Parsec Scale Properties of Brightest Cluster Galaxies

Elisabetta Liuzzo[1,2]

Gabriele Giovannini [1,2] Marcello Giroletti [1] Greg Taylor[3]

(1) IRA-INAF, (2) University of Bologna , (3) University of New Mexico.

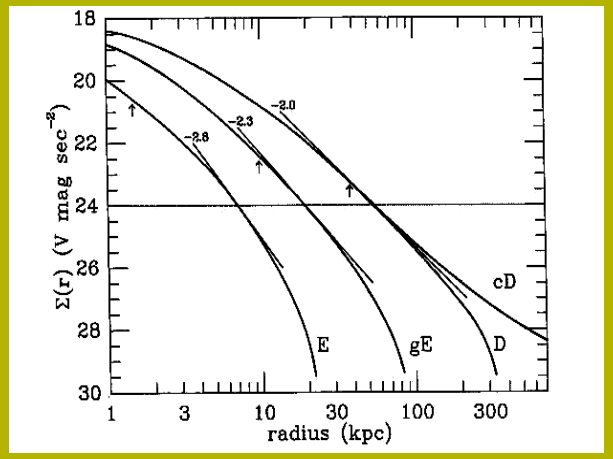
Introduction

Unique class of objects (Yen-Ting Lin et al.2004)

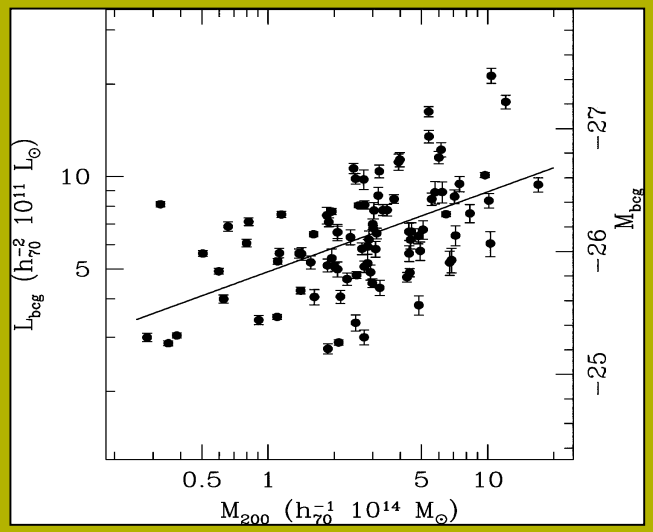
➔ most luminous

➔ most massive (Schombert 1986) (Gonzalez 2004)

➔ extended source



Tonry 1987



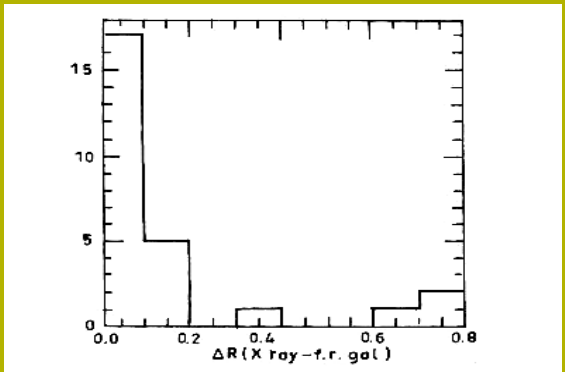
Schombert 1988

→ cD galaxy

- only in clusters
- L relate with cluster properties

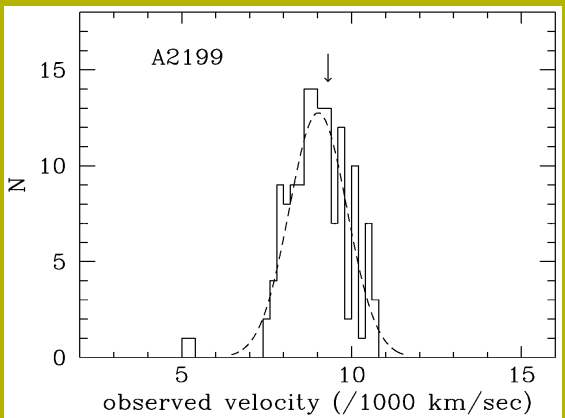
also giant E and D galaxy

➔some BCG shows multiple nuclei → galaxy merger (Lauer 1998)



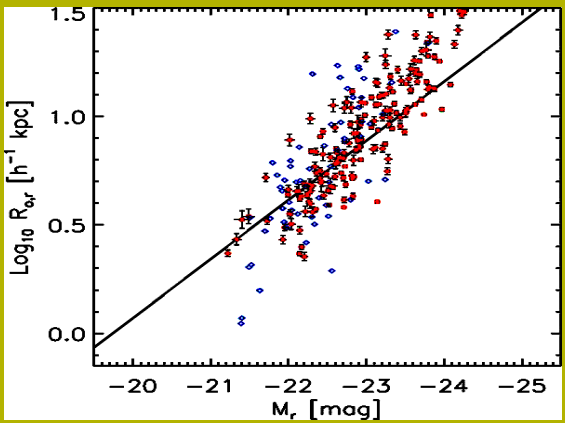
➔ Close to the peak of the cluster X-Ray emission

(Rhee & Latour 1991)



➔ In the v-space they sit near the cluster rest frame

(Oegerle & Hill 2001)



➡ strong offset from FP but little scatter
(Bernardi 2006)

↓

different formation history:

1) cannibalism (Hausman & Ostriker 1978)

2) cooling flow (Cowie & Binner 1977)

3) merger of galaxy (Dubinski 1998)

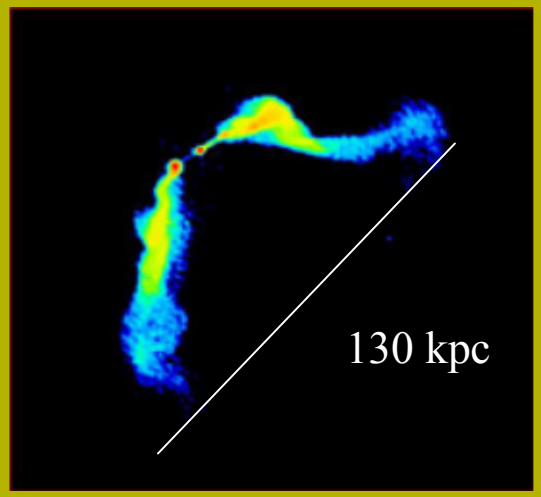
BCG in Radio Band

They are more likely to host radio-loud AGN than other galaxies of the same mass

(Best et al. 2006)

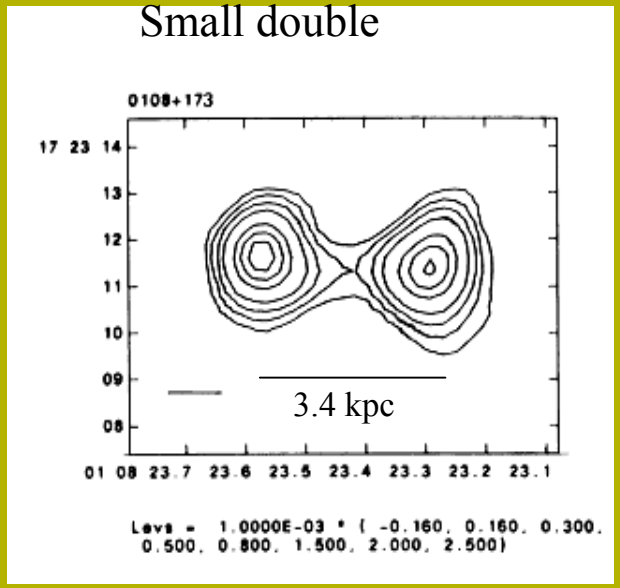
➔ different *kpc* scale morphologies

WAT



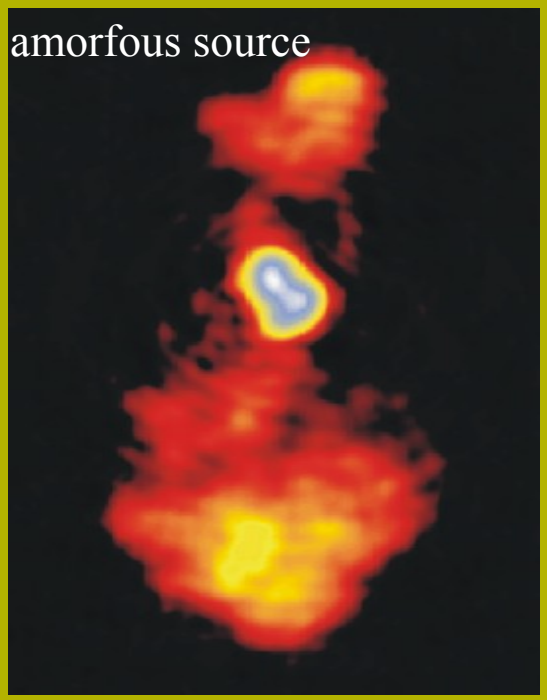
3C465 (A2634)

Small double



IC1634 (A154)

amorfous source



Perseus A

<u>strong interaction</u> with the surrounding medium

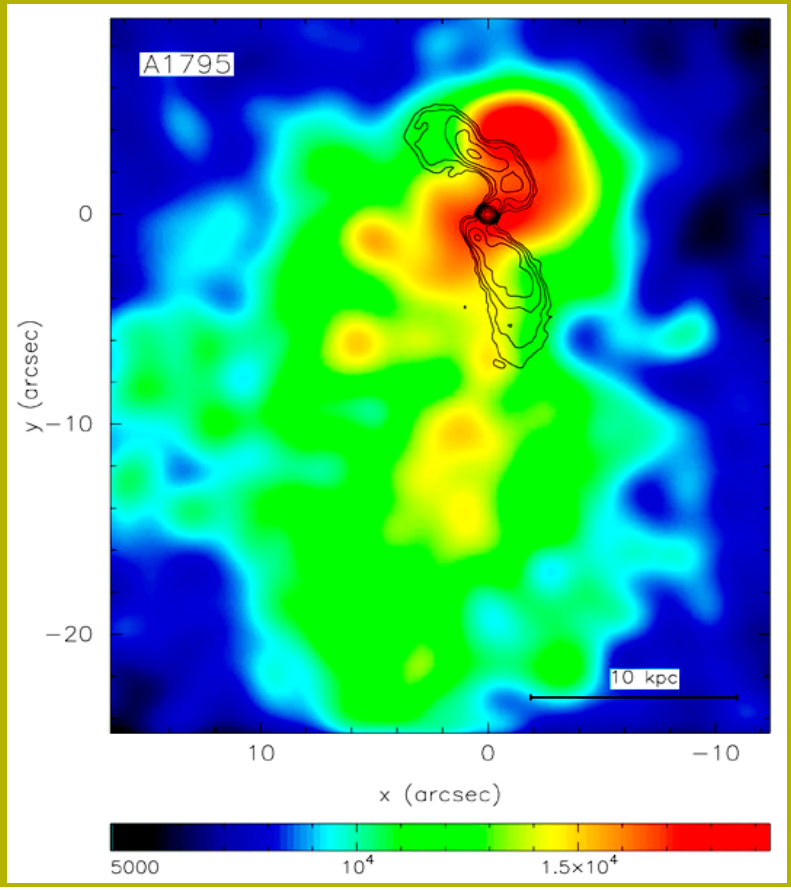
→ BGC and cooling core:

* radio loud BCG in cooling core clusters (Eilek and Owen. 2006)
* X-ray cavities – Radio Lobes

(Dunn and Fabian 2008)

↠ arrest or slow down of the cooling process.

CHANDRA +VLA

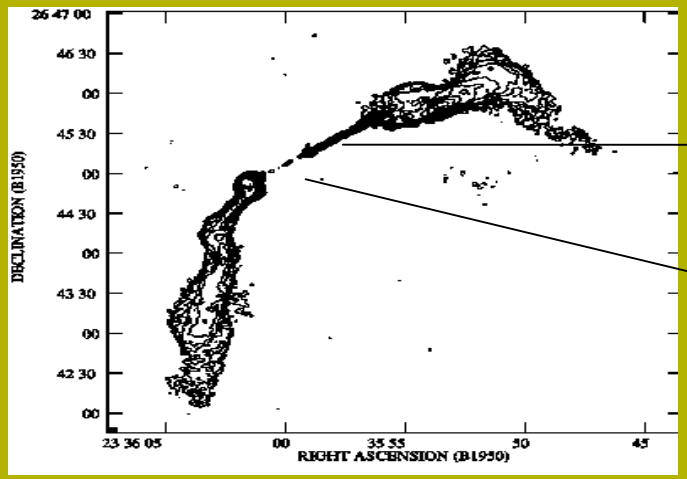


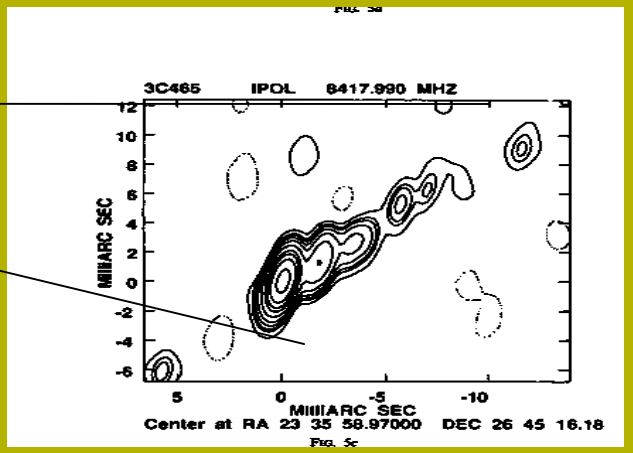
B2 1346+26

central cD in A1795
z = 0.06326
relaxed cluster

→ *pc* scale morphology (if studied...)

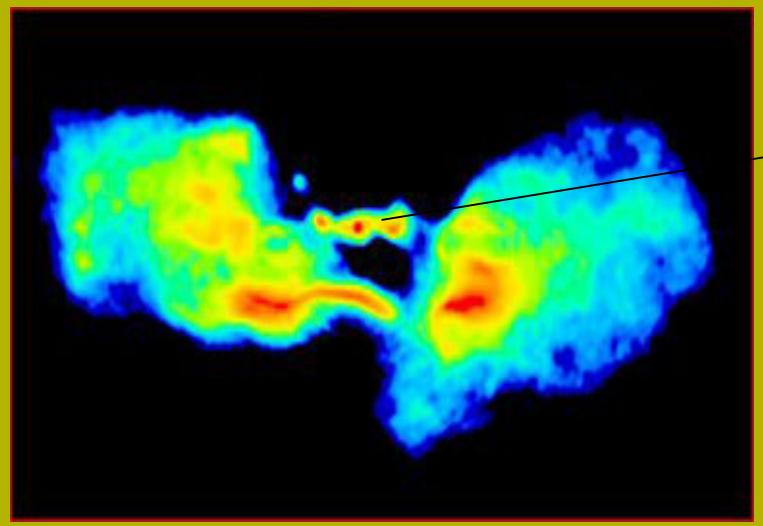
one sided

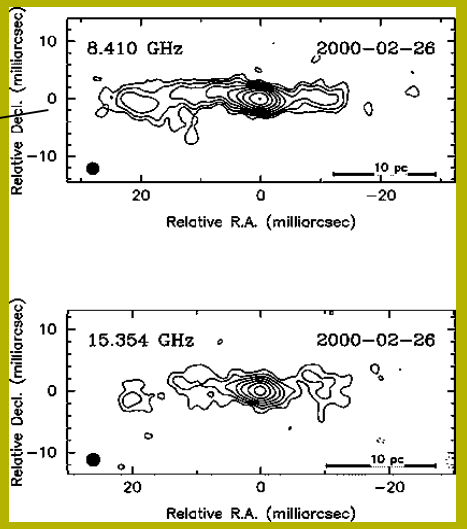




3C465 in A2634
(Venturi et al. 1995)

two-sided





3C338 in A2199
(Gentile et al. 2007)

The Sample

A262
A347
A400
A407
A426
A539
A569
A576
A779
A1185
A1213
A1228
A1314
A1367
A1656
A2147
A2151
A2152
A2162
A2197
A2199
A2634
A2666

- All Abell Clusters with DC ≤ 2 and Declination > 0º
- VLBA at 6 cm
- phase referencing mode
- polarization
- Detection rate VLBA : 59%
- Resolution : 3 x 1.8 mas
- Noise ~ 0.1 mJy/beam

--- Core radio quiet VLA and VLBI

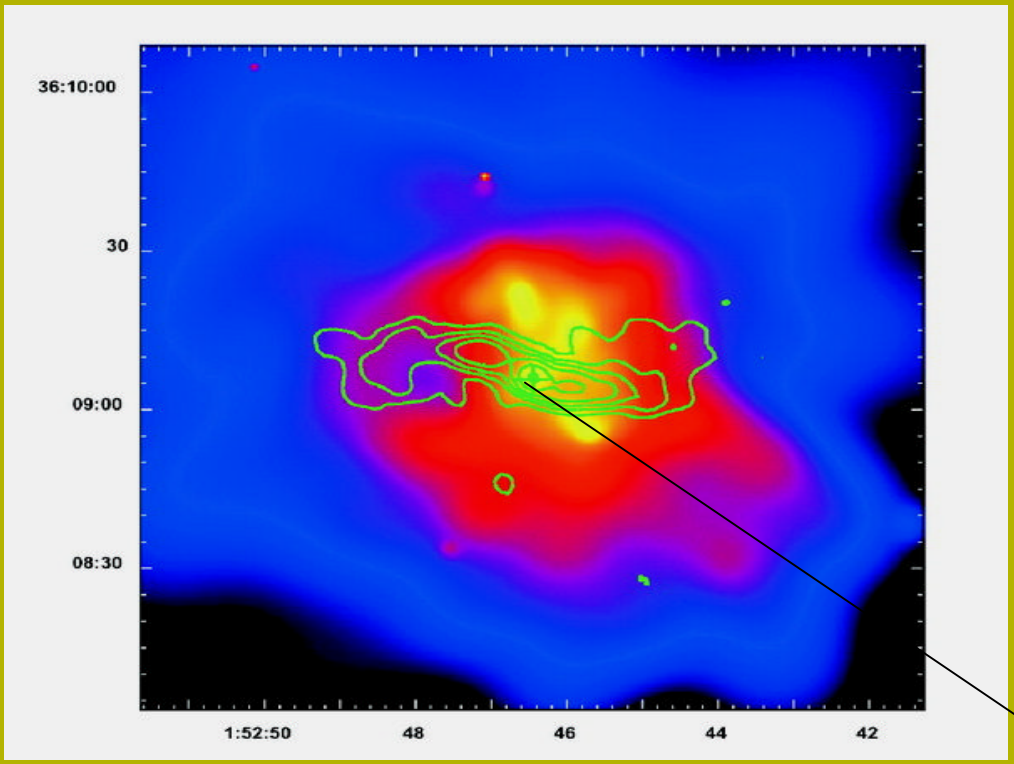
--- Radio loud VLA / Radio quiet VLBI

--- Radio loud VLA and VLBI

N.D.:
radio quiet?
sensitivity?
position?

Observational Results.

A262



Colour: CHANDRA

contour VLA-B 20 cm

- BCG: NGC708

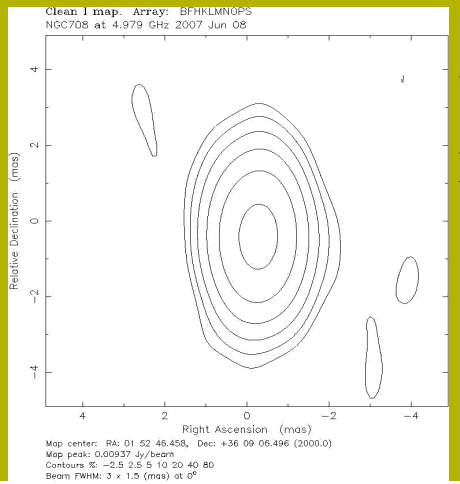
- relaxed cluster:

X-ray cavities + radio lobes,

balance of cooling losses

(Blanton et al. 2004)

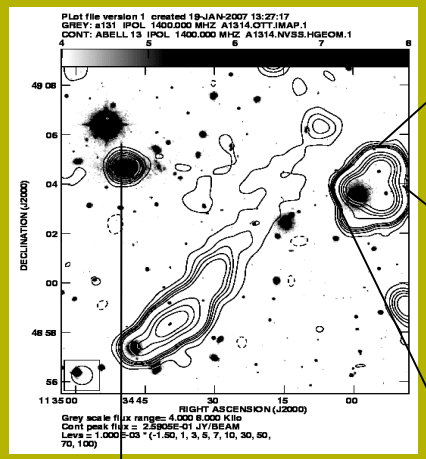
-VLA: no radio-jet, no strong core



VLBA 5GHz

peak=9.4mJy/beam

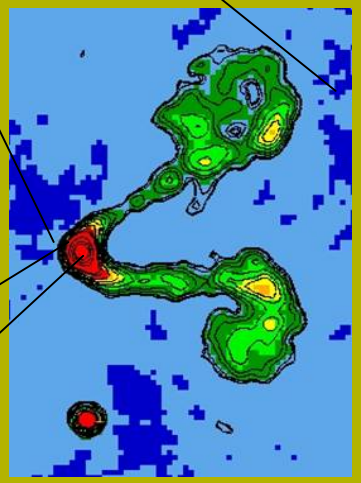
NVSS + optic



IC708

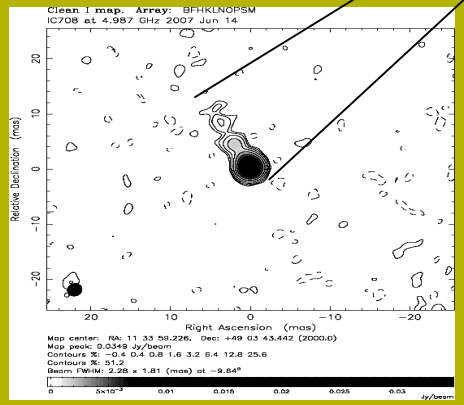
IC712

VLA



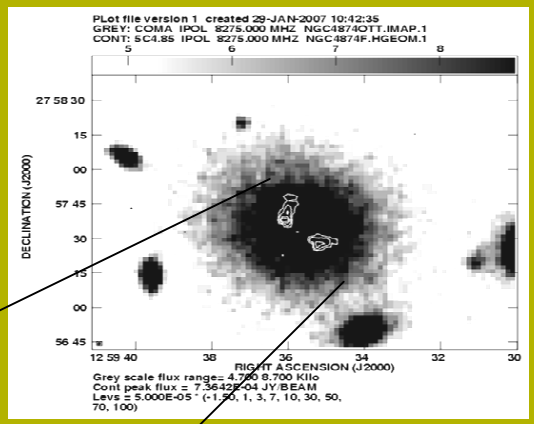
A1314:

2 sub-clusters



VLBA

VLA 8.4GHz+ optic



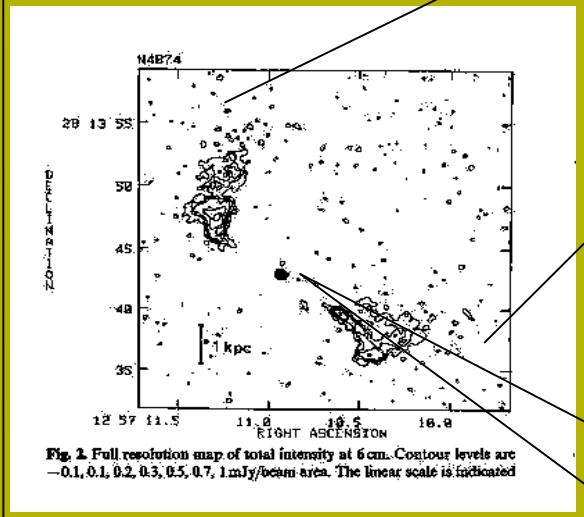


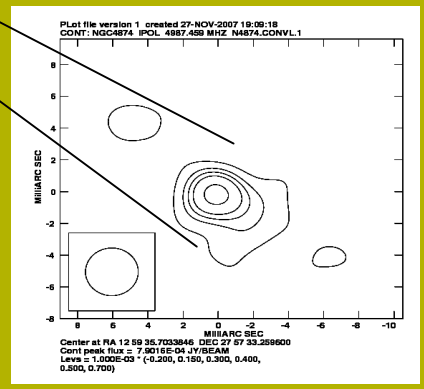
Fig. 2. Full resolution map of total intensity at 6 cm. Contour levels are −0.1, 0.1, 0.2, 0.3, 0.5, 0.7, 1 mJy/beam area. The linear scale is indicated

A1656(Coma):

-BCG NGC4874

-merging cluster

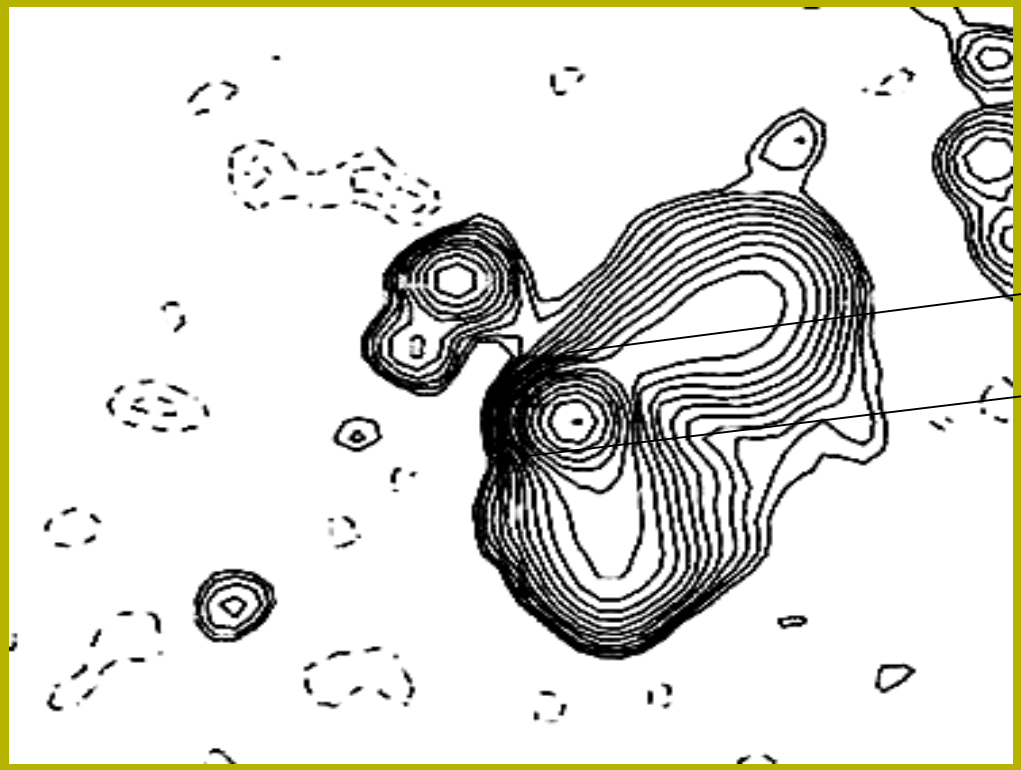
VLA 5 GHz



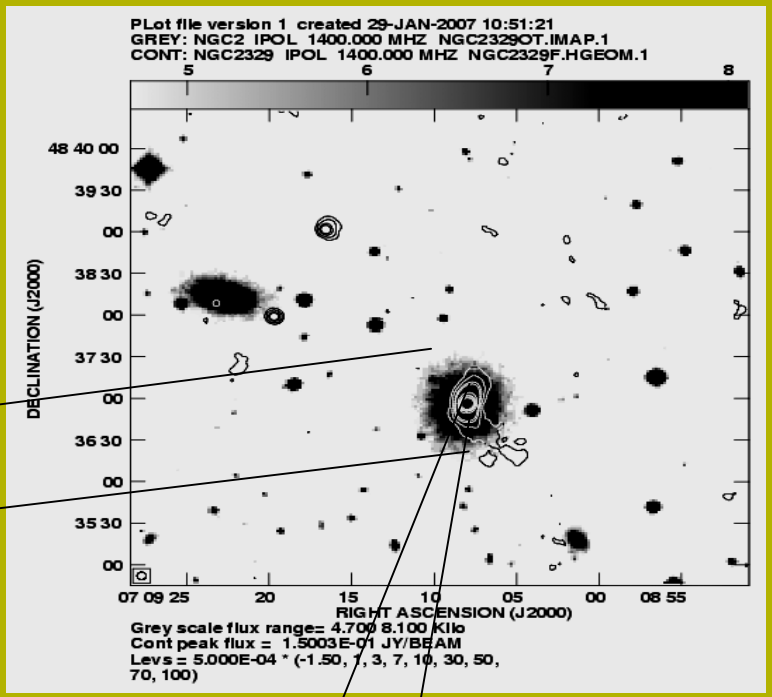
VLBA

A569

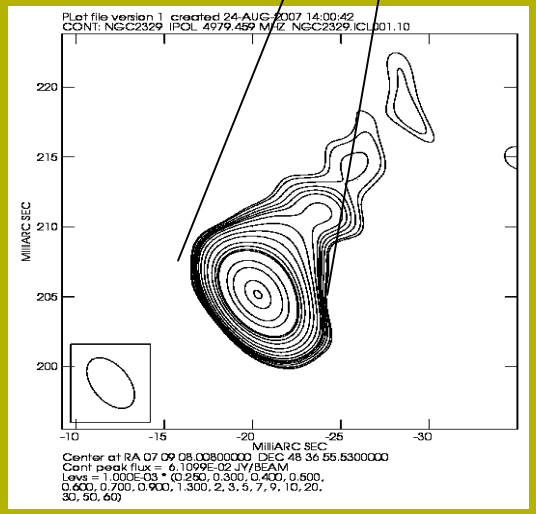
NVSS



FIRST



VLBA



- BGC: NGC2329
- merging cluster

A400

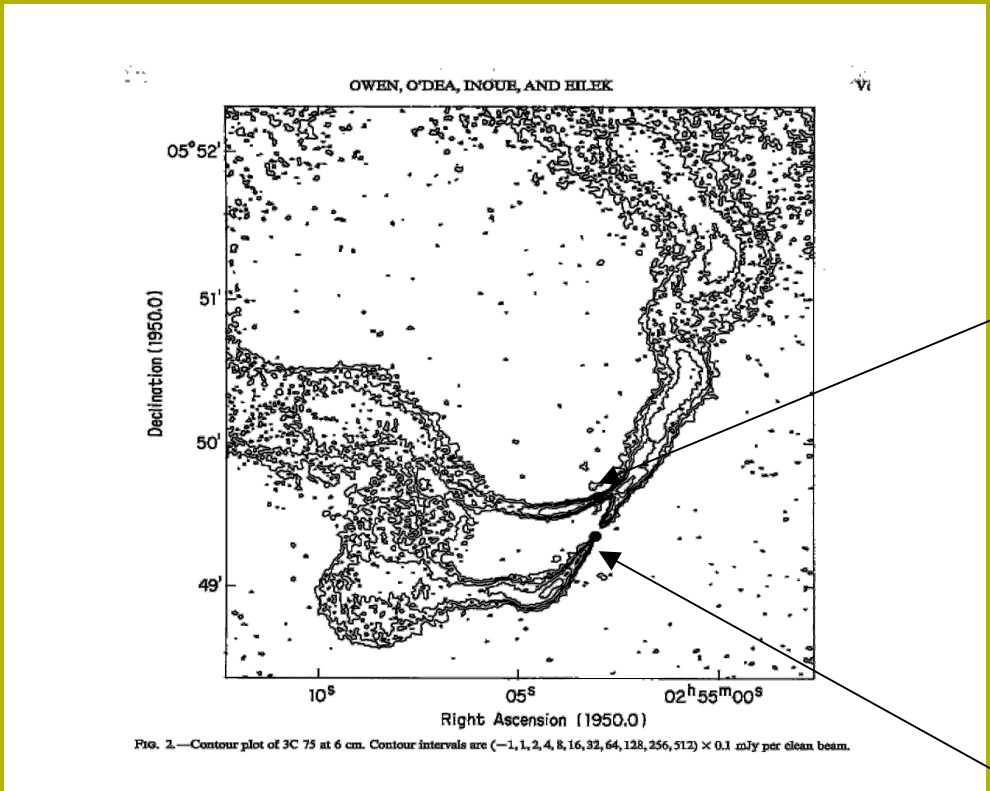
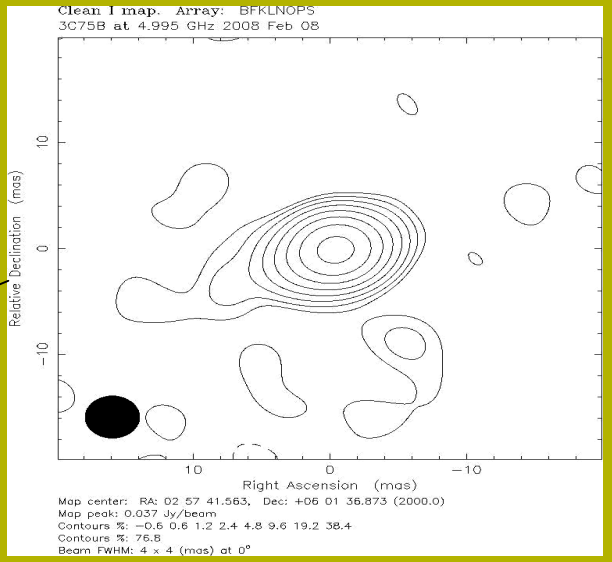
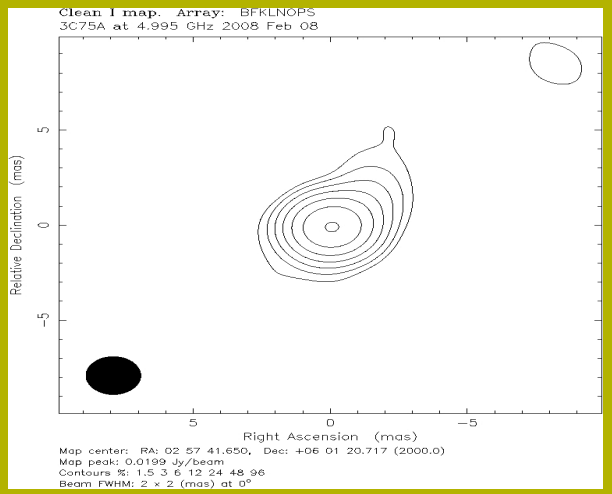


FIG. 2.—Contour plot of 3C 75 at 6 cm. Contour intervals are (−1, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512) × 0.1 mJy per clean beam.



- 3C 75B



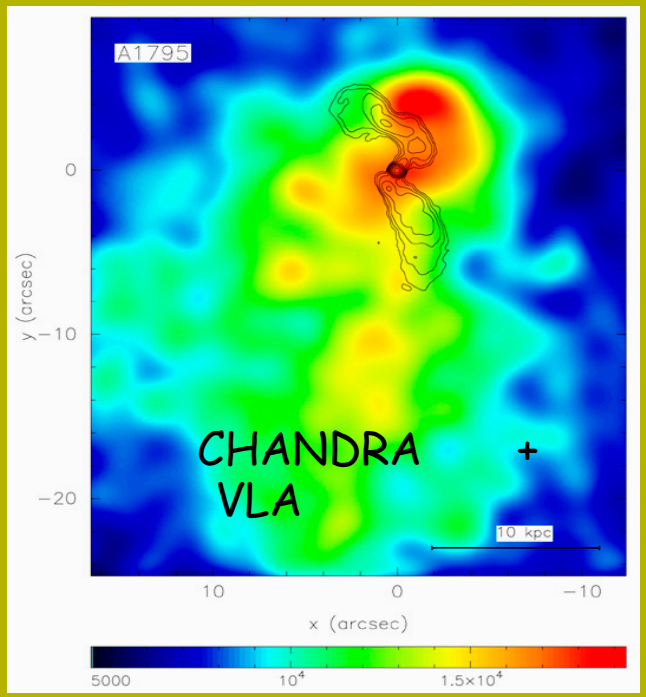
- 3C 75A

- BGC: 3C 75
- multiple nucleus galaxy
- cD formation

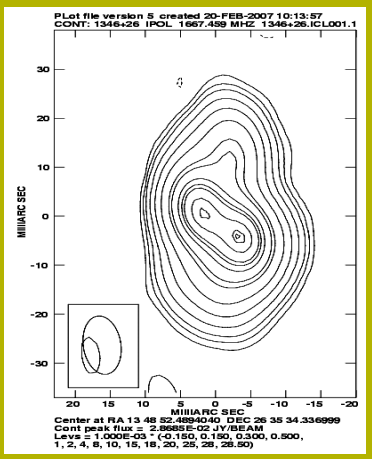
Outside the Sample....

B2 1346+26 in A1795

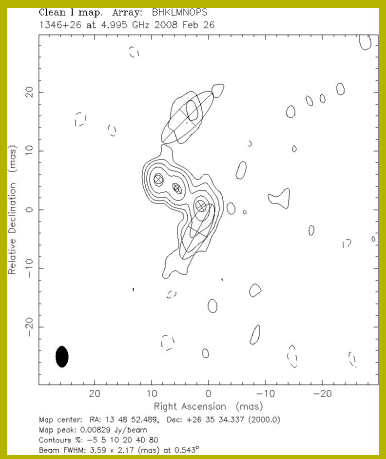
- BCG of A 1795
- in BCS
- z = 0.0633
- 4C 26.42 (M_v = -23)
- cD galaxy



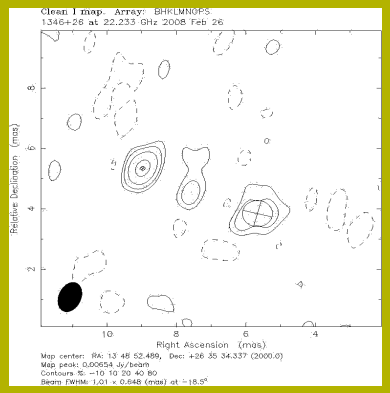
VLBA 20 cm



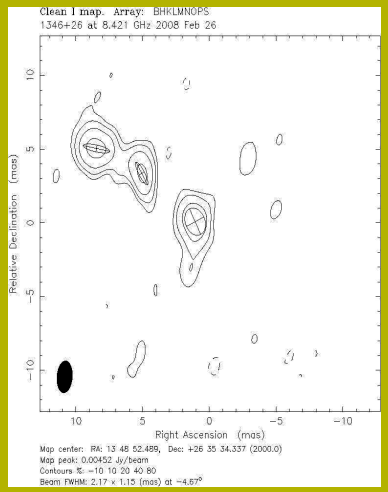
VLBA 6 cm



- cool core
- VLBA: two sided

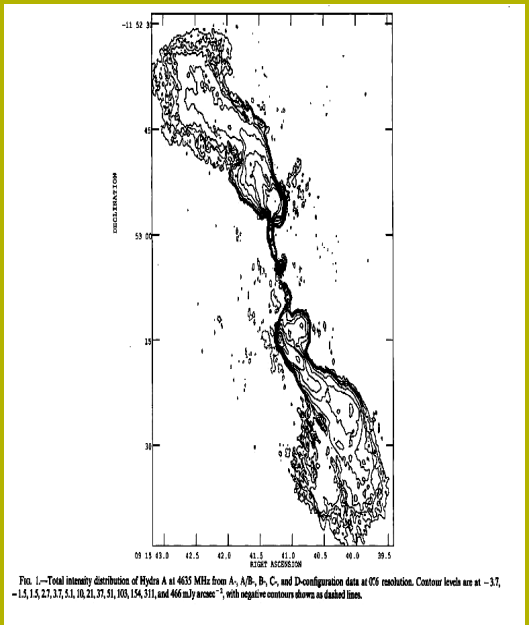


VLBA 1 cm



VLBA 3 cm

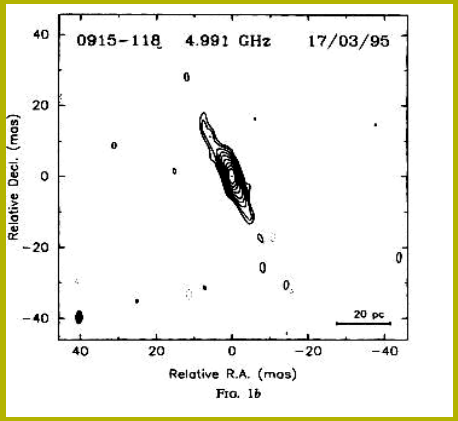
Hydra A in A780



- HT source
- z = 0.0548
- BCG

→ - **cooling flow**

→ - VLBA : two sided



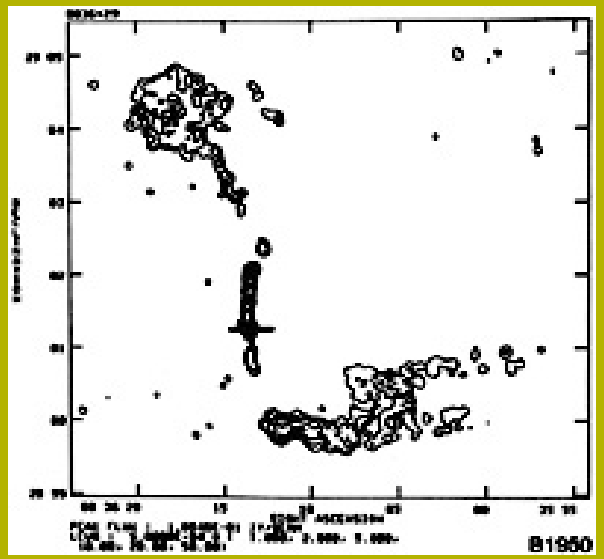
Interaction with the surrounding medium

(Taylor 1996)

beam: 3.7 x 1.5 mas
rms : 0.1 mJy/b
peak = 154 mJy/b

VLA 6 cm

B2 0836+29-II in A690

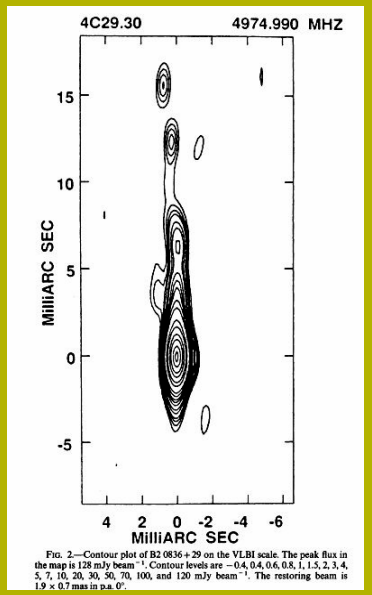


- cD
- WAT
- z= 0.079
- in BCS

→ - **no cool core**

→ - VLBA: one sided

(Venturi et al. 1995)



And a few more cooling clusters: A2052, A2390, A2597 which show a two-sided pc scale structure

From our complete sample (nearby clusters) and a few literature data on BCGs in rich clusters (Abell clusters):

Cluster morphology	#	two-sided	one-sided	point	N.D.
BCG in relaxed clusters:	10	**7 (70%)**	-	1 (10%)	2 (20%)
BCG in merging clusters:	22	-	**13 (59%)**	1 (5%)	8 (36%)

Not Detected sources are mostly BCGs with a radio quiet core also in VLA images

Preliminary Conclusions.

Merging clusters:

- one-sided pc scale structure ➔ relativistic jets in very low power sources (e.g. Coma, A1314) and in more powerful sources (e.g. 3C465)

Relaxed clusters:

- two-sided jets ➔ mildly relativistic jets?! → Interaction with surrounding medium? ---- > need of better statistic

- evidence of recurrent activity regimes: 3C338, A262, 3C 84

Only nuclear component and ND sources
- both in merging and relaxed clusters
- sensitivity?
- radio quiet?----> steep spectrum?
- restarted radiosource ? Duty cicle?
- ????

↳need of high quality observational data and a larger sample

Future perspectives

- estimate fundamental parameters : β, θ, H, spectral index
- polarization data
- connection between radio and X-Ray properties (e.g. cooling rate)
- improve image sensitivity

explain possible connection of the parsec and kpc scale structure of the single source

- make larger our sample
- make control sample non BCG
- statistical study

correlate the BCG properties with their particular formation history and environment

Thank you

Name	cooling	radio large-scale	radio VLBI	BCG	β ~ 1 ?
A262	y	double-no core, jets	core	ngc708	?
A347	SCF	radio quiet	N.D.	ngc910	-
A426	y	compact core + MH	two-sided	3C84	?
A2152	MCF	Tail rs	N.D.	ugc10187	-
A2199	y	double-restarted	two-sided	3C338	?
A1795	y	double	two-sided	4C26.42	?
A780	y	double	two-sided	Hydra A	?
A2390	y	MSO	two-sided	B2151+174	?
A2052	y	bright core+halo (FRI)	two-sided	3C317	?
A2597	y	asymmetric rs (FRI)	two-sided	pks2322-123	?
A400	n	WAT	one-sided	3C75A	y
		WAT	one-sided	3C75 B	y
A407	n	Tail	one-sided	ugc2489	y
A539	n	radio quiet	N.D.	ugc3274	-
A569	n	WAT	one-sided	ngc2329	y
A576	n	Tail	one-sided	cgcg261-059	y
A690	n	WAT	one-sided	0836+29 II	y
A779	n	radio quiet	N.D.	ngc2832	-
A1185	n	radio quiet	N.D.	NGC3550	-
A1213	n	FR I	one-sided	4C29.41	y
A1228	n	radio quiet	N.D.	IC2738	-
A1314	n	WAT small	N.D.	IC712	-
		WAT	one-sided	IC708	y
A1367	n	WAT small	N.D.	Ngc3842	-
		HT	one-sided	3C264	y
A1656	n	WAT small	one-sided	ngc4874	y
A2147	n	WAT small	N.D.	ugc10143	-
A2151	n	WAT small	core	ngc6041	?
A2162	n	FR I – no core	N.D.	ngc6086	-
A2197	n	point	one-sided	ngc6173	y
A2634	n	WAT	one-sided	3C465	y
A2666	n	Tail	one-sided	ngc7768	y