HI Absorption Safari
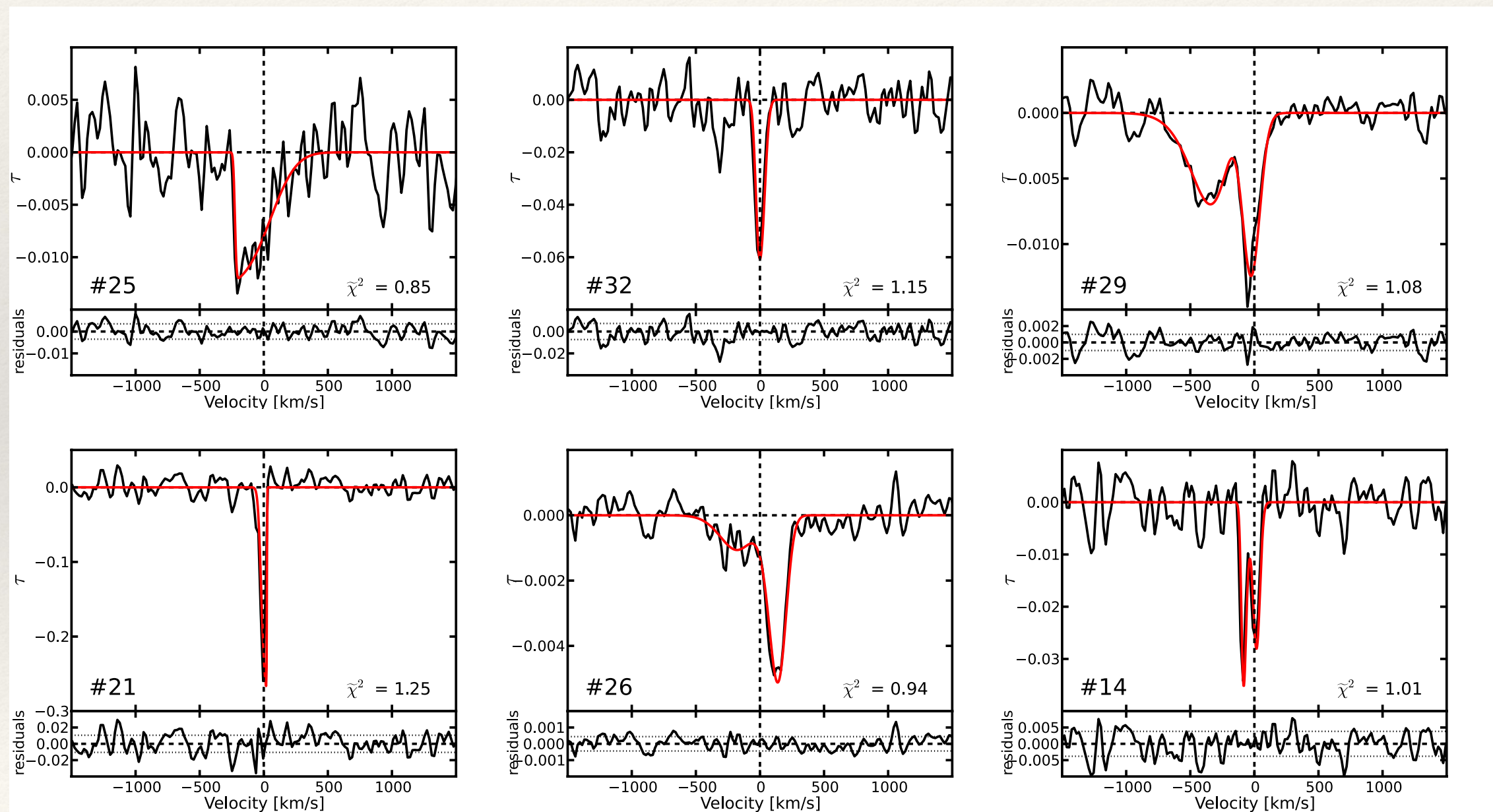
Finding and characterising the Neutral Hydrogen in the radio AGN Population

Filippo Maccagni, Katinka Geréb, Raffaella Morganti, Tom Oosterloo, James Allison
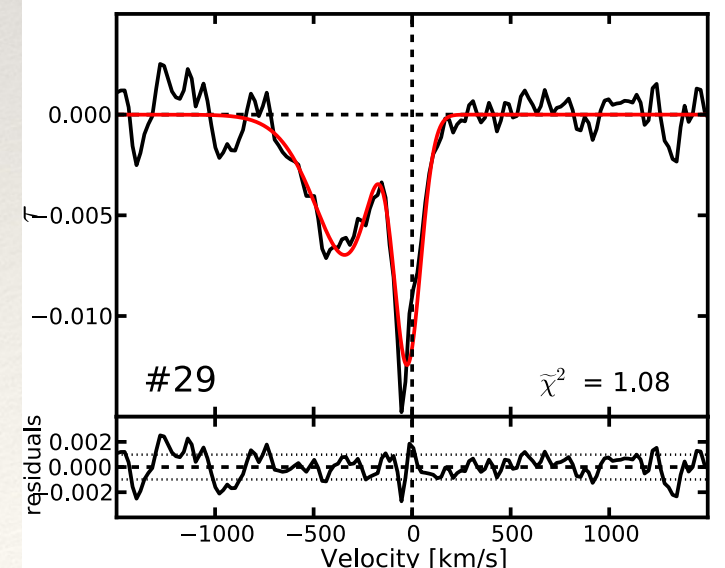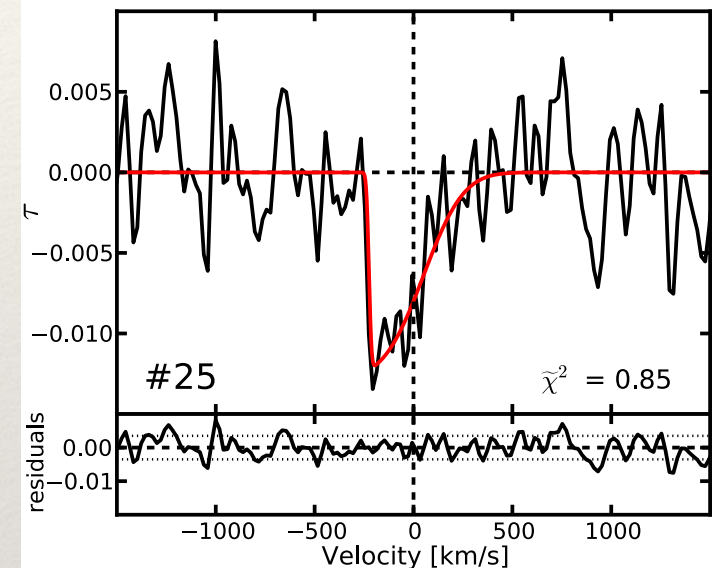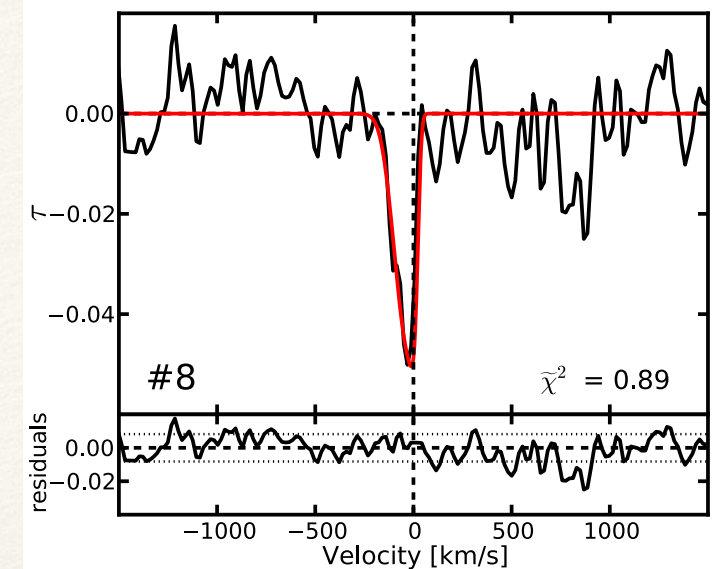
HI Absorption Surveys

HI Absorption studies have comparable detection rate to emission ones in early type galaxies:

(+) Optical depth of an absorption line depends on the brightness of the background source.

(-) Absorption is detectable only against the radio continuum.

- Absorption is complementary to emission:
  - Explore the HI in the central regions of galaxies.
    - understand AGN activity.
      - inflows/outflows of cold gas may influence the radio activity.

- HI Absorption surveys are planned in all SKA pathfinders:
  - ASKAP - FLASH (Sadler)
  - Apertif - Morganti & Gupta
  - MeerKat - Gupta & Srianand
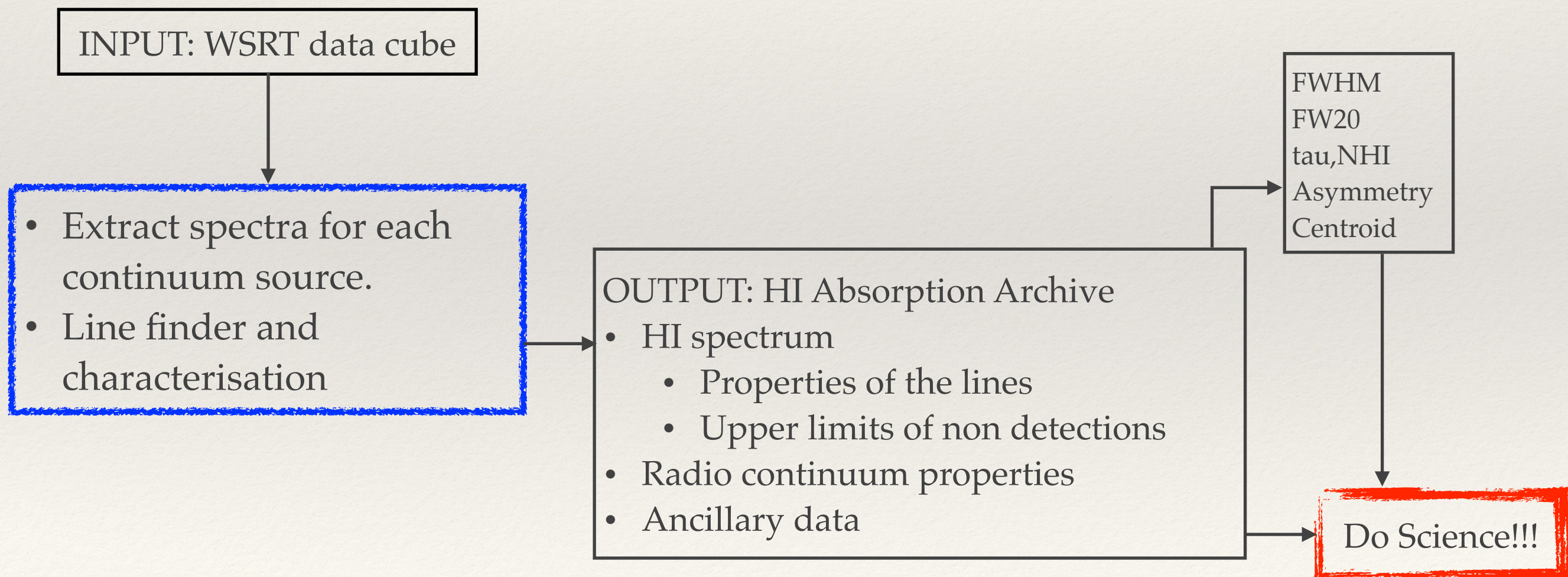
HI Absorption Safari

Shallow HI Absorption survey with the Westerbork Telescope:

- 250 sources between 0.023<z<0.25 and S1.4GHz>30 mJy

- 4/6 hours of observations with 14/8 antennas

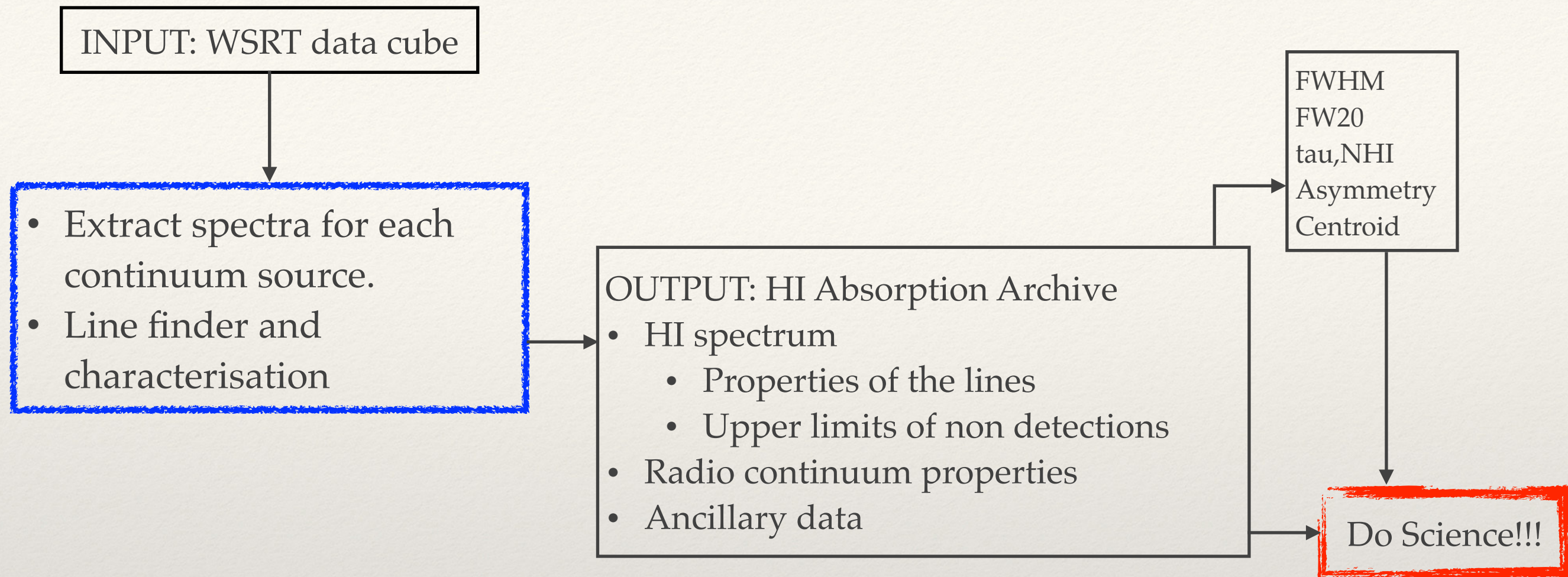- **Observations still on-going. Published results on the first 101 sources:**

    Geréb et. al 2014 arXiv:1407.1799; Geréb, Maccagni et al. 2015 arXiv:1411.0361

Survey in preparation for Apertif: 1 SaFaRi = 1 day of Aperitif

- build an <u>automatic setup</u> to find and characterise the HI absorption lines

INPUT: WSRT data cube

- Extract spectra for each continuum source.
- Line finder and characterisation

OUTPUT: HI Absorption Archive
- HI spectrum
  - Properties of the lines
  - Upper limits of non detections
- Radio continuum properties
- Ancillary data

FWHM
FW20
tau,NHI
Asymmetry
Centroid

Do Science!!!

HI Absorption Safari

INPUT: WSRT data cube

- Extract spectra for each continuum source.
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FWHM
FW20
tau,NHI
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OUTPUT: HI Absorption Archive
- HI spectrum
  - Properties of the lines
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Do Science!!!

Science goals:
- explore the occurrence of HI absorption in radio AGN.
- characterise the absorption lines.
- which properties of the HI are related to the radio activity?
- stack the data:
  - which are the average properties of the HI in different kind of AGN?
- model the HI absorption lines.

HI Absorption SAFARI

- Extract spectra for each continuum source.
- Line finder and characterisation.

J. Allison Bayesian Line Finder
- developed for HIPASS data [Allison et al. 2012]
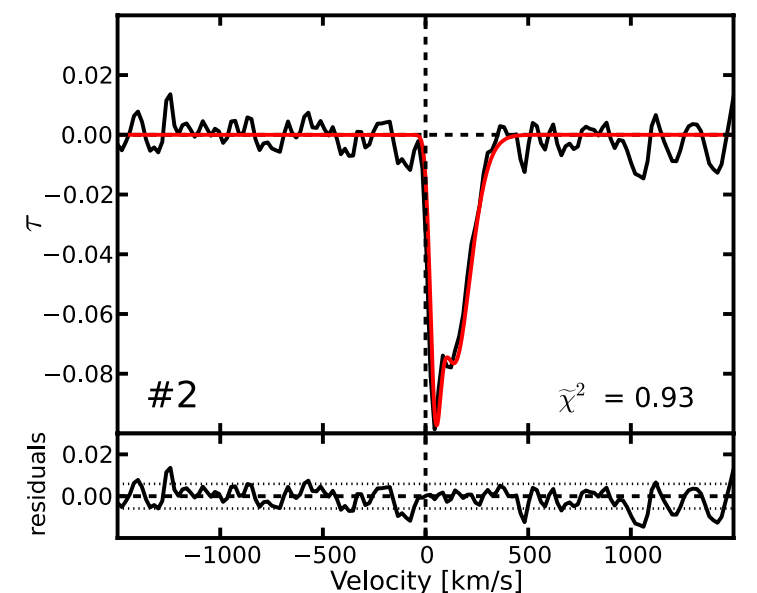- adapted and applied to the WSRT SaFaRi data
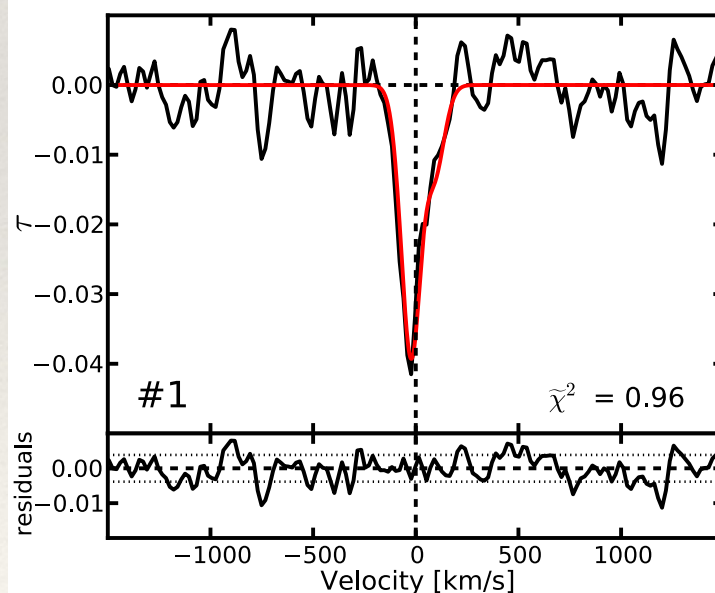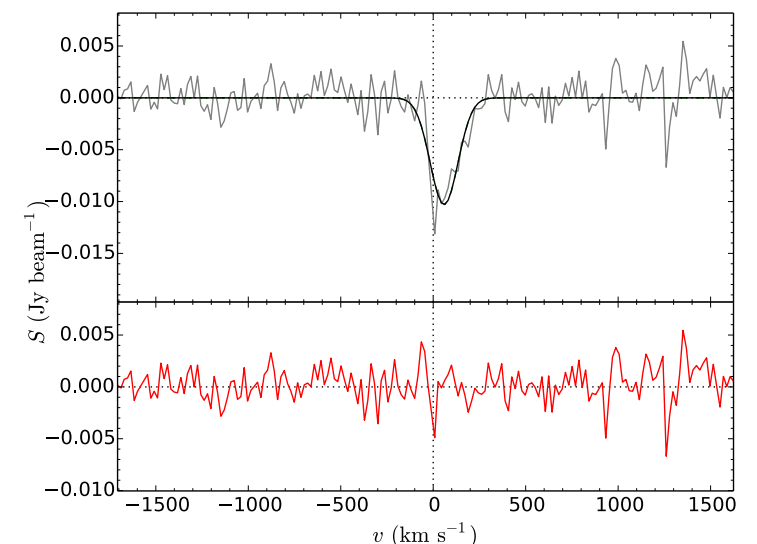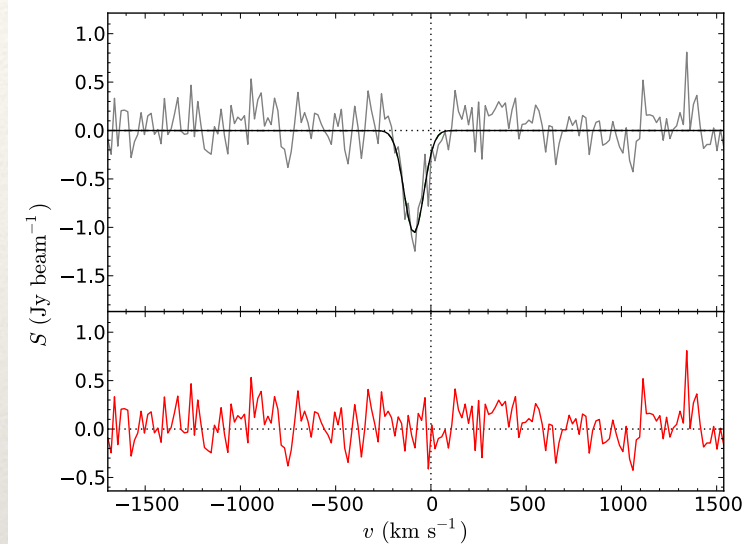
Line Finder:

- HI absorption lines are quickly and correctly identified independently of S/N

Line Characterisation:

- Safari: Busy Function
  [Westmeier et al. 2014]

HI Absorption Zoo

Do Science!!! → Safari sample:
253 Galaxies
0.023<z<0.25
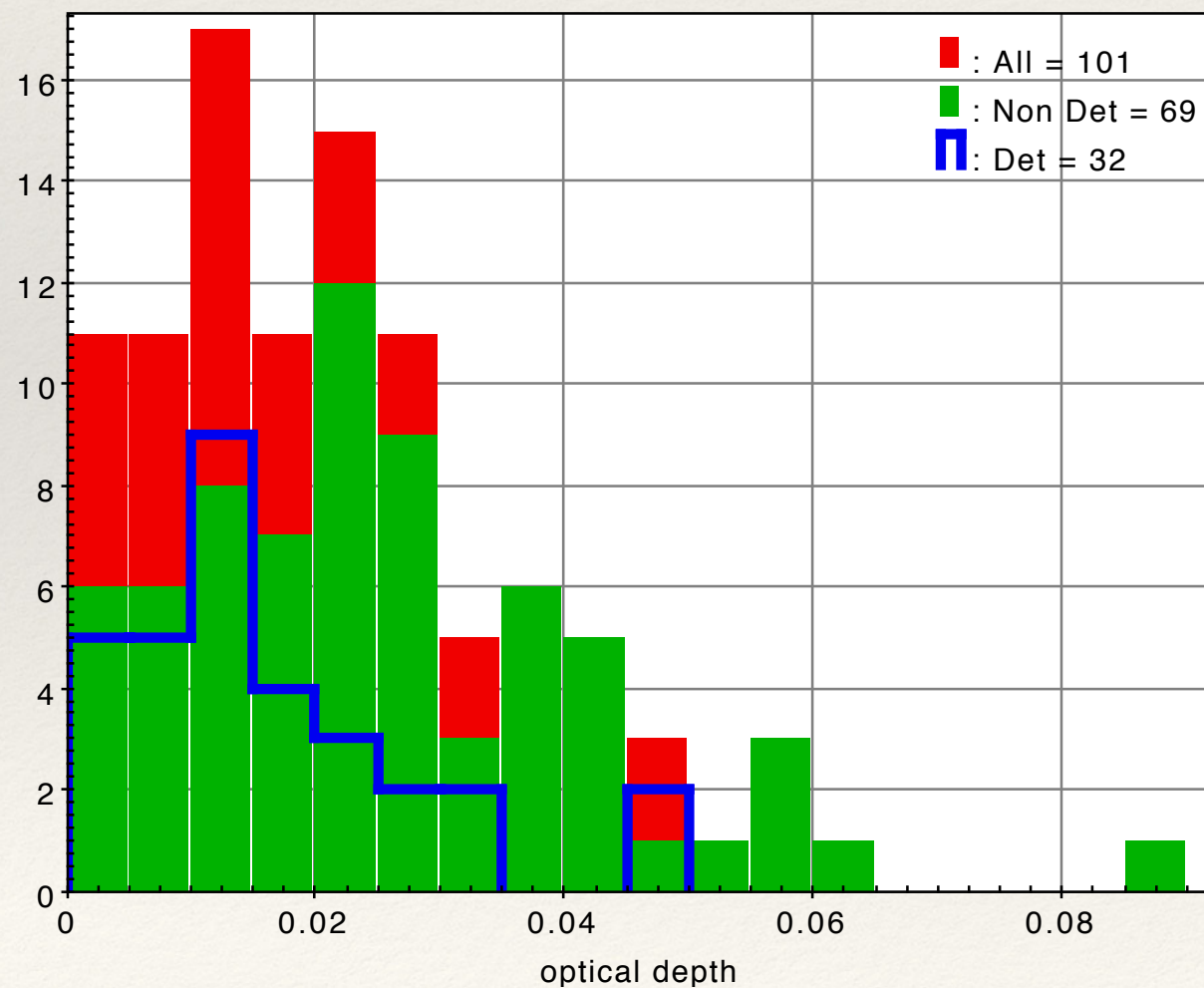S1.4GHz > 30 mJy
SDSS spectrum

→ **HI Absorption Zoo**
[Geréb et al. 2014; Geréb, Maccagni et al. 2015]
<u>101 sources</u>
0.023<z<0.25
S1.4GHz > 50 mJy
- 32 detections
- Stacking of non detections

: All = 101
: Non Det = 69
: Det = 32

- **High detection rate: 30%**
- **Wide variety of line shapes**
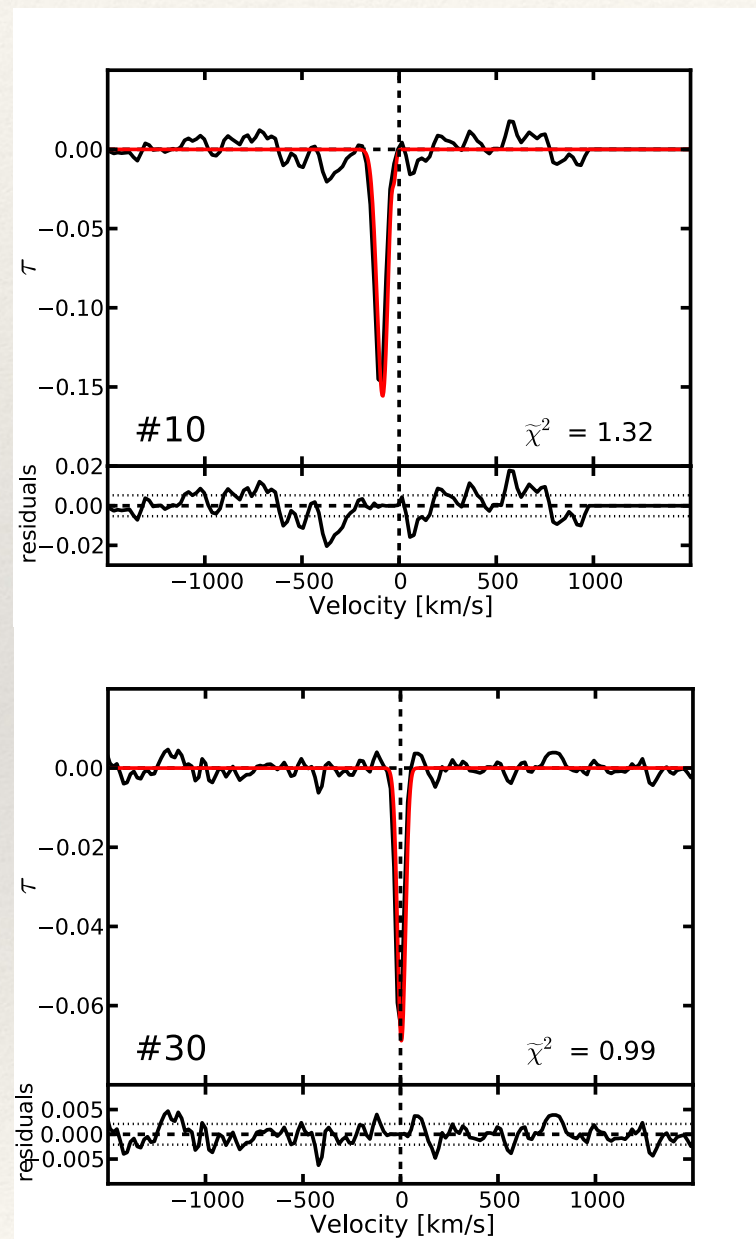
HI Zoo: analysis of the detections

Do Science!!!

Do different morphologies identify different HI structures?
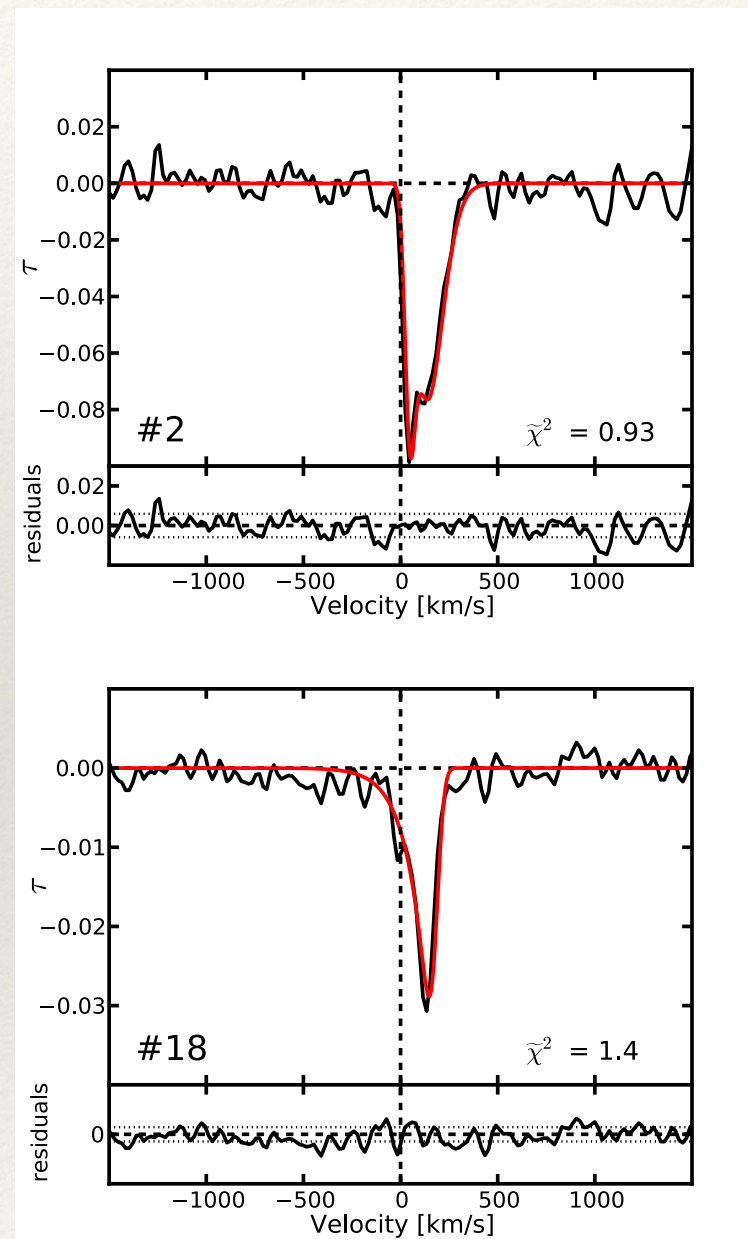
We identify three families of lines:
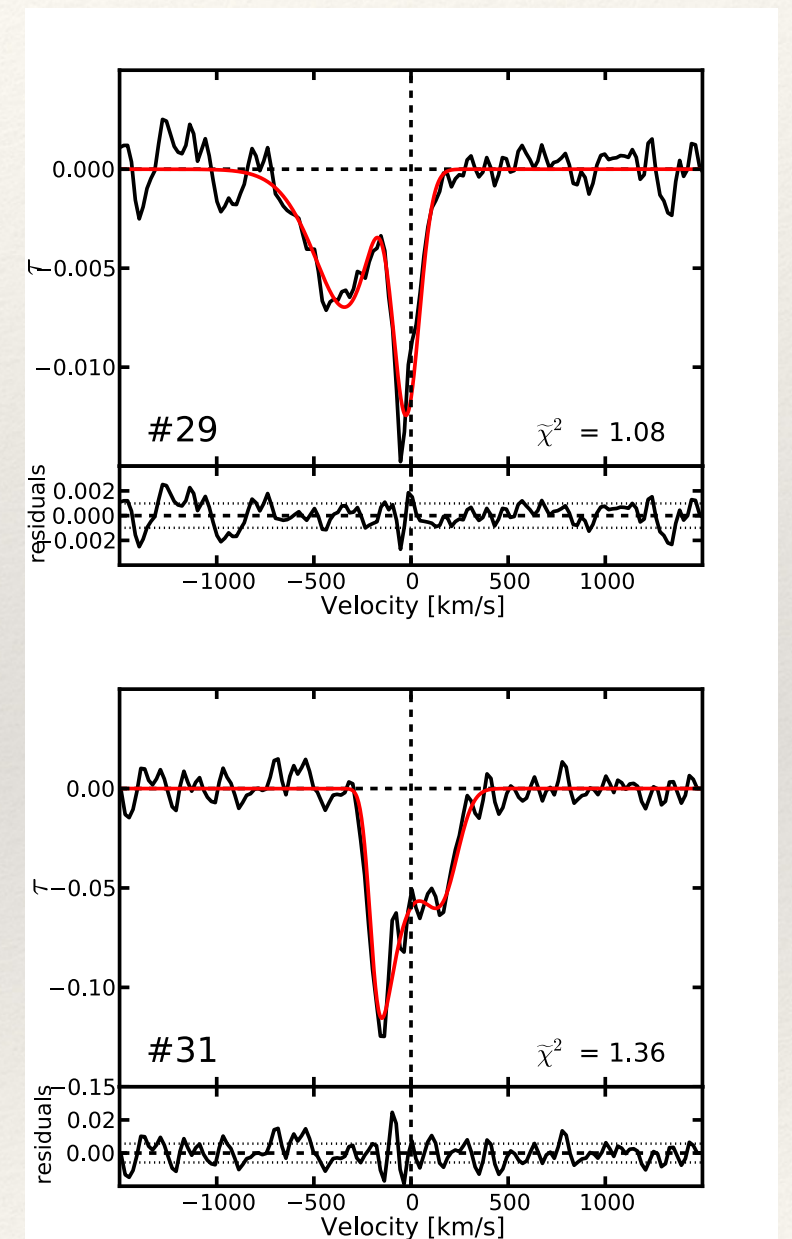
[Geréb, Maccagni et al. 2015]

Narrow Lines

Blended lines

Multiple component lines

Rotating disks

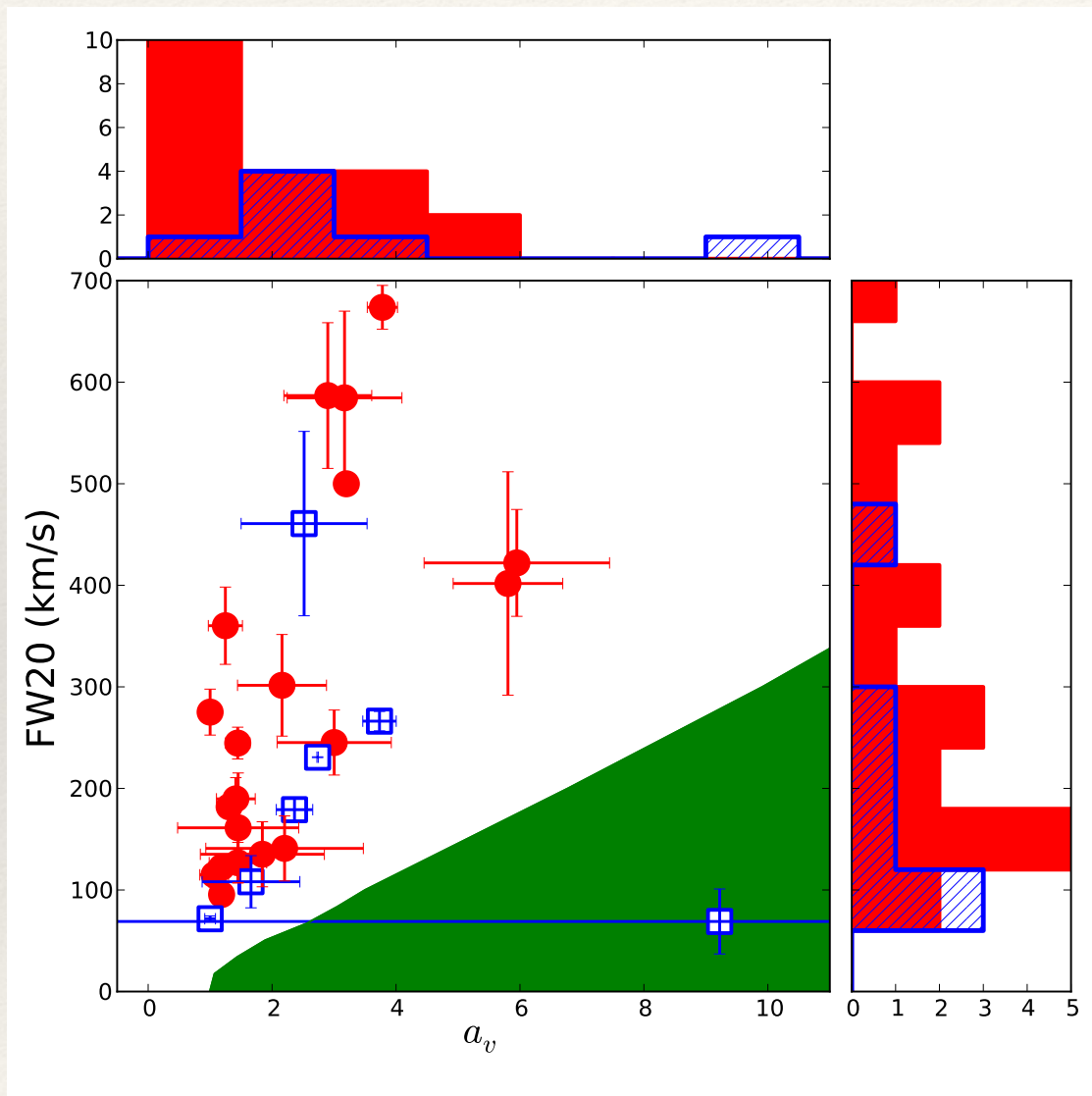Rotating disks + more?

Rotating disks +
Inflowing / Outflowing gas

HI Zoo: statistics over the detections

Do Science!!!

Radio AGN classified in Compact and Extended
- Poissonian statistics on different parameters of the lines

Asymmetry vs. FW20

Compact sources, i.e. young AGN, are the most asymmetric.
- **Cold gas is likely to influence the first stages of the radio activity**
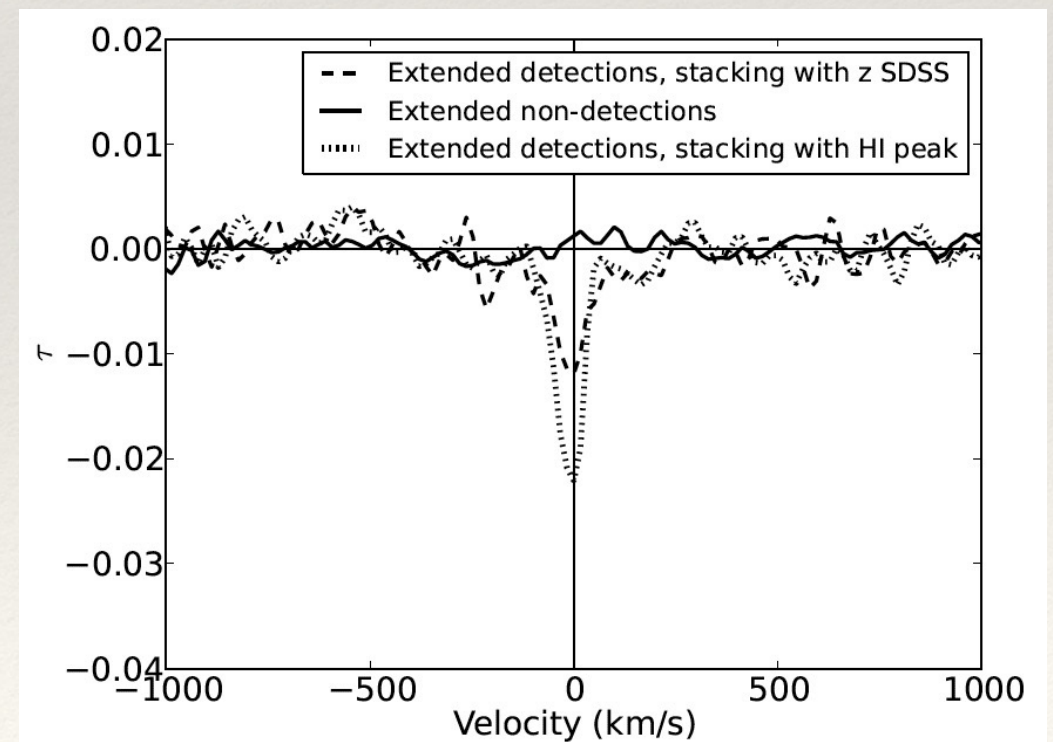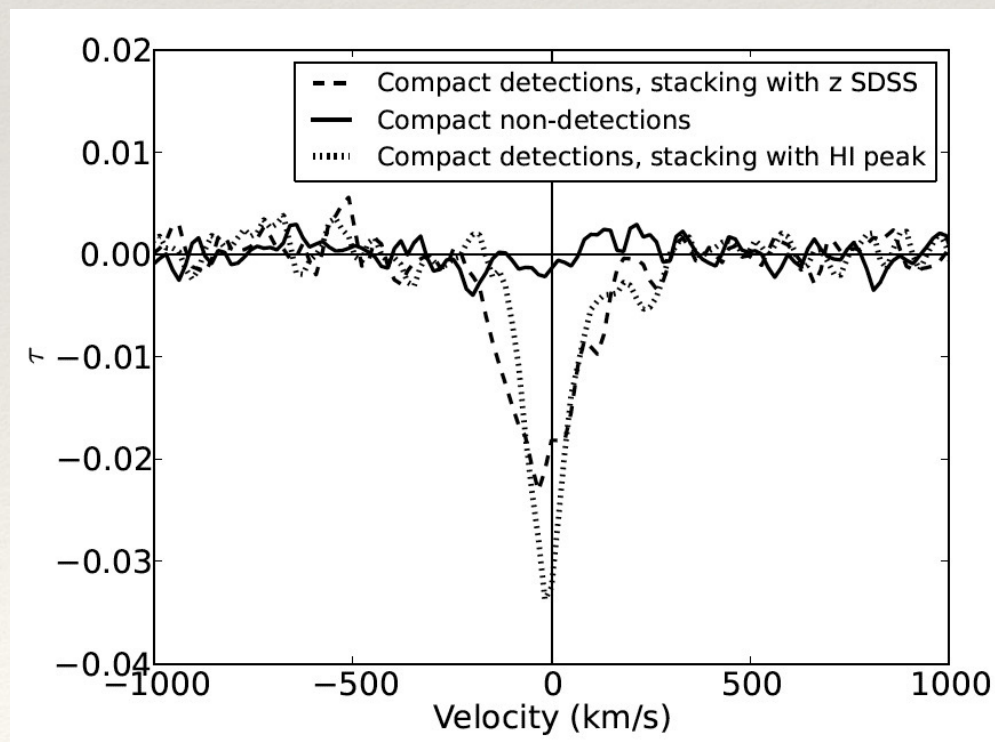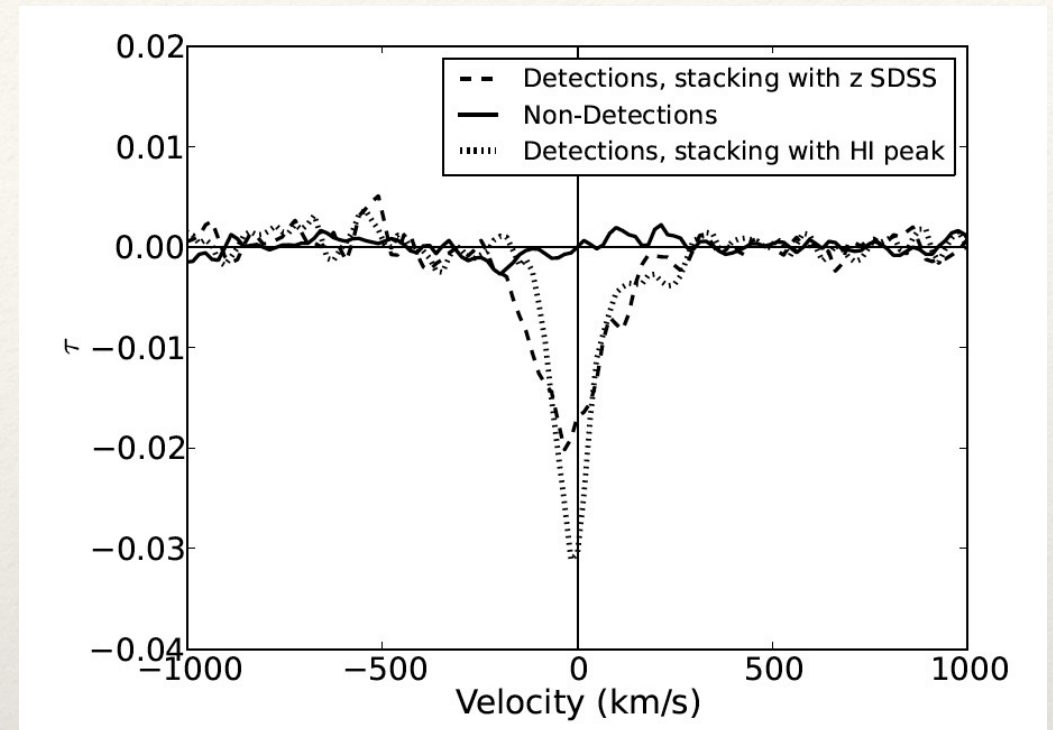
a_v ↑ ↔ FW20 ↑

HI Zoo: stacking

Do Science!!!   Analysis of the average properties of the HI absorption lines   [Geréb et al. 2014]

MAIN RESULTS:
- Dichotomy in the HI occurrence:
  - Radio sources either have or not have HI

- Compact (i.e. young) radio sources have broader profiles
- HI is more unsettled in these sources
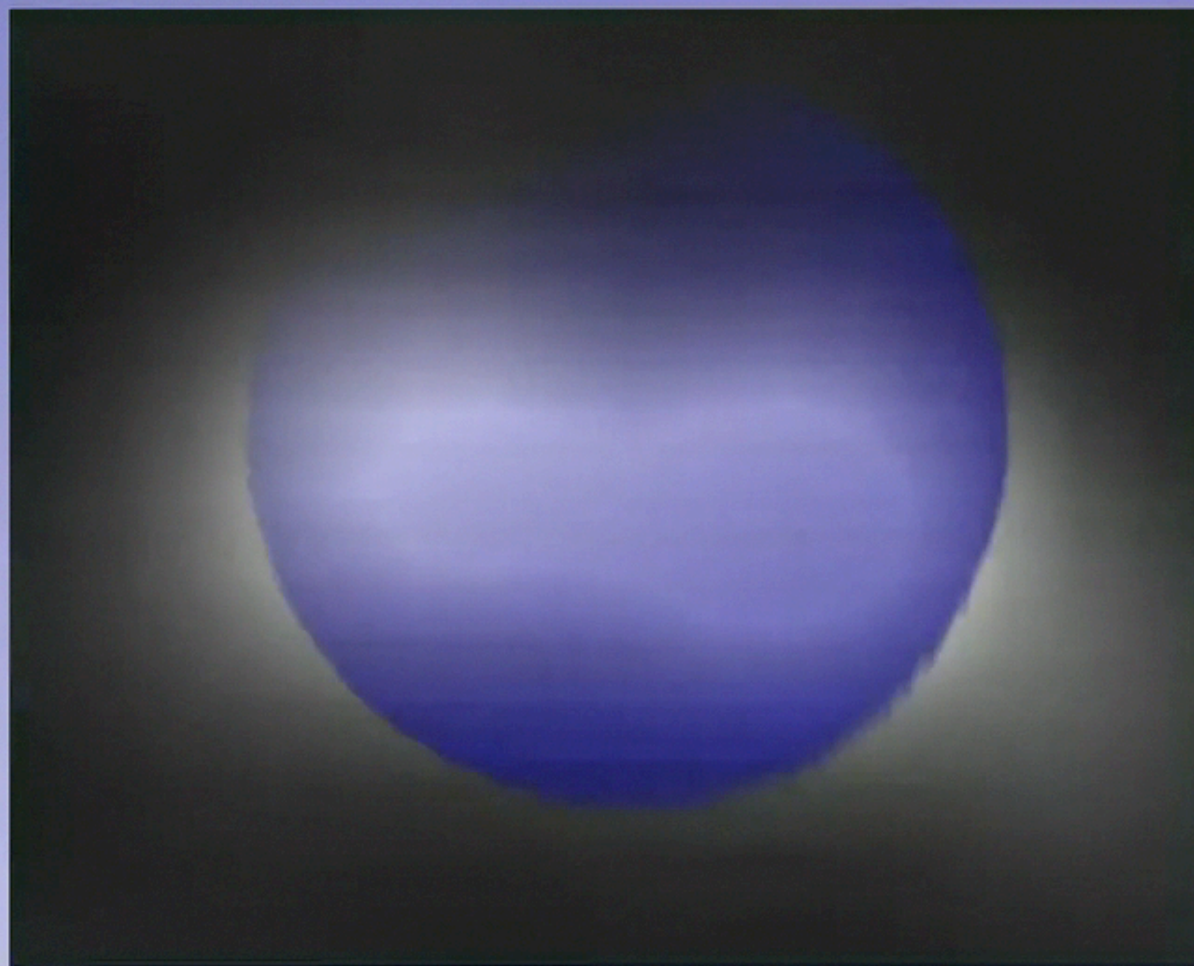
HI absorption modeling

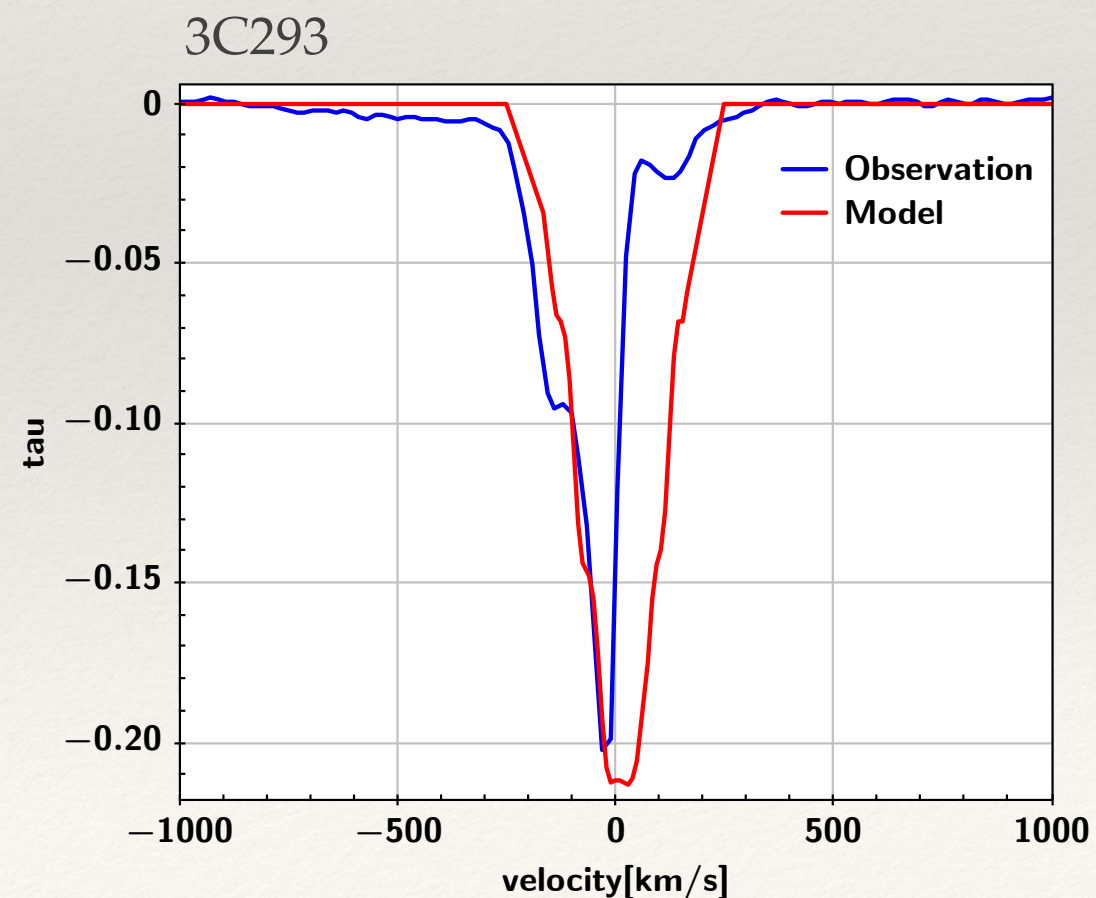→ Model the HI absorption line against the radio continuum

[Gallimore et al. 1999, Philstrom 2003]

Hypothesis: absorption lines are due to HI disks around the radio continuum.
Thesis: orientation effects explain the results of stacking and the variety of lines.

1. Model disk in (x,y,z)
2. Fit in optical depth the detected HI absorption line.

3C293

Conclusions

- HI absorption surveys are the best to identify radio sources rich of Neutral Hydrogen.
- Short integration time and high detection rate: comparable to the emission for local early-type galaxies (ATLAS3D).
- Absorption allows to expand HI studies at high redshift.
- HI absorption traces the interaction between the radio activity and the cold ISM.

HI Absorption Zoo:

- HI absorption lines are heterogeneous since they trace HI in different physical conditions.
- Radio sources either have or not have HI.
- In compact and powerful radio sources the HI appears to be more unsettled.
  - HI may play an important role in the first stages of the radio activity.

Future work:

- Complete the analysis over the entire Safari sample.
- Modelling of HI absorption lines to understand the importance of orientation effects.

APERTIF tomorrow (ALPHA 6)? Give us the data, we're ready for Science!!!