Extended radio emission in narrow-line Seyfert 1 galaxies

Järvelä, Dahale, Crepaldi, Berton & Antonucci 2022, A&A, 658:12

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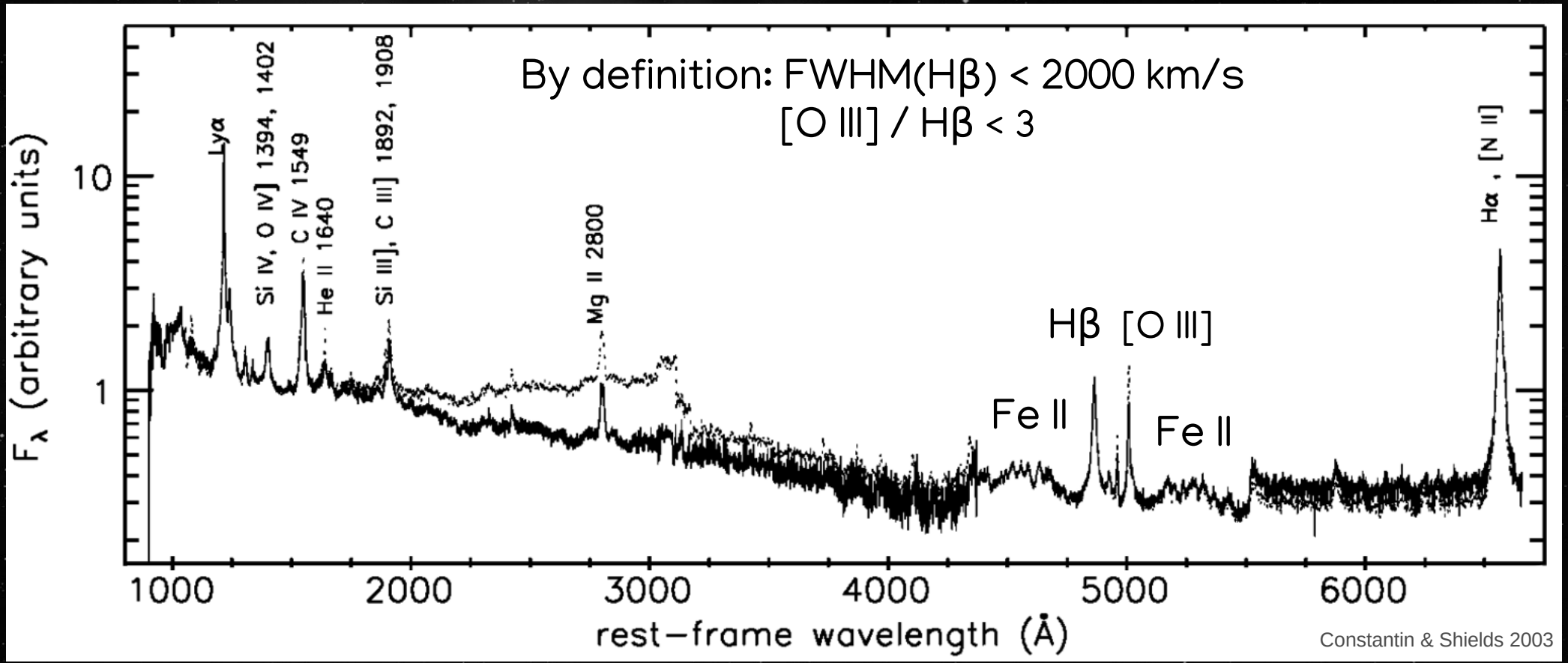
May 19, 2022
Growing black holes: accretion and mergers
Kathmandu, Nepal

Narrow-line Seyfert 1 galaxies

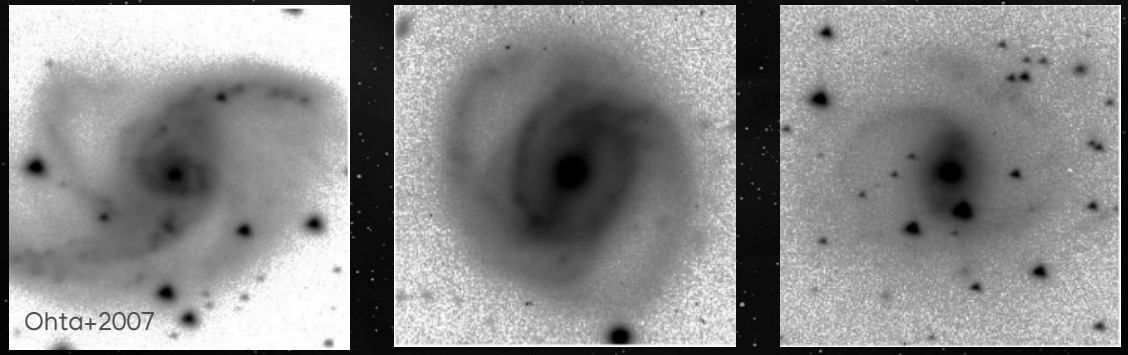
a subclass of population A

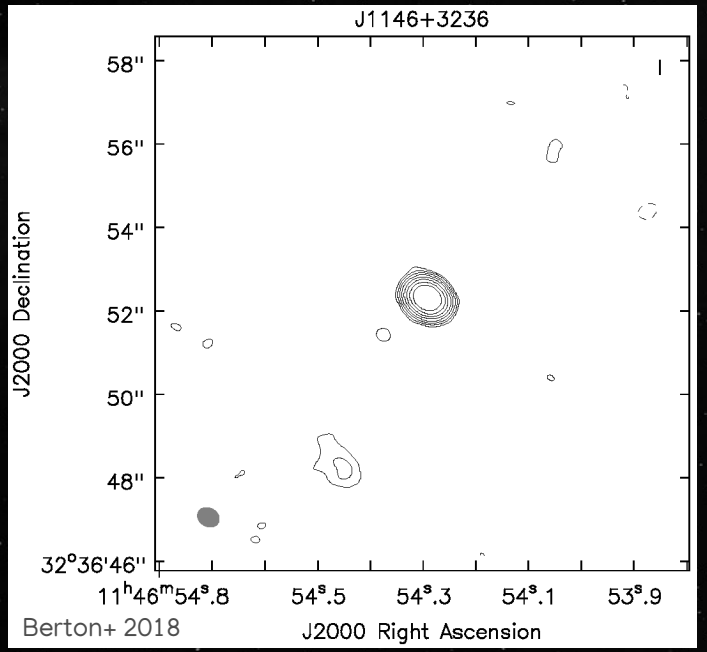


Constantin & Shields 2003

Narrow-line Seyfert 1 galaxies

- Low mass black hole (< 10^8 M_{sun}) accreting at high Eddington ratio (0.1 to super-Eddington)
- Strong soft X-ray excess, high-amplitude variability at short time-scales
- Compact radio morphology, majority not even detected in radio (yet)
- Hosted by barred spiral galaxies

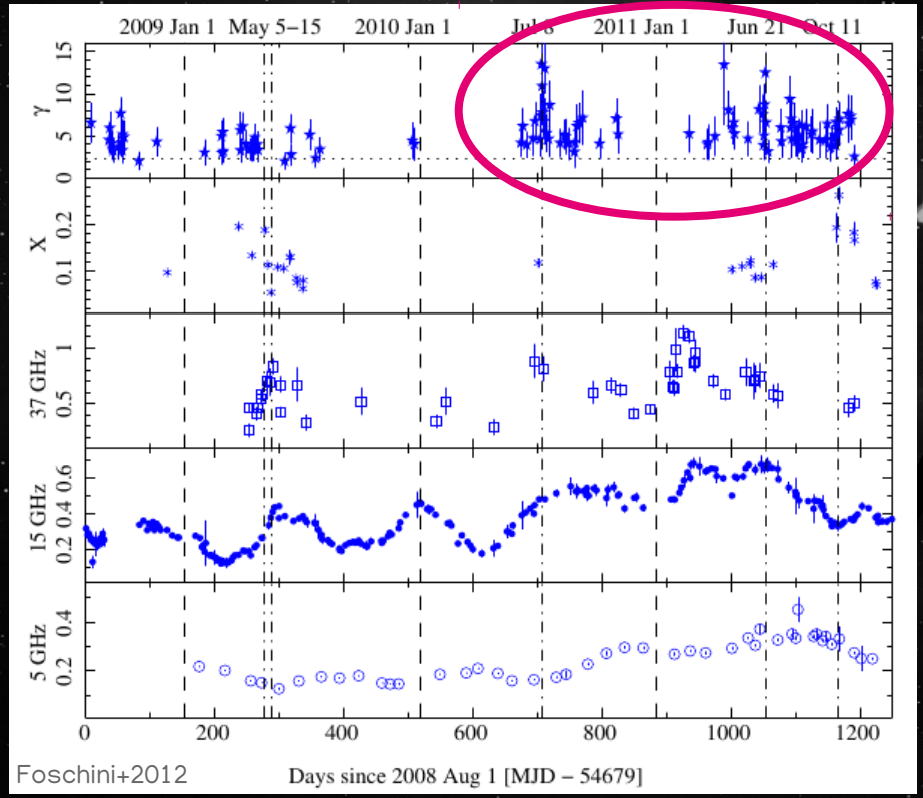




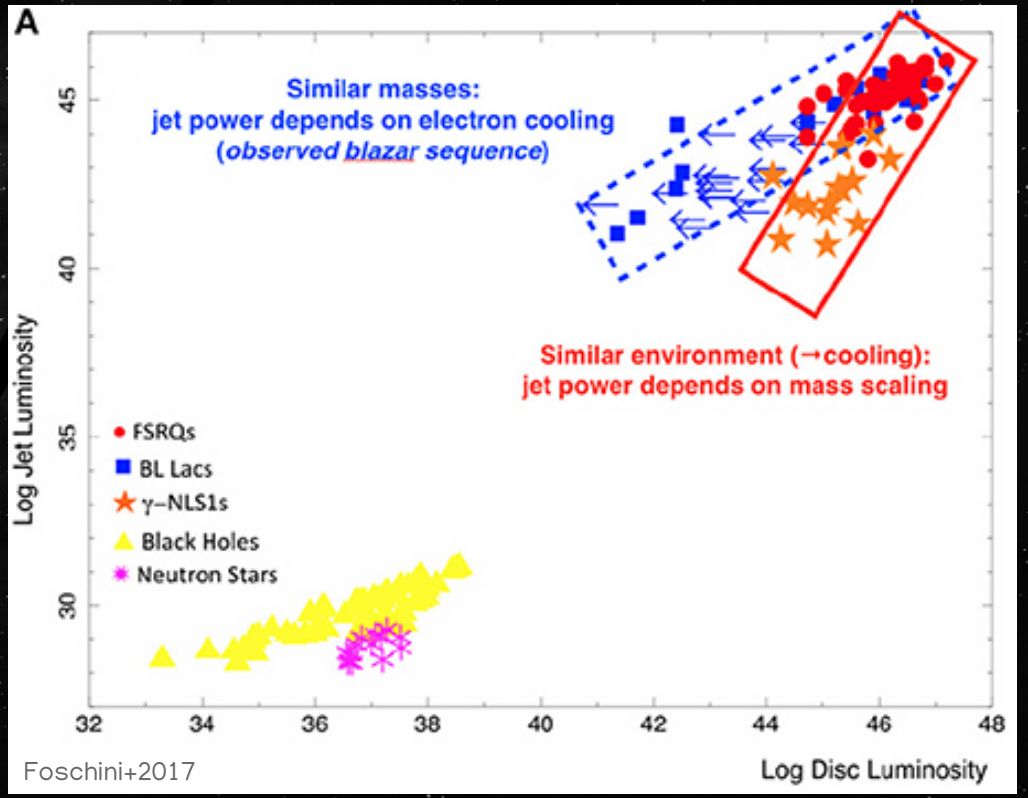
Relativistic jets in NLS1s!

...even if their black hole mass, host galaxy type, and radio morphology are all "wrong"

PMN J0948+0022



Foschini+2012



Foschini+2017

Crisis of the jet paradigm

- Discovery of relativistic jets in NLS1s contradicts the conventional jet paradigm
- What are the necessary conditions to launch a jet?
- How is the jet triggered and its activity maintained?

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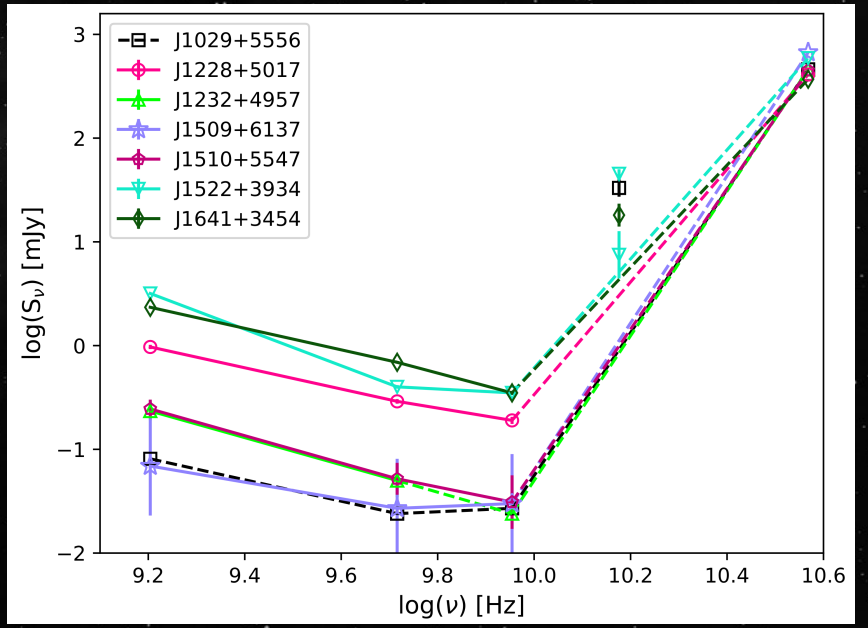
...and the confusing NLS1s

- NLS1s are very diverse as a class
  → Most seem totally radio-silent, but a fraction host relativistic jets
  → Different subclasses? Intraclass evolution?
- What are the parent populations?

Death of radio-loudness
(as we knew it)

- Vague parameter, arbitrarily set threshold
- Not suitable to be used to classify variable sources, with varying contribution from the host galaxy
- Misses several groups of sources:
  → absorbed jets
  → low-power / misaligned jets
- Classification should be based on physical properties



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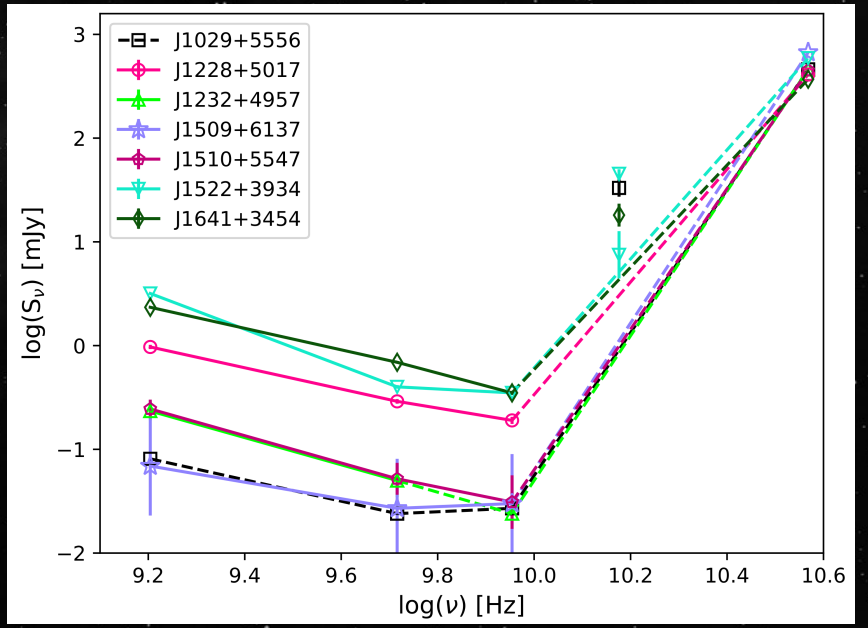
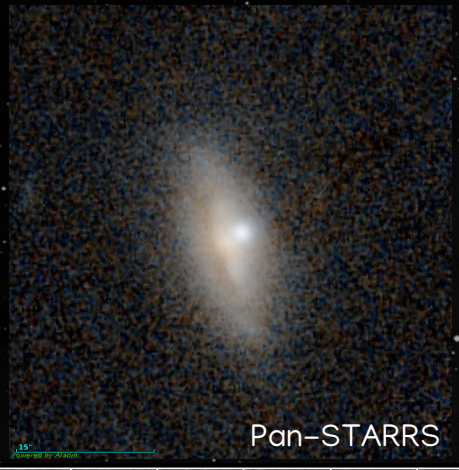
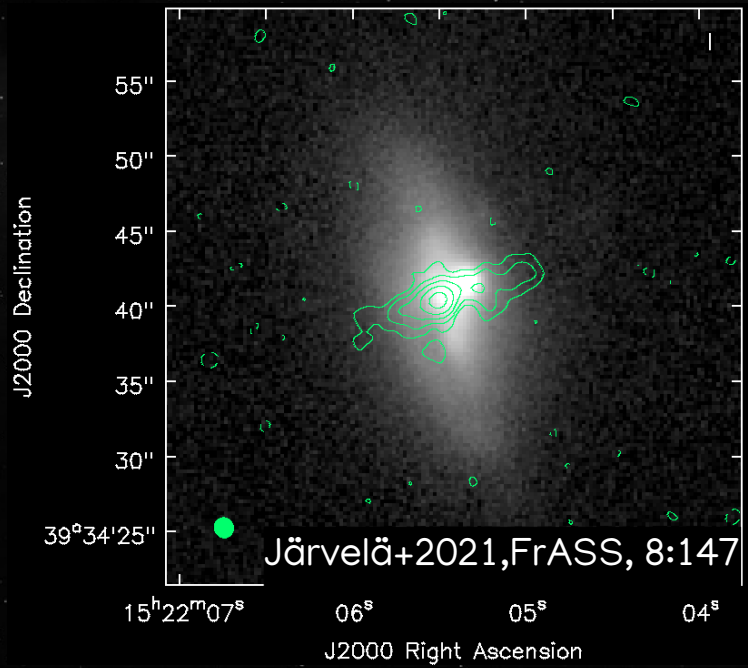
...but how?



Low-frequency radio emission

- Complicated for AGN not dominated by the jets
- NLS1s are an ideal laboratory since they show a diverse ensemble of properties
  - → jets with varying power, from weak to relativistic
  - → outflows induced by winds / jets
  - → shocks due to AGN-ISM -interaction
  - → star formation activity in the host





Sample and data

- Original sample from Berton+2018
  → sources with extended radio emission (N=44)
  → includes a little bit of everything, except radio-silent sources
- Data from Karl G. Jansky Very Large Array in A-configuration
  → central frequency 5.2 GHz,
  bandwidth 2 GHz,
  resolution 0.5 arcsec,
  rms < 10 µJy / beam

Aims and methods

- Aim was to study the origin(s) of the radio emission using spectral index information
- Cleaning with CASA using the mt-mfs algorithm
  → radio maps + tapered maps
  → allows simultaneous fitting in frequency and in space, resulting in spatially resolved spectral index maps
- Additional near-infrared data to estimate radio emission from star formation

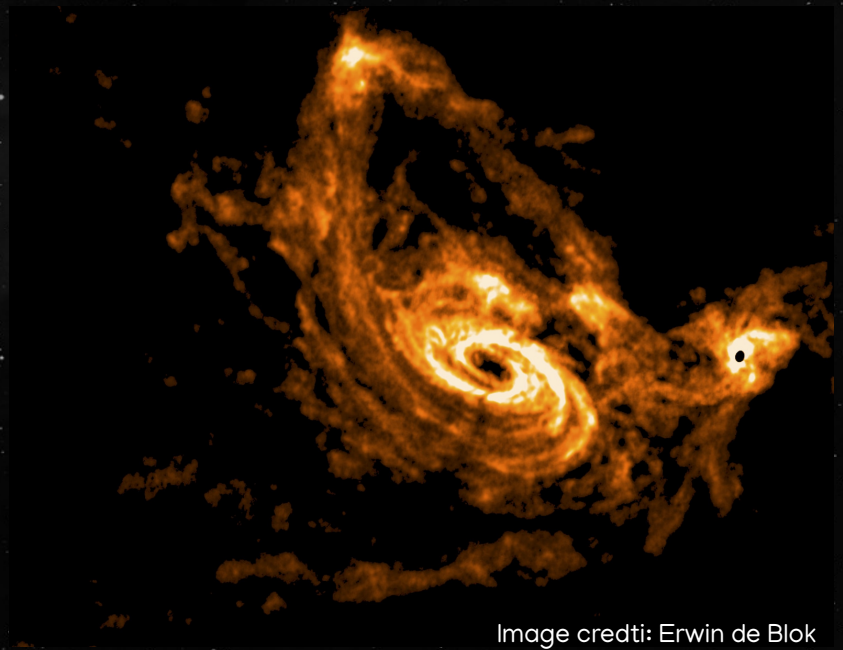
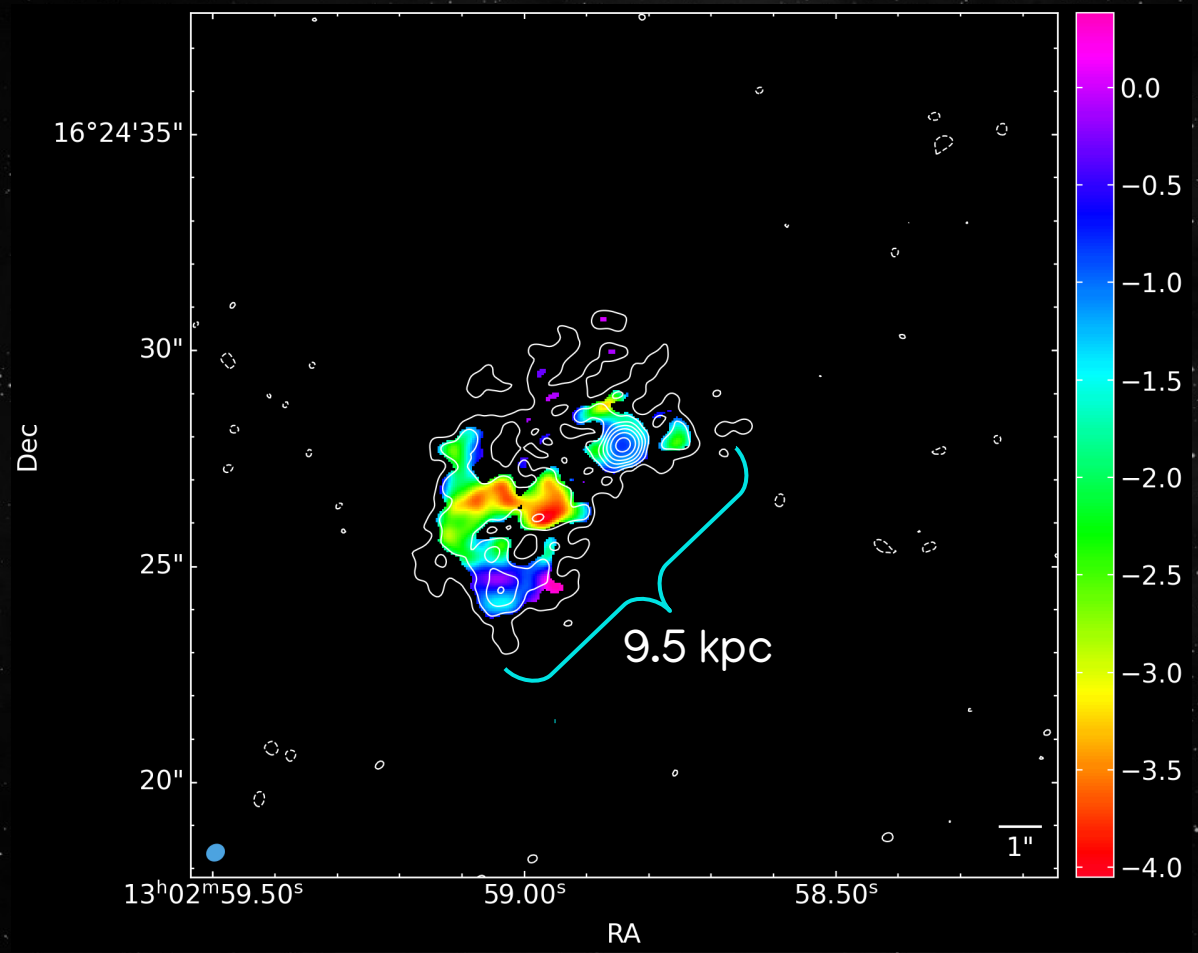


Image credti: Erwin de Blok

Highlights: J1302+1624 (Mrk 783)



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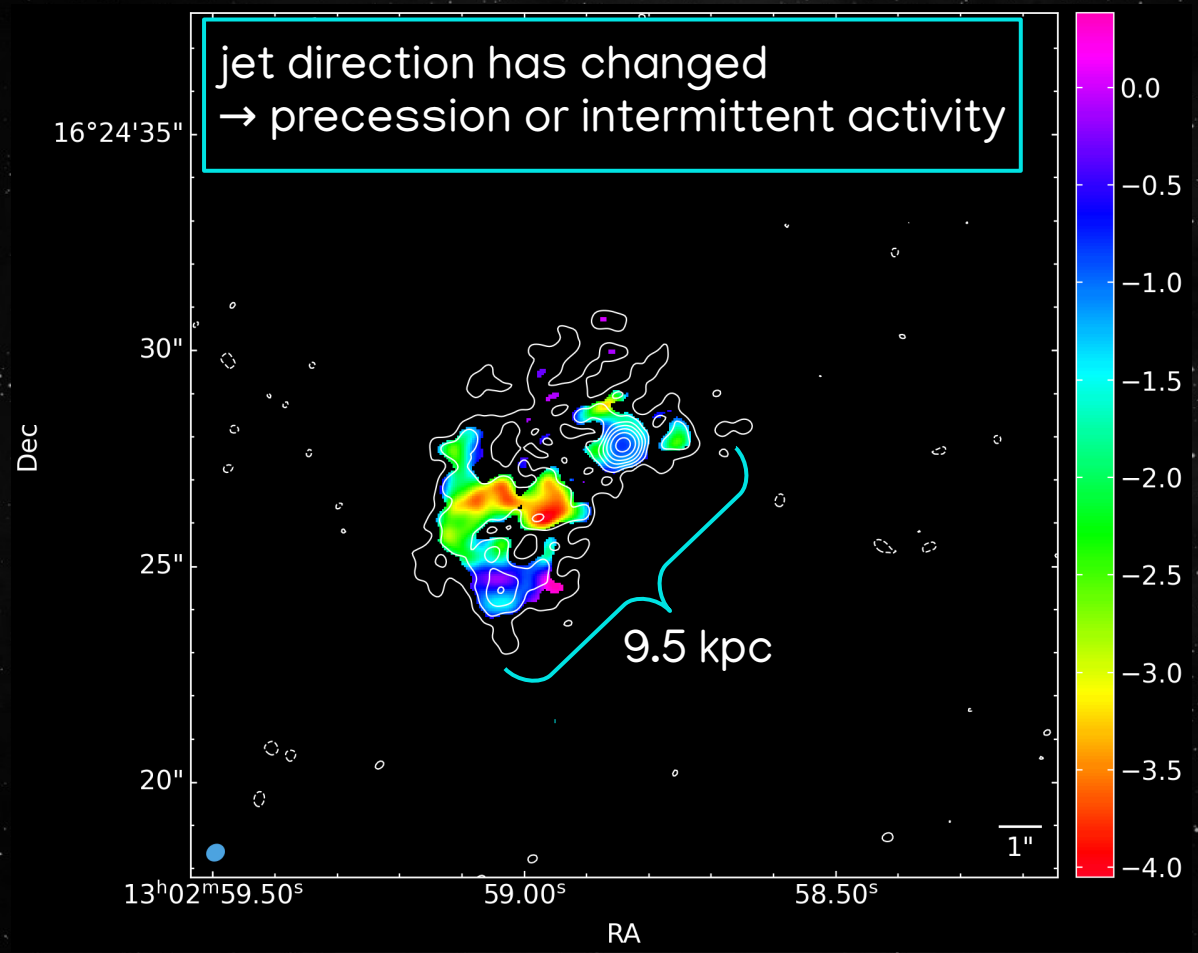

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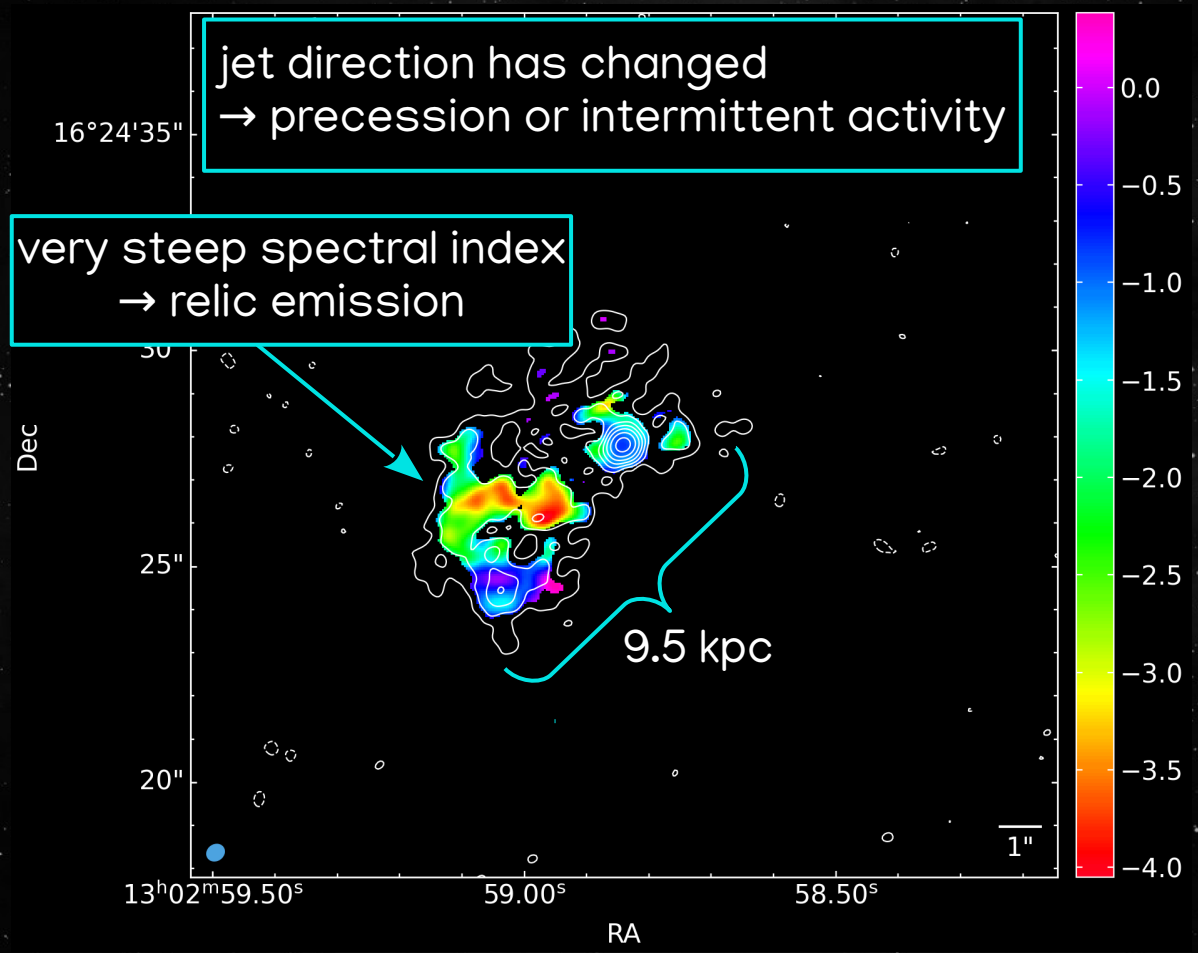

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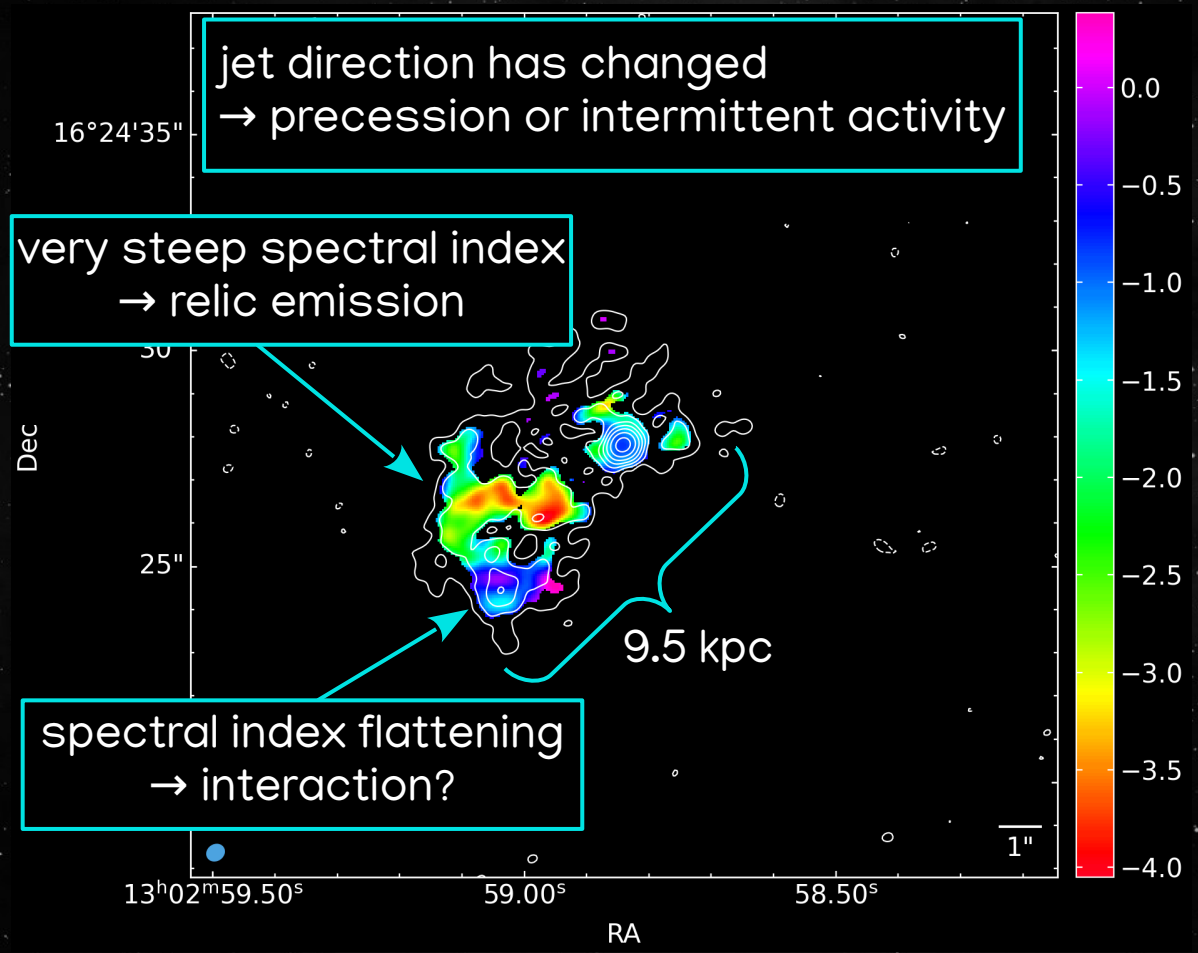

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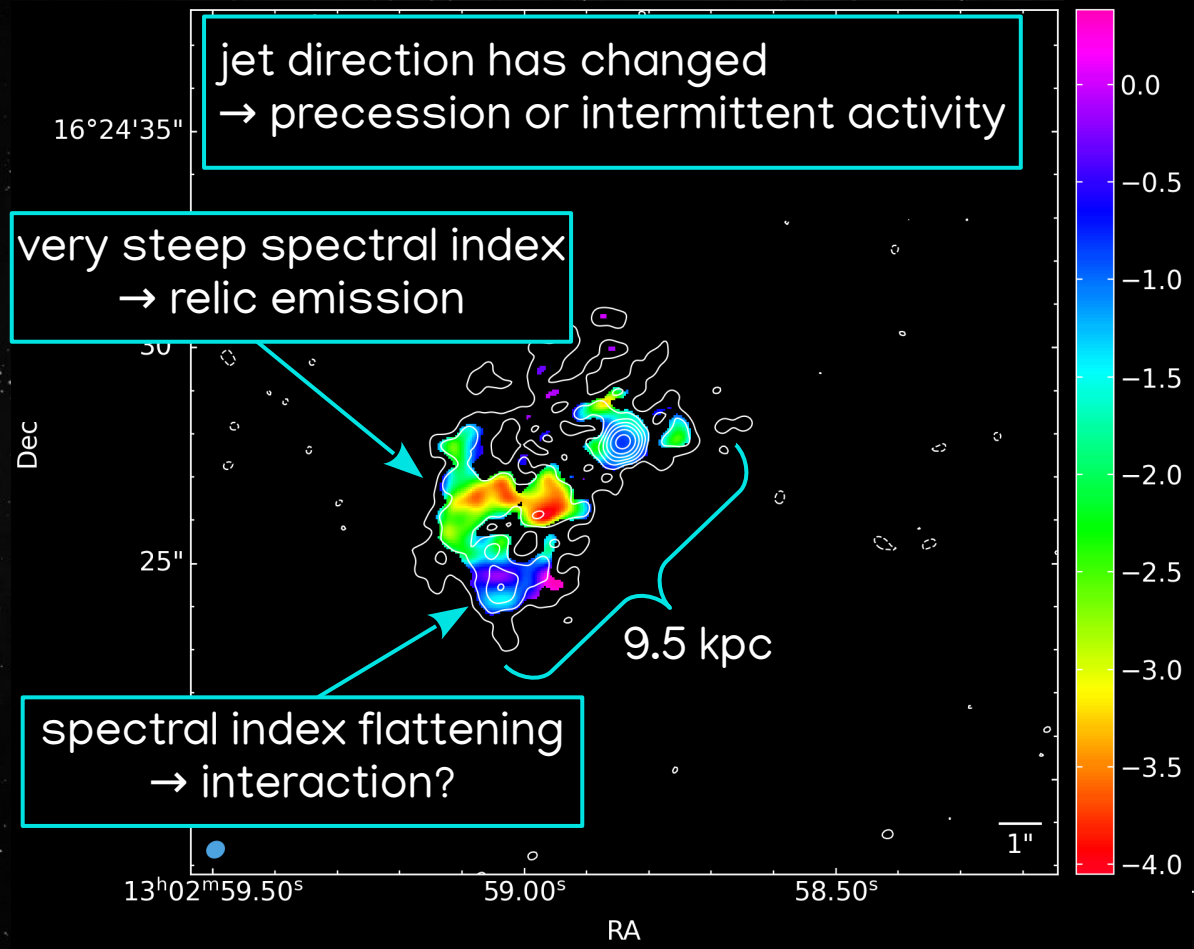
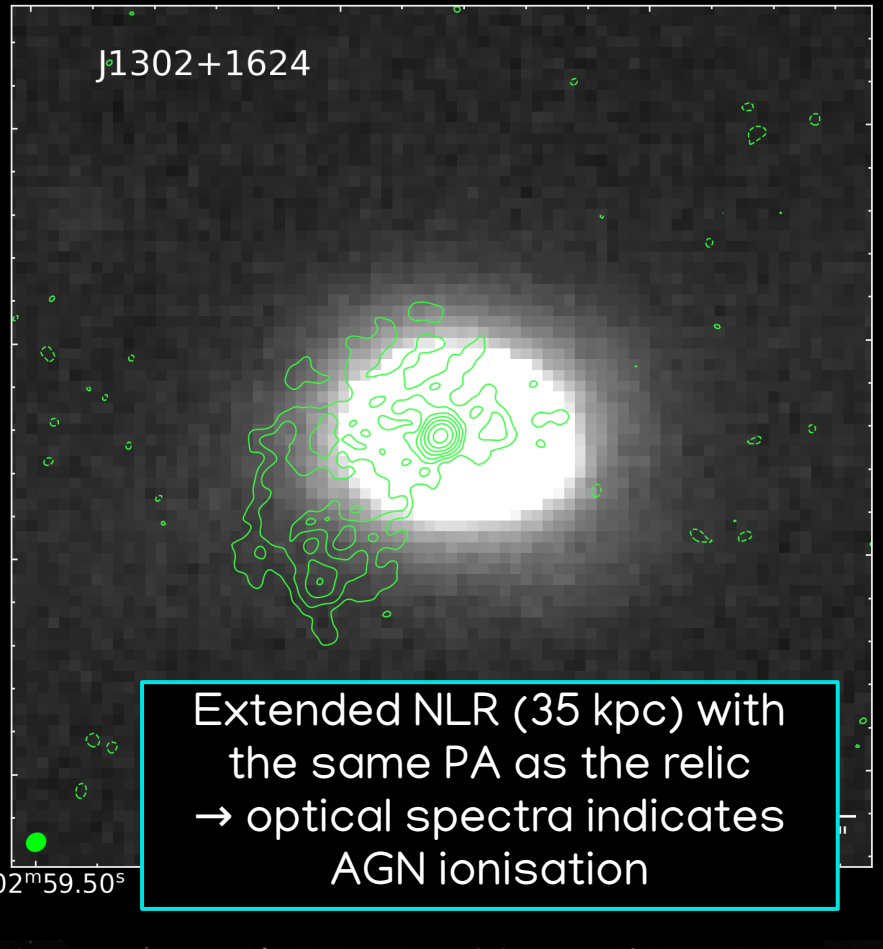
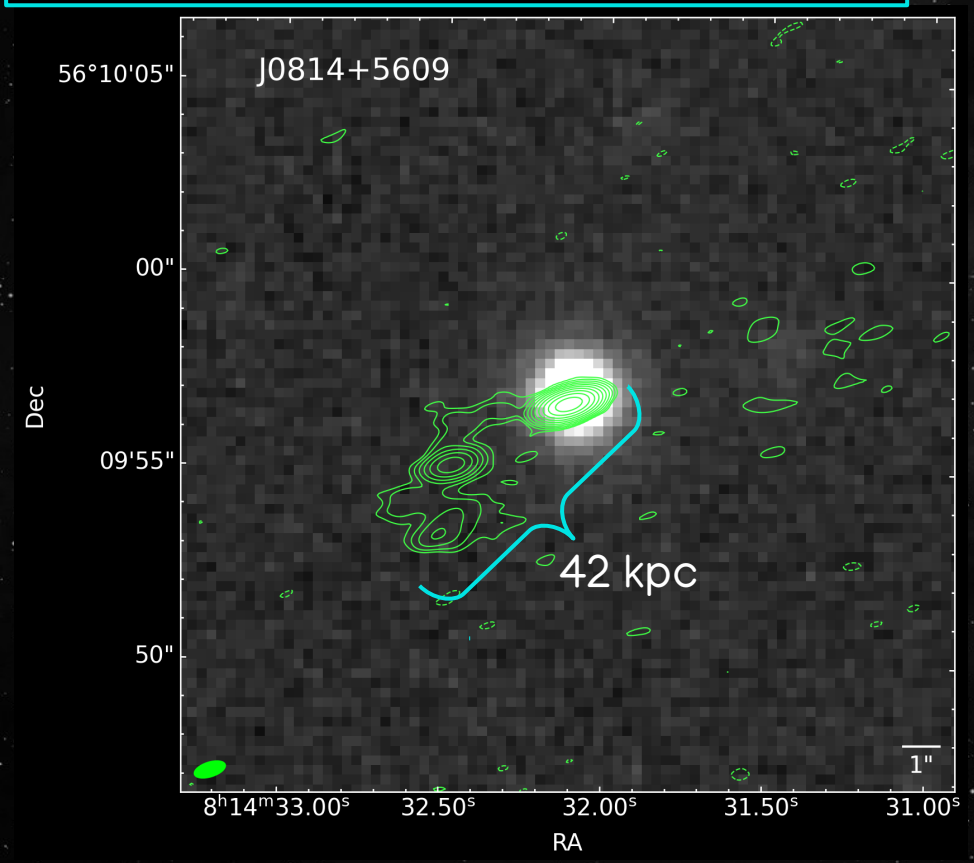




J0814+5609

based on the jet/counter-jet flux density ratio the inclination is about 45 deg



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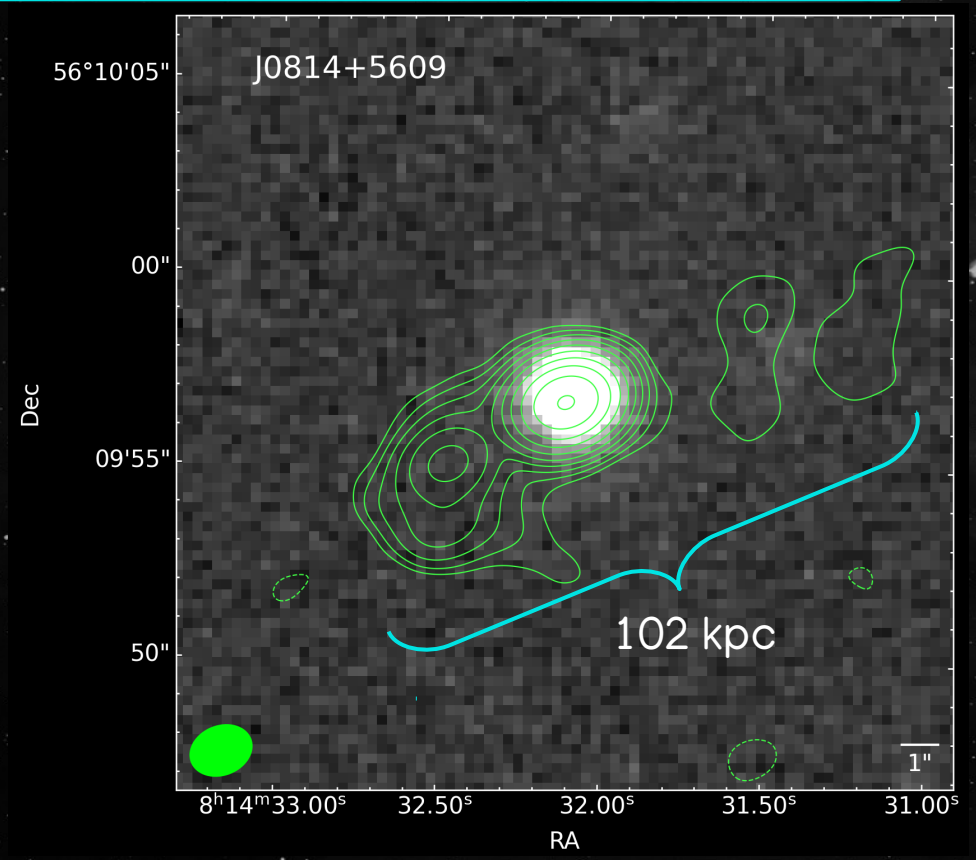

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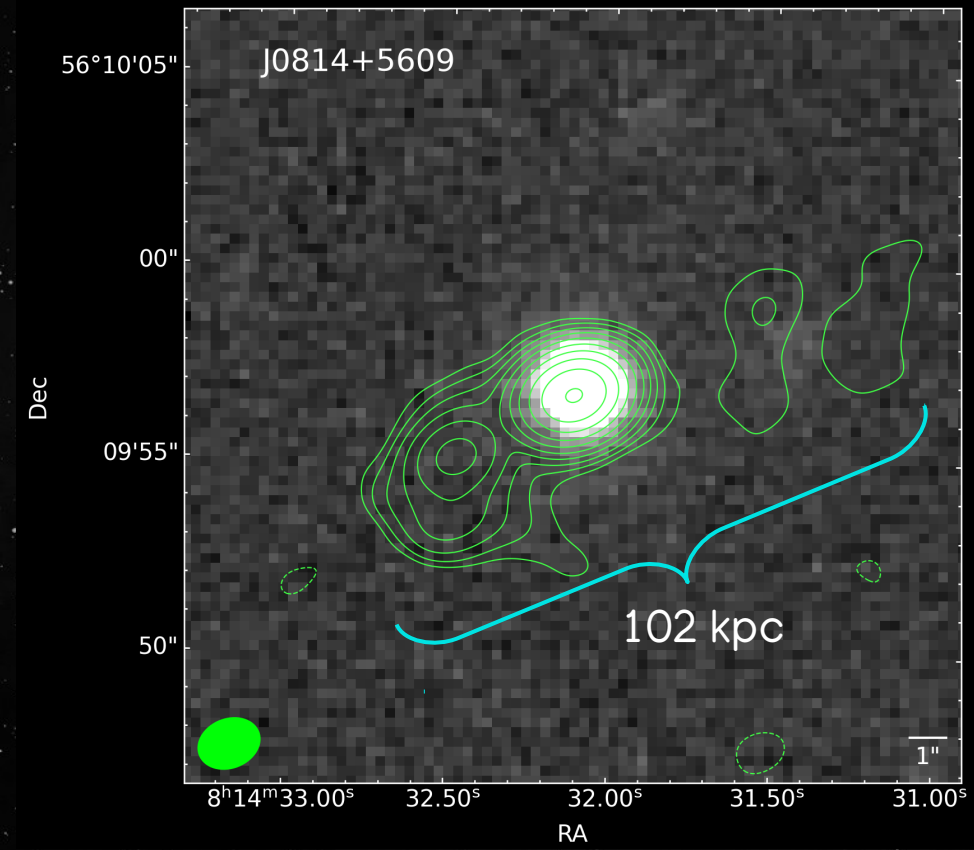

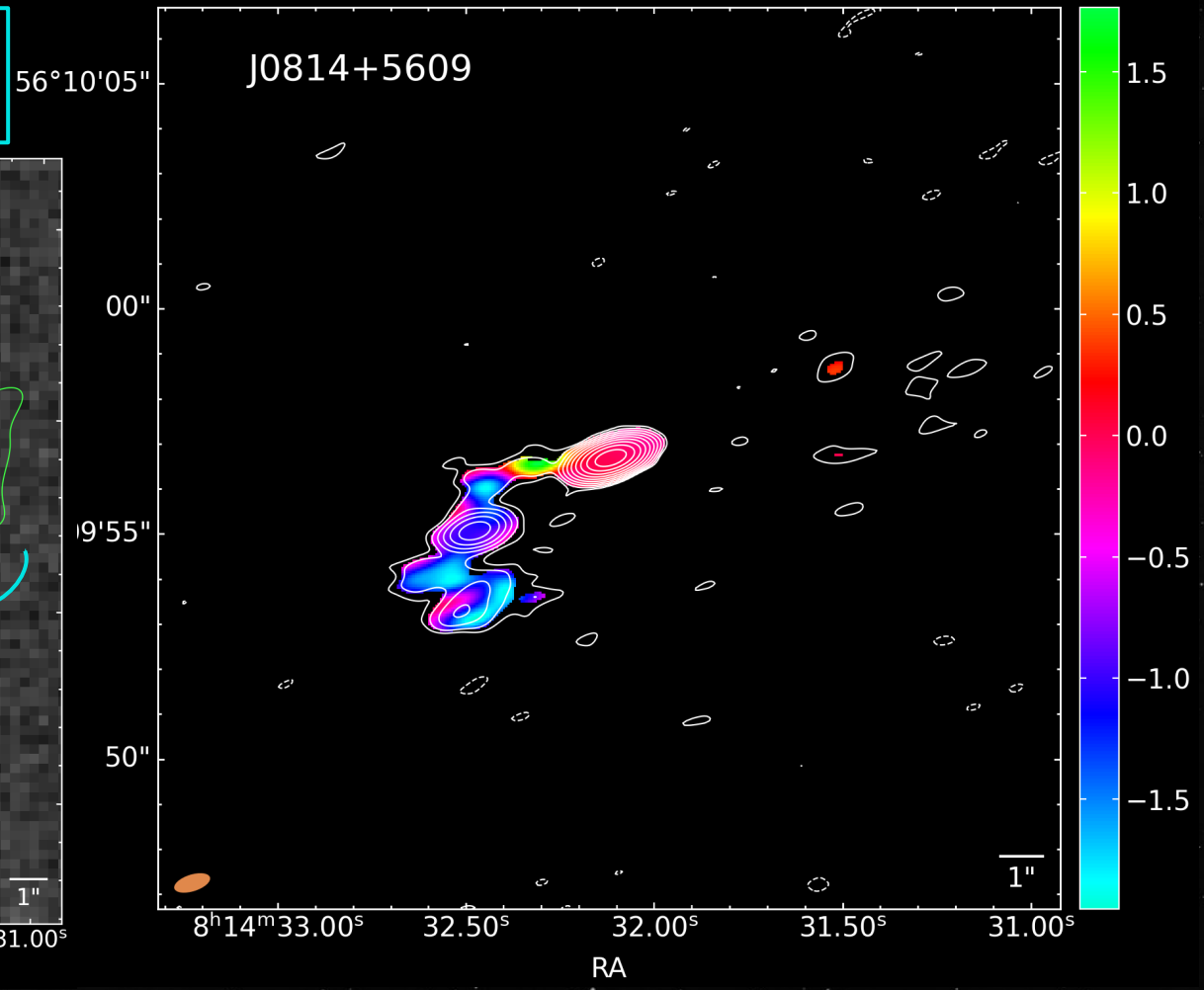

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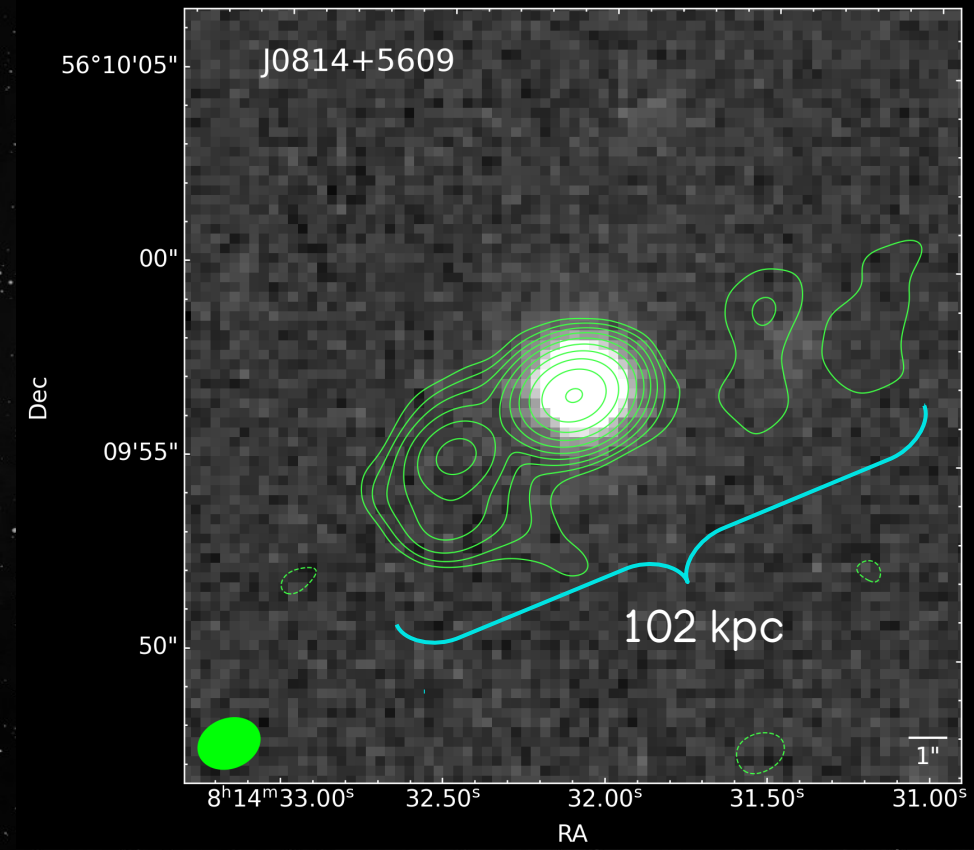

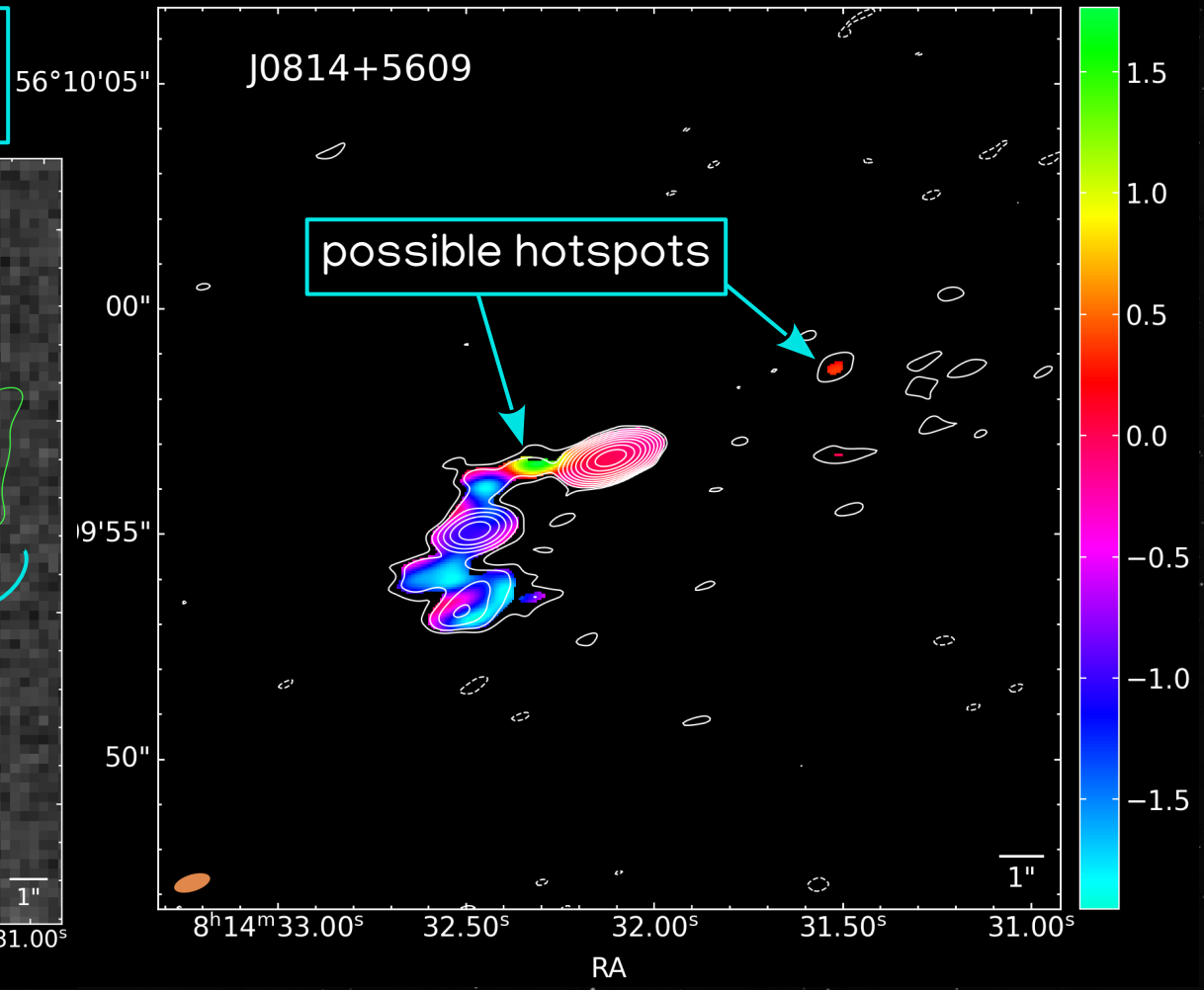

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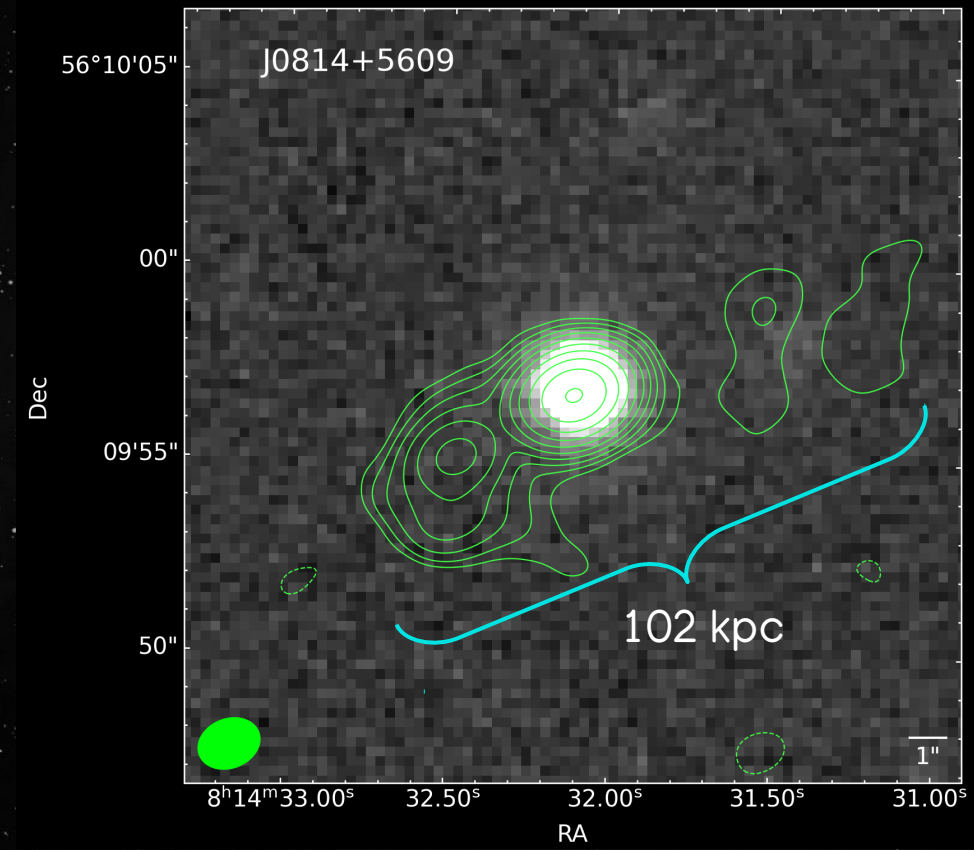
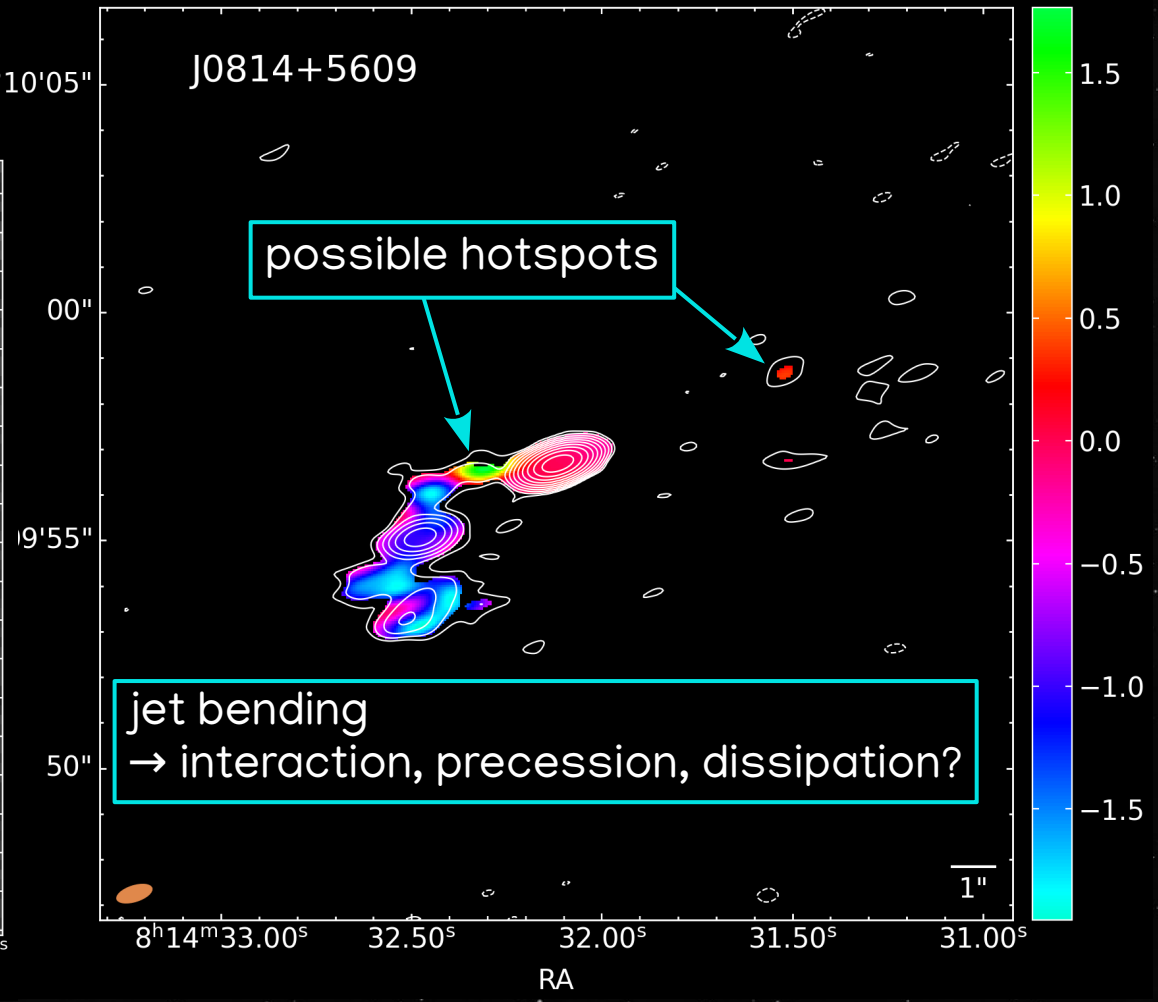
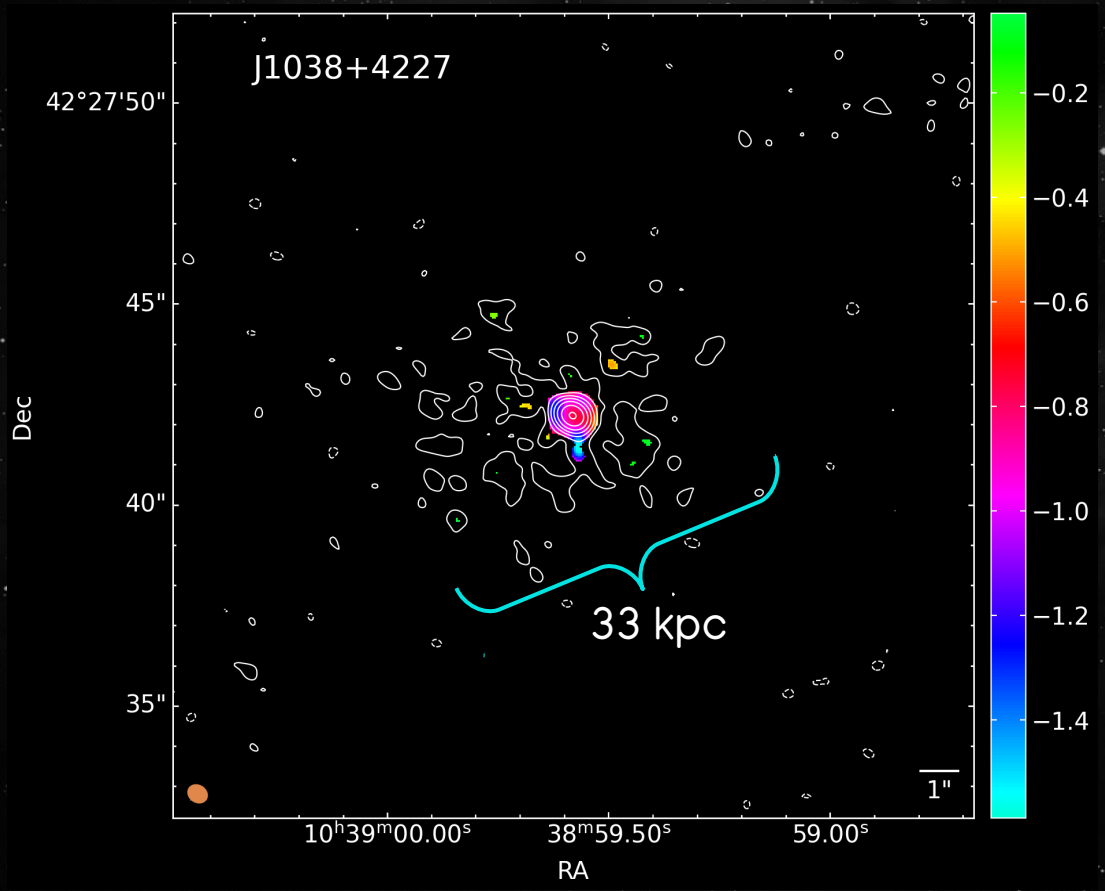
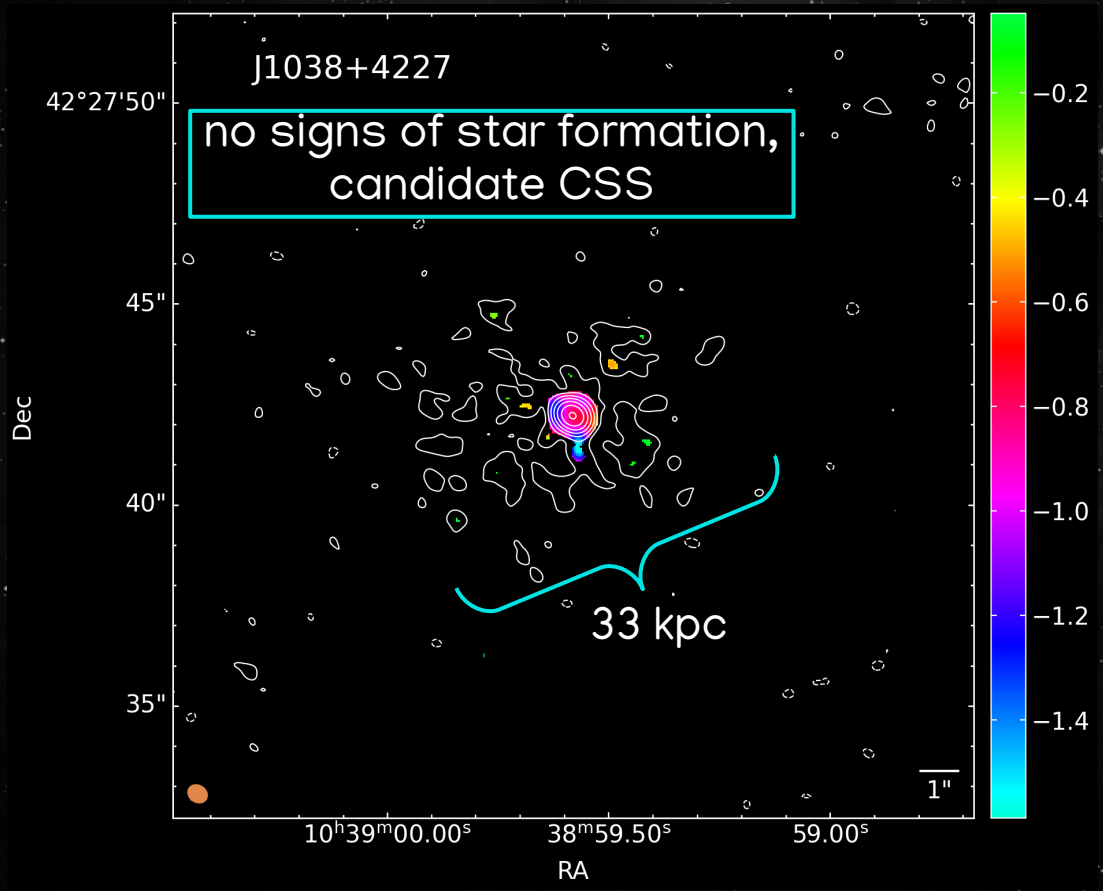




J1038+4227


J1038+4227
42°27'50"
45"
40"
35"
Dec
33 kpc
1"
10h39m00.00s
38m59.50s
59.00s
RA
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4

J1038+4227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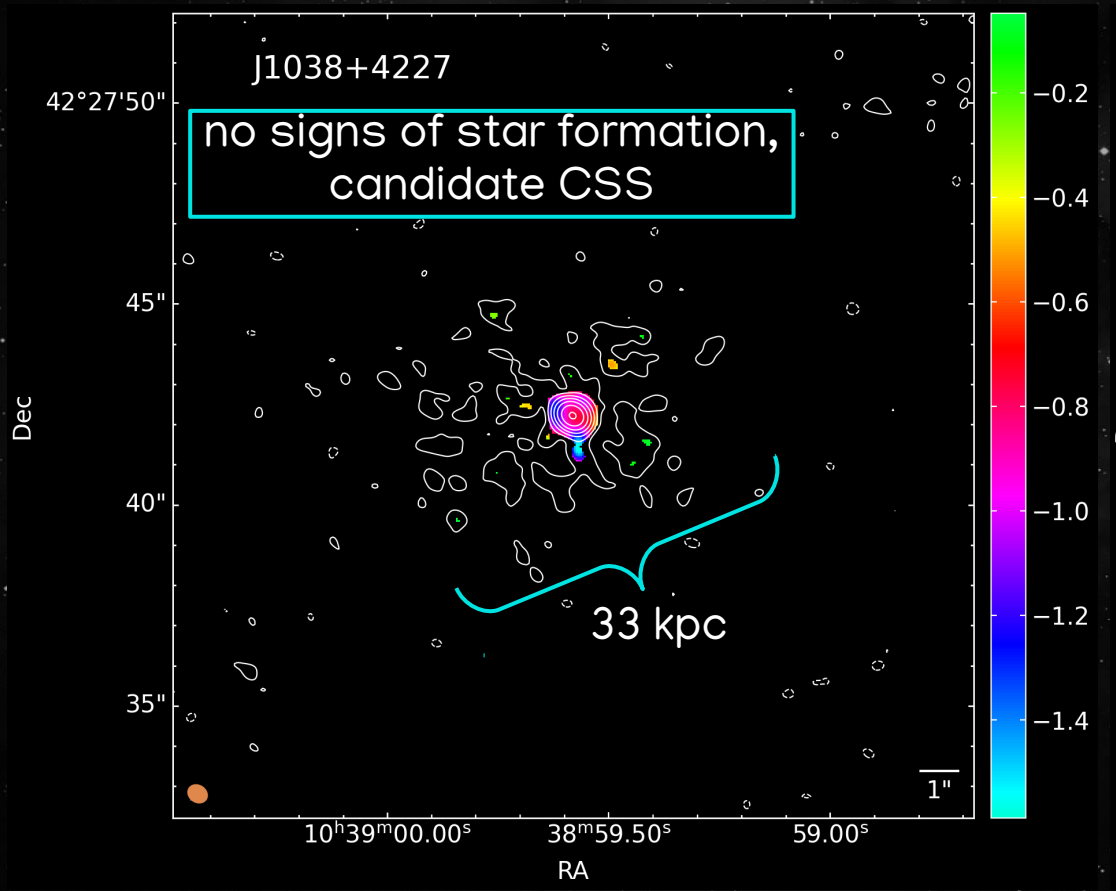
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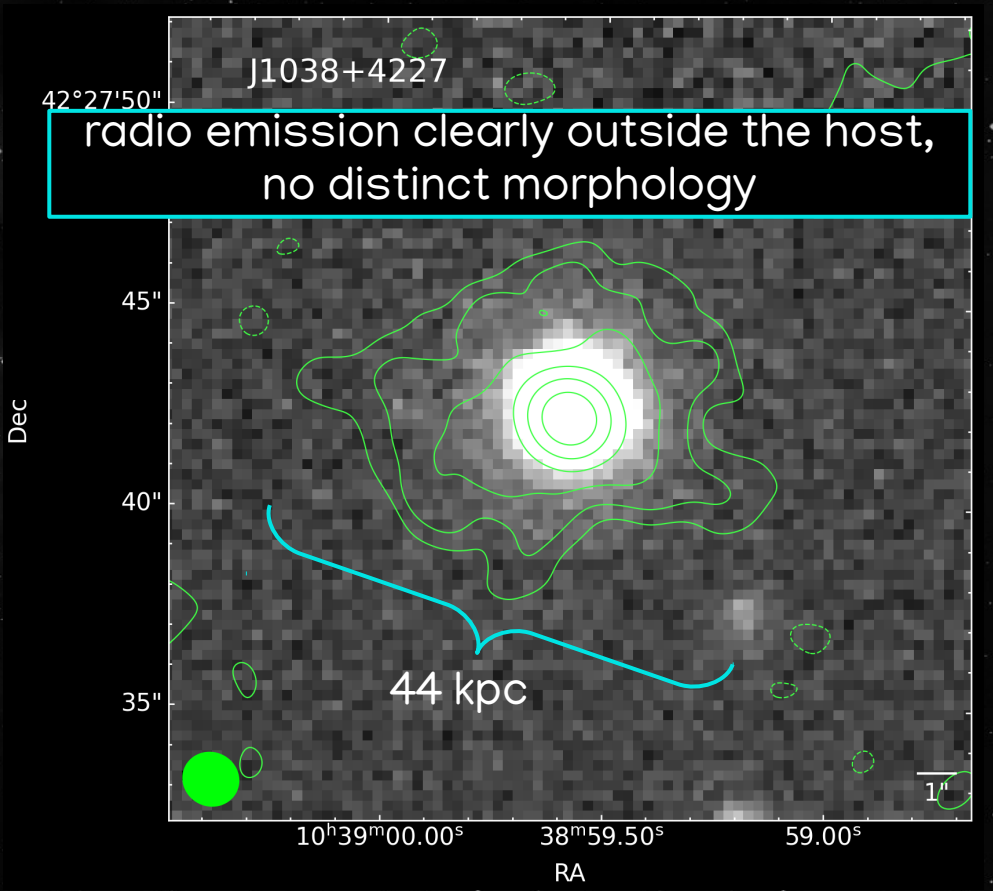
J1038+4227
radio emission clearly outside the host,
no distinct morphology
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Dec
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RA

Results in a nutshell

- One third AGN-dominated
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- In addition: one BLS1, the puzzling “halo” object, one candidate NLS1 with absorbed jets

Take-home messages

i.e. issues and how to fix them

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  → no assumptions based on the classification only
  → we should discuss the classification criteria in general
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  → we need more reliable AGN and SF activity indicators

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...and future work

- high-resolution radio imaging
- confirm the optical classification
- starting to characterise the whole population, including the radio-silent sources

Thanks!