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GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung



First Results:

ATLASpix Energy Calibration with X-rays

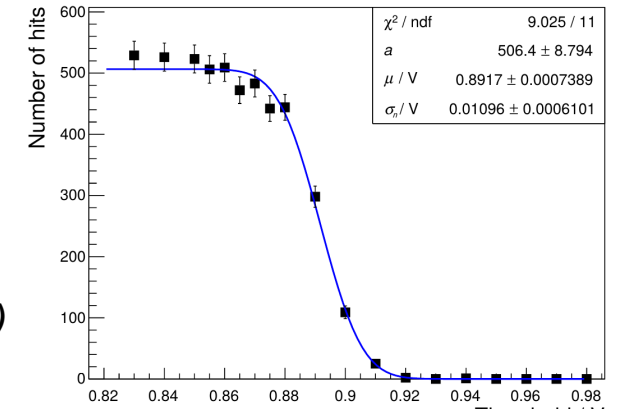
Vertex and tracking detector technology meeting
CERN, January 19th, 2021

Jens Kröger
Heidelberg University & CERN

Energy Calibration: How to?

- mono-energetic X-rays:
 - β -source: Fe-55
 - fluorescence: Cu, Fe, Ti, (Ca)

*All plots from PhD thesis
Adrian Herkert (Heidelberg)
for Fe-55*



- threshold scan, then 3 options

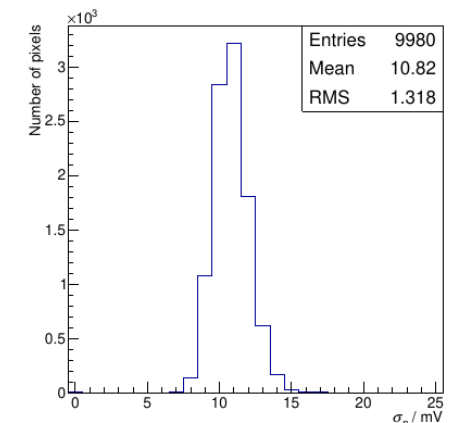
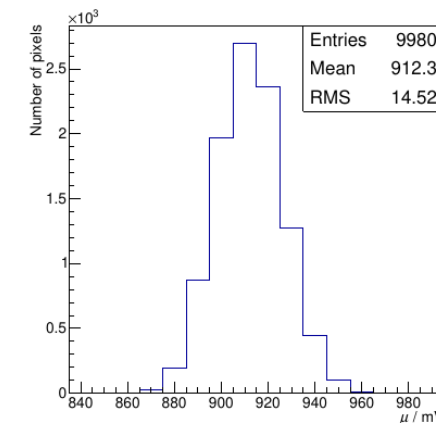
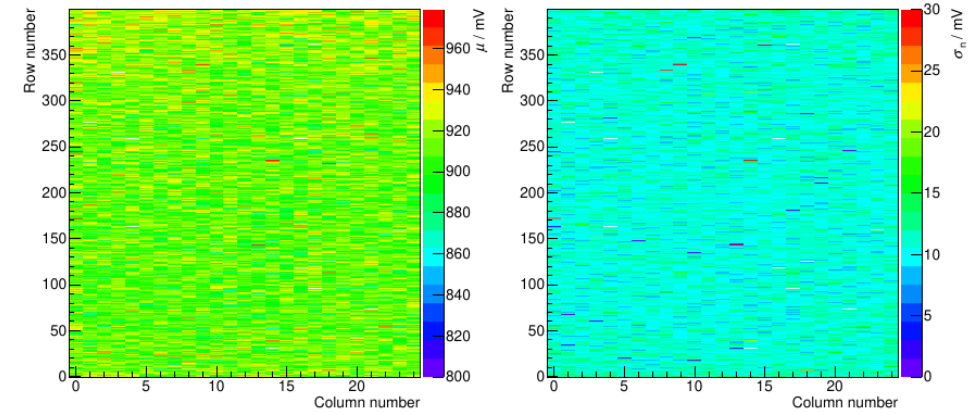
- fit s-curve
 - for each pixel
 - for matrix

$$f_s(x) = \frac{a}{2} \left(1 - \operatorname{erf} \left(-\frac{x - \mu}{\sqrt{2}\sigma_n} \right) \right)$$

$$\operatorname{erf}(x) = \frac{1}{\sqrt{\pi}} \int_{-x}^x e^{-t^2} dt$$

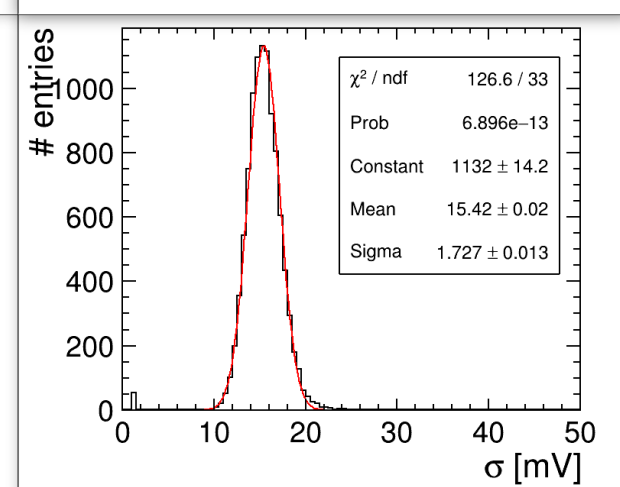
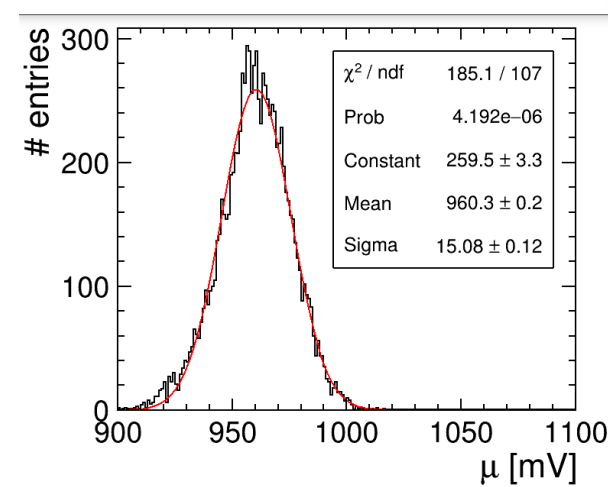
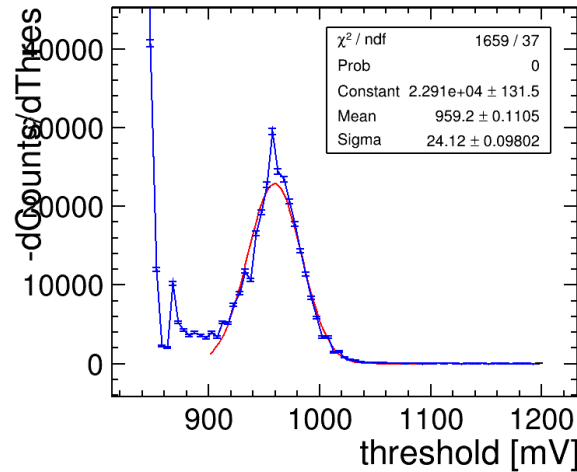
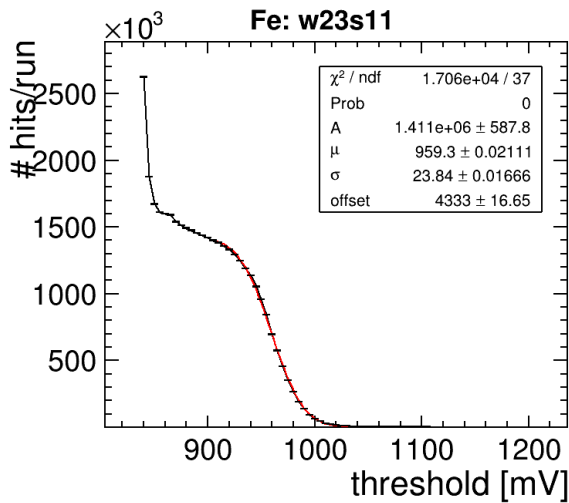
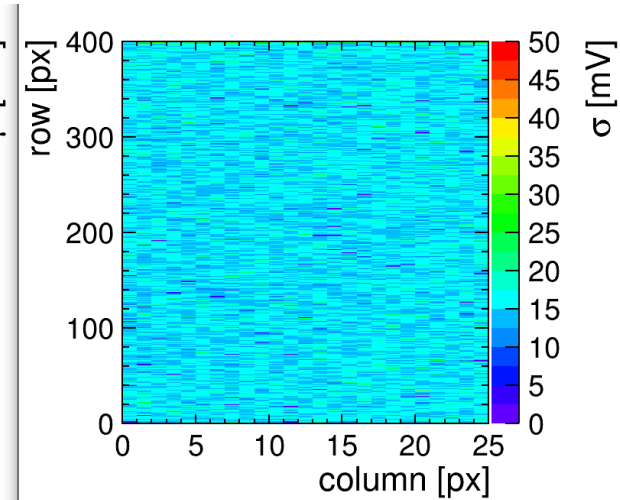
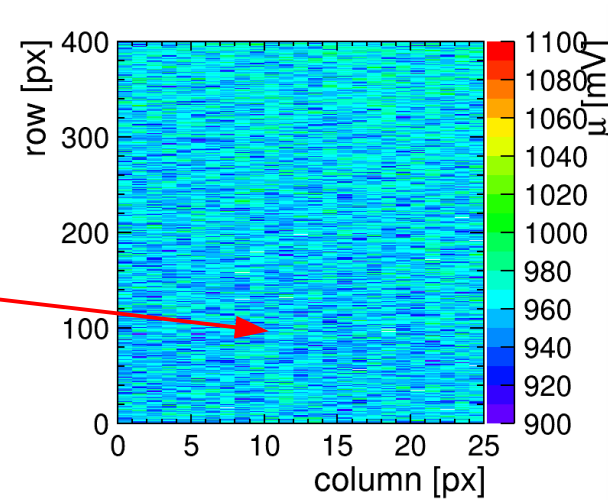
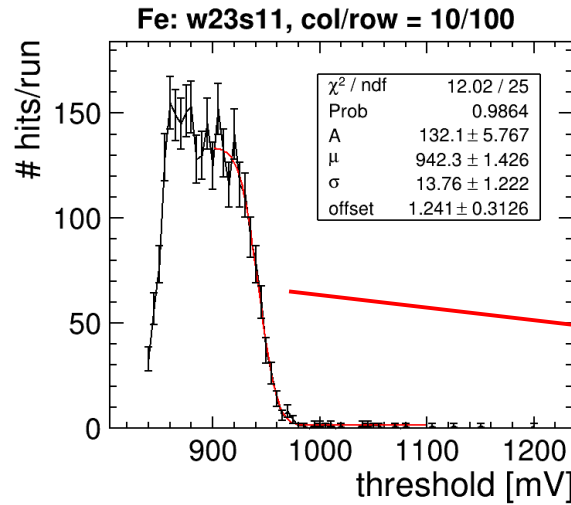
- fit gaussian on -dCounts/dThreshold

- extract signal-to-noise: $\overline{\text{SNR}} = \frac{\overline{\mu} - \text{baseline}}{\overline{\sigma}_n}$



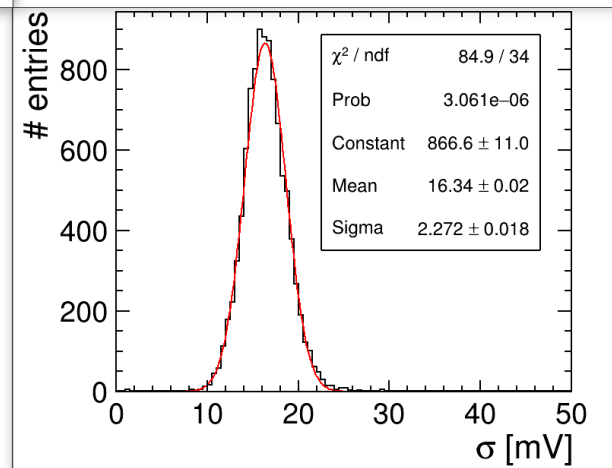
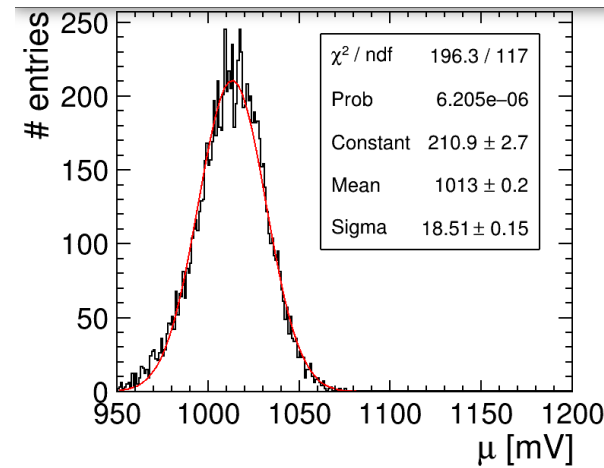
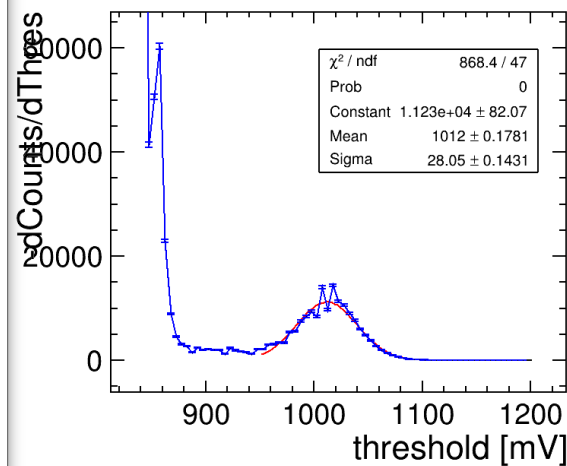
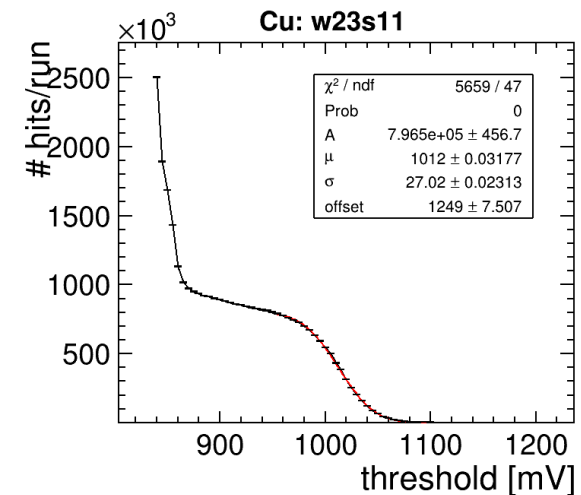
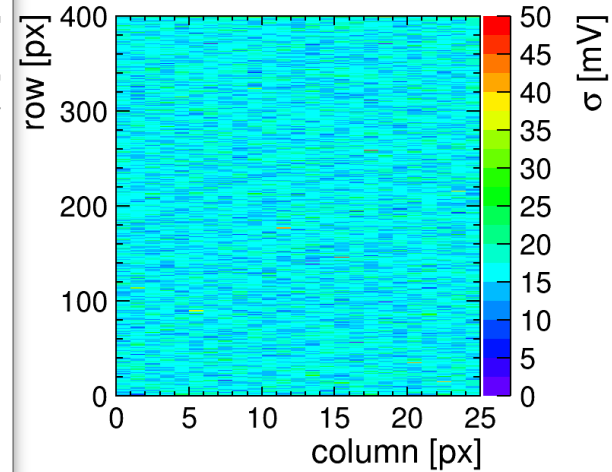
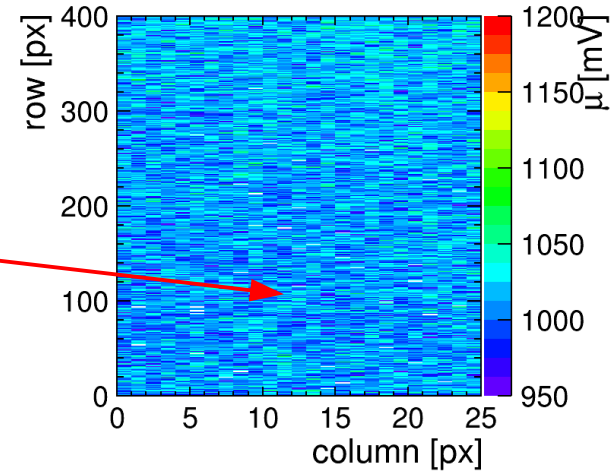
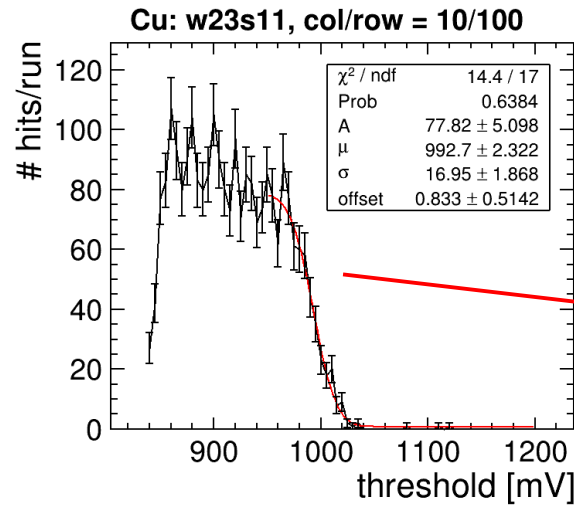
w23s11: Target = Fe

- bias = -50V



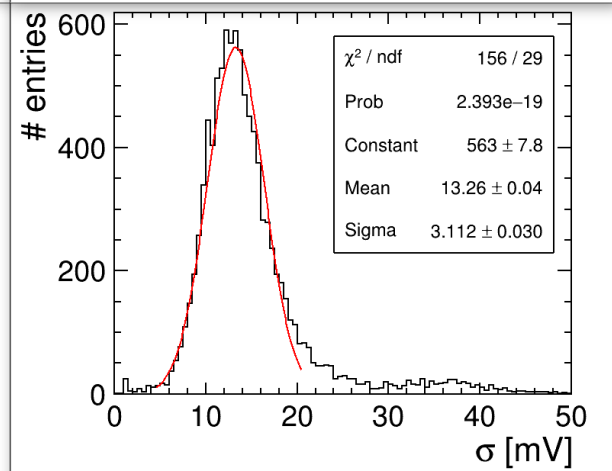
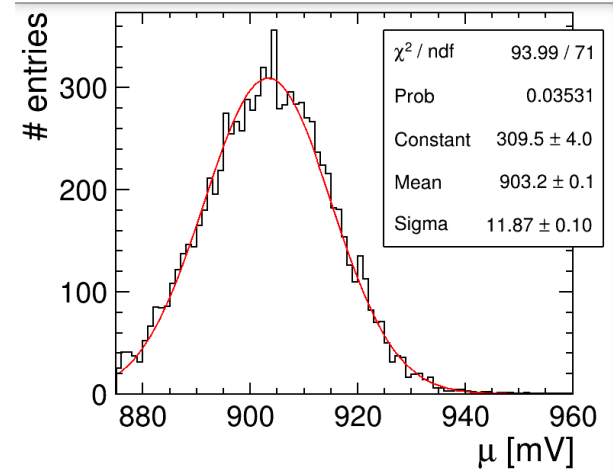
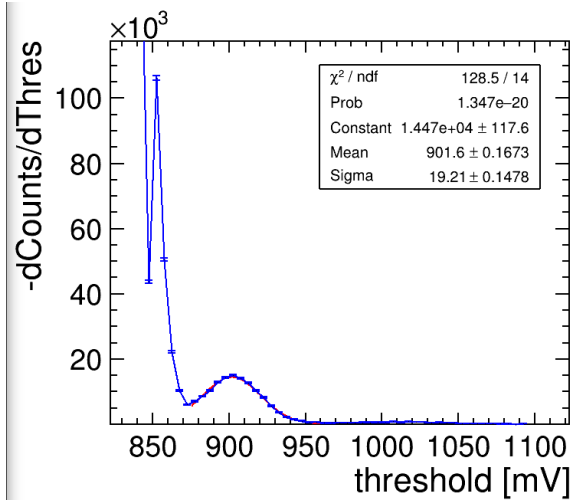
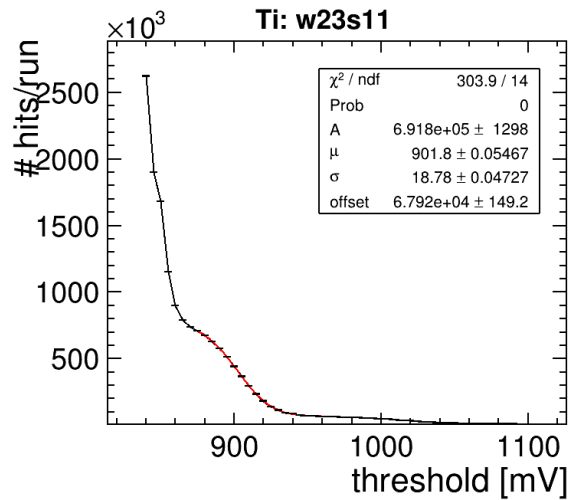
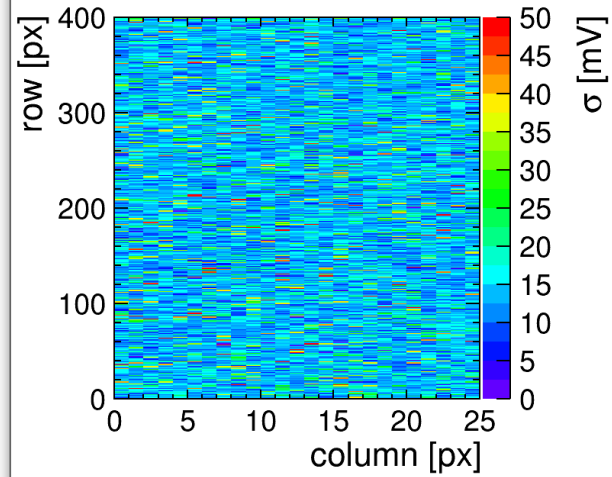
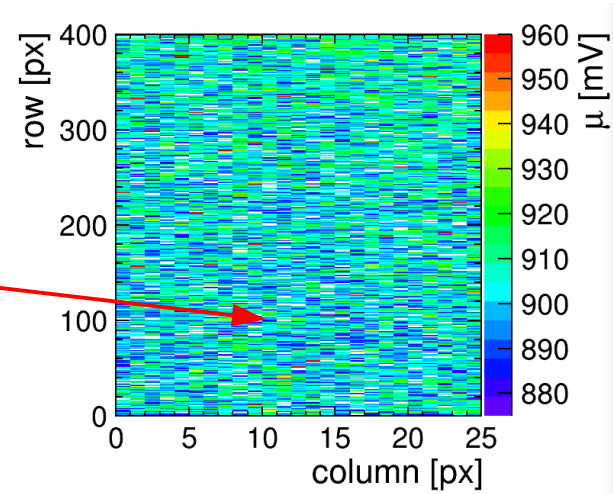
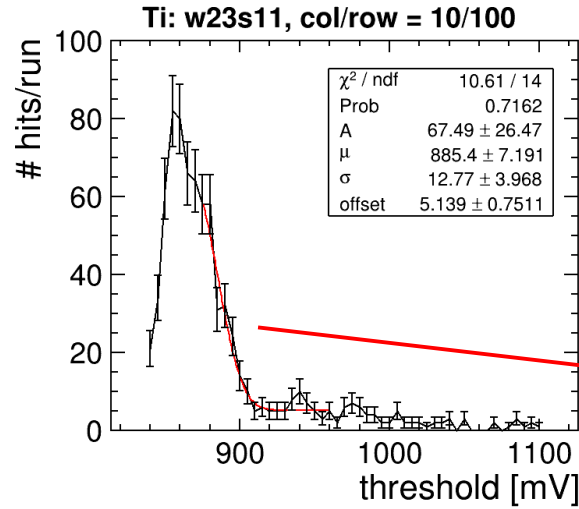
w23s11: Target = Cu

- bias = -50V



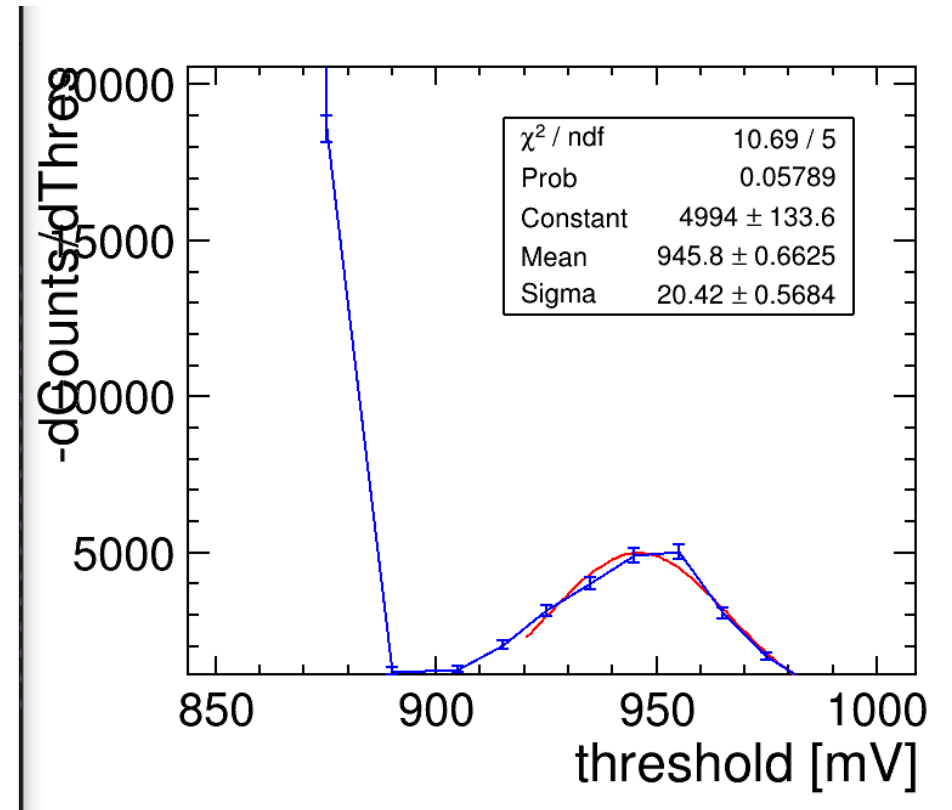
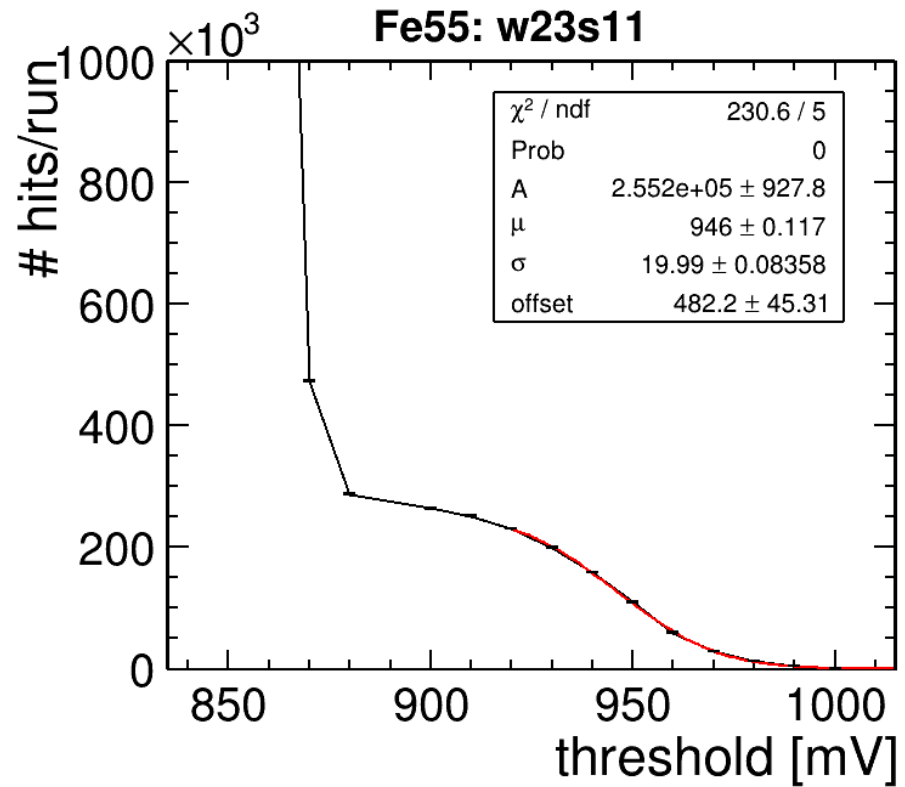
w23s11: Target = Ti

- bias = -50V



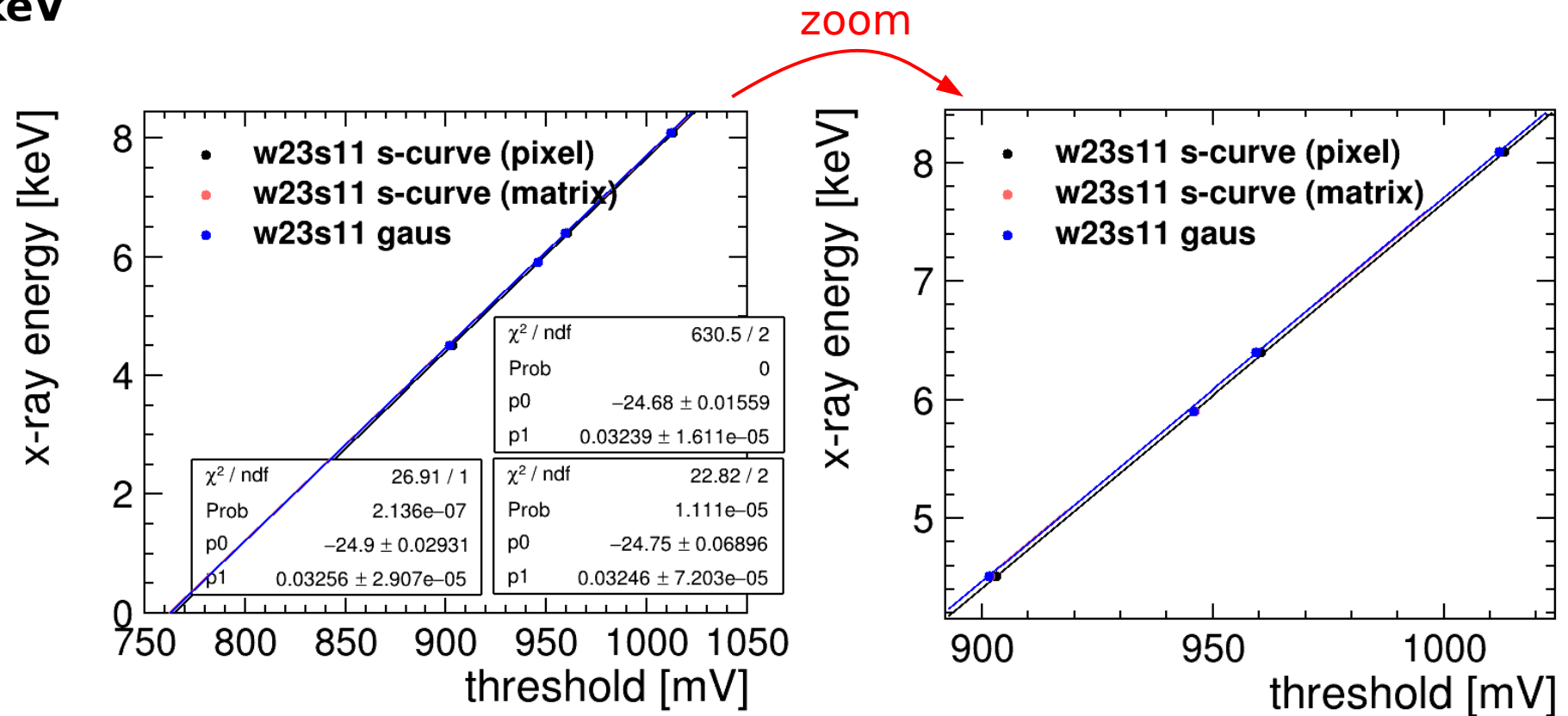
w23s11: Fe-55

- bias = -50V



w23s11: Compare s-curve/gaus

- very linear behaviour
- all 3 strategies very similar:
 - slope ~ 32.5 eV/mV ~ 8.7 e-/mV
 - or **gain** ~ 31 mV/keV
- **but:**
 - expect baseline at 800mV
 - observe at 764mV → investigate!



Compare different samples

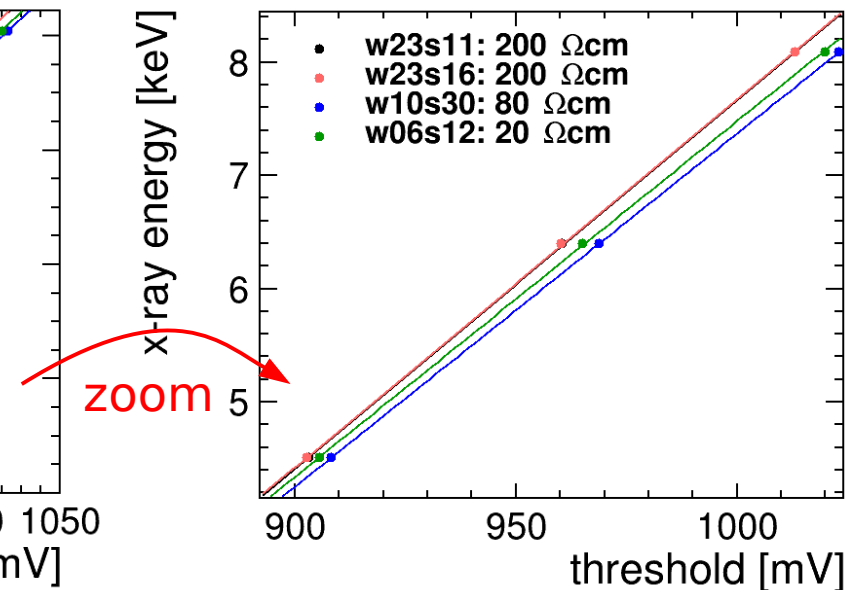
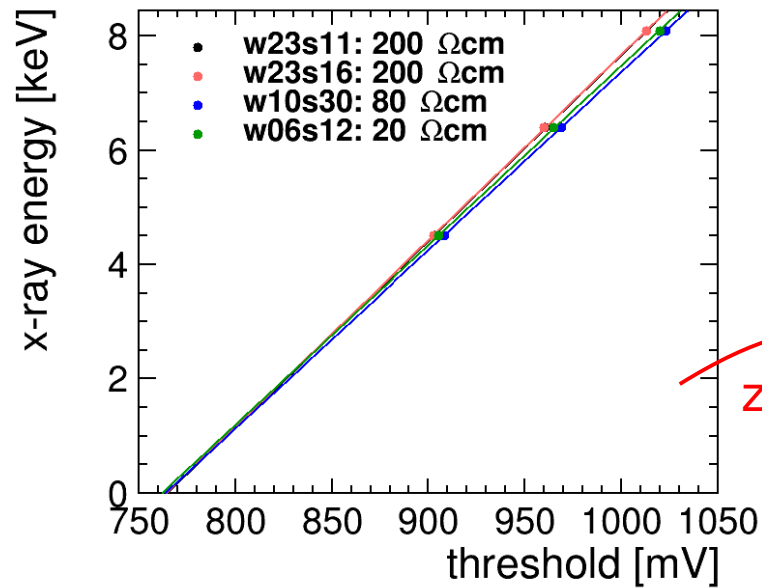
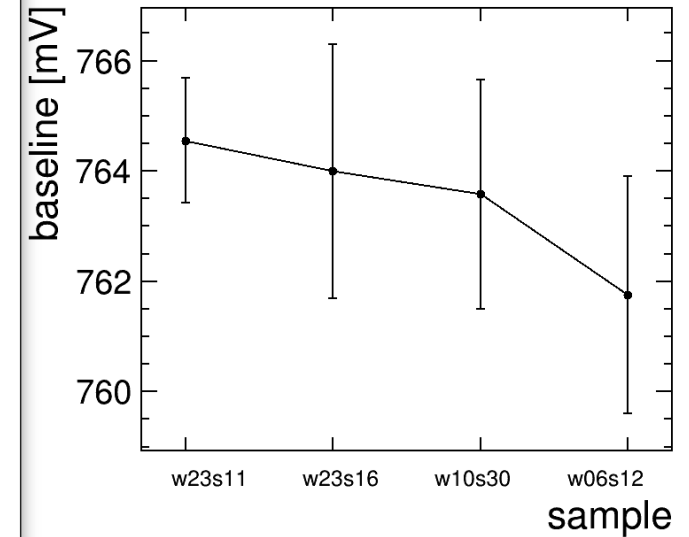
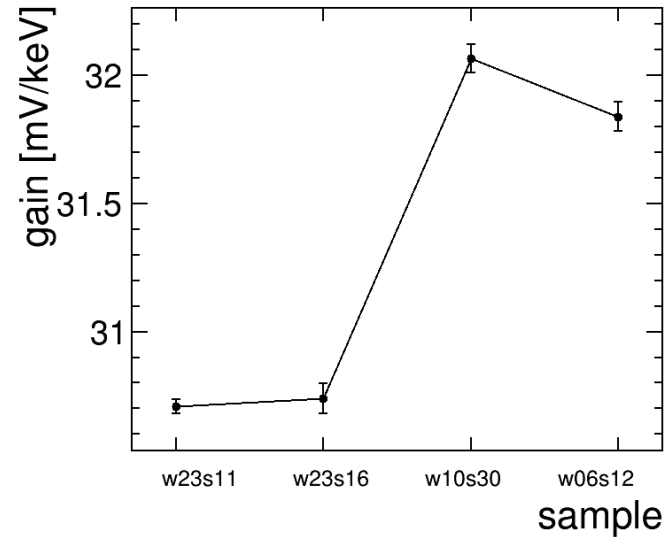
- samples:

- w23s11 and w23s16: 200 Ωcm
- w10s30: 80 Ωcm
- w06s12: 20 Ωcm

- comparable performance for all resistivities

- explanation:

- x-ray absorbed completely
→ same charge/signal size for all
- different for MIPs
→ depends on depleted volume

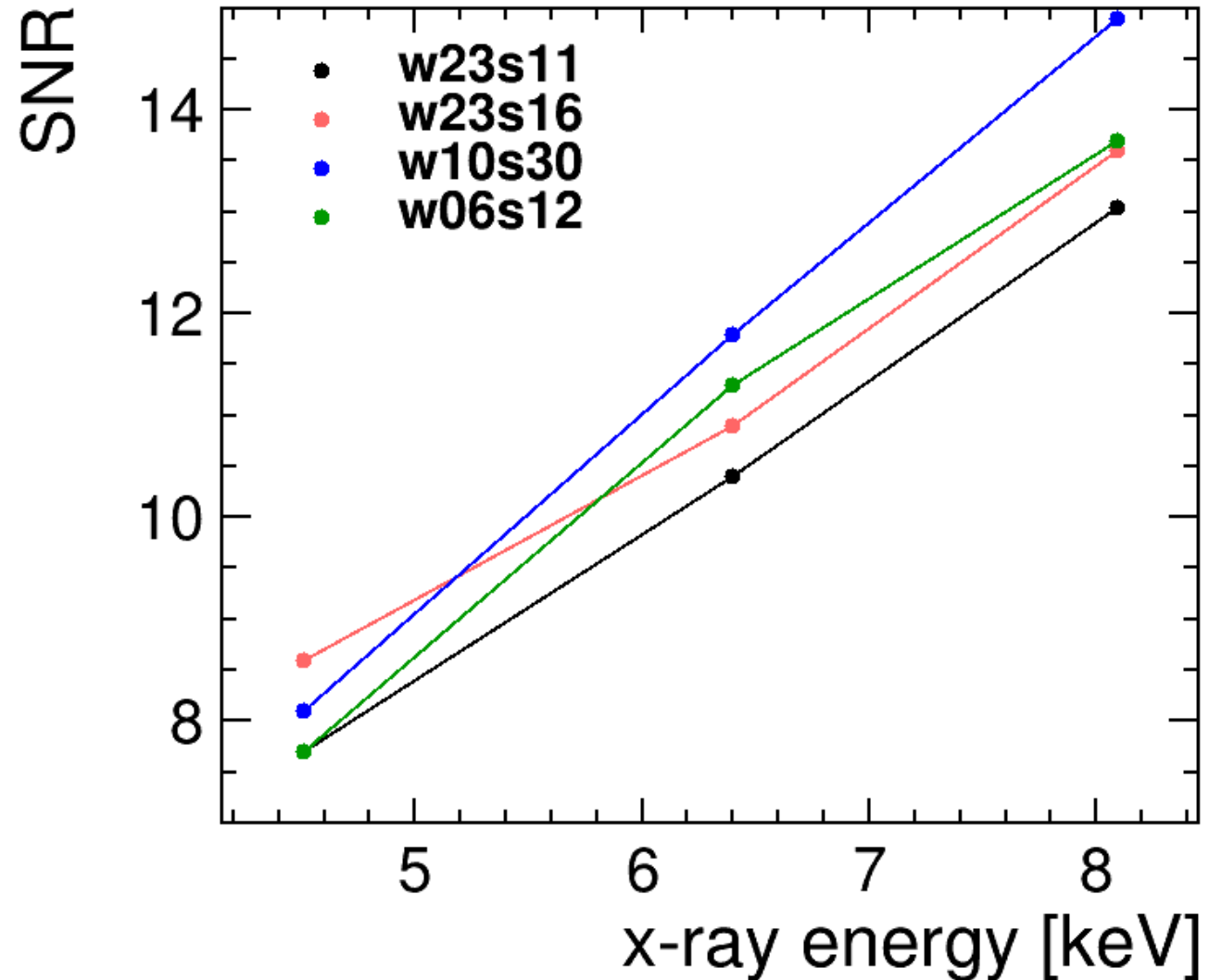


Signal-to-Noise

- calculated assuming 800mV baseline:

$$\overline{\text{SNR}} = \frac{\bar{\mu} - \text{baseline}}{\bar{\sigma}_n}$$

- clear trend:
→ larger signal → larger SNR
- to do:
→ re-iterate when baseline is understood



Summary

- energy calibration with x-rays:
 - gain ~ 31 mV/keV
(independent of resistivity)
 - baseline ~ 760 mV
- SNR $\sim 8-14$
 - re-iterate when baseline is understood

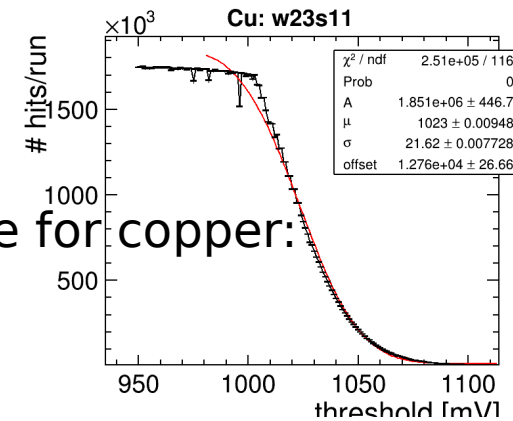
Outlook

- check why baseline ~ 760 mV
- energy calibration for different bias
 - expectation:
 - x-ray absorbed completely
→ same charge/signal size for all
 - if charge collection “complete”:
→ no dependence on bias
 - compare with MIP peak (test-beam)
 - expect bias/resistivity dependence
- ToT calibration

Backup

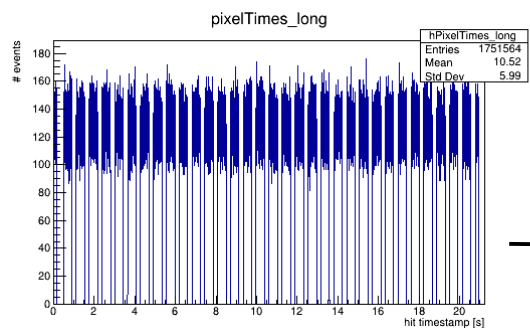
Readout saturation (older data set)

→ Choose low enough x-ray intensity!!!

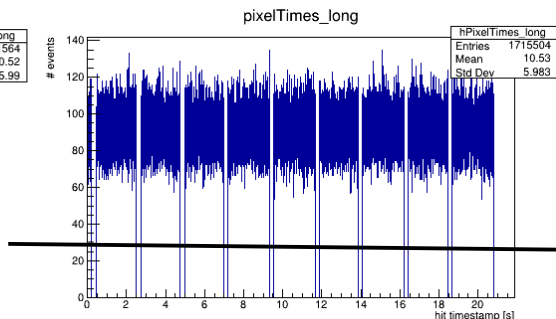


same for copper:

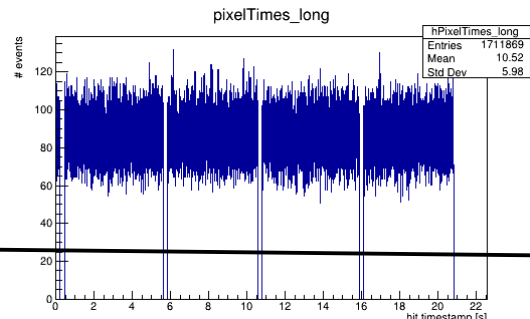
thpix = 970mV



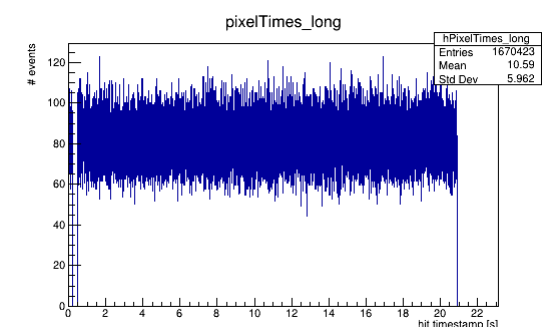
thpix = 976mV



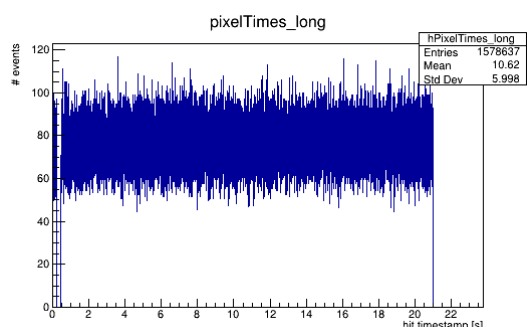
thpix = 977mV



thpix = 978mV



thpix = 979mV



thpix = 980mV

