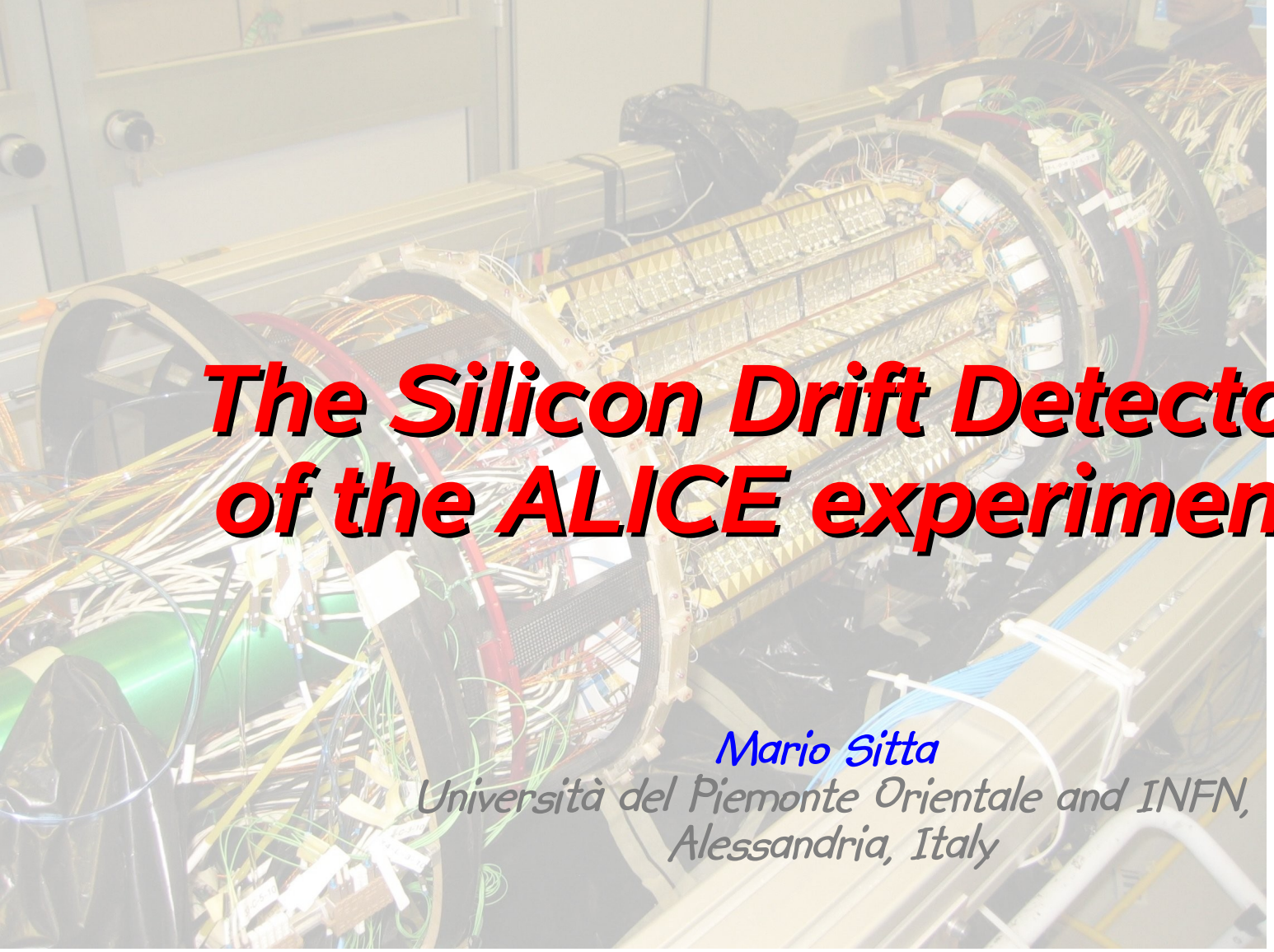


The Silicon Drift Detector of the ALICE experiment

Mario Sitta

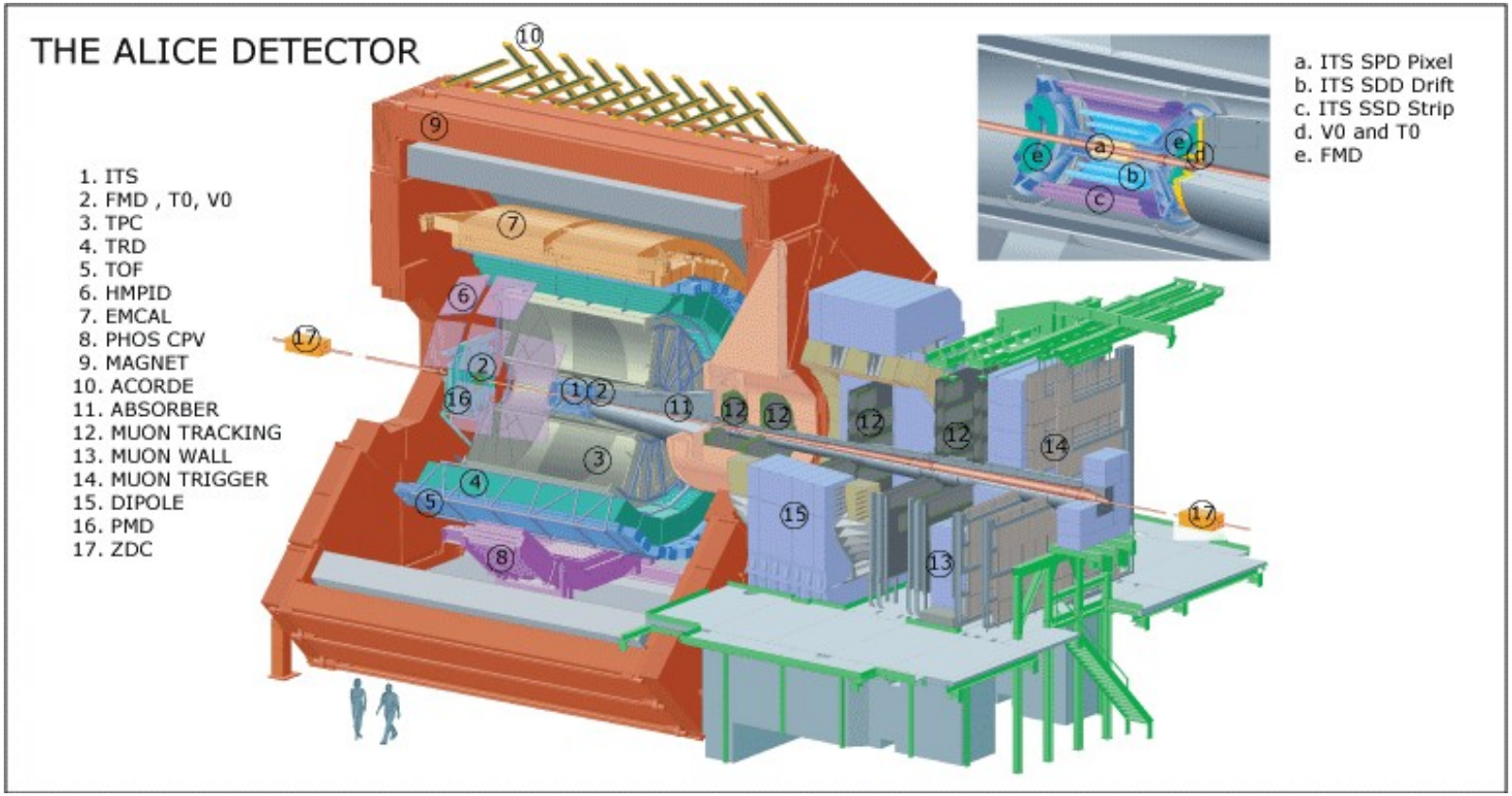
Università del Piemonte Orientale and INFN, Alessandria, Italy

12th Vienna Conference on Instrumentation – Feb. 15th 2010

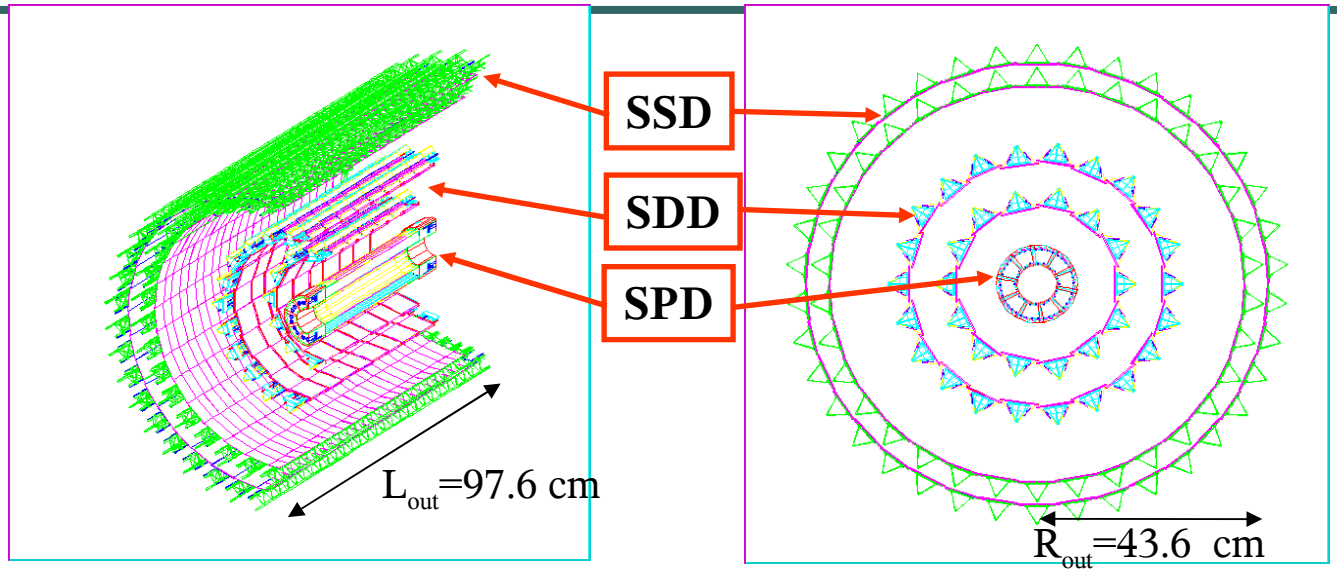
Overview

- The Silicon Drift Detectors in ALICE
- Detector calibration during last year's data taking period
  - ⇨ drift speed
  - ⇨ charge calibration
- Results from cosmic and pp runs
- Summary

The Alice Experiment



The Inner Tracking System

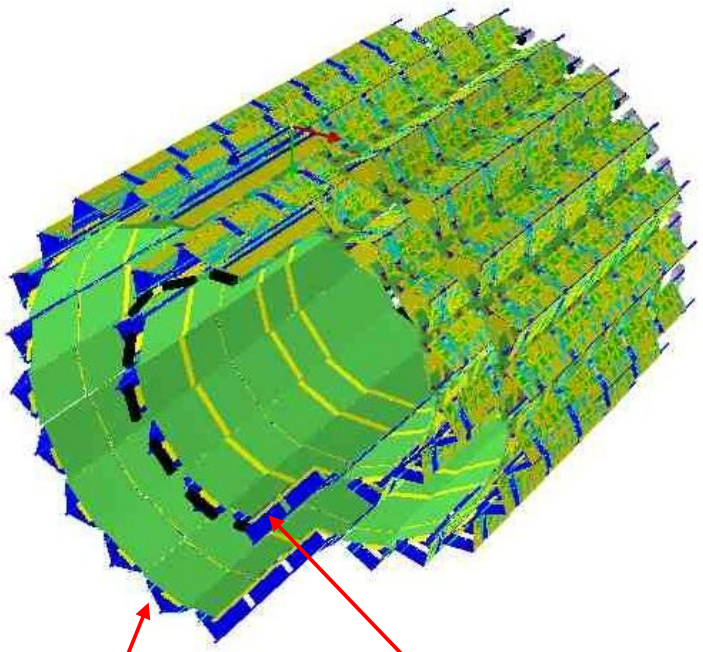


Silicon Pixel Detector (SPD):
- ~10M channels
- 240 sensitive vol. (60 ladders)

Silicon Drift Detector (SDD):
- ~133k channels
- 260 sensitive vol. (36 ladders)

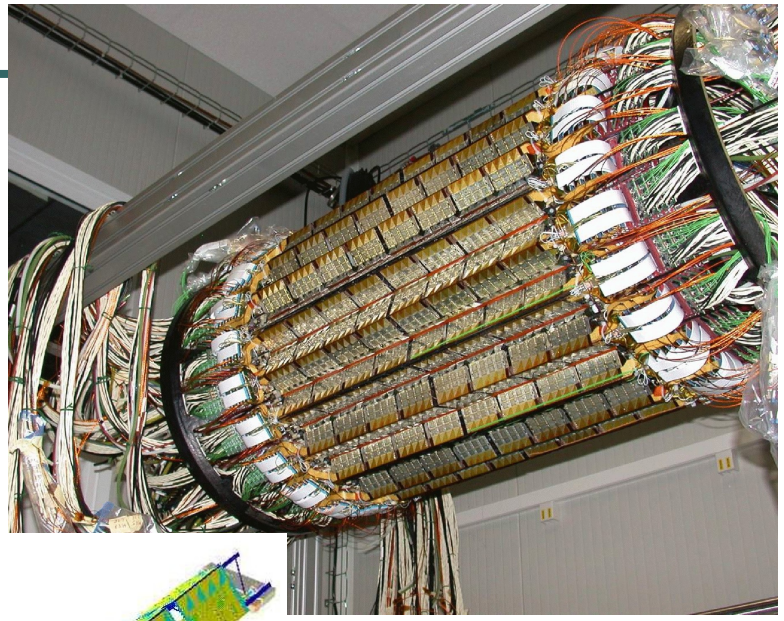
Silicon Strip Detector (SSD):
- ~2.6M channels
- 1698 sensitive vol. (72 ladders)

The Silicon Drift Detector



Layer 4
22 Ladders

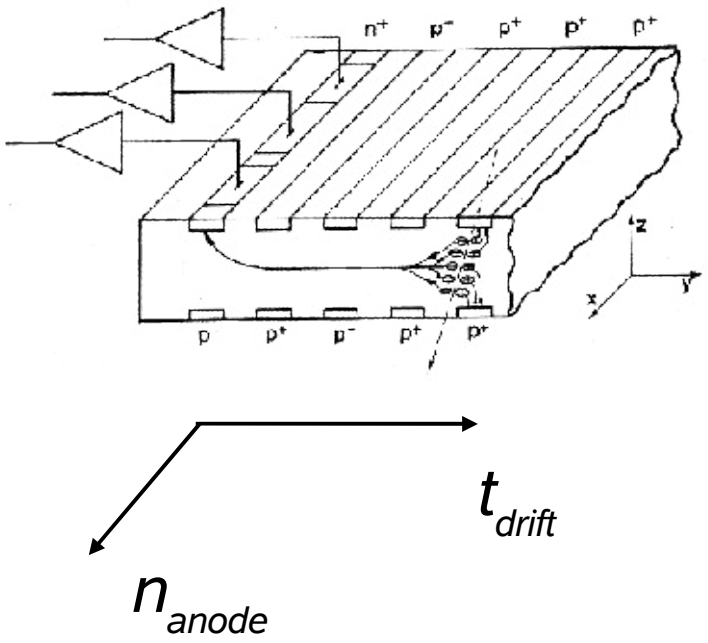
Layer 3
14 Ladders

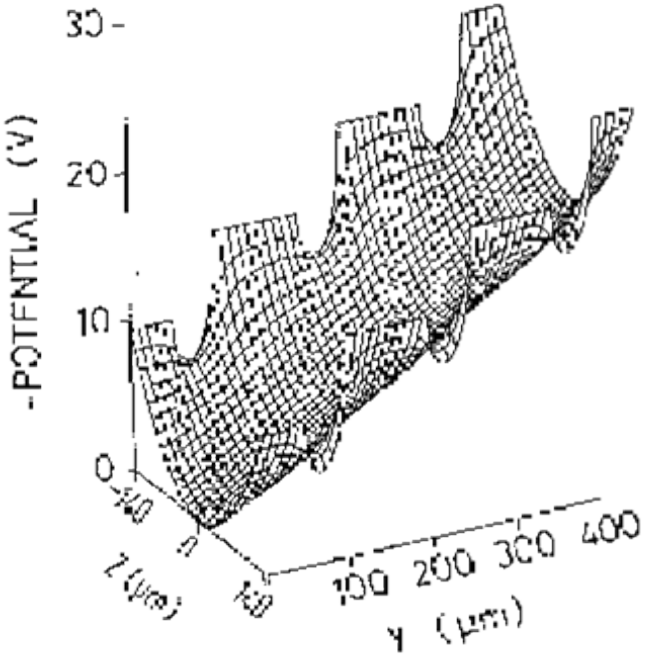


Layer 3: 6 sensors/ladder
Layer 4: 8 sensors/ladder

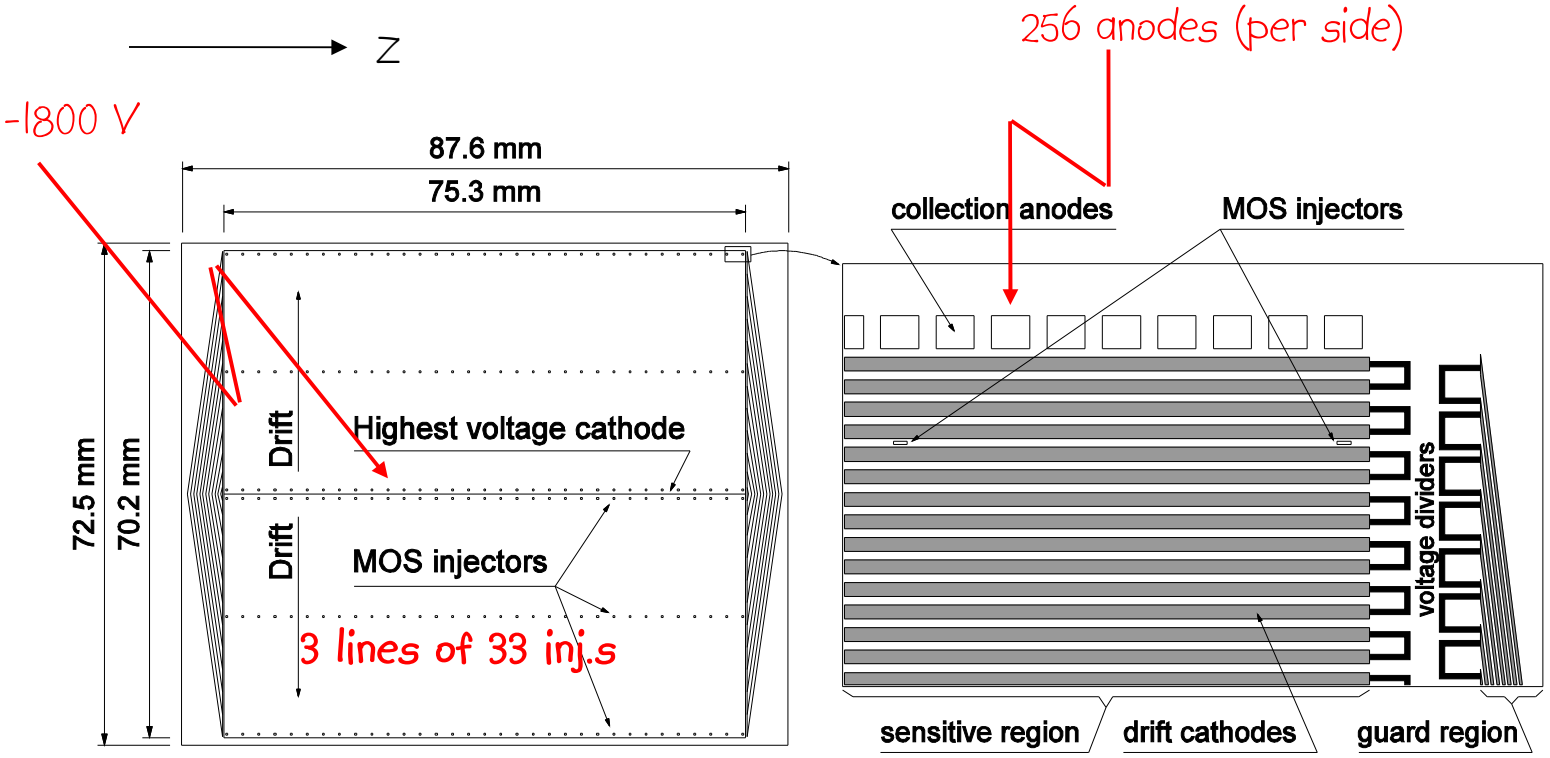
260 sensors in total

The Drift Sensor





The SDD Sensor in ALICE

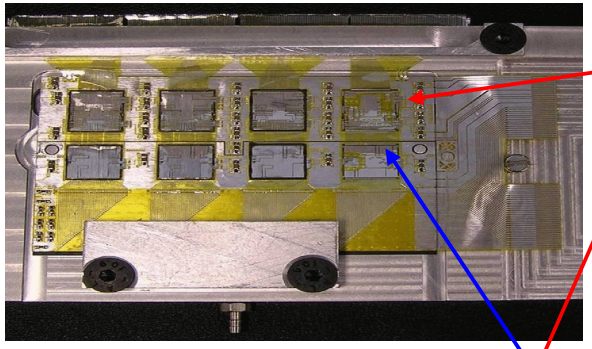


SDD Sensor Summary

Sensitive area	70.17 x 75.26 mm^2
Anode pitch	294 μm
HV (nominal)	-1800 V
Bias voltage (MV)	-40 V
Drift velocity	~ 6.5 μm/ns
Av. resolution (z) (*)	25 μm
Av. resolution (rφ) (*)	35 μm

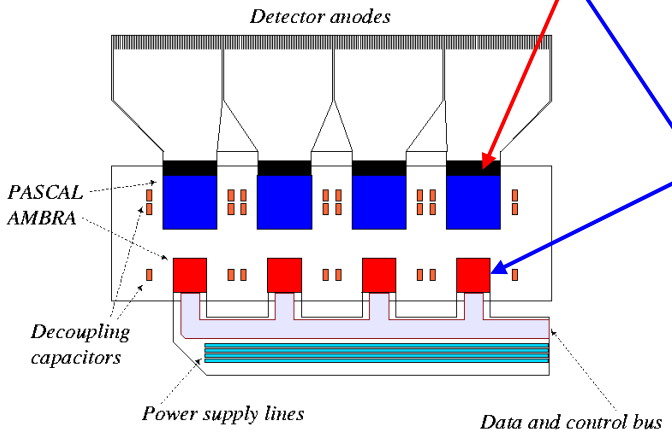
(*) from beam test

Front-end Electronics



PASCAL (Preamplifier, Analog Storage and Conversion from Analog to digital) (64 channels each)

- preamplifier
- analog storage
- ADC
- @ 20 or 40 MHz

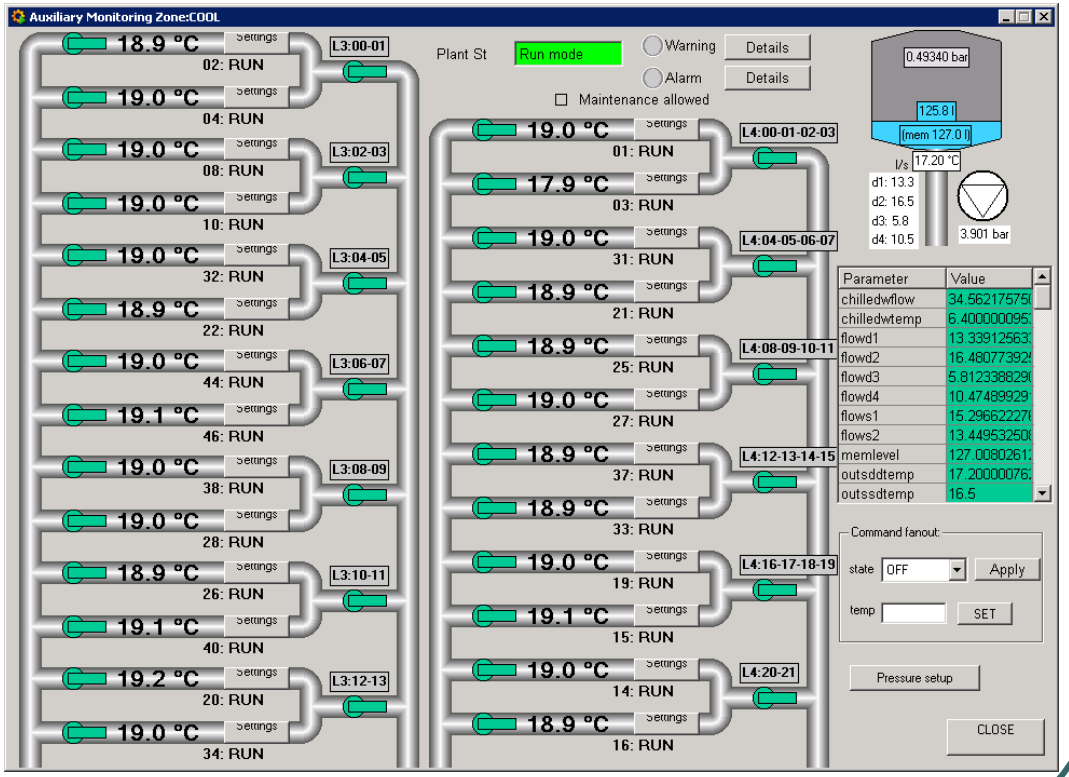


AMBRA (A Multievent Buffer Readout Architecture) (input from PASCAL)

- digital multibuffer
- anode-by-anode baseline equalization
- non-linear data compression (10 to 8 bits)

SDD cooling

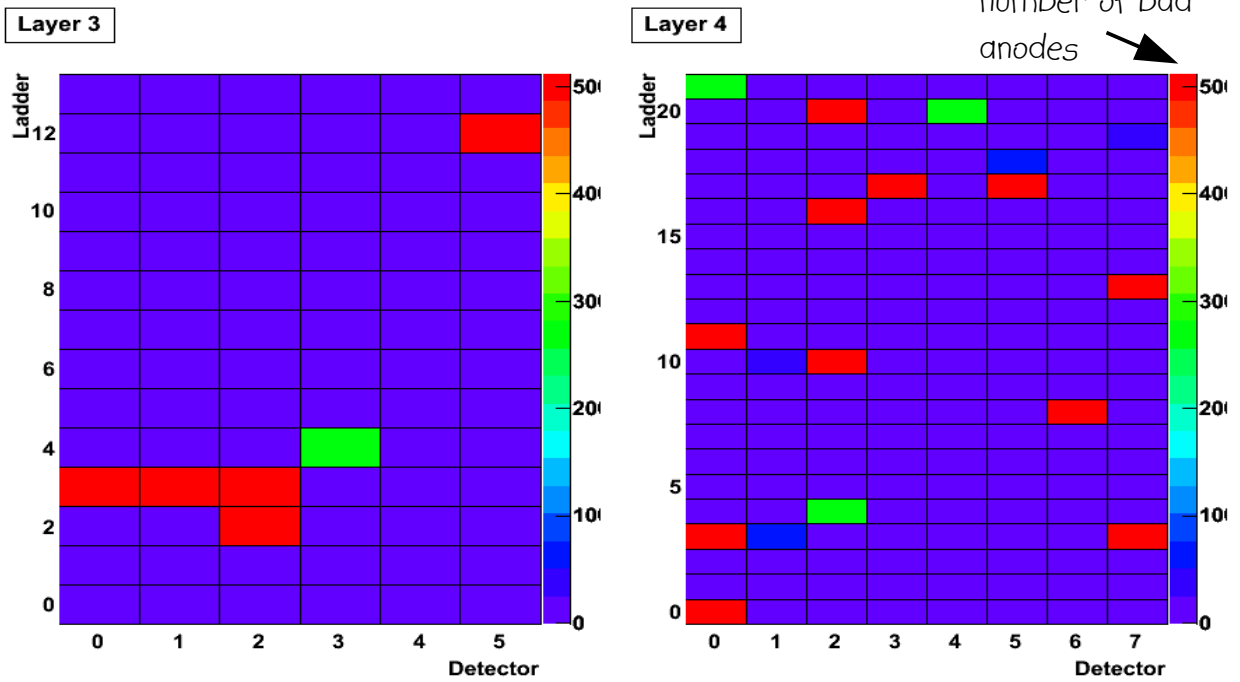
- Water cooled, inside pressure < 1 bar (leak safe) , flow in intermediate state between laminar and turbolent (maximum heat transfer)
- Controlled by dedicated PLC



Bad channels map

- During p-p data taking (end of 2009)
  - 16 modules (out of 260) out of DAQ due to FEE or HV problems
  - 4 modules with 1 hybrid disconnected (1/2 of channels dead)
  - ~ 92% of good channels

Colors represent number of bad anodes



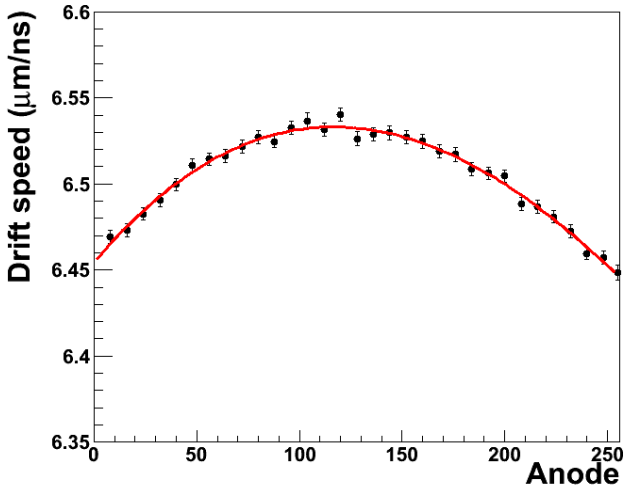
SDD Calibration

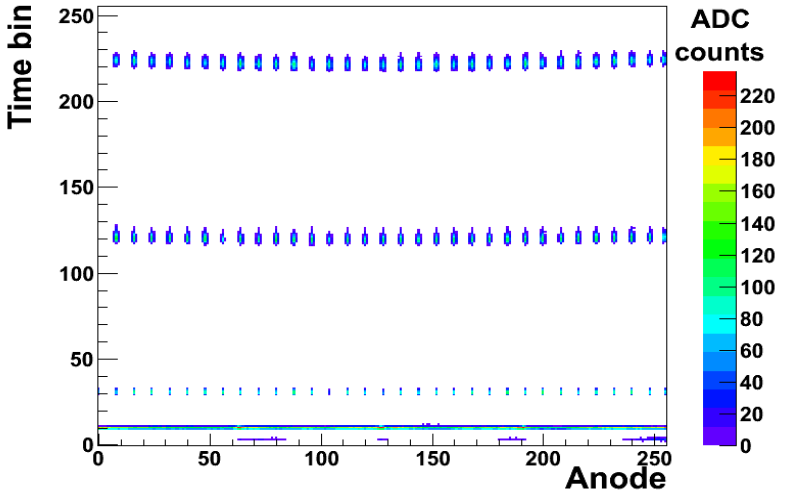
3 run types to extract calibration parameters

- PEDESTAL run
  - Analyzes special SDD calibration runs taken without zero suppression during LHC fill periods (every ≈24h)
  - Provides: **Baselines**, **Noise**, **Common Mode Corrected Noise**, **Noisy anodes**
- PULSER run
  - Analyzes special SDD calibration runs taken with Test Pulse signal to front-end electronics during LHC fill periods (every ≈24h)
  - Provides: **Anode gain**, **Dead anodes**
- INJECTOR run
  - Analyzes injector events collected with special runs every ≈ 6 hrs
  - Plan to improve by collecting injector triggers every ≈ 10 mins. during physics runs
  - Provides **Drift speed** (anode dependent)

Drift Speed Measurement

- 33 (1 each 8 anodes) x 3 MOS injectors on each half module
- Drift speed is extracted from a fit of the measured drift time vs. the known drift distance



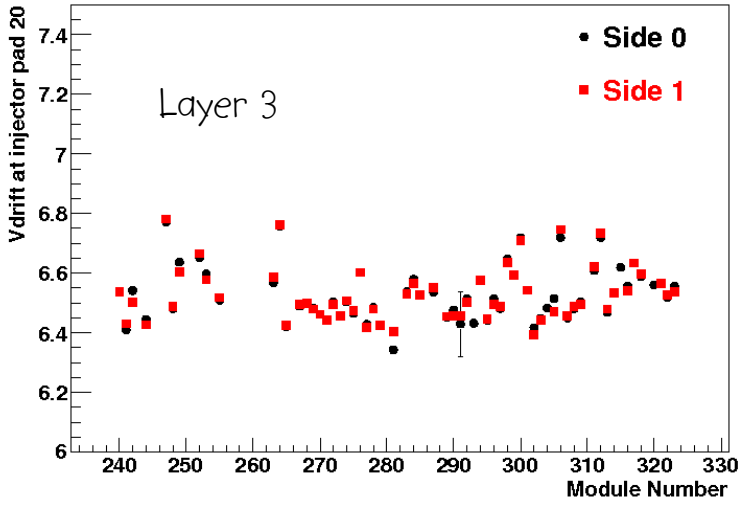


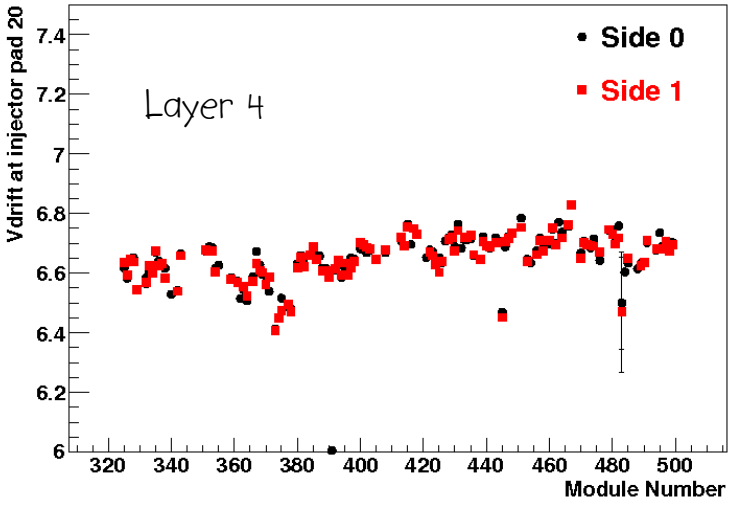
- Drift speed depends on anode number
  - ⇨ inversely proportional to temperature ($\propto T^{-2.4}$)
  - ⇨ heat sources (voltage dividers) located on module edges

Temperature vs. Module

- Drift speed depends on
  - Dopant concentration
  - Temperature

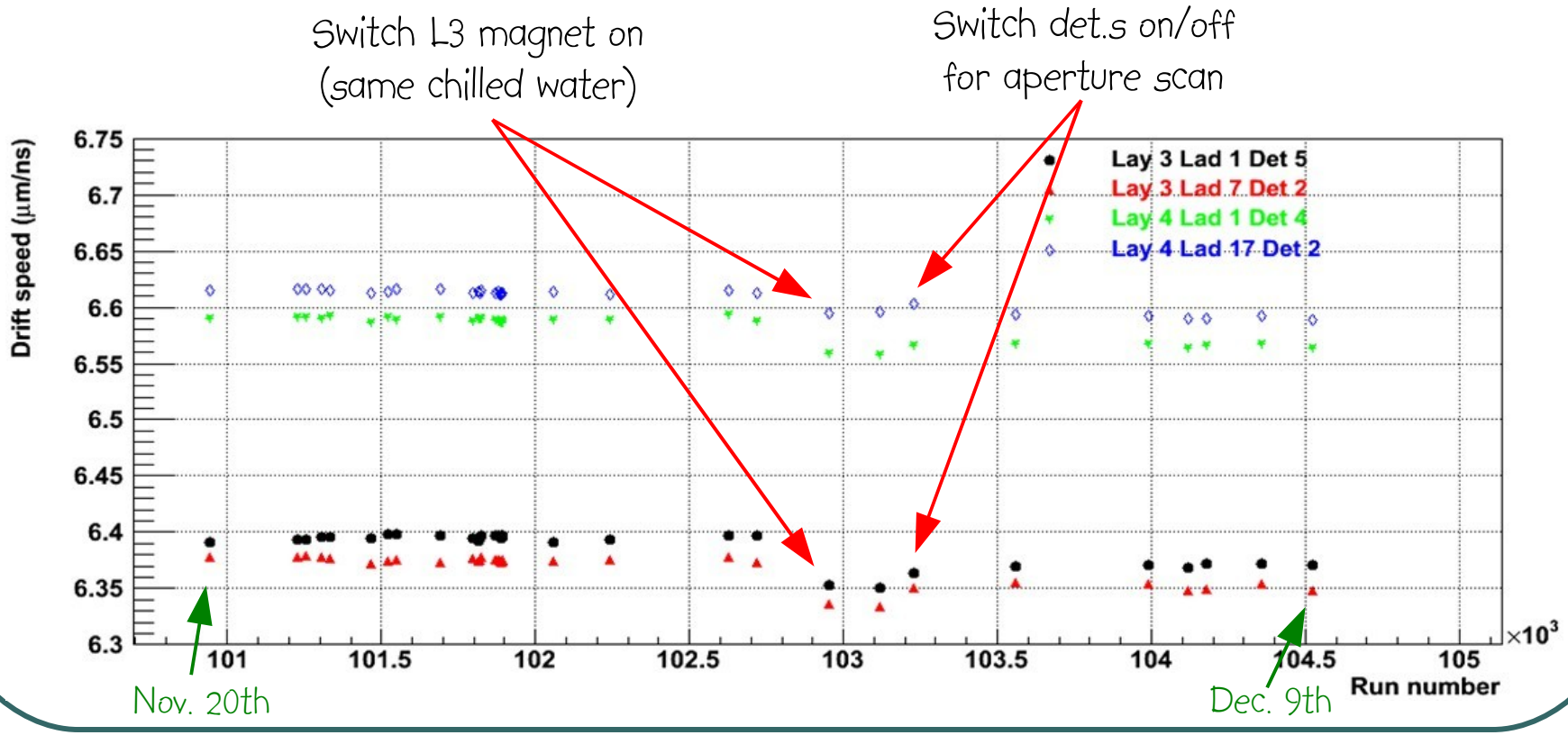
$$v_{drift} = \mu_e E \quad , \quad \mu_e \propto T(K)^{-2.4} \Rightarrow T(K) = 293.15 \cdot \left(\frac{v_{drift}/E}{\mu_e^{293K}} \right)^{-\frac{1}{2.4}}$$





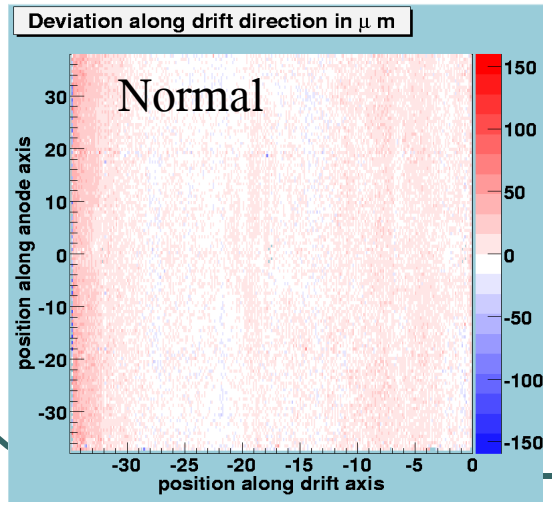
Drift Speed vs. Time

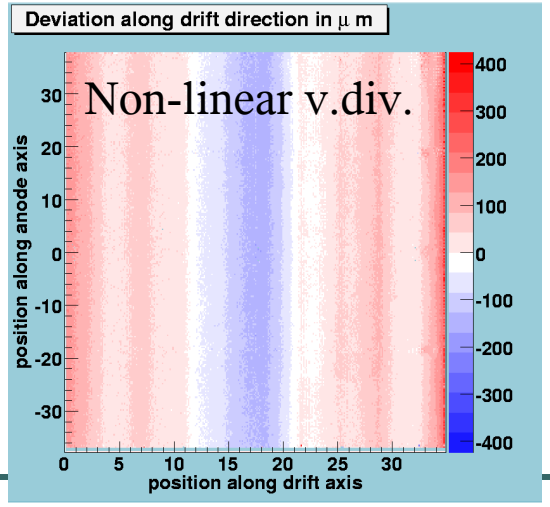
- Remarkable overall stability during p-p runs

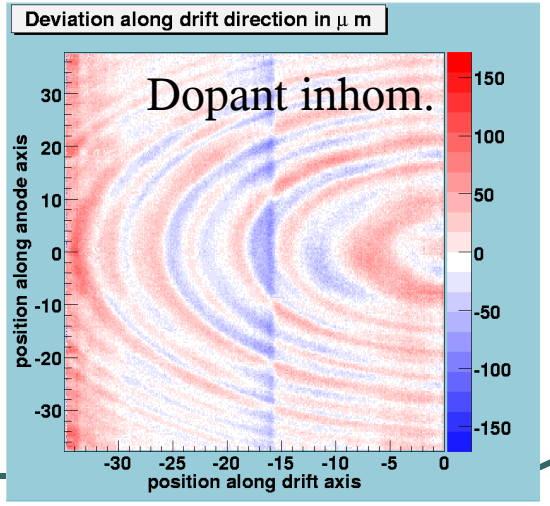


SDD Correction Maps

- All 260 modules fully characterized before assembling in ladders
  - charge injected in >100,000 positions using an infrared laser
  - for each laser shot, compute residual between reconstructed and original coordinate
  - maps of systematic deviations of drift coordinate (due to non-linear voltage divider or dopant concentration inhomogeneities) to be used to correct the time coordinate at reconstruction phase

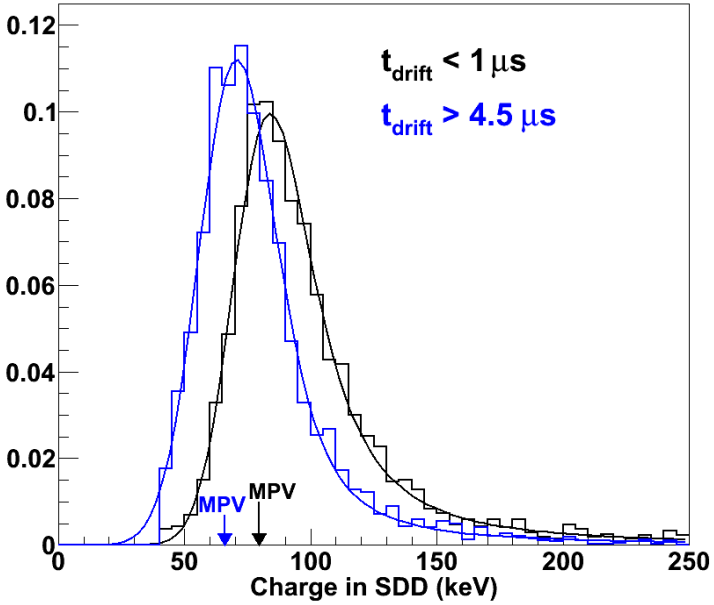






SDD Charge Calibration

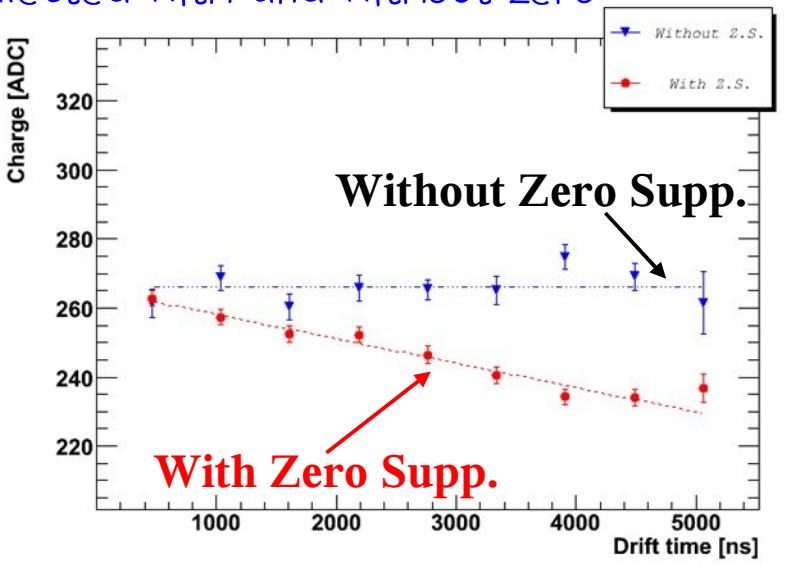
- Distribution of cluster charges from cosmic tracks, fitted with a Landau function
- Possibility to obtain with good precision the conversion factor ADC units to keV (most probable value for energy deposition of a MIP in 300 μm of silicon: 84 keV)



Charge vs. Drift Distance

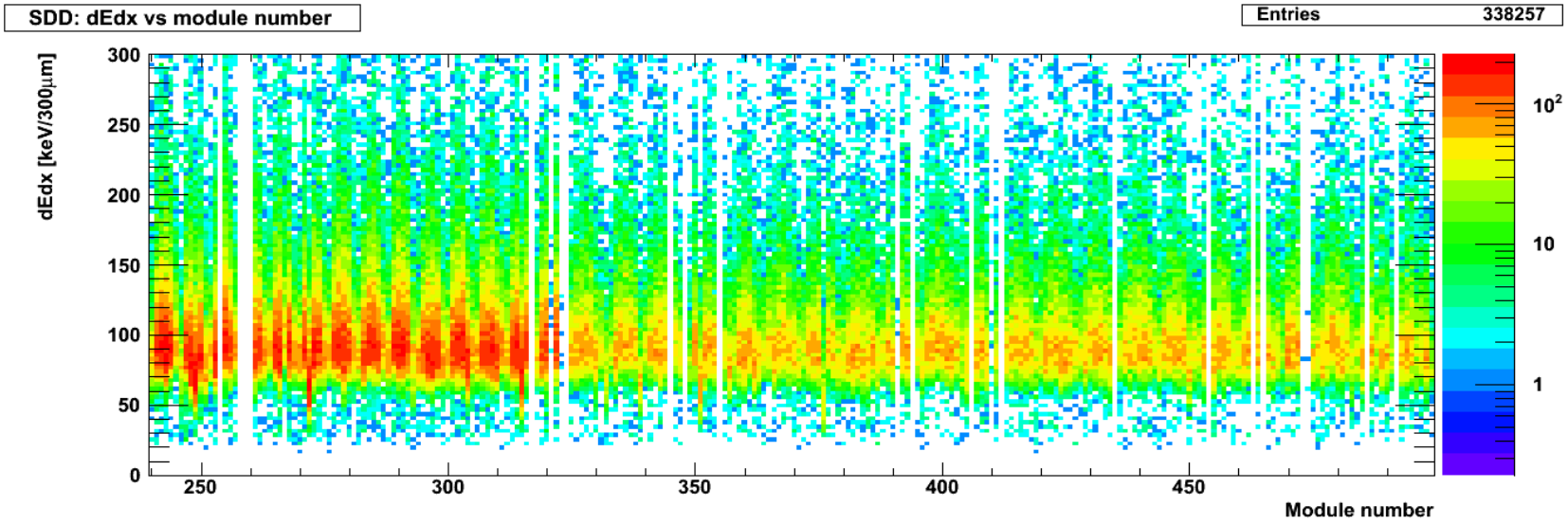
Cluster charge depends on drift distance

- larger drift distance ⟹ larger charge diffusion ⟹ wider cluster tails cut by the zero suppression
- quantitatively reproduced with MonteCarlo simulations
- crosschecked with cosmic muons collected with and without zero suppression with a test setup
- can be corrected at reconstruction phase



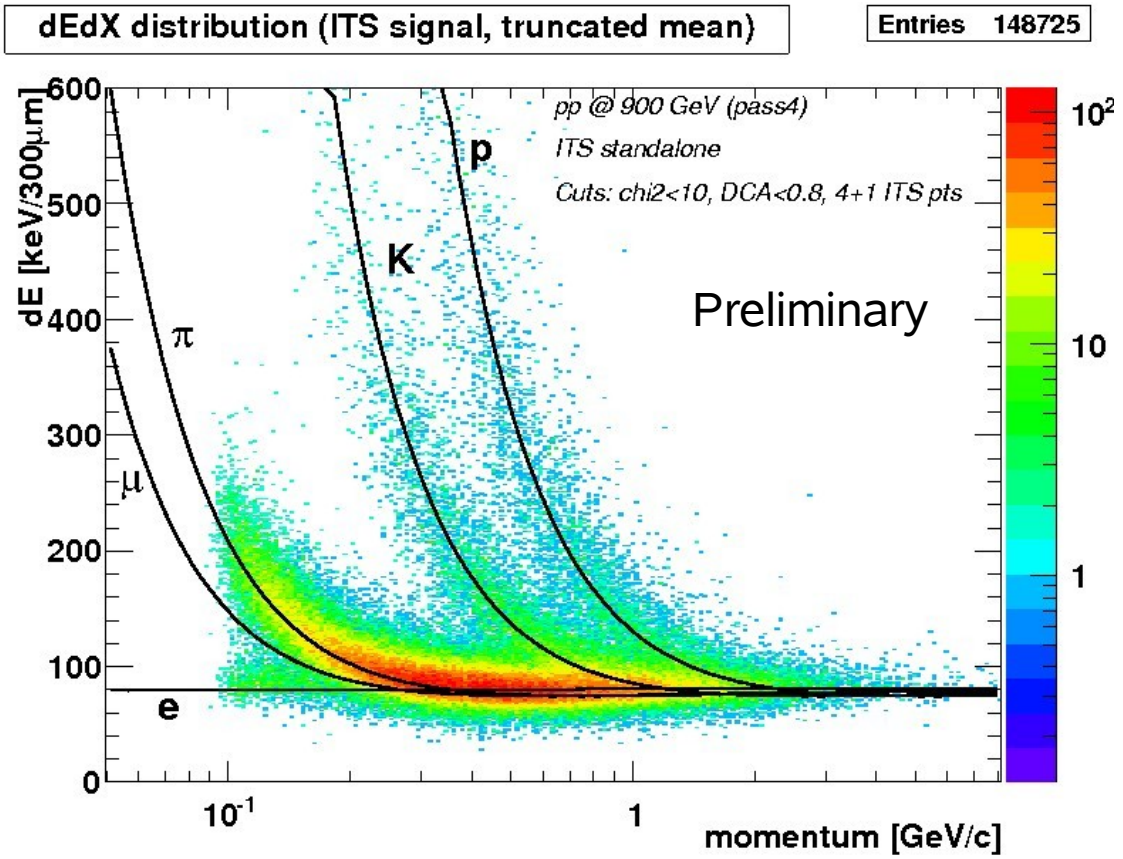
SDD dE/dx

- For more than 85% of the modules, the dE/dx distributions have the MPV within 5% from the expected value of 84 keV
  - Charge Collection Efficiency completely under control
  - Special correction needed only for 15 modules with lower CCE, all of them traced-back to hardware problems (applied voltages, silicon purity)

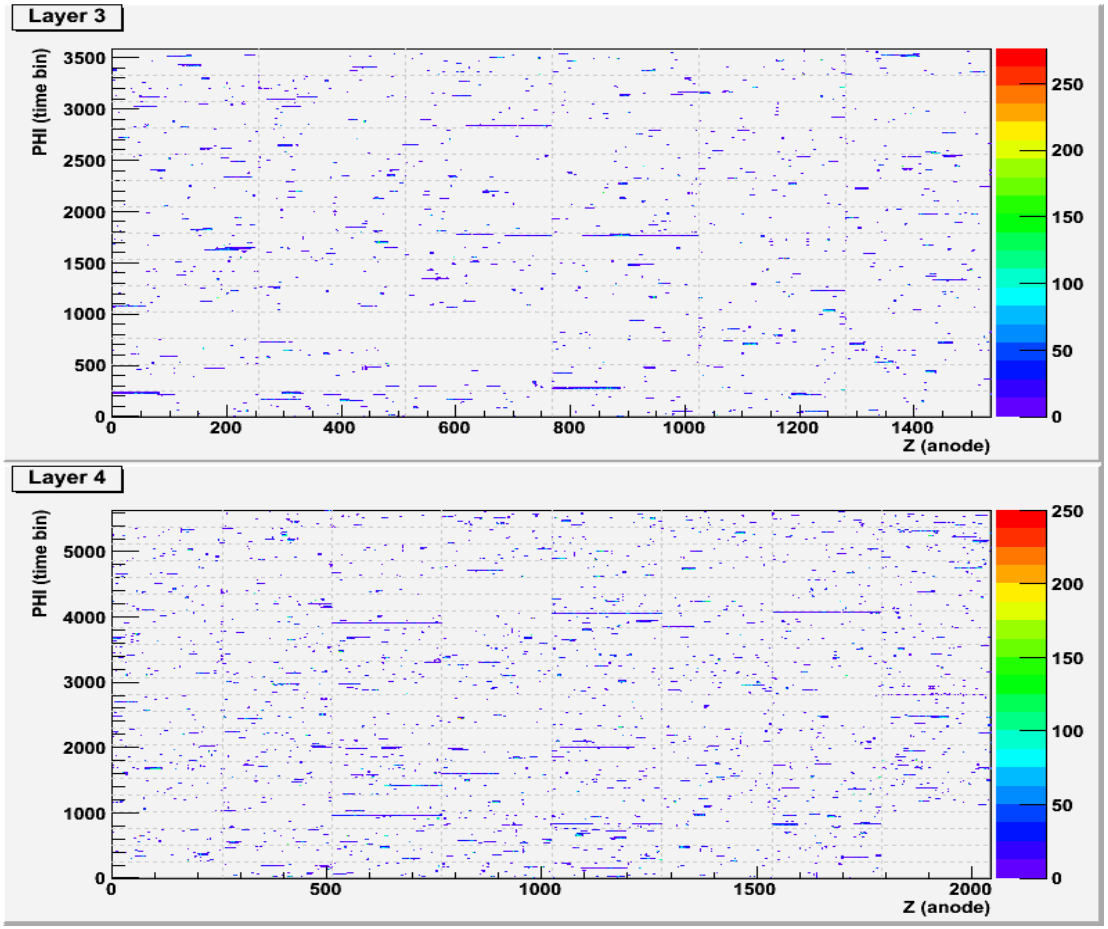


ITS dE/dx

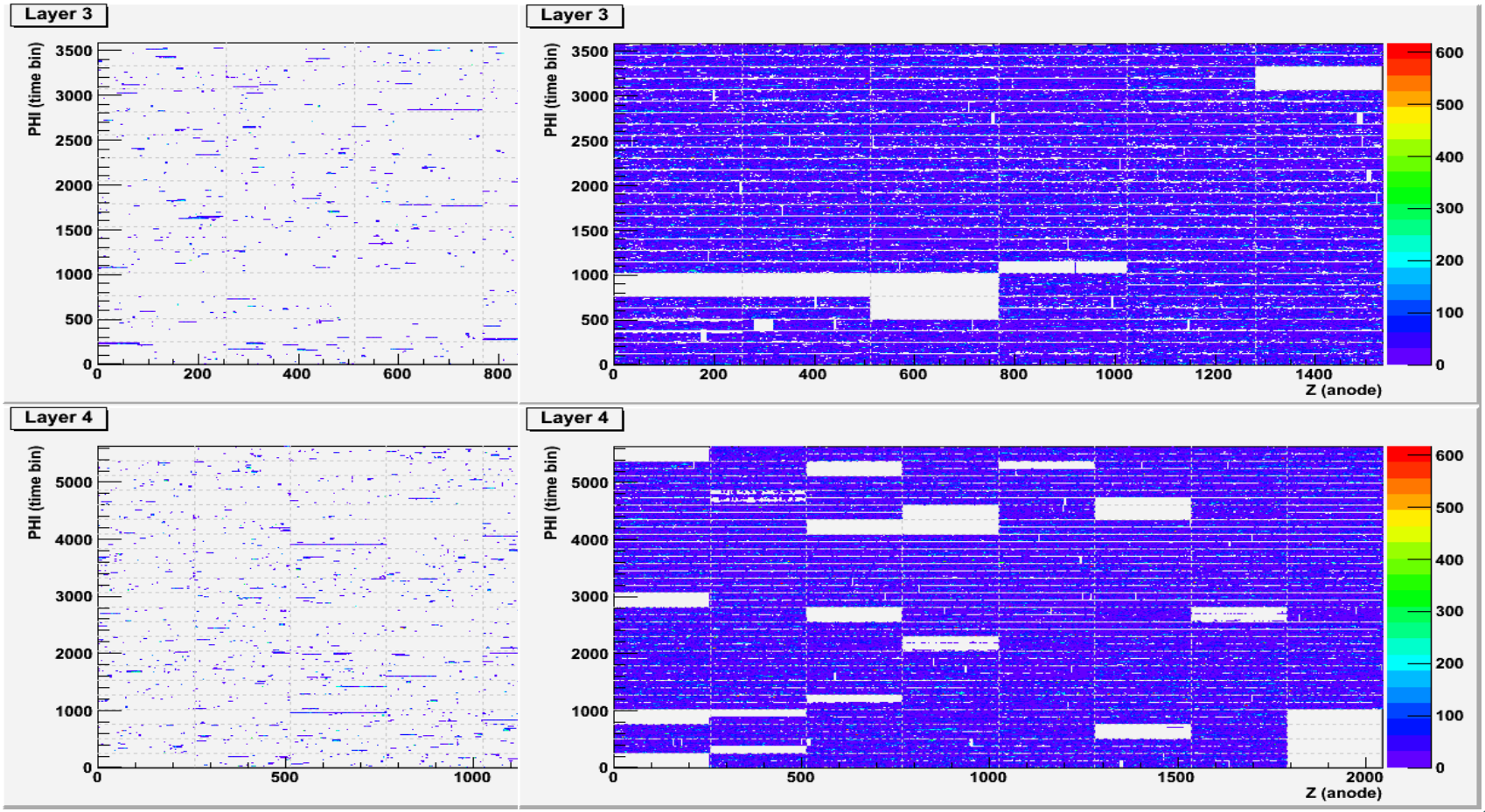
- Truncated mean from SDD+SSD dE/dx vs. track momentum



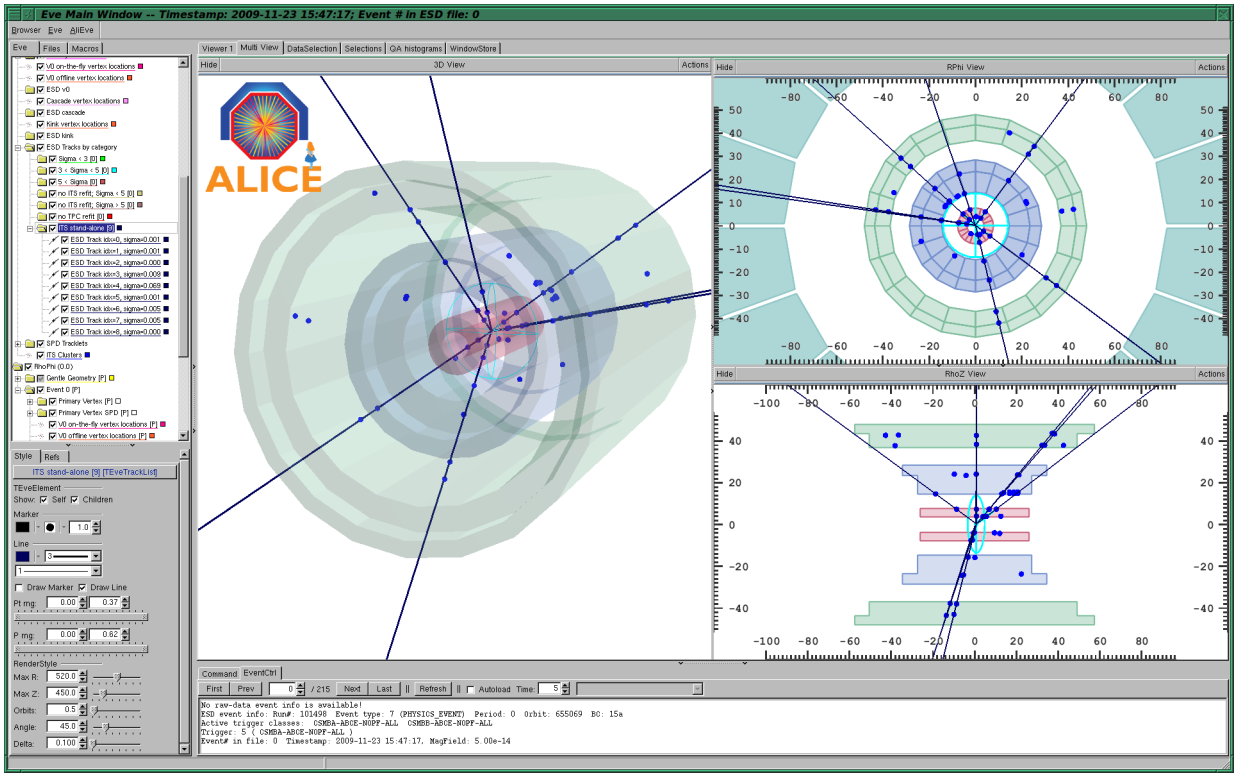
SDD data taking during injection tests



SDD data taking during injection tests



SDD data taking during *pp* collisions

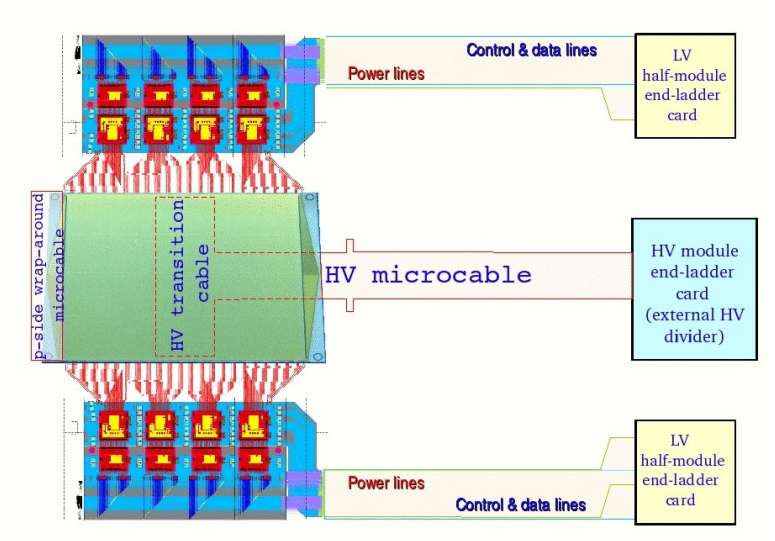


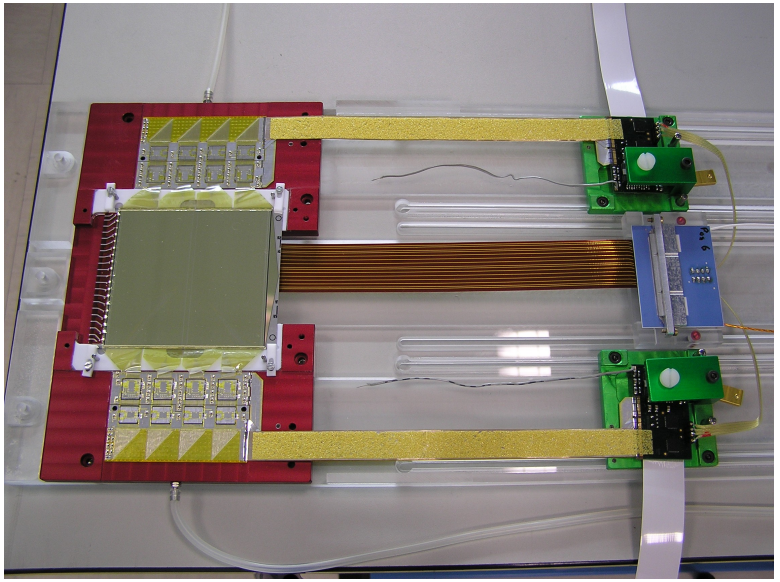
Summary

- 94% of SDD modules were in acquisition in 2009
- Data from cosmic events were collected to debug and monitor the system
- Frequent calibration runs were performed to proper measure of noise, gain and drift speed
  - stability of all monitored parameters (drift speed in particular)
  - charge calibration and efficiency as expected
  - detector behaviour well understood and under control
- SDD were in acquisition since very first LHC collisions, and are ready for the forthcoming long data taking period

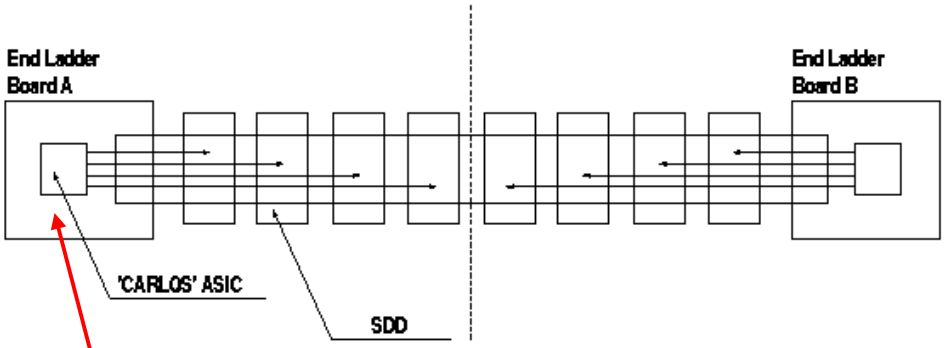
Backup

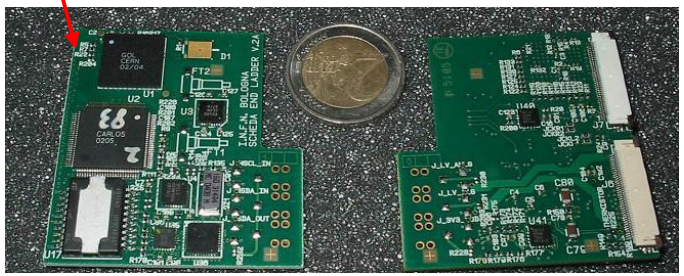
SDD Module Readout





End-ladder electronics



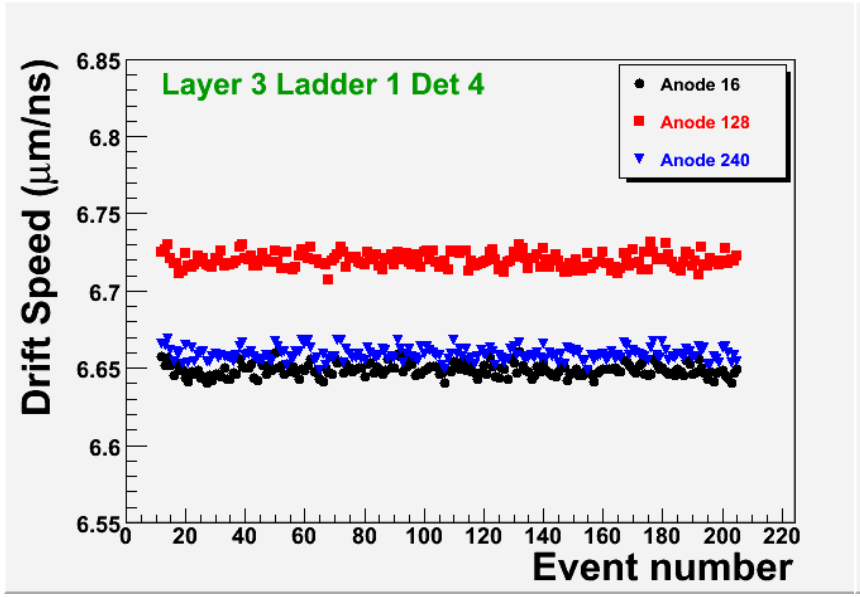


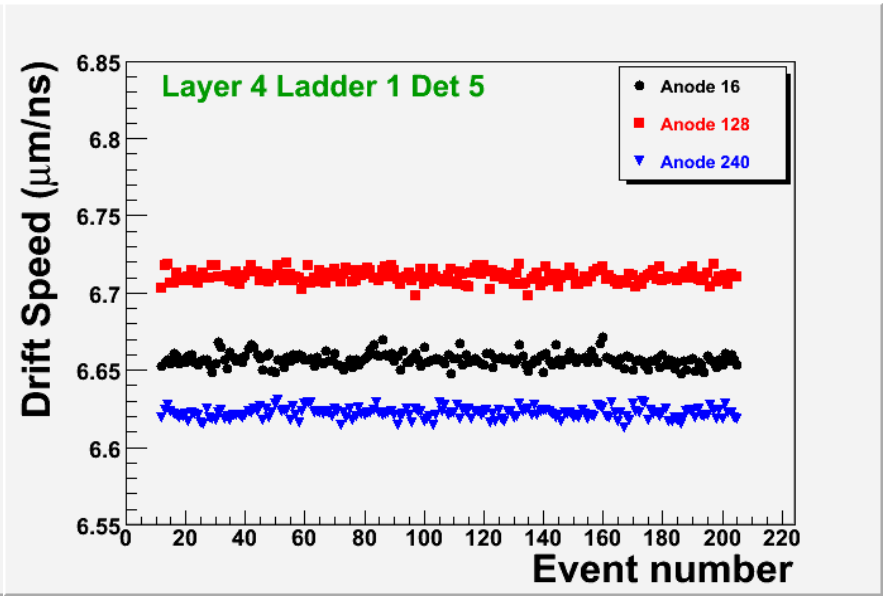
CARLOS (Compression And Run Length encOding Subsystem)

- 8 inputs fed in parallel by AMBRAs
- 1 CARLOS per SDD module
- 2D 2-threshold compression
- format data and feed the DAQ R/O

Drift Speed stability

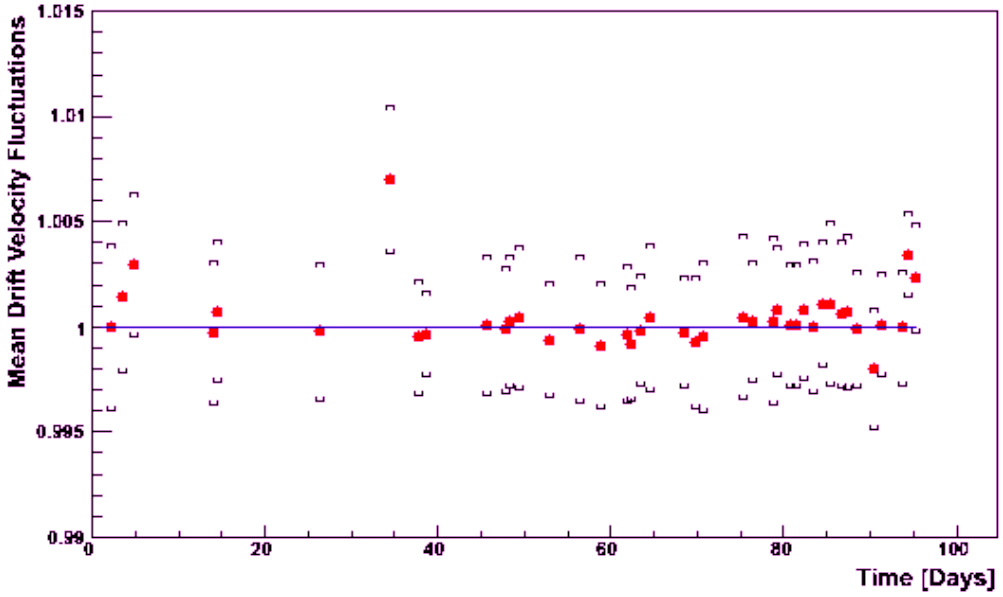
- Drift speed constant on a time scale of 1 hour of data taking
  - about 5 triggers/minute, 200 analyzed events from a raw data file



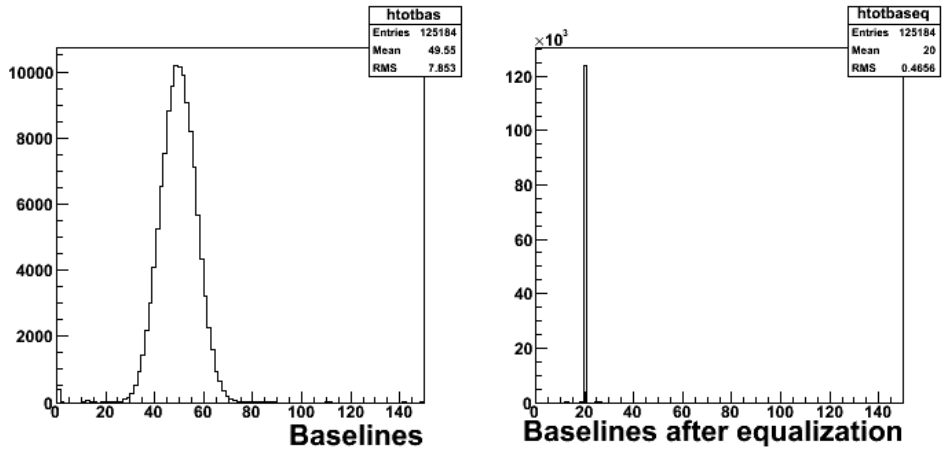


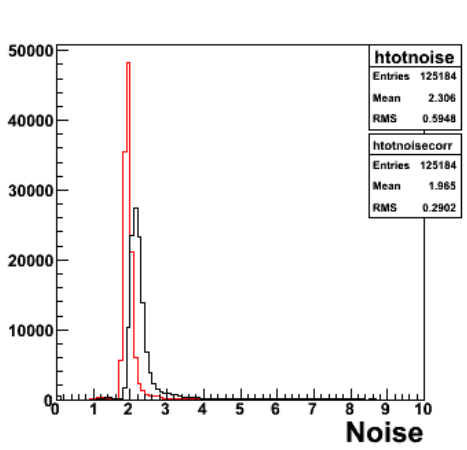
Drift Speed vs. Time

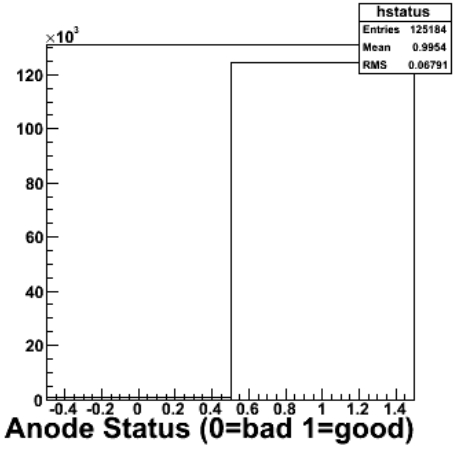
Layer 3, Ladder 6, Mod 275, Anode 200

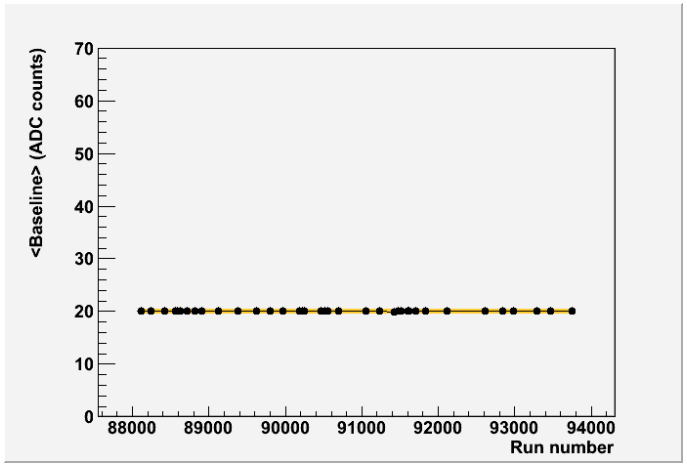


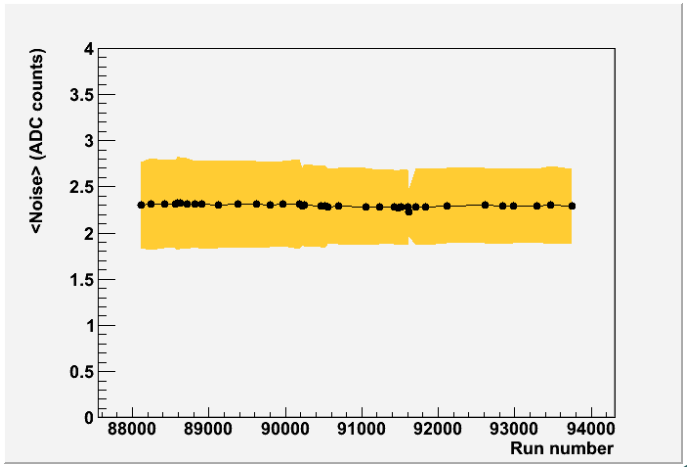
Pedestal Run



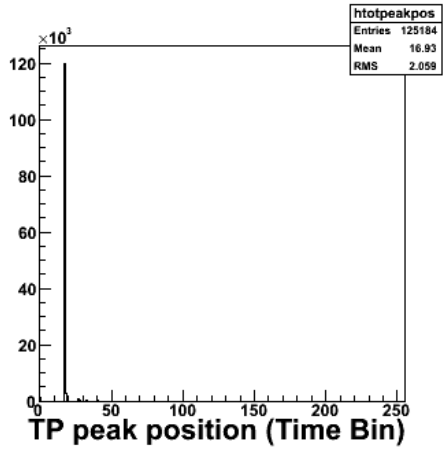


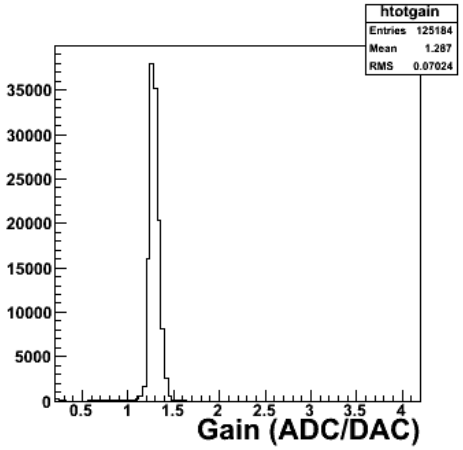


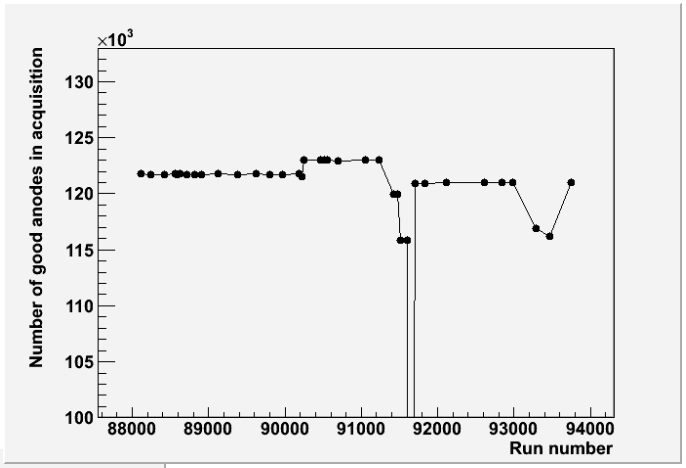


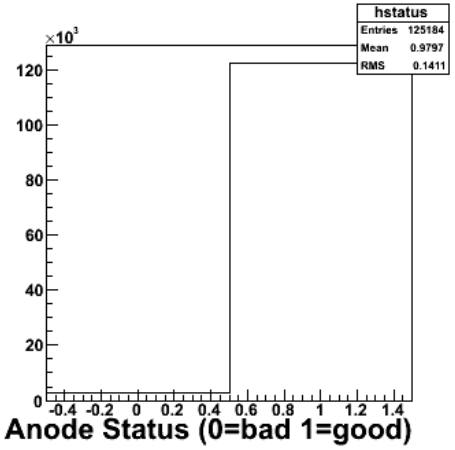


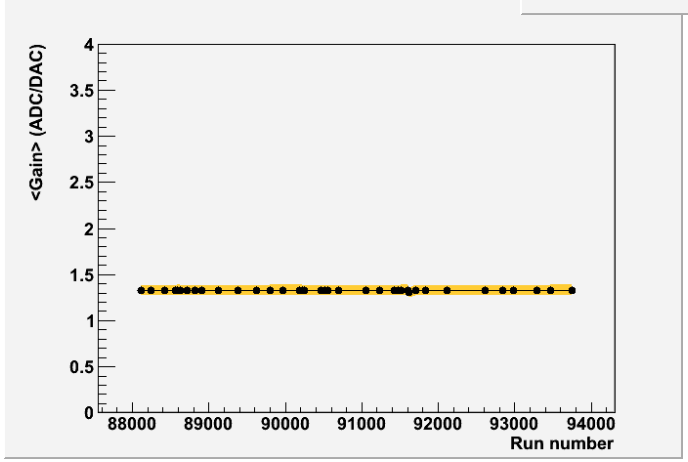
Pulser Run


htotpeakpos
Entries 125184
Mean 16.93
RMS 2.059
TP peak position (Time Bin)


htotgain
Entries 125184
Mean 1.287
RMS 0.07024
Gain (ADC/DAC)


Number of good anodes in acquisition
Run number


hstatus
Entries 125184
Mean 0.9797
RMS 0.1411
Anode Status (0=bad 1=good)


<Gain> (ADC/DAC)
Run number