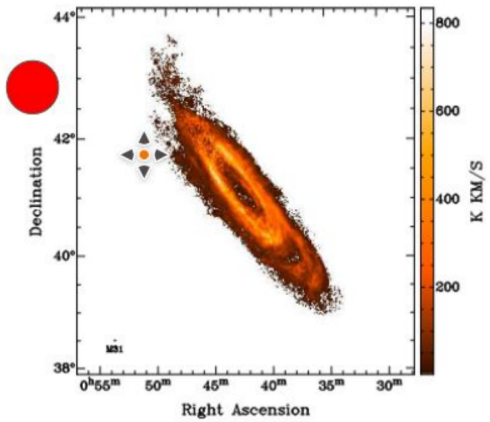
# Extragalactic HI:
## Distant galaxies with the GBO 20m?

2021 Single Dish Workshop Group 2

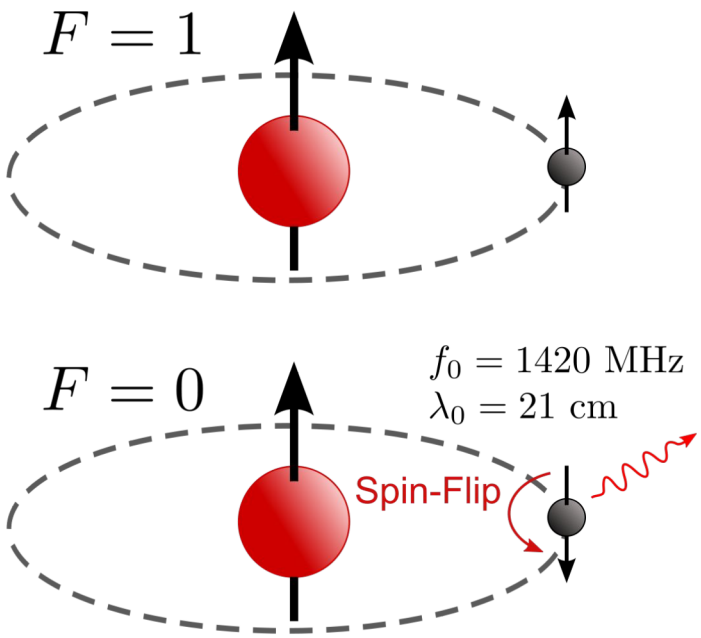



**Group 2 - Extragalactic HI**
***(Scientific Lead: Sravani Vaddi)***

(1) Manas Awasthi (*virtual, INDIA*)
(2) Hayley Roberts (US)
(3) Sankalp Choudhuri (*virtual, INDIA*)
(4) Peter Teuben (*virtual, UMD*)
(5) David Sukow (US)
(6) Michael Hardegree-Ullman (US)
(7) Tim Proudkii (US)

# Background

- Neutral atomic hydrogen (HI) is the most abundant and simple atom in the Universe
- HI's spin-flip transition at 21cm falls in the radio region of the electromagnetic spectrum
- Through the use of radio telescopes, HI is easily detectable in our galaxy (1956)
  - Instrumental in determining the structure of our galaxy.
  - Rotation curve and dark matter.
- Can we see HI in other galaxies with the 20m GBO radio telescope?



# M31 and NGC 628

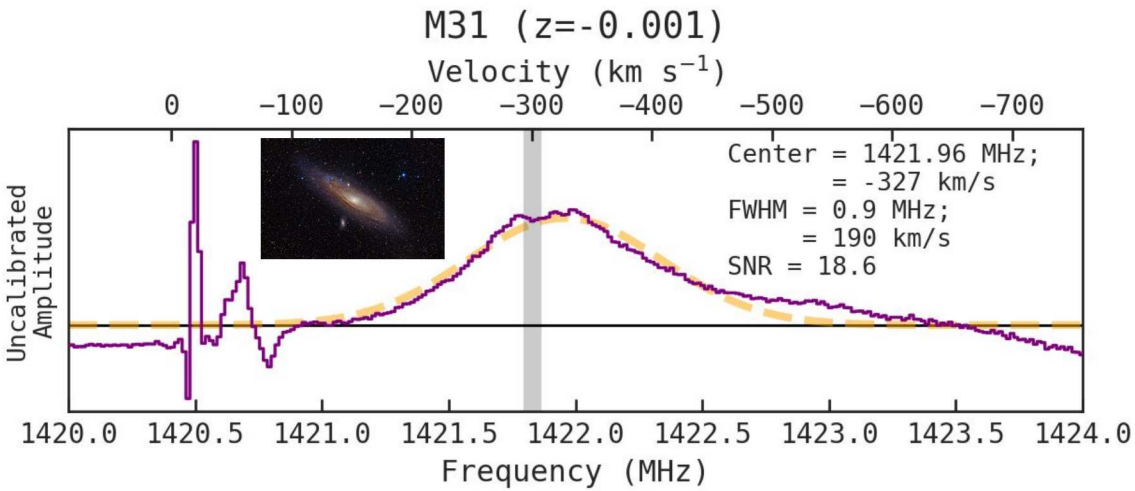
Using On-Off observing, we observed for:

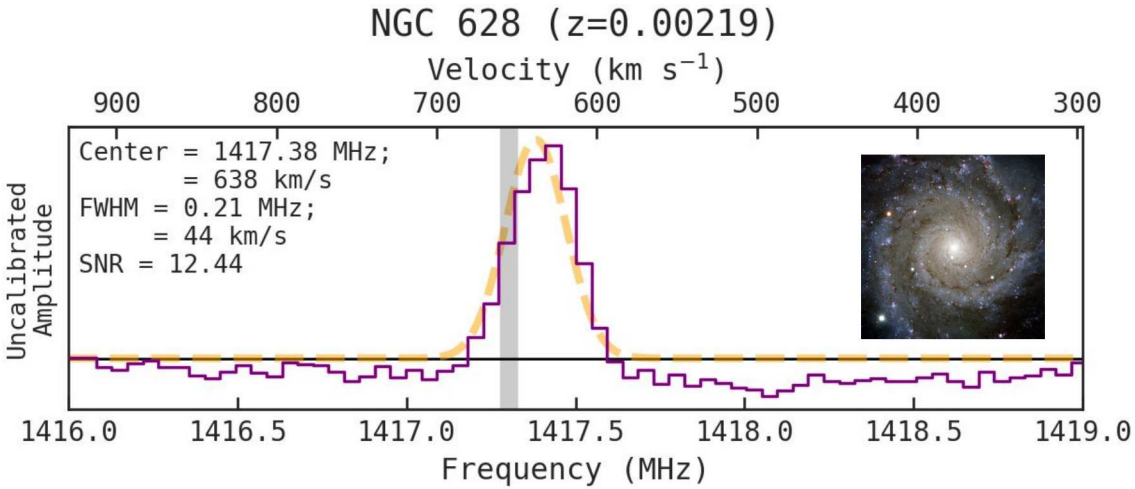
- 200 seconds on
- 200 seconds off

Other information:

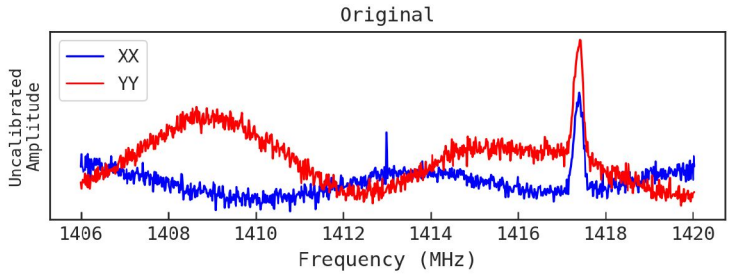
- High resolution mode
- Used the other frequency to search for the 1667 OH line - nothing showed up which is to be expected

2 first observations - make sense!

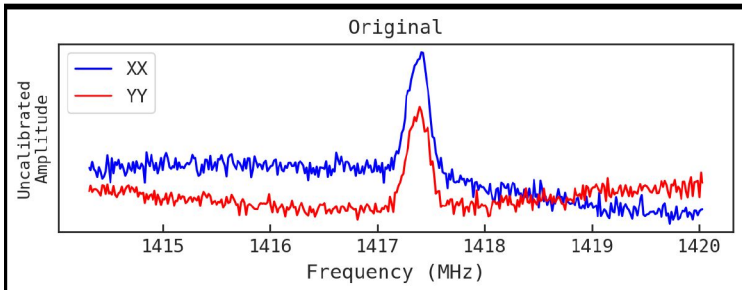


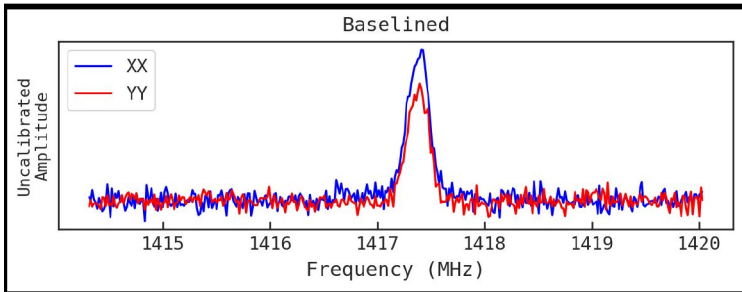
# Reducing Data - Explaining with NGC 628



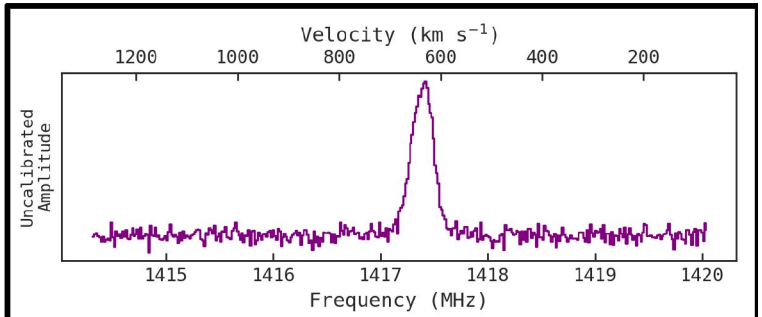

**Step 1:** Looking at the full bandwidth of data, we can see our original spectra



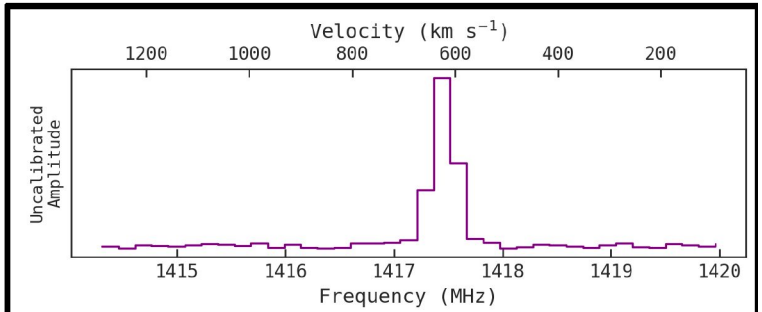

**Step 2:** Cropping to our line area makes it easier to baseline and let's us ignore RFI features.




**Step 3:** We baseline using a 3rd degree polynomial in each polarization while excluding the area of our line.




**Step 4:** We average the two polarizations to get a total amplitude.




**(Optional) Step 5:** We can bin our spectra to try to recover some faint signals - this was done for our non-detections.

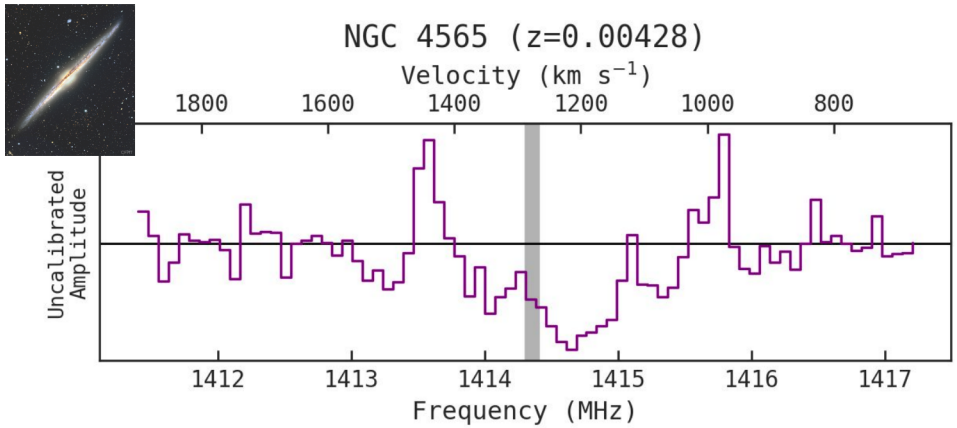
# Non-Detections: NGC 4565, NGC 1530, NGC 3976

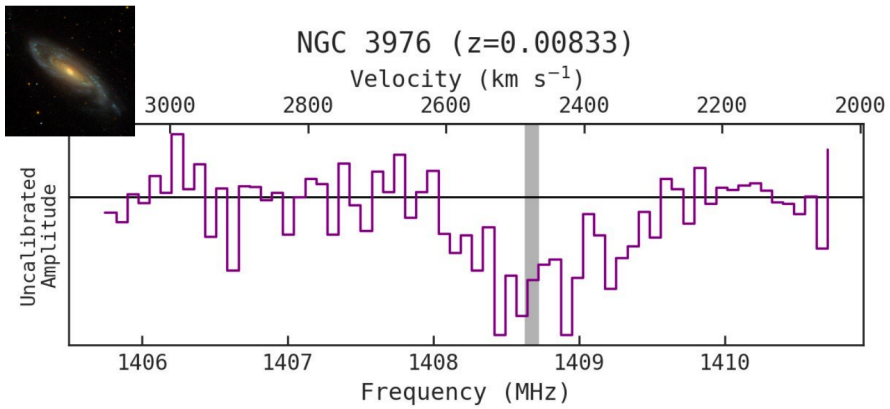
Some galaxies where HI should've been detected yielded non-detections with the 20-m

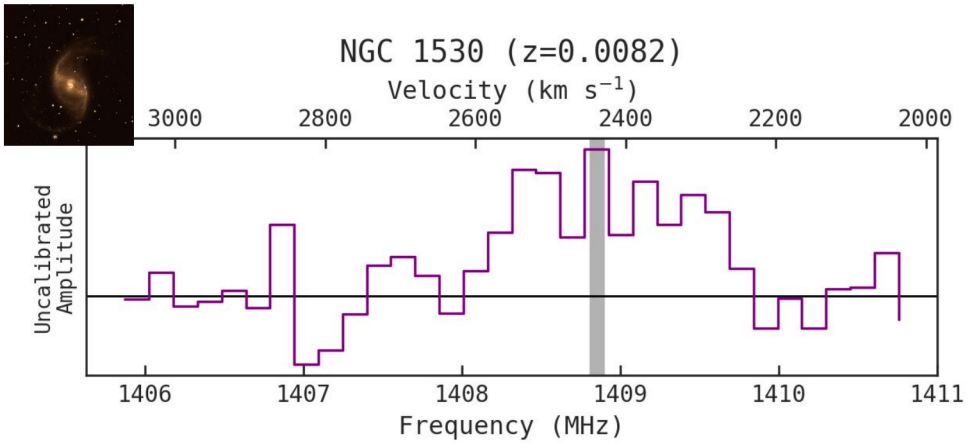
Attempted to bin channels to help detect weak signal, without success.

But maybe if you squint…

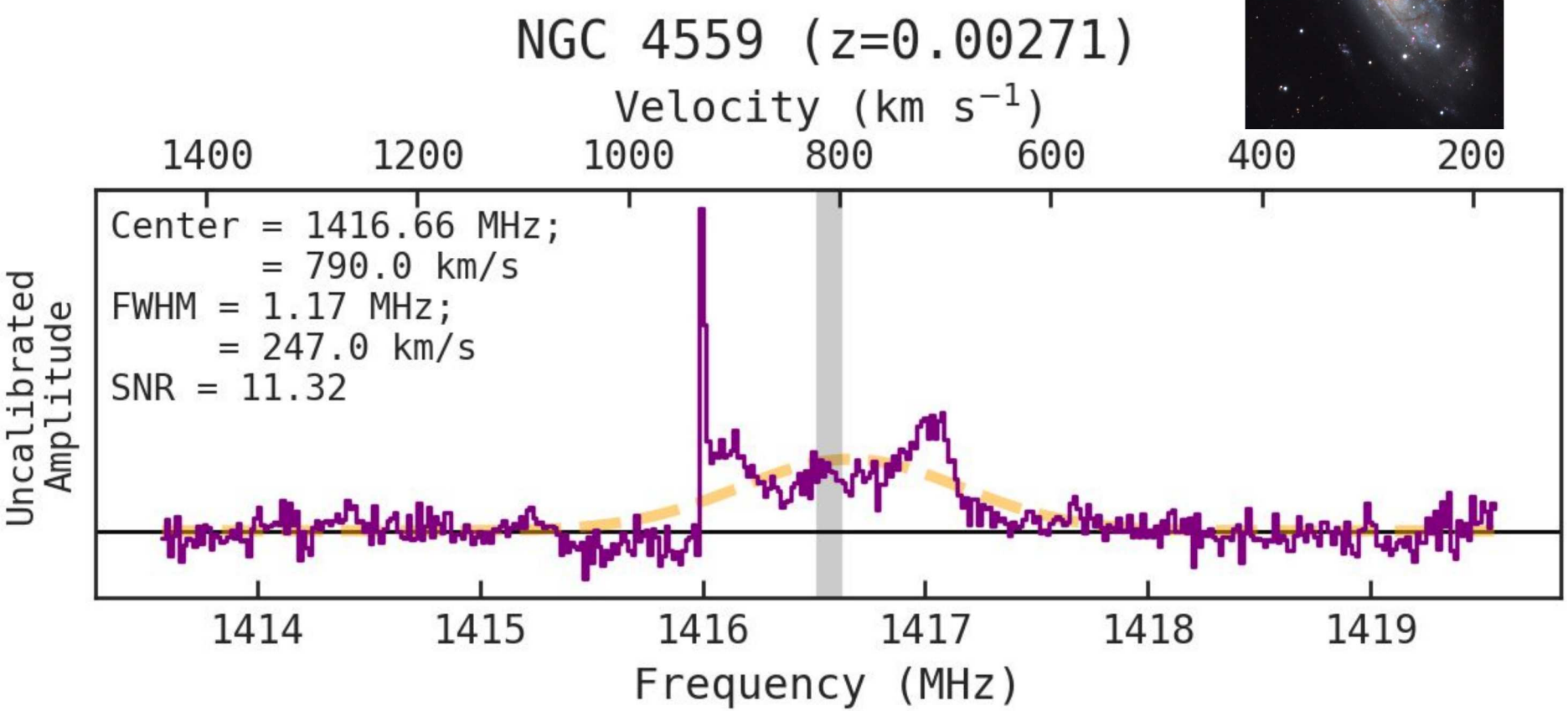
Grey vertical lines show where the line should be if we had detected it



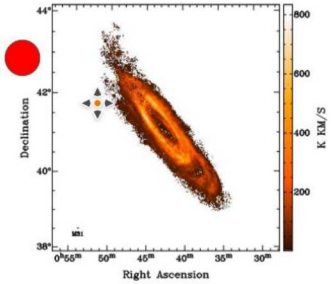



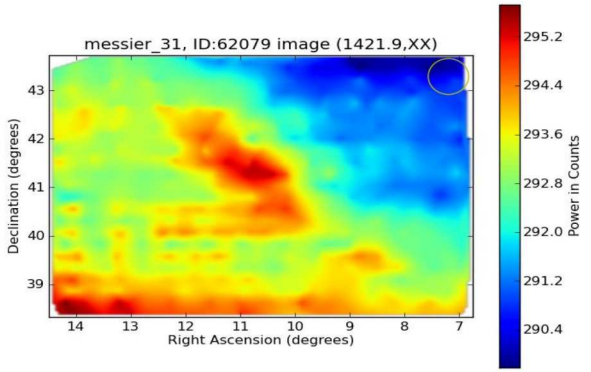



# New Observation to Confirm Our Findings



# Mapping



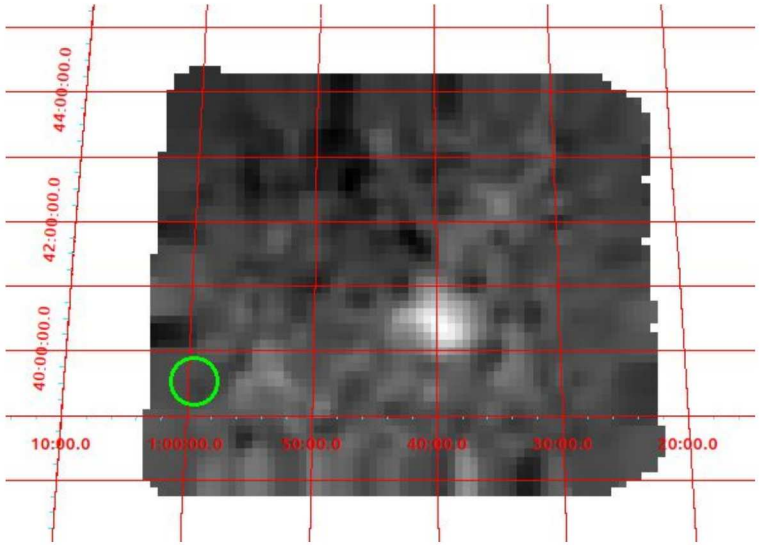

M31 is the only good candidate that covers enough degrees to try a map.
We tried a 6x6 degree area which should give us 8x8 independent points.

The SDFITS file was converted to FITS cube using an improved gtbgridder (v0.6pjt)

**One Channel map shown on the right:**
One channel from cube.
Map at one particular velocity.
Green circle = 20m beam

**Few issues/questions with gbtgridder:**

1. Line cube still has residual baseline
2. Spatial edge effects from gridder
3. Small scale structure < beam ?
4. First channel wrong?



M31 channel map made from a cube created by gbtgridder, shown in ds9

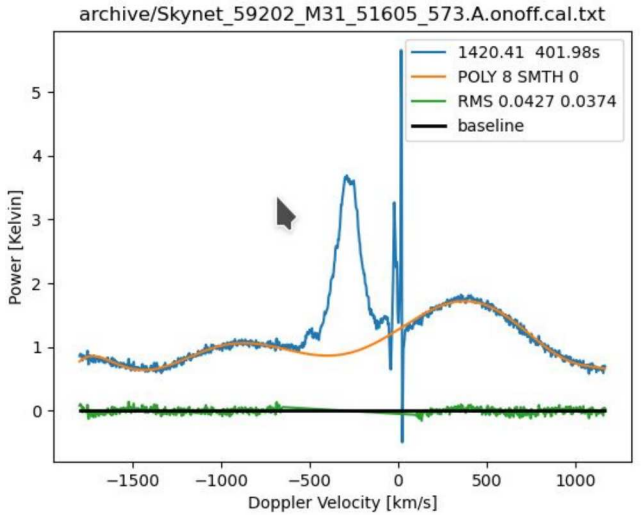
# Calibration and the Radiometer Equation

$$\Delta T = k_1 \frac{T_{sys}}{\sqrt{\beta \cdot t_{\text{int}}}}$$

(P K Manoharan's talk)

Our data was not properly calibratable, but we like to argue that by comparing our M31 data to archival M31 data we can understand this scaling a bit and reproduce the correct brightness.

1. The $T_{SYS}$ mentioned in the spectrum header is really a scaled $T_{SYS}$, but otherwise data obeys the radiometer equation, with $k_1$ ~ 1.3 +/- 0.1
   Or did we forget factor 2 in $t_{int}$?
2. Archival M31 data suggest that YY/XX ~ 1.1-1.2,
   But difficult to judge baseline near galactic HI
   Can group 4 address this?
3. Our two M31 data have scalings 3.2 and 6.4, but perfectly arrived at archival 2.5K value
4. N628 has scaling ~0.8, N4559 has ~0.5-1 based on known fluxes from NED
5. For our undetected we have no idea what the scaling is




Baseline and Noise analysis plot, made by plotsp1.py

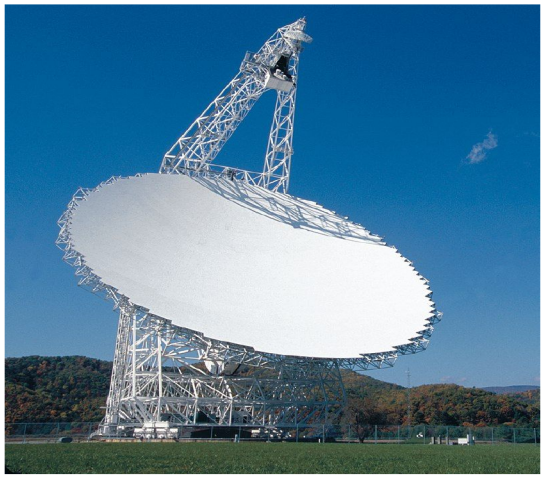
# Future plans

1. Get the calibration right as that would have helped us utilise the 20m telescope to its full potential. Verify the radiometer equation to confirm and better understand the performance and limitations of the telescope.
2. More observing time, with more time on each target and more targets.
3. A larger telescope would further aid in detecting extragalactic HI, although some of that work has been done by telescopes such as the GBT.

## What did we get and didn't get?

- Successfully confirmed HI in galaxies up to z = 0.0028
- Did not detect HI in any galaxies beyond z = 0.0030

*Also depends on the amount of HI present in these galaxies



# No Paper yet, but we can share our Data and Code!

https://github.com/teuben/sdss

Makefile has commands for reproducible figures and data values.

*We are grateful to Sravani, Will and Brenne for their guidance :)*

## Questions?

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