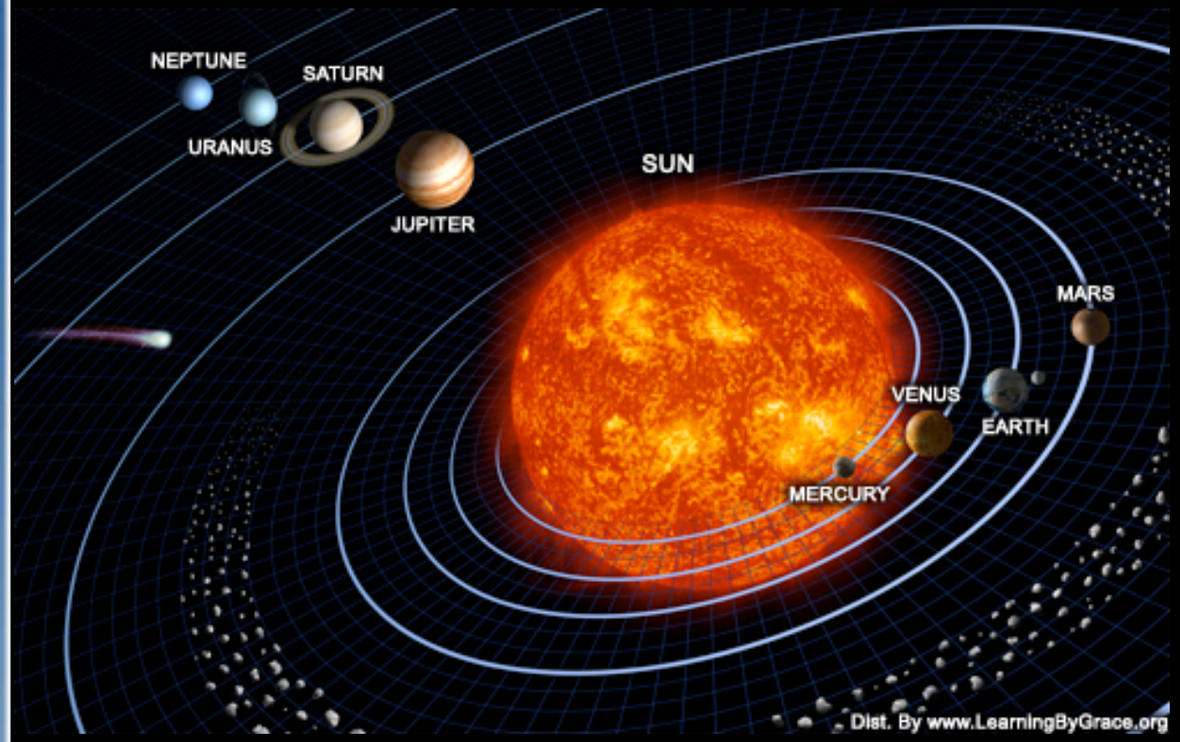
The Green Bank Telescope

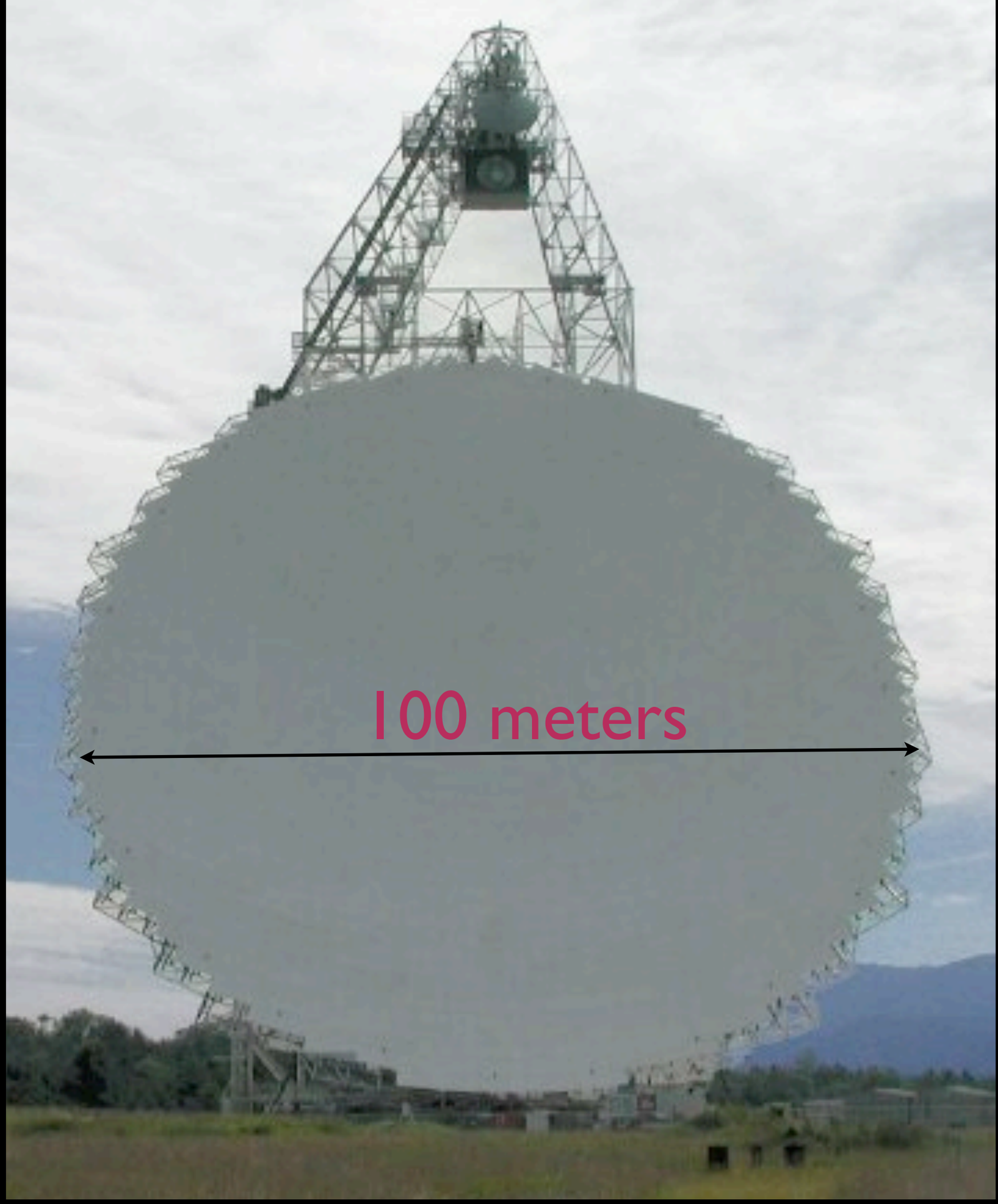
and the Solar System



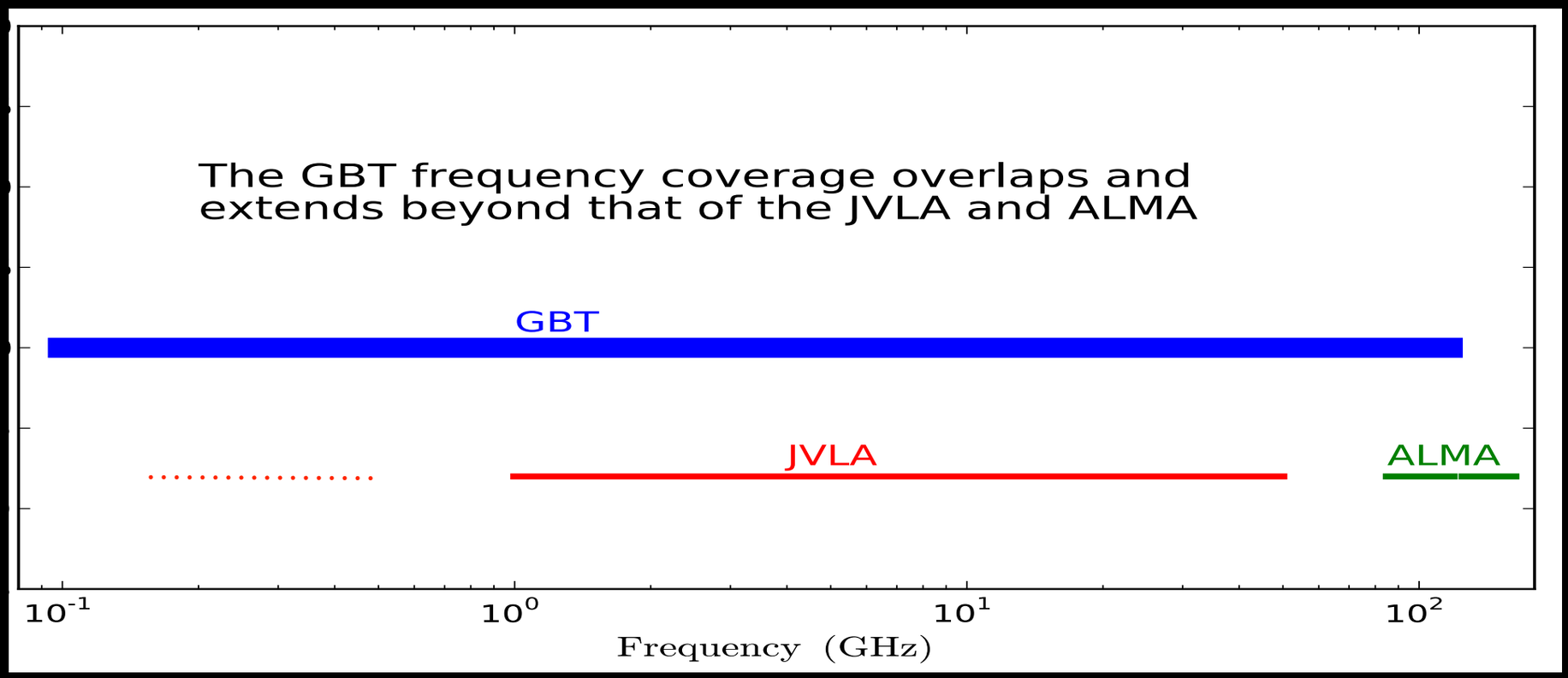
Felix "Jay" Lockman
NRAO, Green Bank WV

The Green Bank Telescope (GBT)

Sensitivity
Sky Coverage
Frequency Coverage
Radio Quiet Zone



- 100 meter diameter unblocked
- Receivers cover 0.1 to 100 GHz
- Excellent point-source sensitivity
- Unsurpassed sensitivity for extended objects
- >85% of total sky covered $\delta \geq -46°$
- Location in the National Radio Quiet Zone
- Competitively Scheduled



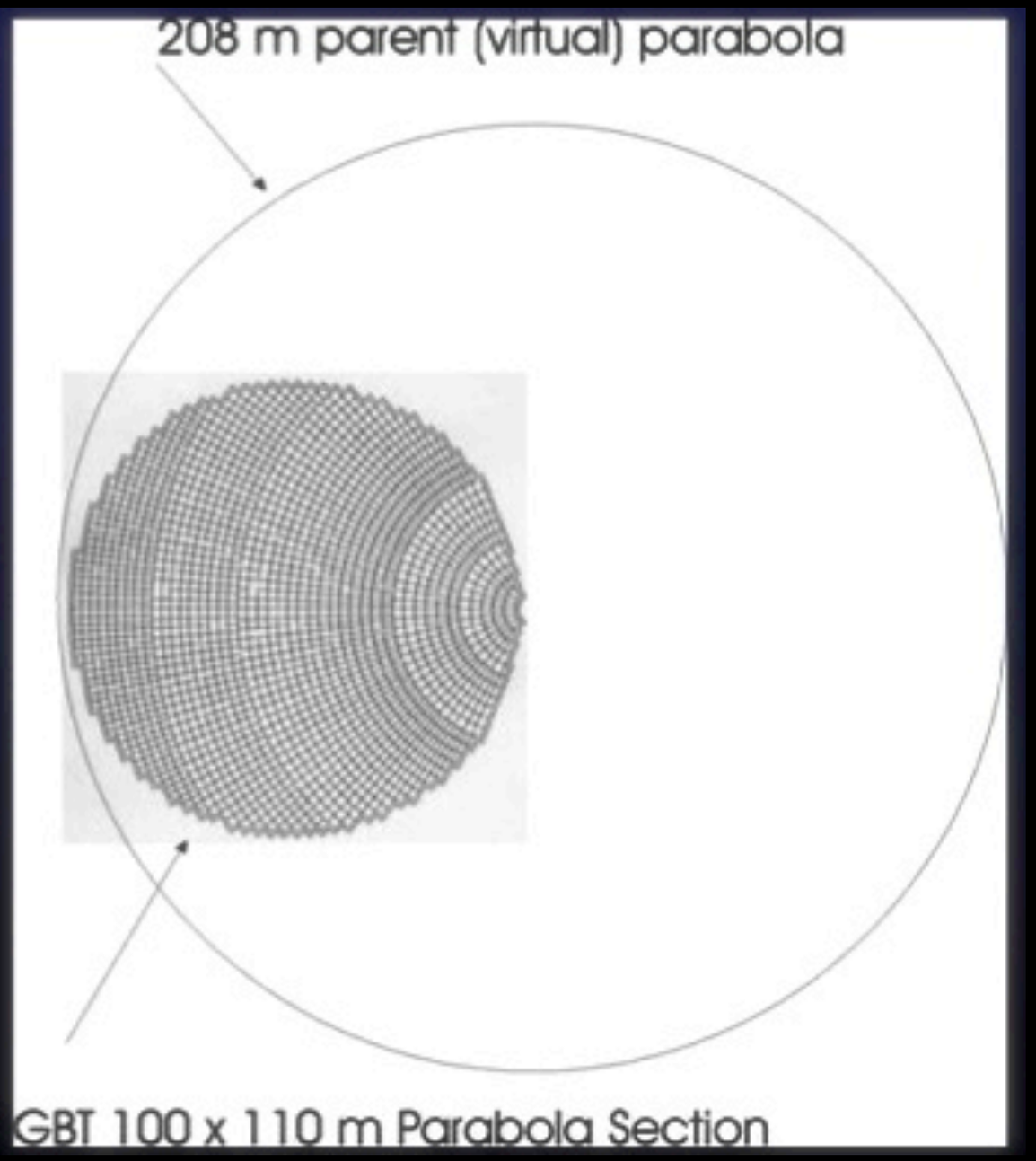
National Radio Quiet Zone

Appalachian Mountains

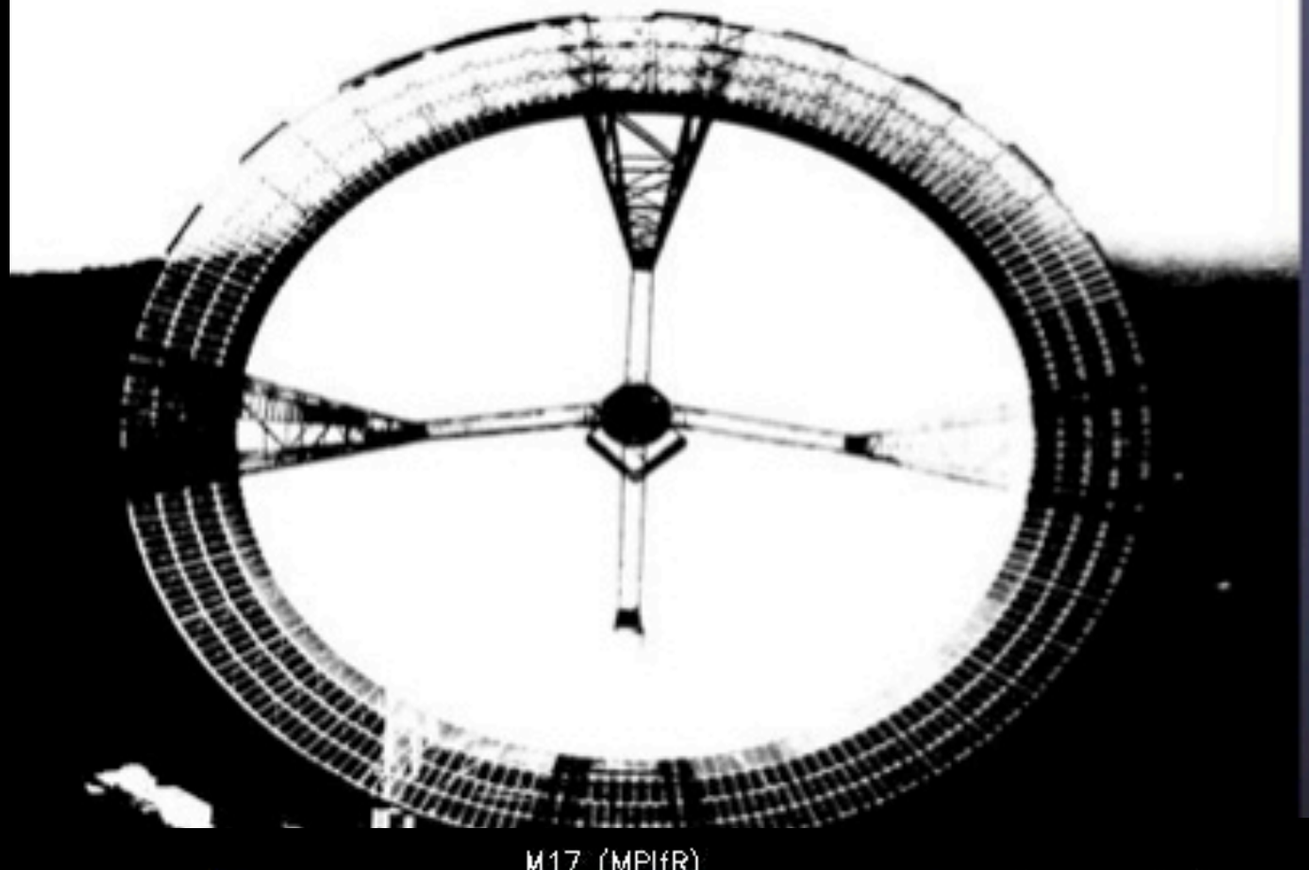
Washington D.C.

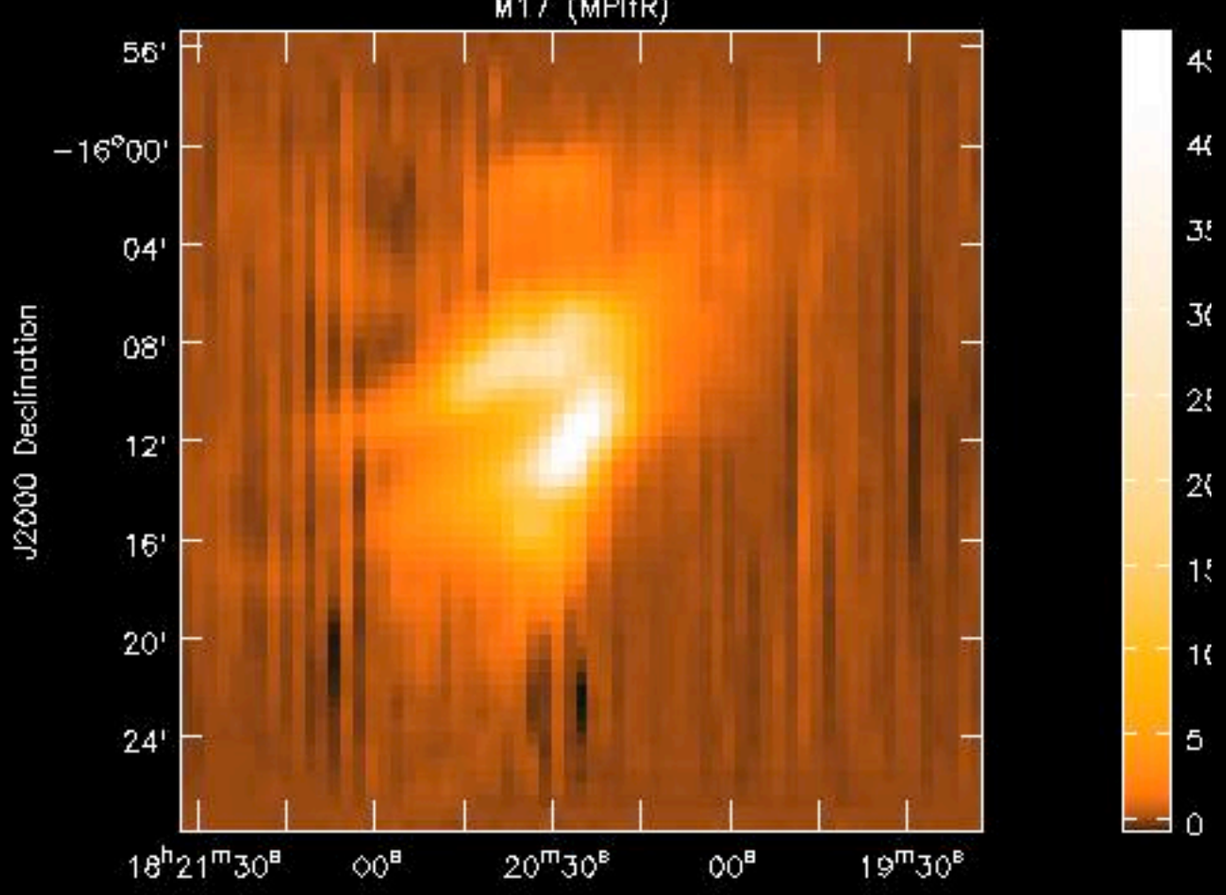
Effelsberg, Germany 100m

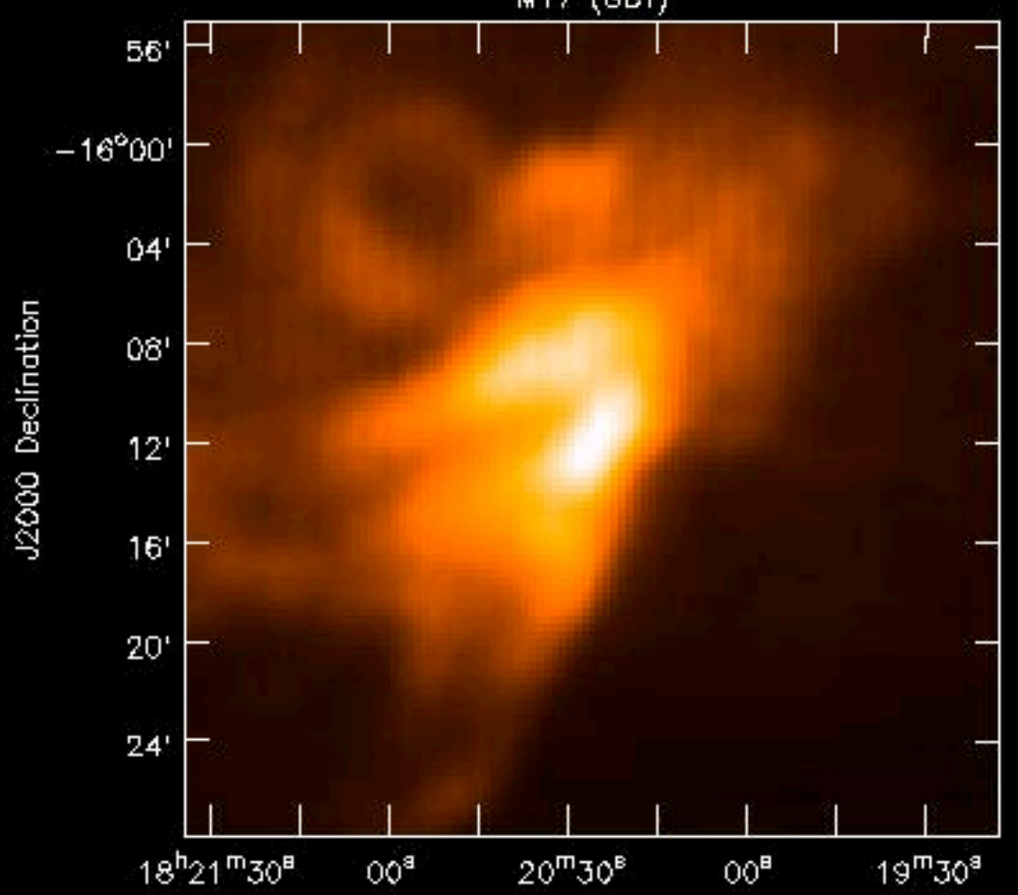
GBT 100m


208 m parent (virtual) parabola
GBT 100 x 110 m Parabola Section

The Effects of Blockage -- Reduced Dynamic Range





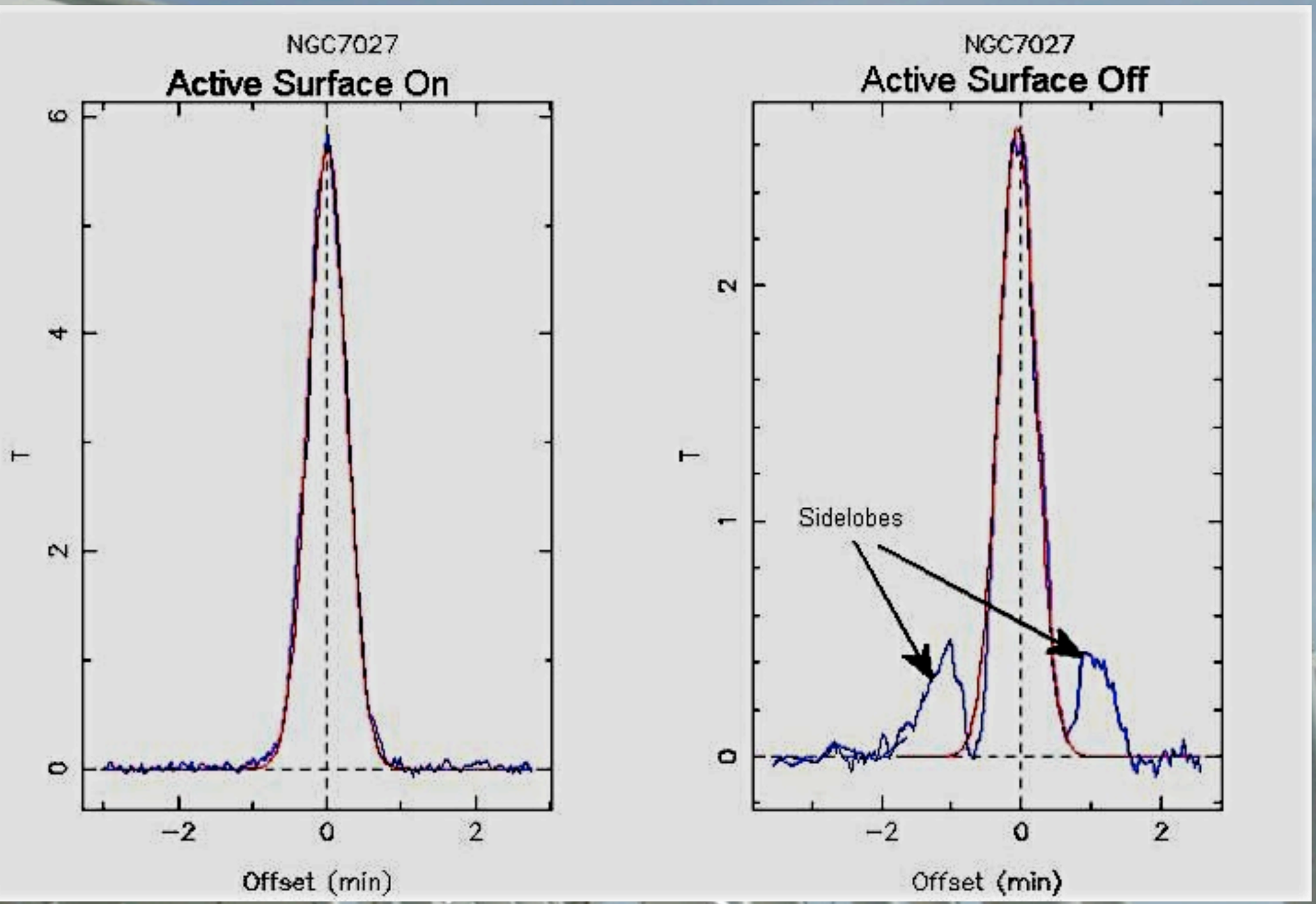


The Active Surface

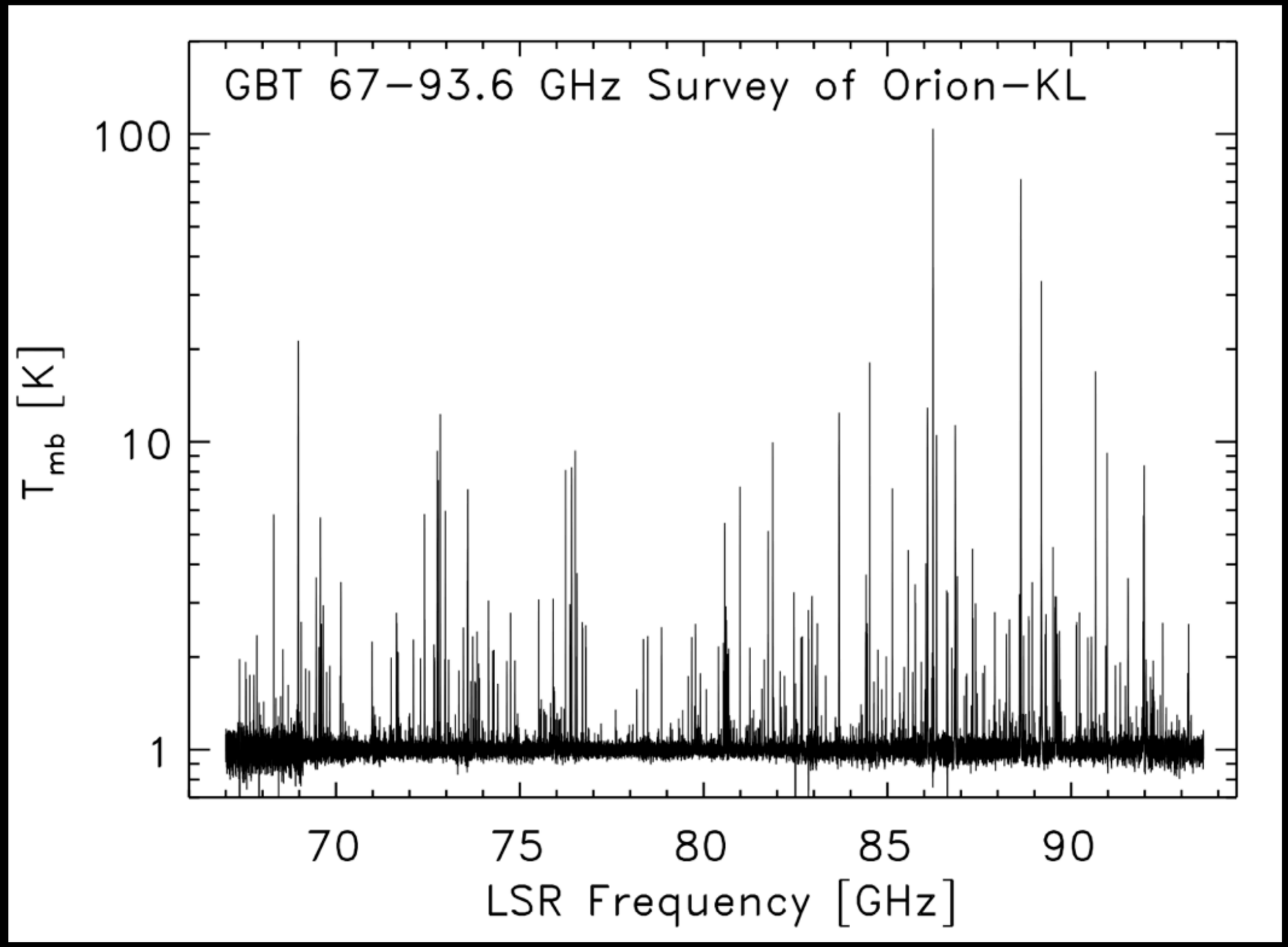
RMS < 240μ at night
the goal is 210μ

The Active Surface

RMS < 240μ at night
the goal is 210μ



GBT W-band Spectral Survey

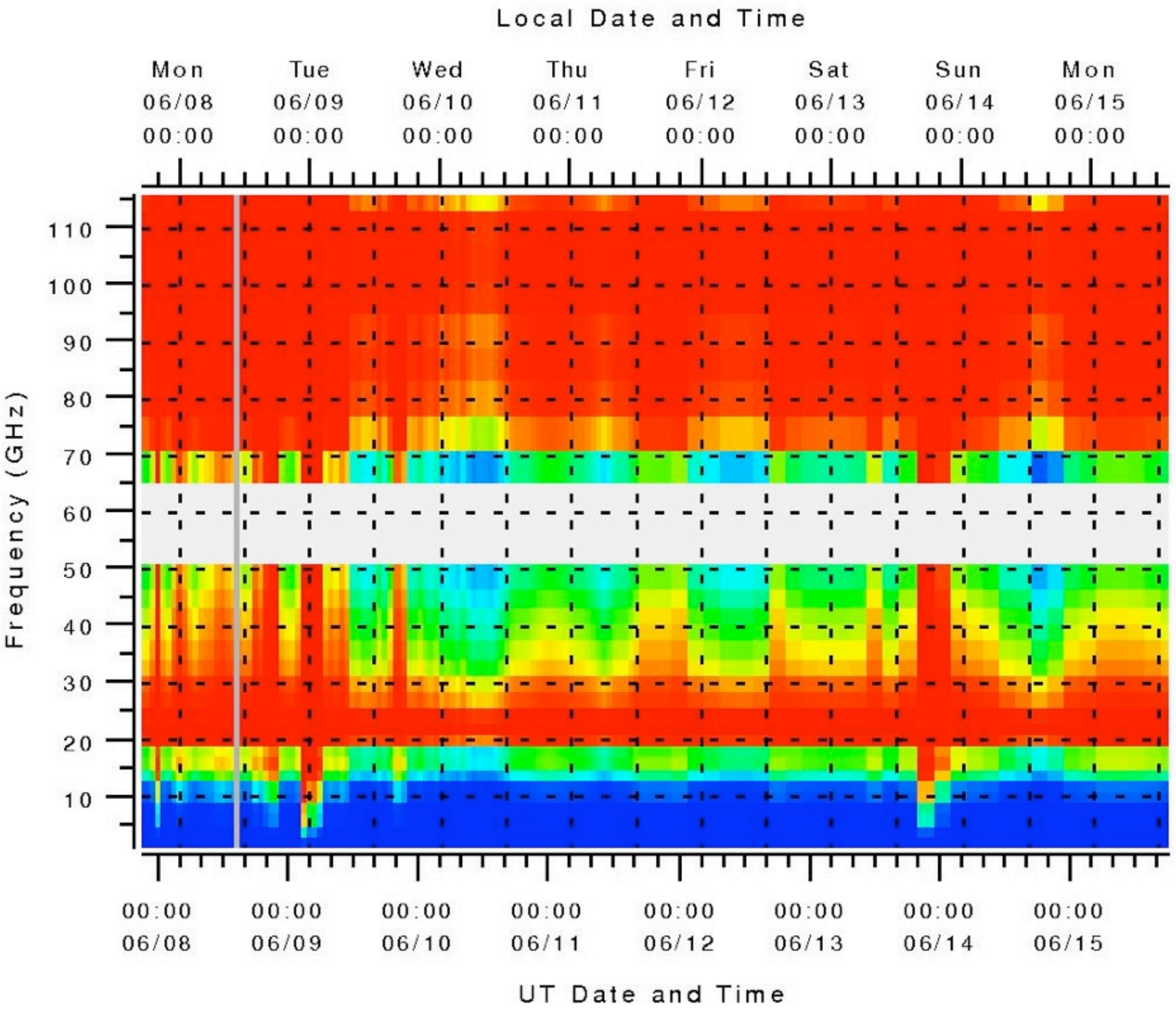


Frayer et al. (2015)

Usage
6220^h in 2014
~1/3 at $\nu \geq 18$ GHz

- Point source sensitivity of a ~120m telescope
- Point source sensitivity $\sqrt{2}$ better than VLA at $\lesssim$2 GHz

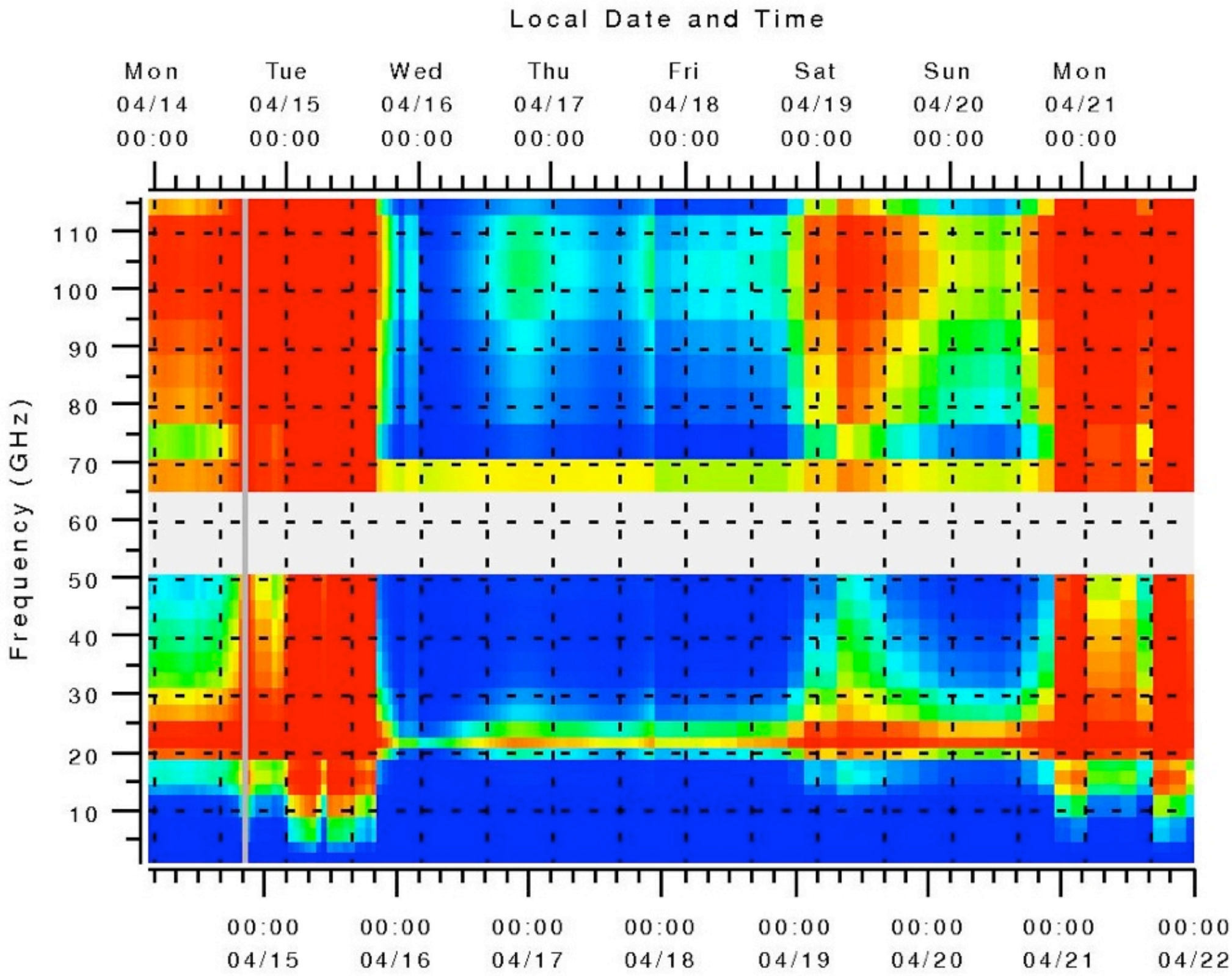
DSS Overview
Efficiencies from Atmospheric Opacities (EffAtmos)



Ron Maddalena,
prognosticator

DSS Overview

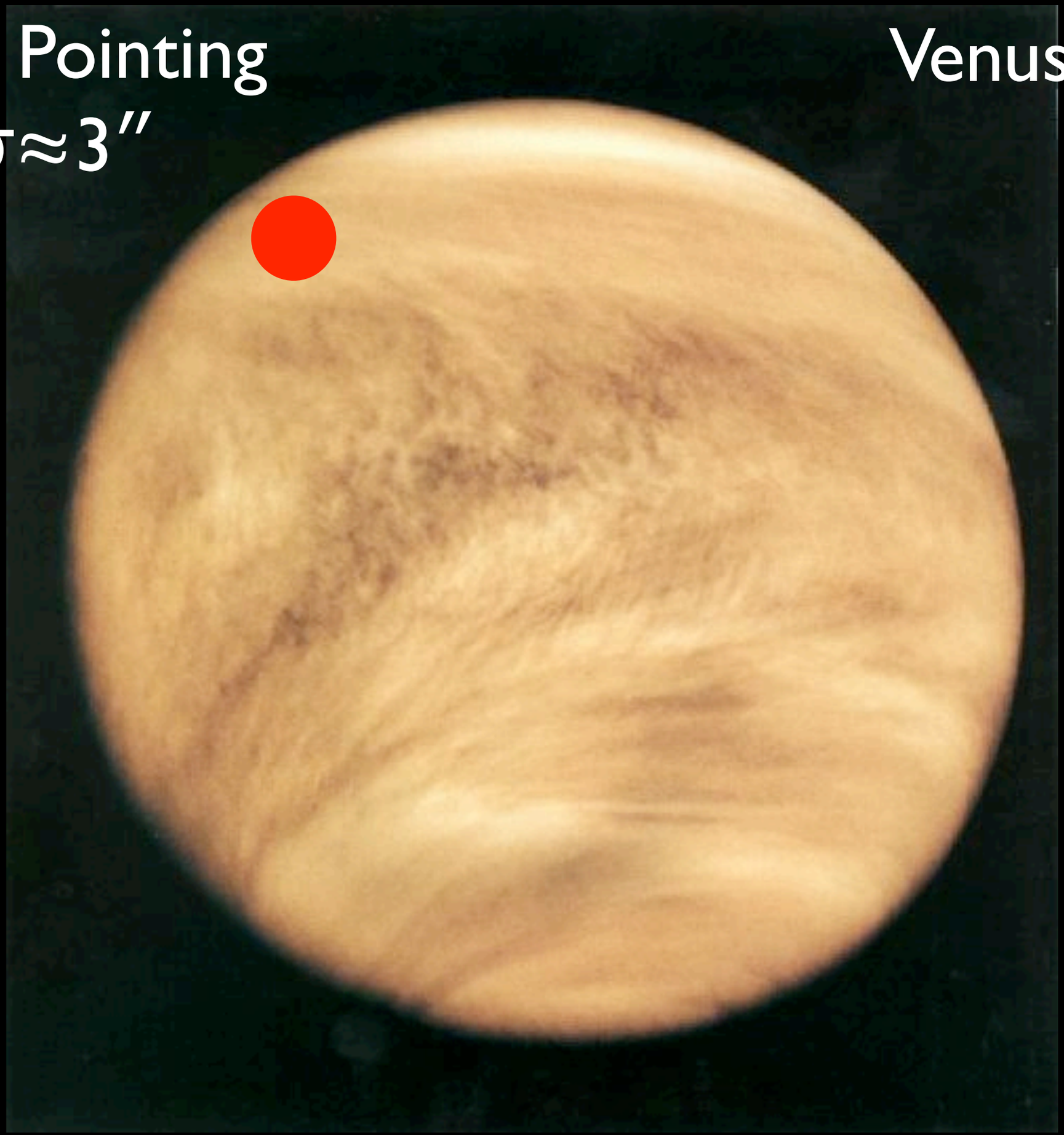
Efficiencies from Atmospheric Opacities (EffAtmos)



GBT Pointing
σ=2.7″

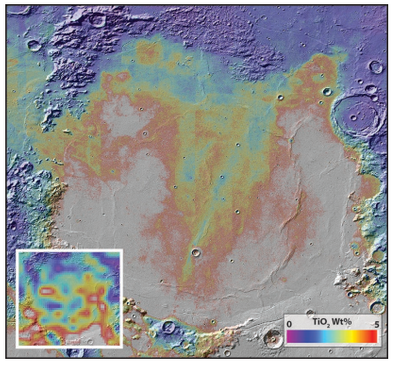
GBT Pointing
σ≈3″

Venus 60″

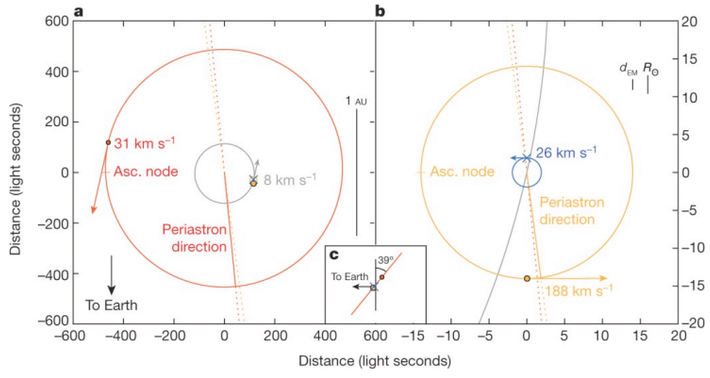


The GBT in 2014

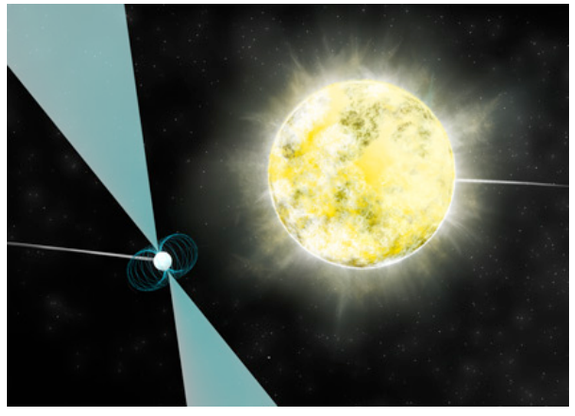
Jan



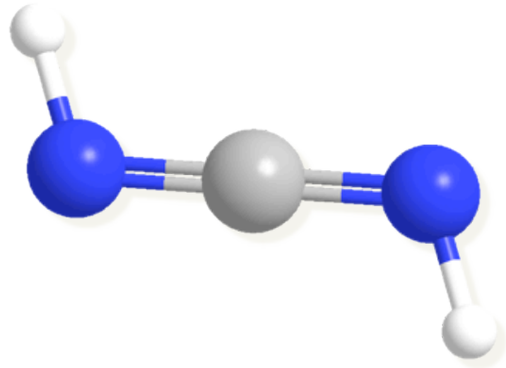
Feb



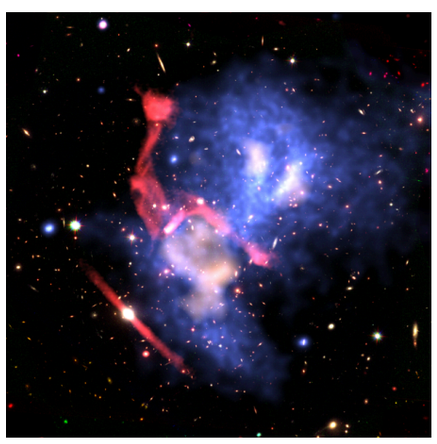
Mar



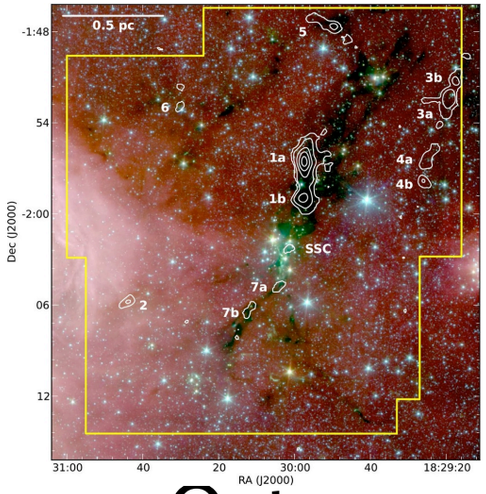
Apr



May

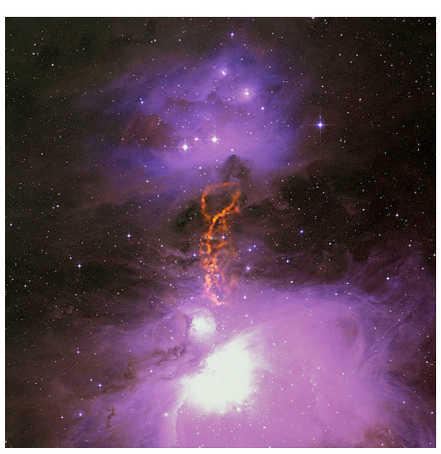


June



July

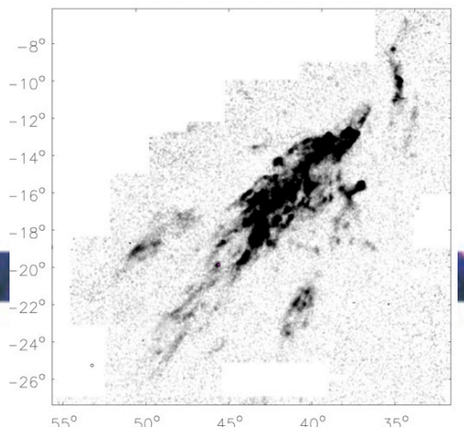
Aug



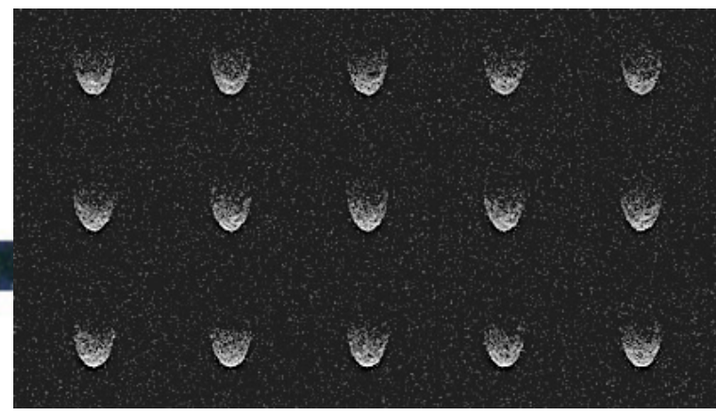
Sept

Oct

Nov

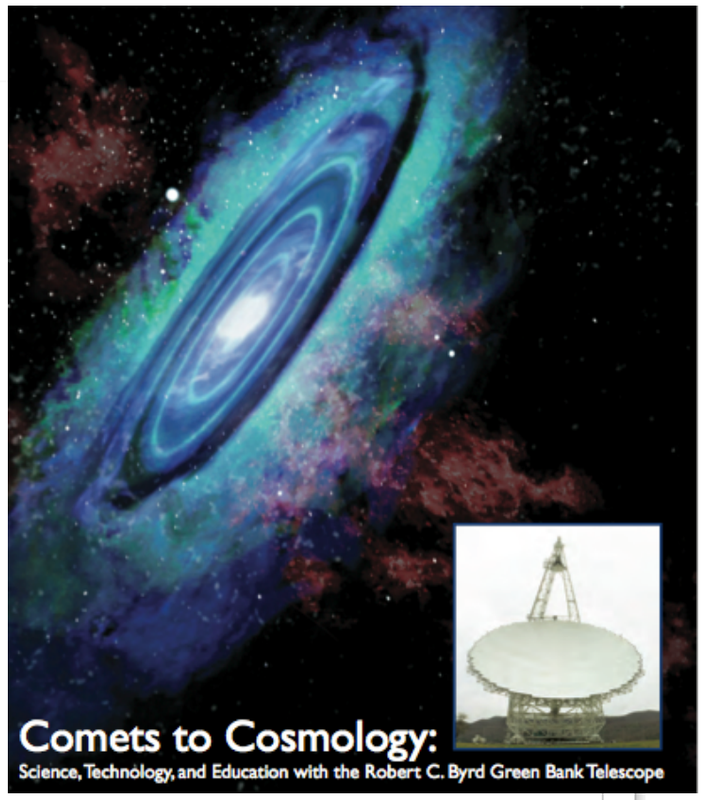


Dec



Research areas of most-cited GBT publications

(November 2014)



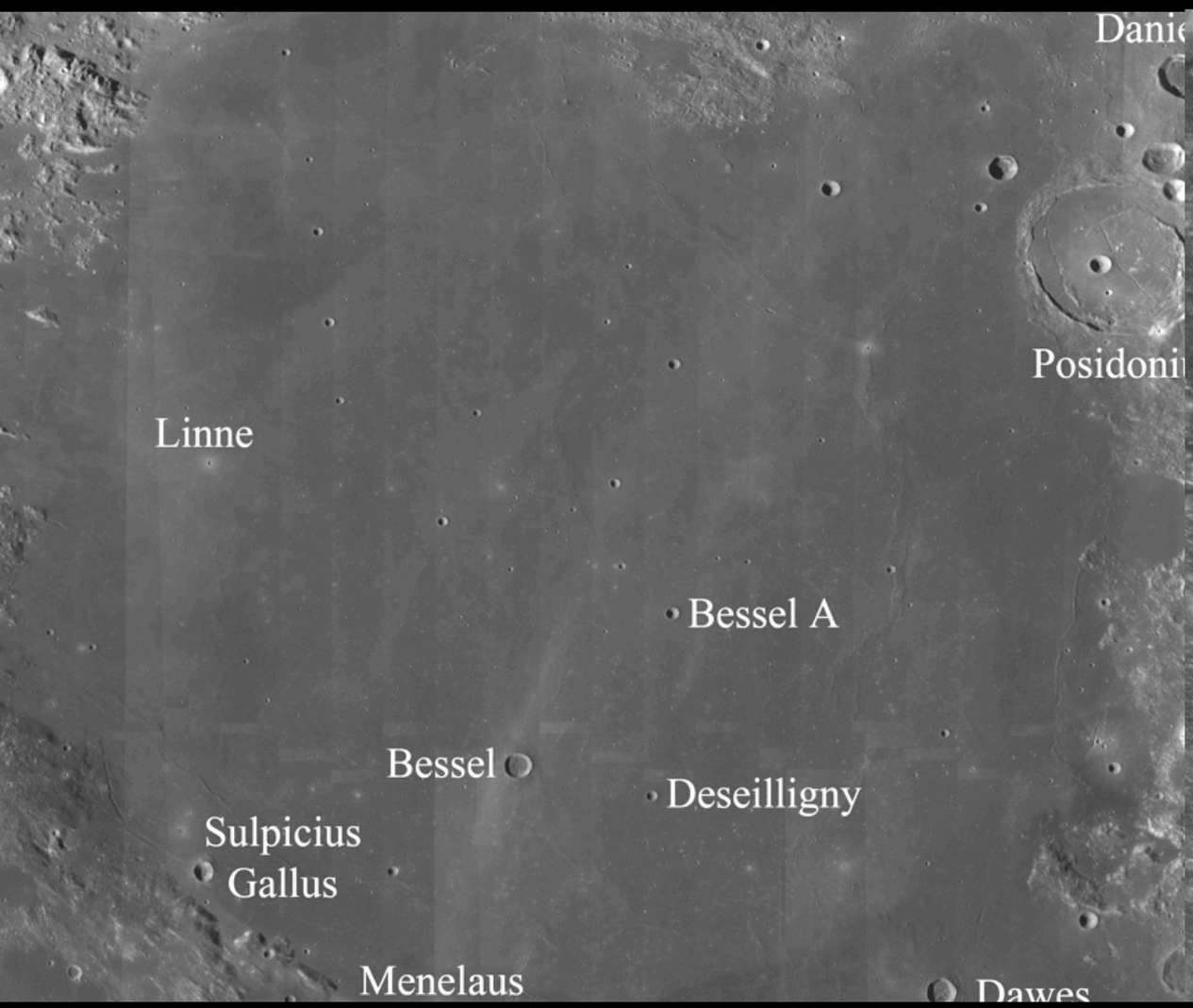
Pulsars and compact objects
Gravity and General Relativity
Galactic Hydrogen surveys
Interstellar Chemistry
The internal structure of Mercury
Evolution of spiral galaxies
Star formation & pre-stellar objects
Studies of a binary black hole
Hydrogen content of galaxies
Molecules in highly redshifted galaxies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

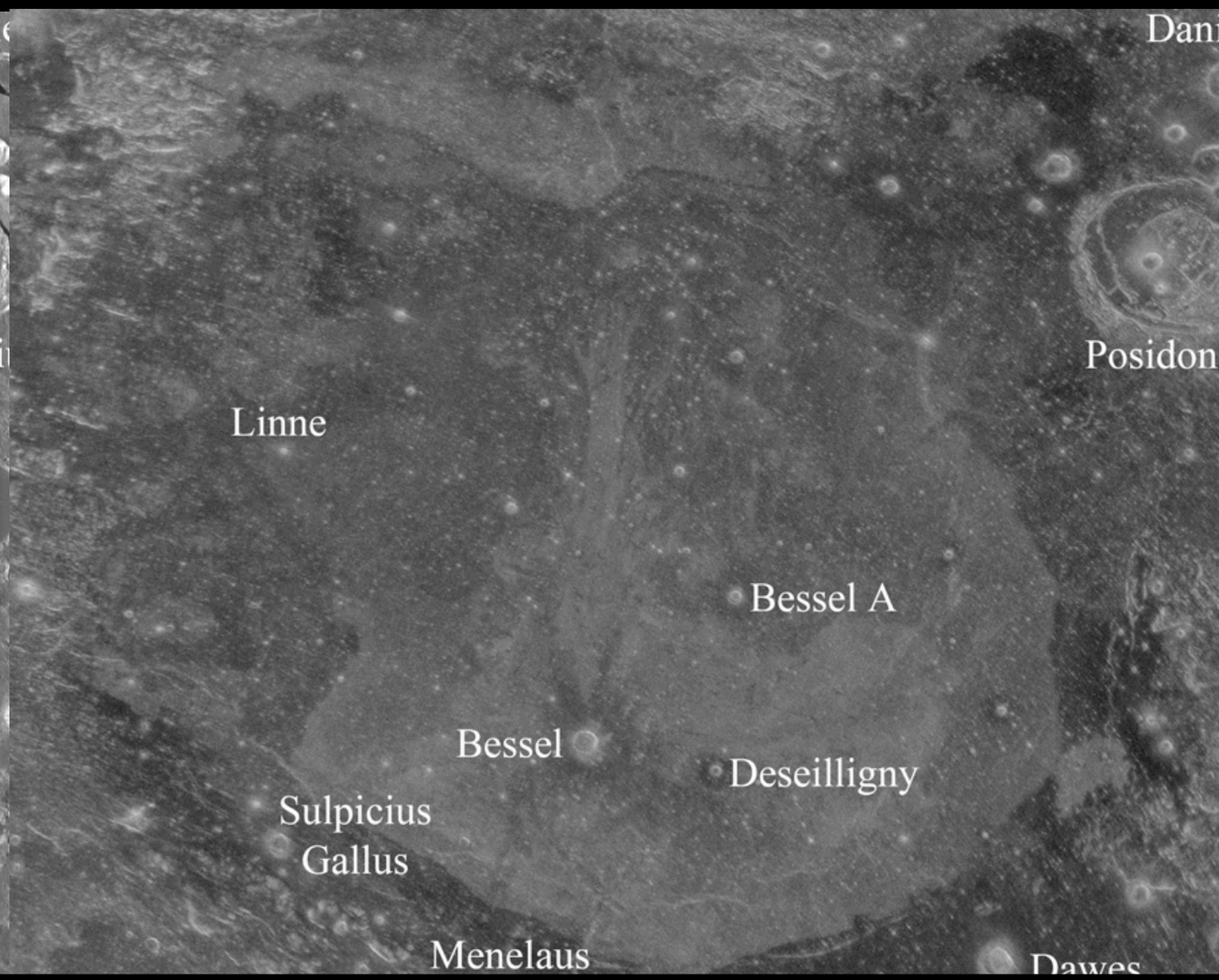
Bi-static radar studies with Arecibo

GBT receiving

OPTICAL

70cm RADAR

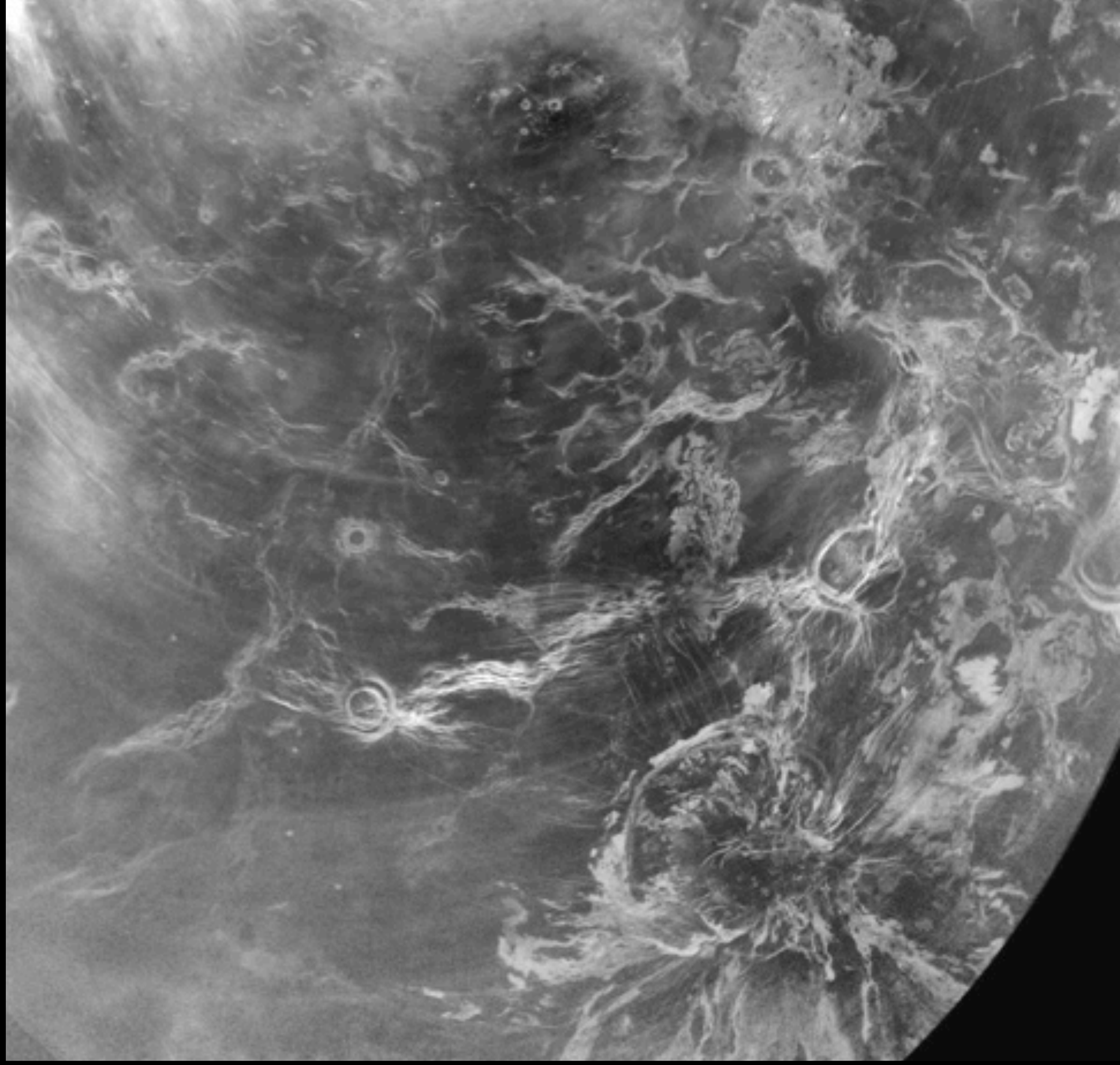




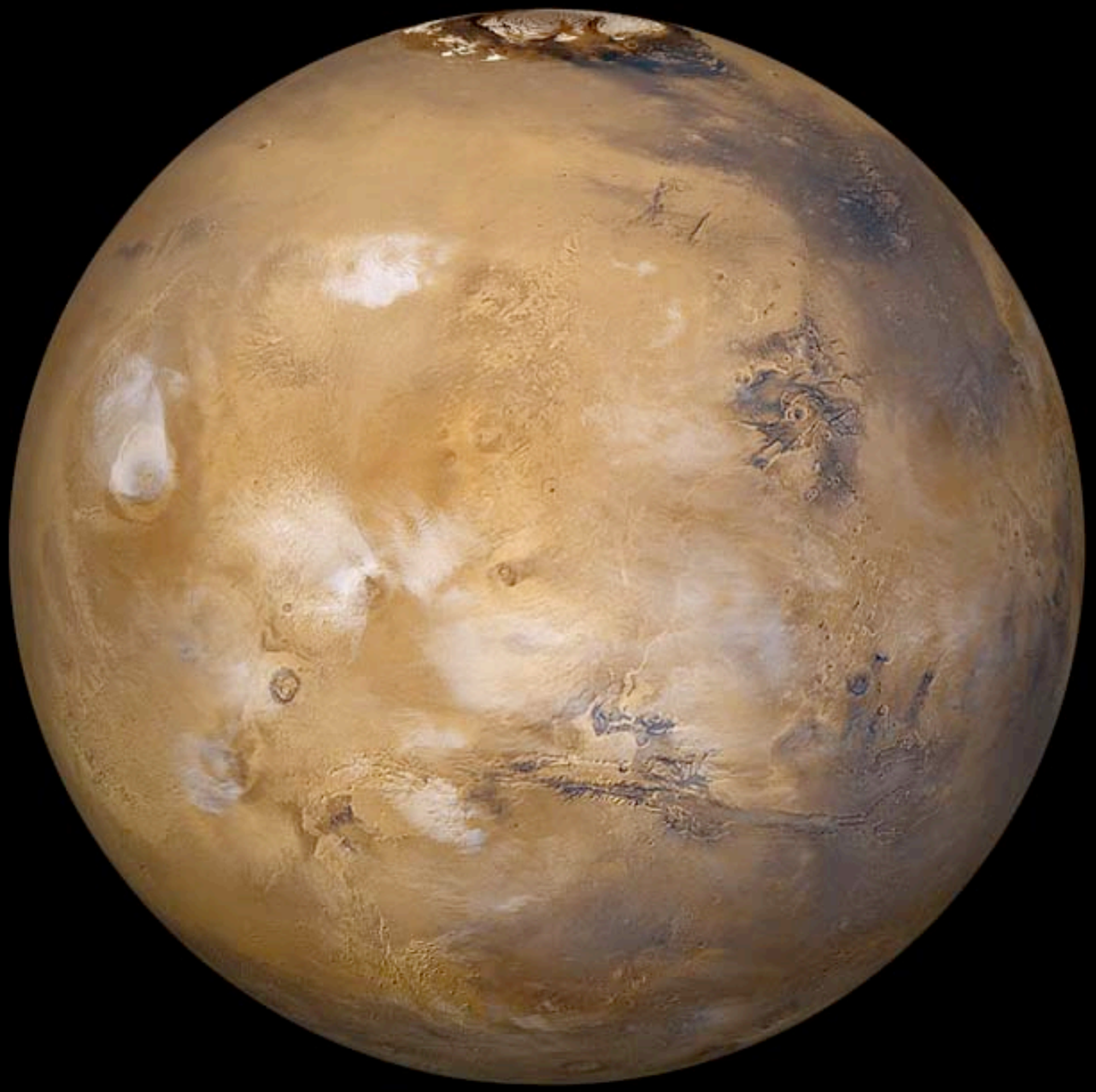
Campbell, B.A. et al. JGR-P 2014

VENUS RADAR

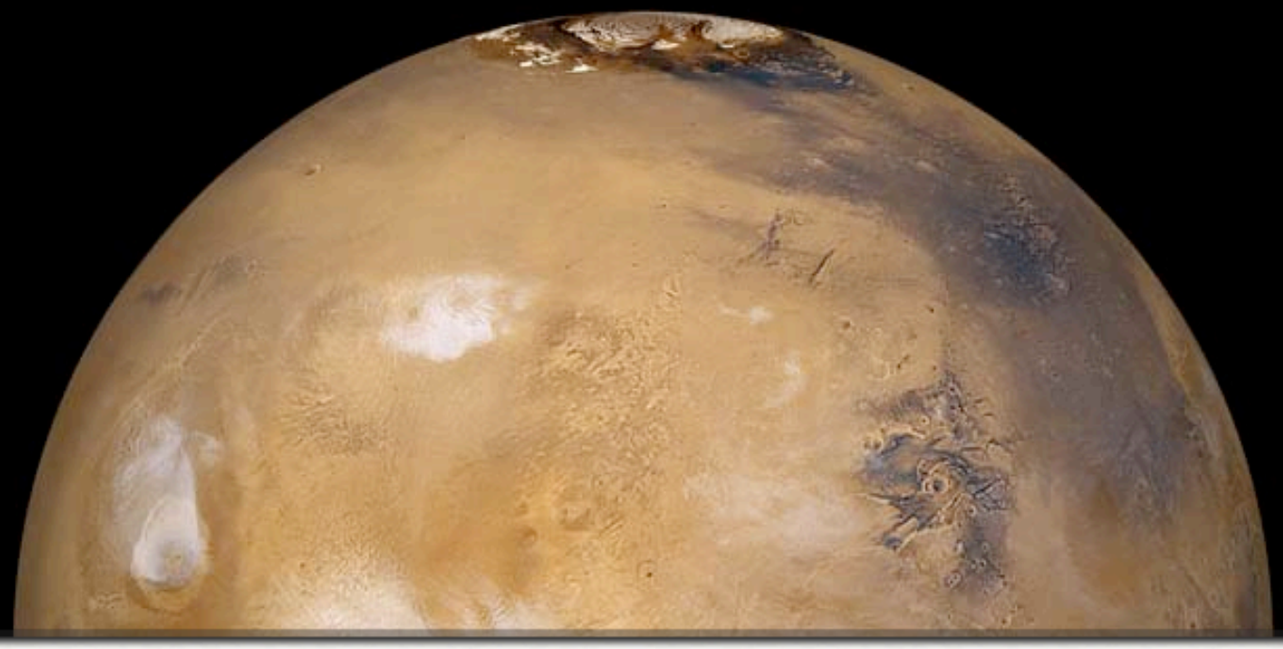
B. Campbell

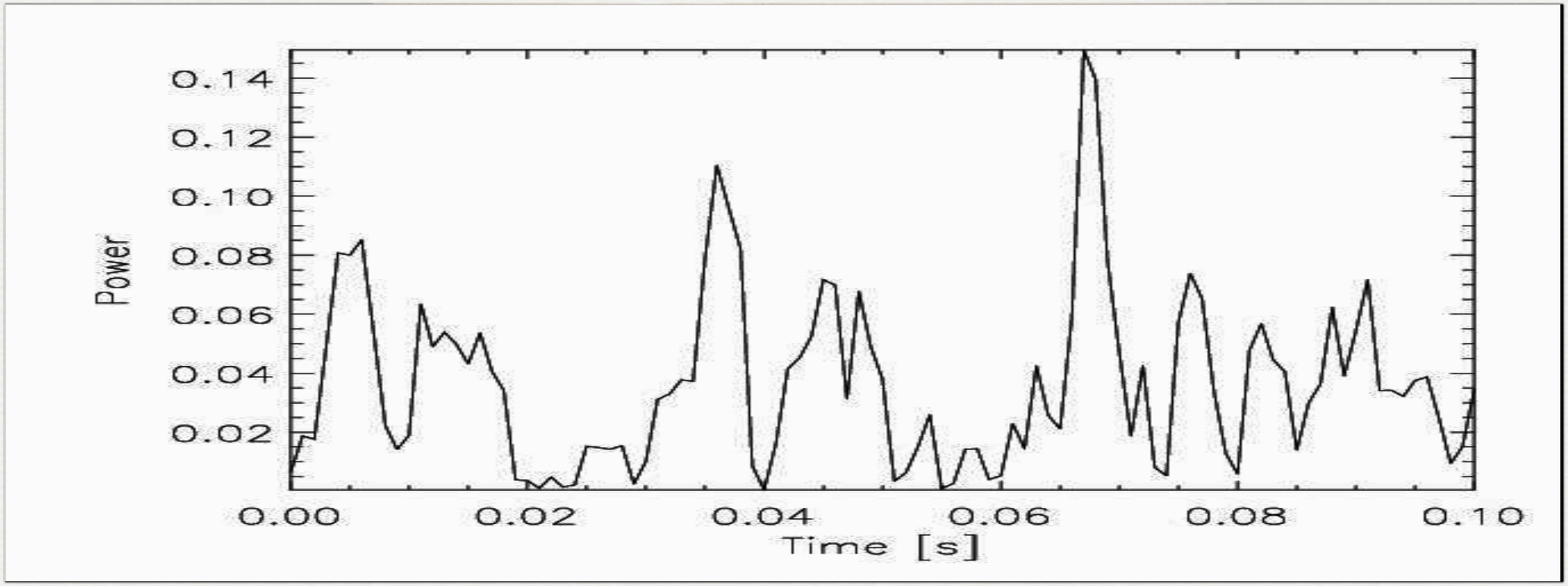


A radar return is speckled

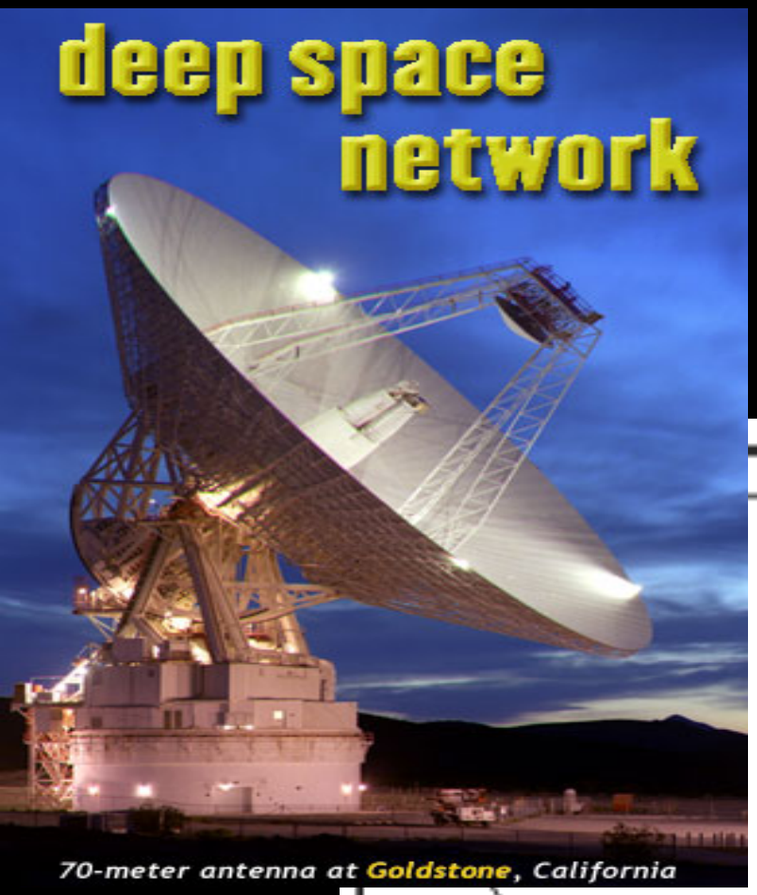


A radar return is speckled

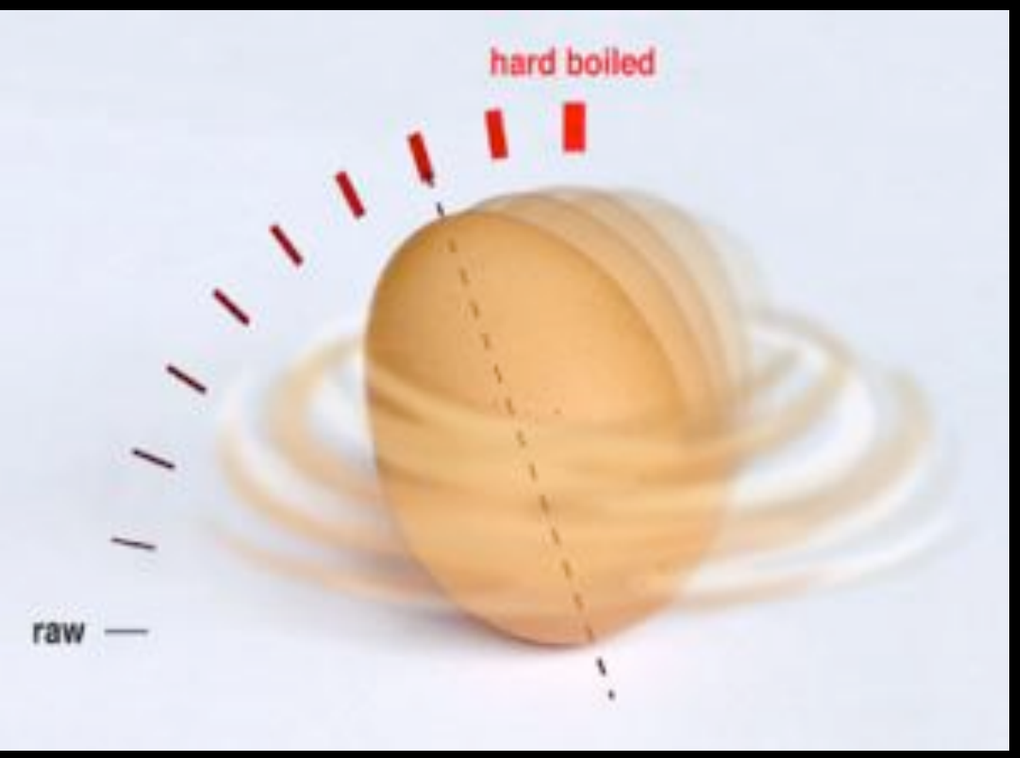




Cross correlate speckle arrival times



70-meter antenna at Goldstone, California



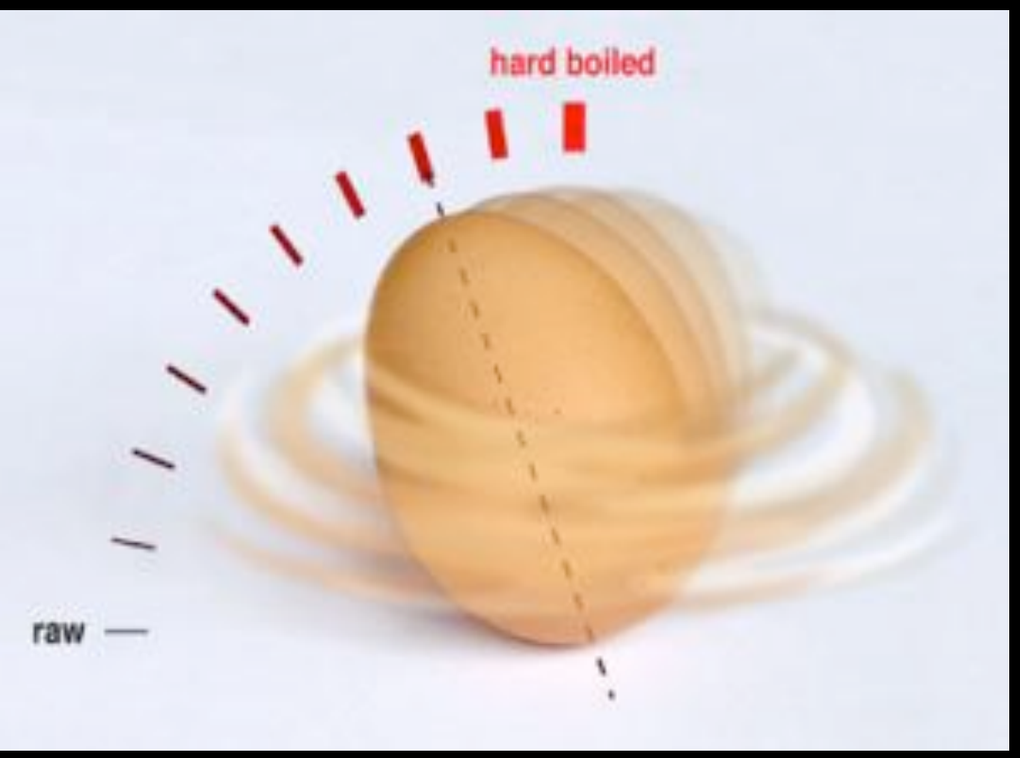
4 May 2007 | $10

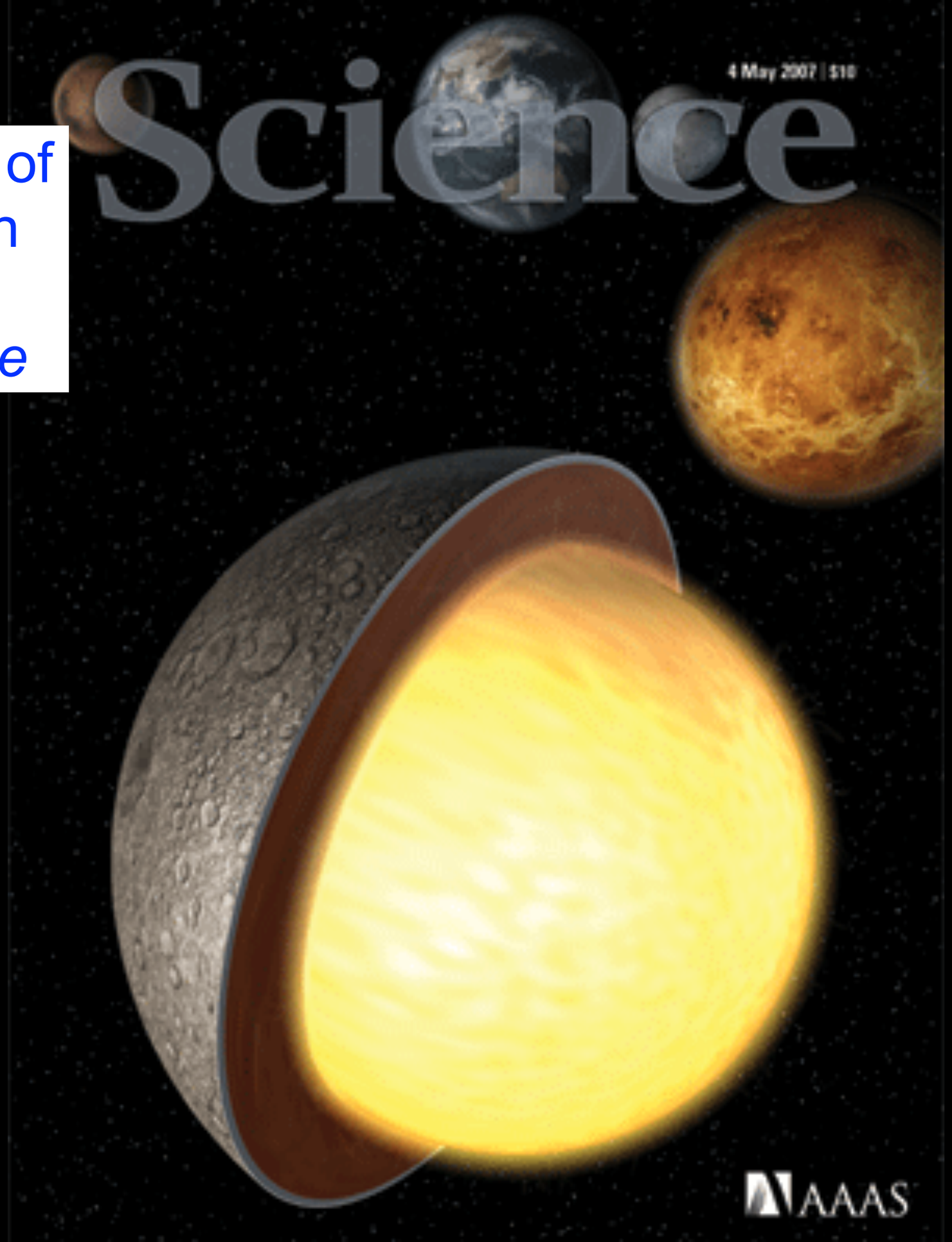
Science

AAAS

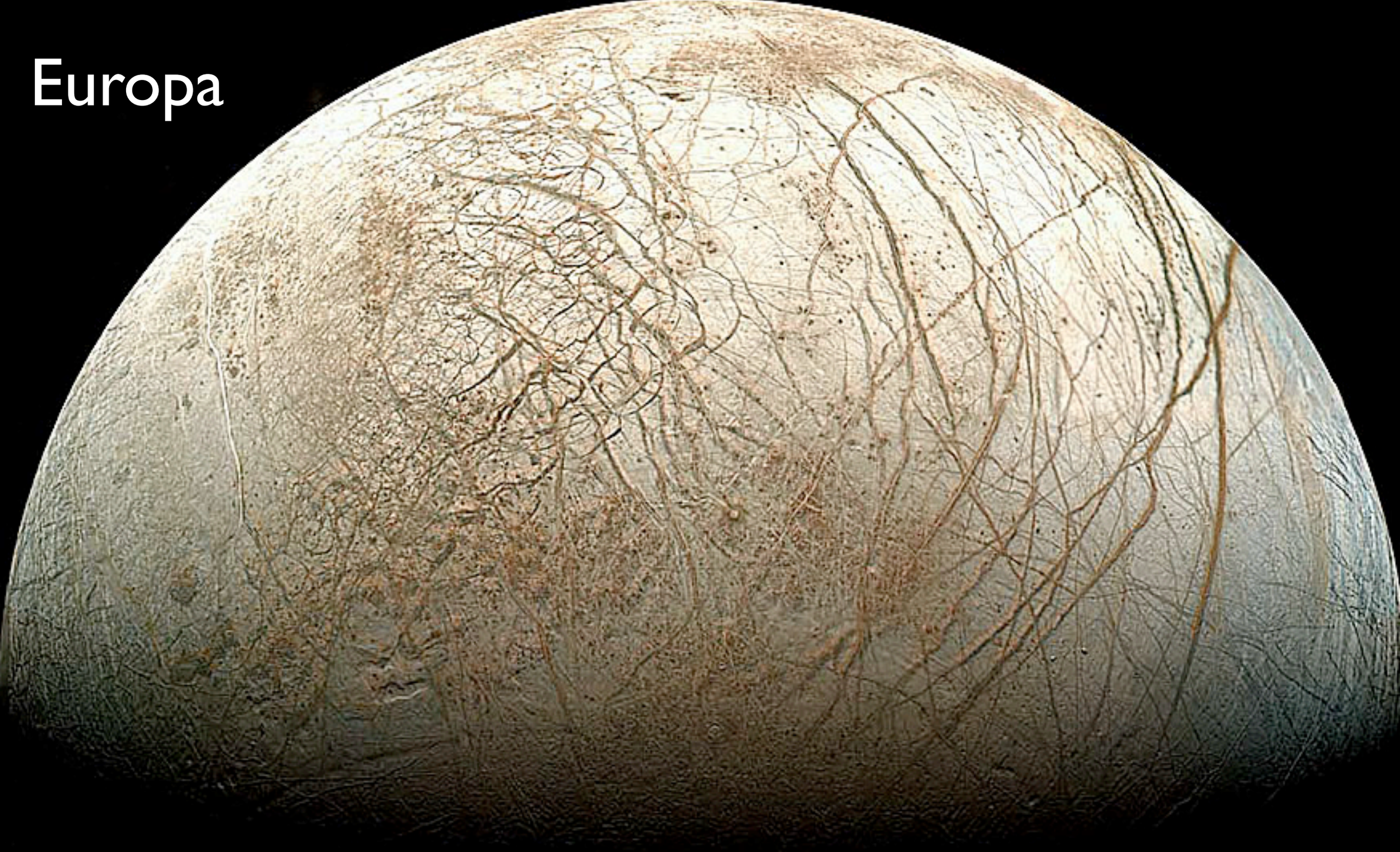
“Large Longitude Libration of Mercury Reveals a Molten Core”

Margot et al. 2007 Science





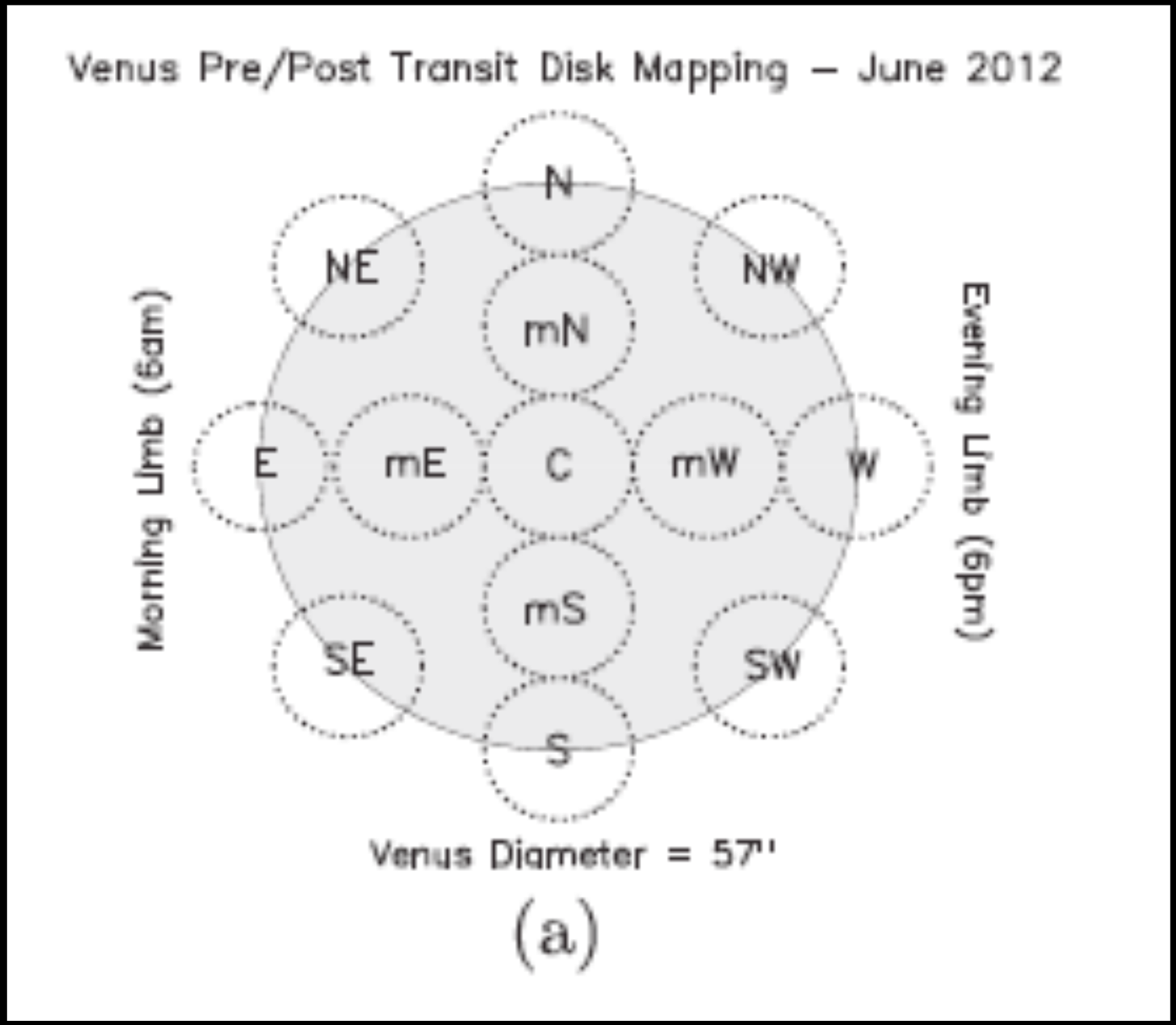
Europa



Chelyabinsk, Russia -- Feb. 15, 2013

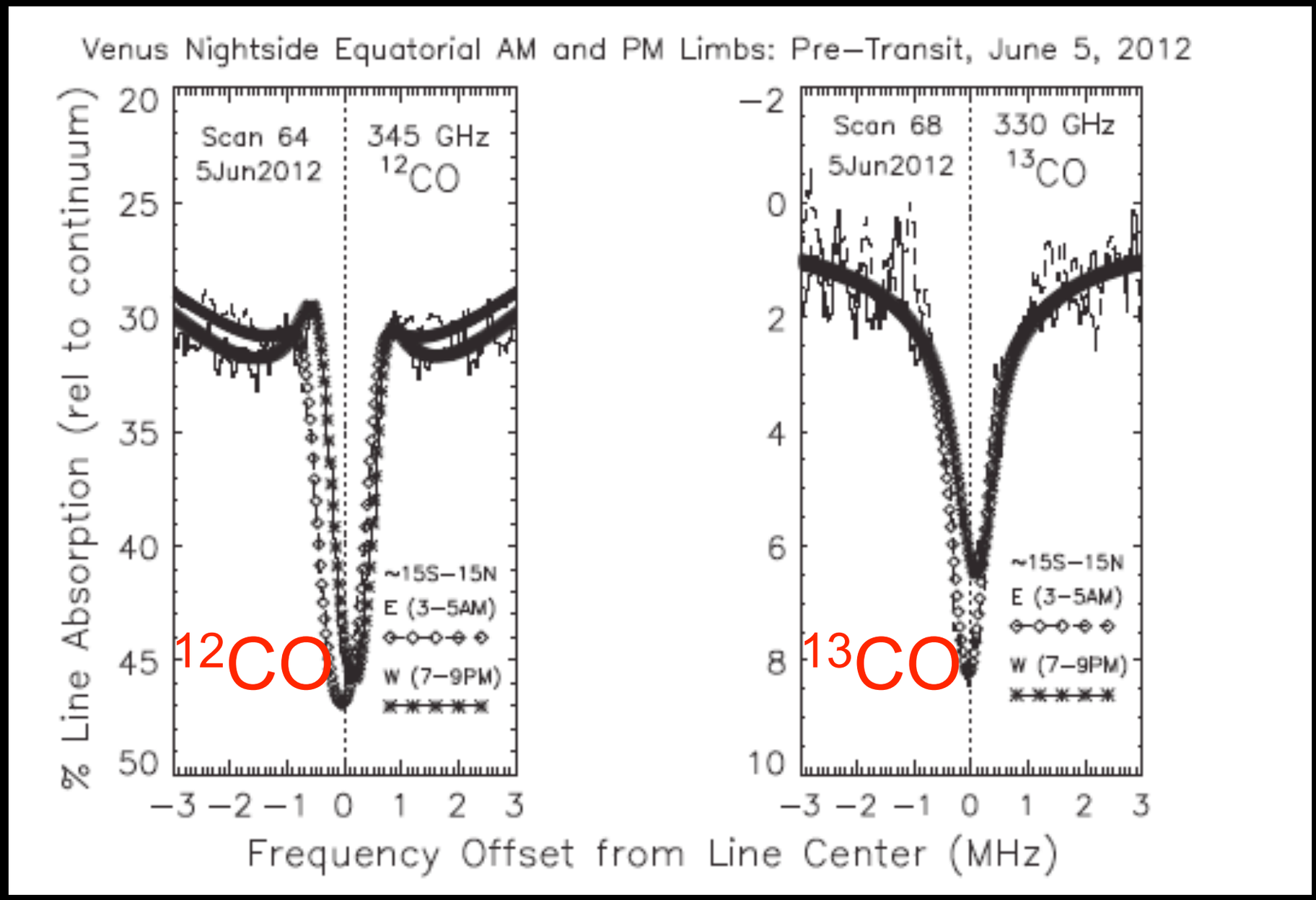

Goldstone-GBT
27 Jan 2015
Asteroid 2004BL86

Venus



JCMT - 350 GHz 14″
Clancy, Sandor, Hoge 2015

Venus



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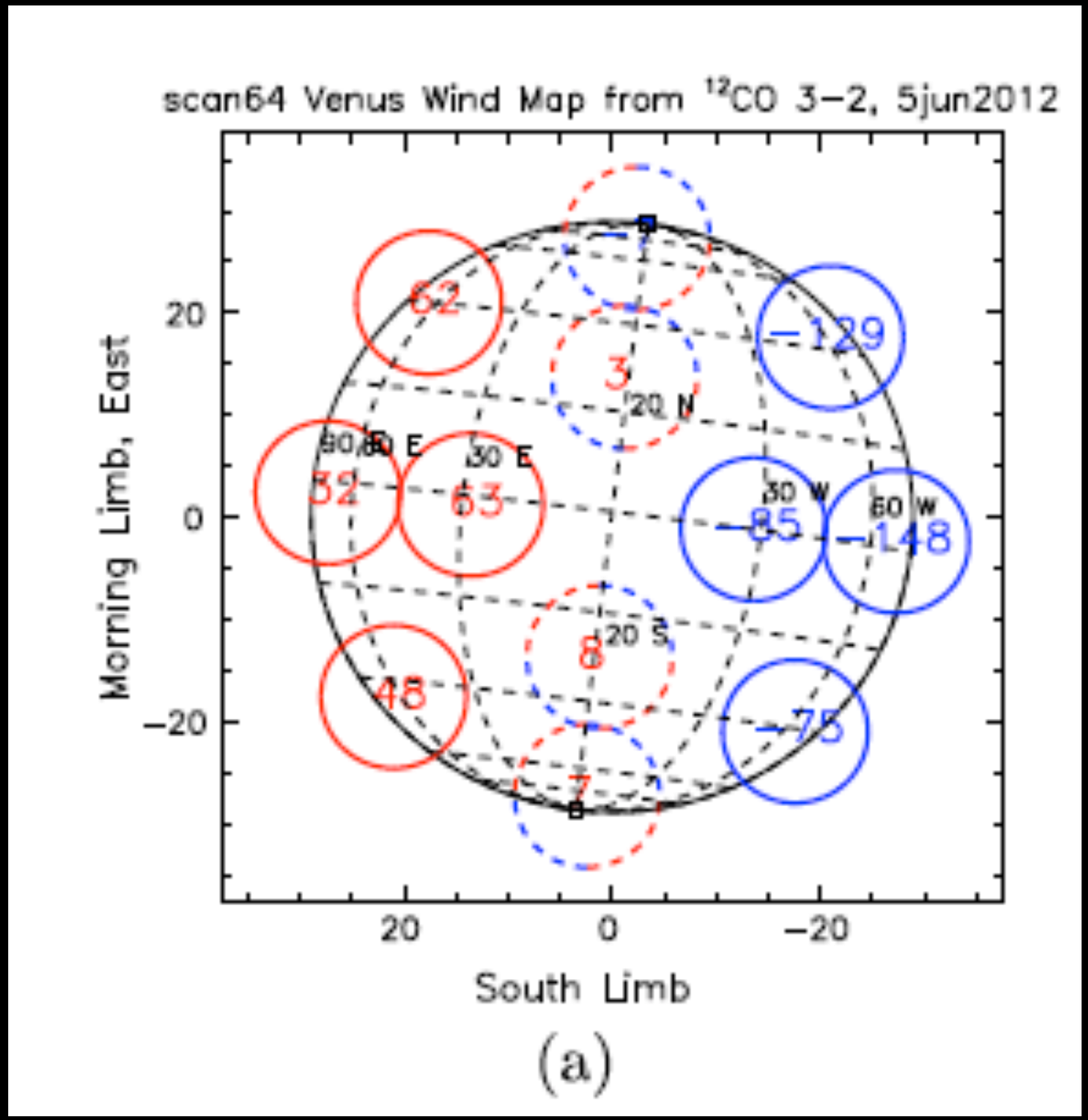
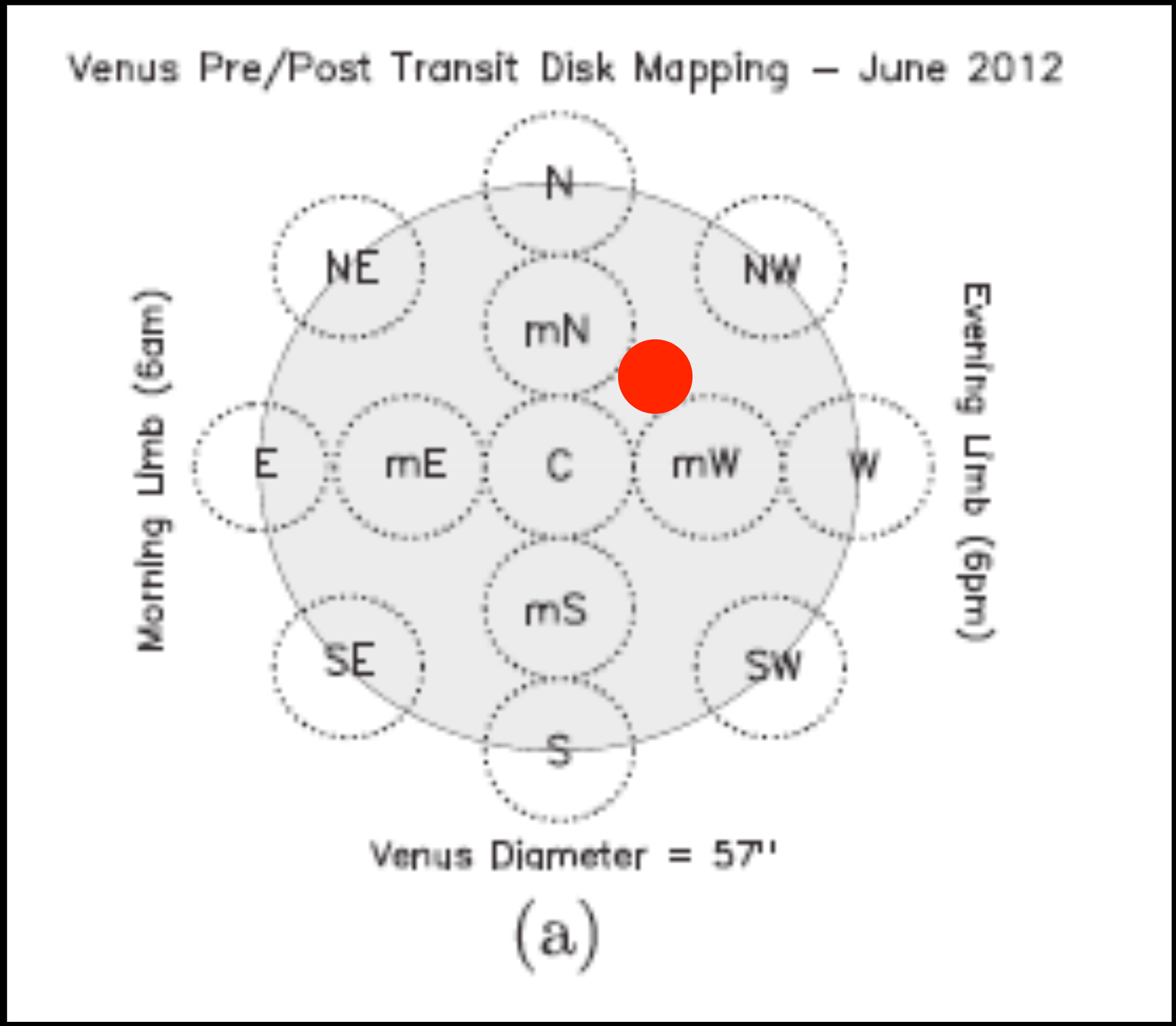
Venus



(a)

JCMT - 350 GHz 14″
Clancy, Sandor, Hoge 2015

Venus



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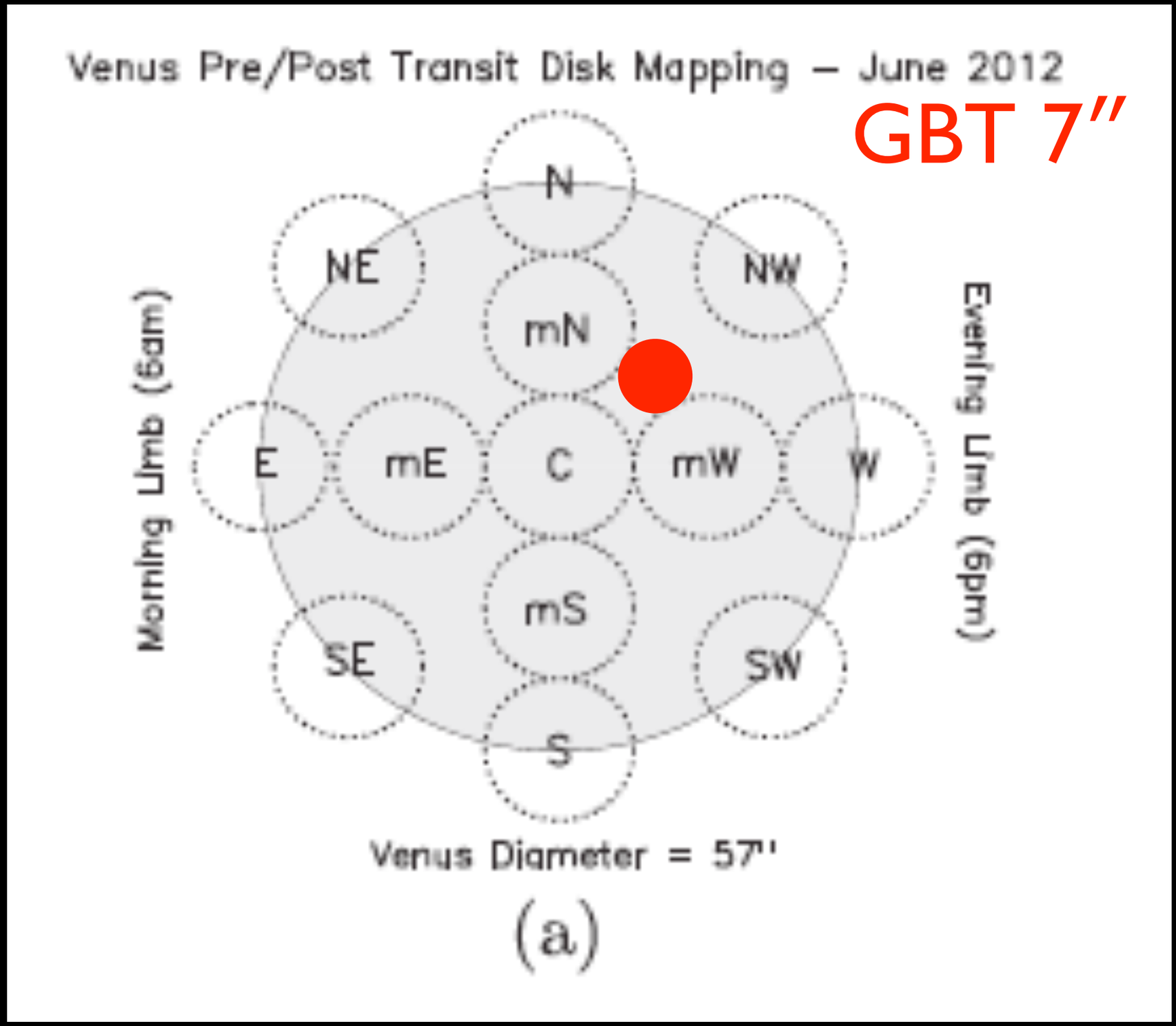
Venus



JCMT - 350 GHz 14″
Clancy, Sandor, Hoge 2015

A digression on the sensitivity of radio telescopes

point source

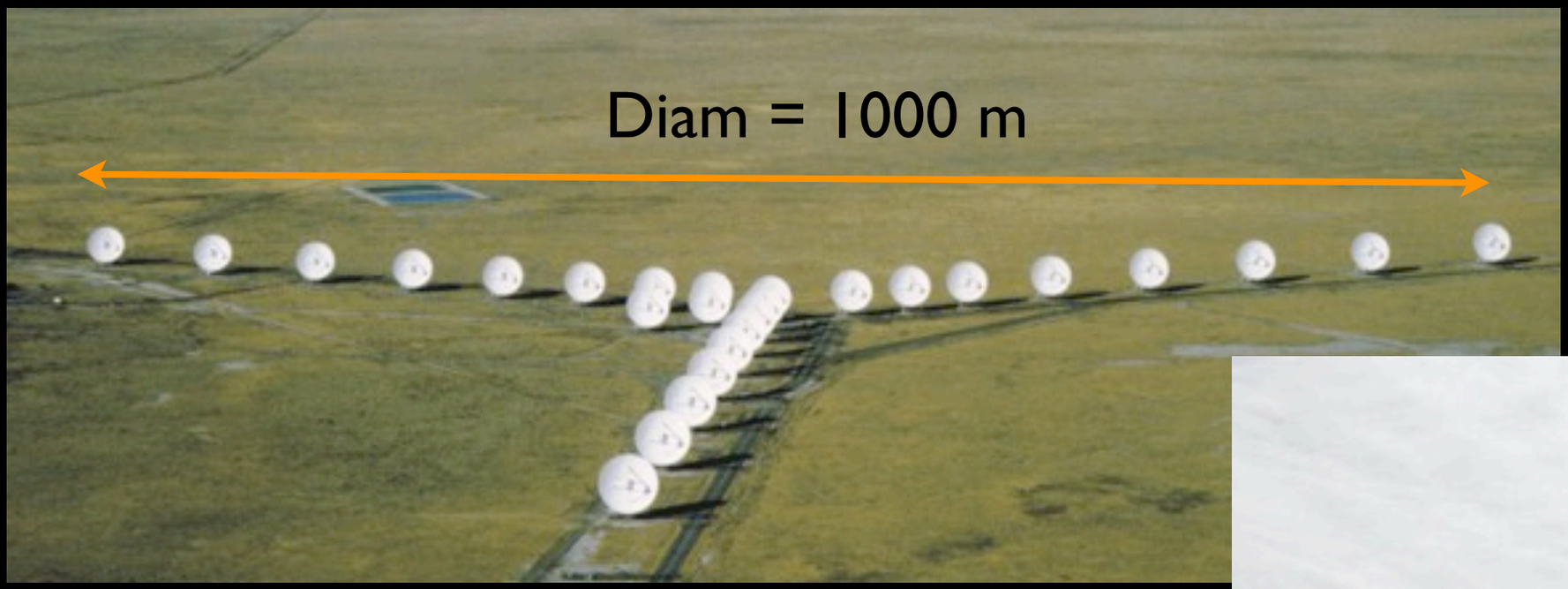
$$t \propto \frac{1}{A_e^2}$$

A digression on the sensitivity of radio telescopes

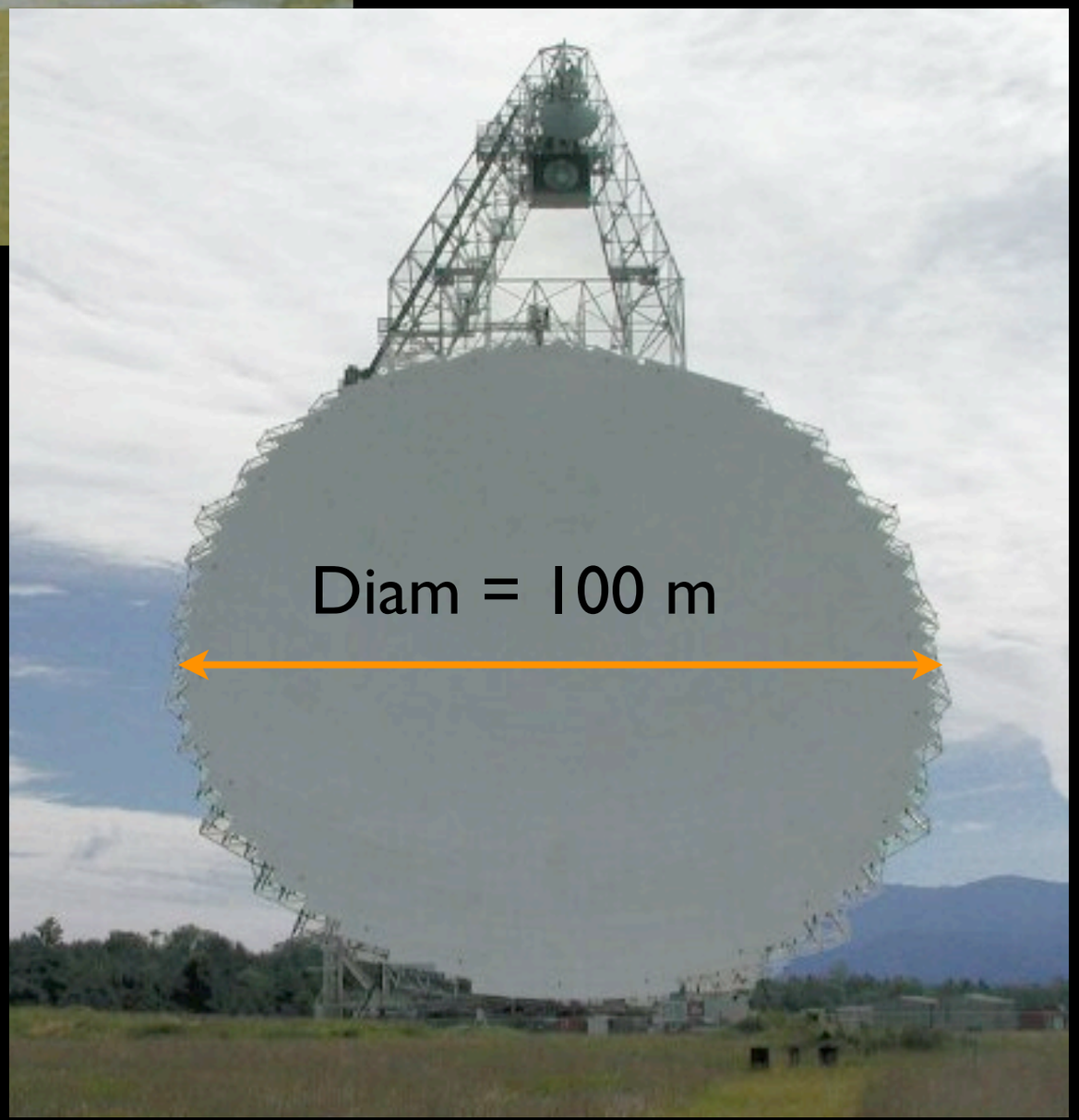
point source $$t \propto \frac{1}{A_e^2}$$

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	$\sim 10^6$	

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

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A digression on the sensitivity of radio telescopes

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ASKAP	~10^6	

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

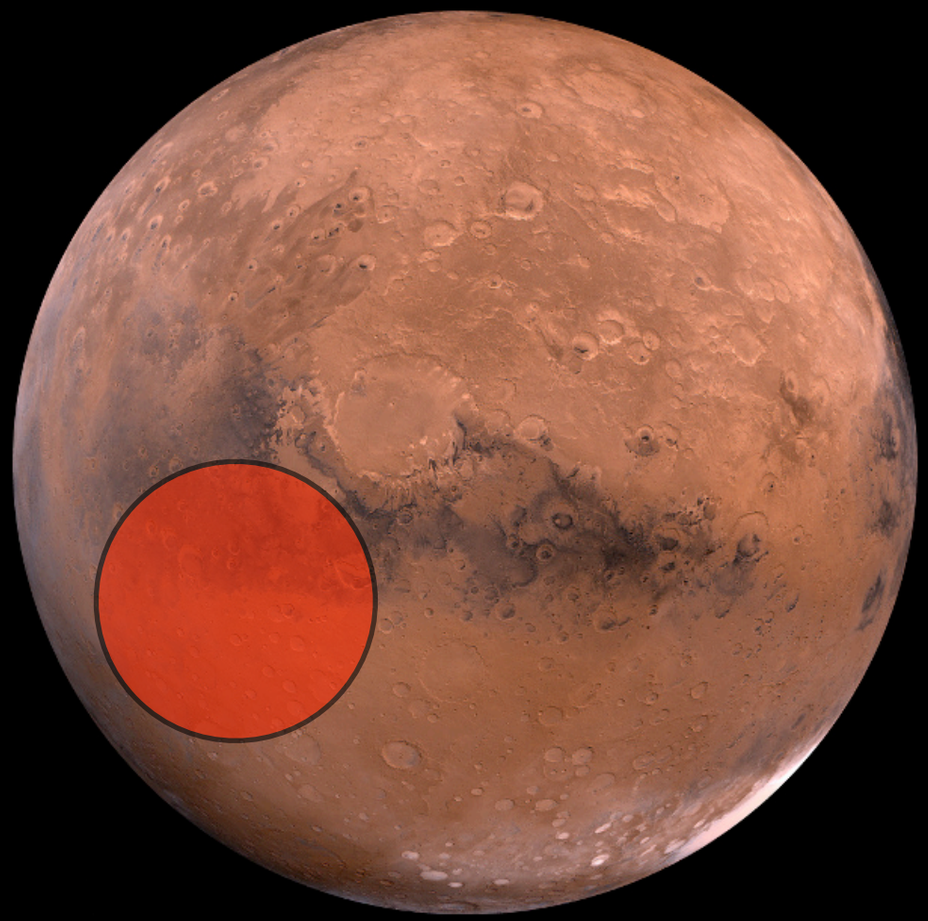
This is not related to the issue of missing short spacings

GBT and ALMA at 86 GHz
Mapping a 100 km/s line over a 3'x3' field

RMS noise	GBT 9" 16 pixel	GBT 9" 100 pixel	ALMA 1" 50x12m	ALMA 5" 50X12m	ACA 23" 12X7m	ALMA-TP 70" 4X12m
1 mJy / beam	2 hr	21 min	1 hr	1 hr	800 hr	600 hr
2 mK / beam	2 hr	21 min	6000 hr	9 hr	17 hr	9 min

Mars

3.5″ - 21.5″



GBT beam 7″

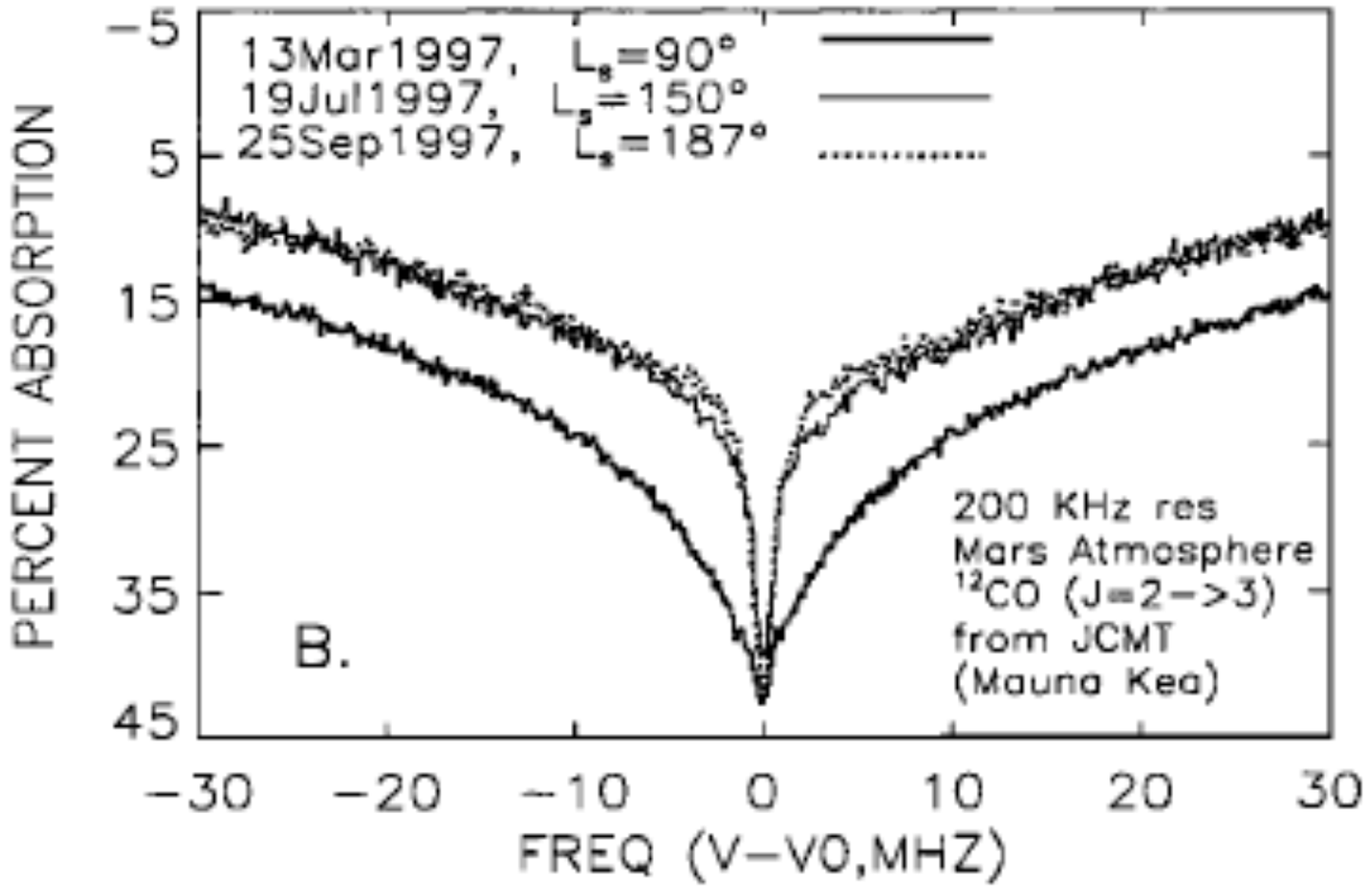
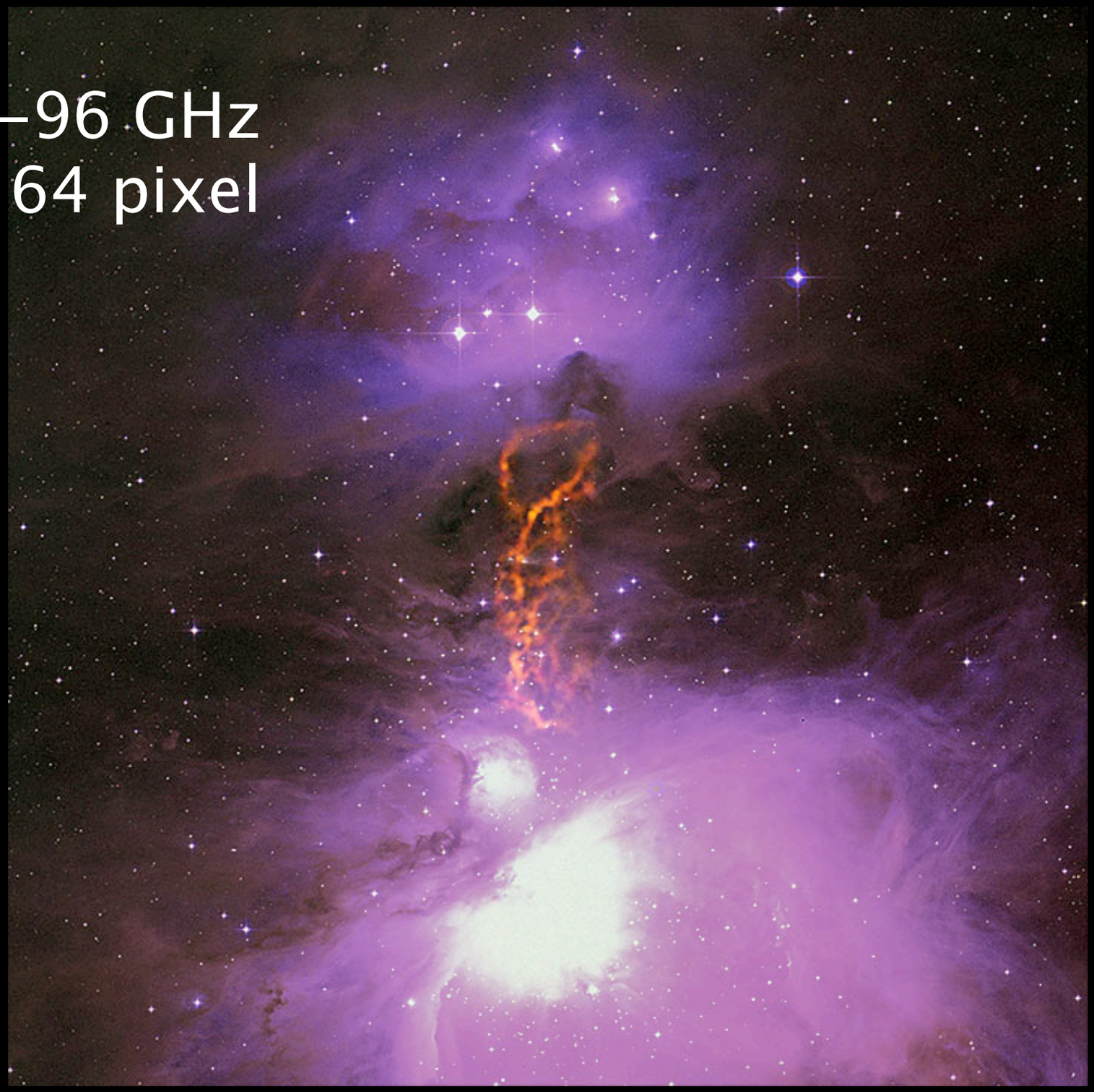


Figure 1. 346 GHz spectra of Mars atmospheric ^{12}CO, obtained from the James Clerk Maxwell Telescope in 1996 and 1997. The observed brightness temperature is presented as percent absorption relative to the full disk blackbody continuum. A) The initial September 1996 spectrum (400 KHz resolution) compared to a model fit, B) Comparison of the line center absorption at 200 KHz resolution observed in March, July, and September 1997.

JCMT
Clancy & Sandor JGR 1998

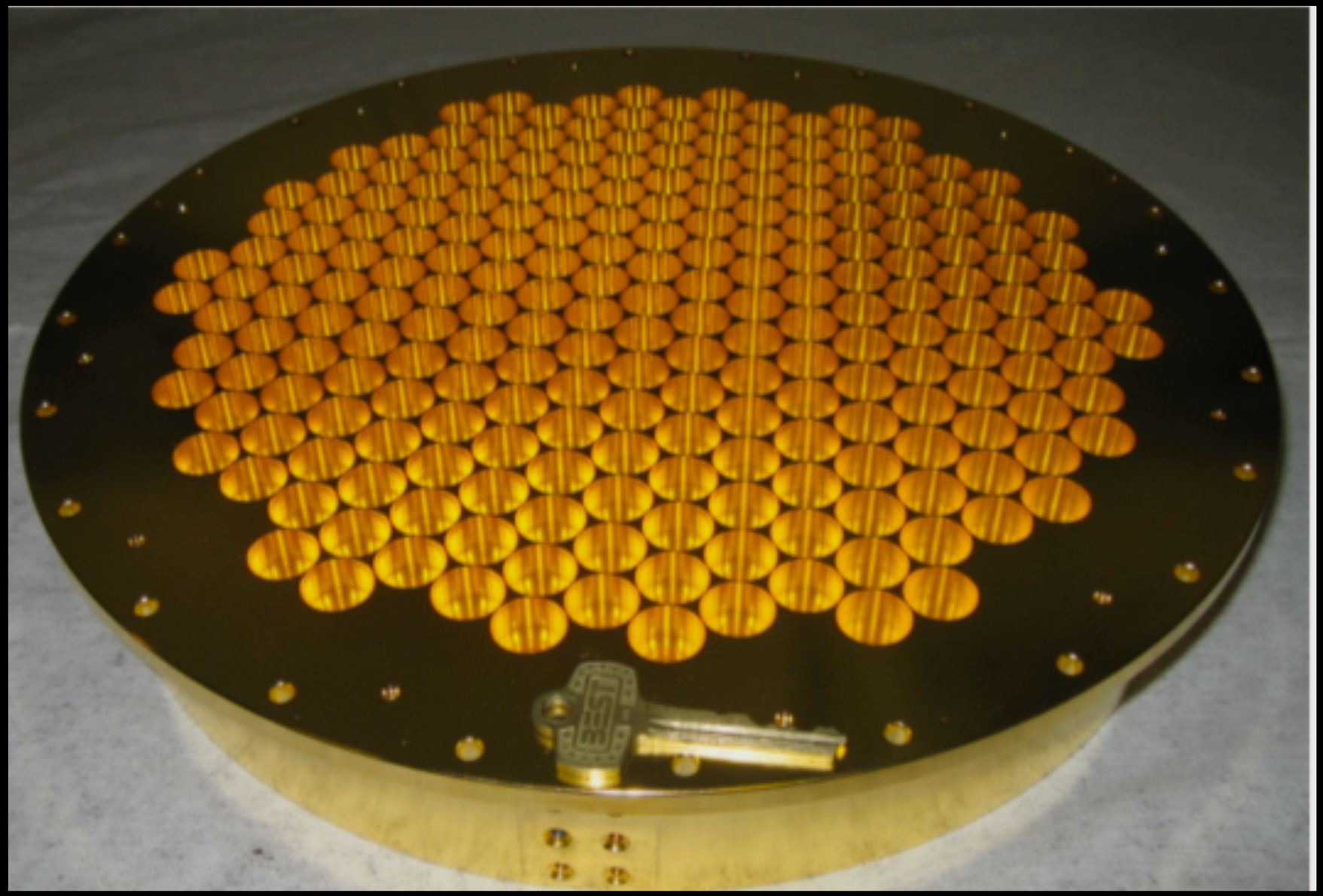
GBT MUSTANG Bolometer Array

81–96 GHz
9″ 64 pixel

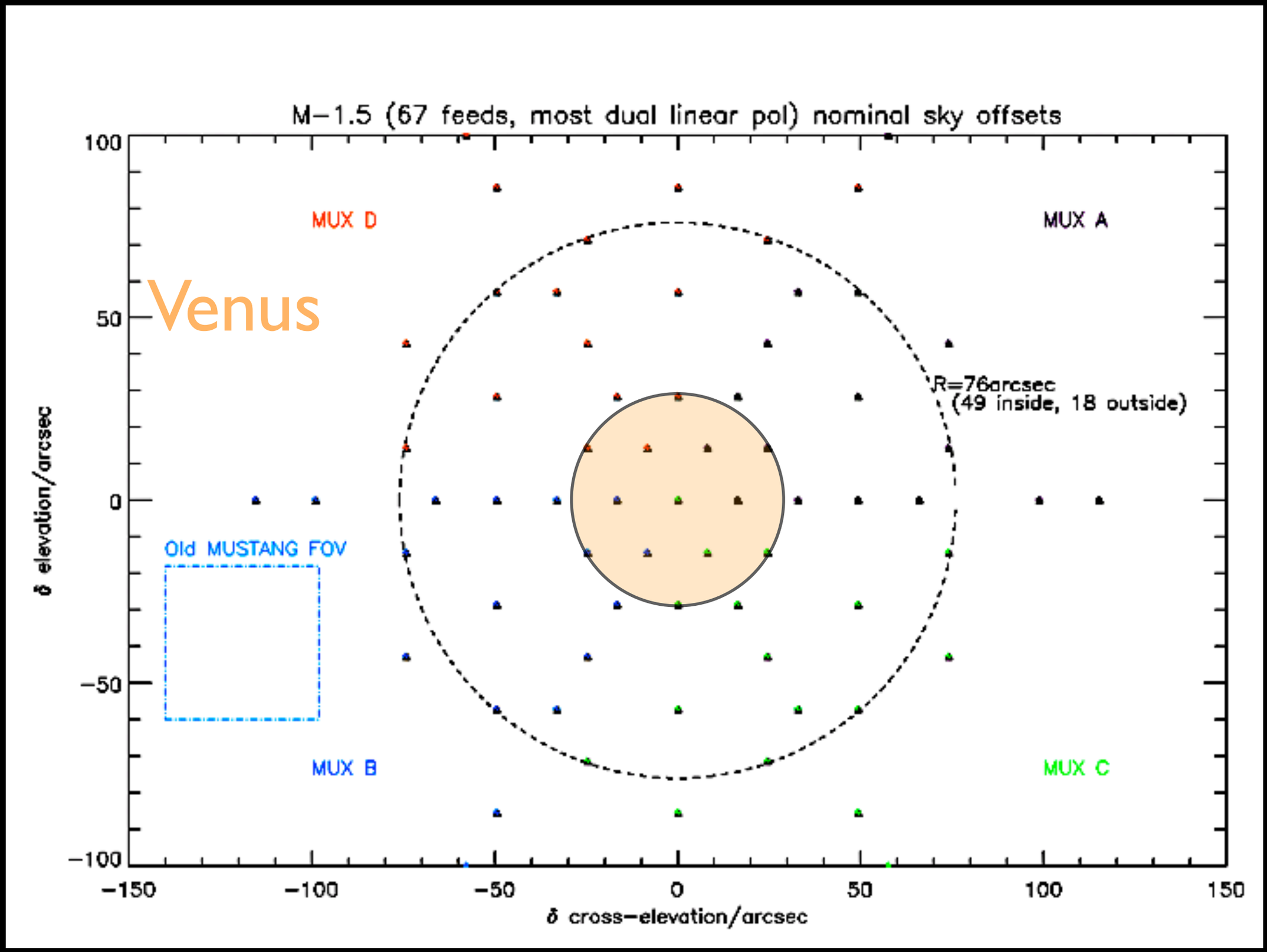


5’

GBT MUSTANG-1.5



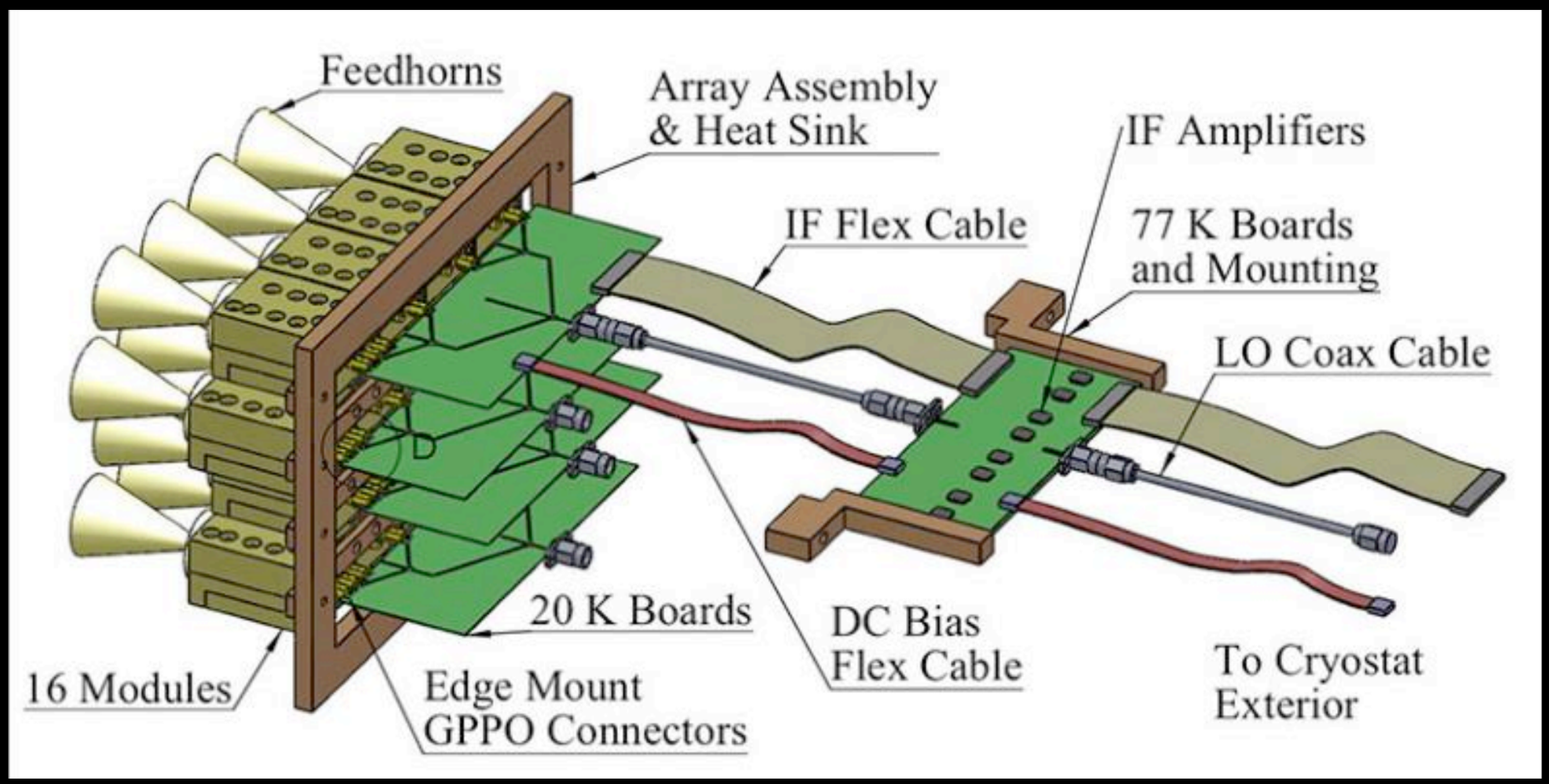
GBT MUSTANG-1.5



ARGUS -- 8″ GBT spectroscopy at 3mm

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

Coming soon....

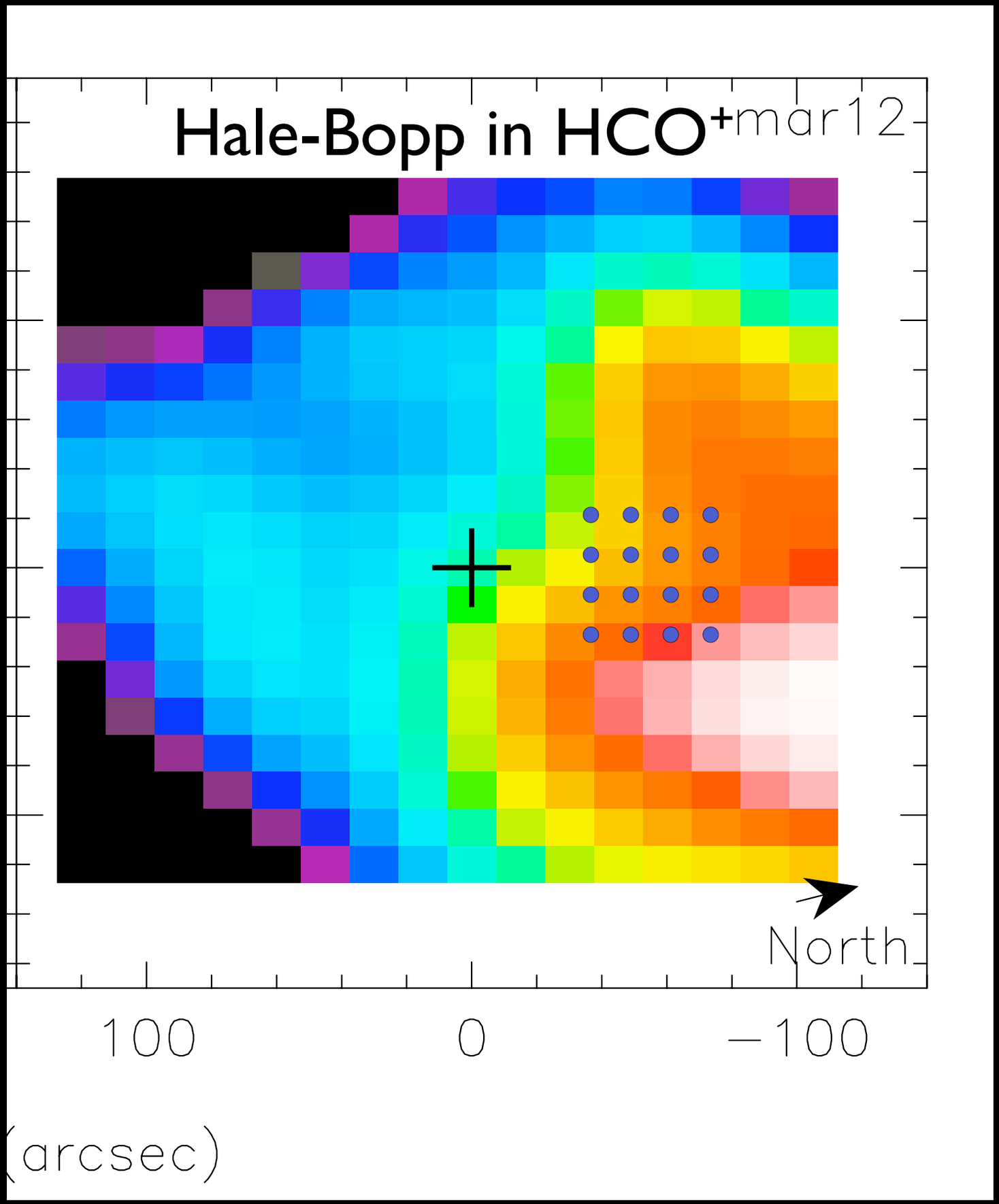


ARGUS Spectral Lines

Species	Transition	Freq. [GHz]	Species	Transition	Freq. [GHz]
$H^{13}CN$	1–0	86.340	^{13}CS	2–1	92.494
$H^{13}CO^+$	1–0	86.754	$\mathbf{N_2H^+}$	1–0	93.173
SiO	2–1	86.847	$C^{34}S$	2–1	96.413
$HN^{13}C$	1–0	87.091	**CS**	2–1	97.981
$\mathbf{C_2H}$	1–0	87.317	$C^{18}0$	1–0	109.782
HCN	1–0	88.632	^{13}CO	1–0	110.201
$H^{15}NC$	1–0	88.866	$C^{17}0$	1–0	112.359
$\mathbf{HCO^+}$	1–0	89.189	**CN**	1–0	113.491
HNC	1–0	90.664	**CO**	1–0	115.271

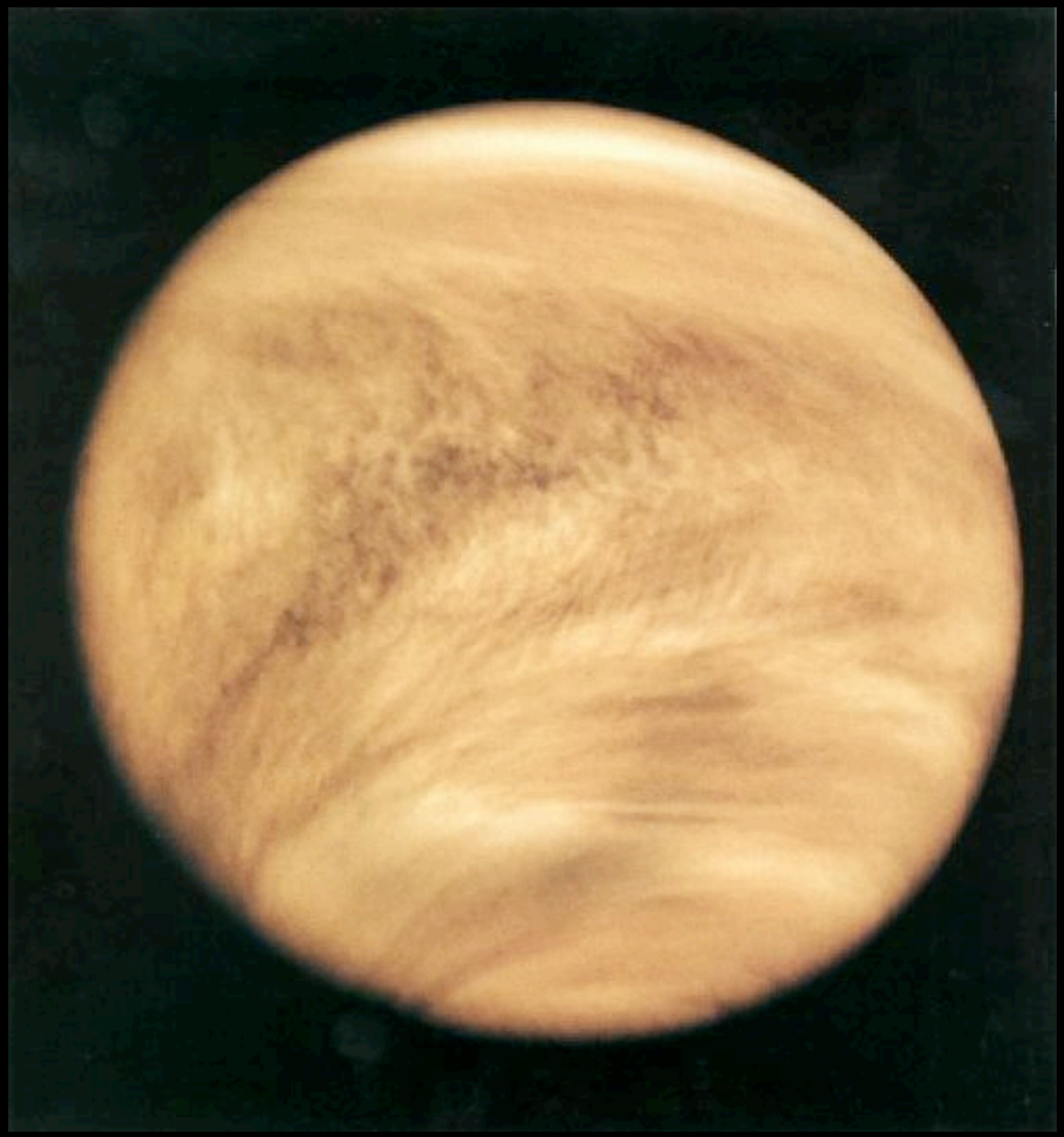
Table 2. List of some key transitions from 85–116 GHz. Names of the principal isotopic species are in bold.

Comets

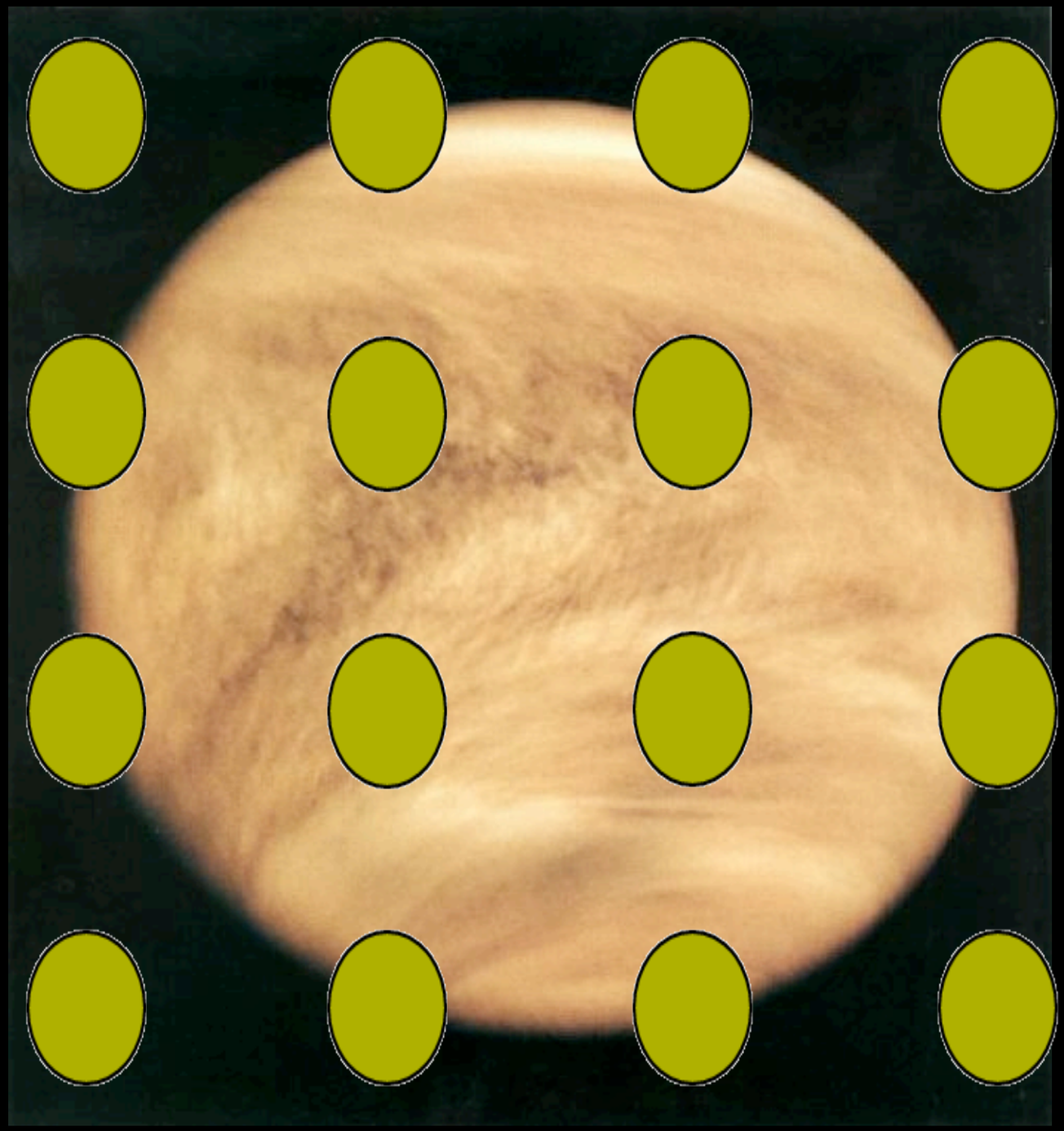


ARGUS footprint

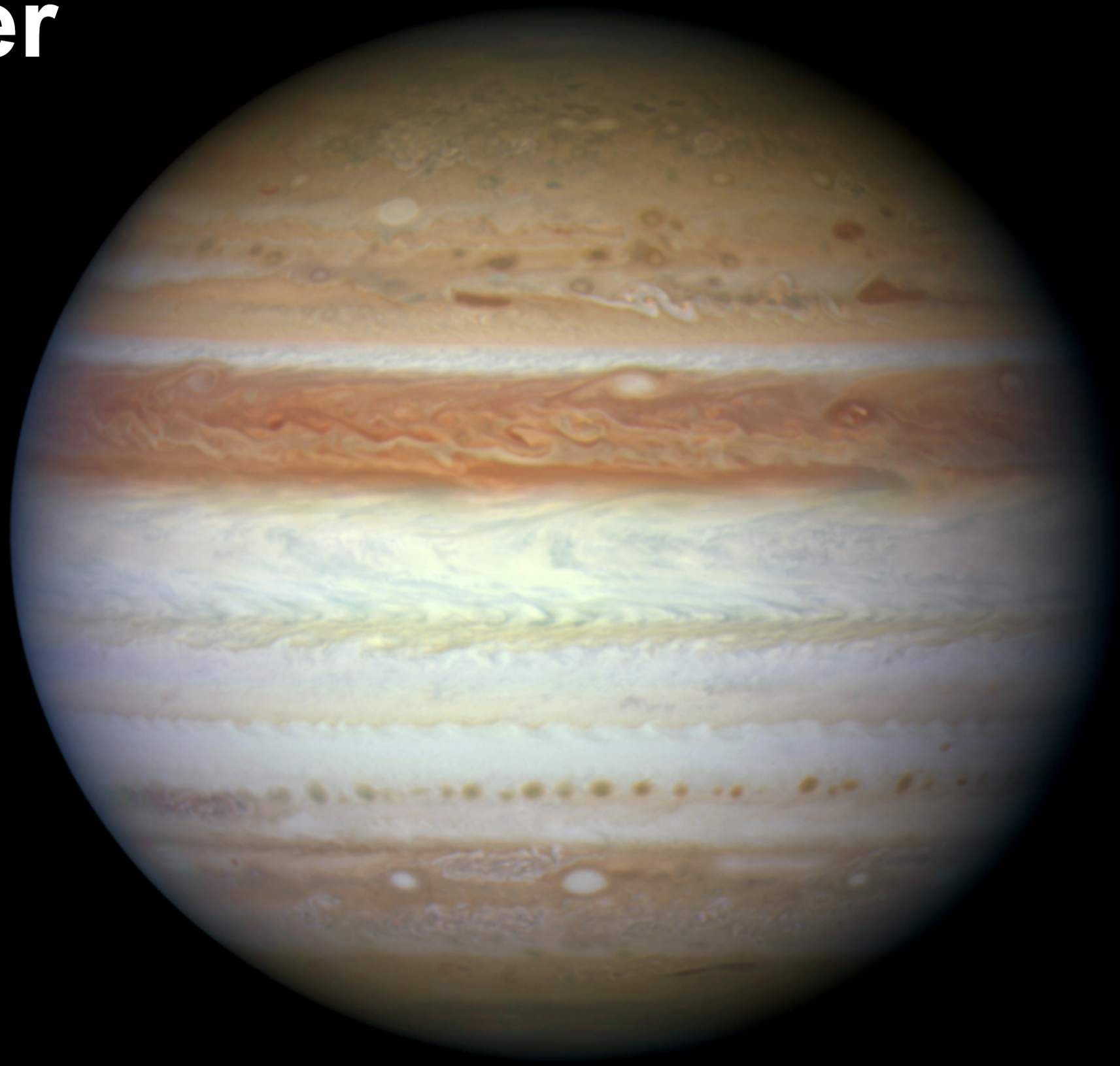
ARGUS -- 8″ GBT spectroscopy at 3mm



ARGUS -- 8″ GBT spectroscopy at 3mm



Jupiter



30″ - 50″

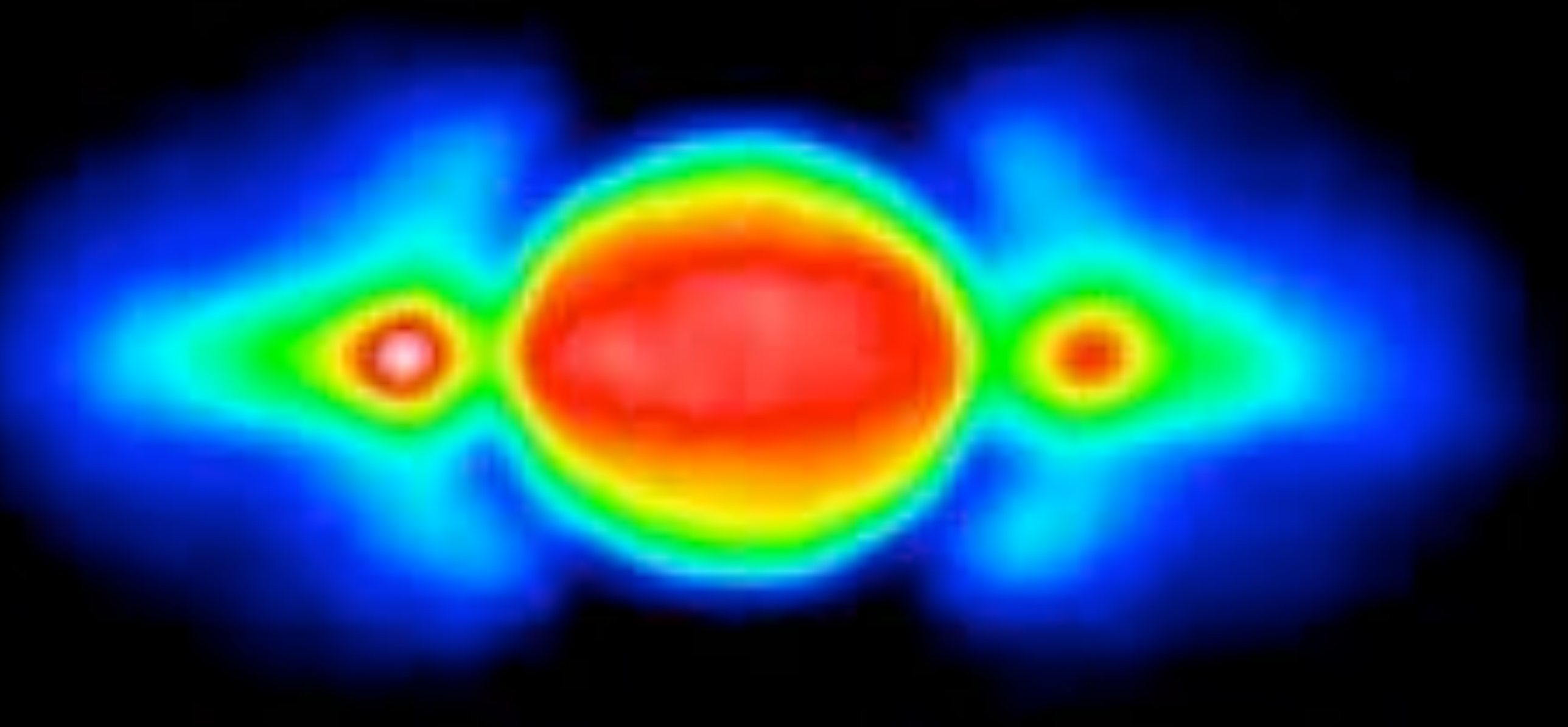
HST

Jupiter

30″ - 50″

HST

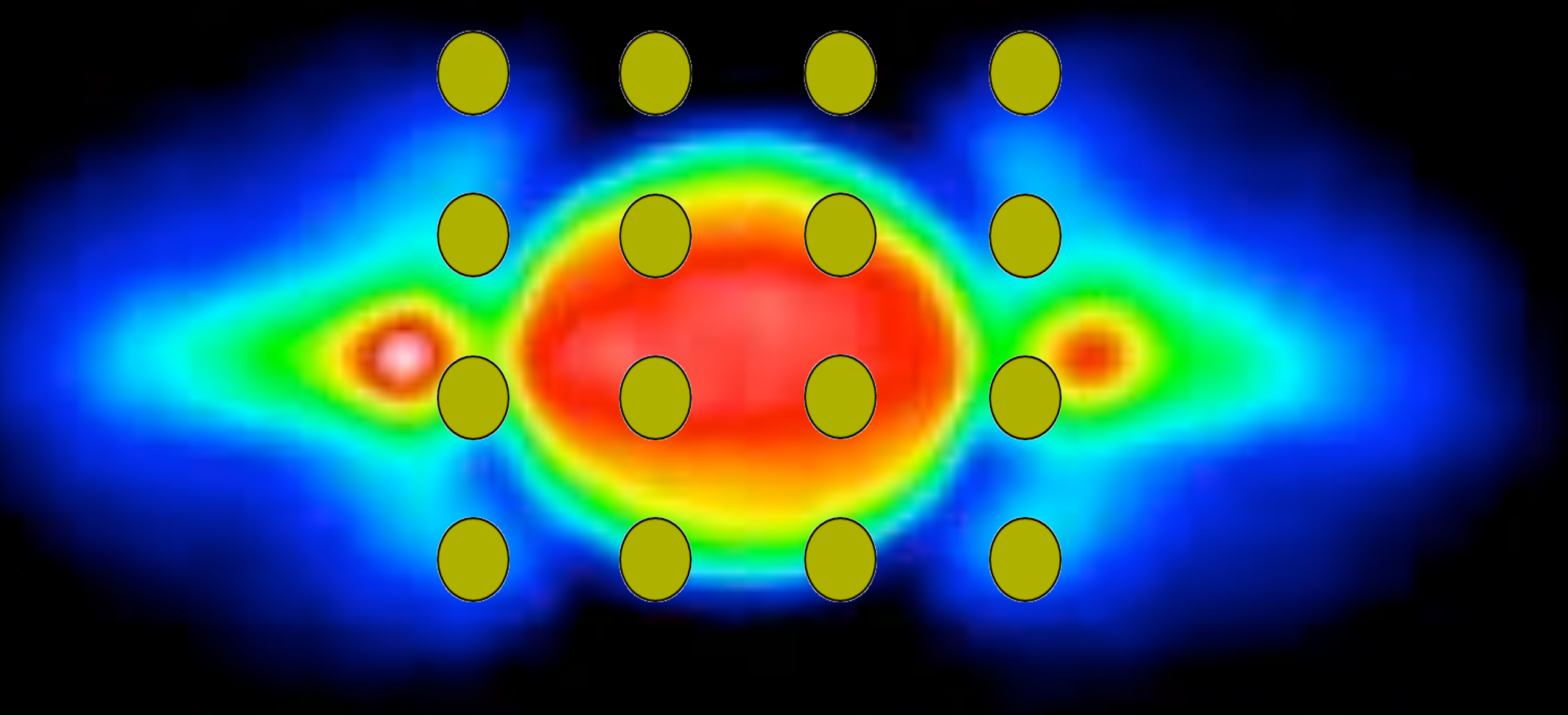
Jupiter



30″ - 50″

VLA 13cm

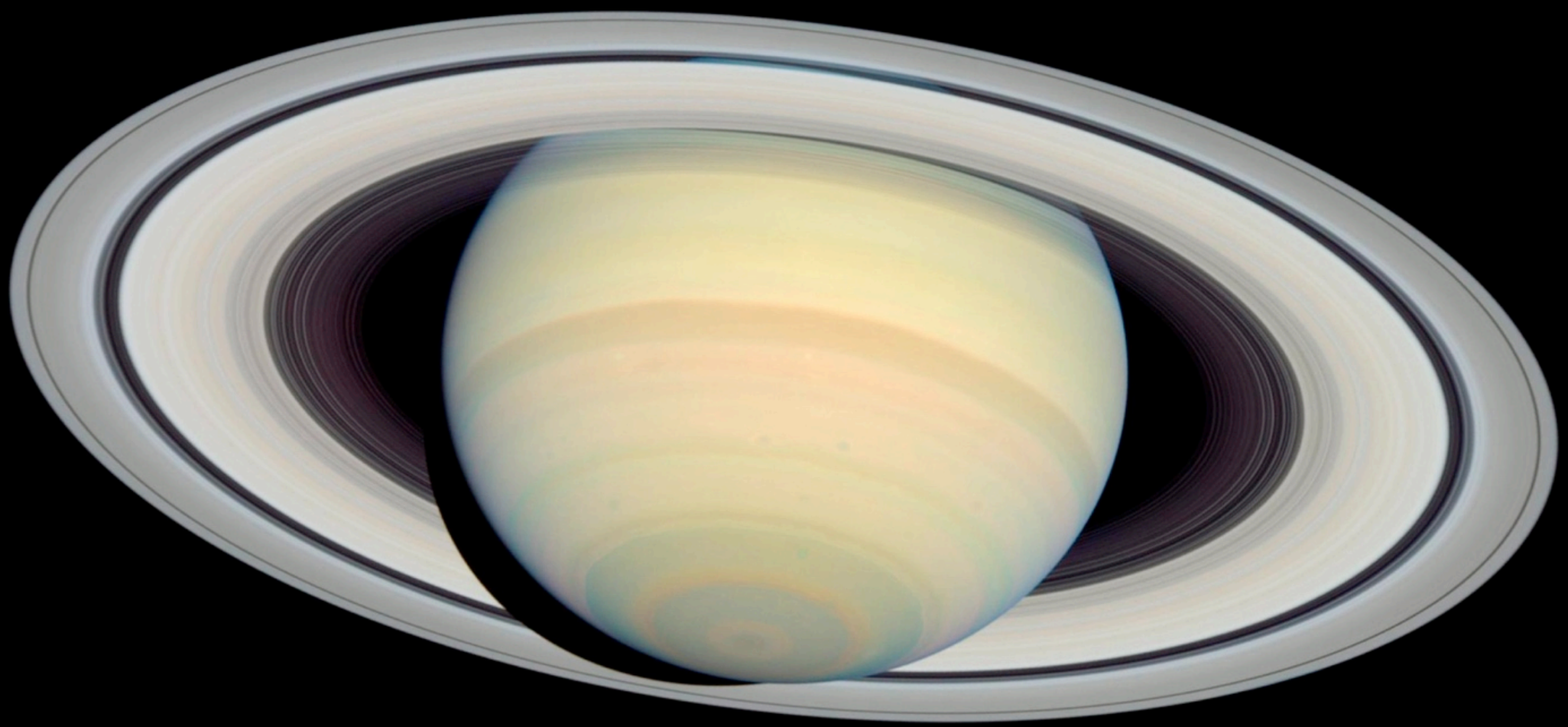
Jupiter



30″ - 50″

VLA 13cm

Saturn



15″ - 20″

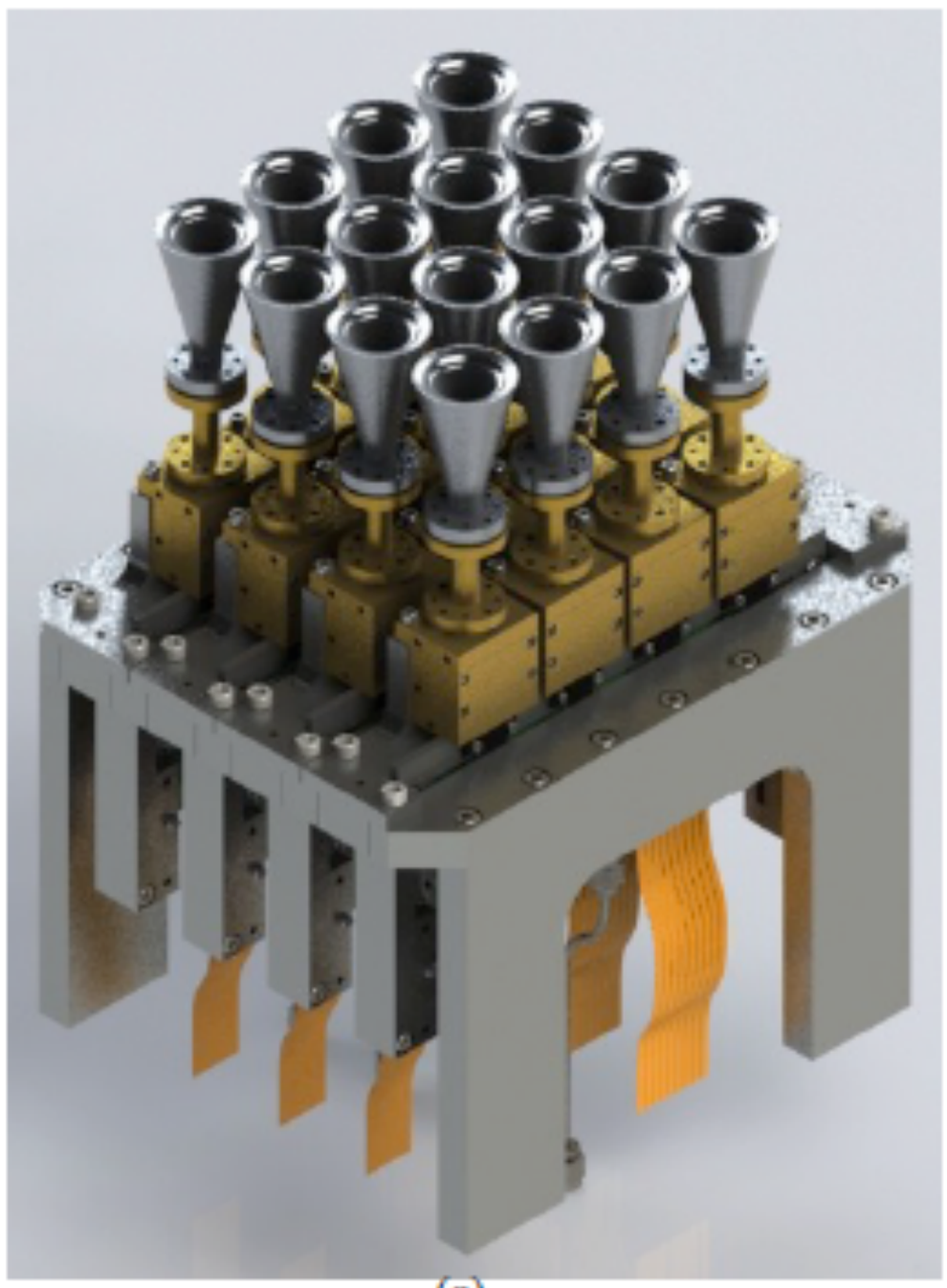
HST

Saturn

15″ - 20″

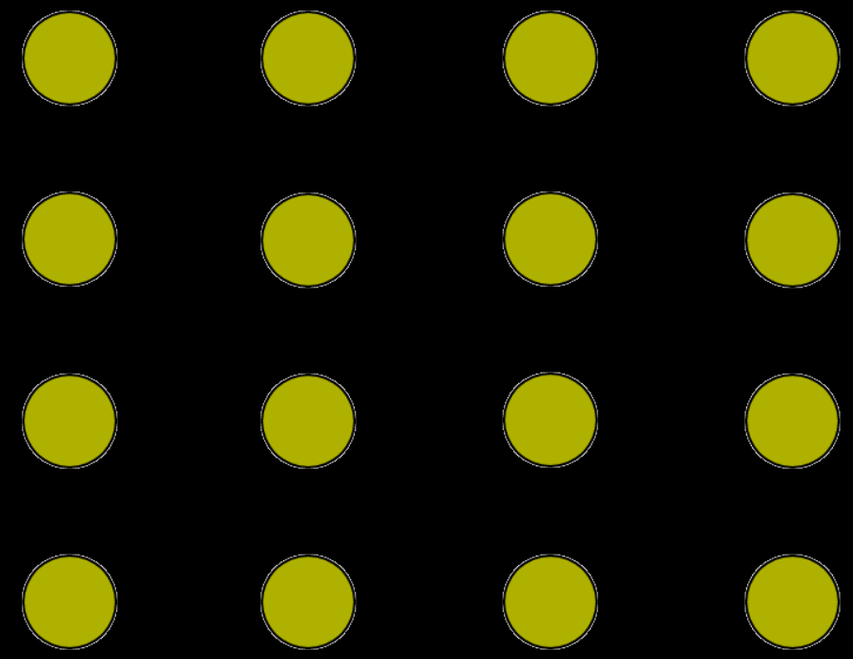
HST

ARGUS



(a)

footprint

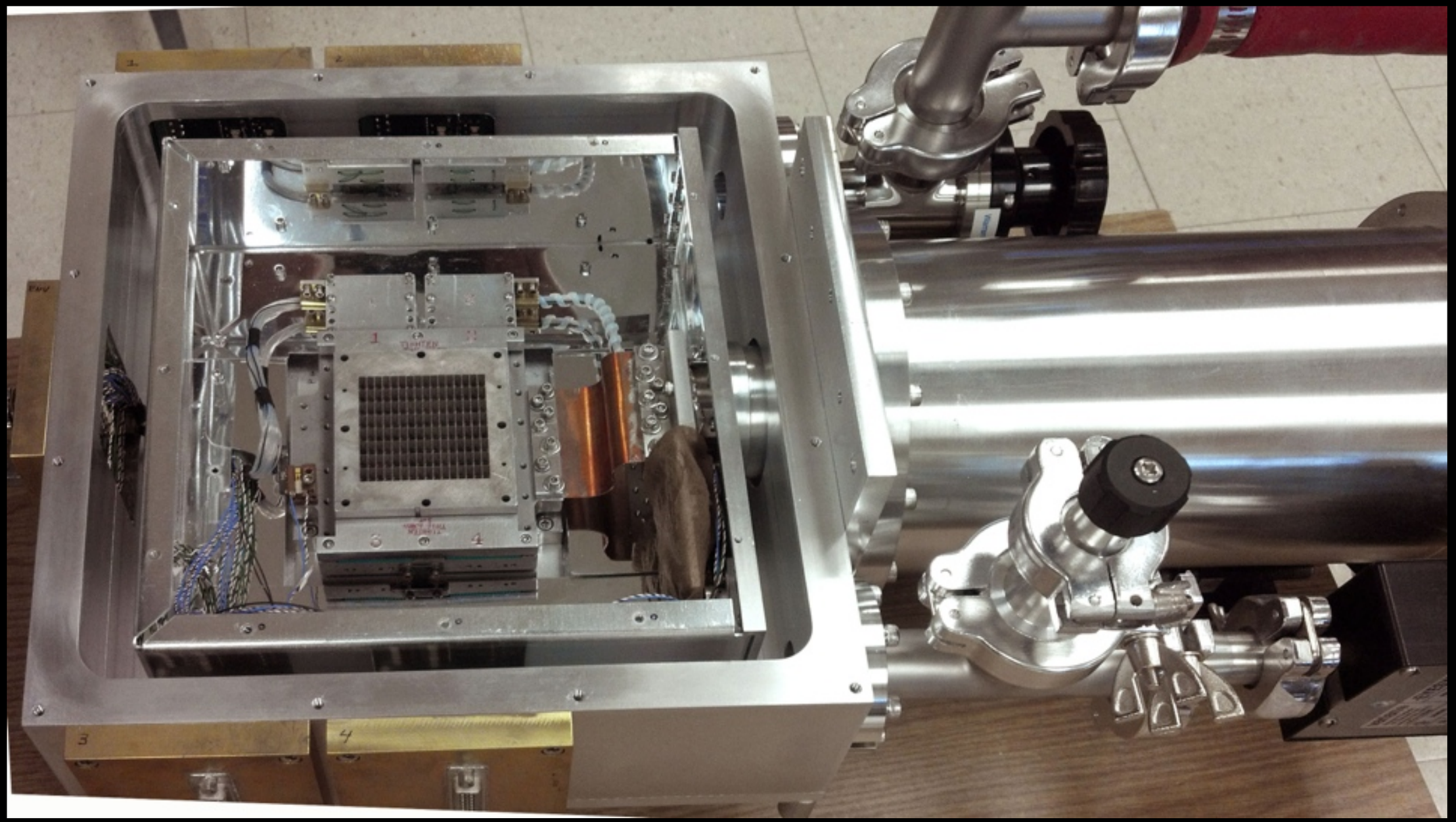


≈4% complete sampling

UMass Scalable 75-115 GHz PAF

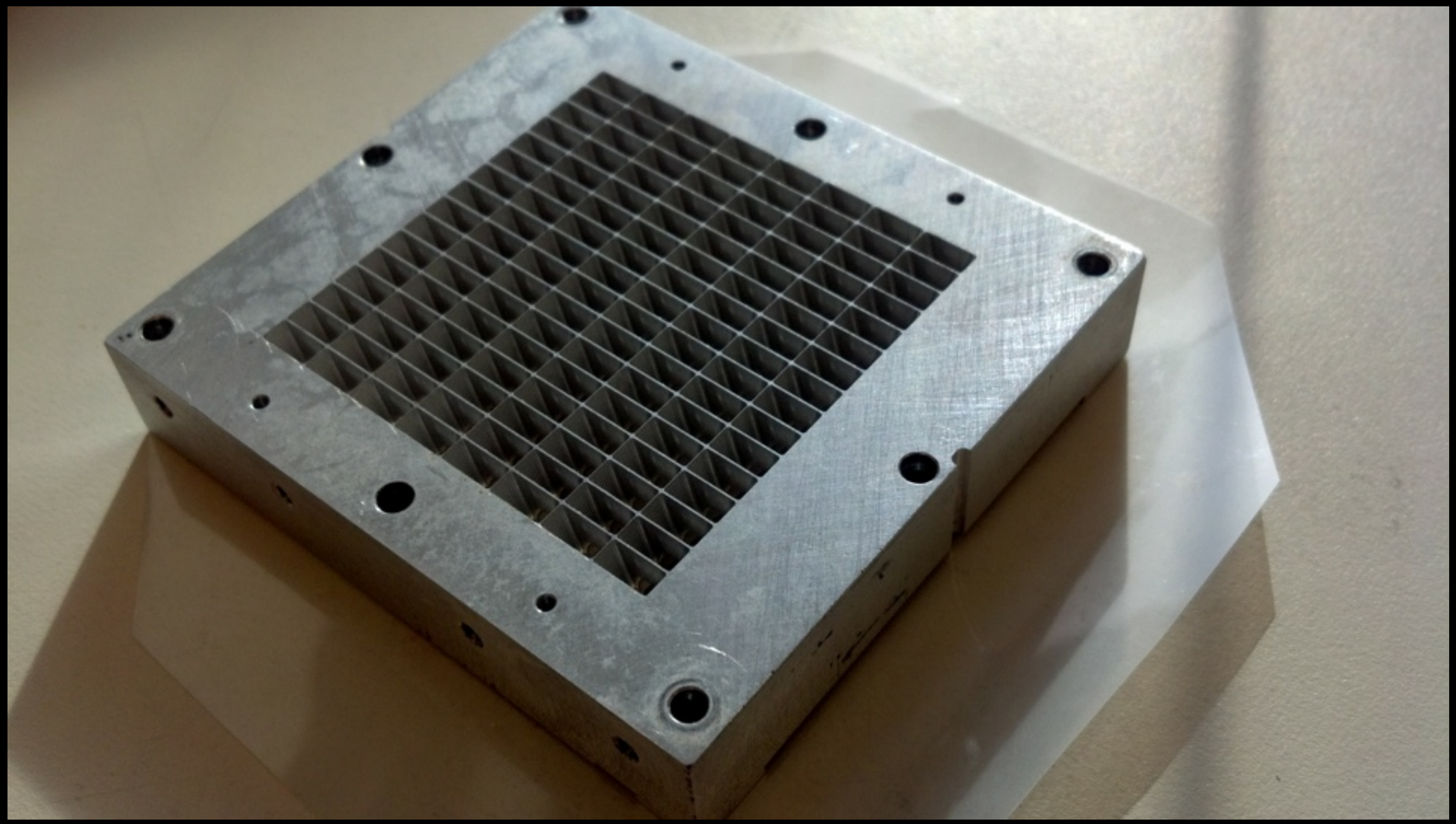
The wave of the future

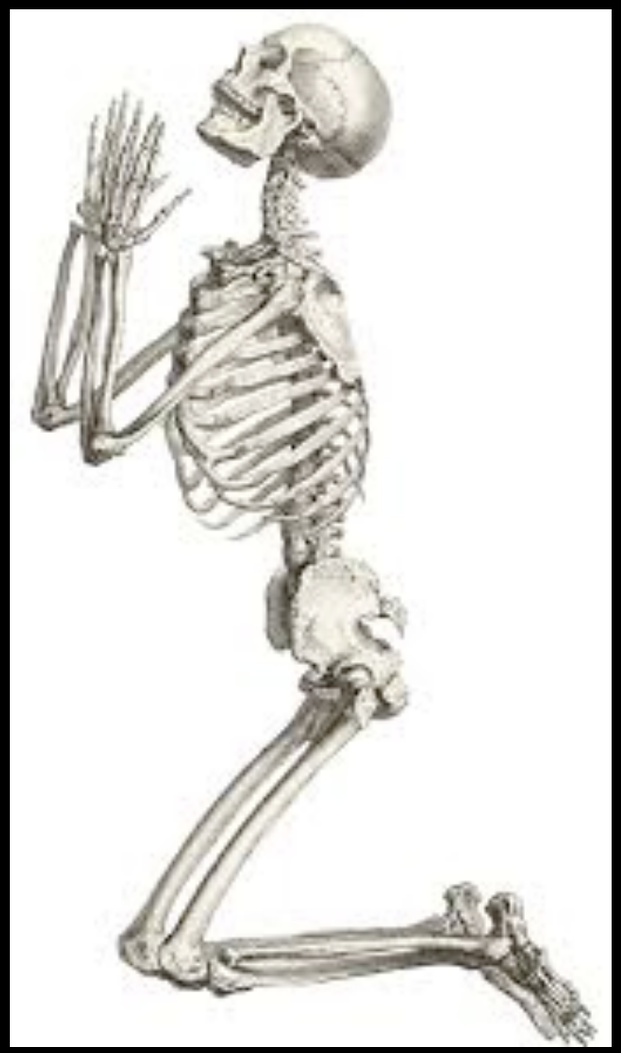
UMass Scalable 75-115 GHz PAF



The wave of the future

UMass Scalable 75-115 GHz PAF





How do I get to use the GBT?