Software and data analysis

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Outlook:

- Software development
- Testbeam results

→ Focus on news since Paris.

EUDET Annual Meeting 2008, JRA1 Session
NIKHEF Amsterdam, 06/10/2008

Part I: Software development

- Reminder
- Usability
- New features

Reminder: EUTelescope

- Set of Marlin processors: Every step of the analysis chain is implemented as a separate processor

Advantages:
- If the behaviour of a given telescope setup is well understood, several steps can be merged together
- Storing intermediate data can reduce processing time

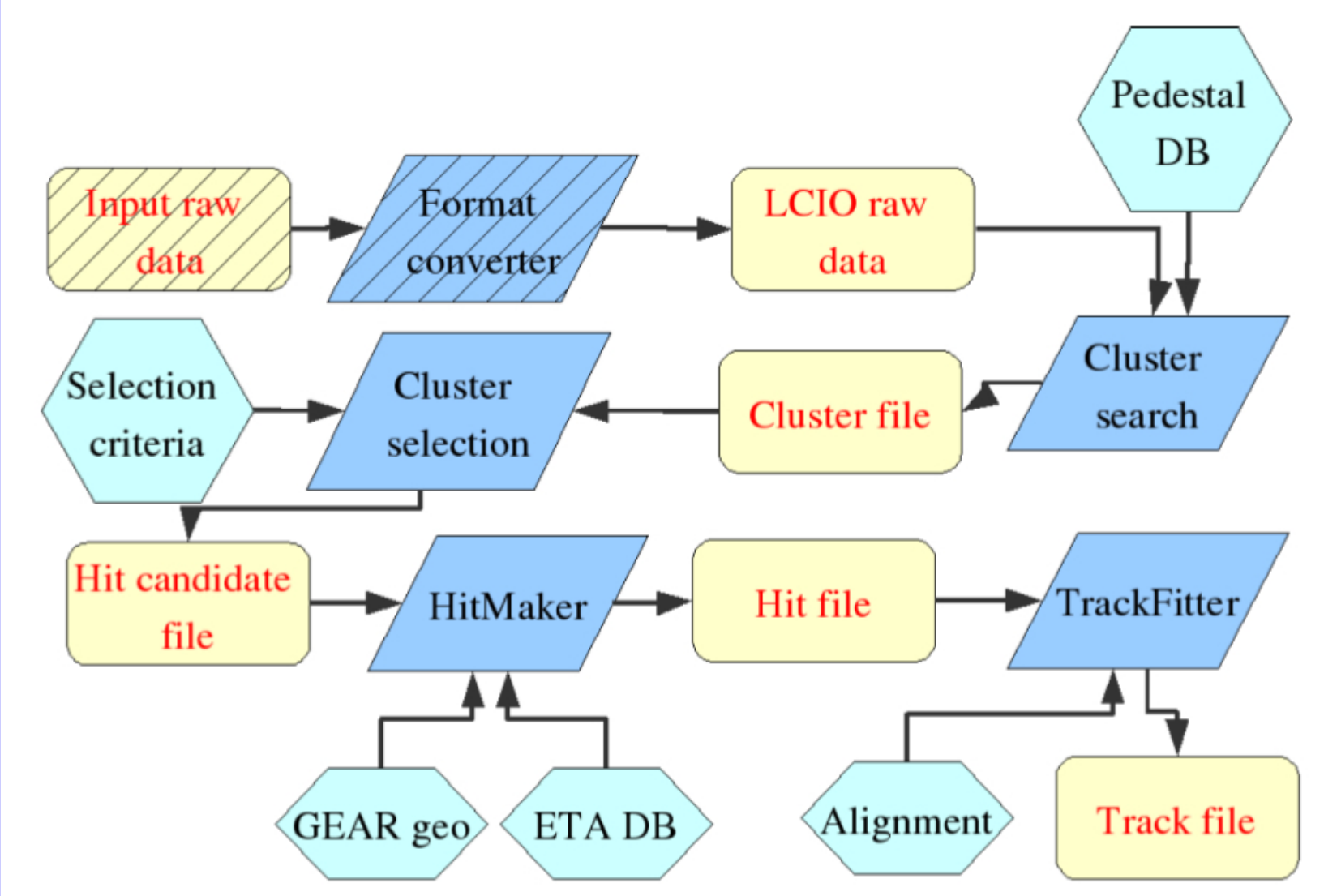
- User integration possible at different levels of the analysis

- Based on the existing ILC software framework (Marlin, LCIO, GEAR, (R)AIDA, CED, …)

- Good experience with running on the GRID

- CVS and documentation:
http://ilcsoft.desy.de/portal/software_packages/eutelescope

Reminder: analysis scheme



Usability

An increased number of detector R&D groups is adopting the EUTelescope package!

Several issues have been adressed to ease the installation and usage of EUTelescope:

- **Installation procedure:**
  - Encourage usage of ilcinstall
  - *Dependencies*: Marlin and LCIO
  Optional: MarlinUtil, GEAR, AIDA, ROOT, LCCD, CED, eudaq
  (it is possible to compile without these for minimal features)
  - install.cfg files are provided for minimal and complete installations

- **Keep documentation updated**

- **A tutorial was held in May 2008** (availabe on the JRA1 webpage)

Usability II

- **Preparing the transition from CVS to SVN:**
  - R/W access to the repository can be provided by the project leader(s) and not anymore by the CVS responsible in Zeuthen
  - R/W access will be based on personal SSL certificates (like for the GRID)
  - Users can create their own branches and when their code is mature enough it can be merged into the main trunk

- **GRID operation:**
  - The submission scripts were rewritten to use the new ILCSoft installation on the CE
  - In the future we aim for a unique submission script for execution on the local machine as well as on the GRID

- **Stability:** In general the package is stable and runs without crashes

New feature: universal reader

Most common scenarios for user integration in the DAQ system:
- *Integration at DAQ SW level*: The user provides own DAQ hardware, but the data are treated by the EUDAQ software
- *Integration at trigger level*

In the first case EUDAQ allows to include DUT data in the native output file → safest possible synchronisation

Universal native reader:
- Very general data reading and conversion processor
- Automatically detects from the native EUDAQ files which sensors were used and converts the information from the native format to LCIO
- Users are invited to provide a small piece of code to read their sensors

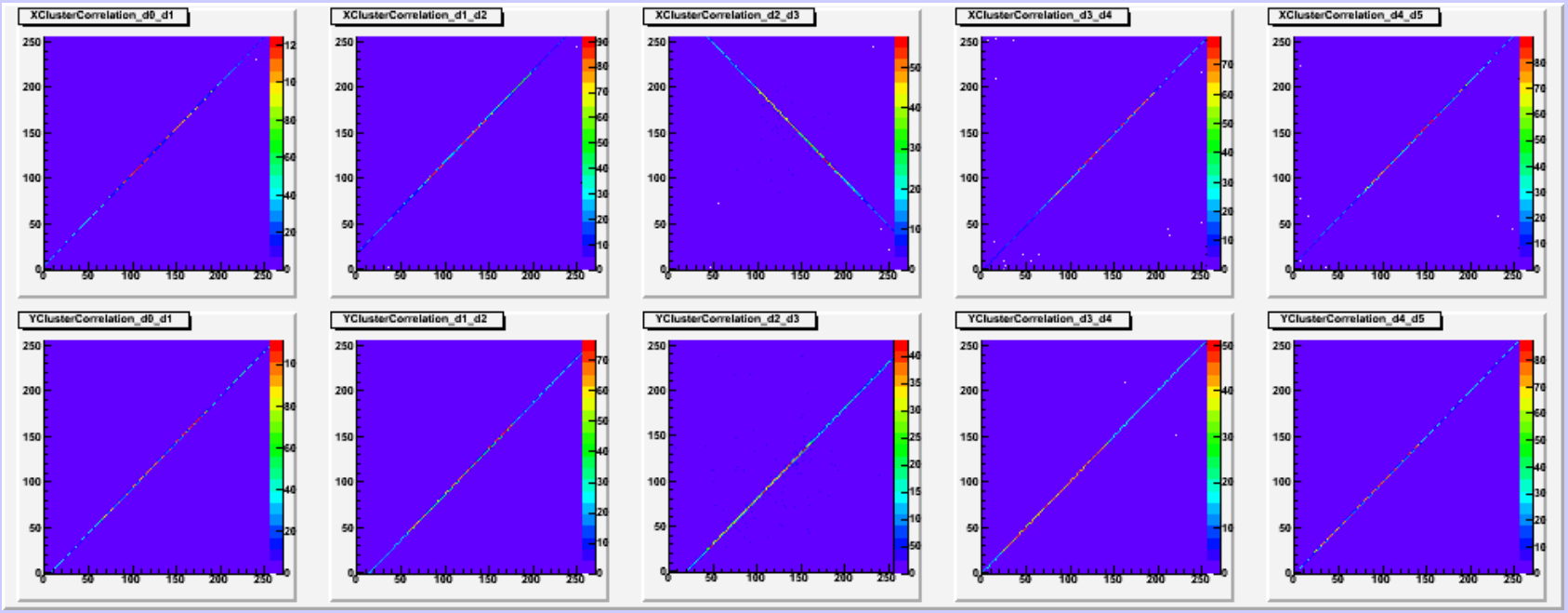
Alternative: EUDAQ now able to write LCIO files

New features: Correlator

New simple processor to display correlations of hits and clusters in different telescope planes

Useful to:
- Monitor the data quality
- Verify the geometry description
- Check alignment

Next step:
Correlate telescope planes with the DUT



New feature: Alignment

- The new alignment procedure is based on the Millepede II package by V. Blobel

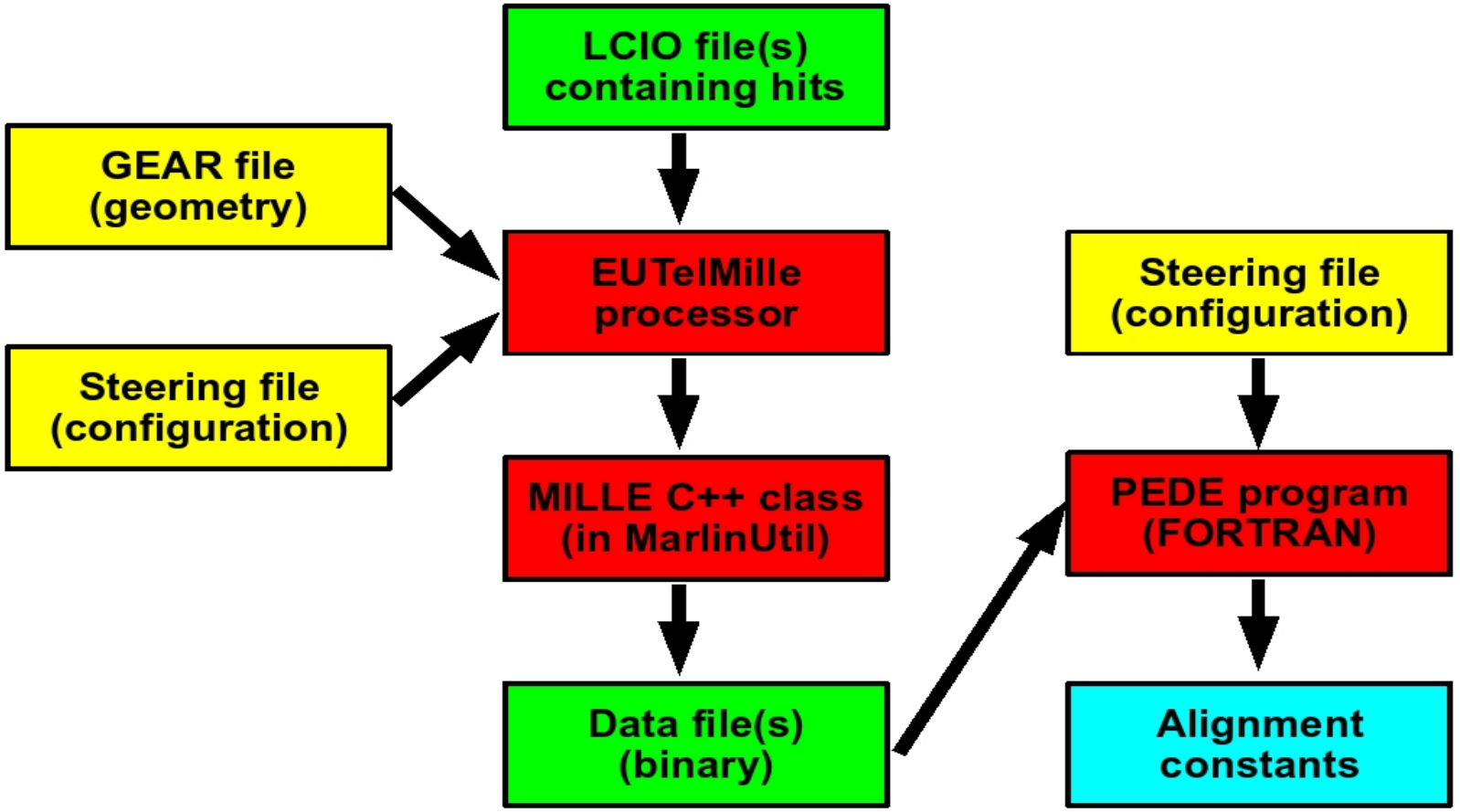
- A simultaneous fit using full tracks is performed to derive the alignment constants

- Modular implementation:
  - The Mille class has been included in MarlinUtil
  - It is used by the EUTelMille processor to generate binary files
  - The actual minimisation is done by the pede program (Fortran)

- EUTelMille can execute pede and generate the needed steering file
→ The alignment can be fully controlled in the Marlin XML-File

- It is possible to redirect the output of pede into a condition that can be stored in LCCD and read by Marlin using a conditions processor

Alignment scheme

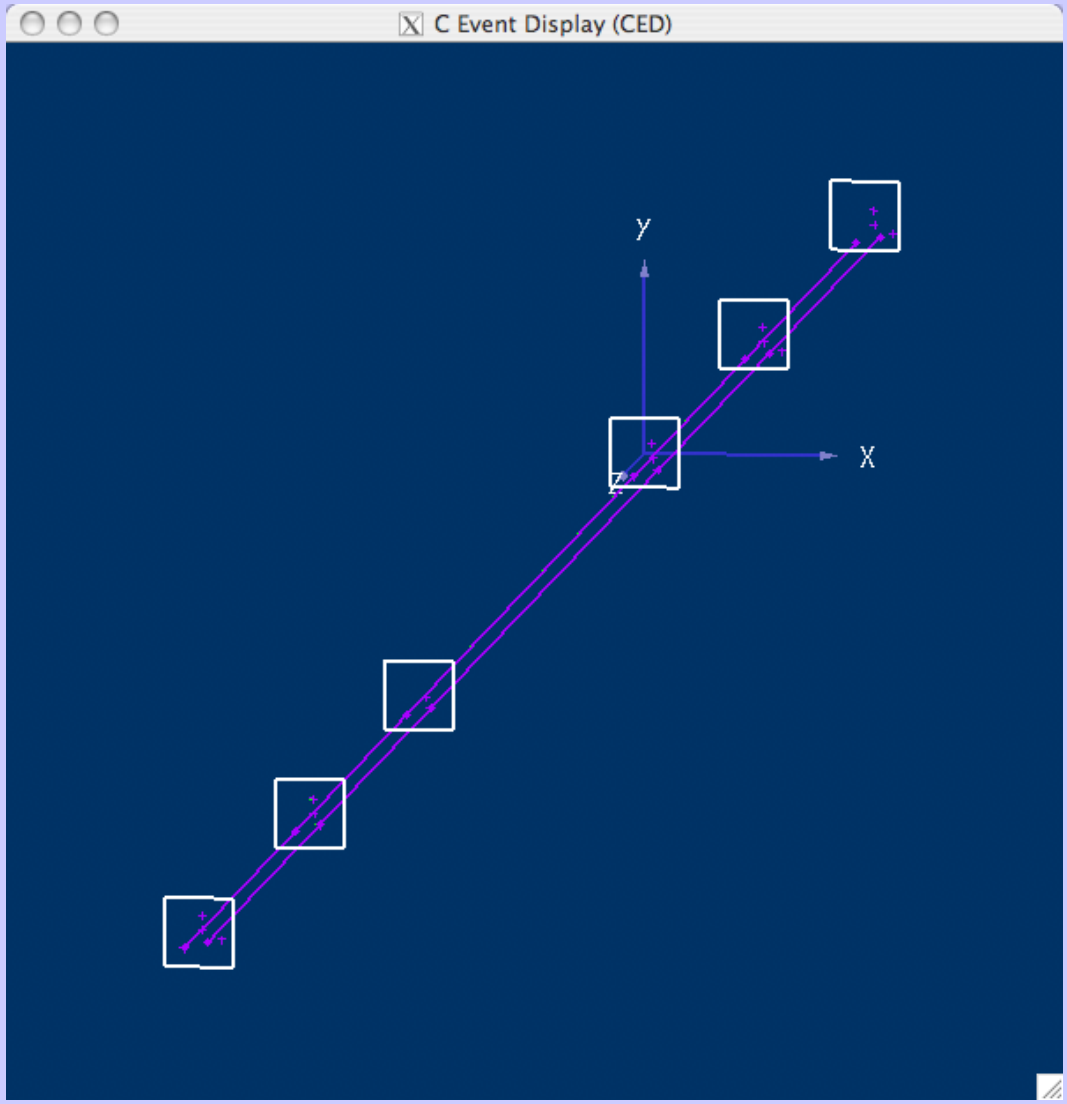


Improved event viewer

- Based on CED and CEDViewer

- Allows to display any set of hits (before / after alignment)

- New feature: draw tracks and impact positions of tracks in the telescope planes



Summary on software

- The package EUTelescope is in good shape and is utilised by an increasing number of groups

- During the last year lot of effort to increase the usability

- New features:
  - Universal reader
  - Correlator
  - Alignment
  - Improved event viewer

Part II: Testbeam results

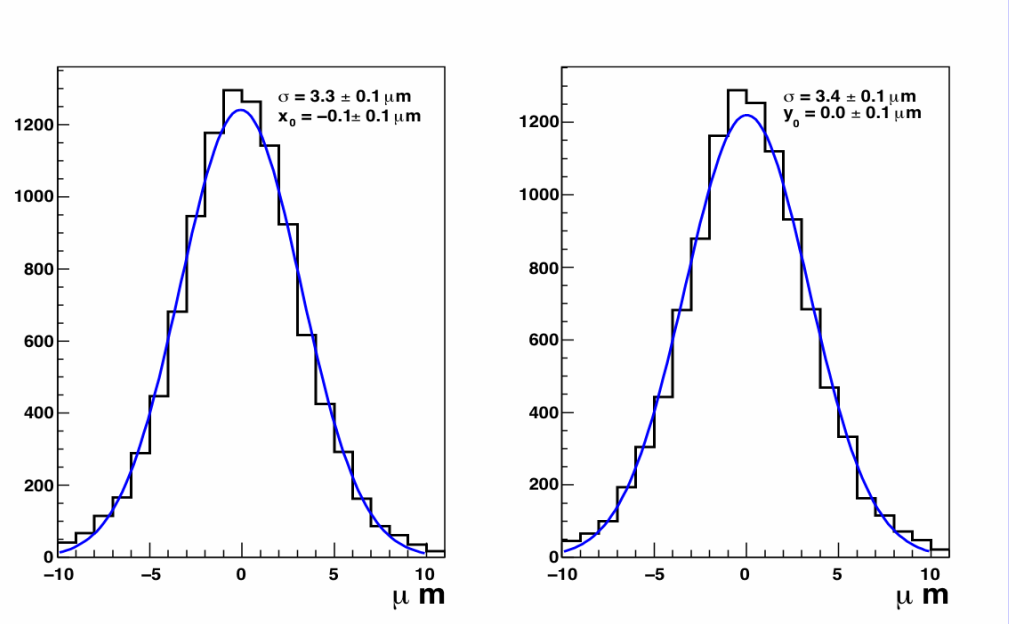
- Highlights of 2007 data
- First user experience
- Summer 2008

Highlights of the 2007 data

The analysis of the data taken in 2007 is finished (August at DESY, September at CERN)

- 180 GeV hadrons at CERN

- Sensor resolution about 3.0 □m (as expected)



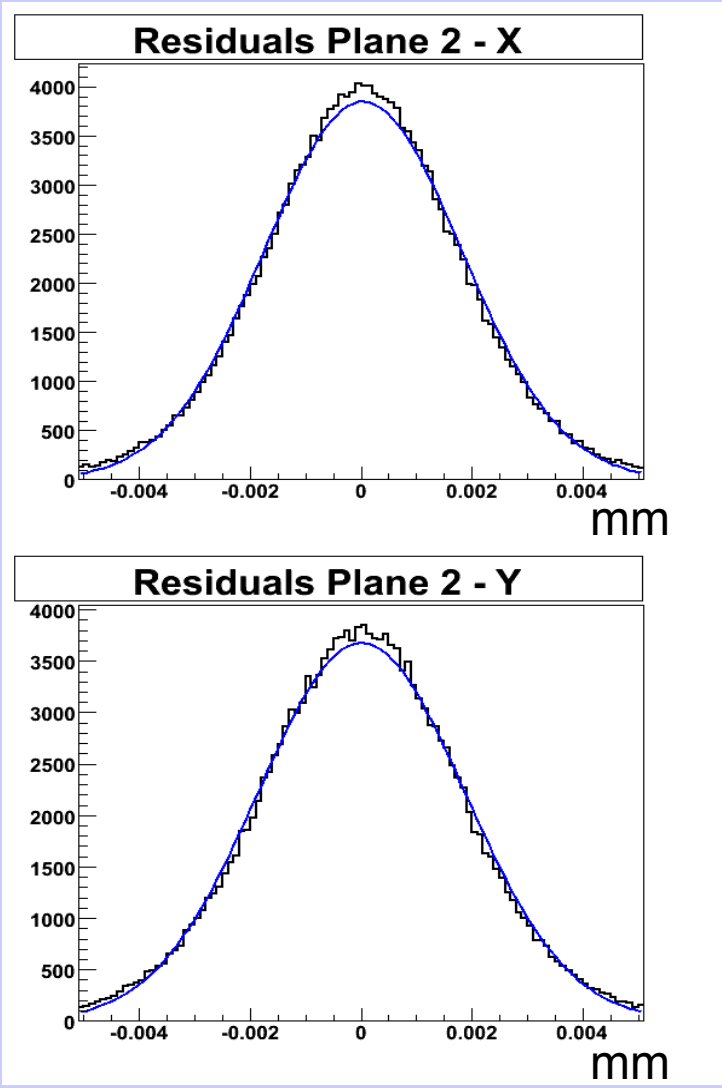
Sensor as DUT	σ(MimoTEL) – X	σ(MimoTEL) – Y
0	2.94 ± 0.03 μm	3.11 ± 0.03 μm
1	2.68 ± 0.03 μm	2.83 ± 0.03 μm
2	2.91 ± 0.03 μm	3.00 ± 0.03 μm
3	2.85 ± 0.03 μm	2.93 ± 0.03 μm
4	2.94 ± 0.03 μm	3.03 ± 0.03 μm

Example alignment

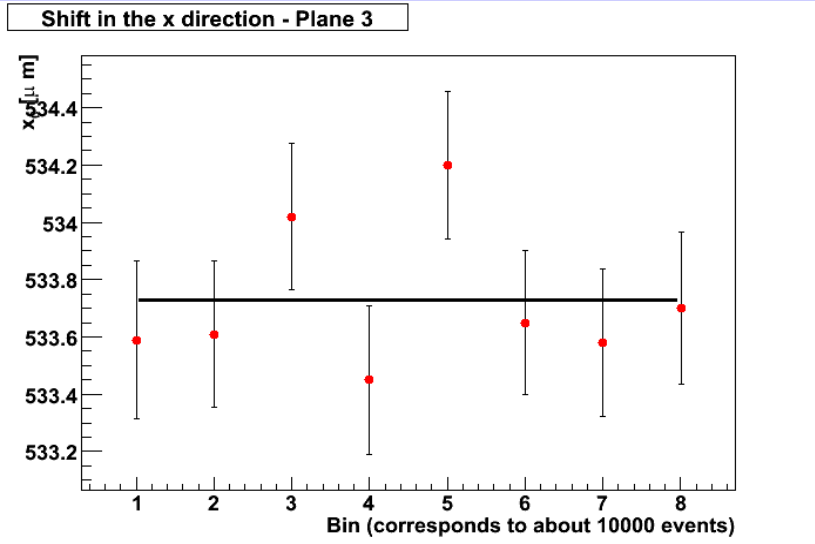
- 3 GeV electron data recorded at DESY

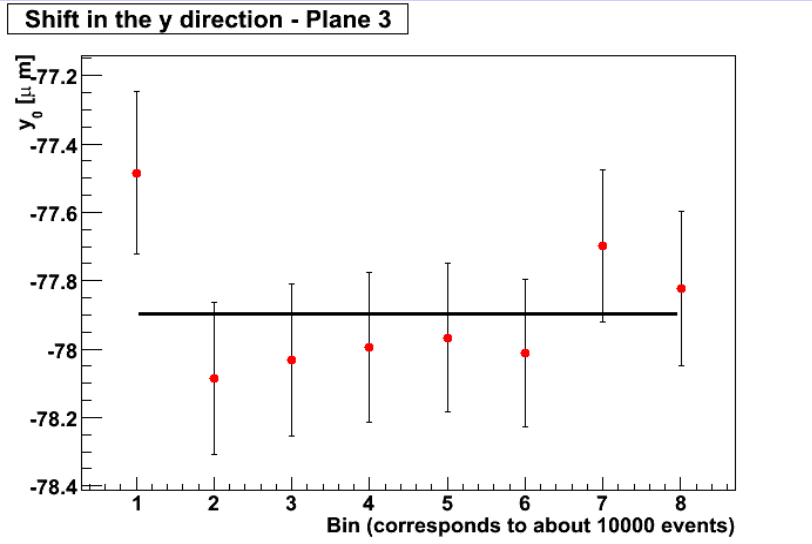
- Typical values of the Alignment constants:
  - shifts in X and Y: a few hundred μm
  - Rotation around the beam axis: a few mrad

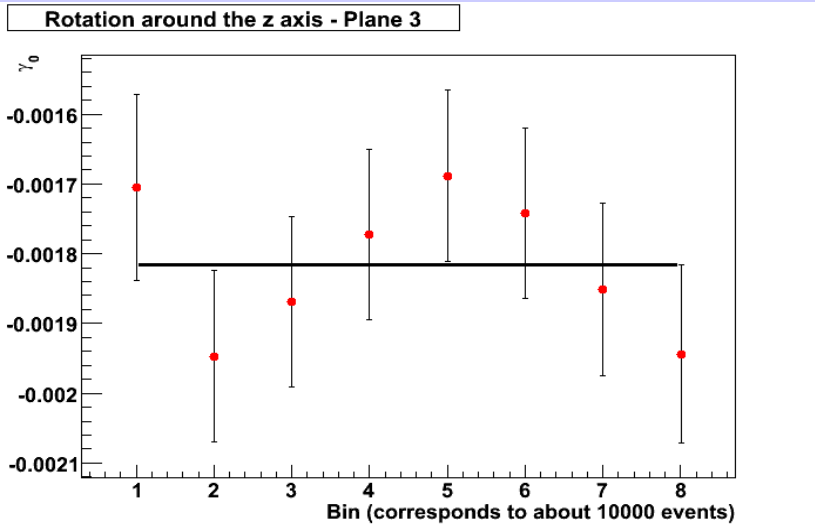
Sensor	Residuals X Mean [μm]	Residuals Y Mean [μm]
0	-0.003±0.002	-0.023±0.002
1	-0.012±0.004	0.036±0.005
2	0.032±0.004	0.005±0.005
3	-0.020±0.004	-0.005±0.005
4	0.001±0.002	-0.002±0.002



Alignment stability



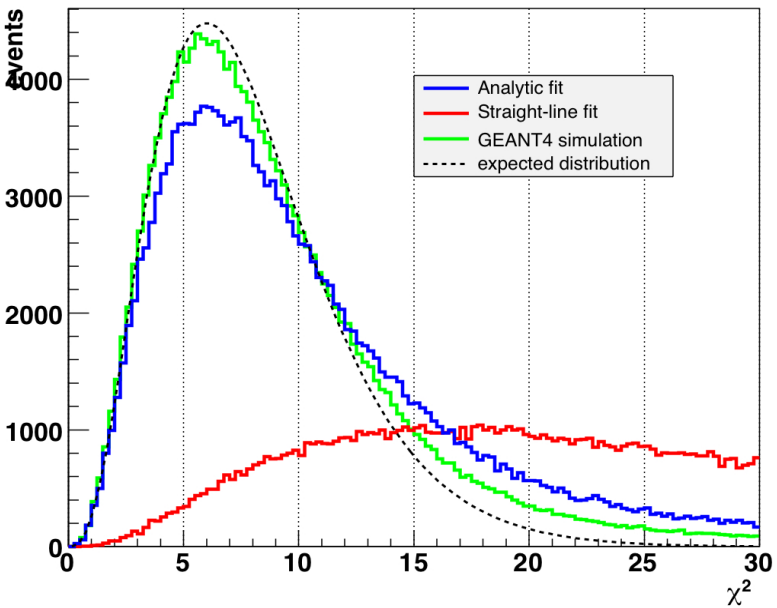


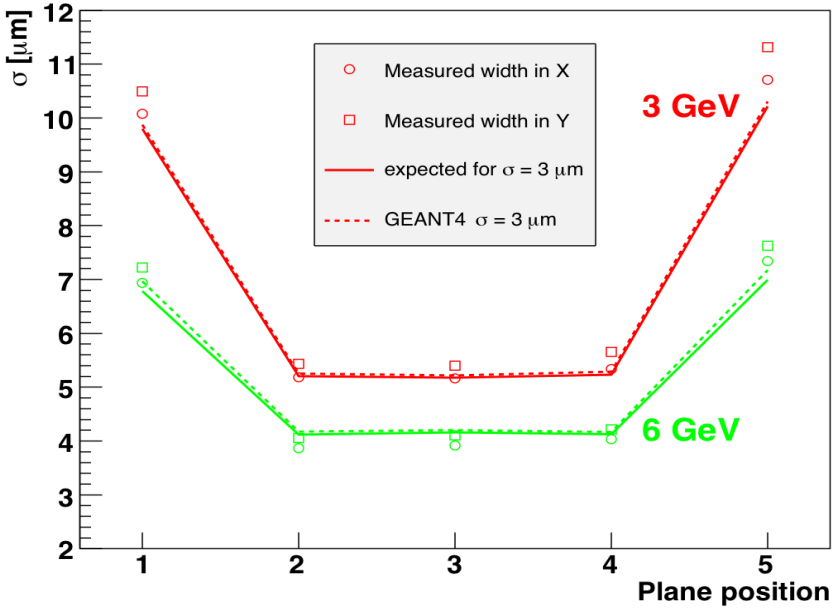


No problems visible

3 GeV data from DESY, other samples similar

Comparison of DESY data with simulation





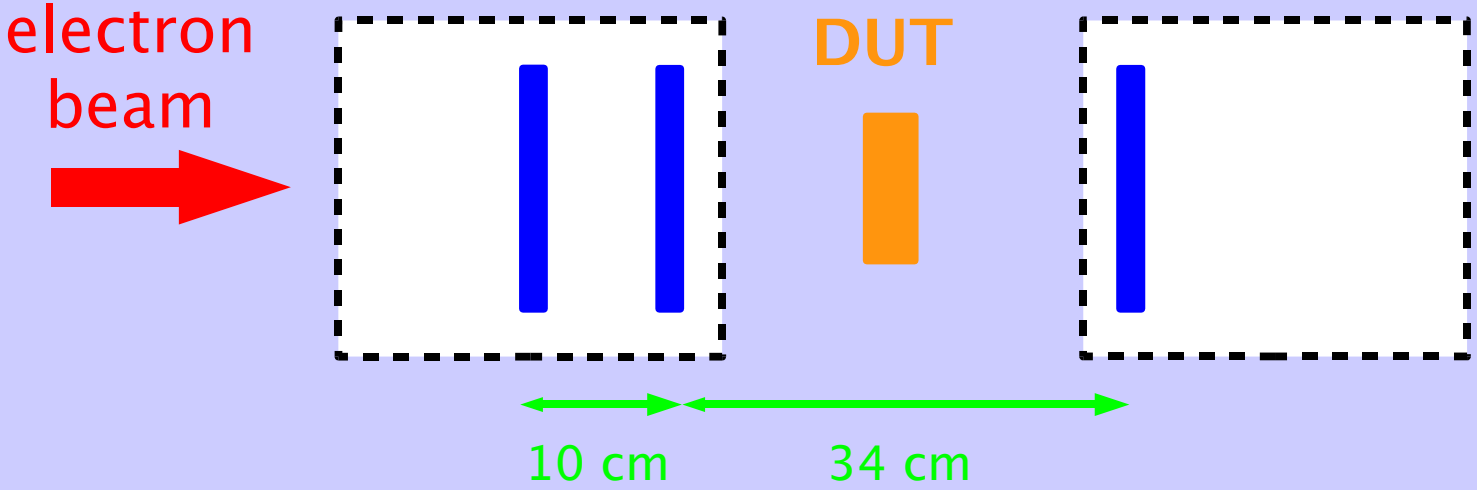
MS is considered by analytic fit

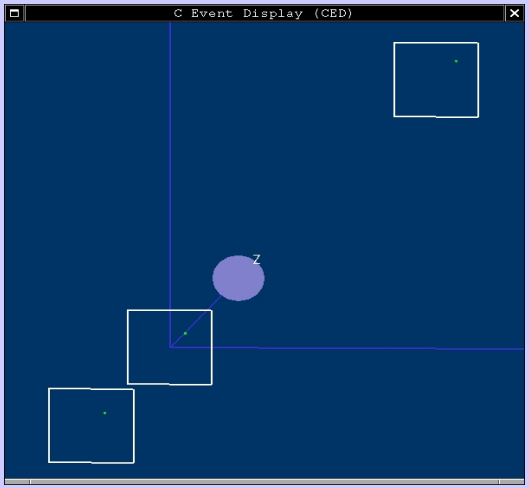
$$\Delta\chi_i^2 = \underbrace{\left(\frac{y_i - p_i}{\sigma_i}\right)^2}_{\text{position measurement}} + \underbrace{\left(\frac{\Theta_i - \Theta_{i-1}}{\Delta\Theta_i}\right)^2}_{\text{multiple scattering}}$$

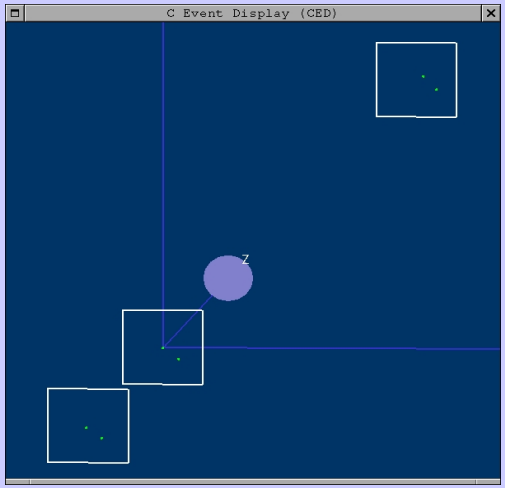
Good agreement of data with expectation and simulation (Geant4)

First user experience: BeamCal at DESY

Goal:
Measurement of the mean number of charge carriers created by a MIP in sCVD diamond

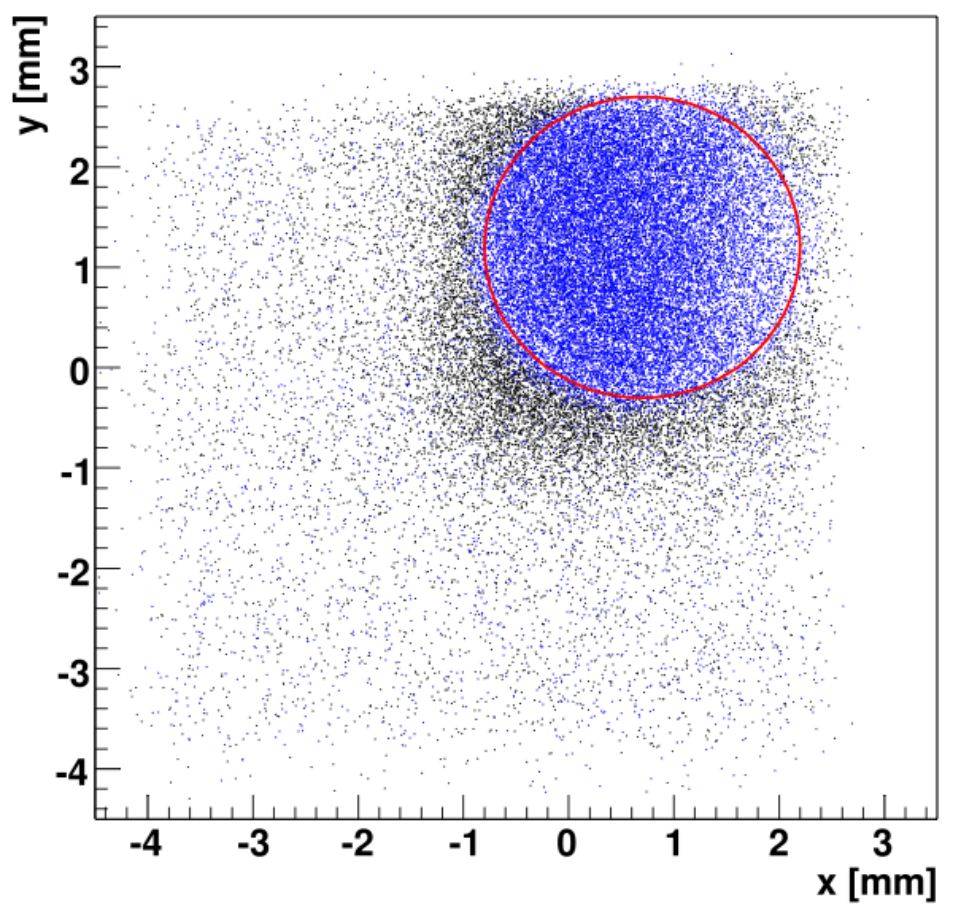






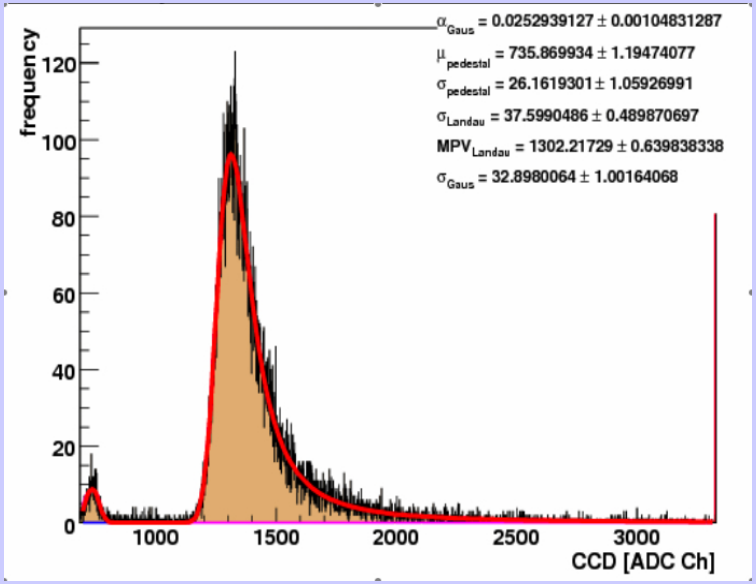
December 2008 at DESY:
85.000 events in RAW mode taken in less than 24 hours.

Particle positions in the DUT plane



Use the telescope to **avoid border effects**.

Black: sensor signal below cut.
Blue: sensor signal above CCD cut



Overview summer 2008

User	Beam	Events
SiLC	SPS	1500000
CALICE	PS	320000
TAPI	SPS	100000
MimoRoma	SPS	25000
DEPFET	SPS	2300000
ISIS	SPS	600000
EUDET	SPS	350000

Includes telescope characterisation:

- Energy scan (E = 20, 40, 60, 80, 100, 120 GeV)
- Temperature scan: One sensor as DUT (T = 8, 12, 16 °C)
- Threshold scan: One sensor as DUT in ZS Mode (sigma = 2.0, 2.5, 3.0, 3.5, 4.0)
- Mimosa 18 as DUT in EUDET telescope

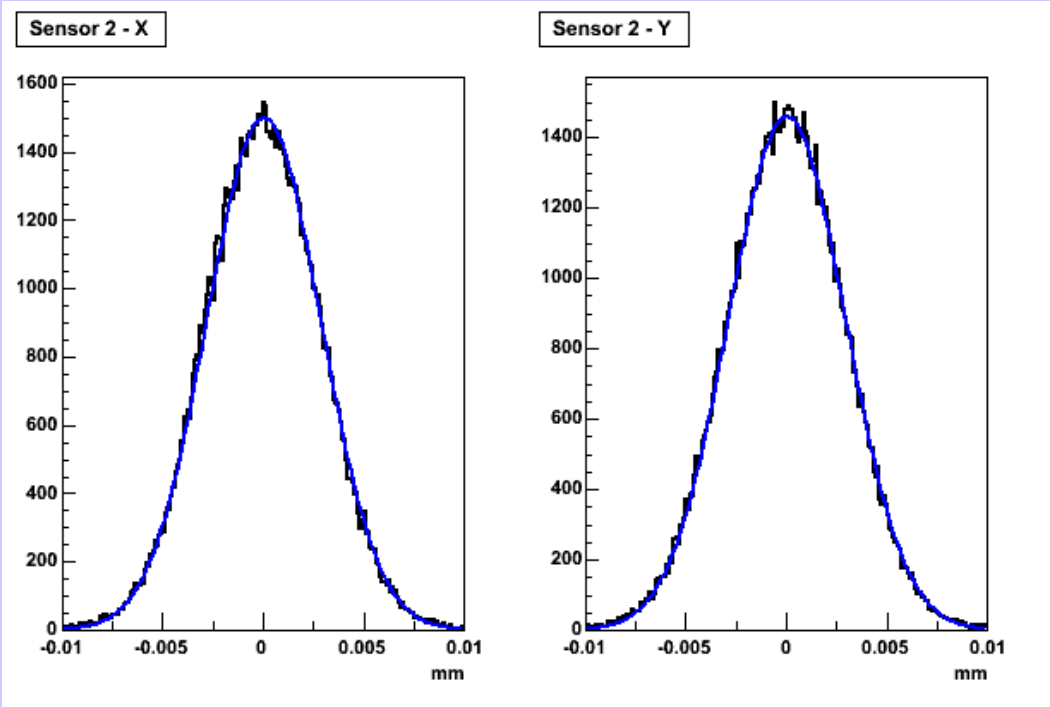
SiLC, CALICE, MimoRoma, DEPFET and ISIS report in this meeting → will not discuss here

First look at the SPS data

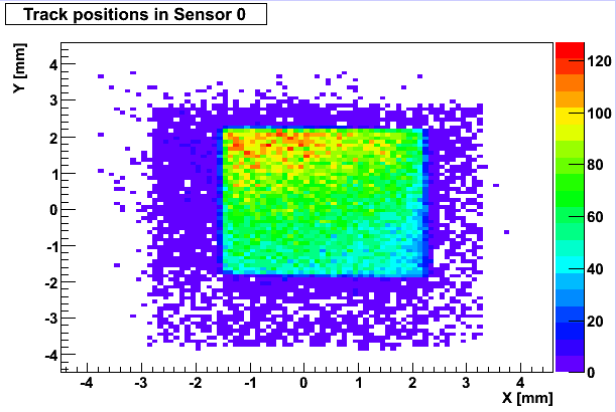
Test analysis of run 4192 – 4196:
≈ 100000 events with low multiplicity

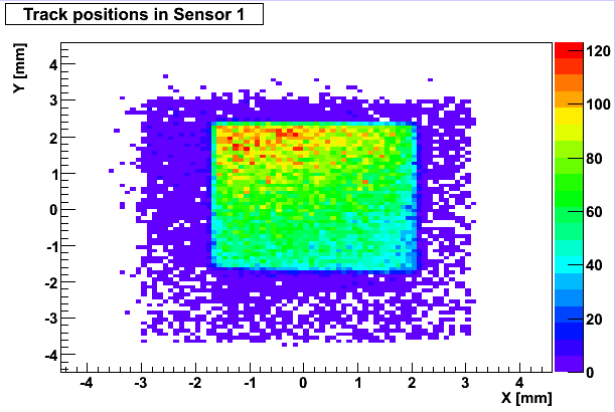
- 120 GeV hadron beam
- Taken during DEPFET Period
- No η correction
- Demonstrator fully working:

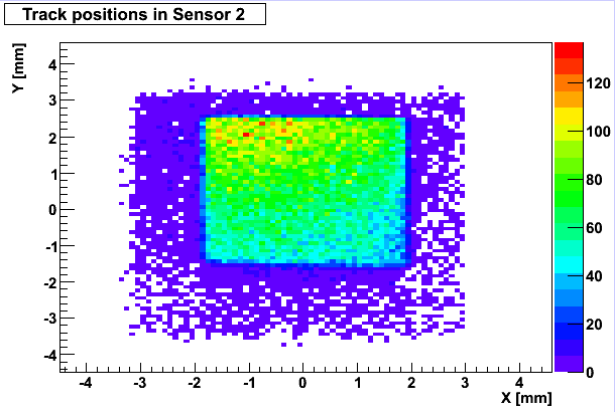
6 sensors operating in ZS mode!

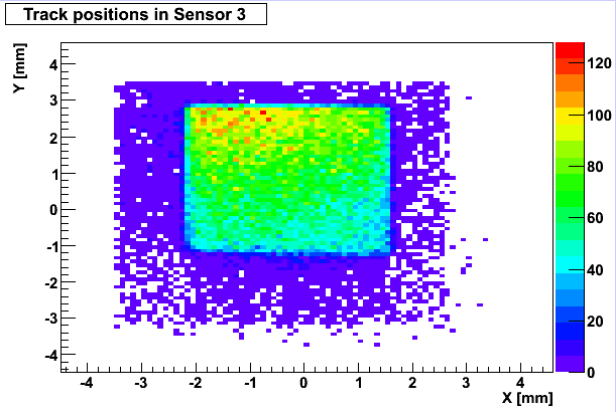


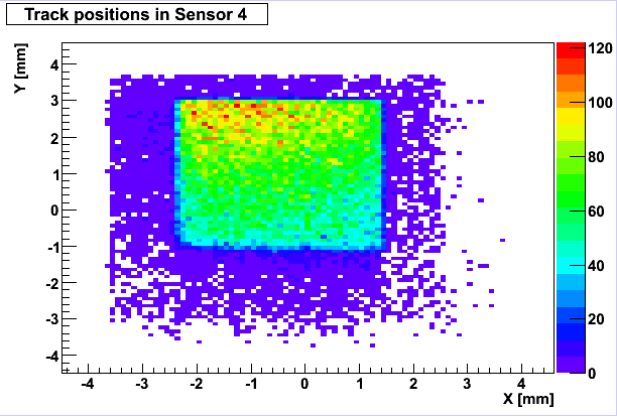
Track positions in the sensors

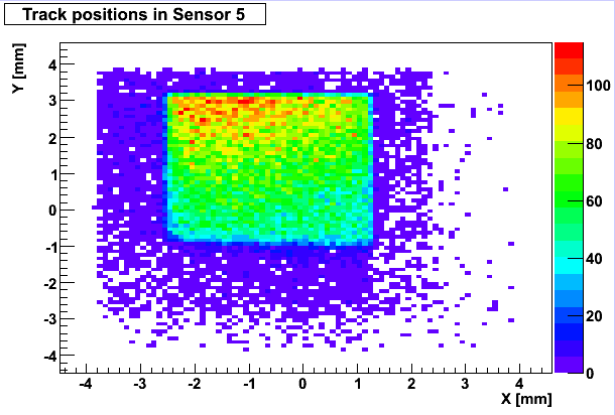






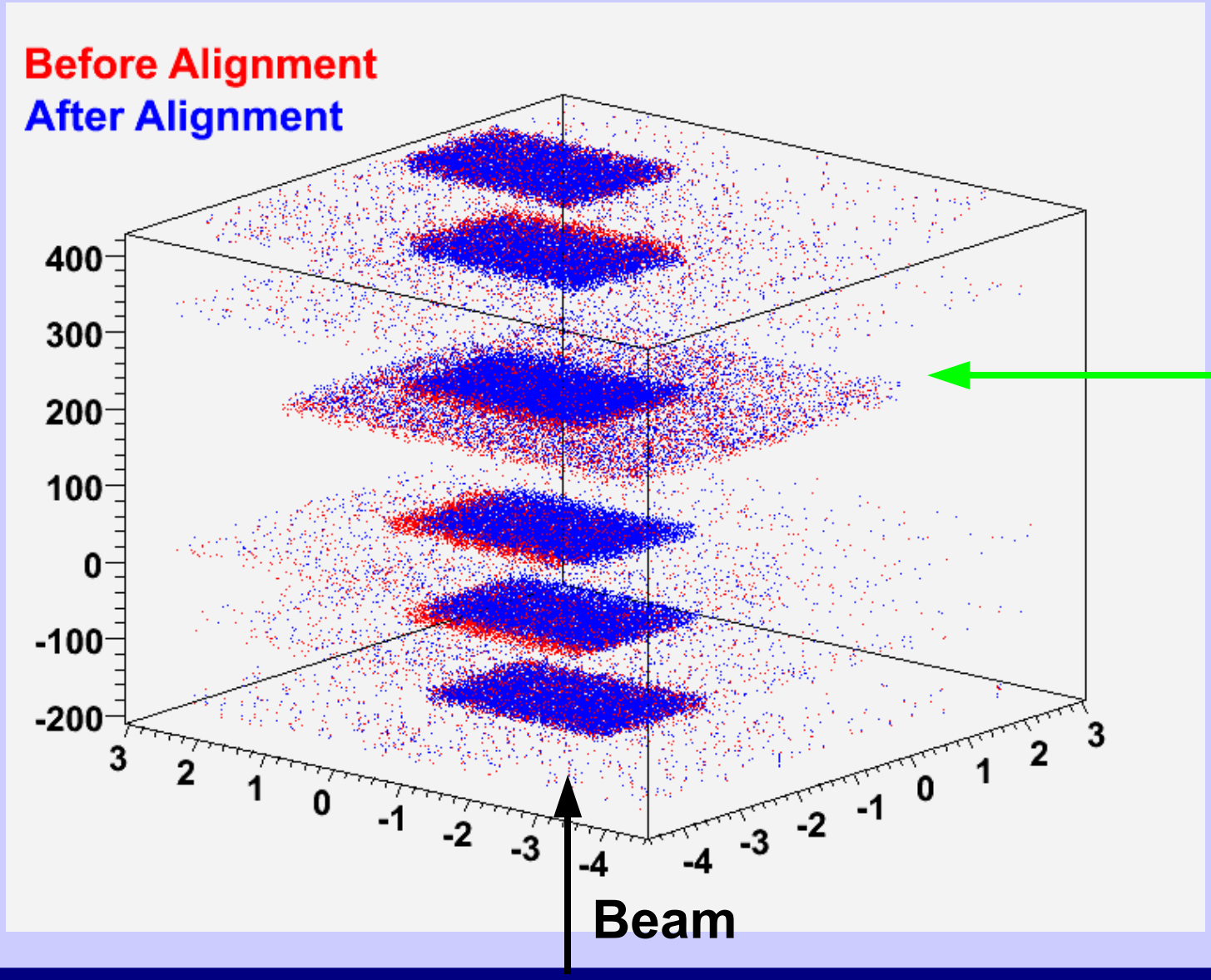






- Trigger window clearly visible
- No problems observed

Mimosa 18 as DUT



Mimosa 18 as DUT in a telescope of five MimoTEL sensors

Mimosa 18

Analysis ongoing...

User analysis

- Most (all?) users of the telescope are using EUTelescope for their data analysis

- The DUT integration is performed on different levels:
  - *Minimal integration*: Use ROOT-File with track positions in DUT layer from EUTelescope in user analysis code
  - *Full integration*: Use EUTelescope also for analysis of the DUT data (example: DEPFET → see talk by Julia F.)

- Support for user analysis is provided by the JRA1 analysis group (this is becoming mayor effort)

- Code from user analyses is added to the repository to increase the overall functionality of the package → everybody benefits

Summary on analysis

- The analysis of the data from the testbeams in 2007 was successful
- Encouraging results from user measurements
- Processing of the data from the summer 2008 is ongoing, first checks are promising
- Stay tuned for lots of exciting results...

Related documents

- **EUDET-Report-2007-01:** EUDET Telescope Geometry and Resolution Studies
- **EUDET-Report-2007-06:** First Test Beam Results from the EUDET Pixel Telescope
- **EUDET-Memo-2007-20:** EUTelescope: tracking software
- **EUDET-Memo-2007-58:** Towards a Measurement of the Mean Number of Charge Carriers Created by a MIP in sCVD Diamond using the EUDET Telescope