The EUDET High Resolution Telescope

Philipp Roloff (DESY) for the EUDET Consortium

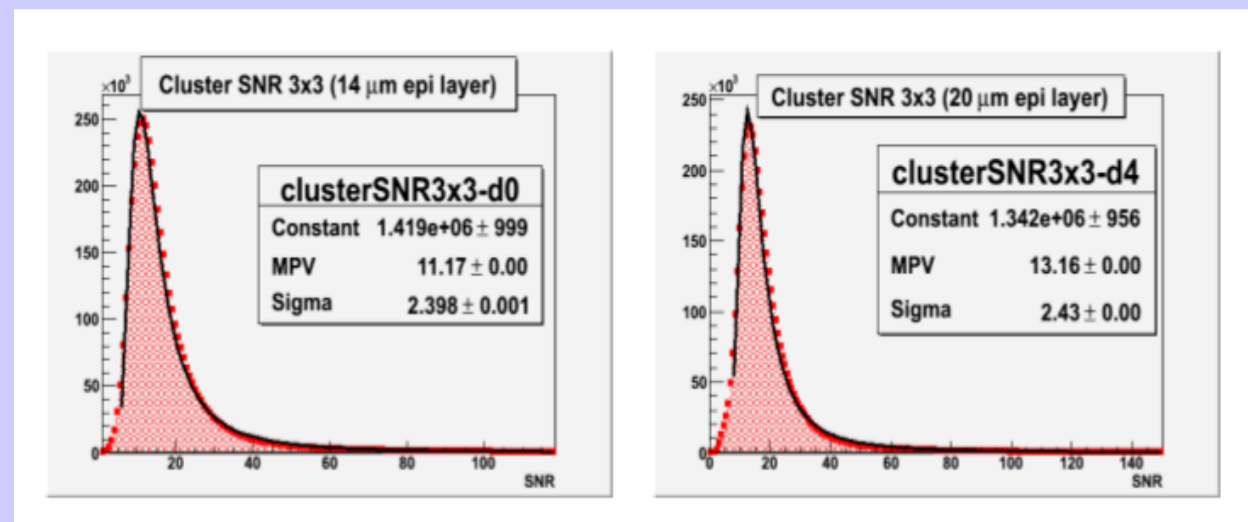### PSD 2008, University of Glasgow

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The Sensor (MimoTEL)

- MAPS (Monolithic Active Pixel Sensor)
- Designed in the AMS 0.35 OPTO process
- 4 sub-arrays with 64x256 pixels each
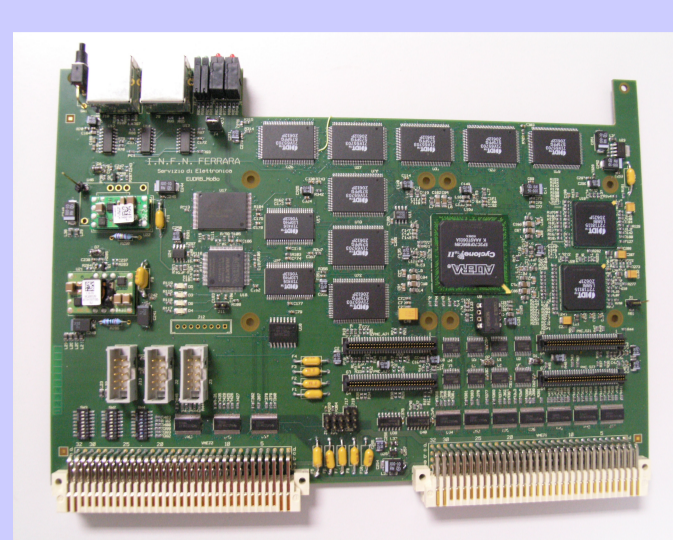- 30x30 µm² pixel pitch, 7.7x7.7 mm² active area
- Intrinsic resolution: 3.0 µm

T = 21ºC

Noise
single pixel:
≈ 3,6 ADC
(17 e⁻)

Sensor	Epi layer	Seed pixel ADC	Seed pixel S / R	3 x 3 Cluster ADC	3 x 3 Cluster S / R
0	14 µm	47.2	12.5	131.0	11.2
1		46.2	12.2	129.0	10.9
2		47.3	12.8	130.3	11.3
3	20 µm	47.5	10.9	151.4	11.0
4		46.3	12.6	147.6	13.2

The DAQ Board (EUDRB)

- VME 64x and USB 2.0
- One board per sensor

- Transparent mode (RAW)
- **Zero Suppressed mode** (ZS): Online Correlated Double Sampling (CDS), only addresses and signals of pixels above a user-defined threshold are transferred

The Trigger Logic (TLU)

- Replacement of a NIM crate
- Coincidence of scintillator signals
- Provides event numbers and timestamps
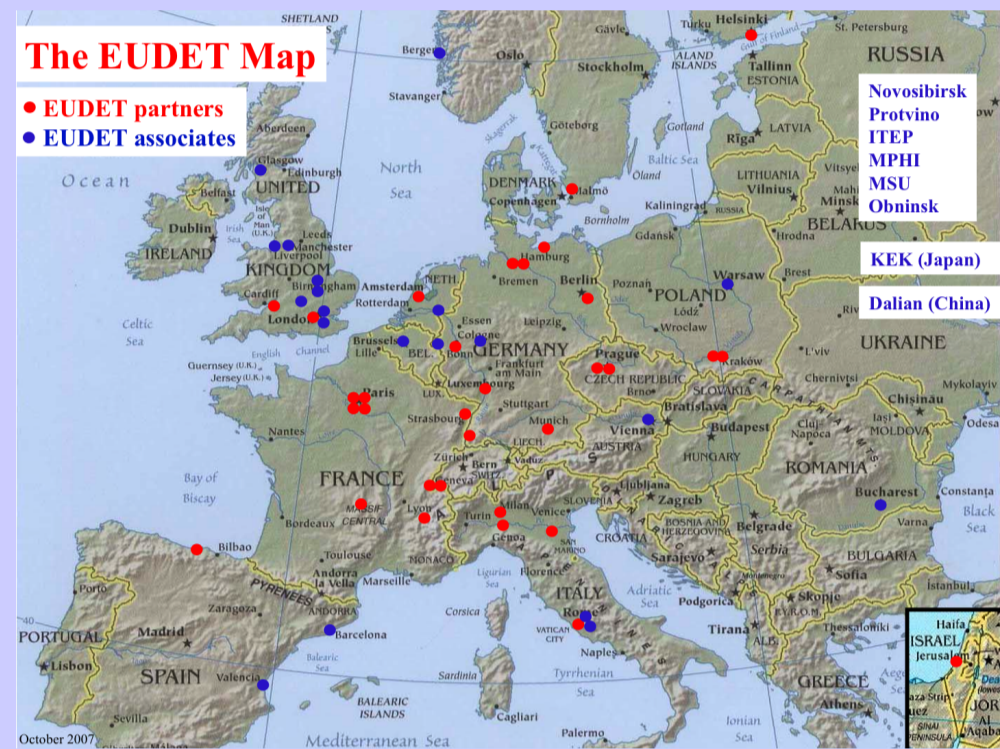- LVDS and TTL interfaces

The DAQ SW (EUDAQ)
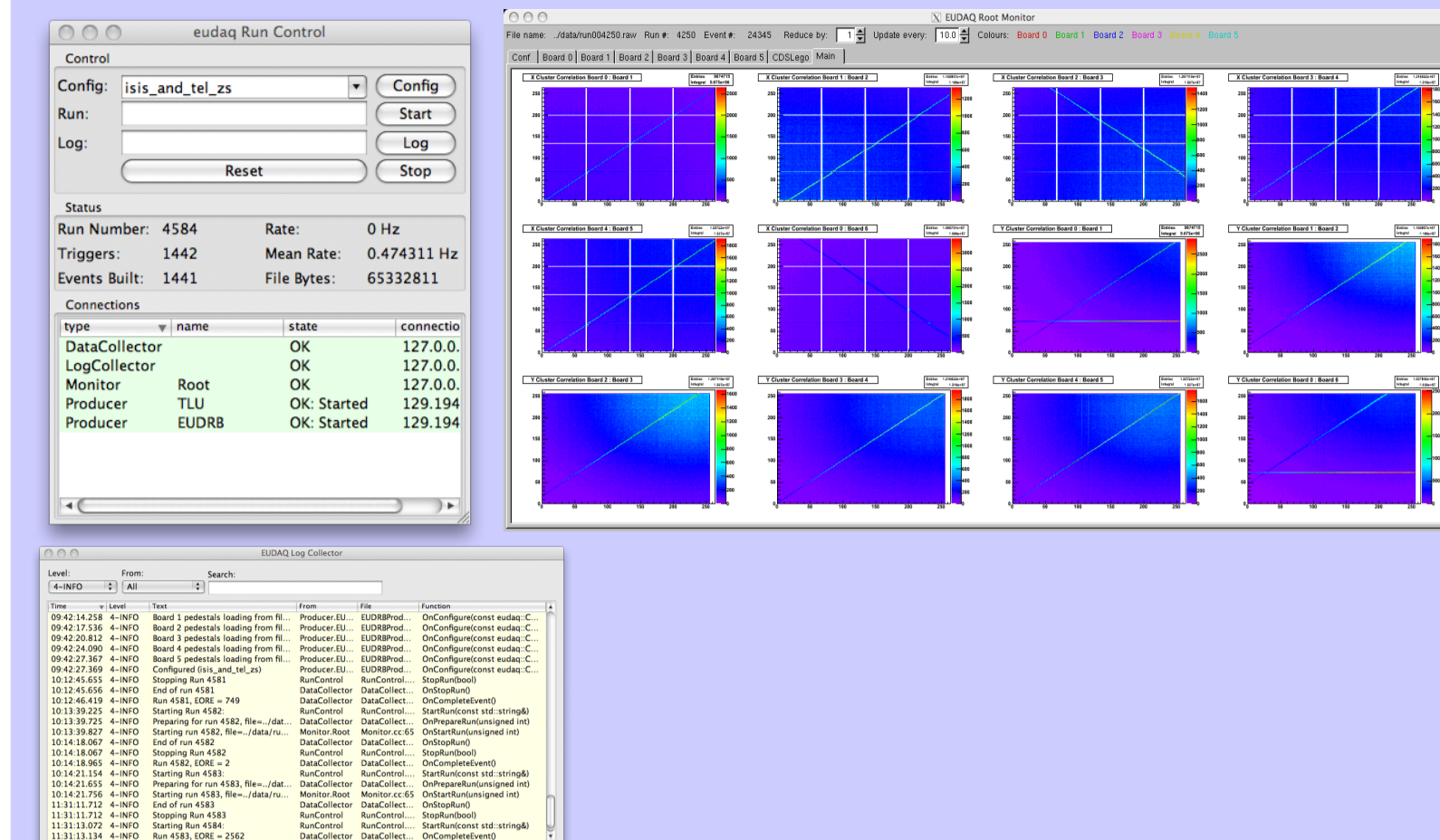
- Custom DAQ software implemented in C++
- Highly modular, allowing DUTs to be easily integrated into the framework
- Distributed (TCP/IP)
- Runs on MacOS, Linux or Windows (with cygwin)
- Provides powerful online monitoring
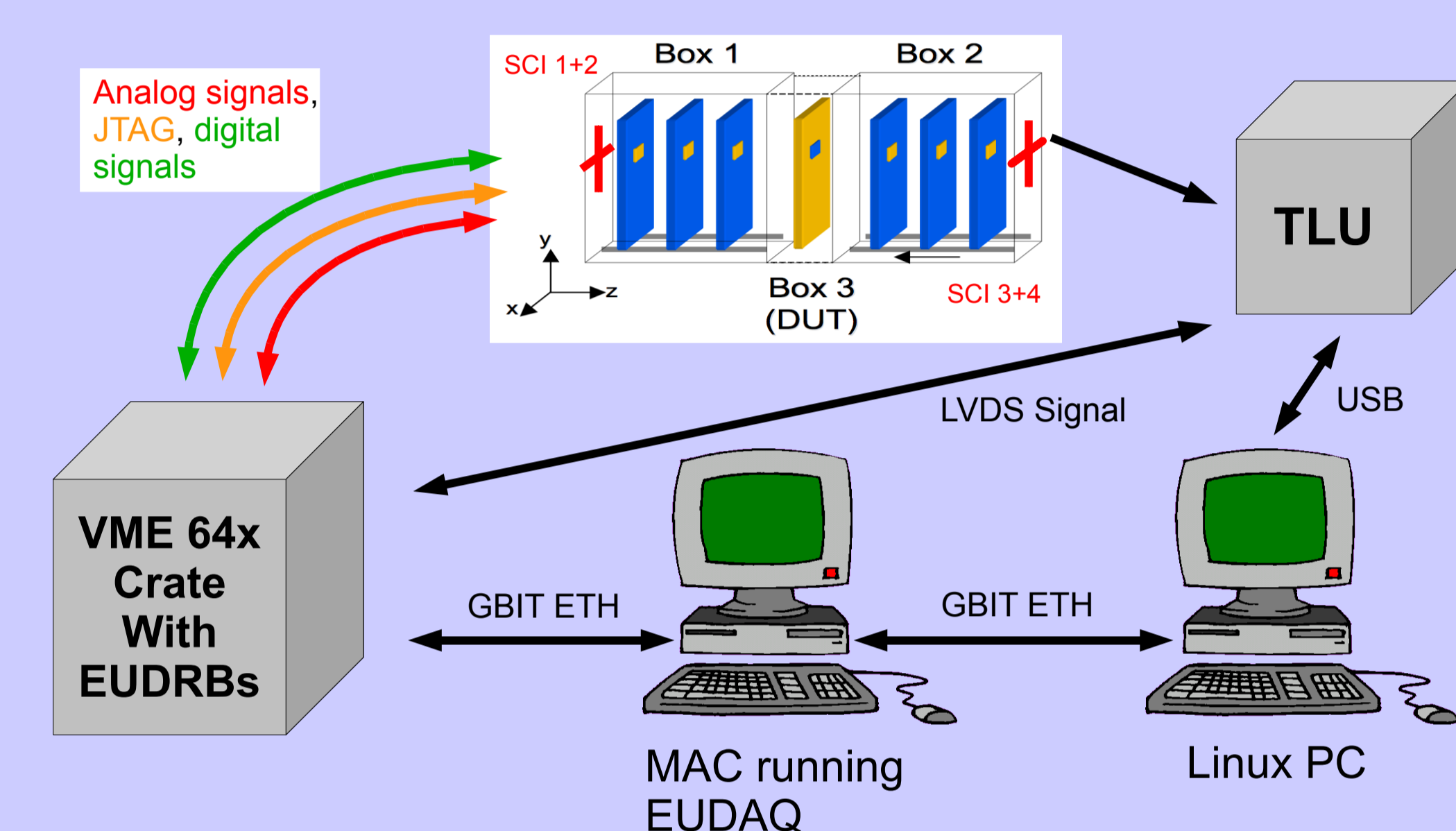- *http://projects.hepforge.org/eudaq/*

EUDET

EUDET:
- Infrastructure for detector R&D towards the ILC
- Supported by the EU in the 6th Framework Programme

JRA1: Improvement of the testbeam infrastructure within EUDET
- PCMAG (1 Tesla)
- **High Resolution Pixel Telescope**

First phase: "Demonstrator" simple sensors, analog readout → this poster
Second phase: Move data processing to the sensors (zero suppression)

Come and use it...

www.eudet.org: You can apply for travel support through the **Transnational Access** and use the EUDET test beam infrastructure

testbeam.desy.de: You can apply for **testbeam time** at DESY

For more information contact
ingrid.gregor@desy.de

The Analysis Software: EUTelescope

- **Collection of Marlin Processors**

- Data is stored in the LCIO format

- The DUT data can be integrated at different steps of the analysis chain

- Prepared for running on the Grid

CVS and documentation are available here:
http://ilcsoft.desy.de/portal/software_packages/eutelescope

Overview

Testbeams:

06 / 2007, DESY	First installation	
08 / 2007, DESY	Taking data with 3 and 6 GeV electrons	
09 – 10 / 2007, SPS	Taking data with 180 GeV hadrons DEPFET (first DUT integration) and SiLC use the telescope	
12 / 2007, DESY	FCAL uses the telescope	
04 / 2008, Cadarache	Telescope DAQ used for neutron measurements at the AMANDE facility	
05 / 2008, SPS	SiLC uses the telescope	
07 / 2008, PS	CALICE uses the telescope	
08 – 09 / 2008, SPS	MimoRoma, DEPFET and LCFI use the telescope	

- Up to **6 planes in 2 boxes**
- Possible to include a high resolution sensor (10 µm pitch) close to Device Under Test (DUT)
- Complete system includes cooling, Mechanics, DUT positioner and scintillators
- Can be transported from DESY to CERN (PS and SPS) and other locations

User integration:
- The DUT can be connected to the TLU or better integrated to the EUDET DAQ system
- For the offline analysis a track file can be provided or the DUT can be integrated in the analysis stream
We provide help and examples for both steps!

Telescope mechanics
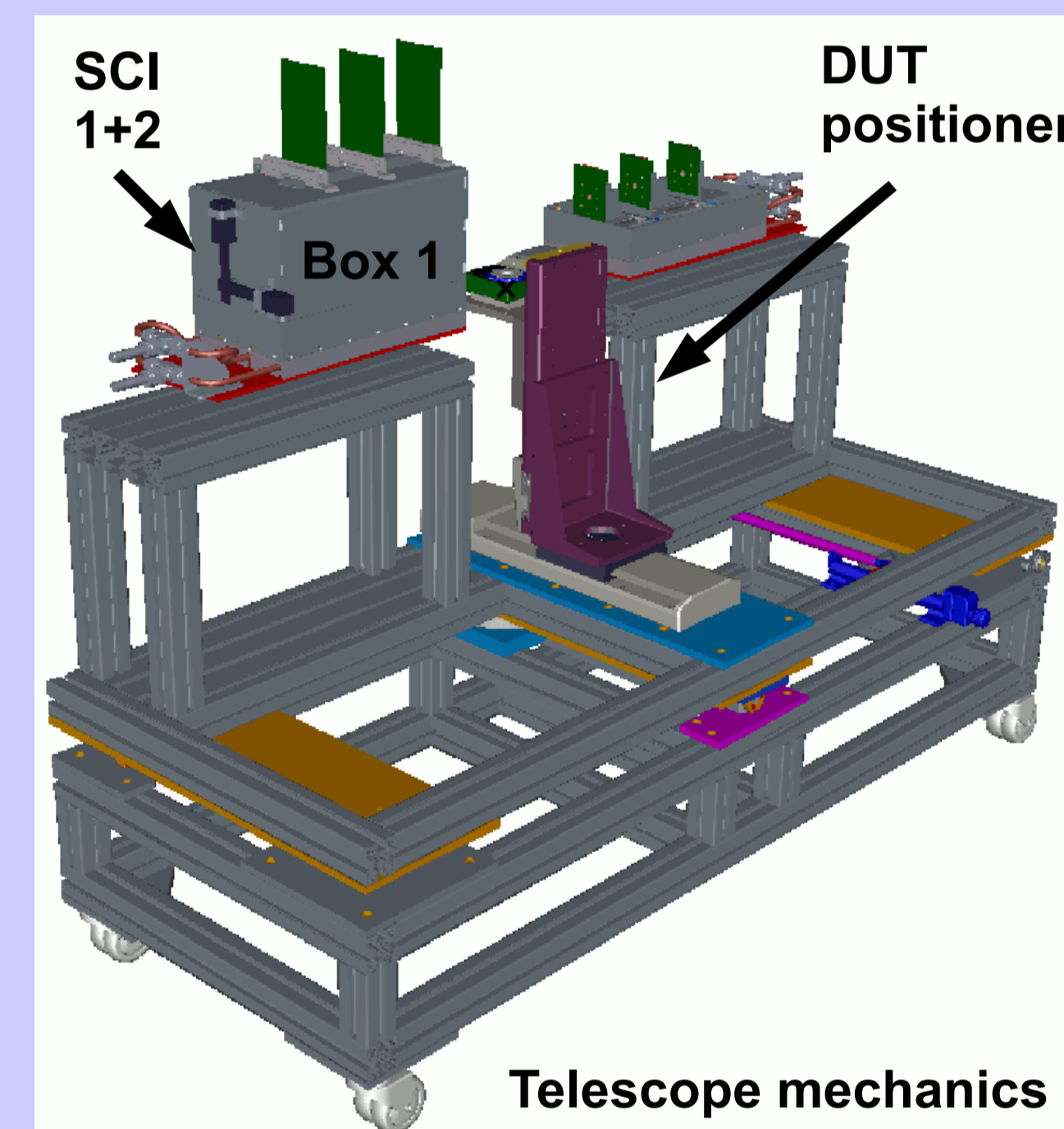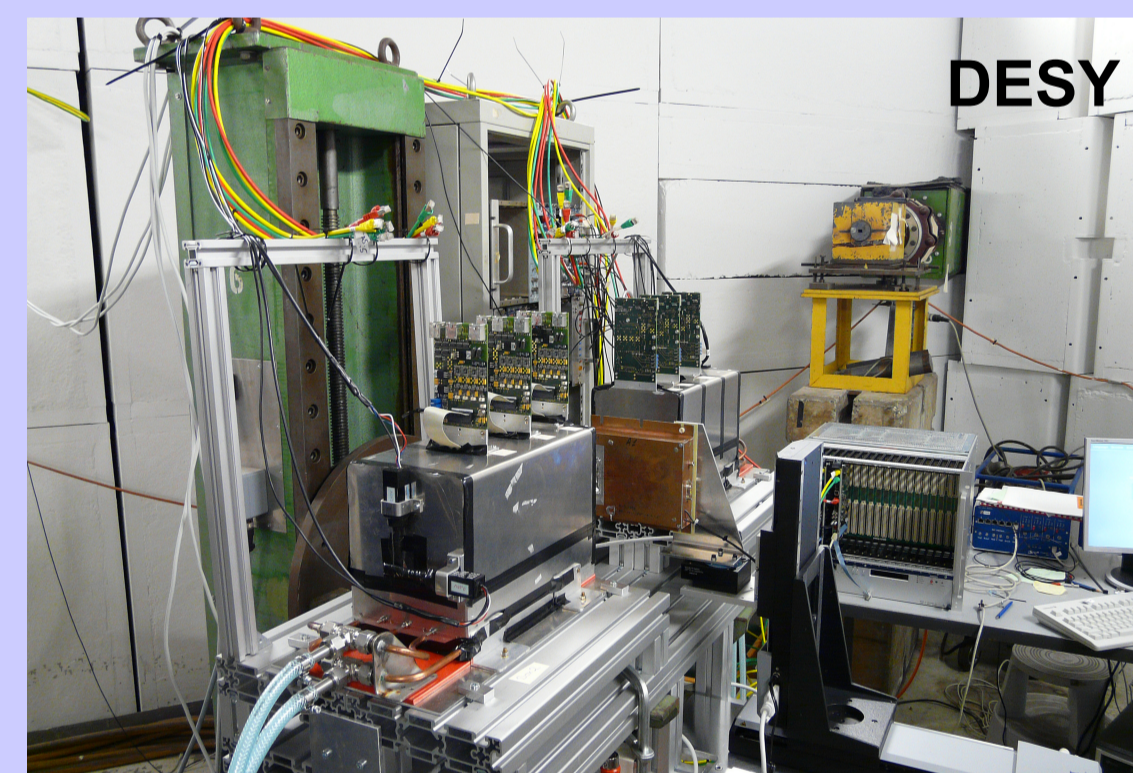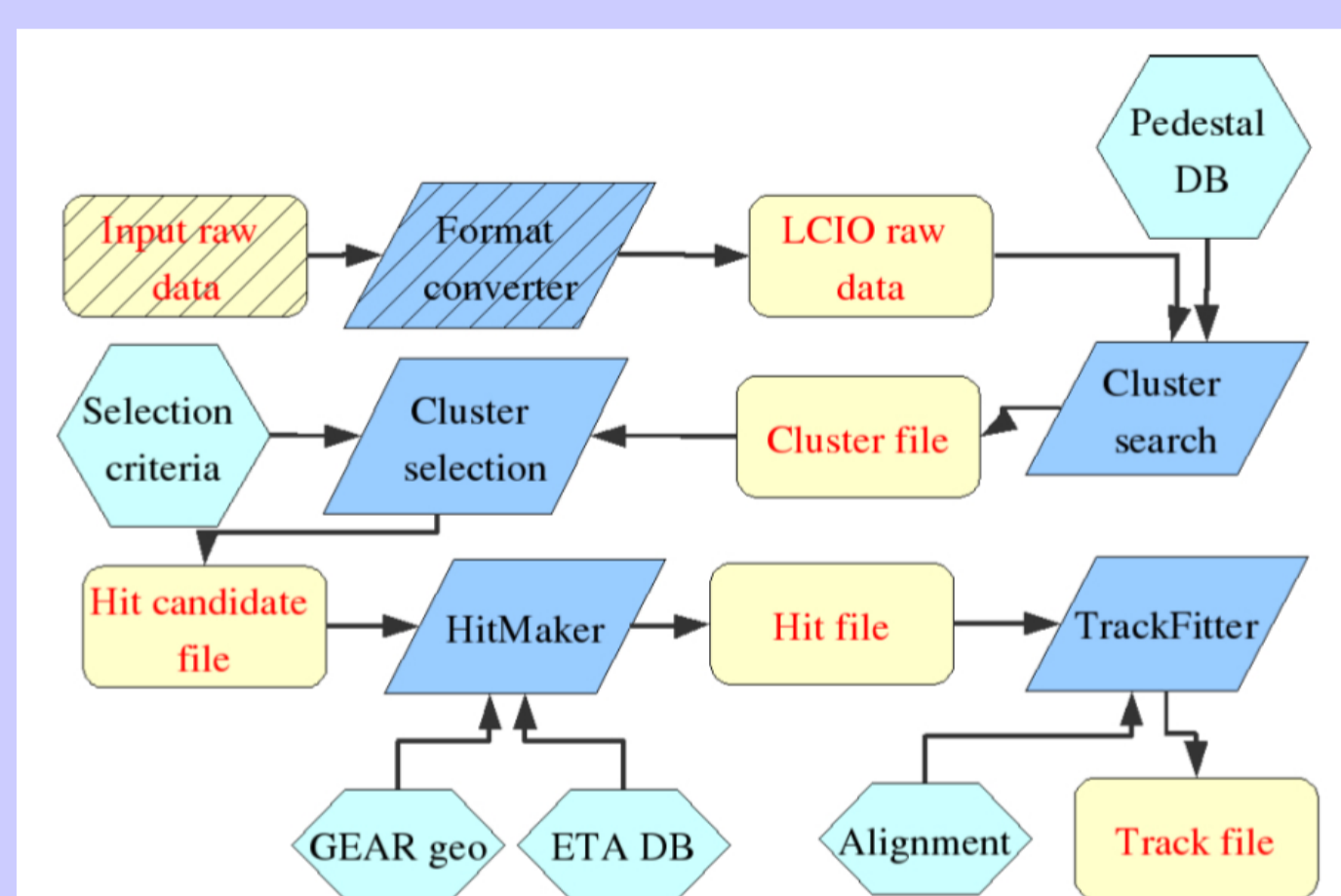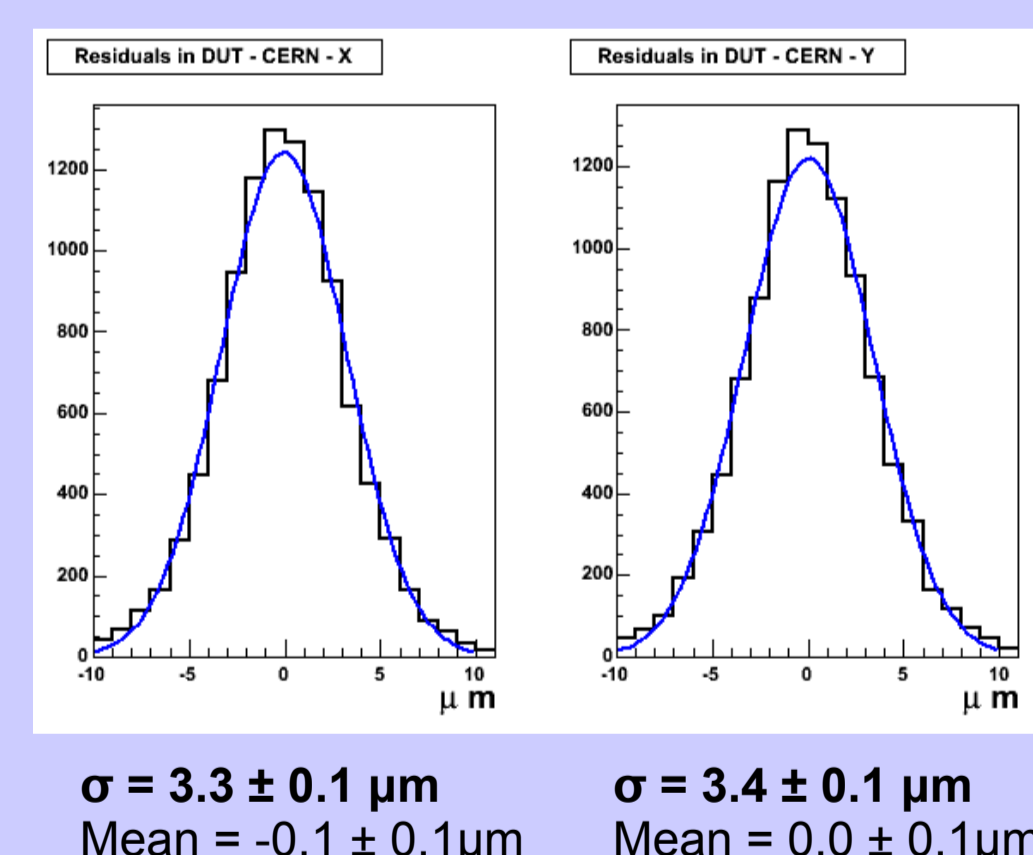
Resolution with 180 GeV hadrons
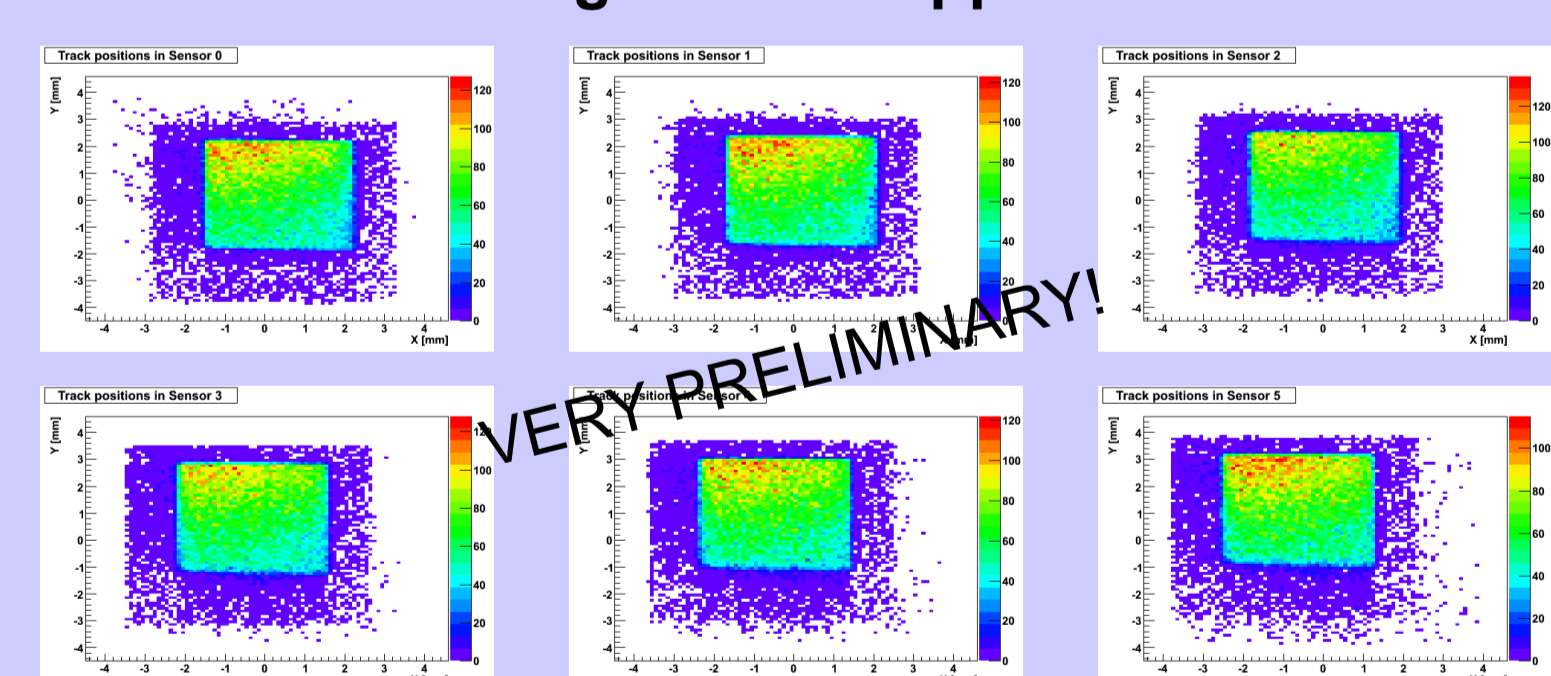
- Multiple scattering can be neglected → Fit straight tracks

- "DUT mode": the middle sensor (out of 5) is not used in the track fit

Observed width: σ = 3.4 µm (consistent with
$\sigma_{MimoTEL}$ = 3.0 µm and
$\sigma_{Telescope}$ = 1.6 µm)

σ = 3.3 ± 0.1 µm
Mean = -0.1 ± 0.1µm

σ = 3.4 ± 0.1 µm
Mean = 0.0 ± 0.1µm

Testbeams in summer 2008

Full system at CERN (taking data at the moment):
6 Sensors running in zero suppressed mode

VERY PRELIMINARY!

Multiplicity is low (1 track / event)
→ Trigger window (4x4 mm) is visible.

The alignment procedure

- The alignment procedure is based on the MILLEPEDE II program
- A simultaneous fit using full tracks if performed to derive the alignment parameters

Typical values of the alignment constants:
- Shifts perpendicular to the beam:
a few hundred micros
- Rotation around the beam axis:
a few mrad

Test with 3 GeV data recorded at DESY

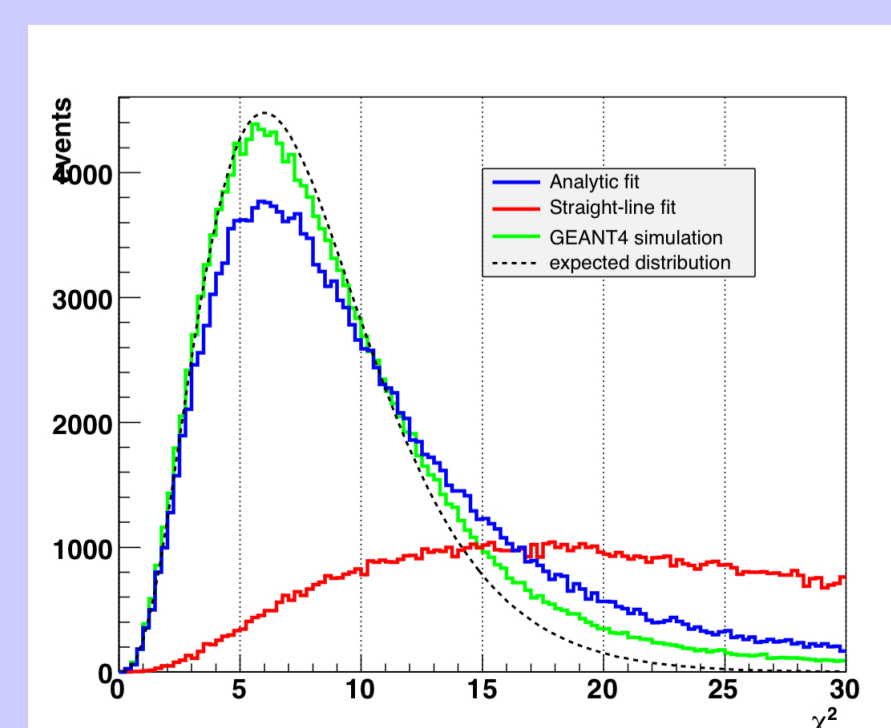| Sensor	Residuals X Mean [µm]	Residuals Y Mean [µm]
0	-0.003 ± 0.002	-0.023 ± 0.002
1	-0.015 ± 0.004	0.036 ± 0.005
2	0.032 ± 0.004	0.005 ± 0.005
3	-0.020 ± 0.004	-0.005 ± 0.005
4	0.001 ± 0.002	0.002 ± 0.002

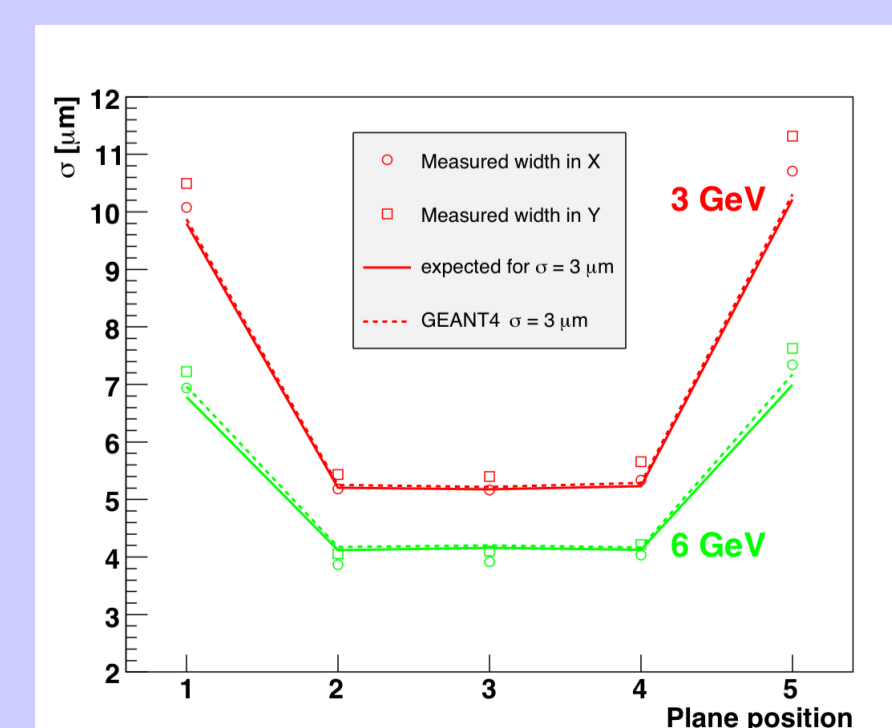→ **Alignment precision better than 0.05 µm!**
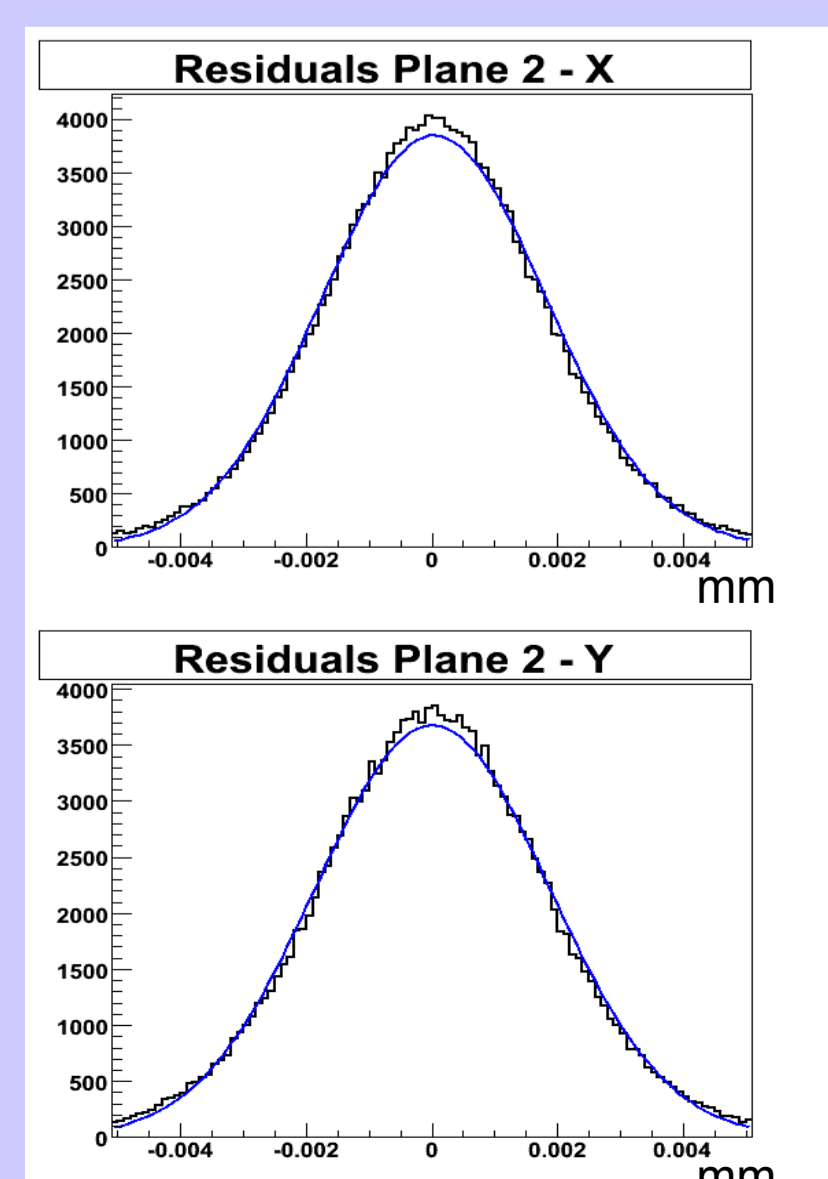
Resolution with electrons

The testbeam at DESY provides 3 and 6 GeV electrons.
→ **Analytic fit takes multiple scattering into account**

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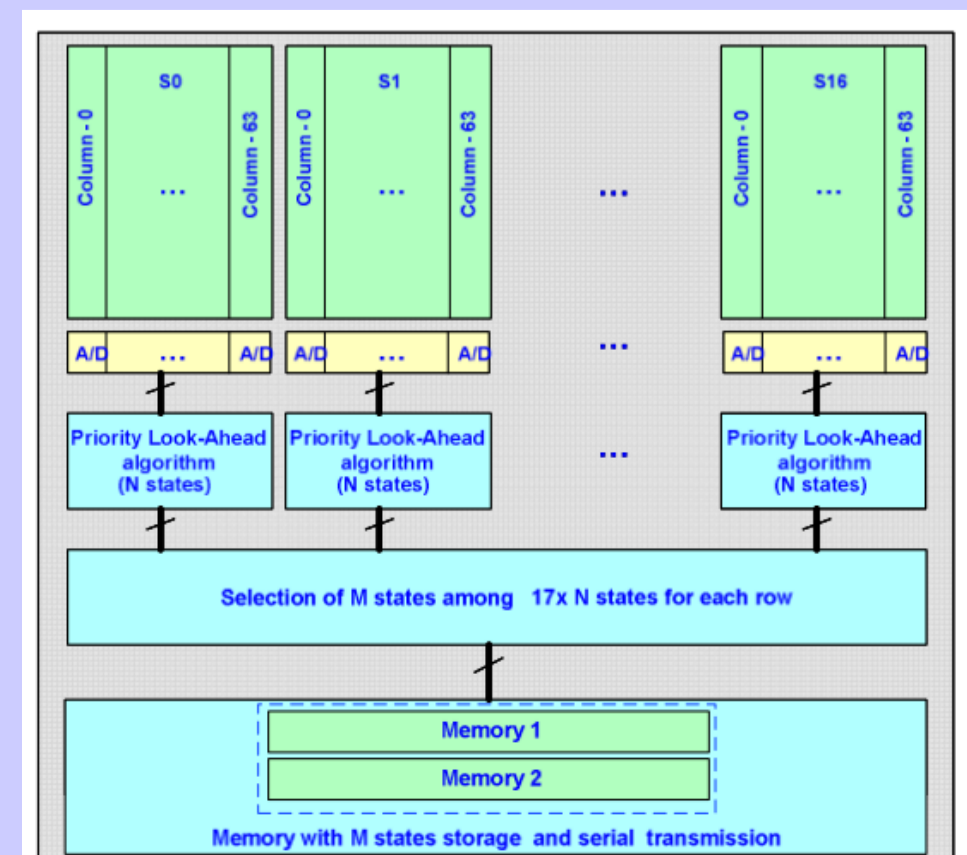
position measurement   multiple scattering

Good agreement between measurement, expectation and GEANT4

Observed residual widths for different telescope sensors used as DUT

Outlook: Mimosa 26

Sensor for the final telescope:
Mimosa 26
= Mimosa 22 (binary output)
+ SUSE01 (hardware clustering and sparsification)

Main parameters:
- 1152 x 576 pixels
- 18.4 µm pixel pitch
- 21.2 x 10.6 cm² active area