QUIET: Status and Plans

JPL Polarimeters

- Polarimeters
- B-mode Science
- Collaboration
- Module Calibration/Optimization
- Performance
- Where we must improve

"Report from the Field"

CAPMAP

Princeton, Chicago, Miami, JPL Collaboration

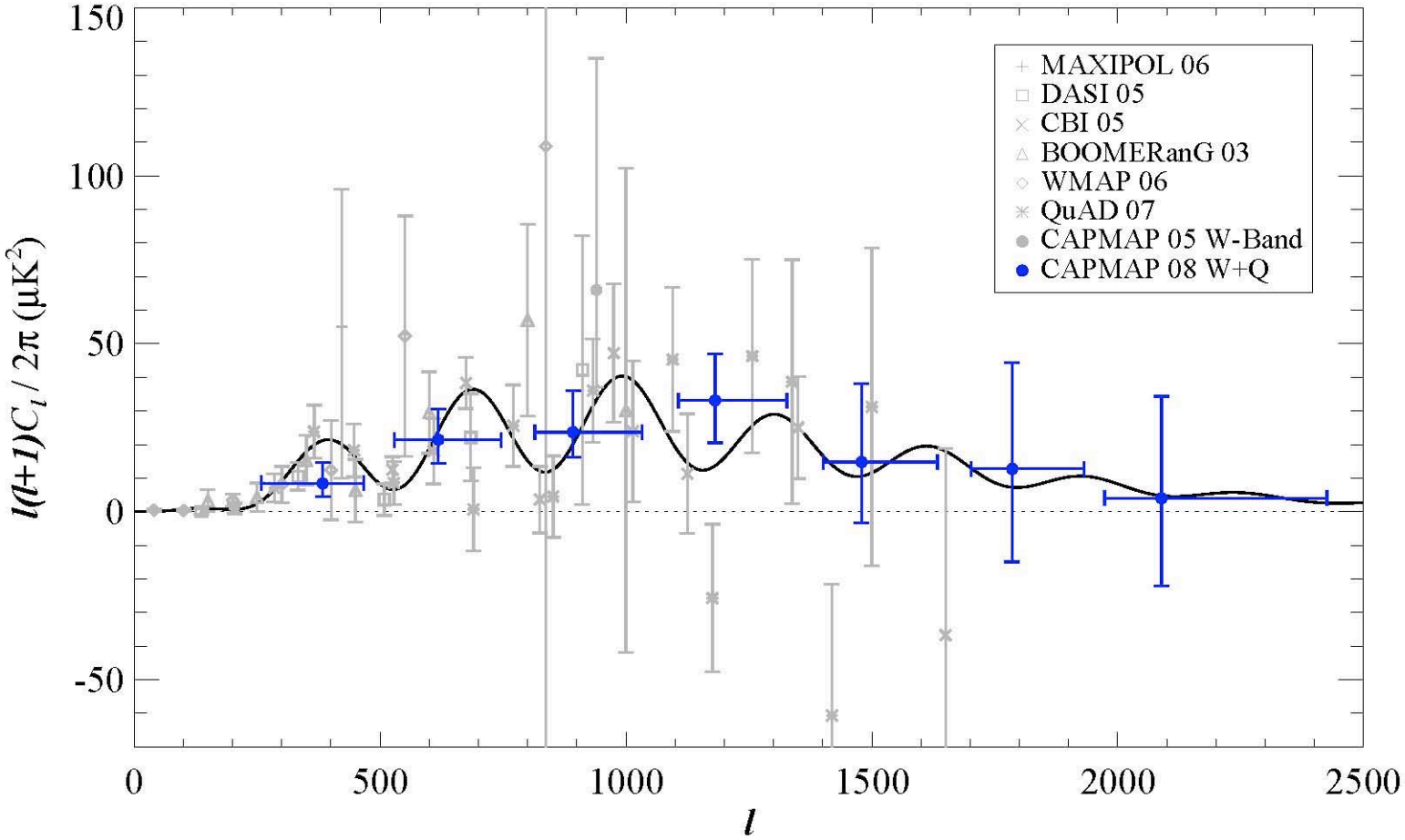
Crawford Hill, NJ

16 Correlation Polarimeters:
12 W-Band (84-100 GHz)
4 Q-Band (35-45 GHz)

Same LNAs as QUIET
Different packaging

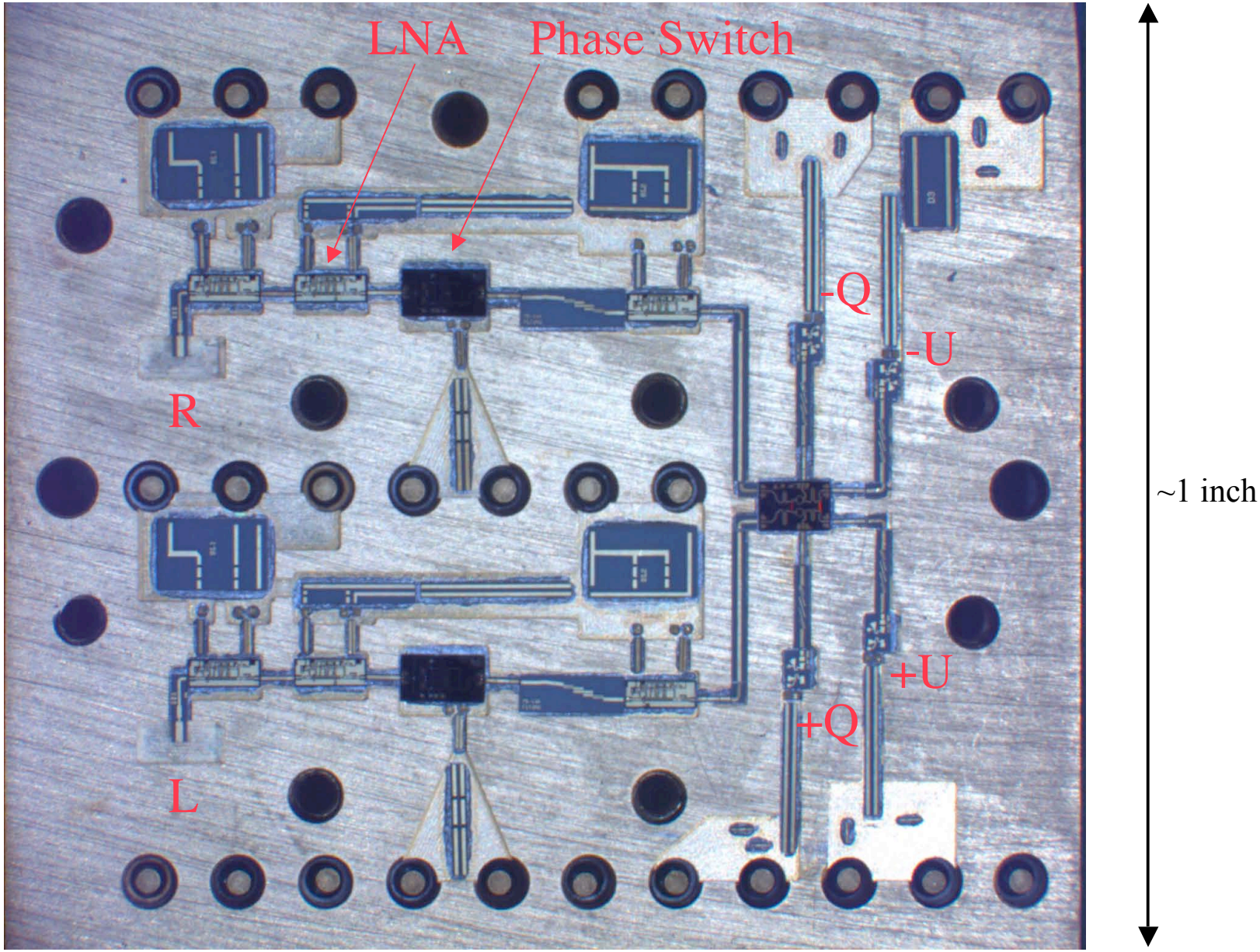
3 months of data (2004/5)

E-mode Results

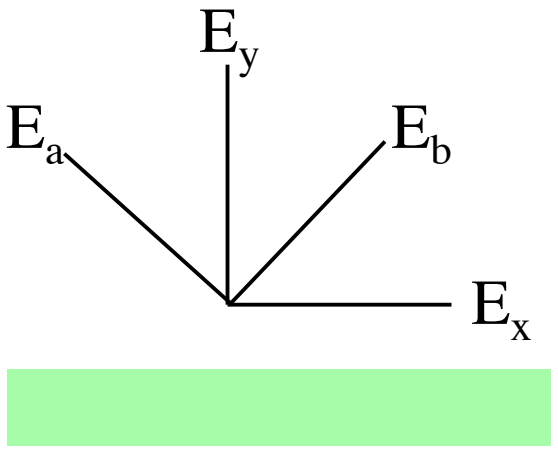


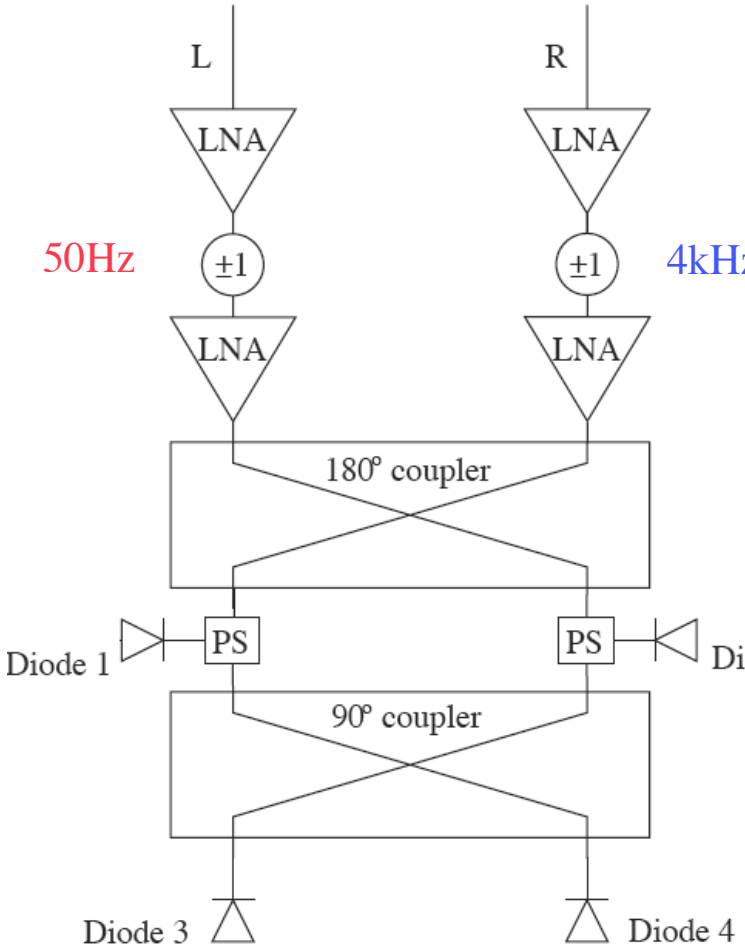
11 σ detection: best, with CBI
(later eclipsed by QUAD)

QUIET‘s 90 GHz Radiometer on a Chip“



QUIET L/R Correlator: Simultaneous Q/U measurements





$$|L \pm R|^2 = |(E_x + iE_y) \pm (E_x - iE_y)|^2 = \underbrace{4E_x^2, 4E_y^2}_{Q}$$

$$|(L \pm R) + i(L \mp R)|^2 = |L \mp iR|^2 = |L|^2 + |R|^2 \mp 2\,\mathrm{Im}(RL^*)$$

$$\mathrm{Im}(RL^*) = \mathrm{Im}(E_x + iE_y)^2 = 2E_xE_y = \underbrace{E_a^2 - E_b^2}_{U}$$

High Speed Sampling

18 bits @ 800 kHz

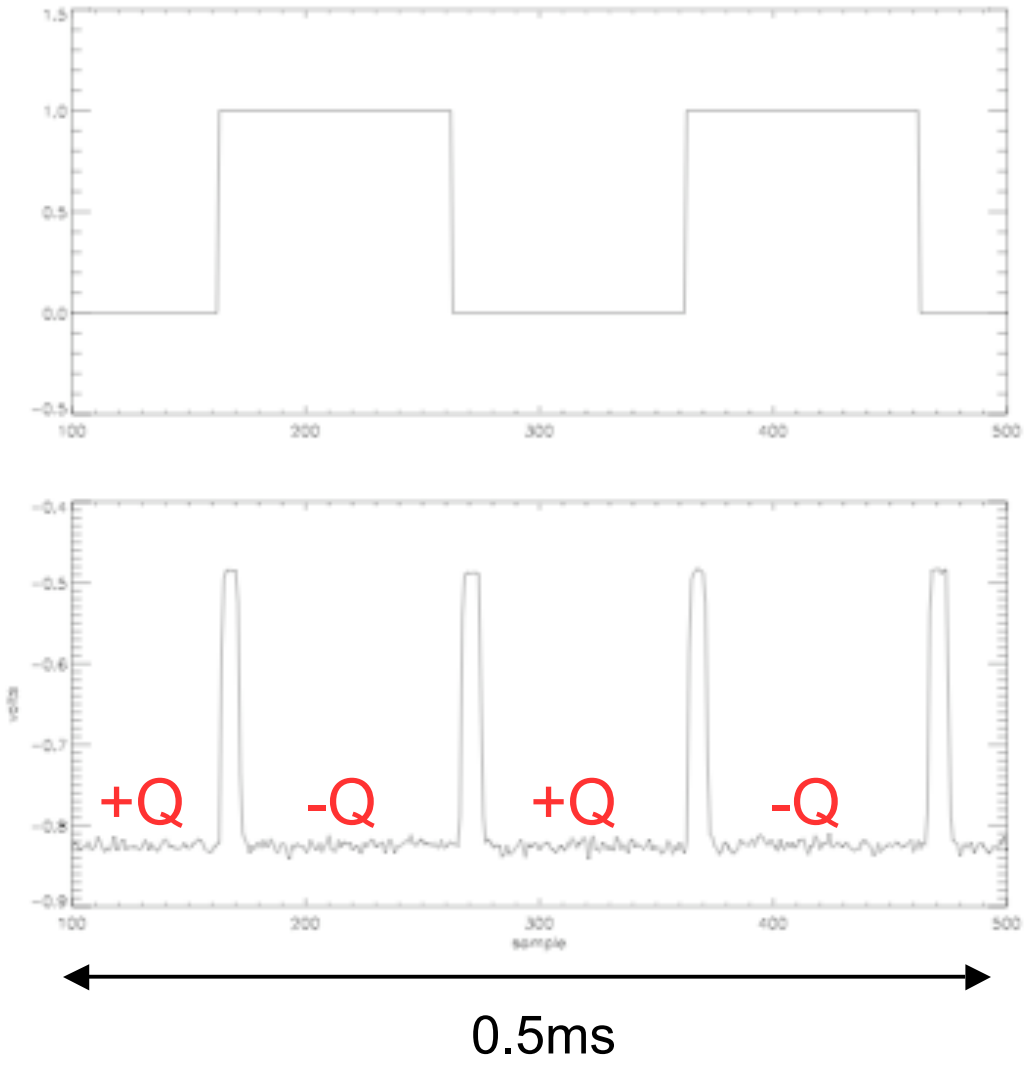
Q/U measurement every 250 μs

Monitors high-frequency noise

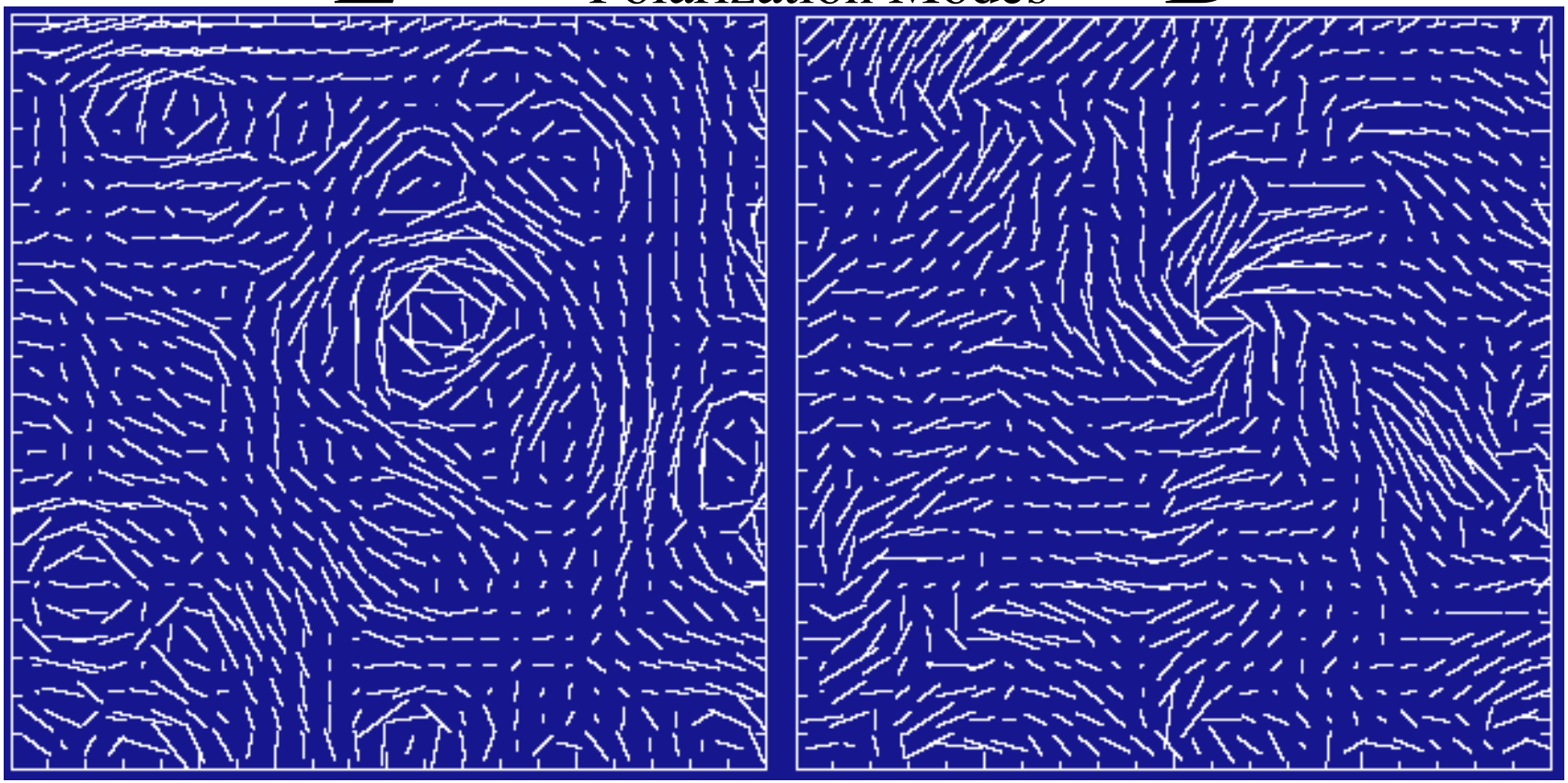
Permits Quadrature Samples

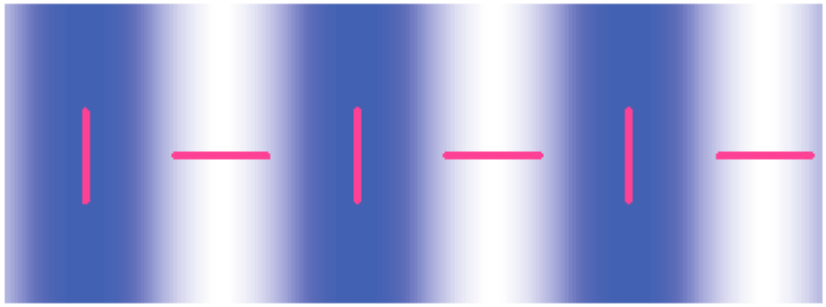
- TOD noise with no signal

Demodulation with FPGA

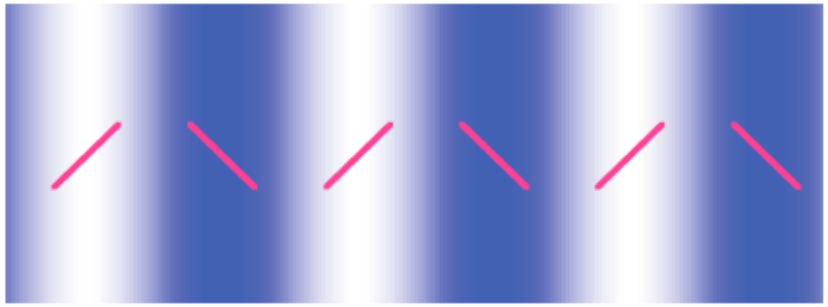


E Polarization Modes B





E: from Density Perturbations

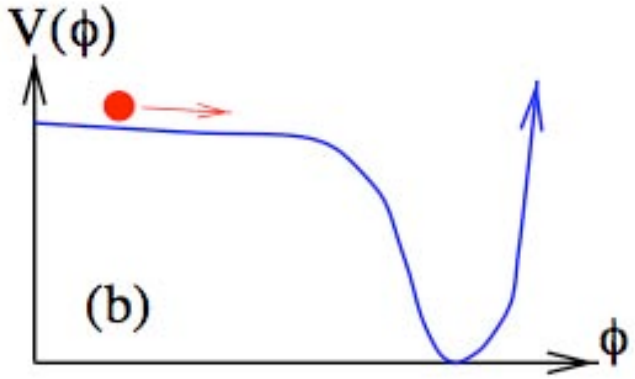


B: only from Gravity Waves

Key Advances Will Come From Isolation of B-modes

Optimism for Gravity Waves ?

(Pagano et al., astro-ph 0707.2560)

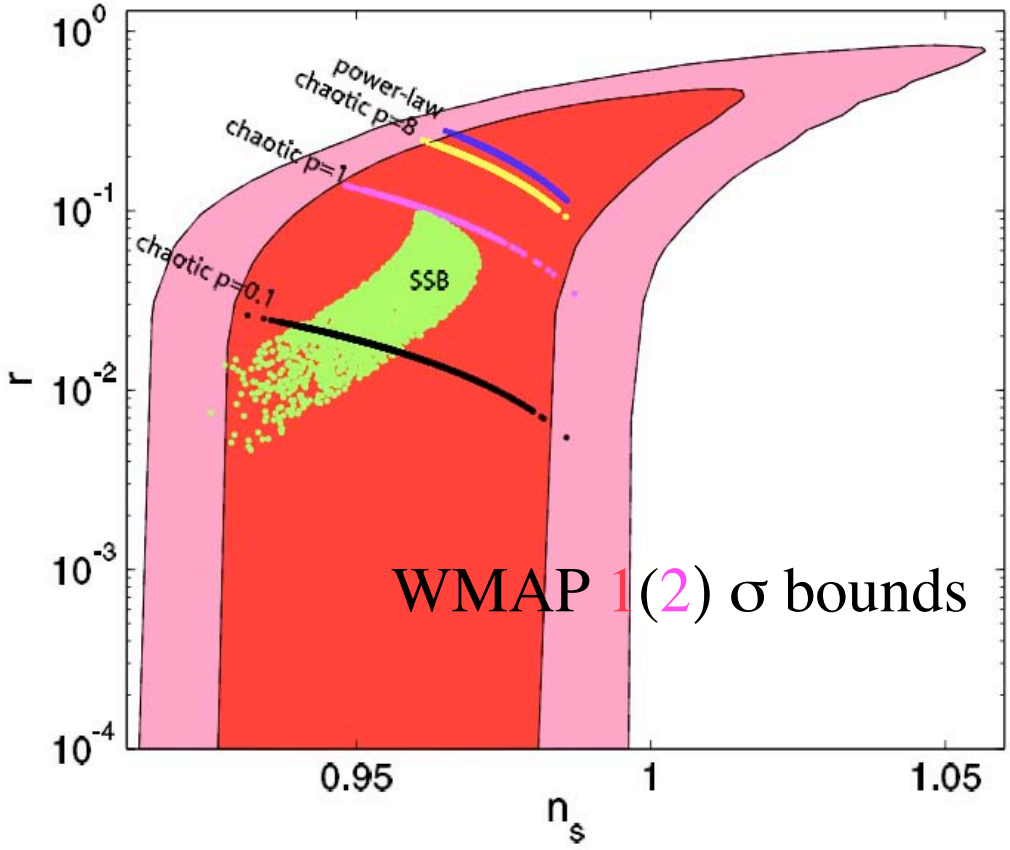


$$\varepsilon = \frac{m_{PL}^2}{16\pi}\left(\frac{V'(\phi)}{V(\phi)}\right)^2 ; \eta = \frac{m_{PL}^2}{8\pi}\left(\frac{V''(\phi)}{V(\phi)}\right)$$

$$n_S \approx 1 - 6\varepsilon + 2\eta$$

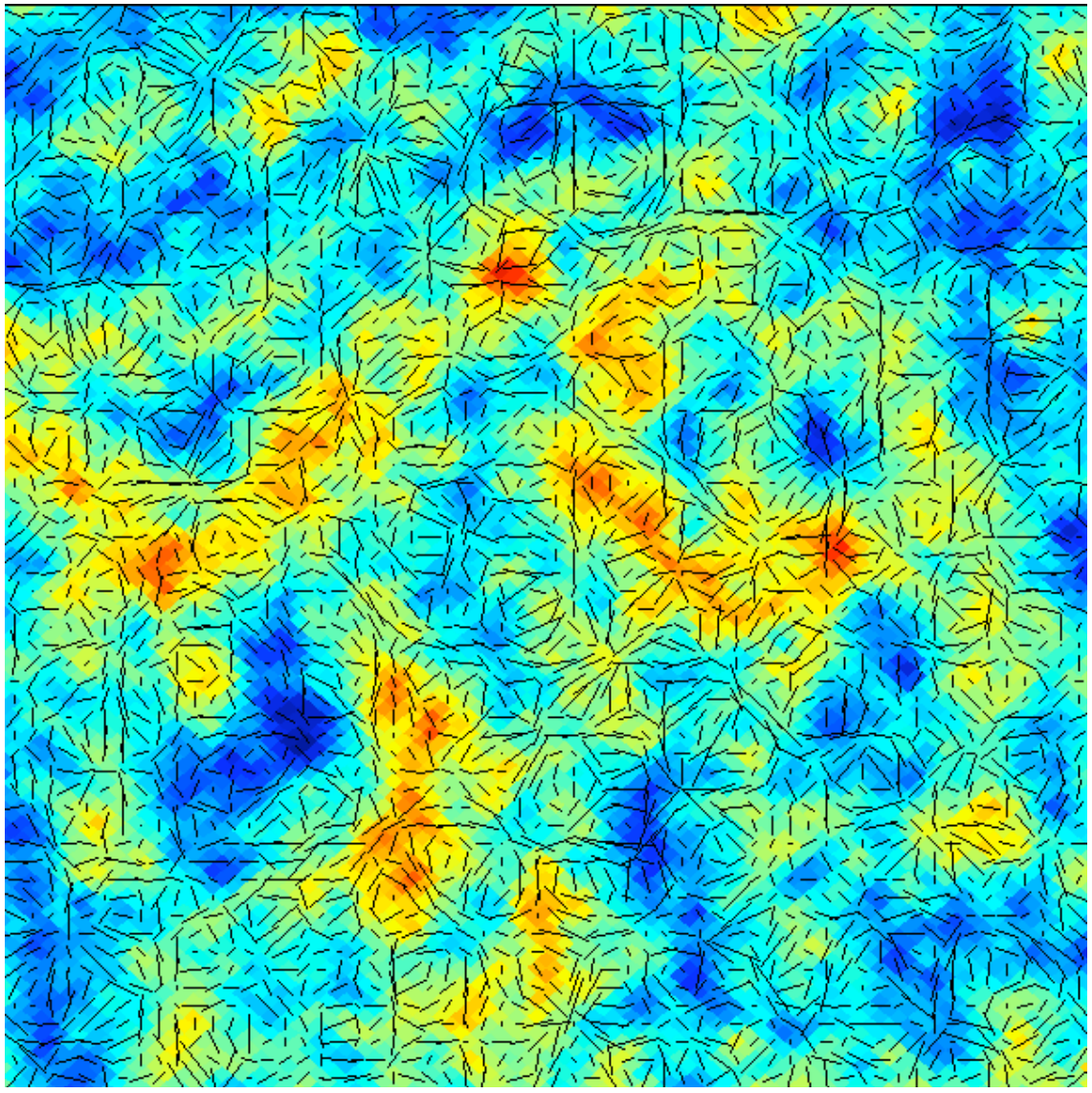
$$r \equiv T/S = 16\varepsilon$$

$$n_S \neq 1 \Rightarrow r \neq 0$$



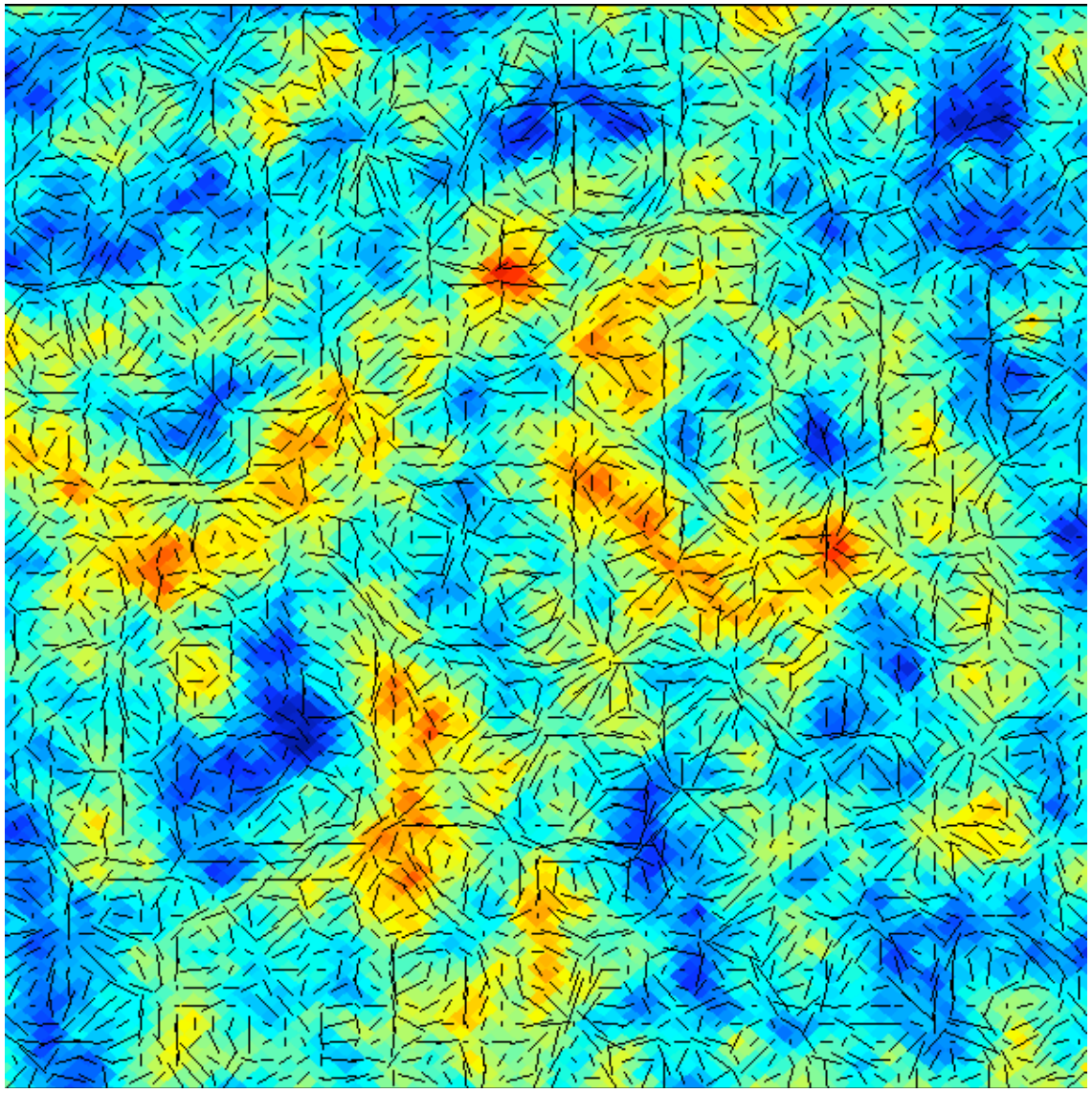
Simulated sky with T/S=0.2

10 deg by 10 deg field

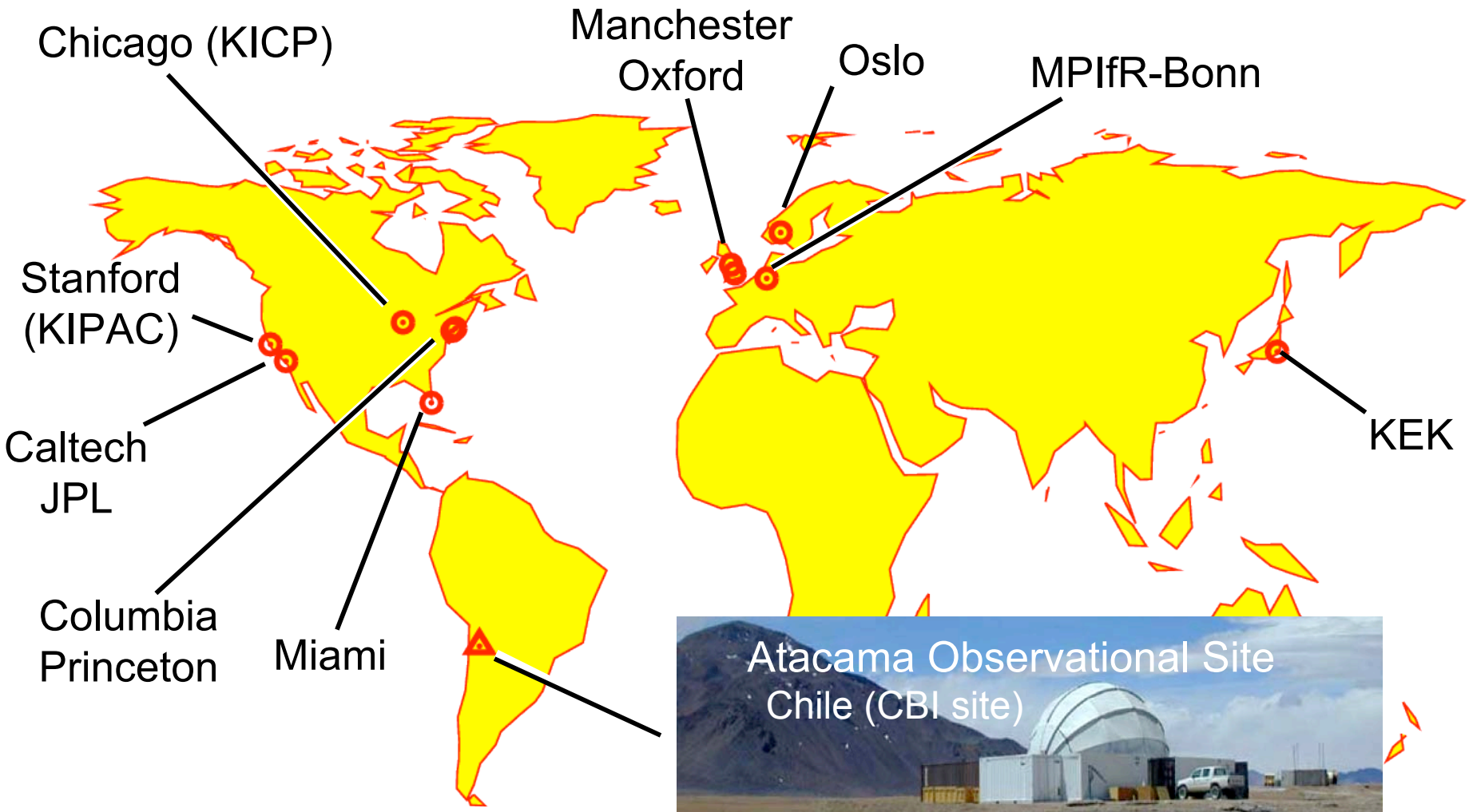


Simulated sky with T/S=0.0

10 deg by 10 deg field



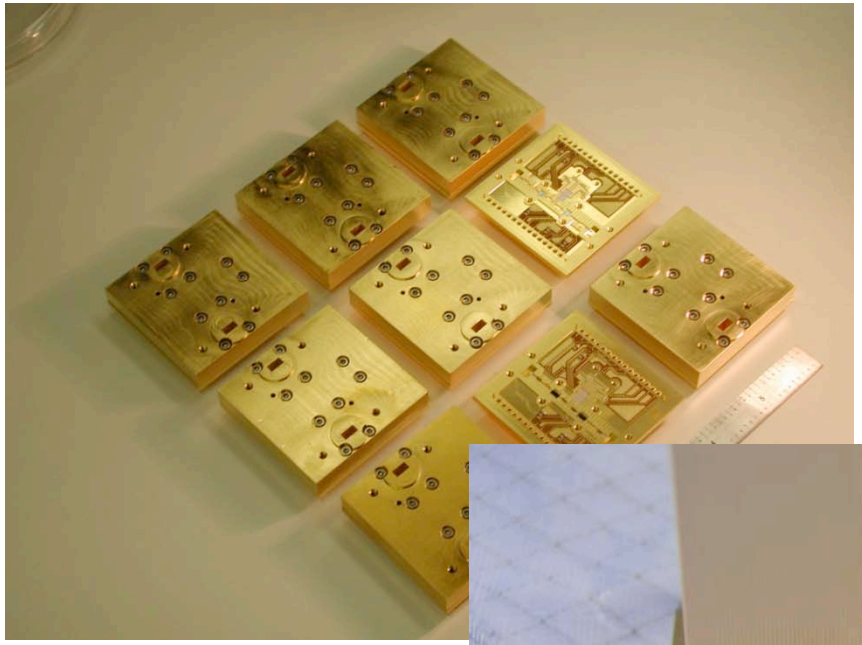
Q/U Imaging ExperimenT Collaboration



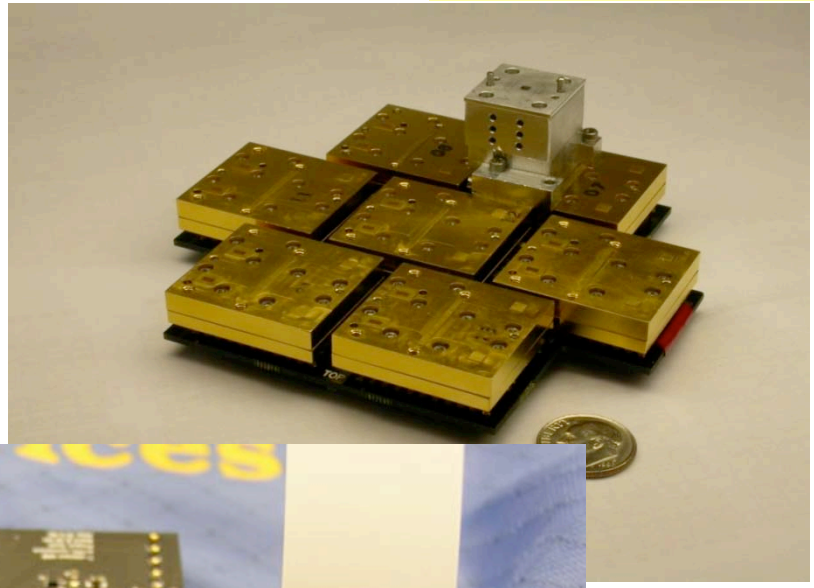
5 countries, 12 institutes, ~30 people

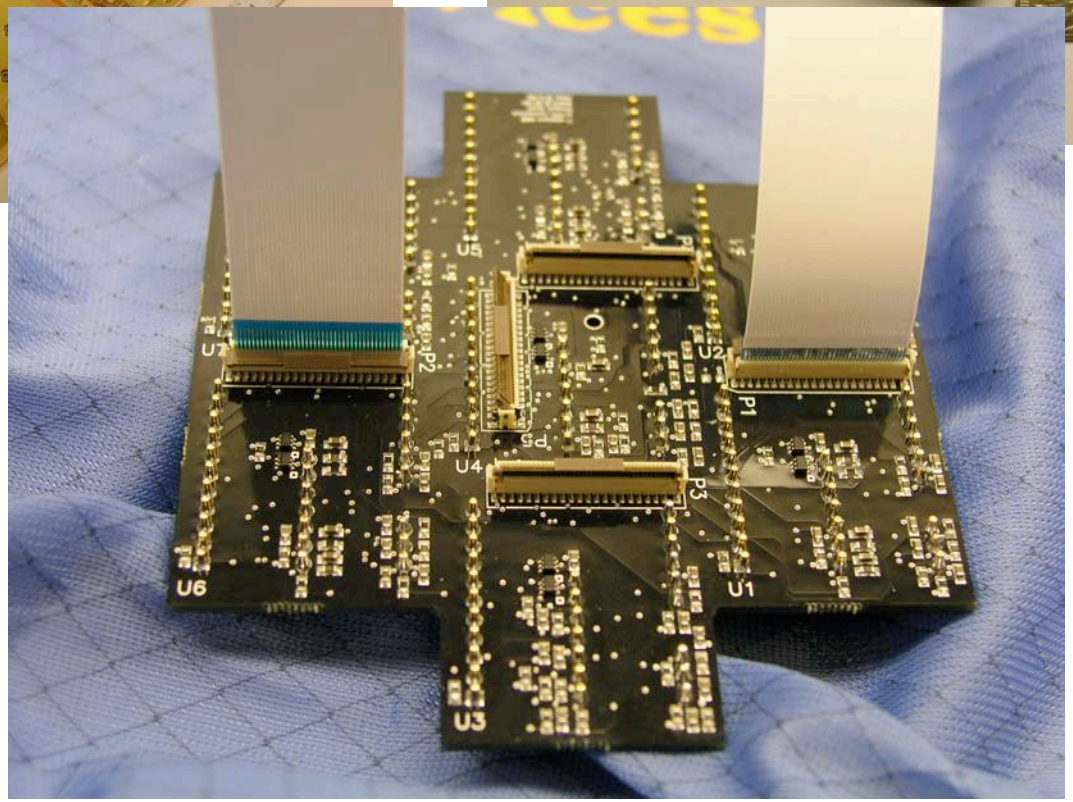
„Radiometer on a Chip“

Q-Band (44 GHz)

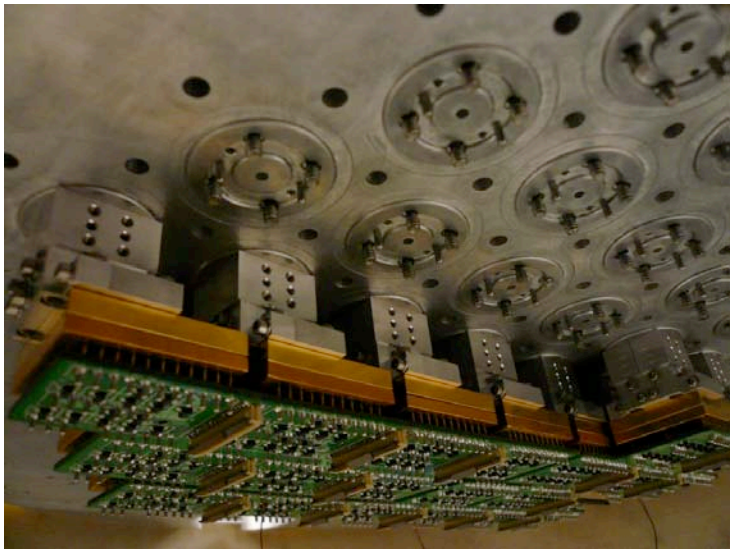


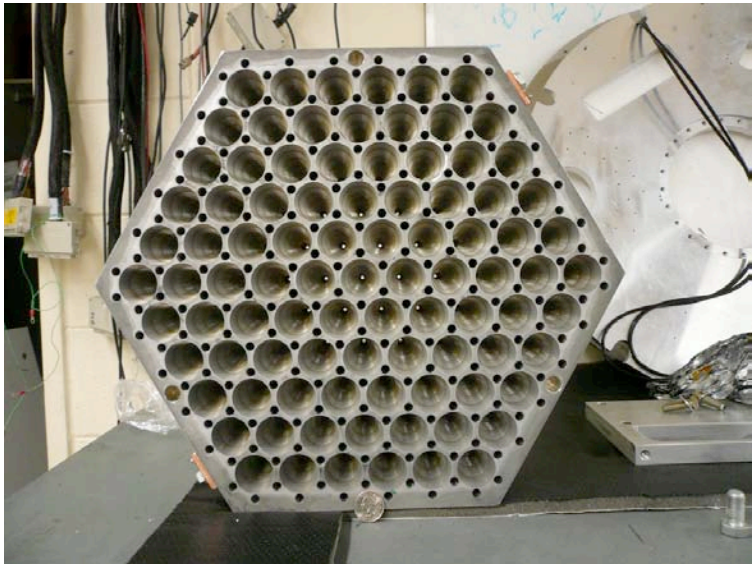
W-Band (90 GHz)





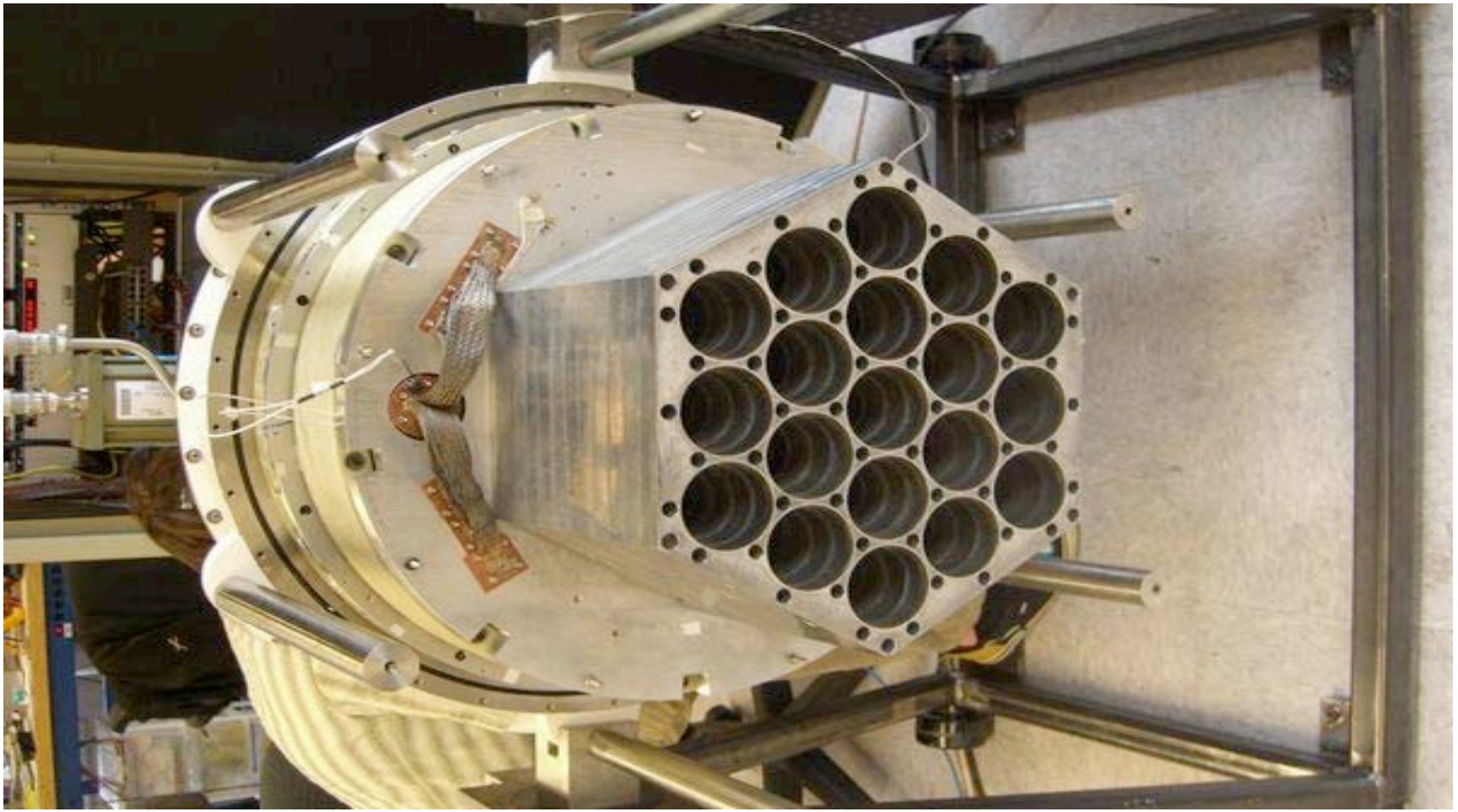
W-band Receiver Integration



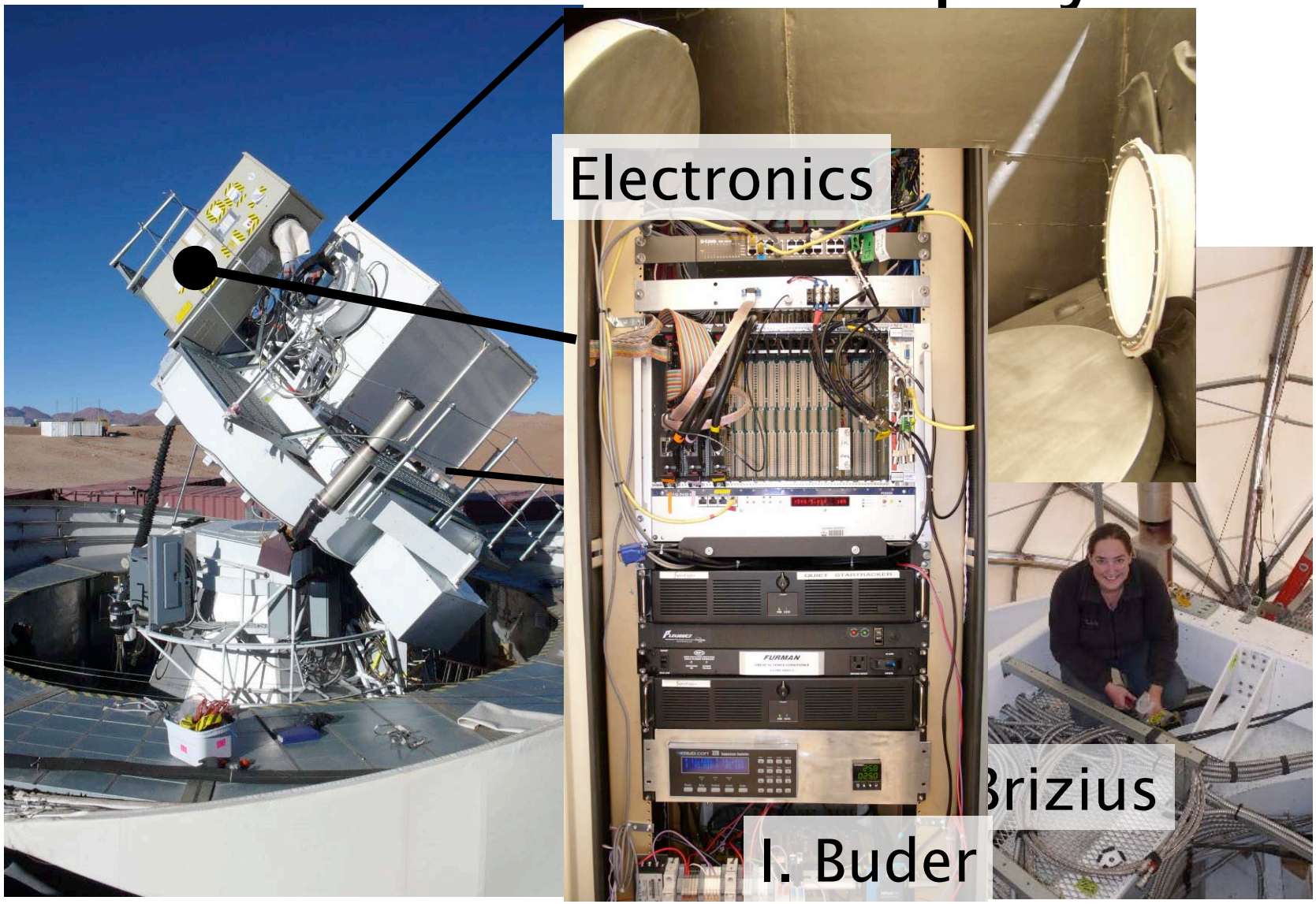


Q-band Receiver

(Integrated at Columbia
operating since 10/08)

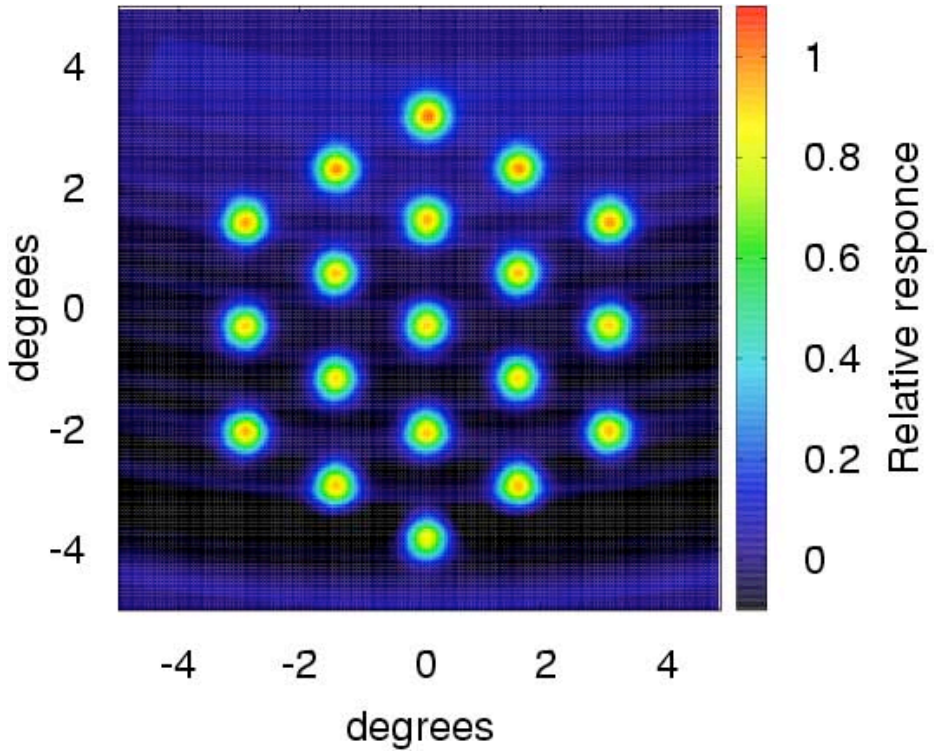


QUIET has been deployed

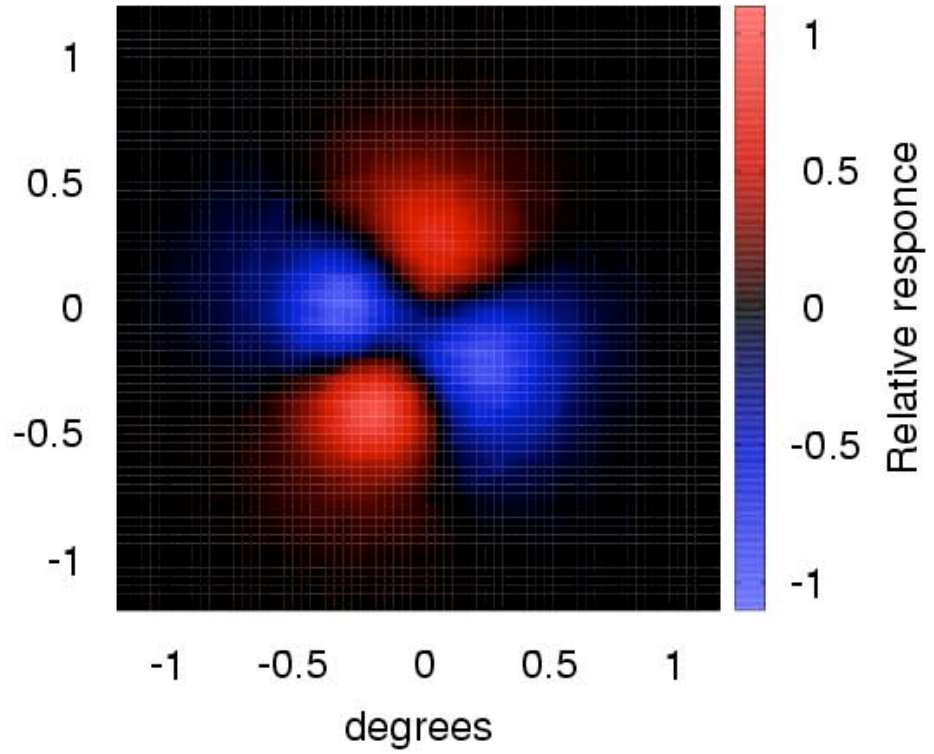


The Moon in Q-band

Total power

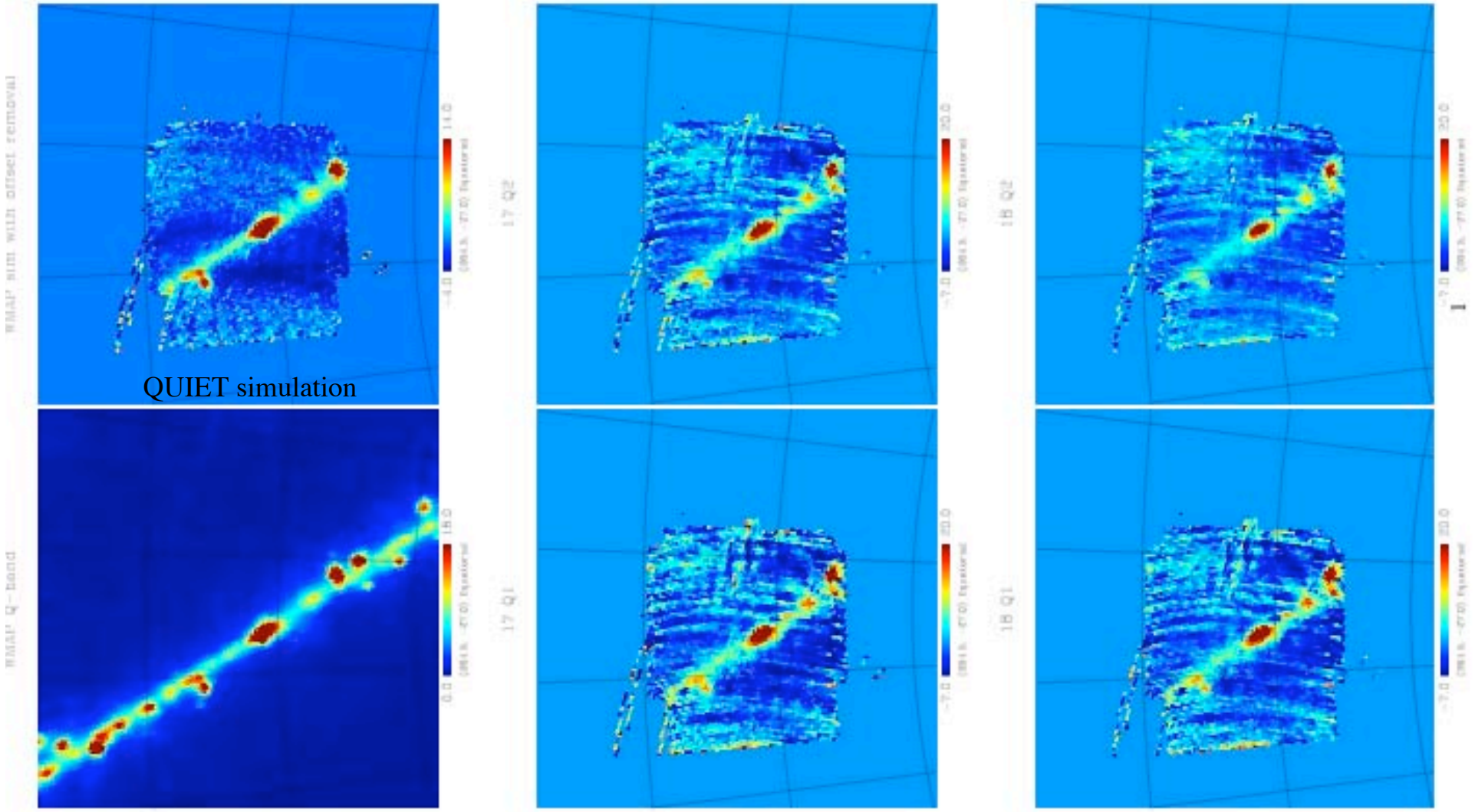


Polarization



The Galaxy in Q-band

(Hardware & Analysis: D. Samtleben, MPI)

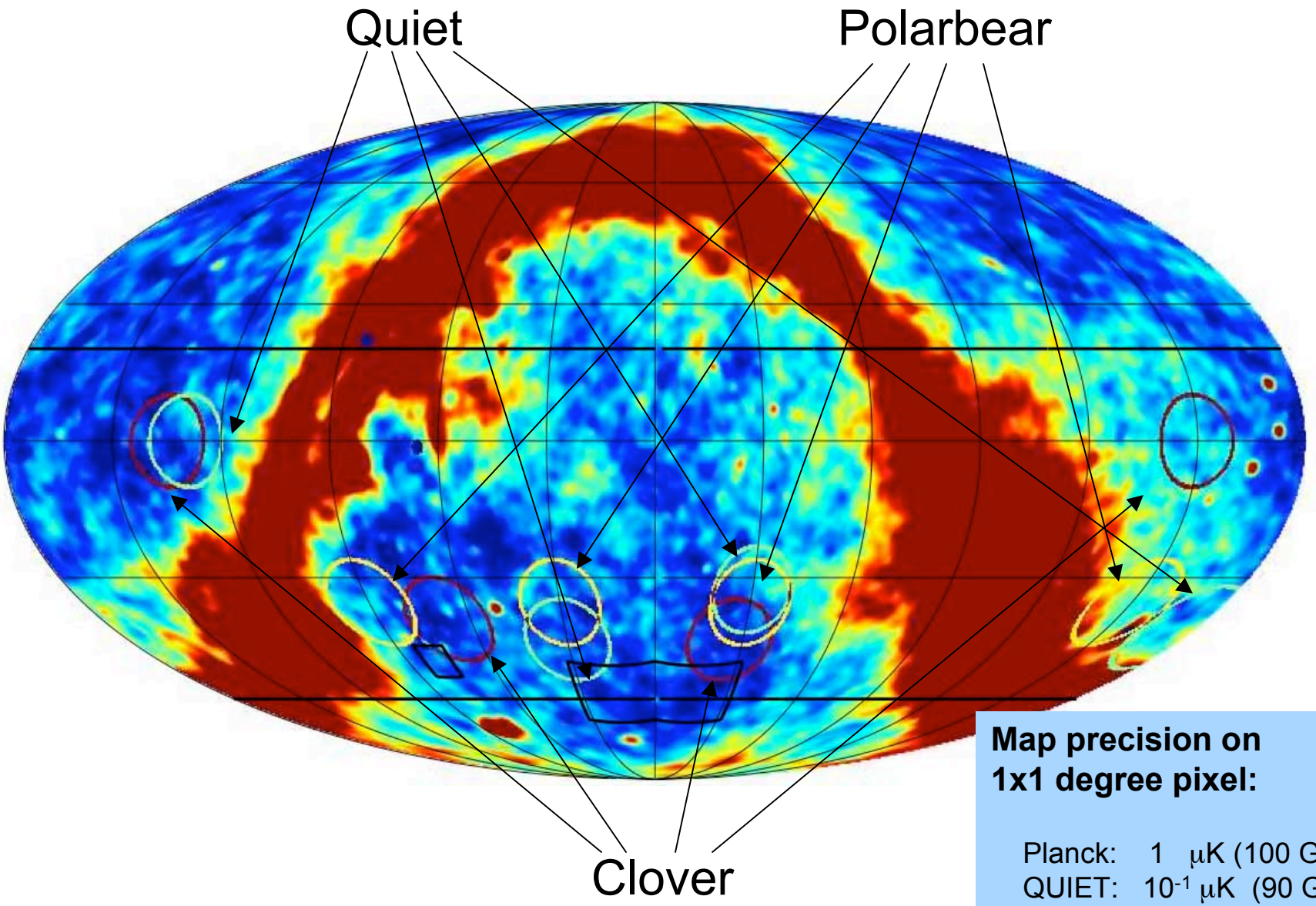


WMAP

~5hrs of QUIET data

CMB Patches

(D. Samtleben)



Map precision on 1x1 degree pixel:

Planck: 1 μK (100 GHz)
QUIET: 10^{-1} μK (90 GHz)

Operations Supported by Saint & NSF

QUIET & Polarbear

We've agreed to scan the same patches

(surely CLOVER will follow)

Hugely positive for systematics and the study and removal of foregrounds

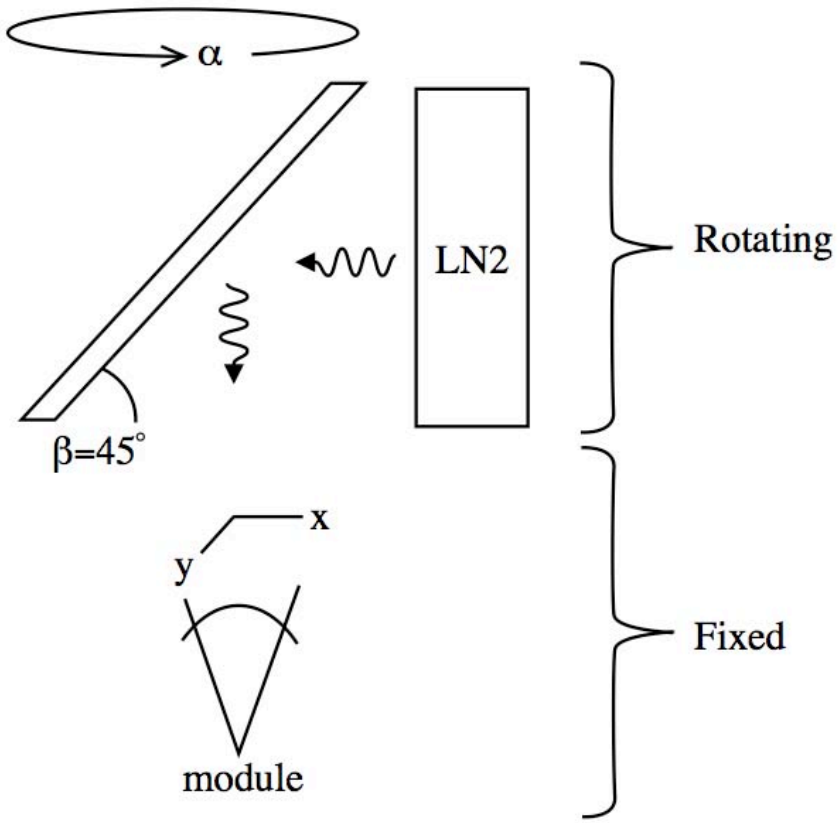
Q-band array Performance in the Field: 17 Modules

- Proposal: 40uks $^{0.5}$
- Actual: 70uks $^{0.5}$

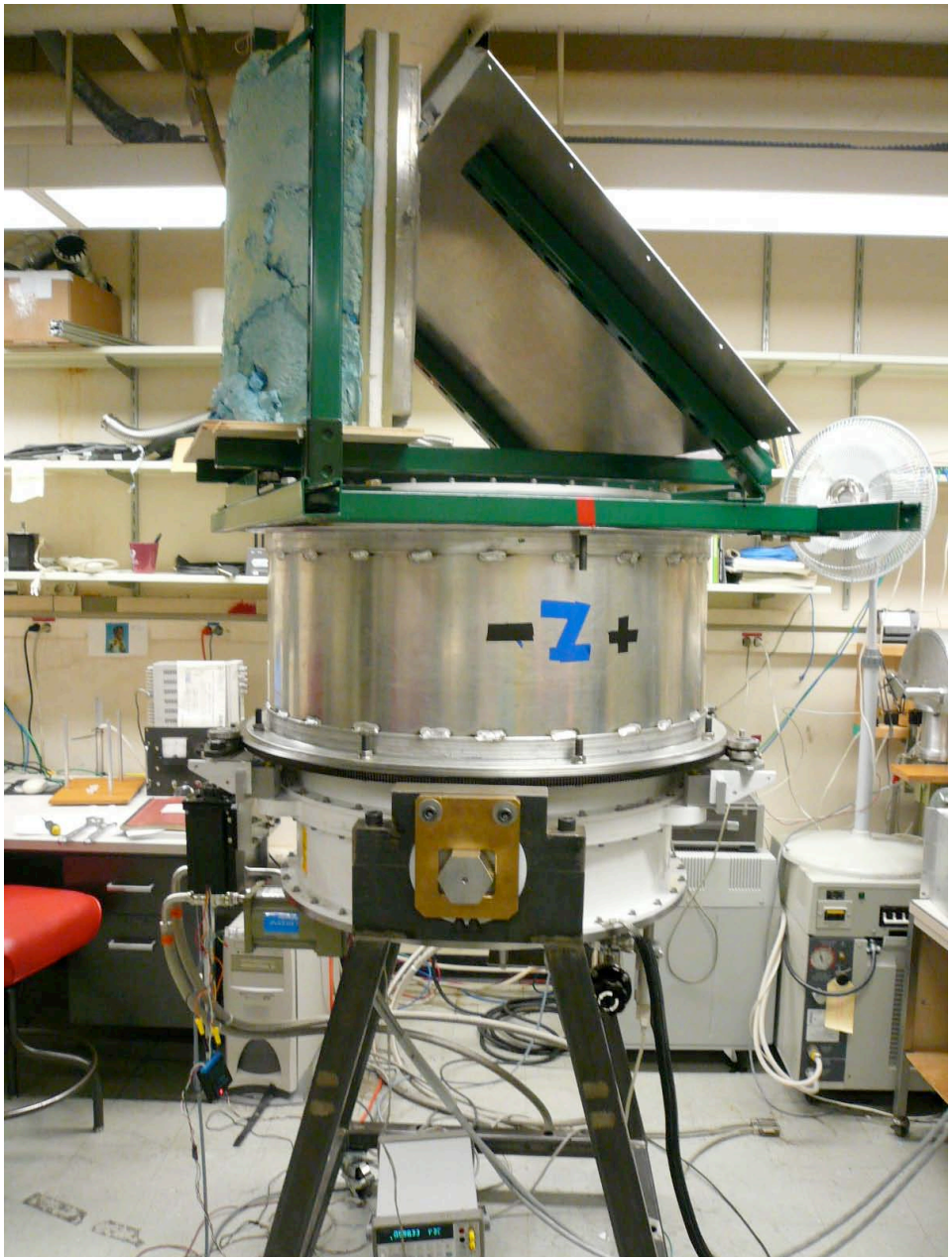
Recent Activity, W-band Modules

- JPL-Chicago-(MPI)
- 5 times more modules than Q
- Our “money channel”
  - ~5 times less foreground level
- Most of the effort in the collaboration

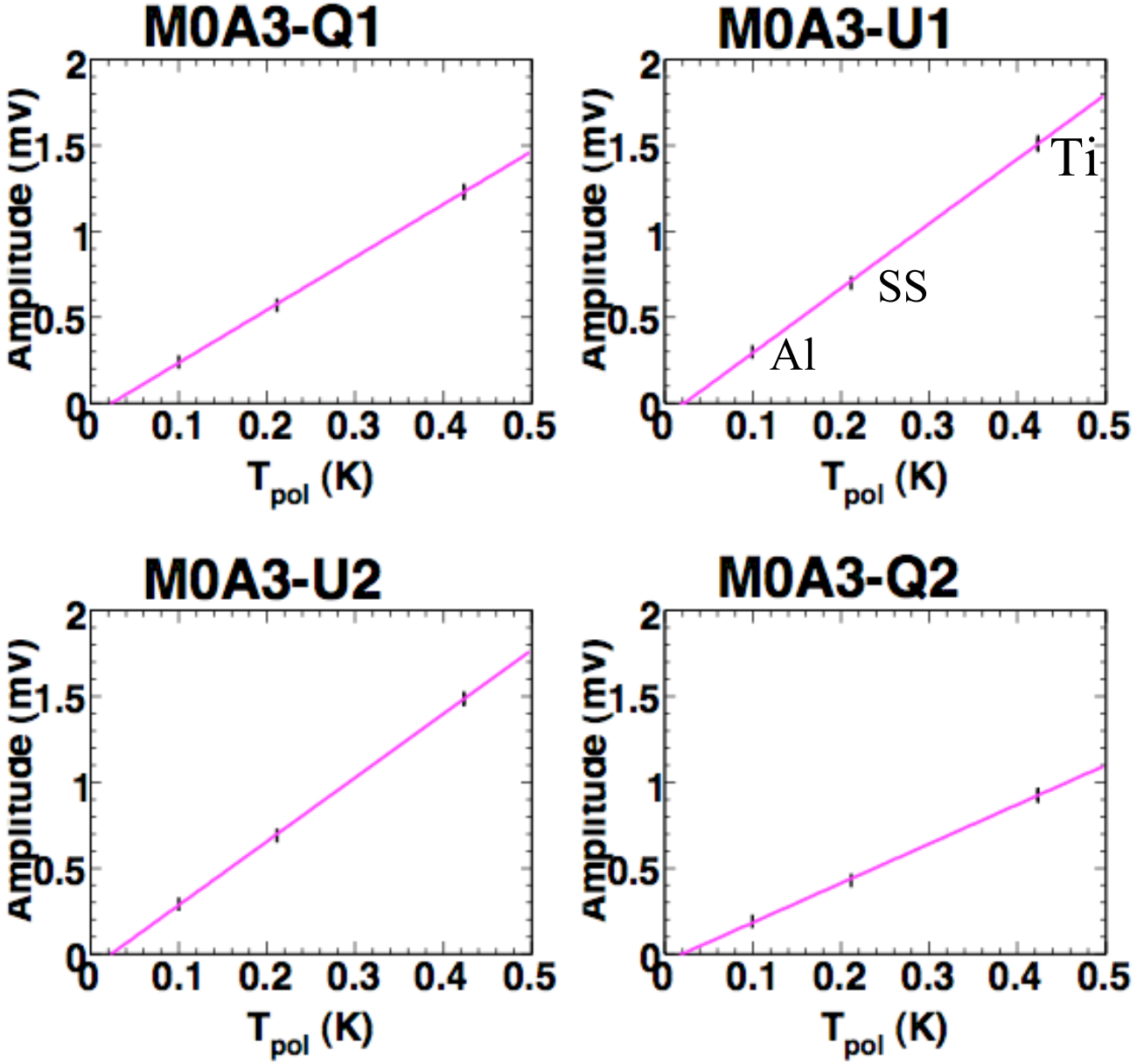
QUIET Calibration/Optimization

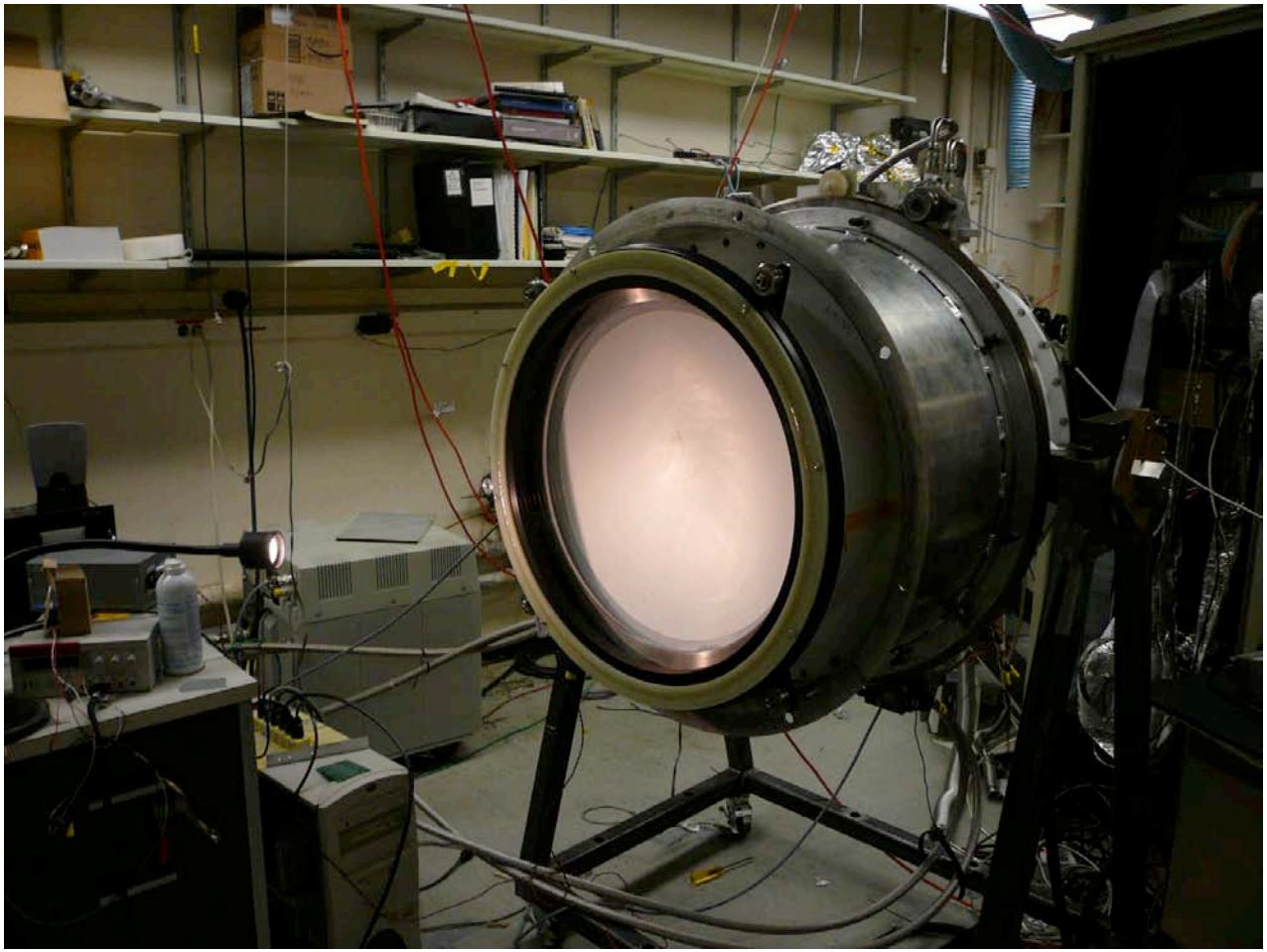


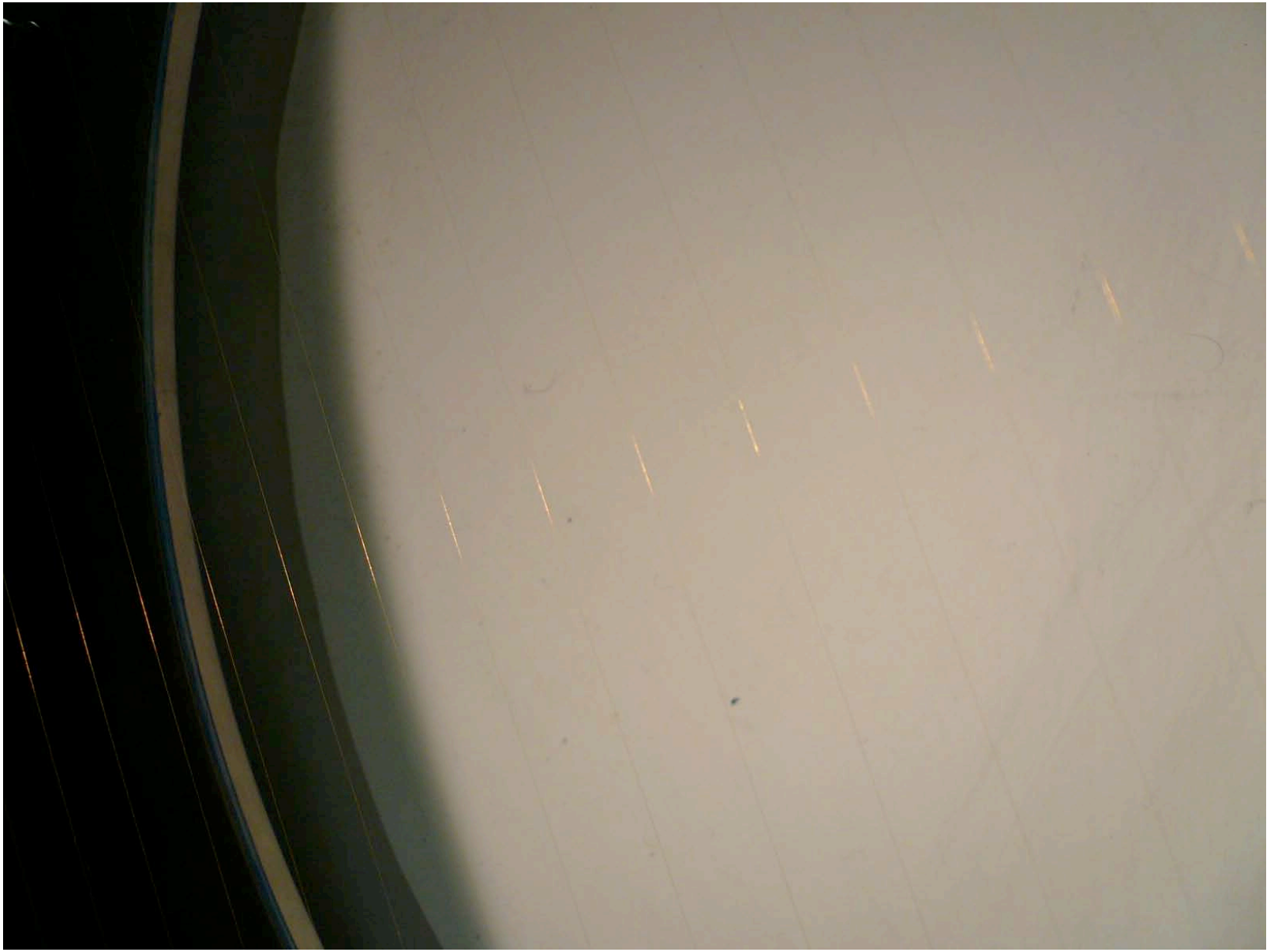
$$U_{observed} = (U_{reflected} + U_{observed})$$
$$= -\sqrt{4\pi\nu\rho\varepsilon_0}(\cos\beta - \sec\beta)(T_{plate} - T_{load})$$
$$\cong 116 \text{ mK (Al)}$$


-Z+

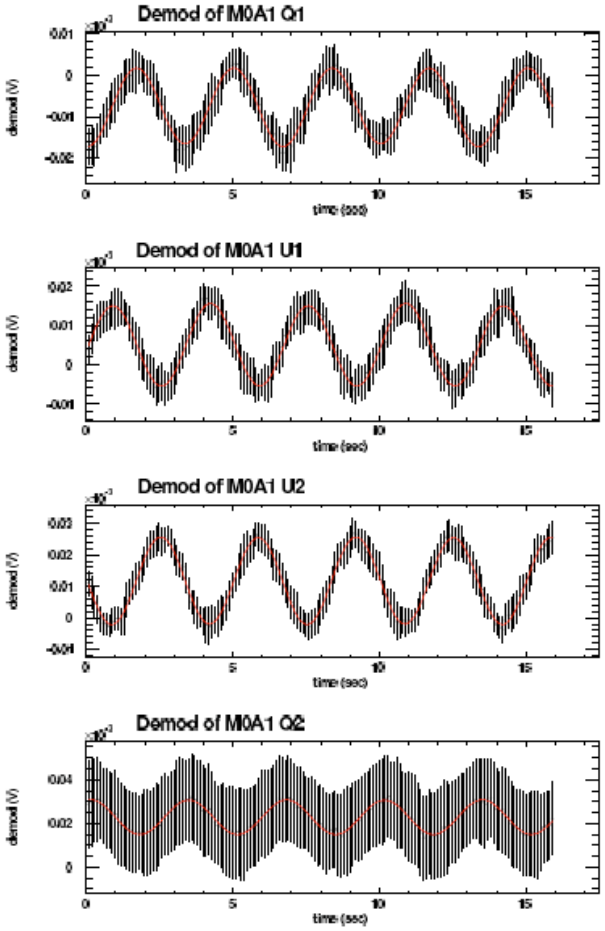
Polarized Gain/Sensitivity



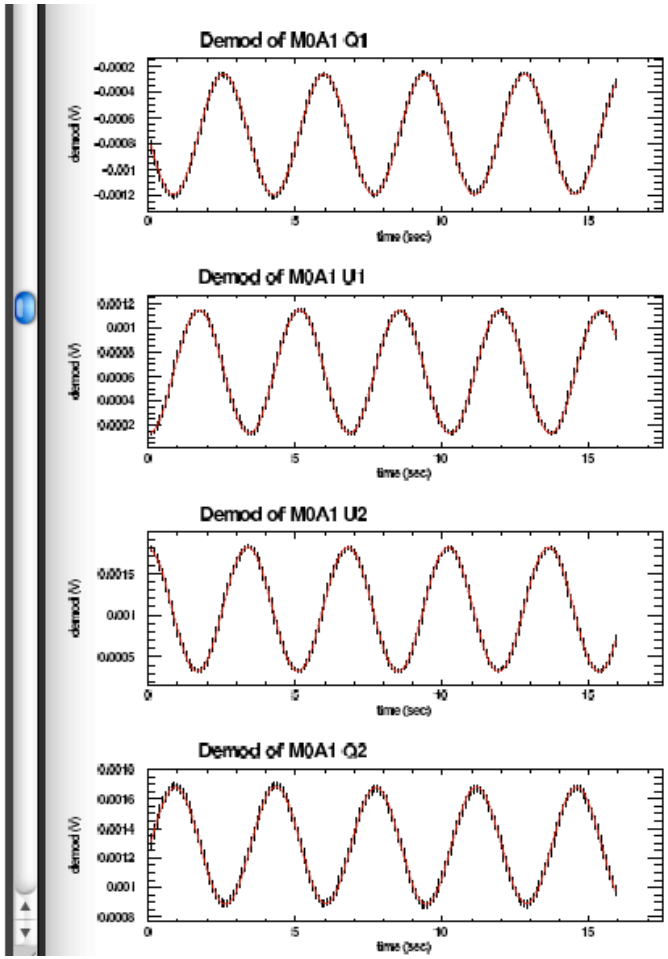


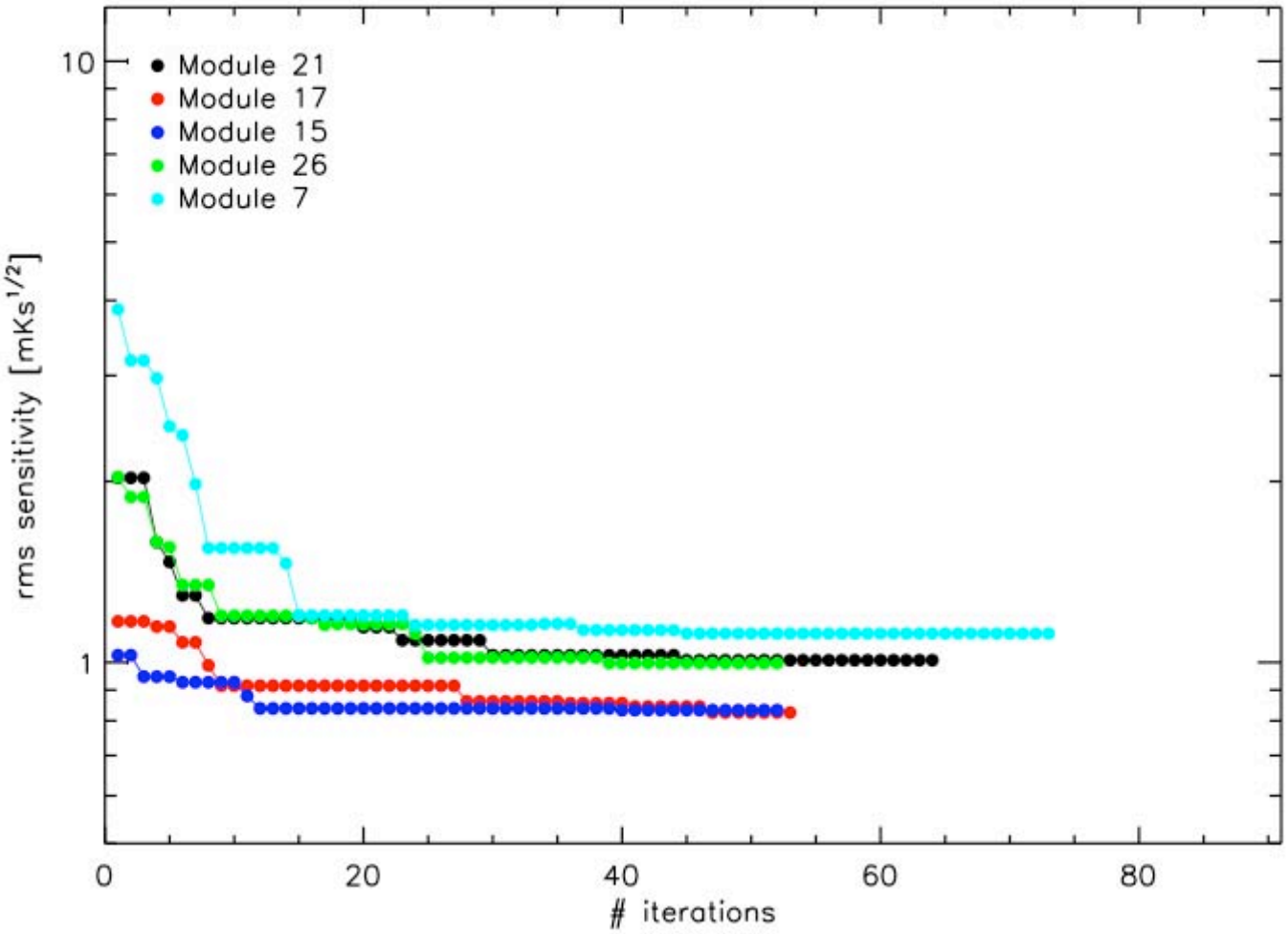


Rotating Plate



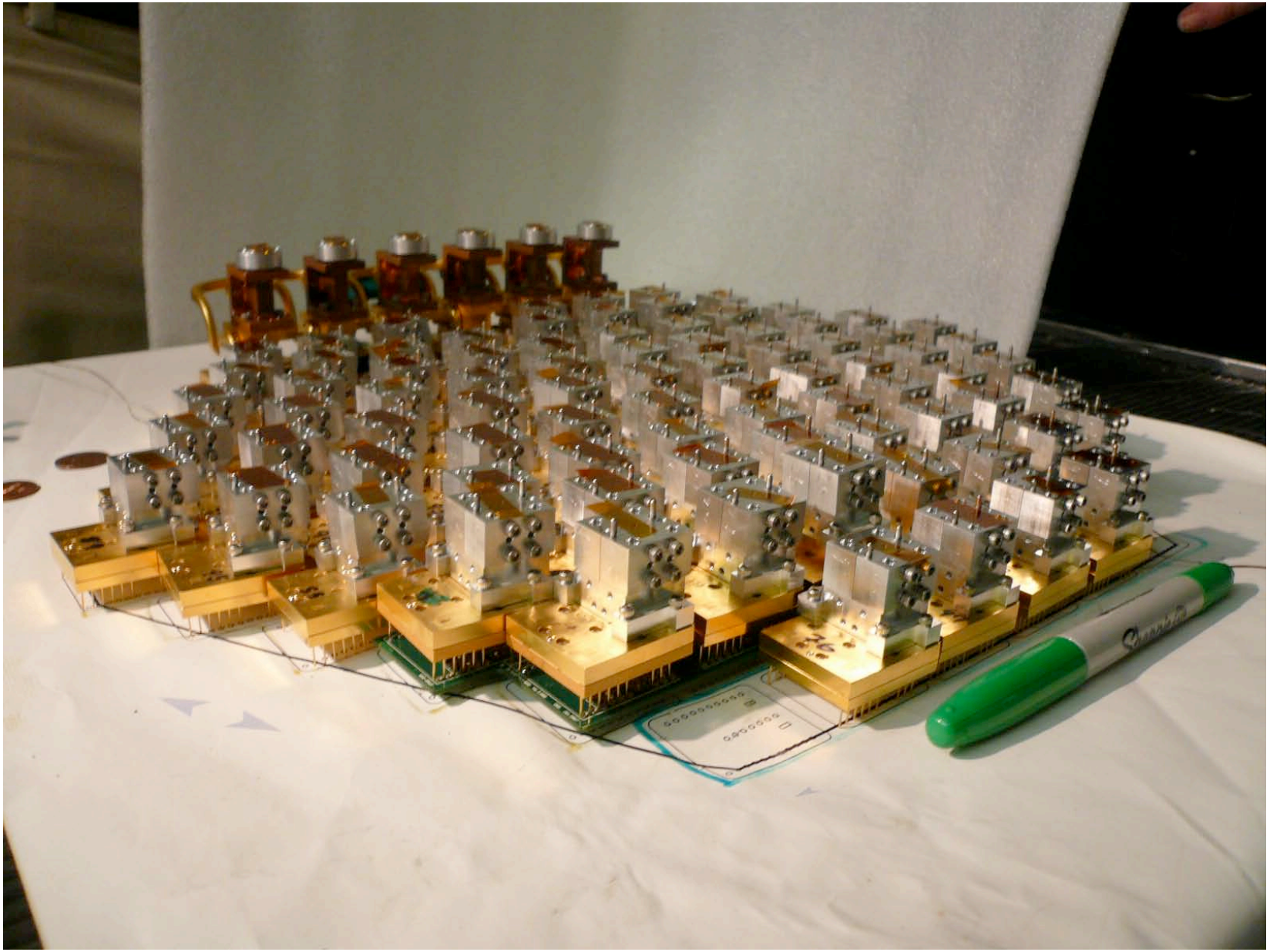
Rotating Wire Grid



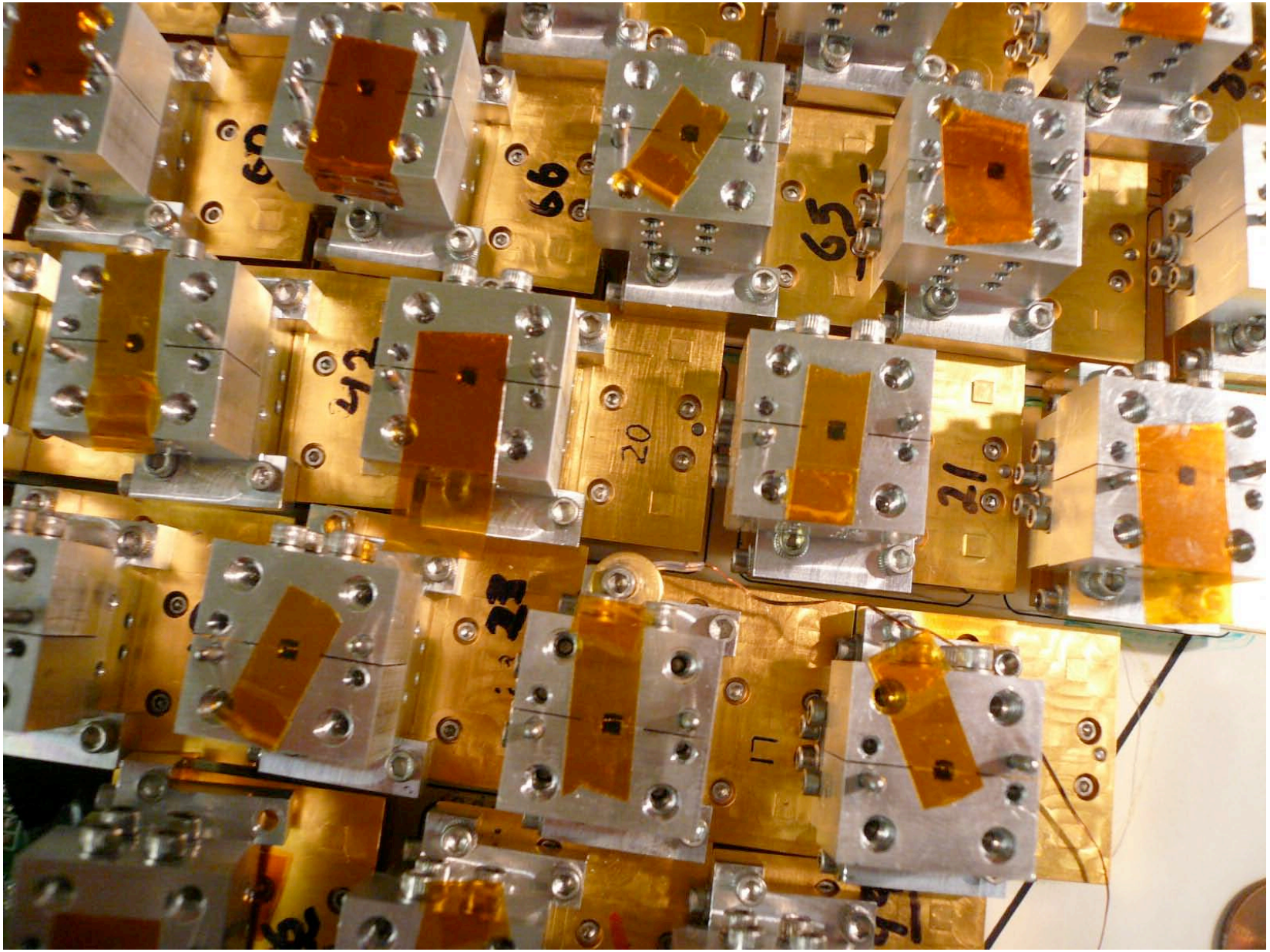


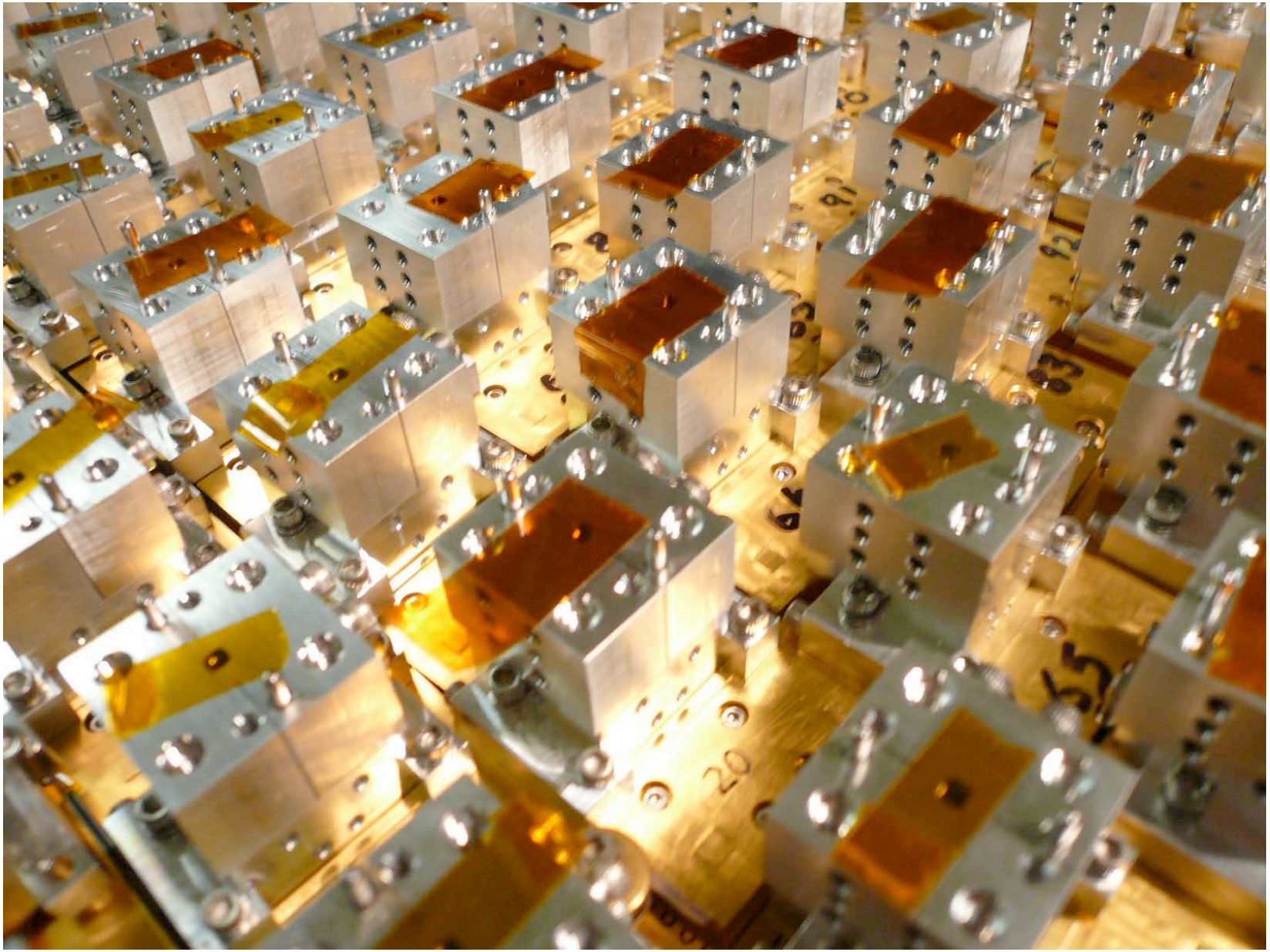
- Down-hill simplex optimization
  - Starting with JPL bias values
  - Works on 10 gate and drain voltages
- ~5 hours to optimize the array

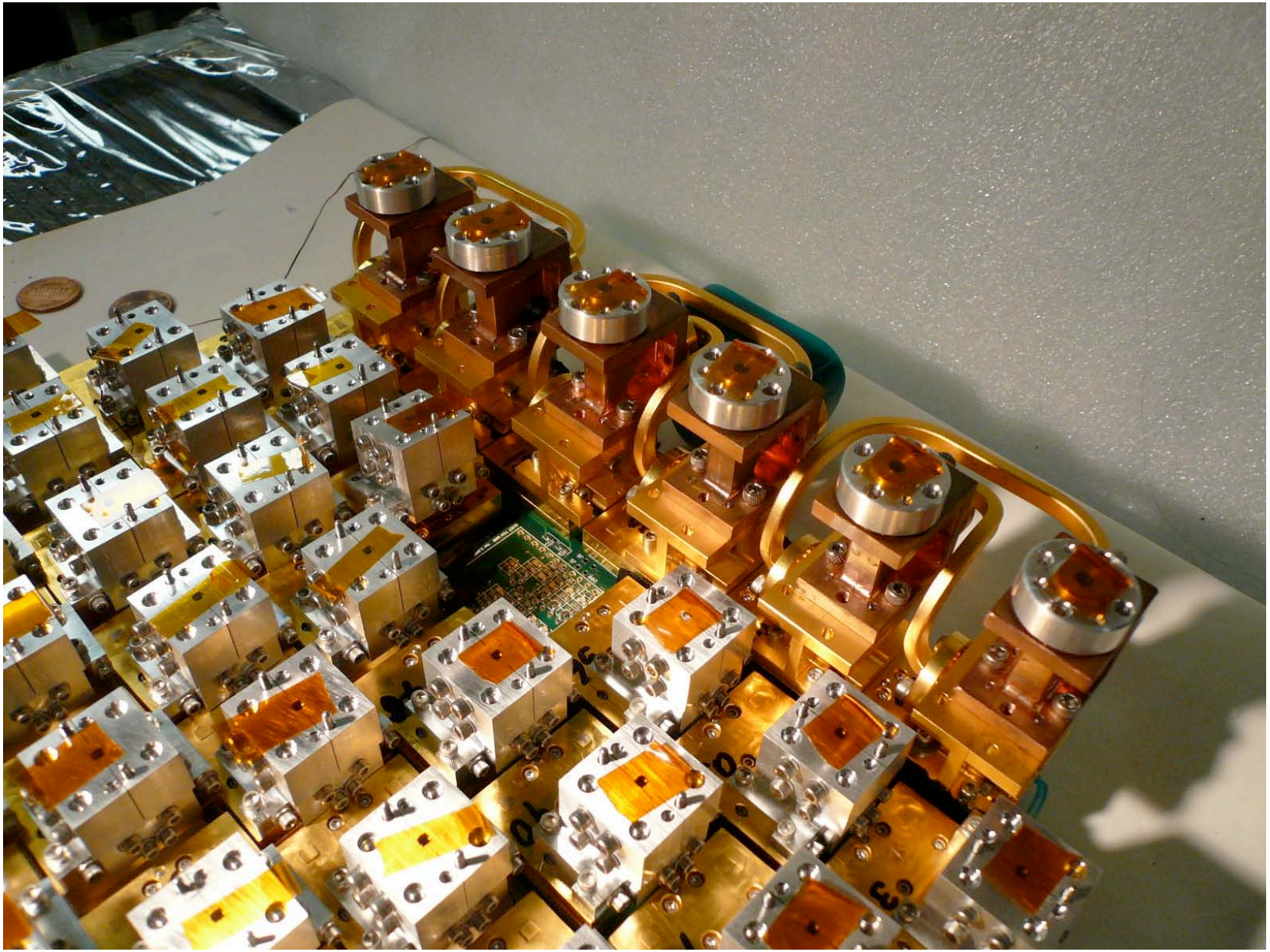
The Full W-band Array



Modules: K. Cleary


66
63
42
20
21
23

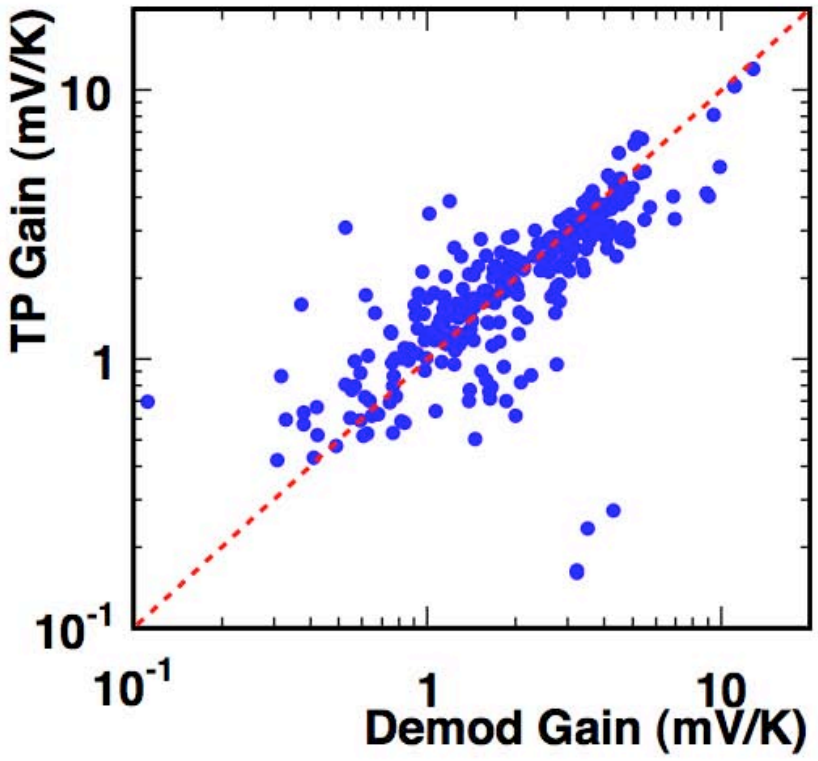


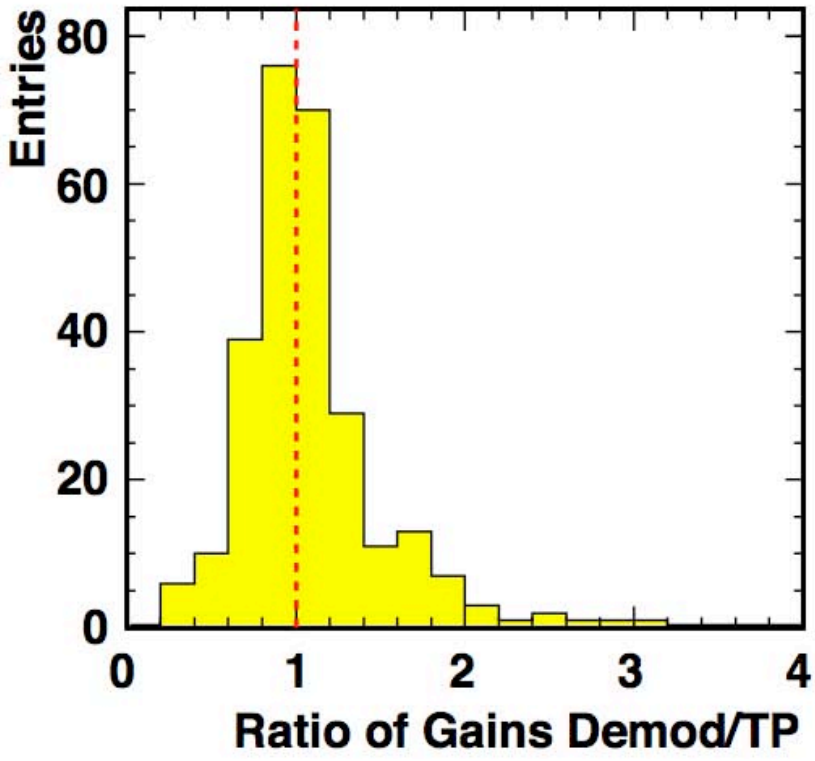


Statistics on the 84 Modules

- Gains from TP and Polarized signals
  - Measured with 77 and 87 K loads
  - Consistent results on average
    - Implies arms are on average phased correctly
    - Larger systematic on TP gain
- <BW> : ~12 GHz (proposal said 18)
- $<T_{rec}>$: 125 K (proposal said 45)
- Best T_{rec} : 65 K
- We may be saturating at 77K (hopefully)
  - 20 K load available in about a week
  - Will know for sure when we get to the site

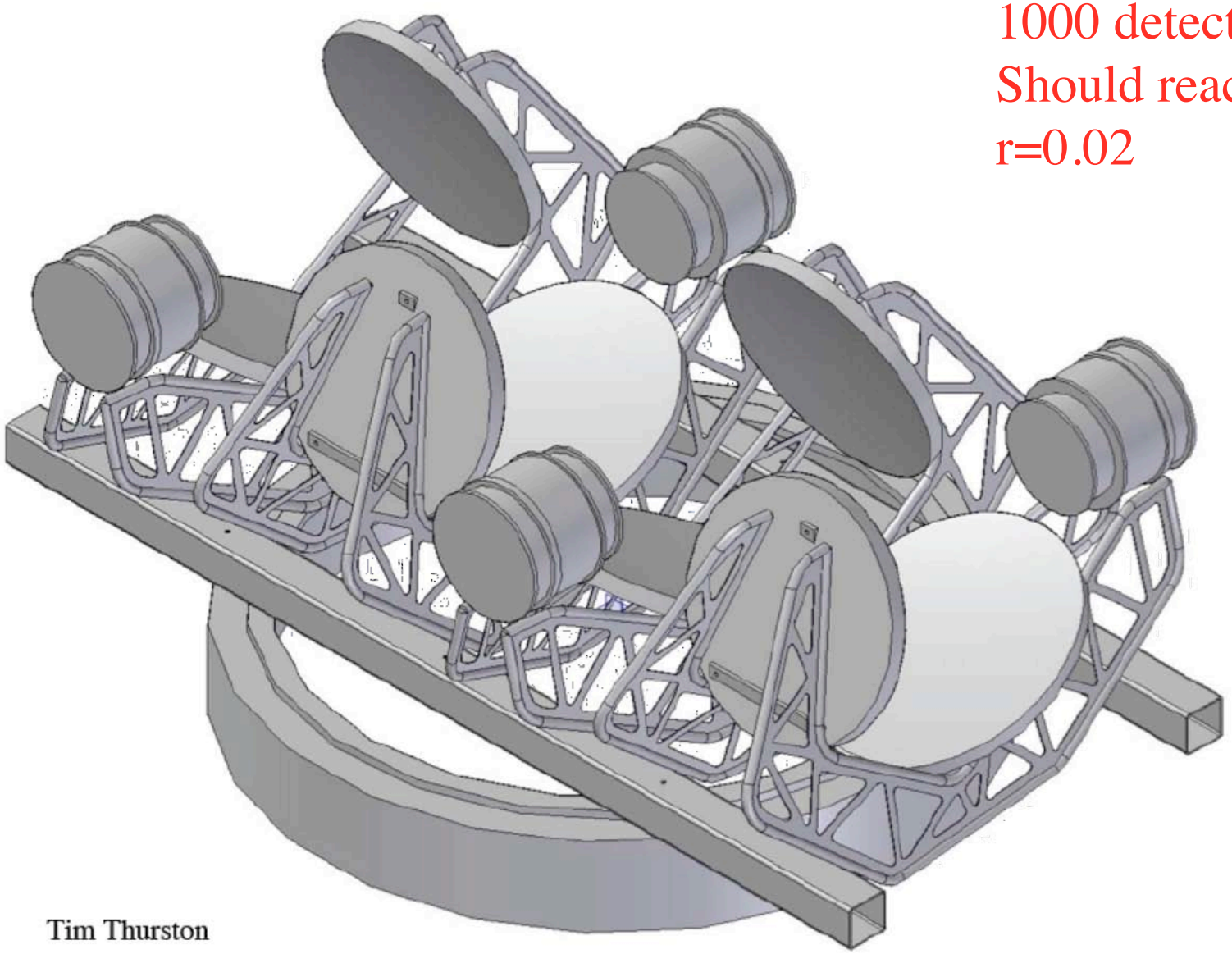
For the experts: comparing TP gains with Polarized gains





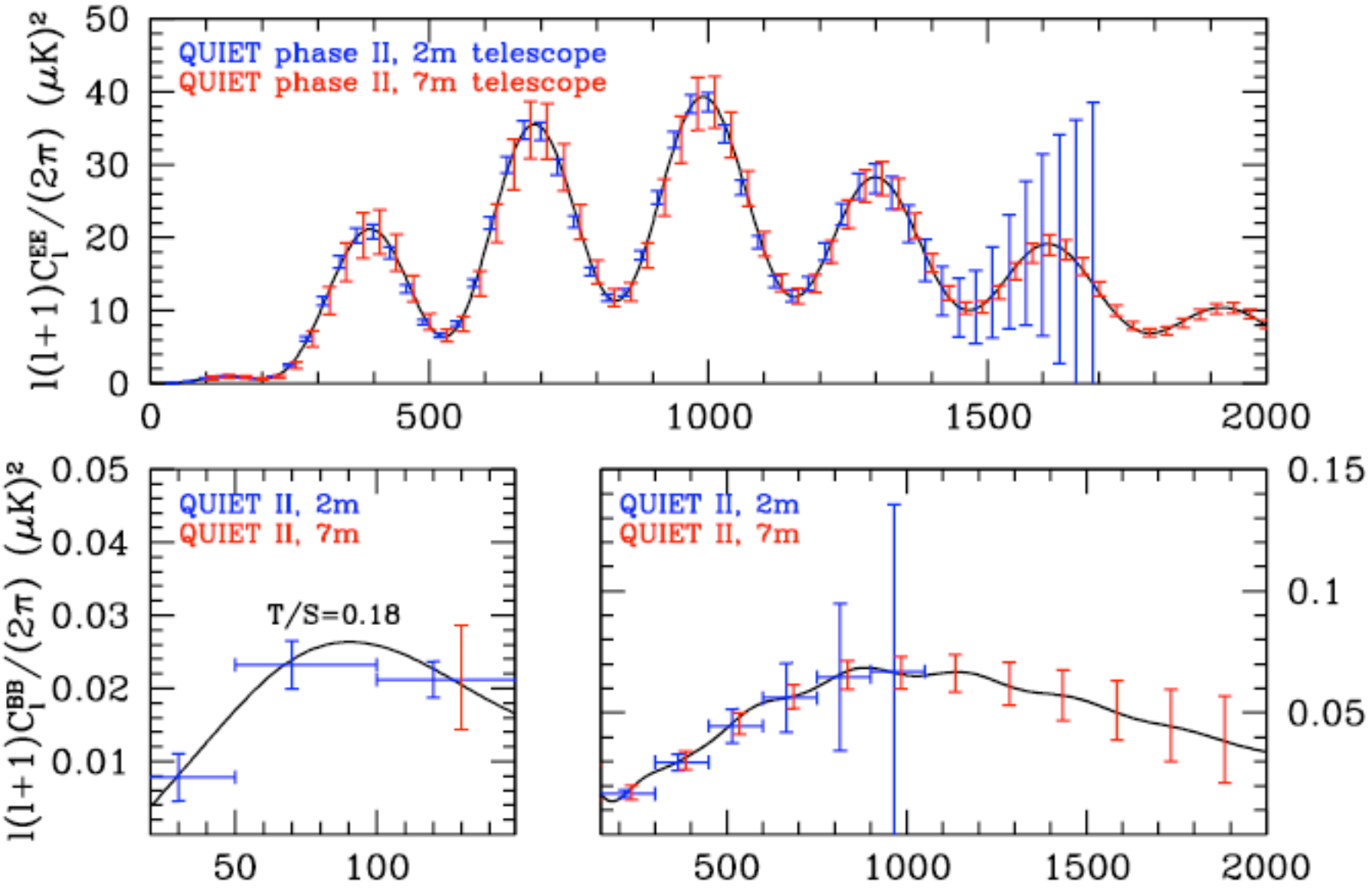
Phase II Telescopes

1000 detectors
Should reach
r=0.02



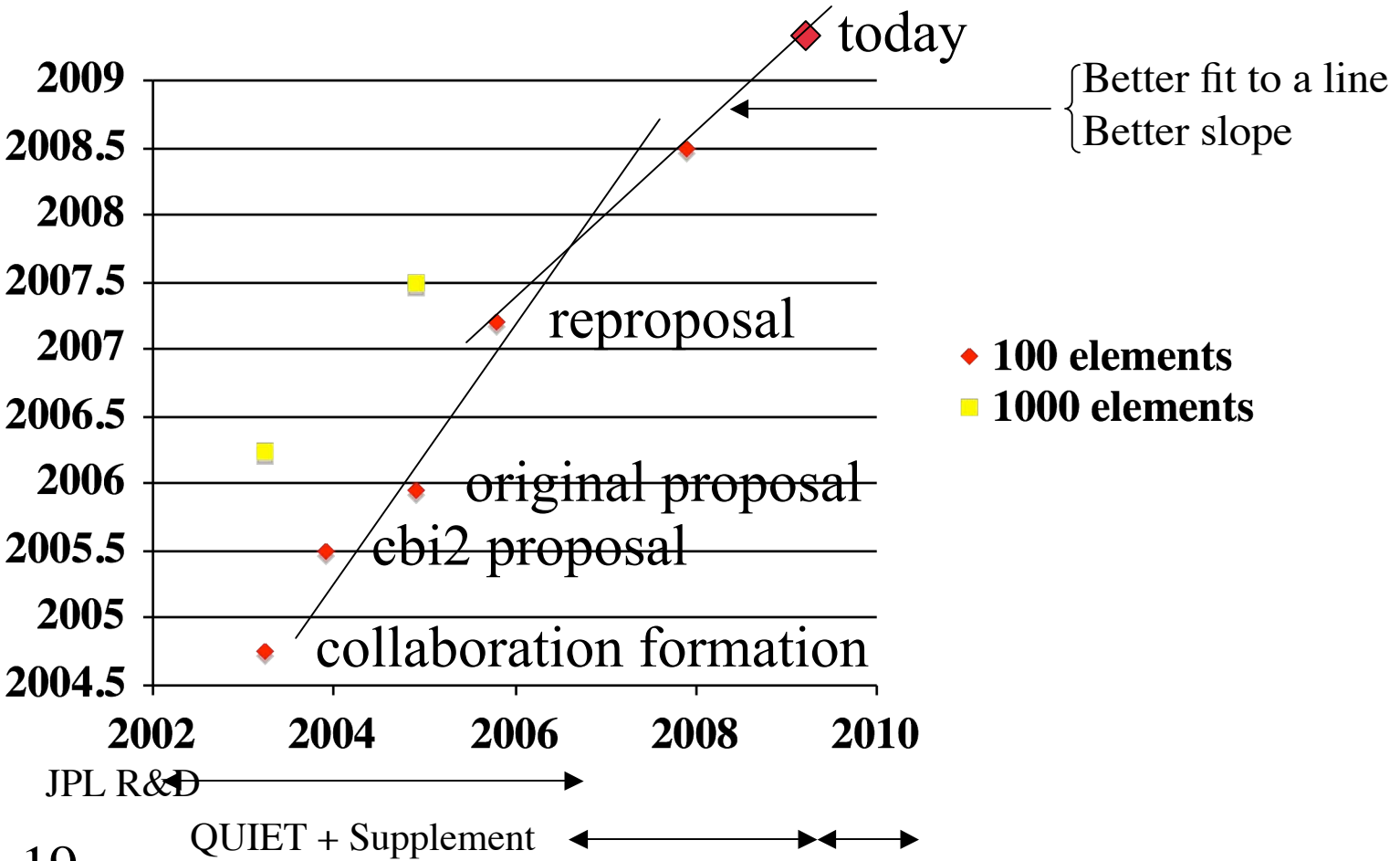
Tim Thurston

QUIET: phase II forecasts (90 GHz alone)



What We've Said about Schedules vs Time

(Dec 2007)



19

~~15~~ man years towards understanding modules from students and postdocs outside CIT/JPL

Plan to Achieve This Goal

- This technology is clearly worth pursuing
- QUIET Phase II would use perhaps 1500 Modules
  - Need to improve performance: T_{rec} ~ 50 K (10Q.L.)
    - Otherwise can't compete with Bolometers
  - Need a plan to produce them more rapidly (18 months)
    - Last 64 Phase I modules came at 10/month
    - FNAL is interested here as are other groups within QUIET
  - Proposal needs to be submitted in August
    - Production of new modules: 3/10 - 3/11
  - L/R OMT leakages need improvement
- Upgrades to T_{rec} ~ 3Q.L. will make for a long-lived, productive program

THE END