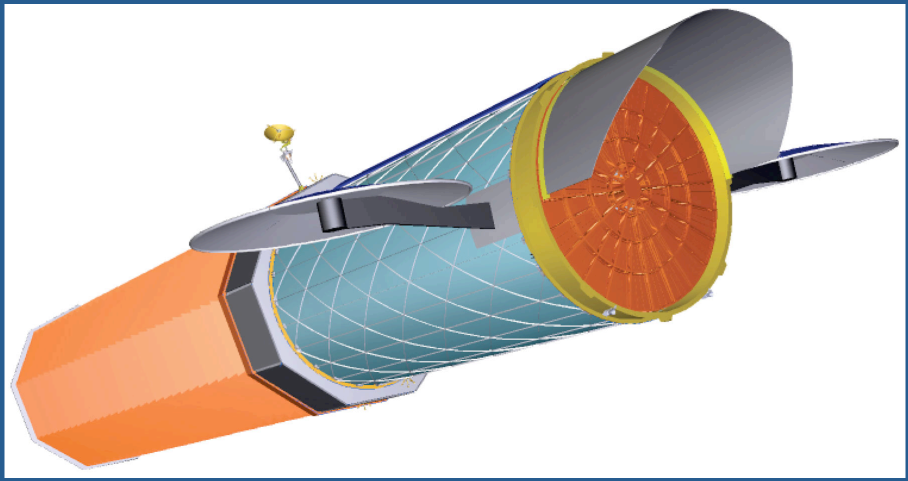
IXO Tean Meeting

January 28-29, 2009 — Cambridge, MA

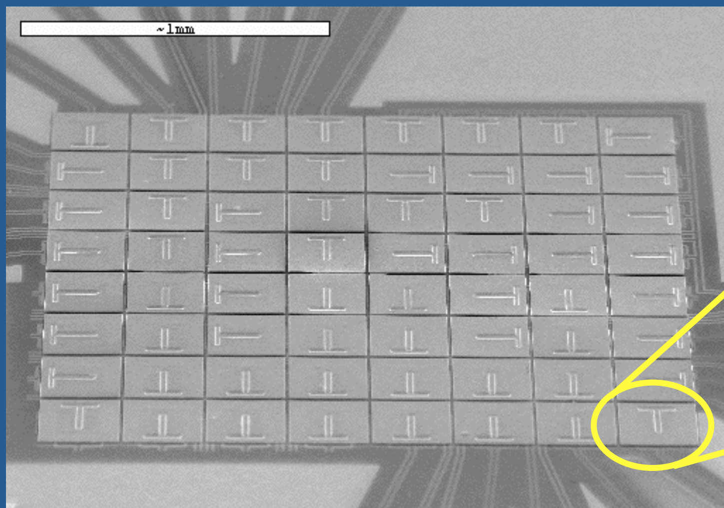
Count-Rate Performance for X-Ray Microcalorimeter Spectrometer

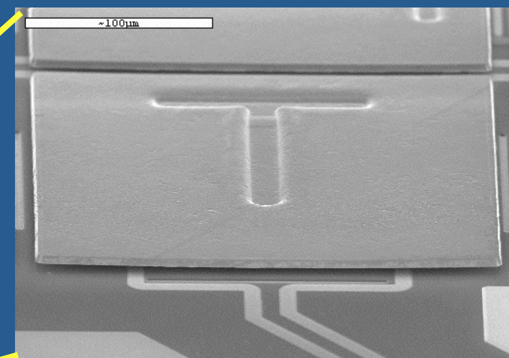
Presented by Richard Kelley

NASA/GSFC

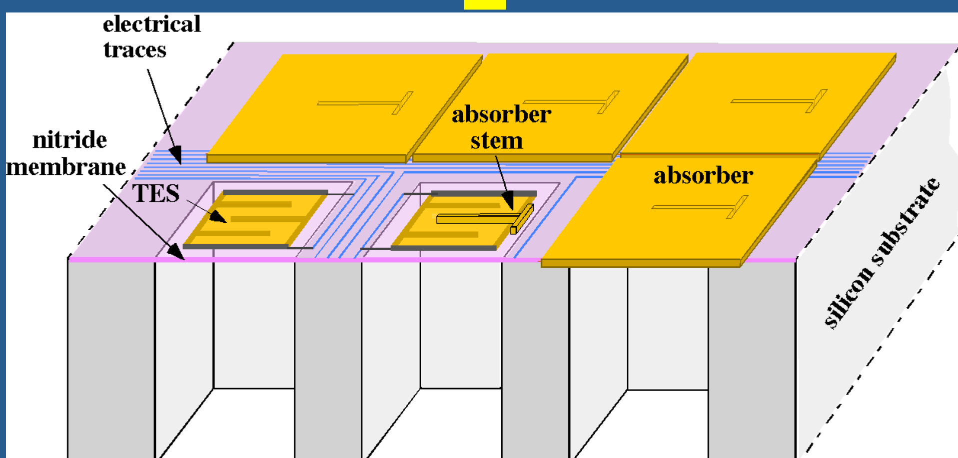


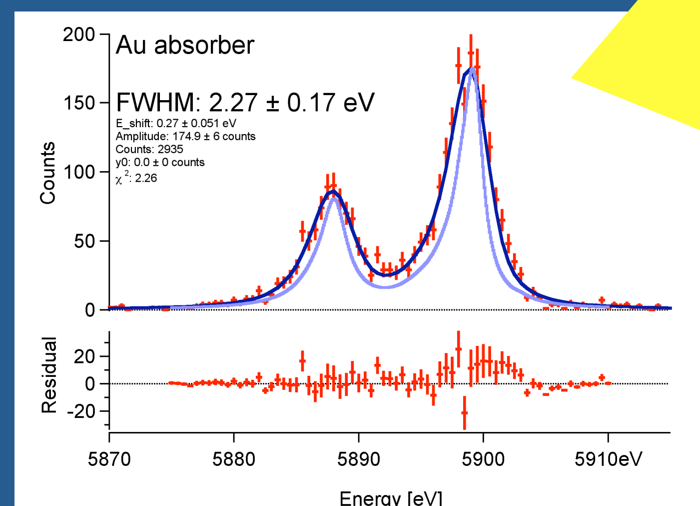
Basic TES Array design – GSFC



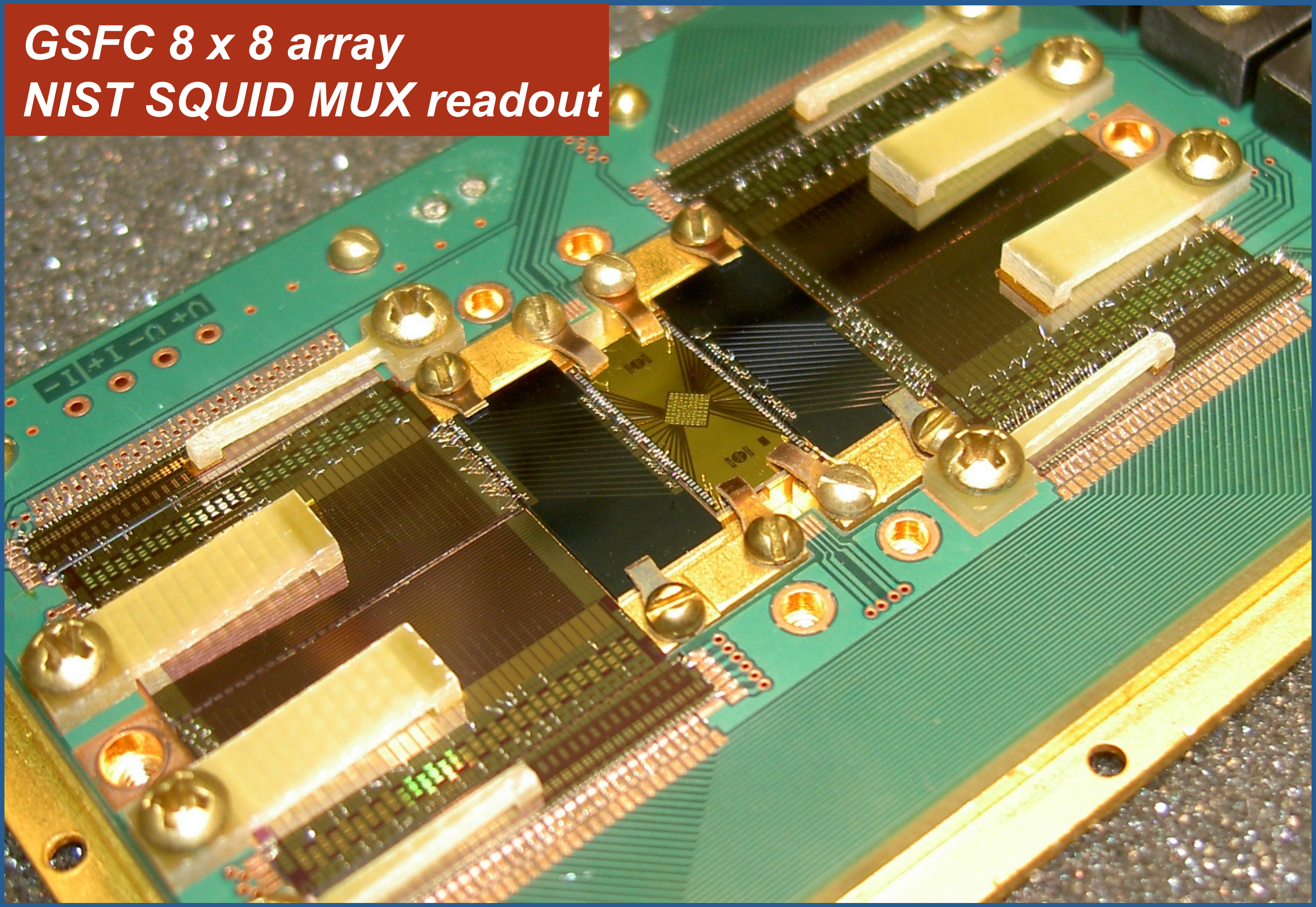


250 μm

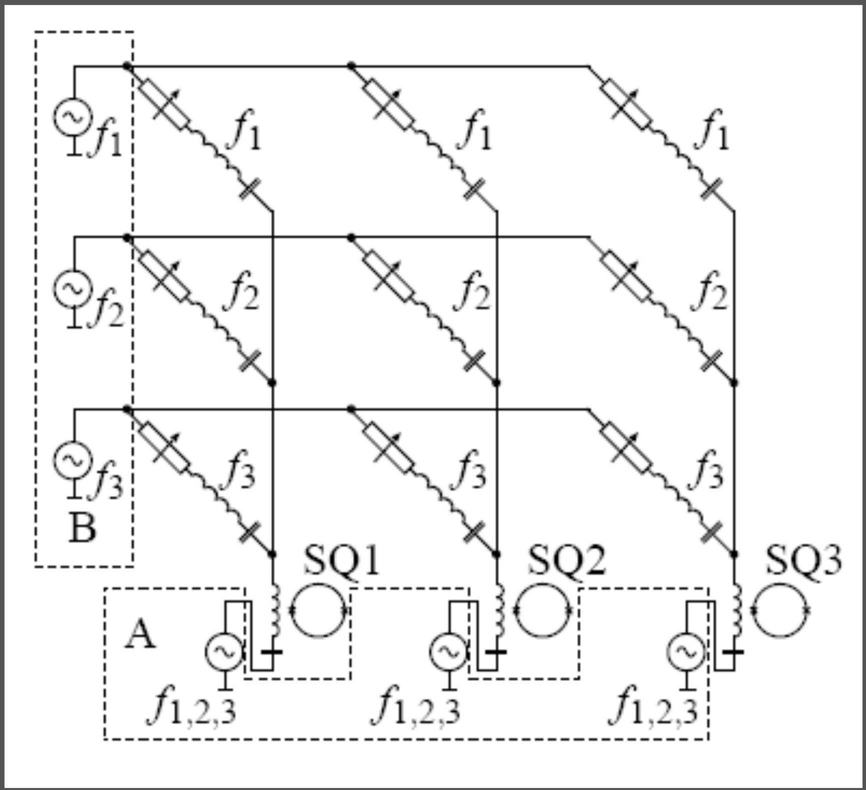




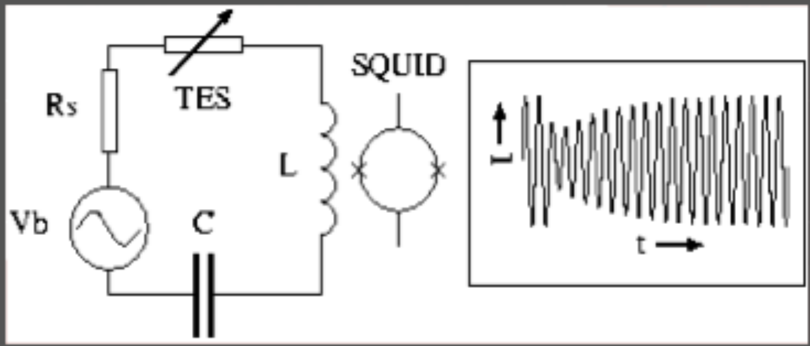
Multiplexed TES calorimeter array



Frequency-Division Multiplexing - SRON

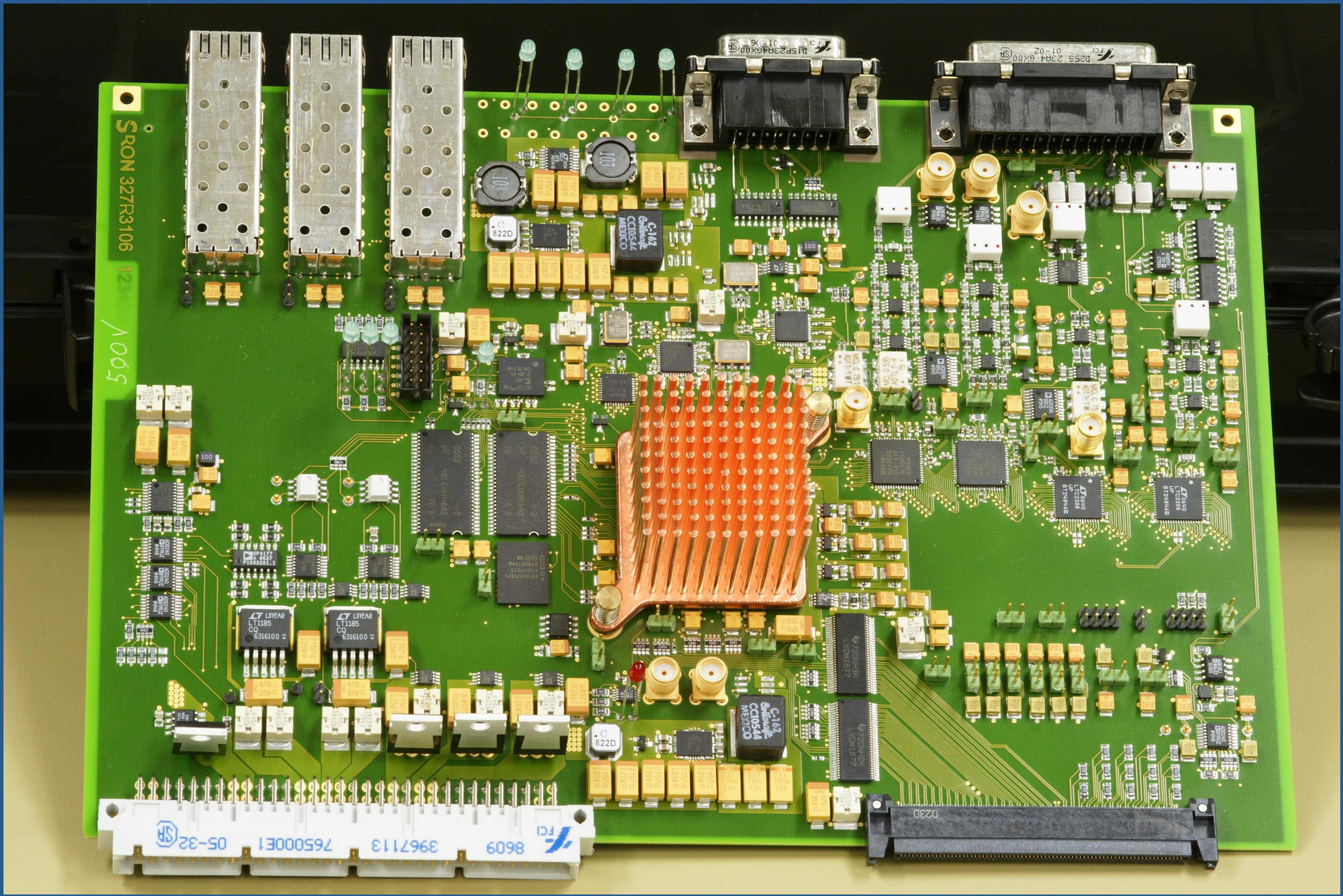


- AC-bias of TES; so that it acts as AM-modulator



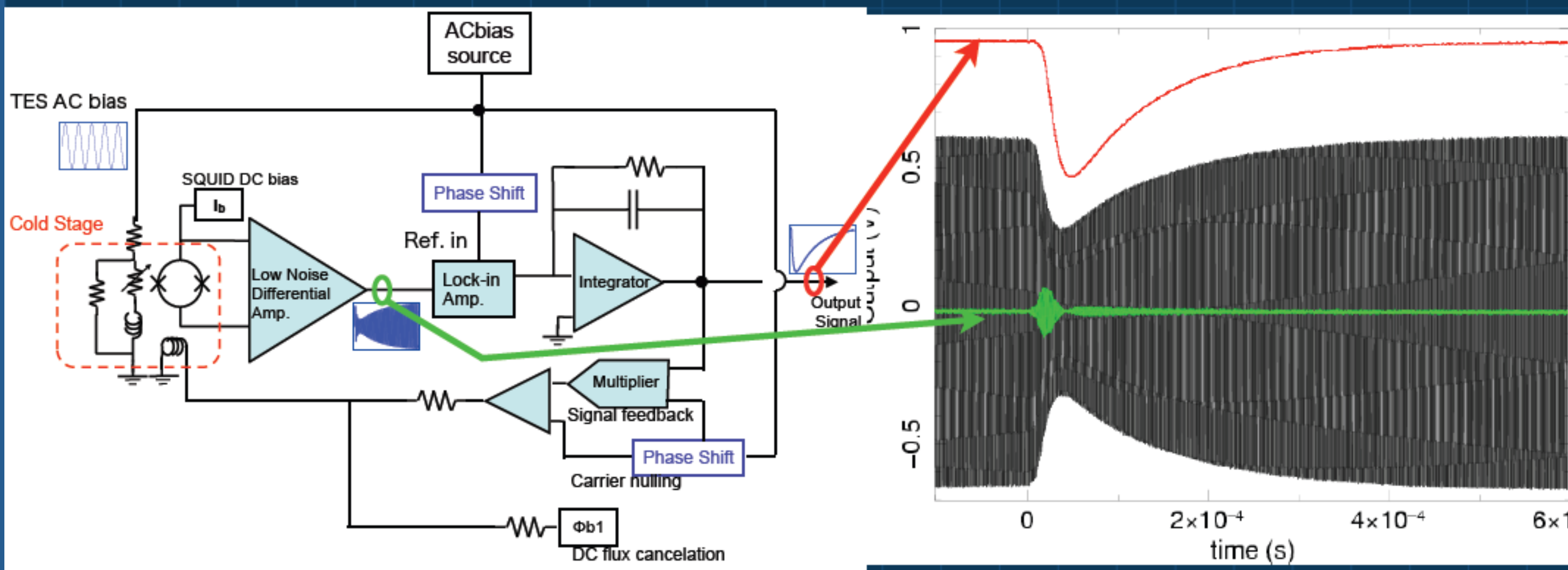
- LC noise blocking filter per TES
- One SQUID per column
- Base-band feedback to increase dynamic range, and to linearize SQUID response
- 1 – 10 MHz frequency range
- 200 - 300 kHz separation will enable multiplication of 32 – 45 pixels/channel

SRON Base Band Feedback electronics



Work on FDM readout in Japan

Analog base-band feed back



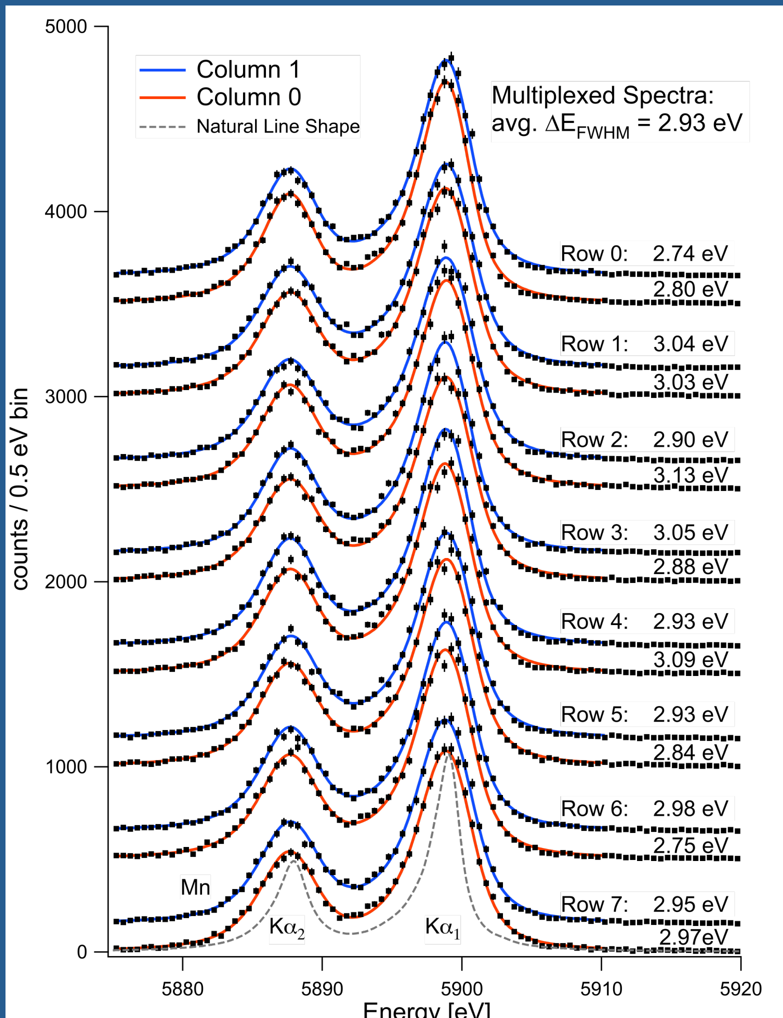
Feedback off
Feedback on

TES Calorimeter Meeting

Three-day meeting held at Goddard 12-14 January 2009 to discuss TES x-ray calorimeter issues in the context of the IXO mission. Nine panel discussions on the following topics. ~ 40 participants from the US, Europe and Japan.

- Core Array (single-absorber TES)
- Extended array (i.e., multi-absorber TES)
- Multiplexing techniques
- Signal Processing and Counting Rate Issues
- Anticoincidence Detector & Background Modeling
- Detector Modeling and Analysis Tools
- Issues for the design of the focal plane assembly
- Instrument Electronics: Power & Mass
- Cooling approaches

2 x 8 pixels read out with SQUID MUX



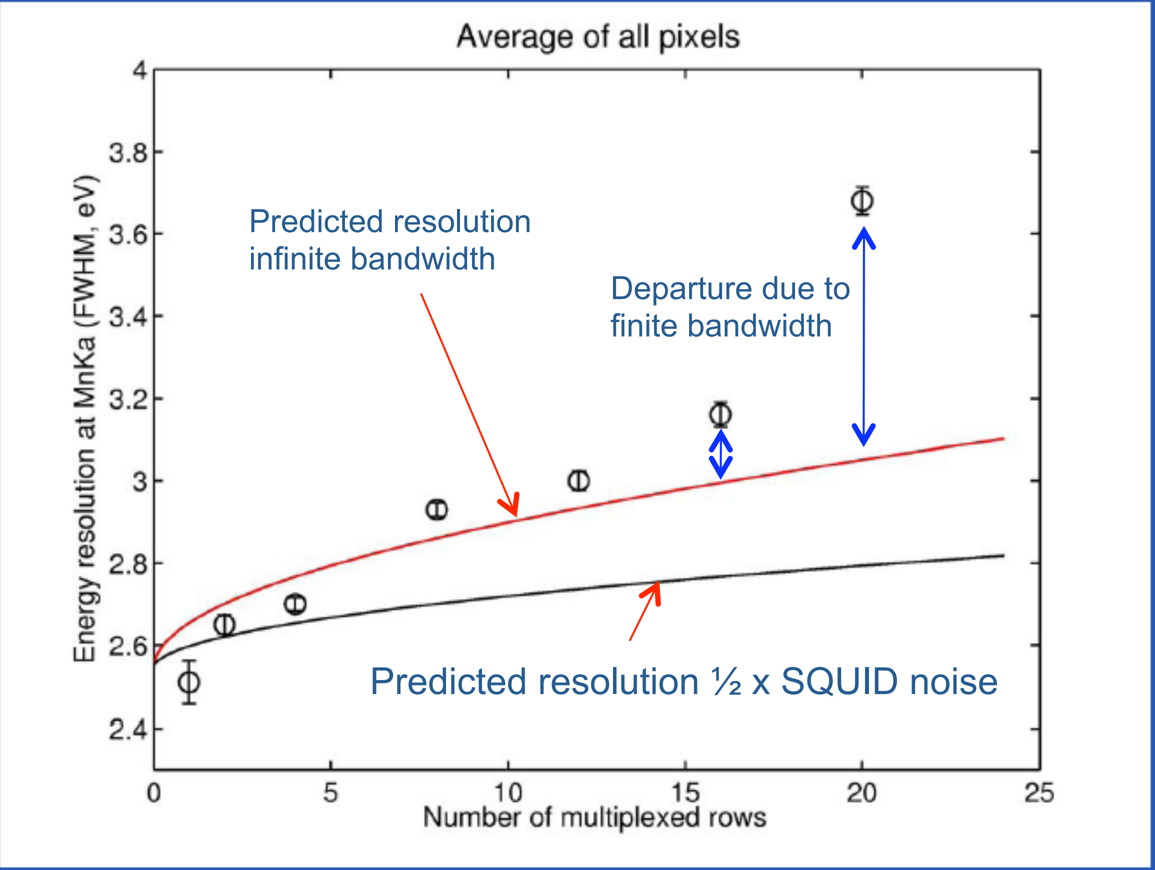
- ~ 30,000 counts per pixel from ^{55}Fe source
- ~ 500,000 total
- $\tau_{\pm}$ = 280 μs (critically damped)

$$\langle \Delta E_{FWHM} \rangle = 2.93 \pm 0.02 \text{ eV}$$

GSFC

NIST National Institute of Standards and Technology

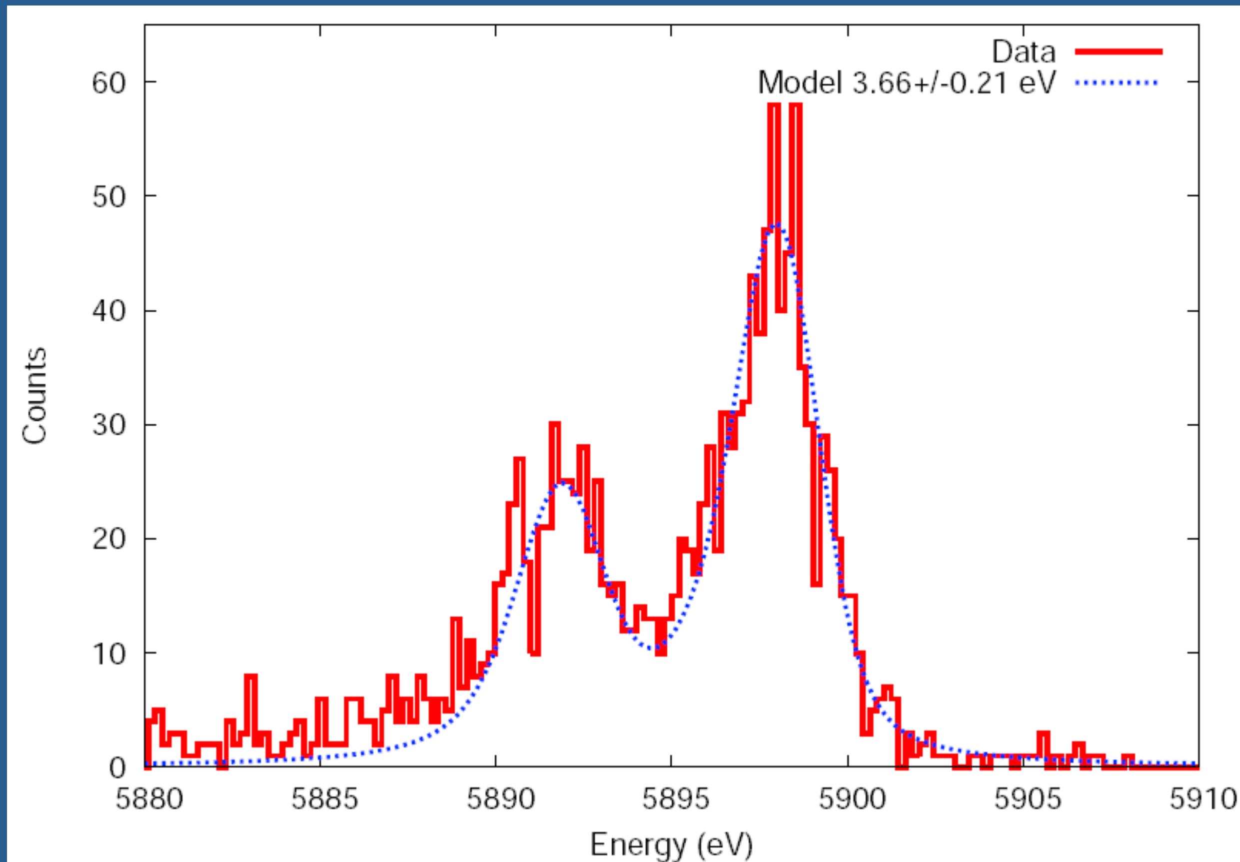
Extend the excellent behavior of N_{row} = 8 to N_{row} = 32 for fast, hi-res TESs



- Reduce present SQUID noise
  - heat sinking of chips
  - SQUID biasing
- Make row-switching time → 4x faster
  - New room-temperature electronics
  - New cryogenic MUX designs

NIST National Institute of Standards and Technology

Initial results from SRON – single pixel under AC bias



best energy resolution 3.7 eV (2.5eV under DC bias)

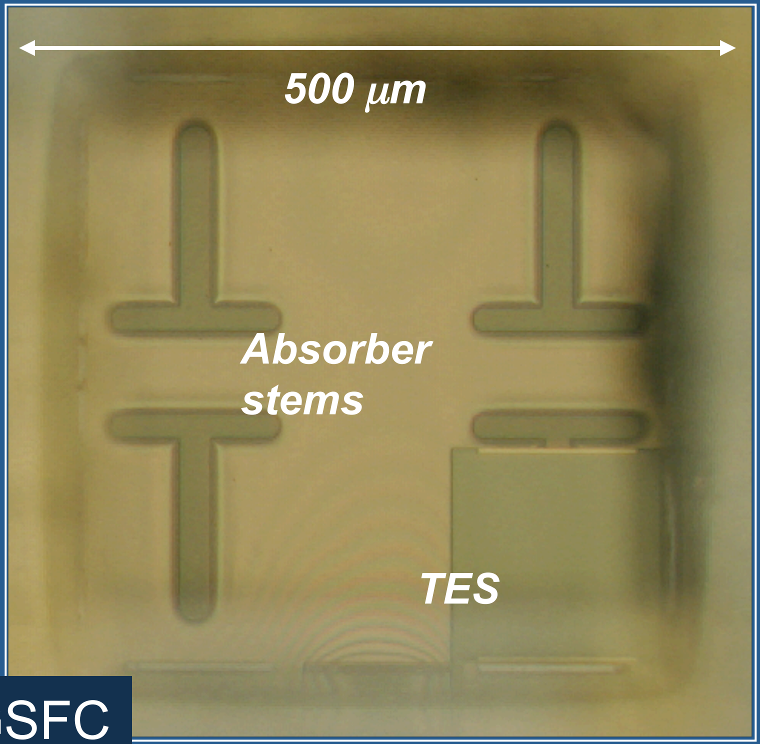
Electronics noise ~ 2.5eV

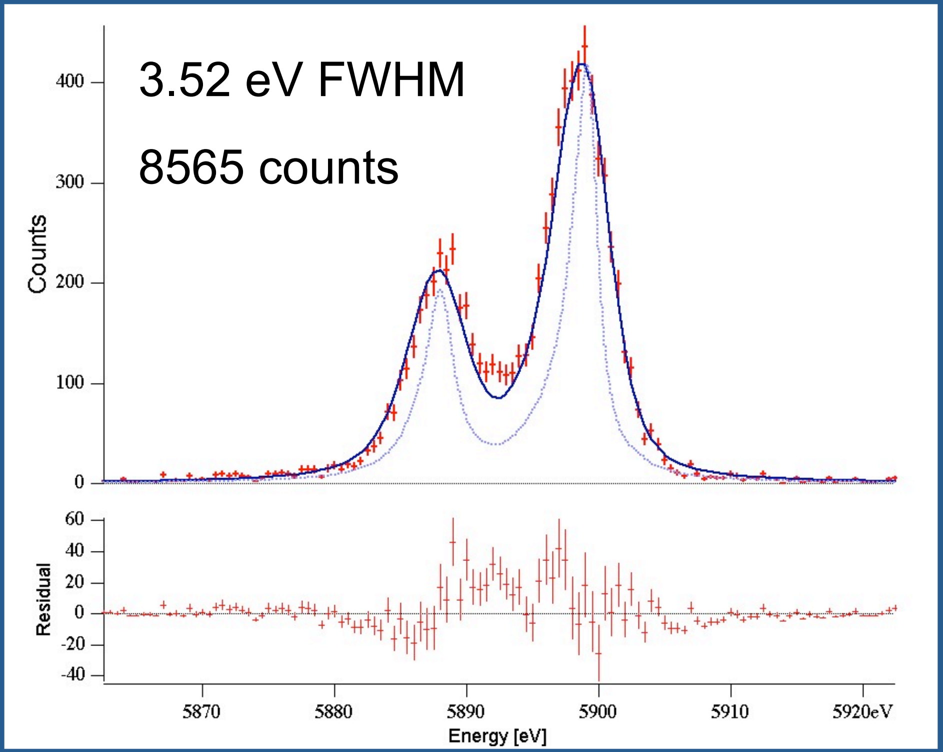
Note: sqrt(2.5^2 + 2.52^2)=3.5eV. But also gain drift issues.

Alternative extended focal plane options

Larger absorber size means heat loads and wiring density less problematic with new IXO configuration.

- Single large 500 μm absorber (no links).
- Achieved 3.5 eV FWHM (no position sensitivity).
- Further reducing G could enable MUXing of more channels.





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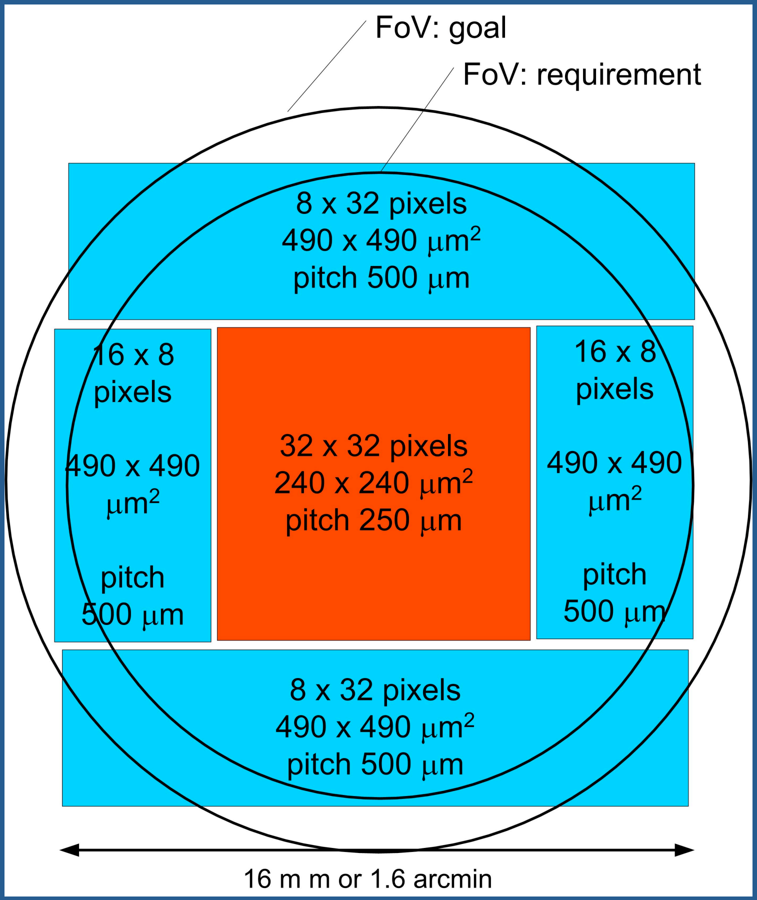
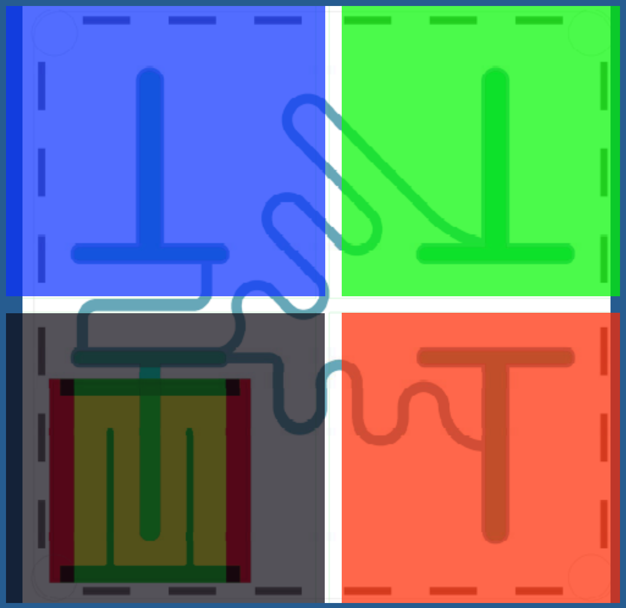
ESA Reference TES Array for XEUS → IXO

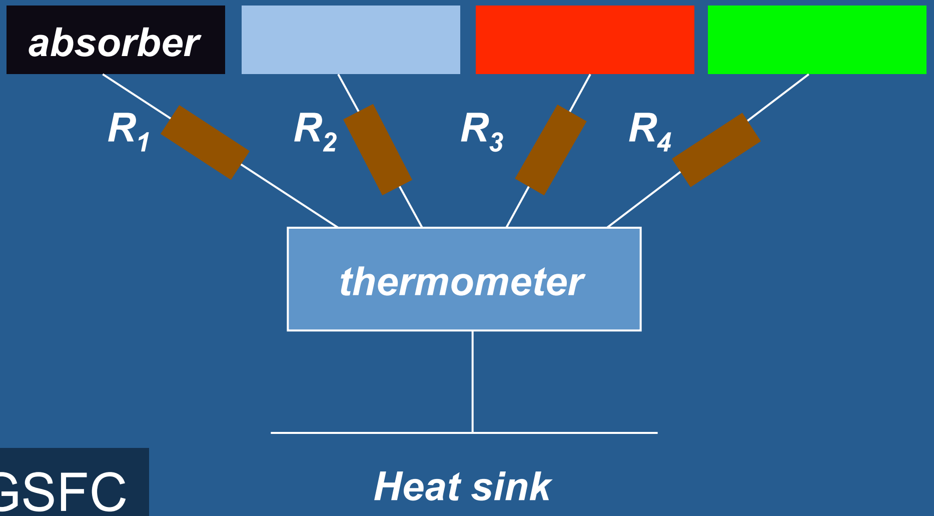


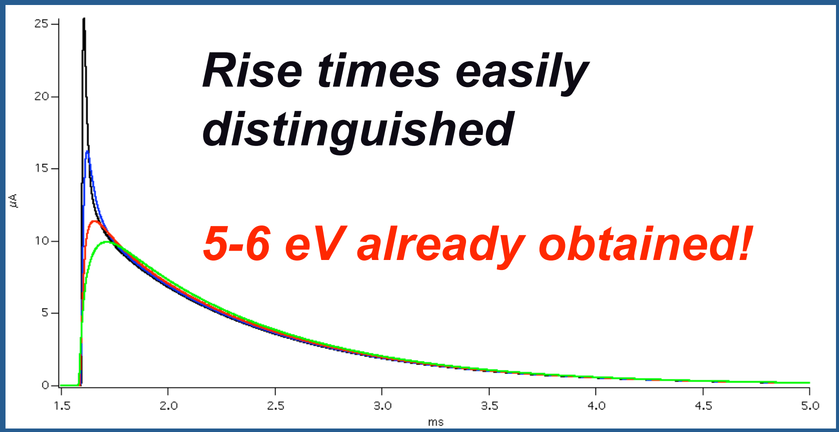
Multi Absorber TES - 1 TES, 4 absorbers

Simple approach:

Separate absorbers (e.g., 4) connected to a single TES, each with a different thermal conductance.







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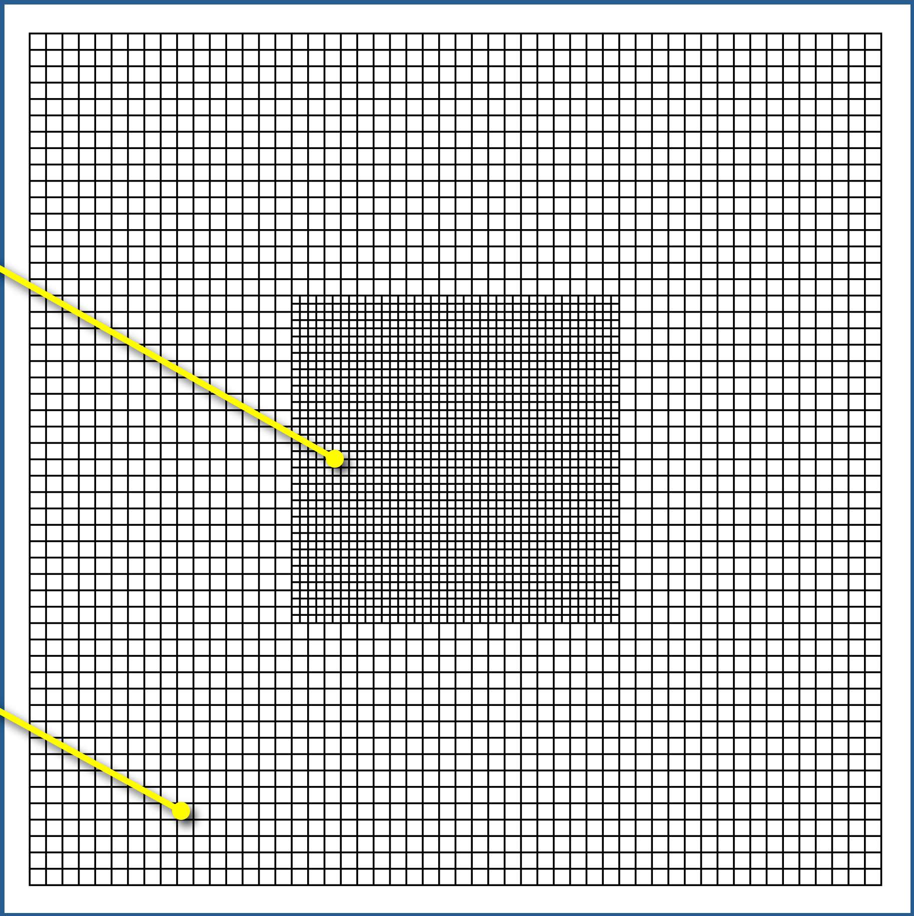
Extended Field of View

Central, core array:

- ***Individual TES - one absorber/ TES (40 x 40 pixels)***
- ***300 x 300 μm pixels (3" pixels; 2' FOV overall)***
- ***2.5 eV resolution (FWHM)***
- ***Speed < 300 μsec (time constant)***

Outer, extended array:

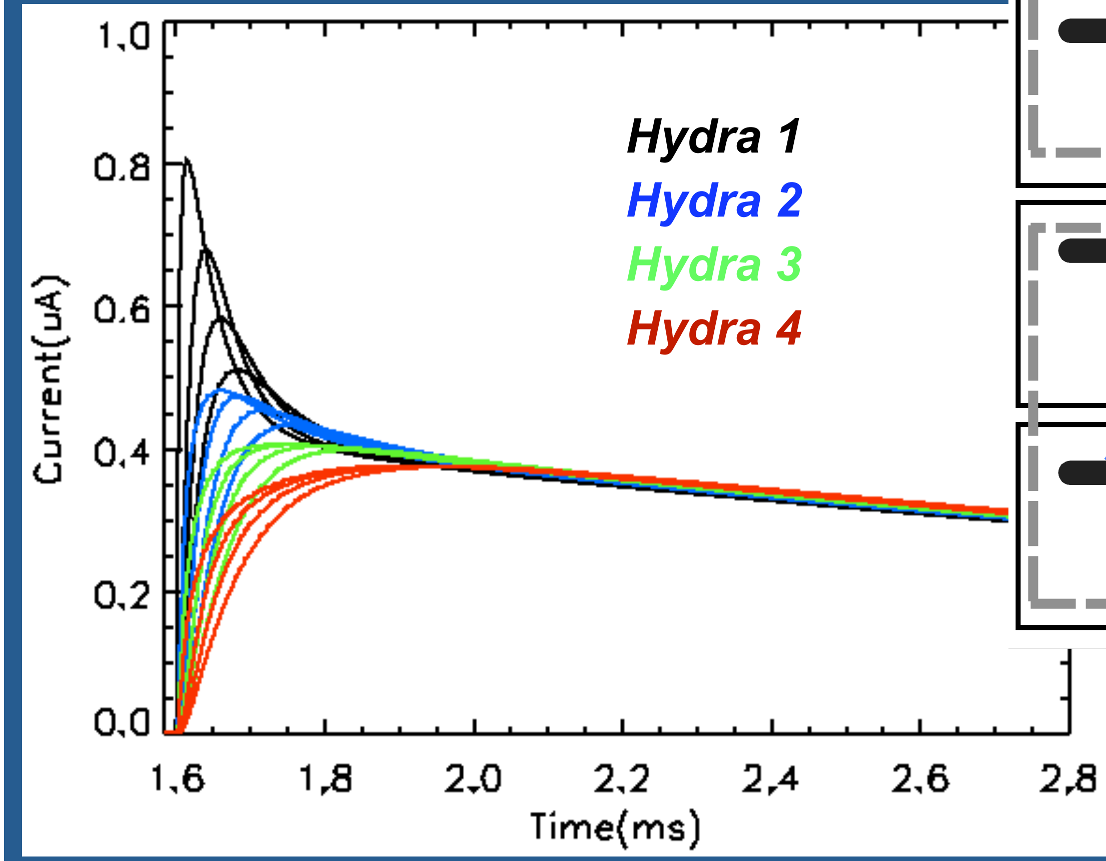
- ***Four absorbers/TES***
- ***52 x 52 pixels (total of 2176 readout channels)***
- ***600 x 600 μm pixels (6" pixels; 5.5' FOV overall)***
- ***< 10 eV resolution***
- ***~ 2 msec time constant***

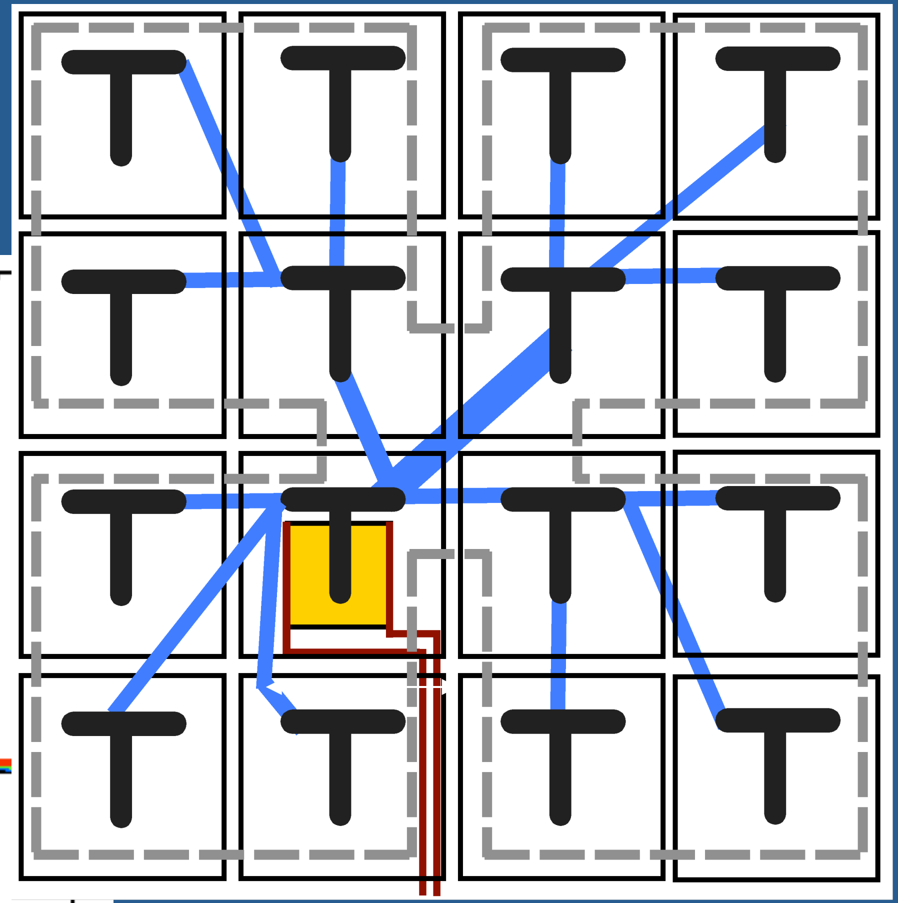


Other Hydra Options

4x4=16 300 μm absorbers

- 4 small Hydras connected to a single TES
- for increased angular resolution





300 μm absorbers

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XMS Detector System Roadmap

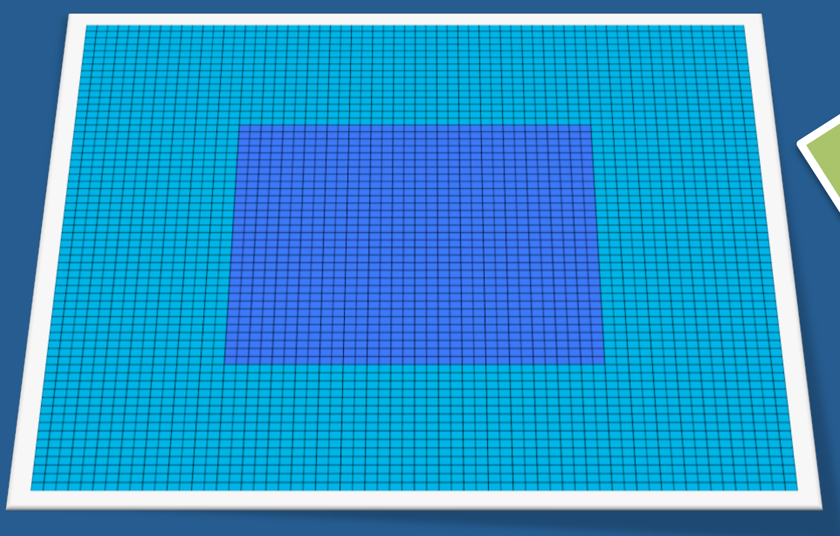
core array, pre-protoype demonstration (flight-like pixels, 8x8 array, 2x8 MUX)

core array protoype demonstration (flight-like pixels, 32x32 array, 3x32 MUX)

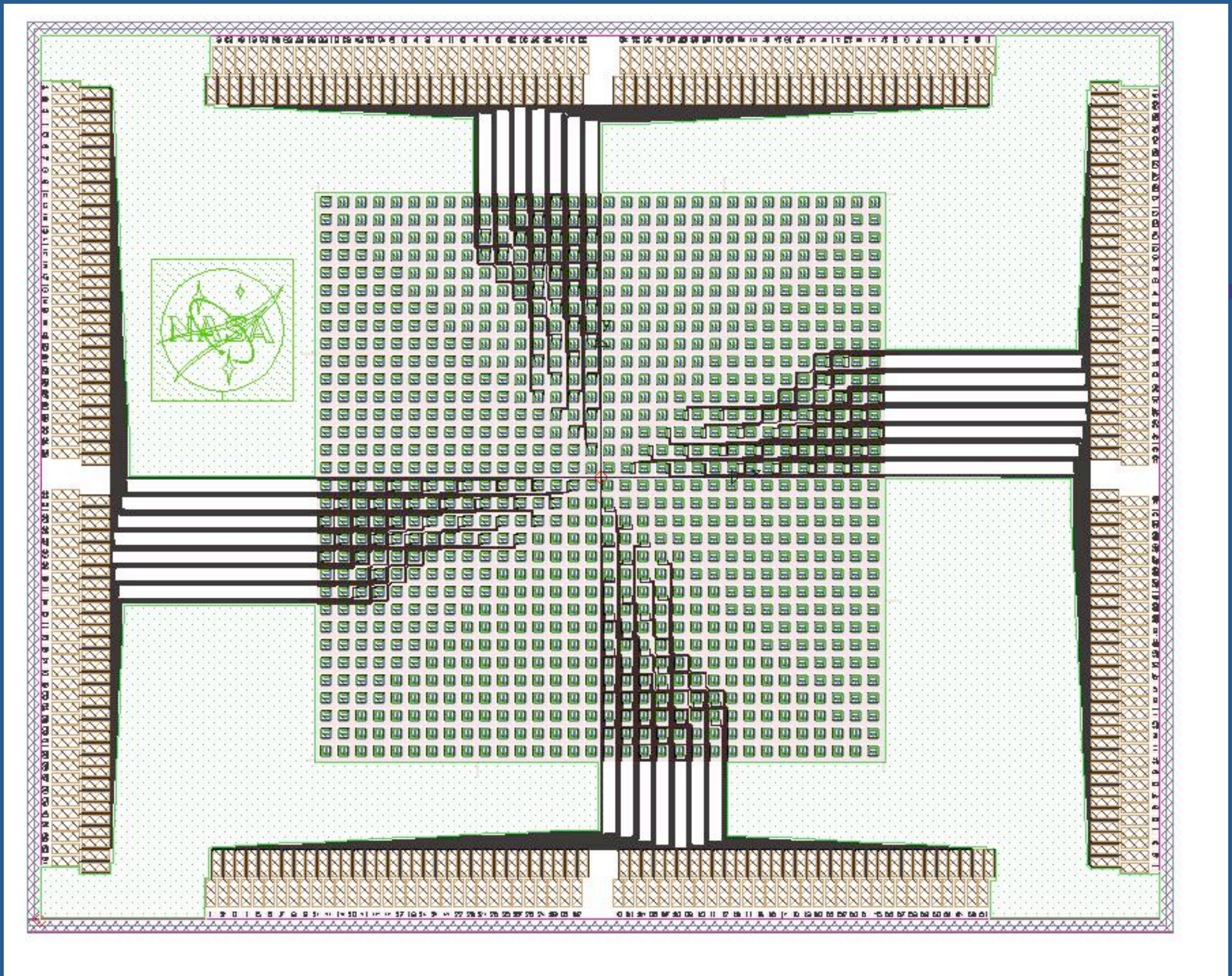
detector assembly prototype demonstration (TRL6)

extended focal plane concept demonstration

particle veto concept demonstration



New 32 x 32 array under construction at GSFC

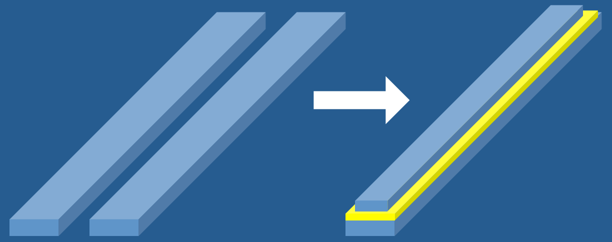


- 15 mm x 19 mm chip size and pad pitch were designed for compatibility with existing readout platforms

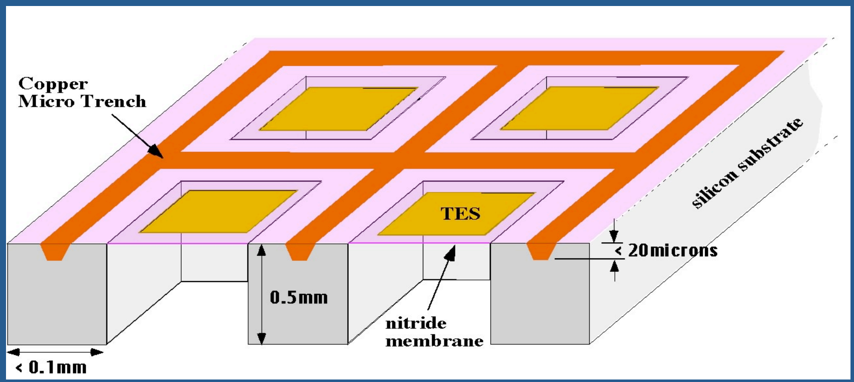
In microstrip version, 256 pixels (25% of array) brought to pads, but interior wiring necessary for 1024 pixels is included to prove required density.

Core array milestone progress and schedule

- **First 32x32 arrays with planar wiring to be tested soon**
- **Goal of producing arrays with microstrips by end of March**
- **32x32 arrays with integrated heatsinks by end of September**
- **pushing to reach milestone by year's end**
  - in collaboration with NIST
  - new test platform (coming up anyway for new EBIT TES spectrometer)
  - software development
    - to handle the high live data rates
    - to extend the XRS-style real-time data processing to arbitrary array scales
-



Superconducting traces separated by SiO_2 insulator



Cryocooler Options and Trade-offs

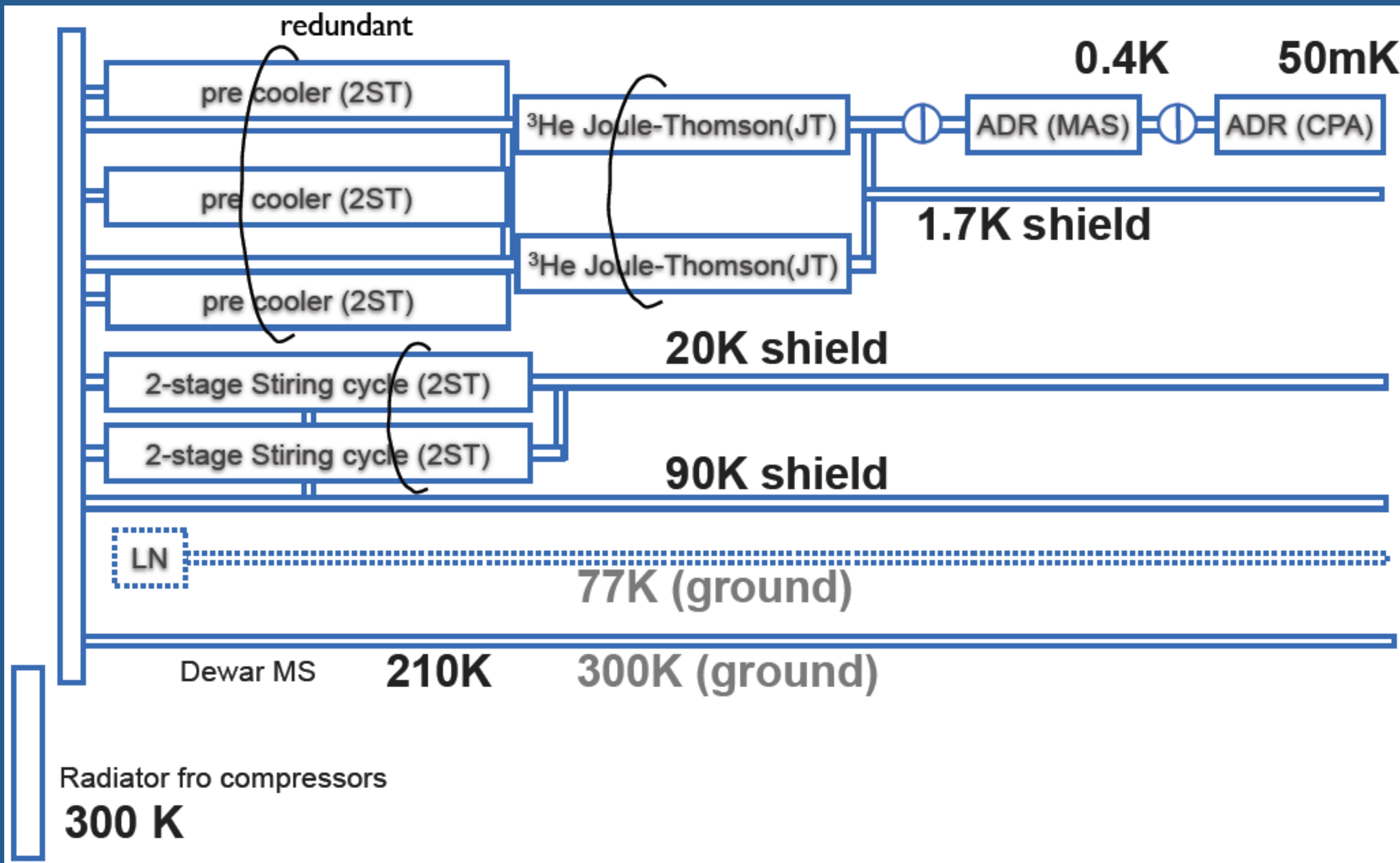
Use of cryocoolers in space continues to expand.

- Numerous approaches trade-offs to be made based on expected heat loads and required degree of reliability

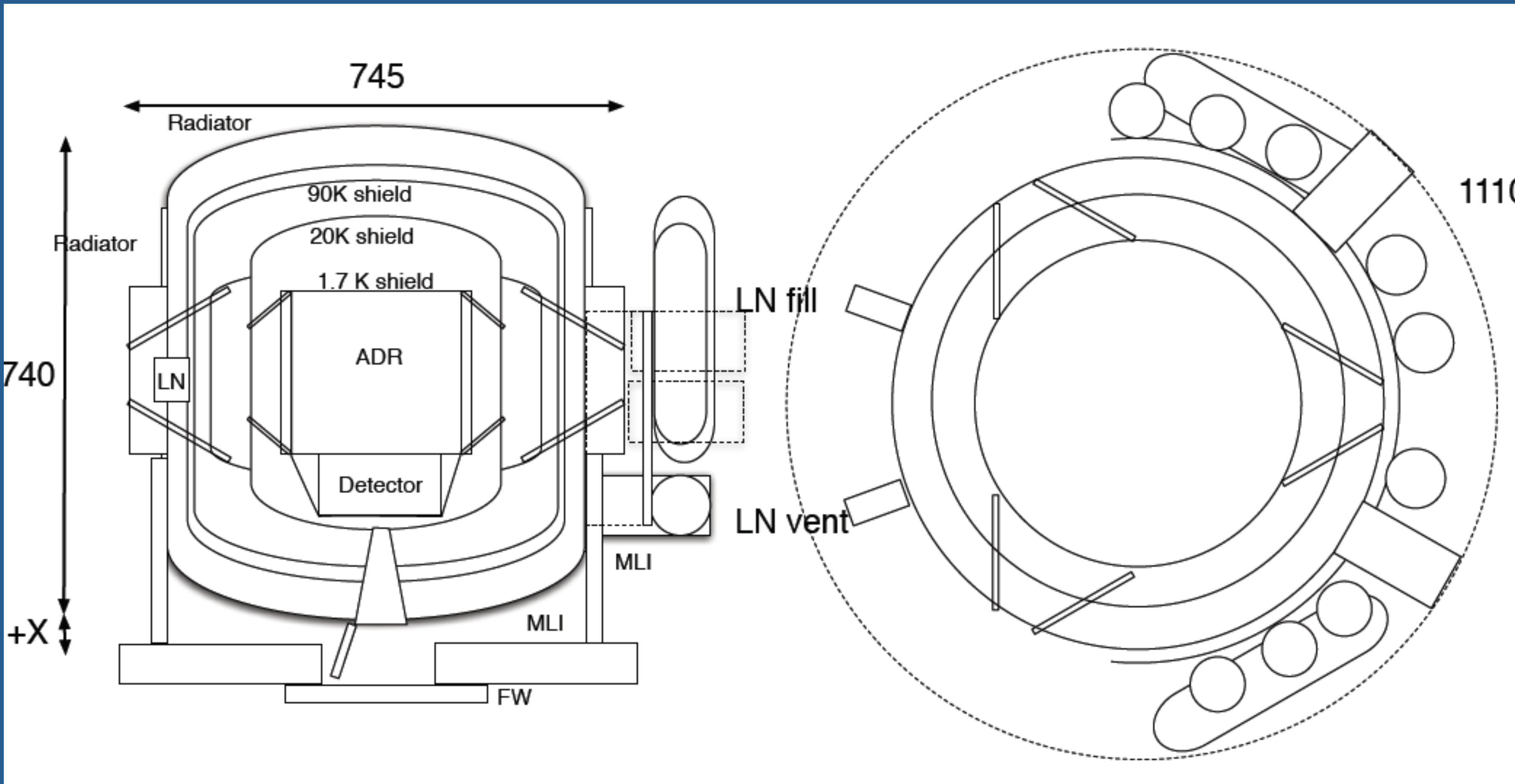
Excellent presentations at IWG Meeting on Tuesday, January 27 by:

- Lionel Duband – overview in Europe
- Ali Kashani – overview in US
- Ryuichi Fujimoto – overview in Japan

Dewar approach for ESA Studies



ESA/JAXA dewar (ISAS/SHI design)



M = 280 kg (without design contingency)

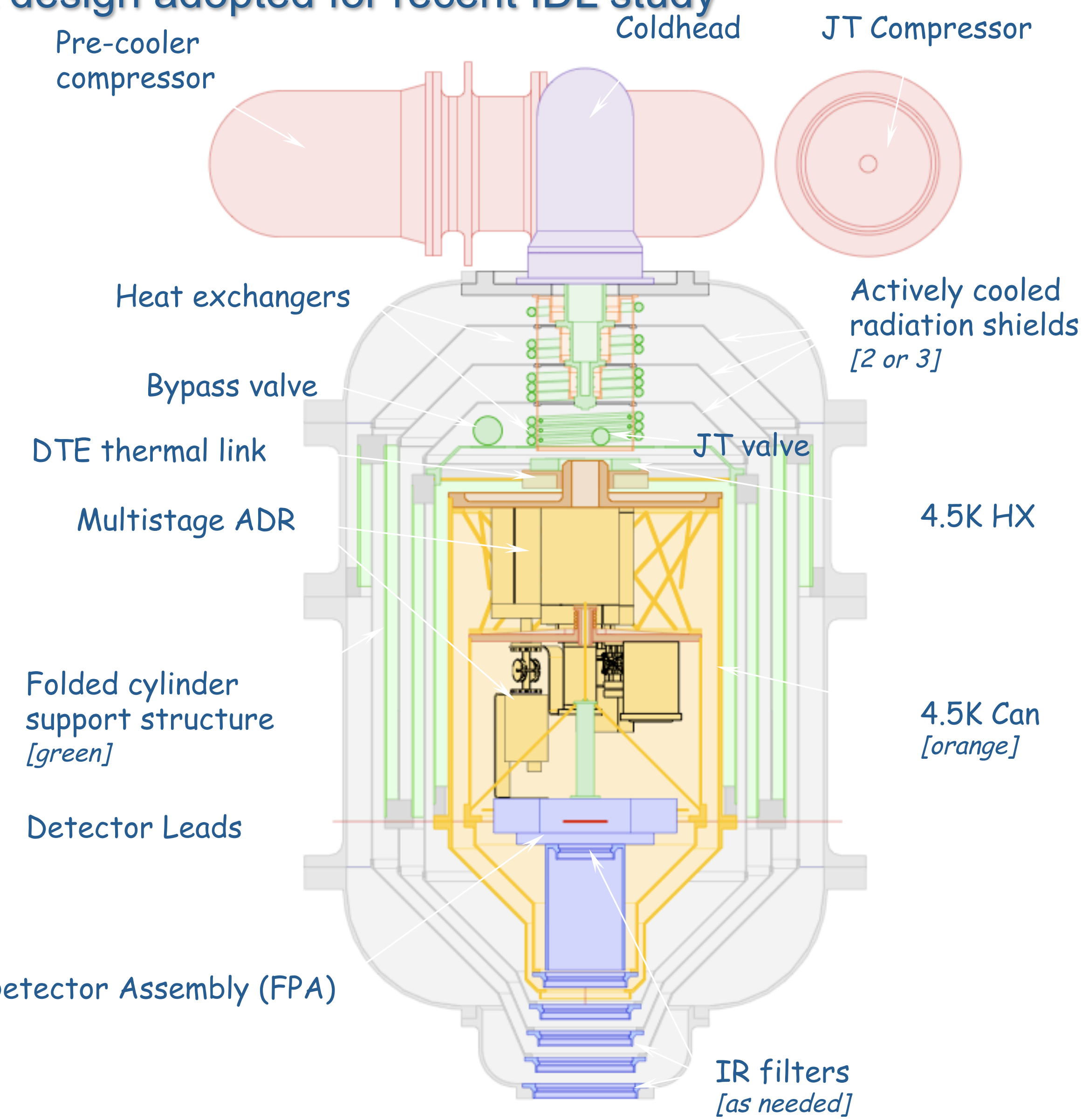
Cryostat design adopted for recent IDL study

-Representative hybrid design to
cover US and Japanese vendors

- PT or Stirling coldhead: radiation
shields to match cold stages (3 or 2)

- Compressors shown floating:
mounting to cryostat or
elsewhere vibration dependent

- Drop-in 4.5K can with ADR and FPA



Estimated Mass:

257 kg, including instrument electronics (without design contingency). Mass of dewar and cooler drive electronics = 190 kg.

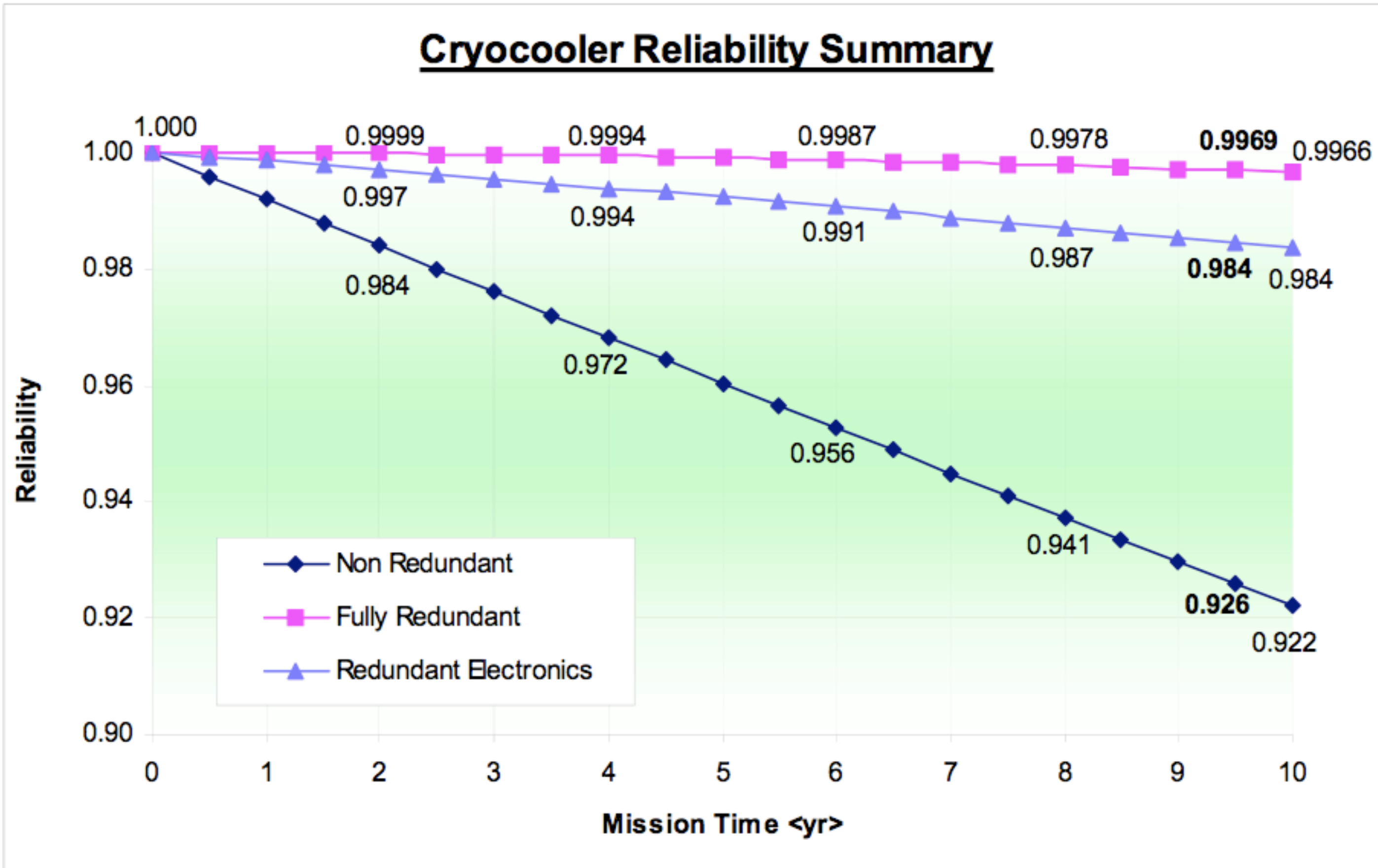
Power:

Operating		
	Average	649 W
	Peak	709W
Standby		215 W

Data Rate Requirement:

Average	41 kbps
Peak	1680 kbps

NGST Reliability (Pulse Tube Pre-Cooler)



Single-String System	10 Year Reliability
Cryocooler	0.9223
Cryocooler Control Electronics	0.9355
Mechanical Assembly	0.9858

Estimating through Geant4 and ad-hoc ray tracing simulations the residual background to be expected

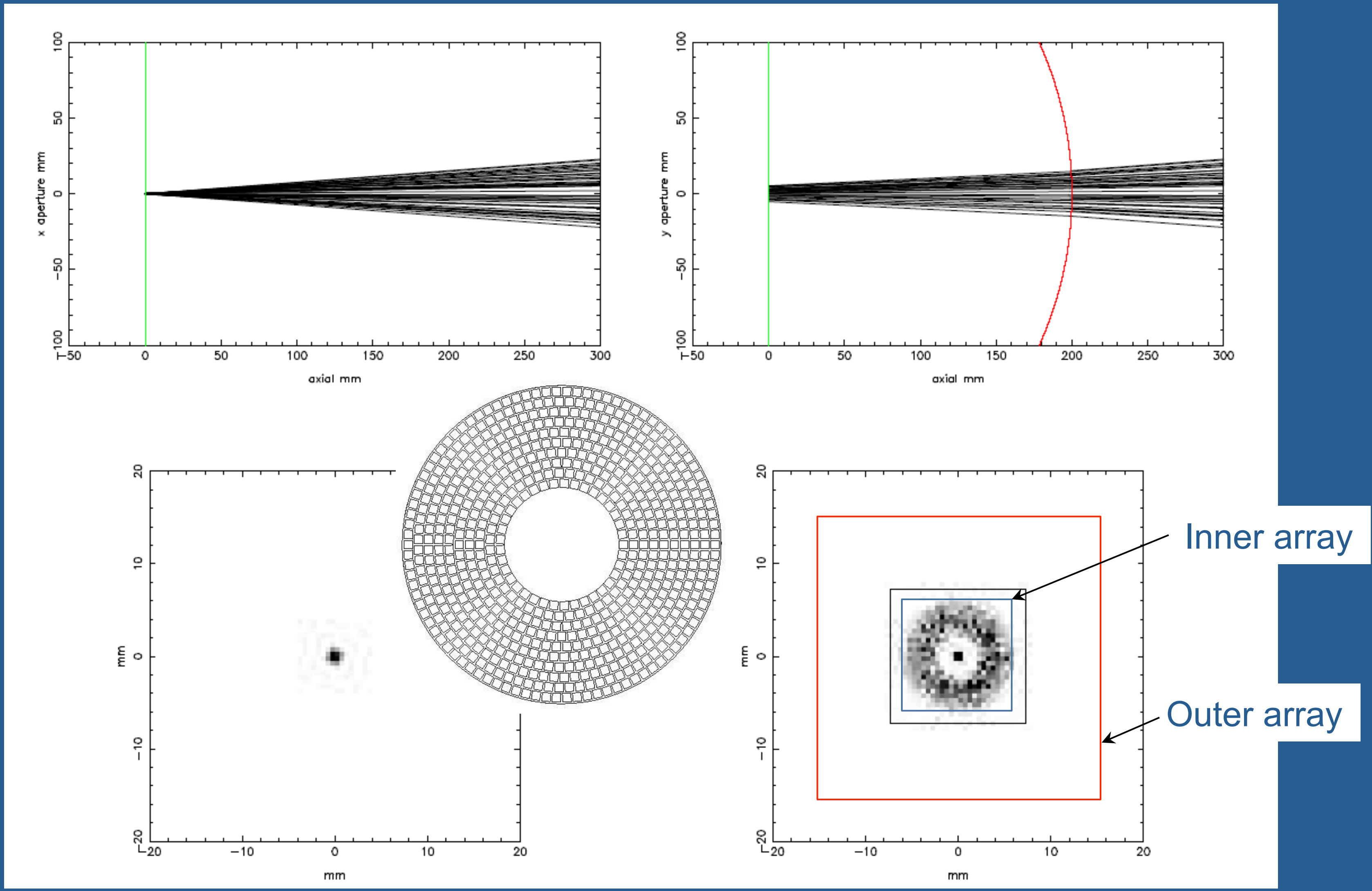
E. Perinati

on behalh of the IXO italian team at INAF, INFM, IFN and TAS

Outline

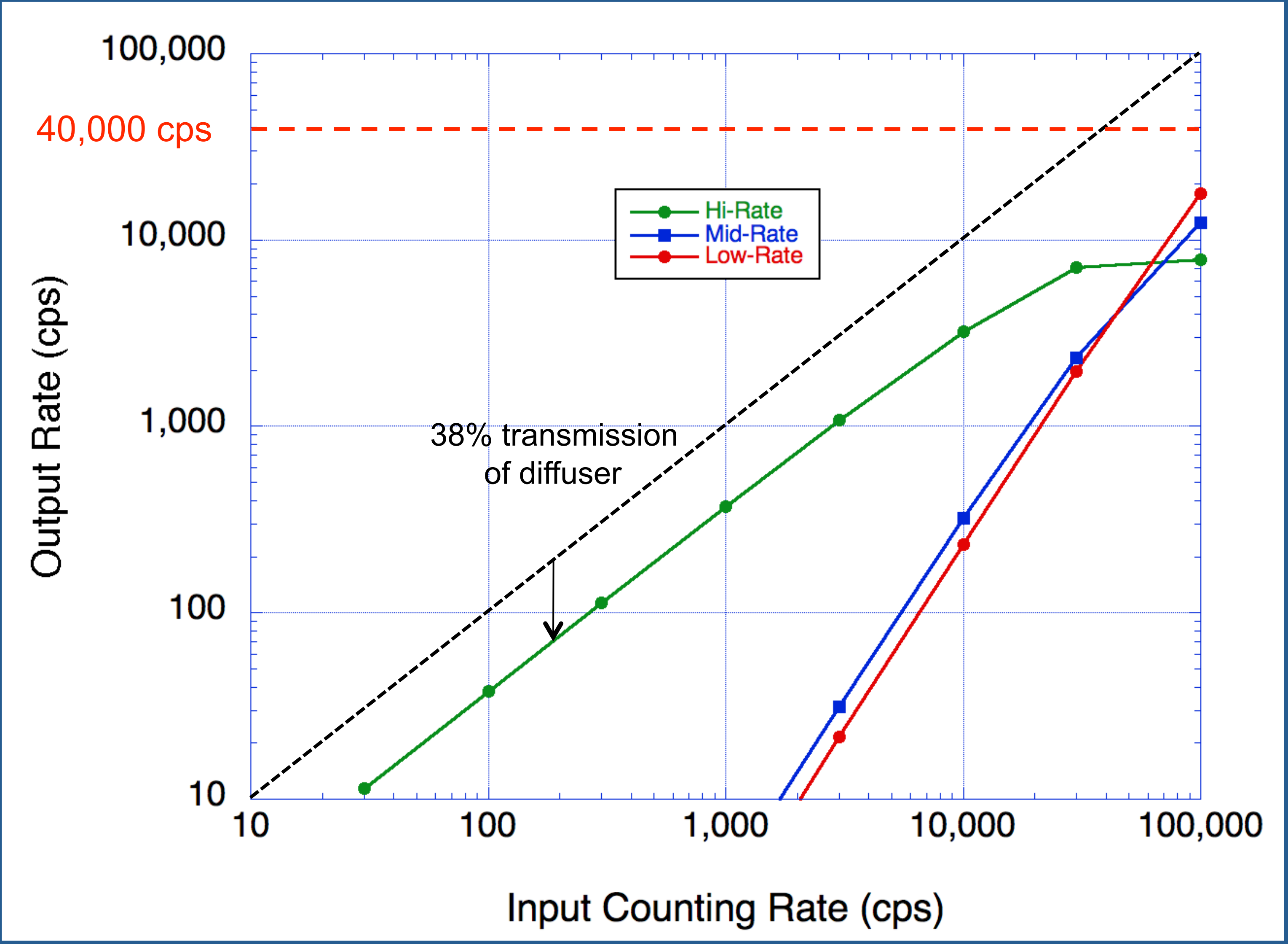
- IXO/XMS: modeled geometry and cosmic NXB rates in L2
- ACD efficiency and residual background on TES (preliminary results of G4 simulations)
- Comparison with Suzaku/XRS background data
- Summary & next steps

Bright Source Diffuser – Slumped Micro Channel Plate (MCP)

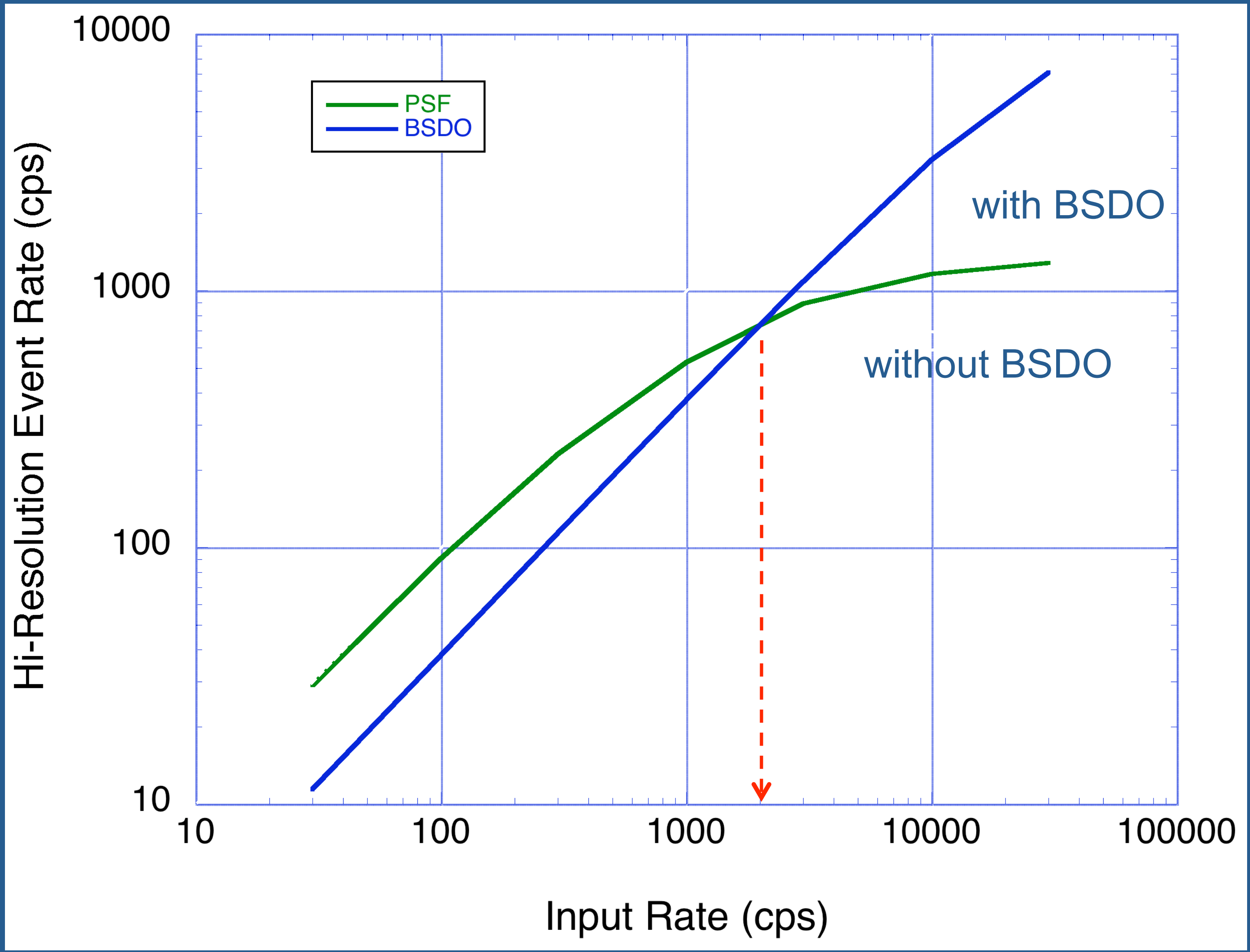


R. Willingale 2008

Output Rates vs. Input Rate with Diffuser



Comparison *of Hi-Res* Event Rate with and without Diffuser



TES Calorimeters Issues Discussed at IXO TES Meeting

TES

- Control of T_c reproducibility
- Diffusion (need for high thermal conductance absorbers)
- Different apparent heat capacity SRON and GSFC devices
- Different apparent electrical and thermal cross-talk in SRON and GSFC devices
- Energy resolution under different bias conditions (e.g., AC vs. DC)
- Detector models: Unaccounted for noise, heat capacities
- Drift and stability issues; Sampling rate issues
- Background effects; estimated background rates; how to reduce secondaries
- Heat-sink temperature-stability under background radiation (e.g., tests)
- Issues associated with different readout schemes – time division, frequency division, other techniques based on time division.

Multiplexed read-out

- Performance limits for TDM and FDM (scaling laws); other approach (e.g., code-division)
- System stability issues (need for parallel calibration Signals)
- SQUID switching under itching
- Detector assembly issues: how to get all those leads out, heat sinking, magnetic shielding (B-sensitivity)
- Electronics – power, speed issues, parts availability

Requirements for PDD and upcoming Decadal Survey documents; *Presentations will soon be on GSFC IXO website.*

Acknowledgements – IXO TES Calorimeter Participants

Germany - Joern Beyer

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USA – GSFC - Joe Adams, Jay Chervenak, Mike DiPirro, Megan Eckart, Fred Finkbeiner, Richard Kelley, Caroline Kilbourne, Scott Porter, Peter Shirron, and Stephen Smith