INAF

New developments at Istituto di RadioAstronomia and magnetic field studies

LOFAR Magnetism KSP Workshop, Bologna
24-25 November, 2011

Aims of the Institute include:

- Scientific research ➔
galactic and extragalactic radio astronomy, geodesy

- Technological research ➔
design and fabrication of radio instrumentation

- Management of the Italian Radio Astronomical facilities ➔ 3 Radiotelescopes + 1 close to completion

~60 perm staff member
plus Univ. Prof.,
PhD students,
postdocs,
fellows,
undergraduate st.

<u>Observing facilities</u> : **Northern Cross Radio Telescope**

B2 and B3 catalogues of radio sources

Now : test bed for new technologies, LOFAR

Medicina Antenna (32 m)

Freq. Agility , Fiber optic connection

Noto Antenna (32 m)

Active surface, 43 GHz receiver
Under major repair
Will be connected by fiber optic

Sardinia Radio Telescope SRT

Fully steerable, 64m diameter, paraboloidal radio telescope.

Alt- Azimuth mounting

Wide frequency range: from 300MHz to 110GHz.

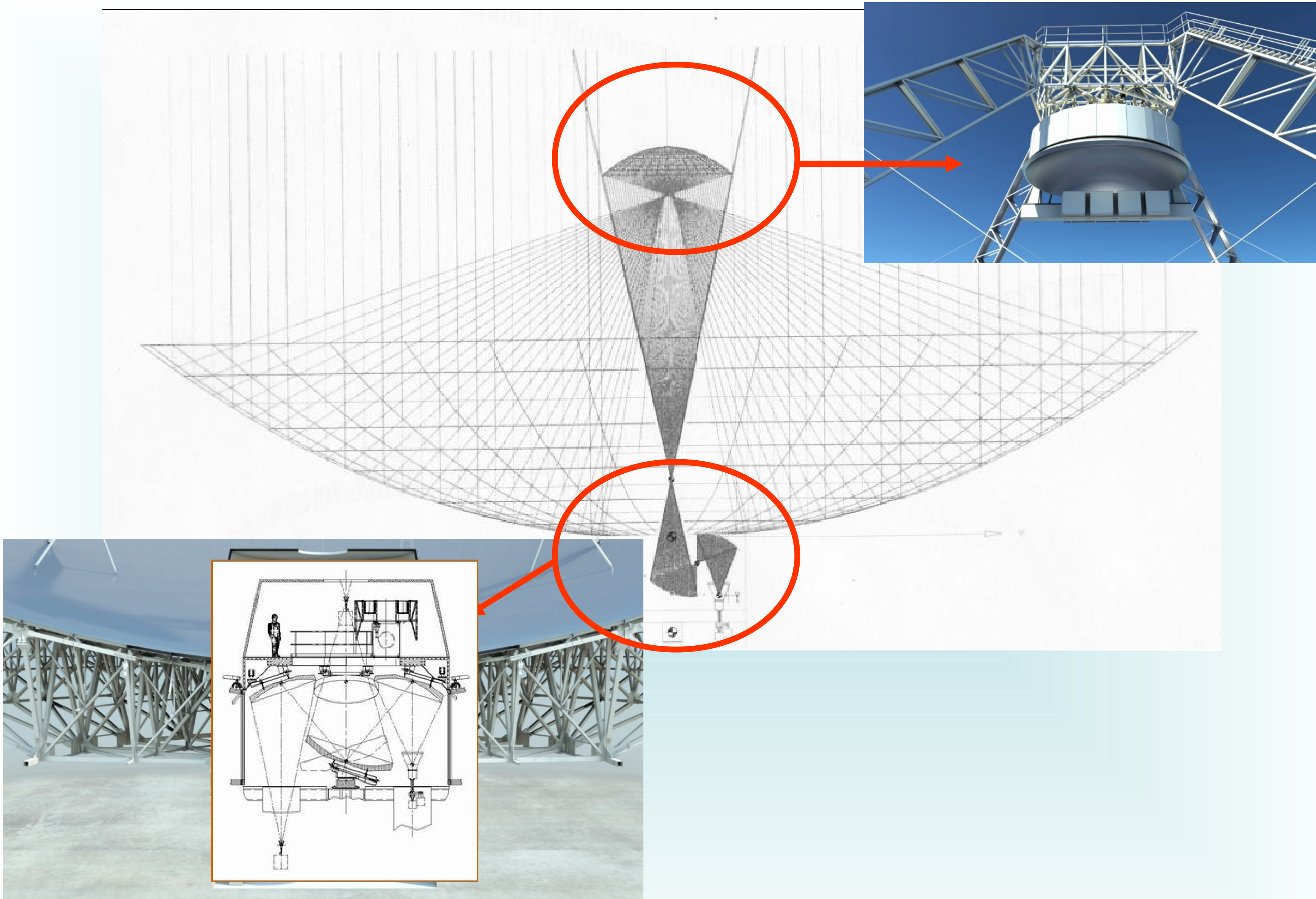
3 main focal positions

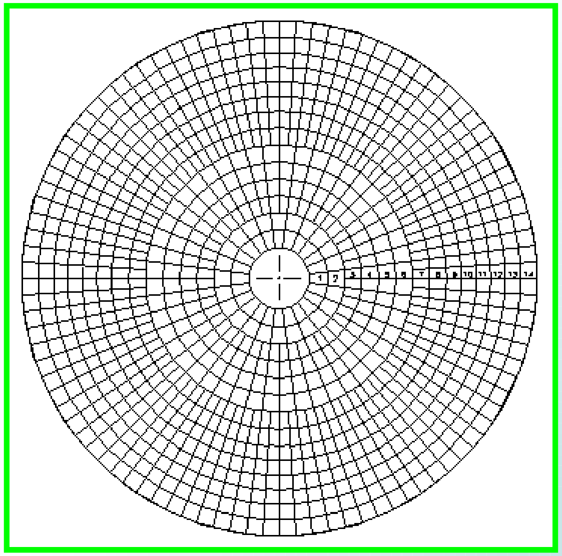
Can host up to 17 receivers

Active surface: efficiency ranges from about 63% (at ~10GHz)
to about 35% (at ~100GHz)

Fiber optic connection

Transmitting capabilities





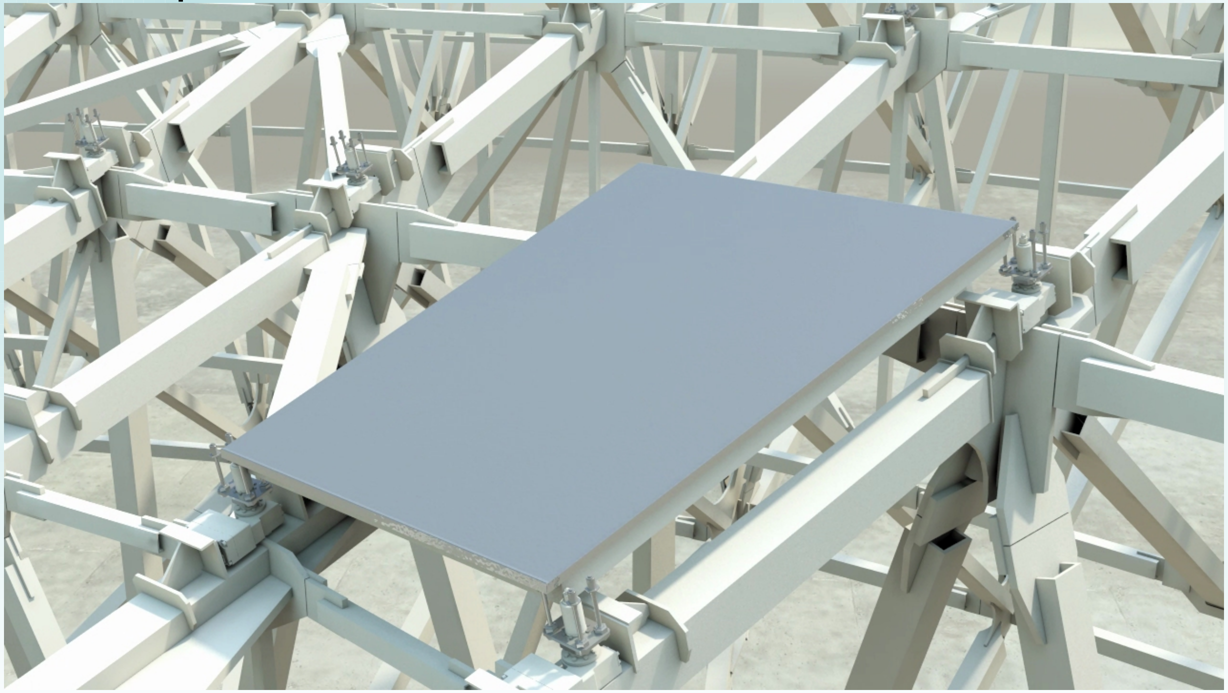
Main reflector active surface:

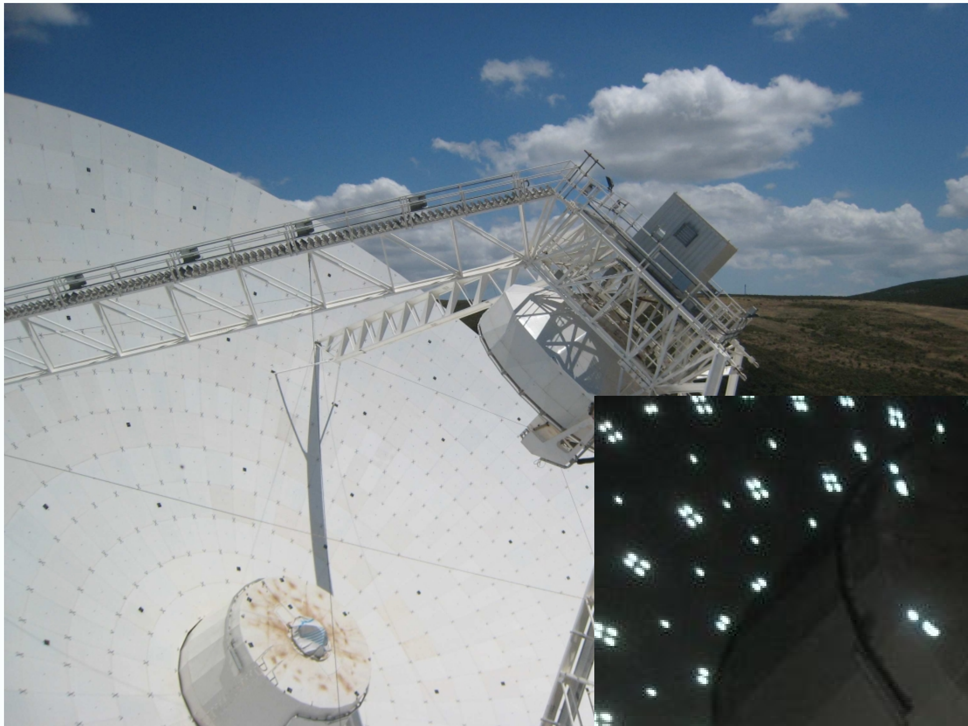
1008 panel + 1116 mechanical actuators

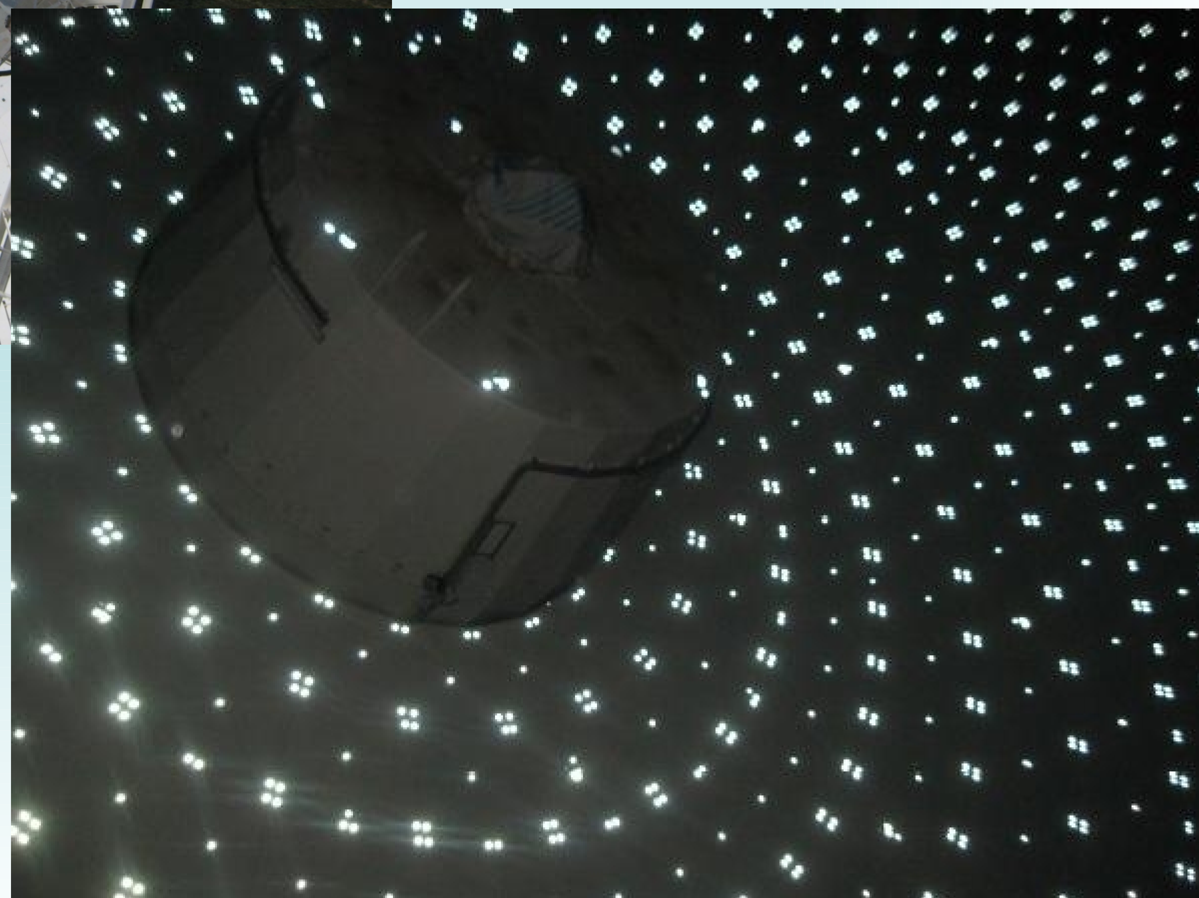
Alignment specs:

Panels : 500 µm (duty) → 300 µm (goal) rms

Panel 4-corners on each single actuator: ≤ ± 100 µm





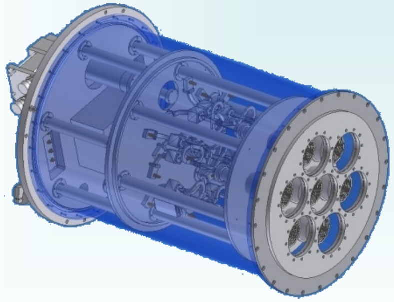


SRT First light RECEIVERS

310-420 MHz
1.3-1.8 GHz } **Dual Band** **Primary focus**

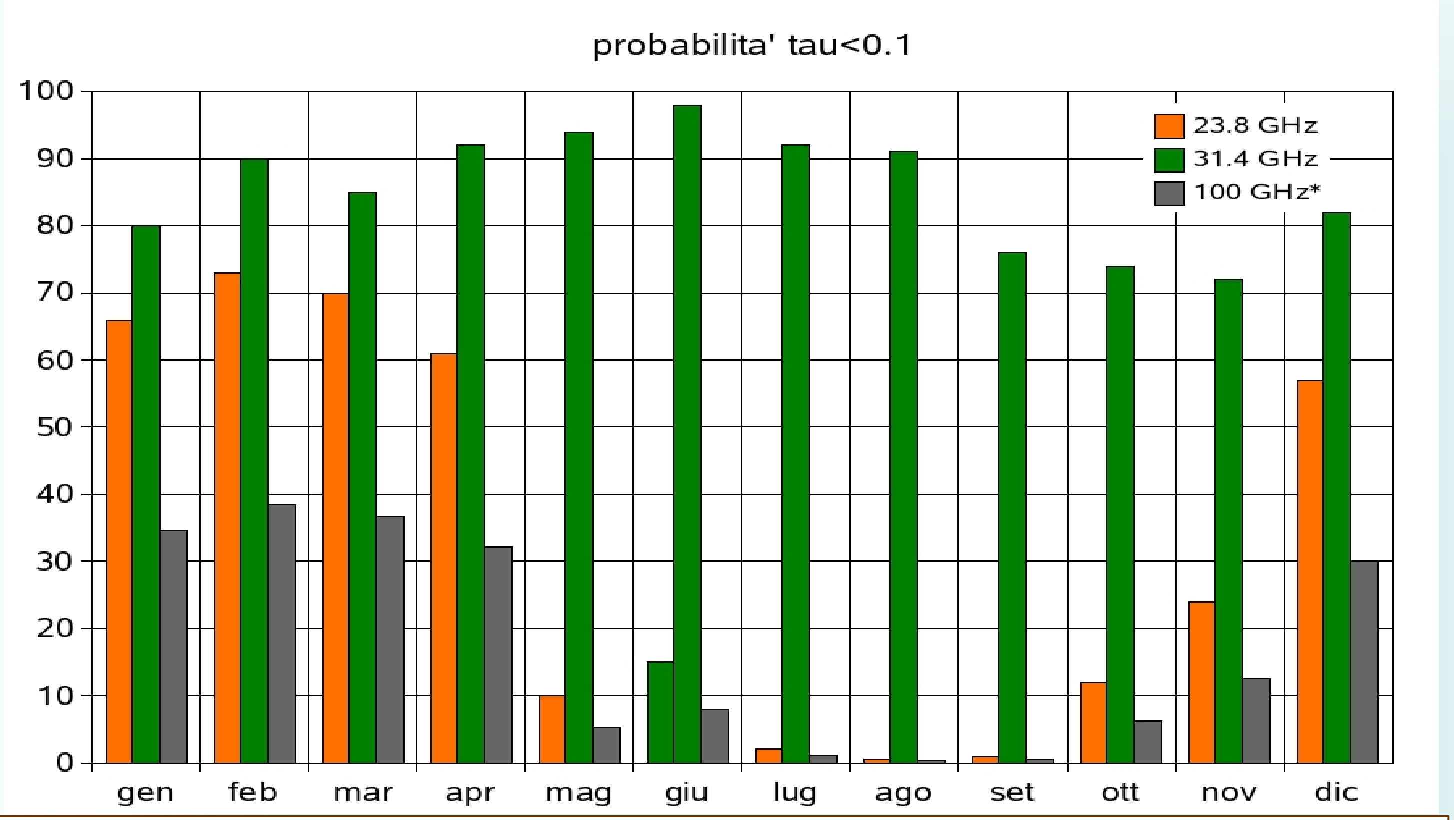
5.7-7.7 GHz **Mono-feed** **BWG focus**

18-26 GHz **Multi-feed 7 pixels** **Gregorian focus**




L-R polarization (17 db)

SRT has been conceived to work at high frequencies



Observing time (in %) with an expected atmospheric opacity τ<0.1
23.8 GHz 31.4 GHz 100 GHz (Ambrosini et al.)

(23.8 and 31.4 GHz measured, 100 GHz extrapolated)

Scientific topics

Pulsars
Supernovae
Star formation regions in the Galaxy
Masers
Gas in external galaxies
AGN
Galaxy clusters

IRA Projects

λ m/cm → **SKA**

(e)VLBI, RadioAstron, SRT, LOFAR

λ mm/sub-mm → **ALMA**

VLBI mm, SRT, ARC

in synergy with other bands

Lines of Scientific Research

- **Extragalactic radio sources**
- **High resolution studies of AGN (VLBI)**
- **Surveys (radio, optical, IR, X-ray, CMB)**
- **Non thermal phenomena in galaxy clusters**
- **Stars and star formation**
- **Theoretical developments**
- **Geodesy**

Observations with modern instruments in all bands

Astron. Astrophys. 94, 61–66 (1981)

ASTRONOMY AND ASTROPHYSICS

The Polarization of the Tail Radio Source B2 1615+35

A Discussion of the Physical Conditions and Acceleration Mechanism in a Tail Radio Source

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ASTRONOMY AND ASTROPHYSICS

Research Note

Linear Polarization Measurements at λ11 cm

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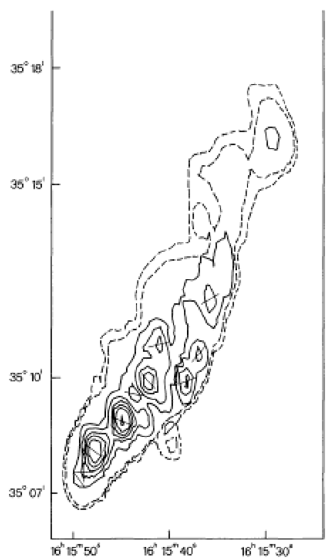


Fig. 1

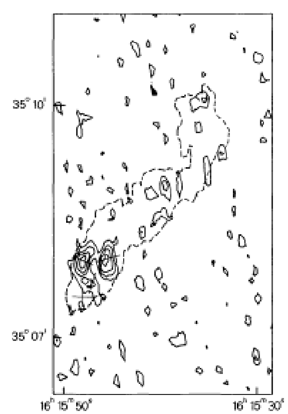


Fig. 2

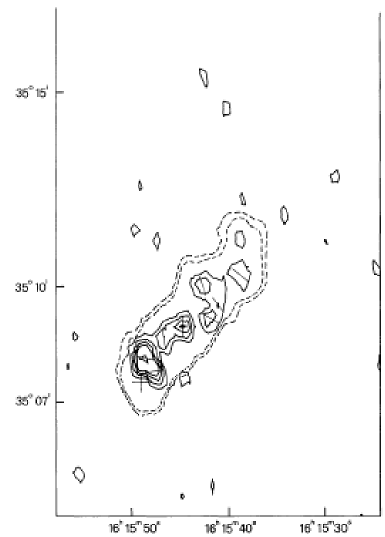


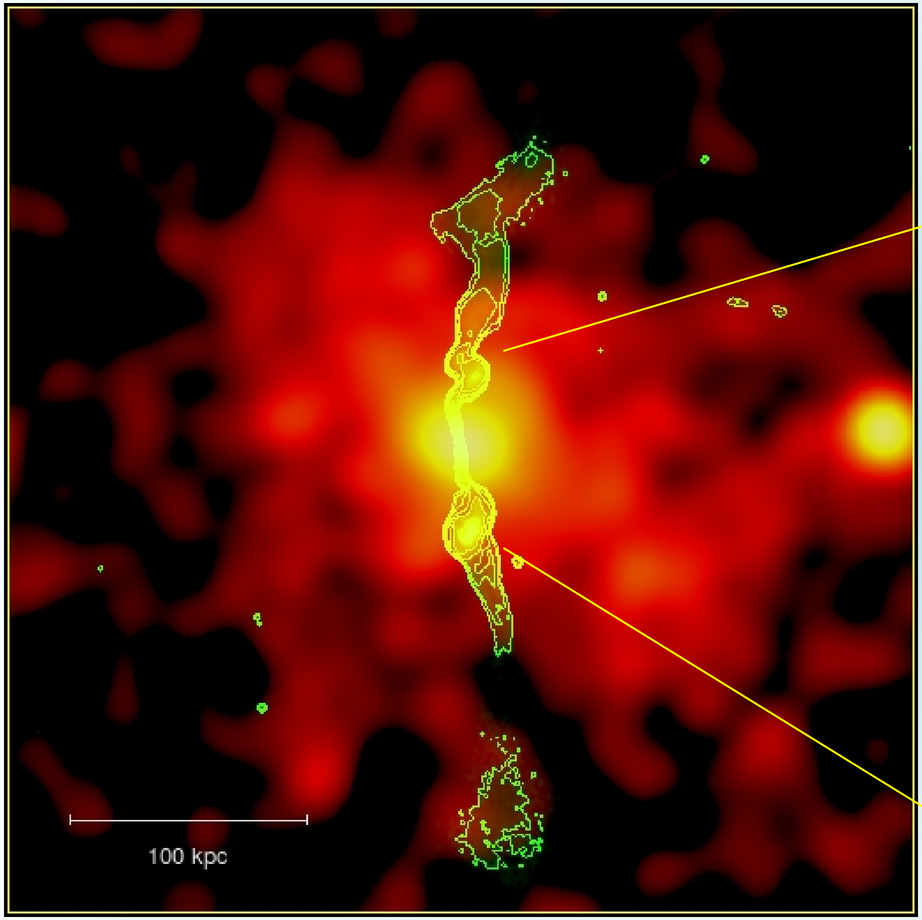
Fig. 3

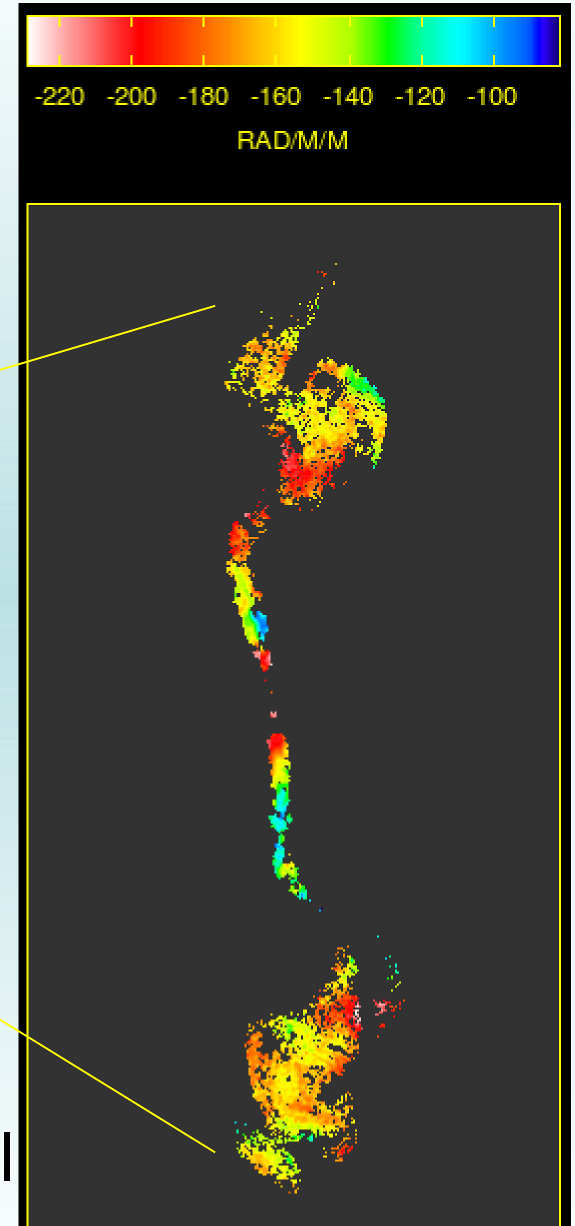
Fig. 1. Contour map of polarized intensity at 1.4 GHz. Contour levels are: 2, 4, 6, 8, 10, 15, ... mJy/beam area. Arrows represent the directions of the electric vector. The two broken contours are total intensity at brightness levels of 2.5 and 5.0 mJy/beam area. A cross marks the position of the nucleus of NGC 6109. 1 mJy/beam are = 0.6 K

Fig. 2. Contour map of polarized intensity at 5.0 GHz. Contours are: 2, 3, 4, ... mJy/beam area. Arrows represent the directions of the electric vector. The broken line represents a total intensity at a brightness level of 2.5 mJy/beam area. 1 mJy/beam area = 0.43 K

Fig. 3. Contour map of polarized intensity at 5 GHz, degraded to the same resolution as the 1.4 GHz map. Contour levels are: 4, 6, 8, ... mJy/beam area. Arrows represent the directions of the electric vector. The two broken lines represent total intensity at brightness levels of 2.5 and 5.0 mJy/beam area. 1 mJy/beam area = 0.5 K

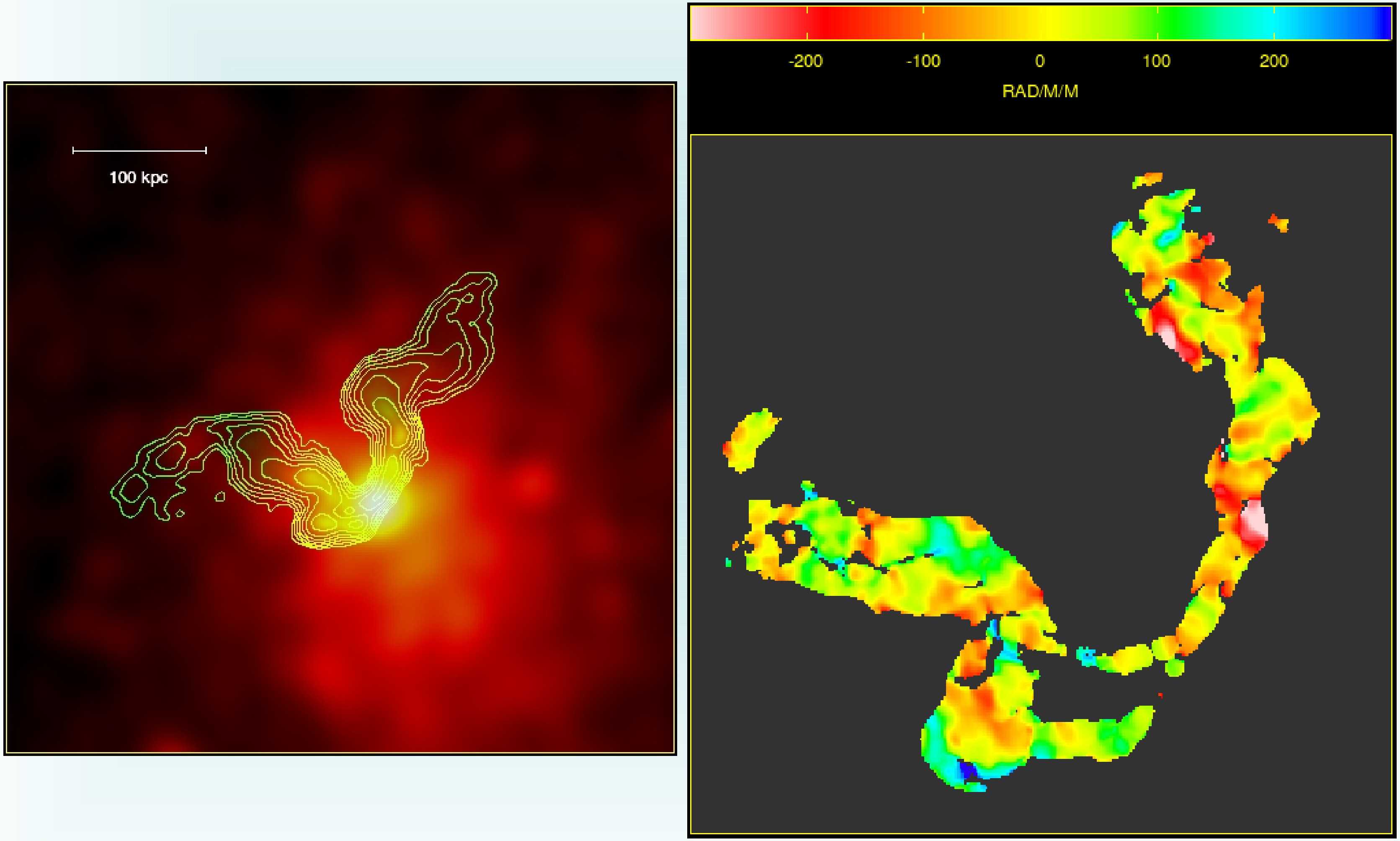
3C449 (Feretti et al.1999, Guidetti et al. 2010)





Important to distinguish internal and external effects

3C 75 (Eilek & Owen 2002, Murgia et al. 2010)



Other examples: Govoni+, Murgia+, Guidetti+, Laing+

Other sudies:

olarization and RM in young sources (Compact Steep Spectr

ndication of strong interaction between jet and clouds
n the ISM

3C147

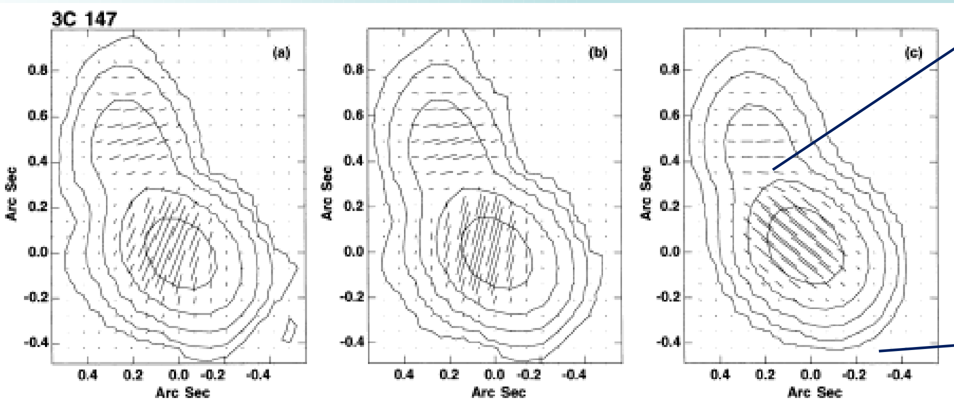
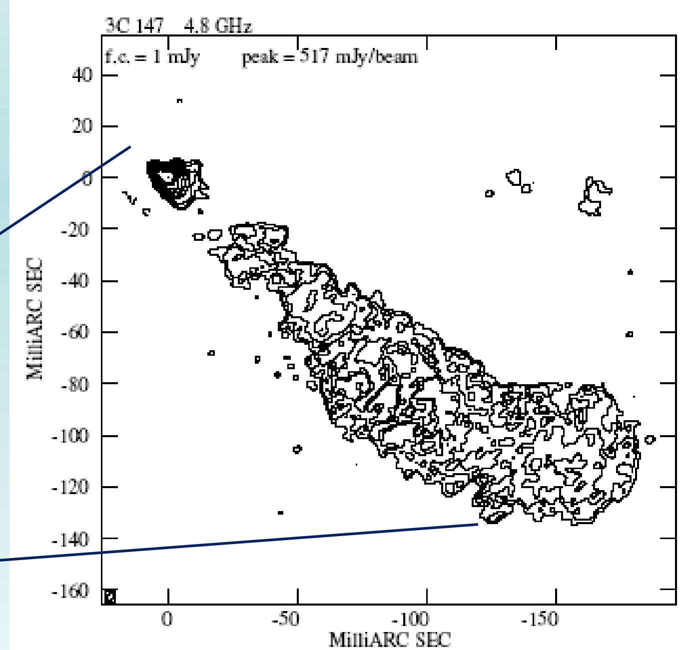


Figure 2. Images of 3C 147 at 8.1, 8.5 and 14.9 GHz in panels (a), (b) and (c) respectively, all with a resolution of $0.28 \times 0.23\,\mathrm{arcsec}^2$ along 24°.3. Polarized-intensity vectors are superimposed on the total-intensity contours. The contours are plotted at $(1, 4, 16, 64, 256) \times 6\,\mathrm{mJy\,beam^{-1}}$ for 8.1 and 8.5 GHz, and at $\times 3\,\mathrm{mJy\,beam^{-1}}$ for 14.9 GHz. The lengths of the polarization vectors are $114\,\mathrm{mJy\,beam^{-1}\,arcsec^{-1}}$ at 8.1 and 8.5 GHz, and $190\,\mathrm{mJy\,beam^{-1}\,arcsec^{-1}}$ at 14.9 GHz.



Rossetti+2009
Mantovani+2010

Interpretation

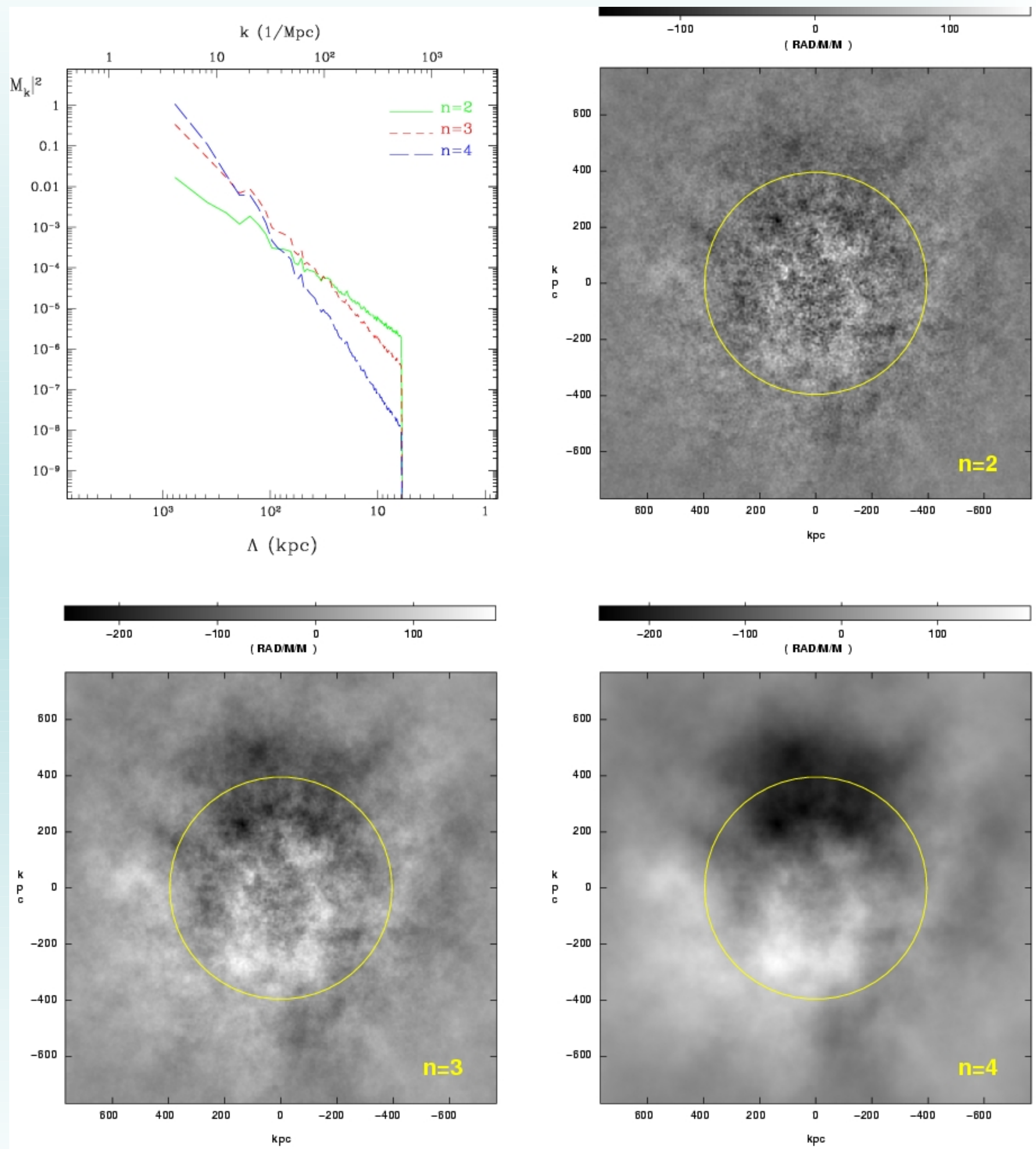
Dedicated software tools have been developed to constrain the magnetic field power spectrum parameters and their uncertainties (Murgia et al. 2004, Laing et al. 2008)

3D multi-scale fields,radial decrease in field strength, range of coherence scales

Derive synthetic images of

- **RM**
- **fractional polarization**
- **synchrotron emission**

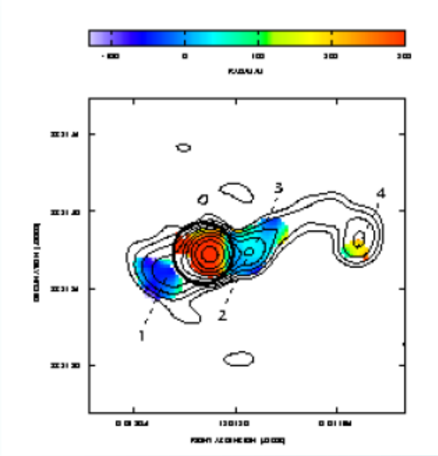
for comparison with observations

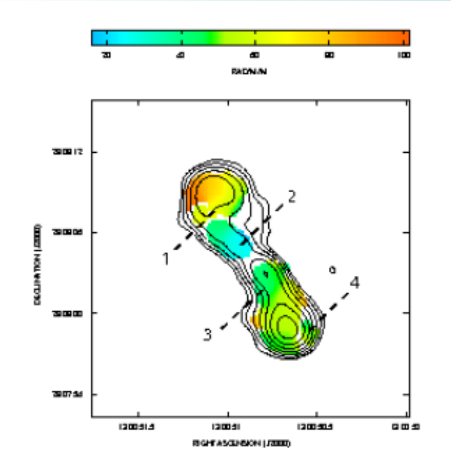


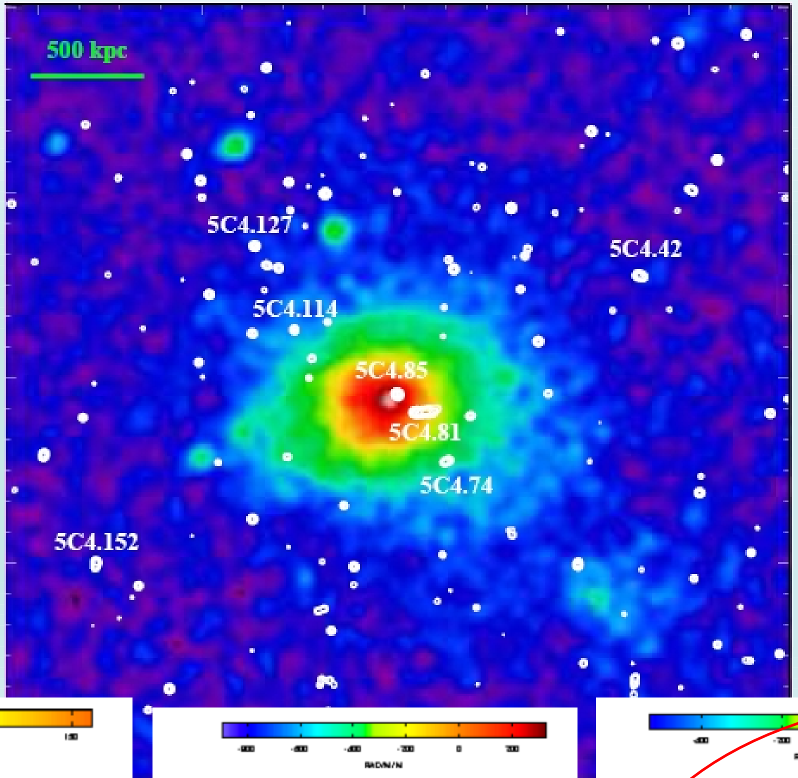
Murgia et al. (2004)

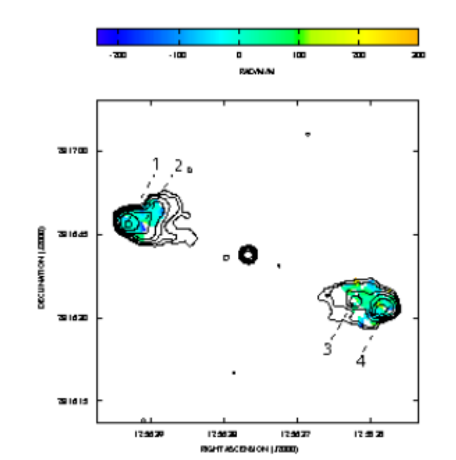
Coma

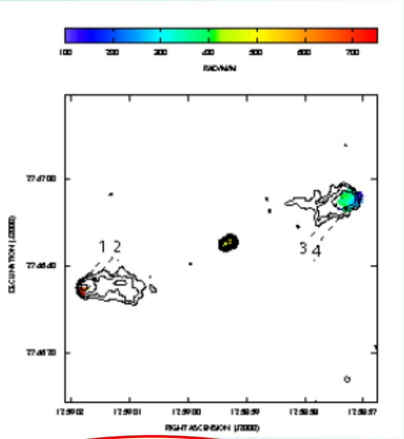
Bonafede et al. 2010

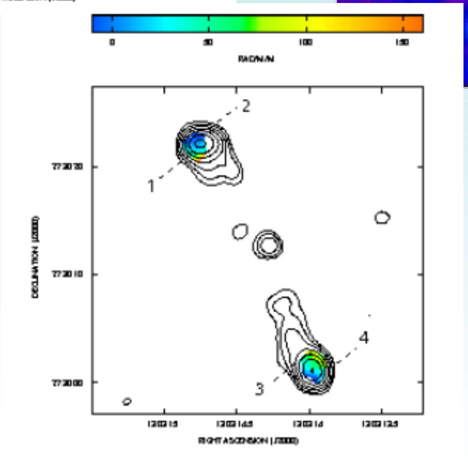


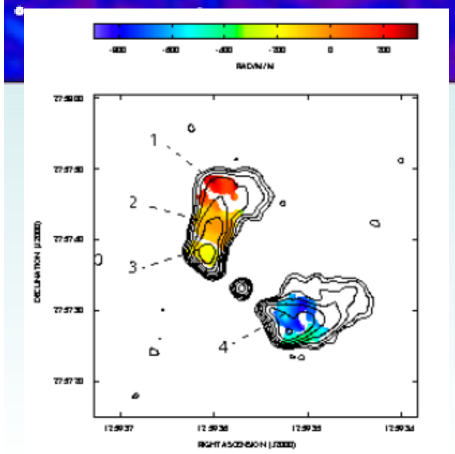


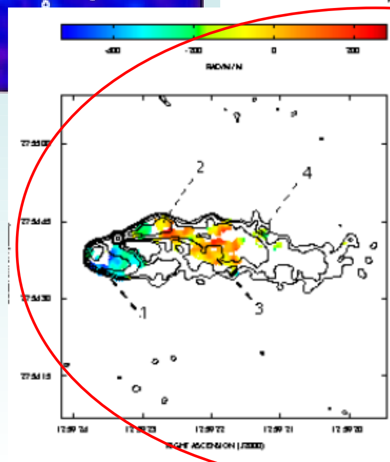




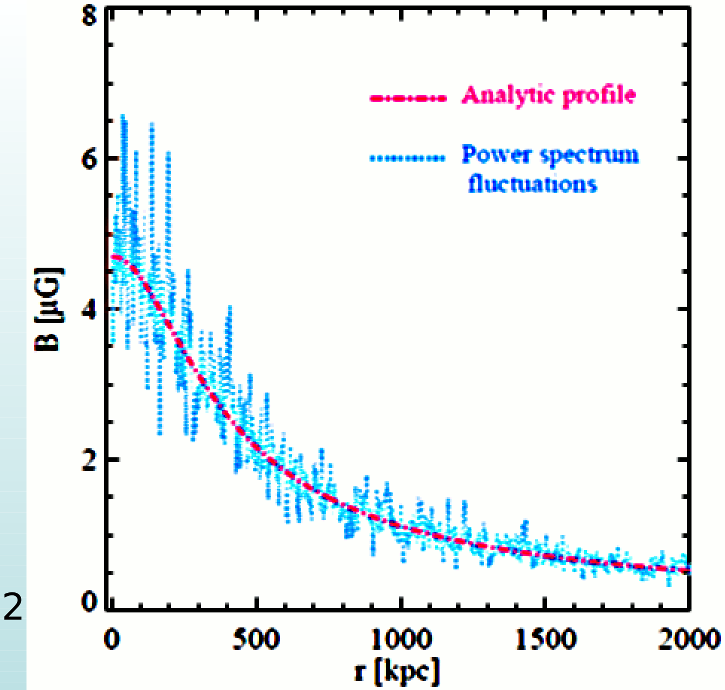








NGC 4869
Feretti et al. 1995



RM values reproduced by

$B_0 = 4.7_{-0.8}^{+0.7}$ μG

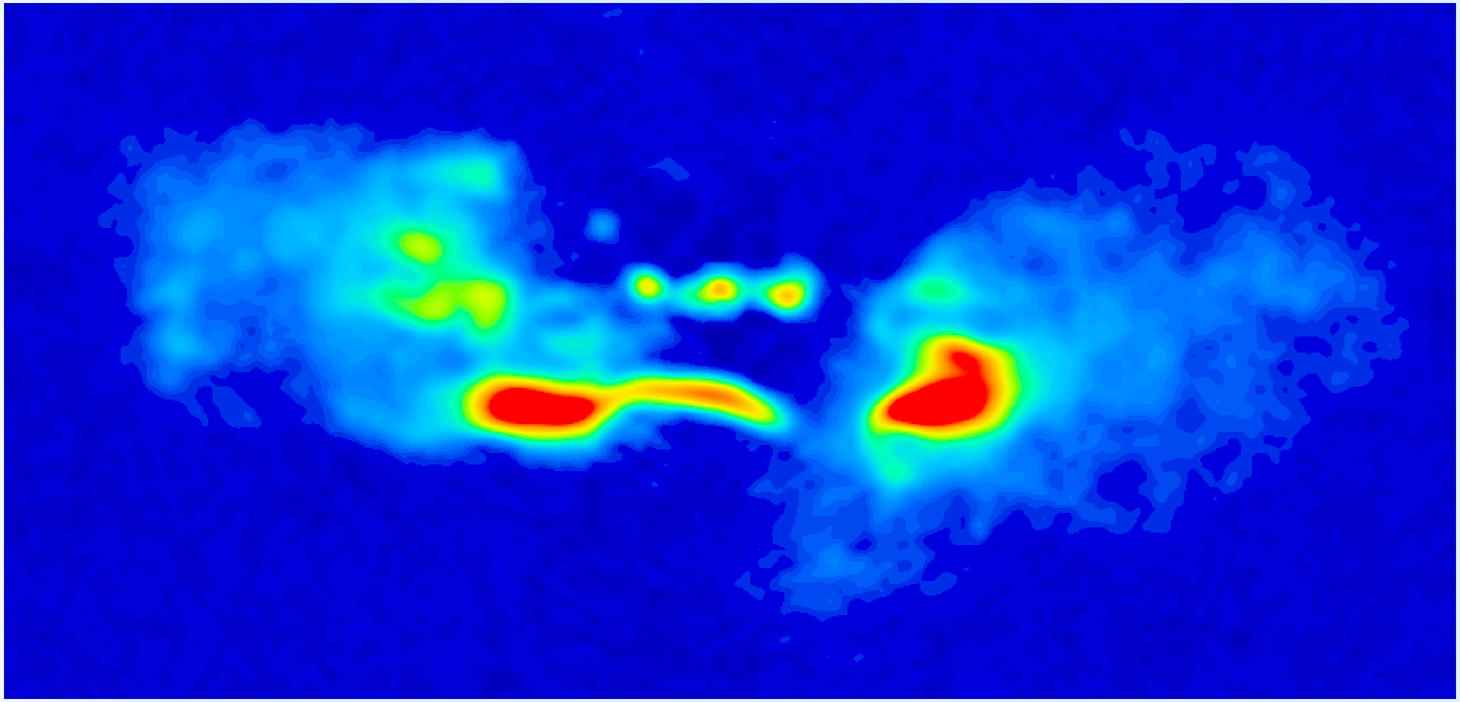
B profile scaling as $n^{0.5}$ (-0.1, +0.2

Kolmogorov power spectrum

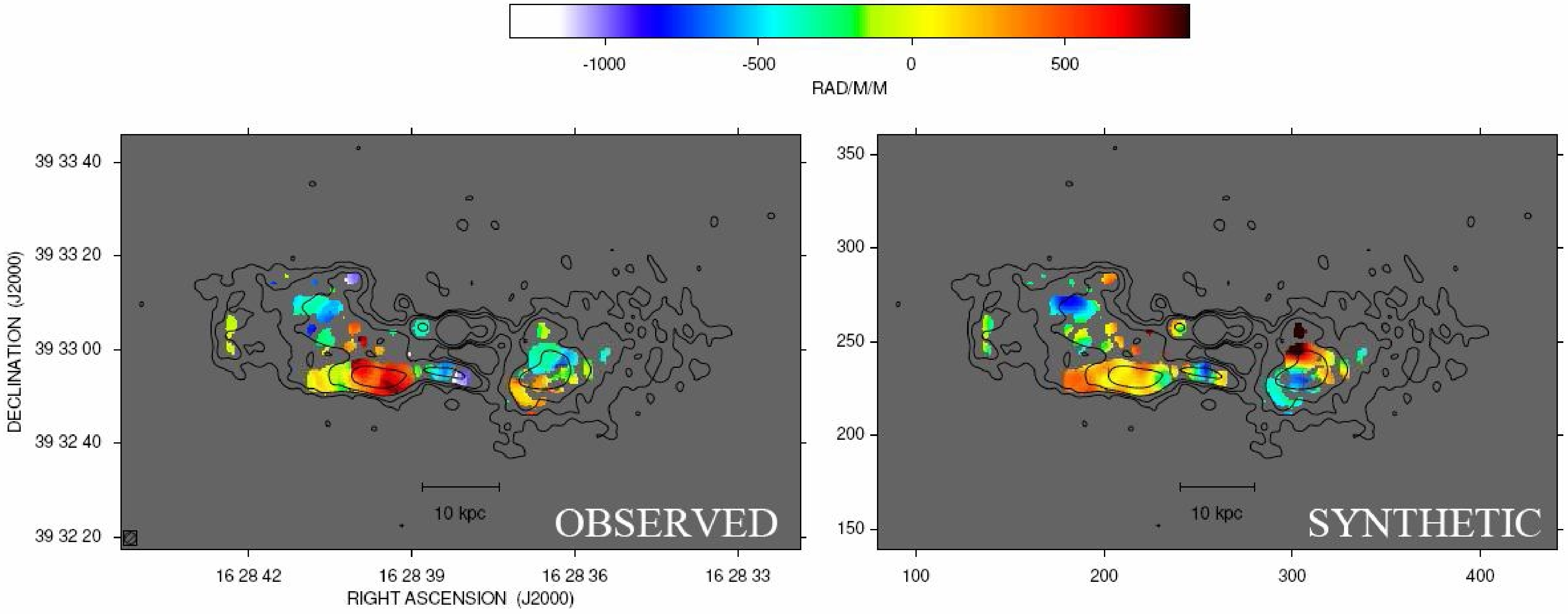
coherence scales in the range 2 – 34 kpc

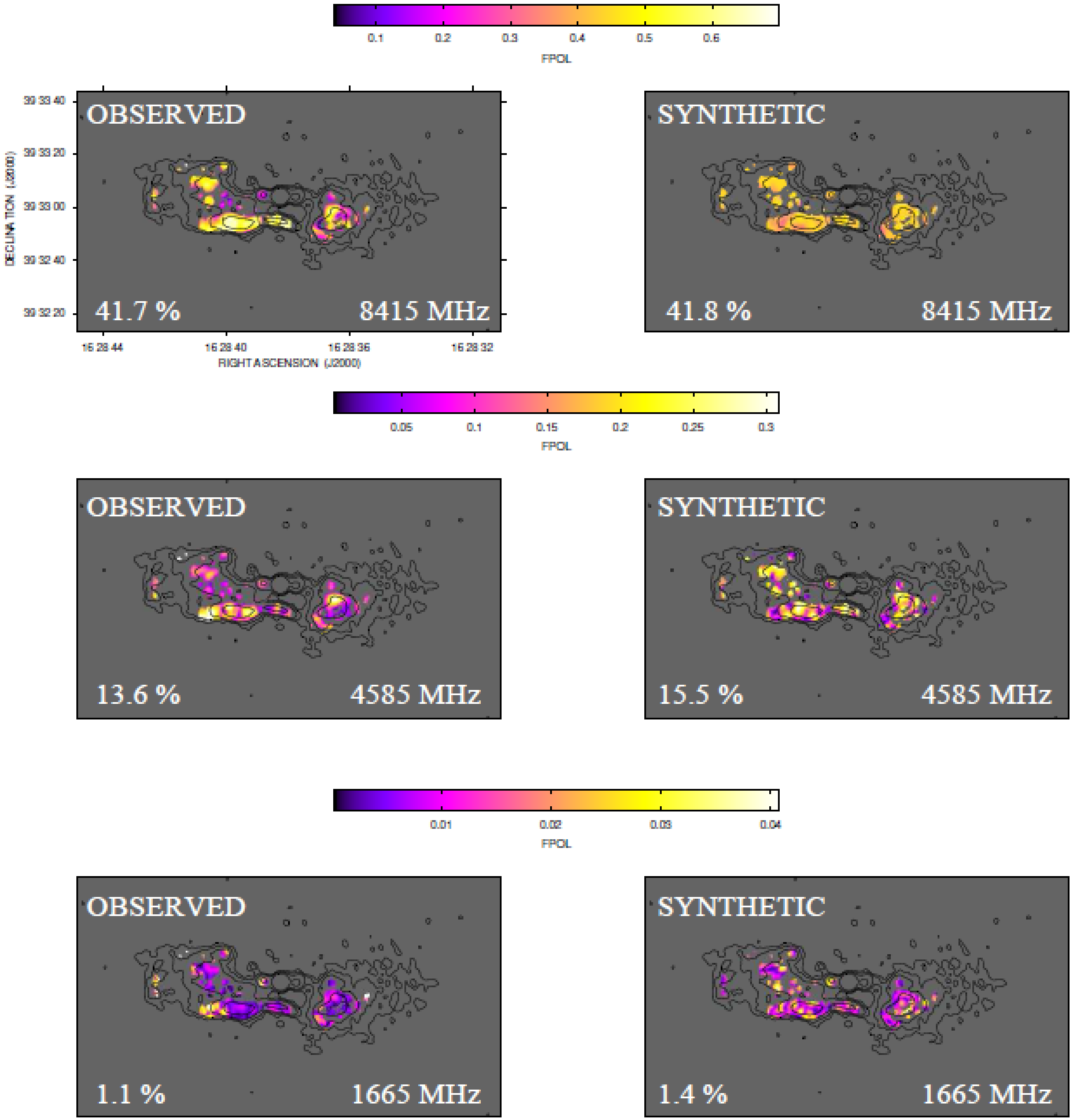
Source	Projected distance kpc	n. of beams	$\langle RM \rangle$ rad/m^2	$\sigma_{RM,obs}$ rad/m^2	Err$_{fit}$ rad/m^2	σ_{RM} rad/m^2
5C4.85	51	35	-256±50	303	46	299±36
5C4.81	124	56	-120±22	166	48	159±17
5C4.74	372	10	372±51	154	44	148±41
5C4.114	532	16	51±4	16	2	16±3
5C4.127	919	7	21±30	65	36	54±26
5C4.42	1250	33	6±12	56	43	36±11
5C4.152	1489	4	32±27	37	28	24±21

3C 338 (Vacca et al. 2010)



3C 338 (Vacca et al. 2010)





$B_0 \sim 10\ \mu G$
Radial decrease $\propto n^{0.9}$
Power spectrum index=2.7
Λmin = 0.7 kpc
Λmax = 35 kpc

(Vacca et al. 2011)

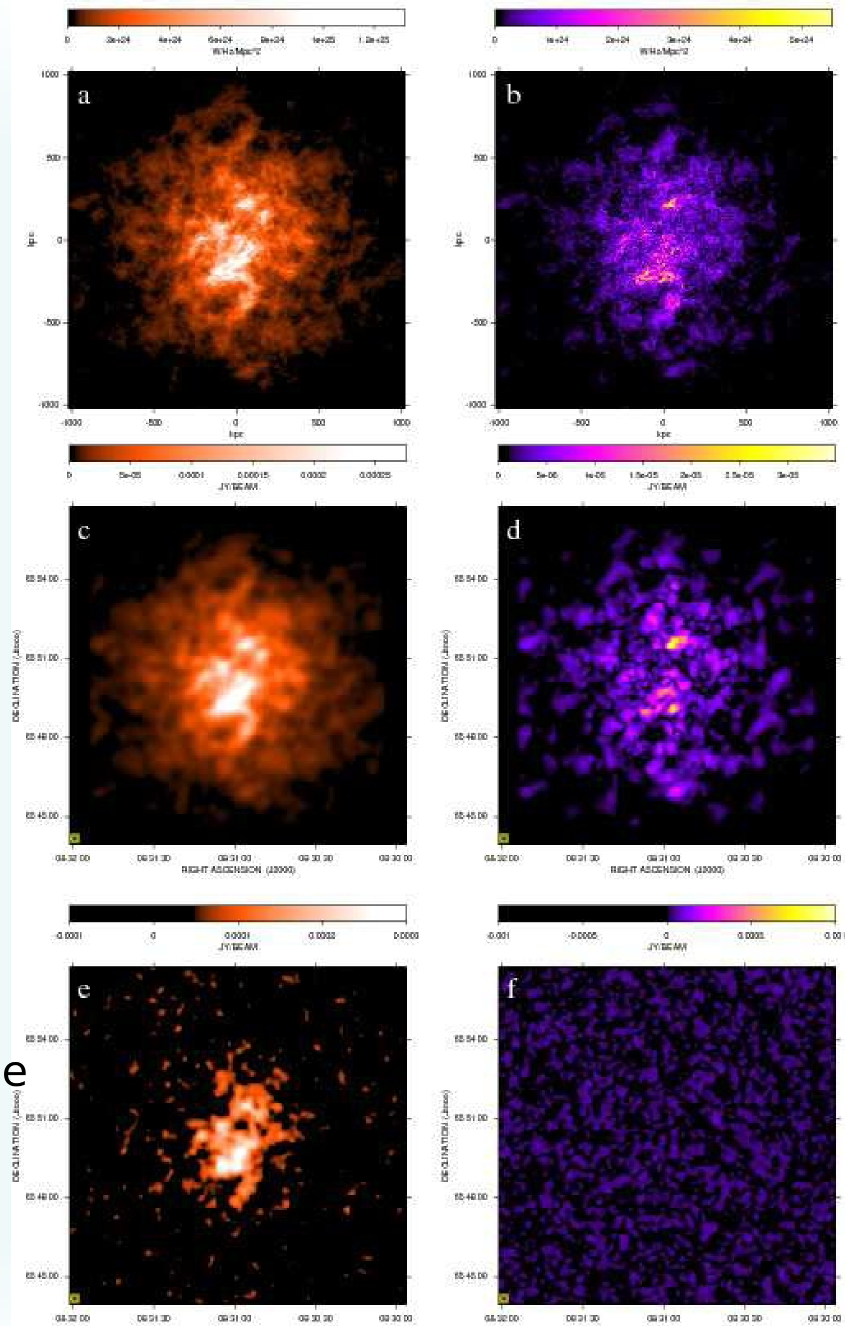
A665

B field power spectra affect <u>brightness</u> and <u>structure</u> of halos, beside their polarization

1'

15''

15''
+ noise



V. Vacca et al. 2010

$B_0 \sim 1.3\ \mu G$

Radial decrease $\propto n^{0.5}$

Total intensity Polarized intensity (synthetic images)

Conclusions

Instrumental improvements in Italy

High sensitivity data and numerical techniques
for B field studies in RS and IGM

Big Interest to LOFAR