A strong recollimation shock far from the core of the radiogalaxy 3C120.

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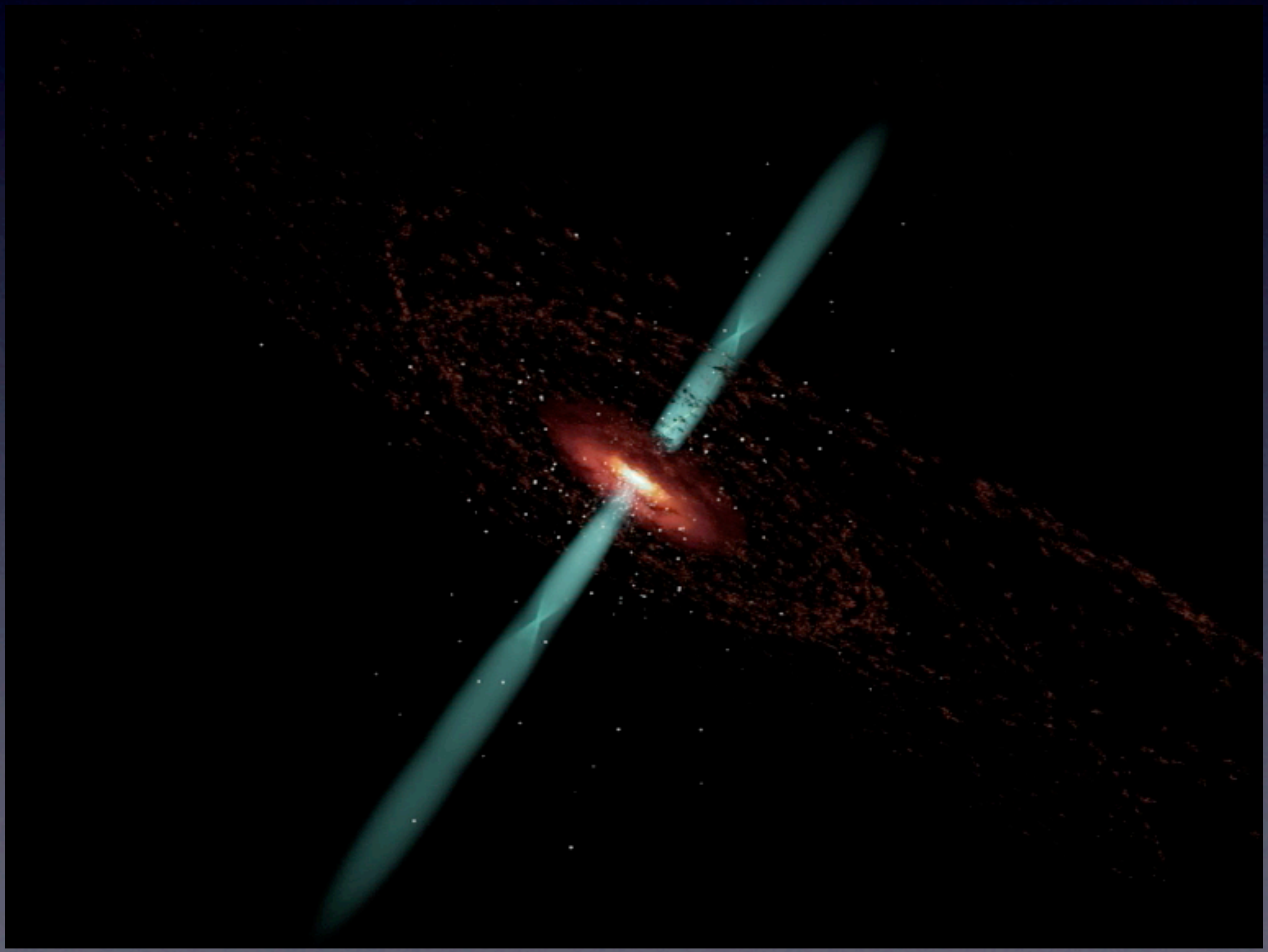
AGN (Active Galactic Nuclei)

A special class of galaxies that show un unusual amount of emission.

supermassive black holes (with masses ~ $10^6 - 10^9$ M⊙), located at the center of these galaxies



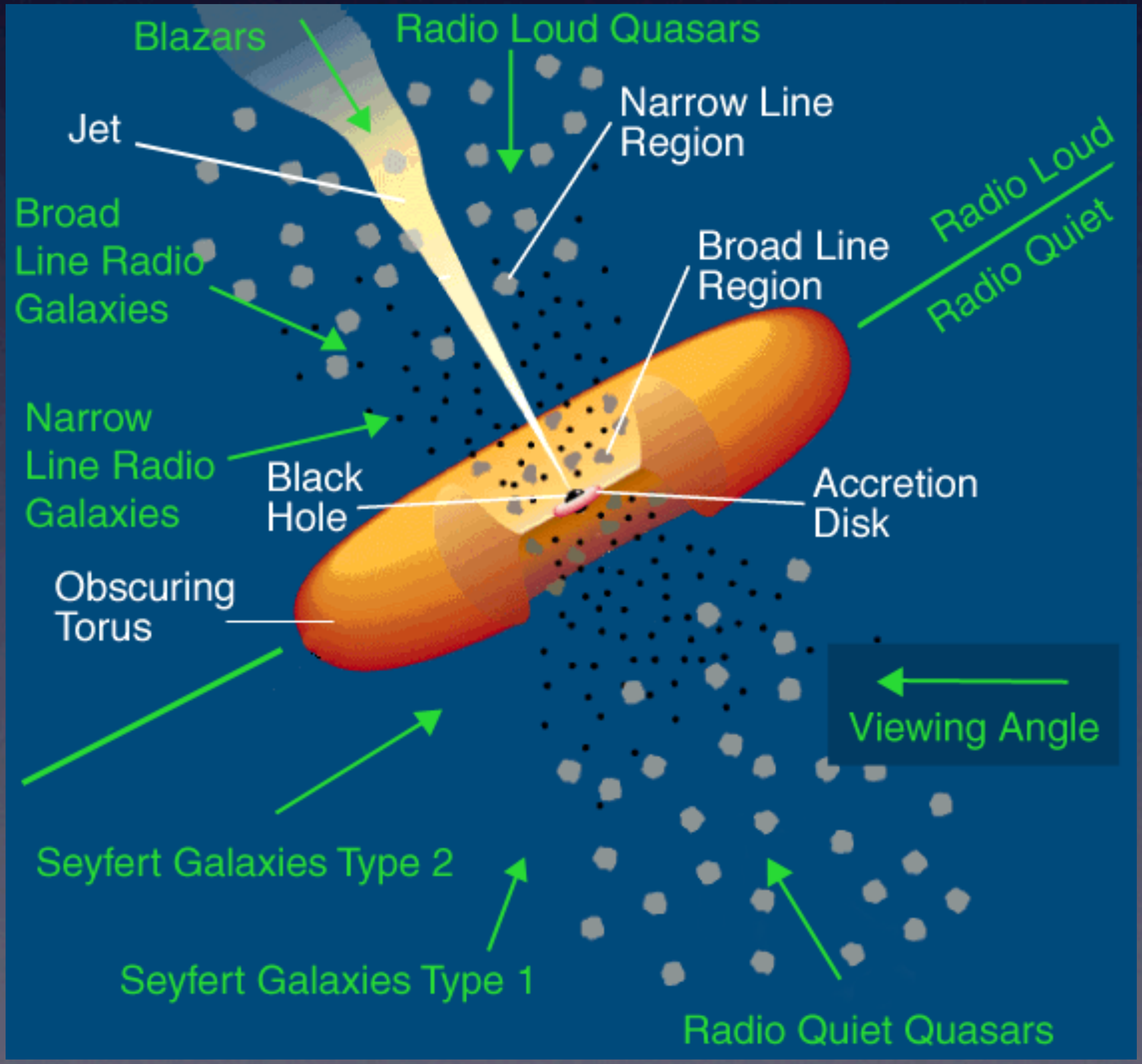
Radio quiet / Radio loud AGNs

$$R = \frac{Lradio(5GHz)}{Loptical(440nm)}$$

[10-100] - RADIO LOUD: eliptical galaxies, extended jets
(Radiogalaxies, Steep Spectrum Radio Quasars, Blazars)

[0.1-1] - RADIO QUIET: spiral and eliptical, no large jets
(Radio Quiet Quasars, Seyferts)

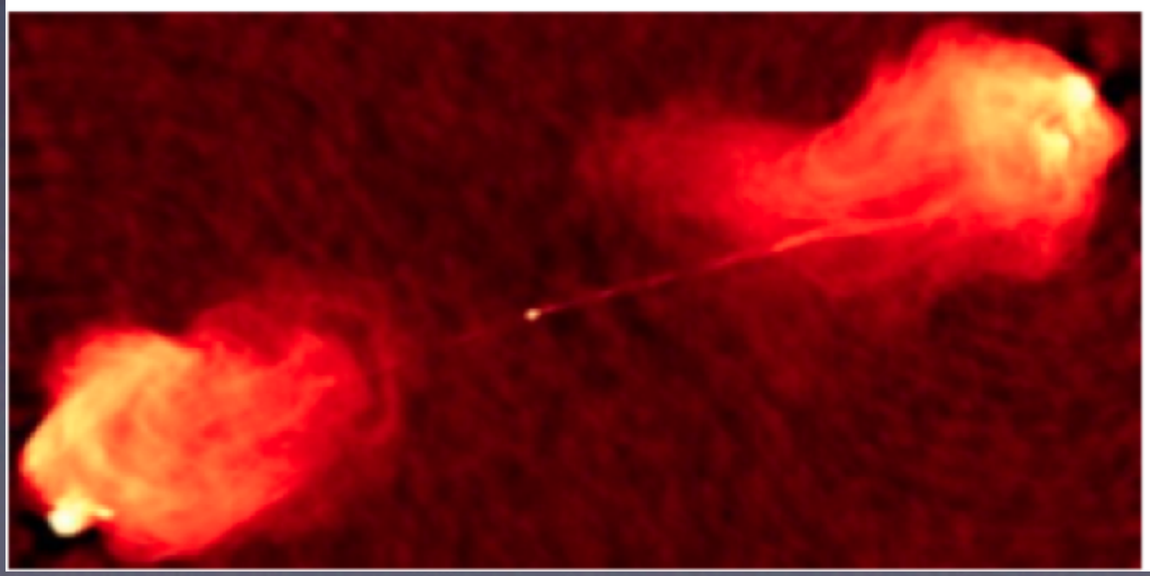
The Unified Model (Urry&Padovani, 1995)

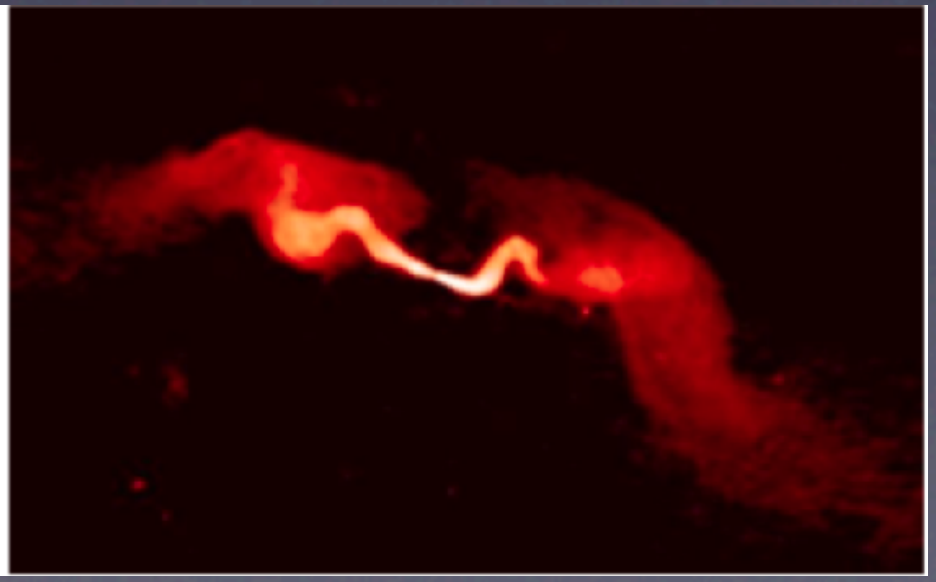


RADIOGALAXIES

Different Radio Power and different morphlogy (Fanaroff & Riley, 1974) :

FRII ($P_{1.4GHz} > 10^{24,5} Watt / Hz$) FRI ($P_{1.4GHz} < 10^{24,5} Watt / Hz$)





Relativistic jets in AGN

Open question:

- ✳ production mechanism of the jets
- ✳ particles that forms the plasma
- ✳ mechanism for the collimation of the jets
- ✳ role and morphology of the magnetic field →
- ✳ etc...

Synchrotron emission:
electrons that spiral around the magnetic field lines

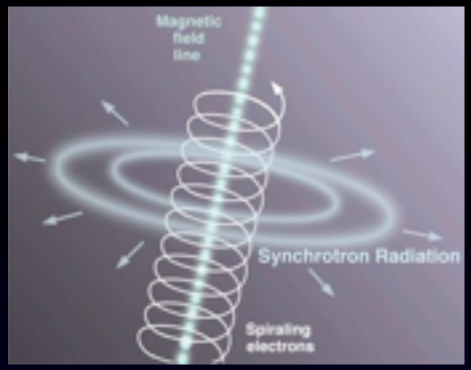
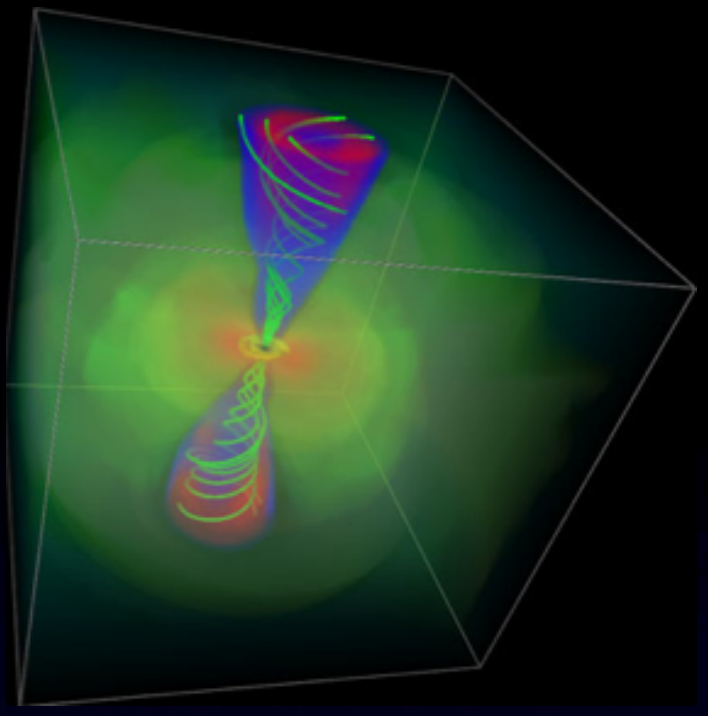


Image:Gemini Observatory

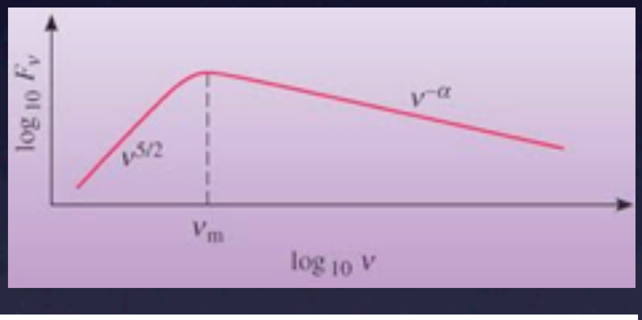


McKinney & Blandford (2009)

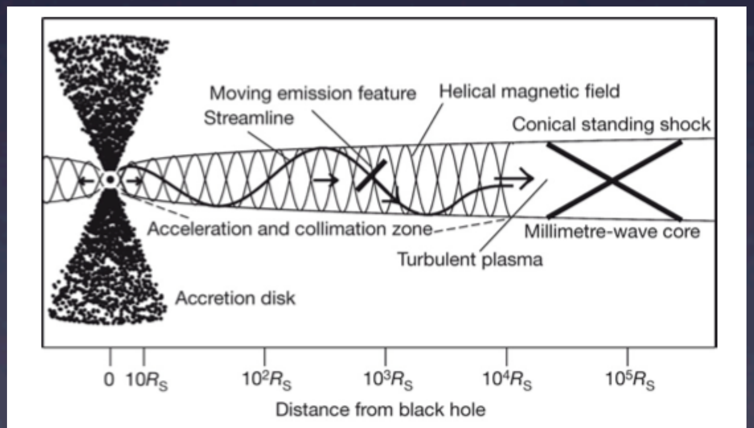
Common features: *Core + Stationary or sub/superluminal knots*

✳ the nature of the ***core*** is still unclear

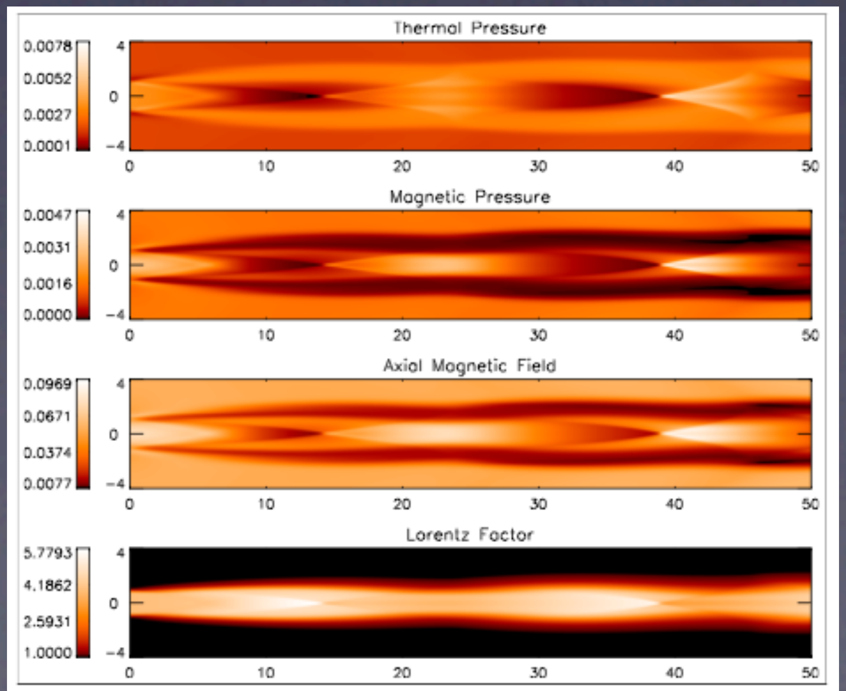
- transition region between optically thick and optically thin emission



- stationary recollimation shock caused by differences in pressure between the jet and the external medium

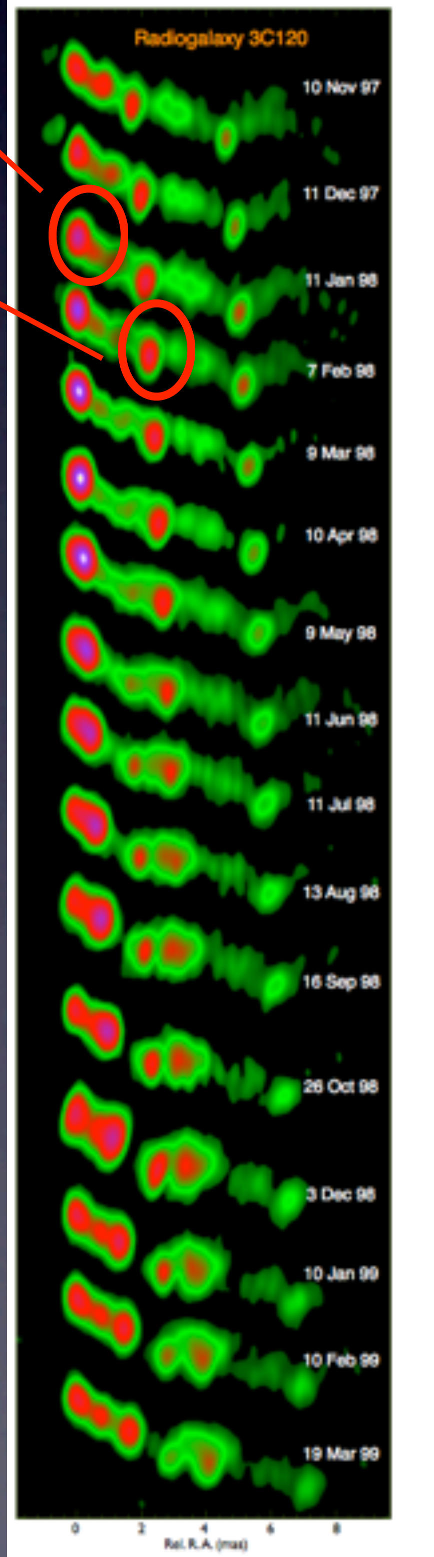


(M.Roca-Sogorb PhD thesis)



core

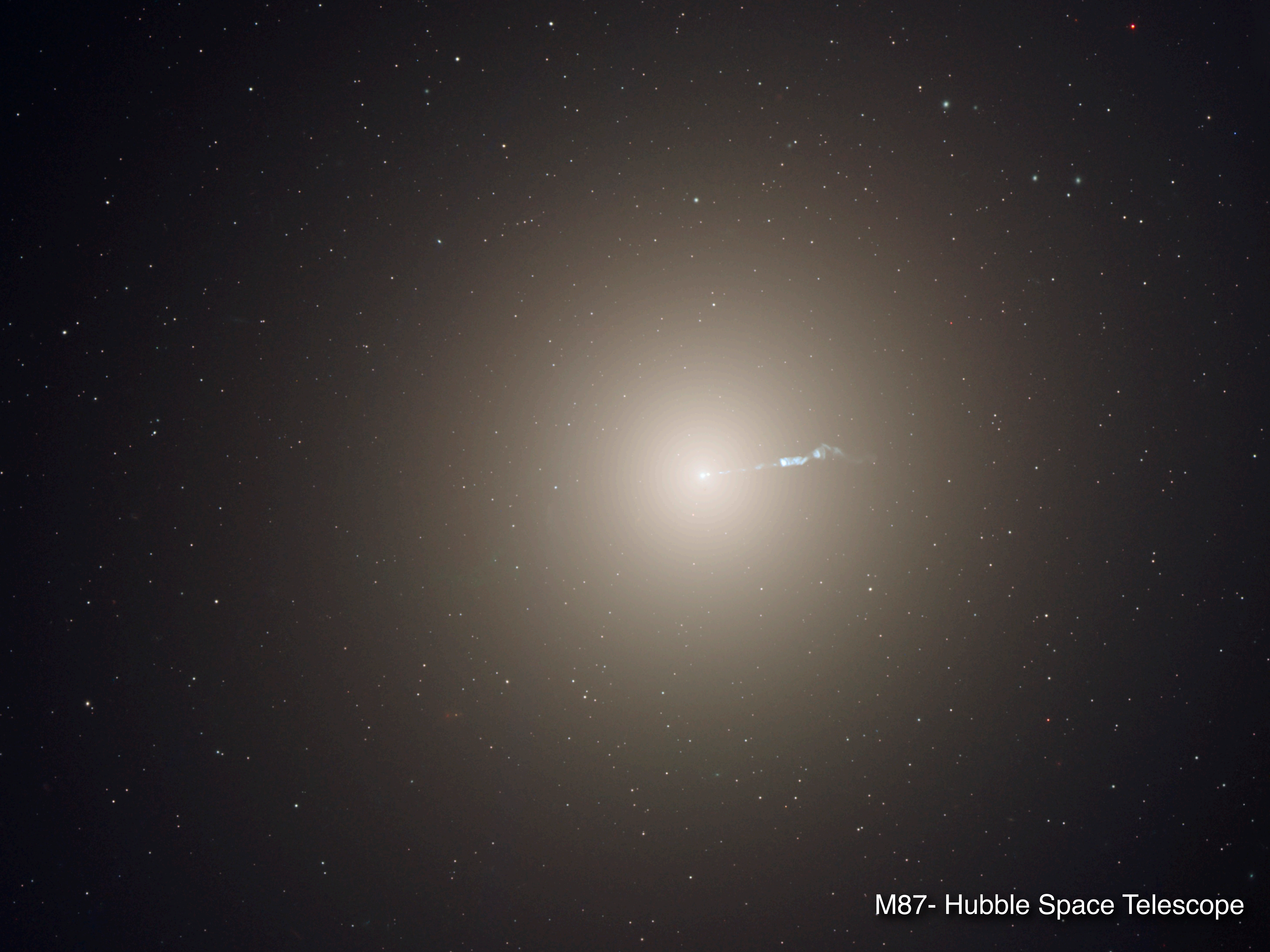
moving knot



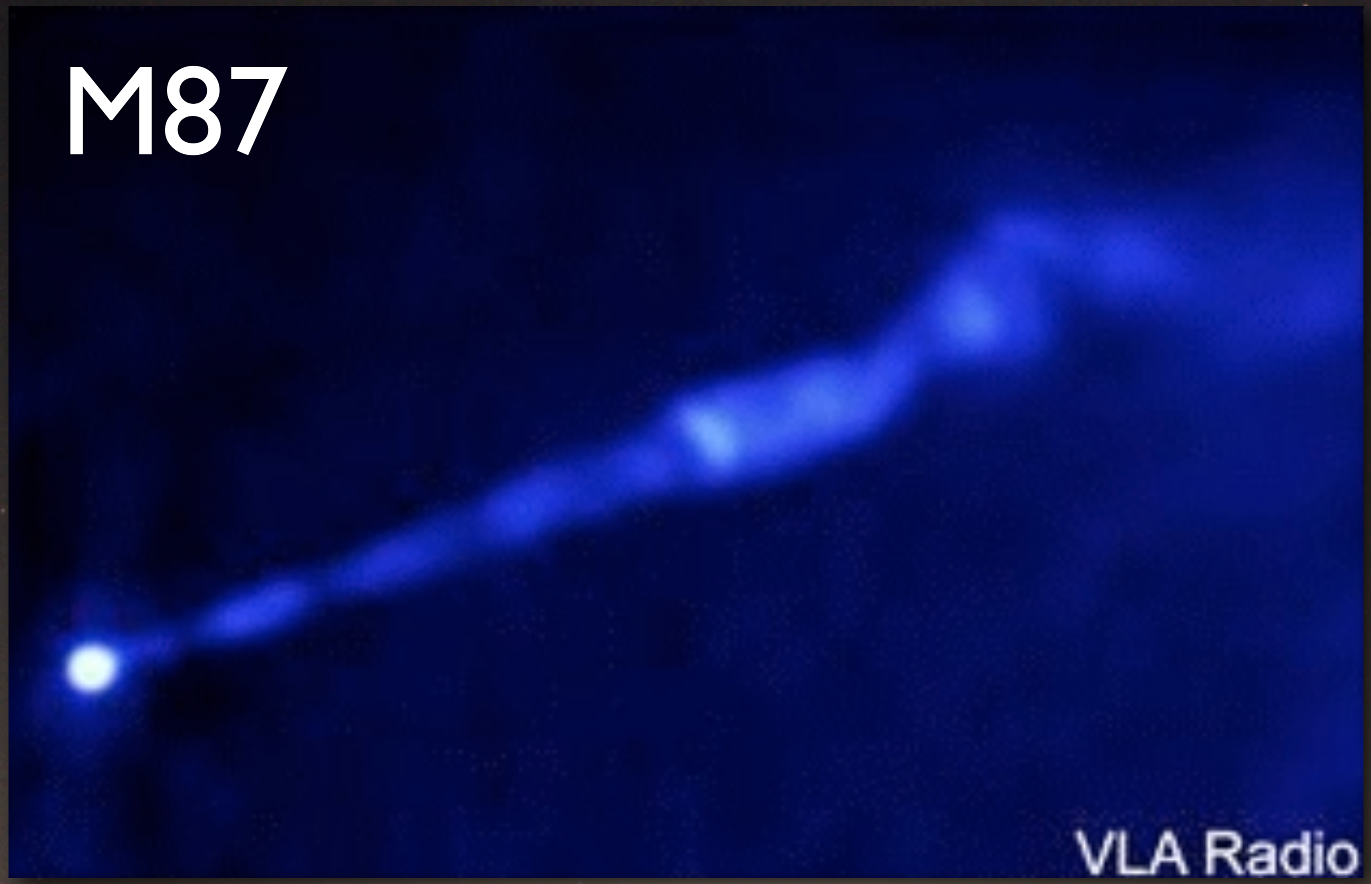
Gómez et al. (2011)

✳ production mechanism of the ***stationary knots***

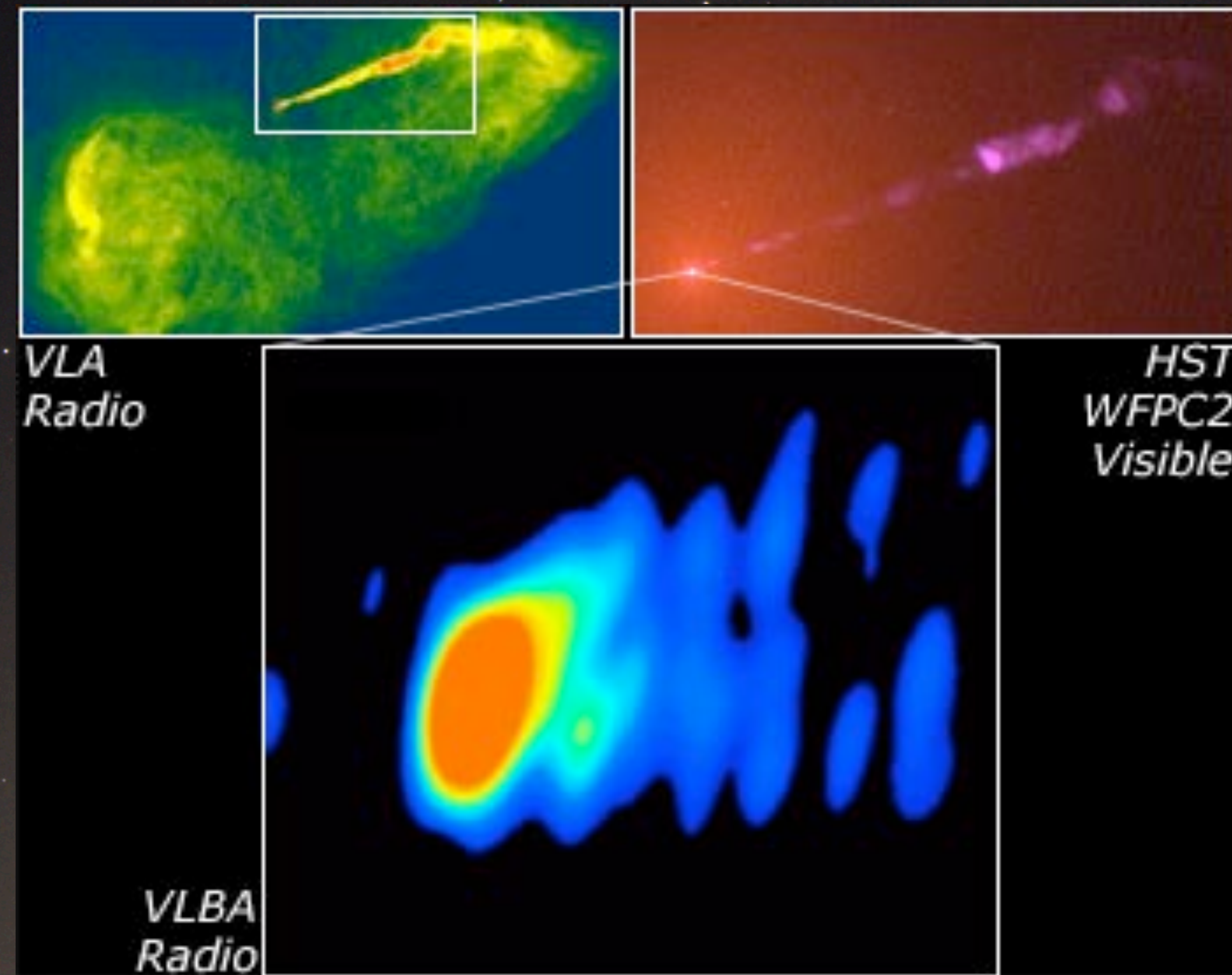
- jet bending that increases the doppler factor
- ***recollimation shock*** where the particles are accelerated and the magnetic field is compressed and amplified leading to enhanced emission.

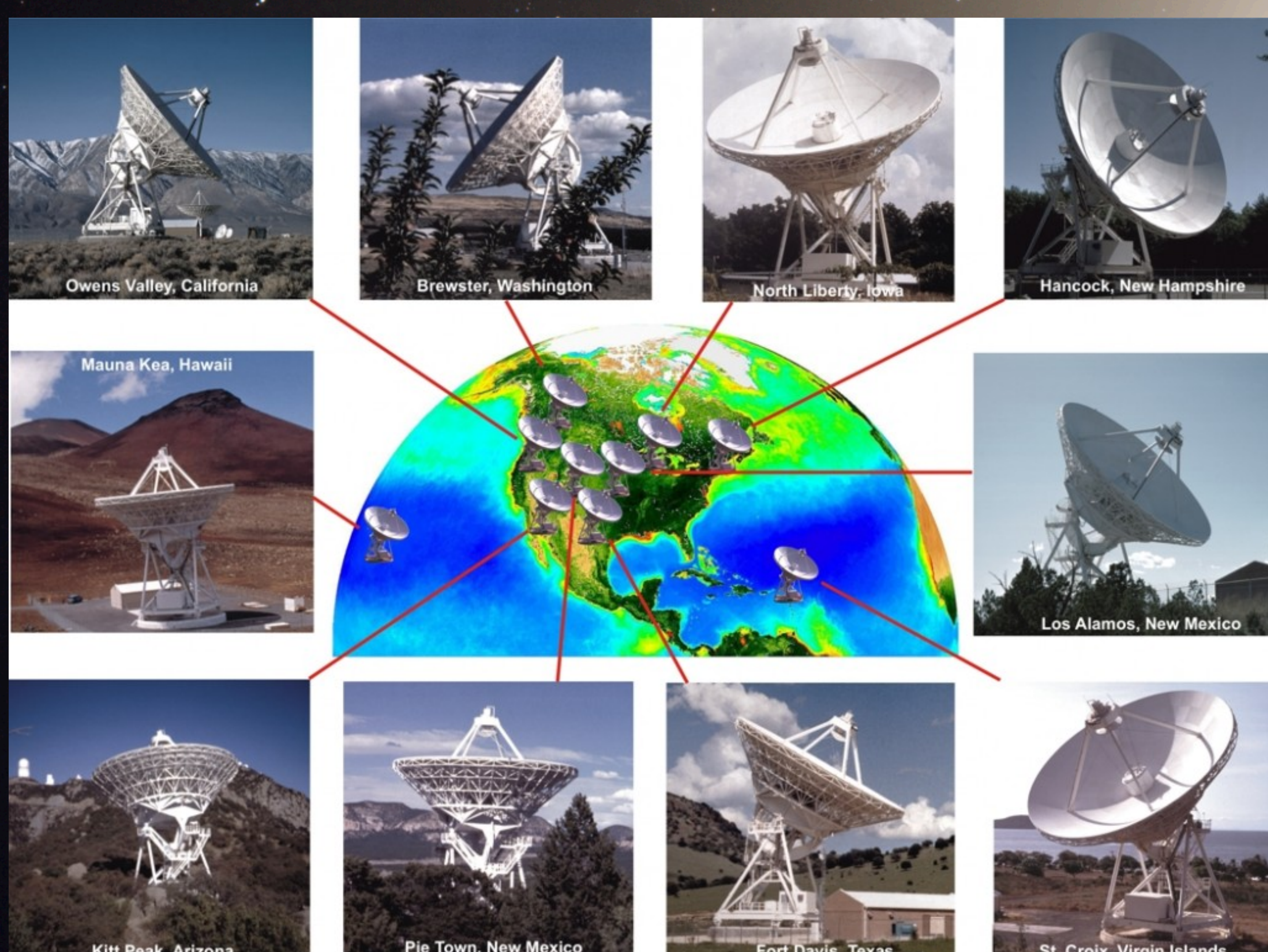


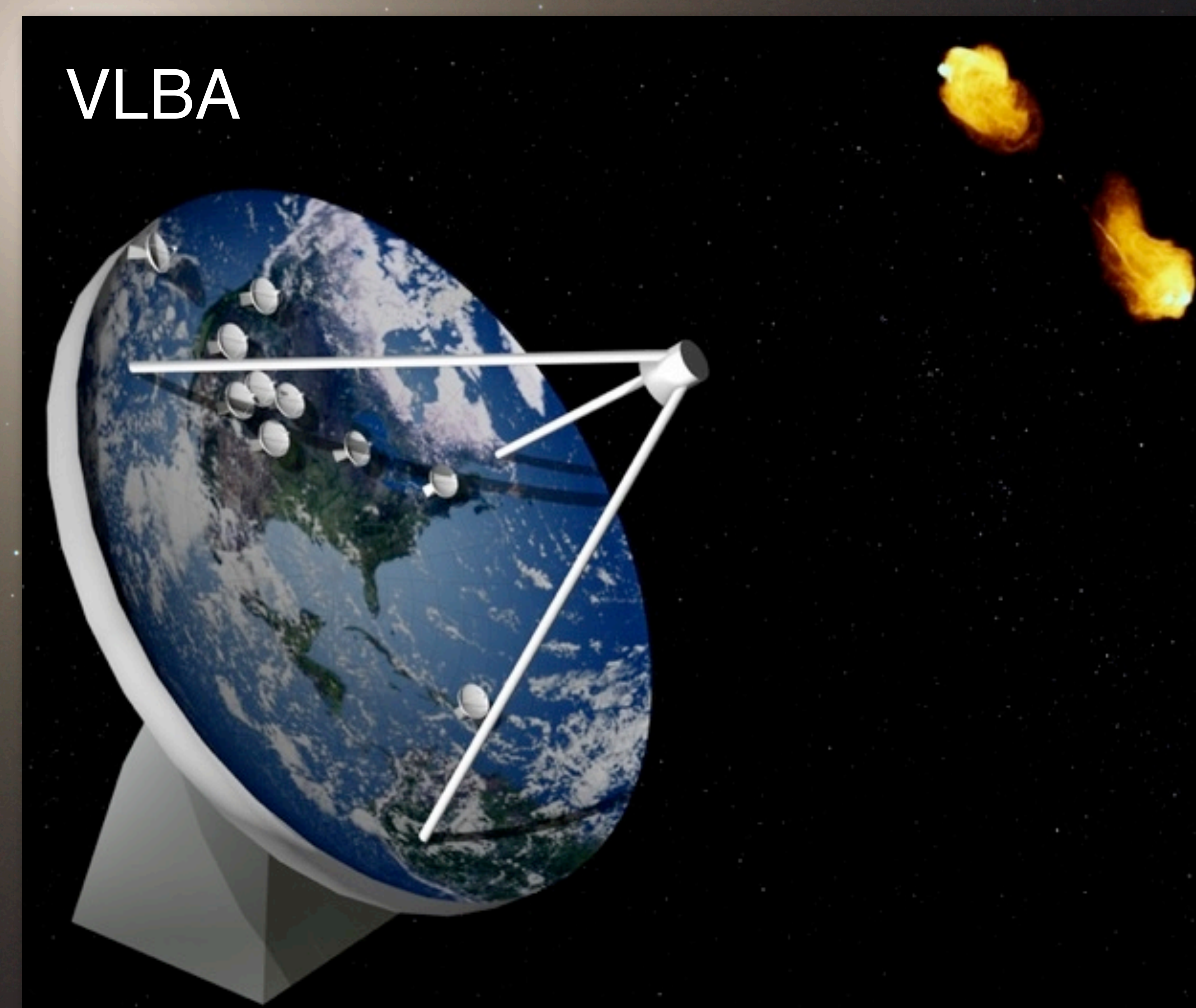
M87- Hubble Space Telescope


M87
VLA Radio


VLA


VLA
Radio
HST
WFPC2
Visible
VLBA
Radio


Owens Valley, California
Brewster, Washington
North Liberty, Iowa
Hancock, New Hampshire
Mauna Kea, Hawaii
Los Alamos, New Mexico
Kitt Peak, Arizona
Pie Town, New Mexico
Fort Davis, Texas
St. Croix, Virgin Islands

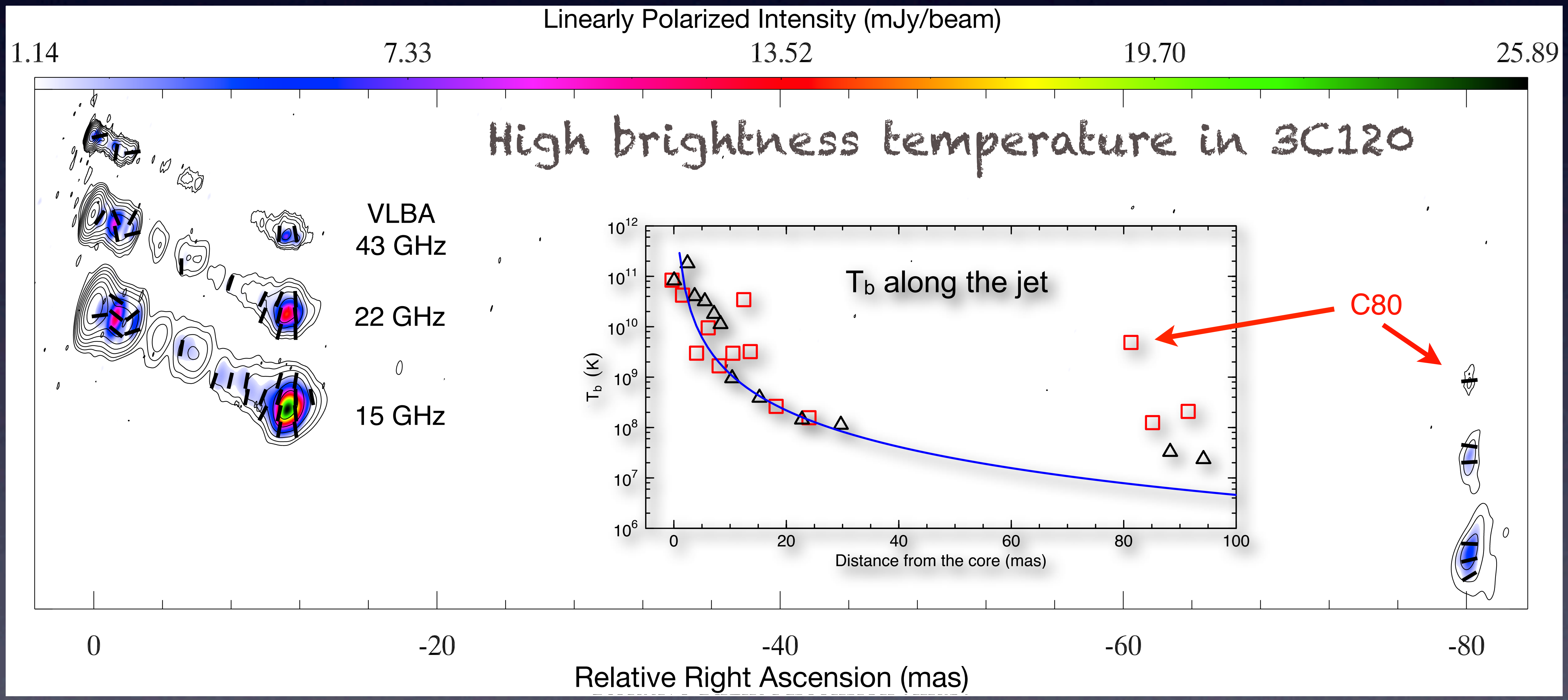

VLBA

The radiogalaxy 3C 120

- active and relatively nearby (z = 0.033) radio galaxy,
- blazarlike one-sided superluminal radio jet → ***Doppler Boosting*:** relativistic effect that increase the emission of the jet pointing toward us and a decrease in the emission of the counter jet.
- peculiar component located at 140 pc from the core (C80/A80)

(Roca-Sogorb et al., 2010; Gómez et al., 2011)

- hight brightness temperature (~ 600 larger than expected at such distance)



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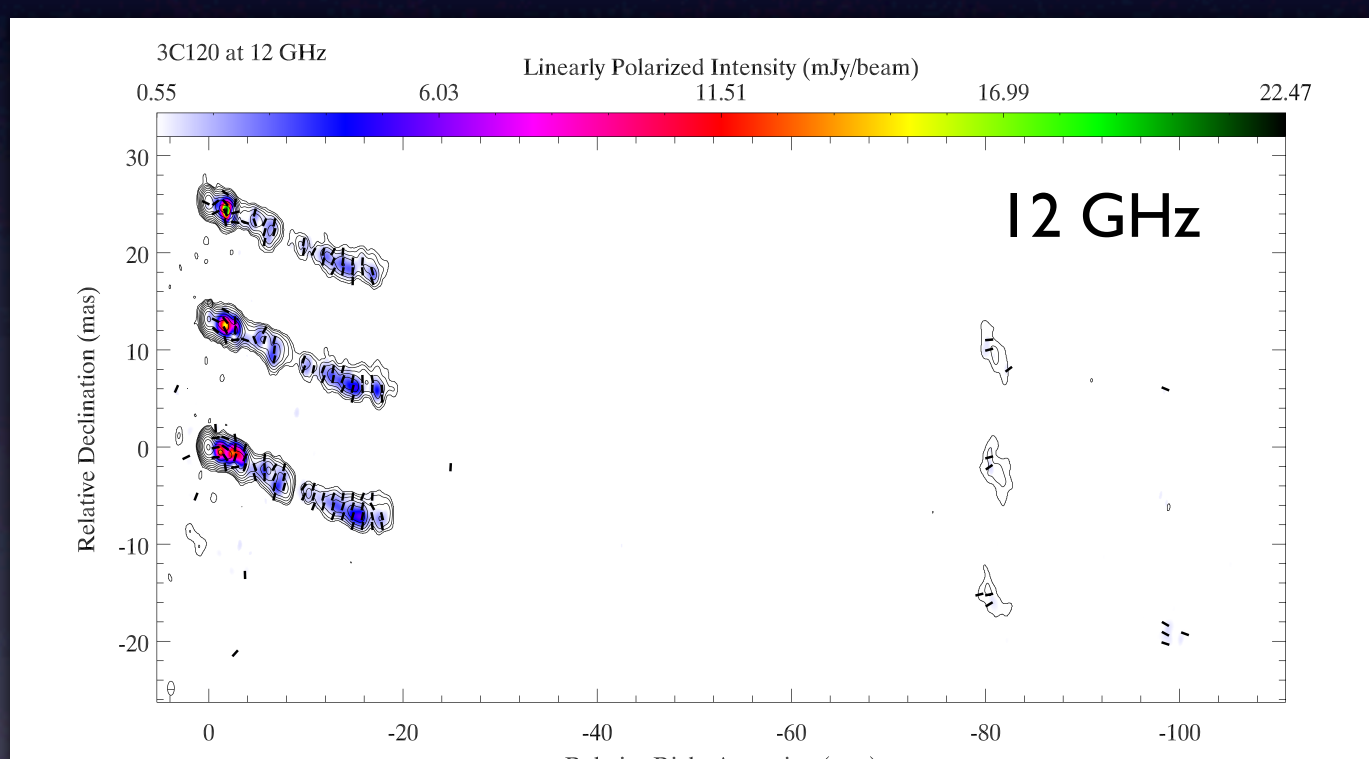

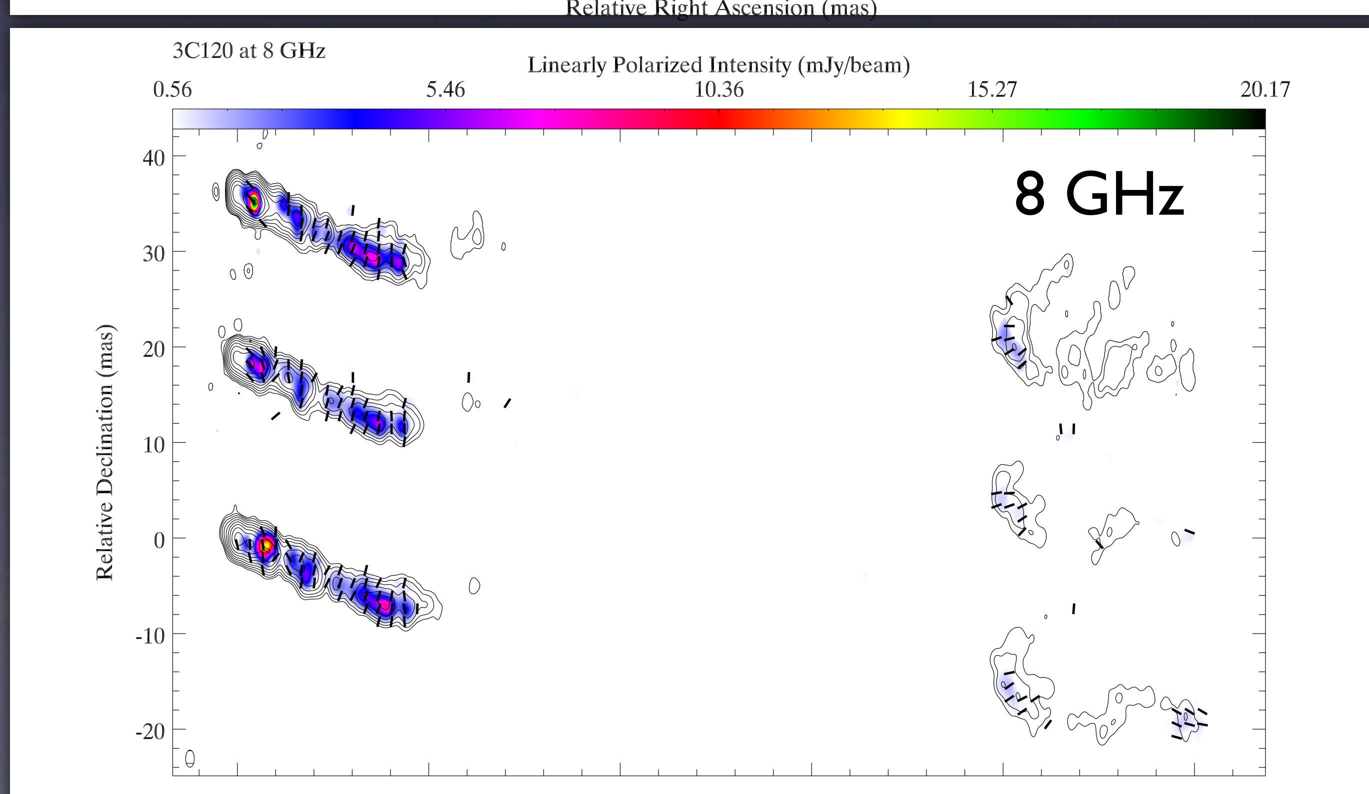

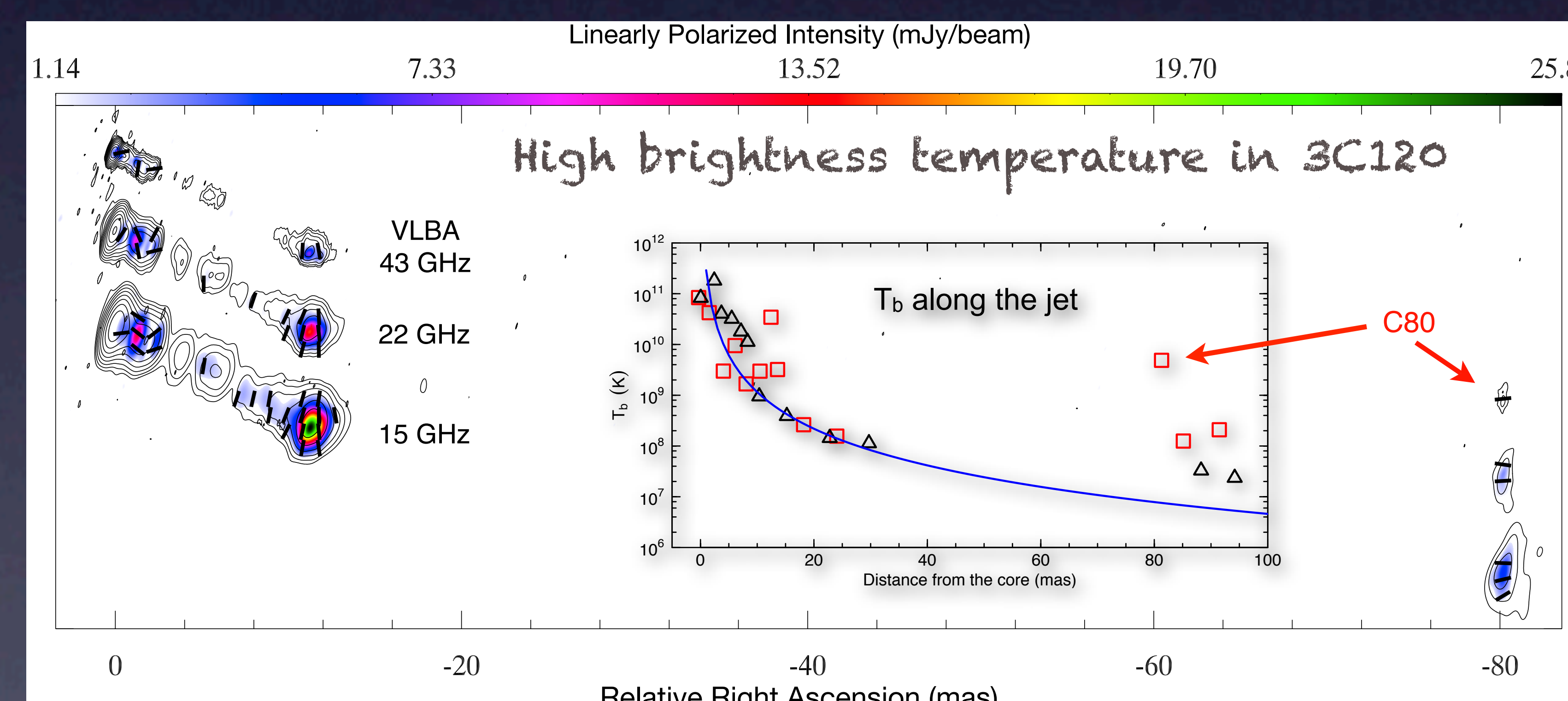

(Roca-Sogorb et al. 2010)

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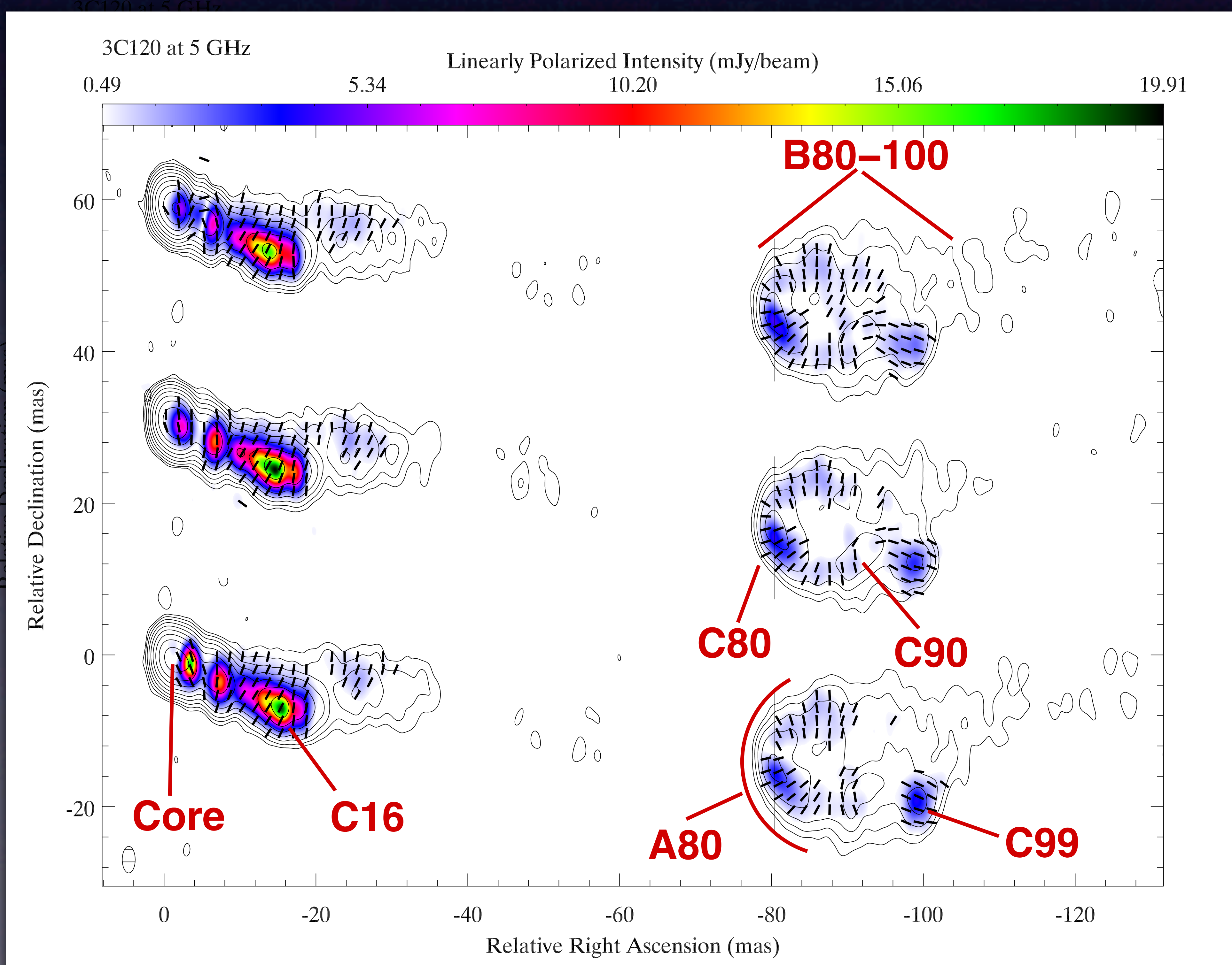
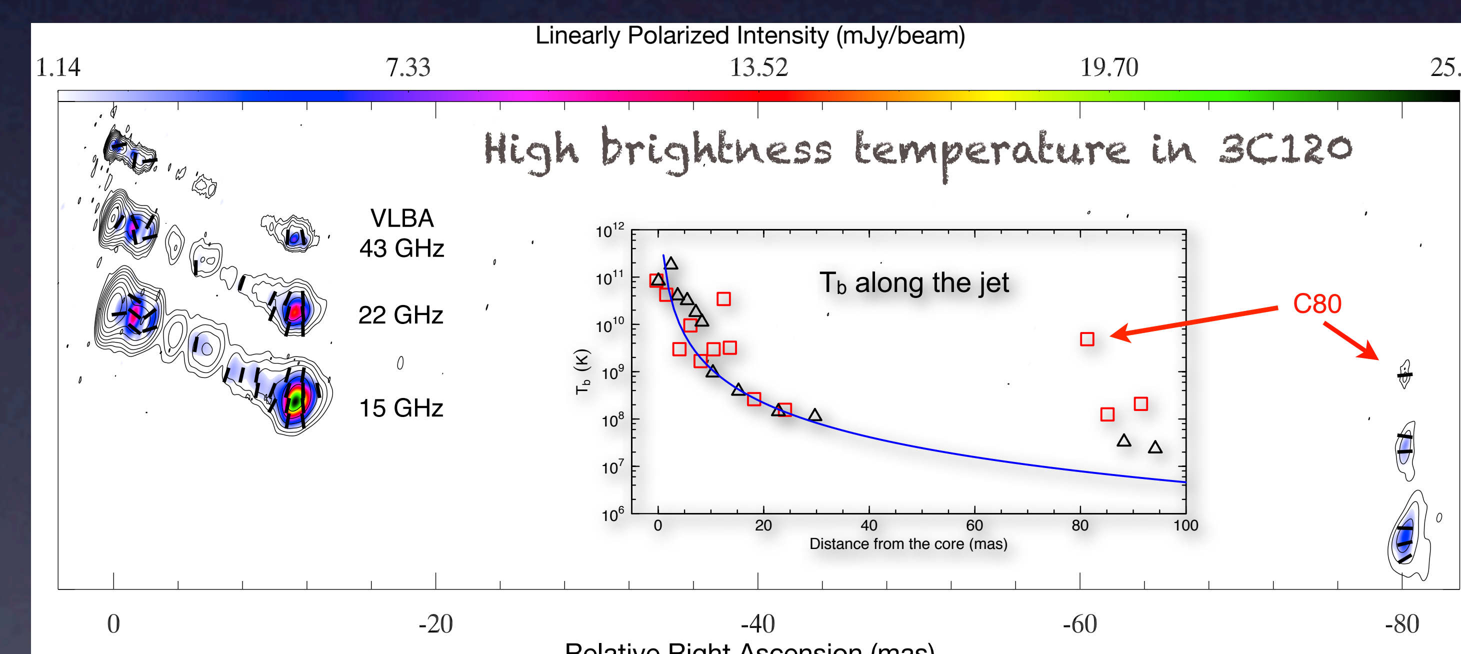




(Roca-Sogorb et al. 2010)

Faraday Rotation screen

Faraday Rotation: when an electromagnetic wave pass thought a magnetized plasma the polarization plane rotates

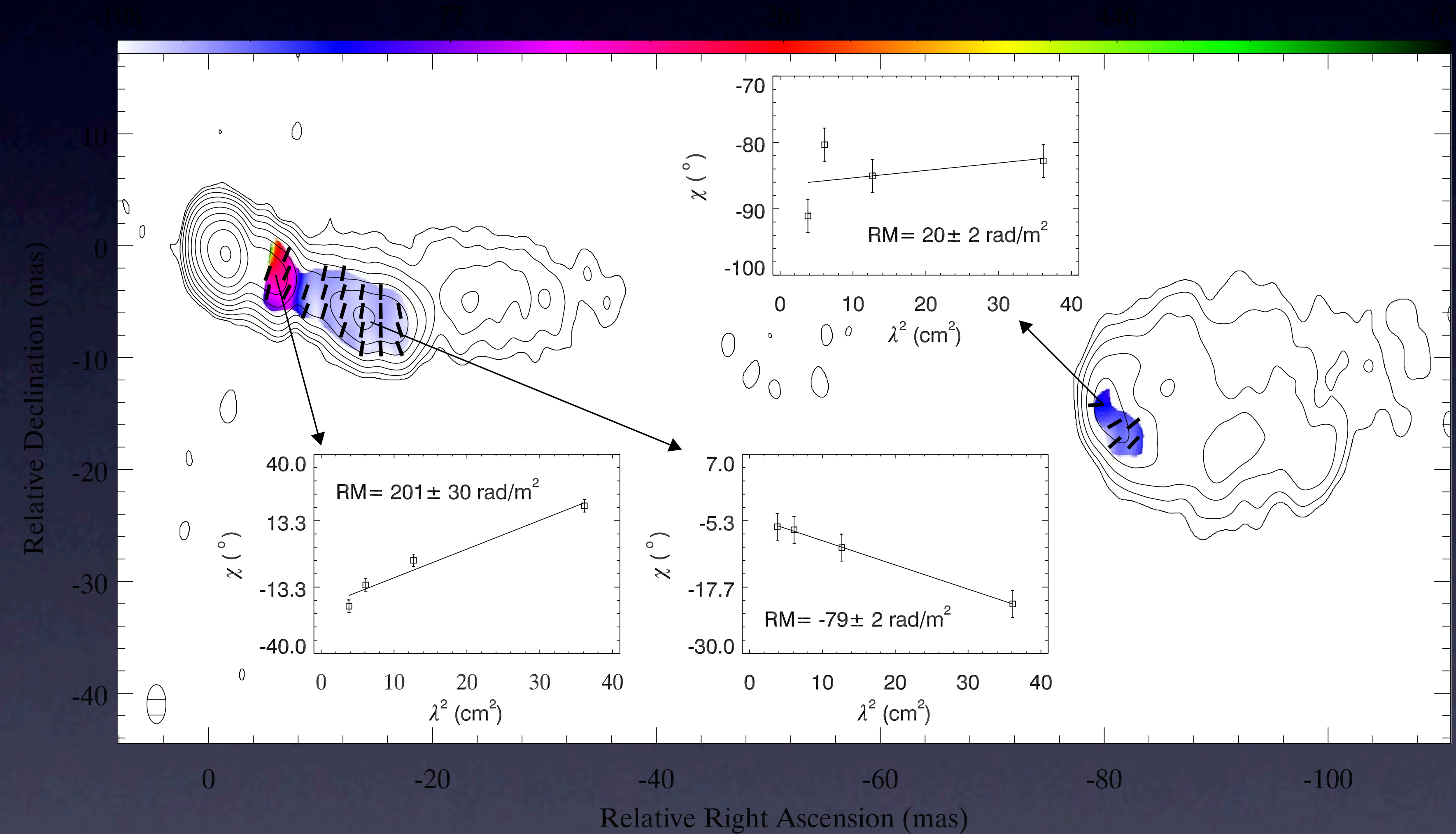
$$\chi = \chi_0 + RM\lambda^2 \quad ; \quad RM = 812\int_0^L n_e \vec{B}\cdot d\vec{l}\,[rad \cdot m^2]$$

Observed EVPA

Intrinsic EVPA

electron density

magnetic field along the line of sight



Component C80/A80 has a small rotation measure of 20 ± 2 $rad \cdot m^{-2}$, leading to a Faraday rotation in the EVPAs at our longest observing wavelength of 6 cm (5 GHz) of 4 degrees, within the estimated error in our absolute calibration of the EVPAs.

↓

our EVPA maps of C80/A80 are not affected by Faraday rotation.

Results

Agudo I., Gó mez J. L., Casadio C., Cawthorne T. V., Roca-Sogorb M., The Astrophysical Journal, 752, 92 (2012)

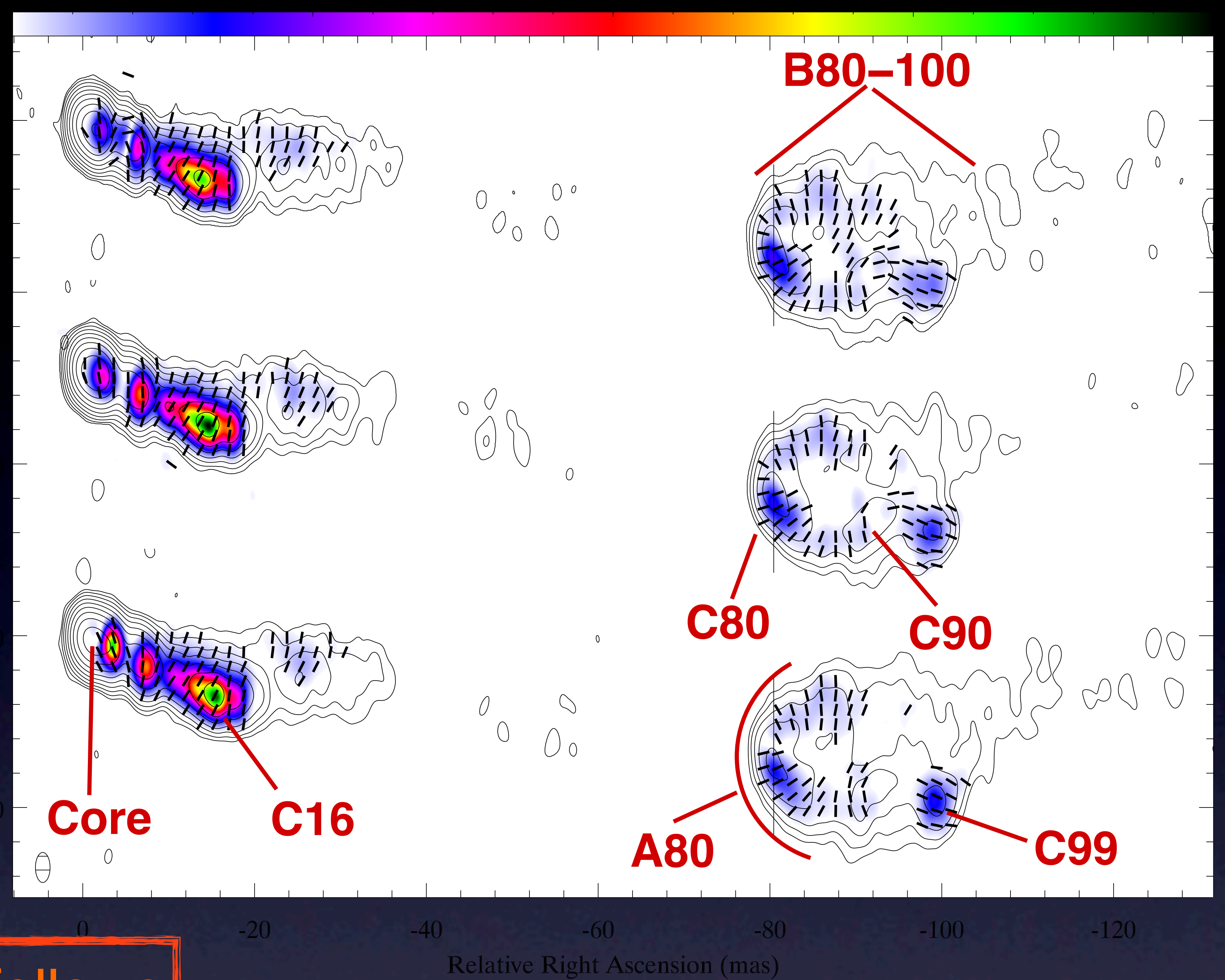
The arc structure ~80 mas from the core

✓ a bubble-like extended emission region larger than ~20 mas along the jet axis and ~20 mas across the jet axis;

✓ emission in C80/A80 shows a very peculiar structure in arc;

✓ hight temperature brightness (~ 600 larger than expected at such distance), as in Roca-Sogorb et al., 2010;

✓ The orientation of the EVPAs in C80/A80 remain perpendicular to the arc structure;



magnetic field compressed in a direction that closely follows the structure in arc seen in total intensity, as would be expected in the case of a ***stationary shock***.

Kinematics of B80-100 region

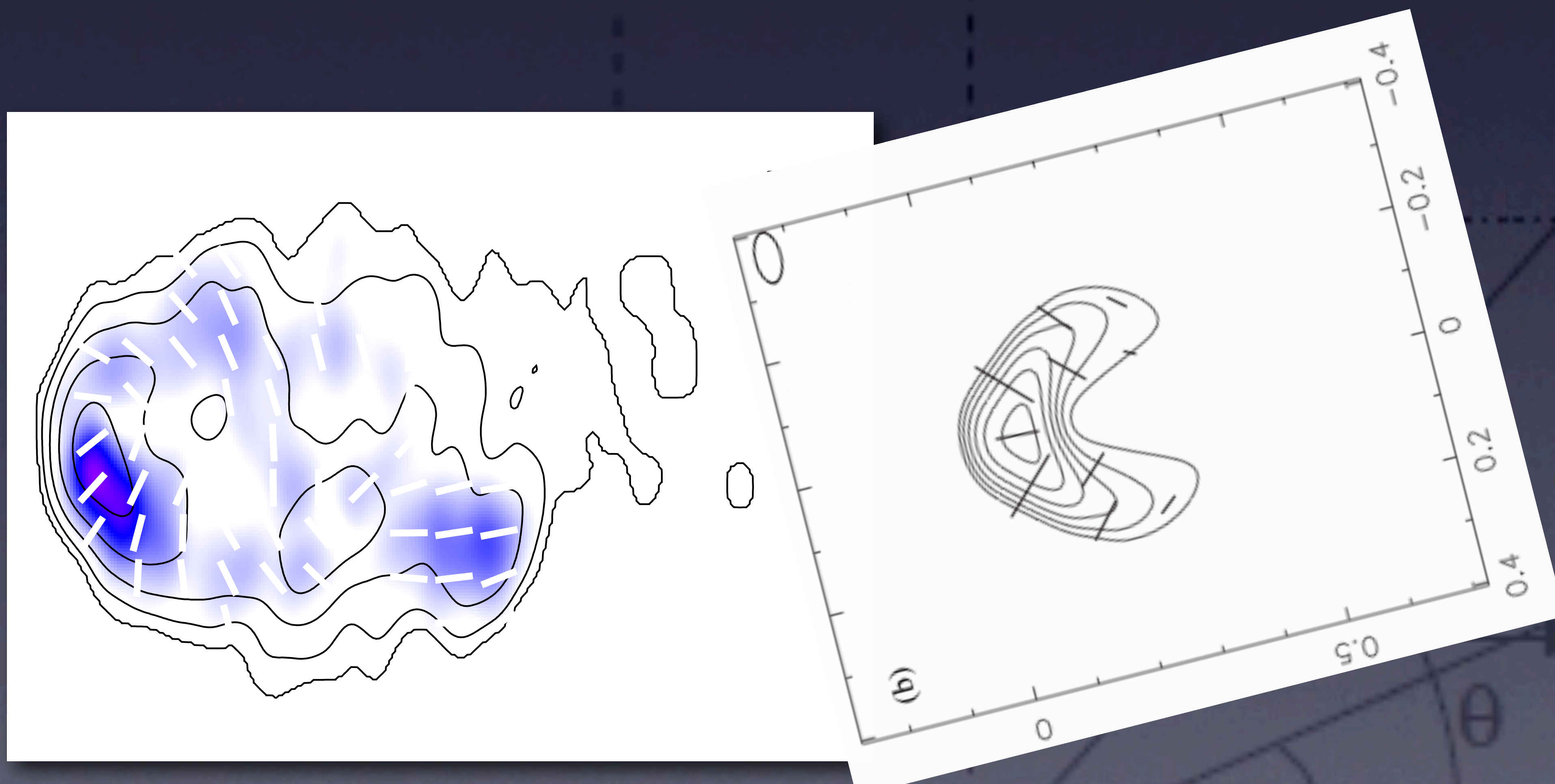
✓A new bright and compact jet region located ~ 99 mas from the core (C99)

✓C80 has remained stationary (Roca-Sogorb et al., 2010; Gomez et al., 2011), but downstream of its position component C90 and C99 reveal superluminal proper motion ($v_{C90} = 3.4 \pm 1.0c$ and $v_{C99} = 3.0 \pm 1.1c$).

C80/A80, as a strong recollimation shock?

- Unusually high Tb;
- Stationarity ;
- Features moving at superluminal speed dowstream C80/A80 ;
- Peculiar structure in arc of the magnetic field;

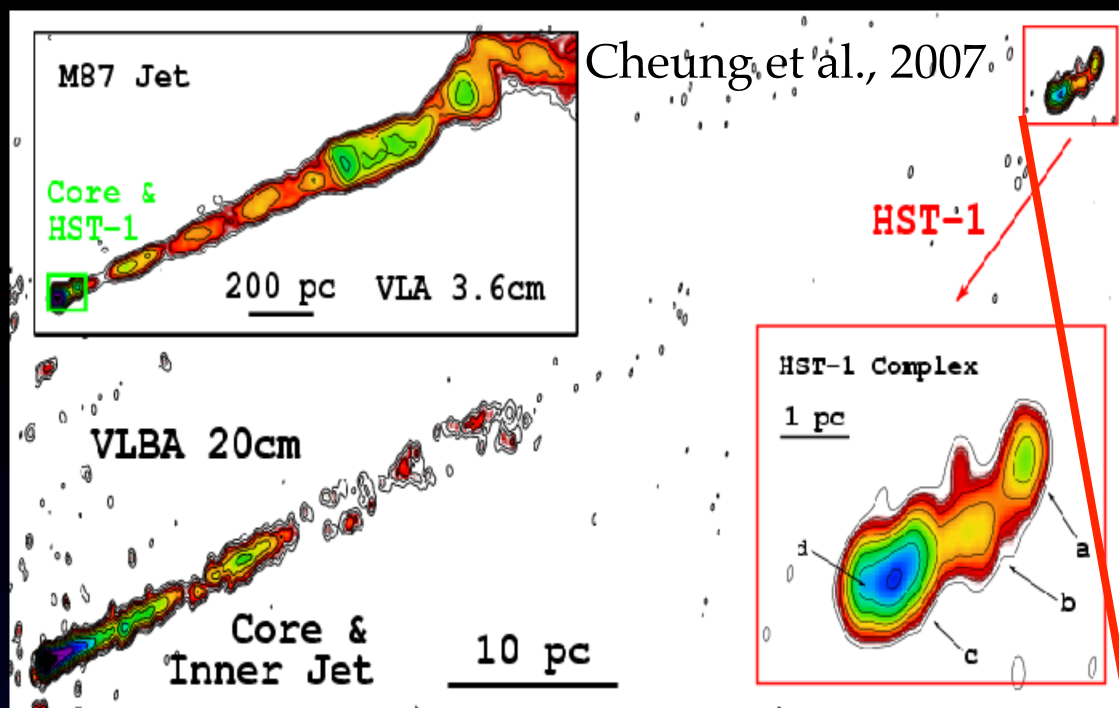
} **Possible recollimation shock**



Our simulations based on the synchrotron emission from a conical shock, as described by Cawthorne (2006), reproduce quite closely the observed total and linearly polarized emission structure, the electric vector distribution, and the increased brightness temperature of C80/A80, allowing constraints on the values of the jet flow in 3C 120 and the geometry of the conical shock at ~ 80 mas from the core.

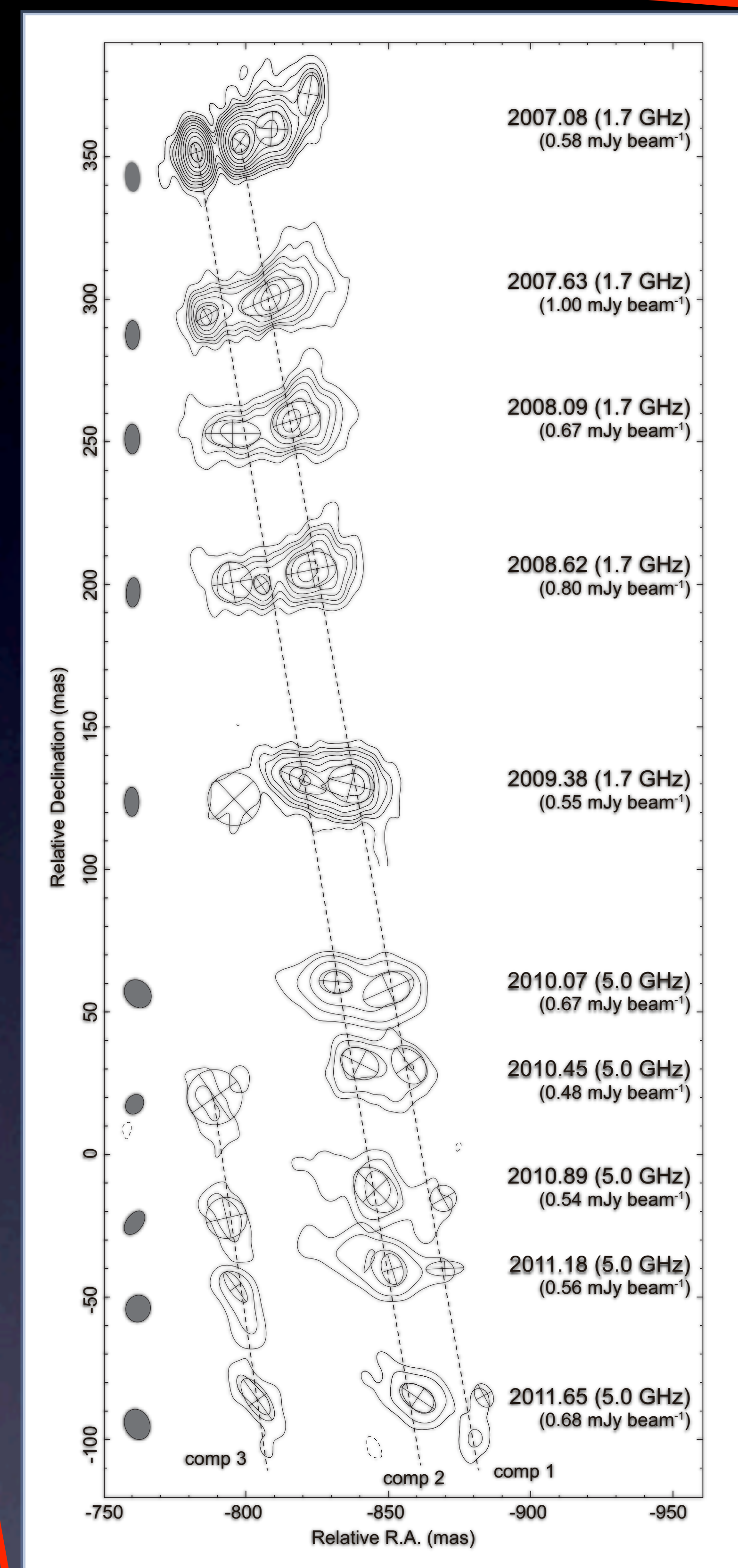
✦ **C80, well described by numerical simulation of a conical recollimation shock with a cone angle of 10 degrees, a viewing angle of 16 degrees, and the upstream Lorentz factor** $\gamma_u = 8.4$

A similar case in the nearest radiogalaxy: the recollimation shock in M87



Giroletti M. et al., Astronomy & Asrophysics (2012)

VLBA at 1.7 GHz + e-EVN at 5 GHz
between June 2009 and October 2011



comp 1-2
quite variable in flux
and morphology
superluminal speed ~ 4c

comp 3
superluminal speed ~ 6c
appears only from 2010.45

M87
- nearby galaxy (D = 16Mpc),
- massive BH (6.4 x 10^9 M_{sun}),
- bright and resolved jet
- well studied at all wavelengths from radio to gamma

HST-1
- ~70pc from the core
- it emits at different frequencies
- at high resolution, composed by superluminal components

Possible hypothesis:
the third faint component is part of a weaker stationary emission located in the upstream that start to bright only when a new component pass trough it. (recollimation shock)

\+

HST- 1 is in the location where the jet of M87 changes from a parabolic to a conical shape. (Asada & Nakamura 2012)

GRACIAS !