D. JACOBS
SES 598

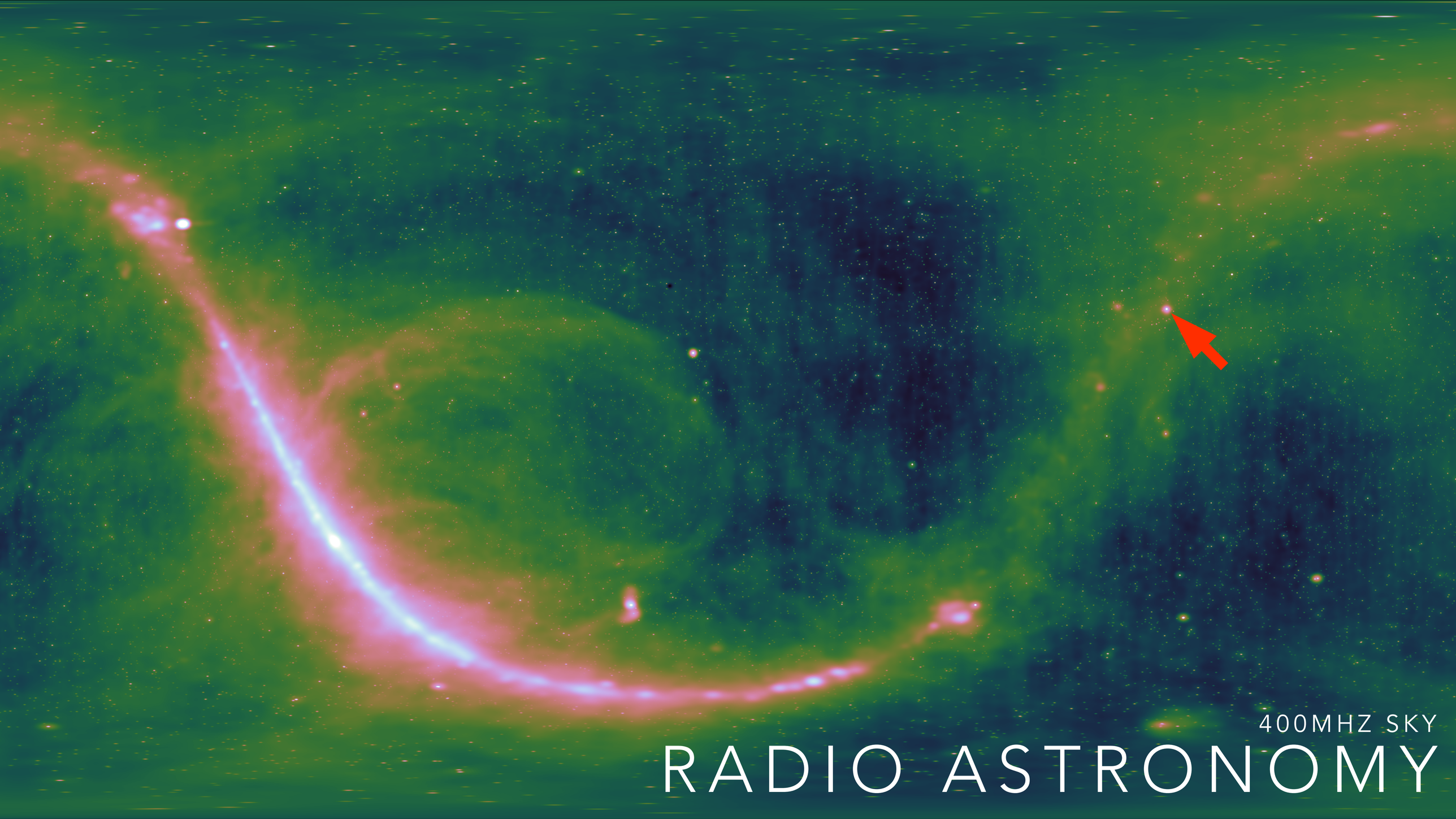
RADIO ASTRONOMY LECTURE 2

GREEN BANK, WV

RADIO ASTRONOMY

SKY MAP WITH 300’ AT 4.85 GHZ

CONDON ET AL

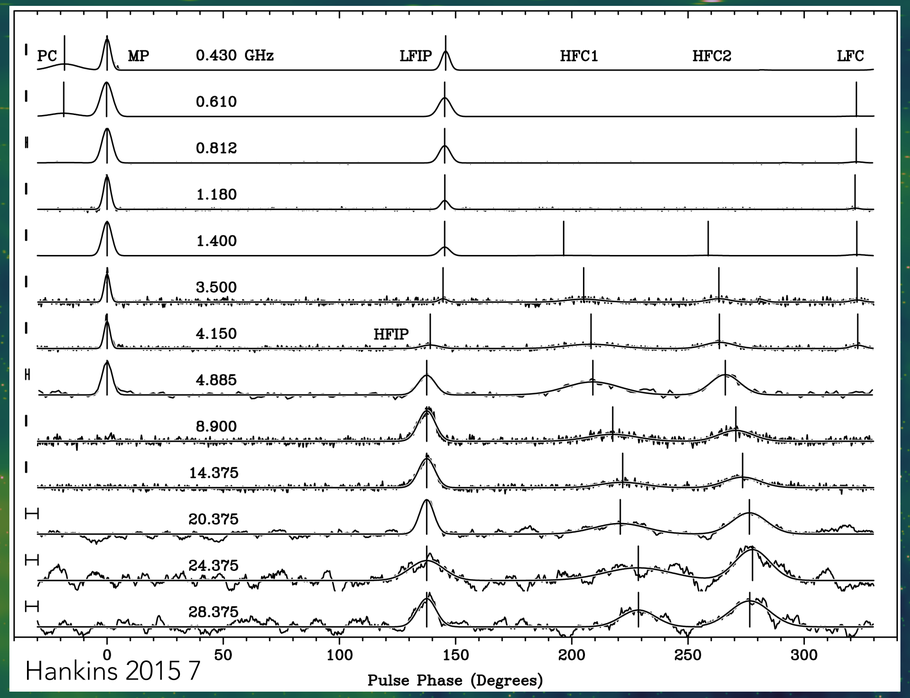

400MHZ SKY
RADIO ASTRONOMY

VLA 5GHZ

Crab Nebula
Supernovae recorded by Chinese astronomers 1054AD

400MHZ SKY

RADIO ASTRONOMY



33ms pulsar detected at Arecibo

400MHZ SKY

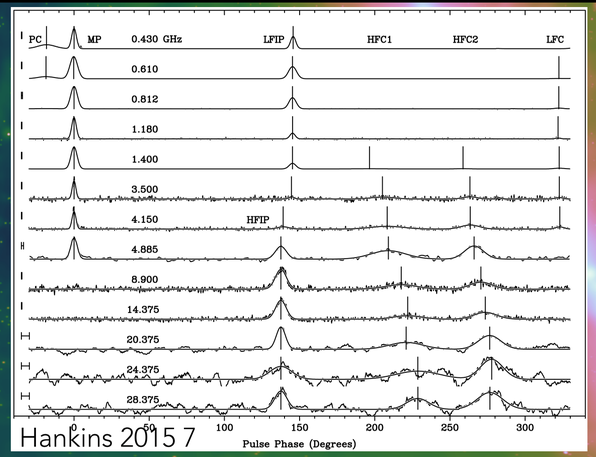
RADIO ASTRONOMY

VLA, 5GHz

But wait theres more…

Chandra, Xrays

The brightest X-ray source in the sky.



Hankins 2015 7

33ms pulsar detected at Arecibo

400MHZ SKY

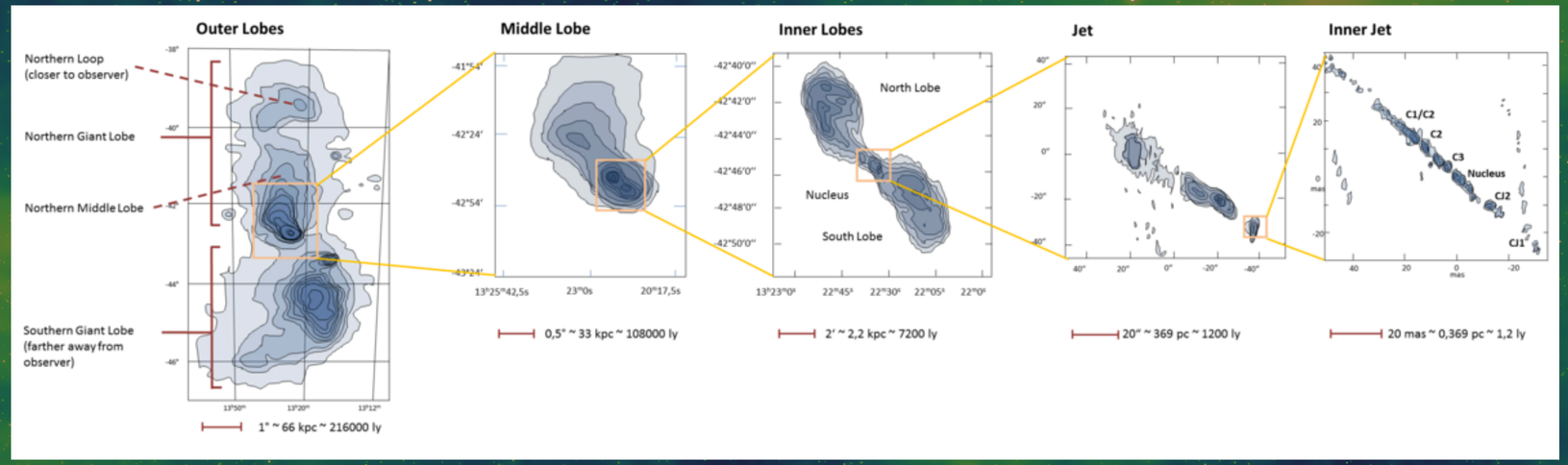
RADIO ASTRONOMY

Note Moon for scale

ATCA 5Ghz

600 kpc

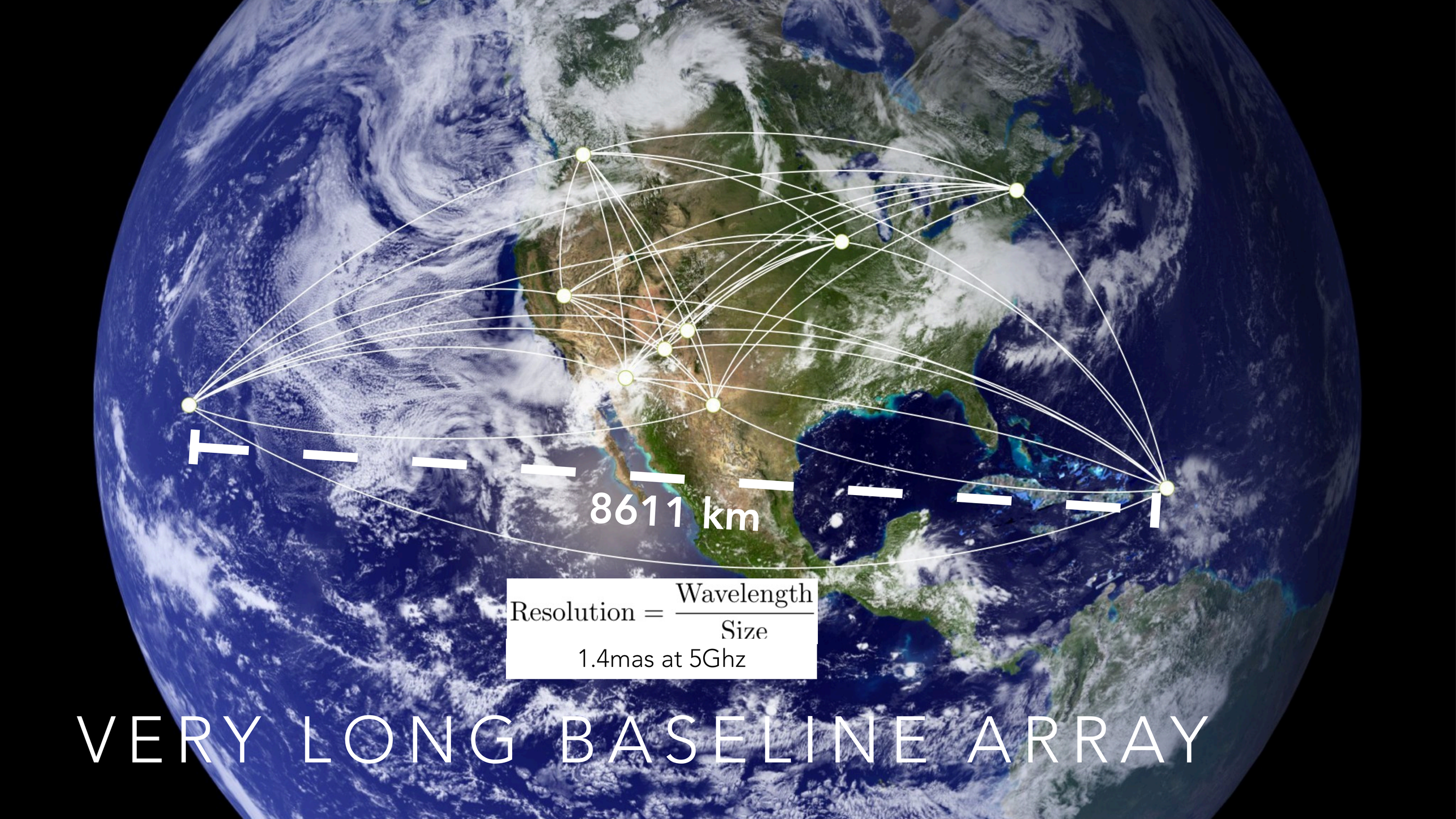
Compare: Distance to Andromeda 800kpc



VLBI

400MHZ SKY

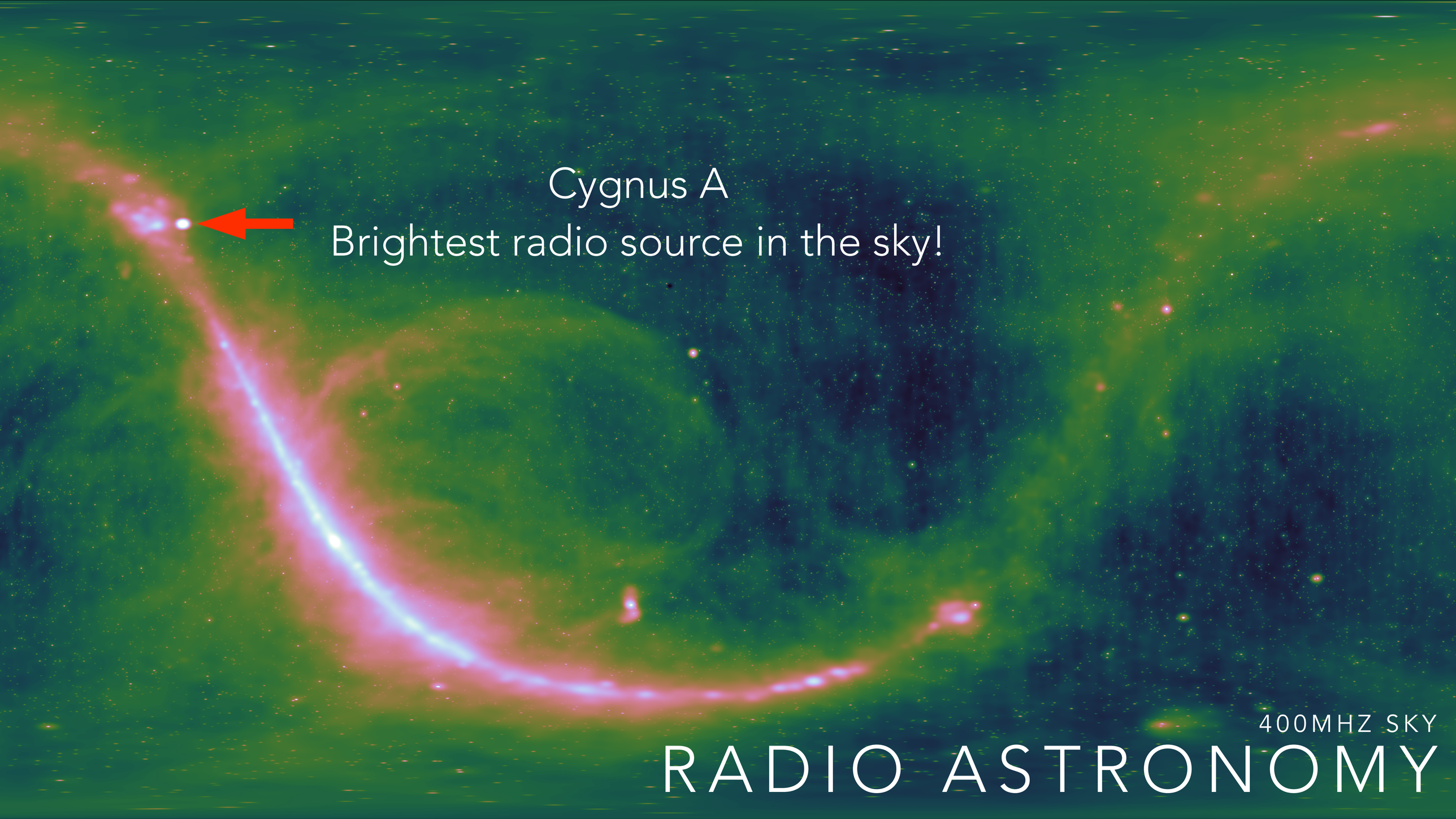
RADIO ASTRONOMY

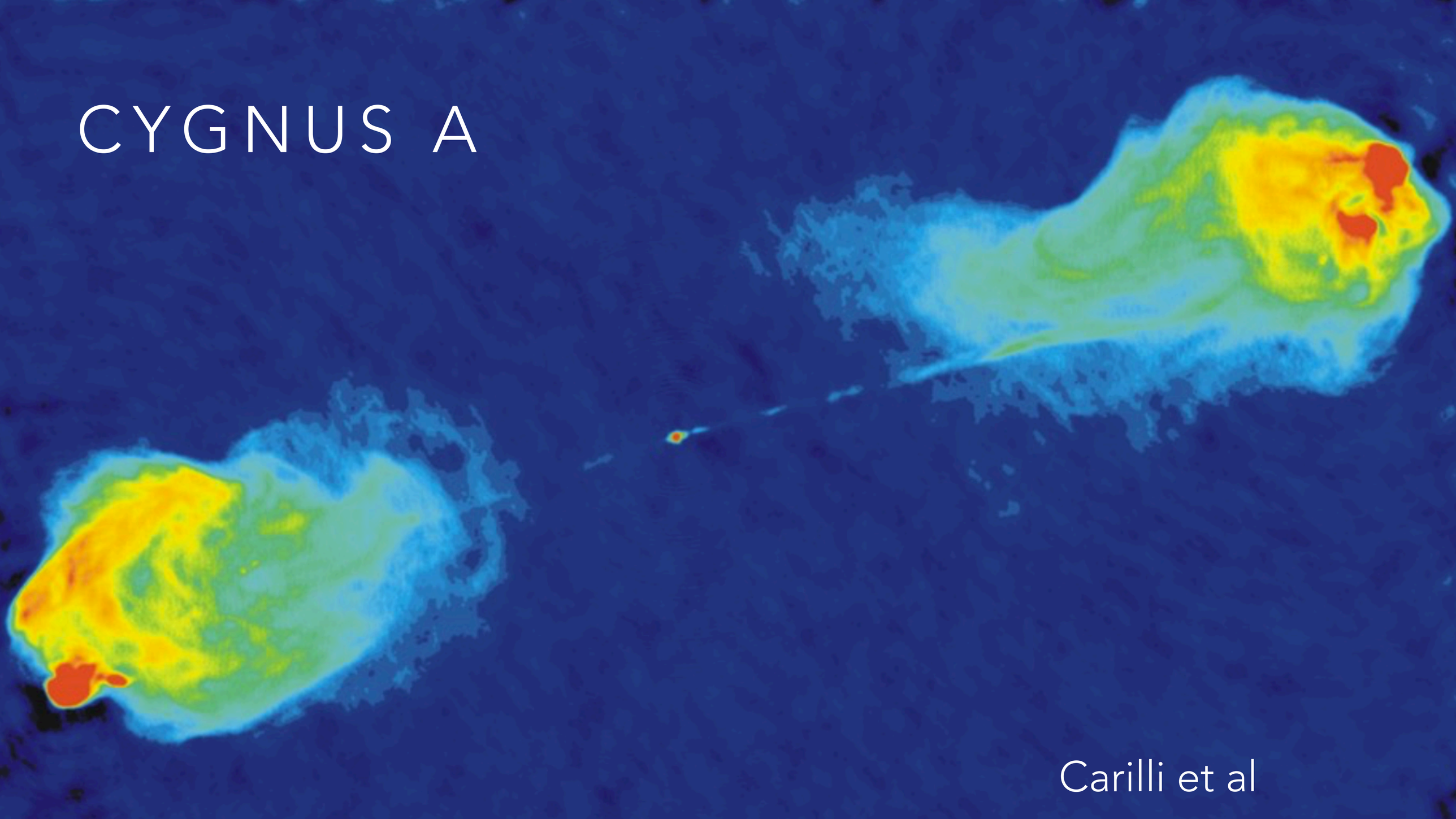


$$\text{Resolution} = \frac{\text{Wavelength}}{\text{Size}}$$

1.4mas at 5Ghz

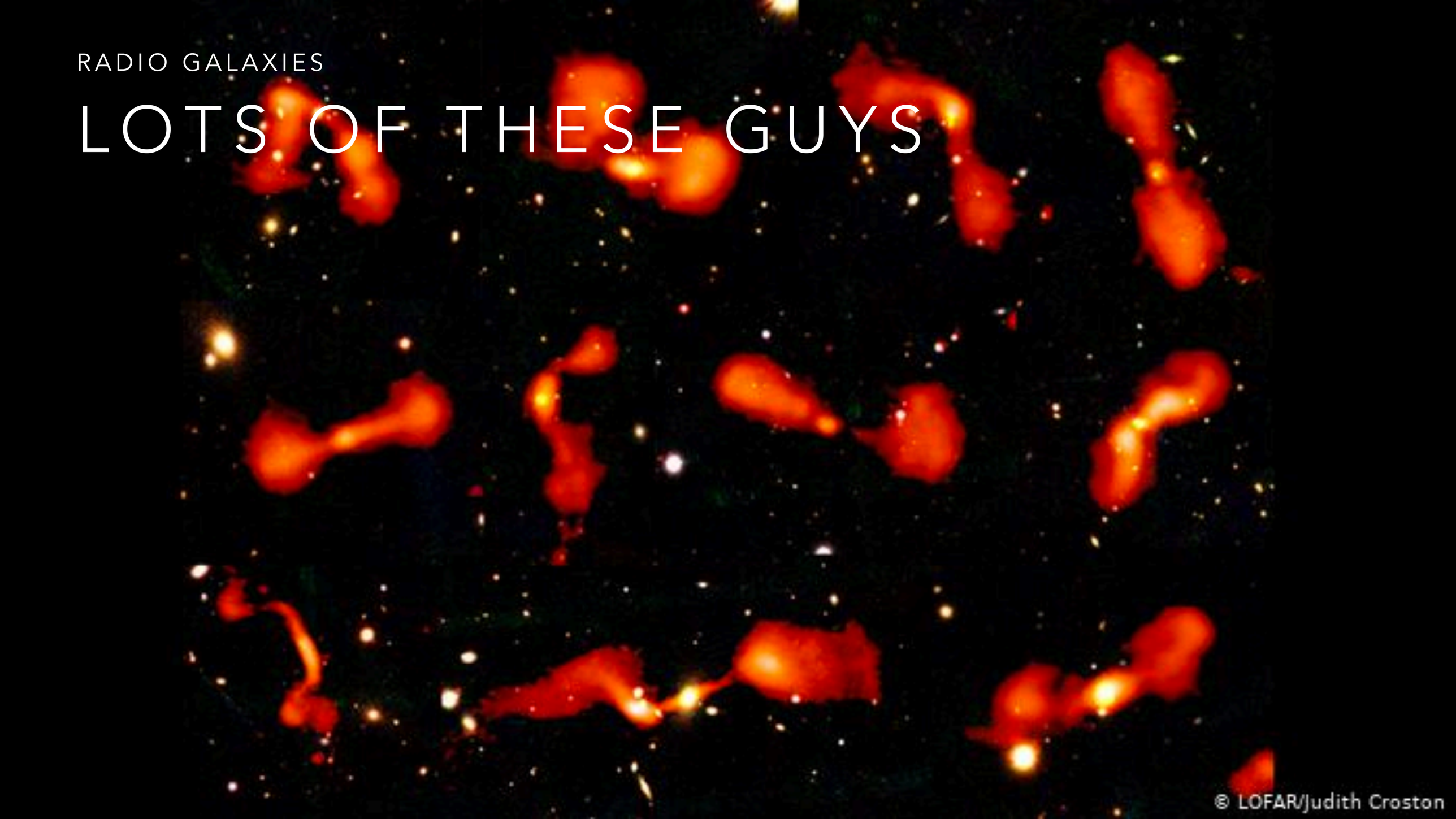
VERY LONG BASELINE ARRAY


Cygnus A
Brightest radio source in the sky!
400MHZ SKY
RADIO ASTRONOMY


CYGNUS A
Carilli et al

RADIO GALAXIES

LOTS OF THESE GUYS

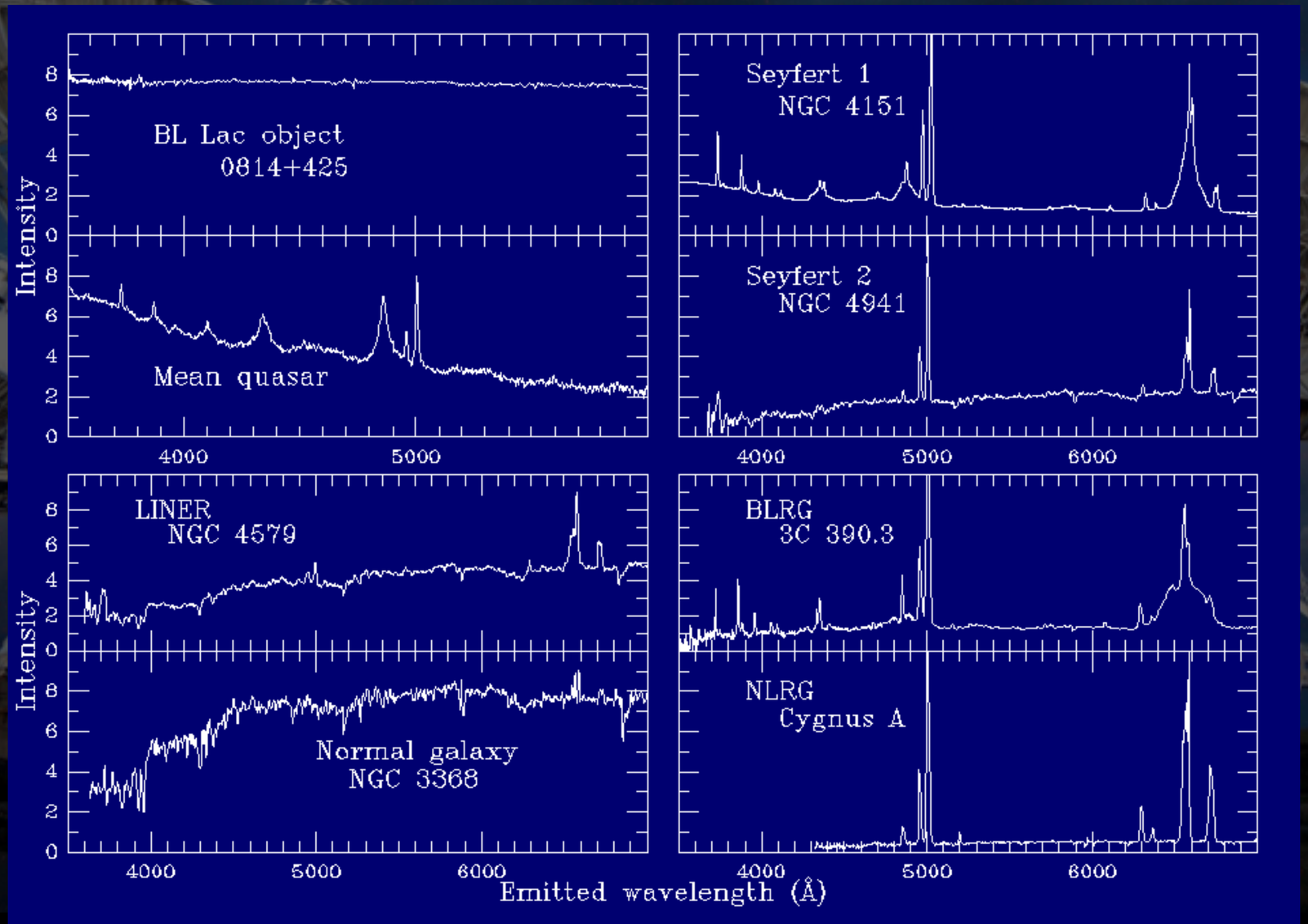


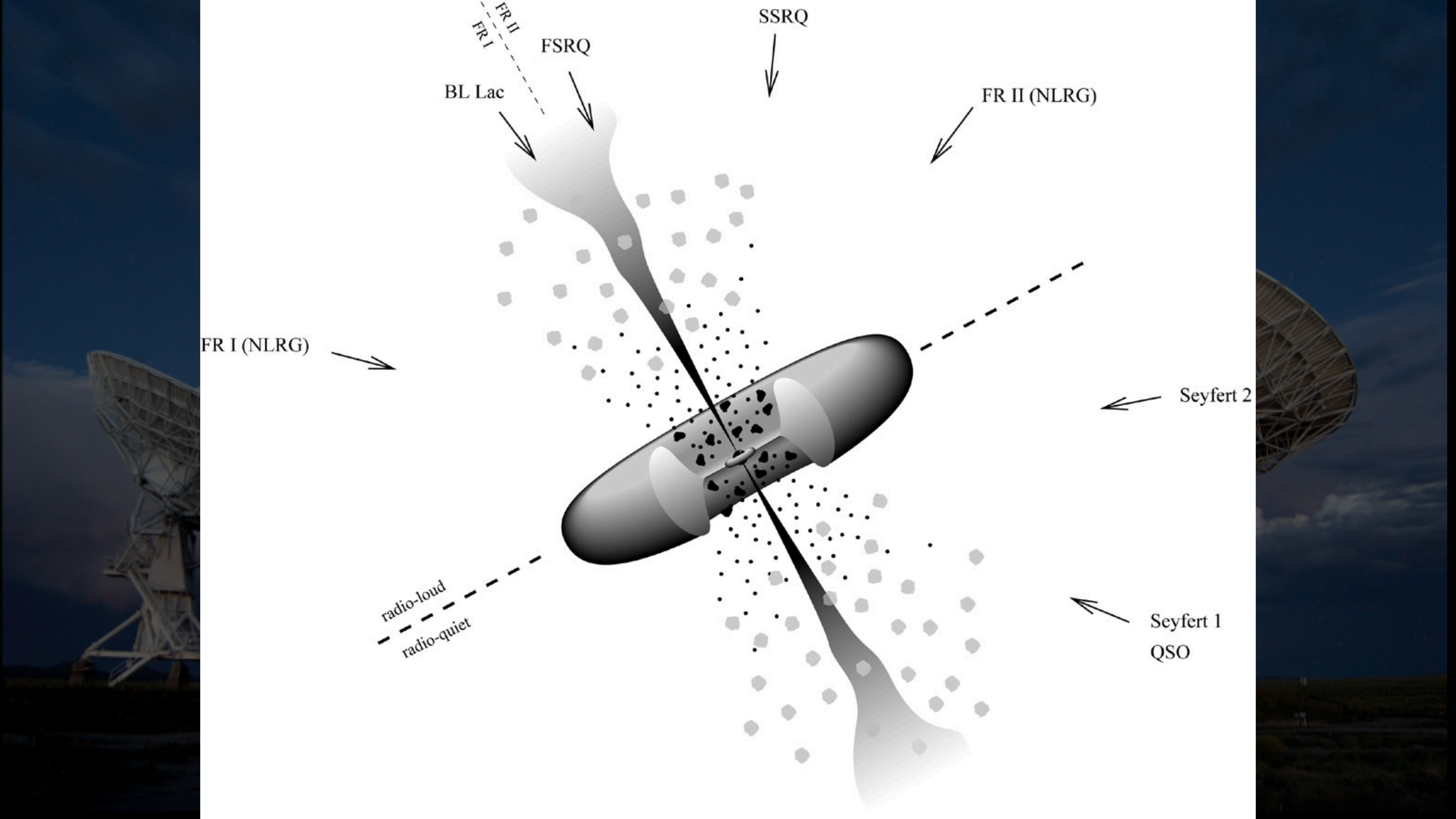
VISIBLE IN THE OPTICAL TOO!

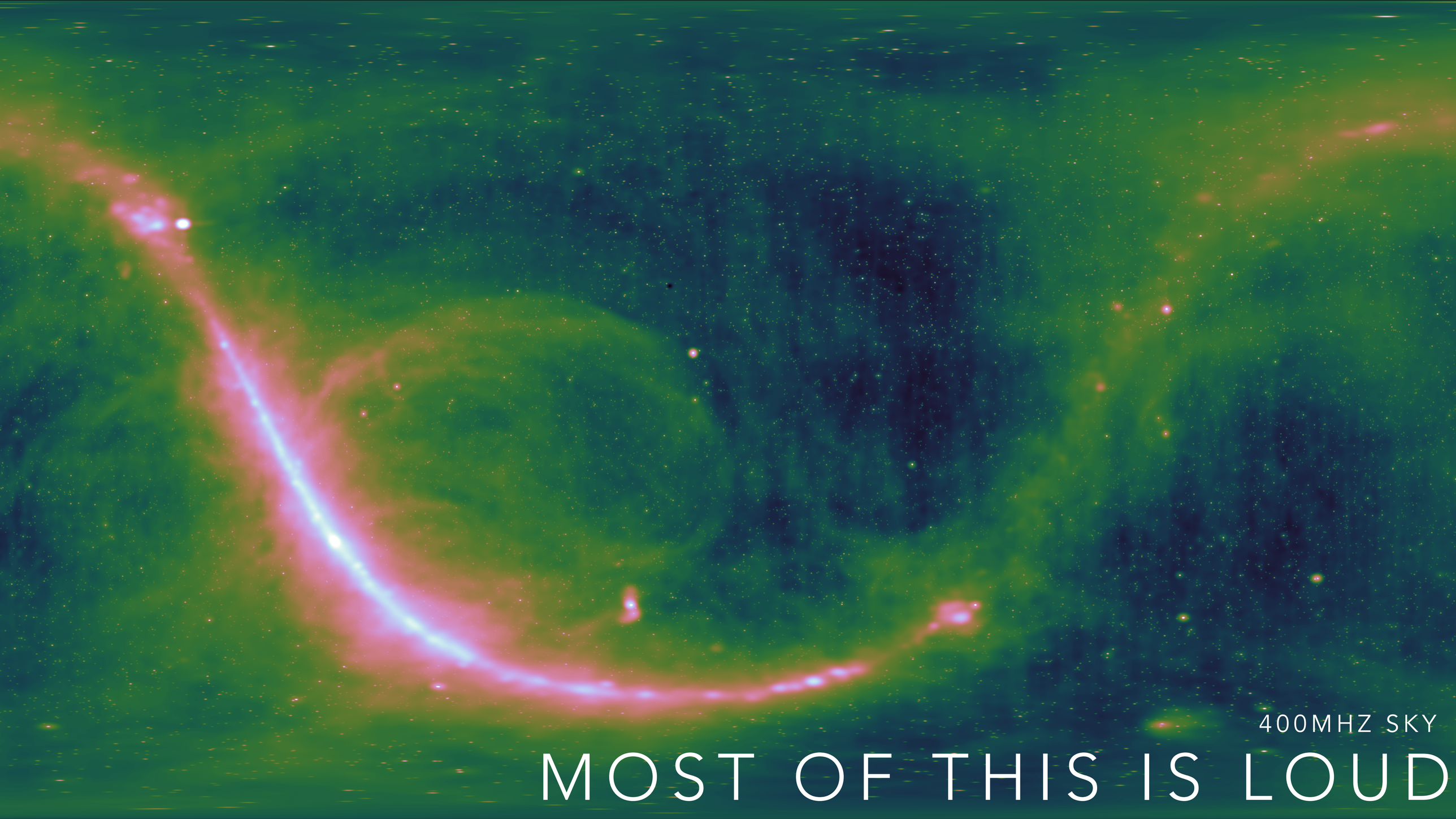
3C 273

Looks like a star, sort of

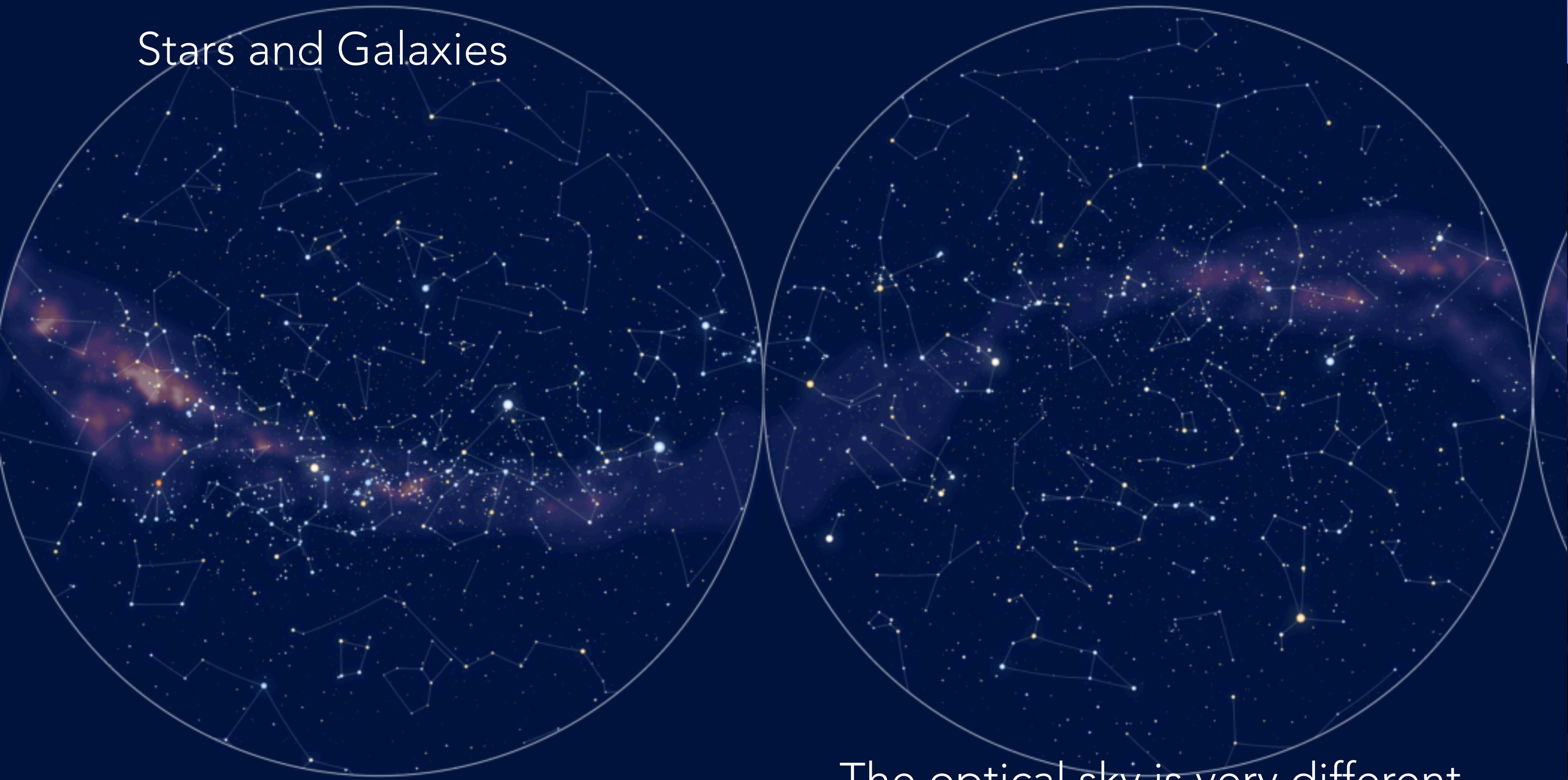
TO THE SPECTRUM



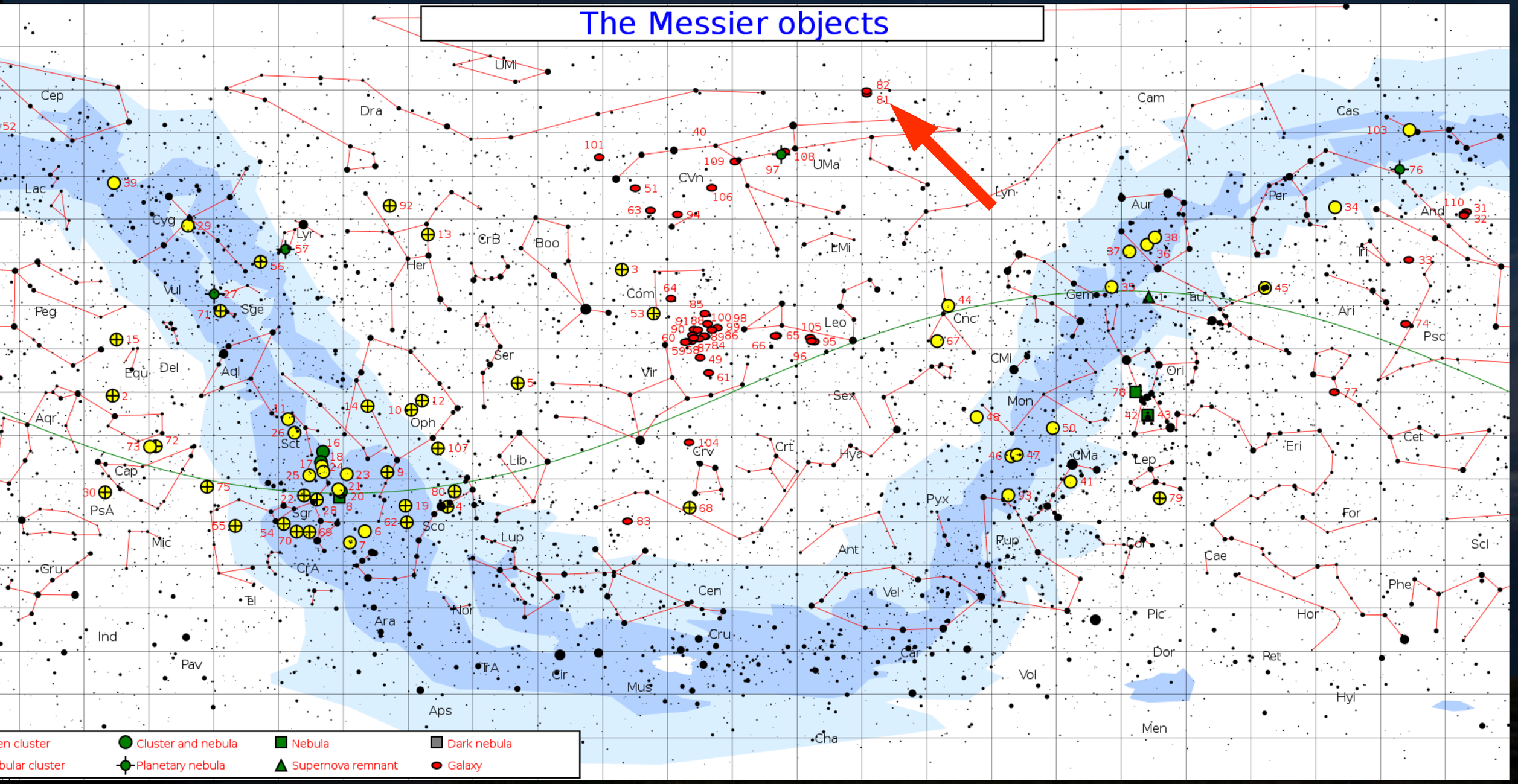

FR II
FR I
SSRQ
FSRQ
BL Lac
FR II (NLRG)
FR I (NLRG)
Seyfert 2
radio-loud
radio-quiet
Seyfert 1
QSO


400MHZ SKY
MOST OF THIS IS LOUD

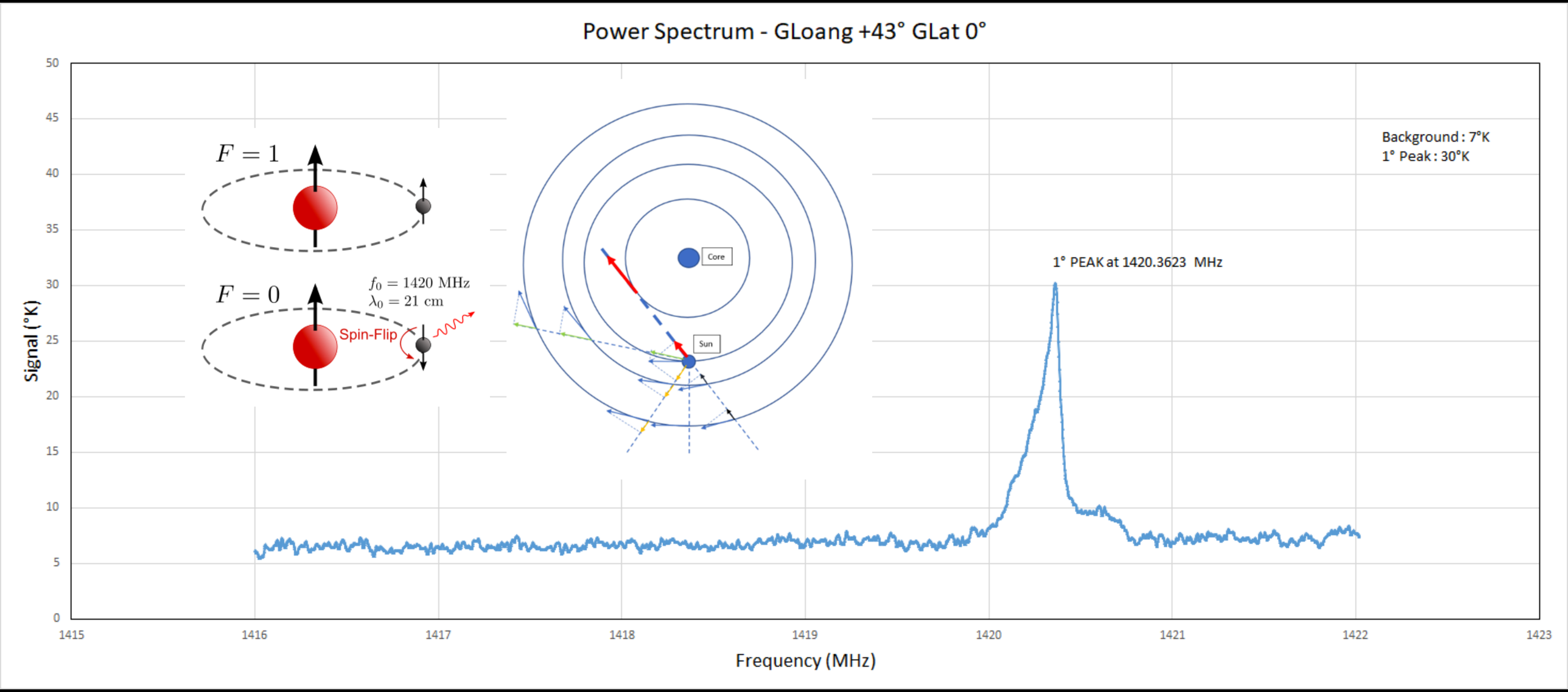
Stars and Galaxies



The optical sky is very different

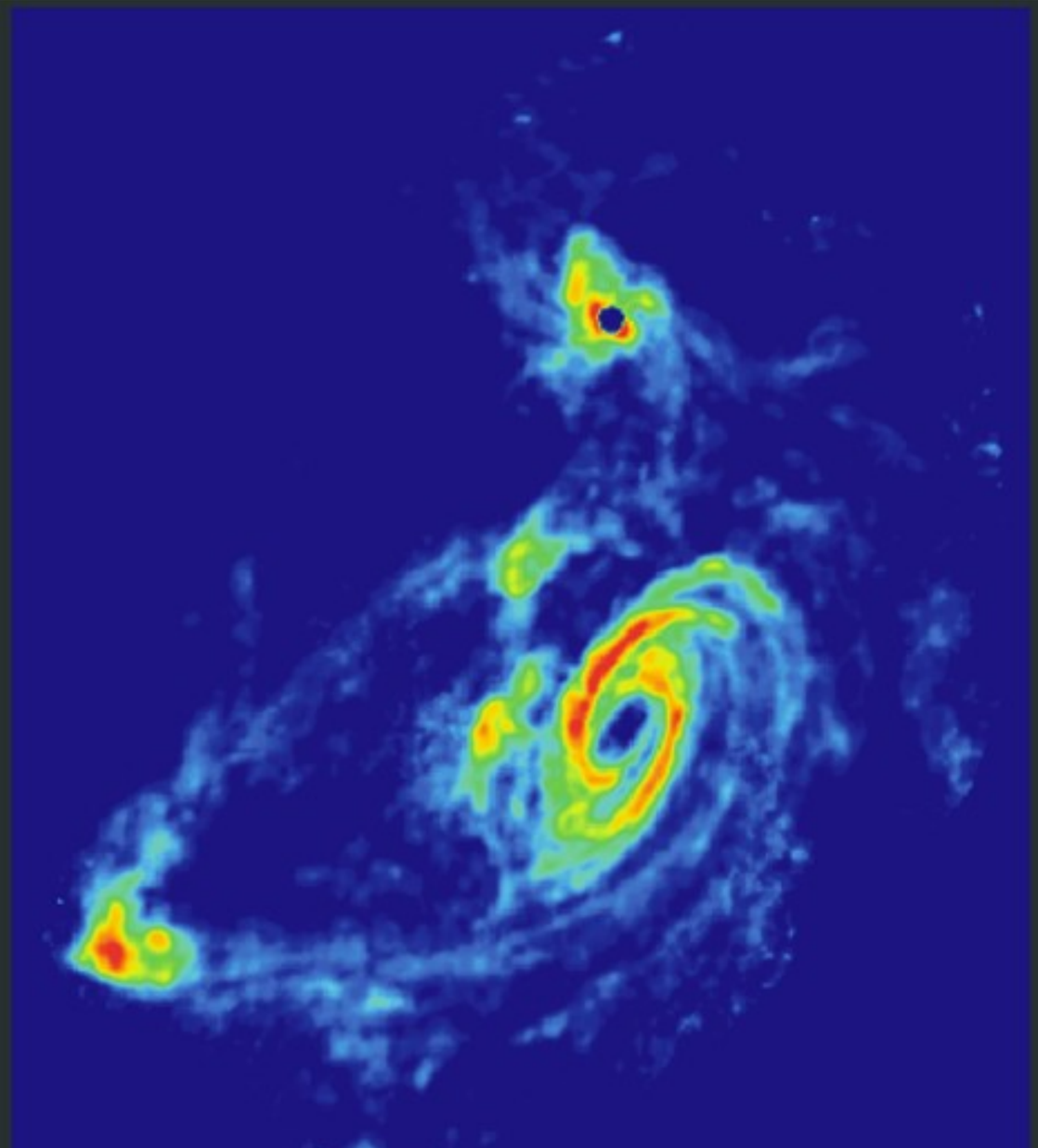

The Messier objects
UMi
Cep
Dra
Cam
Cas
Lac
Cyg
Lyr
CrB
Boo
UMa
CVn
Lyn
Aur
Per
And
Tri
Peg
Vul
Sge
Her
Com
LMi
Gem
Tau
Ari
Psc
Equ
Del
Aql
Ser
Vir
Leo
Cnc
CMi
Ori
Aqr
Sct
Oph
Sex
Mon
Cet
Eri
Cap
Lib
Crv
Crt
Hya
CMa
Lep
PsA
Sgr
Sco
Pyx
For
Mic
Lup
Pup
Col
Scl
Gru
CrA
Ant
Cae
Tel
Cen
Vel
Phe
Ind
Ara
Nor
Pic
Hor
Pav
TrA
Cir
Cru
Car
Dor
Ret
Mus
Vol
Hyi
Aps
Men
Cha
Cluster and nebula
Nebula
Dark nebula
Planetary nebula
Supernova remnant
Galaxy

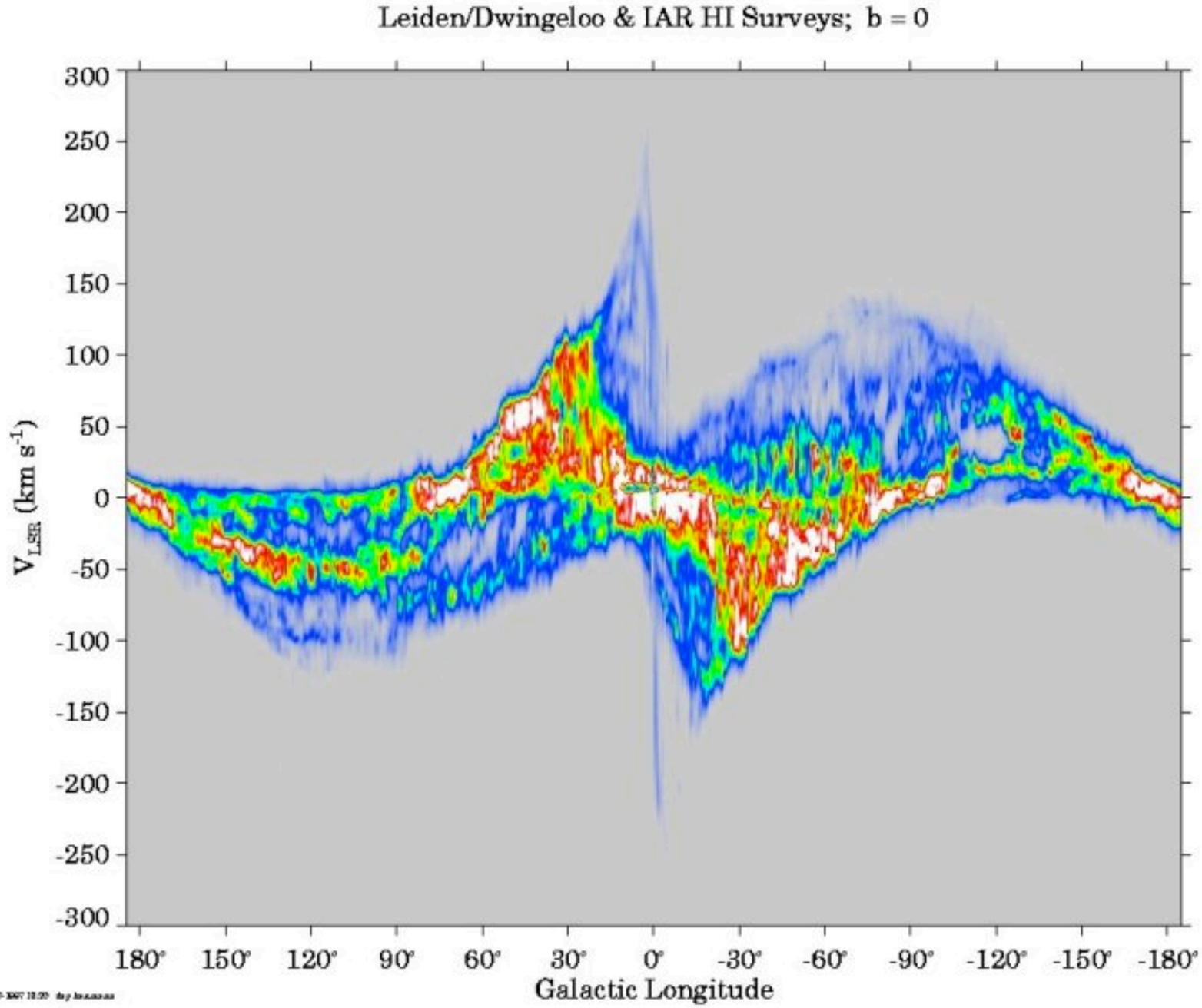
M81 in Optical

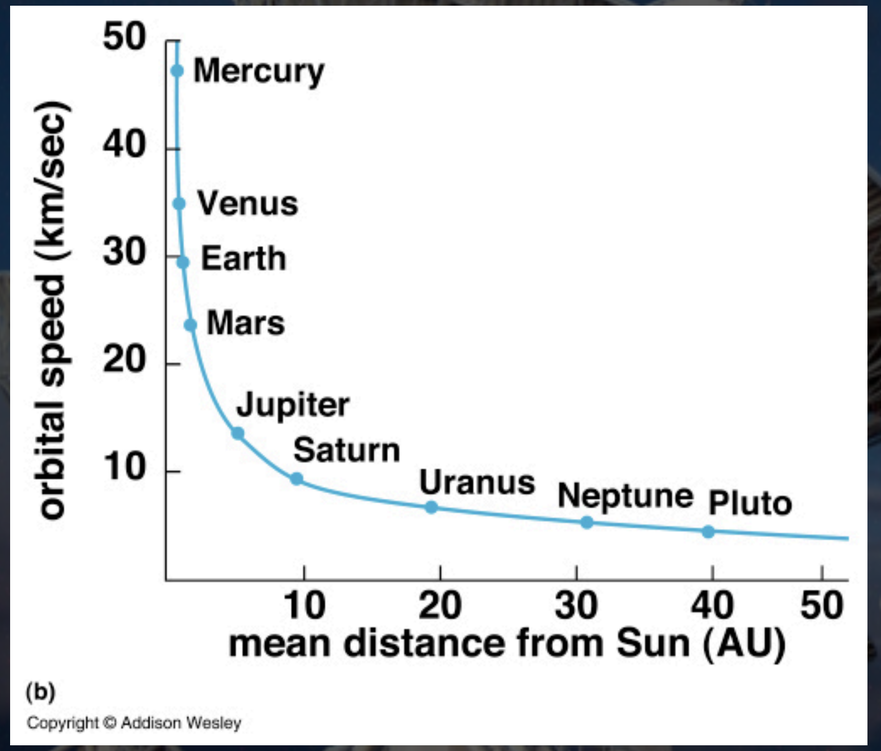

Power Spectrum - GLoang +43° GLat 0°
Signal (°K)
Frequency (MHz)
50
45
40
35
30
25
20
15
10
5
0
1415
1416
1417
1418
1419
1420
1421
1422
1423
$F = 1$
$F = 0$
$f_0 = 1420$ MHz
$\lambda_0 = 21$ cm
Spin-Flip
Core
Sun
Background : 7°K
1° Peak : 30°K
1° PEAK at 1420.3623 MHz

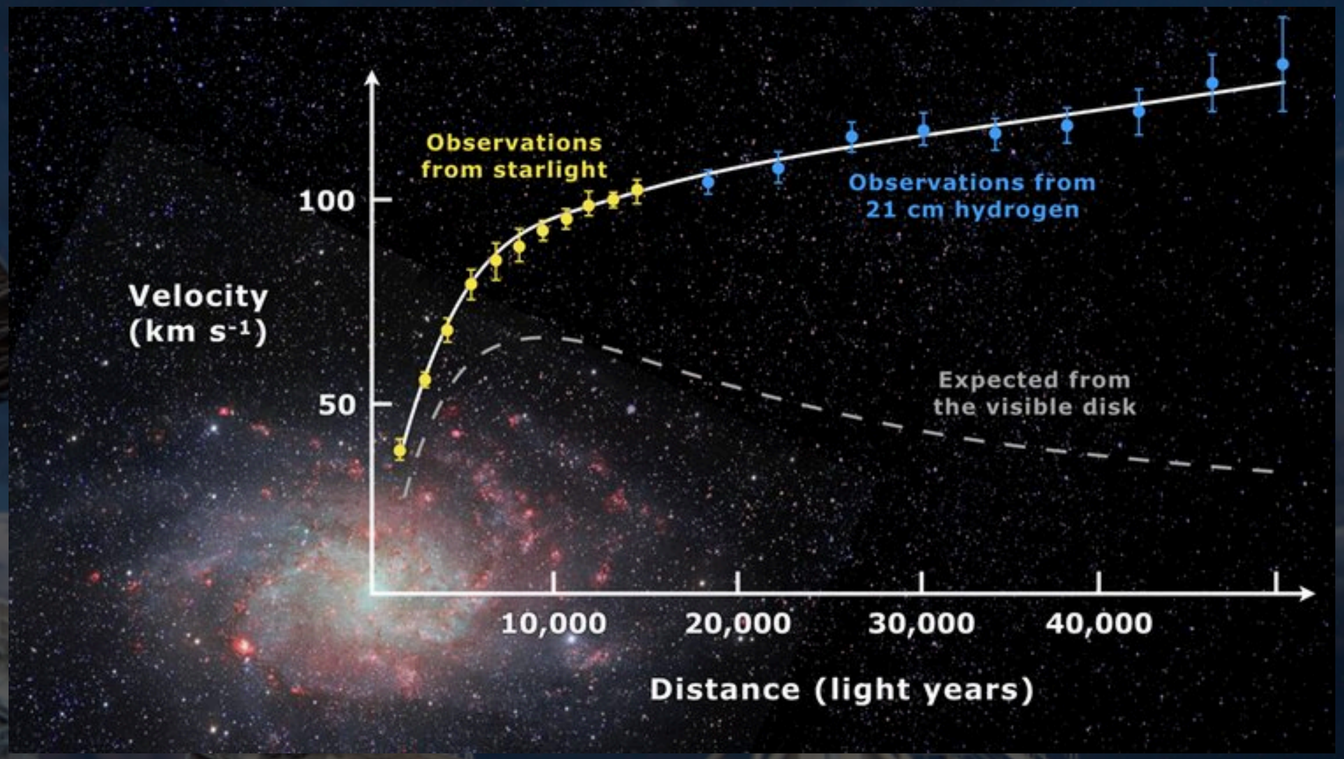
M81 in Optical

M81 in HI - 21cm



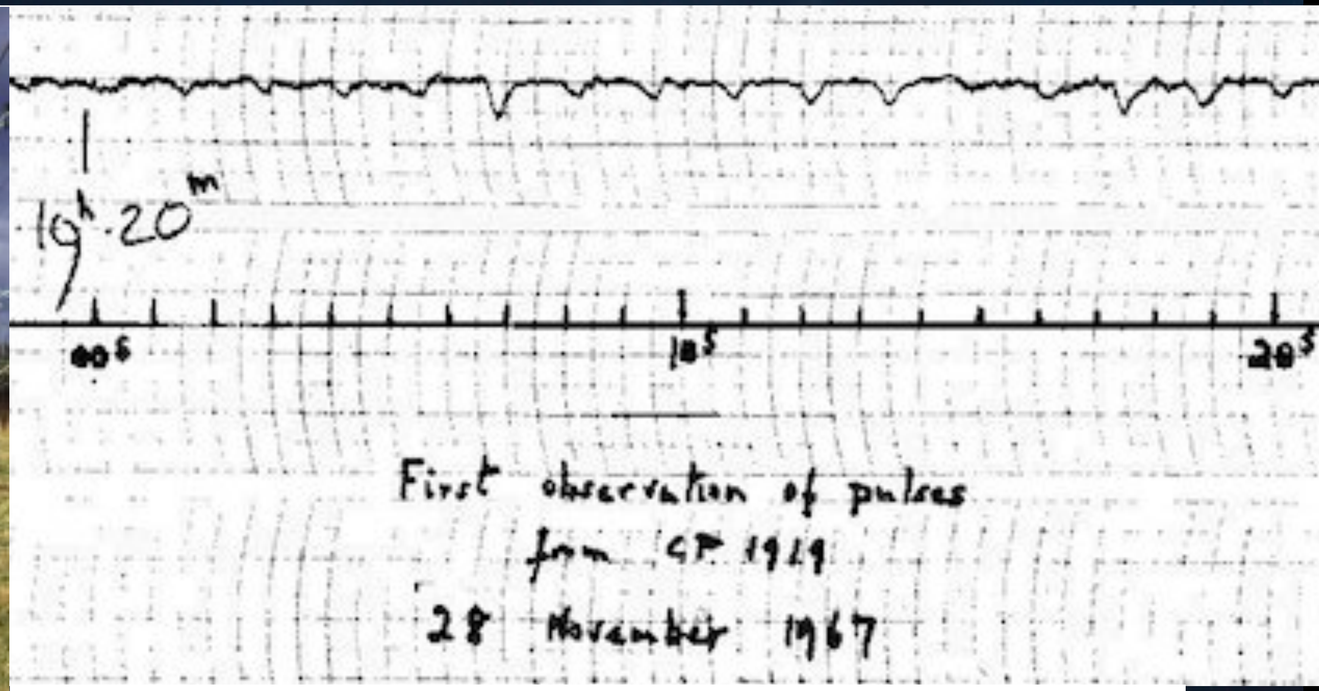

Leiden/Dwingeloo & IAR HI Surveys; b = 0
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
V_{LSR} (km s^{-1})
180°
150°
120°
90°
60°
30°
0°
-30°
-60°
-90°
-120°
-150°
-180°
Galactic Longitude


orbital speed (km/sec)
50
40
30
20
10
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
10
20
30
40
50
mean distance from Sun (AU)
(b)
Copyright © Addison Wesley


Observations from starlight
Observations from 21 cm hydrogen
Velocity (km s⁻¹)
100
50
Expected from the visible disk
10,000
20,000
30,000
40,000
Distance (light years)

PULSARS

Cambridge/ Mullard RAO Interplanetary Scintillation Array
ca 1968



Observation of a Rapidly Pulsating Radio Source

by

A. HEWISH
S. J. BELL
J. D. H. PILKINGTON
P. F. SCOTT
R. A. COLLINS

Mullard Radio Astronomy Observatory,
Cavendish Laboratory,
University of Cambridge

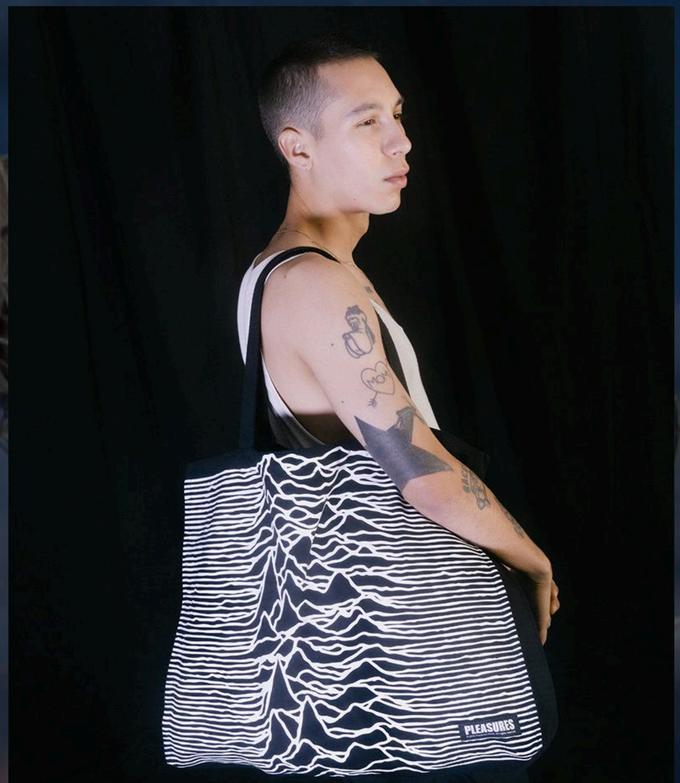
Unusual signals from pulsating radio sources have been recorded at the Mullard Radio Astronomy Observatory. The radiation seems to come from local objects within the galaxy, and may be associated with oscillations of white dwarf or neutron stars.

In July 1967, a large radio telescope operating at a frequency of 81·5 MHz was brought into use at the Mullard Radio Astronomy Observatory. This instrument was

of three others having remarkably similar properties which suggests that this type of source may be relatively common at a low flux density. A tentative explanation

The IPS array today.

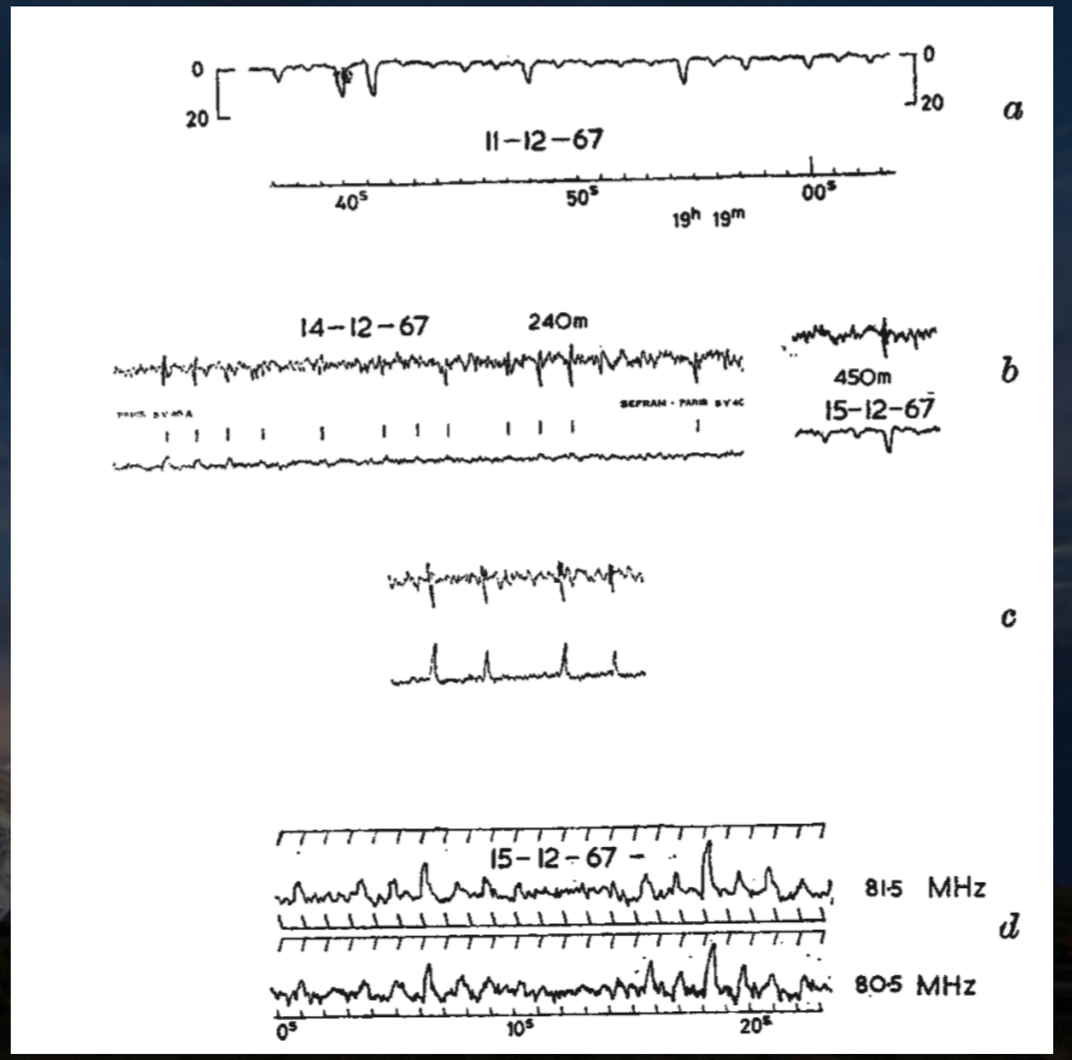
Copper thieves have had their way with it.



Pulsars are ubiquitous.

DISCOVERY

- Object name: PSR1919+21
- Pulses are extremely regular
- Pulses are delayed at lower frequencies



Hewish, Burnell, et al 1967

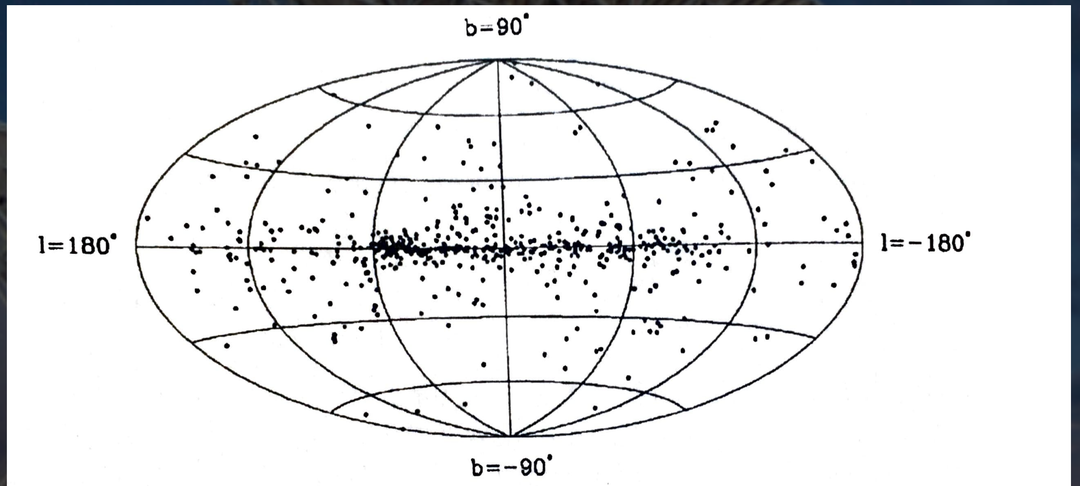


Fig. 11.9 Distribution of 558 pulsars in Galactic coordinates (from Taylor et al. 1993)

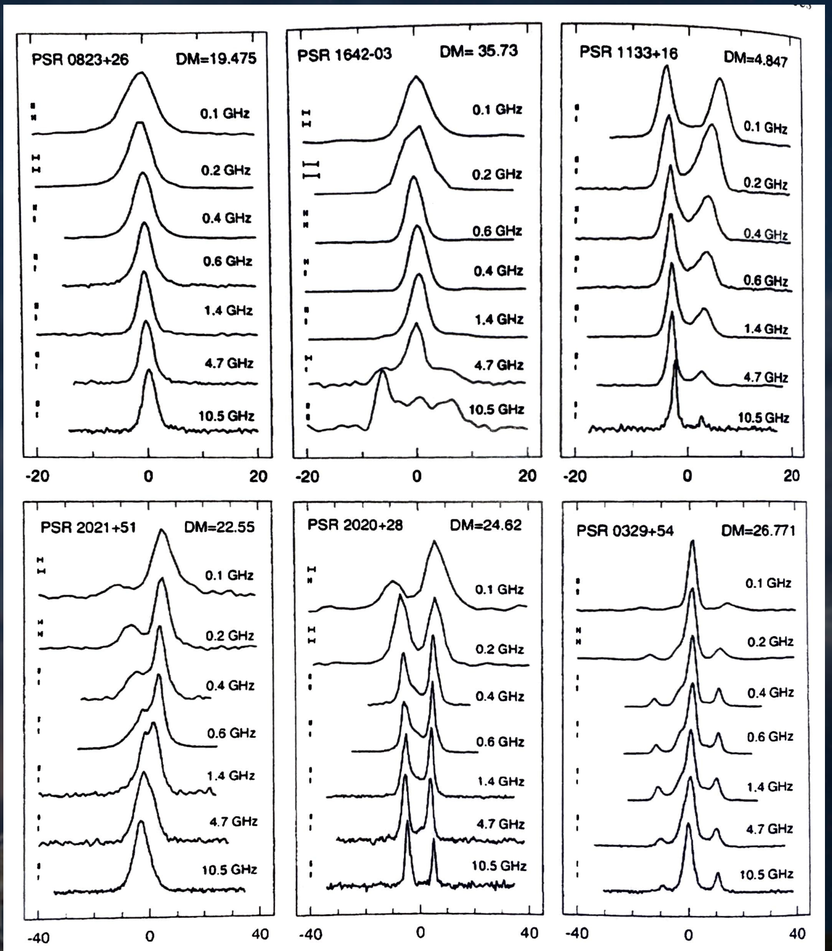
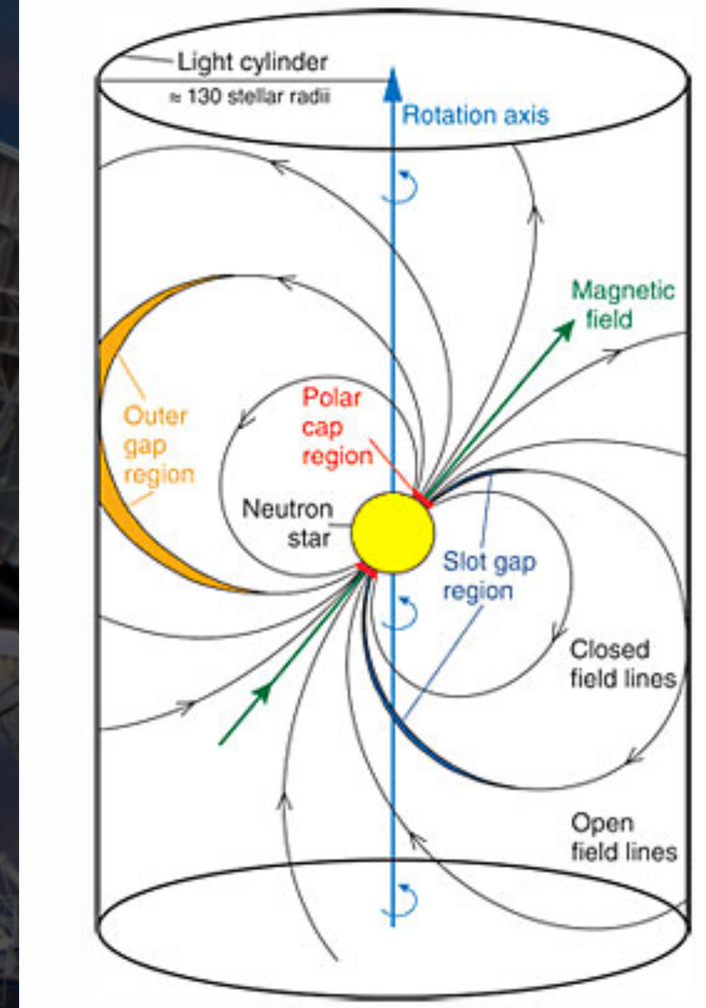
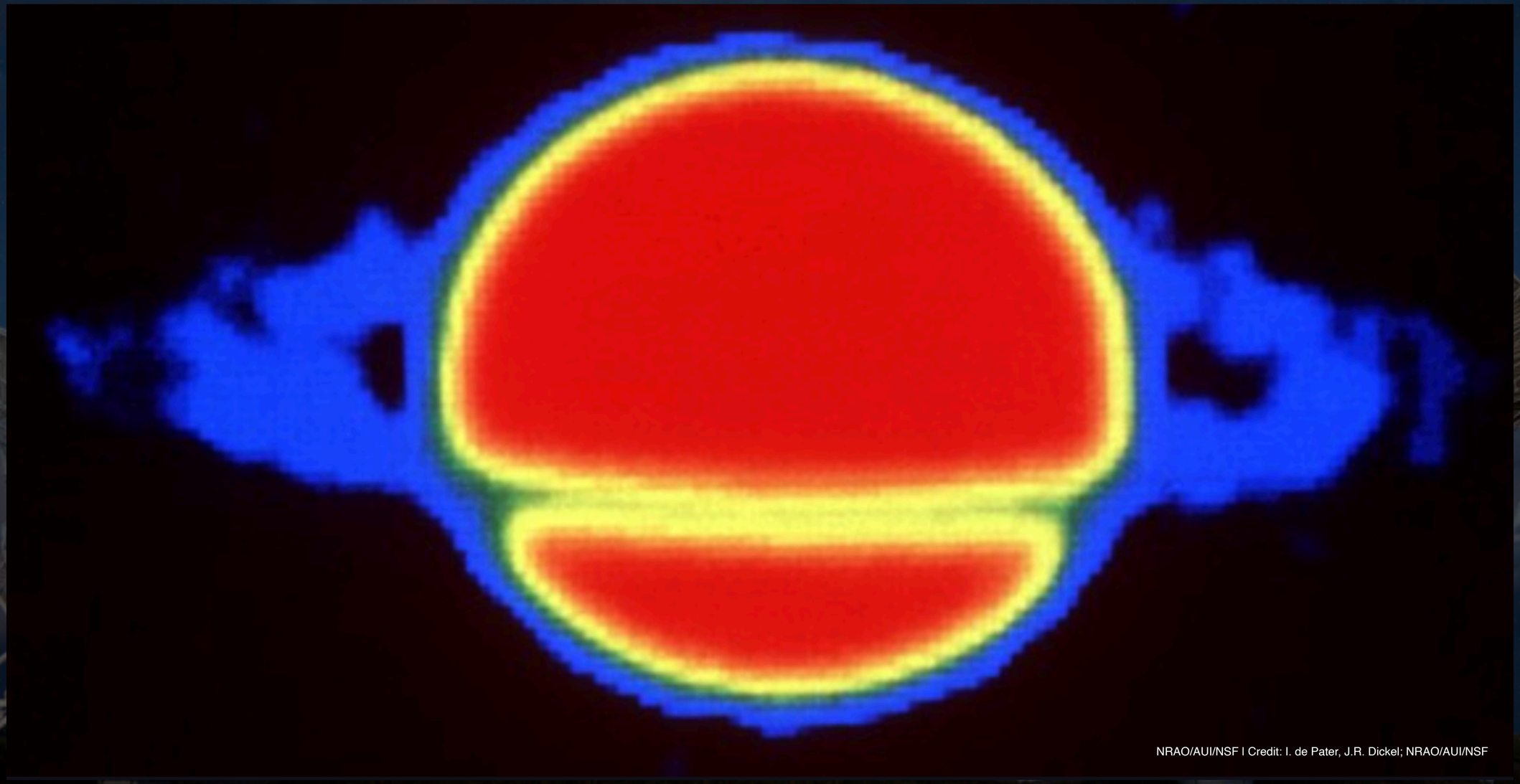


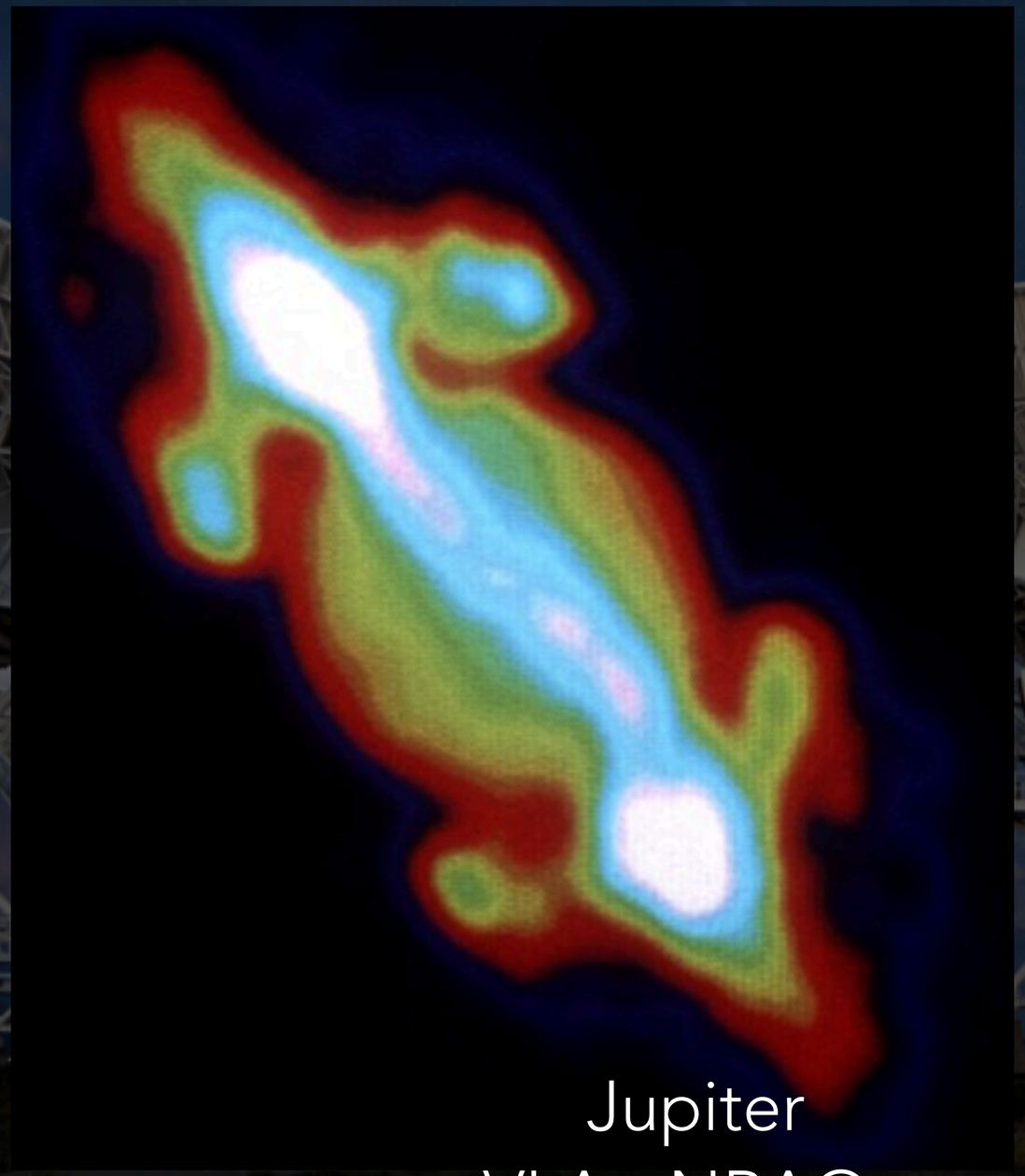
Fig. 11.10 Integrated pulse profiles plotted in the same rotation scale for each pulsar for frequencies 0.1–10.5 GHz. The pulse dispersion has been removed (figure from data in Kuzmin et al. 1998)


Light cylinder
≈ 130 stellar radii
Rotation axis
Magnetic field
Outer gap region
Polar cap region
Neutron star
Slot gap region
Closed field lines
Open field lines

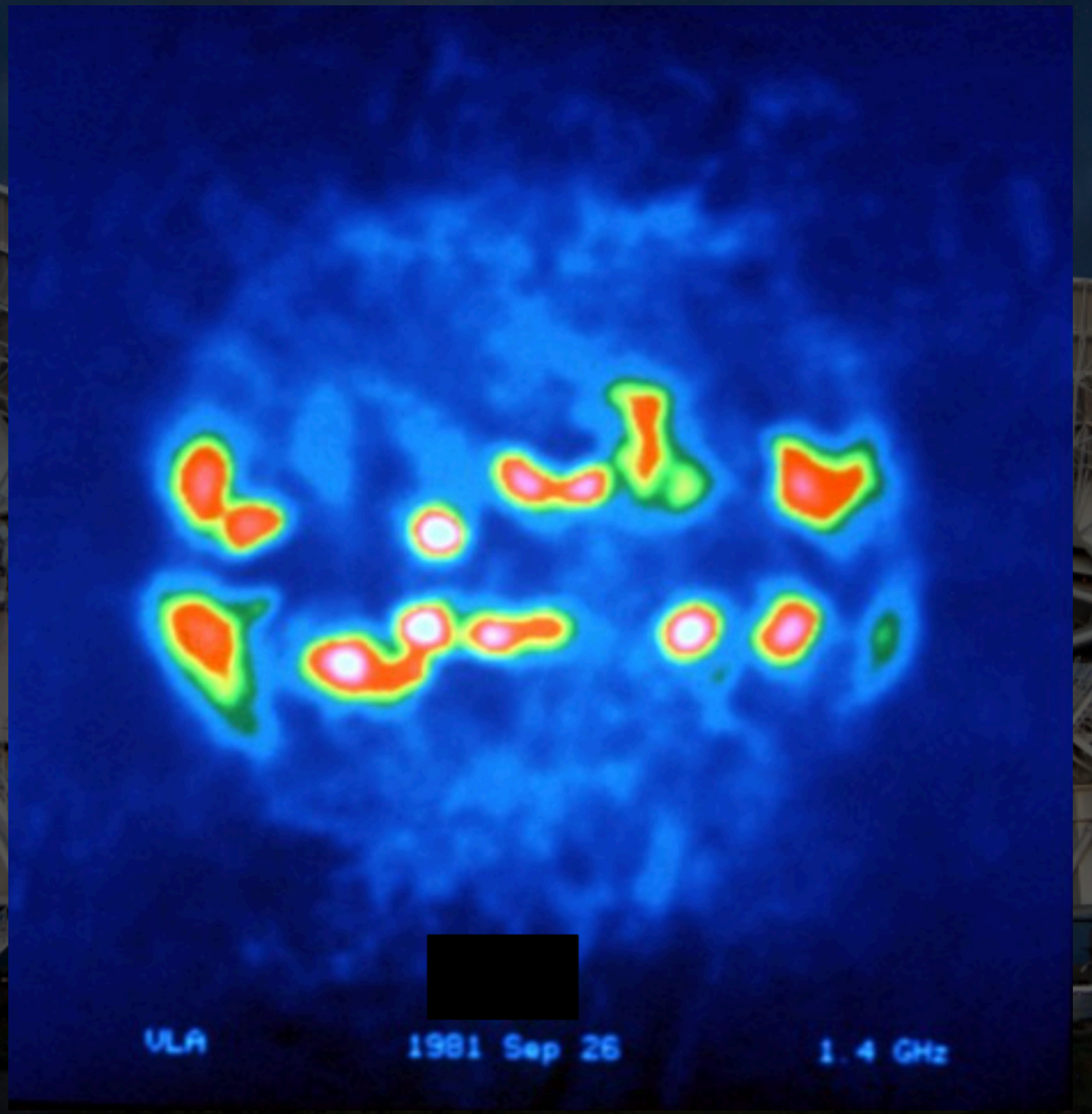


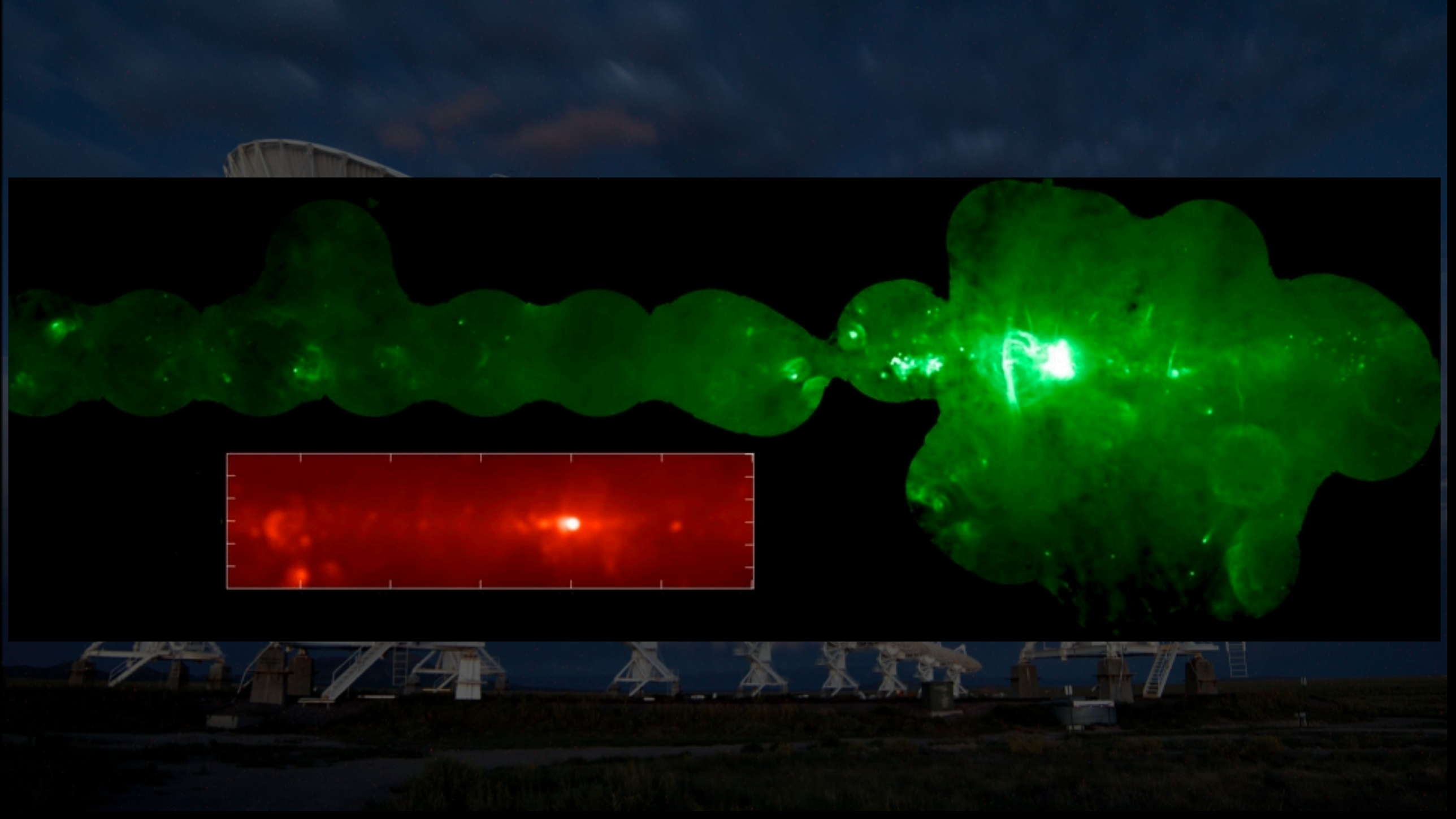
NRAO/AUI/NSF I Credit: I. de Pater, J.R. Dickel; NRAO/AUI/NSF

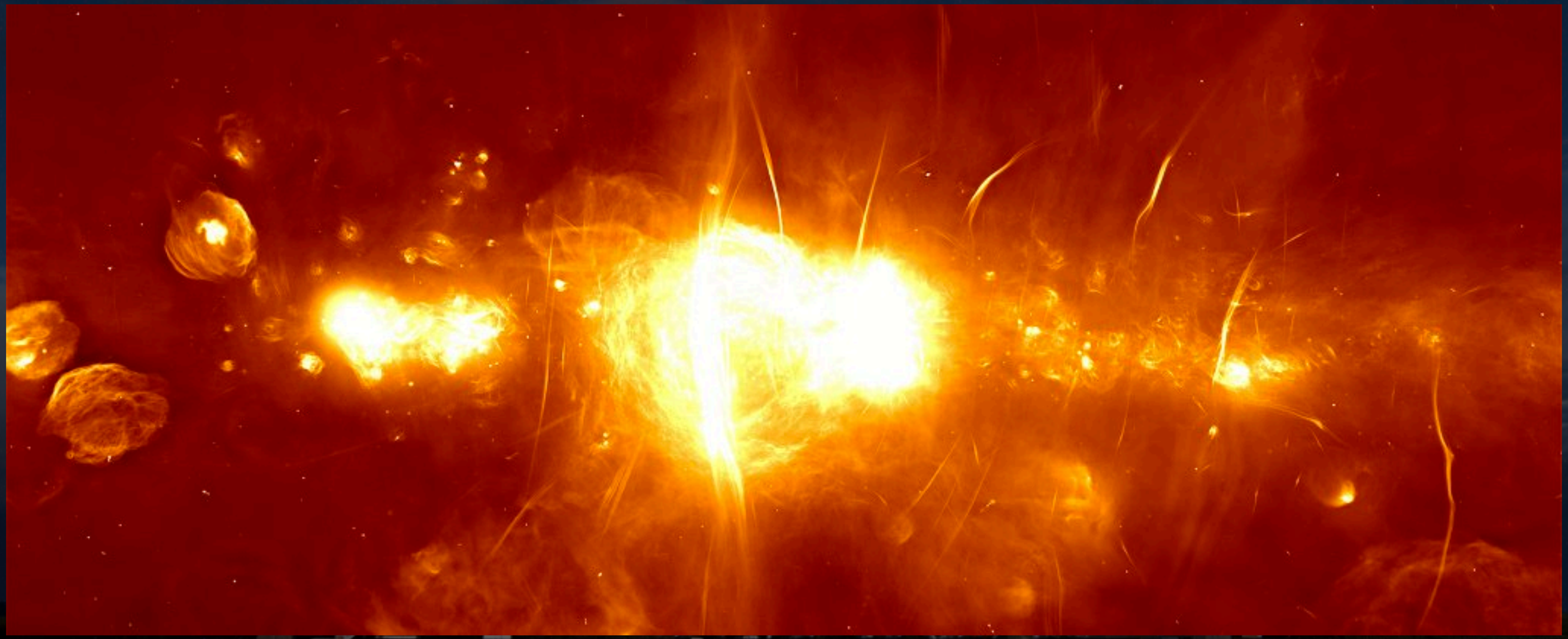
Saturn



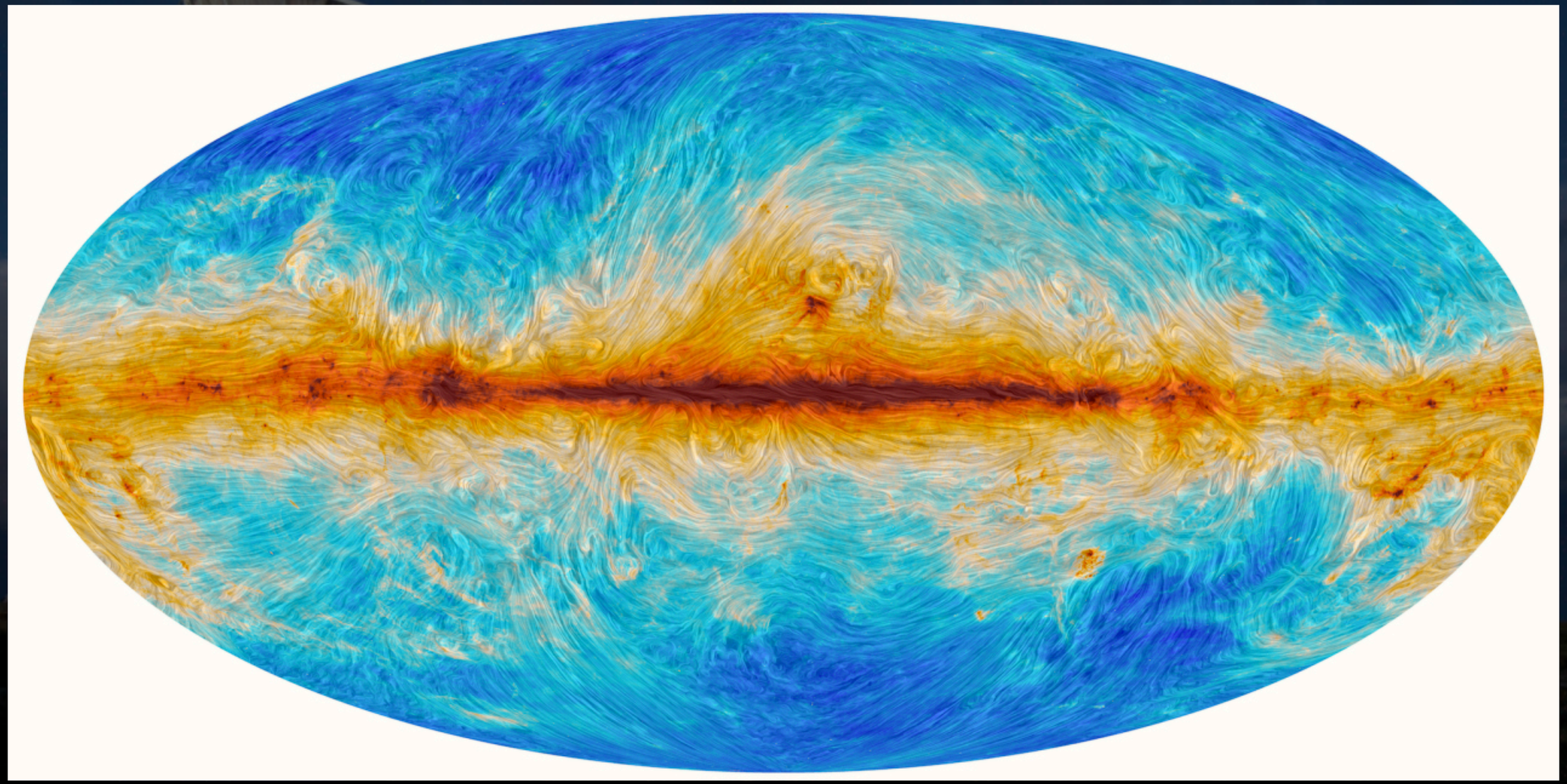
Jupiter
VLA - NRAO


VLA
1981 Sep 26
1.4 GHz

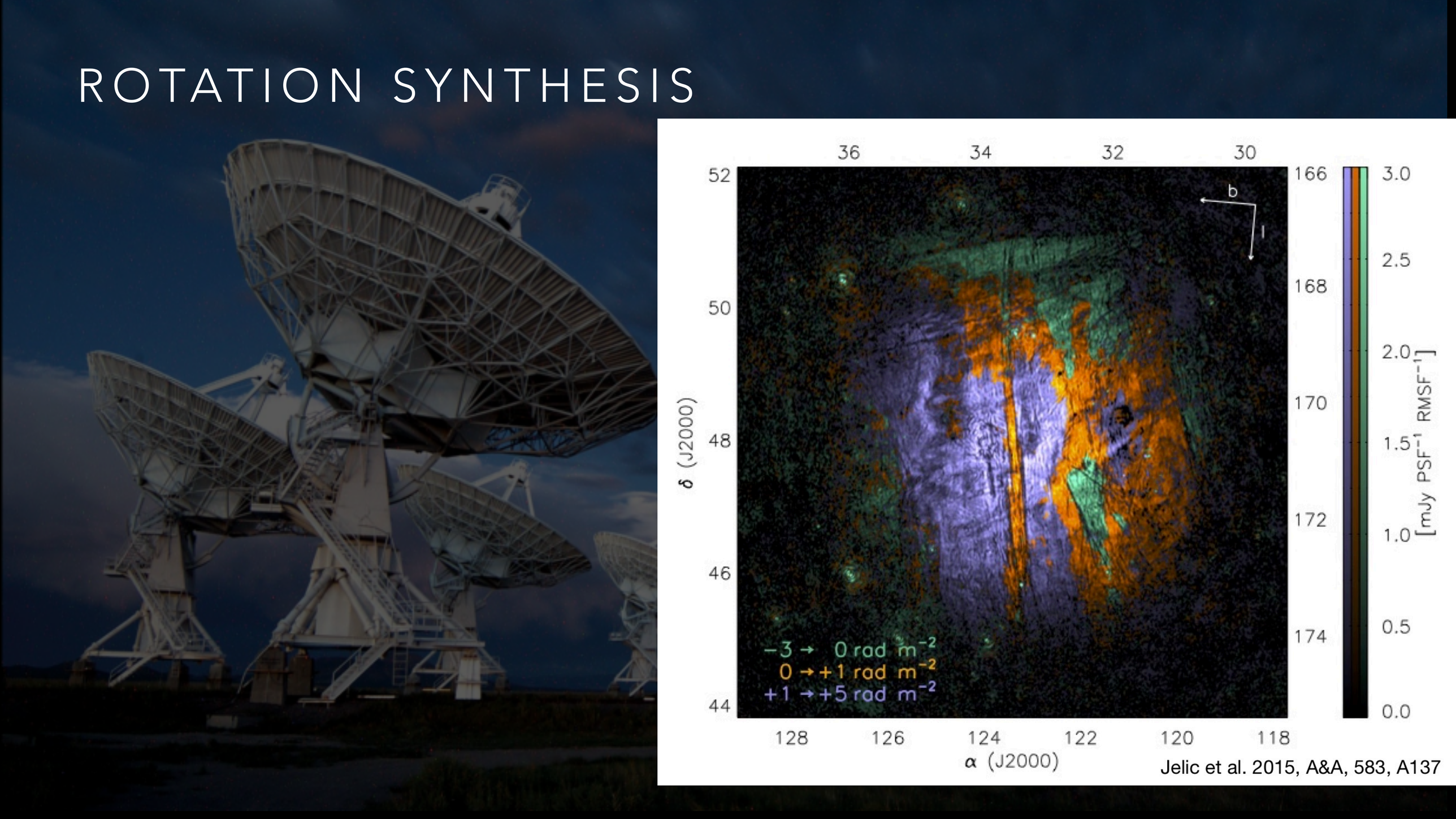




PLANCK MEASUREMENTS OF POLARIZATION



ROTATION SYNTHESIS



Jelic et al. 2015, A&A, 583, A137

HOMEWORK

- Discussion: Why Radio is tricky (re ALMA ProxCen analysis)
- Brightness
- Emission mechanisms

- For next Monday, read and comment on.
- Anglada et al 2017
  ui.adsabs.harvard.edu/abs/2017ApJ...850L...6A/
- Macgregor et al 2018
  ui.adsabs.harvard.edu/abs/2018ApJ...855L...2M/