# The Millimeter-wave Bolometric Interferometer

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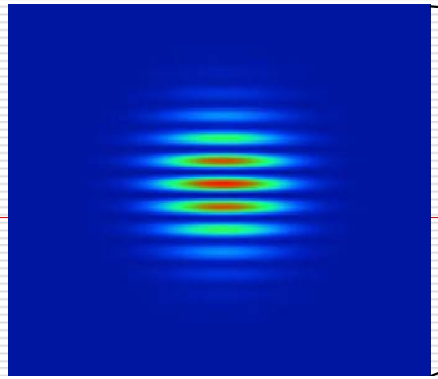
# The MBI on site at Pine Bluff Observatory

- Proof of concept
  - MBI is not sensitive enough to see B-modes
- Minimization and control of systematics are important
  - Interferometry and signal modulations reduce systematic effects
- Operates in 90-110 GHz atmospheric window

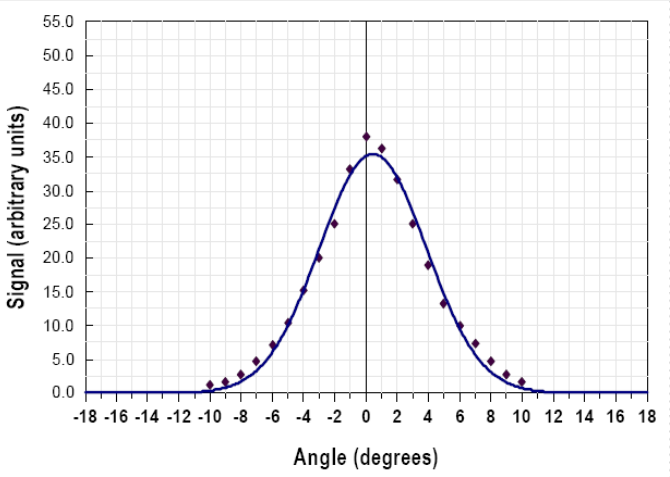
# Optical Schematic

- Corrugated Sky Horns
- Ferrite Phase Modulators
- Reflecting optics as Beam Combiner
- Bolometer Array



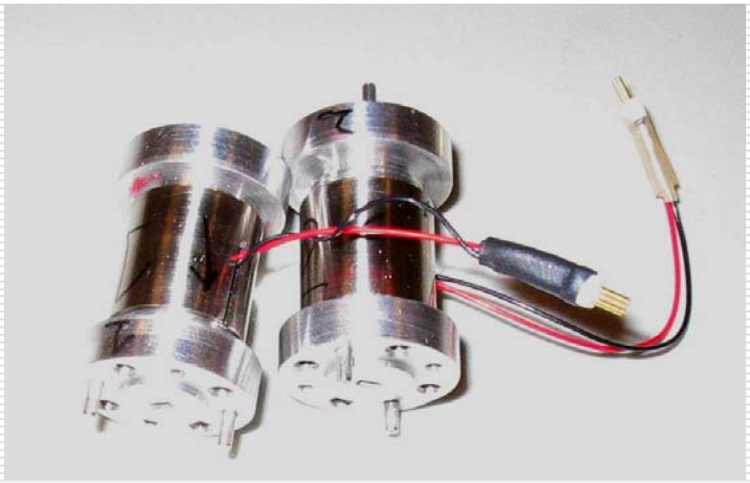
# Sky Horns

- Corrugated Feed horns
- Close to ideal Gaussian beam shape
- x and y polarization beam widths the same to within 1%
- Single mode optics follow



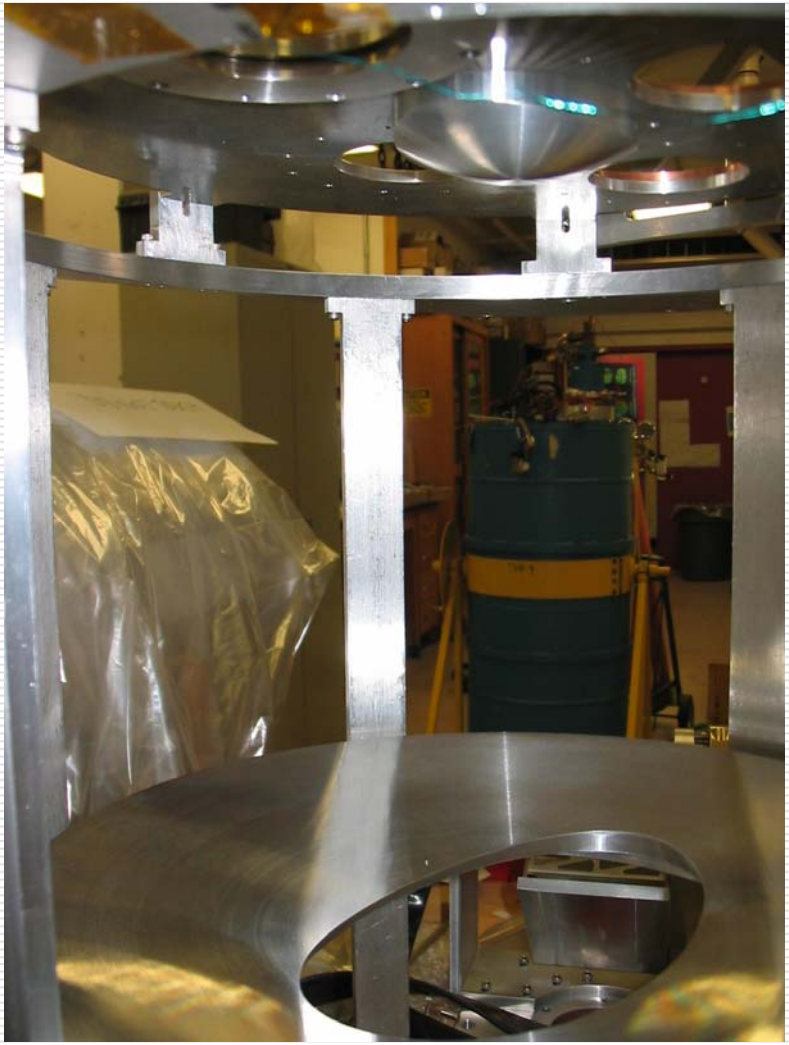
# Phase Modulators

- Ferrite Phase Modulators are Faraday Rotators
- X or Y polarization selected (2 of each)
- Polarization is shifted + or – 90 degrees



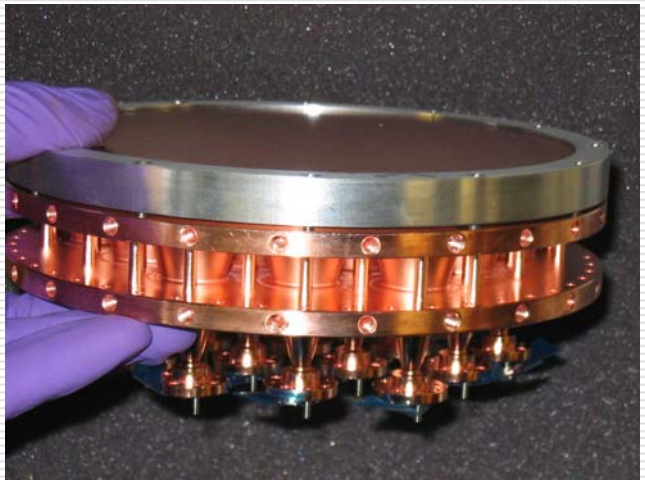
# Beam Combiner

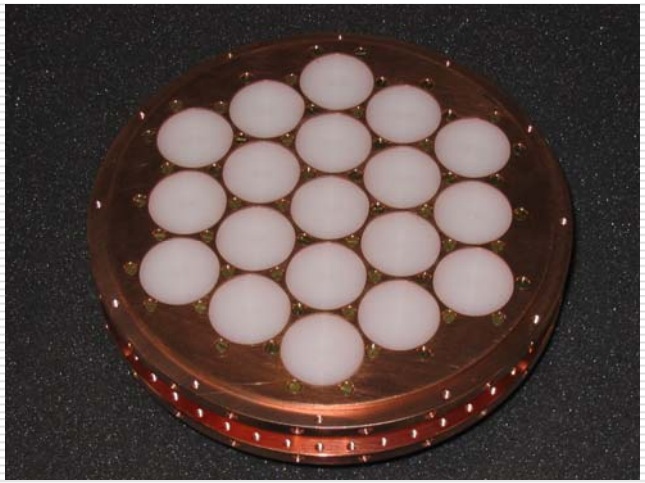
- Reemitting into the optics performs a Fourier Transform
- Open optics allow all four signals to interfere
- Detector positions produce unique phase relations between inputs
- Easily scalable for many inputs



# Focal Plane

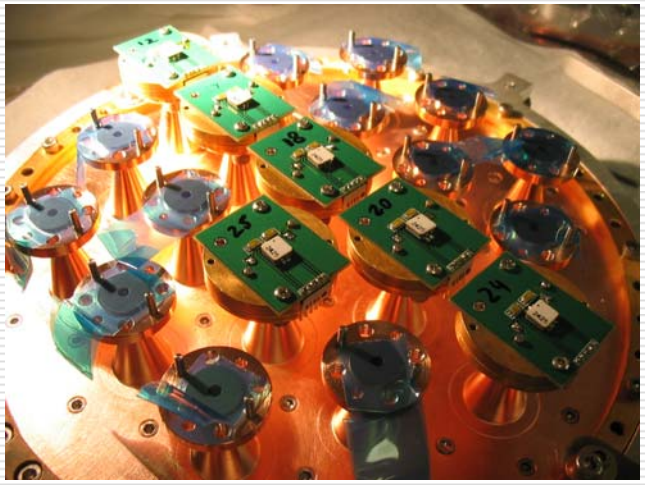
- Single piece of copper with conical horns backed by bolometers
- Metal mesh filter to constrain band width
- Polyethylene lenses to help flatten the phase front at the detectors

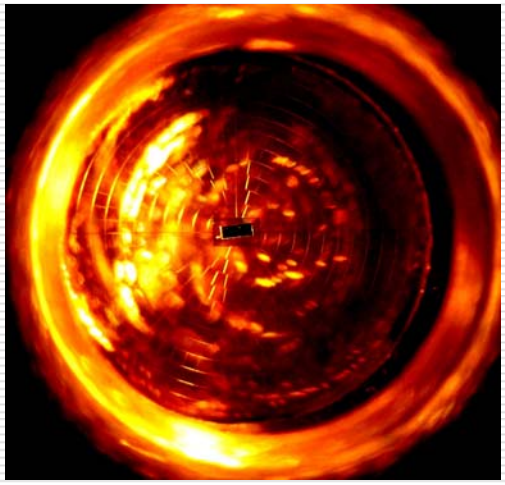




# Detectors

- ACBAR Spiderweb Bolometers
- Not polarization sensitive
- Polarization selected in previous optics
- AC Current Biased
- One would like thousands of detectors to observe B-modes, the MBI has 16.



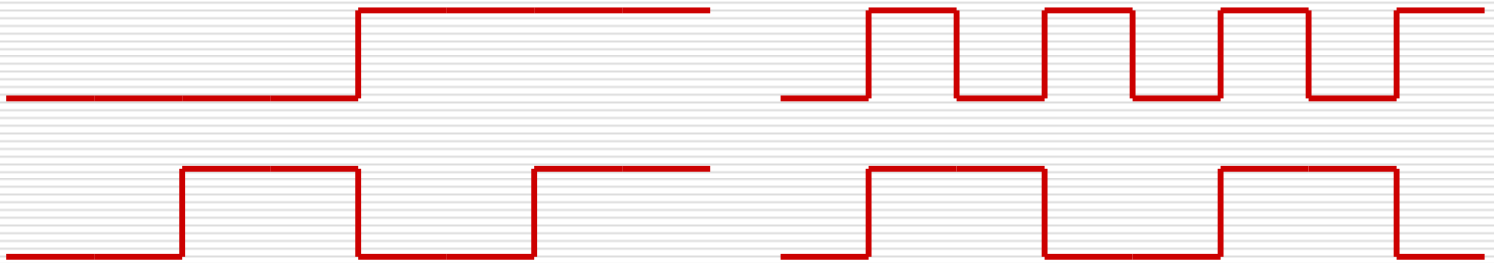


# The MBI Modulations

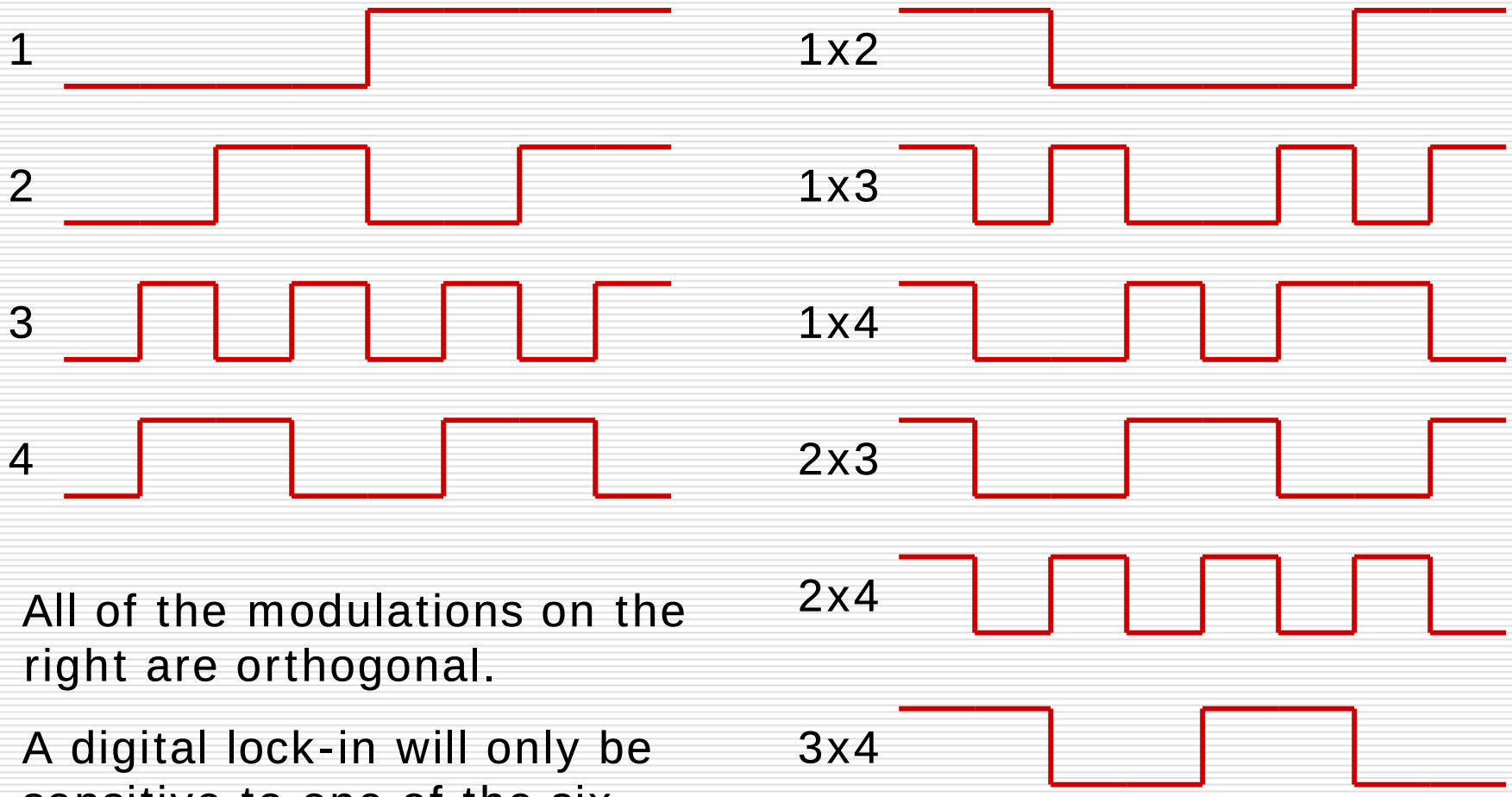
- Bolometers are AC current biased at 208 Hz
- A Field Programmable Gate Array (FPGA) board with a lock-in amplifier programmed onto it is used to read out the signal from each bolometer

# The MBI Modulations

- Each input is has its phase modulated with a unique Walsh function.
- Walsh functions take values of 1 and -1. For the MBI these correspond to phase shifts of +90 or -90 degrees.



# The MBI Modulations




All of the modulations on the right are orthogonal.

A digital lock-in will only be sensitive to one of the six.

# The MBI Modulations

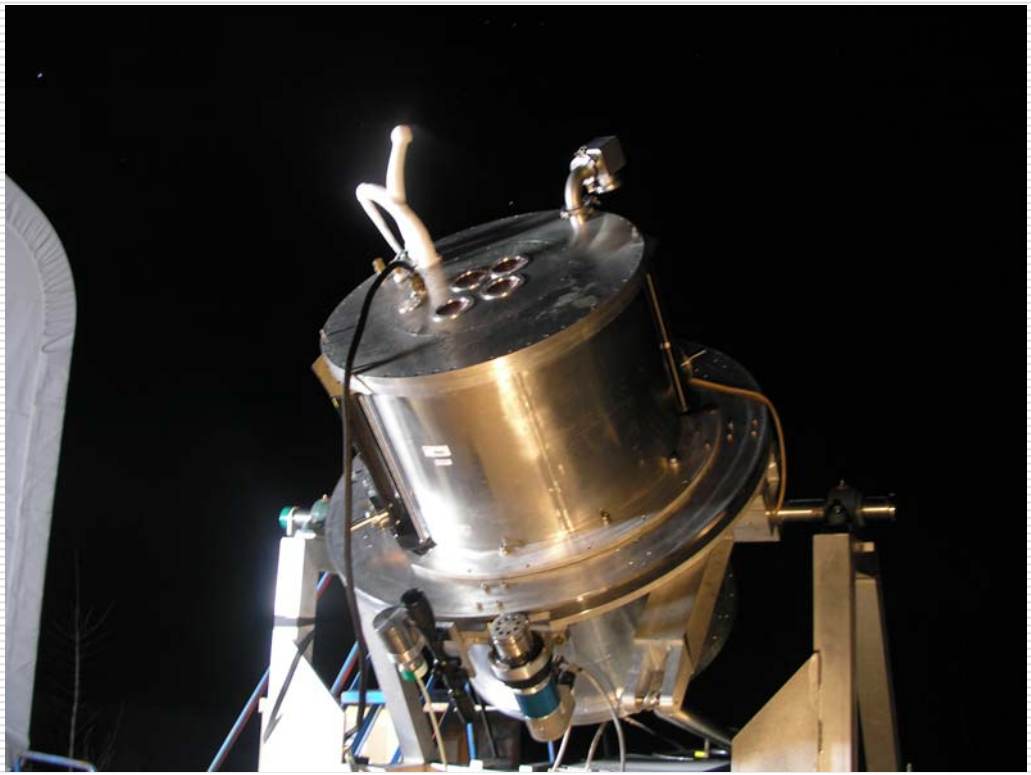
- By using digital lock-in methods we can identify the signal on a single bolometer from just one of the baselines.
- In principle this can be done for an arbitrary number of inputs.
- The task is easier if you can use multi-state phase shifters.

# The MBI Modulations

- The image on the focal plane is reconstructed after lock-in.
- The amplitude and position of the fringes are used to calculate the visibilities.

# Current State of the MBI

- First Observing run completed



# Data taken were beam maps and diagnostic scans

- Raster scans of Gunn oscillator
- Drift scans of Sun
- Drift scans of blank sky
- Beam maps of individual sky horns
- Interference fringes from two sky horns

# The MBI Collaboration

- Brown University
  - Greg Tucker (PI)
  - Andrei Korotkov
  - Jerry Vinokurov
- University of Wisconsin – Madison
  - Peter Timbie
  - Peter Hyland
  - Amanda Gault
- University of California San Diego
  - Brian Keating
  - Evan Bierman
- LLNL
  - Shafinaz Ali
- Pune University
  - Siddharth Malu
- University of Richmond
  - Ted Bunn
- Cardiff University
  - Peter Ade
  - Carolina Calderon
  - Phil Mauskopf
- University of Illinois
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- Manchester
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  - Créidhe O'Sullivan
  - Marcin Gradziel
  - Gareth Curran

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# Raster Data and Top-Down Optical Layout