Receiver and Array Workshop

Bonn 19-20 September 2010

Tony Readhead:

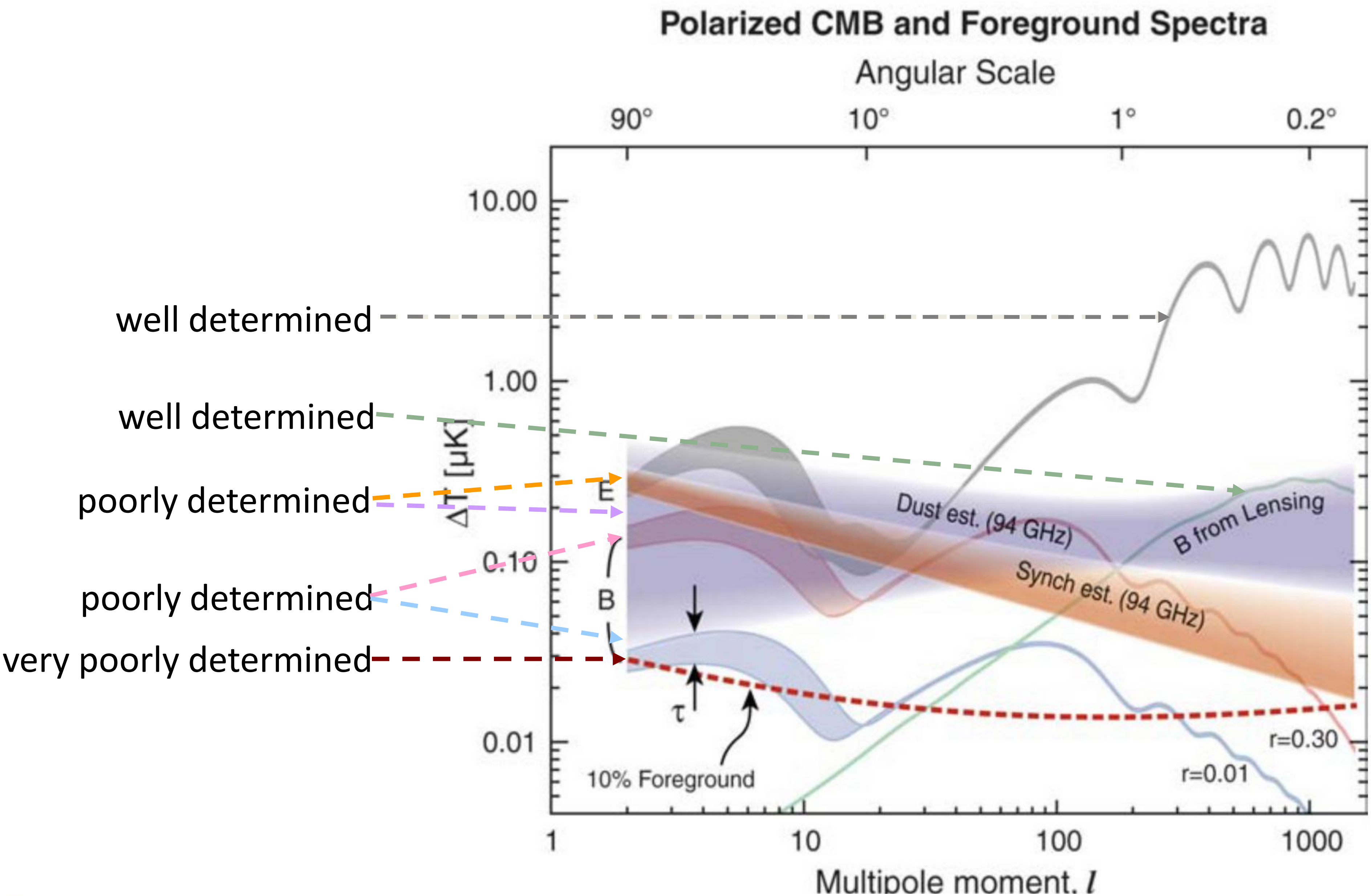
Summary of two Keck Institute Workshops:

September 2008 & March 2009

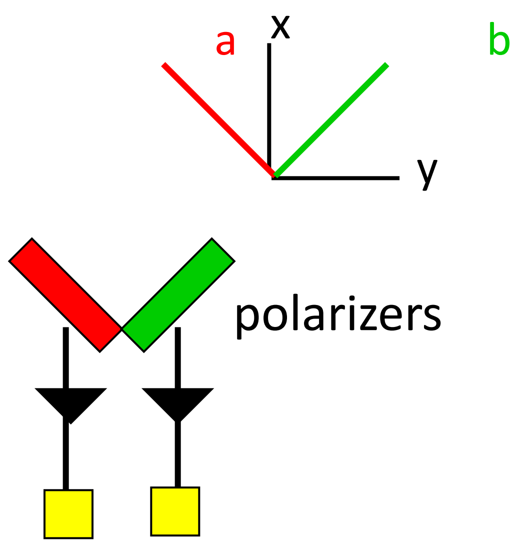
Caltech

Keck INSTITUTE FOR SPACE STUDIES

JPL


well determined
well determined
poorly determined
poorly determined
very poorly determined
Polarized CMB and Foreground Spectra
Angular Scale
90°
10°
1°
0.2°
10.00
1.00
0.10
0.01
ΔT [μK]
E
B
τ
Dust est. (94 GHz)
Synch est. (94 GHz)
B from Lensing
r=0.30
r=0.01
10% Foreground
1
10
100
1000
Multipole moment, l

Advantages of MMIC Arrays over Bolometer Arrays:

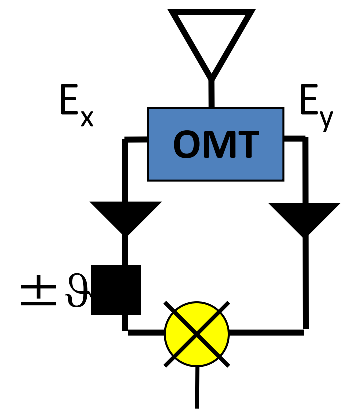


$G_a E_a^2$ $G_b E_b^2$

Differencing Bolometers

$E_x \sim E_a + E_b$

$E_y \sim E_a - E_b$



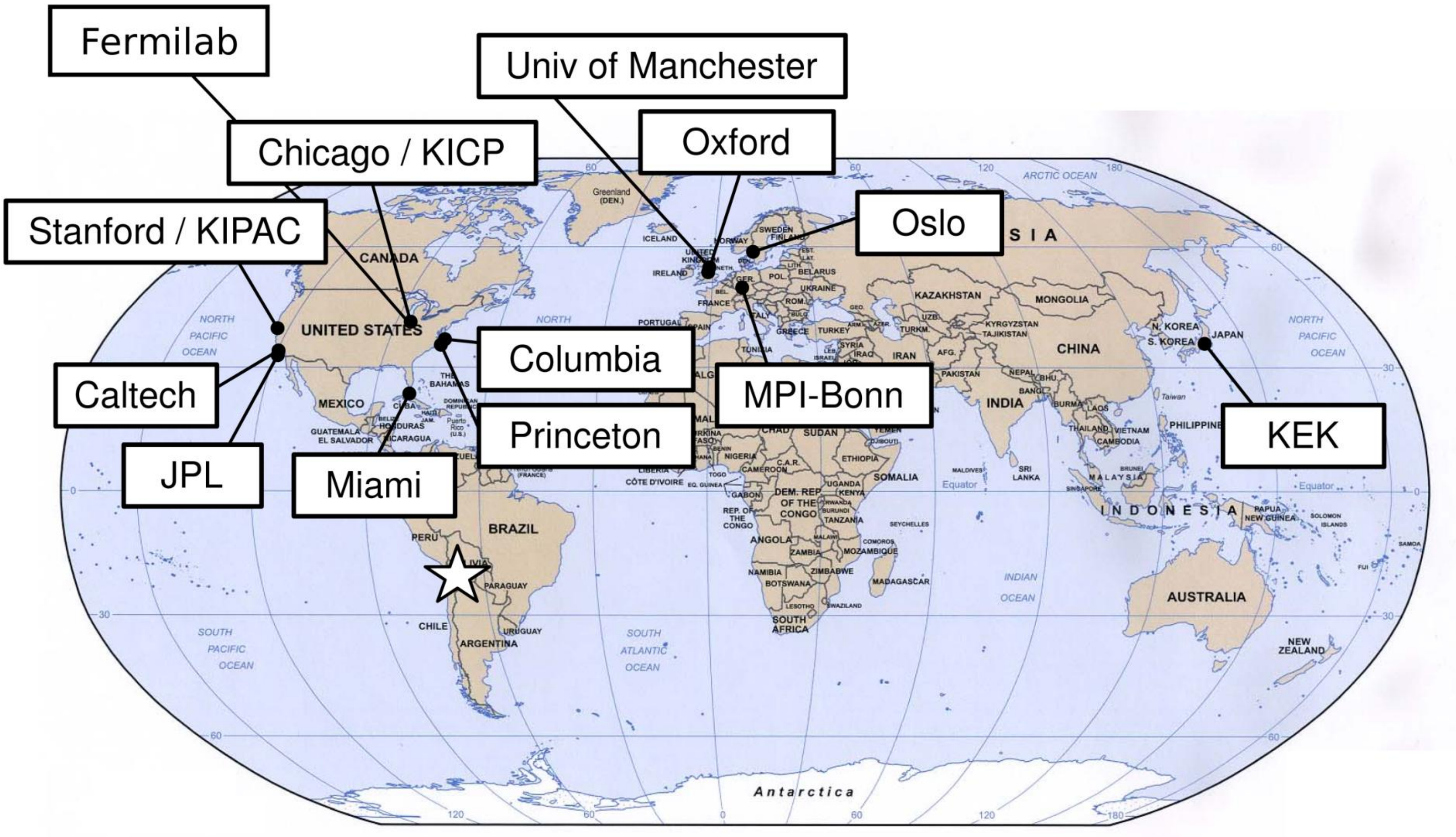
$G_x G_y (E_x E_y) \sim G_x G_y (E_a^2 - E_b^2)$

Correlation Polarimetry

1) Can use the correlation receivers, phase switching, etc., to subtract off large systematic offsets
2) Interferometry
3) Spectroscopy
4) Can operate at 20K *vs.* 300 mK

Disadvantage: 1) Sensitivity - but if we can achieve ~ quantum MMICs compare well
2) Power - but Sb-based devices require half the power of InP devices

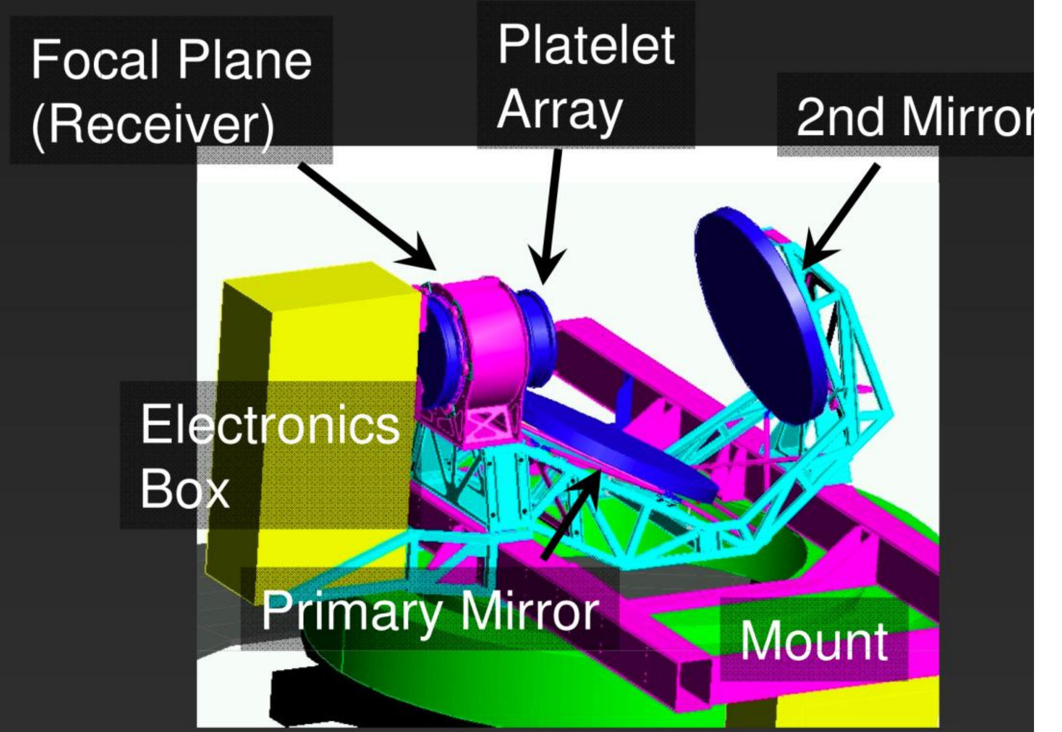
The QUIET Collaboration

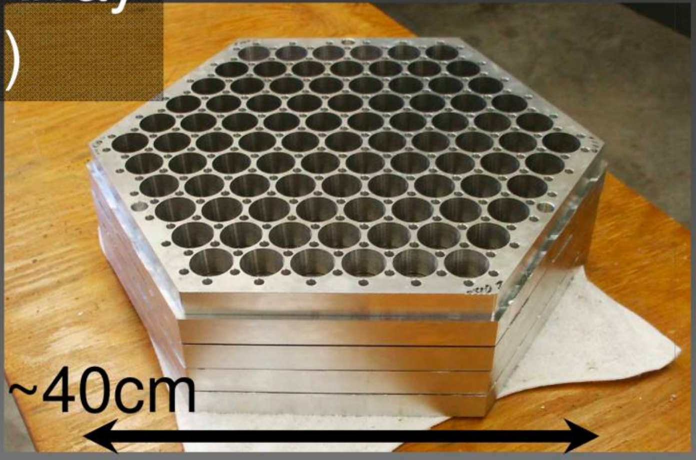


PI: Bruce Winstein, Chicago

Telescope

- 1.4m primary mirror
- Resolution in FWHM:
  - 13 arcmin (W-band)
  - 28 arcmin (Q-band)
- Inherit CBI mount

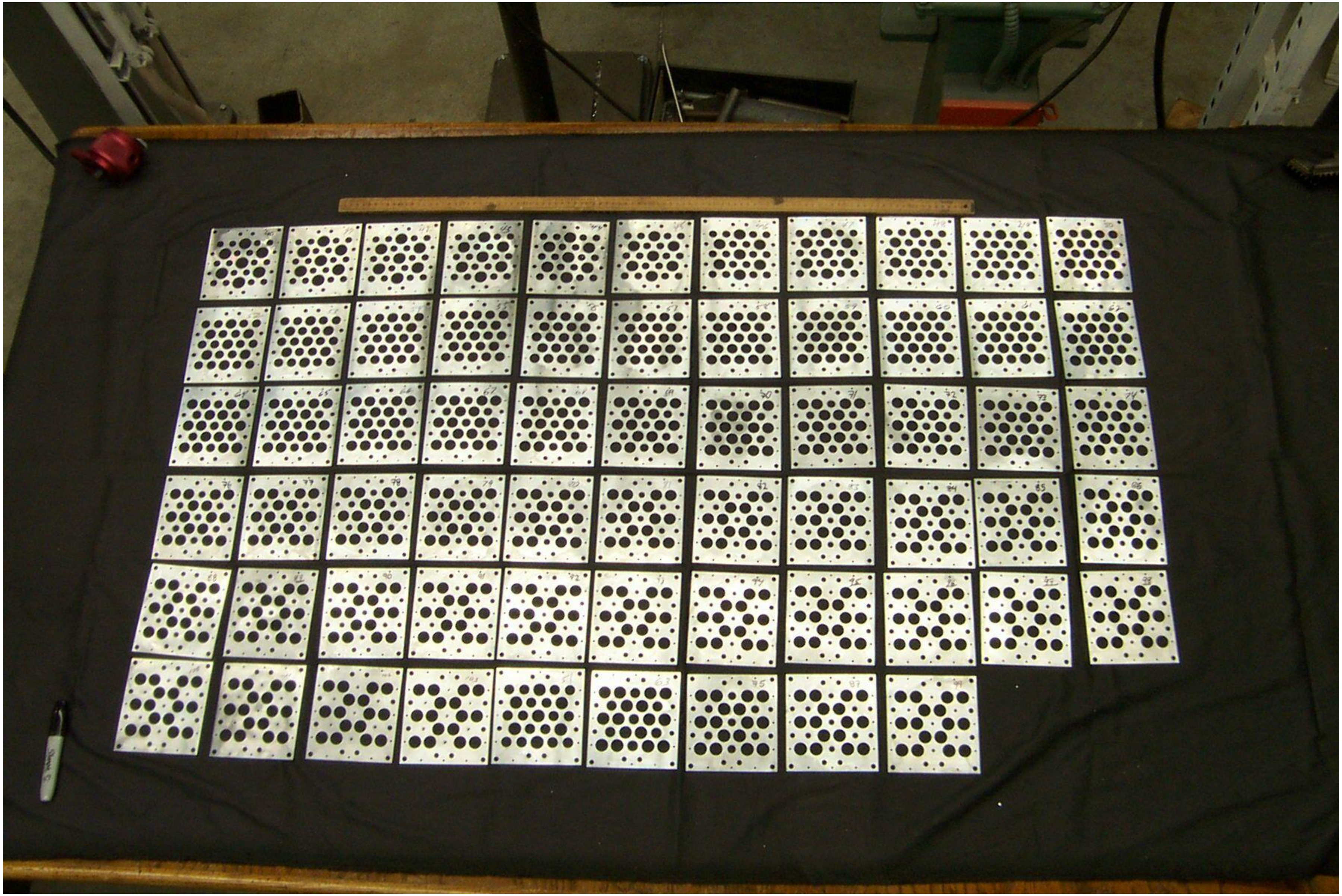




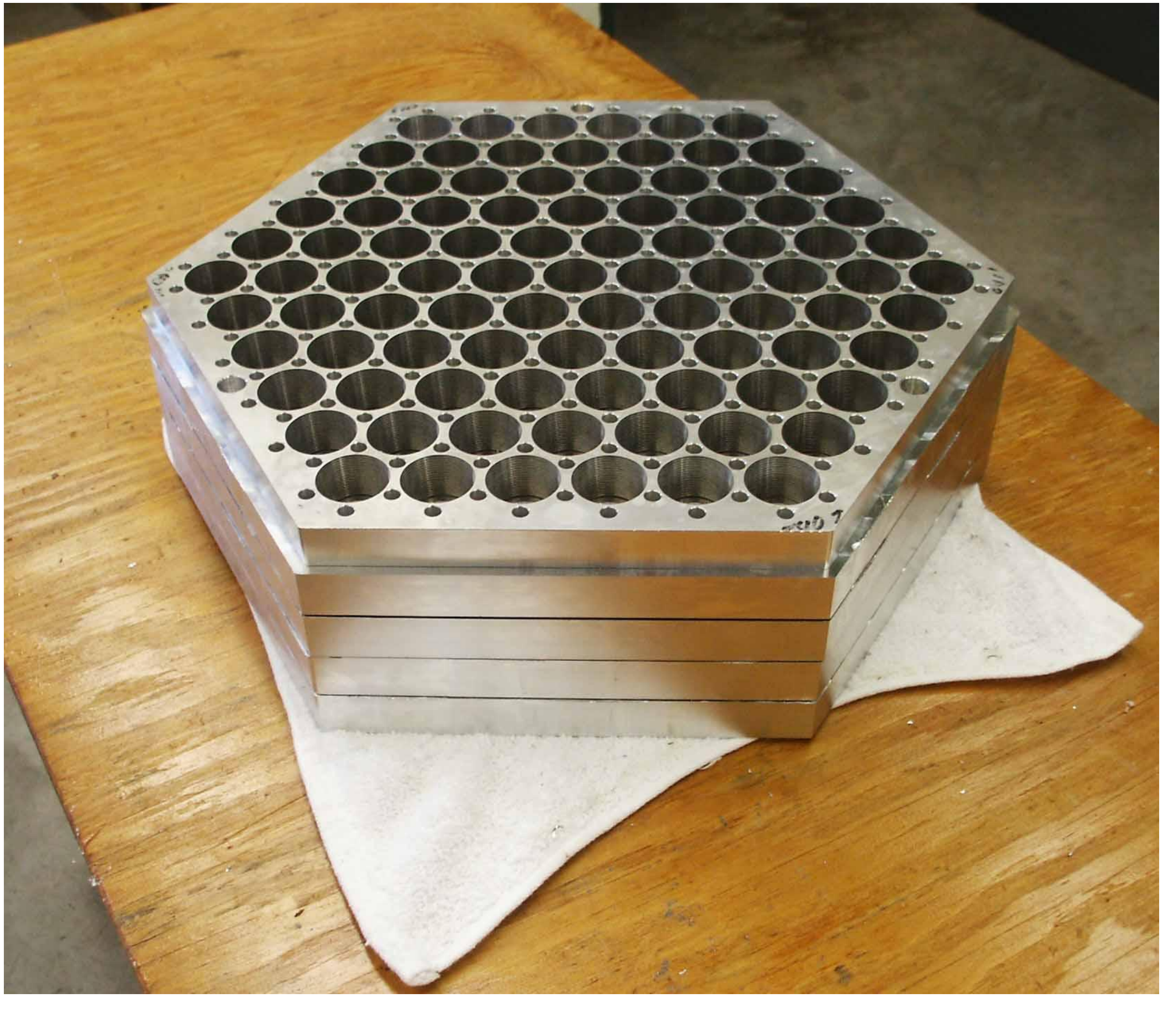
Platelet Array
(W-band)

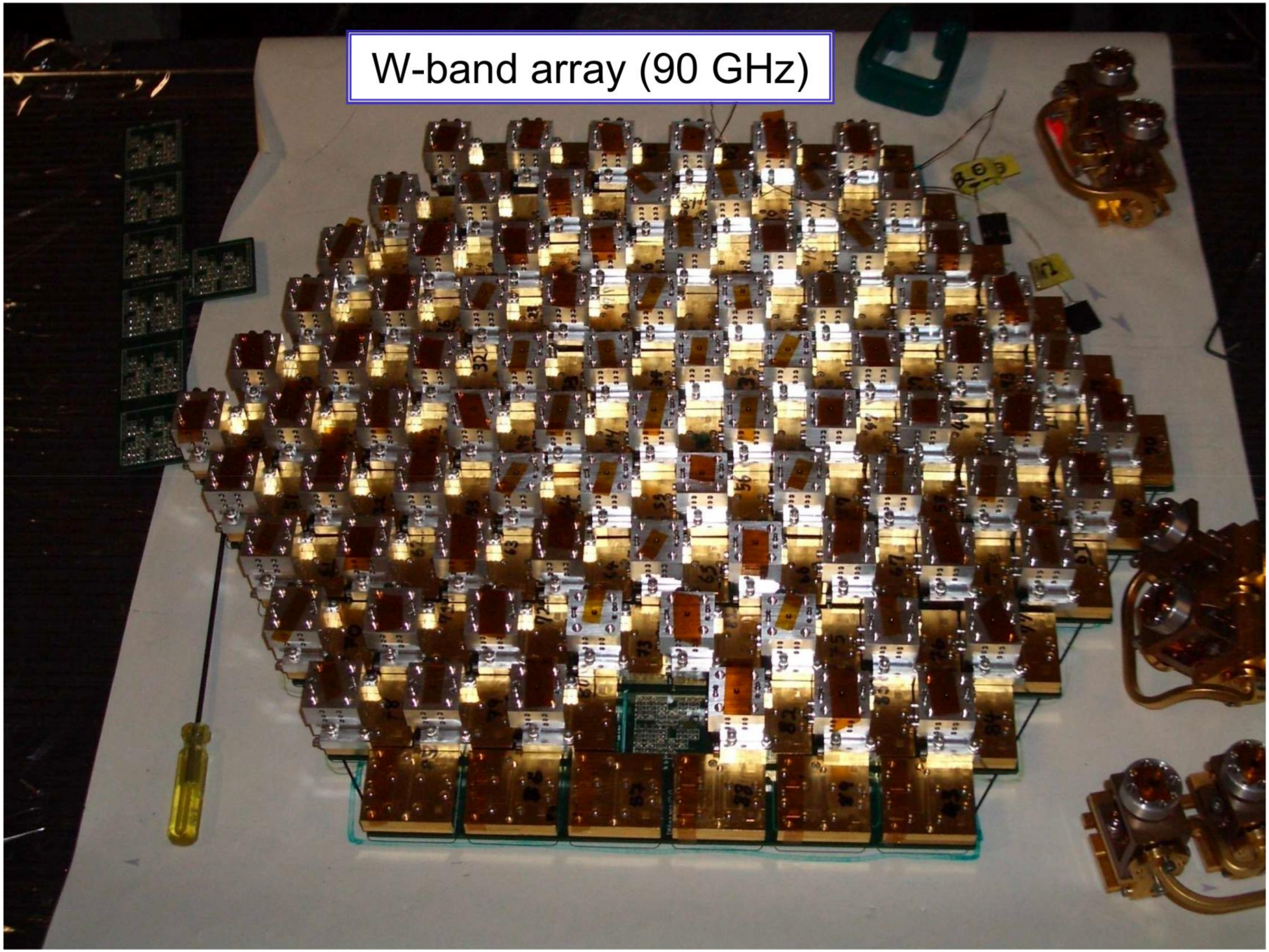
Mirrors & Support Structure

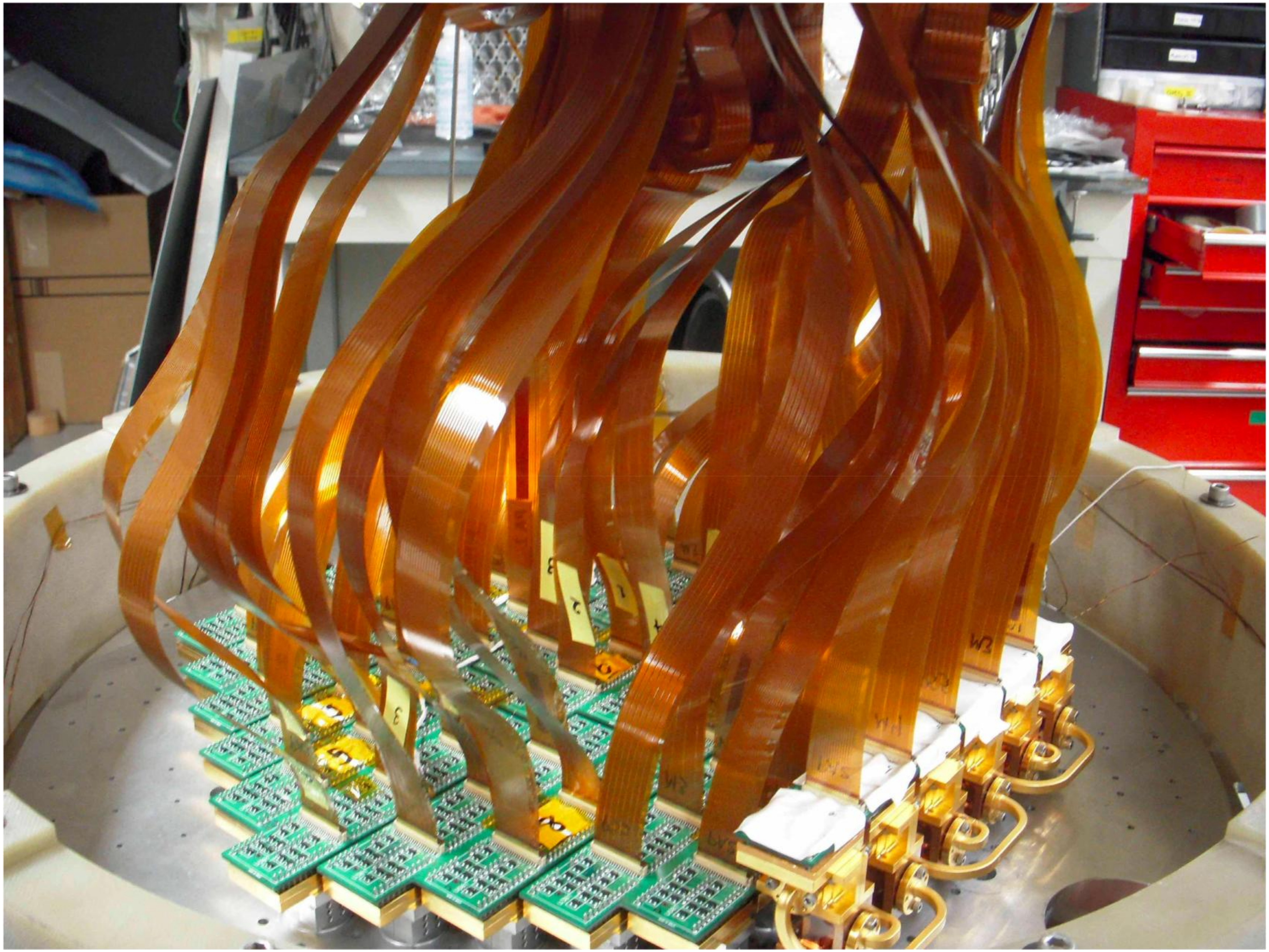
Q-Band Observations Oct ‘08 – June ‘09



91 Element W-band Array

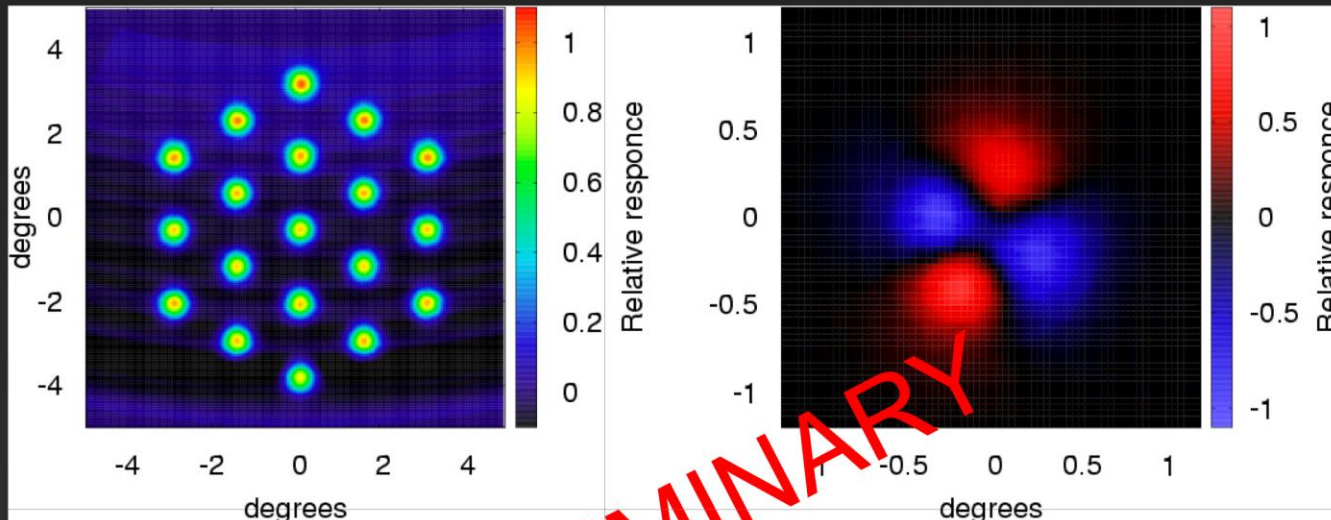



W-band array (90 GHz)

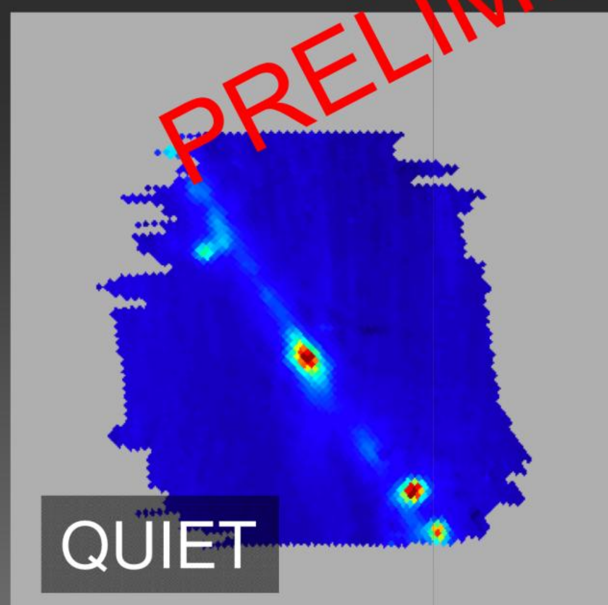


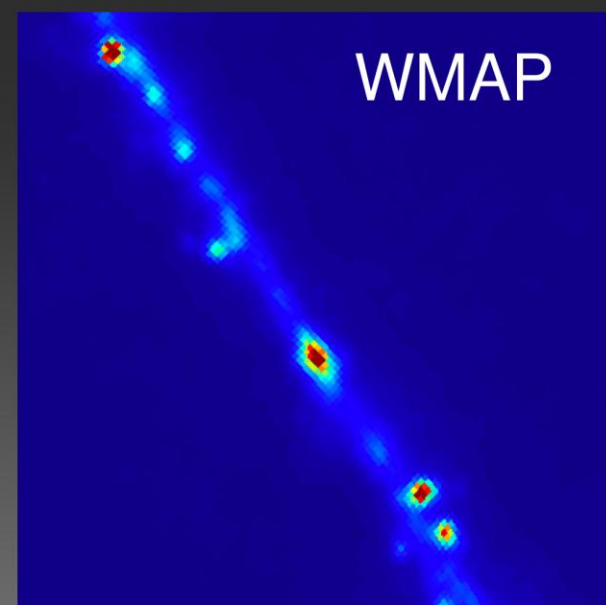
Preliminary Data

Moon



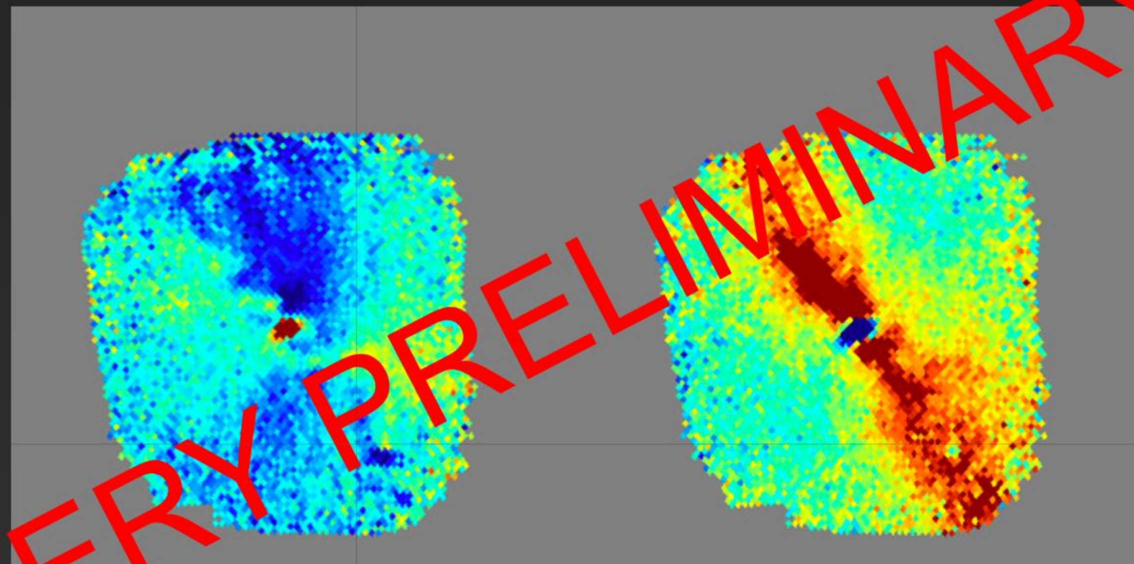
Galaxy
(TT, <100 hrs)



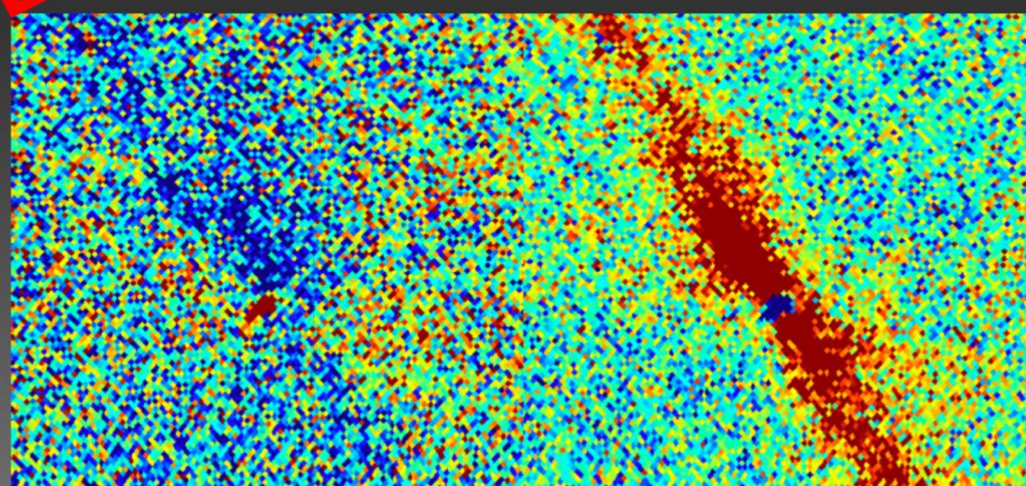


Preliminary Data (Cont'd)

Galaxy
(Pol., <100 hrs)
sytematic efects
not considered yet

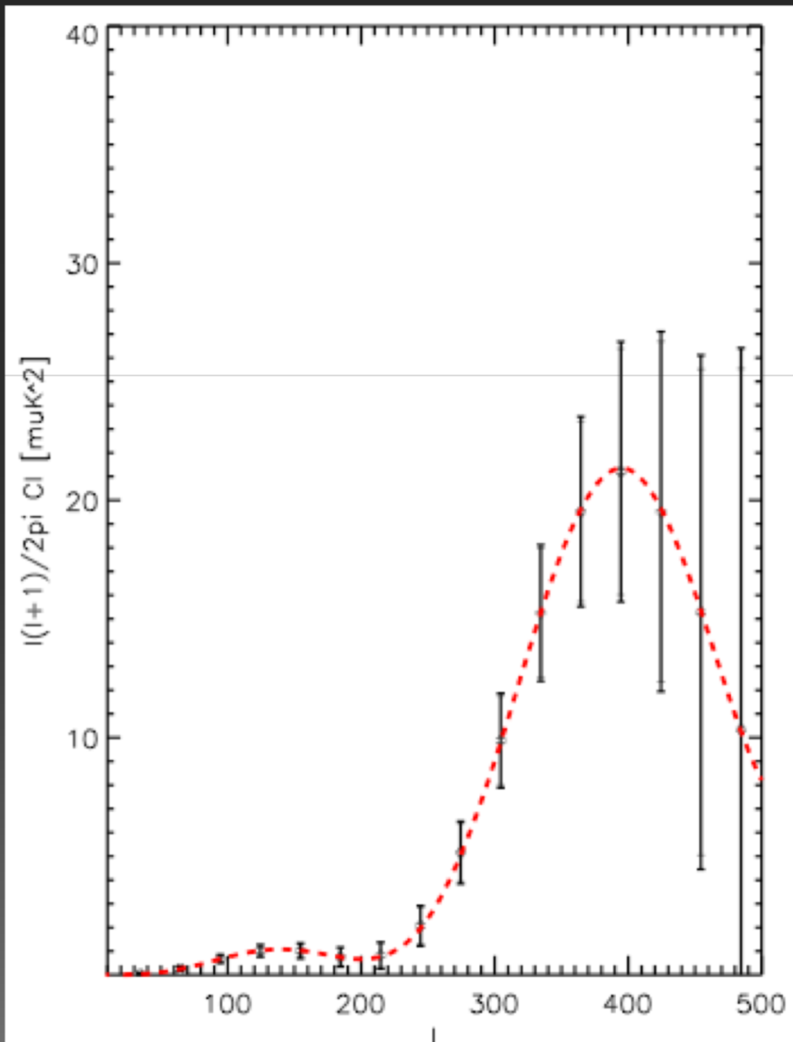


WMAP

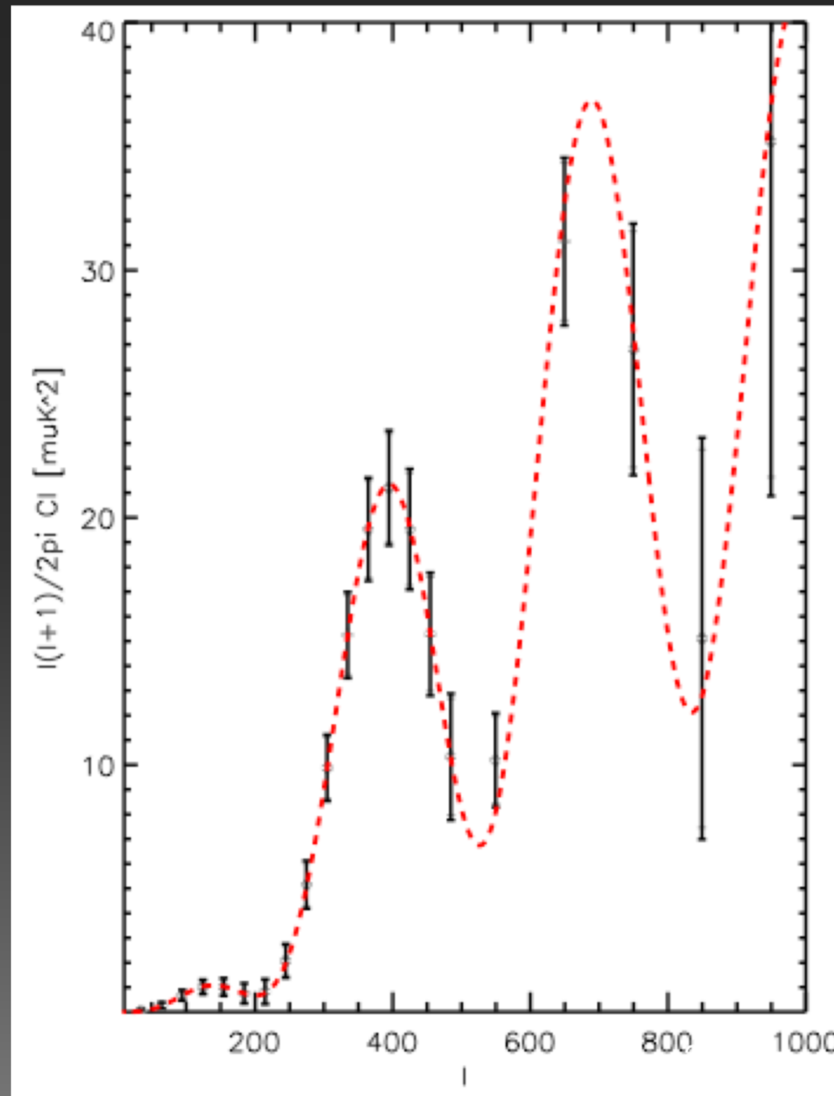


Phase-I E-mode Power-Spectra Forecasts

Q-band
(already collected)



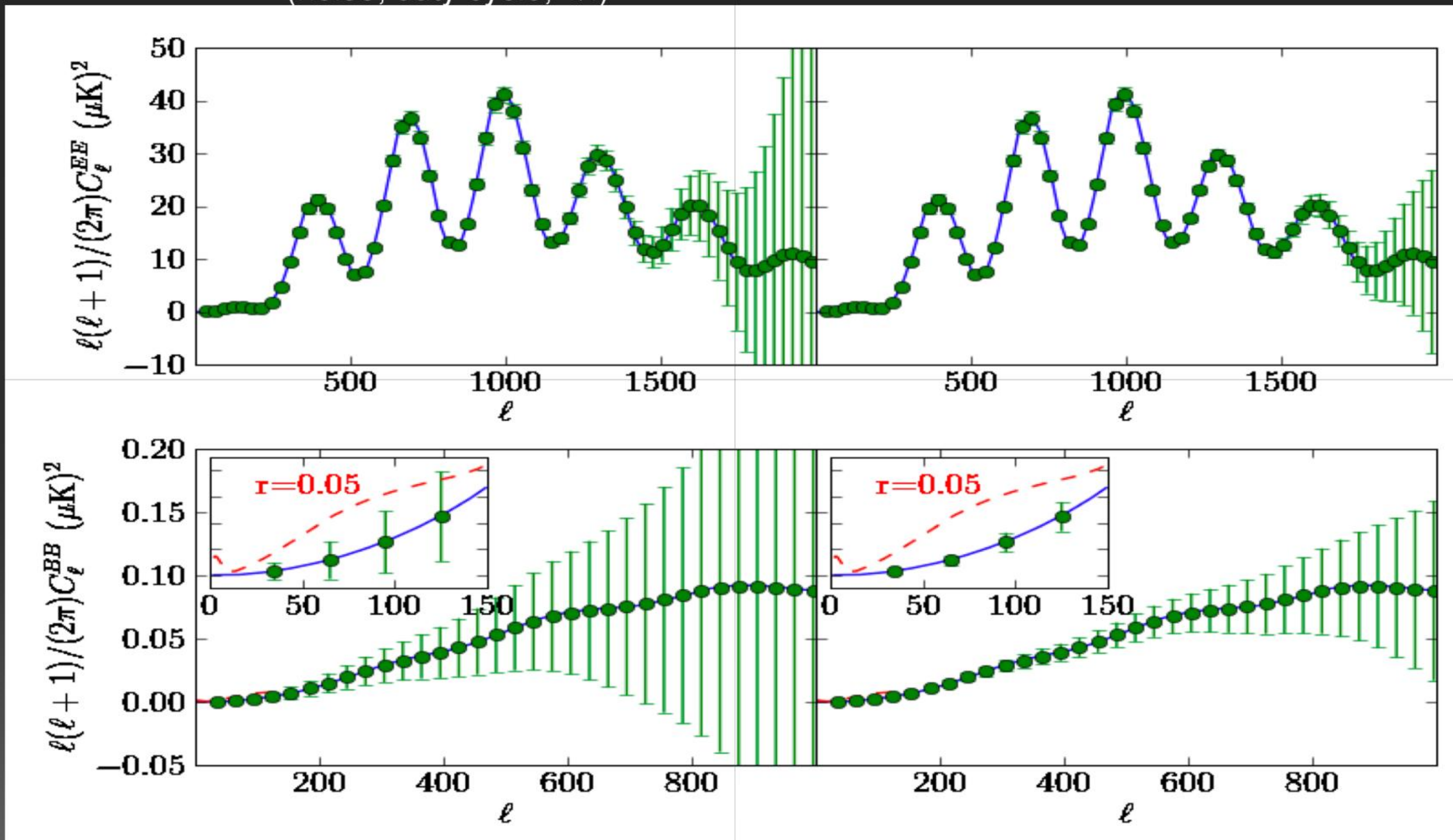
W-band
(expected)



QUIET Phase-II (1600 pixels)

Current Performance
(noise, duty cycle, 1/f)

Likely Improvements



No foreground assumed

0.018	Δr	0.005
10σ	lensing	35σ

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Keck Institute for Space Studies

Coherent Instrumentation
for
Cosmic Microwave Background Observations

Coherent Receiver Arrays for Astronomy and Remote Sensing

Report of a Study Program

Keck Institute for Space Studies
California Institute of Technology
Jet Propulsion Laboratory

Key finding of Report:

MMIC and MMIC Array development aimed at

< 3x quantum noise up to 150 GHz
incorporated in modules without loss of performance

=> Proposal for

Cahill Radio Astronomy Laboratory (CRAL)

Coherent Receiver Arrays for Astronomy and Remote Sensing

Proposal for Technology Development Support for the Large Study Program: Coherent Instrumentation for Cosmic Microwave Background Observations

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Keck Institute for Space Studies
California Institute of Technology
Jet Propulsion Laboratory

Cahill Radio Astronomy Laboratory (CRAL)

Gaier, Readhead, Weinreb

Kangaslahti, Samoska (JPL)

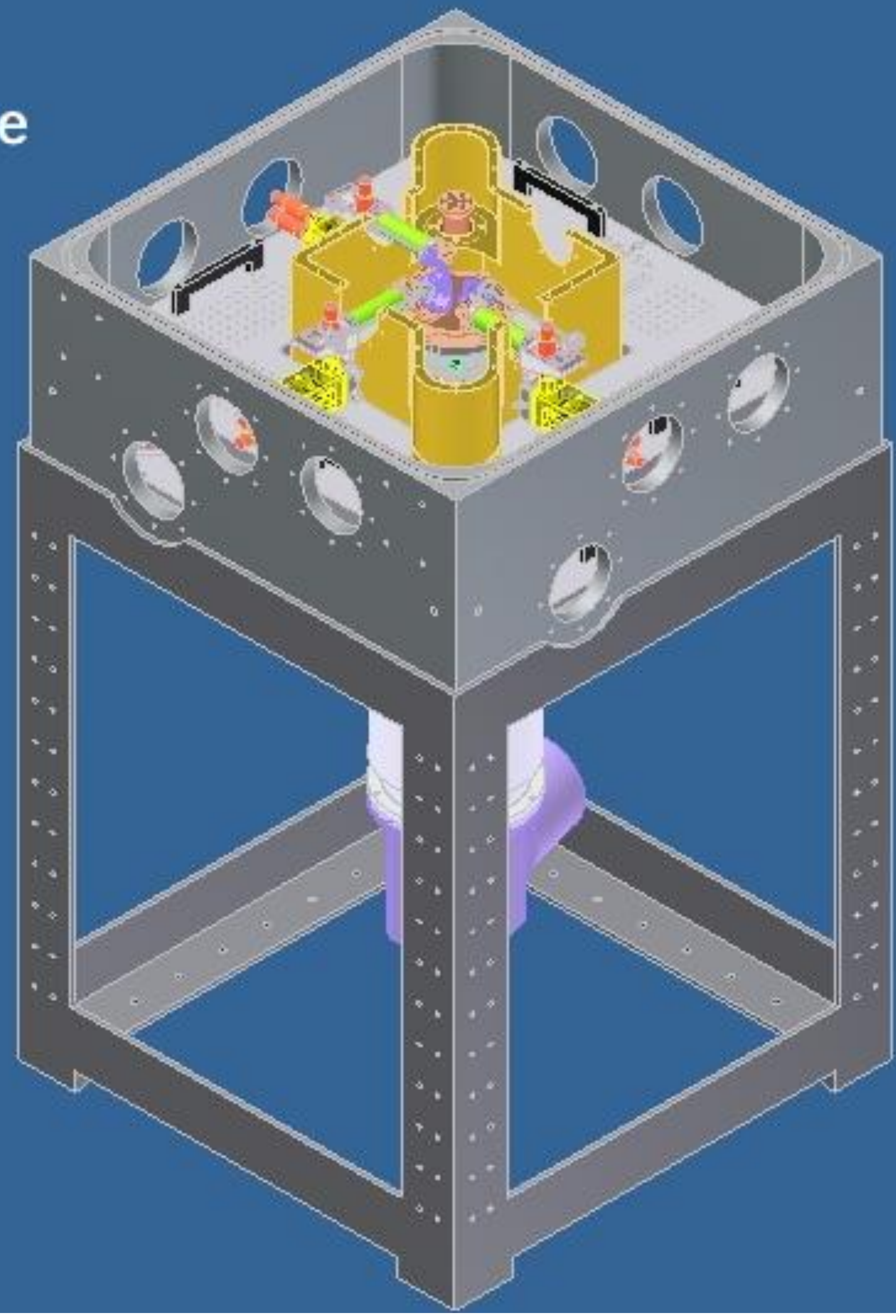
Kieran Cleary (SRF) – in charge of RF lab
Glenn Jones (Jansky Fellow) – in charge of digital lab

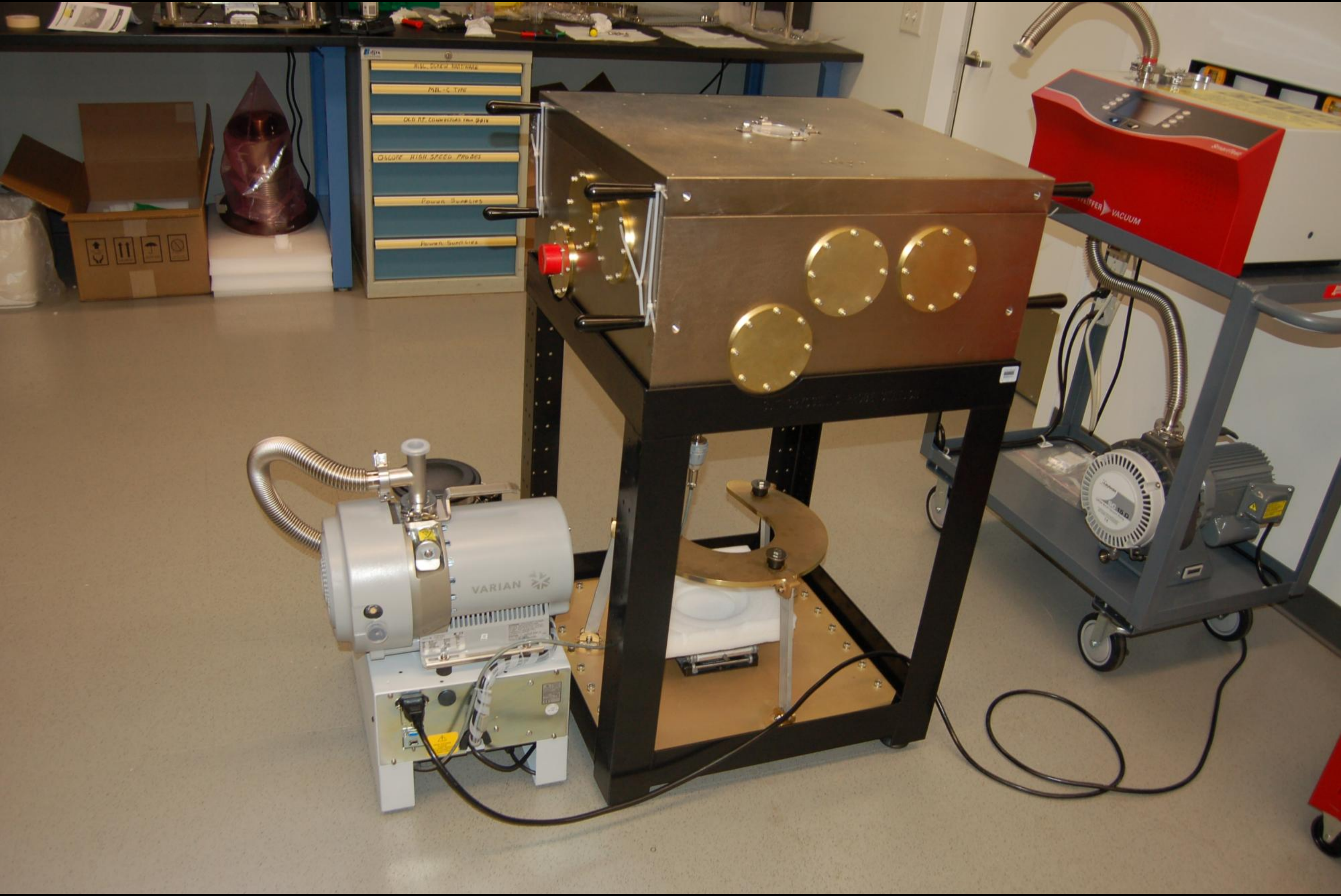
Oliver King (KISS Fellow)
Rodrigo Reeves (Post-doc)

Grad students: Kunal Mooley, Joey Richards, Damon Russell,
Walter Max-Moerbeck, Matthew Stevenson

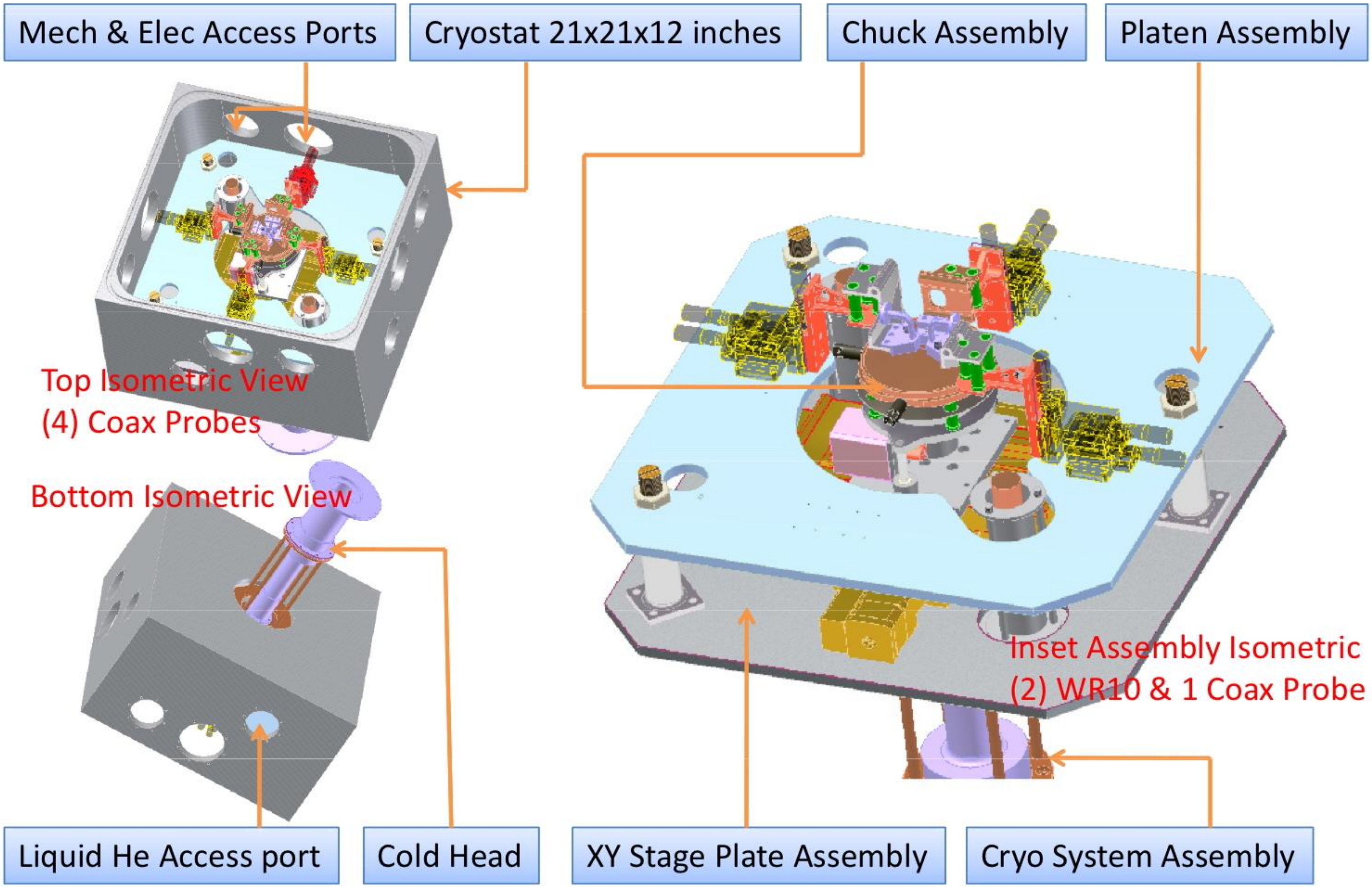
Undergraduate student: Kirit Karkare

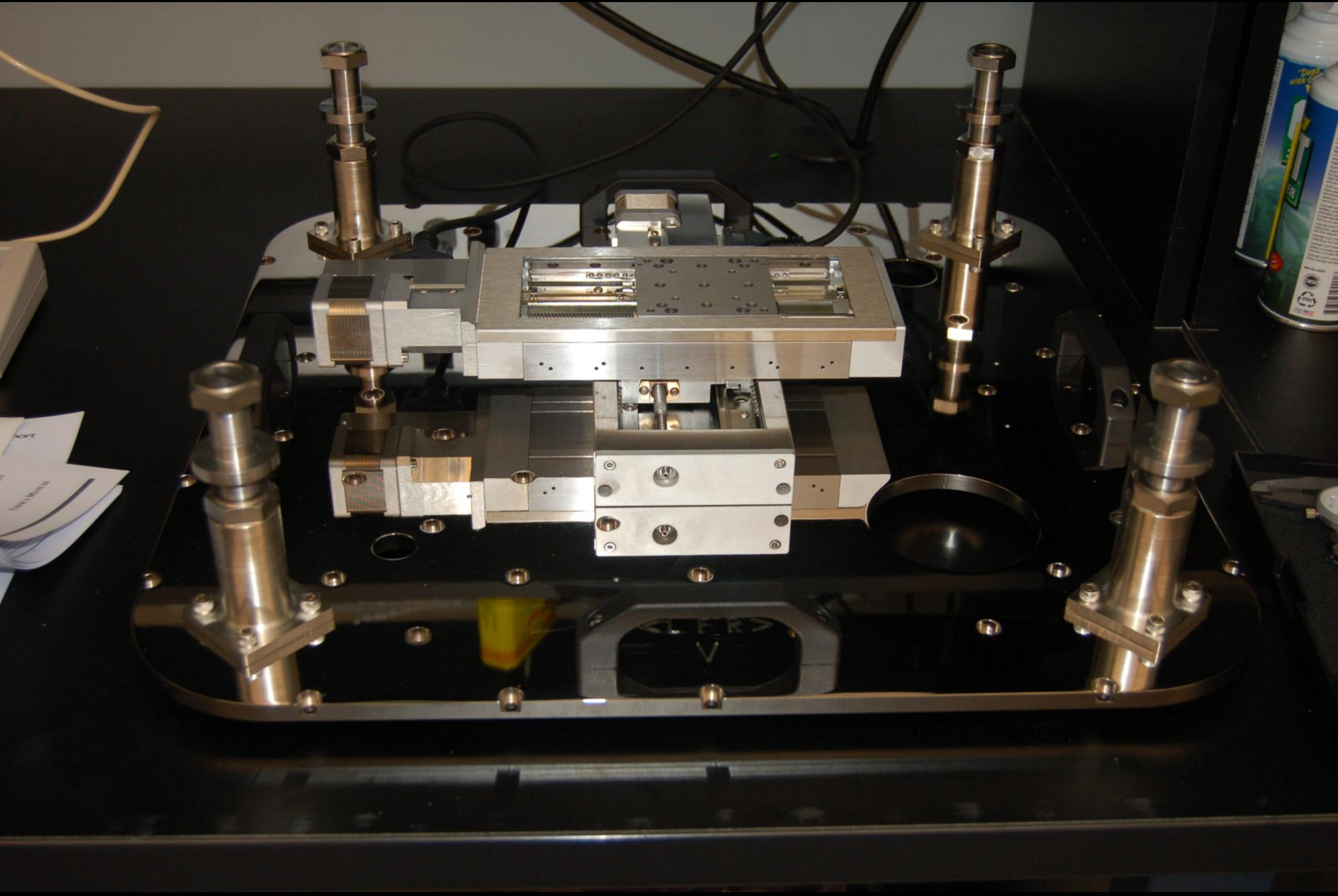
Caltech Cryogenic Probe Station




VARIAN

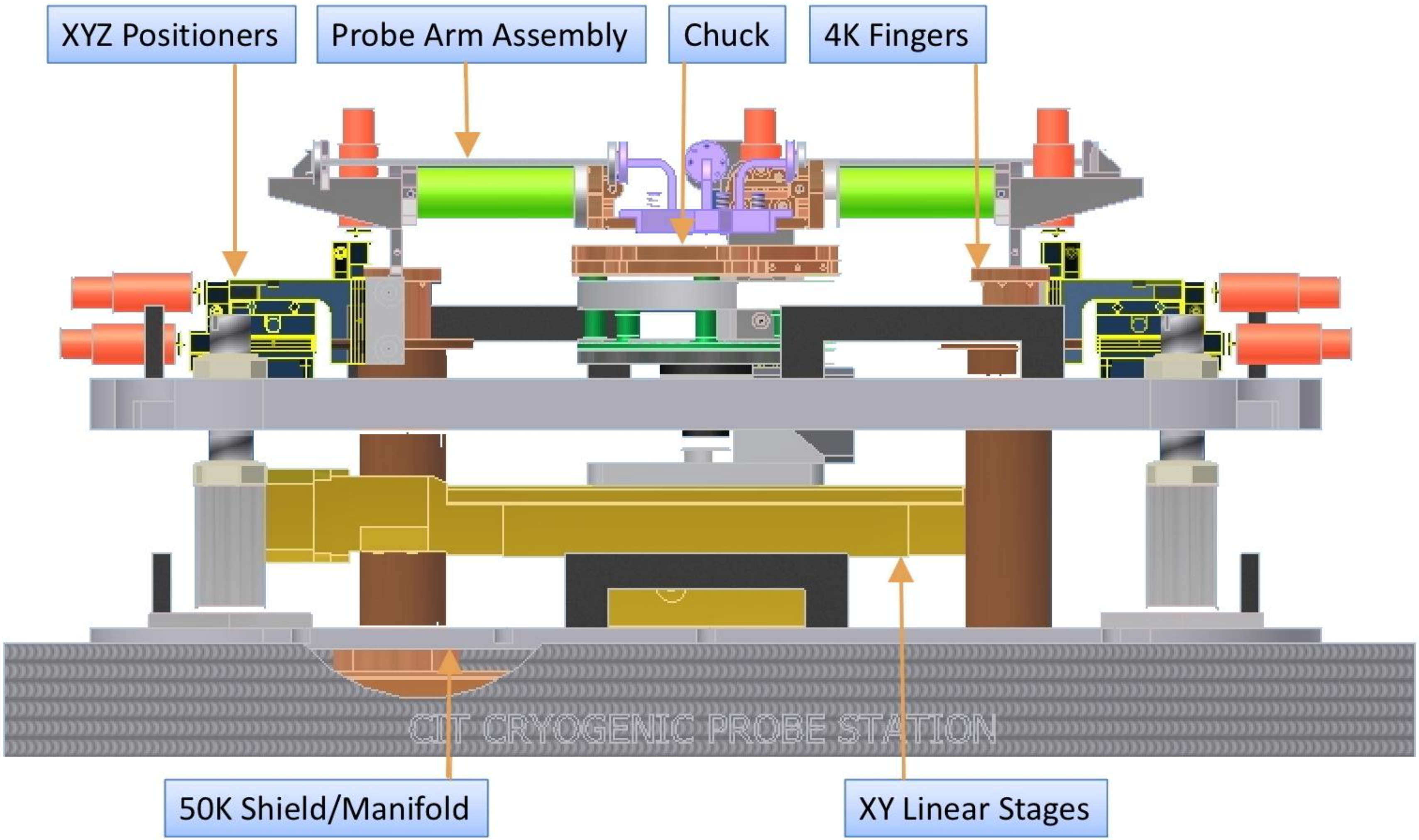
Overview


Mech & Elec Access Ports
Cryostat 21x21x12 inches
Chuck Assembly
Platen Assembly
Top Isometric View
(4) Coax Probes
Bottom Isometric View
Inset Assembly Isometric
(2) WR10 & 1 Coax Probe
Liquid He Access port
Cold Head
XY Stage Plate Assembly
Cryo System Assembly



Inset Assembly Side View

(WR10 Probes)



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ACR's Suggested Aims:

1) This HEMT-MMIC Community really needs to coordinate its efforts in order to get the support it needs to carry out technical developments the fields require (cf.bolometers). This needs the support of observatory directors, department heads, and groupd leaders.
2) We must have "transformational" science drivers and develop the case for these covering whole s[pectrum of science, cosmology, astrophysics, planetary science, remote sensing
3) We need multiple foundries to be developing these devices so that alternative approaches can be tested.
4) We must aim to get state-of-the-art "radio cameras" and spectrometers on key telescopes in the next five years (no later!).
5) We must convince the funding agencies (US, Europe, Japan, China, India, Australia, Canada) that this is a Key area for development

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