Eliminating Anomalous Low Energy Tails in Hard X-ray TES Micro-calorimeters Using Electroplated Bismuth

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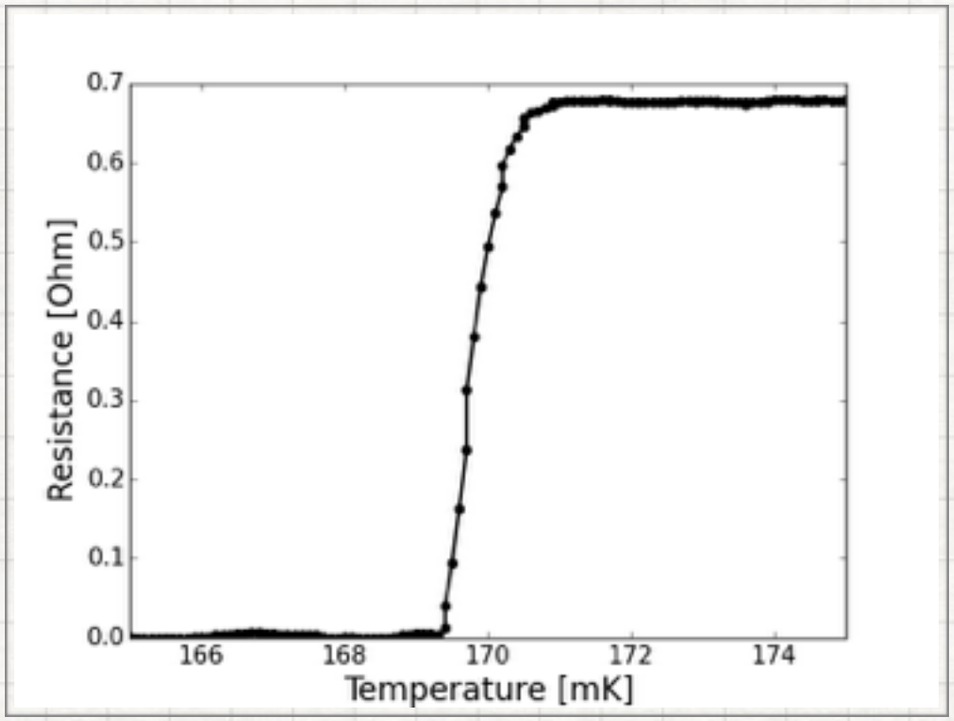
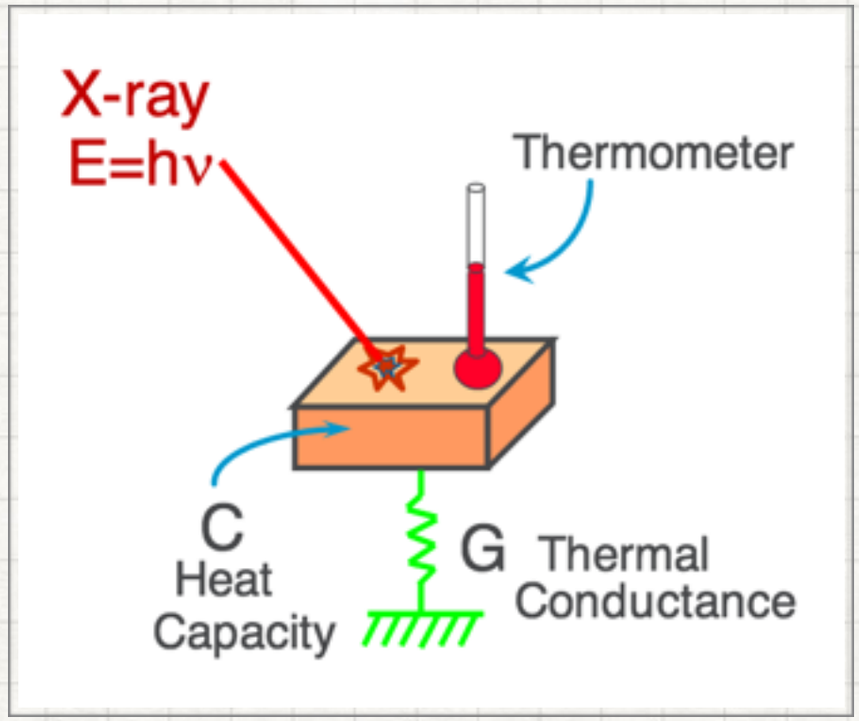
TES

TES (Transition Edge Sensor) can be used as **calorimeter** to measure x-ray photon energy.





Absorber:

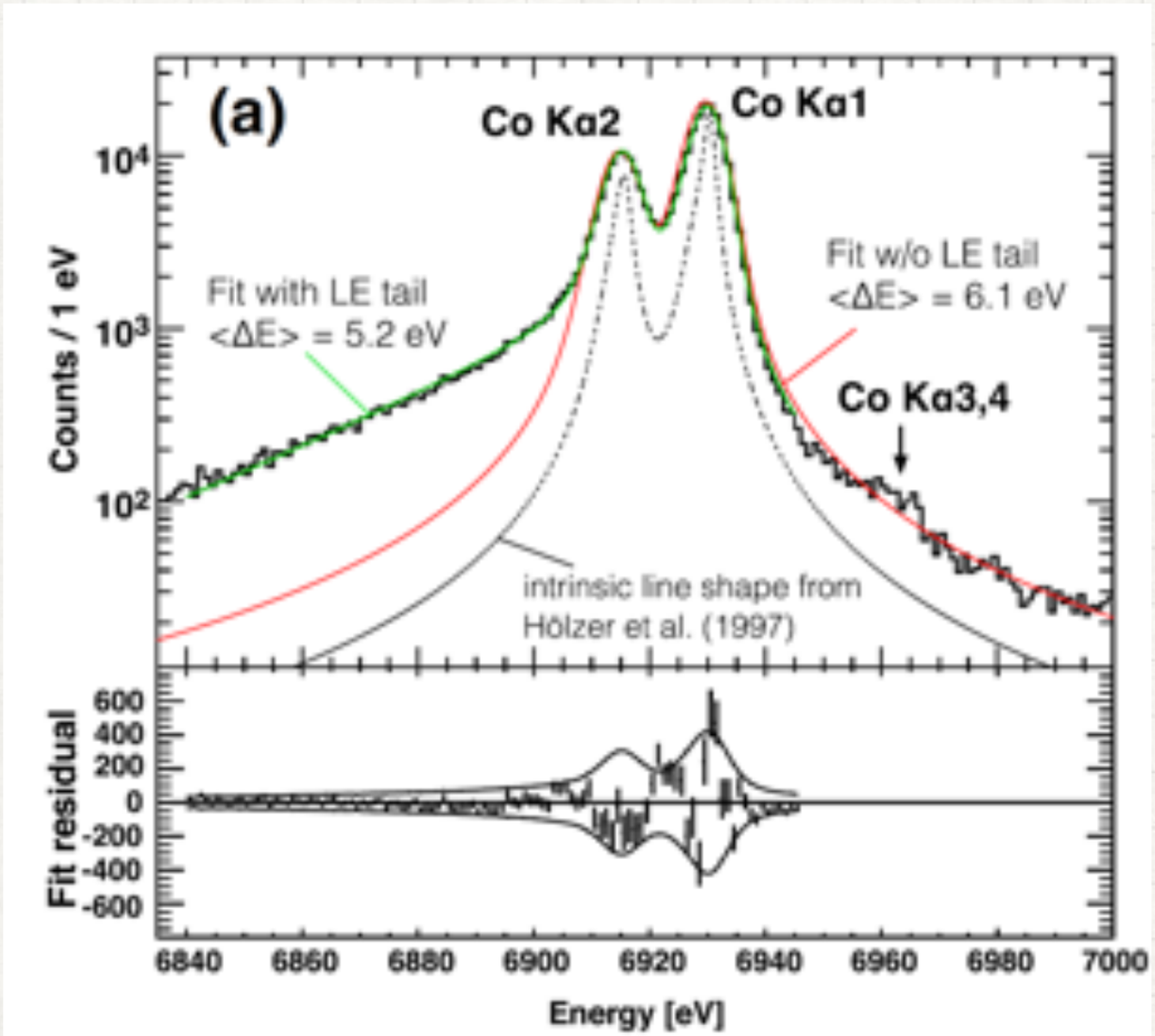
sufficient x-ray stopping power

small specific heat capacity $(\Delta E \propto \sqrt{C})$

Bi	semimetal: small C atomic number 83: large x-ray stopping power

problem: evaporated Bi produces low energy tail

low energy tail produced by evaporated Bi

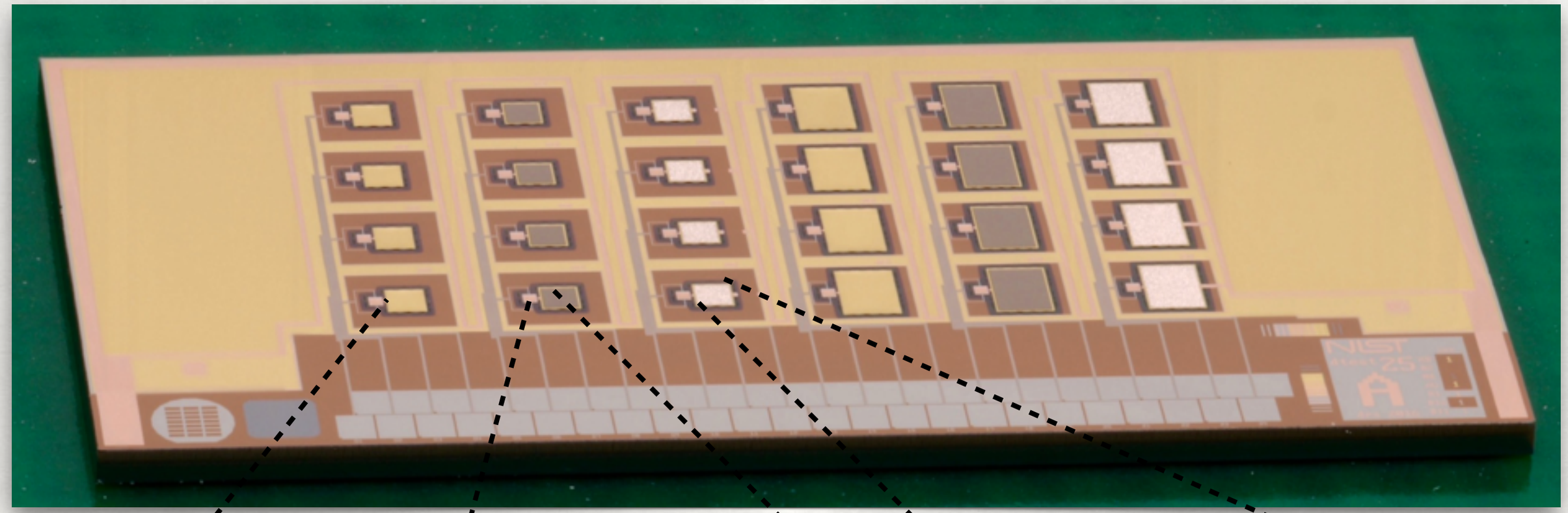


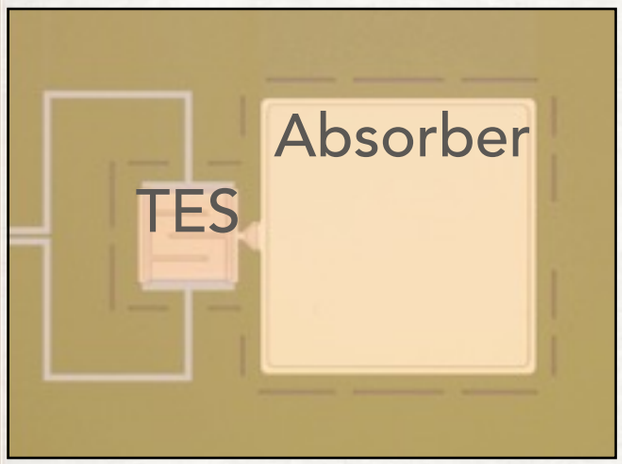
Tatsuno, H., Doriese, W.B., Bennett, D.A. et al. *J Low Temp Phys* (2016) 184: 930. doi:10.1007/s10909-016-1491-2

Other deposition method?

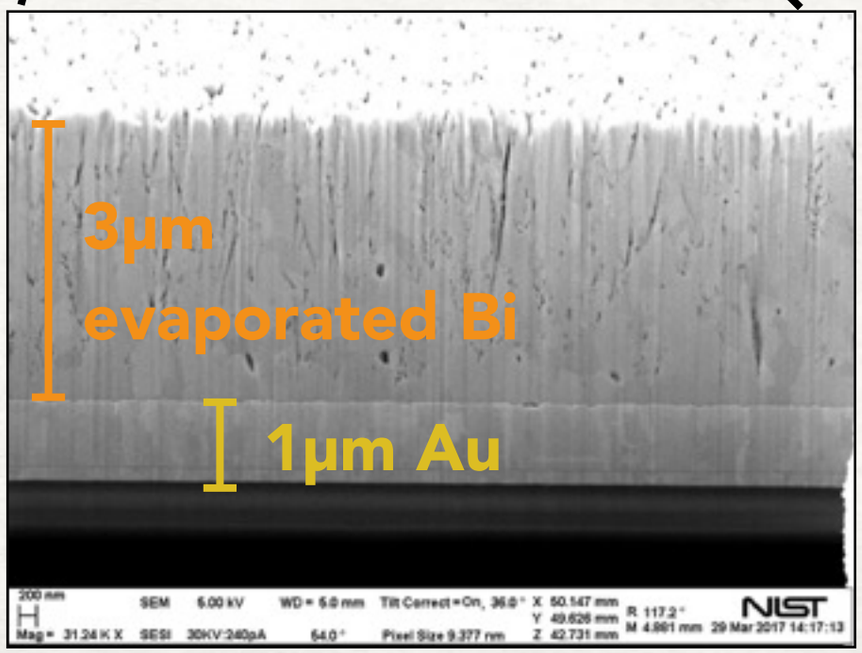
electro-plating Bi

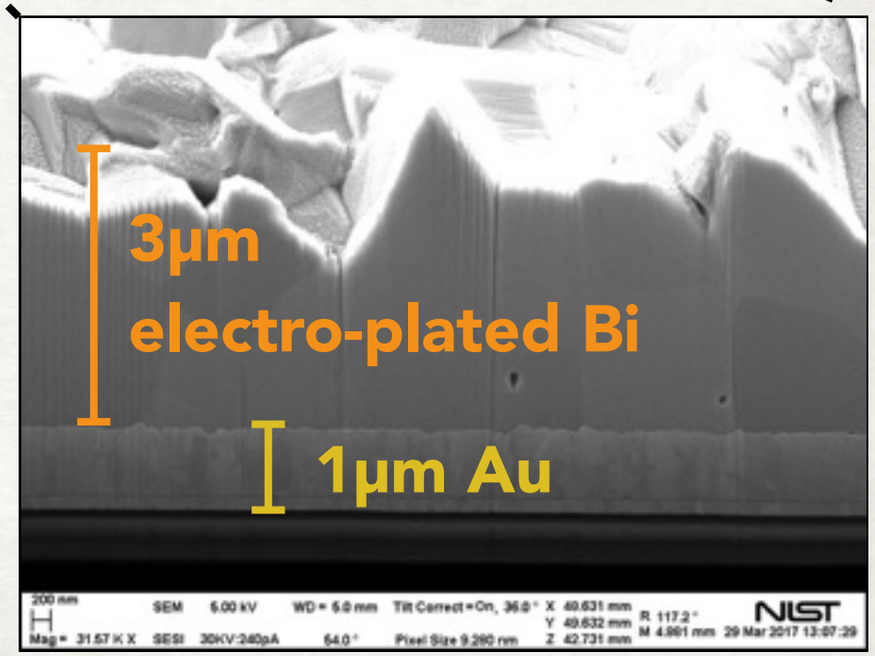
DEVICE PHOTO



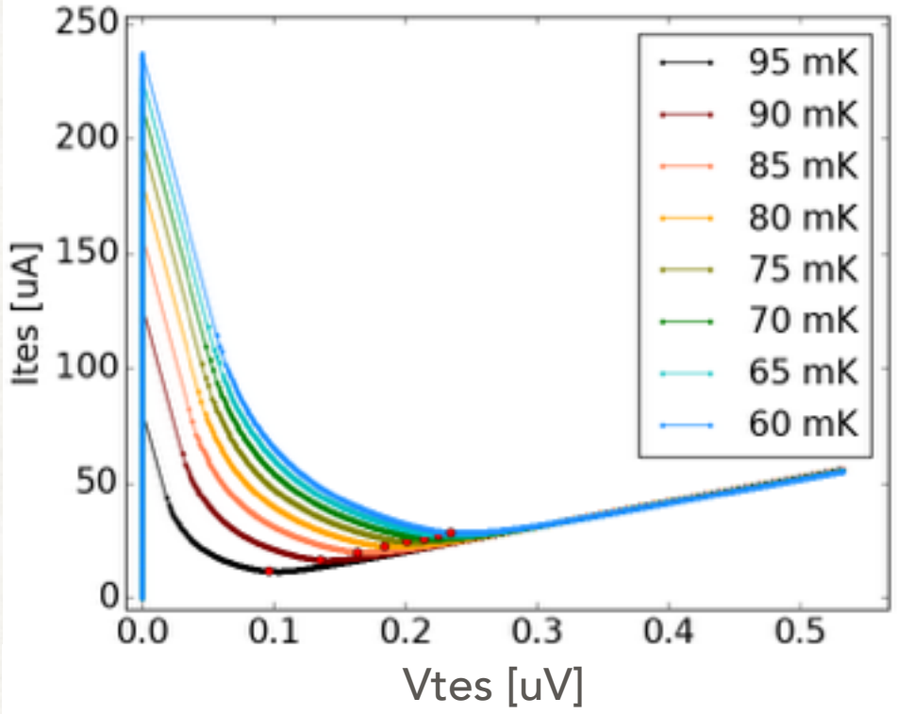


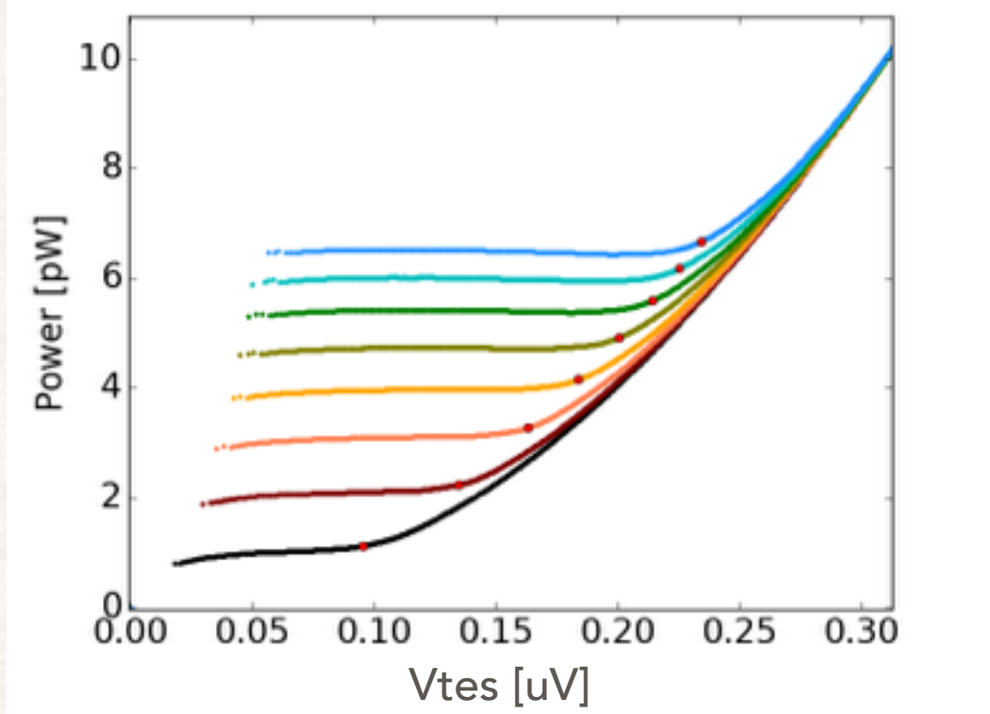
1μm Au

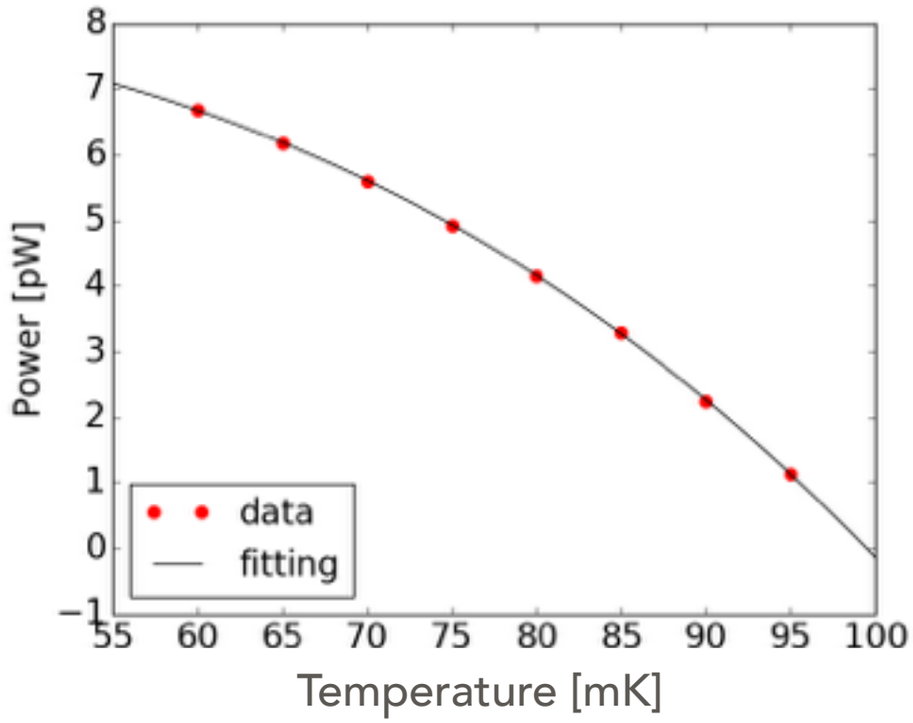




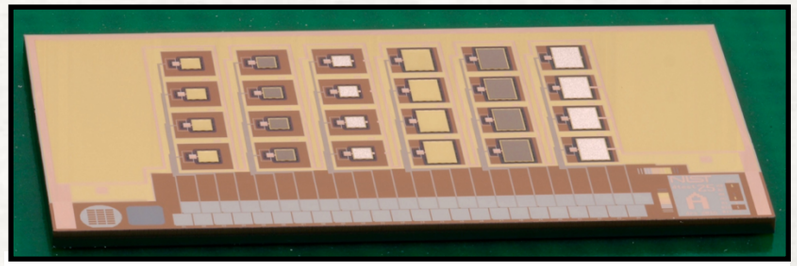
THERMAL CONDUCTANCE G

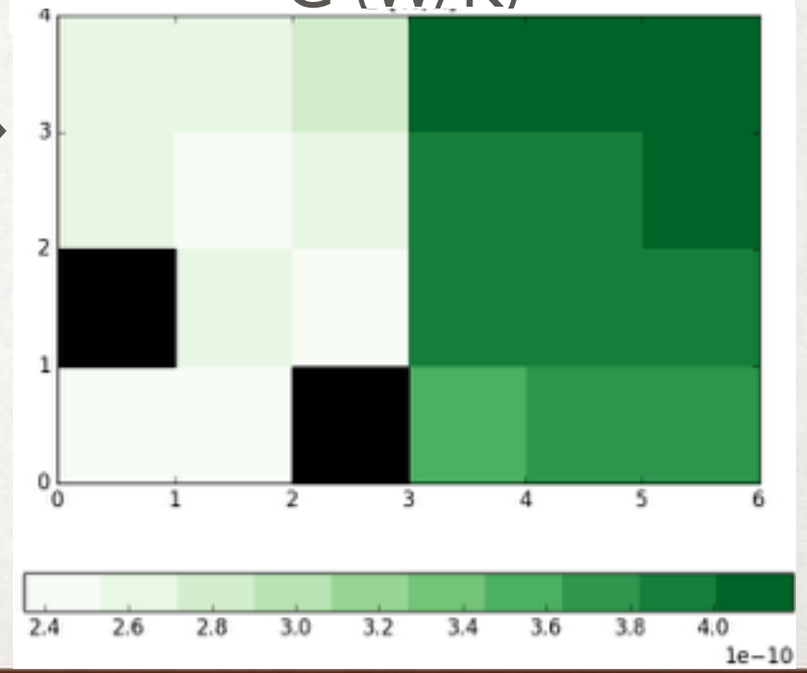






$$P_J = \frac{G_c}{nT_c^{n-1}}(T_c^n - T_b^n).$$

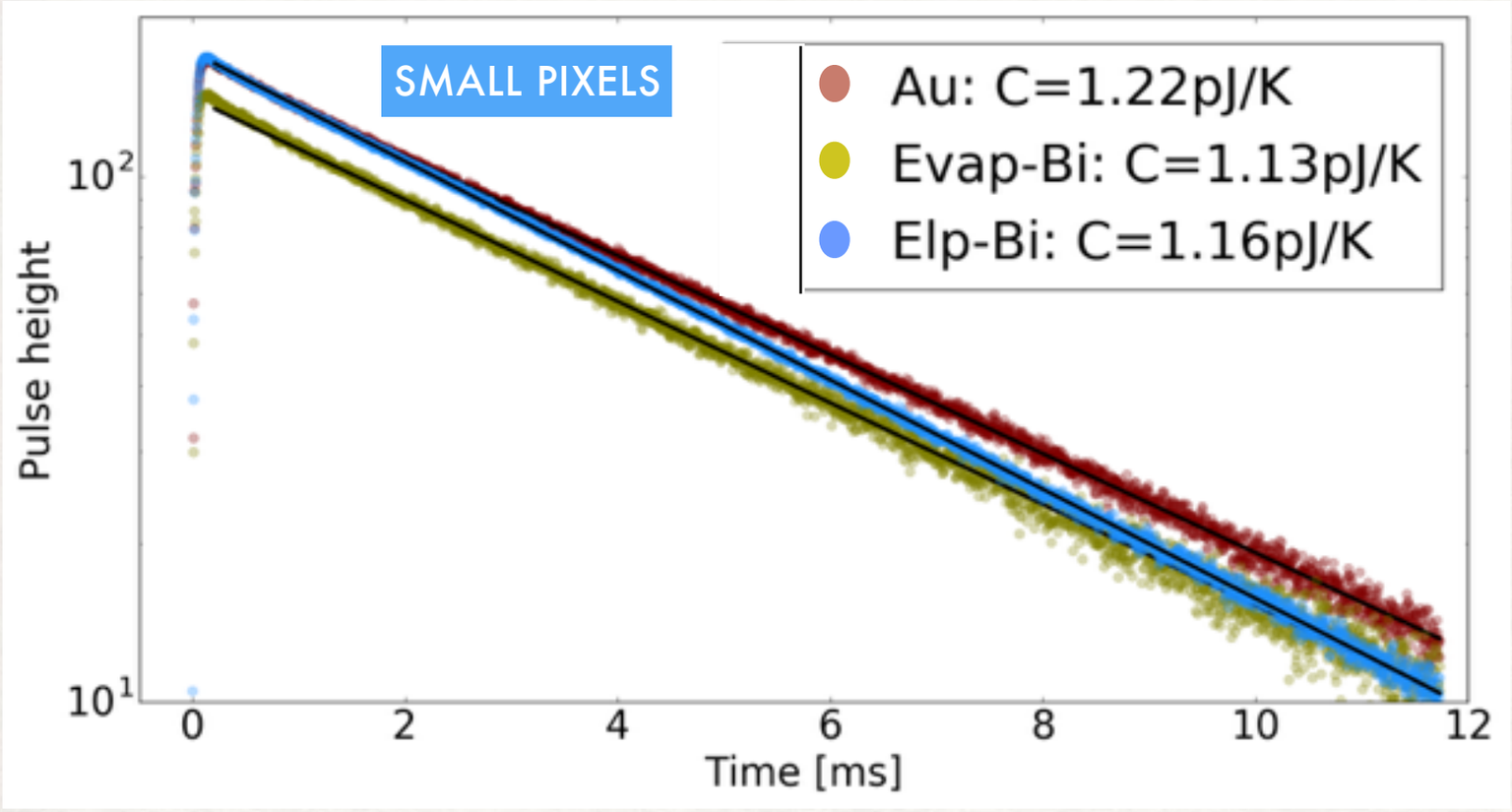




G values are calculated from IV measurements.

HEAT CAPACITY C

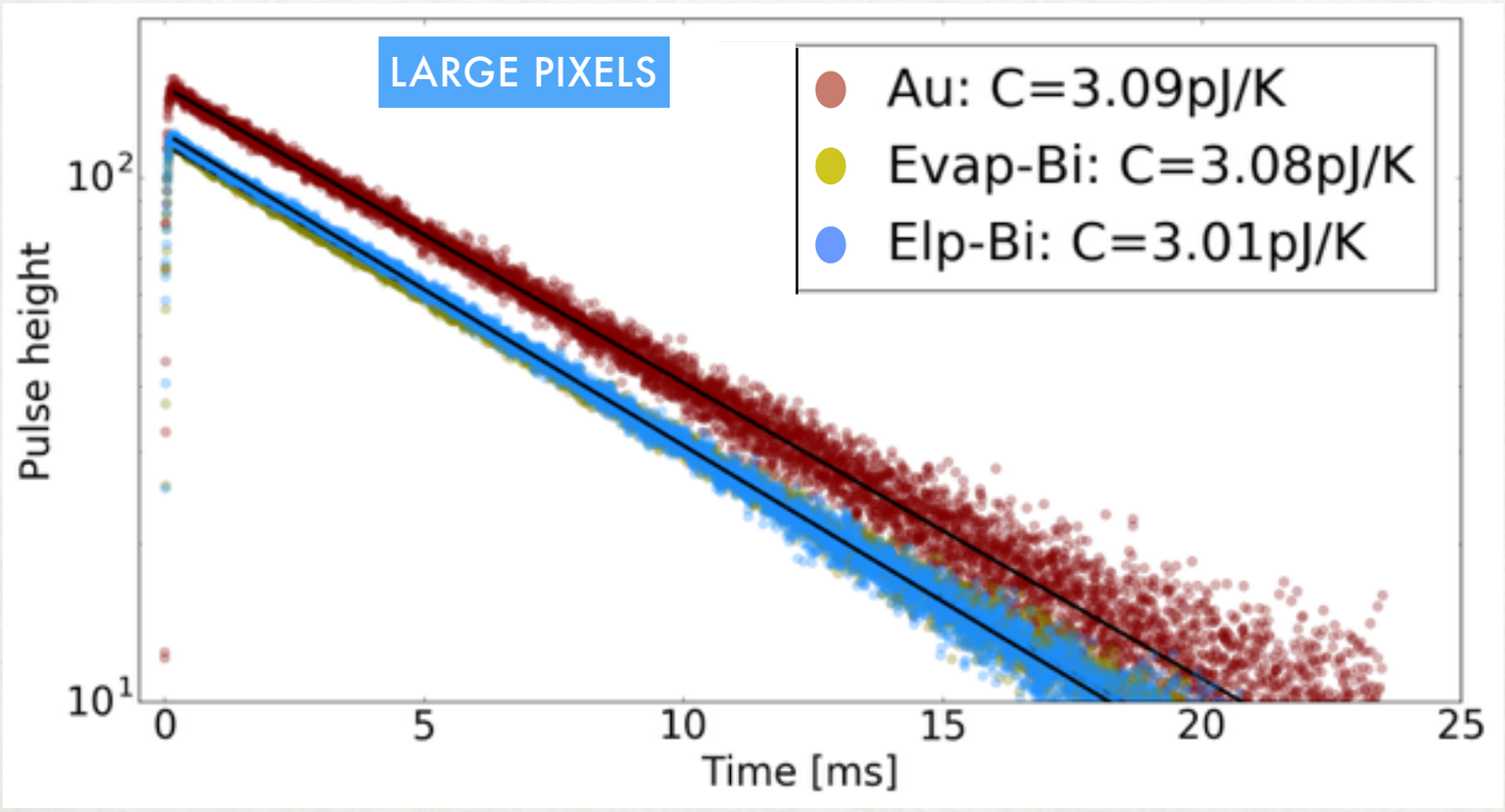
When the TES is biased high in transition, pulse decay time ≈ C/G



	small pixels	large pixels	large/ small ratio
perimeter (μm)	1860	3000	1.61
average C (pJ/K)	1.16	3.03	2.61 ≈1.62^2

a) 3 μm Bi does not sensibly increase C
—> no resolution penalty.

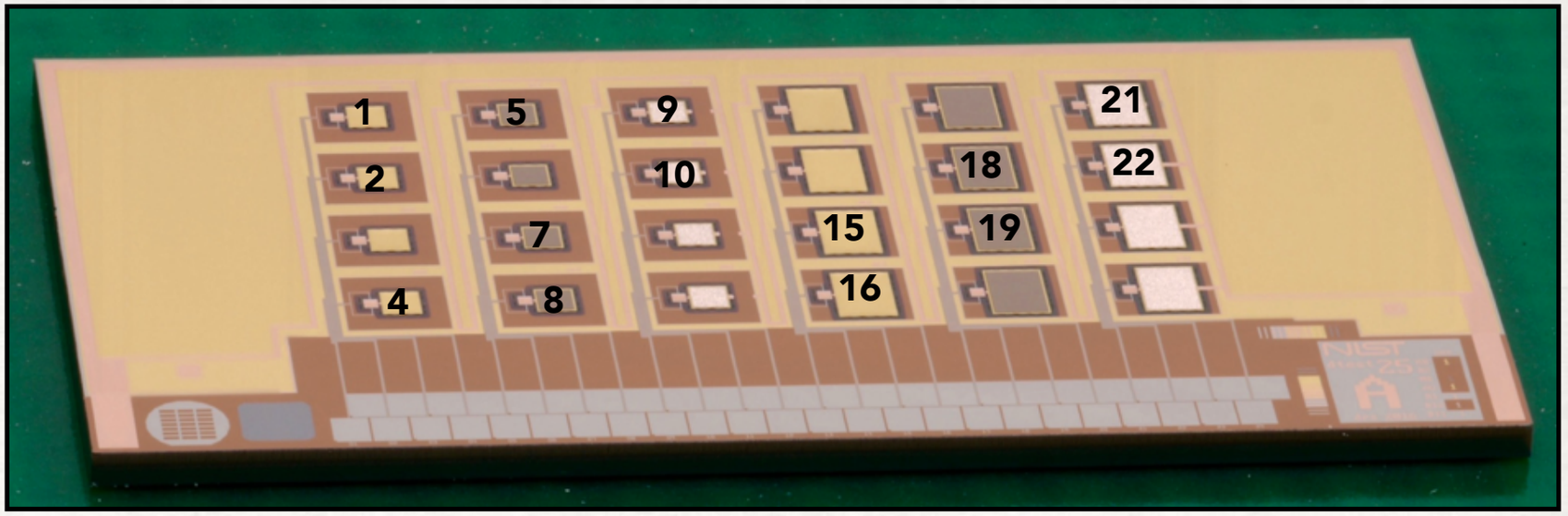
b) C scales with the pixel volume

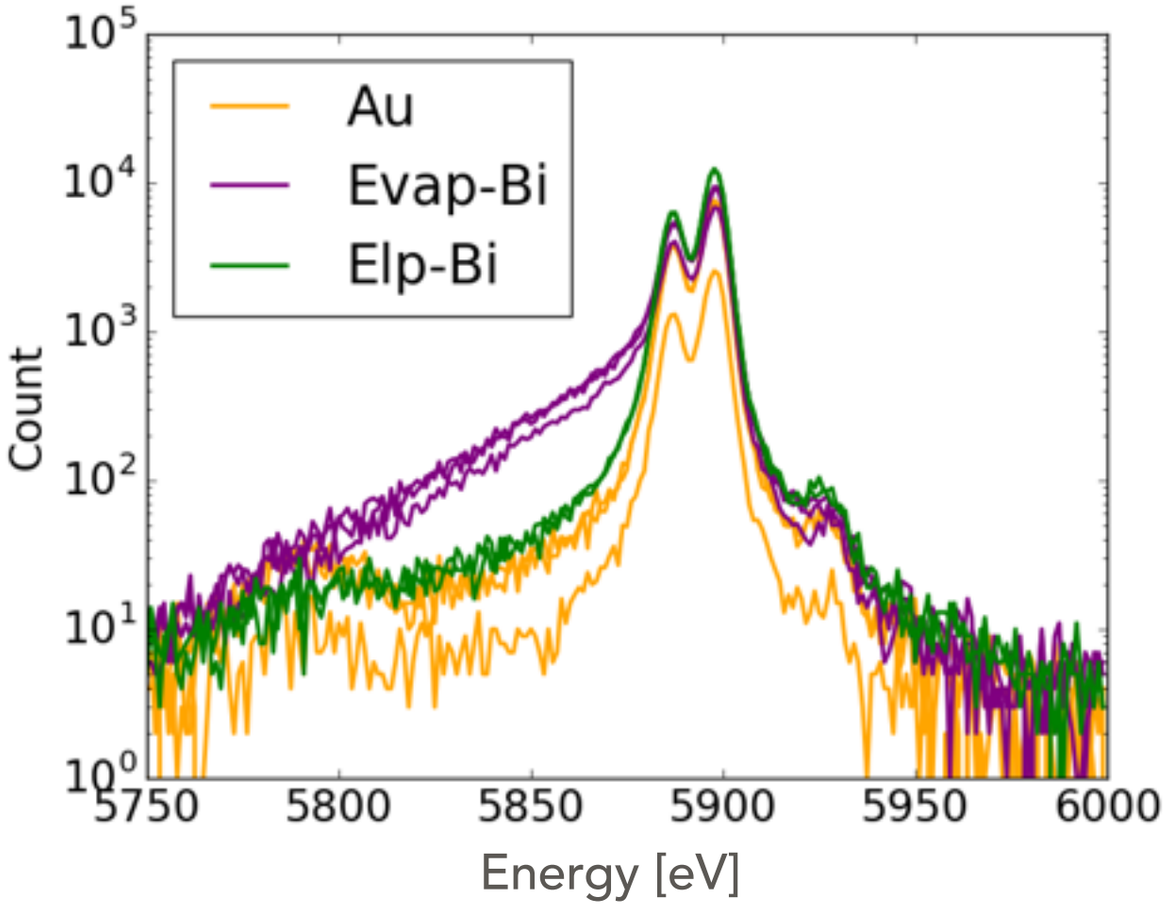


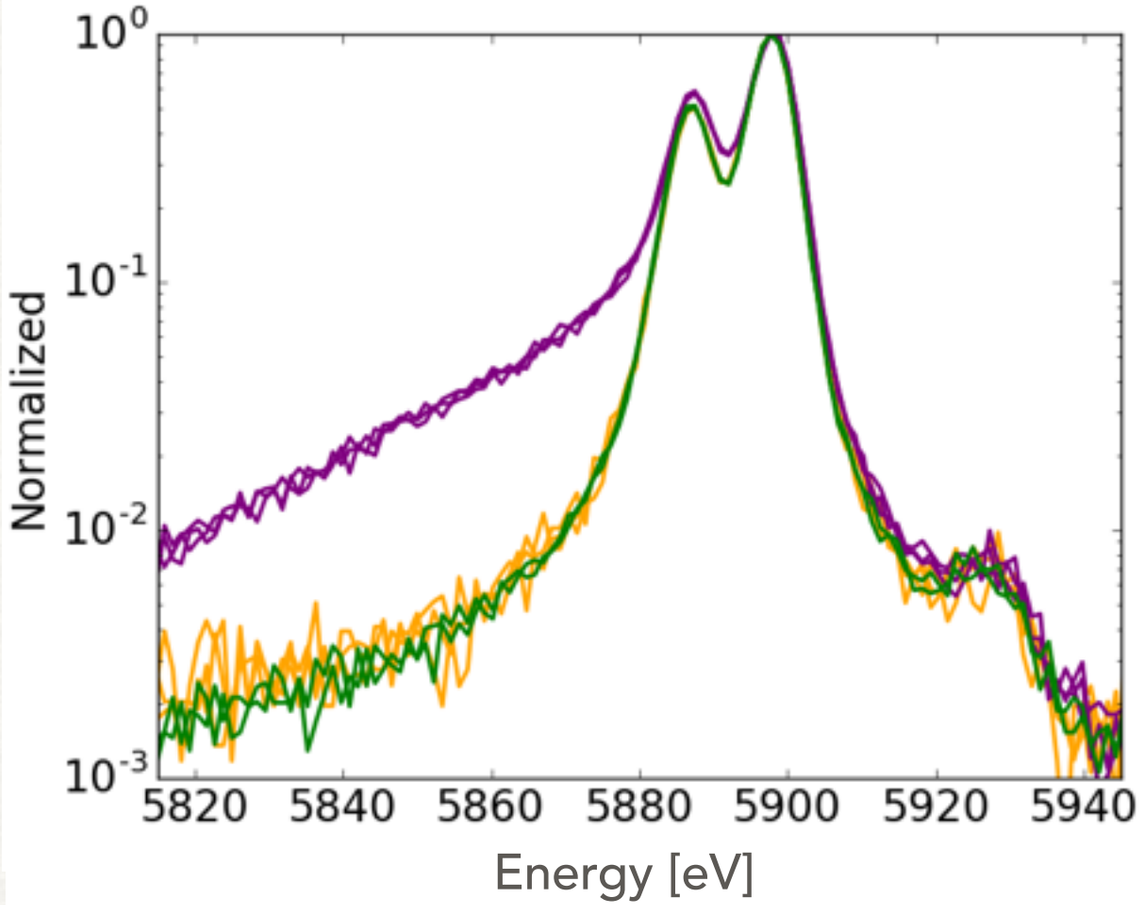
SPECTRA

Mn Kα line
on selected small pixels
(designed for x-rays around
6 KeV)

SMALL PIXELS

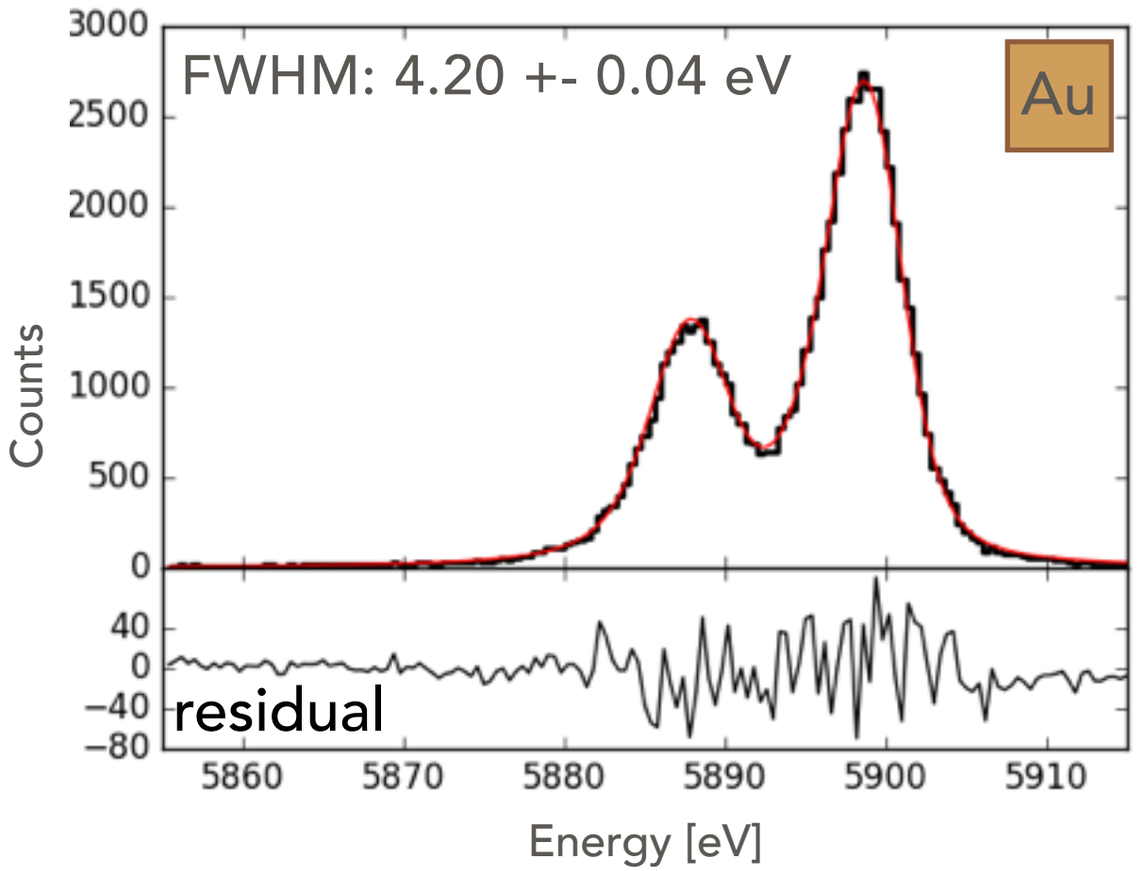


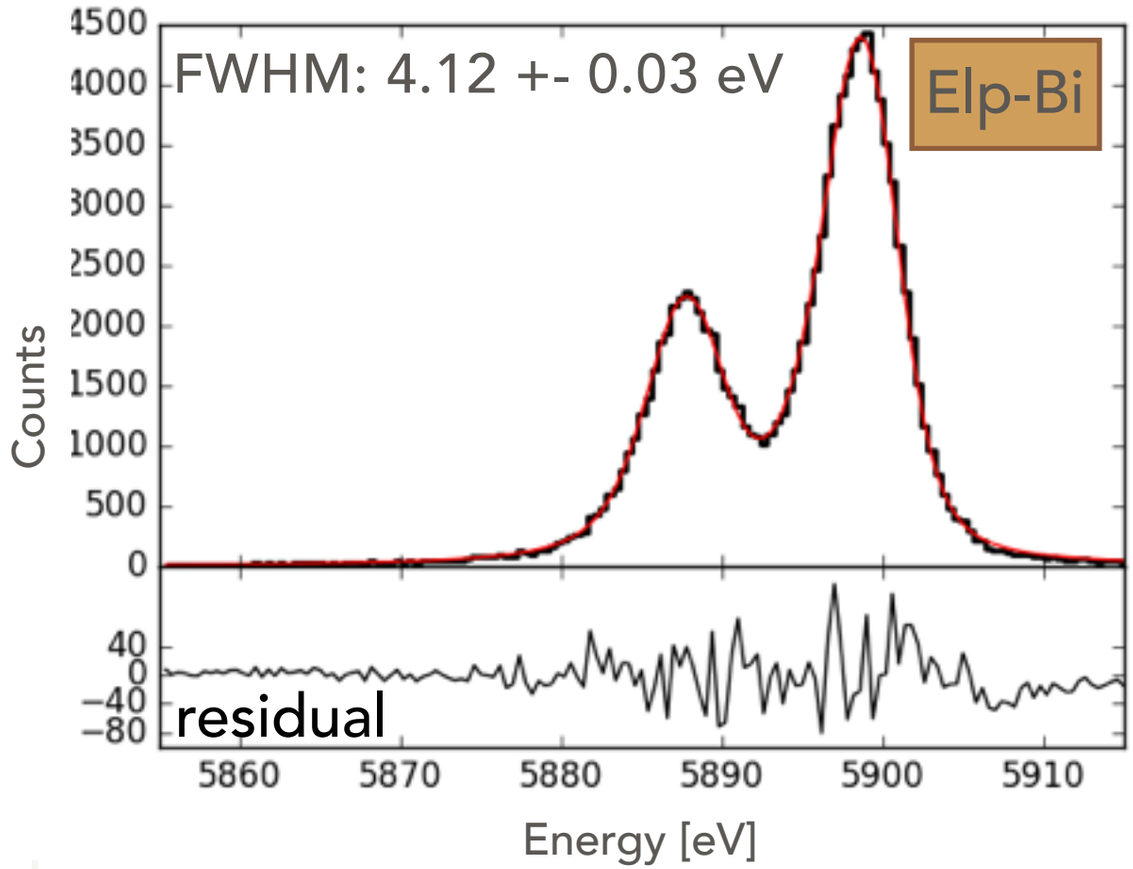


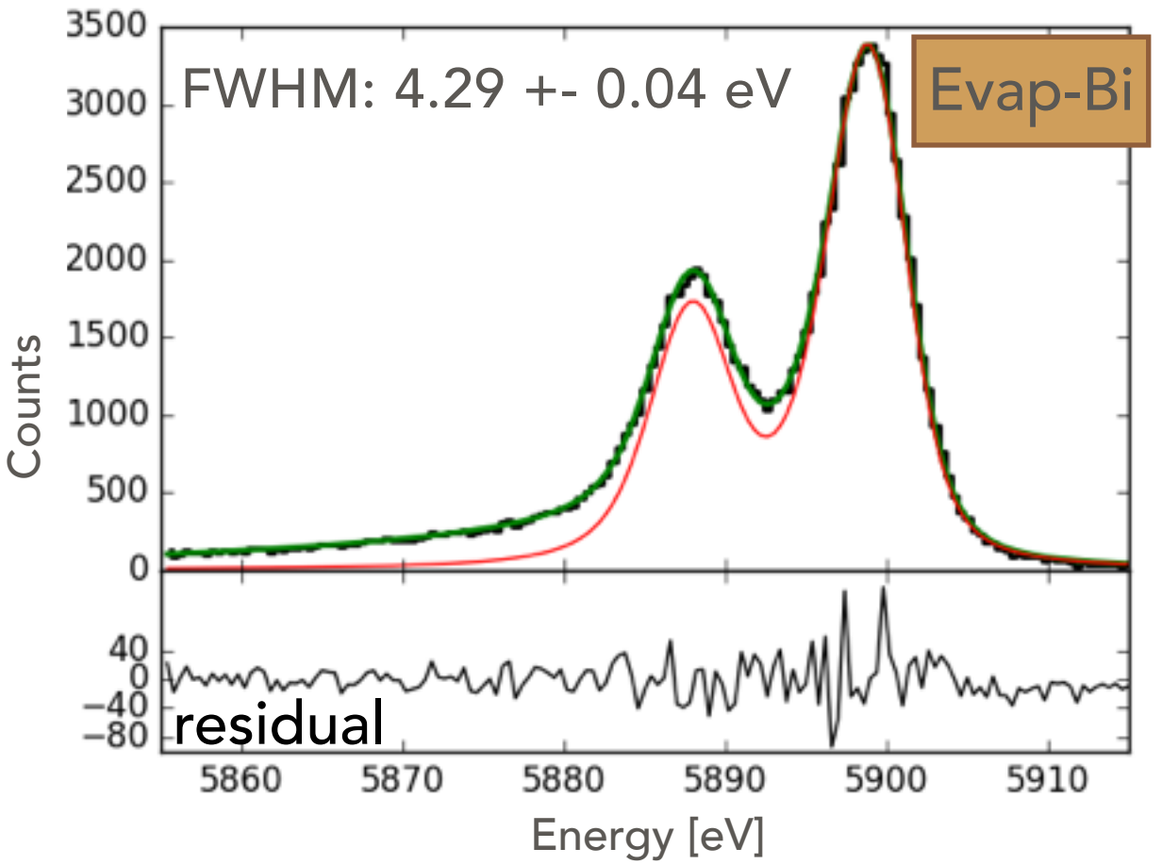


a) Low energy tails show in Evap-Bi pixels.

b) Spectra from Au and Elp-Bi are same.





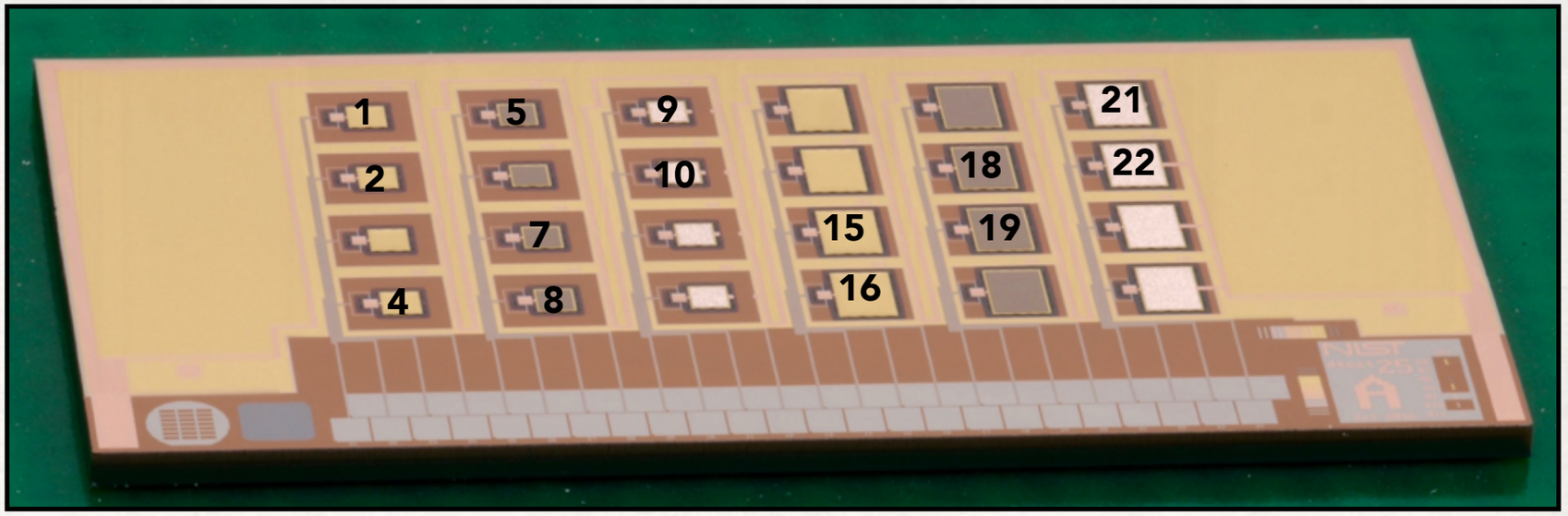


a) Energy resolutions for the three types of pixels are similar.

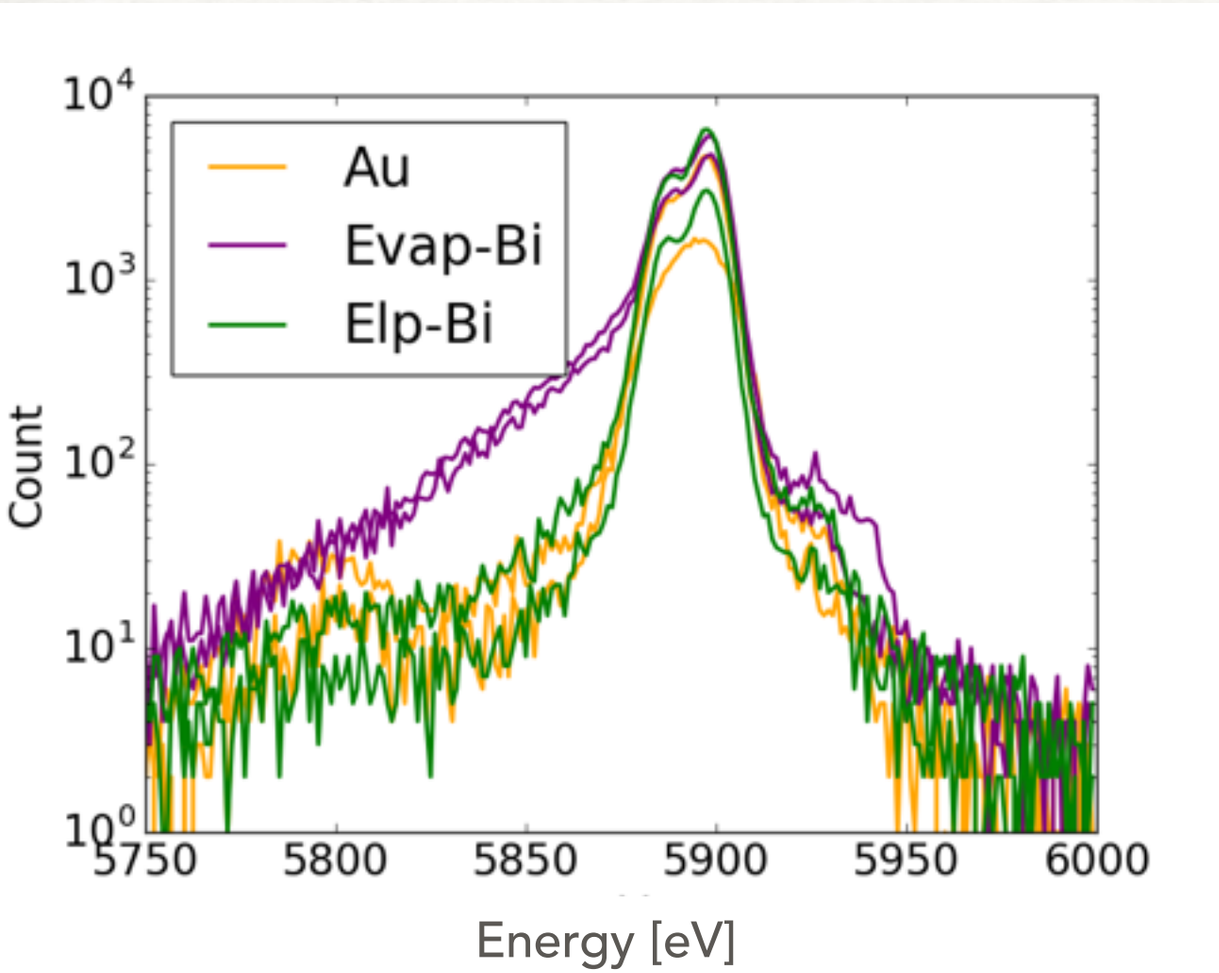
b) Evap-Bi has a low energy tail.

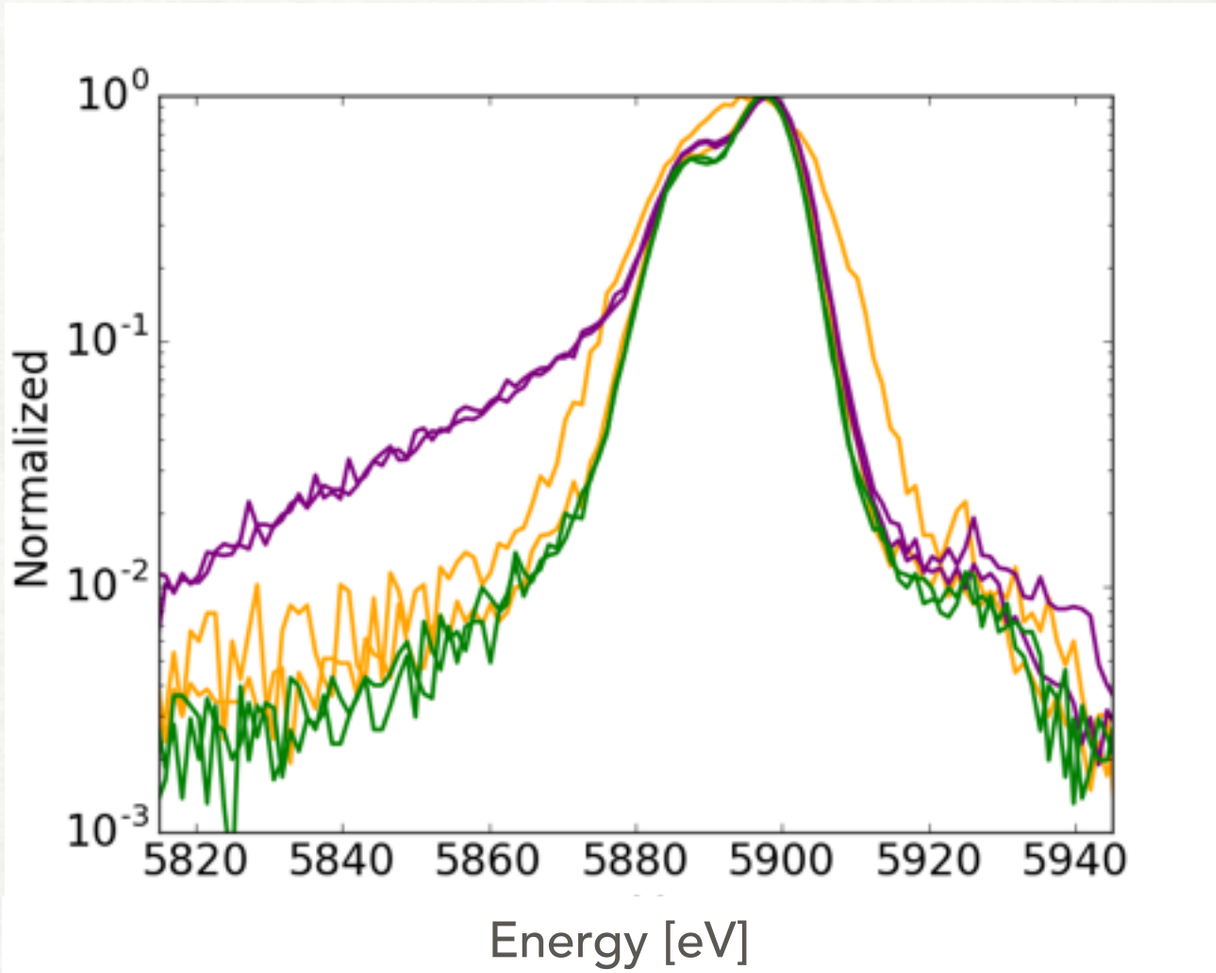
SPECTRA

Mn Kα line
on selected large pixels
(designed for x-rays above 30 KeV)



LARGE PIXELS





Show similar low energy tail feature.

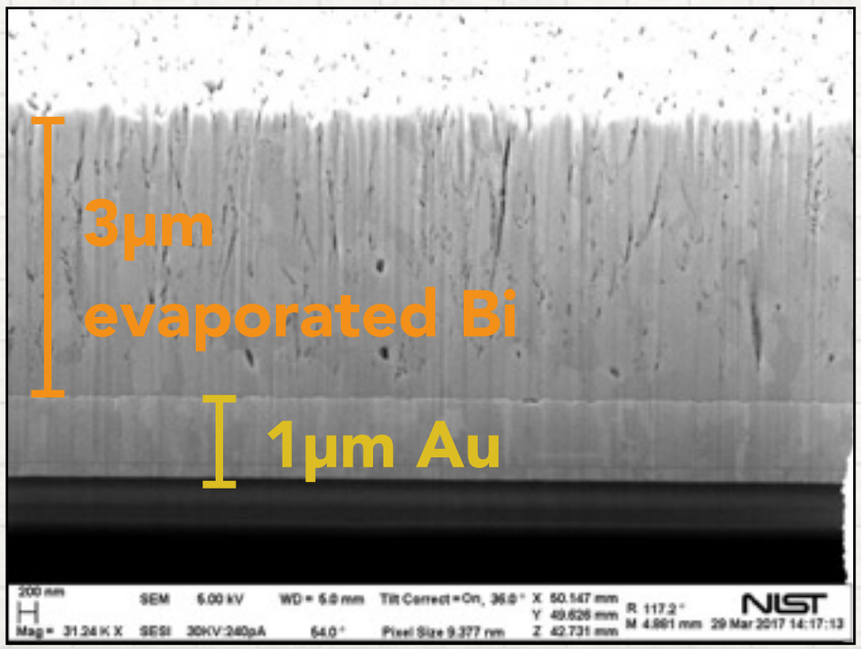
CONCLUSION:

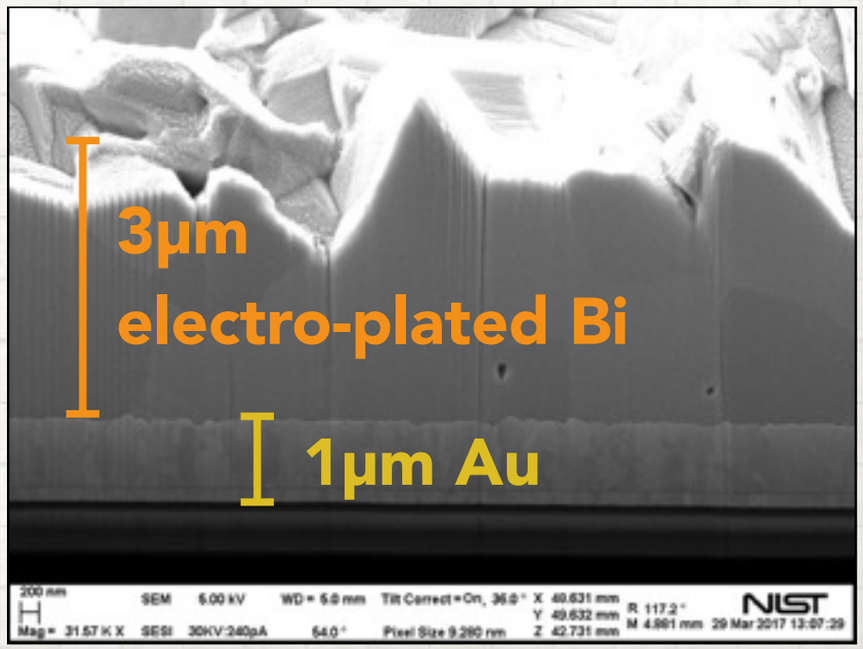
a) Successfully fabricated devices with two different sizes absorbers made of **Au, Au + evaporated Bi and Au + electroplated Bi** on the same chip for easy comparison.

b) TES pixels with Au, Au+Evap-Bi, Au+Elp-Bi absorbers show **similar C, and energy resolution**.

c) The Au and Au+Elp-Bi pixels do not show **low energy tails** as the Au+Evap-Bi pixels.

d) The physical mechanism is still unclear but is probably due to the different thermalization properties of the two very different films.





Thanks!

Q & A