Recurrent Radio Activity in Active Galactic Nuclei

Marek Jamrozy

Jagiellonian University, Kraków, Poland

Tidal Disruption Events and AGN Outbursts

25-27 June 2012

European Space Astronomy Centre,

Madrid, Spain

C. Konar

D. Koziel-Wierzbowska

A. Kuzmicz

J. Machalski

K.-H. Mack

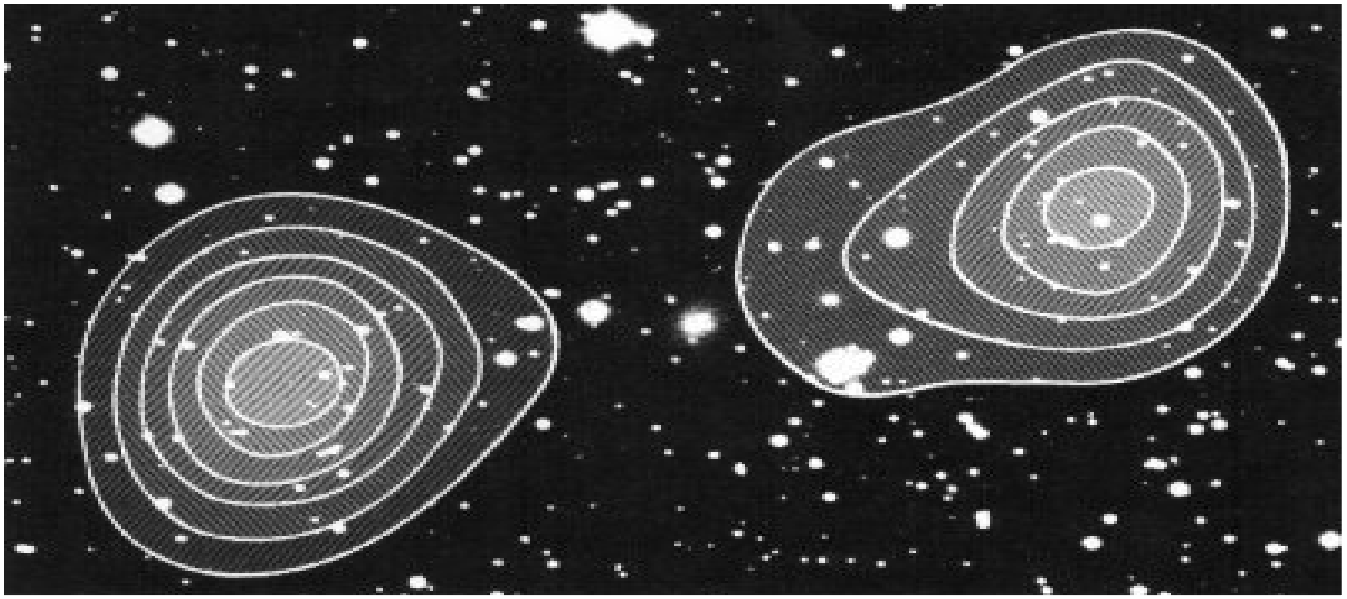
D.J. Saikia

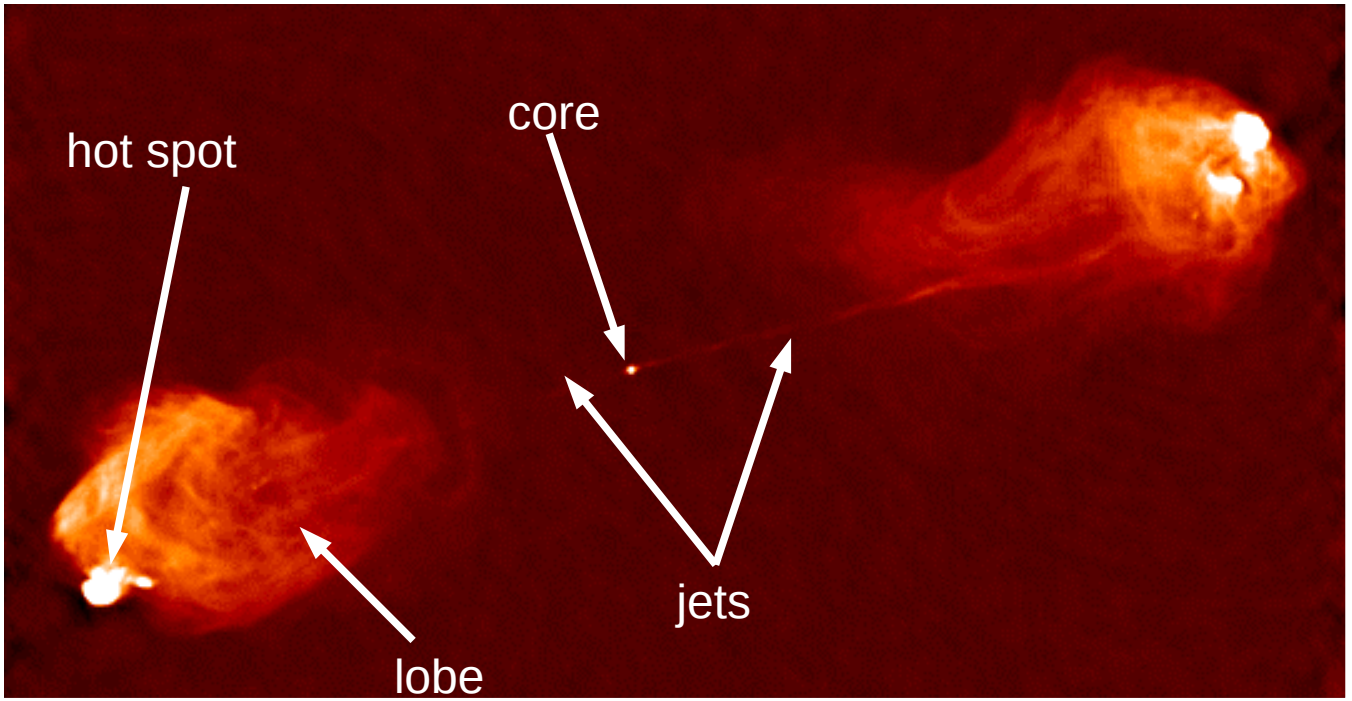
A. Siemiginiowska

L. Stawarz

S. Zola

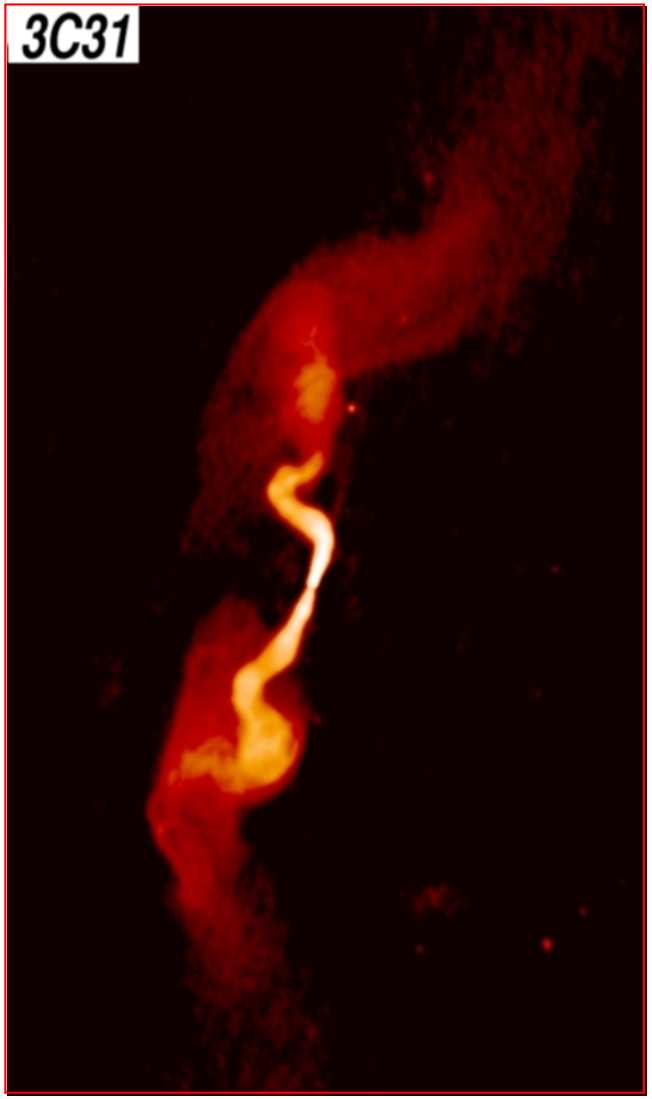
Cygnus A



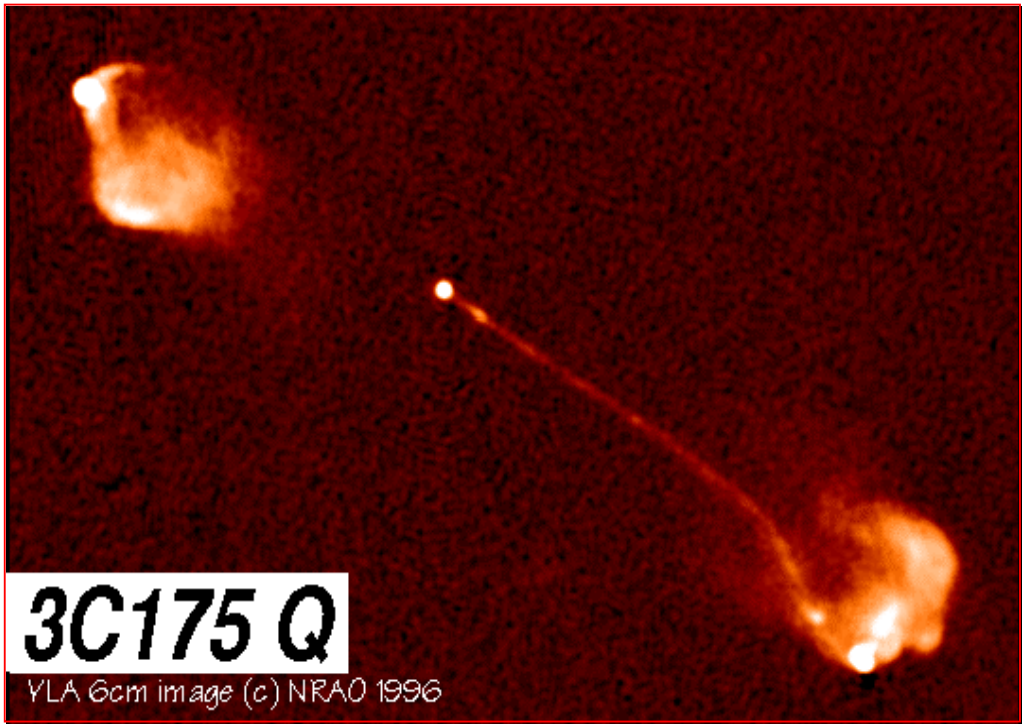


z=0.0561

size
2 '
100 kpc



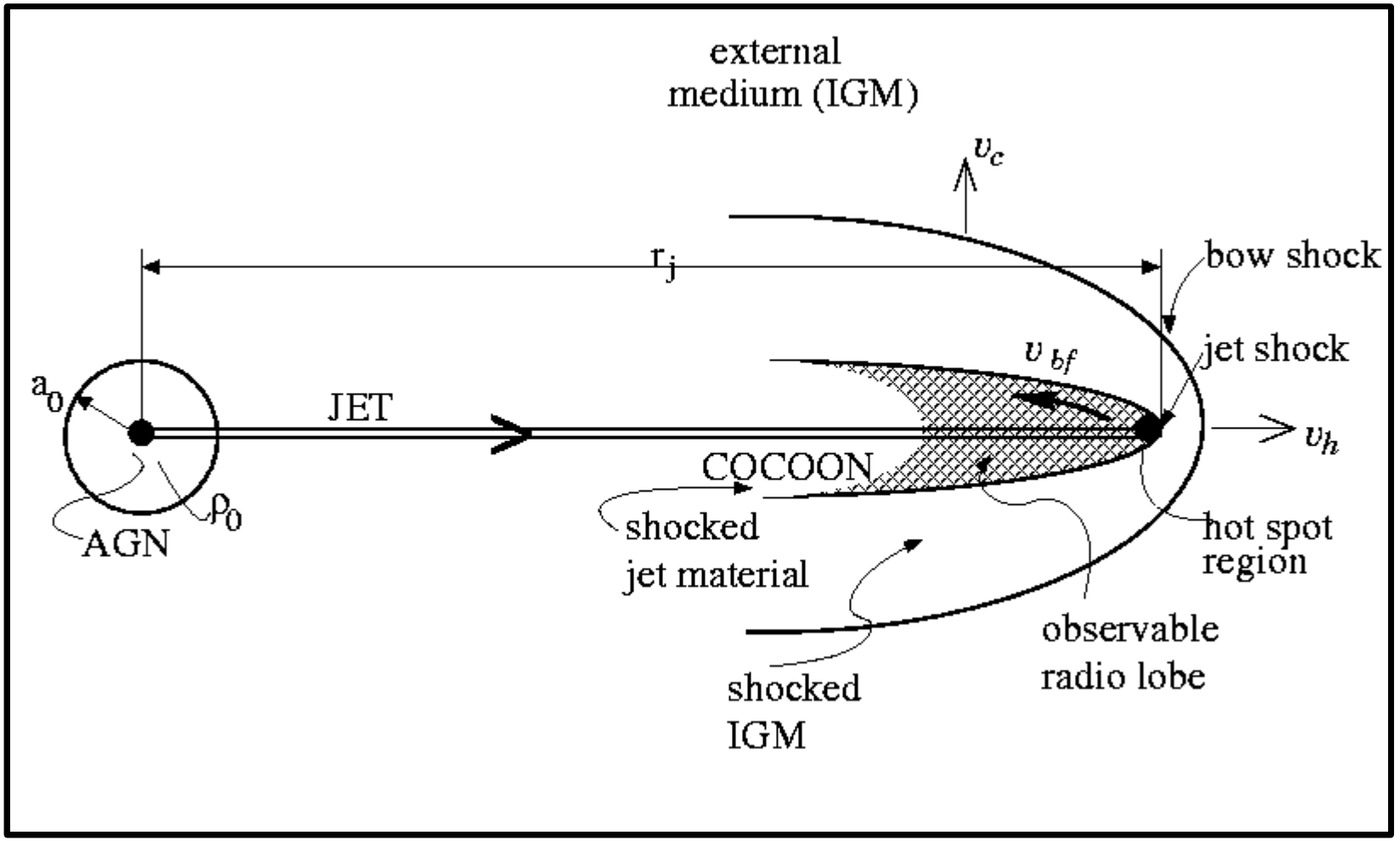
FRI



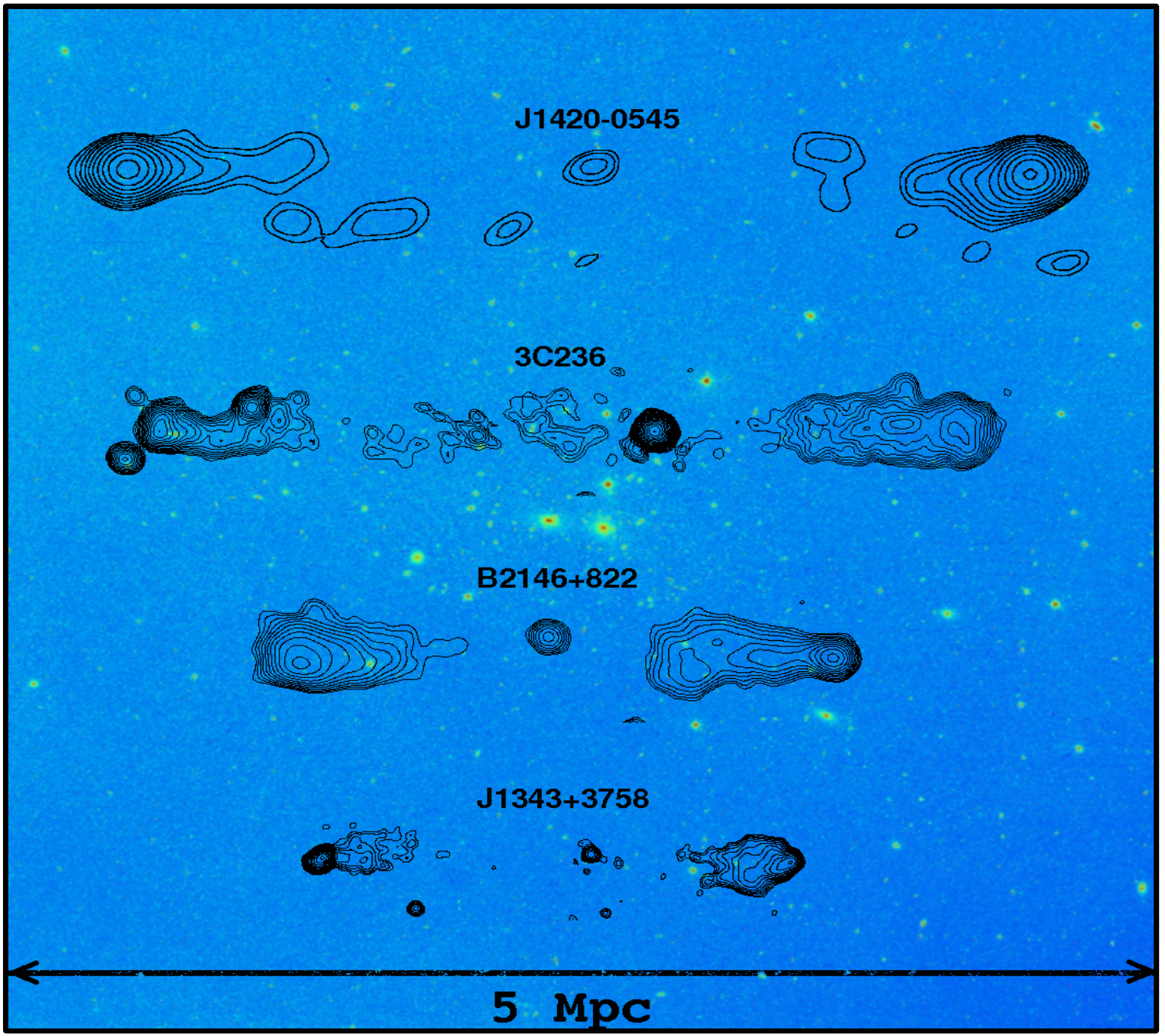
Fanaroff& Riley 1974

FRII

Time evolution



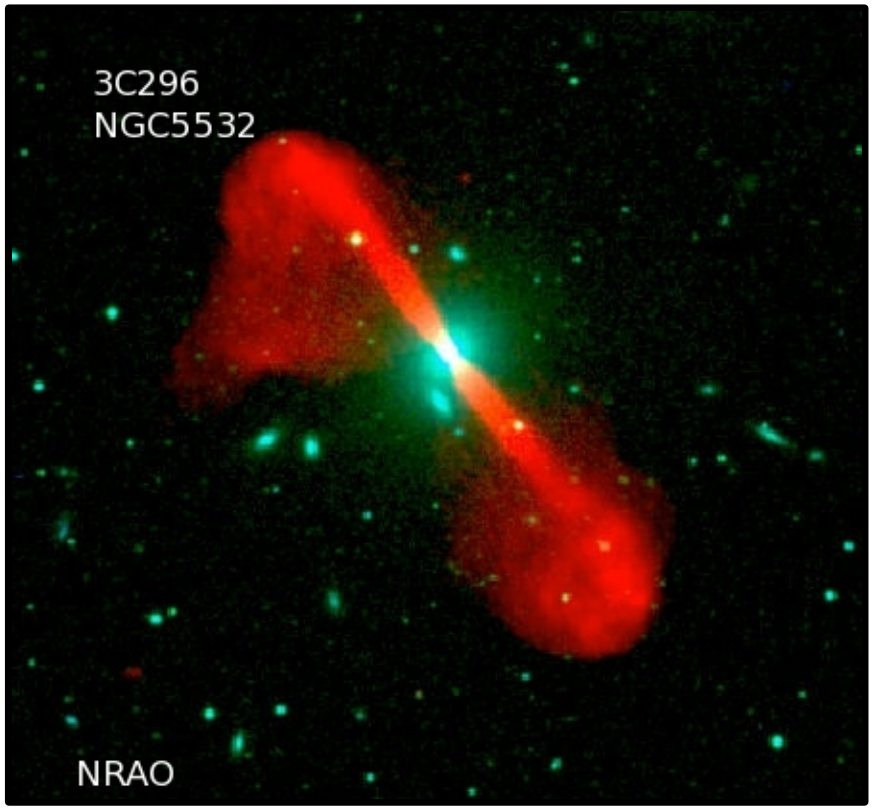
The largest radio galaxies



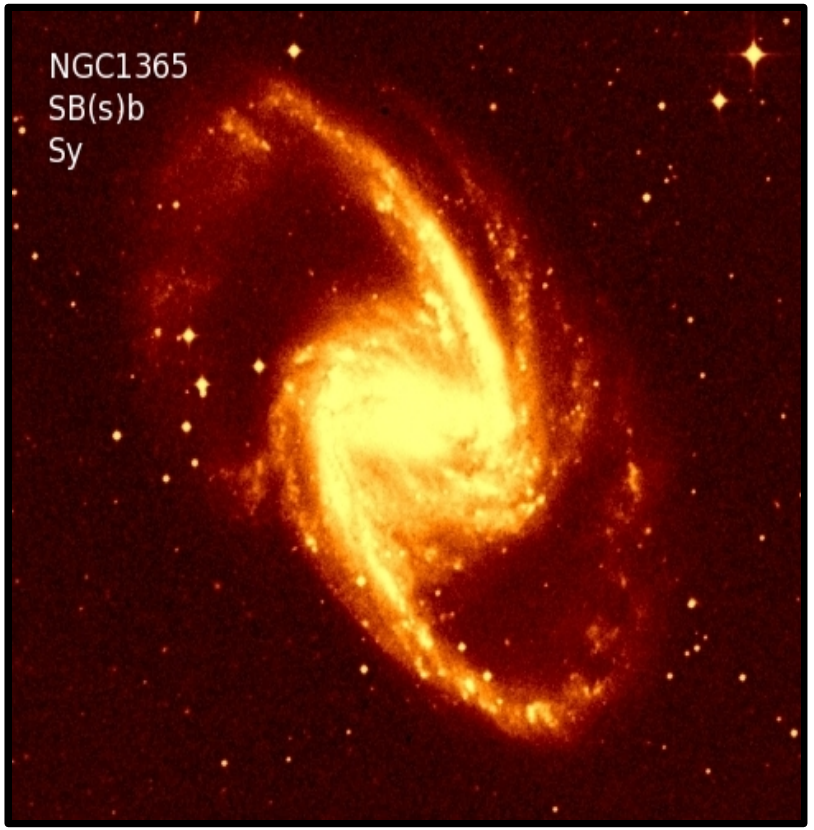
Machalski et al., 2008, ApJ, 679, 149

AGN host galaxies

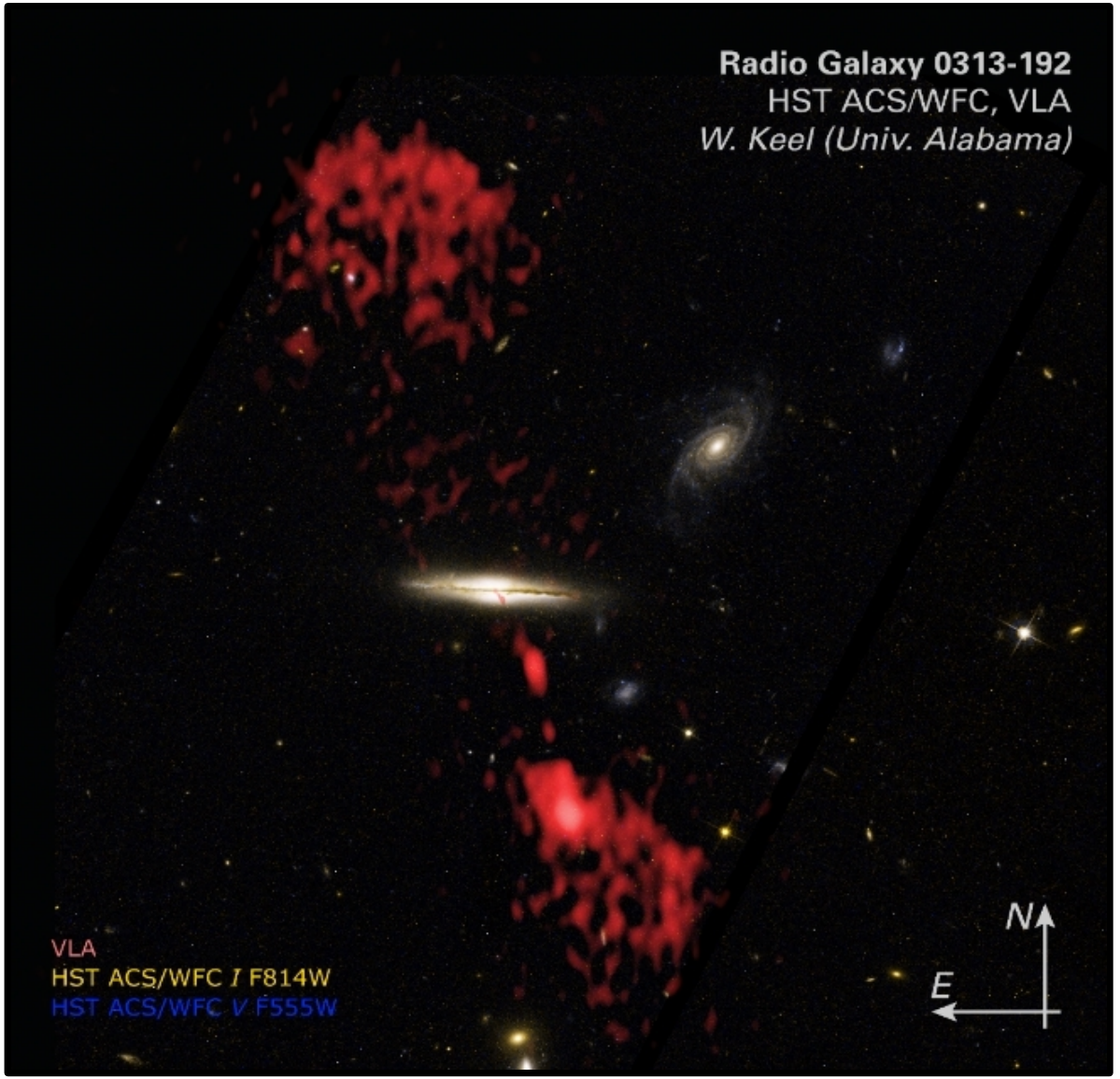
Early type galaxy AGN hosts have strong radio emission a large-scale jets

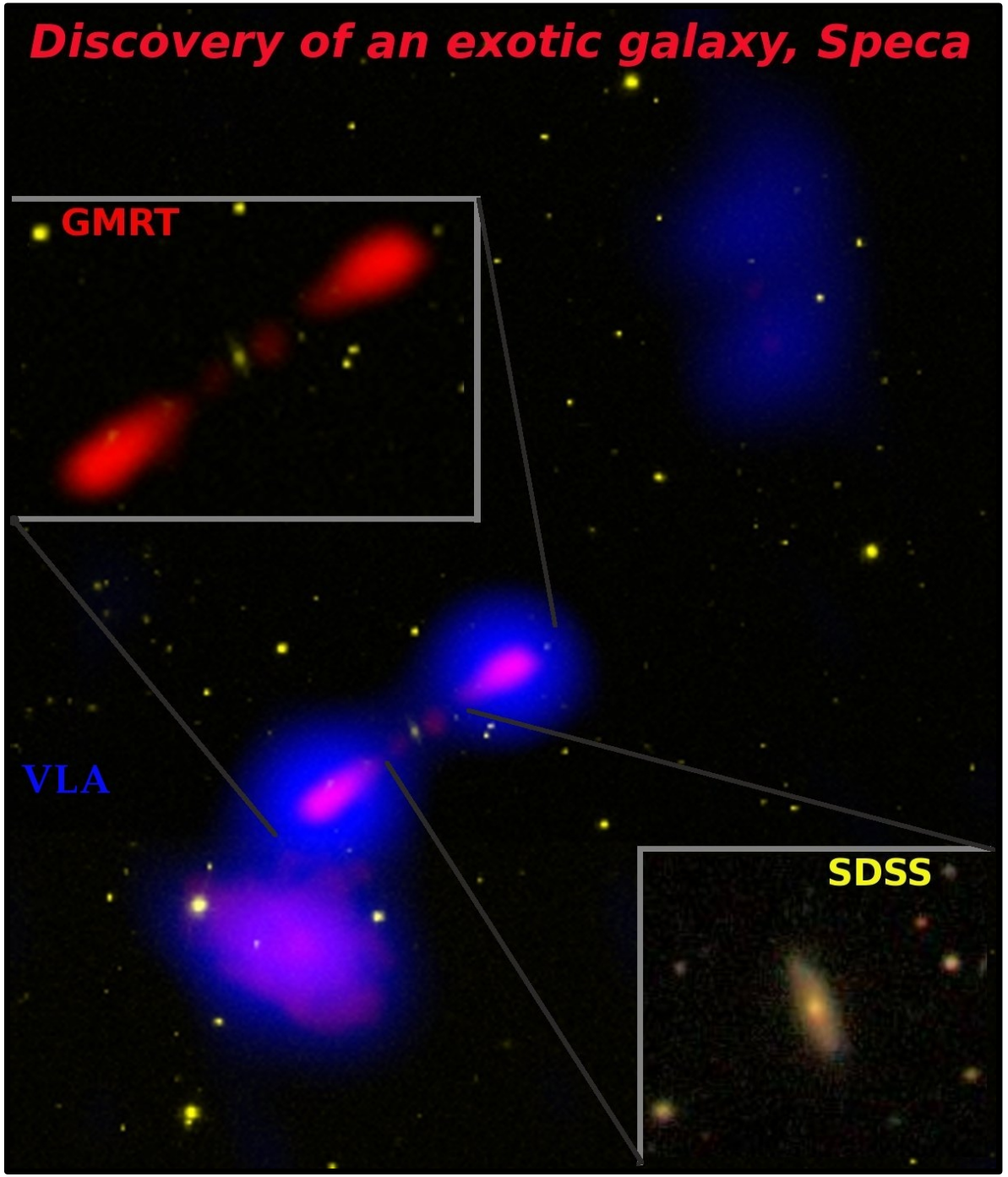


Late type galaxy AGN hosts have weak radio emission small-scale jets



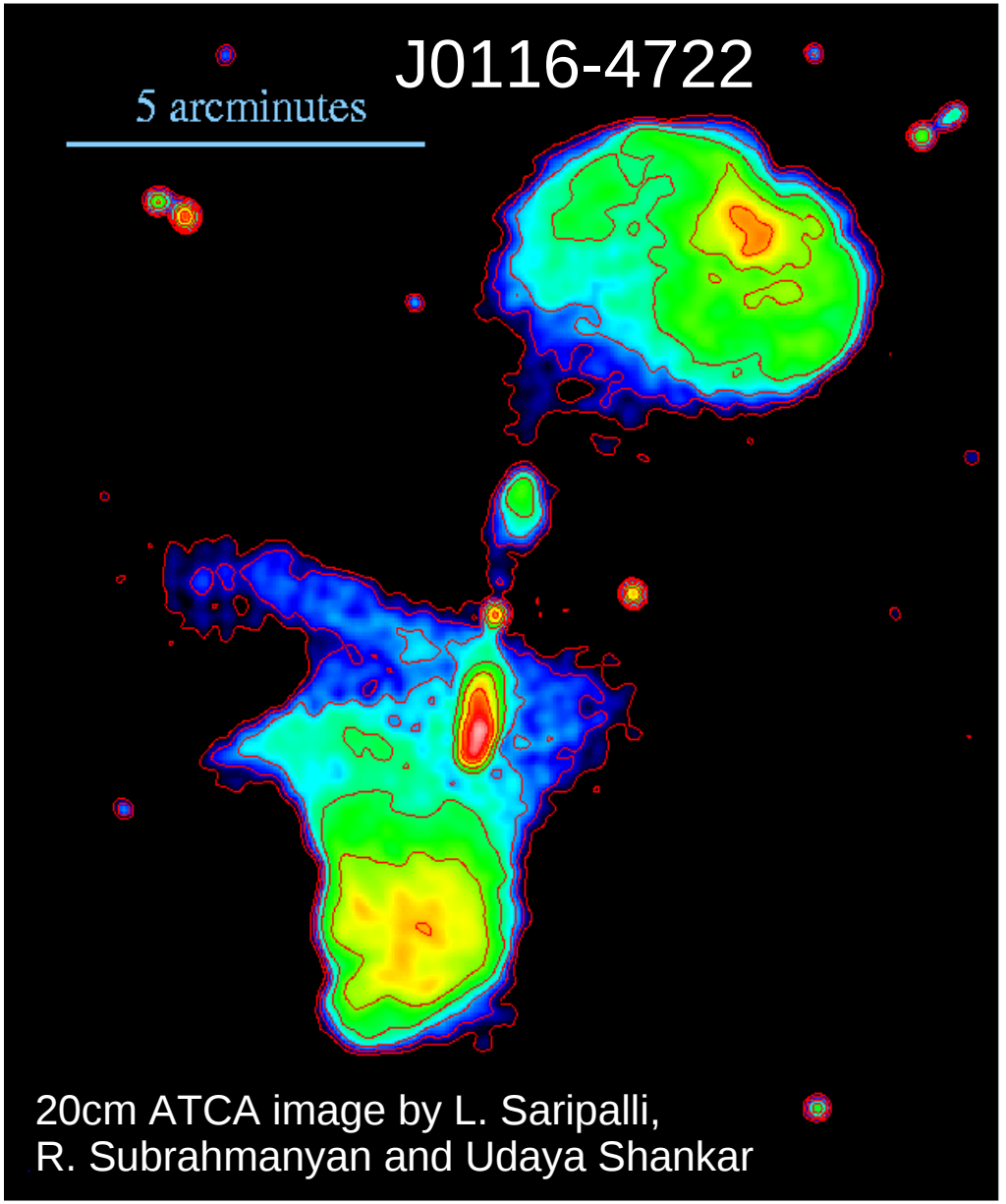
.... there are few exceptions





z= 0.137,
spiral-host
triple-double radio galaxy

Hota et al., 2011, MNRAS, 471L, 36



Double-Double Radio Galaxies

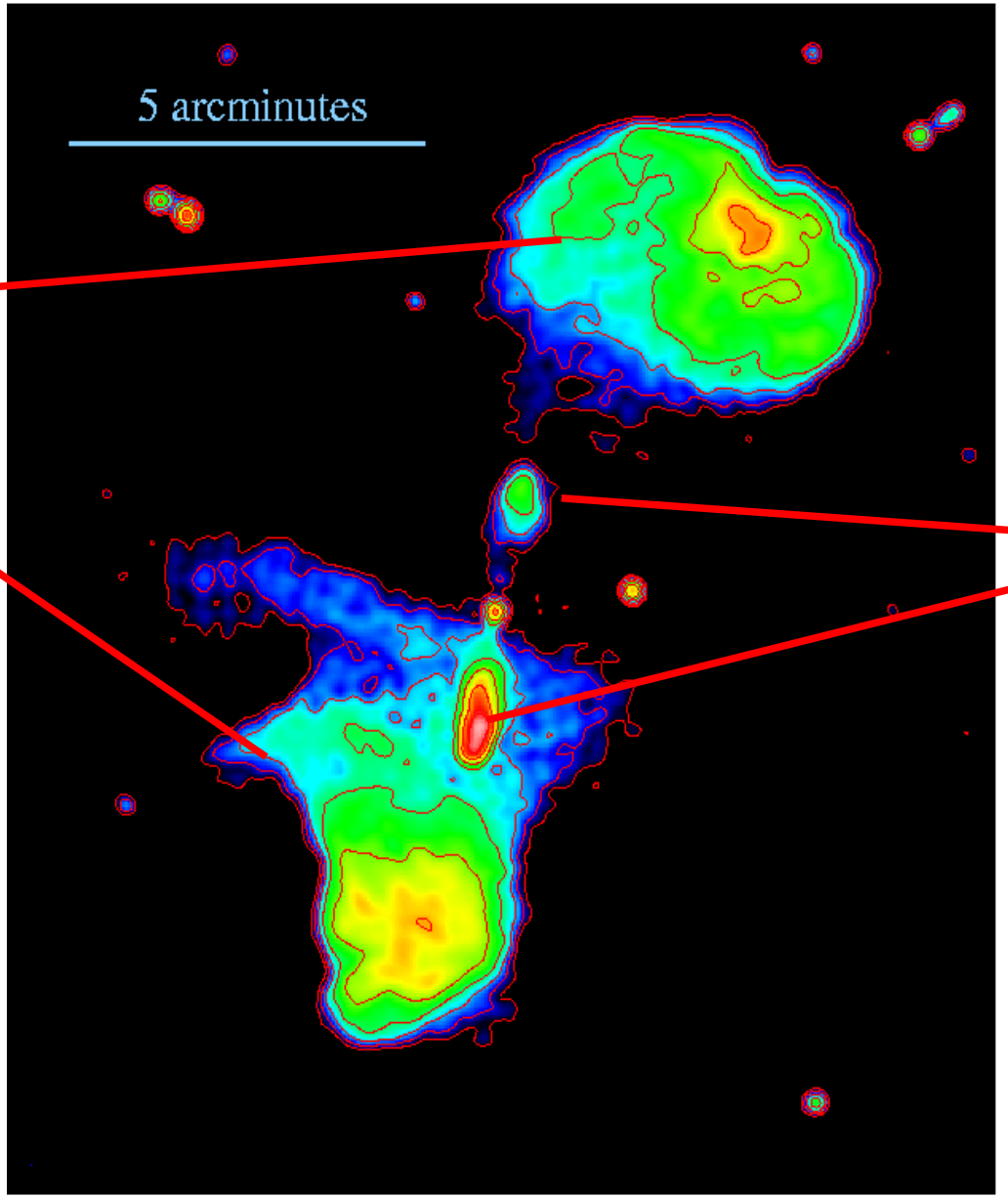
DDRG – two unequall sized , two sided, double lobed, edge-brightened (FRII) radio sources from two different cycles of activity
(Schoenmakers, 2000, MNRAS, 315, 371)

interruptions related to:
- refueling of the central engine
- instabilities in the accretion disk
- jet production machanism

~20 objects known (Saikia, & Jamrozy 2009)

Saripalli, Subrahmanyan, Udaya Shankar, 2003, ApJ, 590, 181

Age determination



older?

younger?

Synchrotron Radiation

Synchrotron emission results from relativistic electrons spiraling in weak magnetic fields

Energy distribution $N(E) \sim E^{p}$

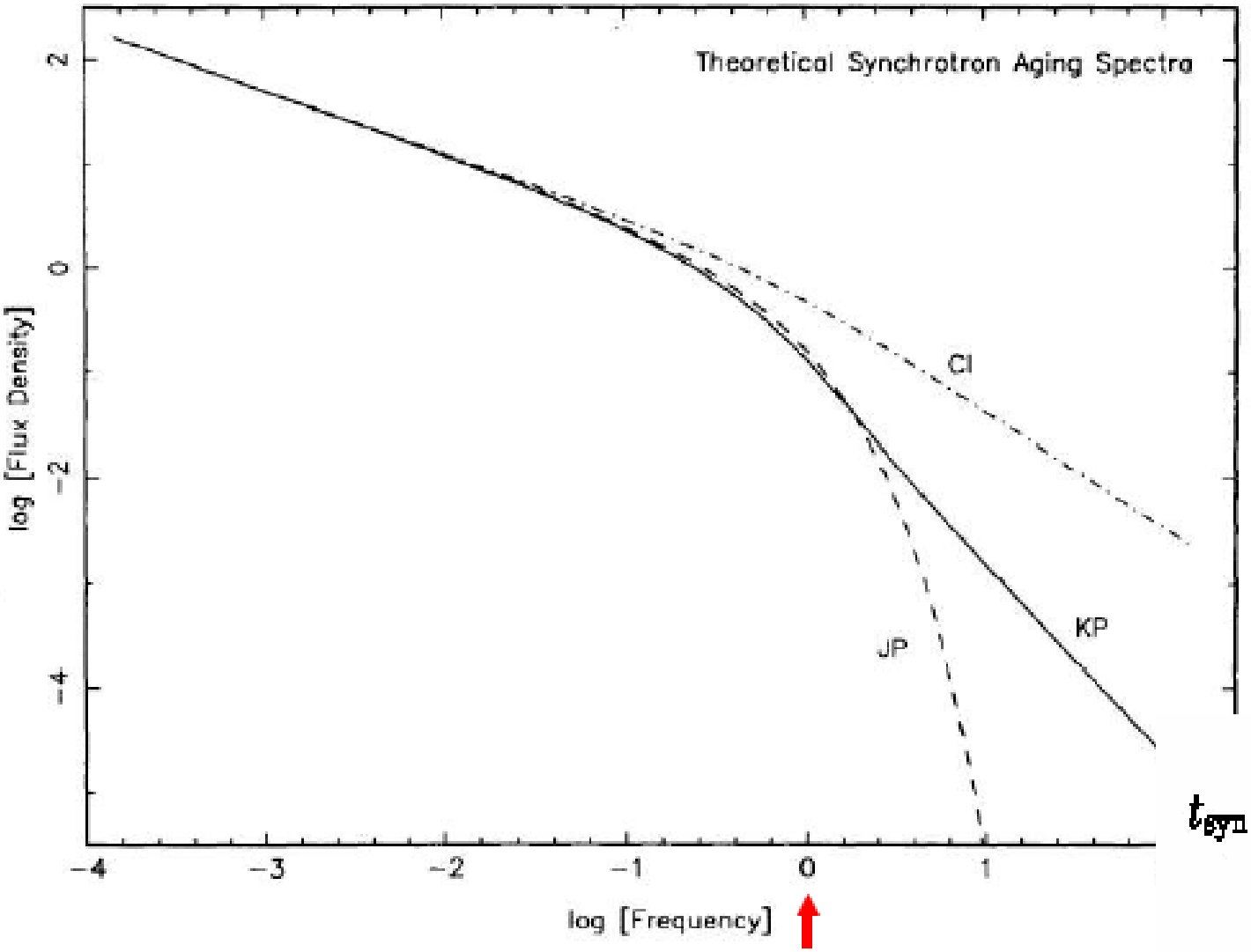
Spectrum shape $S_{\nu} \sim \nu^{-\alpha}$ (for radio galaxies p=-2.5, α=0.75)

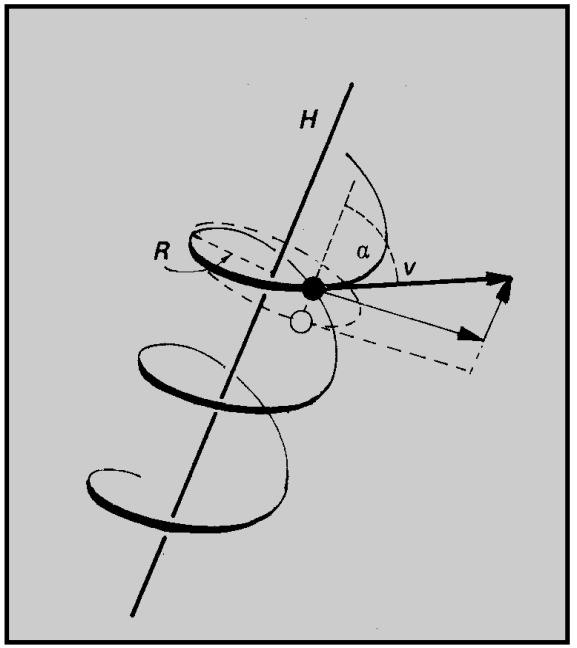
Evolution of radio spectrum with time:
steepening of the spectrum at high frequencies results from the radiative losses of electrons with the highest energy

Spectral model parameters:

- α_{inj}: power law index at frequencies lower than the break frequency
- ν_{br}: break frequency after which the spectrum steepens
- behavior of the spectrum after the break frequency

Spectral models



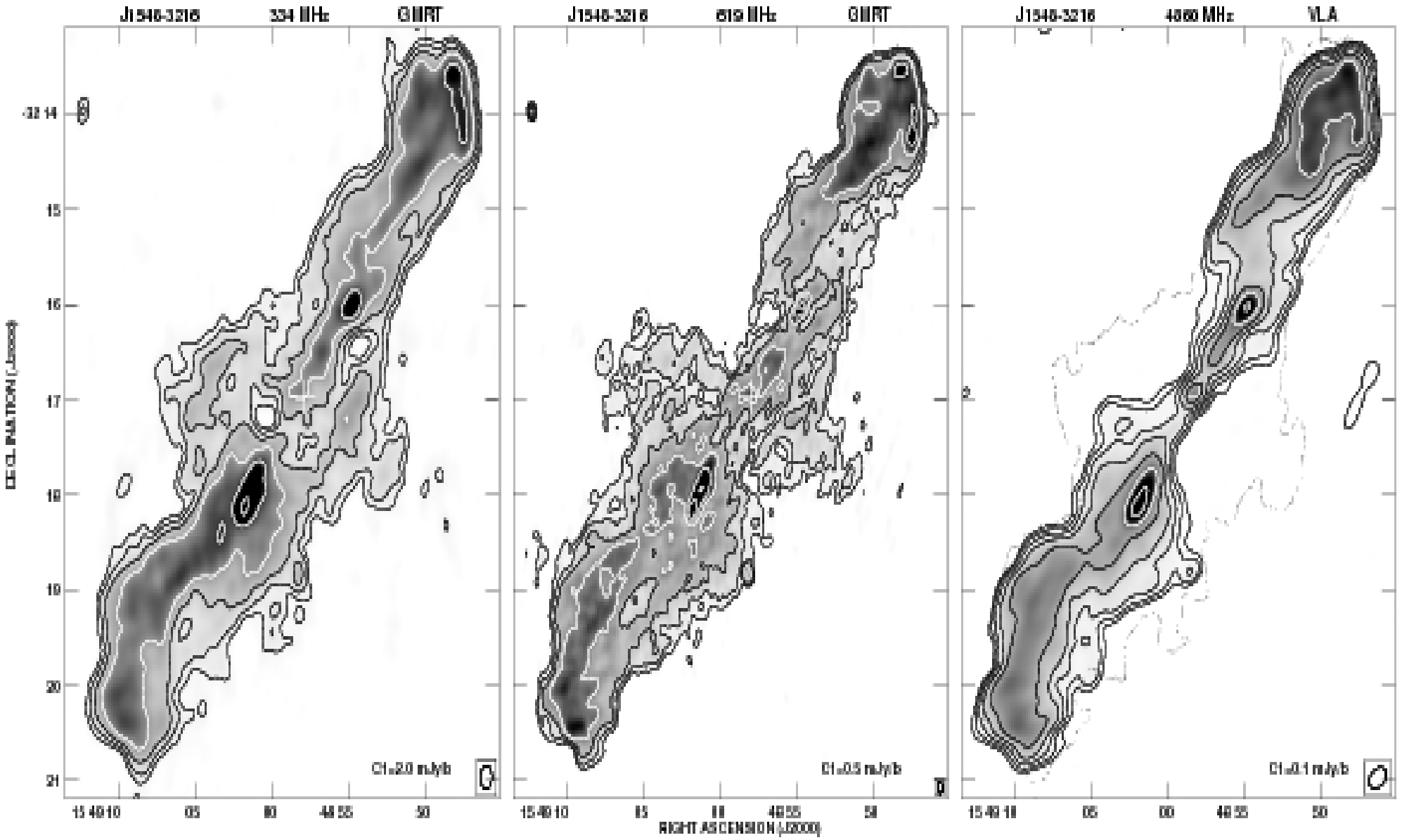


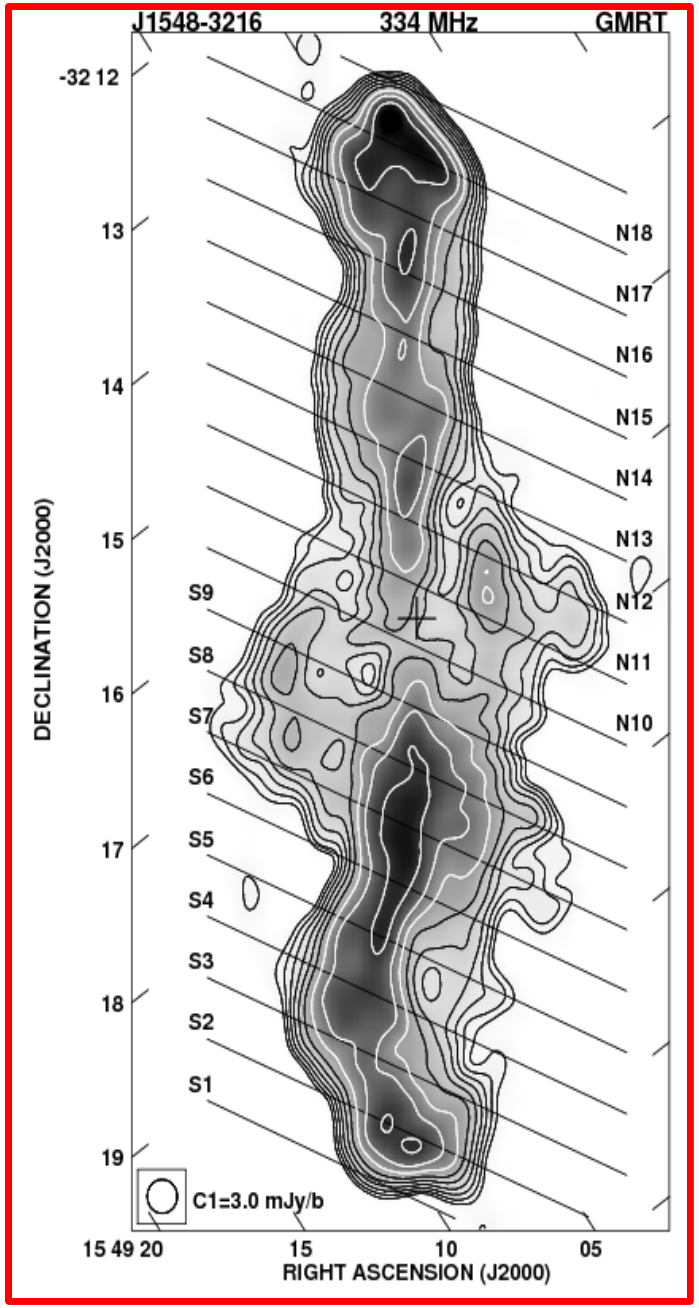
$$t_{\rm syn} \propto \frac{B^{1/2}}{(B^2 + B_{\rm IC}^2)} [\nu_{\rm br}(1+z)]^{-1/2}$$

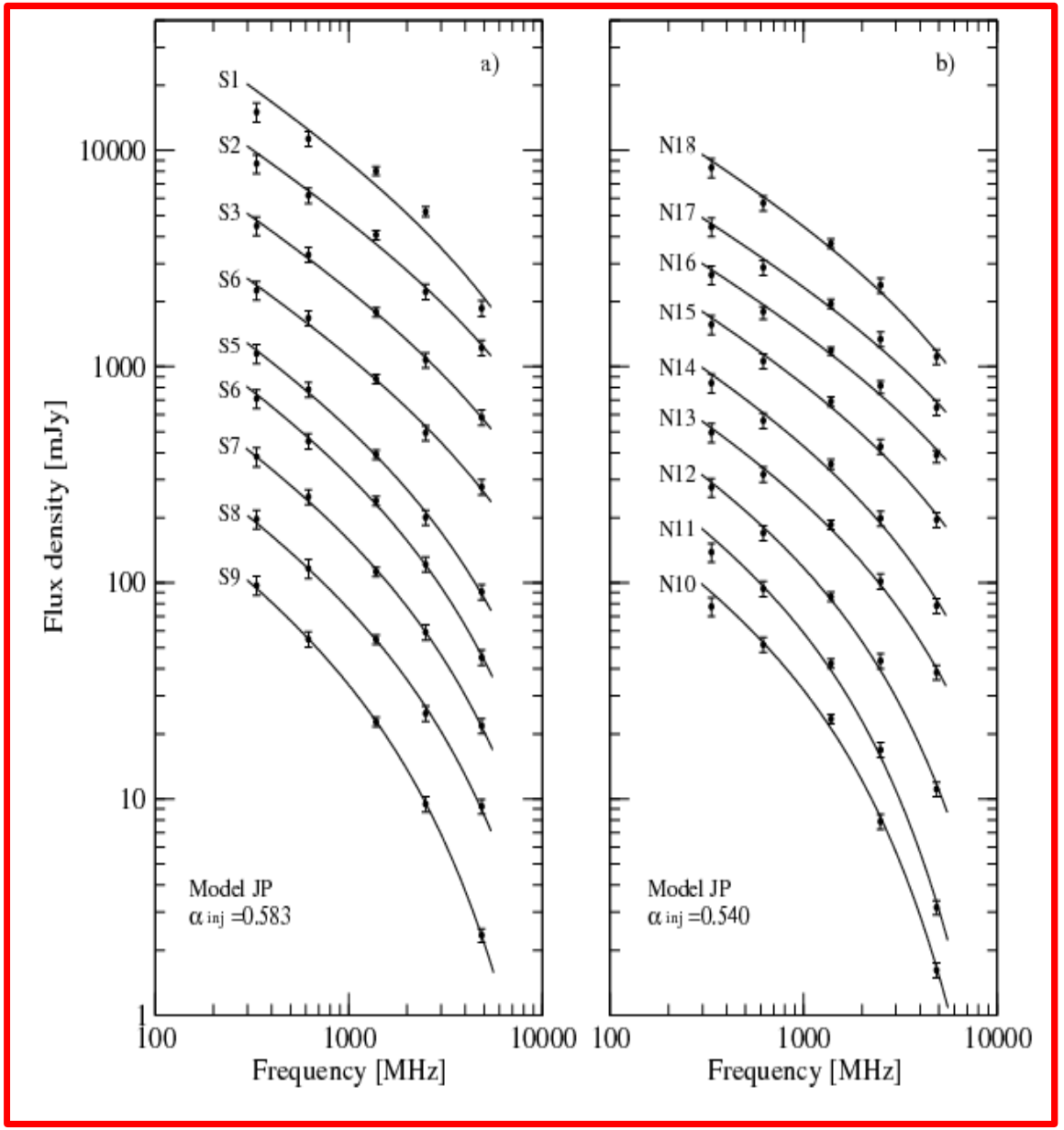
$$B_{\rm IC} = 0.32(1+z)^2 \ \ [\rm nT]$$

$$B \sim B_{\rm eqv} \propto \frac{1+\kappa}{\eta} \left(\frac{L}{V}\right)^{2/7}$$

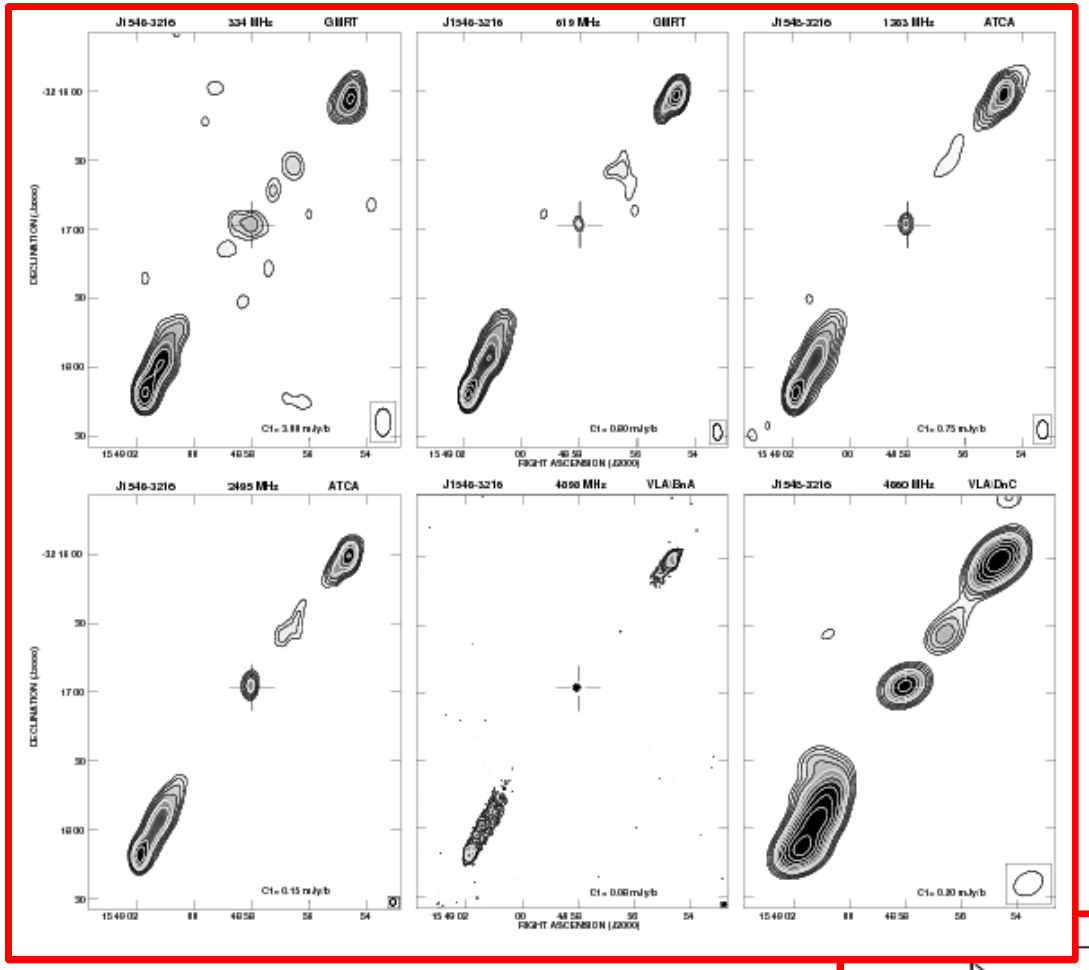
J1548-3216 multifrequency radio maps: GMRT , VLA



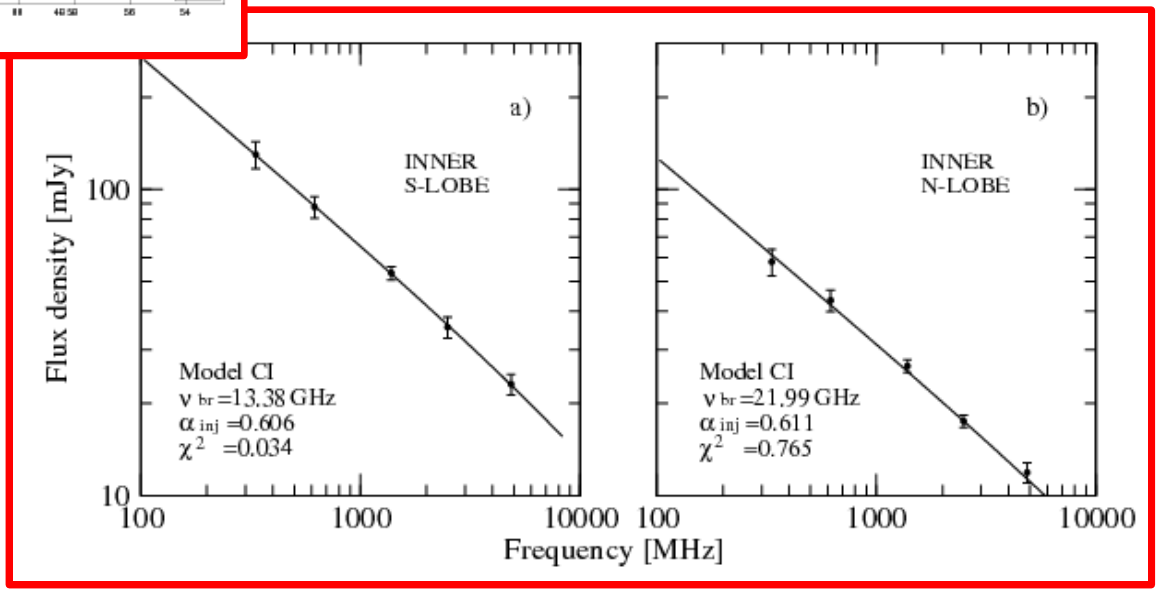


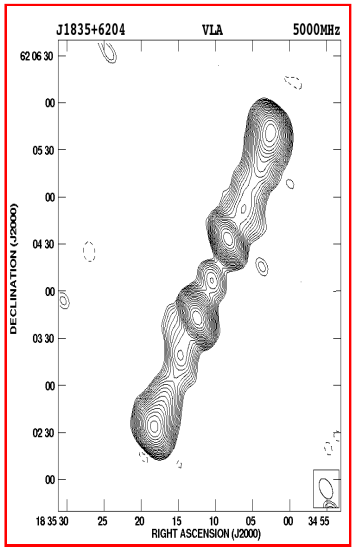


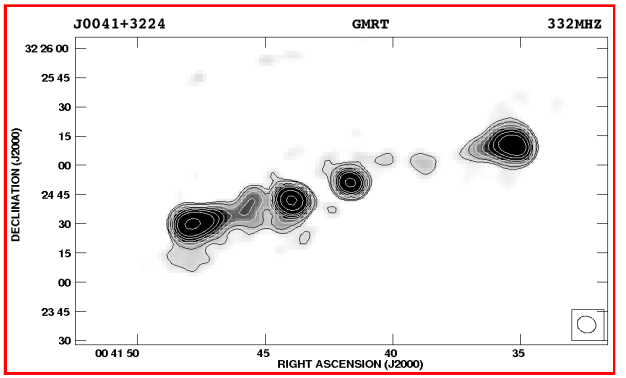
Spectral age 75 Myr



Spectral age 9 Myr







	J1835+6204	J0041+3224
synch. age [Myr]	22	26
quiescent phase [%]	<5	4-28

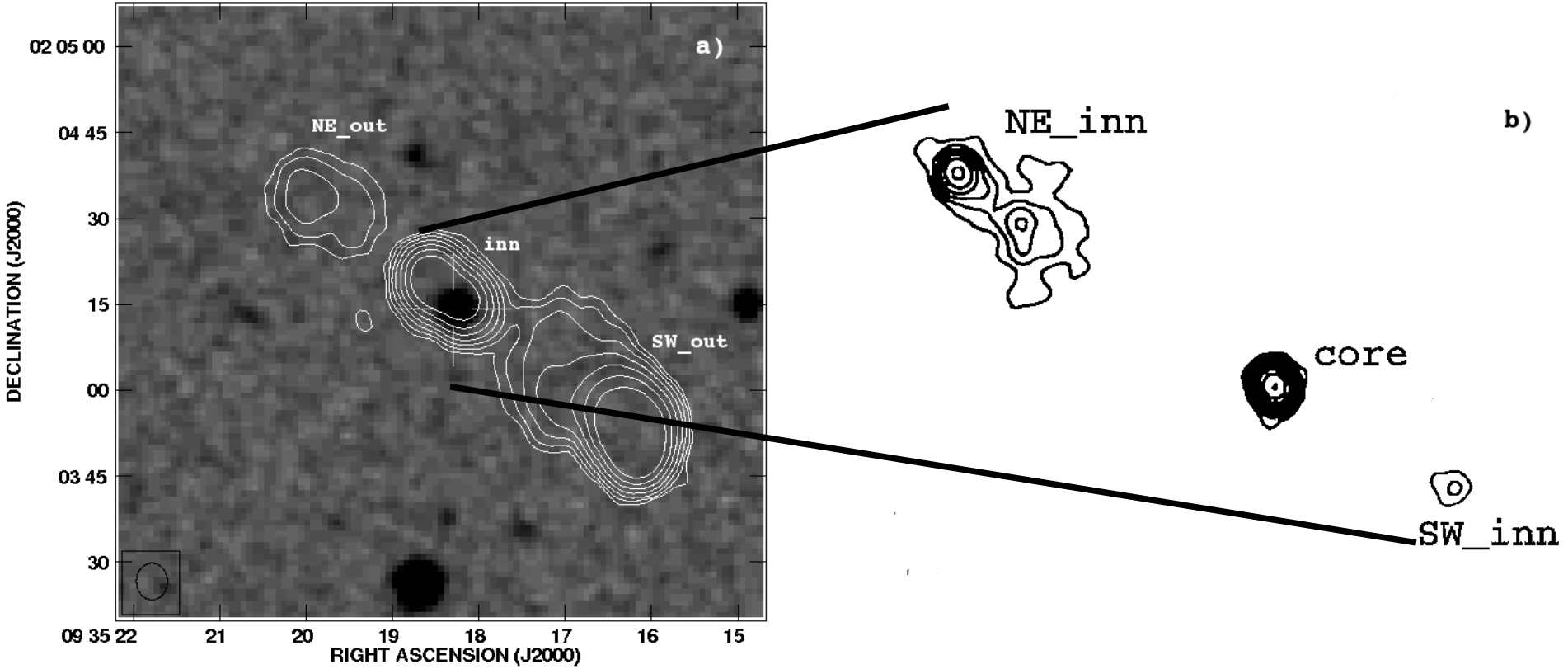
Konar et al. 2012, MNRAS, in print

Table 1: Sources with evidence of recurrent activity

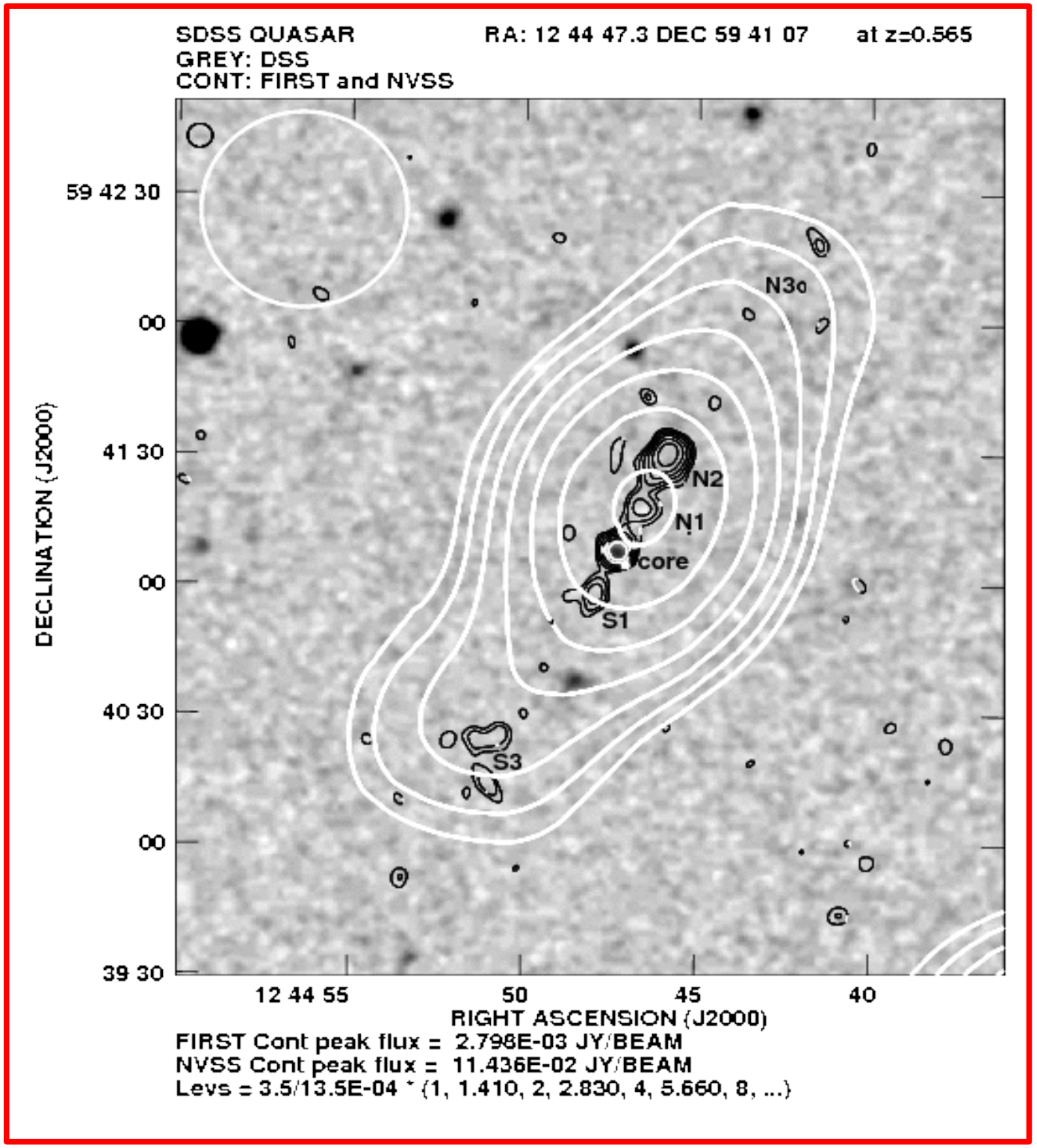
Source	Alt. name	Opt. Id.	Red-shift	l_{in} kpc	l_o kpc	Notes	References
J0041+3224	B2 0039+32	G	(0.45)	171	969	DDRG	1
J0116−4722	PKS 0114−47	G	0.1461	460	1447	DDRG	2
J0821+2117	TXS 0818+214	G	(1.0)	5.4	547	DDRG	19,20
J0840+2949	4C29.30	G	0.0647	36	639	DDRG	18
J0921+4538	3C219	G	0.1744	69	433	DDRG	3,4,5
J0929+4146		G	0.3650	∼30, 652	1875	TDRG	6,39
J0935+0204	4C02.27	Q	0.6491	70	470	DDRQ	16
J1006+3454	3C236	G	0.1005	1.7	4249	DDRG	7,8,9
J1158+2621	4C26.35	G	0.1121	138	483	DDRG	10
J1242+3838		G	0.3000	251	602	DDRG	6
J1247+6723	VII Zw 485	G	0.1073	0.014	1195	DDRG	11,12
J1325−4301	Cen A	G	0.0018	∼12	∼600	DDRG	28,29,30,31,32,40
J1352+3126	3C293	G	0.0450	1.6	190	misaligned DDRG	36,37,38
J1406+3411	3C294	G	1.7790		126	relic X-ray	45,46
J1453+3308	4C33.33	G	0.2481	159	1297	DDRG	6,17
J1504+2600	3C310	G	0.0538	∼90	320	Flatter-α bubbles	25,26
J1548−3216	PKS 1545−321	G	0.1082	313	961	DDRG	13,35,41,43
J1651+0459	Her A	G	0.1540		513	Steep-α relic	23,24
J1835+6204	8C 1834+620	G	0.5194	369	1379	DDRG	6,27,44
J1844+4533	3C388	G	0.0917		∼70	Steep-α relic	21,22
J1959+4044	Cyg A	G	0.0561		136	relic X-ray jet	33,34,42
J2223−0206	3C445	G	0.0562	130	612	DDRG	14,15

Saikia & Jamrozy, 2009, BASI, 37, 63

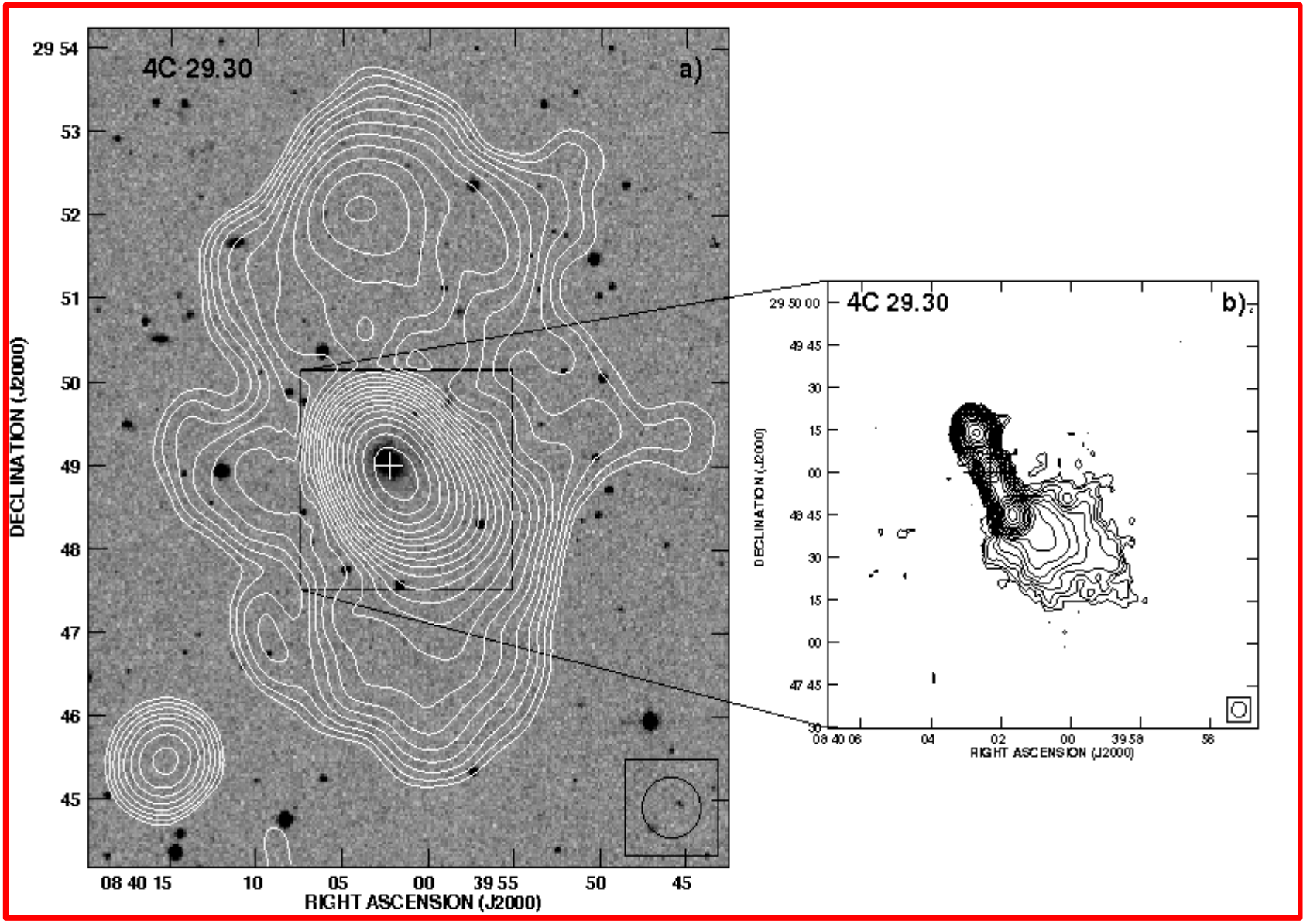
4C02.27 DDRQ



Jamrozy, Saikia, Konar, 2009, MNRAS,399, 141

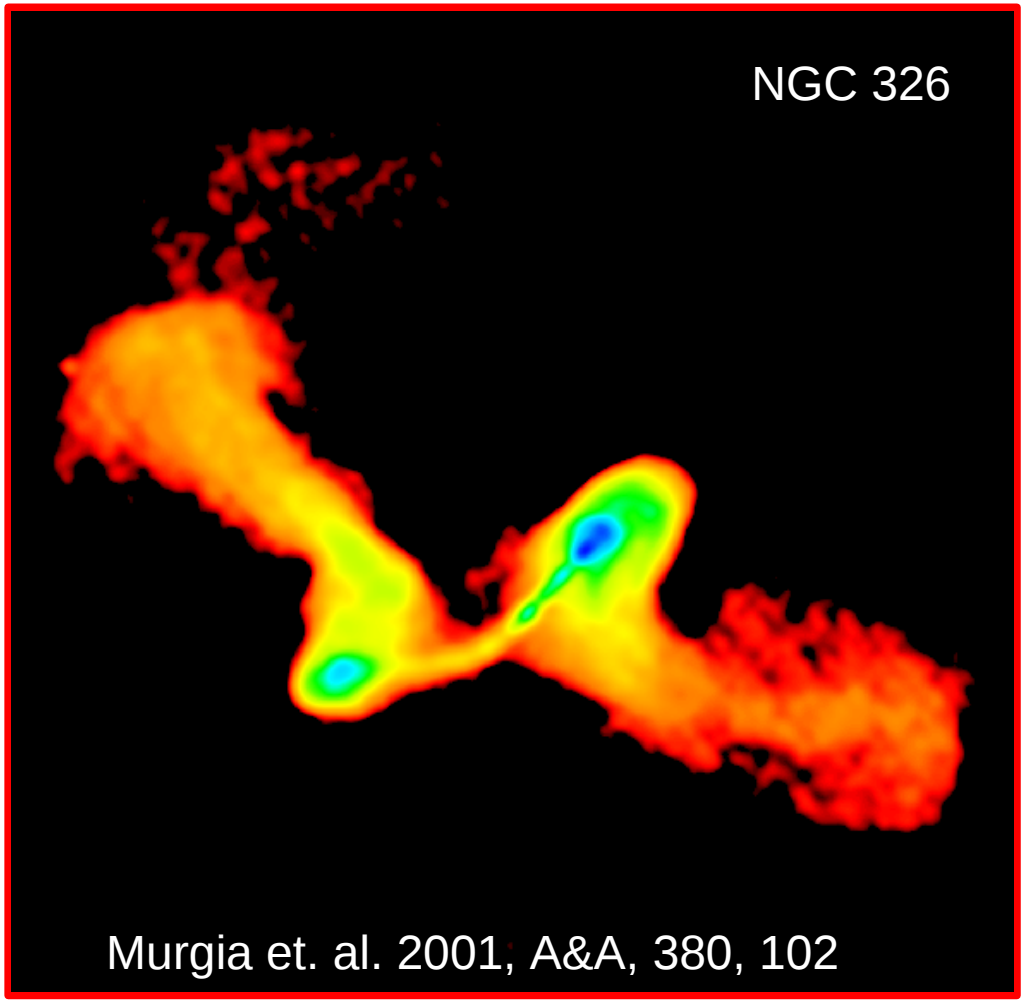


Saikia & Jamrozy, 2009



Jamrozy, Konar, Saikia, Stawarz, Mack, Siemiginowska, 2007, MNRAS, 378, 581

Siemiginowska, et al. 2012, ApJ, 750, 124

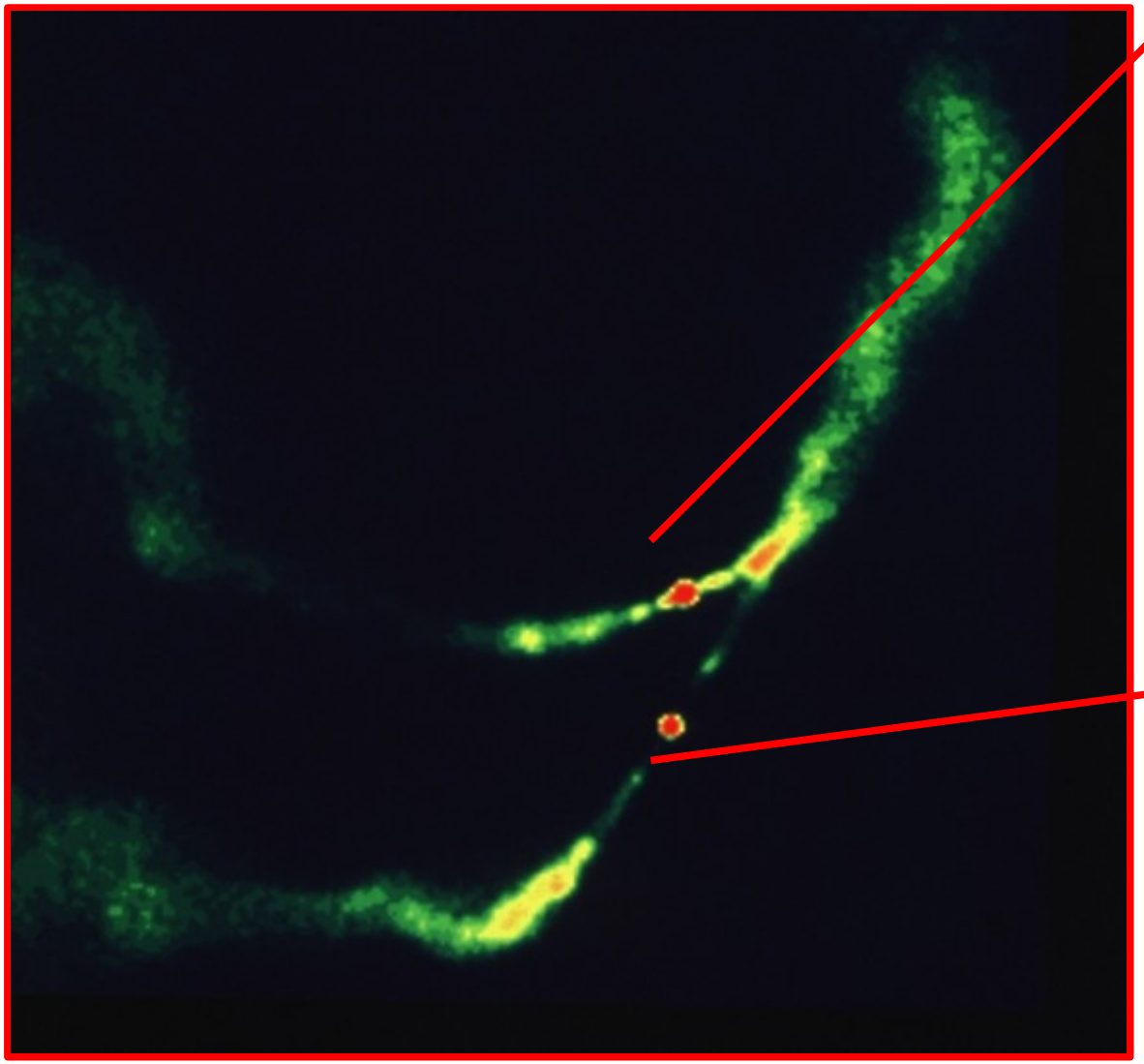


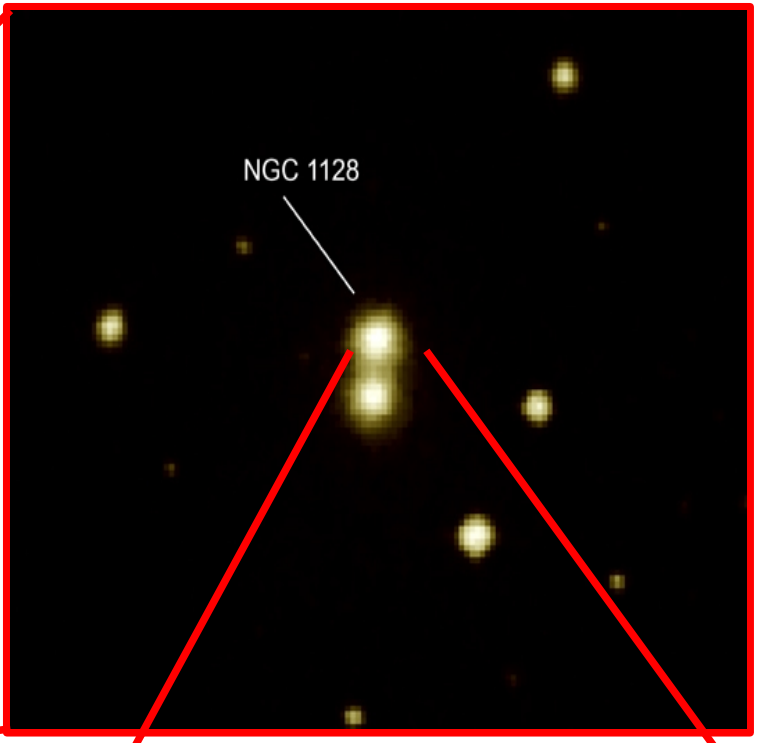
X-shaped sources

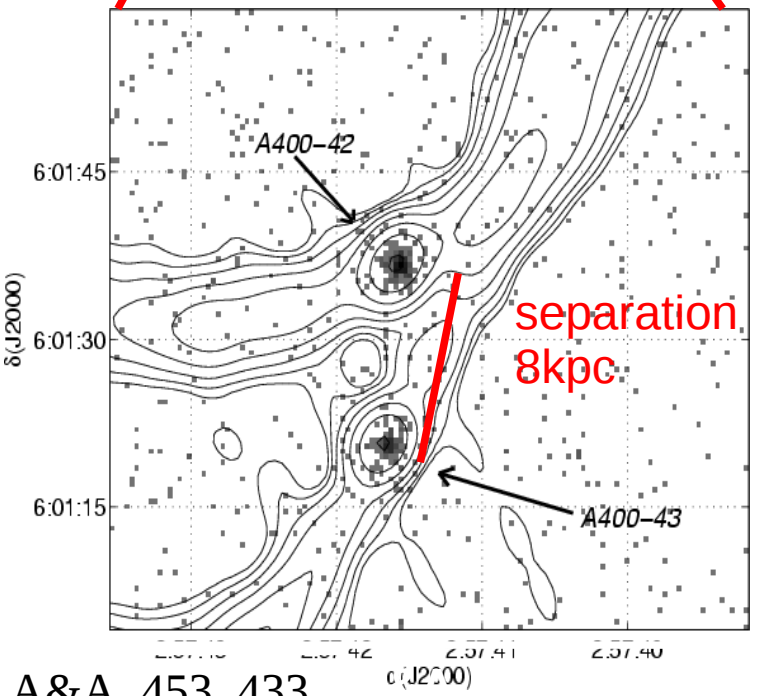
two low-surface-brightness lobes oriented at an angle to the high-surface-brightness radio lobes, giving the total source an `X' shape.

the two pairs of lobes pass symmetrically through the location of the host galaxy.

- backflow (Leahy and Williams 1984),
- buoyancy (Worrall, et al. 1995),
- conical precession (Parma, et al.1985),
- reorientation of the jet axis (e.g. Dennett-Thorpe et al. 2002),
- **existence of an unresolved binary AGN system with two pairs of jets (Lal, Rao 2007).**

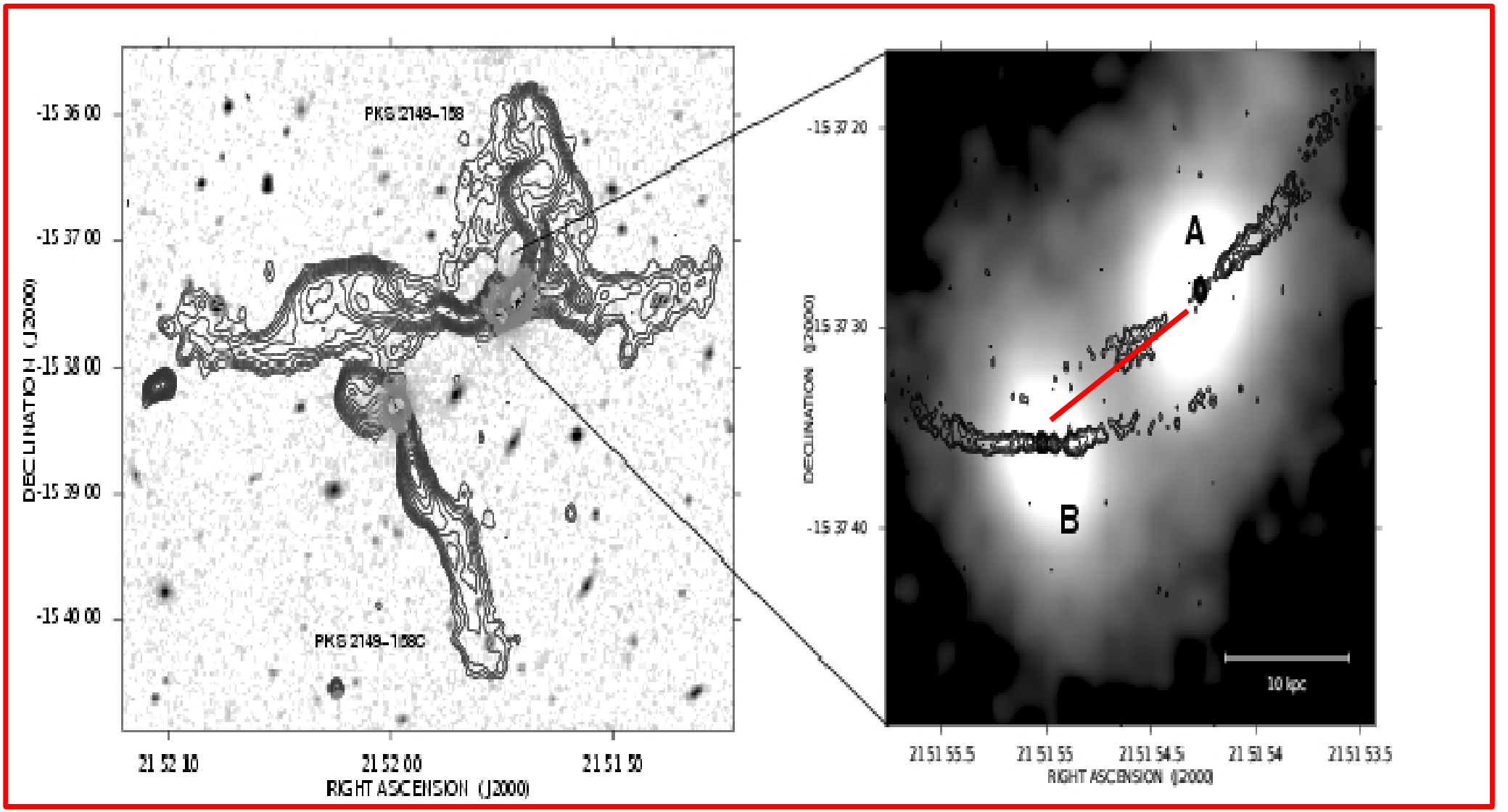






3C75

Hudson et al., 2006, A&A, 453, 433



PKS 2149-158

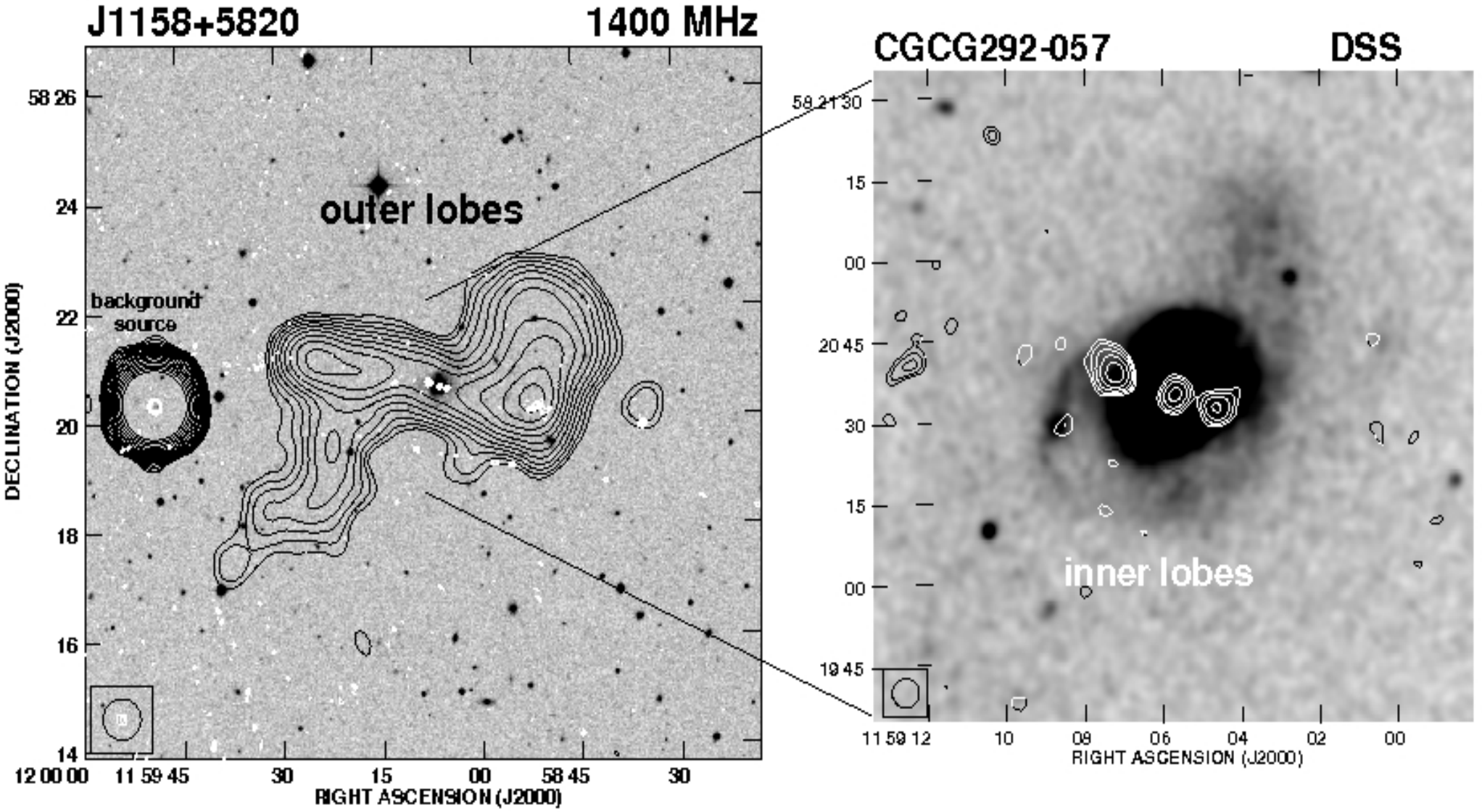
separation 13.5” = 15.8kpc

Guidetti et al., 2008, A&A, 483, 699

All in one

- FRII/FRI
- DDRG
- X-shape
- Recent merger

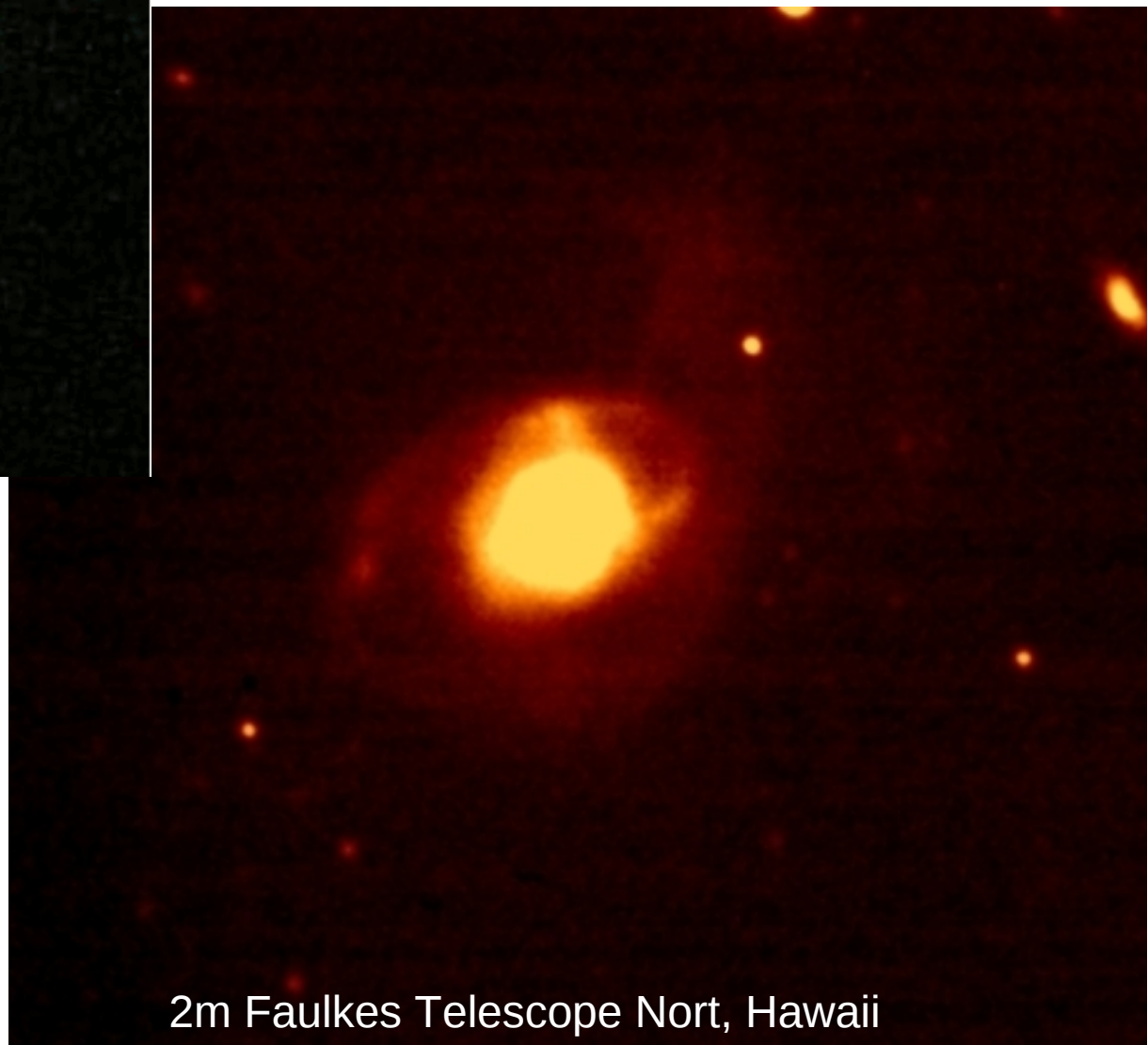
CGCG292-057



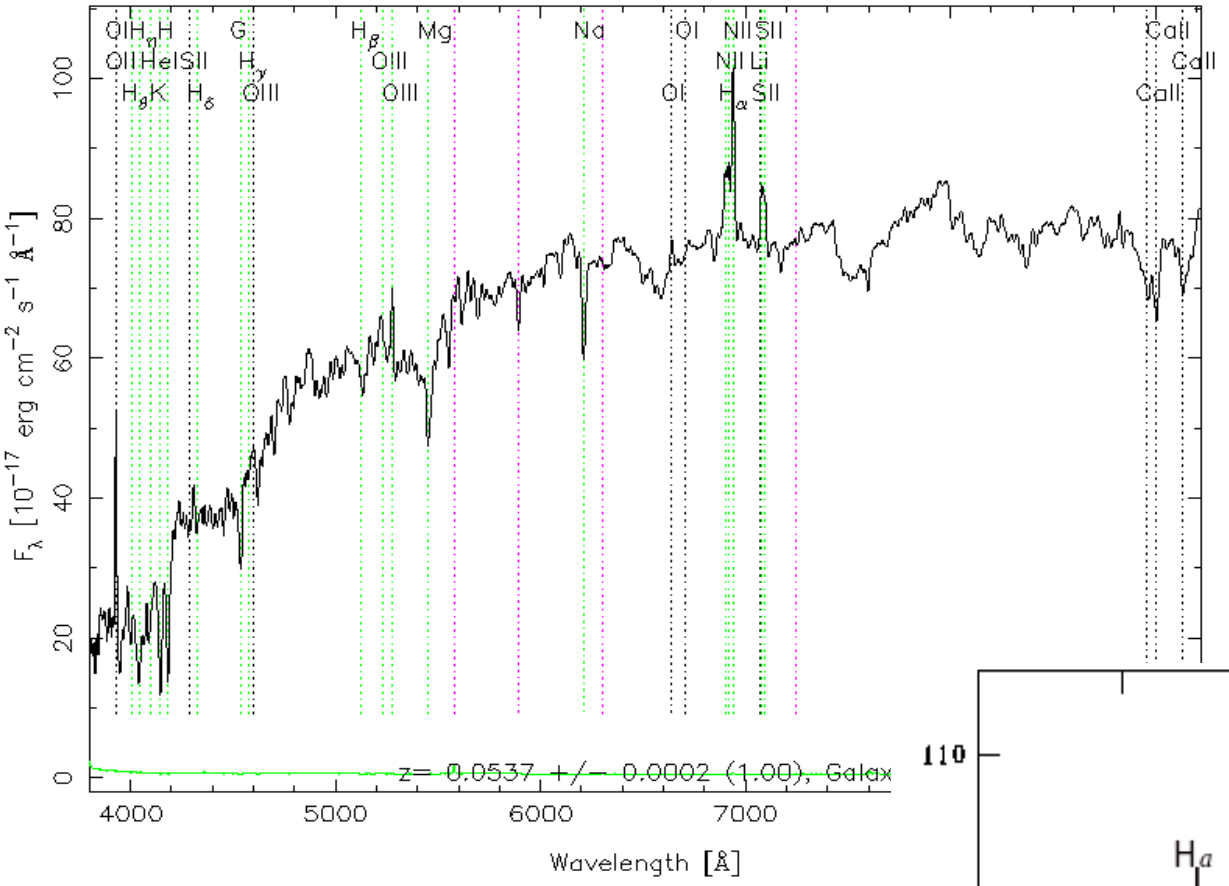
Koziel-Wierzbowska, et al., 2011, MNRAS, 422, 1546,

u 16.85
g 14.97
r 14.13
i 13.68
z 13.38

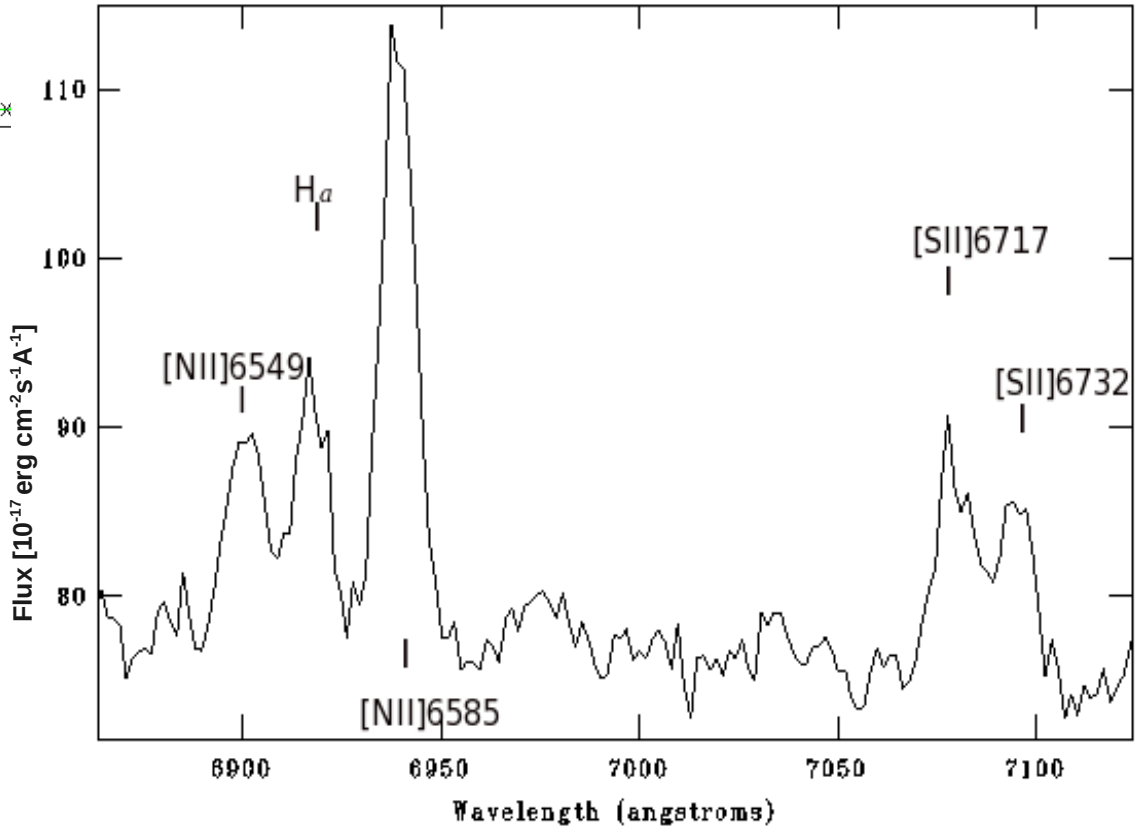
concentration index 2.814
early type gal. < 2.83< late type gal.



RA=179.77364, DEC=58.34322, MJD=52790, Plate=1313, Fiber=441



z = 0.053716

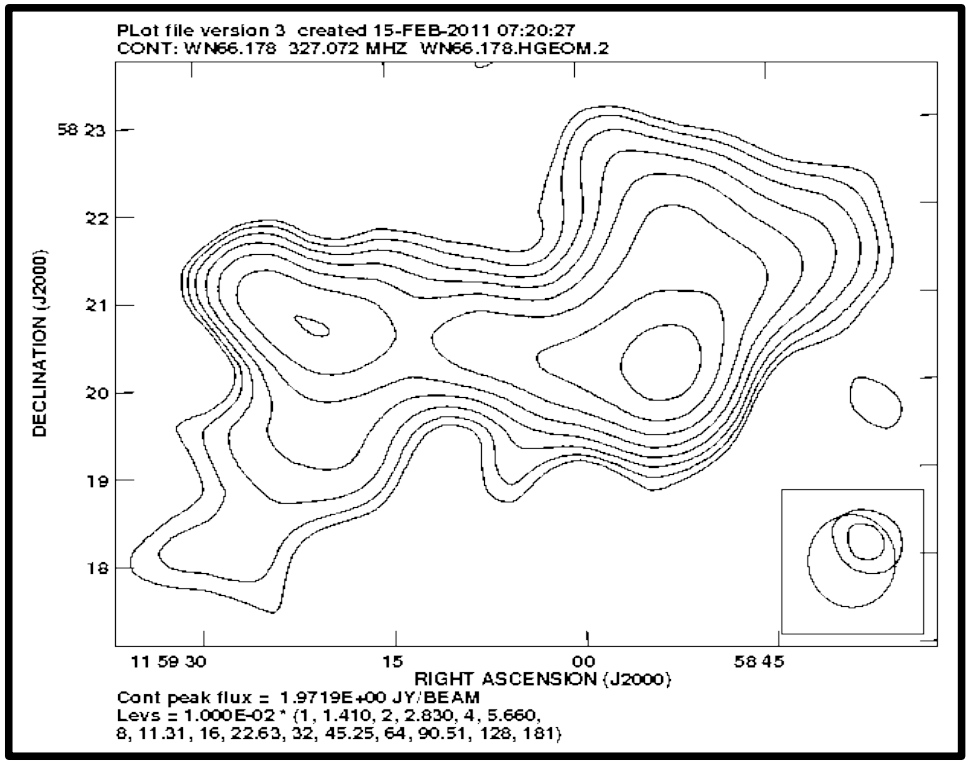


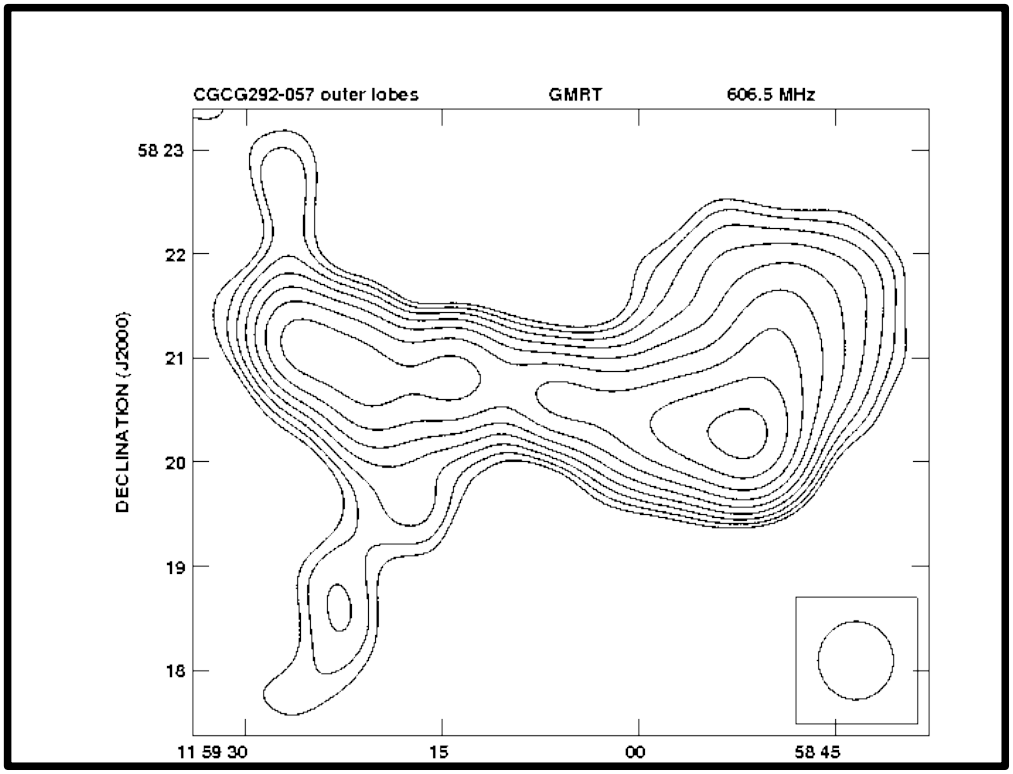
AGN of LINER type

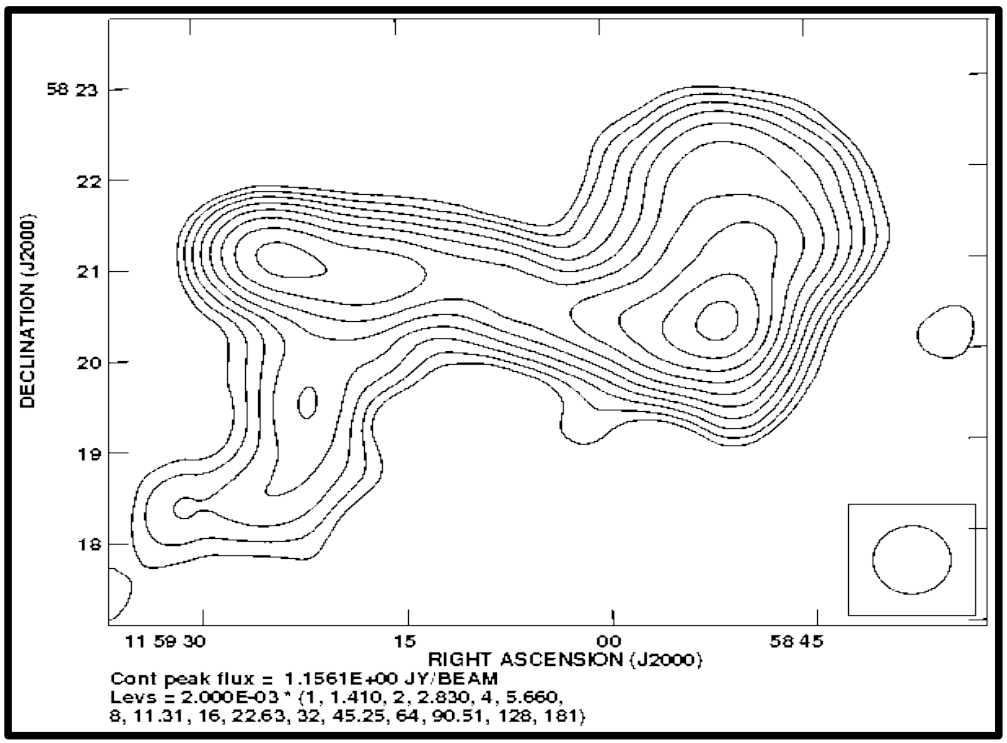
log(BH mass/$M_\odot$) = 8.47+/-0.32

The goal of our study is to understand the relationship between the central AGN and the environment of the galaxy.

CGCG292-057 provides a unique opportunity to measure both the age of the radio source and the star formation history of the galaxy, both of which are connected to the merger history of the galaxy.



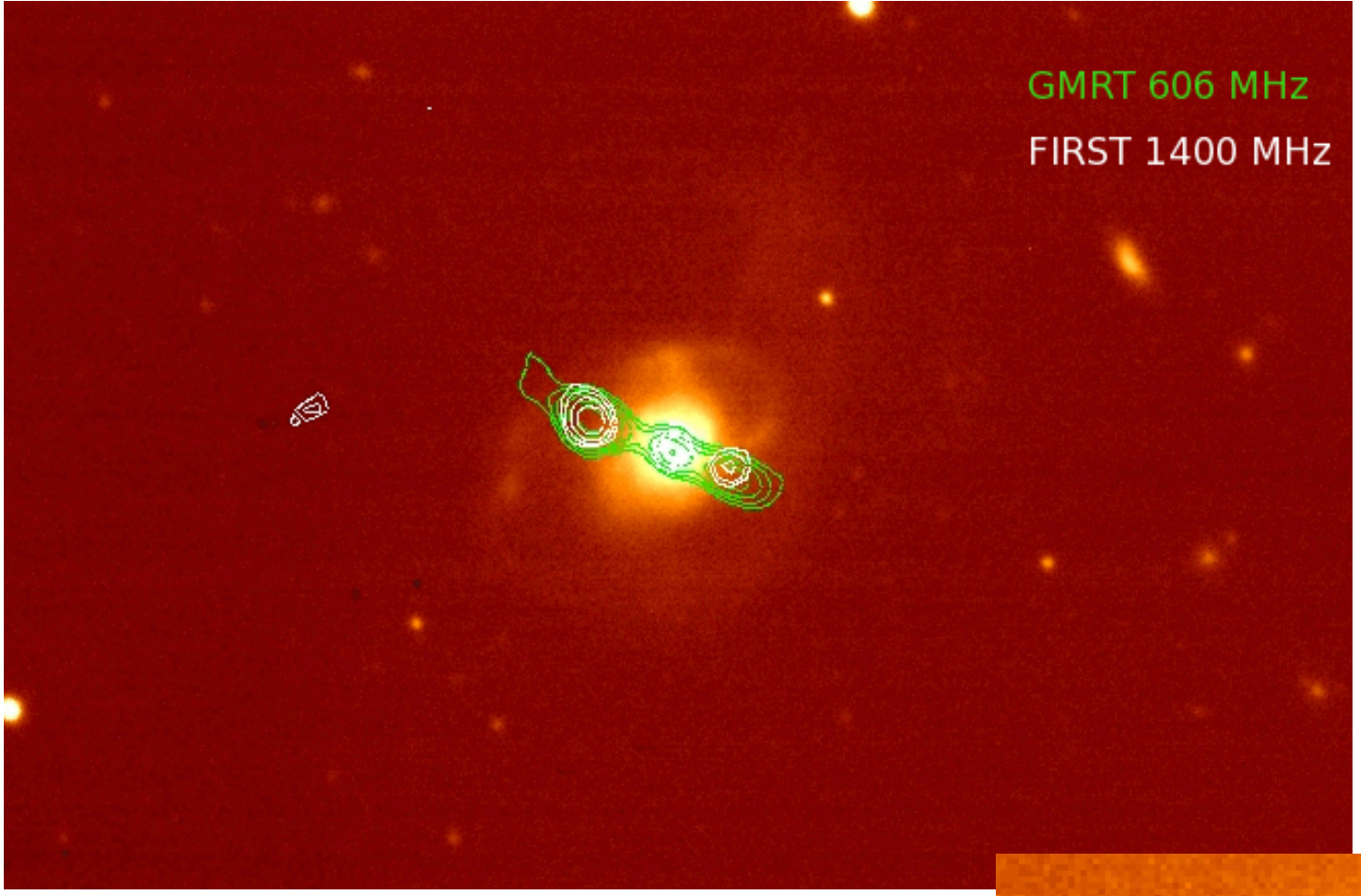


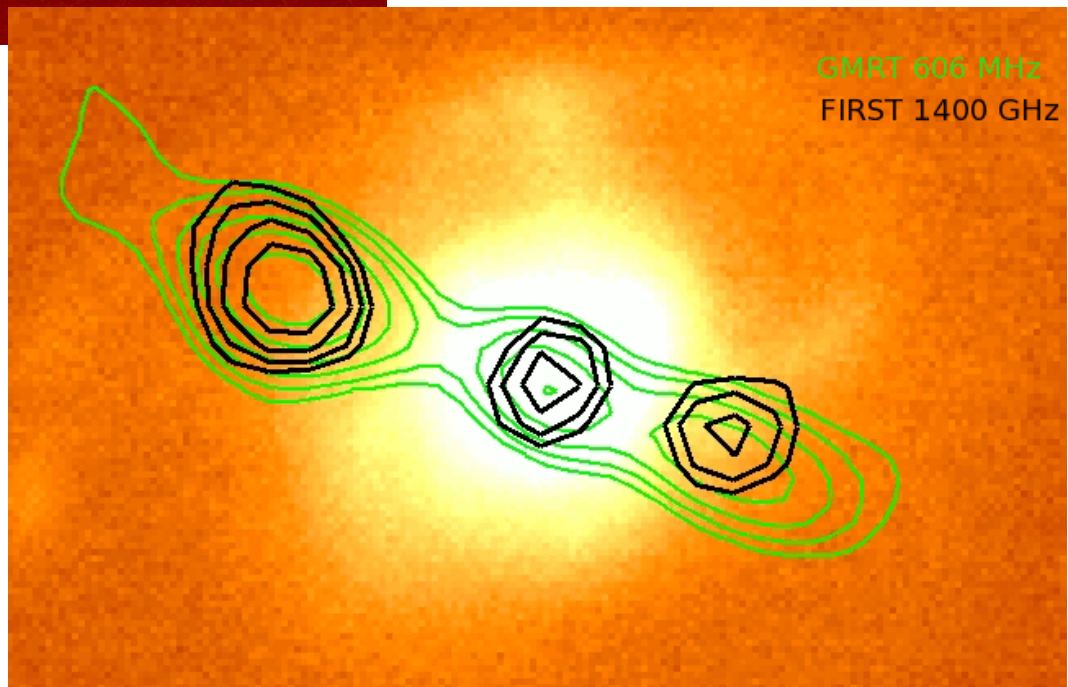


size= 266 kpc

arm-length ratio = 1.17

$\log P_{1.4GHz}$ = 24.33 W/Hz
(below the FRI/FRII luminosity break)





size 23.1 kpc

arm-length ratio 1.54

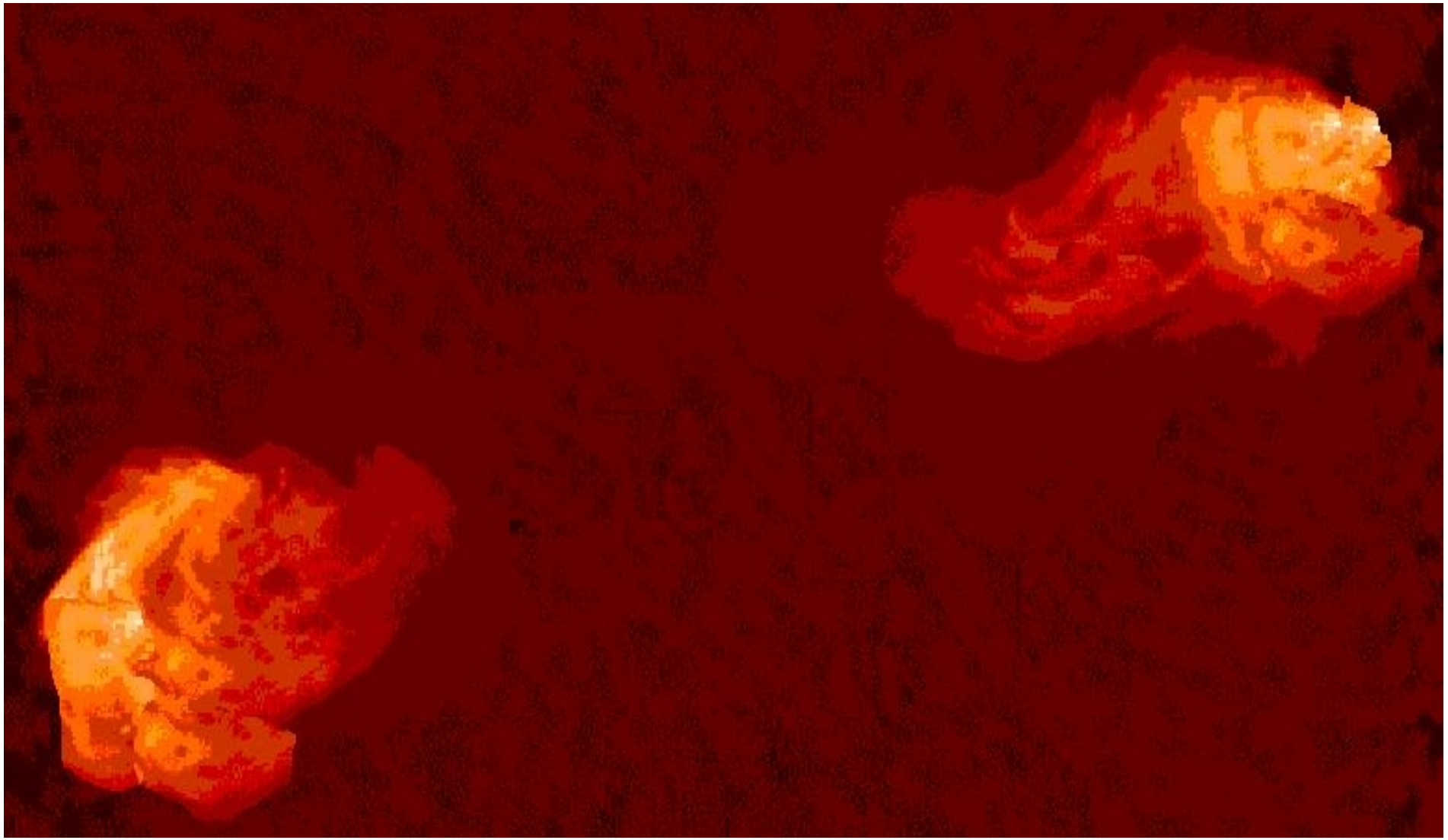
peak-flux ratio 1.50

inclination angle ~79 degr

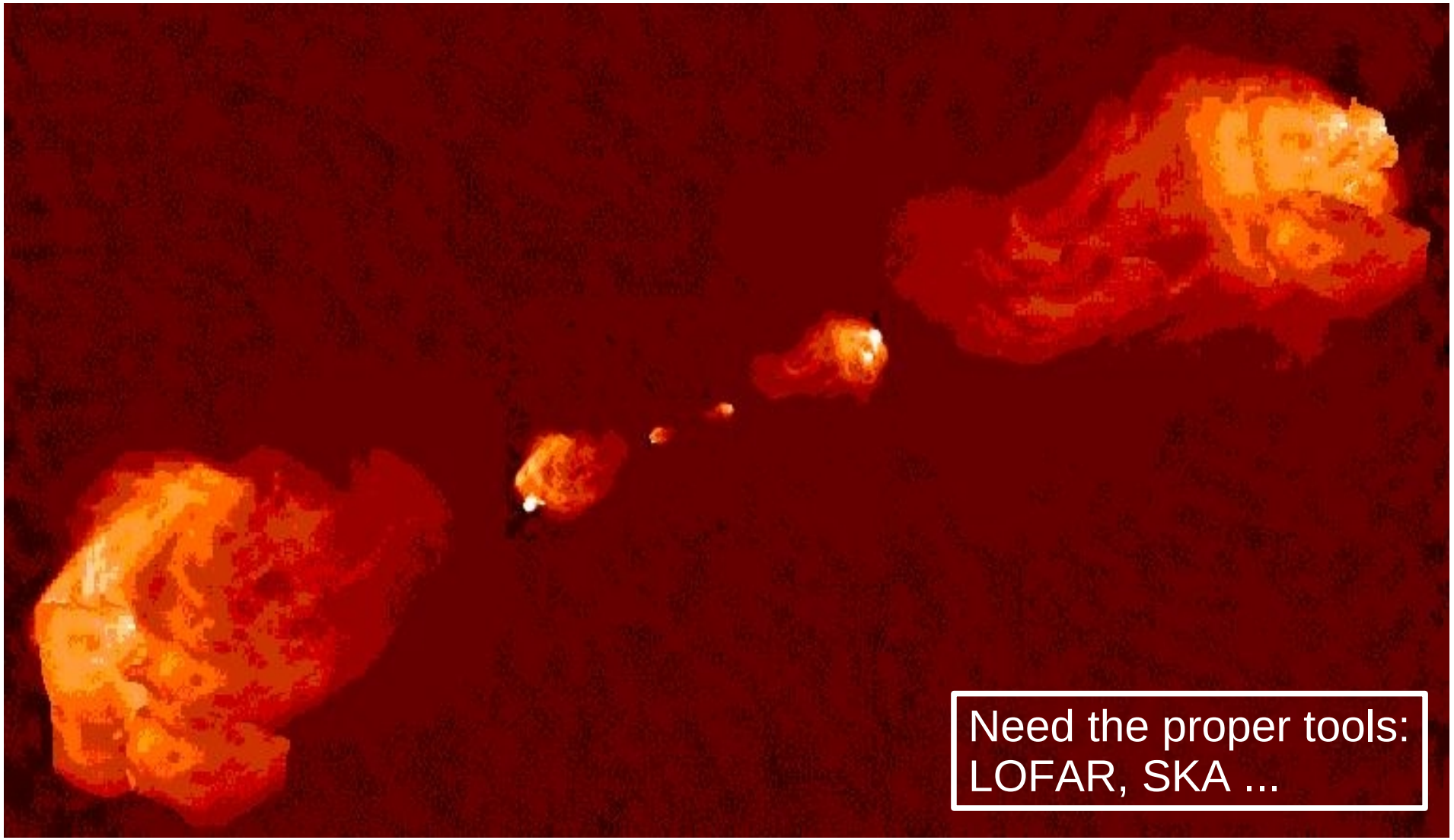
The aim of our work in the radio domain is to obtain physical parameters of the outer an the inner lobes of CGCG292-057 on the basis of a wide range multifrequency radio obsrevations (GMRT and VLA)

- spectra of the outer and inner lobes
- spectral and dynamical age
- injection spectra of each cycle of activity
- time scales of activity and relation to the host galaxy
- interaction of the inner lobes with the ISM

Dying Cygnus A



Reincarnated Cygnus A



Thank you