A potential HI intensity mapping project with Chinese space VLBI telescopes

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2022-05-23

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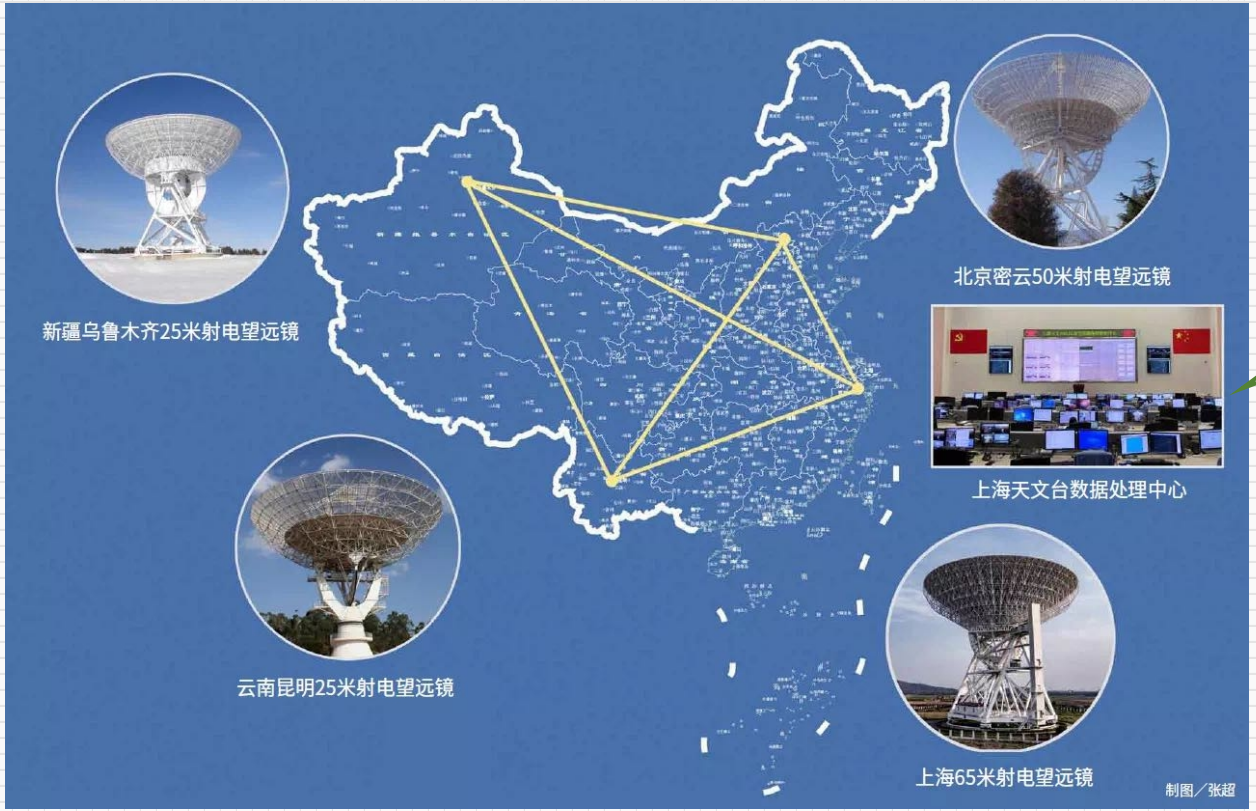
background information

HI intensity mapping

you must already know...

VLBI is the highest angular resolution observation technique to date and has already made impressive achievements in astrophysics, astrometry, and deep space exploration.

Chinese VLBI Network (CVN)



headquarter
@ SHAO

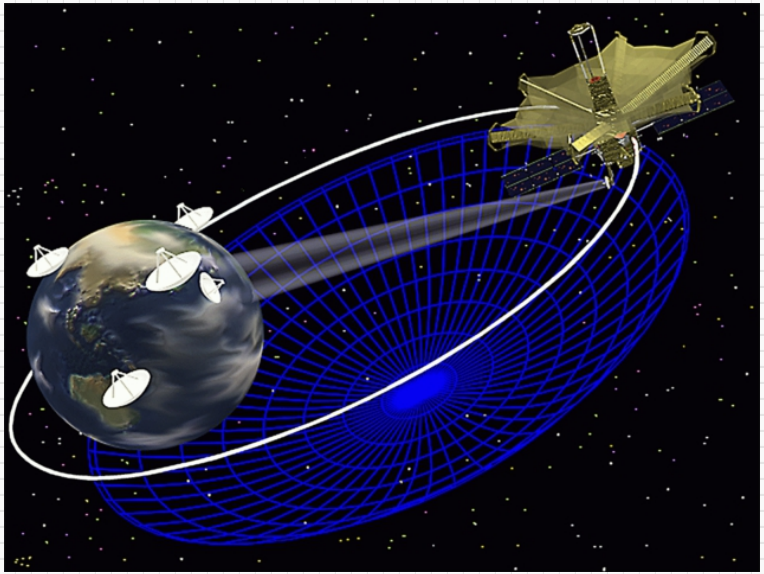
video: *https://www.youtube.com/watch?v=q35djQdc3WU*

Space VLBI

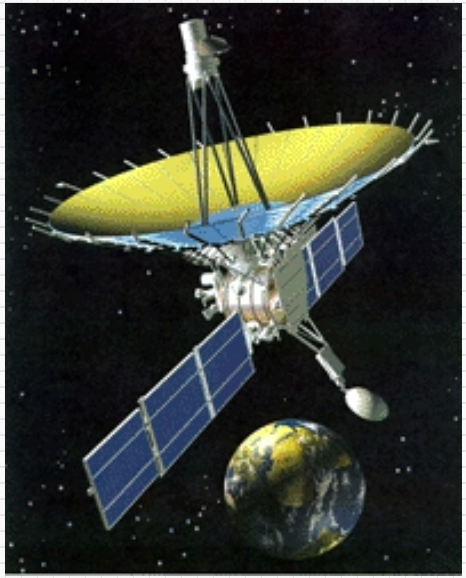
- The highest resolution of ground-based VLBI is limited by the diameter of the Earth, and one way to obtain higher resolution is to launch radio telescopes into space to form space-ground or space-based VLBI arrays together with ground-based or other space-based telescopes.

- With a clean electromagnetic environment, space-based radio telescopes can also avoid artificial radio interference on Earth and absorption of low-frequency signals by the Earth's atmosphere, thus reducing the data calibration difficulties that have long plagued radio astronomers and improving the quality of observations.

Space VLBI



VSOP (VLBI Space Observatory Programme)
led by Japan (1997-2005)
1.6, 5 GHz



RadioAstron
led by Russia (2011-2019)
0.3, 1.6, 5, 22 GHz

What will happen

Chinese space VLBI (led by SHAO, CAS)

- launch two 30-meter aperture radio telescopes to space
- operate at 30 MHz-1.7 GHz
- observation modes:

  independently observe in space in single-dish mode;

  form a space-space baseline;

  a space-ground VLBI network together with FAST and SKA telescopes

Chinese space VLBI

time line:

launch in 2026

designed life period:

8 years

orbital period:

33.15 hours

frequency bands:

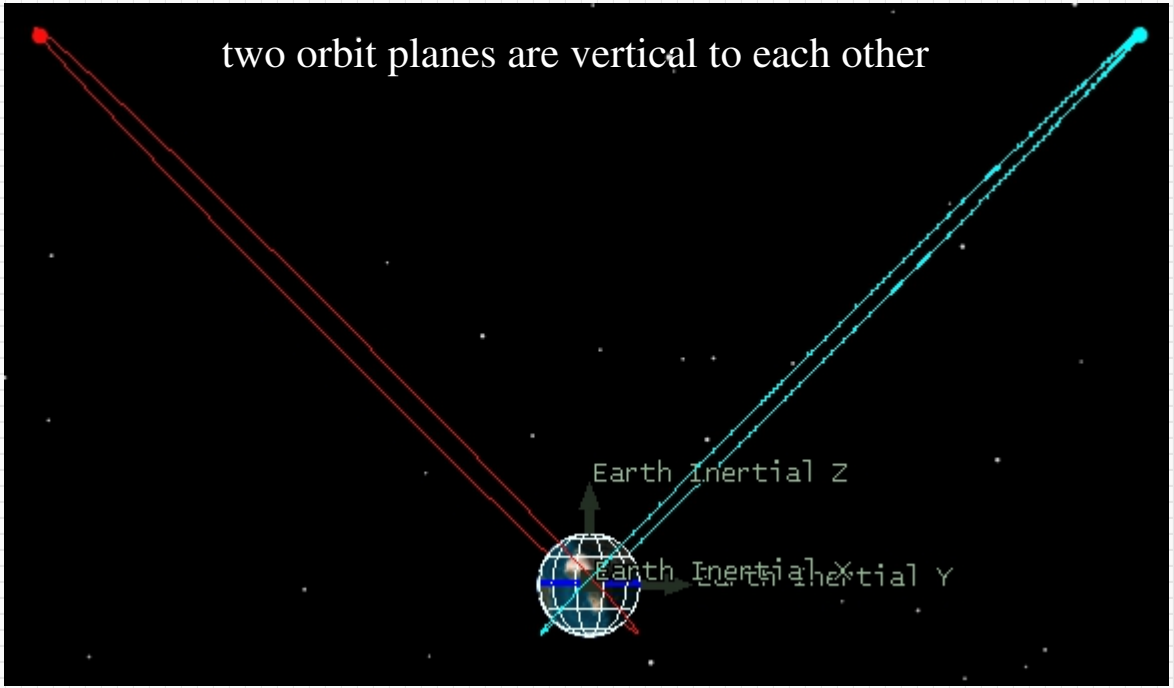
30-120 MHz

130-170 MHz

310-350 MHz

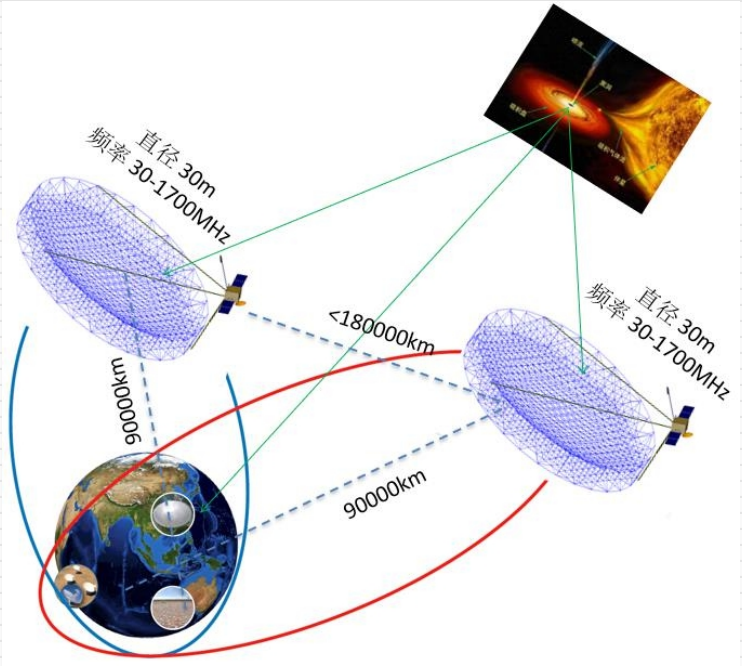
580-1150 MHz

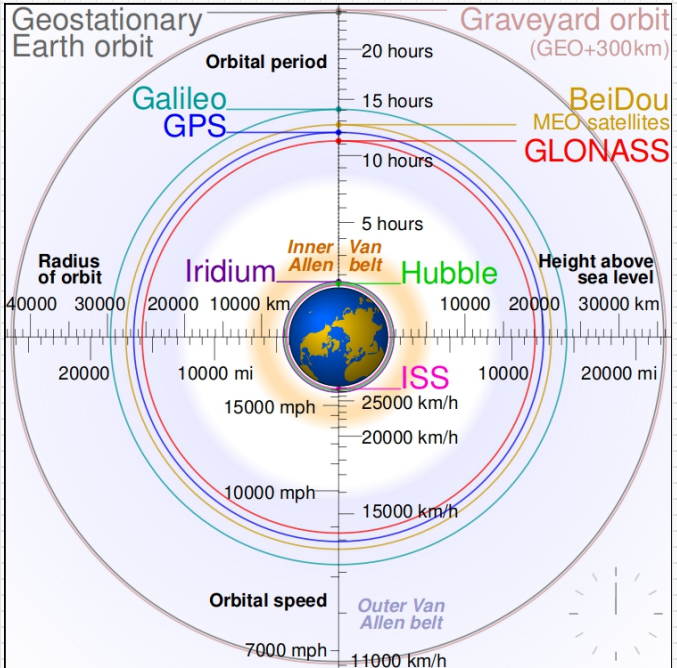
1000-1700 MHz



Chinese space VLBI

orbit	2,000-90,000 km
Geo satellite (L1)	35,785 km
moon orbit	384,400 km





Chinese space VLBI

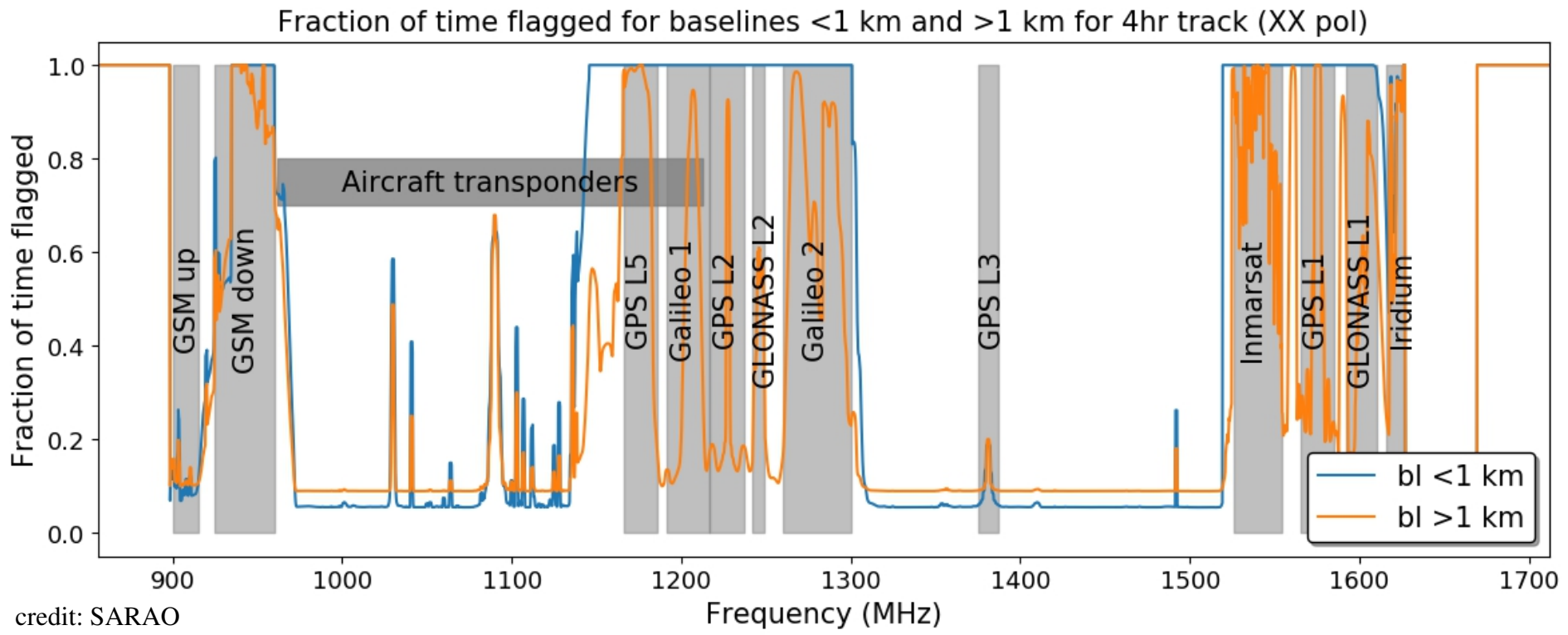
4+1 goals:

- HI intensity mapping
- mechanisms of outflow from supermassive black holes
- acceleration and collimation mechanisms of AGN jets
- exoplanet formation and habitability
- micro-arcsecond radio celestial sphere reference frame

about HI intensity mapping: what we are suffering

some fact we know from MeerKAT

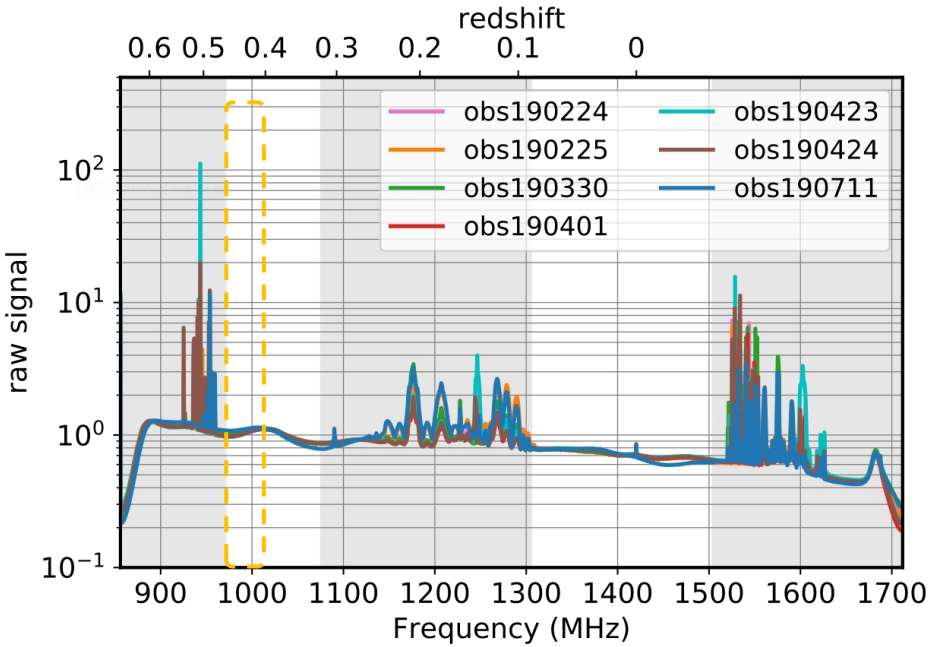
- RFI (satellites + local)

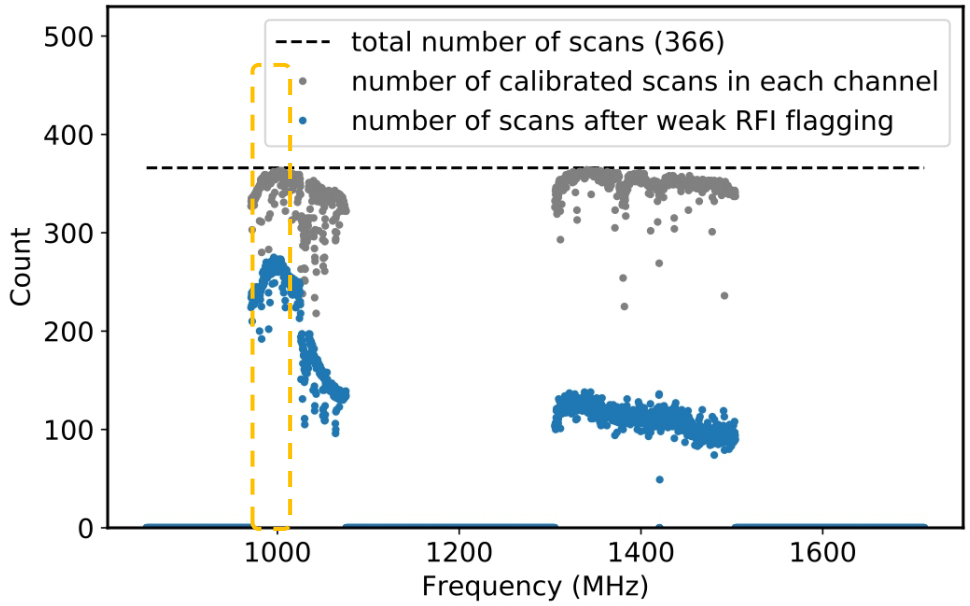


credit: SARAO

some fact we know from MeerKAT

- RFI (satellites + local)

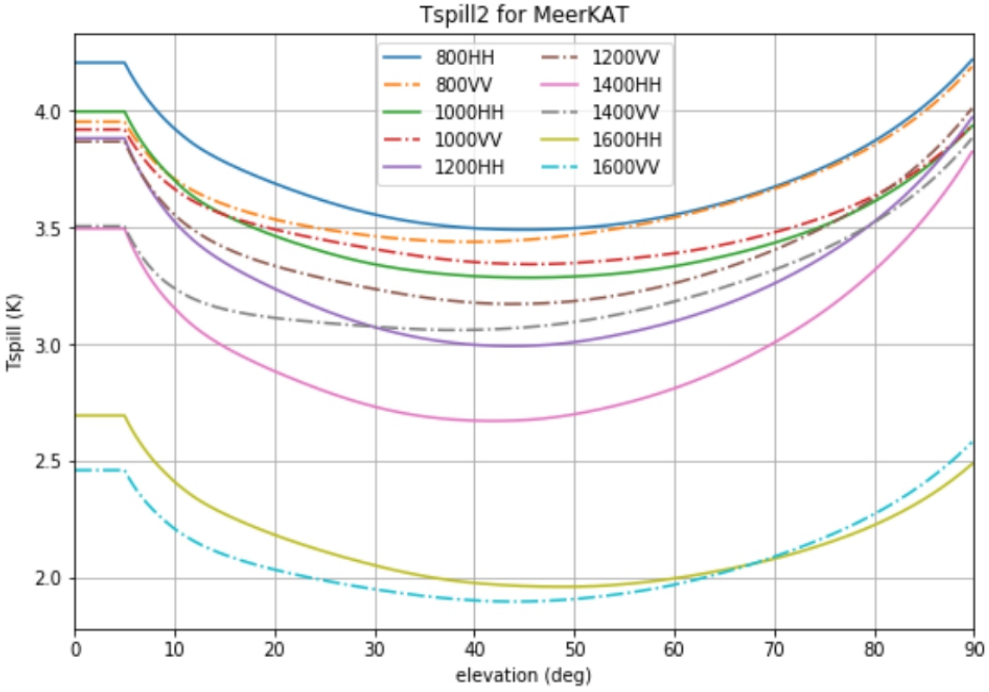




at last we only have $973.2 < \nu < 1014.6$ MHz ($0.40 < z < 0.46$)

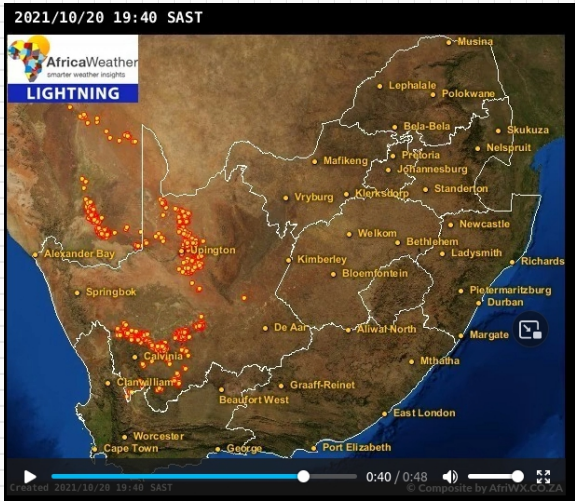
some fact we know from MeerKAT

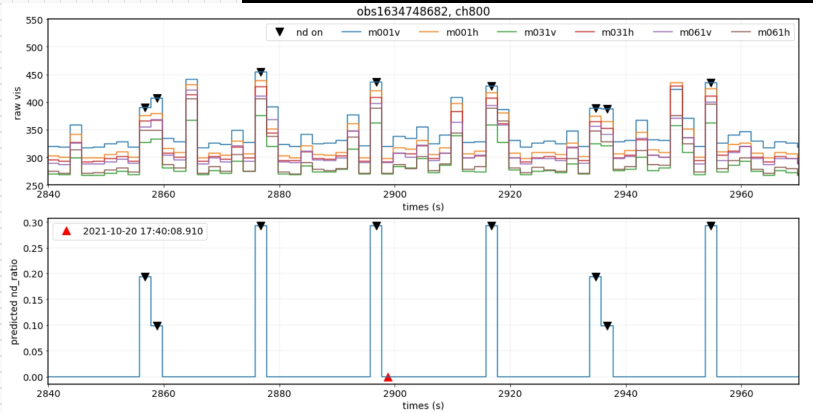
- RFI (satellites + local)
- atmosphere
- ground pickup



some fact we know from MeerKAT

- RFI (satellites + local)
- atmosphere
- ground pickup
- weather (lightning)
- beam changing (elevation)

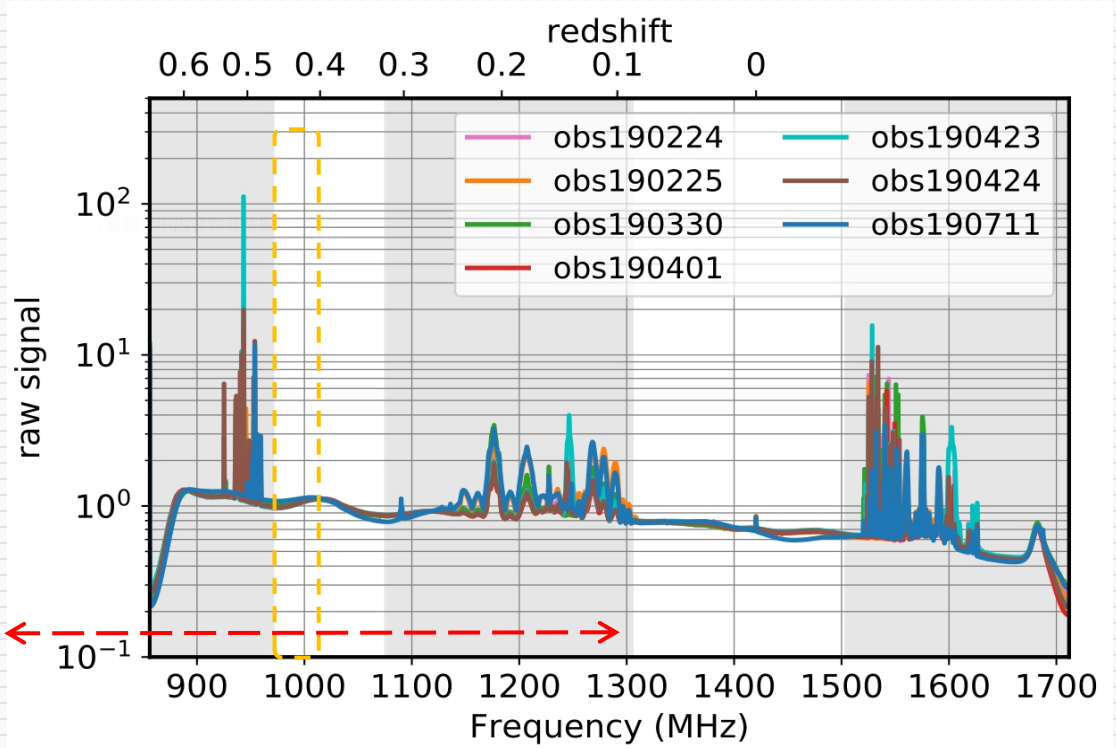




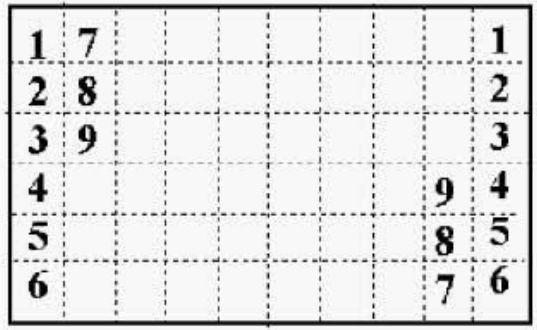
about HI intensity mapping: what we can expect

A RFI free window in L-band

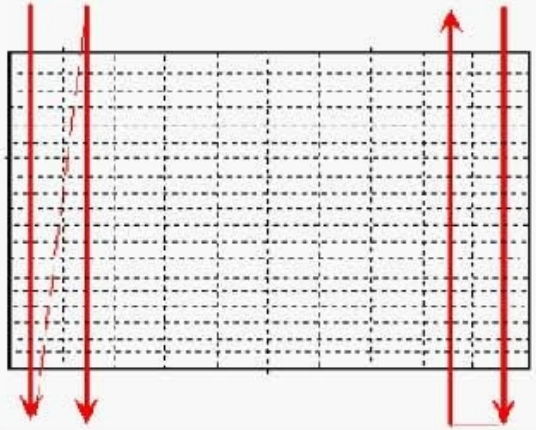
we can focus on 0.1<z<0.5 (1290-947 MHz) and
try 0.5<z<1.0 (947-710 MHz)

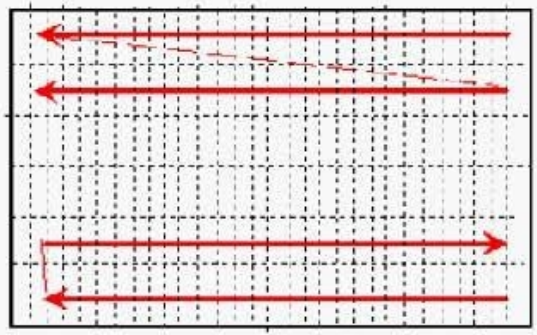


Types of maps



- Point map
  - Sit, Move, Sit, Move, etc.
- On-The-Fly Mapping
  - Mangum, Emerson, Greisen 2008, Astro& Astroph.
  - Slew a column or row while collecting data
  - Move to next column row
  - Basket weave
  - Should oversanple ~3x Nyquist along direction of slew

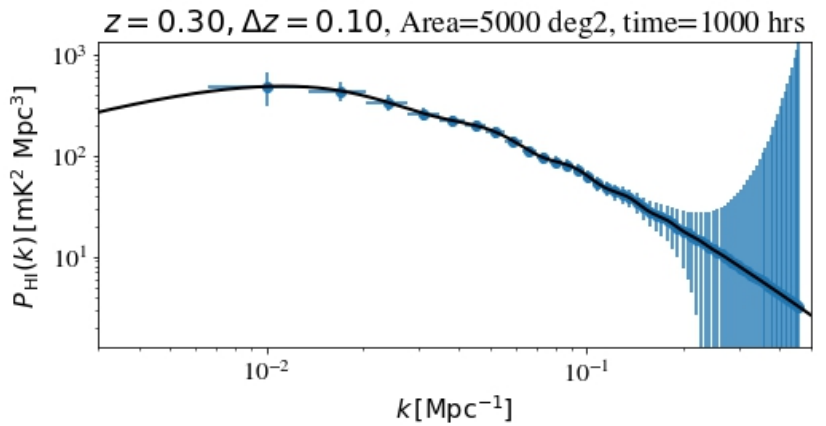


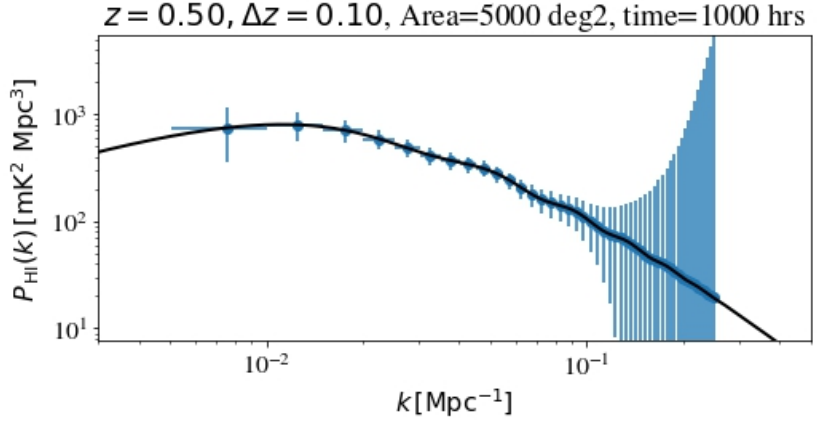


1000 hrs, 5000 deg2

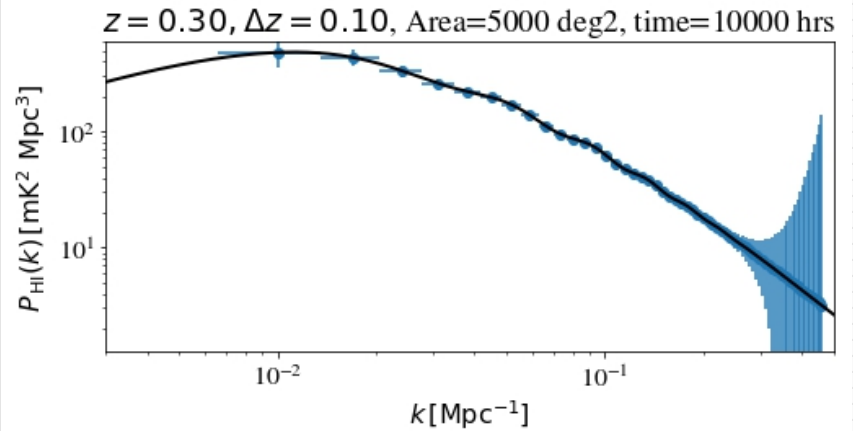
code from *Ze* and *Alkistis*

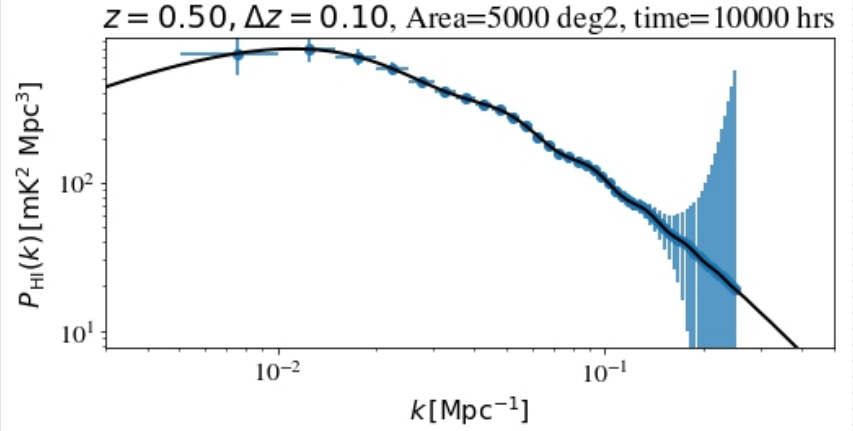
https://github.com/meerklass/MeerKLASS/





10000 hrs, 5000 deg2





0.1<z<0.5 (1290-947 MHz)

- we have 10000 hrs
- focus on dark energy (thanks *Marta* and *Mario*)

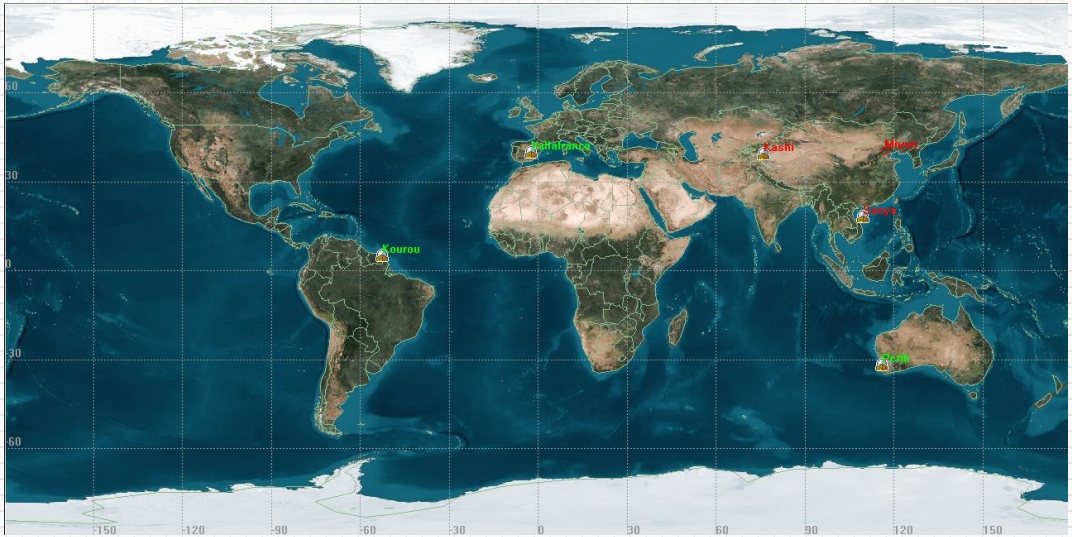
0.5<z<1.0 (947-710 MHz)

- limited by current proposed time 10000 hrs
- cross-correlation with ground-based HI IM data

more information
(just for fun)

we have a Uber

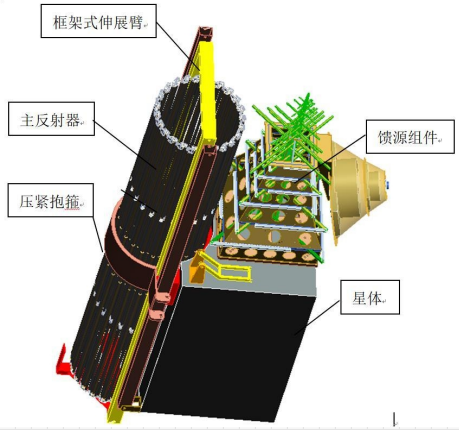
we have wifi

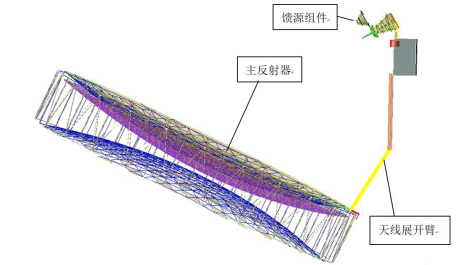


地面站名称	地理位置	所属机构	天线口径	工作频段
密云站	北京密云 Beijing	中科院 CAS	12 米	S/X
三亚站	海南三亚 Hainan	中科院 CAS	12 米	S/X
喀什站	新疆喀什 Xinjiang	中科院 CAS	12 米	S/X
Kourou 站	French Guiana	ESA	15 米	S/X
Villafranca 站	Spain	ESA	15 米	S/X
Perth 站	Australia	ESA	15 米	S/X

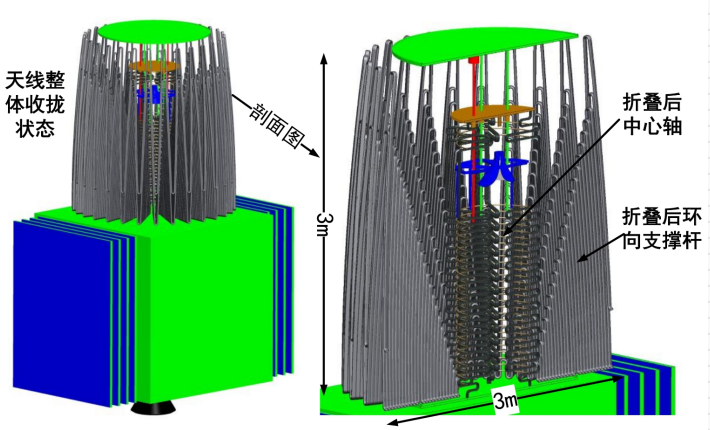
How to pack/unpack the luggage

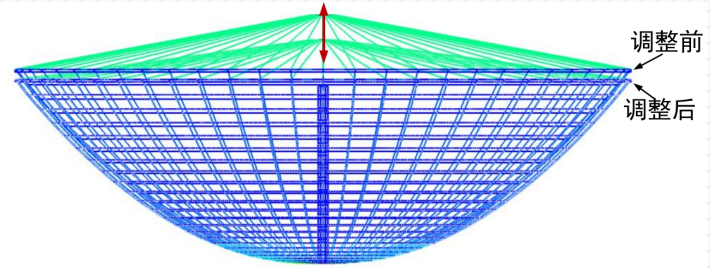
Plan A



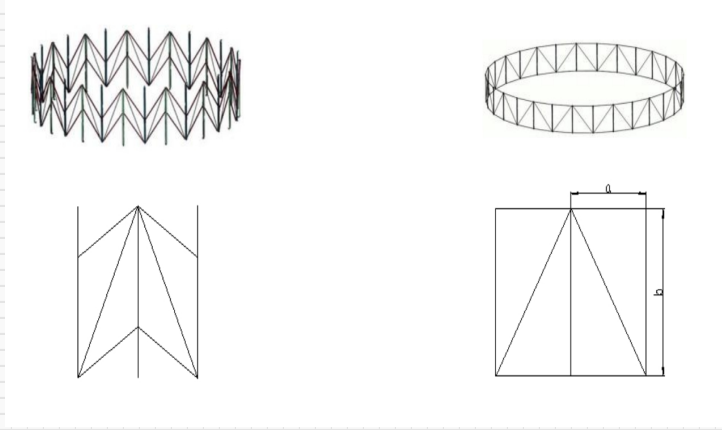


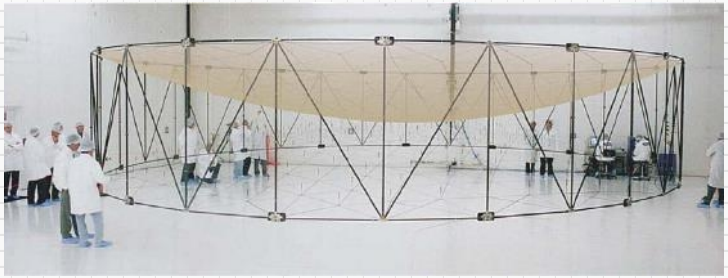
Plan B





Plan C





To be continue...

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