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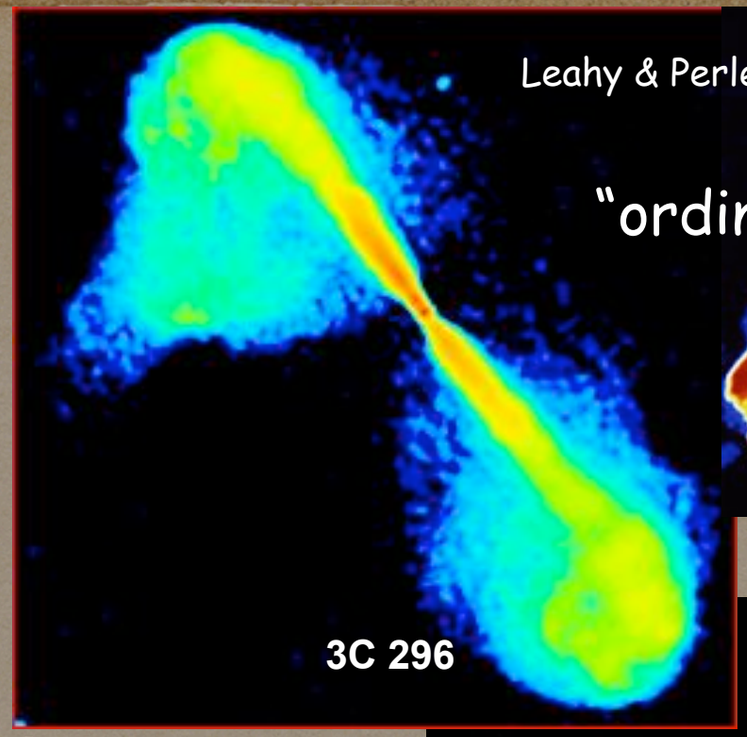
A tale of a bent, head-tail radio galaxy

With due thanks to

Ishwara-Chandra C.H. (NCRA-TIFR)

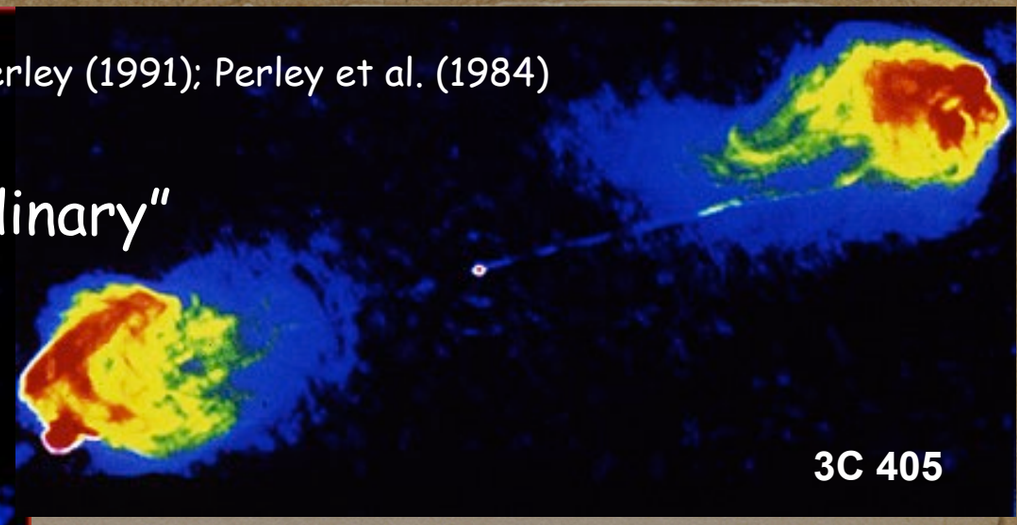
TAXONOMY

- FR I / FR II (FR 1974)
  - radio luminosity & morphology
  - Physically important distinction is whether the jet terminates at a shock.
  - In the local universe,
    - FR Is are in group/cluster
    - FR IIs are field/isolated
- Head-Tail radio galaxies
  - NAT / WAT (Jaffe & Perola 1973)
  - cluster potential & environment
- X-shaped / winged radio galaxies
  - merger / re-orientation / ???



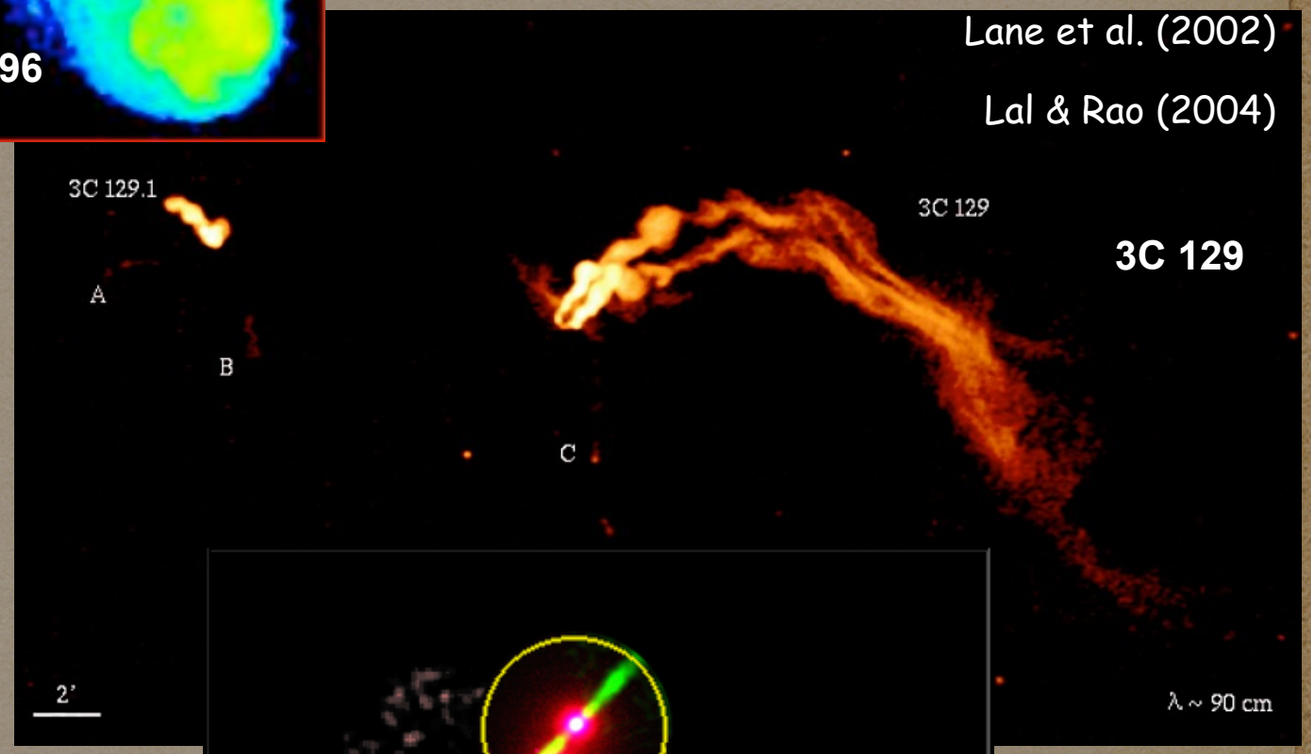
Leahy & Perley (1991); Perley et al. (1984)

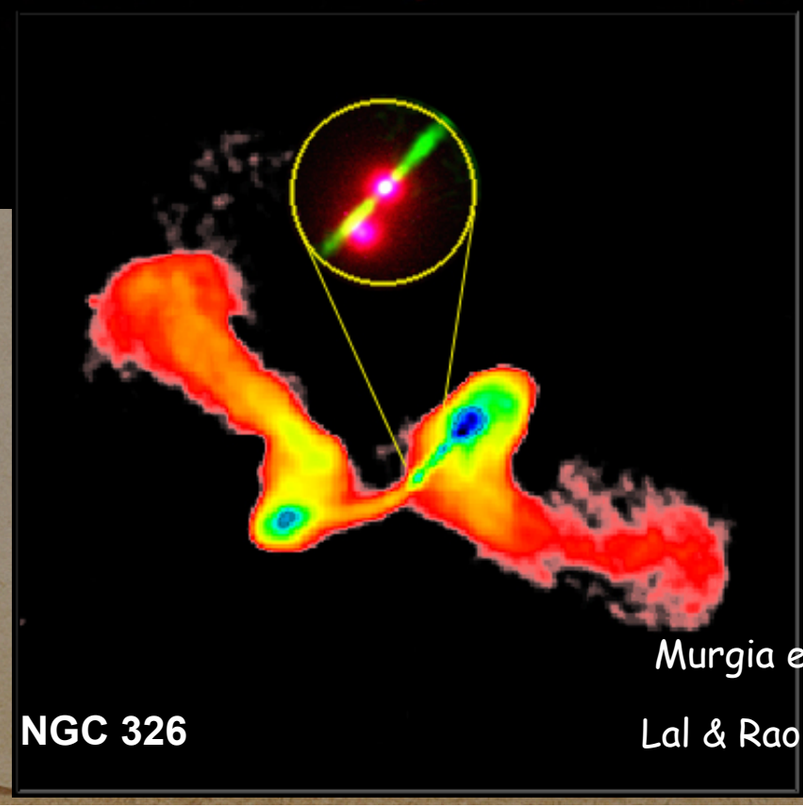
"ordinary"



Lane et al. (2002)

Lal & Rao (2004)





Murgia et al. (2001)

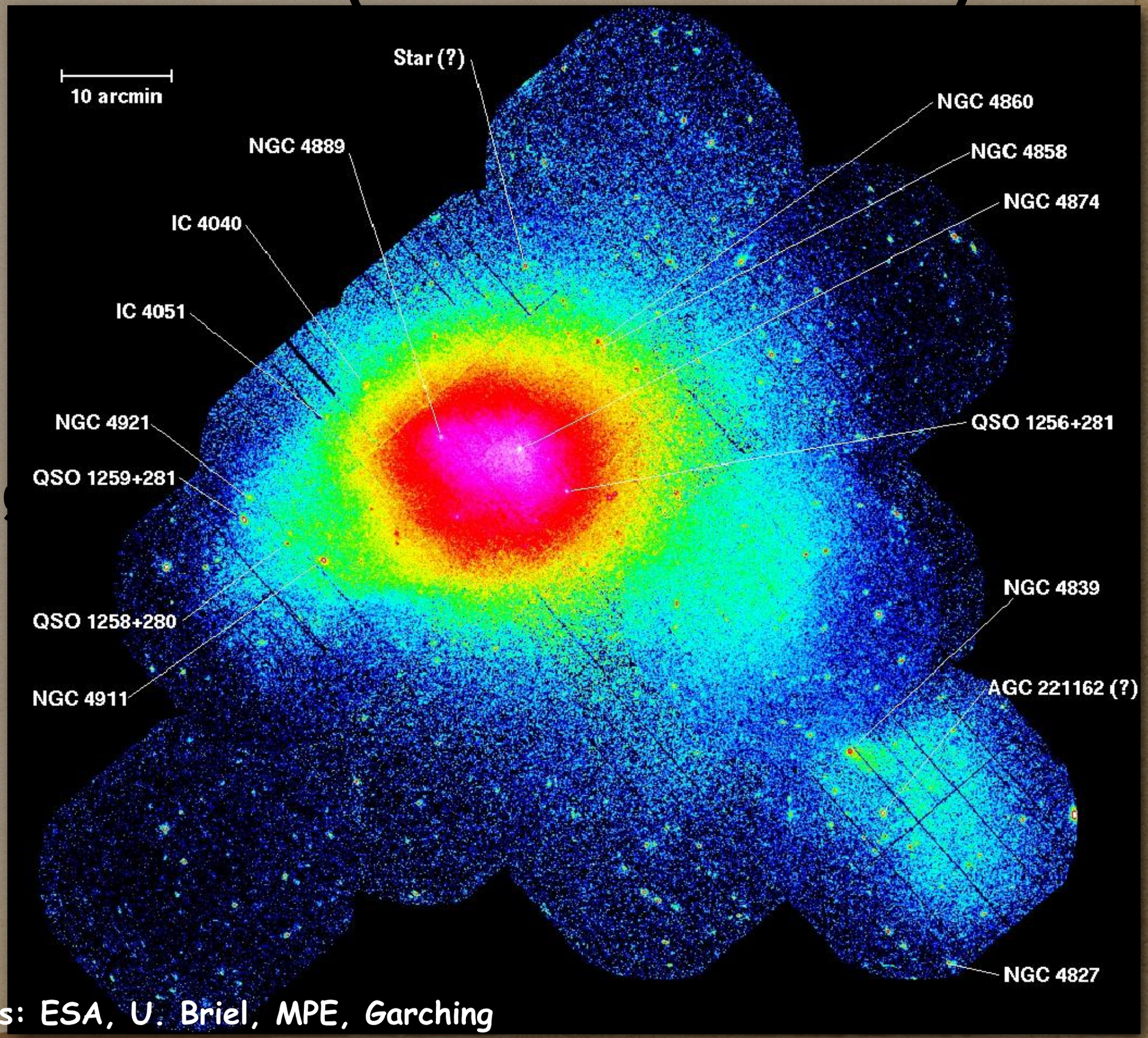
Lal & Rao (2005, 07)

THE COMA CLUSTER (A.K.A. ABELL 1656)

$z = 0.0235$

469 pc/arcsec

existence of low surface brightness emission envelopin the halo and relic (Kronberg+ 2007)



uGMRT: 250-500 MHz

300-500 MHz band synthesis

28 antennas

2048 channels

198.0 MHz bandwidth

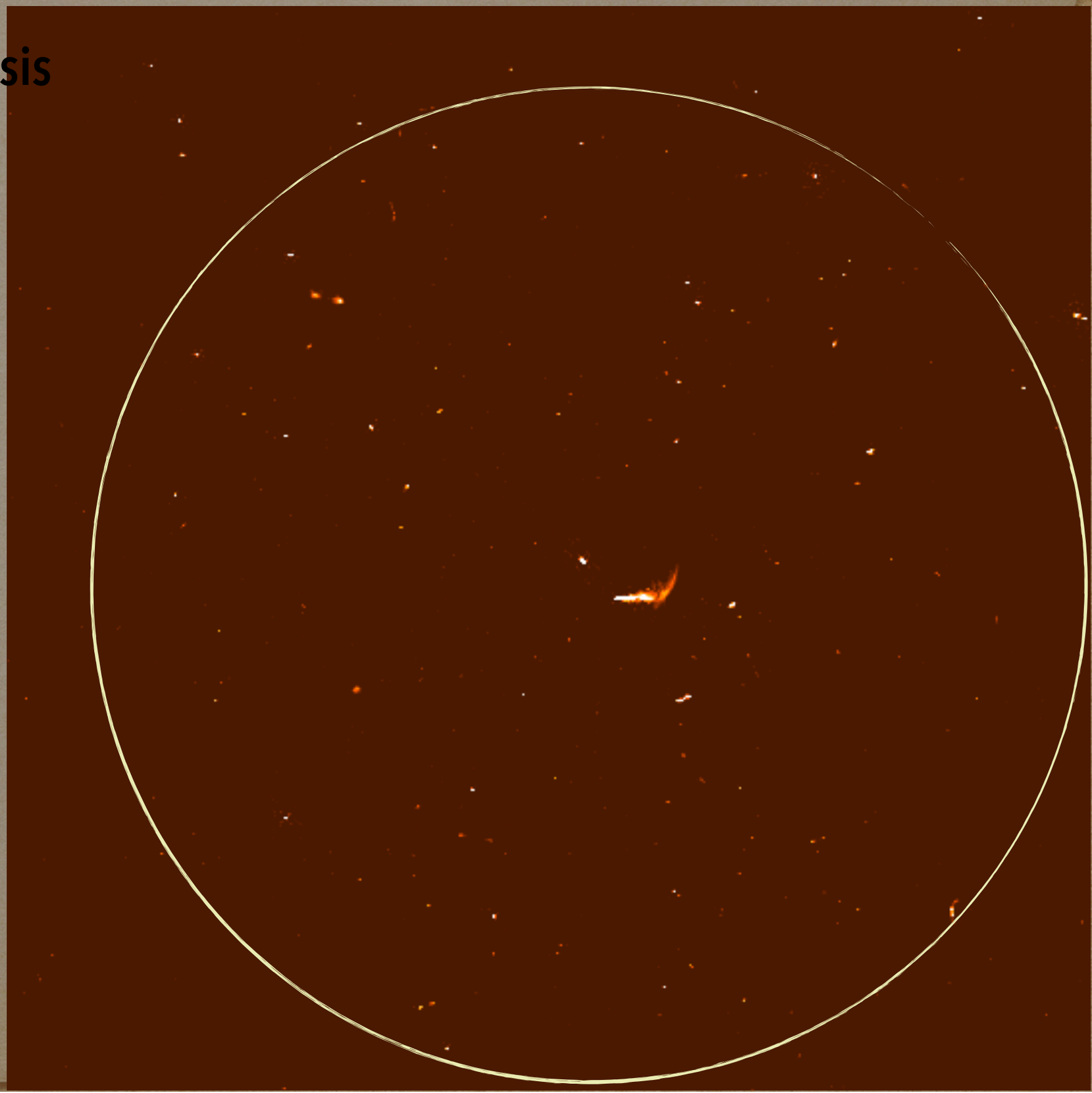
4 x 30 min

DR ~3460

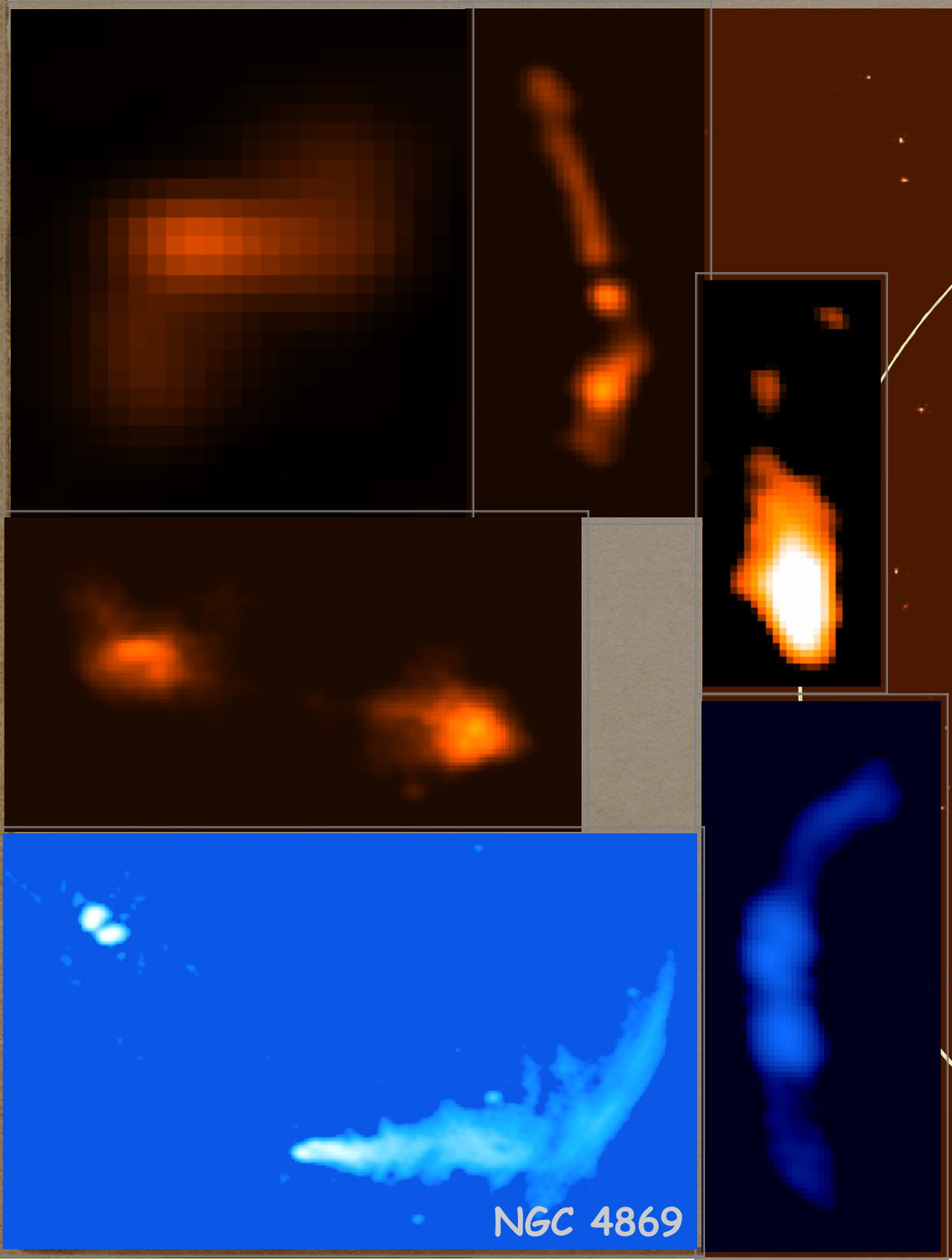
RMS noise

~0.03 mJy/beam

this is ~2.5 x thermal

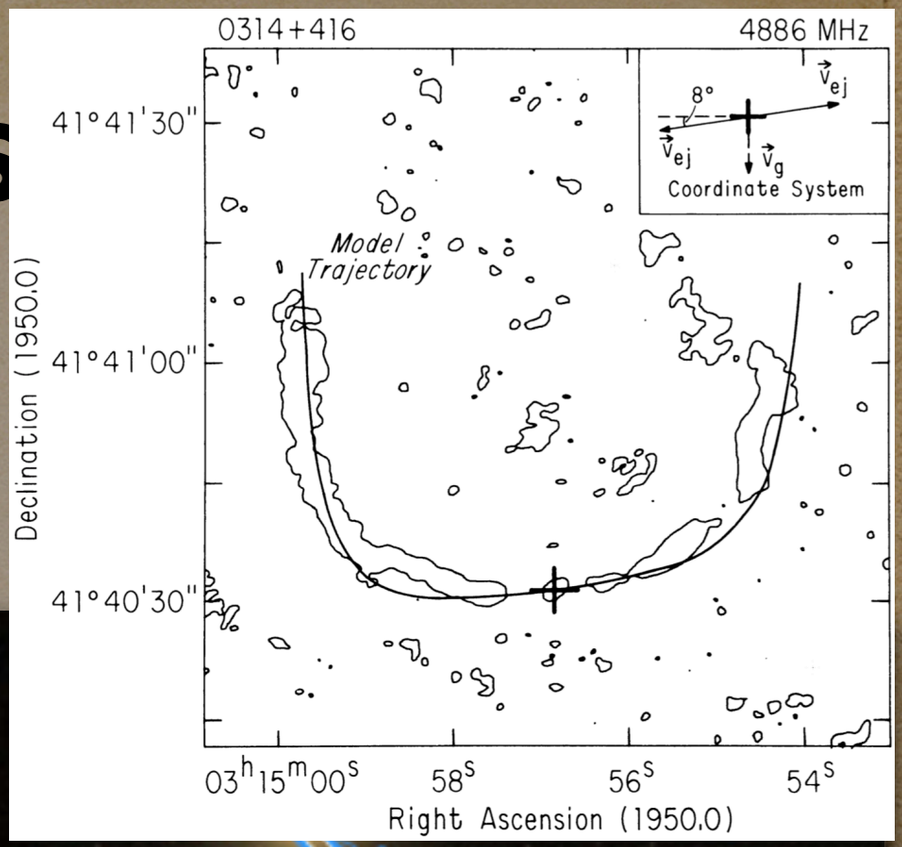


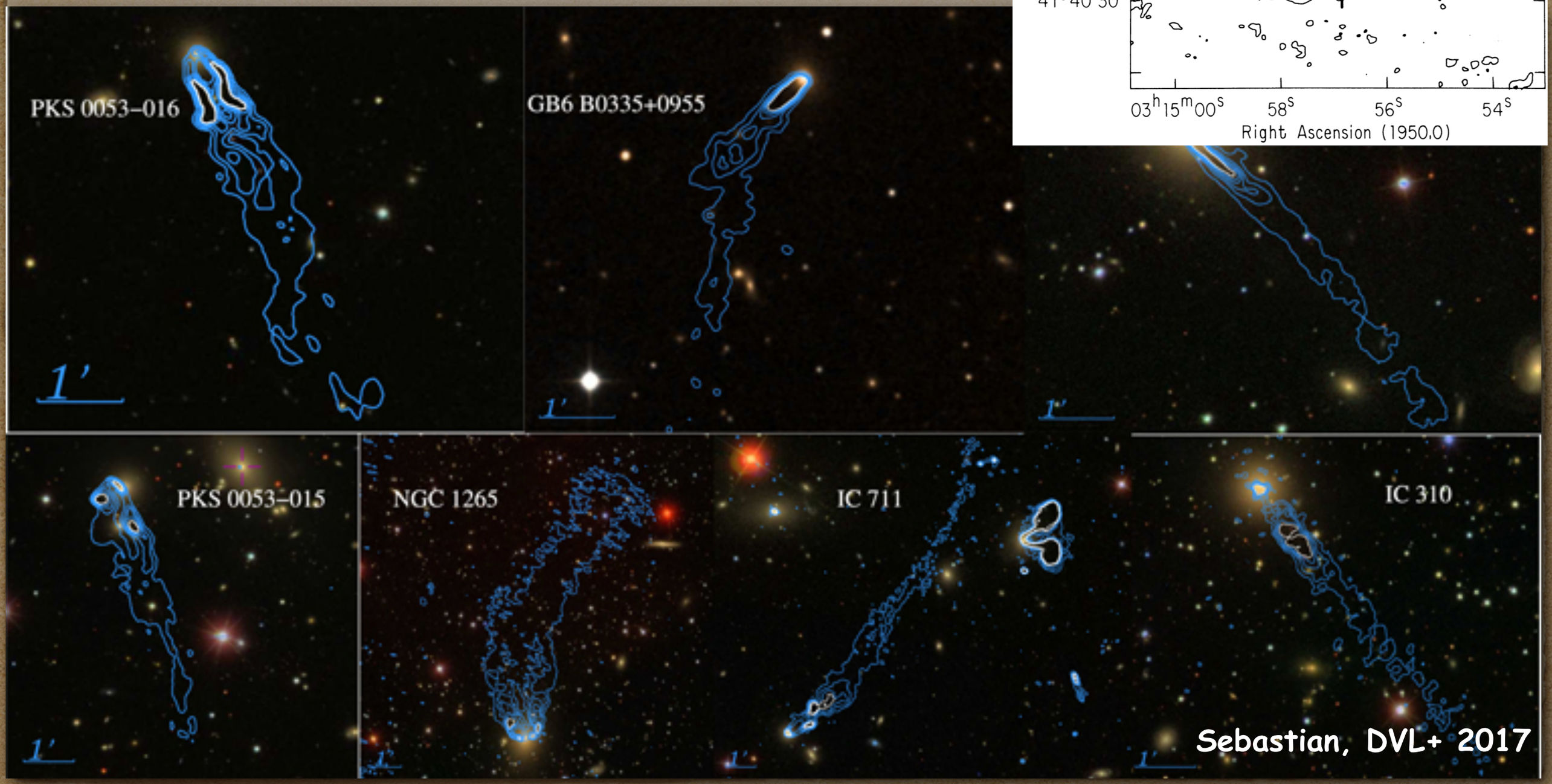
COMA CLUSTER (RADIO SOURCES)



HEAD-TAIL RADIO GALAXIES

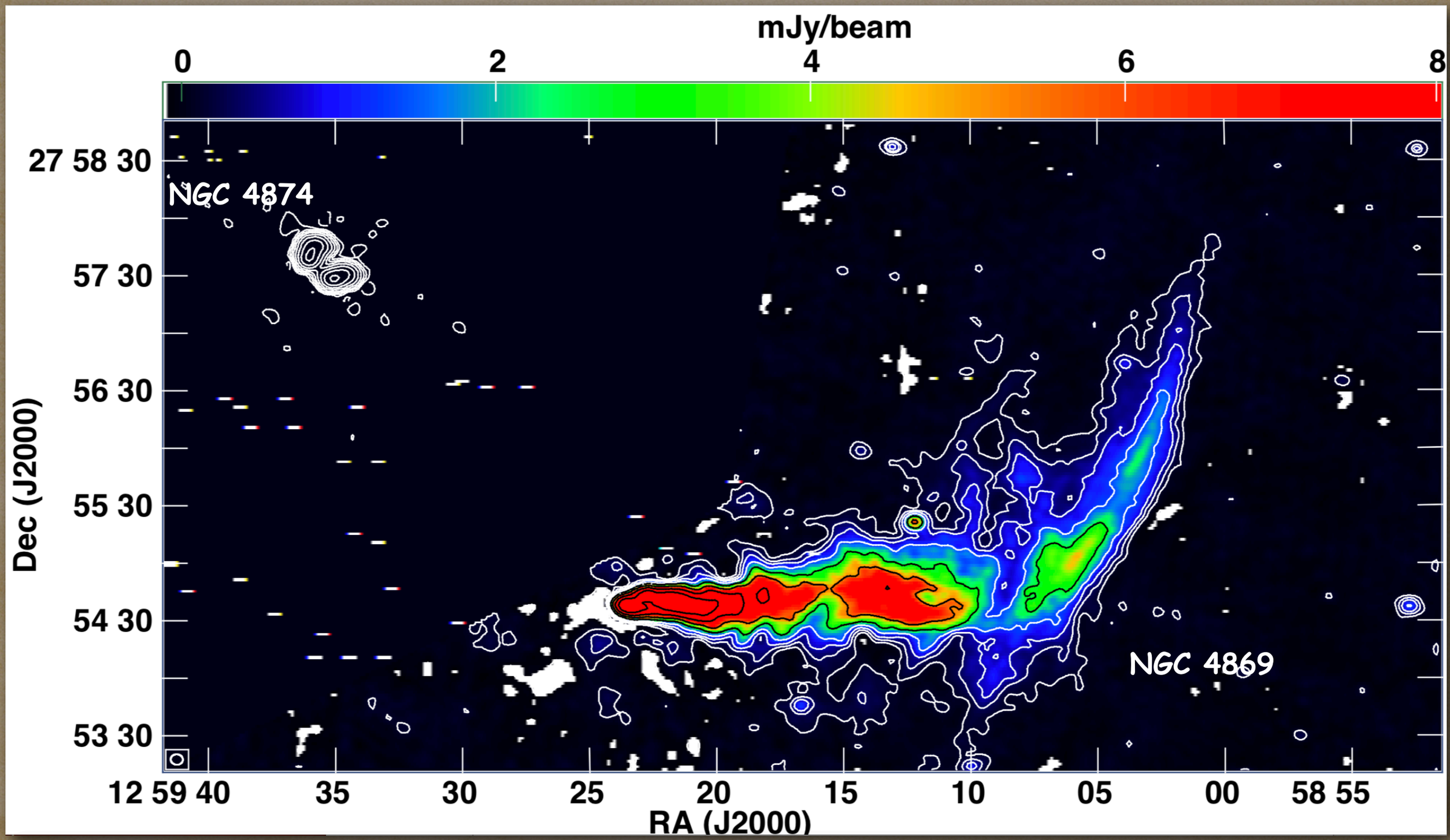
- NAT / WAT (Jaffe & Perola 1973)
- cluster potential & environment





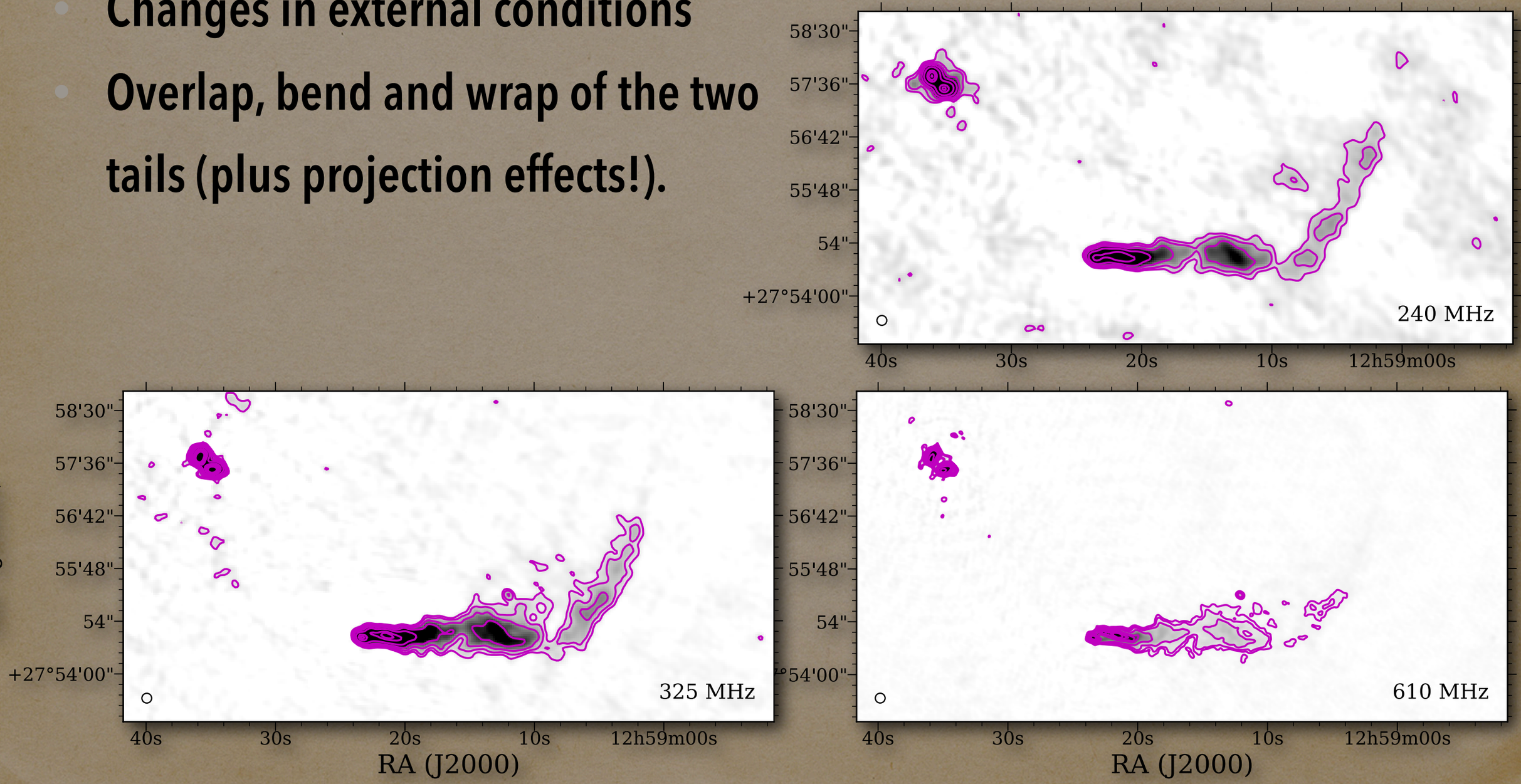
Sebastian, DVL+ 2017

NGC 4869 USING UPGRADED GMRT



NGC 4869 using legacy GMRT

- A core and prominent four distinct regions
- Pinch
  - Changes in external conditions
  - Overlap, bend and wrap of the two tails (plus projection effects!).

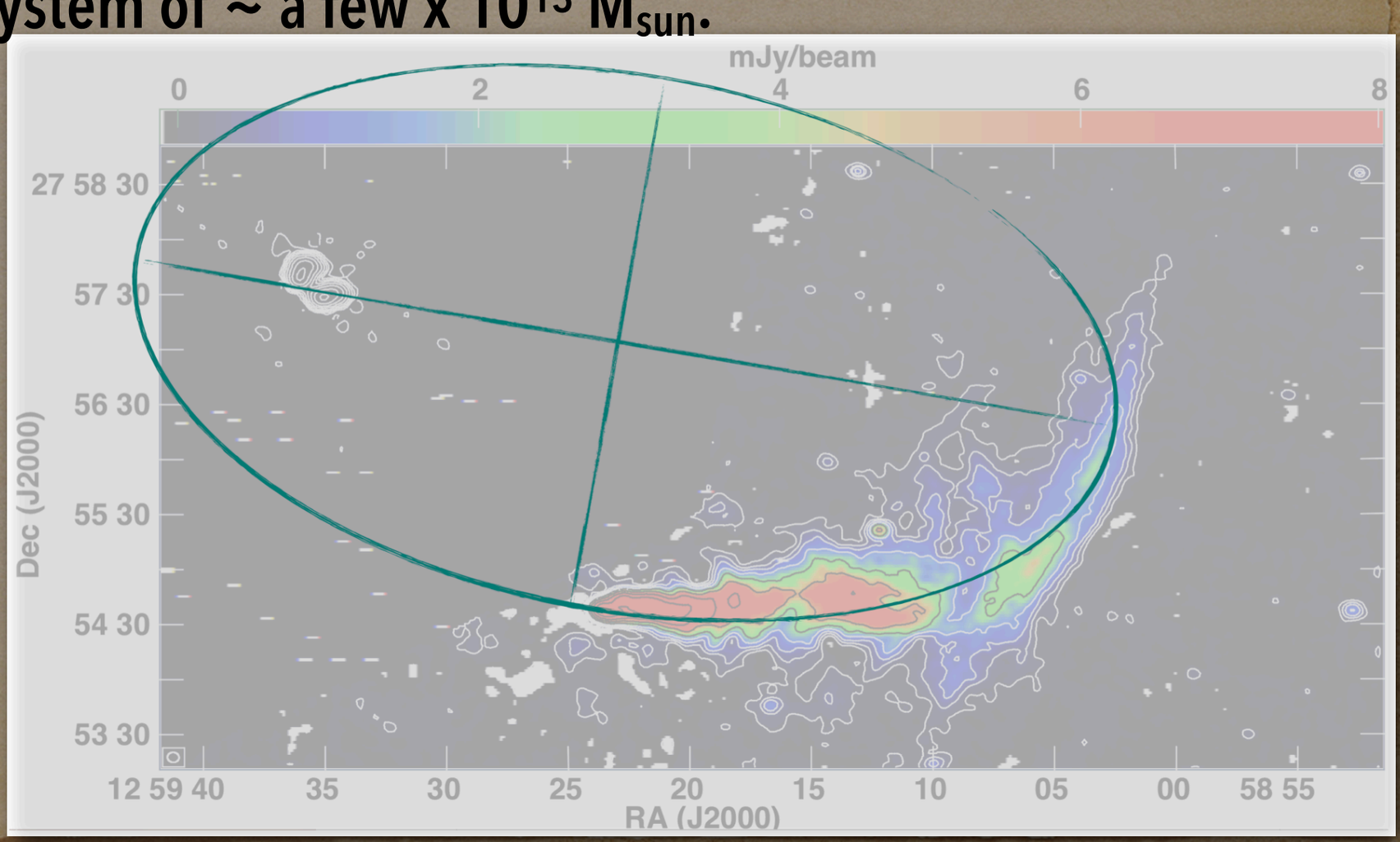


MOTION OF NGC 4869 AROUND NGC 4874

Mass-to-light ratio and the curvature of the tail of NGC4869

inclination angle of 59 deg, moving at a speed of ~1000 km/s

- eccentricity of 0.85, semi-major axis of ~4.5 arcmin (=130 kpc),
- an orbital period of ~a few x 10^8 yr, and
- total mass for the system of ~ a few x 10^{13} M_{sun}.



RADIO SPECTRA

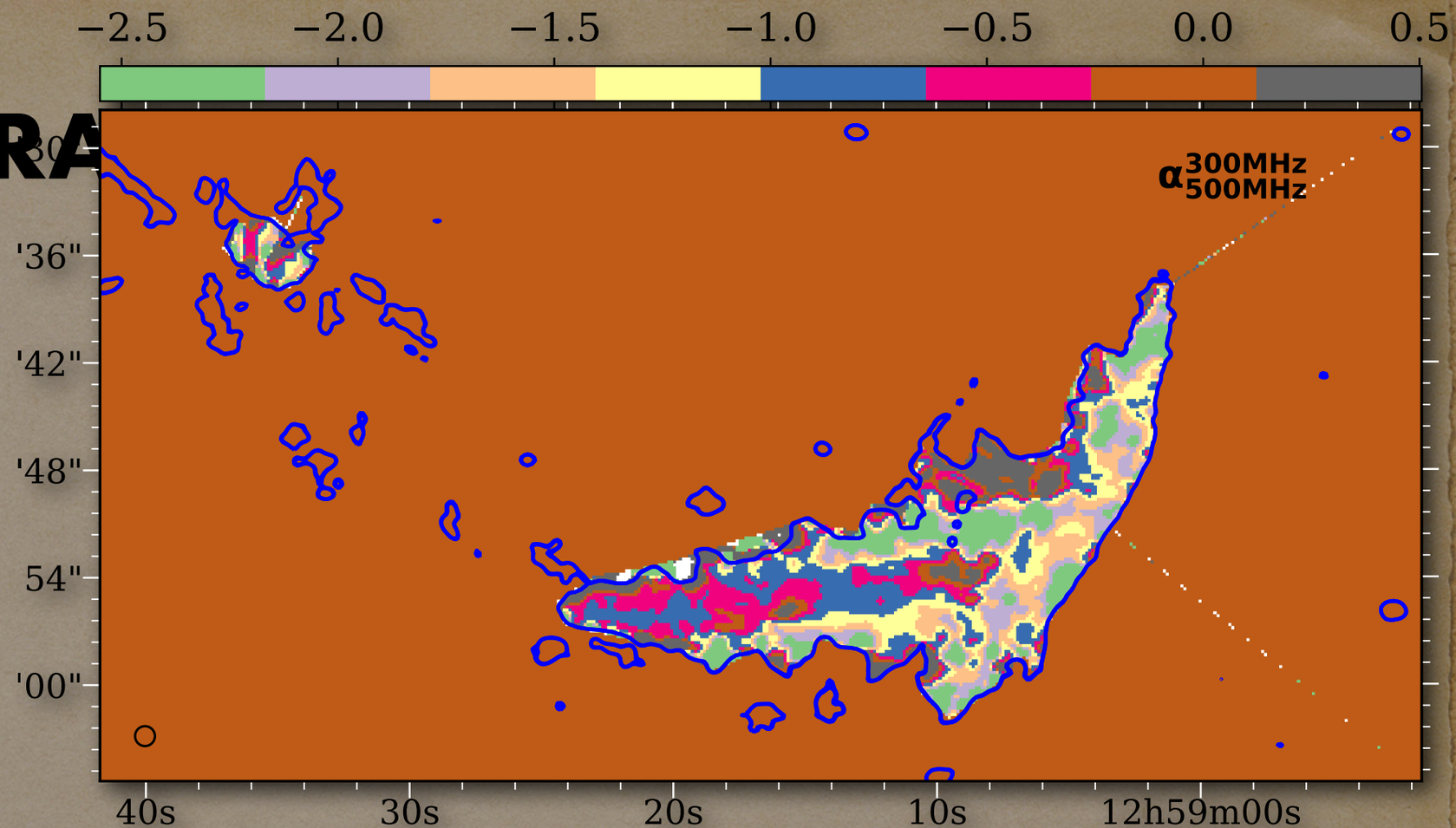
Jet:

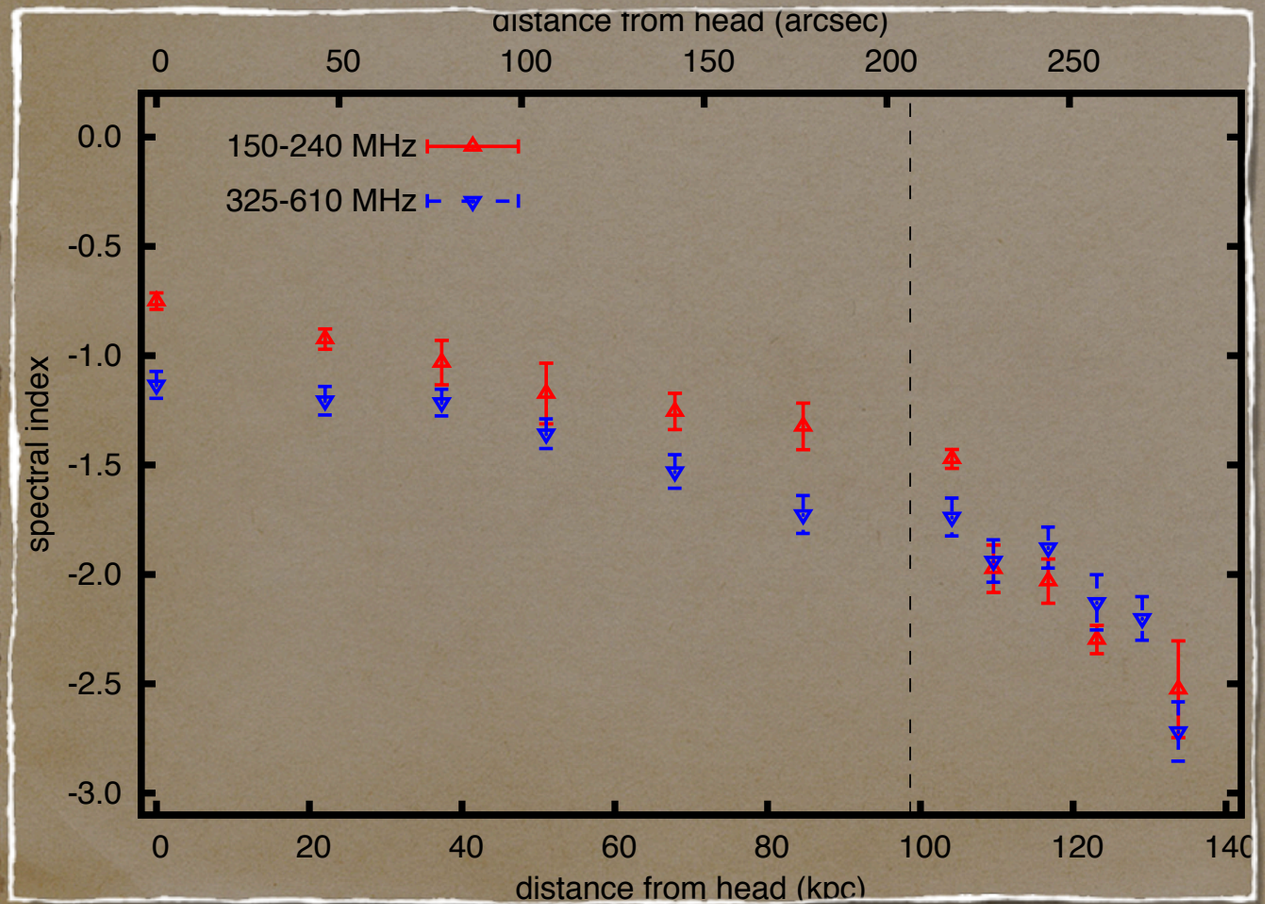
Content -

electron+positron

plus "heavy particles"

from thermal matter?





Jet:

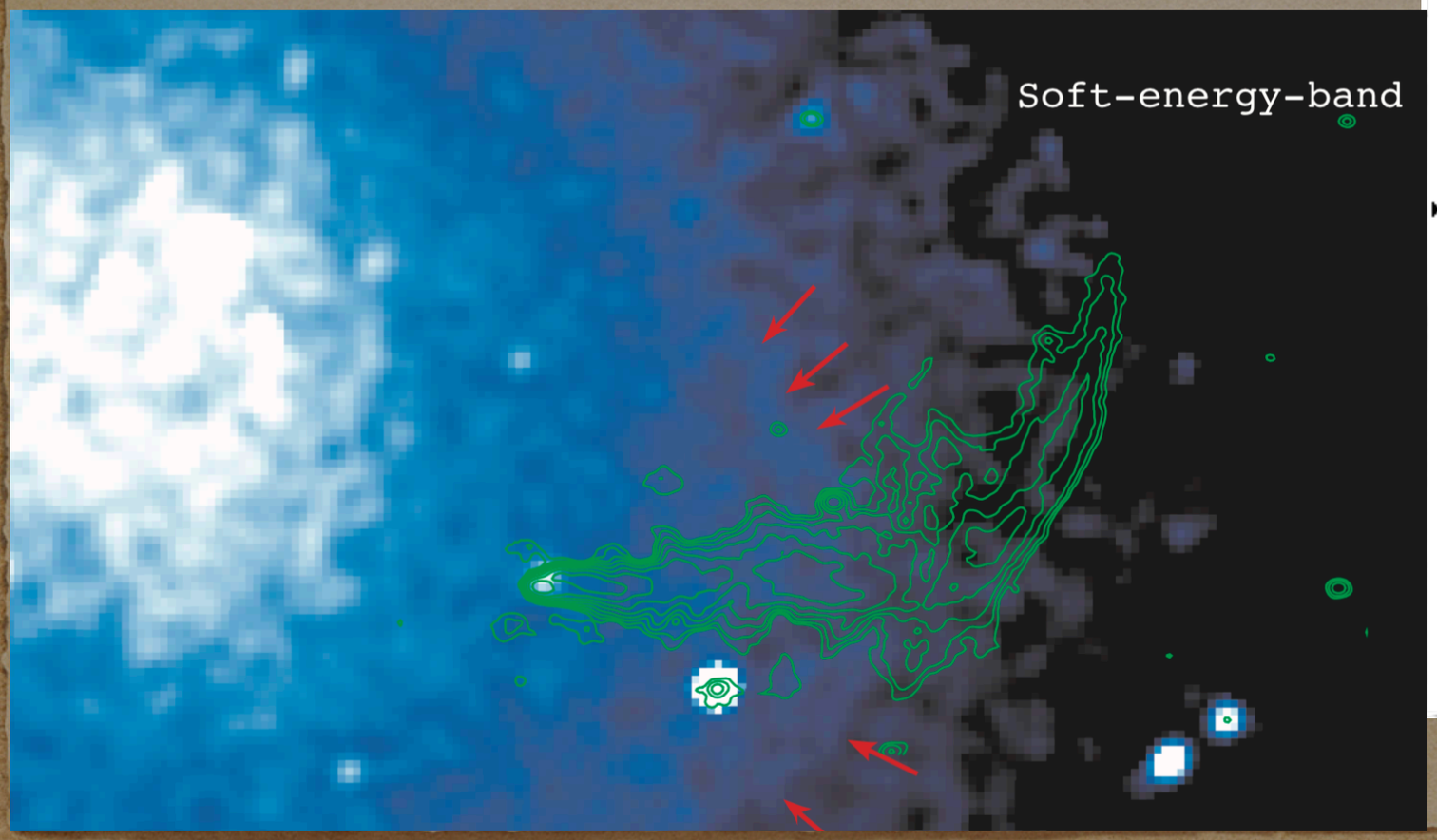
Velocity - sheath travels 30% slower than spine (Bicknell 1994).

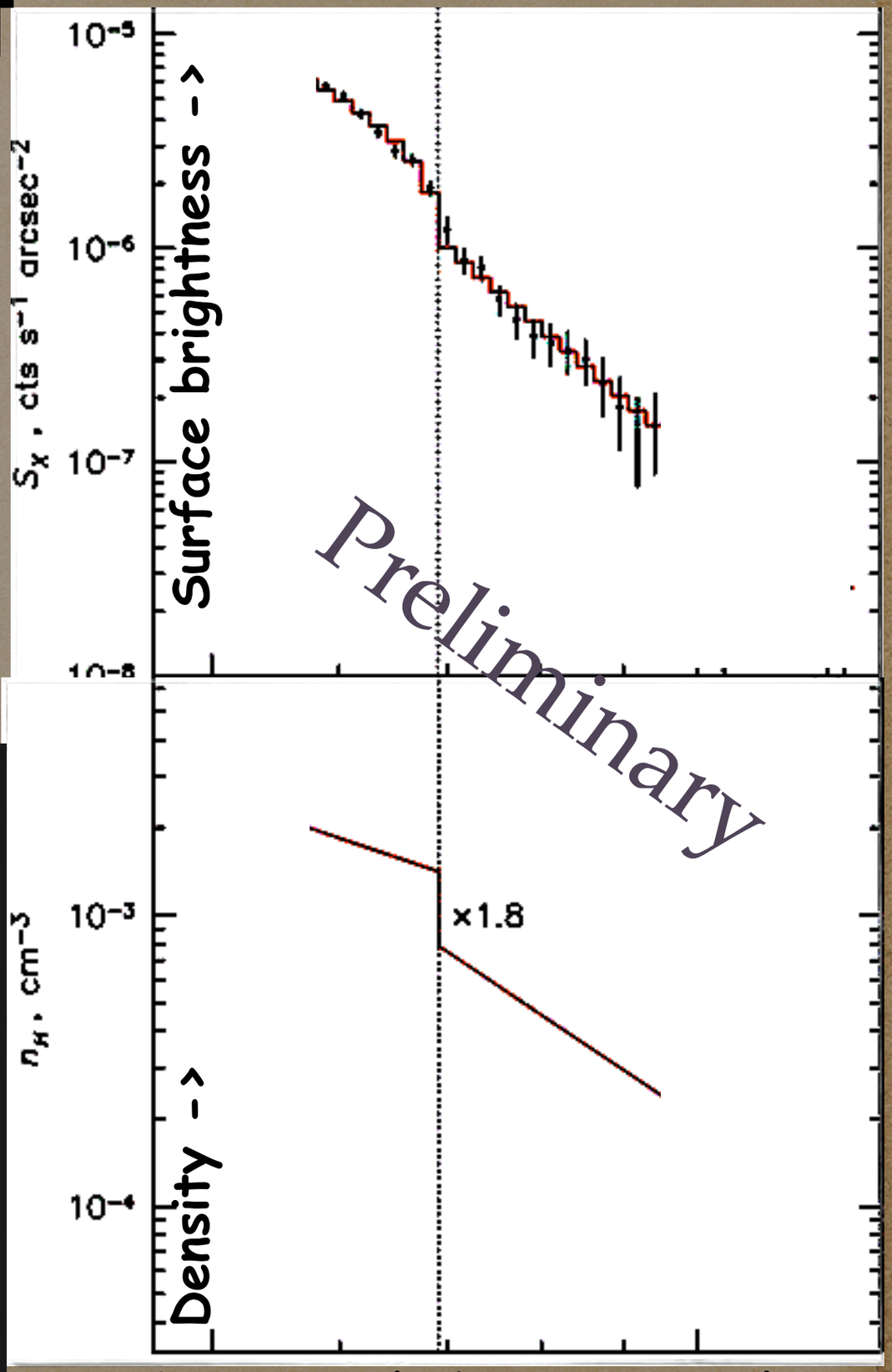
Amount of entrainment - gas in line emitting regions ~10^7 M_{sun} in 10^7 yr.

HOT GAS ENVIRONMENT

Chandra + uGMRT:

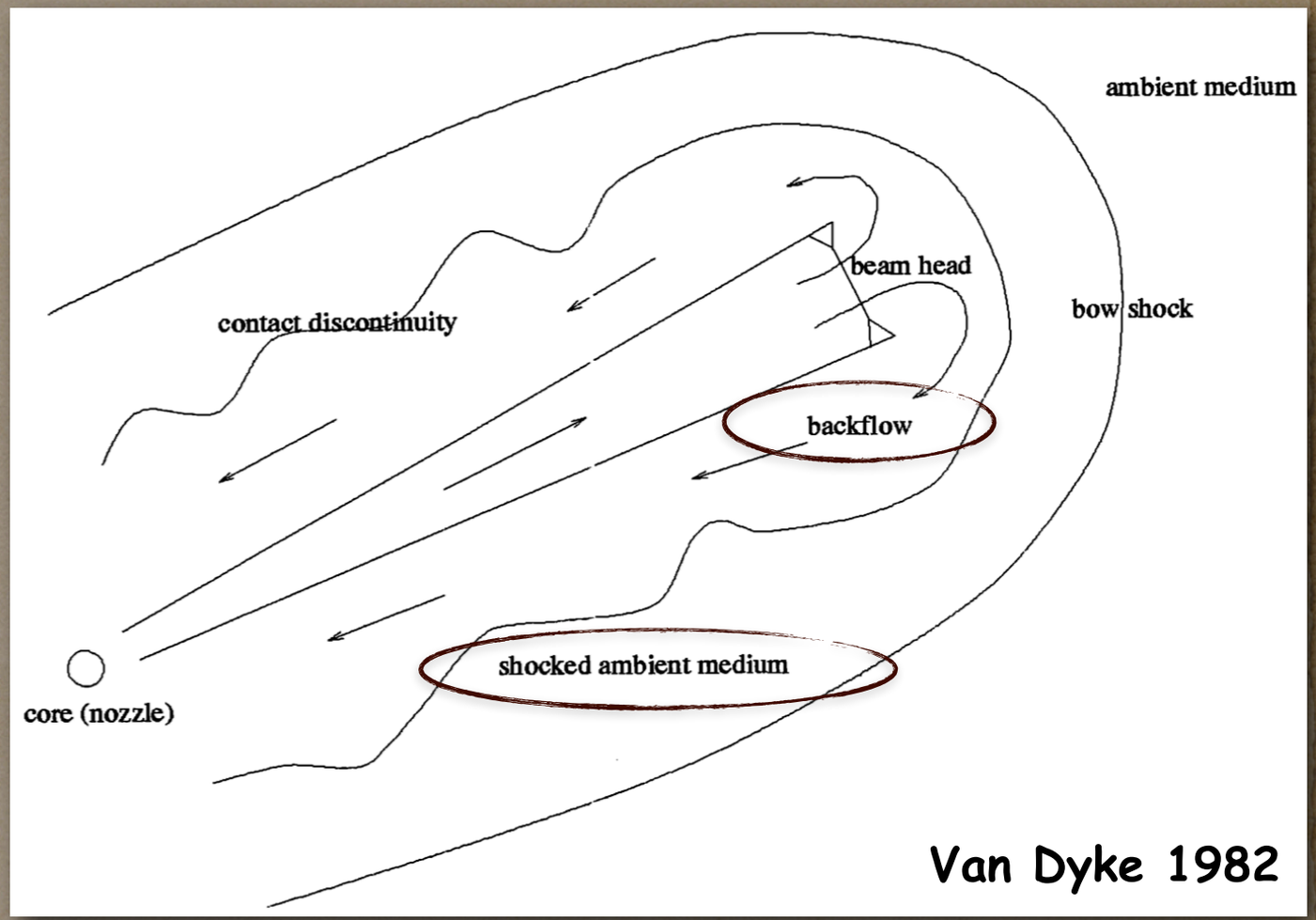
- flaring of a straight, collimated jet at approximately the position where it crosses the surface brightness edge seen in the hot gas.





K-H vs. MAGNETIC KINK INSTABILITY

- Velocities of the shocked ambient gas and the back flow plasma material are very different, there is the potential for creating strong K-H instabilities at the contact discontinuity (Loken+ 2002).



- The propagating radio jet when moves to a shallower density region, causes the jets to re-collimate and the toroidal magnetic field to build-up and become unstable to the 3D magnetic kink instability => flaring of jet! (Tchekhovskoy 2015).

SUMMARY

THANK YOU ALL FOR ATTENTION!

Faint synchrotron radiation in "Coma"!

- NGC 4869 one of the most interesting radio source in the Coma cluster.
  - The elliptical host galaxy shows weak radio core, two oppositely directed radio jets and a long low-surface brightness tail, which begins after sharp bends in the jets.
  - Motion of NGC 4869 around NGC 4874.
  - The spectral structure shows presence of a clear steep-spectrum sheath on to a flat-spectrum radio spine.
    - Jet content: e^{-1}–positron plasma + "heavy particles" (admixture of thermal matter?)
  - presence of a surface brightness edge, exactly at the location where the collimated radio jet has bent.

Source morphology is a combination of KH-/kink-instabilities and its motion around the cluster potential.