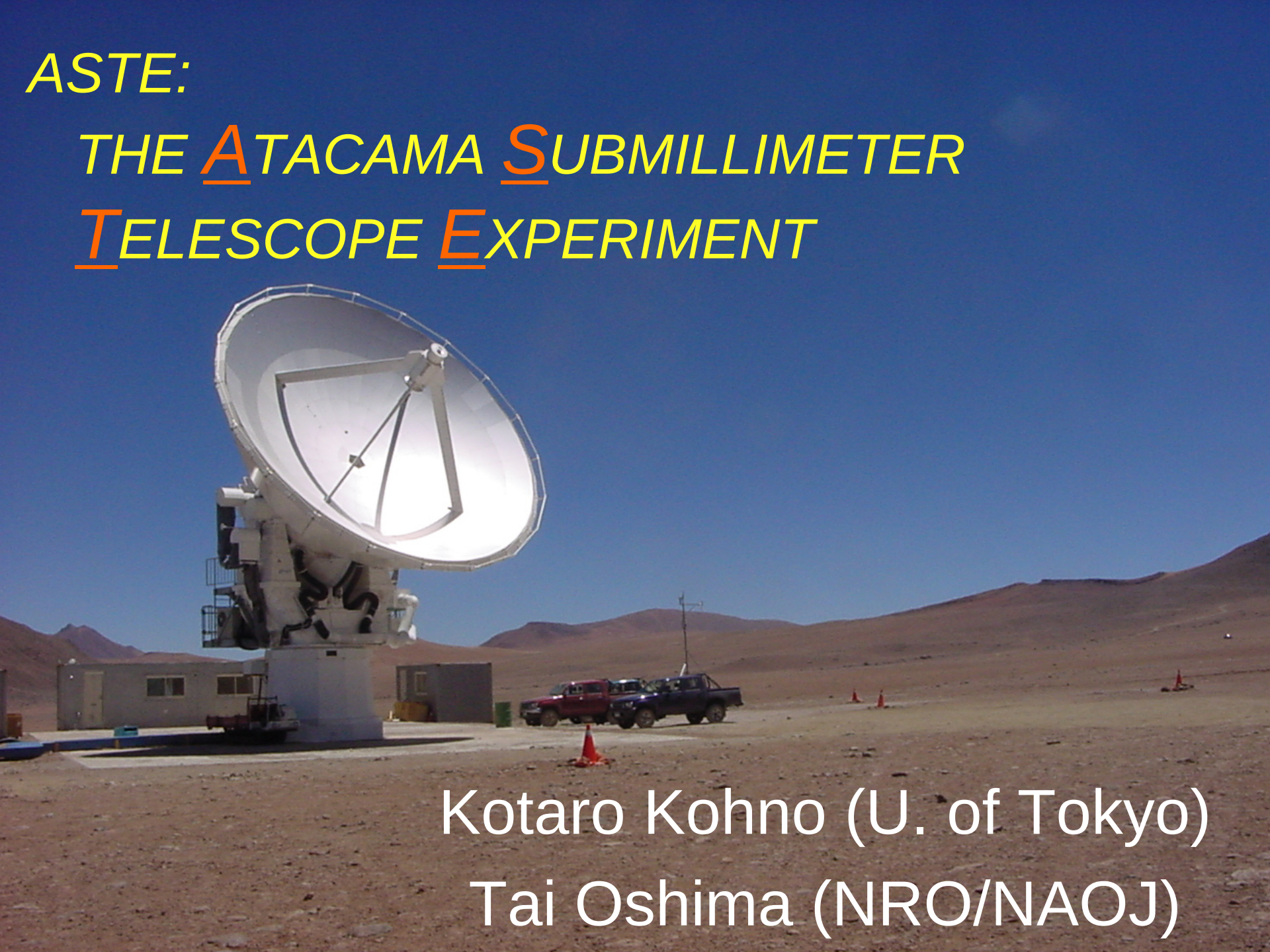
ASTE: THE ATACAMA SUBMILLIMETER TELESCOPE EXPERIMENT



Kotaro Kohno (U. of Tokyo)
Tai Oshima (NRO/NAOJ)

Bolometer Camera Development

Multi Color Bolometer Camera

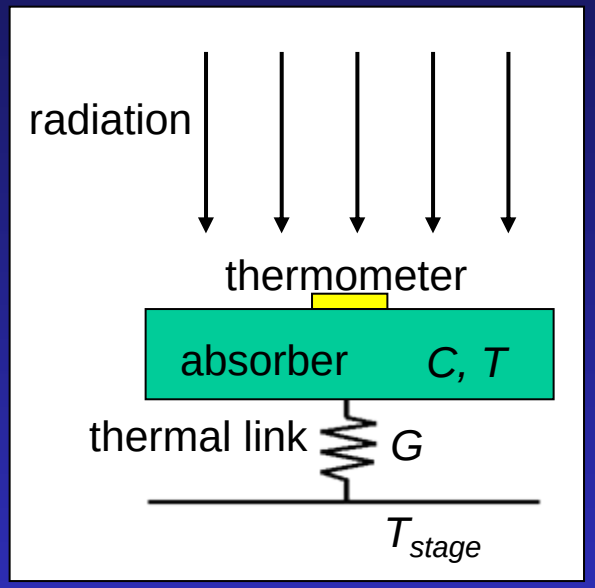
Phase	I	II	III
When	2010/10	2011/6	2012/6
Bands	2	2	2
Frequency	270/350GHz	270/350GHz	350/650GHz
Wavelength	1.1mm/850μm	1.1mm/850μm	850μm/450μm
Pixels	169/271	169/271	271/881
Beam(FWHM)	28/22”	28/22”	22”/11”
Field of View(‘)	7.5	7.5	7.5
NEFD(mJy/√s)	10/35	10/35	35/80
Options			more bands?(O’Brient+2009)

What is a Bolometer?

- Measures radiation power as temperature rise
  1. Power input to absorber
  2. Temperature rise ∝ 1/G measured by thermometer
  3. Readout as electrical signal
- ➔Low temperature detector
  - Typically T < 0.5K
- Thermometer types
  - Semiconductor
  - Transition edge Sensor (TES)
- Figure of merit: Noise equivalent Power
  - Thermal fluctuation (phonon) noise

    $NEP \sim (4k_B T^2 G)^{1/2}$ [W/√Hz]
  - Photon noise

    $NEP \sim (P_{opt} h\nu)^{1/2}$ [W/√Hz]



TES bolometer array

- **TES bolometer**

  TES: Utilize rapid resistance change in superconducting – normal state transition

  – High sensitivity and fast response

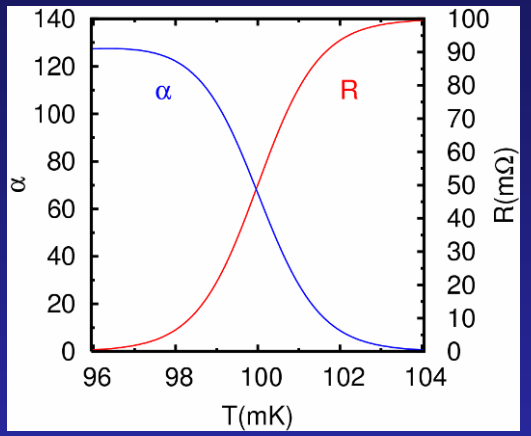
  – High yield based on micromachining technique

  – Multiplexable

  ➔ Large & sensitive array

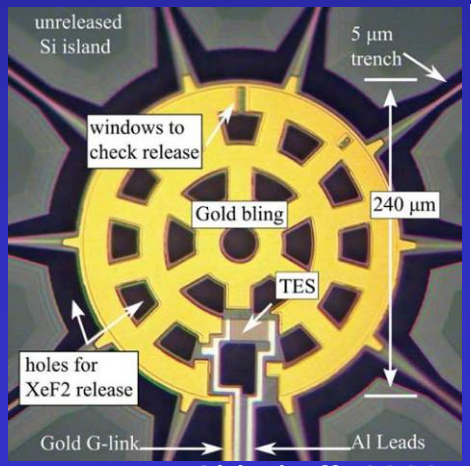
  – Low vibration sensitivity ➔ use of mechanical cooler

  ➔ No more cryogens! + remote operation capable!

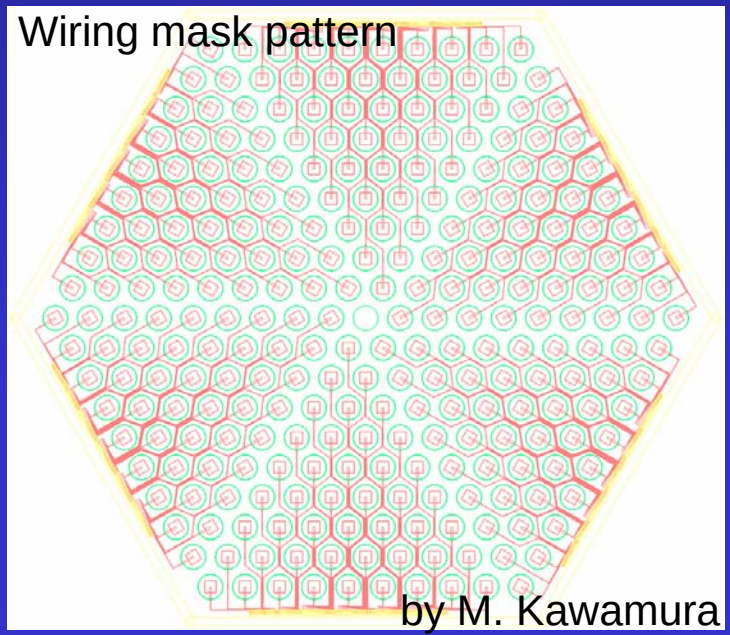


- **Array design** based on SPT spider web type absorber (UCB et al.)
- **Coupling to optics**
  – conical horn array
  – resonance cavity
- Bolometer NEP(expected)
  – 60aW/√Hz @ 270GHz
  – 70aW/√Hz @ 350GHz
  – 100aW/√Hz @ 650GHz

  ➔ Background limited (BLIP)



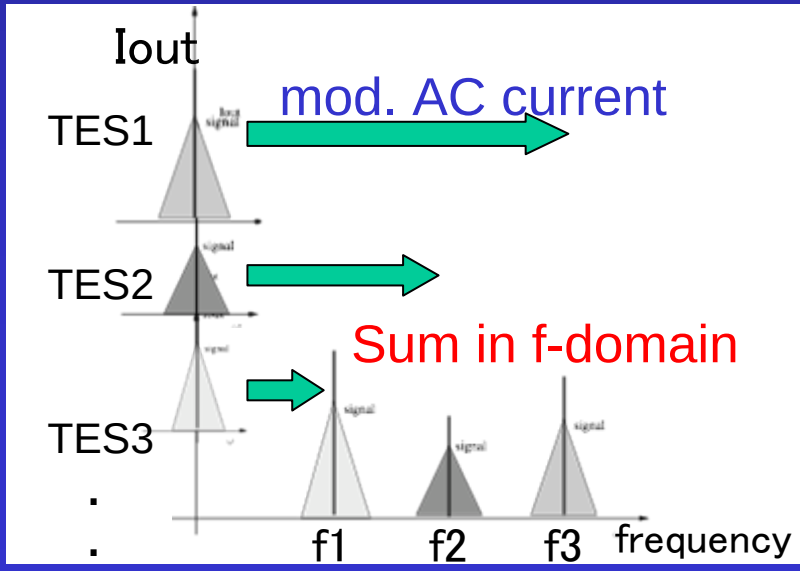
Shirokoff+2009

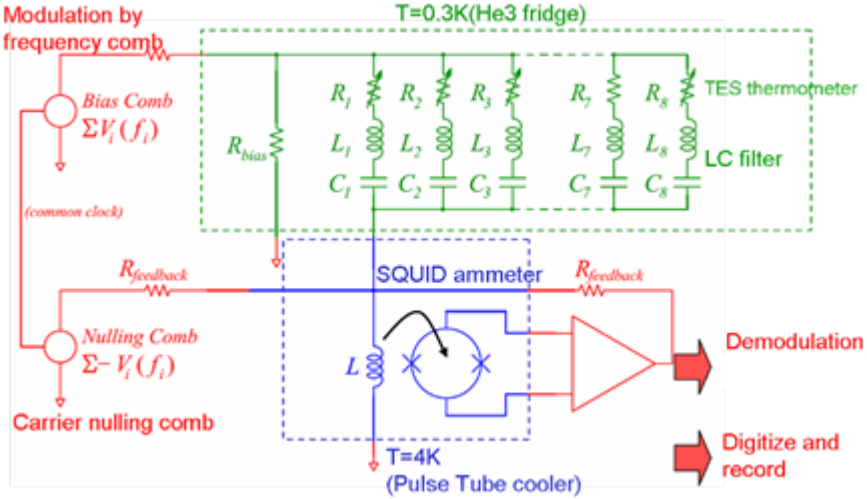


Multiplexed Readout

- Very low noise SQUIDs as ammeter
- Frequency Domain Multiplexing (fMUX)
  - method
    1. TES modulation with AC current (~100kHz band per TES)
    2. Summation of modulated signals in frequency domain
    3. Demodulation
  - No extra power dissipation at ultra low temperature stage
  - Higher resistance to microphonics
- FPGA based Digital fMUX developed by McGIll, UCB
  - Compact
  - Low power consumption
  - Stable operation

  ➔ suitable for remote operation with ASTE

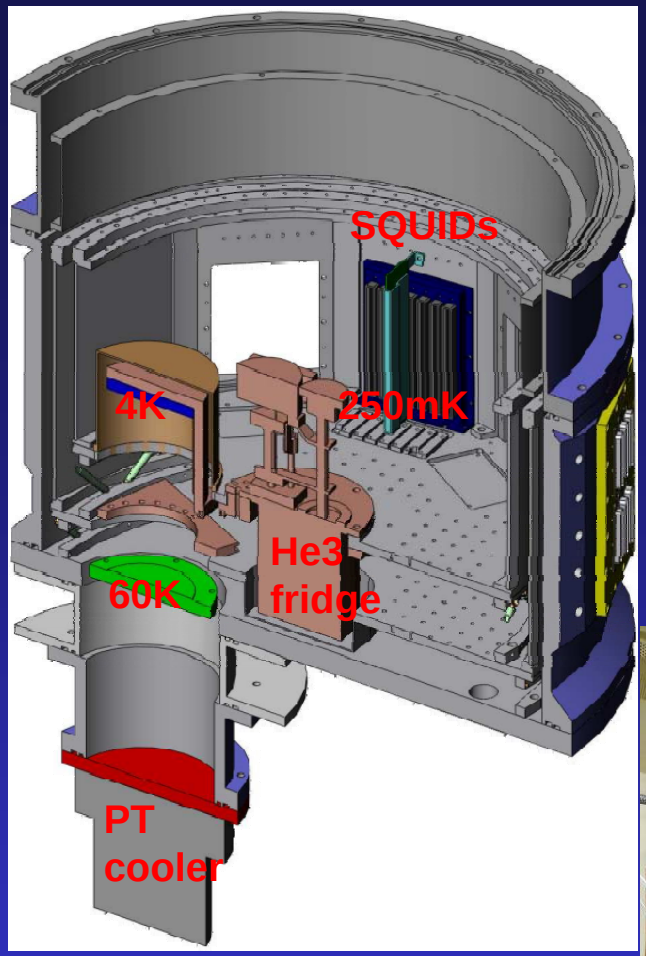




UCB, McGill

Cryogenics

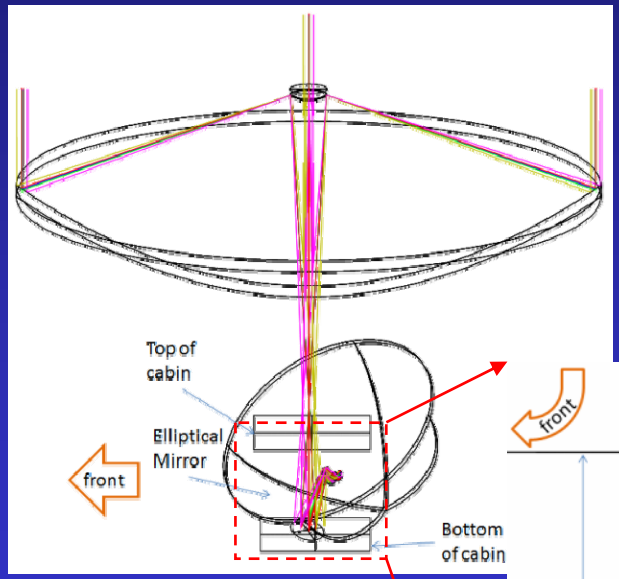
- Pulse Tube cooler
  - T=3.5K, 60K
  - Cooling power 1.0W@4K
  - ½ day to 4K
  - very low vibration
- He3 sorption cooler
  - precooled by He4 sorption cooler
  - T=250mK ultracold stage
  - T=350mK buffer stage
  - Hold time 50hr@no load
  - Cycle time < 4hrs

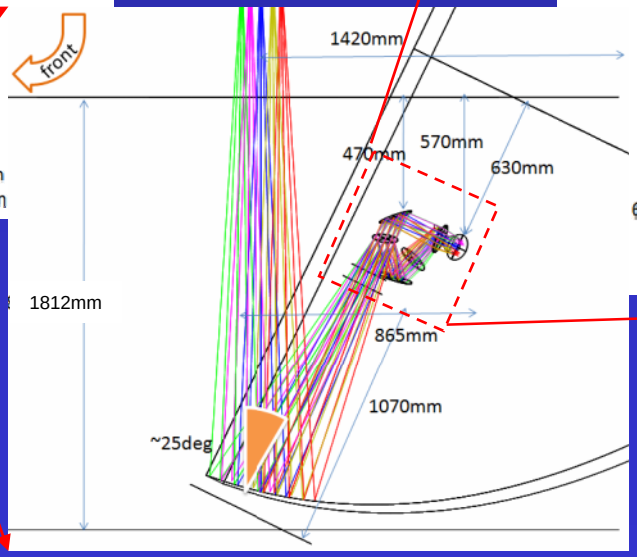


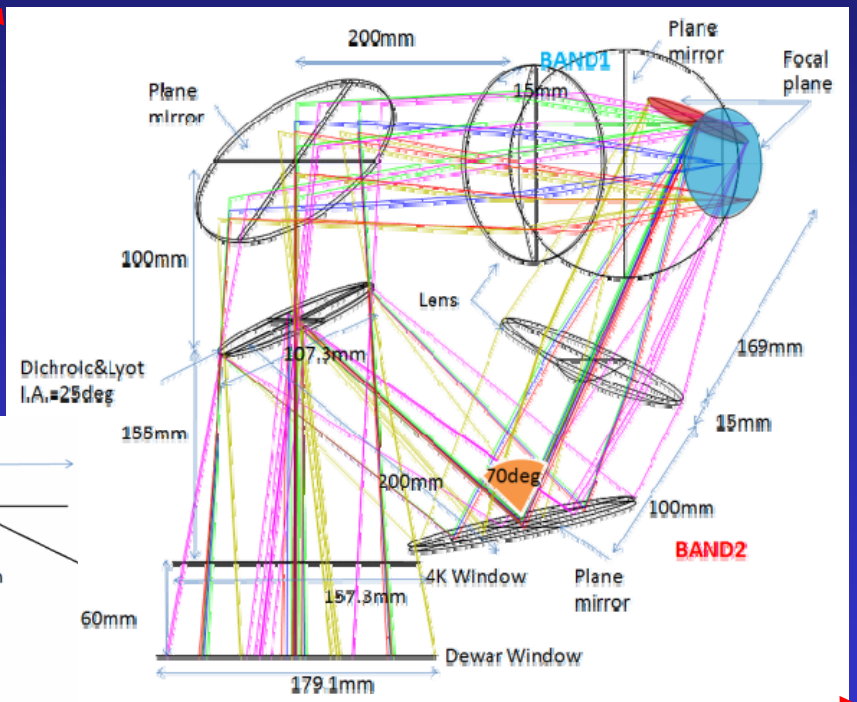
Optics

- Very compact dichroic optics design
- Two color optics enclosed in 60cm cube

➔ upgradable to wide band multi-chroic bolometers



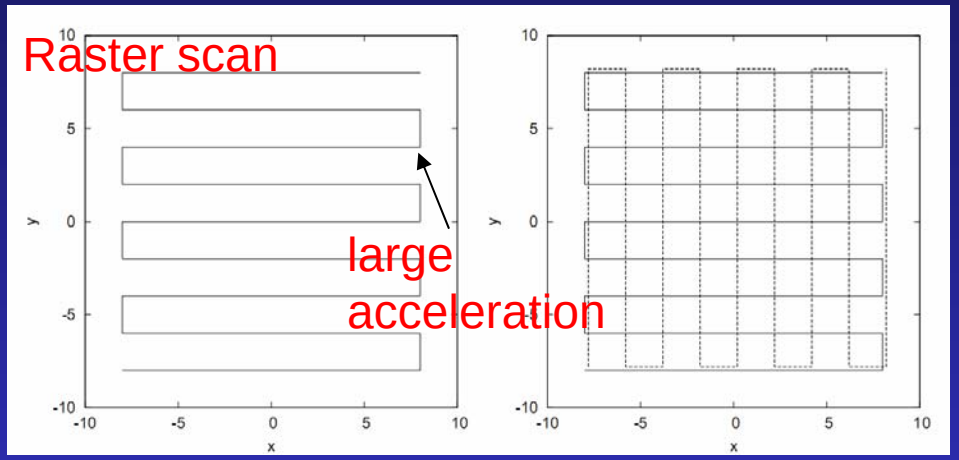




Cold reimaging optics
Takekoshi, Minamidani et al.

Scan observation

- Target region not fully covered with a glance
  ➔ scan observation for nice maps!
- requirements
  - Low overhead
    - low acceleration
  - Resistance to noise
    - e.g. 1/f noise
  - Feasibility
    - You can't jump around!



➔ LISSAJOUS scan: demonstrated with AzTEC/ASTE!