Position-Sensitive TES: Latest Results and Current Issues

Enectalí Figueroa-Feliciano
Kavli Institute for Astrophysics and Space Research
Massachusetts Institute of Technology

PoST Collaboration

E. Figueroa-Feliciano, N. Iyomoto, S. R. Bandler, R. P. Brekosky, J. A. Chervenak, F. M. Finkbeiner, R. L. Kelley, C. A. Kilbourne, F. S. Porter, T. Saab, and J. E. Sadleir

Massachusetts Institute of Technology

NASA

UNIVERSITY of FLORIDA

Outline

- Basic Principles
- Segmented Absorbers PoSTs
- Continuous Absorber PoSTs
- Impedance Fitting and Characterization
- Future Work

Segmented Absorber PoSTs

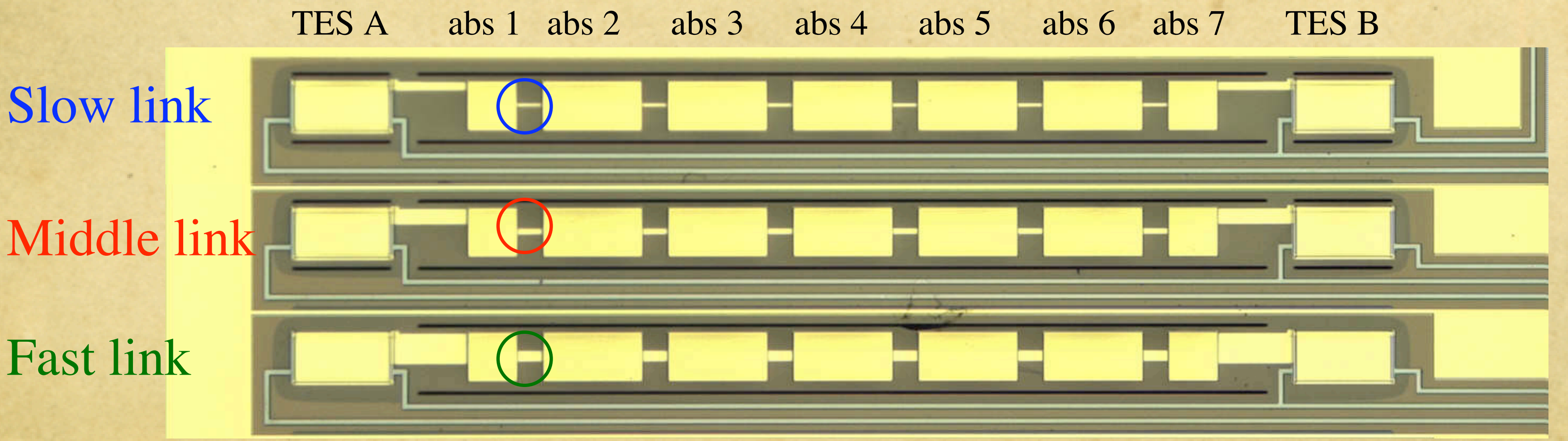
Tested 3 different link conductances on otherwise same devices

Au absorber = 0.95 μm thick

C_{abs} = 1465 fJ/K (/abs), G_{abs} > 290 nW/K (/abs) @T_c

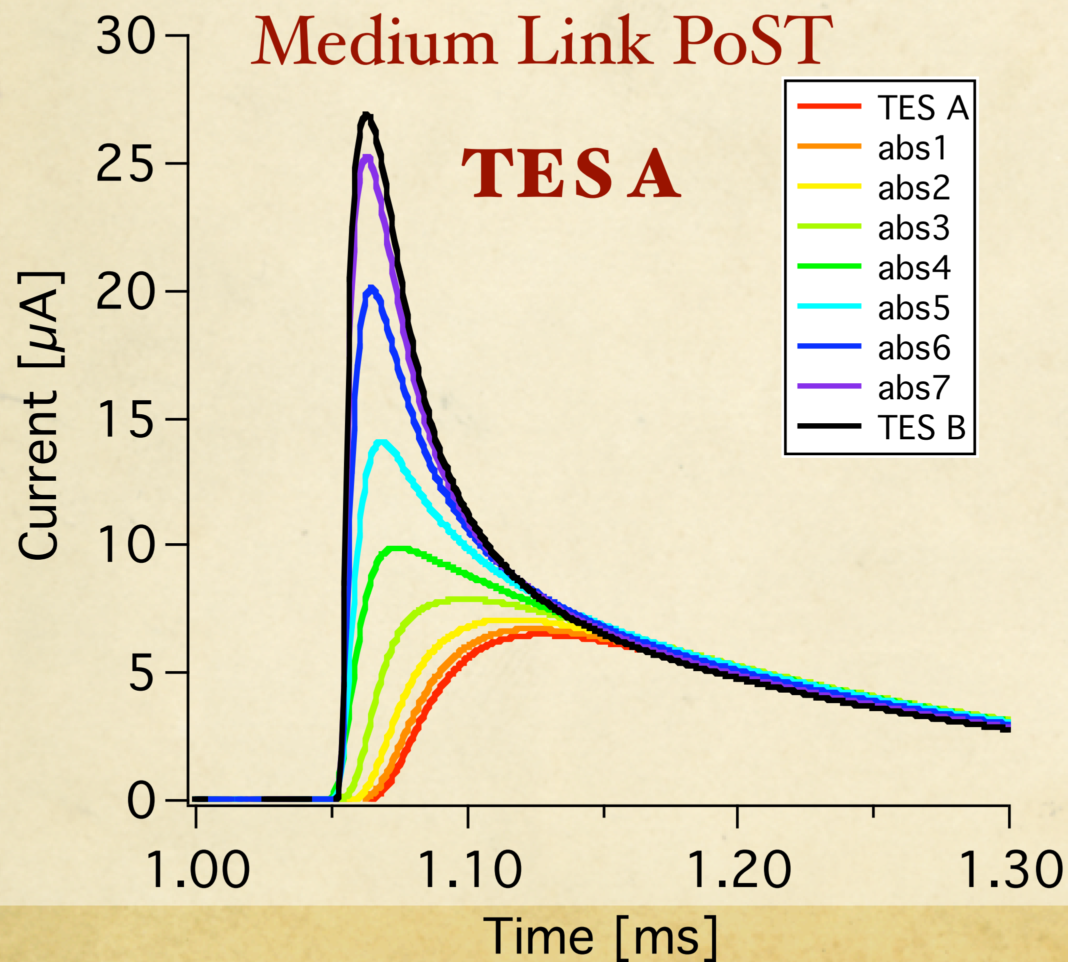
G_{link} = 17 nW/K, 34 nW/K or 68 nW/K @T_c

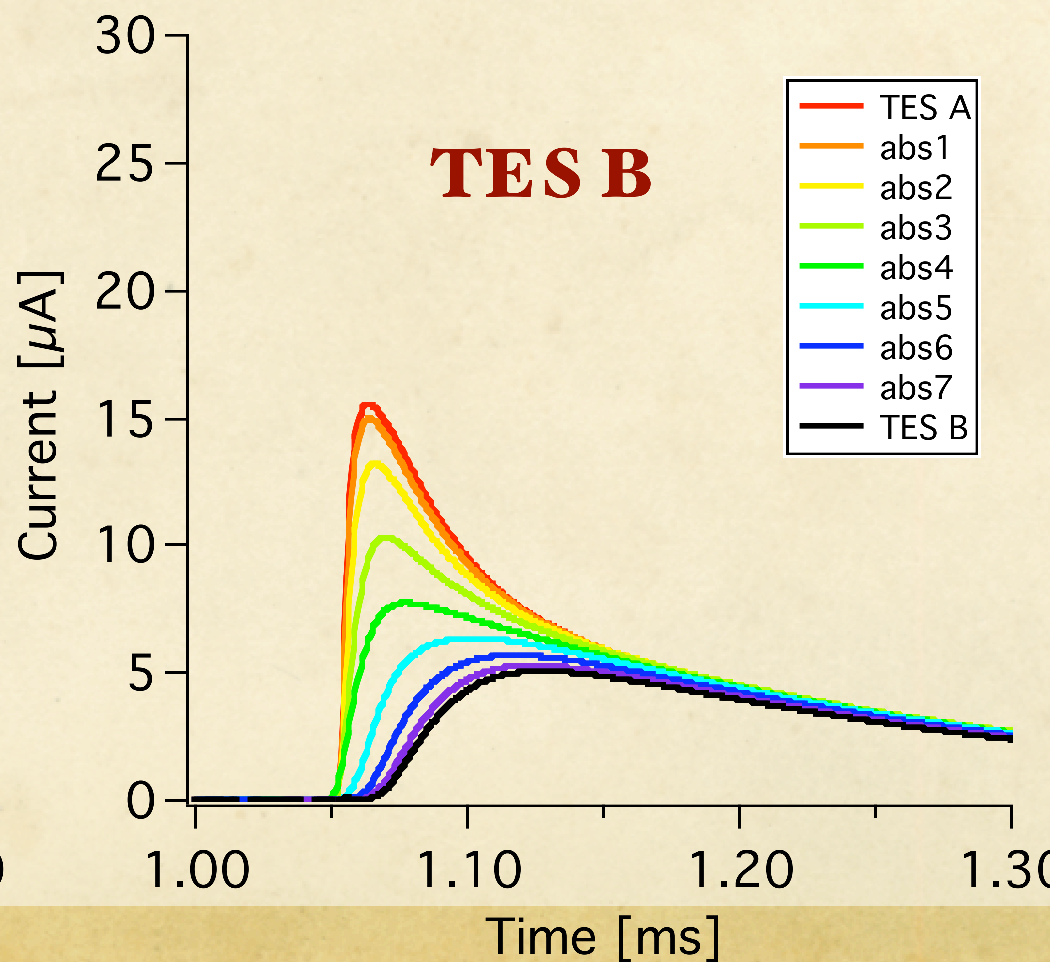
Mo/Au TES (no absorber on TESs) T_c = 141 mK



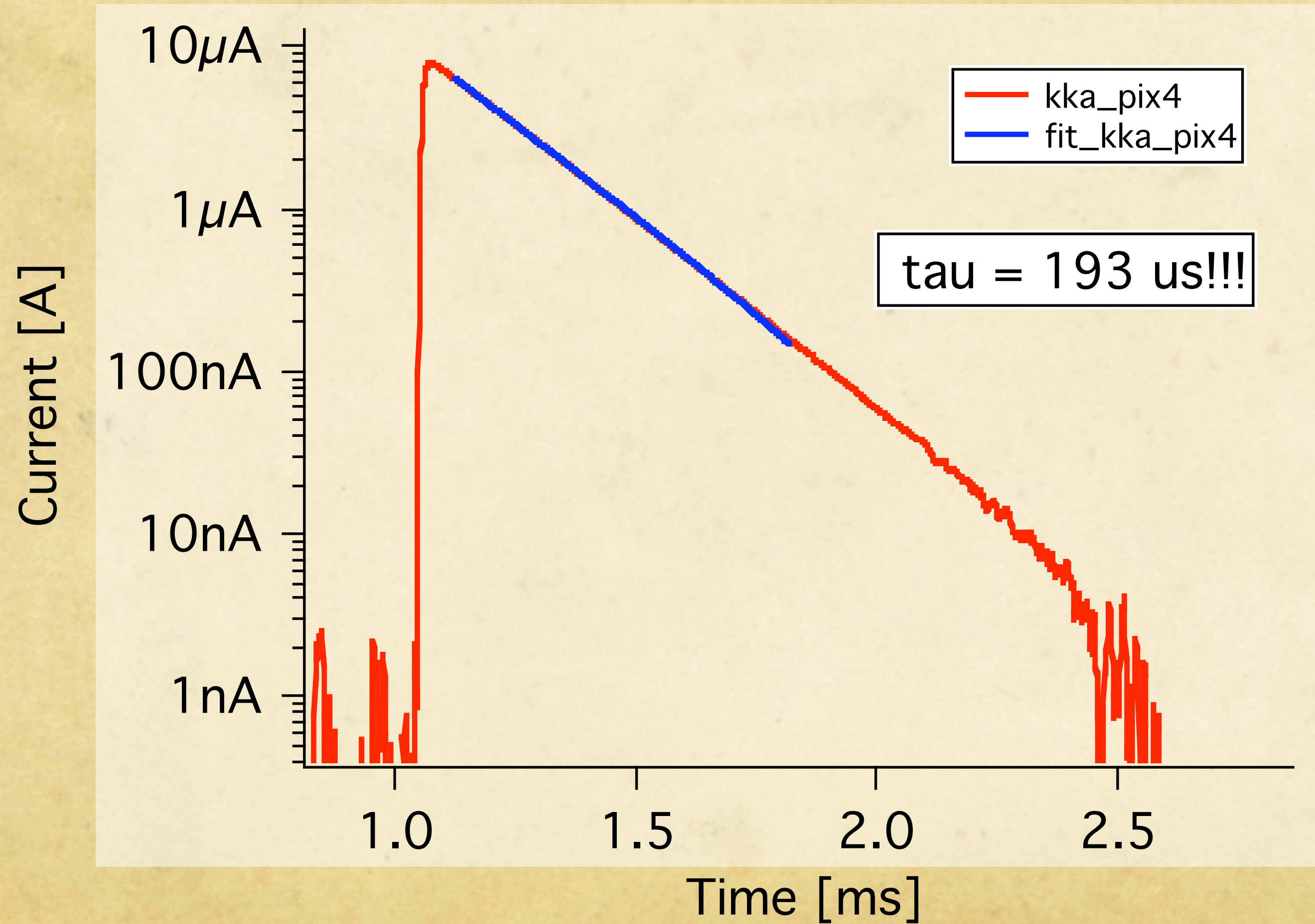
PoST Average Pulses

Device is not symmetrical!

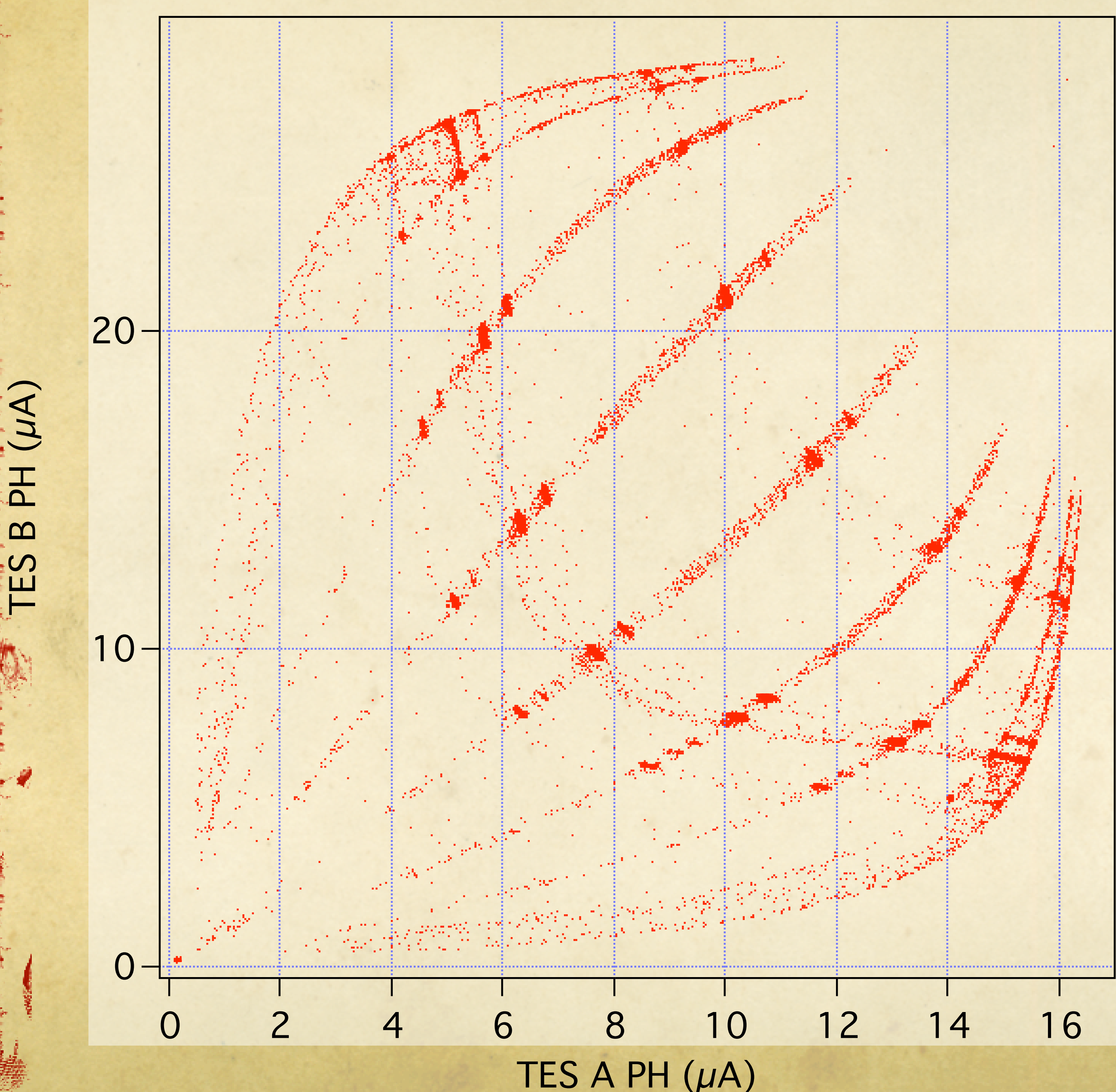




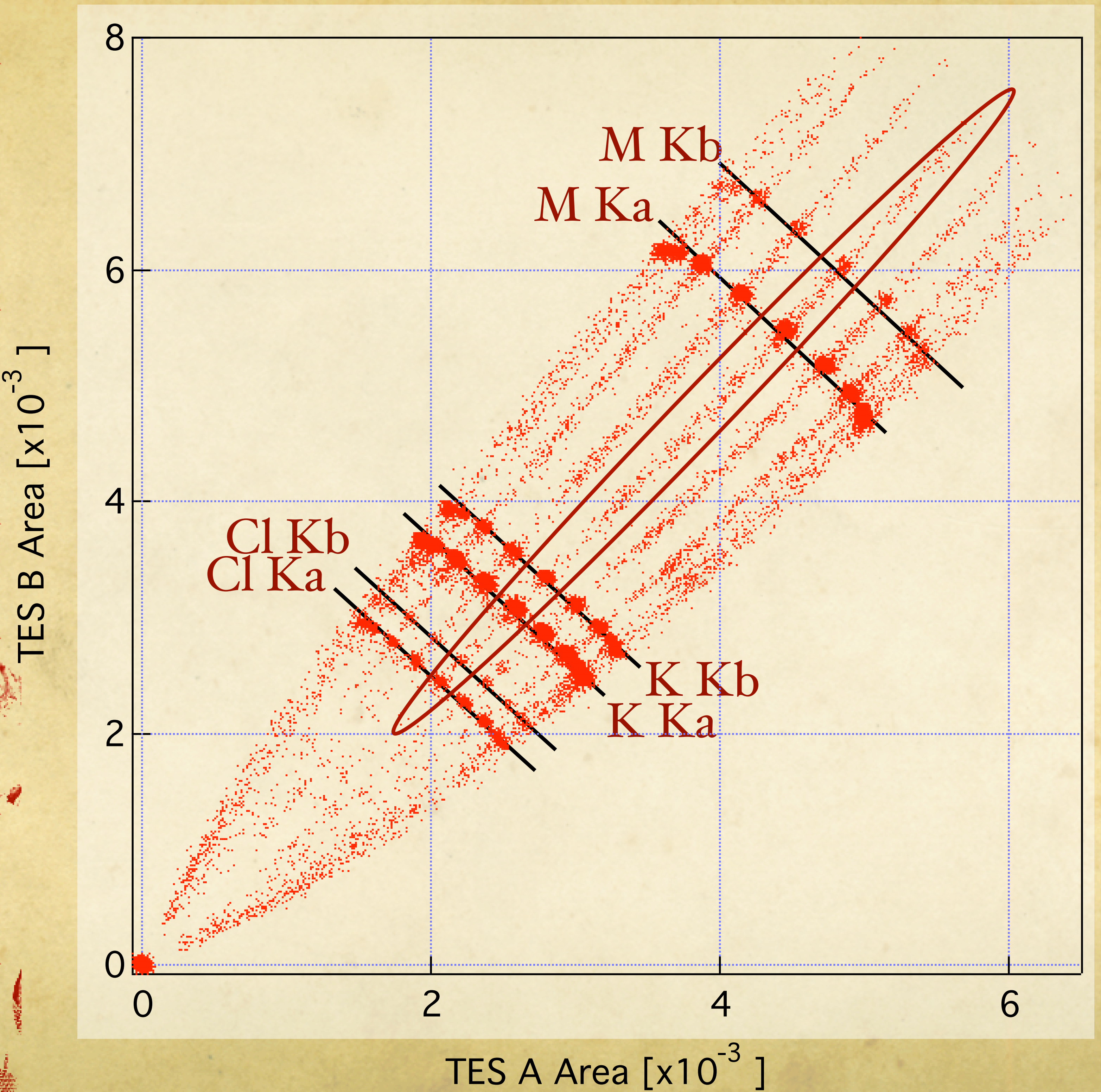
This device is FAST!



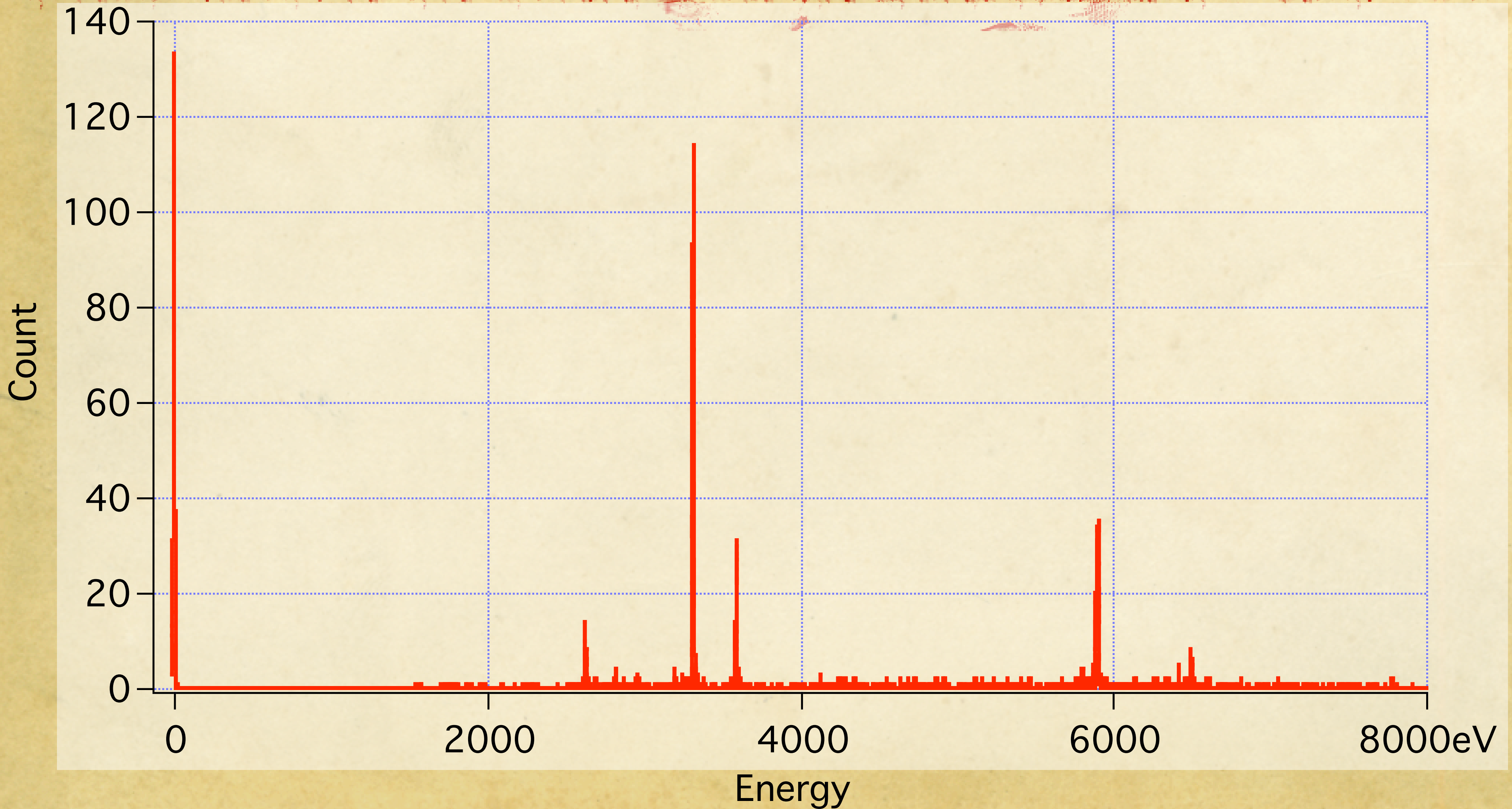
Pulse Height vs. Pulse Height



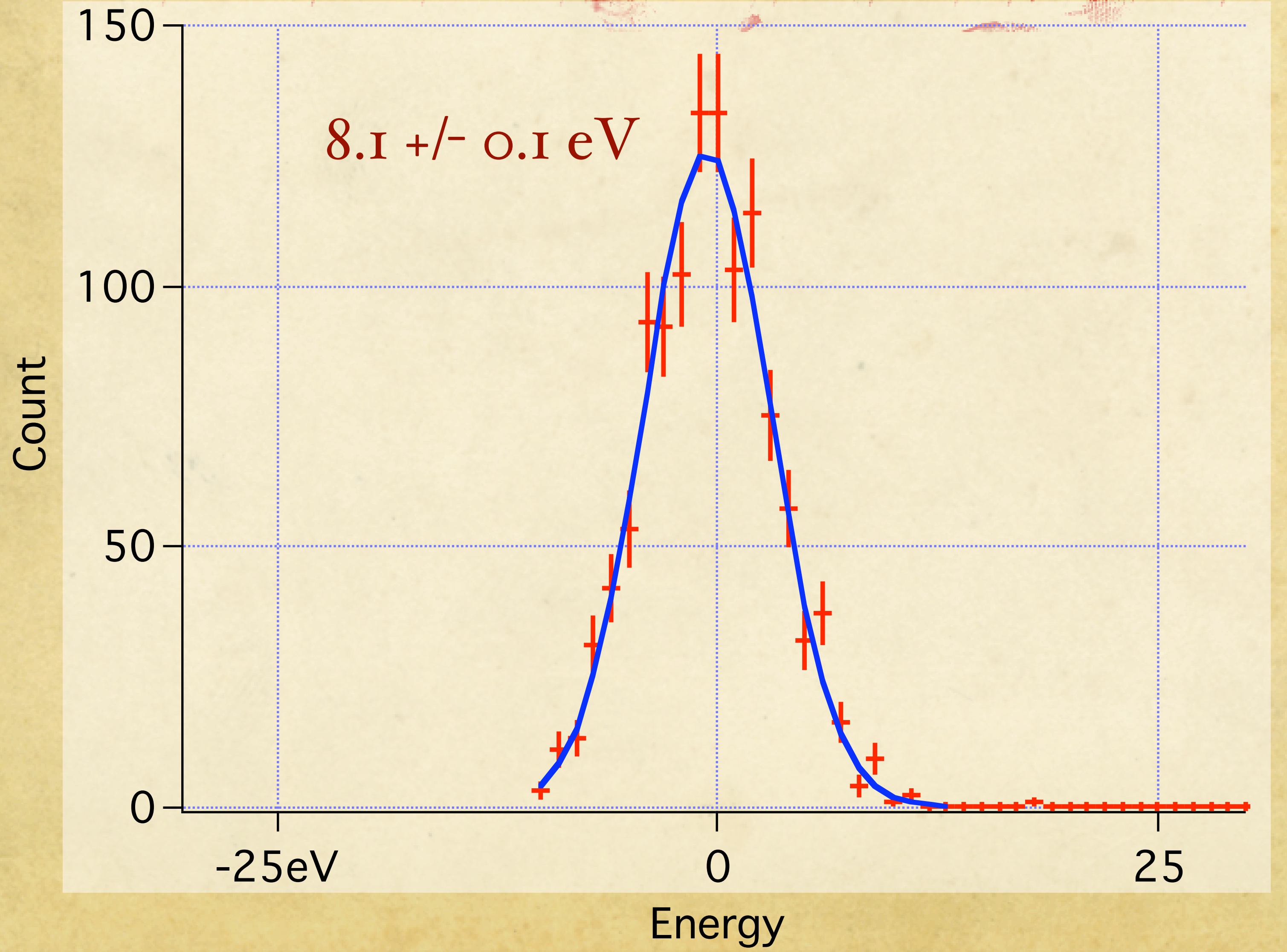
Pulse Area vs. Pulse Area



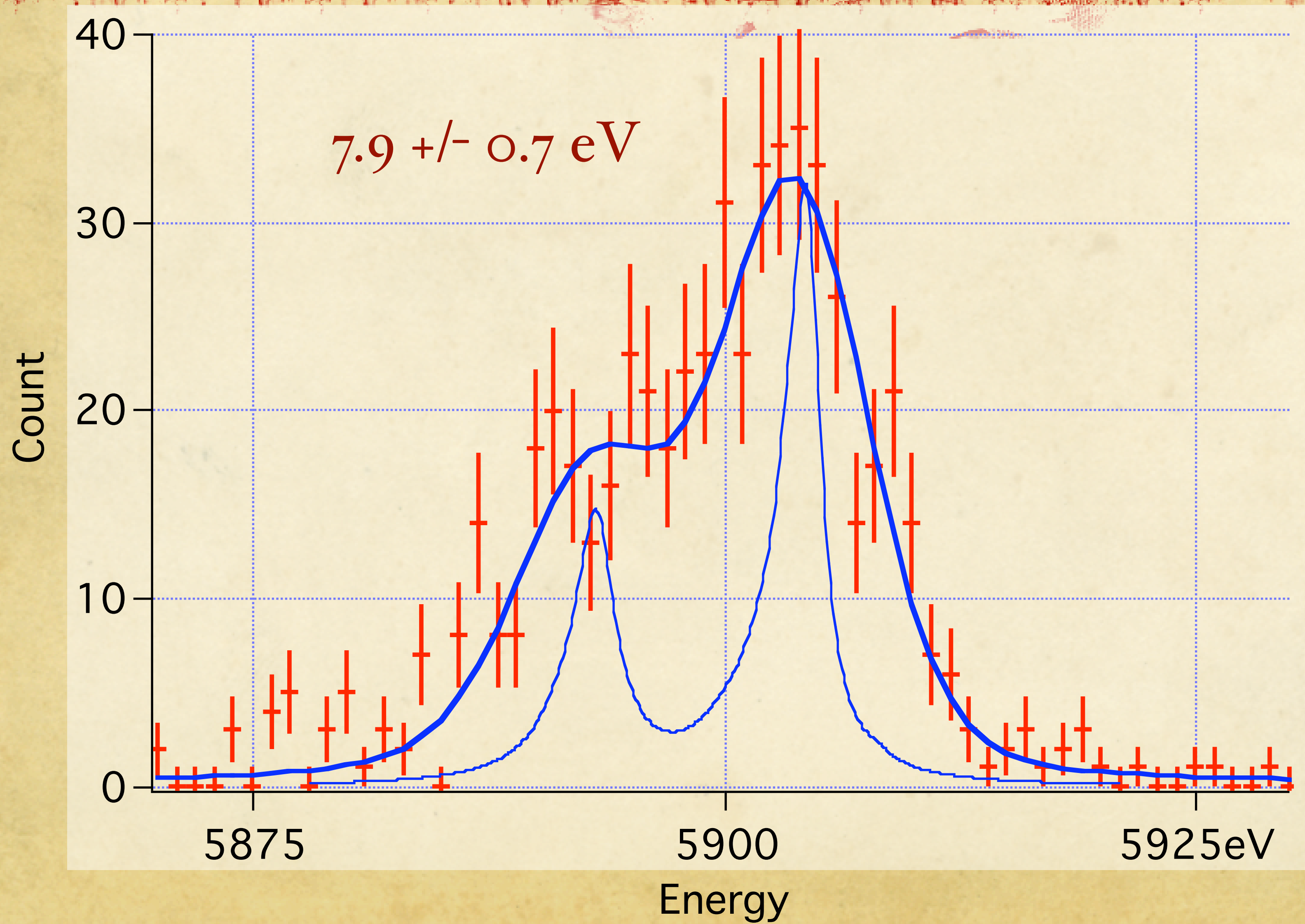
Pixel 4 Spectrum



Baseline Resolution

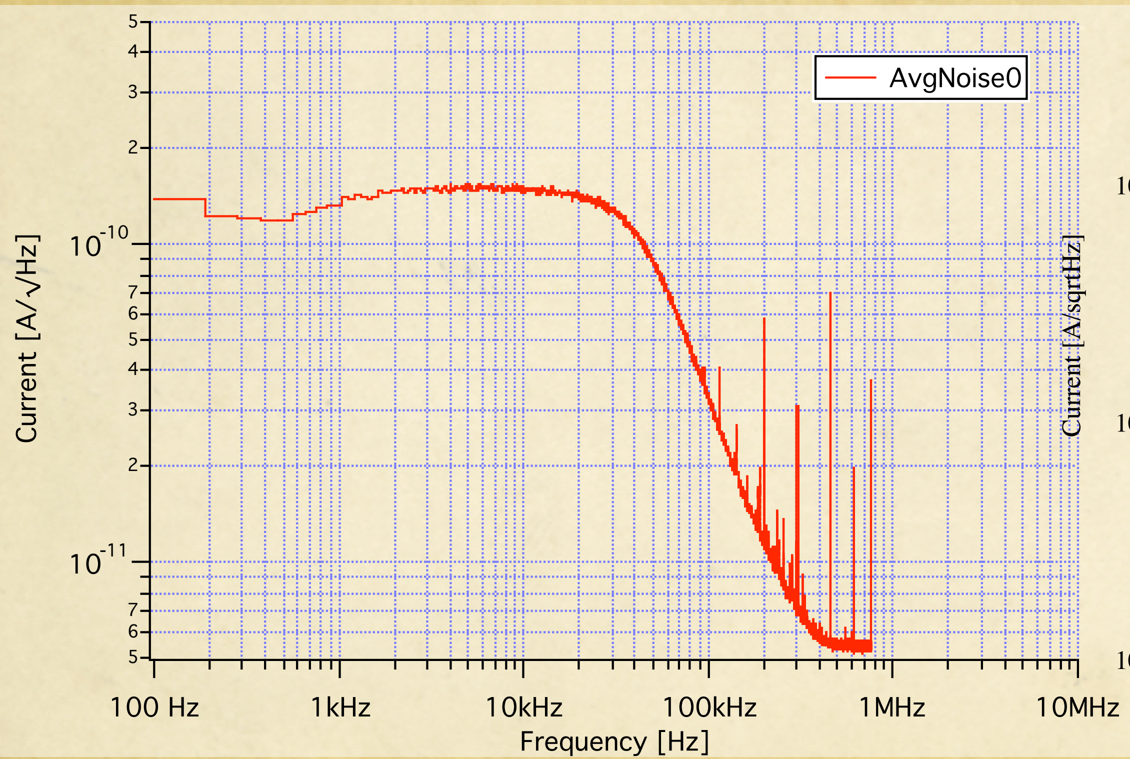


Manganese Ka Resolution

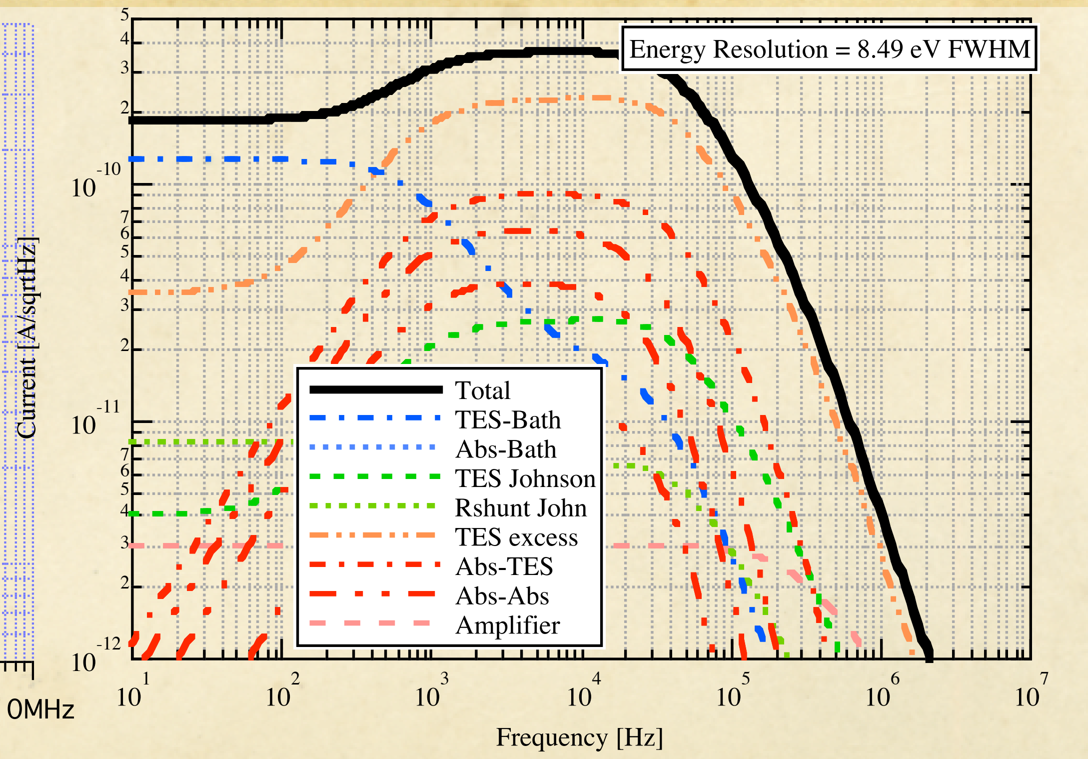


Noise Spectrum:
8.5 eV prediction, not a fit!

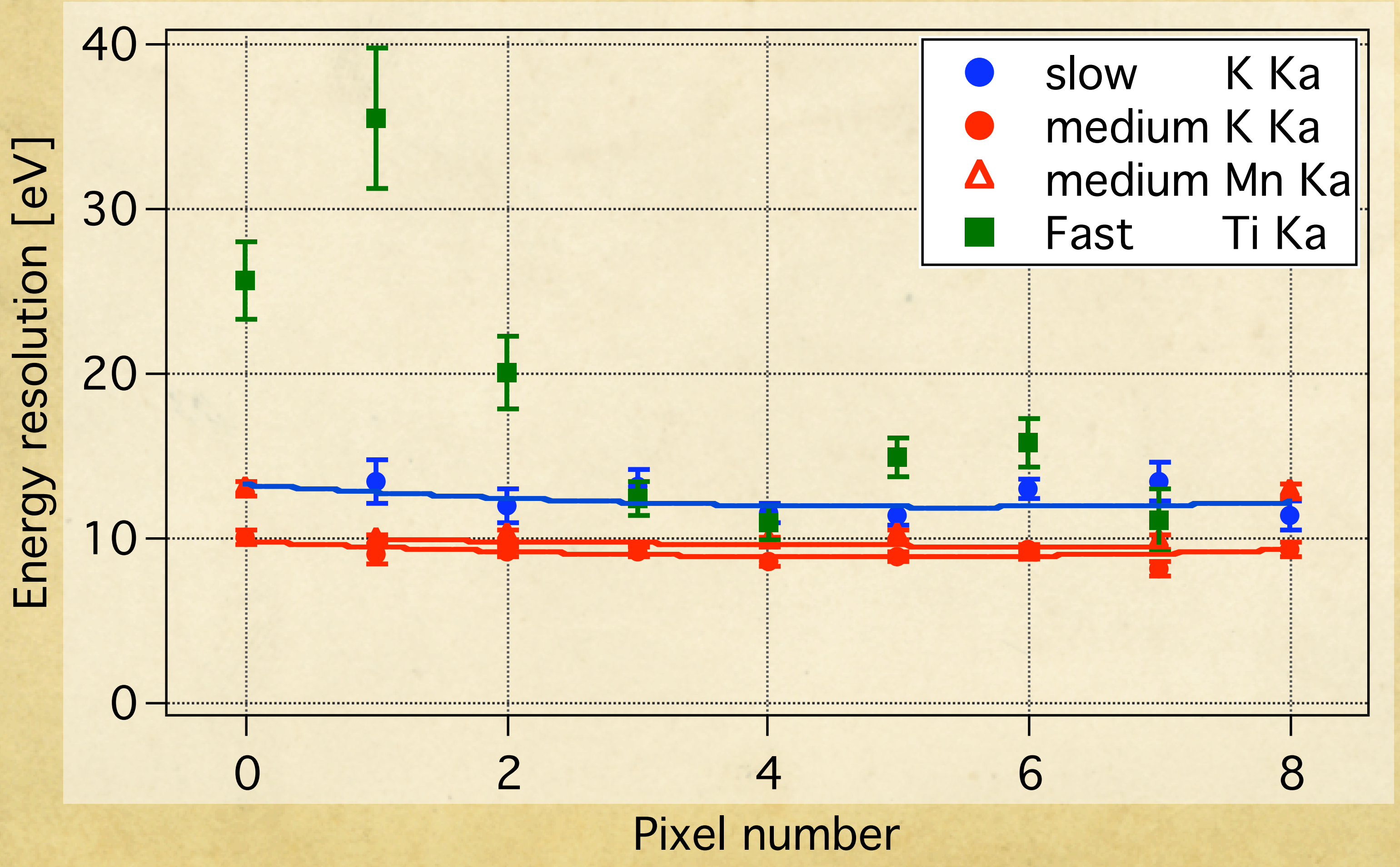
Actual Noise



Model Noise, with Excess noise 9 times Johnson



Resolution vs Pixel for 3 values of Gabs



Continuous Absorber PoSTs

Continuous PoST

Bi/Cu/Bi = 0.1/0.6/6.5 μm

C_{abs} = 2610 fJ/K, G_{abs} = 62 nW/K @T_c

Similar diffusion constant (G_{abs}/C_{abs})

to the segmented absorber PoST with the medium link.

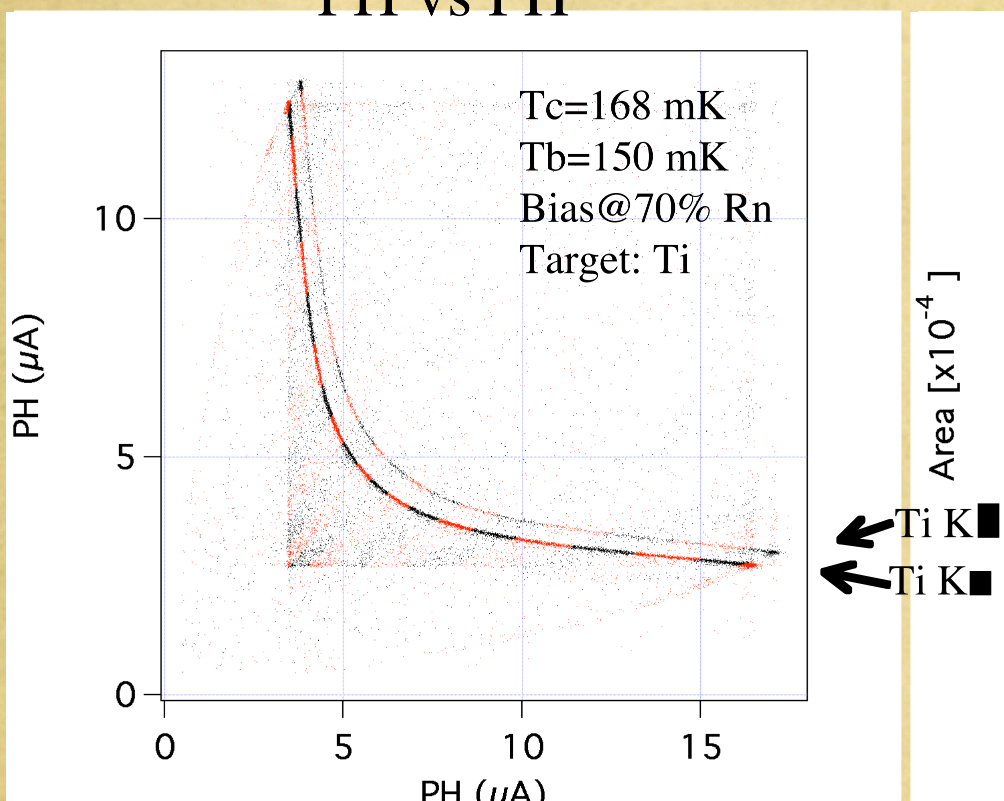
Mo/Au TES

TESs are covered with the absorber.

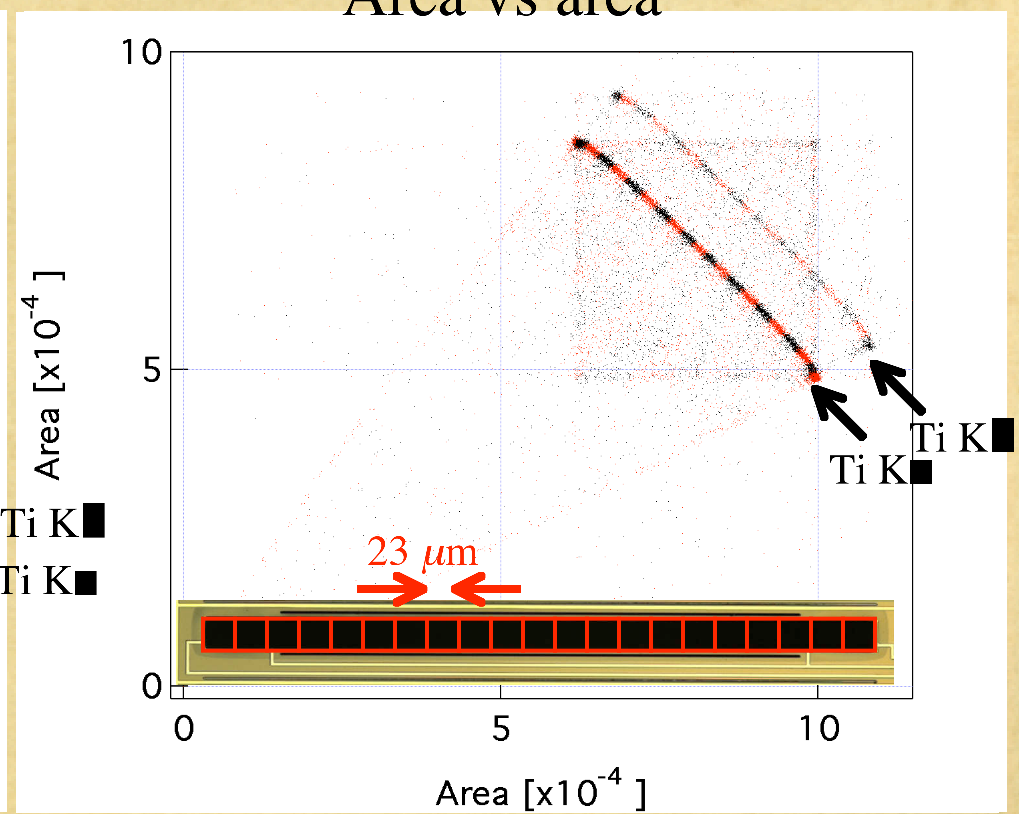
T_c = 168 mK (due to Bi diffusion into Au)

How to Define pixels

PH vs PH

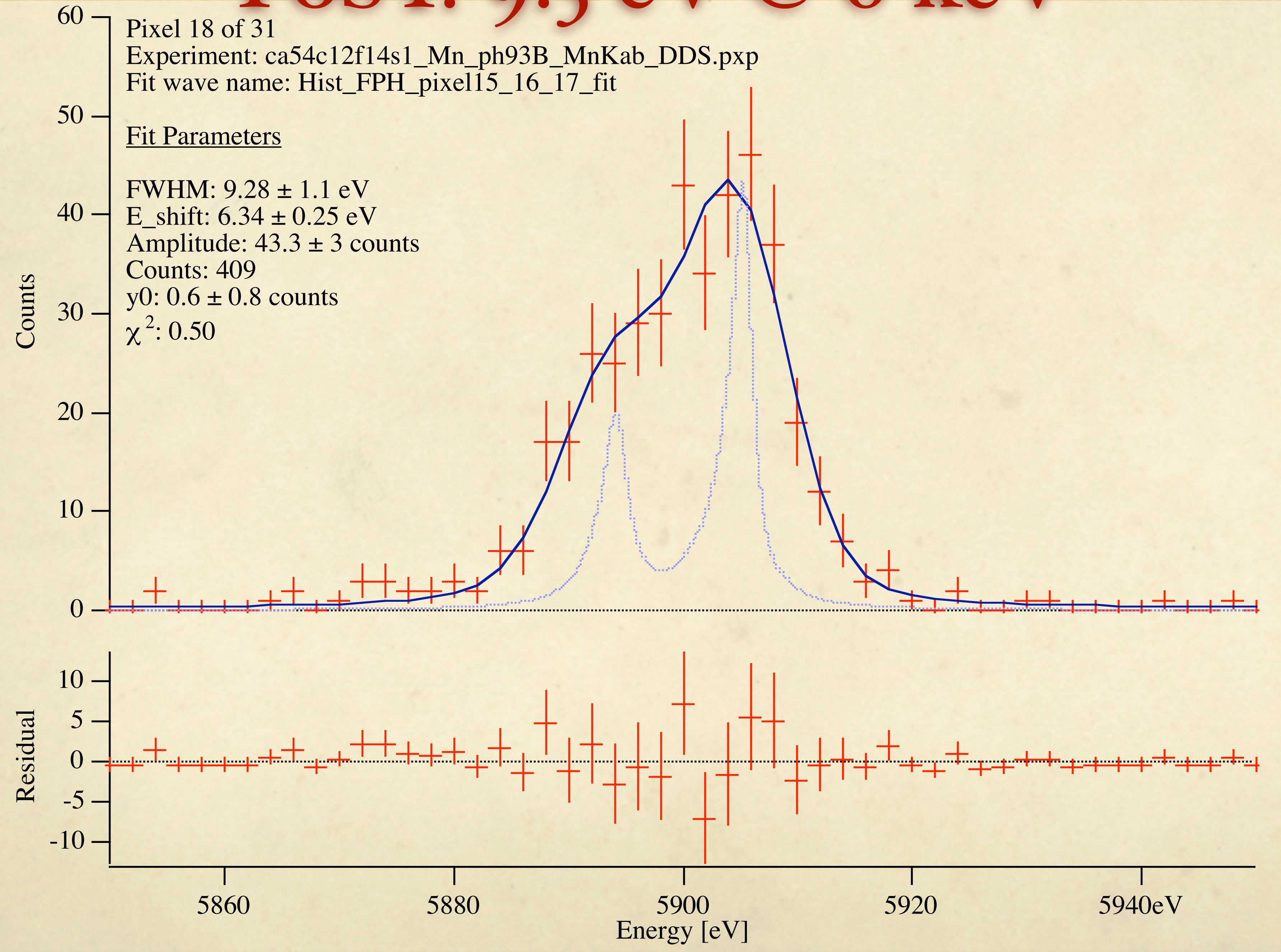


Area vs area

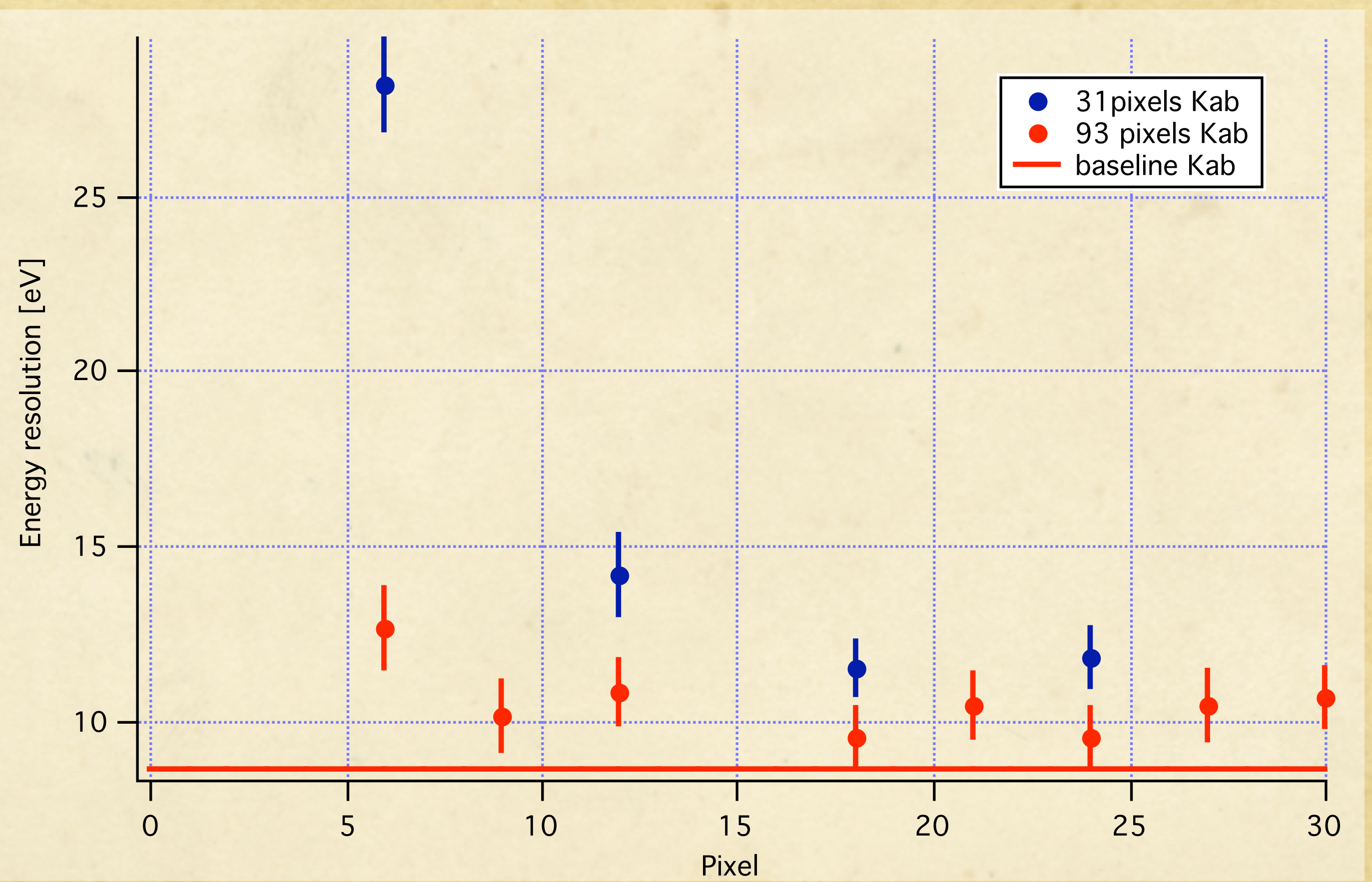


- Ratio of pulse area (TES A/TES B) --> X-ray hit position
- Divide into 93 groups with equal number of pulses (2.18 mm = 23 µm x 93)

Best Resolution on Continuous PoST: 9.3 eV @ 6 keV

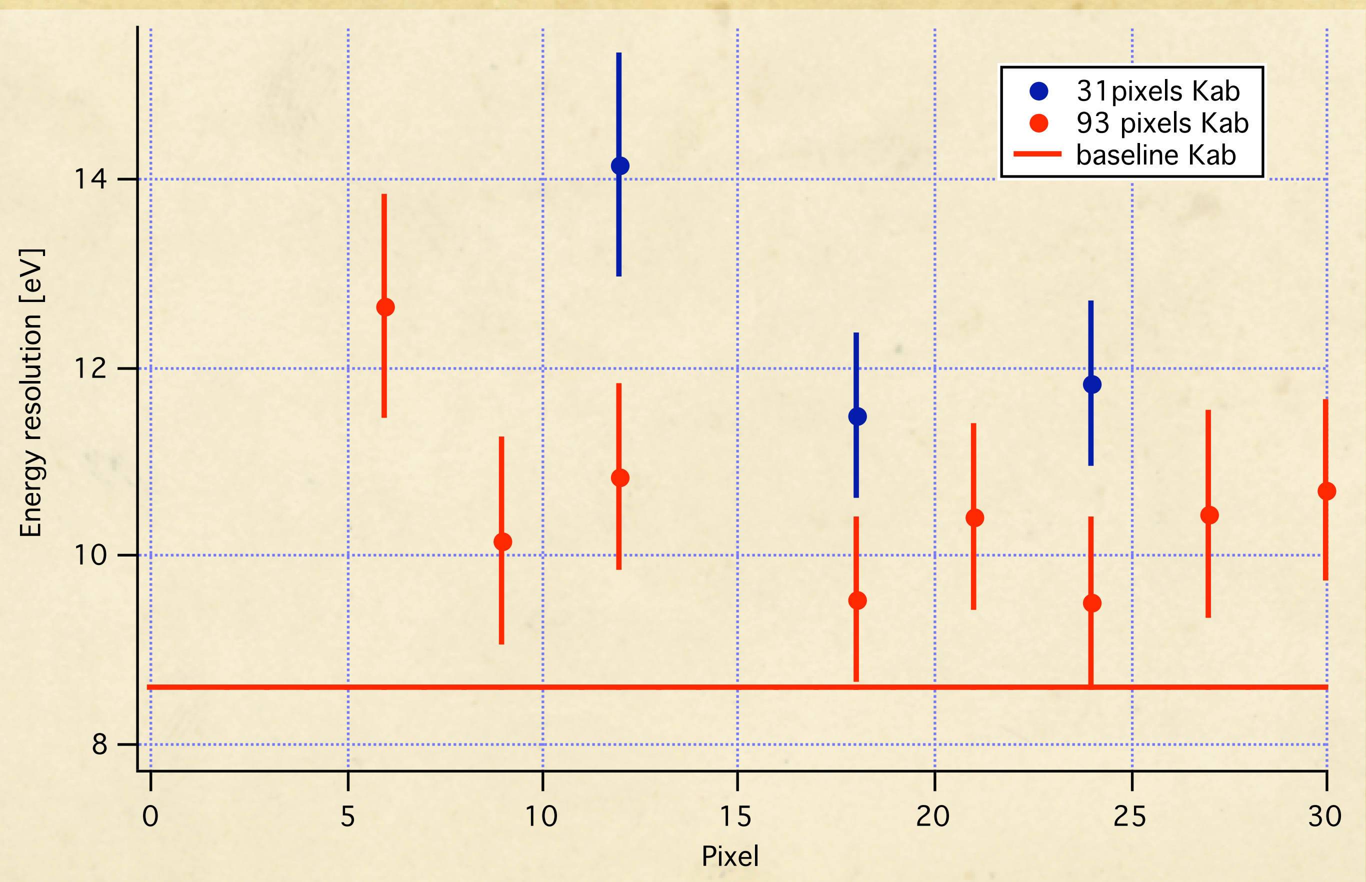


Resolution for several pixels along the Continuous PoST



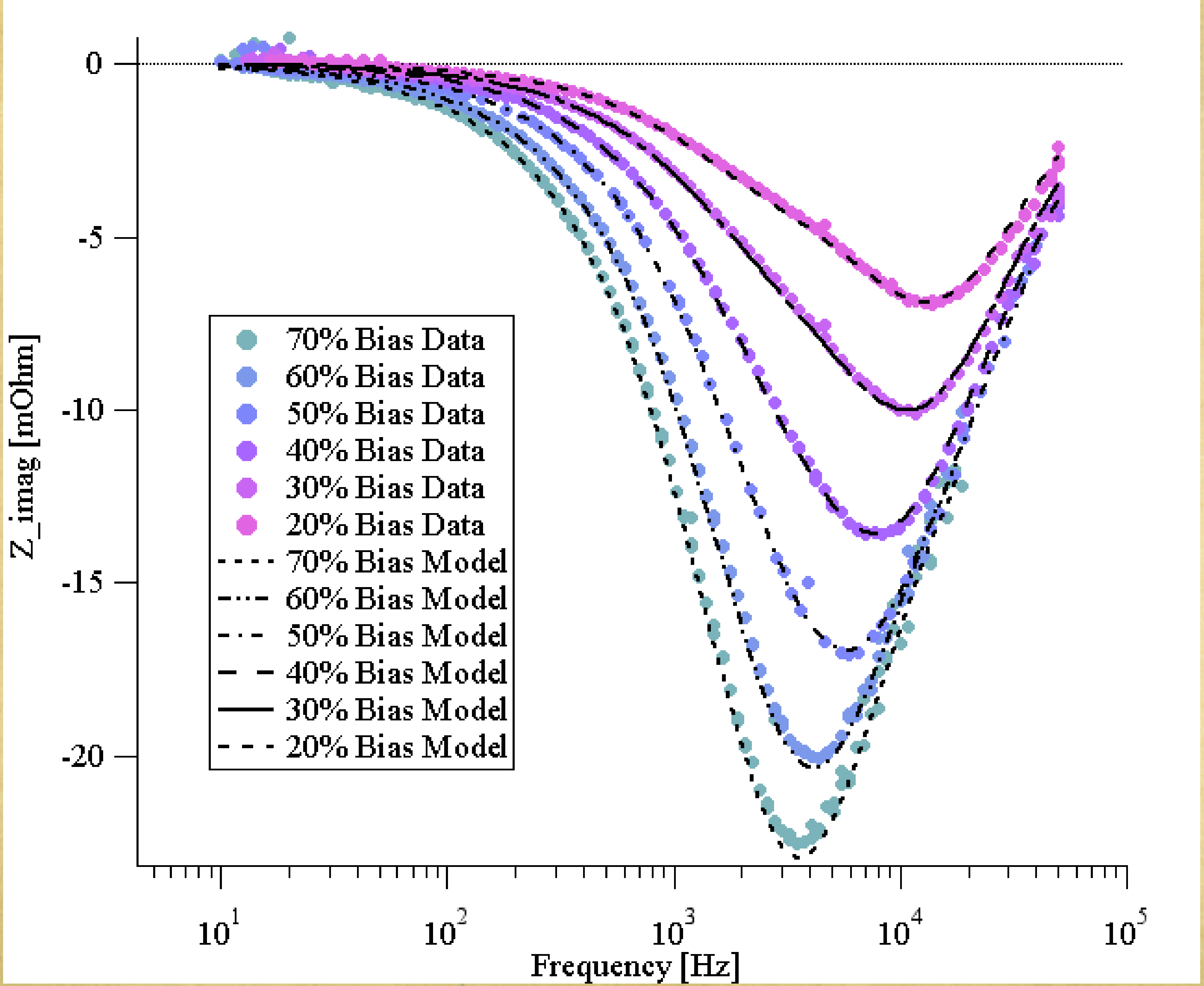
← Total PoST Length →

Resolution for several pixels along the Continuous PoST

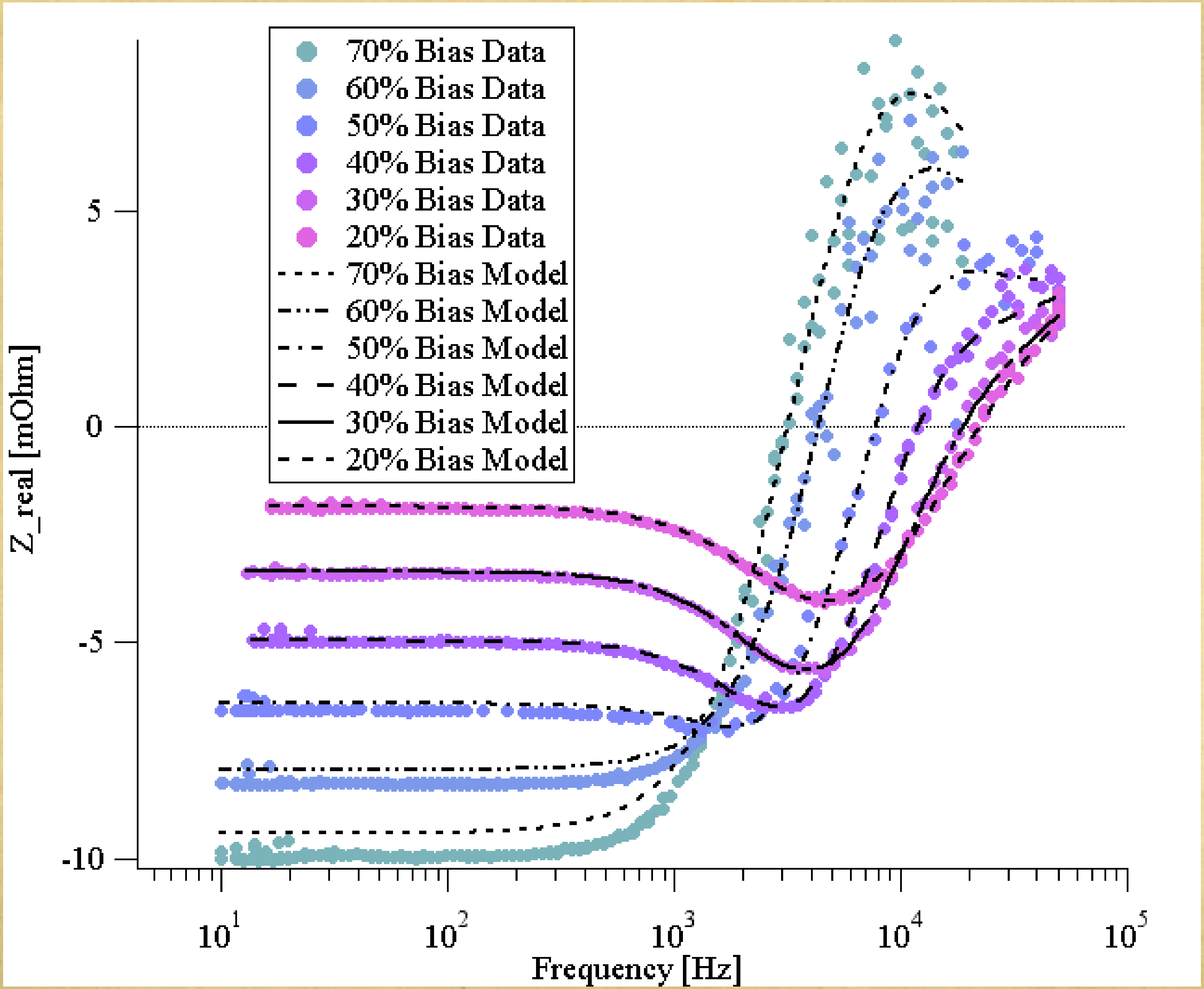


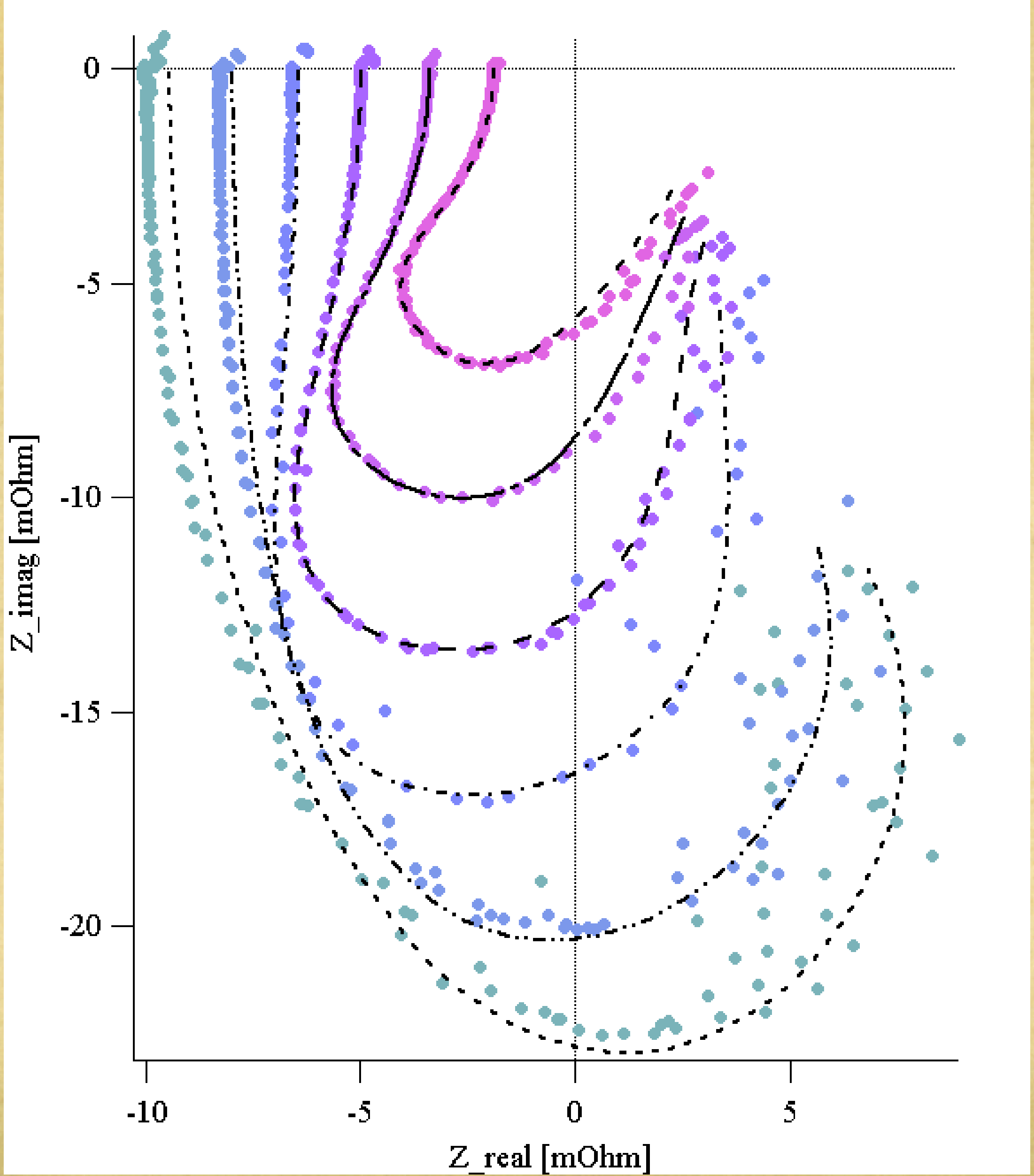
← Total PoST Length →

Impedance Fits on Continuouse PoST



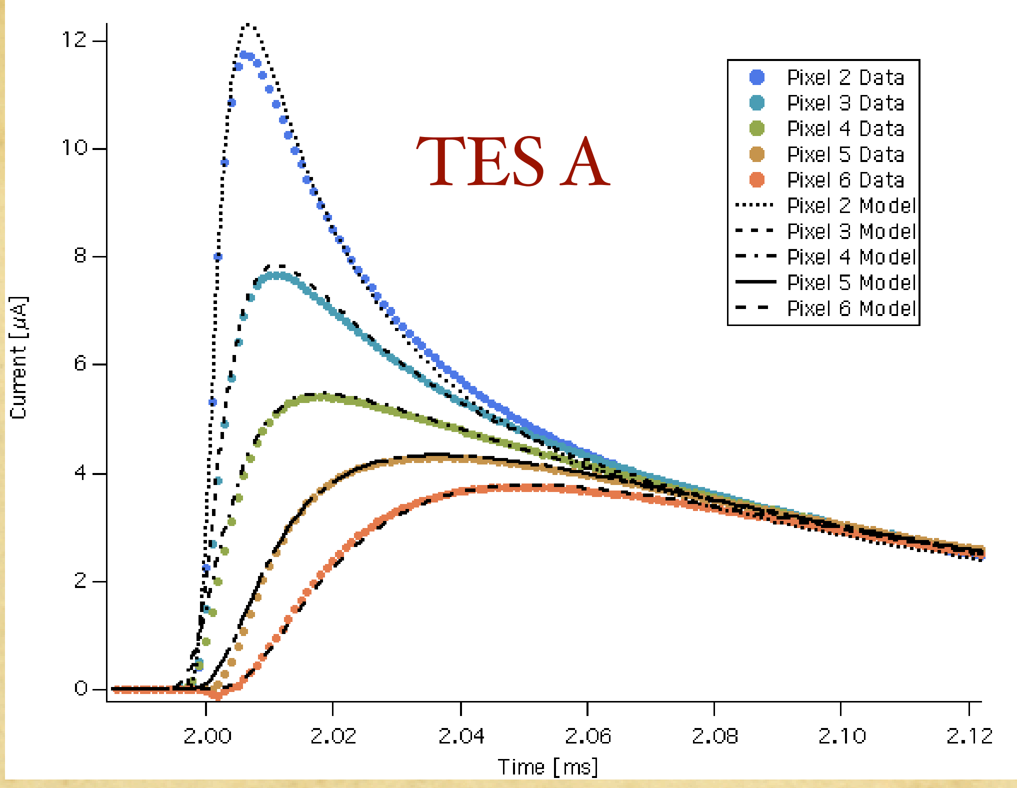
Z_imag [mOhm]
0
-5
-10
-15
-20
70% Bias Data
60% Bias Data
50% Bias Data
40% Bias Data
30% Bias Data
20% Bias Data
70% Bias Model
60% Bias Model
50% Bias Model
40% Bias Model
30% Bias Model
20% Bias Model
10^1
10^2
10^3
10^4
10^5
Frequency [Hz]

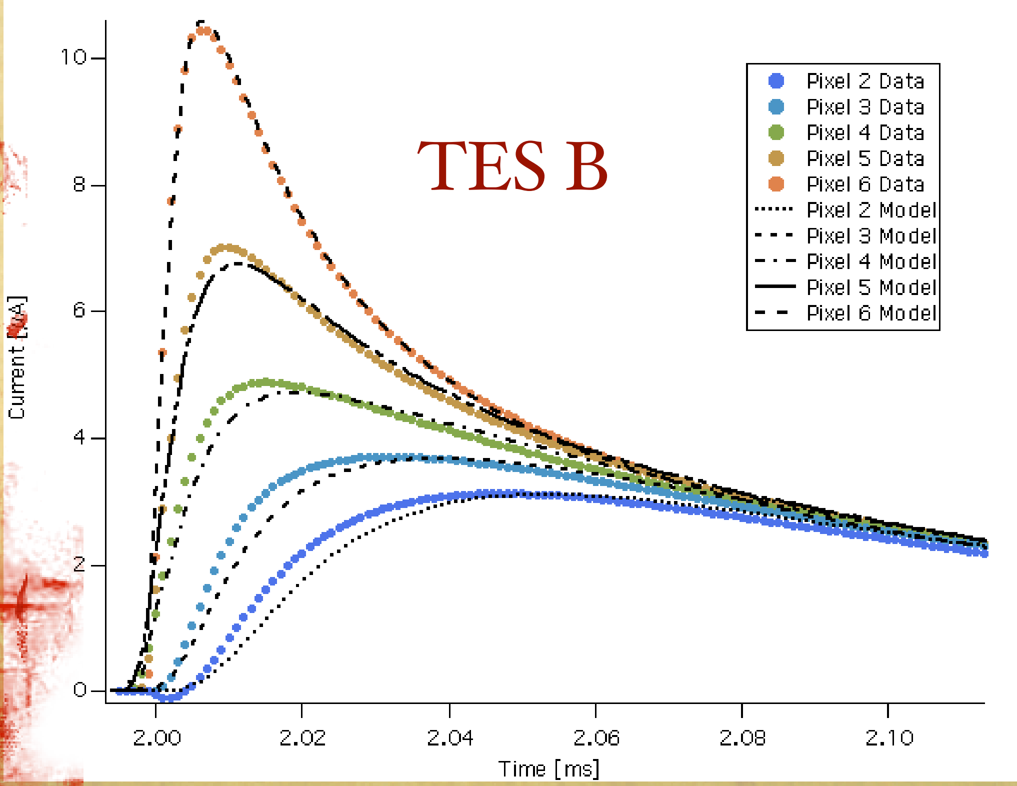

70% Bias Data
60% Bias Data
50% Bias Data
40% Bias Data
30% Bias Data
20% Bias Data
70% Bias Model
60% Bias Model
50% Bias Model
40% Bias Model
30% Bias Model
20% Bias Model
Z_real [mOhm]
5
0
-5
-10
10^1
10^2
10^3
10^4
10^5
Frequency [Hz]



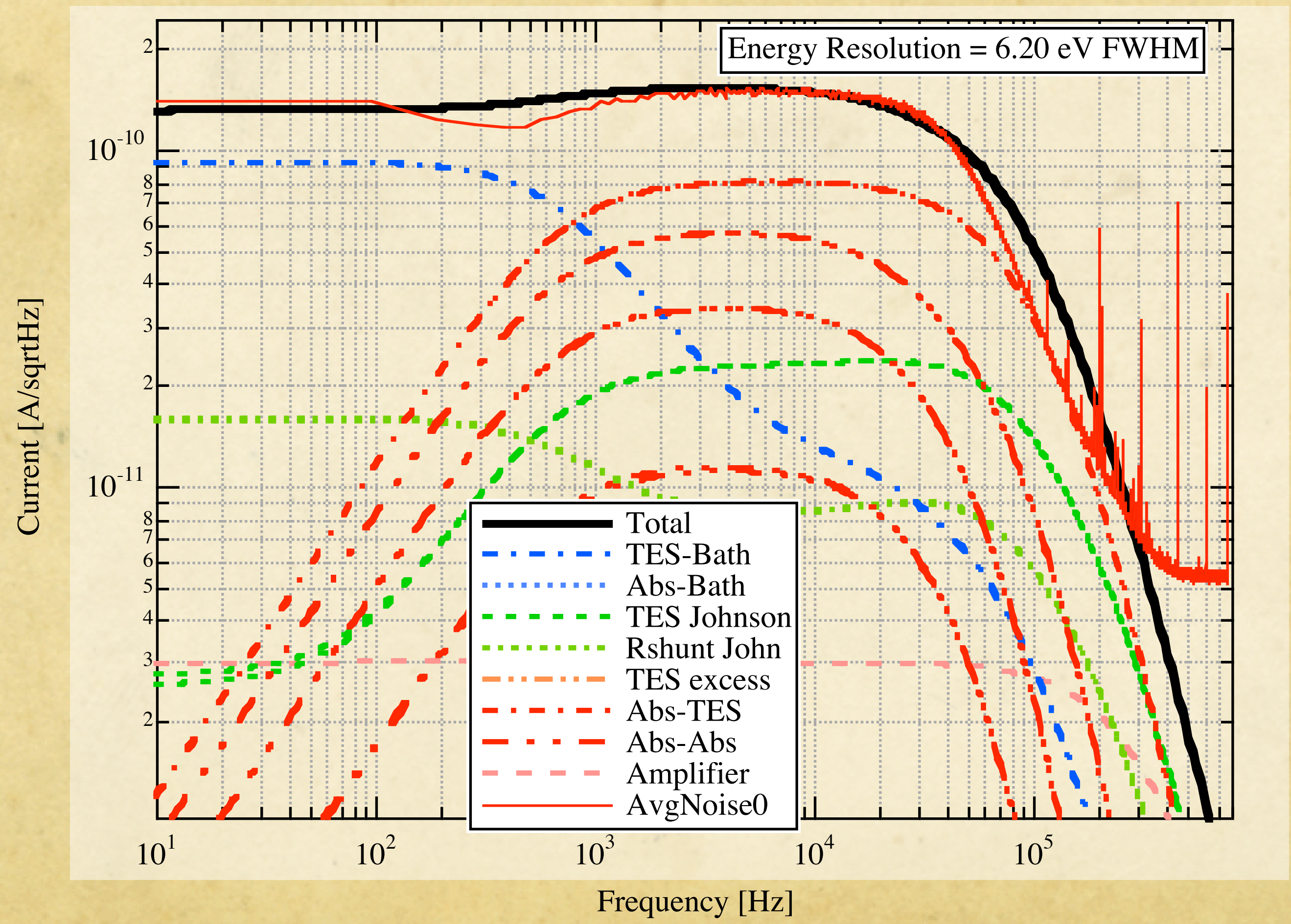
0
-5
-10
-15
-20
Z_imag [mOhm]
-10
-5
0
5
Z_real [mOhm]

Average Pulse data from continuous PoST and prediction from Impedance Fit Model





Noise Prediction vs Data
Looks Good but can fit other ways!



Beta as a function of Alpha in a TES

Linear R(T,I)

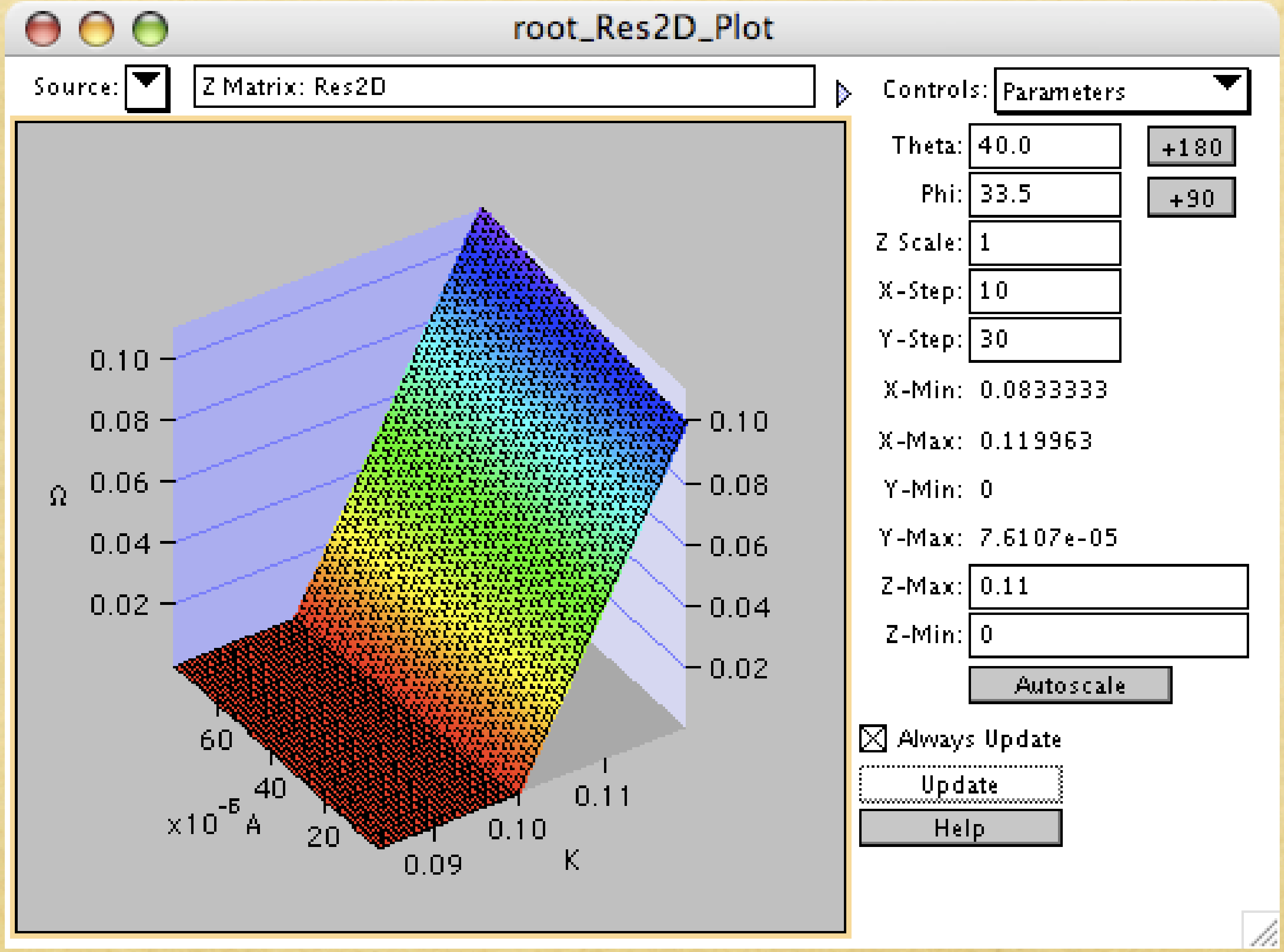
$$R = \alpha \frac{T}{T_o} + \beta_i \frac{I}{I_o} + R_o$$

$$\alpha = \left. \frac{T}{R} \frac{\partial R}{\partial T} \right|_{I=\mathrm{const}}$$

$$\beta_i = \left. \frac{I}{R} \frac{\partial R}{\partial I} \right|_{T=\mathrm{const}}$$

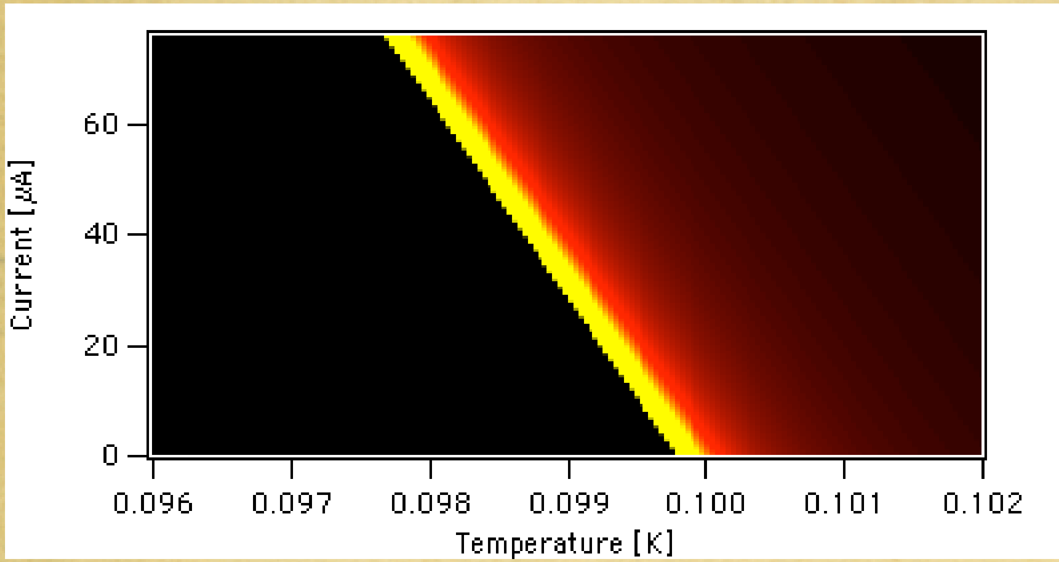
$$\beta_i = \alpha \frac{I}{T} \frac{n}{m} = \alpha \frac{I}{T} \frac{dT}{dI}$$

R(T,I)

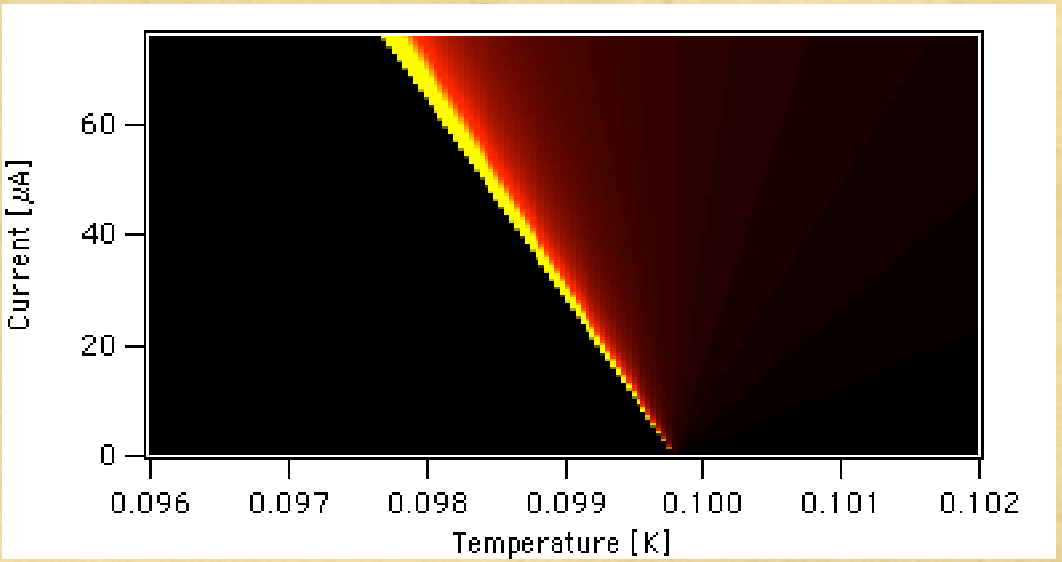

root_Res2D_Plot
Source:
Z Matrix: Res2D
Controls:
Parameters
Theta:
40.0
+180
Phi:
33.5
+90
Z Scale:
1
X-Step:
10
Y-Step:
30
X-Min: 0.0833333
X-Max: 0.119963
Y-Min: 0
Y-Max: 7.6107e-05
Z-Max:
0.11
Z-Min:
0
Autoscale
Always Update
Update
Help
Ω
0.10
0.08
0.06
0.04
0.02
0.10
0.08
0.06
0.04
0.02
60
40
20
x10⁻⁶ A
0.09
0.10
0.11
K

alpha(T,I) and beta(T,I)

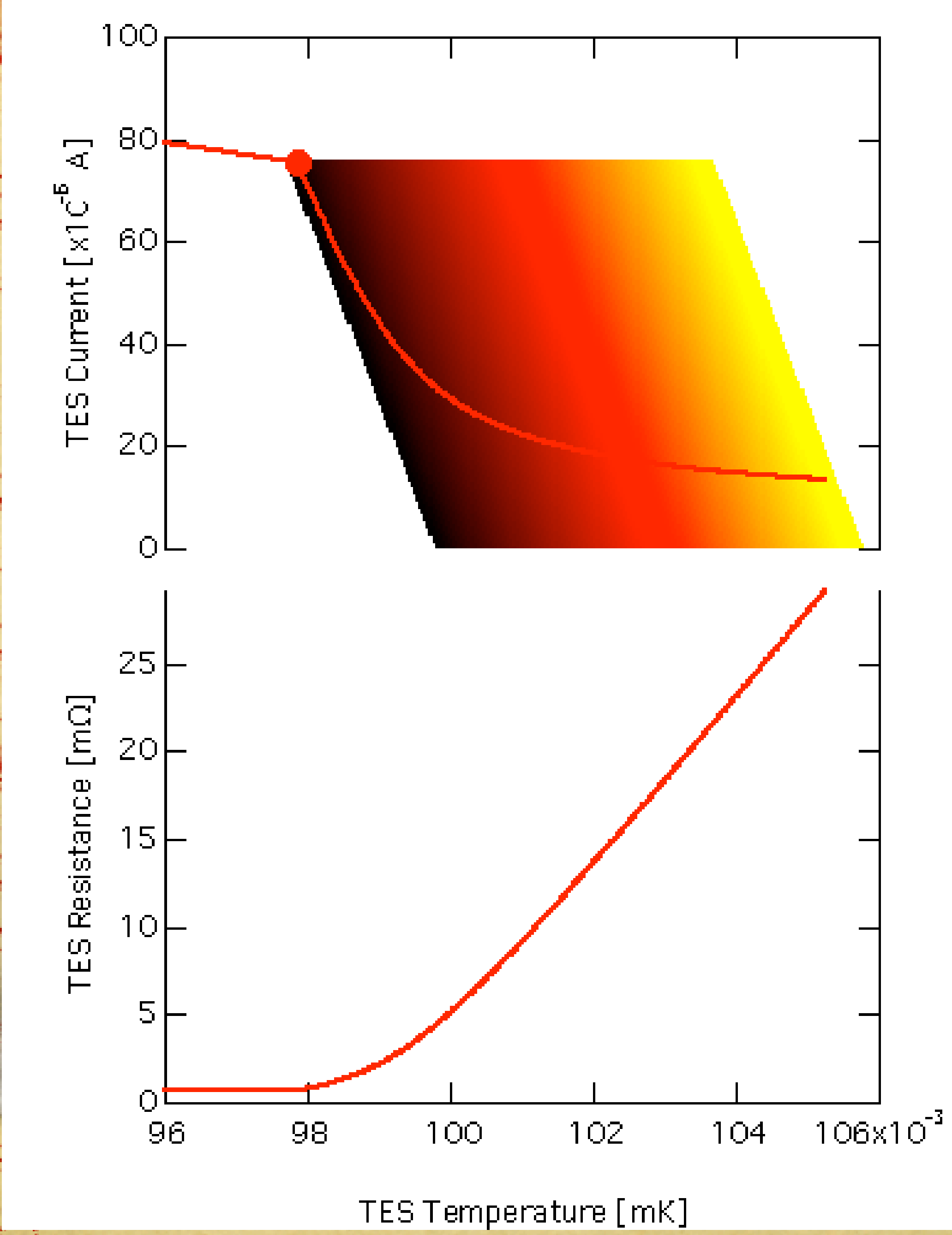
Alpha



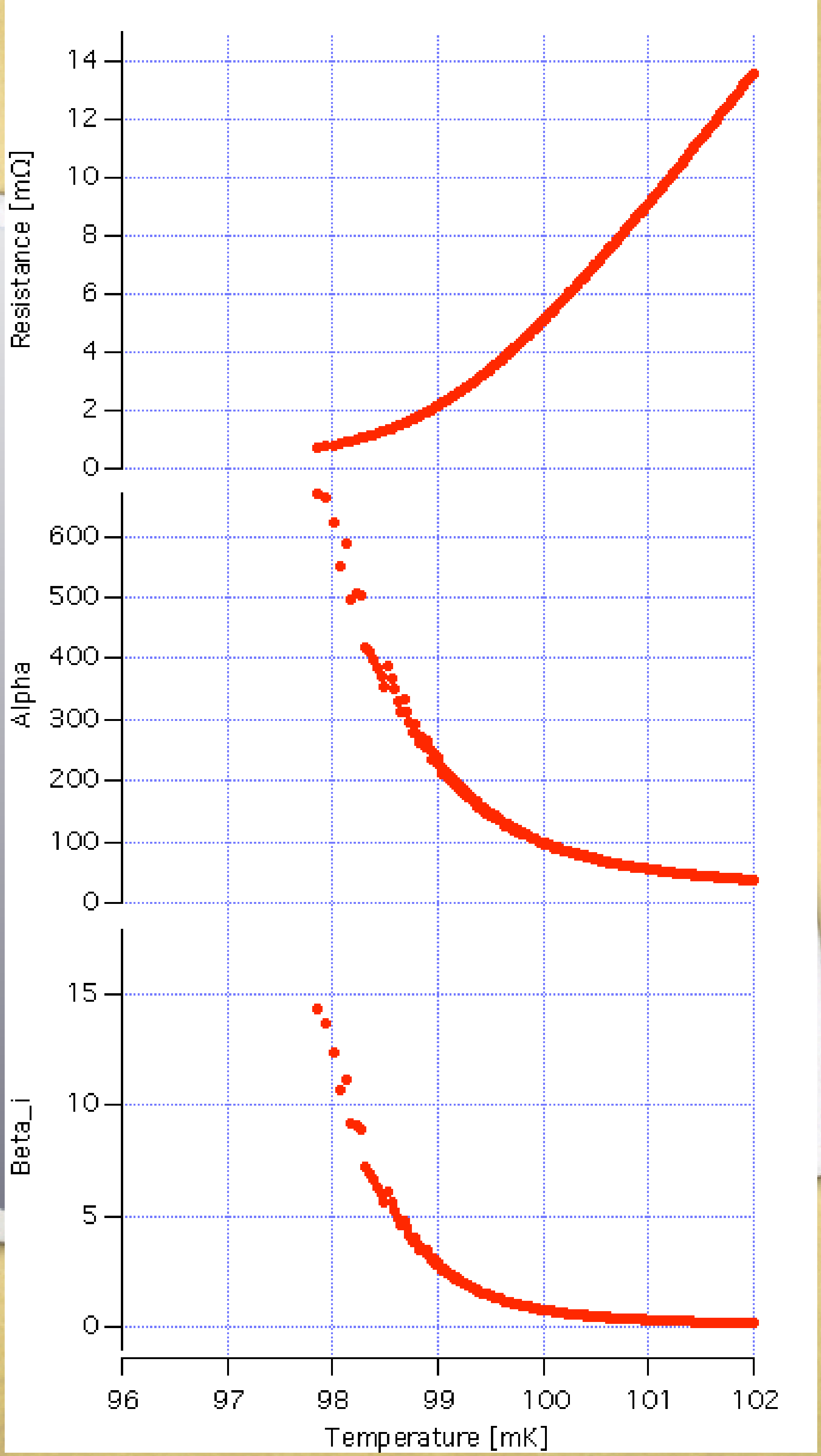
Beta



Bias Path through linear R(T,I)

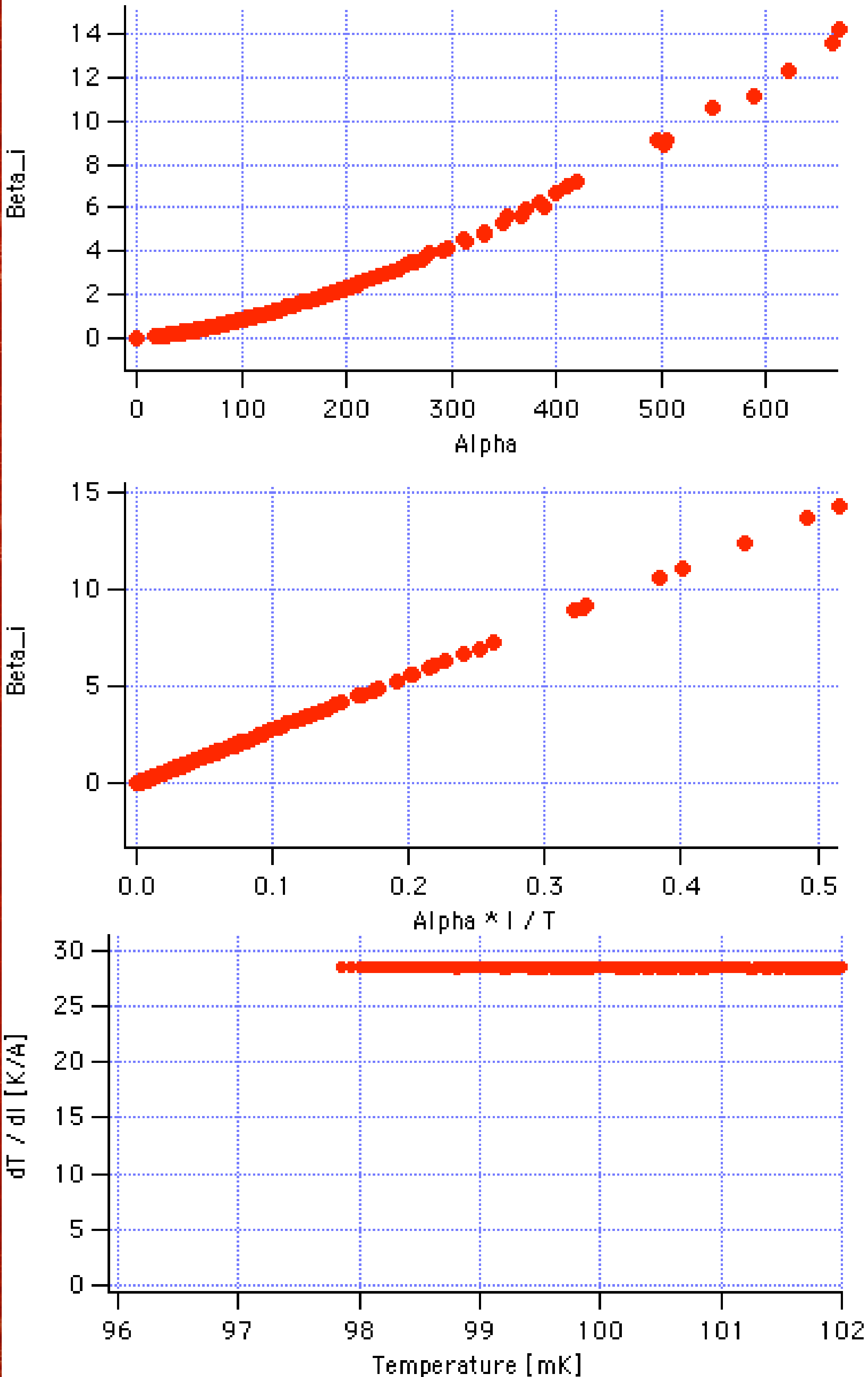


R, alpha and beta



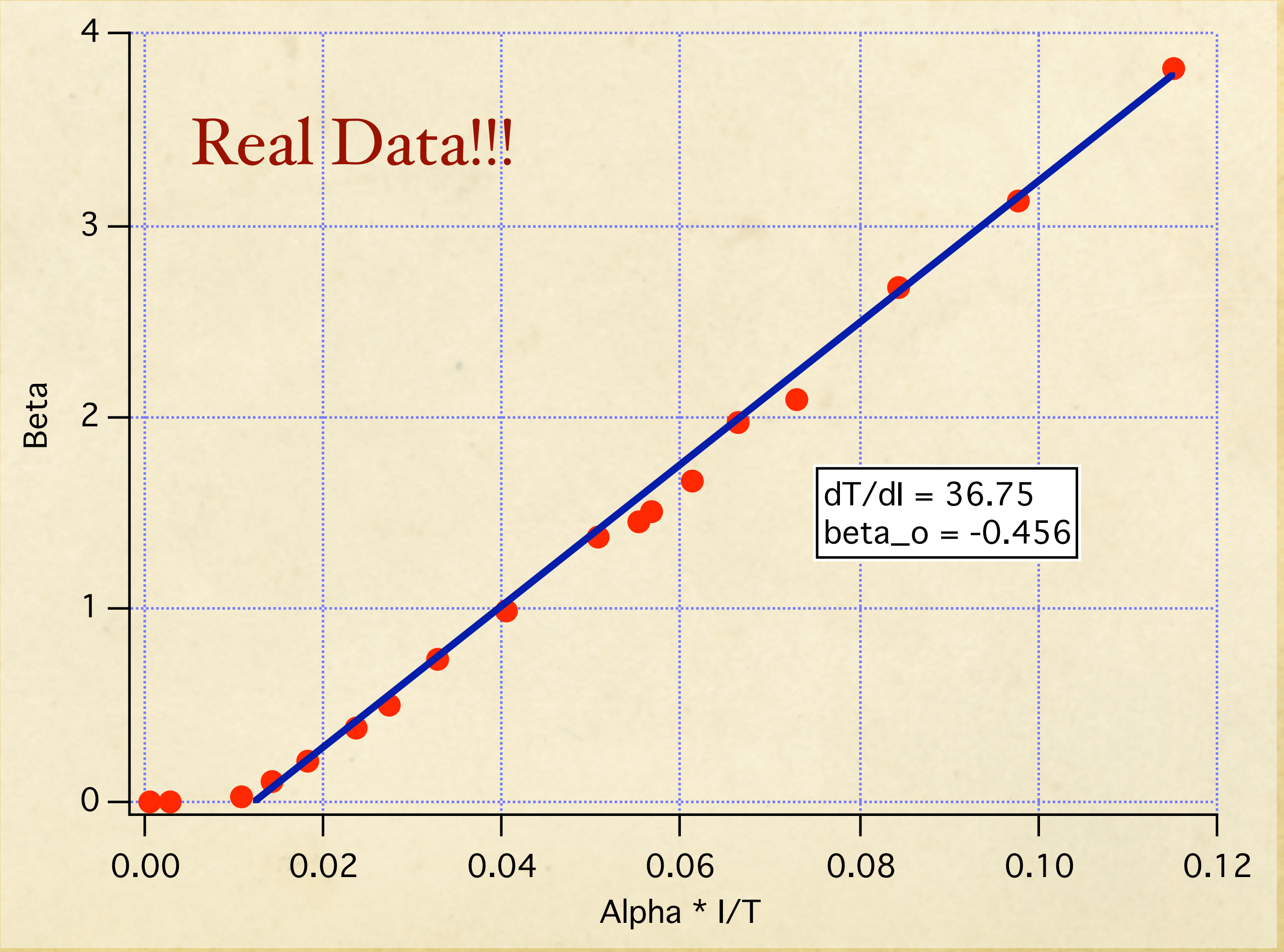
beta = f(alpha)

$$\beta_i = \alpha \frac{I}{T}\frac{n}{m} = \alpha \frac{I}{T}\frac{dT}{dI}$$



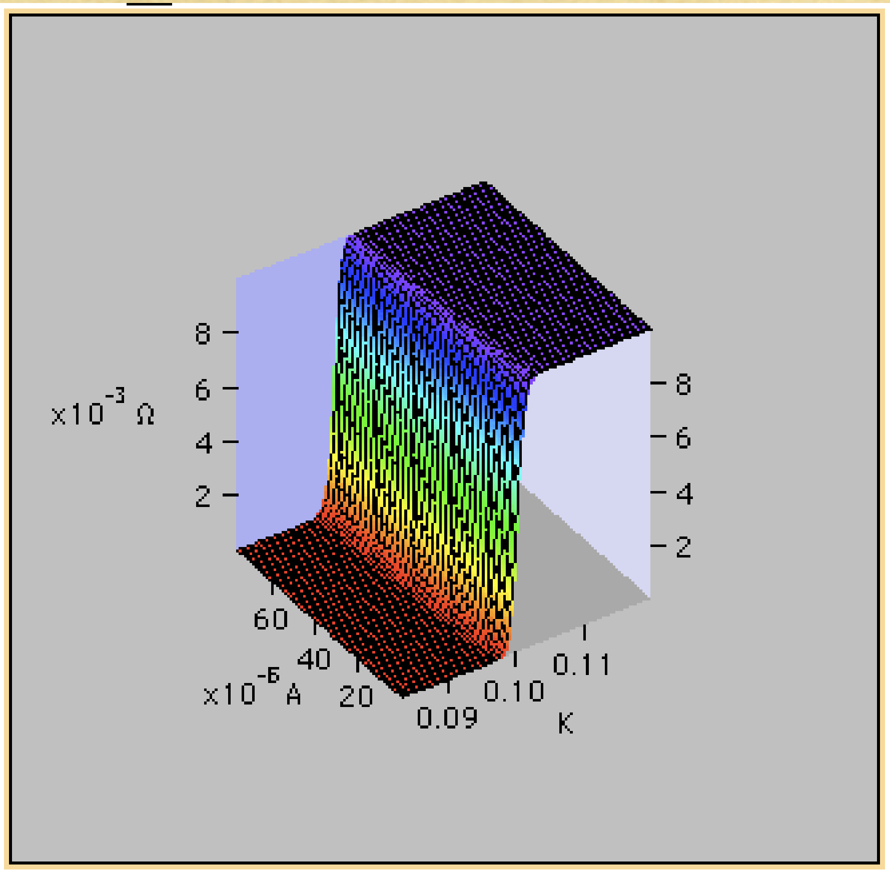
Beta for real Data!!!
dT/dI = 36.75

$$\beta_i = \alpha \frac{I}{T} \frac{dT}{dI} + \beta_o$$

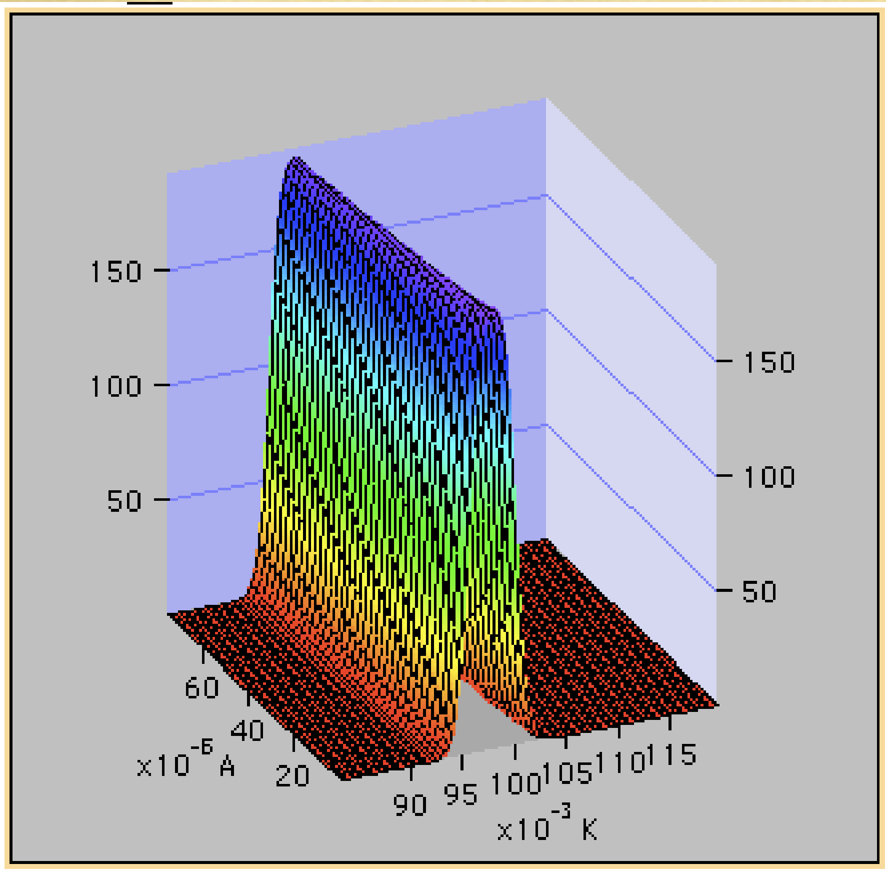


Non-Linear R(T,I)

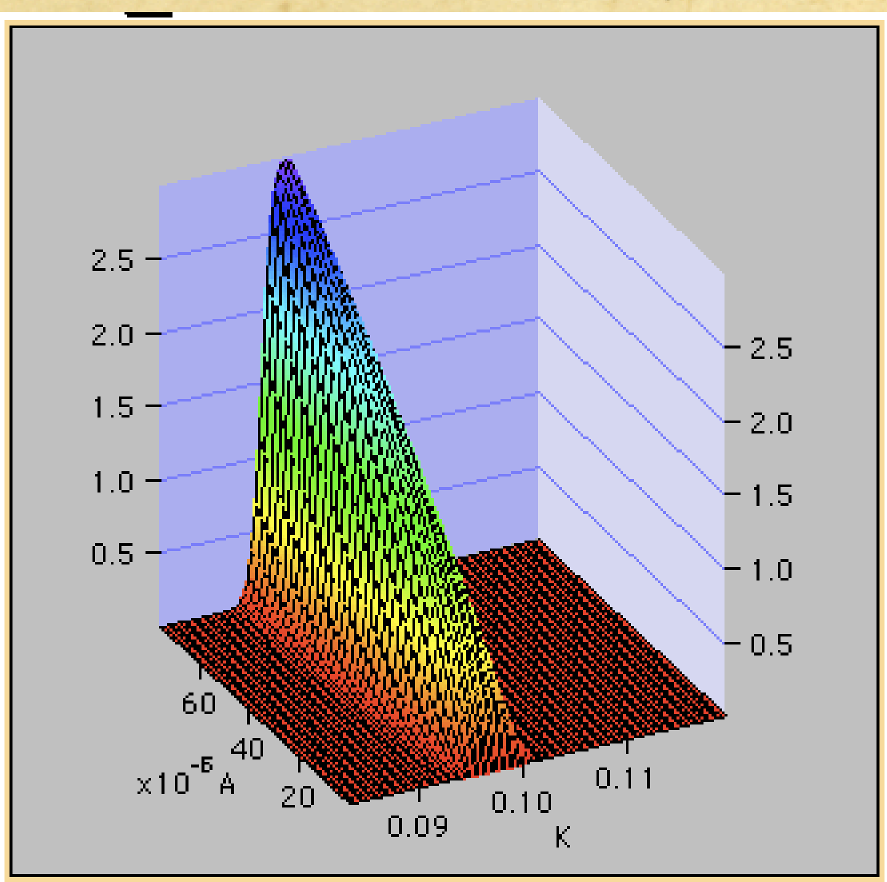
$$R(T,I) = \frac{R_n}{2}\left(1 + \tanh\left[\frac{\alpha_o}{T_c}\left(T - T_c + \left(\frac{I}{A}\right)^{2/3}\right)\right]\right)$$



Alpha and Beta

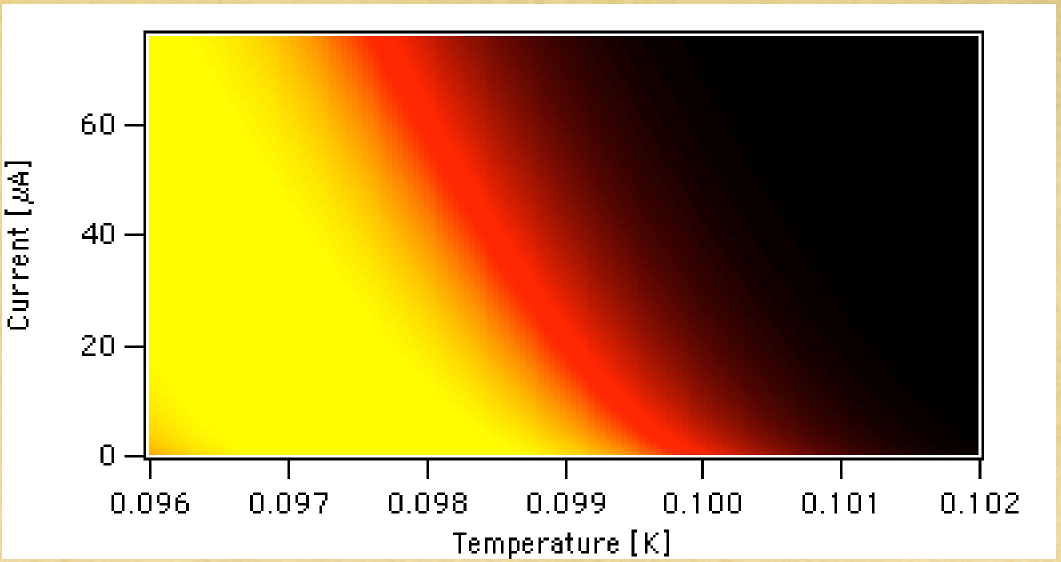


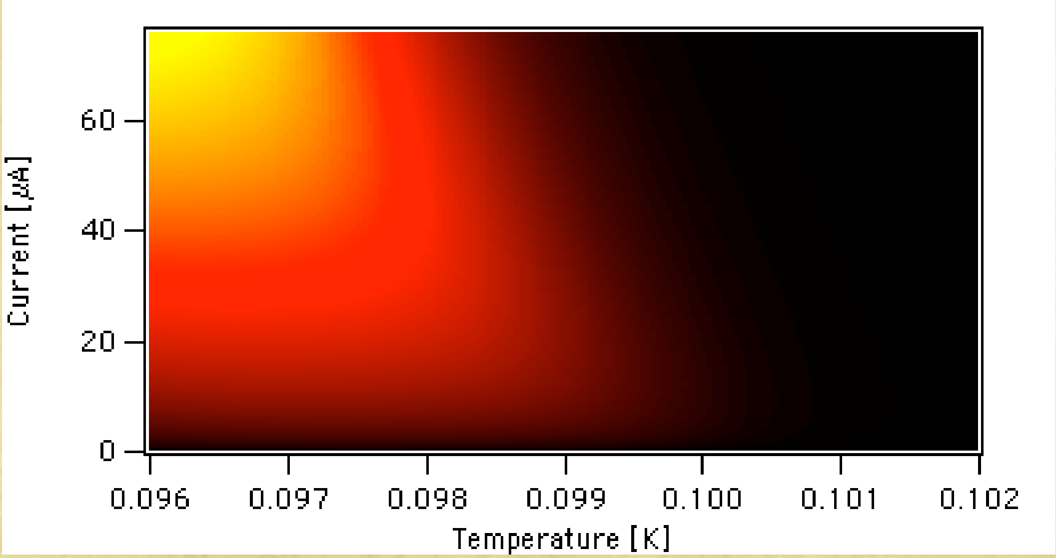
Alpha



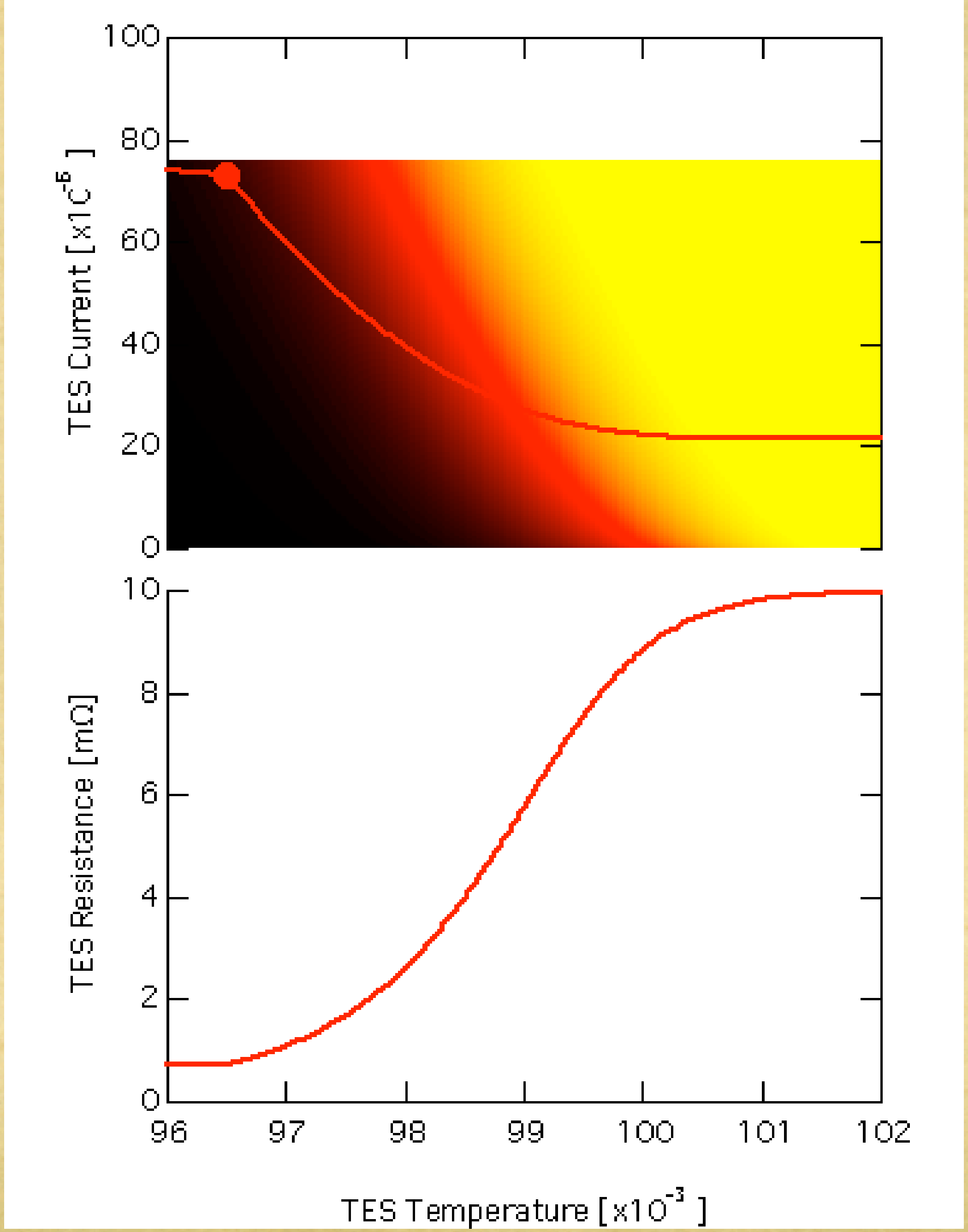
Beta

Alpha and Beta vs Current and Temp

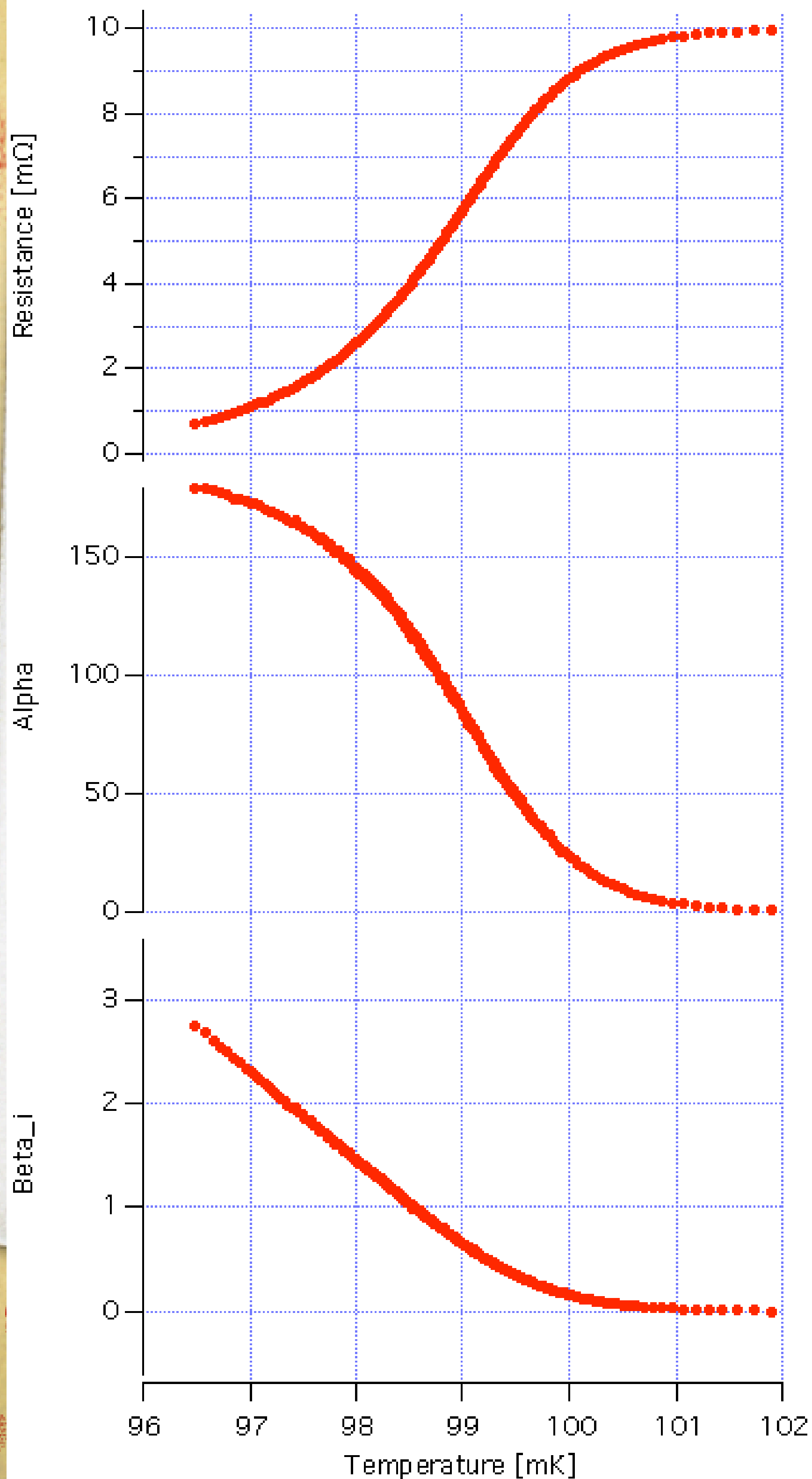




Bias Point Path



R, alpha and beta through bias curve



Beta vs Alpha and dT/dI