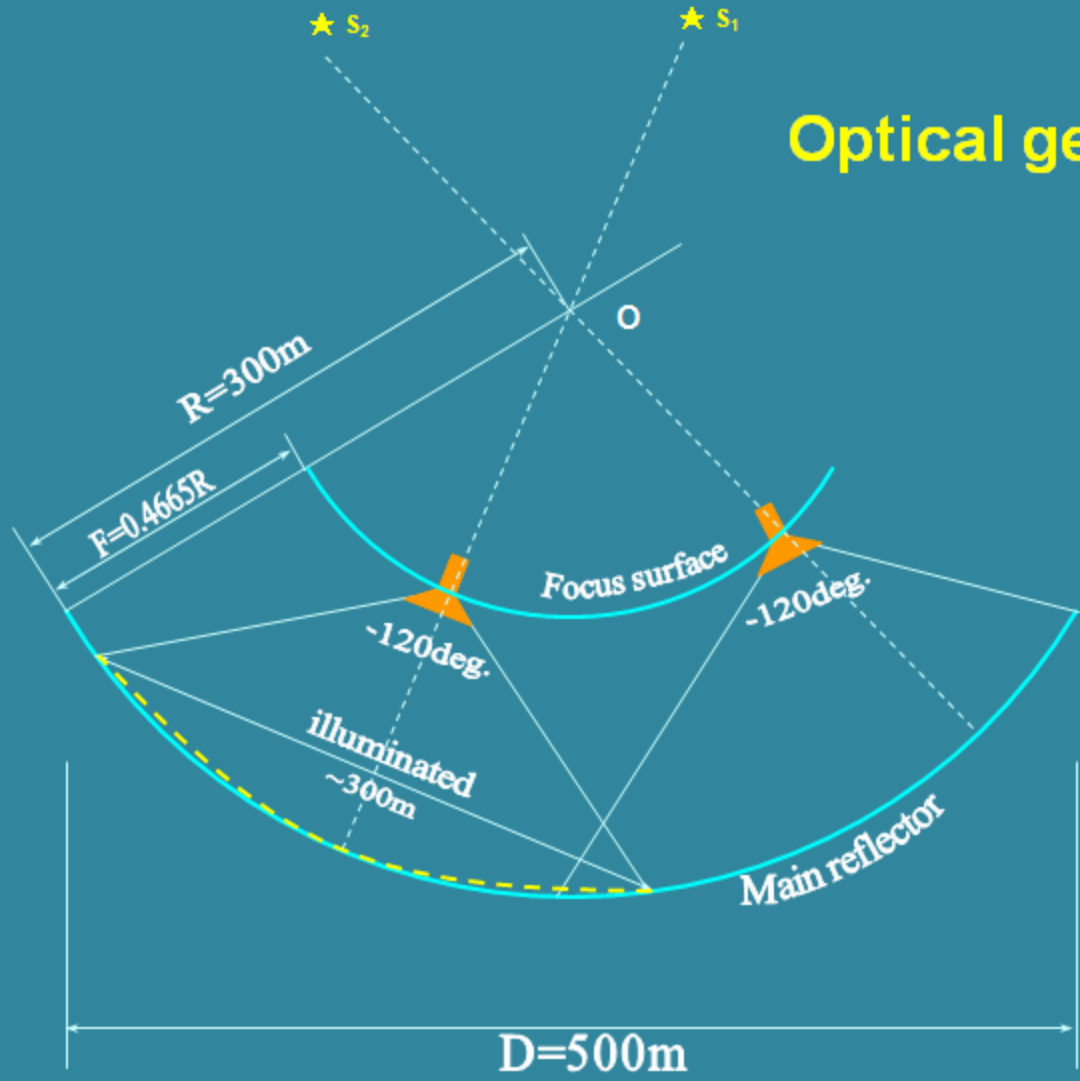
Quick Bird Fly Oct. 6, 2005



FAST model construction process



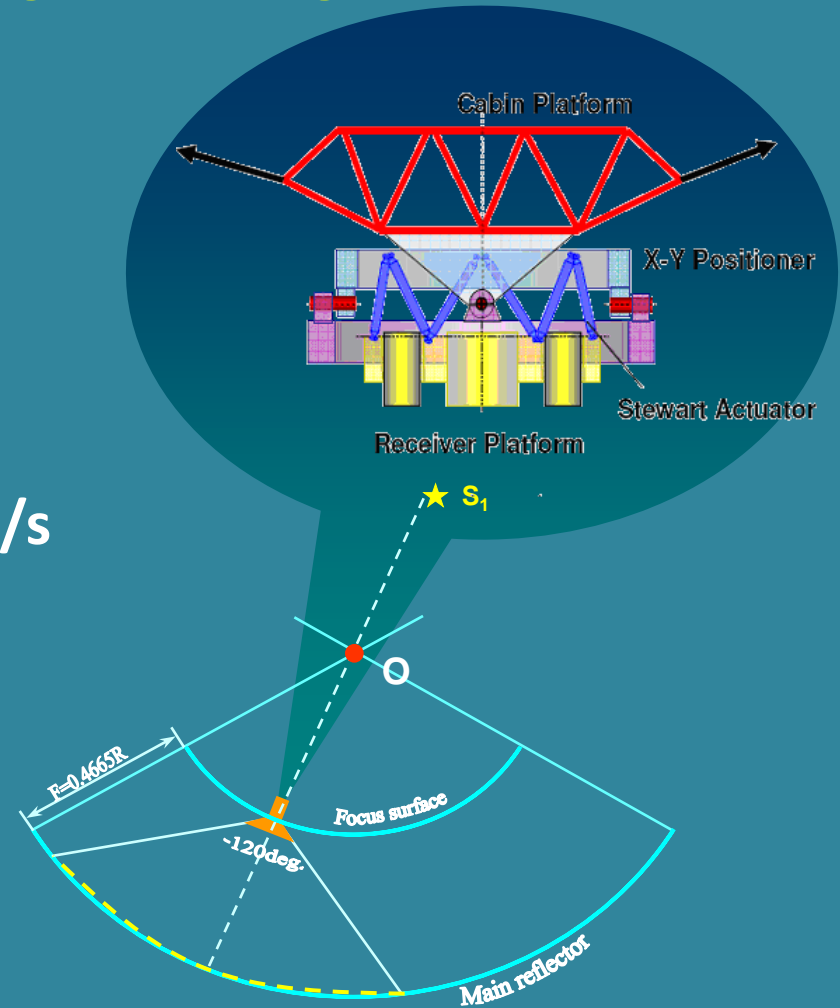
Optical geometry



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''



2. General Technical Specification

Spherical reflector: Radius $\sim 300\text{m}$, Aperture $\sim 500\text{m}$, Opening angle $110\sim 120^\circ$

Illuminated aperture: $D_{\text{ill}}=300\text{m}$

Focal ratio: $f/D = 0.467$

Sky coverage: zenith angle 40° (up to 60° with efficiency loss) tracking hours $0\sim 6\text{h}$

Frequency: $70\text{M} \sim 3\text{GHz}$ (up to 8GHz in future upgrading)

Sensitivity (L-Band) : $A/T \sim 2000$, $T \sim 20\text{K}$

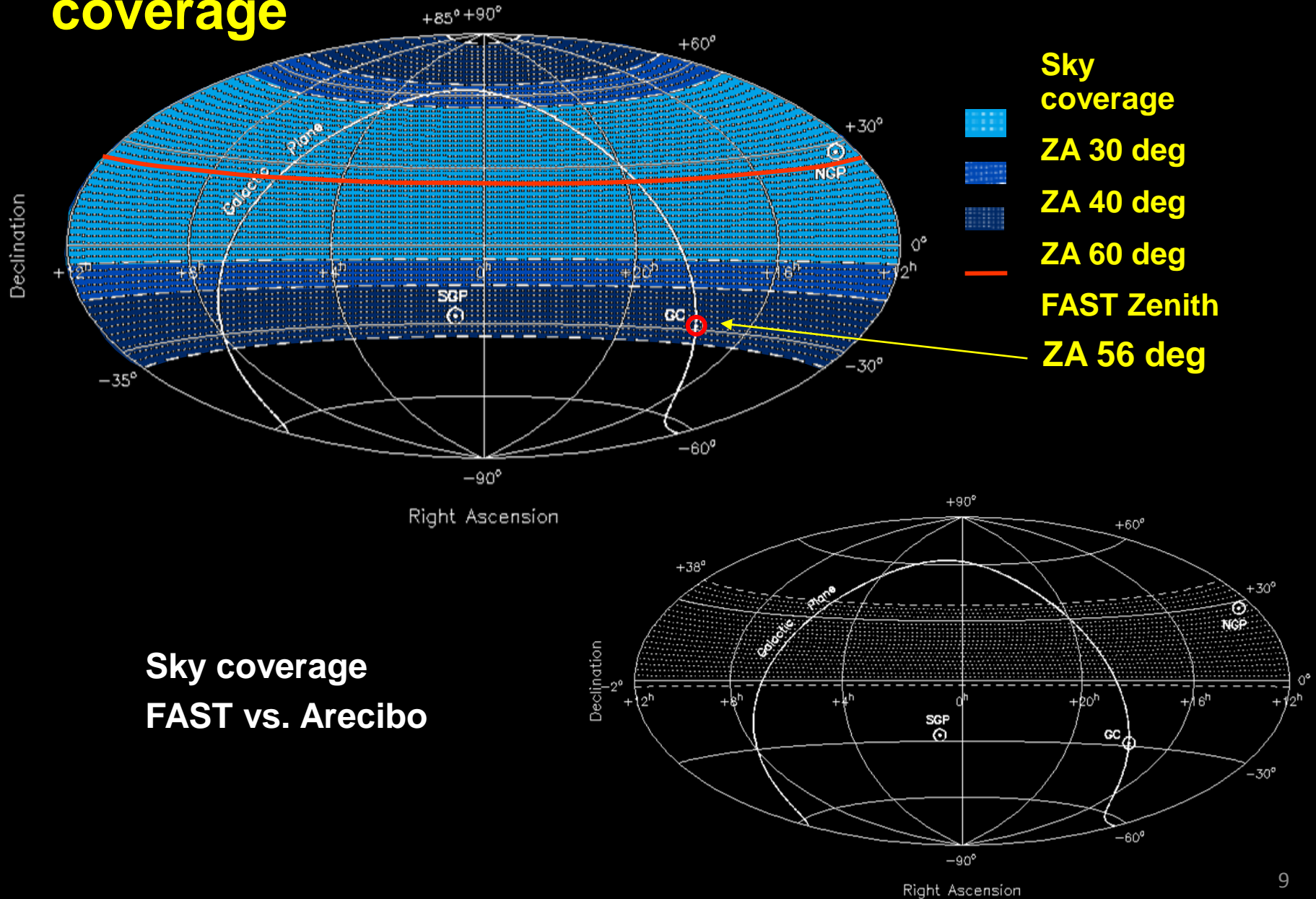
Resolution (L-Band) : $2.9'$

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

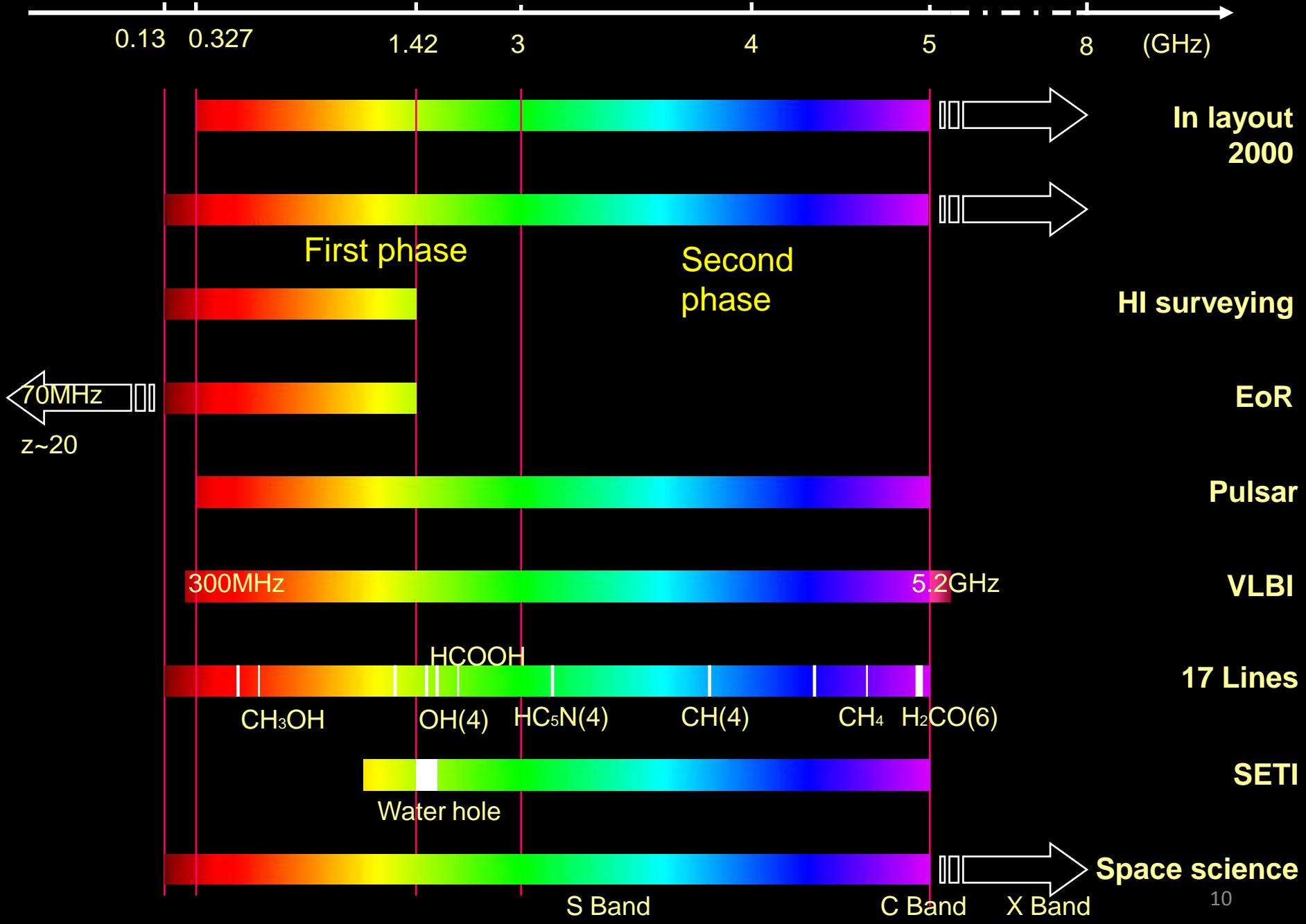
Slewing: $<10\text{min}$

Pointing accuracy: $8''$

Opening angle - sky coverage



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 L narrow 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) survey
- Pulsar research
- VLBI network
- Molecular line study (including recombination lines, masers)
- Search for Extraterrestrial Intelligence (SETI)

HI studies with FAST

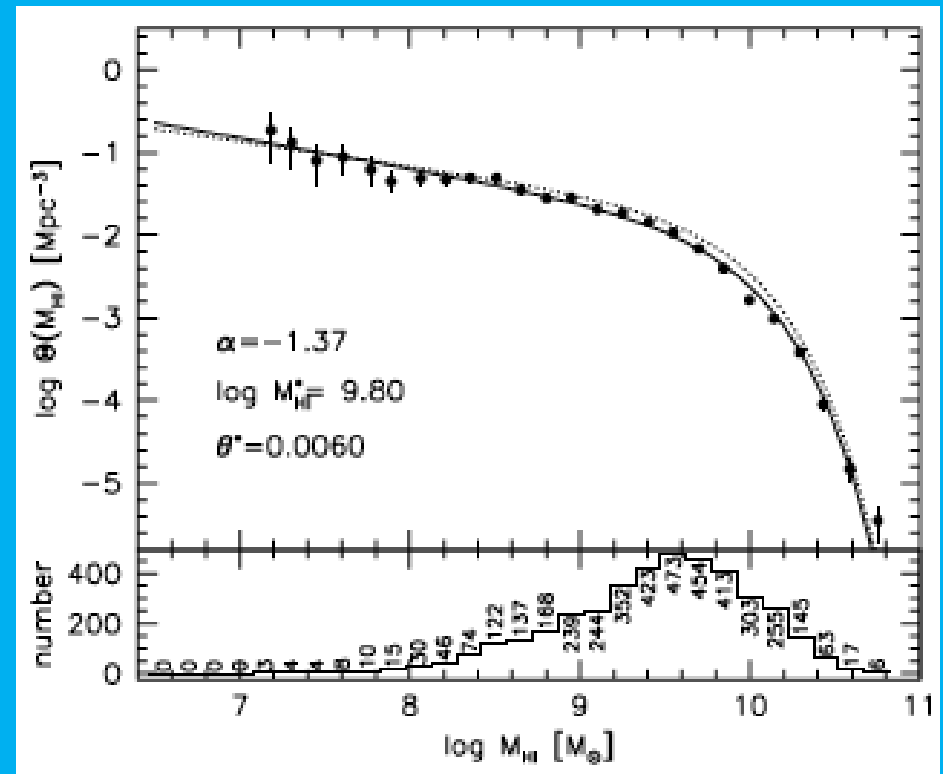
- Extent of HI Disk - truncation
- Extended rotation curve to extreme large distance
- Cold Dark Matter Satellite (Λ CDM)
- HI Mass Function
- Voids
- Surveying Milky Way (FV, Magellanic Stream ...)
- HI gas in high redshift galaxies
- HI gas in galaxy clusters and groups
- High z OH megamaser

A FAST all-sky HI survey

- Using a 19 beam L-band receiver to map the FAST sky
- Focus on the extra-Arecibo sky first
- Expect 3 million detections with $M_{\text{HI}} < 10^{11} M_{\odot}$ out to $z \sim 0.2$ in a range of environments including Virgo, Coma, Hydra, Ursa Major clusters and Shapley supercluster plus neighboring voids.
- About 2000 detections will have $M_{\text{HI}} < 10^7 M_{\odot}$ with $D < 15$ Mpc.
- The number of detections is an order of magnitude larger than expected for any planned surveys with Arecibo or ASKAP.

Key HI Science Goals

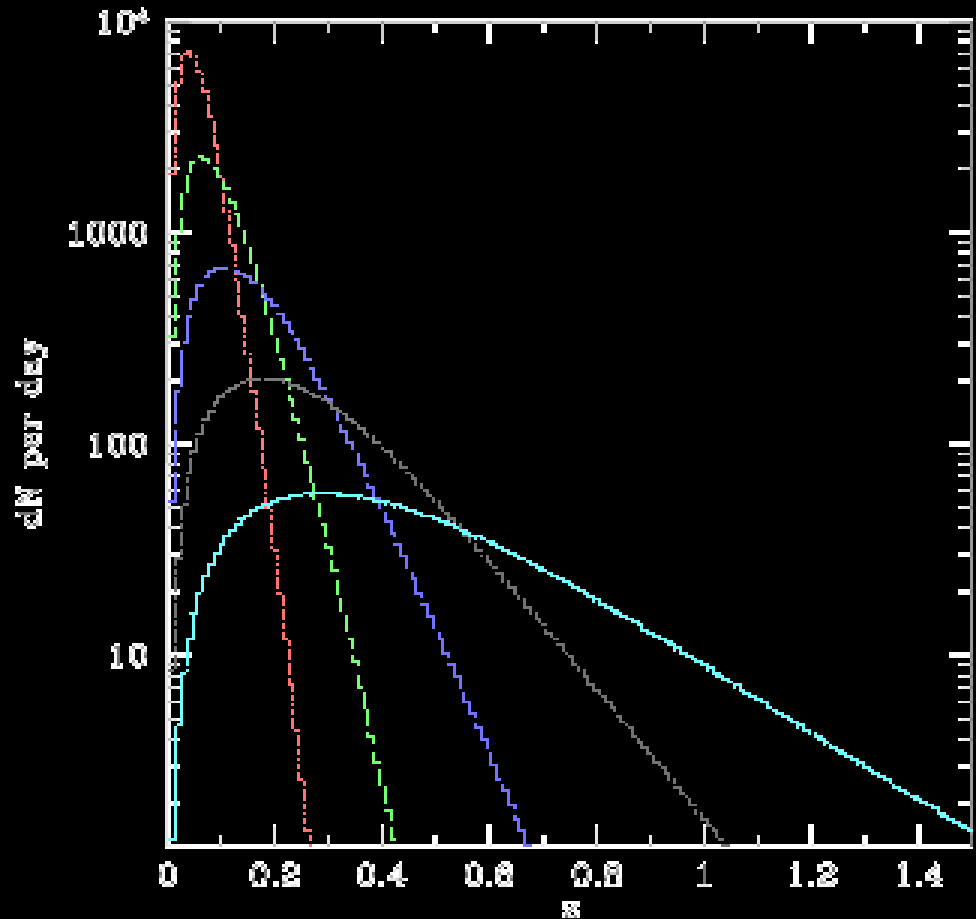
- How do the HI properties of low-mass galaxies compare in different environments at $z \sim 0$?
- HI mass function -- wider range of M_{HI} over a larger volume of space
- Power spectrum
- More detection of dark galaxies

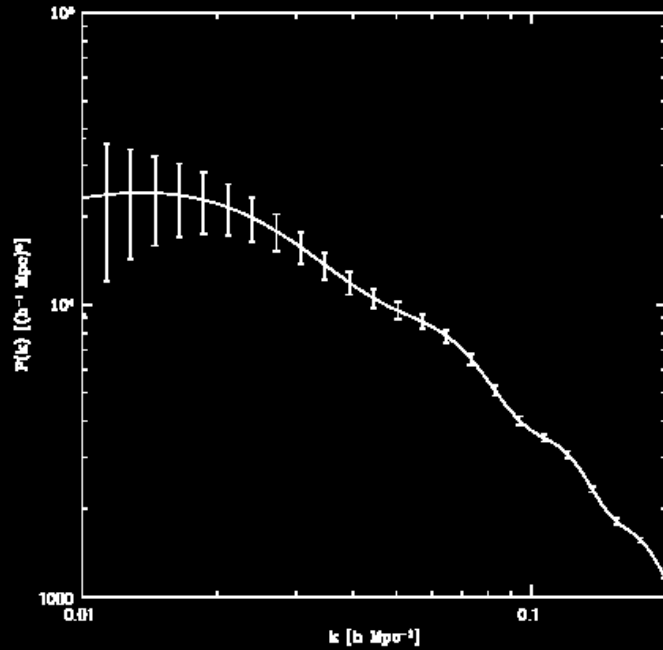
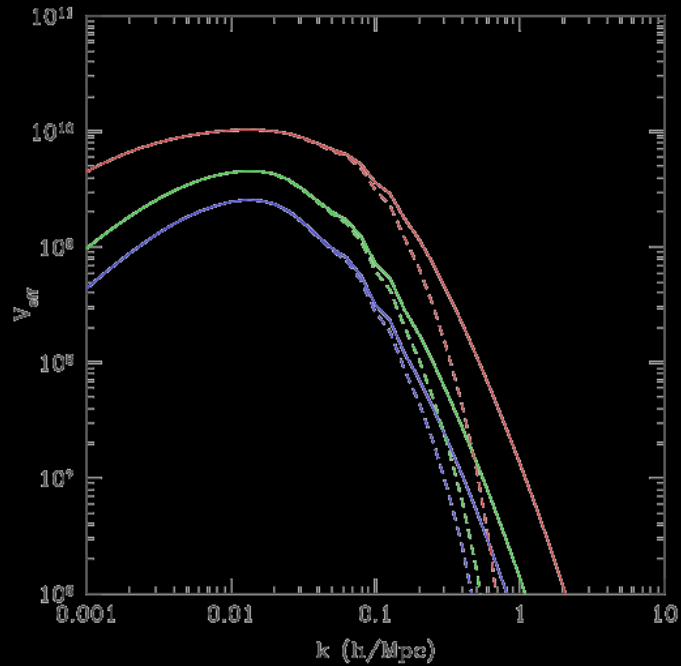


Duffy et al (2008)

Number of galaxies to be detected per day (18h) using FAST 19 beams with different scan range

- 6 sec
- 60 sec
- 600 sec
- 6000 sec
- 60000 sec





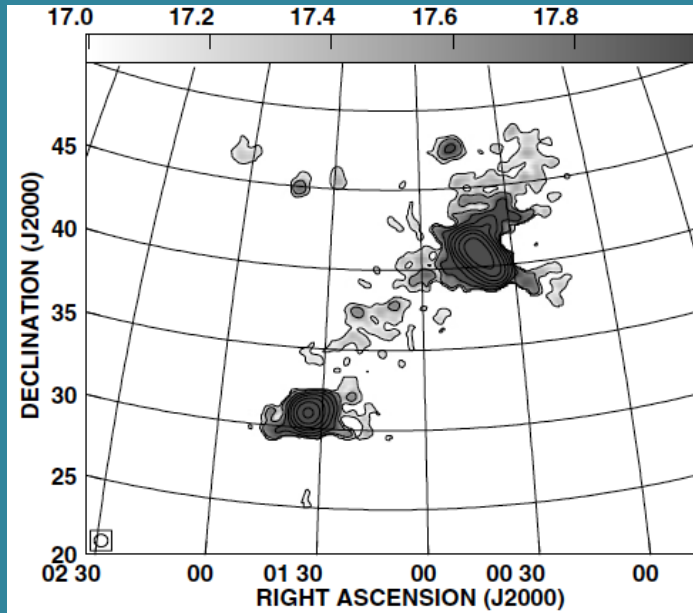
**Xuelei Chen V_{eff} vs scale $^{1/4}$
sky coverage survey by
FAST**

- 6 s 44 days
- 12 s 88 days
- 1 min 440 days

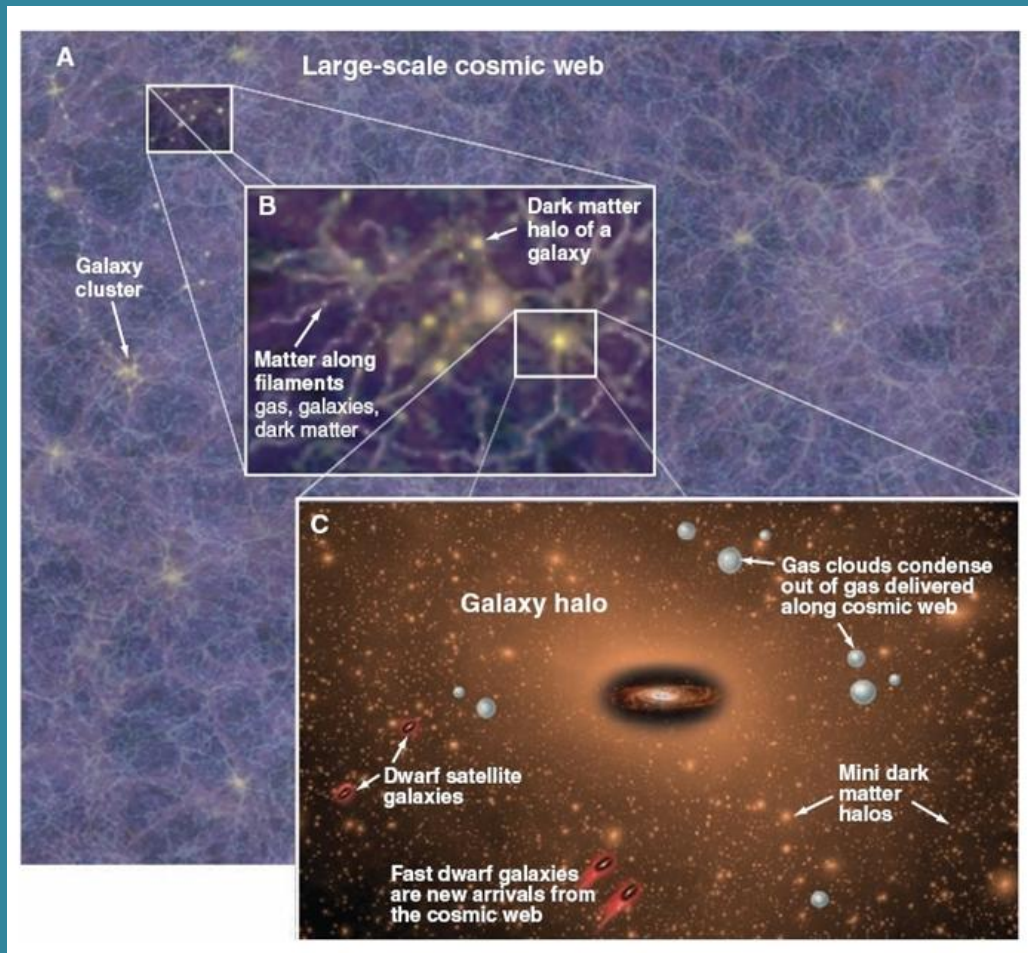
Duffy et al (2008)

Deep mapping the environment of nearby galaxies

- Map the HI around 50 big galaxies in different environments
- Science goals:
 - How is gas accreted from the IGM onto galaxies?
 - Find missing satellite galaxies
 - Map the cosmic web

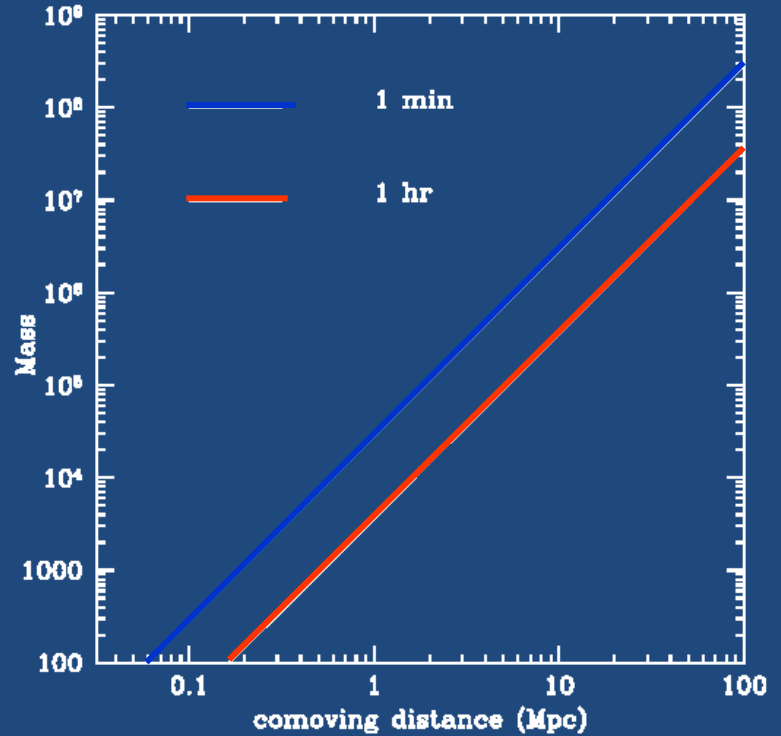


Cosmic web



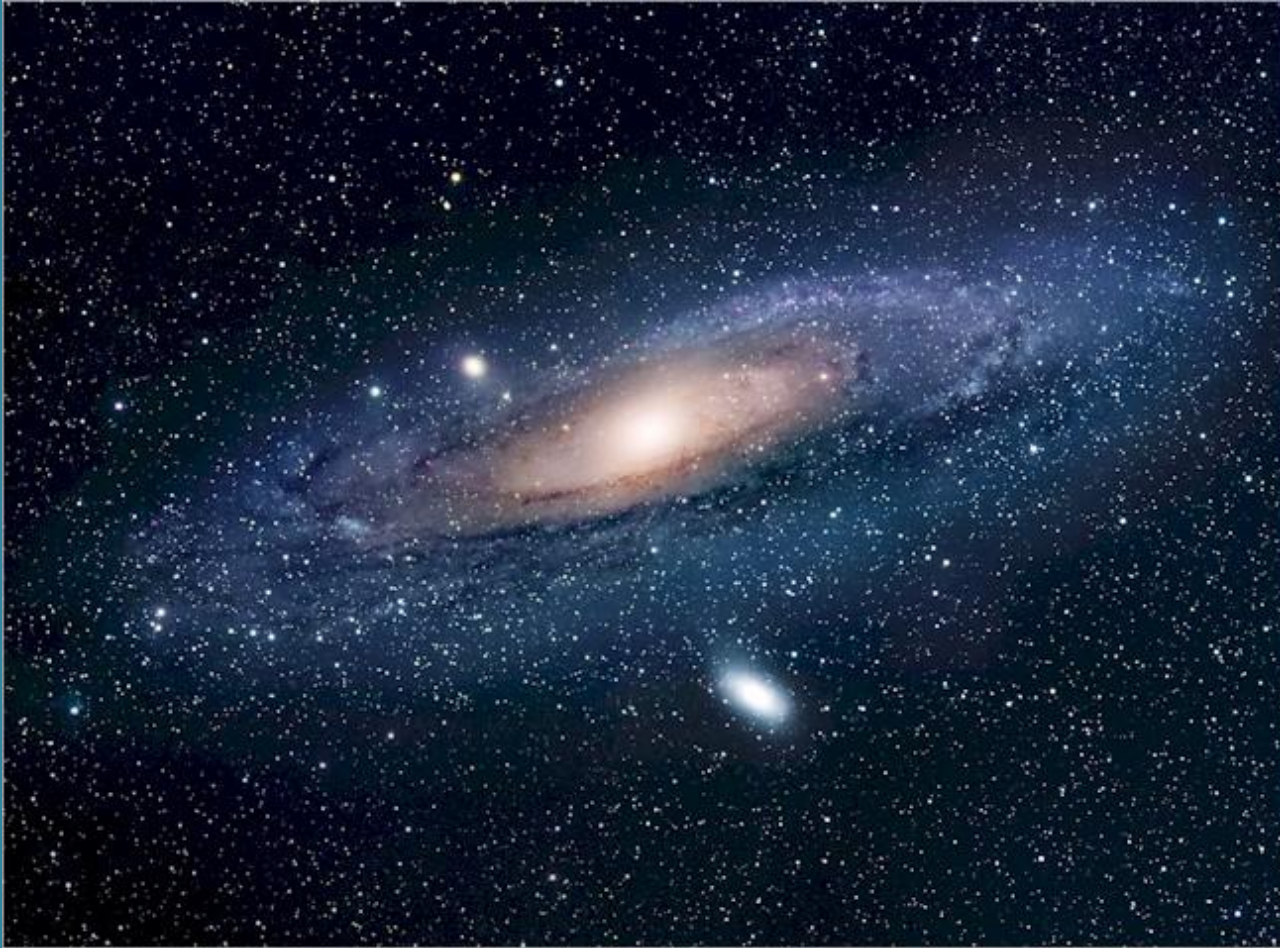


Kravtsov - Simulation on dark matter distribution in a normal galaxy

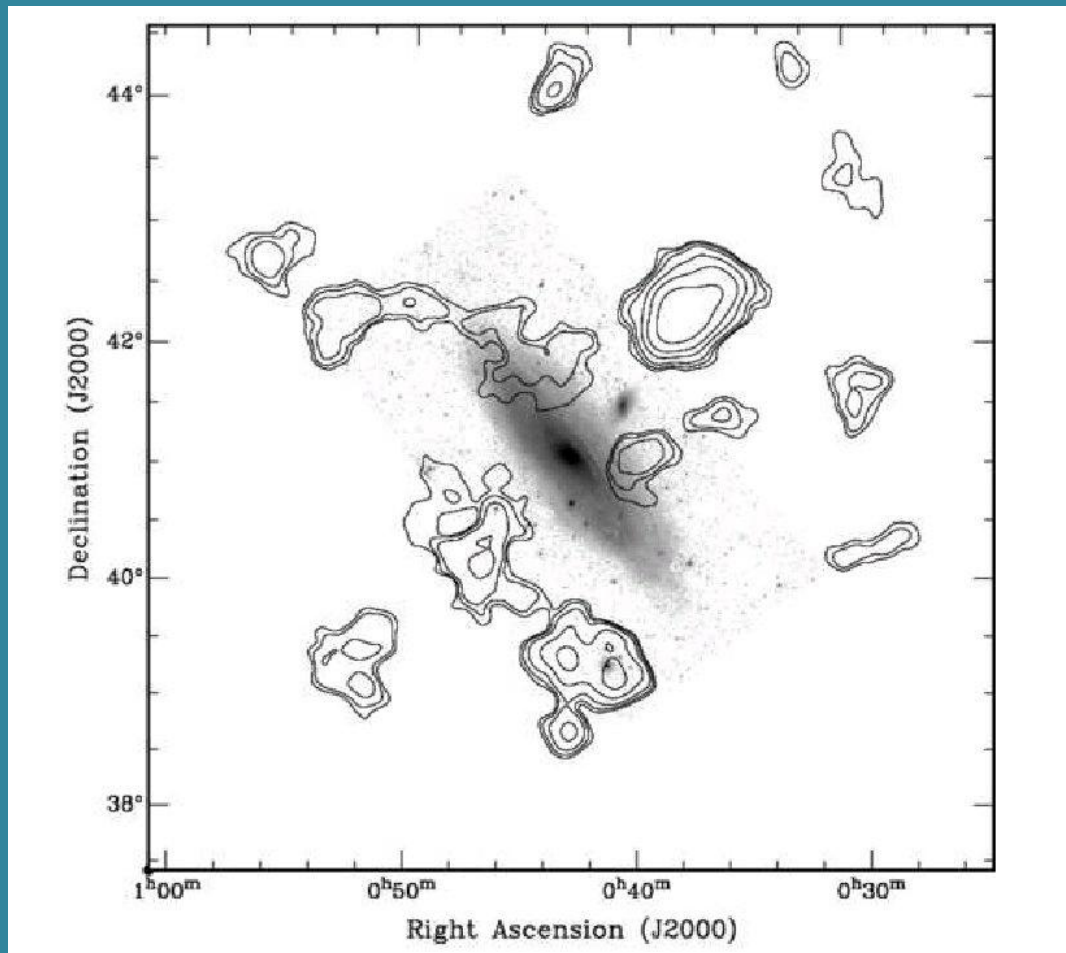


**Xuelel Chen – Estimated FAST detection sensitivity of 1 min & 1 h
Line width 30km/s, S/N -10**

M31



HI map of M31

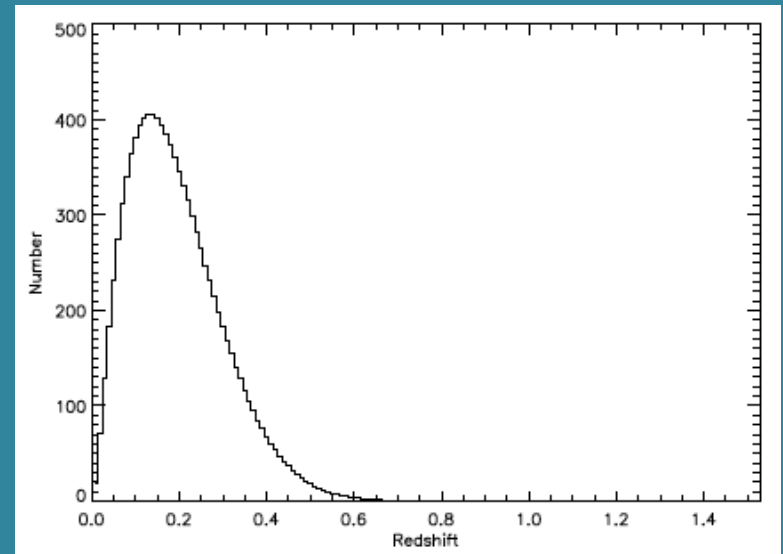
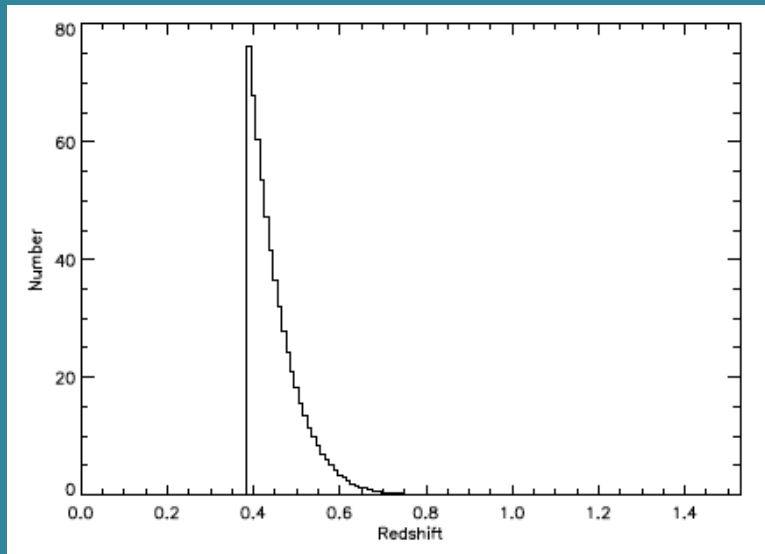


High z observations of HI

- An HI deep field
- HI observations of selected high z sources
 - Groups and clusters
- Observations of HI absorbers at high z
- Intensity mapping

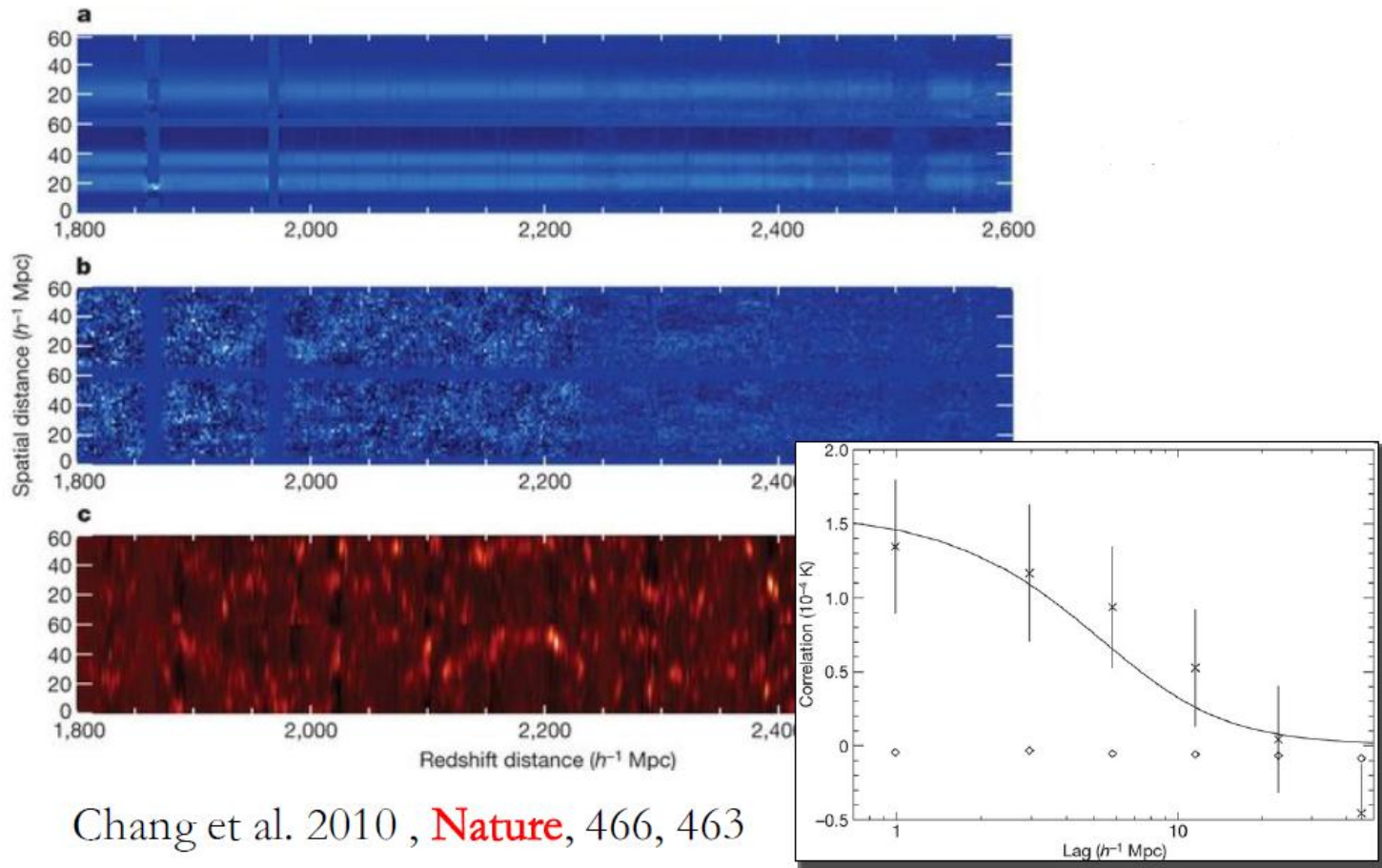
An HI Deep Field

- A survey of a 1 square degree region with a single pixel receiver at 40 hours per beam will take about 5000 hours.
- The survey could detect 10,000 galaxies at $z \leq 0.66$ in a wide range of environments. This is twice the number of galaxies that the planned SKA pathfinder deep fields expect to have.



(D.J. Pisano)

Intensity Mapping



Stacking/intensity mapping needs optical redshifts!



Summary

- FAST has very high sensitivity and large coverage of the northern sky
- Good for searching for weak signals, low surface density structures
- First light expected in 2016

FAST science group

HI all sky survey, ISM in Milky Way and nearby galaxies, high z galaxies and gal clusters.

Website: fast.bao.ac.cn