The parsec-scale jet-driven HI outflows in powerful radio galaxies

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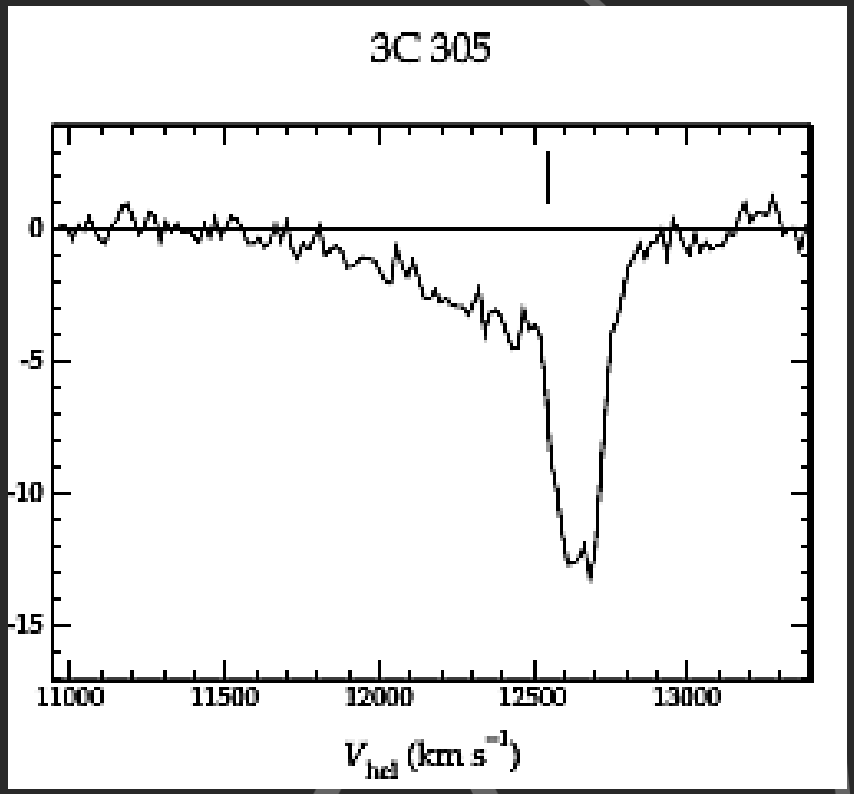
HI outflows

(Massive) HI outflows detected in absorption in several radio sources
(e.g., Morganti et al. 2001, 2005, 2016, Mahony et al. 2013)

Tracing AGN-ISM interaction on galactic scales

Need to constrain the properties and location of the outflow

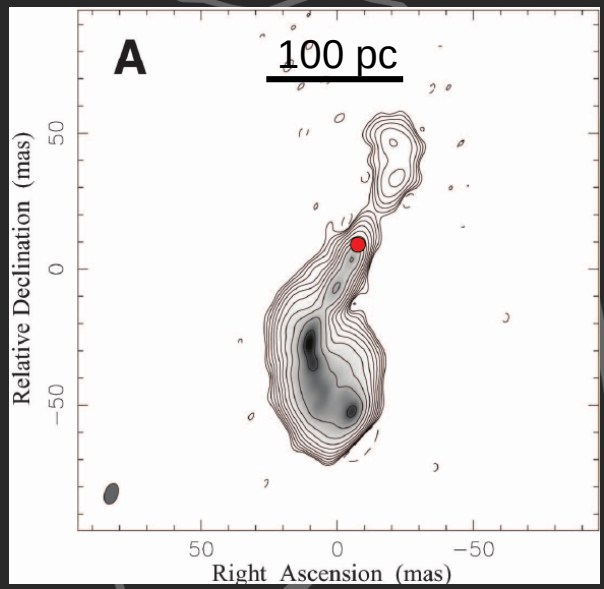
Requires sub-arcsec resolution observations -> VLBI



Credit: Morganti et al. 2005

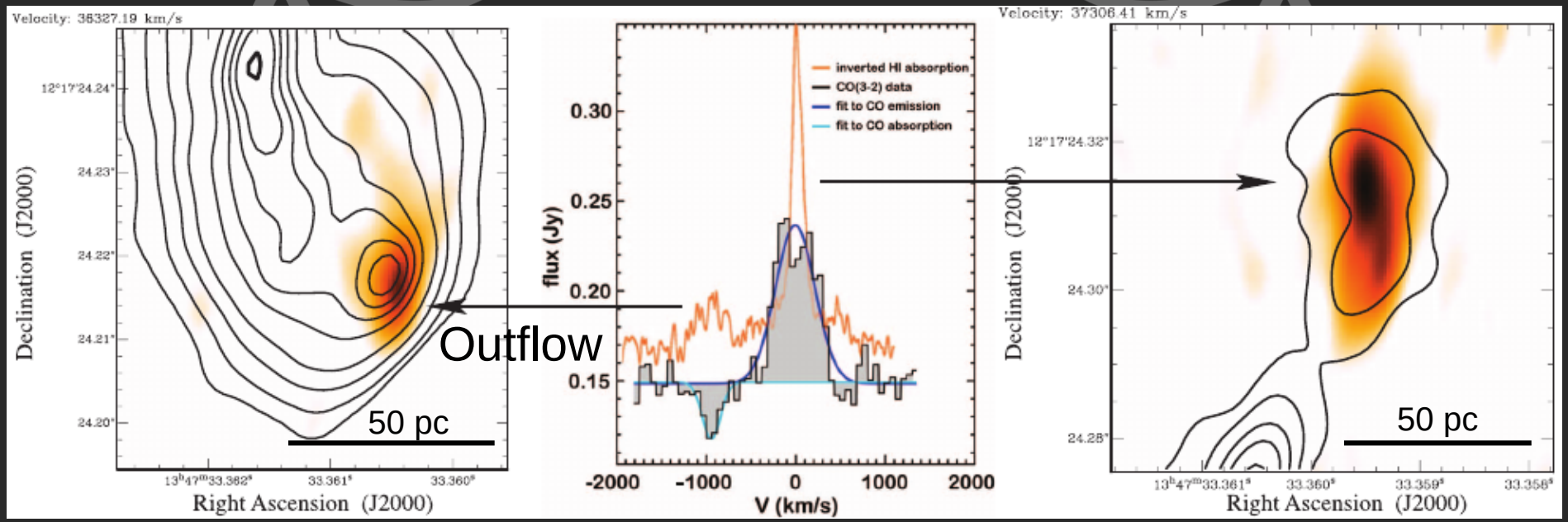
4C 12.50

Re-started radio galaxy at z=0.1215



Outflow located co-spatial to the southern lobe (Morganti et al. 2013)

- HI mass: 1.6×10^4 M_{Sun}
- Rate: 16-29 $M_{Sun} yr^{-1}$
- Density: 150-300 cm^{-3}



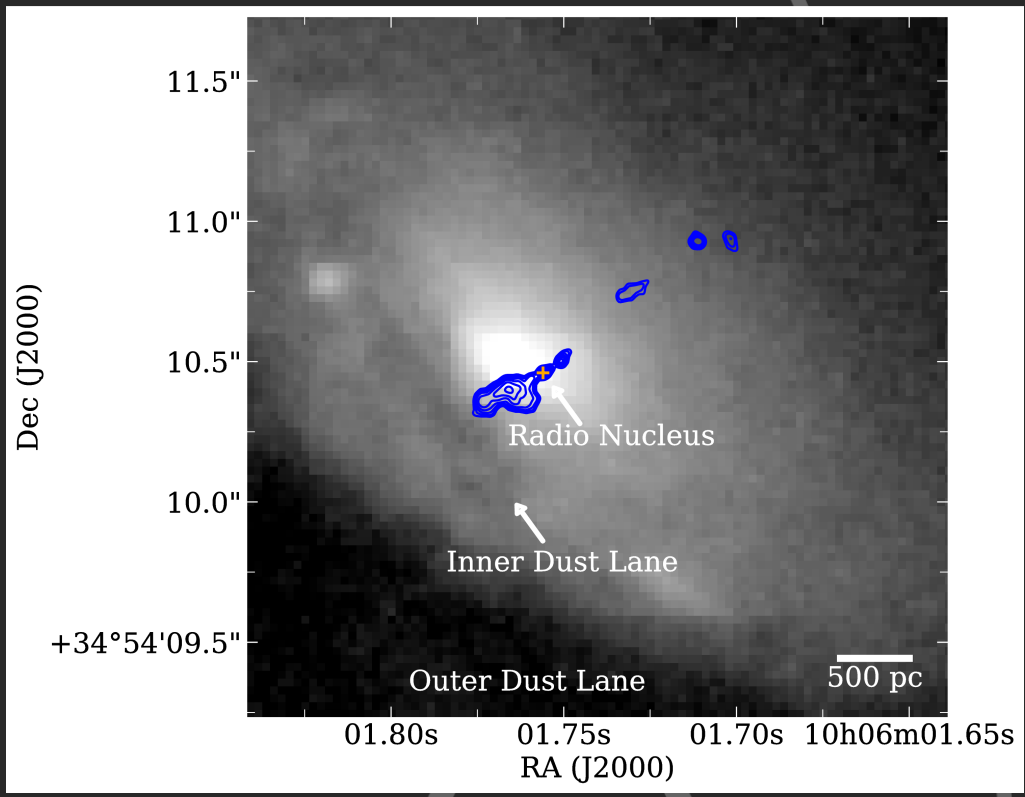
Credit: Morganti et al. 2013

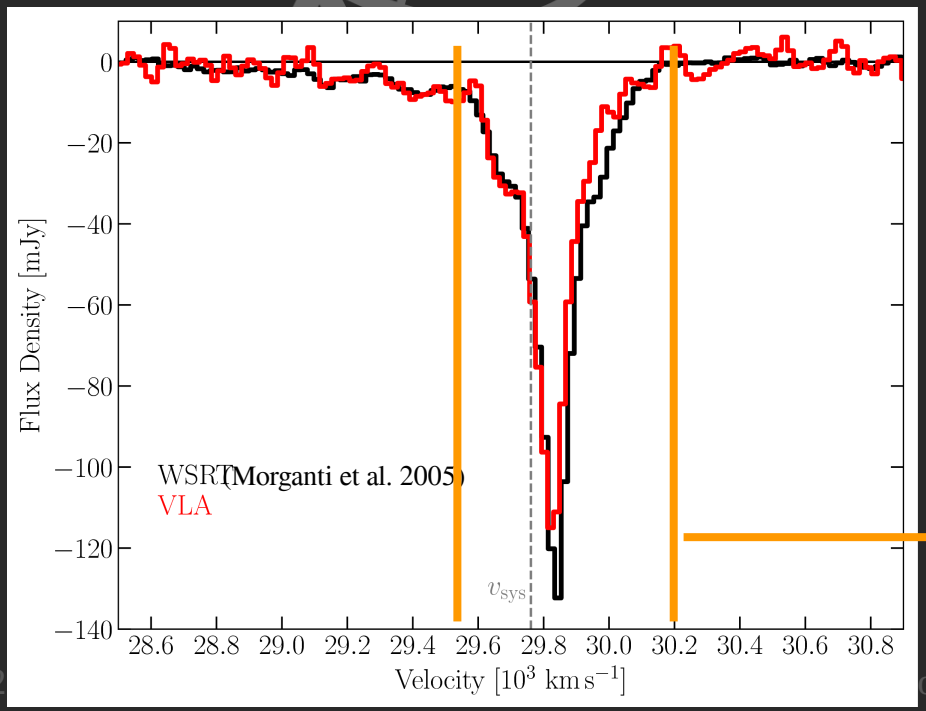
The sample

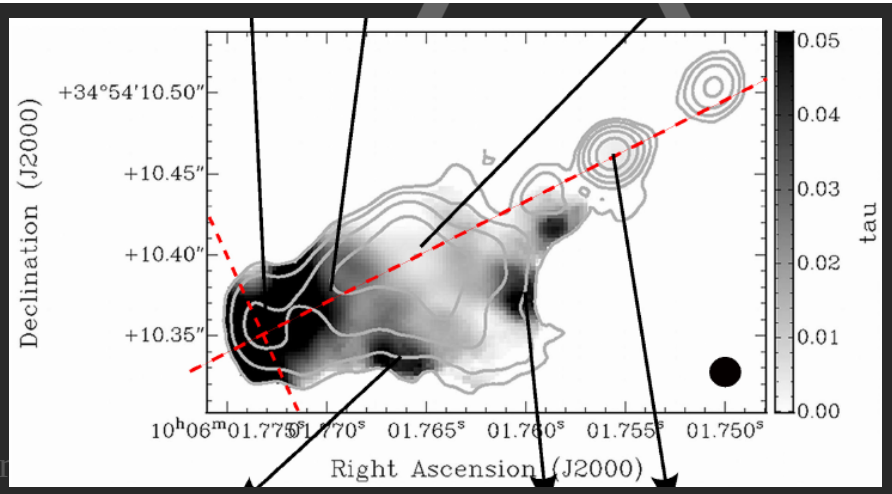
4C +12.50 | **3C 236** | 4C +52.37 | 3C 293

Giant re-started radio galaxy at z=0.1 (Barthel et al. 1985, Schilizzi et al. 2001)

Very broad HI outflow (~1000 km/s)







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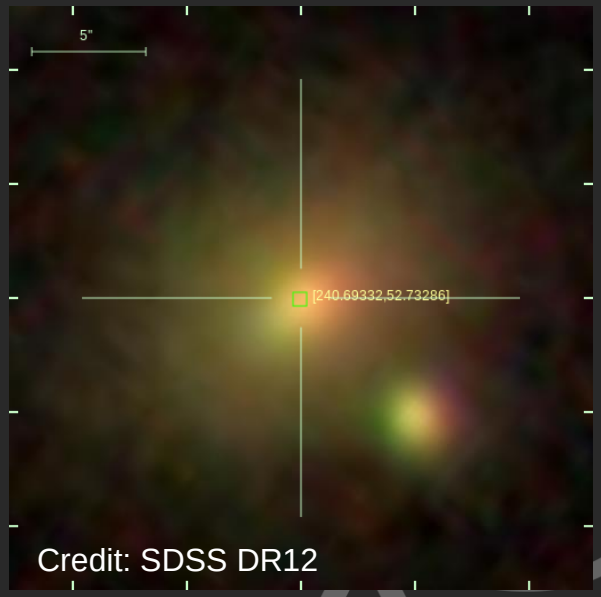
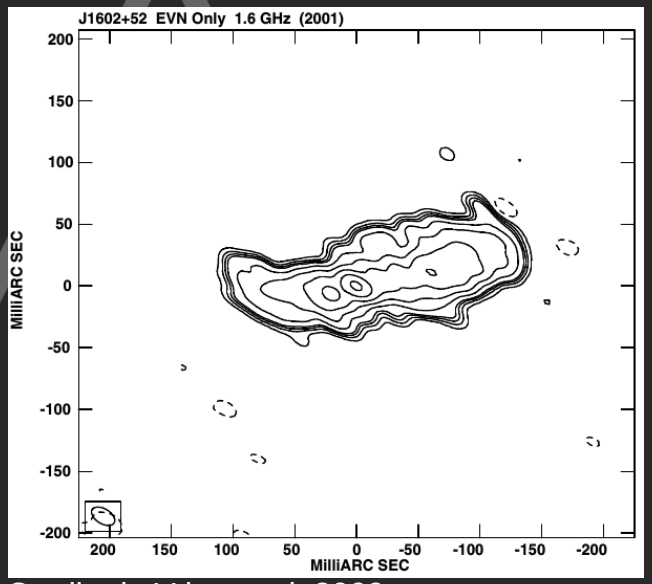


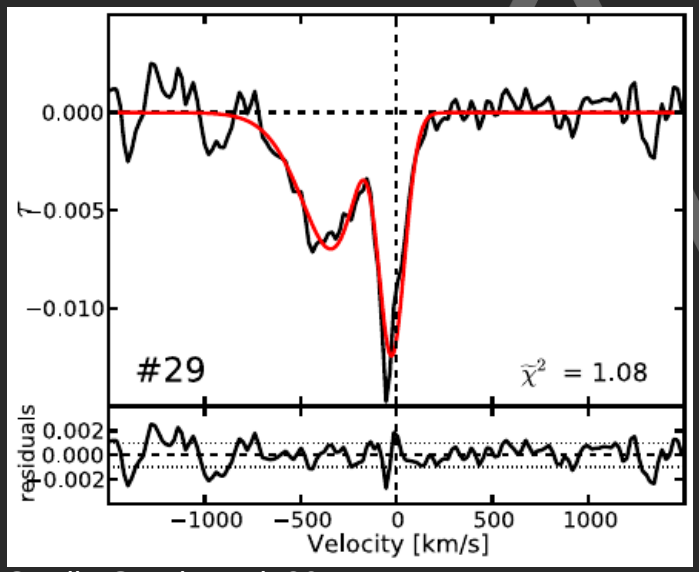
Credit: SDSS DR12

Compact symmetric object at z=0.106
(e.g., de Vries et al. 2009)

Gas-rich host galaxy (Maccagni et al. 2017)



Credit: de Vries et al. 2009



Credit: Gereb et al. 2015

The sample

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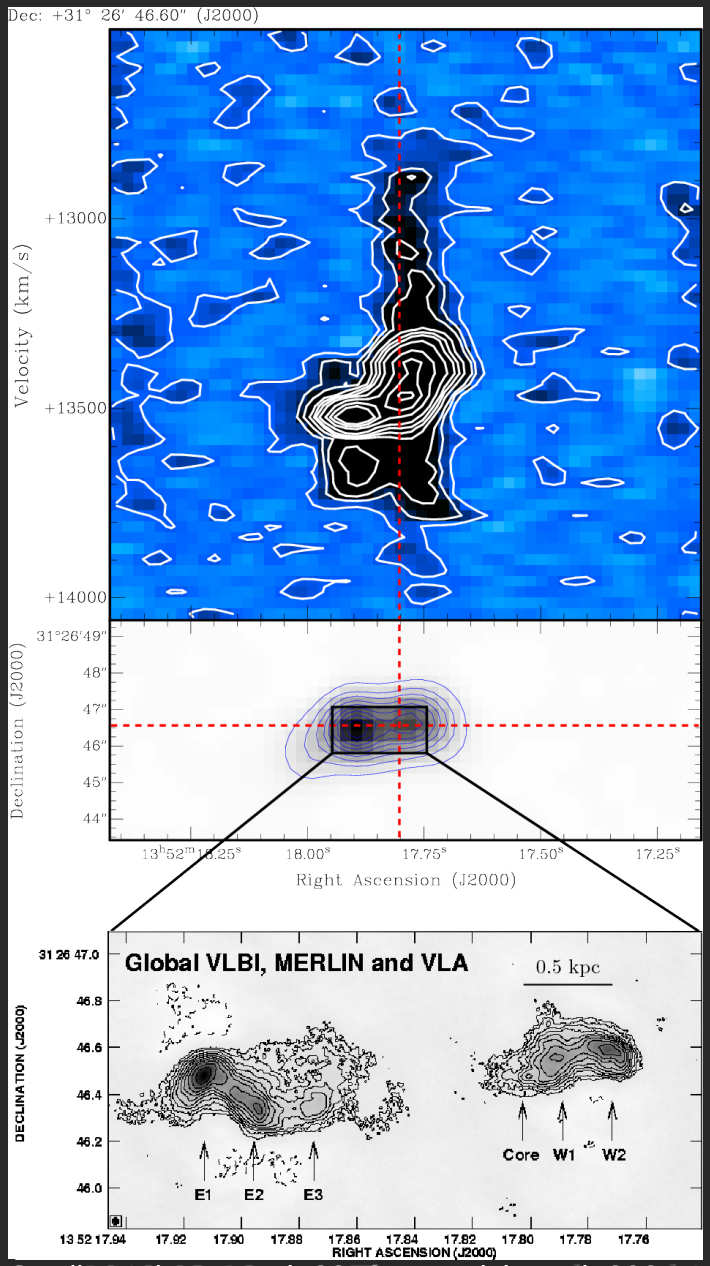
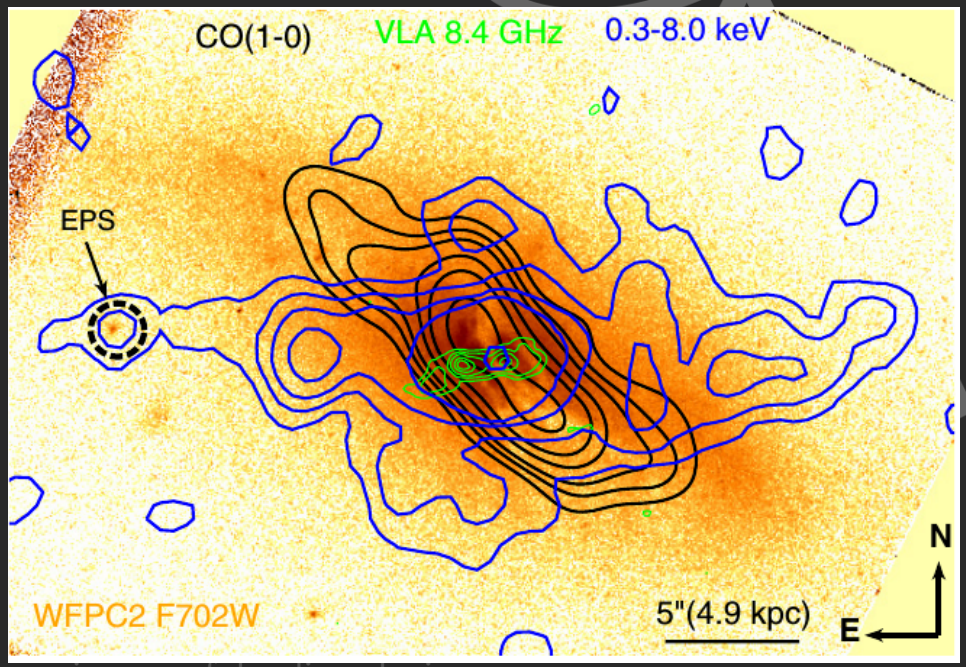


Credit: Mahony et al. 2013, Beswick et al. 2004

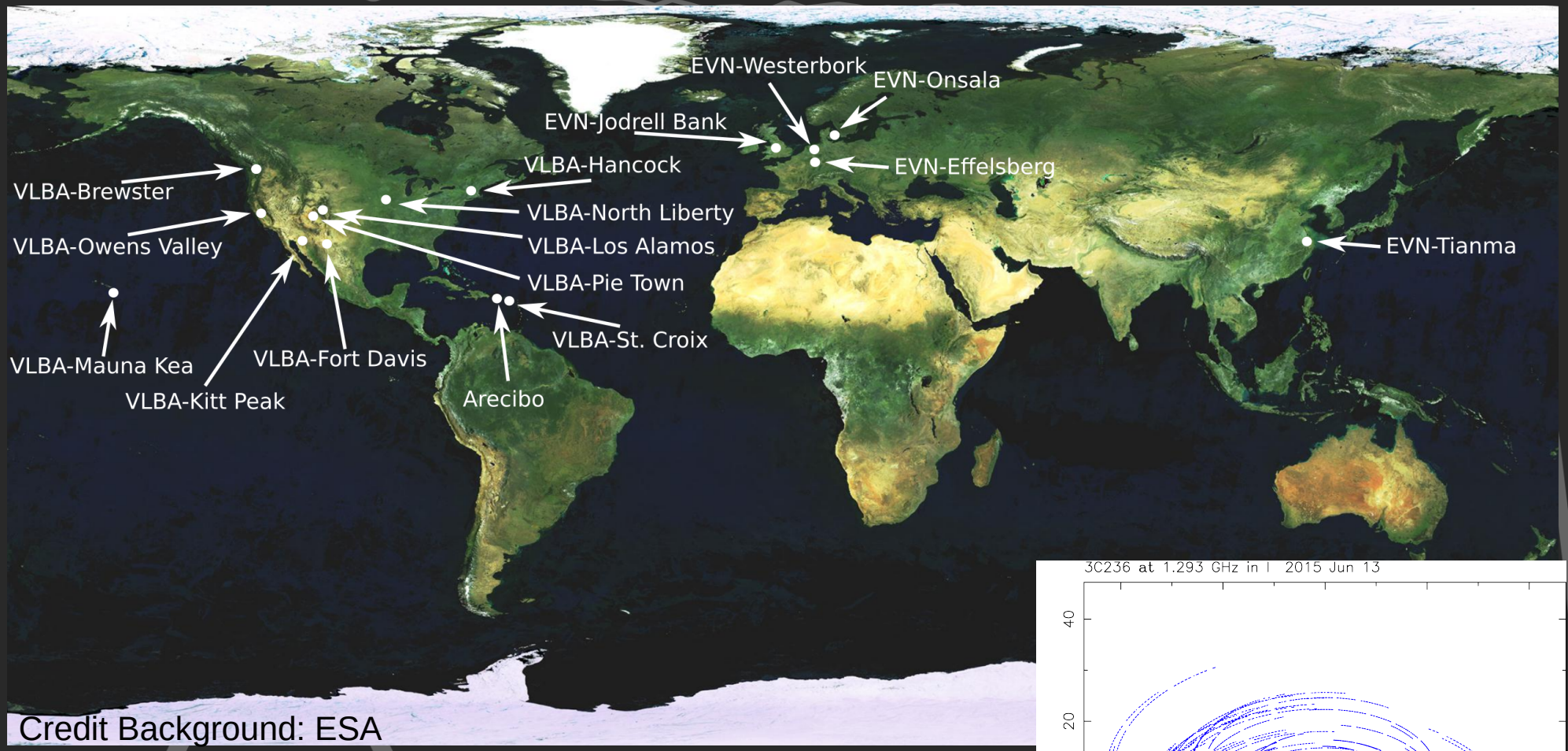
Re-started radio galaxy at z=0.045
(Sandage 1966, Beswick et al. 2014)

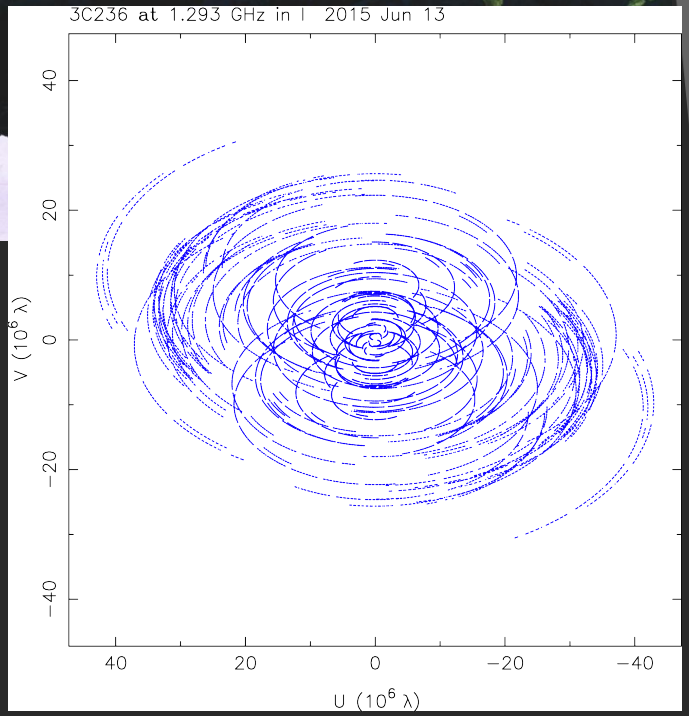
Complex radio morphology and gas distribution



Credit: Lanz et al. 2015

Global VLBI HI Observation





EVN + VLBA + Arecibo

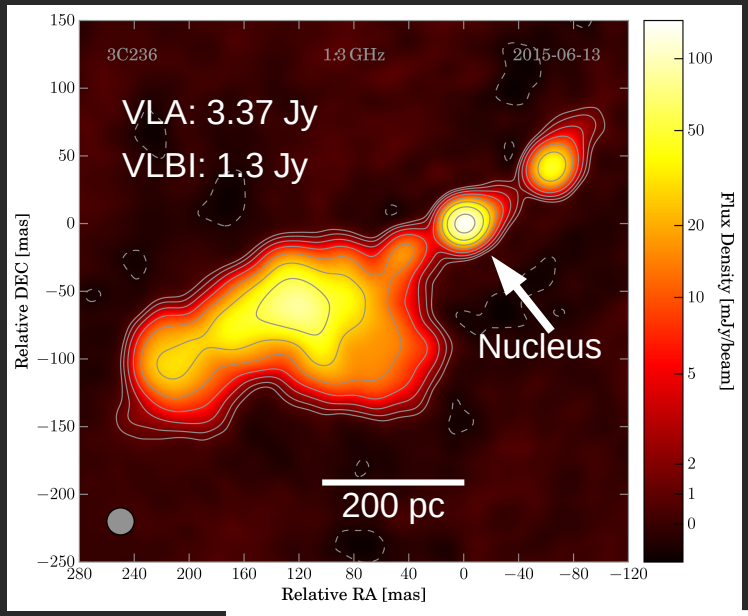
Angular resolution: 20 mas

BW: 16 MHz (512 channels)

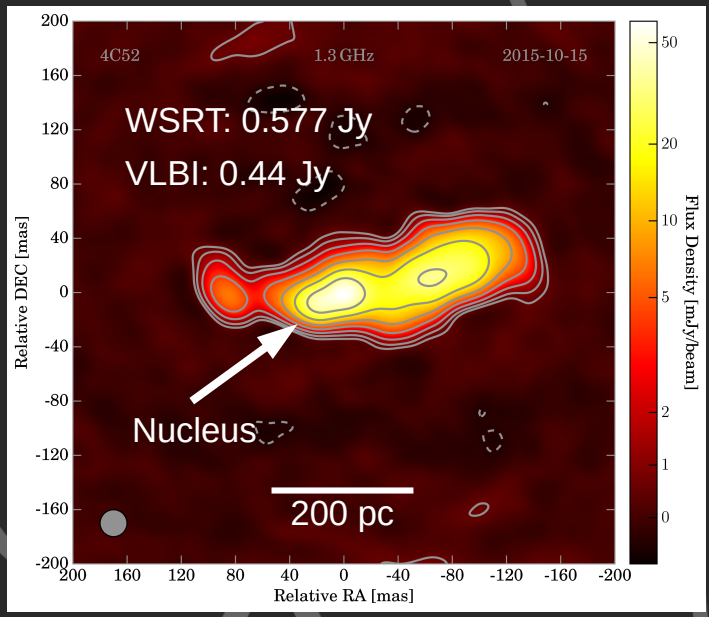
Redshift limit of VLBI: ~0.1

Continuum Images

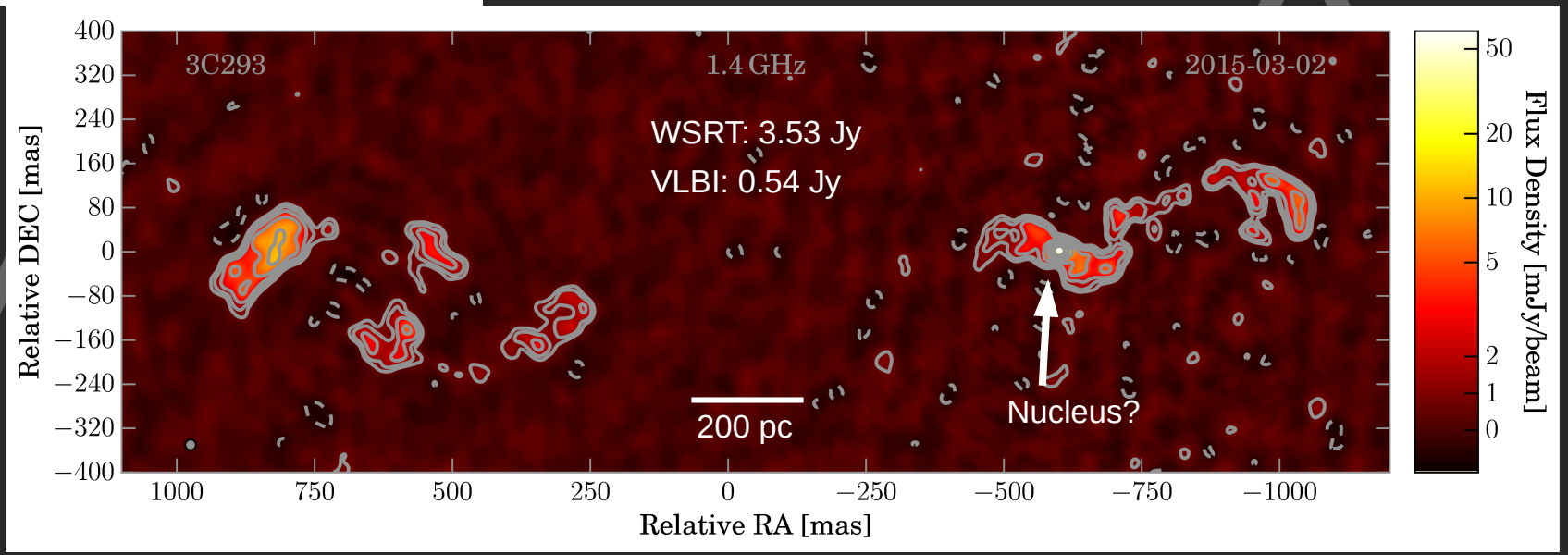
3C 236



4C +52.37

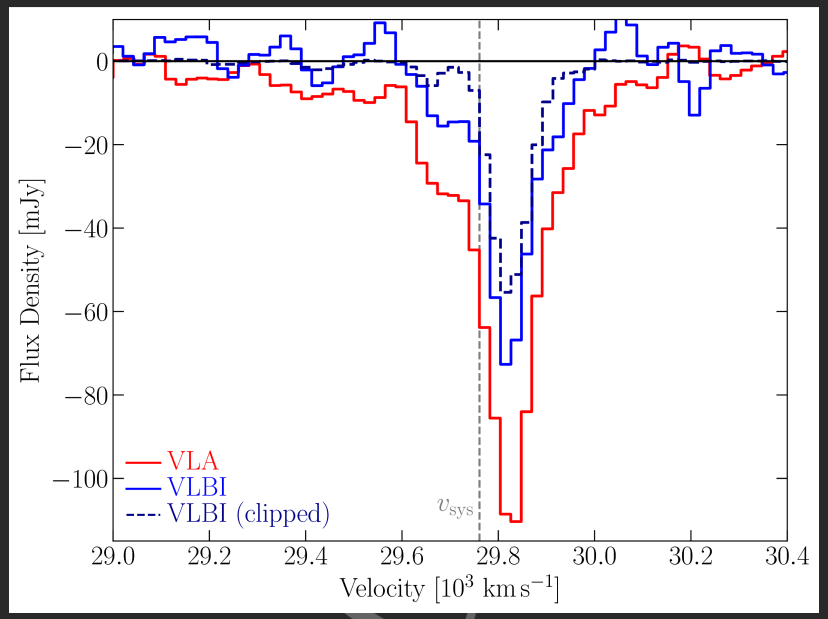


3C 293



HI Absorption spectra

3C 236



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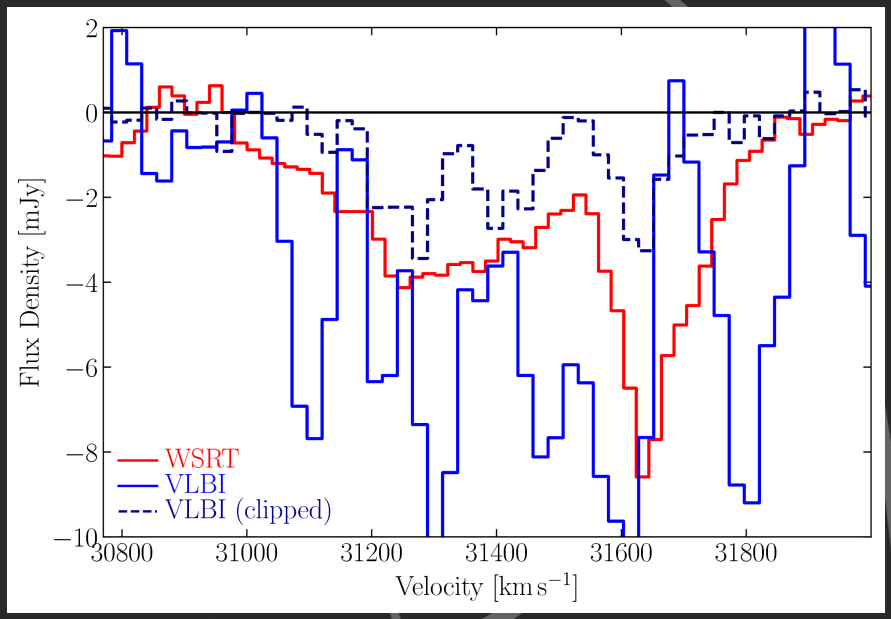

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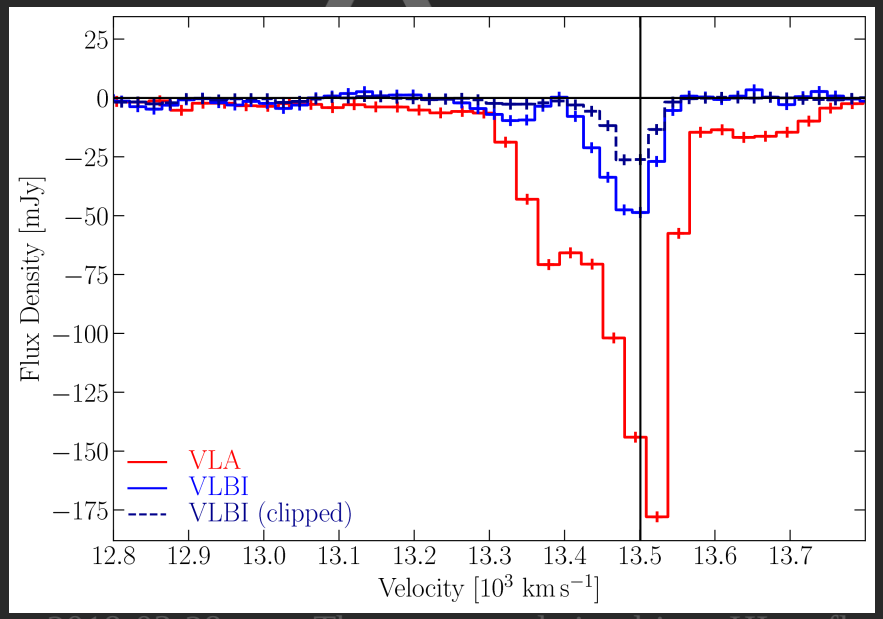
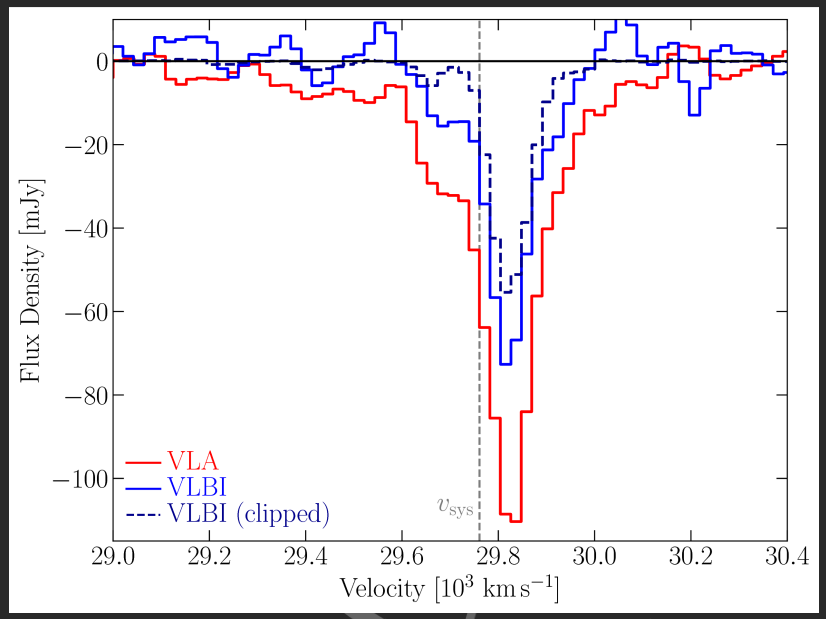


HI Absorption spectra

3C 236



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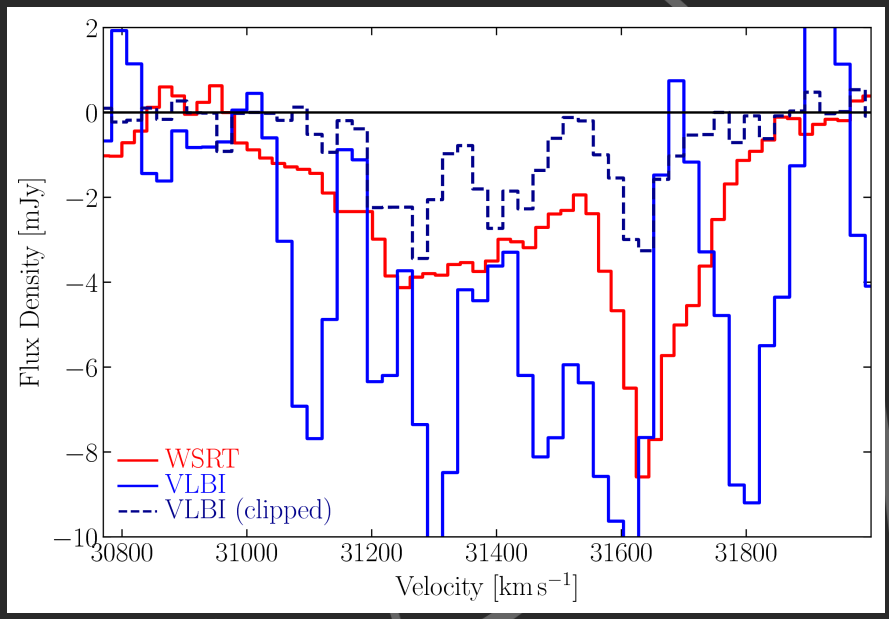
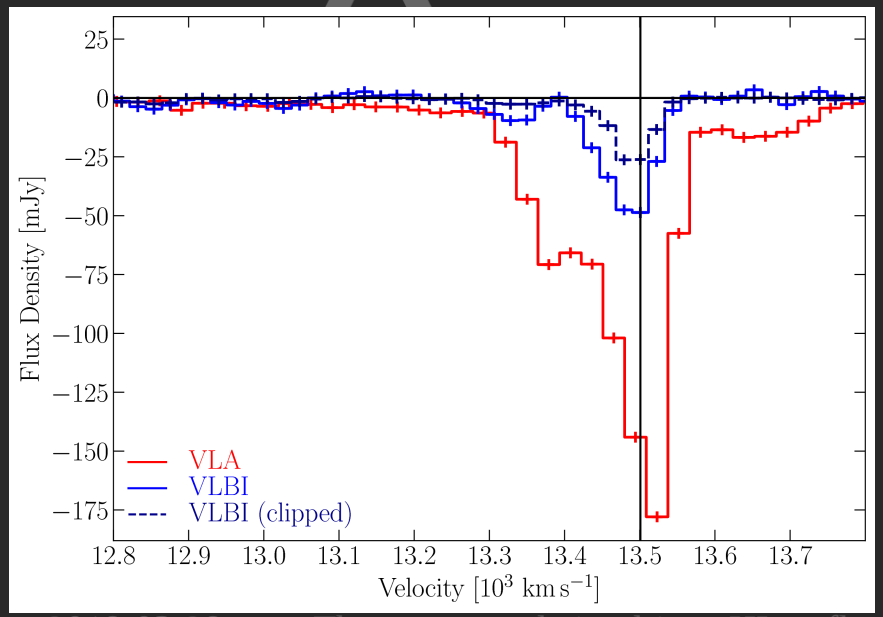
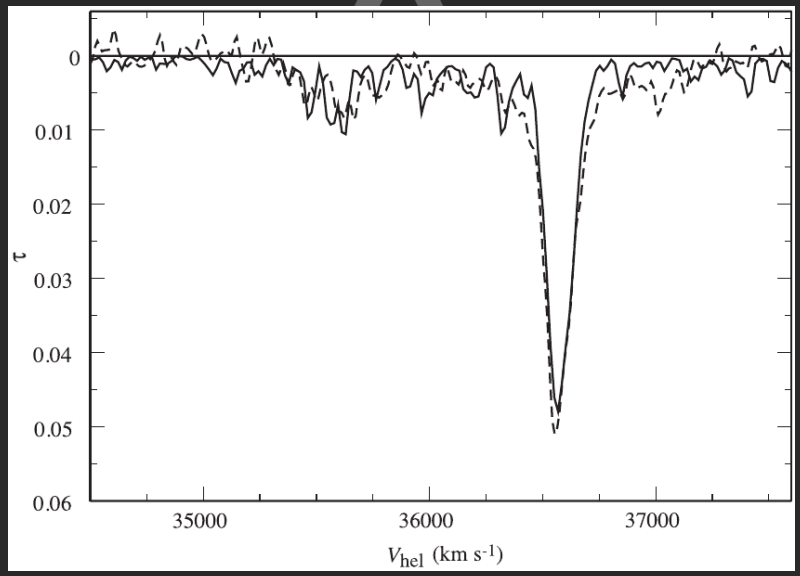


3C 293

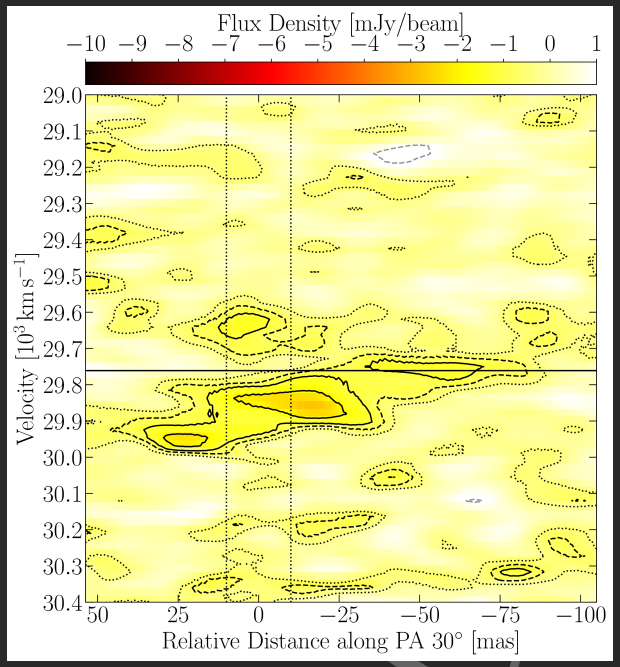


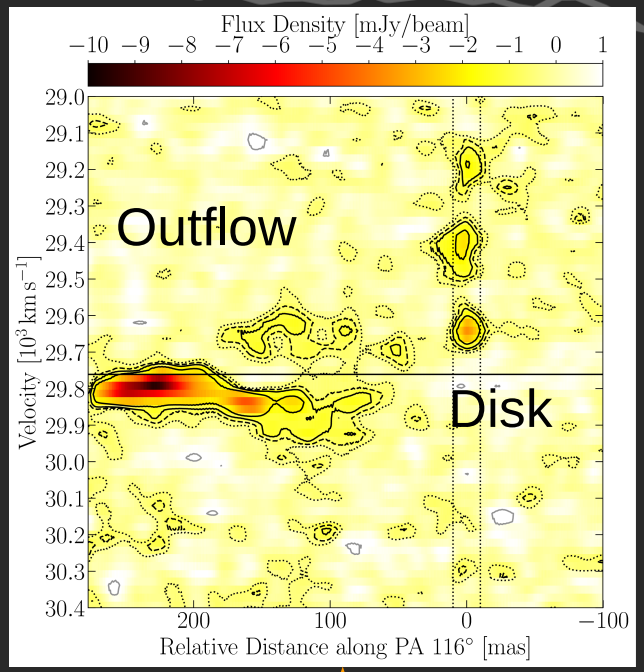
4C +12.50



Credit: Morganti et al. 2013

3C236 - HI Gas Distribution





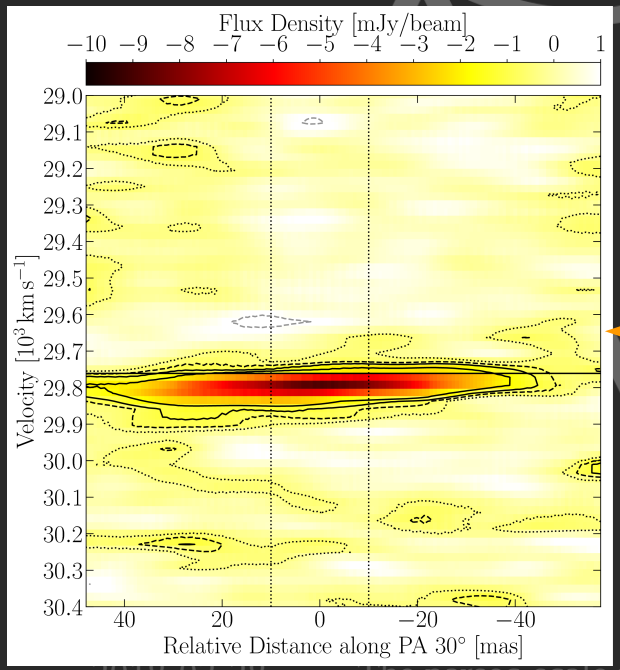
Height of HI disk: > 400pc

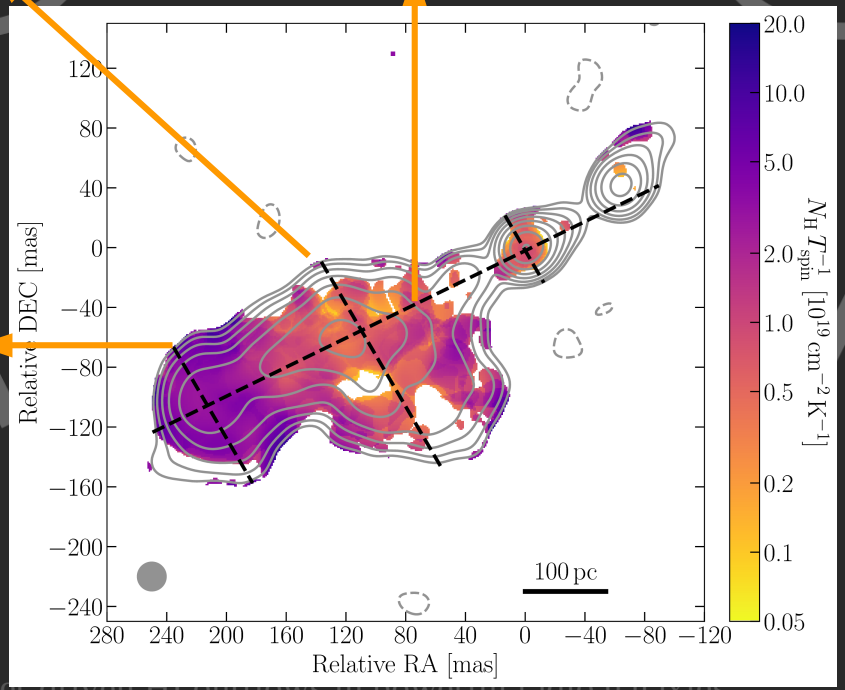
Outflowing gas in the nuclear region:

HI mass: ~2.8x10^4 M_{Sun}

Rate: ~5 M_{Sun} yr^{-1}

Density: ~120 cm^{-3}





Schulz et al. submitted

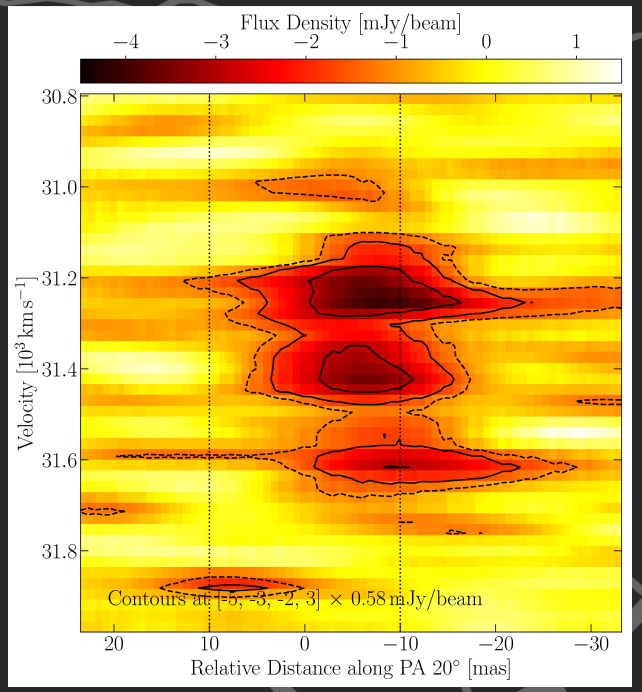
4C 52.37 - HI Gas Distribution

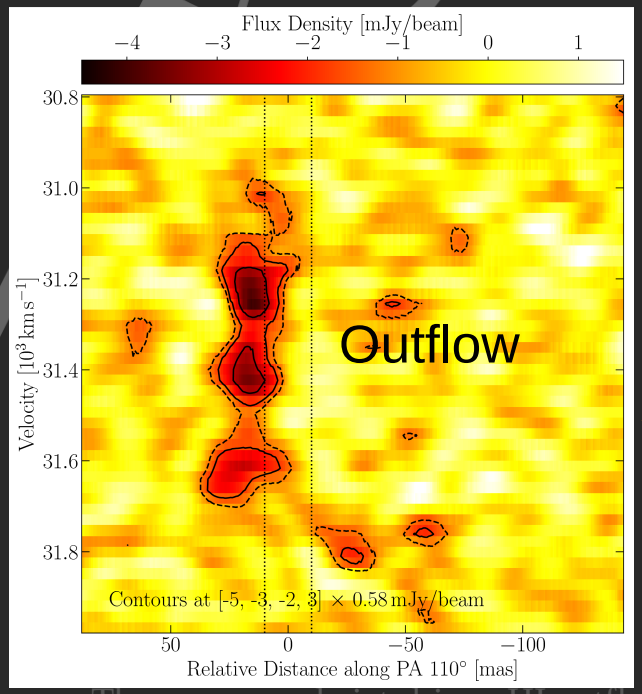
Outflowing gas:

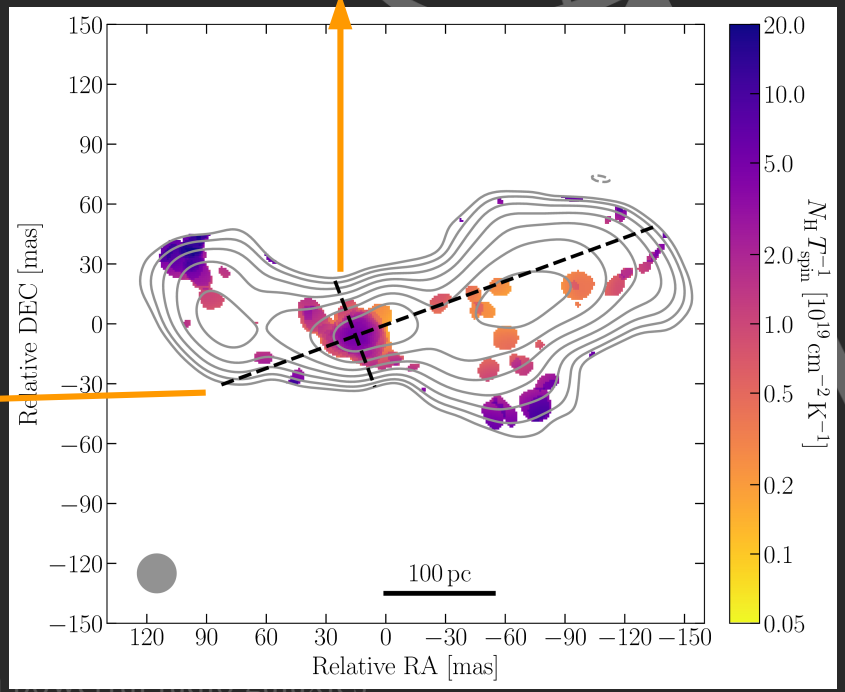
HI mass: ~4x10^5 M_{Sun}

Rate: ~13 M_{Sun} yr^{-1}

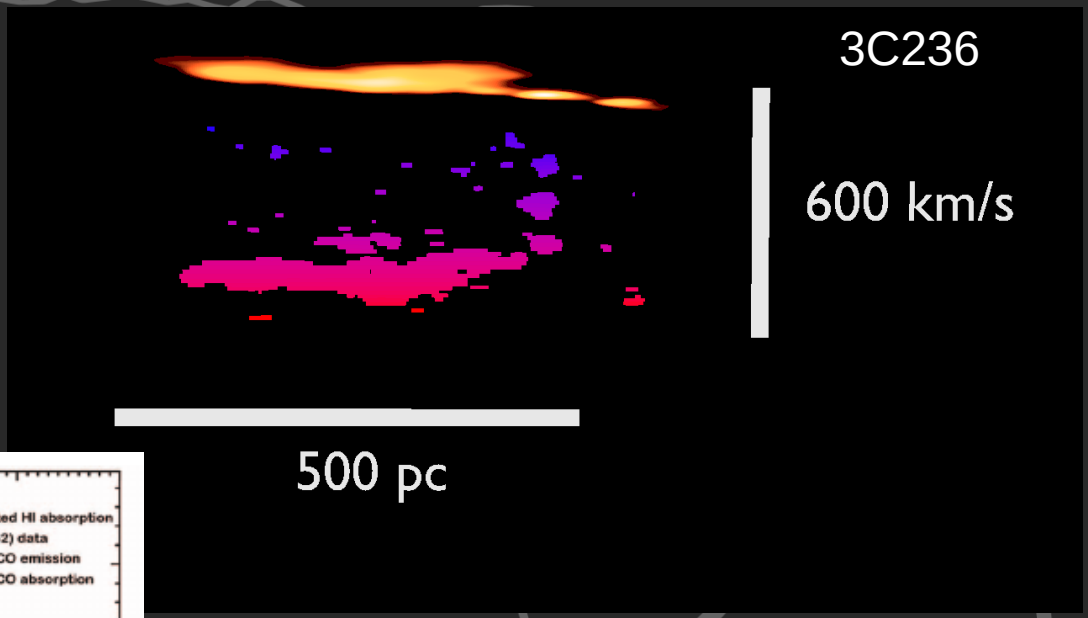
Density: ~500 cm^{-3}



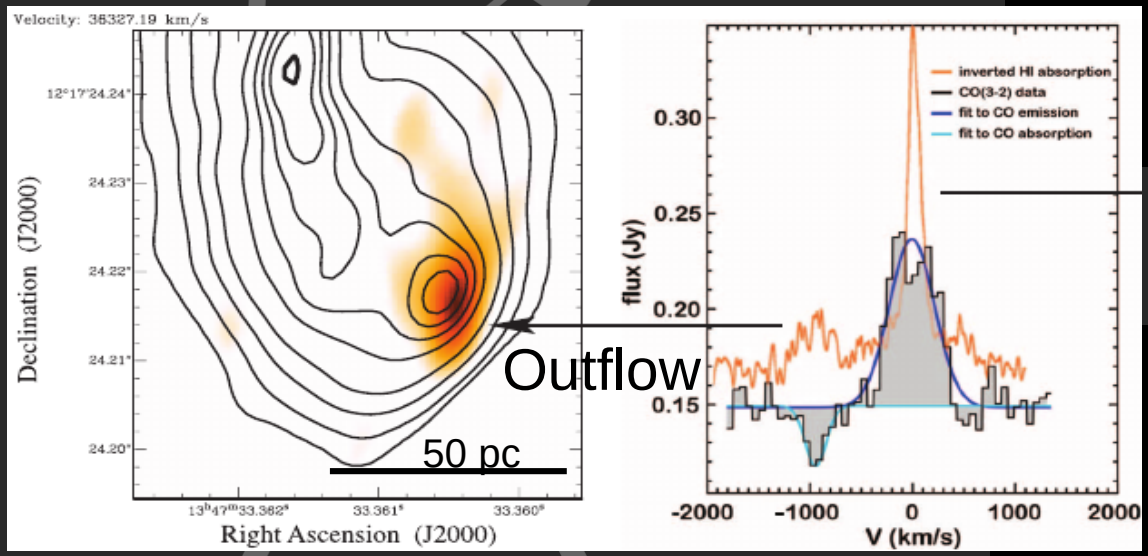




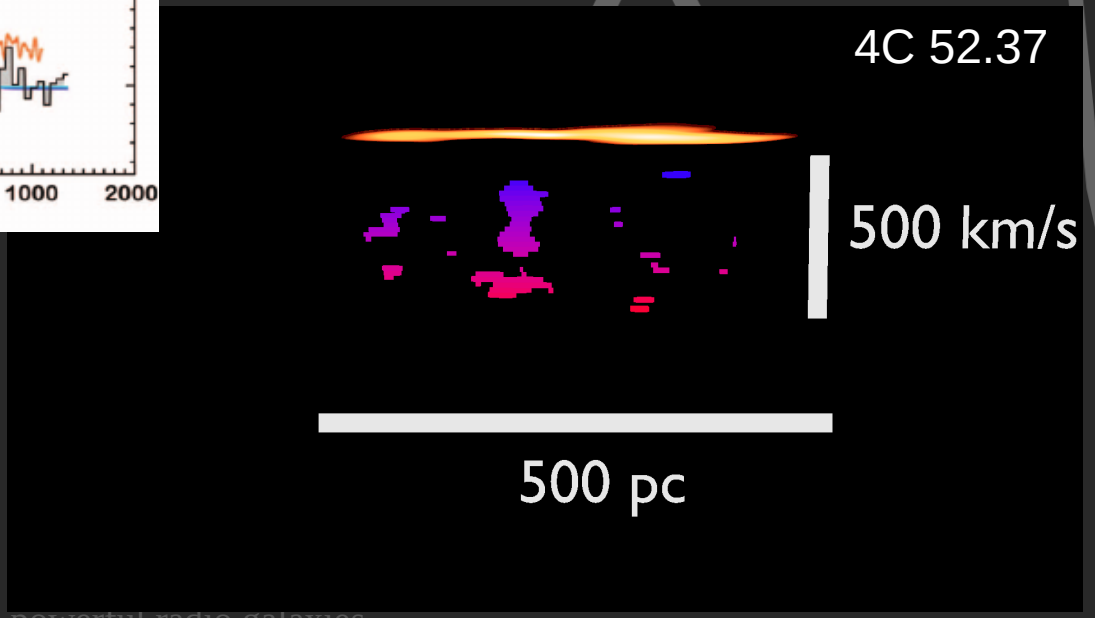
Comparison



4C 12.50



Credit: Morganti et al. 2013



Summary

VLBI observation to characterise the HI outflow

HI outflow has clumpy structure

HI clouds close to the AGN (in projection)

VLBI follow-up important for upcoming HI absorption surveys