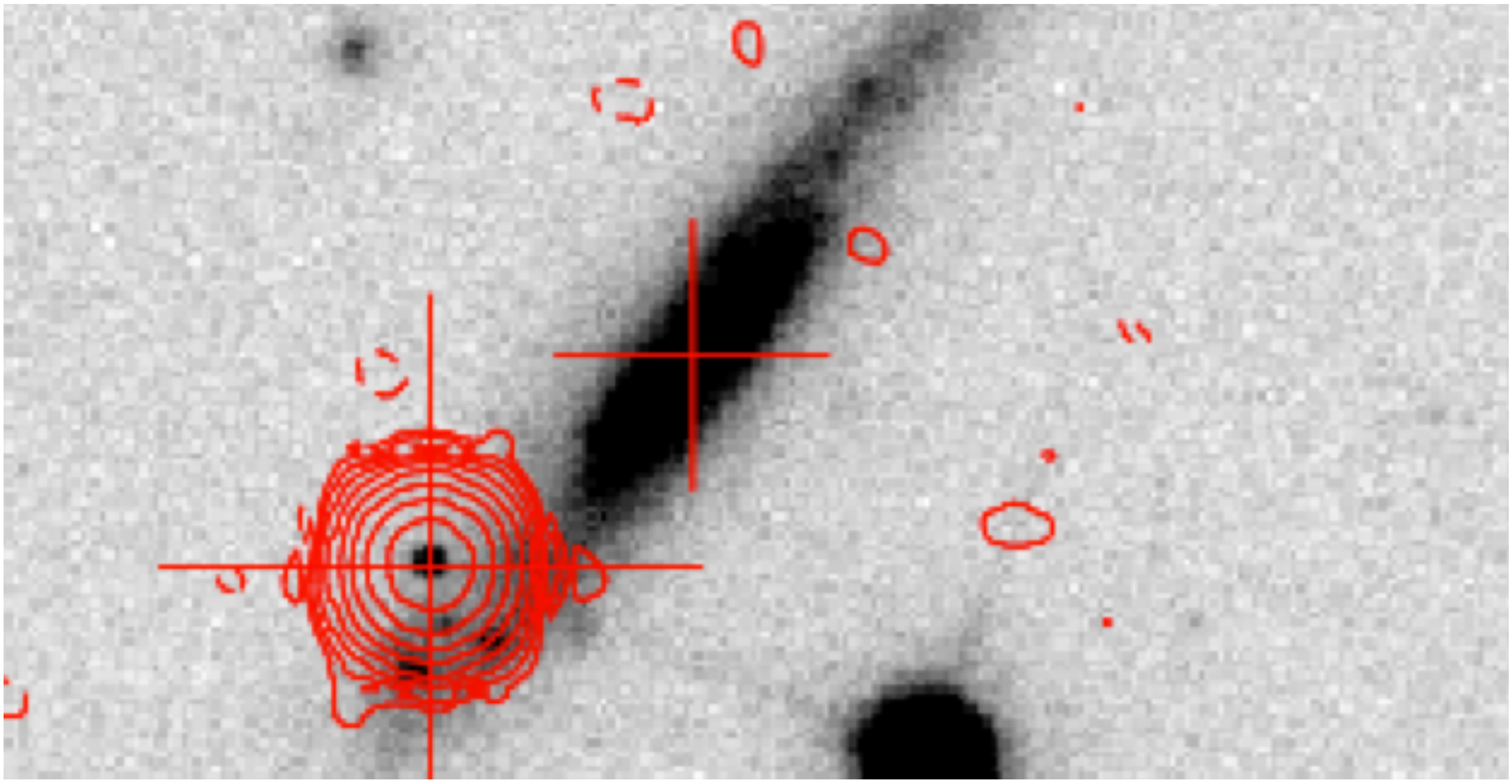


uGMRT and MeerKAT Absorption Line Surveys

Neeraj Gupta (IUCAA)

R. Srianand, Gitika Shukla, Tanvir Hussain (IUCAA);
MALS collaboration (SALT+NOT), and NRAO CASA

Radio absorption line searches driven by optical surveys

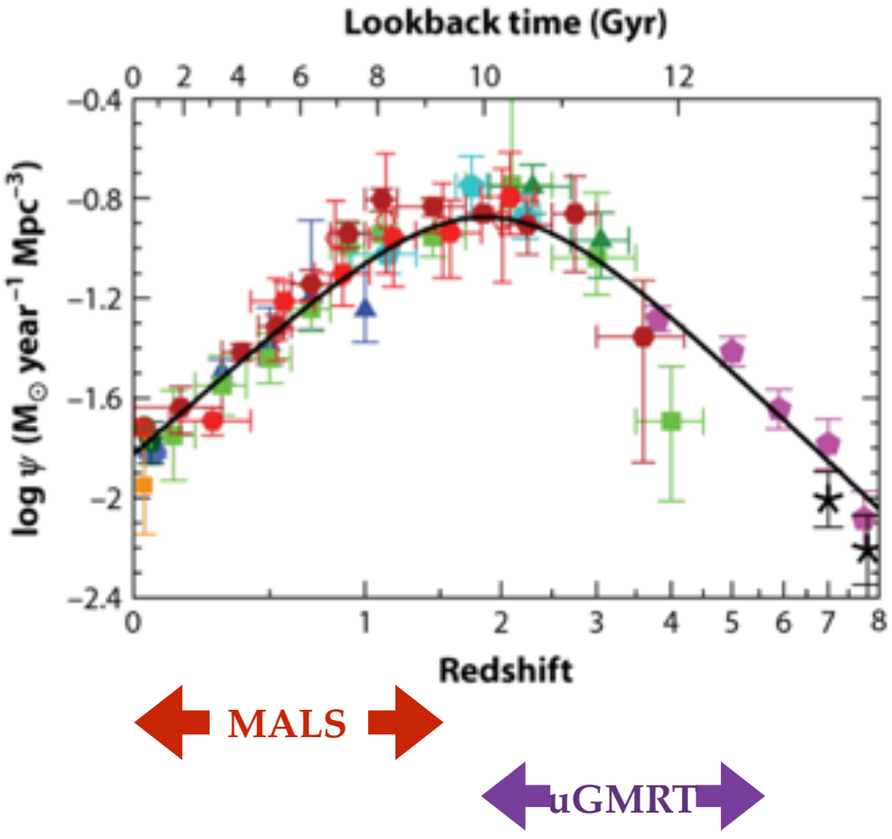
(Multi-wavelength information is essential but - in this case - can limit the scope)

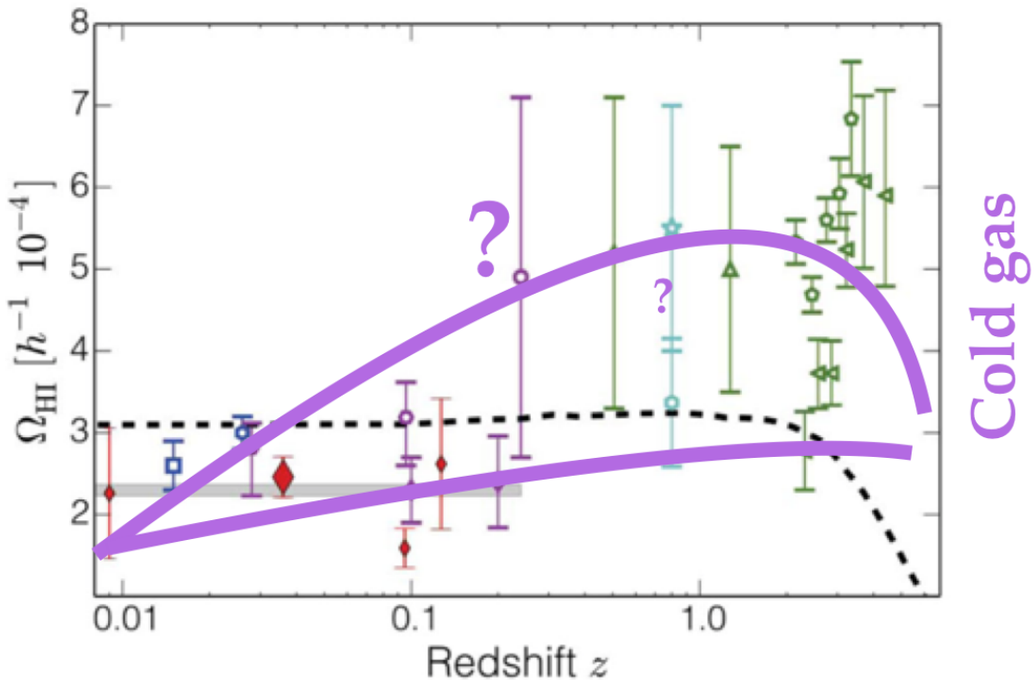
Dust-unbiased surveys of radio absorption lines

- uGMRT: 0<z<0.4 blind search of intervening HI 21-cm absorption
- uGMRT: 2<z<5 blind search of intervening and associated absorption
- MeerKAT Absorption Line Survey: 0<z<1.5:
  - deep HI + OH absorption survey for associated and intervening absorption

Possible only to due to wide-band capabilities

Evolution of cold gas in galaxies





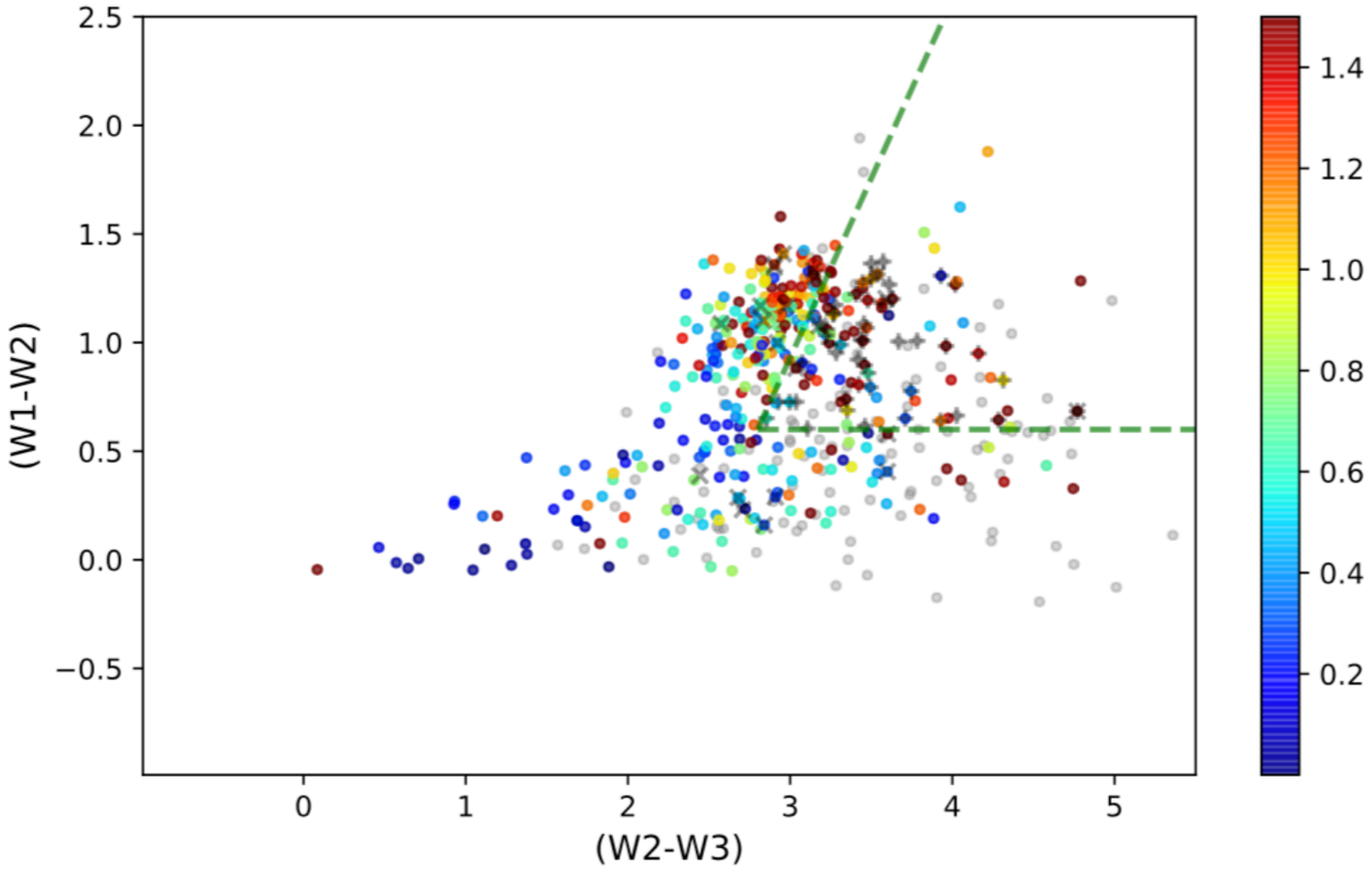
MALS

uGMRT

HI 21-cm and OH 18-cm absorption to trace cold atomic and molecular gas

uGMRT (band-5) blind HI 21-cm absorption line search (0<z<0.4)

uGMRT (band 5): 0<z<0.4

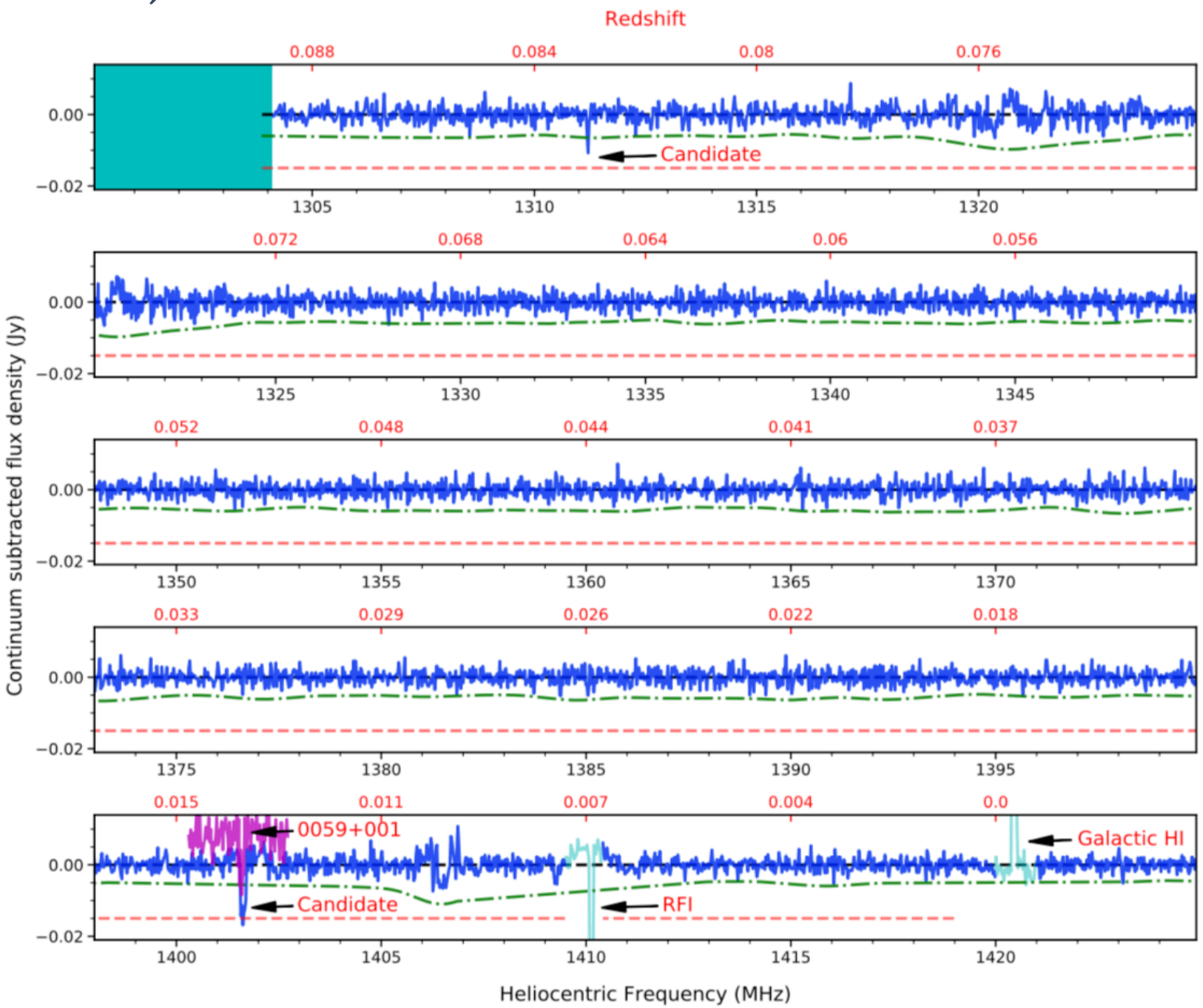


Sample: 1.4 GHz flux density > 1 Jy and WISE color cuts (no dust bias)

50/117 observed (Jan/Feb 2018): ~30 mins per source

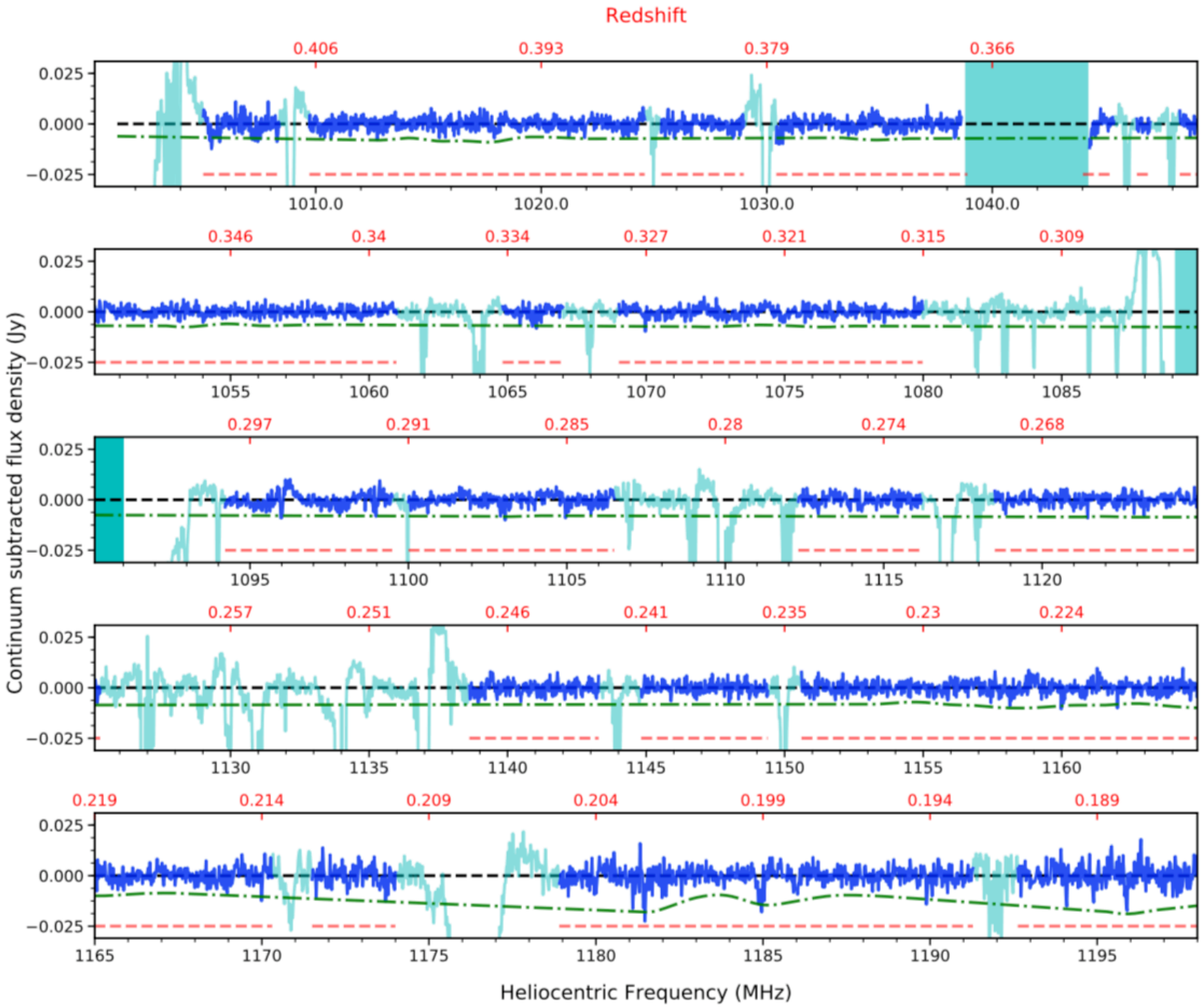
Two frequency settings (200 MHz/ 8192 channels)

uGMRT (band 5): 0<z<0.4



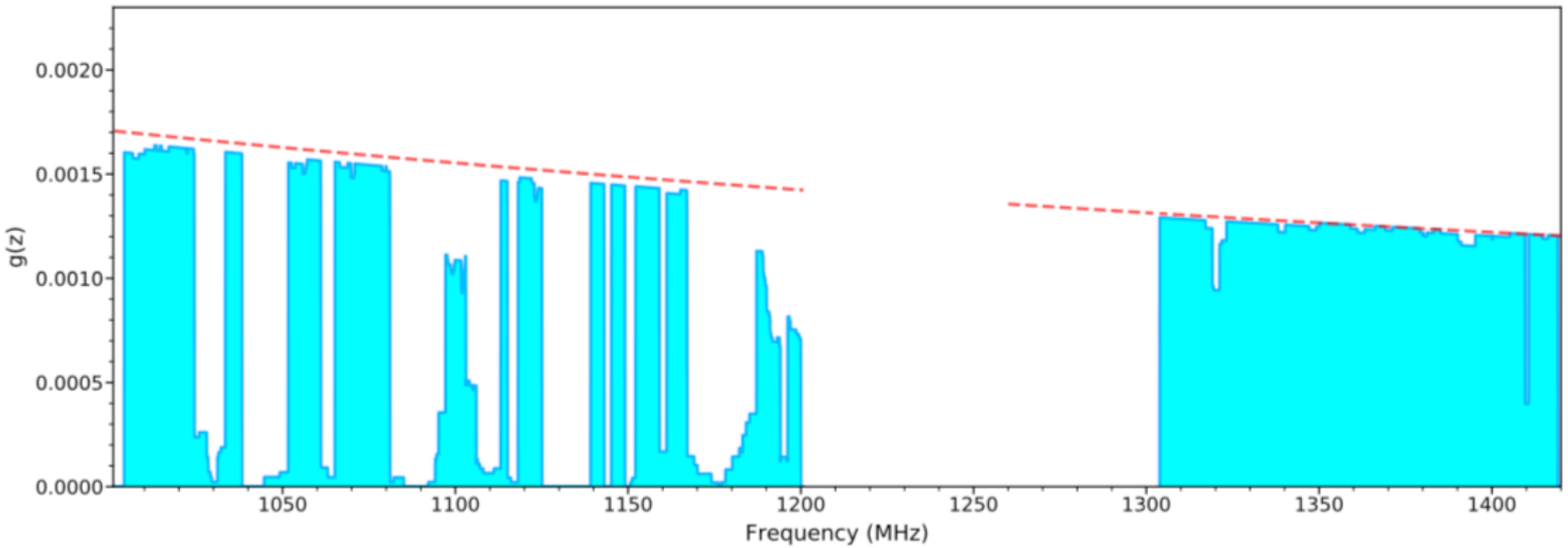
Higher-frequency setup

uGMRT (band 5): 0<z<0.4



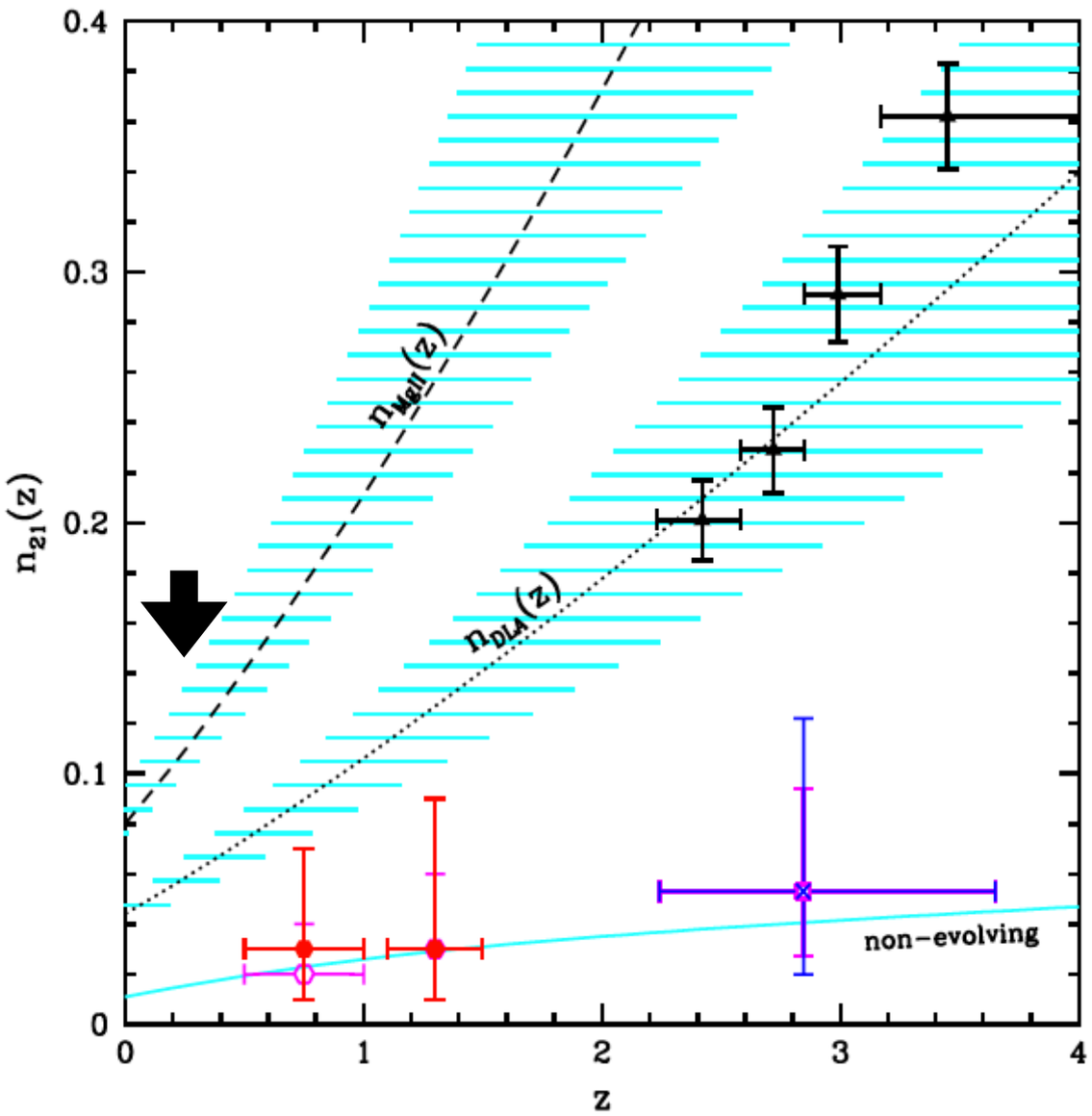
Lower-frequency setup

uGMRT (band 5): 0<z<0.4



g(z): the sensitivity function for 5×10^{19} cm^{-2} gas (50% loss due to RFI)

uGMRT (band 5): 0<z<0.4



Total Redshift path ~ 9

Larger survey to constrain cold gas cross-section is needed.

The MeerKAT Absorption Line Survey (MALS)
(0<z<1.5)

PIs: N. Gupta and R. Srianand

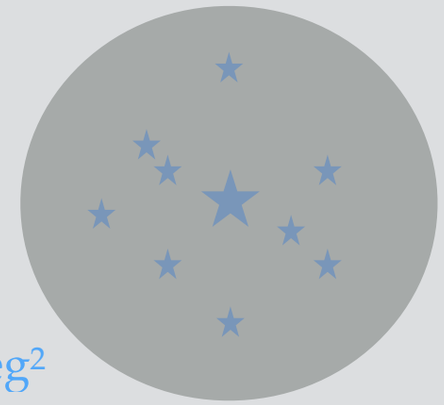
http://mals.iucaa.in/

The MeerKAT Absorption Line Survey (MALS)

MALS phase	Number of pointings	Time per pointing (mins)	Spectral rms† (mJy beam^{-1})
L-band (900-1670 MHz)	740	56	0.5
UHF-band (580-1015 MHz)	370	121	0.6

† 900-1670 MHz; ‡ 580-1015 MHz.

Each pointing will be centered on a >400 mJy radio source.



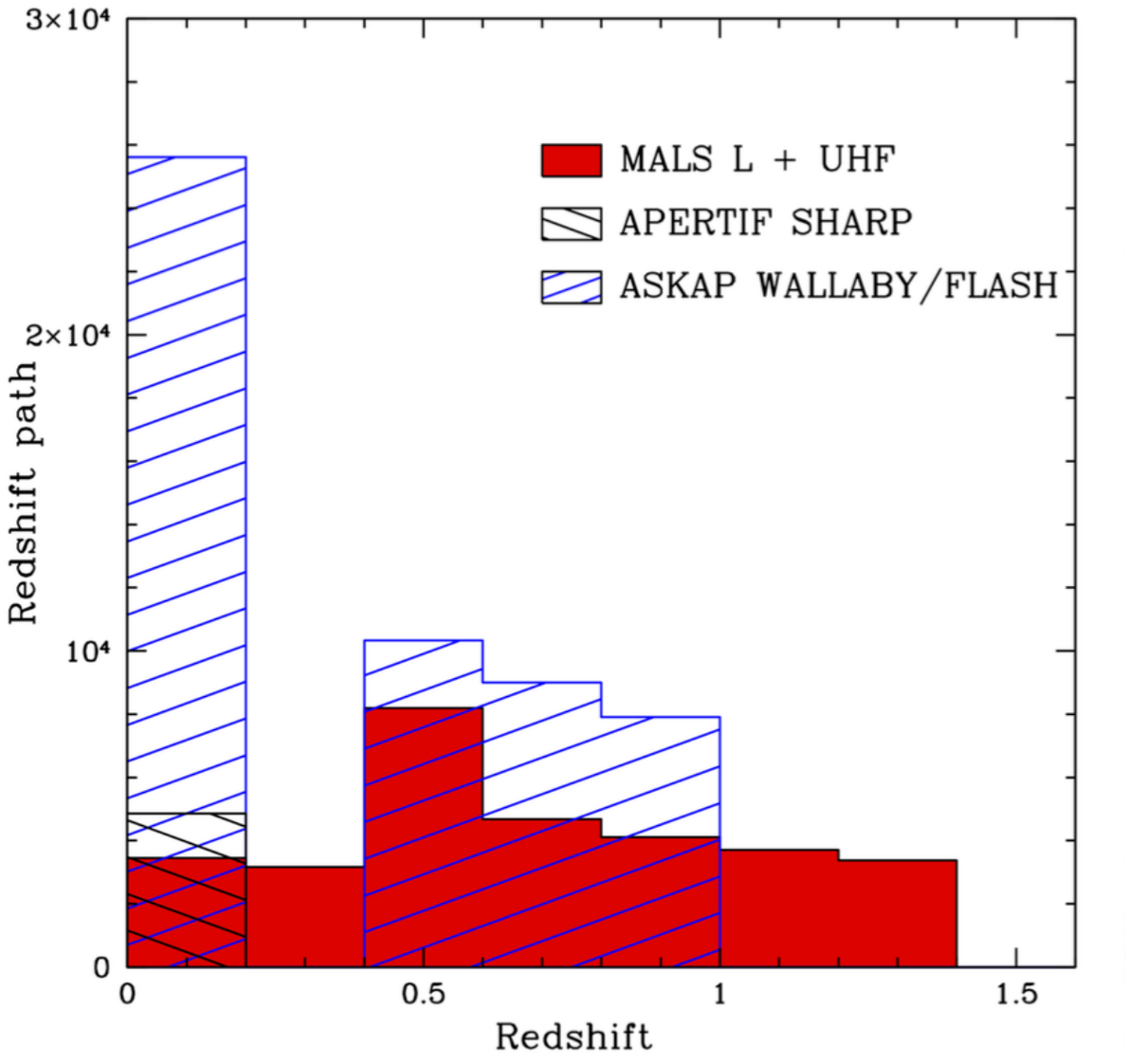
L-band: 1 deg^2

Total 1655 hrs

Main science themes:

- Evolution of cold gas in galaxies and its relationship with SFR density **(~200 detections)**,
- Fuelling of AGN, AGN feedback and determining fraction of dust-obscured AGNs **(~500 detections)**,
- Variation of fundamental constants of physics: most stringent constraints (comparable to terrestrial atomic clocks).

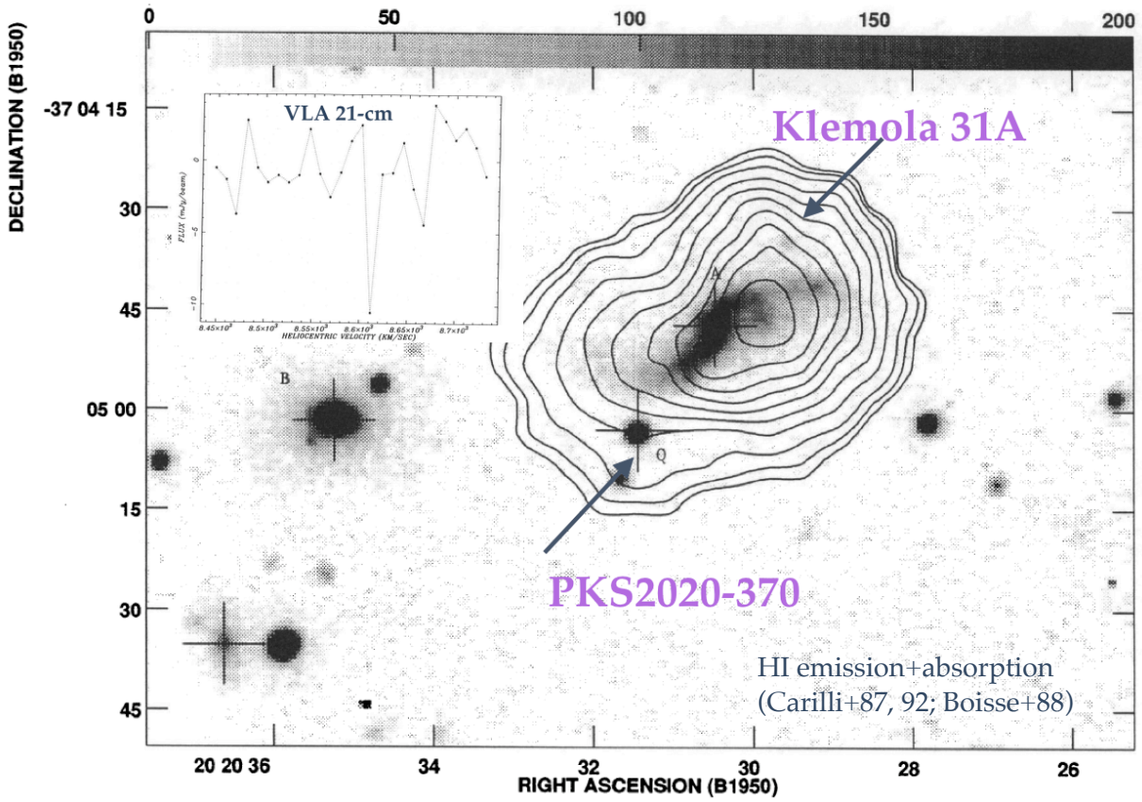
Comparison with other surveys



Uniform coverage over 0<z<1.5

+ HI emission, and deep continuum and polarisation images

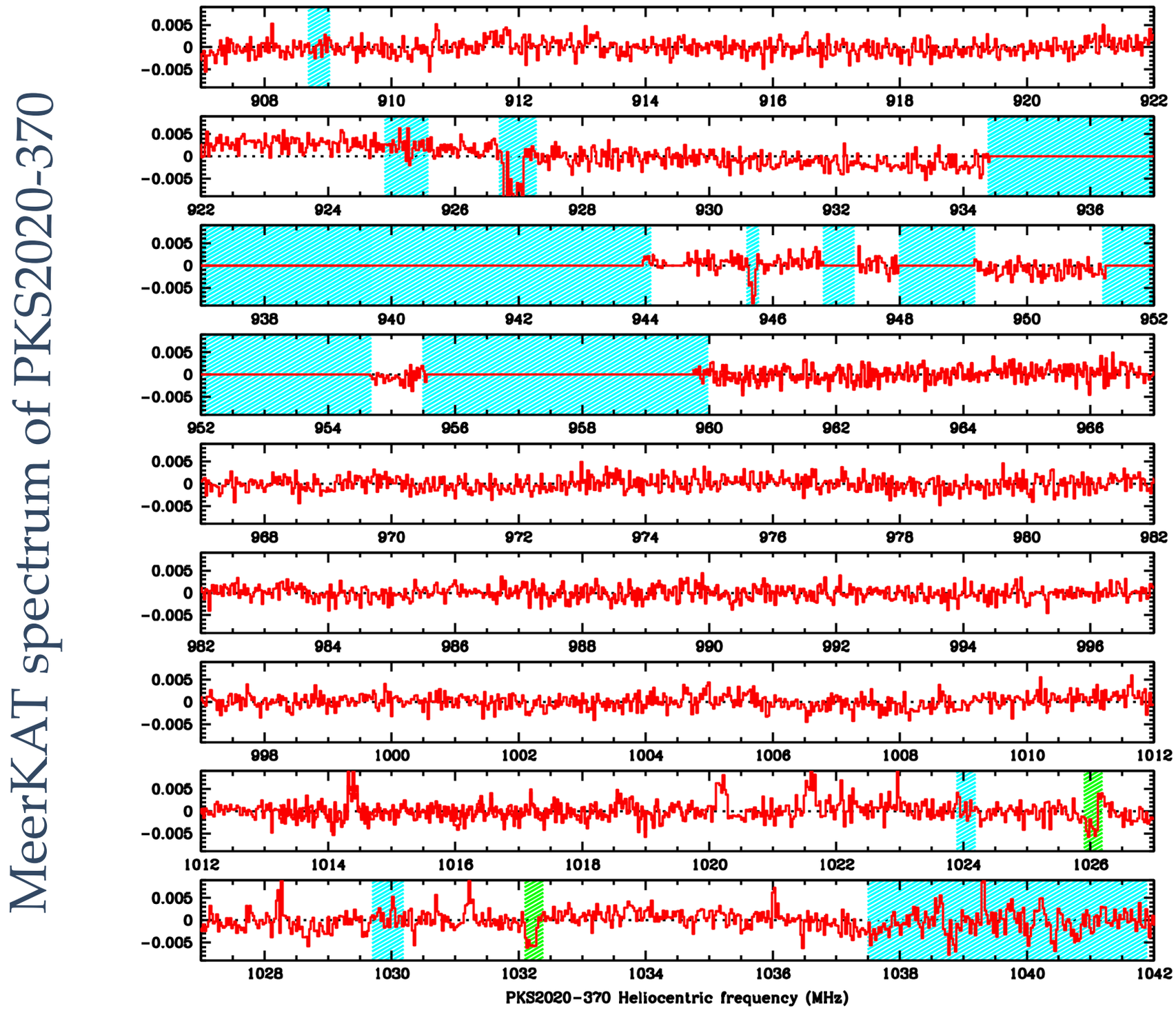
MALS: commissioning (PKS2020-370)



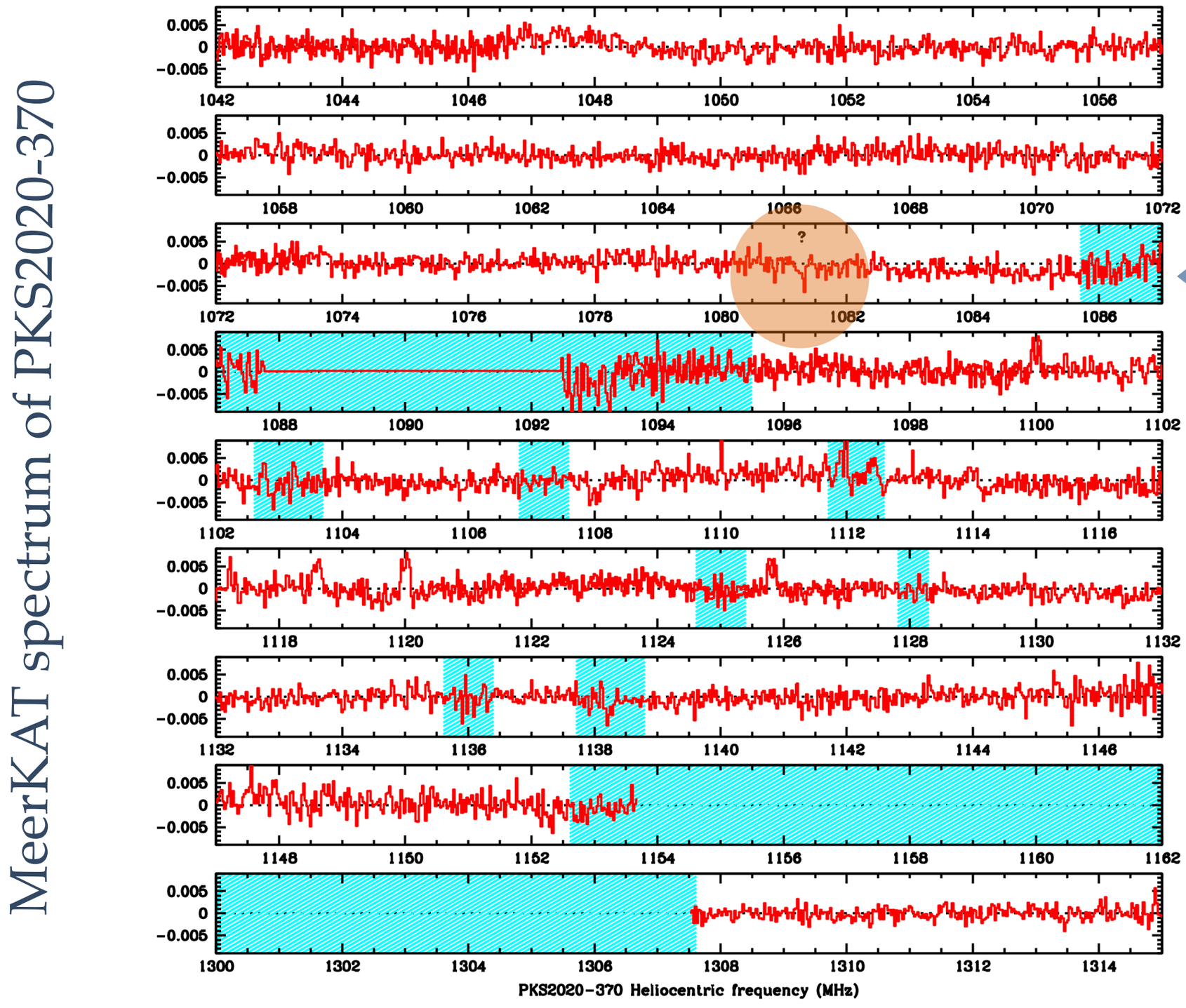
- MeerKAT-16
- Lband: 856 MHz
- ROACH-2 correlator: 32K mode
- Flux/BP: PKS1934-638
- Gaincal: PKS1954-388
- On-source time: 5.8 hrs
- Data Volume: 700 GB

Date of observation	Antennas
D1: Nov 7, 2017 (UTC 15:23 – 21:40)	16 antennas: m003, m006, m021, **m023**, **m032**, m033, **m039**, **m043**, **m044**, **m045**, **m050**, **m053**, m054, m057, m059, m061
D2: Nov 9, 2017 (UTC 17:30 – 21:28)	14 antennas: m003, m006, **m011**, m021, m033, **m048**, **m051**, **m052**, m054, **m055**, m057, m059, m061, **m062**

MALS: commissioning (PKS2020-370)

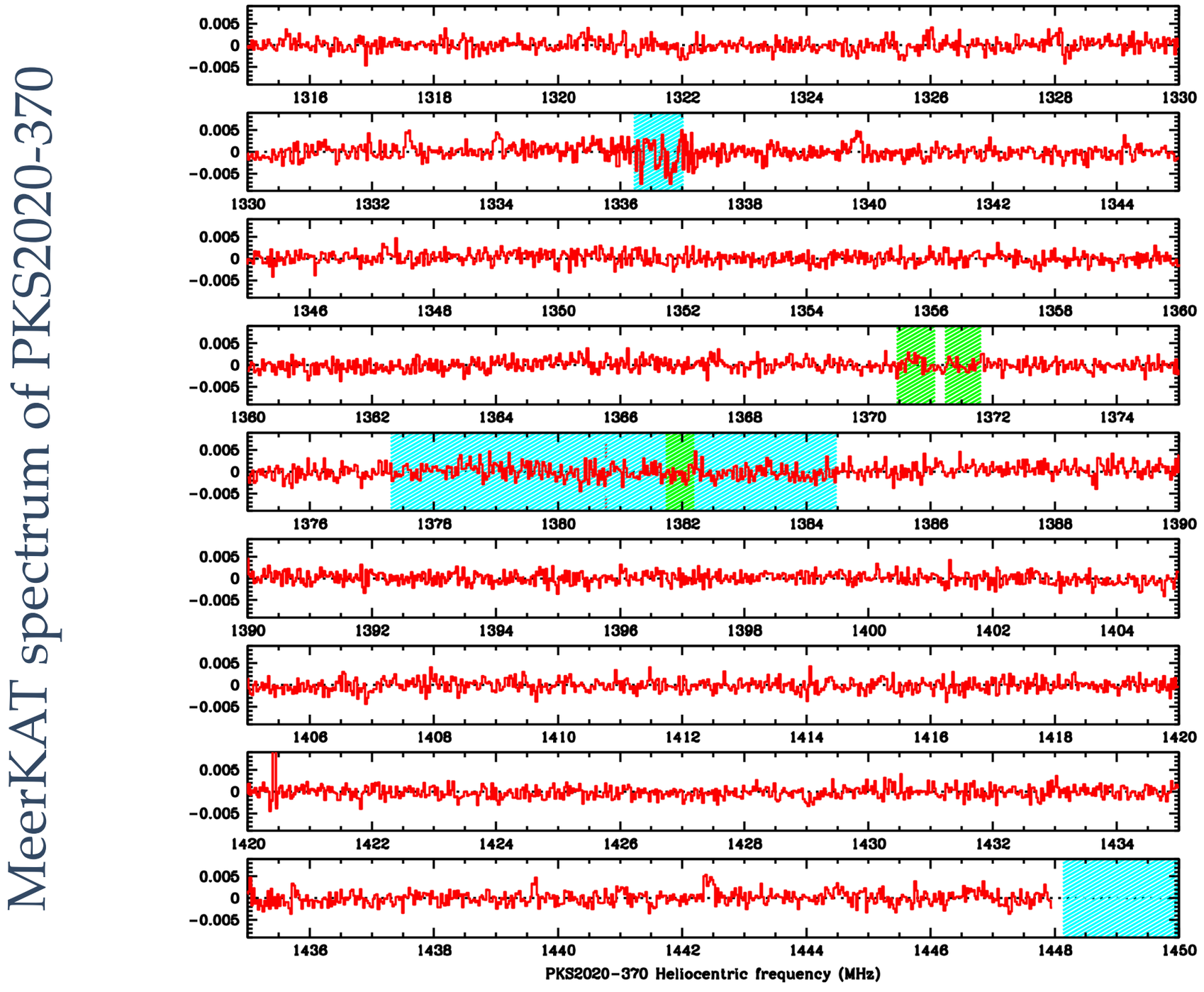


MALS: commissioning (PKS2020-370)



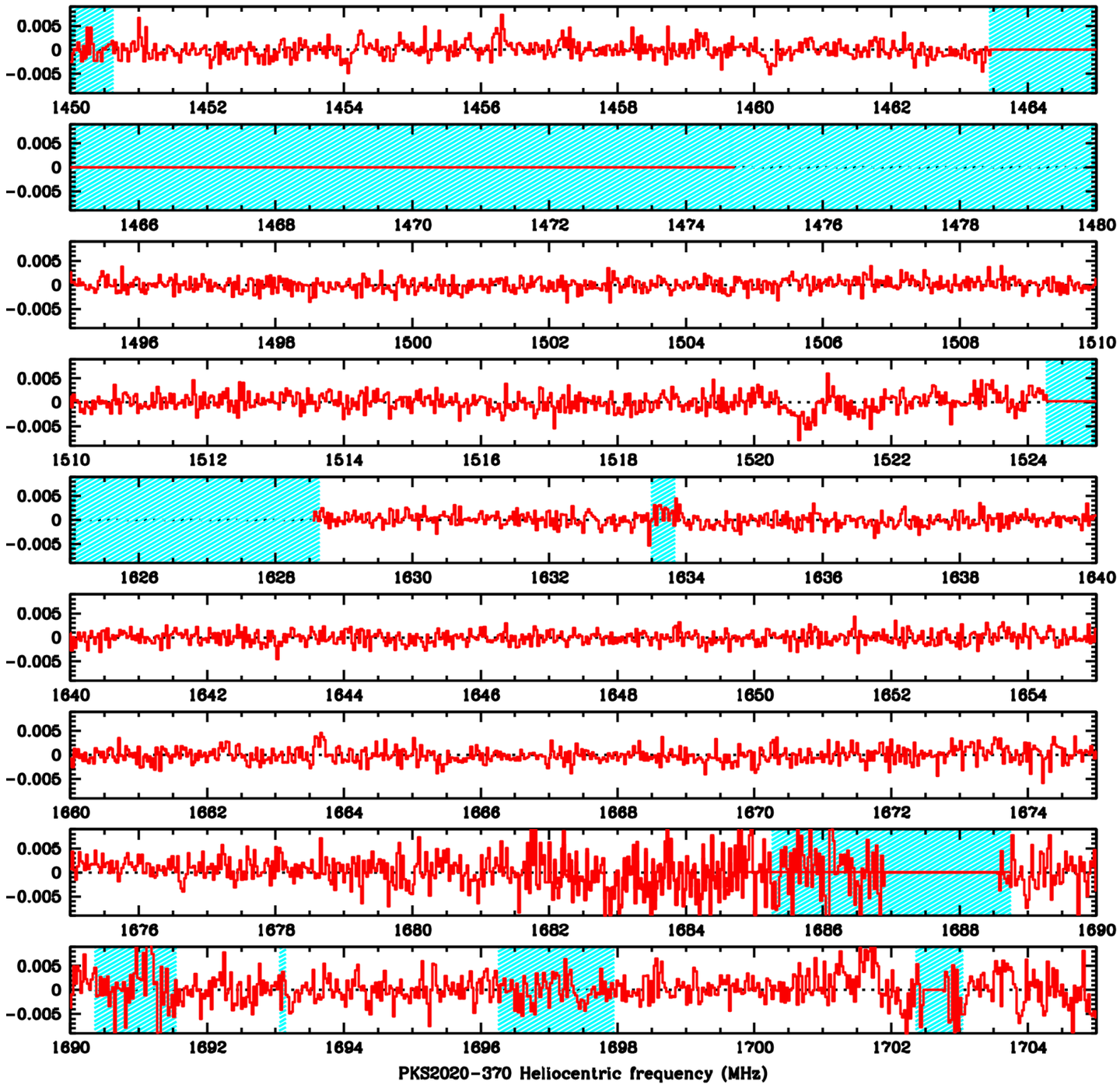
Tentative

MALS: commissioning (PKS2020-370)



MALS: commissioning (PKS2020-370)

MeerKAT spectrum of PKS2020-370



MALS: commissioning (PKS2020-370)

MeerKAT spectrum of PKS2020-370

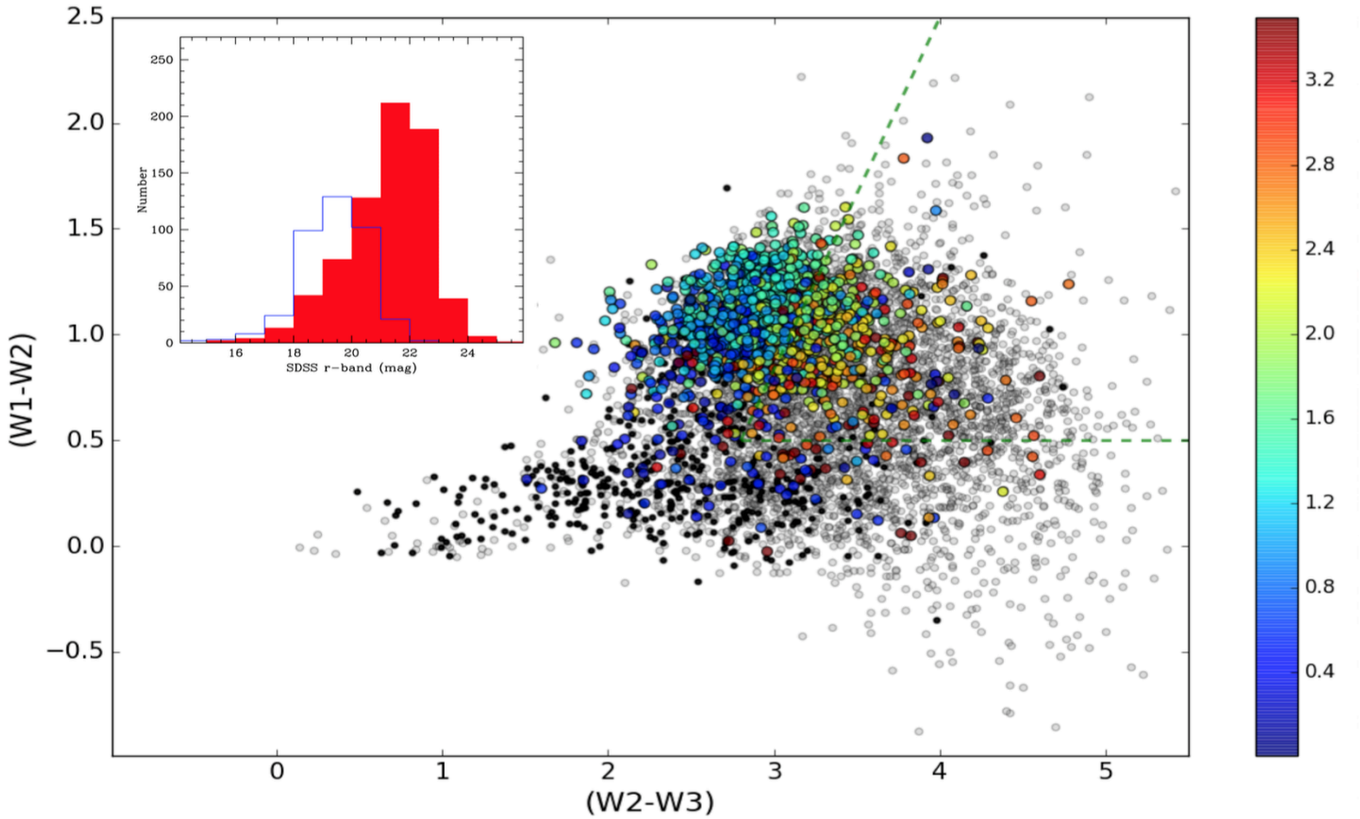
- Variability of HI 21-cm line
- Spectral rms higher by 1.3 - 1.5 (only in 32K mode)

Frequency (MHz)	Observed spectral rms (mJy/beam)	Theoretical spectral rms (mJy/beam)	Flux density (mJy)
1000	1.4	1.1	362
1150	1.4	0.9	353
1400	1.2	0.9	355
1650	1.2	0.9	355

Looking forward to SKARAB 32K mode.

MALS: SALT/NOT survey

- Scarcity of bright (>200 mJy) high-z quasars in the southern hemisphere
- Lack of uniform spectroscopic catalog

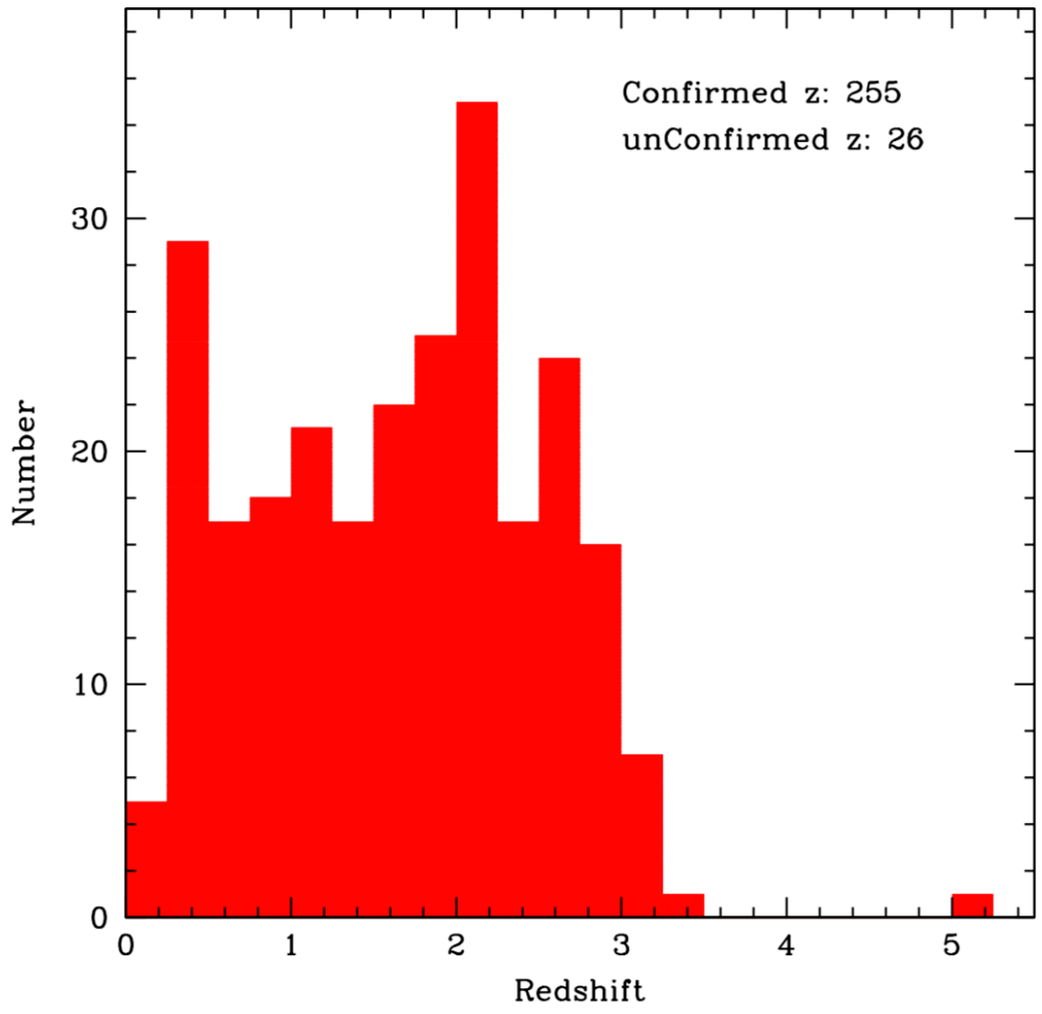


Sample of 373 targets observed

SALT: 232 (IUCAA, Rutgers and South Africa collaboration; 180 hrs)

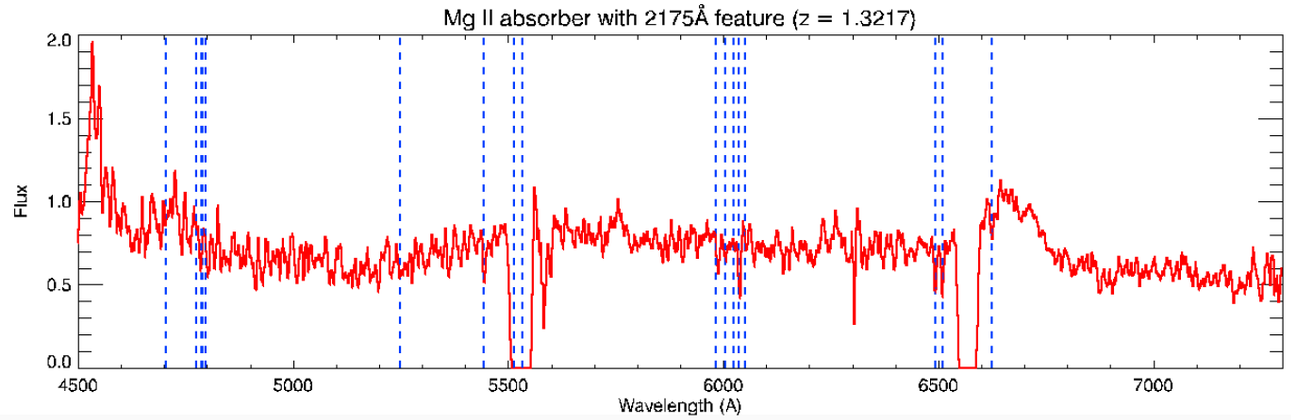
NOT: 94 (Published as Krogager+18; 6 nights)

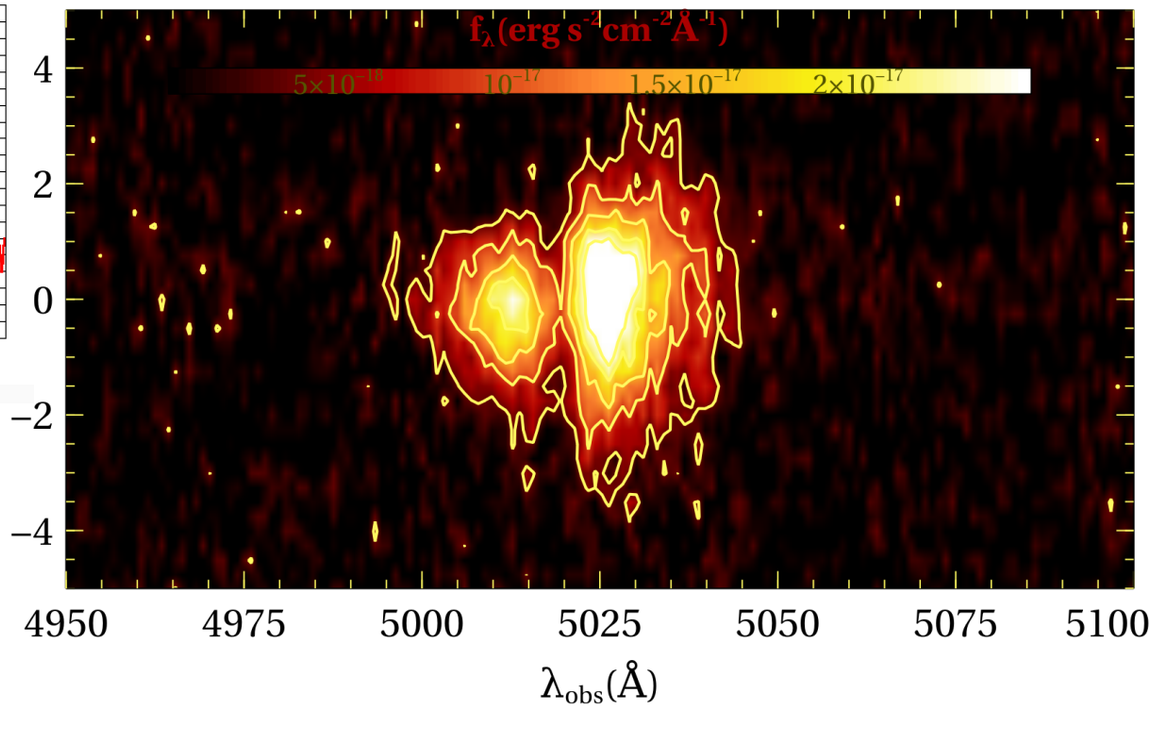
MALS: SALT/NOT survey



(Unique IR selected sample for AGN and absorption line studies)

The brightest radio loud quasar at z>5





Detection of dust signatures

(order of magnitude larger than SDSS)

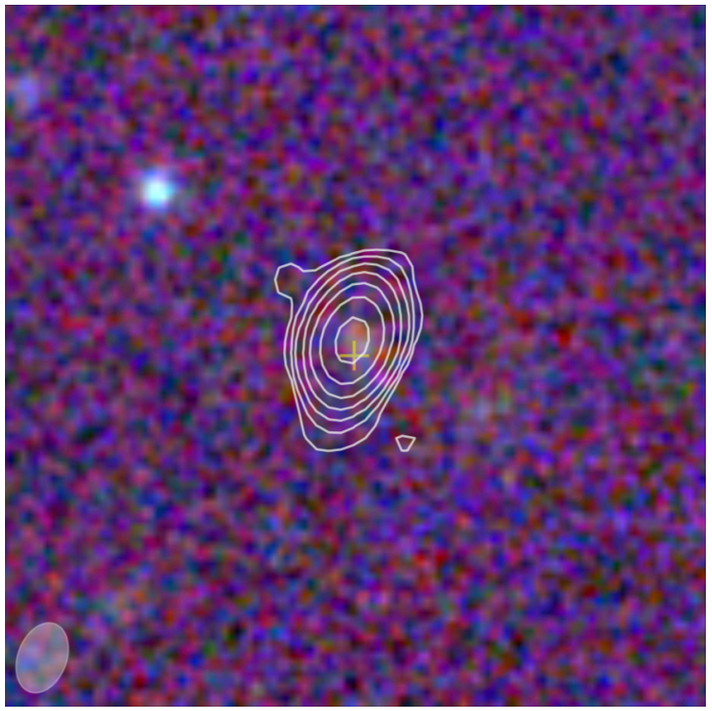
Extended Lya halos

(Hosted by powerful radio sources)

Unique IR selected sample for AGN and absorption line studies

Remaining objects: blazars, dusty AGNs, and high-z quasars

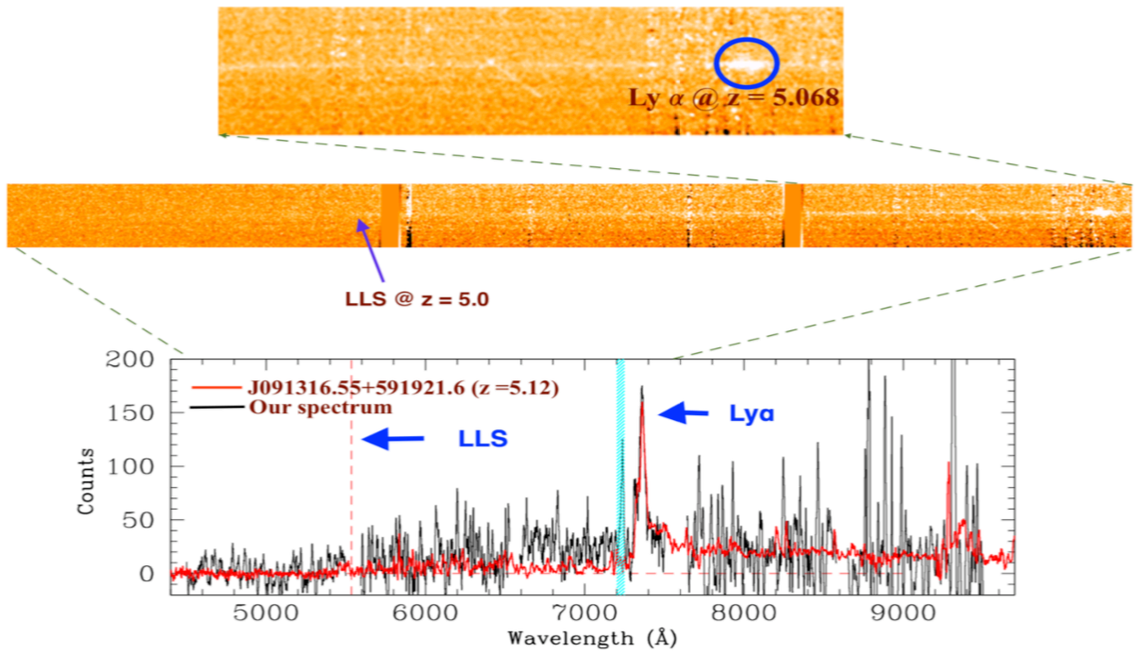
The brightest radio loud quasar at z>5



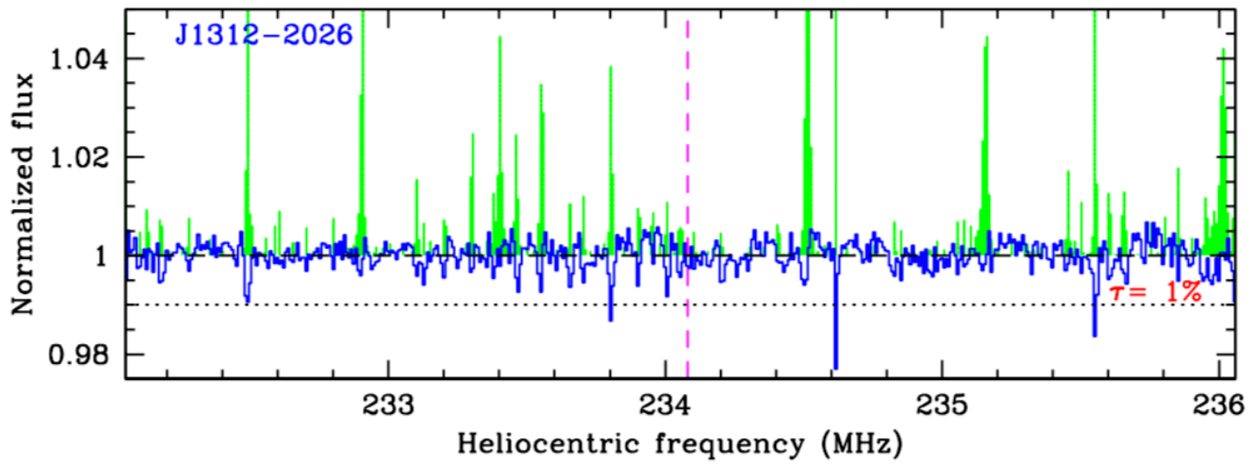
PS1(yig) - uGMRT(1.4GHz)

$L_{1.4GHz} = 1.2 \times 10^{29}$ W / Hz; R = 1.4×10^{4}

Hosted by a Compact Symmetric Object?



SALT spectrum



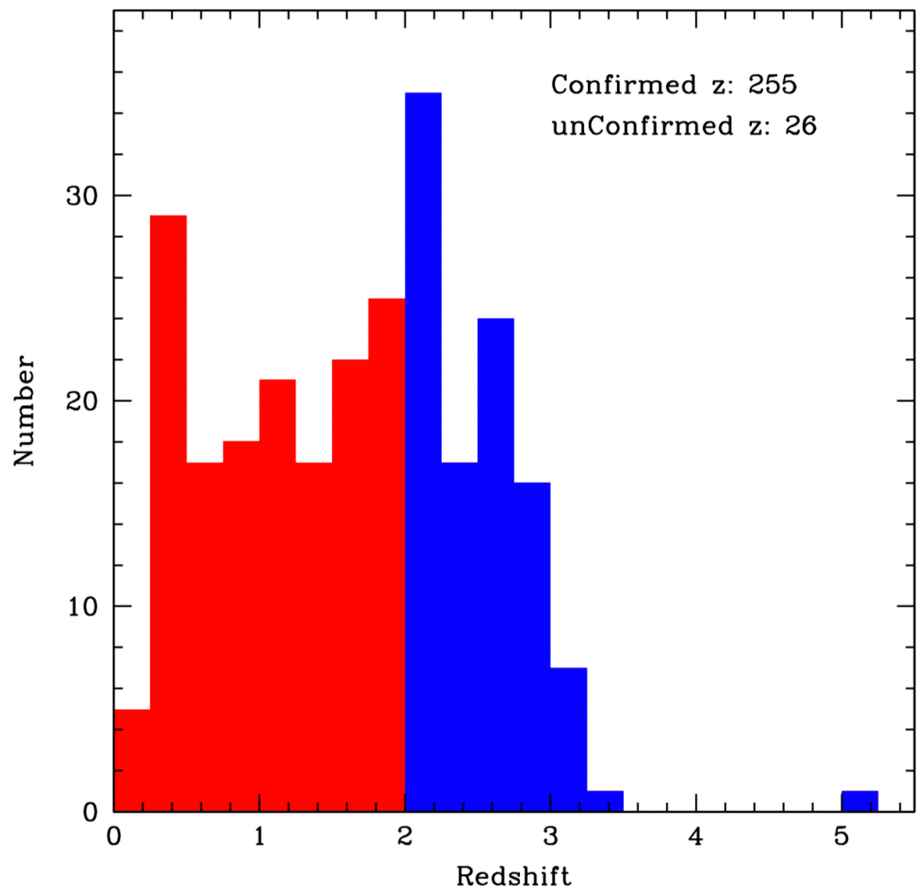
uGMRT band-2 spectrum

uGMRT (band-2,3) blind HI 21-cm absorption line search

(complete information on Lya and CIV absorption from SALT/NOT)

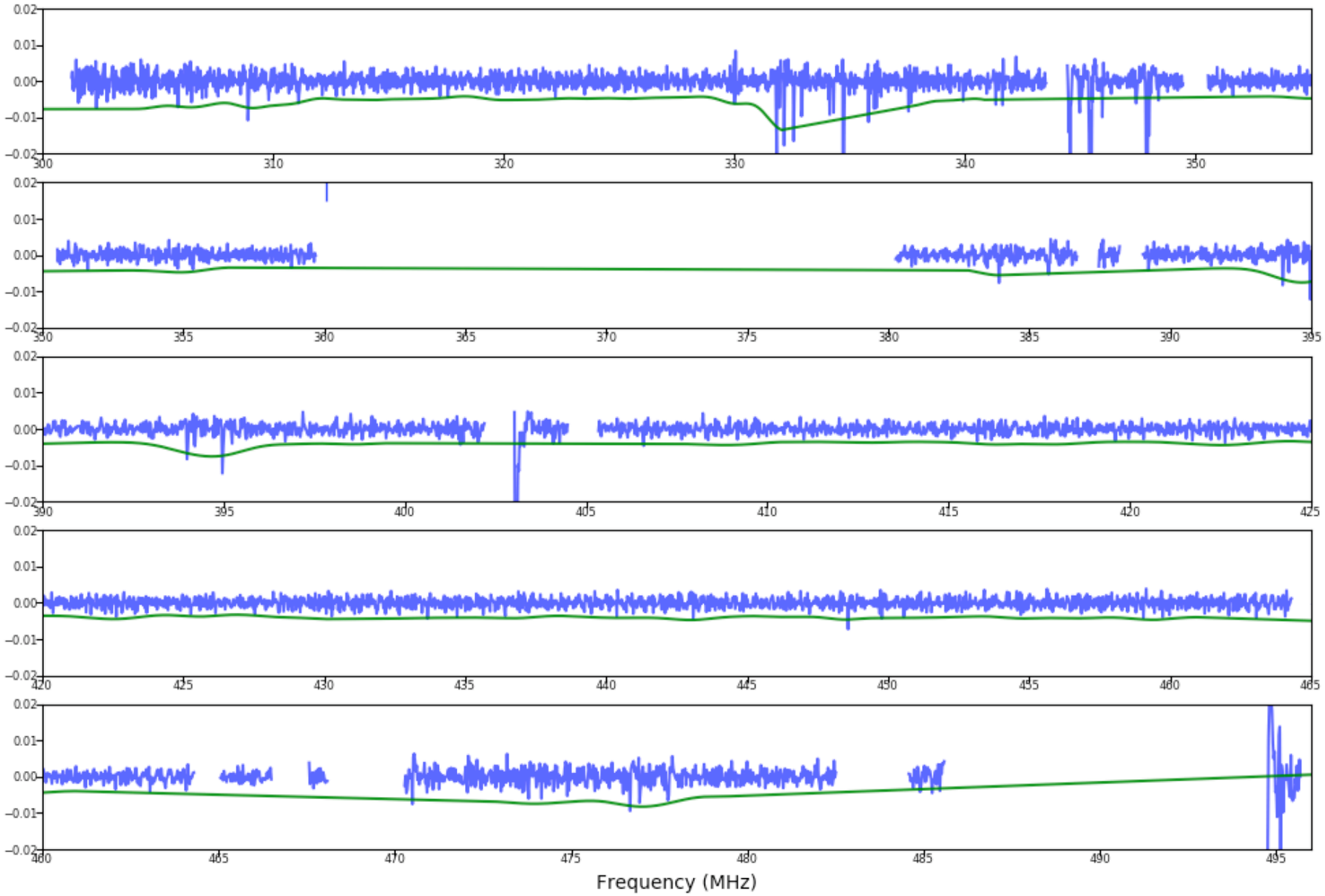
uGMRT (band 2,3)

All 102 objects observed (Sep 2018): ~45 mins per source
Single frequency settings (200 MHz/ 8192 channels)



Redshift path, Δz=60

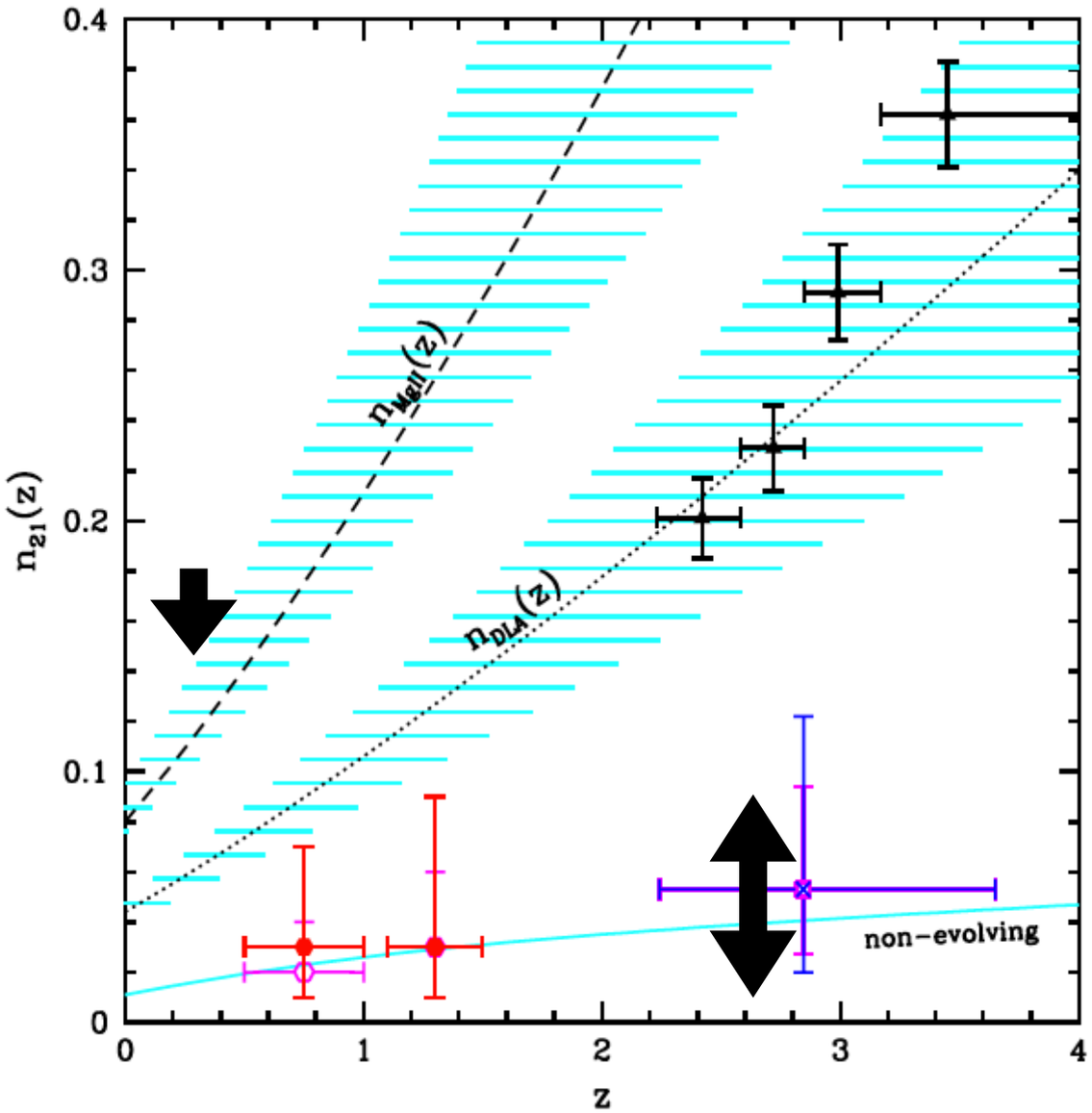
uGMRT (band 2,3)



2 intervening and 5 associated absorption candidates

(First exploration of Band-2: need confirmation at higher spectral resolution)

uGMRT: L and P-band constraints on n_{21}



Summary

- First results from:
  - uGMRT: 0<z<0.4 blind search of intervening HI 21-cm absorption
  - uGMRT: 2<z<5 blind search of intervening and associated absorption
- MeerKAT Absorption Line Survey: 0<z<1.5:
  - deep HI + OH absorption survey for associated and intervening absorption