MMIC Array Receivers and Spectrographs Workshop 2

23-24 March 2009

Focal Plane Array Program at NRAO

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NRAO

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

NRAO Focal Plane Array & Camera Program

- Long-Term Vision:
  - Technical Development for Square Kilometer Array
    - Beam Forming Arrays (Low Frequency through ~λ 1 cm)
    - Increase FOV for interferometers – ALMA, EVLA

- Near-Term Vision
  - Scientific Enhancement for GBT through Large Format Arrays
    - Bolometer Cameras at 3 mm
    - Spectroscopic Systems at Key Frequency Bands
      - 3 mm (W-Band)
      - 1.3 cm (K-Band)
      - Others (e.g, 7 mm)
      - Testbed for SKA work – beam forming arrays

Status & Goals

- GBT Pathfinder Instruments
  - MUSTANG Bolometer Camera (64-pixels) – Early Science
  - 7-pixel K-Band (1.3 cm) Array under construction (for spectroscopy)

- Beam Forming R&D work
  - Collaborative program with BYU
    - MRI grant in progress
    - Instrumentation tests on 20 Meter telescope at GB

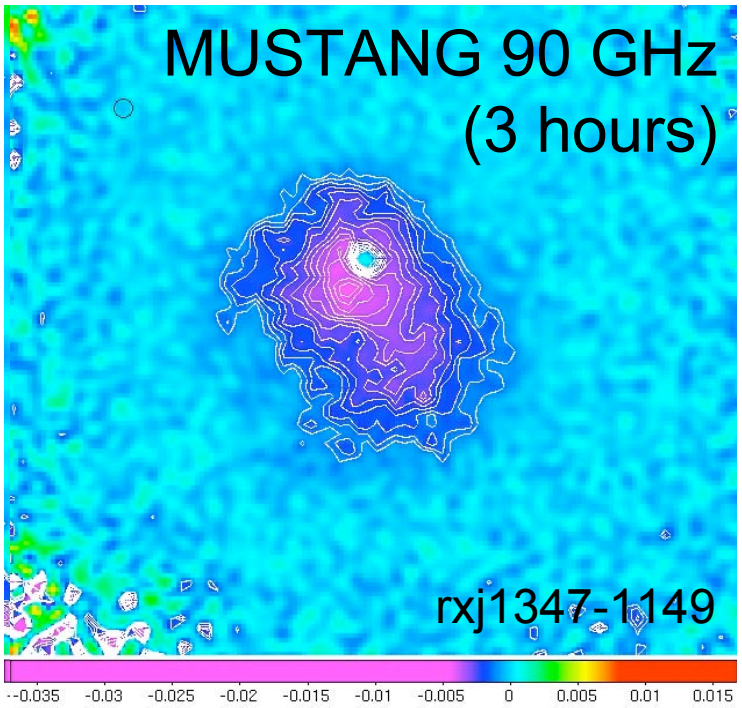
- MRI proposal to expand MUSTANG to 256 pixels submitted
- Proposal for 1000-element bolometer camera developed
- Concept for large format (e.g. 100-element) 3 mm array for GBT under development

MUSTANG (64 pixel bolometer array)

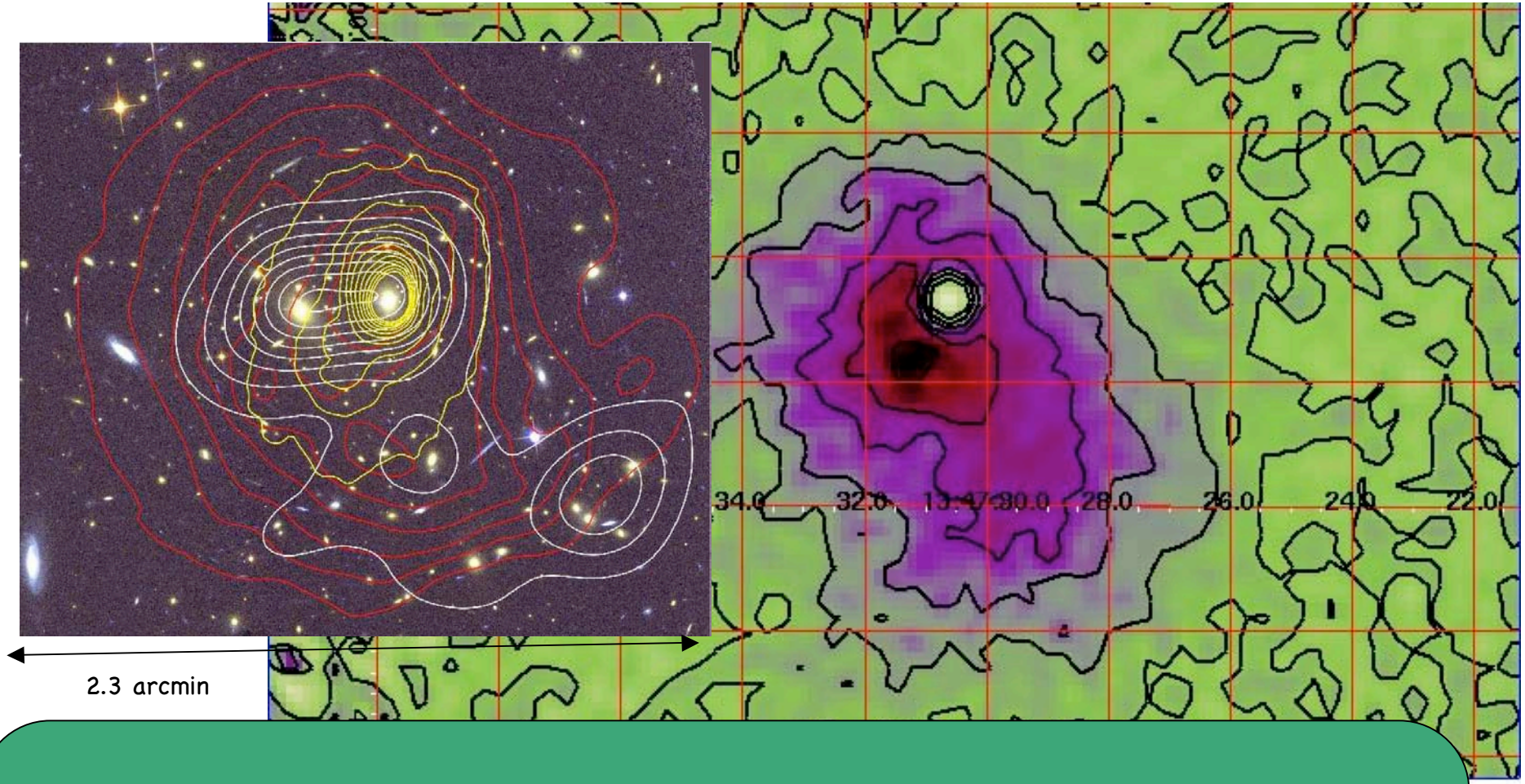
Resolution	9” (FWHM)
Beam spacing	4”
N-pixel	8x8
Current sensitivity	T_{sys}=140K
Target sensitivity	T_{sys}=28K
Bandwidth	18 GHz

- Currently 5x from photon noise
- Arrays 1x photon noise exist
- 4x increase in Npix ~$500k
- 16x increase in Npix~$3M

- 120 detectors on GBT ~ ALMA for 3mm continuum mapping speed



- First MUSTANG+GBT Detection of SZ! Bodes well for use of SZ as a detailed probe of ICM physics [Mason et al.]

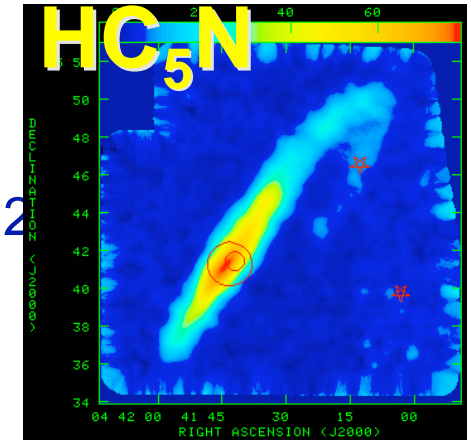


Lensing Mass Map
Galaxy Density
Xray Surface Brightness

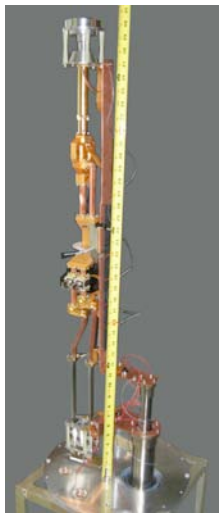
Optical + Xray (Left)
Bradac et al 2008

MUSTANG SZ (Right)
Similar angular scales

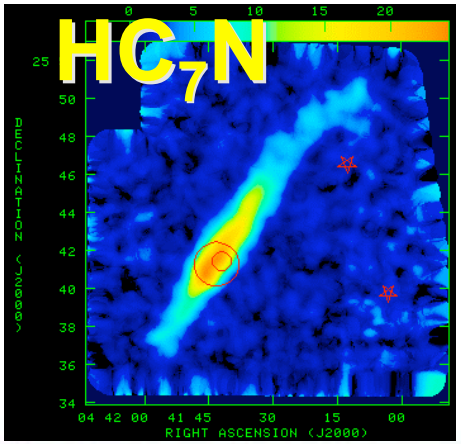
GBT Spectral Line FPAs



- 7-pixel prototype K-band Array to be released in late 2
  - First element tested on the sky – results excellent



- Next step involves increasing the number of pixels
  - 100+ pixel W-band (3 mm) array
  - 61-pixel K-band (1.3 cm) array
- Signal transmission and processing infrastructure required
  - Need increased data transmission capability
  - Need new signal processing system



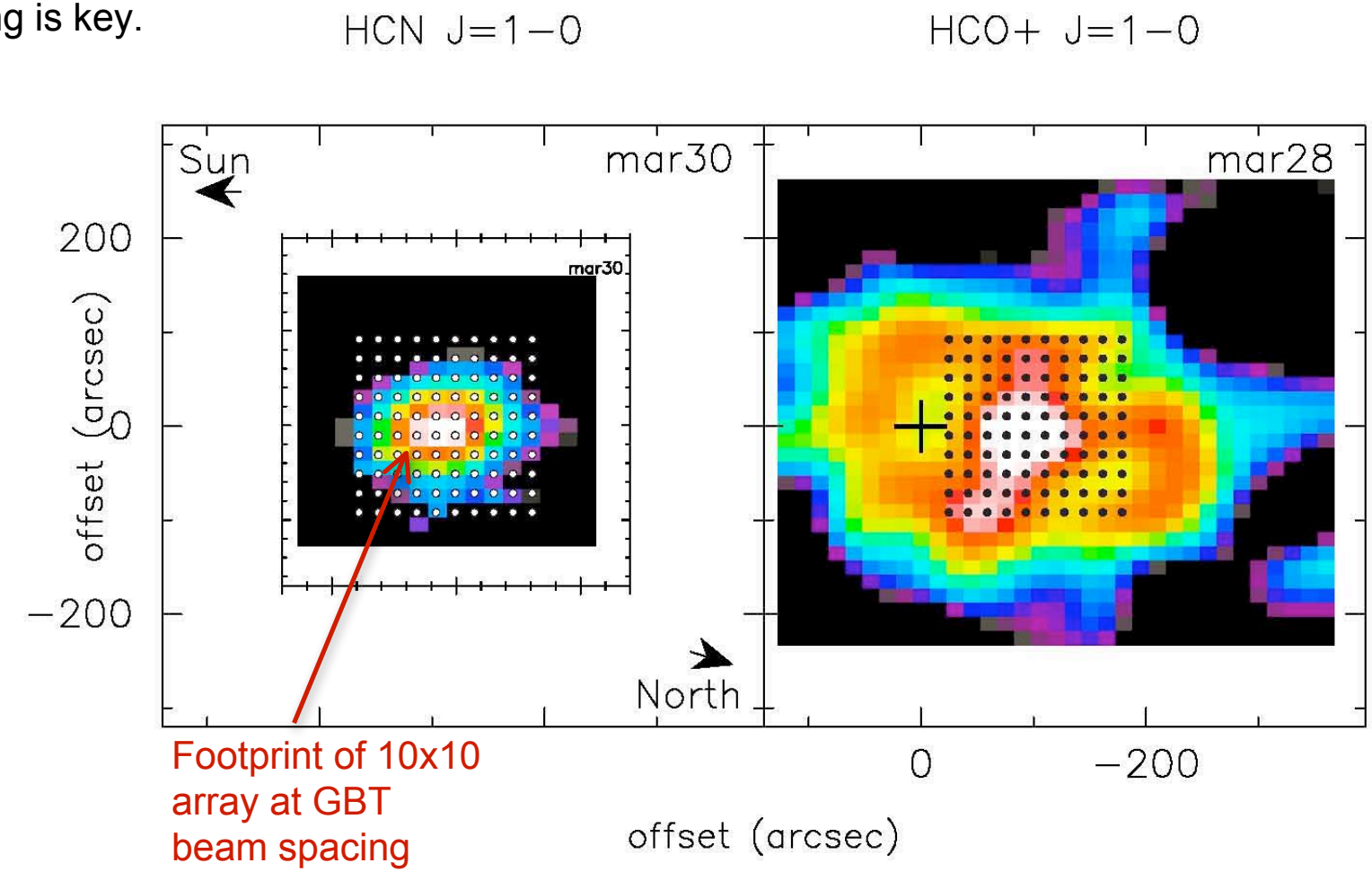
Large Format FPAs

- Building a large FPA has no technological blocks, but.....
- Full cost of first large array is very expensive:
  - R&D into:
    - Packaging the system
    - Calibration algorithms to take advantage of the multiple beams
    - Data displays both for quick look (while observing) and data reduction
  - Need digitized data transmission system
    - Current system is $30k/line; Need R&D into something less expensive
  - New backend- FPGA technology would be straightforward to use
  - astructure

Estimated cost for first, large-format FPA is $25-$30M
Want to reduce this cost through R&D (w/ partners)
Subsequent arrays would be ~1/4 cost.
NRAO is seeking partners for such projects.

Science Application – Molecular Line Imaging of Comets

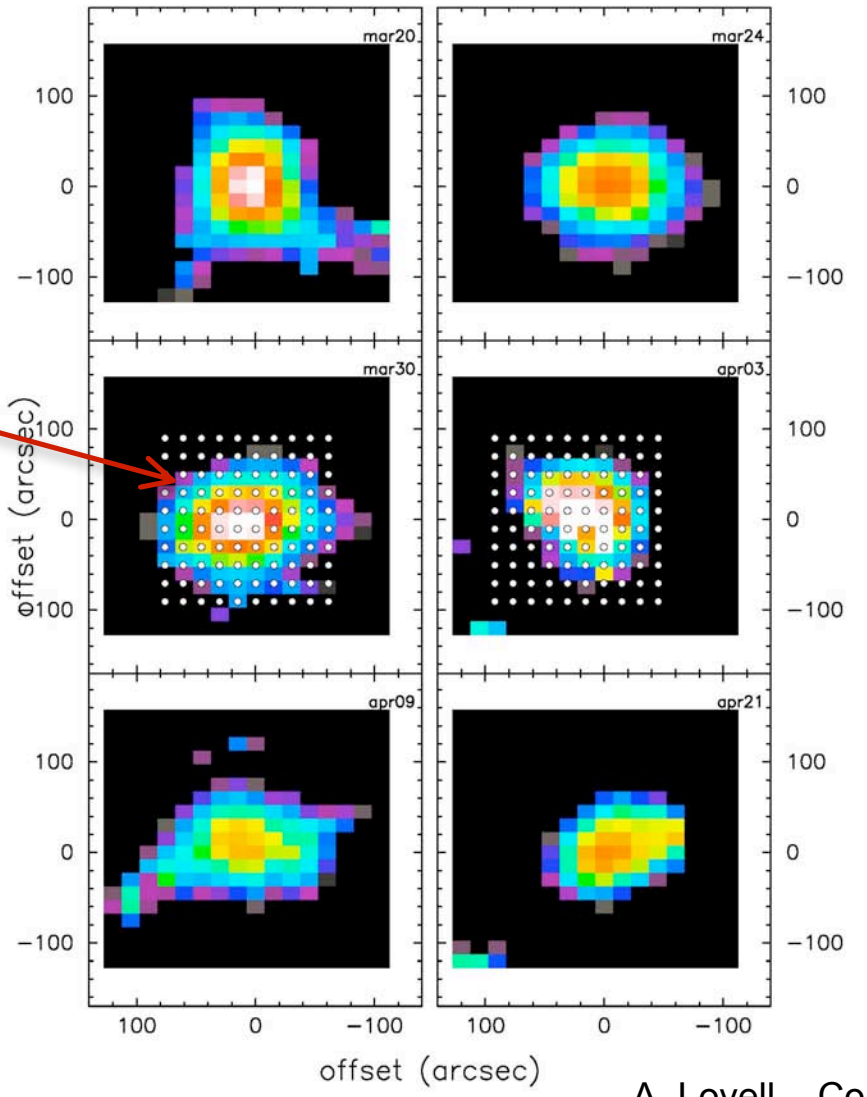
Cometary line emission is time-variable, with low surface brightness (large, filled aperture will be optimal). One molecular species gives rise to another (e.g. HCN → HCO+), so rapid, sensitive imaging is key.



Footprint of 10x10 array at GBT beam spacing (image resolution will be x7 higher)

A. Lovell – Comet Hale-Bopp / FCRAO

Science Application – Molecular Line Imaging of Comets



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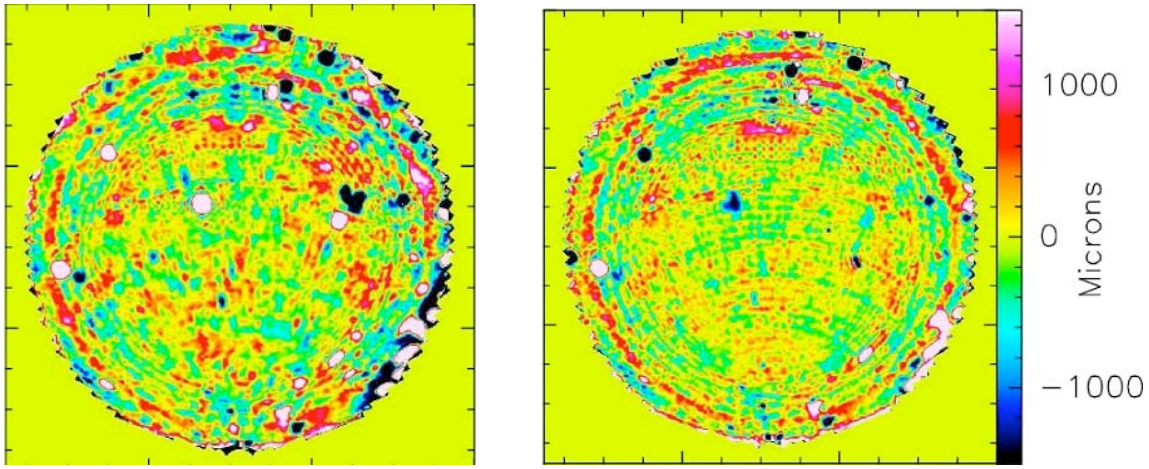
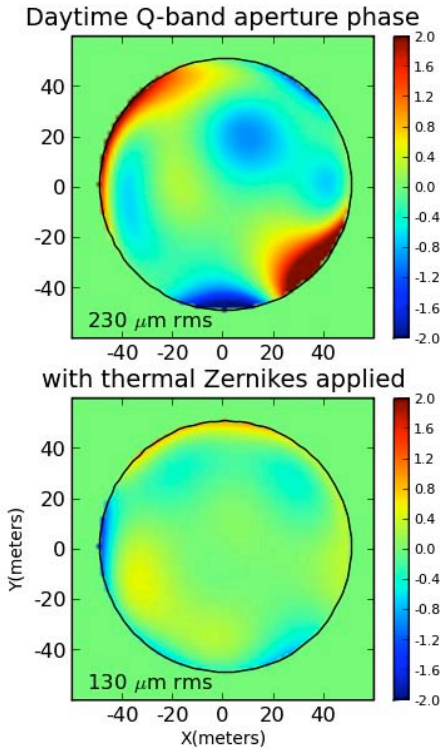
Optimizing the GBT for 3 mm Operation

- Holography project has reached 15% aperture efficiency at 90GHz
- Goal of 35% (20%) aperture efficiency at 90 (115) GHz



Phase-coherent Holography



Out-of-Focus (OOF) Holography

Optimizing the GBT for 3 mm – Continued: Dynamic Scheduling System (DSS)

- ≥20% of Green Bank's weather is usable at high frequencies
  - GBT high frequency time is highly oversubscribed
  - Need to ensure the best possible use of a limited resource
  - GBT DSS will maximize science output at high frequencies

- GBT DSS will be released Fall 2010 in prototype form with enhanced versions to follow

Next Steps

- NRAO is writing "Requests for Information" papers for the Decadal Survey (due April 1) that will emphasize the FPA program
- Developing science and technology drivers for a 3 mm (W-Band) Array
- Actively seeking partners!
  - Contact Karen O'Neil in Green Bank