QUIET

The Search for B-Mode Polarization in the Cosmic Microwave Background Using Coherent HEMT Detectors

A Proposed New Initiative for Fermilab

April 17-18th 2009 FCPA Retreat

Fritz DeJongh, Scott Dodelson, Dave McGinnis,

Hogan Nguyen, Albert Stebbins

Outline

- Bruce Winstein, the QUIET Principle Investigator:

  The QUIET Experiment, the Science, and the case for Fermilab involvement

- What have we done thus far ?

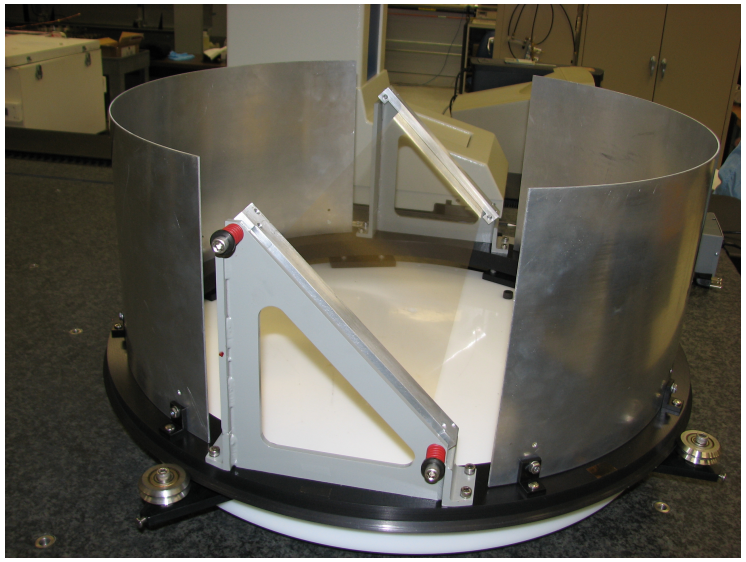
- Our proposal for QUIET Phase II involvement

- Request to the FCPA

Through the talks, we will address Dan's questions

Is the science interesting and worthy of pursuit ?
Why should Fermilab get involved ?
What are the risks and the next steps ?
Do we have the team carry out what we intend to do ?

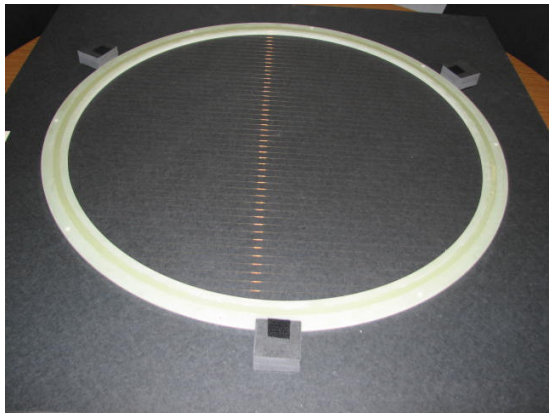
QUIET R&D at Fermilab



Large and accurate rotatable wire grids to produce and modulate polarized microwaves

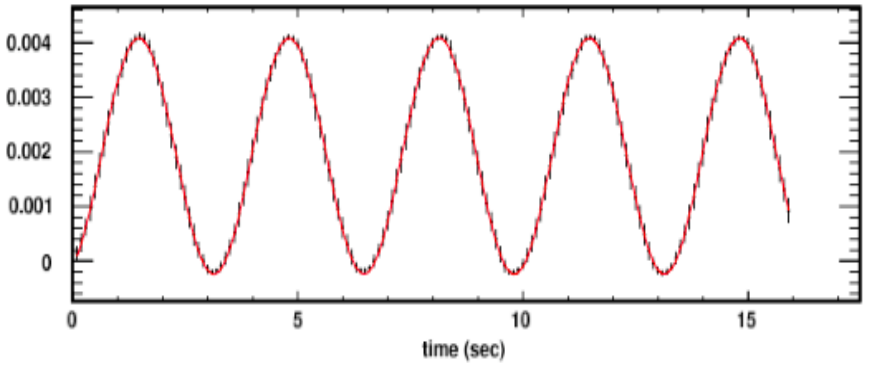
Made by PPD chamber winding group using HEP techniques

In use at KICP lab in Chicago since Feb 09 to optimize detector settings, calibrate relative "angles" of all modules, and provide absolute response to known input polarization signal



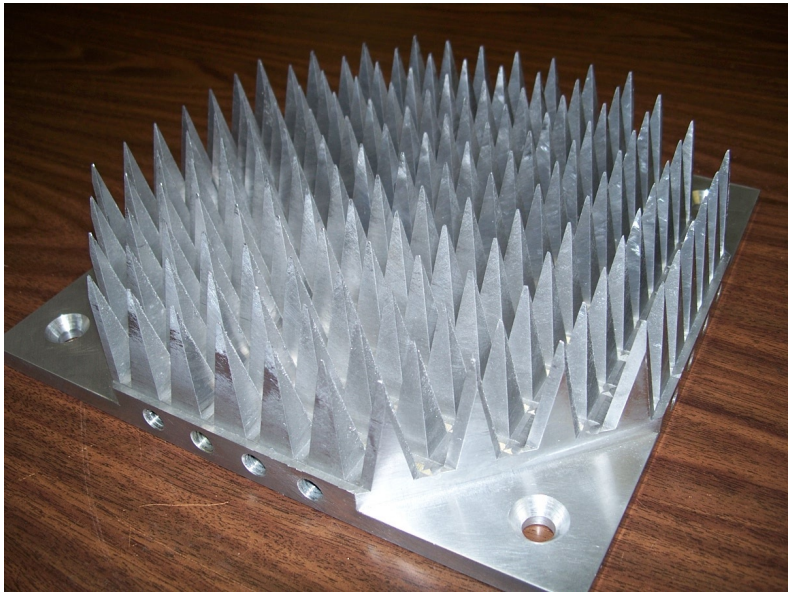
Typical Stokes-Q Response from a W-band Module

Grid rotates to modulate the polarization



Will be deployed in Chile in May 09

D. Butler, J. Korienek, C. Lindenmeyer, W. Newby, J. Wilson. Not pictured: J. Montes, R. Rucinski, K. Schultz



QUIET R&D at Fermilab

20 Kelvin Black Body Microwave Source For Full-System Characterization

A significant job carried out primarily by PPD Technical Staff:

A vacuum tank with a high-strength microwave-transparent vacuum window with anti-reflective coating.

A Microwave-absorbing epoxy cast over an aluminum core

A Commercial 5W@20K Cryocooler

To be delivered to KICP in Chicago in April 09, for full-system W-band characterization

Mimics the sky noise in Chile, while in a laboratory setting

Why Fermilab ?

1600 W-band modules for QUIET Phase-II

QUIET will need a National Lab Partner with Experience in Delivering Large and Complex Detector Arrays.

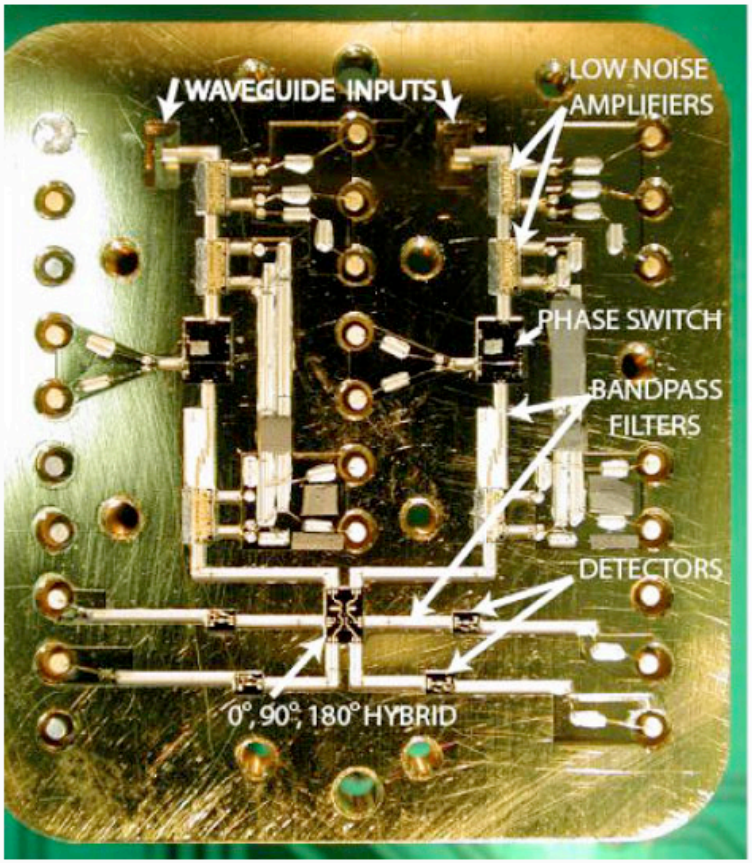
Extensive experience in PPD for Microdetector Assembly, QA, and Production Tooling and Testing.

Facility tools to do the job

Large clean rooms and Lab space for Testing
Wirebonding Machines
Optical Measurement Tools
Glue Robots
Micron-accuracy Pick-and-Place Machines

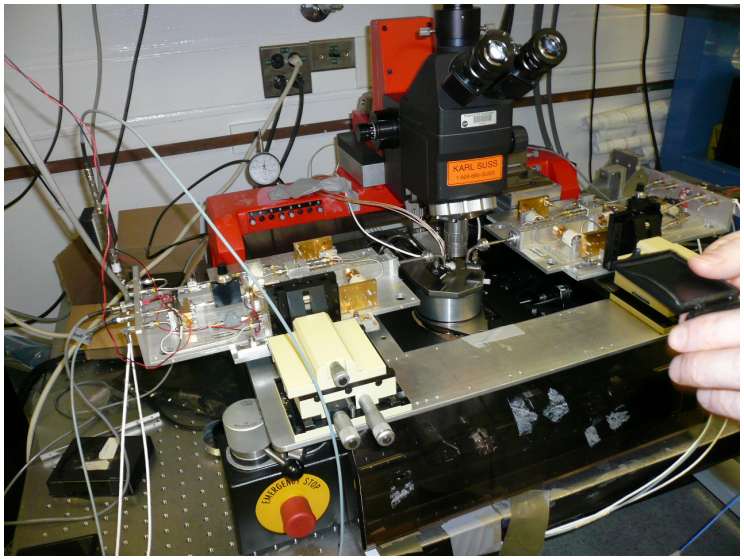
We believe the core expertise exists in Fermilab PPD for QUIET W-band assembly, for example at the Sidet Facility.

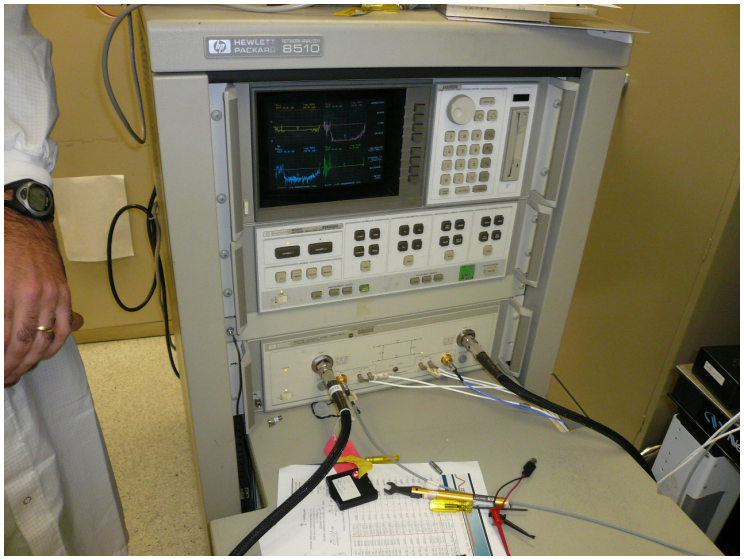
1" W-band HEMT module



Why Fermilab ?

W-band electronics noise performance is crucial for success



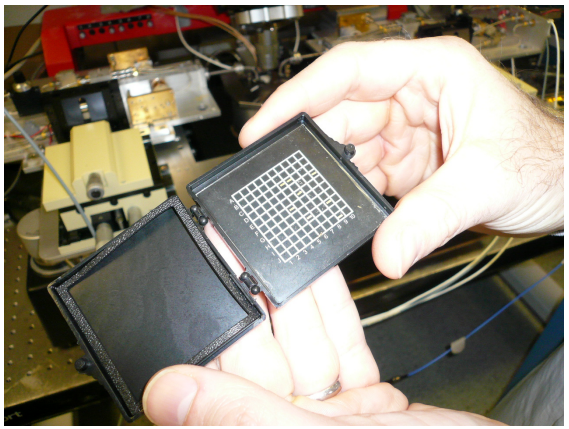


Noise performance can be addressed and understood by RF expertise at the Lab

Simulation tools
Electronics circuit design
Hardware

RF/microwave VNA probe station at JPL

HEMT-based
Low Noise Amplifier
Dies to be probed



QUIET R&D at Fermilab

- DeJongh and Nguyen visited JPL in Dec 08, entered discussions with Winstein and JPL staff on QUIET.
- Rotatable Wire Grid delivered to collaboration in Feb 09
- Received W-band module fabrication notes from JPL in April 09
- 20 Kelvin Black Body Source to be delivered to collaboration in April 09

Completed

- Nguyen to take shifts in Atacama, Chile in May 09
- **Approved for hosting a QUIET Collaboration and Phase II meeting at Fermilab in June 09**
- Receive circuit design from JPL, and begin microwave simulation work.
- R&D on W-band module fabrication

Our next Steps

Risks

Technical

QUIET Phase I is currently running. Science quality Q-band observations is well underway and will complete in May 09. W-band operations will commence in May-June 09. A lot of details have been worked out and solved.

QUIET Phase II would build on successes of Phase I. No Major Technical Changes.

Scientific

Q-band data already collected in Phase 1 should yield observation of the 1st and 2nd peak in E-mode polarization.

Competitive measurements of the EE and TE power spectra.

Even if T/S were too small to be observed, there is B-mode expected from Gravitational Lensing (e.g. from massive neutrinos and dark matter).

Pursue QUIET Phase II data-taking during module production.
A continuous stream of science data even during project construction.

Management

CMB research on this scale have not occurred within DOE labs. But our proposal is still at a modest level.

Why Fermilab ?

History and Strong Tradition of Intellectual Leadership

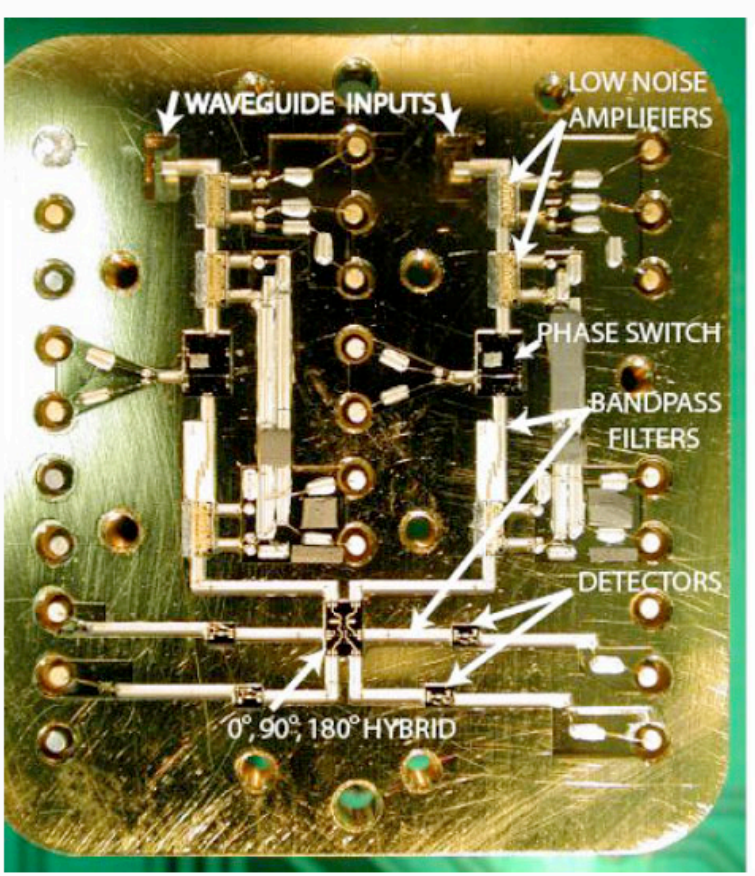
Dodelson and Stebbins were among the first to understand the importance of primordial CMB polarization.

A core for a strong Fermilab scientific team

Dodelson, Stebbins:	theory, analysis, scan strategy
DeJongh, Nguyen:	Detector fabrication, cryogenics
McGinnis:	RF/microwave circuit design and technology

… And others who have expressed interest …

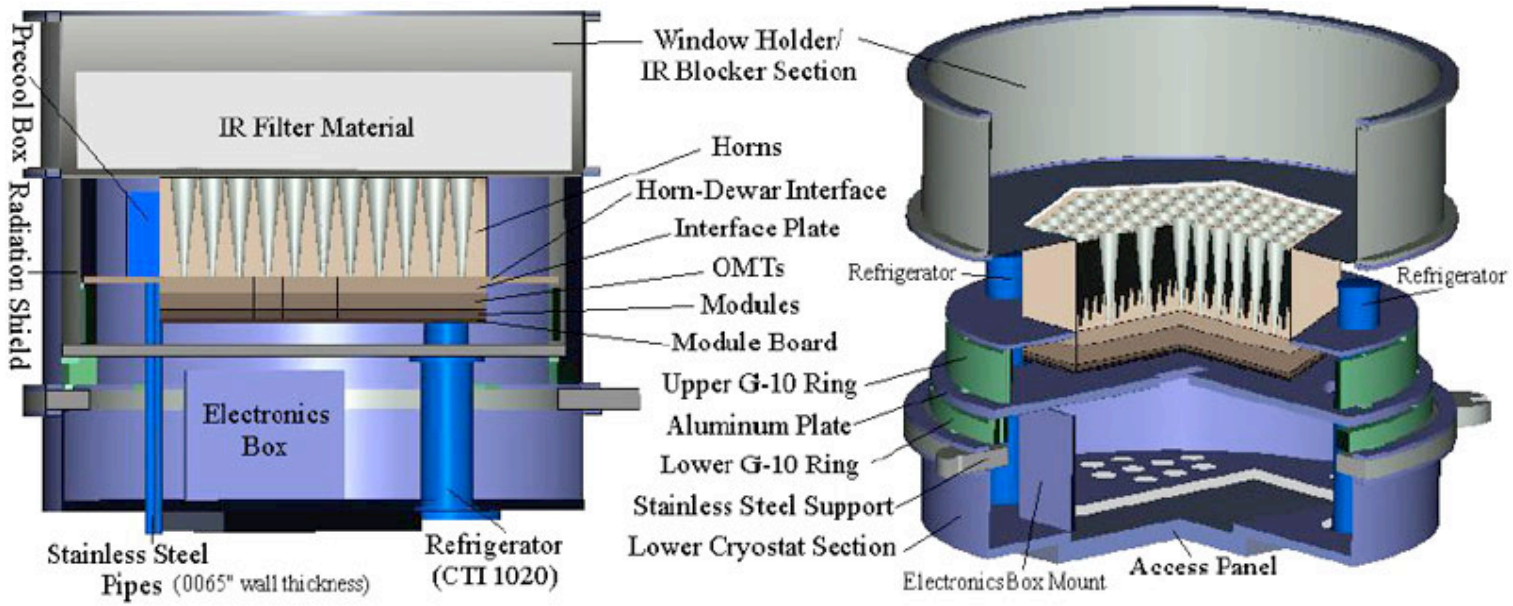
The QUIET Collaboration is inviting us to take a leadership role.



Possible Additional Scope of Fermilab Involvement

Final detector assembly and Characterization at Fermilab before deployment (ala DeCam).

An exciting possibility



The current QUIET Fermilab Scientific team would have to grow

Request to the FCPA

Thank you for the support thus far from the FCPA and PPD.

We request endorsement for continued Fermilab scientific, engineering, and technical support of R&D to explore QUIET Phase II involvement. **We have a clear direction for proceeding**.

The FCPA is a major representative in the community of scientists interested in the cosmic frontier:

> We request a strong statement of support to the PASAG, conveying the importance of this science and our enthusiasm for this project.

We request endorsement for Fermilab to be a scientific member of QUIET Phase II. The NSF is pleased with these discussions of Fermilab involvement, and would view the QUIET Phase II project even more favorably.

Back up Slides

Very Rough Estimate of Scientific, Engineering, and Technical Labor

Project phase	Details	Duration	# techs	#engineers	#scientists
Proposal develoment	Phase II - R&D	Now - Sept '09	0.5 x 8	0.5 x 8	1.5 x 8
	Phase II - Fermi role	(# x months)	0	0	0.5 x 3
	Phase I - build cryo-load		2 x 3	0	0.5 x 7
	Phase I - Install at Chile		0	0	1 x 1
Design	assembly tooling	Sept '09 - June -10	1	1	0.5
	module design		0.5	0.5	0.5
	scientific planning		0	0	1
Production	module production	June '10 - June '12	2.5	1	0.5
Integration, Installation, Commissioning, Systems test		January '11 - June '13	0	0	2
Operations and Analysis		June '11 - June '15	0	0	2

A production rate of a few modules per day