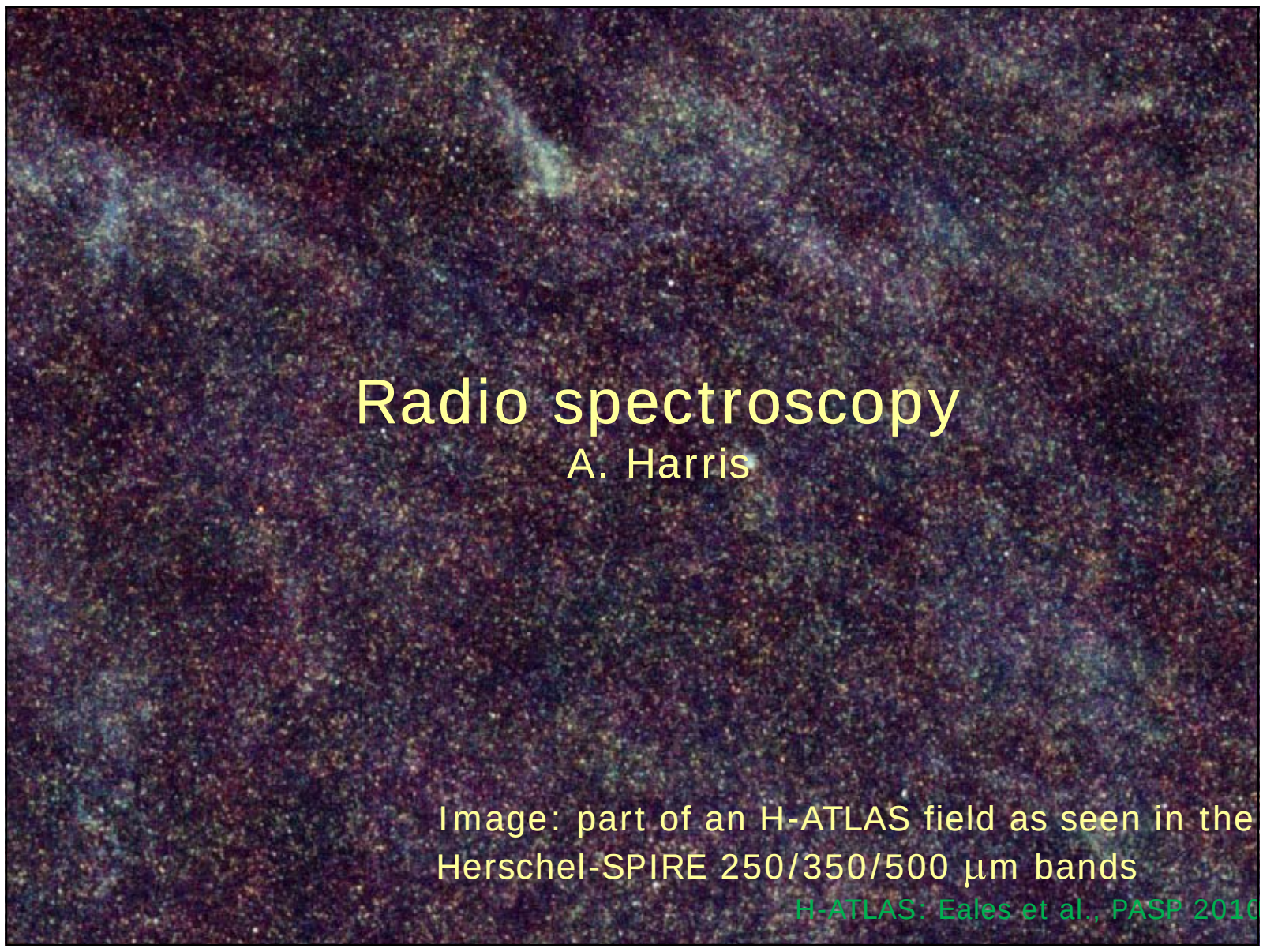


Annoying question at a NSF Science and Technology Center Review

"Are the graduate students being properly prepared to enter the 21st century job market?"

General, strong background:
- Physics
- Applied math
- Computer science

Diverse and useful skills:
- Computing (programming, modeling)
- Instrumentation

Key questions for radio astronomy

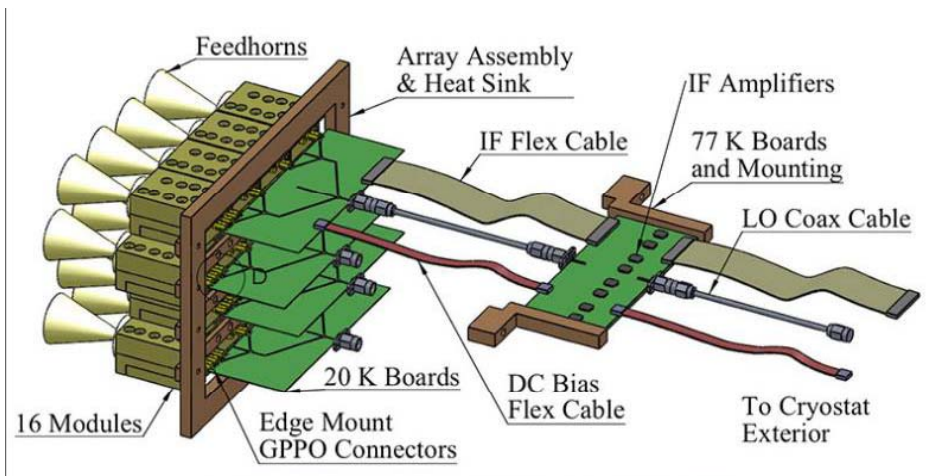
- Among the most important topics in radio astronomy are:
  - Structure in the Cosmic Microwave Background (power spectrum, polarization)
  - The era of galaxy formation
    - Finding the early galaxies
    - Investigating and understanding local templates
  - Star formation
  - Structure of molecular clouds
  - Structure of active and normal galactic nuclei

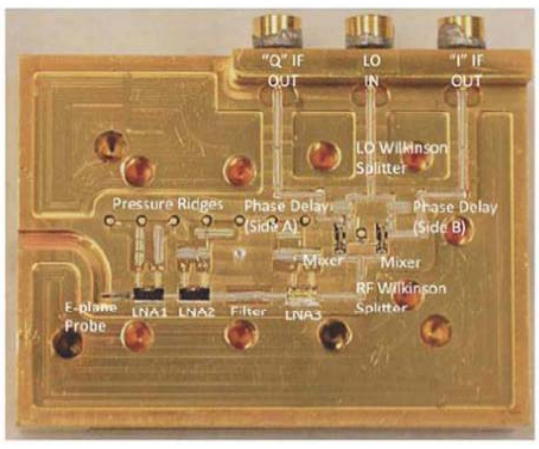
16 element scalable W-band focal plane array for the GBT

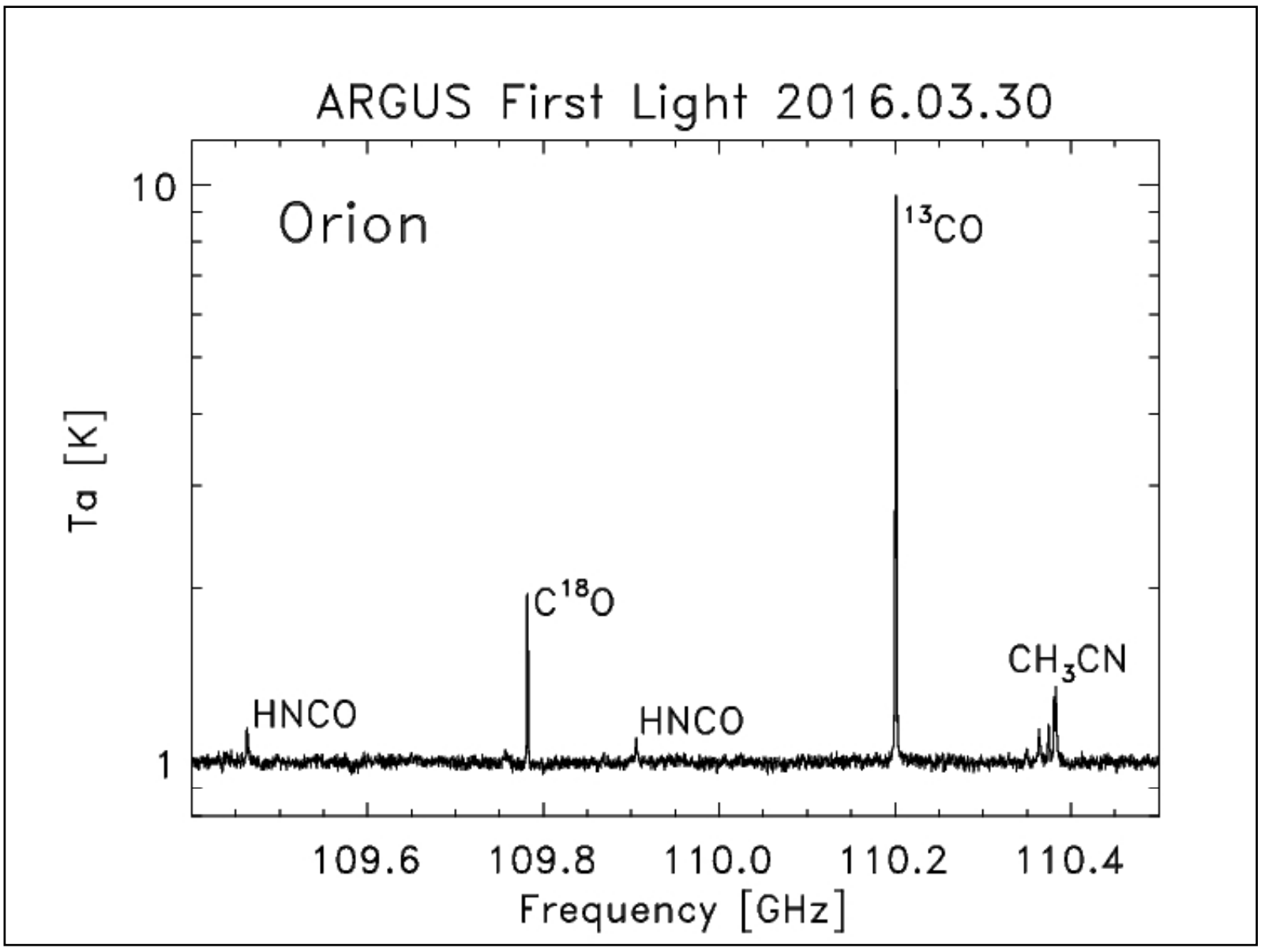
Argus is being commissioned on the GBT. It is a collaboration between Stanford U. (PI Sarah Church), Caltech, JPL, Univ. Maryland, Univ. Miami, and NRAO.

Frequency operation range: 75-115.3 GHz

Tsys~75K

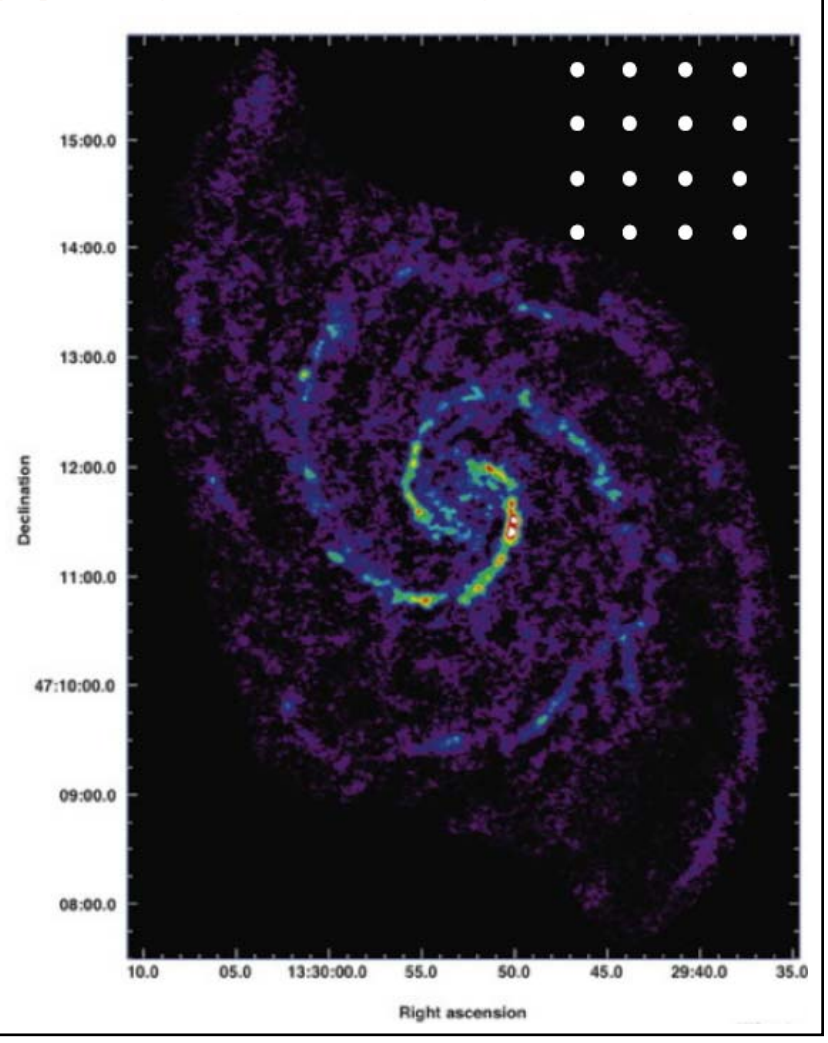


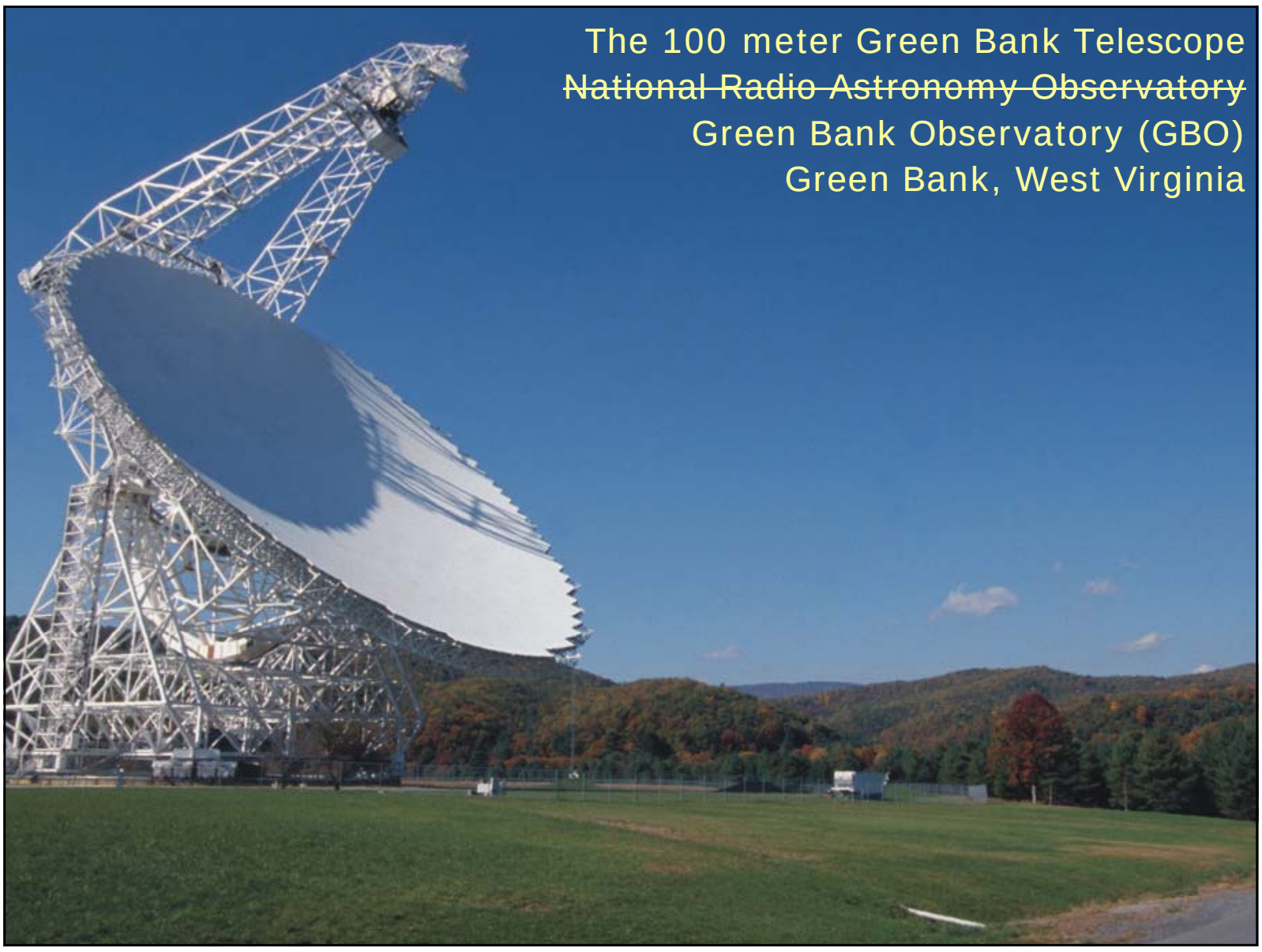




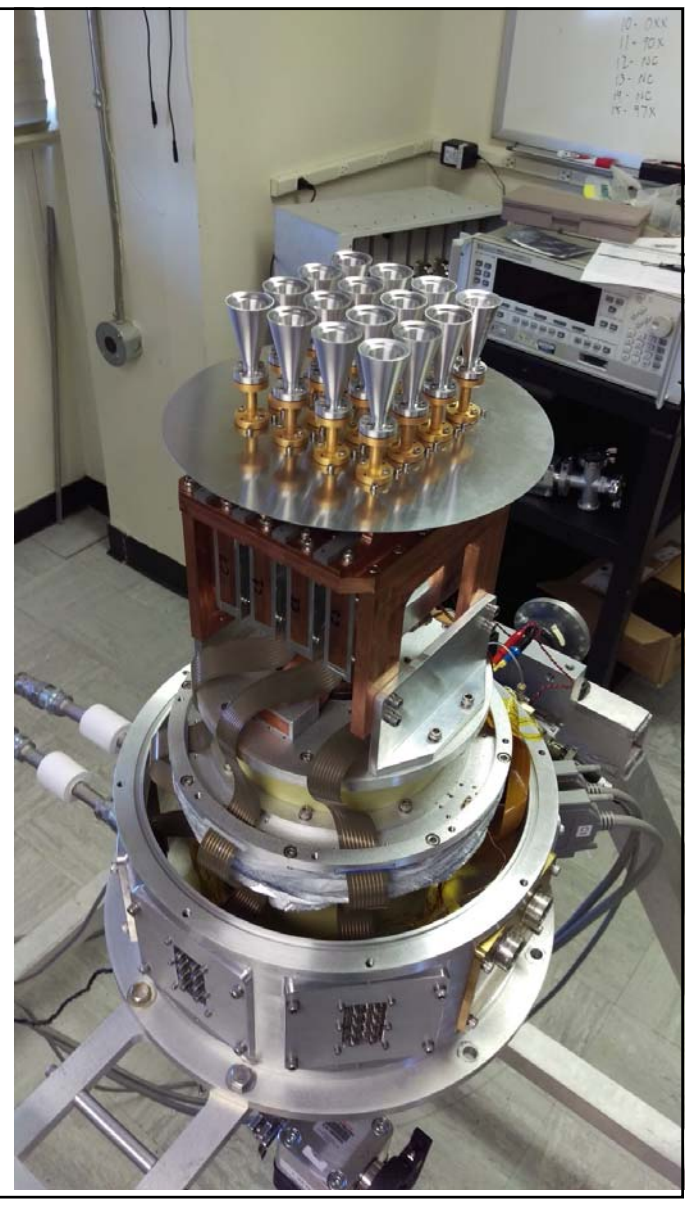
Large area mapping with Argus

- Spectral imaging in HCN, HCO^+, ^{13}CO, $C^{18}O$
  - Dense regions
  - Column densities
- Galactic and extragalactic star formation
  - Galactic filaments
  - Extragalactic GMCs
  - Galactic center
  - Extragalactic nuclei

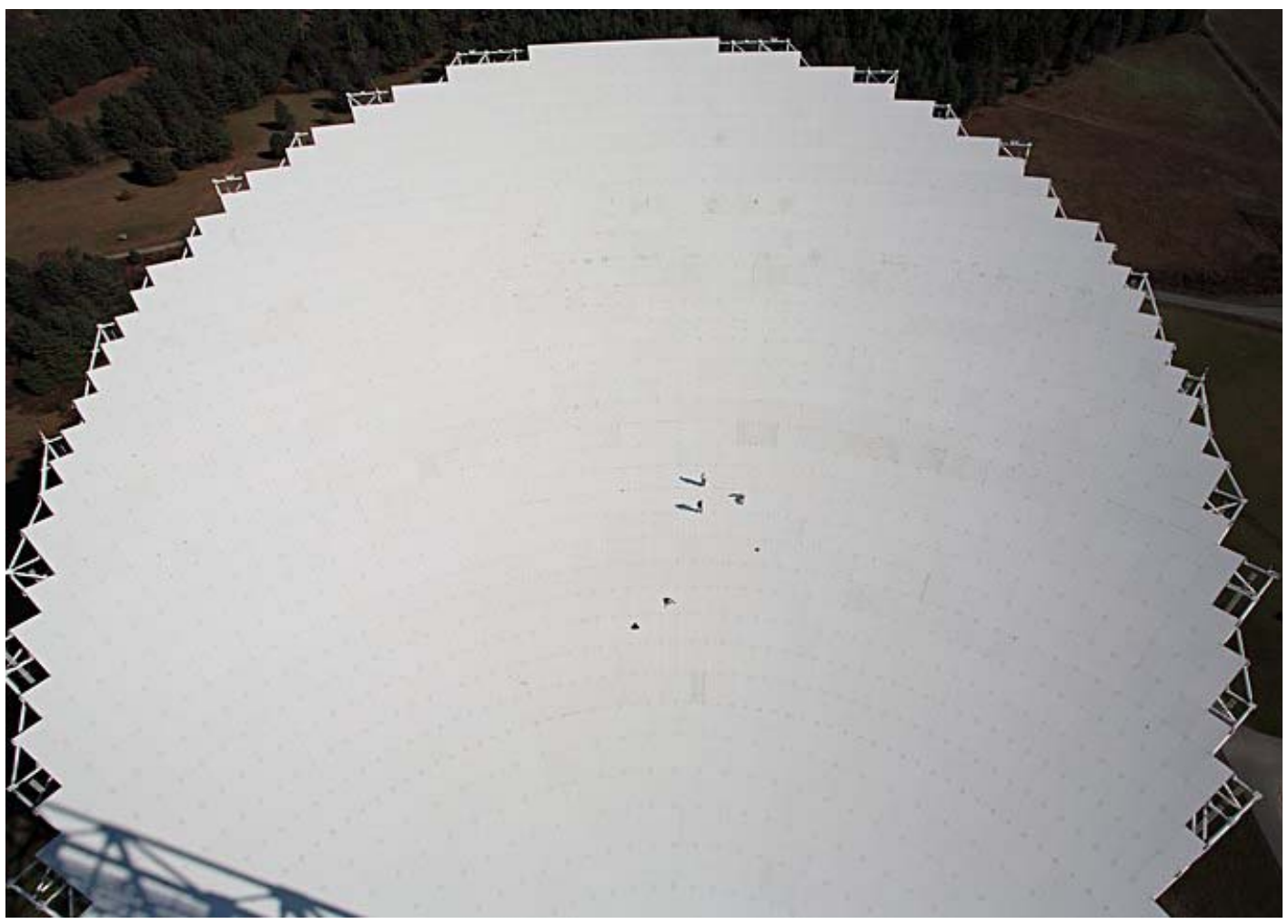



The 100 meter Green Bank Telescope
~~National Radio Astronomy Observatory~~
Green Bank Observatory (GBO)
Green Bank, West Virginia


Argus
ARGUS



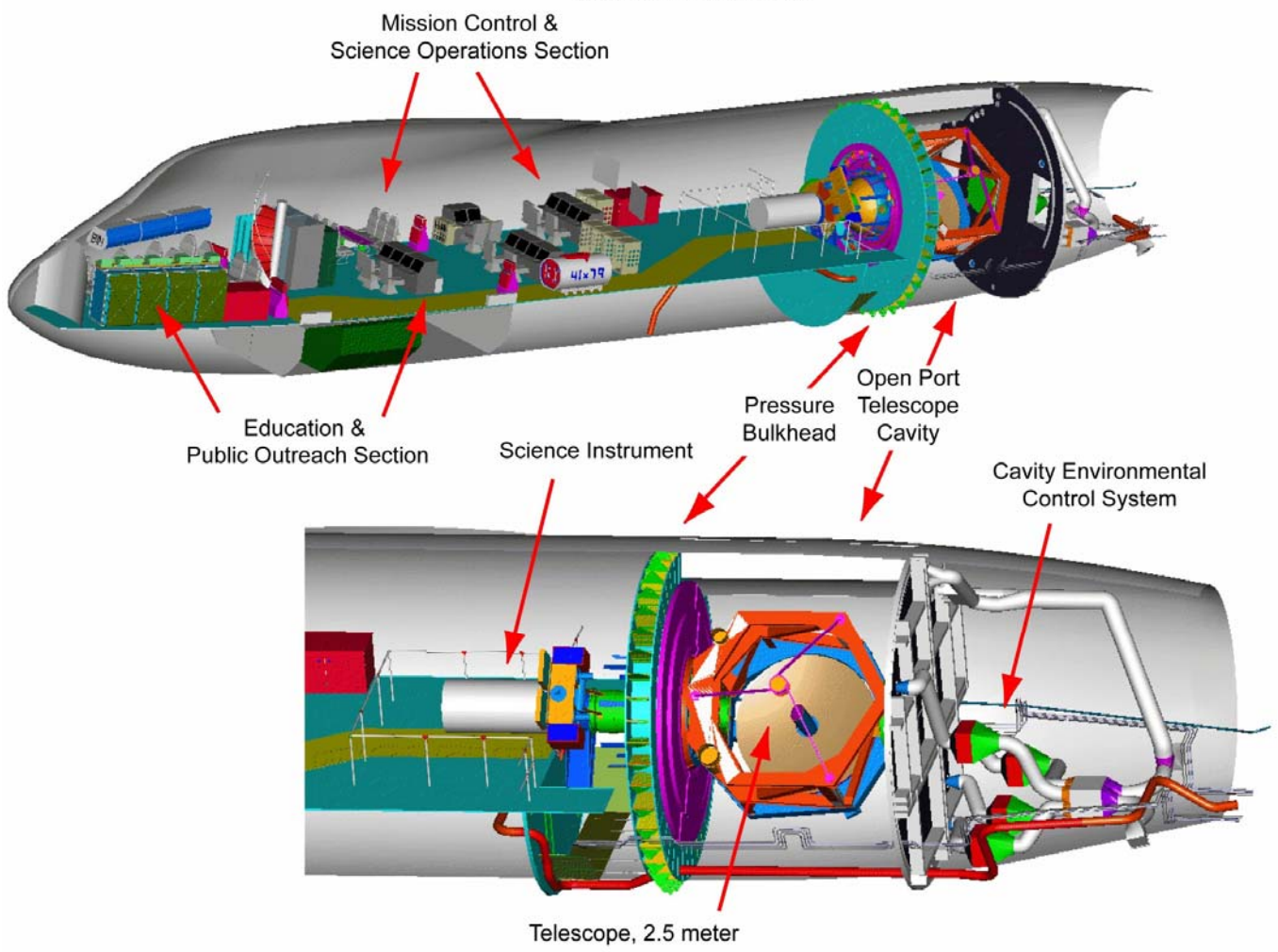
The view from the top



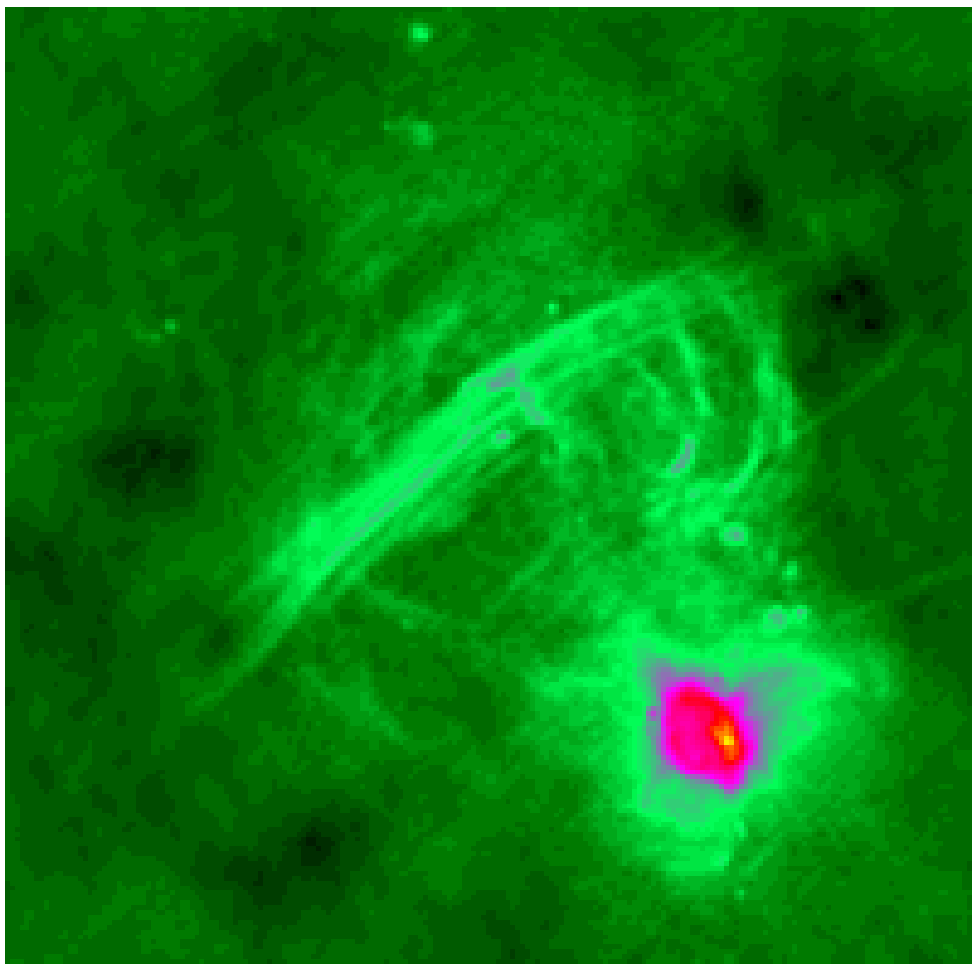
Stratospheric Observatory for Infrared Astronomy (SOFIA)

Layout of Personnel and Accomodations

(upper deck not shown)

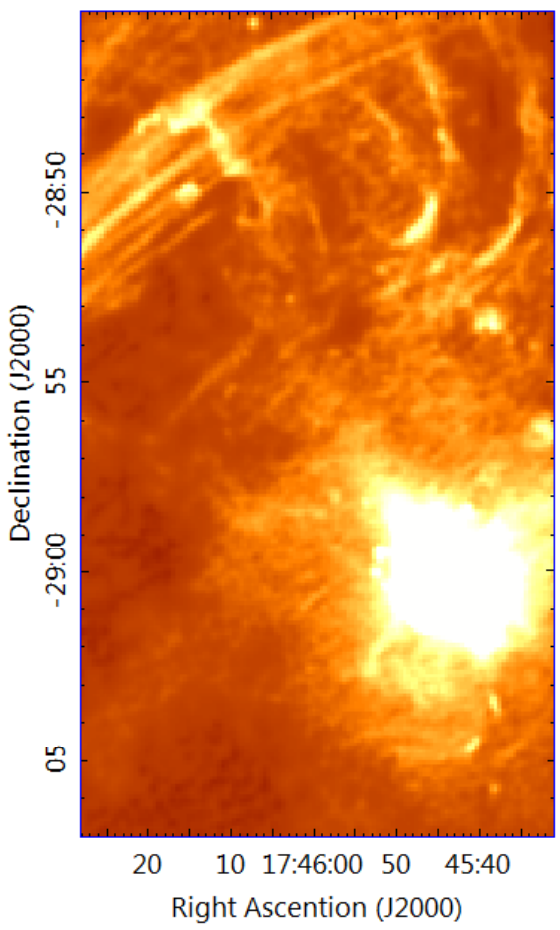


Galactic Center in radio continuum



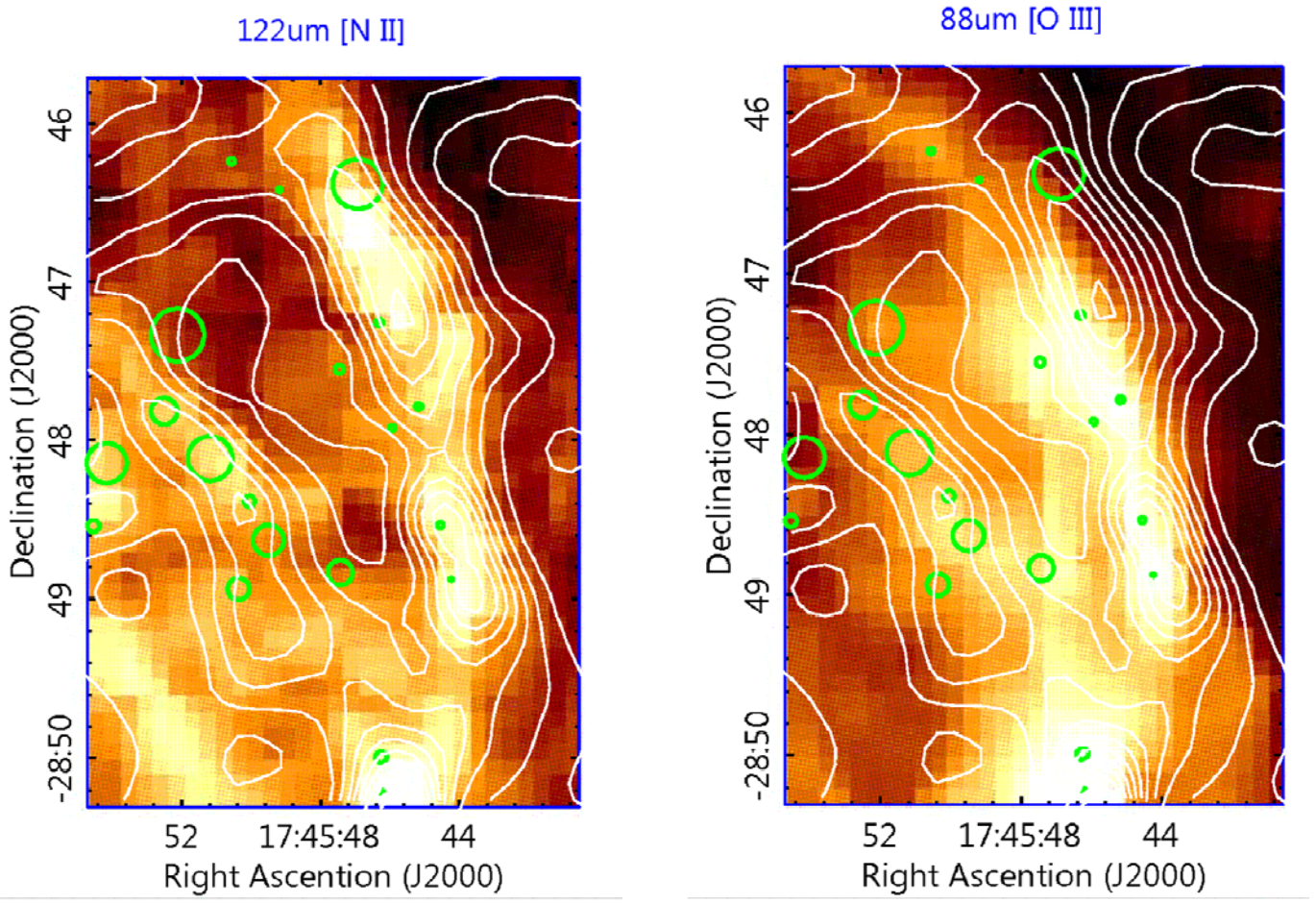
VLA image

What warms the dense molecular material in the Galactic center?



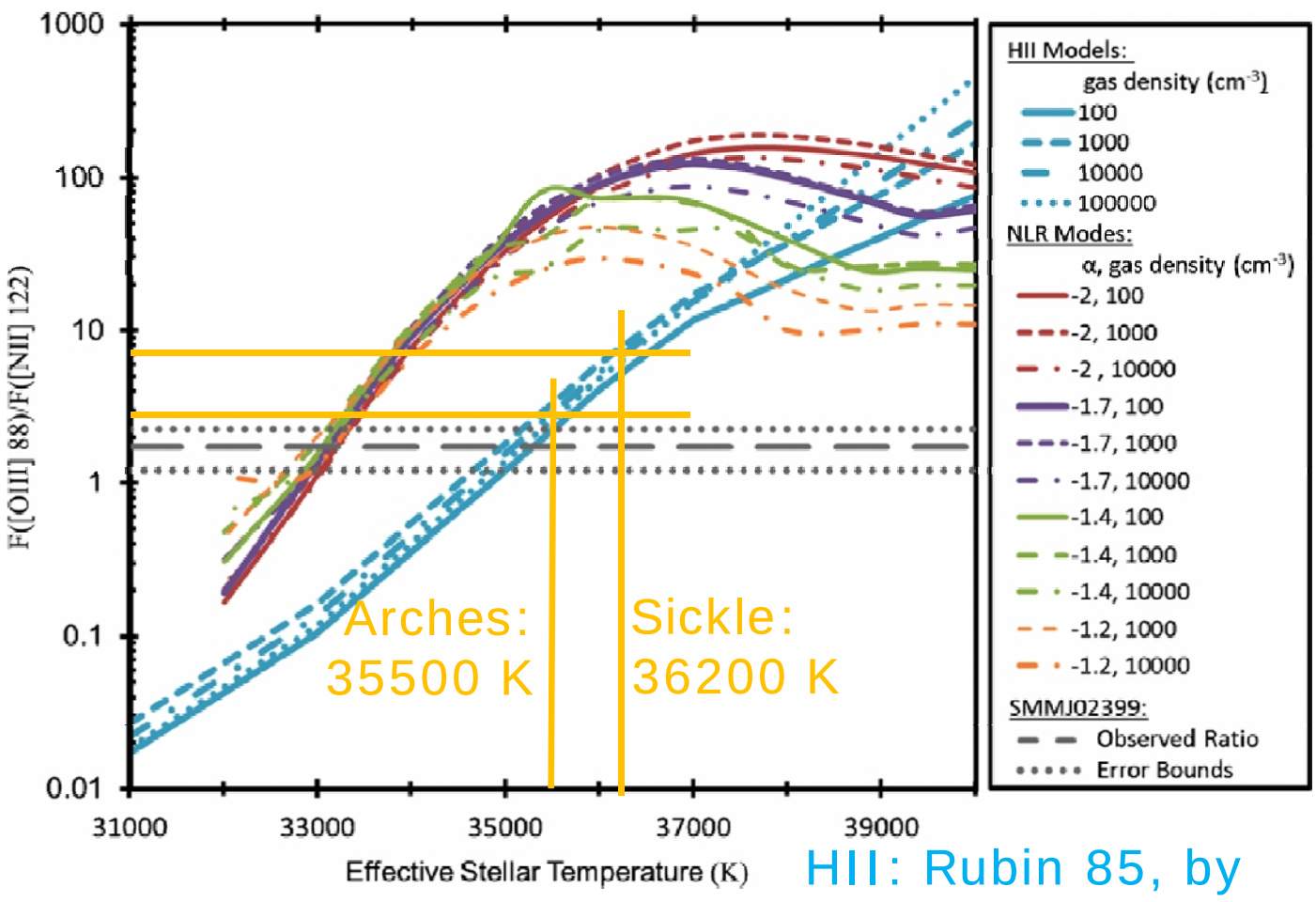
- Center molecular clouds are substantially warmer than disk clouds (e.g. Güsten+85)
- Lots of energy available: a black hole, hot stars (UV), intersecting orbits and colliding stellar winds (shocks), X-rays, rigid magnetic fields, radio lobes… A pretty active nucleus
- A galactic nucleus we can understand in detail
  - At 8.3 kpc, 10” = 0.4 pc

[N II] and [O III] in the Arches



Green circle diameter ∝ MSX point source catalog 8um/24um

[O III]/[N II] in J02399-0136 and in the Galactic center Arches



HII: Rubin 85, by

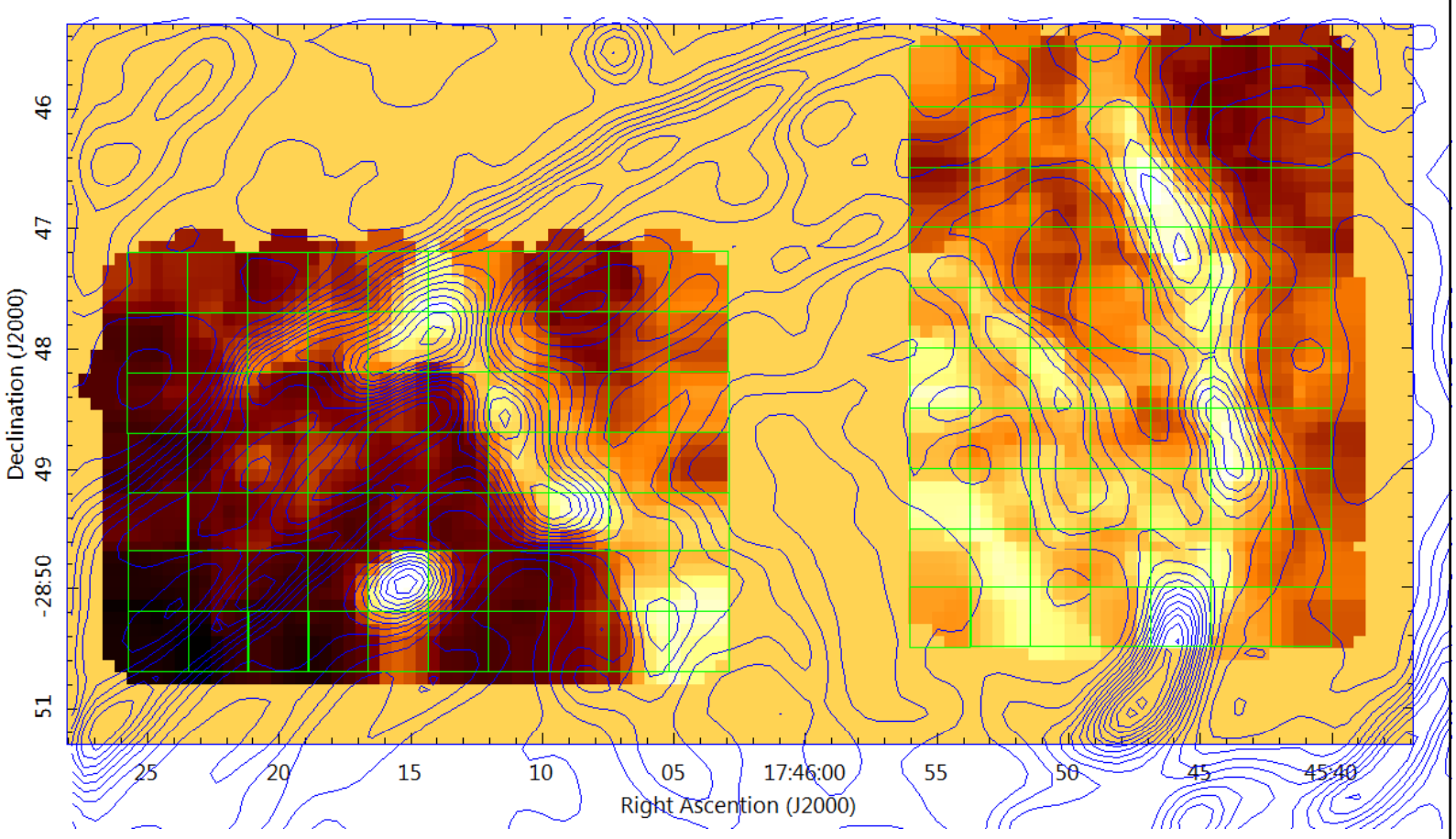
A solution?

Cluster of early O, WR stars

$$I \propto \int n_e^2 \, \mathrm{d}\ell$$

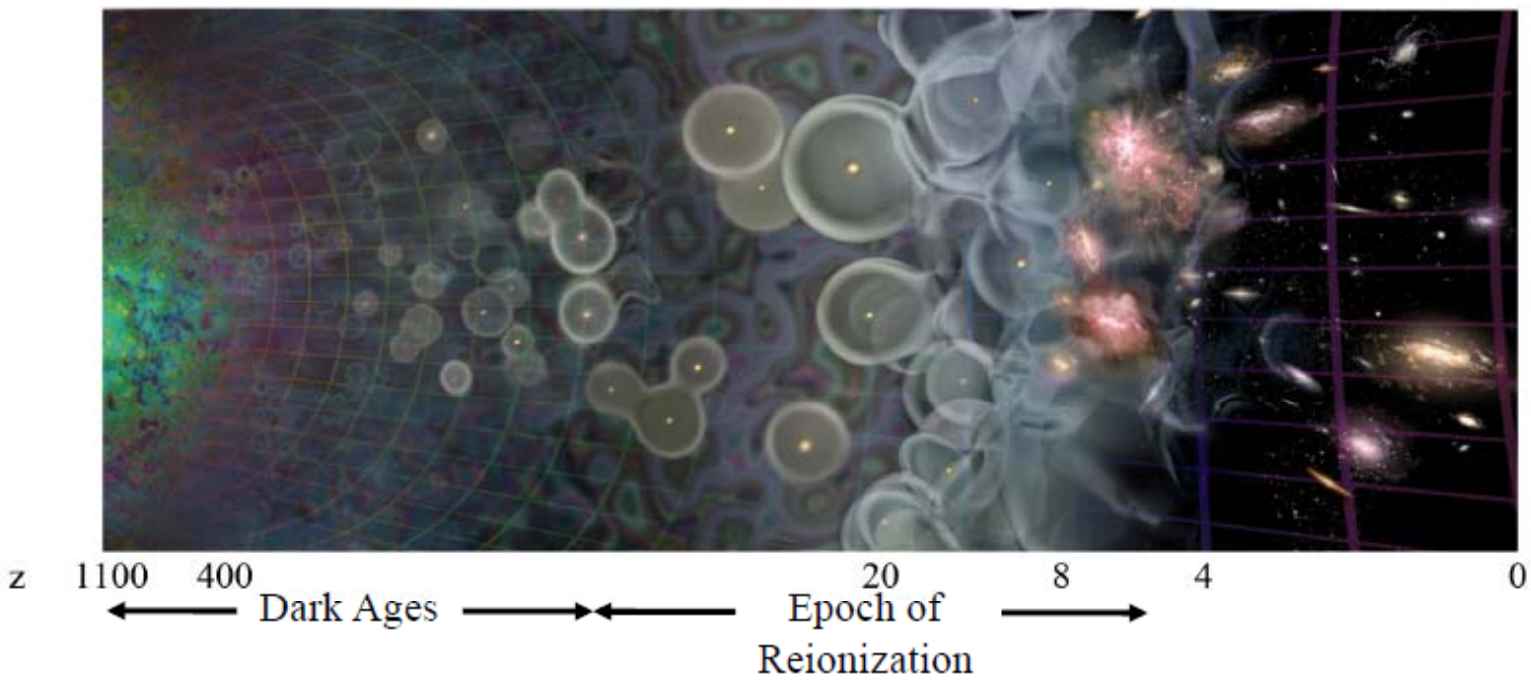
- Geometrical dilution can't change field hardness
- No O stars? Unlikely.
- But: density gradient at cloud edge can soften radiation field with distance into cloud, reducing apparent [O III]/[NII] ratio
- Test with SOFIA FIFI-LS [N III] observations scheduled for summer 2016: does [N II] have same spatial distribution as [O III] or as [N II]?

FIFI-LS footprints on the Galactic Center's Sickle and Arches

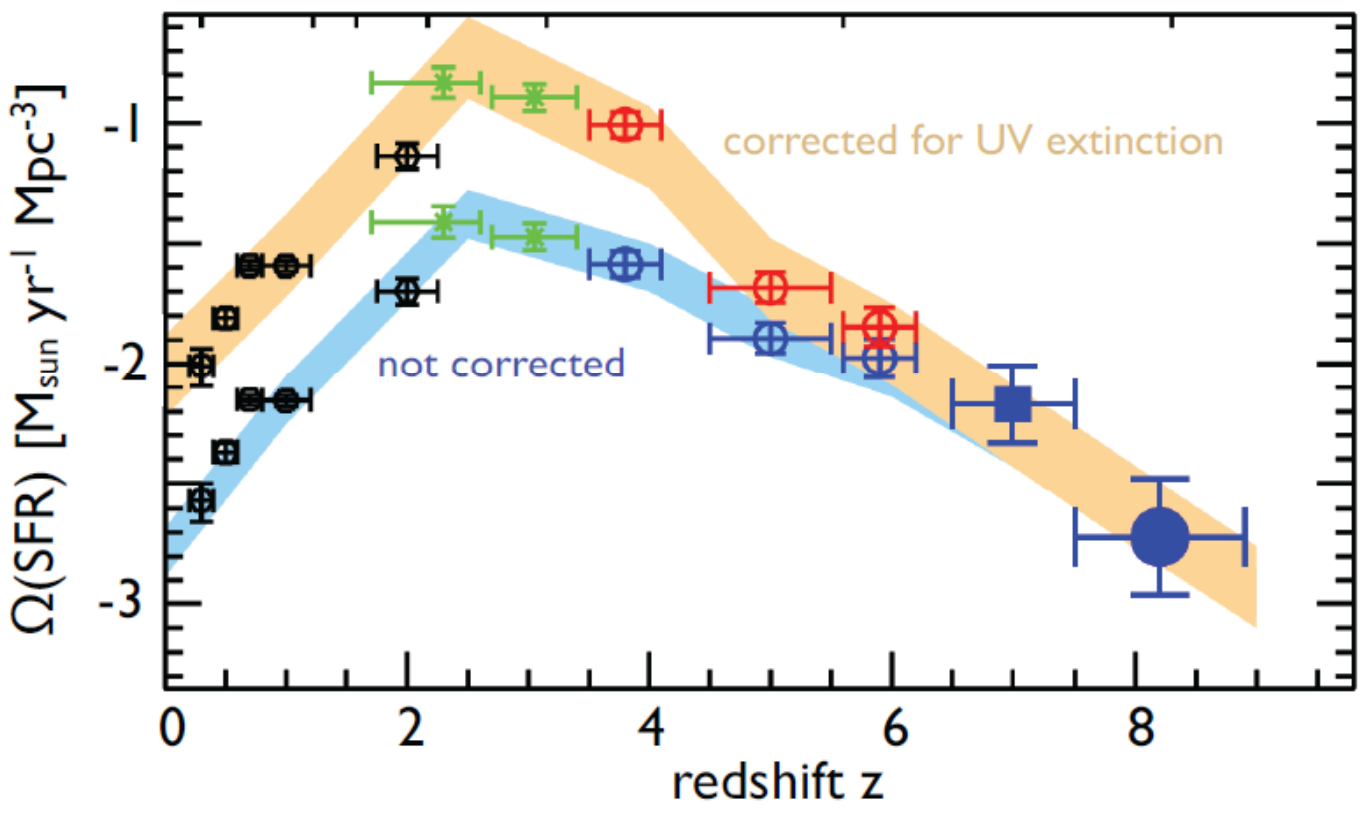


Color Herschel-PACS [N II]; contours 20 cm radio continuum

Universe's structure formation



Cosmic star formation rate density vs. redshift



Carilli & Walter 2013, after Bouwens et al. 2010

The Zpectrometer
ultrawideband correlation spectrometer

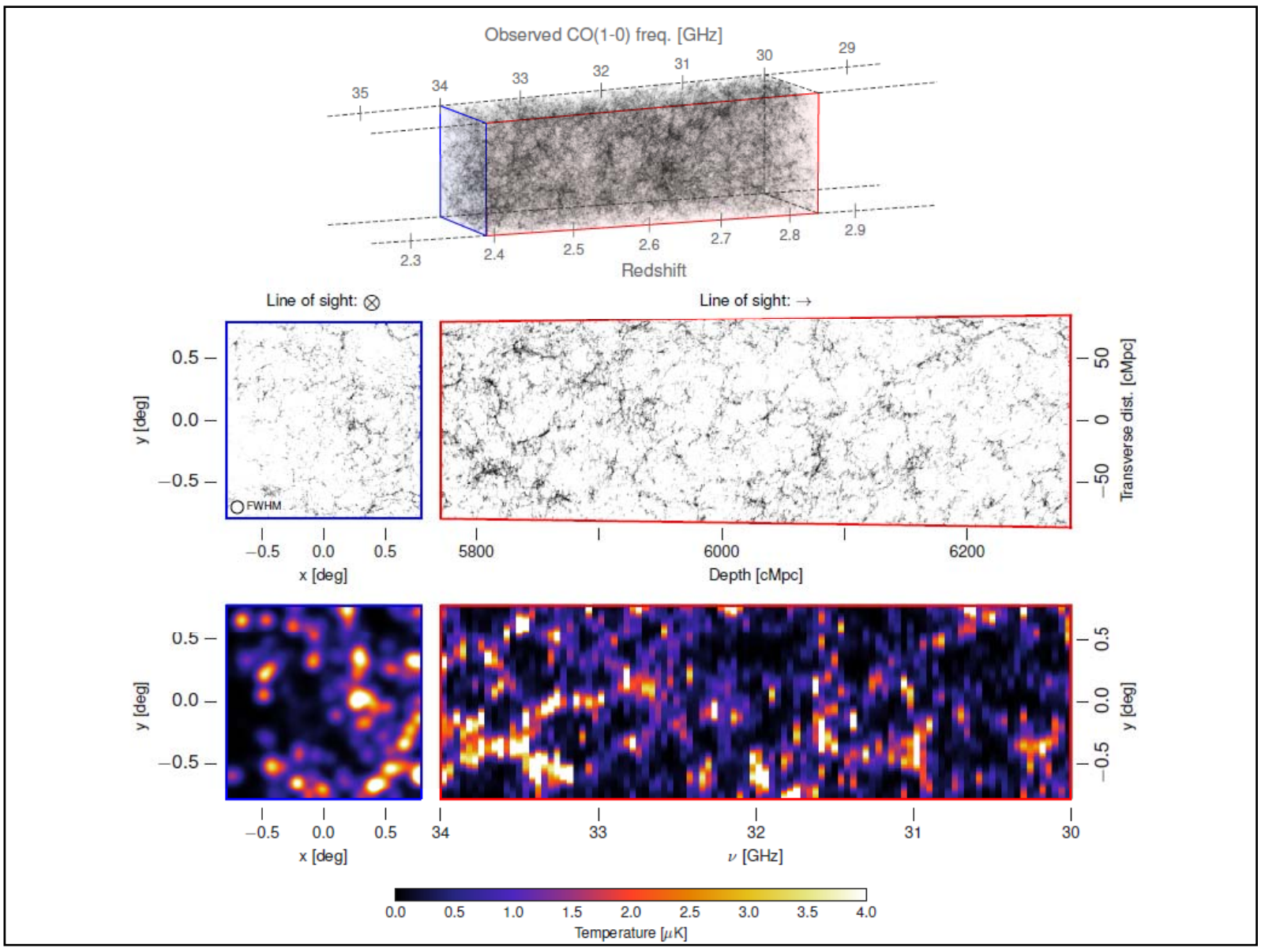
NSF ATI Program award AST-0503946 to UMD

The 100 meter diameter Robert C. Byrd Green Bank Telescope (GBT)

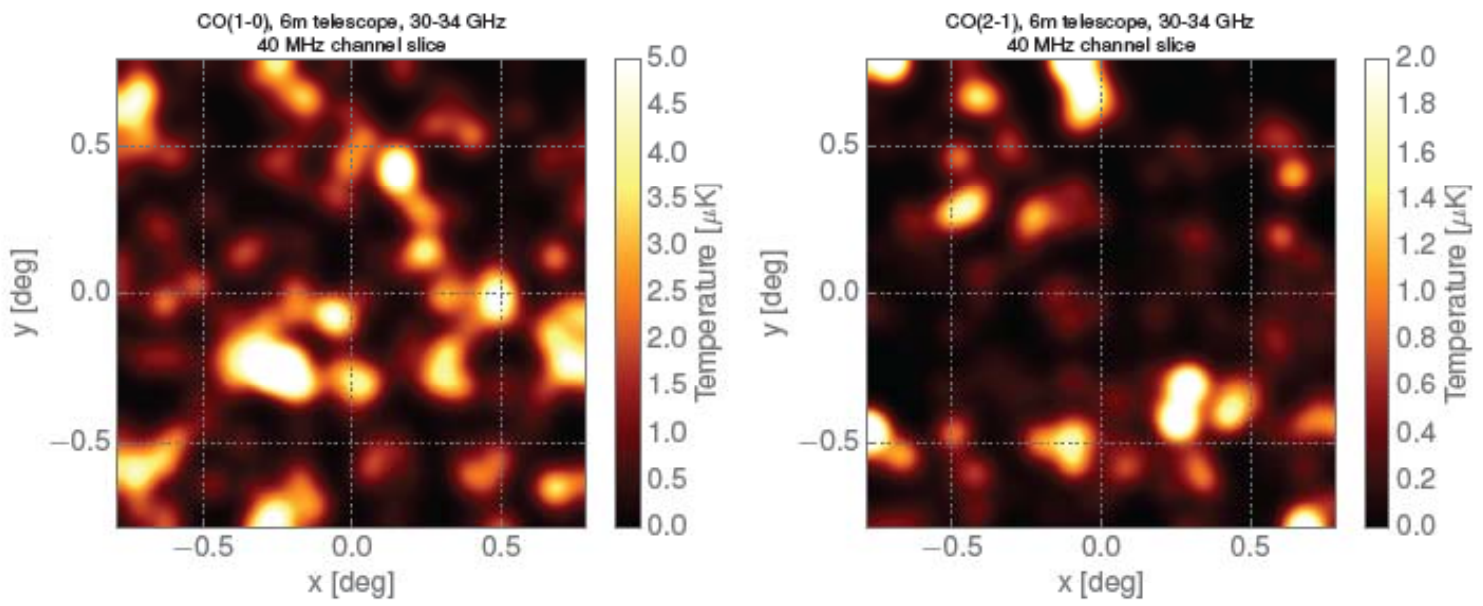
UMD's Zpectrometer correlators on the GBT receiver turret

COMAP survey properties at z ~ 2.9

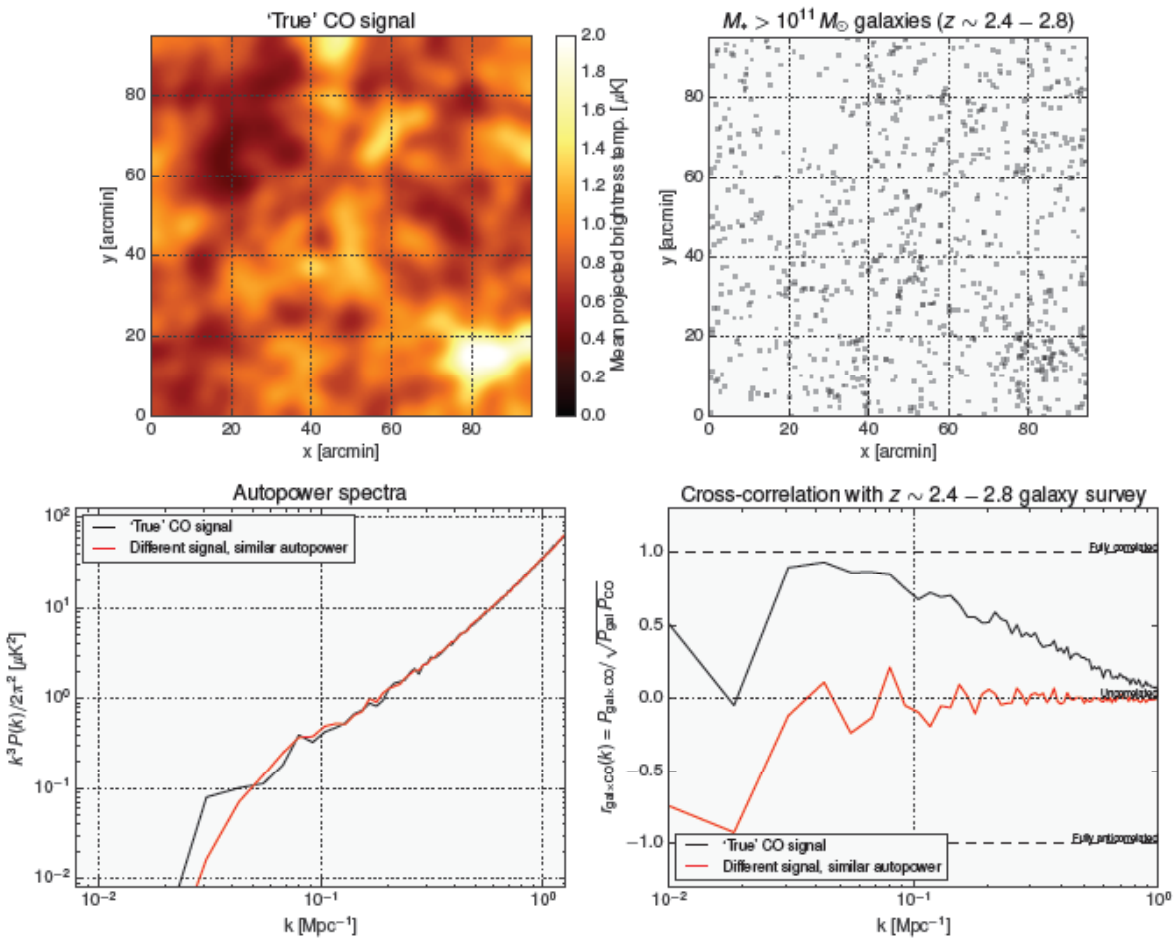
- Sensitive to *clusters* of galaxies
- 10 m telescope, 26-34 GHz; 29 GHz center frequency, ~3.4' beam
- Beam size corresponds to a comoving ~6 Mpc
- $\Delta z \sim 0.006$ matches the linear and line of sight scales
- This corresponds to $\Delta f \sim 48$ MHz, or ~165 "slices" in an 8 GHz bandwidth (covering ~1 Gyr)
- Comoving volume of ~600 Mpc^3 for each "slice" (each covering ~60 Myr)



Simulated integrated intensity images



Cross-correlation distinguishes signal from noise



Potential projects

- Herschel HIFI and SOFIA Galactic center (data analysis; with MPIfR Bonn, UCLA, Cornell). A great second-year project.
- Argus observations and mapping software for the GBT: dense gas mapping of galaxies and galactic filaments at 4 mm wavelength (With Boltatto or Mundy)
- COMAP CO integrated intensity experiment to trace star formation near the peak of the galaxy formation and mass assembly era (High risk, high gain in a big international project)