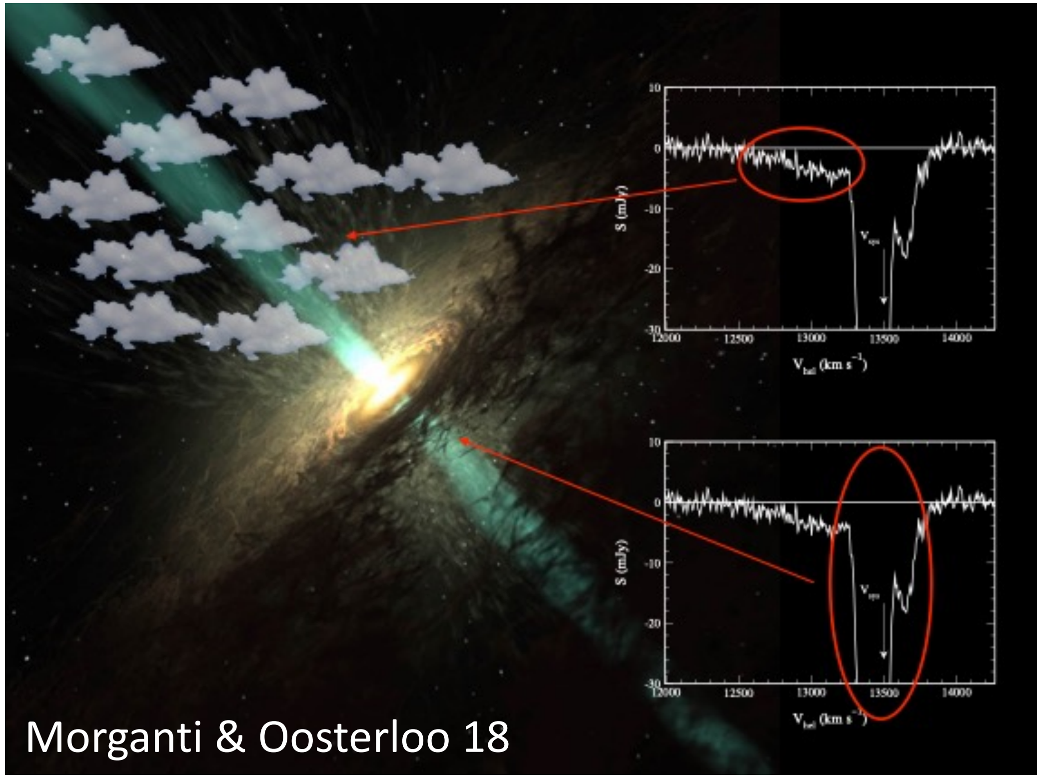
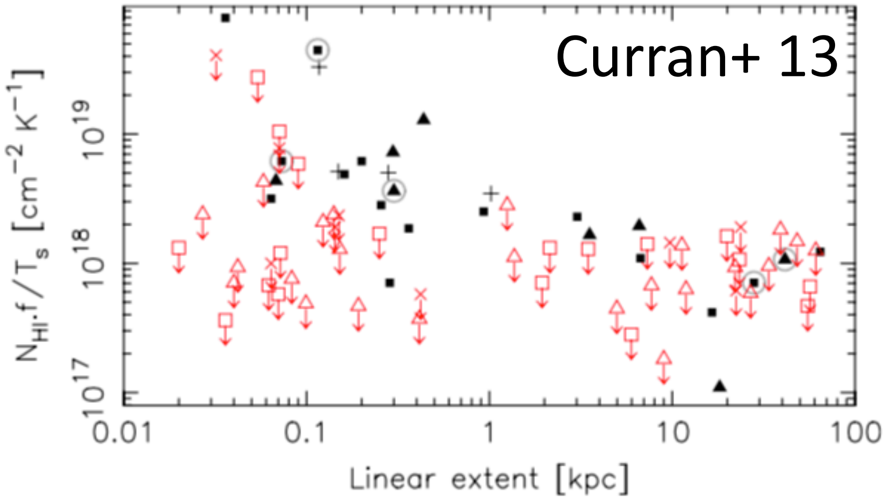
The gaseous natal environments of GPS & CSS sources with ASKAP-FLASH

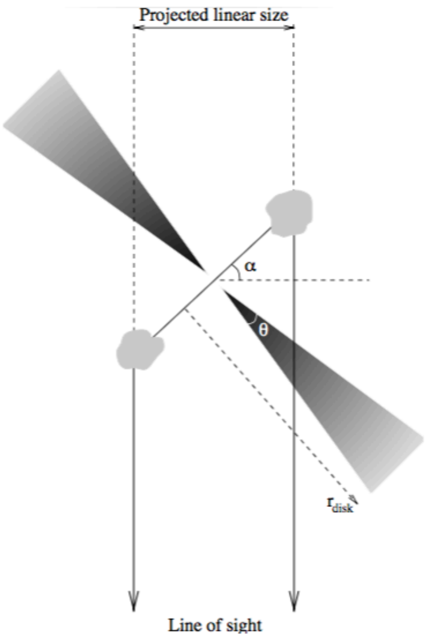
James Allison (University of Oxford)

given on behalf of the FLASH Survey Science Team

Why care about an HI absorption survey?





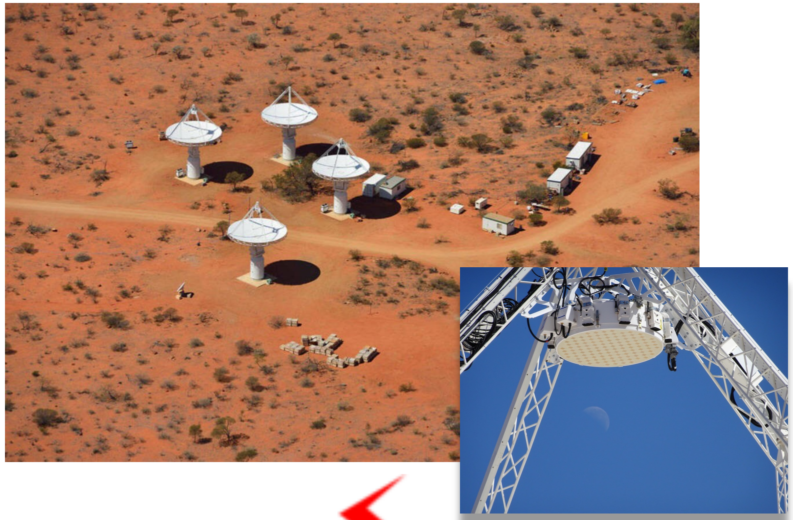


HI absorption probes kinematics on sight-line to the radio AGN → outflows, infalling clouds, circumnuclear disks

HI absorption selected radio sample should preferentially select intrinsically compact AGN

First Large Absorption Survey in HI (FLASH)

- A wide-field **HI absorption survey** with the Australian SKA Pathfinder
- One of ten ASKAP surveys
- **3 - 5 mJy** per beam per **6 km/s**
- **95 µJy** per beam **continuu**
- **34,000 square degrees**
- **700 – 1000 MHz**
- z_{HI} **= 0.4 – 1.0**



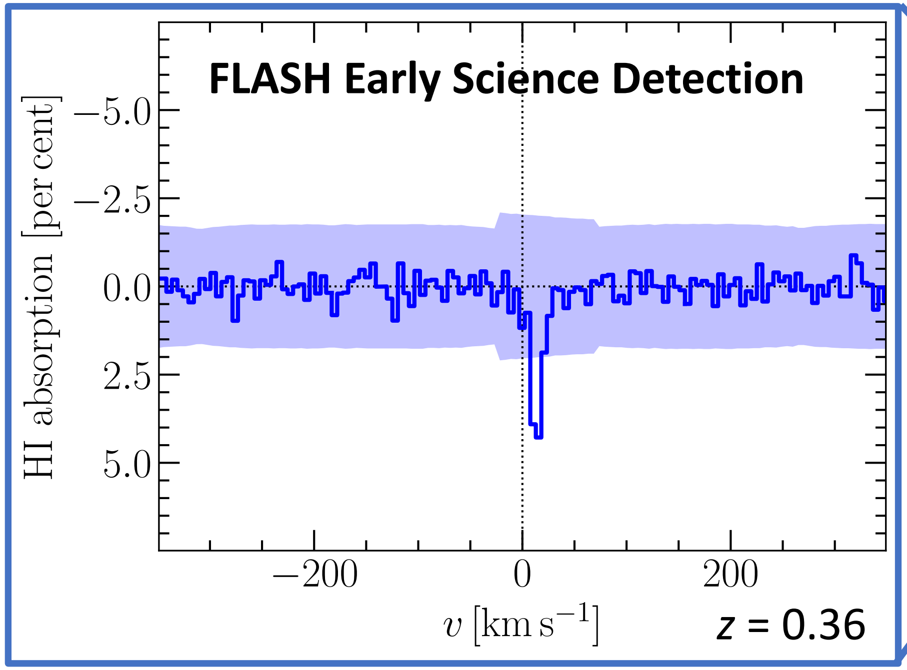
ASKAP-FLASH

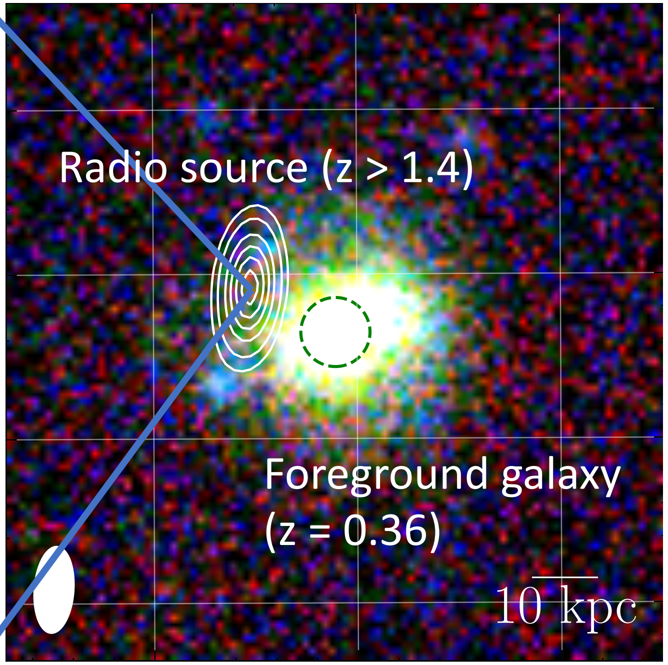
https://askapsurveys.wixsite.com/flash

Allison, Sadler+ in prep.

FLASH science goals

- About ~ 1000 intervening and ~ **1000 associated/intrinsic** absorbers





Allison+ 20, MNRAS (arXiv:2004.00847)

Key science goals include:

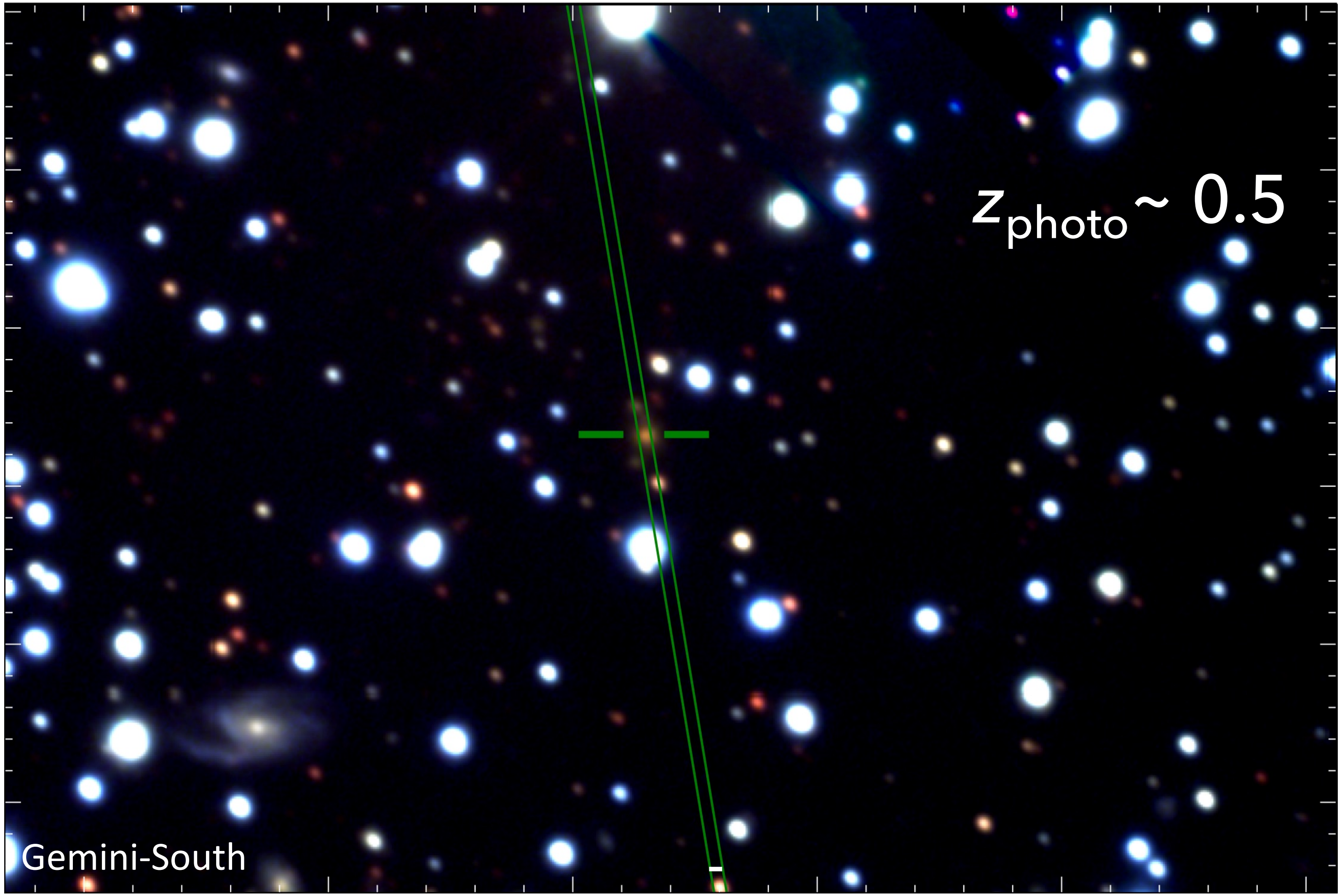
1) **Cosmological evolution of HI** in galaxies – particularly the **cold phase (CNM)** HI
2) The nature of **HI-absorption-selected galaxies** and their environments
3) Mechanisms for **triggering and feedback in distant radio-AGN**
4) **Multi-phased gas in distant radio- AGN** through e-ROSITA synergies

Allison, Sadler+ in prep.

Peaked spectrum sources with FLASH

- PS sources are intrinsically compact within the galactic stellar disk → more likely to intercept cold HI gas
- Expected detection rates about **30%** (versus 15% for extended sources) from low redshift surveys (Maccagni + 2017)
- Assuming a 20% compact population → FLASH should detect **several hundred HI absorbers** associated with **PS sources** out to ***z* = 1**
- Any significant deviation from this expectation would point towards an **evolution** in the **gas content** of the population of young radio AGN towards **cosmic noon**
- Interpretation requires multi-wavelength follow up (i.e. optical spectral classification of the AGN and host galaxy)

PKS1740-517: Case study

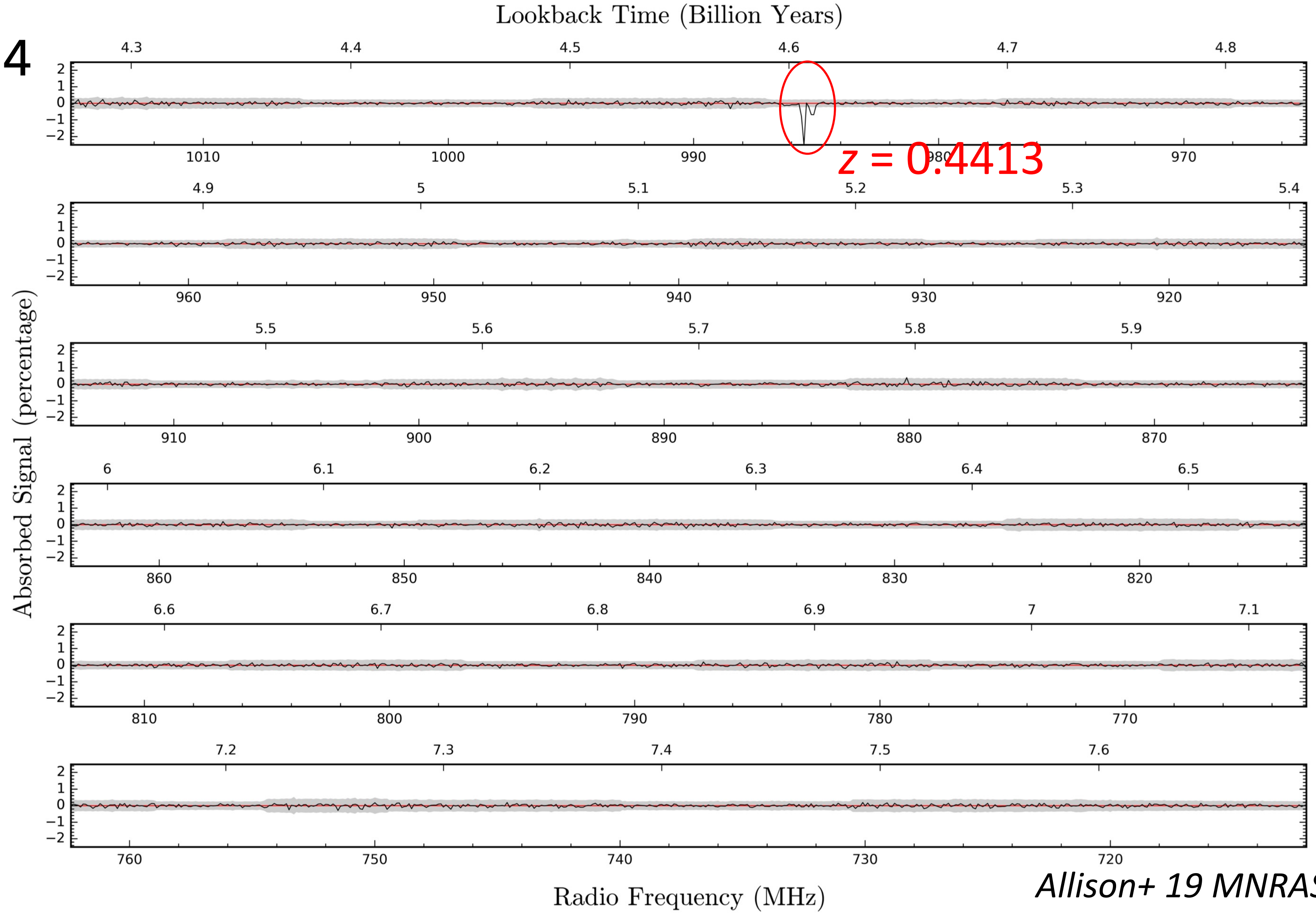


1.5 arcseconds

Allison+ 19 MNRAS (arXiv:1810.08507)

PKS1740-517: ASKAP HI discovery spectrum

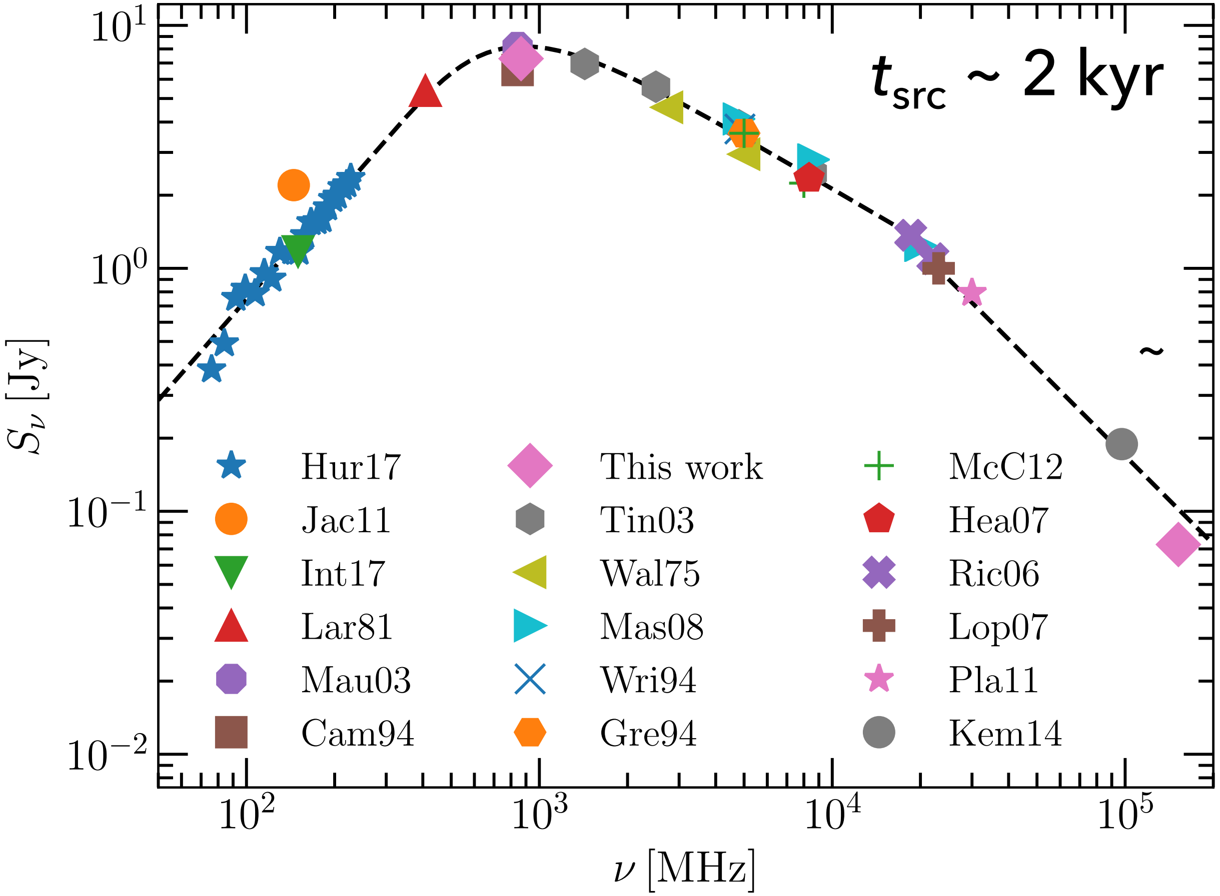
z = 0.4

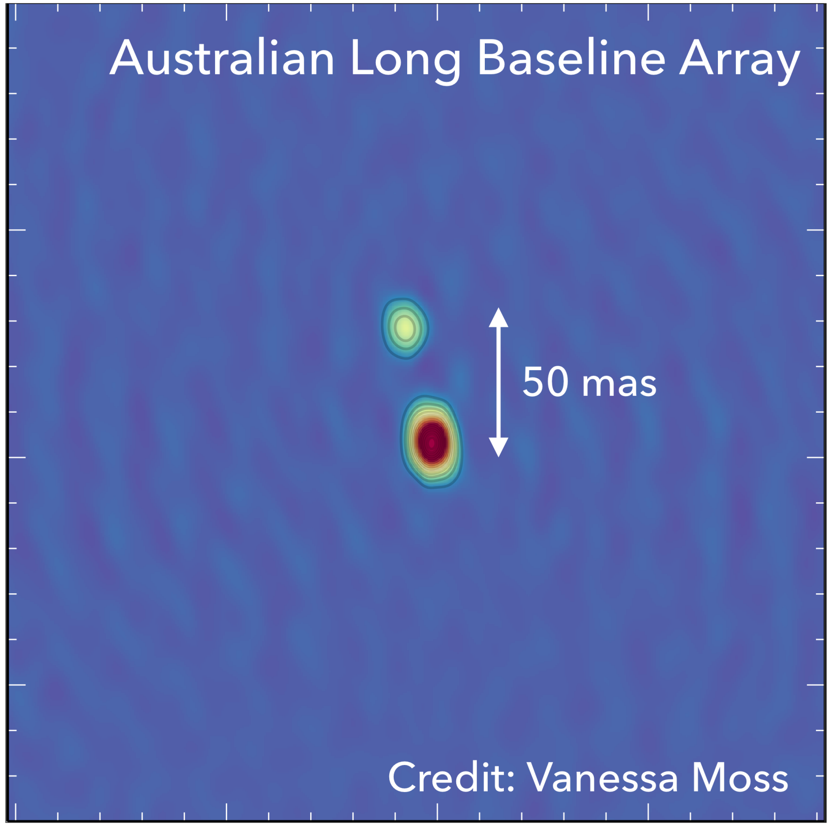


z = 1.0

Allison+ 19 MNRAS (arXiv:1810.08507)

PKS1740-517: Radio properties





$P_{1.4GHz}$ = 3.0 x 10^{27} W Hz^{-1}

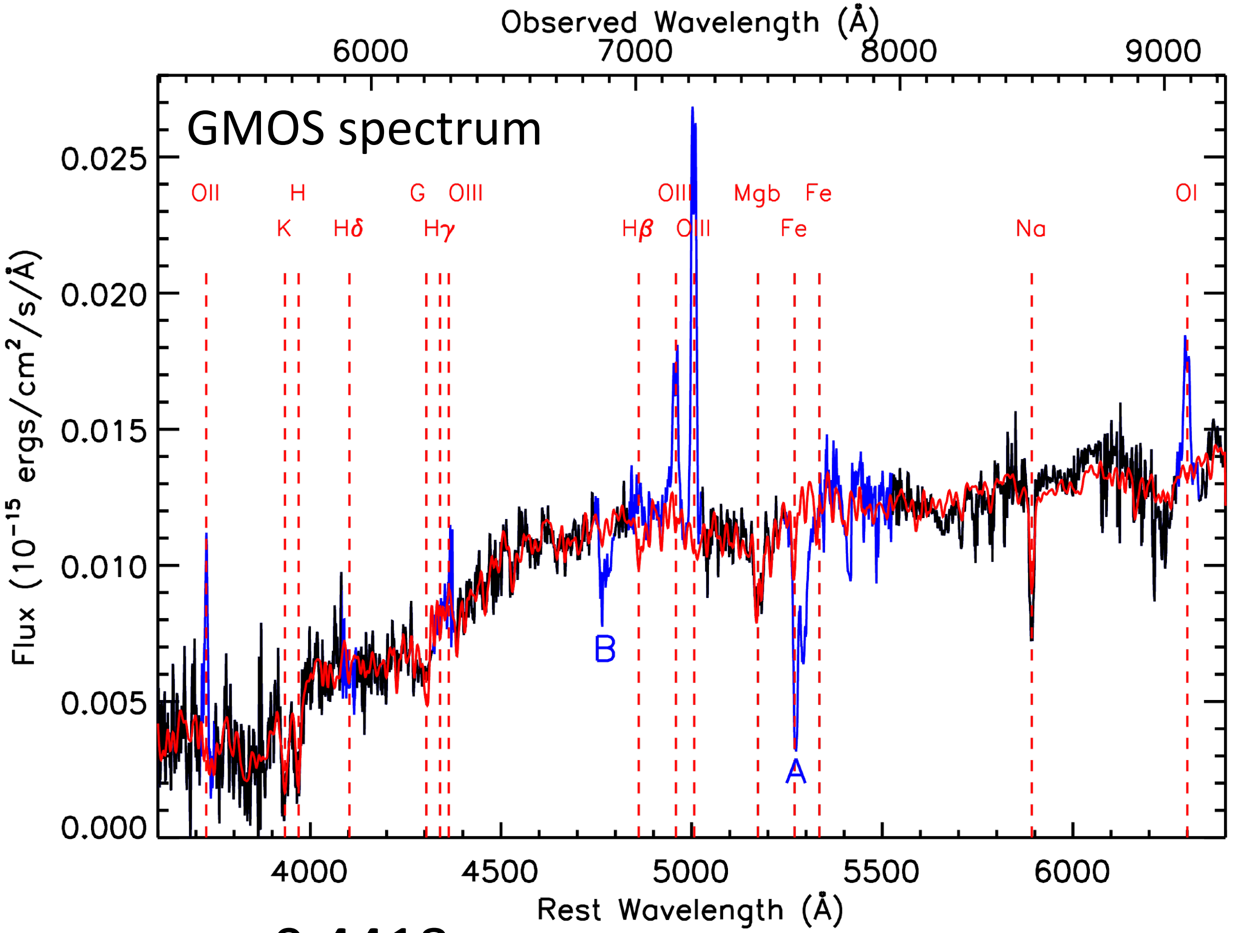
L_{5GHz} = 6.6 x 10^{43} erg s^{-1}

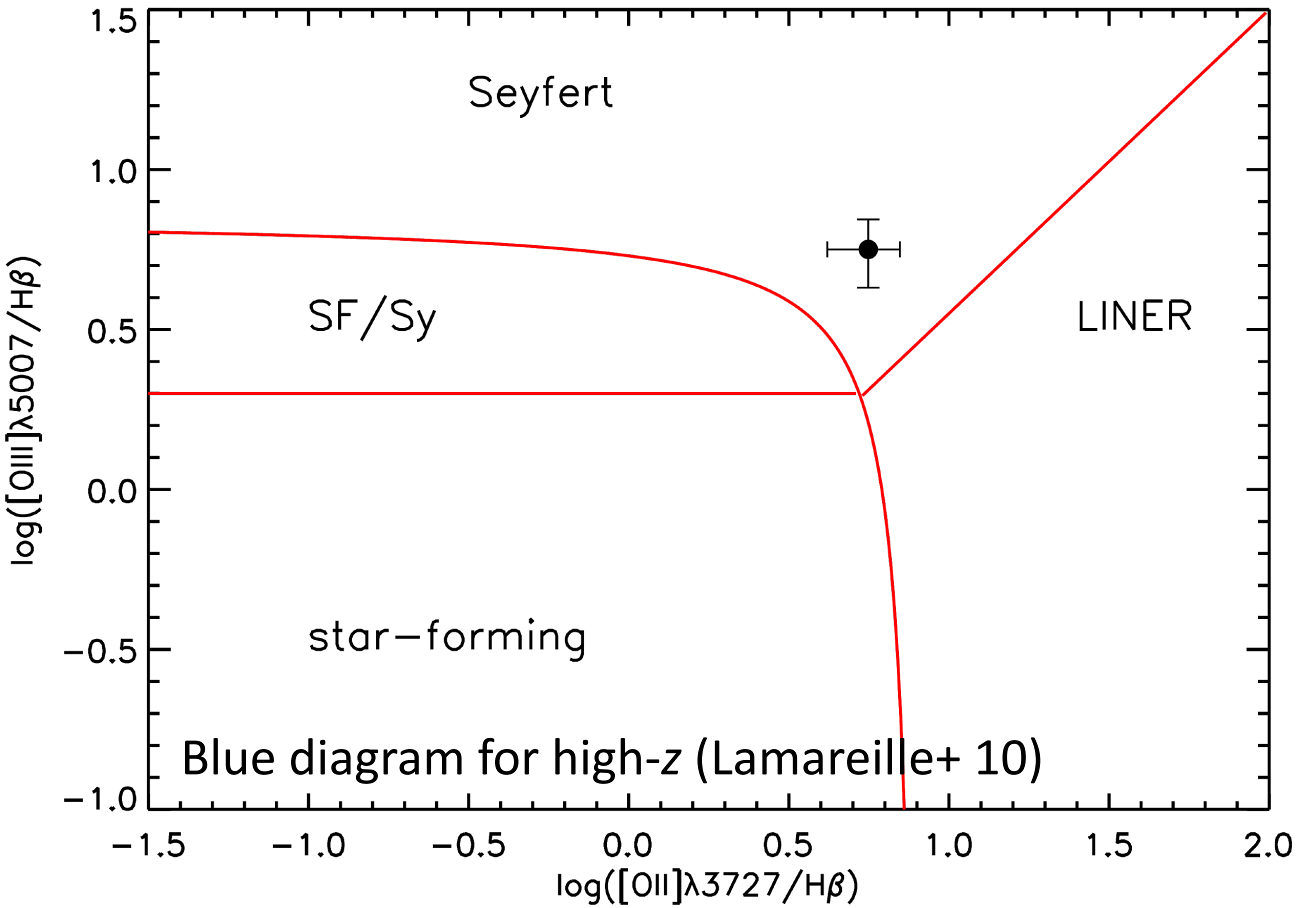
($L_{2\text{-}10keV}$ = 6.2 x 10^{44} erg s^{-1})

($N_{H,X}$ = 1.2 x 10^{22} cm^{-2})

Allison+ 19 MNRAS (arXiv:1810.08507)

PKS1740-517: Emission line AGN (HERG)



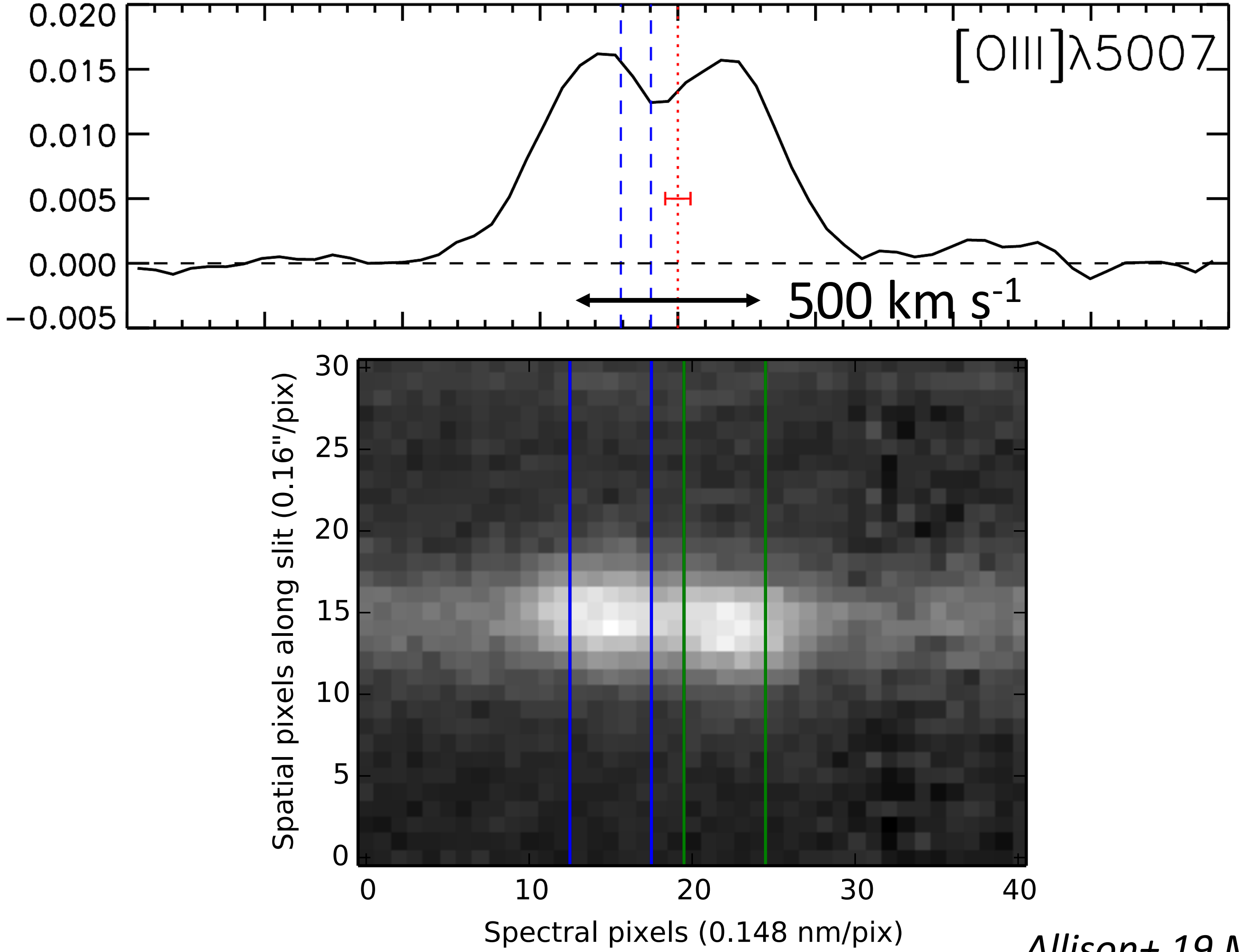


$z_{AGN} = 0.4418$

$L_{[OIII]} = 3 \times 10^{41}$ erg/s

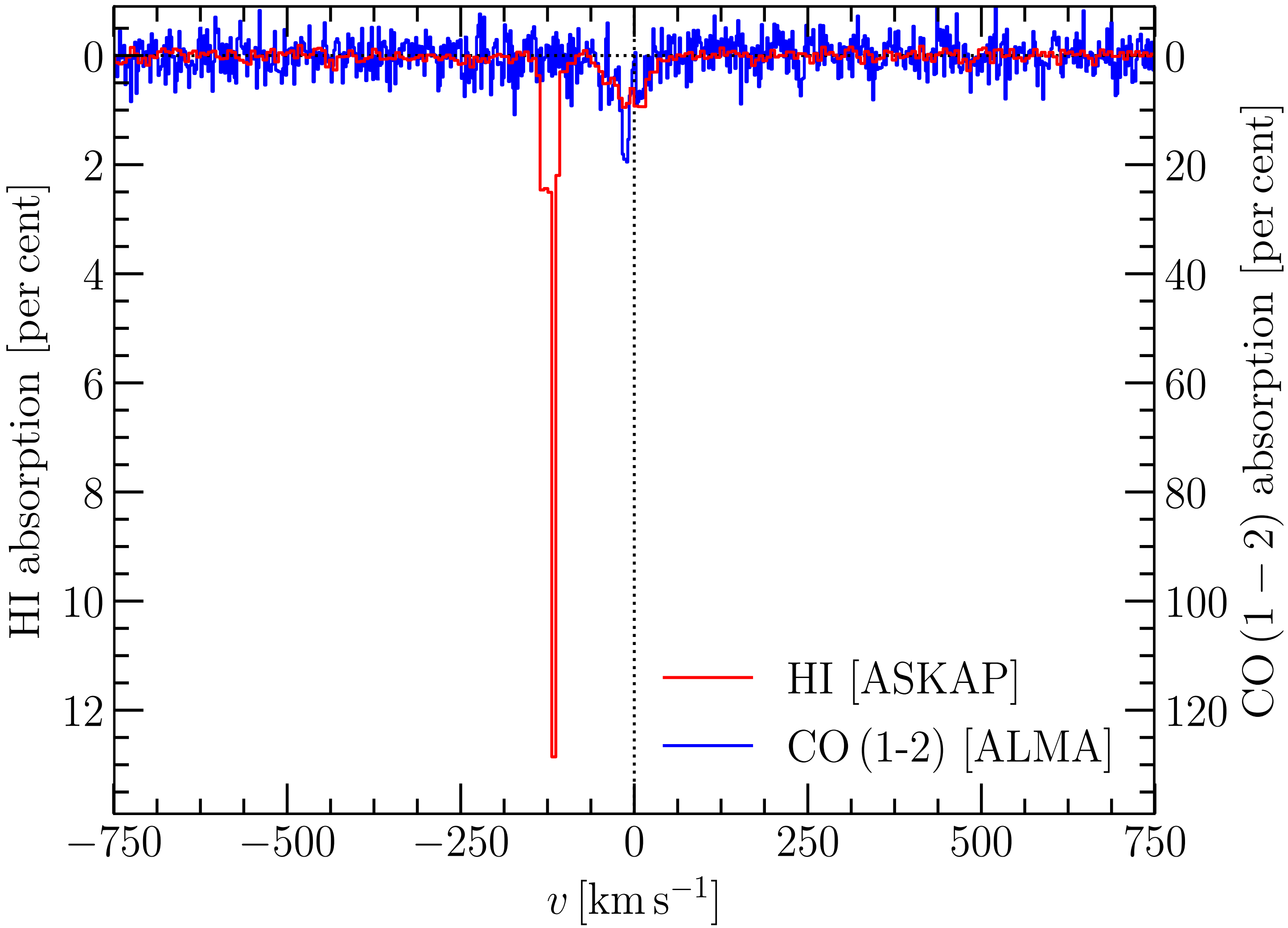
Allison+ 19 MNRAS (arXiv:1810.08507)

PKS1740-517: Gas reservoir (ionized)



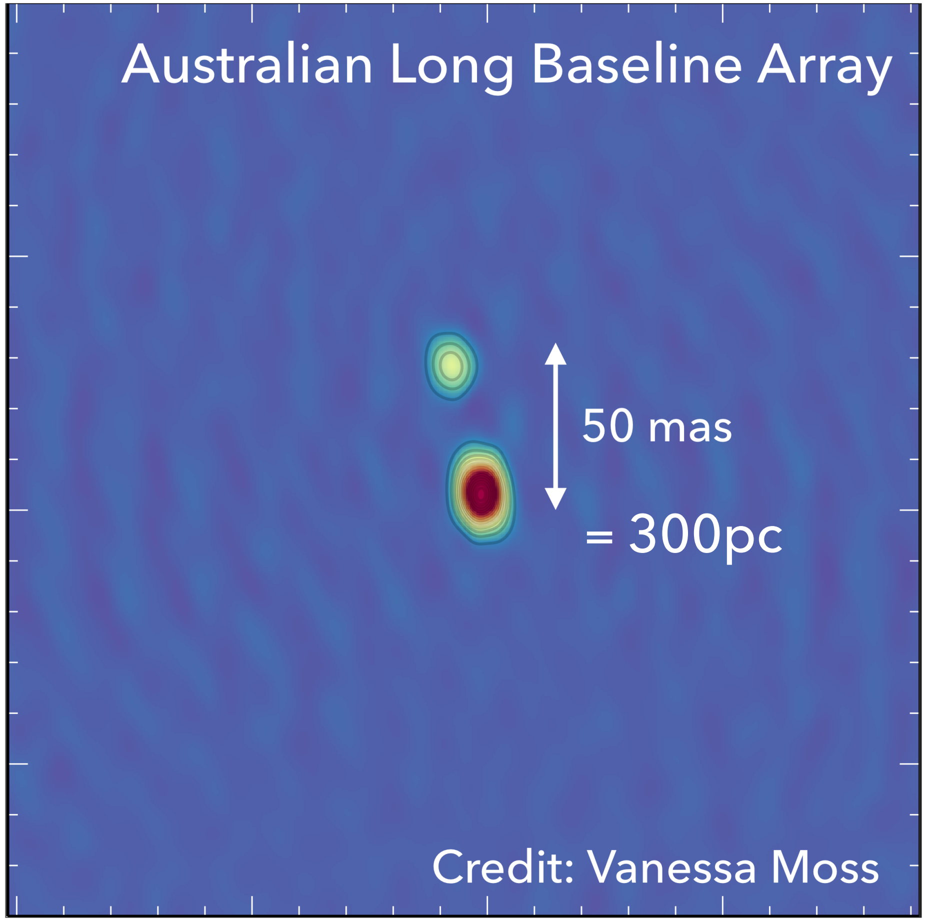
Allison+ 19 MNRAS (arXiv:1810.08507)

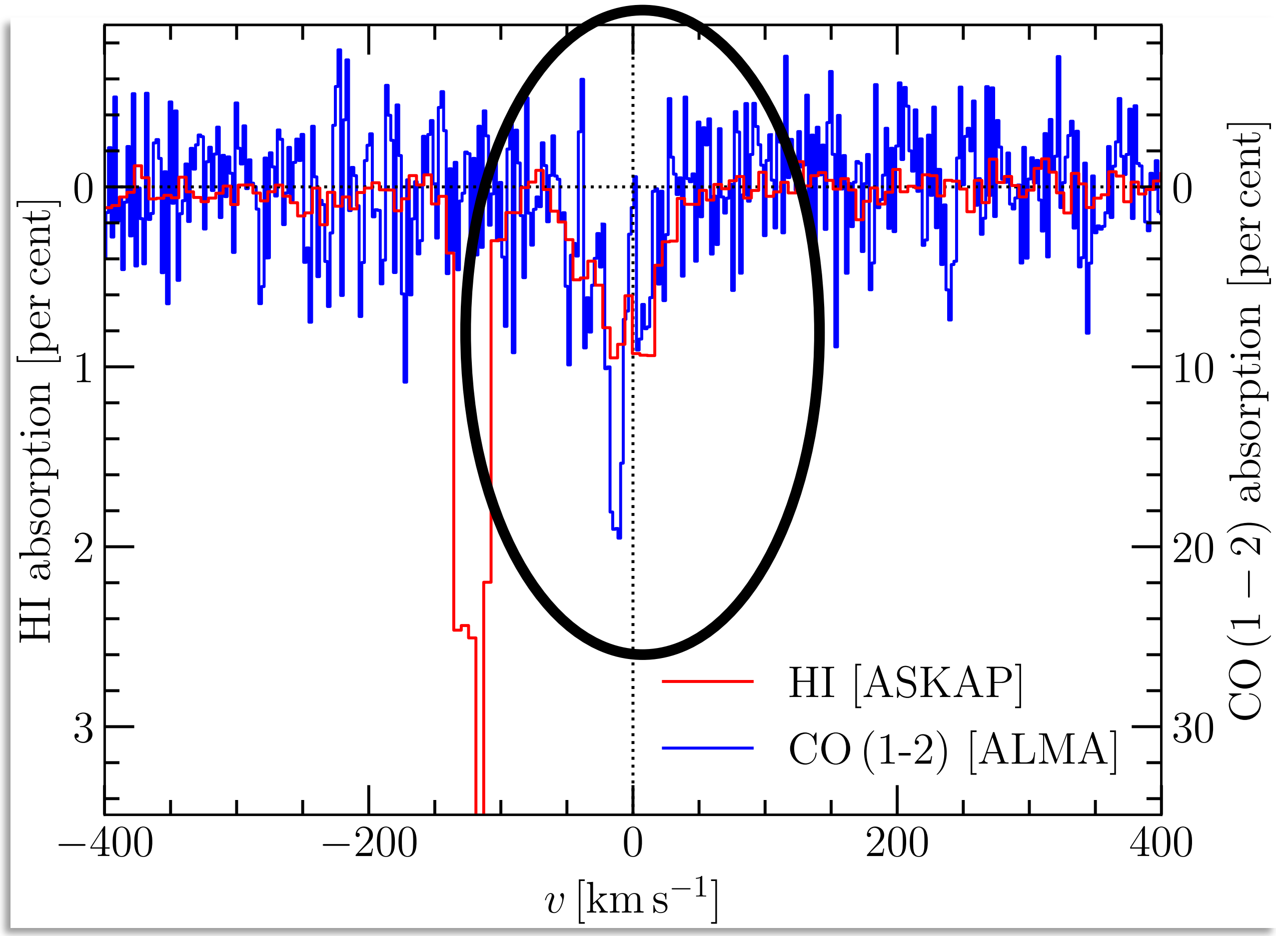
PKS1740-517: Gas reservoir (neutral)



Allison+ 19 MNRAS (arXiv:1810.08507)

PKS1740-517: Gas reservoir (neutral)

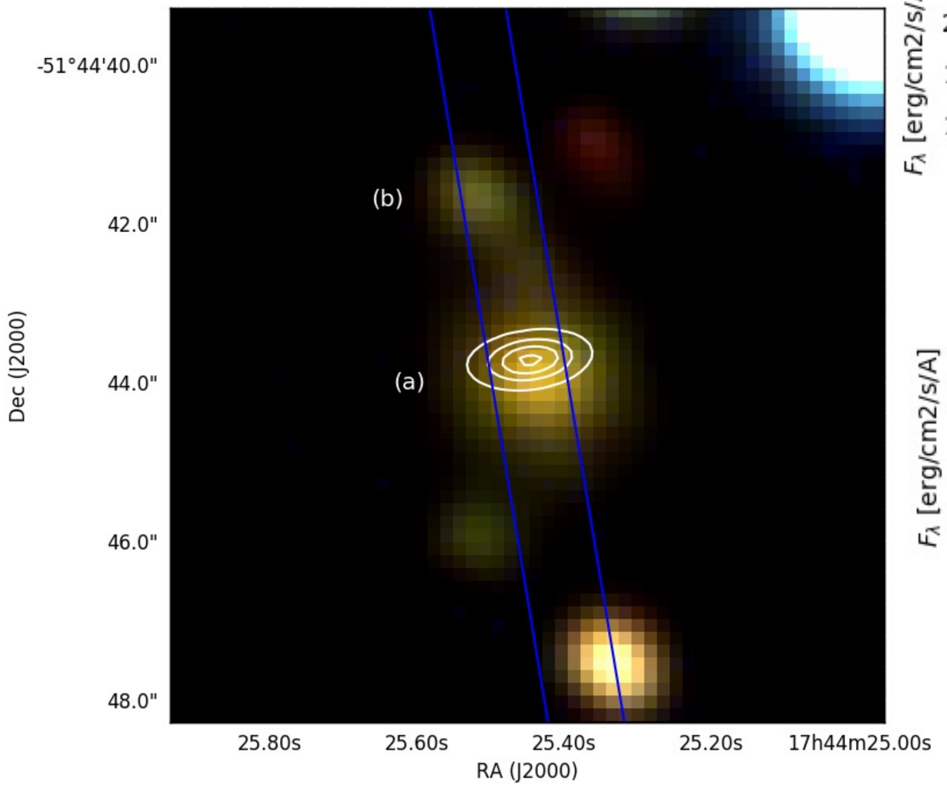


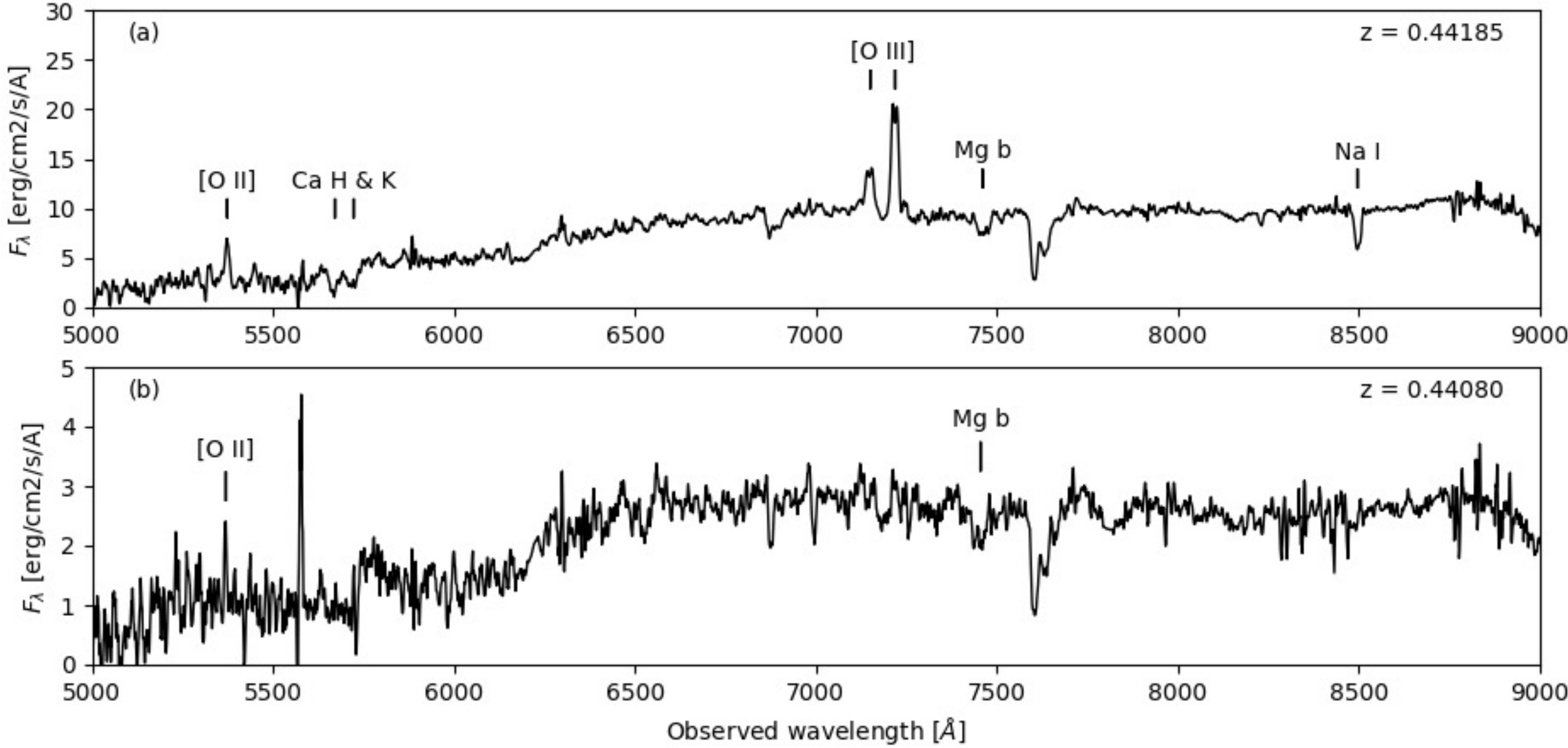


$N_{HI} = N_{H2} \sim 10^{20}$ cm^{-2} M_{HI} (r<2kpc) ~ 10^7 $M_\odot$ M_{H2} (r<2kpc) ~ 10^8 $M_\odot$

Allison+ 19 MNRAS (arXiv:1810.08507)

PKS1740-517: Interaction feeding reservoir





t_{dyn} ~ 50 Myr

t_{src} ~ 2 kyr

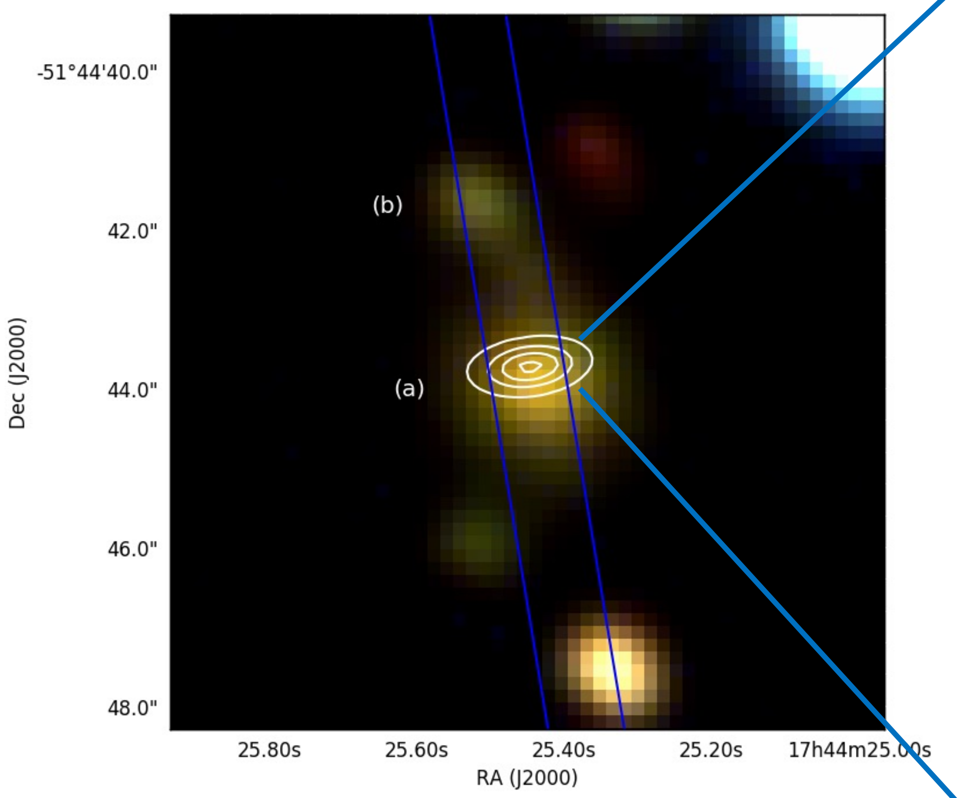
Companion (b) SFR ~ 0.1 $M_\odot$ yr^{-1}

$\Rightarrow M_{stellar}$ ~ few 10^9 $M_\odot$

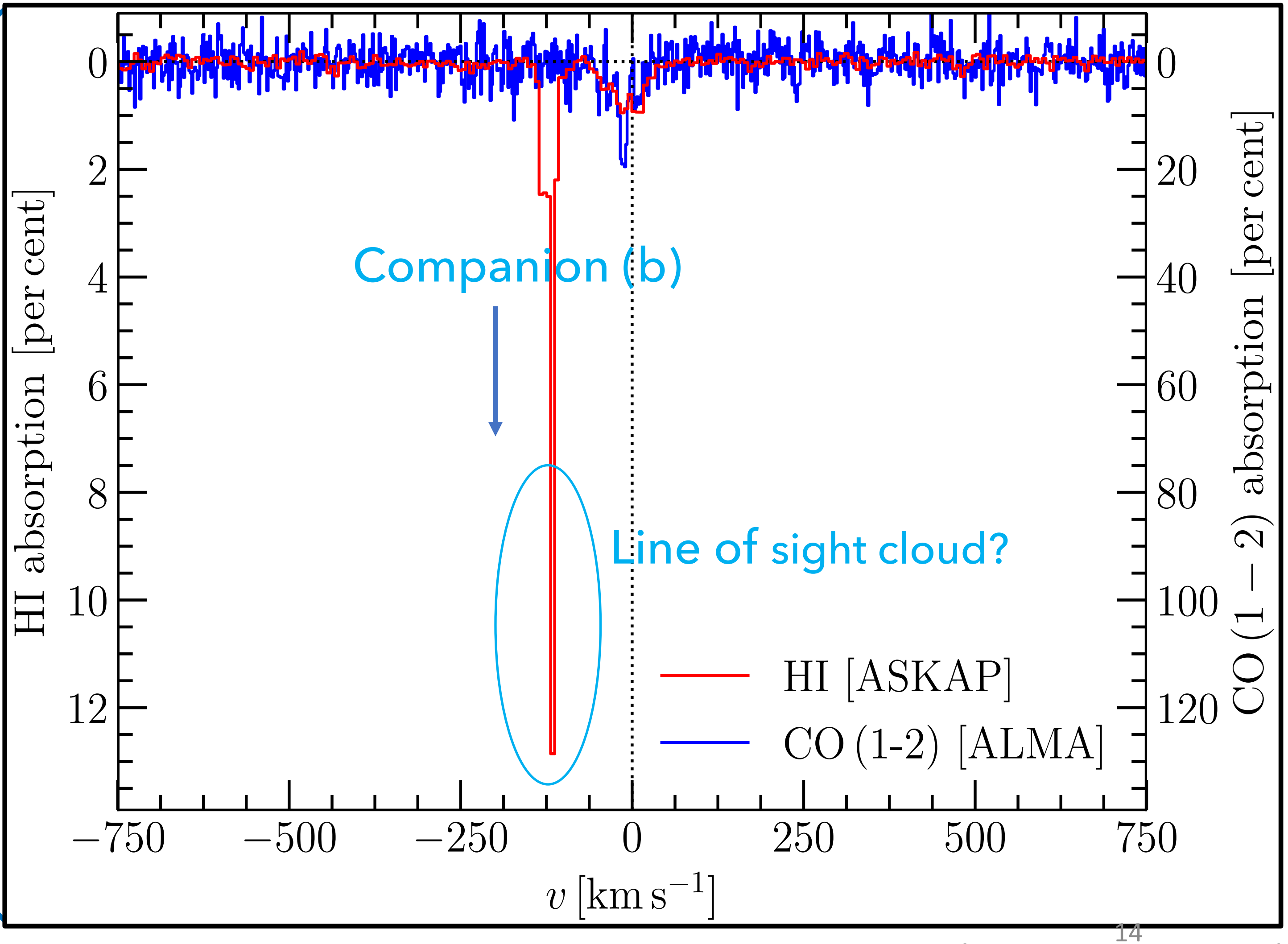
$\Rightarrow M_{HI+H2}$ ~ few 10^8 $M_\odot$

Allison+ 19 MNRAS (arXiv:1810.08507)

PKS1740-517: Interaction feeding reservoir



t_{dyn} ~ 50 Myr
t_{src} ~ 2 kyr



Allison+ 19 MNRAS (arXiv:1810.08507)

FLASH Pilot: The first 1000 square degrees

- Pilot field observations completed in early 2021
- Data team currently working through processing and QA

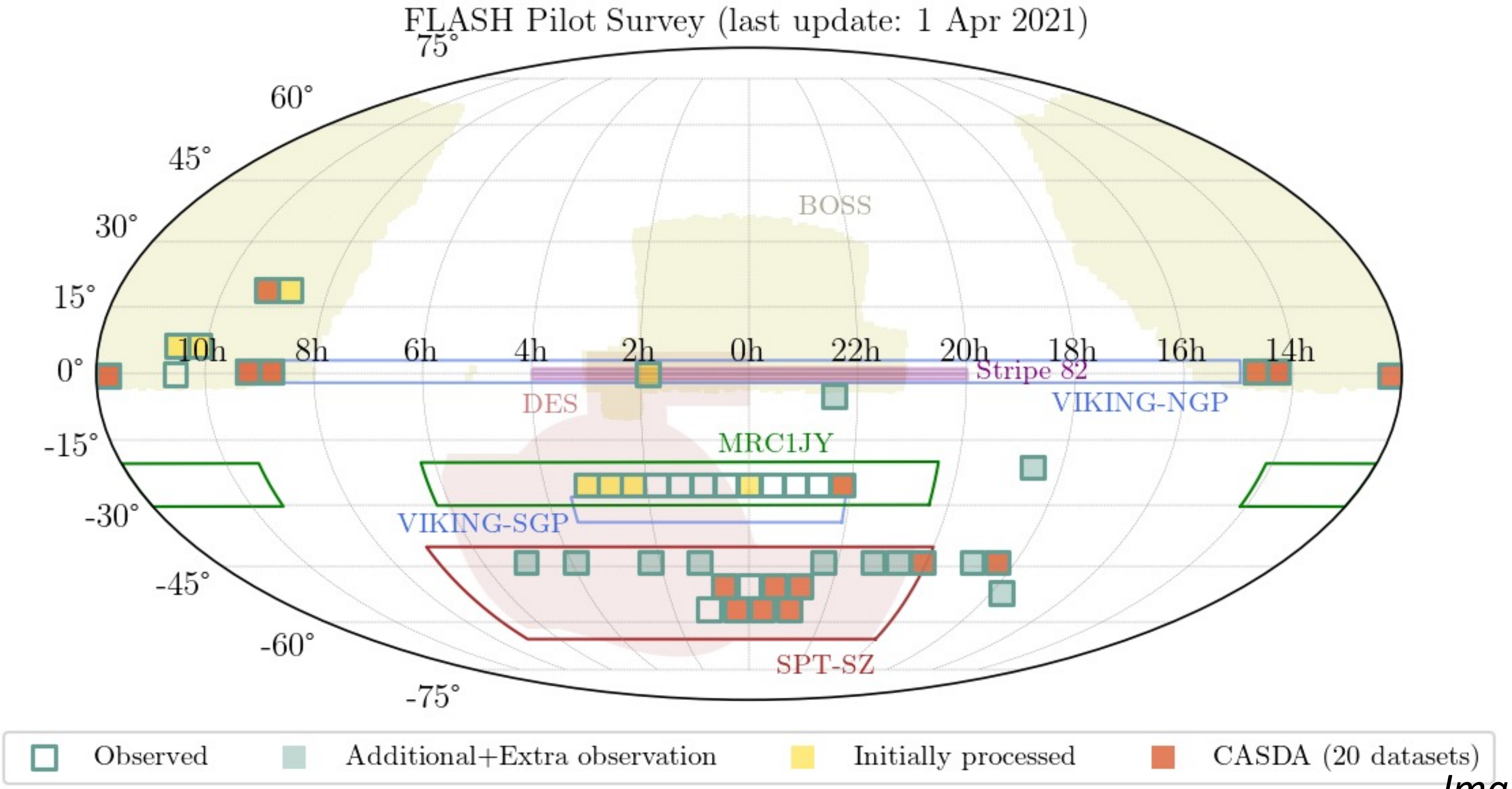
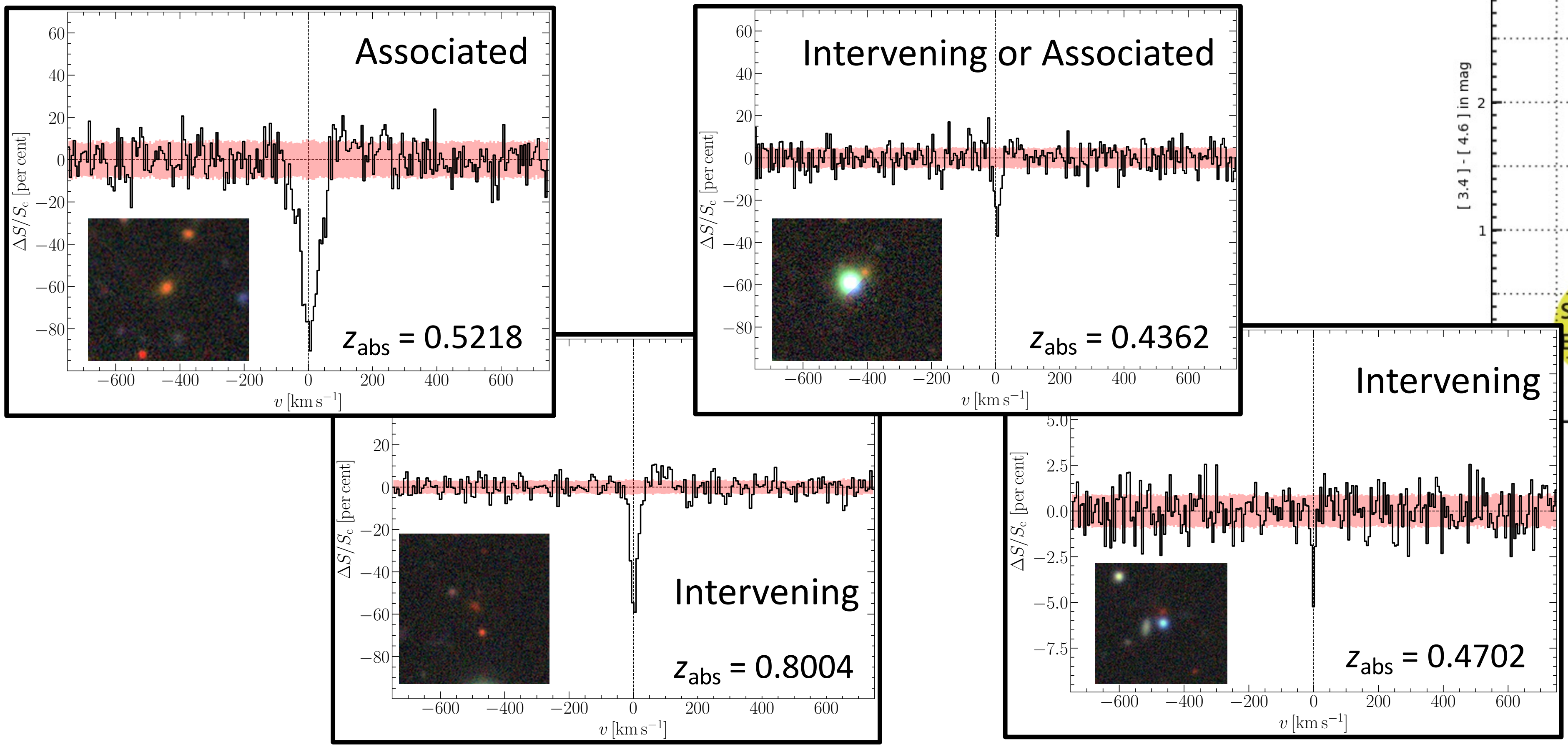
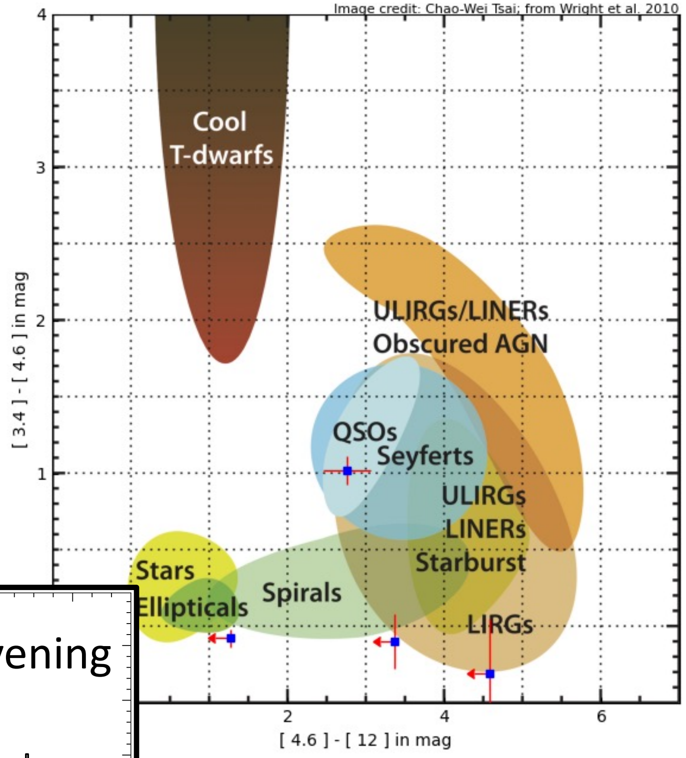


Image credit: Hyein Yoon

FLASH Pilot: The absorber detections

- Six absorbers in fraction of data processed so far
- At least three are associated with AGN





Compiled by Renzhi Su

FLASH Pilot: Peaked spectrum sample

Brandon Venville - Cold gas in CSS/GPS sources from the FLASH pilot survey

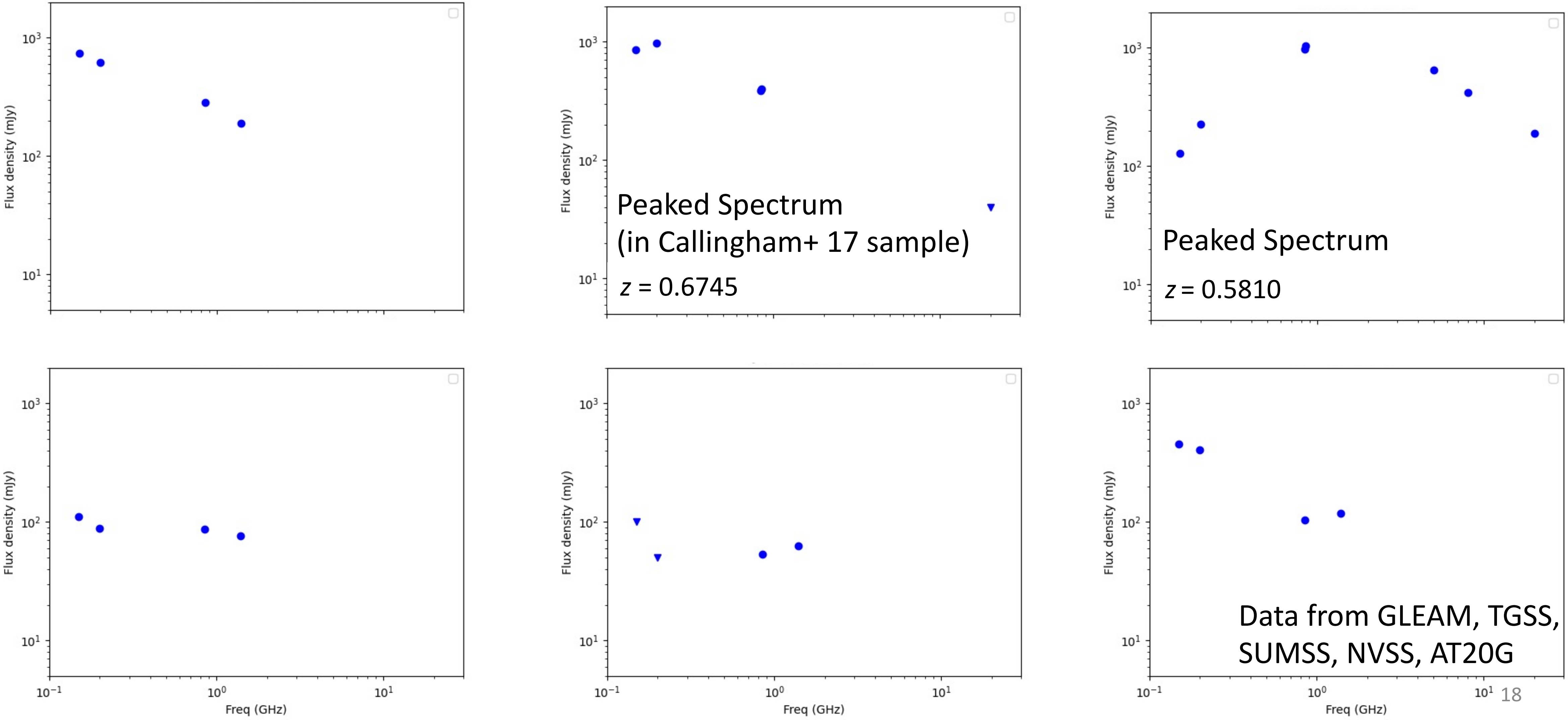
Work in progress: 2021 undergraduate Honours project (Swinburne Univ.)

- Combine Callingham et al. (2017) MWA peaked-spectrum objects with newly-identified GPS sources from GLEAM/RACS/ATPMN/AT20G
- Search for HI absorption (at $0.4 < z < 1$) in the ASKAP HI spectra of these peaked sources
- Use photometric redshift estimates from IR WISE data if no spectroscopic redshift available

Questions to address:

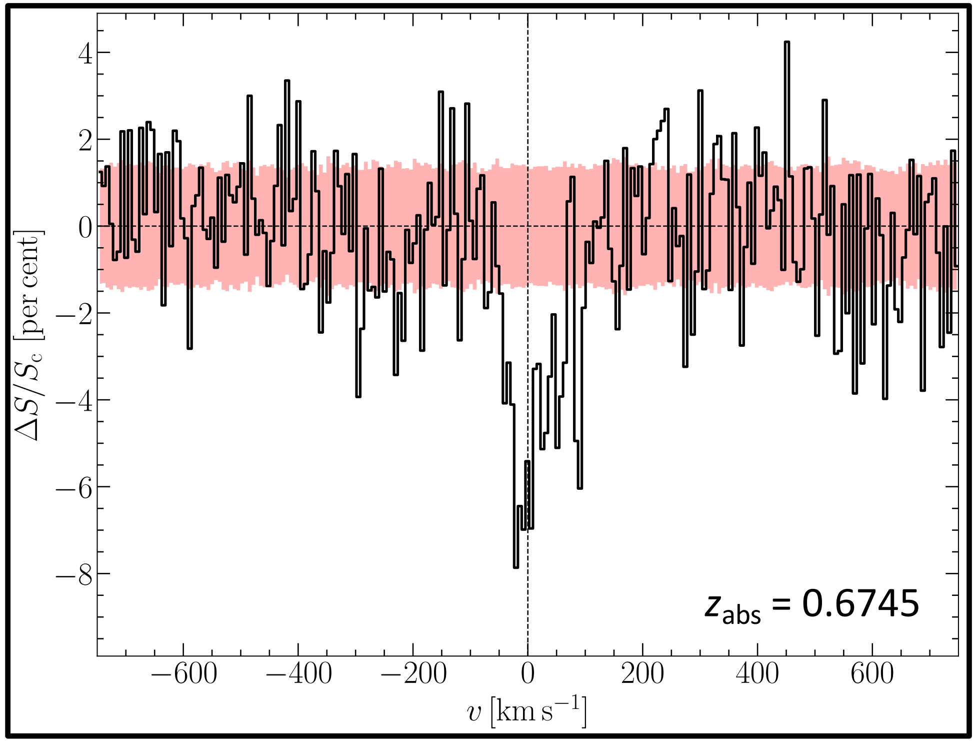
- Is the **detection** rate of HI absorption higher in CSS/GPS sources than in the general radio- galaxy population? How common are objects like PKS 1740-517?
- Do the HI absorption properties of CSS/GPS sources **evolve with redshift?** (i.e. how do the HI properties at $z > 0.4$ compare with those seen in local samples at low redshift?)

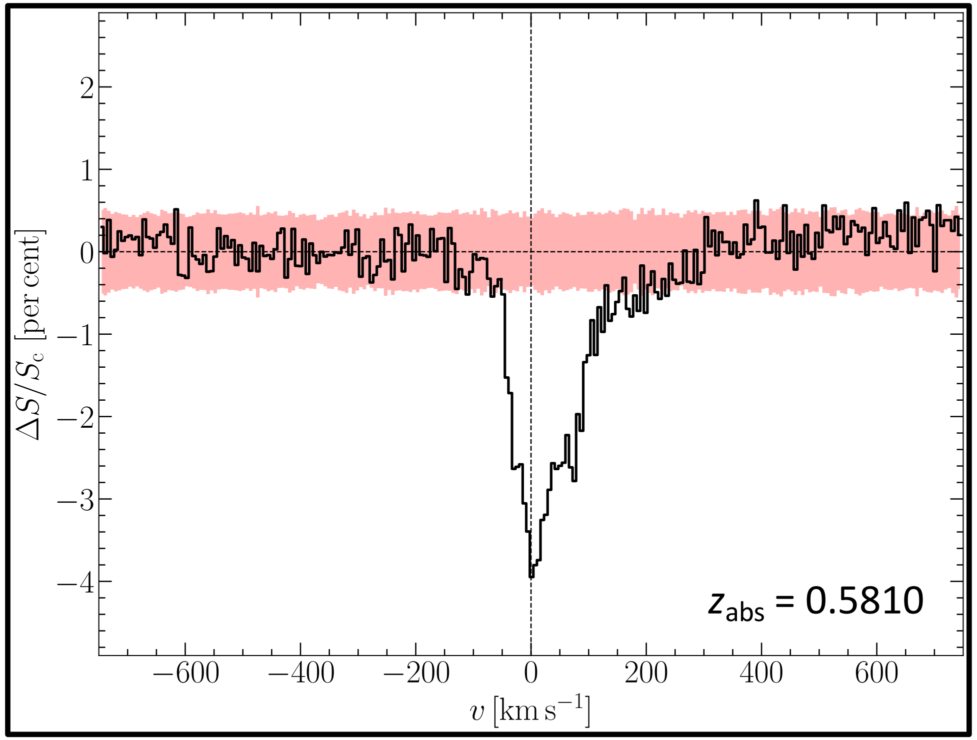
FLASH Pilot: Peaked spectrum sample



FLASH Pilot: Peaked spectrum sample

- 2/3 associated HI absorbers in peaked spectrum radio AGN, consistent with relative detection rates in nearby RGs (Maccagni+ 17)
- Profile asymmetries consistent with non-circular gas kinematics seen in nearby compact radio galaxies (Gereb+ 15)





Summary

- HI absorption maps the **kinematics of neutral gas** in the **central regions** of active galaxies; outflows, infalling clouds
- FLASH is an ASKAP survey for HI absorption in galaxies out to ***z* = 1**
- We expect **several hundred HI absorbers** in **peaked spectrum sources**
- Aim to determine evolution of gas in the population
- In early science we detected PKS1740-517; a young (GPS) radio AGN in a massive host & triggered by interaction with gas rich companion
- Interpretation requires multi-wavelength follow up (optical spectroscopy, VLBI radio continuum, ALMA CO imaging)
- First 1000 sqd now complete and being processed, stay tuned for many detections