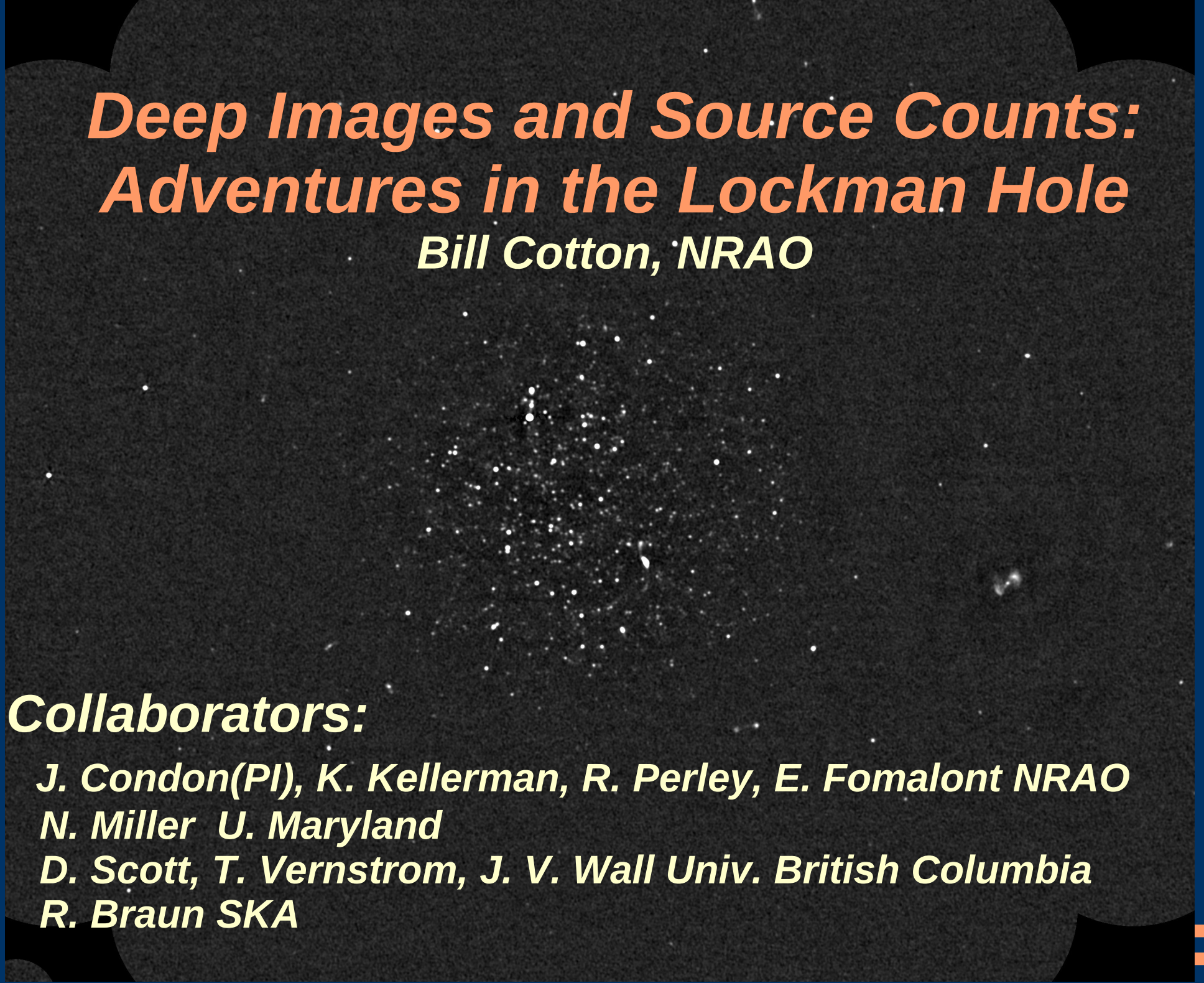
Deep Images and Source Counts: Adventures in the Lockman Hole

Bill Cotton, NRAO



Collaborators:

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Motivation

- Explore unexpected result of ARCADE-2 CMB balloon experiment's excess brightness at 3 GHz.

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- Use upgraded JVLA sensitivity to measure faint source population

Known Radio Source Populations: AGNs

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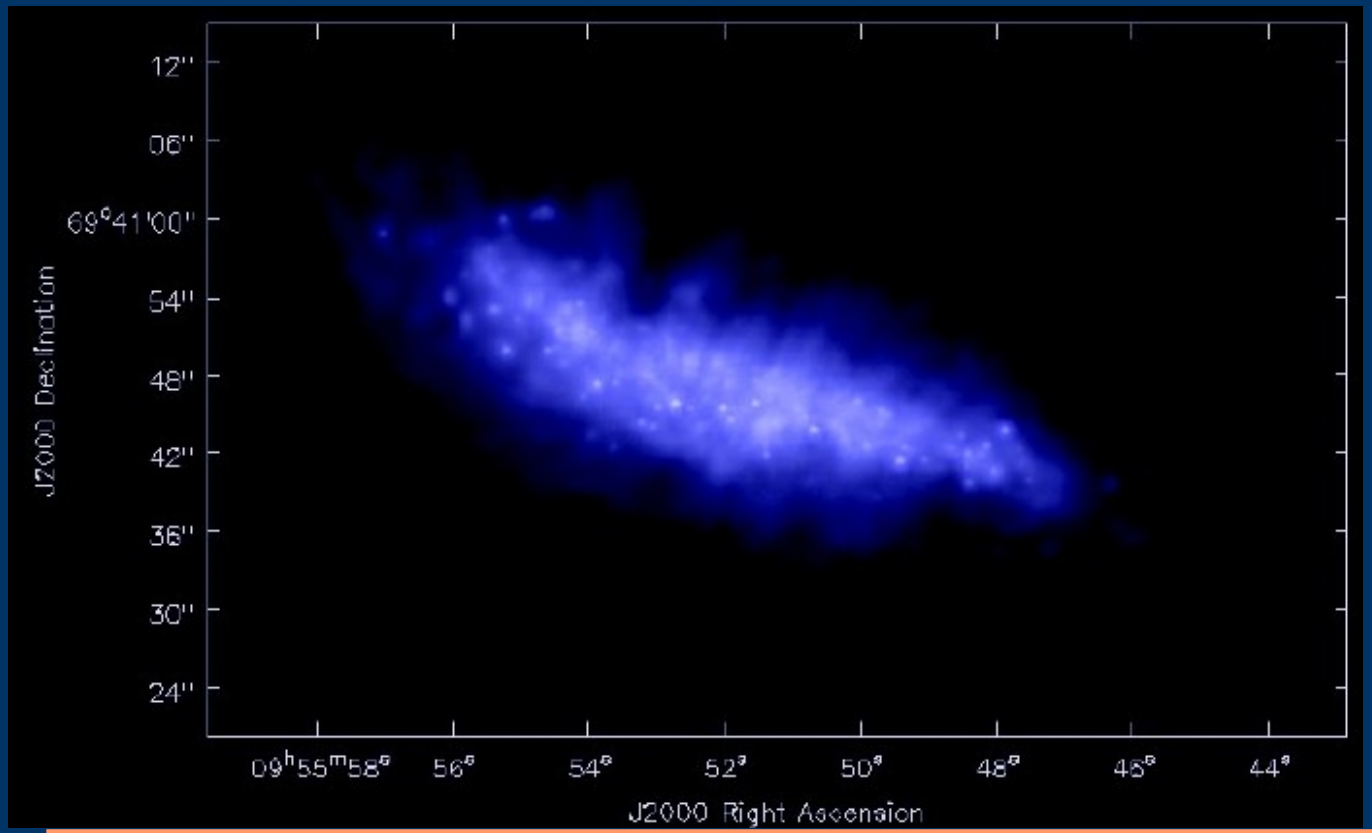
- Only a fraction of AGNs are radio loud
- Possibly a phase of all AGN activity cycles

Known Radio Source Populations: Star forming galaxies

Massive star formation leads to radio emission through cosmic rays, SNe and HII regions.



M82 EVLA
J. Marvel PhD NMT

Star formation in Galaxies

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- Star formation generally fainter than AGN
- Galaxies more numerous than radio loud AGN
- Fainter than ~ 1 mJy star forming galaxies dominate the radio source population

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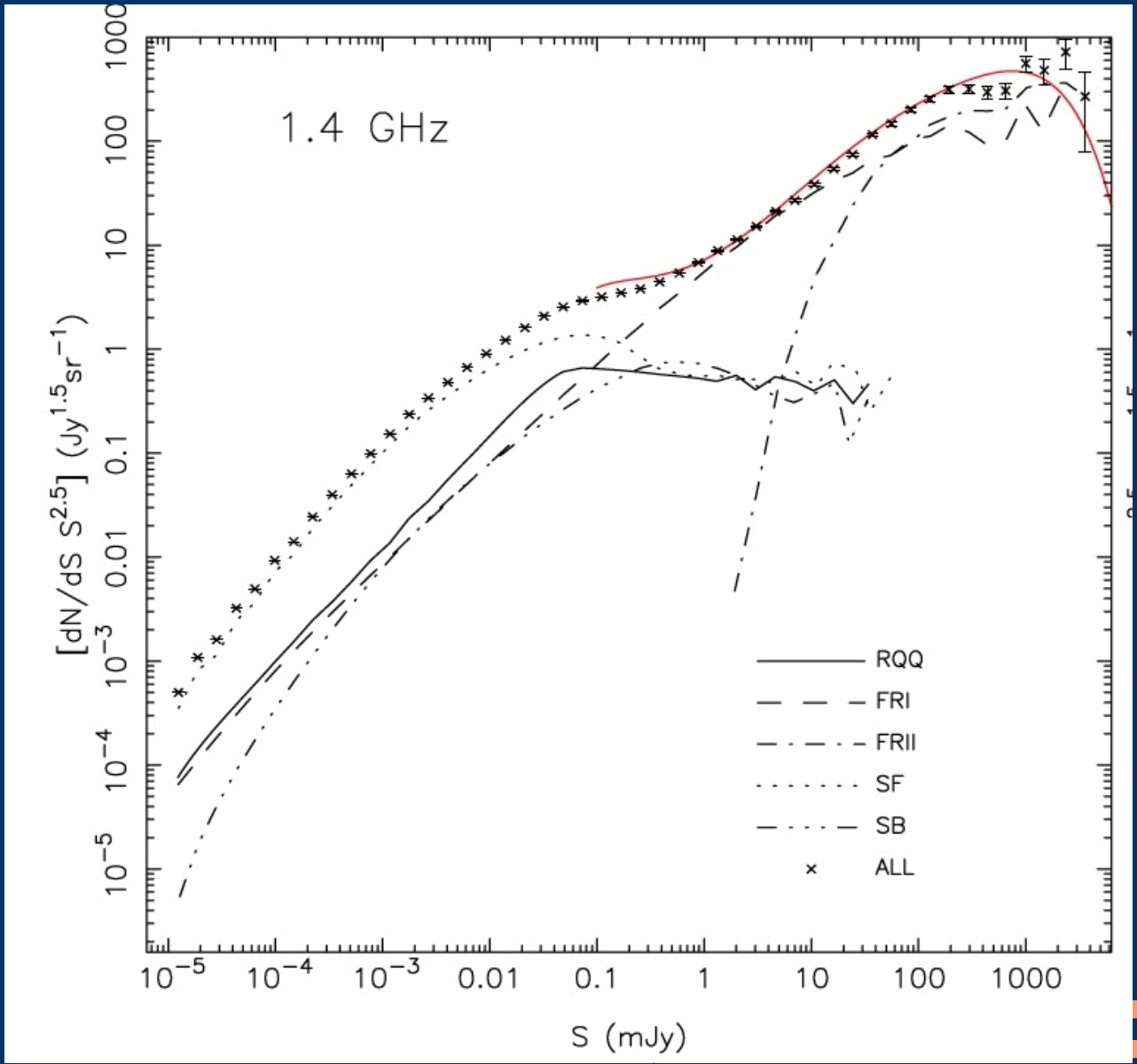
- Observed local luminosity can be used with evolution scaling laws to predict source counts
- Strong evolution required for source counts ruled out steady state universe

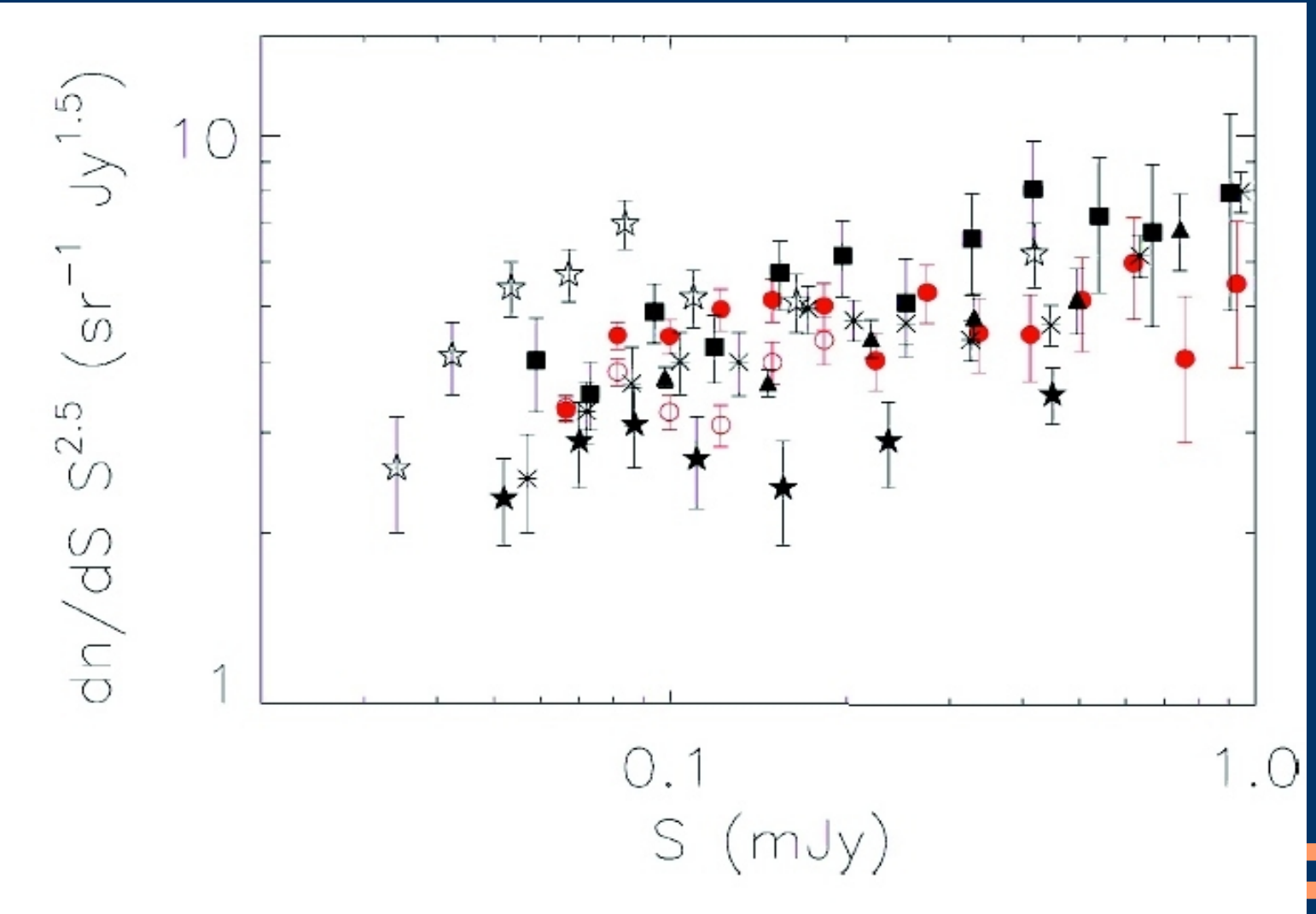
Predicted Source Counts



Euclidian normalized source counts from SKA simulations (Wilman et al, 2008)
red line = observations

Previous Faint Source Counts

- Previous deep surveys give large scatter in source counts. “Cosmic variance”?



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- Different groups used different correction techniques.

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- “P of D” analysis extracts source counts from pixel distribution.
- Minimal corrections to extracted source counts
- Good statistics from using many pixels.

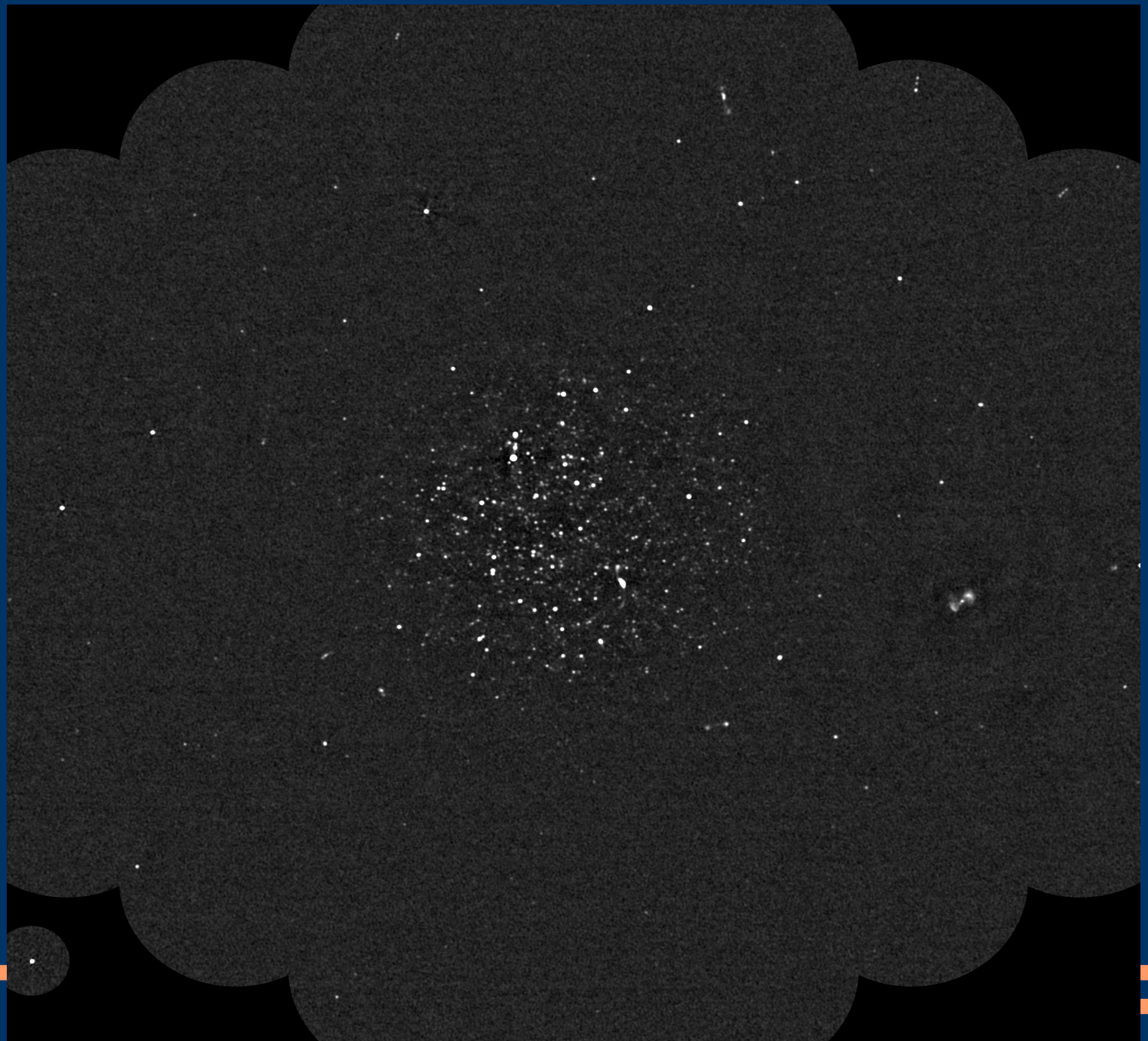
Survey Details

- 57 hours of (partial) EVLA in S band (2-4 GHz) on a pointing in the Lockman Hole, C config.
- 1 μJy RMS image, 8” resolution
- Wideband/widefield imaging to get images in each spectral window
  - Bin data in frequency (spectral windows)
  - Joint CLEAN from weighted average residual
  - Bins individually CLEANed

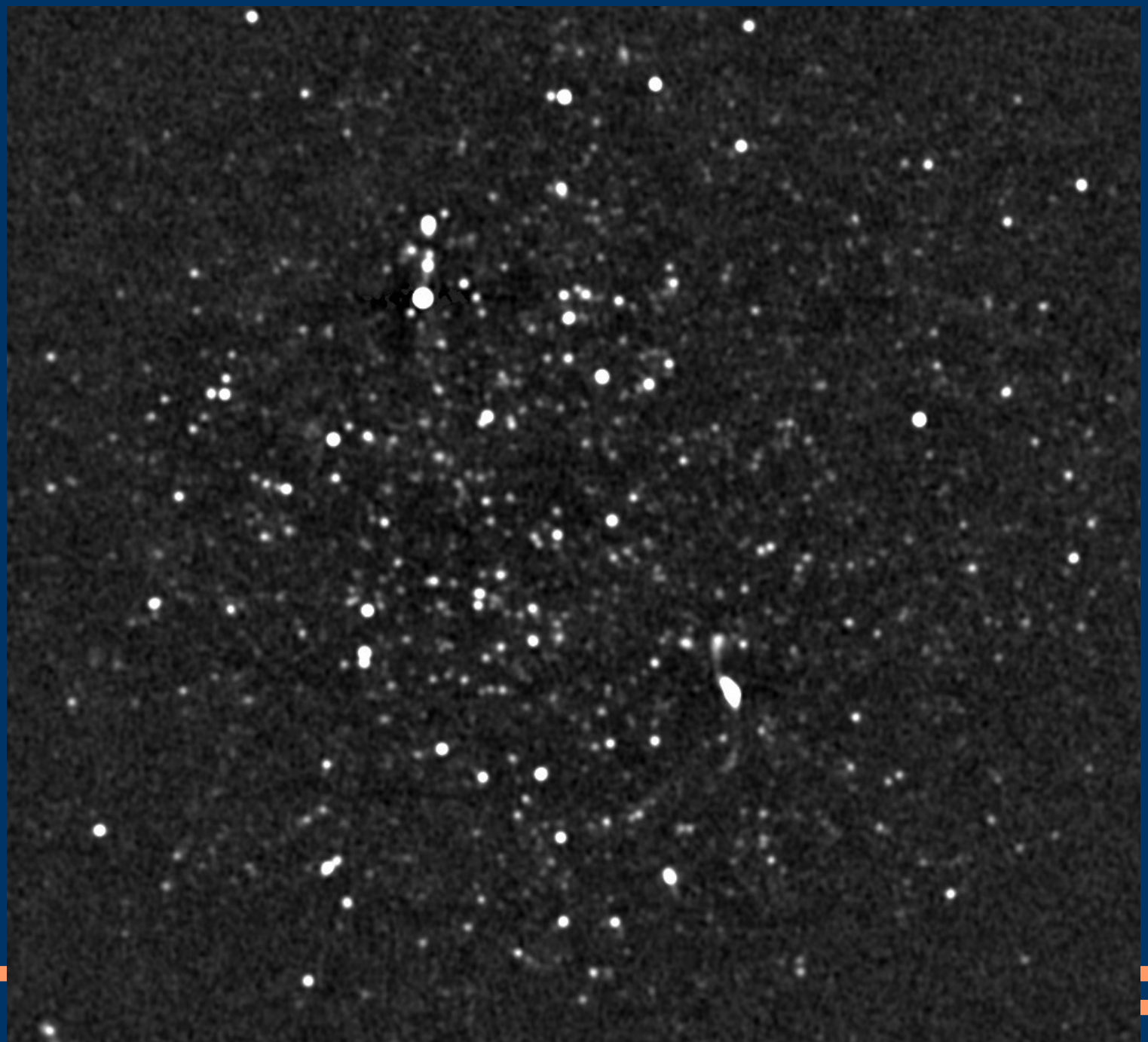
Survey Details, cont'd

- Special beamshaping of the residual beam in Obit to get constant and known psf in frequency
  - Taper and Robust per SW to get dirty beam smaller than target
  - Shallow CLEAN not to distort pixel distribution.
  - After CLEAN, convolve residuals up to target size
- Derive final image correcting for spectral index, effective frequency, RMS and beamshape.

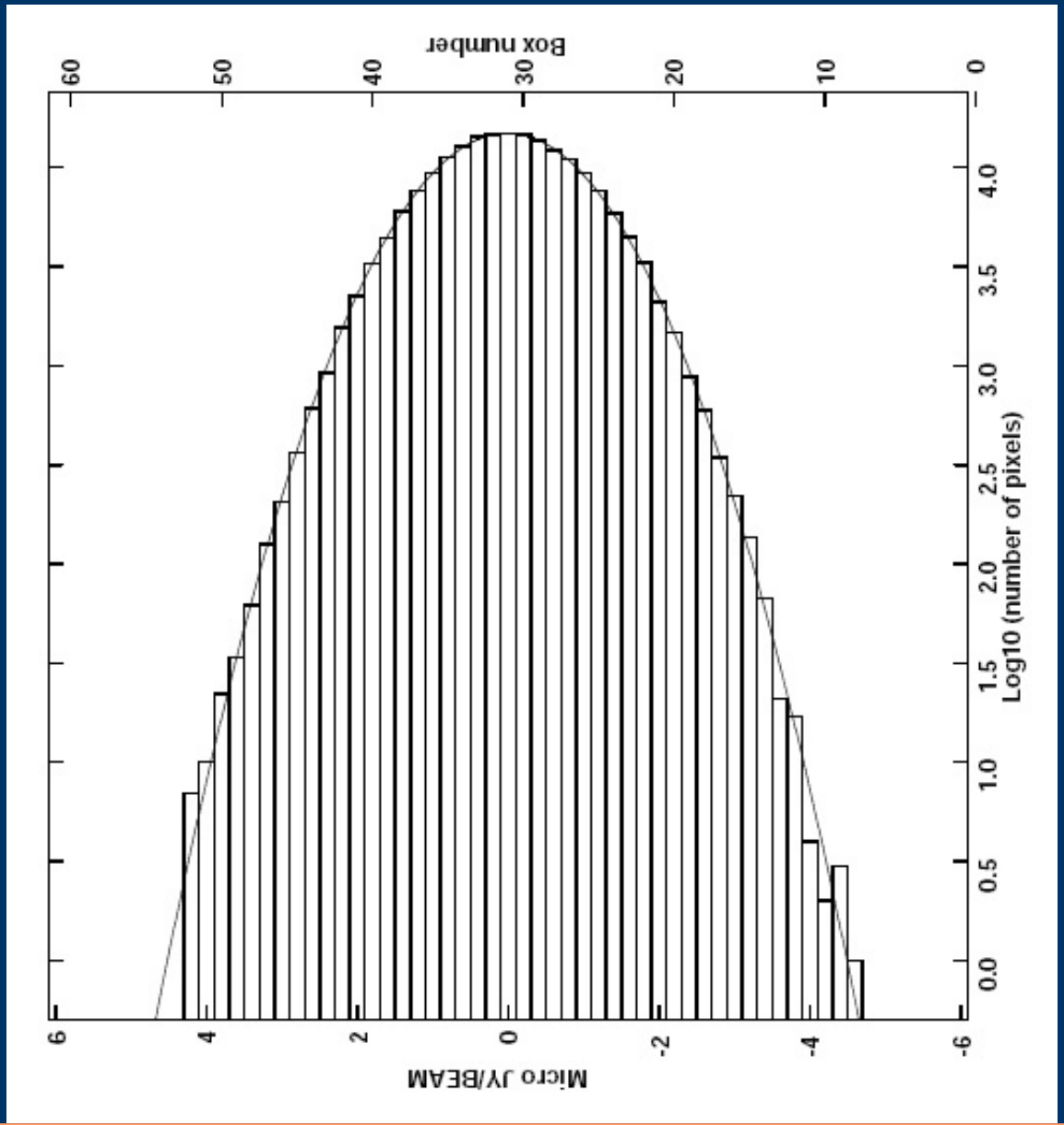
Confusion limited image



Confusion limited image detail

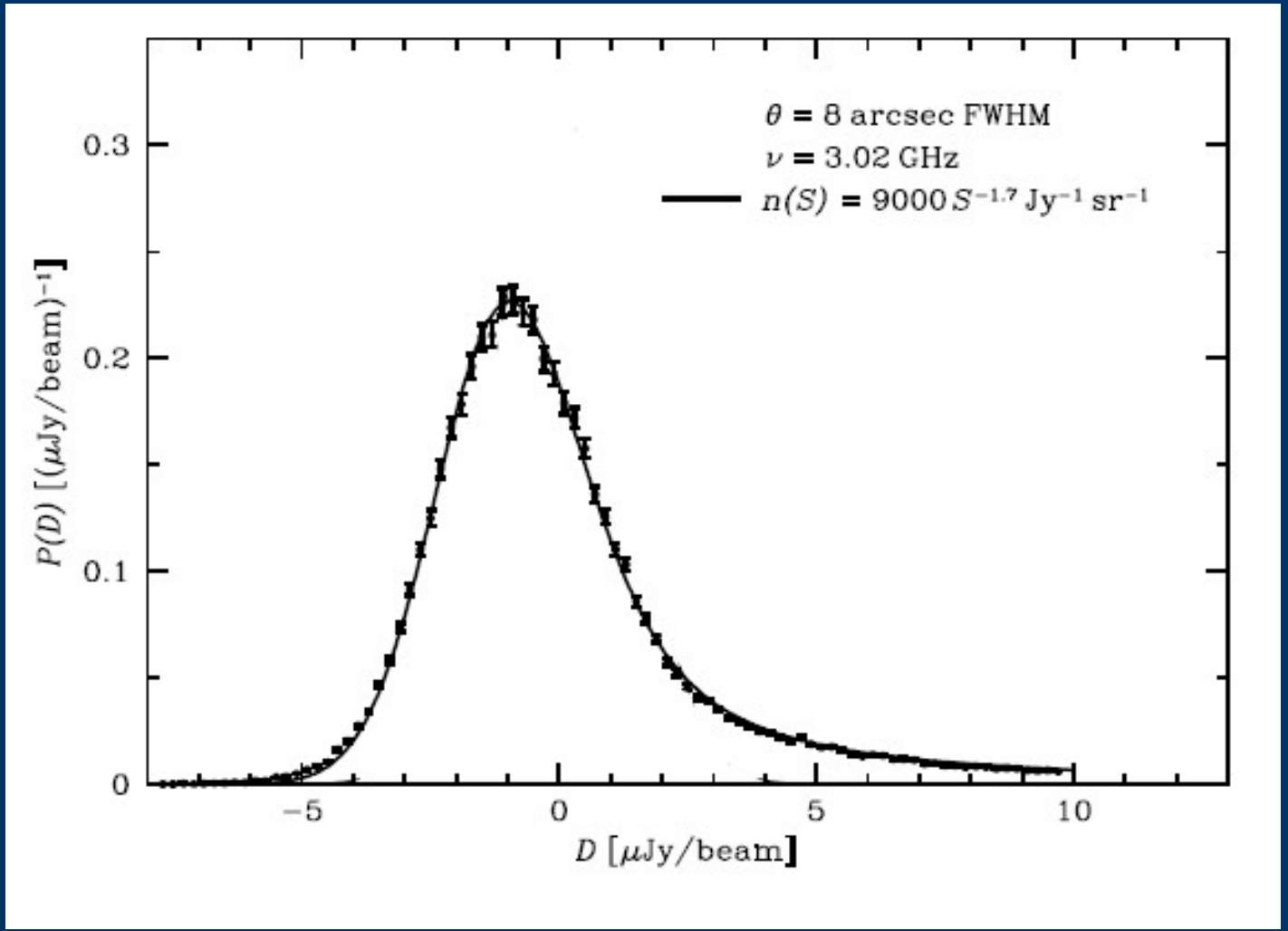


Source free Pixel distribution



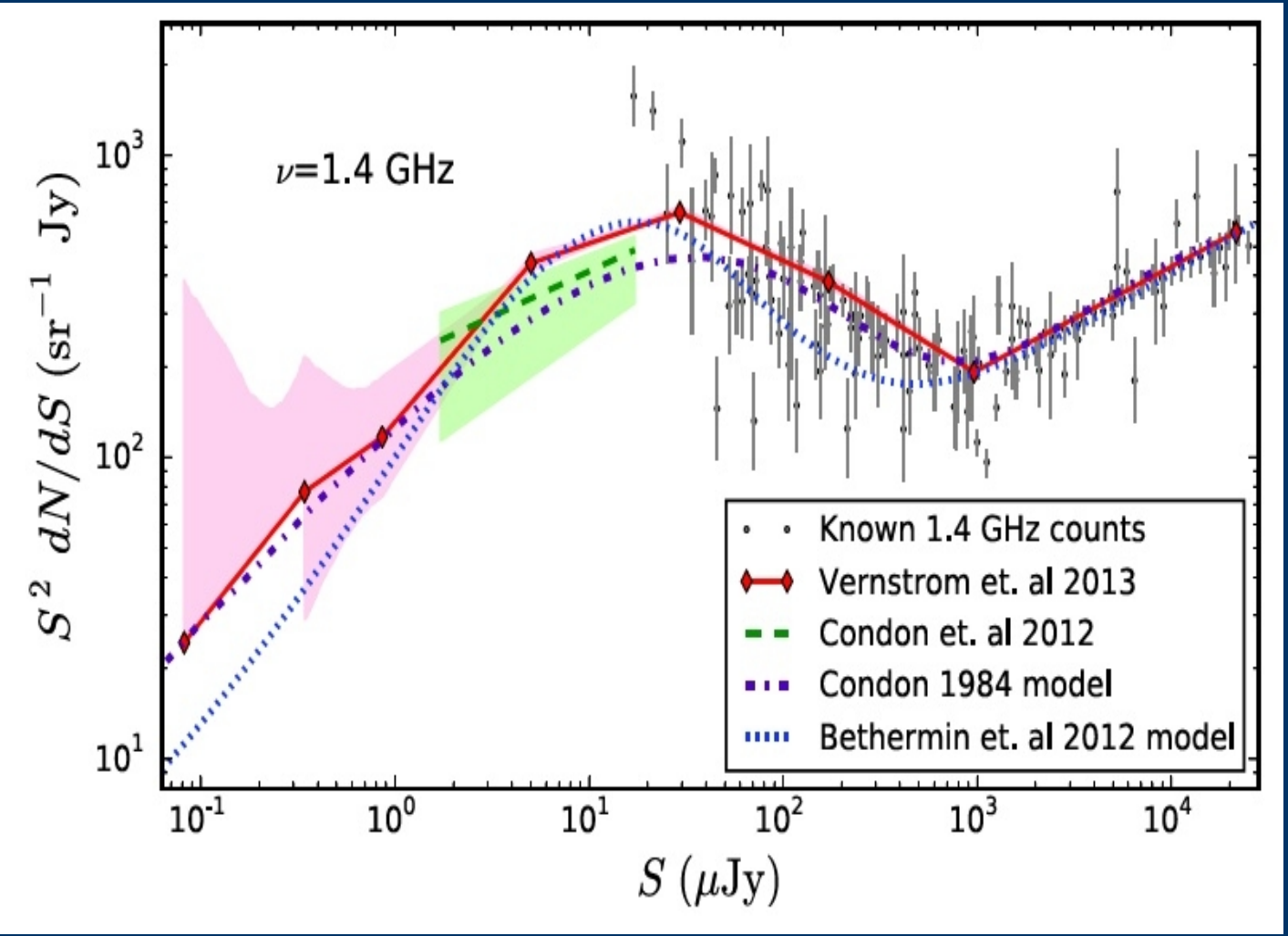
Pixel distribution, P of D

- Initially fit with power law distribution

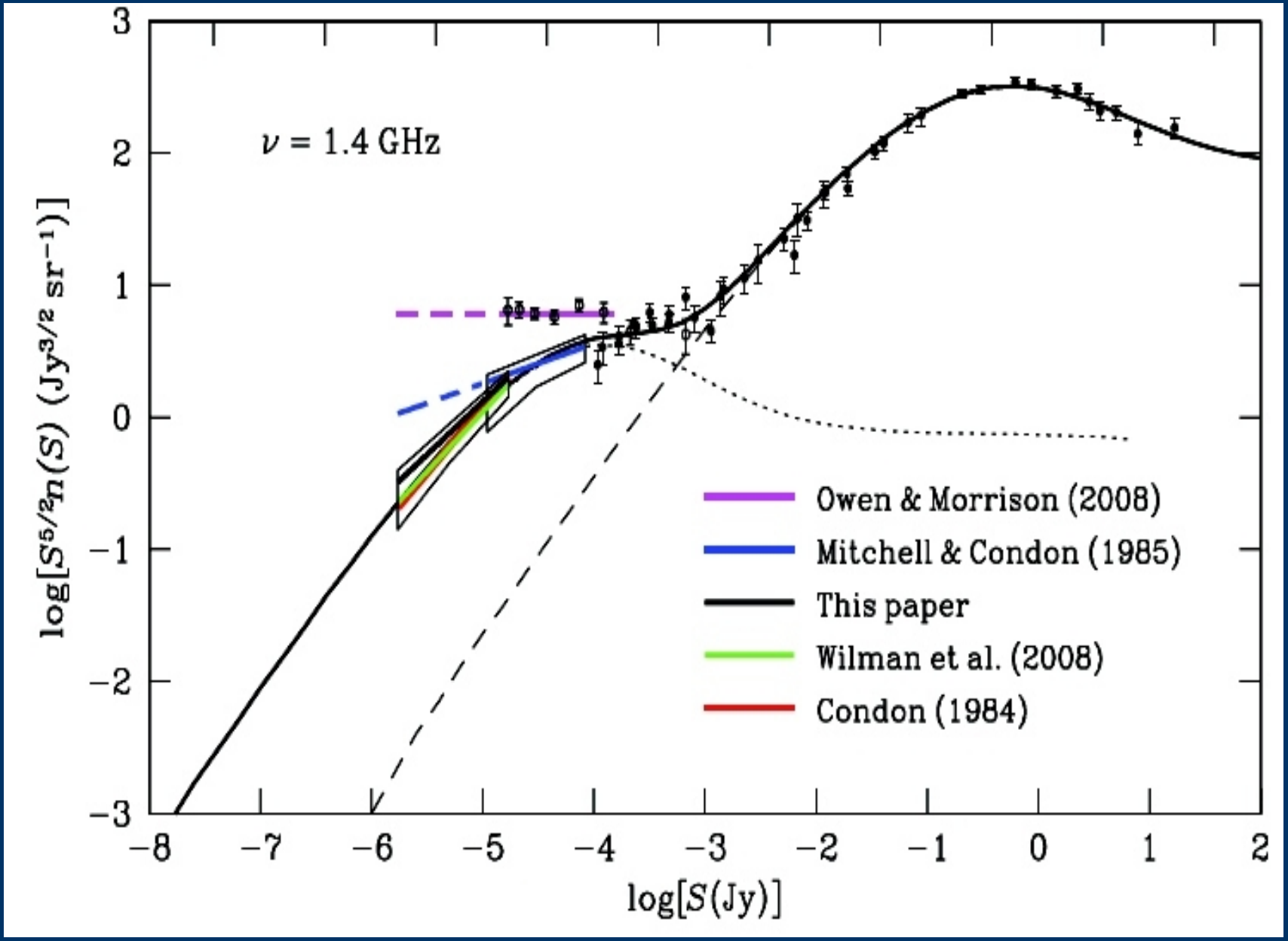


Pixel distribution, P of D

- Then MCMC analysis constraining source counts above 50 nJy



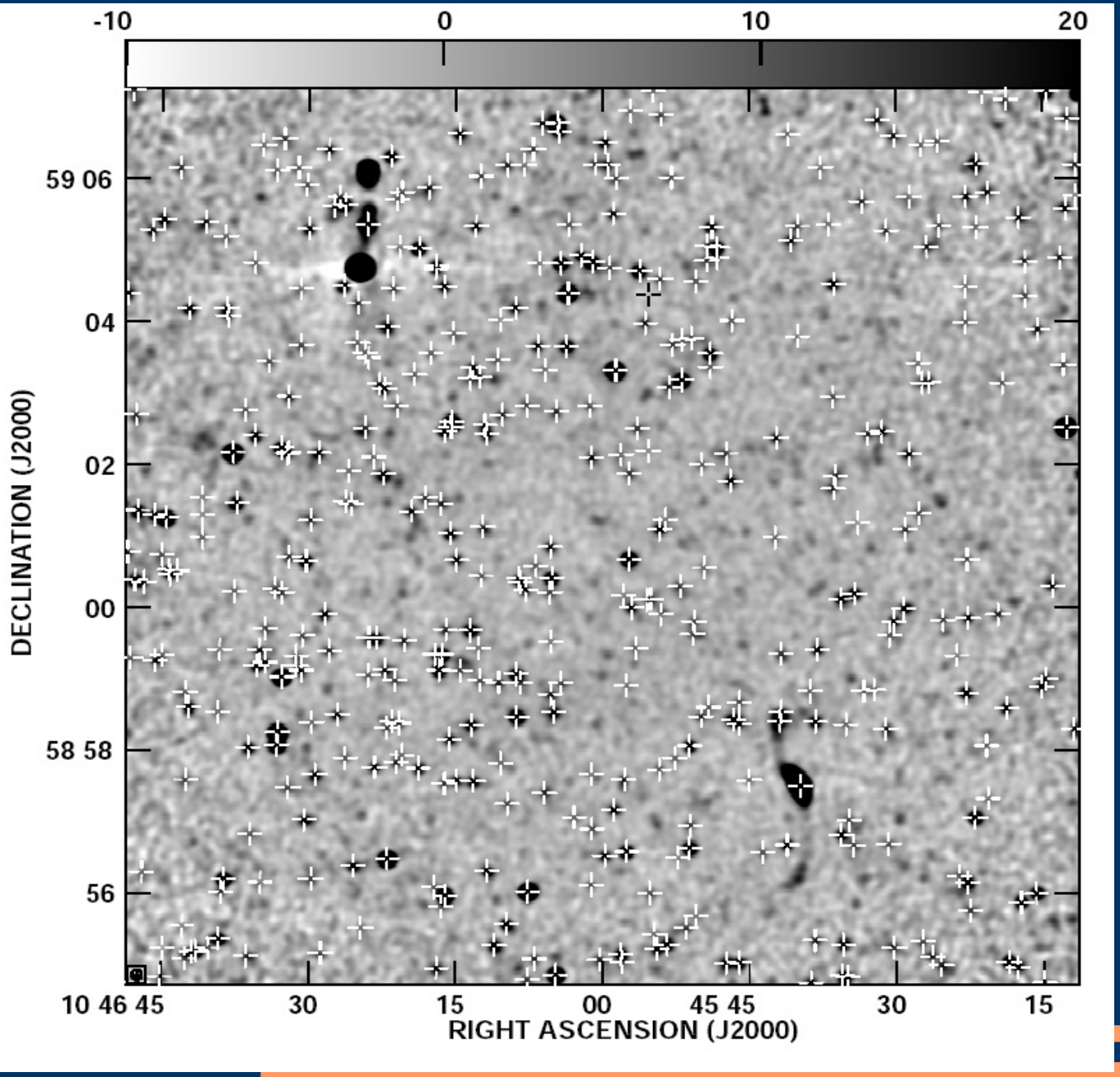
Source Counts



Source counts

- Good agreement with theoretical expectations
- Very different results from Owen & Morrison 2008, Why?
- Same pointing center → not “cosmic variance”

Confusion v. Owen & Morrison 2008



S band image with OM sources as +

Source counts

- Very different results from Owen & Morrison 2008, Why?
- Same pointing center → not “cosmic variance”
- See same sources.
- Difference from corrections applied, source size?

Current: Source Size Distribution

- Source sizes generally determined from fitting sources in high resolution image.
- Poorly constrained at low SNR.
- Stronger sources may not well characterize fainter sources.
- Proposal to use ratio of 2.5” (B config) to 0.7” (A config) to determine source area.
- Have B resolution image
- A config. High priority this Summer

2.7” Resolution detail

Polarization

- Expect star forming galaxies to be weakly polarized
- Russ Taylor claims to have detected weak, polarized sources.
- Appear to be AGNs, 20% AGN μJy fraction?
- Need beam images to remove off-axis polarization
- A config. polarization images.

Constraints on Evolution

- Evolving all local populations with luminosity $L(z) \propto (1+z)^{4.7}$ predicts source counts
- No other adjustments
- Can be modeled as all sources in a shell at z~0.8
- Source counts very consistent with same evolutionary law for AGN and star formation

Summary

- For first time resolved star formation peak in faint source counts
- Counts are consistent with same evolution law for AGN and star formation powered sources to z~1
- Currently measuring source size distribution.

Oh Yeah

- For the ARCADE 2 3 GHz excess be due to a population of sources would require more sources than galaxies in the universe.