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HK 30.5

Application of a Versatile Digital Readout System for the PANDA Micro Vertex Detector

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Outline

- **Introduction**
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  - *Silicon Pixel Detector Characterization*
- **Experimental Setup**
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- **Readout of the Atlas FE-I3**
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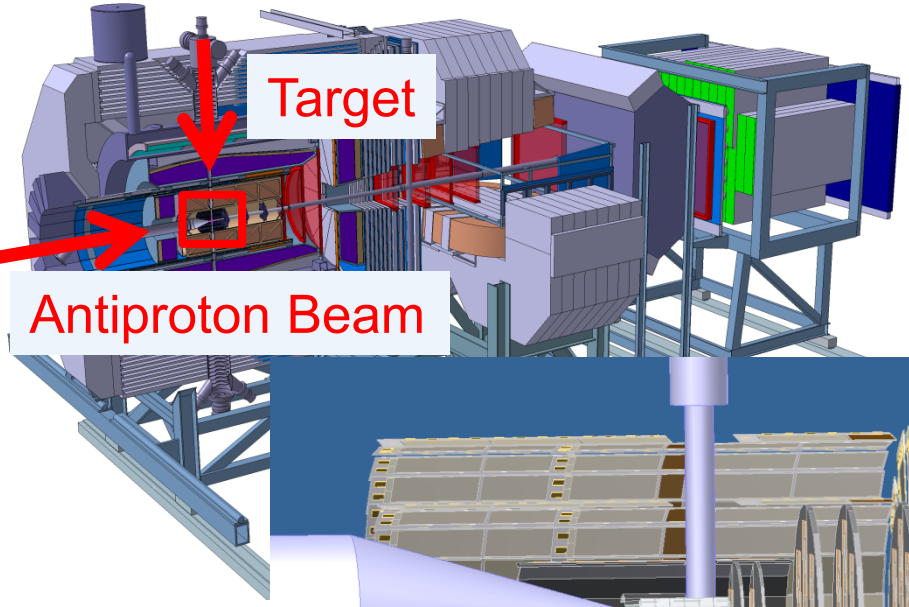
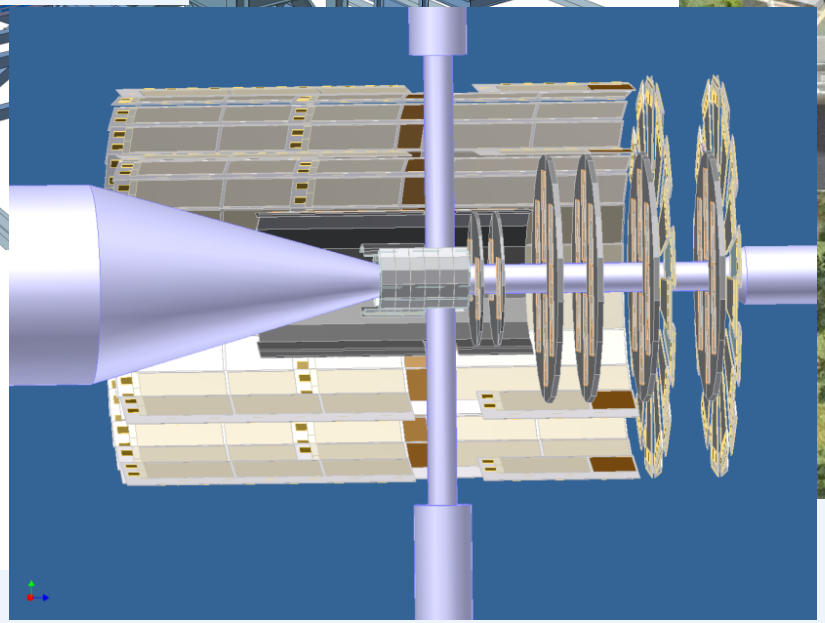
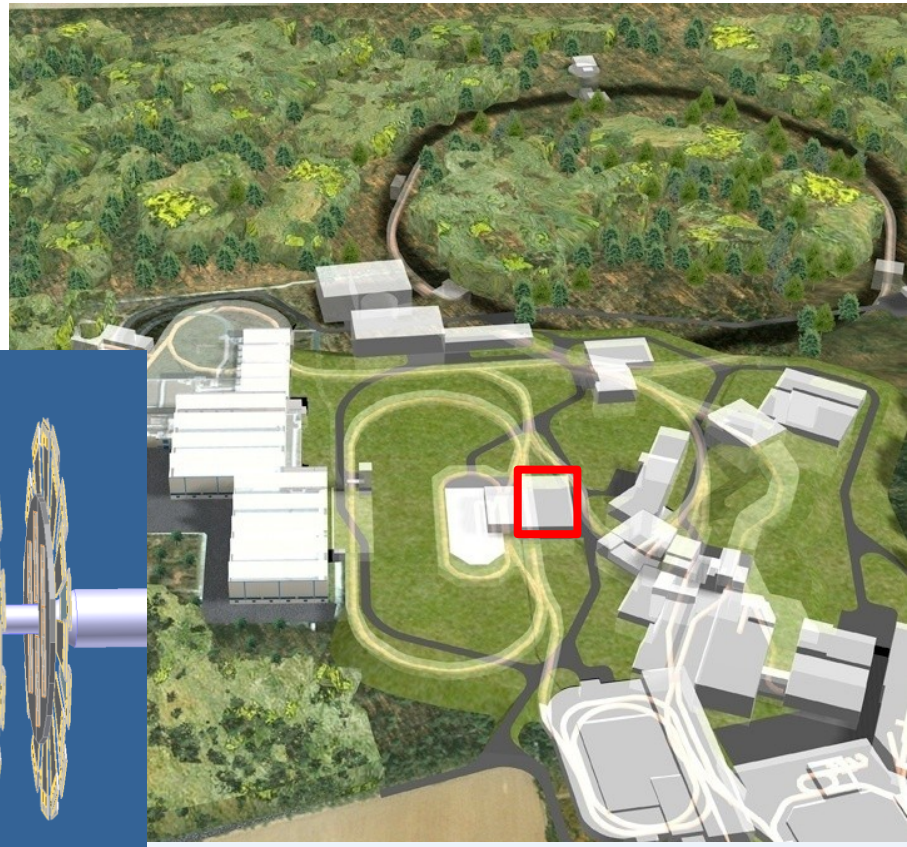
  - *Pixel Characterization*
  - *Threshold Tuning*
  - *TOT Response*
- **Connection to the PANDA ToPiX Prototype**
- **Summary**

PANDA and the MVD







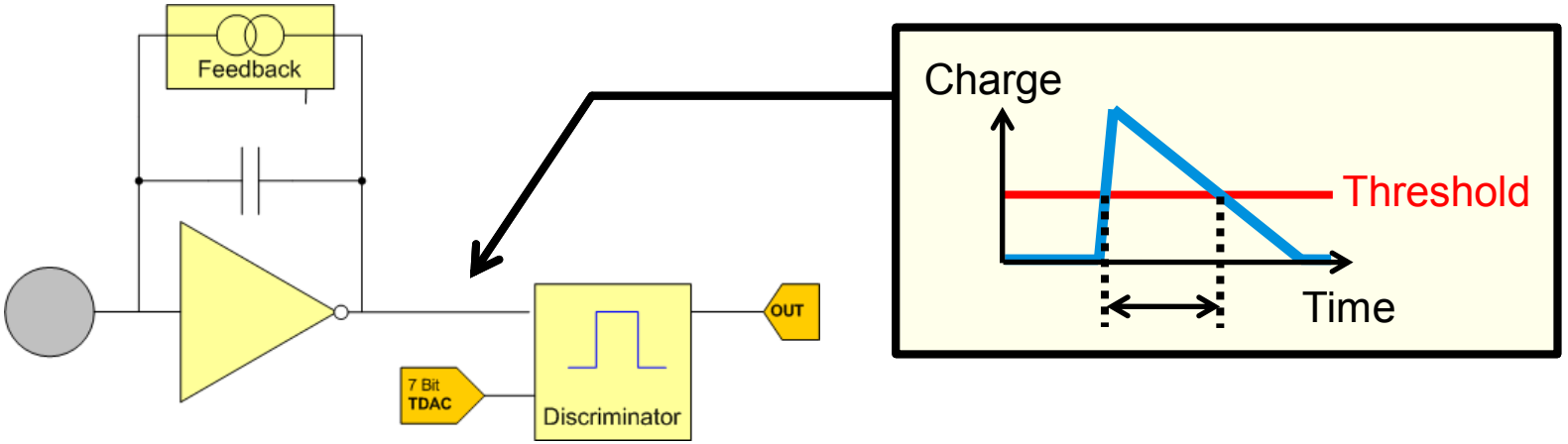
Details:
→ **Group Report HK 40.1**, T. Stockmanns

Antiproton – Proton
fixed target experiment in the
charm mass energy region

Silicon Pixel Detector Characterization

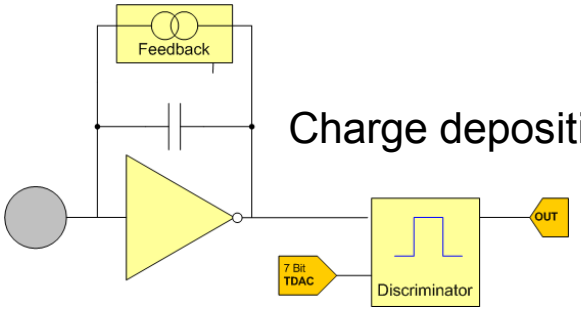
- Microvertex detector: Silicon pixel and strip sensors
- Pixel detector frontend electronics
  - ***FE-I3*** → *used in Atlas detector*
  - ***ToPiX*** → *custom electronics under development*
- **Individual TOT measurement circuit** per single pixel cell
  - *Accuracy improvement (charge sharing), dE measurement*
  - *Characteristic parameters: Threshold, noise*
- Operation parameters controlled by on-chip registers

Details on ToPiX:
→ **HK 40.2**, D. Calvo

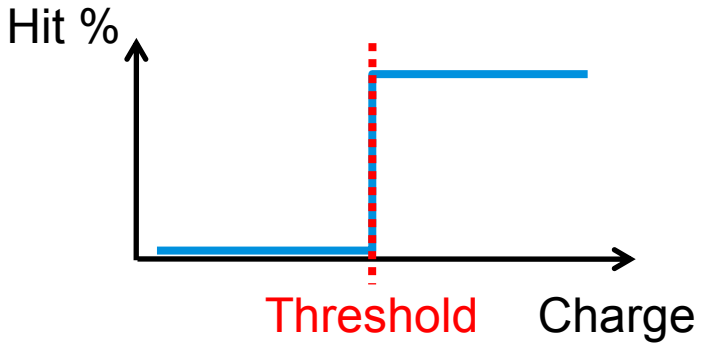


Silicon Pixel Detector Characterization

Hit detection by discriminator



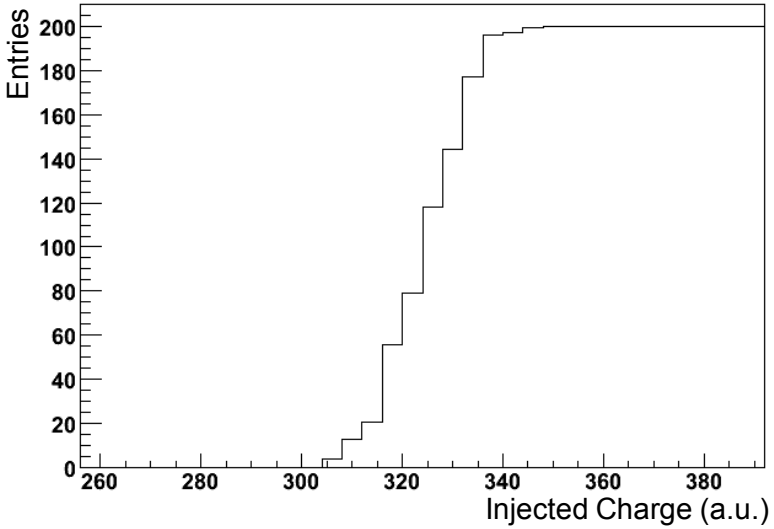
Ideal pixel response



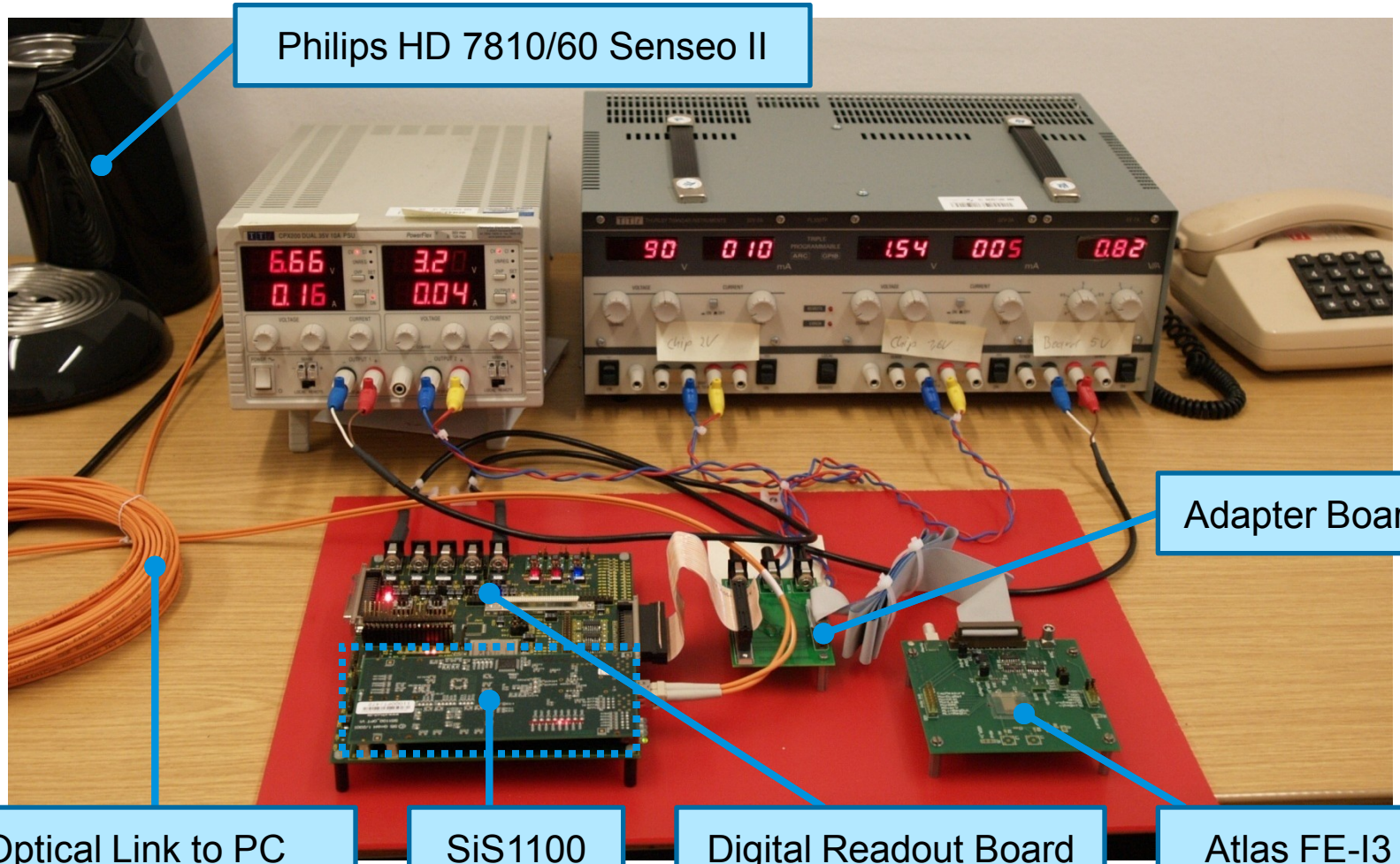
Reality:

Noise charge + Signal charge

Noise: Gaussian distribution
→ Pixel response: Error function
(Convolution of Gaussian + Heaviside)

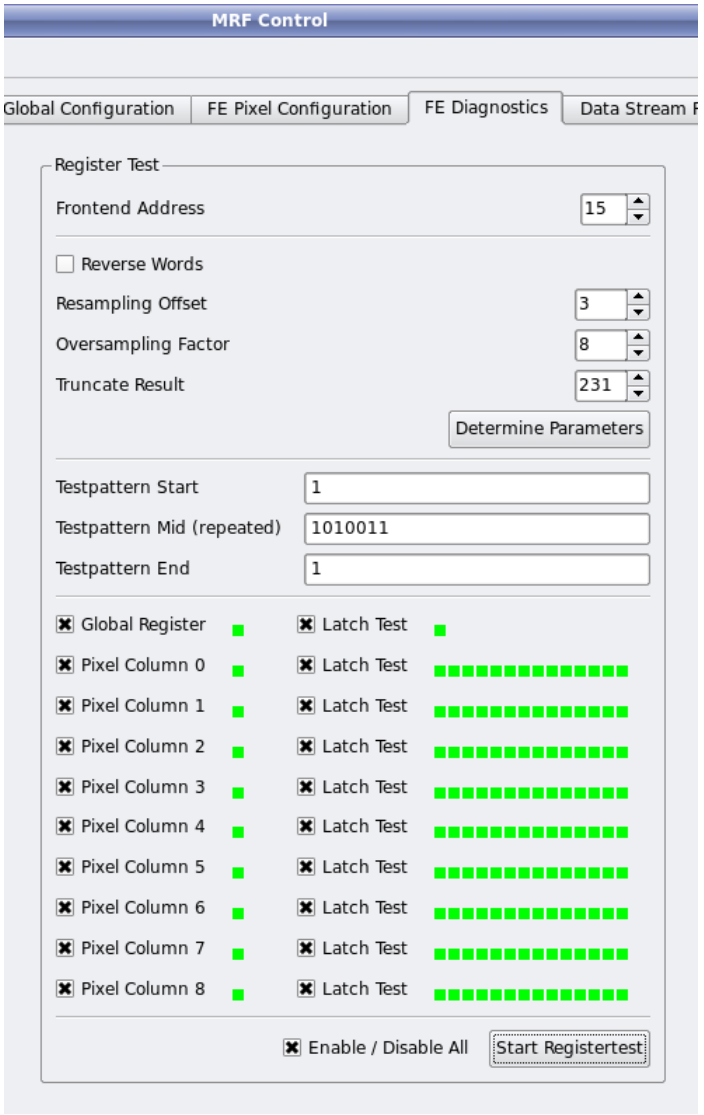


Experimental Setup: Digital Readout System



Verification of Base Functionality

FE-I3 test panel and results →



Atlas FE-I3 register test:

Comparison: Known data ⇔ Returned data

Shift register + **latches**

1. Transmission of known data (shift register)
2. Configuration of latches
3. Shift register flush
4. Readback of latches (to shift register)
5. Readback of shift register
6. Data comparison

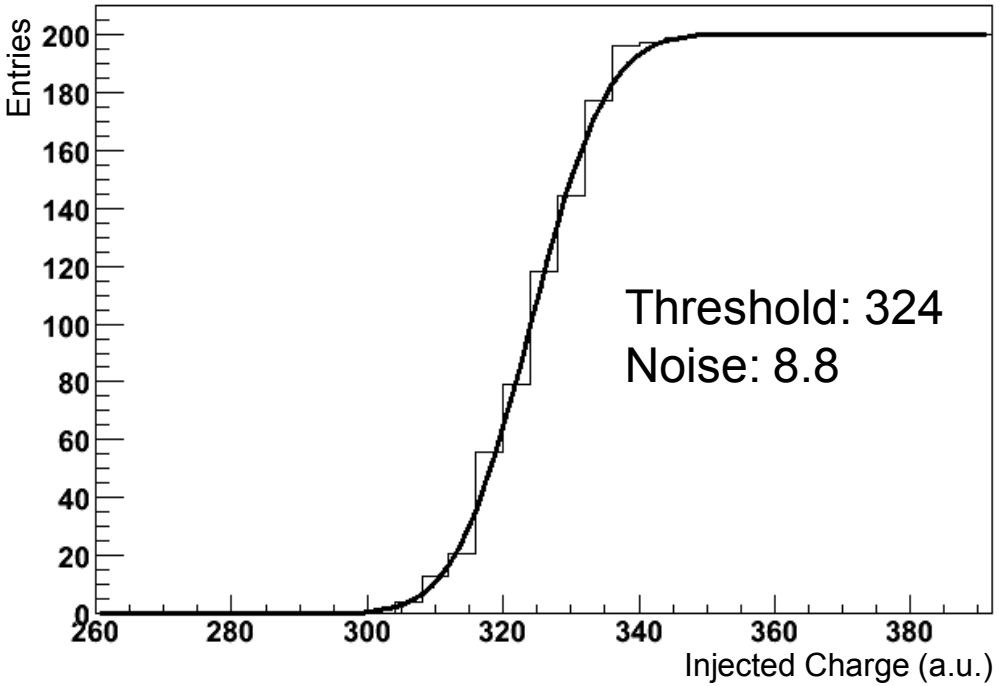
green light → test passed

red light → test failed

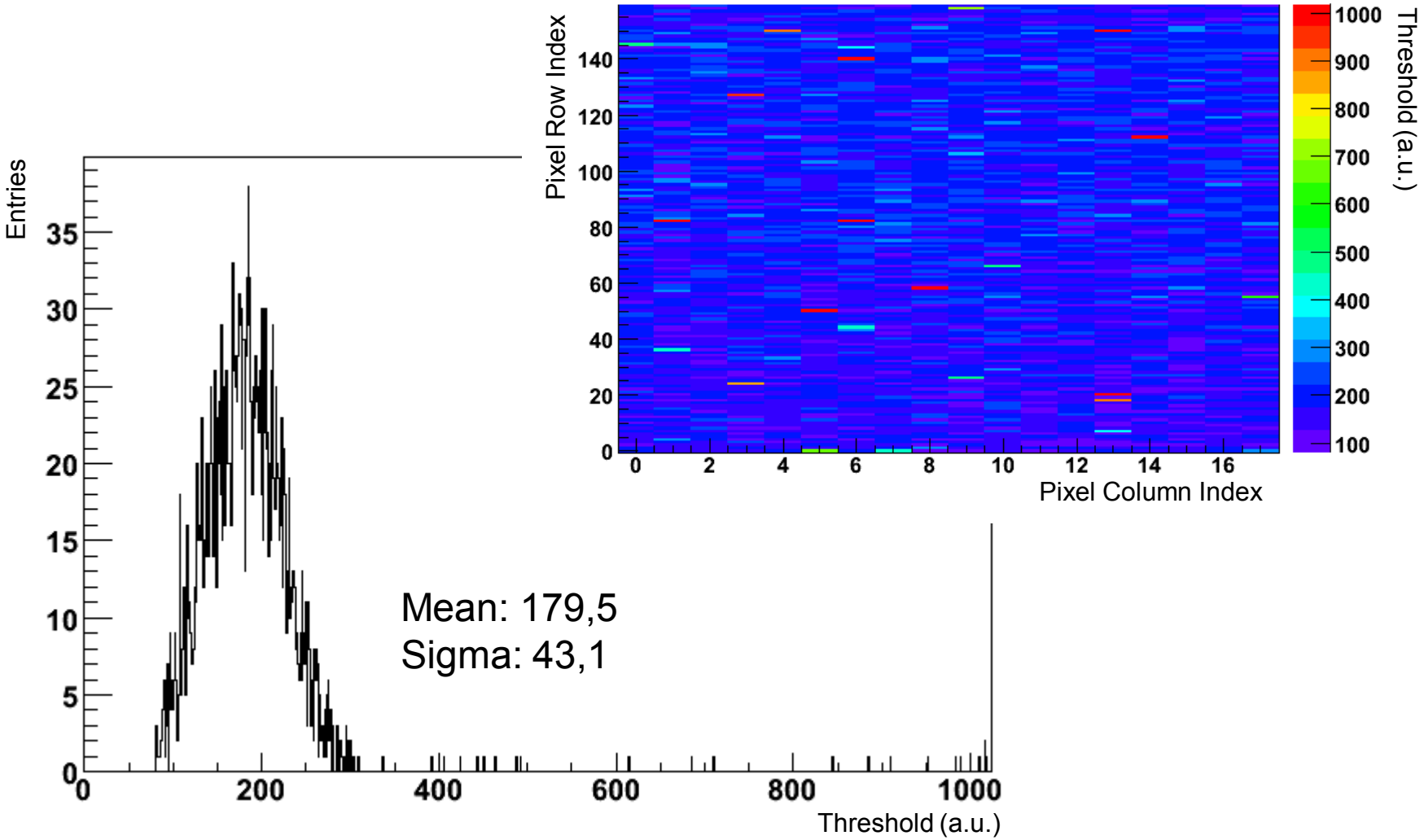
Silicon Pixel Detector Characterization

- **Noise σ** and **Threshold μ**
- Characteristics determination → **Threshold scan**
  - *Repeated injection of a set of known charges*
  - *Record response % as function of injected charge*

$$f(x) = \frac{A}{2} \cdot \left(1 + \mathrm{erfc}\left(\frac{x-\mu}{\sigma \cdot \sqrt{2}}\right)\right)$$

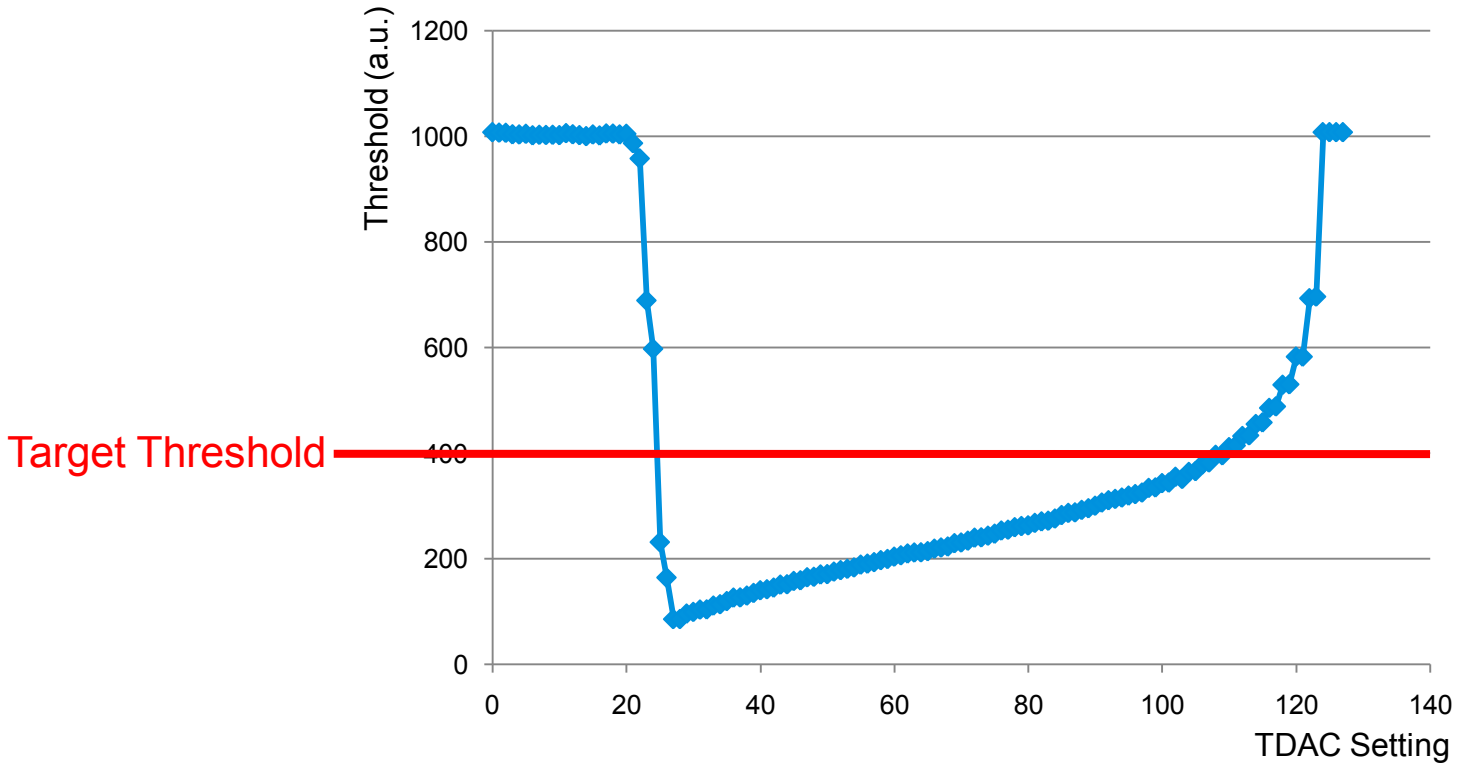


Threshold Distribution (Untuned FE-I3)

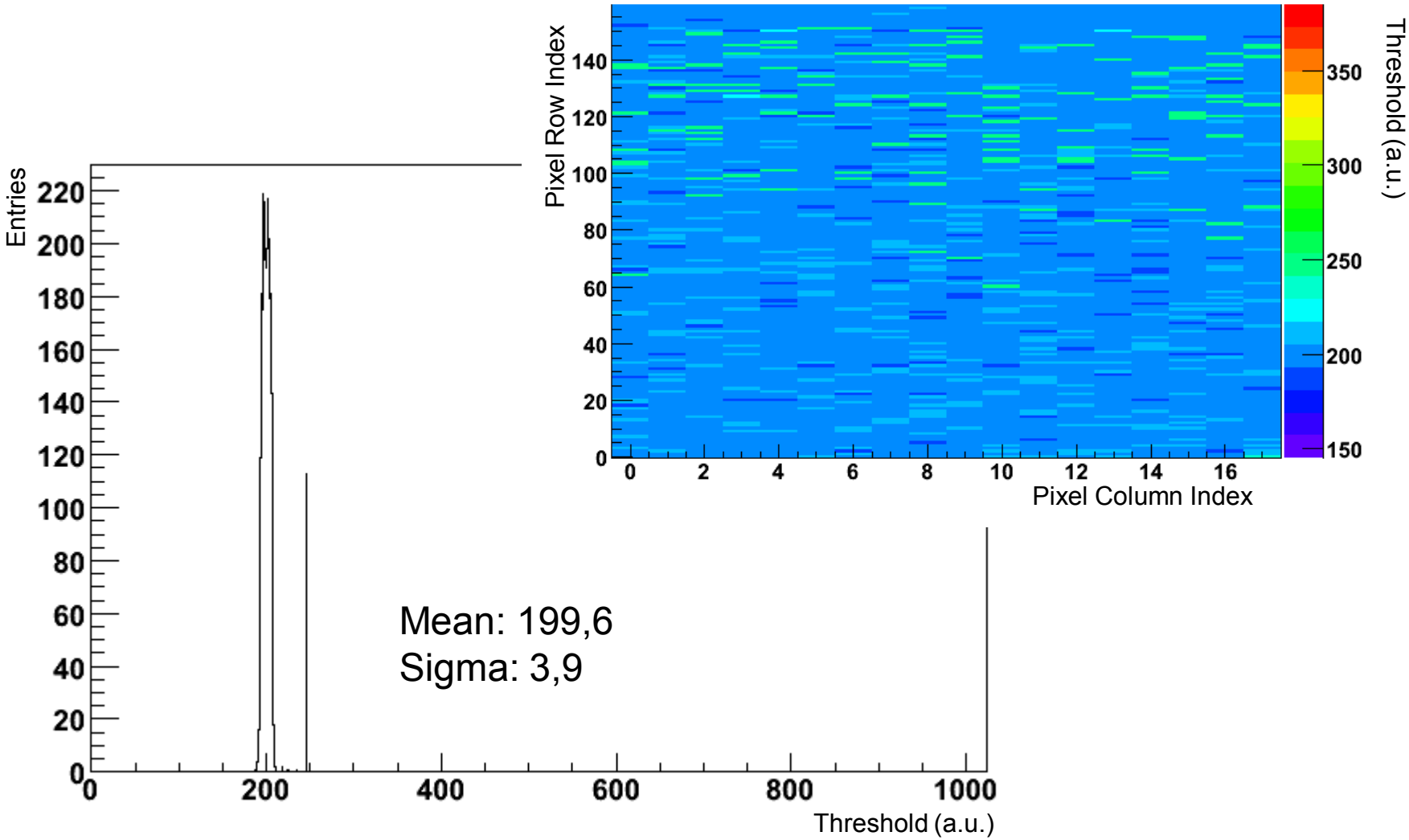


Threshold Tuning (Quick Tune)

- Threshold tuning via **per-pixel TDAC** setting
  - *Intervall halving method*
  - *One Iteration per TDAC bit*

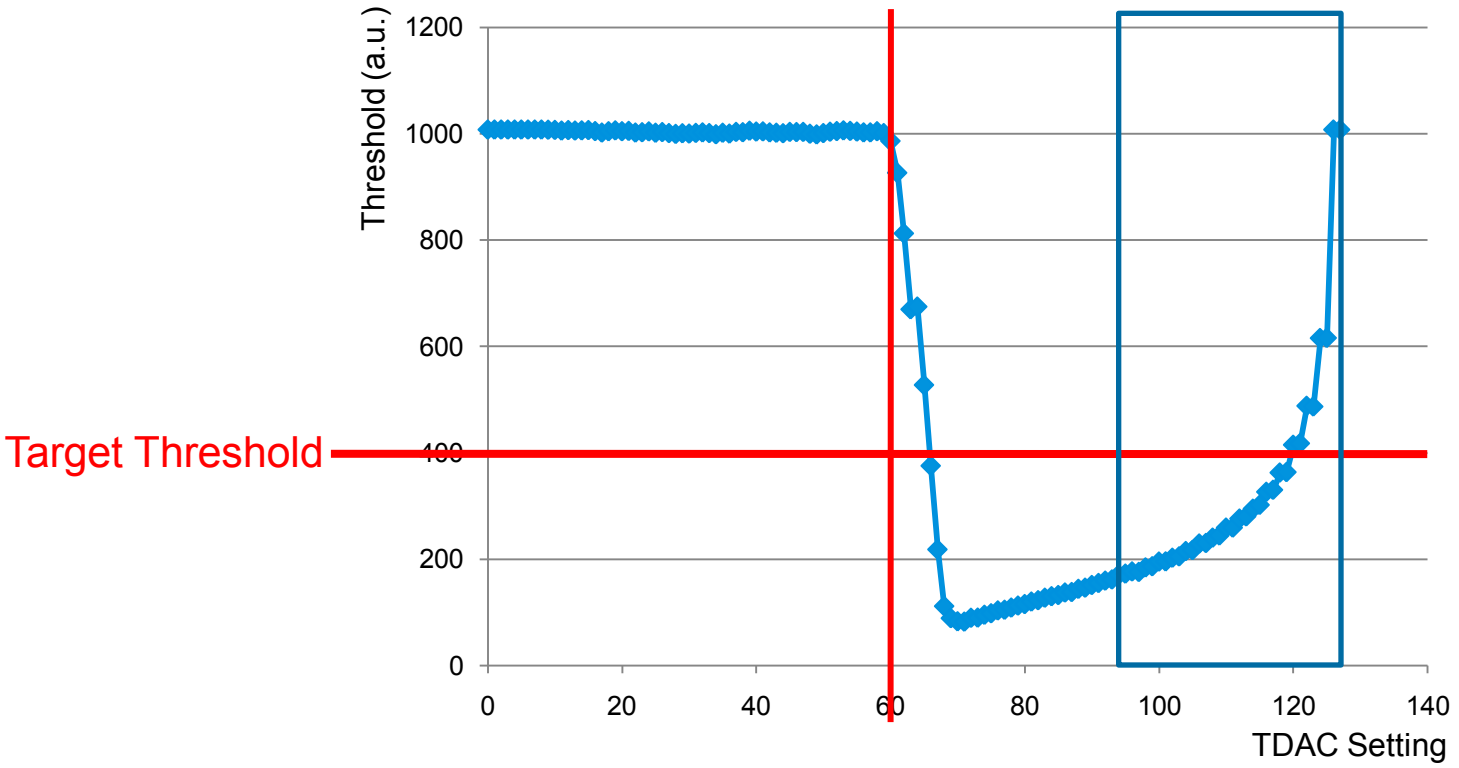


Threshold Distribution (After Quick Tune)

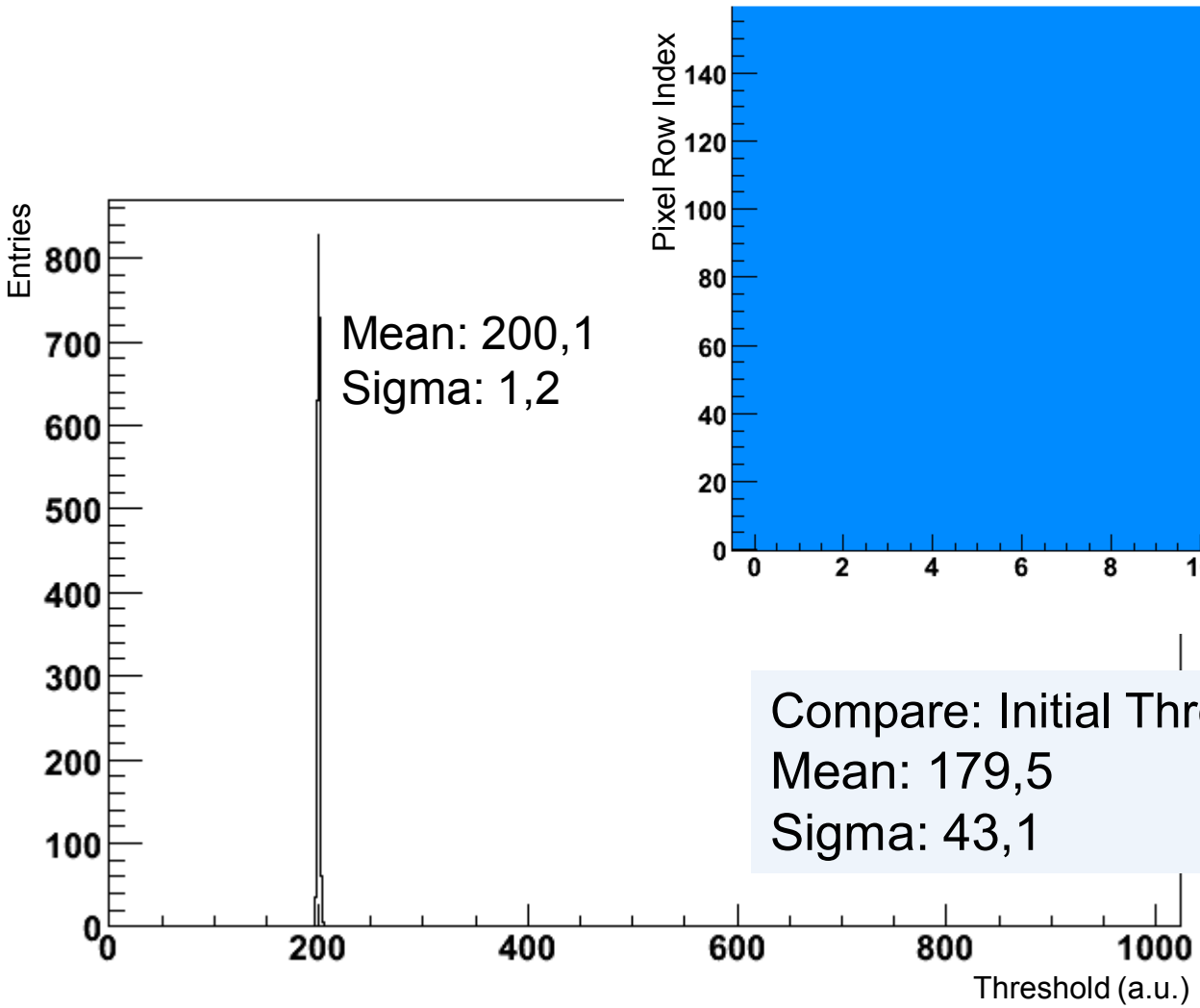


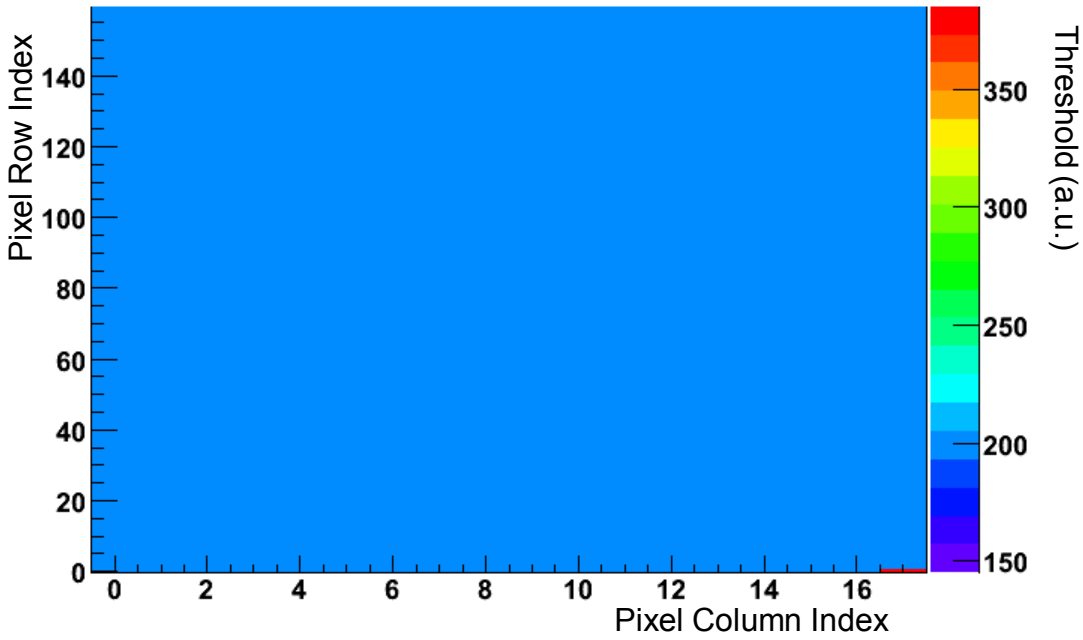
Quick Tune Limitations → Fine Tune

- **Quick tune:** Pixel must be out of noise at first tuning step
- **Fine tune:** Analyzes slope within window
  → needs more measuring points



Threshold Distribution (After Fine Tune)

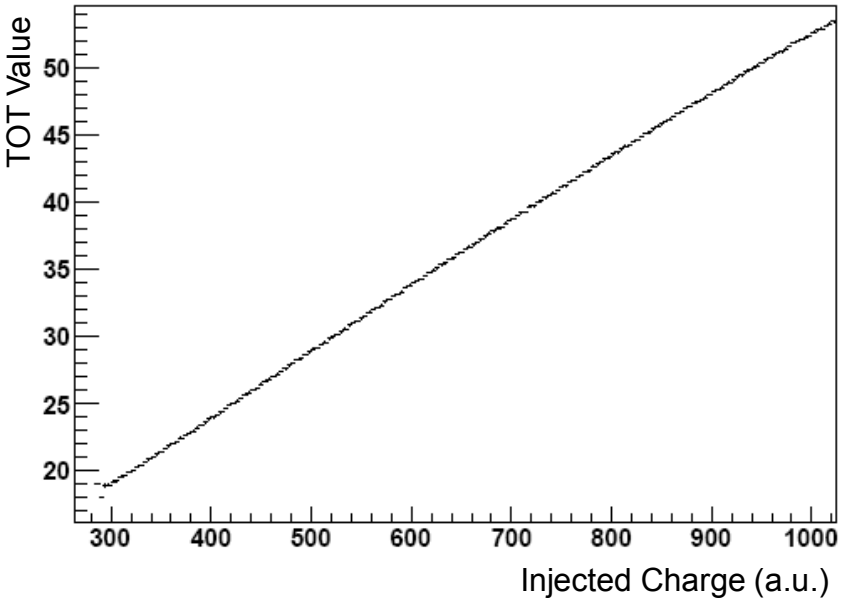


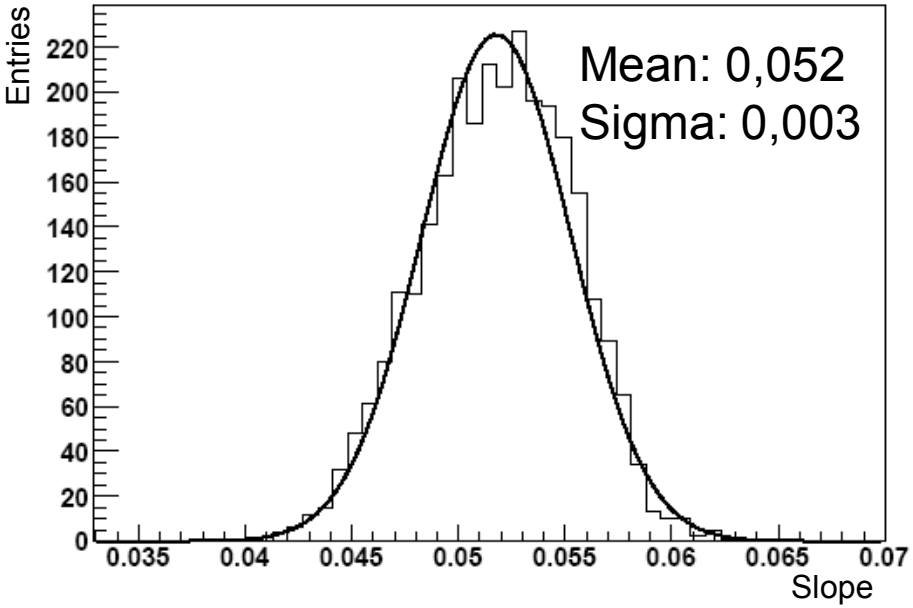


Compare: Initial Threshold Distribution
Mean: 179,5
Sigma: 43,1

TOT Response

TOT Data for injected charges (single pixel)

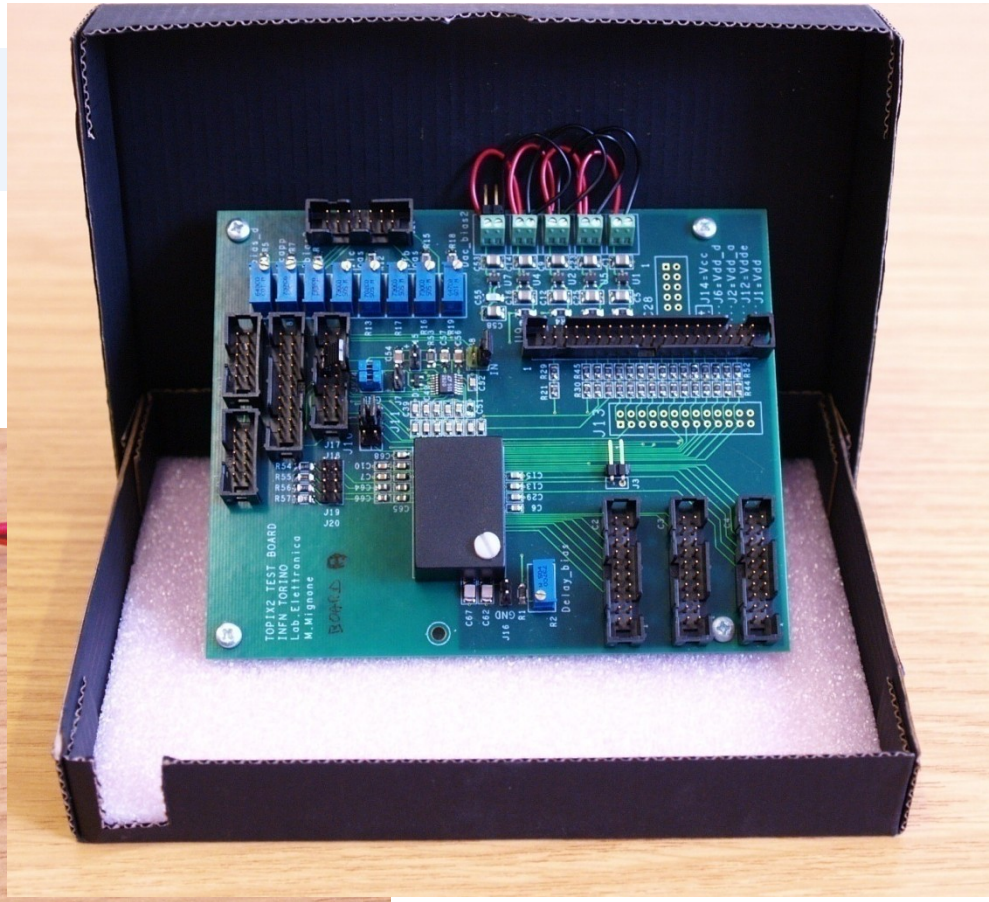




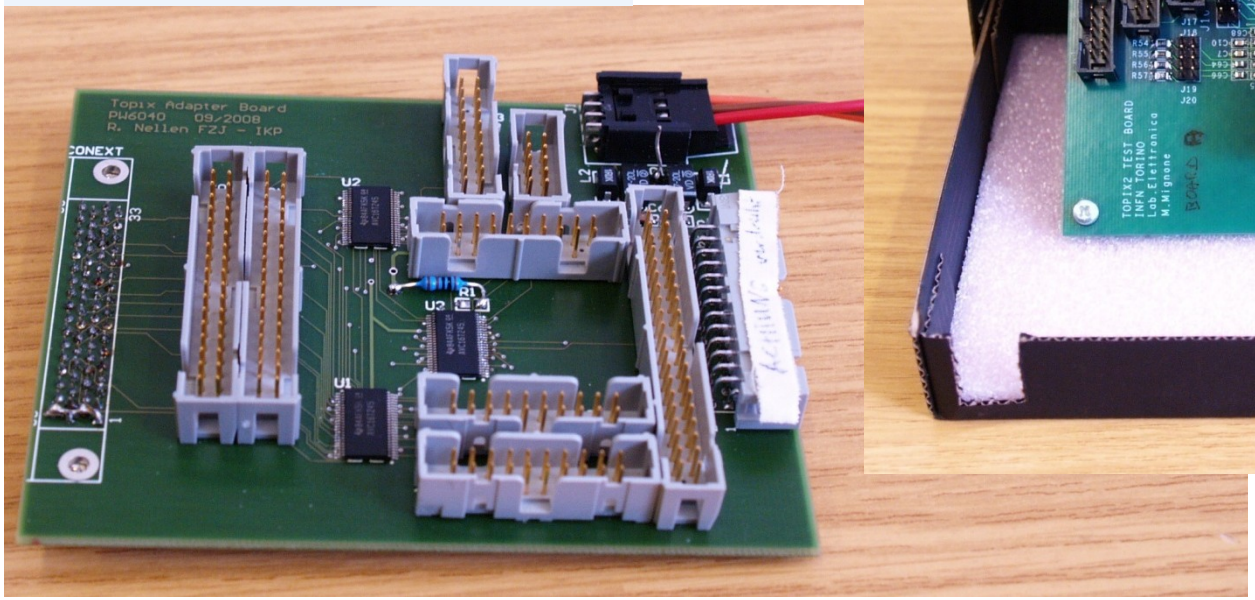
Slope distribution of TOT ⇔ Charge response functions (full chip)

Connection to the ToPiX Prototype

ToPiX FE
mounted on DUT support



Adapter Board



Summary

- Silicon pixel detector characterization: Threshold & noise
- Measurements with the digital readout system
  - *Verification of frontend chip‘s base functionality*
  - *Individual pixel‘s response to charge injection*
  - *Theshold distribution of on-chip pixels*
  - *Threshold tuning to target value*
  - *TOT Response to charge injection*
- Connection to the PANDA ToPiX Prototype

Details on the digital readout system:
→ **HK 67.98**