Report on the Test Beam with the LP-Module 2 Quadboars + GEMS

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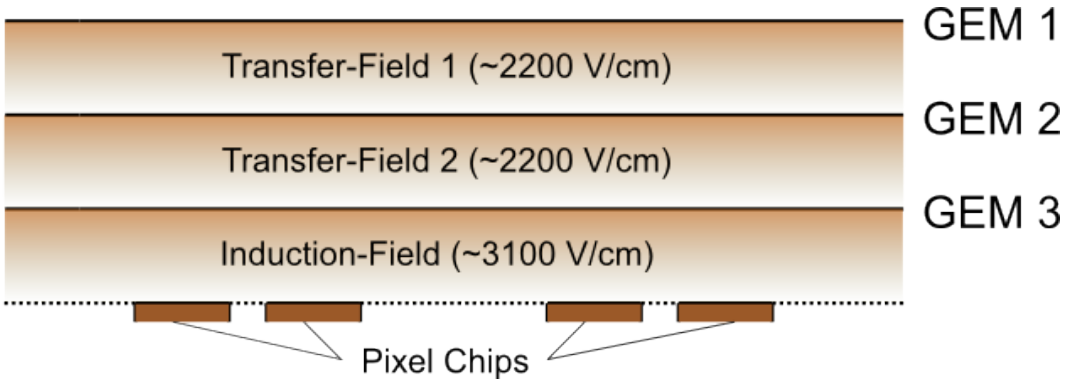
GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

The Module

- Amplification with standard CERN GEMs (tripple GEM stack)
- Distance between GEMs and between GEM and chips is 1 mm
- Readout with 8 pixel chips (two Quadboards designed by NIKHEF)
- 256 x 256 pixels per chip: 55 µm x 55 µm pixel size
- >0.5 Mio channels (largest number of channels ever installed in a TPC)
- Readout frequency 55 MHz



The Module

anode plane

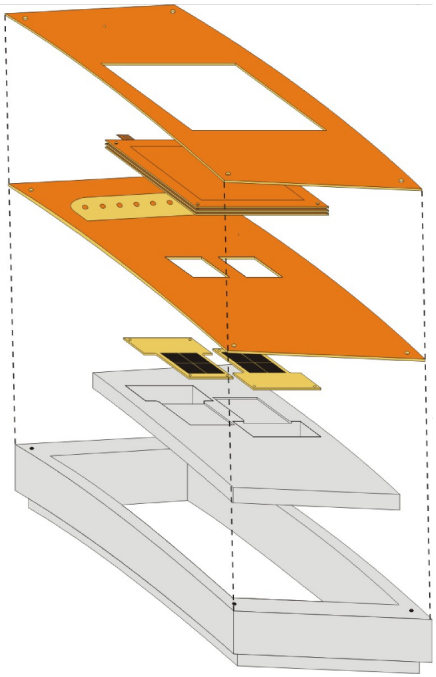
GEMs

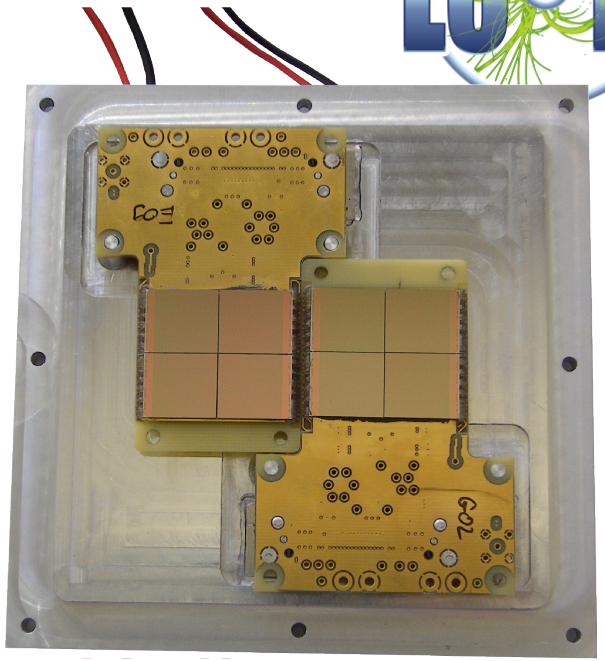
readout plane

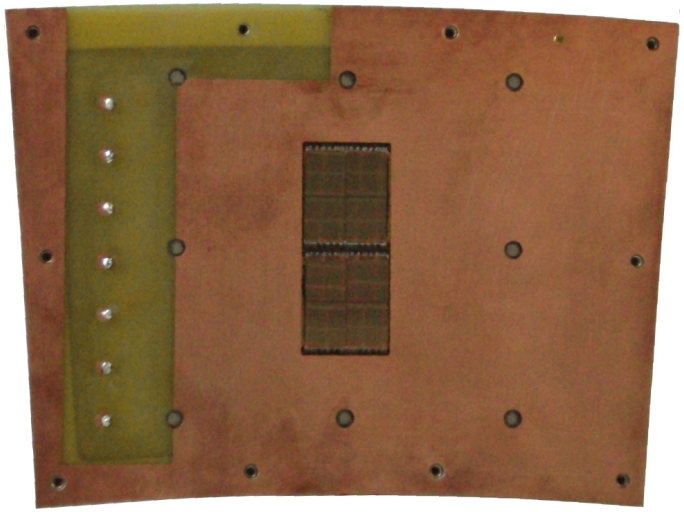
quad-boards

reinforcement of anode plane

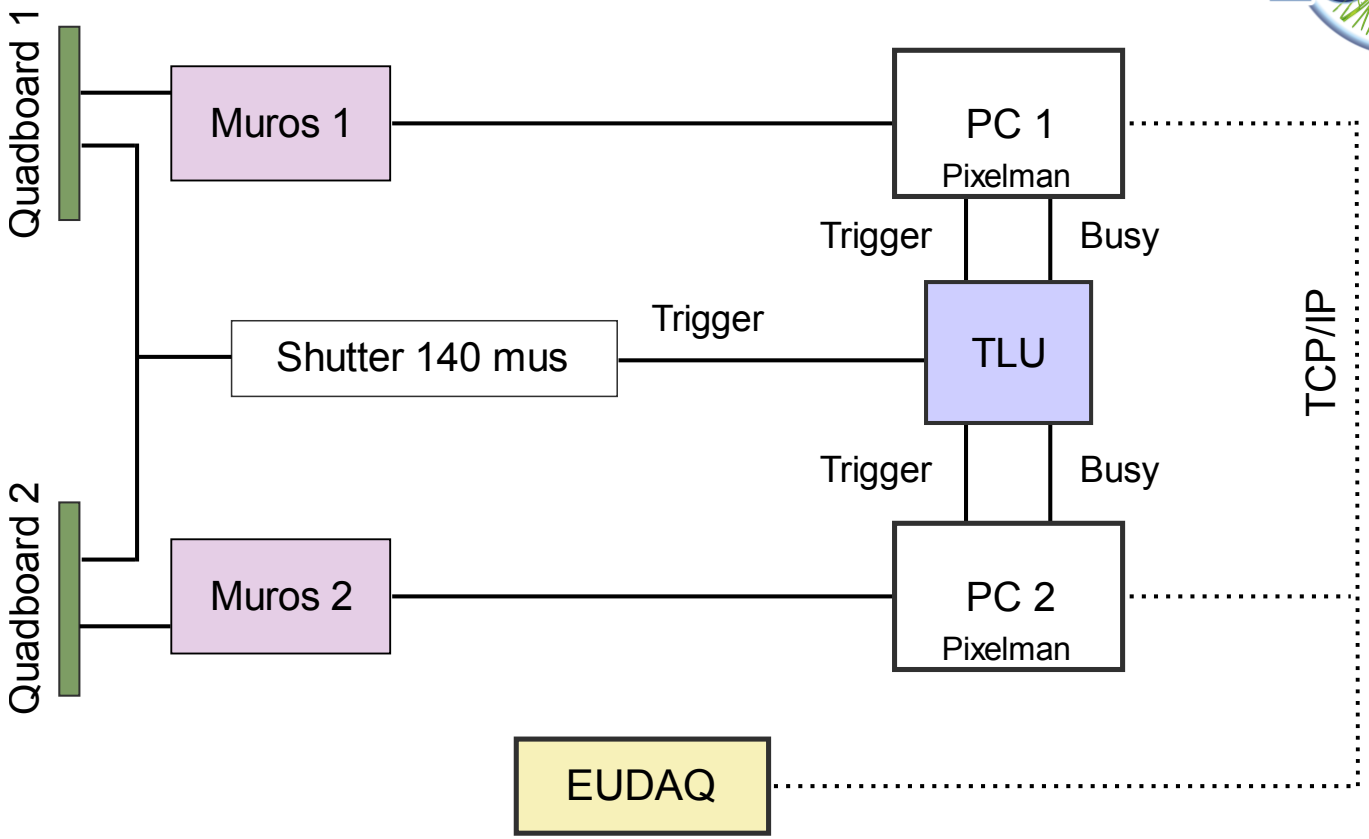
redframe







Readout Scheme



- DAQ PCs synchronised with **T**rigger **L**ogic **U**nit
- Data is send to EUDAQ

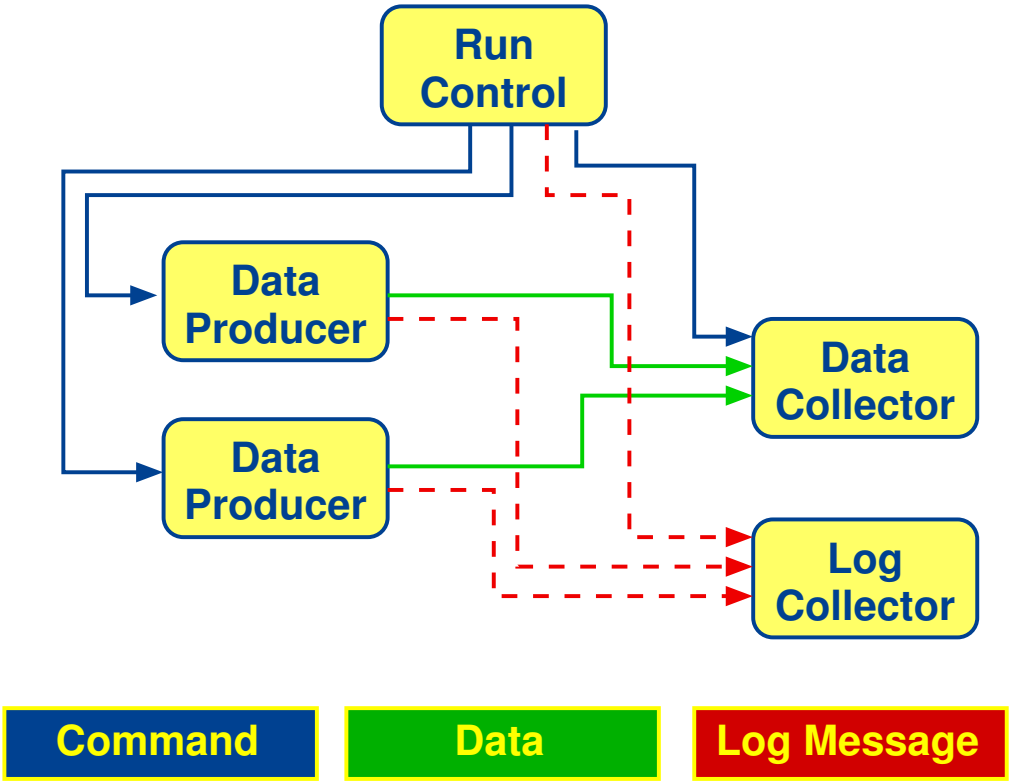
EUDAQ: The EUDET Data Acquisition System

DataProducer: Pixelman plugin which communicated with EUDAQ

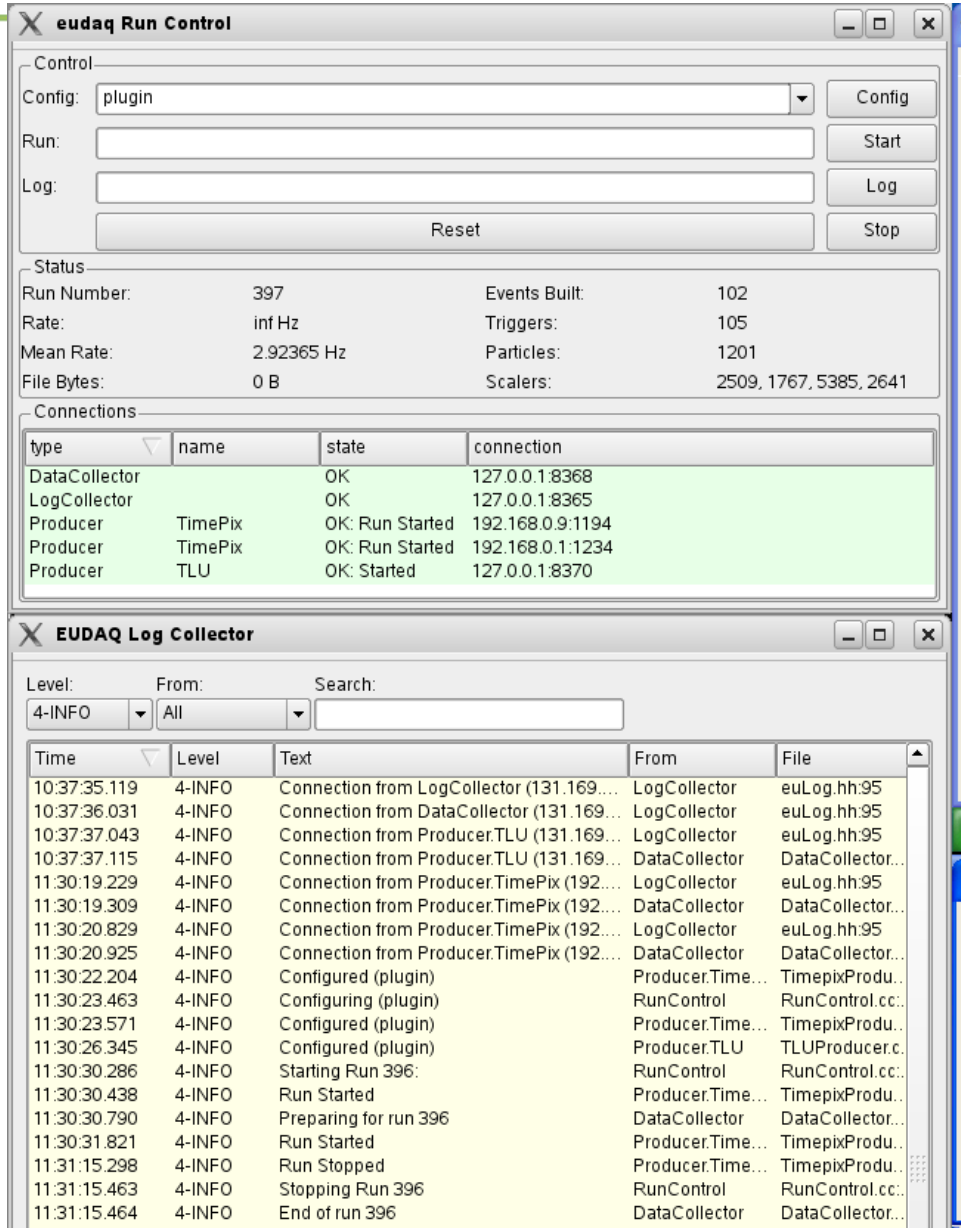
- Receives commands from Run Control
- Sends data to Data Collector
- Sends messages to Log Collector

DataCollector:

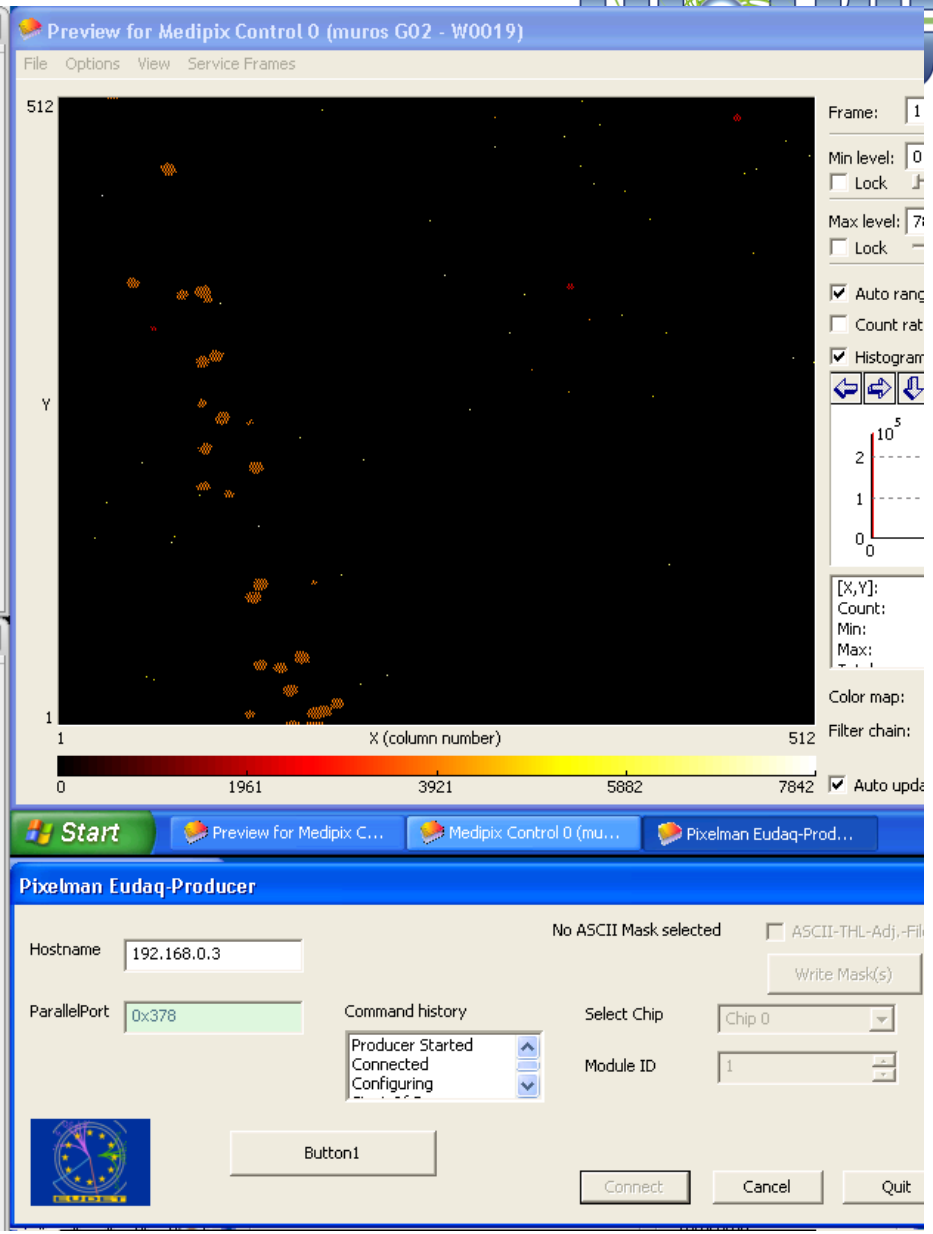
- Receives raw data
- Performs event building
- New: Plugin mechanism
  LCIO converter plugin for every raw data format
- Data collector writes common LCIO file



Screenshot



EUDAQ RunControl and LogCollector



Pixelman event display and PixelmanProducer

Parameters Settings

He/CO_2 70/30:

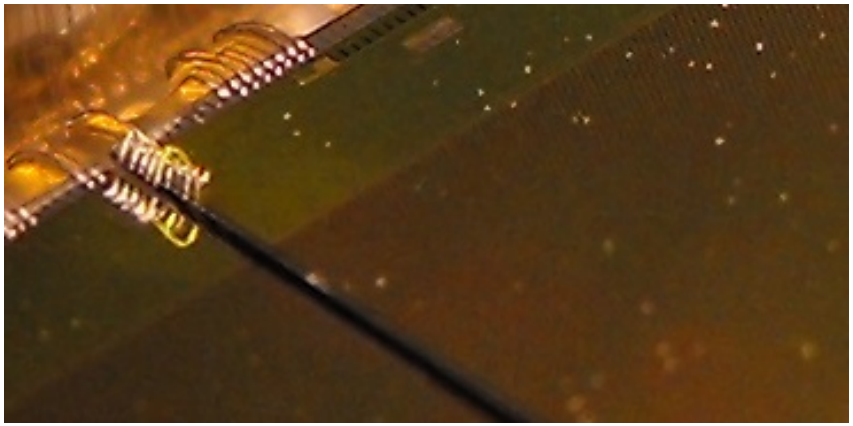
Drift distances [cm]	4.3 ; 10 ; 15 ; 20 ; 25 ; 30 ; 40 ; 50
Angles	5° ; 10° ; 0° ; -5° ; -10°
Particle energies	1 GeV ; 1.6 GeV ; 2.6 GeV ; 3.8 GeV ; 5 GeV
GEM voltage	355 V ; 370 V ; 385 V ; 395 V ; 405 V ; 415 V
Magnetic field	0 T ; 1 T

T2K Gas:

Drift distances [cm]	4.3 ; 10 ; 15 ; 20 ; 25 ; 30 ; 40 ; 50
Angles	5° ; 10° ; 0° ; -5° ; -10°
Particle energies	1 GeV ; 1.6 GeV ; 2.6 GeV ; 3.8 GeV ; 5 GeV
GEM voltage	260 V ; 270 V ; 280 V
Magnetic field	0 T ; 1 T
Laser Dots with 1 T	

Breakdown

- Module worked fine in He/CO_2 for two weeks.
  No HV problems
- Frequent trips in T2K gas (module and field cage).
  In the last night of data taking a discharge destroyed one Quadboard



- Bond wires reach into the induction gap (some of them were not protected with glue)
- Brown spot on the GEM at position of bond wires

Short term solution:

- Protect all bond wires with resin
- Make bonds as flat as possible

Long term solution:

- Through silicon vias on the chip

Analysis with MarlinTPC

Aim of the reconstruction:

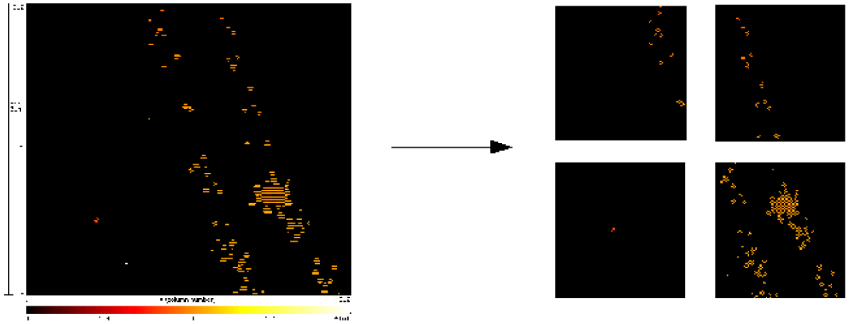
- Reconstruct individual clusters
- Fit the track
- Determine the point resolution

→ already done for single chips

Strategy:

- Subdivide Quadboard raw data into data of single chips
- Adapt existing processors for multiple chips
- Include the exact geometric alignment of the chips with GEAR
- Create new processors for analysis

Divider Processor:

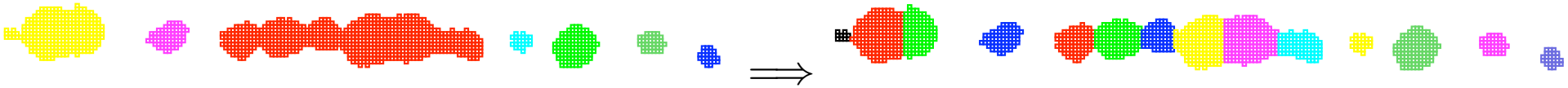


Example: Cluster Separator

Clusters are split along cluster axis

Short drift distances:

- Algorithm works fine



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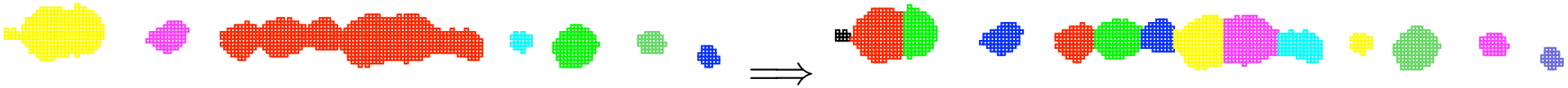
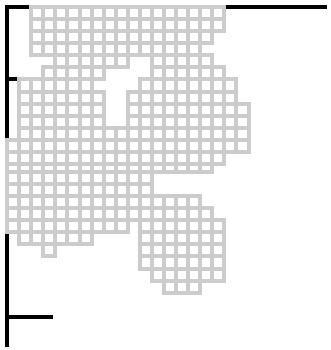
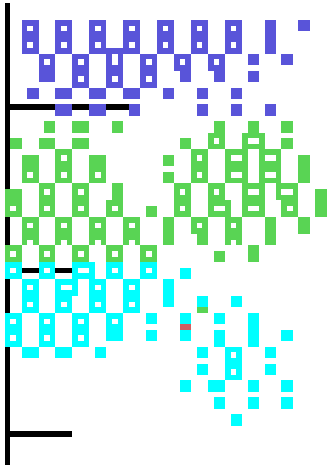
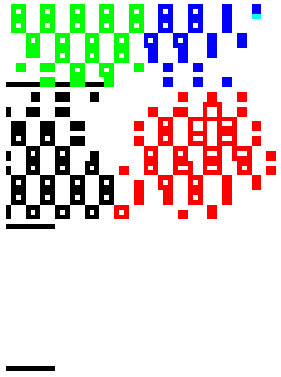


Long drift distances:

- Algorithm is not optimized yet
- Need to apply algorithm twice
- But: Algorithm loses some data on the second pass



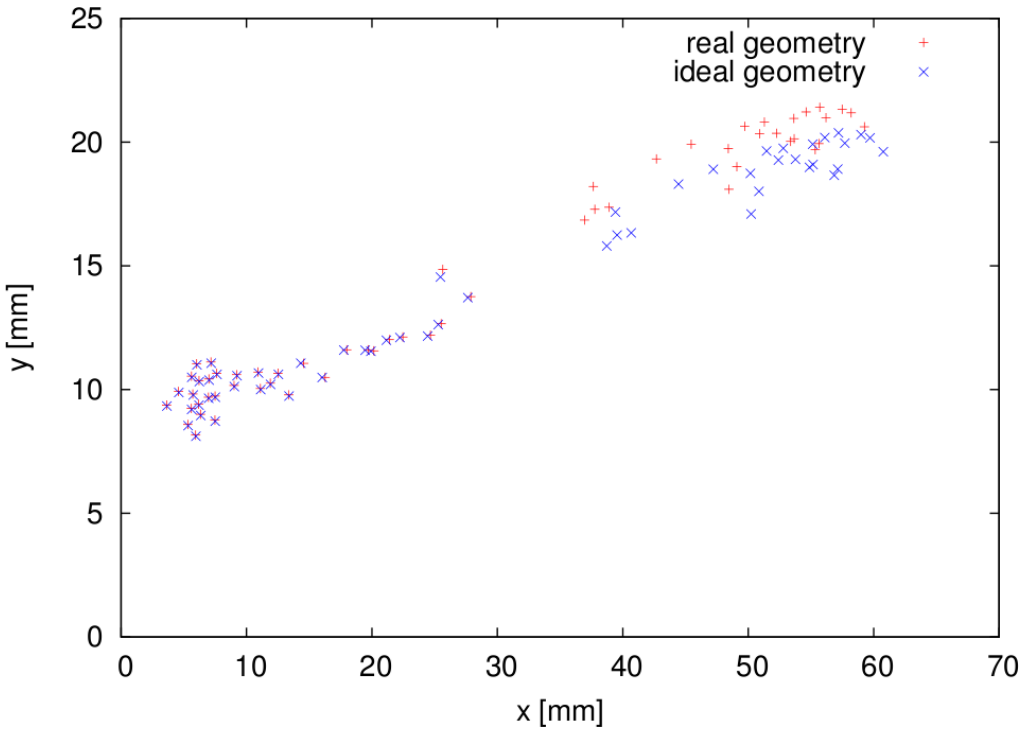




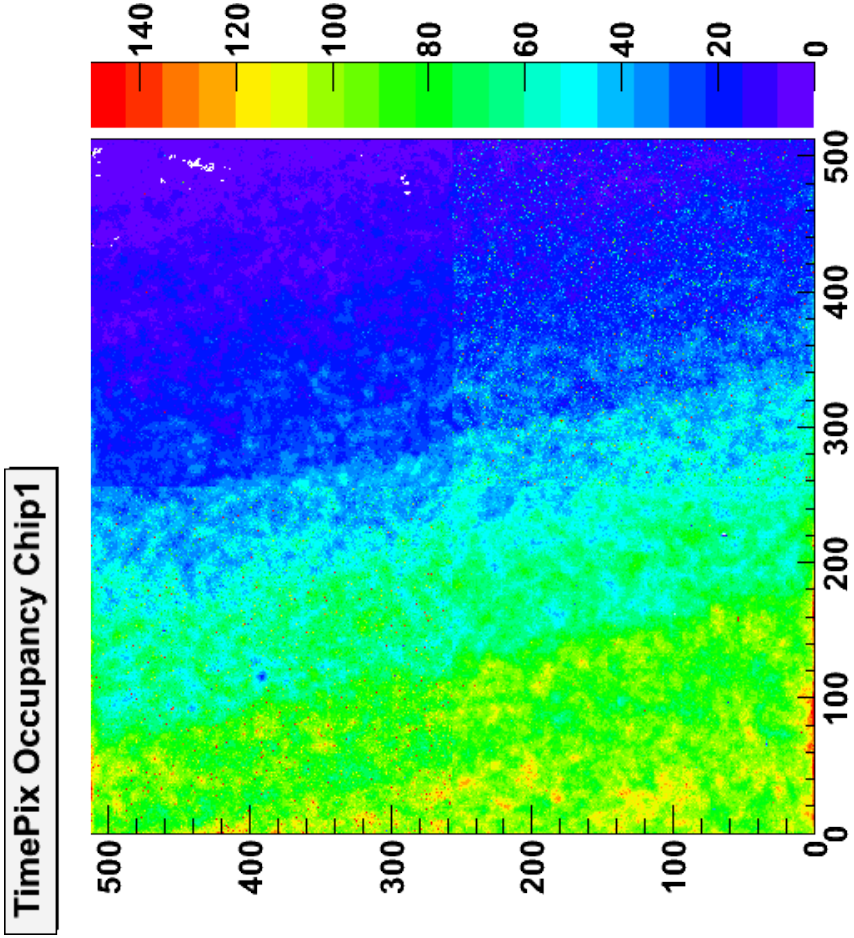
Alignment

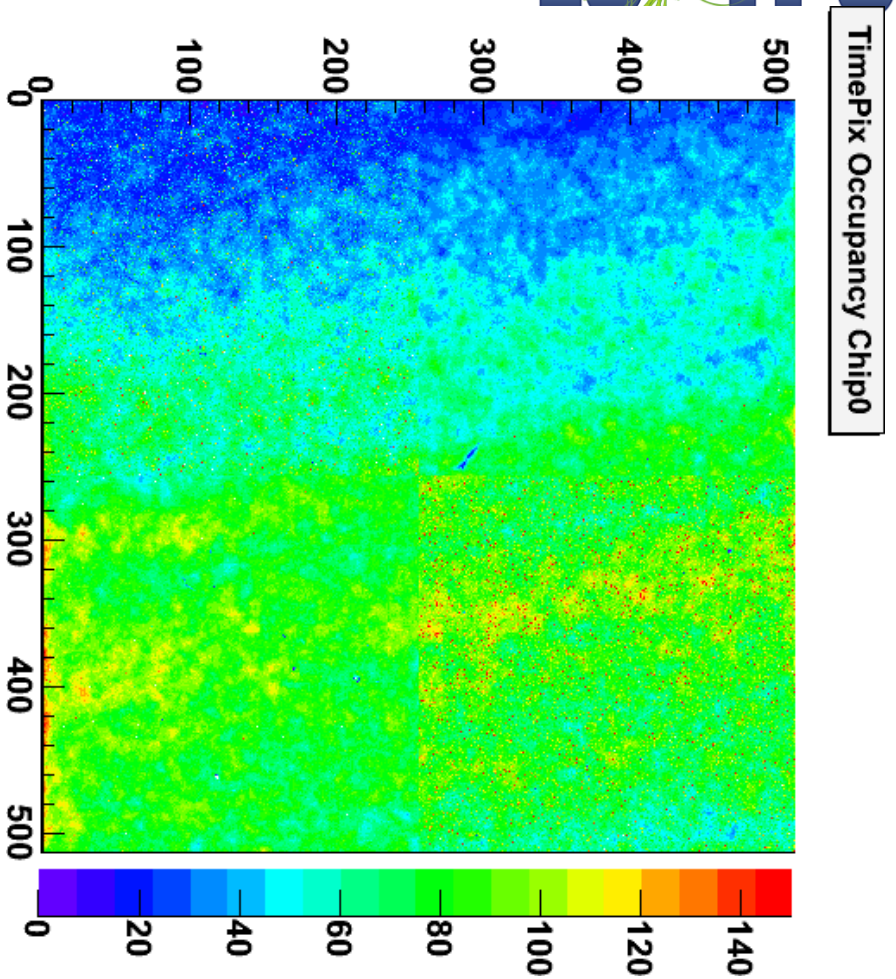
Goemetry file:

- Alignment has been measured with movable table and microscope
- Exact Geometry is provided by GEAR: Displacement of each individual chip can be defined



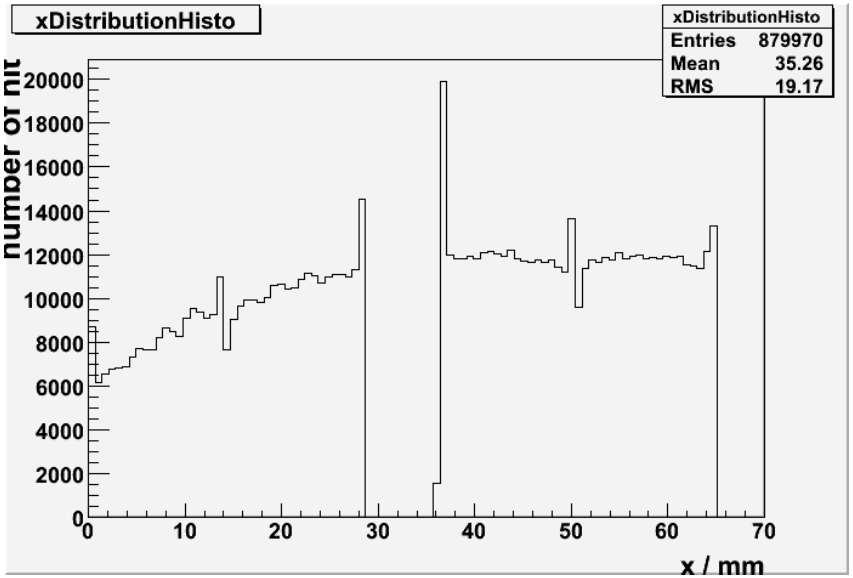
Occupancy

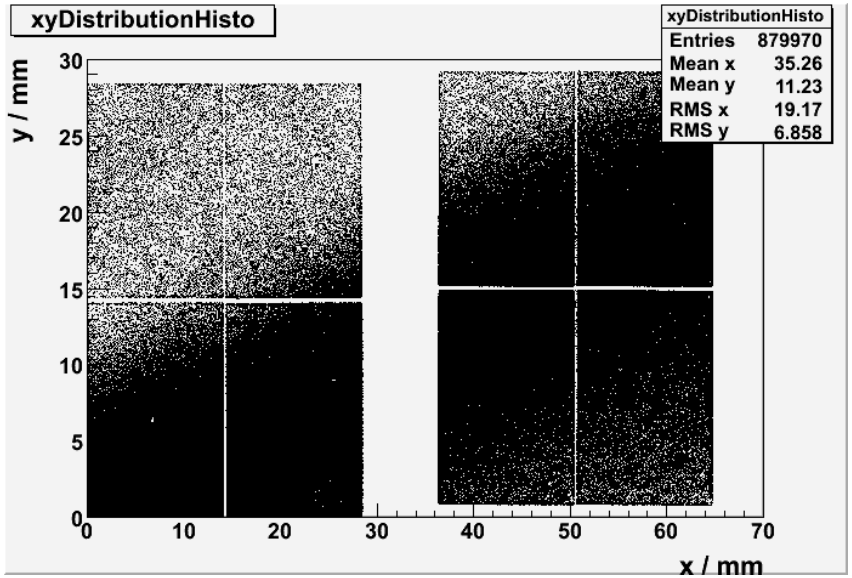




- Homogeneous response over the whole module
- Beam profile clearly visible
- Hot area near the gap between the boards

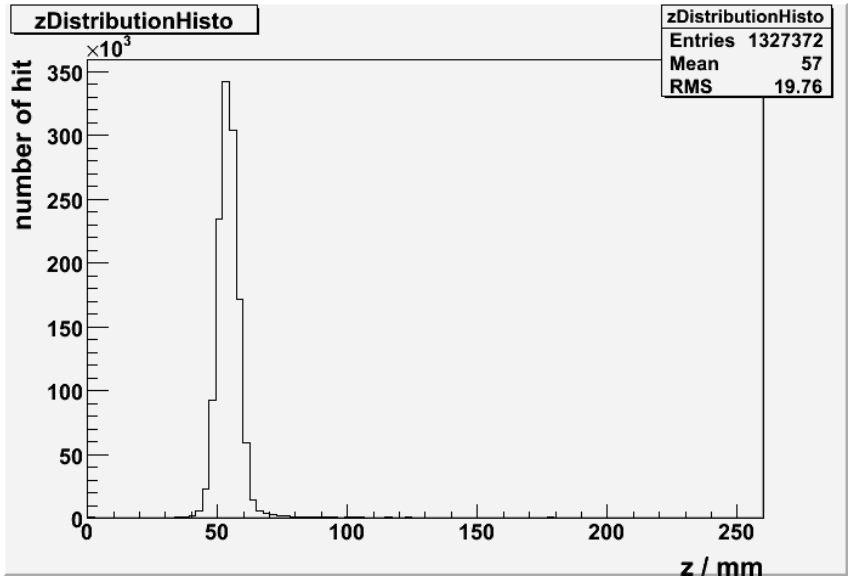
XY Distribution Processor

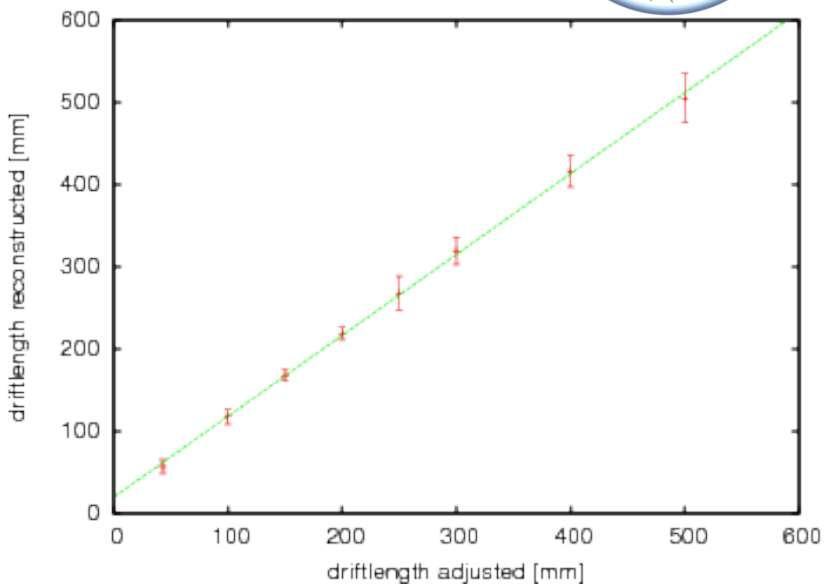




- Reconstructed plot behave like event display
- Inhomogeneous electric field and binning effects lead to clearliy visible chip boarders

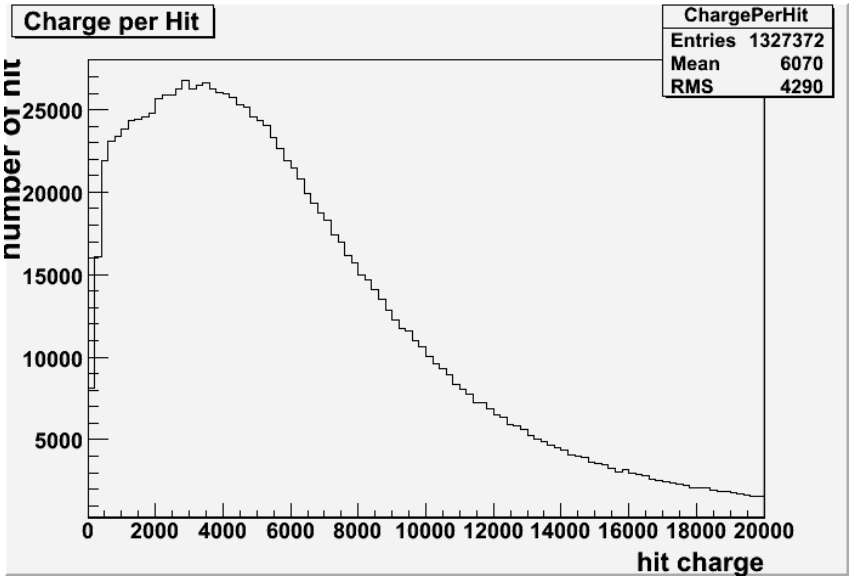
Z Reconstruction

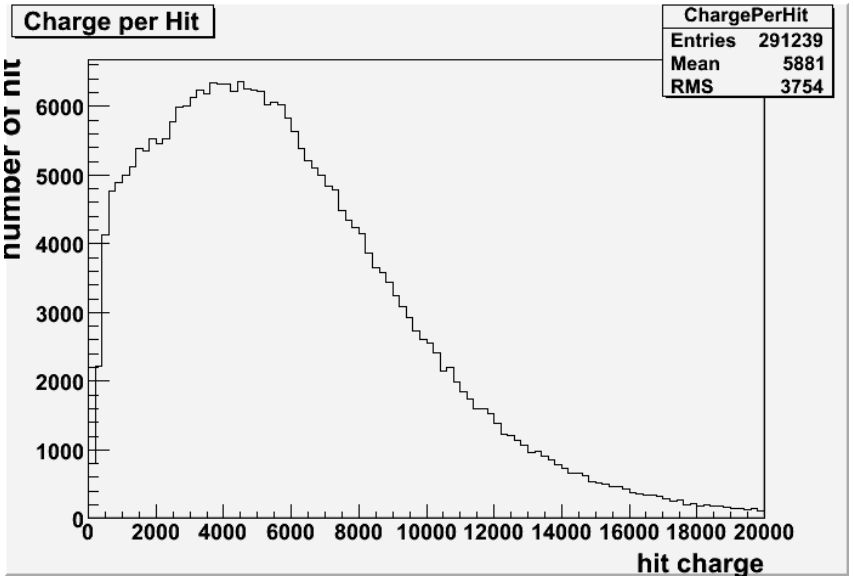




- Convert drift time to drift length with help of drift velocity calculated by Magboltz
- Fit: $z' = (0.984 \pm 0.011)z + (19.802 \pm 2.981)$
- Offset corresponds to cable and trigger delay (uncorrected)
- Indication for homogeneous drift field, little contamination in gas mixture and correct reconstruction

Charge Per Hit





- Amplification independent from distance
- Primary electrons with longer drift can be better seperated

Summary & Outlook

Summary

- LC-Module with two QuadBoards + GEMs sucessfully operated
  - World record: more than 500,000 channels
- Breakdown due to discharges is understood
- First analysis plots behave like expected
- Analysis ongoing

Outlook

- Improve reconstruction algorithms
- Study track properties (momentum resolution)
- Fix damaged quad board