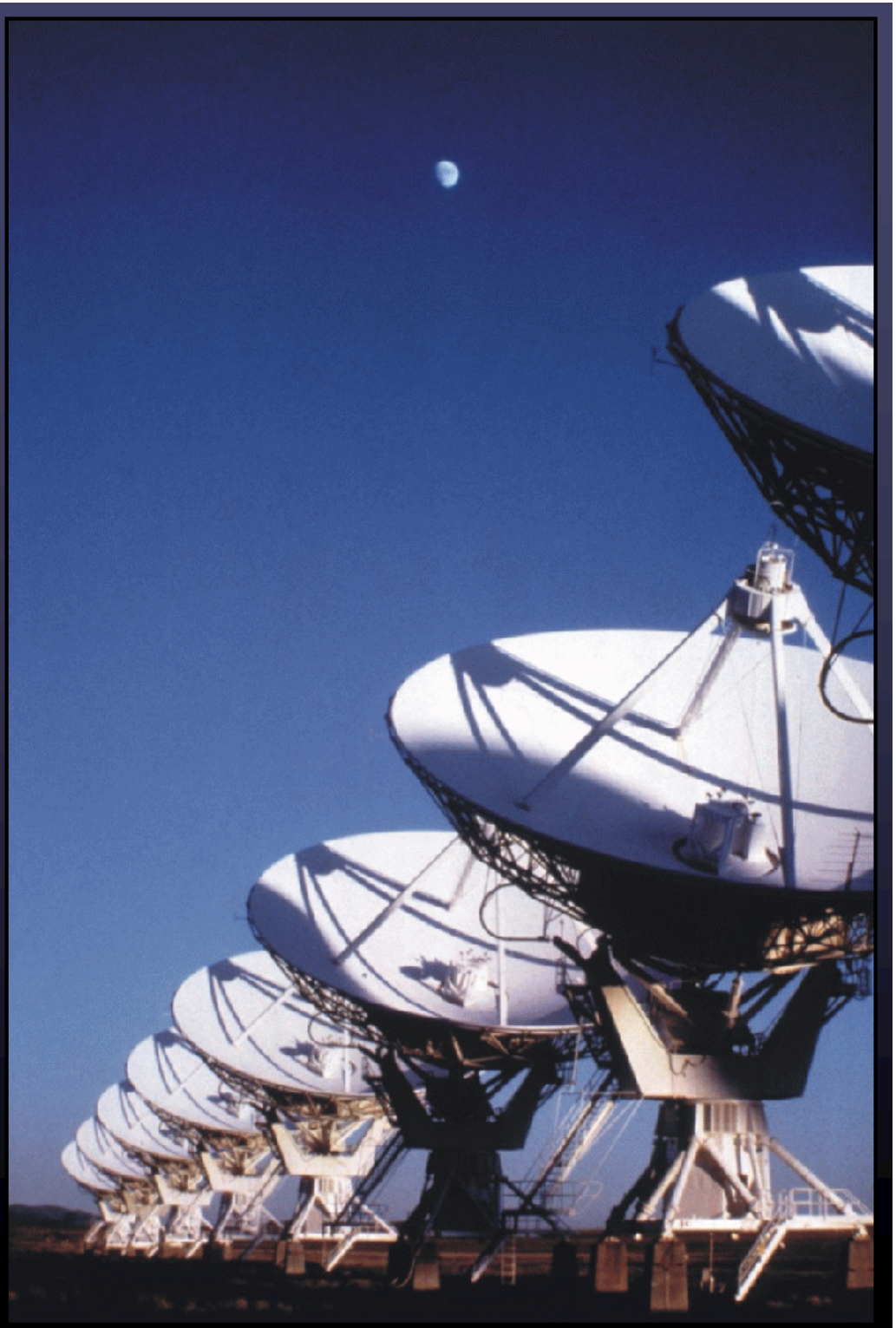
Non-thermal sources

Greg Taylor

University of New Mexico



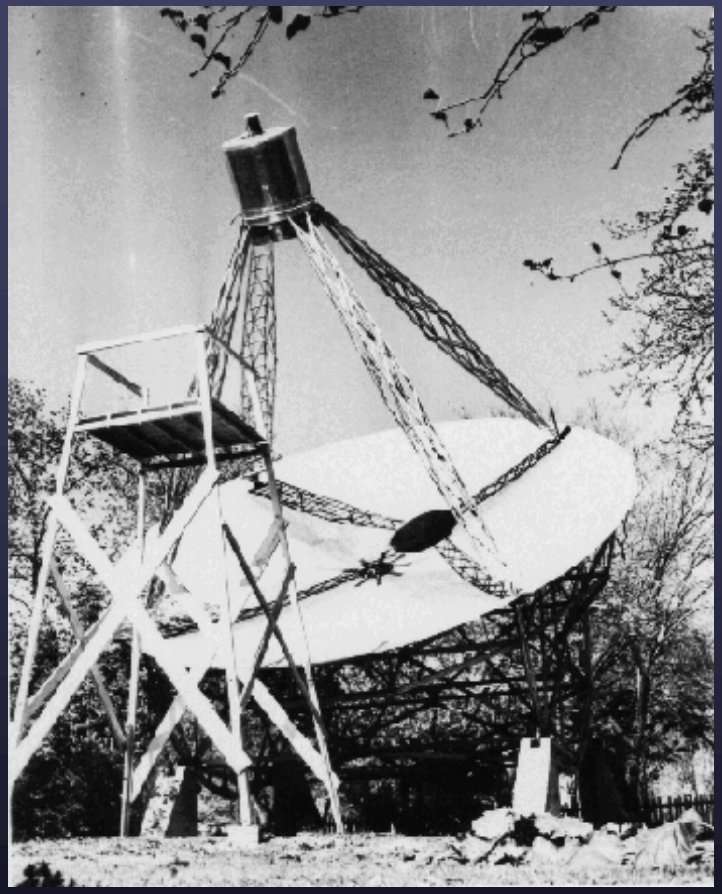
Astronomy 423 at UNM

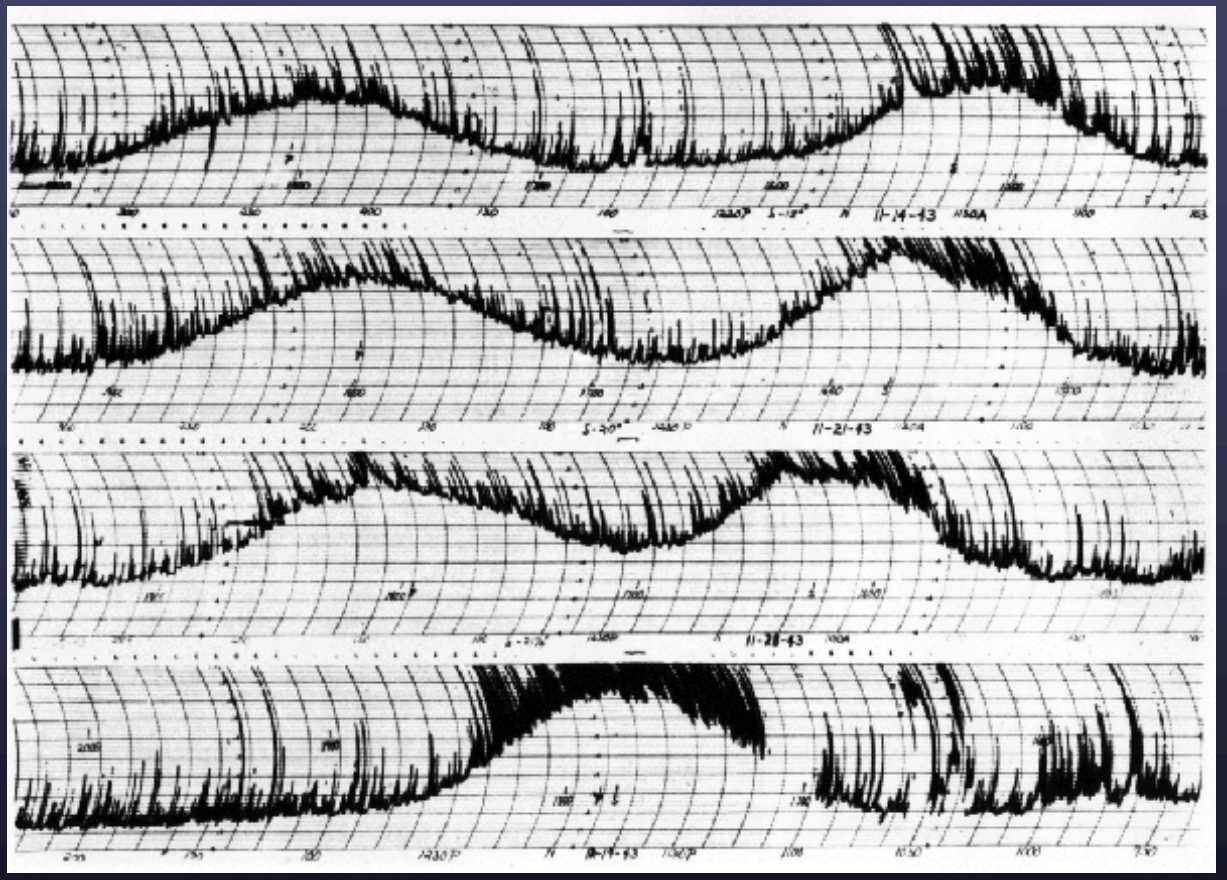
Radio Astronomy

Announcements – The Sprint to the Finish

- HW9 is due on Monday, April 19
- April 19 - Thermal sources + review on Monday
- April 21 - Exam2 on Wednesday
- May 3; teams 421 and 422 (VLA projects)
- May 5; teams 423 and 424 (LWA projects)
- Presentations should use slides (powerpoint, keynote, etc.) and aim for 21+10 (talk + Q&A)
  Everybody in the group needs to take a turn speaking
- May 7 - Written reports due

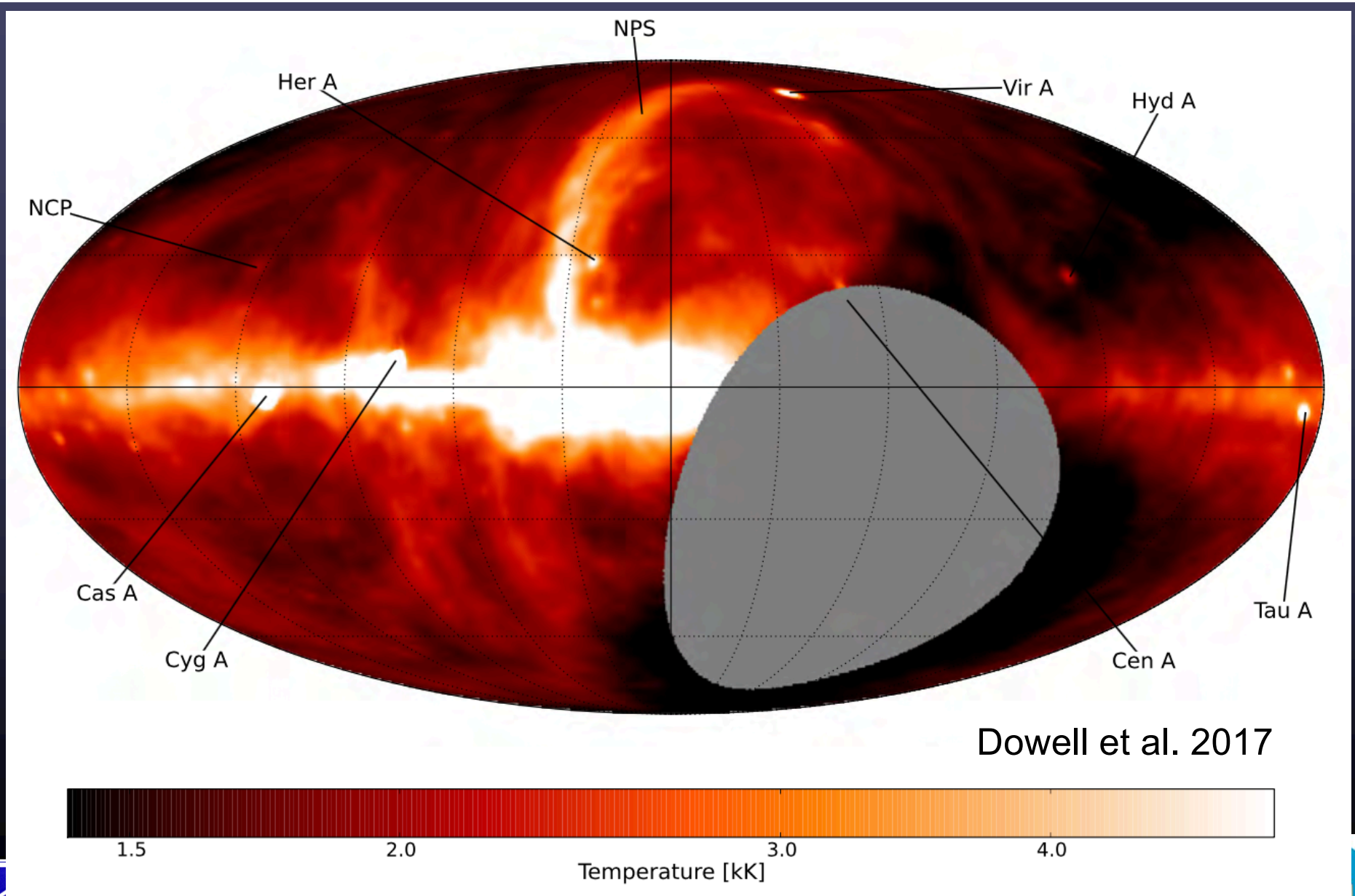
Non-Thermal Sources





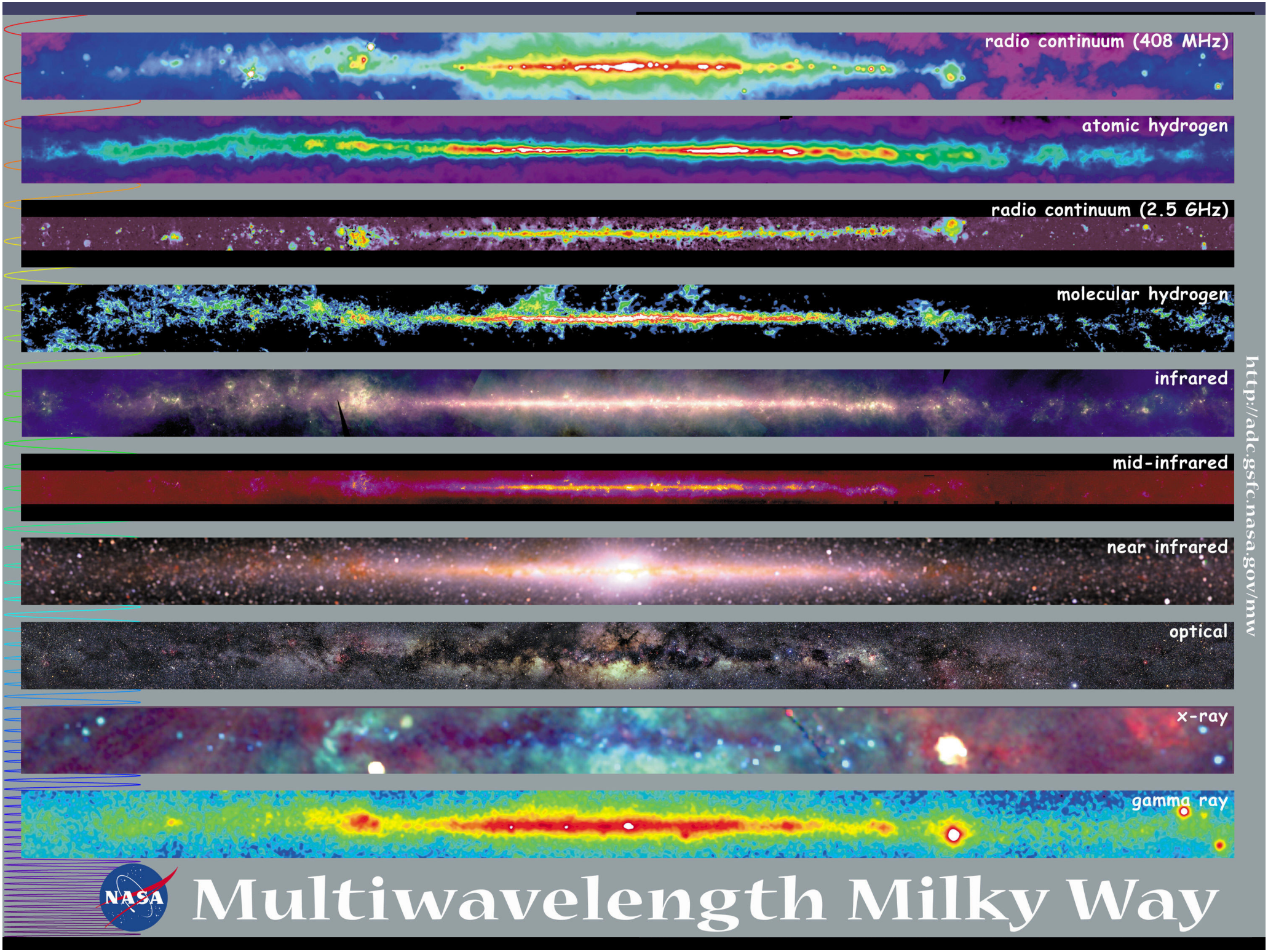
Grote Reber's telescope and Radio Frequency Interference in 1938

The Milky Way at 74 MHz from LWA1



The Radio Sky

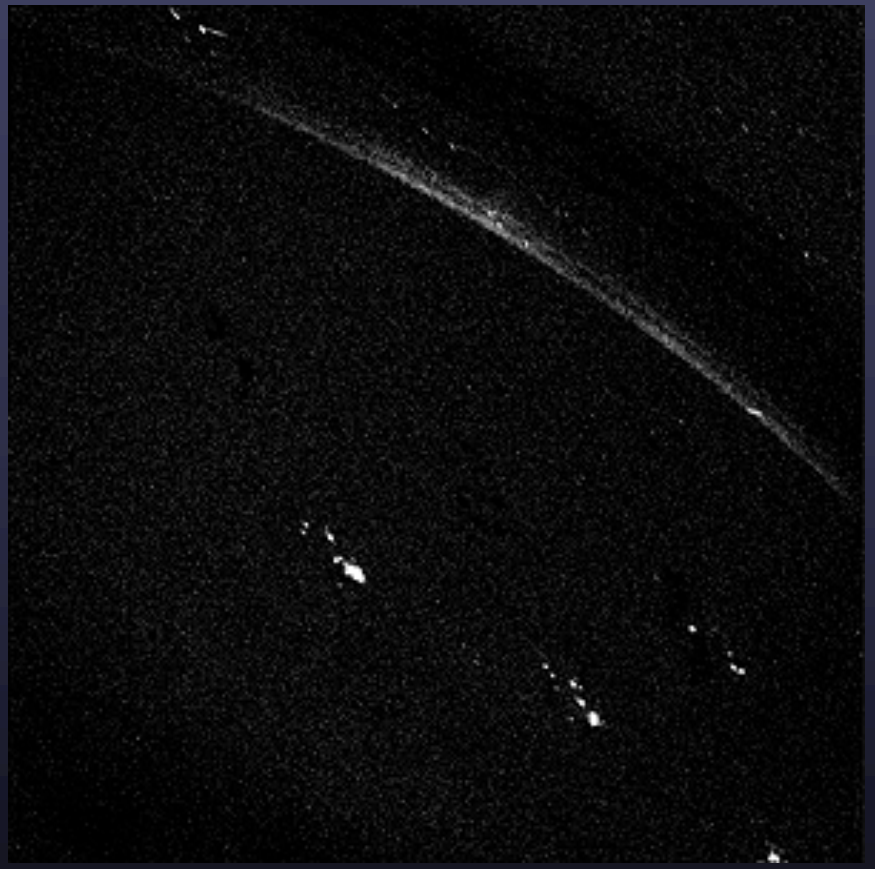
5 GHz image from 300 ft,Condon et al.


radio continuum (408 MHz)
atomic hydrogen
radio continuum (2.5 GHz)
molecular hydrogen
infrared
mid-infrared
near infrared
optical
x-ray
gamma ray
http://adc.gsfc.nasa.gov/mw
NASA
Multiwavelength Milky Way

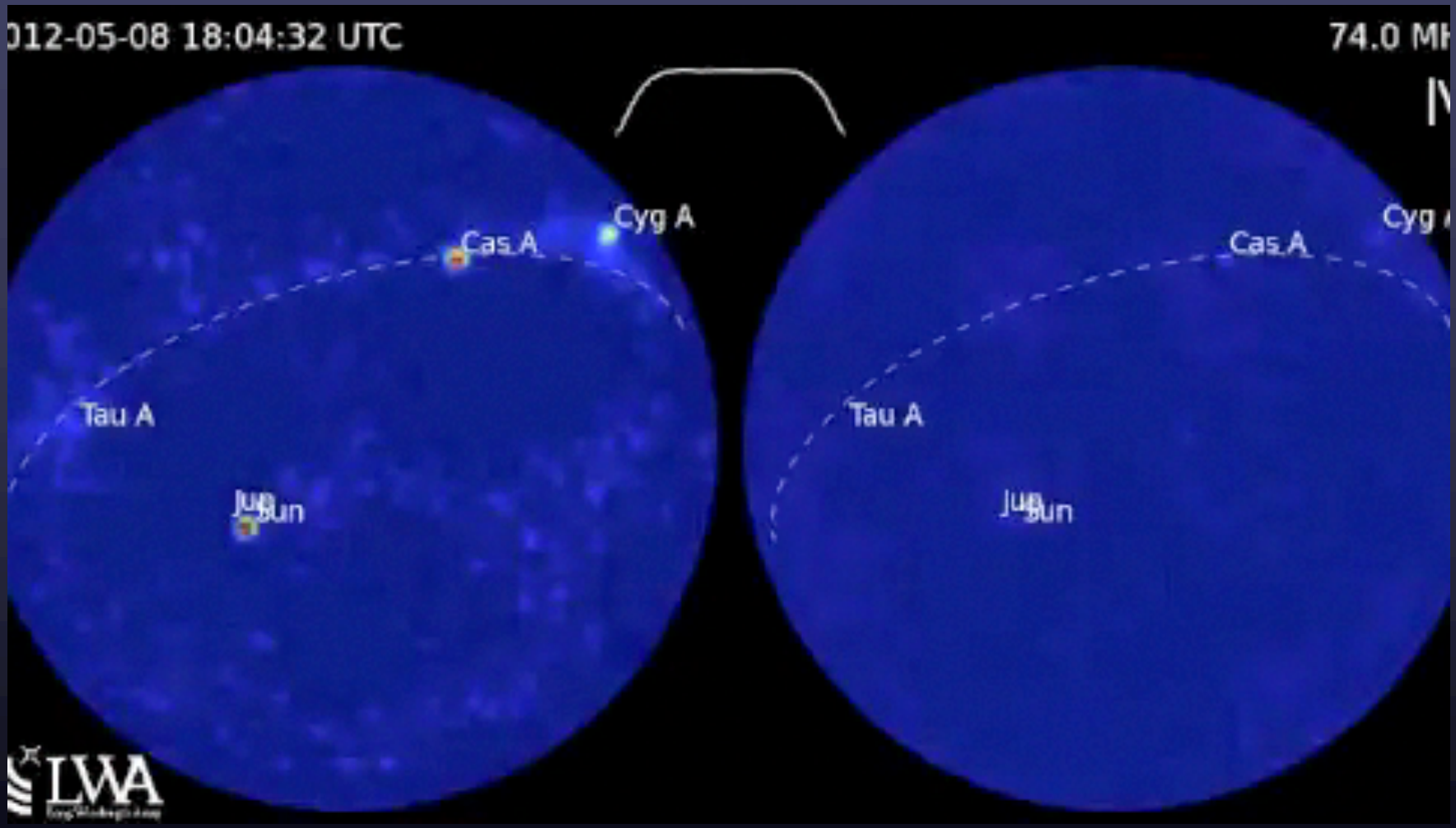
Lightning

On Earth

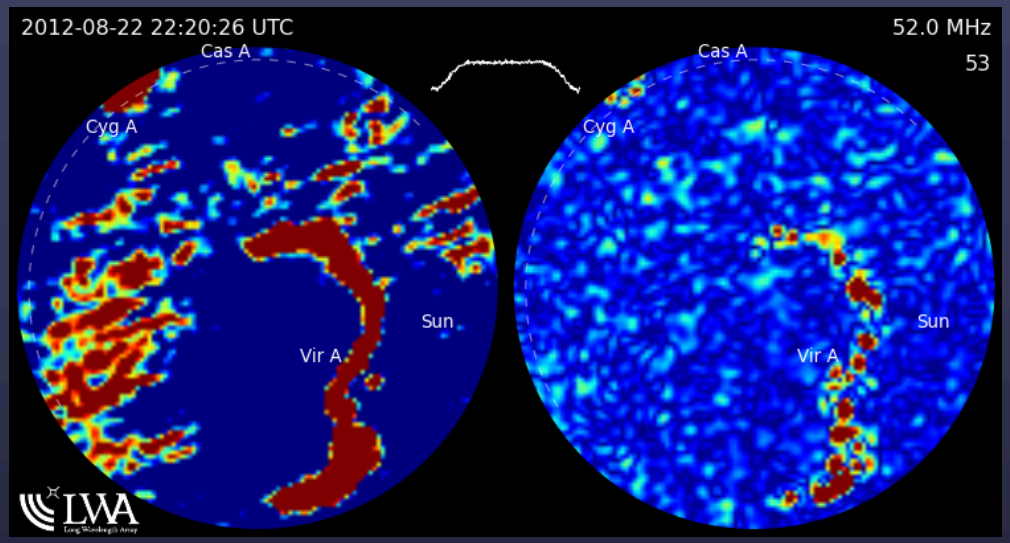
On Jupiter

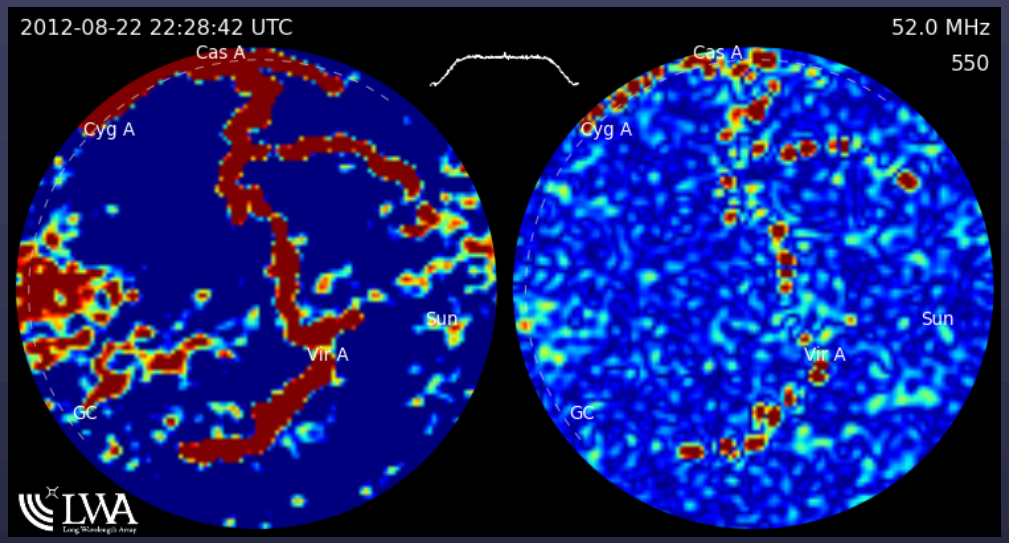


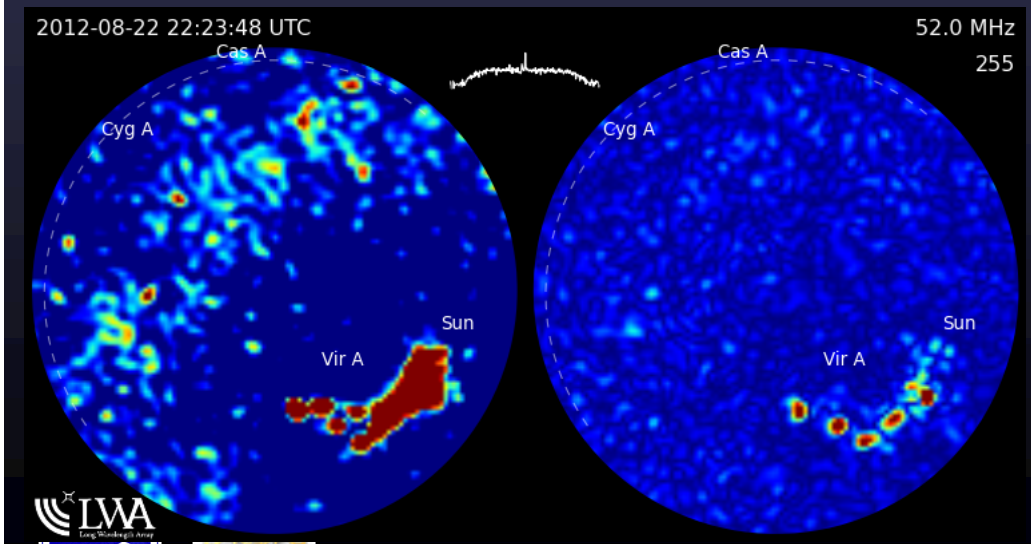
Lightning

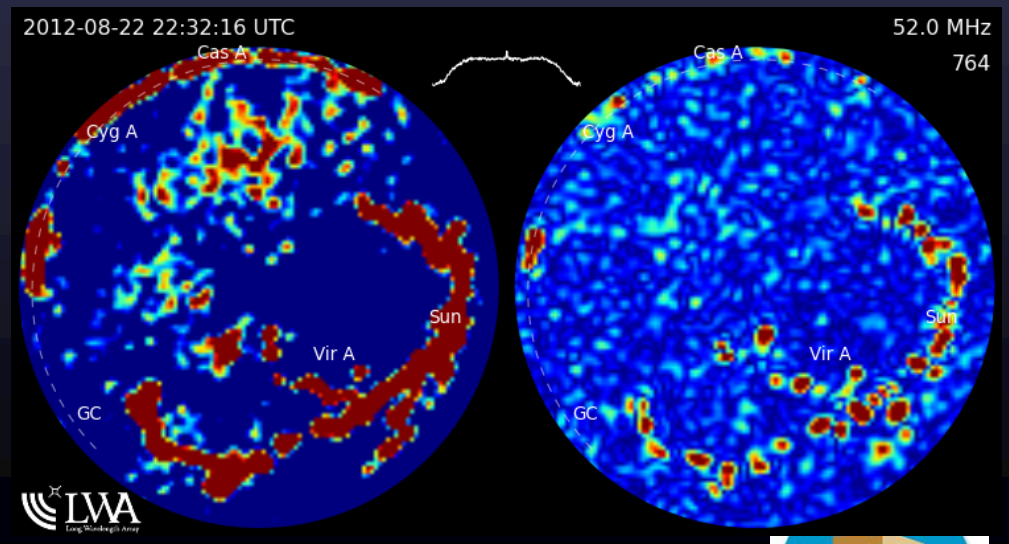

012-05-08 18:04:32 UTC
74.0 MH
Cyg A
Cas A
Tau A
Sun
Cyg
Cas A
Tau A
Sun
LWA

Lightning

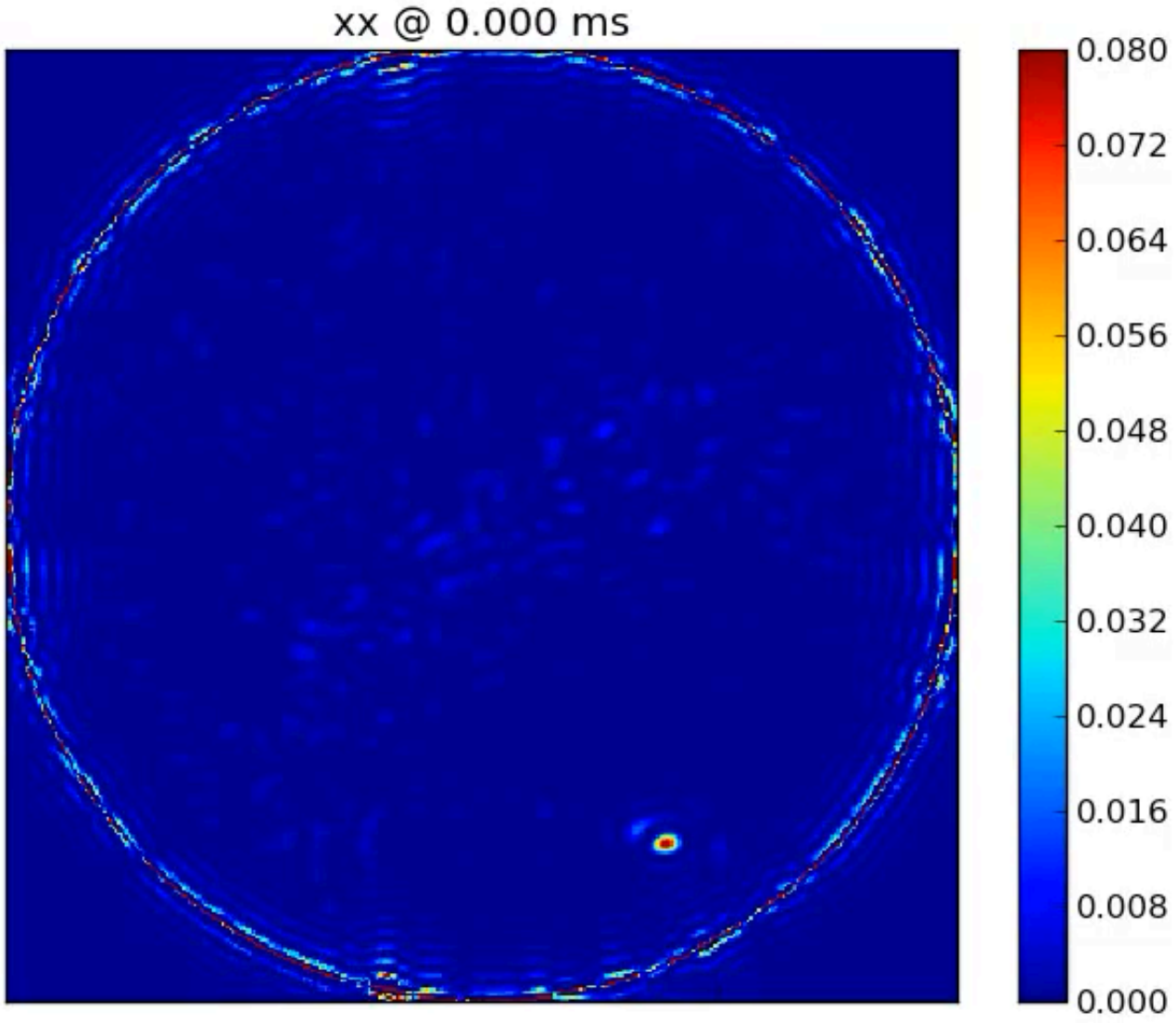

2012-08-22 22:20:26 UTC
52.0 MHz
53
Cas A
Cyg A
Sun
Vir A
Cas A
Cyg A
Sun
Vir A
LWA


2012-08-22 22:28:42 UTC
52.0 MHz
550
Cas A
Cyg A
Sun
Vir A
GC
Cas A
Cyg A
Sun
Vir A
GC
LWA

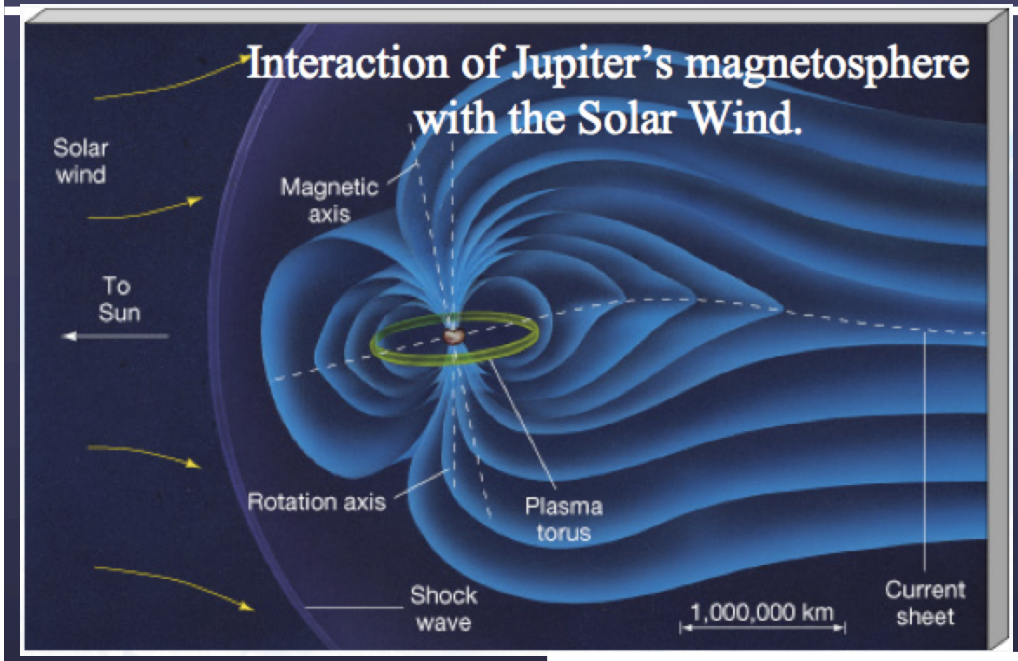

2012-08-22 22:23:48 UTC
52.0 MHz
255
Cas A
Cyg A
Sun
Vir A
Cas A
Cyg A
Sun
Vir A
LWA

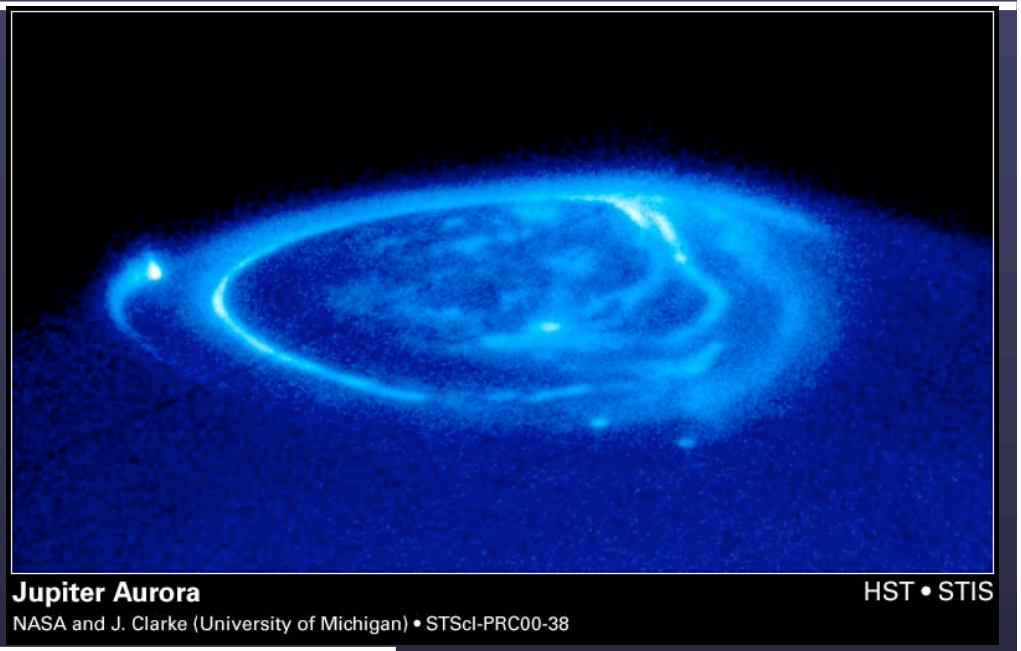

2012-08-22 22:32:16 UTC
52.0 MHz
764
Cas A
Cyg A
Sun
Vir A
GC
Cas A
Cyg A
Sun
Vir A
GC
LWA

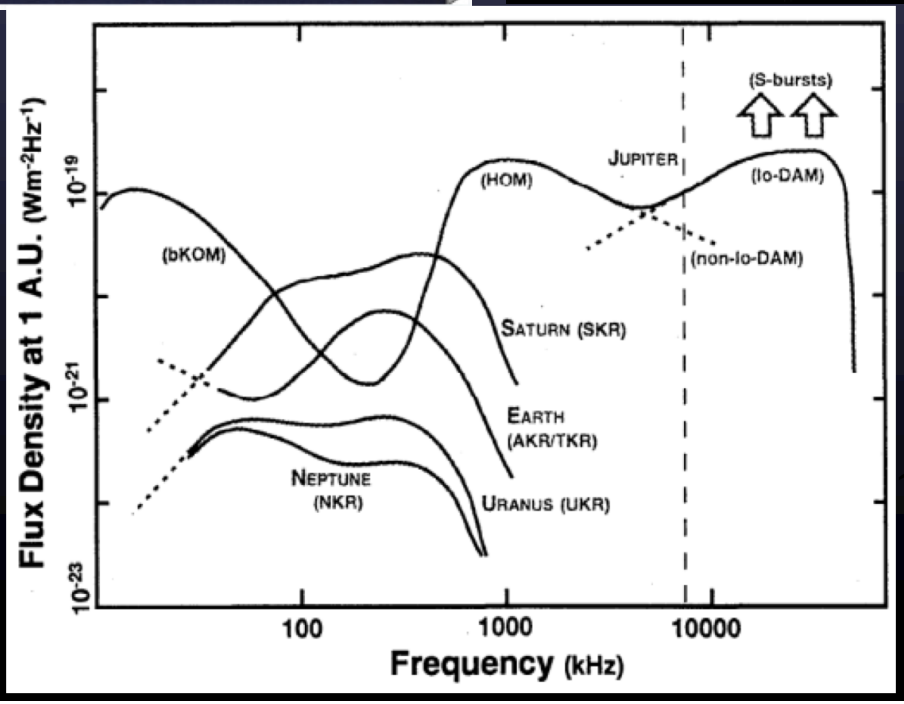
Lightning - @40 microsecond steps



Jupiter



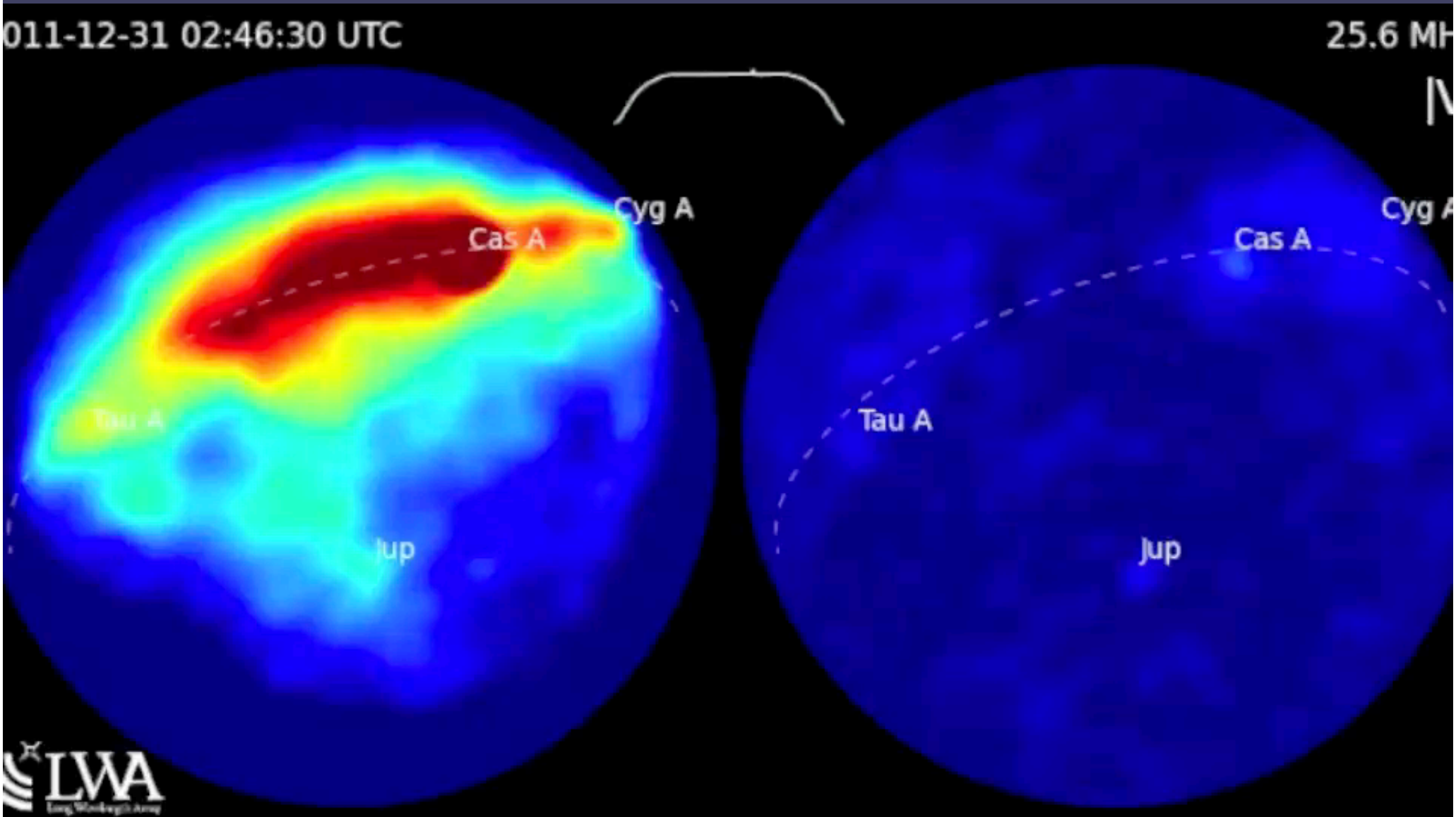




Zarka (19

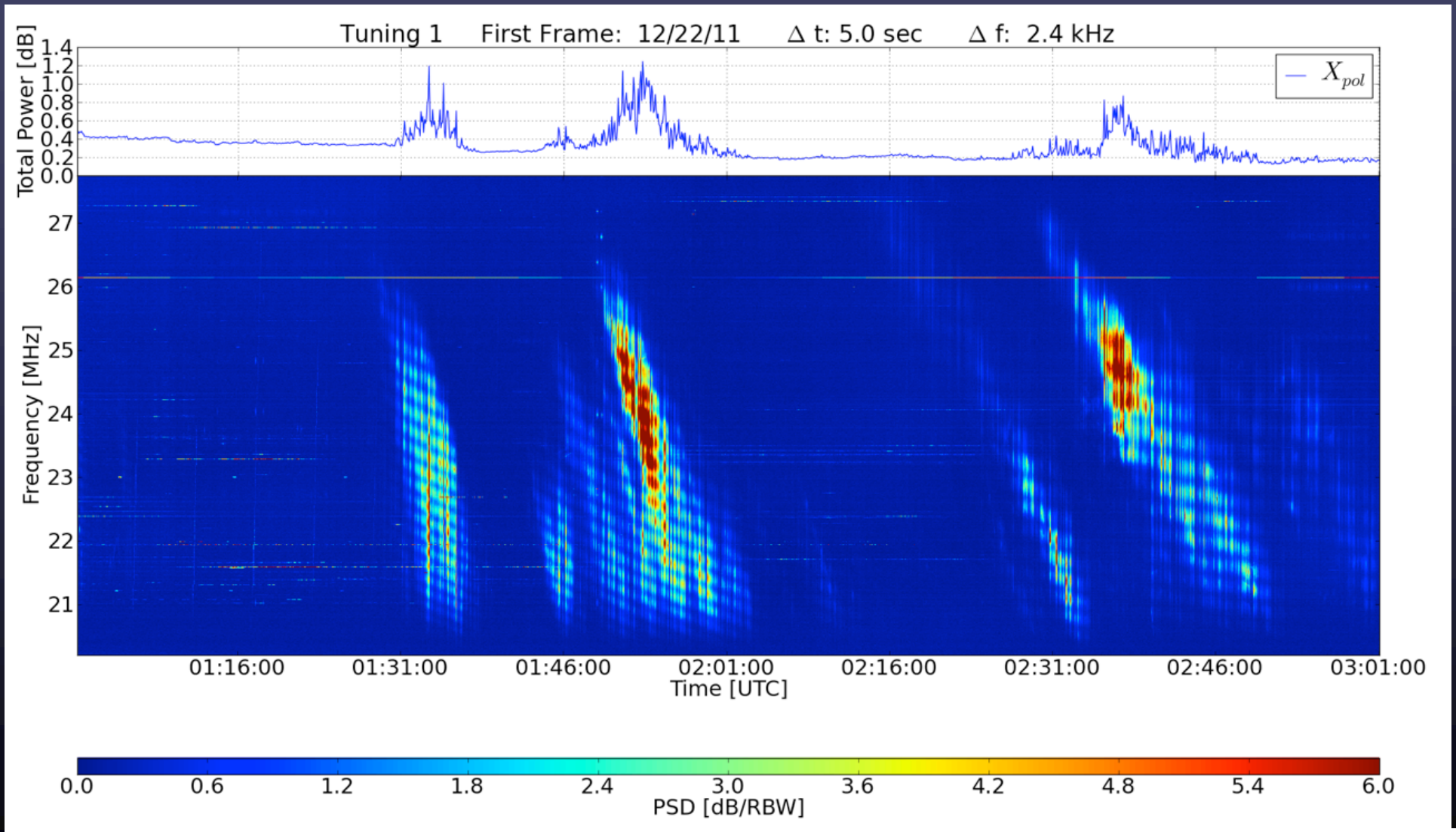
The University of New Mexico

2011 Dec 31

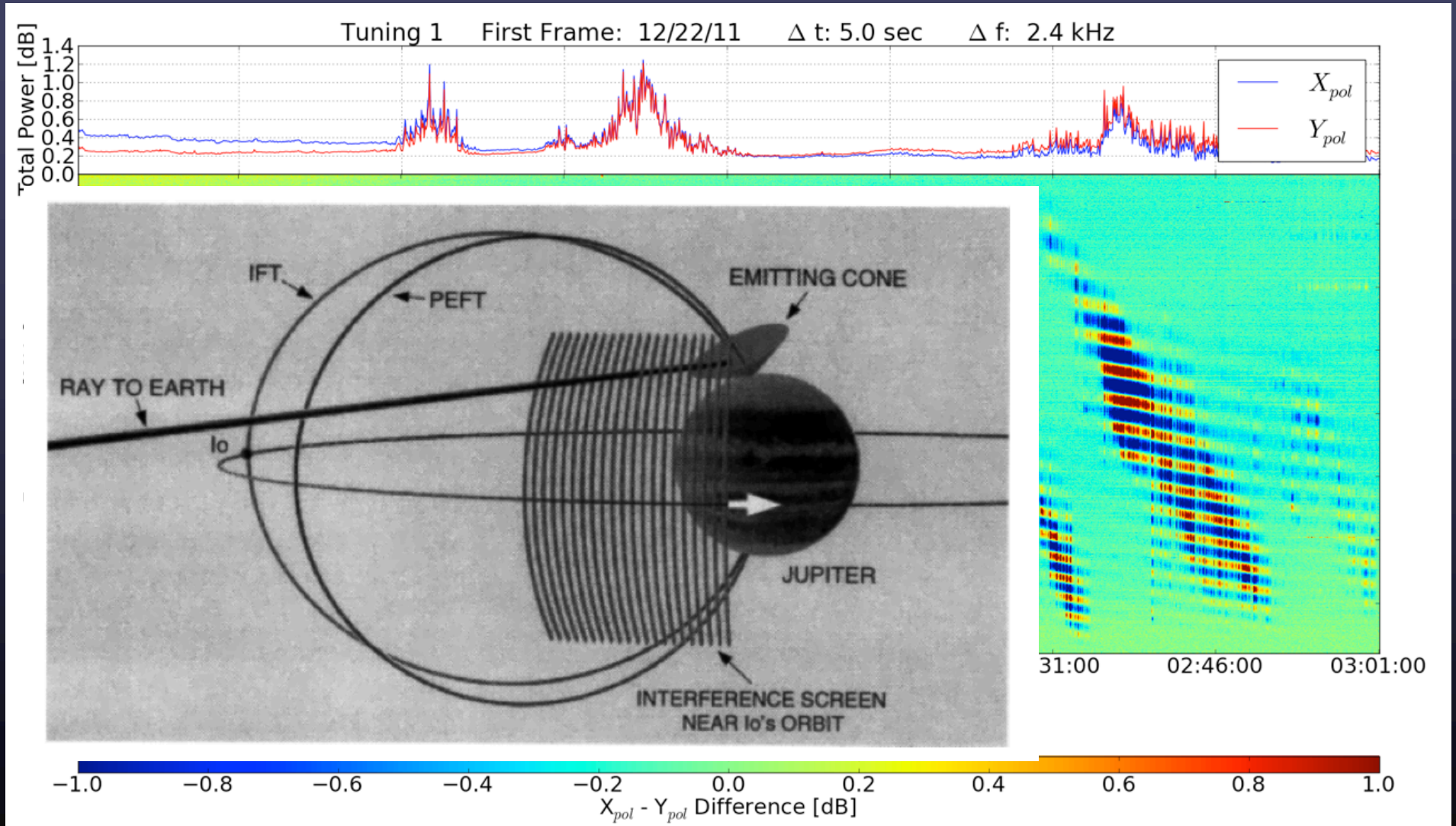


Jovian Bursts

Decametric Jovian Emission



Decametric Jovian Emission



Clarke e

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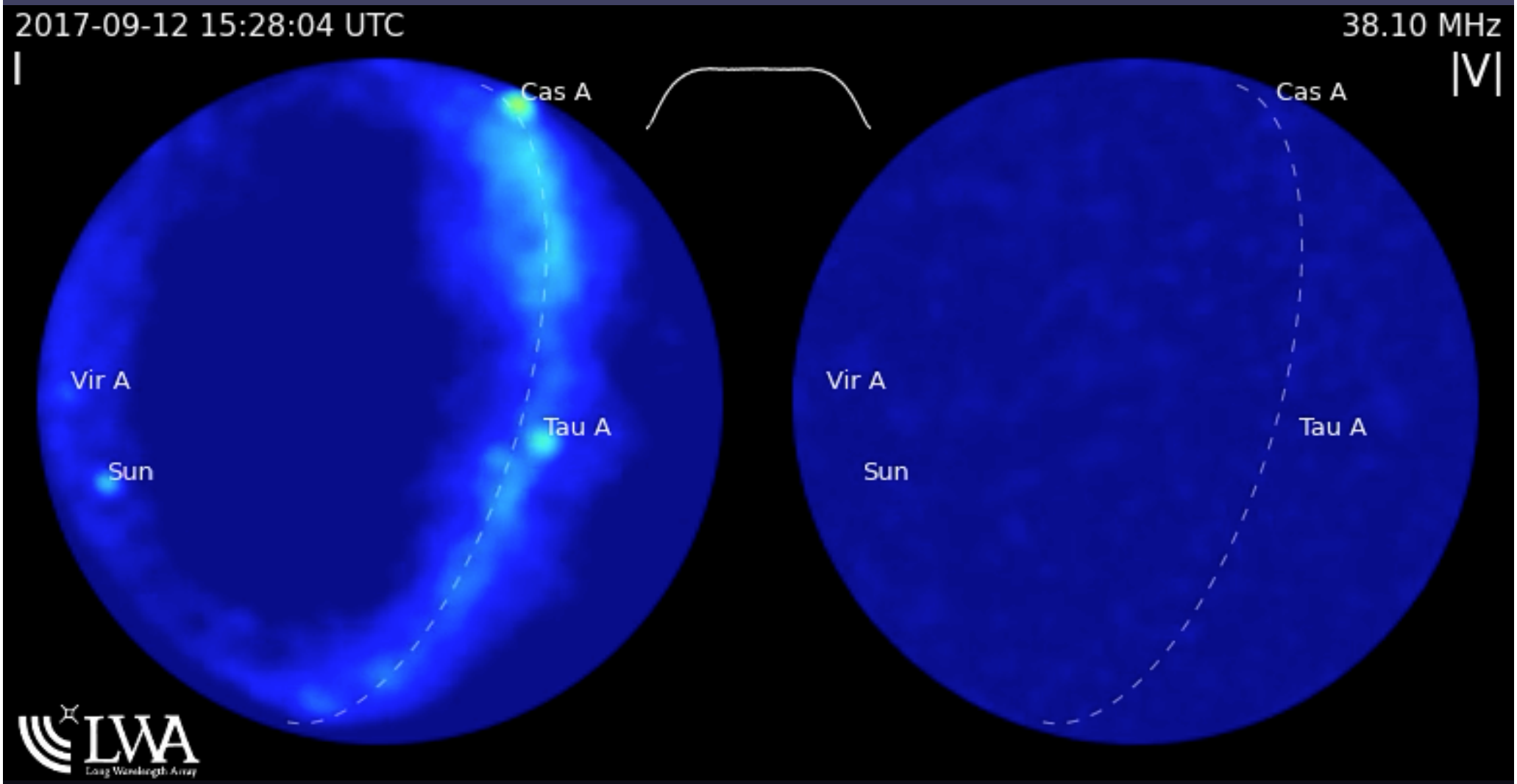
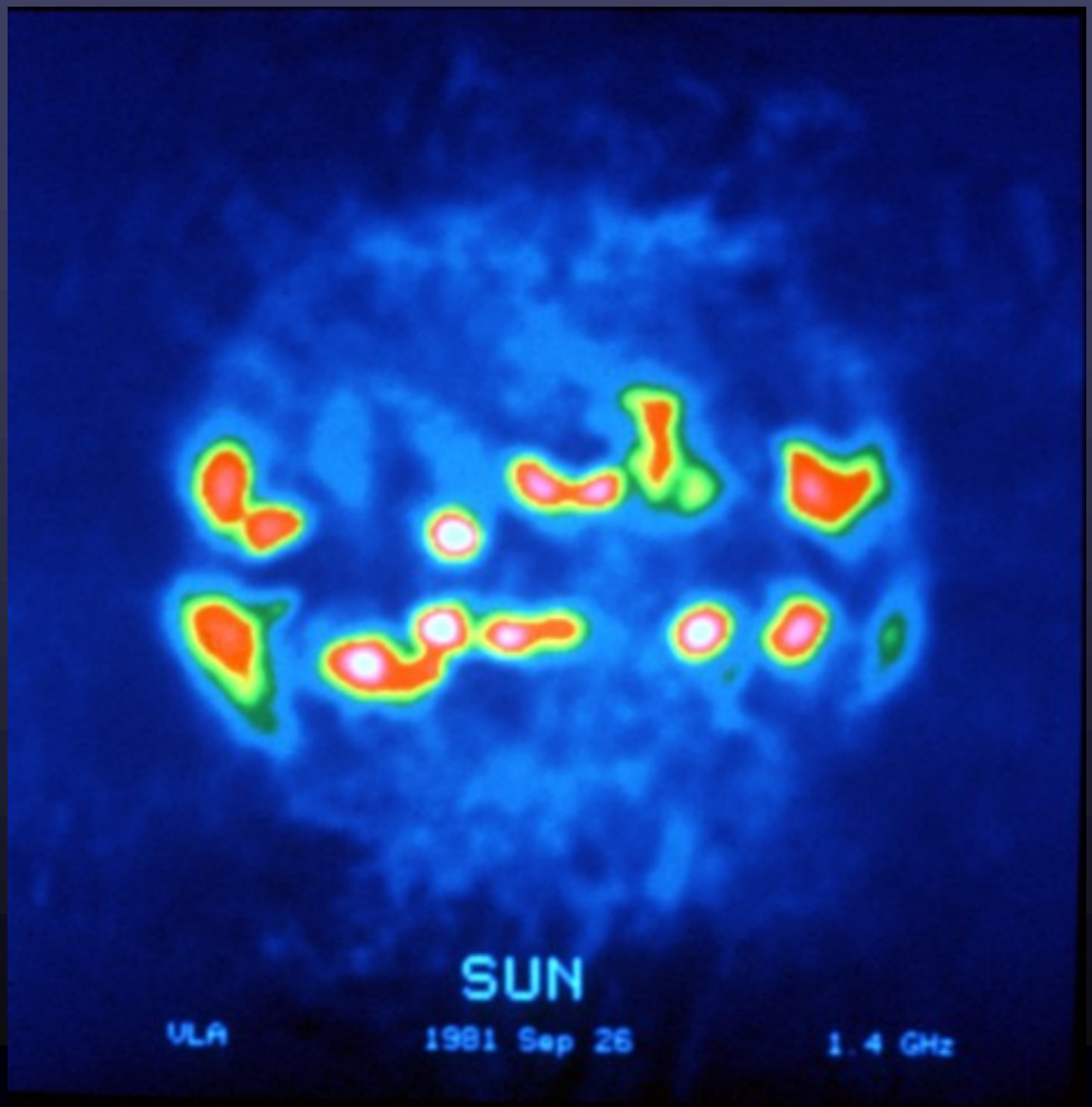
Solar activity in the radio



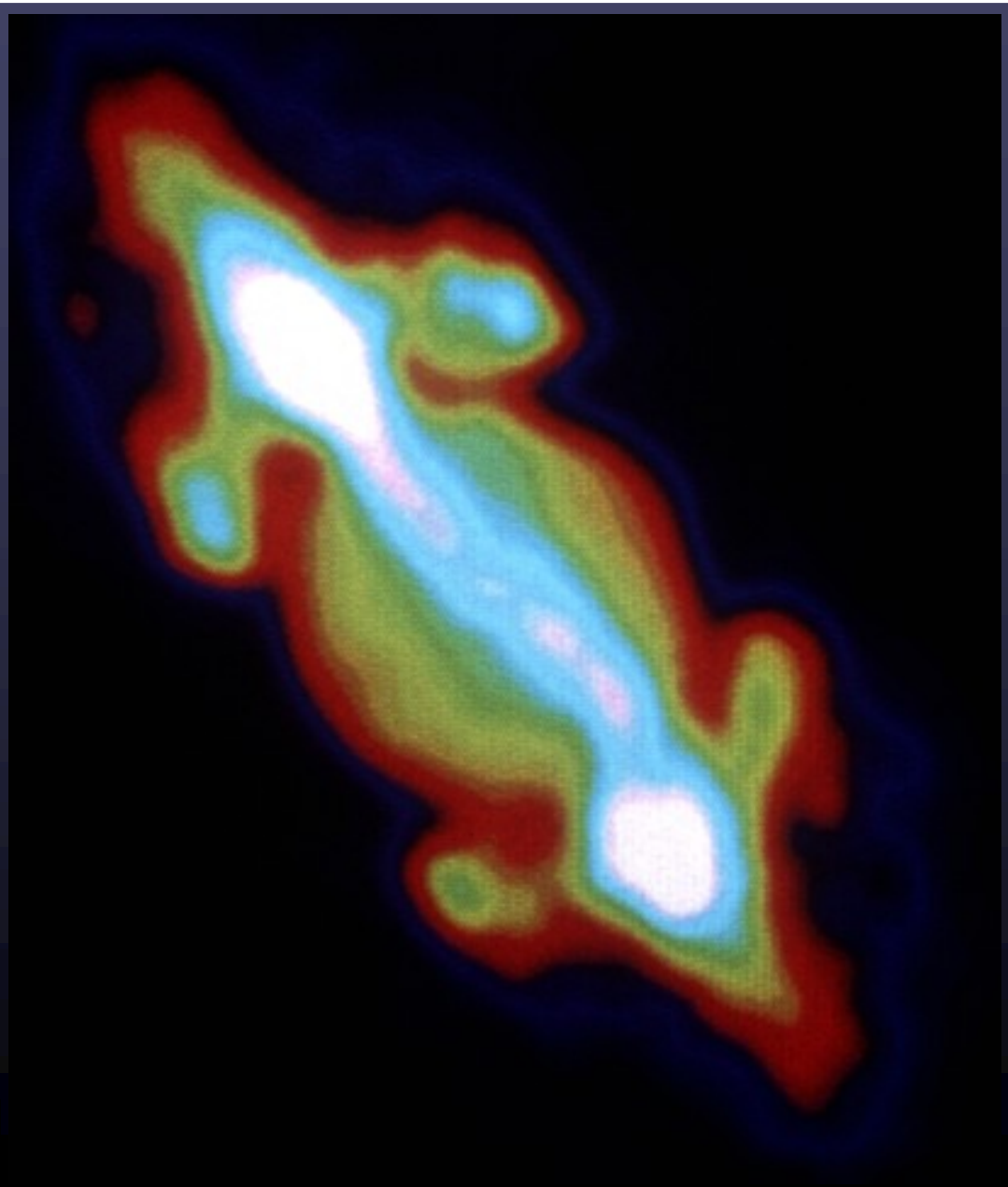
The University of New Mexico

Solar activity in the radio



G. Taylor, Astr 423 at UNM

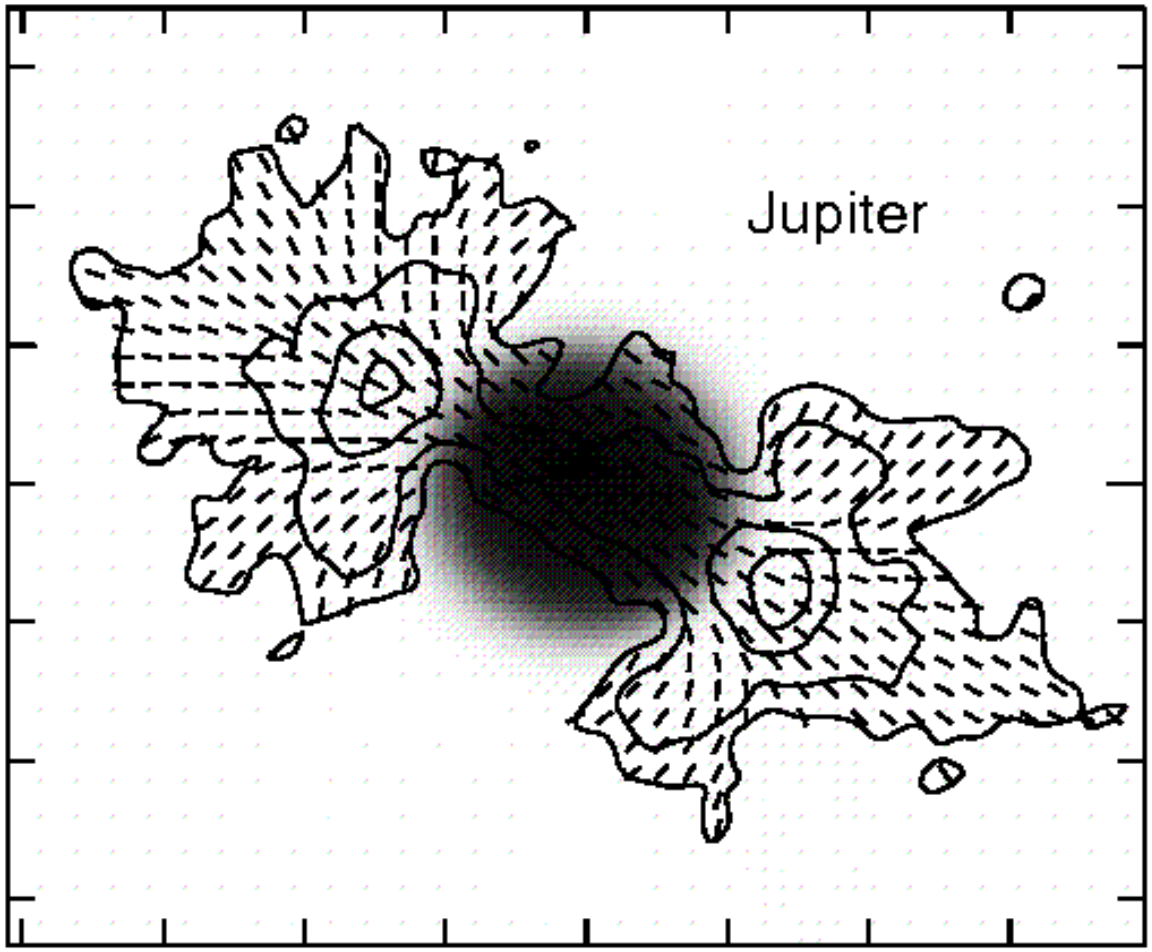
Picture of Jupiter in the radio with the VLA



detection of the magnetic belts around Jupiter

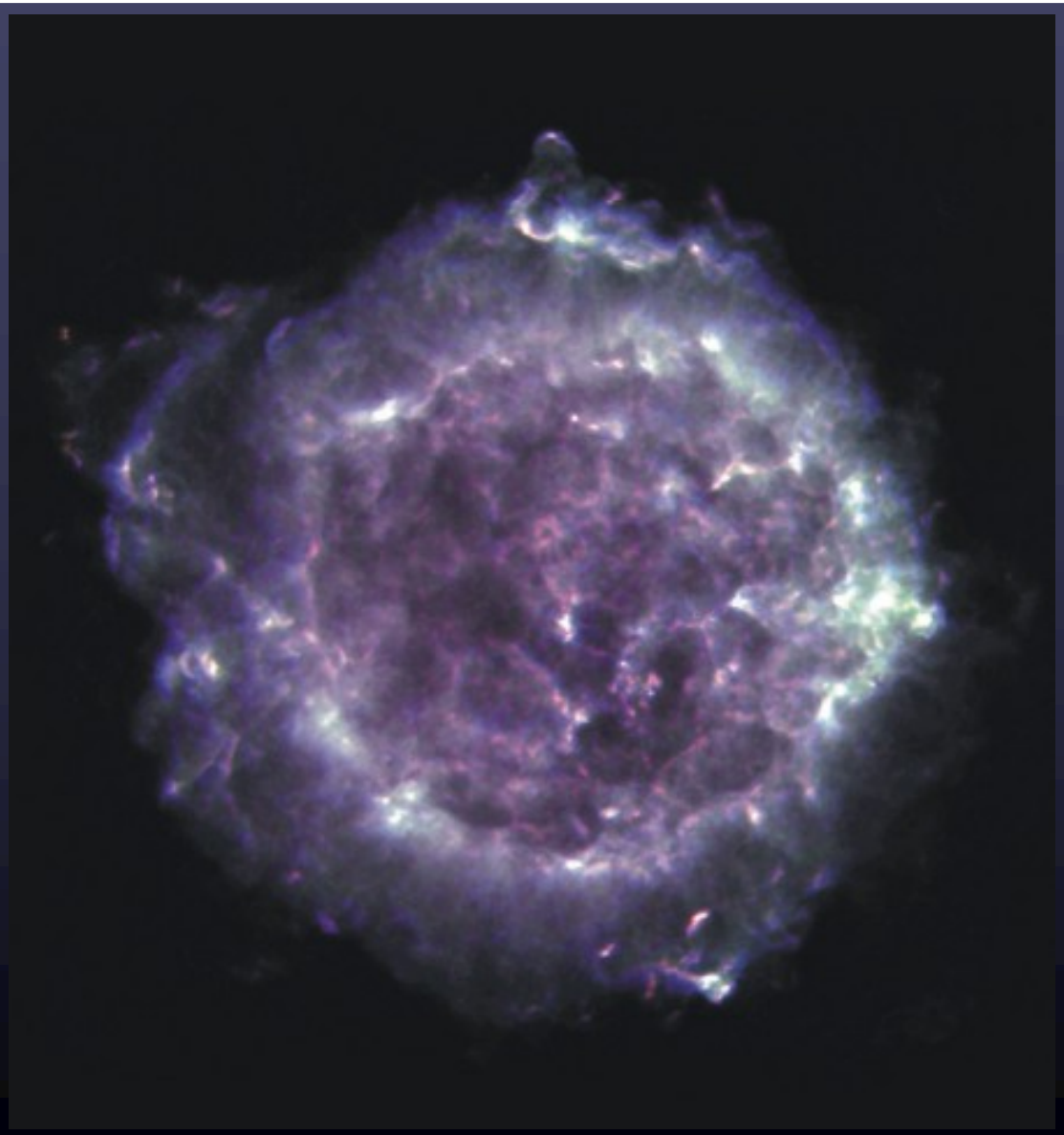
synchrotron emission from energetic particles in magnetic fields

>SNTHS IMAGN SUMMR SCHUL



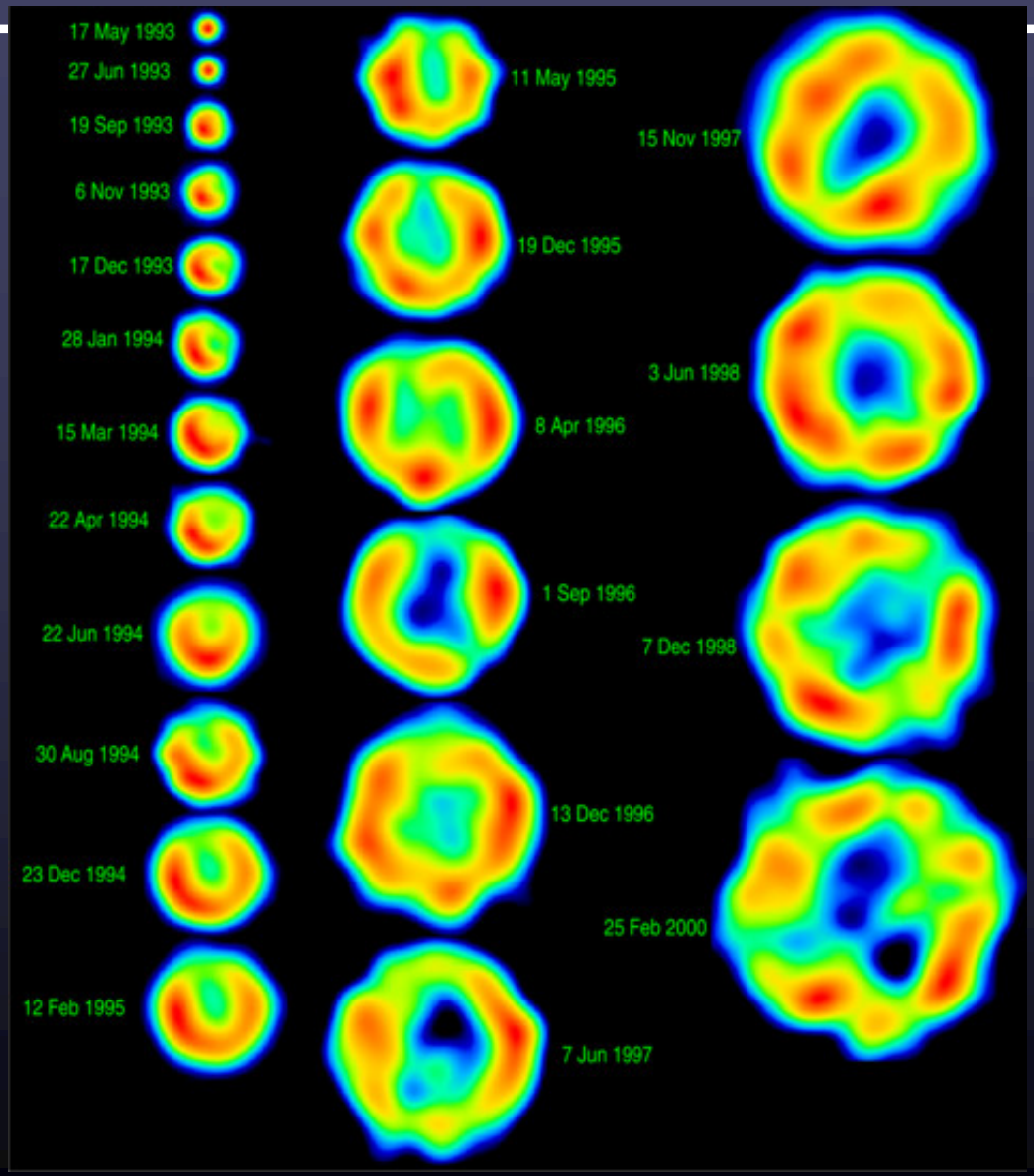
June 20-27, 2000
Socorro, NM, USA

Supernovae



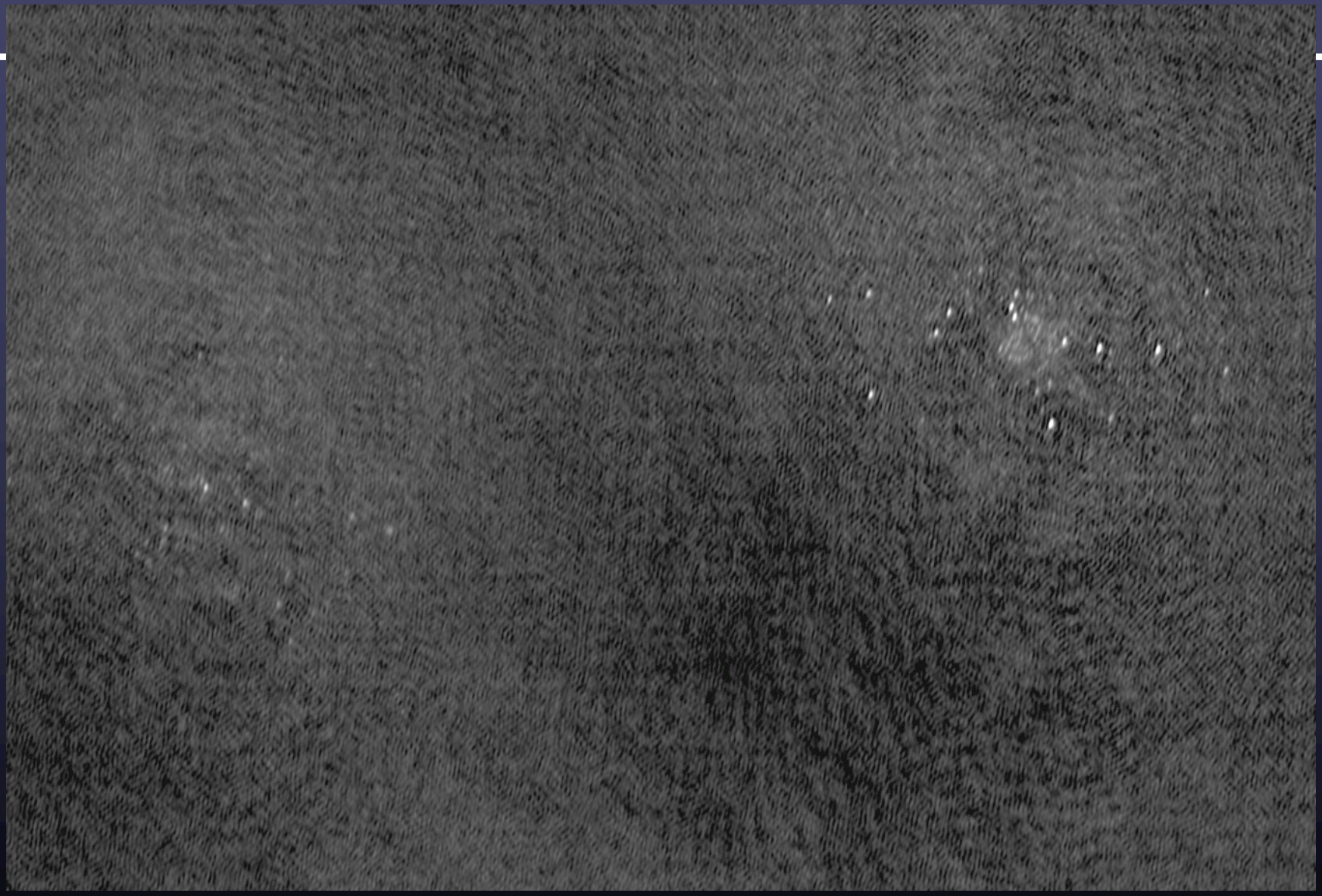
Cass A
Rudnick et al.

A Young Supernova



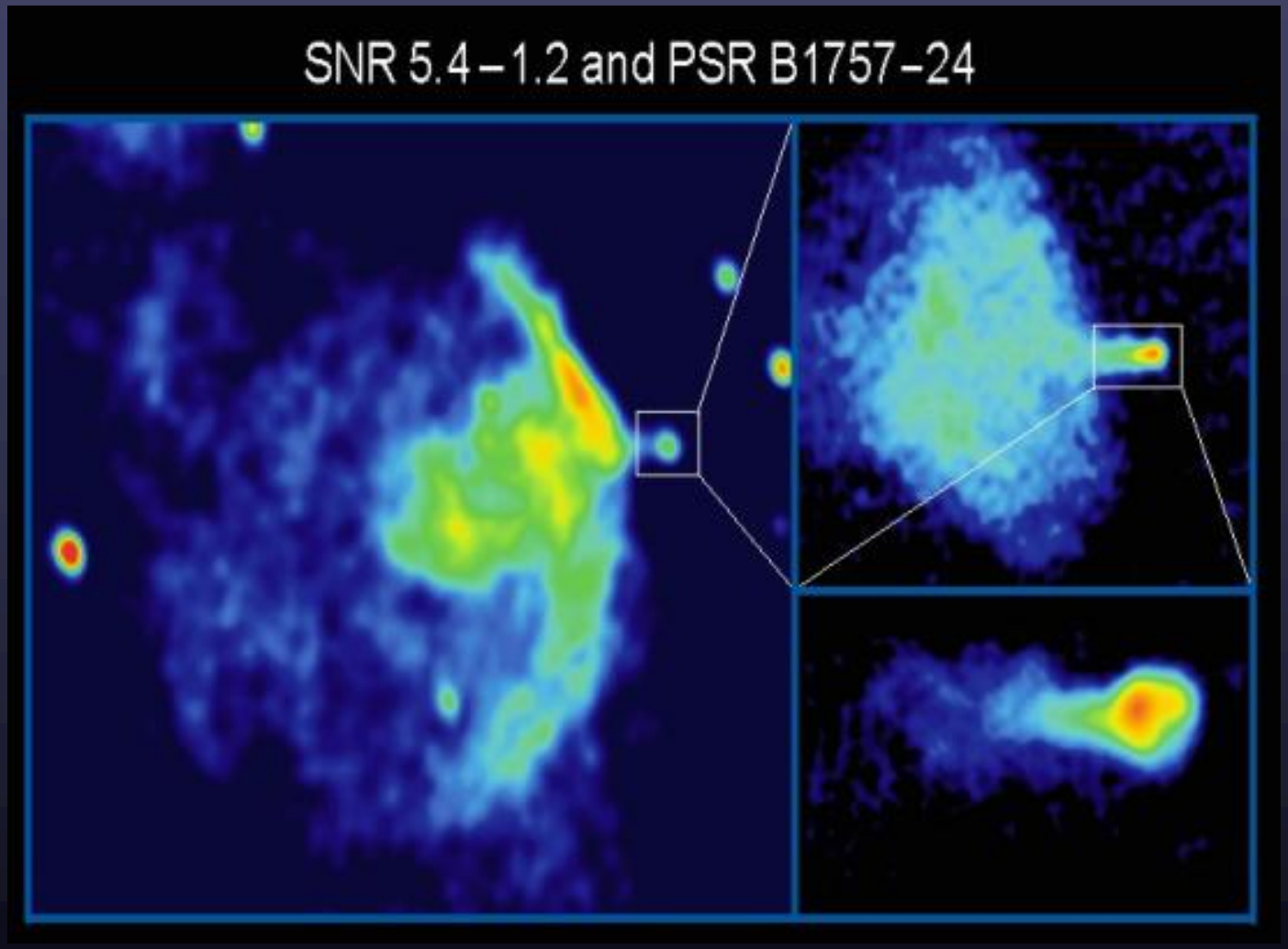
SN 1993J
Rupen et al.

Arp 220 - A starburst Galaxy



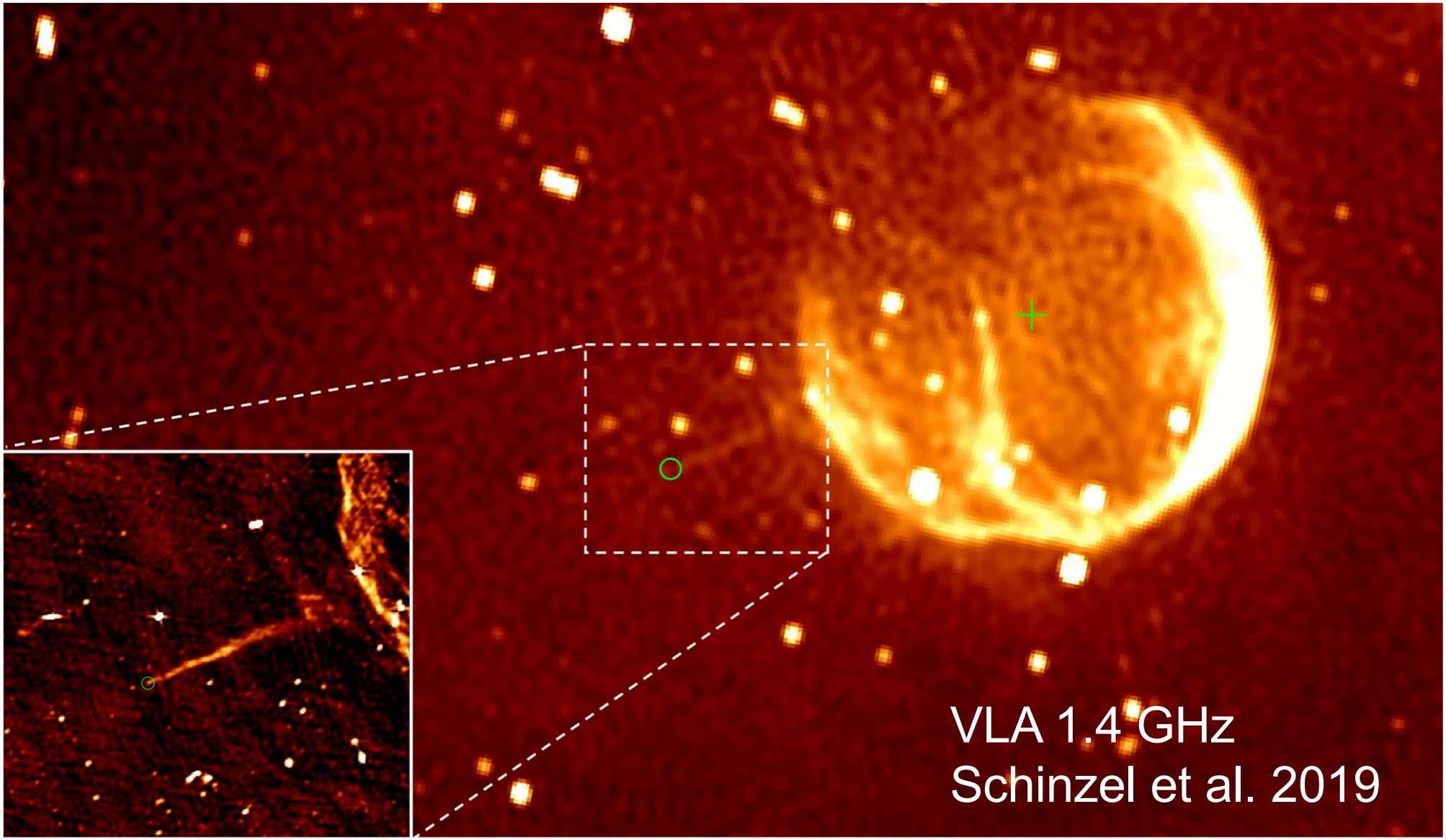
VLBA Image of the core of Arp 220 at 1.4 GHz - Lonsdale et al. in prep

The Duck

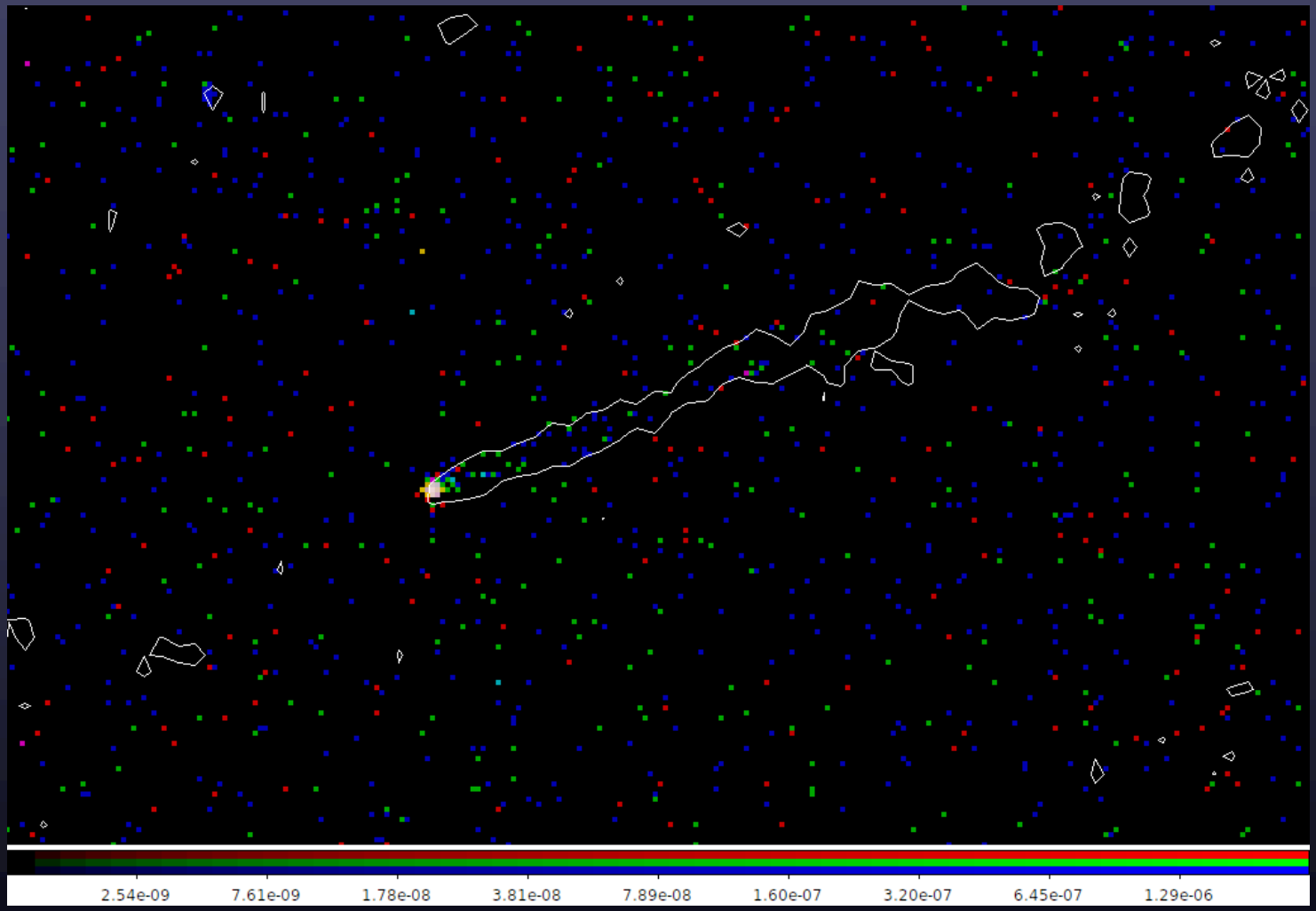


Gaensler et al.

The Cannonball Pulsar J0002+6216 and SNR CTB 1

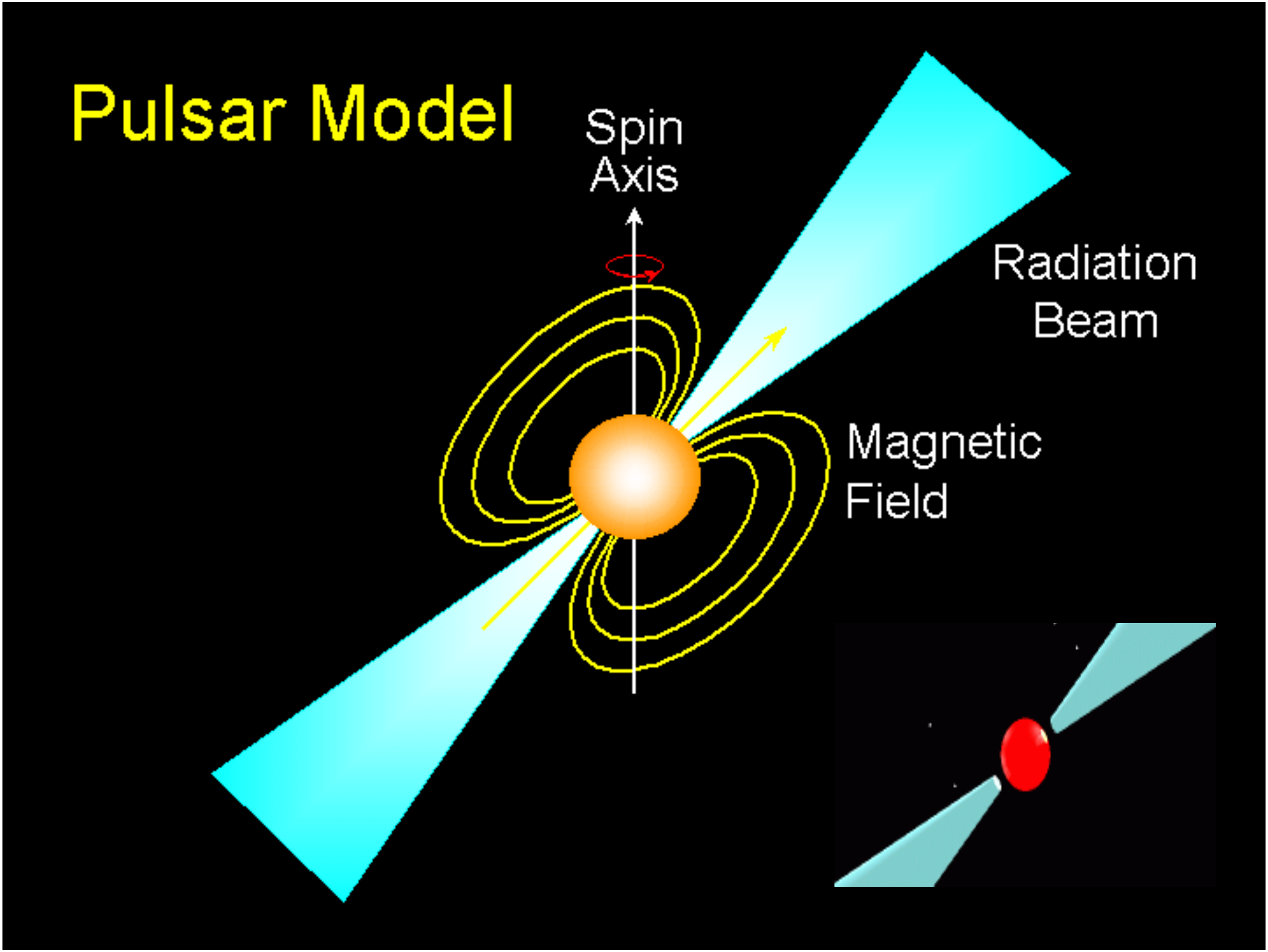


The Cannonball Pulsar J0002+6216 and SNR CTB 1

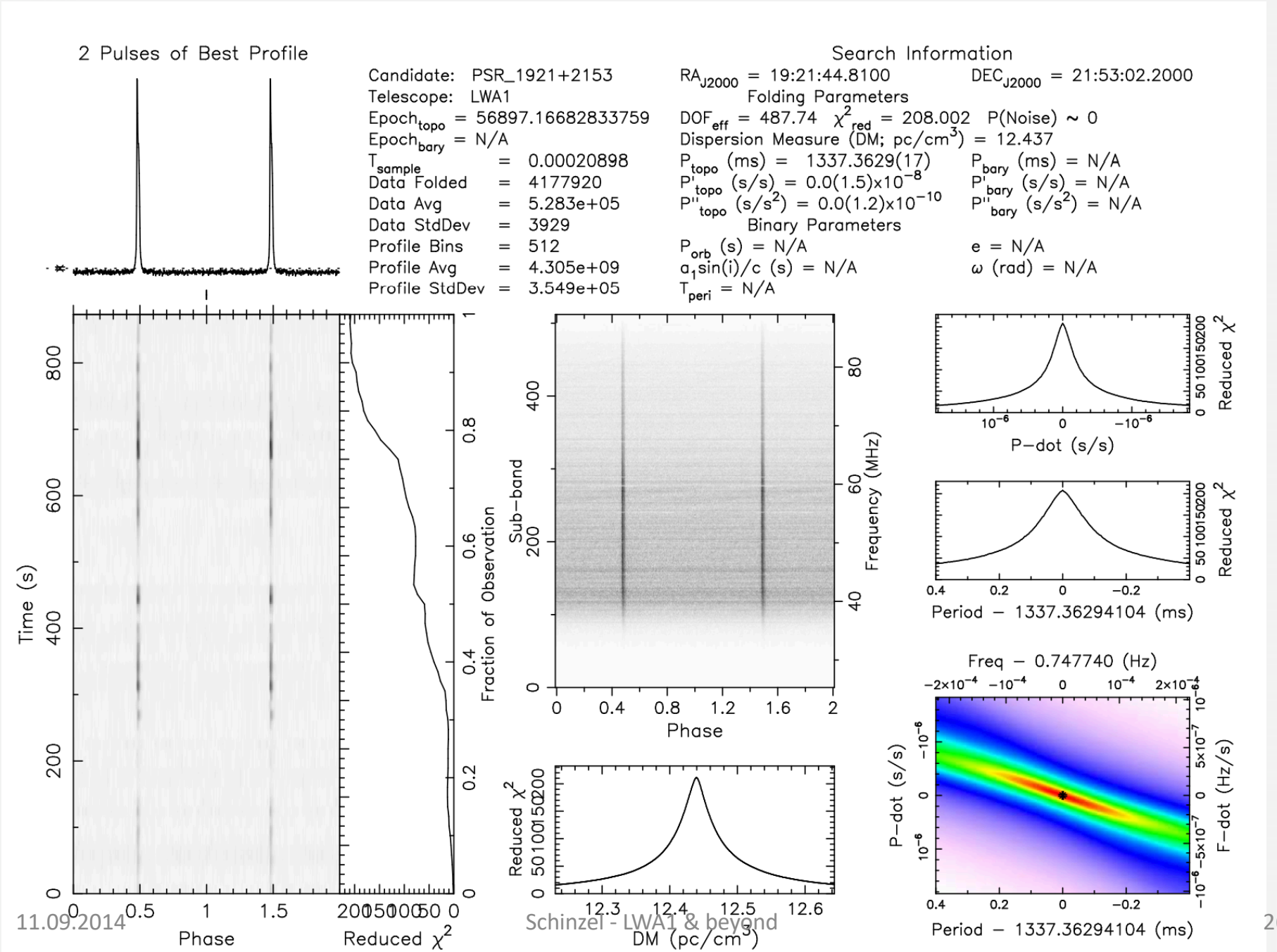


8 GHz VLA contour
+
Chandra X-ray

courtesy
Pratik Kumar


Pulsar Model
Spin Axis
Radiation Beam
Magnetic Field

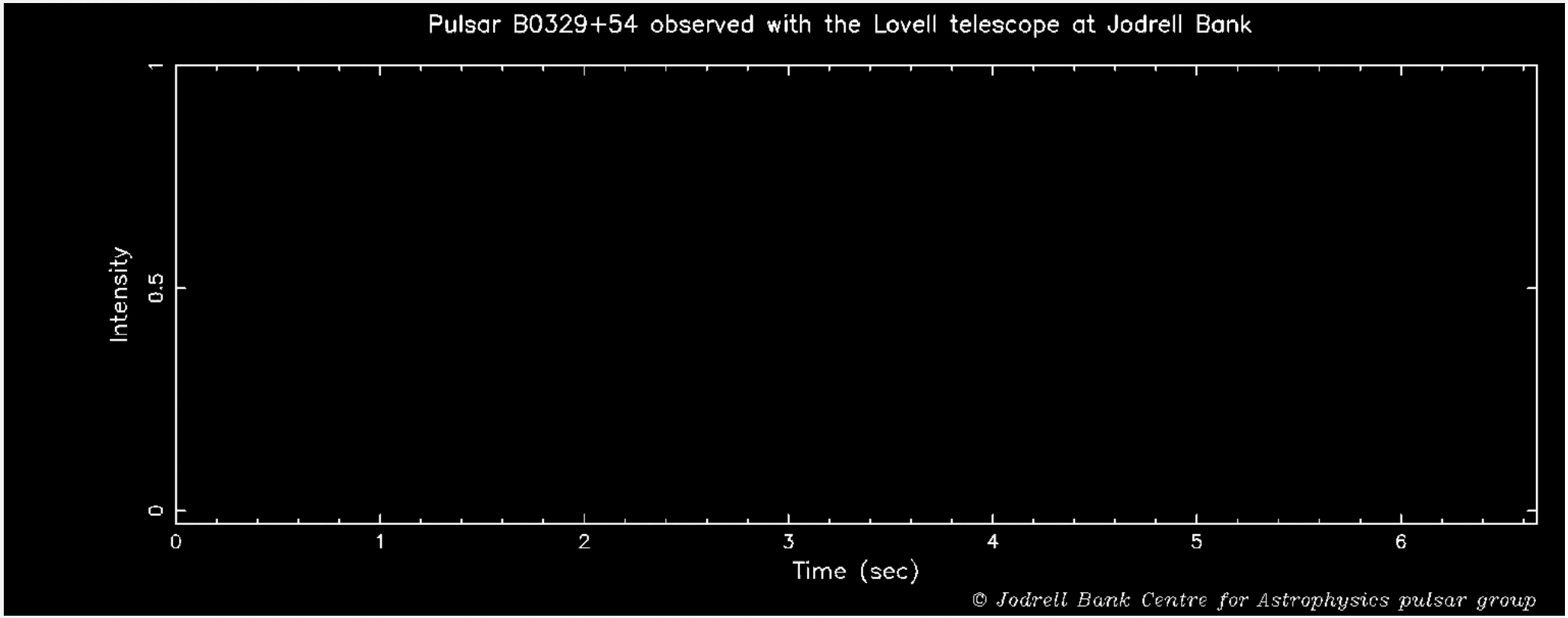
Typical LWA Observation of a Pulsar



Study the Universe, See the World

Jocelyn Bell and Alan Rogers at URSI-2011 meeting in Istanbul

The Sound of Pulsars

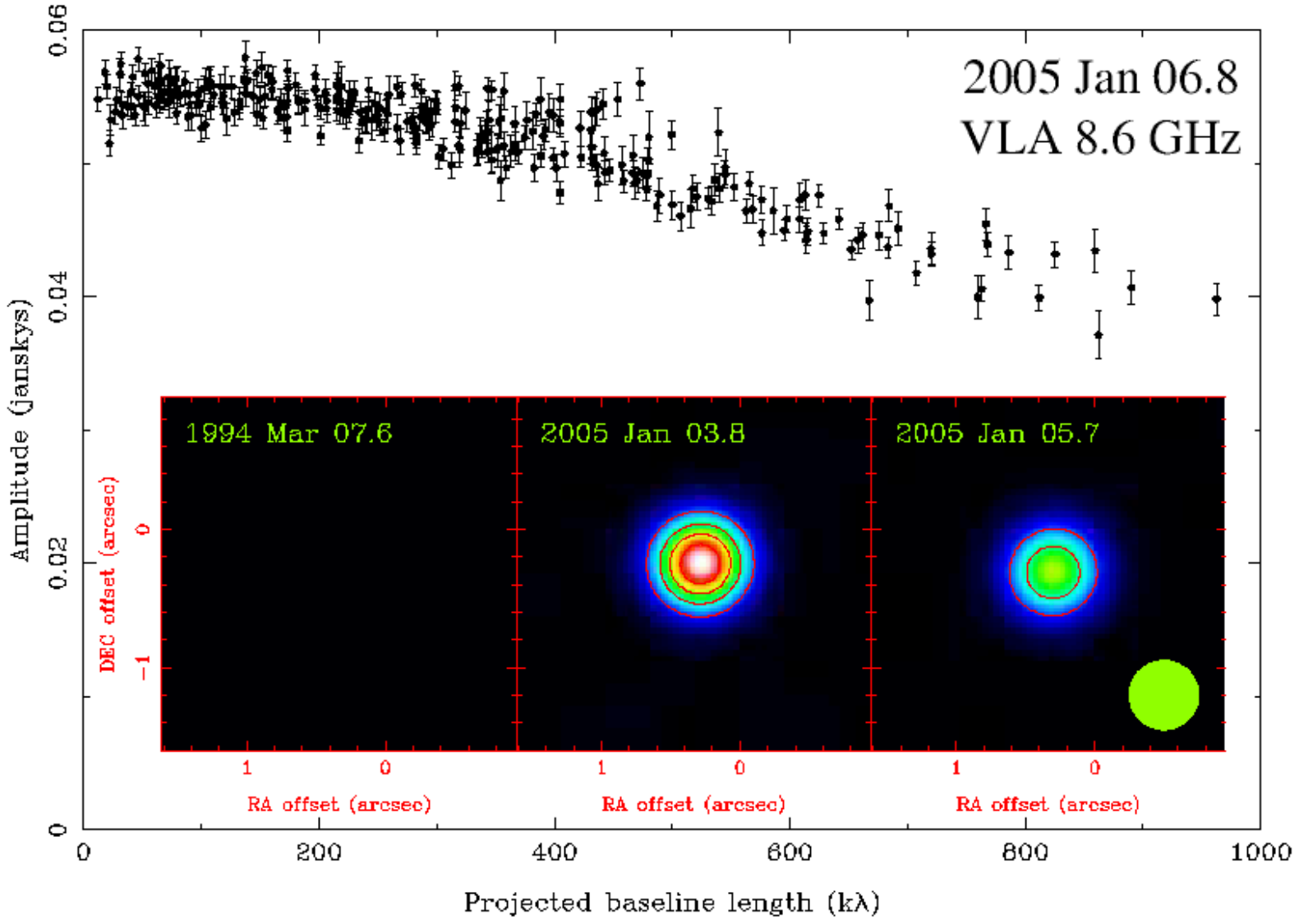


B0329+54, A bright pulsar with period 0.714520 sec

The Sound of Pulsars

47 Tucanae, A globular cluster with 22 millisecond pulsars

Giant Flare from the Magnetar SGR 1806-20

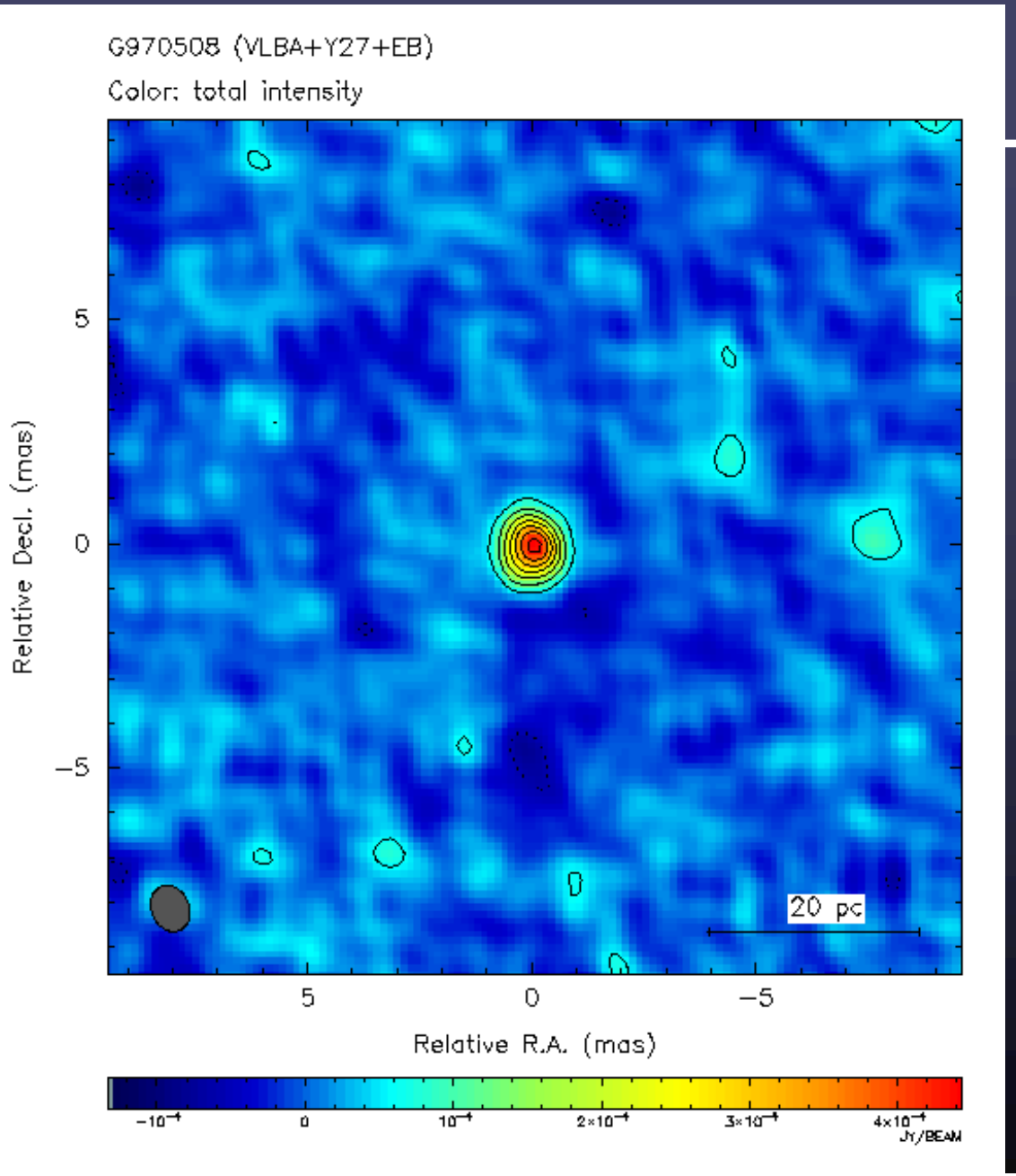


Gaensler et al 2005

Gamma Ray Bursts

GRB 970508

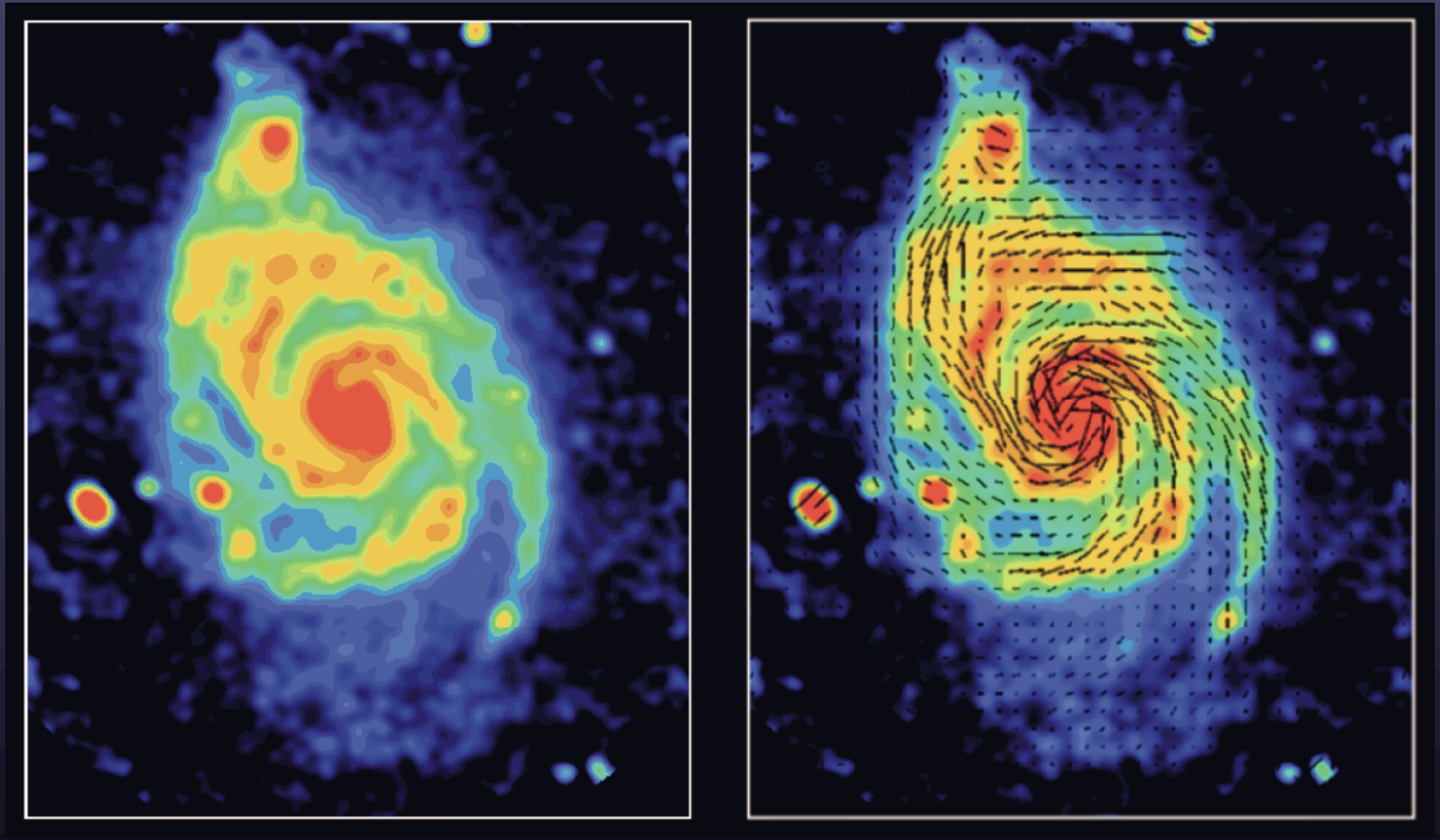
- First GRB Afterglow detected in the radio
- absolute position to < 1 mas
- Size < 10^19 cm (3 lt years)
- Distance > 10000 lt years



Taylor et al 1997

Normal Galaxies

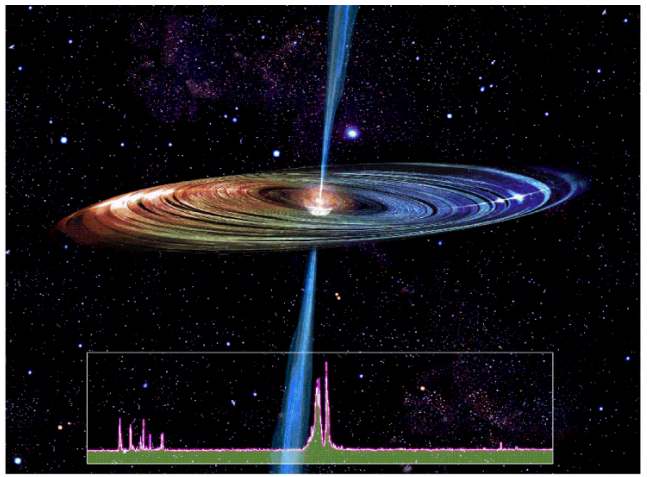
M51



Beck et al

NGC 4258

- Considered best evidence of a supermassive black hole
- Can estimate central mass
- Can estimate distance to host galaxy



NGC 4258

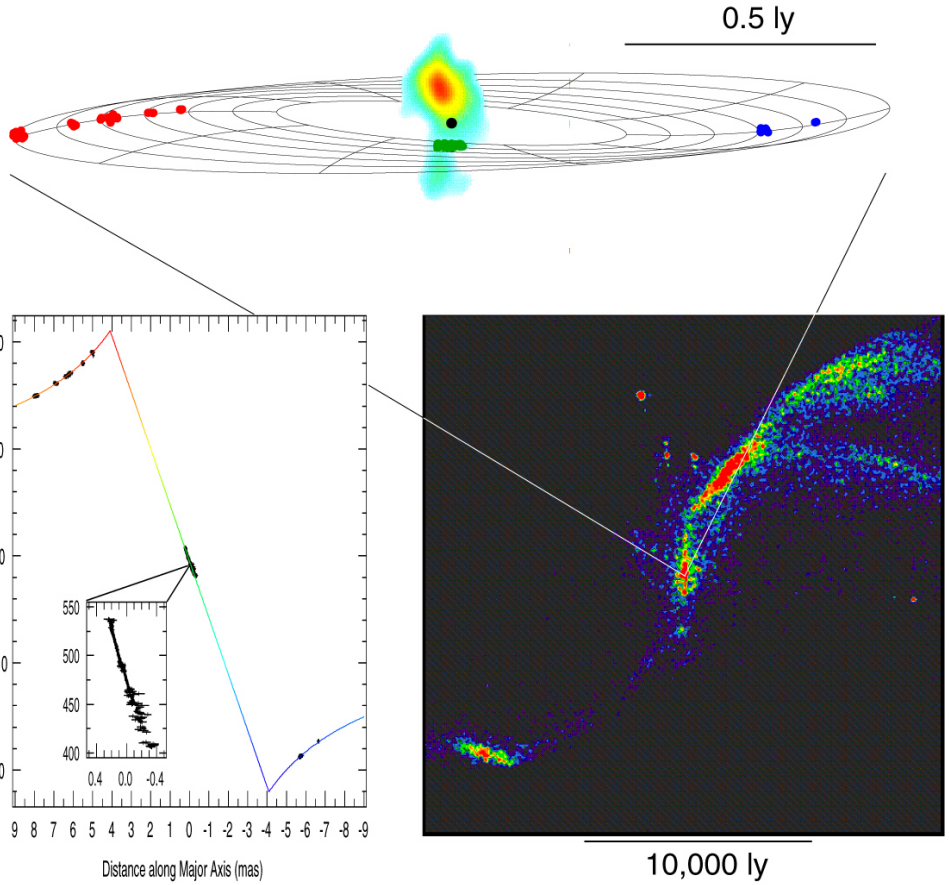
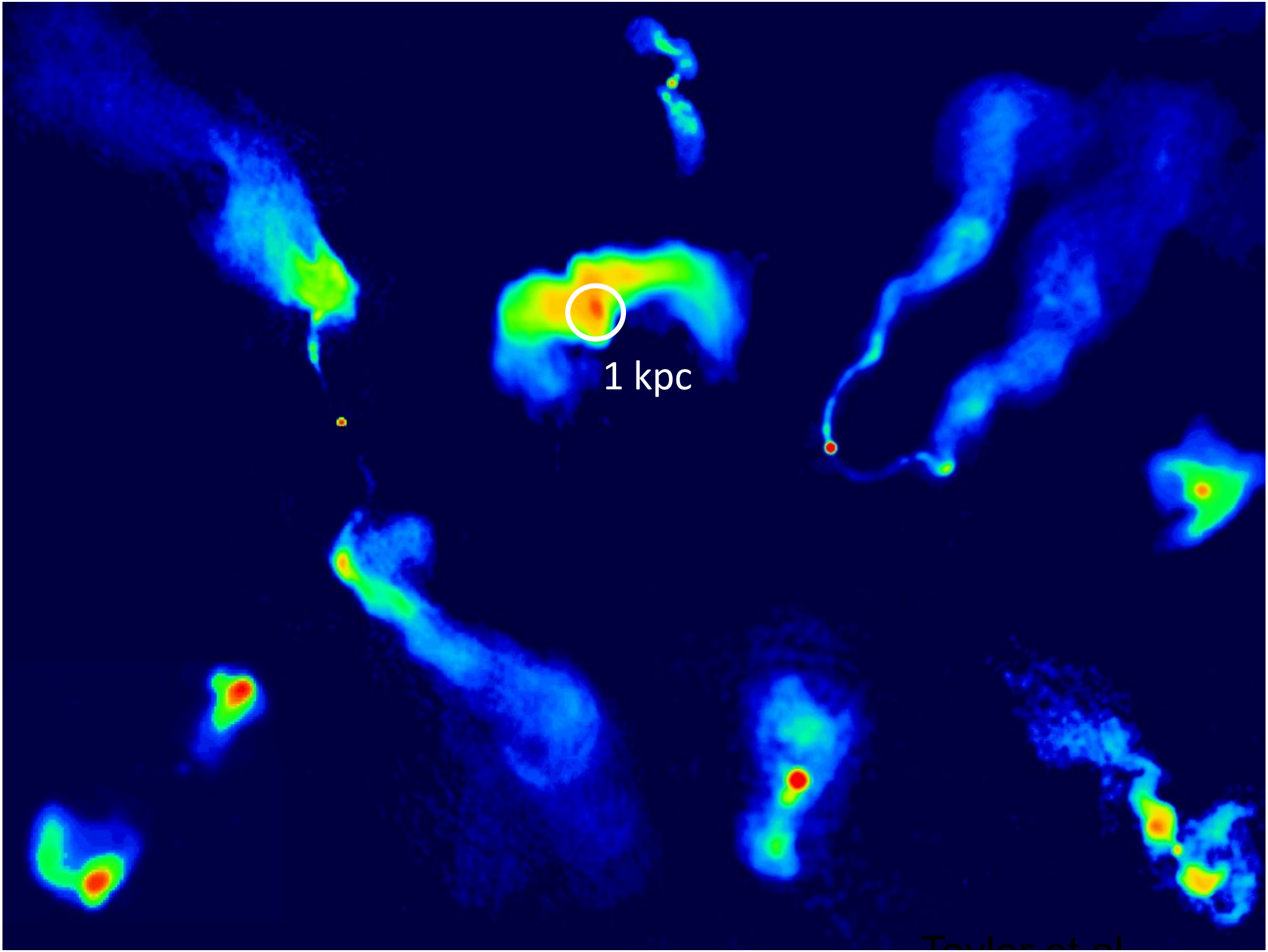
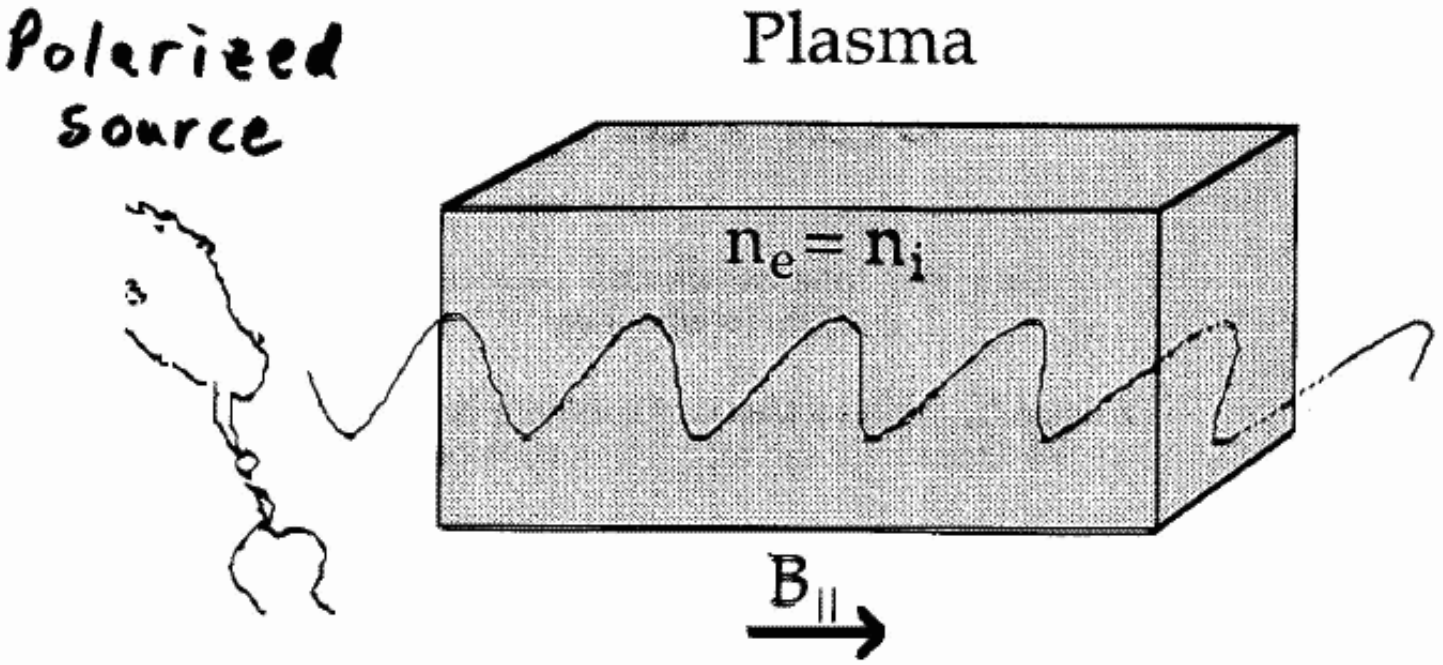


image courtesy Lincoln Greenhill
(see Miyoshi et al 1995
Herrnstein et al 1999)


1 kpc

Faraday Rotation

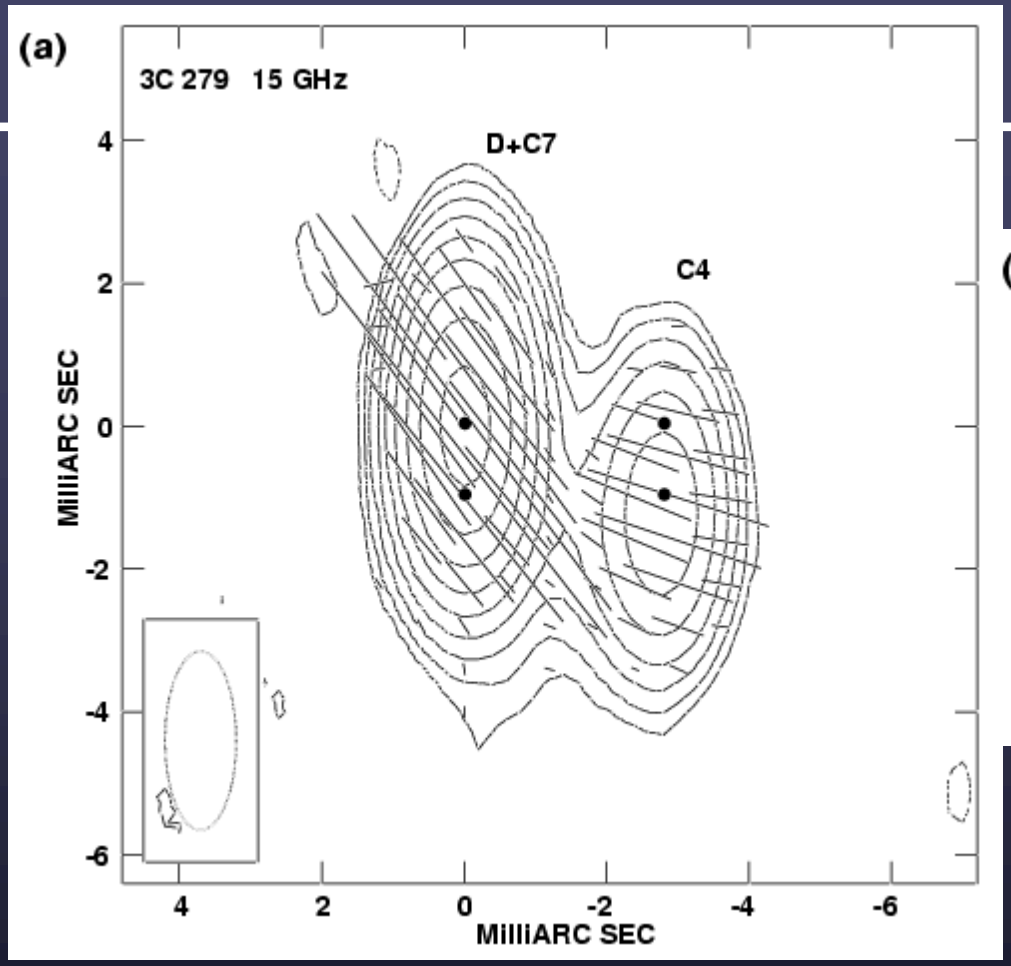


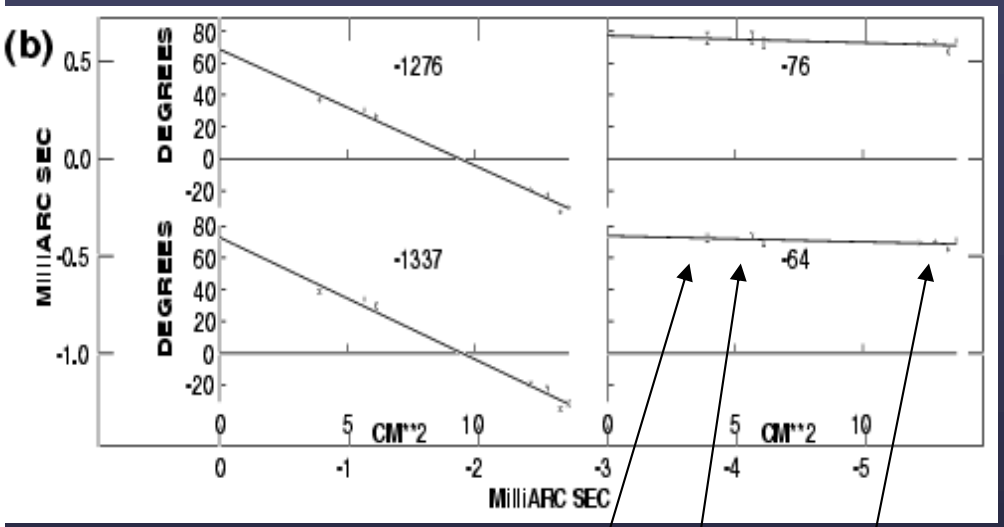
$$\Psi = \Psi_o + RM\,\lambda^2$$

$$RM = 812 \int_0^L n_e B_{||}\, dl \text{ radians/m}^2$$

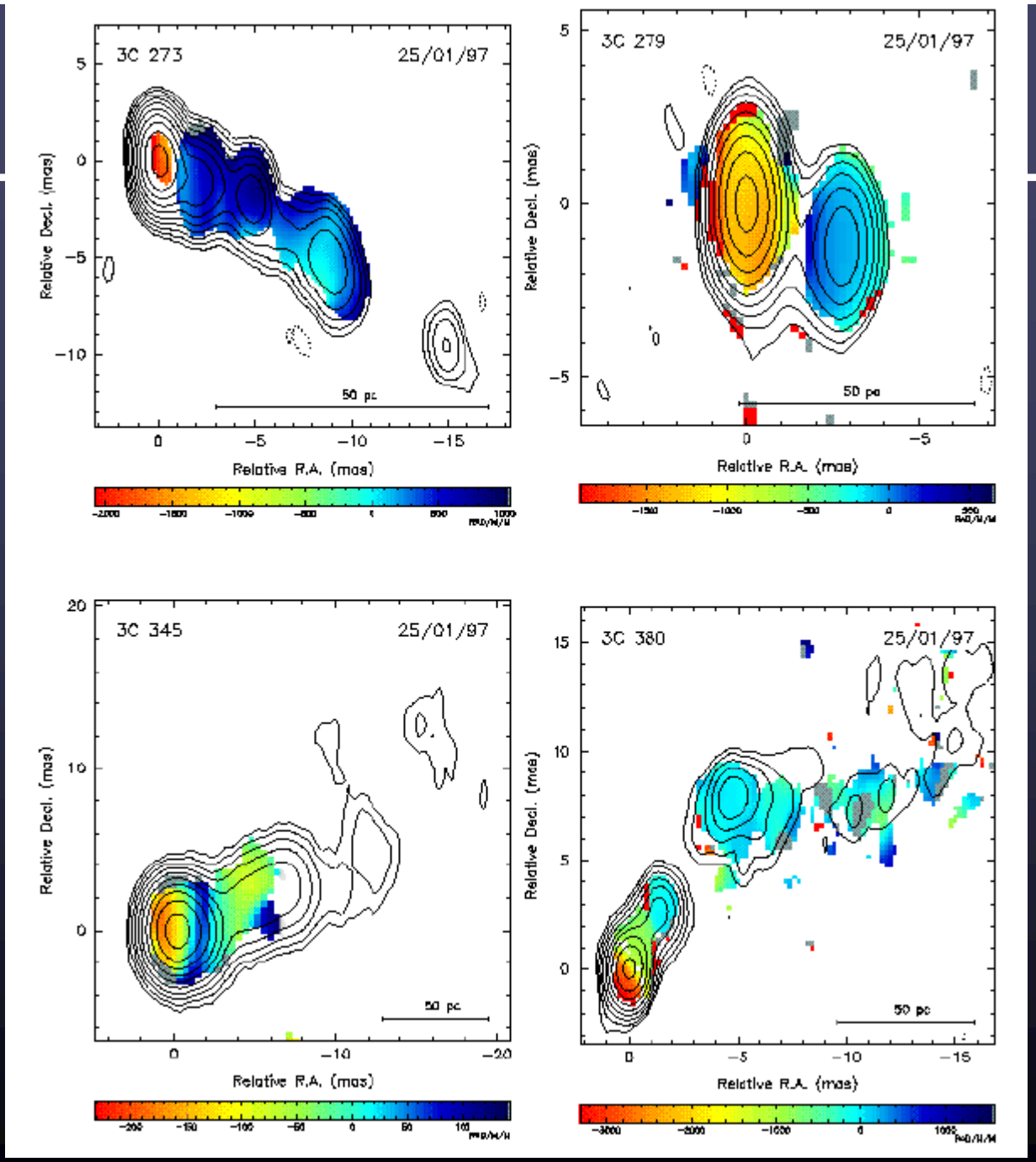
L ← kpc; $B_{||}$ ← mGauss; n_e ← cm^{-3}

Taylor (1998)





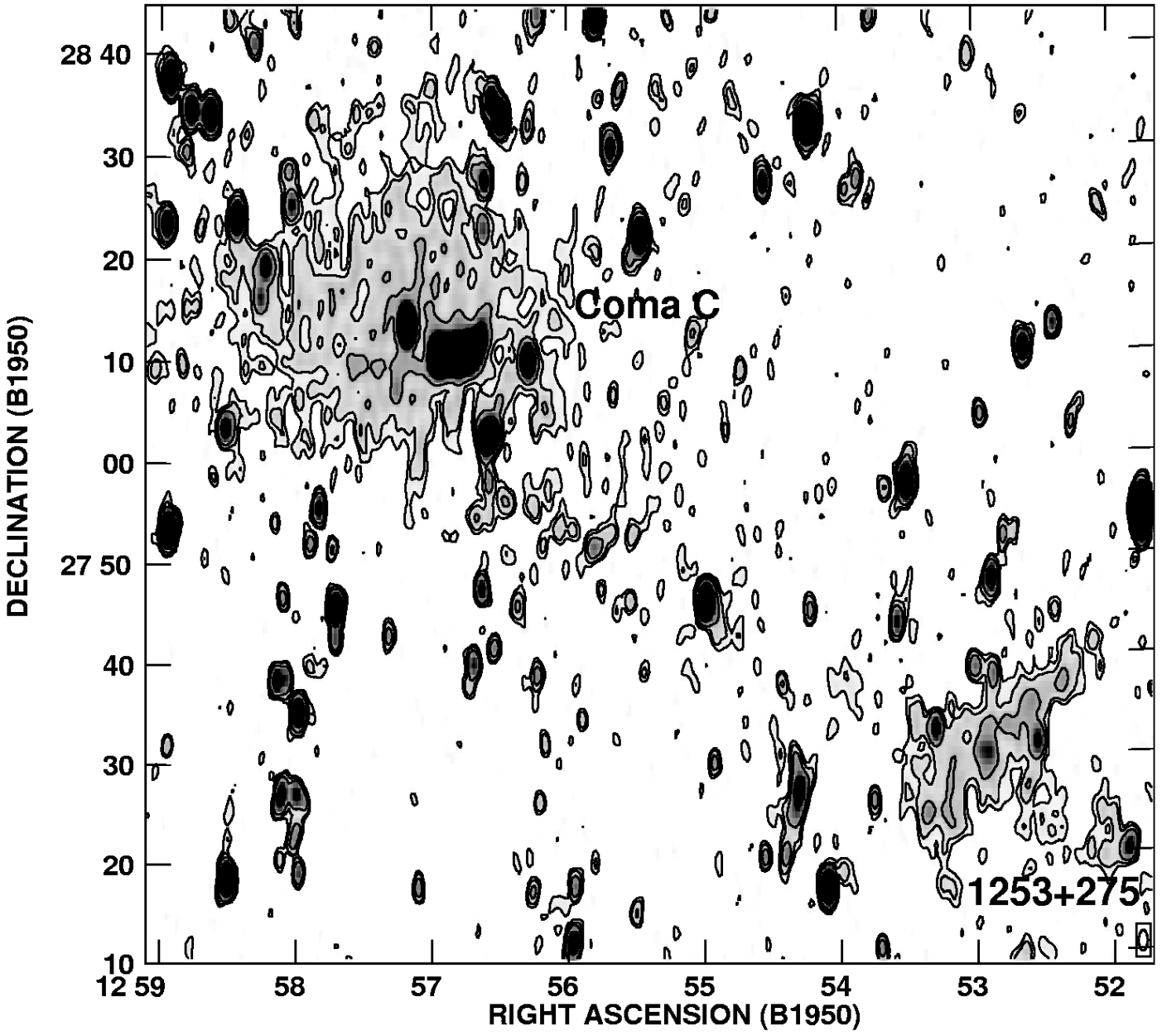
15 12 8 GHz



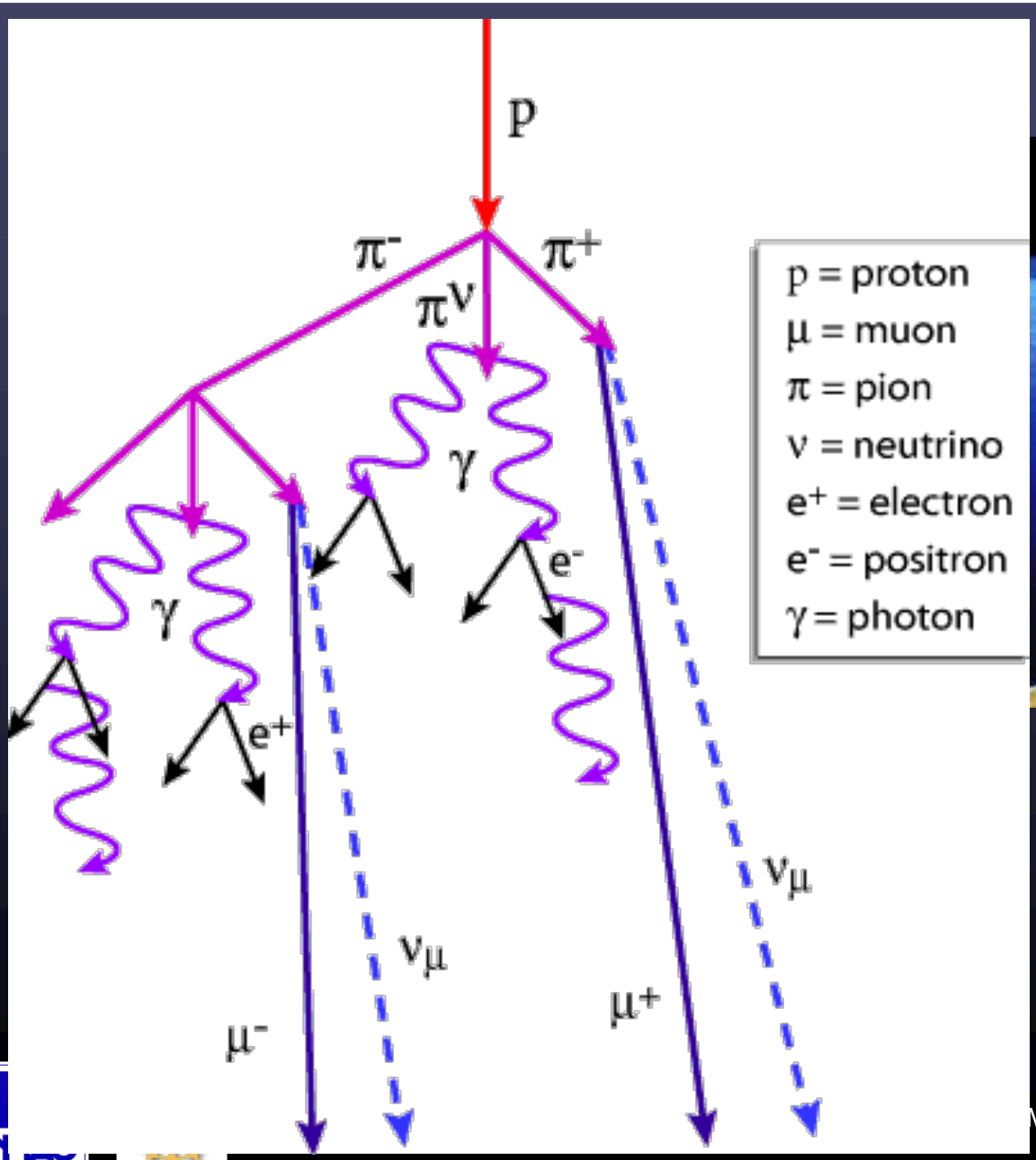
Feretti et al. 1998

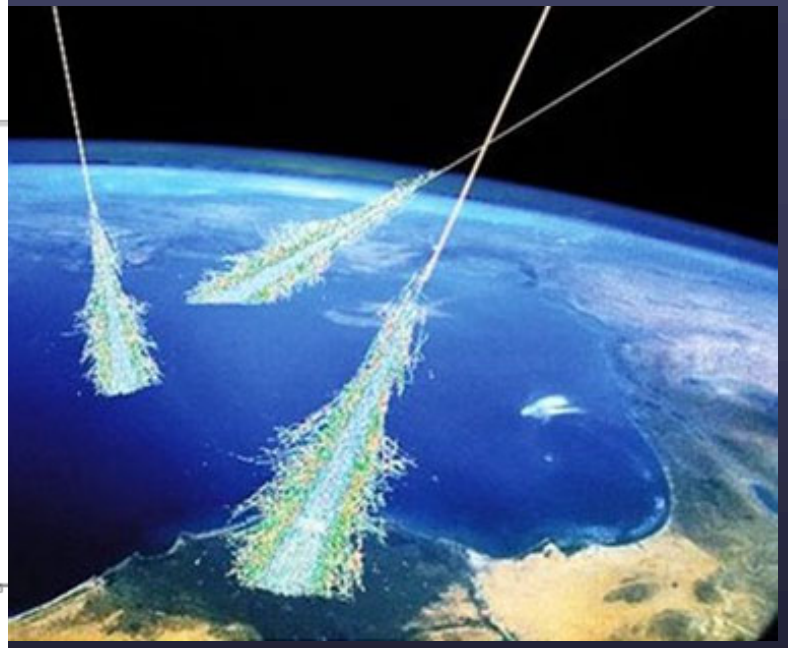
WSRT at 90cm

B ~ 0.4 μG



Cosmic Ray Air Showers





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Non-Thermal Sources

- Man-made signals (RFI)
- Cosmic ray air showers
- Solar Flares (Active Sun), also flare stars and brown dwarfs
- Planetary magnetospheres
- Lightning (from storms on planets and locally as RFI)
- Planetary Radar/Spacecraft telemetry
- Supernova Remnants
- Gamma-ray Bursts and their afterglows
- Pulsars
- Magnetar flares
- Masers
- X-ray binaries/microquasars
- Normal galaxies (cosmic ray population)
- Active Galaxies (including Quasars, Blazars, etc.)
- Intracluster medium (halos and relics)
- Dark-matter decay

Further Reading

http://www.nrao.edu/whatisra/mechanisms.shtml
http://www.nrao.edu/whatisra/
www.nrao.edu

Synthesis Imaging in Radio Astronomy
ASP Vol 180, eds Taylor, Carilli & Perley

This lecture is on the course web page:

http://www.phys.unm.edu/~gbtaylor/astr423