Probing the gas content of radio AGN with HI absorption stacking

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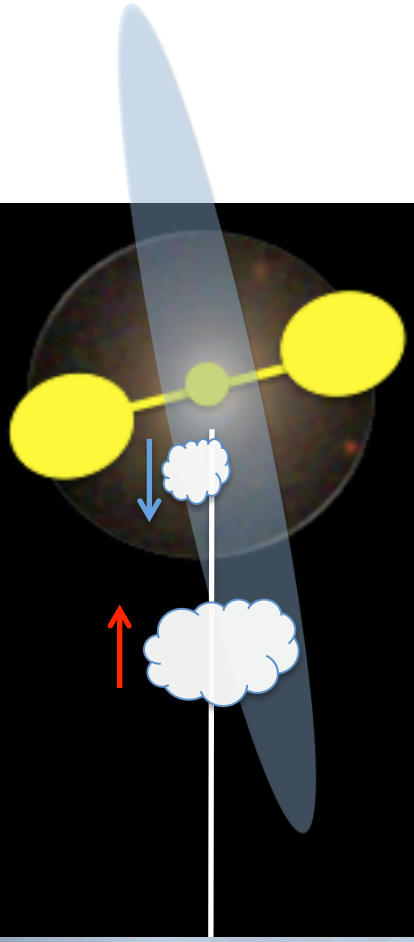
HI gas in radio AGN

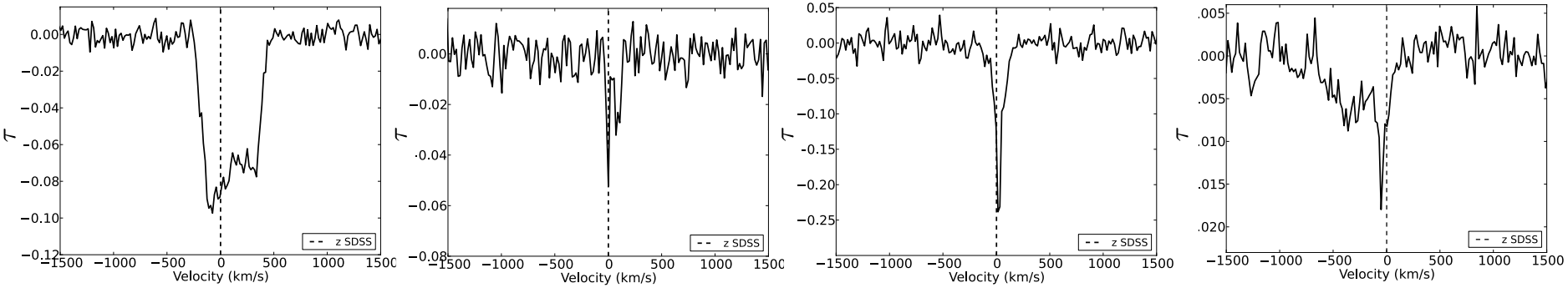


- Complex kinematics : disks, inflow / outflow (fuelling / feedback) *Gas plays many different roles in AGN!*
- Typically hosted by ETGs: ATLAS^{3D}
- Trend between detection rate & radio morphology:
  HI-rich compact (< 10 kpc) vs. HI-poor extended (> 10 kpc)
- Snapshot WSRT observations (4 hours) to collect a large, homogeneous sample of AGN
  → HI absorption stacking for the first time!
- Preparation for future blind HI surveys (Apertif, ASKAP…)

The AGN sample:

- 101 sources in the SDSS spectroscopic catalog
- $0.02 < z < 0.23$
- $S > 50$ mJy peak flux in the FIRST survey.

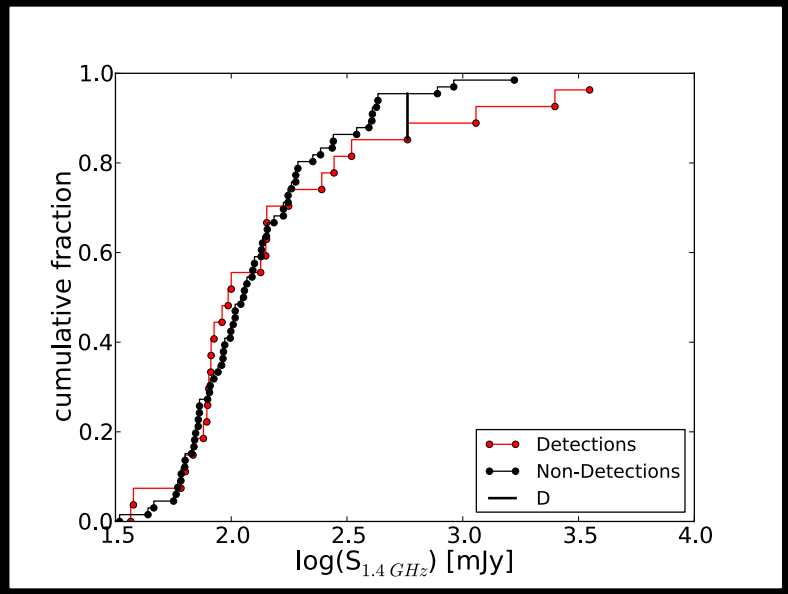
The HI absorption "Zoo"



30 percent detection rate, the optical depth limit is τ = 0.02 - 0.08 for a 50 mJy source
(van Gorkom+ 1989, Emonts+ 2010)
(Allison+ 2014; 2 % detection rate above τ = 0.3)

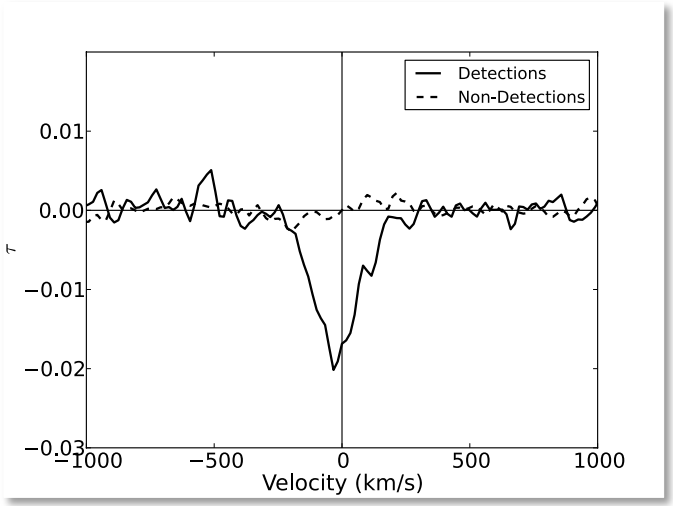
No flux density dependence

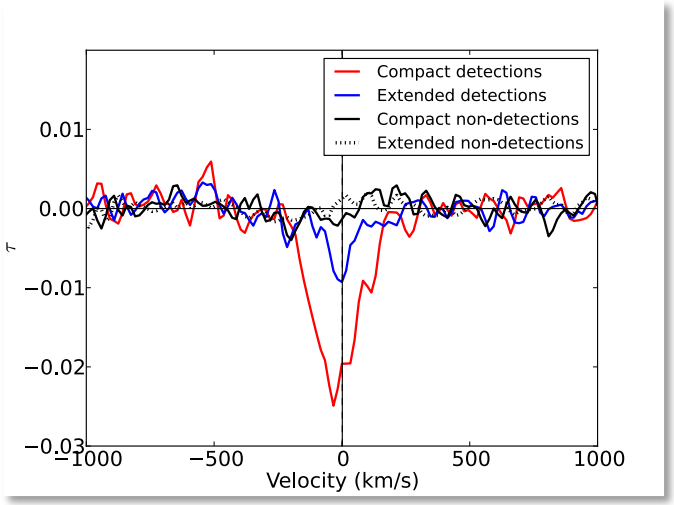
- HI absorption studies can be extended to lower fluxes
- Good news for future surveys



HI absorption stacking

- Stacking in optical depth





Dichotomy in the stacked profiles

- Detections N(HI) ~ 7 x 10^{20} cm^{-2} , upper limits stay undetected N(HI) < 6 x 10^{19} cm^{-2}

Compact vs. Extended

- Different τ and FWHM. $FWHM_{Comp}$ ~ 203 km/s, $FWHM_{Ext}$ ~ 130 km/s
- $N(HI)_{Comp}$ ~ 9 x 10^{20} cm^{-2} , $N(HI)_{Ext}$ ~ 2.4 x 10^{20} cm^{-2}
- Dichotomy of detections vs. upper limits remains

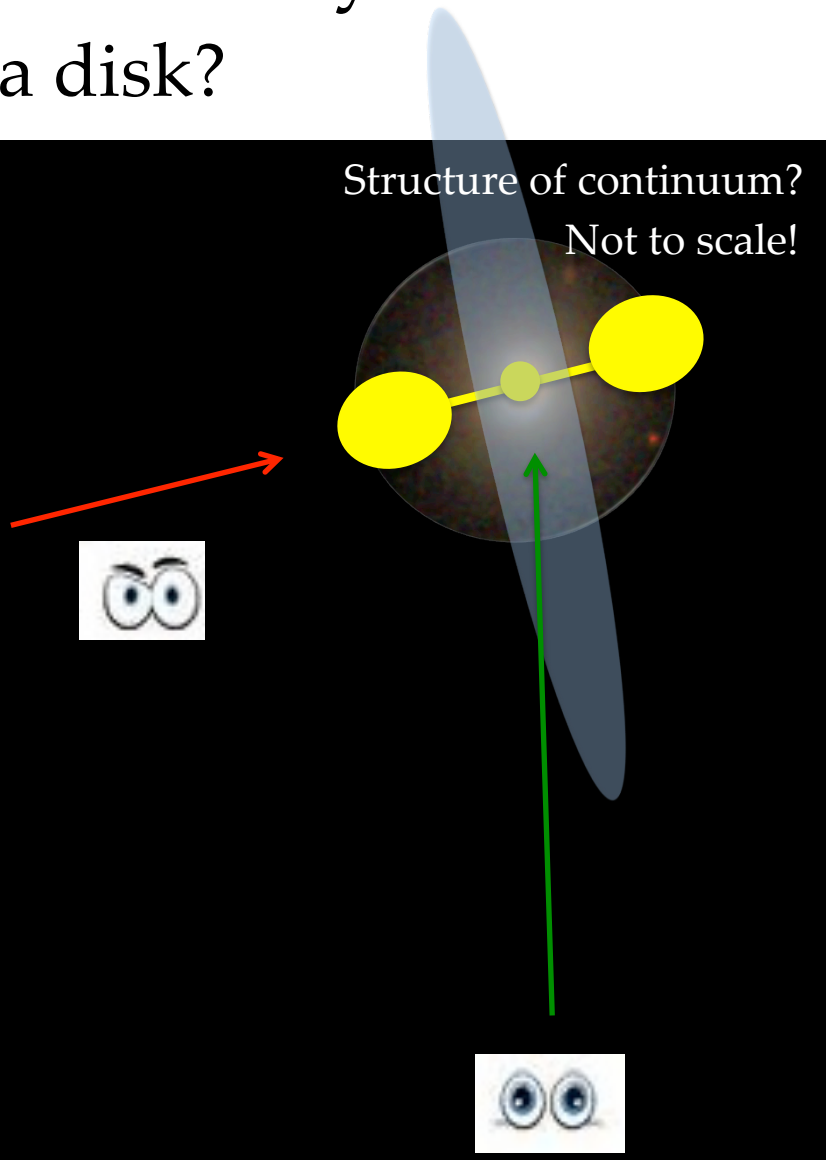
The origin of the dichotomy:
Orientation of a disk?

Extended:
- detection rate (17%) agrees with ATLAS^{3D} disk fraction (25%)

Compact:
- Higher detection rate (40%)
- Young GPS, CSS sources from CORALZ with lots of gas, 55% detection rate
- + Stacking: higher N(HI)

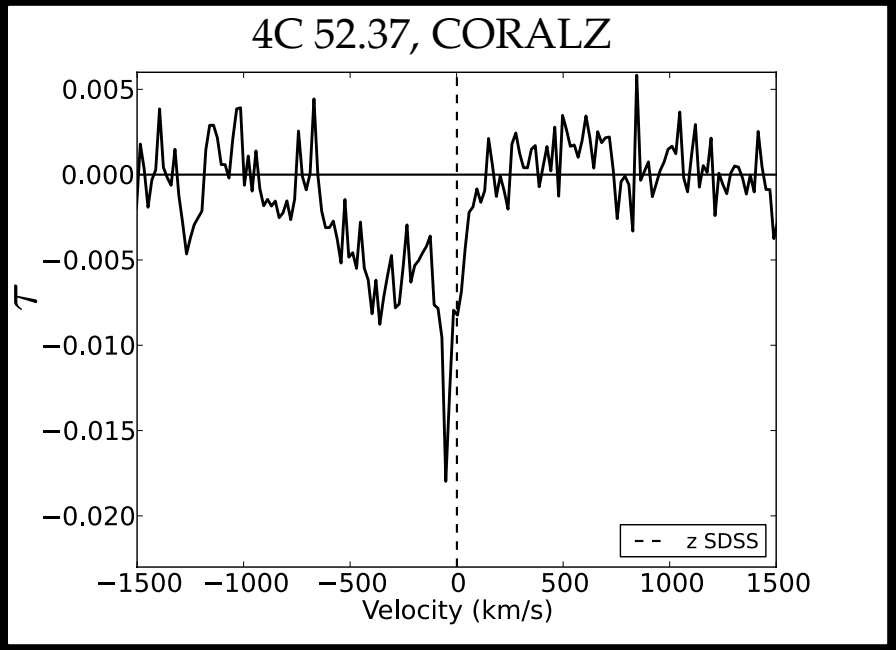
(Pihlstrom+ 2003, Gupta+ 2006, Chandola+ 2011)

Some dichotomy is orientation related, but it looks like compact (young) AGN have more gas. Gas involved in nuclear activity?



Outflows

- (Young) AGN with lots of gas can drive outflows

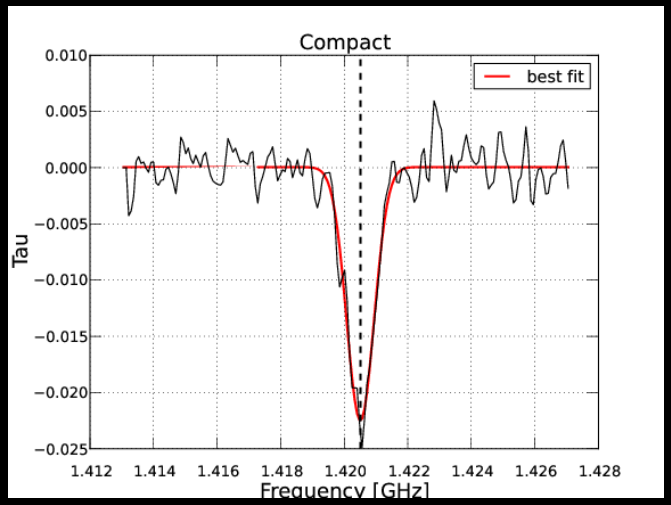


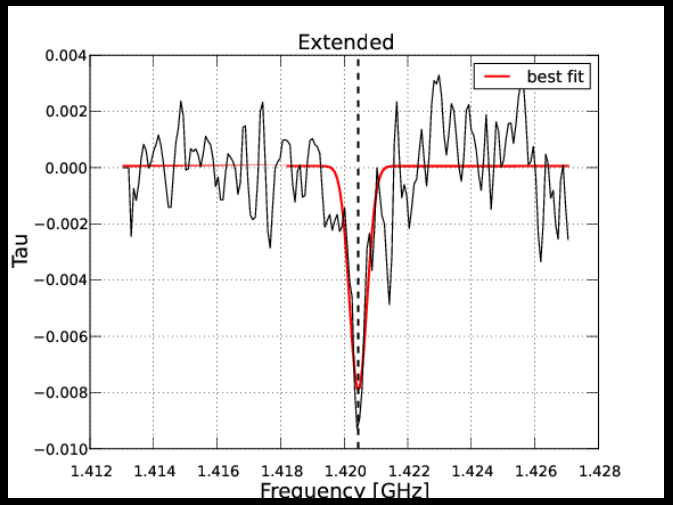
- + 2 known outflows in our sample: 3C 293 and 3C 305
- 10 % of the detections show outflow!

The Future

- Above τ of a few percent detection rate of HI is 30% – lots of new detections by future surveys, even outflows!
- Detection of HI is not limited by flux density – future surveys can explore lower fluxes
- ATLAS^{3D} + our results: HI emission and absorption are tracing the same kind of gas structures – we can use absorption at high redshift in AGN/SF where emission sensitivity declines
- If the HI dichotomy holds at lower tau (?) – perhaps stacking is more useful for studying/ comparing groups of objects rather than pushing to lower detection limits
- Compact vs. Extended: detection rate & stacking – different ISM properties (τ & FWHM)

- Stacking with SDSS redshift: $FWHM_{Comp}$ = 203 km/s $FWHM_{Ext}$ = 130 km/s





- Stacking with HI peak: $FWHM_{Comp}$ = 114 km/s $FWHM_{Ext}$ = 76 km/s