High resolution observations of neutral hydrogen absorption and the jets of 3C293

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Collaborators:

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- et al

Overview

1. (Very) quick overview of the radio galaxy 3C293
2. Summary of observational results
   - Lower resolution VLA & MERLIN observations
   - HST/MERLIN observations of the jet
   - Combined VLBI, MERLIN & VLA observations of HI absorption & radio jet

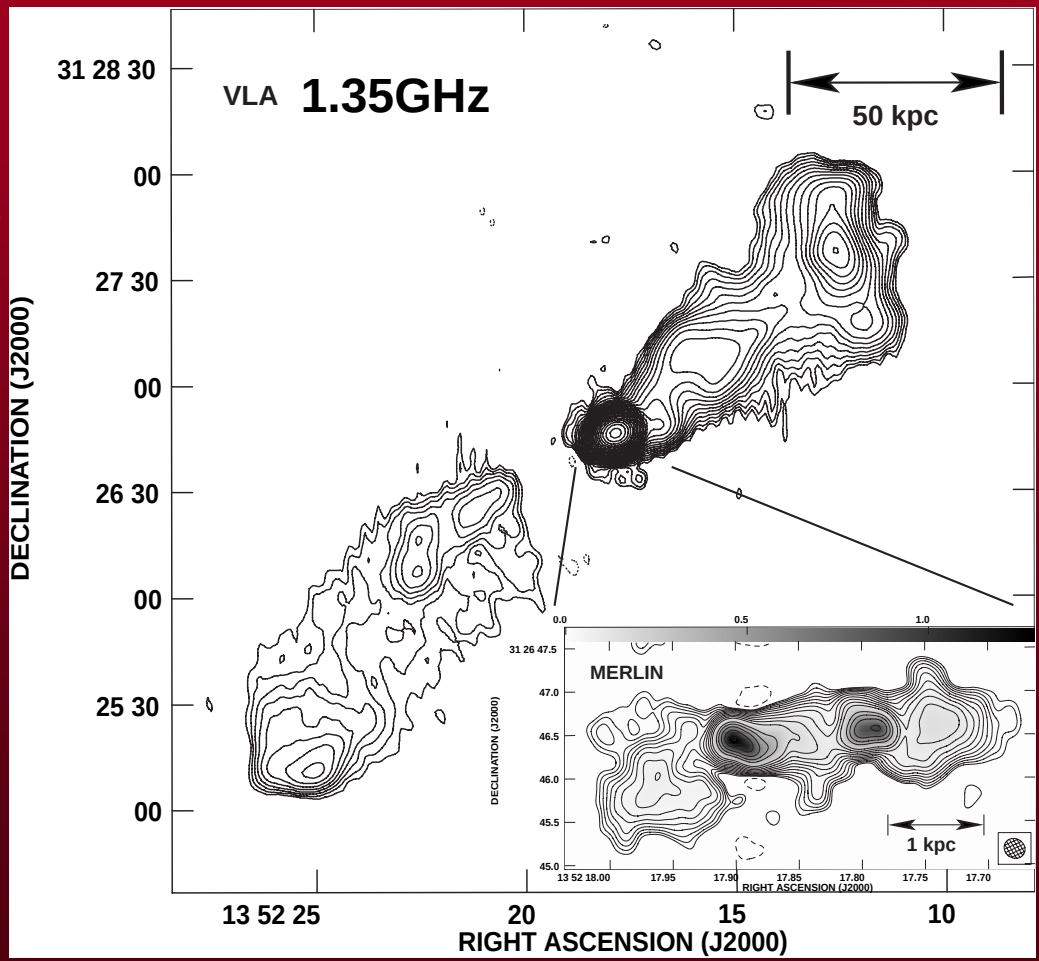
Introduction & Observations

- 3C293
  - Nearby Radio galaxy (D=180Mpc; implies 1”=815pc)
  - Significant signs of merger (dust lanes, a nearby companion galaxy)
  - Significant gas content (CO, Evans et al 1999 & HI)
  - Fast gas outflows (Morganti et al see previous talk)
  - Large scale radio jets/lobes
  - Steep spectrum core
- Observations
  - Radio: 1.4 GHz VLA, MERLIN & Global VLBI, 5GHz MERLIN continuum (JET & HI absorption)
  - Optical/IR : HST, NICMOS. (IR Jet)

Large to intermediate scale jets

- VLA B-config 1.35GHz
- Double ~100kpc scale jet
- Bright central core region

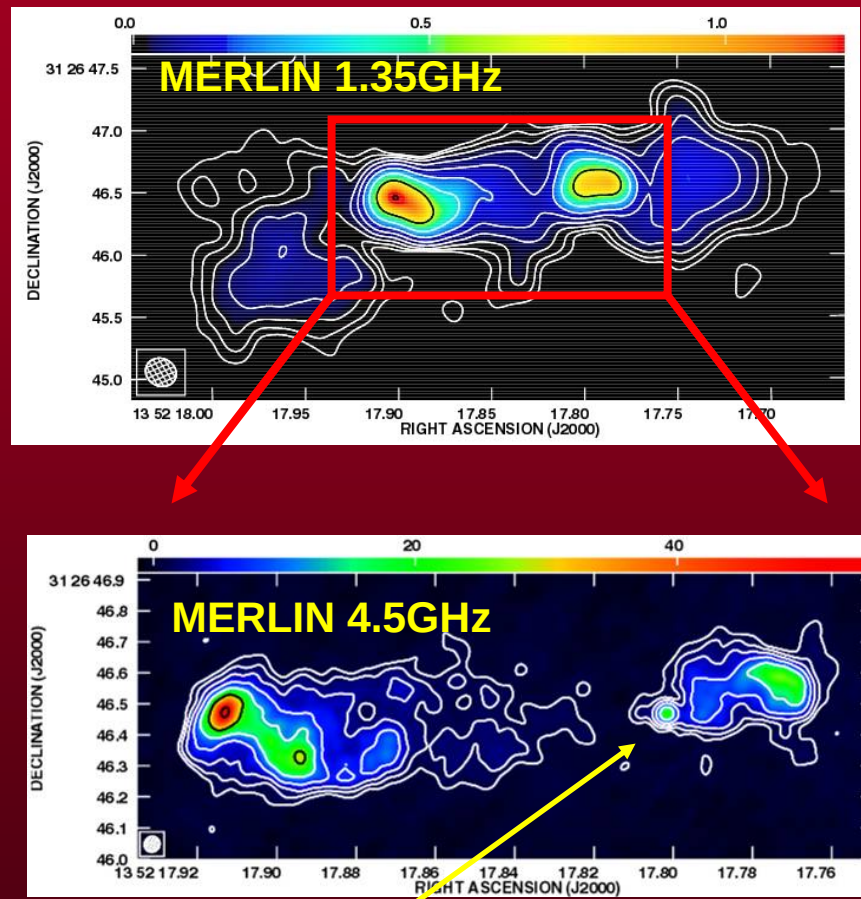
- Inner jet PA ~90 degrees (Significant change compared to large scale jet)



The inner jet (1)

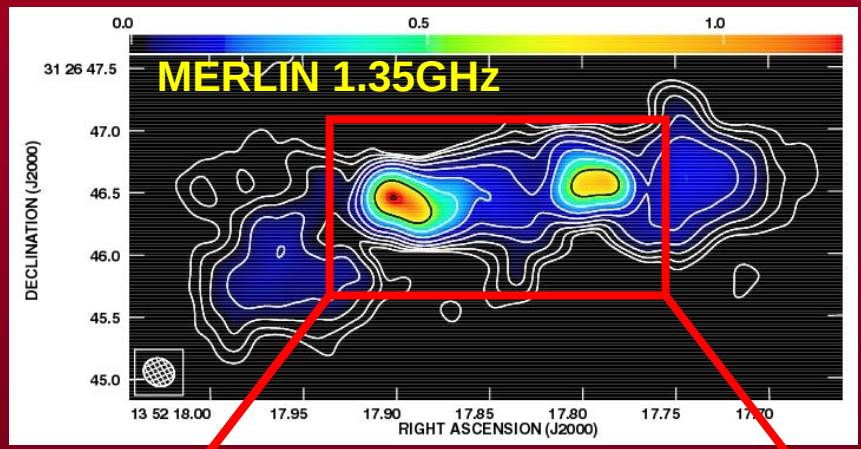
- At sub-arcsec angular resolutions the inner central few kiloparsec radio jet breaks into multiple components along an east-west orientation.
  - Steeply inverted spectrum of core

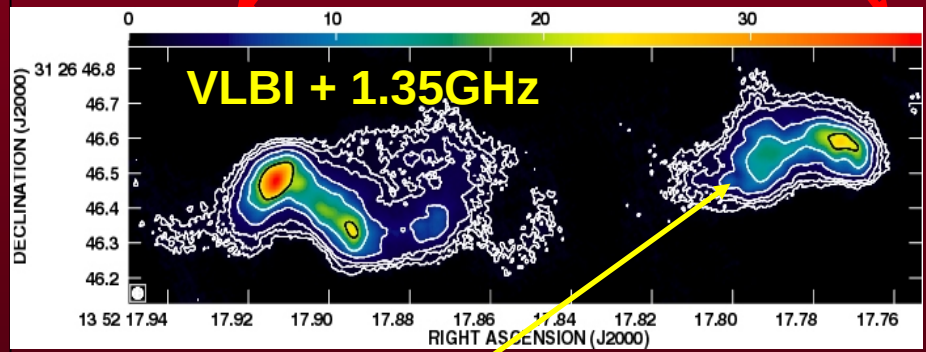
$\alpha \sim -1$ (Akujor et al 1996)



The inner jet (2)

- At sub-arcsec angular resolutions the inner central few kiloparsec radio jet breaks into multiple components along an east-west orientation.
  - Steeply inverted spectrum of core is barely visible at 1.3GHz
    - Fitted size of core <17pc

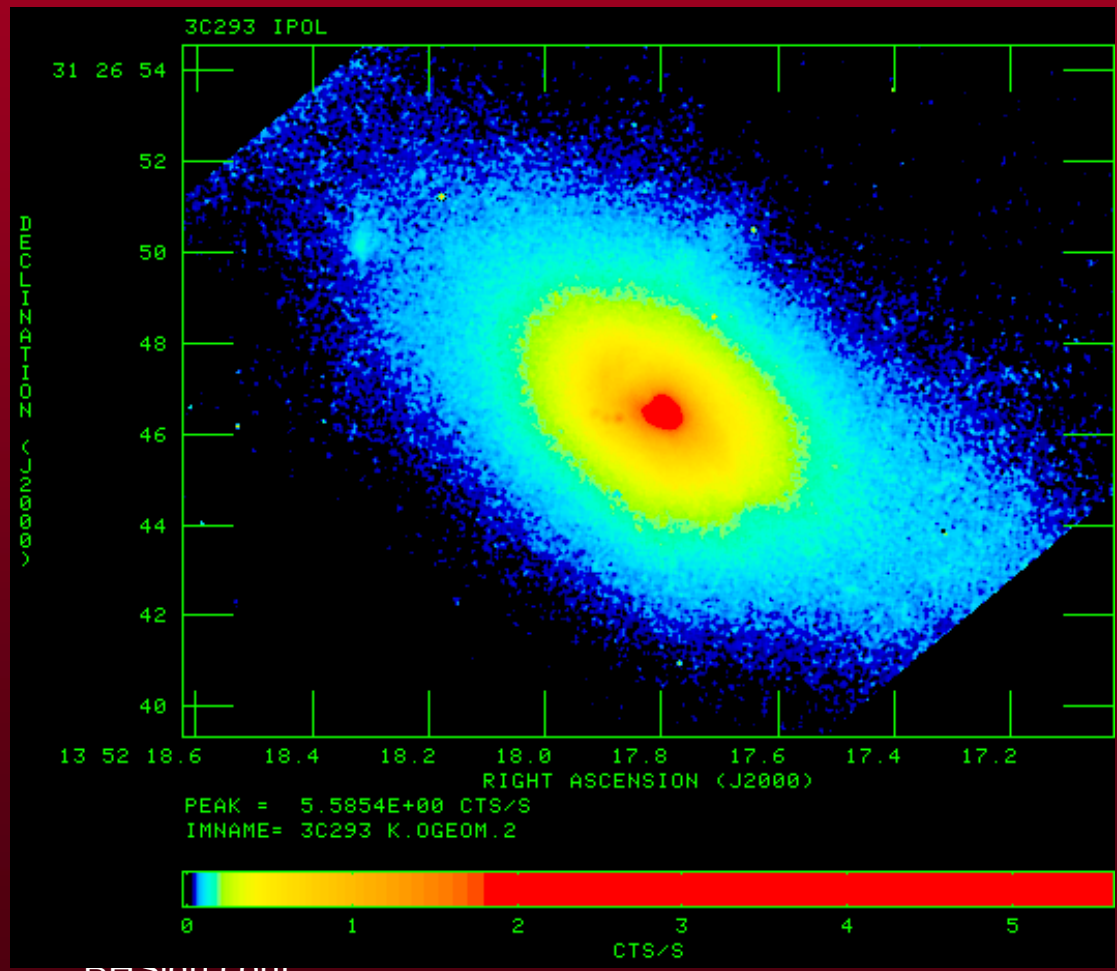




CORE

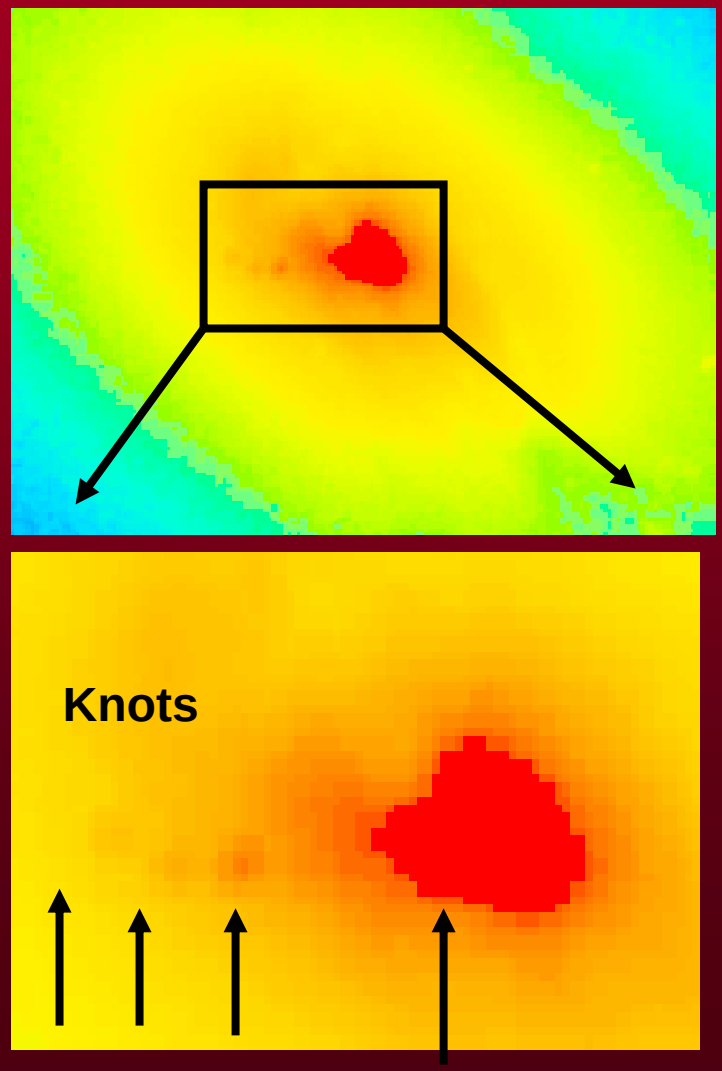
Infrared jet

- **HST imaging of the centre of 3C293 at 1.6μm reveals a string of knots of emission coincident with the knots observed in the radio emission**



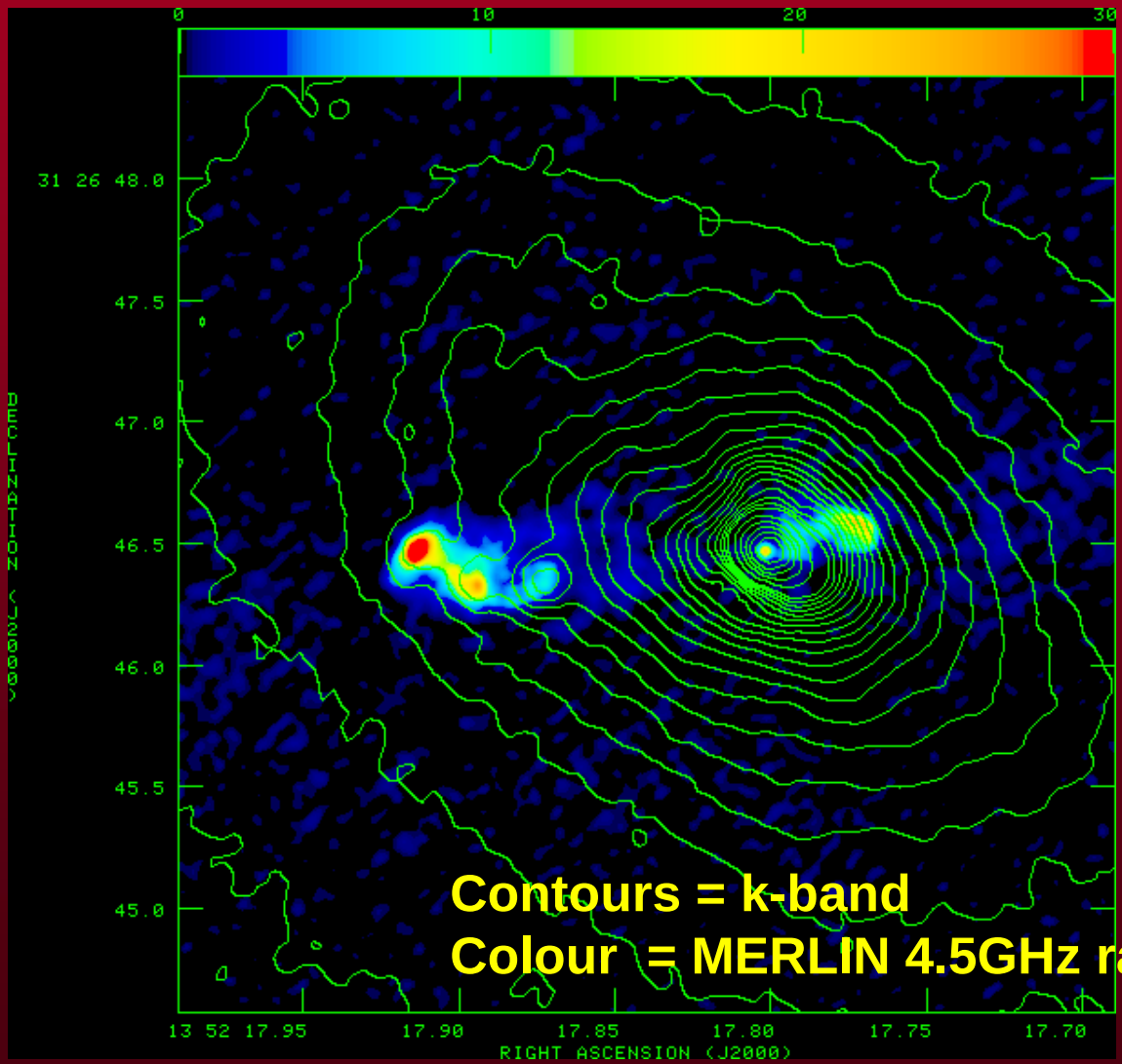
Zoom in on Infrared jet (2)

- **HST imaging of the centre of 3C293 at 1.6μm reveals a string of knots of emission coincident with the knots observed in the radio emission**



Infrared Jet

- **Approaching eastern Shows weak optical/IR jet emission coincident with the inner radio jet components**



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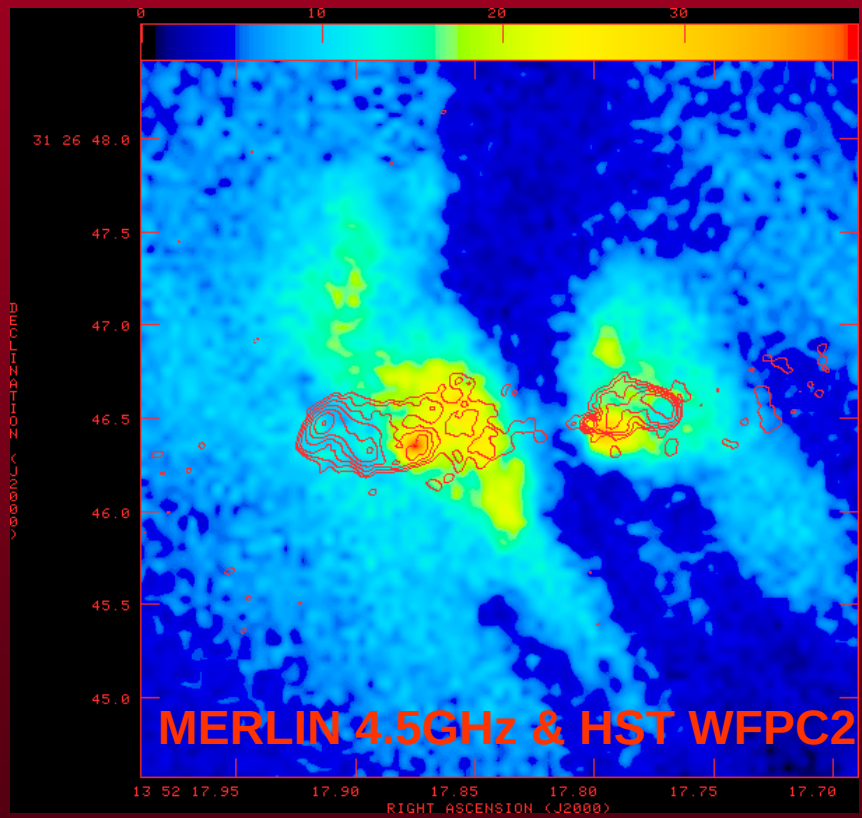
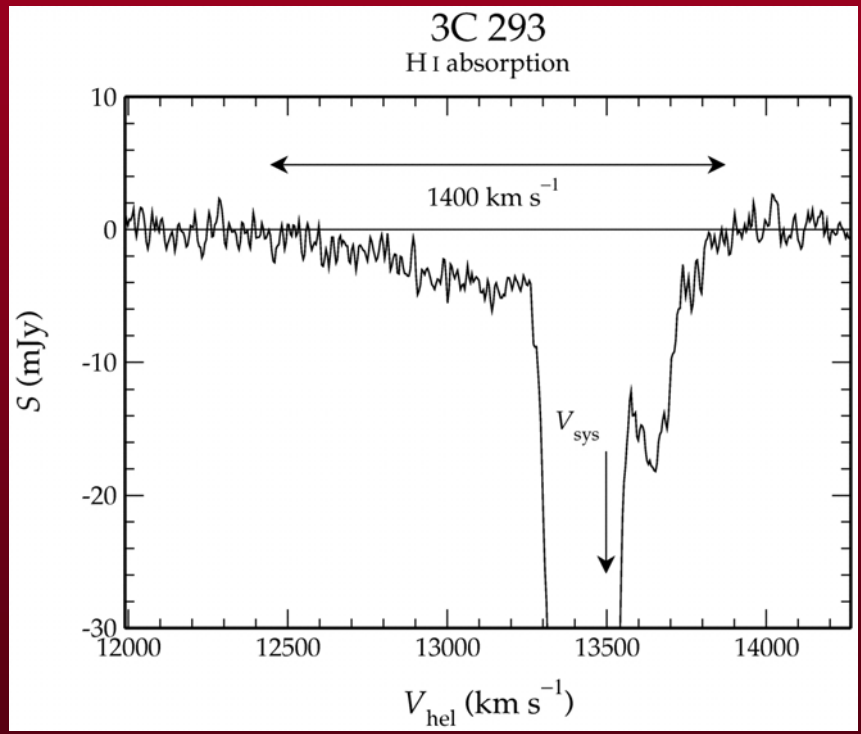
The neutral ISM

- 3C293 is a very distorted and dust rich radio galaxy
- Extensive ~north-south dust lanes



HI absorption

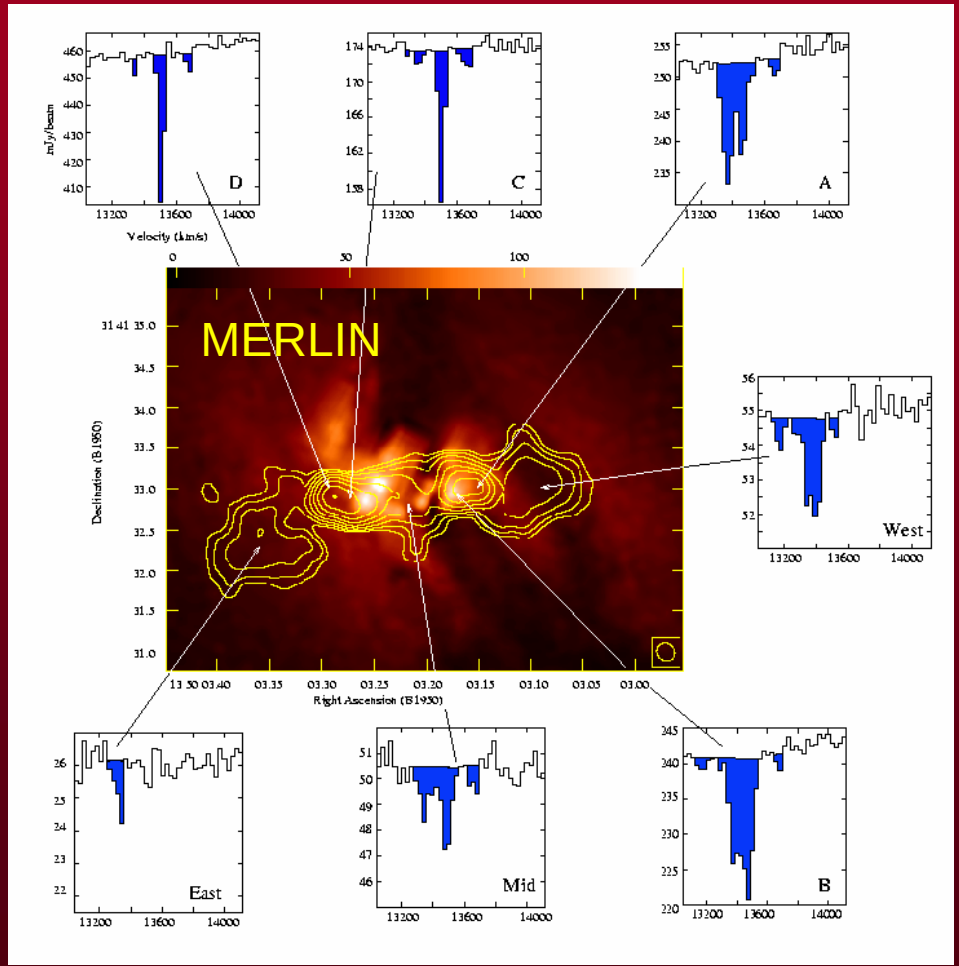
- Very broad & deep HI absorption seen in sensitive WSRT observations.
- Outflows Jet-ISM interactions…. Toward the inner eastern jet??



Morganti et al 2003 ApJ 593, L69

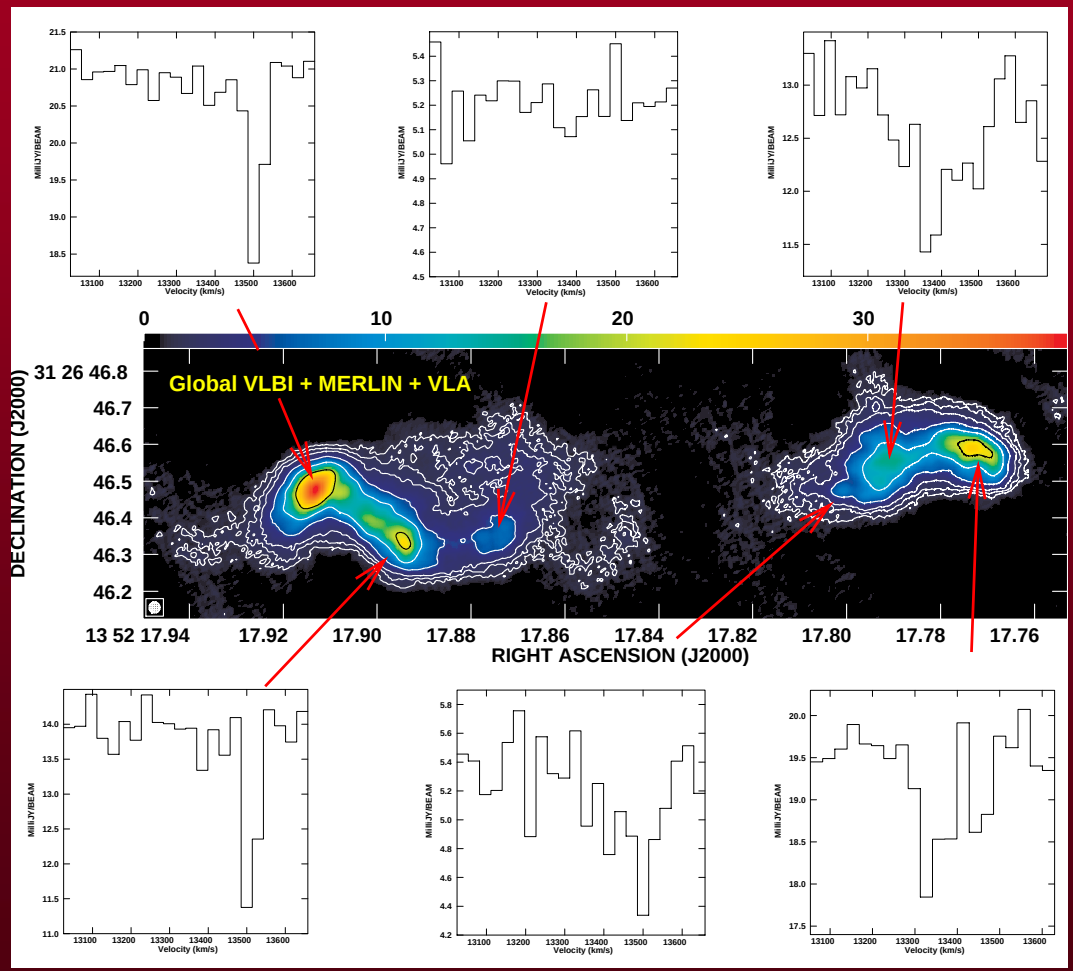
HI Absorption (1)

- Extensive MERLIN HI absorption
- Eastern side :- Narrow absorption
- Western side :- broad(er) absorption
- Opacities ~0.01-> 0.2
- N_H~10^{21} atoms cm^{-2}



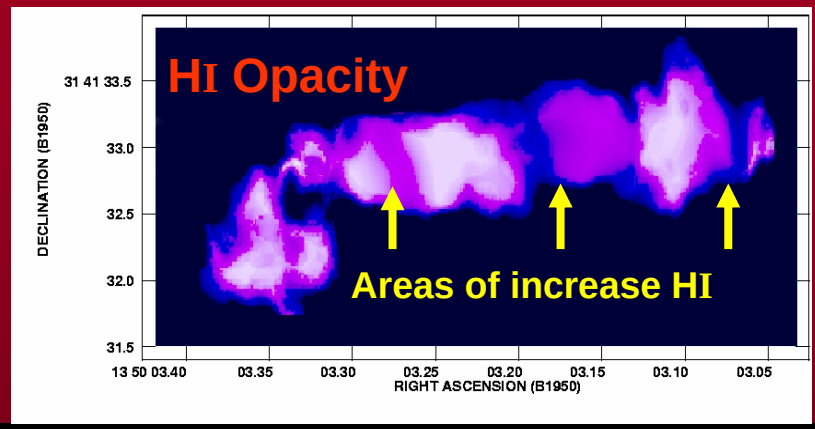
HI Absorption (2)

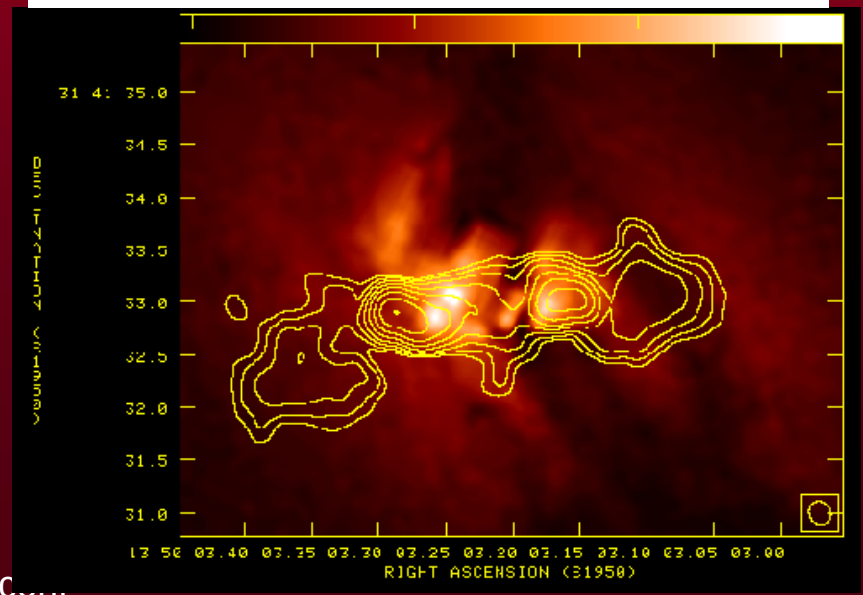
- Combined VLBI & MERLIN & VLA observations result in an increase in resolution of a factor of ~10 (to 30mas) whilst preserving lower order interferometric spacings



Distribution of HI

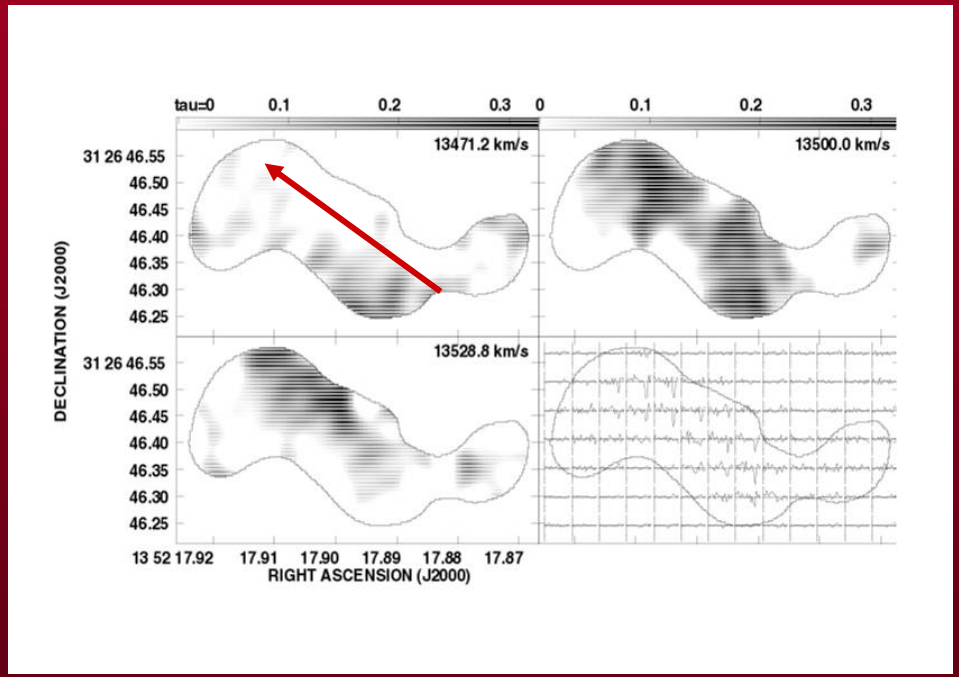
- The dust distribution is strongly correlated with areas of increased HI opacity.
  - Dust and Neutral gas spatially related
  - In particular the narrow HI absorption





Narrow absorption

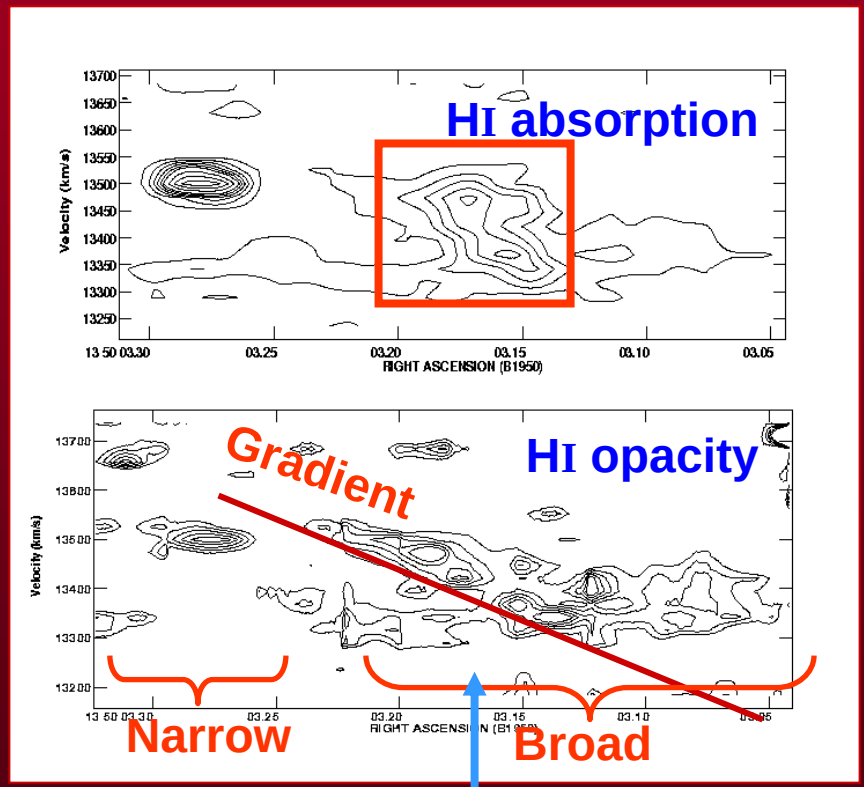
- At mas angular resolution the velocity structure of the narrow component is resolved against the eastern jet.
  - Small velocity gradient
    - Gas and dust rotating in the out reaches of the source.
    - VG ~50kms^{-1}arcsec^{-1}



Position-Velocity

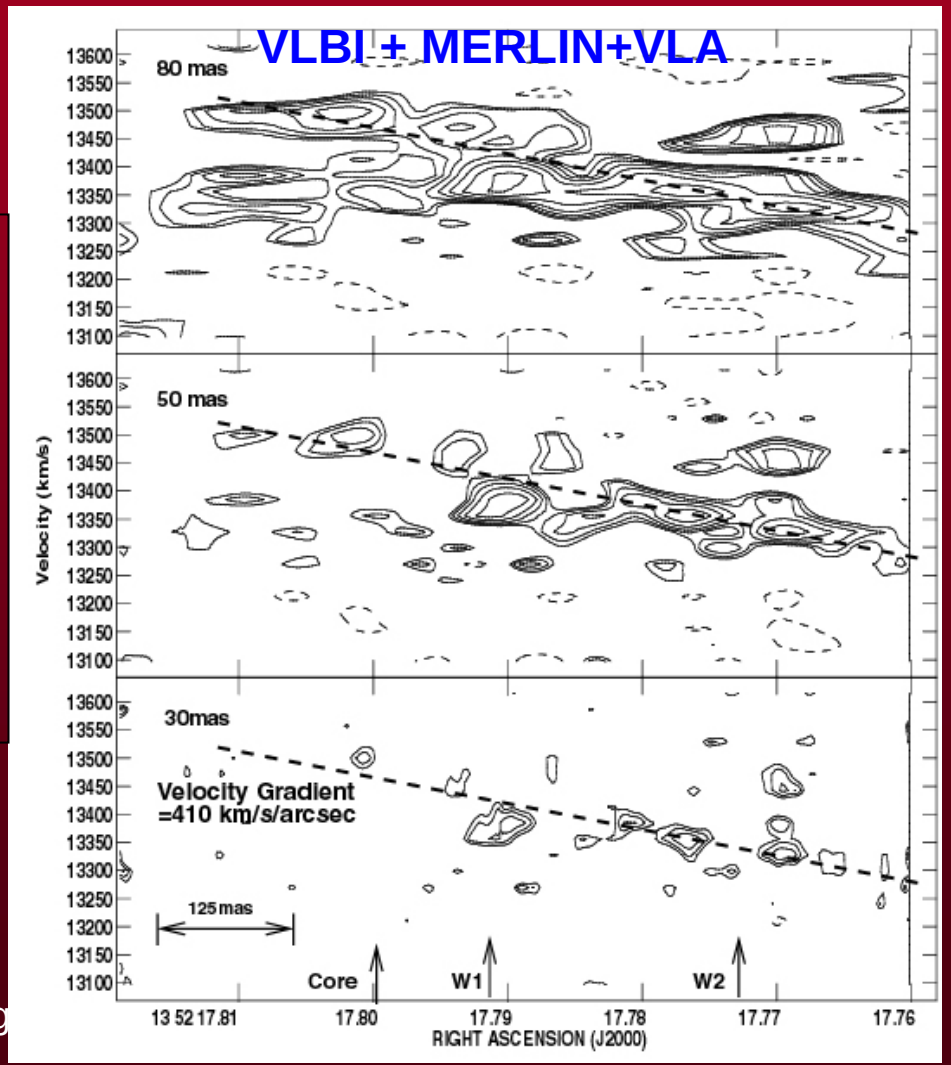
MERLIN – 200mas angular resolution

- On ~200mas angular scales. Velocity gradient centred upon the core(?)
  - Implying a rotating gas in the central kpc.
- Or two distinct velocity structures (??)
  - Possibly not associated?
  - blue shifted components related to outflow?



Position-Velocity

- However stepping up the resolution the absorption breaks up many composite components.
  - Lack of illuminating background continuum



Conclusions

- 3C293 is both an unusual and enigmatic radio galaxy.
- Steeply inverted radio core
- Radio/IR jet
  - **Large PA shifts in the radio jet alignment**
    - Jet interaction with the ISM and/or multiple outbursts of activity

    (- interaction induced??)
- Extensive HI absorption
  - **Deep nuclear absorption (N_H~10^{21} atoms cm^{-2})**
  - **Narrow absorption is strongly correlated with the dust distribution**
  - **Broad absorption toward the core and western jet**
    - Possible velocity gradient in lower resolution data. Implies central mass <10^9 solar masses (r< few hundred parsecs).
    - At mas resolution gradient breaks up – can be interpreted as independent gas structures.
  - **Do not have sensitivity to confirm location of broad HI outflows**