# DEPFET Beam Test Studies in Bonn

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# Test Beam Setup 2008 SPS/CERN

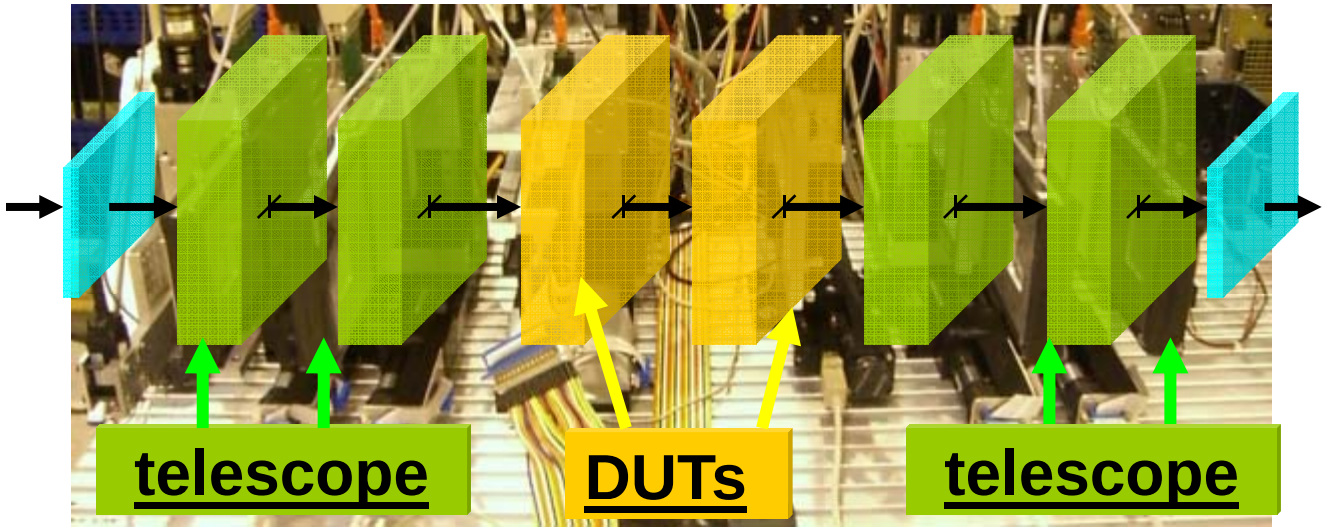
Telescope:
4x COCG L
32x24 µm² Pixel

DUT I:
COCG S
24x24 µm²

DUT II:
24x24 µm²
Capacit. Coupled
Clear gate

EUDET-TLU:
- coincidence-trigger
- Event numbering
- Detector Busy

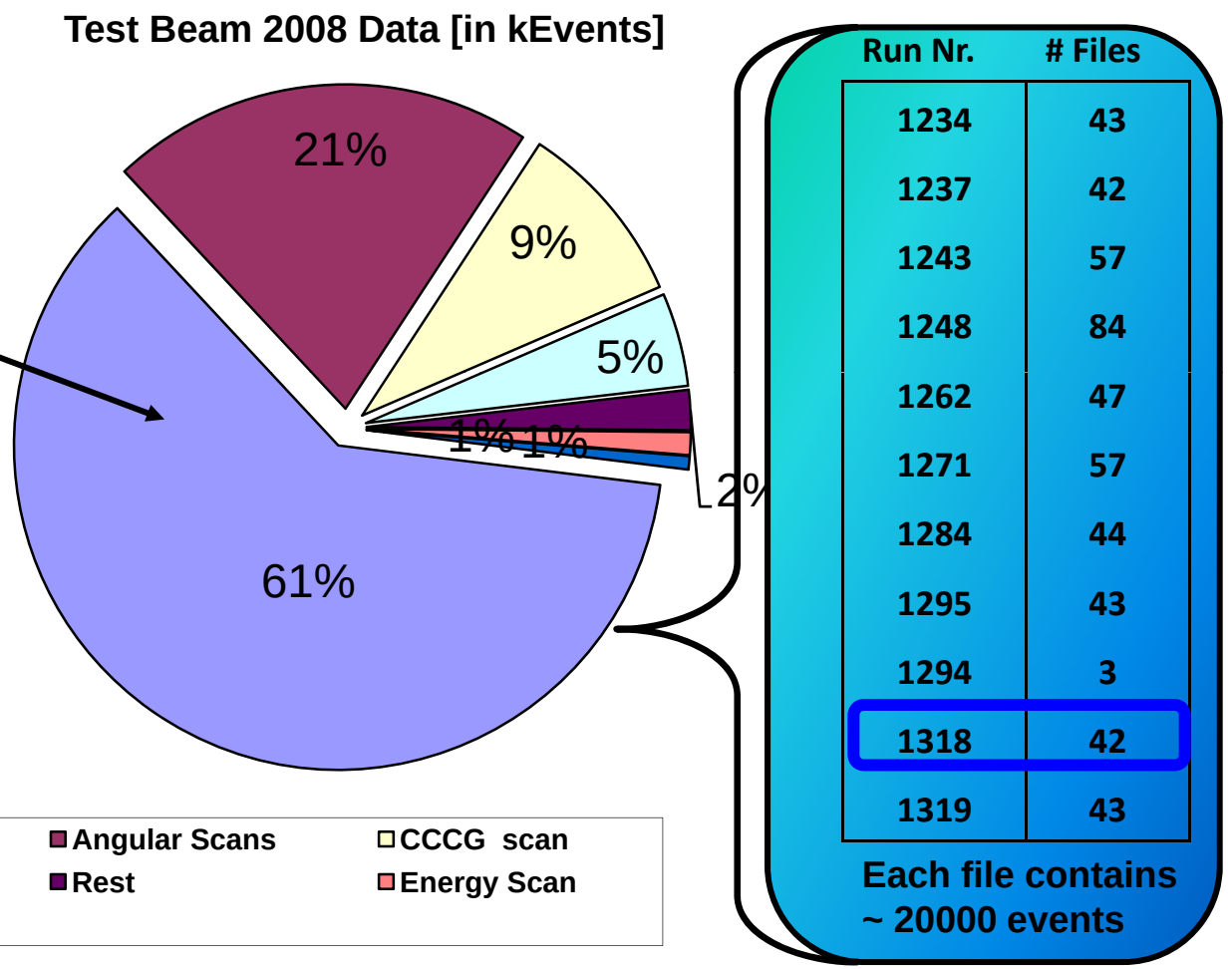
DAQ Software:
- TCP/IP Sever/ Client structure
- Modular
- Compatible with EUDET telescop



# Test Beam 2008 Data Overview

Total :
~ 20 Millionen Events
~ 5 TB data

| | in kEvts |
|---|---|
| High Statistics | 11941 |
| Angular Scans | 4134 |
| CCCG scan | 1815 |
| Backplane scan | 909 |
| Rest | 389 |
| Energy Scan | 222 |
| V_Edge scan | 128 |




| Run Nr. | # Files |
|---|---|
| 1234 | 43 |
| 1237 | 42 |
| 1243 | 57 |
| 1248 | 84 |
| 1262 | 47 |
| 1271 | 57 |
| 1284 | 44 |
| 1295 | 43 |
| 1294 | 3 |
| 1318 | 42 |
| 1319 | 43 |

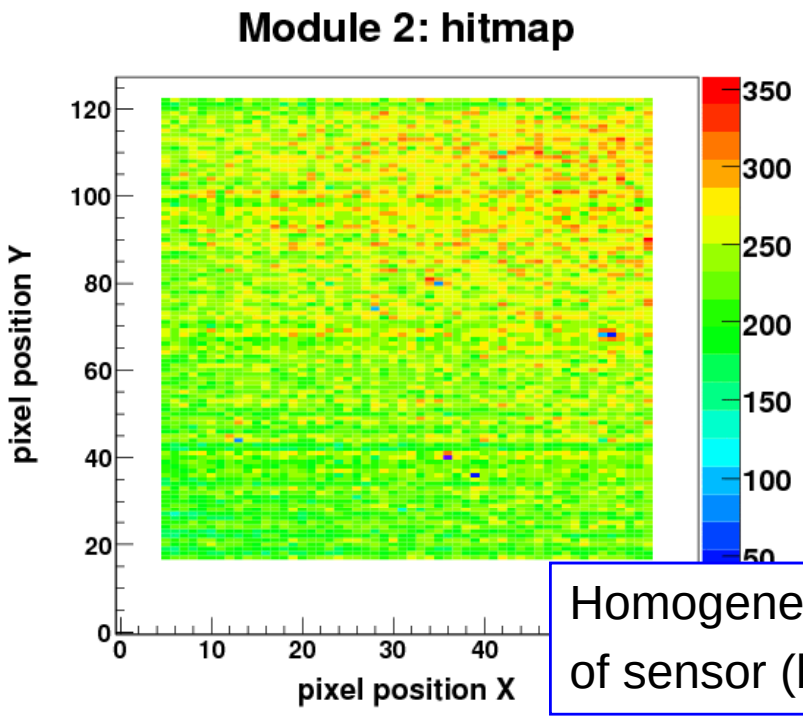
Each file contains
~ 20000 events

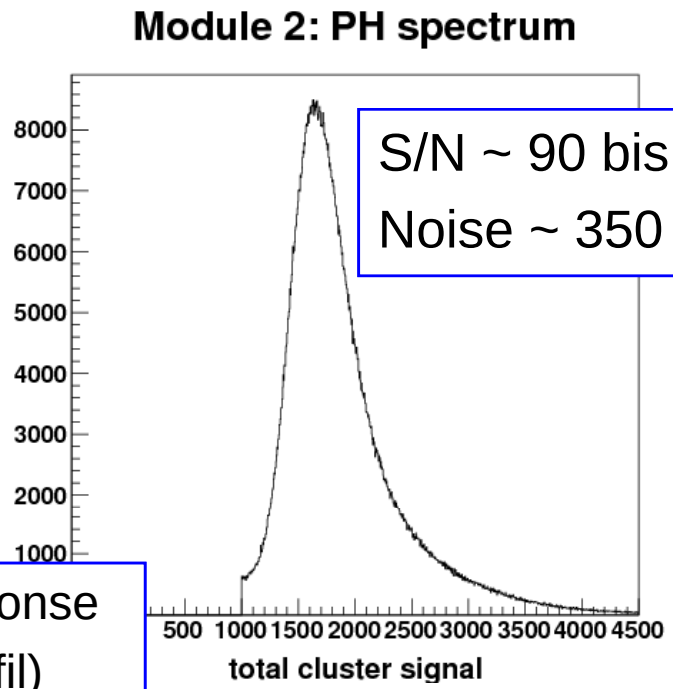
# Data Processing

1. Pedestals with hit rejection (two iterations)
2. Common Mode Correction with hit rejection
3. Noise before and after CMC
4. Clustering
   a) Seed cut: $S/N_{Pixel} > 5\ \sigma$
   b) Search from highest to lowest signal in event
   c) 5x5 pixel cluster + masking of cluster pixel for seed search

# Data Processing

After applying a cluster cut results for module 2, 6, and 14 are good:
➔ homogeneous response




S/N ~ 90 bis 125
Noise ~ 350 e-

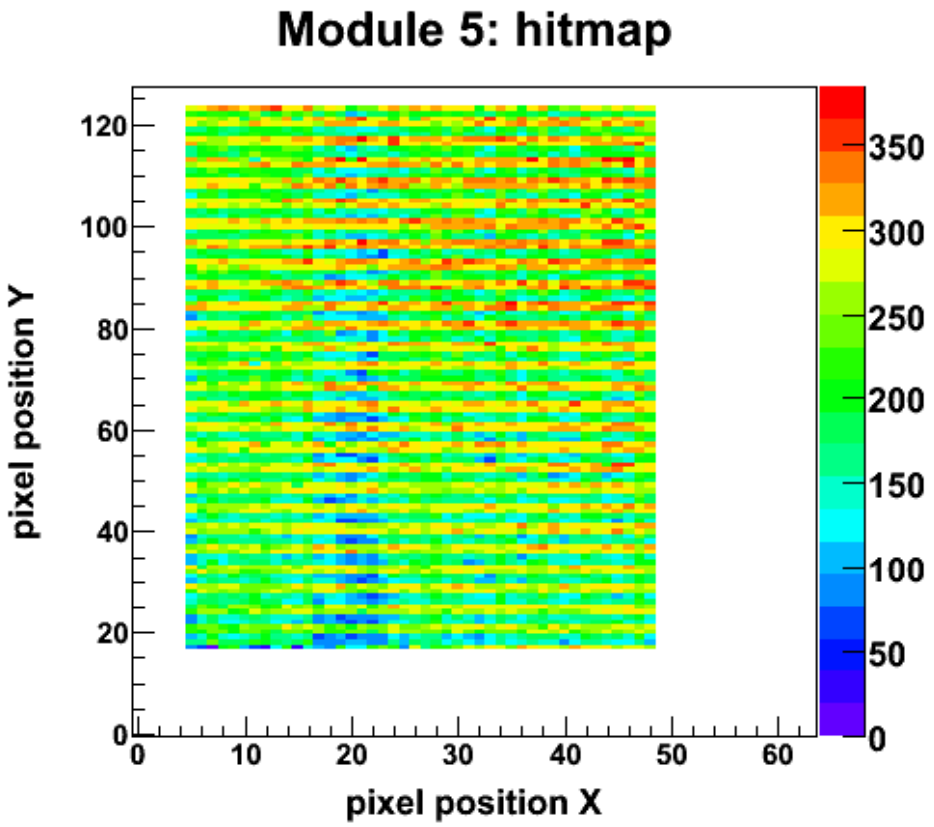
Homogeneous response of sensor (beamprofil)

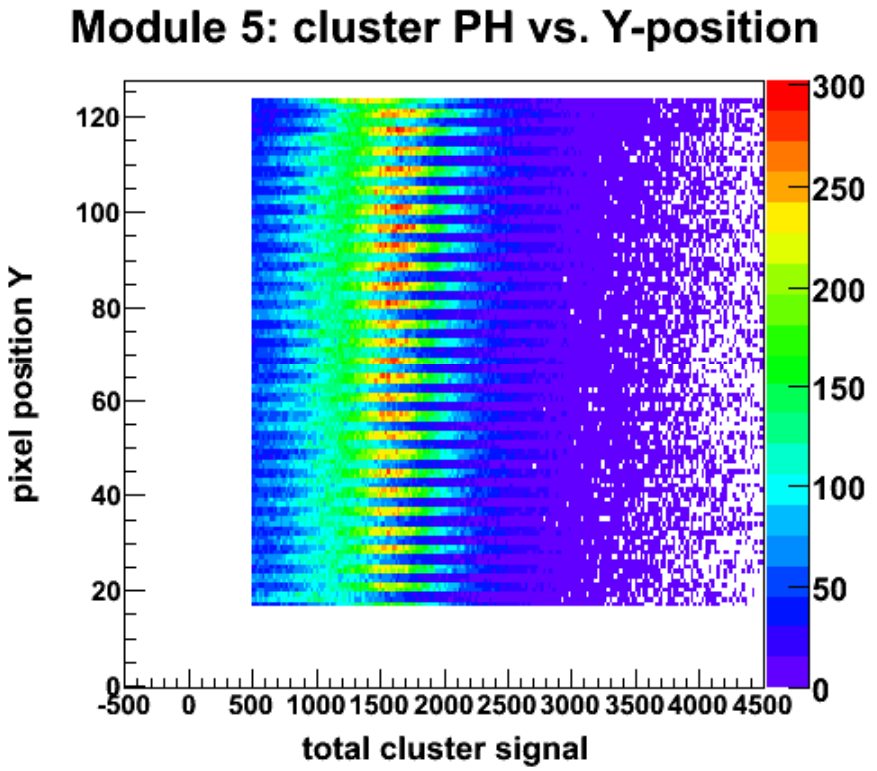
# Data Processing

Module 5 and 7 show row dependend behavior

➔ probably due to biasing problem

➔ complicated powering in TB, varies with TB nights



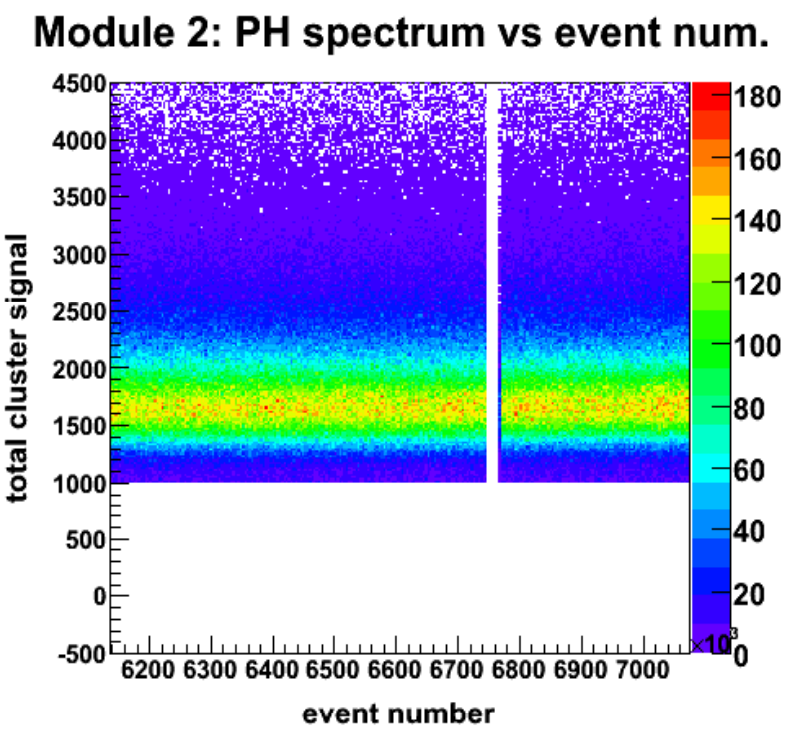



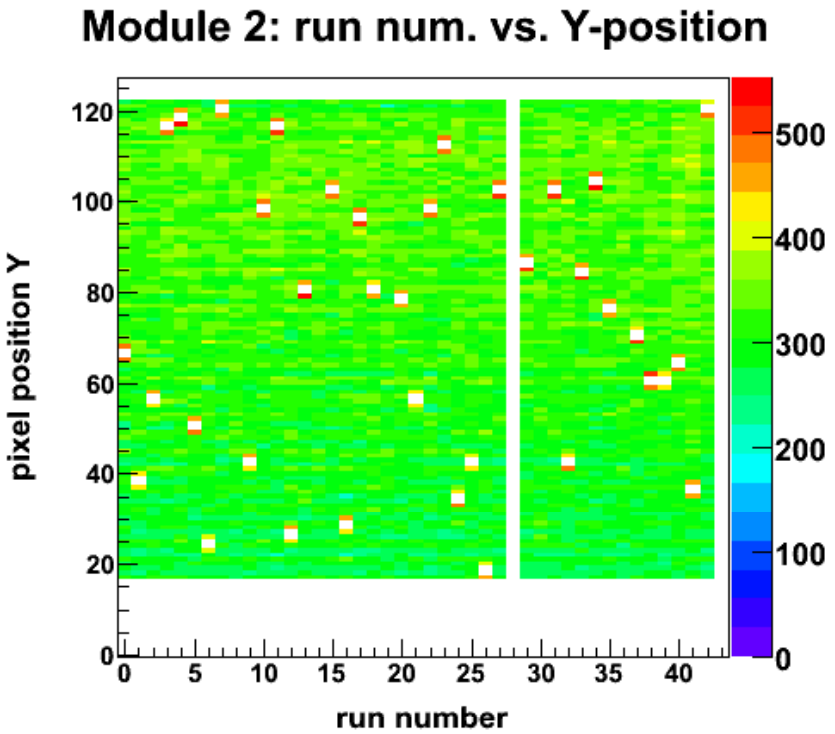
# Data Processing

1 million events in Run 1318, taken over one entire night

➔ A few subruns removed

➔ Otherwise very stable operation, no principle change in sensor behavior



# Position reconstruction

Using eta method for in-pixel position reconstruction

- Corrects for non-linear charge sharing (unlike center-of-gravity)
- Eta distribution is mapping signal(charge) spread between the two highest pixels

$$\eta = \frac{p_r}{p_l + p_r}$$

- Assuming uniform pixel illumination the integrated eta function gives the in-pixel position
- Due to double pixel structure three different approaches were tried

1. „Single:“ just one eta distribution ignoring double pixel structure

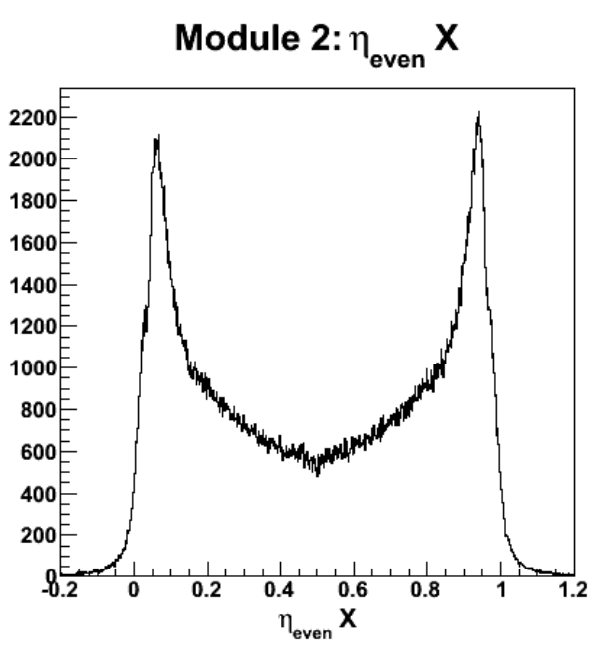
2. „Dual:“ two eta distributions, one for each pixel types

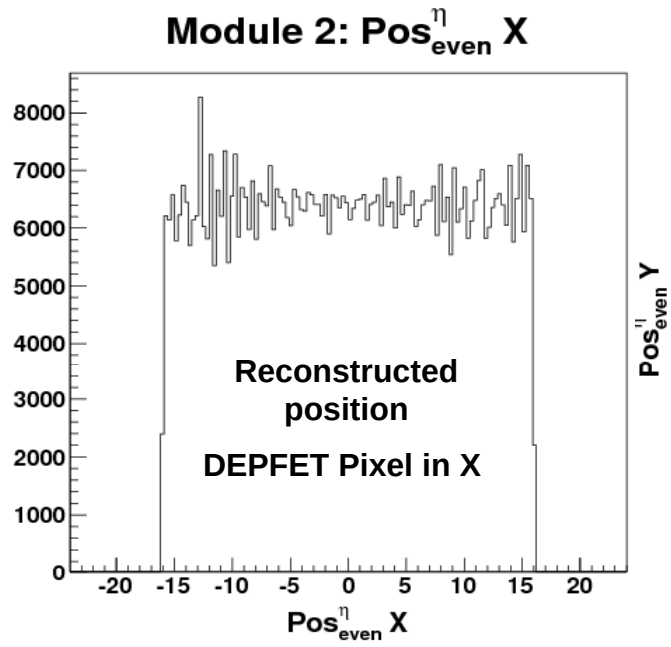
2. „Double:“ one eta distributions covering both pixel types

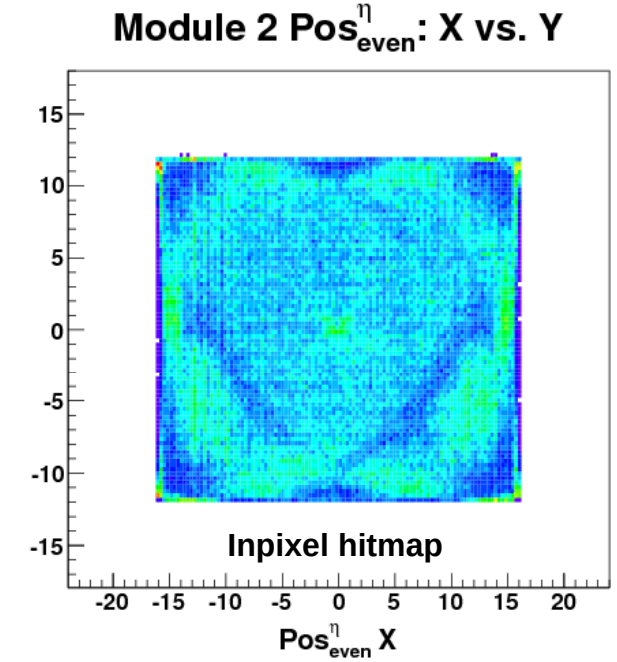
# Position reconstruction

Using eta method for in-pixel position reconstruction

- Eta distributions look like expected
  (two peaks at left and right pixel center respectively)
- Reconstructed position should have unifrom in-pixel distribution
  ➔ true for 1D (strip detector, projection on axis of pixel)
  ➔ 2D case(pixel) is complicated ➔ new algorithm?



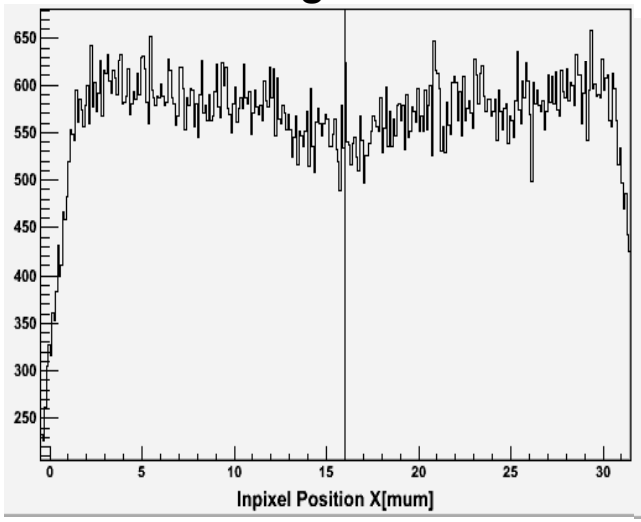



# Tracking & Alignment

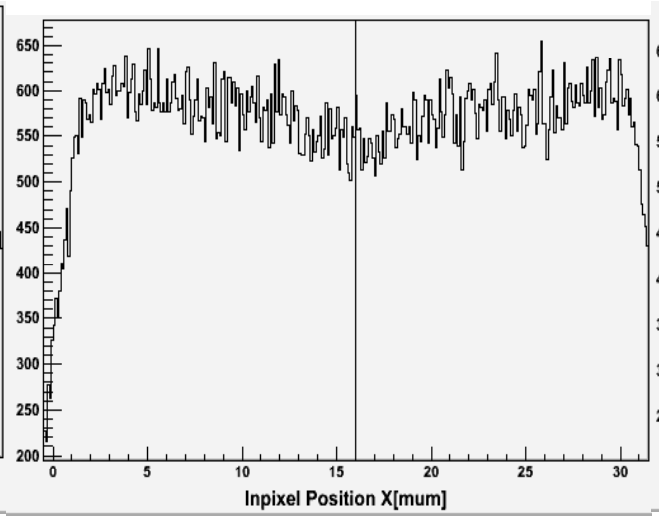
Tracking and alignment software developed by M. Mathes in Bonn for ATLAS pixels TB

- Takes simple root trees with positions for each module
- Possible alternative: EUDET/LCIO analysis frame work
  ➔ tracking package as stand alone soon feasible
- In-Pixel track density should be uniform ➔ 1D it looks okay

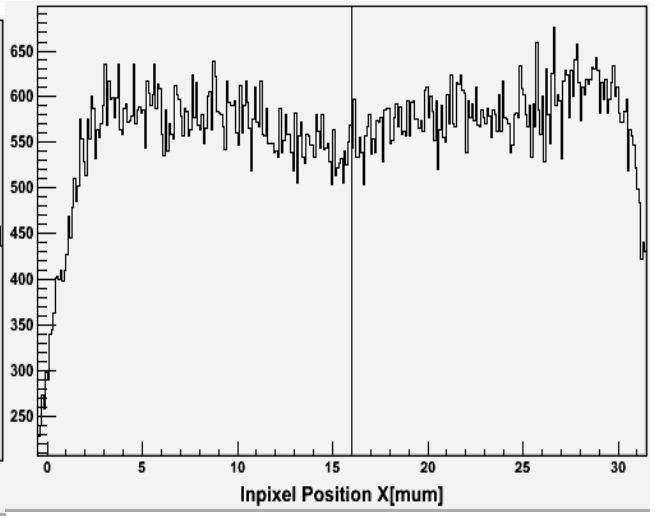
**Single ETA**




**Dual ETA**




**Double ETA**

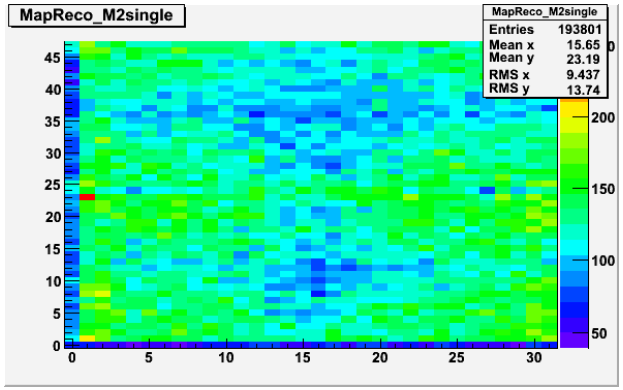


# Tracking & Alignment

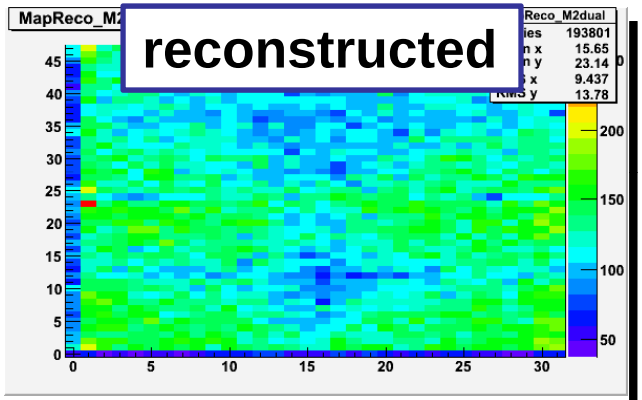
In 2D: In-pixel density maps of reconstructed (η) and tracking position not unifrom!

➔ tracking with (simple & nice) simulated data looks fine

➔ probably the 1D eta approach not the best for 2D pixel

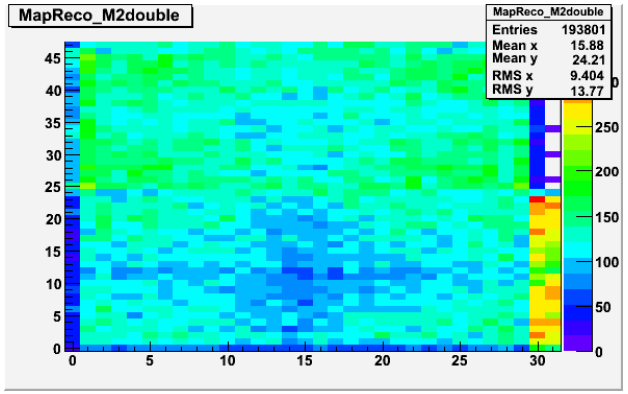



Single ETA

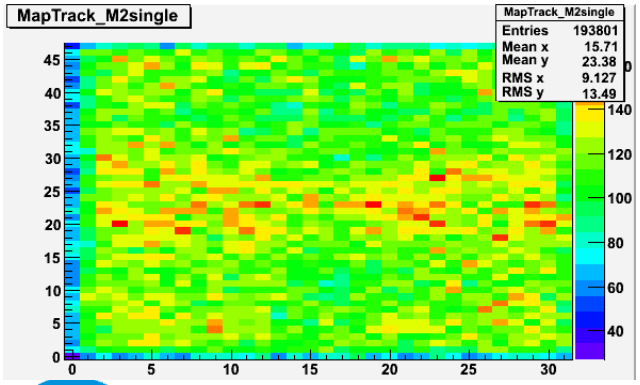


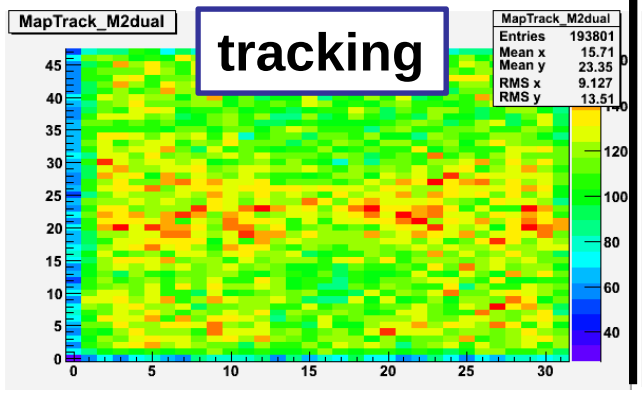

reconstructed

Dual ETA

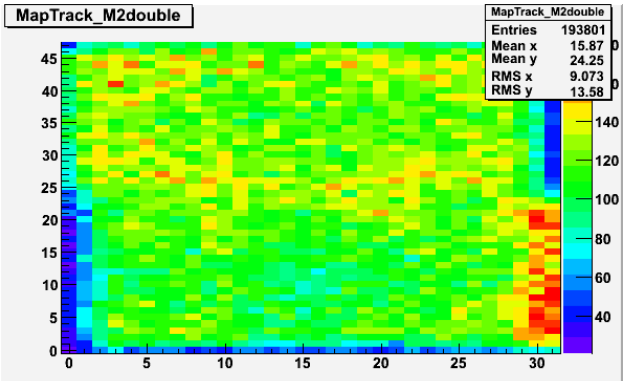



Double ETA



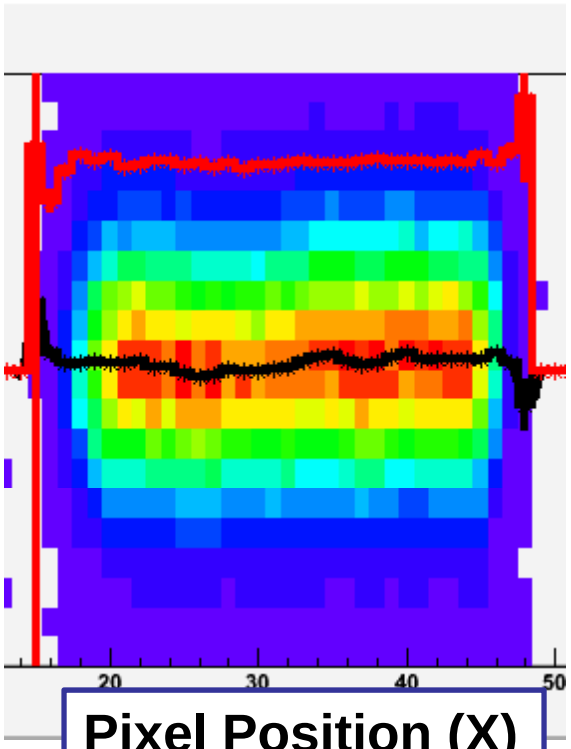

tracking



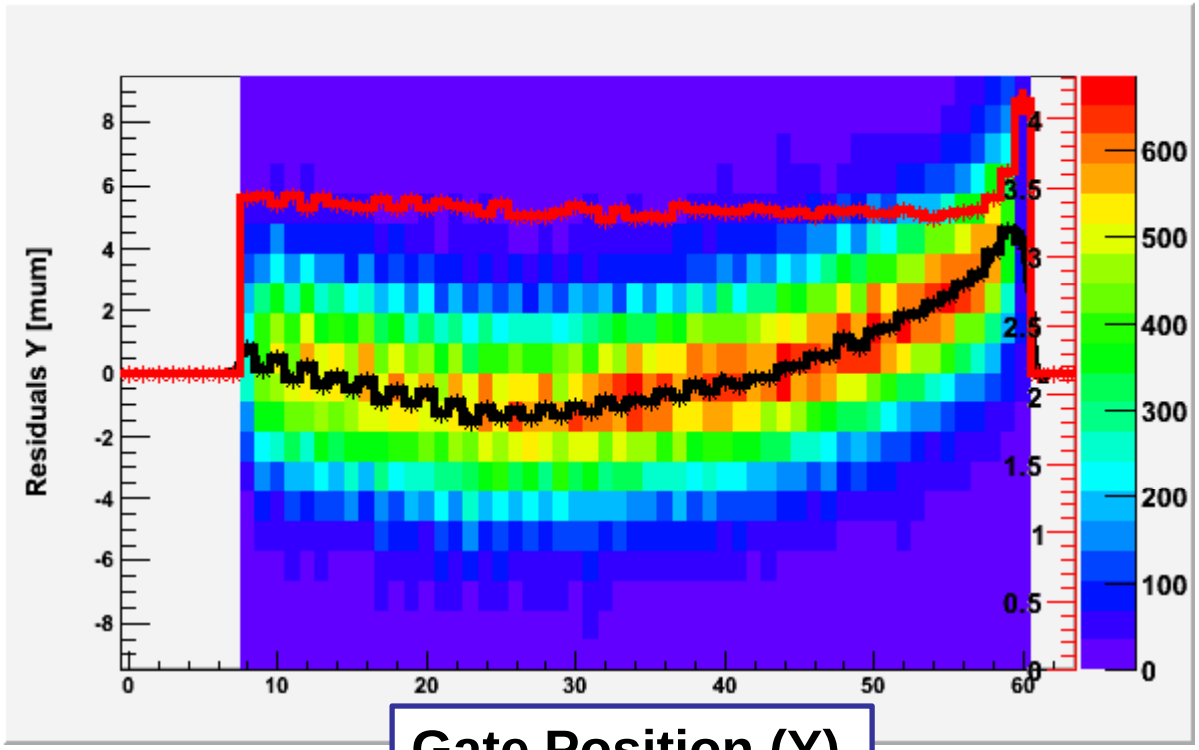
# Residuals across sensor

Residuals show (for some modules) strong dependence on pixel position in senor matrix

- alignment seems fine
- Apply large scale correction ?




Pixel Position (X)

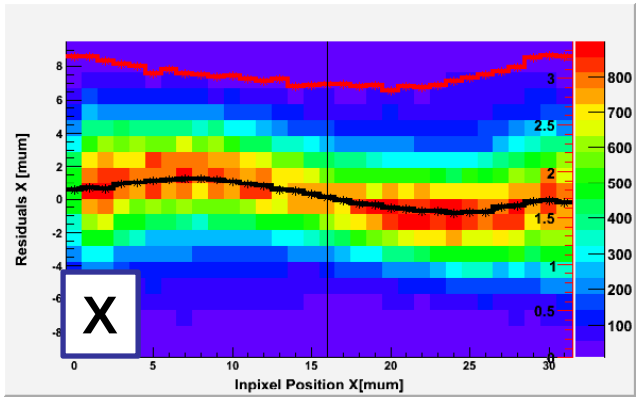



Gate Position (Y)

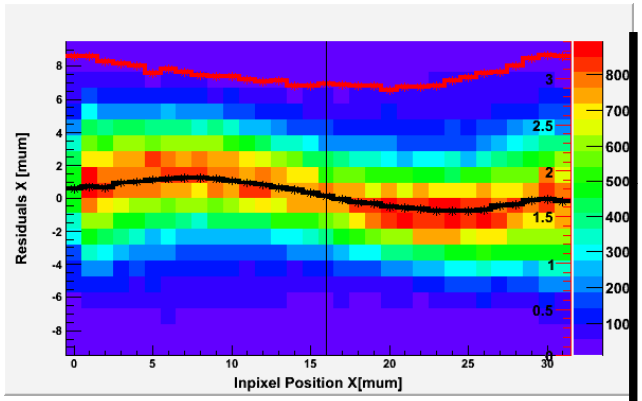
# Residuals In-Pixel

Some residual dependence on in-pixel position.

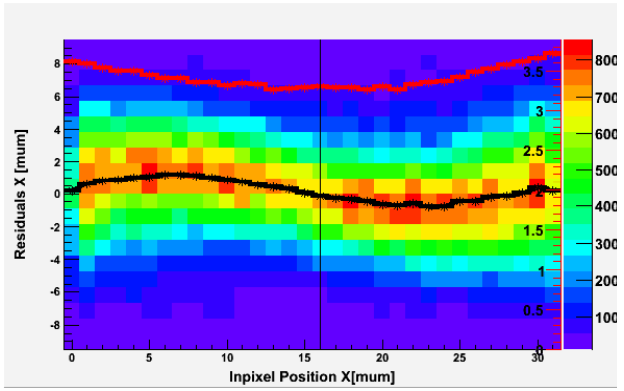
The three eta methods show similar results



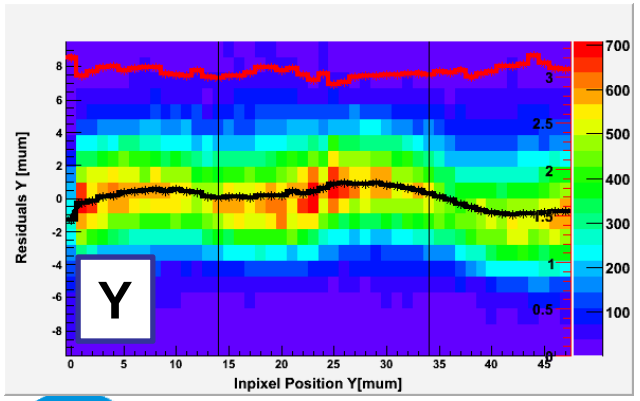

Single ETA

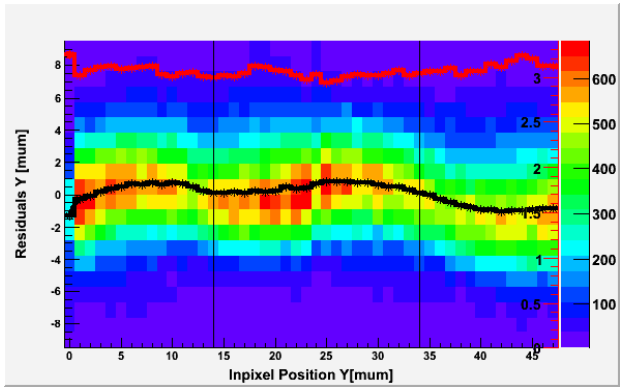


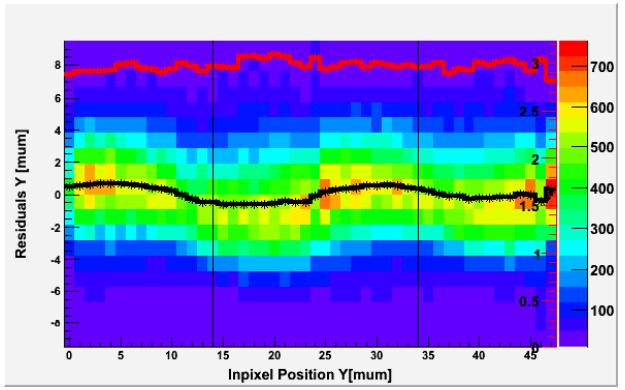

Dual ETA




Double ETA



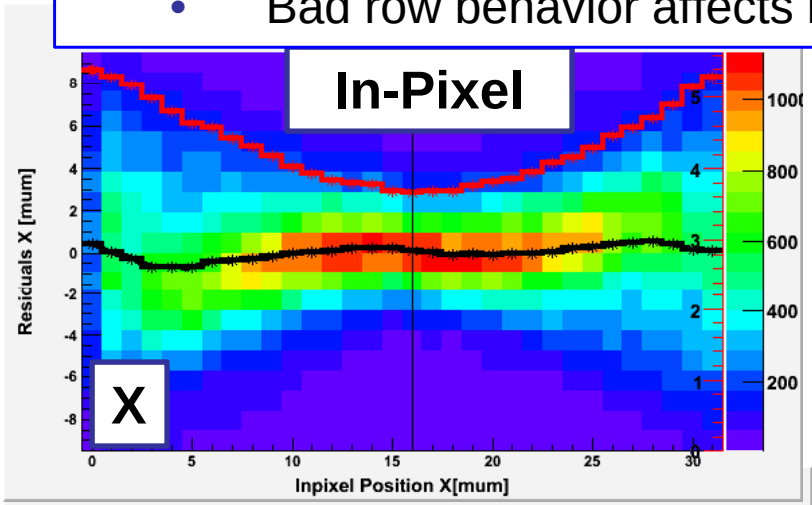



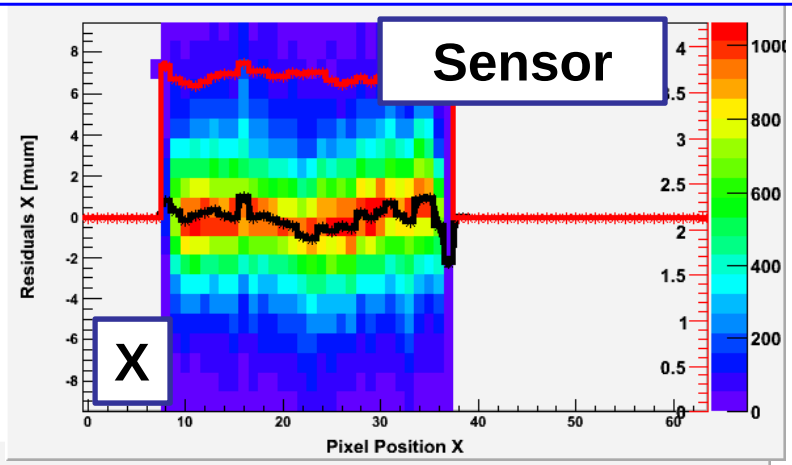



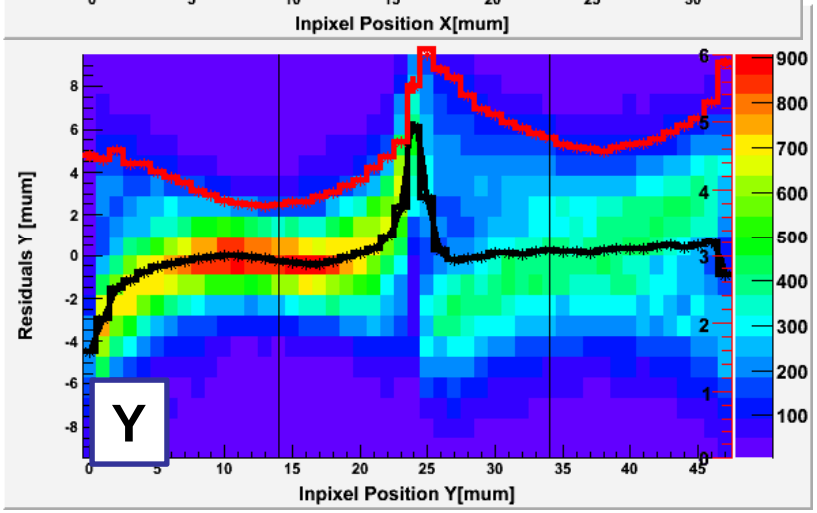
# Residuals for a bad module (#5)

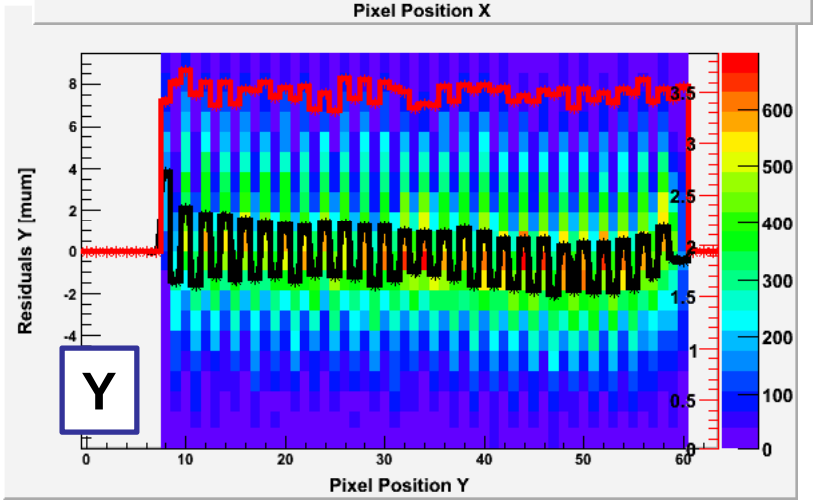
Here the effects are much more severe...

- Bad row behavior affects reconstruction



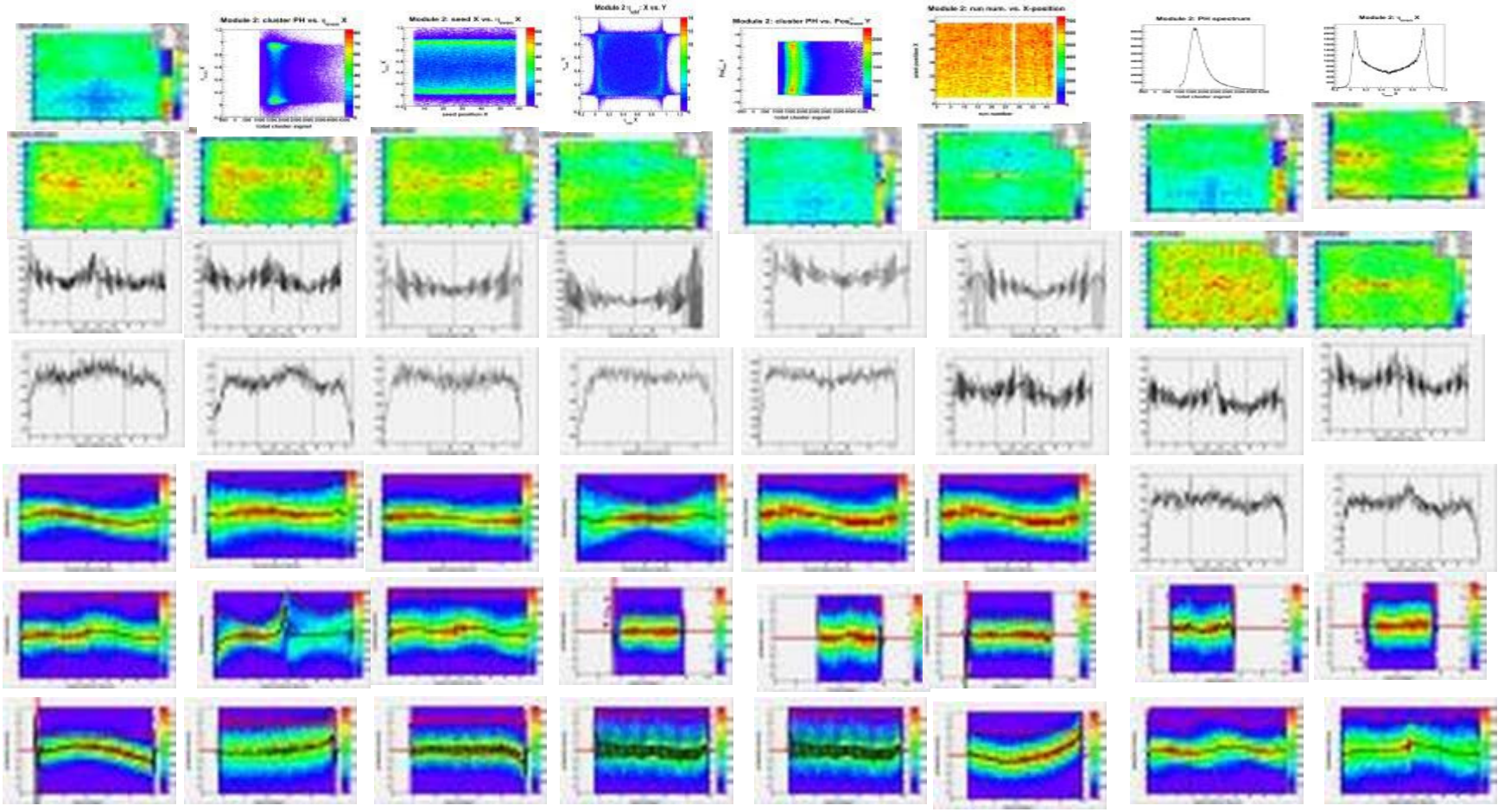



# Lots of plots…

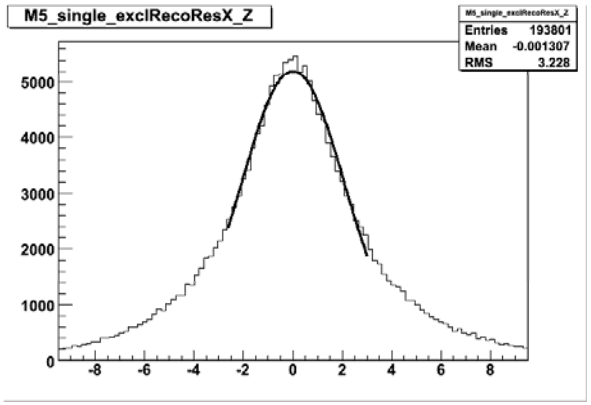
Upload of root files with histograms on the DEFET Twiki page



# Residuals Summary

- Residuals for X comparable to Prague results
- Residuals for Y not as good as Prague results
  - ➔ Module 11 not included
  - ➔ LSC not included
- Difference still not fully understood

| Module | 2 | 14 | 11 | 6 | 5 | 7 |
|---|---|---|---|---|---|---|
| Incl X | 1,3 | 1,4 | | 1,8 | 1,9 | 1,8 |
| Incl Y | 1,3 | 1,3 | | 1,8 | 2,3 | 1,8 |
| Excl X | 3,0 | 2,3 | | 2,2 | 3,1 | 3,4 |
| Excl Y | 2,9 | 2,2 | | 2,3 | 3,4 | 3,4 |
| Prague X | 2,8 | 2,1 | 2,10 | 2 | 3 | 3,4 |
| Prague Y | 2,4 | 1,7 | 1,7 | 1,8 | 2,4 | 2,8 |




Some residuals have huge wings
e.g. ρ ~3.4➔2.4 (PRG:2.4) µm

# Outlook

In-Pixel studies:

- Charge collection properties (Seed, Cluster PH)
- Efficiency & Purity (will be difficult...)
- Some of the results will be in the root files on the DEPFET wiki pages
- Most of it will be ready for the paper

New position reconstruction methods...

# Summary

- Run1318 (1 M events) analyzed, Mod. 11 not included
- 3 modules show good performance
- 2 modules have issues due to bad biasing
- Residual dependence along sensor area
  ➔ large scale correction...
- Residual dependence & non uniform illumination in-pixel
  ➔ eta reconstruction method may not be the best choice
- Residuals are in the order of 2 ~ 3 microns

- In-Pixel studies now started ➔ e.g. charge collection
- Other long runs will be included if biasing is okay

# New position reconstruction methods

Multivariat Methods e.g.

- Neuronal networks
- Boosted Decision Trees
- Different input parameters
  - Moments of cluster
  - Highest/all signals

Simulations:

- Signal, Noise
- Crosstalk
- Charge cloud properties