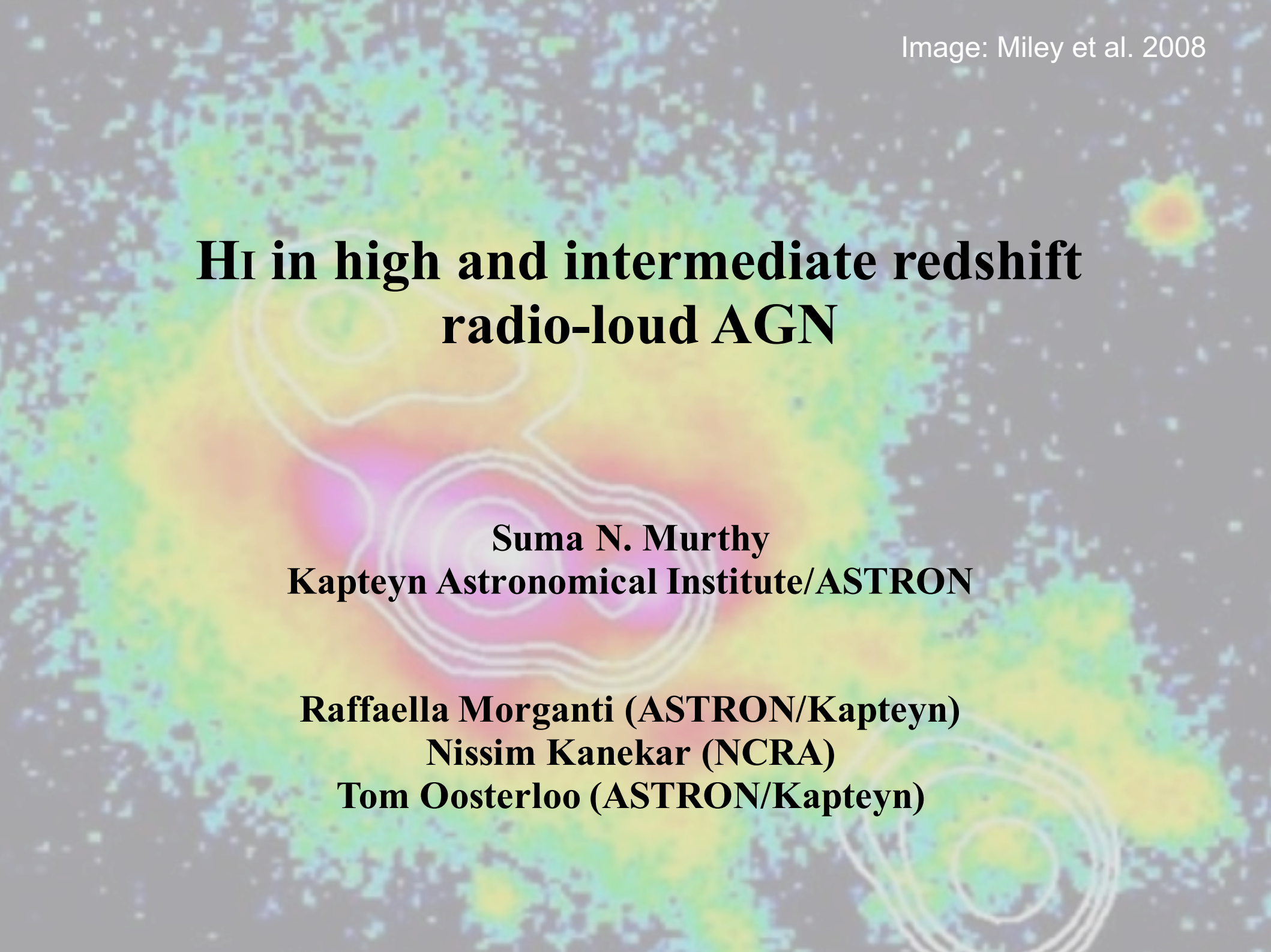

HI in high and intermediate redshift radio-loud AGN

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Outline

- What does associated HI absorption tell us?
- Scenario at high redshift.
- Two approaches:
  - High redshift radio galaxies
  - ‘Low’ luminosity intermediate AGN
- Summary

HI Absorption in Radio AGNs

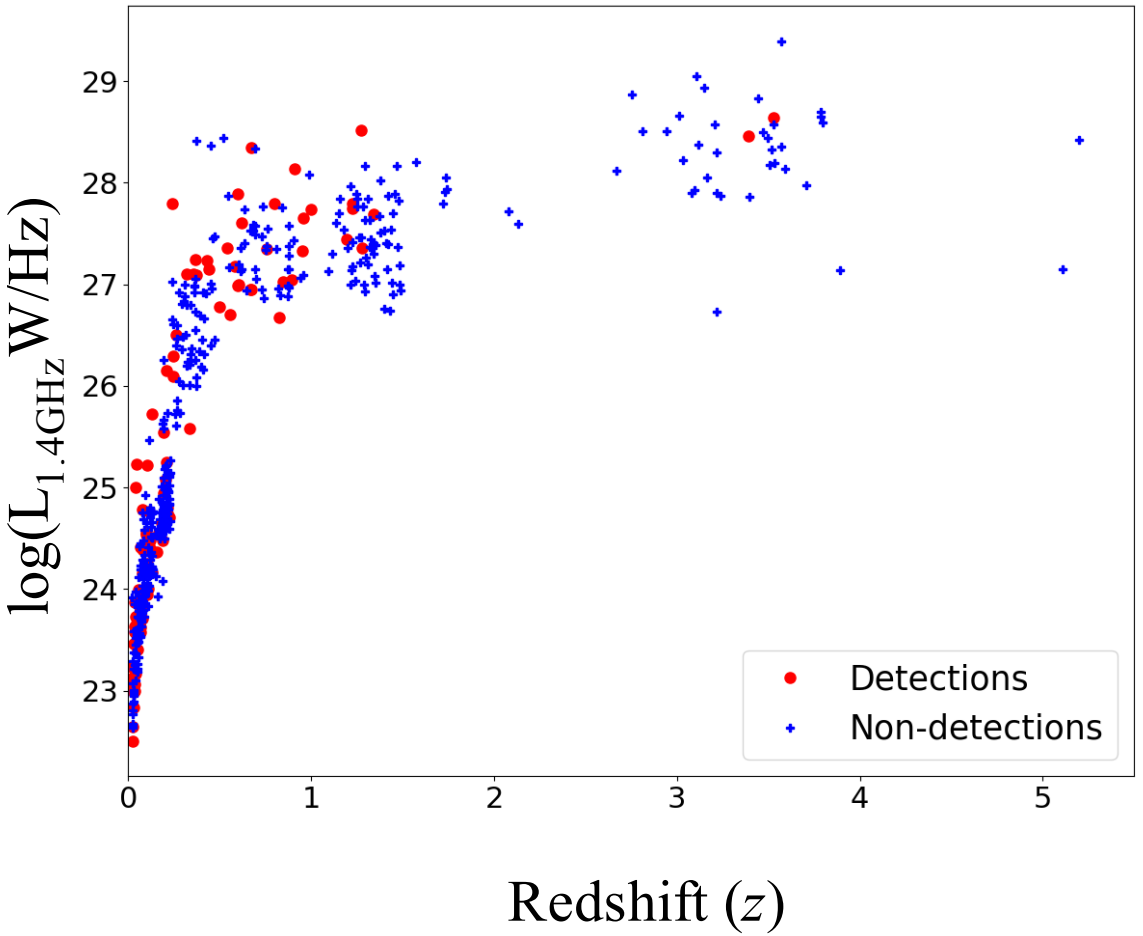
- HI absorption: Cold gas at high spatial resolution and high z in AGN.

- HI absorption in large samples:
  - Young compact AGN more likely detected (40%)
  - Extended (old) AGN less likely (13%)
  - All outflows in powerful young AGN

(e.g. Vermeulen et al. 2003, Gereb et al. 2015, Maccagni et al 2017)

At High Redshifts

- ~150 searches at z >1; 7 detections.
- Detection rate: ~ 5%
- Why?
  - Selection bias: High AGN Luminosity (UV and 1.4 GHz)
  - Redshift evolution of cold gas.

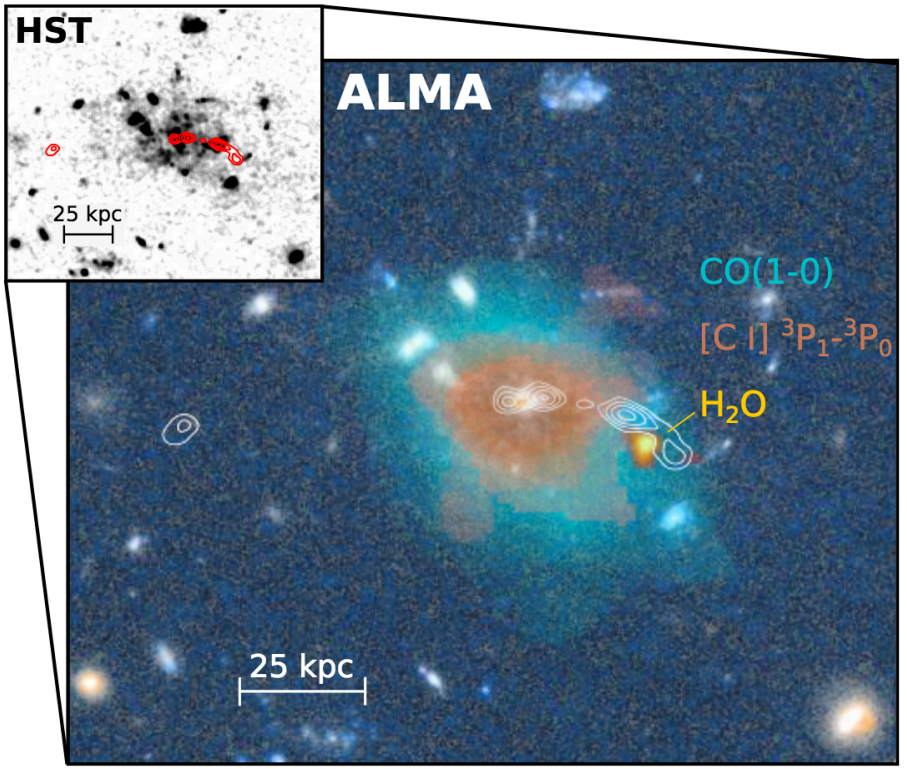


Scenario at high redshifts

- UV-faint AGN @ high z ➔ small & heterogeneous sample
  (Curran et al. 2013,16)
- Uniform sample @ all z ➔ Flat spectrum and GPS.
  (Aditya et al. 2016,17,18a,b)
  - GPS: same detection rate.
  - FSS: redshift evolution but luminosity correlates with z.
  - Redshift evolution and luminosity degenerate.
- Should mind AGN luminosity!
- Majority are flat spectrum AGN ➔ Sample different AGN classes.

Different population: High-z radio galaxies

- Powerful AGN.
- Commonly located in protoclusters.
  (e.g. Hatch et al. 2014)
- 38% detection rate of CO emission
  (e.g. Emonts et al. 2014)
- 60% Ly-α absorption detection rate.
  (e.g. van Ojik et al. 1997)
- > 200 known at $z > 2$. (Miley et al. 2008)
- 17 searched for HI 21cm absorption.
  (e.g. Rottgering et al. 1999, Curran et al. 2016)
- One confirmed detection at $z = 3.395$.
  (Uson et al. 1991)
- One tentative detection at $z = 2.429$.
  (Rottgering et al. 1999)

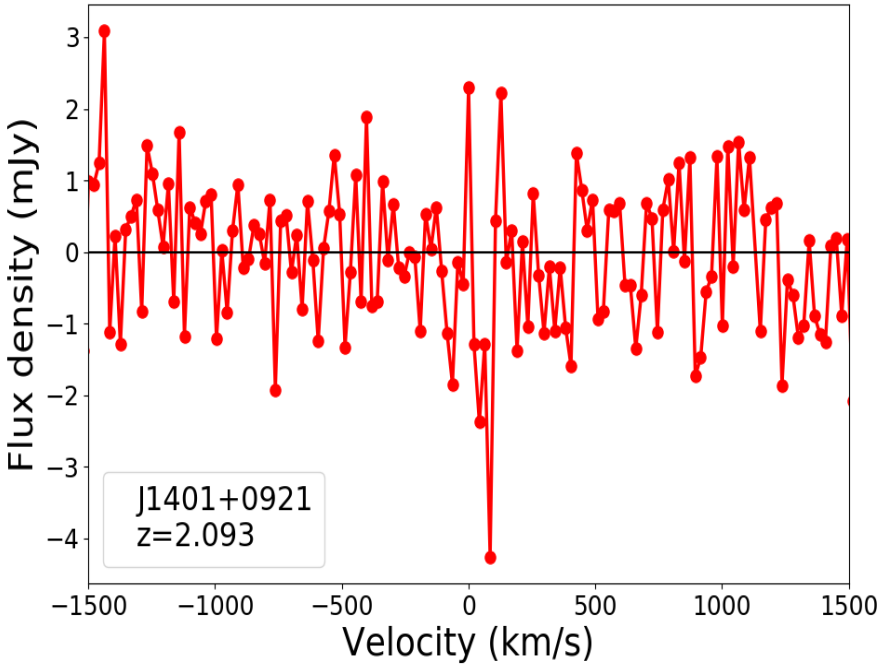


Emonts et al. 2018

High-z radio galaxies

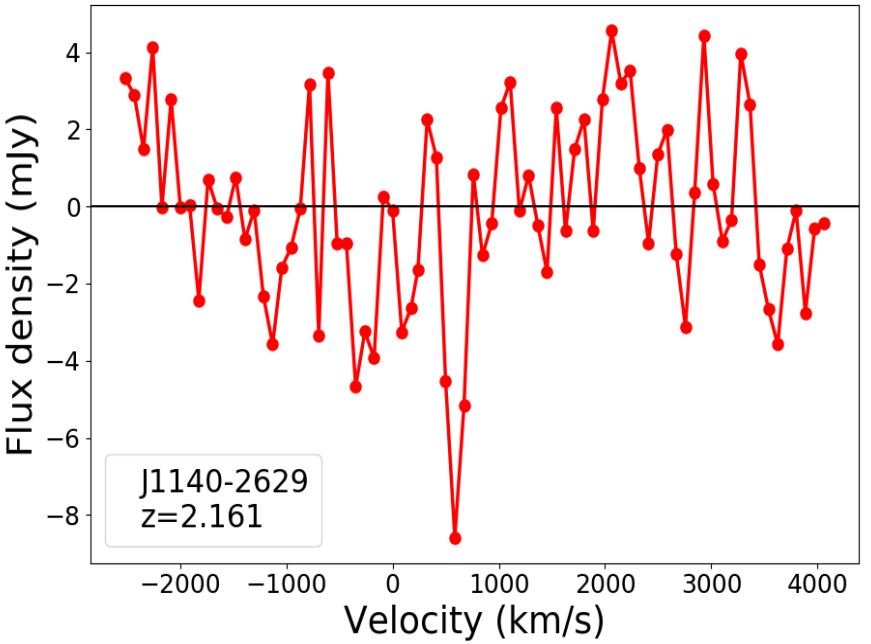
- Our full sample: HzRGs with flux density > 200 mJy at $2 < z < 4.25$.
- Observed 32 HzRGs with the uGMRT Band 3.
- ~ 1 – 2 hours on source.
- 14 analysed.
- Typically 40-50% data loss due to RFI.
- 3σ optical depth limits: < 1% per 40 km/s channel.
- 2 tentative detections of associated HI absorption.

J1401-0921; $z \sim 2.1$



- Close to systemic.
- Peak optical depth: 1.4%.
- FWZI: ~80 km/s.

J1140-2629; $z \sim 2.2$



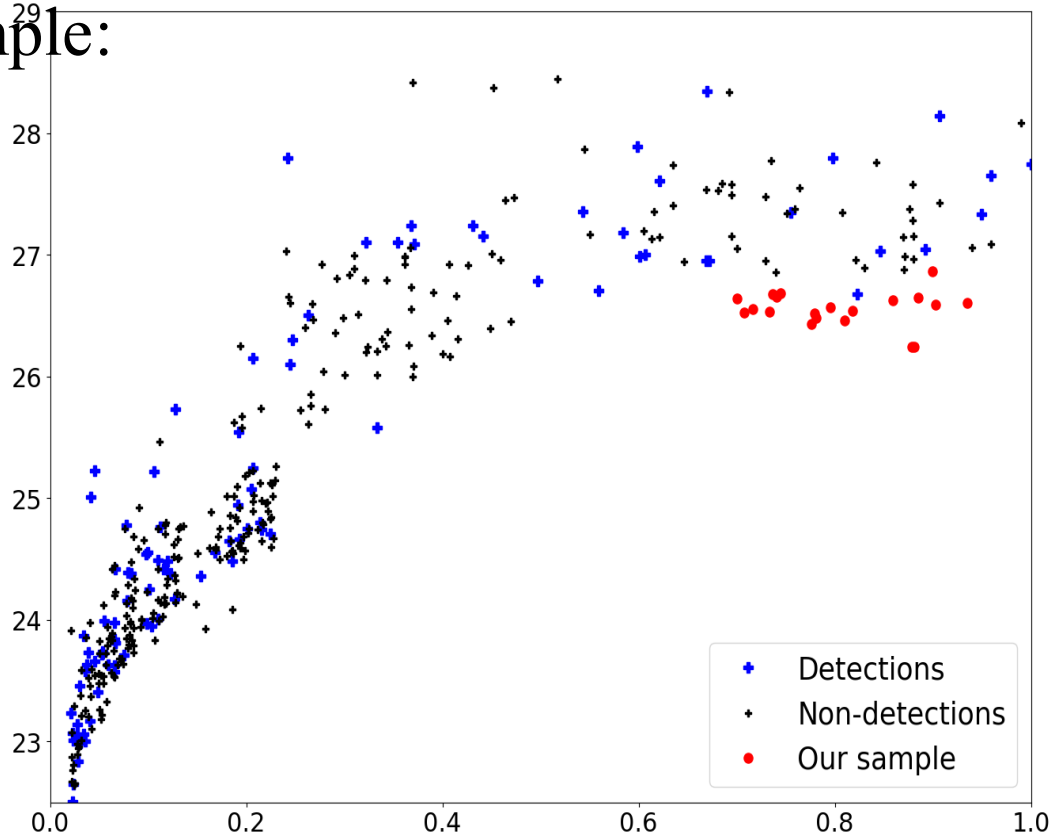
- Redshifted by ~550 km/s.
- Peak optical depth: 0.4%.
- FWZI: ~260 km/s.

High-*z* radio galaxies

- 3-sigma HI column density sensitivity ~ 10^{20} cm^{-2} (T_{spin} = 100 K)
- Covering factor could be an issue.
- HzRGs with CO emission good candidates for these searches?
- ~10% detection rate consistent with low-*z* results.
- Does luminosity not matter?
- Numbers are yet low for strong conclusions.

‘Low’ luminosity AGN at intermediate redshifts

- SDSS-FIRST cross-matched sample: $L_{1.4GHz} < 10^{27}$ W/Hz.
- Observed 21 AGNs.
- Preliminary analysis: no strong absorption.
- Aditya 2019: 4/11 detections but at higher luminosity!
- Host galaxy issue?
- Again, does luminosity not matter?



Summary

- Associated HI absorption ⇒ Interplay between gas and radio activity.
- Detection rate is low at high-z.
- But the searches are also dominated by flat spectrum AGN.
- HzRGs could be suitable candidates for high-z searches.
- We detect two tentative detections: luminosity may not be an effect.
- Intermediate redshift searches also seem to suggest luminosity may not be a factor.
- But many free parameters at high z. More samples needed.
- More ancillary information needed.