Young radio galaxies in the early Universe

A serendipitous HI 21-cm line absorption survey with the MWA

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ON BEHALF OF

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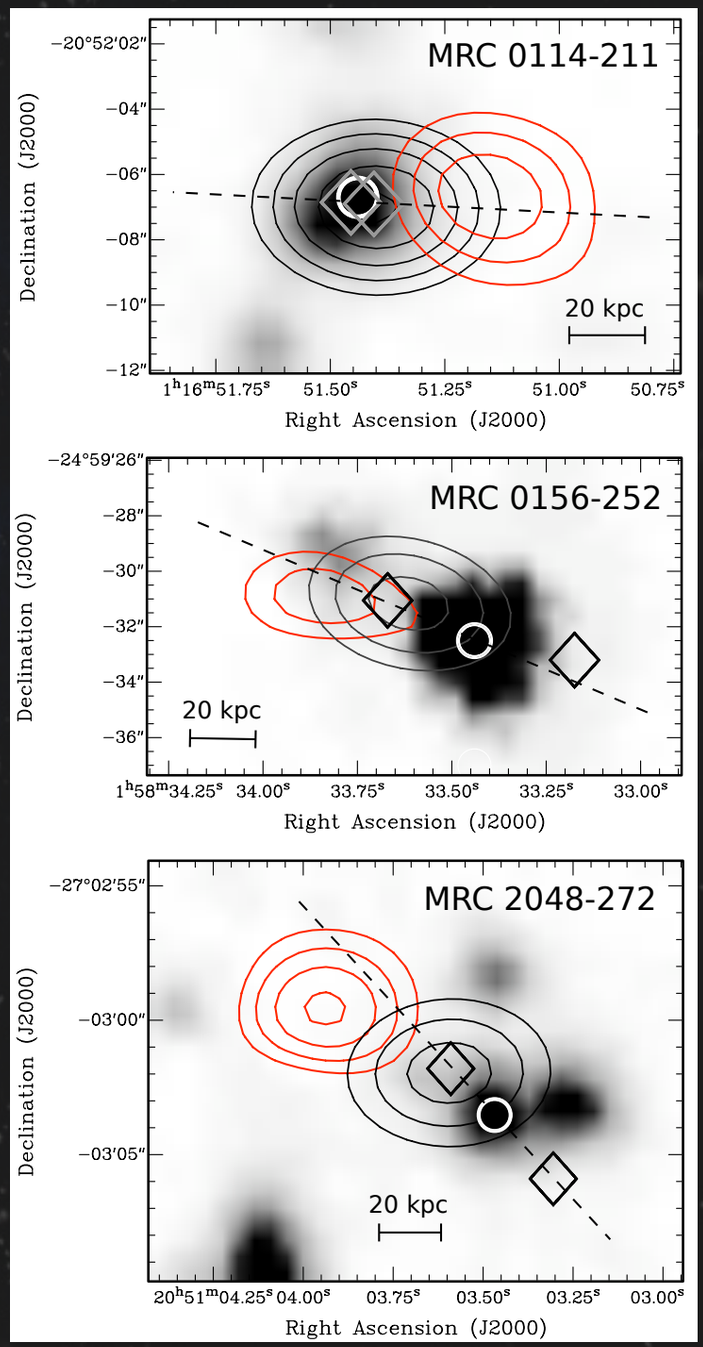
- Elizabeth Mahony (USyd/CAASTRO)
- Martin Bell (UTS)

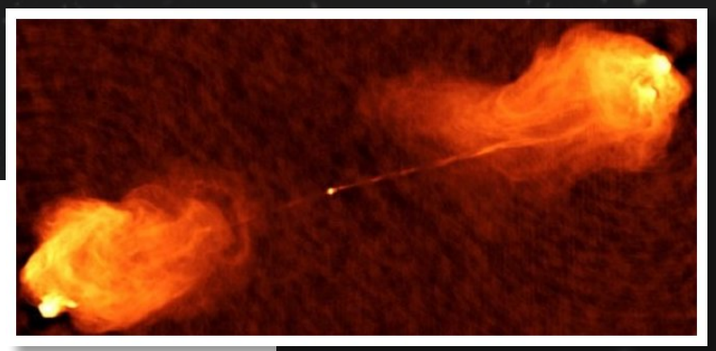
BEACONS OF GALAXY FORMATION IN EARLY UNIVERSE

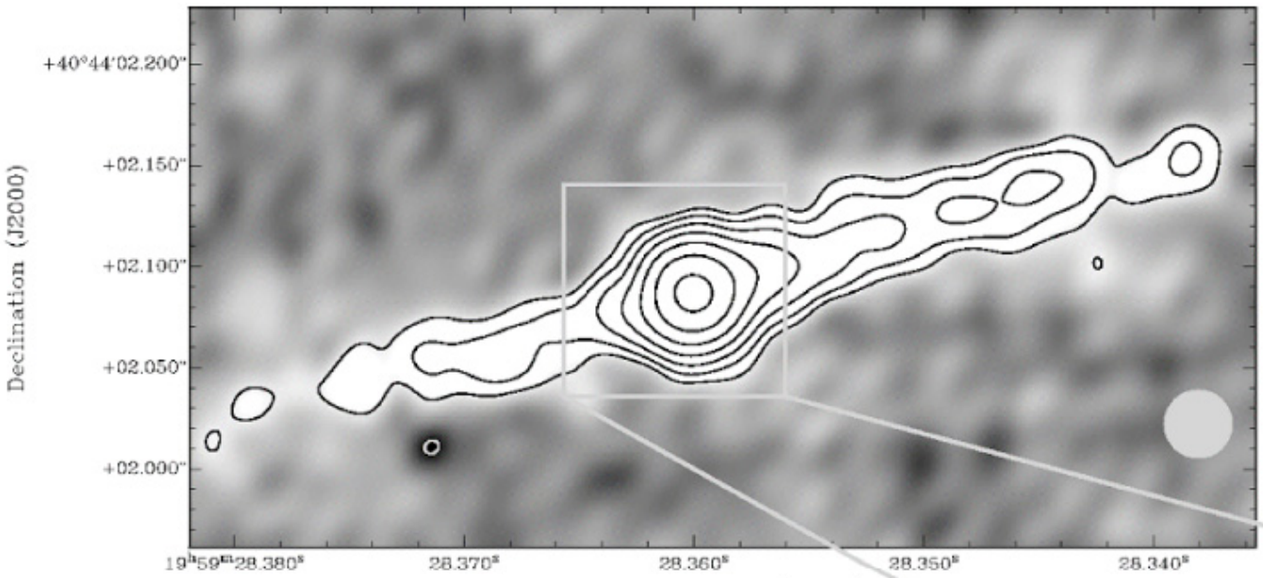
- In the nearby Universe, radio galaxies regulate gas cooling in massive haloes and ultimately limit galaxy growth (Croton+ 06)
- In the high redshift ($z > 2$) Universe, powerful RGs are located in regions of massive galaxy formation
- Significant role in triggering star formation (Emonts+ 14) & driving fast outflows of gas (Nesvadba+ 08)



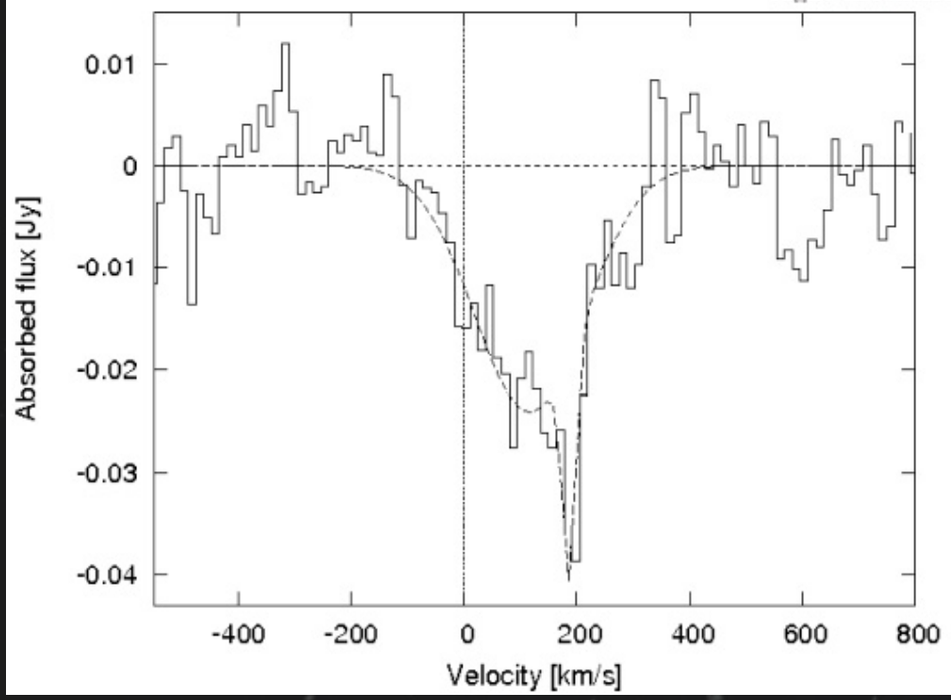
Emonts+ 14

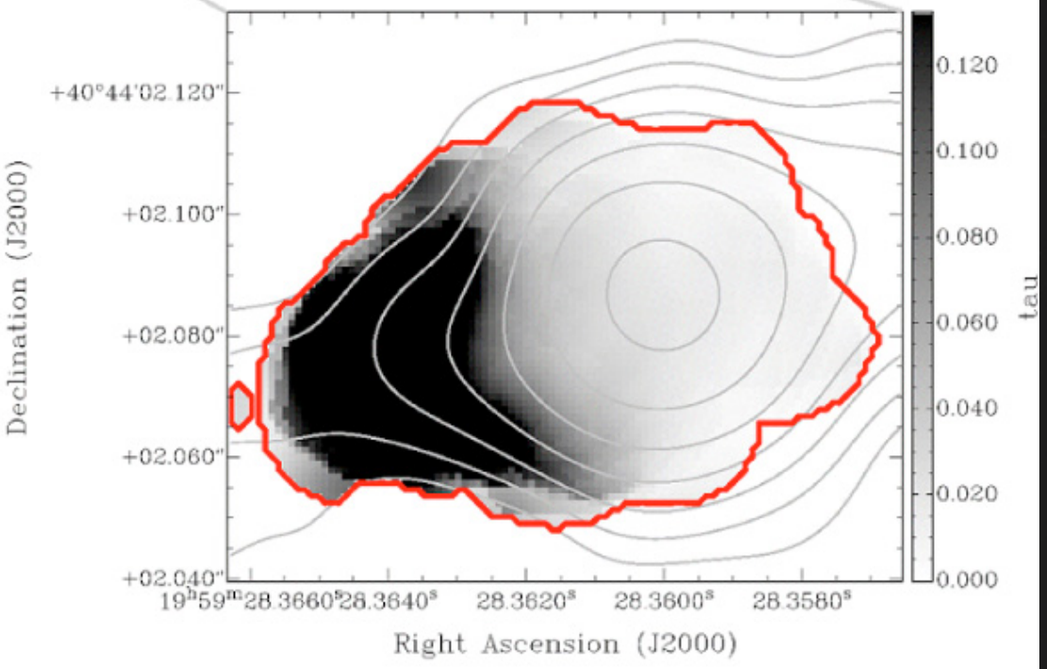
21-CM LINE ABSORPTION





Cygnus A
Struve & Conway 10





DETECTABILITY

- Several factors determine absorption detectability

The line-integrated fractional absorption $\Delta S/S_{\rm cont}$ i.e. **the observable**

The fractional area of source covered by the absorber

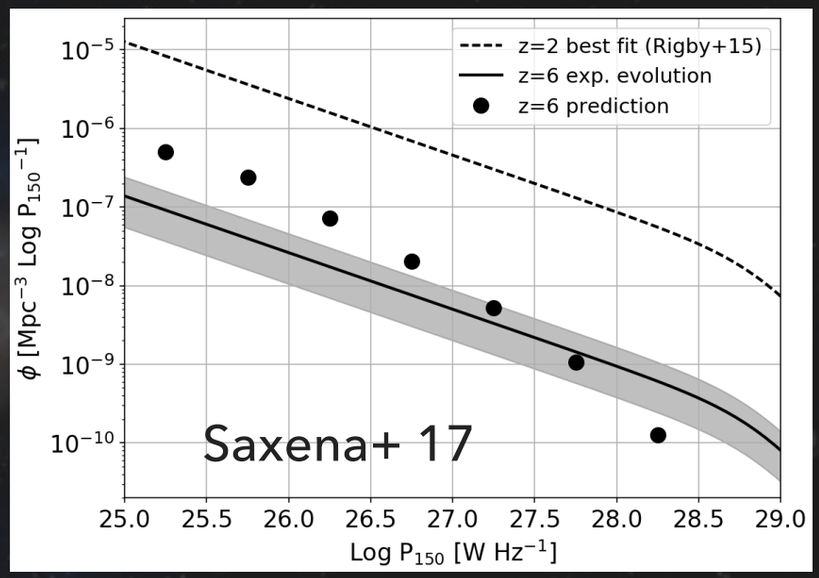
$$\int \tau_{\rm obs}(v)\,{\rm d}v \approx \left(\frac{N_{\rm HI}}{1.823\times10^{20}\,{\rm cm^{-2}}}\right)\left(\frac{f}{1.0}\right)\left(\frac{100\,{\rm K}}{T_{\rm spin}}\right)\,{\rm km\,s^{-1}}$$

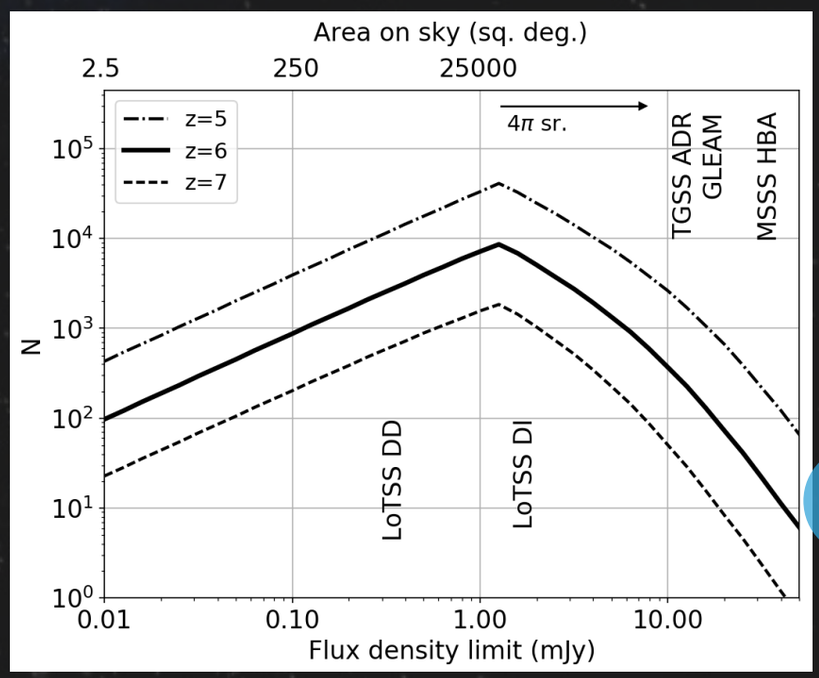
The total HI column density

The harmonic mean excitation ("spin") temperature for the 21-cm line

THE EXPECTED NUMBER OF BRIGHT Z > 5 HZRGS

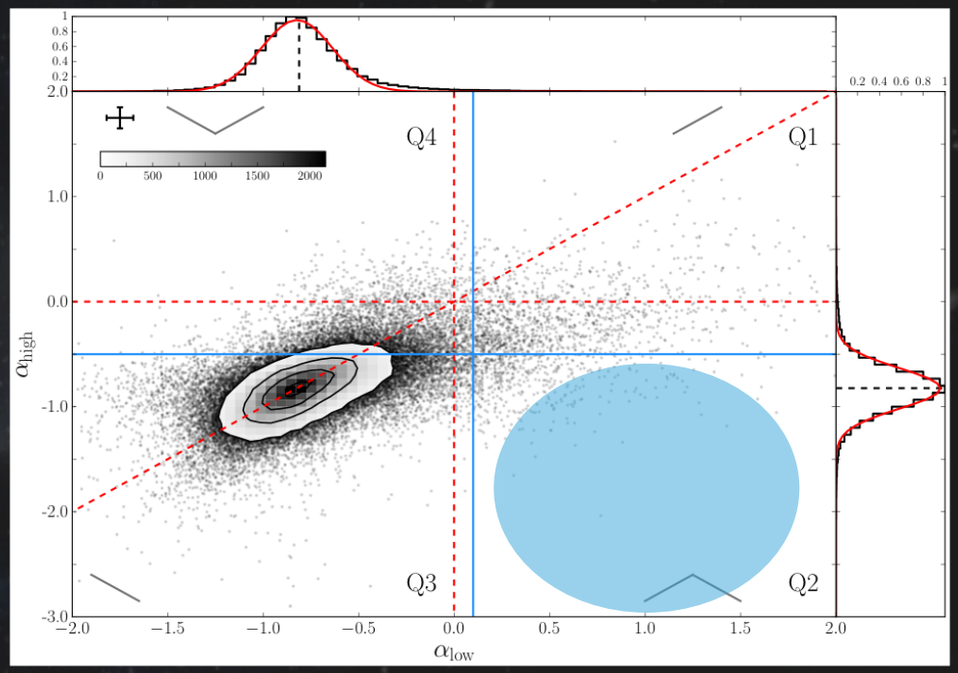
- Need sufficient population of radio-loud (S_{200} > 100 mJy) background radio sources
- Saxena+ 17 modelled the evolving radio AGN population based on:
  - Evolving SMBH mass function
  - Eddington ratio distribution
  - Various energy loss mechanisms
- Expected number ~10 at $z > 5$

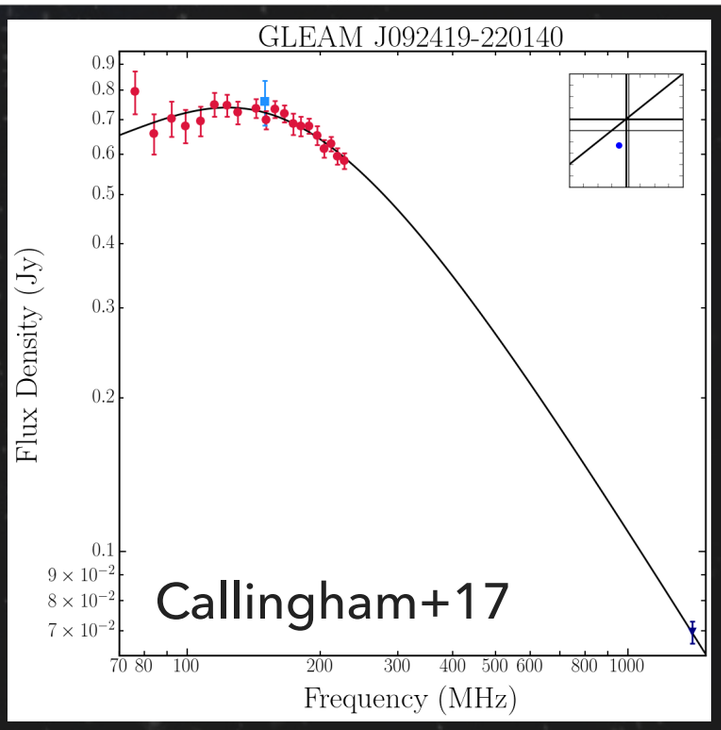




EXTREME HZRG CANDIDATE SAMPLE

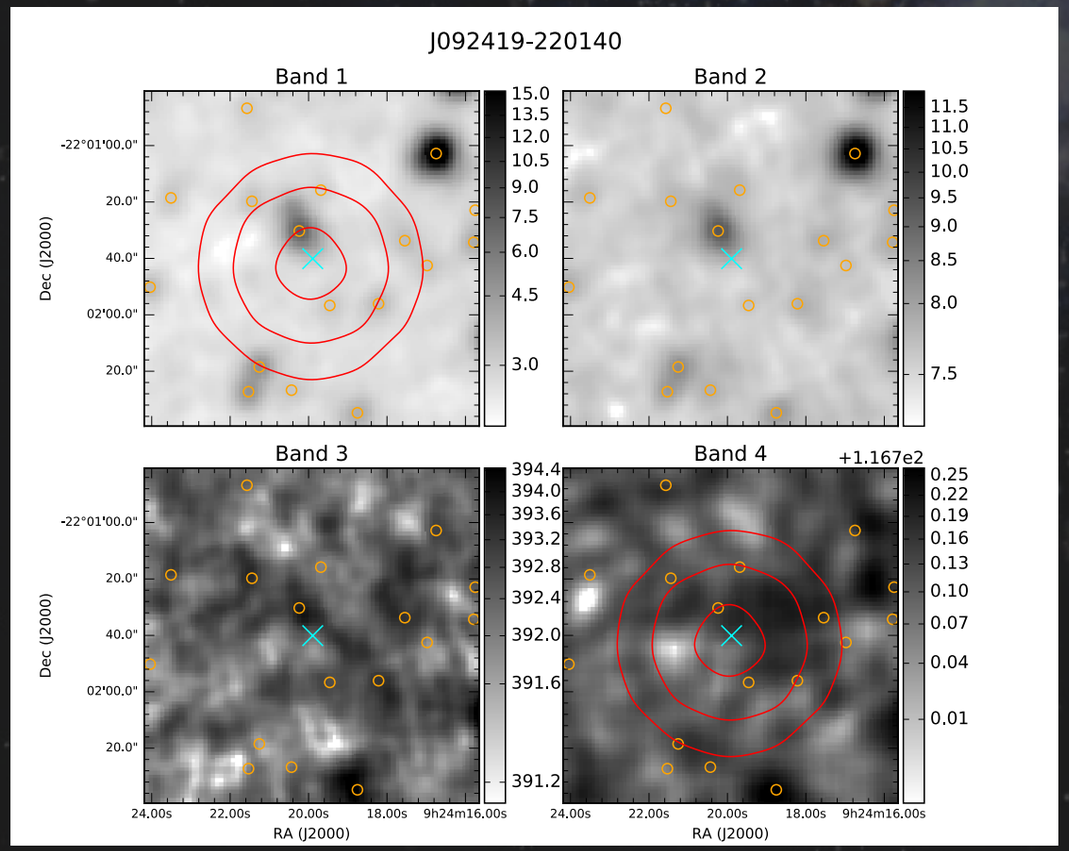
- Parent sample (Callingham+17):
  - Bright S_{200} > 160 mJy
  - MHz-peaked radio sources
    - High-z analogues of GPS sources (Copperjans+ 16)
  - Ultra-steep spectra (α < -1) based on the known α vs z relationship
- → Radio source embedded in a dense environment at z > 2

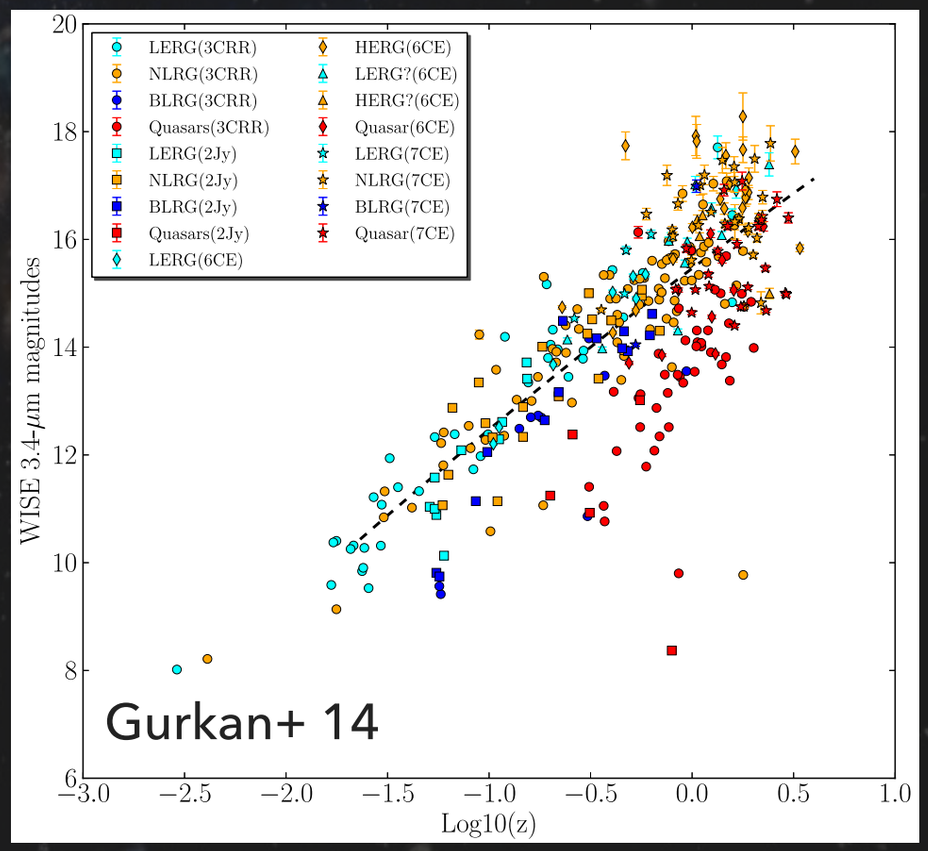




EXTREME HZRG CANDIDATE SAMPLE

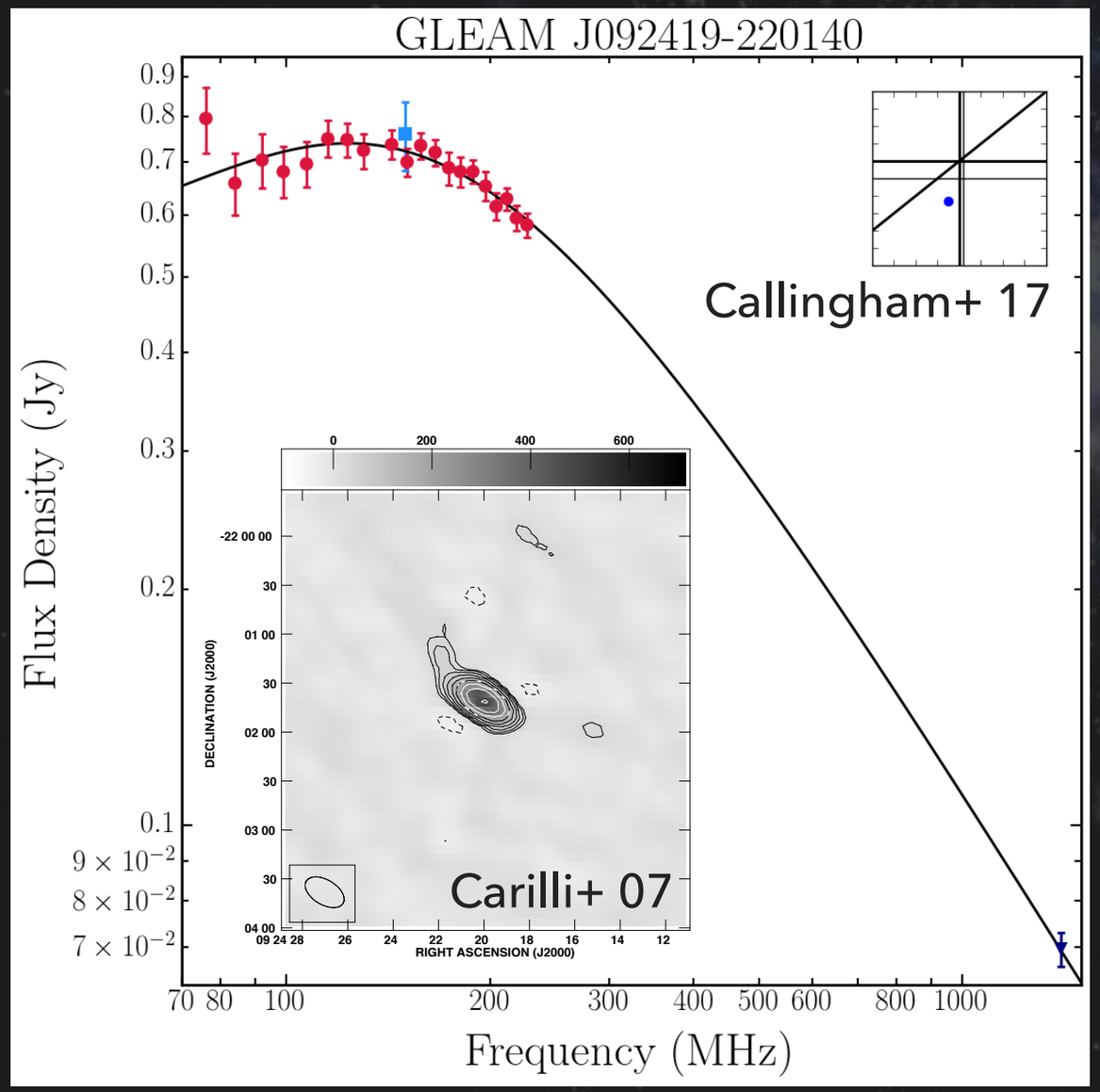
- Further multi-wavelength selection
  - No spectroscopic redshift and no detection in the visible
  - No detection in the mid-IR (All-sky WISE; Wright+ 10)

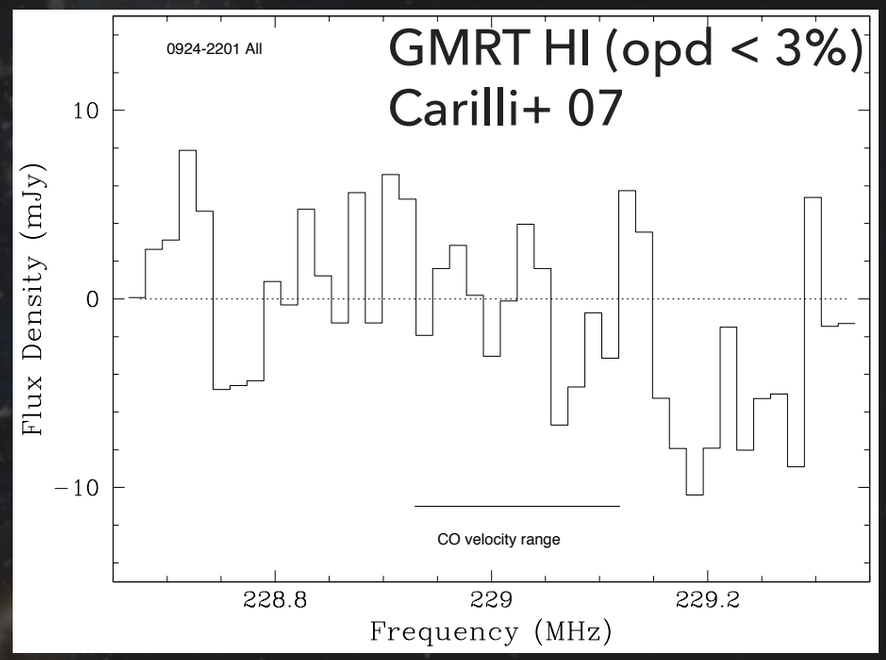


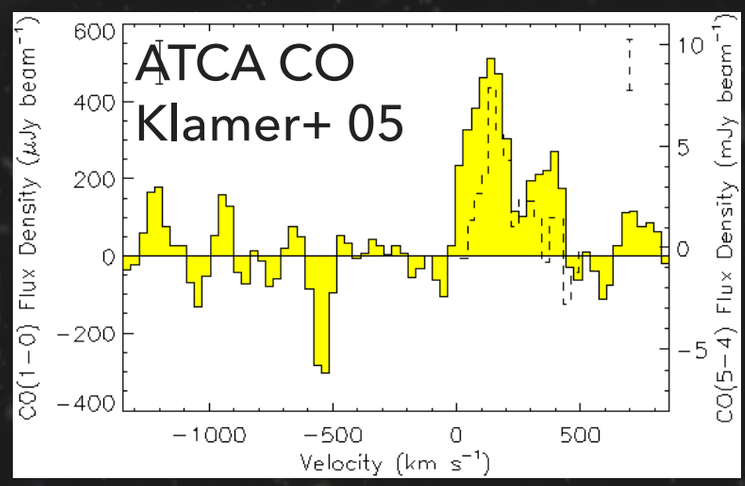


KNOWN EXAMPLE: TN J0924−2201

- Highest redshift radio galaxy (z = 5.19; van Breugel+ 99)

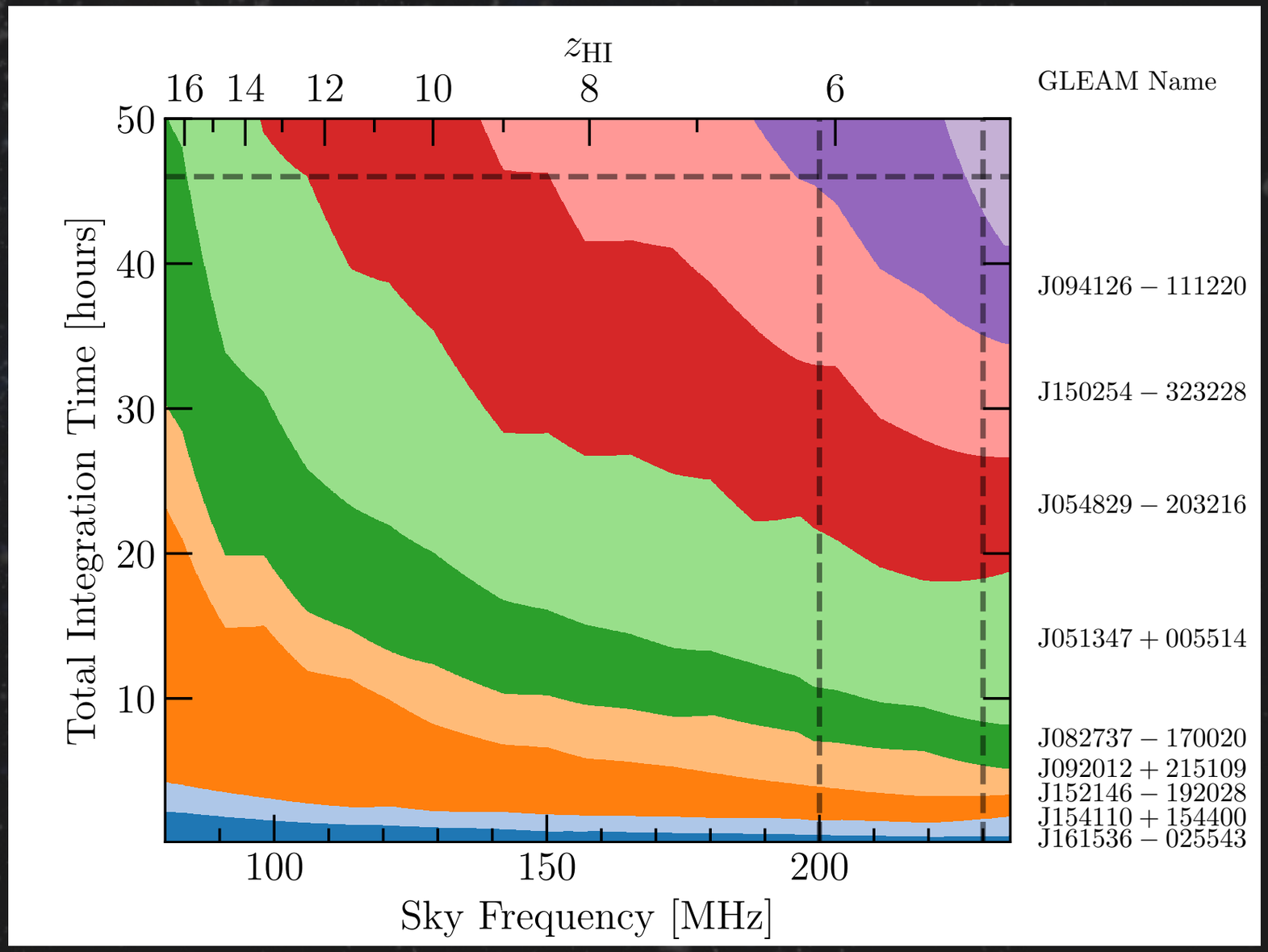






FINAL SAMPLE & BAND SELECTION

- Final selection based on integration time
- Detect $N_{HI} > 5 \times 10^{20}$ cm^{-2} atomic gas clouds
- Take into account
  - Source SED
  - T_{sys} vs freq.



DATA PROCESSING "PIPELINE"

- Fully automated multi-step pipeline
- Uses existing tools developed by Andre Offringa and the GLEAM team
- Experience from Chenoa Tremblay's doctoral work
- Wide-field continuum imaging & deconvolution
- Subtract MF CLEAN component model from visibilities
- Full spectral resolution imaging only at position of target
- Image-based subtraction of residual broad-band signal

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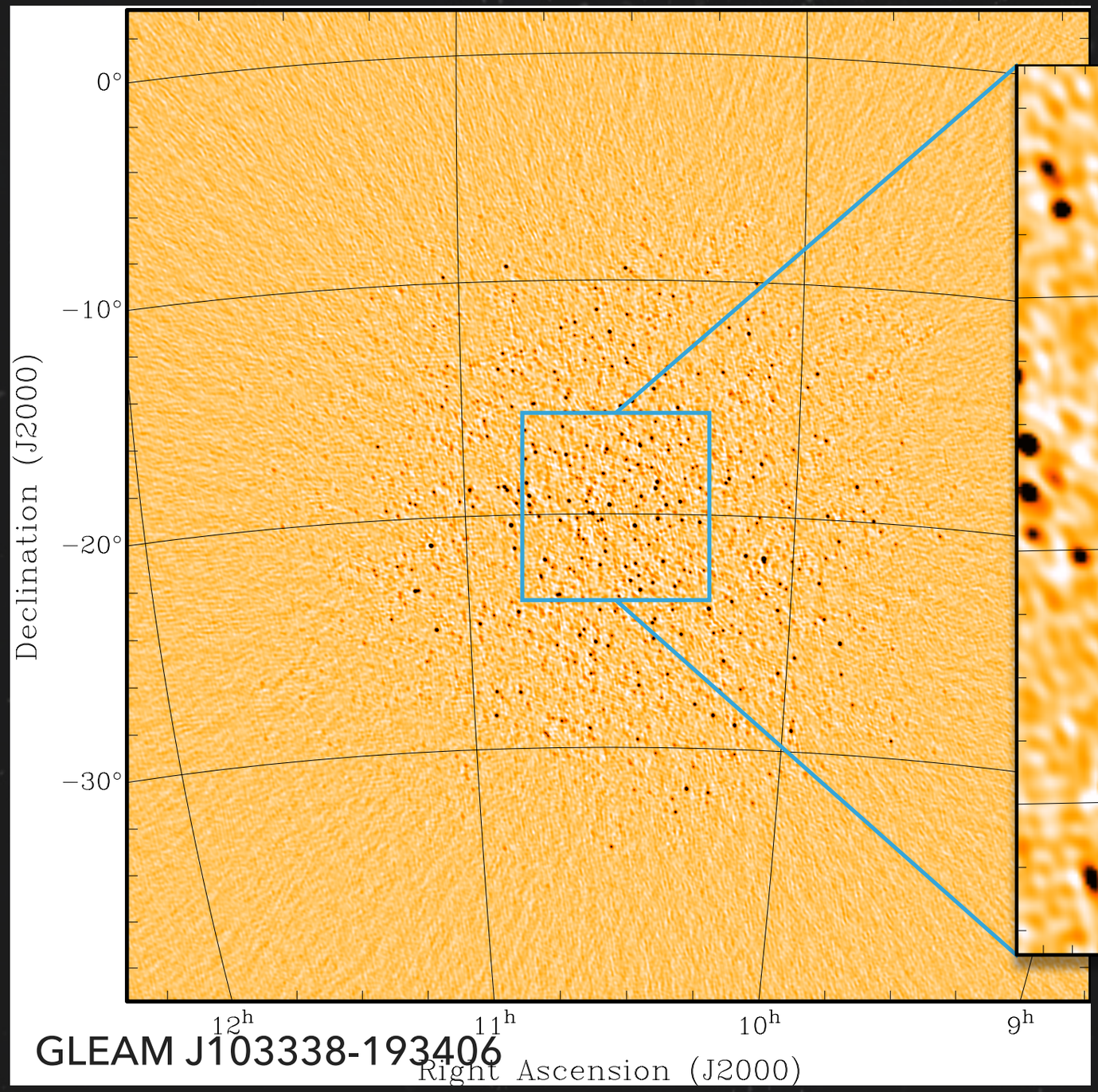
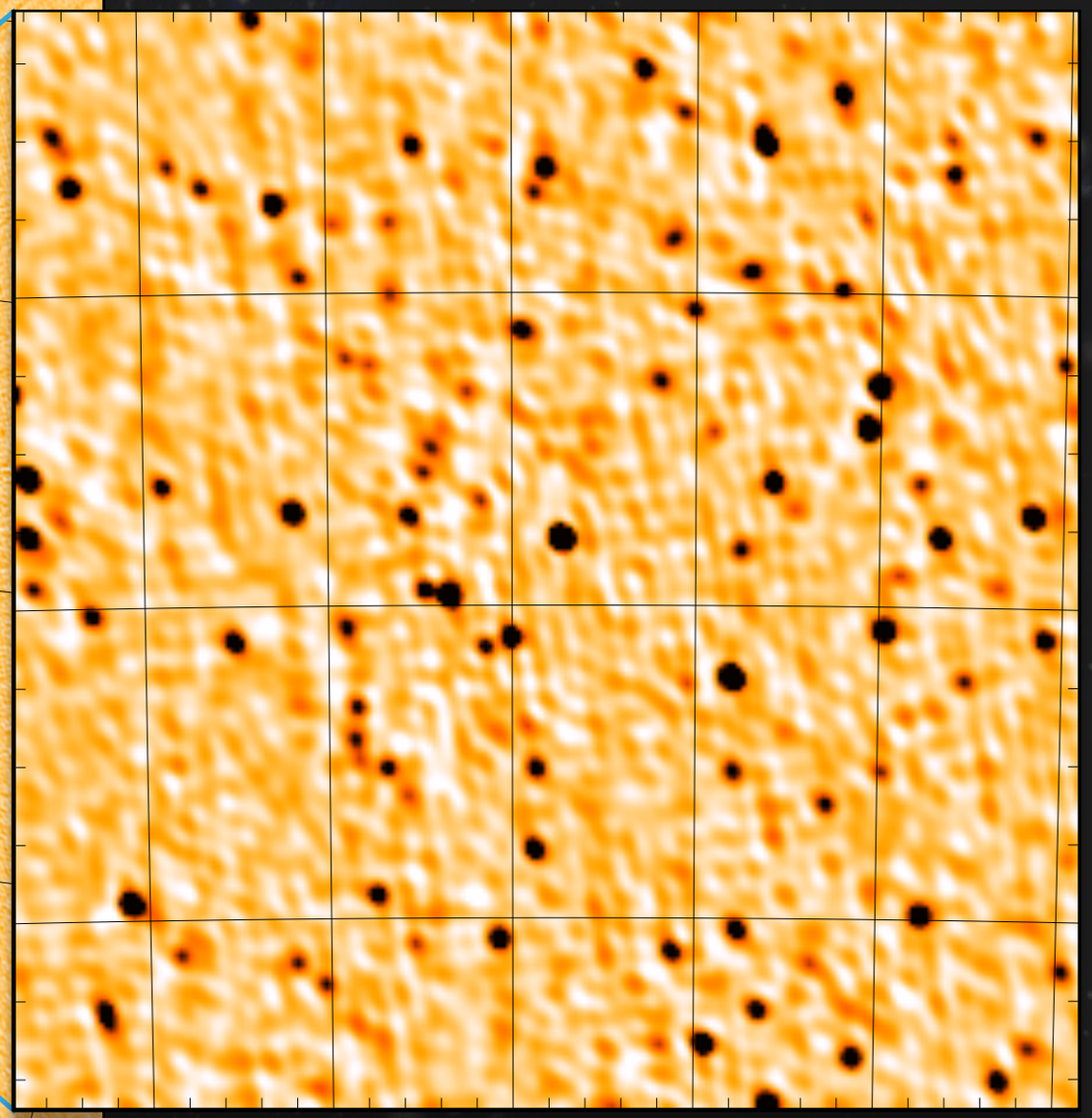
EARLY RESULTS — PHASE II COMPACT "HEX" ARRAY





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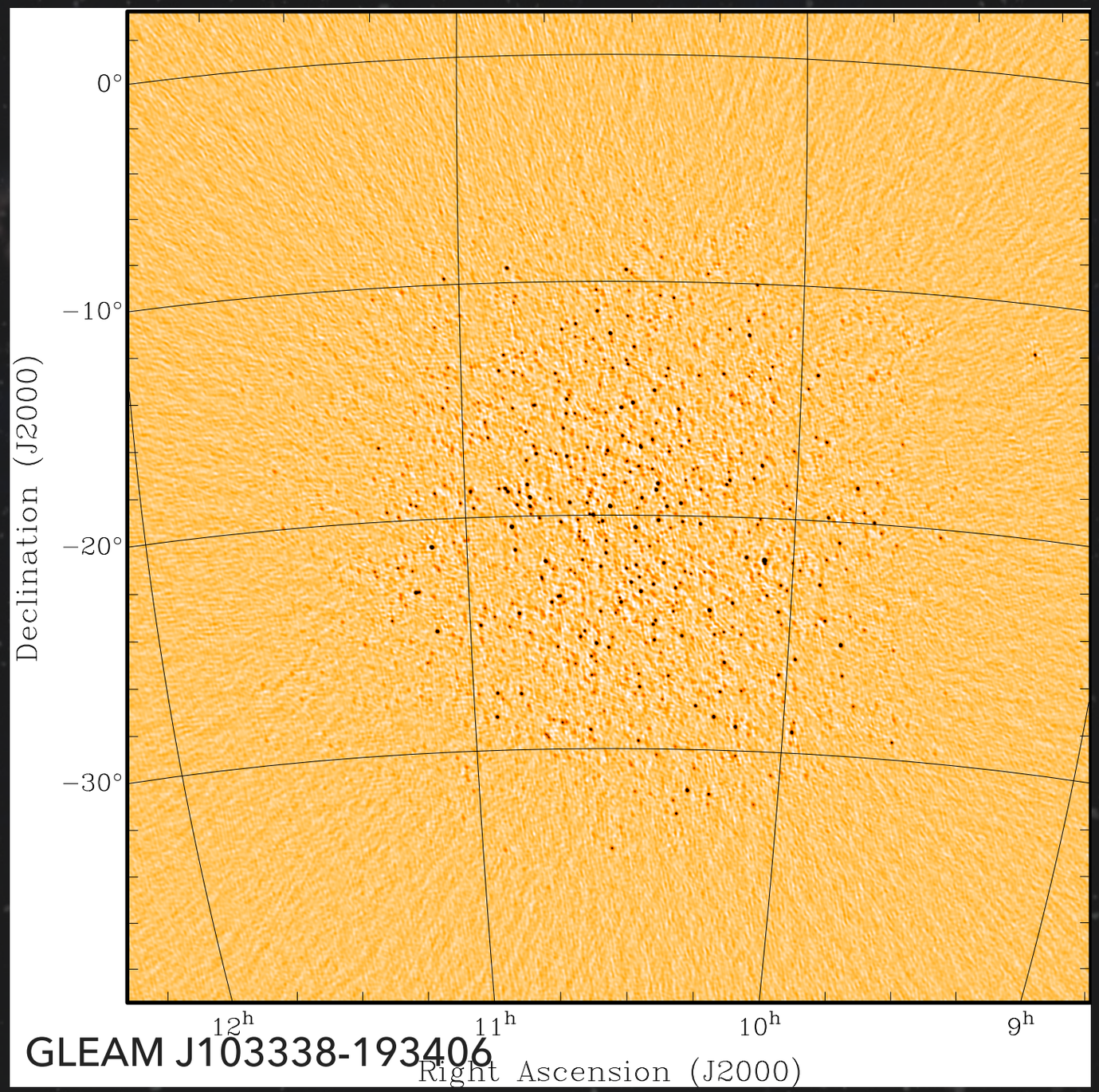

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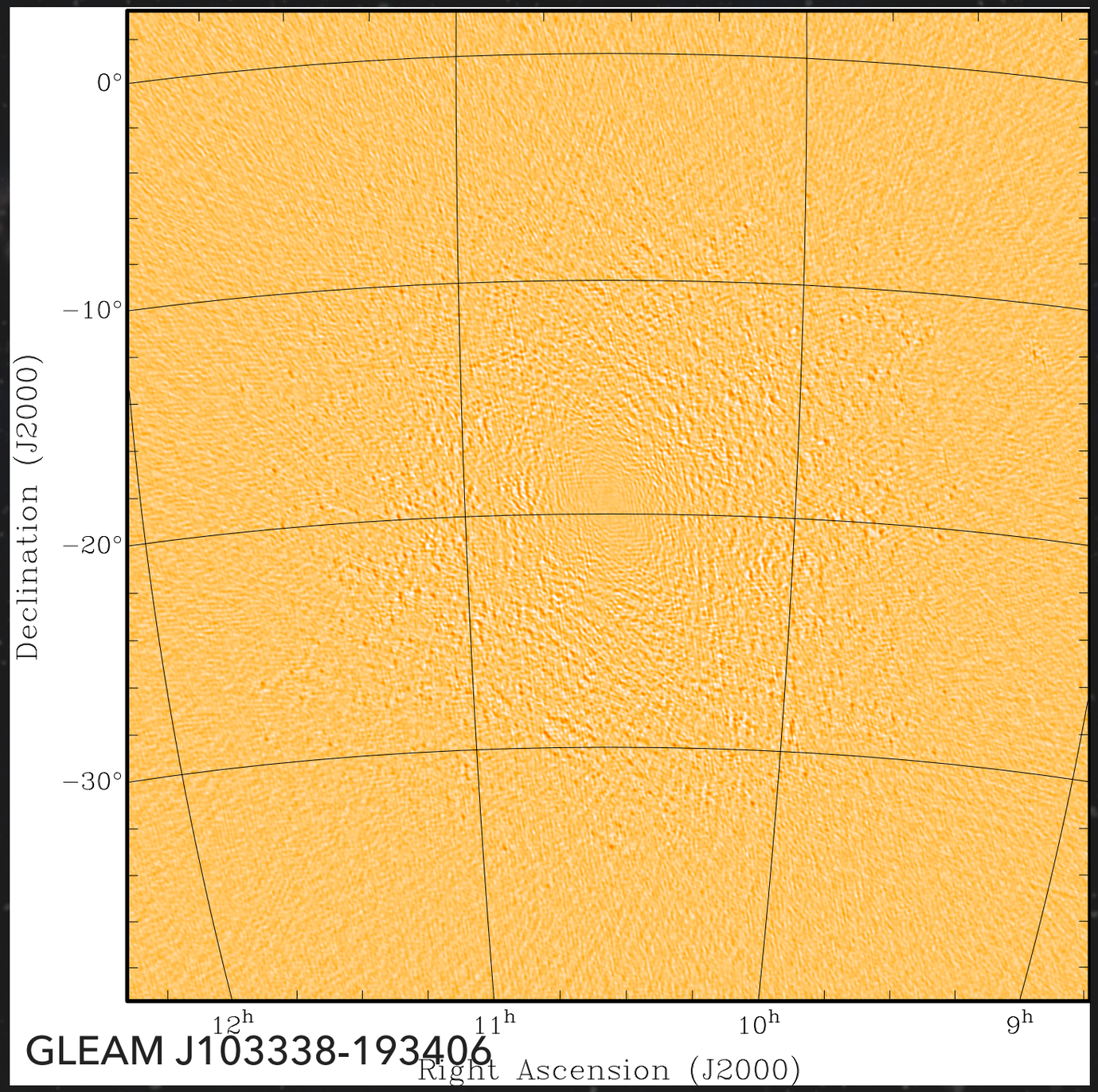

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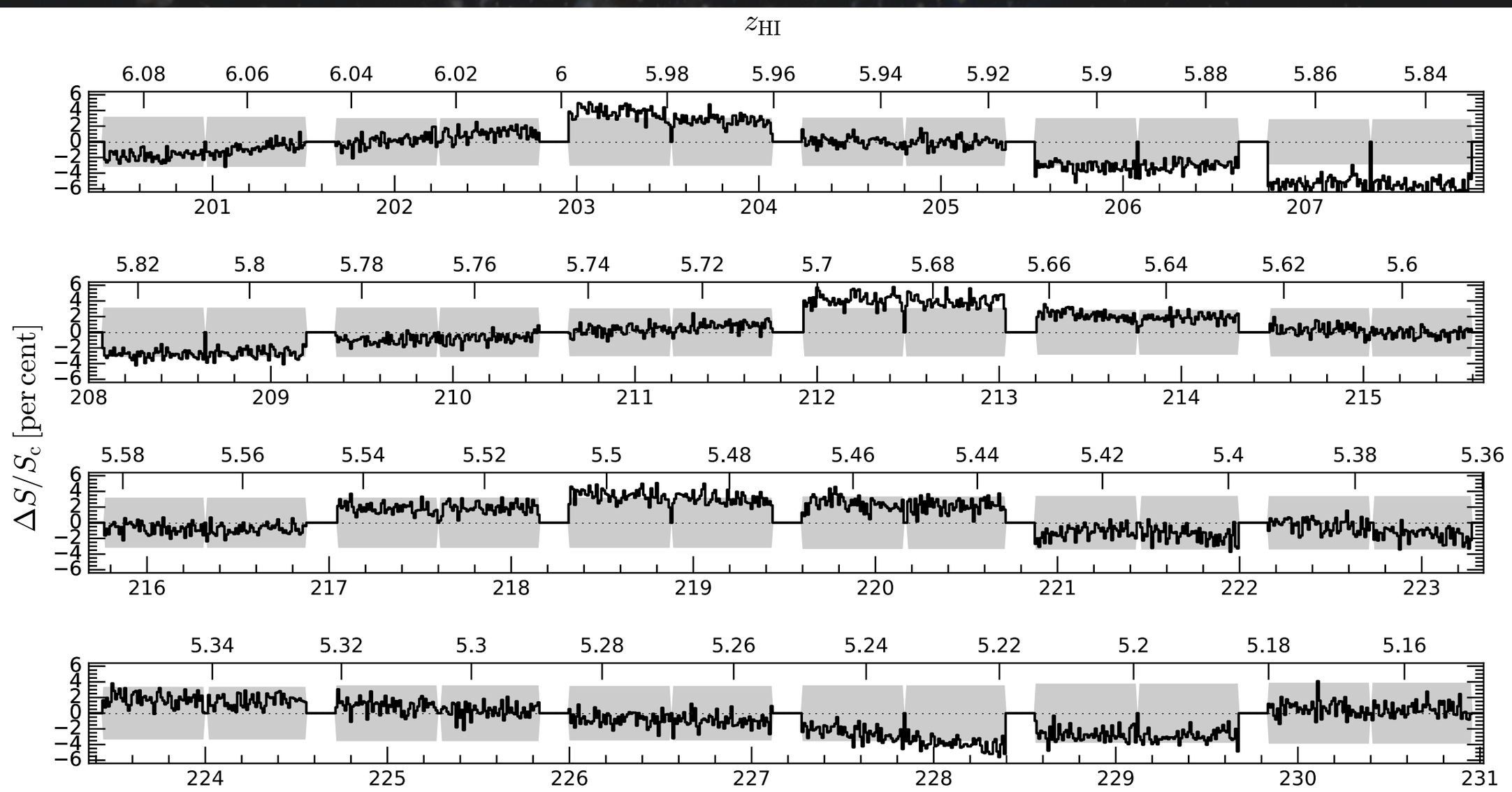

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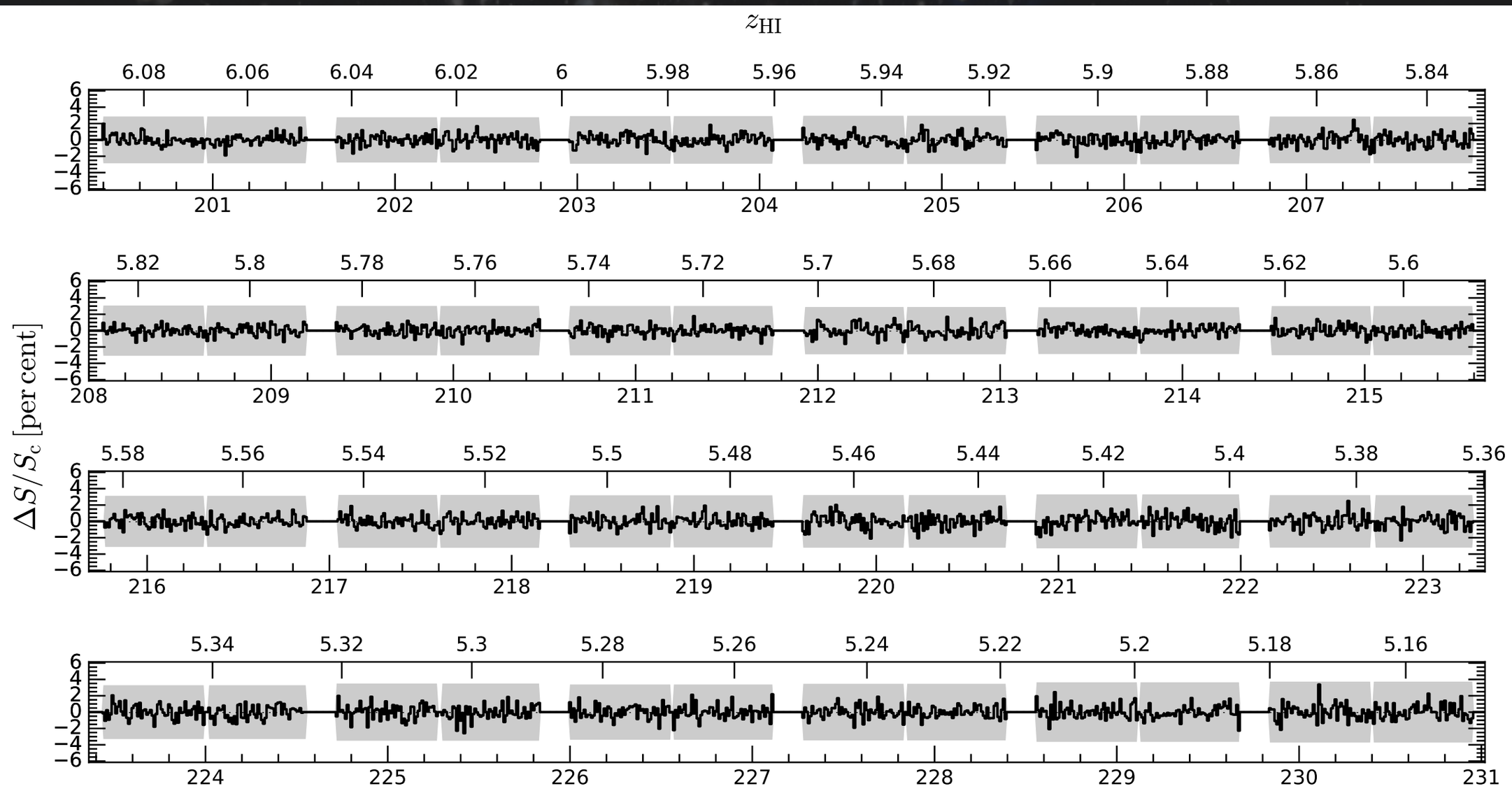

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SUMMARY

- High redshift radio galaxies are signposts to proto cluster & massive hierarchal structure formation in early Universe
- Targeted survey for HI 21-cm absorption towards candidate high redshift radio galaxies
- First data obtained and early results promising.
- Further developments required → peeling very bright sources, better continuum subtraction, extended MWA …
- Interested in helping? Please chat with me (james.allison@sydney.edu.au)