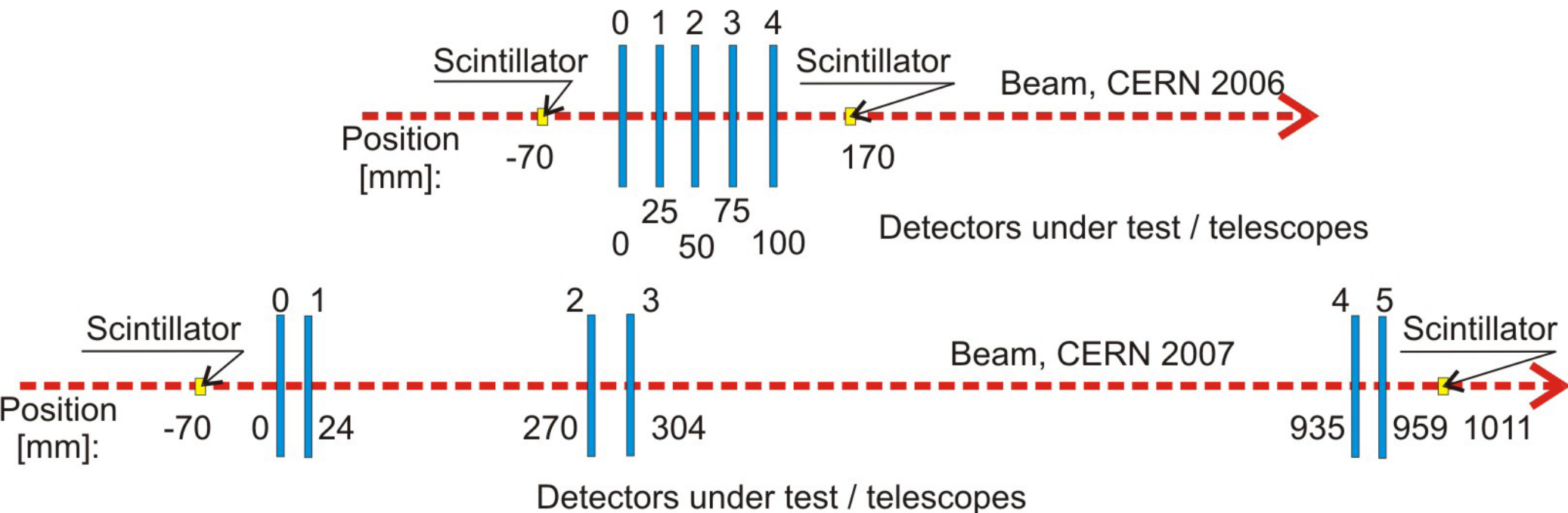# DEPFET Beam Tests

DEPFET Testing Methods

1st Open Meeting of the SuperKEKB Collaboration (December 10-12, KEK, Japan)

Peter Kodyš for the DEPFET collaboration

Beam Tests 2005-2007

DESY: three beam tests with 2-6GeV e⁻ , tuning of readout, gain studies, multiple scattering too high for detailed resolution studies, so solution was to go to CERN high energy beam tests.
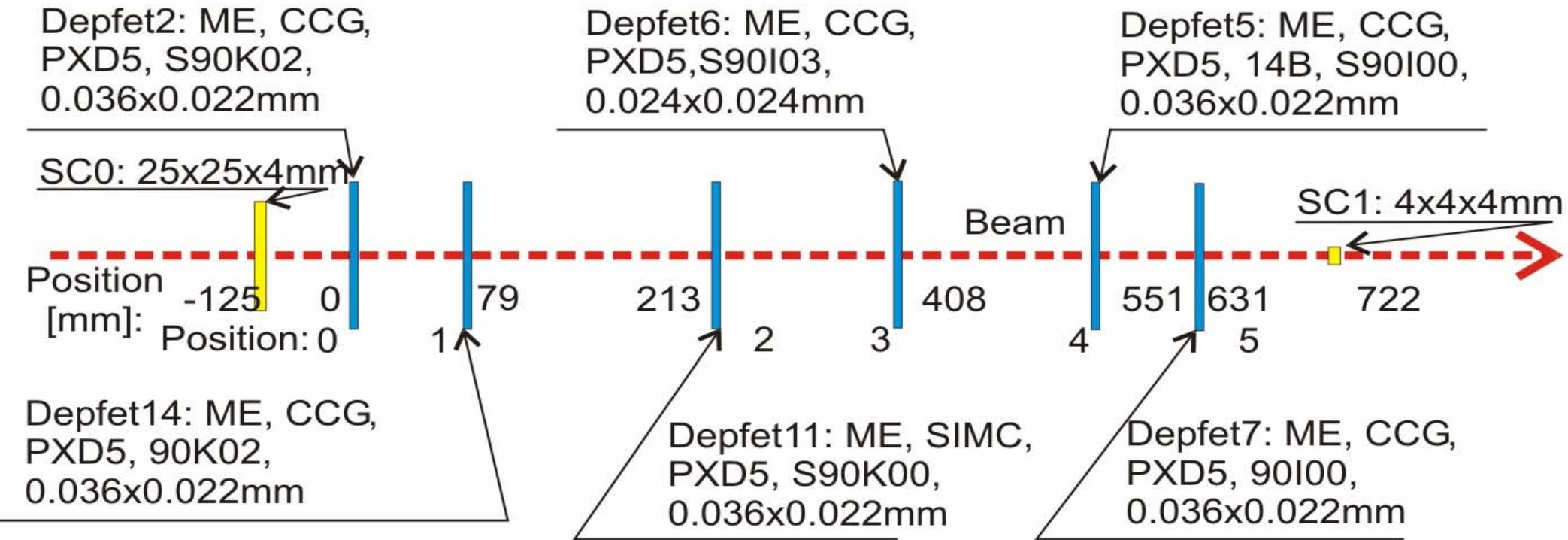
Two beam tests at CERN SPS (2006,2007) with 180 GeV π^+ and 4-5 detectors.

Geometries of the CERN DEPFET beam tests in 2006 (top) and 2007 (bottom).

Beam Tests 2008

Two beam tests at CERN PS(p 6 GeV)+SPS (π^+ 120 GeV) with 6 detectors.

Depfet2: ME, CCG,
PXD5, S90K02,
0.036x0.022mm

SC0: 25x25x4mm

Depfet6: ME, CCG,
PXD5,S90I03,
0.024x0.024mm

Depfet5: ME, CCG,
PXD5, 14B, S90I00,
0.036x0.022mm

SC1: 4x4x4mm

Beam

Position [mm]:   -125   0   79   213   408   551 631   722
Position: 0   1   2   3   4   5

Depfet14: ME, CCG,
PXD5, 90K02,
0.036x0.022mm

Depfet11: ME, SIMC,
PXD5, S90K00,
0.036x0.022mm

Depfet7: ME, CCG,
PXD5, 90I00,
0.036x0.022mm

Geometry of the CERN DEPFET beam tests in 2008 SPS

Beam Tests 2008 CERN SPS

Pre-test beam:

- Characterization of module and prediction of properties for TB

Basic analysis:

- Data preprocessing, alignment
- Evaluation of module resolution
- Evaluated scans:
  - High statistics scan (stability of properties)
  - Edge scan (edge effects)
  - Bias scan
  - Energy scan
  - Angle scan
- More than 20 million acquired events
- More than 15% of events contain "good" track over 6 modules
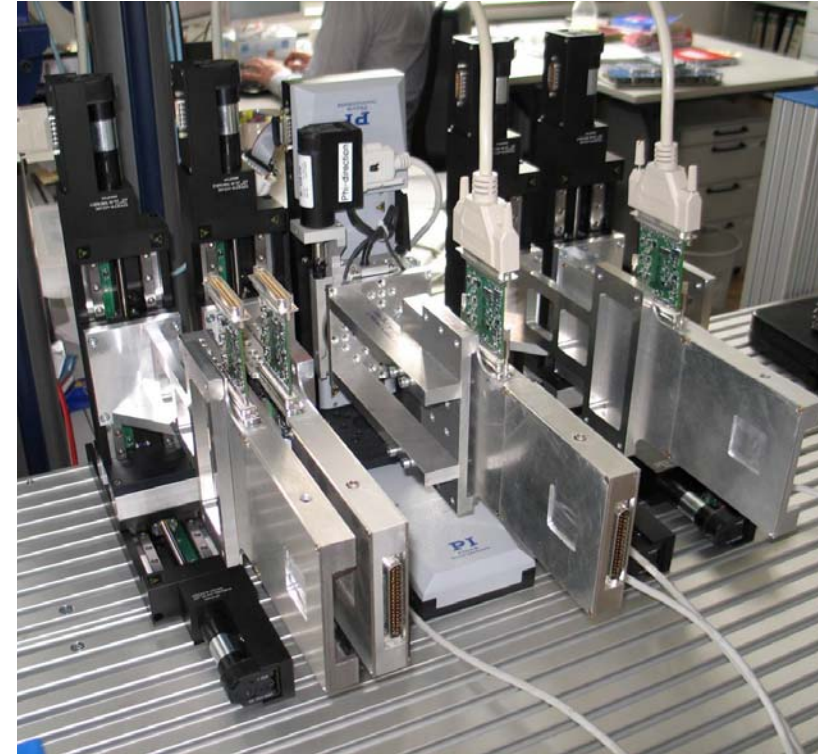
Very successful beam test, best spatial resolution for 24x24μm pixels better than 1 μm
Analysis in progress.

Beam Tests 2008 CERN SPS

Test Beam 2008 Data [in kEvents]
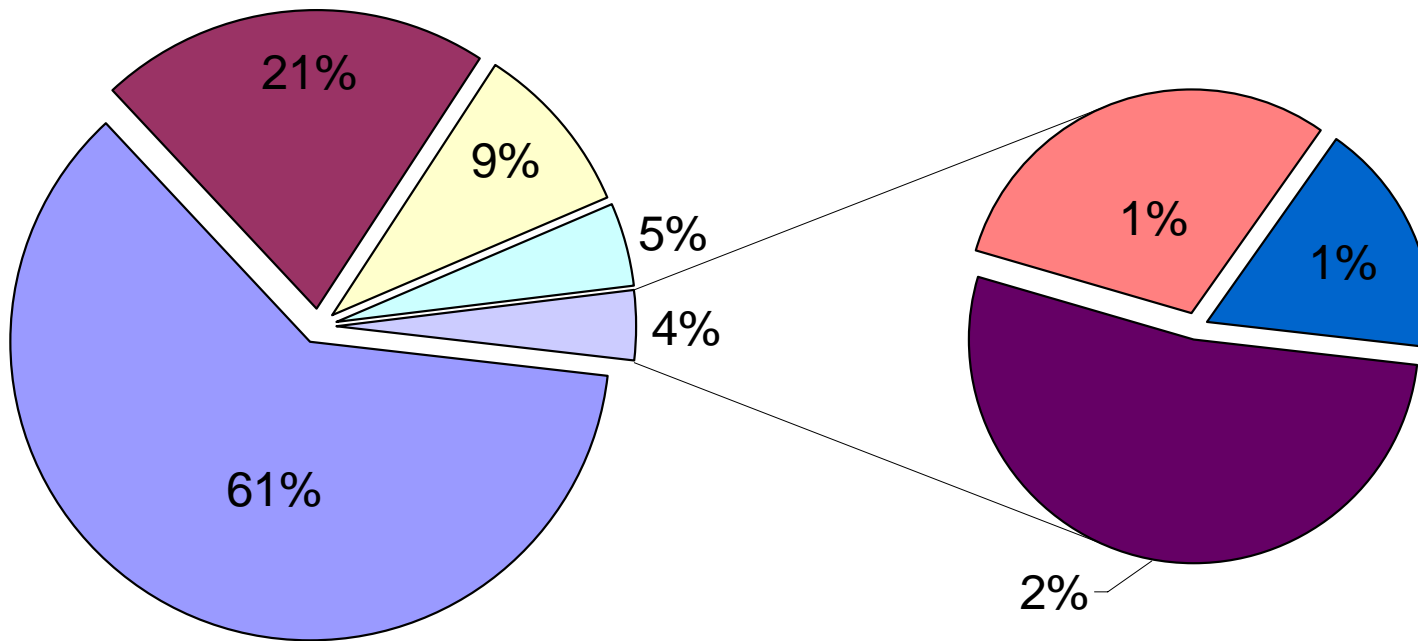
High Statistics	11941
Angular Scans	4134
CCCG scan	1815
Backplane scan	909
Rest	389
Energy Scan	222
V_Edge scan	128

in kEvts

**Legend:** ■ High Statistics ■ Angular Scans □ CCCG scan ☐ Backplane scan ■ Rest ■ Energy Scan ■ V_Edge scan

High Statistics: 12 million events for in-pixel studies
Mostly taken over night

Capacitative Coupled Clear Gate: 1.8 Million events
Clear High, Clear Low, Clear Gate studies
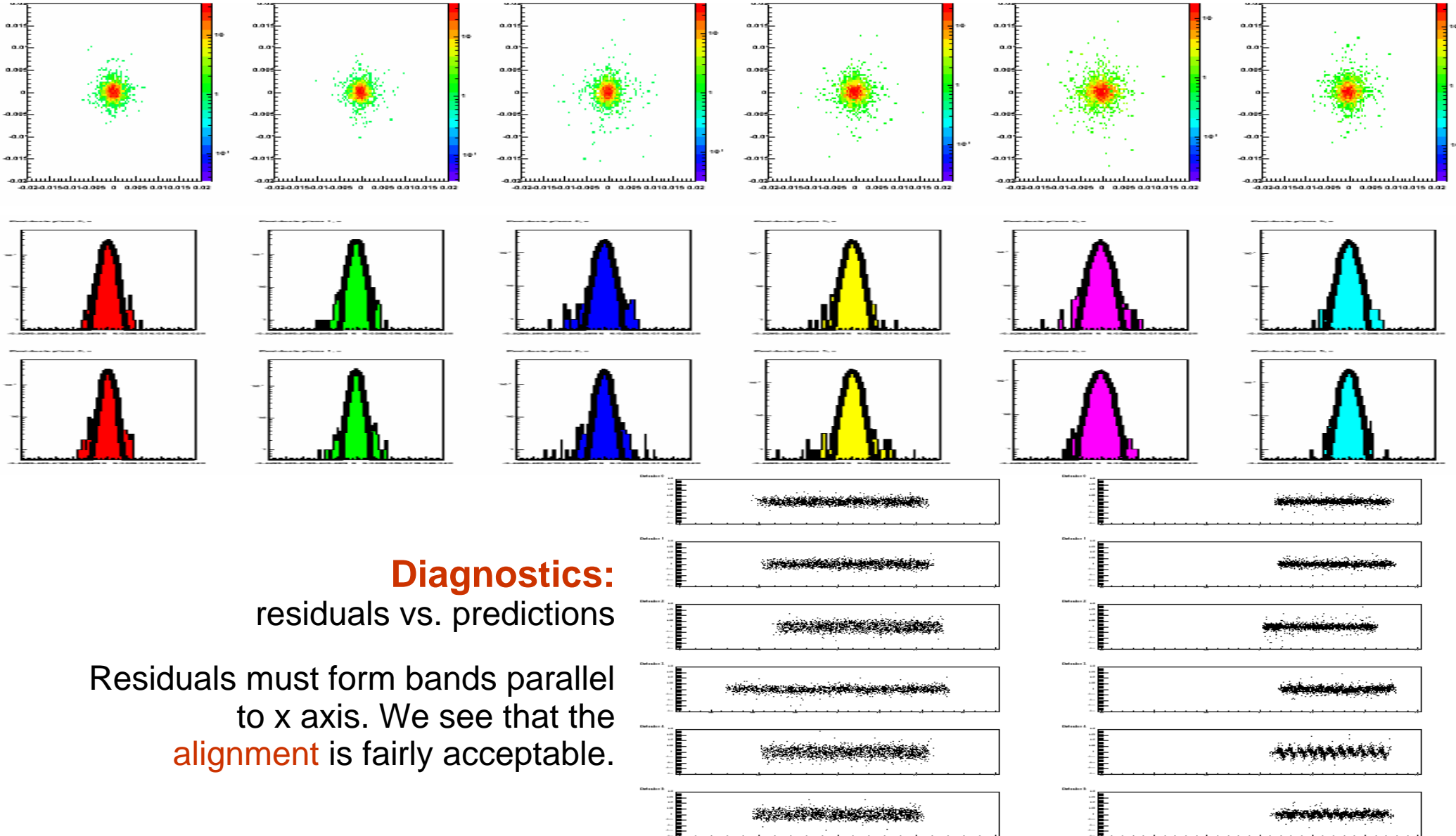
Beam Tests – Integration

TB CERN 2008 SPS H6: Successful integration of DEPFET to EUDET telescope system!
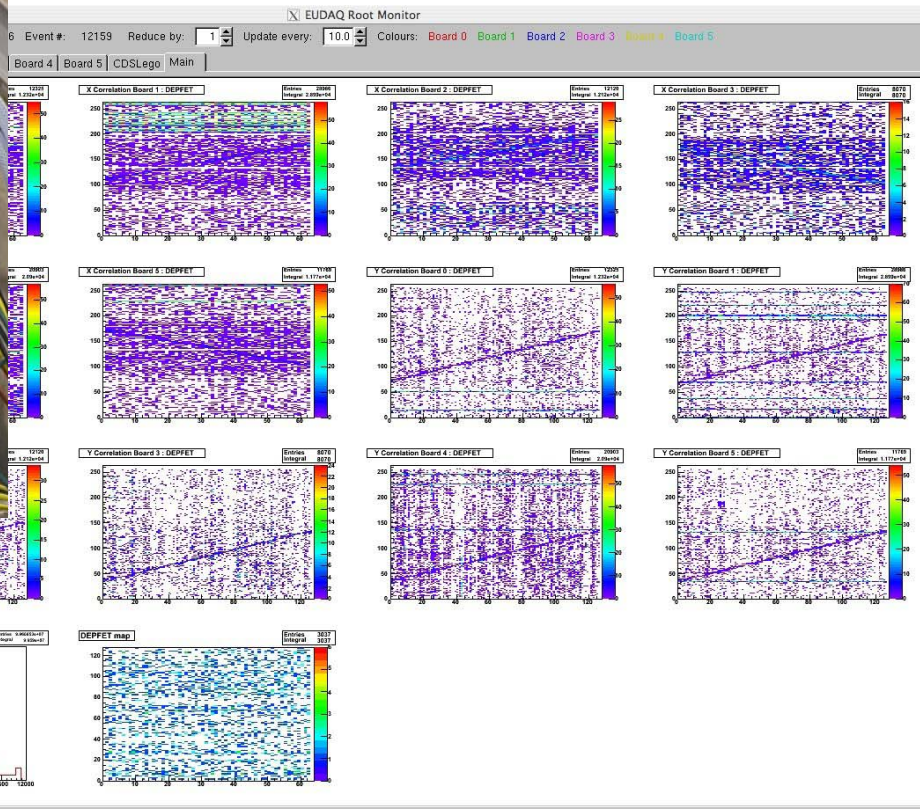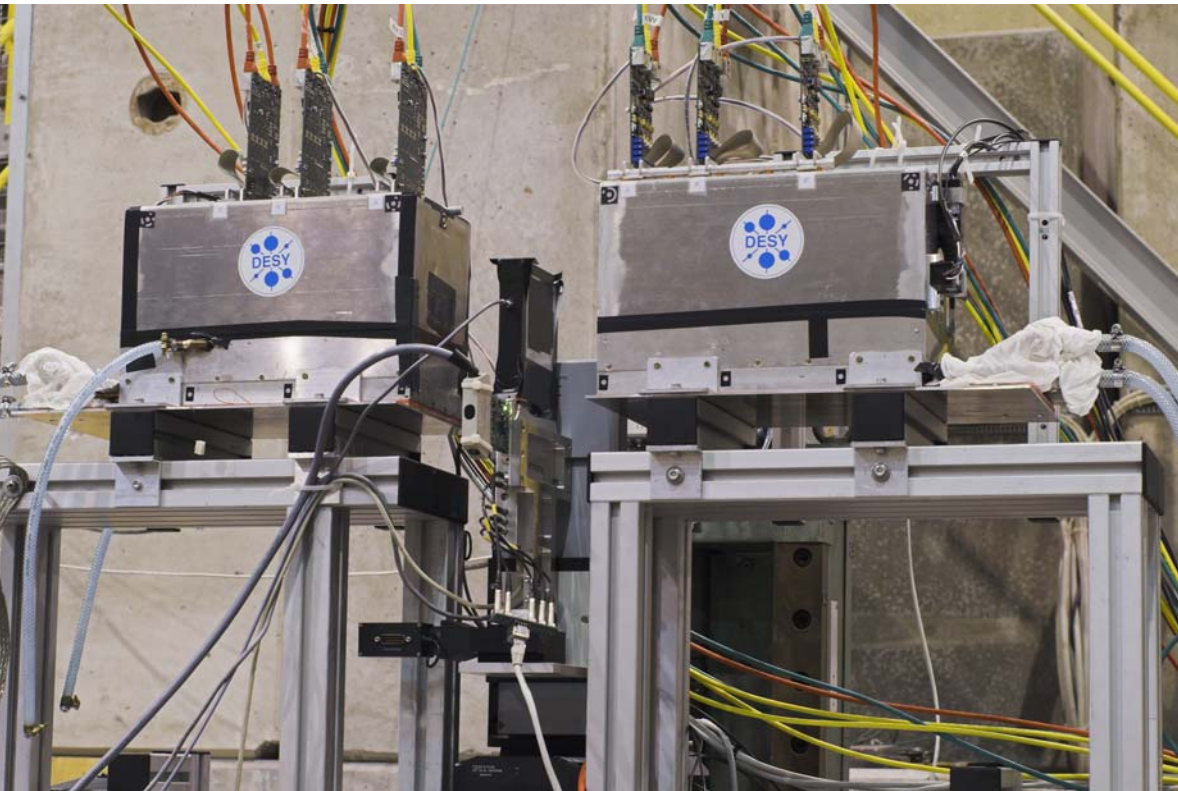
Correlation plots
DEPFET+EUDET telescopes

Beam Tests - Analysis

Residual final plot including **multiple scattering**, **track fitting error** and **detector resolution**
2D and 1D plots for all modules show **very good uniformity**

Diagnostics:
residuals vs. predictions

Residuals must form bands parallel to x axis. We see that the **alignment** is fairly acceptable.

DEPFET Laser Test

1. Laser tests were performed using a red 680 nm (~4μm thickness of charge creation), infra red 900 nm (~150μm) and 1055nm (~4μm) semiconductor laser with calibrated beam power control system.

2. High statistics scans of 20 x 20 points on a grid of 2.5 μm for a wide range of laser beam powers.

3. Each point was probed by 50 pulses to eliminate laser noise and to obtain precise pixel response.

4. Laser power was controlled, monitored and calibrated to energies generating the same charge per laser pulse as a typical particle in a beam test.

5. Tests are performed in many sites: Uni Bonn, MPI Munich, CU Prague, IFIC Valencia, …

December 10, 2008, KEK SuperKEKB

Cluster size in few pixels area
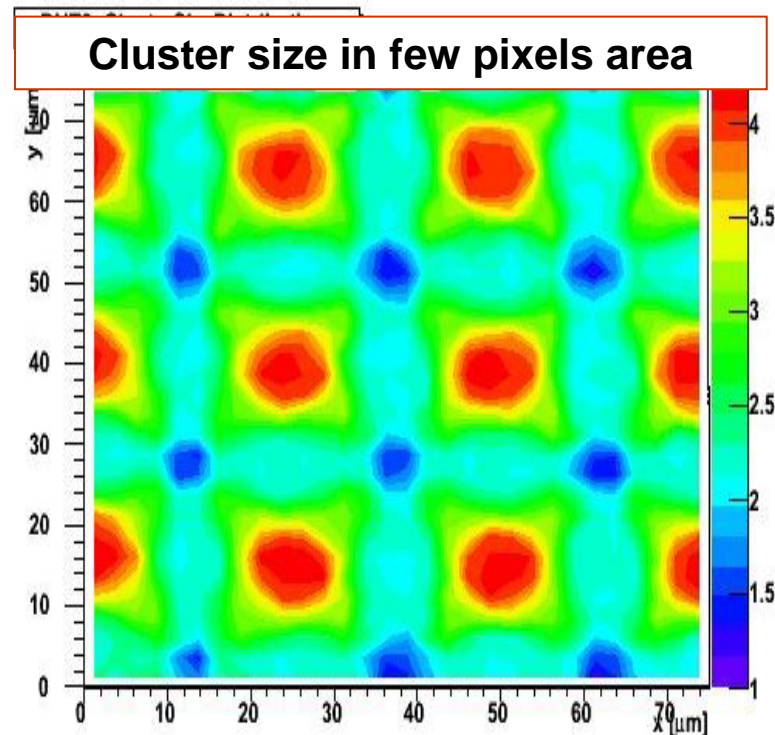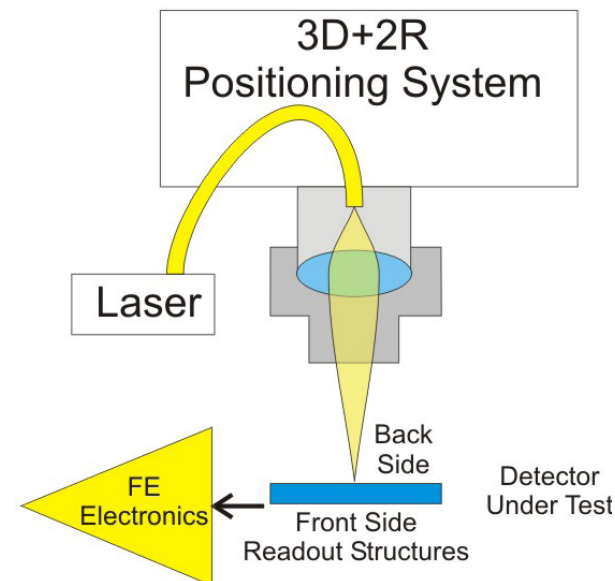
DEPFET Source Tests – Tool For Characterization

$\gamma-$ source ^{133}Ba 30.973 keV -> 8439 e-h pairs, 361 ADU MPV

TB 2008 CERN SPS: 120 GeV π^+ 35700 e-h pairs: 1620 ADU MPV of cluster charge

Lab: 23.3e$^-$/ADU   vs. Beam Test: 24.5e$^-$/ADU
We can conclude it is in good agreement
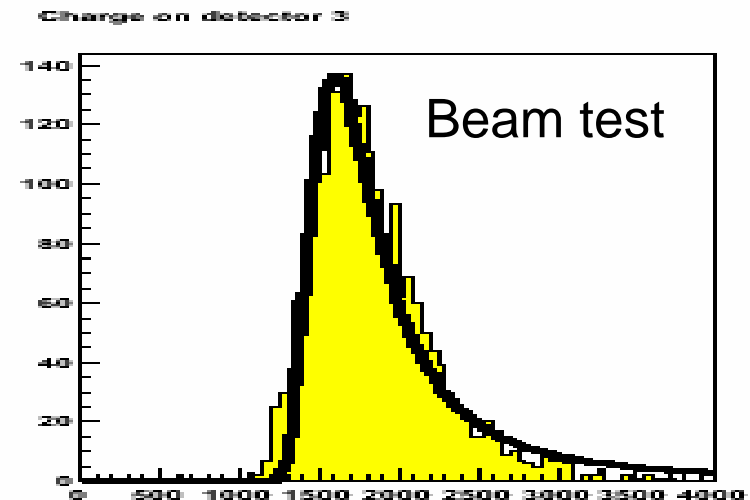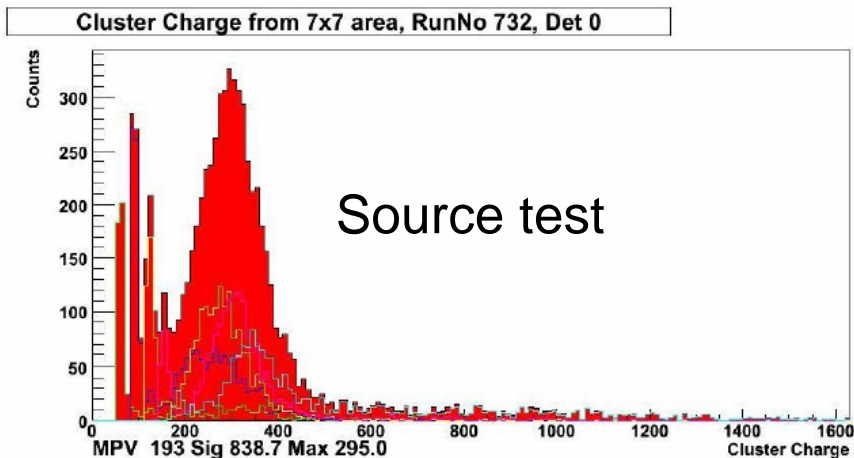

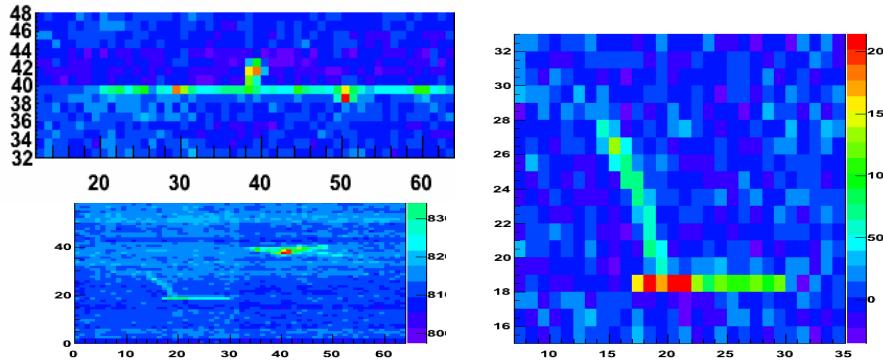Figure 6: Example of Ba spectrum using for measurement of G_q

Tests backed up with simulations

Test beam

Simulation

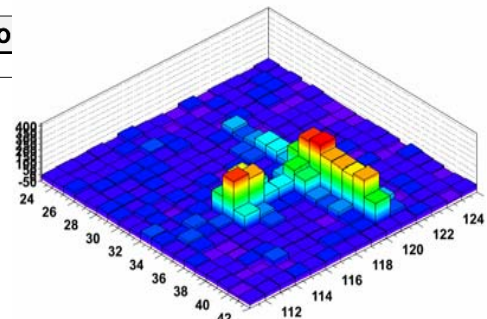### Single particle track over DEPFET detector (36°/72° tilt)

Particle track

Clean simulation
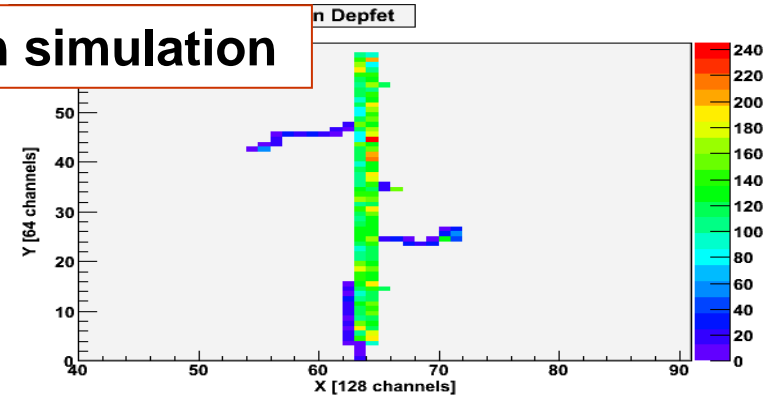
Simulation with realistic noise
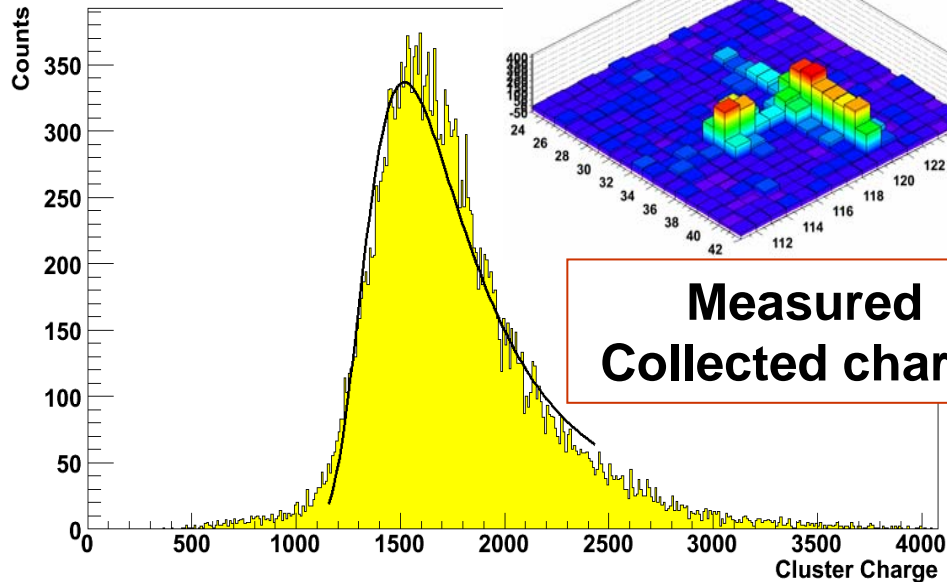
Measured Collected charge
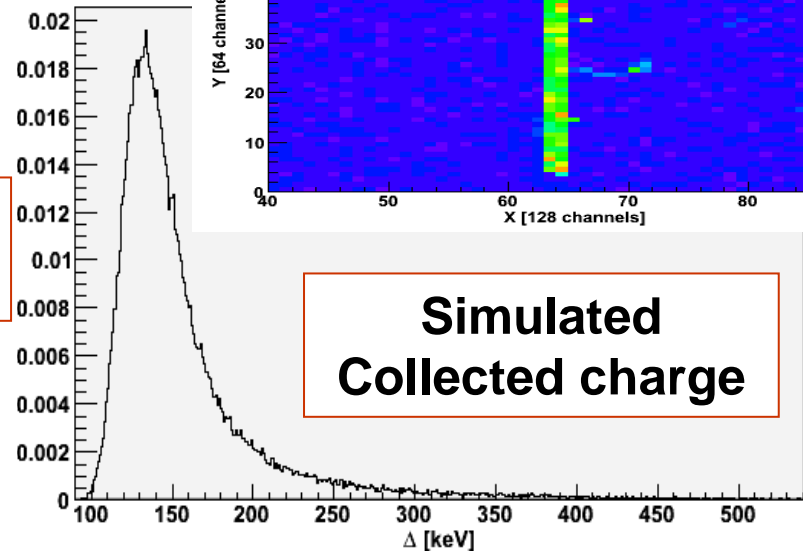
Simulated Collected charge

Results and Discussion – Charge Distribution Calculations

Charge distribution on the detecting surface generated by a particle traversing the detector (solid line), by a red (682 nm) laser beam (dashed line), and by an infrared (1065 nm) laser beam (dotted line). The particle track and laser beam are perpendicular to detector surface. The laser produces 4x more charge than the particle.
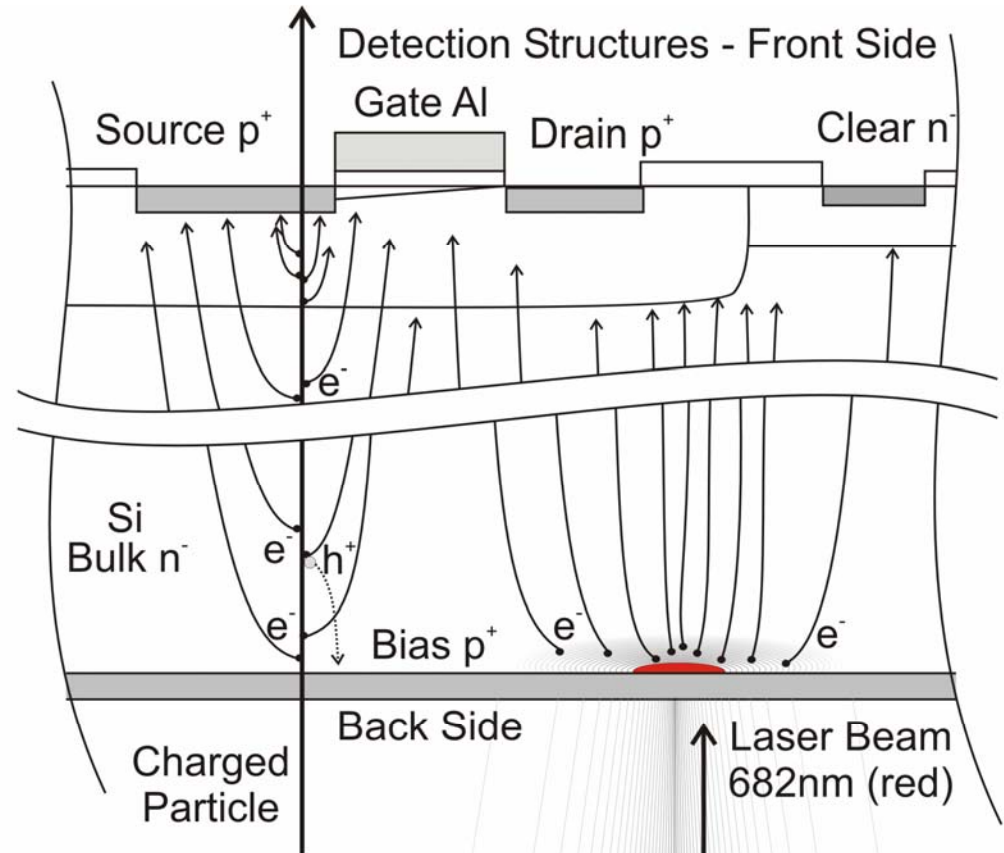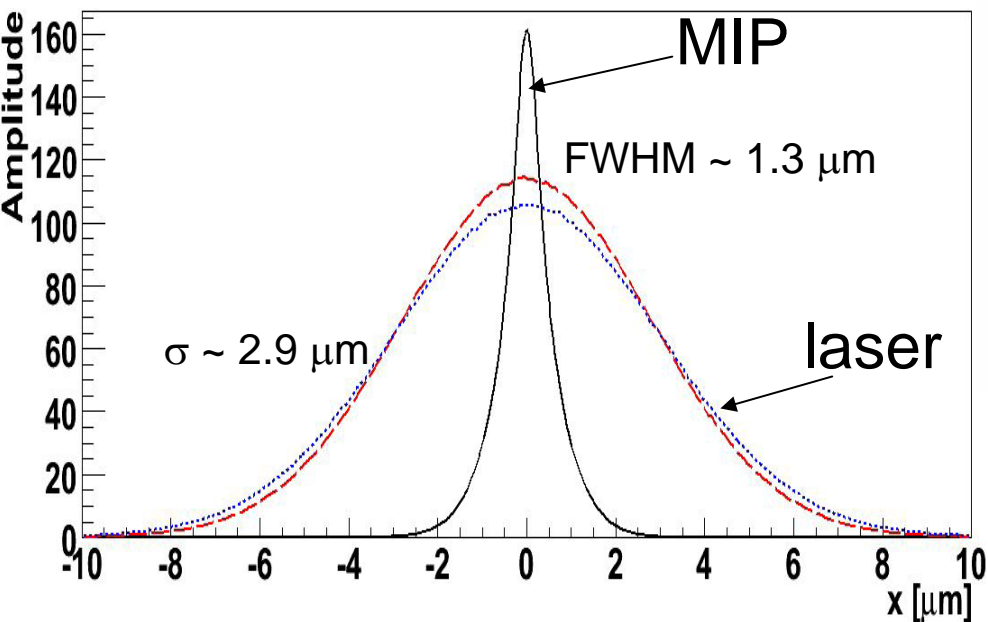
Schematic of charge creation by a particle traversing a silicon detector (left) and by a red (682 nm) laser beam (right).

Summary

- Many successful test beams at 3 accelerators
- DAQ integration with several telescope systems, external trigger, etc.
- Alignment and tracking methods for submicron precision developed (also for self-tracking system)
- Laser and source tests yield important info, as well as simulations
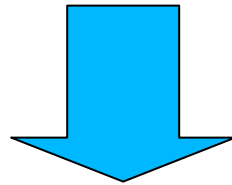
All tools in place to evaluate sBelle DEPFET prototype performance

Work ongoing…