International X-ray Observatory (IXO)

The Implementation of an Imaging X-Ray Spectrometer for the International X-Ray Observatory

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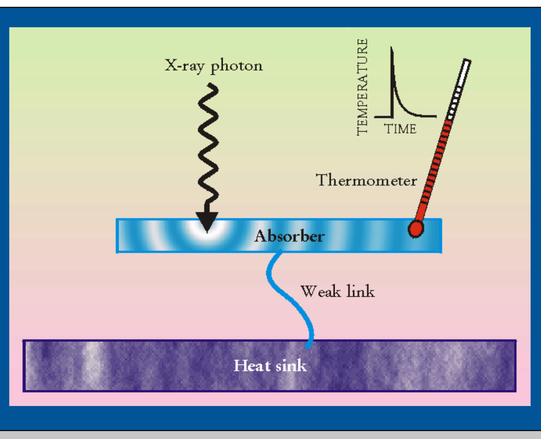
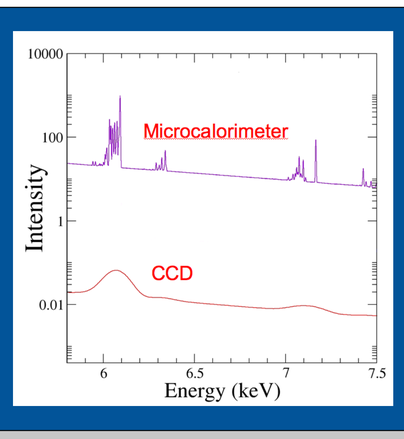


A fundamentally new approach for imaging x-ray spectroscopy:

- *Measure energies of individual x-ray photons as heat*
- *Measure position using array of calorimeters*

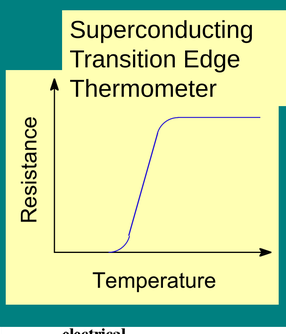
Spectral resolution of ~ 2 eV possible throughout 1-10 keV band with ~ arcsec imaging at the focus of IXO



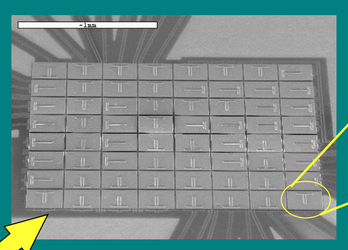
X-ray CCDs provide excellent imaging but have low spectral resolution

X-Ray Calorimeter Technology – Transition Edge Sensor

Superconducting Transition Edge Thermometer

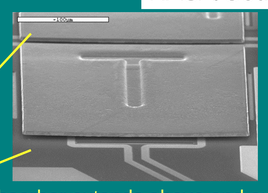


Transition at ~ 100 mK and only about 1 mK wide.

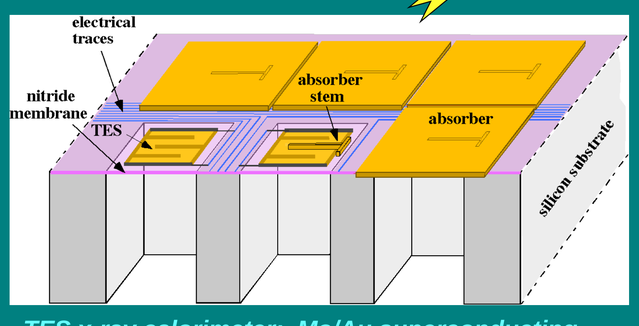


8 x 8 array of TES devices

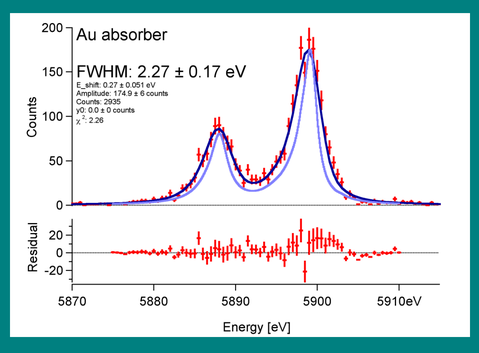
NASA/Goddard



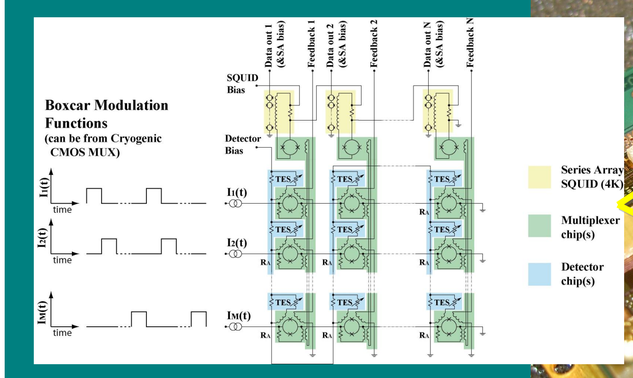
Absorber extends above and out from thermometer area to cover traces and provide high fill factor. substrate

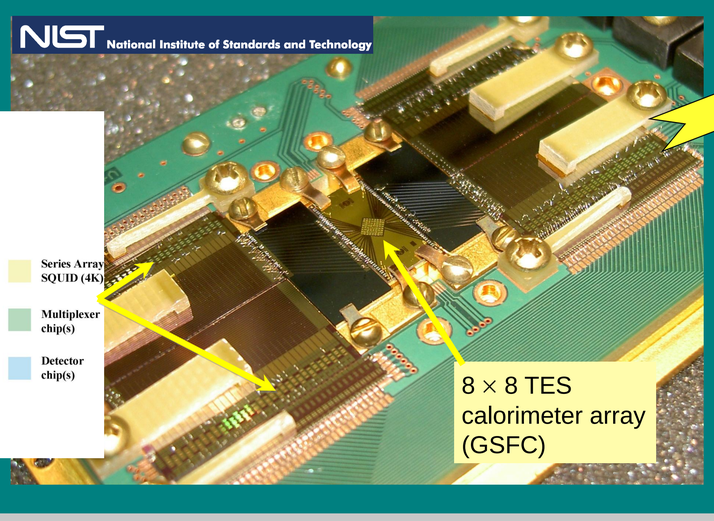


TES x-ray calorimeter: Mo/Au superconducting thermometer with Au/Bi absorber



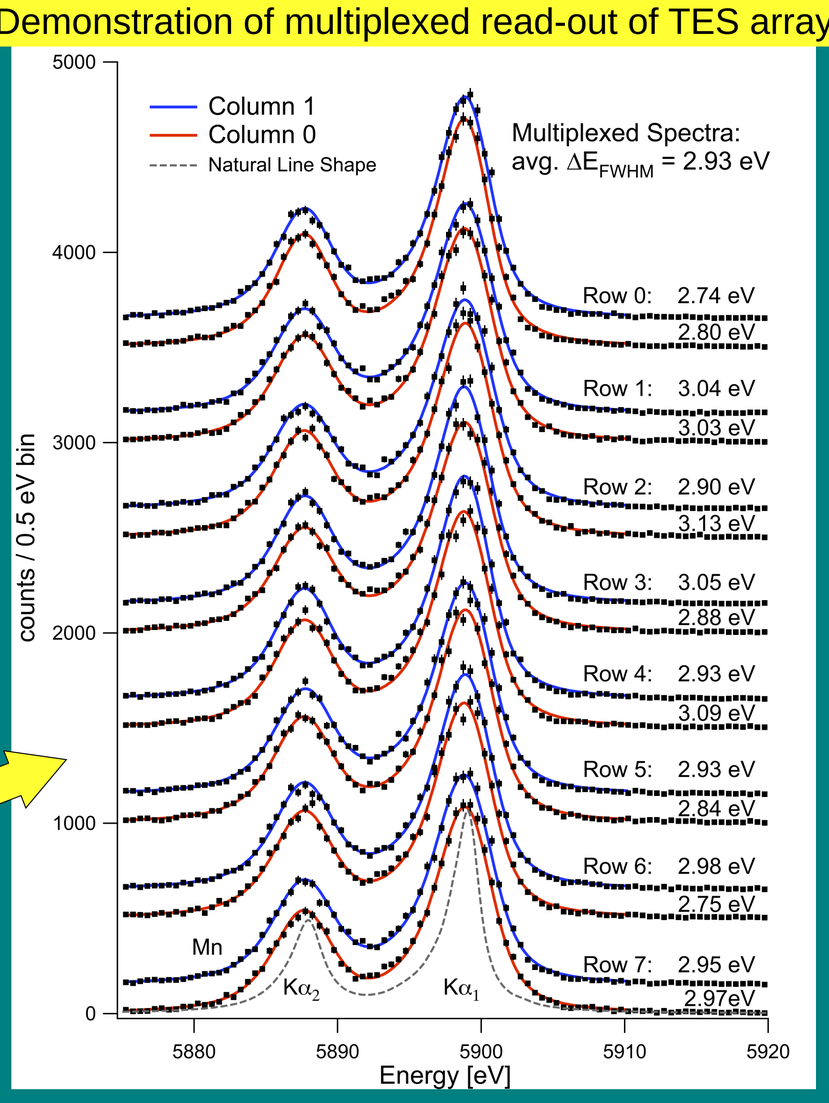
TES technology well-suited for high-speed SQUID multiplexing.





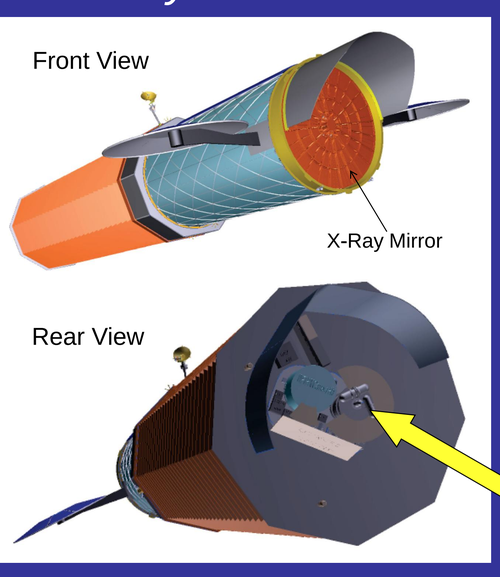
8 × 8 TES calorimeter array (GSFC)

Demonstration of multiplexed read-out of TES array

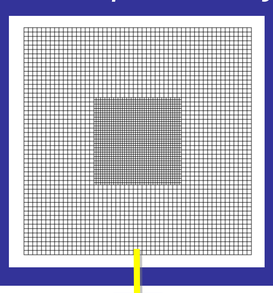


Results of a 2-column by 8-row multiplexing demonstration using a microcalorimeter array developed at Goddard and SQUID multiplexing electronics developed at NIST/Boulder (see Poster 457.13 - Randy Doriese et al. "Progress Toward A Kilopixel Time-division Multiplexer For IXO") The black points show histograms of MnK X-rays from an ^{55}Fe source for each pixel acquired simultaneously, with vertical offsets for clarity and fits overlaid in blue/red.

An X-Ray Calorimeter Spectrometer for IXO – the X-Ray Microcalorimeter Spectrometer (XMS)



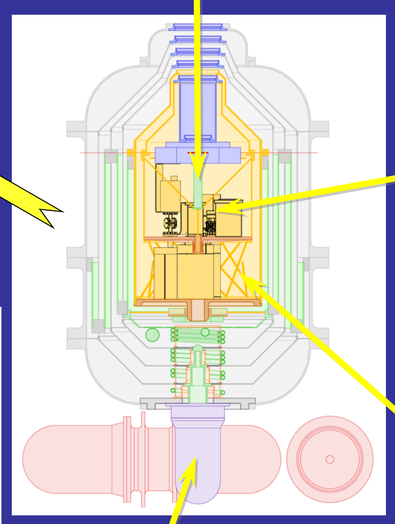
~ 4000 pixel array

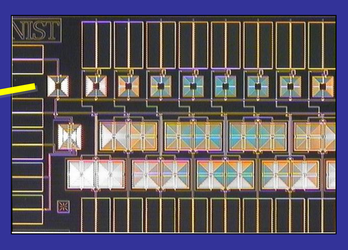


High Technology Readiness Reference Design:

- 32 x 32 TES microcalorimeter array
- MUX SQUID readout
- Continuous ADR
- Cryocoolers

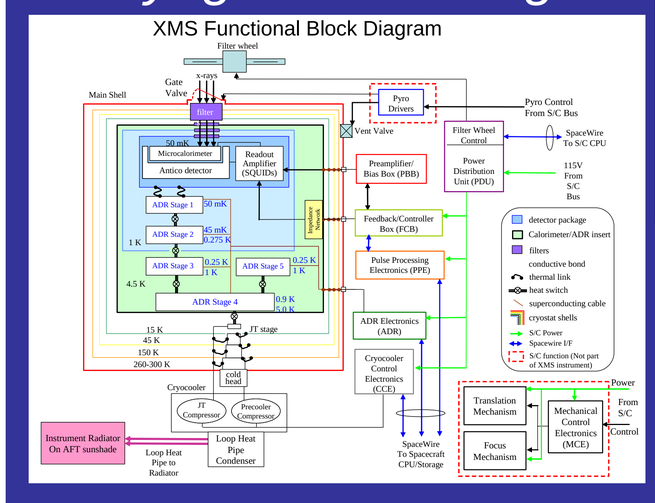
Multiplexed SQUID readout: enables larger arrays and low power dissipation



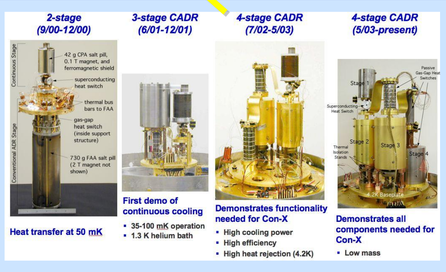


Multi-stage ADRs

Cryogen-free design



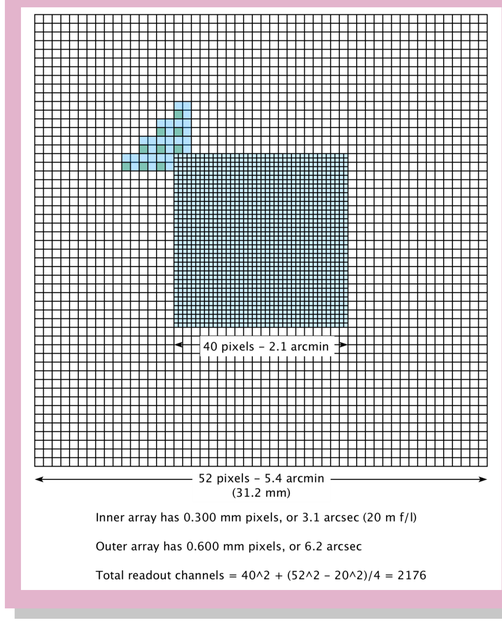
Cryocooler (Joule-Thomson + Pulse Tube)



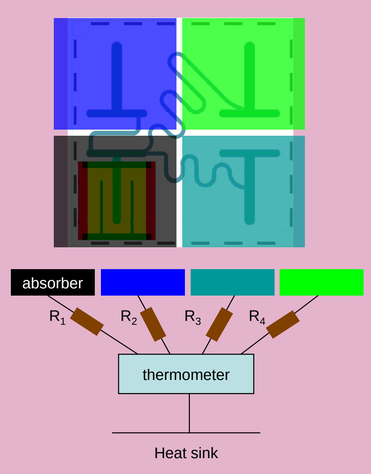
Reference Array Design:

Inner array with 300 μm pixels
- 3 arcsec pixels; 2.1 arc min FOV
- 2.5 eV energy resolution (FWHM)
- ~ 150 - 300 μsec time constants

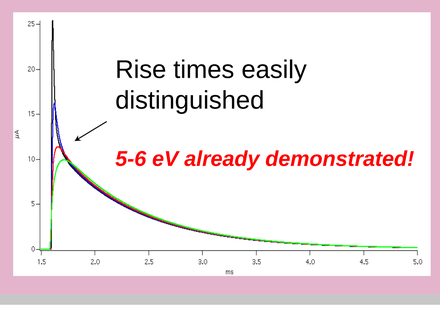
Outer Array with 600 μm pixels
- 6 arcsec pixels; 5.4 arcmin FOV
- < 10 eV energy resolution (FWHM)
- ~ 1-2 msec time constant

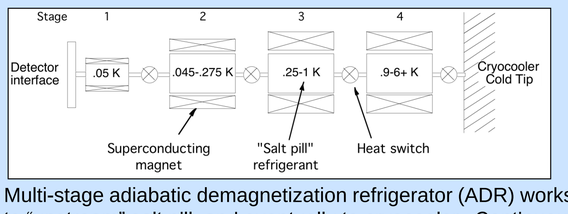


Multi Absorber TES - 1 TES, 4 absorbers



Simple approach to extend focal plane coverage:
Separate absorbers (e.g., 4) connected to a single TES, each with a different thermal conductance.





Cooling Stage	Temperature	Cooling Power	Temperature Stability	Heat Rejection Temperature
Detectors, 1st stage SQUIDs	50 mK	5 μW	2 μK rms	6 K
2nd stage SQUIDs	1 K (TBR)	230 μW	TBD	

Multi-stage adiabatic demagnetization refrigerator (ADR) works by continuously transferring heat of magnetization to "upstream" salt pill, and eventually to cryocooler. Continuous removal of up to 5 μW at 50 mK.