Green Bank Telescope Science Program

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NRAO, Green Bank WV

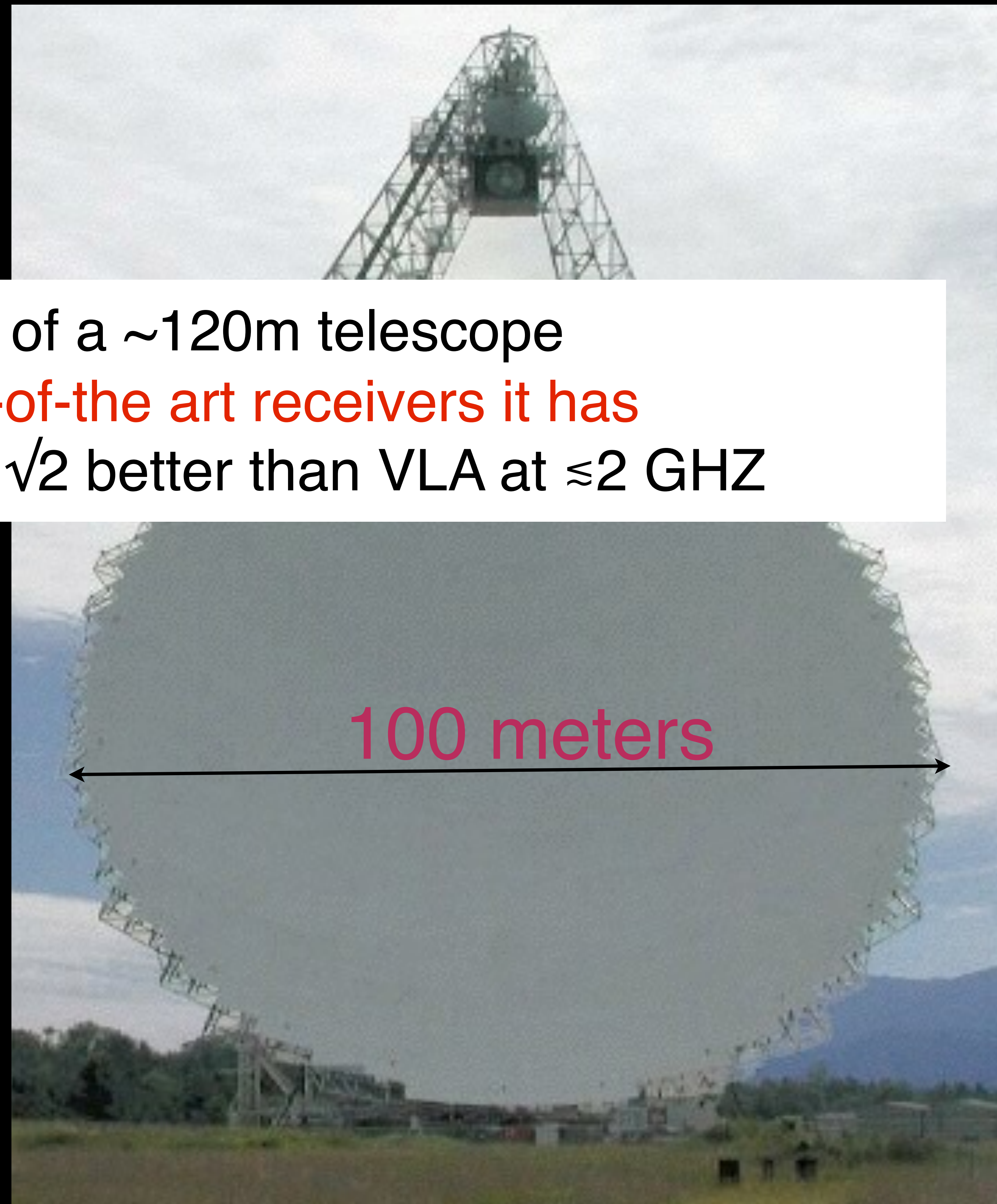
The GBT

- Point source sensitivity of a ~120m telescope

With its state-of-the art receivers it has

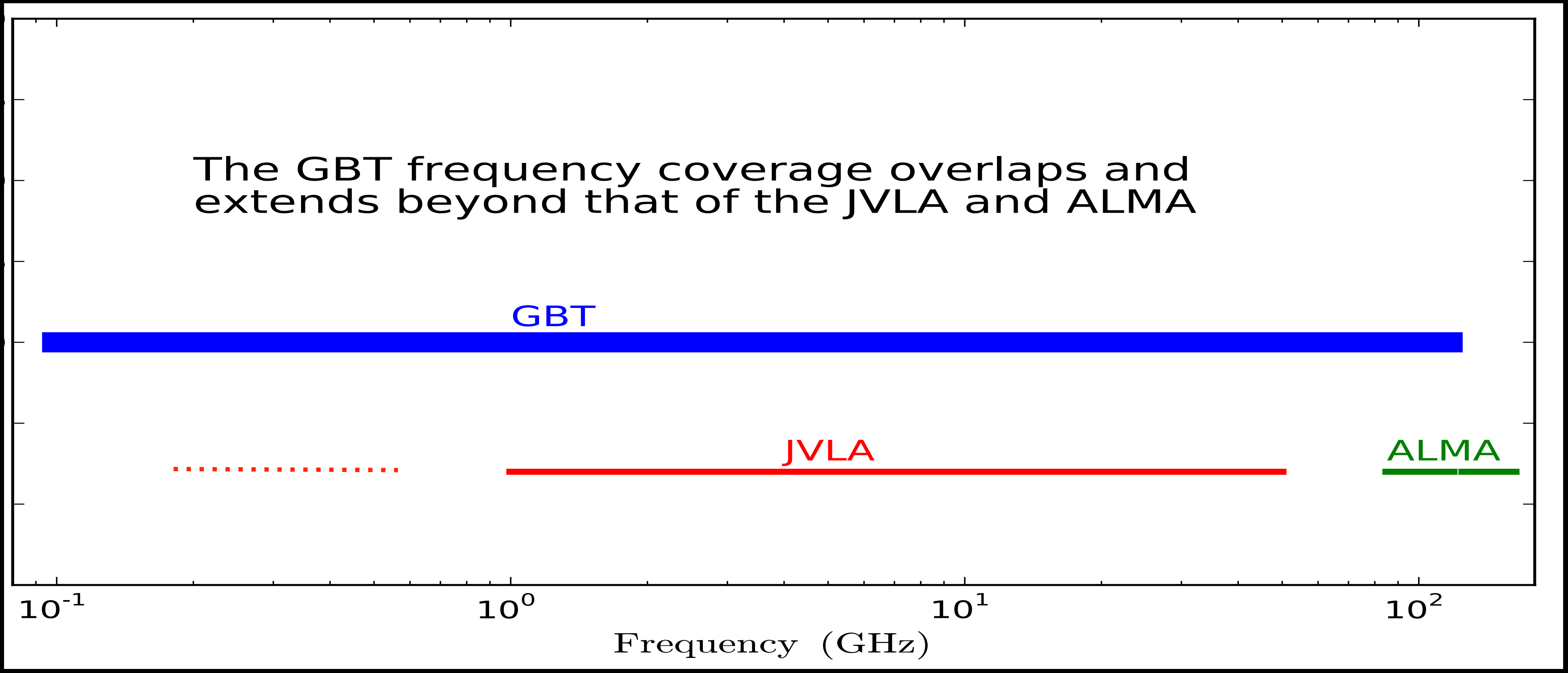
- Point source sensitivity √2 better than VLA at ≲2 GHZ

In 2014
6220^h for science
~⅓ at $\nu \geq 18$ GHz




National
Radio
Quiet
Zone
Appalachian Mountains
Washington D.C.

- Receivers cover 0.1 to >100 GHz
- >85% of total sky covered   δ≥-46°
- National Radio Quiet Zone
- Competitively Scheduled

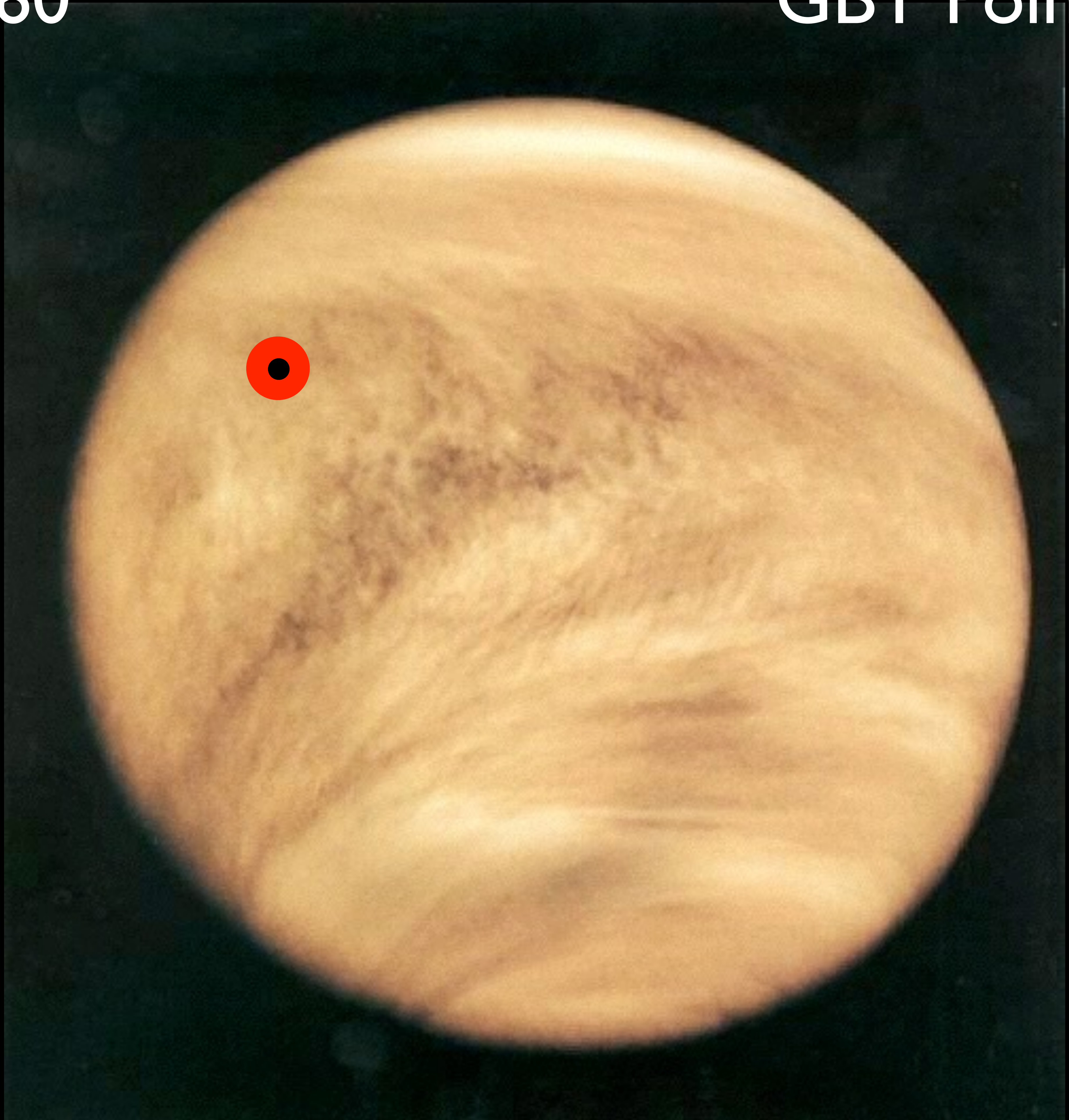


GBT Pointing

$\sigma \approx 2''$

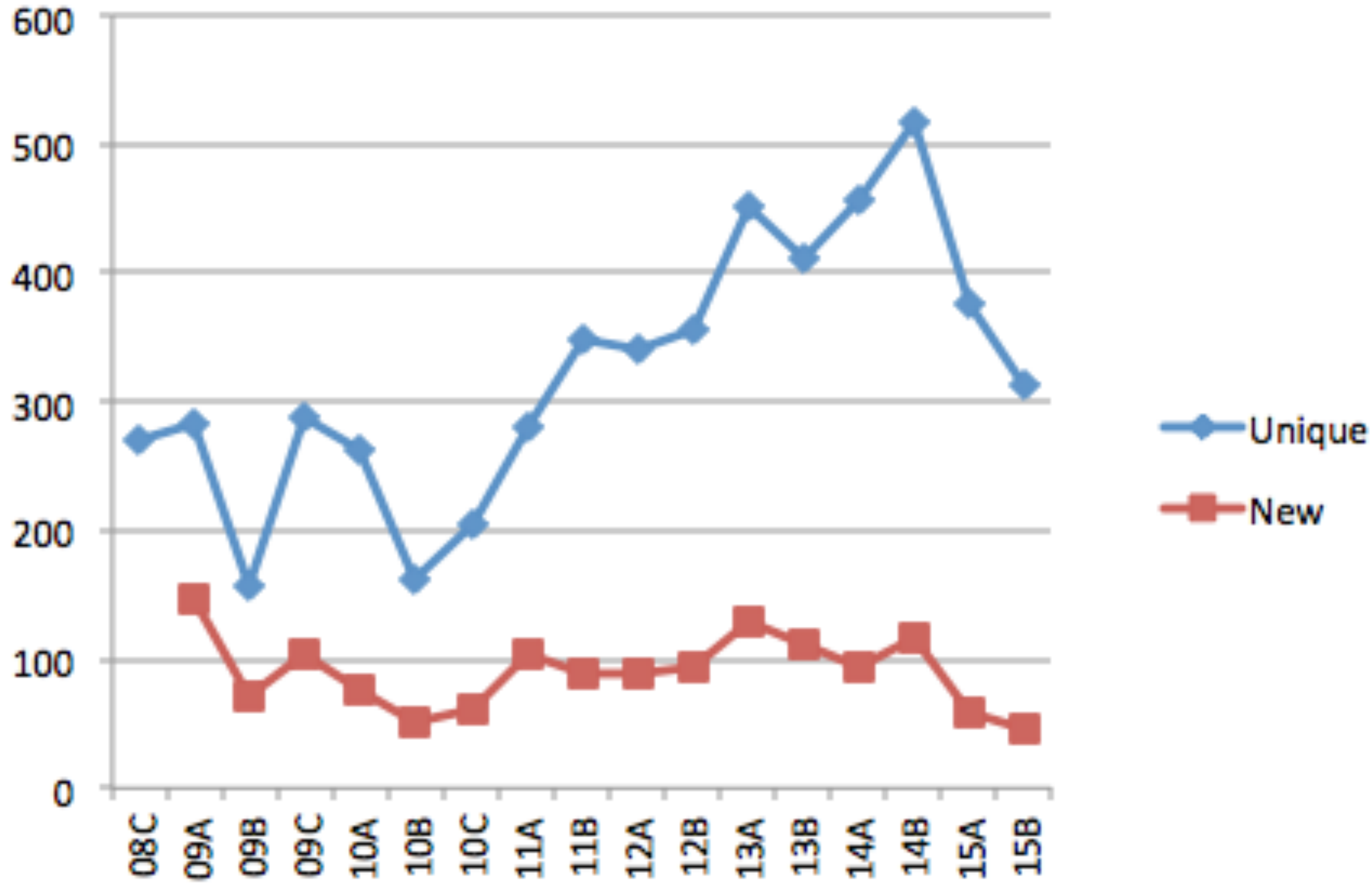
Venus 60”

GBT Pointing 2”



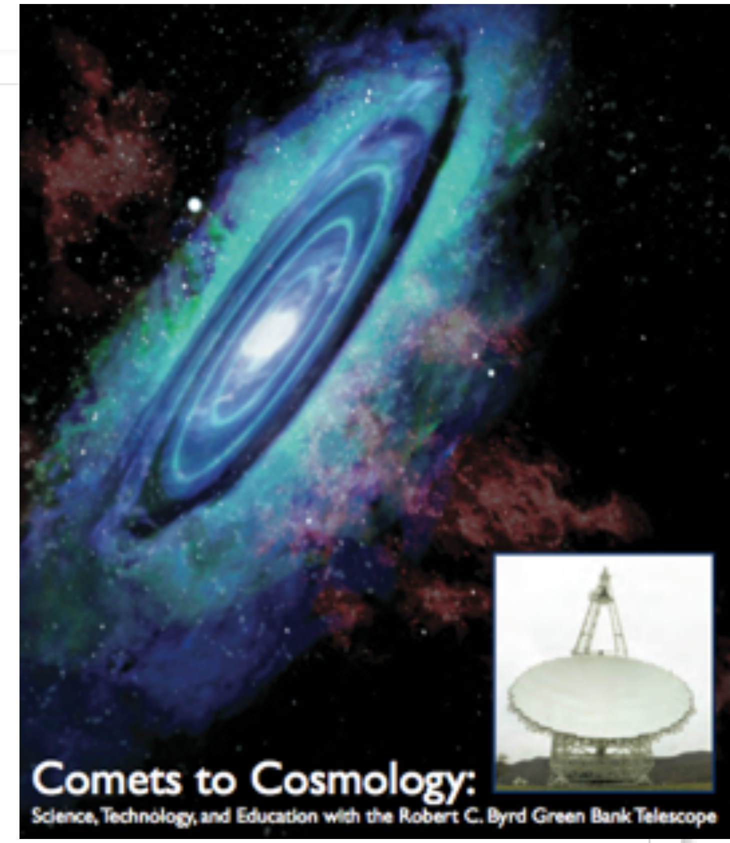
GBT Proposers per Proposal Cycle
Total Proposers: 1712

Total GBT Users ~1200



Research areas of most-cited GBT publications

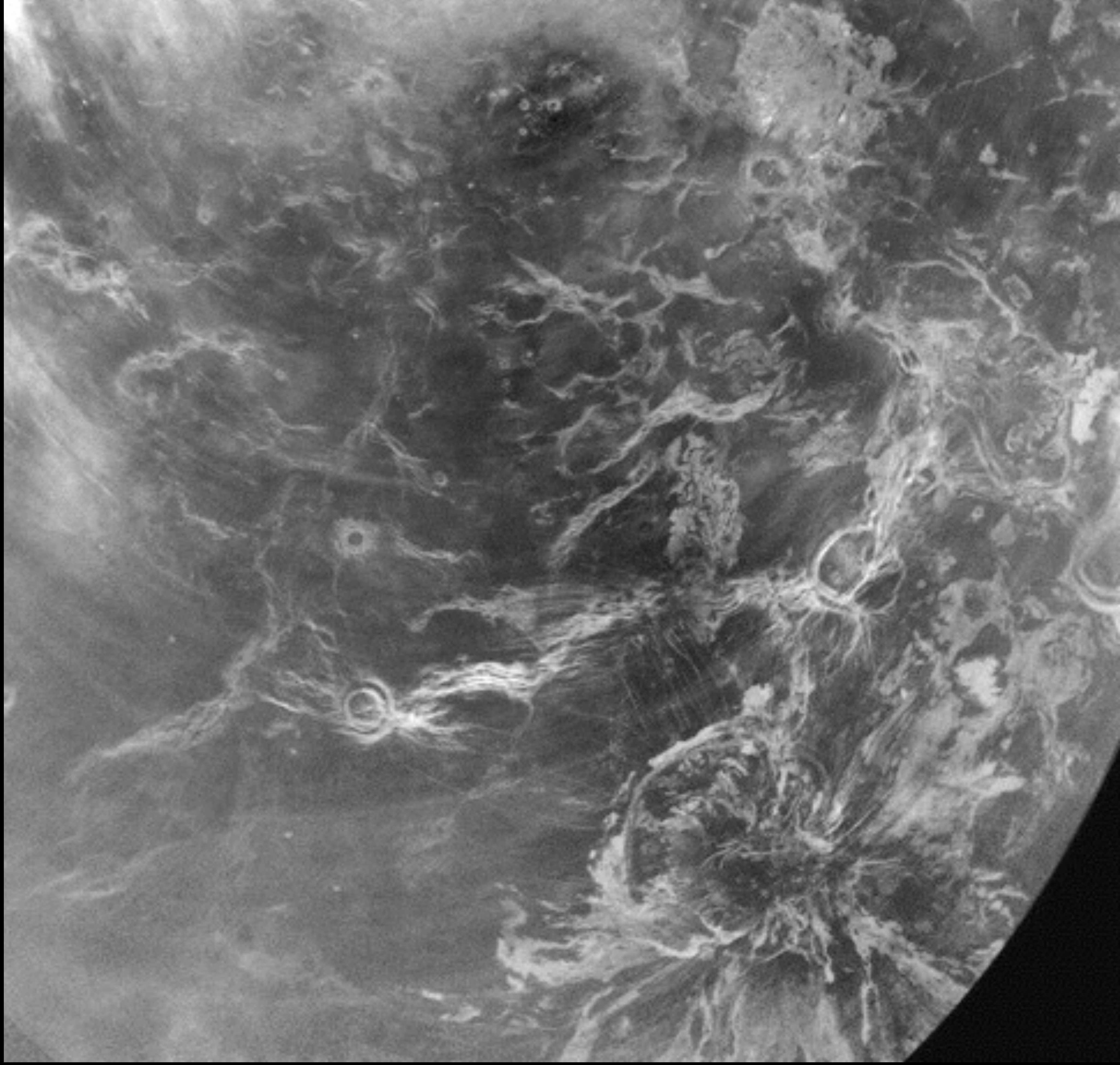
(November 2014)



Pulsars and compact objects
Gravity and General Relativity
Galactic Hydrogen surveys
Interstellar Chemistry
The internal structure of Mercury
Evolution of spiral galaxies
Star formation & pre-stellar objects
Studies of a binary black hole
Hydrogen content of galaxies
Molecules in highly redshifted galaxies
Anisotropies in the cosmic Infrared background

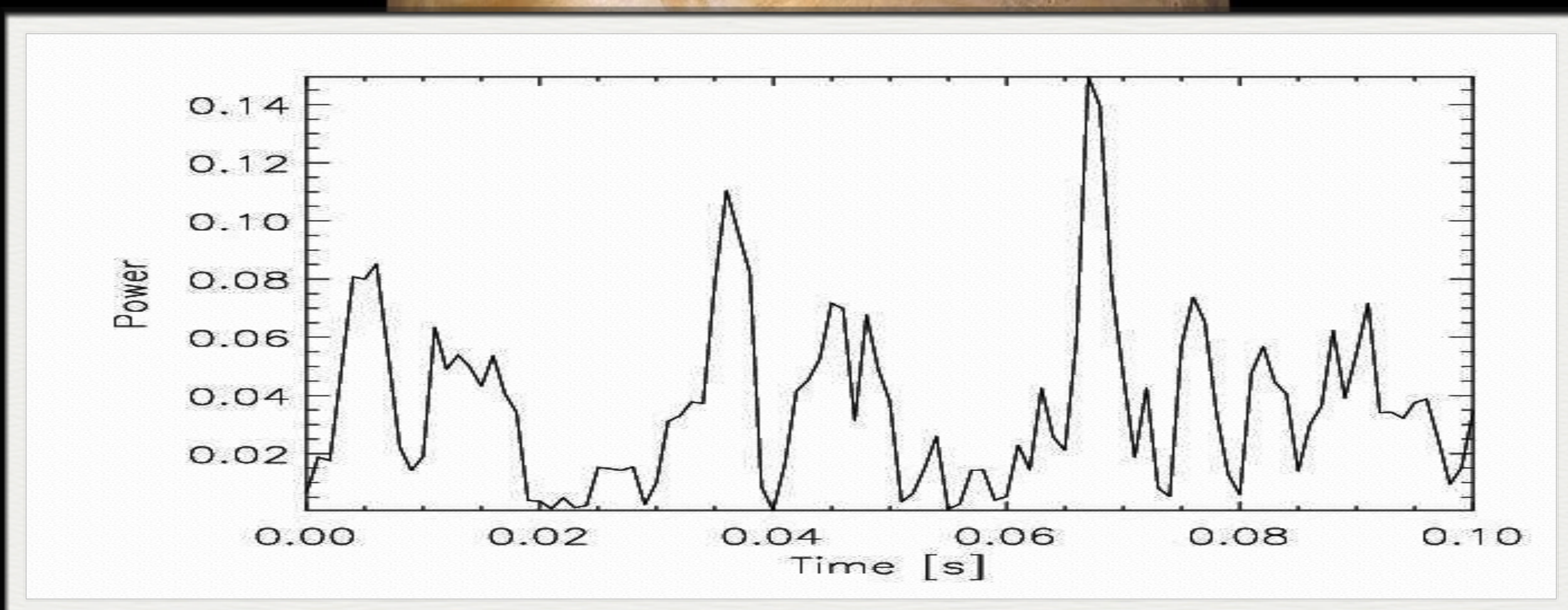
VENUS
Arecibo
+
GBT

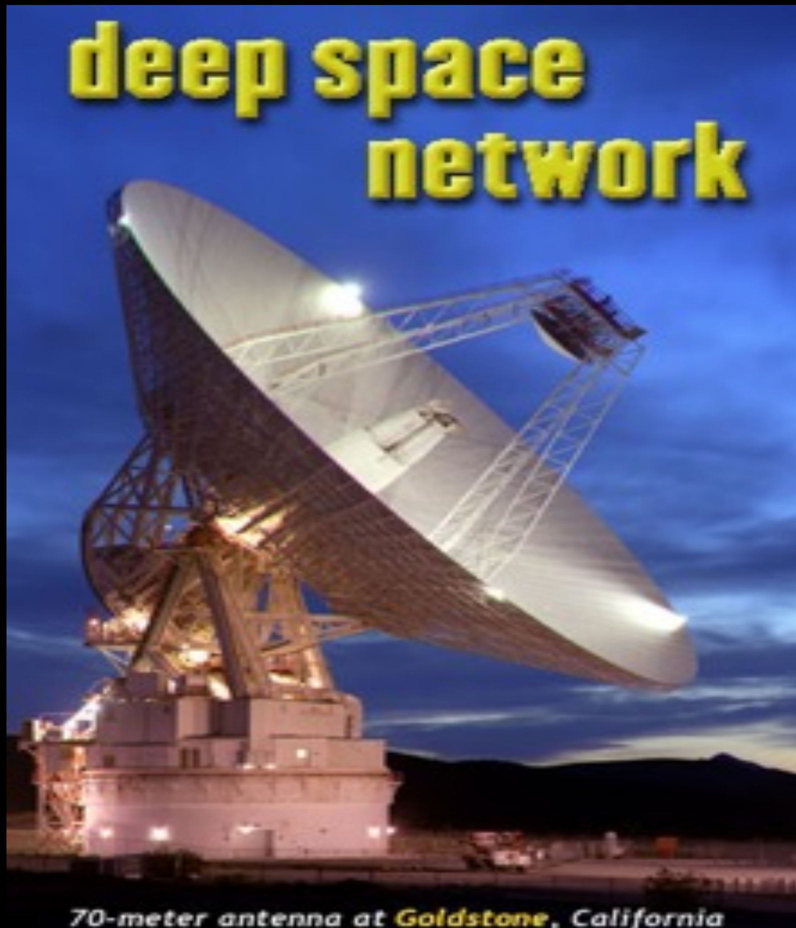
B. Campbell

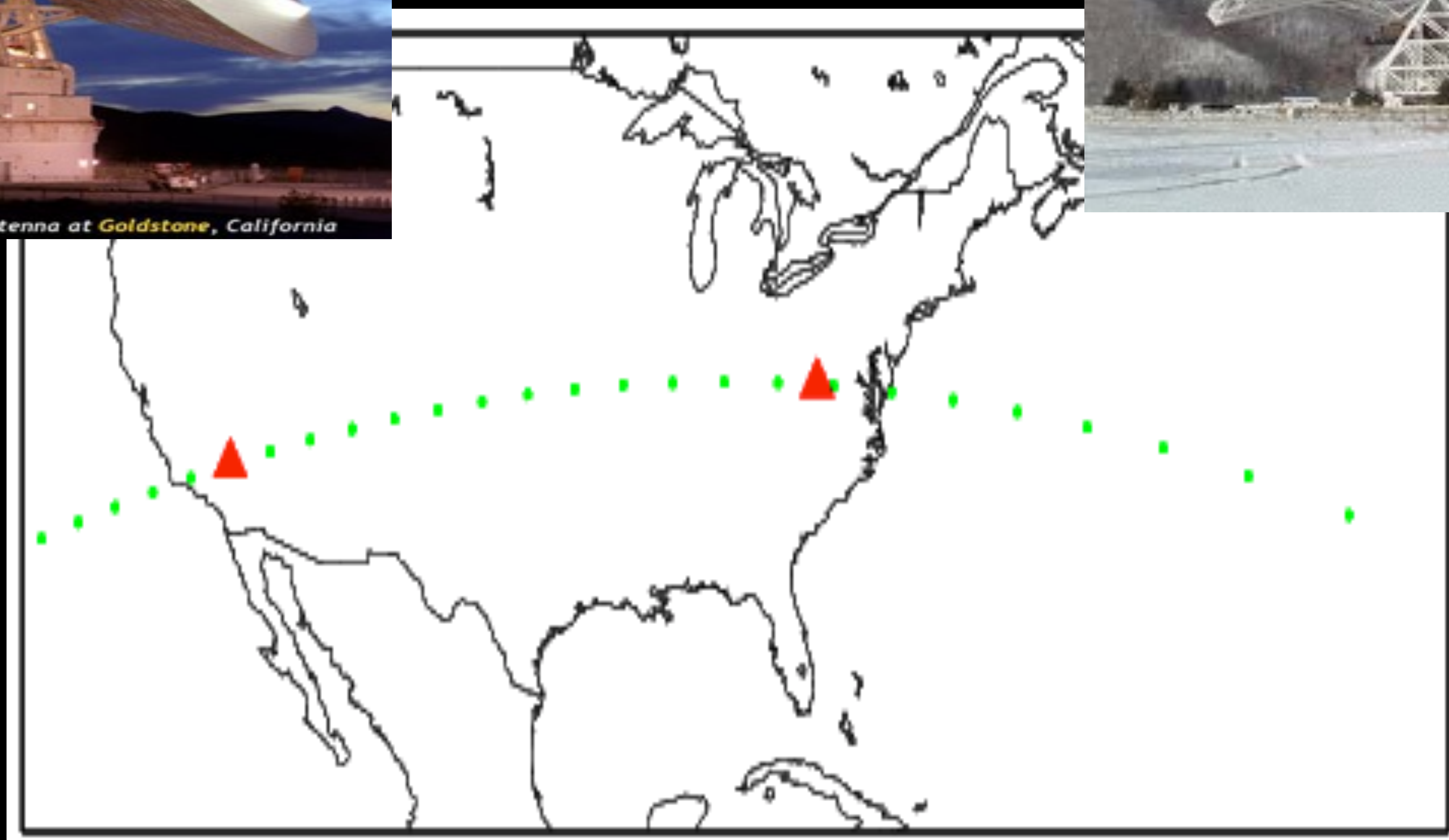


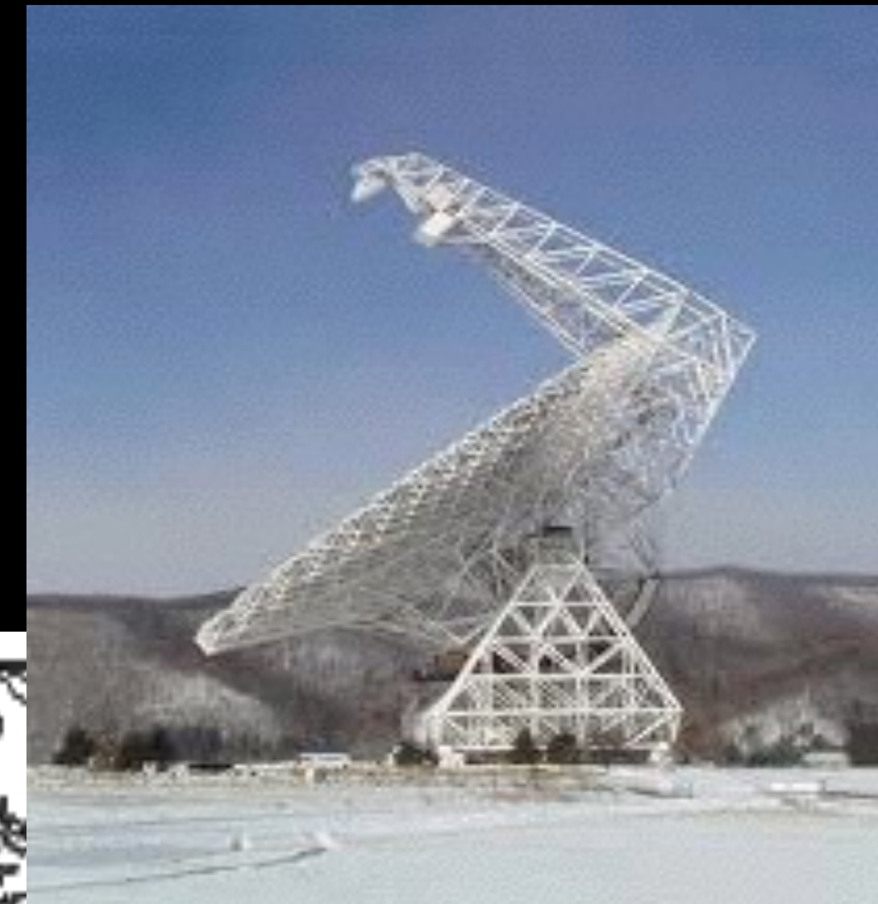
A radar return is speckled

The radar return is speckled

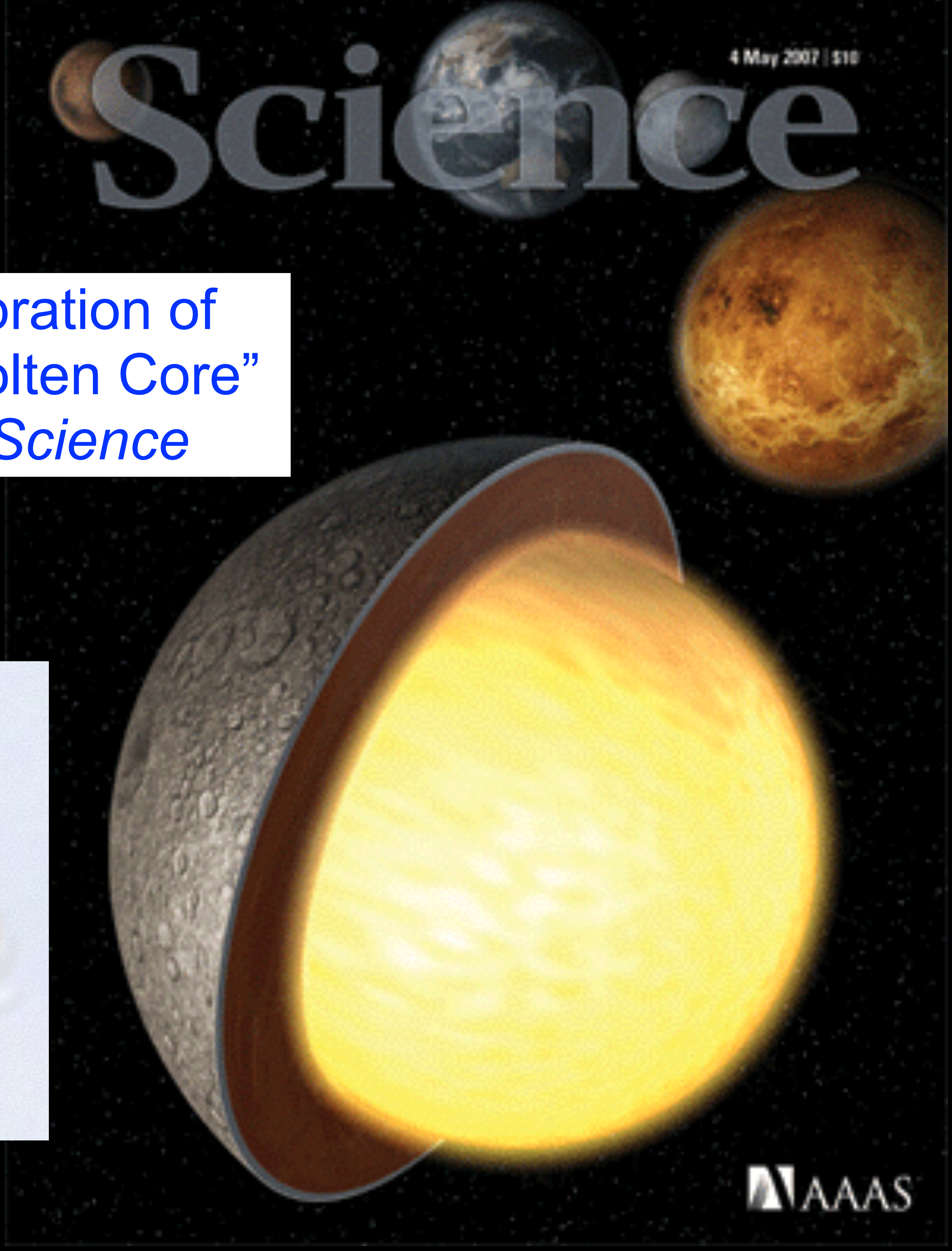


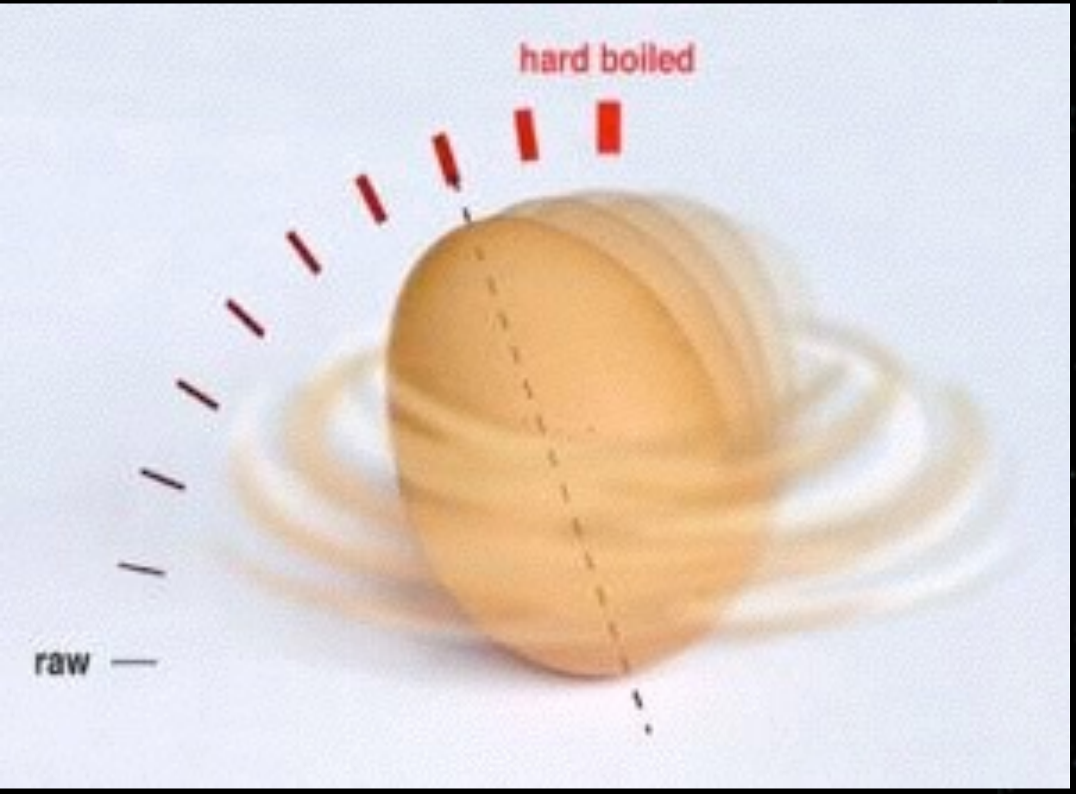

deep space network
70-meter antenna at Goldstone, California





“Large Longitude Libration of Mercury Reveals a Molten Core”
Margot et al. 2007 Science

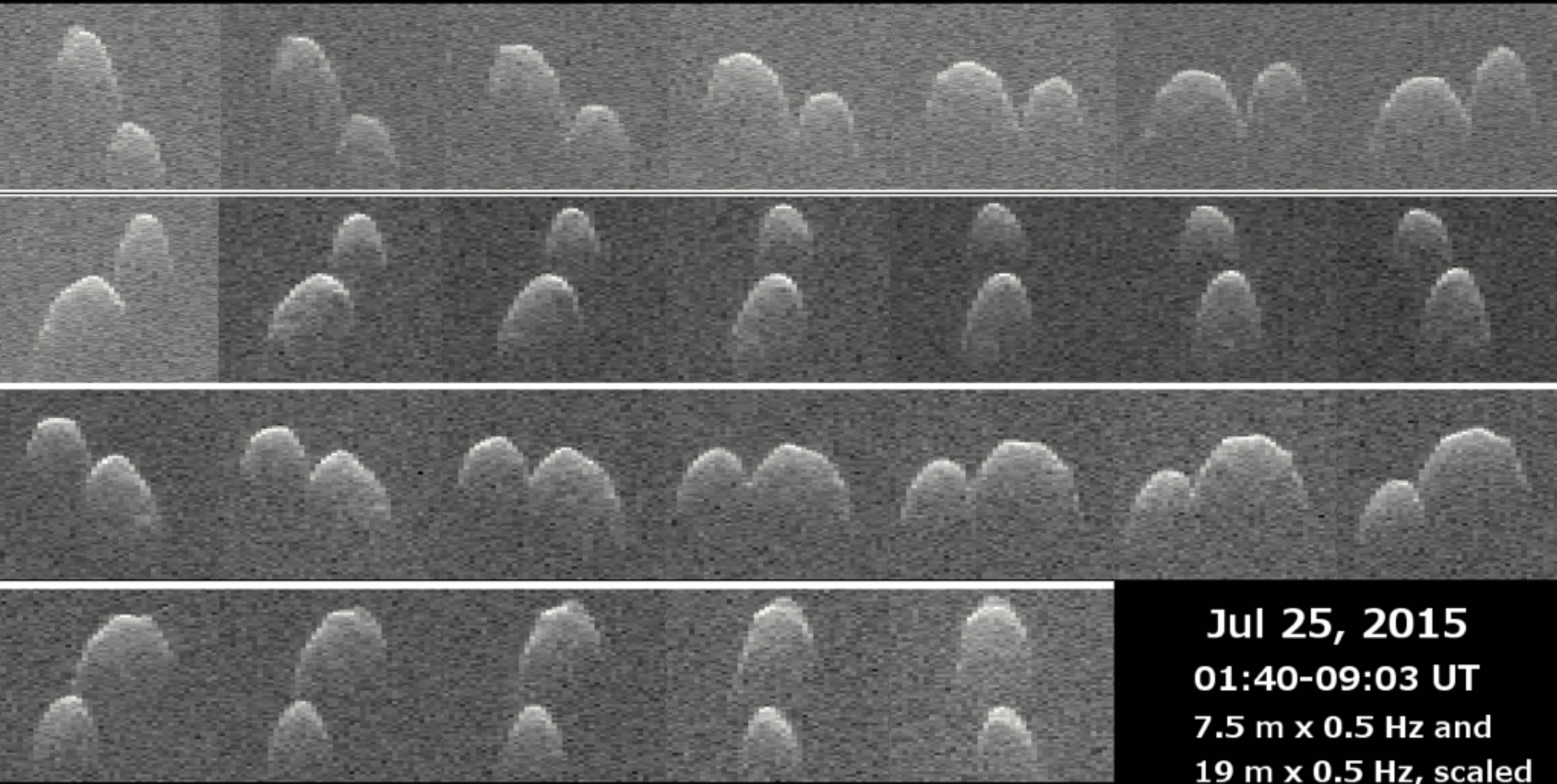




Chelyabinsk, Russia -- Feb. 15, 2013


Goldstone-GBT
27 Jan 2015
Asteroid 2004BL86

(85989) 1999 JD6



Jul 25, 2015
01:40-09:03 UT
7.5 m x 0.5 Hz and
19 m x 0.5 Hz, scaled

Goldstone-GBT bistatic radar images

~18x the distance to the Moon

GBT -- The Premier Pulsar Telescope

Fastest Pulsar

Most Massive Pulsar

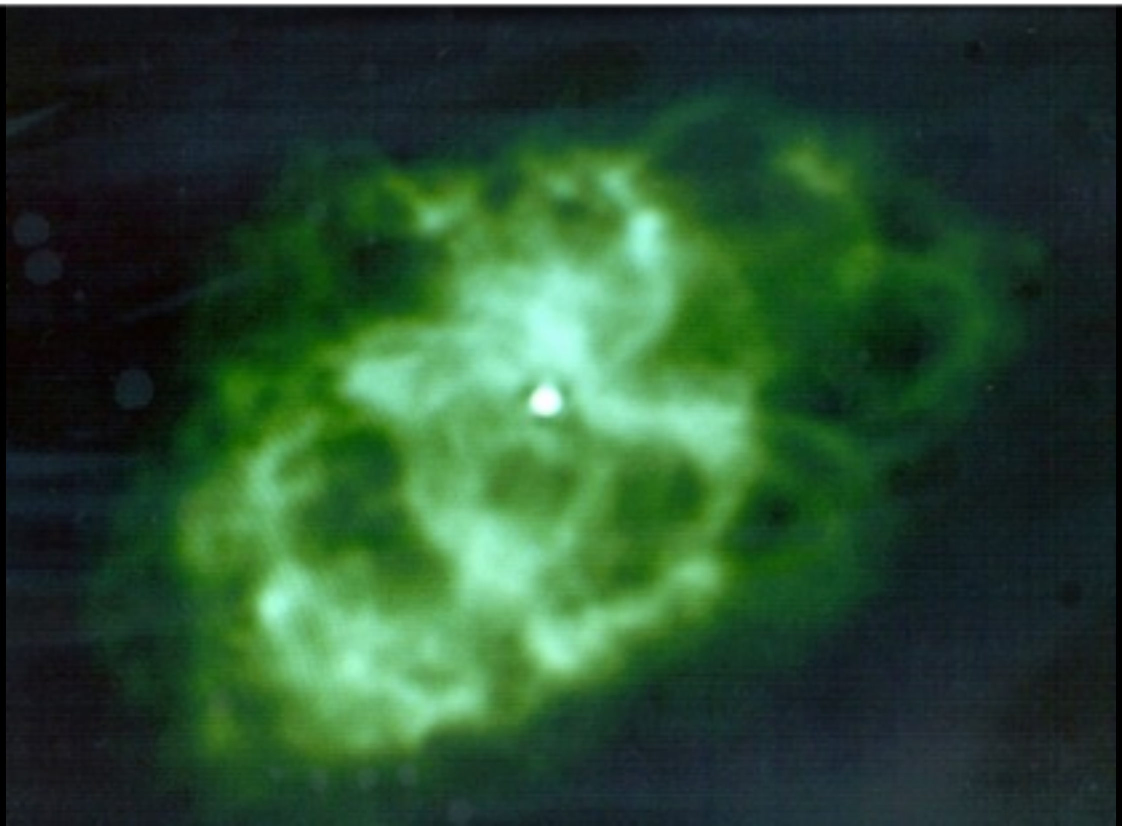
Pulsars in Globular Clusters

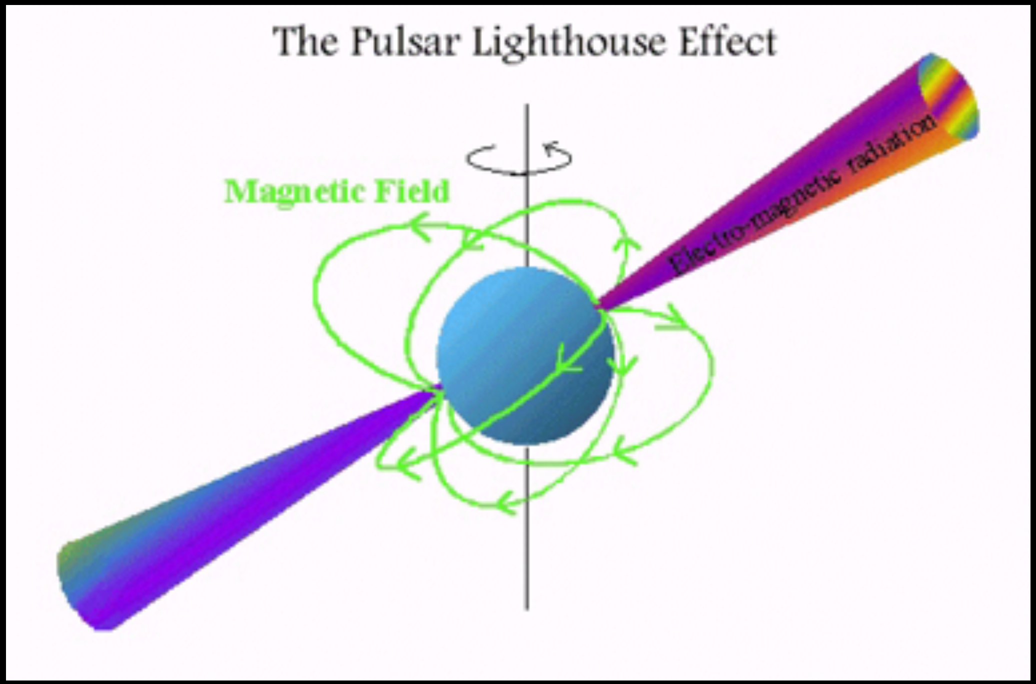
Tests of General Relativity

Relativistic Spin Precession

Pulsar in a three-body system

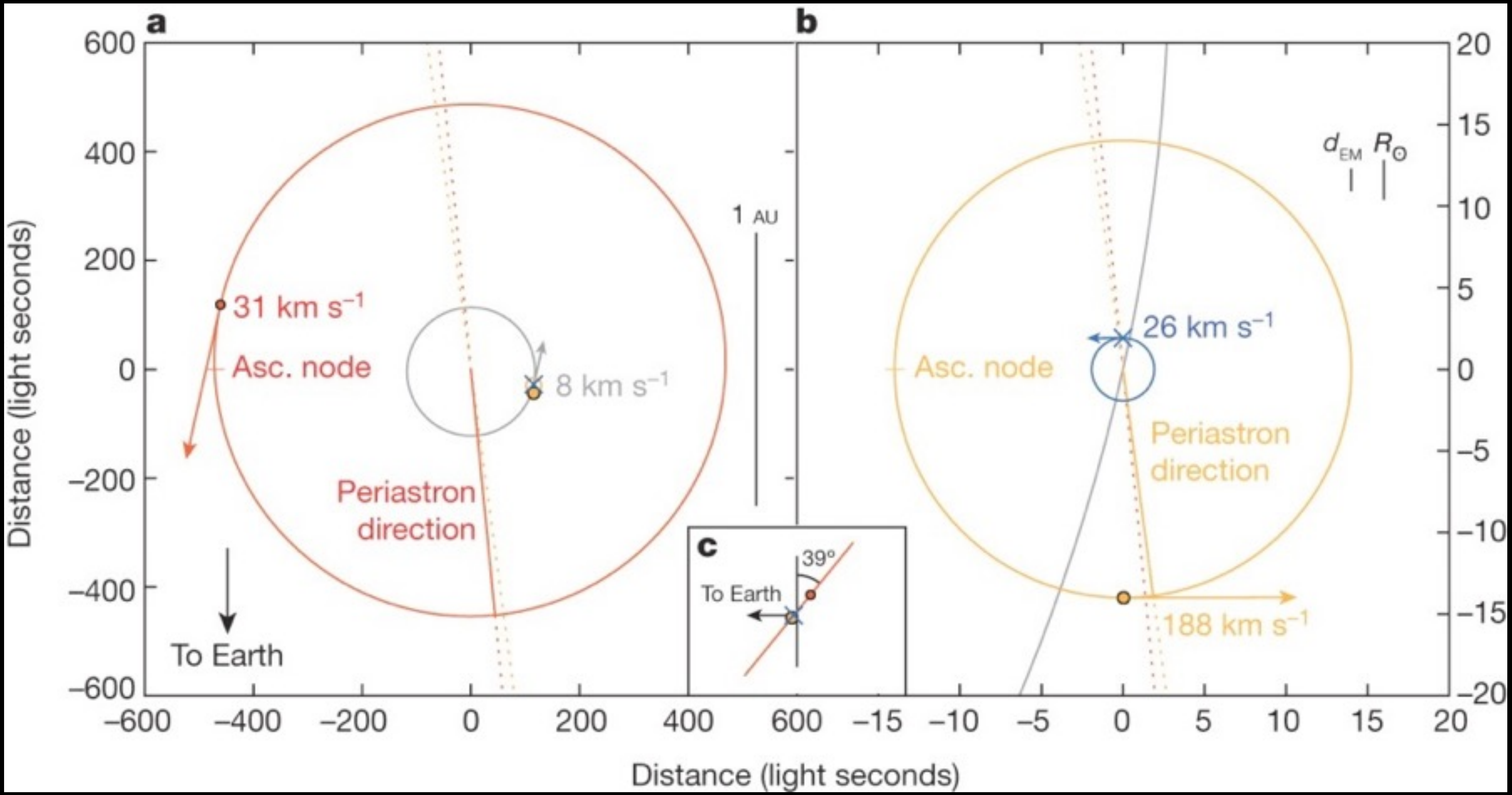
Coolest white dwarf star (a diamond as big as the Ritz)





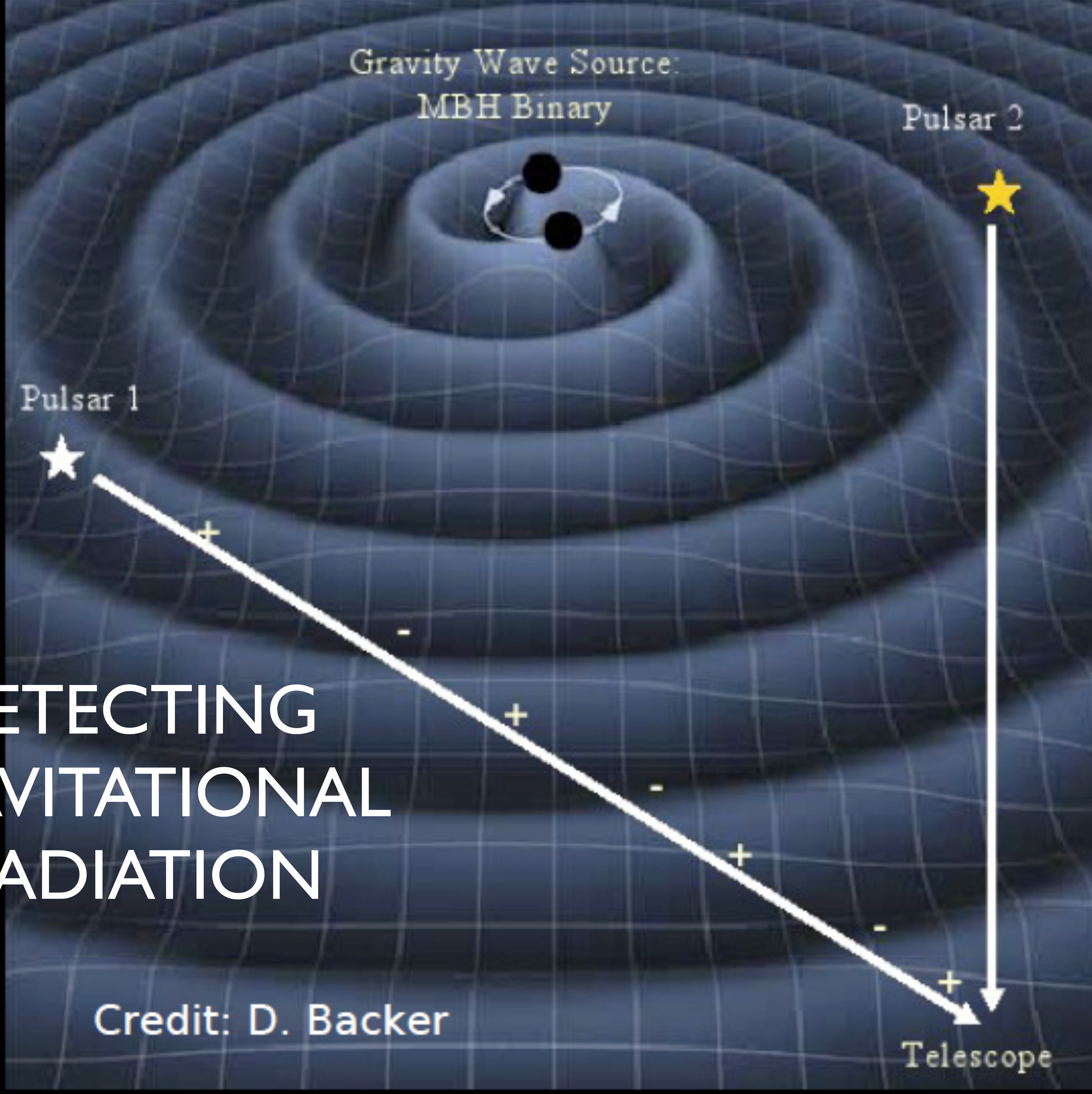
A Pulsar in a Triple System
ARECIBO+ GBT

Ransom et al. (2014) Nature



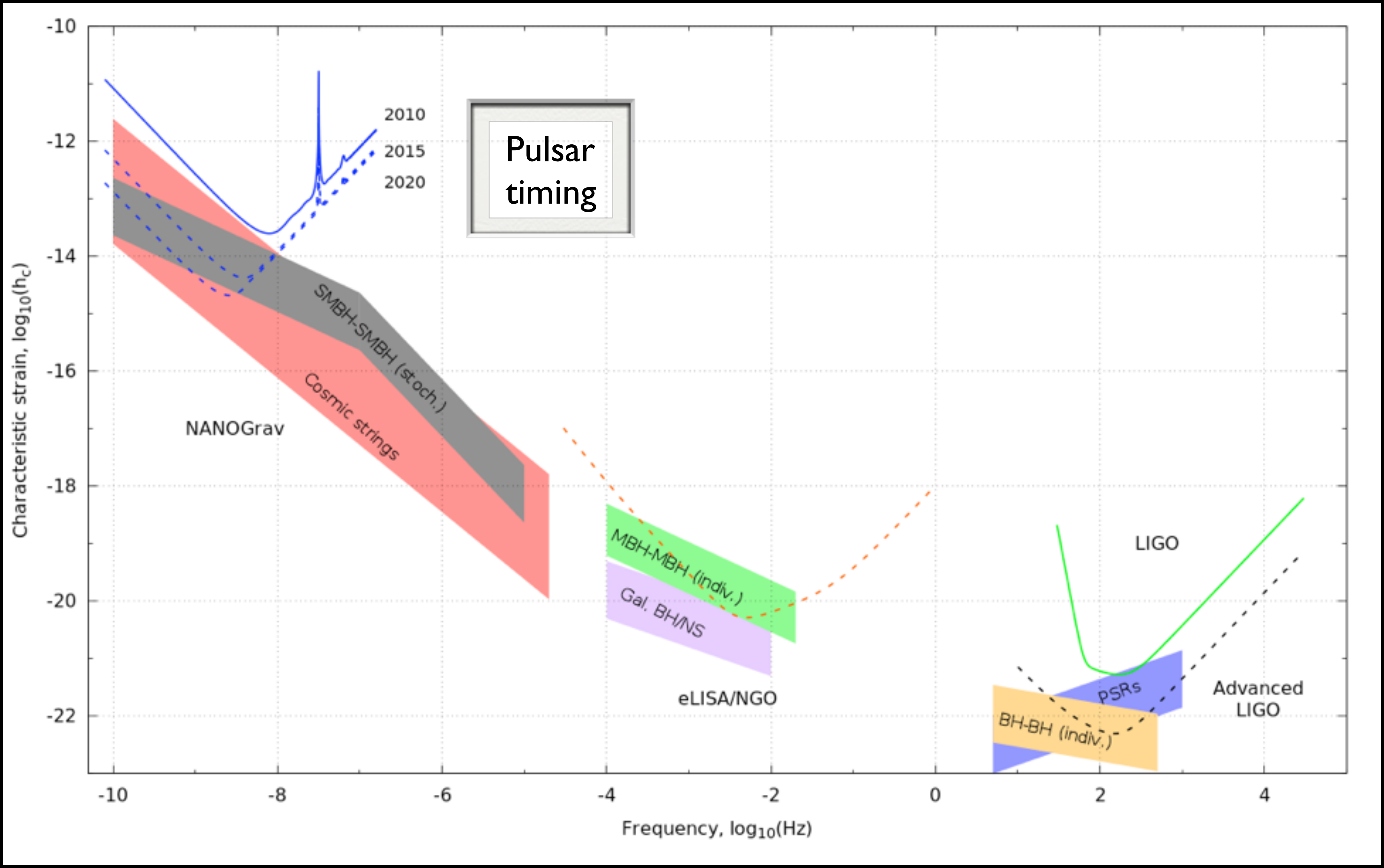
$$F = ma = GmM/r^2 \quad ???$$

DETECTING GRAVITATIONAL RADIATION



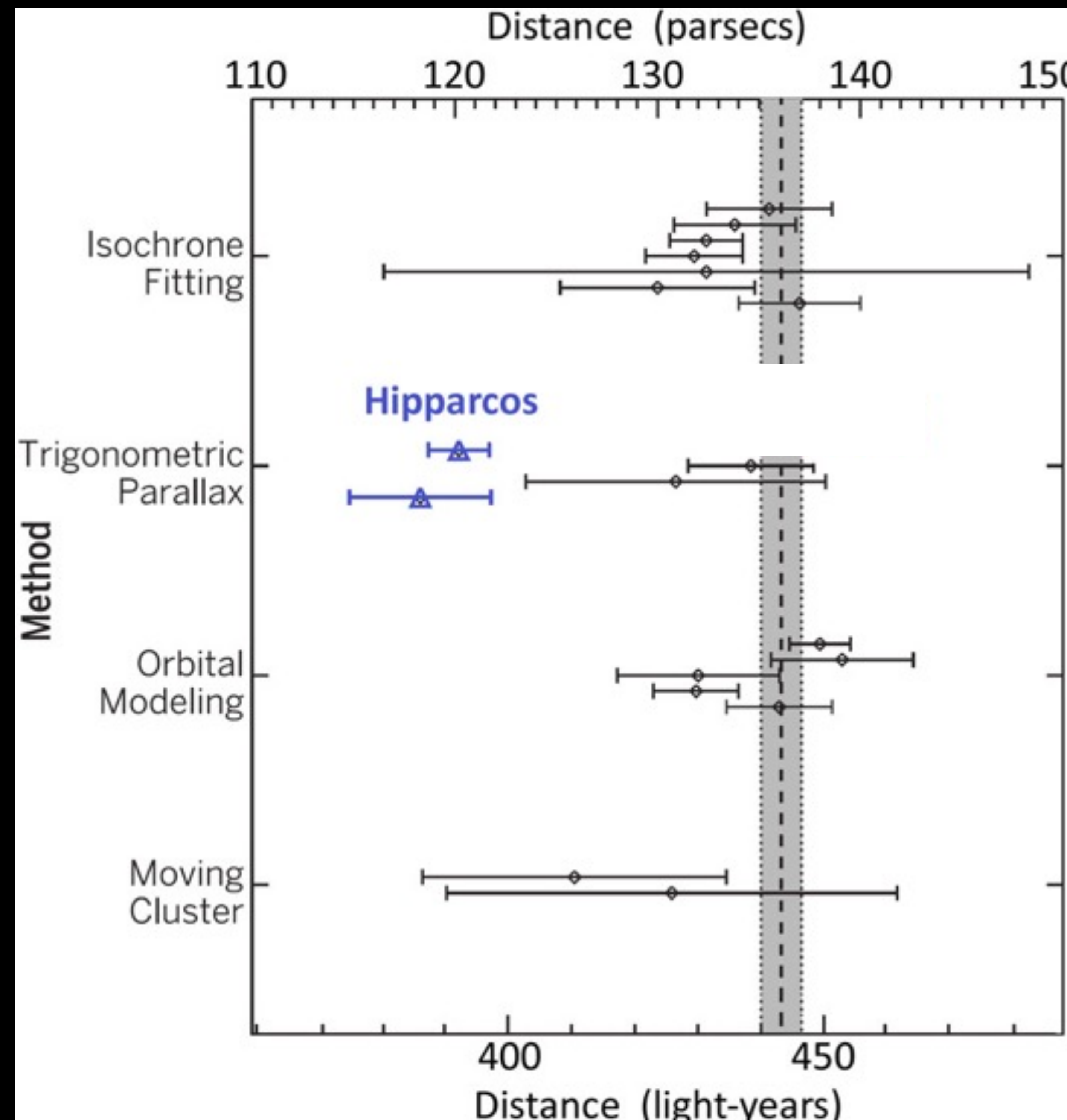
Credit: D. Backer

Predicted Power in Gravitational Radiation



A VLBI Resolution of the Pleiades distance controversy

Melis et al. (2014)



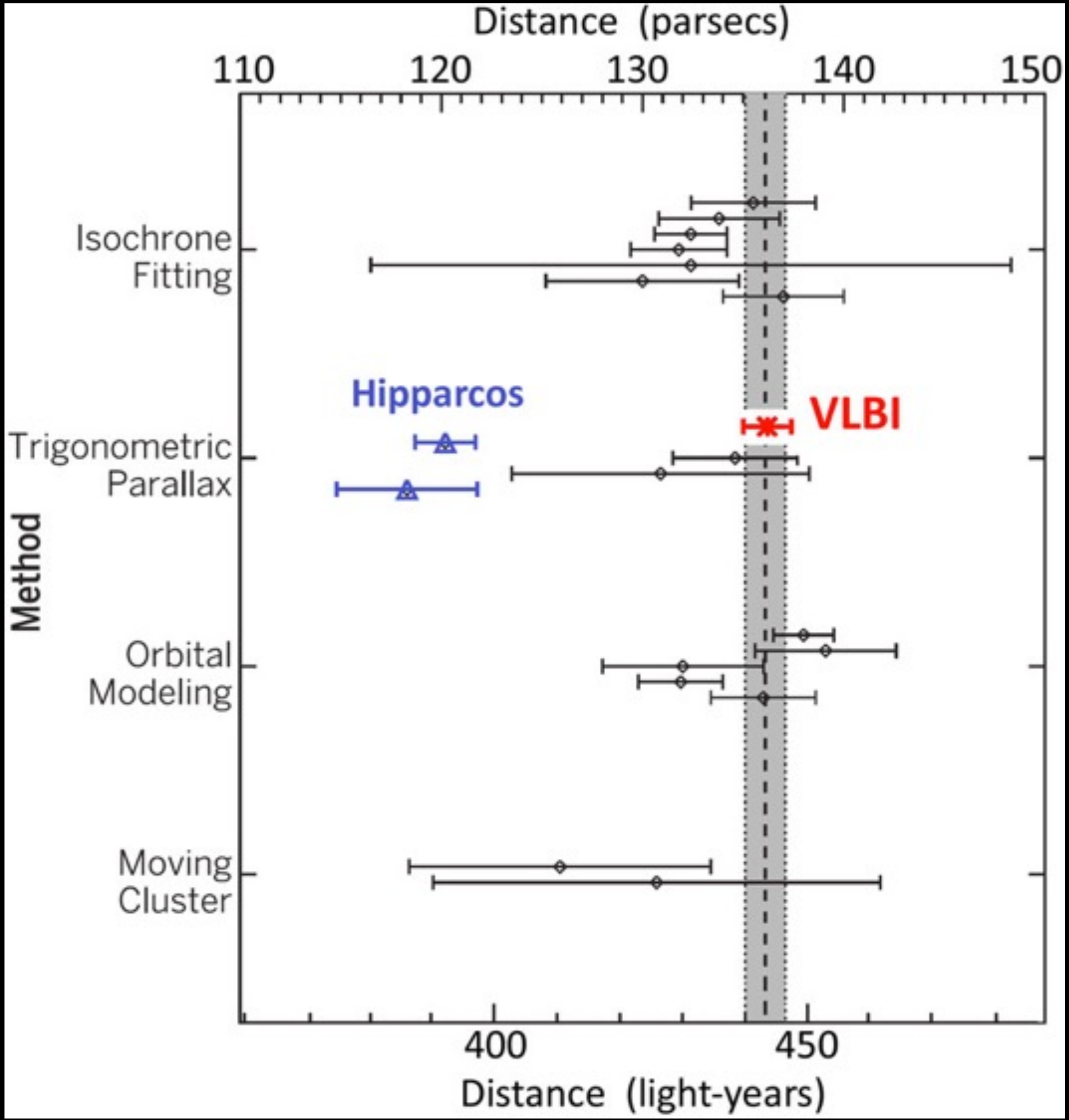
VLBA + GBT + Effelsberg + Arecibo

errors < 0.0001″

134.8 ± 0.5 pc
138.4 ± 1.1 pc
135.5 ± 0.6 pc
136.6 ± 0.6 pc
errors < 1%

A VLBI Resolution of the Pleiades distance controversy

Melis et al. (2014)

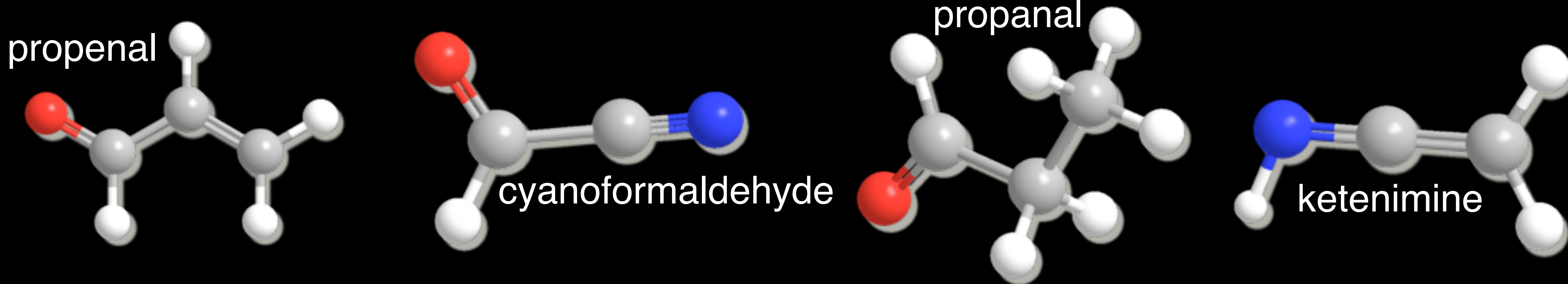


22 GHz H_2O Masers

Braatz, Kuo et al.

Discovered by the GBT
Monitored by the GBT
Imaged by the VLBA + GBT

The Chemistry of Interstellar Space



Some (of the 17+) New GBT Molecule Detections

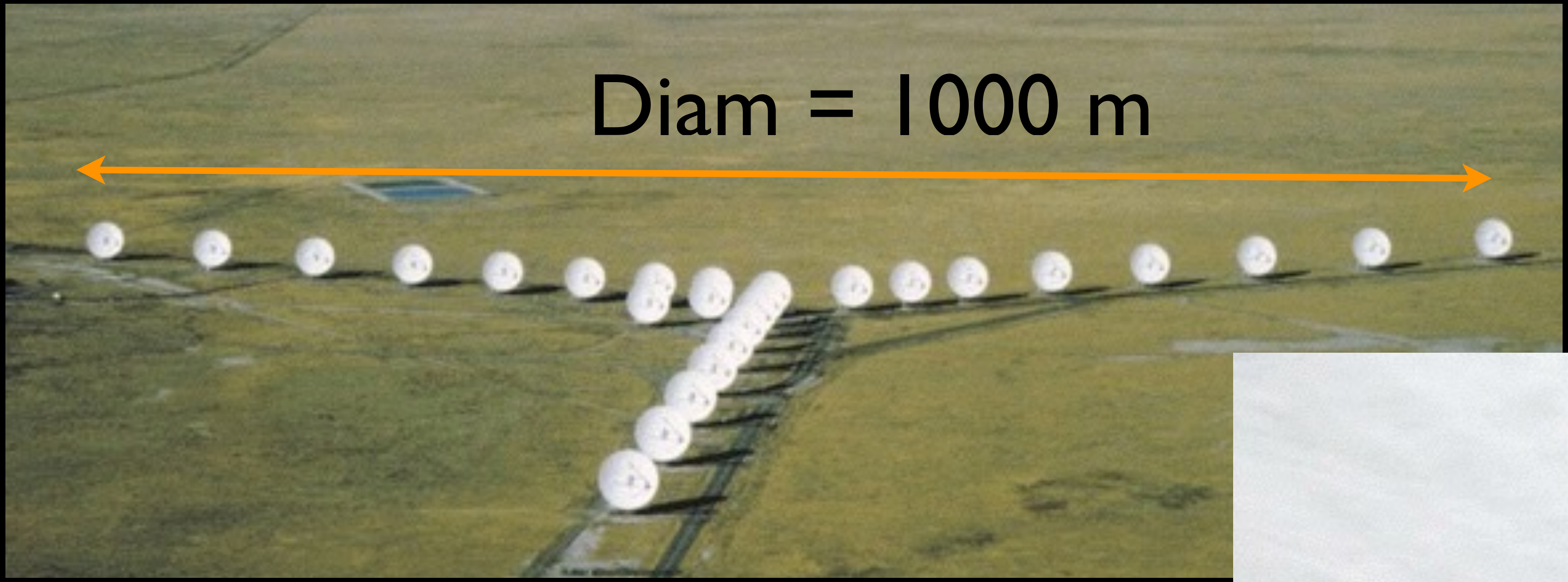
C_6H^-

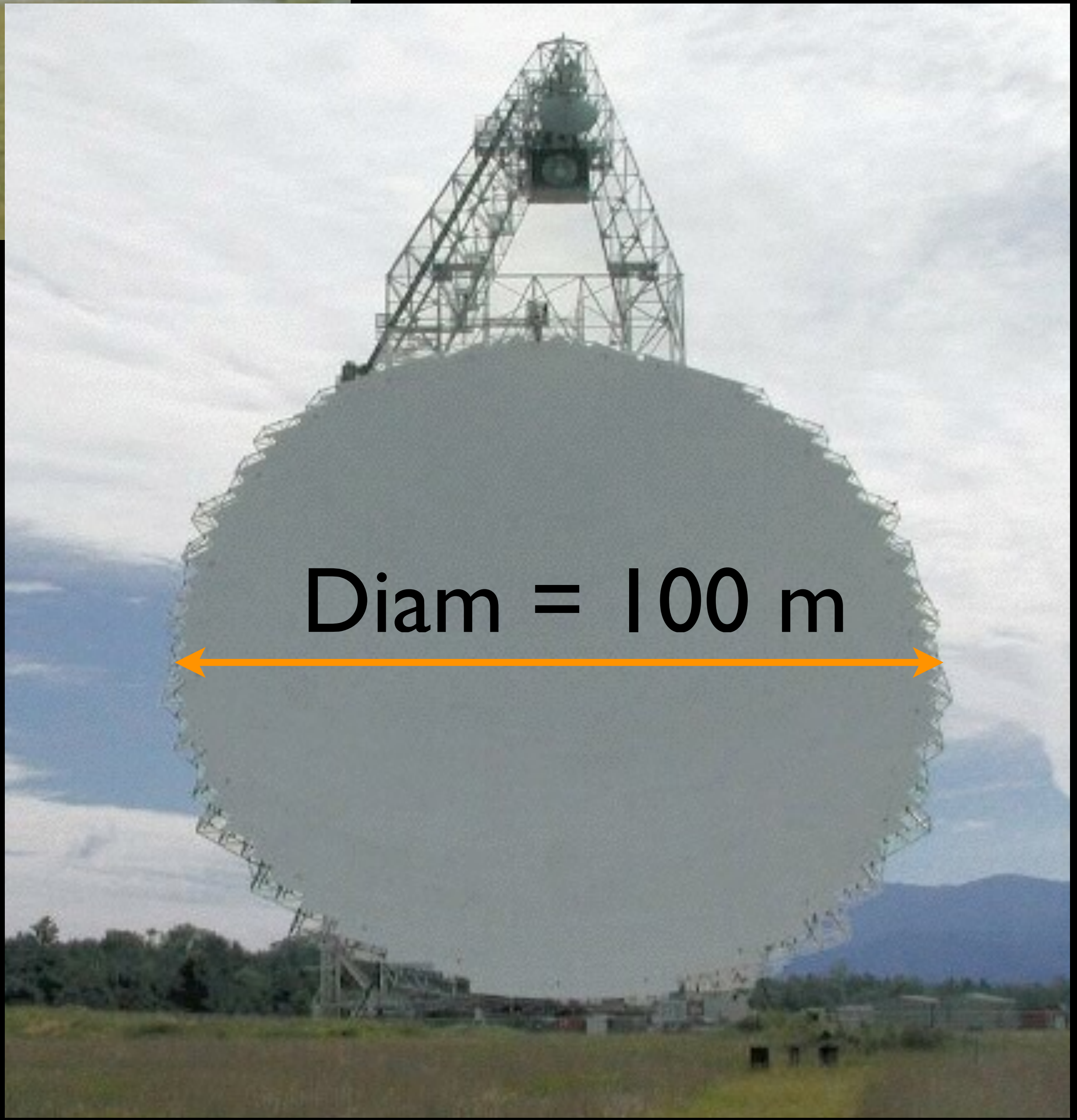
A digression on the sensitivity of radio telescopes

point source $$t \propto \frac{1}{A_e^2}$$

extended source $$t \propto f^2 \propto \frac{Diam^4}{A_e^2}$$

A digression on the sensitivity of radio telescopes





$$t \propto f^2 \propto \frac{Diam^4}{A_e^2}$$

A digression on the sensitivity of radio telescopes

Instrument	f^2	21cm HPBW
GBT	1	9.1’
Arecibo	1	3.2’
VLA-D	$\sim 10^4$	46”
VLA-C	$\sim 10^6$	14”
VLA-B	$\sim 10^8$	4.3”
ASKAP	$\sim 10^6$	

$$t \propto f^2 \propto \frac{Diam^4}{A_e^2}$$

A digression on the sensitivity of radio telescopes

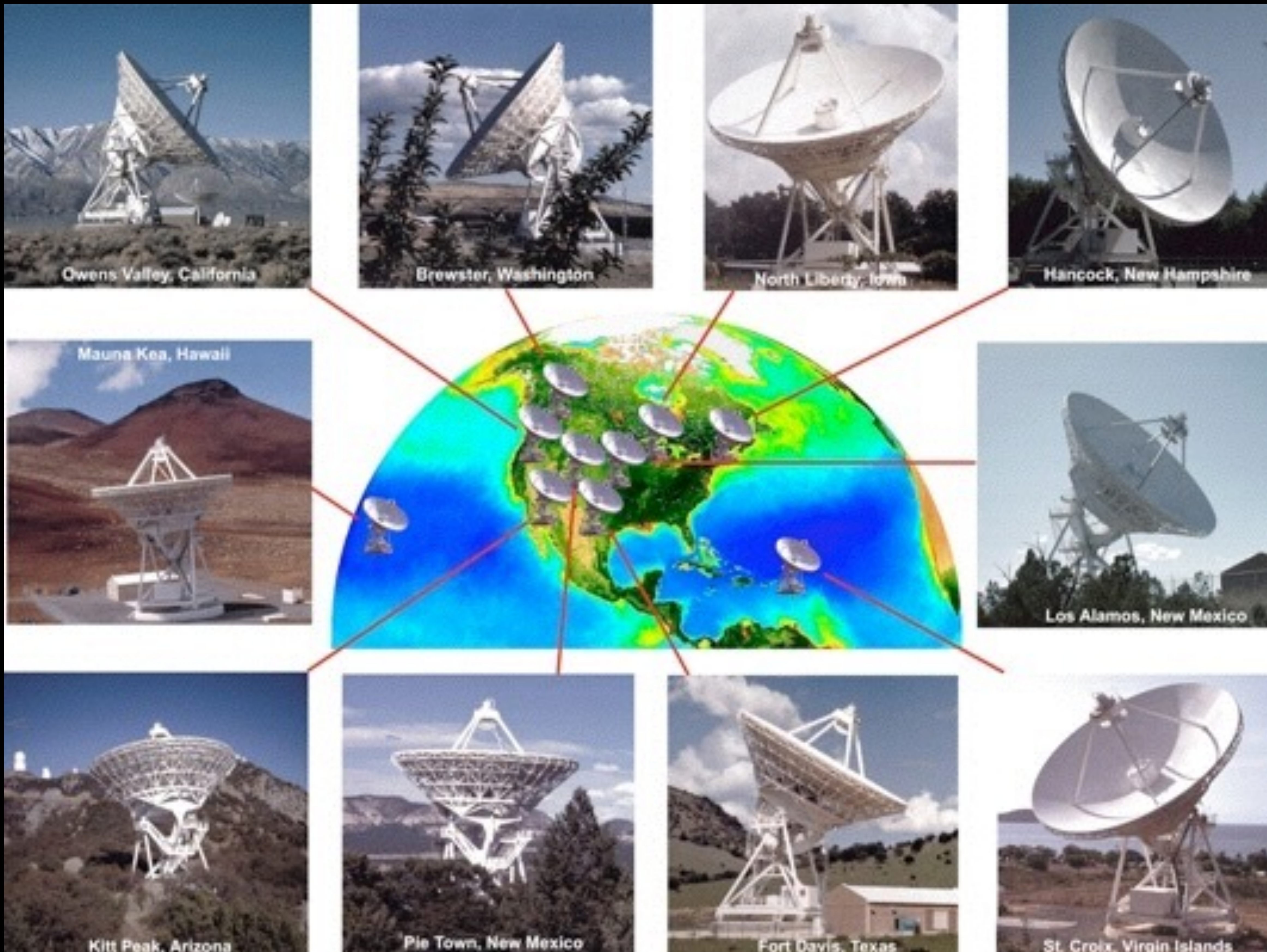
Instrument	f^2	21cm HPBW
GBT	1	9.1’

For a given collecting area, the brightness sensitivity is always greatest for a filled aperture

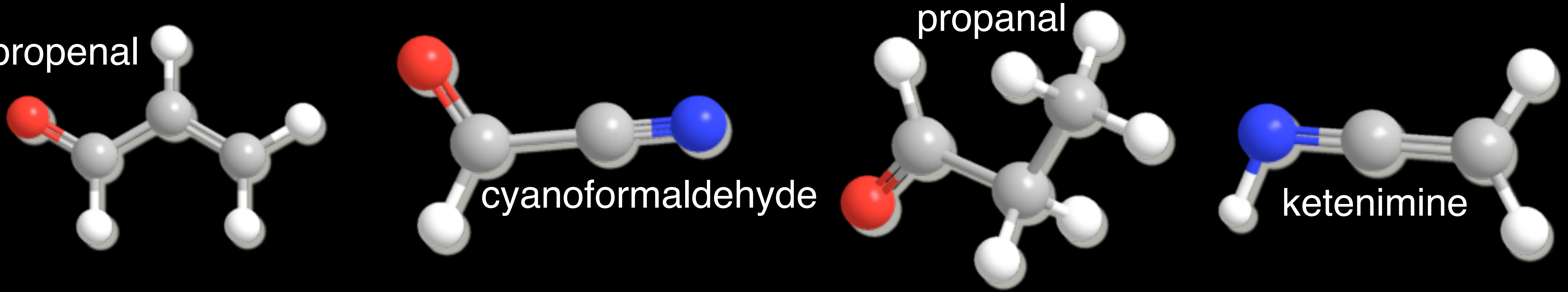
For a given angular resolution, the brightness sensitivity is always greatest for a filled aperture

This is not related to the issue of missing short spacings

VLBA Limited to $T_b > 10^5$ K



The Chemistry of Interstellar Space



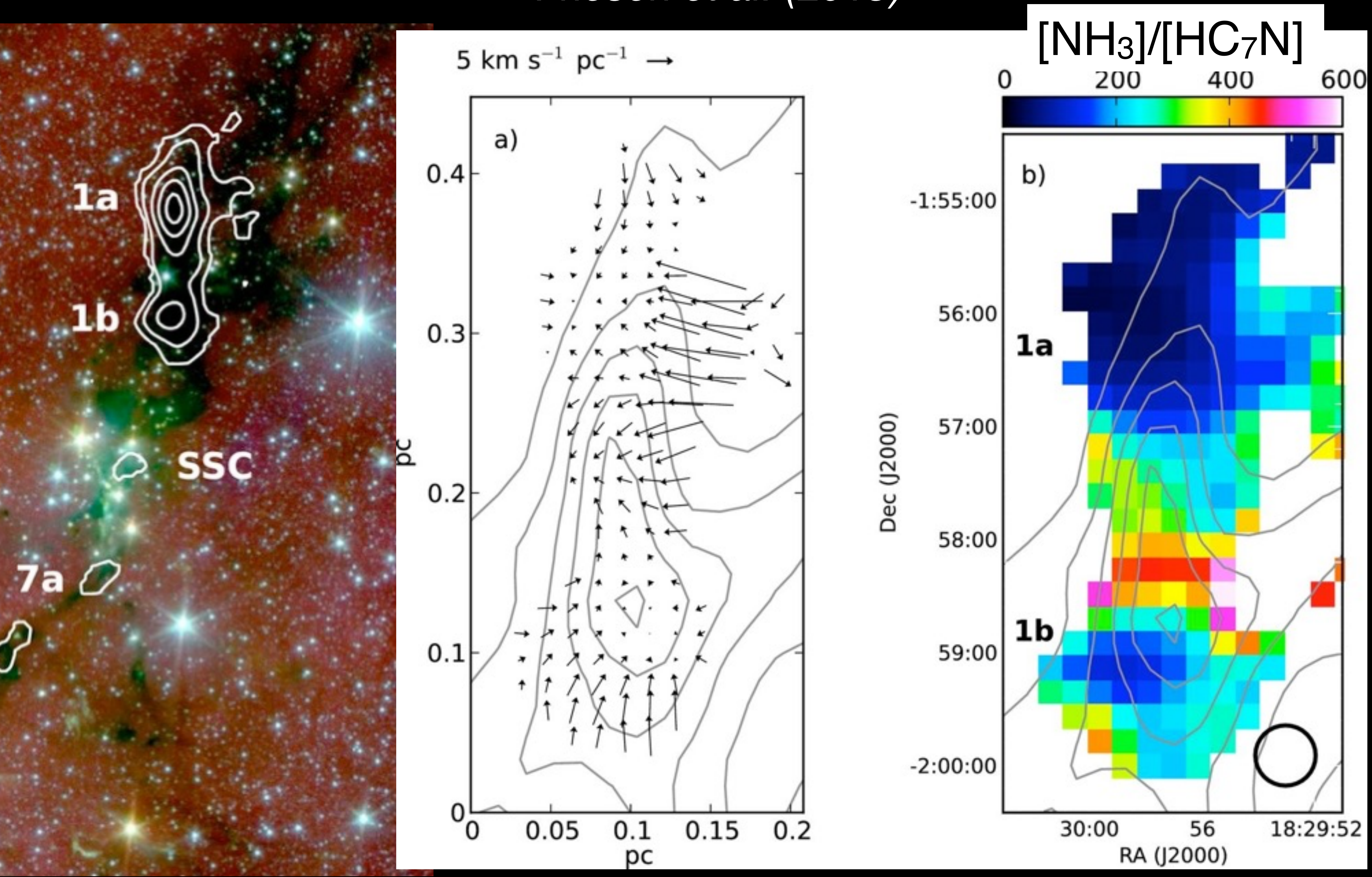
Hot new chemistry discovery today!

Some (of the 17+) New GBT Molecule Detections

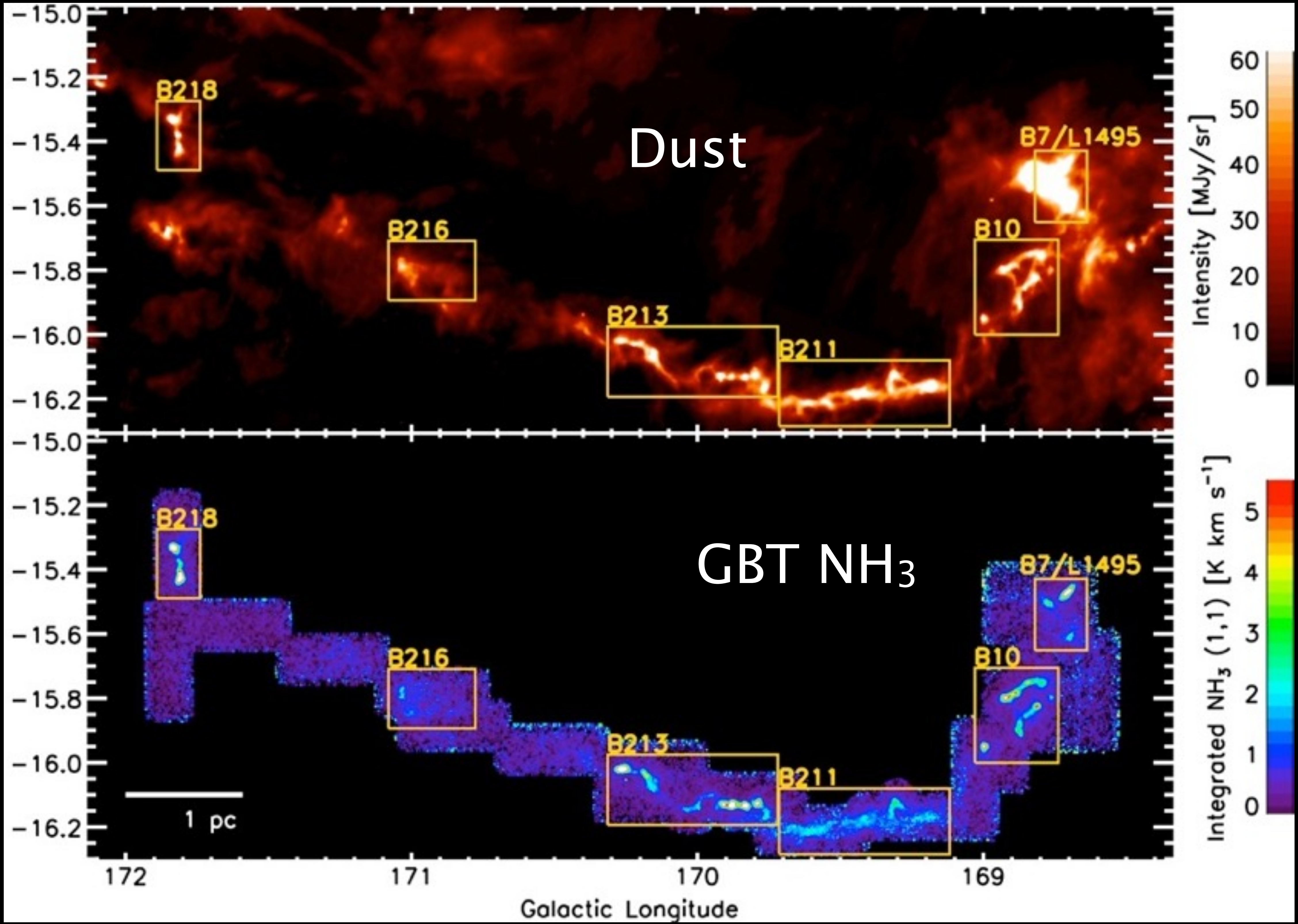
C_6 H-

HC_7N: A Chemical "Clock" in a Molecular Cloud?

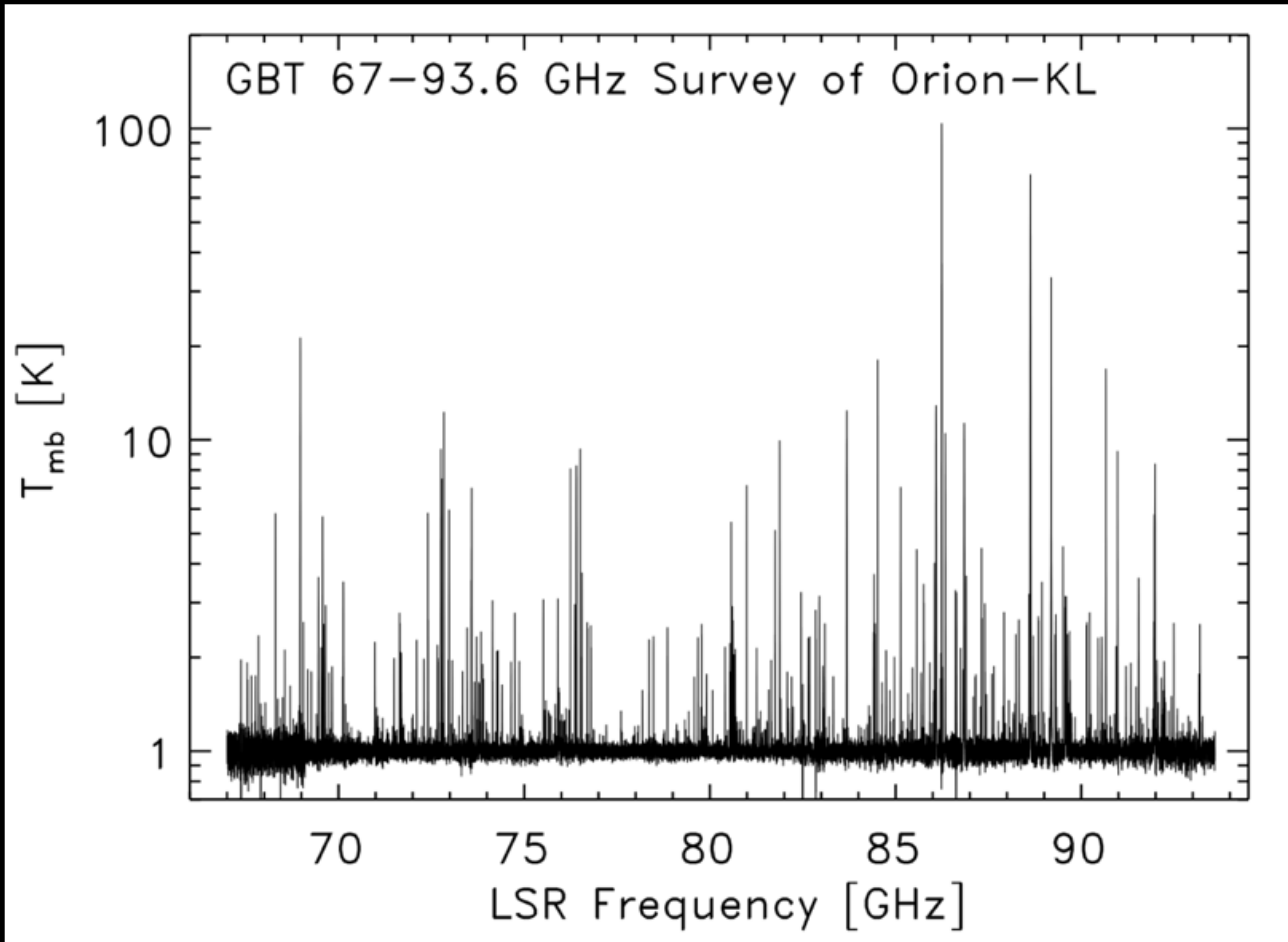
Friesen et al. (2013)



Star Formation in a Filament in Taurus



Young Min Seo et al. 2015 ApJ 805, 185



Frayer et al. 2015

GBT detection of mm-cm sized "dust" in star-forming clouds

Schnee et al. (2014)

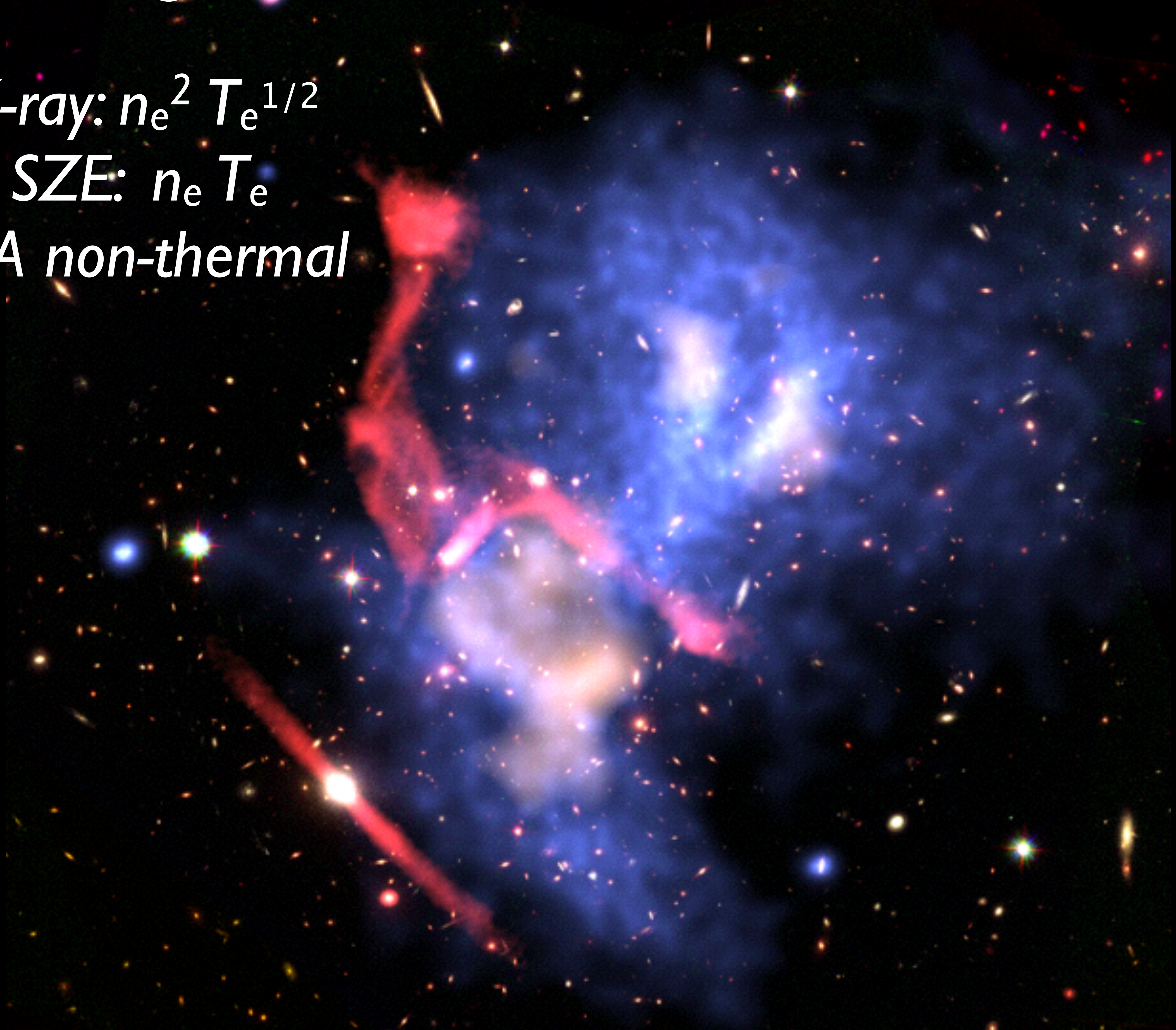
MUSTANG
Bolometer Array
3.3mm
81–96 GHz

No Hydrogen in the Milky Way's Dwarf Galaxies

Galaxy	L ($L_\odot$)	M_{HI} ($M_\odot$)
Segue I	340	<11
UMa II	41,000	<74
Bootes II	1,000	<38
Coma Ber	3,700	<62
Ursa Mi	280,000	<63
Draco	280,000	<133
Spitzer Cloud		400
Hydra II		<200*

GBT results from Spekkens et al. 2014

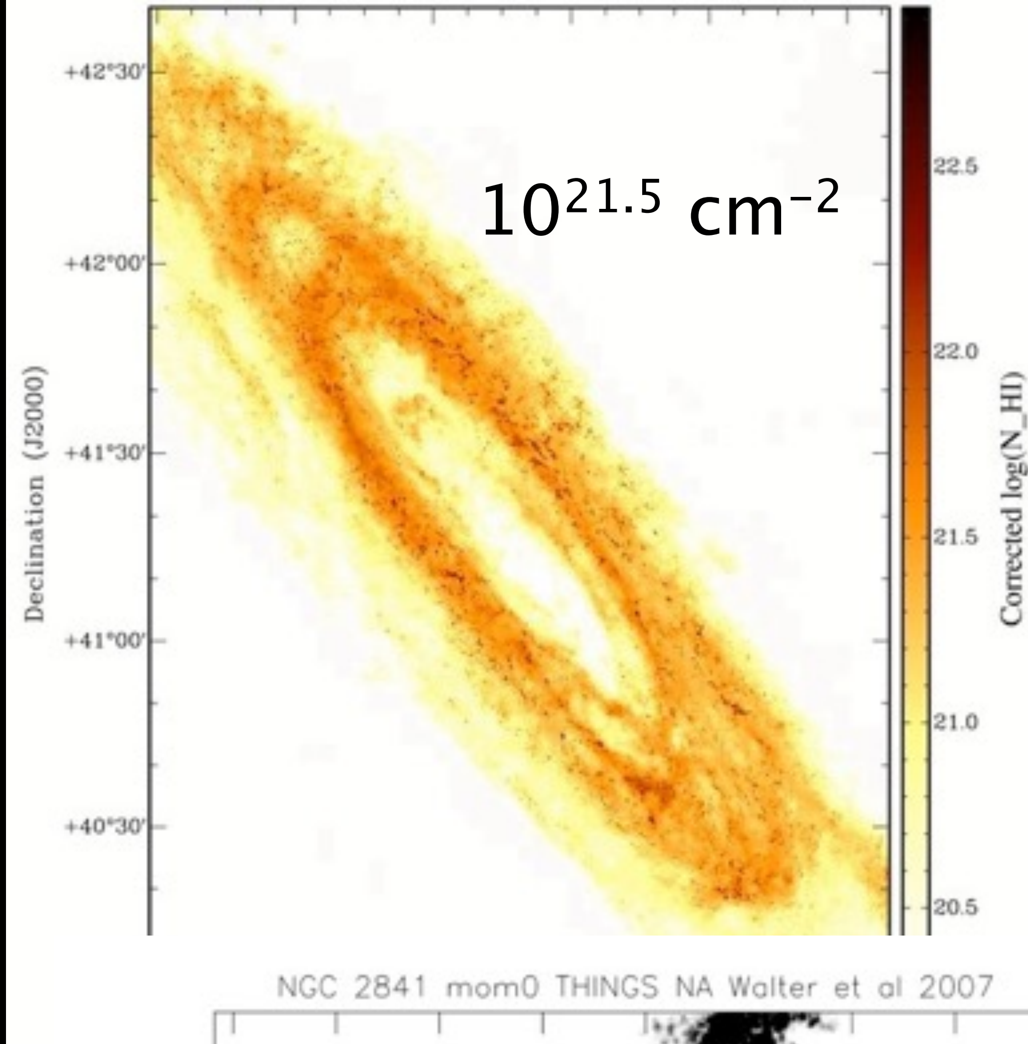
GBT High-Resolution 3mm SZE in a Cluster

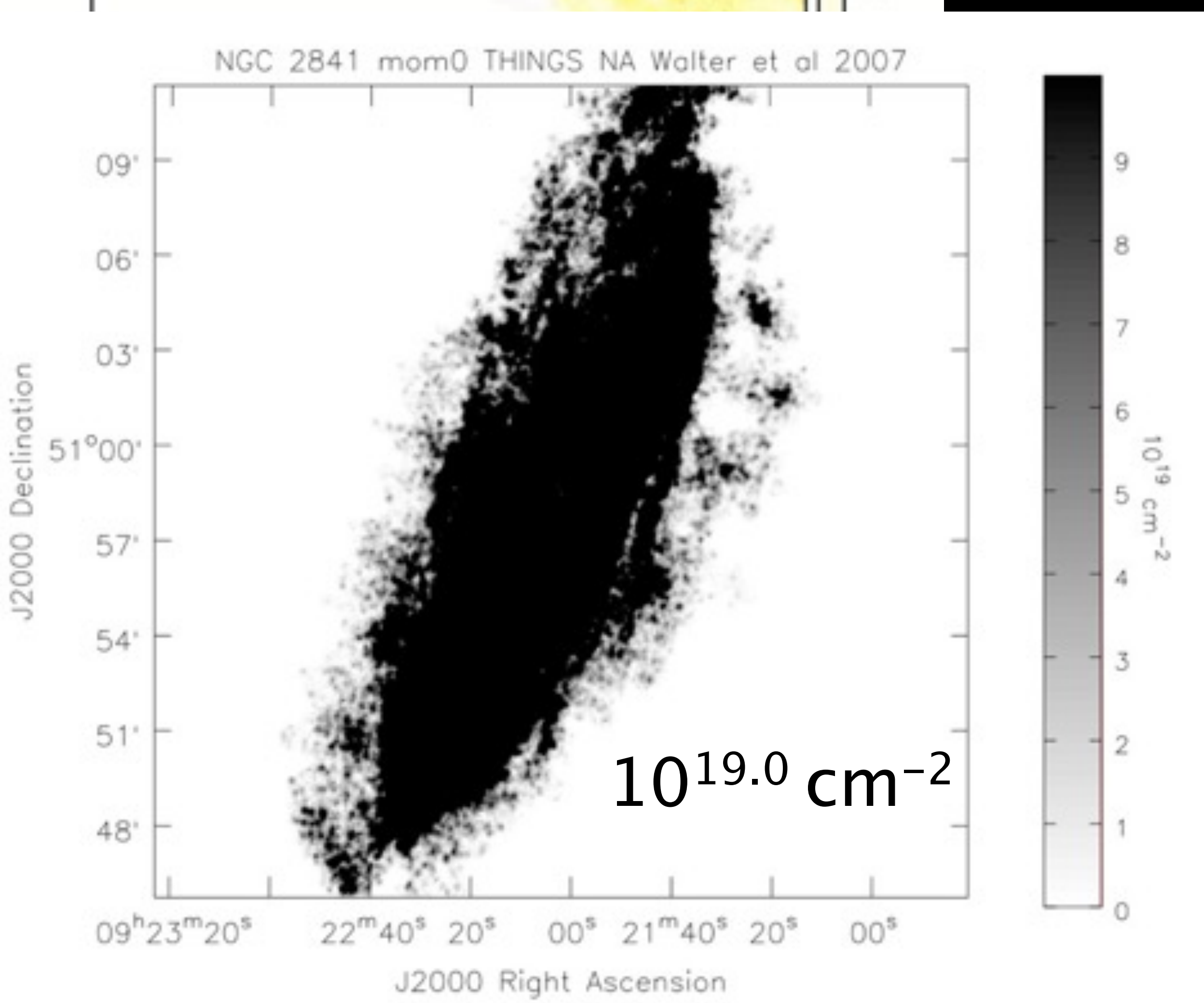


X-ray: $n_e^2 T_e^{1/2}$

SZE: $n_e T_e$

VLA non-thermal





THINGS VLA Survey

Walter et al. 2008

30″ $3\sigma=10^{19.5}$

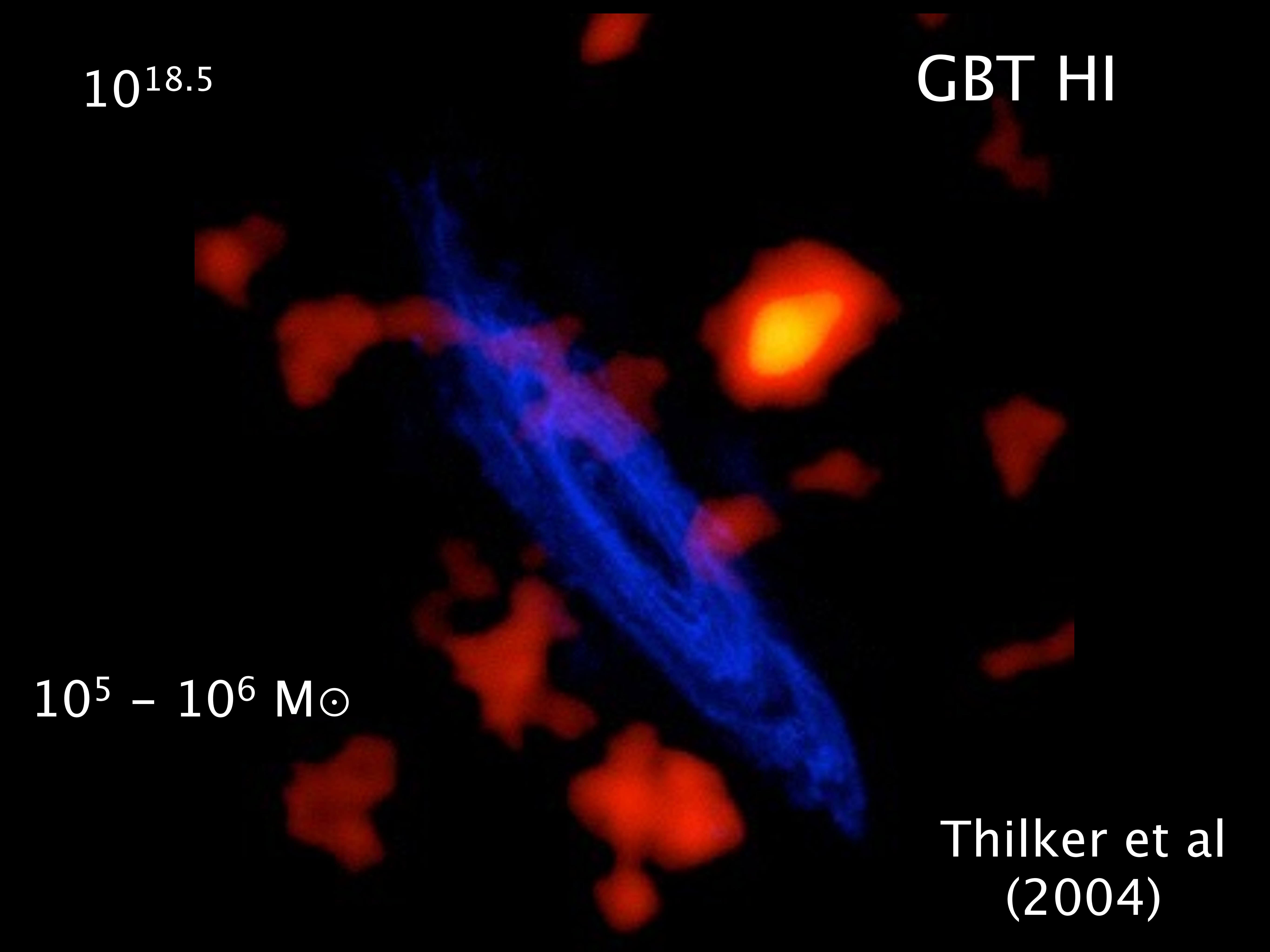
6″ $3\sigma=10^{20.5}$

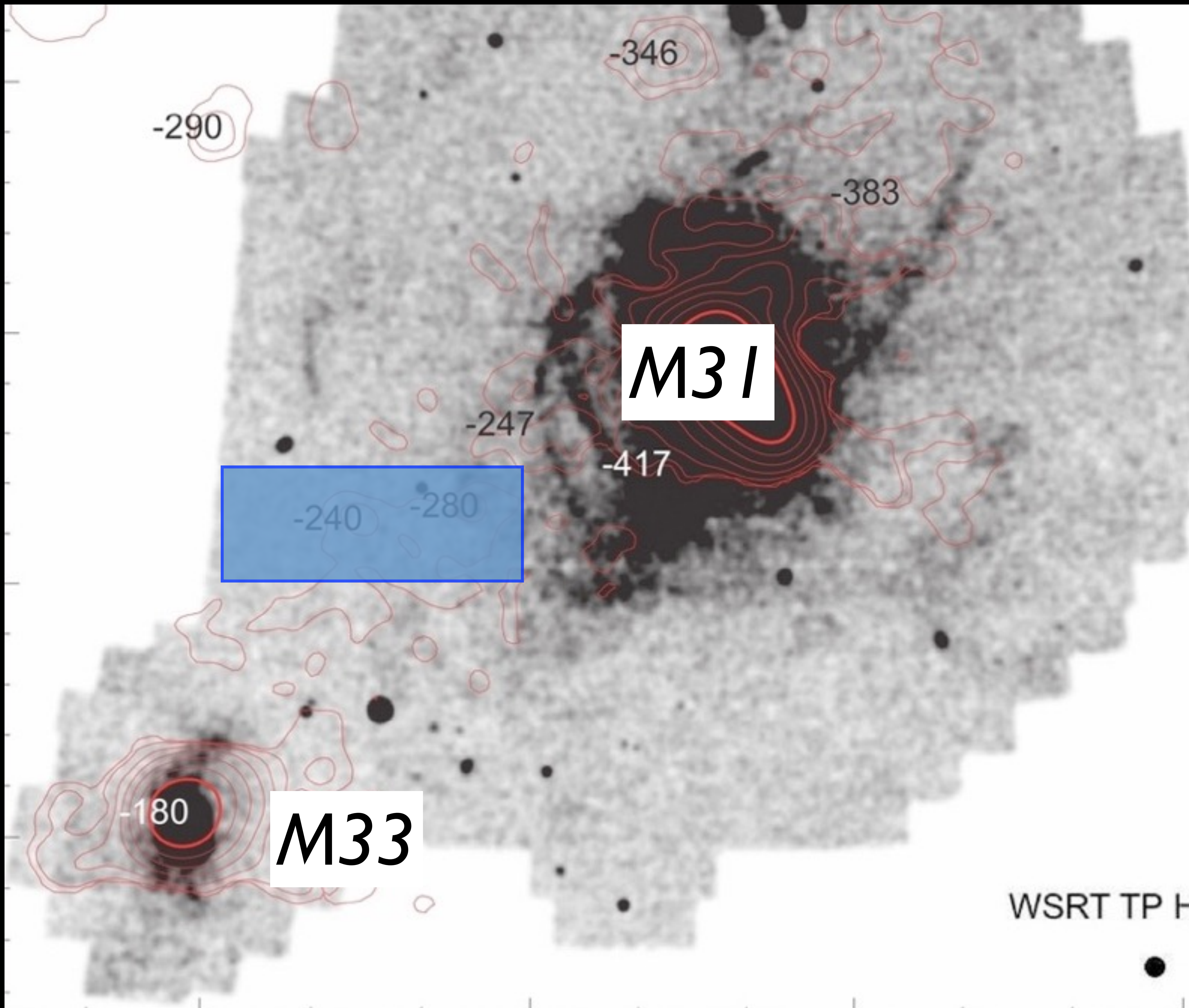
HALOGAS WSRT Survey

Heald et al. 2011

15″ to N_{HI} limit ~$10^{19.0}$

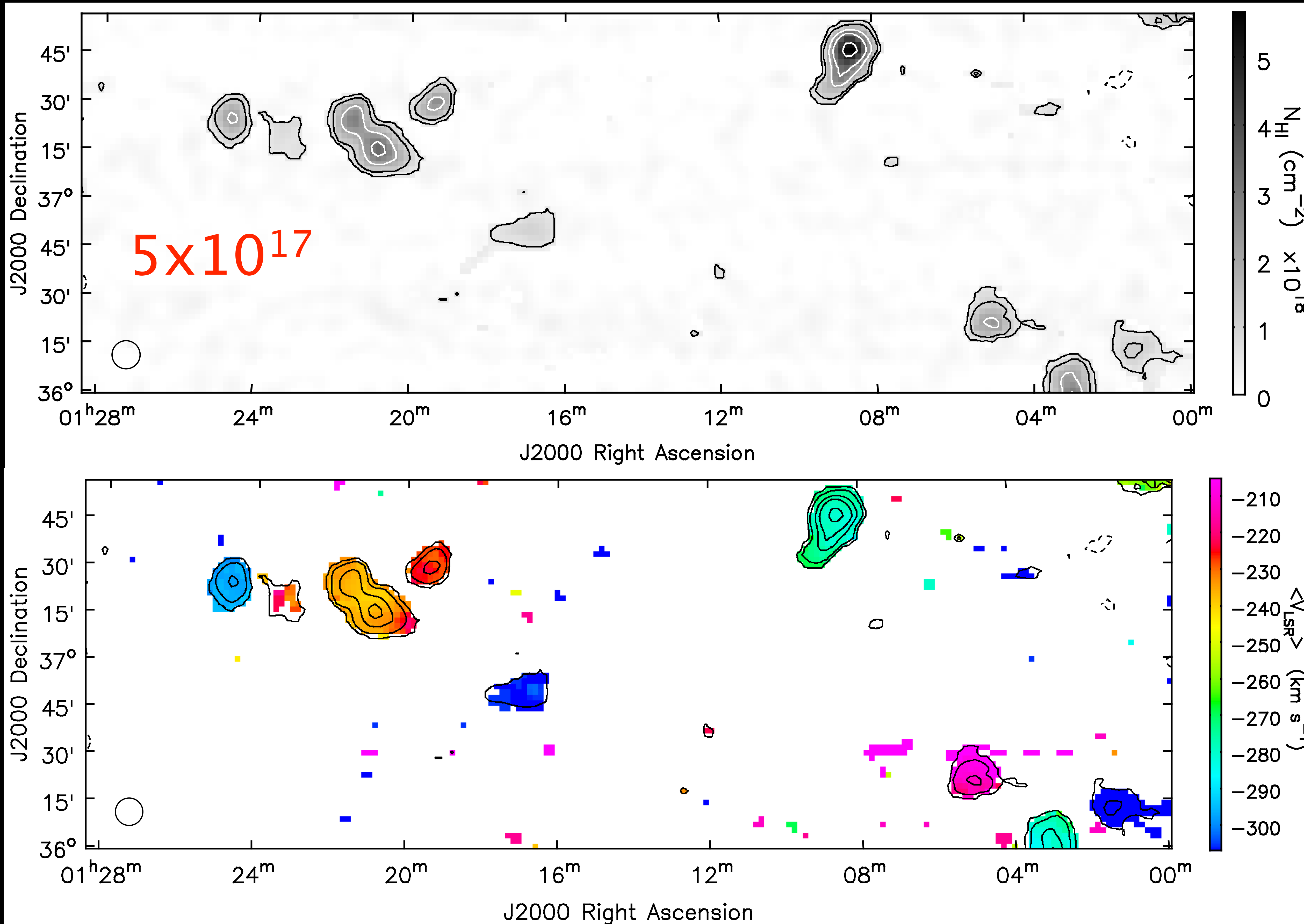
120 hours per galaxy


$10^{18.5}$
GBT HI
$10^5 - 10^6$ M⊙
Thilker et al
(2004)



-346
-290
-383
M31
-247
-417
-240
-280
-180
M33
WSRT TP H

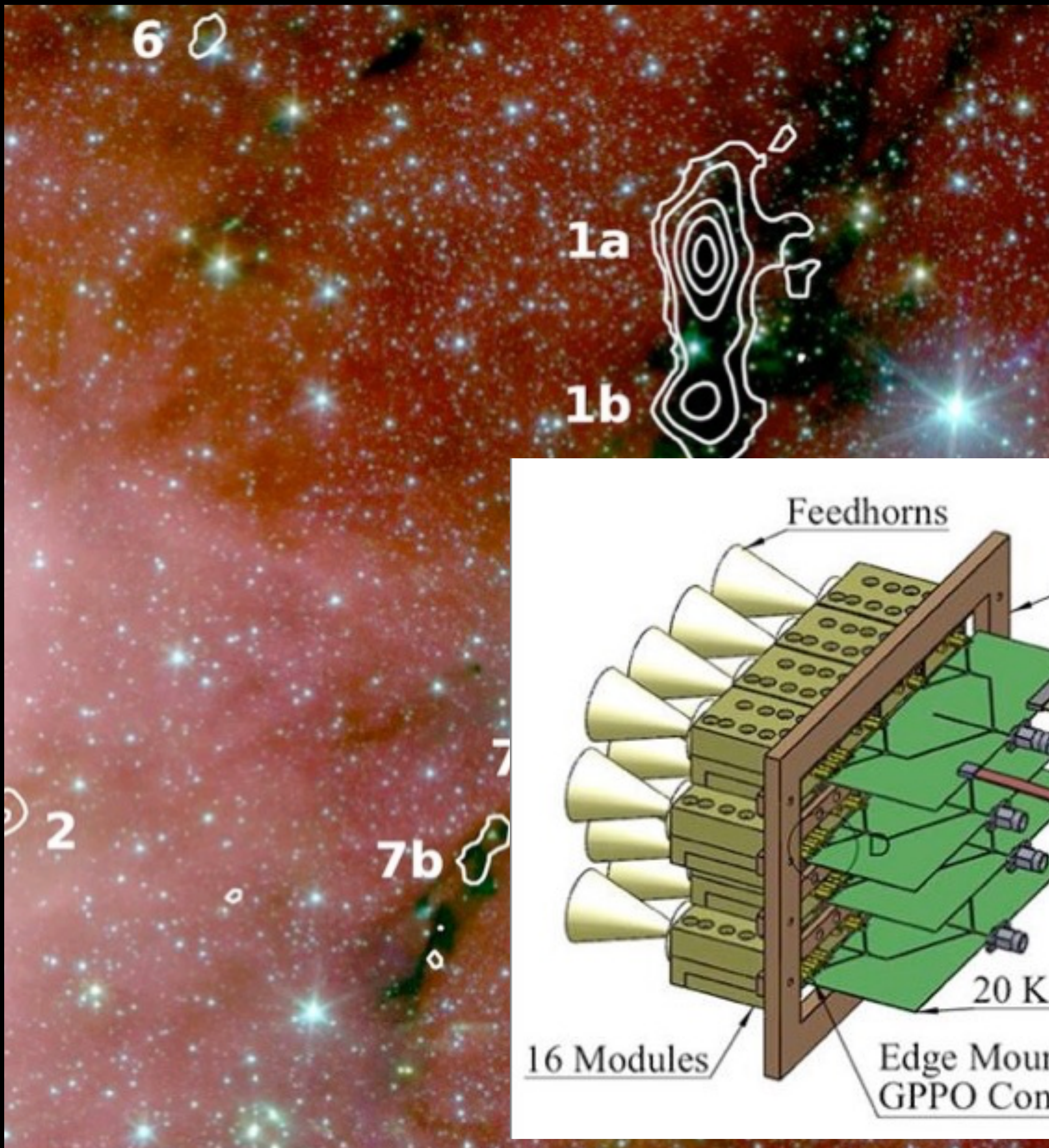
M31-M33 Clouds

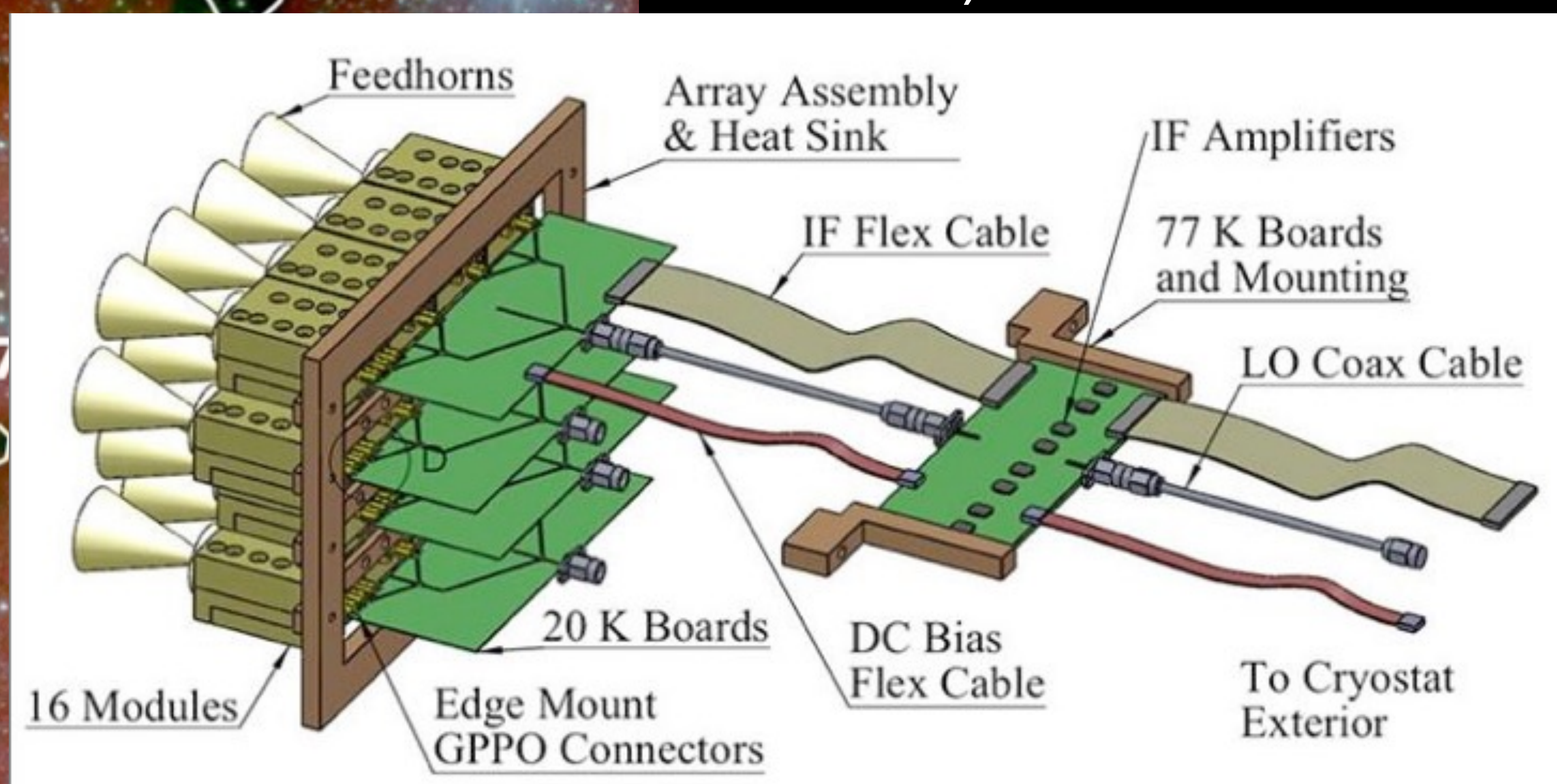


The GBT in 2016+

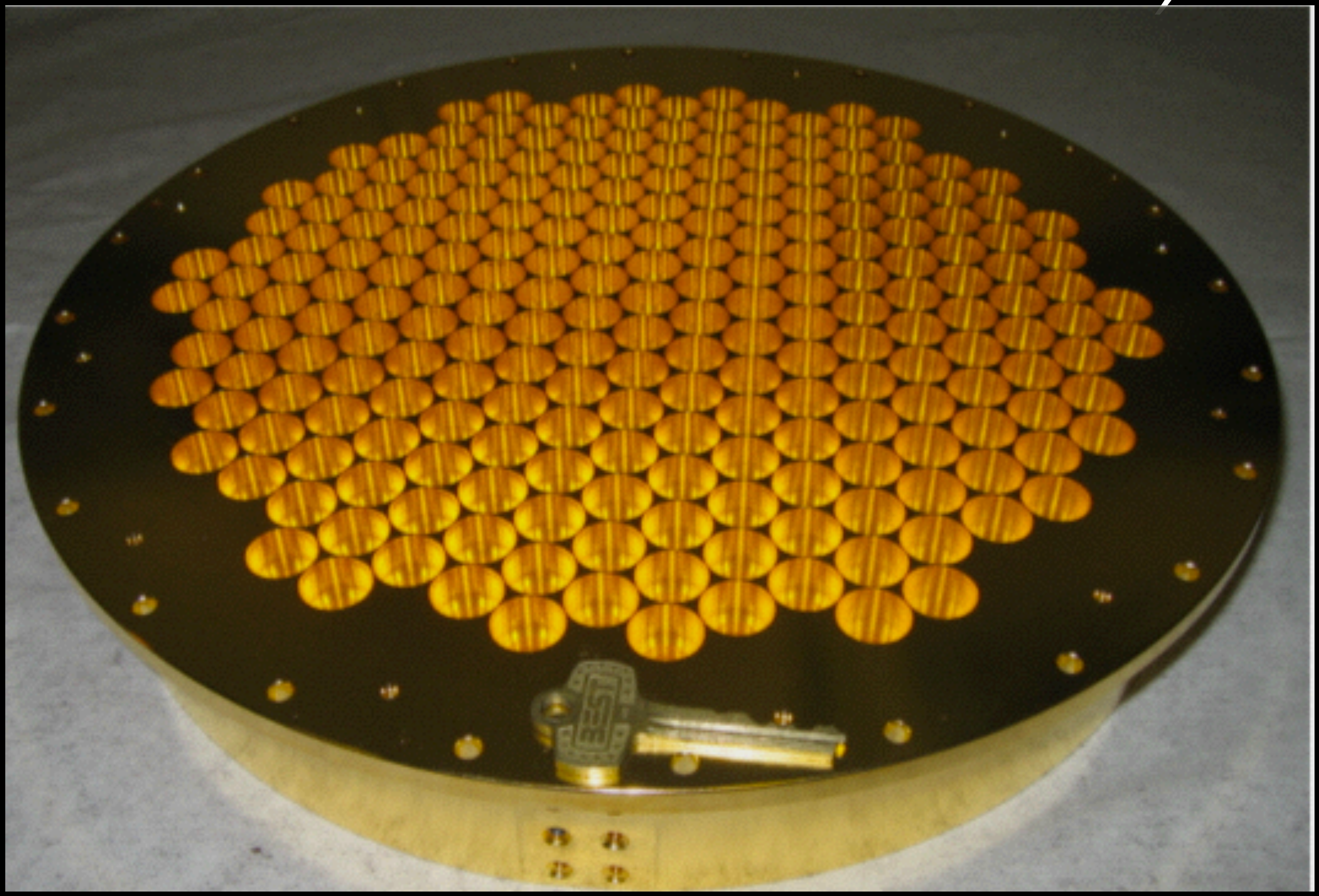
ARGUS -- 8″ GBT spectroscopy at

- 16 element scalable 75-115 GHz FPA
- Stanford/CIT-JPL/UMd/ Miami/NRAO
  (NSF grant to Stanford)





GBT MUSTANG - 2 *(NSF grant to Univ Penn)*



223 pixels

>4’ FOV

35x faster than MUSTANG