New results on the parsec-scale properties of the Bologna Complete Sample

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The Bologna Complete Sample

B2 and 3CR radio sources with $z < 0.1$

B2: $S(408) > 0.25$ Jy
3CR: $S(178) > 10$ Jy
Declination greater than 10^{o}
Galactic latitude $|b|$ larger than 15^{o}

Being selected at low frequency it is not affected by observational biases related to orientation effects.

Nearby sources: good linear resolution; high + low power
$z = 0.1$ ➔ 1 mas = 1.8 pc
VLBI data are available now for 77/94 sources (core > 5 mJy)
Giovannini et al. ApJ 552, 508; ApJ 618, 635;
Liuzzo et al. in preparation

The large scale morphology of observed sources is:
51 FR I -- 14 FR II -- 12 compact sources

-Two-sided sources on the pc scale are 30 %

-Consistent with a j/cj ratio R ≤ 5 if jet velocity = 0.9 – 0.99c

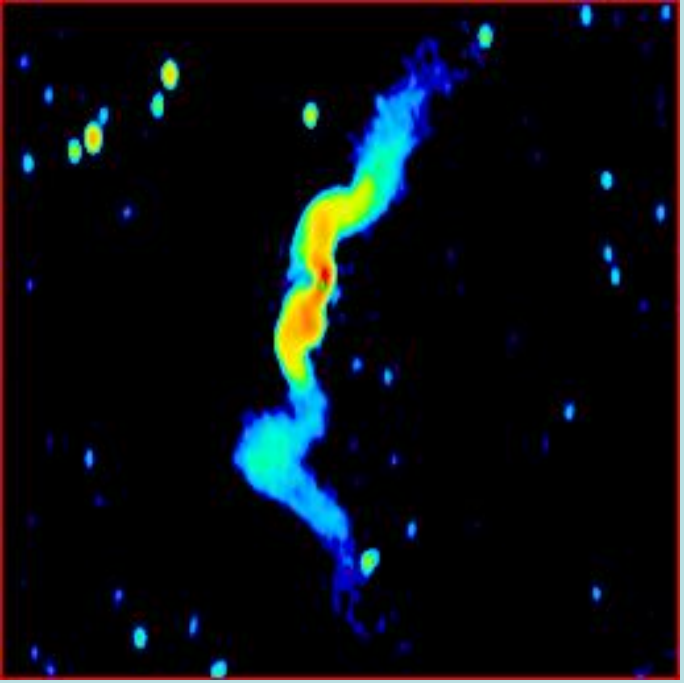
- pc scale jets move at high velocity.
No correlation has been found with core or total radio power

- All FR II two-sided are NLRG.

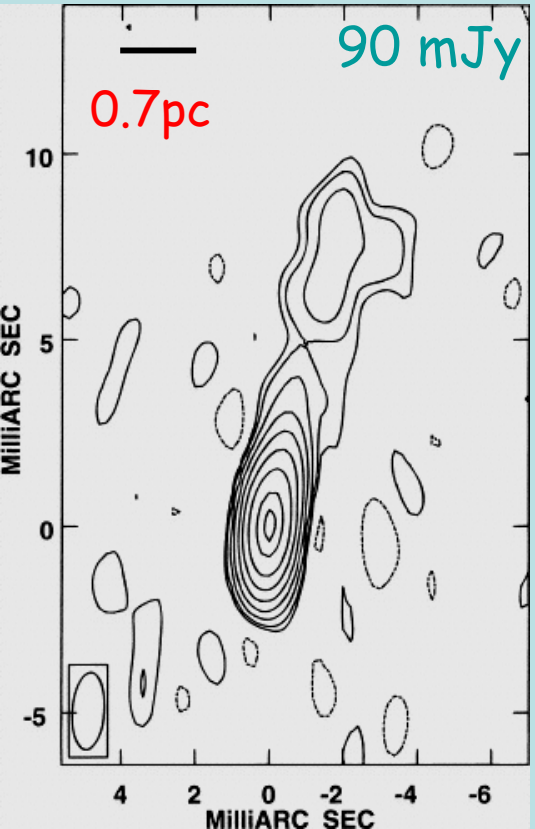
-Two-sided sources show low power radio cores.

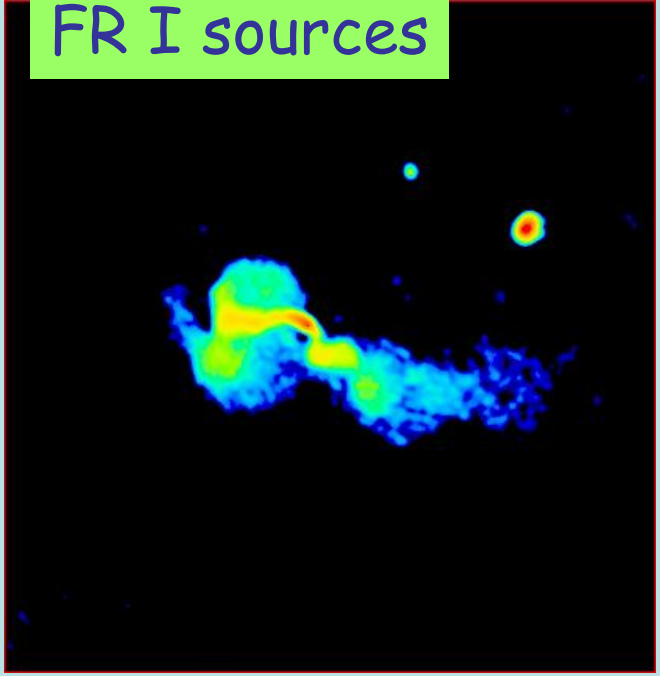
- In most sources there is a good agreement between the pc-kpc scale jet orientation

FR I sources

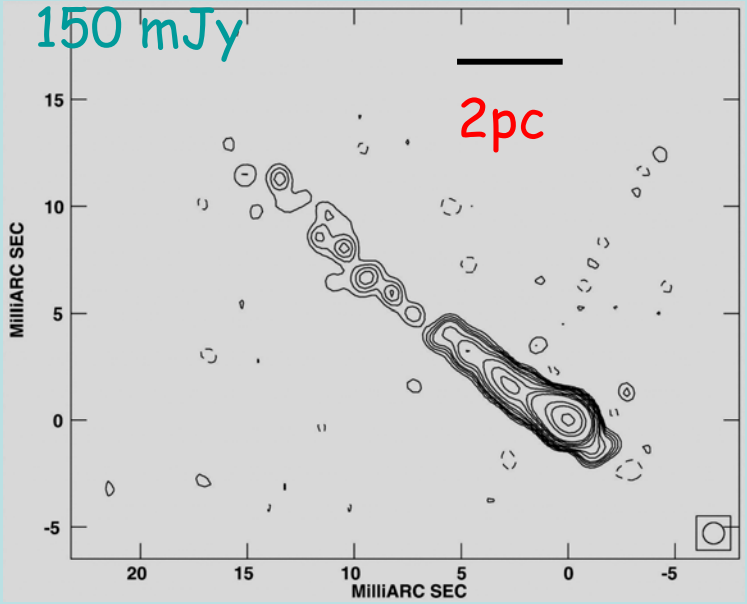


3C 31

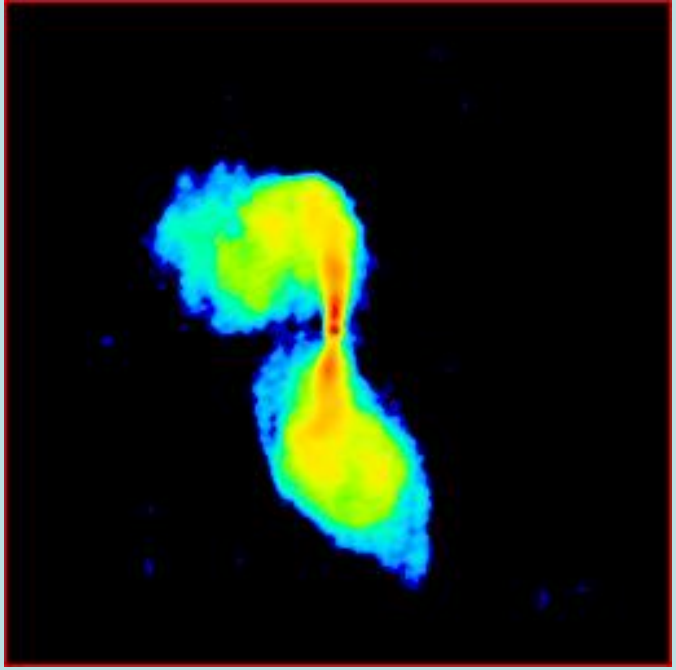




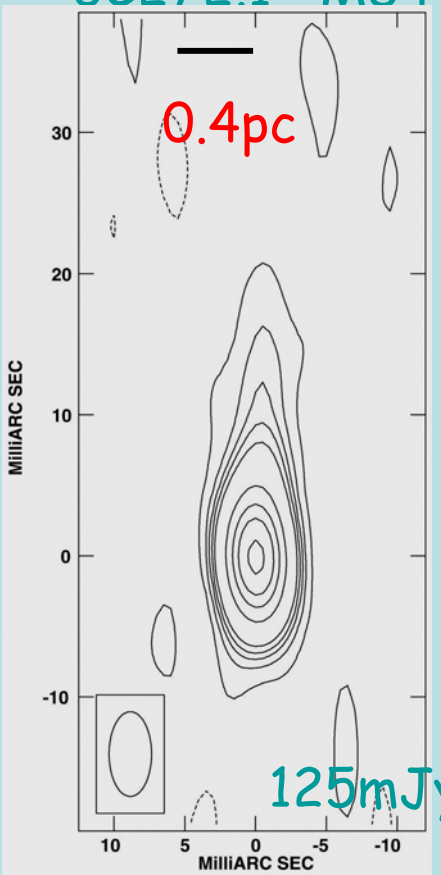
3C66B



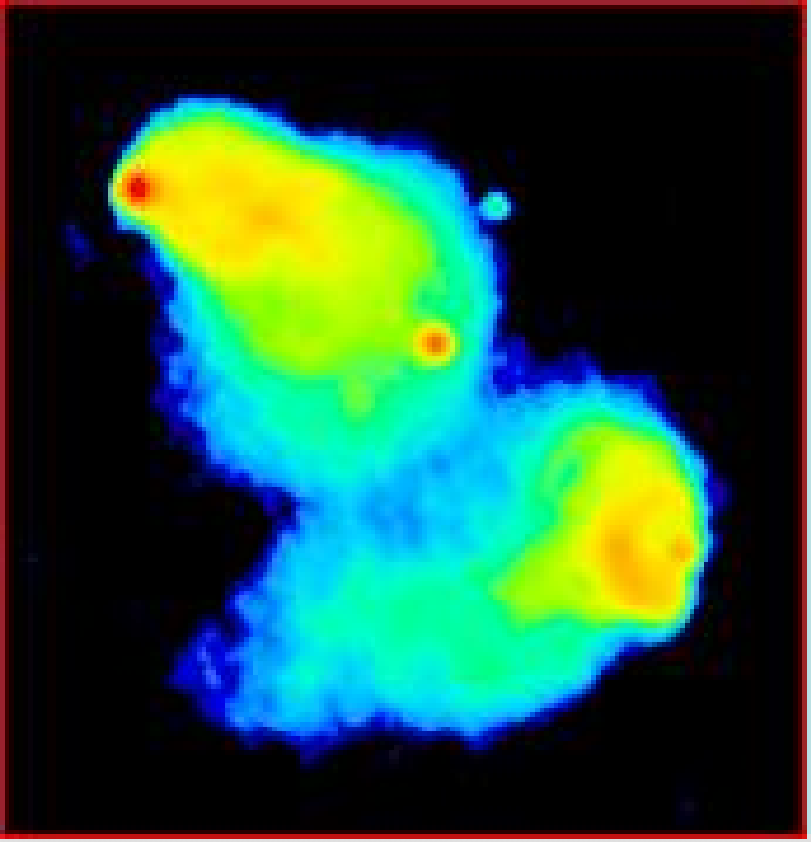
Opt. + IR jet

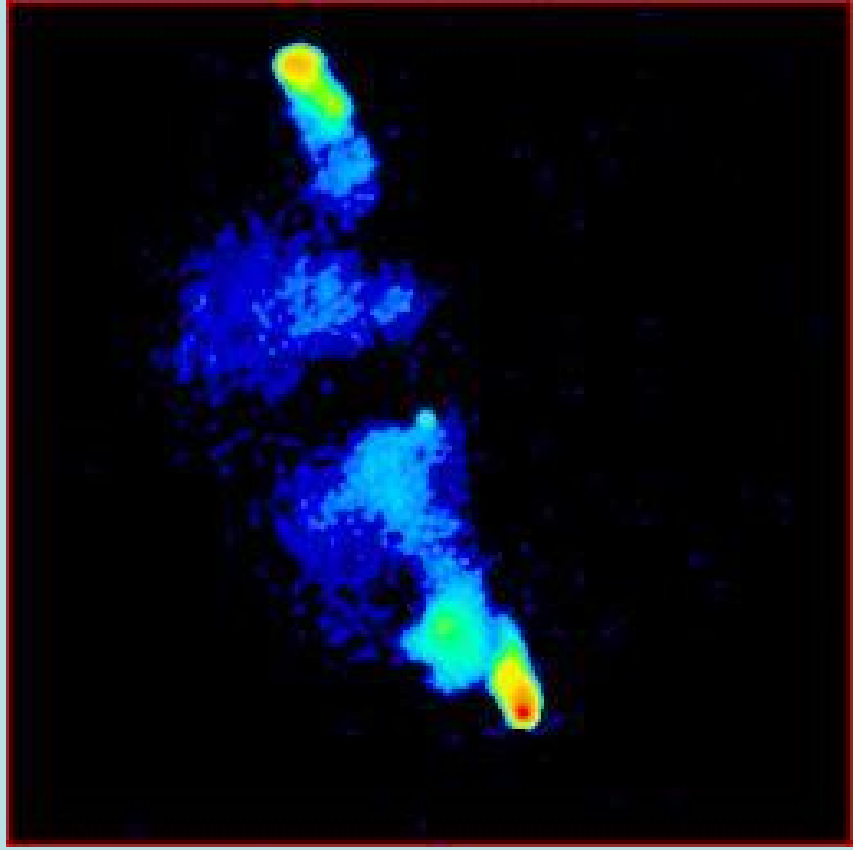


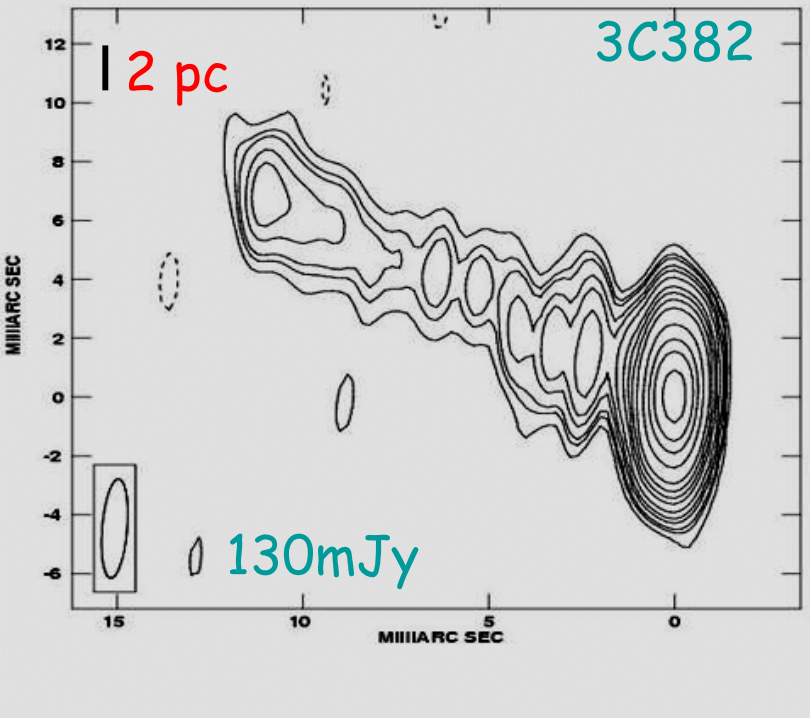
3C272.1 M84



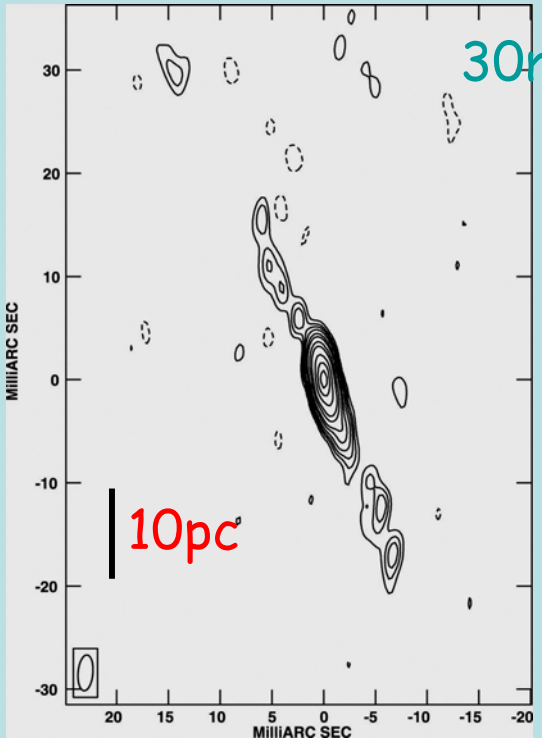
FR II

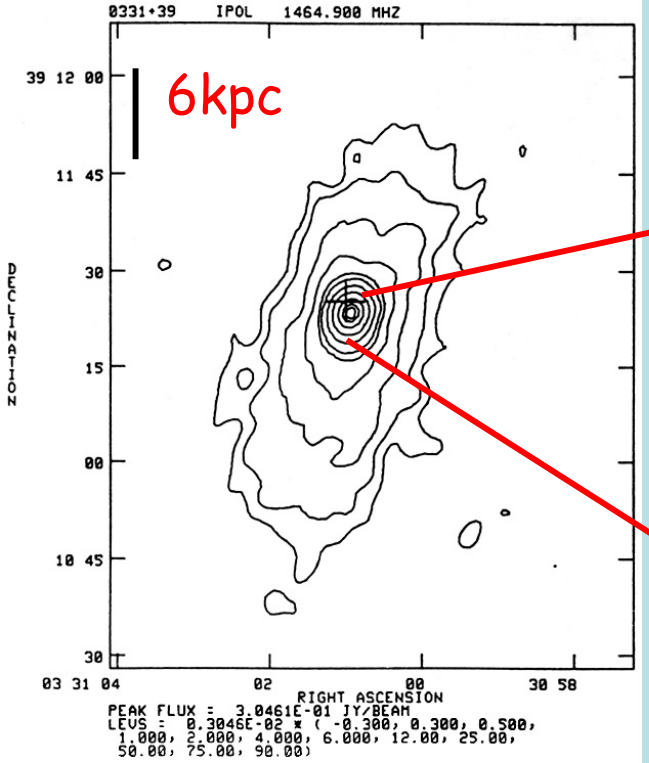


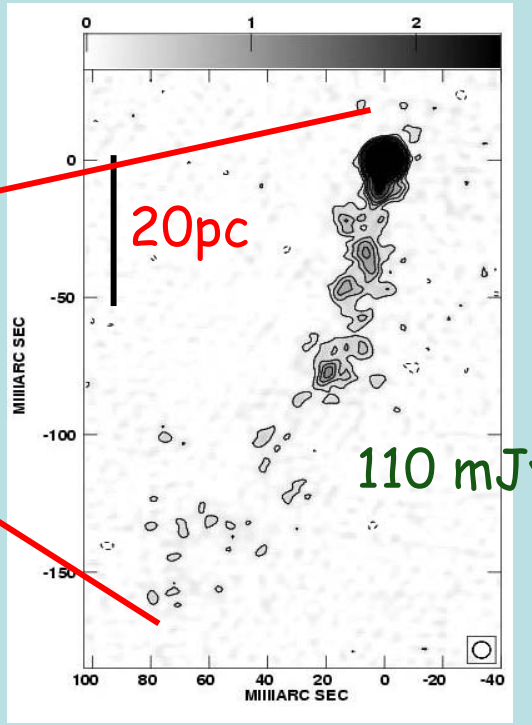



3C382
2 pc
130mJy
MilliARC SEC
MilliARC SEC

3C33

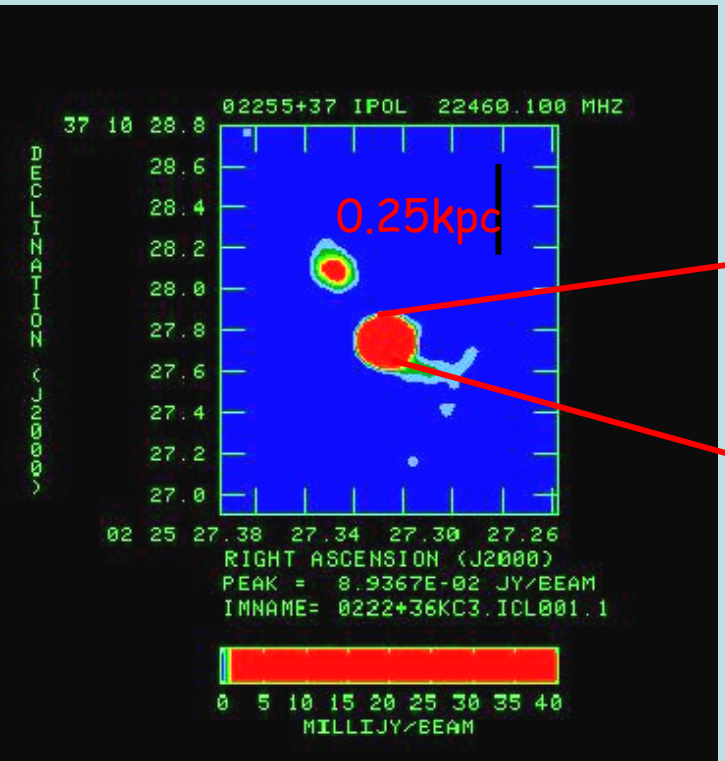

30mJy
10pc
MilliARC SEC
MilliARC SEC

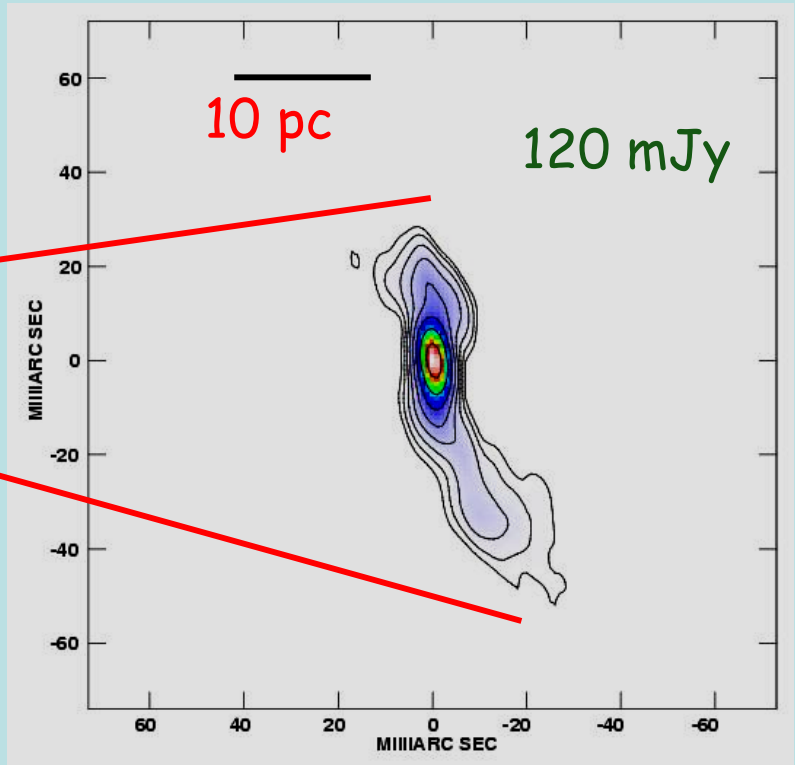




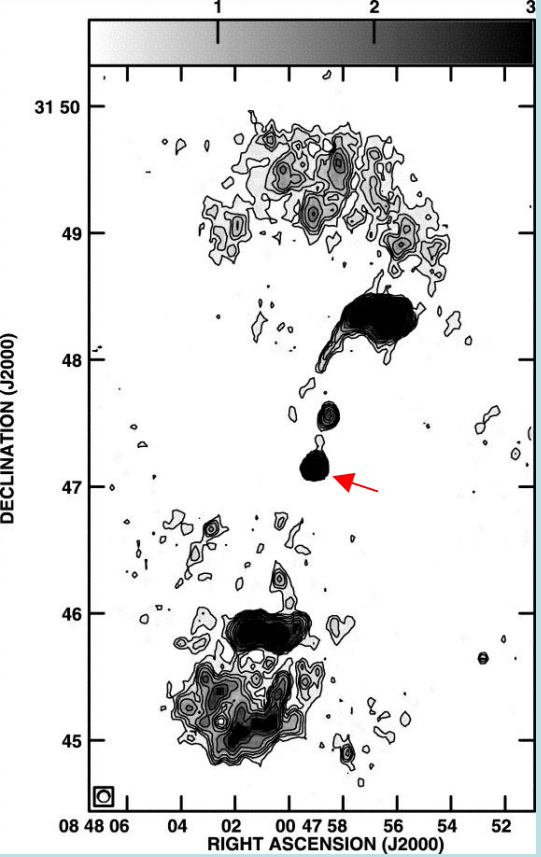
0331+39

Compact

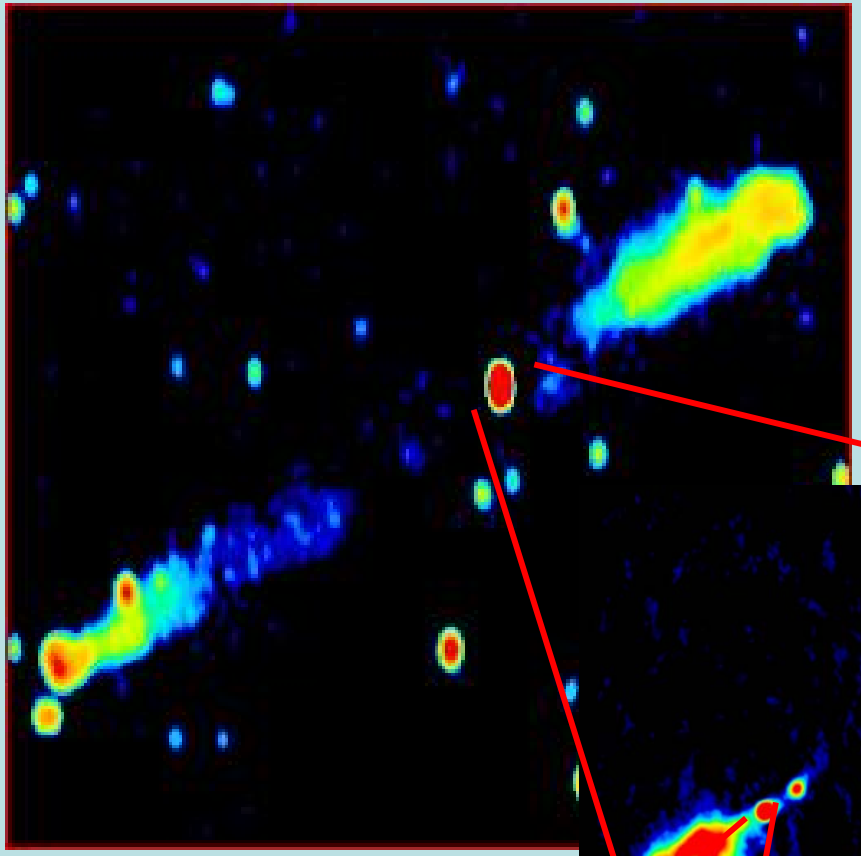




0222+36

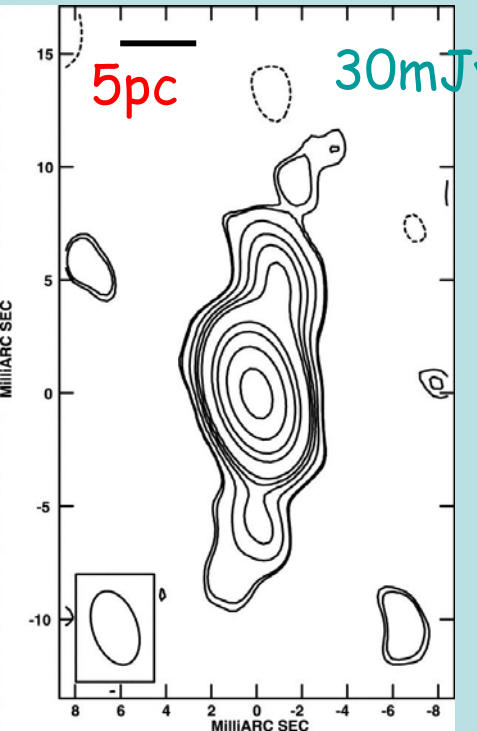


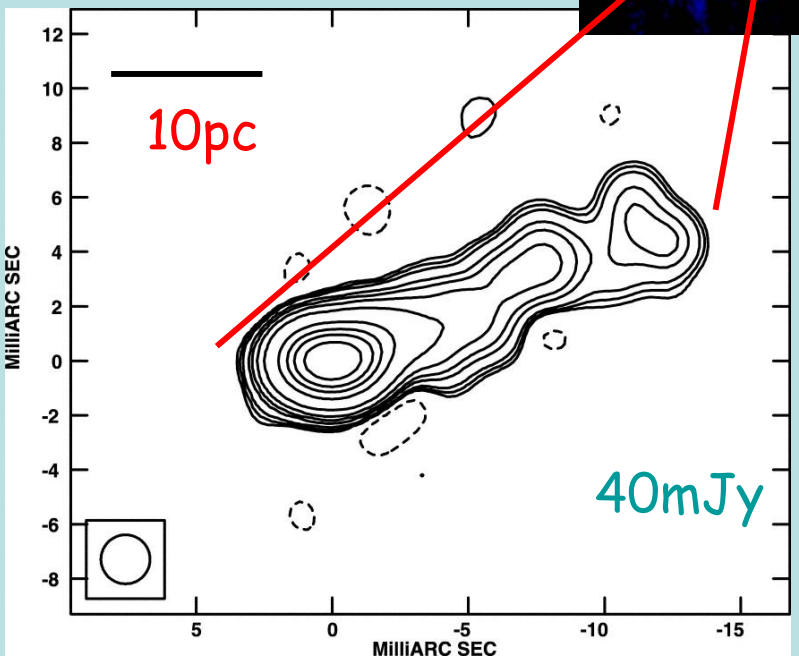
0844+31



3C236
The largest radio galaxy (more than 4 Mpc)

Restarted





Sources with a faint radio core:

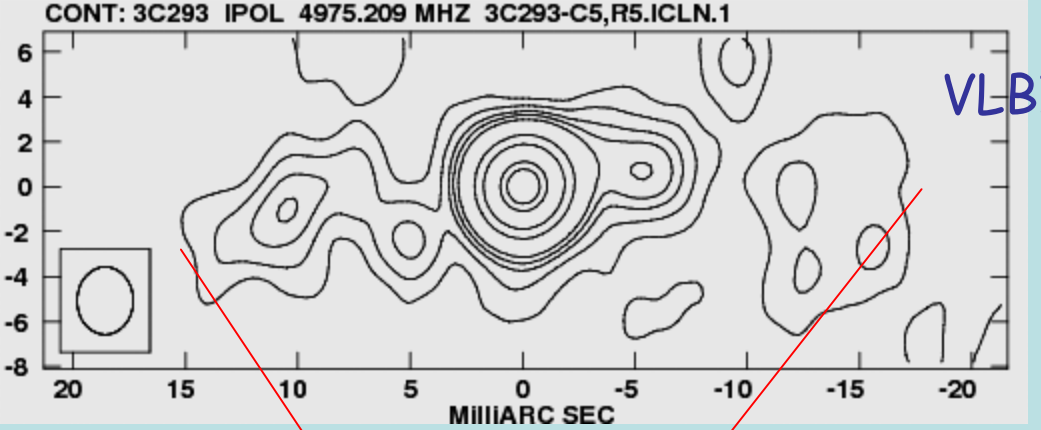
more complex structures

-- restarted activity
-- different orientation angle between pc and kpc structure
-- complex pc scale structure with no dominant core

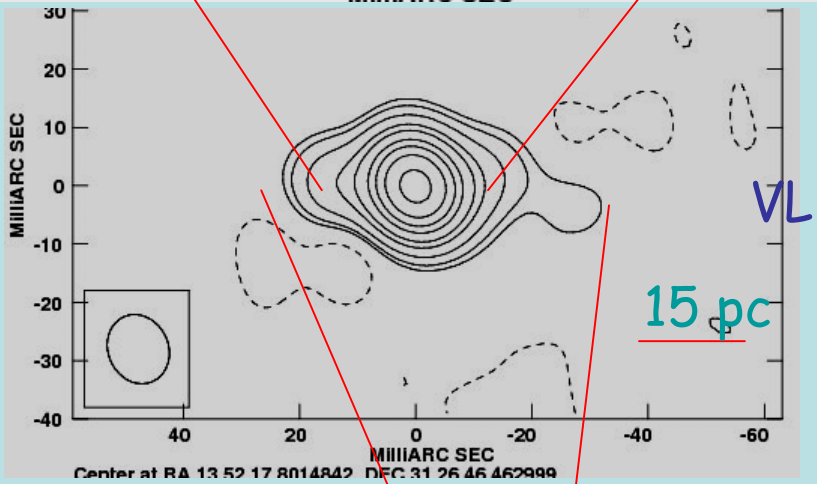
A statistical problem or we are starting to study sources with different properties?

Different ambient medium (e.g. galaxy cluster), Is it important? See talk by Liuzzo, yesterday, on BCG

3C 293



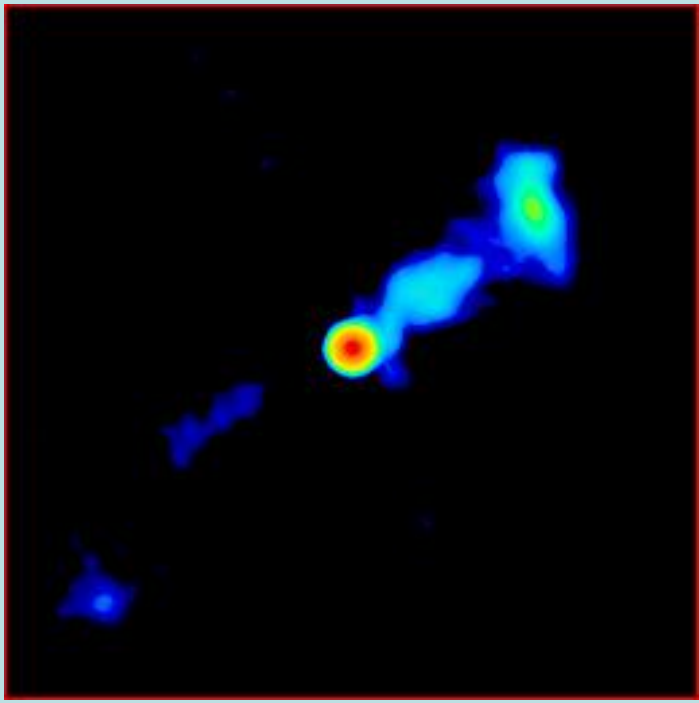
VLBI at 6 cm

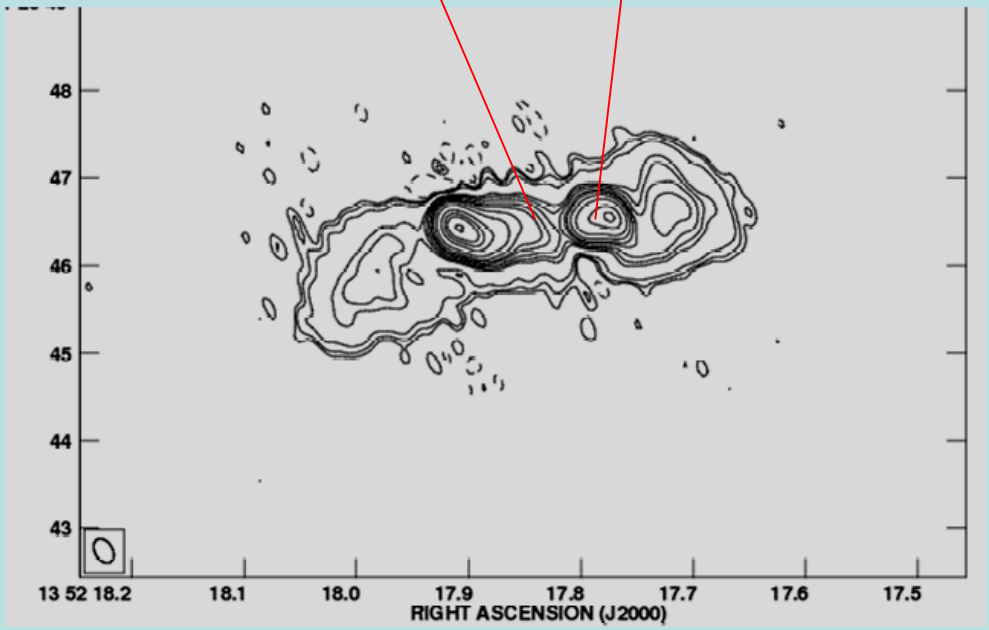


VLBI at 20 cm

15 pc

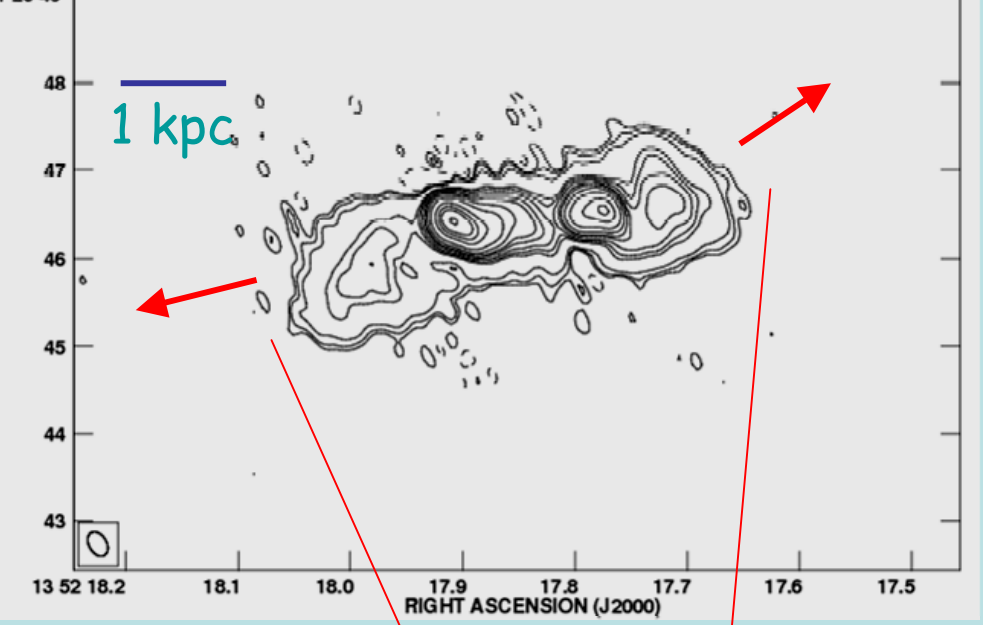
VLA

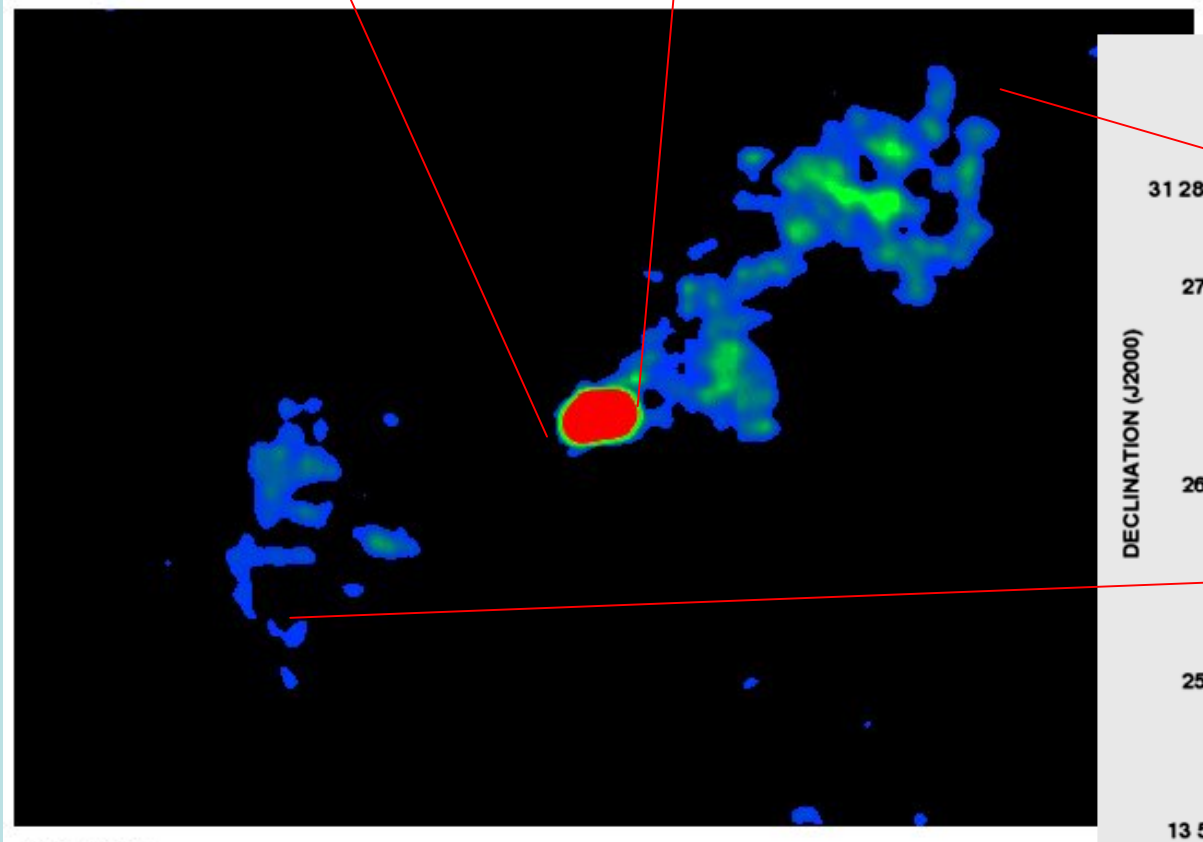




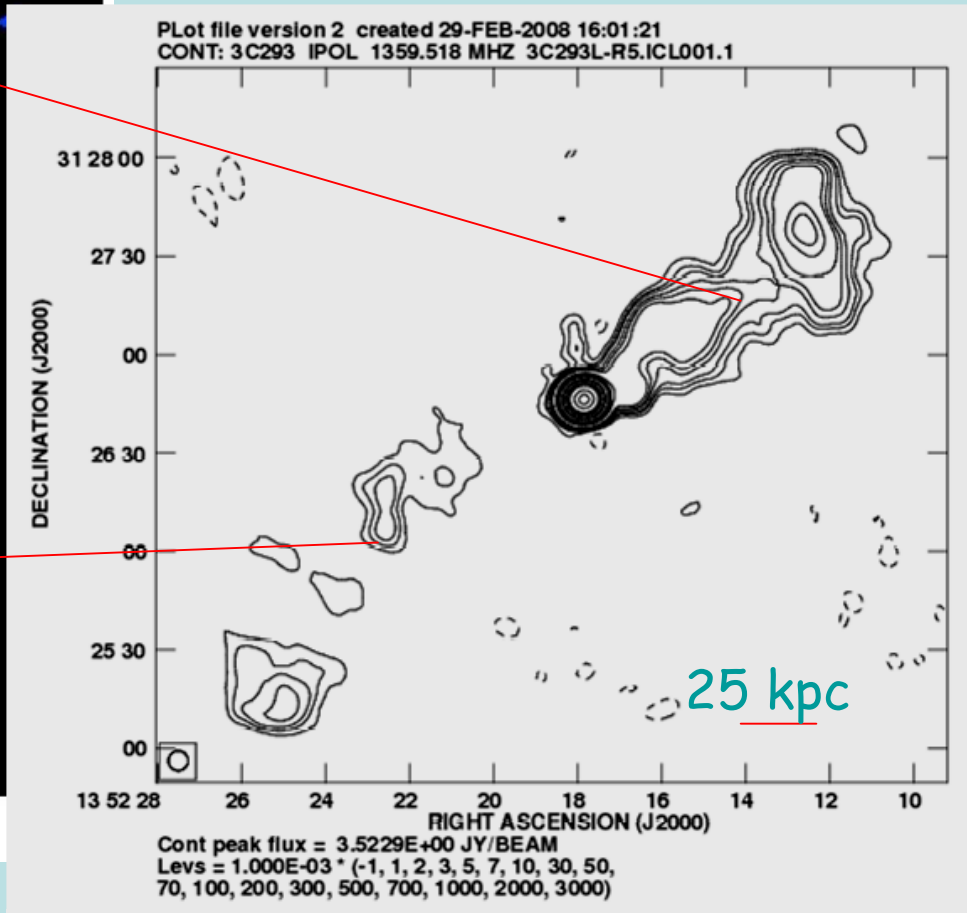
VLA + VLBA_Pt at 6 cm

Van Breugel et al. 1984 discussed the evidence of a rotating disk.
Beswick et al., 2004 found HI in rotation within 400 pc.
After being slowed down the jet may be bent by a fast rotating gas disk.
But highly relativistic two-sided jets are on the plane of the sky and strongly de-boosted, if slow-down, should become brighter.



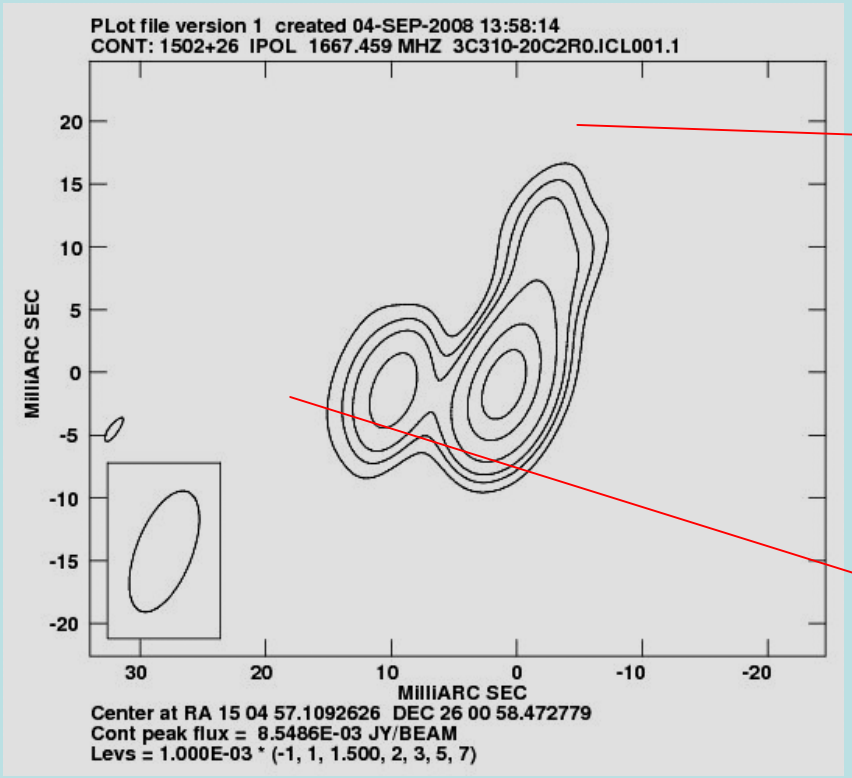


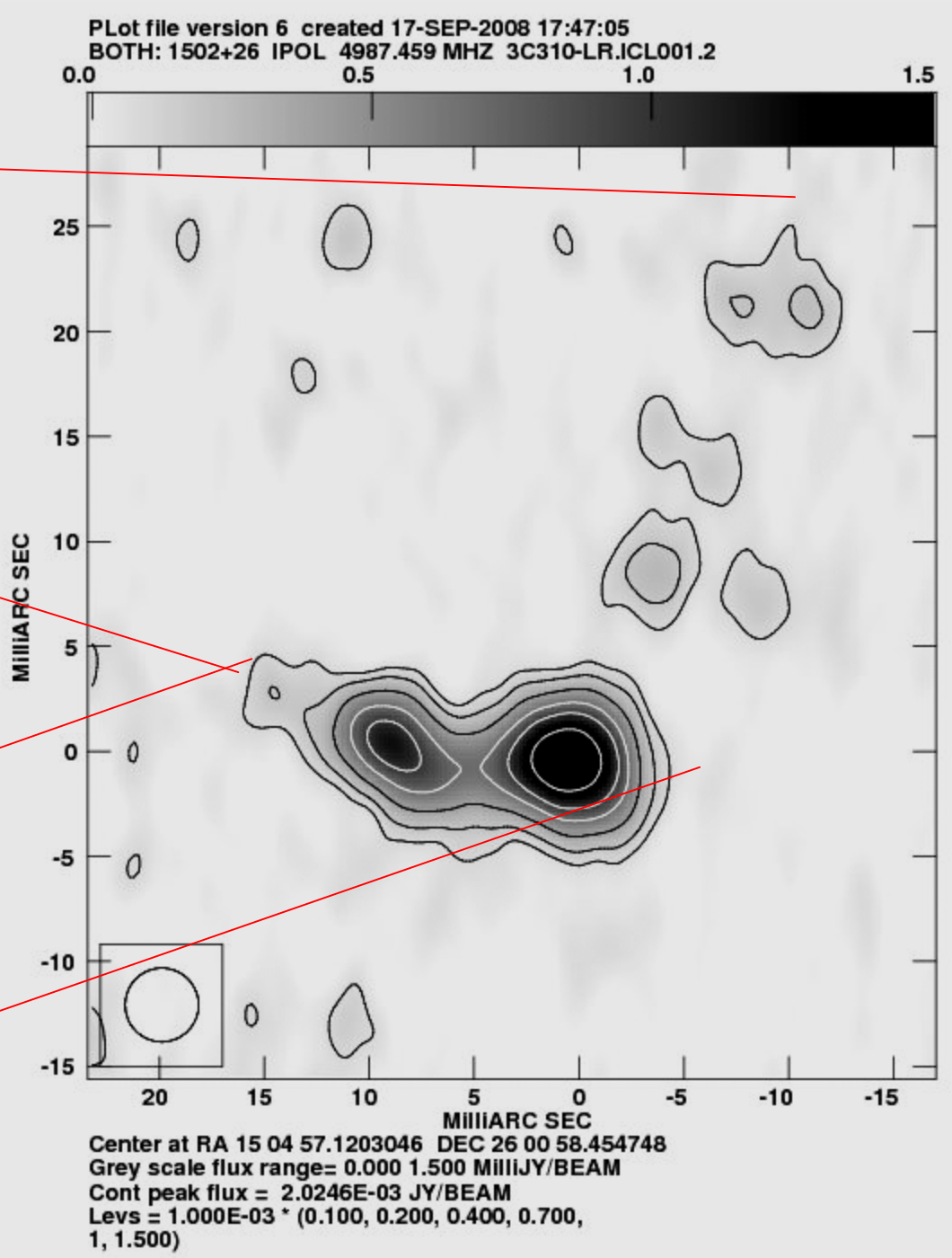
3C293

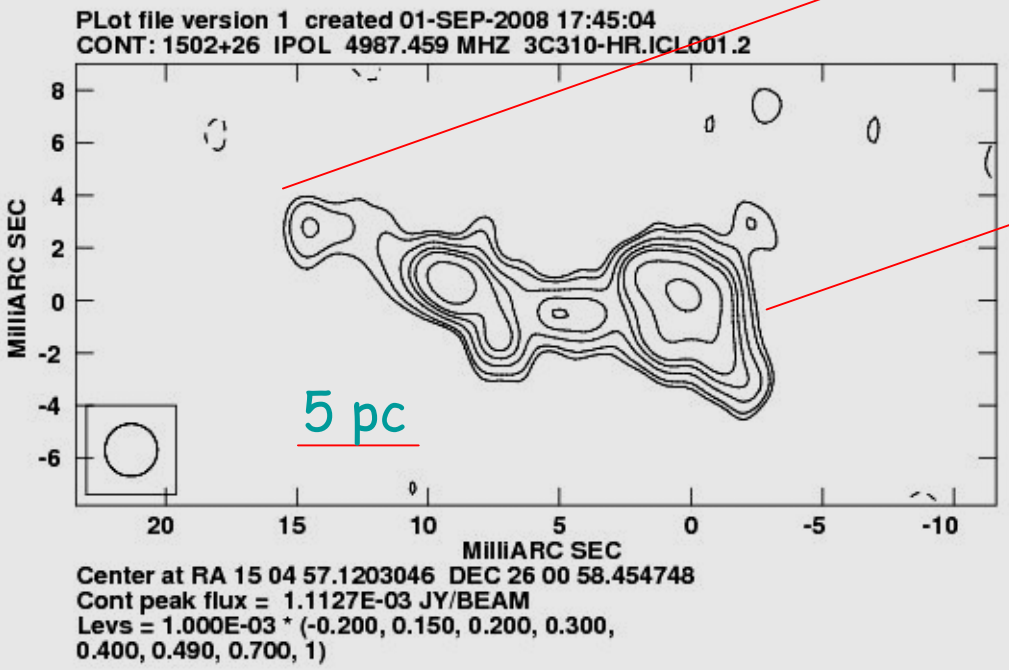


3C 310

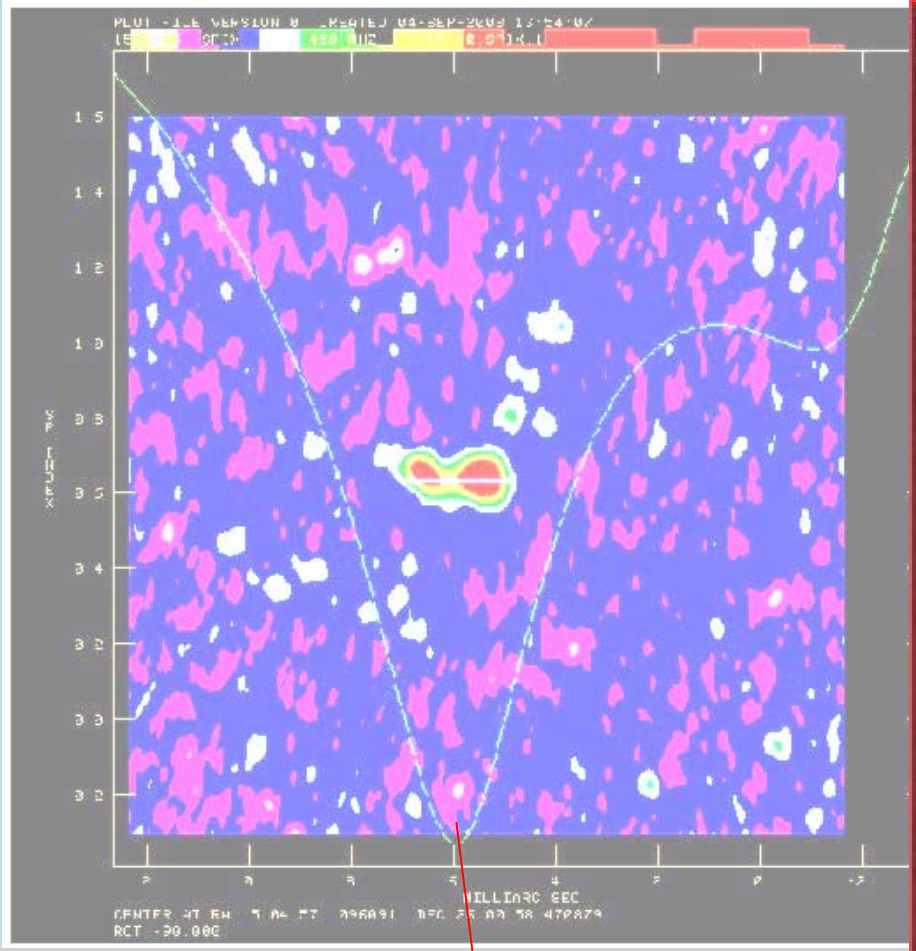
Total size: about 300 kpc

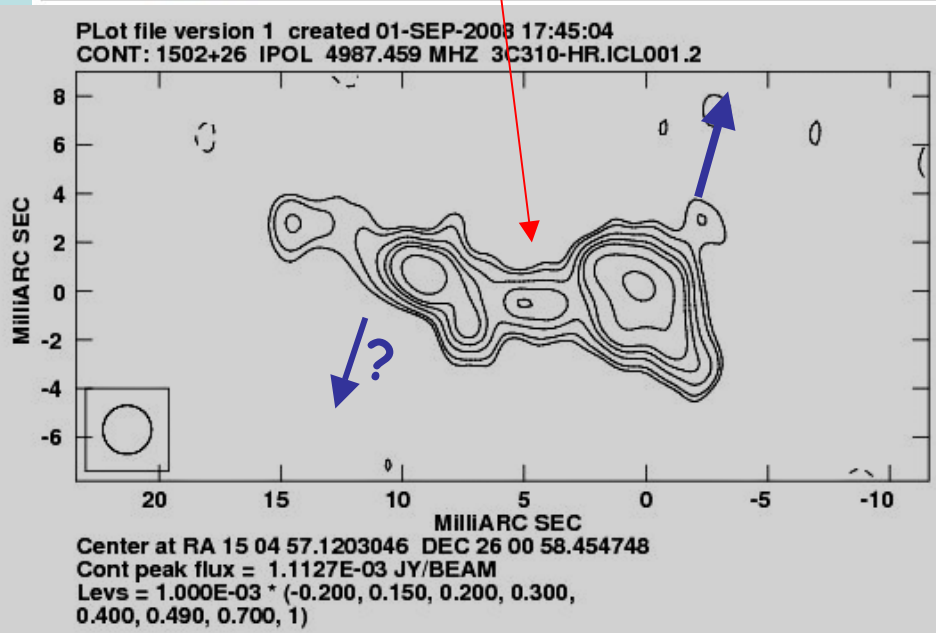




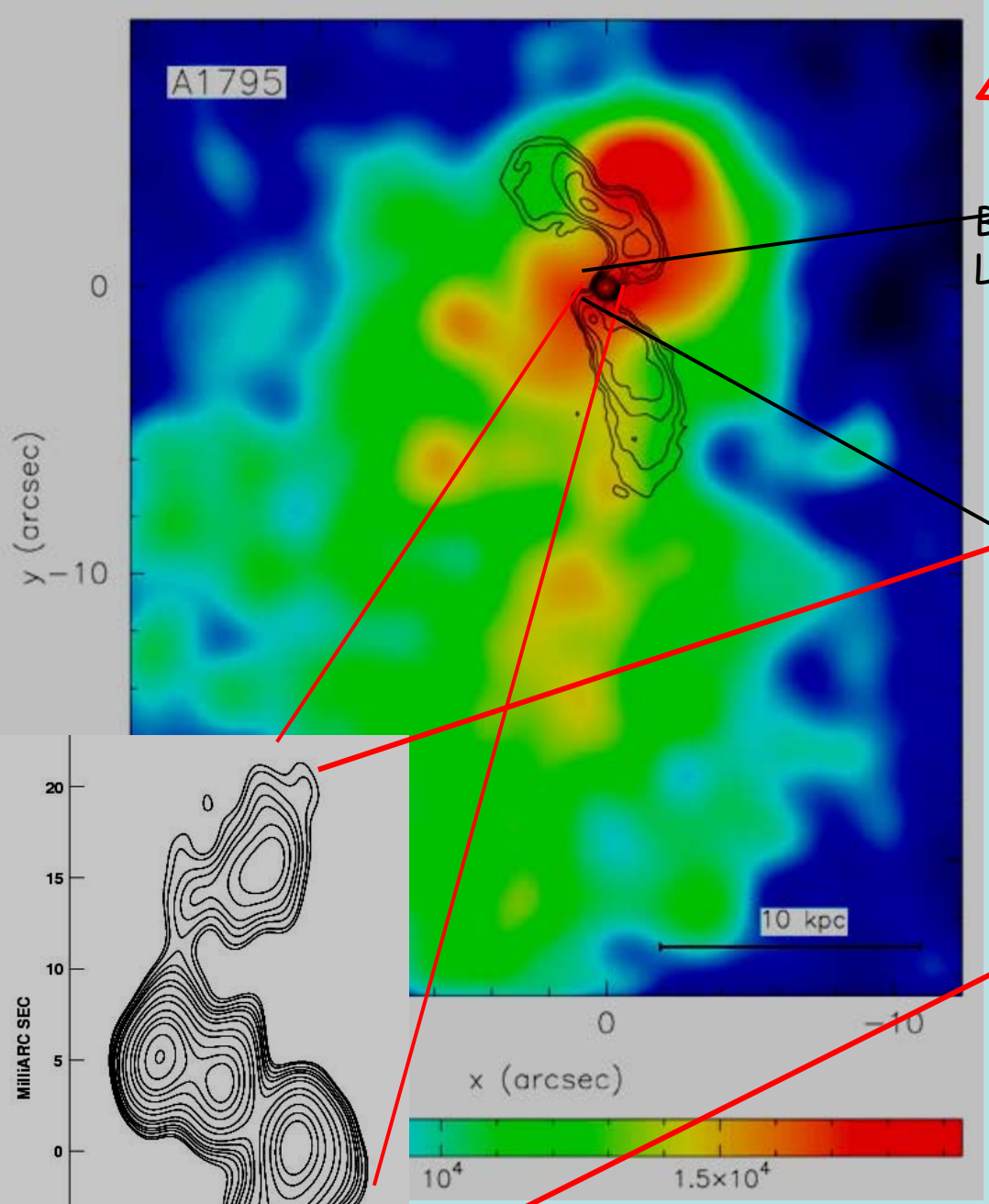


See also Gizani and Garret 2002
6th EVN Symp



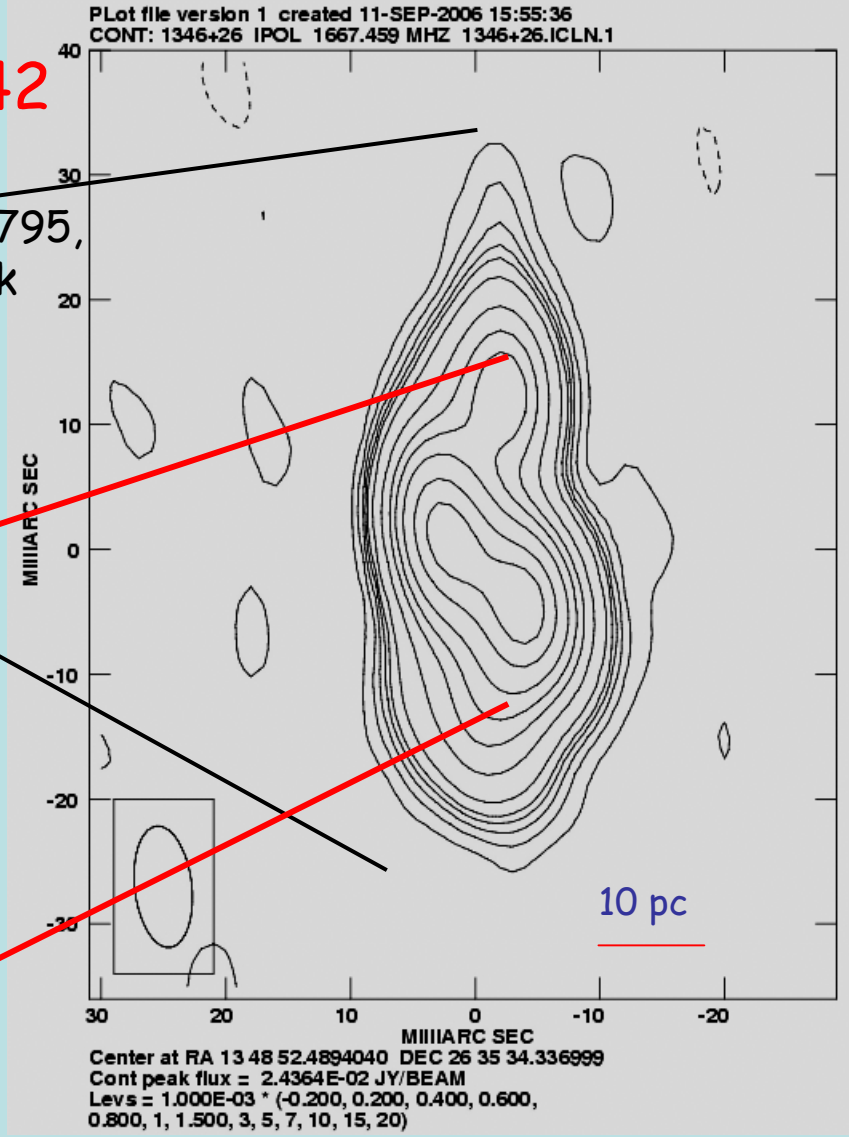


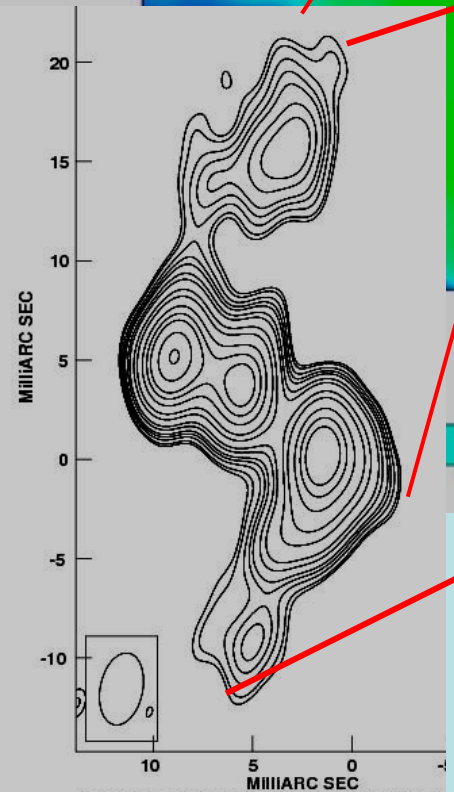
Large change of the jet PA at about 10 pc from the core



4C26.42

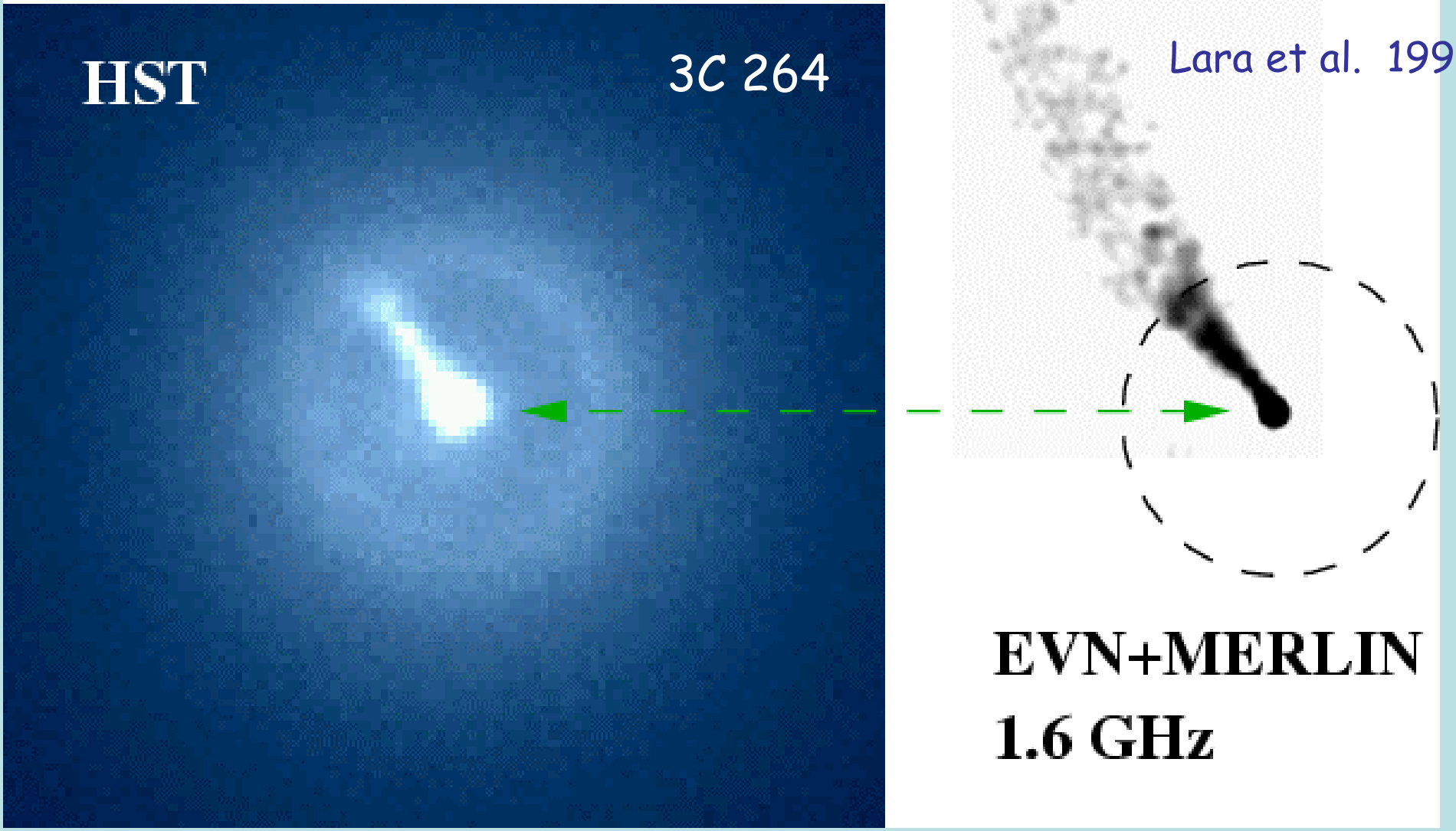
BCG in A1795,
Liuzzo talk





VLBI 6cm

VLBI 20 cm
Phase ref. mode
Peak 24 mJy/b
Noise 0.07 mJy/b



The optical ring is at 200 – 300 pc from the core.

A jet interaction with the ring is suggested by the Jet properties

No jet distortion - because of high jet velocity? one-sided

CONCLUSIONS

- The parsec scale jet morphology is the same in high (FR II) and low (FR I) power sources
- The pc scale morphology is in agreement with expectations from unified models
- There is a good agreement between the pc and kpc scale orientation
- The pc scale jet velocity is highly relativistic in FR II and FR I sources. It is not related to the total or core radio power of the source. No correlation with the kpc scale structure.

3 sources show a symmetric **Z** structure at parsec resolution

Symmetric two-sided structures ➔ on the plane of the sky

Slow jets interacting with a rotating disk ➔ **Z** shaped structure

interaction is present at about 2-3 kpc for 3C293 but only at
< 10 pc (3C310) and at < 15 pc (4C 26.42)

no evidence of de-boosting ➔low velocity pc jets

3C264: relativistic jet + disk at 200 – 300 pc ➔ no distortion

pc-scale **Z** structures are evidence of slow pc scale jets?

Slow jets can create a kpc scale source?

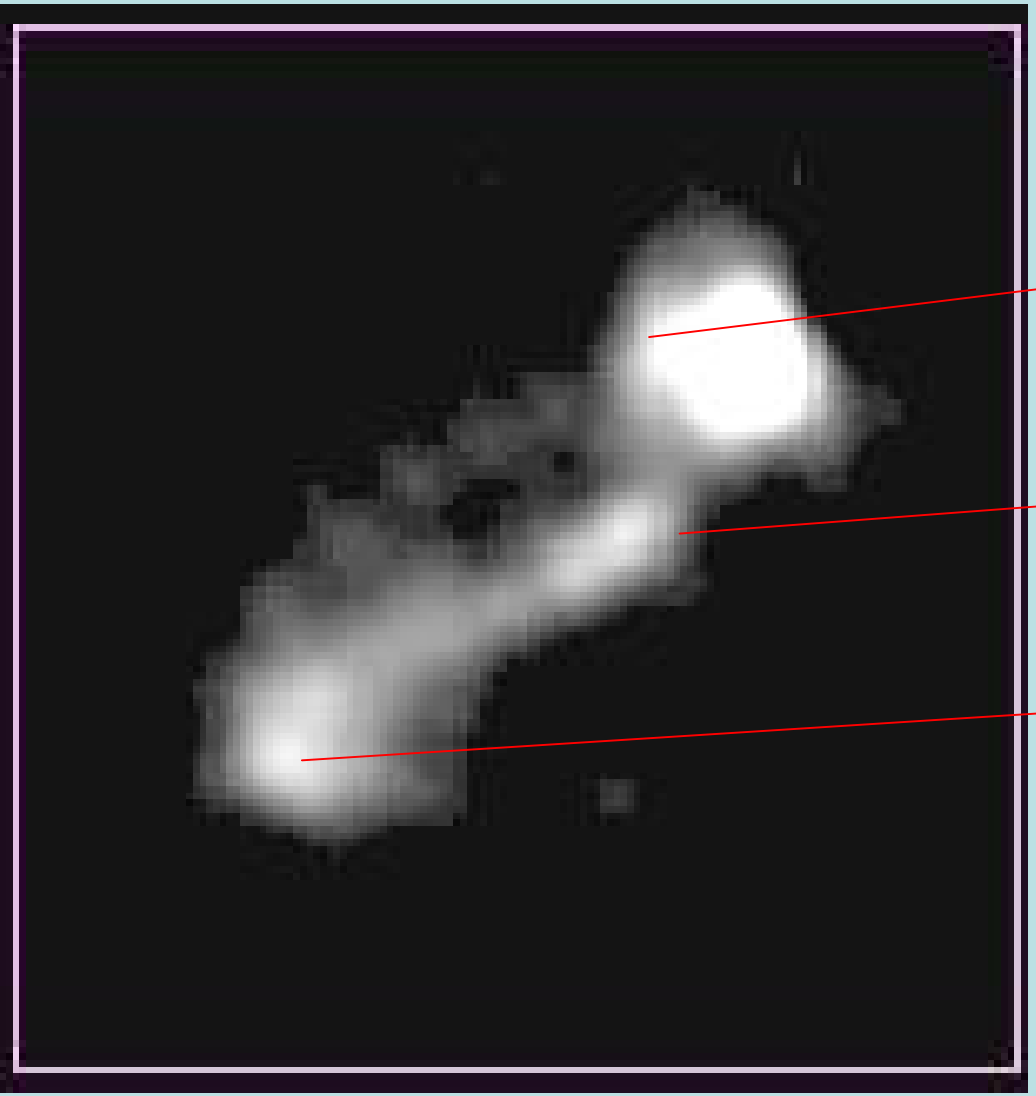
Any connection with two-sided BCG in cooling clusters ??
(Liuzzo talk)

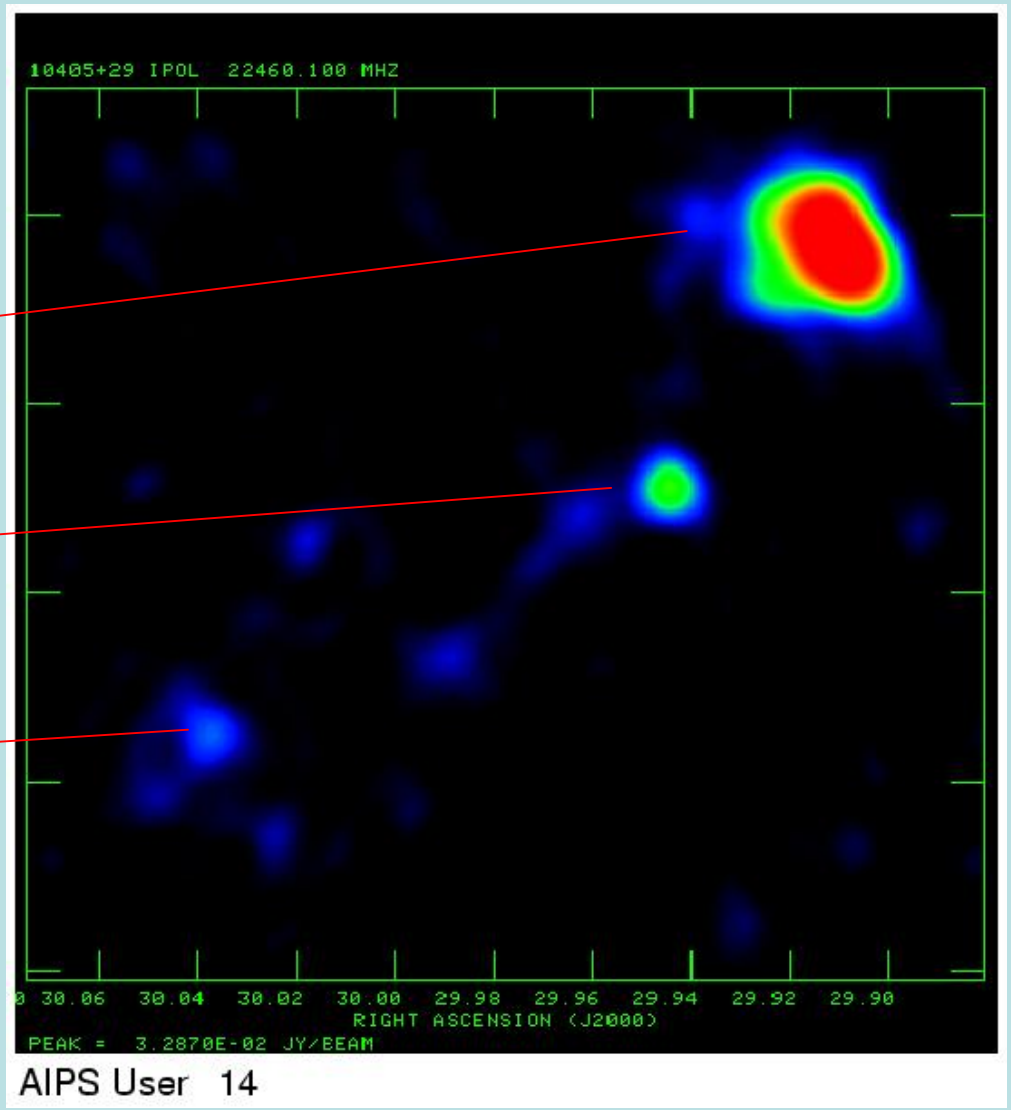
THANKS

- In 3 sources a symmetric Z shaped distortion occurs. Sources are symmetric on the parsec scale suggesting an orientation near to the plane of the sky, or slow pc scale jets. A simple explanation of the jet distortion is a jet interaction with a rotating disk as suggested by Van Breugel et al. for 3C293. This requires a jet slow down.
  Main difference is that the interaction is present at about 2-3 kpc for 3C293 but only at < 10 pc (3C310) and at < 20 pc (4c26.42

- The presence of a disk near to the core (200-300 pc) is evident from HST images in 3C264

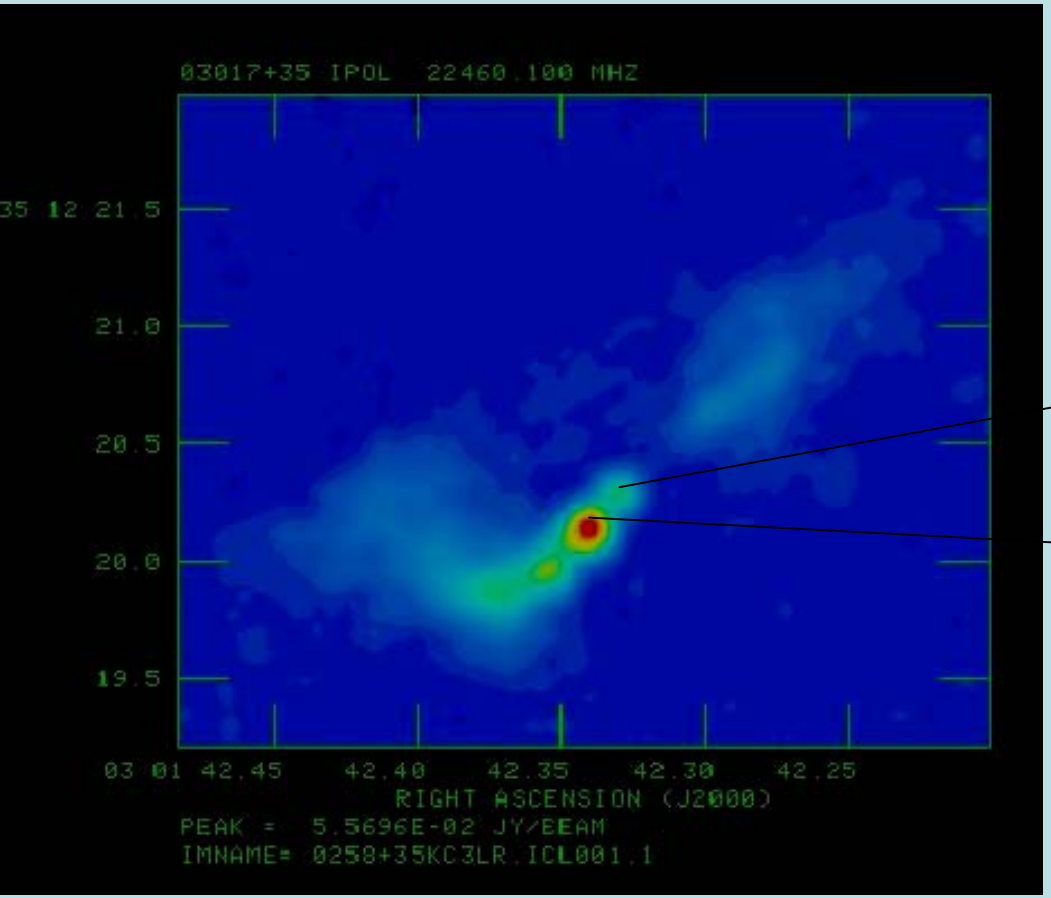
Other possible environmental effects could be at work. We need to compare with X-ray and optical data. Note that 4c 26.42 is at the Center of a cooling cluster

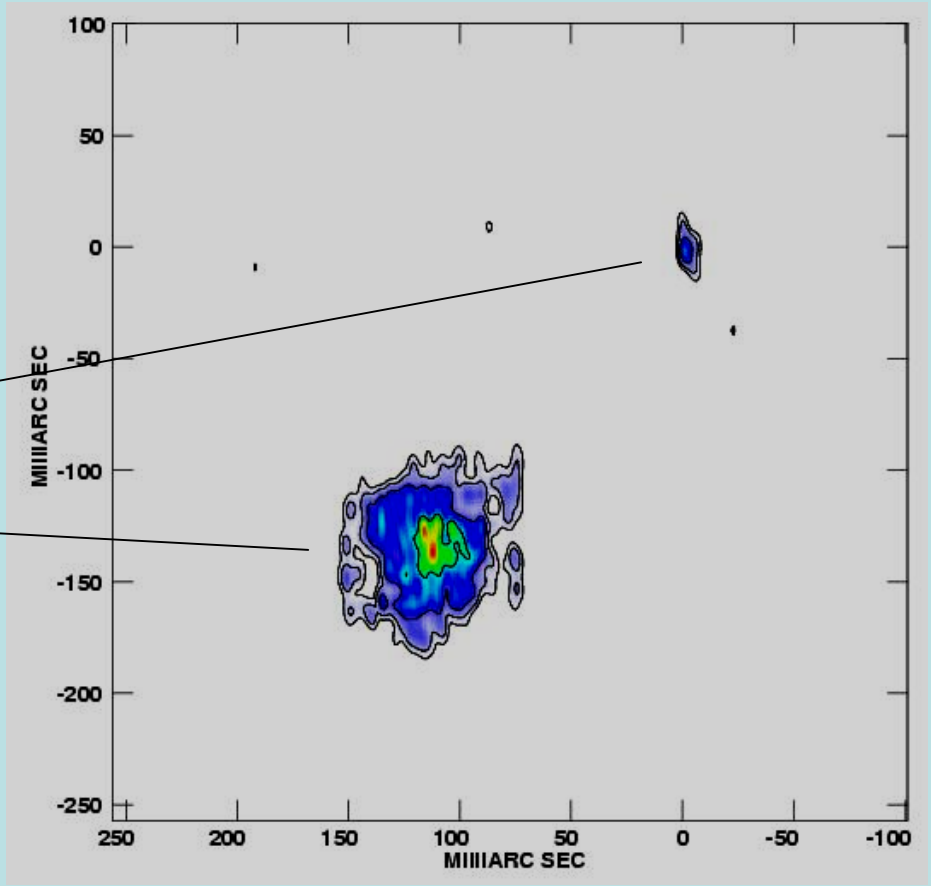



10405+29 IPOL 22460.100 MHZ
30.06 30.04 30.02 30.00 29.98 29.96 29.94 29.92 29.90
RIGHT ASCENSION (J2000)
PEAK = 3.2870E-02 JY/BEAM
AIPS User 14

1055+37

0222+36

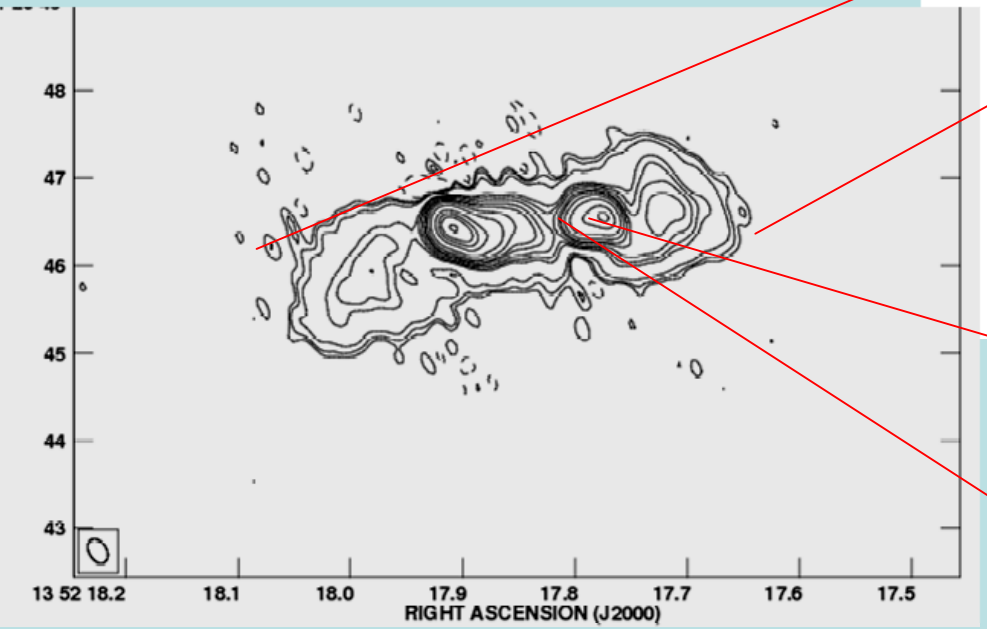


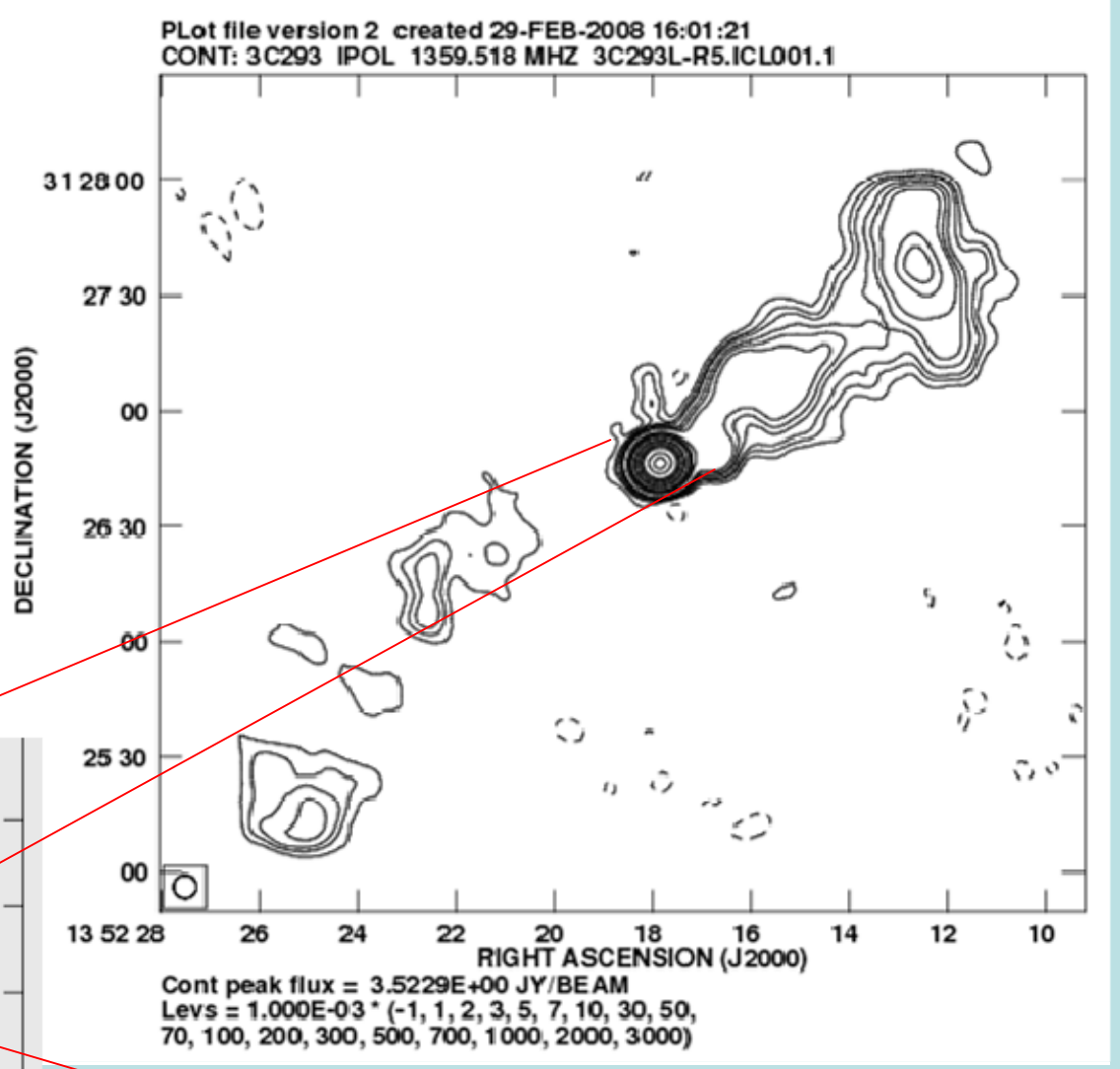


Classified as a low power CSS

Faint radio core, no jets on the parsec scale: large angle?

3C 293


48
47
46
45
44
43
13 52 18.2
18.1
18.0
17.9
17.8
17.7
17.6
17.5
RIGHT ASCENSION (J2000)


PLot file version 2 created 29-FEB-2008 16:01:21
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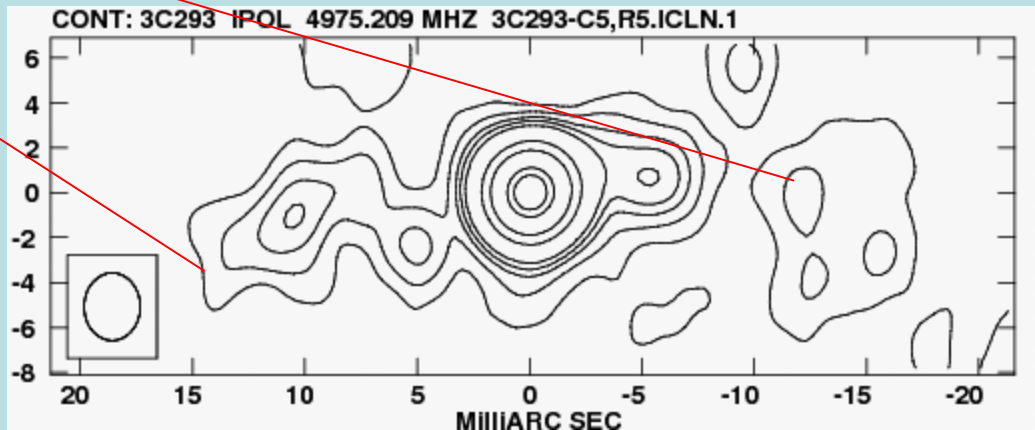
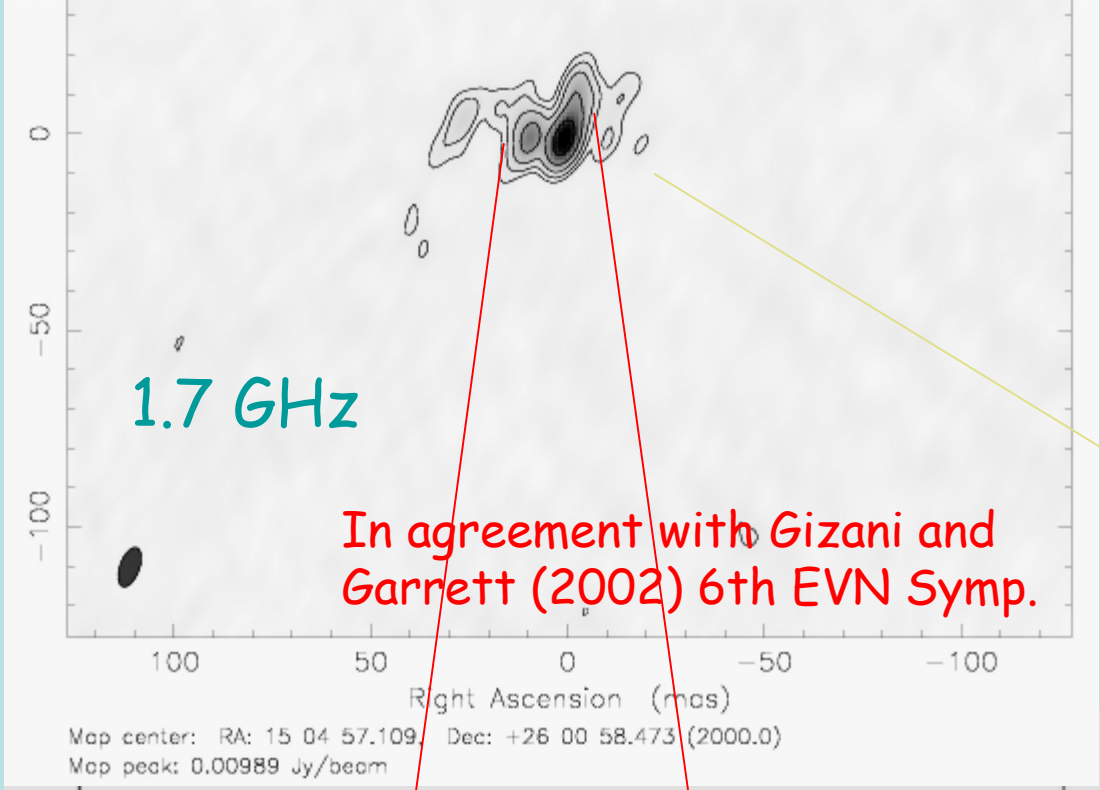
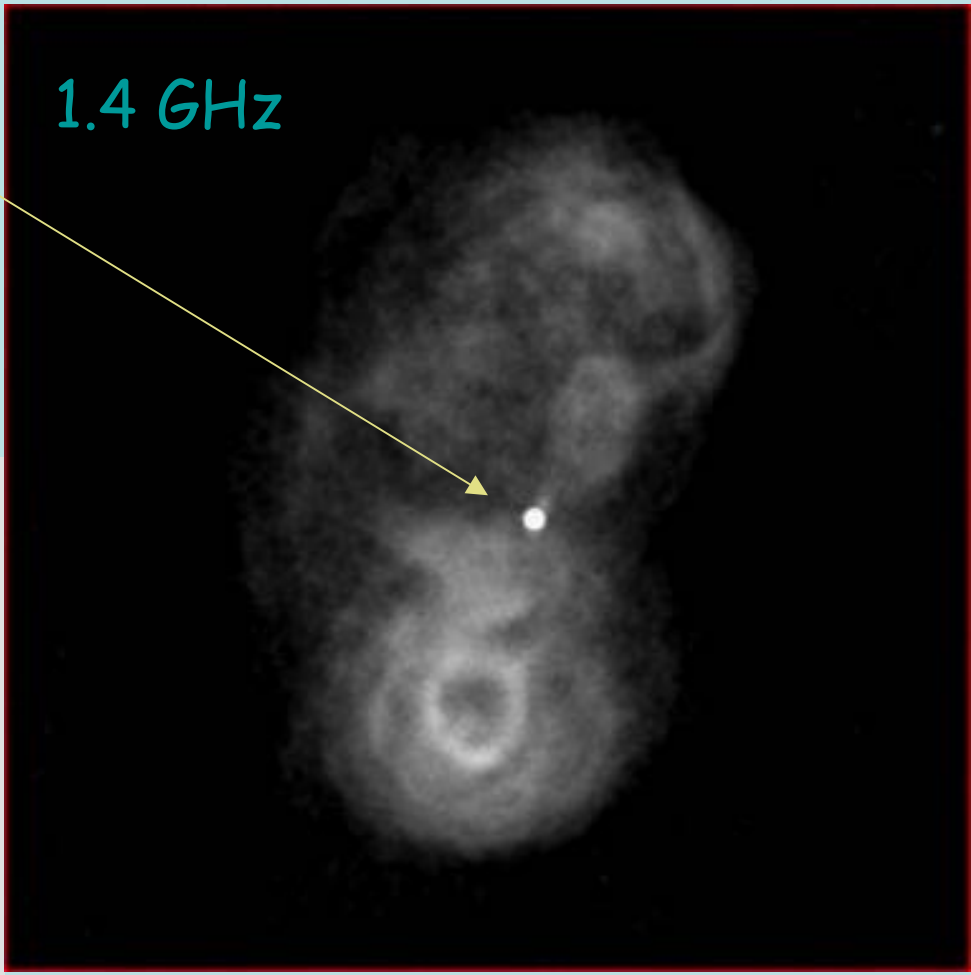
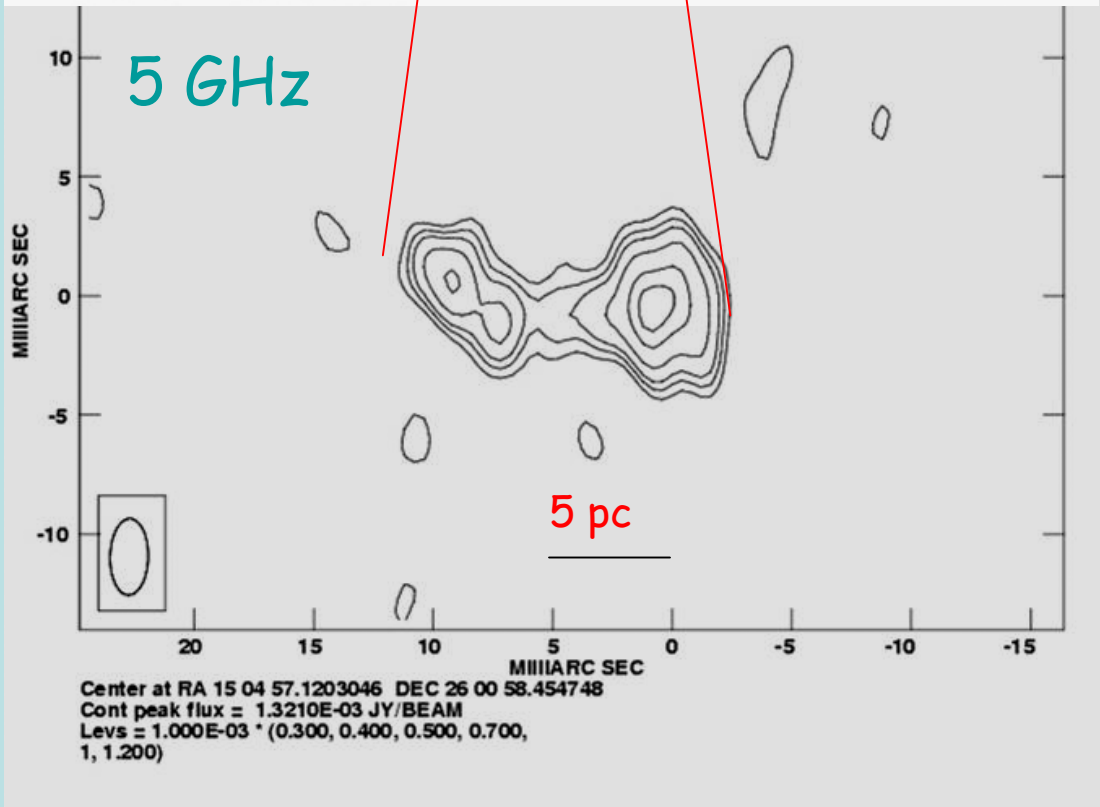
31 28 00
27 30
00
26 30
00
25 30
00
DECLINATION (J2000)
13 52 28
26
24
22
20
18
16
14
12
10
RIGHT ASCENSION (J2000)
Cont peak flux = 3.5229E+00 JY/BEAM
Levs = 1.000E-03 * (-1, 1, 2, 3, 5, 7, 10, 30, 50,
70, 100, 200, 300, 500, 700, 1000, 2000, 3000)


CONT: 3C293 IPOL 4975.209 MHZ 3C293-C5,R5.ICLN.1
6
4
2
0
-2
-4
-6
-8
20
15
10
5
0
-5
-10
-15
-20
MilliARC SEC

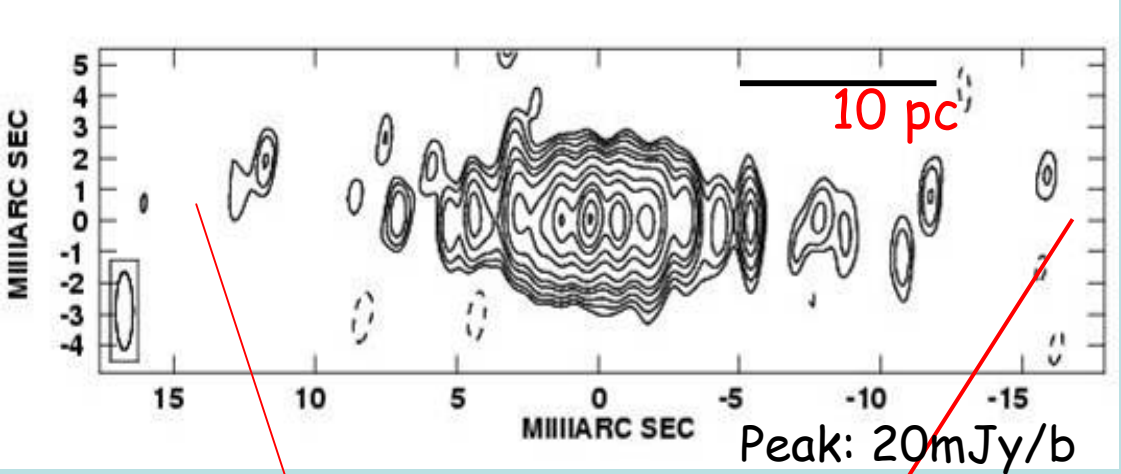
3C 310 VLA B+C
Linear size ~ 300 kpc

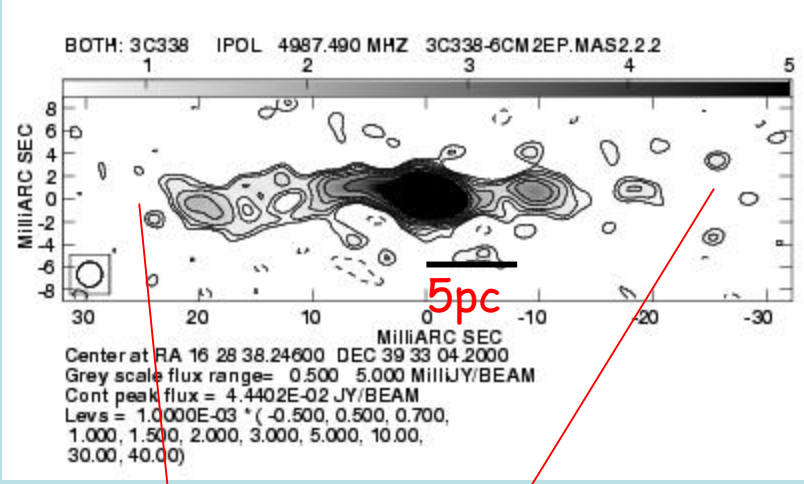






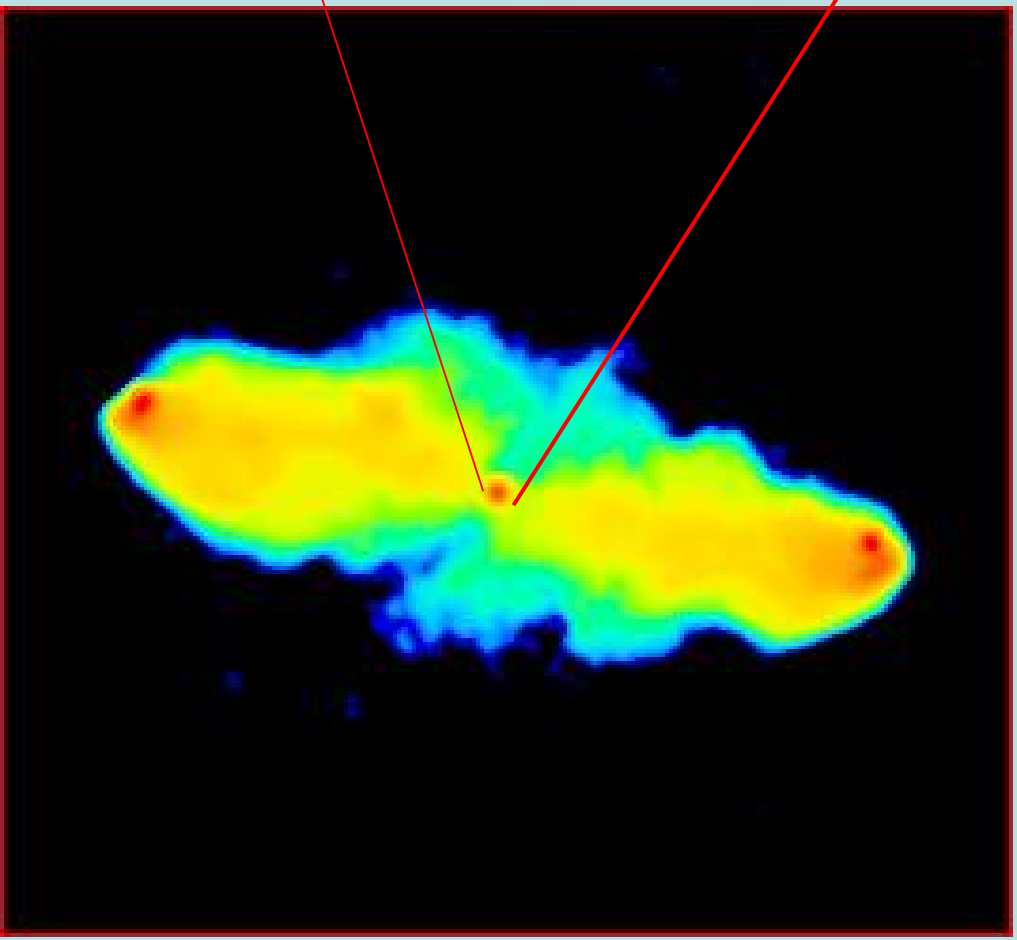
Peak flux 1.3 mJy/b
Noise 0.07 mJy/b

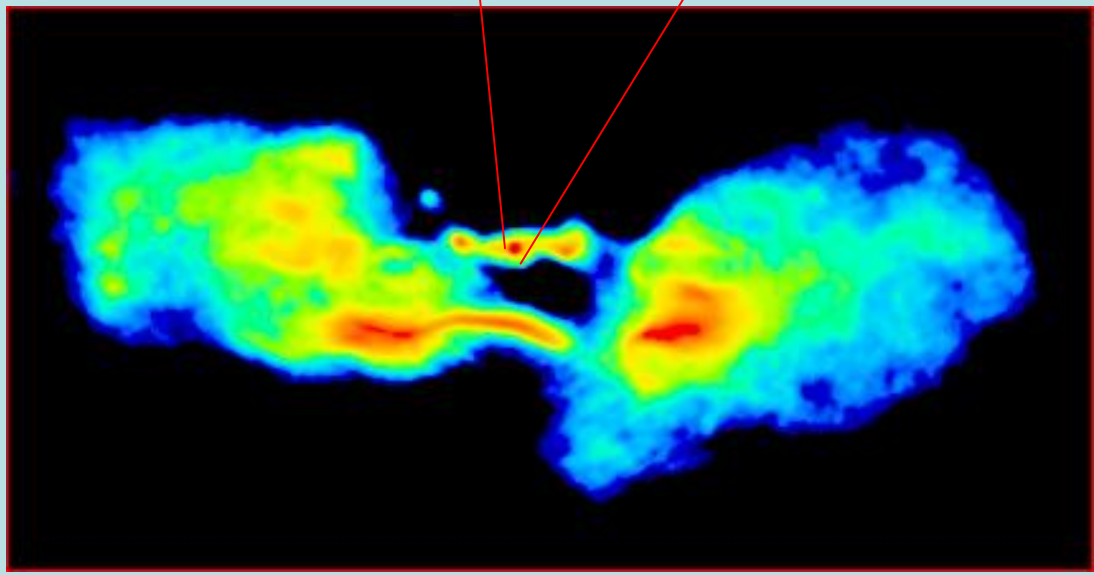




3C 452 a NL FR II radio galaxy

3C 338 a FR I radio galaxy





Two-sided