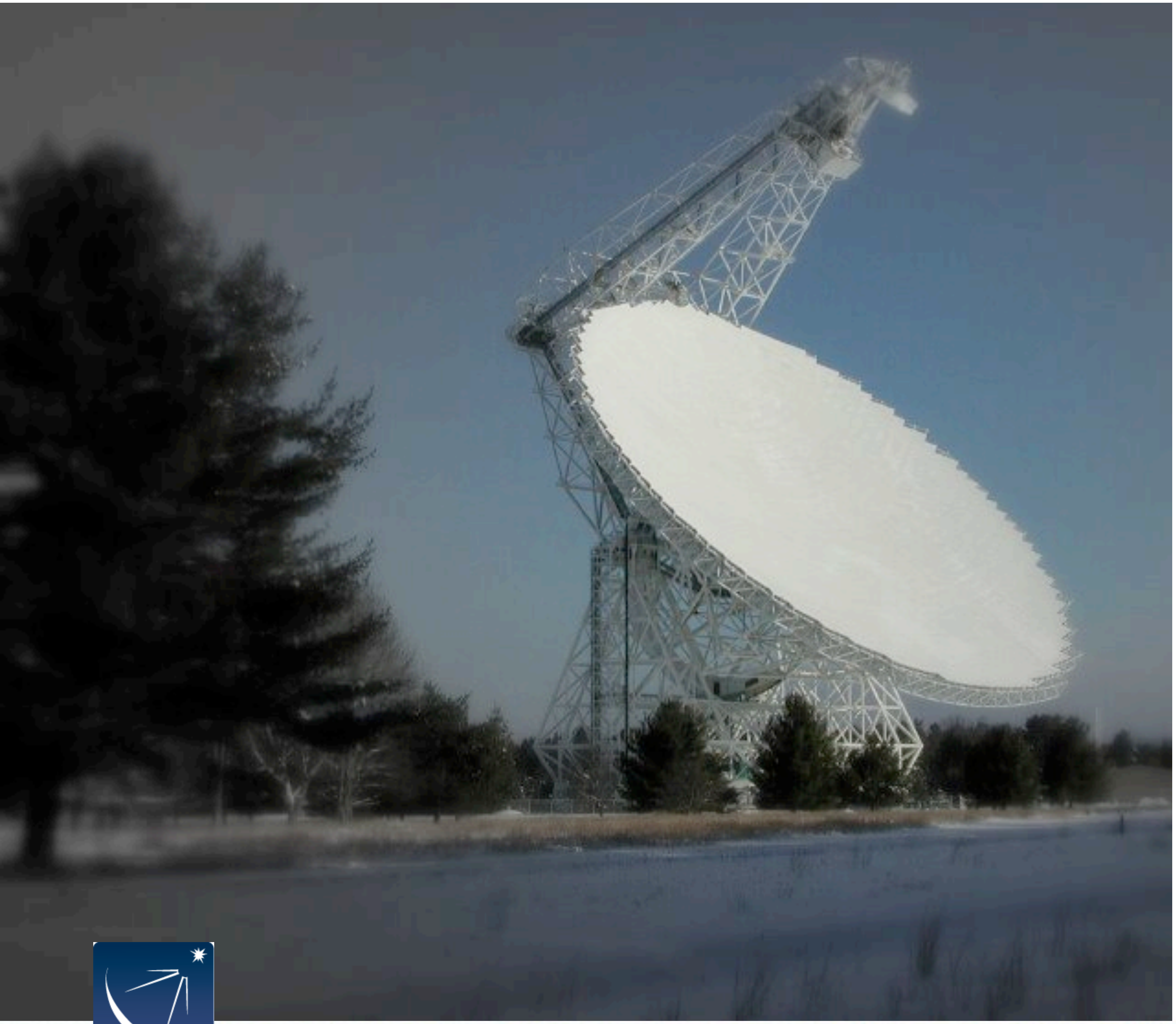
The Green Bank Telescope



Felix James “Jay” Lockman
NRAO, Green Bank

Large Collecting Area
Unblocked Aperture
Low sidelobes gives high dynamic range
Resistance to Interference
Excellent spectral Baselines
Excellent sensitivity to low surface brightness

Frequency coverage from 100 MHz–100 GHz
Spectroscopy, Continuum, Pulsar, VLBI

>85% Sky Coverage $\delta \geq -46°$
Pointing to 1”–2” accuracy
Surface good for 3mm work

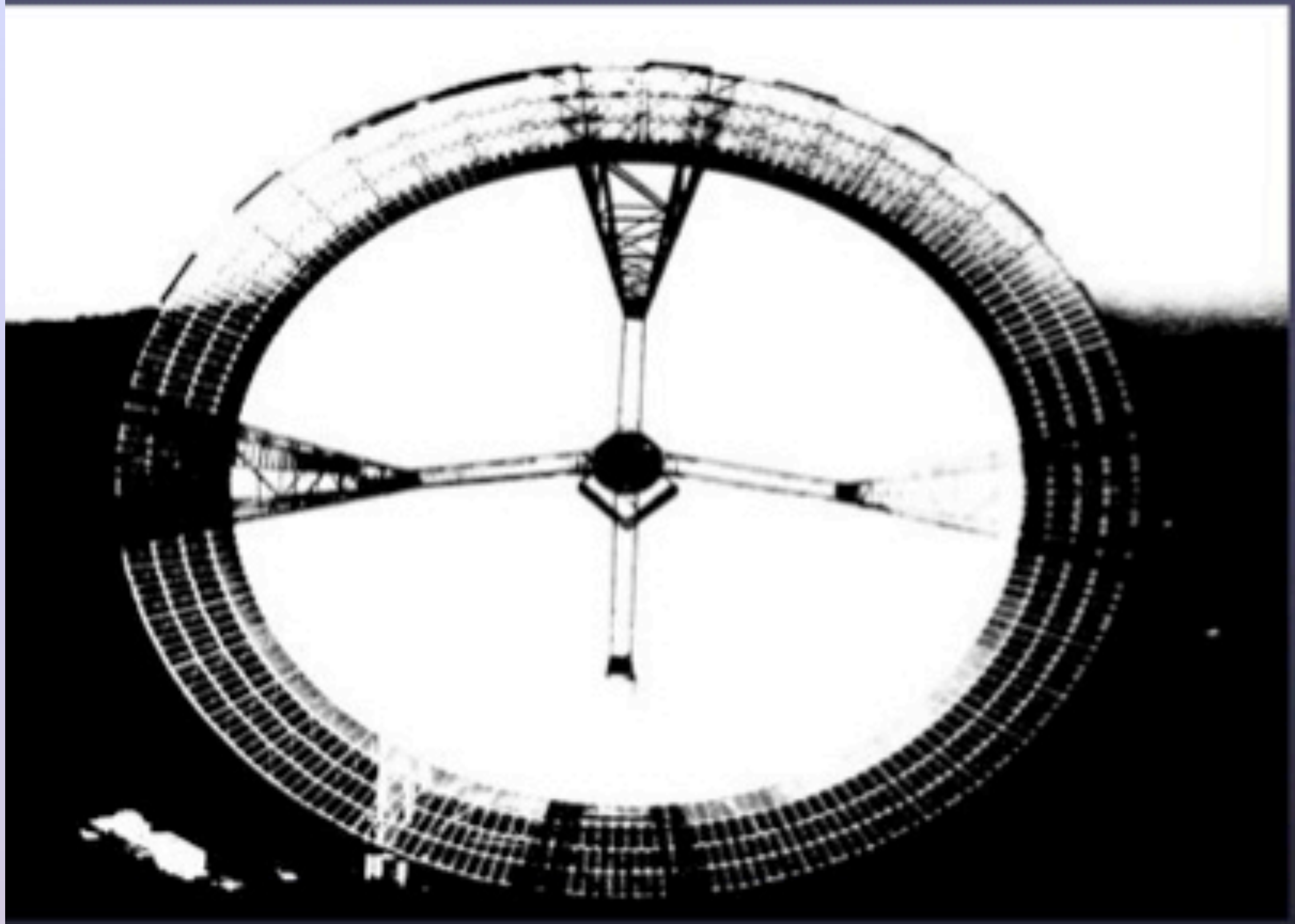
Active Instrument Development Program

Site Protected by a 13000 km^2 Radio Quiet Zone

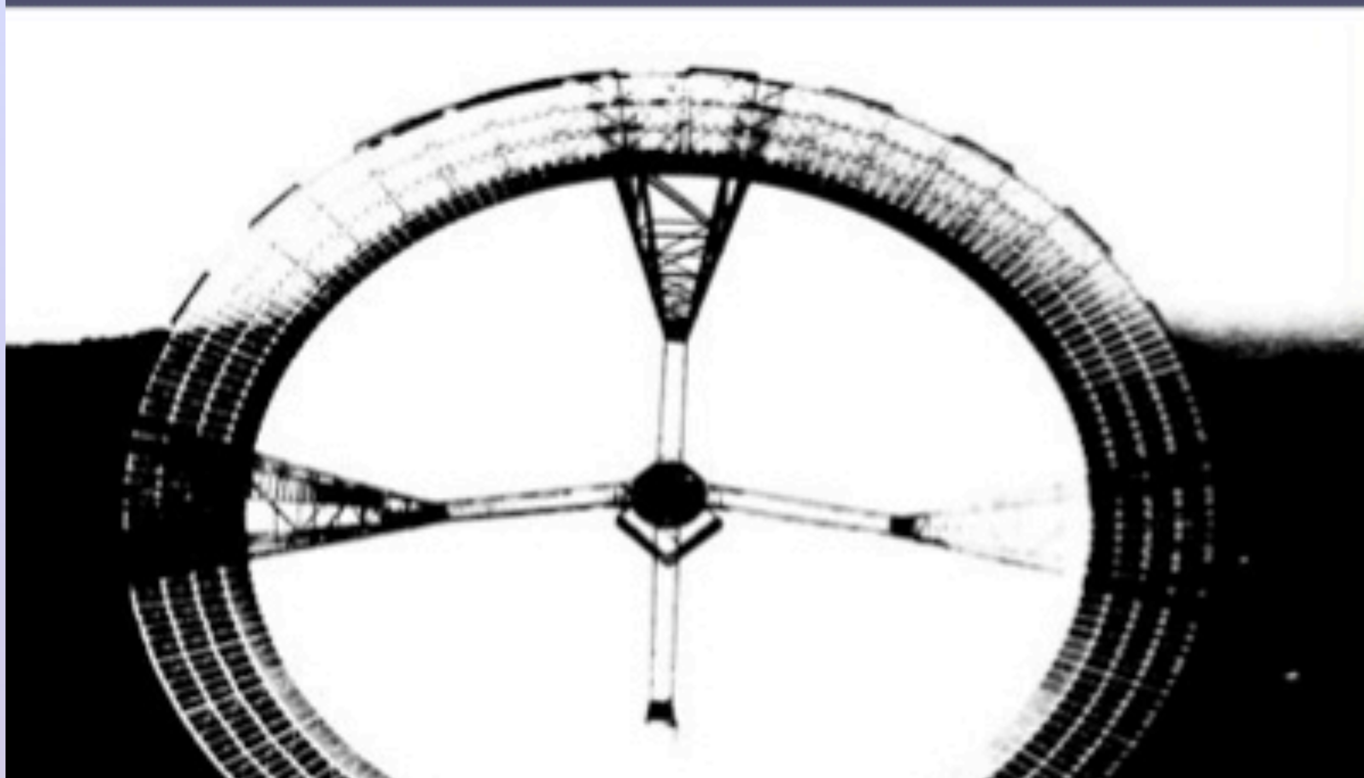

National Radio
Quiet Zone

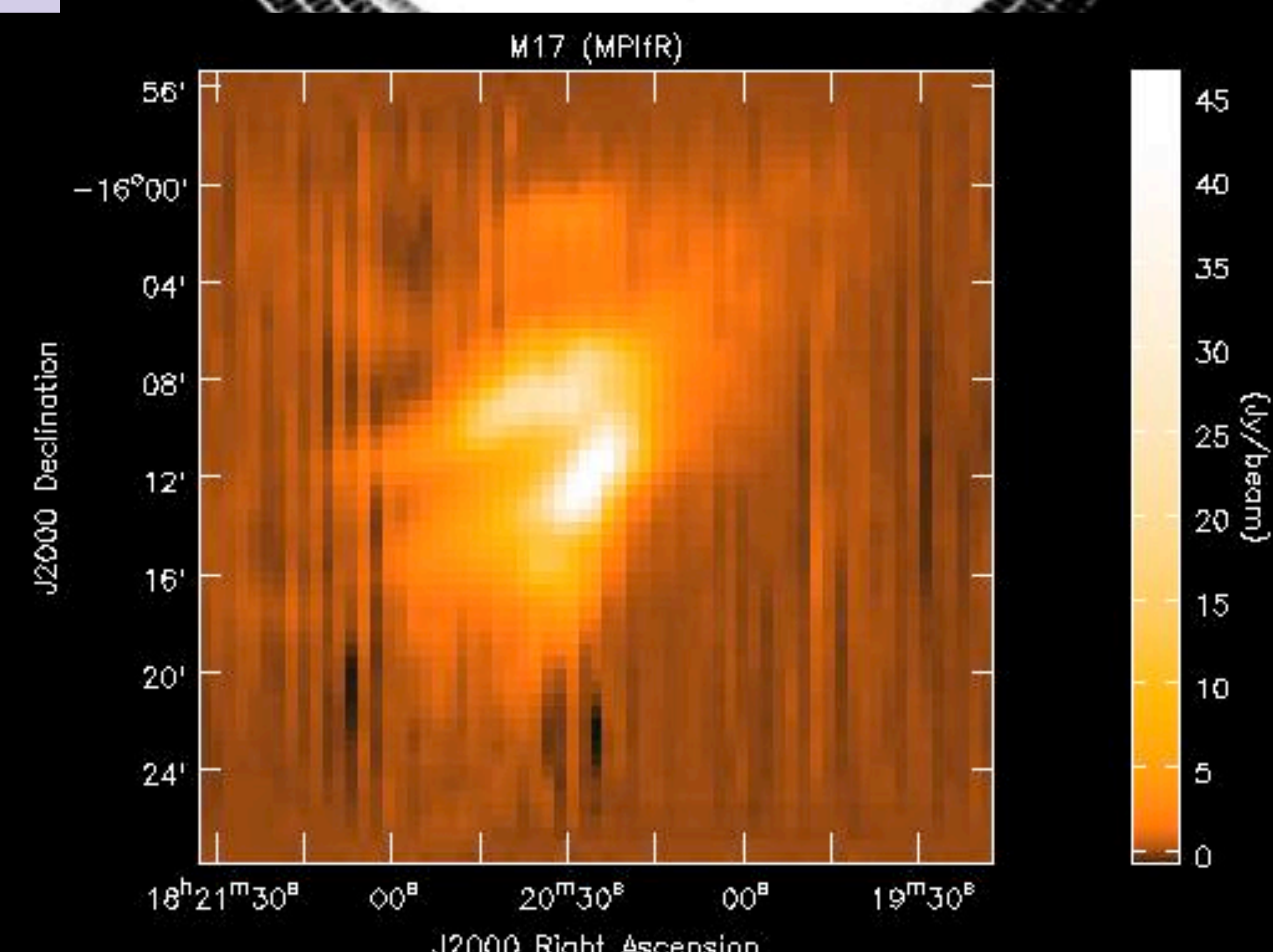
Unblocked Optics for high dynamic range

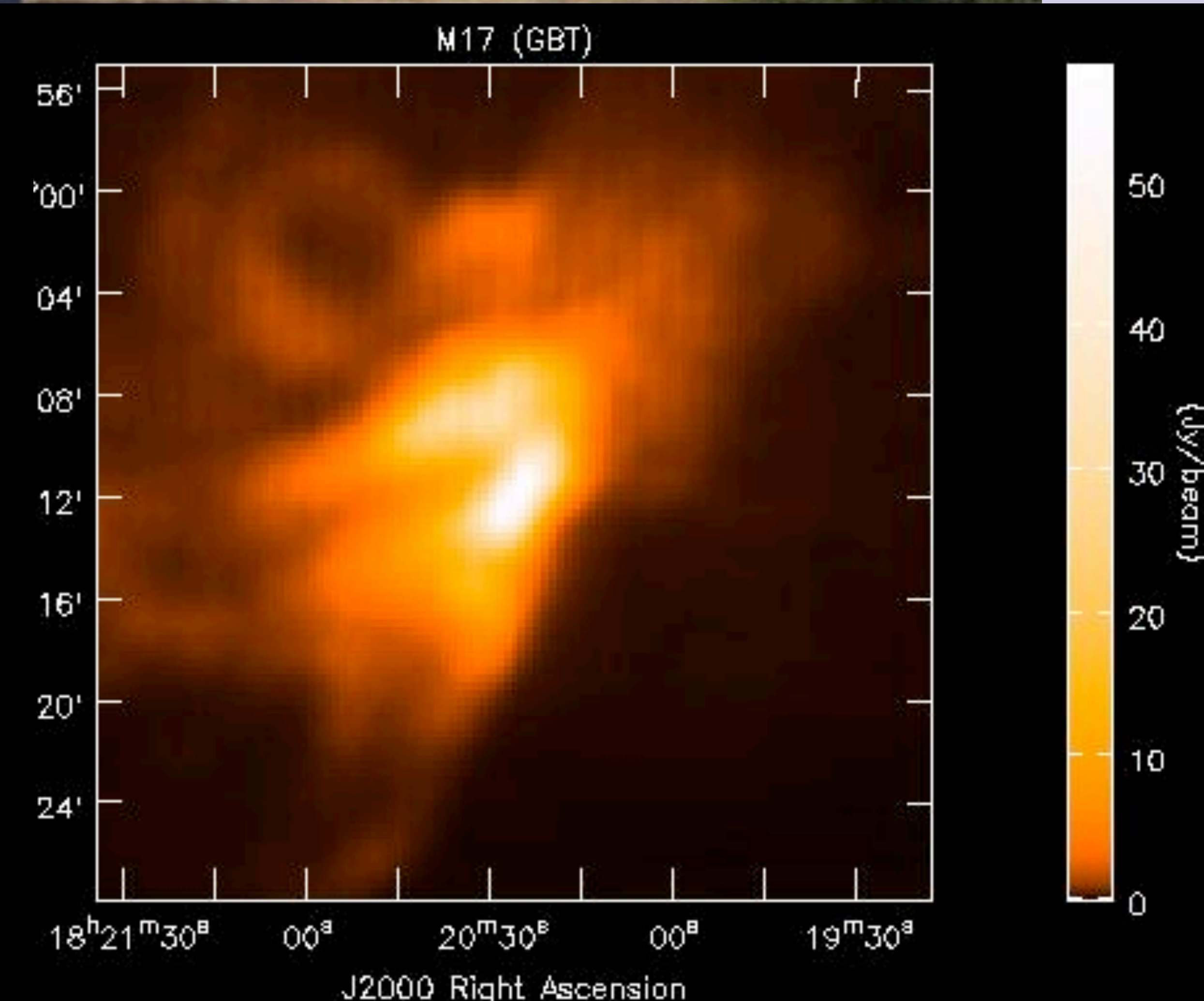
Unblocked Optics for high dynamic range



Unblocked Optics for high dynamic range



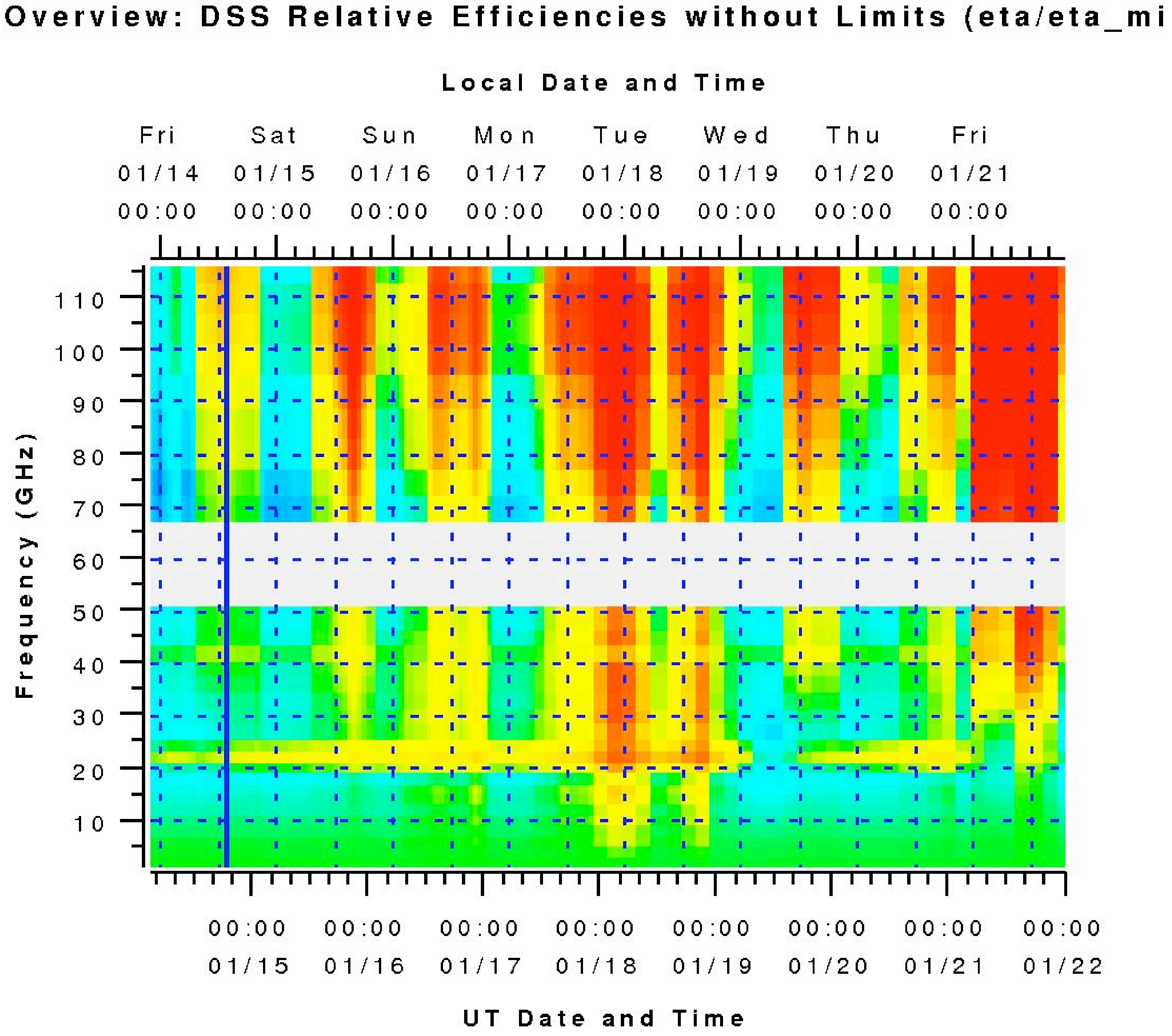




Last updated: Fri, Jan 14, 19:00:00 UT

Ronald J Maddalena
National Radio Astronomy Observatory
Green Bank, WV

GBT Dynamic Scheduling matches the project to the weather

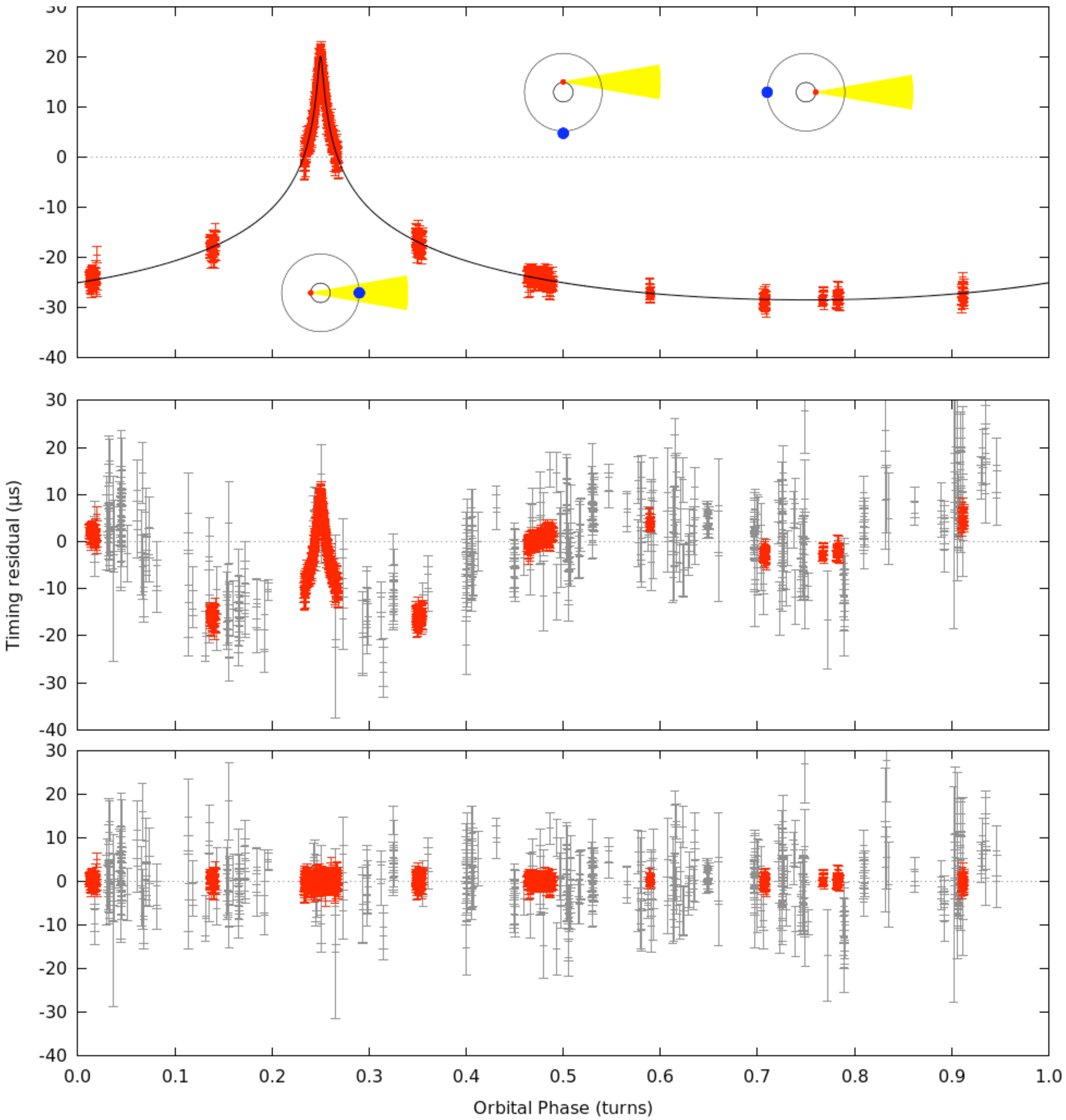


1776 hours of observing at >18 GHz dynamically scheduled in 2010 -- this amount should rise in the coming years

A Cruise Through Some Recent GBT Science

- HI Intensity Mapping
- Discovery of new pulsars
- Redshifted HI and OH
- The most massive pulsar
- Solar System Radar
- New sources of anions
- Water in M31
- Nuclear Black Hole masses
- Shocks in Galaxy Clusters
- Galaxy Growth and Evolution
- Quiescence in Cloud Cores
- Limits on Fundamental “constants”

GBT measurements test fundamental physics with radio pulsar J1614-2230



~1 week of GBT timing observations with coherent GUPPI

Orbital inclination = 89.17(2) deg!

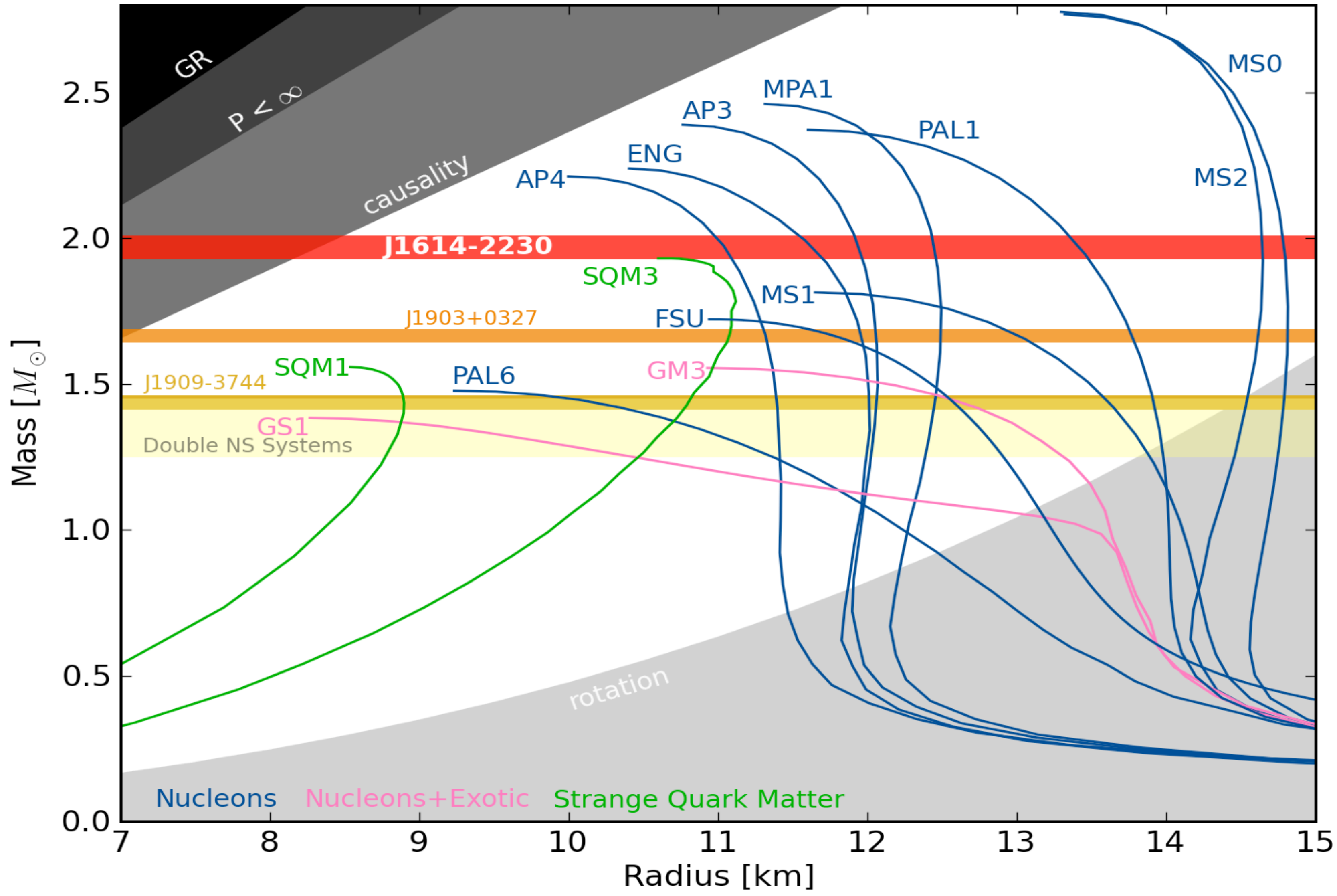
Companion mass = 0.500(6) solar!

Pulsar mass = 1.97(4) solar!

(Demorest et al. 2010)

NRAO

(Demorest et al. 2010)



The new mass determination for PSG J1614-2230 makes it the most massive pulsar known, and rules out a number of soft equations of state for nuclear matter including many “exotic” hyperon, kaon models.

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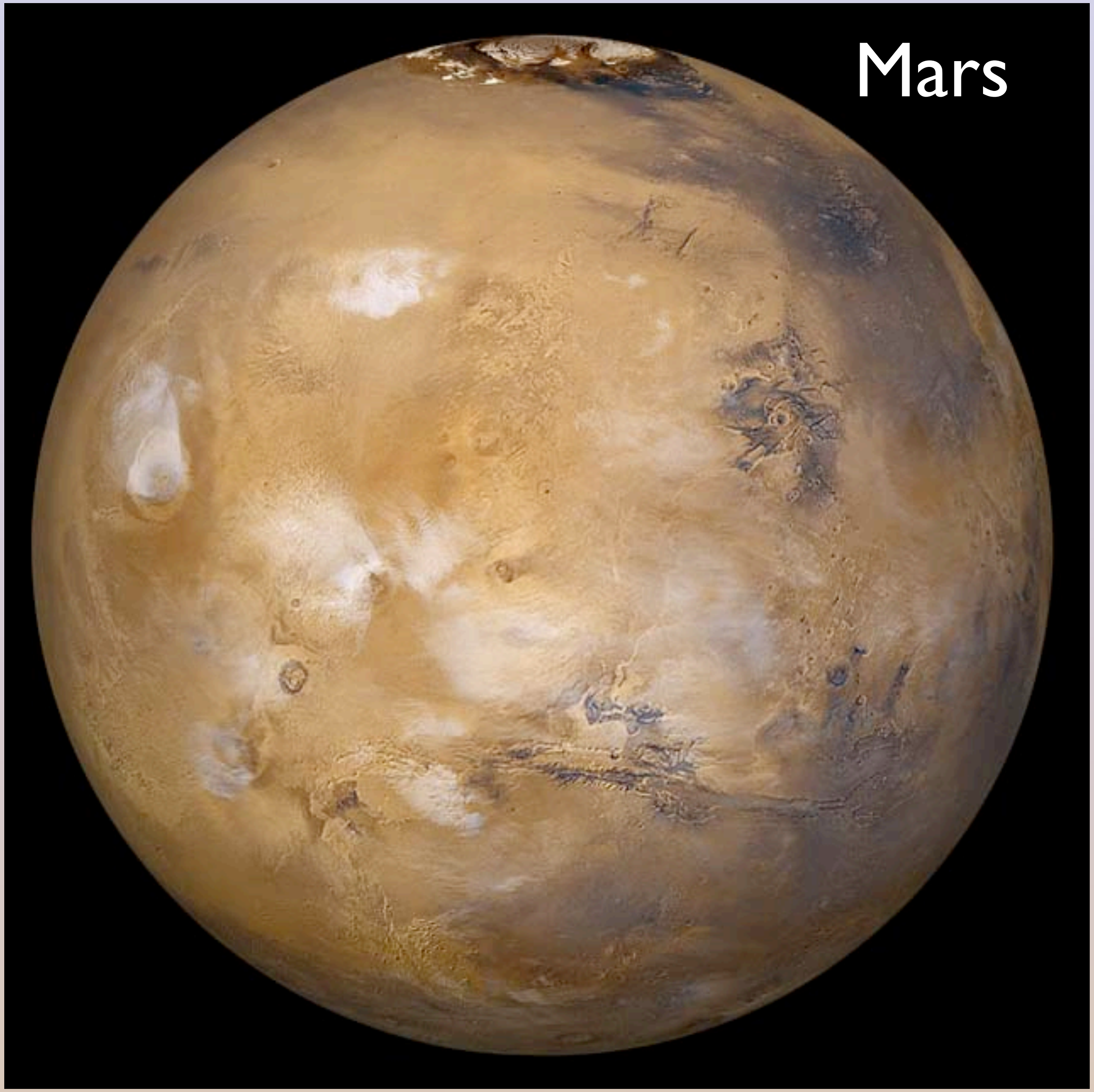
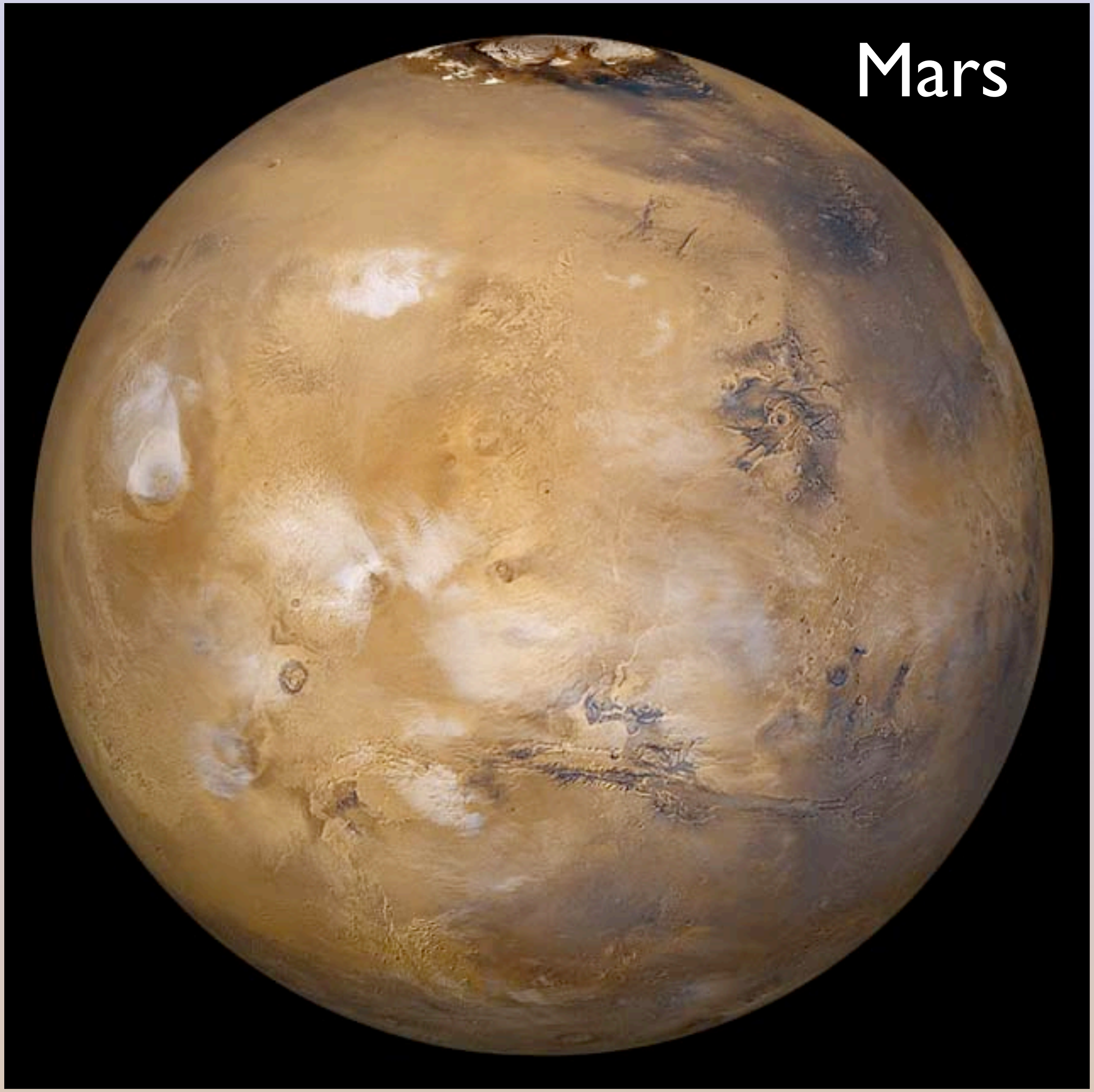
When is a planet like a disco ball?

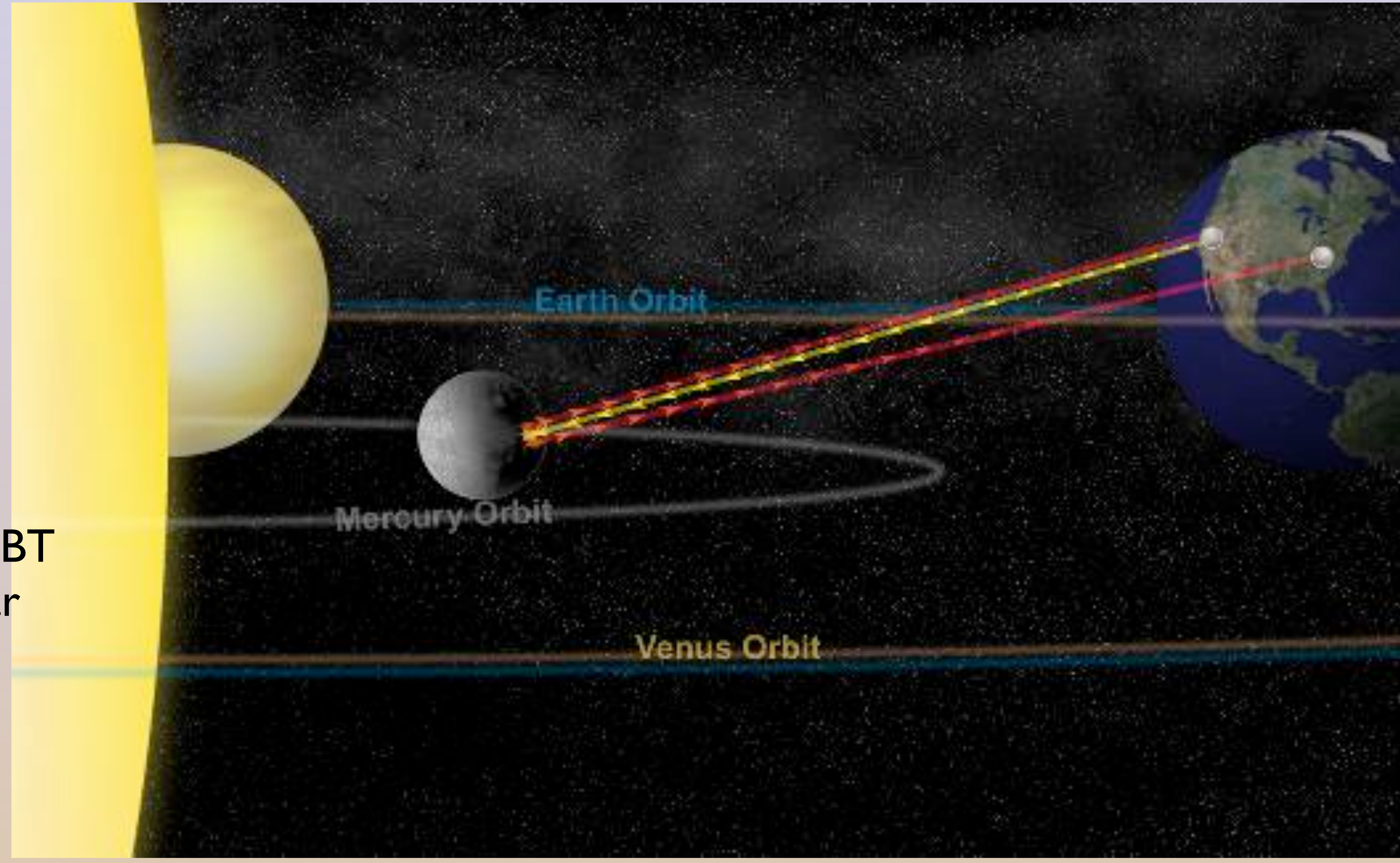


When is a planet like a disco ball?

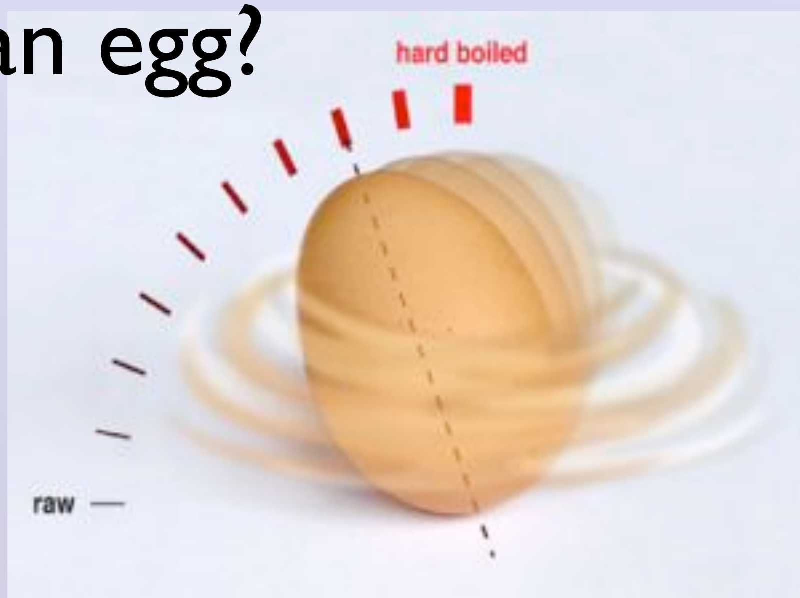
When you illuminate it with radar.

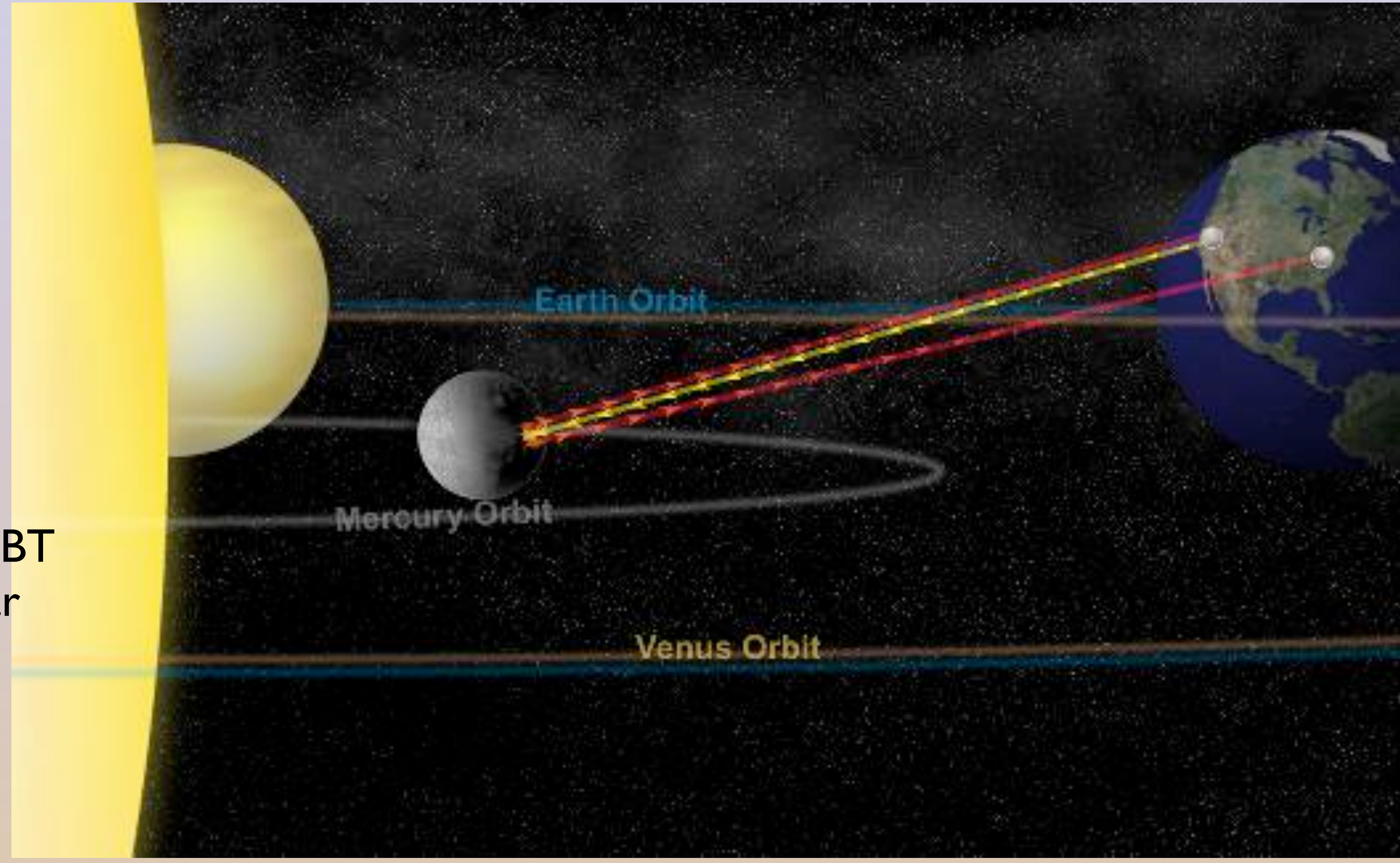


Goldstone + GBT
Bistatic Radar



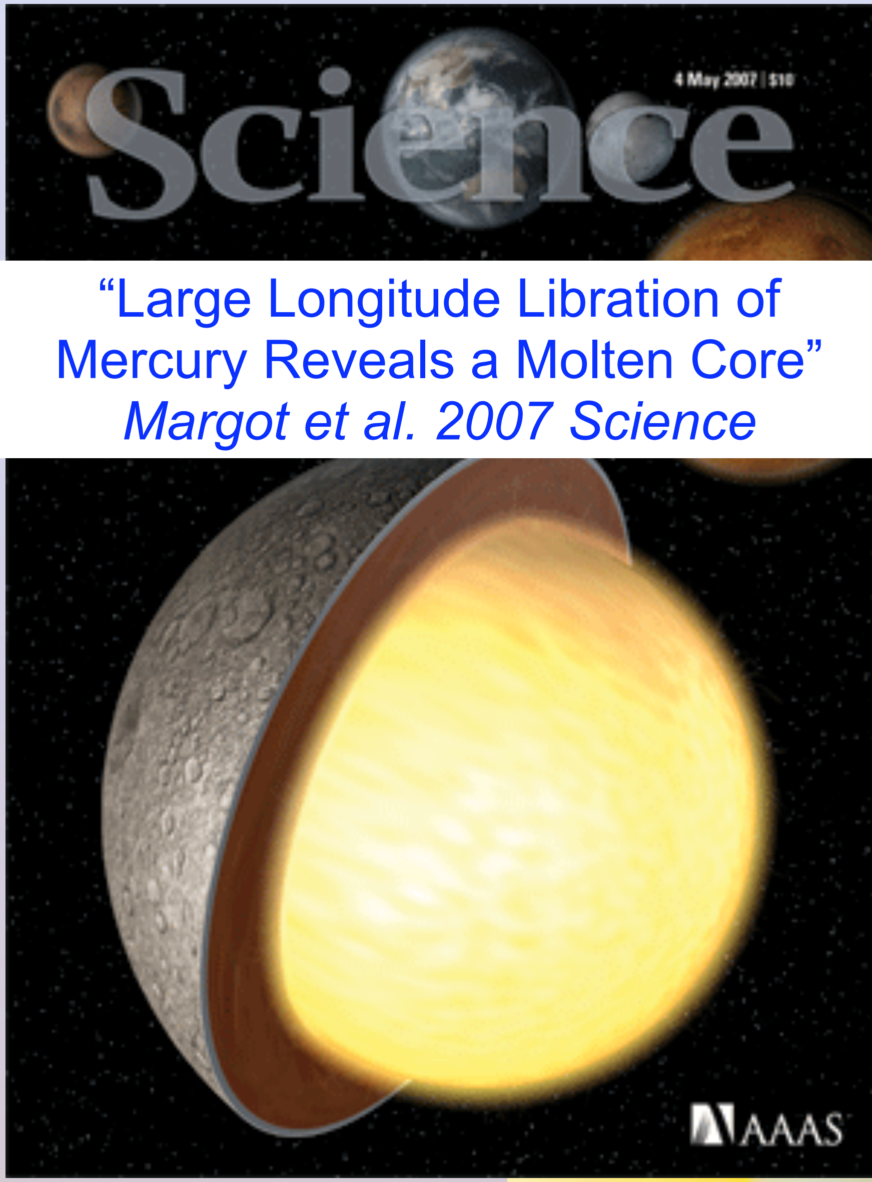
When is a planet like an egg?





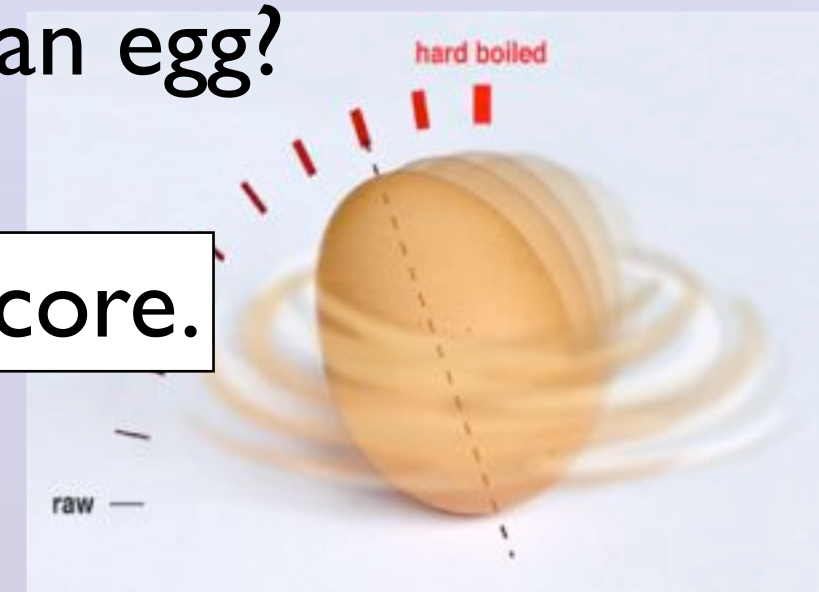
Goldstone + GBT
Bistatic Radar

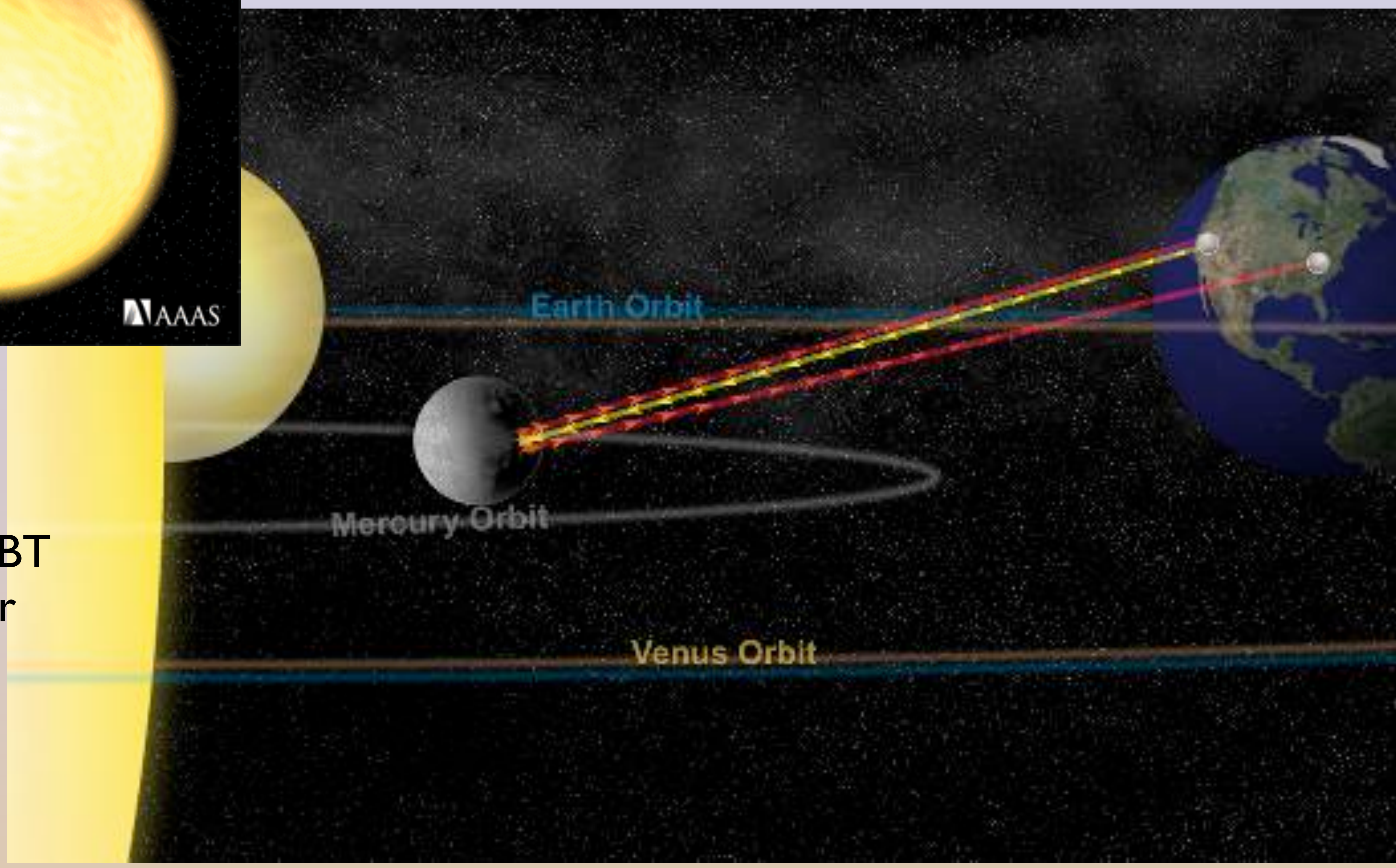
When is a planet like an egg?



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

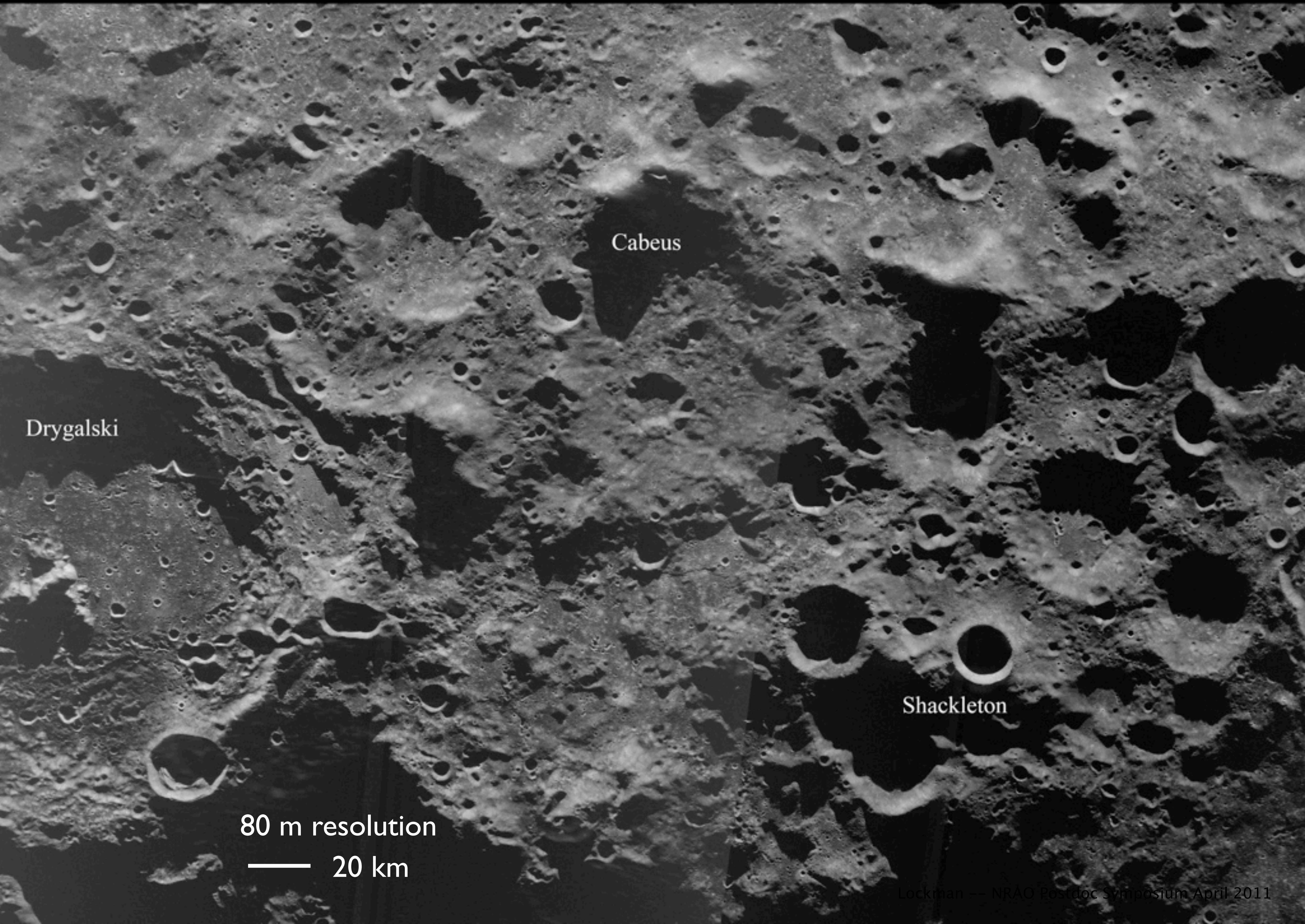
When it has a molten core.





Goldstone + GBT
Bistatic Radar

Arecibo-Green Bank Telescope Radar View of the Moon's South Pole (Courtesy Cornell University/Smithsonian Institution)



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>12 new organic molecules detected including the first interstellar anions: C_6H^- & C_8H^-

Cordiner et al. 2011 new anion sources

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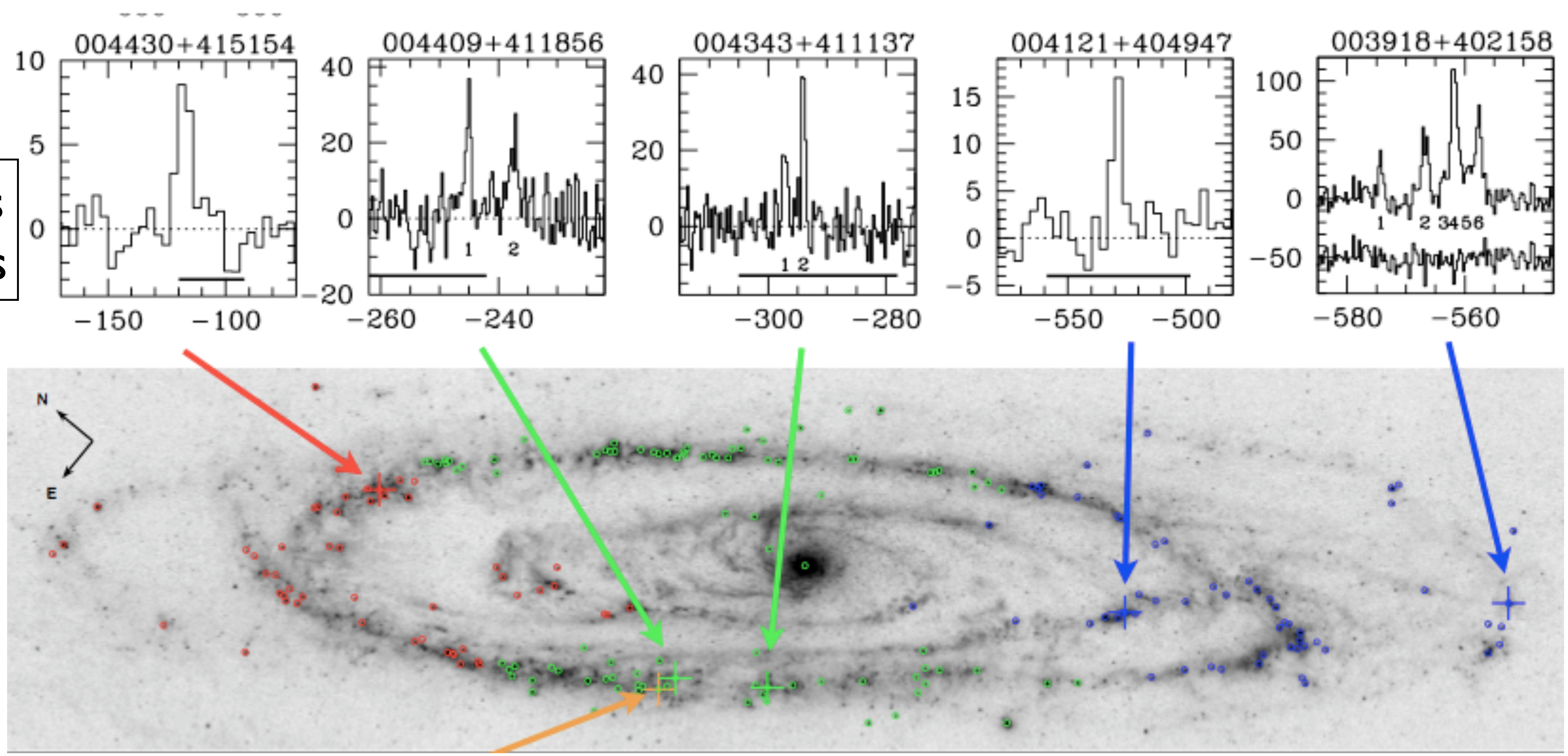
GBT Discovery of H_2O Masers in M31

J. Darling (Univ. Colorado)

The Proper Motion of M31 is the Keystone of Local Group Dynamics

At the distance of M31 the GBT can detect
Galactic analog H_2O masers in 5 minutes

206 sources
5 detections



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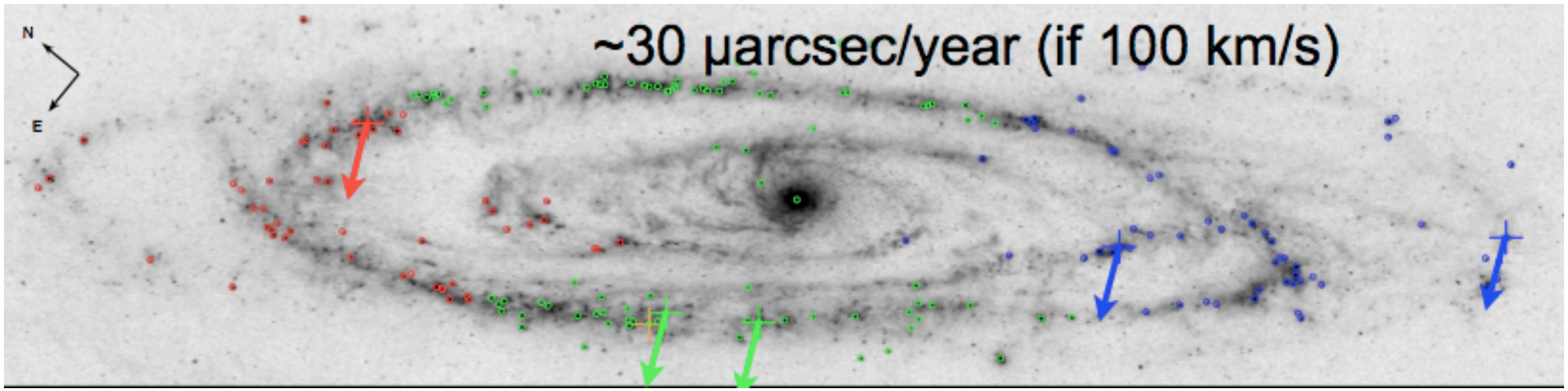
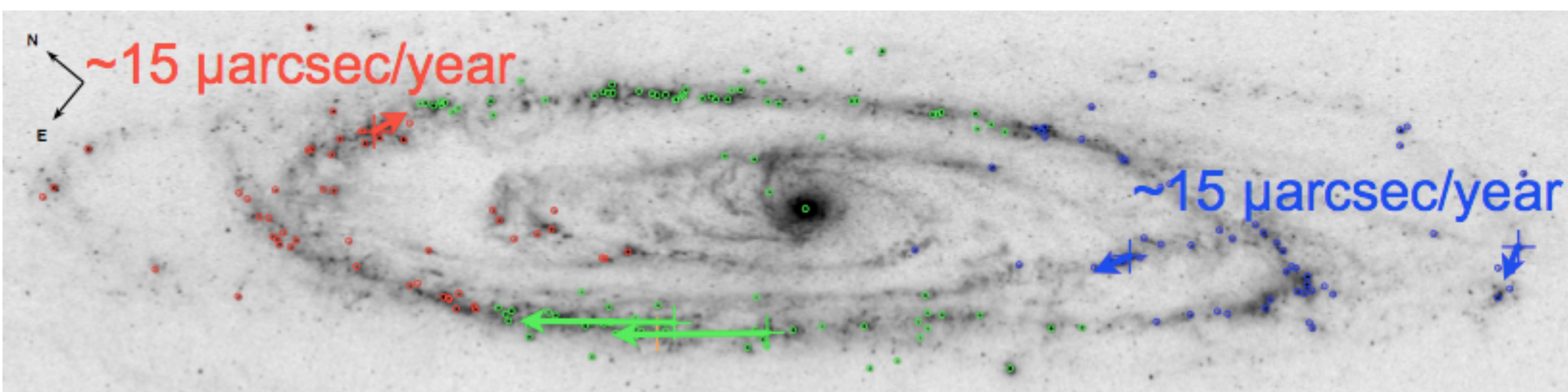


Expect 6σ detection of proper motion in ~3 years

arrows not to scale



~70 μarcsec/year

Proper <u>rotation</u> gives a geometric distance -- expect 10% uncertainty initially

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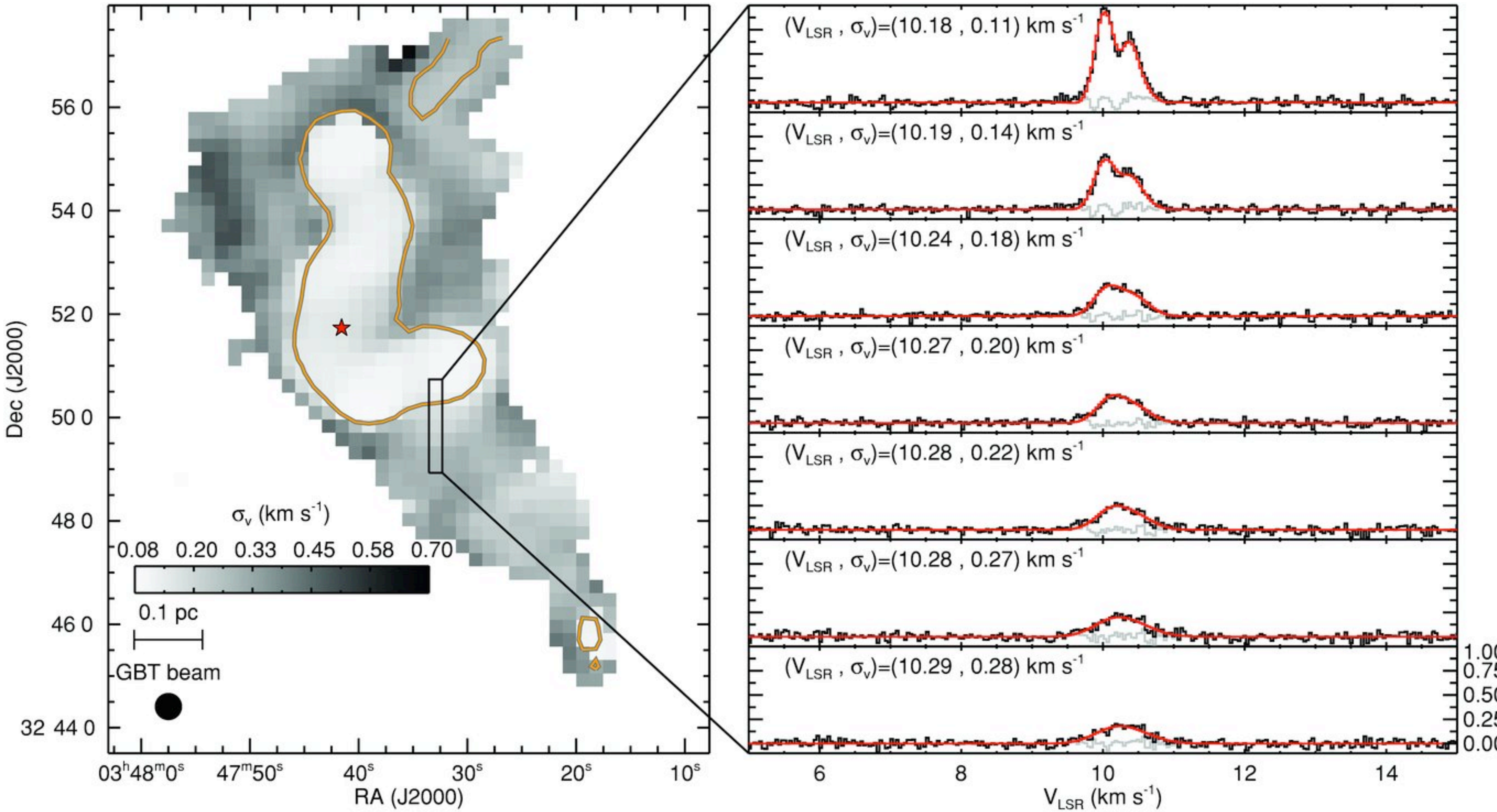
Direct Observation of a Sharp Transition to Coherence in Dense Cores

Pineda et al 2010, ApJ



The GBT K Band Focal Plane Array is up and running

KFPA
NH_3 (1,1)

Ammonia mapping of dark clouds
Finn & Jackson

New Spectrometer on the way (with UCB)

NRAO

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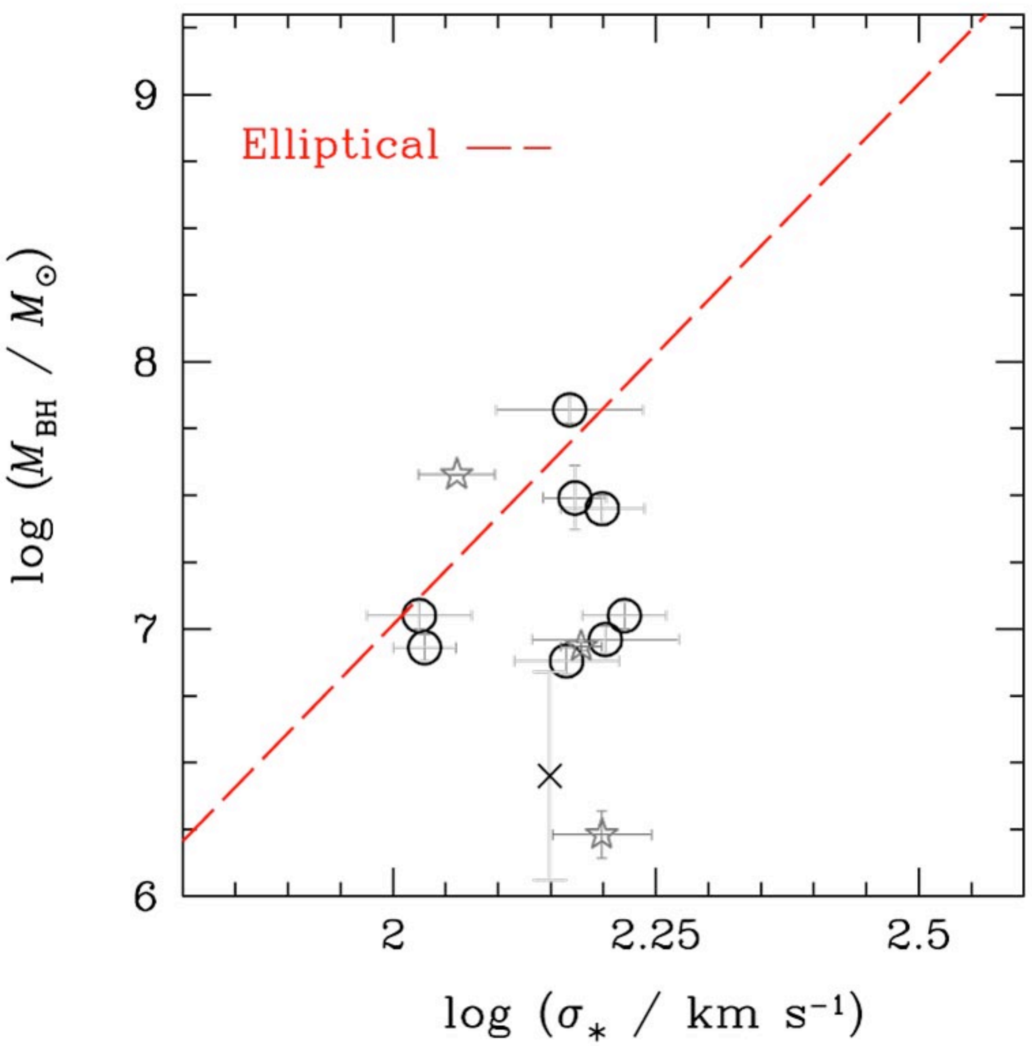
GBT and HSA Measurements of Black Hole Masses

H2O masers discovered with the GBT
Nuclear disk mapped with the HSA
Black Hole masses obtained for Seyfert galaxies

SMBH masses in Seyfert galaxies lie below the "universal" line defined by SMBH's in elliptical galaxies

Kuo et al. 2011
Greene et al. 2010



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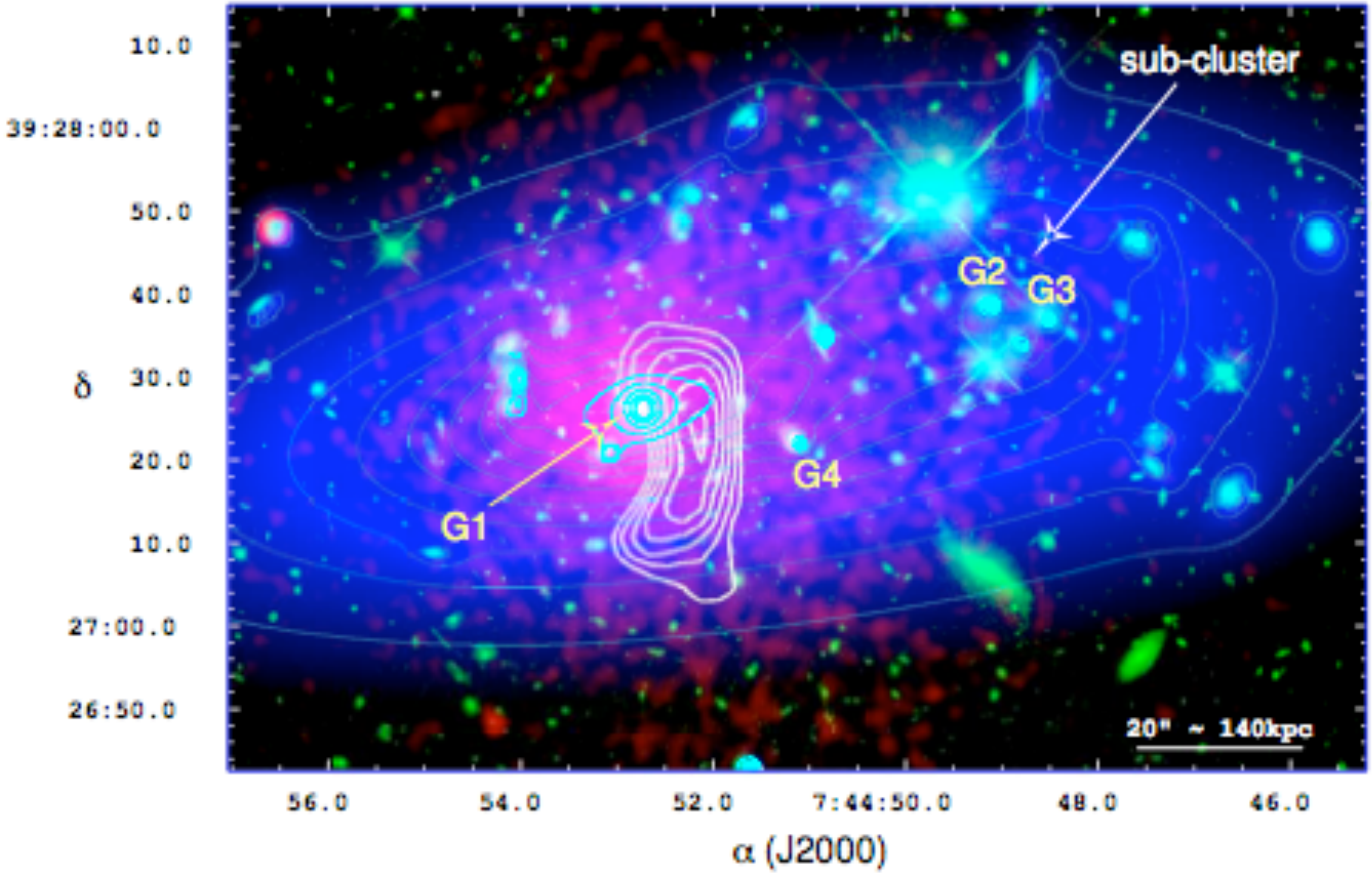
MUSTANG 3mm Bolometer Array

MACS0744+3927 [z=0.69]

Korngut et al (2011)



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A Cruise Through Some Recent GBT Science

- HI In
- Disc
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- Grov
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The ragged edges of HI disks

HALOGAS WSRT Survey
Heald et al. 2011, in press
15" resolution to N_{HI} limit few 10^{19}
120 hours per galaxy

G. Heald et al.: The WSRT HALOGAS survey. I.

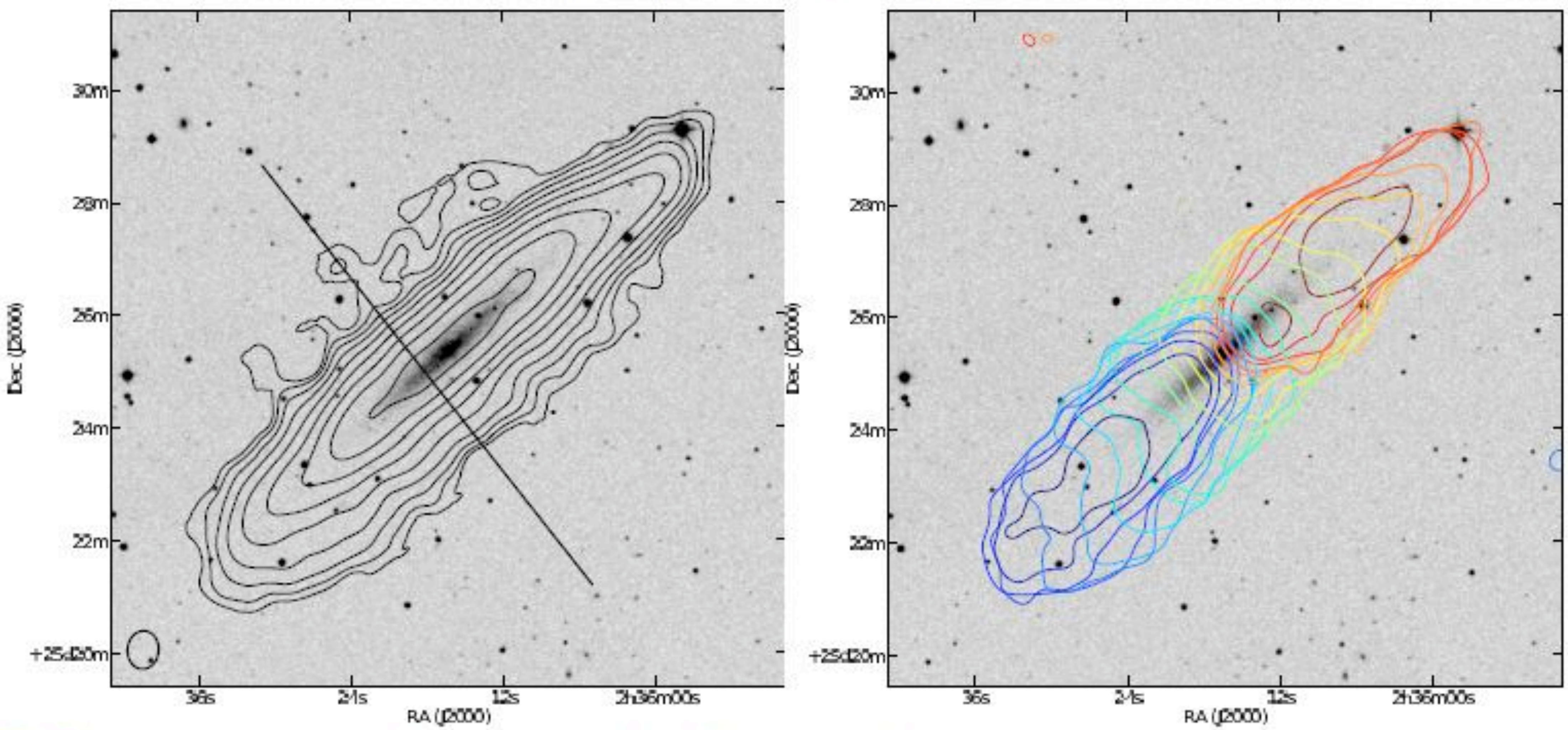


Fig. 1. Overview of the HALOGAS observations of UGC 2082. The *left panel* shows the H I total intensity overlaid on the DSS *R*-band image. The H I contours originate from the 30″-tapered image, begin at $N_{HI} = 1.0\times10^{19}$ cm^{-2} and increase by powers of two. The straight line shows the orientation of the PV slice shown in Fig. 2. The *right panel* shows an overlay of several channels in the lowest resolution data cube, all at a level of 0.9 mJy beam^{-1} (≈3.75σ). The contours are separated by 12.4 km s^{-1}, begin at 593 km s^{-1} (dark blue) and range upward to 815 km s^{-1} (dark red). *Both panels* show the same area of the sky. The beam size of the H I data is shown in the *lower left* corners of the *left panel*.

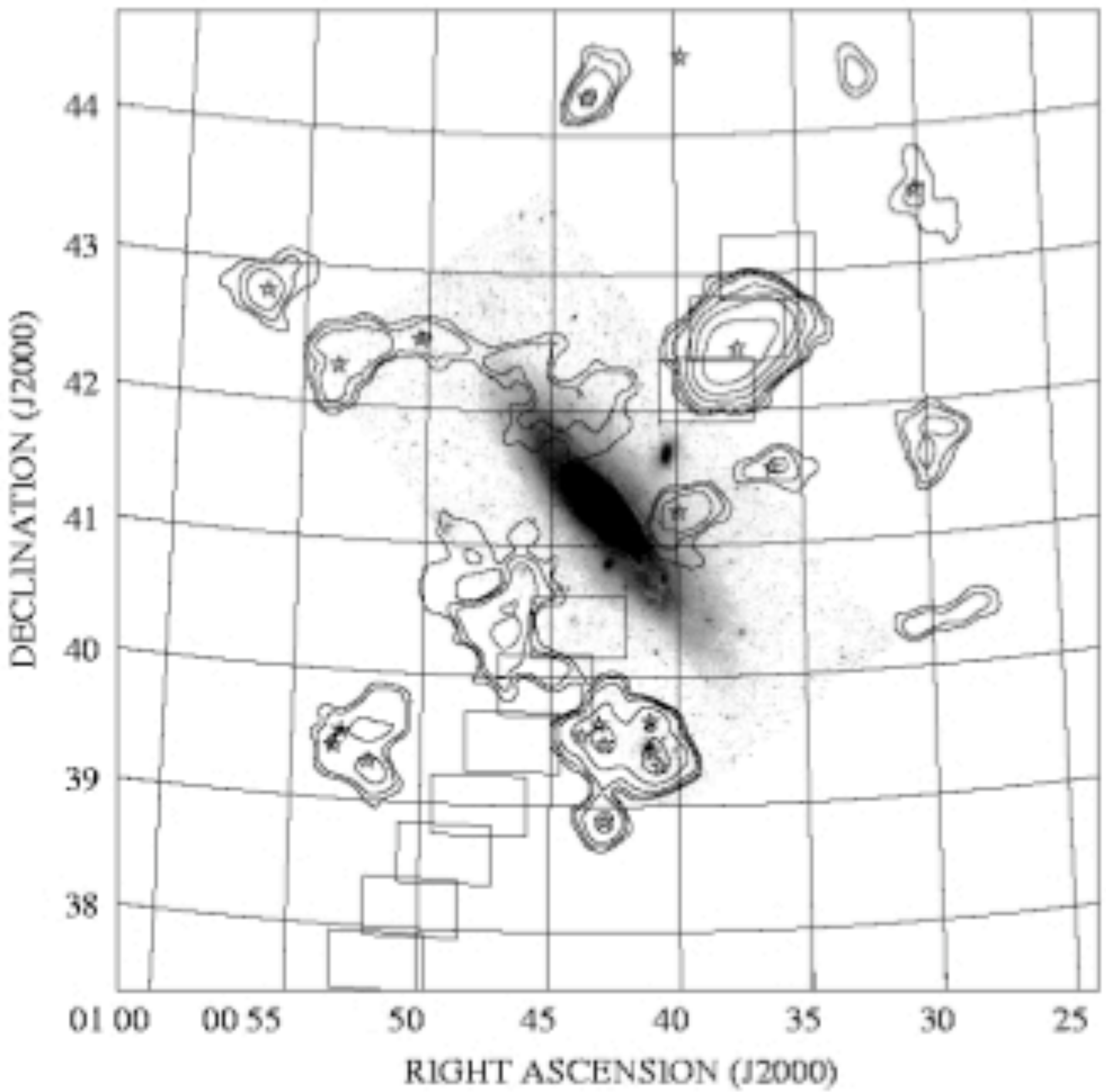
HVCs around other galaxies

M31 -- GBT

Thilker et al. 2004, ApJ, 601, L39

contours at 0.5,1,2,10,20 x 10^{18}

HI Masses = 10^{6-7} M⊙



M33 -- Arecibo

Grossi et al. 2008, A&A, 487, 161

lowest contour 2x10^{18}

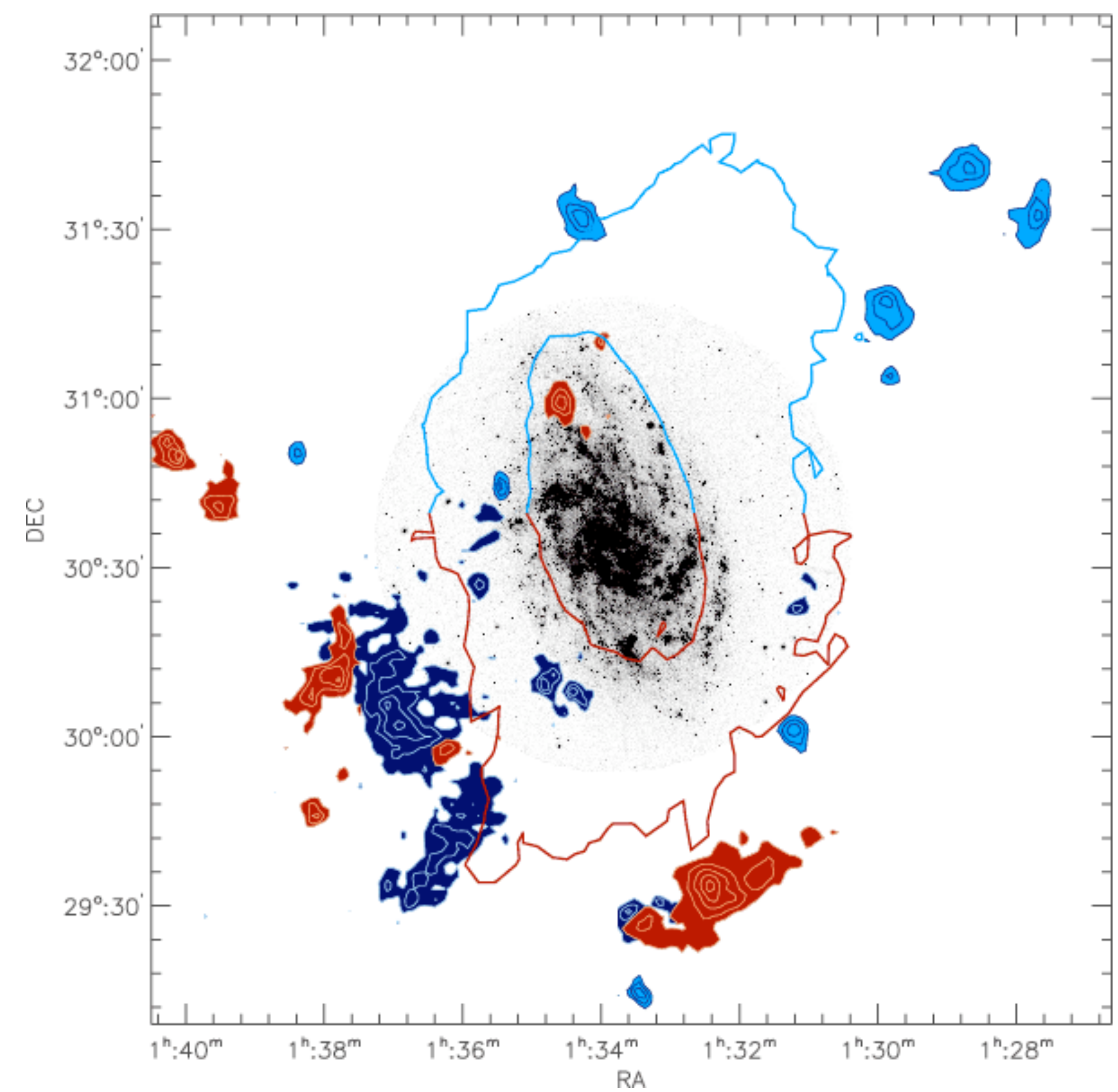


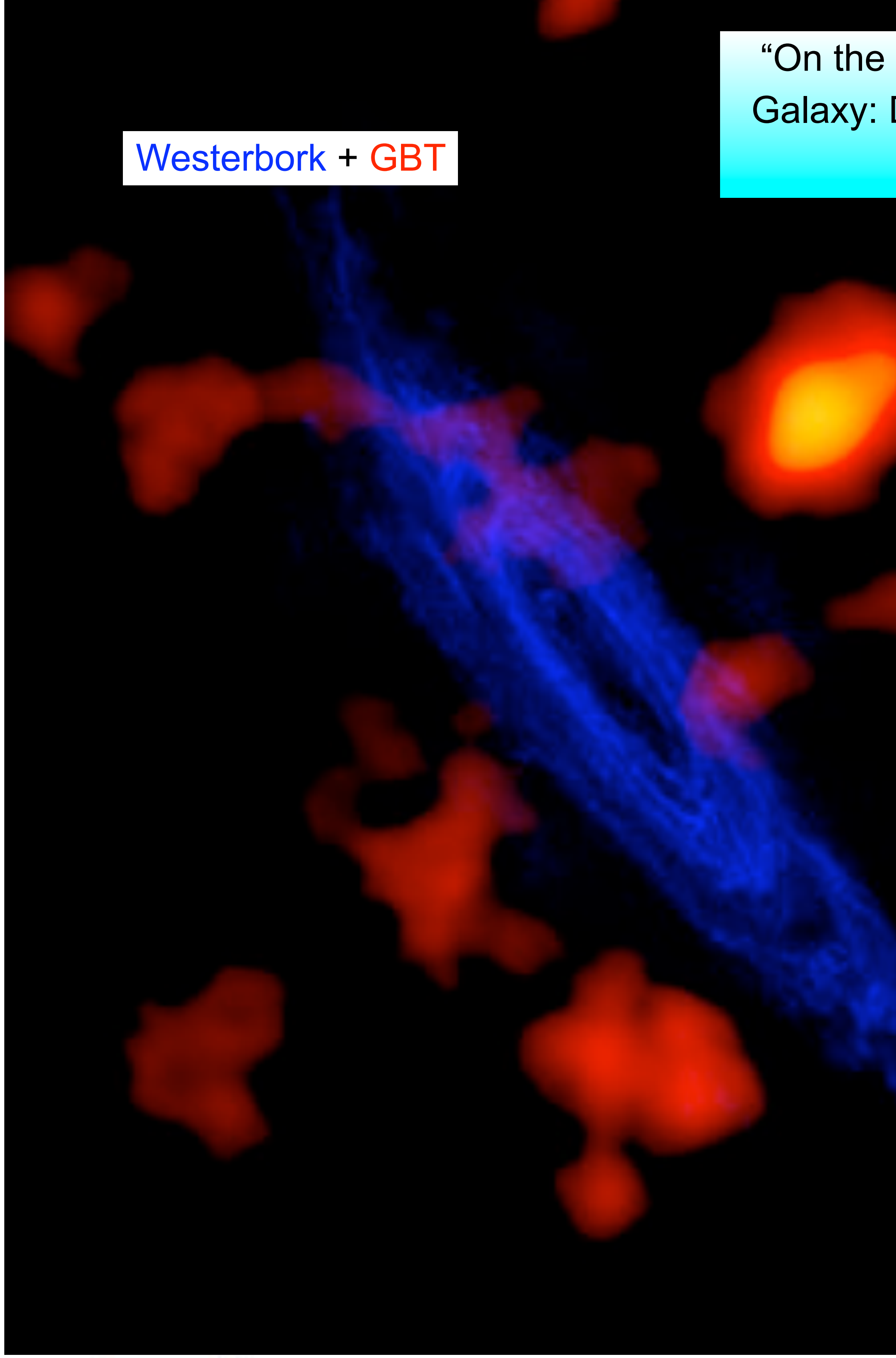
Fig. 2.— Total column density for discrete and diffuse high-velocity H I in the M31 GBT field, after masking emission from Andromeda's inclined, rotating disk. Contours were evaluated at (3 kpc, 72 km s^{-1}) resolution and rendered at 0.5, 1, 2, 10, and 20 × 10^{18} cm^{-2}, then overlaid

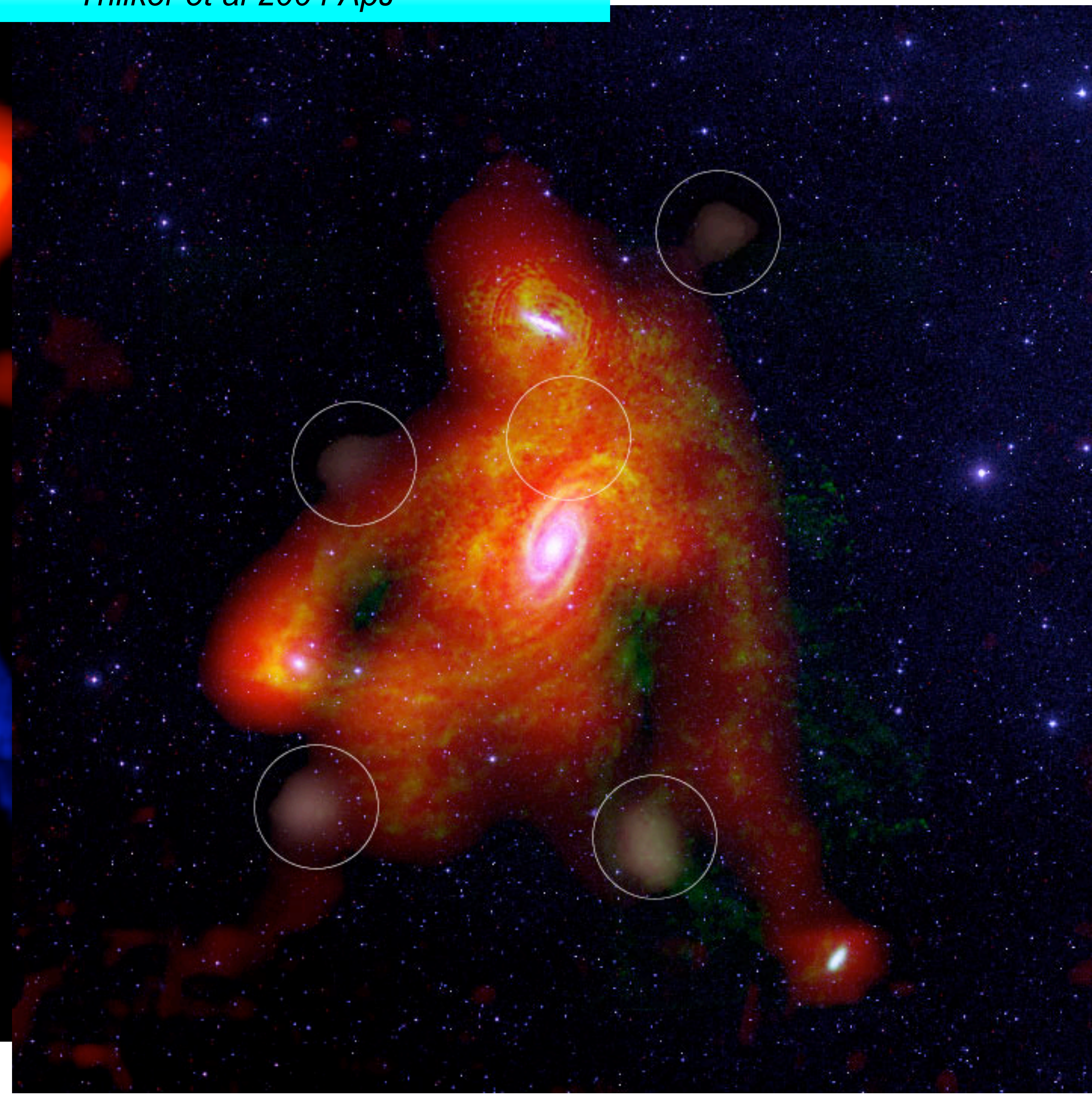
The continuing growth of the Milky Way

“The Smith Cloud: A High-Velocity Cloud Colliding with the Milky Way”
Lockman, Benjamin, Heroux,Langson. 2008 ApJL

"On the continuing formation of the Andromeda Galaxy: Detection of HI Clouds in the M31 Halo"

Thilker et al 2004 ApJ





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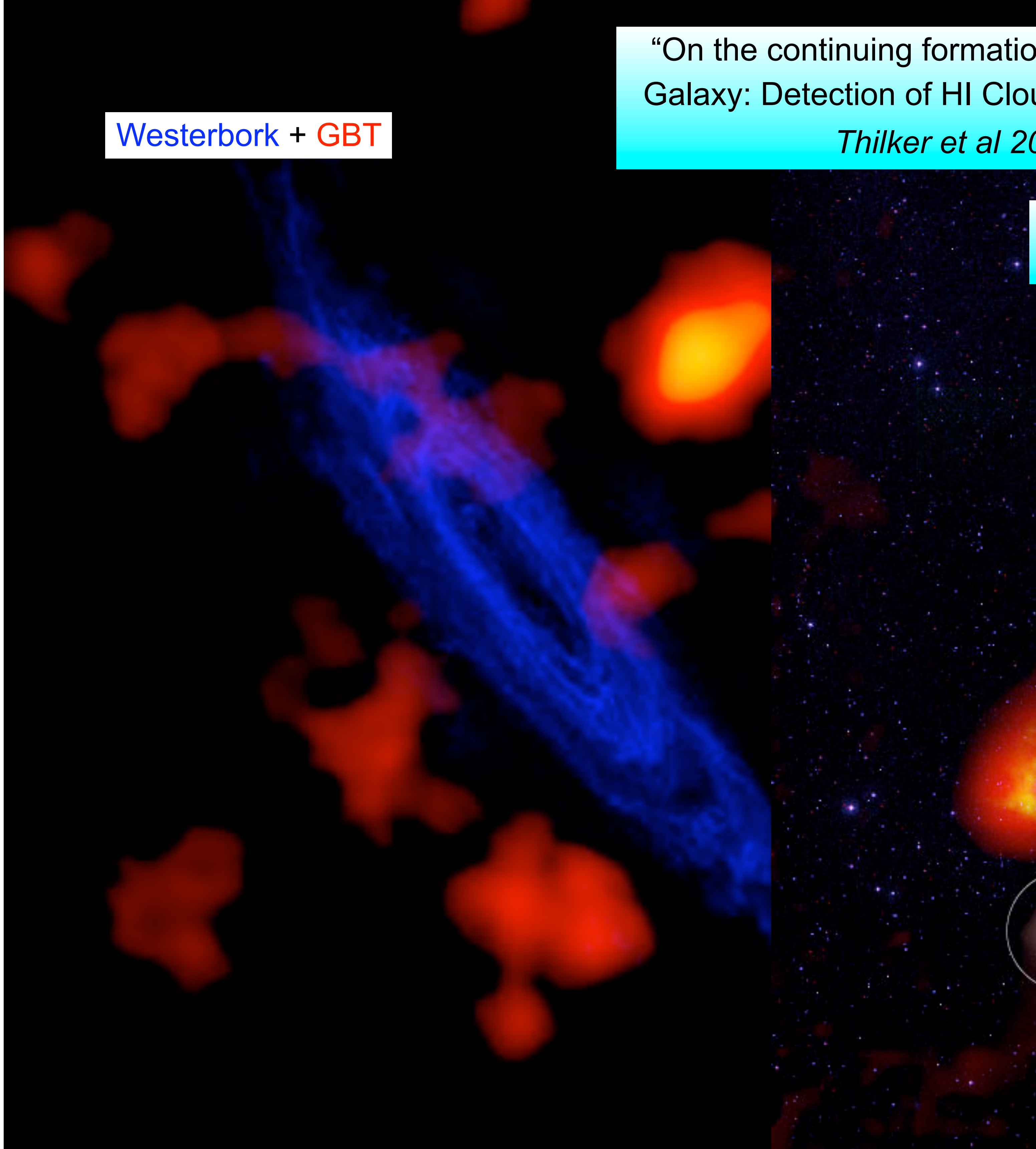
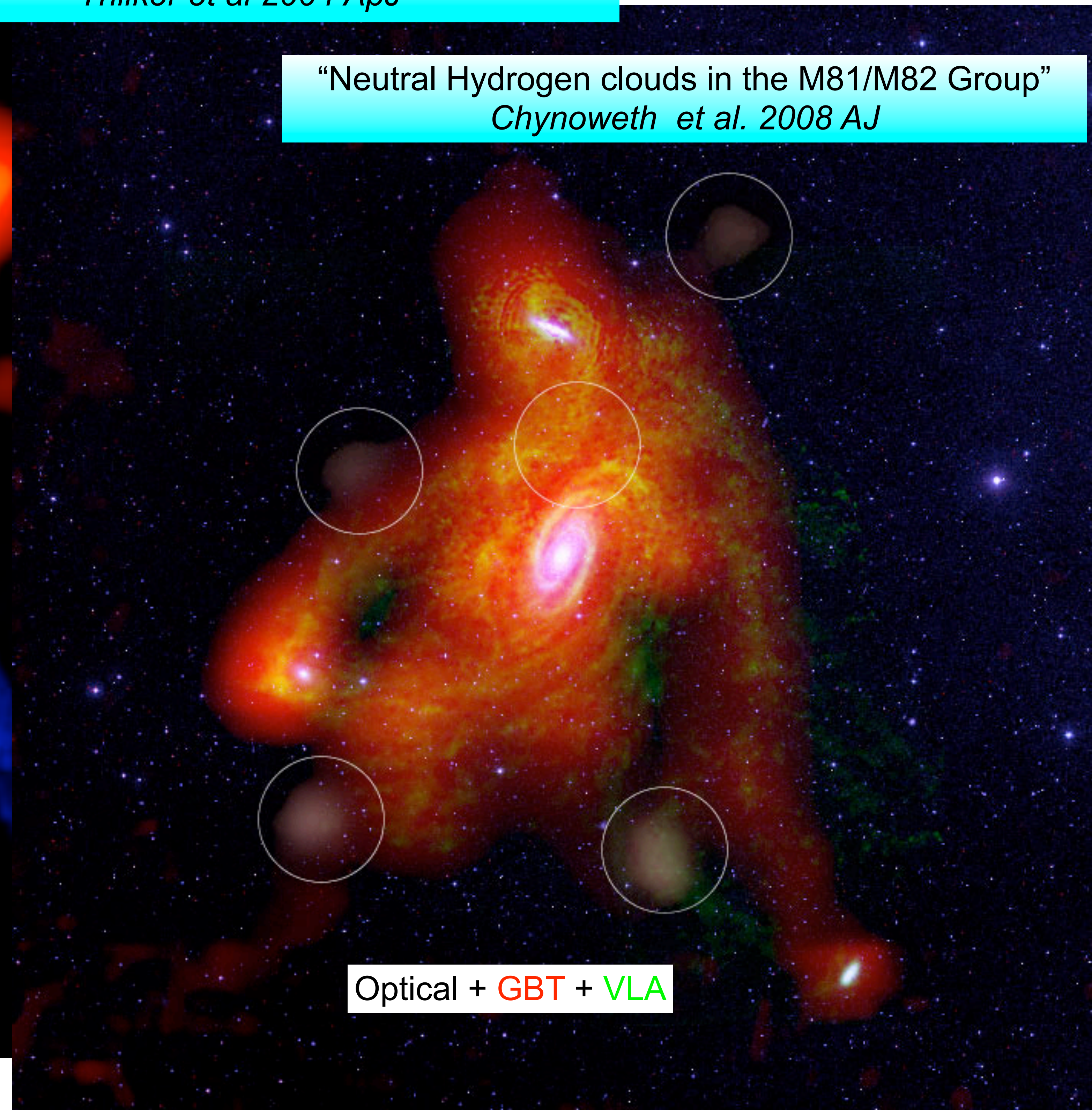
Thilker et al 2004 ApJ



"Neutral Hydrogen clouds in the M81/M82 Group"
Chynoweth et al. 2008 AJ



NRAO

The M31–M33 stream

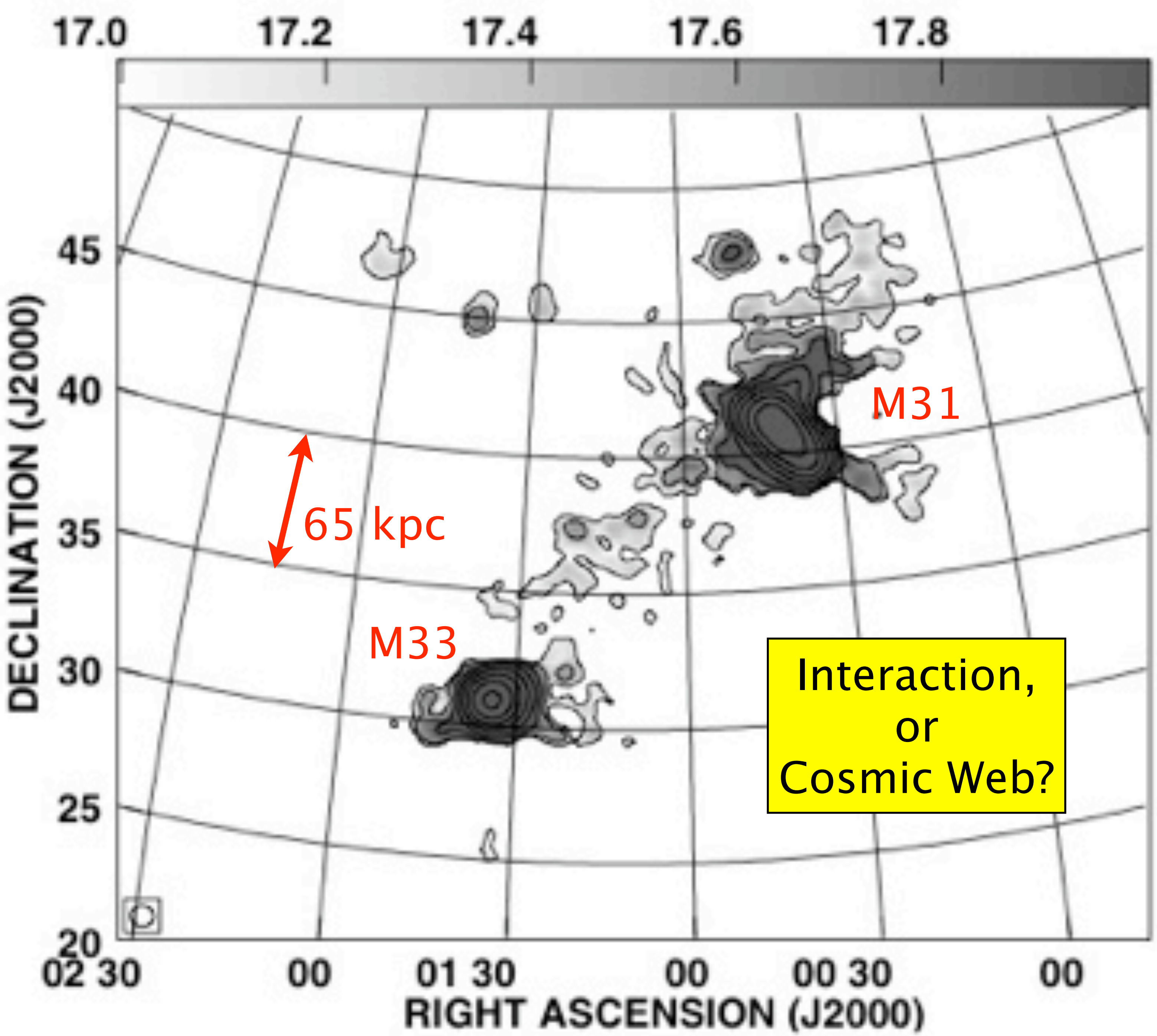


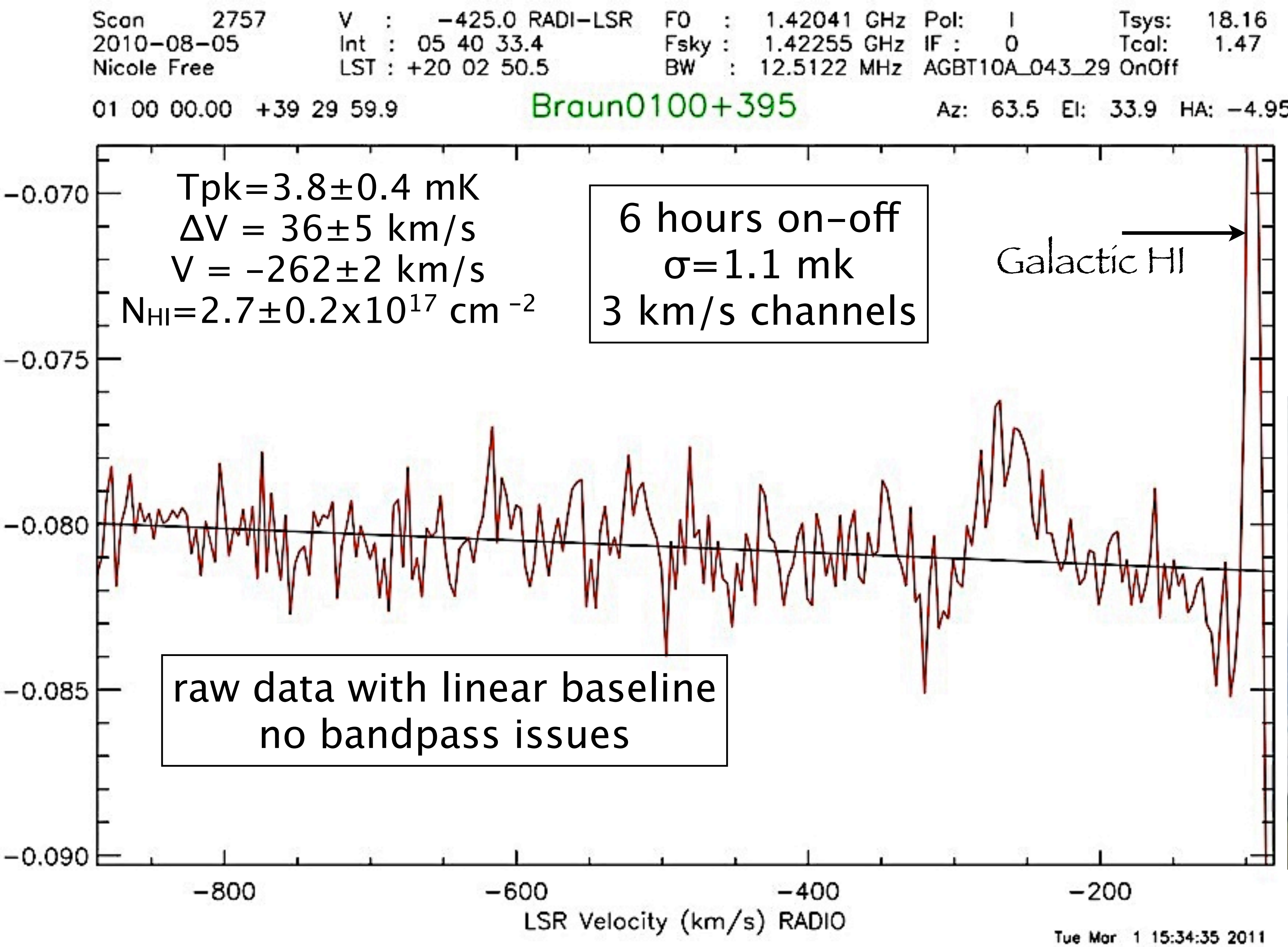
Fig. 9. Integrated H I emission from the subset of detected features apparently associated with M 31 and M 33. The grey-scale varies between $\log(N_{HI}) = 17-18$, for N_{HI} in units of cm^{-2}. Contours are drawn at $\log(N_{HI}) = 17, 17.5, 18, \ldots 20.5$.

Braun & Thilker 2006, A&A, 417, 421
WSRT as single dishes
49' Resolution

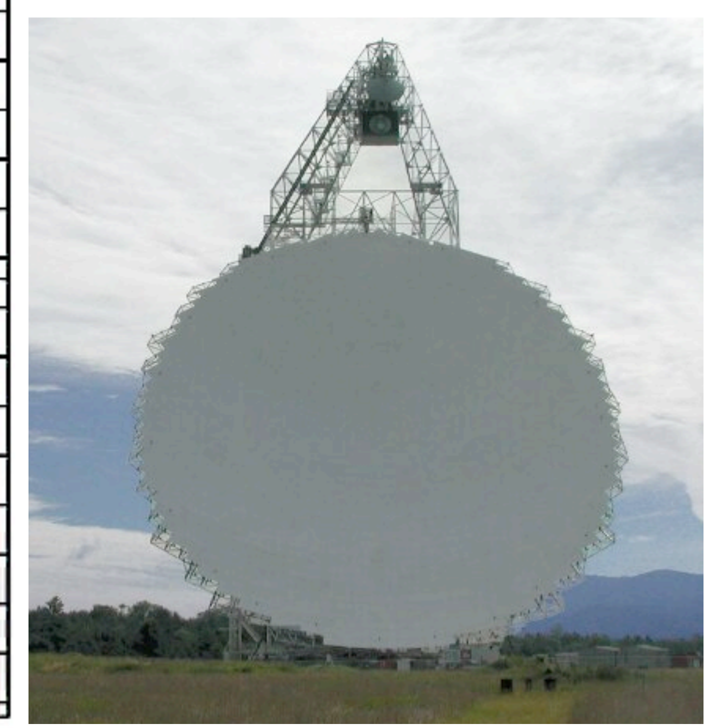
Putman et al.
(2009, ApJ, 703, 1486)
say it's not real!

GBT spectrum of the M31-M33 stream

Free, Lockman & Shields (2011, in prep)



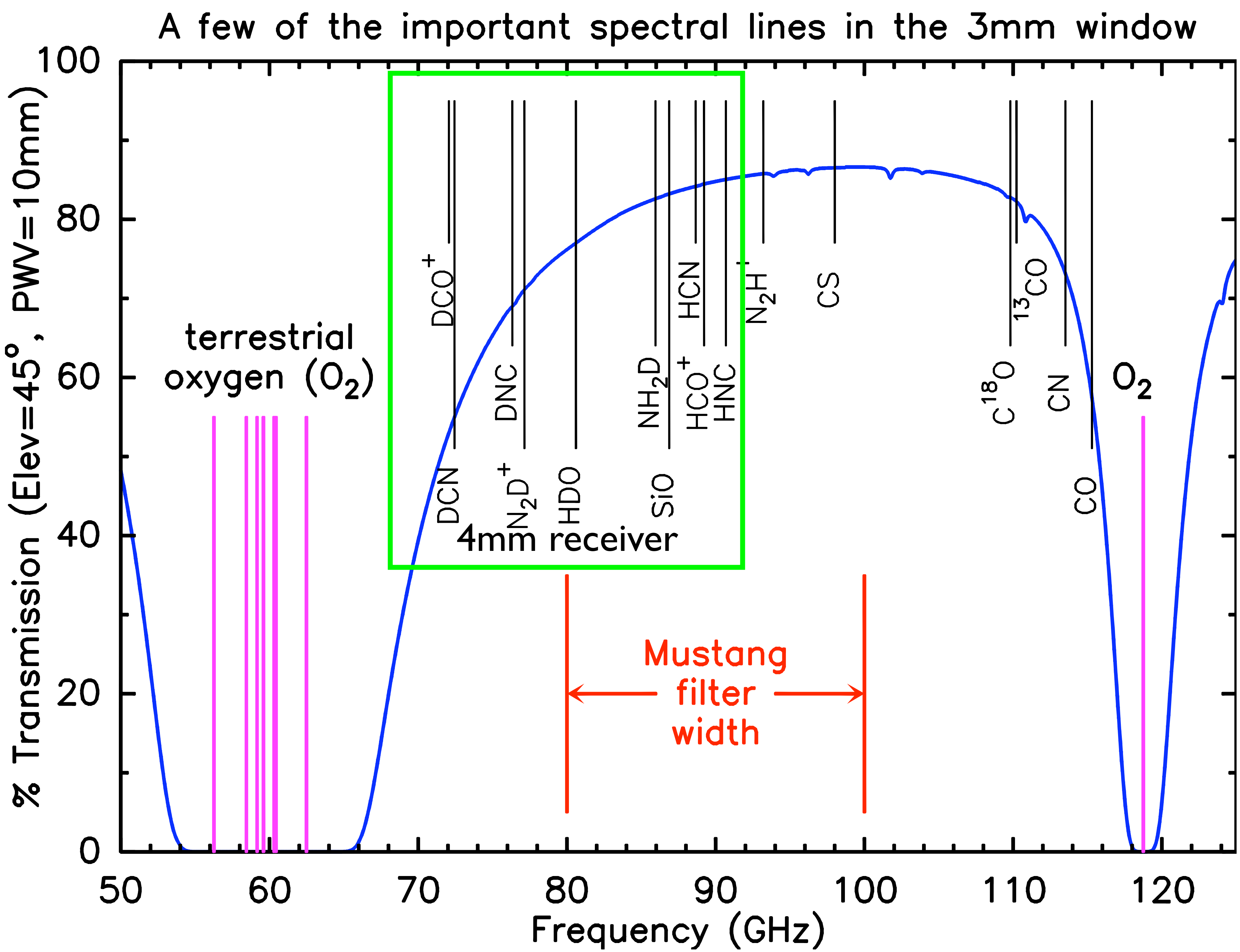
This is the frontier



FLAG -- Focal Plane L-Band Array for the GBT

B. Jeff, K. Warnick et al (BYU)
J.R. Fisher, R. Norrod, A. Roshi (NRAO)

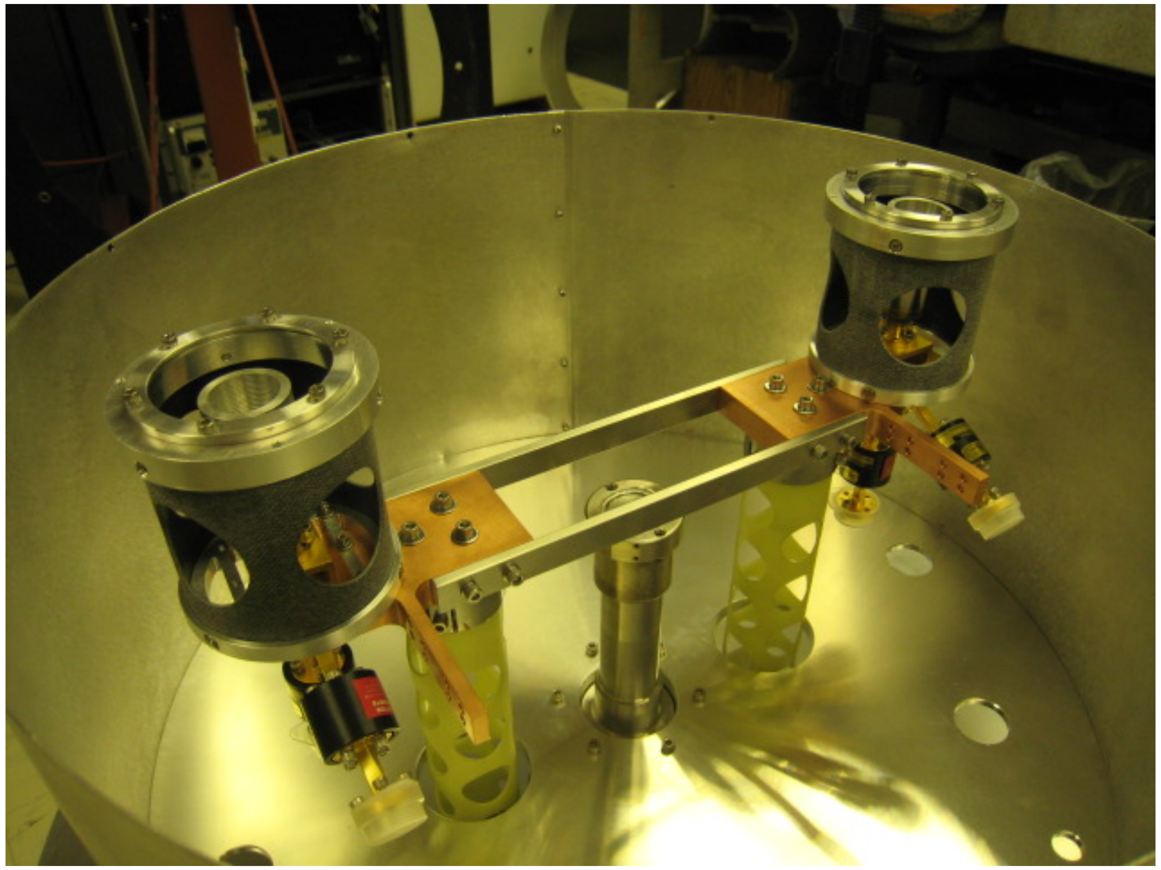
- 19 dual polarized elements. Cryogenic PAF system
- Tsys $\sim$ 20 K; Aperture efficiency $\sim$ 75 to 80 %
- 7 beams; spacing 0.5 FWHM to 1 FWHM
- Frequency coverage – 1300 to 1800 MHz; Backend for processing signals



A few of the important spectral lines in the 3mm window
% Transmission (Elev=45°, PWV=10mm)
Frequency (GHz)
100
80
60
40
20
0
50
60
70
80
90
100
110
120
terrestrial
oxygen (O2)
O2
4mm receiver
DCO+
DCN
DNC
N2D+
HDO
NH2D
SiO
HCN
HCO+
HNC
N2H+
CS
C18O
13CO
CN
CO
Mustang
filter
width

GBT 4mm Receiver Project

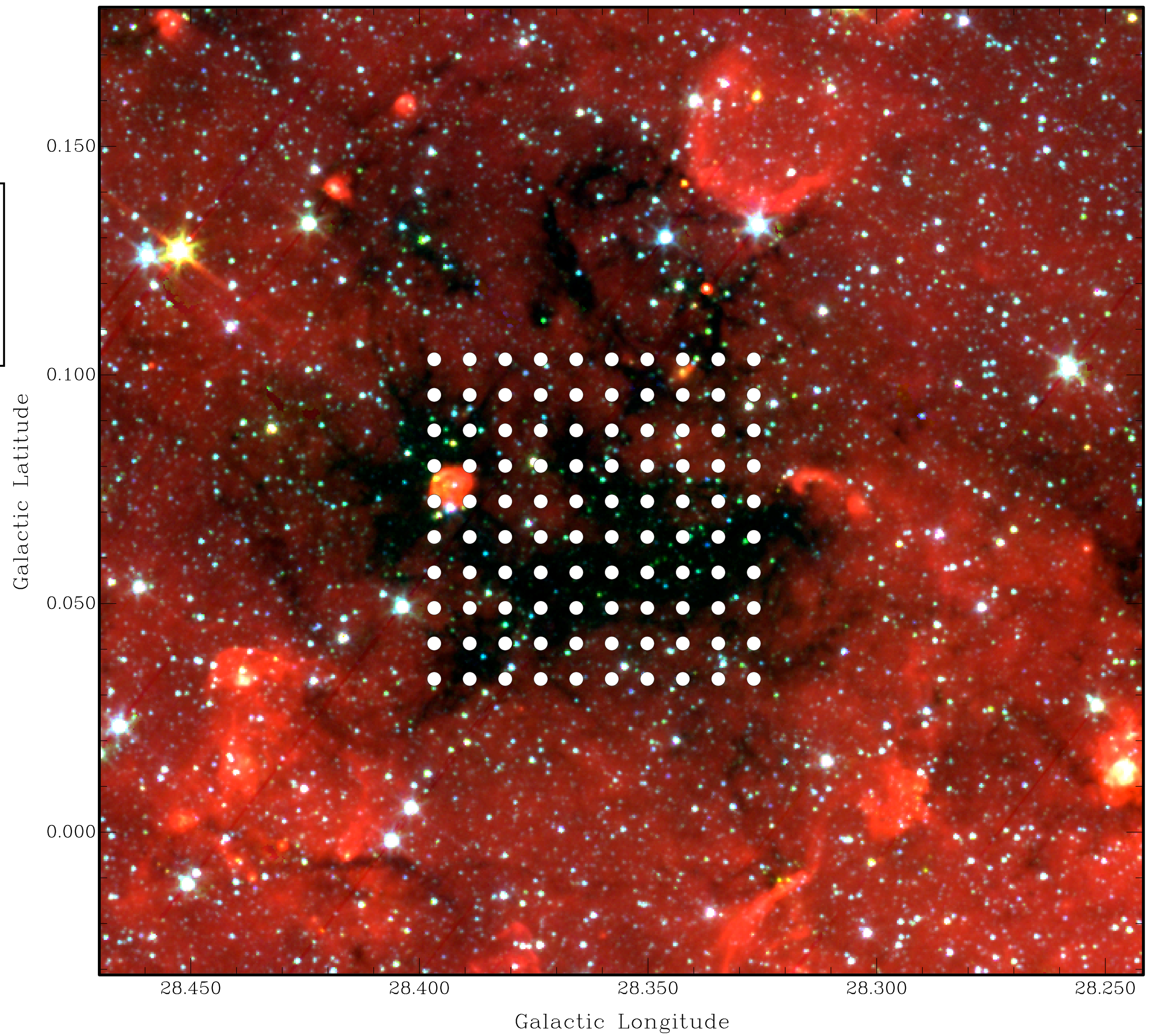
Tunable frequency range: 68-92 GHz (Coverage to 93.2GHz is highly desirable.)
HPBW 11″ to 8″
Tsys = 100 K
Polarization: Dual linear with selection of circular using a 1/4 wave plate for VLB observations.
Number of beams: Two beams each with dual polarization
Beam separation: 4.7 arcmin
Calibration with cold, ambient, and sky loads using optical table

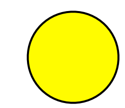


Planned 3mm Focal Plane Array

a wide field mapping complement to ALMA Band 3

GBT 3mm FPA footprint on an Infrared Dark Cloud





ALMA primary beam at 3mm

The Green Bank Telescope

We are entering Green Bank's most productive decade yet