

Report on the Test Beam with the LP-Module 2 Quadboards + GEMs

Christoph Brezina^a, Klaus Desch^a, Julia Furletova^a, Jochen Kaminski^a,
Christian Kahra^c, Martin Killenberg^a, **Frederik Klöckner^a**, Markus Köhli^b,
Thorsten Krautscheid^a, Christoph Krieger^a, Felix Müller^a, Uwe Renz^b,
Markus Schumacher^b, Stefan Tapprogge^c, Michael Zamrowski^c

^a Universität Bonn

^b Universität Freiburg

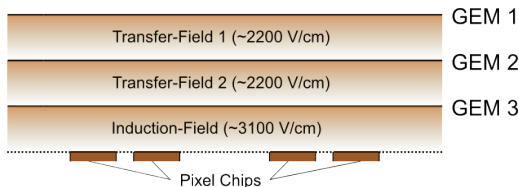
^c Universität Mainz



LC-TPC Collaboration Meeting
DESY, Hamburg, 21. Sept. 2009



- Amplification with standard CERN GEMs (triple GEM stack)
- Distance between GEMs and between GEM and chips is 1 mm
- Readout with 8 pixel chips (two Quadboards designed by NIKHEF)
- 256×256 pixels per chip: $55 \mu\text{m} \times 55 \mu\text{m}$ pixel size
- >0.5 Mio channels
- Readout frequency 55 MHz



The Module

anode plane

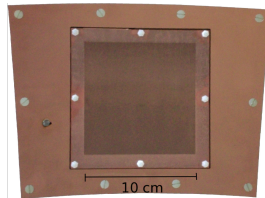
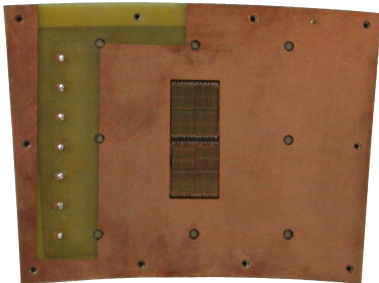
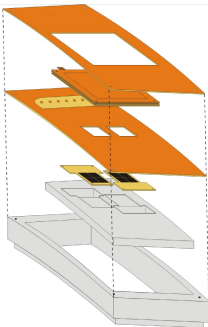
GEMs

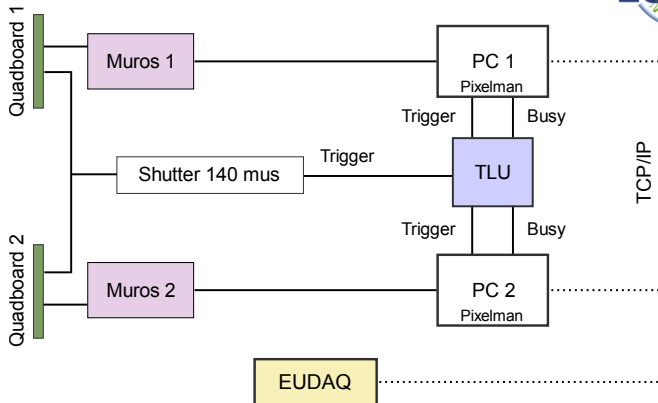
readout plane

quad-boards

reinforcement of
anode plane

redframe





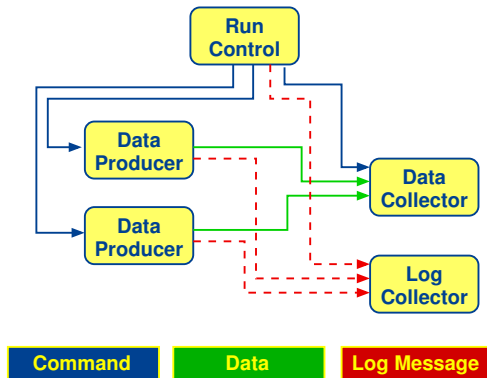
- DAQ PCs synchronised with **Trigger Logic Unit**
- Data is send to EUDAQ

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



eudaq Run Control

Control
 Config:
 Run:
 Log:

Status
 Run Number: 397 Events Built: 102
 Rate: inf Hz Triggers: 105
 Mean Rate: 2.92365 Hz Particles: 1201
 File Bytes: 0 B Scalers: 2509, 1767, 5385, 2641

Connections

type	name	state	connection
DataCollector		OK	127.0.0.1:8368
LogCollector		OK	127.0.0.1:8365
Producer	TimePix	OK: Run Started	192.168.0.9:1194
Producer	TimePix	OK: Run Started	192.168.0.1:234
Producer	TLU	OK: Started	127.0.0.1:8370

EUDAQ Log Collector

Level: 4-INFO From: Search:

Time	Level	Text	From	File
10:37:35.119	4-INFO	Connection from LogCollector (131.169...	LogCollector	euLog.hh:95
10:37:36.031	4-INFO	Connection from DataCollector (131.169...	LogCollector	euLog.hh:95
10:37:37.043	4-INFO	Connection from Producer.TLU (131.169...	LogCollector	euLog.hh:95
10:37:37.115	4-INFO	Connection from Producer.TLU (131.169...	DataCollector	DataCollector...
11:30:19.229	4-INFO	Connection from Producer.TimePix (192...	LogCollector	euLog.hh:95
11:30:19.309	4-INFO	Connection from Producer.TimePix (192...	DataCollector	DataCollector...
11:30:20.829	4-INFO	Connection from Producer.TimePix (192...	LogCollector	euLog.hh:95
11:30:20.925	4-INFO	Connection from Producer.TimePix (192...	DataCollector	DataCollector...
11:30:22.204	4-INFO	Configured (plugin)	Producer Time...	TimepixProdu...
11:30:23.463	4-INFO	Configured (plugin)	RunControl	RunControl.cc...
11:30:23.571	4-INFO	Configured (plugin)	Producer Time...	TimepixProdu...
11:30:26.345	4-INFO	Configured (plugin)	Producer.TLU	TLUProducer.c...
11:30:30.286	4-INFO	Starting Run 396:	RunControl	RunControl.cc...
11:30:30.438	4-INFO	Run Started	Producer Time...	TimepixProdu...
11:30:30.790	4-INFO	Preparing for run 396	DataCollector	DataCollector...
11:30:31.821	4-INFO	Run Started	Producer Time...	TimepixProdu...
11:31:15.298	4-INFO	Run Stopped	Producer Time...	TimepixProdu...
11:31:15.463	4-INFO	Stopping Run 396	RunControl	RunControl.cc...
11:31:15.464	4-INFO	End of run 396	DataCollector	DataCollector...

Preview for Medipix Control 0 (muros G02 - W0019)

File Options View Service Frames

512
 1
 Y
 X (column number)
 0 1961 3921 5882 7842
 512

Frame: 1
 Min level: 0
☐ Lock
 Max level: 7
☐ Lock
☒ Auto rang
☐ Count rat
☒ Histogram
☒ Filter chain:
☒ Auto updt

Color map:
☒ Auto updt

Pixelman Eudaq Producer

Hostname: No ASCII Mask selected ☐ ASCII-TTL-Adj.-FIR

ParallelPort: Command history
 Select Chip:
 Module ID:

EUDAQ RunControl and LogCollector Pixelman event display and PixelmanProducer

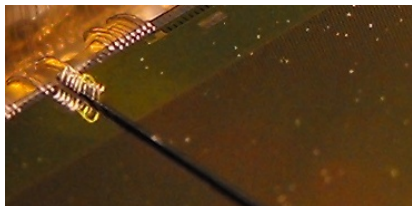
He/CO₂ 70/30:

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	

- Module worked fine in He/CO₂ 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

Aim of the reconstruction:

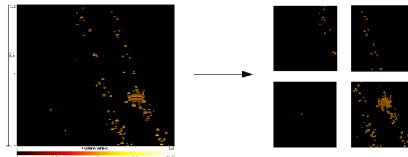
- Reconstruct individual clusters
- Fit the track
- Determine the point resolution

→ 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:



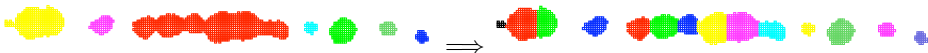
Example: Cluster Separator



Clusters are split along cluster axis

Short drift distances:

- Algorithm works fine



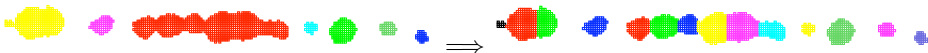
Example: Cluster Separator



Clusters are split along cluster axis

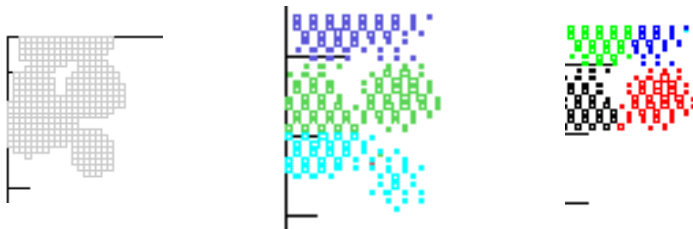
Short drift distances:

- Algorithm works fine



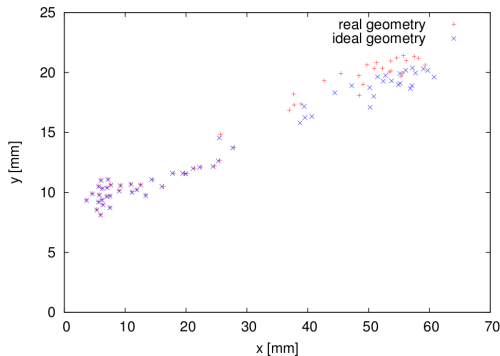
Long drift distances:

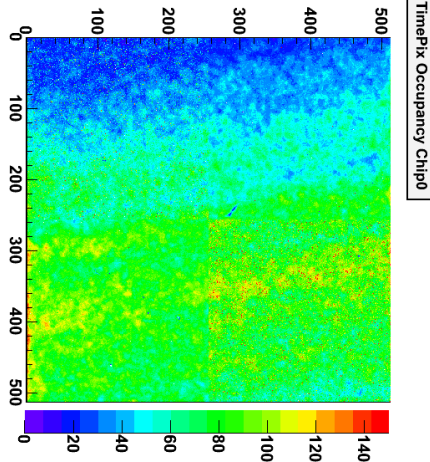
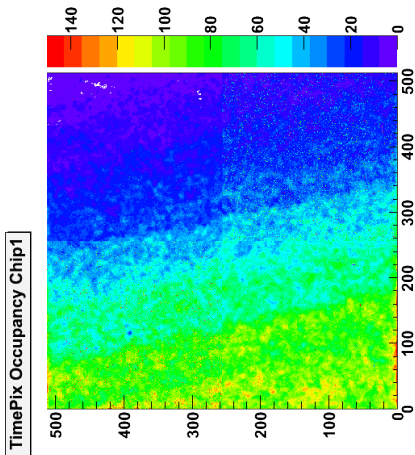
- Algorithm is not optimized yet
- Need to apply algorithm twice
- But: Algorithm loses some data on the second pass



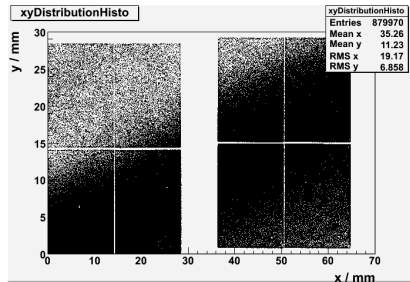
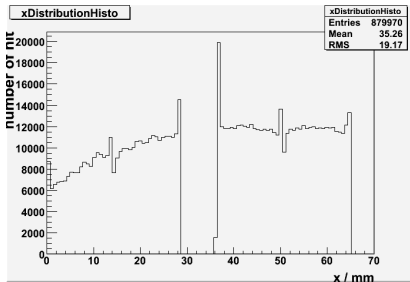
Goemetry file:

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

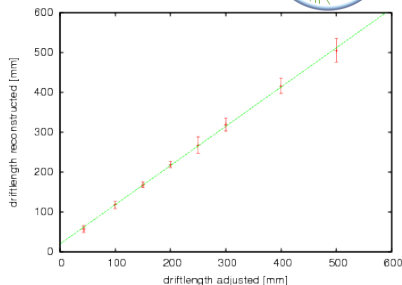
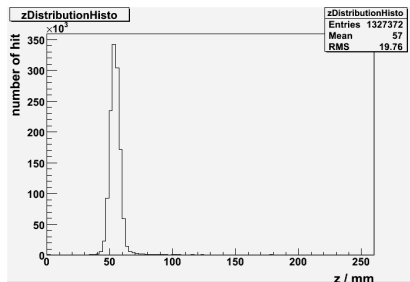




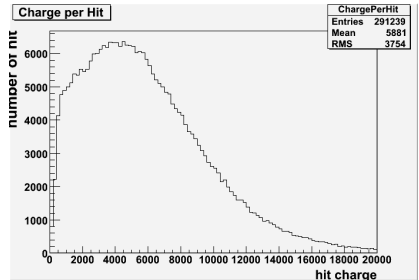
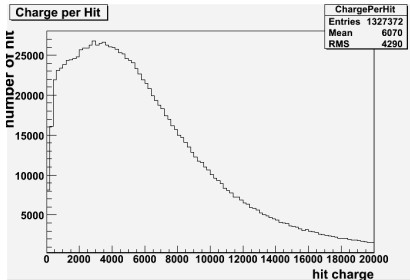
- Homogeneous response over the whole module
- Beam profile clearly visible
- Hot area near the gap between the boards



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



- 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



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

Summary

- LC-Module with two QuadBoards + GEMs successfully operated
 - 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