Studies of compact AGNs at low frequencies with LOFAR

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4. First results:
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    - LOFAR imaging
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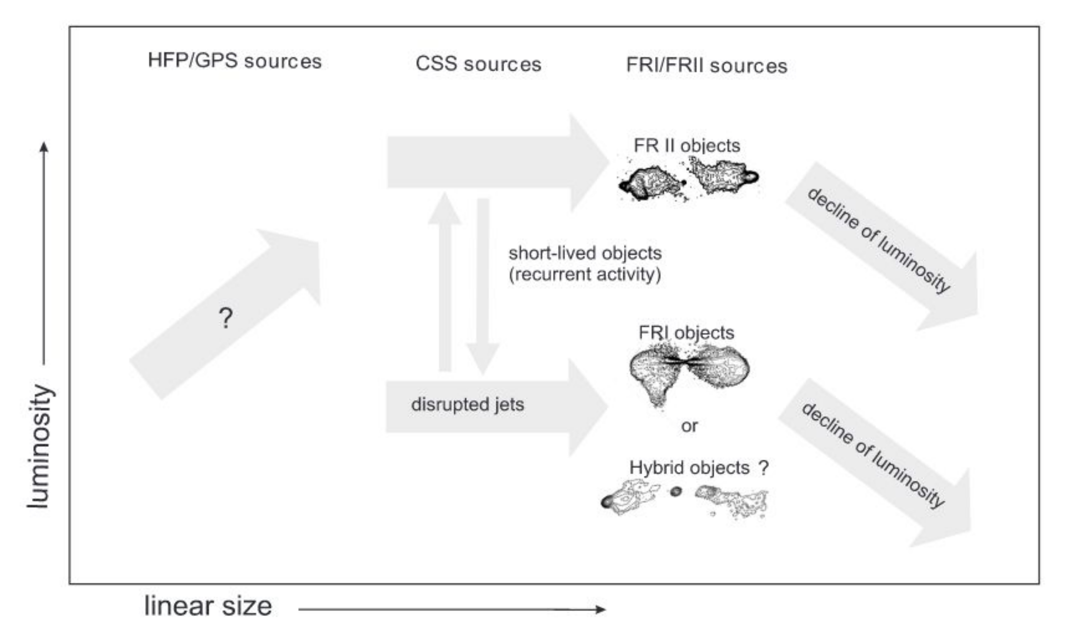
Introduction



Kunert-Bajraszewska et al. 2010

Compact AGNs are:

a. <u>young and evolving into classical double radio galaxies</u> (O'Dea and Baum 1997)
b. temporarily frustrated by their host environments (Wagner and Bicknell 2011)
c. transient on short timescales $< 10^4 – 10^5$ years (Kunert-Bajraszewska et al. 2010)

Different variants of the development of radio galaxies may explain the excess of their early developmental forms in relation to large-scale radio objects.

Goals of the project

The scientific goal of our project is to study the nature of CSS and GPS objects and thus the reasons for their excess. Using LOFAR high and low band data we plan to:

• determine the spectral turnover location and slope in the optically thick part of the synchrotron spectra of GPS/CSS

• study of the absorption processes (free-free or synchrotron self-absorption) and therefore the age of radio sources

• imaging of the oldest plasma with high-resolution in order to characterize the feedback process, the history of the source development and its evolution

Our sample

From a sample of 90 compact AGNs:

Marecki & Kunert-Bajraszewska 2003 - 46 ‘standard’ CSS sources

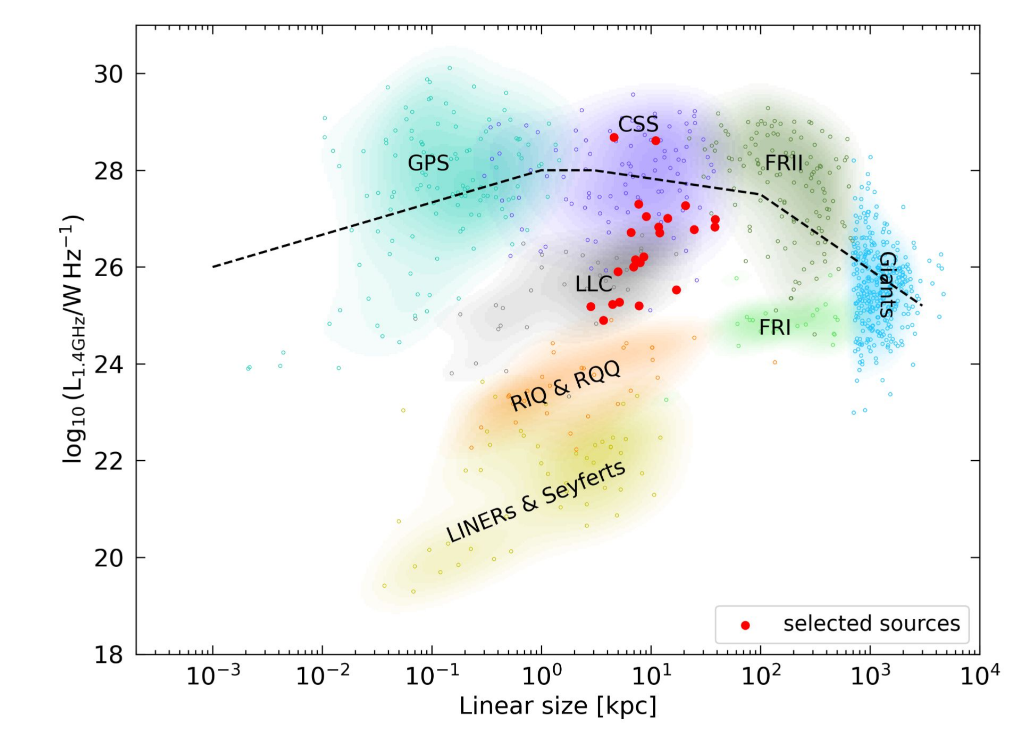
Kunert-Bajraszewska+2010 - 44 LLC sources

we have selected 25 sources best suited for LOFAR high-resolution imaging and multiwavelength analysis.

Selection criteria:

- angular size > 1’’
- observed by >9 INTL LOFAR stations
- observed and resolved at higher frequencies (MERLIN, VLA)

Kunert-Bajraszewska et al. 2025



dashed line - the evolutionary path of strong AGNs
GPS - Gigahertz-Peaked Spectrum
CSS - Compact Steep Spectrum
LLC - Low Luminosity Compact

Spectral peaks at low frequencies

CSS follow the well-known turnover frequency–linear size relationship - turnover due to SSA (Snellen et al. 2000).

For most of the studied sources the turnover frequency will shift to even lower values - they will depart from the established relation and the SSA interpretation. According to:

$$\log_{\nu\_p} = -0.21 - 0.65 \log_{LS}$$

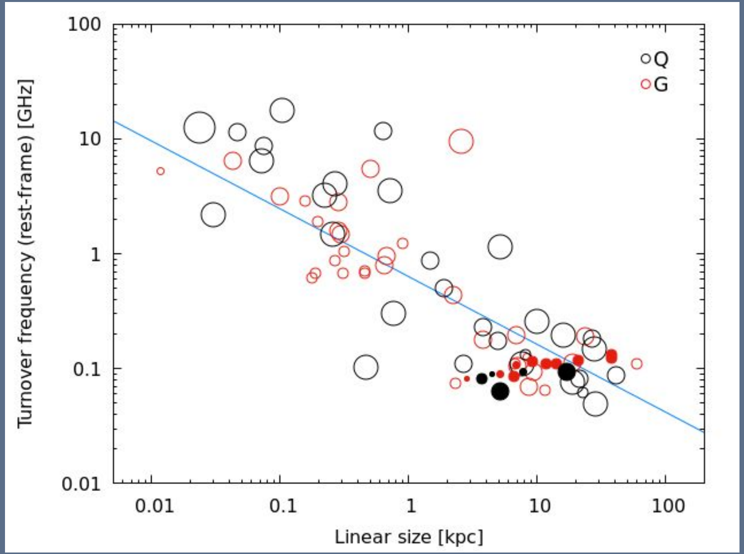
(O'dea 1998)

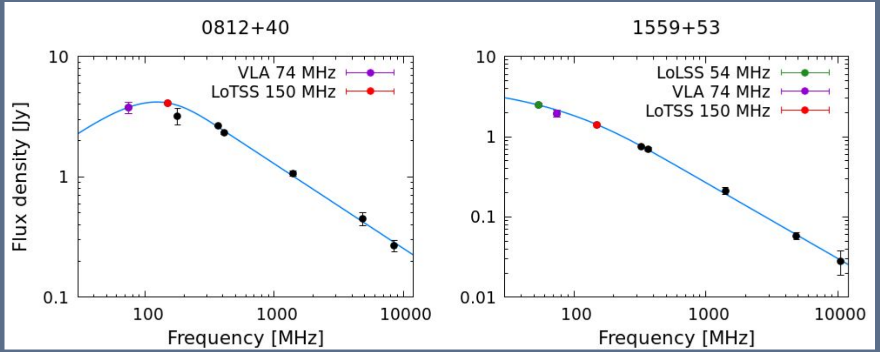
our sources (Vp < 74MHz) should have 20-30 kpc, while some of our sources are 5x smaller.

This might point to a limitation in evolution: either due to dense environment or to decreased (or halted) activity.

Which indicates that the turnover frequency cannot be constrained with the currently available data and must lie below 74 MHz.

Those models will be improved once we obtain new data from the LOFAR LBA Sky Survey (LoLSS) 54 MHz + NeNuFAR 30-80 MHz.



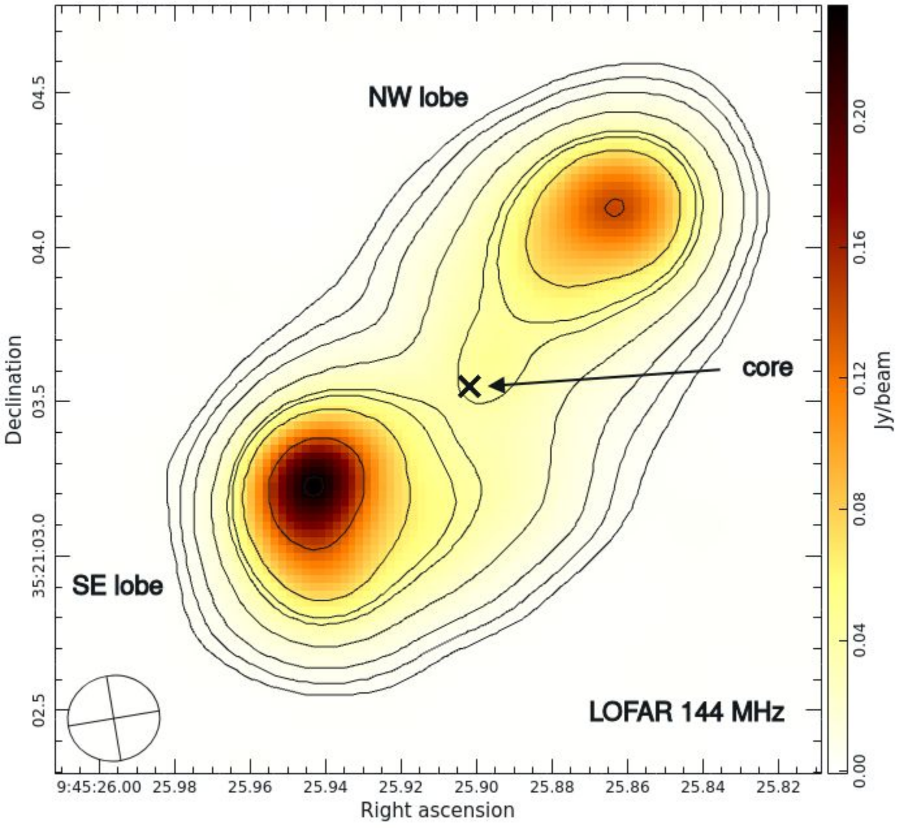


Preliminary analysis of two sources with dedicated INTL LOFAR observations (project LC8_030)

0945+35 (Q)

This source was observed with 48 stations (12 international: DE, FR, SE, UK, PL)

- $\log L_{1.4\ GHz}$ = 25.23 WHz^{-1}
- LAS = 1.32''
- both lobes have similar separation from the core - they have been evolving simultaneously and are of comparable age
- no extended emission on 144 MHz
- the source has been asymmetric from the early stages of activity
- flux ratio ~1.5 at 144 MHz (too small for strong beaming effects)



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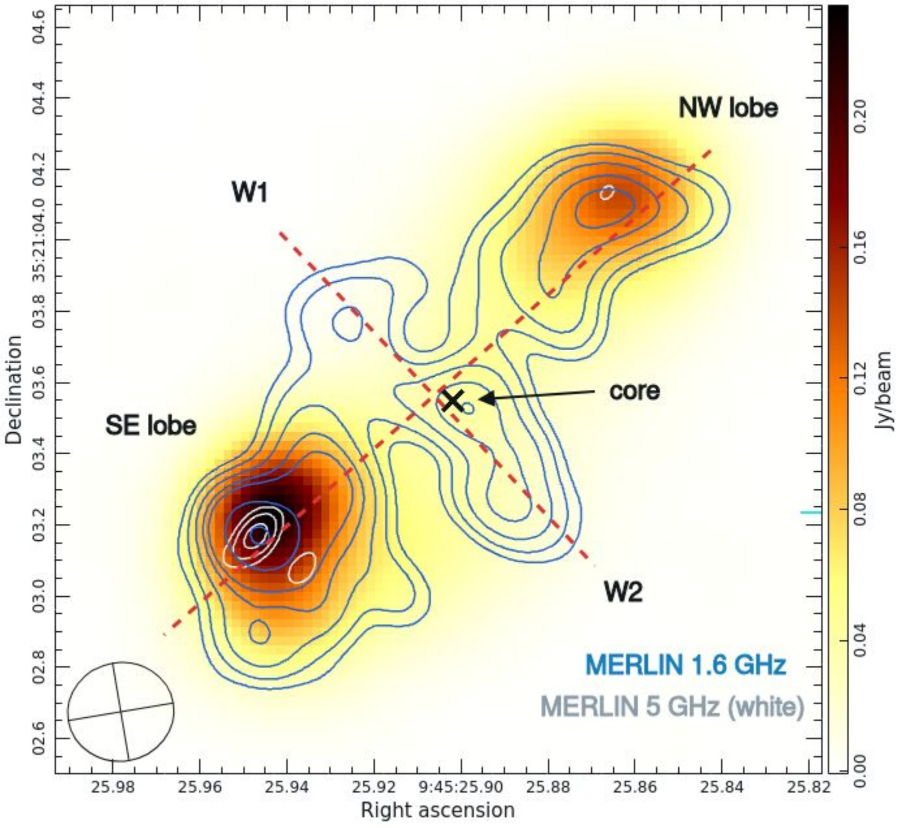
- flux ratio ~1.5 at 144 MHz (too small for strong beaming effects)
- at 1.6 GHz we see extended x-shaped wings (W1 and W2)
- emission backflow? jet re-orientation? or a result of a merger?



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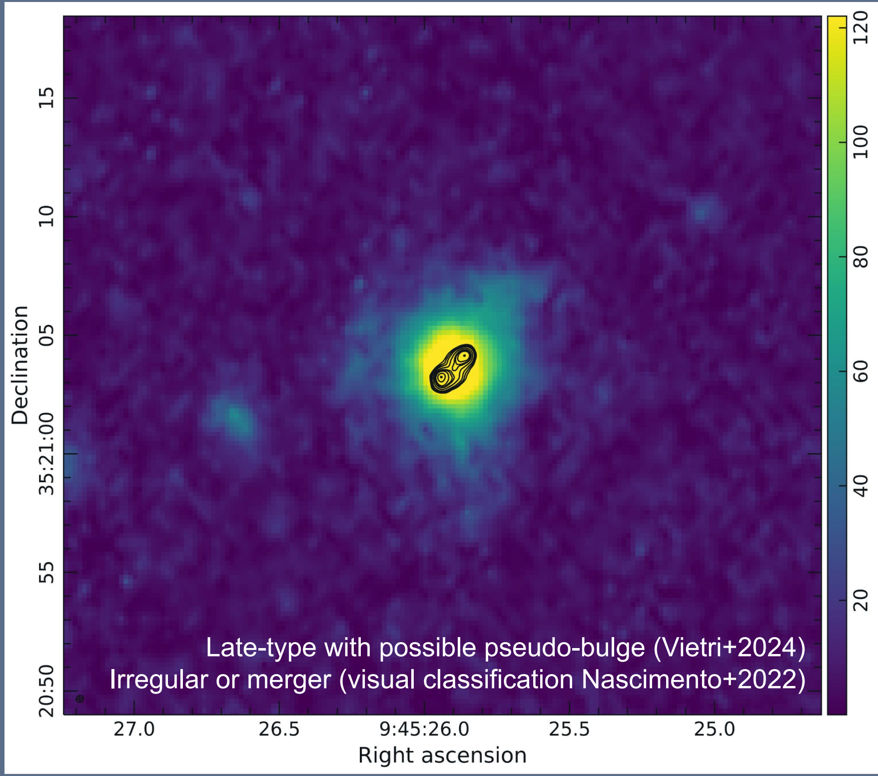
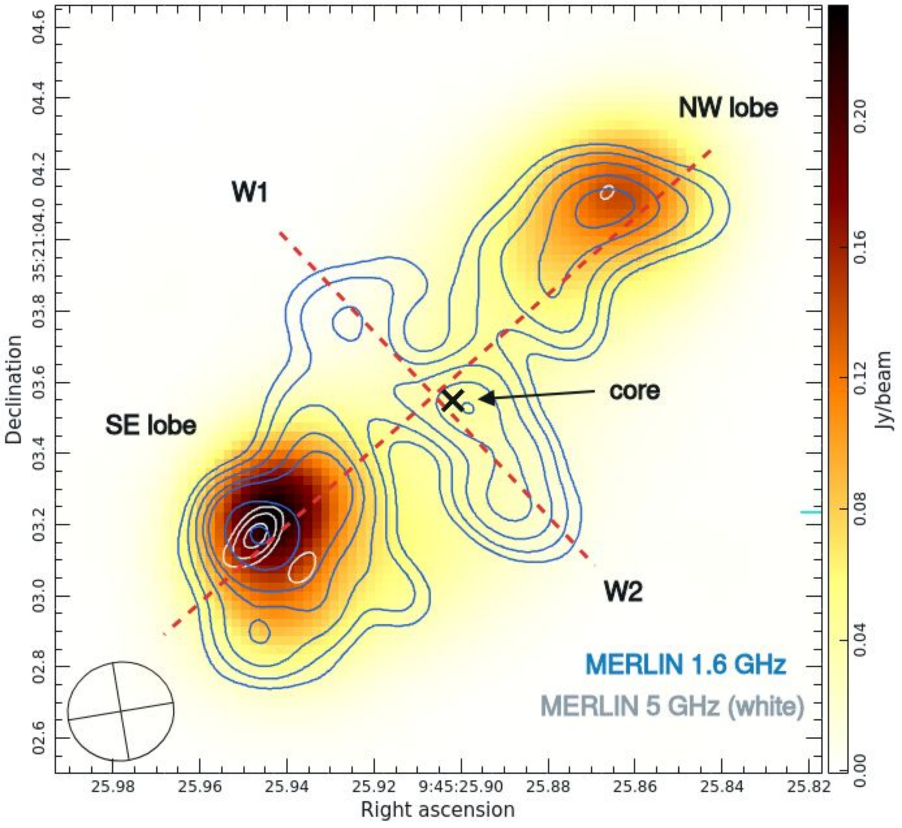
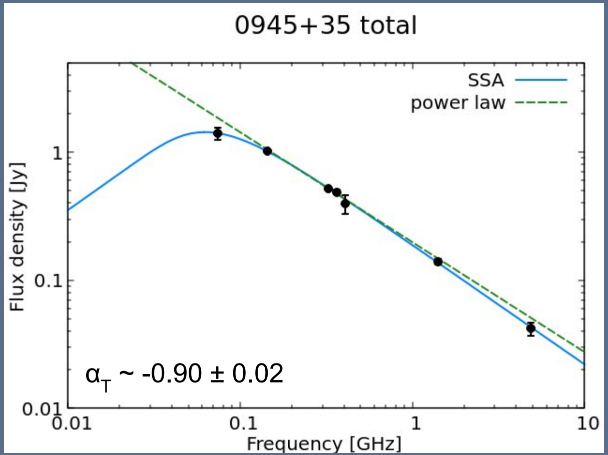
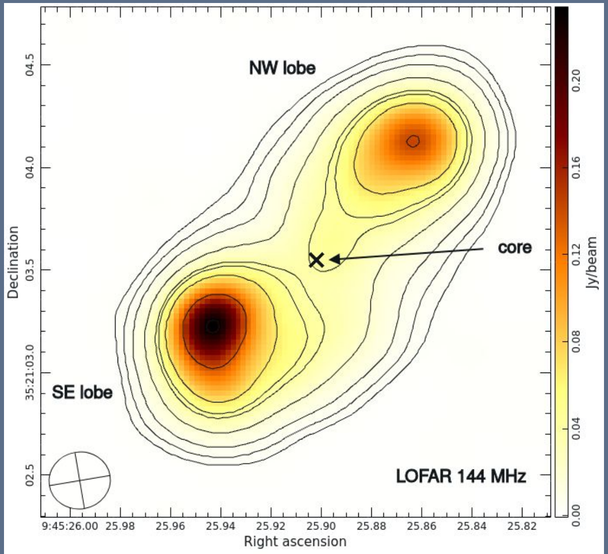
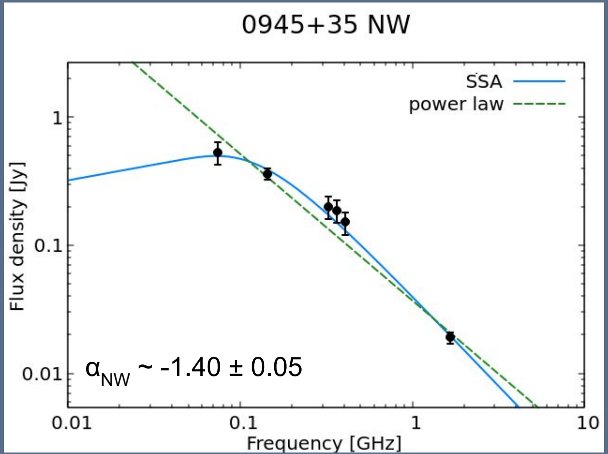


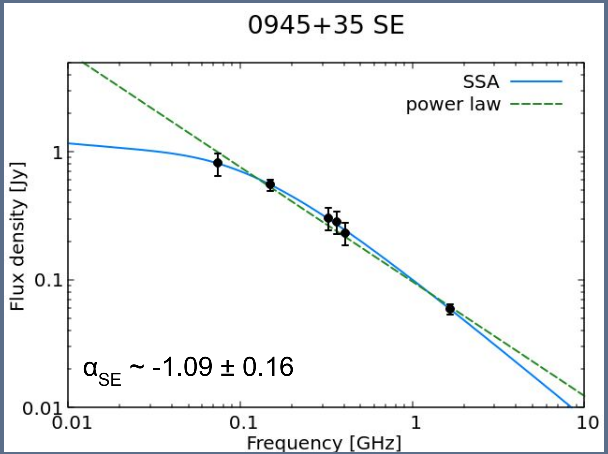


Spectral modelling of 0945+35







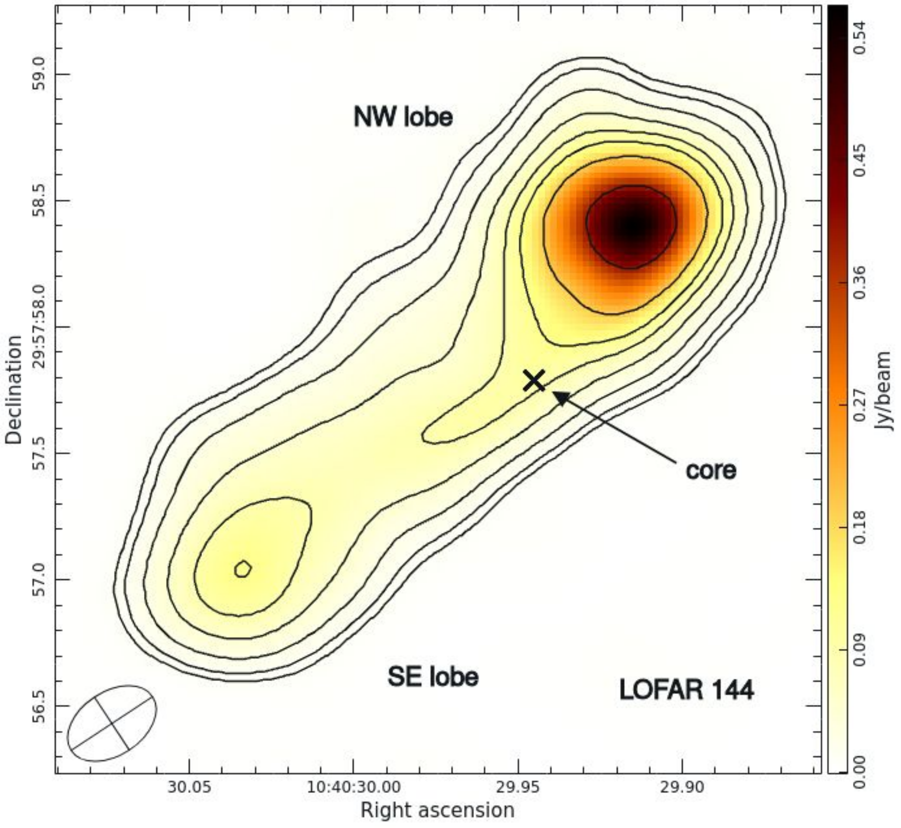


Preliminary analysis of two sources with dedicated INTL LOFAR observations (project LC8_030)

1040+29 (G)

This source was observed by 45 stations (11 international: DE, FR, SE, UK, PL)

- $\log L_{1.4\ GHz}$ = 24.90 WHz^{-1}
- LAS = 2.07''
- separation ratio r_D=1.90 (environment asymmetries?)
- asymmetry seen in the earliest emission - easier propagation on the NW side



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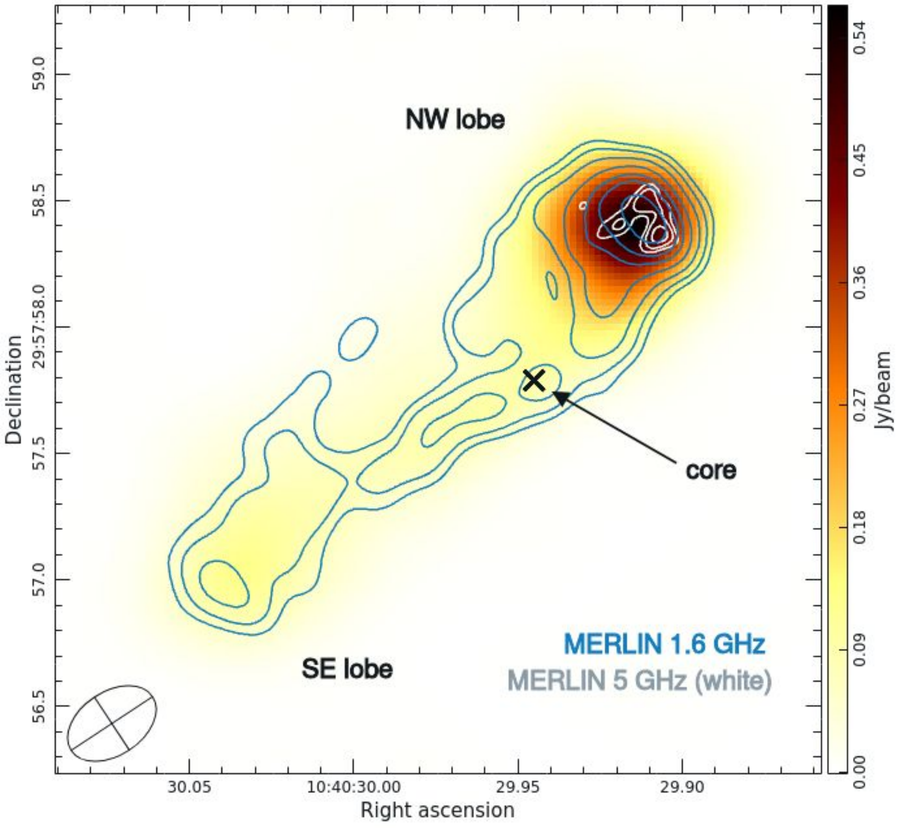

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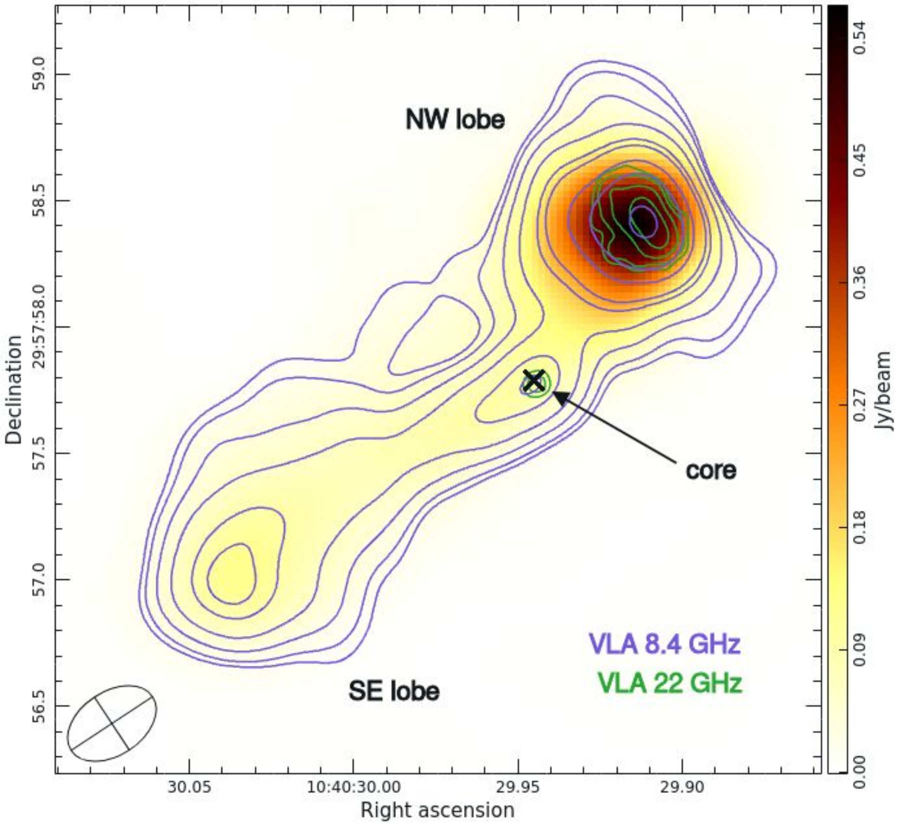
- asymmetry seen in the earliest emission - easier propagation on the NW side
- flux density ratio ~2.5 at 144 MHz and increases for 1.6 GHz
- the higher the frequency the weaker the core (dissipating or obscured)
- ignition of radio activity as a result of a merger?



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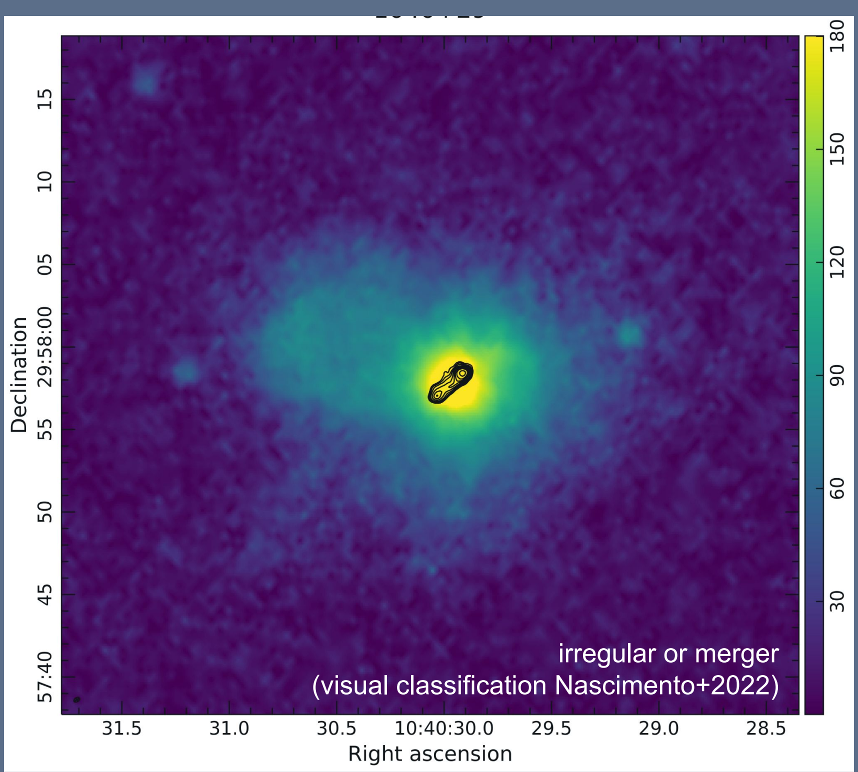
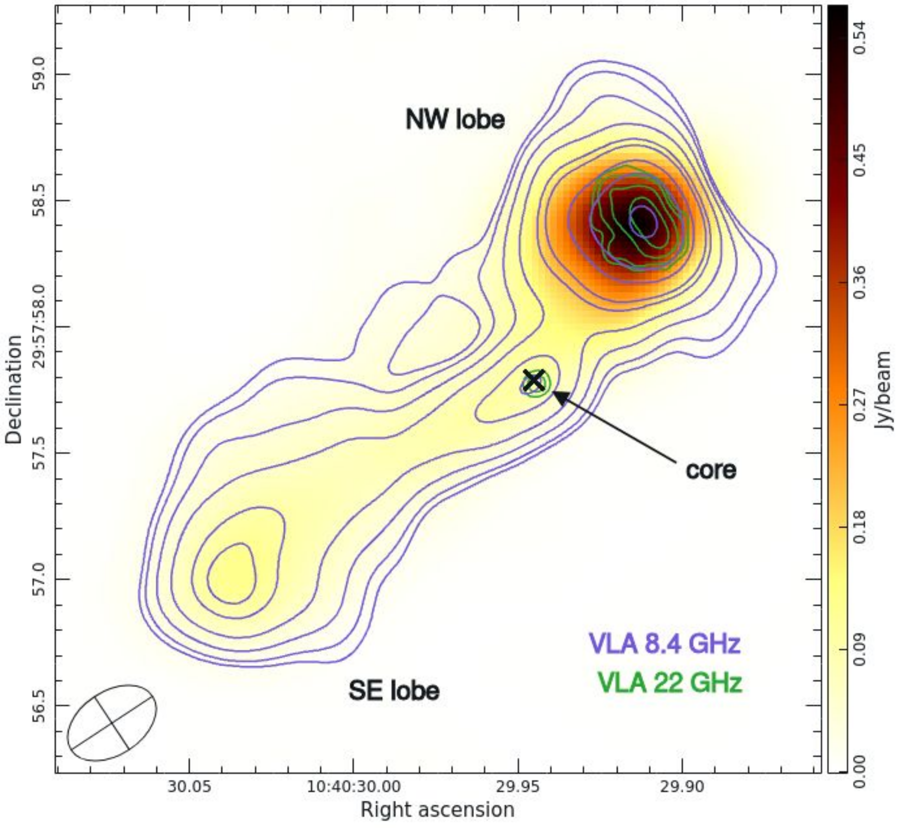
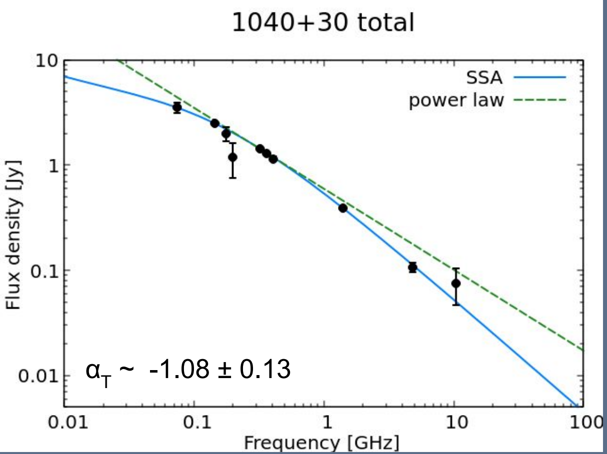
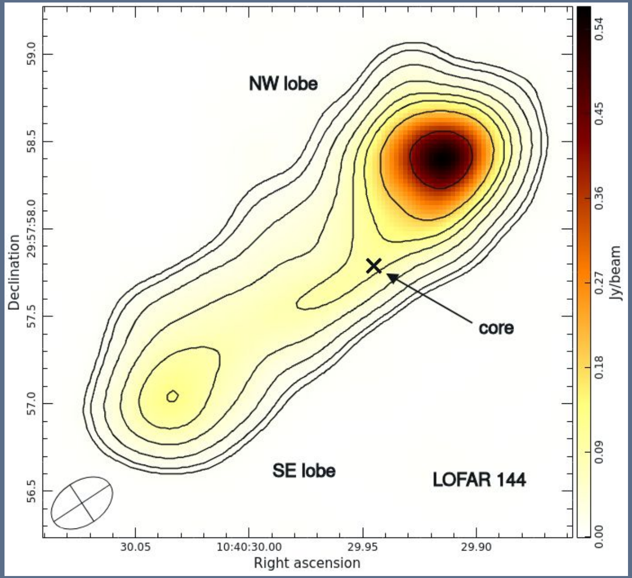
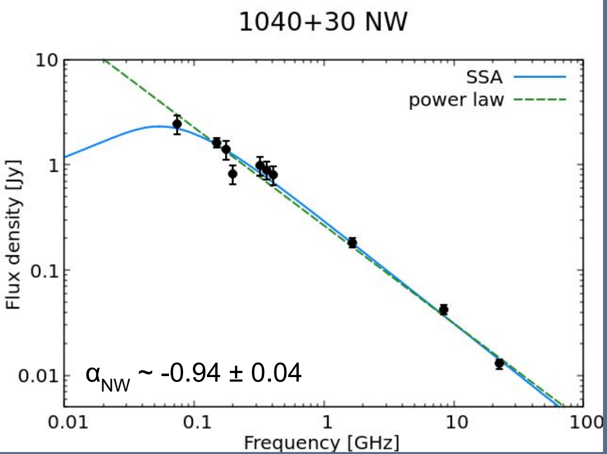


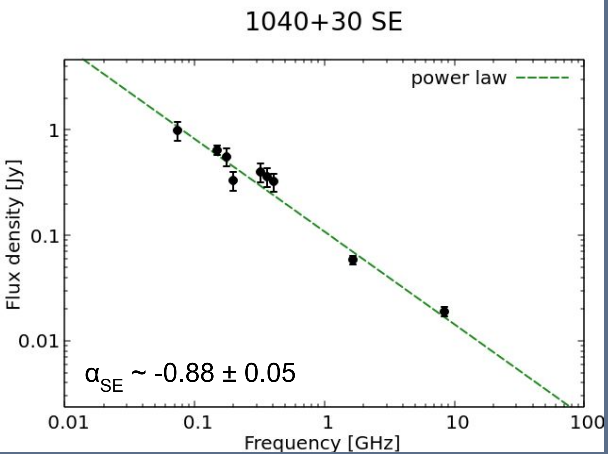


Spectral modelling of 1040+29

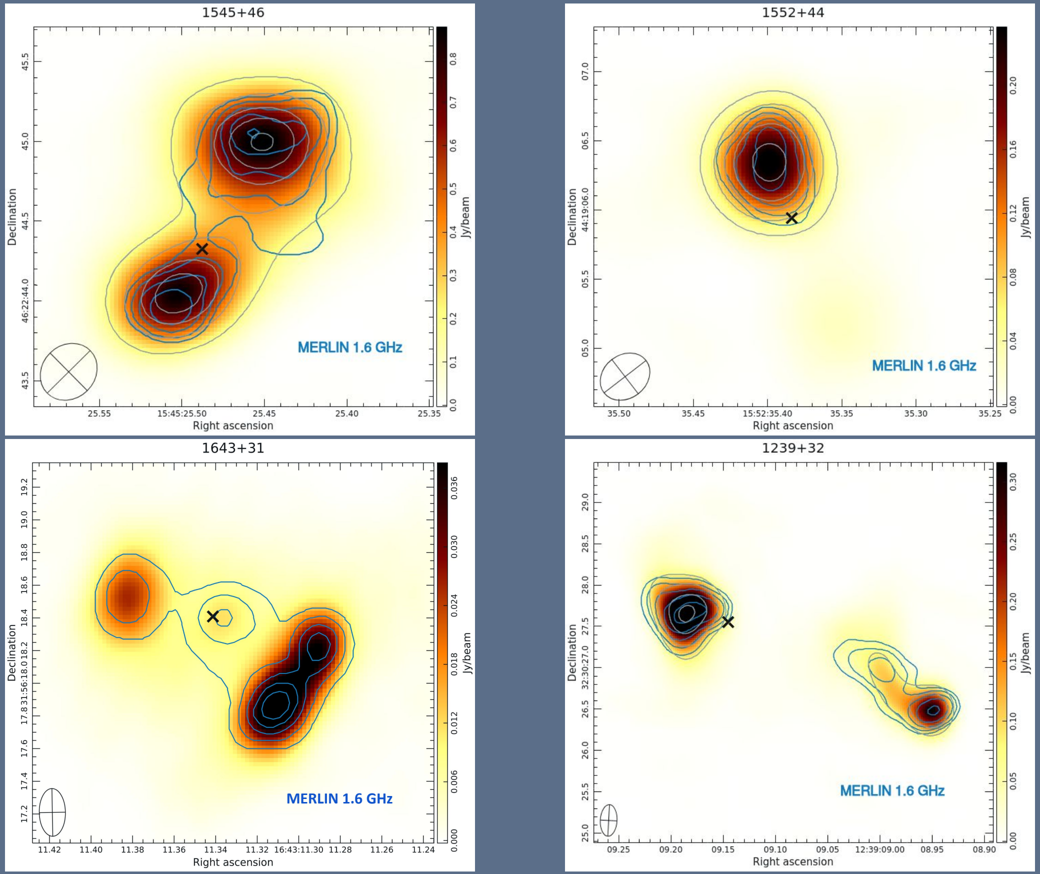


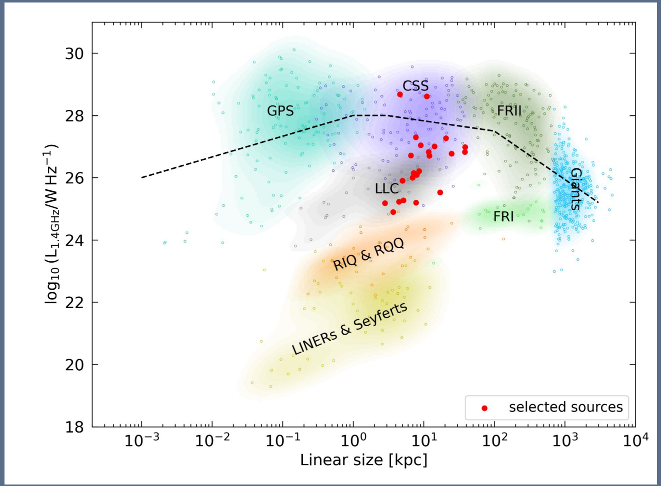






Other sources form the sample





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Summary of the preliminary analysis

- Generally, the turnover frequency cannot be constrained with the currently available data and must lie below 74 MHz.
- We observe a departure from a classical SSA model.
- The asymmetry observed at higher frequencies is also present at 144 MHz and can point to a dense environment.
- Both 0945+35 and 1040+29 have faint cores with steep spectrum - weak radio sources or dissipating?
- The environment is probably dense, turbulent and non-symmetrical.

- Most of the sources are much more compact than expected.

Literature

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