Feedback from low luminosity radio AGNs: A case study of B2 0258+35

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Image: Aleksandar Shulevski

Outline

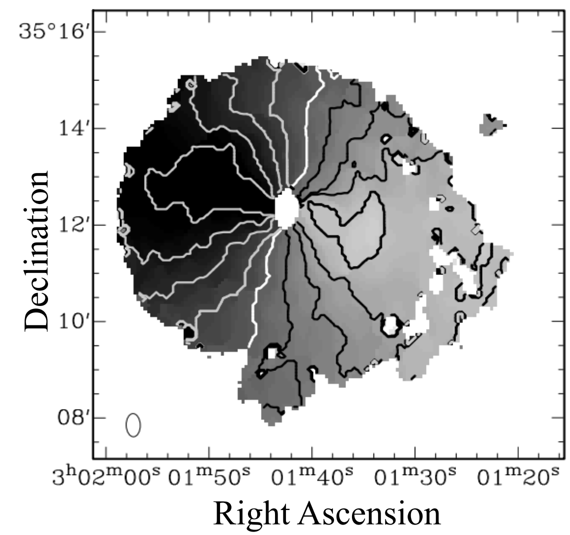
- Why study active galactic nuclei (AGNs)?
- A low luminosity AGN: B2 0258+35
- Future work
- Summary

Why study Active Galactic Nuclei (AGNs)?

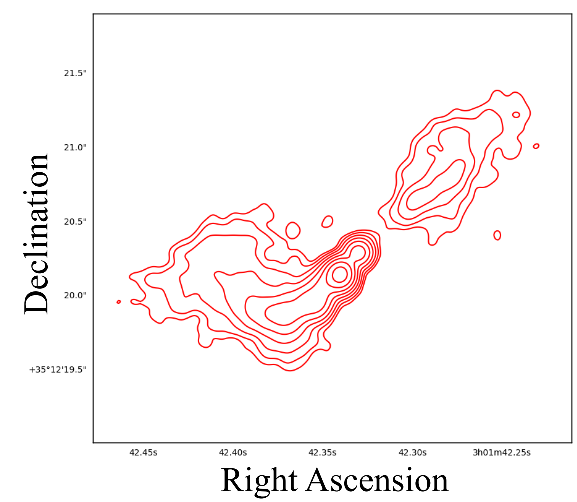
- AGN affects host galaxy evolution
- Feedback not well quantified
- Radio-loud AGN: ~30% of the lot (e.g. Best et al. 2005, MNRAS)
- Jets driven outflows: cold component dominates (e.g. Morganti et al. 1998, AJ; Dasyra et al. 2012, A&A)
- This component is yet to be well understood: detailed studies
    - Needs strong jet-ISM coupling: gas kinematics
    - Low luminosity AGNs are good candidates. (e.g. Best et al. 2005, MNRAS)

B2 0258+35

- Nearby (z = 0.0165), Seyfert 2, low luminosity (1.7 x 10^{24} W/Hz)
  (Emonts, PhD Thesis, 2006; Ho et al. 1997, ApJS)
- Gas rich, early type host galaxy (HI disk of 160 kpc diameter; 1.5 x 10^{10} $M_\odot$)
  (Struve et al. 2010, A&A)
- HI also seen in absorption
- Compact steep spectrum (CSS) source
  - ~1 kpc in size; core and two jets
    (Sanghera et al. 1995, A&A; Giroletti et al. 2005, A&A)
  - Apparent interaction with the ISM
  - Age ~ 0.4 – 0.9 Myr: compact for its age
    (Brienza et al. 2018, A&A)



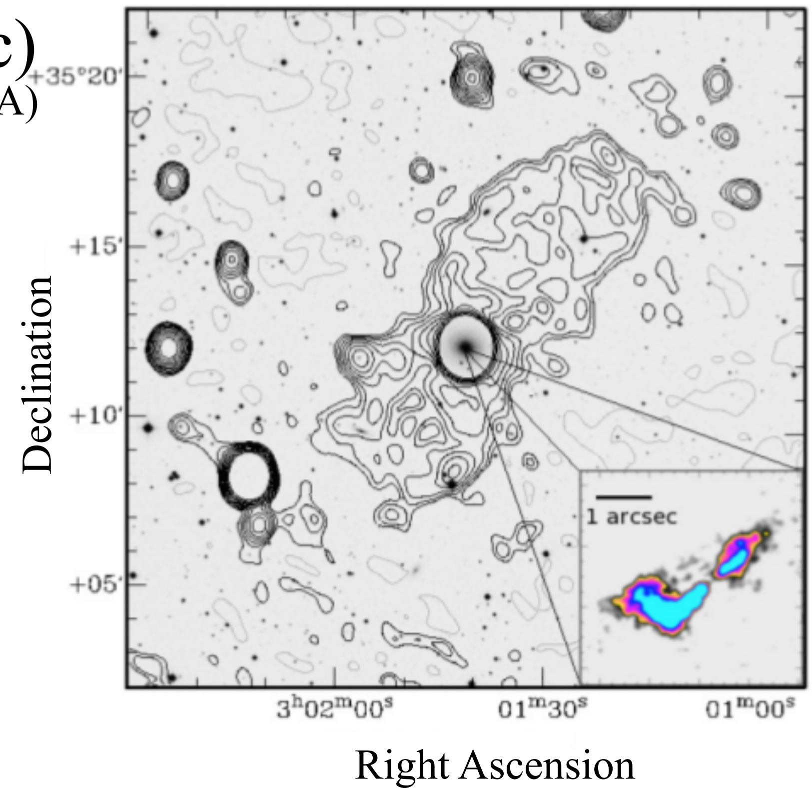
(Struve et al. 2010, A&A)



(Giroletti et al. 2005, A&A)

B2 0258+35

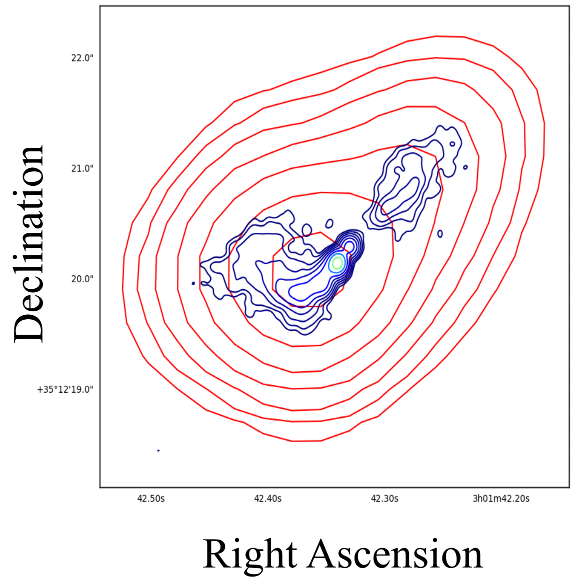
- This galaxy also has large lobes (240 kpc)
  (Shulevski et al. 2012, A&A; Brienza et al. 2018, A&A)
- Extremely low surface brightness
  (~ 4.75 mJy arcmin^{-2})
- Linked to the CSS source?
- Hints from gas kinematics?

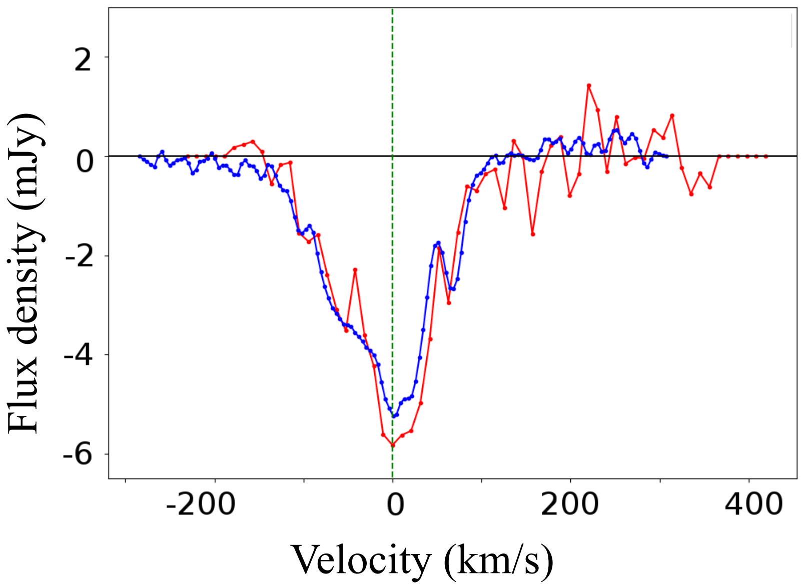


(Shulevski et al. 2012, A&A)

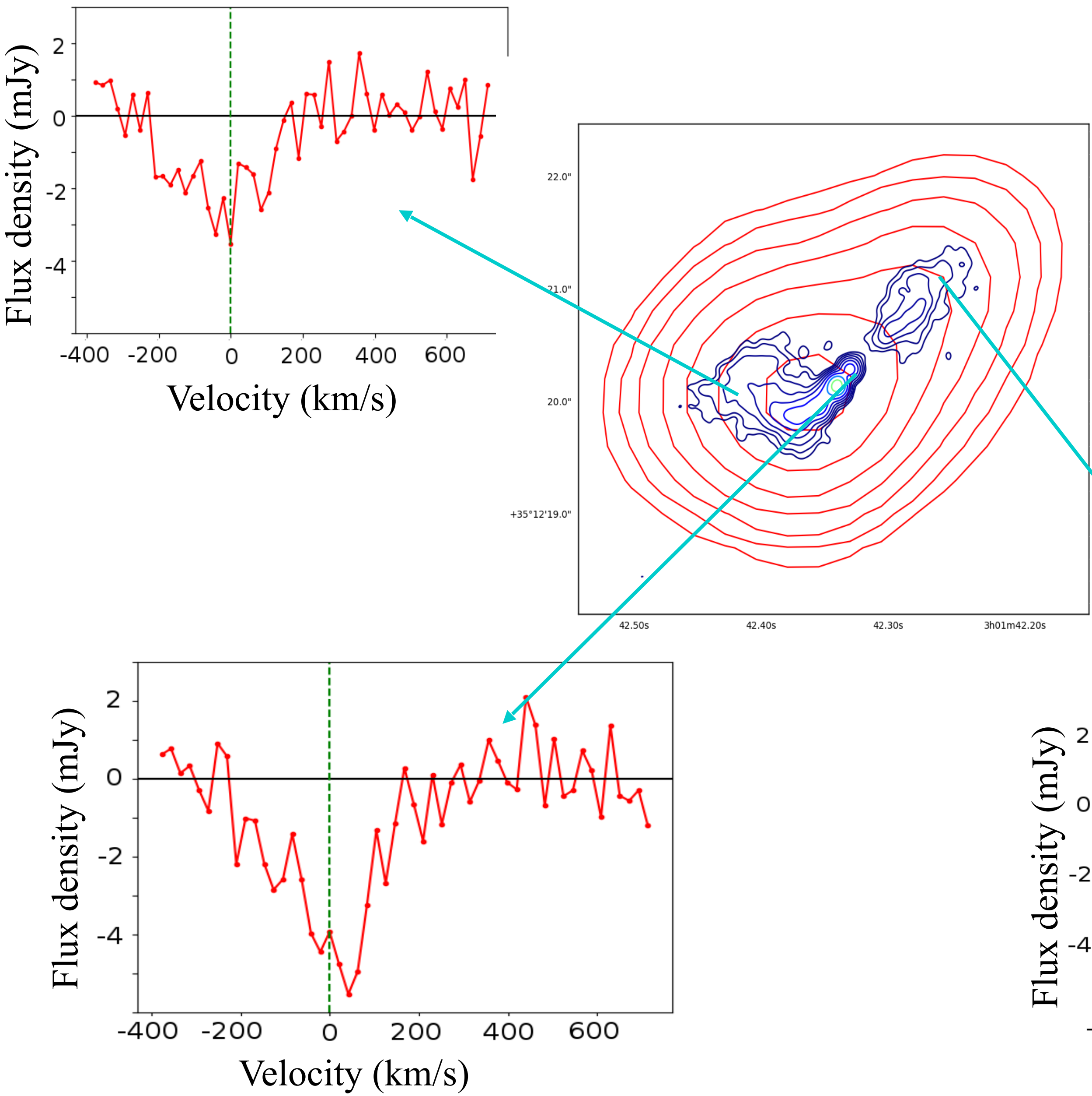
B2 0258+35

- HI absorption against the CSS source (Struve et al. 2010, A&A)
  - Poor spatial resolution (~ 8 kpc): cannot localise the absorption
- VLA A-array observations:
  - Source slightly resolved
  - All the WSRT flux recovered: No continuum in between
  - WSRT and VLA spectra agree
  - Absorption slightly resolved too

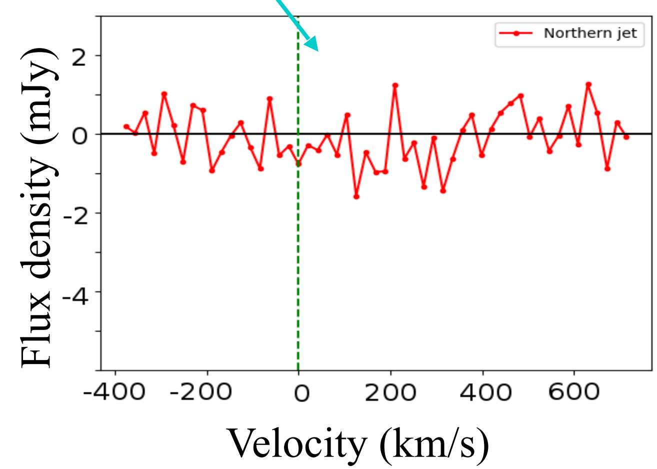




HI absorption profiles

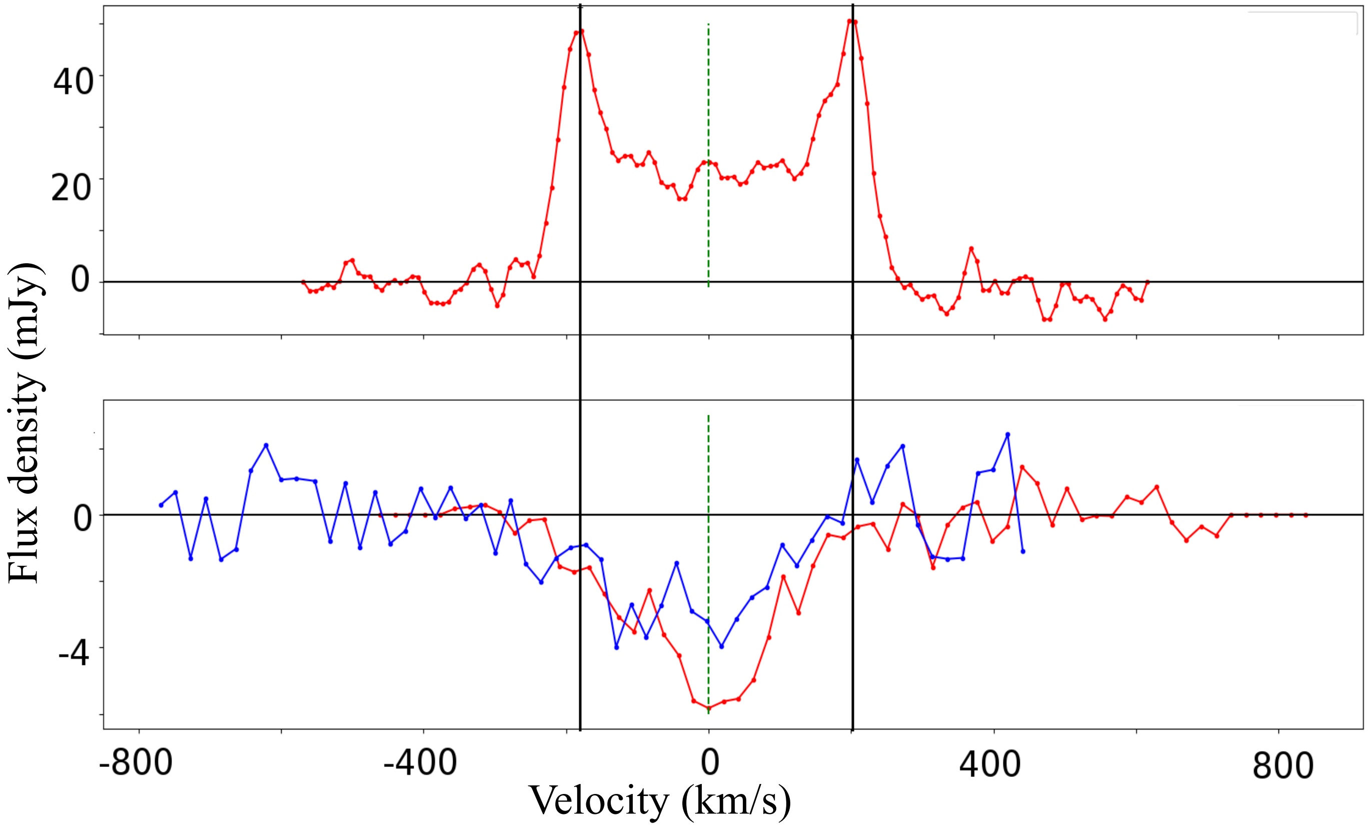


- No absorption against northern jet: Not sensitive
- ~ 400 km/s FWZI
- *Centred* at the systemic
- Column densities: ~1.5 to 2 x 10^{20} cm^{-2} (T_{spin} = 100K)



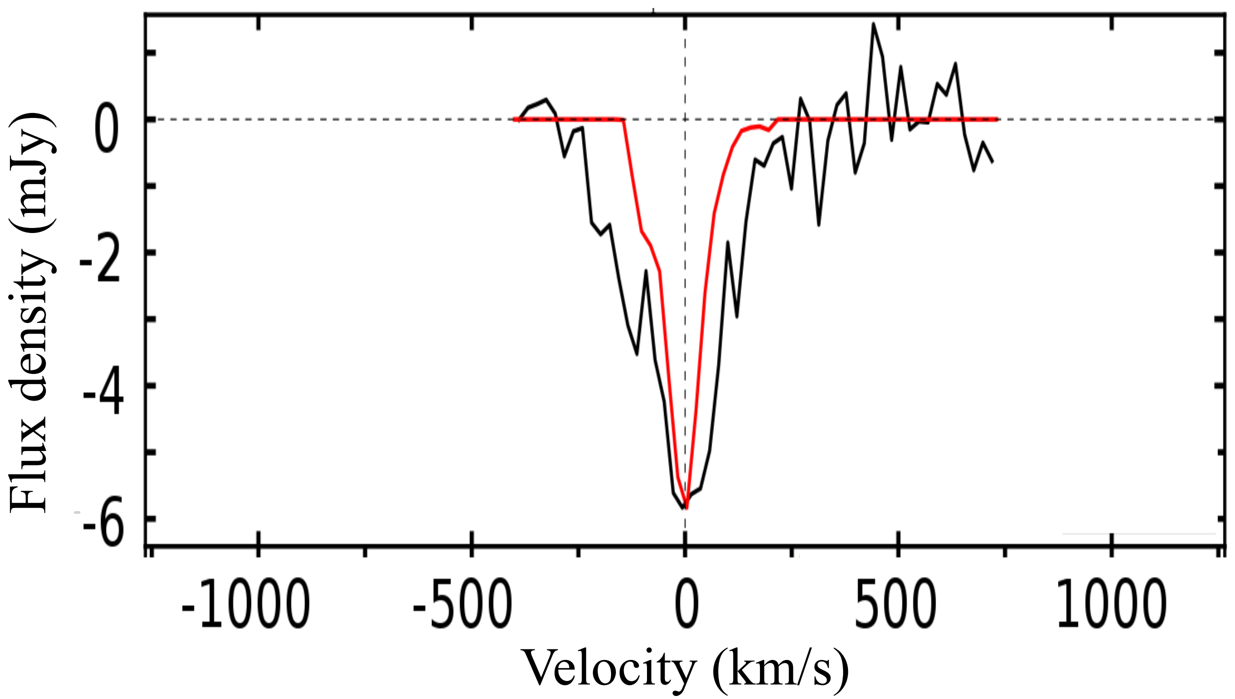
Morphology of the absorbing gas

- CO emission: central ~ 8 kpc (Prandoni et al. 2007, NAR)
- Not the molecular gas counterpart of the large scale disk
- CO, HI absorption profiles match: asymmetry not due to continuum
- Very wide lines; centred at the systemic; blue shifted asymmetry.



Modelling the absorption

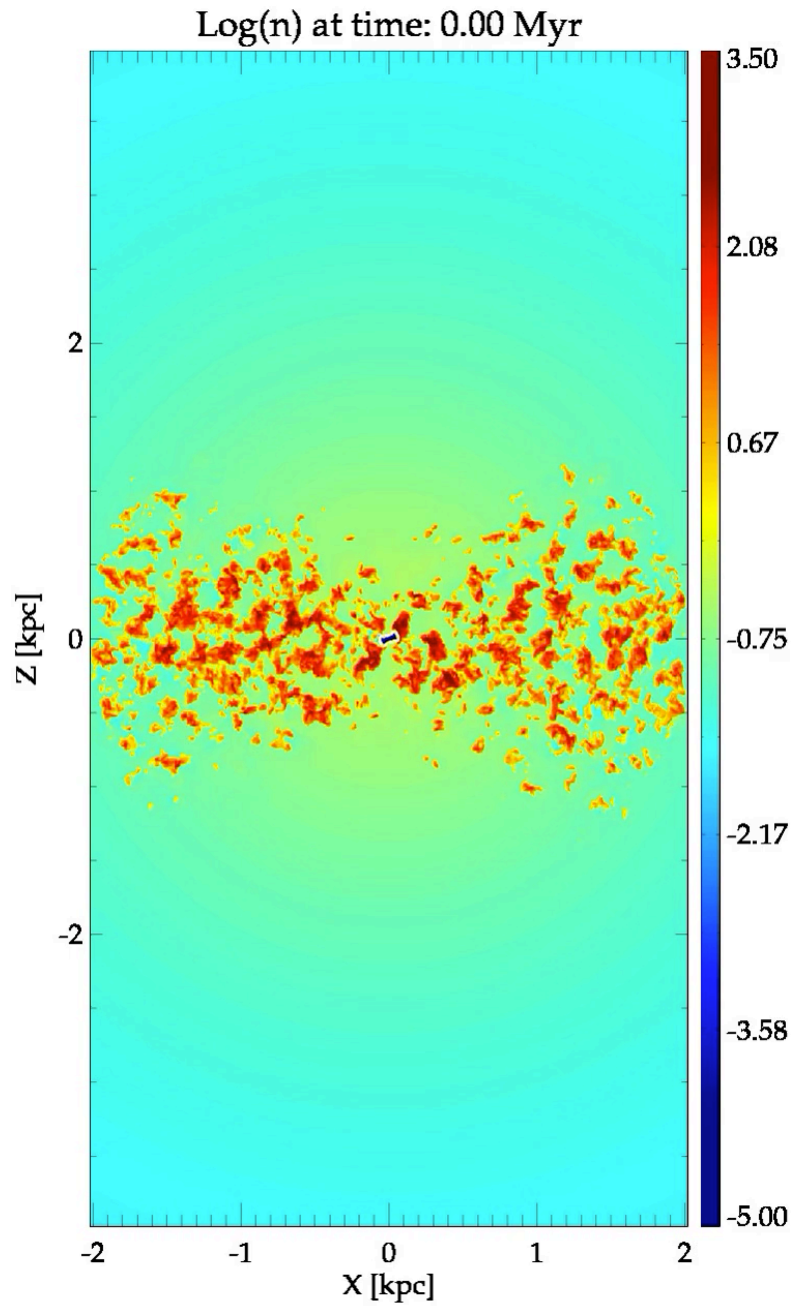
- Optically thin, uniform density, cold disk (velocity dispersion: 8 km/s)
  (Maccagni, 2017, PhD Thesis)
- Not a *cold* disk
- Extra component: turbulence?
- Can jets cause turbulence?



Can jets cause turbulence?

- Possible if they pass through a significant cross-section of the ISM
- Impact depends on the power
  - High-power jets drill through easily ($\geq 10^{46}$ erg/s)
  - Low power jets cause more turbulence
- Jets of B2 0258+35 are most likely expanding into a disk
- Jet power: 8.2×10^{43} erg/s

(Cavagnolo et al. 2010, ApJ)



(Mukherjee et al. 2018, MNRAS)

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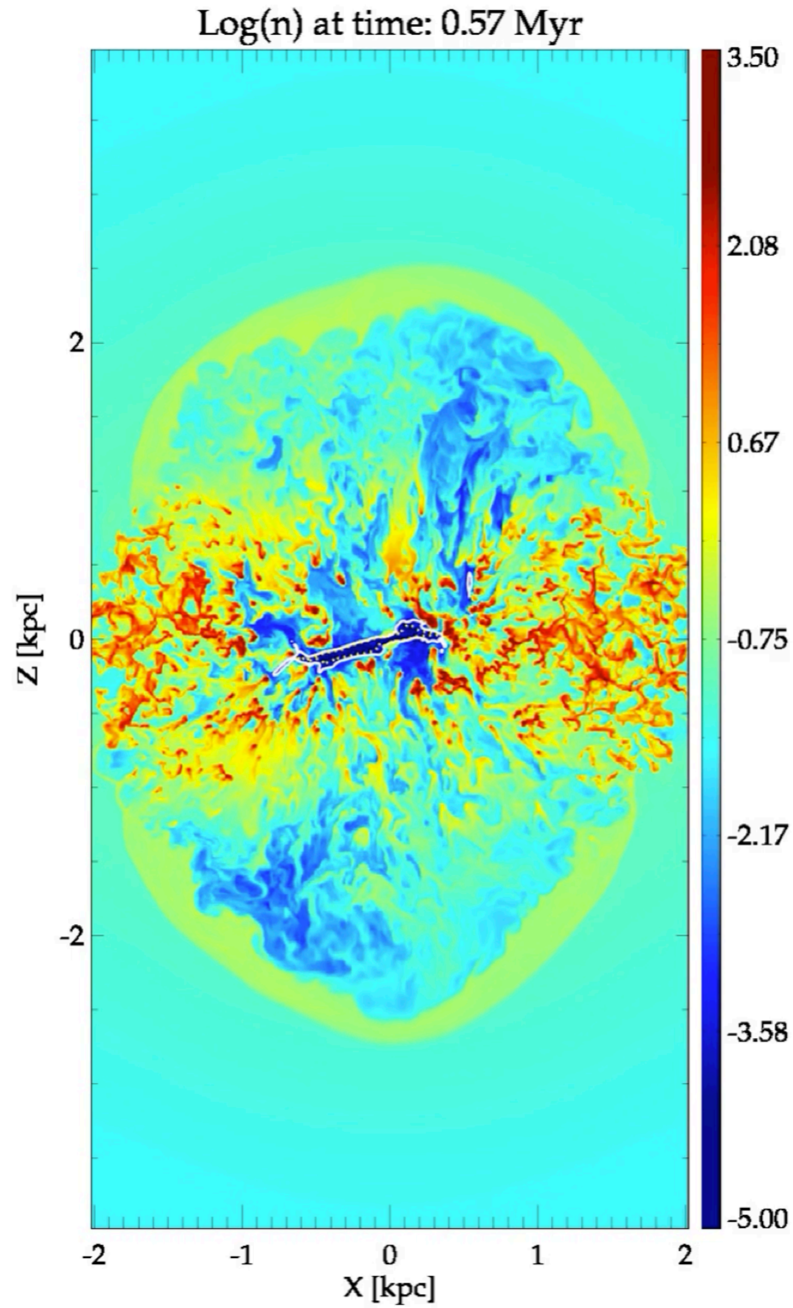

(Mukherjee et al. 2018, MNRAS)

The future

- High resolution CO to understand the jet-ISM interaction better
- What is the impact of the large scale lobes?: X-ray studies
- Are there similar sources?: IC 5063
- Many more with LOFAR: A test for this model possible

Summary

- Radio AGNs may cause significant feedback.
- B2 0258+35: very broad H I absorption and CO emission lines; turbulent disk due to strong jet-ISM interaction?
- May also cause the large scale lobes.
- Only few studies of such targets so far: more studies needed to get a definitive answer.