


The low-frequency compact structure of the radio outflow of 4C55.16

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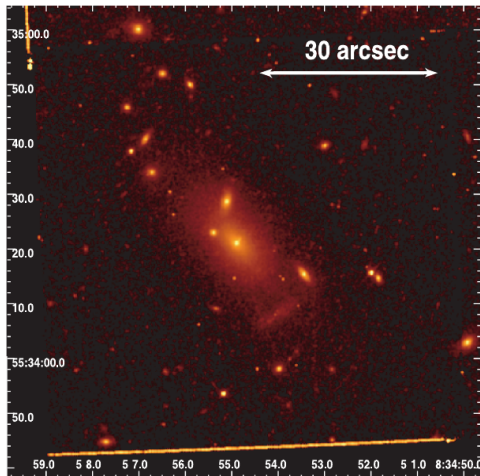


Outline

- 4C 55.16 radio galaxy
- LOFAR Long Baseline (VLBI) observation
- Key points:
 - Resolution, multi scale, maximum resolution
 - Spectral accuracy. Multiwavelength view
 - Sinergies with other instruments: VLA, cm-VLBI/MERLIN, X-ray satellites, ...

Collaborators: Raymond Oonk (Leiden University/Astron), Raffaella Morganti (Astron), Adam Deller (Astron), Kazushi Iwasawa (Universitat de Barcelona), Leith Godfrey (Astron), John Mckean (Astron)

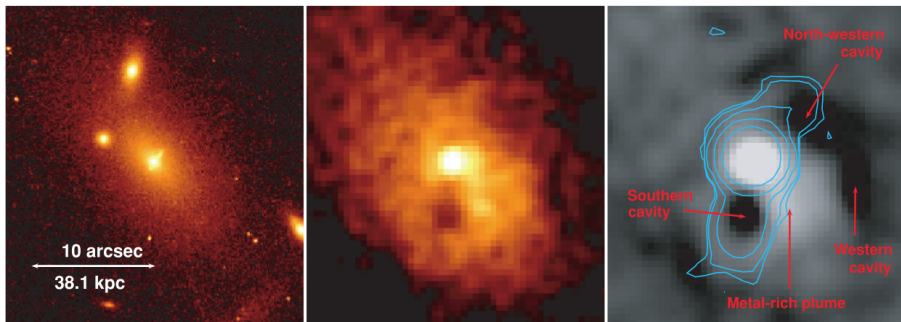
The cluster 4C 55.16



Hlavacek-Larrondo et al. (2011)

- 4C55.16 is located at the centre of a cool core cluster of galaxies.
- $z = 0.2412$.
- $L_X \sim 10^{45}$ erg/s.
- $L_R = 8$ Jy/b at 1.4 GHz.
- Large core flux for a “normal” radio galaxy.

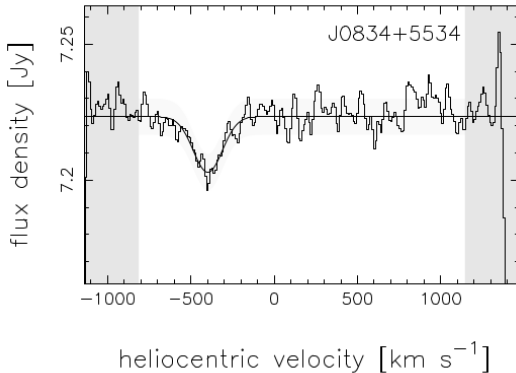
Multiwavelength view



Hlavacek-Larrondo et al. (2011)

- Unusual intracluster iron distribution showing a plume-like feature.
- Large cavities correlated with radio lobes.

HI absorption

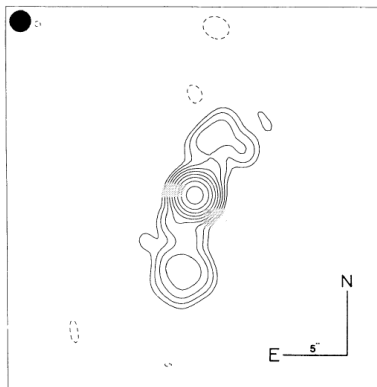


Vermeulen et al. (2003)

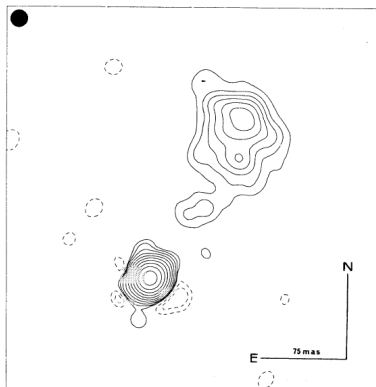
- There is HI absorption.
- Blueshifted by 400 km/s, suggesting gas motion.

Radio structure: VLBI and MERLIN

MERLIN 408 MHz



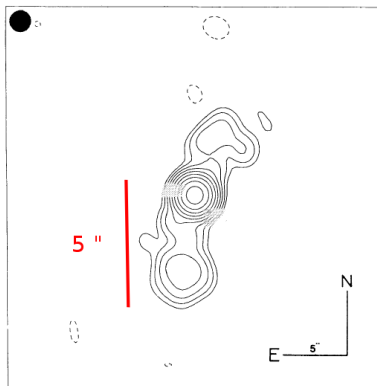
VLBI 5 GHz



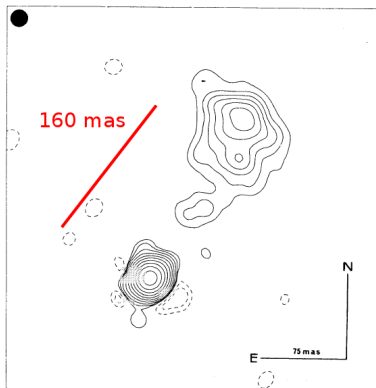
Whyborn et al. (1985)

Radio structure: VLBI and MERLIN

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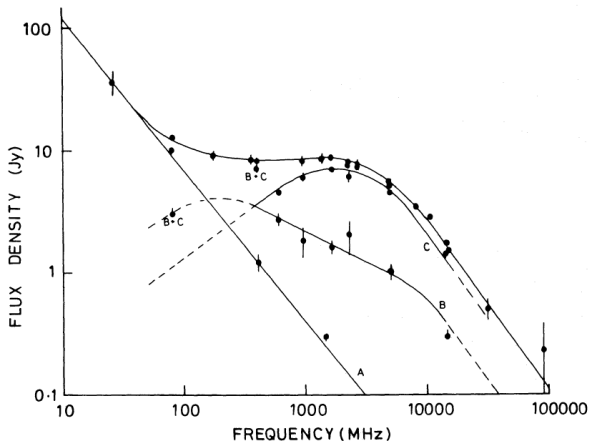


VLBI 5 GHz



Whyborn et al. (1985)

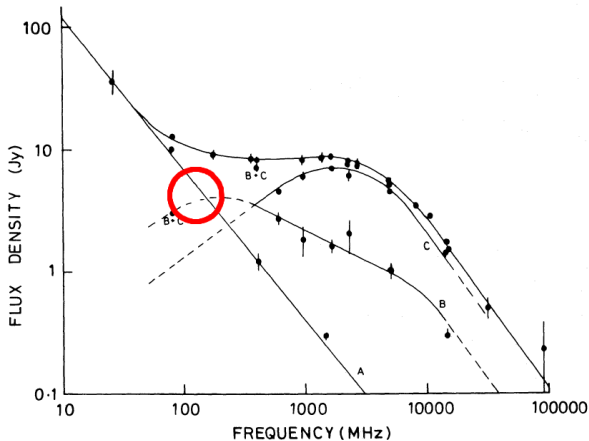
Radio spectrum



Whyborn et al. (1985)

- The core is divided in components C and B (160 mas).
- Component A is the rest of the lobe emission.

Radio spectrum



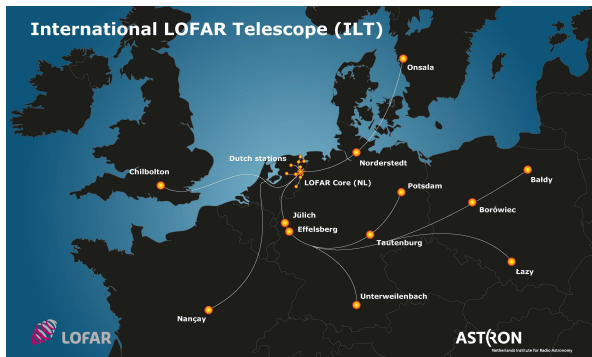
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High-resolution imaging Source morphology

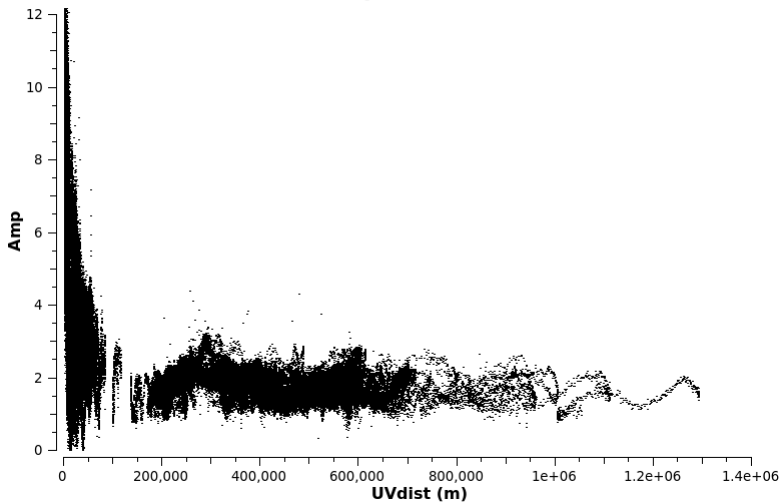
Observations

- February 2015.
- CS + RS + 9 international stations.
- **2 hr.** 120–160 MHz.
- Commissioning LOFAR VLBI observations.

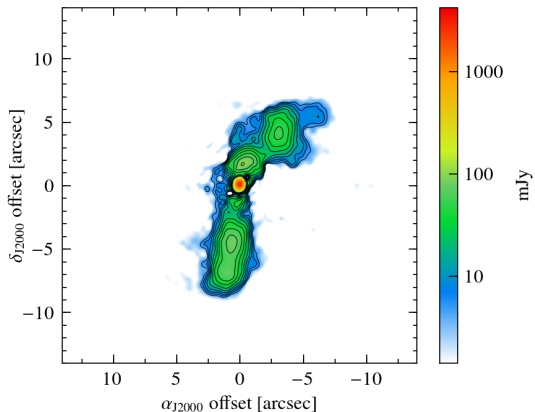


UV regime

Amp vs. UVdist



LOFAR

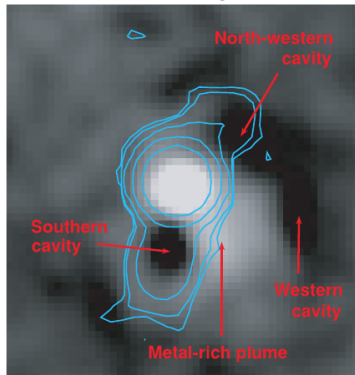


- Resolution is $0.5'' \times 0.4''$.
- Image rms is 0.4 mJy/beam.
- Dynamic range is about 10 000:1

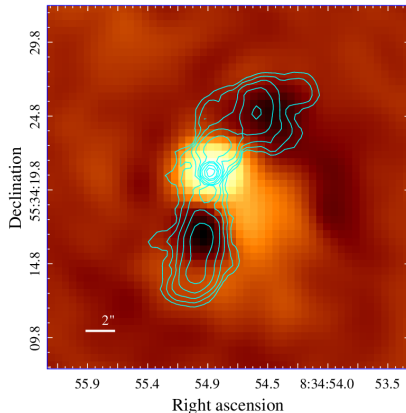
Multi-scale capabilities

Radio structure: link with X-ray cavities

VLA 1.4 GHz

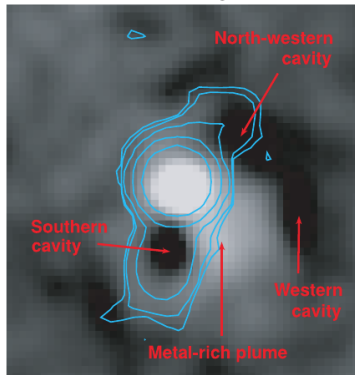


LOFAR 150 MHz

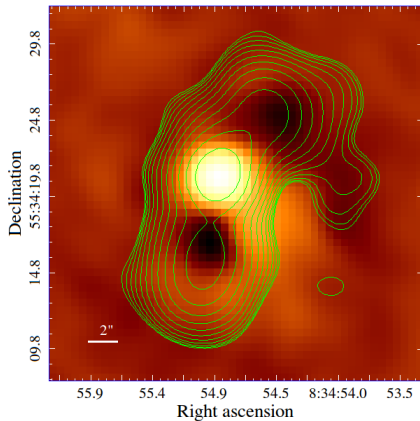


Radio structure: link with X-ray cavities

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LOFAR 150 MHz



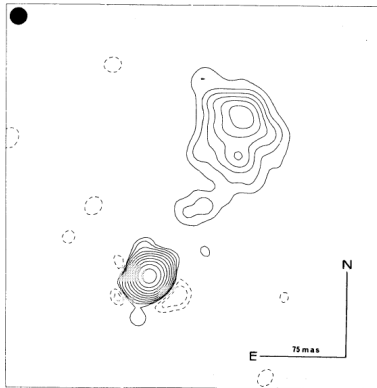
LOFAR at the highest resolution!

- LOFAR high resolution image provides:
 - Beam size: $0.3'' \times 0.2''$.
 - Core size: 210×70 mas at 160 deg.
 - < 1 kpc at $z = 0.24$

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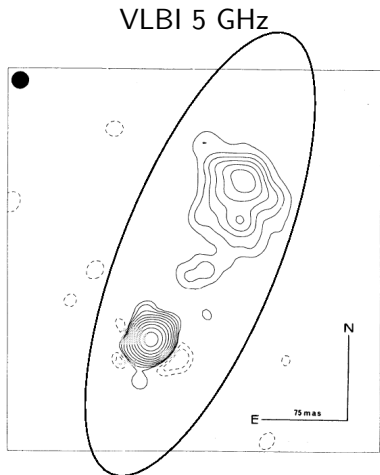
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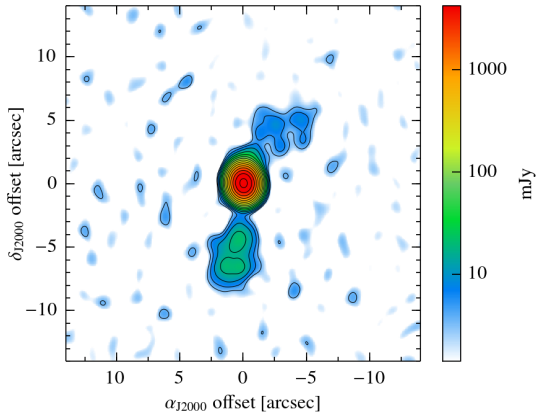
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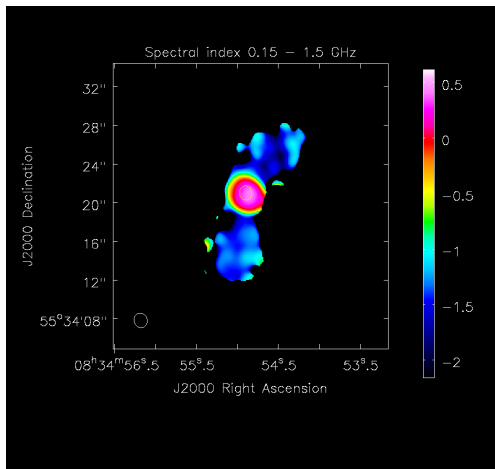
We have resolution commensurable with cm-VLBI!

Spectral information

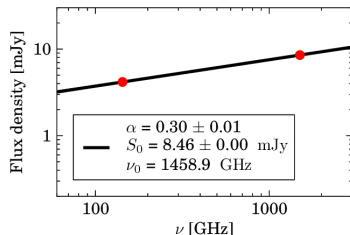


- Four VLA snapshots
- A and B configuration.
- 1.5 GHz

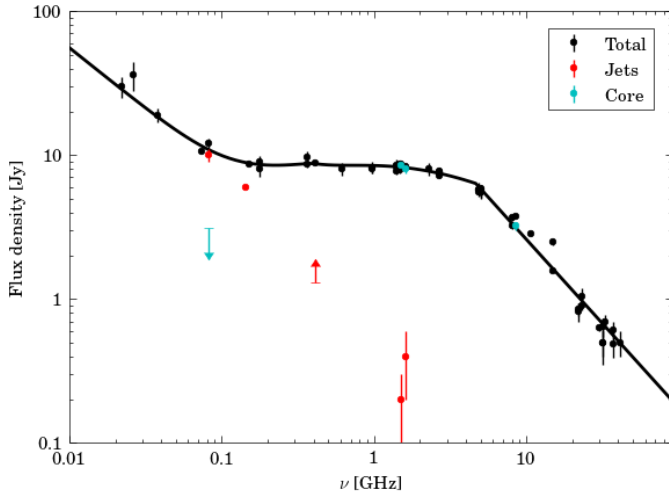
LOFAR - VLA spectral index map



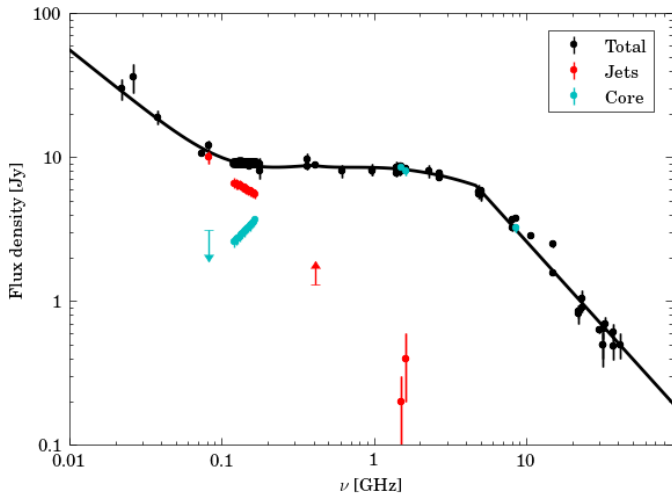
- The core has an spectral index of 0.30 ± 0.01 .
- Northern lobe $\alpha \sim -1.3$
- Southern lobe $\alpha \sim -1.6$



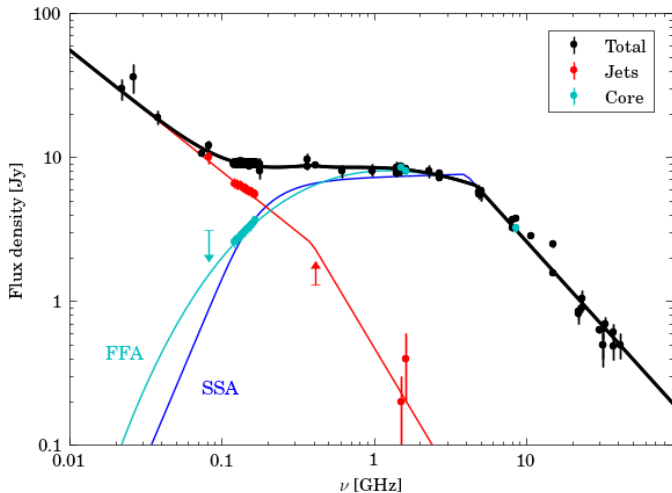
Radio spectrum



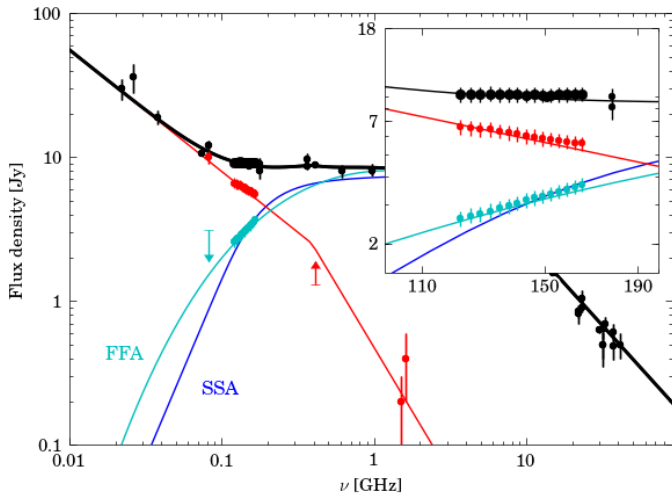
Radio spectrum



Radio spectrum



Radio spectrum



Conclusions

- Technical:
 - Only 2 hours of LOFAR VLBI 9 IS.
 - Sub-arcsec, sub-mJy imaging with high fidelity.
 - Accurate in-beam spectral information of compact structures.
 - Very different scales: compact + diffuse emission.
 - LOFAR VLBI has a strong synergies with other instruments: VLA different frequencies/configurations, cm-VLBI arrays (e-MERLIN, VLBA, EVN), X-ray satellites...
- Scientifically:
 - Describe age/history of radio emission. Link to X-ray cavities.
 - Detailed spectrum. Absorption mechanisms. FFA vs SSA.
 - Compute jet power. Check ratio of energy in relativistic particles to non-radiating particles in the lobes

The End

