



# Arrays of Antenna-coupled Bolometers using Transition Edge Sensors

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LTD 10 – July 10, 2003



# Collaborators

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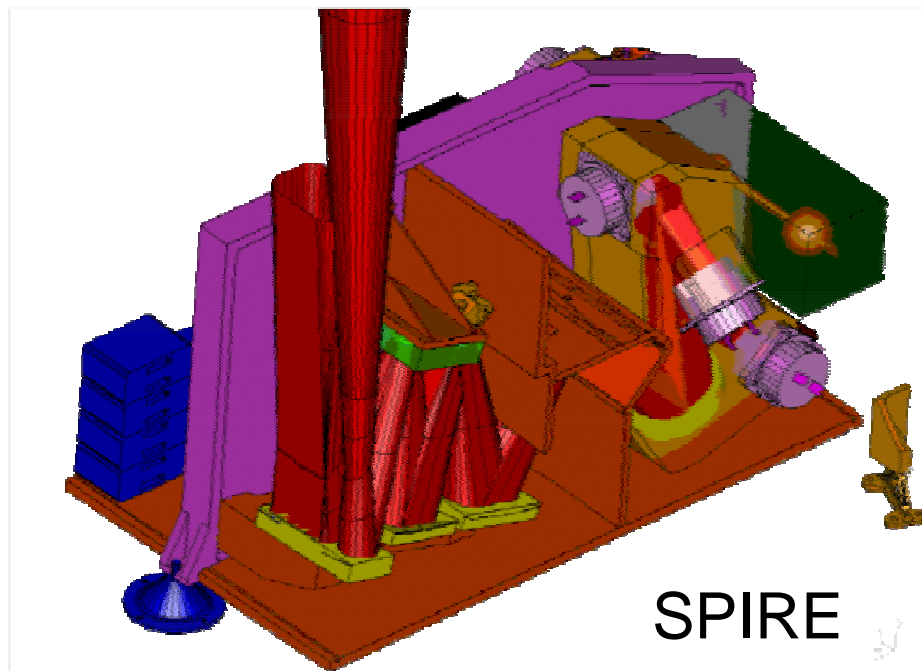
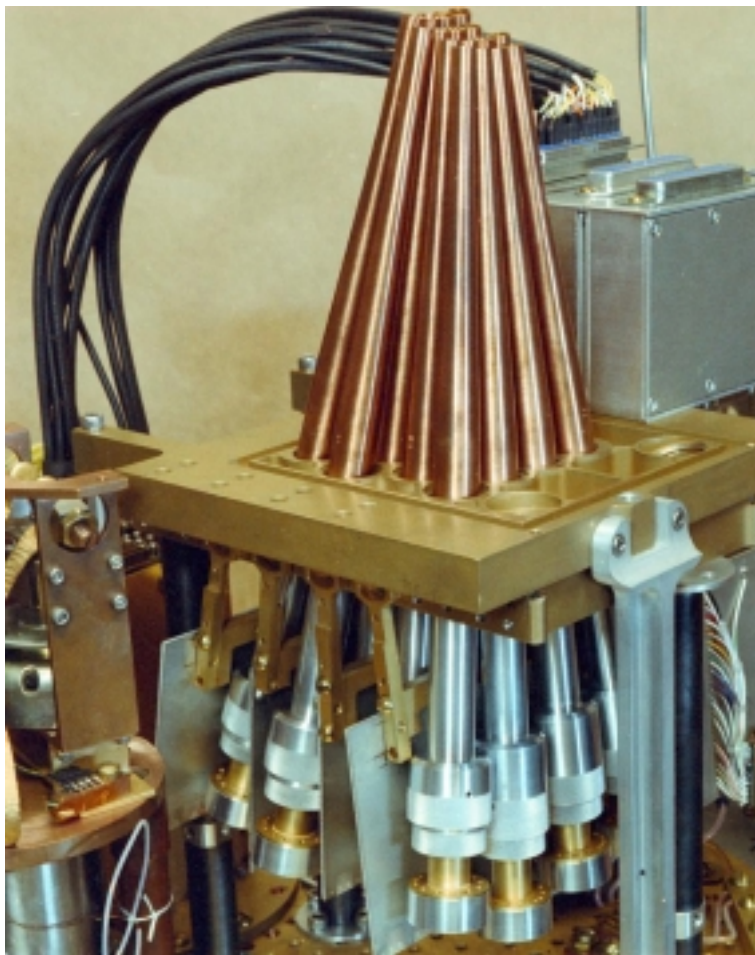
# Bolometer applications

- CMB anisotropy, polarization
- Sunyaev-Zel'dovich effect
- Galaxy/Star Formation

Bolometers are at/near photon noise limit in many applications

→ *Need large bolometer arrays!*

# Traditional designs



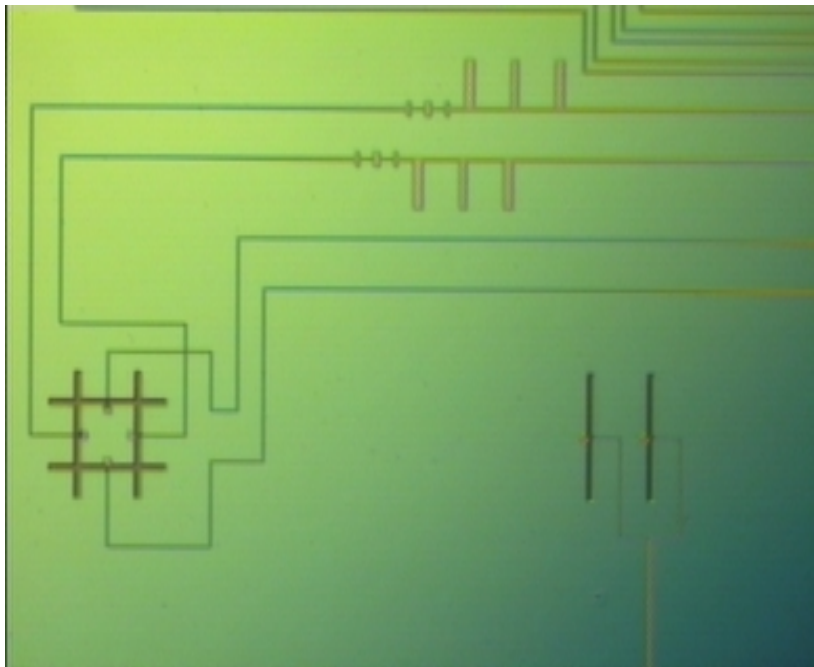
Maxima

# Antenna-coupled bolometers using transition edge sensors (TESs)



- Suited to large array construction
  - Highly integrated optical design
    - On-chip band-defining filters
    - Single substrate multichroic pixel
    - Planar antennas remove need for horns
    - Natural dual polarization operation
  - Standard microfabrication techniques used
  - Multiplexable SQUID readout

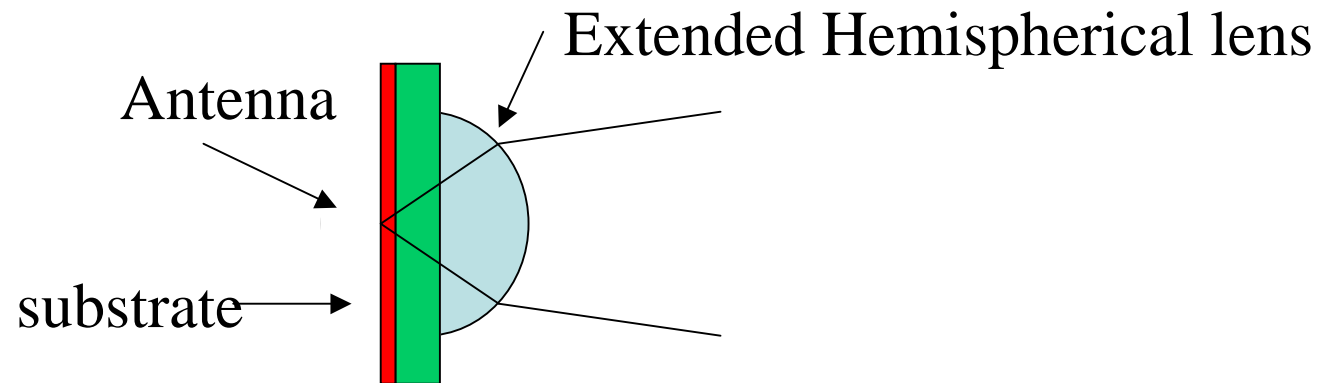
# Antenna-coupled Prototype Pixel



Dual pol. antenna on left (after Chattopadhyay and Zmuidzinas)

- Microstrip fed double slot dipole antenna on a Si extended hemispherical lens
- Bandpass filter at 217GHz, 40% BW
- Lowpass filter to remove spurious passbands
- Microstrip terminated on a nitride suspension, power measured with TES

# Planar Antenna with Dielectric Lens



- Well developed for e.g. SIS mixer work
  - High antenna gain
  - Forward radiation pattern
- Efficient coupling to telescope
  - 80-90% achieved: Similar to scalar horn

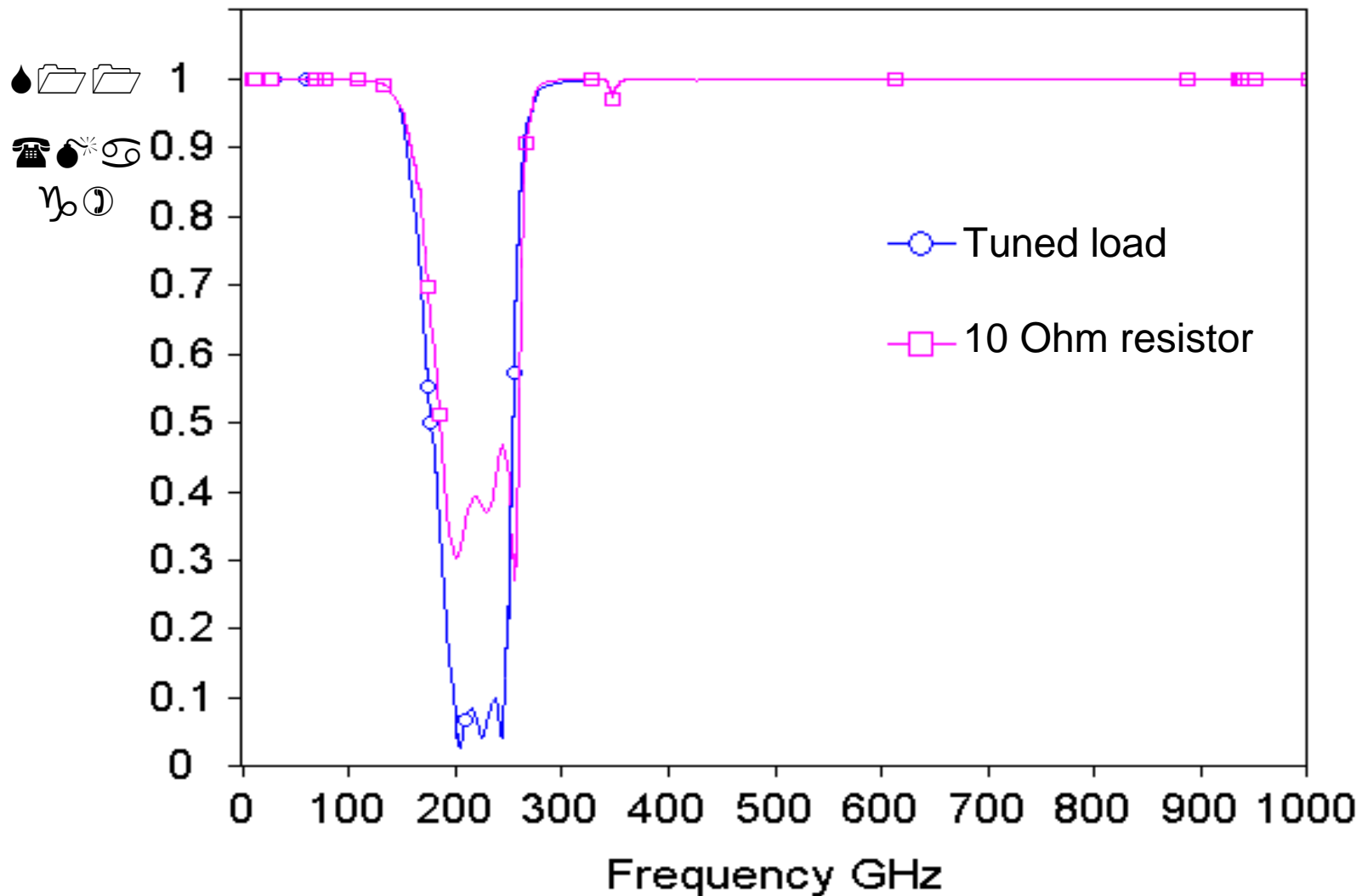


# Load resistor termination

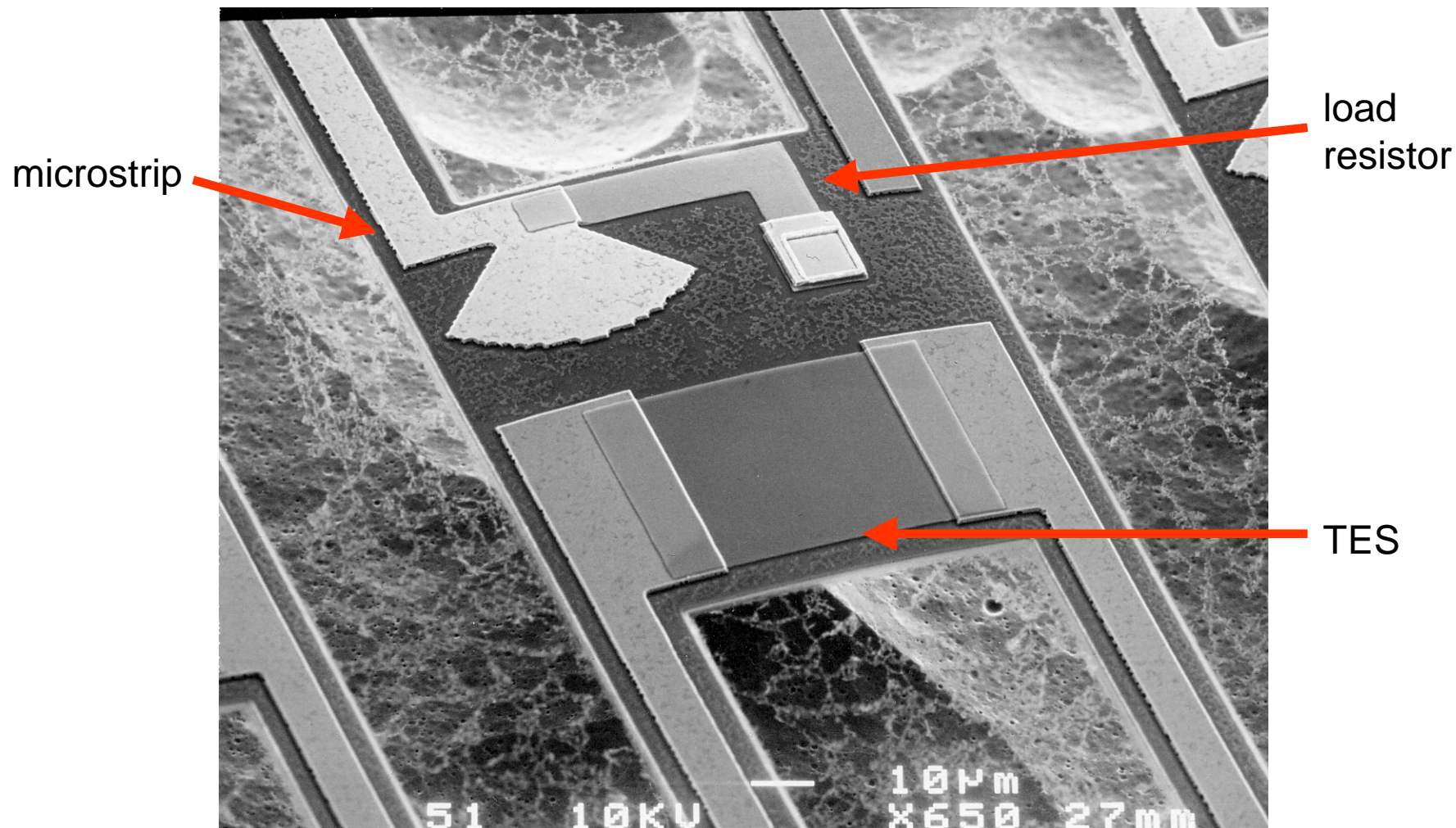
- Load resistor can have significant reactance at these frequencies
- Use a shunt capacitance to tune out the load reactance



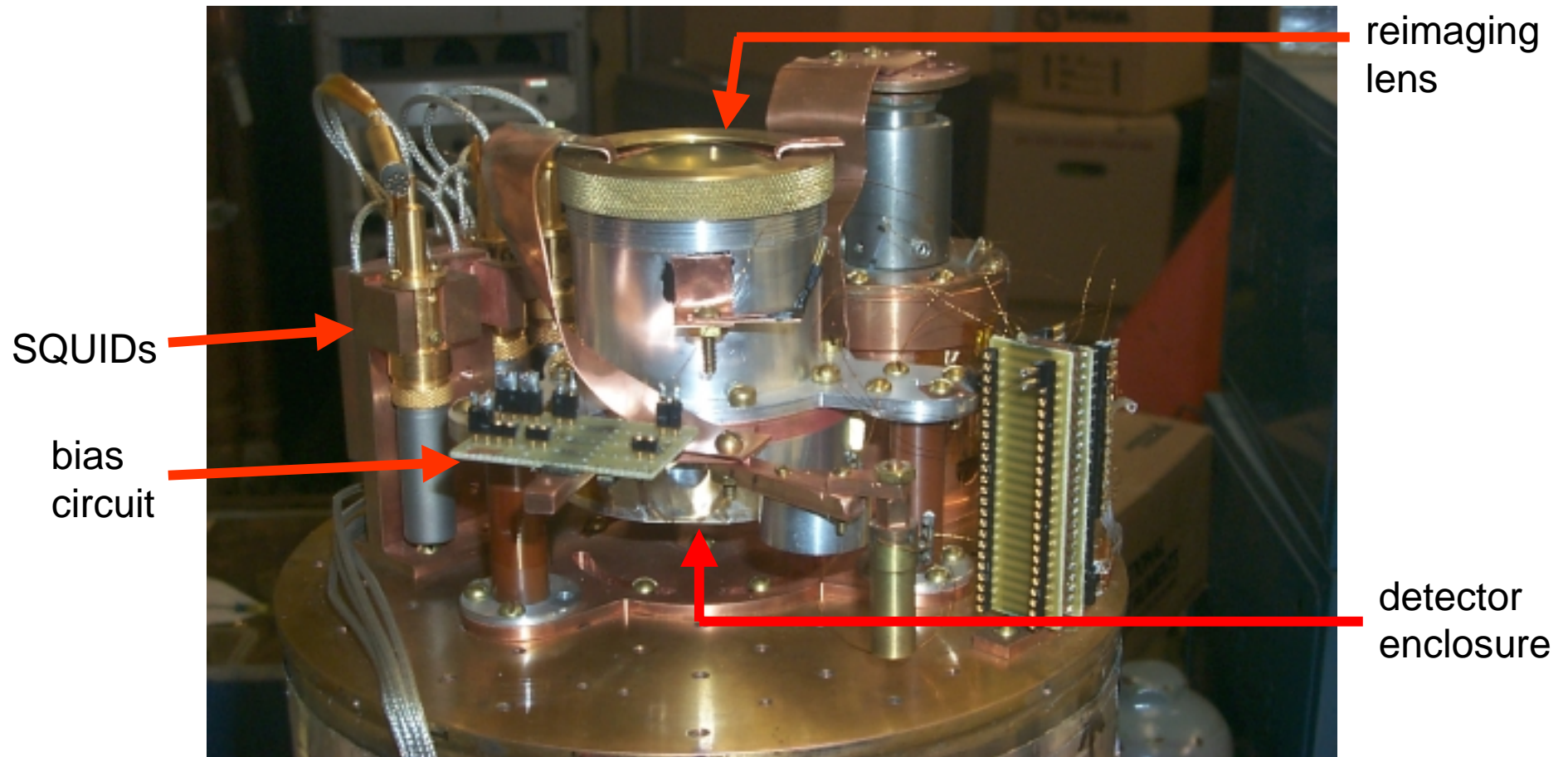
# Filter simulation with and without tuned load



# SEM of nitride suspension



# Optical test setup



Initial optical design: Denis Chouvaev, Chalmers

Mechanical design: Dan Schwan, UCB

# Antenna-coupled bolometer array design

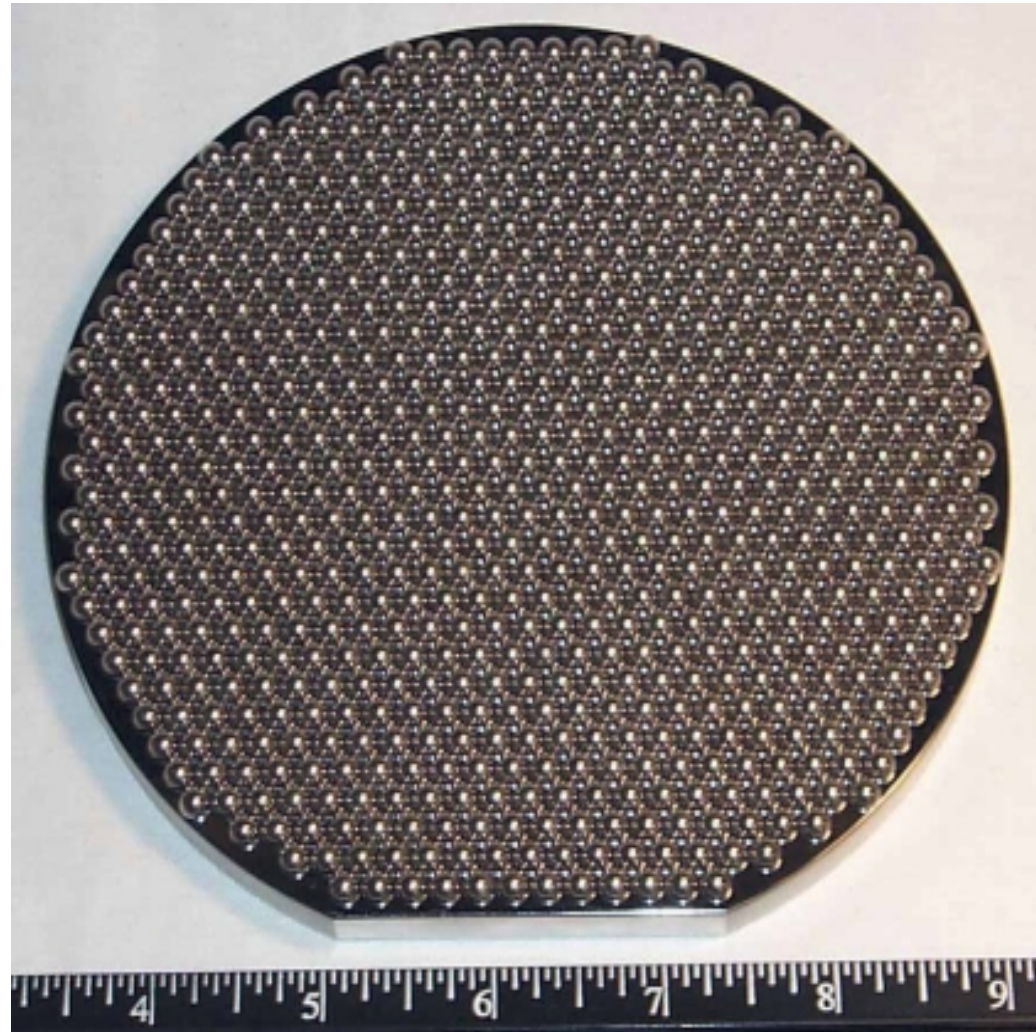


## Optical coupling

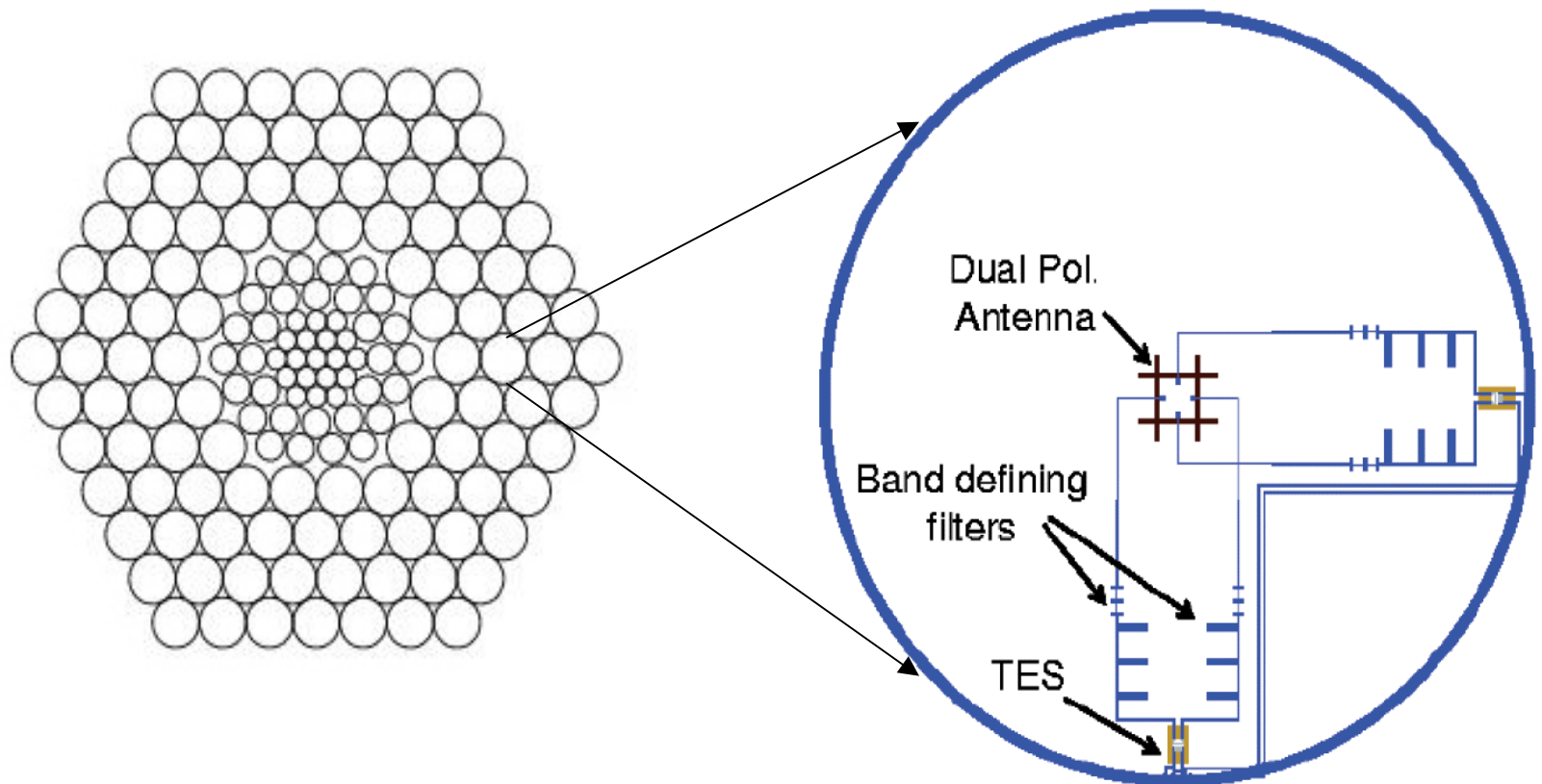
- “Fly’s Eye” lens array (after Buttgenbach)
- Single large dielectric lens (after Filipovic et al.)
- Reflector array (after Filipovic et al)
- Phased array of antennas



# “Fly’s Eye” Lens Array Mechanical Prototype



# POLARBEAR-I focalplane



- 150 pixels x 2 polarizations = 300 single-color bolometers
- 3 Frequency bands, 150, 250, and 350 GHz

# Conclusion

- Established working fabrication process, built prototype pixel
- Currently electrical testing, optical testing soon
- Array fabrication will commence when single pixel operation is verified