# Possible options for XEUS secondary microcalorimeter array and TES microcalorimeter development in Japan

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# Possible options

- Primary high resolution spectrometer
  - ~32x32 = 1024 pixels, 250μm x 250μm/pixel
  - resolution ΔE ~ 2 eV in 0.3 - 10 keV band
- Secondary high resolution spectrometer

  ~32x32 = 1024 pixels

1. Wide field of view with degraded energy resolution
   - ΔE ~ 10 eV but > 1mm x 1mm /pixel → still too narrow (?)
2. Low energy band with better energy resolution
   - ΔE < 1 eV in 0.3 - 1 keV
3. Wide-band (hard X-ray) spectrometer
   - ΔE < 40 eV in 0.3 - 100 keV, ~1mm x 1mm /pixel
4. Combination of the above options

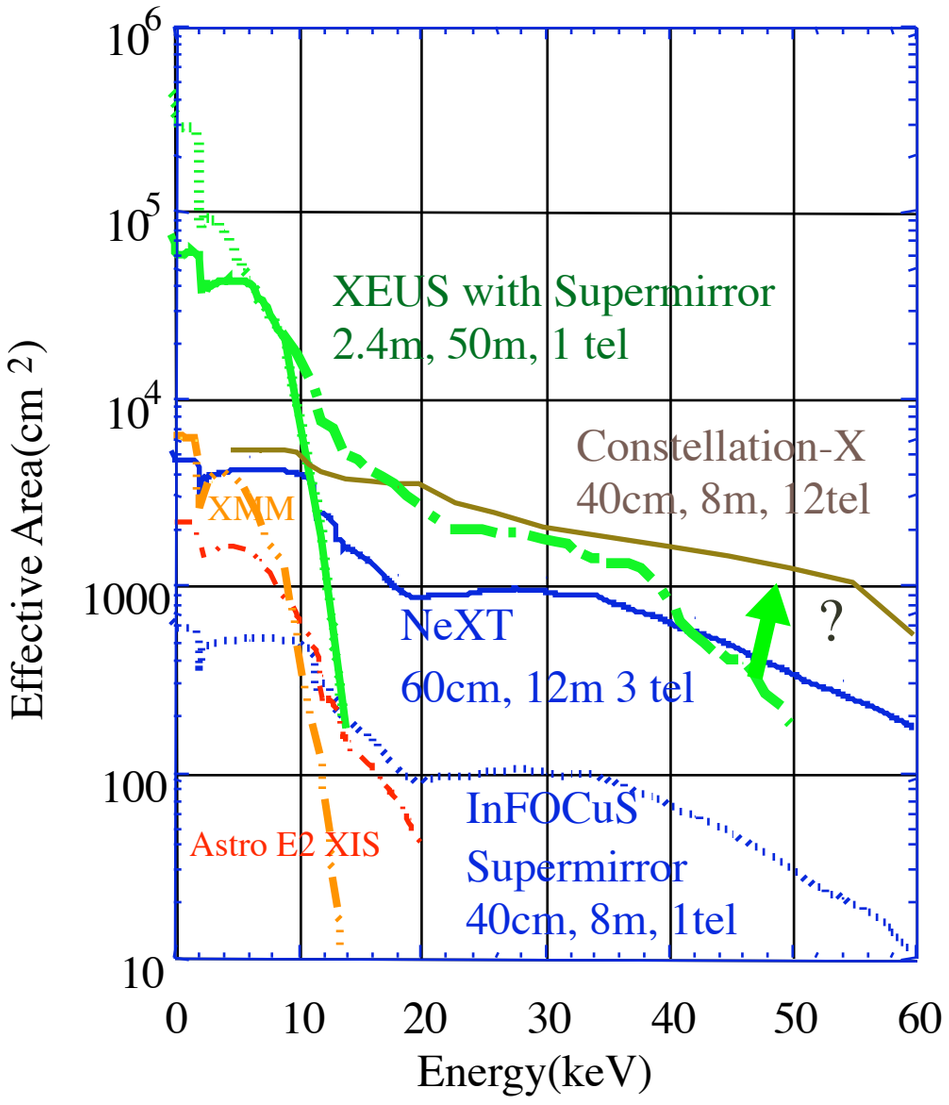
# Low energy options

- With thin X-ray absorbers, good energy resolution can be achieved with TES
  - Energy resolution of TES microcalorimeters

$$\Delta E \propto \sqrt{E_{sat} T} \leq 1\text{eV for } E_{sat} = 1\text{keV},\ T = 100\text{mK}$$

- Science
  - Emission lines from high red-shift objects
  - Absorption line forest in quasar spectra

# Wide energy-band options

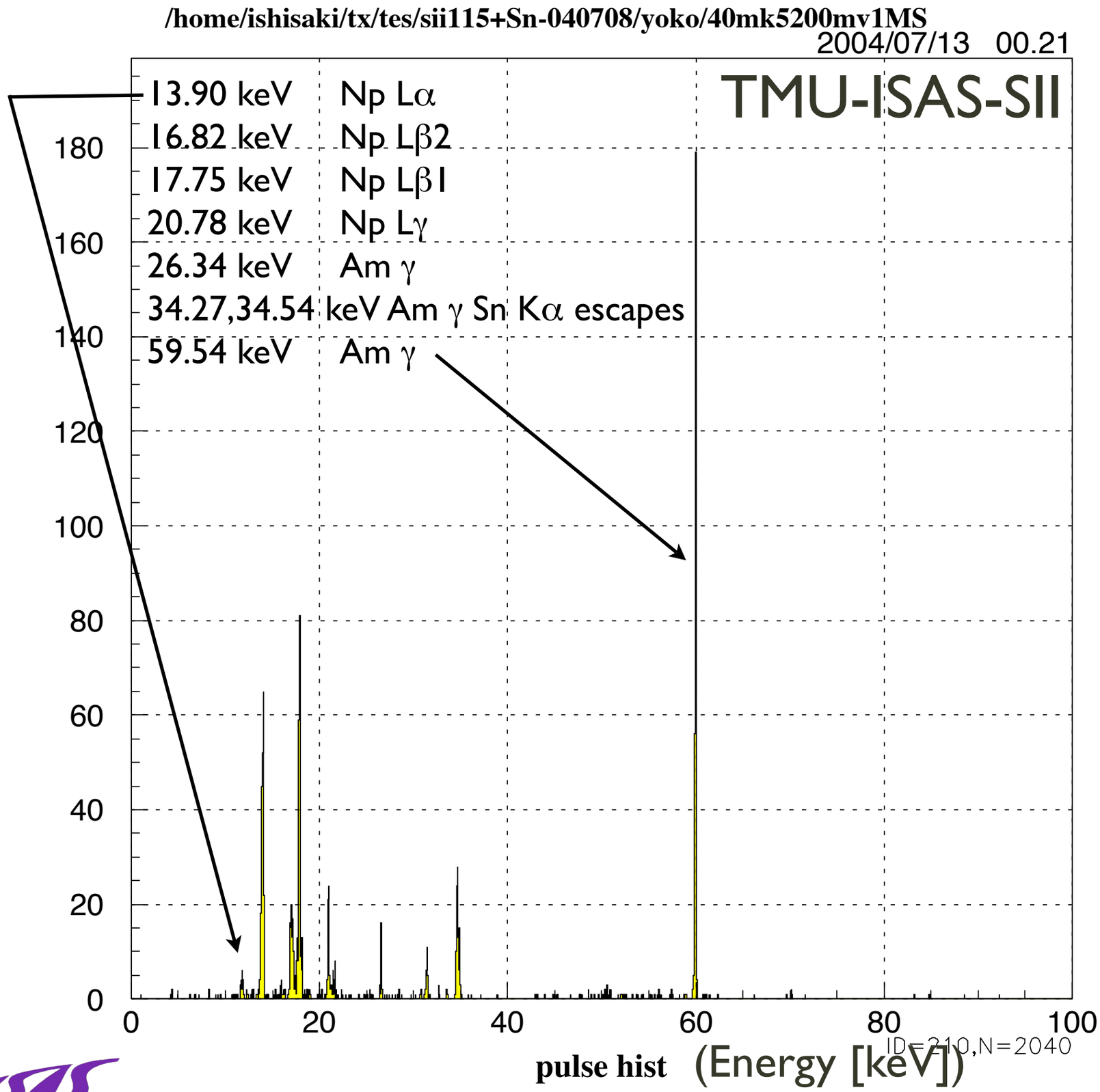



- Multi-layer coated XEUS super mirror
  - 2000 $cm^2$ up to ~ 40 keV
    can be extend to higher energy (?)

- Science
  - Soft Gamma-ray emission lines
    - e.g. $^{44}Ti$ from SNR
  - Cyclotron absorption lines

not so many interesting objects (?)

# Our 1st trial of wide-band TES calorimeter




ΔE=160 eV @ 60keV was obtained with our very first device

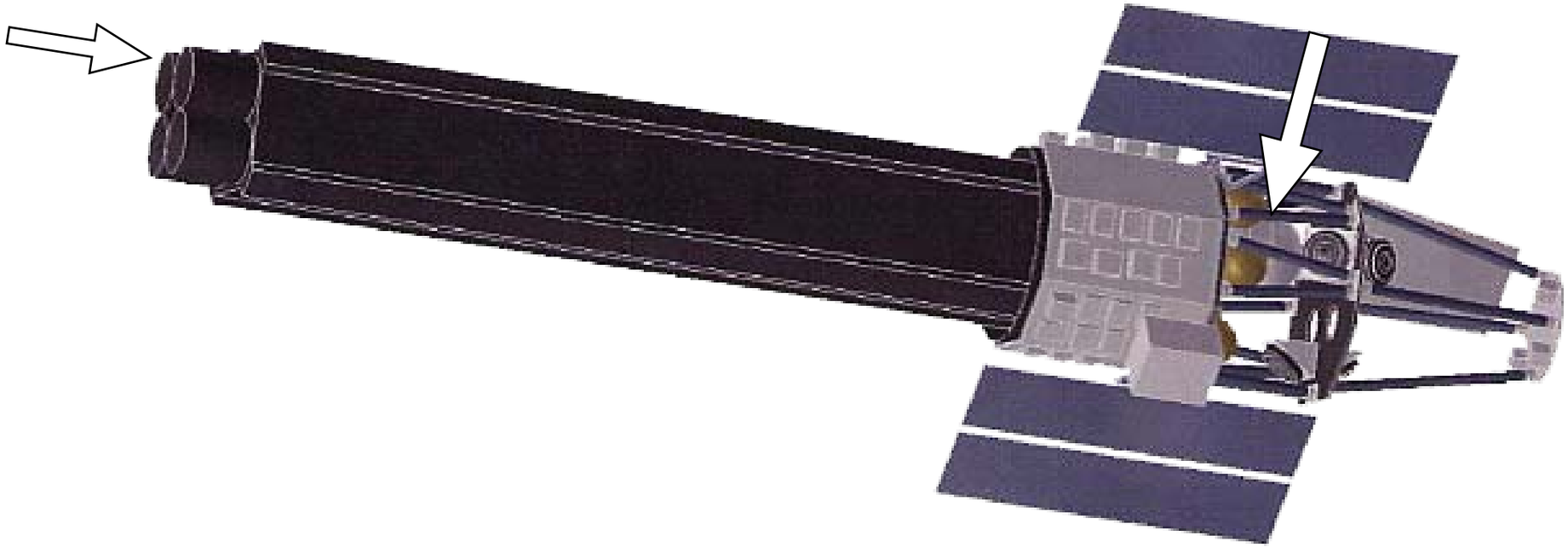
Absorber:

- Tin
- 0.9 mm x 0.9 mm
- 300 μm

# Development of TES calorimeter array for the NeXT mission

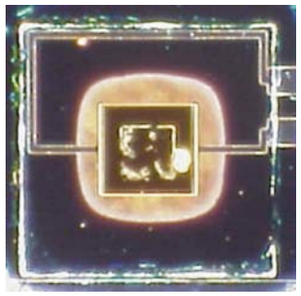
Soft X-ray Telescope
(60cmϕ, 9m FL)

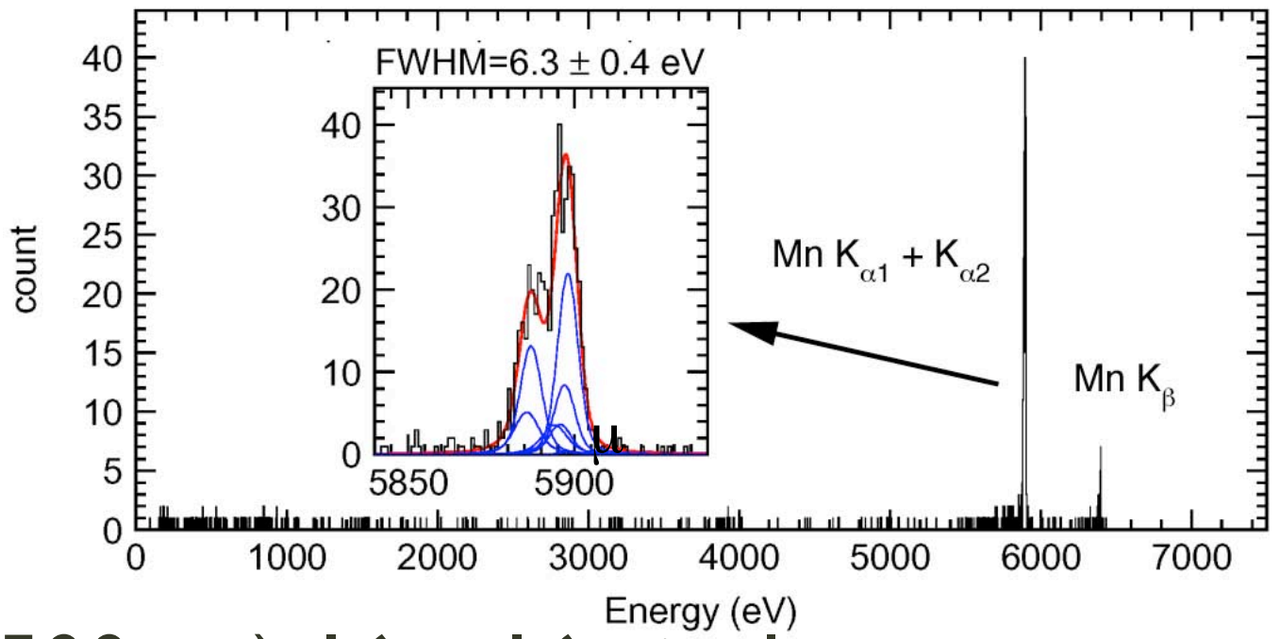
Soft X-ray Spectrometer



# TES calorimeter array

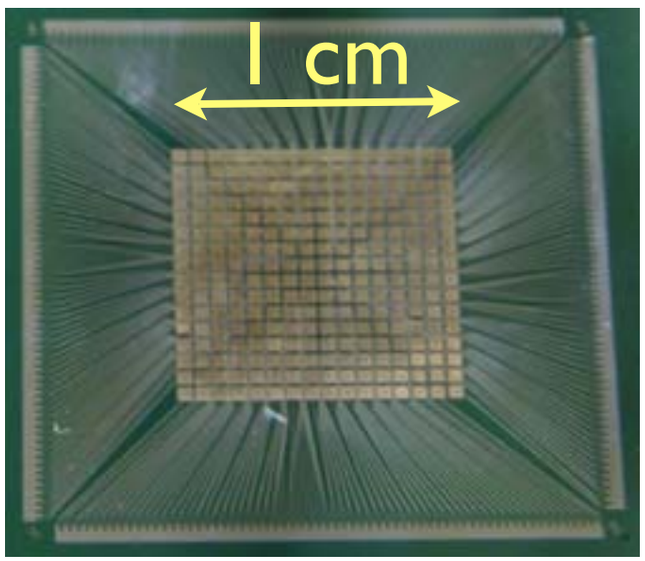
## Small-absorber (180μm) calorimeter






Ishisaki et al. 2004

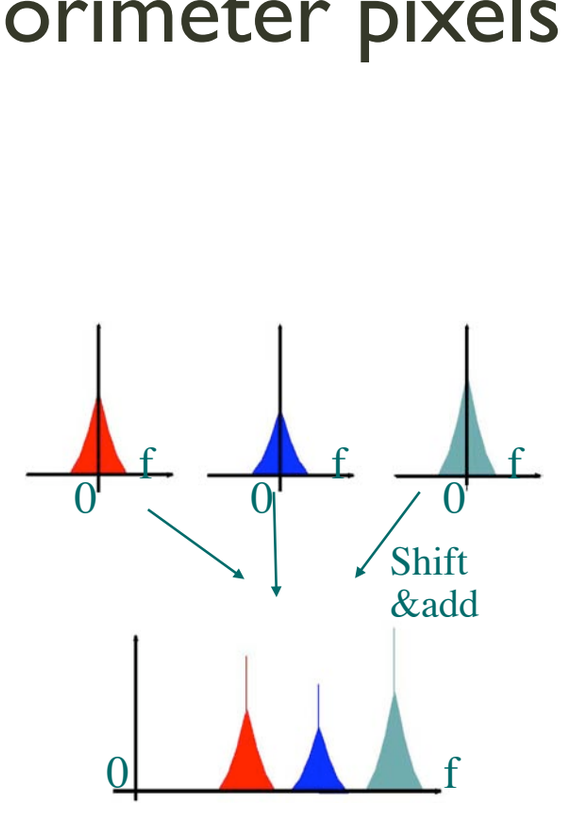
## Large-absorber (500μm) 16 x 16 pixel array (a prototype of SXS array)



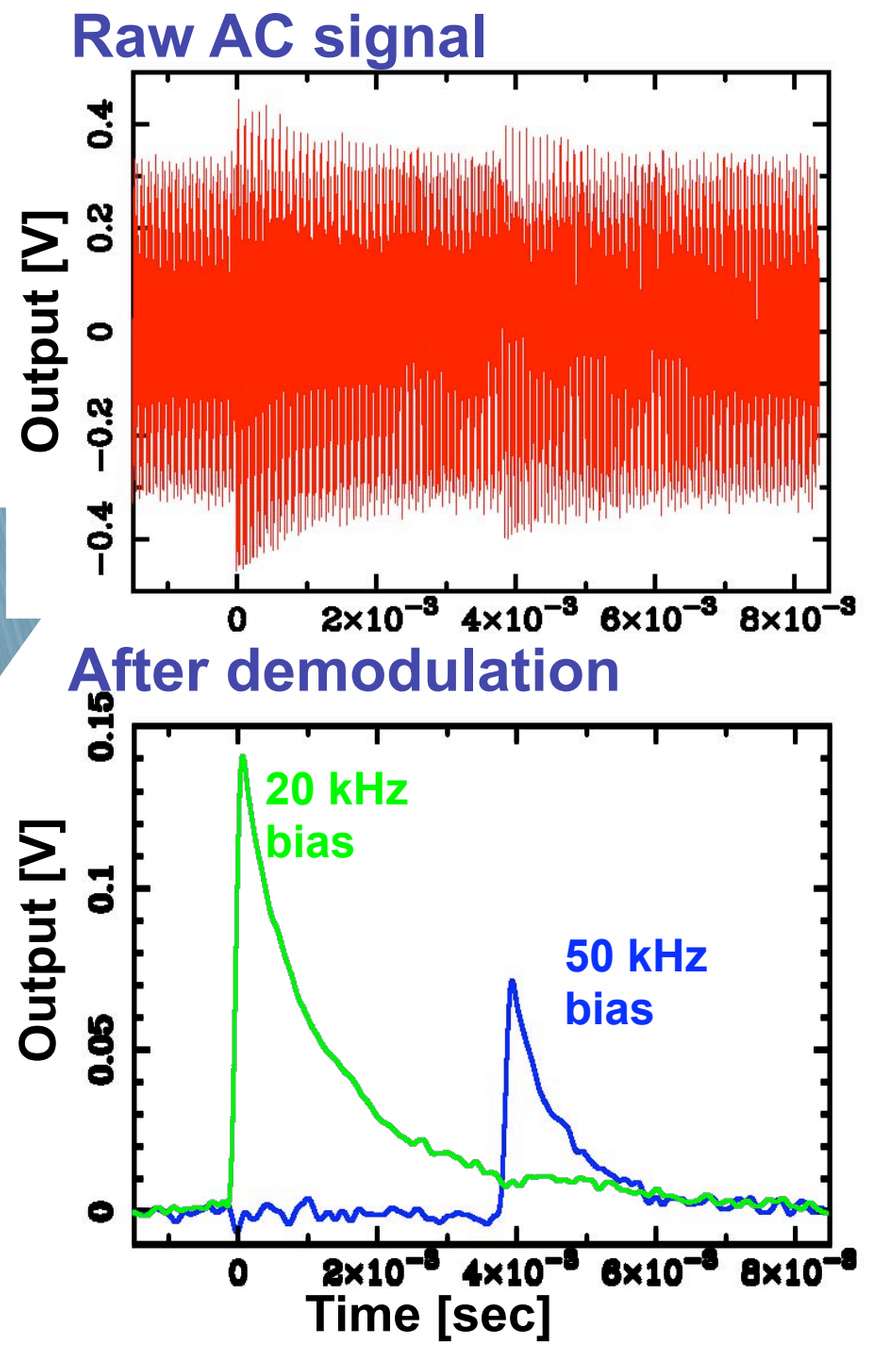

still 28 eV@5.9 keV with a calorimeter of the same absorber size

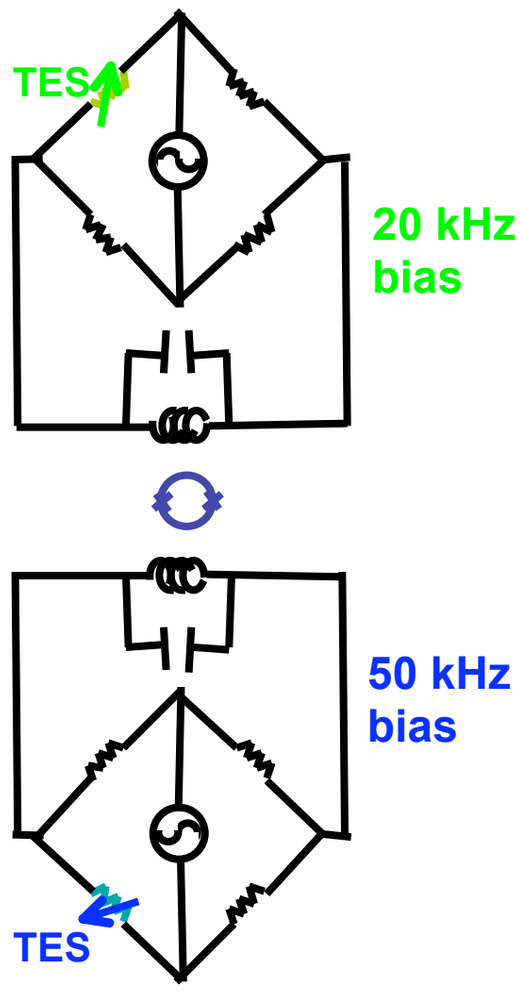
# Low temperature signal multiplexing

demonstrated frequency-division multiplexing of two calorimeter pixels.



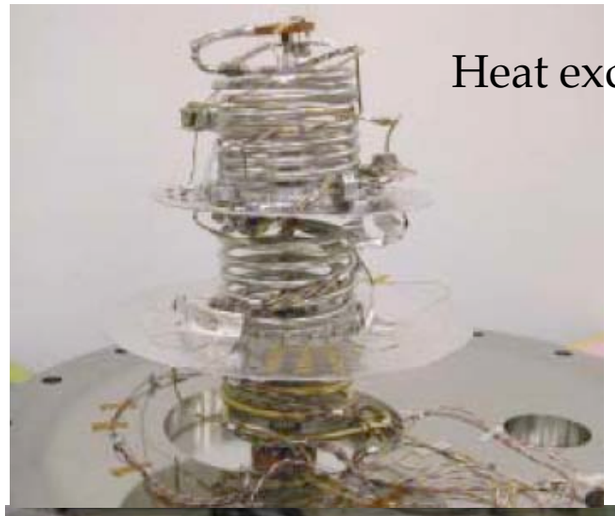

Iyomoto et al. 2004

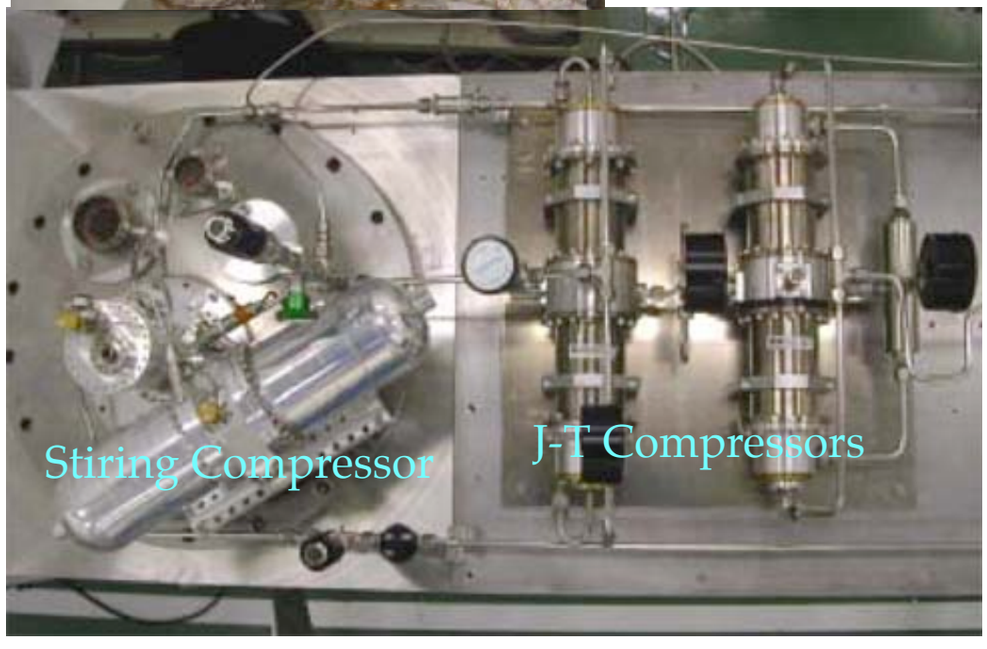


# Cryogenics

## J-T cooler (10mW @ 1.8 K)




Narasaki et al. 2003

## ADR ($T_{lowest}$ = 40mK)