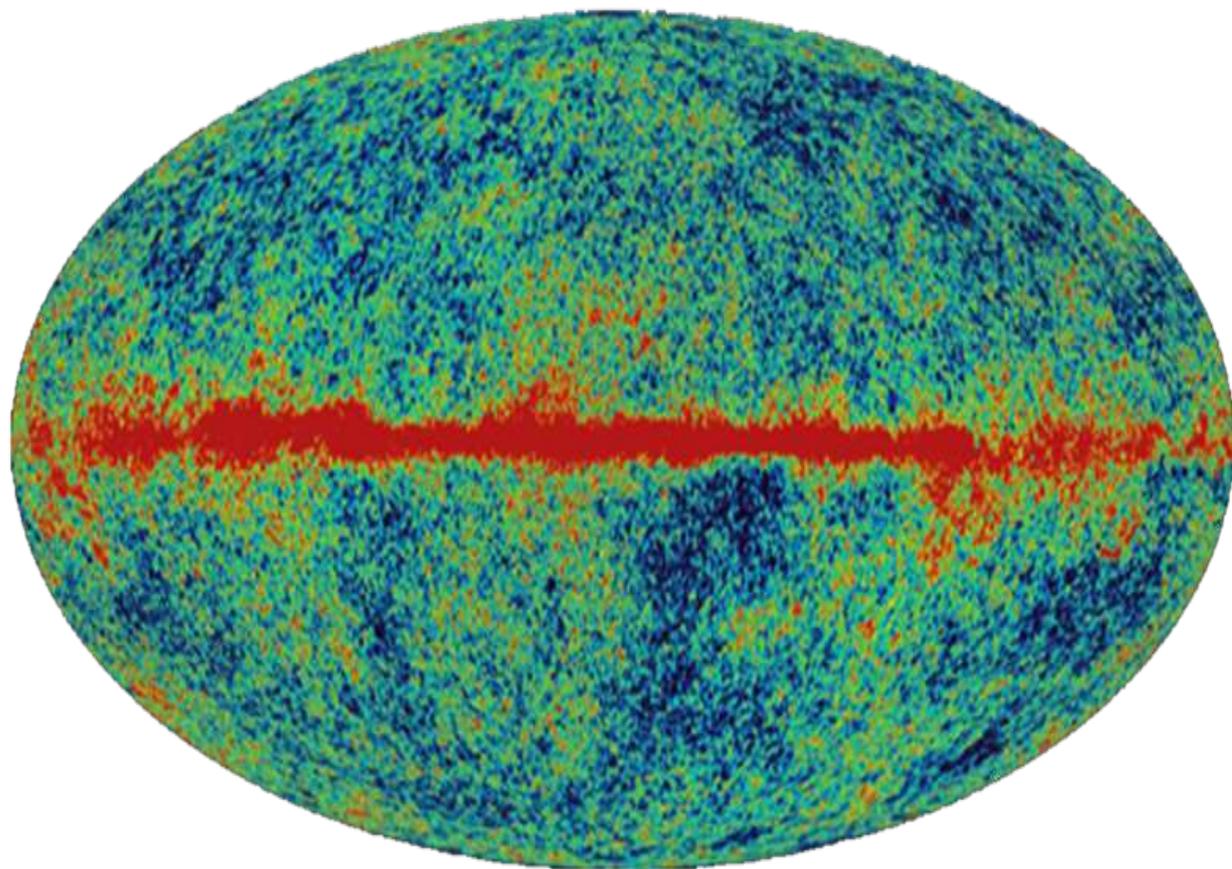


**A Precision
Calibration and Monitoring System for the
QUIET CMB Polarization Experiment**

SCSI Grant Proposal

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The Science of Cosmic Microwave Background B-mode Polarization

A Critical Tool for Probing
the Nature of Inflation

Were there Primordial
Gravitational Waves ?

B-Mode Detection is
perhaps the only way to
see GUT scale physics.

The realization of the importance of CMB polarization has its roots at Fermilab and Chicago: Dodelson, Stebbins, Hu, Kolb, Turner, and others.

Yet Fermilab is currently not involved in any CMB experiments

* Picture from WMAP

The QUIET Experiment

Measurement of CMB Linear Polarization using an array of “coherent” detectors.

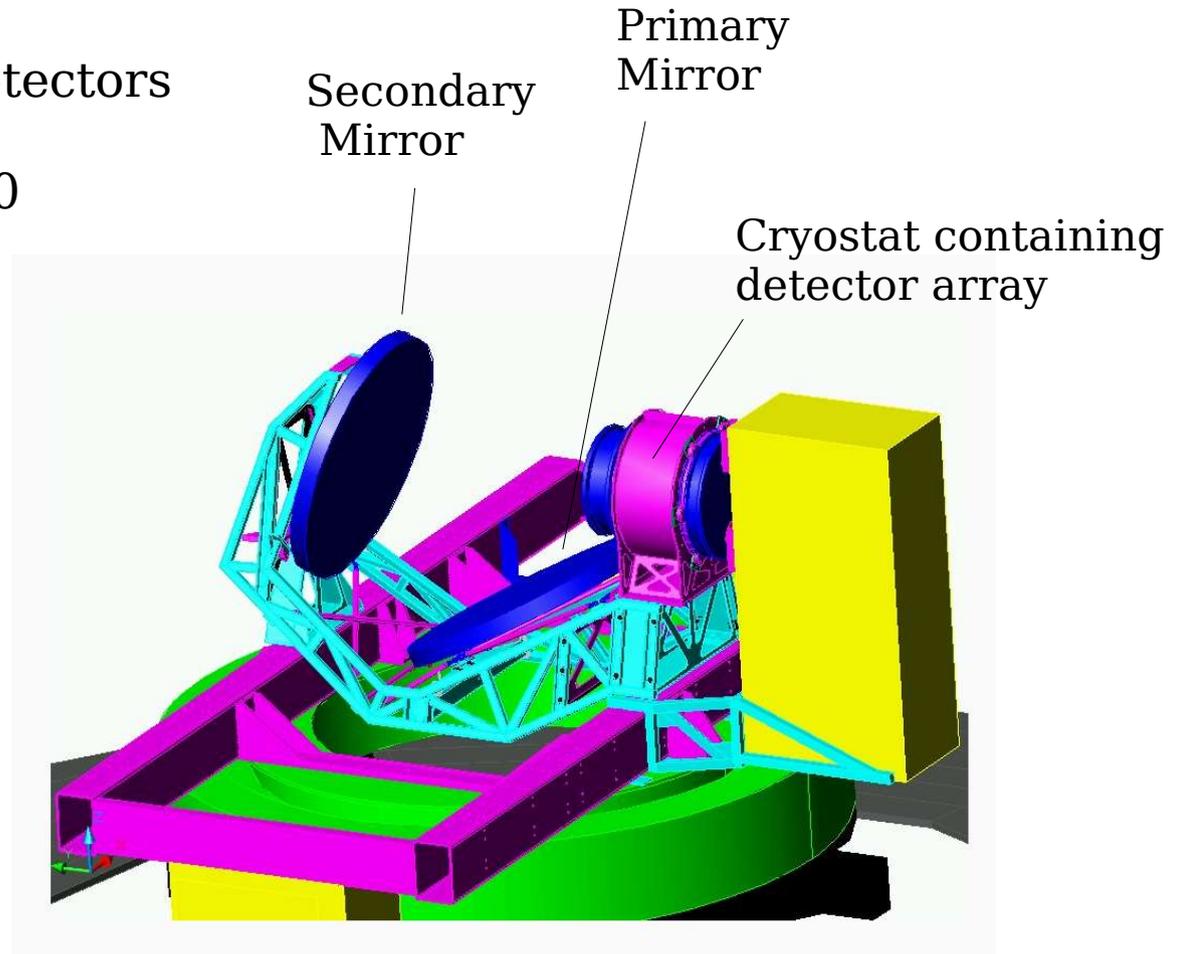
Each detector measures two linear polarization states using a single electronic module.

QUIET Phase-1 (funded): ~ 110 detectors

QUIET Phase-2 (unfunded): ~1300 detectors

Planned 3+ year operation in the Atacama Plateau, Chile.

First run in fall 2008 with an array of 19 detectors.

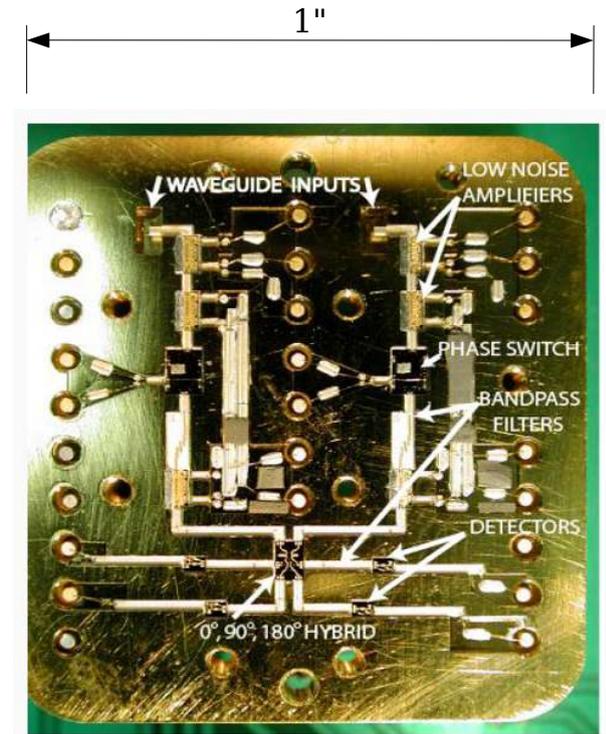
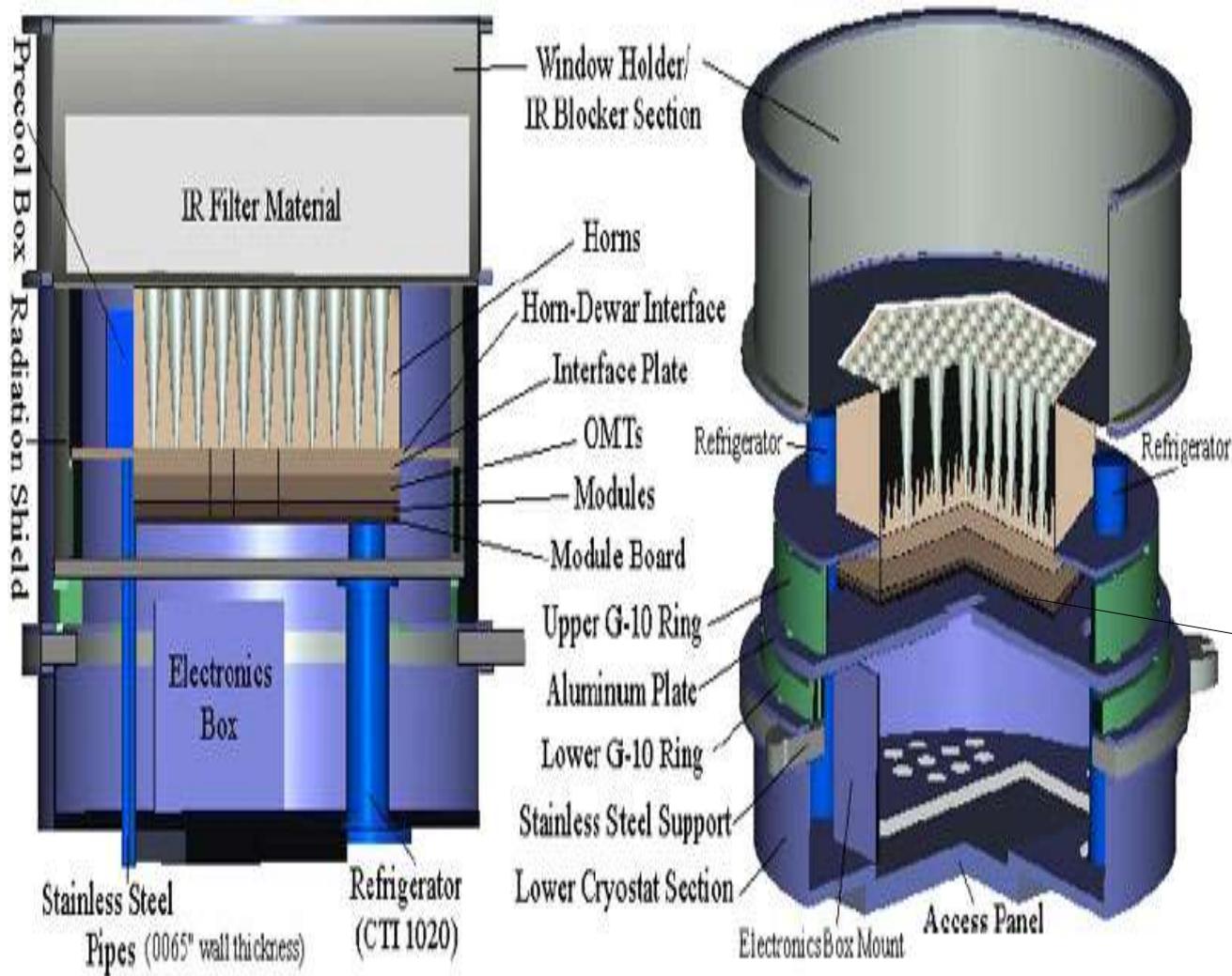


A QUIET Cryostat

(91 detectors shown)

Detectors use High Electron Mobility Transistors (HEMT) to detect microwaves

A QUIET Electronic Module tuned for detecting 90 GHz microwaves



The Need For Calibration and Monitoring

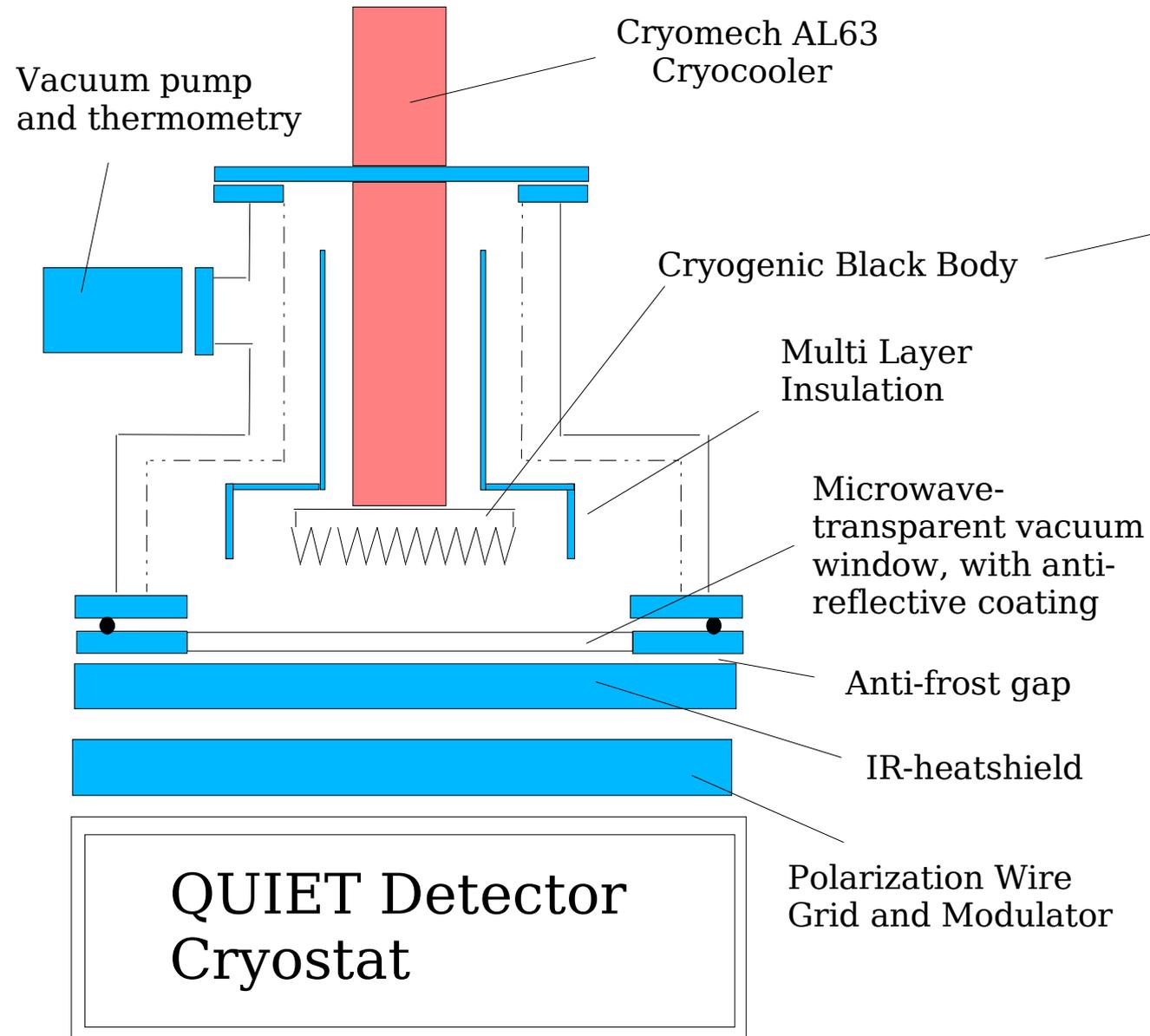
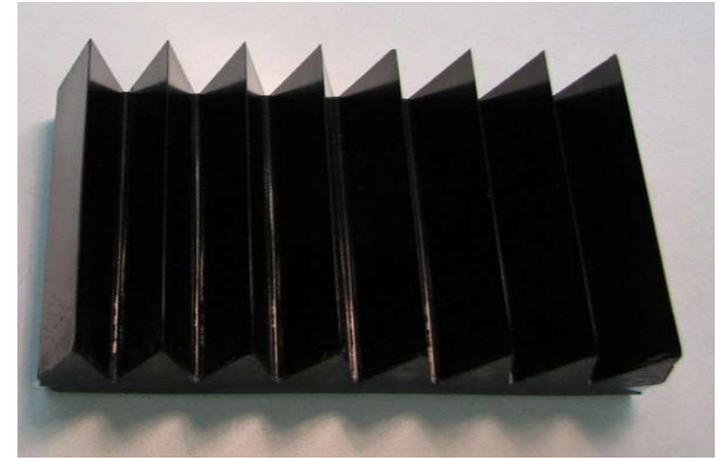
	Power Equivalent (<u>measured in Kelvins</u>)
CMB Polarization Temperature	$< O(\mu\text{K})$
Galactic Foreground Temperature Polarization	$\mu\text{K} - \text{mK}$
CMB Temperature	3 K
Atmospheric Noise (varies with azimuth)	2 - 4 K
Instrument Noise per detector	20 - 40 K

The Experimental Challenge: Requires long sky exposures to make accurate temperature measurements at the sub μK level.

A Key Task for this SCSI Proposal: Simulation of noise, gain drifts, temperature and polarization crosstalk, and nonlinearities. Determine the effect on final result, and benchmark goals that have to be achieved in the calibration and monitoring system.

Another Key Task: A Cryogenic Black Body Source

Black-body prototype
made by PPD



- **Temperature-adjustable and can mimic the sky microwaves**

- **Evaluate performance at KICP.**

- **Probe non-linearity and stability of QUIET HEMT Electronics at KICP.**

- **Minimal R&D ! Use experience from previous CMB experiments**

Benefit to Chicago and Fermilab

- A temperature-adjustable and cold ($\sim 20\text{K}$) Black Body Source is an important tool for CMB experimental science. It is useful for studying any kind of microwave detection technology (HEMT, Bolometers, etc...)
- This source would be far superior to typical sources used in the lab, which use LN_2 at fixed temperature.
- Establish knowledge base on the microwave properties of materials
- Building this source is an **achievable goal at modest cost**. There is minimal R&D.
- For Fermilab, involvement in a competitive CMB experiment that is coming online now !

One Benefit to Experimental CMB Cosmology

Polarization Grids

Used by CMB Cosmologists to produce “temperature-polarized” sources for calibration

Large CMB detector arrays will require large (>1 meter diameter) polarization grids.

Very large and accurate wire grids can be made using HEP techniques.

90 GHz polarization grid made by PPD

(done in 1 afternoon last week !)

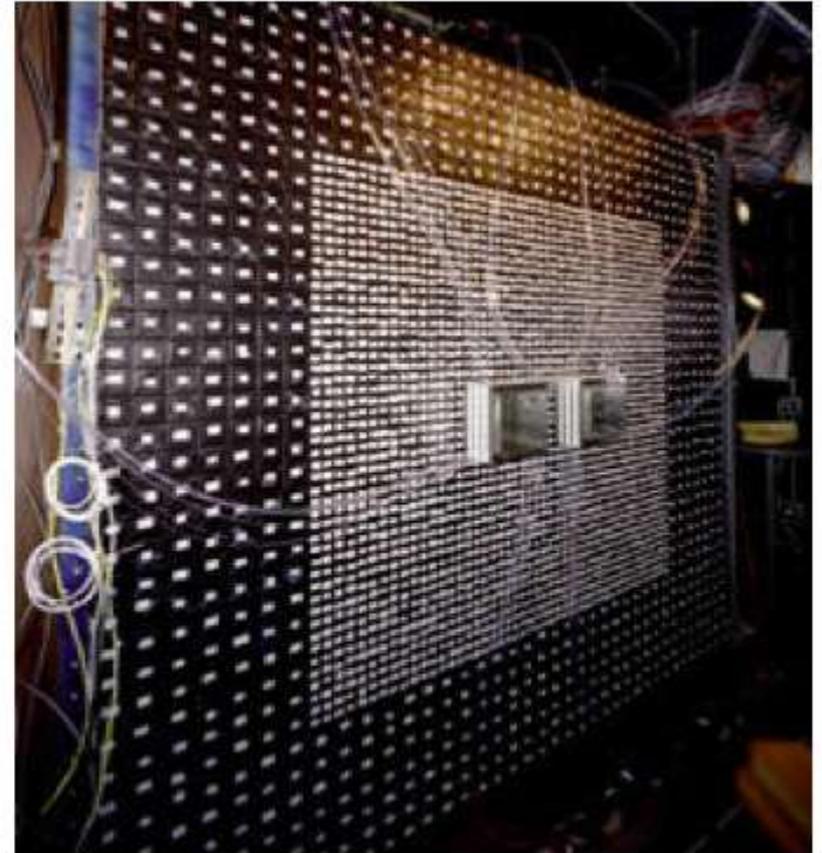


25 μm wire with 150 μm spacing.
Achieved 5 μm placement accuracy

Question for Fermilab: Why QUIET ?

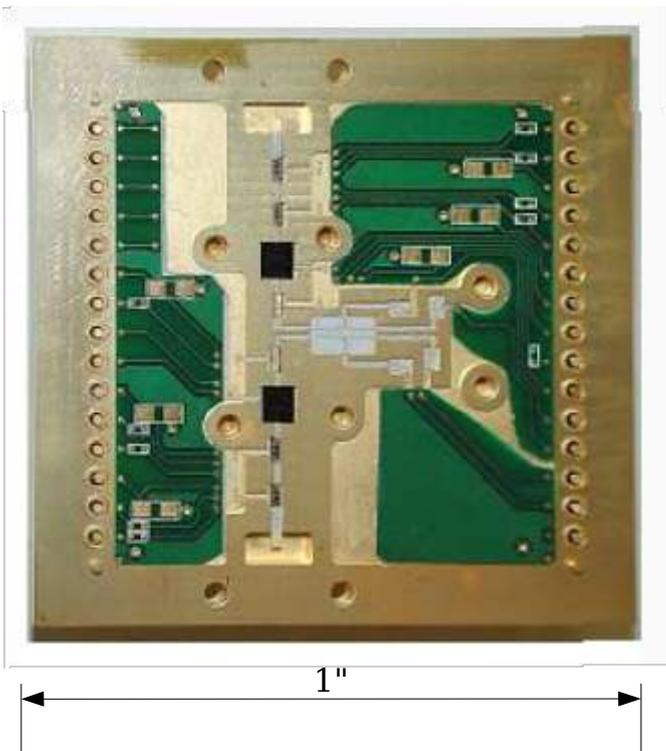
- Involvement in a competitive CMB experiment that is coming online now !
- Building new ties with the CMB community in US universities, NASA (JPL and GSFC), and world wide (Germany, Sweden, Japan)
- **Strengthening the historically strong ties between Chicago-Fermilab, based on mutual interest in a compelling scientific question**

The KTeV CsI Calorimeter



A Possible Outcome of this SCSI Proposal

QUIET Electronic Module
tuned for detecting 40 GHz
microwaves



**QUIET Phase-2 would be funded at
the ~1000 module level !**

**A natural role for Fermilab could
be participation in the large scale
production assembly of the
microdetectors:**

Silicon Tracking detectors for CDF,
D0, and CMS

Astronomical CCD packaging for DES
and SNAP

Budget Request

Salary and Fringe for UofChicago personnel 50% FTE postdoc, 50% FTE student	39.7 K
Materials and supplies for UofChicago	6.9 K
Travel for Fermilab	3.0 K
Materials and Supplies for Fermilab	44.0 K
<hr/>	
Total	93.6 K

Labor funding covers analytical work including simulation, data analysis, and characterization of wire grid, black body source, and HEMT electronics.

M&S funding provides vacuum pump (12K), Thermometry (5K), Polarization Grid and Modulator (6K), Microwave electronics (15K), cart (1K), and contingency (5K).

Received 25K from US/Japan Funding for cryocooler purchase and vacuum components
Received 17K from PPD and FCPA for detector R&D.