Characterisation of Prototype Sensors for the Microstrip Detector System at PANDA

Hans-Georg Zaunick*
Kai-Thomas Brinkmann René Jäkel Ralf Kliemt
Felix Krüger Robert Schnell Thomas Würschig

Institut für Kern- und Teilchenphysik
Technische Universität Dresden

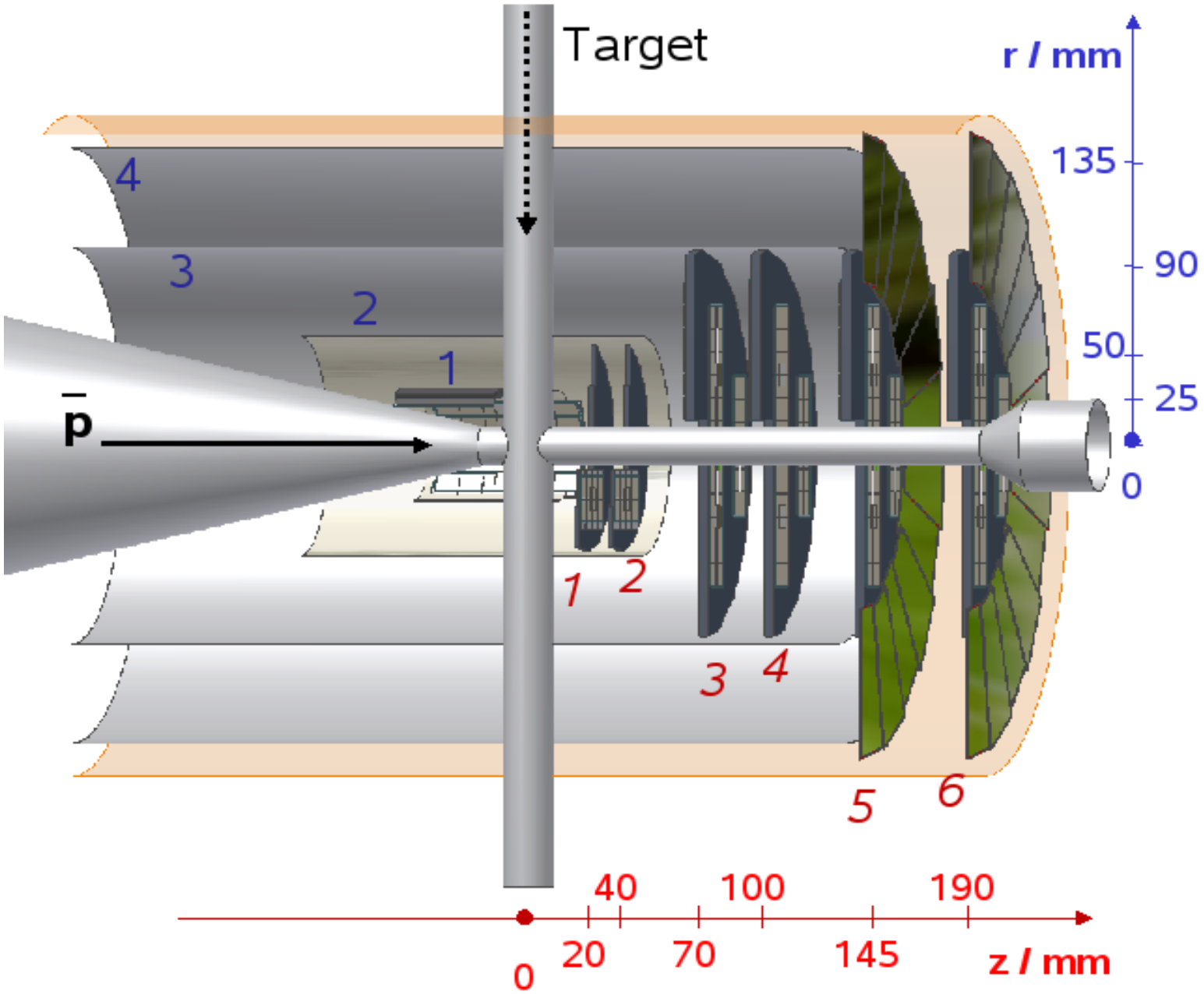
DPG spring meeting, HK25, March 11, 2008

TECHNISCHE UNIVERSITÄT DRESDEN

Outline

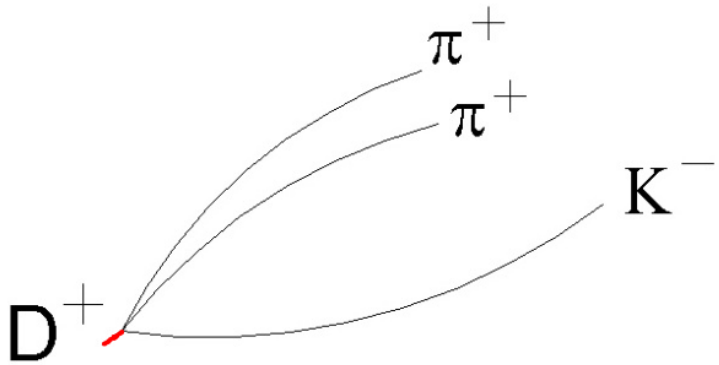
TECHNISCHE UNIVERSITÄT DRESDEN

The PANDA Microvertex Detector



Requirements

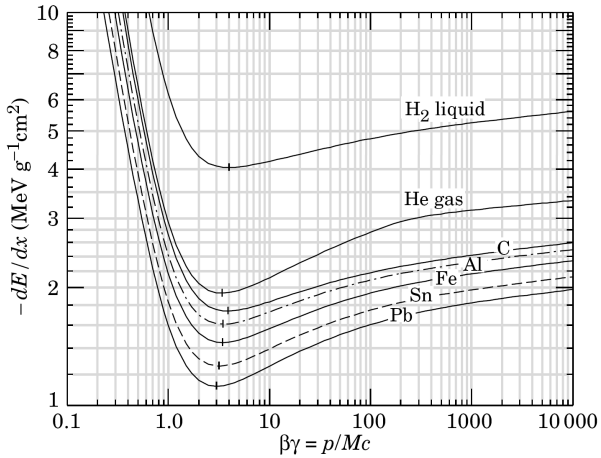
- high spatial resolution
  $\longrightarrow$ D-tagging, p-resolution
- $\frac{dE}{dx}$-information for PID
- time resolution O(10ns)
  $\longrightarrow$high bandwidth
- low power dissipation
- radiation hardness



TECHNISCHE UNIVERSITÄT DRESDEN

Requirements

- high spatial resolution
  $\longrightarrow$ D-tagging, p-resolution
- $\frac{dE}{dx}$-information for PID
- time resolution O(10ns)
  $\longrightarrow$high bandwidth
- low power dissipation
- radiation hardness



Requirements

- high spatial resolution
  $\longrightarrow$ D-tagging, p-resolution
- $\frac{dE}{dx}$-information for PID
- time resolution O(10ns)
  $\longrightarrow$high bandwidth
- low power dissipation
- radiation hardness

Requirements

- high spatial resolution
  $\longrightarrow$ D-tagging, p-resolution
- $\frac{dE}{dx}$-information for PID
- time resolution O(10ns)
  $\longrightarrow$high bandwidth
- low power dissipation
- radiation hardness

Requirements

- high spatial resolution
  $\longrightarrow$ D-tagging, p-resolution
- $\frac{dE}{dx}$-information for PID
- time resolution O(10ns)
  $\longrightarrow$high bandwidth
- low power dissipation
- radiation hardness

TECHNISCHE UNIVERSITÄT DRESDEN

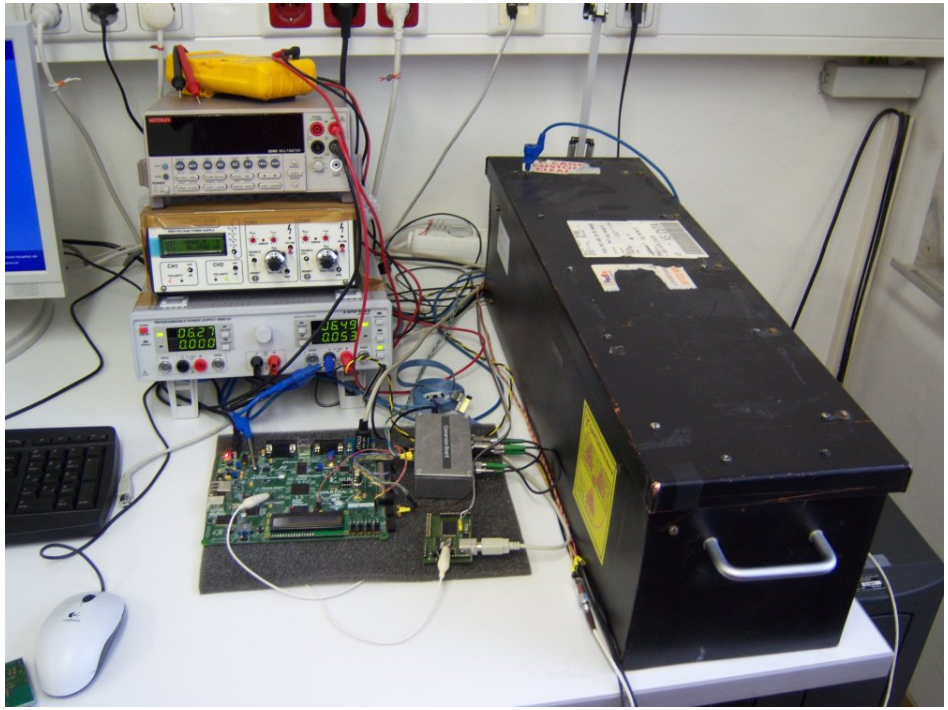
Requirements

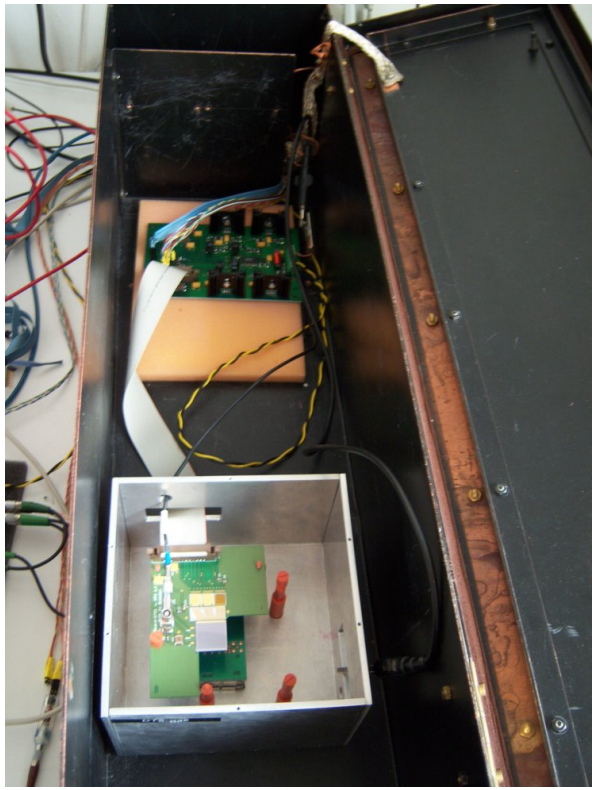
- high spatial resolution
  $\longrightarrow$ D-tagging, p-resolution
- $\frac{dE}{dx}$-information for PID
- time resolution O(10ns)
  $\longrightarrow$high bandwidth
- low power dissipation
- radiation hardness

no 1^{st}-Level Trigger

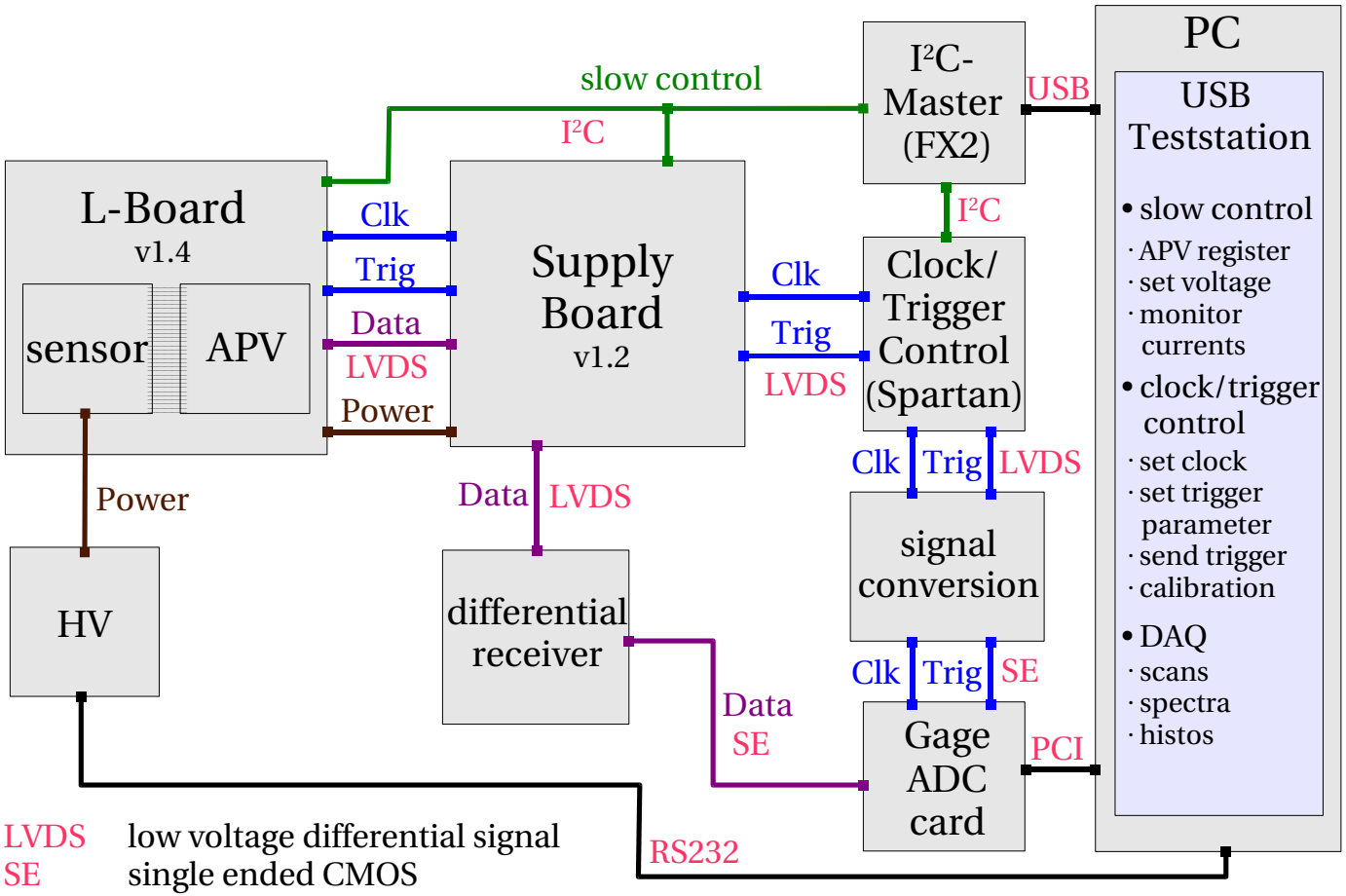
TECHNISCHE UNIVERSITÄT DRESDEN

A Setup for Characterisation of Si-Strip Sensors and Frontends



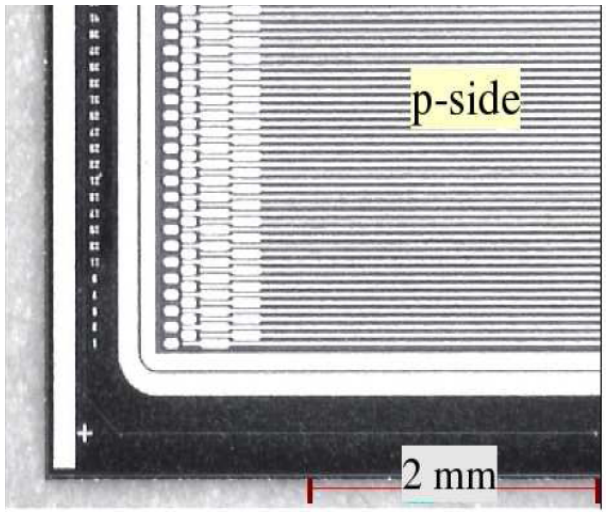


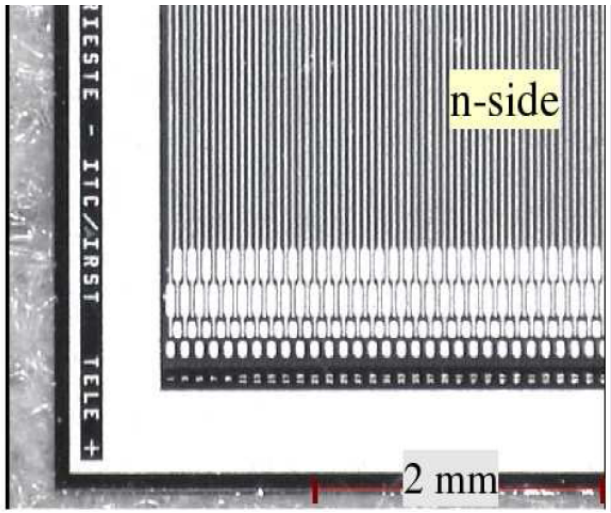
Readout Scheme



Prototype Sensors

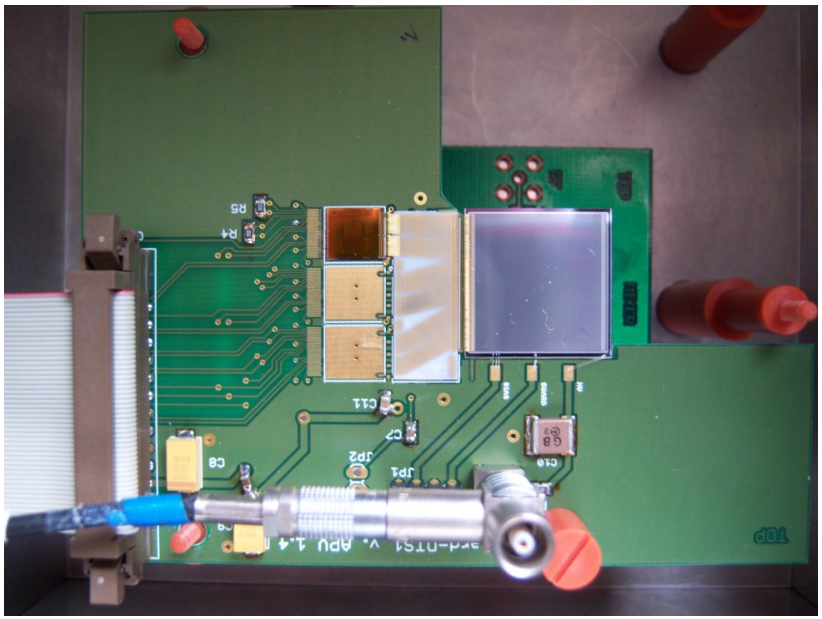
- area $2 \times 2\,cm^2$, thickness $320\mu m$
- 50 μm pitch, 90°stereo angle
- AC-coupled, punch-through biased
- not radiation hard

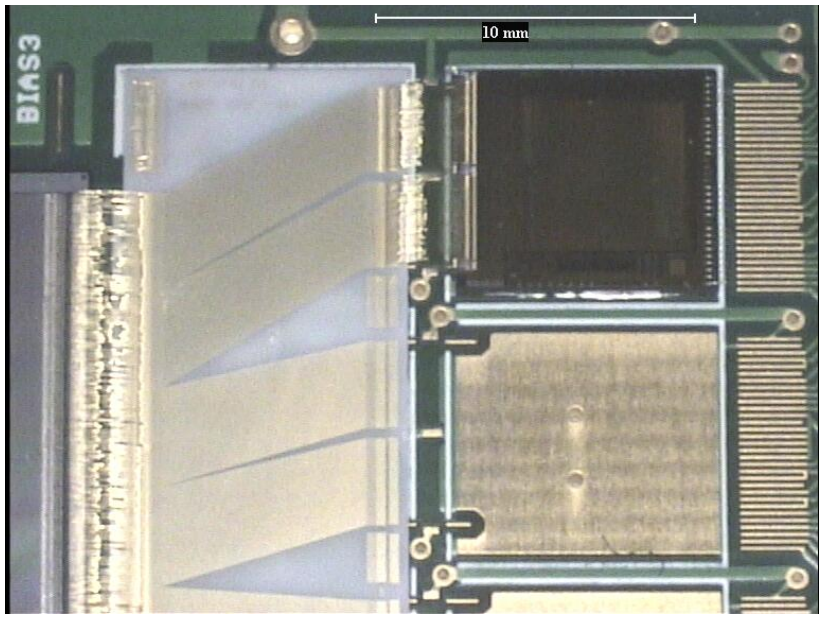




Sensor-PCB

- L-shape for double sided mounting
- mechanical support for sensor/pitch adaptor/FEs
- used frontend chips: APV25

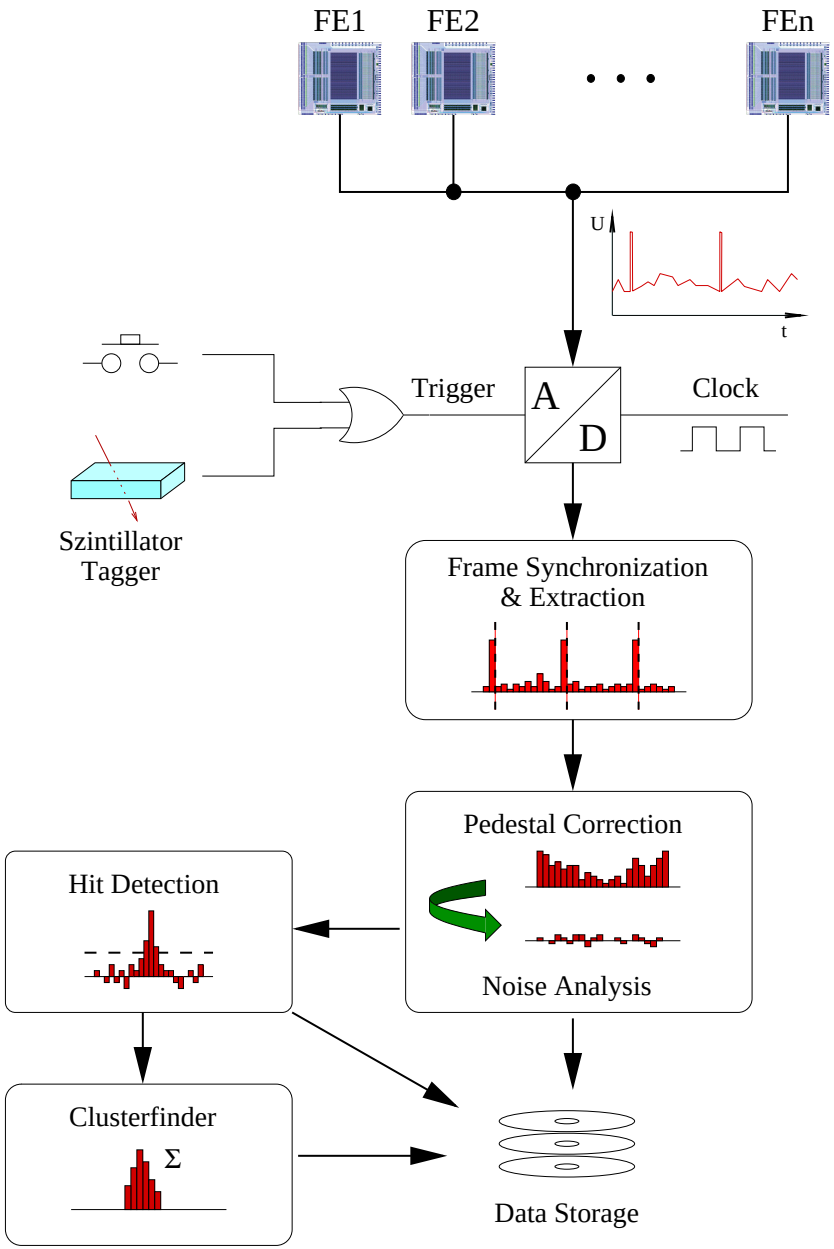




AVT

RHe MICROSYSTEMS

TECHNISCHE UNIVERSITÄT DRESDEN

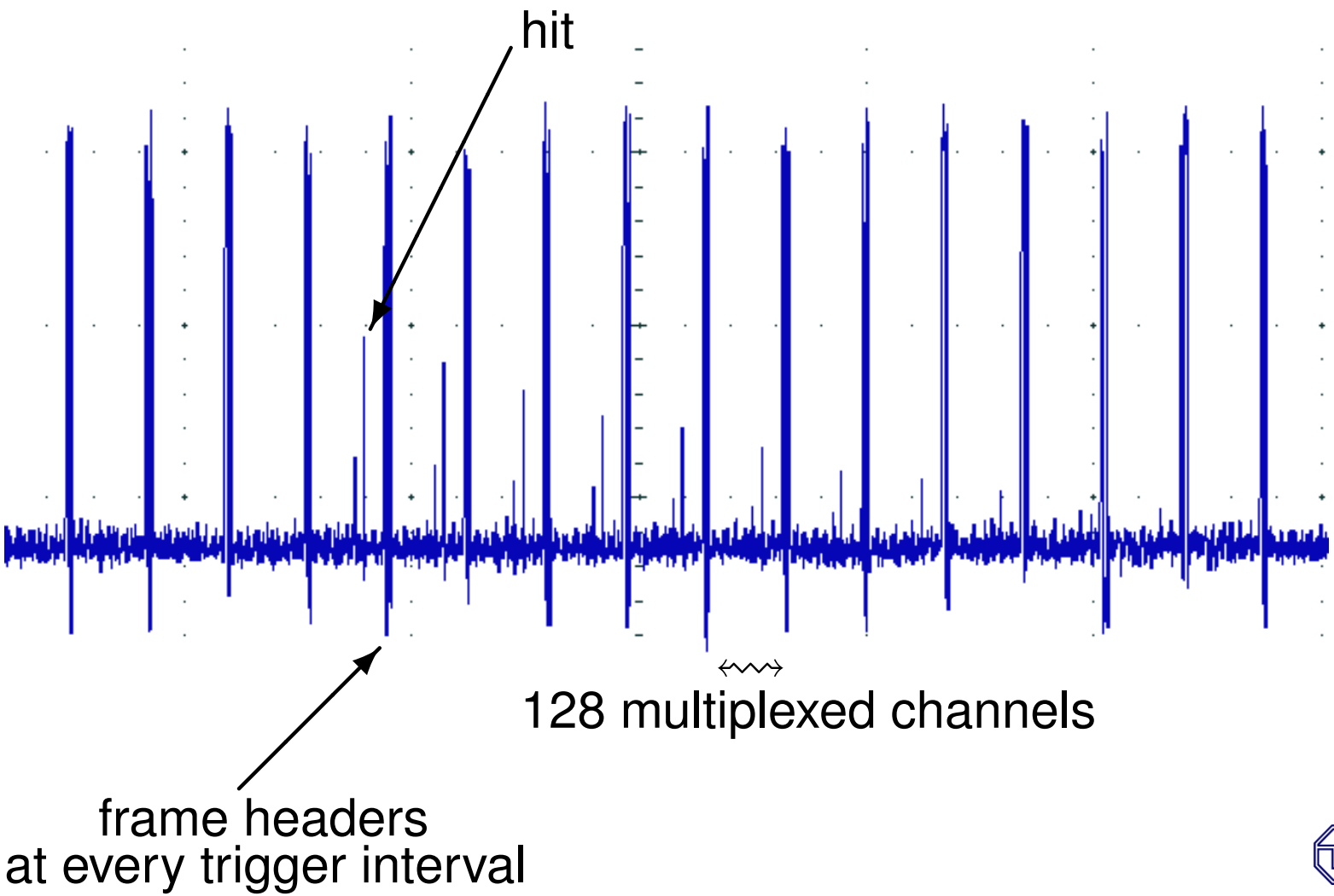


Feature Extraction Scheme

- zero suppression
- reduction of datarate by factor 10...100
- to be implemented into L1-hardware

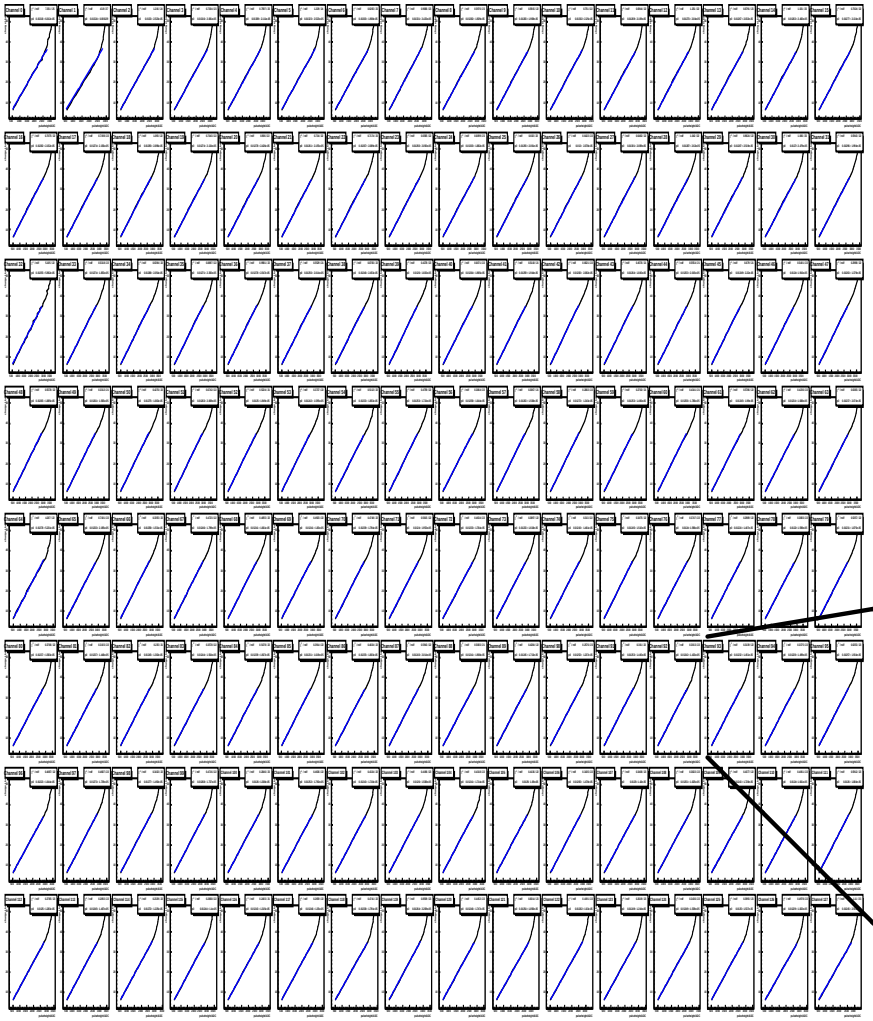
Typical Hit Pattern

- hit channel for $t \propto T_{Shaper}$ distinguishable from noise

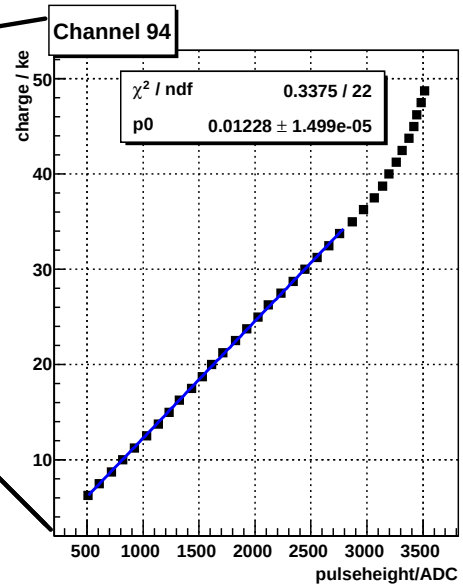


Calibration

- injection of defined charge into FE preamps
- store slope parameters for later charge reconstruction

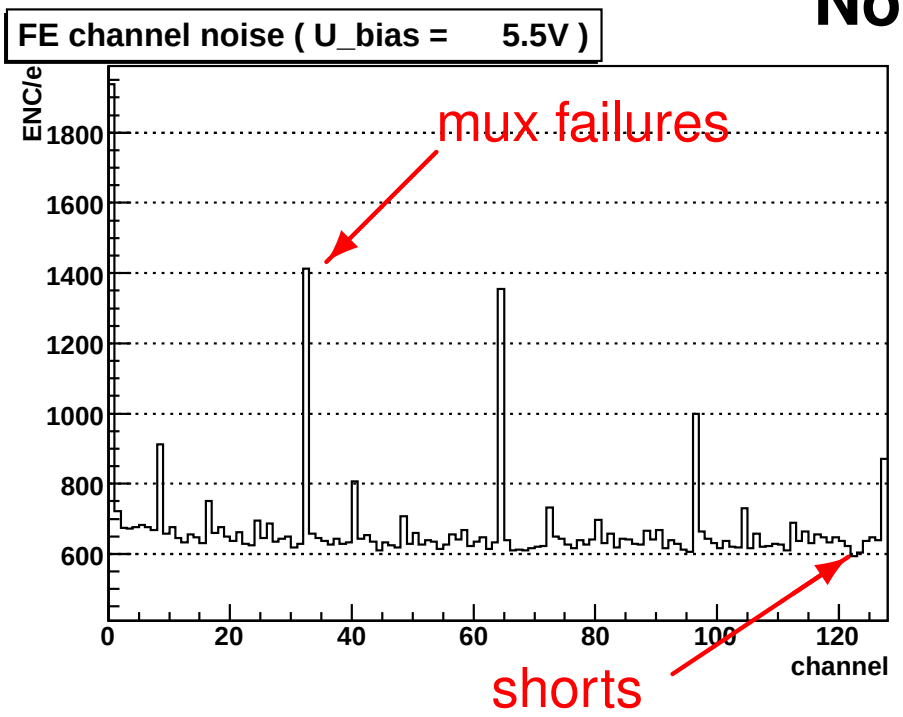


response characteristics of all FE channels



TECHNISCHE UNIVERSITÄT DRESDEN

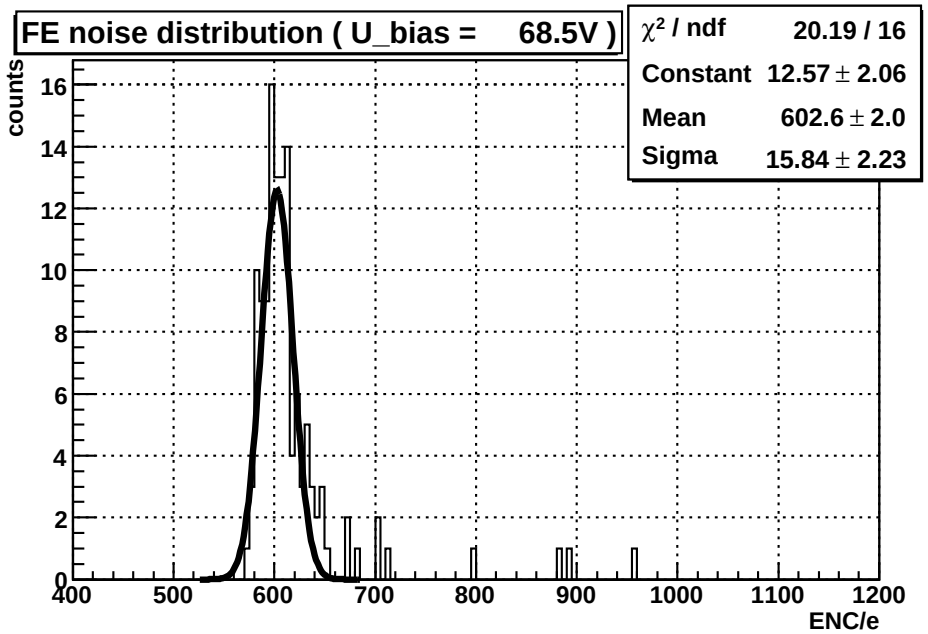
Noise



origin of noisy channels

- unbonded strips
- preamp/mux biassing mismatches
- stray pickup

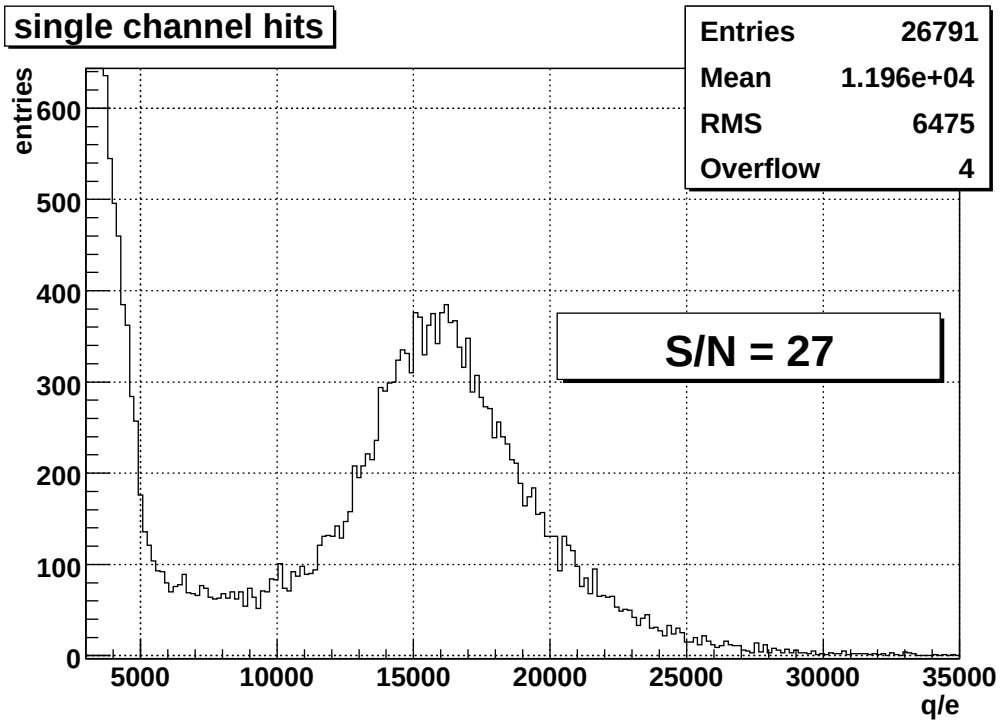
Noise Dispersion



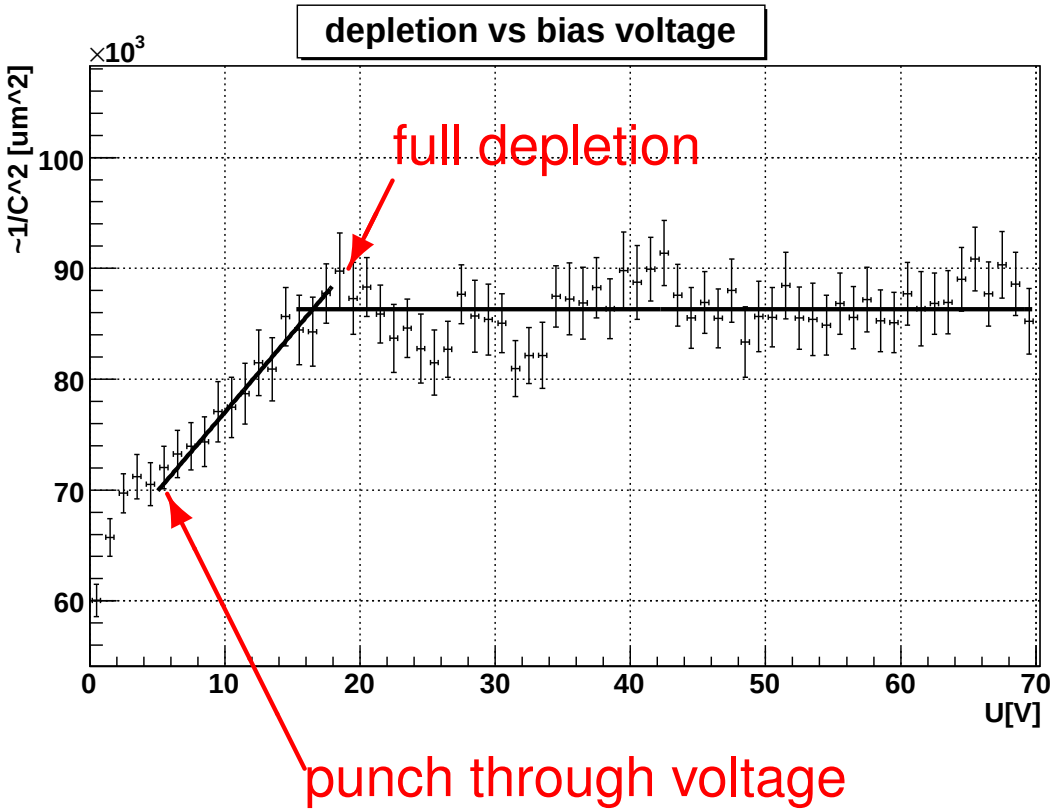
TECHNISCHE UNIVERSITÄT DRESDEN

Signal to Noise Ratio

- measured with ^{90}Sr beta source and scintillator trigger
- ENC=600 e^-



measured sensor depletion characteristics



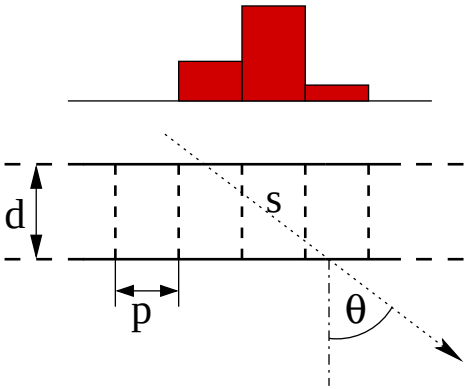
1. measure ENC = $f(U)$

   noise determined by strip-to-bulk capacitance APV25 :
   $ENC = 270e^- + 38\frac{e^-}{pF} \cdot C$

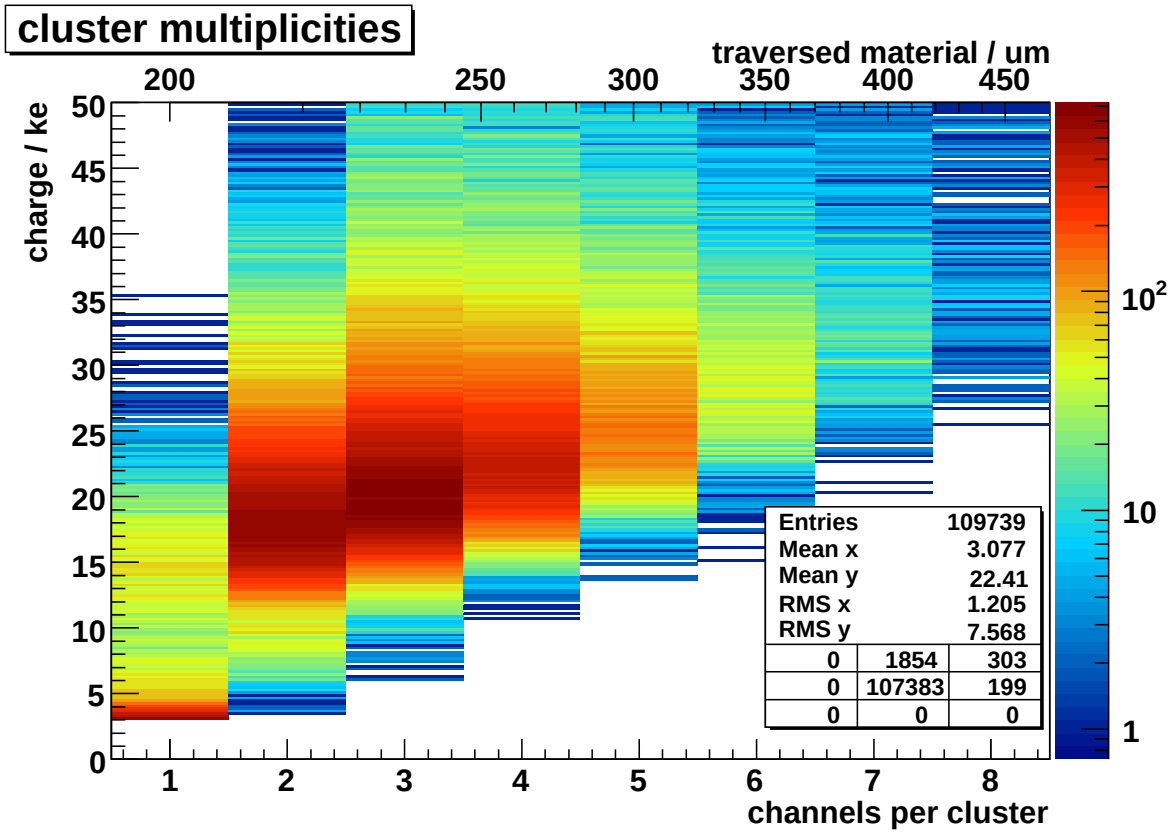
2. extract C

   depletion depth scales with $\frac{1}{C^2}$

Charge Deposition ↔ Cluster Size

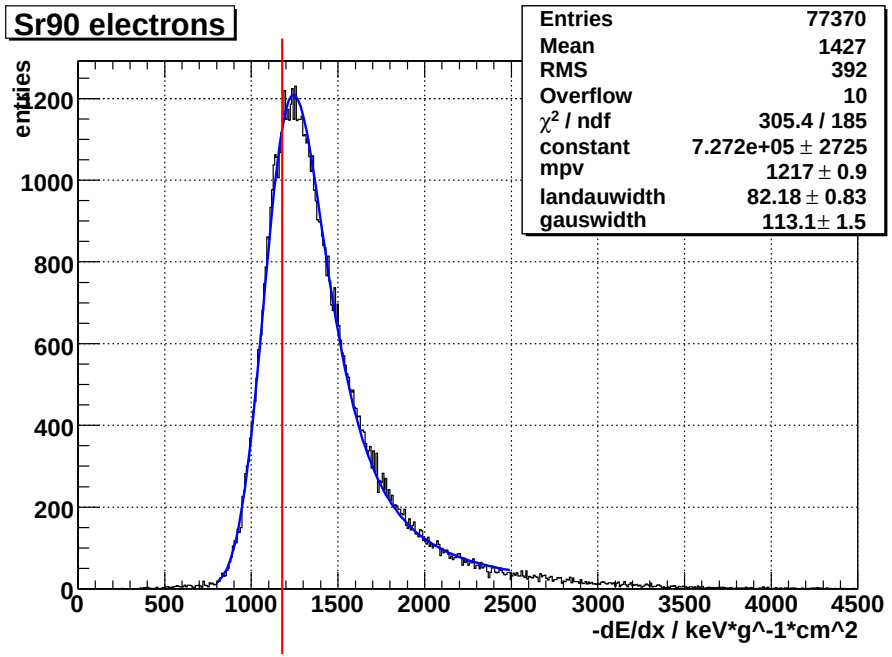


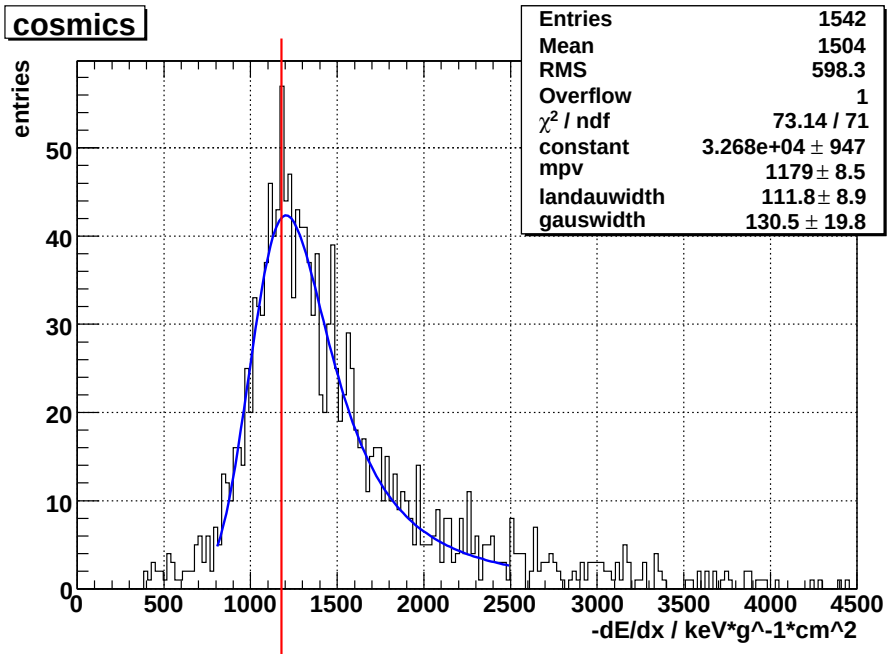
- cluster size reflects tilt of trajectory
  $tan(\theta) = \frac{n \cdot p}{d}$
- particle path length estimated by:
  $s = \frac{d}{cos(\theta)}$



Energy Loss

- particle energy losses convolved with Gaussian noise distribution
- Landau distribution describes spectrum well in vicinity of peak





prediction for MIPs in thin absorbers (Landau/Vavilov/Bichsel)

TECHNISCHE UNIVERSITÄT DRESDEN

Summary

- setup for readout of single sided sensor modules
- scrutinize basic properties, e.g. noise, charge sharing, energy deposition etc.
  $\longrightarrow$ experimental input for feature extraction and reconstruction algorithms

Summary

- setup for readout of single sided sensor modules
- scrutinize basic properties, e.g. noise, charge sharing, energy deposition etc.
  $\longrightarrow$ experimental input for feature extraction and reconstruction algorithms

Outlook

- implement zero suppression and hit finder into FPGA
- test and comparison of different clustering algorithms
- test at ELSA electron beam this summer

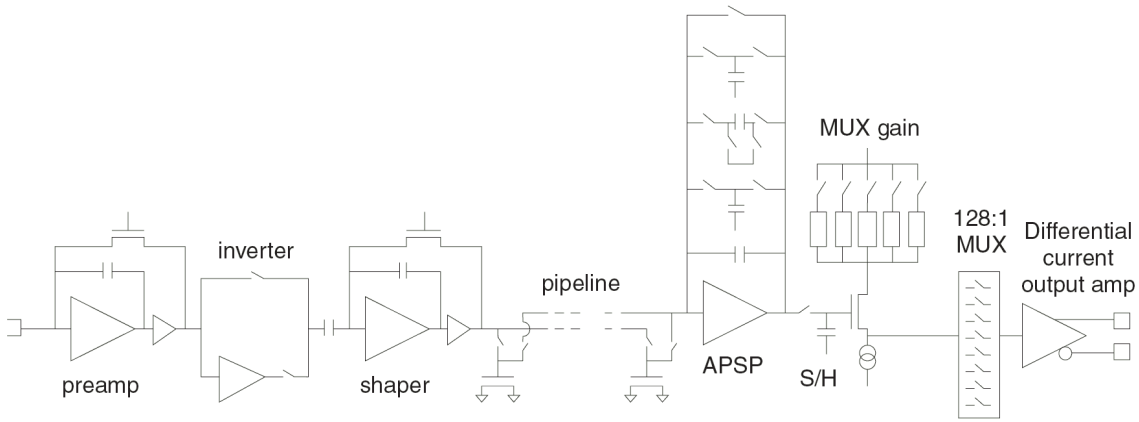
TECHNISCHE UNIVERSITÄT DRESDEN

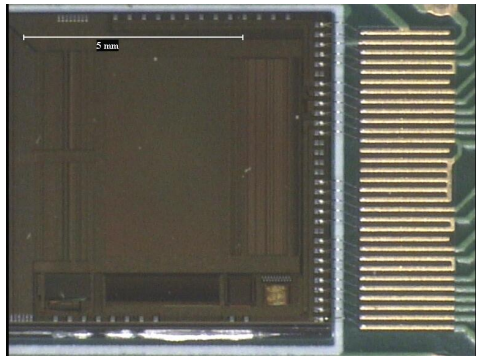
Backup Slides

APV25

- developed for CMS@LHC
- Preamp + Shaper + Analog-Mux
- 128 channels
- adjustable shaping time (50ns nom.)
- low noise: 270e + 38e/pF
- ext. Trigger required

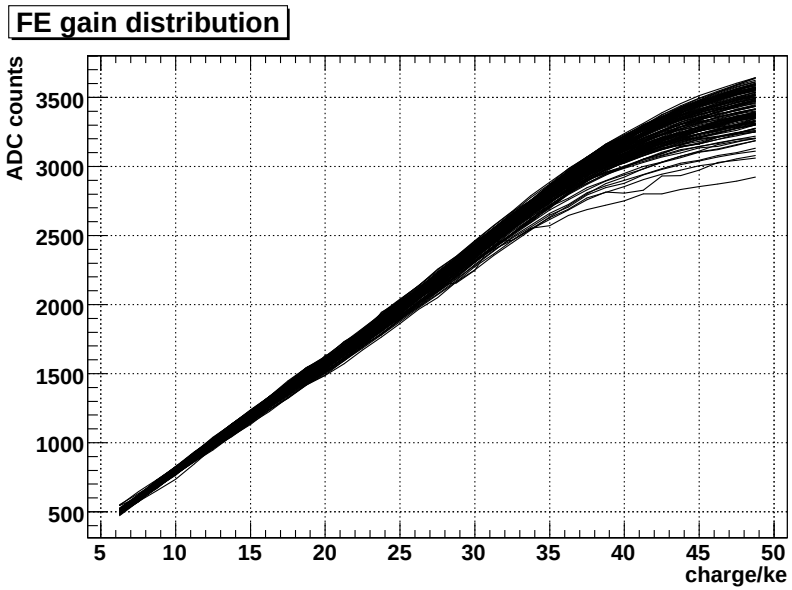
L.L. Jones et al., RAL

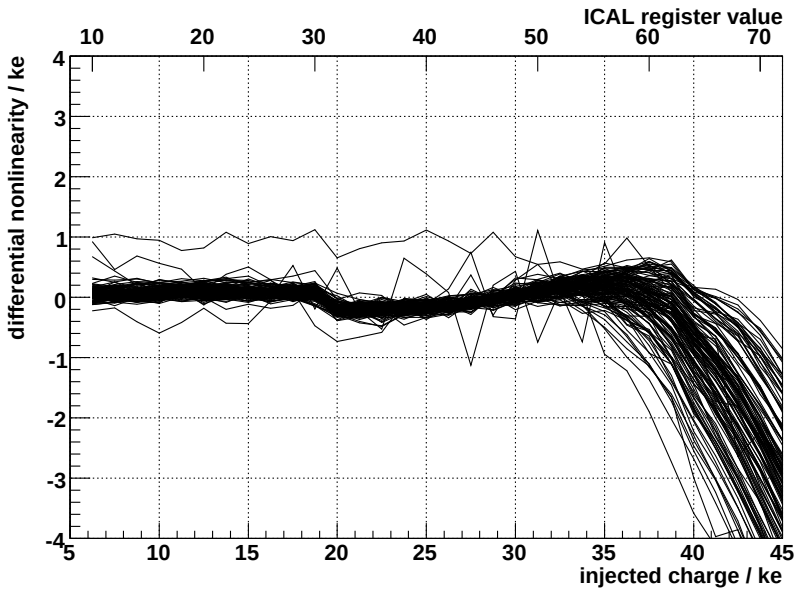


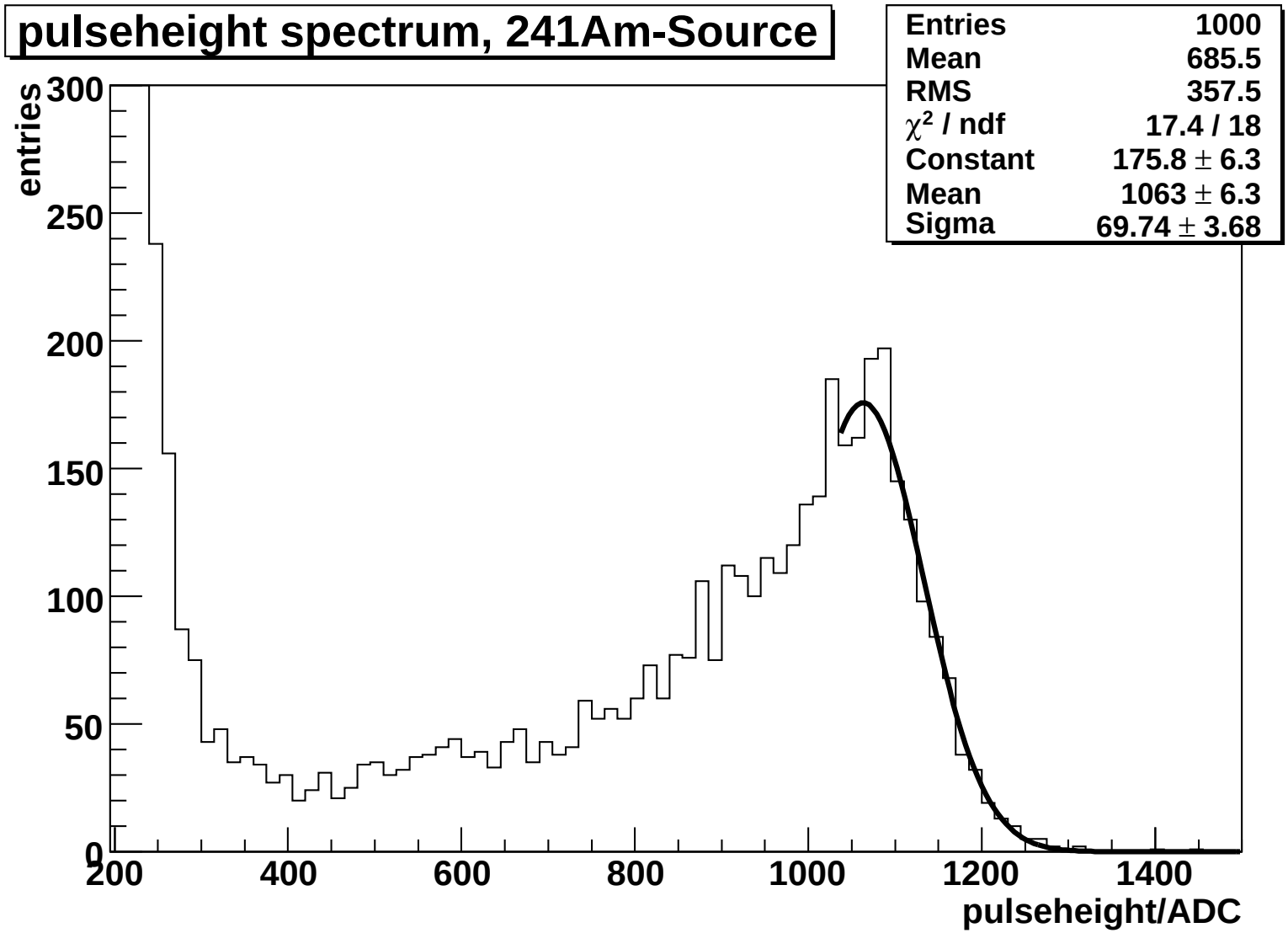


TECHNISCHE UNIVERSITÄT DRESDEN

channel gain characteristics of one selected FE and corresponding nonlinearities



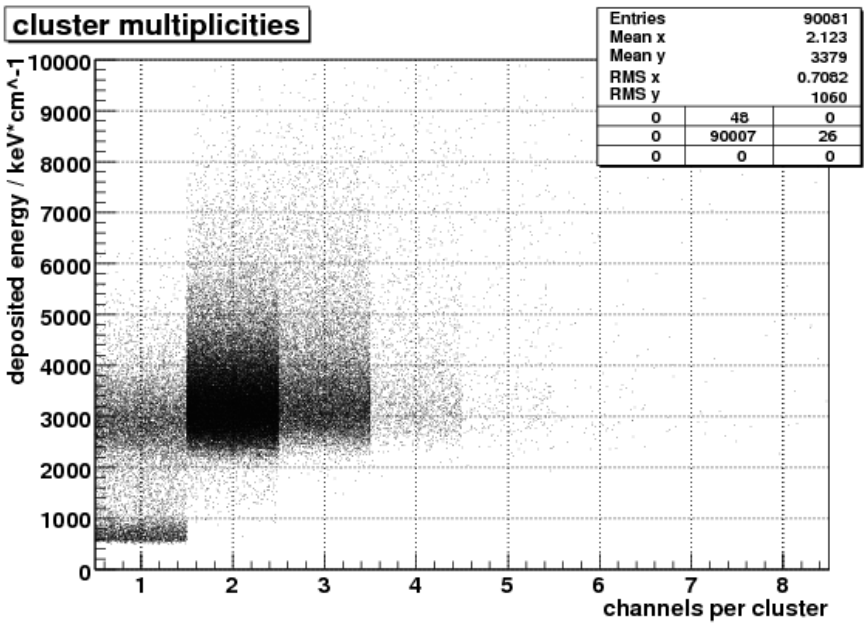




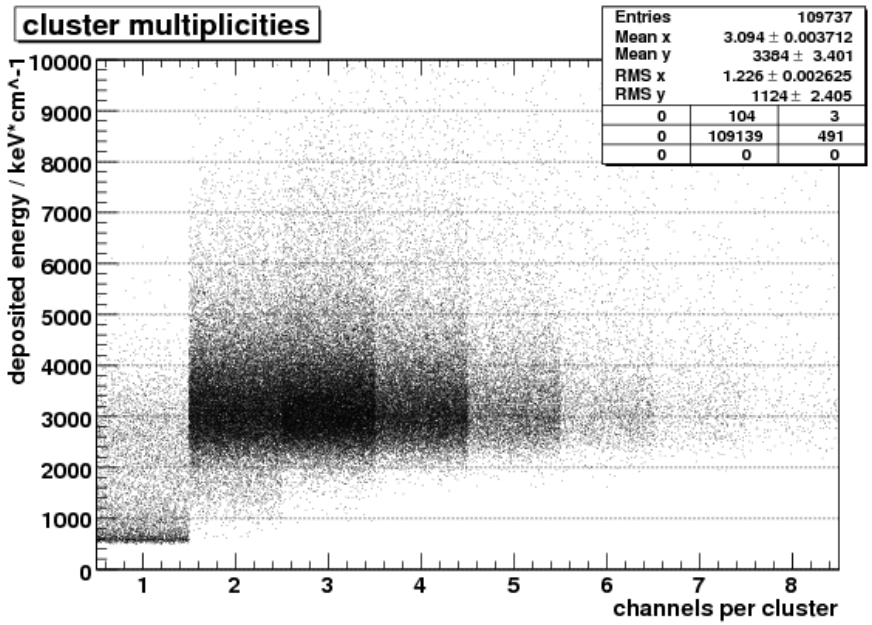
TECHNISCHE UNIVERSITÄT DRESDEN

charge spread at different incident angles

$\theta \approx 0°$



$\theta = (30 \ldots 40)°$



TECHNISCHE UNIVERSITÄT DRESDEN