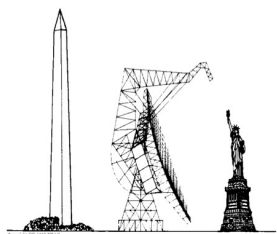


FAST THE WAKING GIANT

Marko Krčo, Di Li, Duo Xu, Ningyu Tang



Five-hundred-meter
Aperature **S**pherical radio
Telescope (**FAST**)



100
meters



GBT
100 m



FAST
(2016.5) 500 m

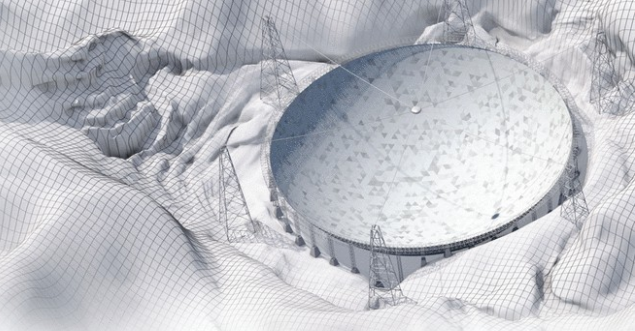


Arecibo 300 m

Radio astronomy writ large

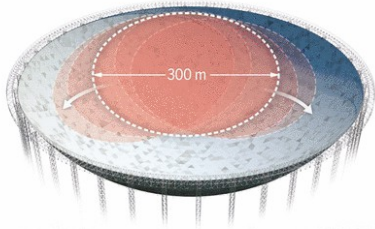


The world's largest radio telescope, China's new Five-hundred-meter Aperture Spherical radio Telescope (FAST), will gather radio signals from the cosmos to catalog pulsars; probe gravitational waves, dark matter, and fast radio bursts; and listen for transmissions from alien civilizations.



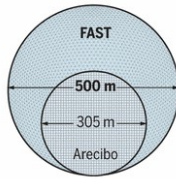
A "bowl within a wok"

FAST's signature innovation is a system that pulls a section of the dish as much as 300 meters across into a parabola to focus cosmic radio waves on receivers. Provided a glitch is resolved, the parabola's position can be shifted in real time to keep it trained on an astronomical object as Earth rotates.



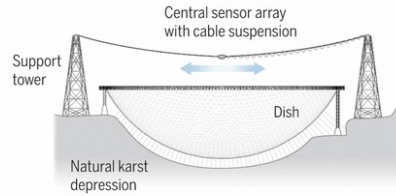
Bigger is better

FAST has more than twice the collecting area of the world's second largest radio telescope, the Arecibo Observatory in Puerto Rico, enabling it to study fainter and more distant objects.



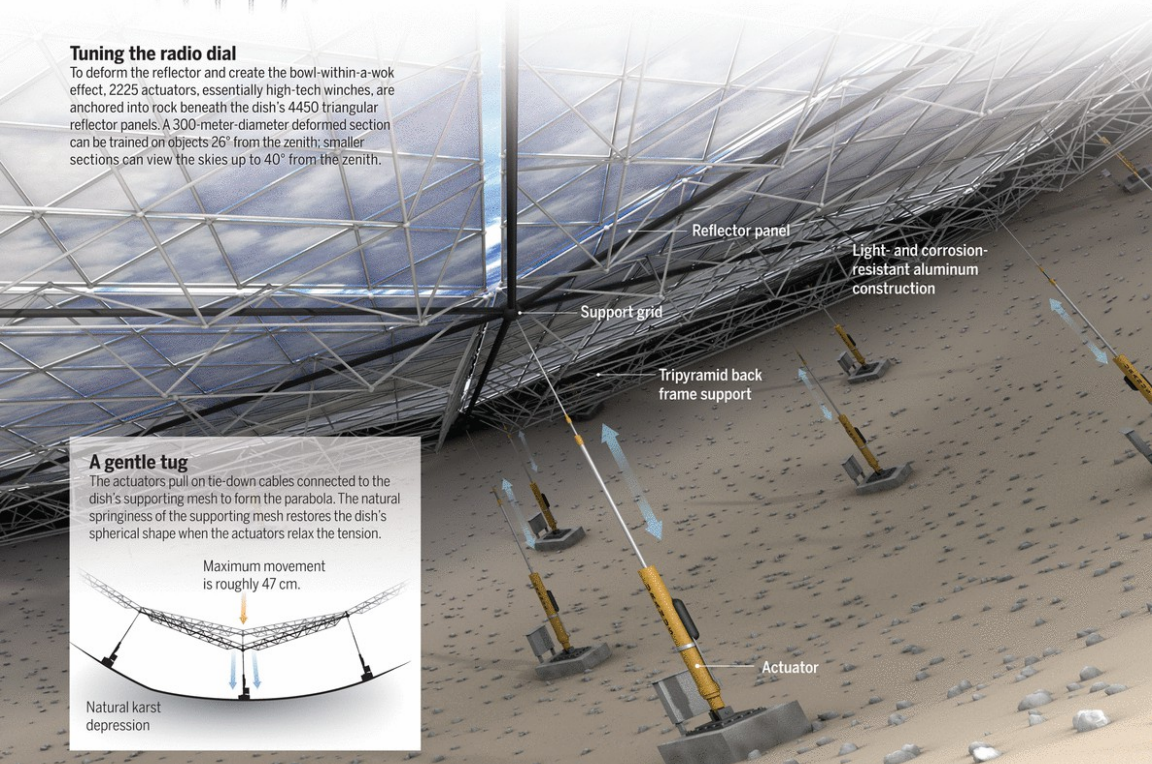
Snug fit

FAST planners studied some 400 karst depressions in southwestern China before deciding Dawodang was just right for cradling the telescope's massive dish.



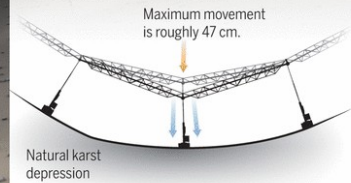
Tuning the radio dial

To deform the reflector and create the bowl-within-a-wok effect, 2225 actuators, essentially high-tech winches, are anchored into rock beneath the dish's 4450 triangular reflector panels. A 300-meter-diameter deformed section can be trained on objects 26° from the zenith; smaller sections can view the skies up to 40° from the zenith.



A gentle tug

The actuators pull on tie-down cables connected to the dish's supporting mesh to form the parabola. The natural springiness of the supporting mesh restores the dish's spherical shape when the actuators relax the tension.



7 sets of frontend

No.	Frequency range ^(a) (MHz)	Number of Beams	Polarization Mode ^(b)	System Temperature ^(c)
1	70-140	1	RCP & LCP	1000
2	140-280	1	RCP & LCP	400
3	270-1620	1	RCP & LCP	150
4	560-1020	1	RCP & LCP	60
5	1100-1900	1	RCP & LCP	25
6	1050-1450	19	X & Y linear	25
7	2000-3000	1	RCP & LCP	25

Timeline

- **Project Approval:** Dec., 2007
- **Commence Construction:** March, 2011
- **Opening ceremony:** Sep. 25, 2016
- **19 beam L-band array:** to be delivered in Dec., 2016
- **Backend upgrade (for commensal survey):**
 - under development, to be expected in Spring of 2017
- **Commissioning:** 2016 - ~2018
- **Operation:** ~2019

Constraints on FAST

- Slewing time: 1.5min - 10min **FAST is slow.**
- Beam and FOV: 3' in L-band, ~26' with 19 beam
- Drift Scan: only feasible mode for large surveys in early years
- Sky coverage: DEC -14° to 66° (-1° to 52° with full gain)
- Confusion limited: in 1 s @ ~ 1 mJy
- VLBI/Timing: moving phase center?

INCOMPLETE LIST OF PLANNED PROJECTS:

- (HIFAST) Galactic HI Emission/Absorption Survey
 - Two drift passes at ~200 days each, starting summer 2017
 - 2.9'/~26' beam, ~10 mJy at 0.1 km/sec
 - 1 BILLION voxel HI map, ~2000 km/sec bandwidth
 - Commensal with Pulsar, FRB, and Extra-Galactic Surveys
- Deep Orion Spectral Line Survey
 - Search for undetected molecules
- OH IR Circumstellar Maser Survey
- Dark Gas Survey
 - Heiles & Troland, 2003 (Arecibo, 79 sources)
 - FAST: 800 quasars in 5 years (4 hrs/source)
- OH Mega-Maser Search
 - FAST has 2.3X Arecibo Sky; Growing IR Galaxy Catalogs

OTHER NOTABLES:

~2000 new pulsars (Improved IPTA), LIGO-FAST-VIRGO (~40-200 hours/FRB),
reionization timing and power (~5-10 new local group gas-rich dwarfs),

The Cosmic Web (10^{16} sensitivity with 8 hours), Breakthrough Initiative, LOFAR Collaboration?

OH Survey Along Sightlines of Galactic Observations of Terahertz C+

- Beam size $\approx 3'$ (Arecibo telescope)
- Galactic longitude range ($32^\circ, 64^\circ$) ($189^\circ, 207^\circ$)
- OH sensitivity: $\sigma \approx 35$ mK
- 151 OH components toward 51 sightlines of GOTC+

➤ All OH emissions conform to ‘Sum Rule’

$$T_b(1612) + T_b(1720) = T_b(1665)/5 + T_b(1667)/9.$$

➤ A correlation was found between C+ intensity $I(\text{C}^+)$ and $N(\text{OH})$ for CO-dark molecular clouds, consistent with C+ and OH being useful tracers of H_2 in CO-dark clouds.

TABLE 1

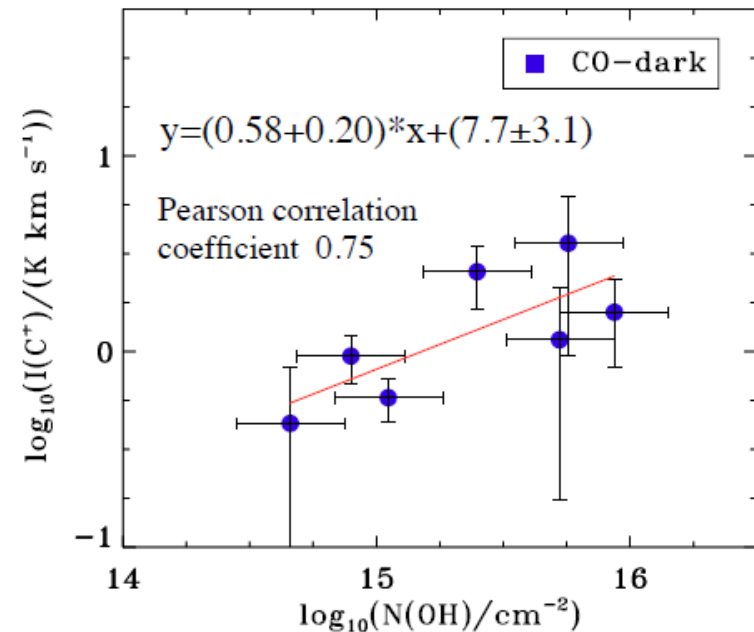
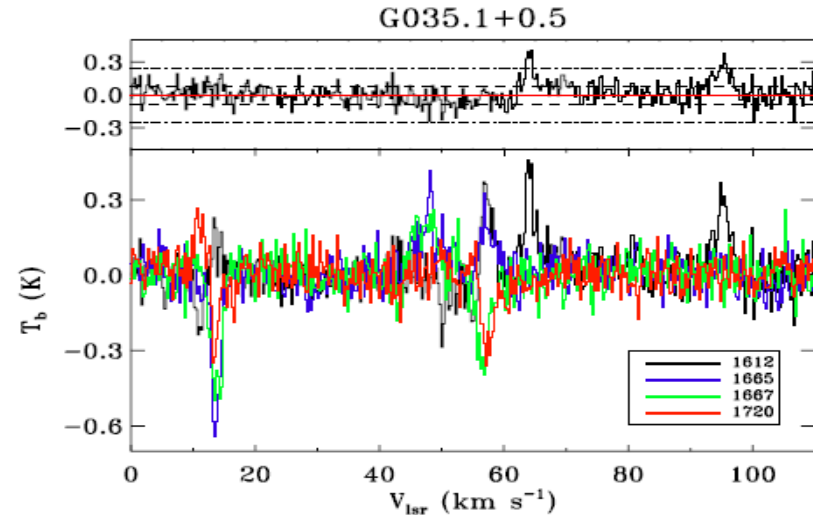
SUMMARY OF DETECTIONS OF ALL 151 OH CLOUDS.

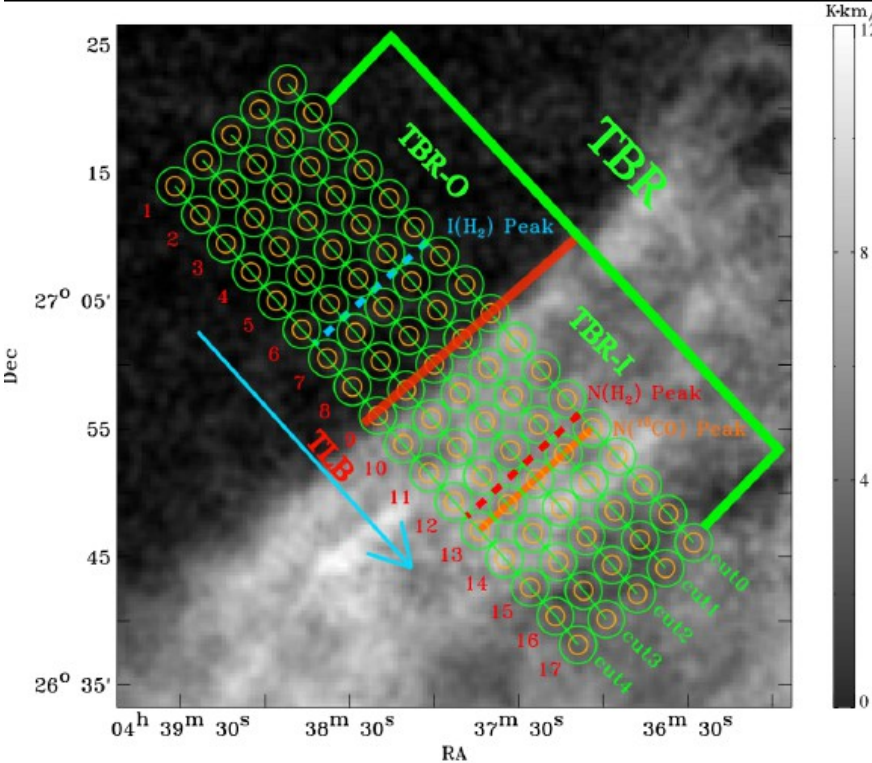
Mask	OH	C ⁺	¹² CO	¹³ CO	Number ^a	HINSA ^b
1	✓	x	x	x	17	1
2	✓	x	✓	x	17	5
3	✓	x	✓	✓	50	24
4	✓	✓	x	x	10	1
5	✓	✓	✓	x	9	2
6	✓	✓	✓	✓	48	16

^a The number of clouds in each mask.

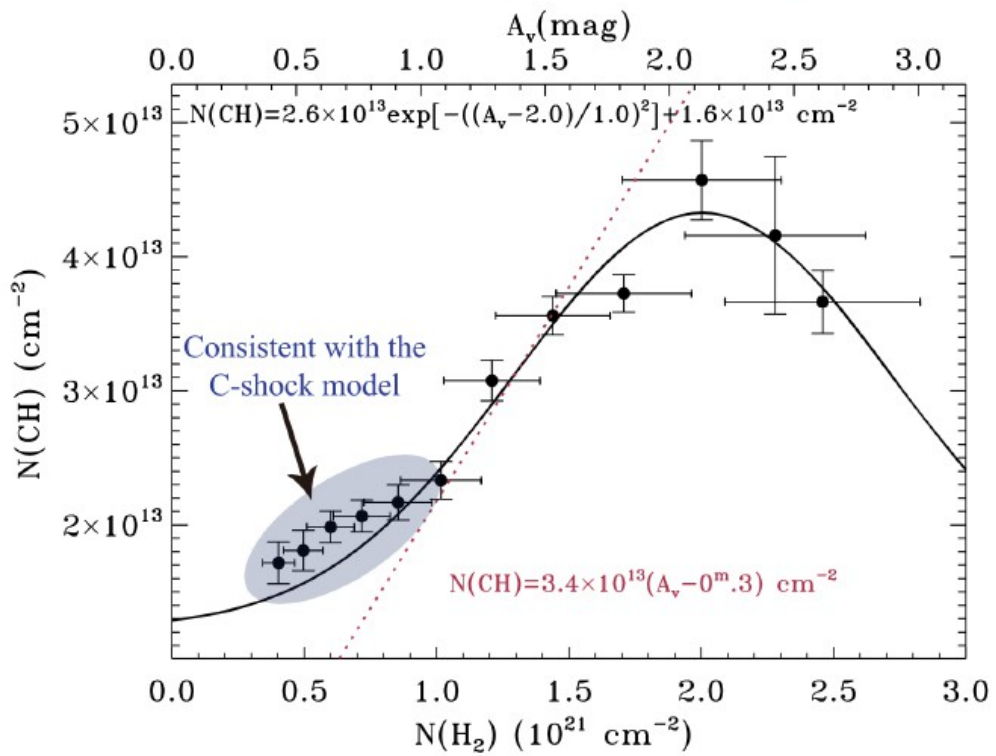
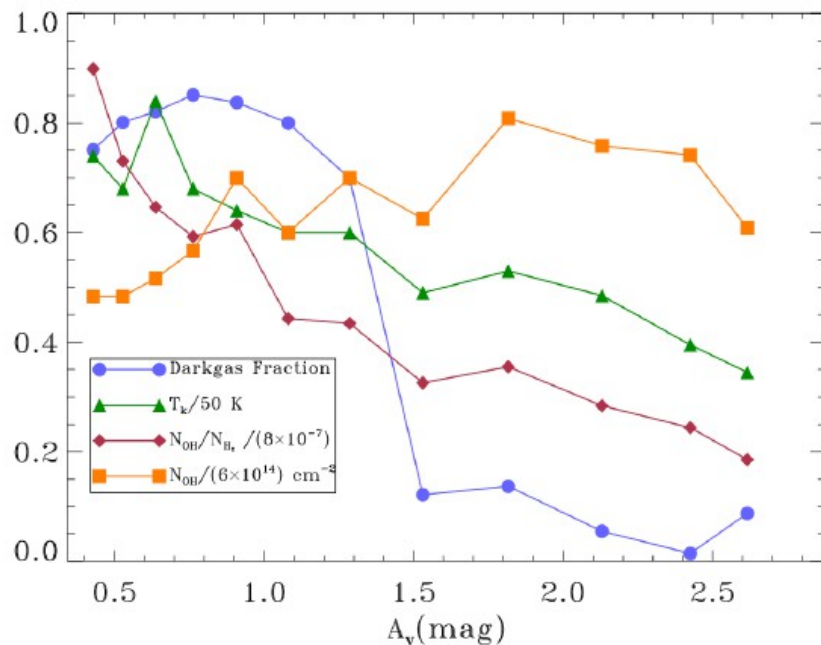
^b The number of HINSA detection in each mask.

candidates.





- ▶ Colliding streams or gas flow at the boundary region
 - ▶ Modeled OH transitions with RADEX
 - ▶ Quantifying OH abundance and CO-dark molecular gas
 - ▶ Conjugate emission of OH 1612 MHz and 1720 MHz indicating C-shock
 - ▶ Overabundance of CH at $A_V < 1$ mag indicating C-shock
 - ▶ CH is a better molecular gas tracer than CO and OH in the transition zone ($0.8 < A_V < 2.1$ mag)
- (Xu et al., 2016)



Thank You!

- To participate in HIFAST survey
contact: Marko Krčo (marko@nao.cas.cn)
- For OH Observing Proposals
contact: Marko Krčo (marko@nao.cas.cn) or Di Li (dili@nao.cas.cn)

- OH Survey Along Sightlines of Galactic Observations of THz C+
Ningyu Tang, et al. (ApJ 2016, submitted)
astrotomny@gmail.com
- Evolution Of OH and CO-Dark Molecular Gas Fraction Across A
Molecular Cloud Boundary in Taurus
Duo Xu et al. (ApJ 2016)
xuduo117@163.com

- KEEP AN EYE OUT FOR CONFERENCE ANNOUNCEMENTS!

HELP

WANTED

Opportunities

- East Asia Core center of Astronomy ([EACOA](#)) Fellow: \$5000/month; two host during tenure
- National Astronomical Observatories of China ([NAOC](#)) Fellowship
- Big Science Center-**FAST Fellowship**
 - Senior fellowship (2weeks - 1month)
 - Key Staff: ~1year
 - Postdoctoral fellowship: 2-3 years @ 2/year
- Chinese Academy of Sciences ([CAS](#)) Fellowship (PIFI etc.)
- Talent program: ~\$400 ~ 500 K startup grant