TB 2008 Analysis in Valencia

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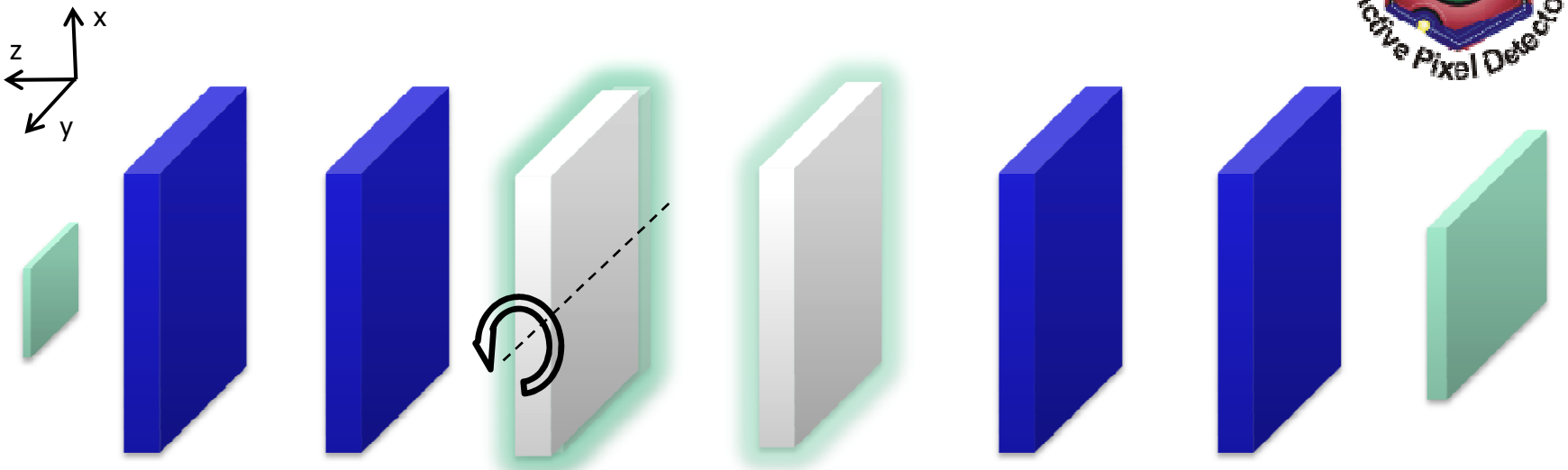
Test Beam Setup



Telescope:

- 4 DEPFET planes
- 32x24μm²
- CCG
- 450 μm thick

DUT:

- 2 DEPFET modules
- Various pixel sizes
- 450 μm thick
- 1 rotating motorstage

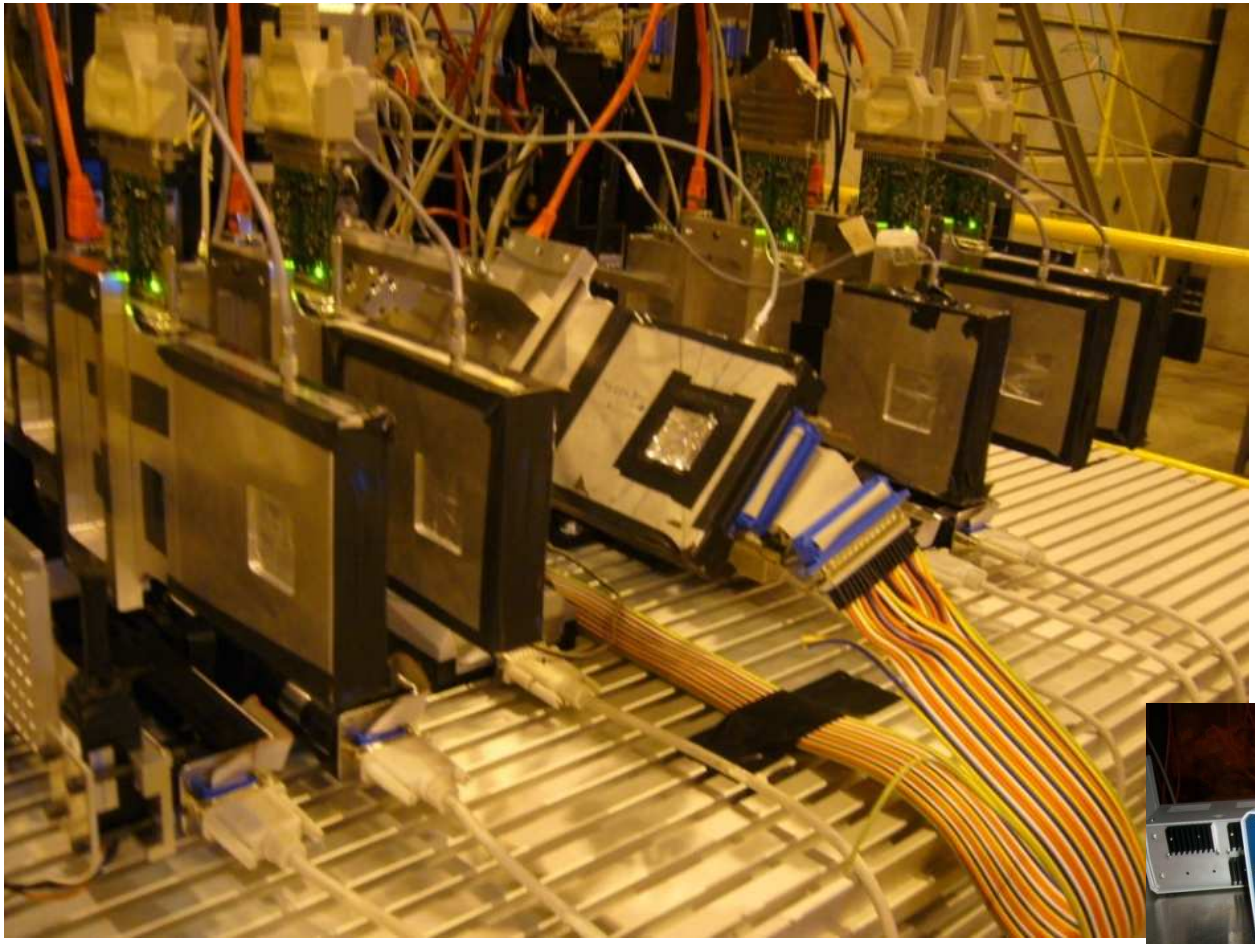
Scintillators:

- 1 Big "Beam finder"
- 1 Finger "Beam allignment"
- Triggering

Trigger Synchronization
via TLU[1] (Trigger Logic Unit)

1.- D. Cussans, EUDET-Memo-2007-02

Test Beam Setup



- General view
- 6 Modules at once
- 1 rotating module

Trigger Logic Unit

SPS Time Measurements: 3 weeks of data

- **Voltage scans:** Cross-check, we're running in optimal settings
  - V_{Bias} to the waffer 150-220V
  - V_{Edge}
  - $V_{ClearHigh}$
- **Angular scan:** To study resolution vs. Cluster size
  - -5, -4, -3, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 3, 4, 5, 6, 9, 12, 18, 36
- **Beam energy scan:** To analyse wheter the separation "multi-scattering-intrinsic resolution" is performed correctly
  - 20, 40, 60, 80, 120 GeV
- **Large statistics:**
  - Charge collection uniformity studies
  - In-pixel studies

3.5 TB of data

20 Million events

Analysis framework: ILC (EUTelescope[1]) Software

Standard analysis tools and reconstruction software used by the ILC community

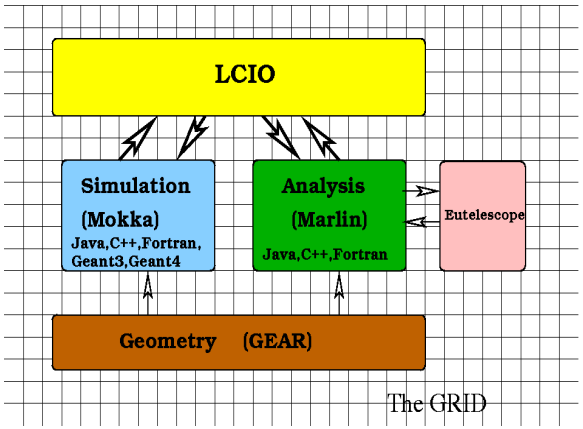
EUTelescope

RAW DATA Reader/Converter ----> Convert DEPFET raw data to LCIO

PedestalNoiseProcessor	Pedestals and noise (adapted to DEPFET row wise com. mode correction)
ClusterFinder	Seed and neighbours cuts
ETACorrection	LCIO ETA→Center of cluster
HitMaker	From cluster to space point
Aligment	MILLEPEDE[2]→Alignment const.
TrackFit	

Analysis

Tools used during processing chain →



1.- Bulgheroni et al, EUDET-Memo-2007-20

2.- Volker Blobel, Millepede II, desy.de/~blobel/

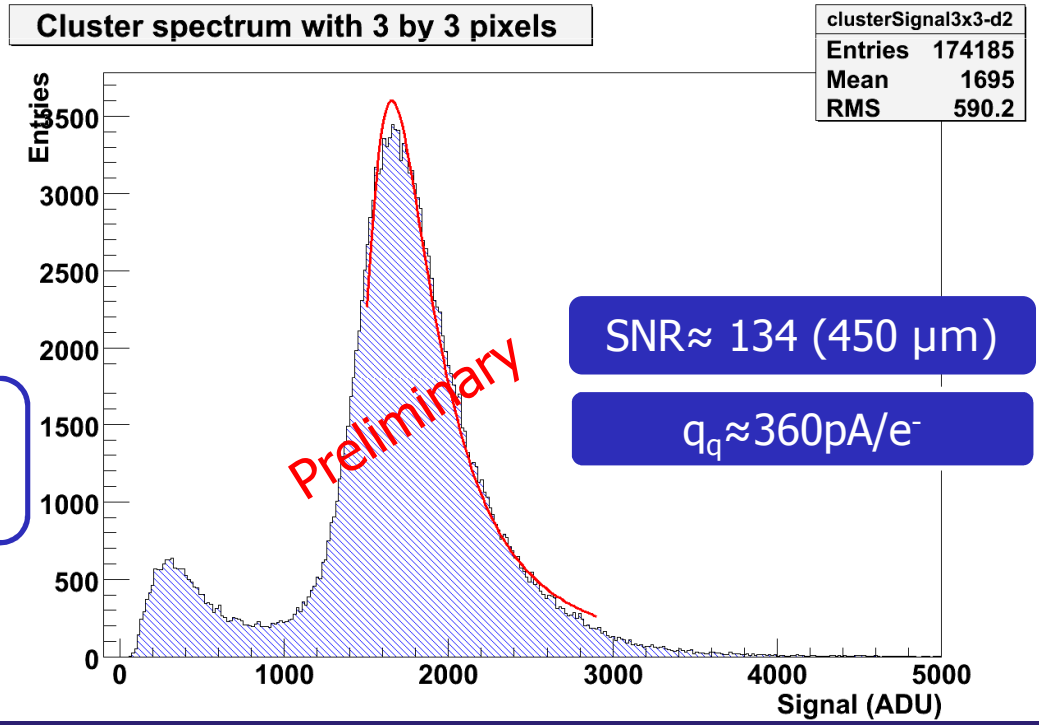
Signal clusters and SNR

- Clustering:
  - Seed: Pixel with largest signal. Requires signal >7σ (seed cut) in central area.
  - Neighbours: Pixels with signal ≥2σ in NxN region around the seed
- Noise:
  - Determined from pedestal variations after common mode substraction

Cluster size	Signal (ADU)
3x3	1715±1
5x5	1725±1

Signal is confined in 3x3 cluster

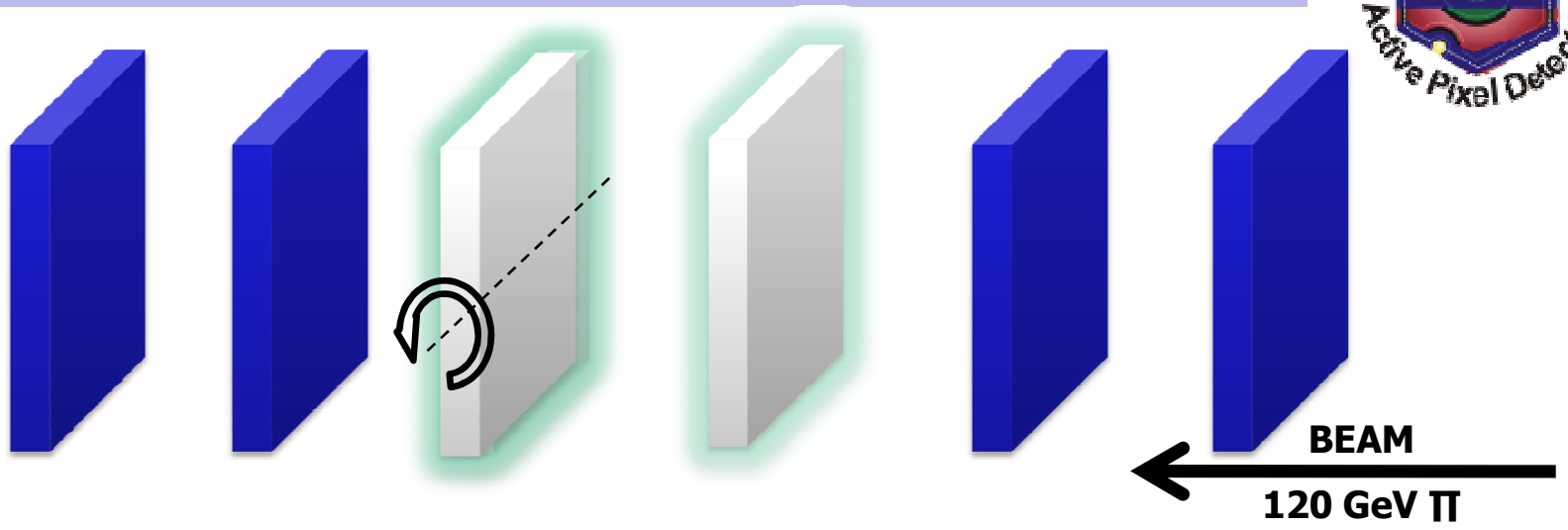
Noise≈ 12.7 ADU≈286e⁻



SNR≈ 134 (450 µm)

q_q≈360pA/e⁻

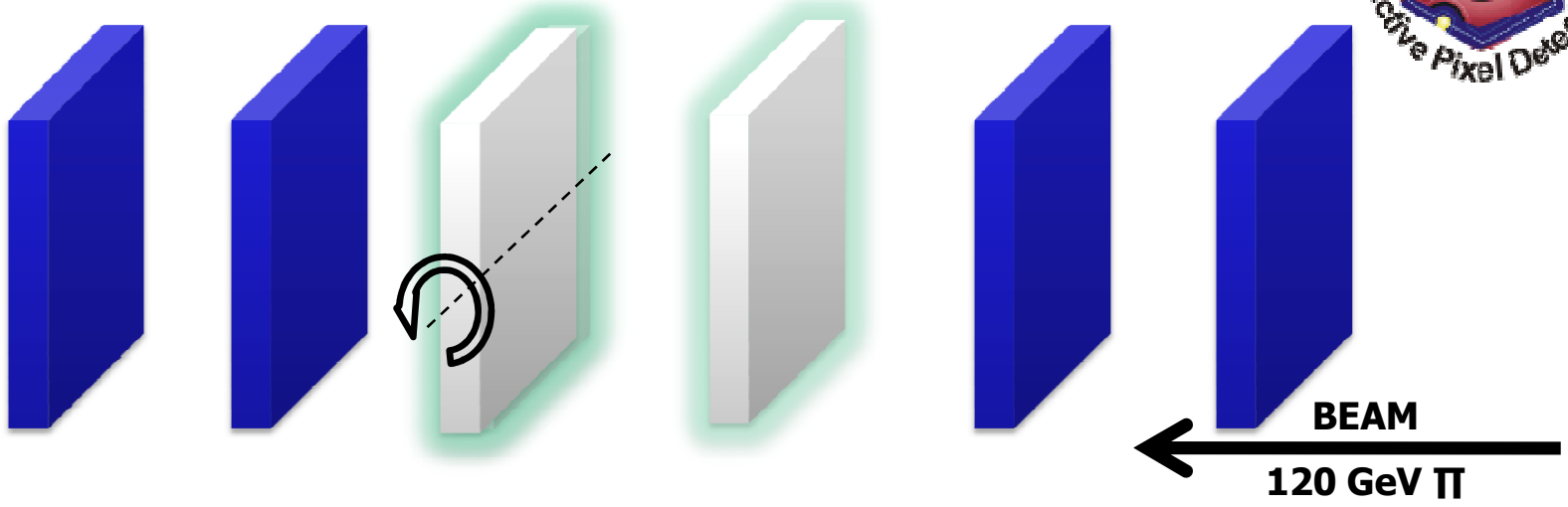
- To summarize



	d0 (32x24)	d1 (32x24)	d2 (24x24)	d3 (32x24)*	d4 (32x24)	d5 (32x24)
Sig3x3(ADU)	1339	1497	1704	1715	1508	1654
Noise (ADU)	12,7	13,4	12,7	13,4	12,8	13,2
SNR	105	112	134	128	118	125
SeedSignal(ADU)	69%	56%	59%	61%	63%	64%
ENC (e^-)	345	326	286	284	309	290
g_q (pA/e^-)	283	316	360	363	319	350

*CCCG: Average value between two halves

CCCG: Test Beam vs. Lab measurements



Module d3: Capacitatively Coupled Cleargate… **a problem with the power supplies??**

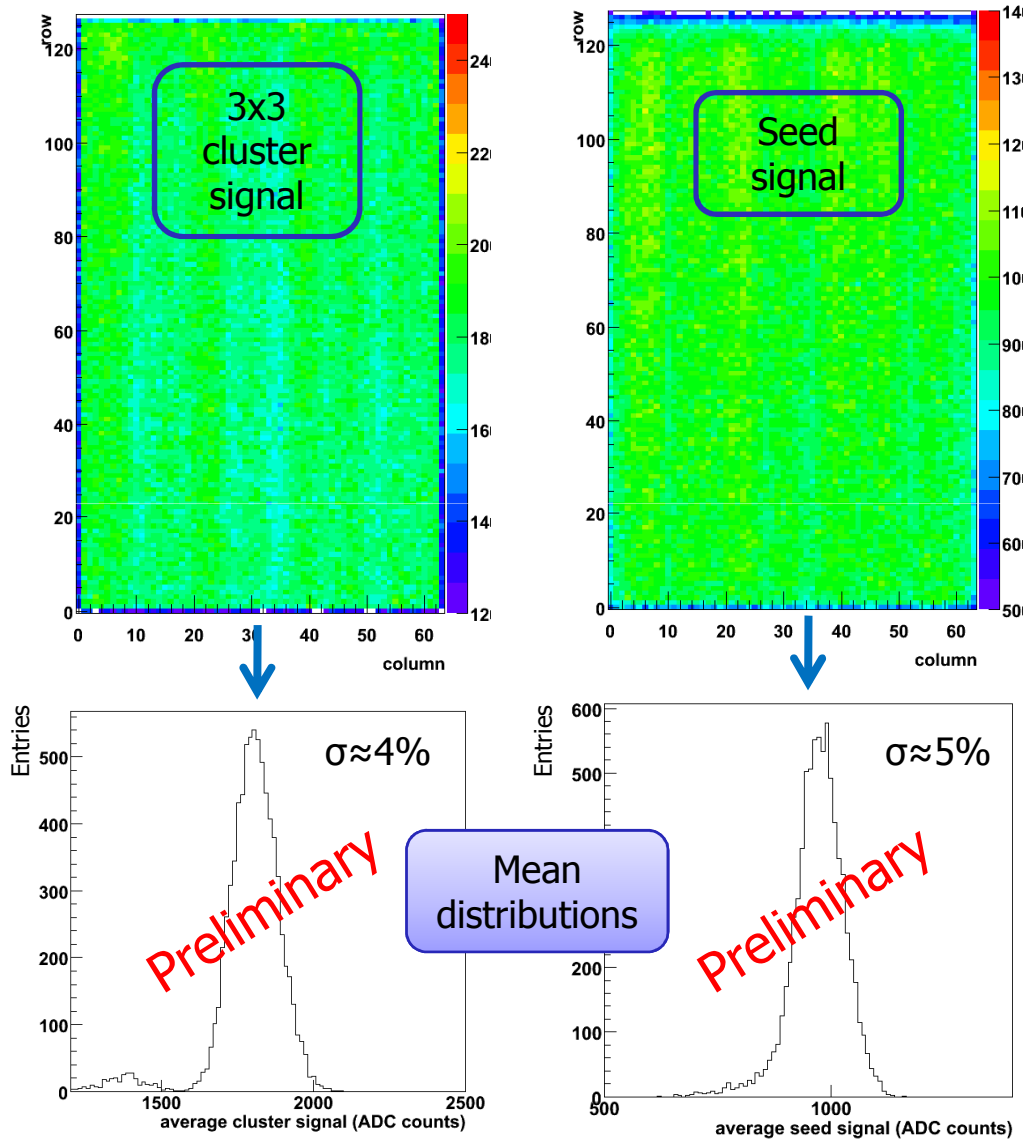
Test Beam

- CCCG part:
  - g_q=372pA/e$^-$
  - ENC=277e$^-$
- Standard part:
  - g_q=355pA/e$^-$
  - ENC=291e$^-$

Lab tests

- CCCG part:
  - g_q=433pA/e$^-$
  - ENC=231e$^-$
- Standard part:
  - g_q=301pA/e$^-$
  - ENC=332e$^-$

Charge collection uniformity

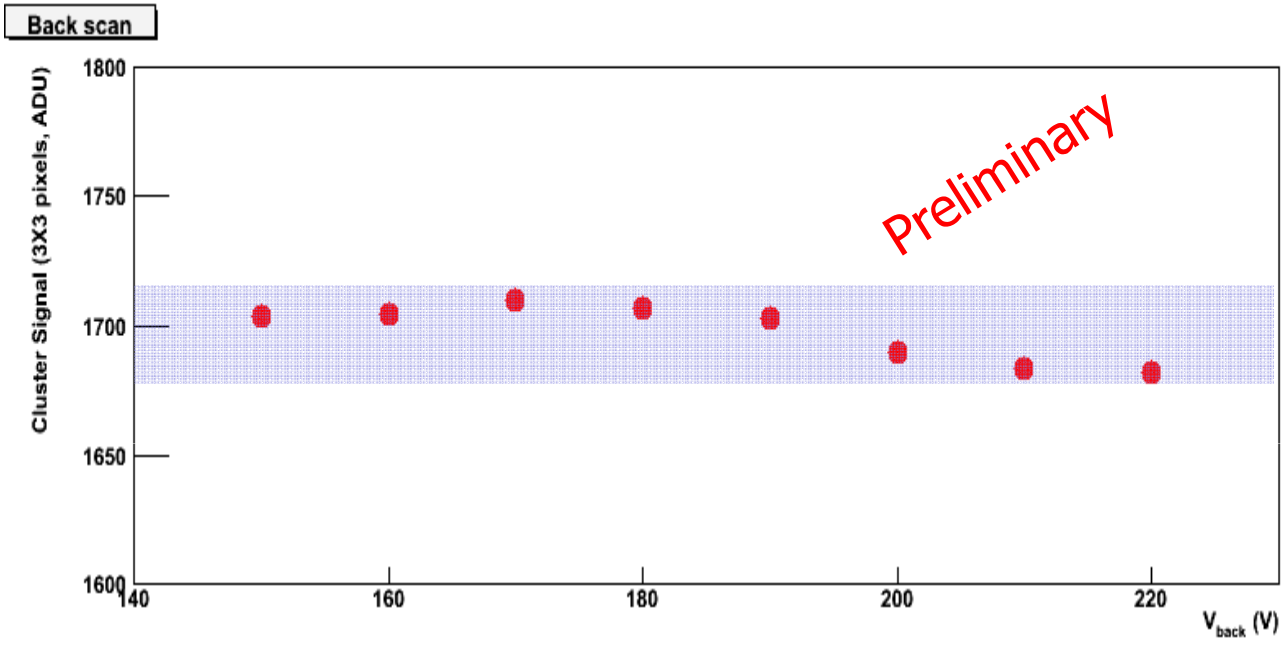


Mean distributions

Mean signal collected on each pixel using 400 MIP's

- Uniform charge collection over the surface of the matrix (less than 5% of variation)
- No masked pixels

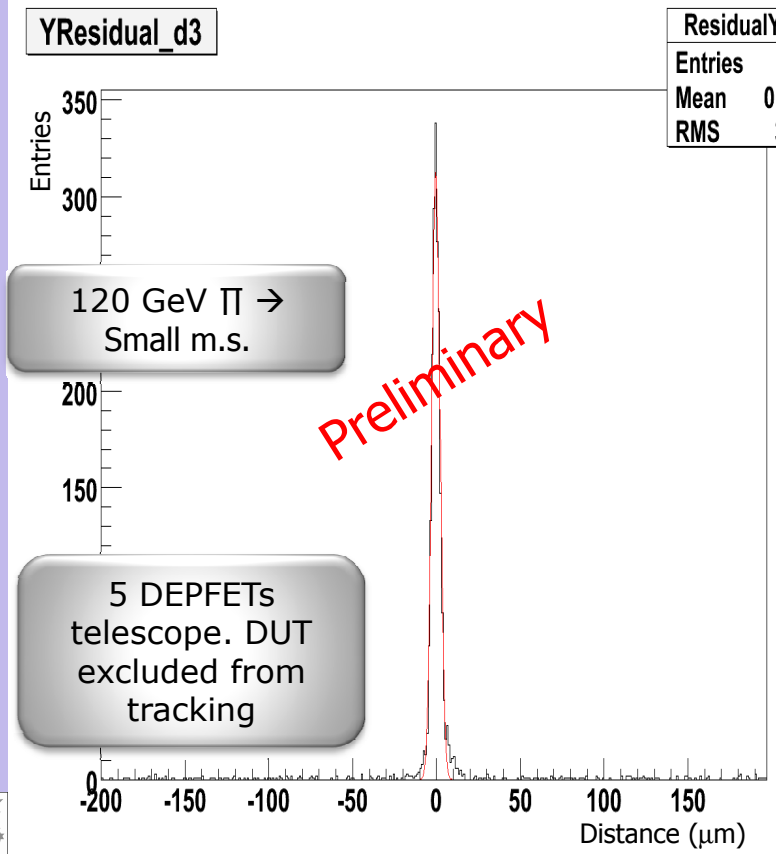
Cluster Signal vs. Bias Voltage



V_{back} (V)	Sig 3x3 (ADU)	Sig 5x5 (ADU)
-150	1704	1720
-160	1705	1717
-170	1715	1725
-180	1707	1707
-190	1703	1706
-200	1690	1691
-210	1684	1684
-220	1682	1686

- Allways working under fully depletion conditions→Charge collection plateau
- Depletion achieved at 'low' voltages ~160V

Position resolution



Module id	Pitch(μm²)	Res X(μm)	Res Y(μm)
d0	32x24	5,6	3,9
d1	32x24	5,0	4,2
d2	24x24	3,5	2,8
d3	32x24	4,3	2,5
d4	32x24	3,9	2,8
d5	32x24	4,9	3,4

$$\sigma^2_{Total} = \sigma^2_{Telescope} + \sigma^2_{DUT} + \sigma^2_{MS}$$

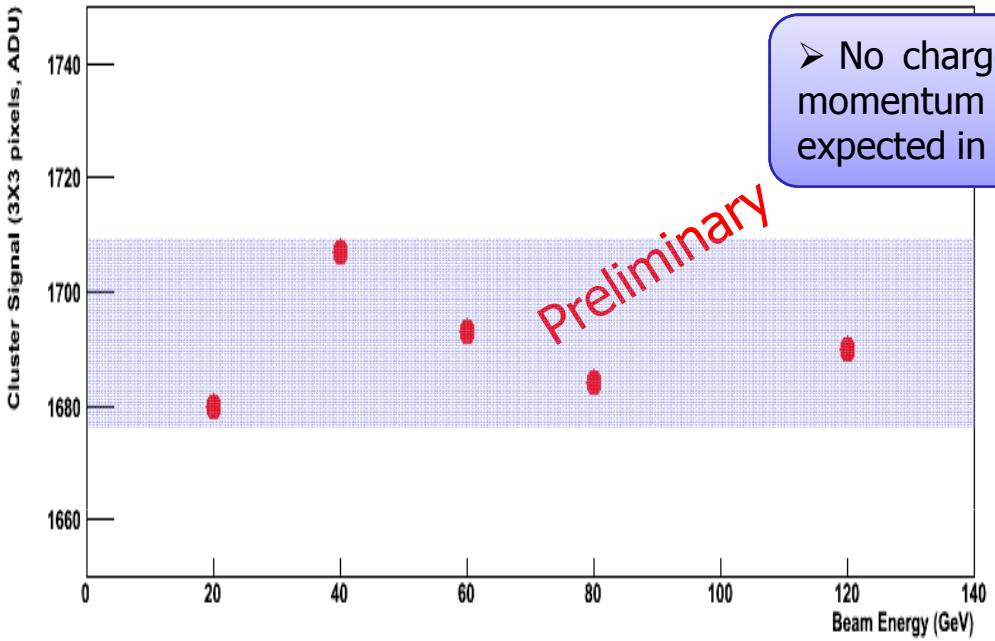
This residuals include telescope, intrinsic and multiple-scattering contributions

- Updated results. A bug was found in the code while trying to exclude the DUT from the fit
- We will try to refine this numbers with a new tracking method

Residuals: Difference in position between the resulting track and the found hit

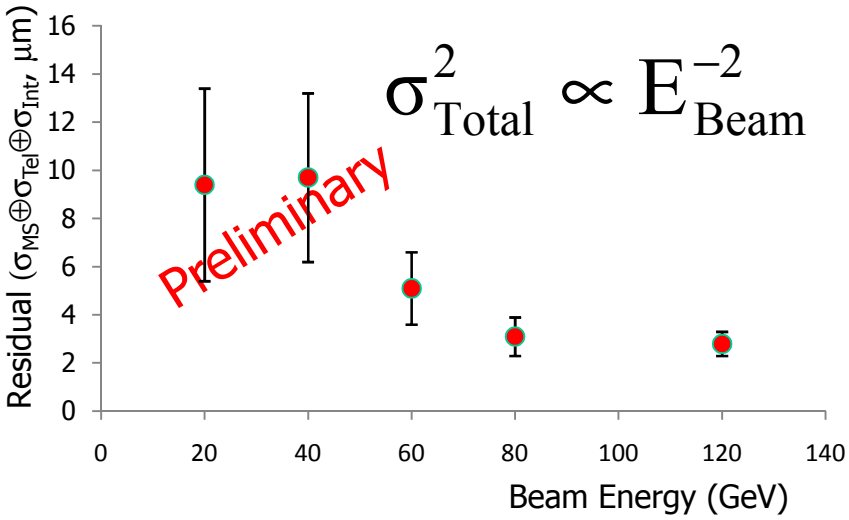
Resolution: Standard deviation of the residual distribution

Pion beam energy scan



➢ No charge variation → No momentum dependence, as expected in this range![1]

E_{Beam} (V)	Sig 3x3 (ADU)
20	1704
40	1705
60	1710
80	1707
120	1703



Study the contribution of σ_{MS} to the σ_{Total}

1.- Hancock et al. Phys. Rev. A 28, 615-620 (1983)

Conclusions

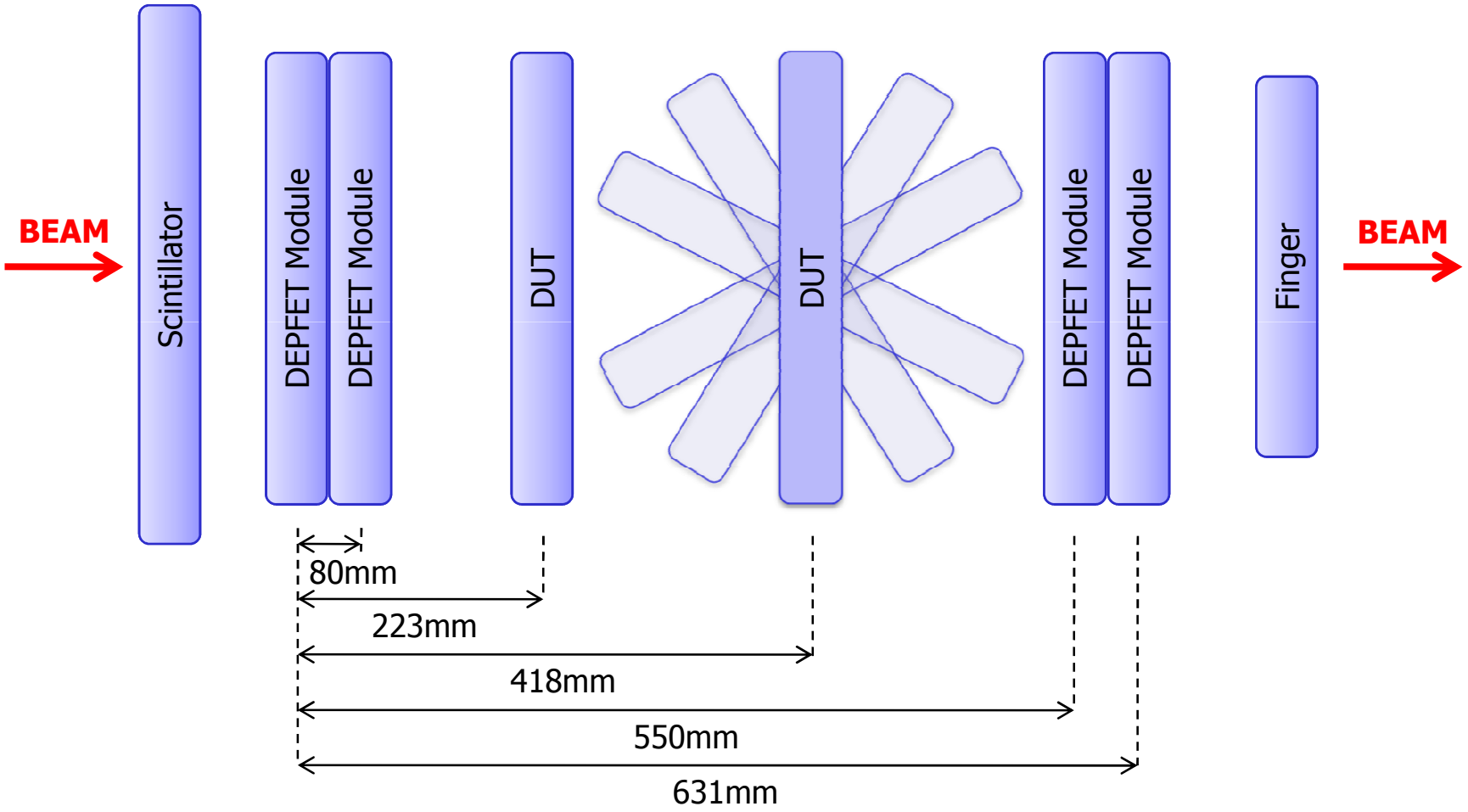
- Test Beam at CERN: Operational aspects
  - 6 DEPFET planes (64x128 pixels matrices) working at the same time on beam. 5 telescope planes and 1 DUT.
  - 20 Mevents collected. Analysis in progress!

- Data analysis and processing
  - DUT (450µm thick) presents good SNR, low noise and high gain.
    - For 50µm, SNR will be smaller by a factor 9.
  - Matrix working in optimal settings, cross check with lab measurements.
  - Position resolution ~2,5µm, including telescope, intrinsic and multiple-scattering contributions.
  - Energy scan could helps to separate the m.s. resolution contribution.
  - Charge uniform over the matrix surface. No masked pixels.

Thank you very much!

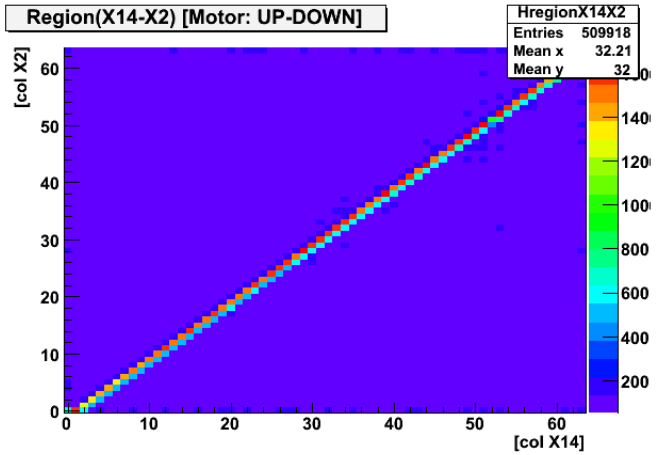
Backup slides

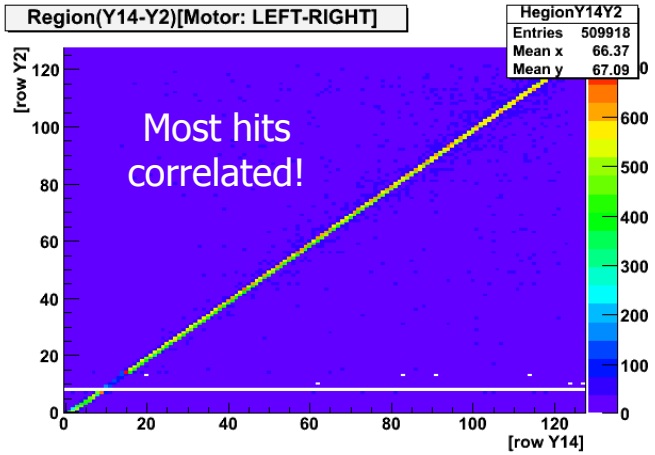
Test Beam Setup: Geometry

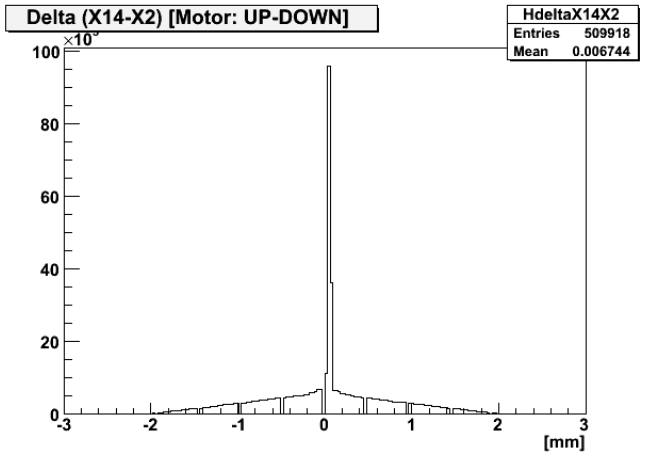


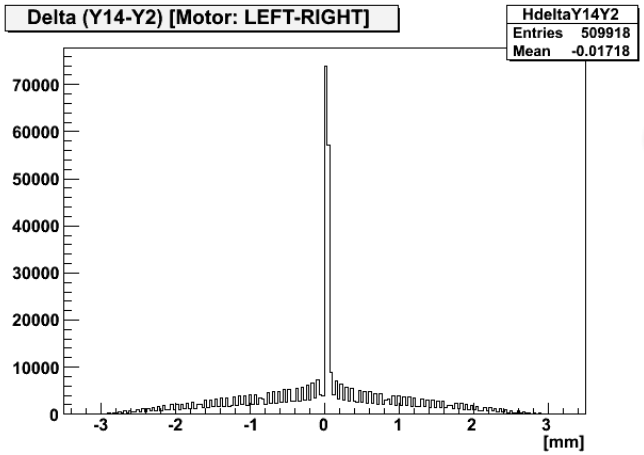
Correlation plots

X and Y hit coordinates in DEPFET plane 1 versus X and Y coordinates in plane 2



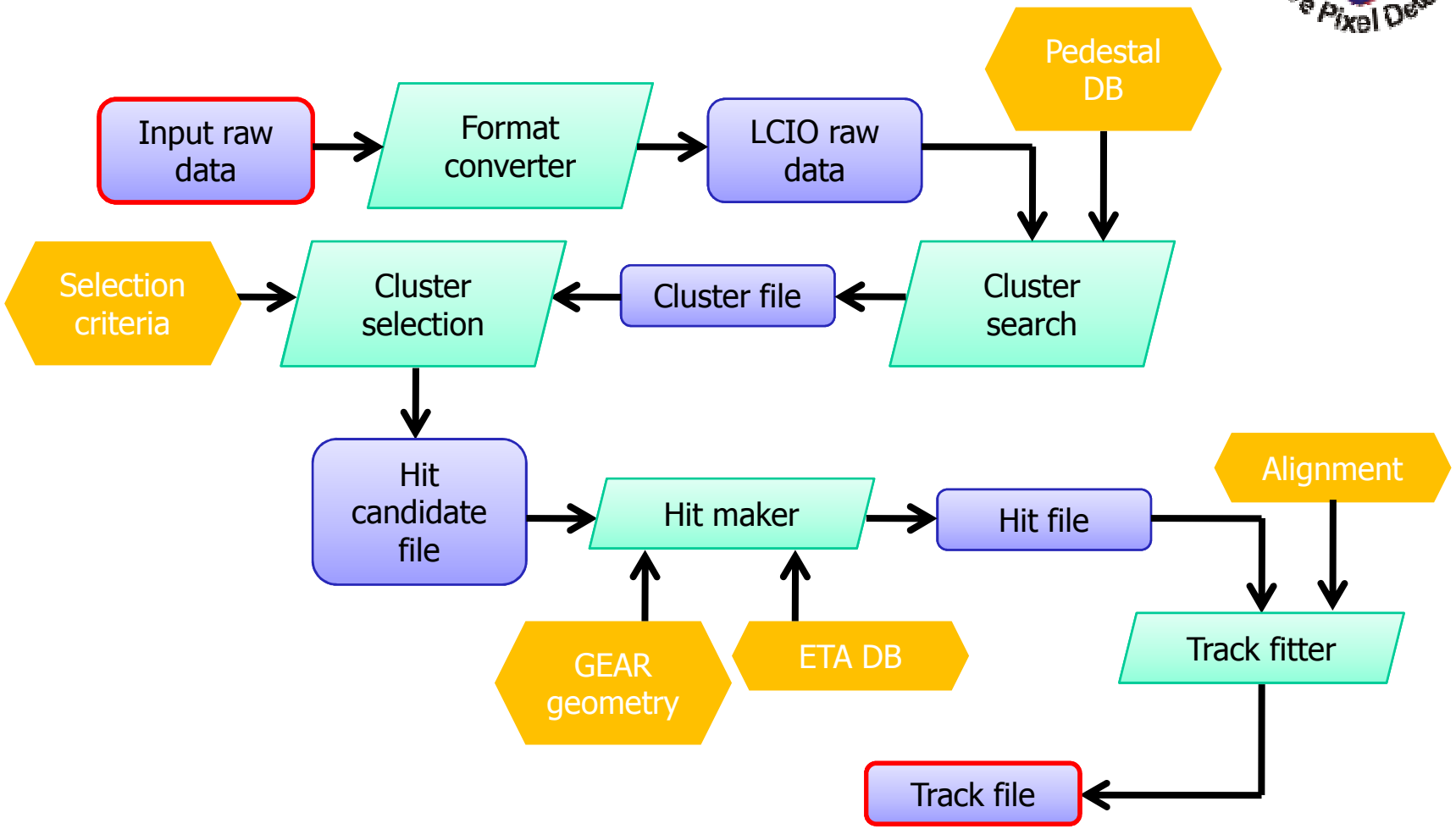




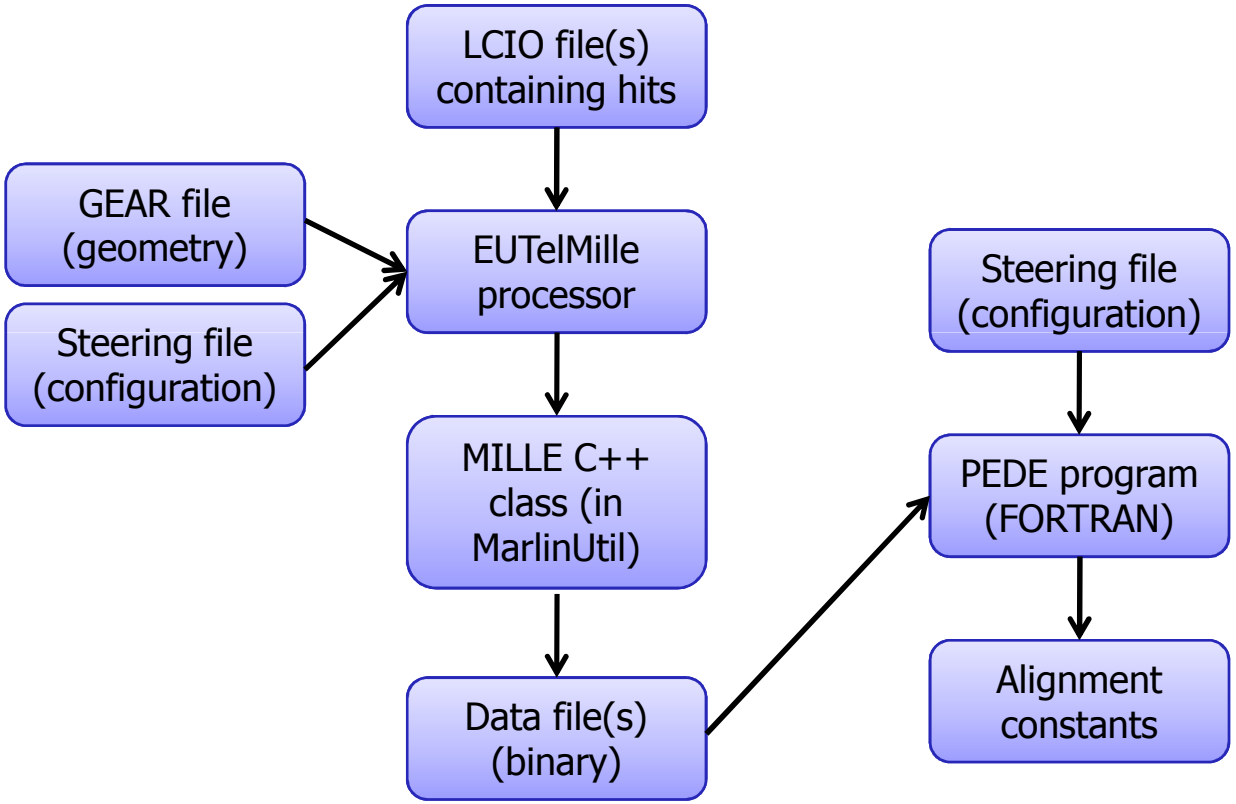


Used for pre-alignment!

Analysis framework: Overall analysis strategy



Analysis framework: MILLEPEDE II in EUTelescope



Analysis framework: ILC (EUTelescope) Software

RAW DATA Reader/Converter → Converts the native raw DEPFET format (.dat) to the LCIO (Linear Collider Input-Output) raw format, with the proper event structure and the correct event model

PedestalNoiseProcessor → Calibrate the output of each pixel detector in order to remove the constant and useless signal. Together with this pedestal value also the noise figure is estimated as the witdth of the pedestal distribution. This can be done in two different ways: Producing the pedestal and noise from a specific run or assuming a known initial value and then keep them update

ClusterFinder → Scan the matrix looking for clusters mean to look for a group of space correlated pixels all having signal above a certain threshold.

ETACorrection → Used to calculate the center of the cluster. It is used as a non linear weighting function in the charge center of mass calculation. Is an experimental approach based on the fact that the probability to find the cluster center is flat over the pixel sufrace. A certain region does not collect more cluster centers than another. The ETA correction is made in two orthogonal directions

HitMaker → This processor must convert a local cluster in the detector frame of reference to space point in the telescope frame of reference. This processor access to the geometry repository.

Alignment → MILLEPEDE II package. Loops over all events and finds track candidates. Obtain the global parameters → the alignment constants. Linear least squares problem solved by a simultaneous fit of all parameters. A large number of tracks can be considered for the alignment.

Gain and noise

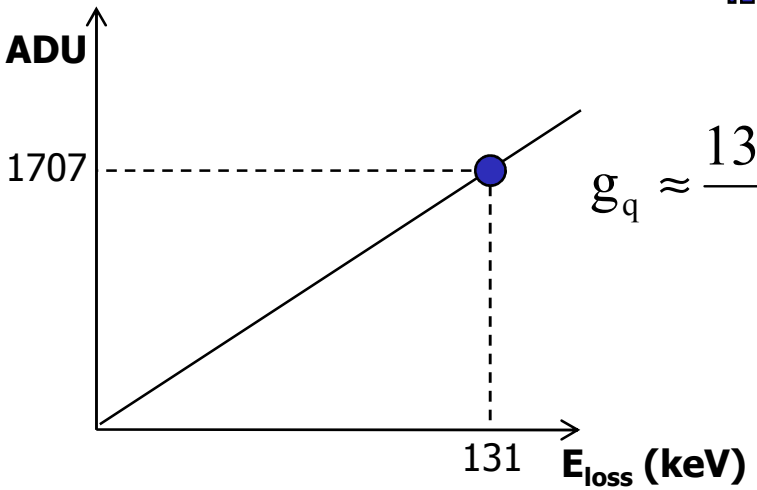
• The most probably energy loss for a MIP in 450µm of Silicon is[1]:

$$\Delta_{mp} = 450\mu m \cdot 0.75 \cdot 388\, eV/\mu m = 35700 e^- = 131 keV$$

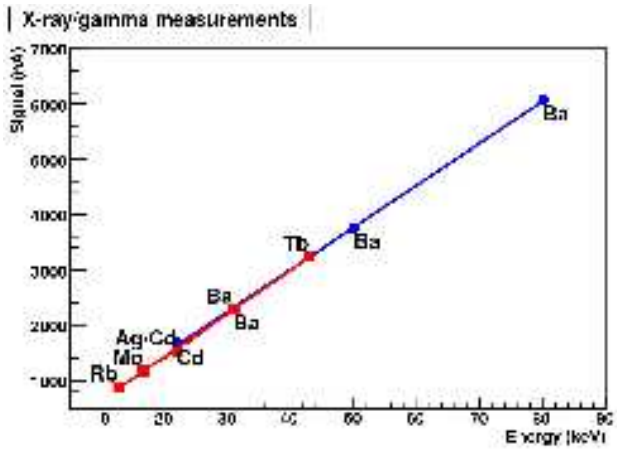
DEPFET Thickness | Scale factor | Mean loss per µm

FIT → y=a+bx → Slope=Gain

b=13.0 ADU/keV



$$g_q \approx \frac{13.0\,ADU}{keV} \cdot \frac{7.7nA}{1ADU} \cdot \frac{3.6 \cdot 10^{-3} keV}{1e^-} \approx 0.360\, nA/e^-$$

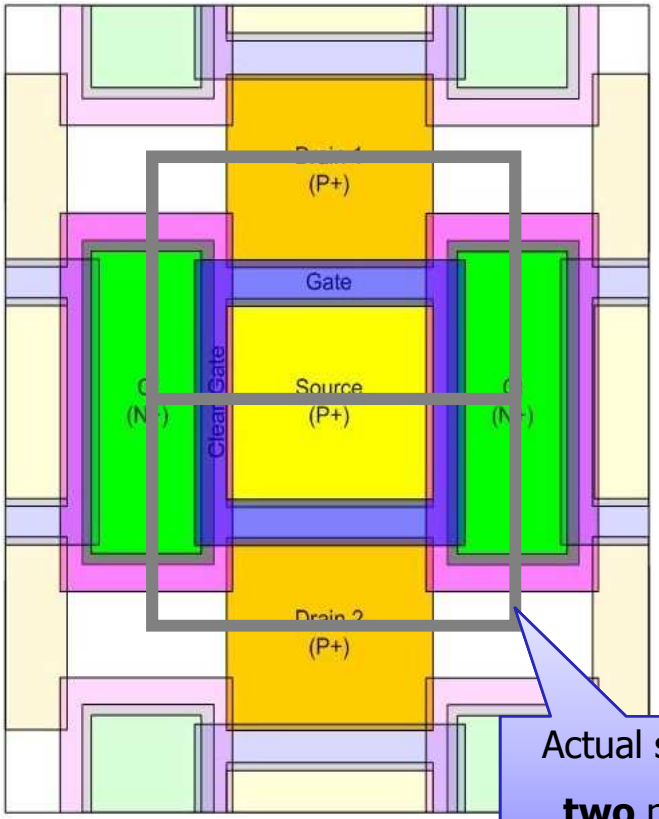


$$ENC = 12.5 ADU \cdot \frac{1 keV}{13.0 ADU} \cdot \frac{1 e^- h}{3.6 \cdot 10^{-3} keV} \approx 267 e^-$$

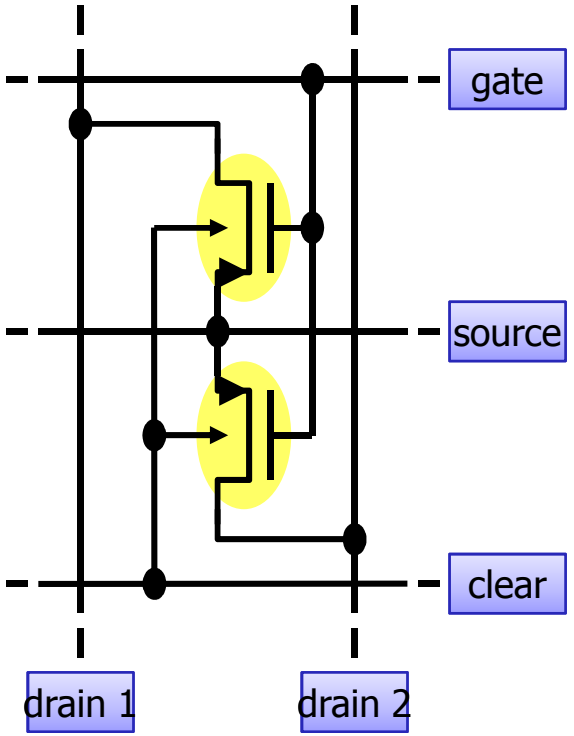
Noise in ADU | Gain | Energy to create e-h

1.- http://pdg.lbl.gov/2008/reviews/passagerpp.pdf

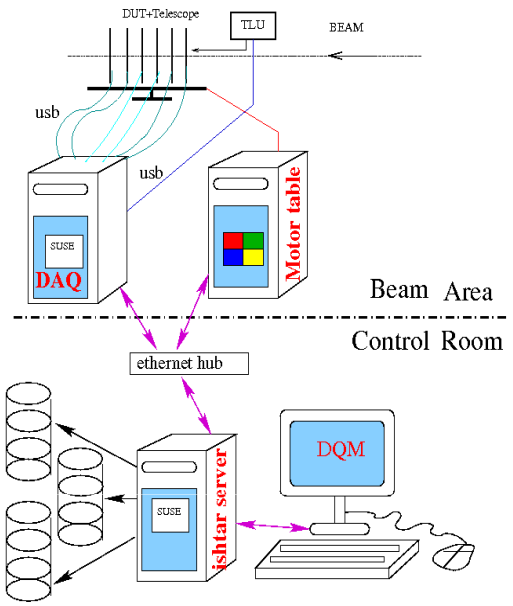
Double pixel structure



Merging two pixels (common source) for reduce the size

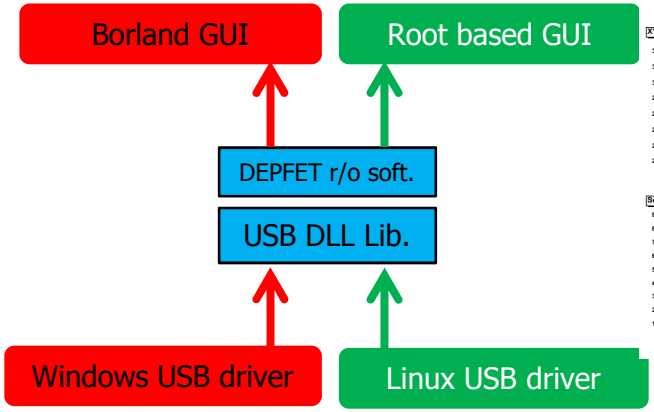


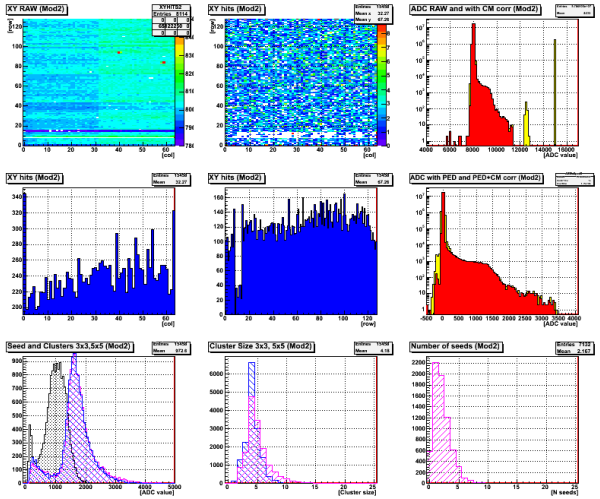
Test Beam DAQ

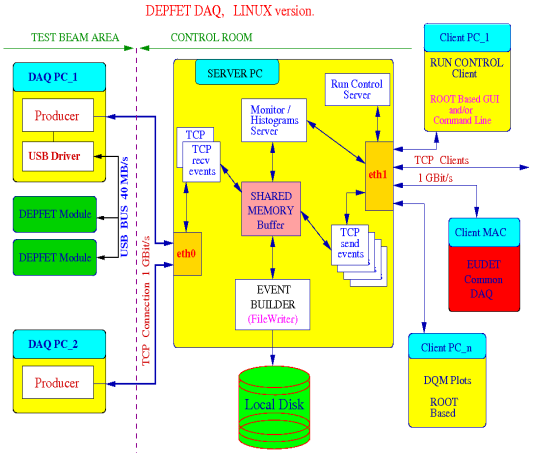


Old Windows DAQ ported to Linux:

- Network distributed system
- Remote control and monitoring
- Easy connection to common DAQ→EUDET DAQ compatible
- Only Open Source software





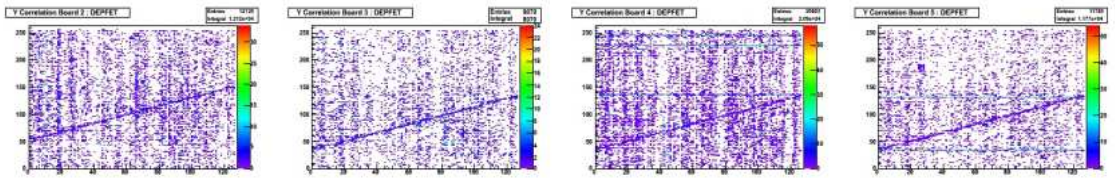


EUDET & DEPFET

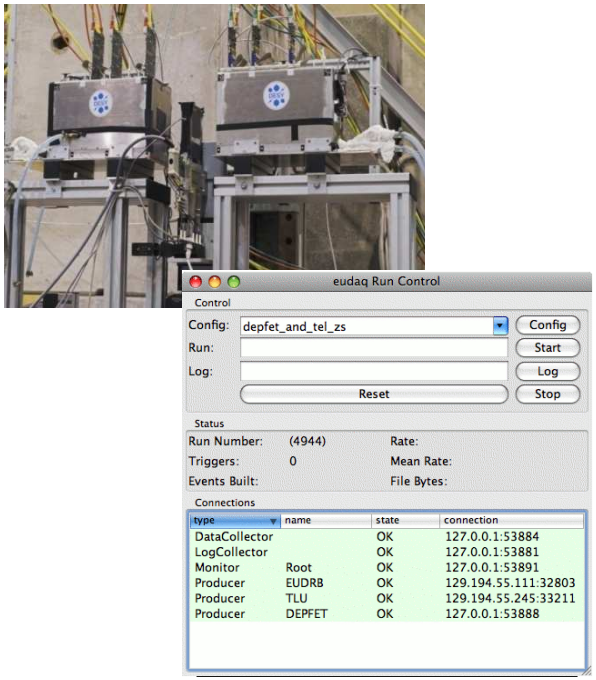
o EUDET → An EU initiative to support detector R&D for a future ILC

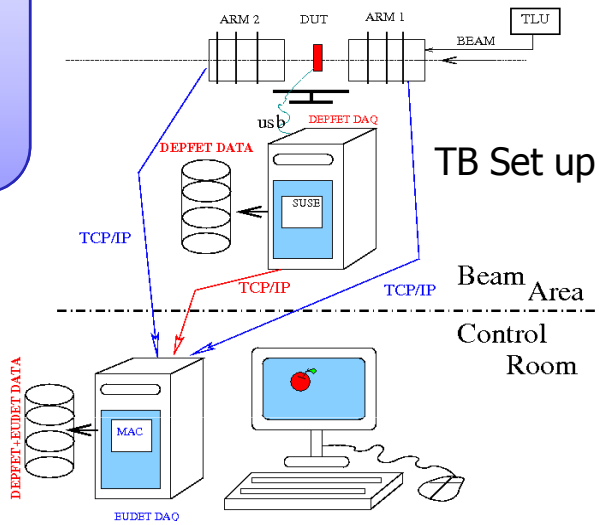
o Beam infrastructure → High resolution pixel telescope using Monolithic Active Pixel Sensors (MAPS) with 256x256 and a pitch of 30µm

o DEPFET → DUT for the EUDET Telescope in TB2008 at CERN (SPS). Significative presence in the EUDET program.



DEPFET & EUDET Correlations





TB Set up

✓ DEPFET was successfully integrated into the EUDET DQM

✓ DEPFET and EUDET Run controls were synchronized→DEPFET software was steered by the EUDET DAQ

✓ DEPFET and EUDET data was merged and stored in a common data file online, using an EUDET "DataCollector".

✓ Special "DEPFET Producer" running on EUDET DAQ responsible for synchronizing data.

✓ 1 Million of events as a DUT during this year