Position-Sensitive Imaging Detectors

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Outline

- General principles and Design Constraints
- Applications
- Superconducting tunnel junctions
- Kinetic Inductance Detectors
- Microcalorimeters
- Large-format arrays

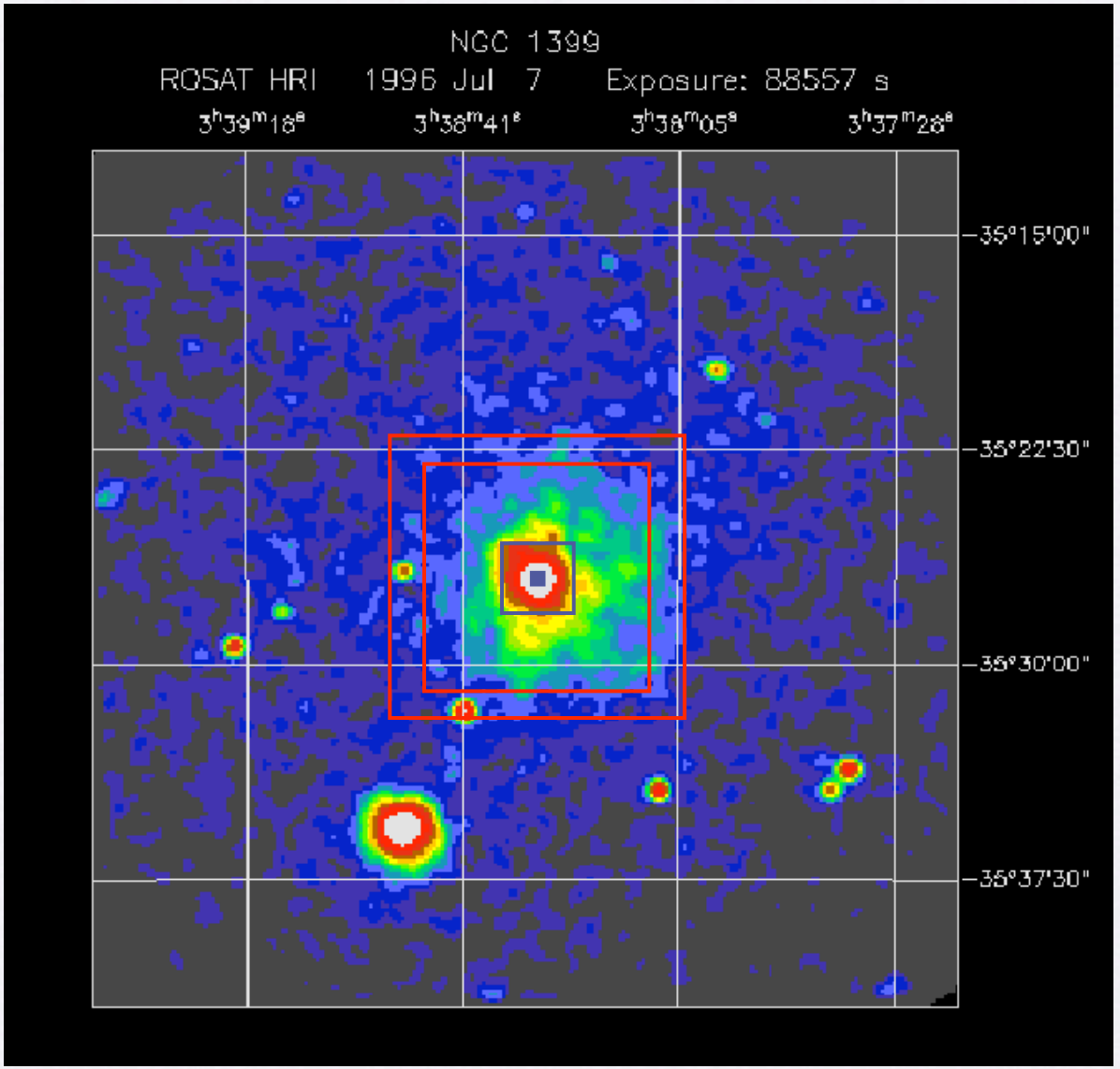
General Principles

- A position-sensitive detector has an absorber that exhibits position dependence.
- Pulse shape variations are used to determine absorption position
- 1-, 2-, or 3-Dimensional designs are possible

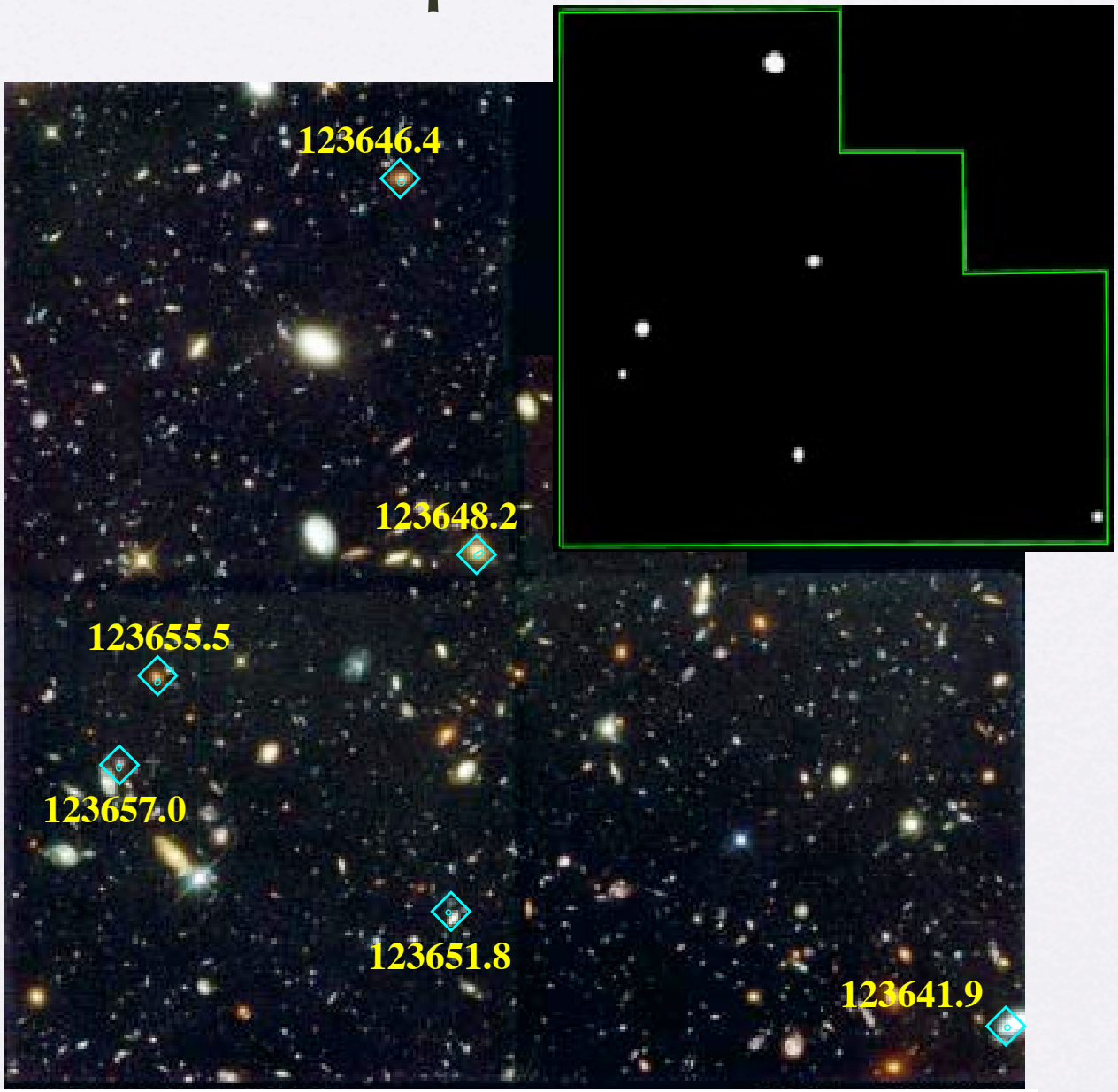
Design Constraints

- We want as large an absorber as possible, but
  - Maximum Count Rate goes down as absorber area increases
  - Energy Resolution degrades from losses or larger heat capacities
- A Hybrid design implementing a high throughput single-pixel central array may offer the best compromise.
- A good application for position-sensitive detectors is one that requires a large number of pixels, has a low count rate, is single-photon counting, and needs good energy resolution.

Astronomy:
The near universe



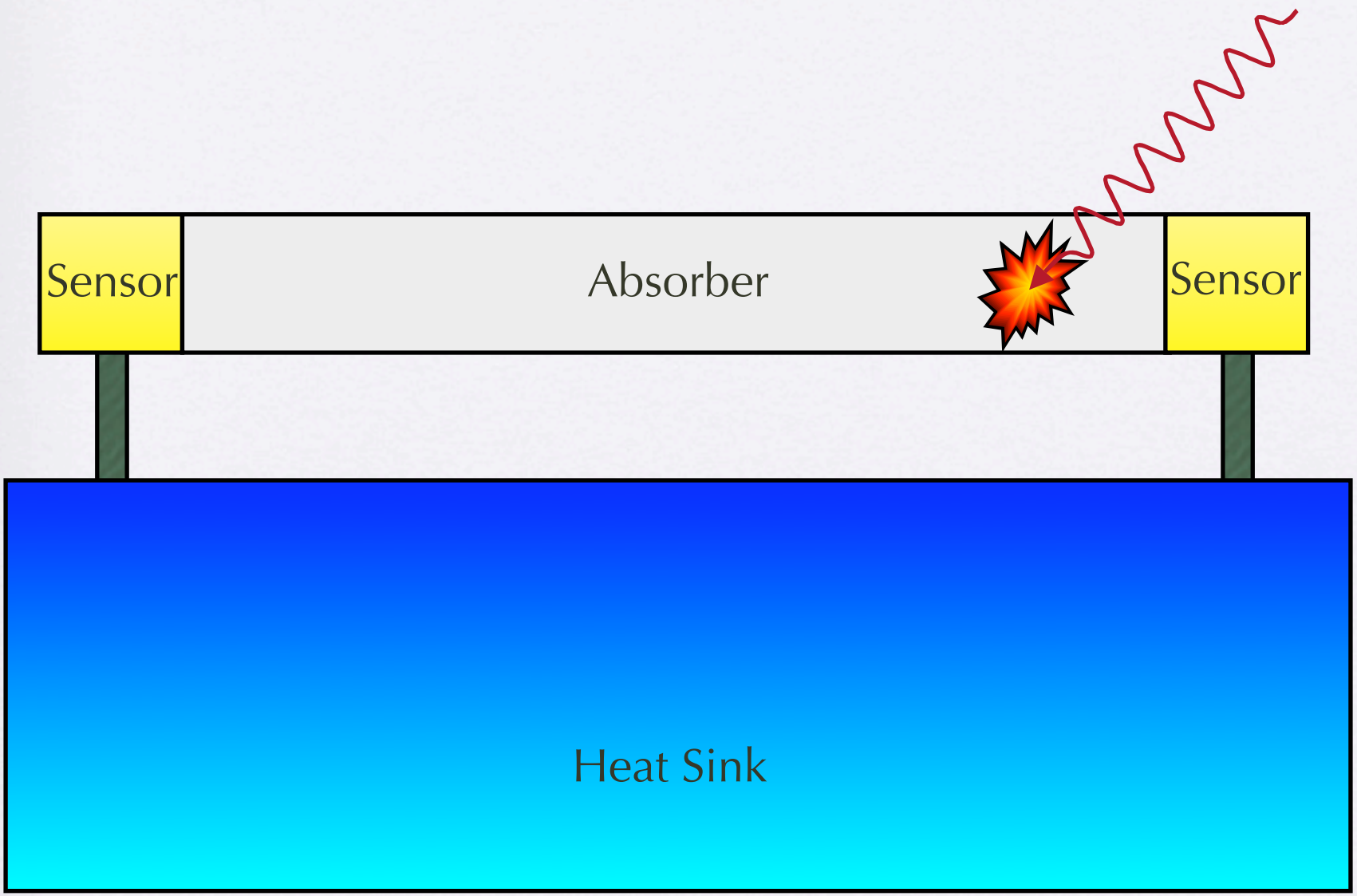
Astronomy:
The deep universe



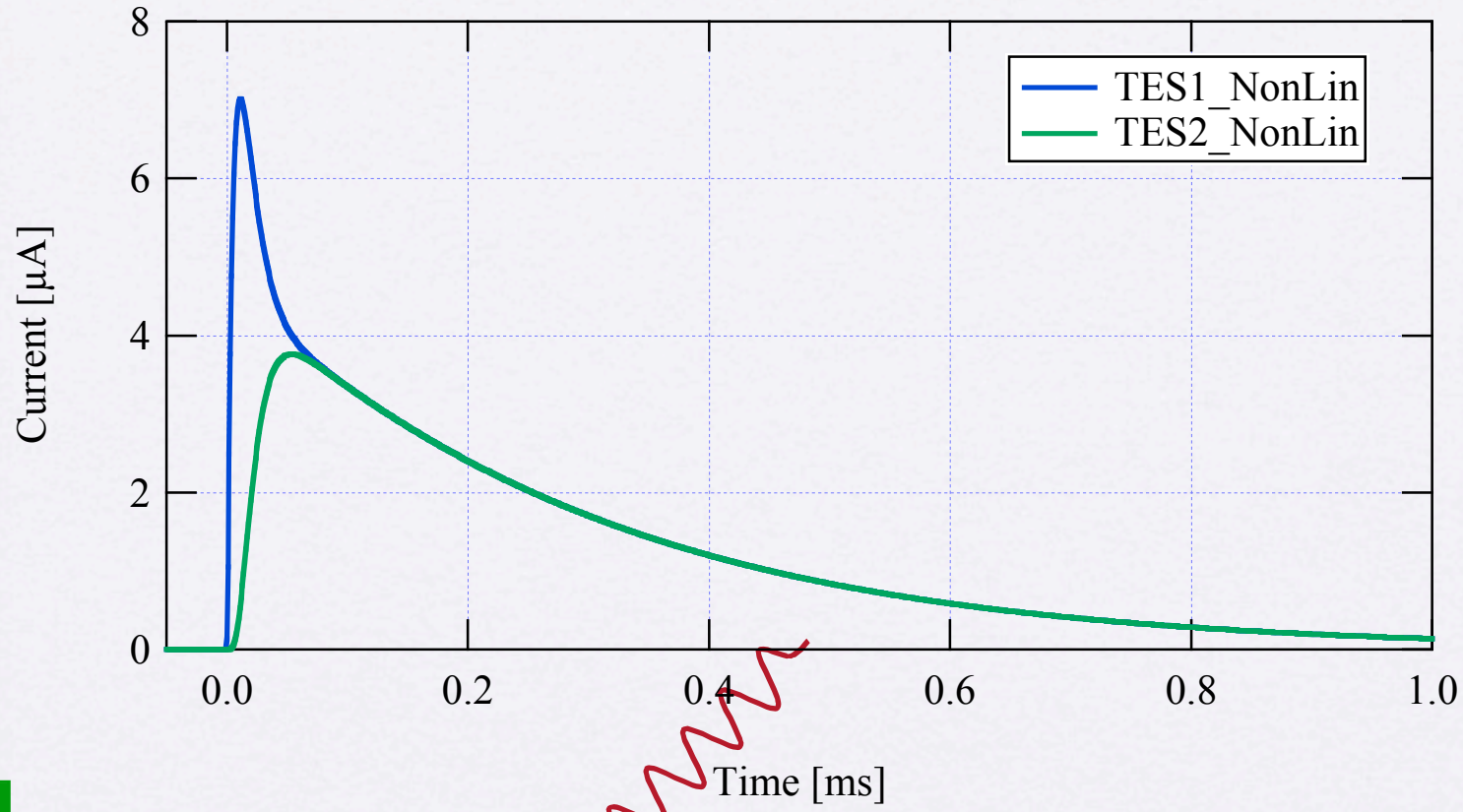
Number of Pixels for different configurations

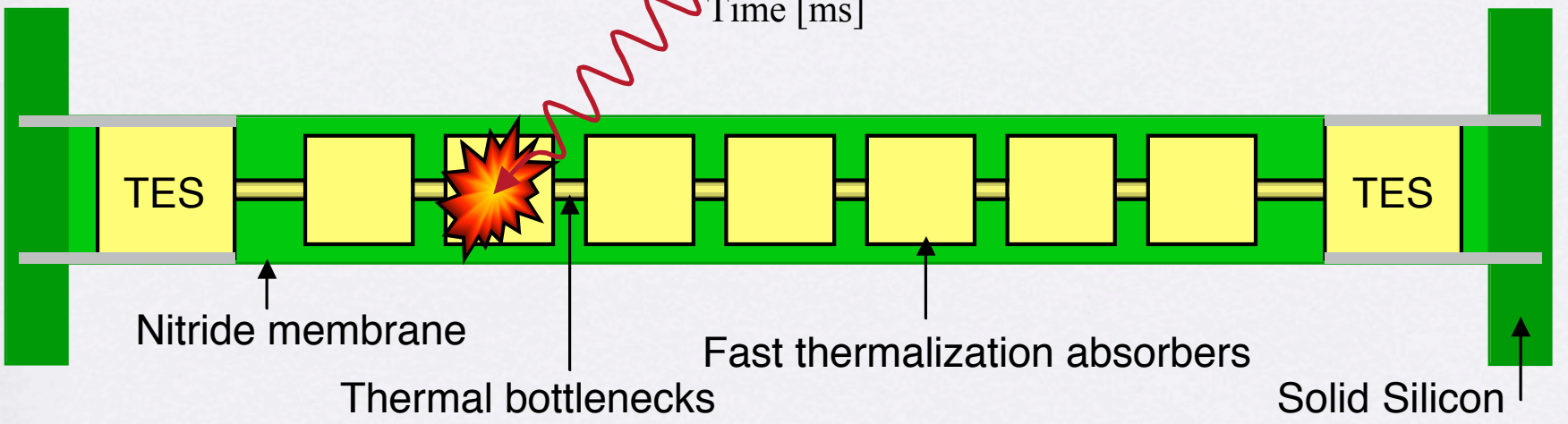
Field of View	1″ pixels	5″ pixels
0.5′	900	36
2.5′	22.5k	900
5′	90k	3.6k
10′	360k	14.4k
20′	1.44M	57.6k
Focal Length for 250 μm pixels	50 m	10 m

Microcalorimeters

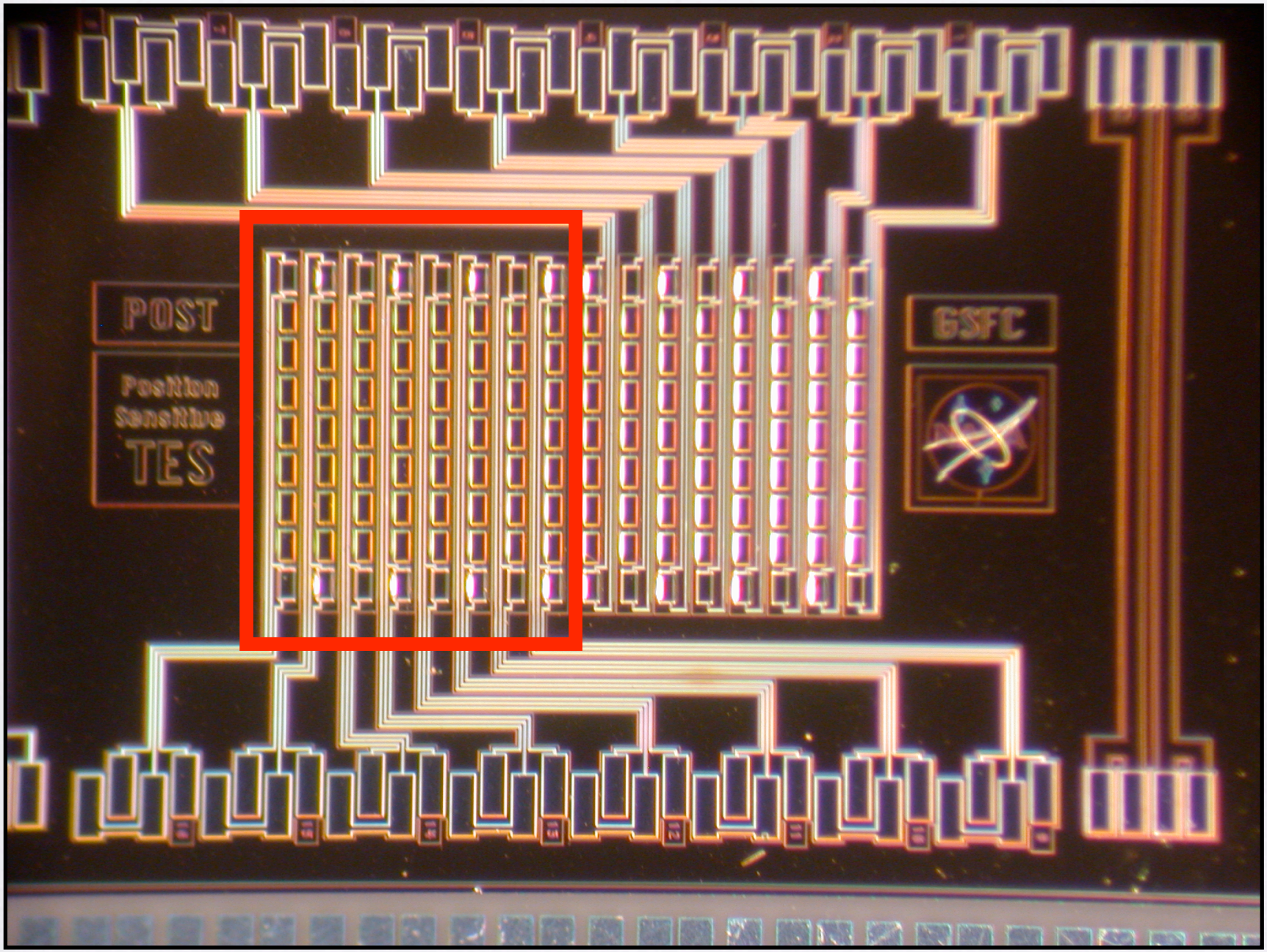


GSFC PoSTs

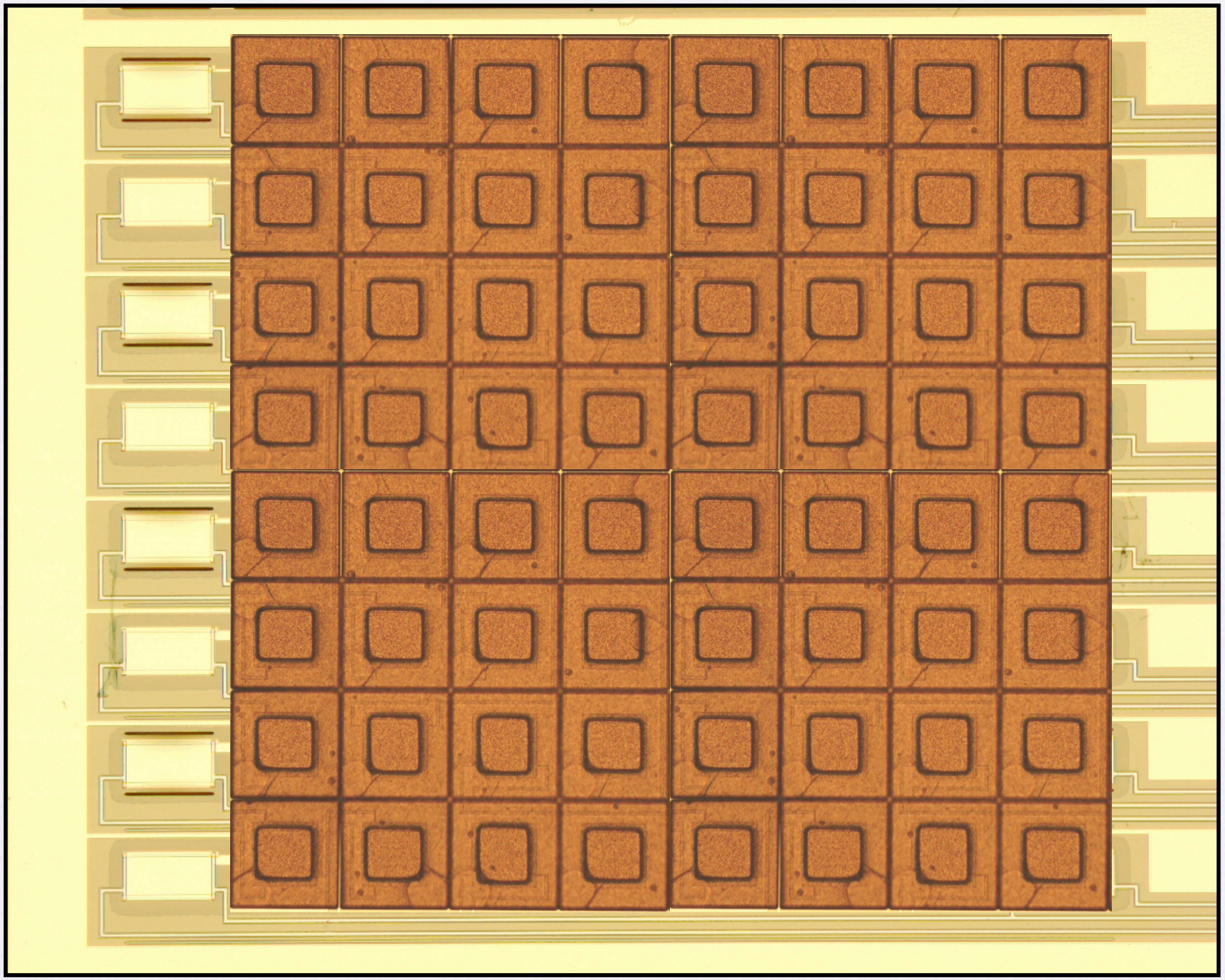

TES1_NonLin
TES2_NonLin
Current [μA]
Time [ms]
0
2
4
6
8
0.0
0.2
0.4
0.6
0.8
1.0


TES
TES
Nitride membrane
Thermal bottlenecks
Fast thermalization absorbers
Solid Silicon

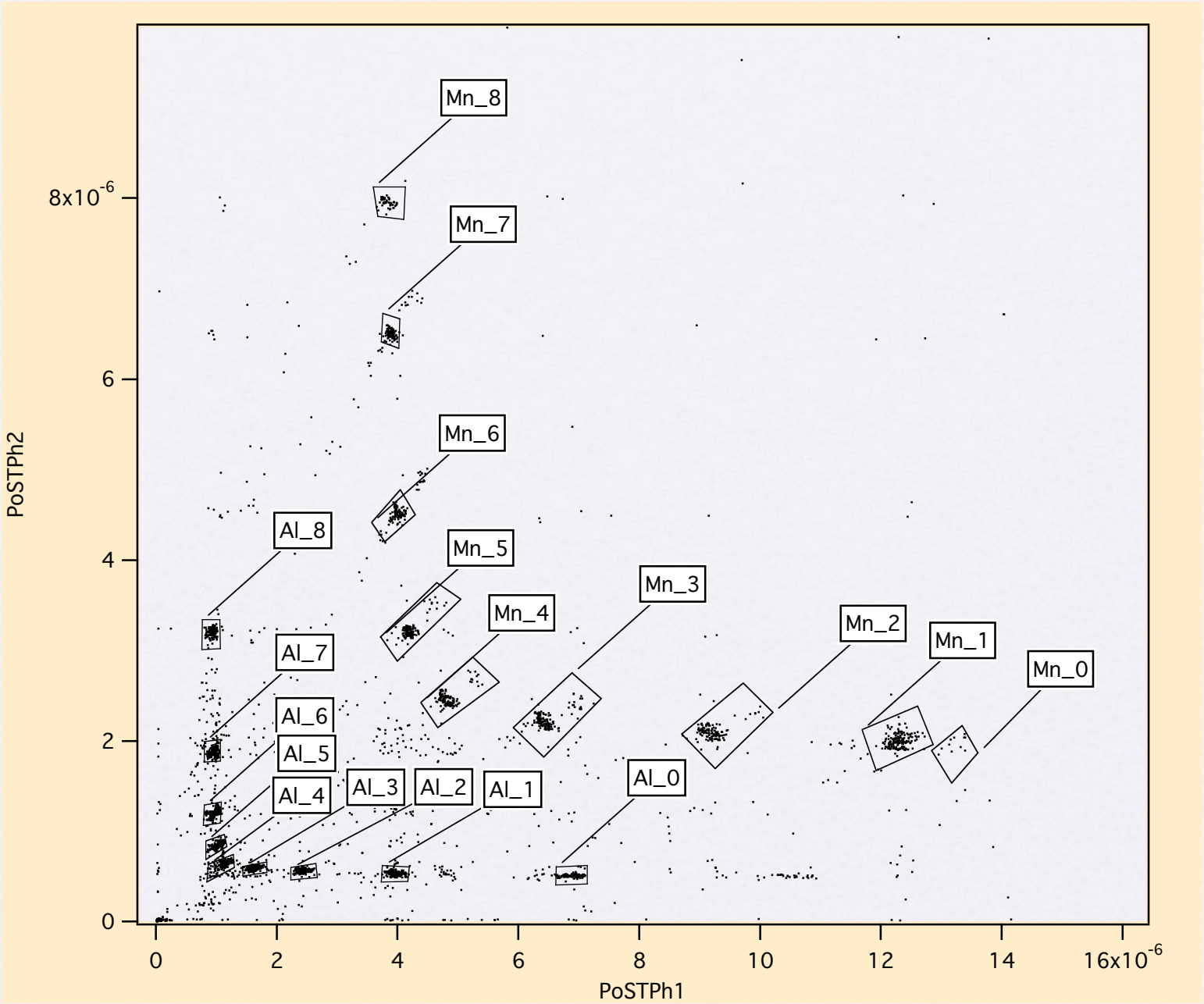
16x9 PoST array



zoom of half the array



First data from new devices



Initial Results

PoST Pixel	Predicted	Baseline	1.5 keV
0 (1st TES)	2.11	7.8	n/a
1	2.25	10.6	51.6
2	2.28	11.9	25.6
3	2.29	11.6	21.1
4	2.29	11.8	18.3
5	2.29	11.7	20.9
6	2.28	11.7	18.0
7	2.25	10.5	42.3
8 (2nd TES)	2.11	8.77	59.4

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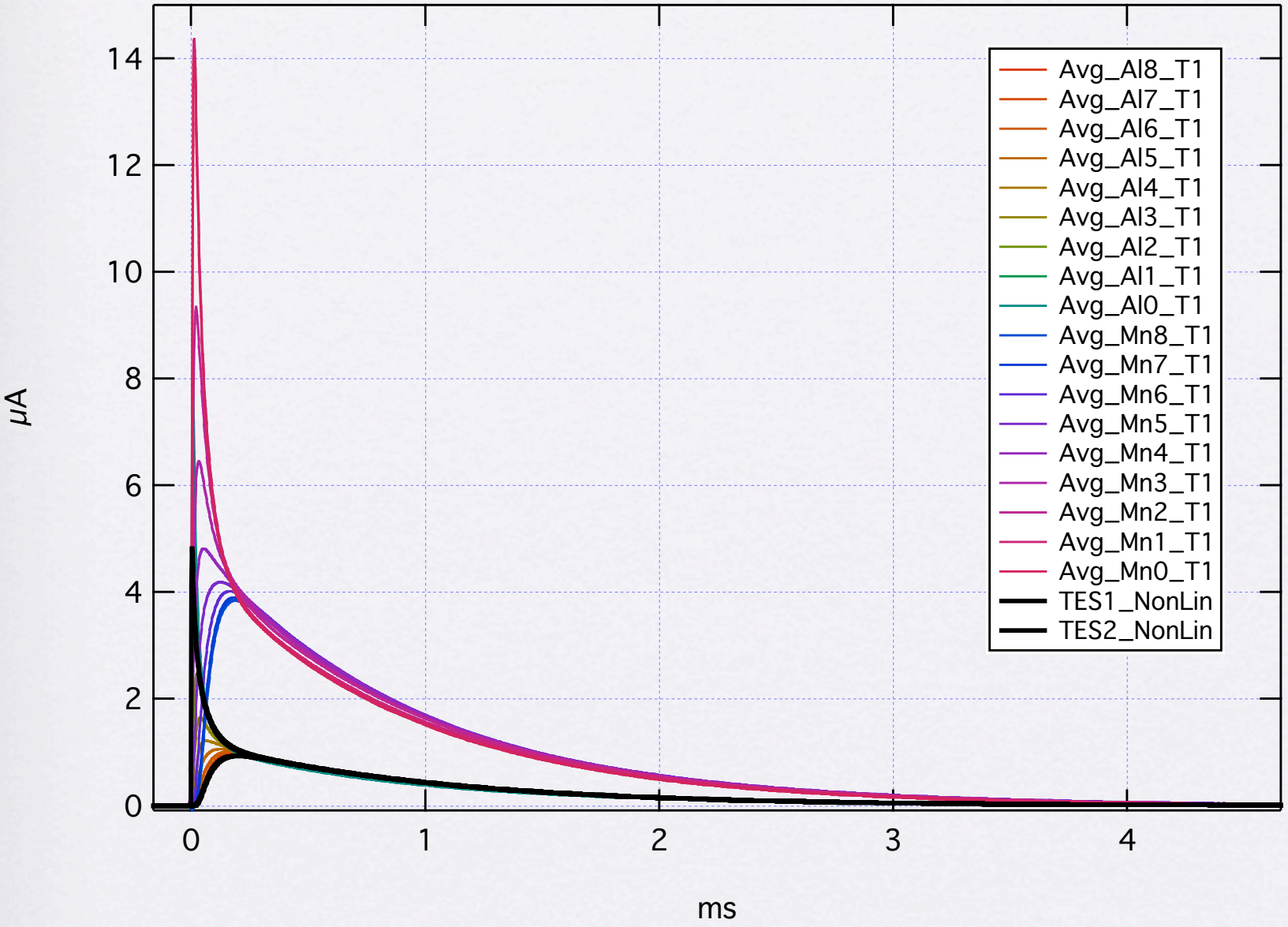
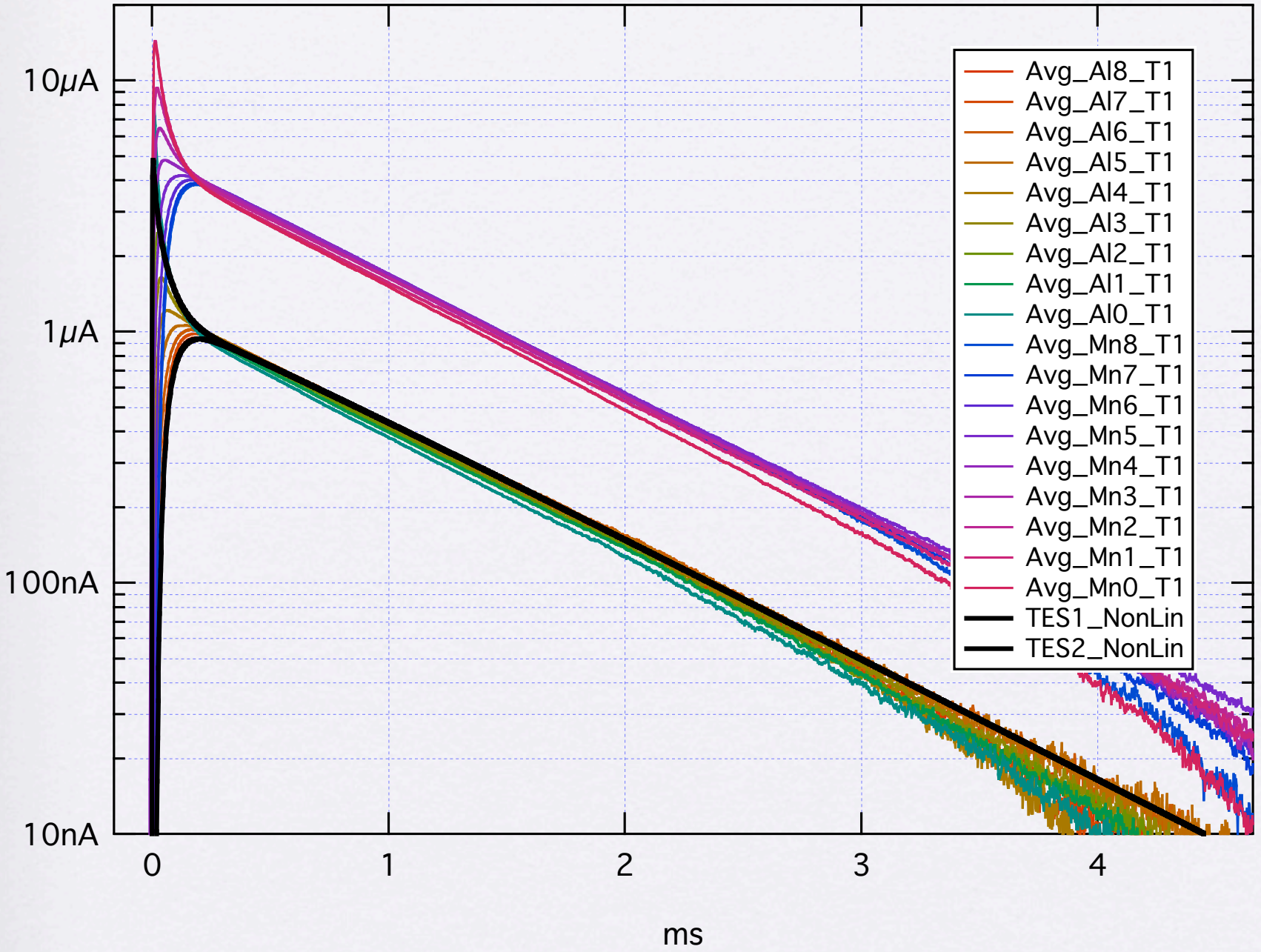
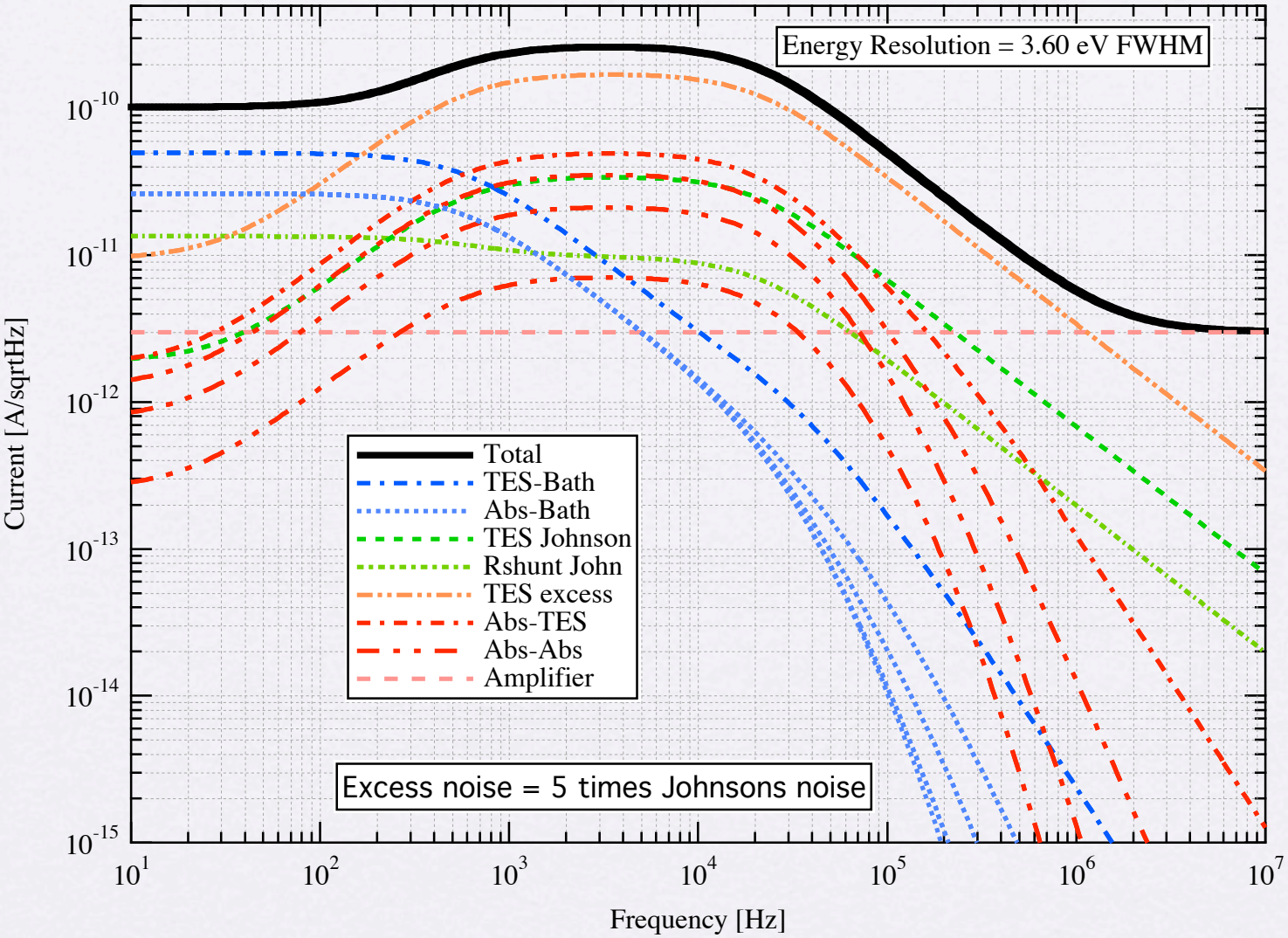
PoST Average Pulses



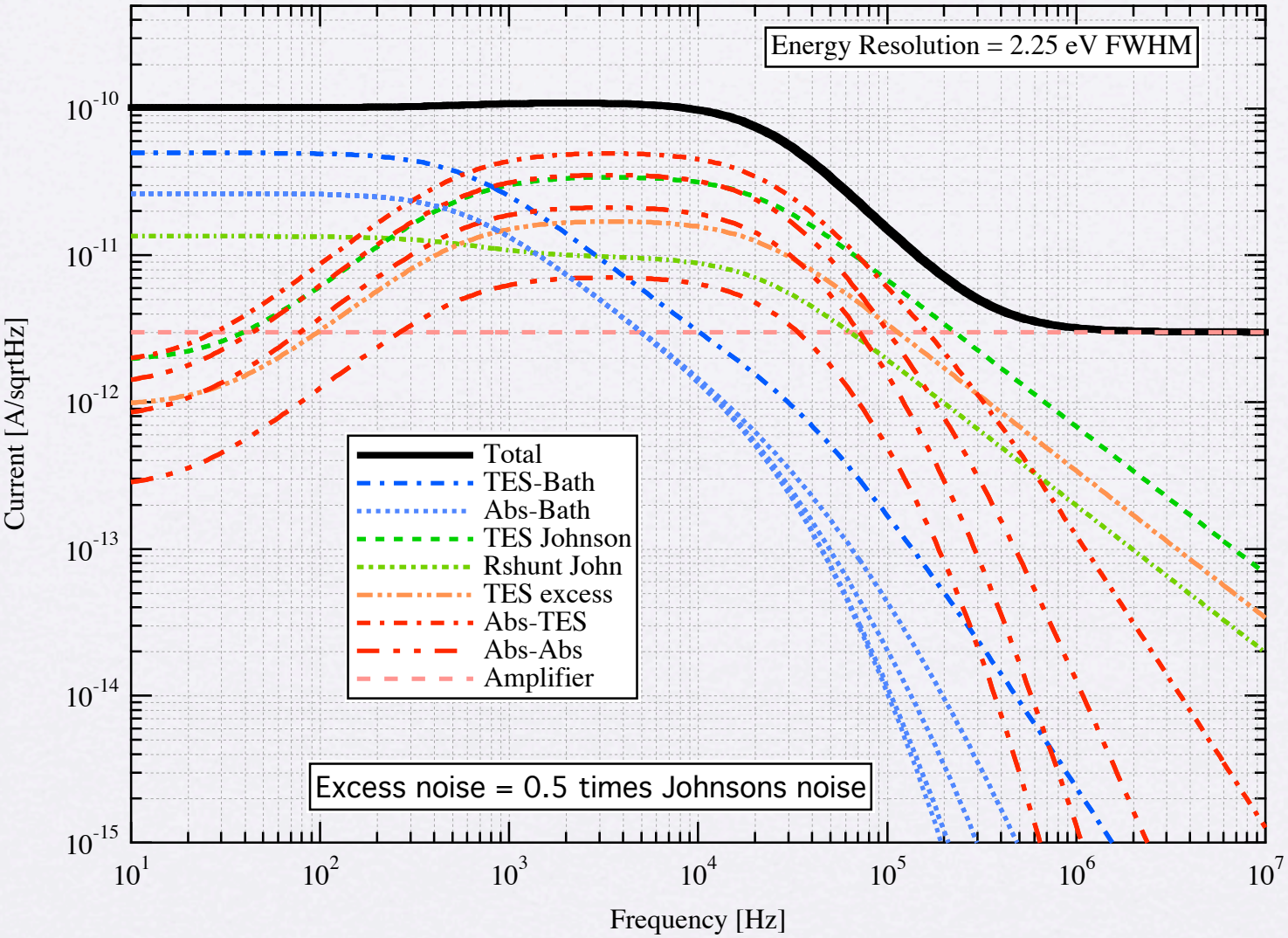
PoST Average Pulses



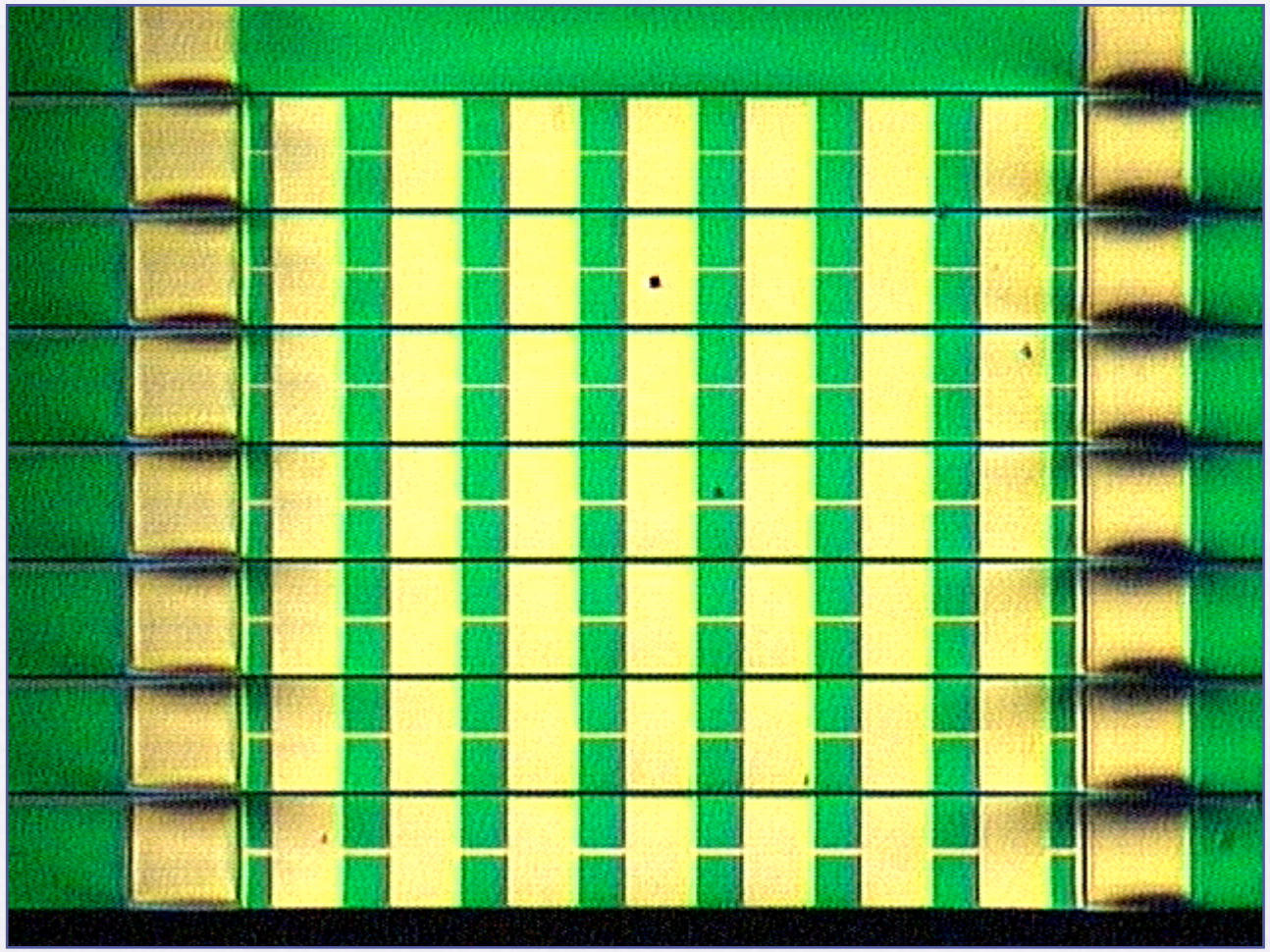
PoST noise

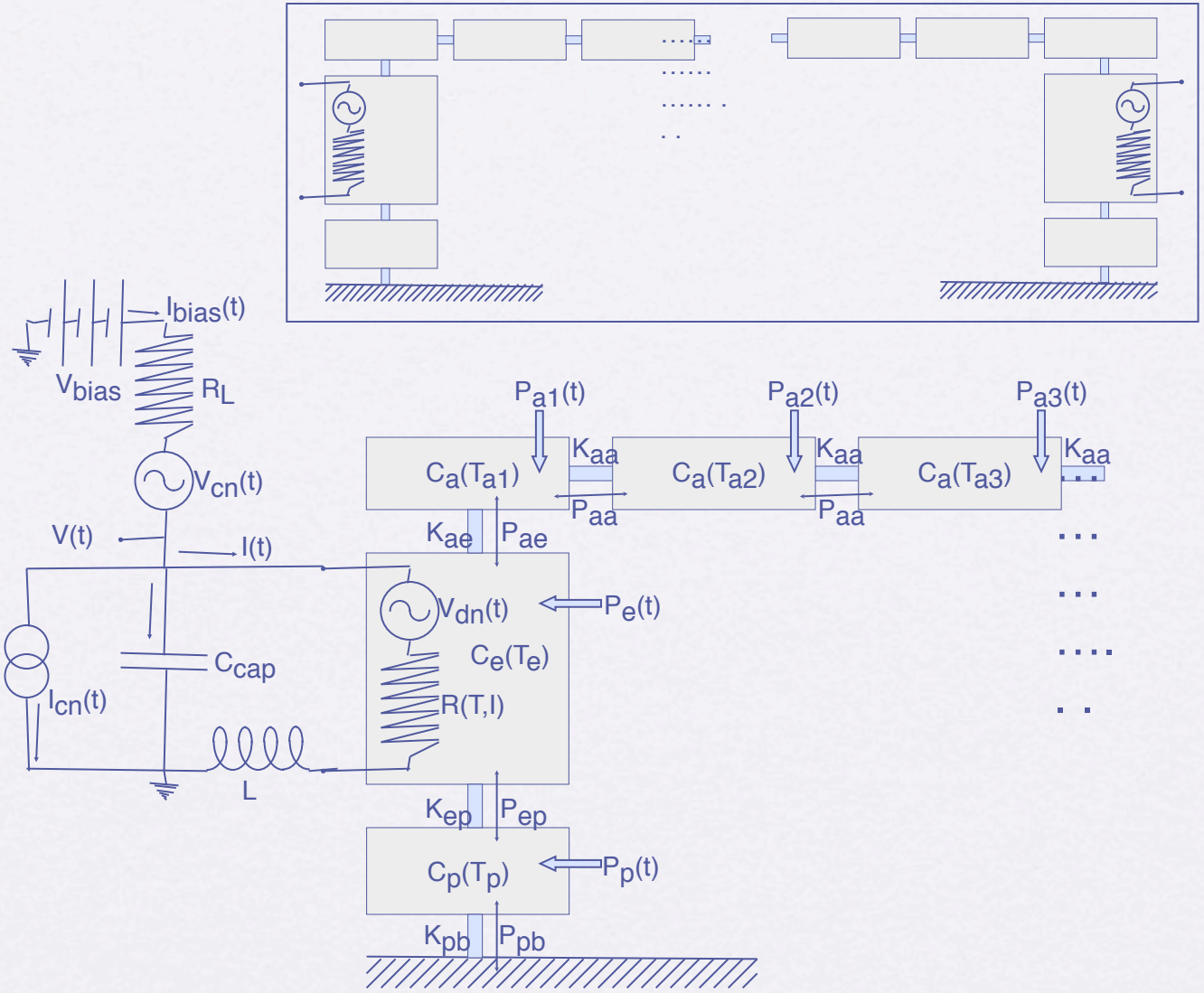

Energy Resolution = 3.60 eV FWHM
Excess noise = 5 times Johnsons noise
Total
TES-Bath
Abs-Bath
TES Johnson
Rshunt John
TES excess
Abs-TES
Abs-Abs
Amplifier
Current [A/sqrtHz]
Frequency [Hz]
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}

PoST noise


Energy Resolution = 2.25 eV FWHM
Excess noise = 0.5 times Johnsons noise
Total
TES-Bath
Abs-Bath
TES Johnson
Rshunt John
TES excess
Abs-TES
Abs-Abs
Amplifier
Current [A/sqrtHz]
Frequency [Hz]
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}

1st Iteration of PoSTs




Ibias(t)
Vbias
RL
Vcn(t)
V(t)
I(t)
Ccap
Icn(t)
L
Pa1(t)
Pa2(t)
Pa3(t)
Ca(Ta1)
Ca(Ta2)
Ca(Ta3)
Kaa
Paa
Kae
Pae
Vdn(t)
Pe(t)
Ce(Te)
R(T,I)
Kep
Pep
Cp(Tp)
Pp(t)
Kpb
Ppb