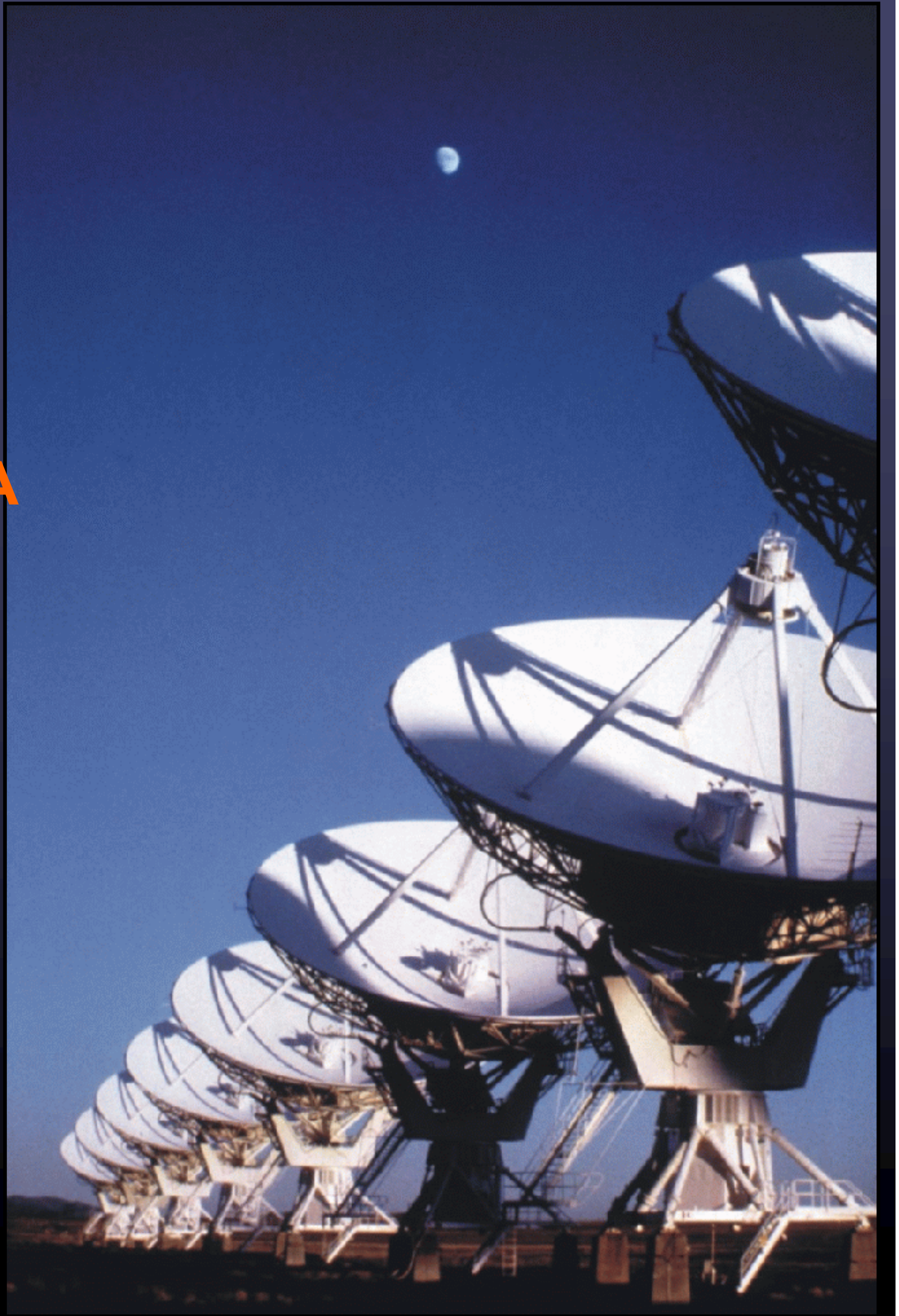
Radio Astronomy Intro, part 2

Some Possible VLA and LWA Observing Projects

Greg Taylor

University of New Mexico



Astronomy 423 at UNM

Radio Astronomy

Announcements

- Observing proposals for VLA and LWA time due on Monday, Feb 1 by 4pm – send by e-mail to gbtaylor@unm.edu. Select projects in class Feb 3.
- Megan's office hours Tuesdays 1-2pm. Zoom link e-mailed to class.
- You can use today's suggestions but you will need to do a little research to flesh them out
  - Strongly advise against "detection experiments"
- Books for the course are available in electronic editions from me (see e-mail with Dropbox link).

What are the benefits to doing radio astronomy?

1. can do it easily from the ground, day and night!

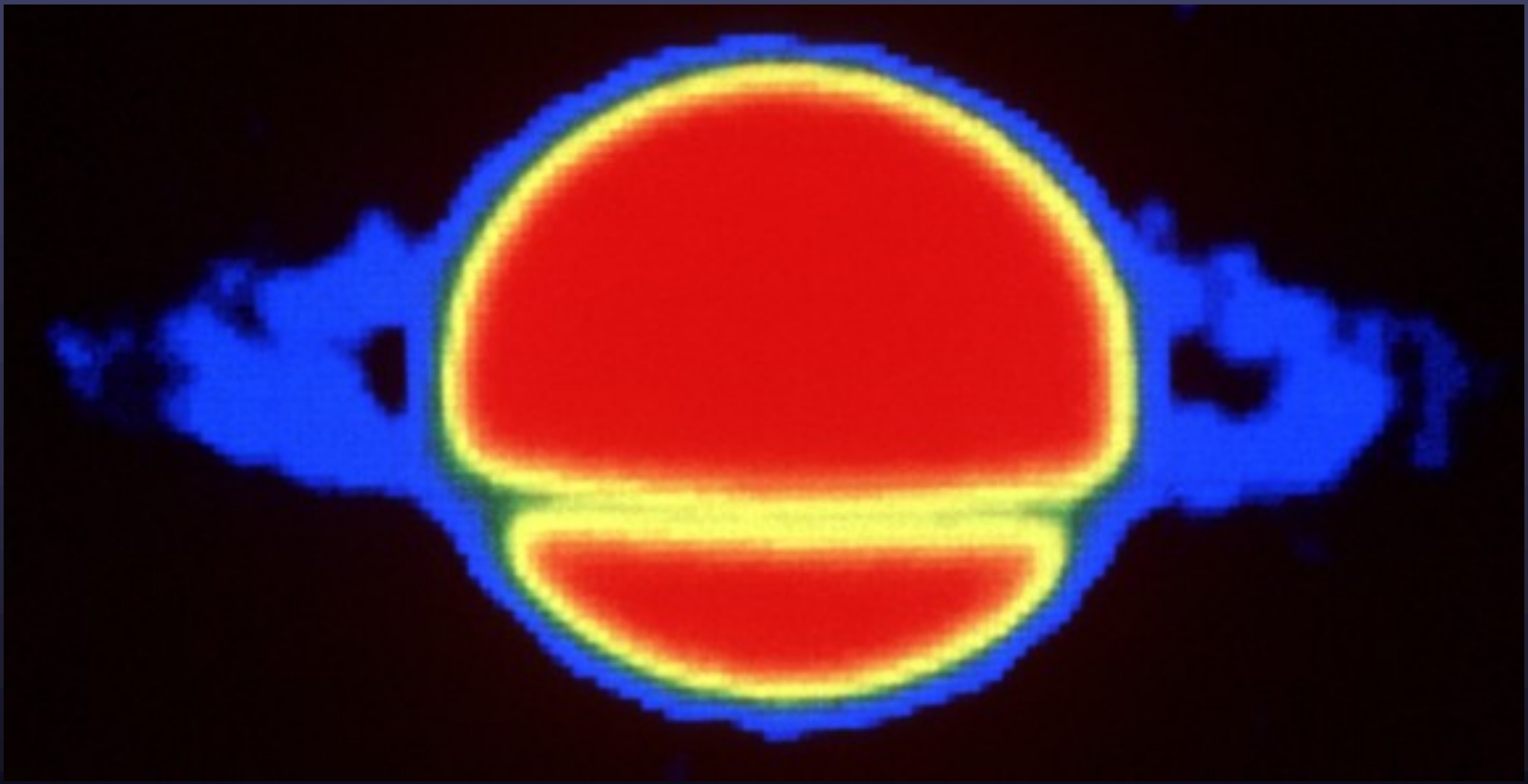
   cheap, easy to repair, upgrade

   round the clock observations – efficient observatories

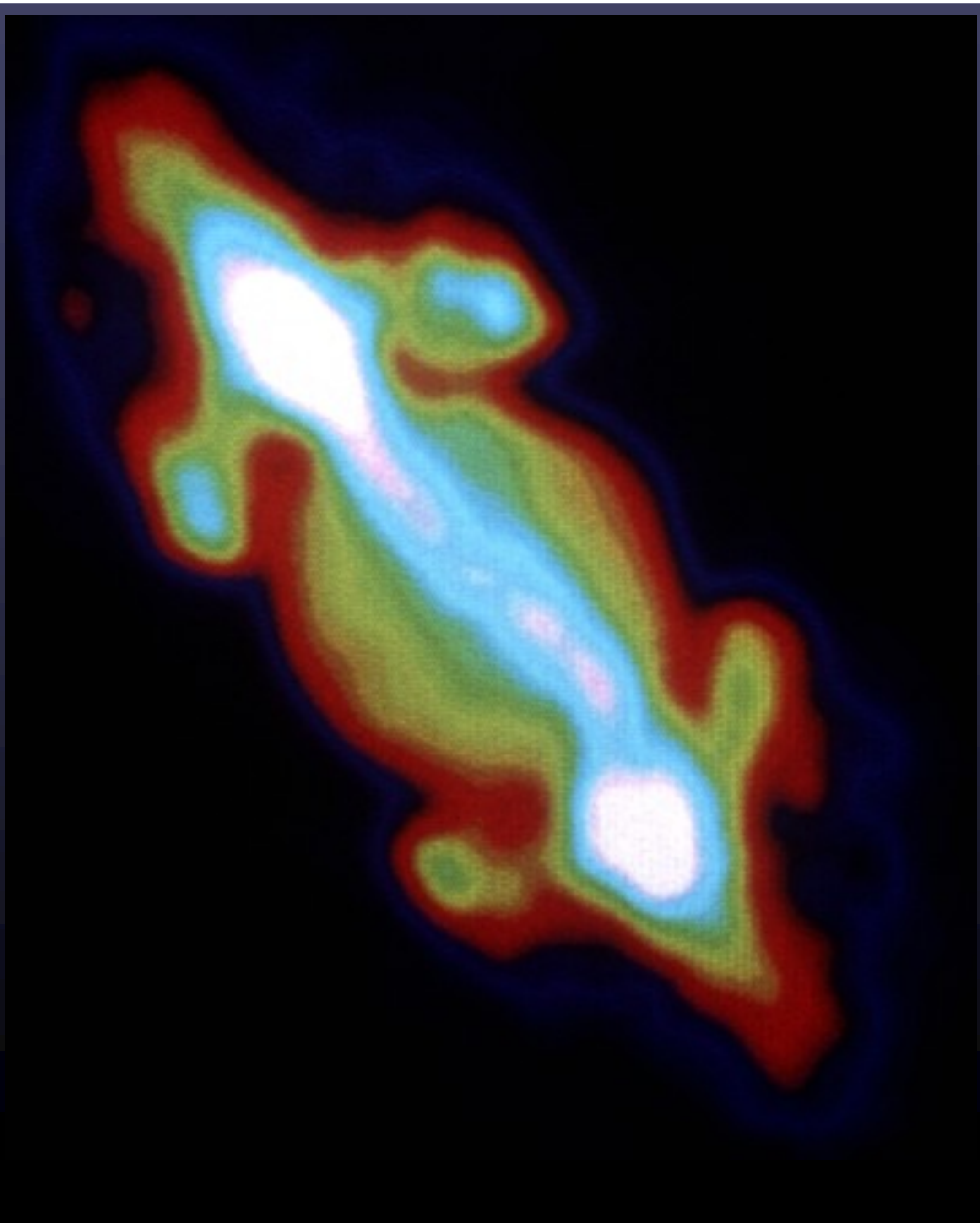
2. some objects/processes are easier to detect in the radio compared to other wavelengths

   - some distant, active galaxies are dominated by radio emission
   - jets from accretion onto a black hole
   - interstellar gas clouds between interacting galaxies
   - magnetic fields
   - coherent emission

Name that object observed in the radio with the VLA

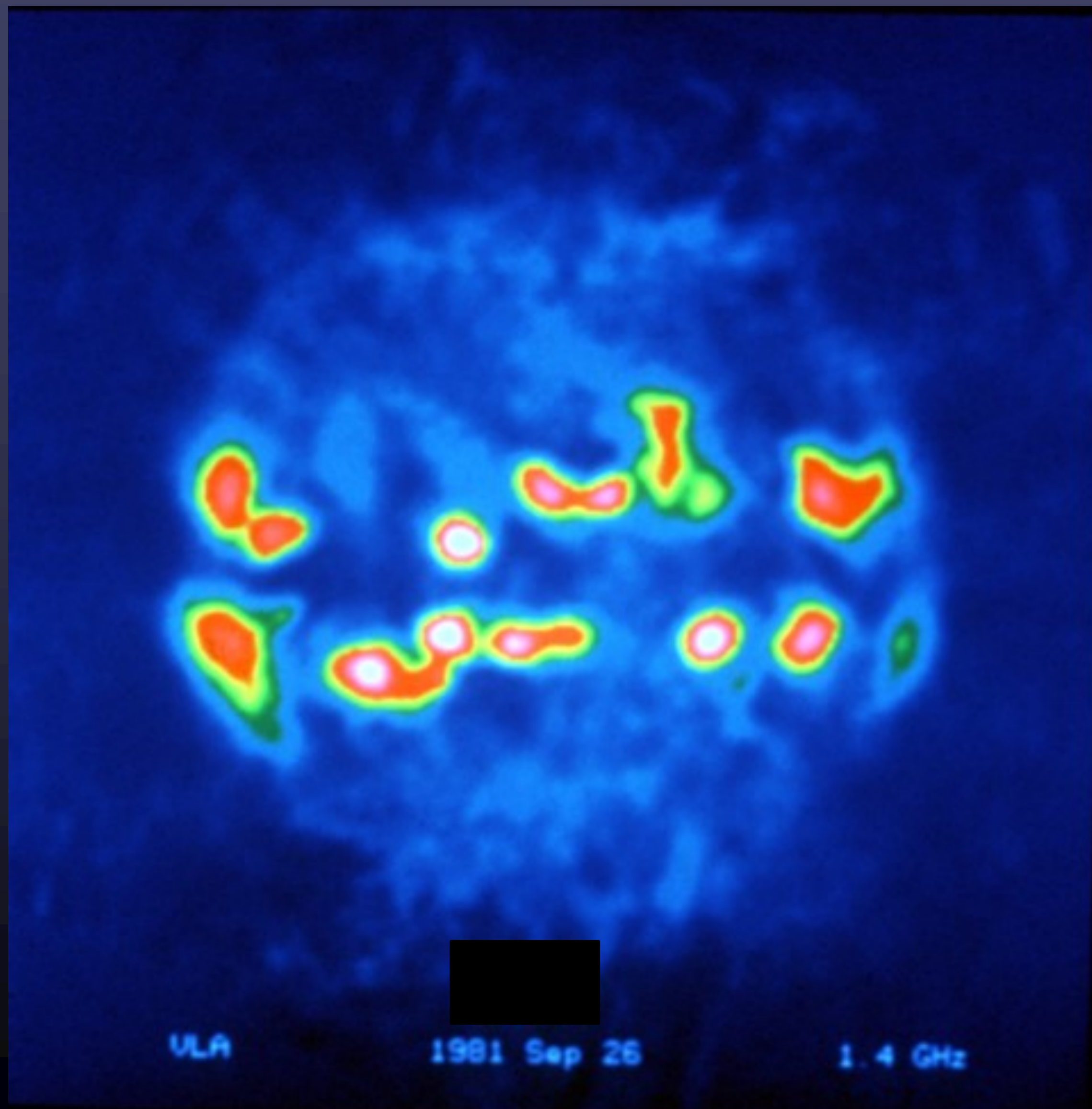


Name that object observed in the radio with the VLA



detection of the magnetic belts around Jupiter

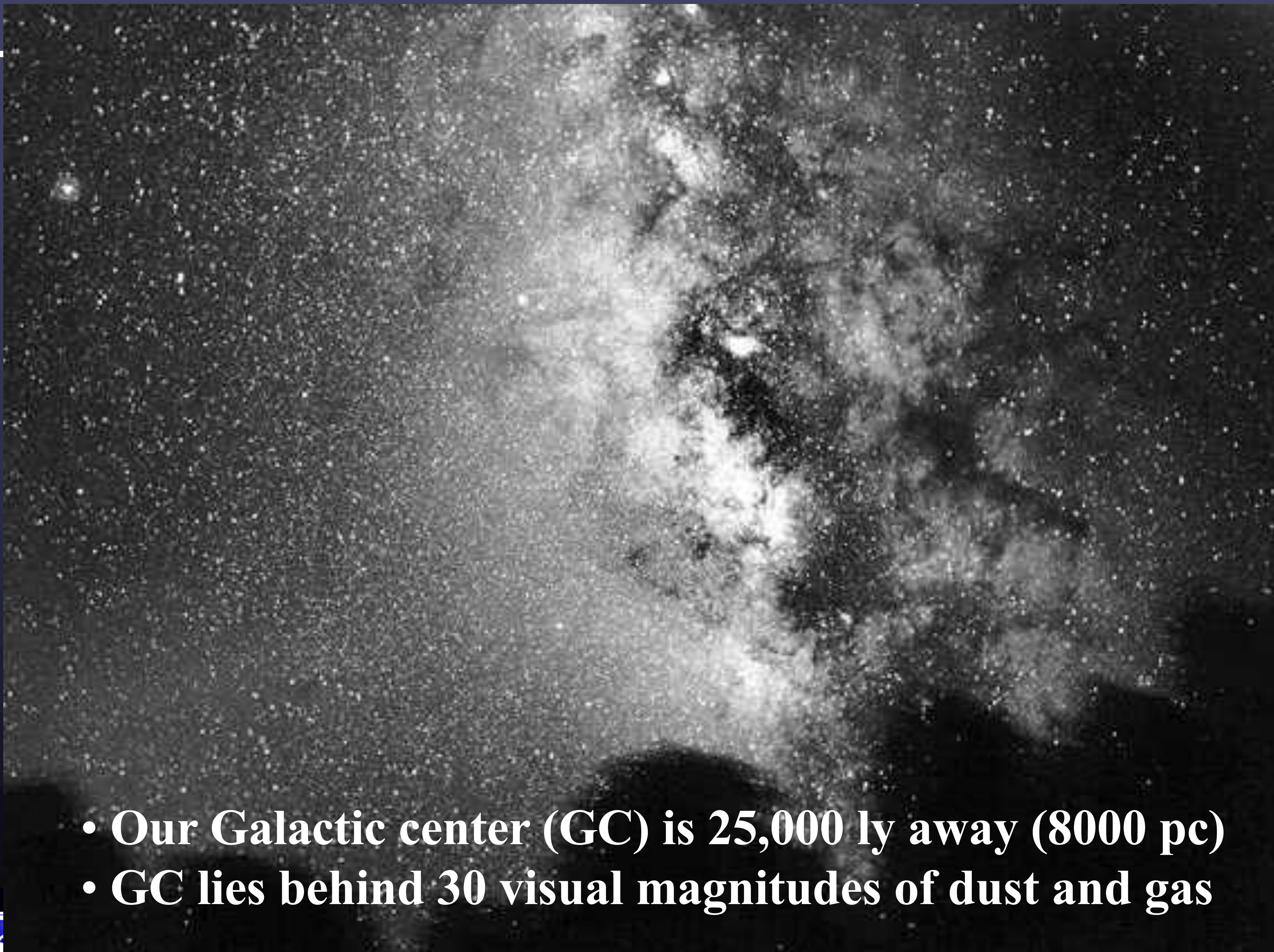
synchrotron emission from energetic particles in magnetic fields


[redacted]
VLA
1981 Sep 26
1.4 GHz

What are the benefits to doing radio astronomy?

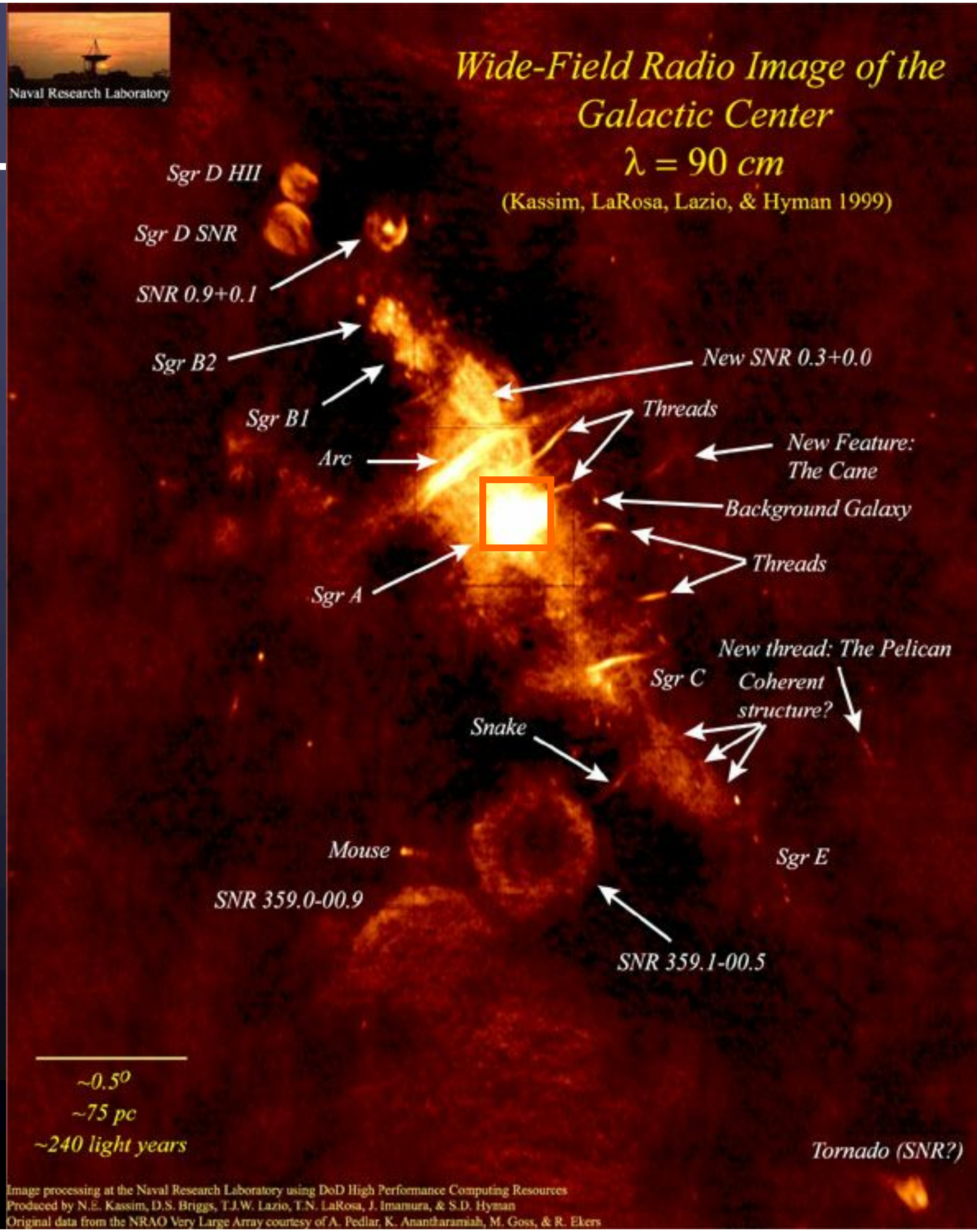
3. radio waves can propagate (fairly easily, sometimes affected) through the interstellar medium

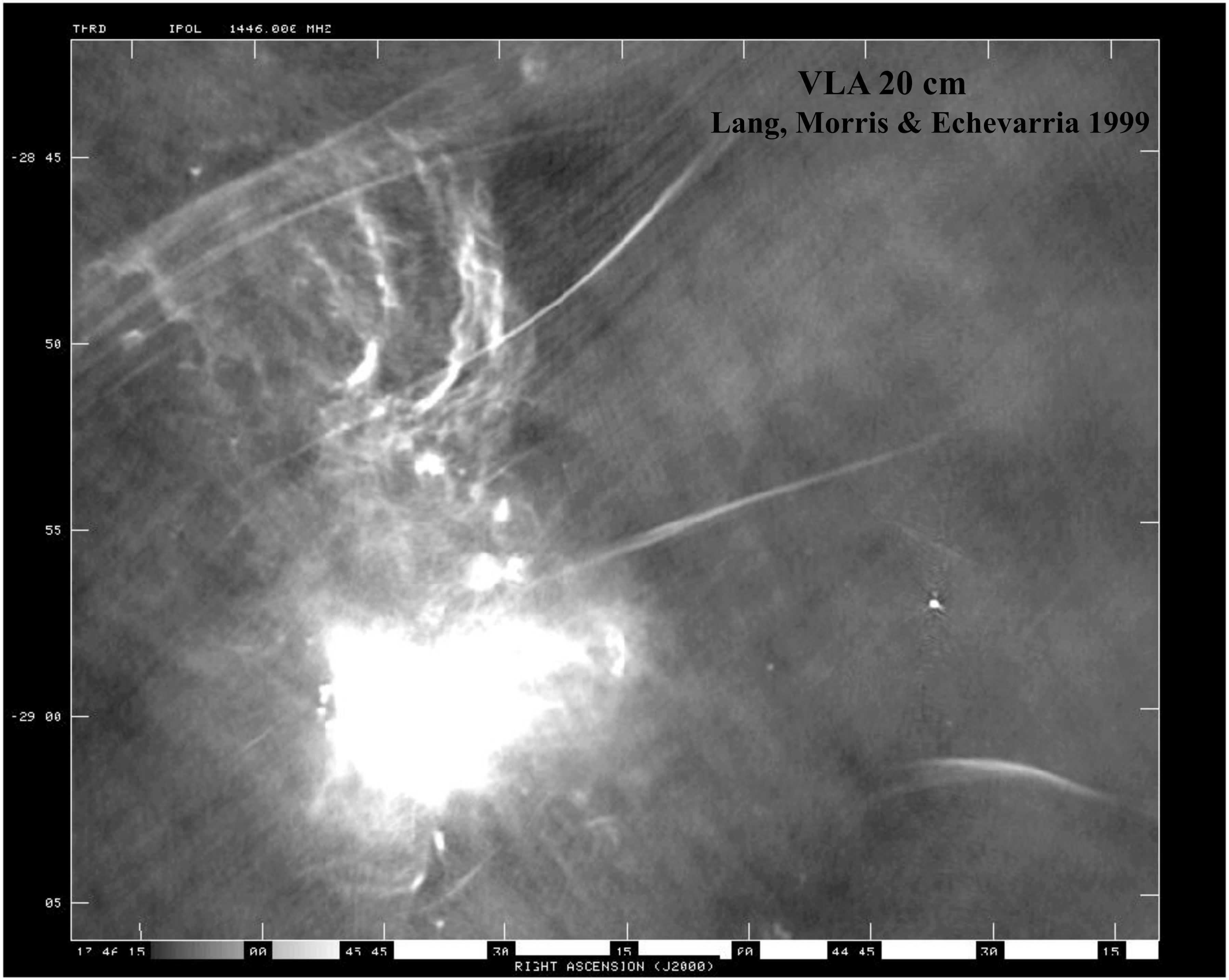
unprecedented views of distant parts of our Galaxy
reveal details of visibly obscured regions – star formation



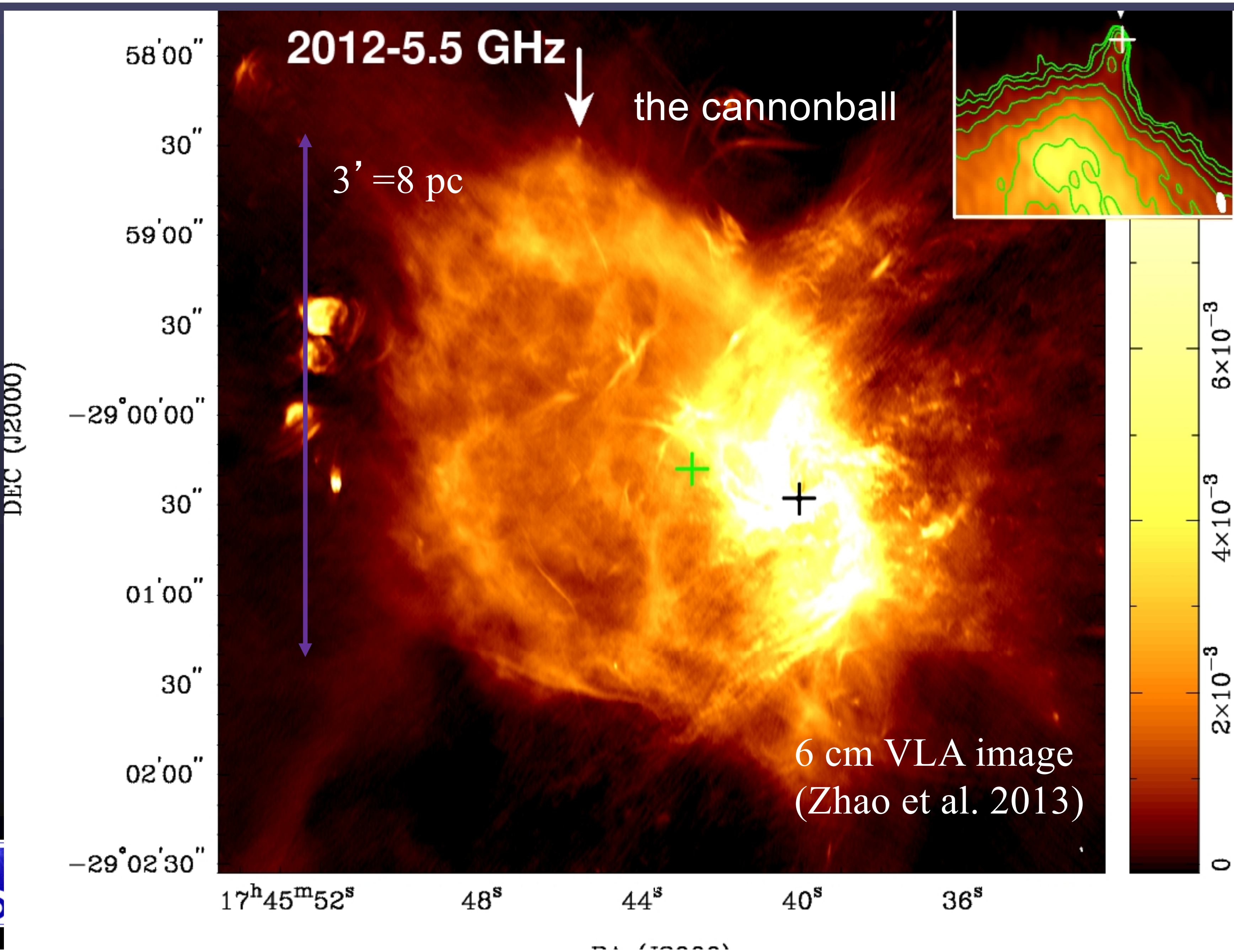
- Our Galactic center (GC) is 25,000 ly away (8000 pc)
- GC lies behind 30 visual magnitudes of dust and gas

VLA image at
λ=90 cm
~45” resolution
inner few degrees
of the Galaxy




TFRD IPOL 1446.00€ MHZ
VLA 20 cm
Lang, Morris & Echevarria 1999
-28 45
50
55
-29 00
05
17 46 15
00
45 45
30
15
00
44 45
30
15
RIGHT ASCENSION (J2000)

"Mini-spiral" of gas spiraling around (and onto) the central supermassive (~4 x 10^6 M_o black hole), SgrA*

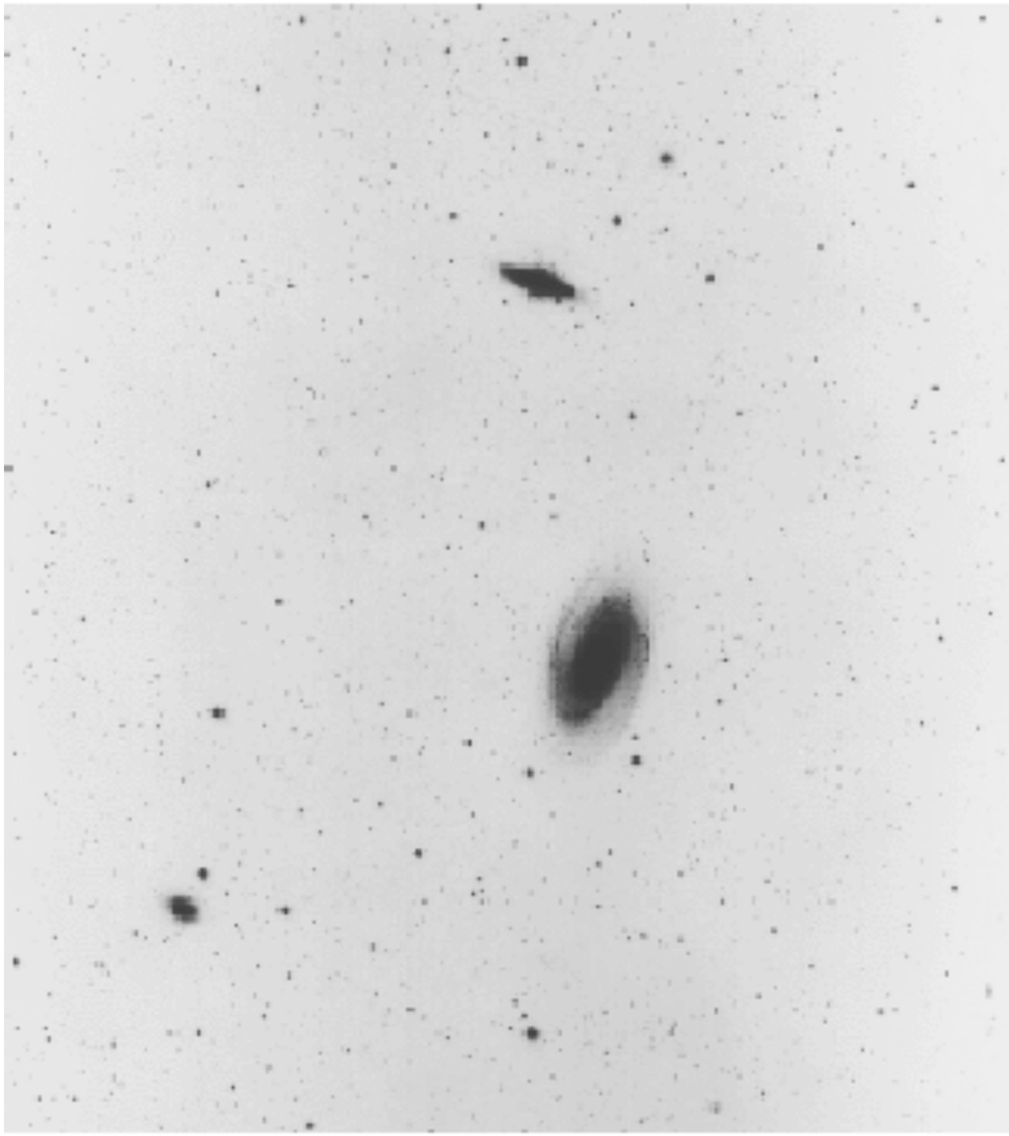


Possible VLA project #1

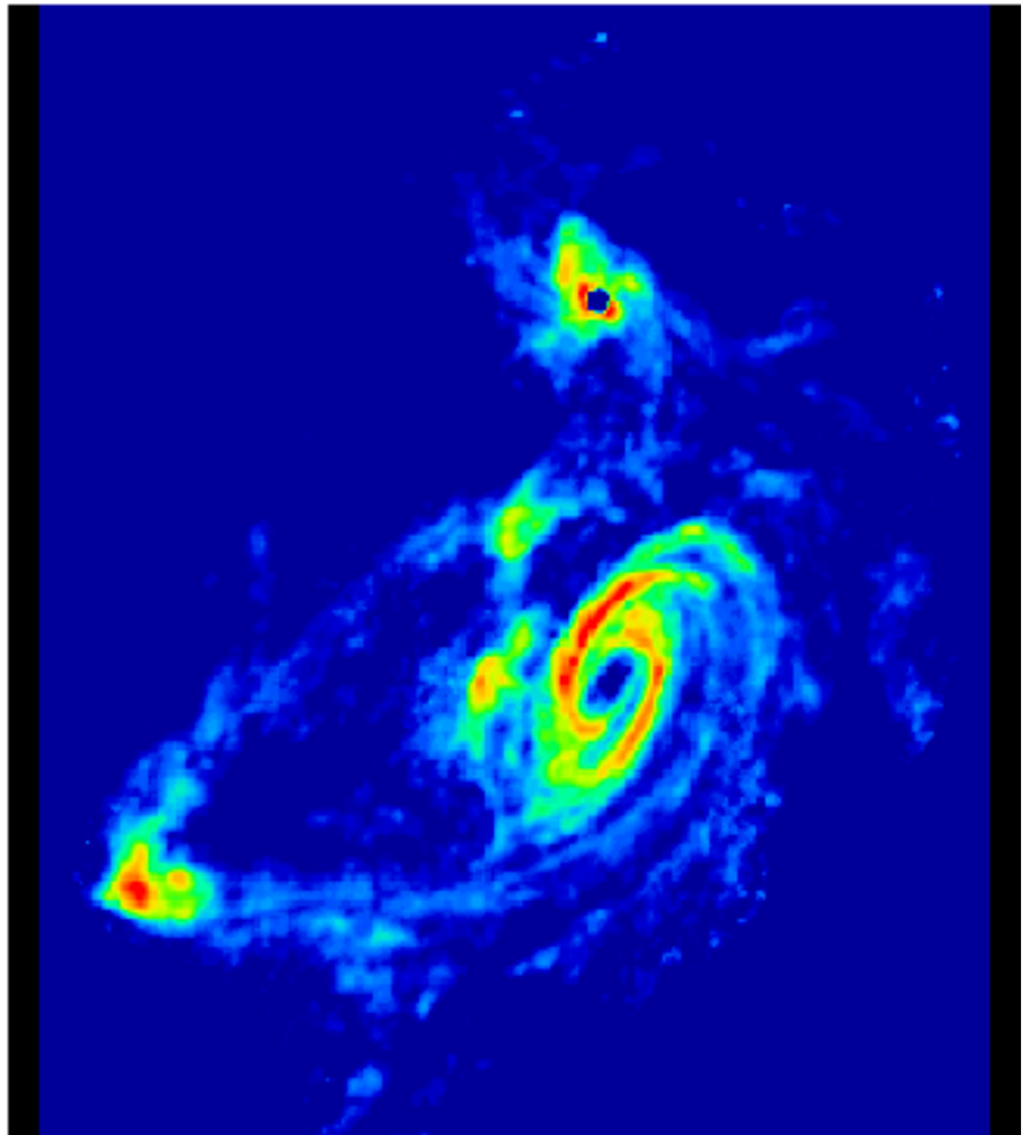
- Look for radio counterparts to compact X-ray sources associated with supernova remnants
  - Expansion of SNRs → age
  - Movement of compact remnant → age
- Look for new pulsars in the galactic plane using Fermi observations (unidentified gamma-ray sources)

TIDAL INTERACTIONS IN M81 GROUP

Stellar Light Distribution



21cm HI Distribution



What are the benefits to doing radio astronomy?

4. radio emission provides a wide variety of quantitative physical information about the source

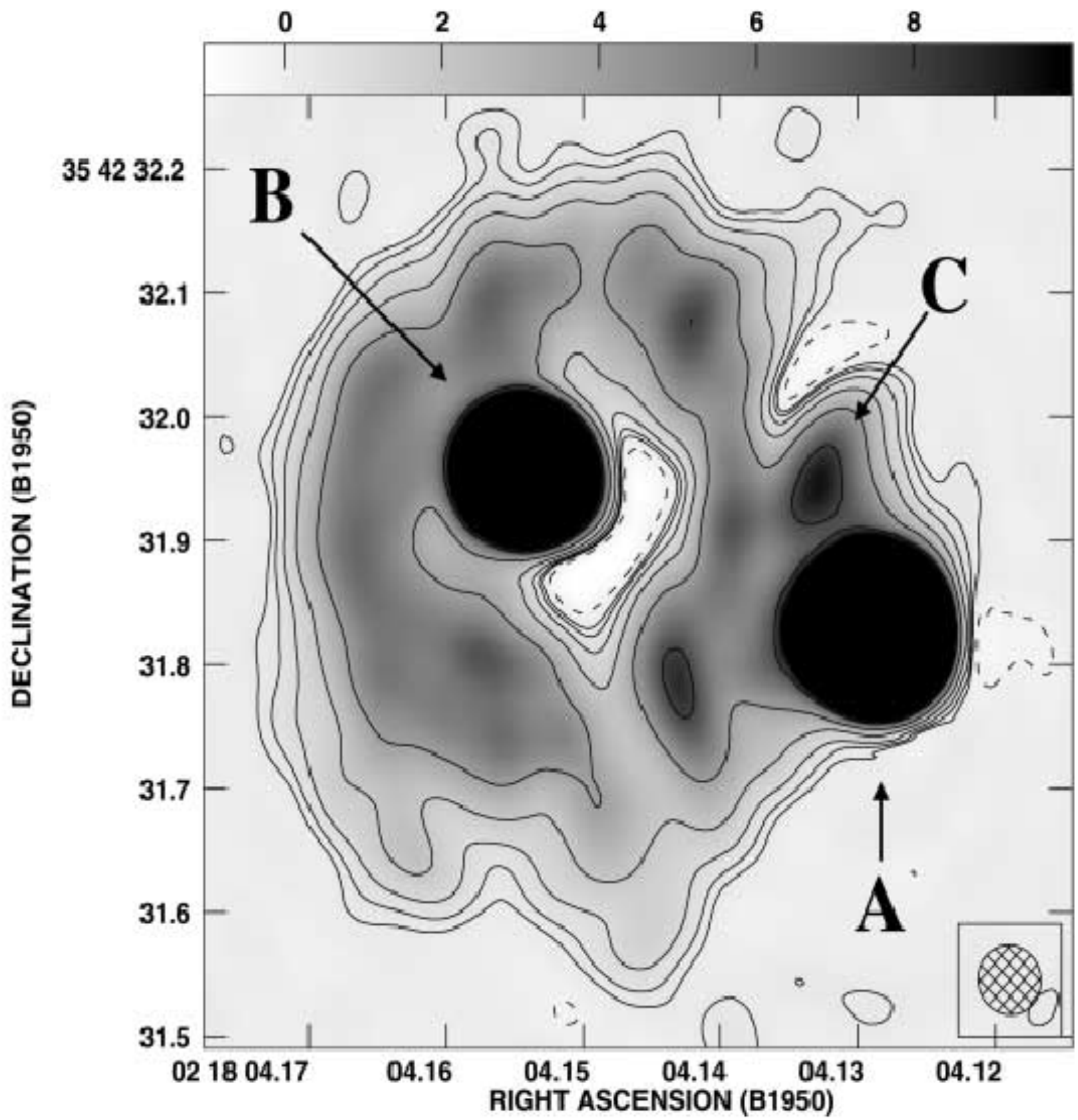
radio continuum emission

- spectral index (flux as a fxn. of frequency) = energetics
- brightness/flux = density, strength of magnetic field
  number of illuminating stars

radio spectral line emission

- width, amplitude of the line = temperature, density
- velocity = kinematic motions of gas, distance

0218+35



0
2
4
6
8
35 42 32.2
32.1
32.0
31.9
31.8
31.7
31.6
31.5
DECLINATION (B1950)
B
C
A
02 18 04.17
04.16
04.15
04.14
04.13
04.12
RIGHT ASCENSION (B1950)

Possible VLA project #2

- Look at new transitions (5 GHz OH)
  - Look at a Gravitational Lens to study ISM of distant galaxy
  - Look at a star forming region in our own galaxy

Differences between optical and radio observing

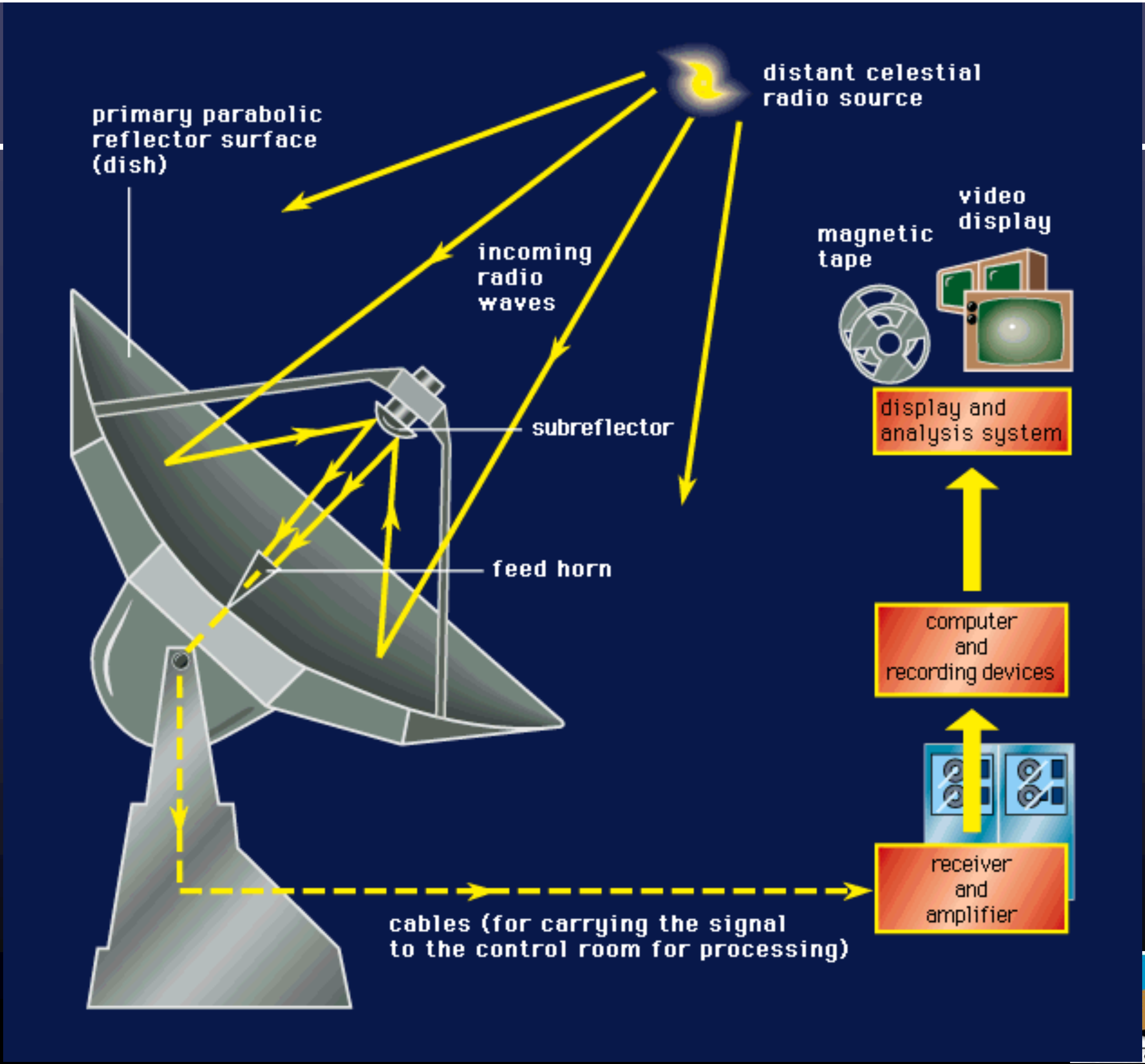
Optical

direct detection via CCD of the cosmic photon, strikes CCD → DETECTION

Radio

- radio wave (cosmic signal) is so weak that it needs to be amplified in order to be processed → *radio hardware*

- measure the wave properties of the radio wave, then reconstruct radio signal


distant celestial
radio source
primary parabolic
reflector surface
(dish)
incoming
radio
waves
subreflector
feed horn
video
display
magnetic
tape
display and
analysis system
computer
and
recording devices
receiver
and
amplifier
cables (for carrying the signal
to the control room for processing)

Parkes 64-m in New South Wales, Australia

Arecibo Radio Telescope, Puerto Rico, RIP

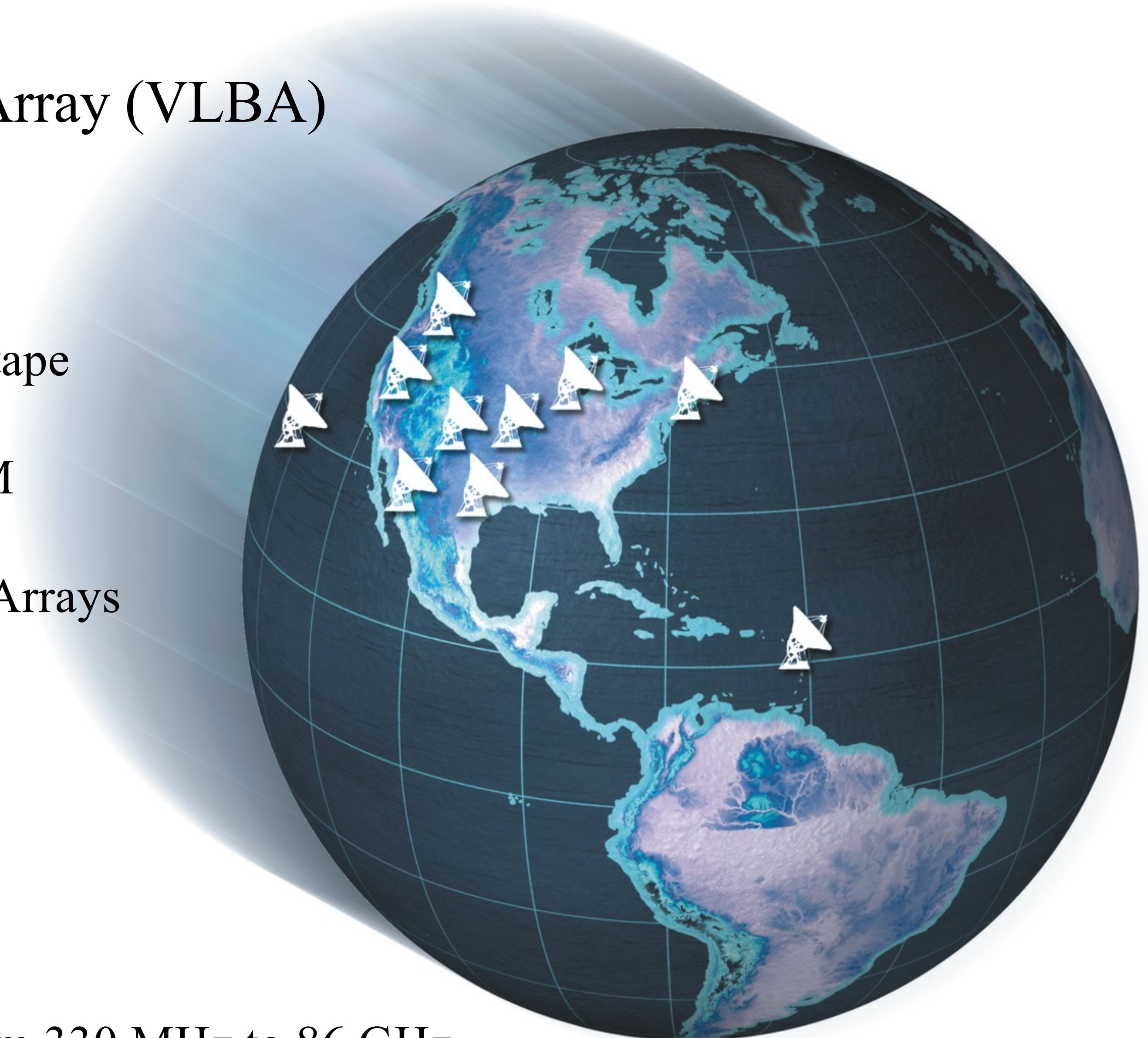
Very Long Baseline Array (VLBA)

Dedicated in 1993

10 antennas recording to tape

Correlator in Socorro, NM

Combinable with Global Arrays

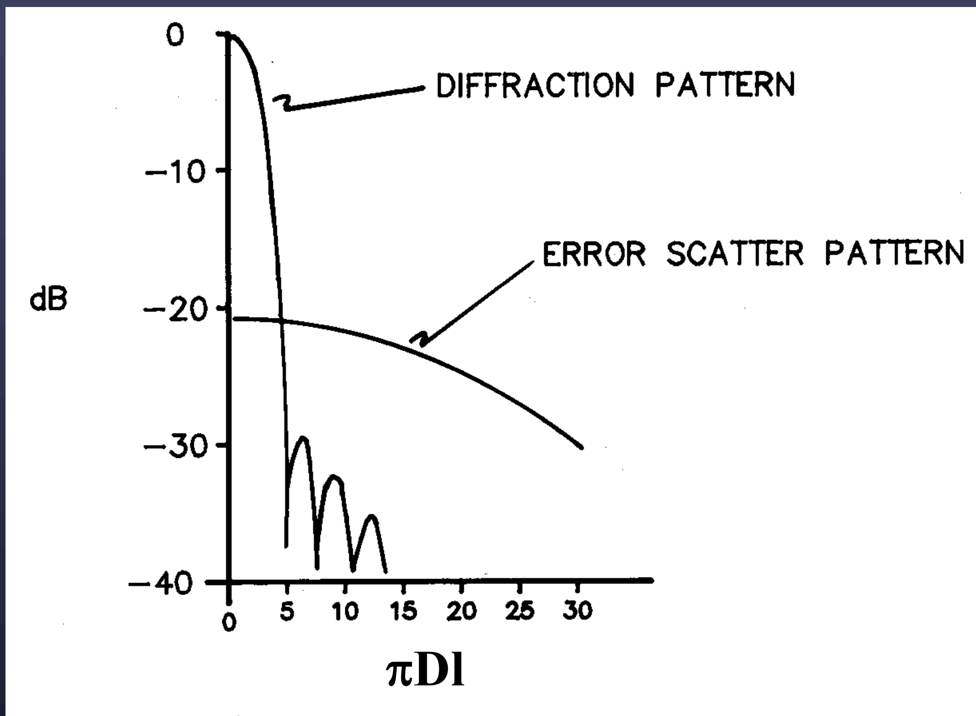


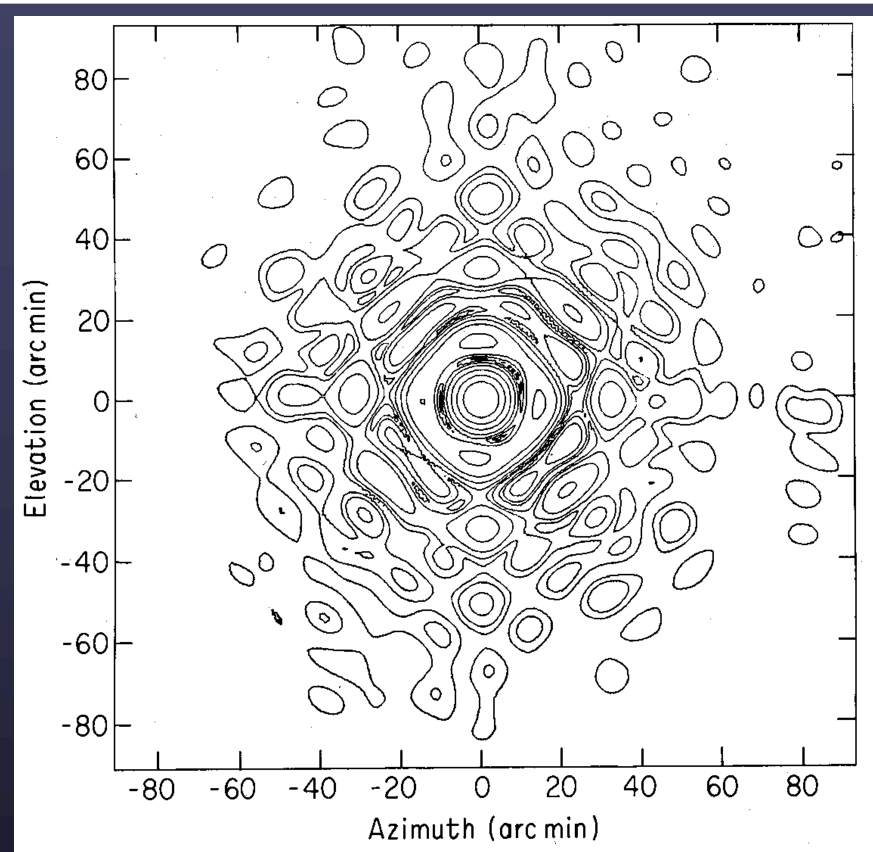
• Frequencies ranging from 330 MHz to 86 GHz

• Angular resolution to 100 microarcseconds at highest frequency

Antenna Performance Parameters

Primary Beam





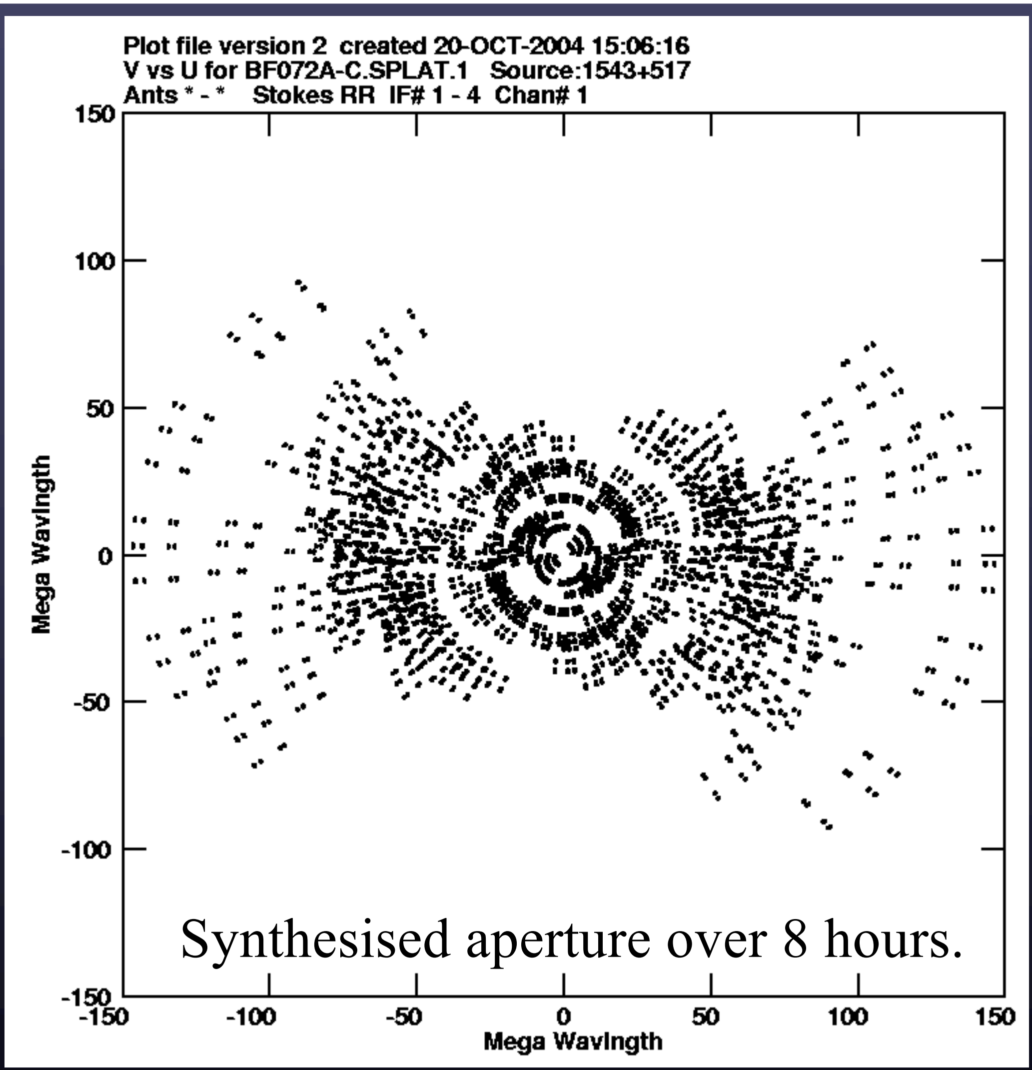
l=sin(θ), D = antenna diameter in wavelengths

contours:at factors of 3 increments

dB = 10log(power ratio)

For VLA: θ_{3dB} = 1.02/D, First null = 1.22/D

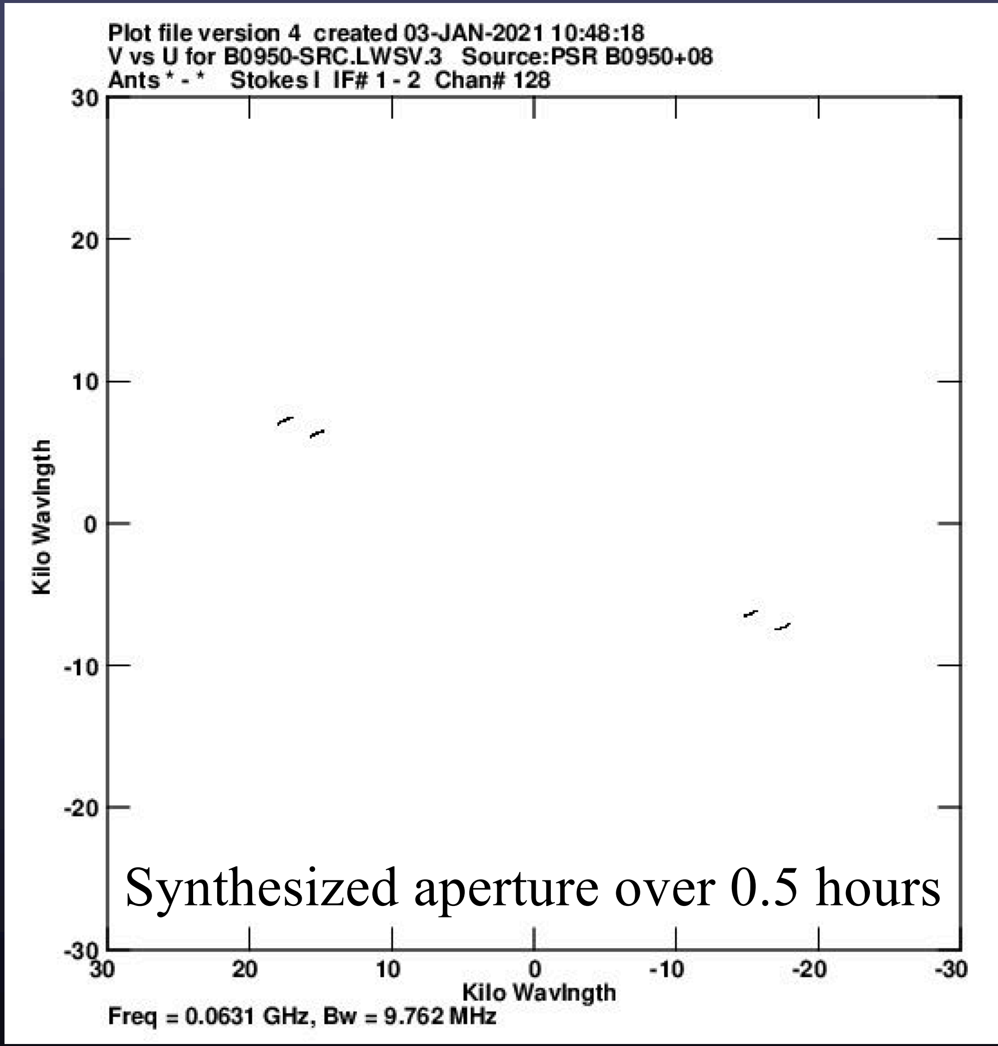
VLBA Synthesised Aperture



Synthesised aperture over 8 hours.

The VLBA
10 antennas each 25 m in diameter

LWA Synthesized Aperture



The LWA
2 antennas each 100 m in diameter

NGC 4258

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

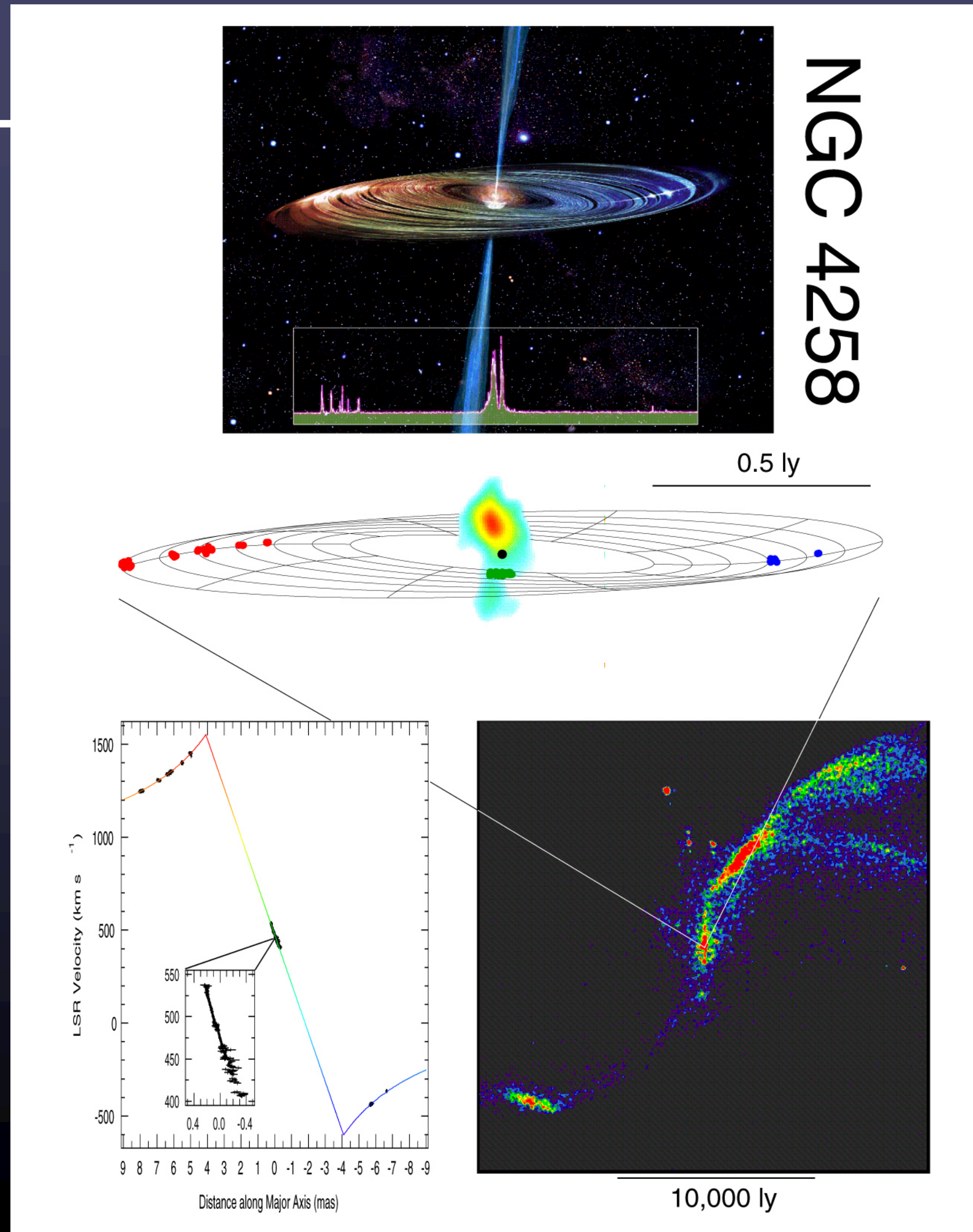


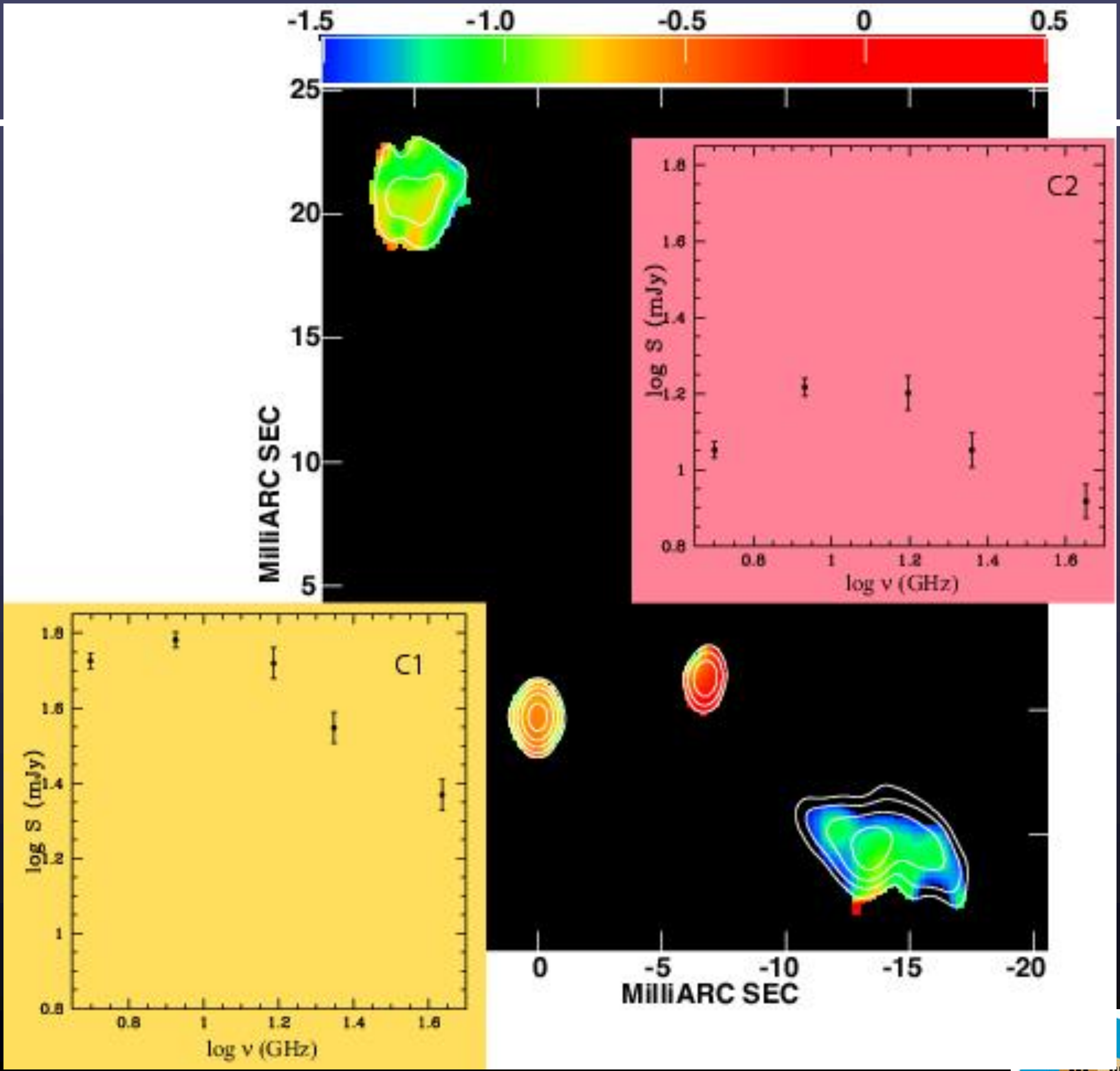
image courtesy Lincoln Greenhill
(see Miyoshi et al 1995
Herrnstein et al 1999)

Possible VLA project #3

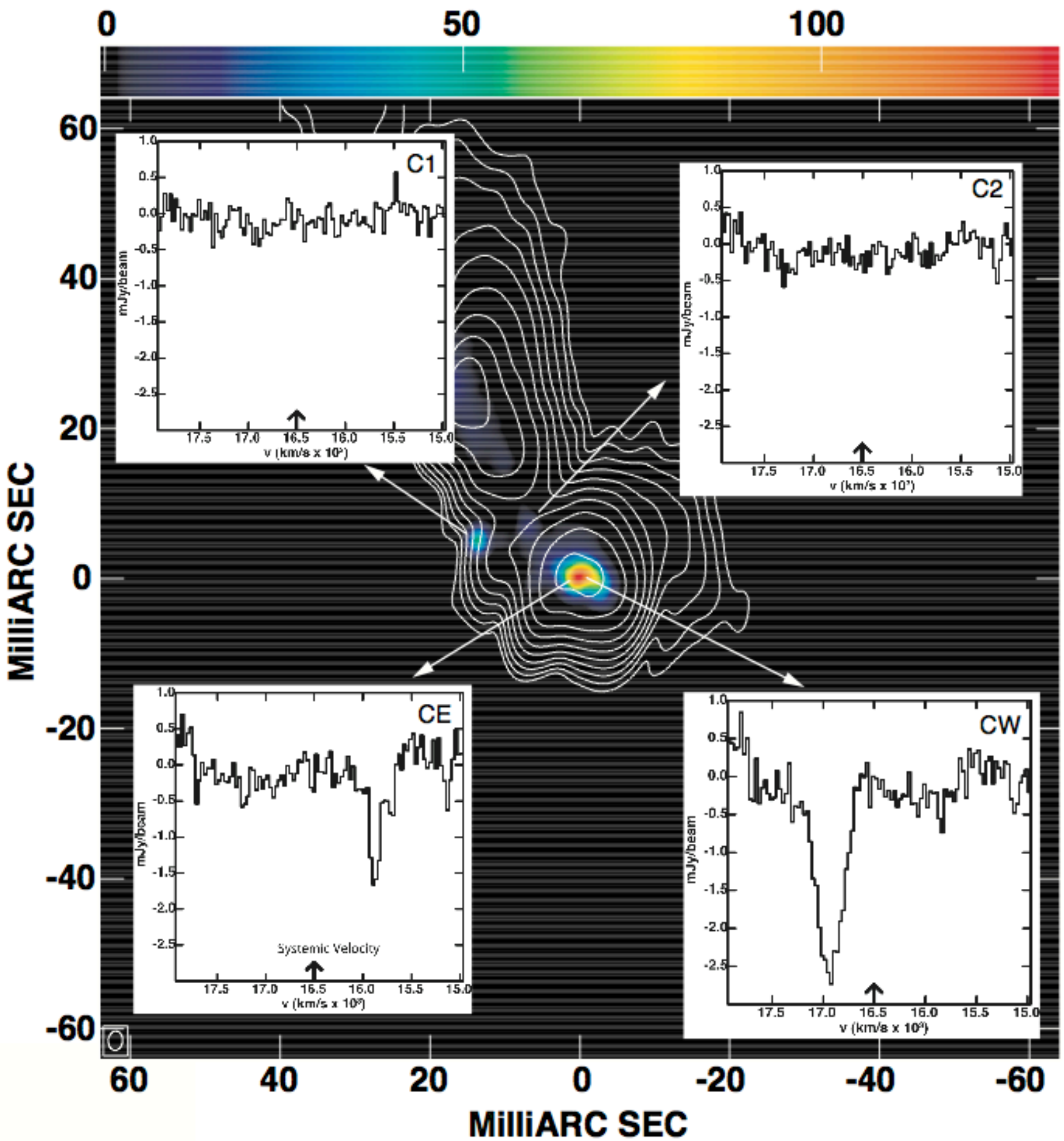
- Look for discrete sources in NGC 4258
  - What is the star formation rate?
  - What is the extent of the radio continuum?

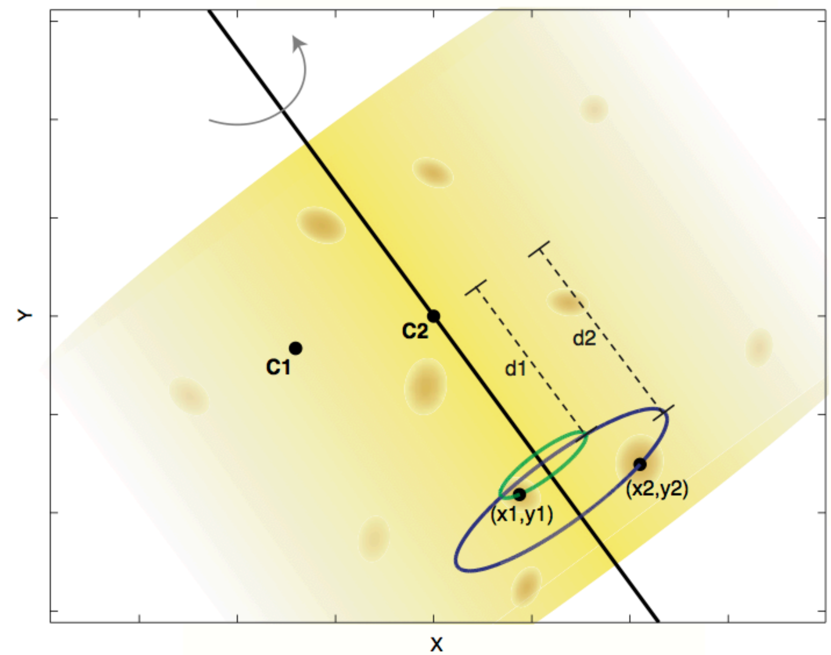
0402+379

Rodriguez et al. 2006



0402+379



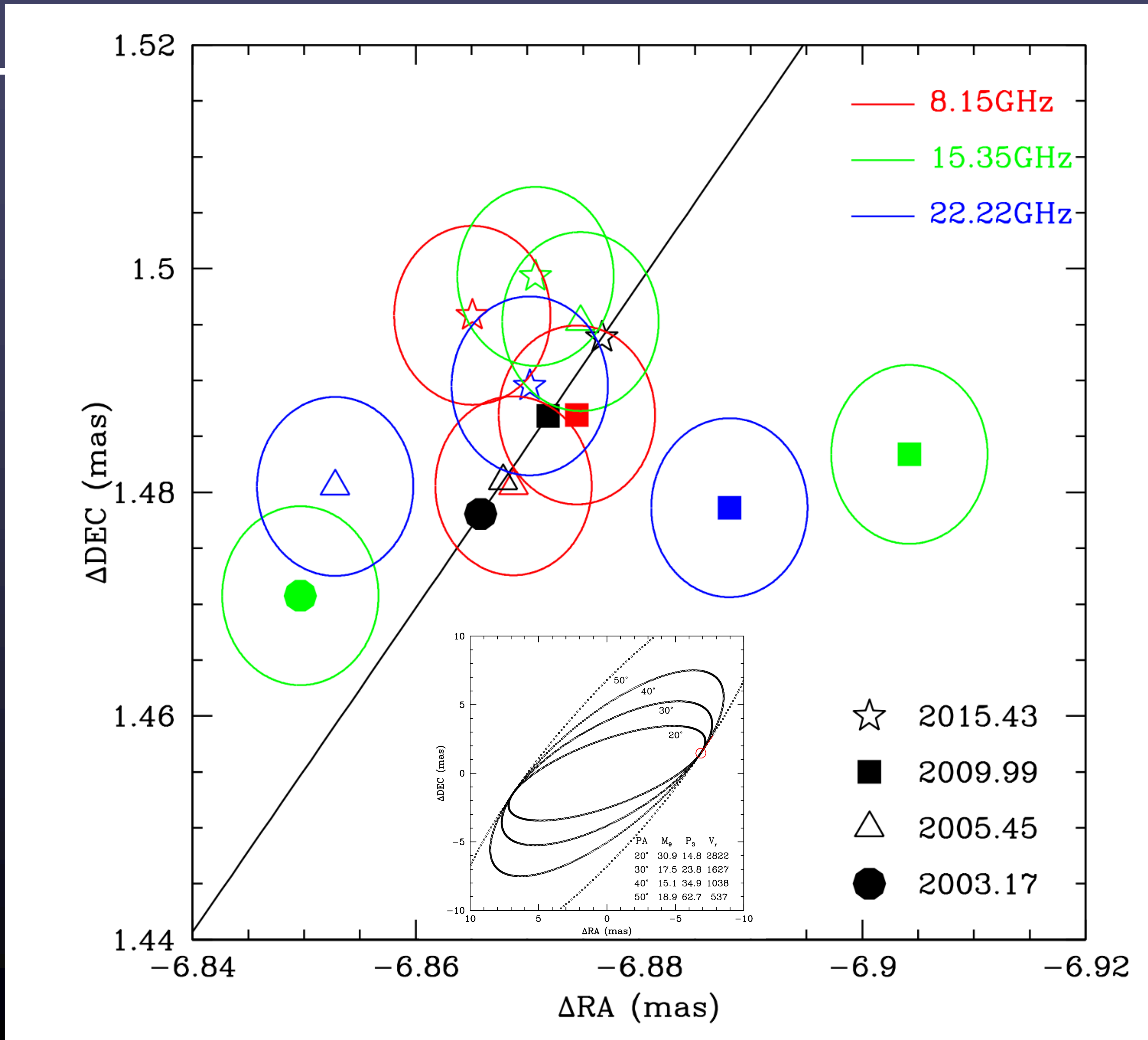


v ~ 600 km/s
r ~ 7 pc

M(C2) ~ 7 x 10^8 M_{sun}

Rodriguez et al. 2009

0402+379



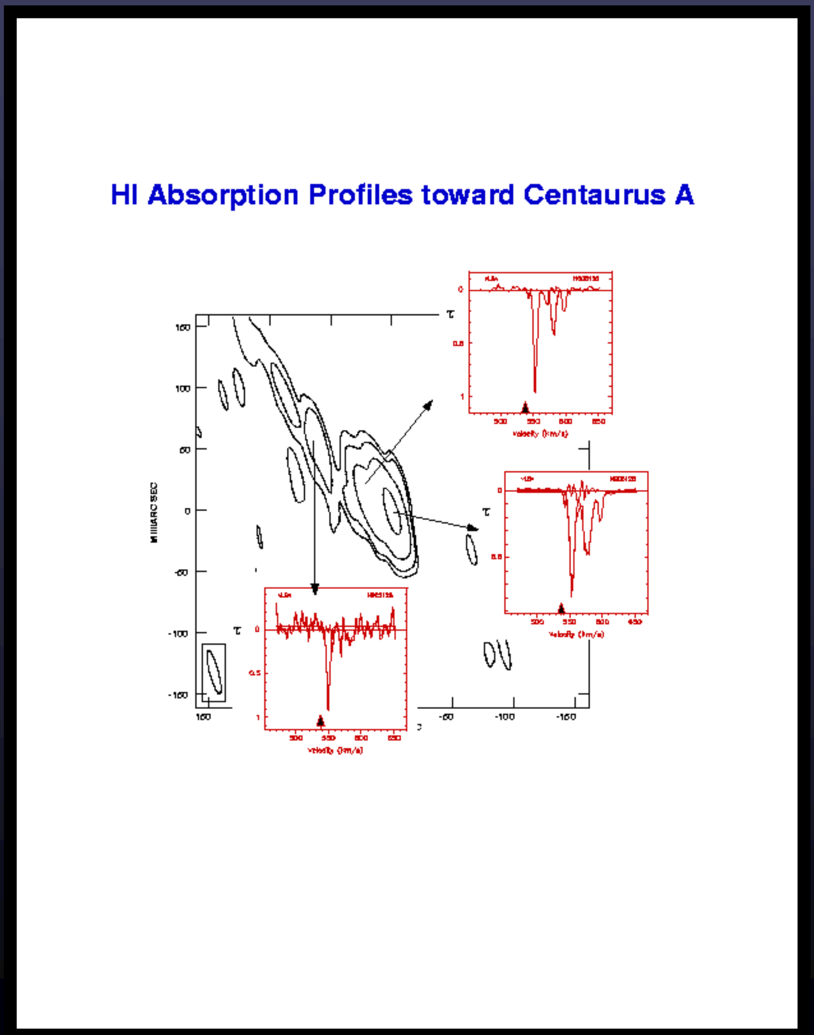
Bansal et al. 2017

Possible VLA project #5

- Measure large scale HI in 0402+379
  - Determine extent of HI absorption in space/velocity
  - Measure line widths, kinematics

Centaurus A – a peculiar galaxy with extensive radio lobes

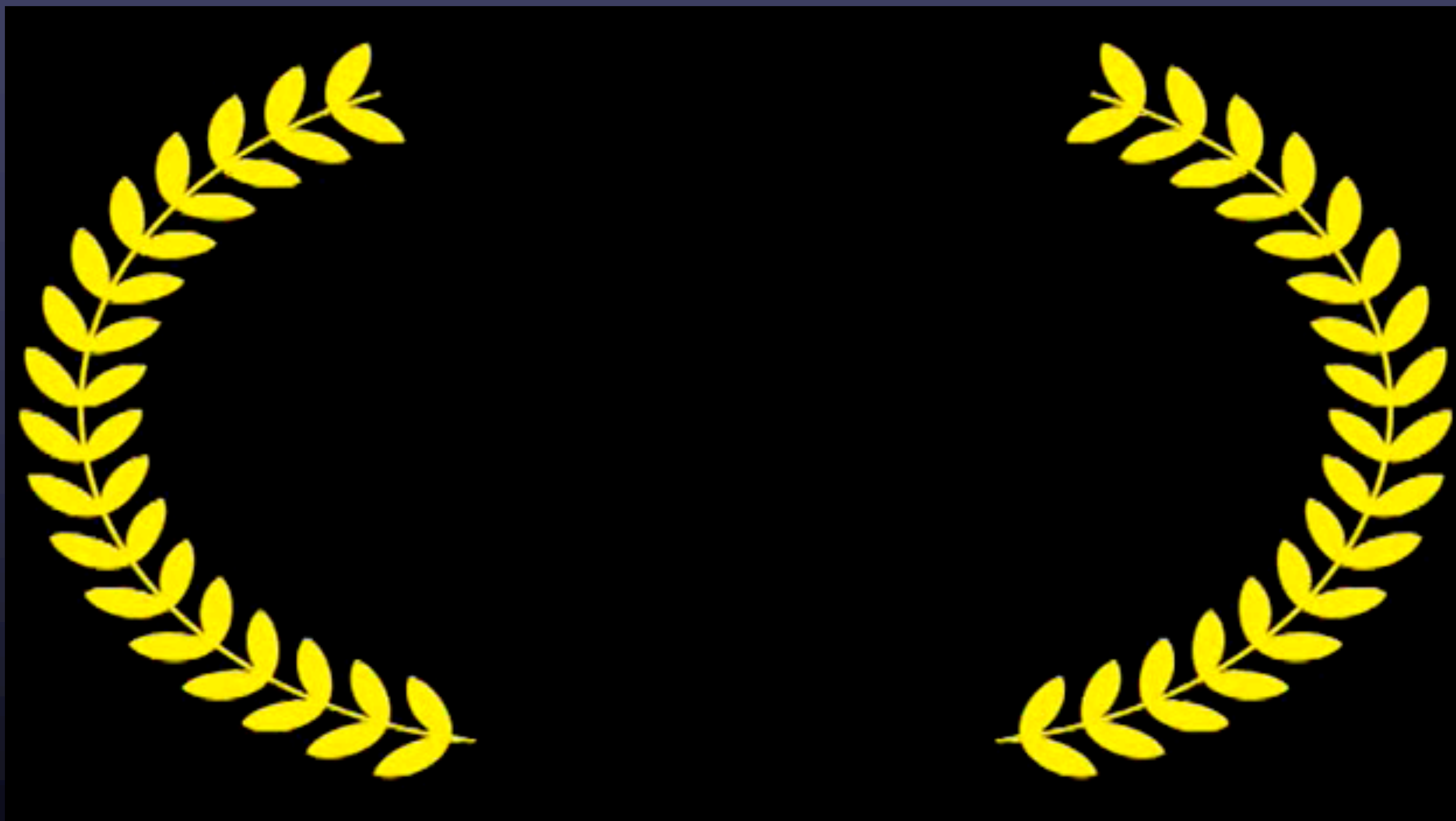
Not All Absorption is Associated with the AGN

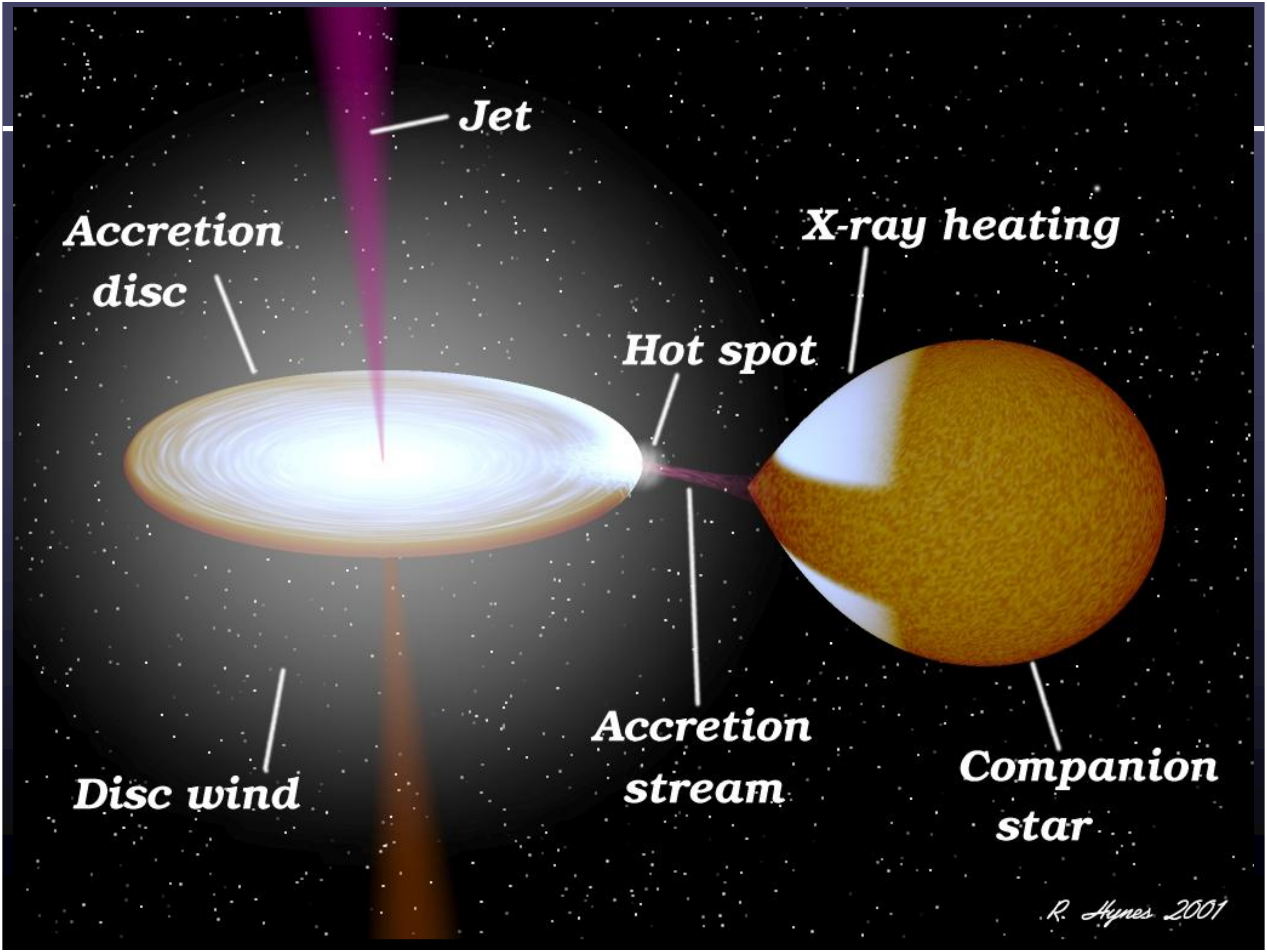


(Peck 1999)

Possible VLA project #7

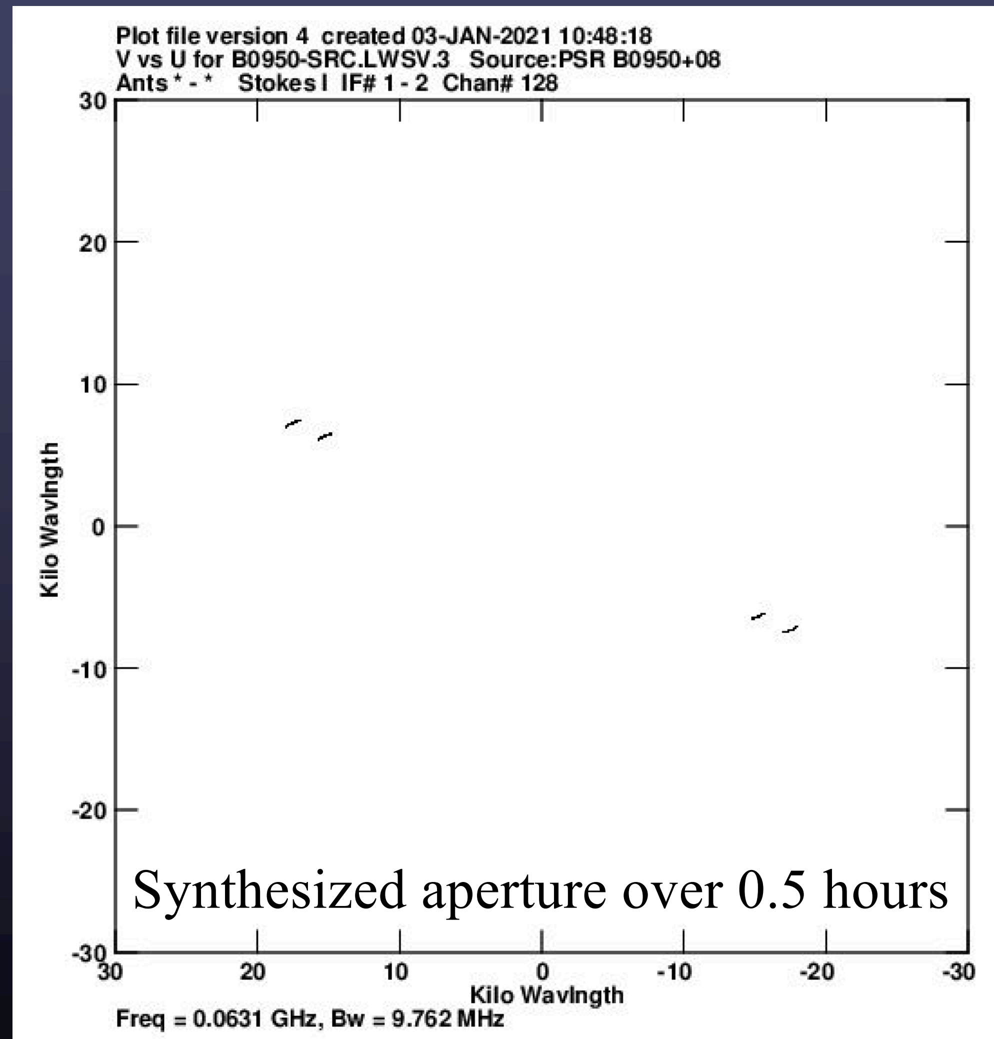
- Search for HI absorption against newly discovered CSOs
  - Determine extent of HI absorption in space/velocity
  - Measure line widths, kinematics
  - (Looked at 3 sources in 2011, no HI)




Jet
Accretion disc
X-ray heating
Hot spot
Accretion stream
Companion star
Disc wind
R. Hynes 2001

LWA Synthesized Aperture

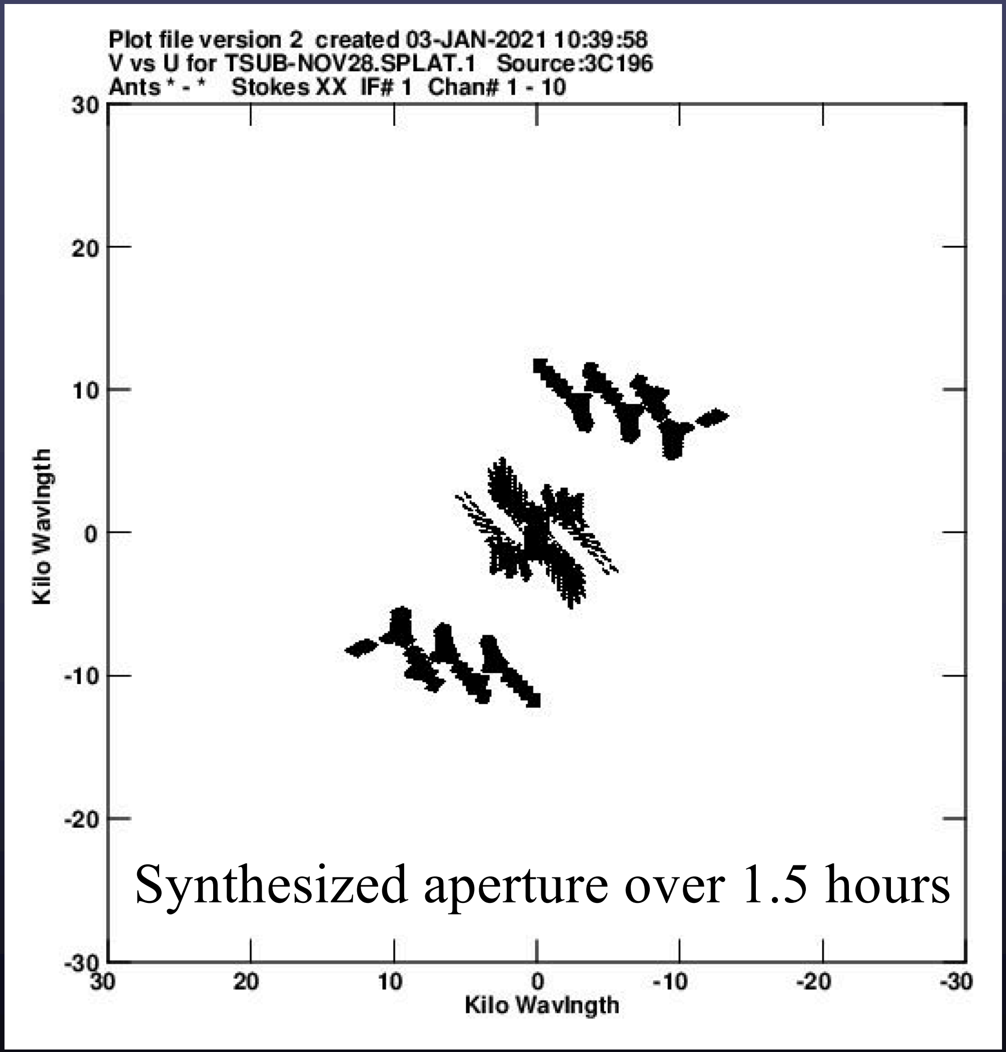
The LWA
2 antennas each 100 m in diameter



VLA 50-86 MHz

New 4 band feeds (MJP)
4 meter band: 50-86 MHz
All 28 installed

ELWA Synthesized Aperture



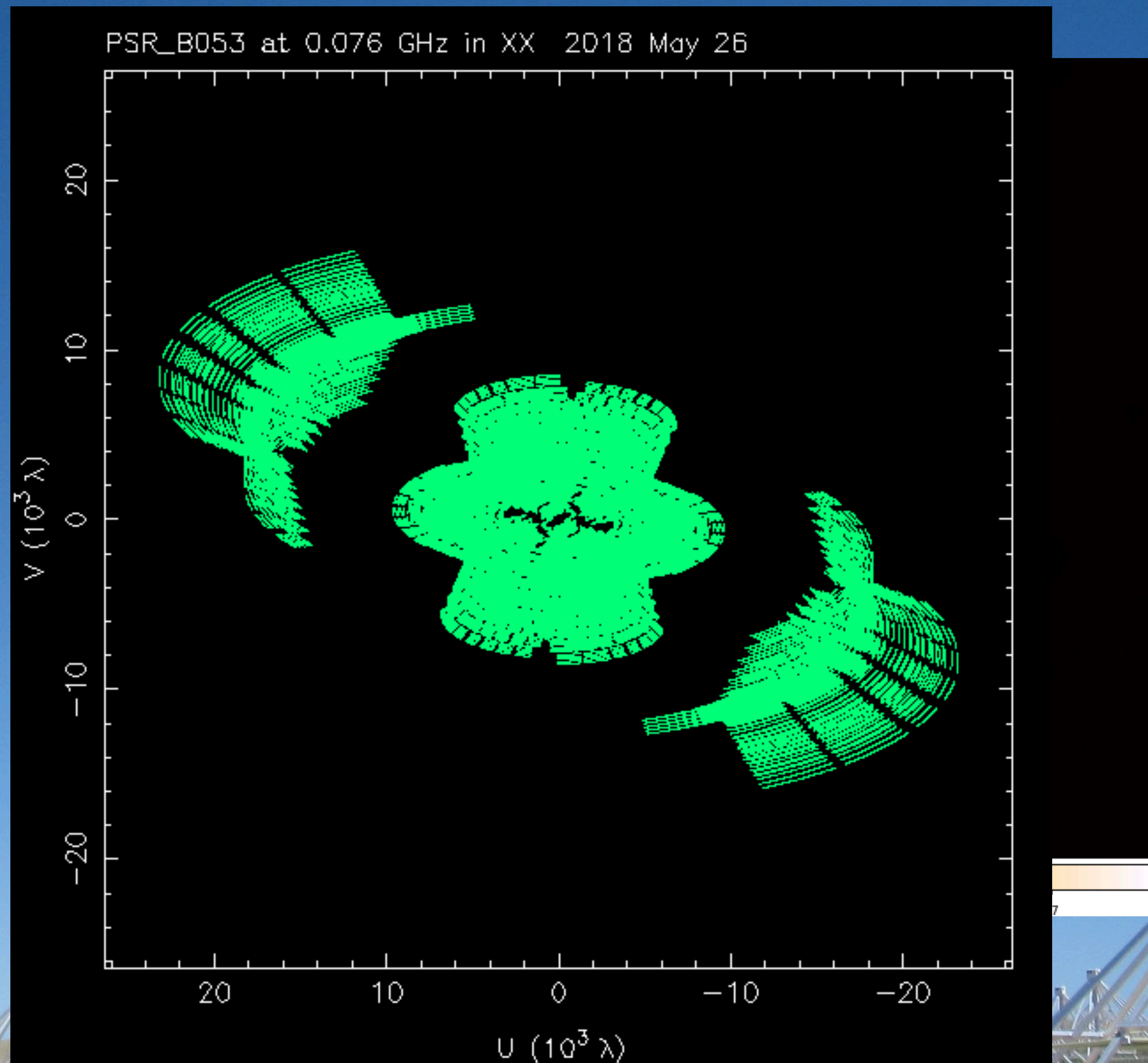
The ELWA
2 antennas each 100 m in diameter
27 antennas each 25 m in diameter

Possible ELWA project #8

- AGN snapshot survey
  - Measure low frequency spectra of bright AGN
  - Look for spectral turnovers
  - Look for scintillation

ELWA - Demonstration

TauA (crab) at 72 MHz
May 26, 2018
2 LWA + 23 VLA
4 hours on source
38 Jy peak
RMS ~ 40 mJy/beam
Resolution ~ 15”



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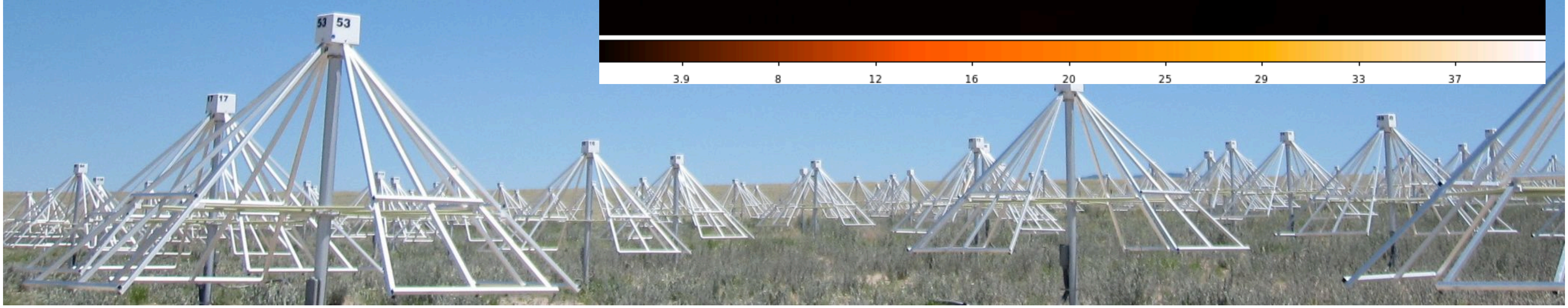
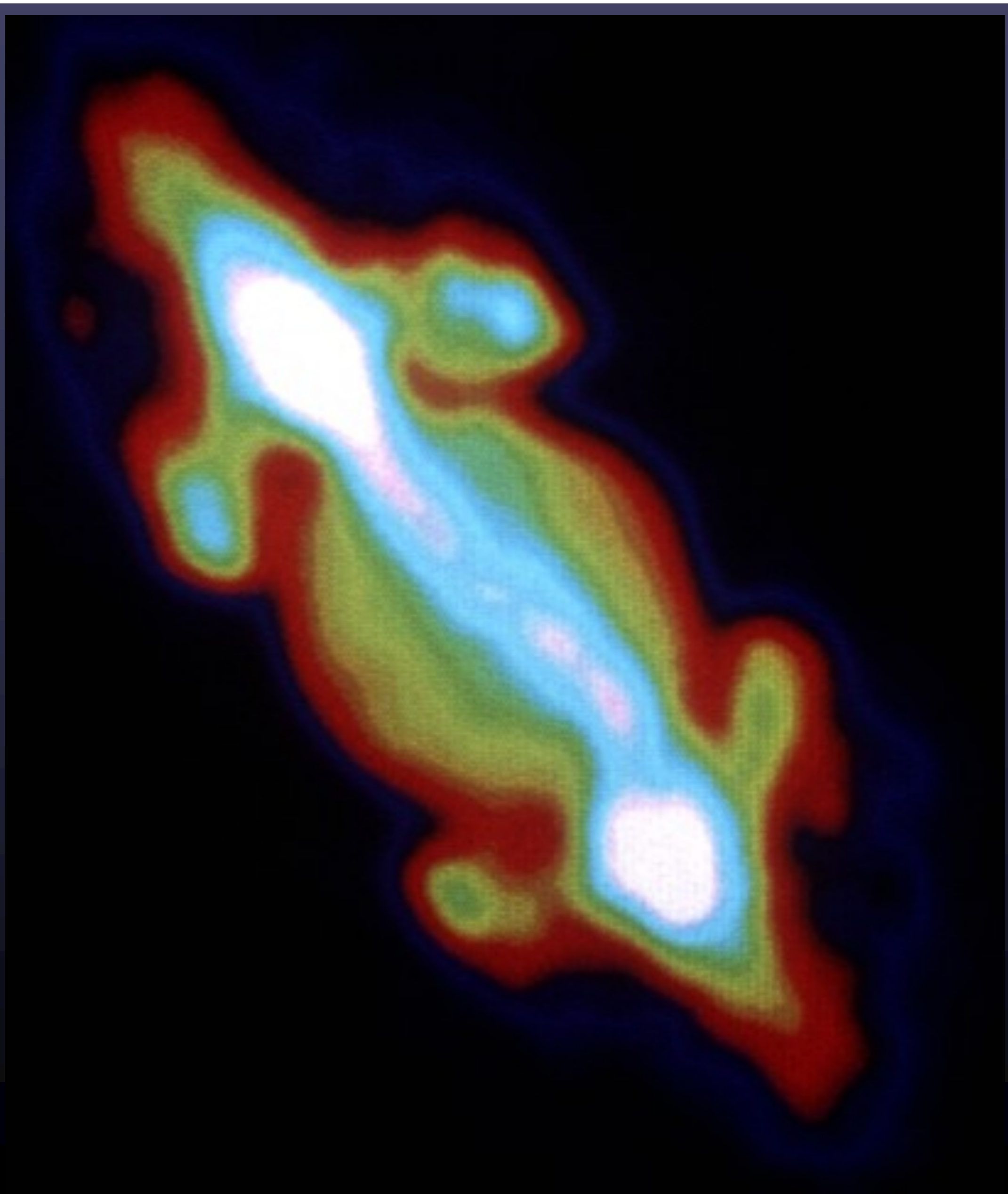


Possible LWA project #8

- Measure properties of Giant Pulses from the Crab
  - Compare with Fermi observations
  - Compare with other low frequency observations
  - Compare with previous LWA observations

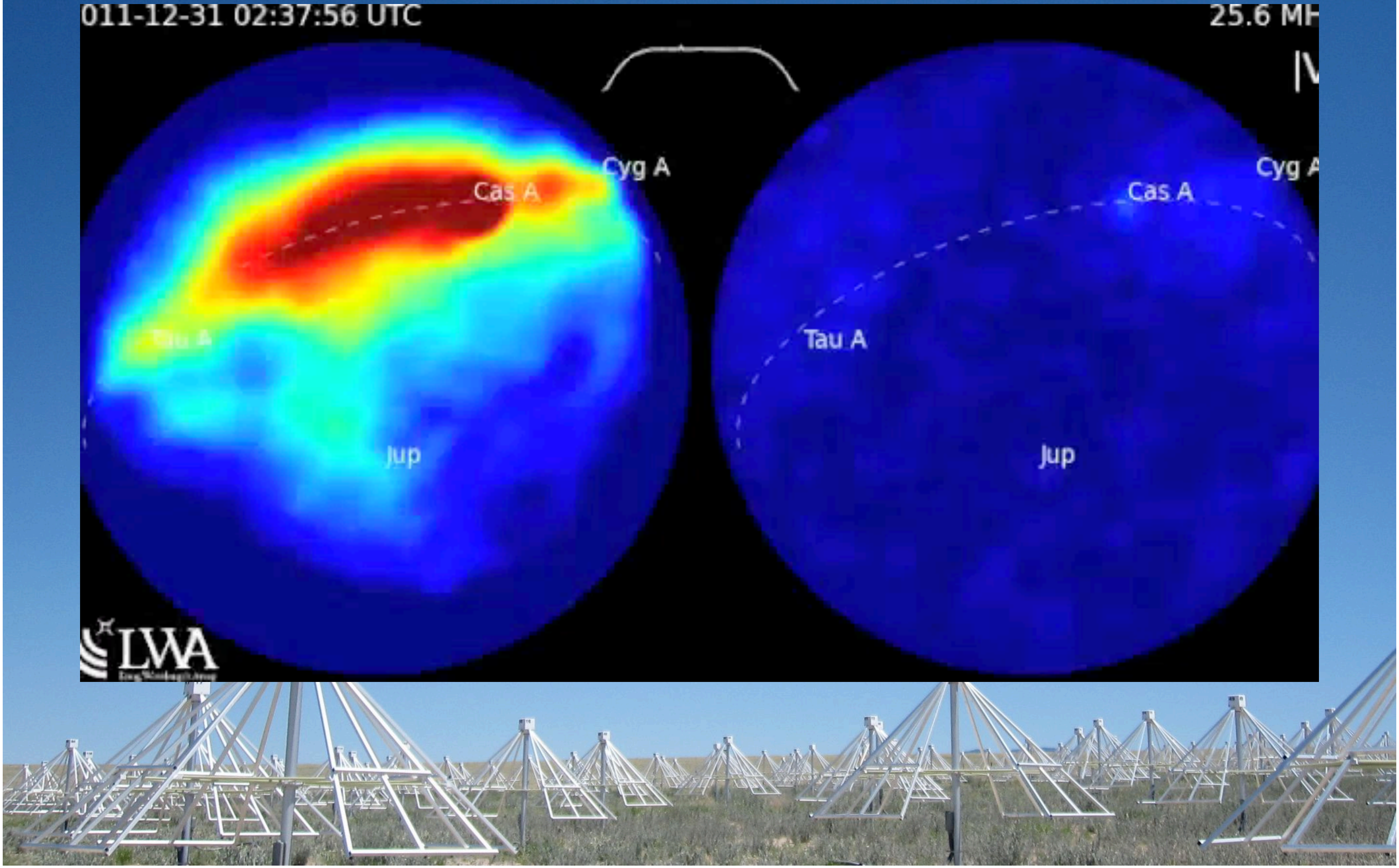
Name that object observed in the radio with the VLA



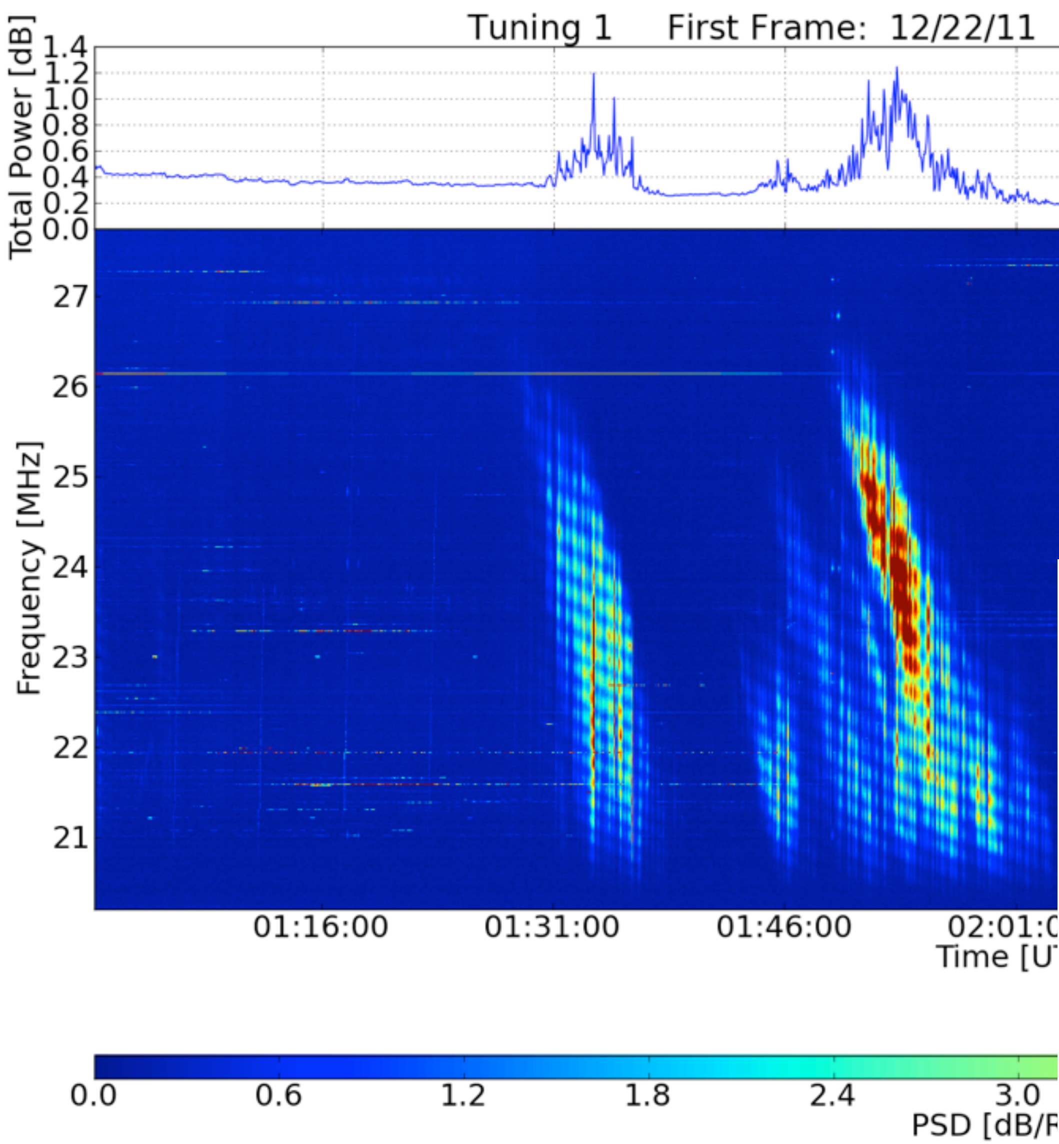
detection of the magnetic belts around Jupiter

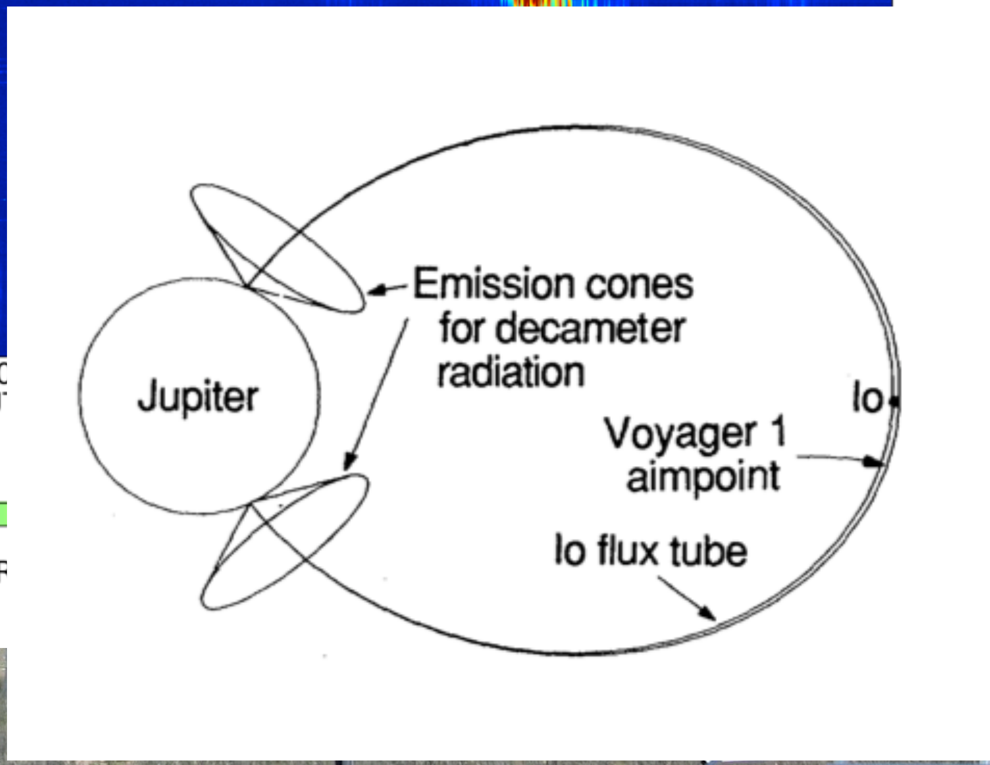
synchrotron emission from energetic particles in magnetic fields

LWA1 Observations of Jupiter



Decametric Jovian Emission





Possible LWA project #9

- Use the LWA interferometer to localize the emission from Jupiter
  - Is RCP from the northern auroral region?
  - Is LCP from the southern auroral region?
  - Does any emission come form outside the poles?

Further Reading

http://www.vla.nrao.edu/astro/
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