Study of transition steepness for wiring and absorber coupling geometries

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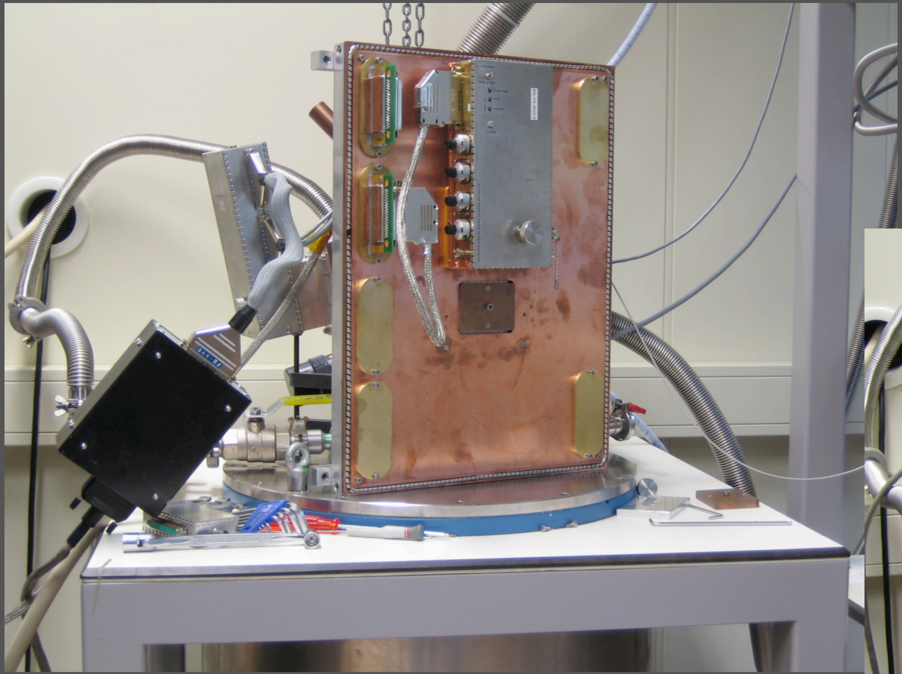
Outline

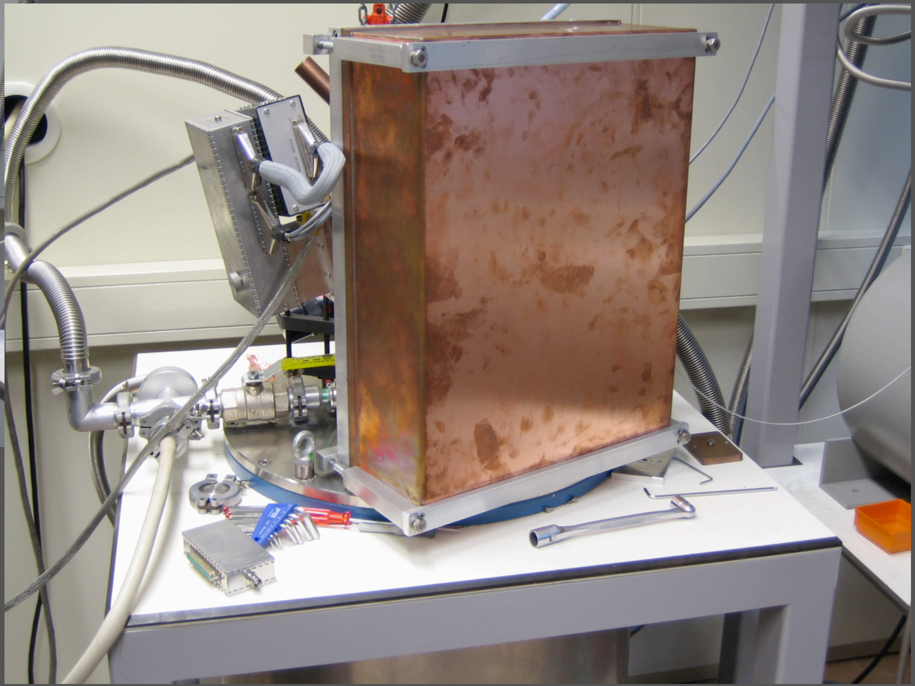
- Setup/performance improvements
- Background of the new detector development
- Transition steepness study
- Absorber coupling
- Recent results: Noise/performance analysis

Performance data

- The EMI shielding has been improved by enclosing the FLL electronics in a Faraday cage and by optimizing the EMI filters
- Improved energy resolution data on our standard single pixel devices
- Long term stability of the set-up
- Good results on array pixels

Set-up improvement by a sarcophagus





The EMI shielding has been improved by enclosing the FLL electronics in a Faraday cage and by optimizing the EMI filters

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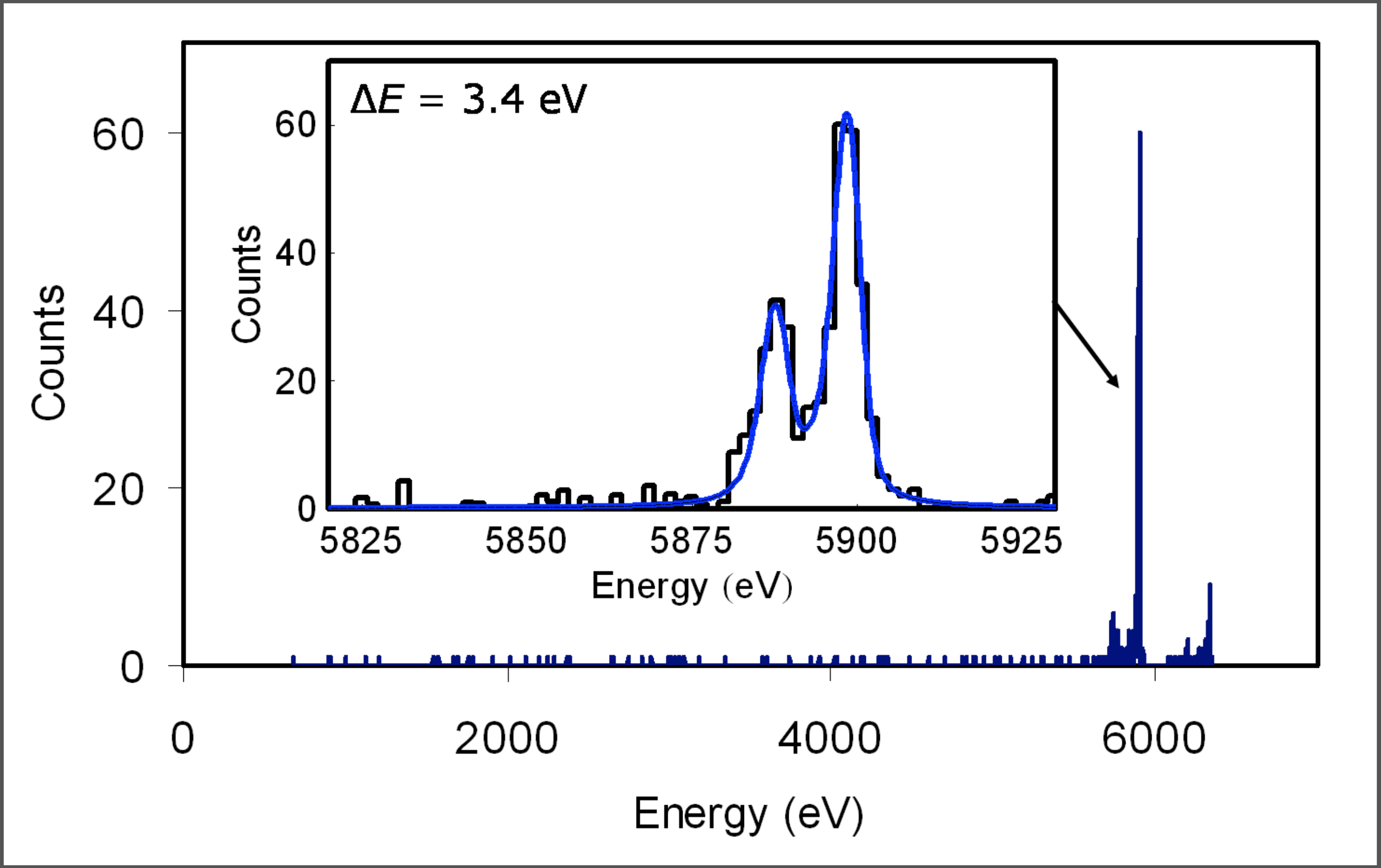
Perfomance data (single pixel)

'Best' SRON single pixel with central absorber (X049)

dE = 3.4 eV @ 6 keV; optimum digital filter applied



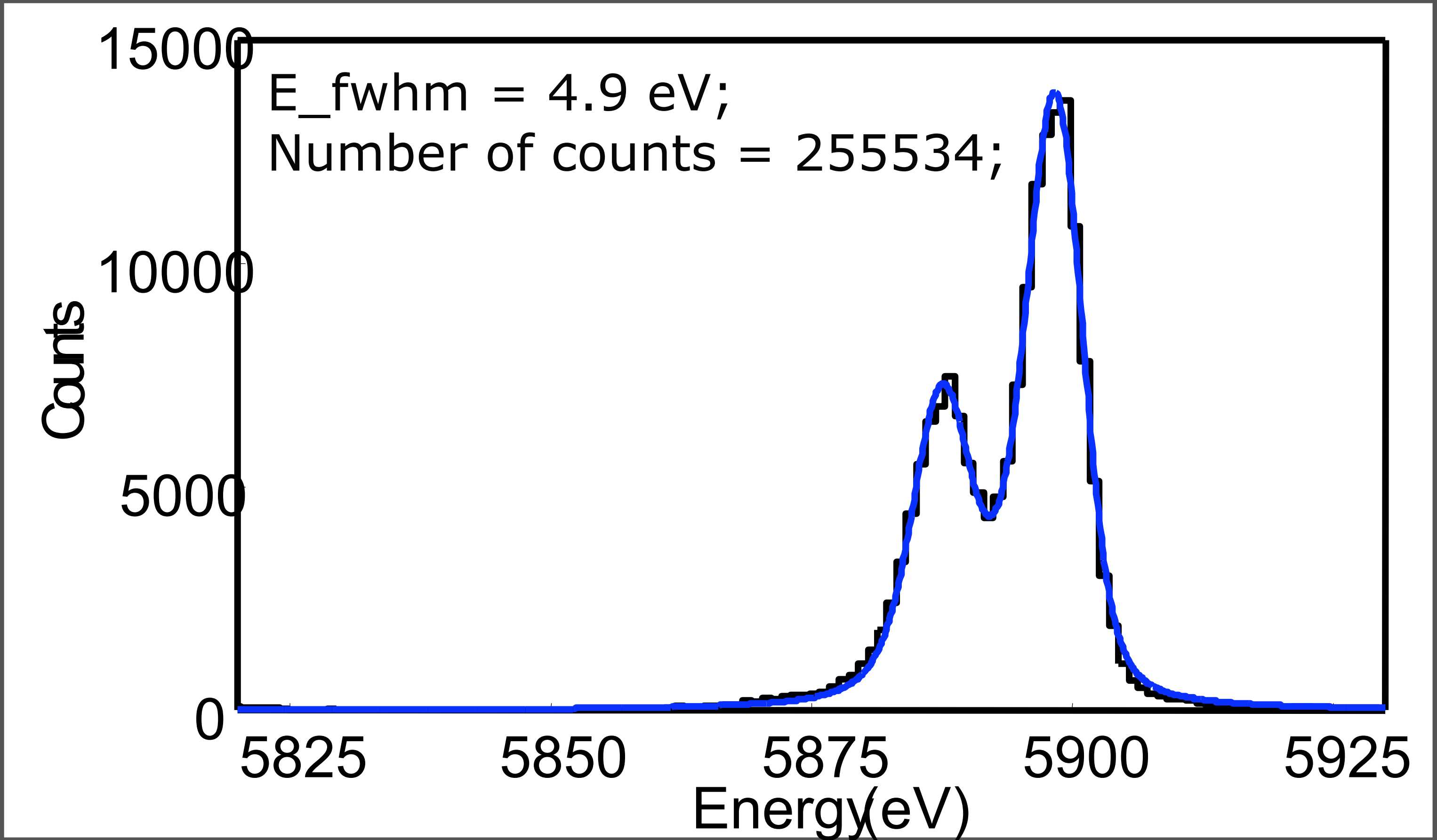
=> Improved energy resolution

Stability issues

16 hours acquisition - SRON single pixel, central absorber (X049,)

dE = 4.9 eV @ 6 keV;using analog filter; 255.000 counts!

No digitized data available, 3.7 eV expected



=> Improved stability

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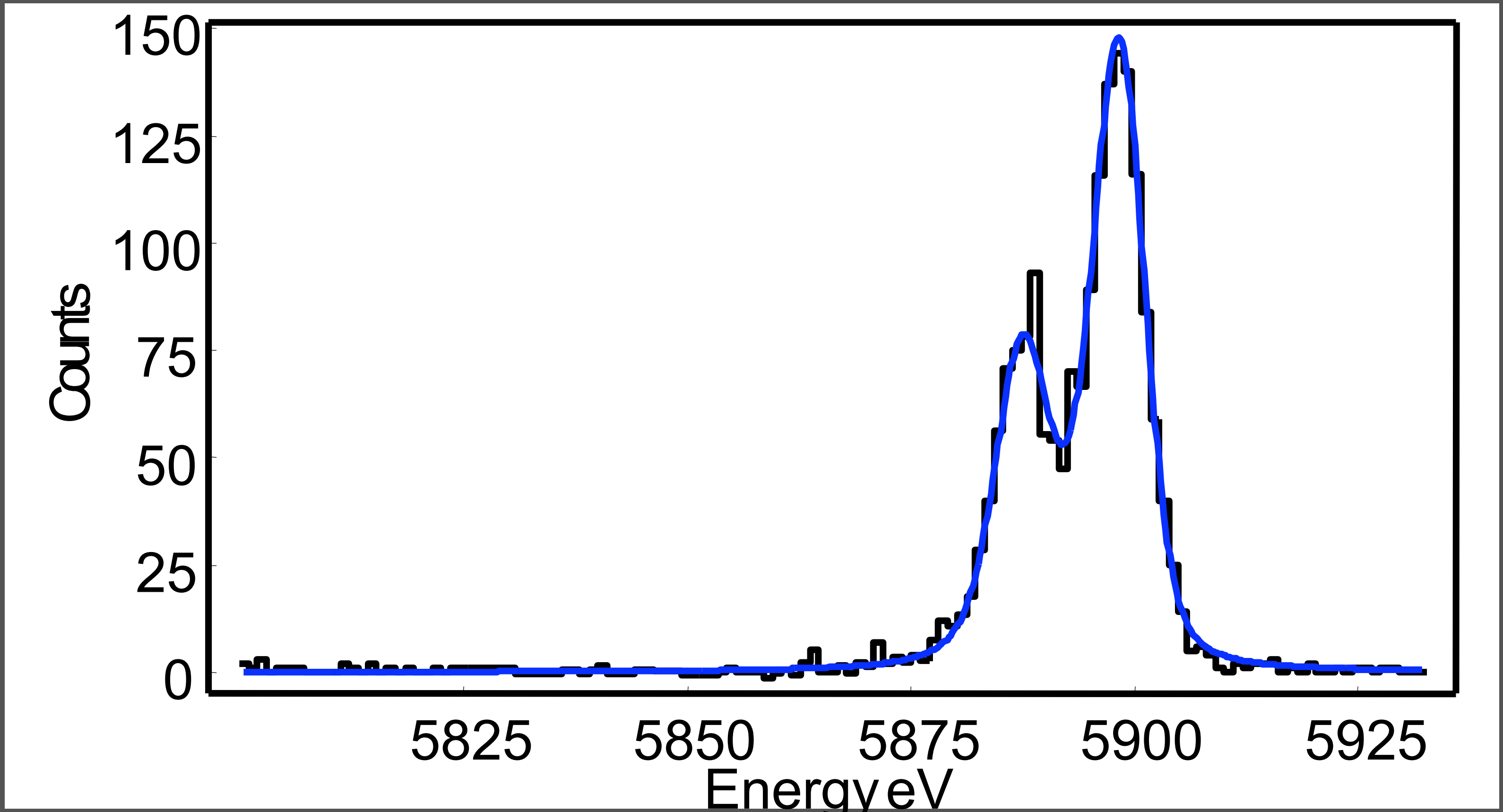
Performance data array pixel

Best' SRON array pixel with central absorber

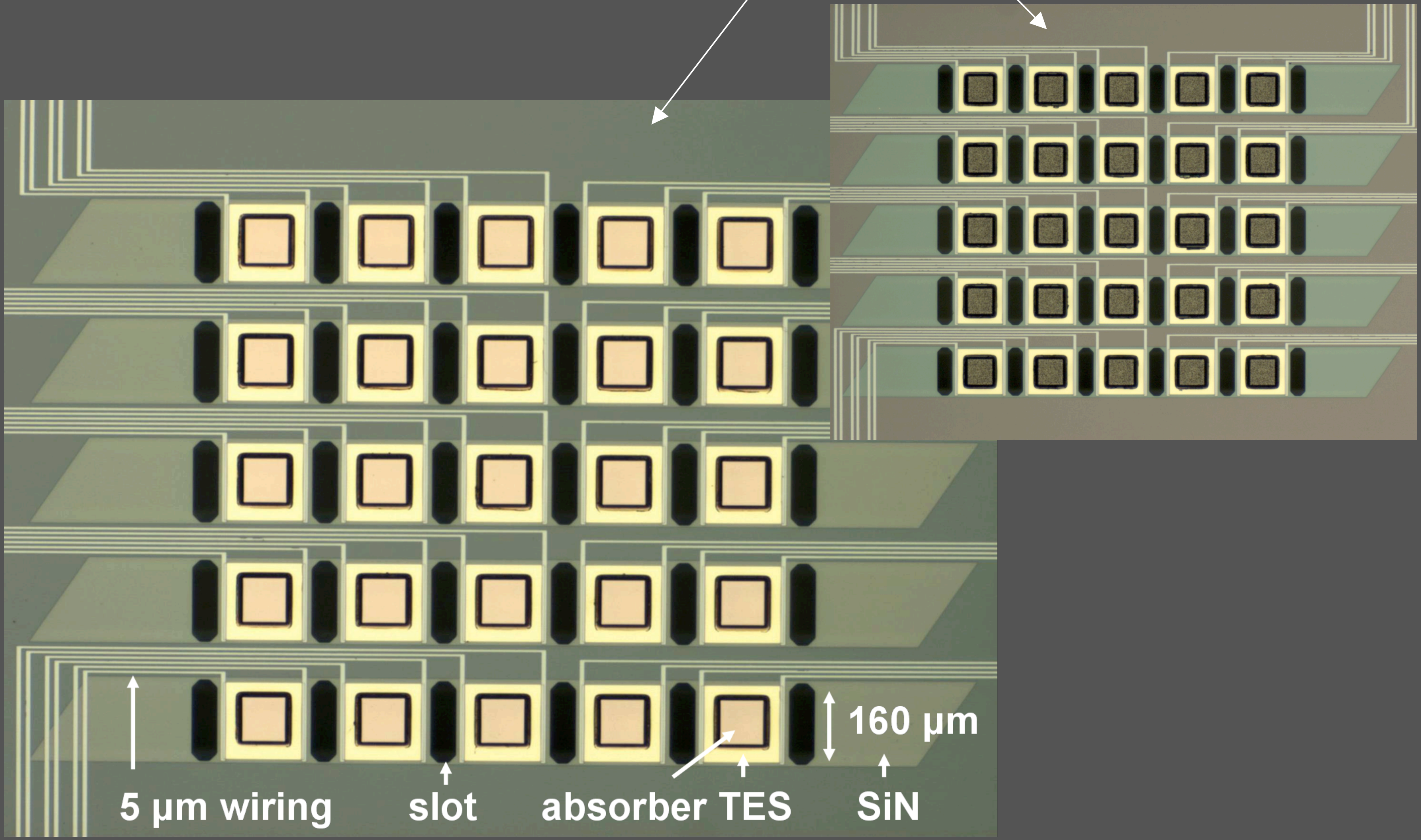
dE = 5.3 eV @ 6 keV; analog filtering applied

Note: the expected after digital filtering: ~ 4 eV (but no data yet)

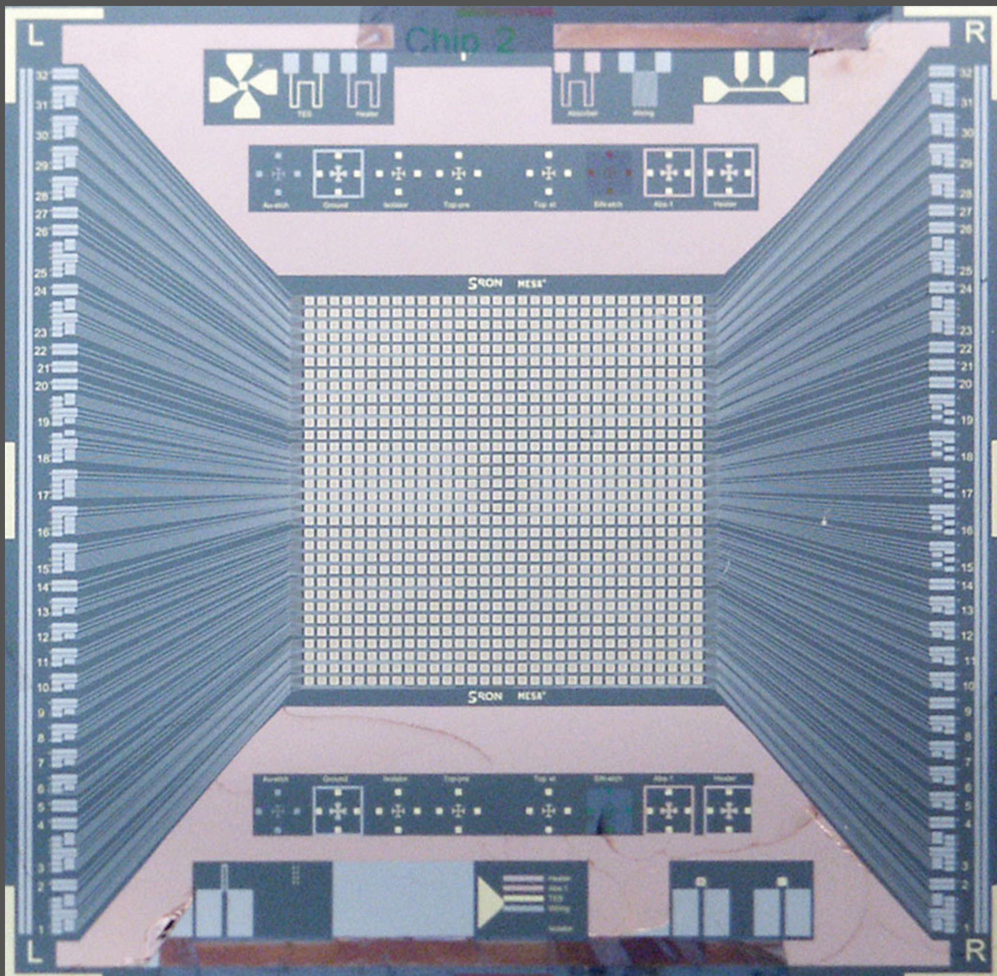


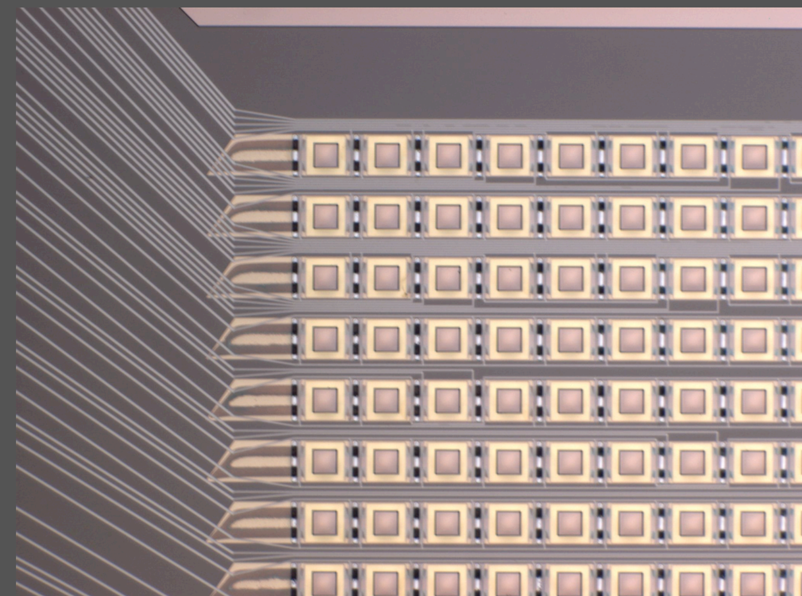
=> Improved energy resolution

Fully functional 5 x 5 arrays with Cu and Cu/Bi absorbers



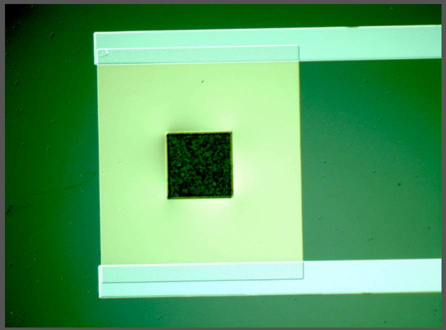
Successful prototyping of 32 x 32 pixel arrays





But: no electrical connections

Motivation microcalorimeter development

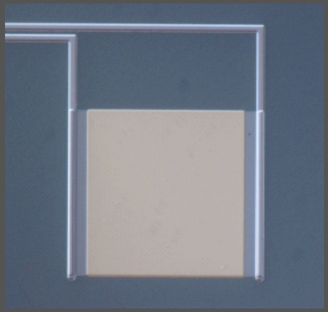


- Classical SRON design requires mushroom-absorber with large overhang => position dependence expected (LTD-11).
  - => design not suitable for high filling factors
- Central absorber designs fixes the α-values of the TES, whereas engineering is required.

Approach

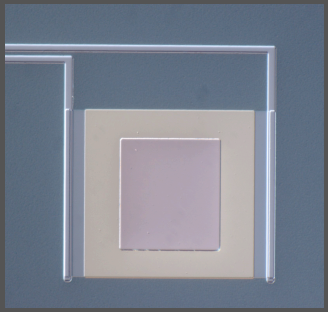
- α-tuning following Joel Ullom's scheme (metal structures on top of the TES)
- Wiring material study, to characterize possible influence on α
- Absorber coupling through a thin isolation layer covering the TES, to avoid absorption position dependence.

Steepness transition in TiAu bi-layers (1)



Bare TES (as reference)
$\alpha \approx 850$ on membrane

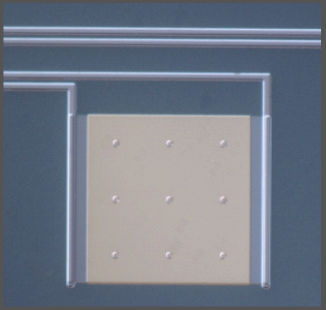
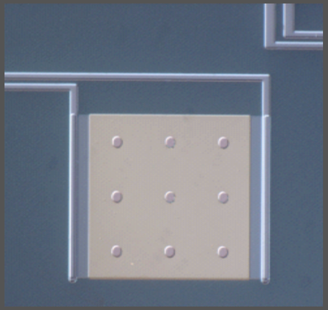
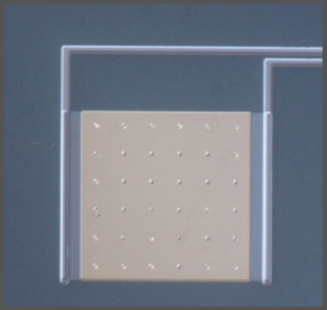
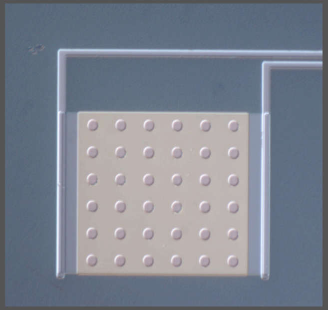
Note: this α is similar to what NIST finds for MoCu



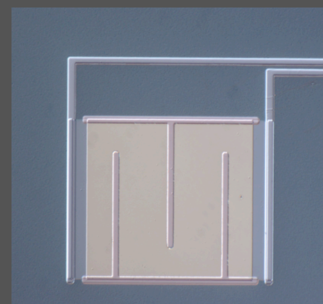
Standard SRON TES with central absorber
$\alpha \approx 100$ on membrane ($\alpha \approx 200$ on solid substrate)

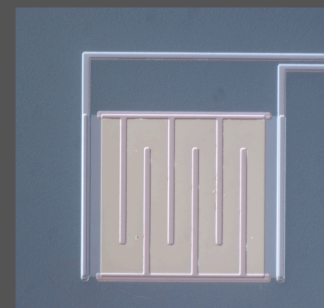
α is affected due to a combination of the geometry (proximity effect + current distribution) and stress

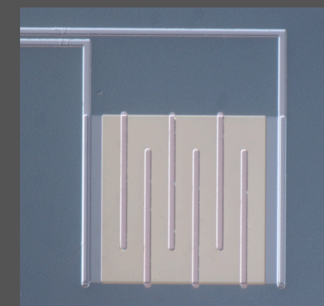
Steepness transition in TiAu bilayers (2) - dots

Fill factor	0.8%	3.2%	1.4%	13.1%
				
On membrane	$\alpha \approx 450$	$\alpha \approx 450$	$\alpha \approx 500$	$\alpha \approx 150$
On substrate	$\alpha \approx 480$			

Steepness transition (3)– bars







On membrane	$\alpha \approx 40$	$\alpha \approx 40$	$\alpha \approx 15$
On solid substrate	$\alpha \approx 50$		$\alpha \approx 80$

=> α -values of barred devices are suppressed too much in TiAu devices

Influence wiring type and layout on α

Results:

- Material type (Nb, Al, and Ti) not of influence on transition steepness
- Wiring layout not of influence on transition steepness

Resulting approach: Nb wiring for arrays, with Al contact leads.

Absorber coupling

Status at LTD-11:

- Lateral diffusion times in mushroom type absorbers possibly troublesome.
- Mushroom type absorbers hard to manufacture

Approach:

Support of mushroom hat by insulating layer between TES and absorber, coupling through metallic contacts, combined with α control through Cu dots.

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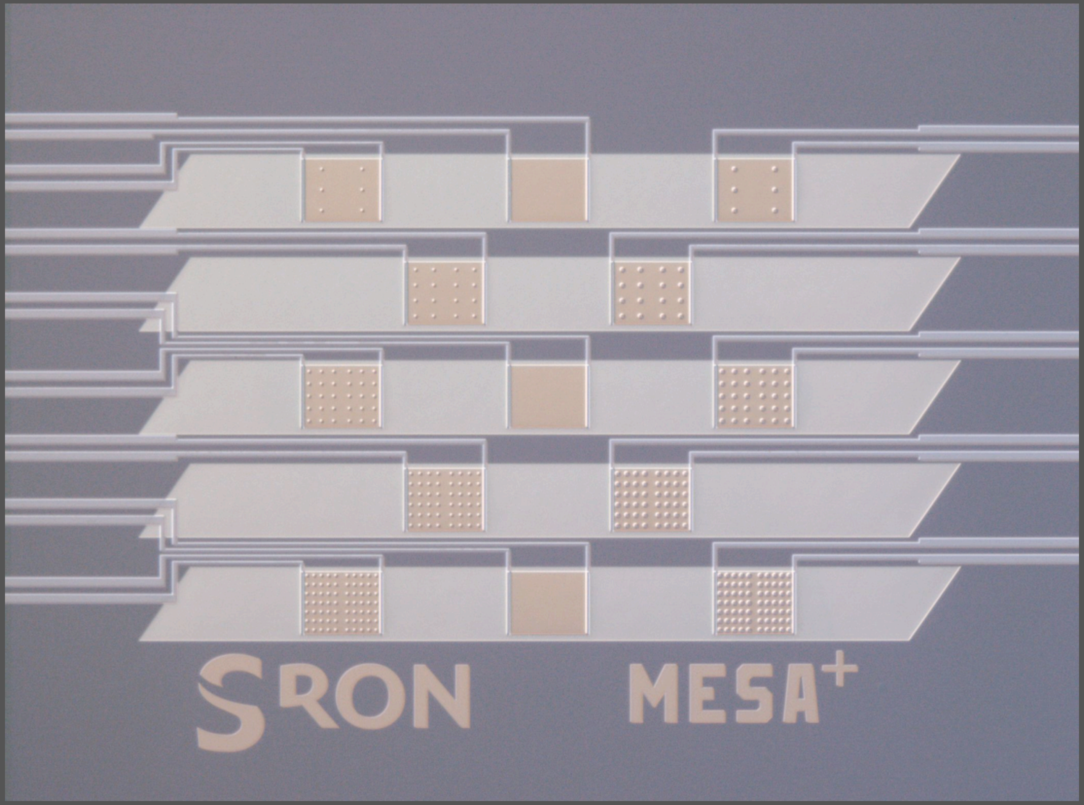
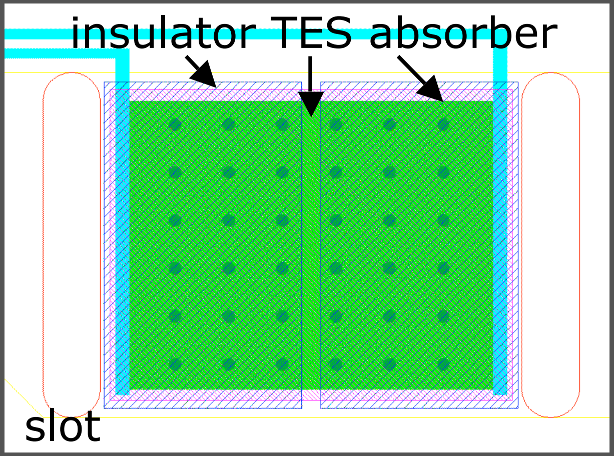
Absorber coupling through central contact

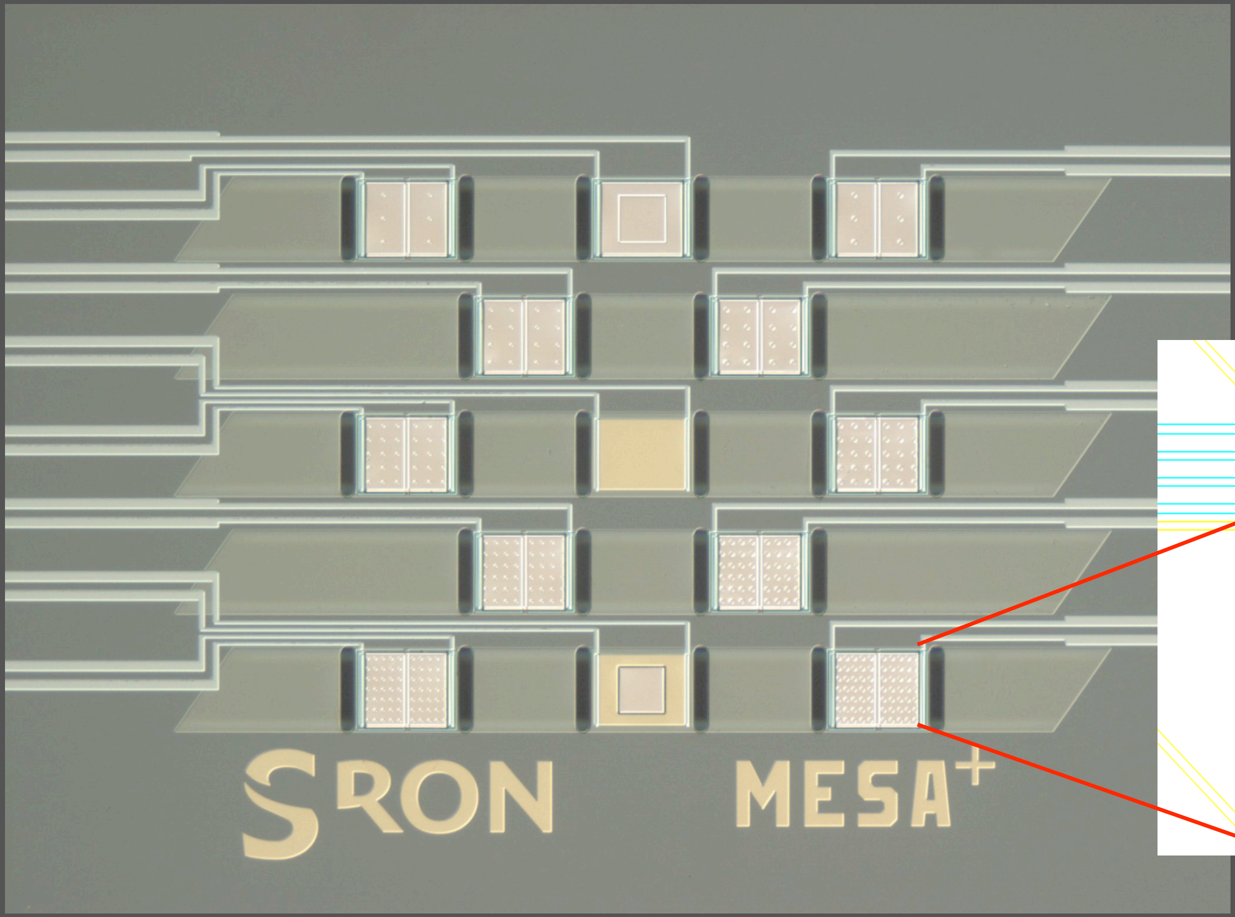
1. Dotted patterns control alpha
2. Dot patterns covered with 100 nm SiO (dots not connected to absorber)
3. A central contact provides coupling of absorber and TES

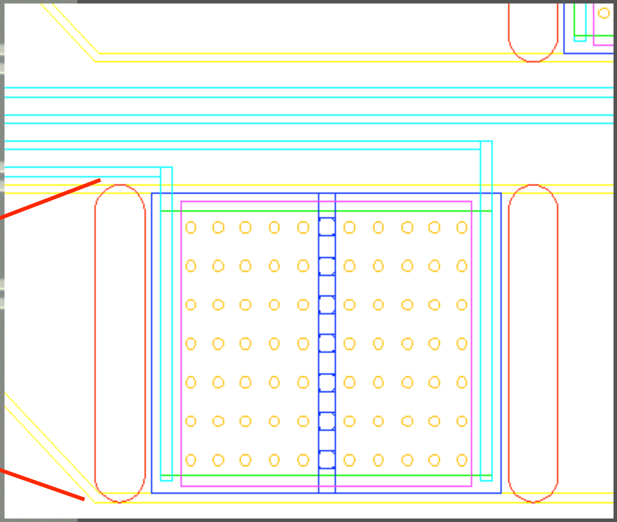




Test structure *before* deposition
of insulator and absorber
with central contact

Fully processed array





Different dot densities
Absorber disconnected from dots by insulator
Absorber TES coupling via central contact (bar or dot pattern)

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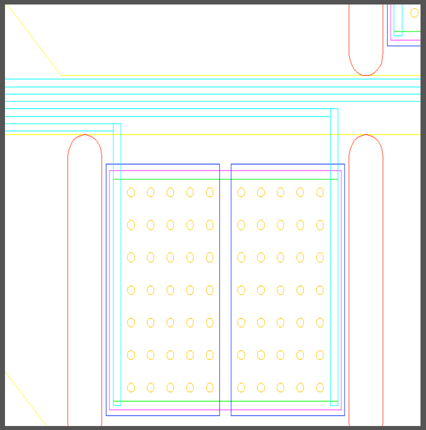
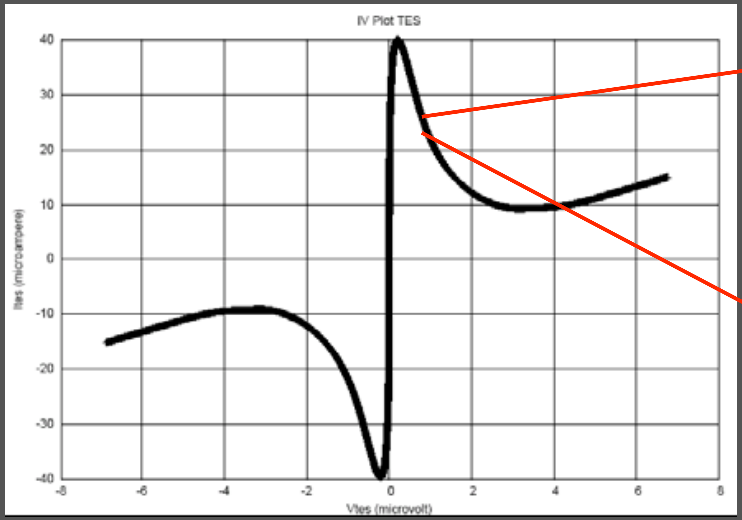
Preliminary results on the new detector design

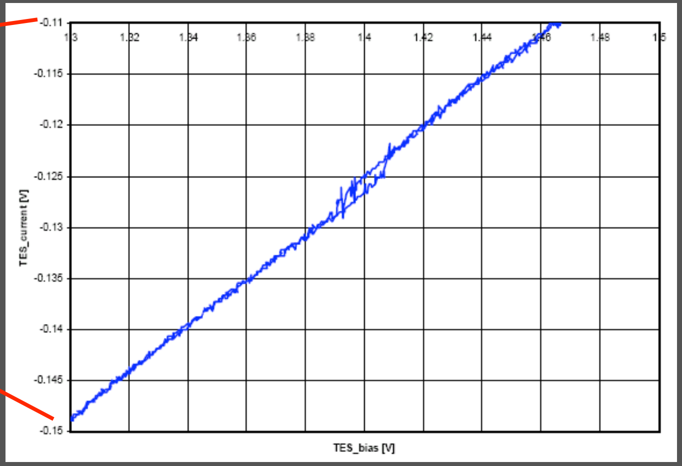
Absorber coupling: 100 nm SiO + contact window



- α tuning functional
- First X-ray results: 7.1 eV (3 eV expected)

- Hysteresis in IV curve, tunable by B-field





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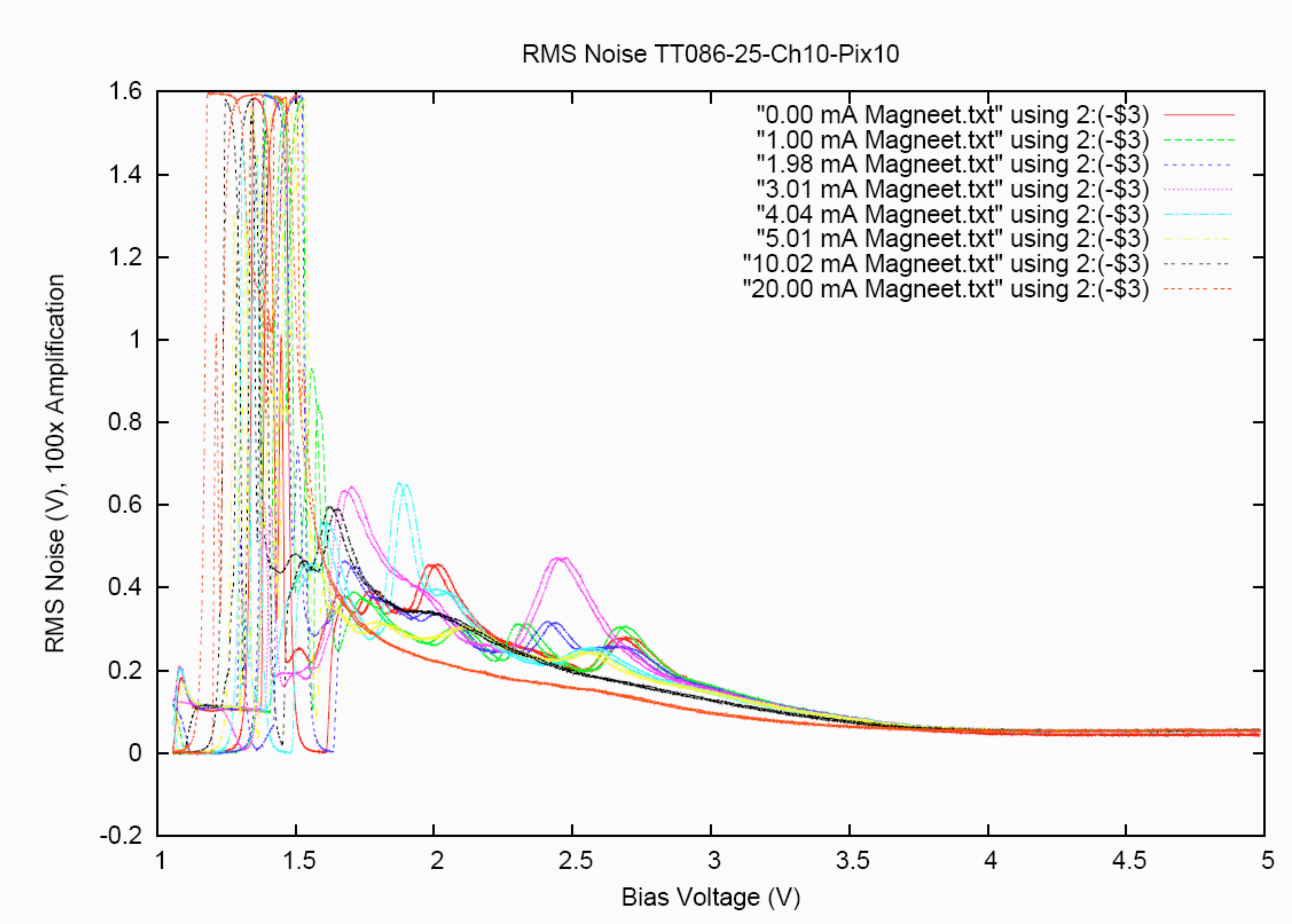
RMS noise features suppressed by B-field



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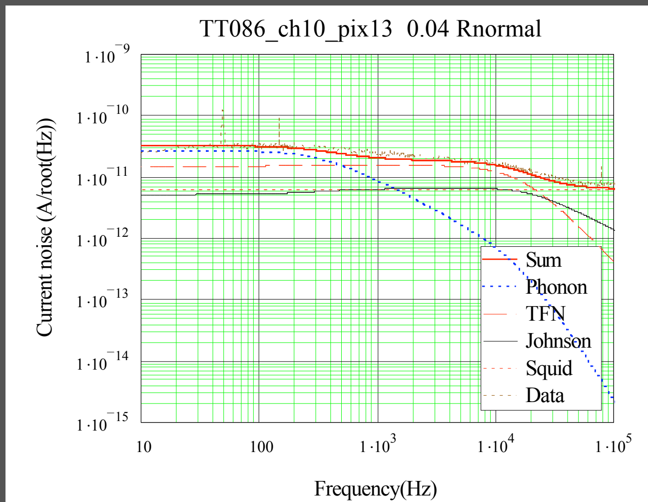
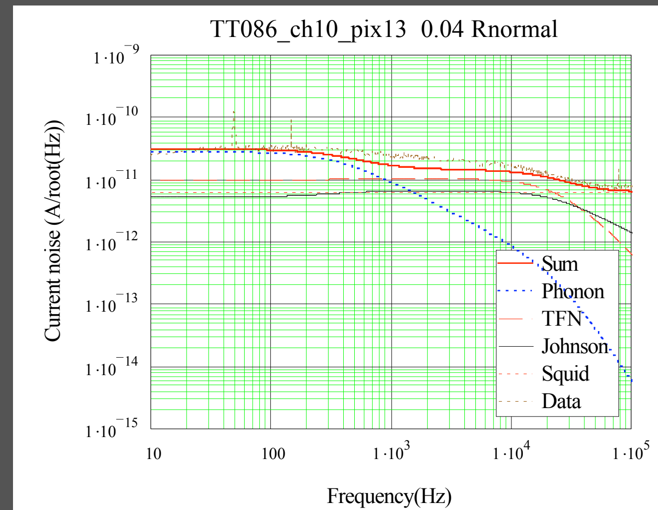
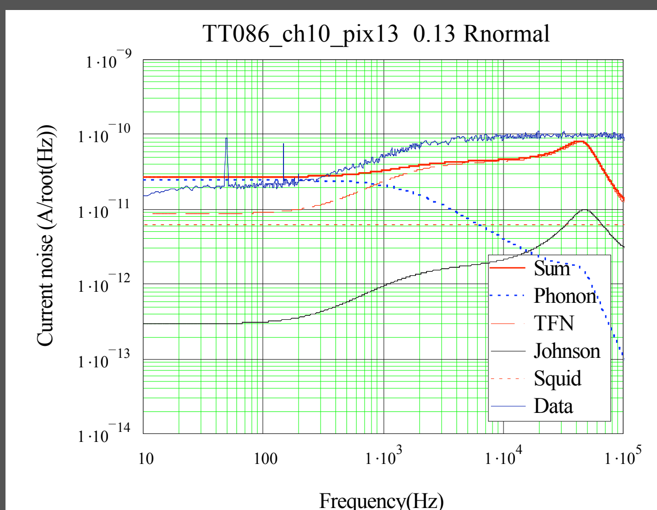
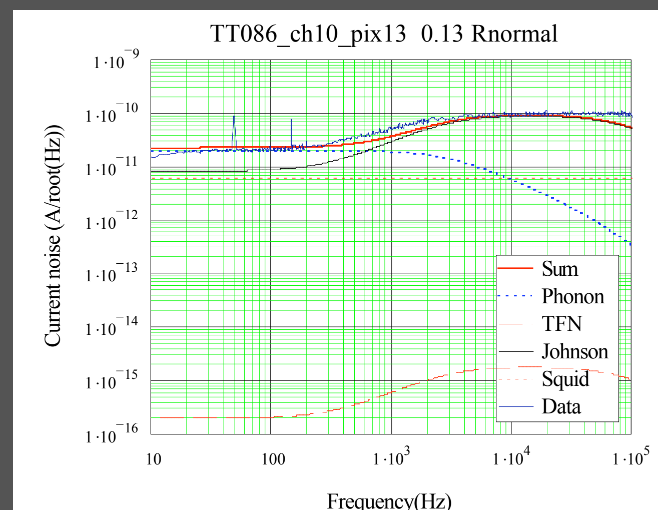
ITFN "M-theory"





α =12
M=2.5





α =160
M=25

- Model parameters from impedance measurements

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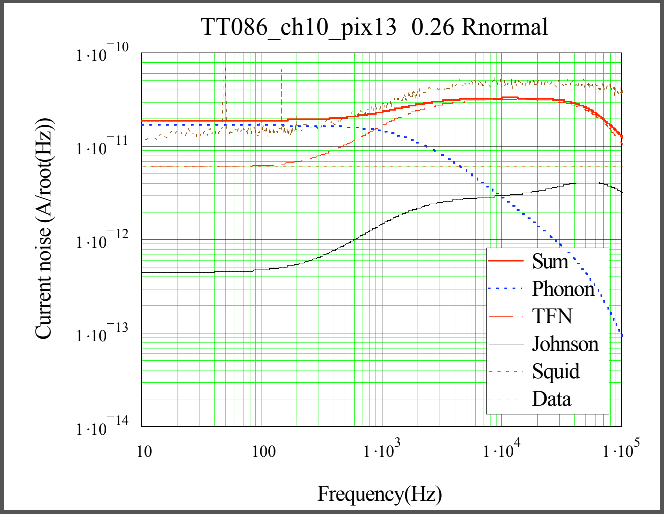
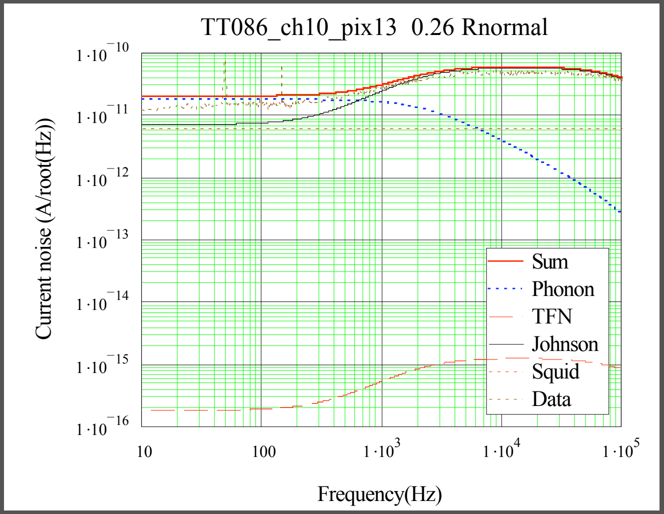
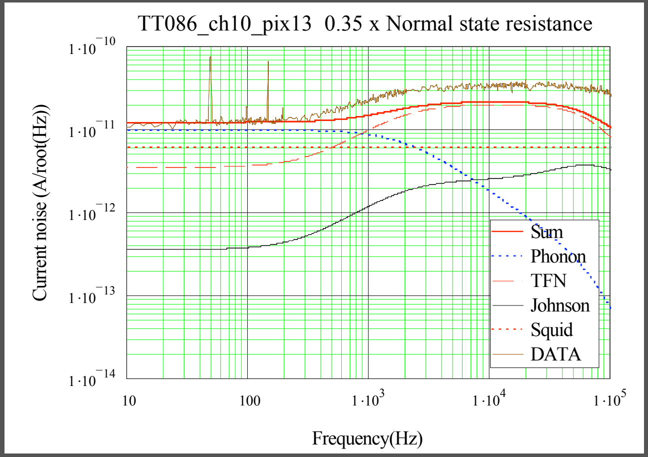
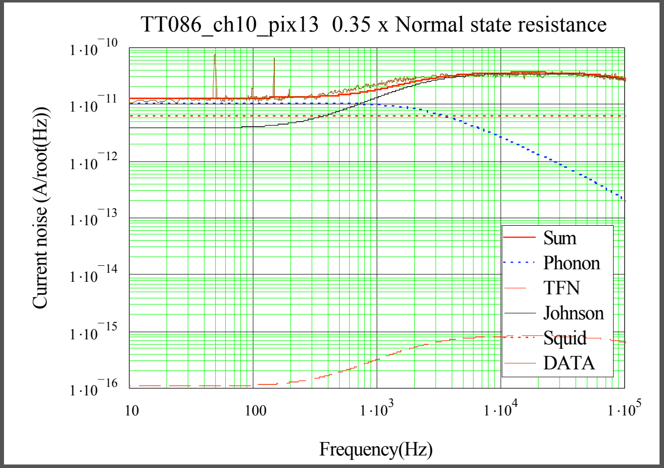
ITFN   "M-theory"





α =75
M=15





α =78
M=10

=> M-theory gives better fits but very high M-values

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Summary and conclusions

- EMI susceptibility setup drastically decreased
- Better performance data on all existing sensors
- Cu dots on TiAu TESs give similar effects on α values
- Absorber coupling through contact windows produced and under study
- Experimental results too fresh for conclusive interpretations