Status Report TPC Task

Klaus Dehmelt

DESY

EUDET Extended Steering Committee-Meeting

31-August-2010

EUDET JRA2/TPC

Main objective: Large Prototype (LP) of a TPC at the DESY testbeam T24/1.

Achievements

- **Oct-2008: Field cage available**
- **Nov-2008: First cosmics with MicroMegas/AFTER electronics in LP**
- **Dec-2008: First testbeam/JRA1 with MicroMegas/AFTER electronics in LP**

JRA1:
Magnet (PCMAG) + infrastructure
T24 Test beam

EUDET JRA2/TPC

Main objective: Large Prototype (LP) of a TPC at the DESY testbeam T24/1.

Achievements

- **Mar-2009: First cosmics/testbeam/JRA1 with JGEM/Altro electronics in LP**
- **May-2009: Data taking/JRA1 with MicroMegas/AFTER electronics in LP and laser setup (Victoria Univ.)**
- **Jun-2009: First cosmics/testbeam/JRA1 with BGEM/TimePix in LP**

JRA1:
Magnet (PCMAG) + infrastructure
T24 Test beam

EUDET JRA2/TPC

Main objective: Large Prototype (LP) of a TPC at the DESY testbeam T24/1.

Achievements

- **Jul-2009: Installation of movable stage**
- **Jul-2009: Data taking/JRA1 with JGEM/ALTRO electronics in LP**
- **Sep-2009: First cosmics/testbeam/JRA1 with BGEM/Altro electronics in LP**
- **Nov-2009: Common data taking/JRA1 with MicroMegas/AFTER electronics in LP and Si modules in PCMAG**

JRA1:
Magnet (PCMAG) + infrastructure
T24 Test beam

EUDET JRA2/TPC

Main objective: Large Prototype (LP) of a TPC at the DESY testbeam T24/1.

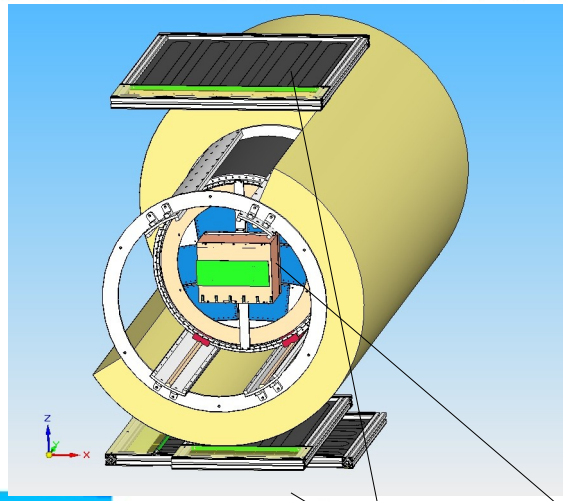
Achievements

- **Mar-2010: Data taking/JRA1 with MicroMegas/AFTER electronics in LP**
- **Mar-2010: Data taking/JRA1 with JGEM/ALTRO electronics in LP**

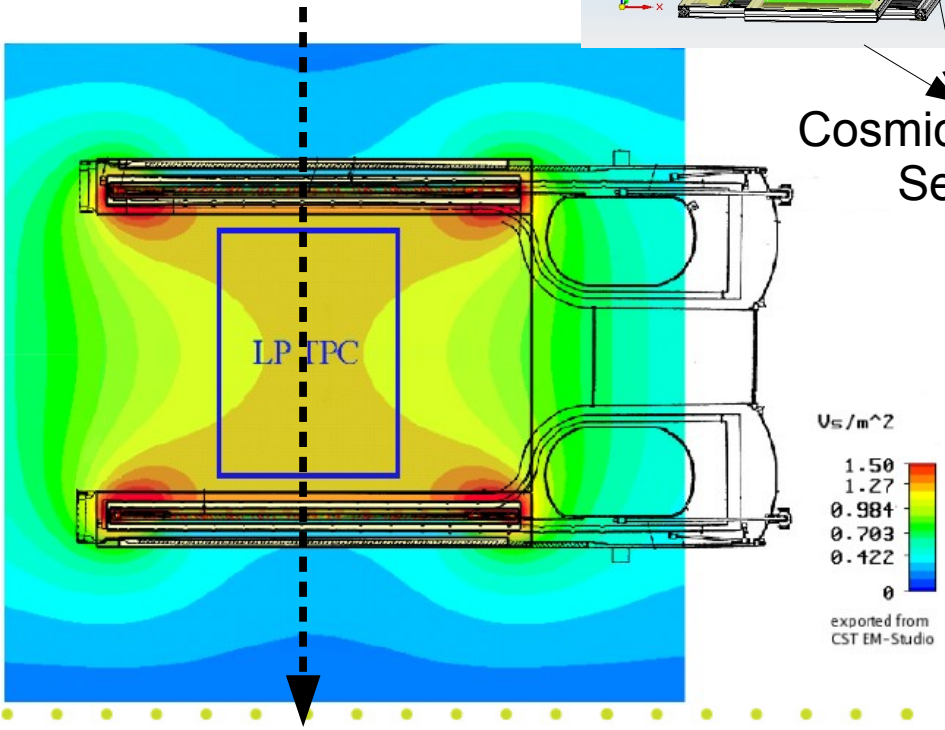
JRA1:
Magnet (PCMAG) + infrastructure
T24 Test beam

DESY Setup

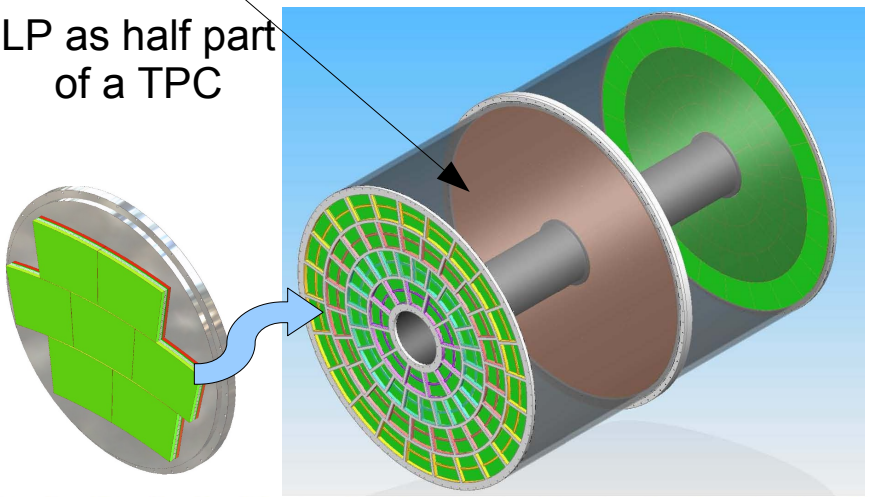
- *PCMAG:* superconducting magnet, up to 1.25 T
- e^- test beam @DESY (1GeV/c<p<6GeV/c)



Cosmic Trigger Setup

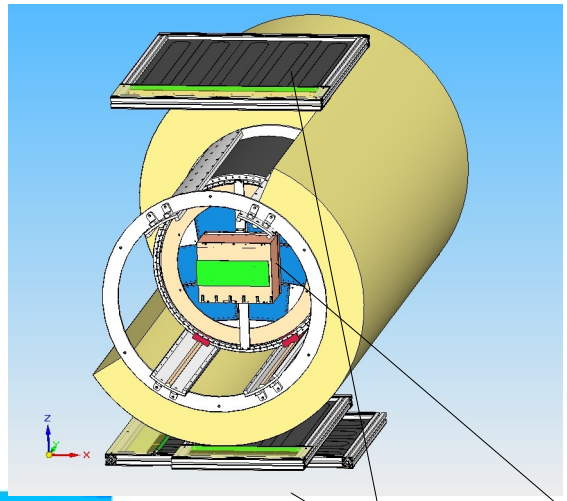


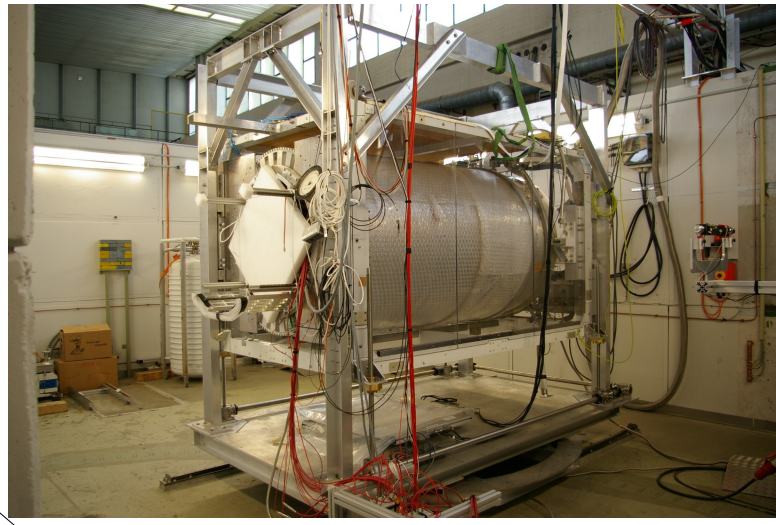
LP as half part of a TPC



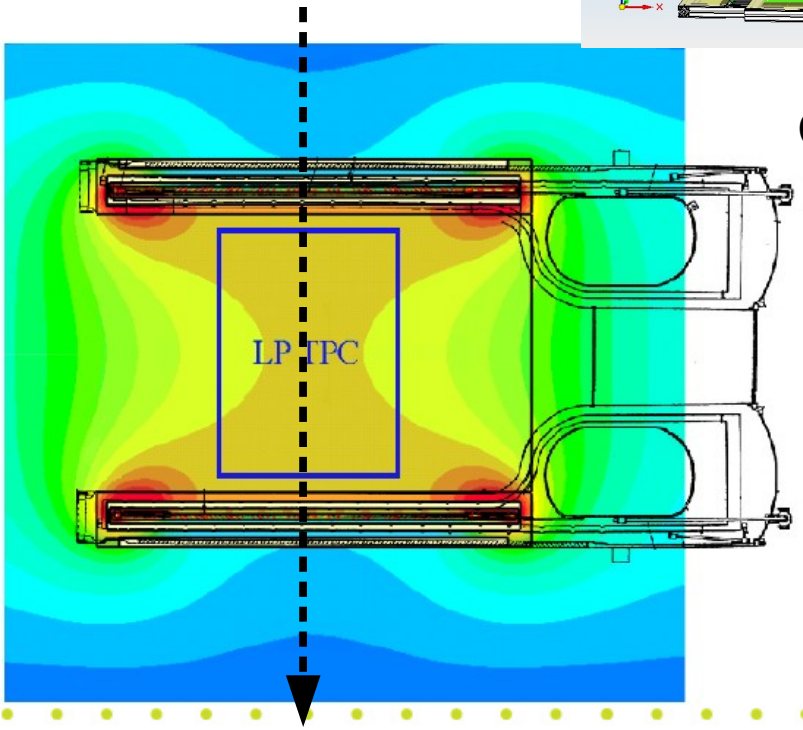
DESY Setup

- *PCMAG:* superconducting magnet, up to 1.25 T
- e^- test beam @DESY (1GeV/c<p<6GeV/c)

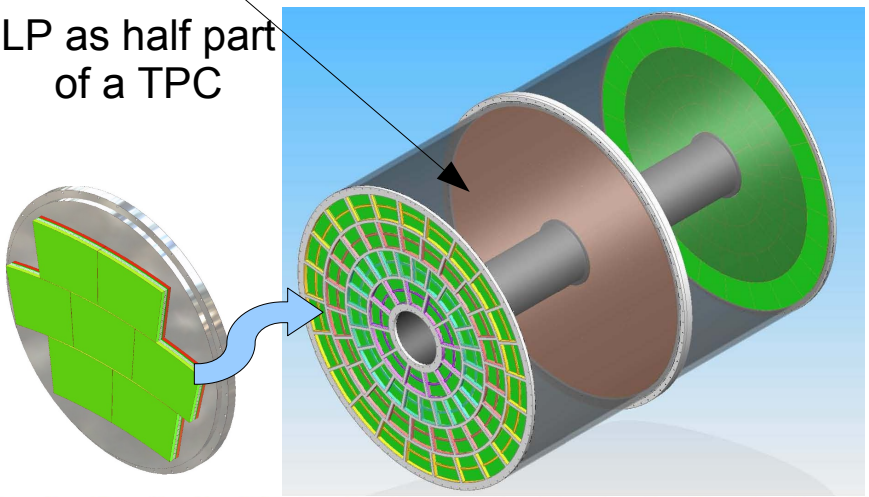




Cosmic Trigger Setup

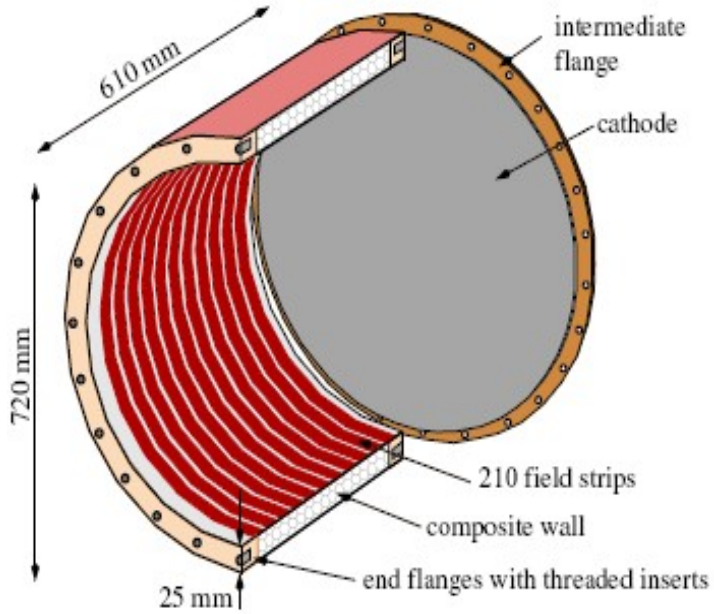


LP as half part of a TPC



Field Cage

- Requirements:
  - **Dimensions**
    - diameter = *O*(800 mm), length = *O*(600 mm)
  - **Lightweight field cage, though stable and flexible to use**
  - **Homogeneous electrical field**

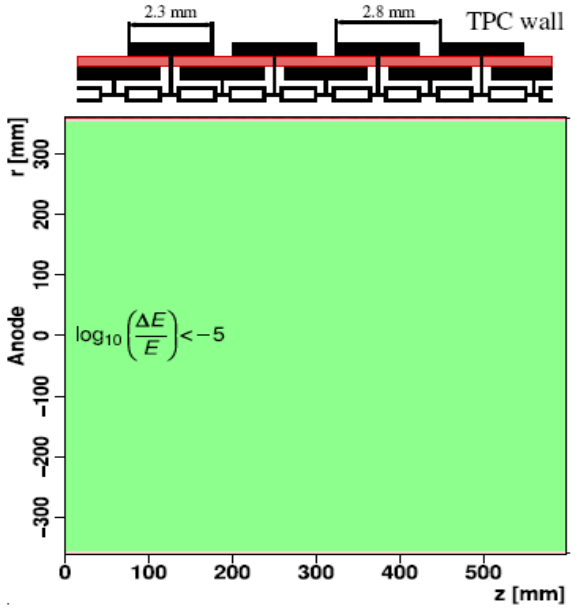


parallel plate capacitor

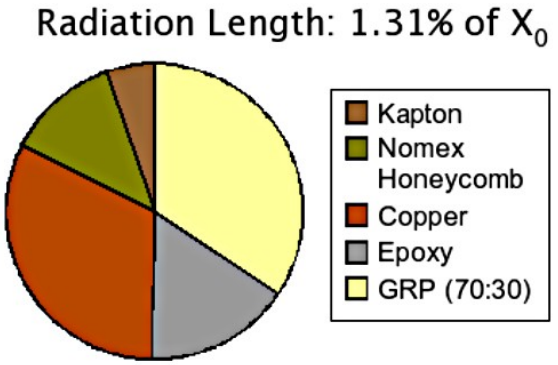
external shiedling (gnd)

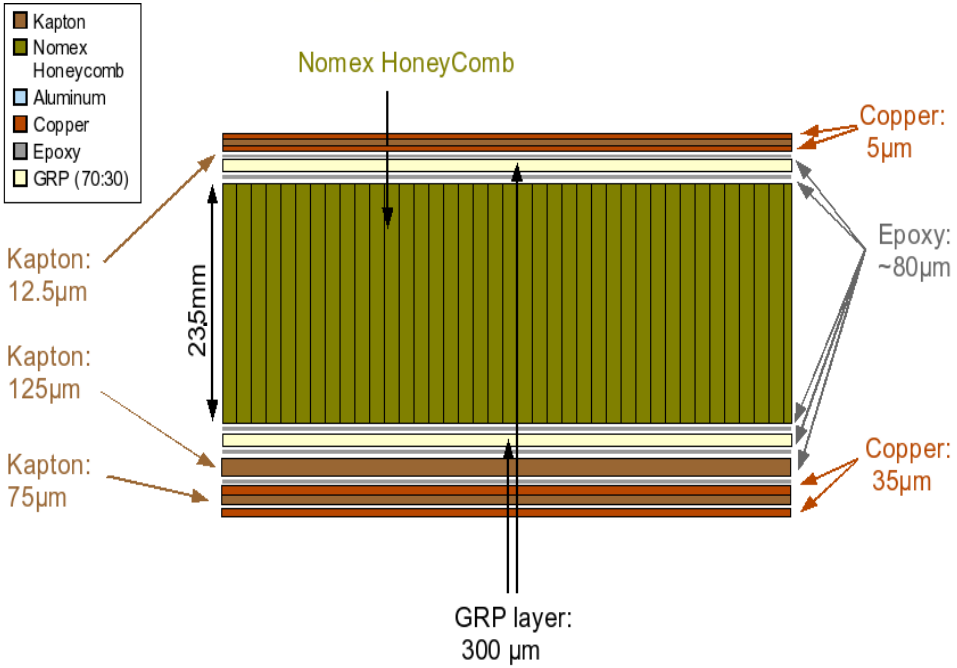
field strips

mirror strips



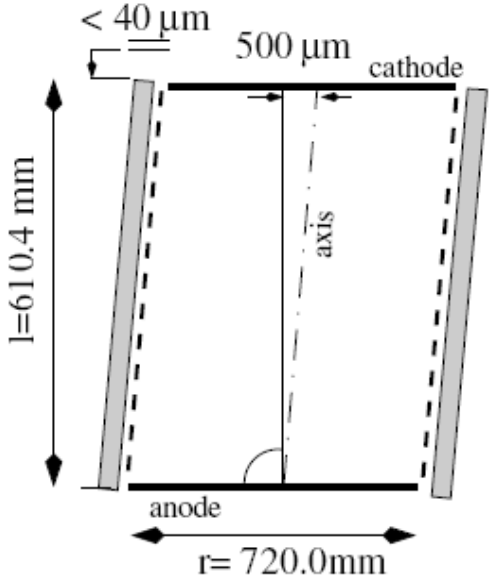
Field Cage

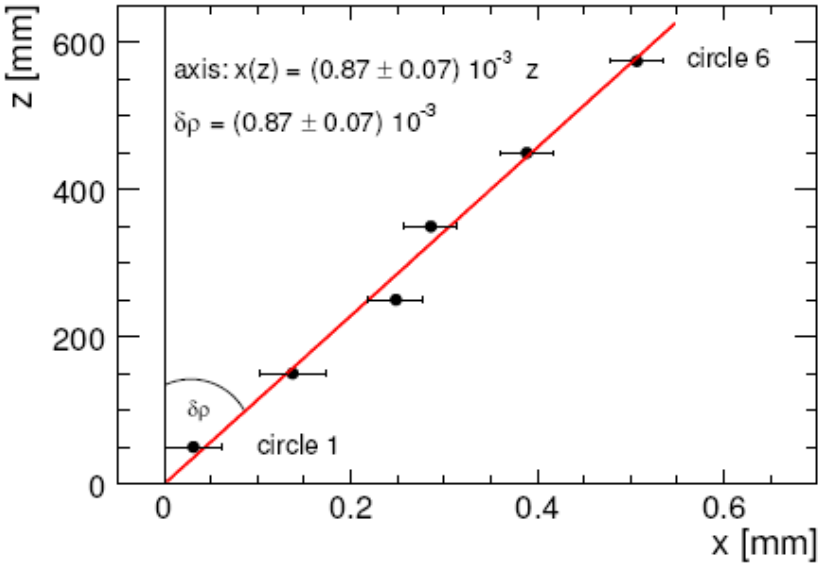


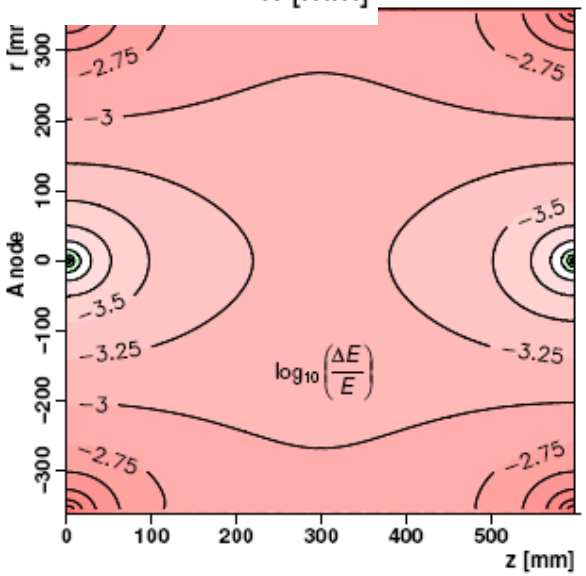


Diameter: Inner 720 mm,
Outer 770 mm
Wall thickness 25 mm
Length 610 mm
HV to be applied: up to 20 kV

Field Cage





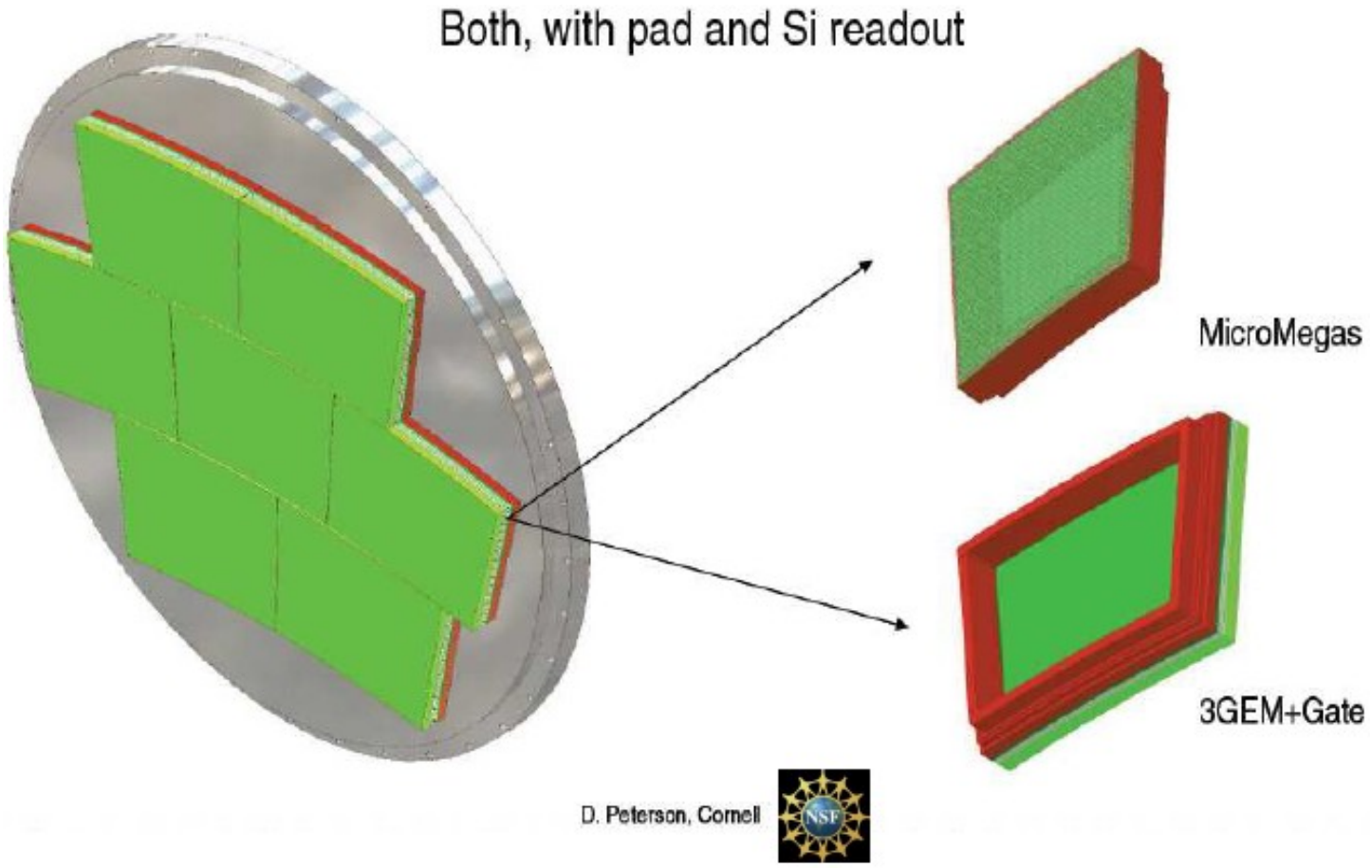


Achieved mechanical accuracy:

- Aligment of the end faces: $\delta l < 40\ \mu m$
- Alignment of field cage axis: $\delta A \sim 500\ \mu m$
- Field quality $10^{-4} \lesssim \Delta E/E \lesssim 10^{-3}$

P. Schade, DESY

End Plate & Readout Modules

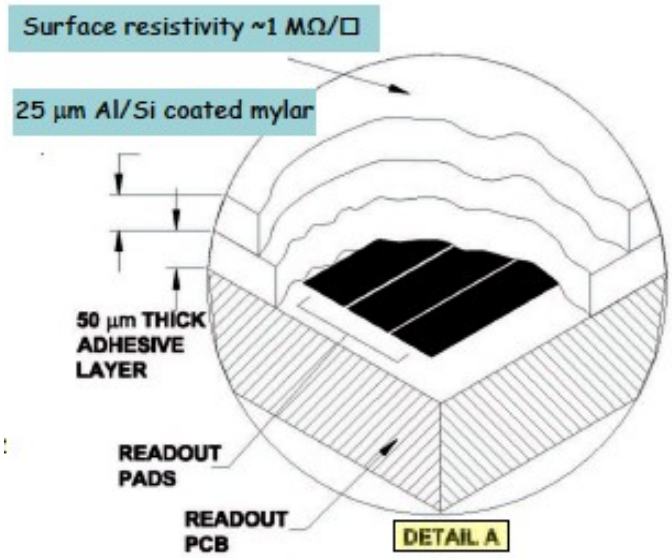


MicroMegas

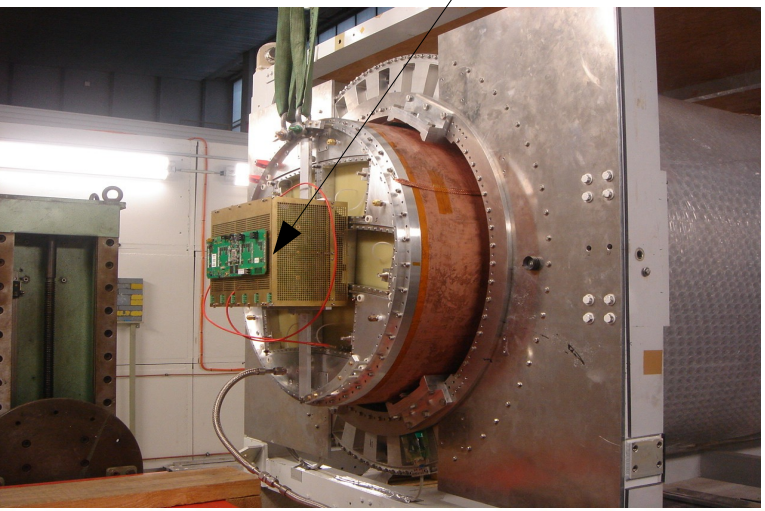
MicroMeGaS for LP:

24 rows x 72 pads
Av. Pad size: 3.2 x 7mm²

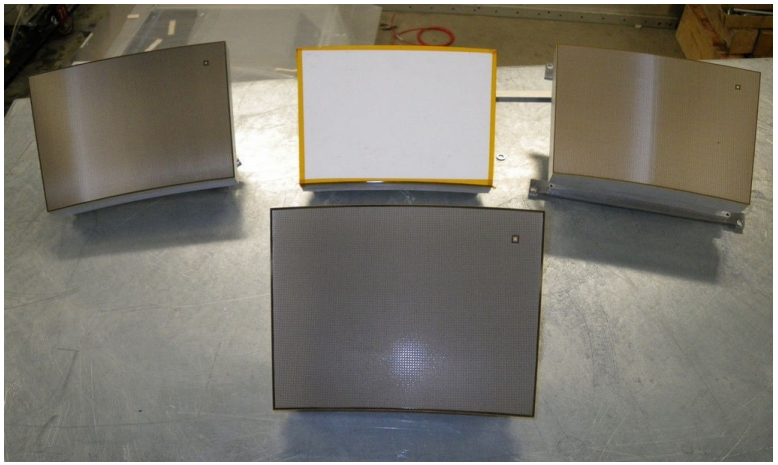
P. Colas, CEA Saclay
M.S.Dixit, Carleton University



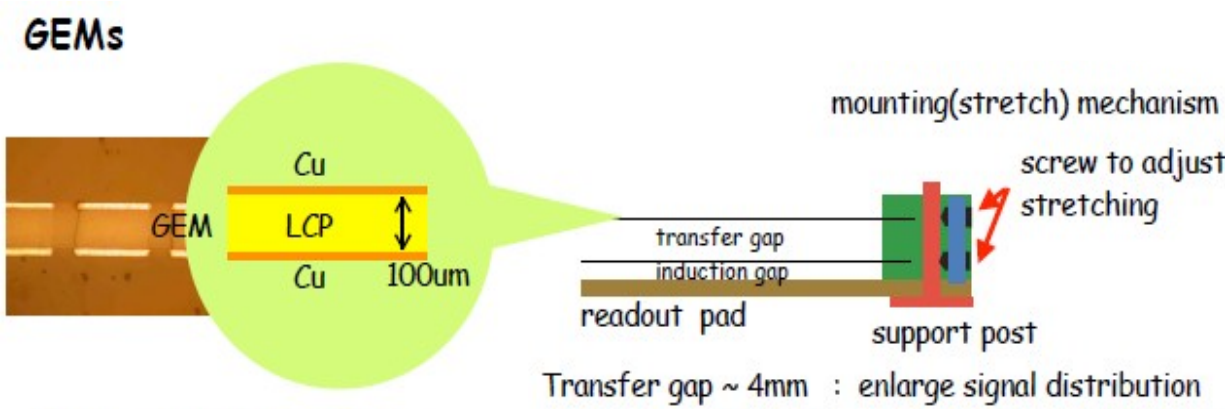
Readout electronics: AFTER (T2K TPC)

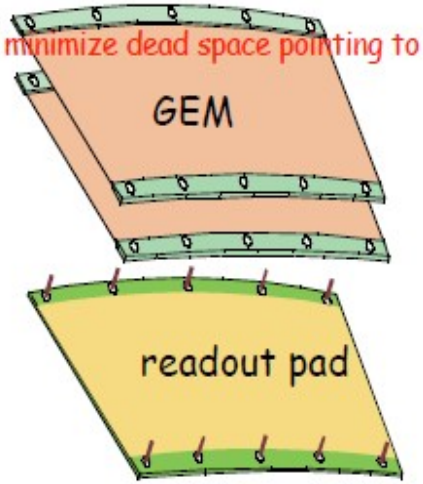


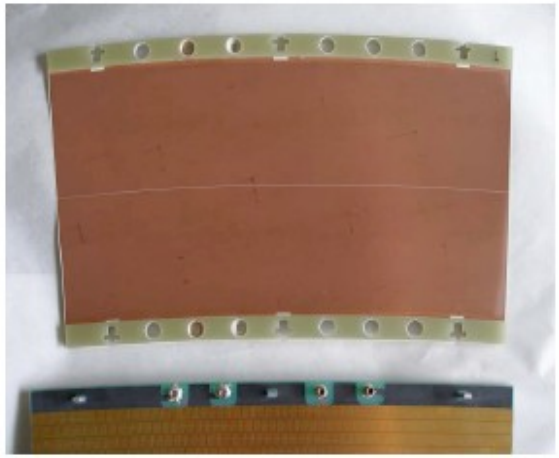
No resistive layer
Resistive Kapton
Resistive ink



JGEM

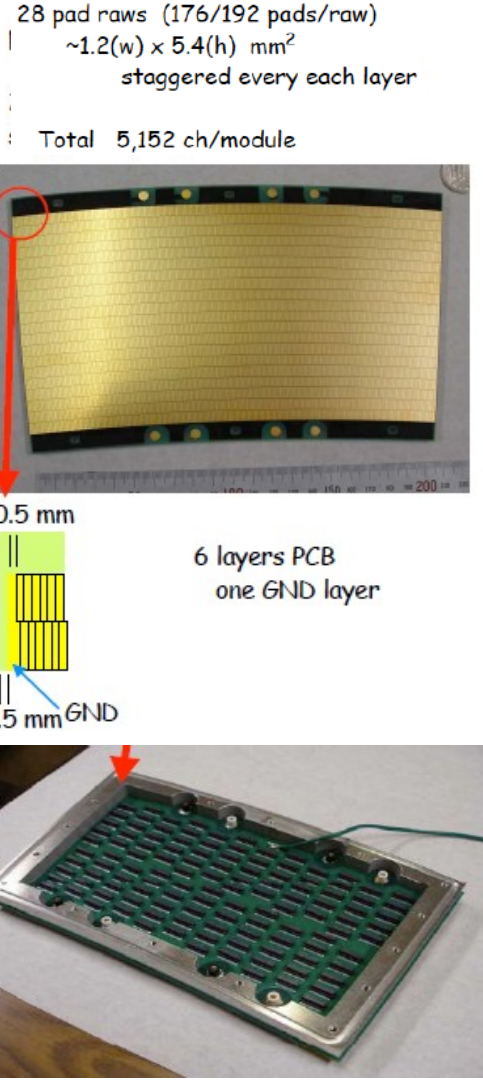




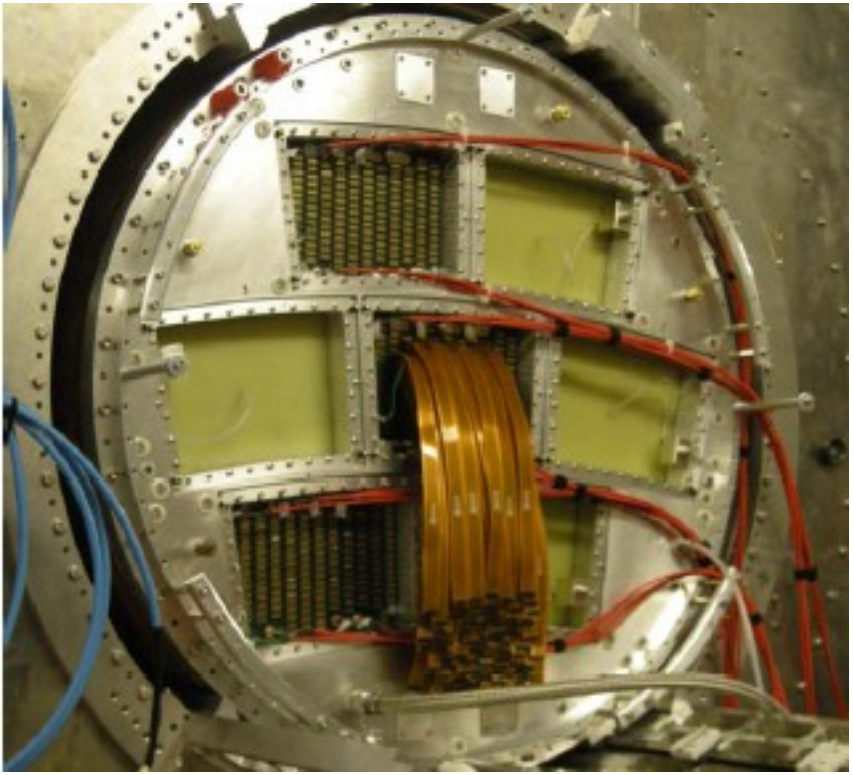


Optional: gating GEM

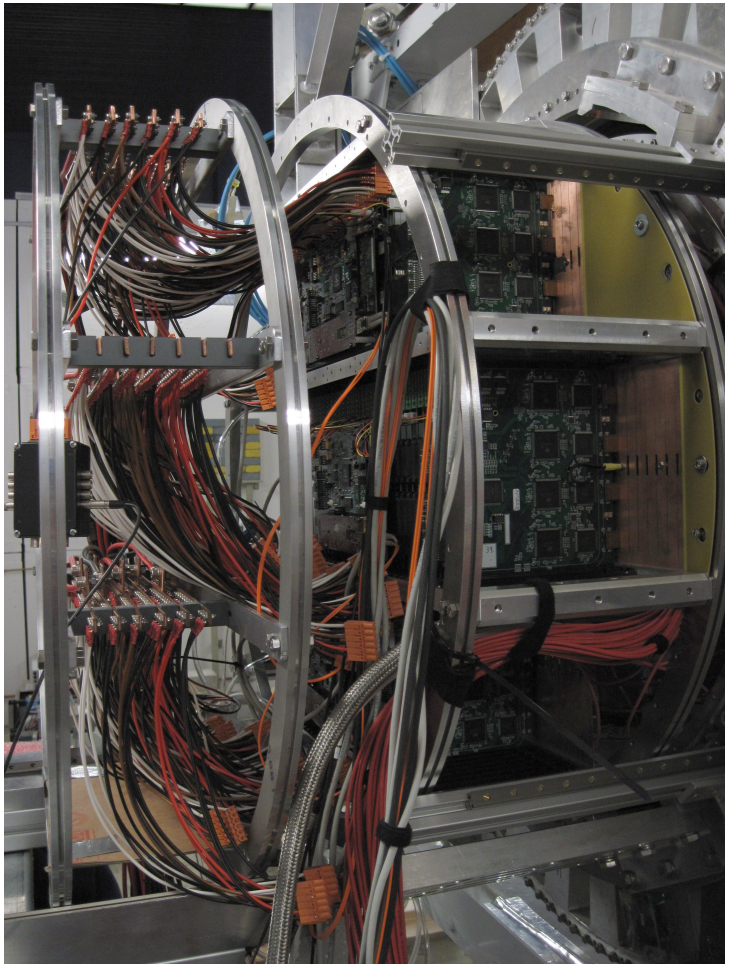
A. Sugiyama, Saga Univ.



JGEM



Up to 10k channels readout electronics



Readout electronics:
Based on ALTRO (ALICE TPC)
L. Joensson, LUND University

Readout Electronics

Three-fold readout electronics:

- ALICE based:
  new PCA16 amplifier chip + ALTRO chip (EUDET & LCTPC) → adopted to ILC environment; designed within EUDET DAQ scheme

- T2K based:
  AFTER electronics for T2K TPC (CEA Saclay)

- TDC based:
  ASDQ chip + TDC (EUDET & Uni Rostock)

AFTER electronics for MicroMeGAS (resistive anode readout)
ALTRO and TDC based electronics will be hooked to the GEM detector modules (connector compatibility)

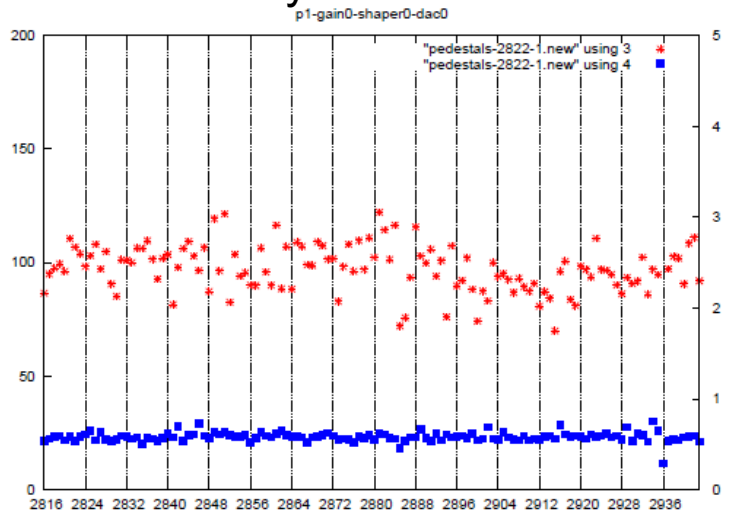
ALTRO Electronics & DAQ

Based on ALTRO chip, developed for ALICE

- 16 ch analog to digital conversion with 10 bit precision
- Digital signal processing, including zero suppression and storage in event buffer
- Sampling up to 40 MHz
- Event storage memory of 1k 10bit words → 50 μs drift time @ 20MHz
  → v_{drift} = 7cm/μs: $L_{drift,max}$ = 350 cm

- PCA16 chip with different choices: w.r.t. peaking time, gain, decay time and signal polarity
- Modifications to FEC: programmability, can be done remotely

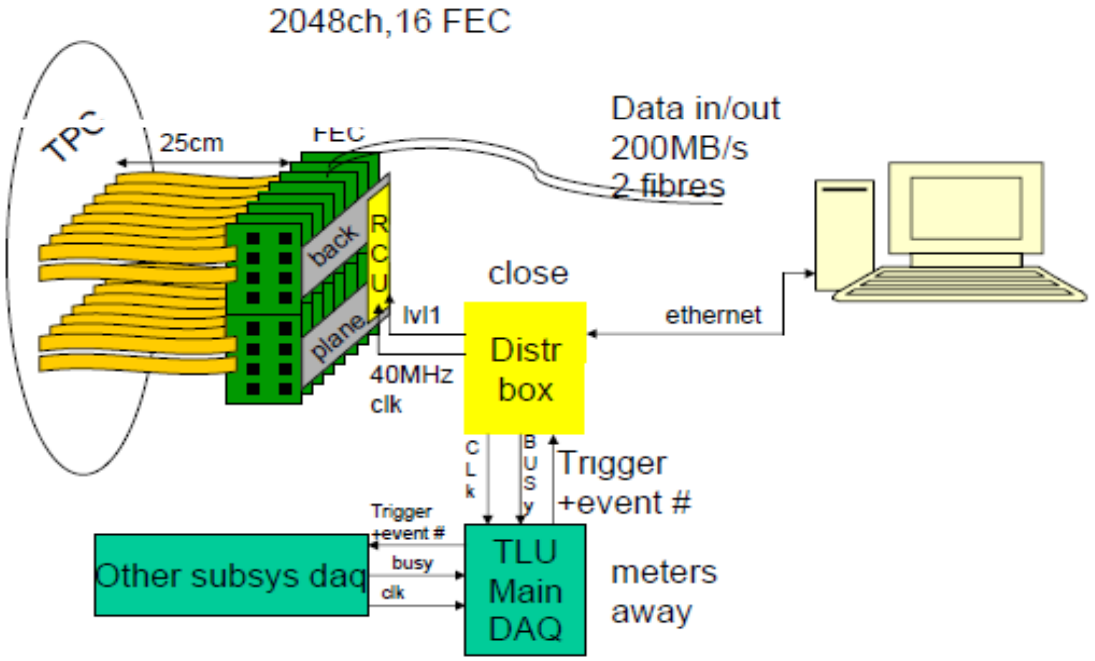
- Typical measurement with 120 ns peaking time (max) and lowest gain (12mV/fC) shows RMS value of ~0.5 ADC counts → ENC of 260 e^-
- At highest gain (27mV/fC) ~1 ADC counts → ENC of 231 e^-
-



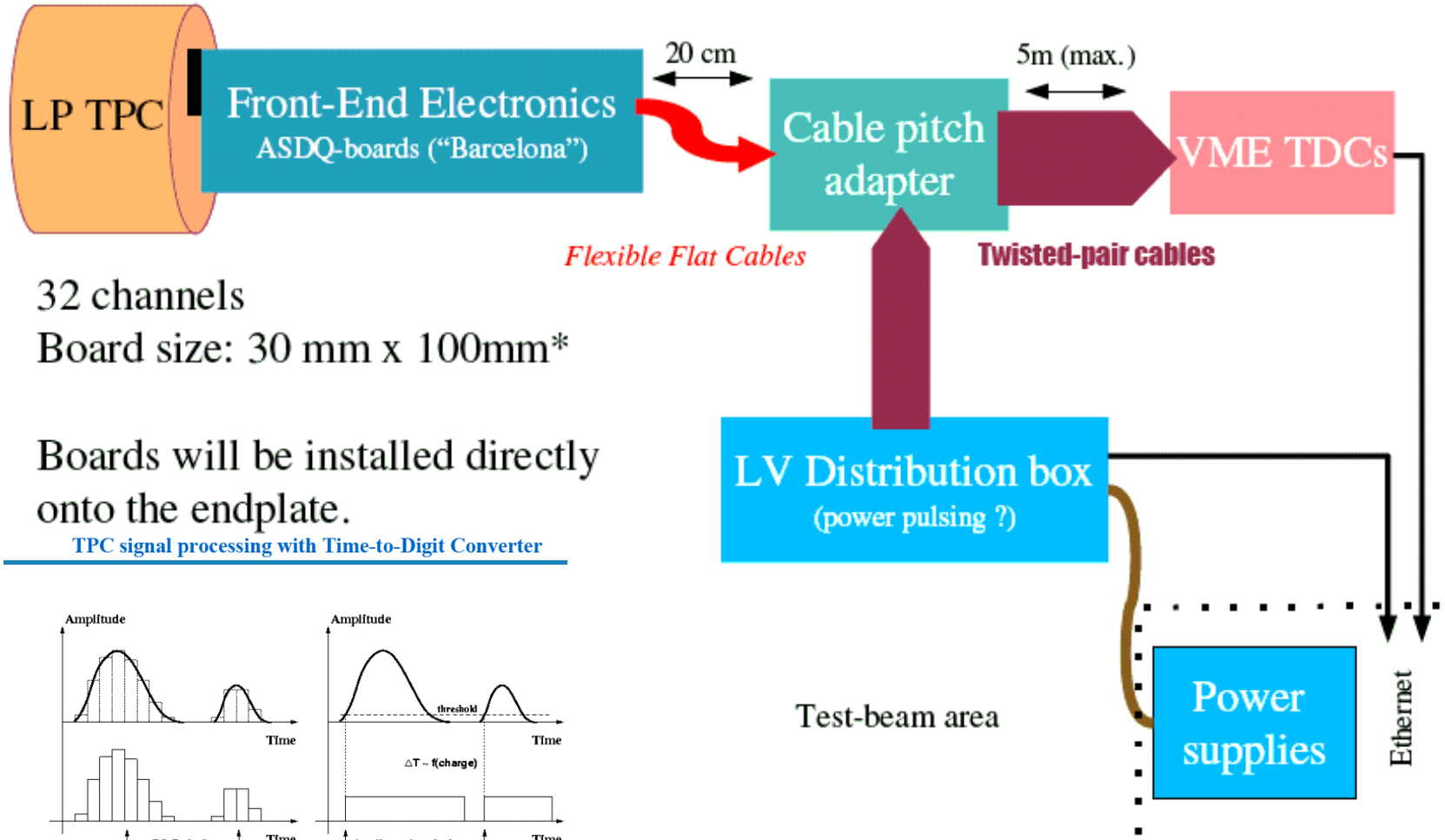
ALTRO Electronics & DAQ

FEC

- Each FEC contains 8 PCA16 & 8 ALTRO chips → 128 ch
- Readout Control Unit (RCU) responsible for readout of data via backplane, up to 32 FECs
- Optical fiber for data transmission
- Received by Detector Read-Out Receiver Card (DRORC), placed in DAQ PC
- Trigger and Timing Control by Trigger Logic Unit (TLU)
- Triggers from TLU received by distribution box (DBOX) and sent via RCU to FECs



Readout Electronics: TDC

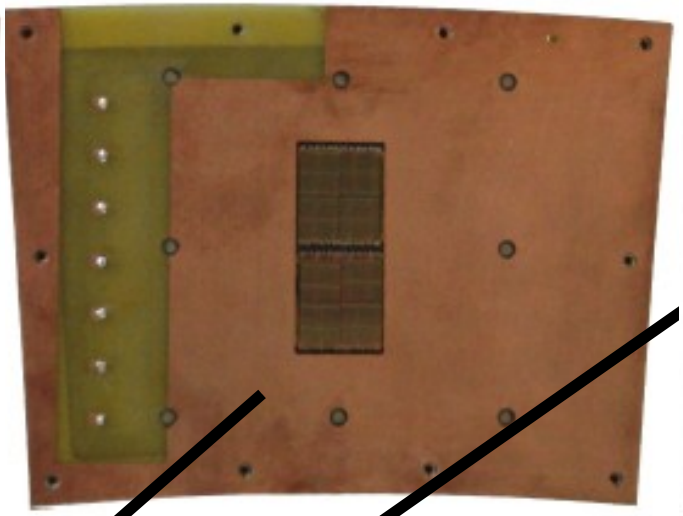


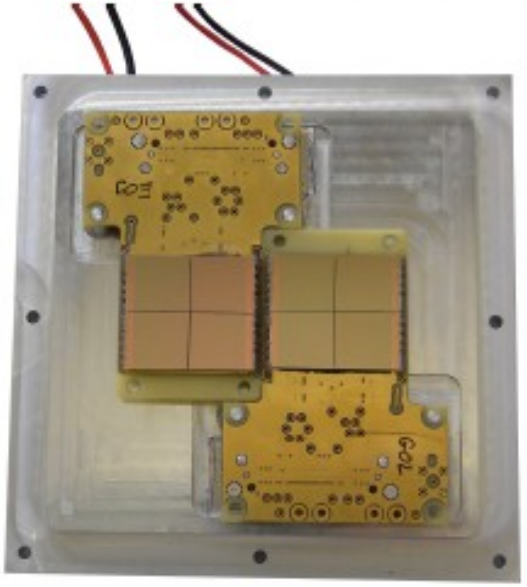
TPC signal processing with Time-to-Digit Converter

- The time of arrival is derived using the leading edge discriminator.
- The charge of the input signal is encoded into the width of output digital pulse.

A. Kaukher, Univ. Rostock

3-GEM Structure & TimePix





anode plane

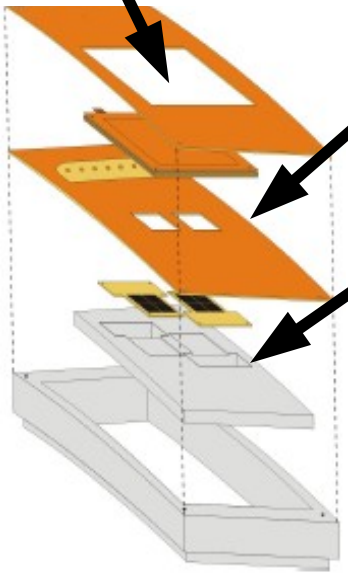
GEMs

readout plane

quad-boards

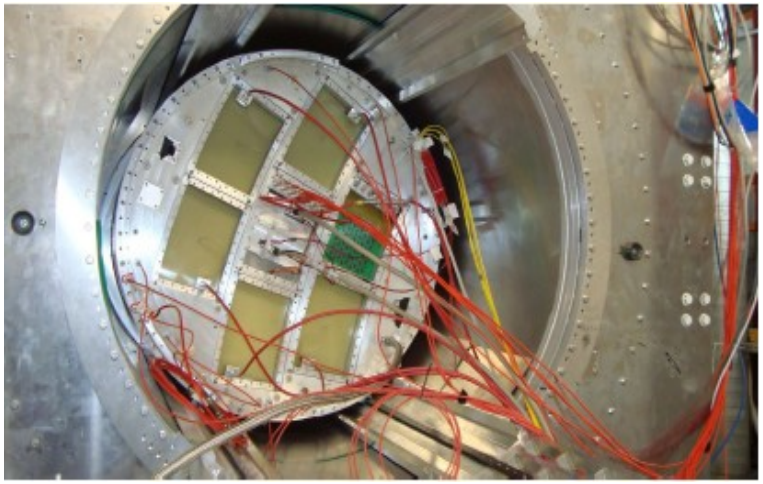
reinforcement of anode plane

redframe

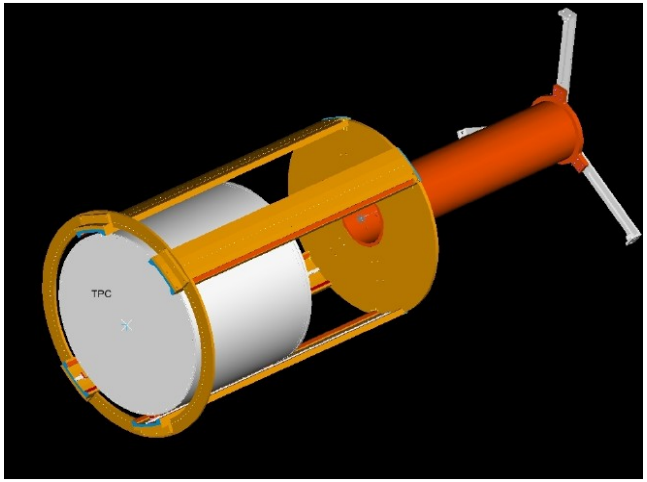


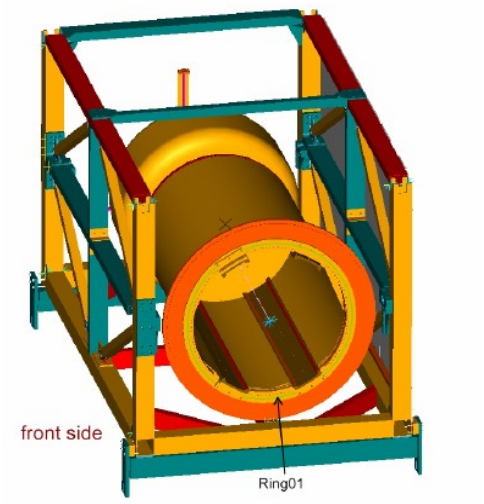
Readout:
2 quadboards
(4 TimePix
Chips each)

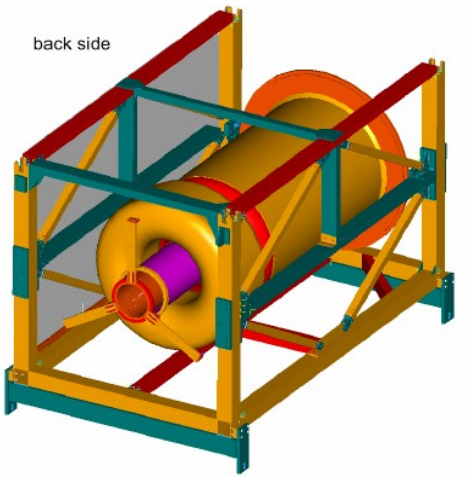
J. Kaminski, Univ. of Bonn



LP Mechanics

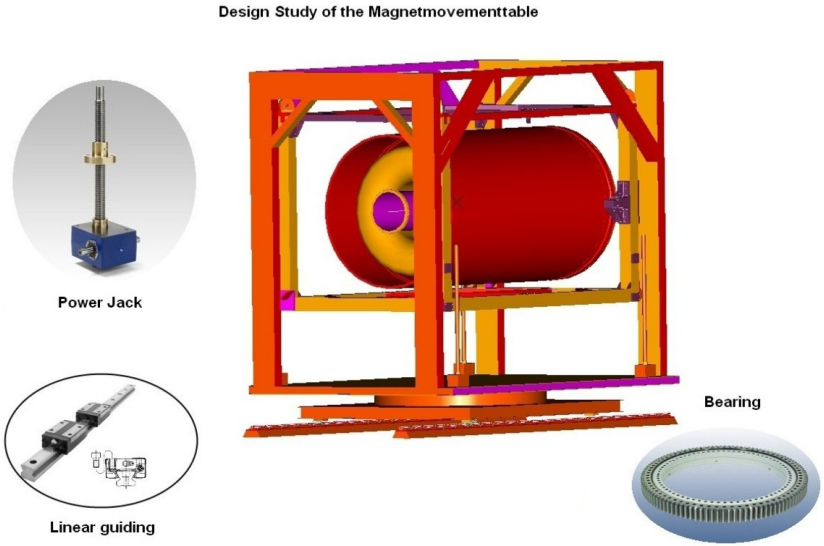






Support structures:

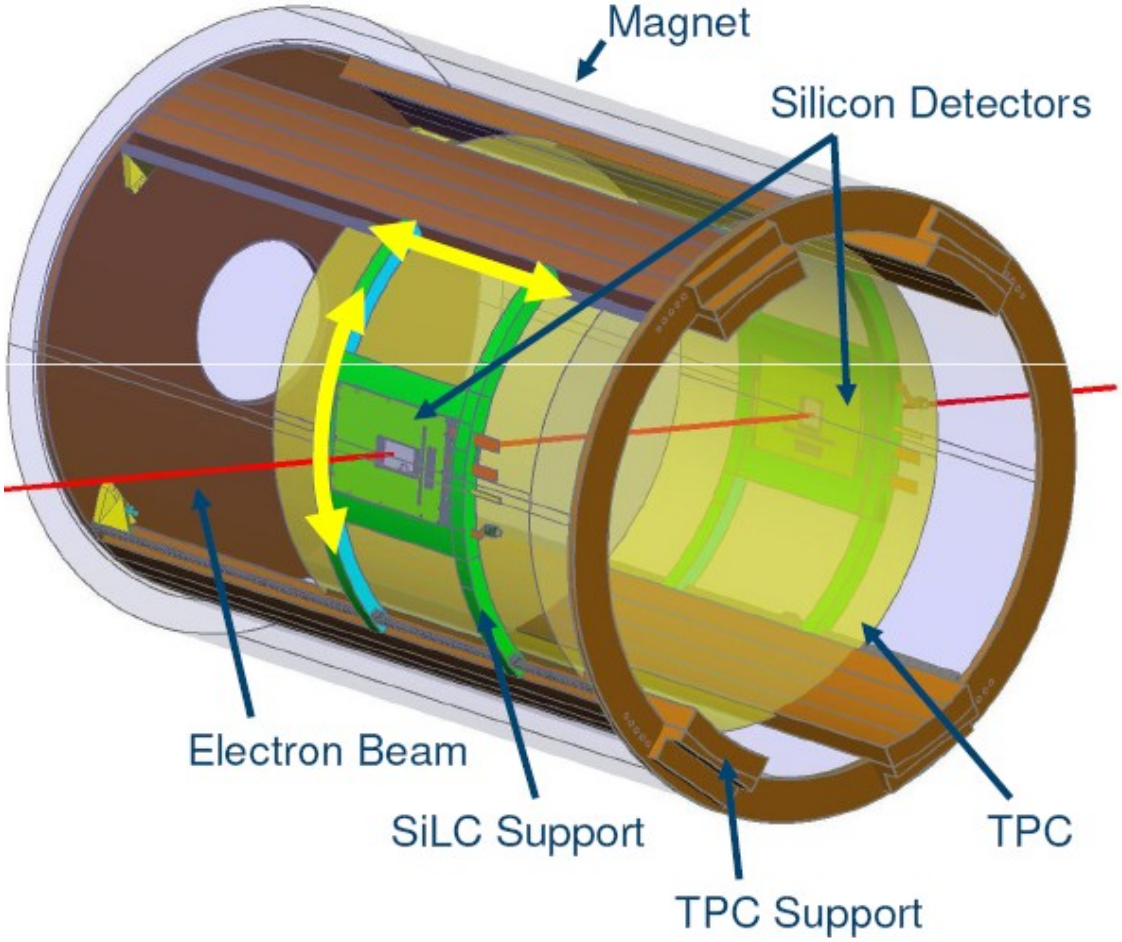
- TPC
- PCMAG

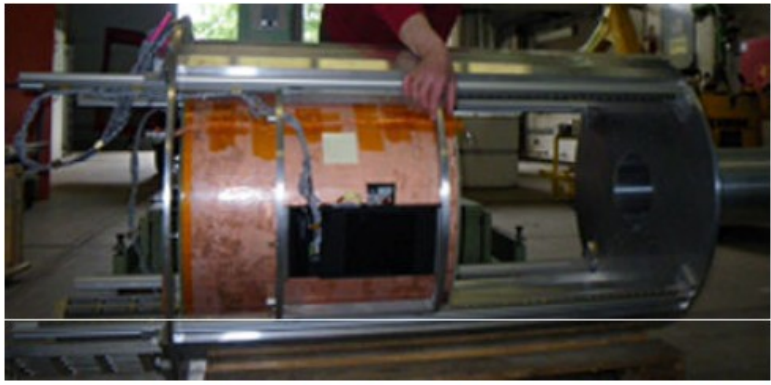


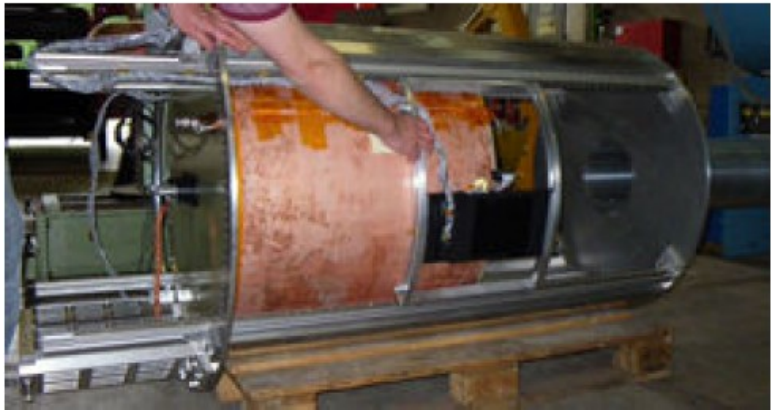
F. Hegner, V. Prahl, R. Volkenborn, DESY

LP Mechanics

Si Envelope



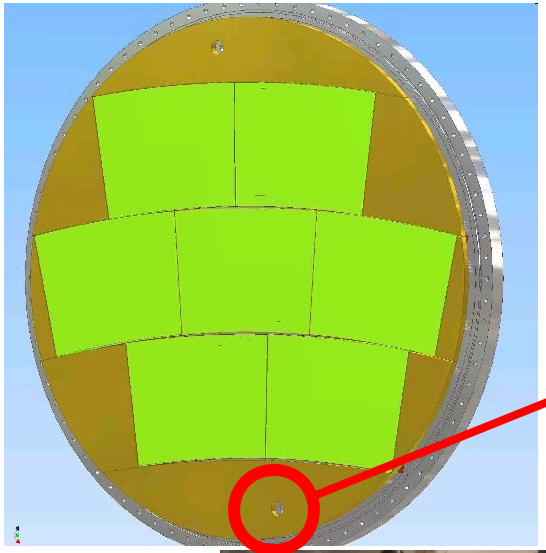


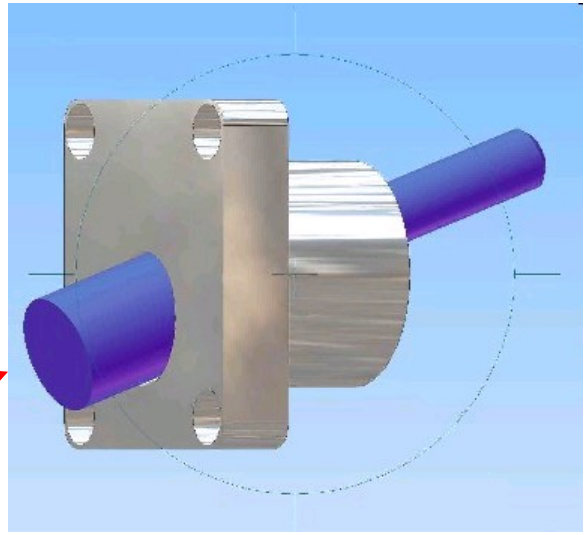


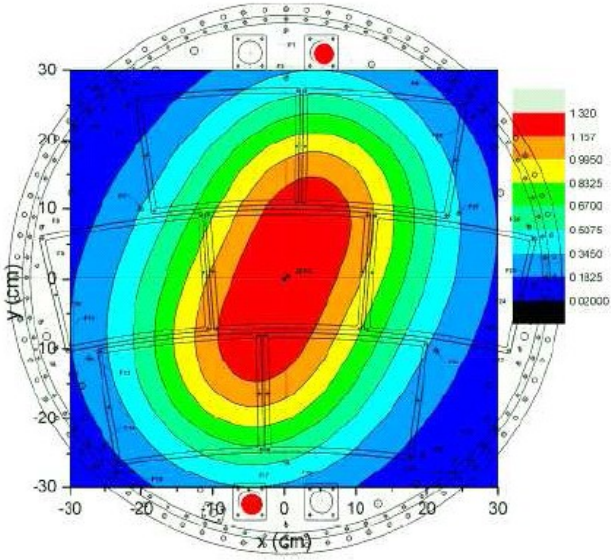
Combined test beam campaign with two Micromegas modules in Nov. 2009

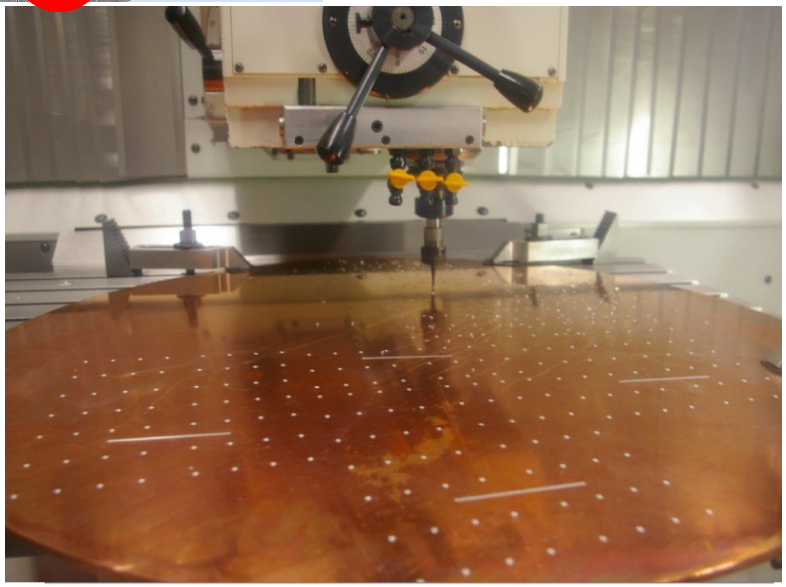
S. Haensel
HEPHY Vienna

Laser Calibration Setup

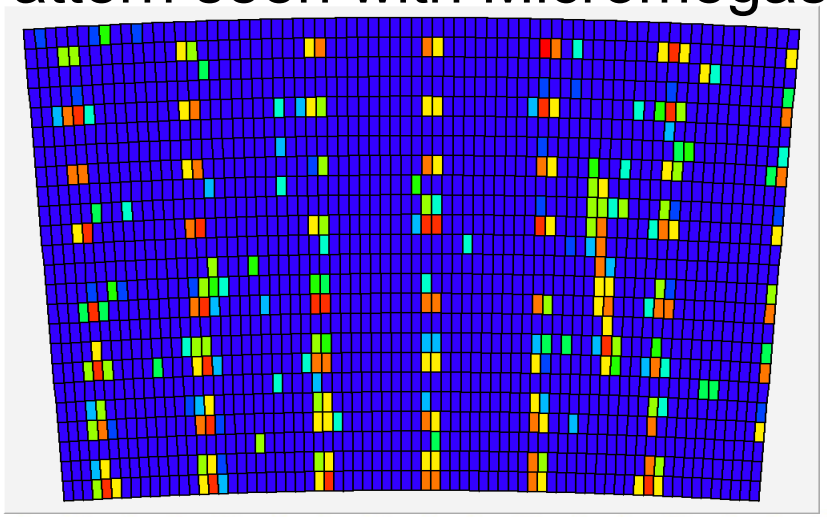








Pattern seen with Micromegas



Status

- Field cage, cathode end plate / alignment wheel, cathodes as part of the LP, one cathode patterned
- 10k channels of ALTRO electronics have been produced and tested
- 6k channels of ALTRO electronics in use
- S-ALTRO development under way
- TLU trigger system available

Status

- Gas-/HV-infrastructure
- Infrastructure for LP present and being used
- Infrastructure for SiLC envelope installed
- LP assembled, commissioned and being tested
- LP with three different amplification technologies operated
- First SiLC run performed
- ~20 weeks of test beam with LP operation so far
- >10M events recorded → ~2TB data on GRID
- → more to come

Summary & Outlook

- We have built and assembled / tested / commissioned a Large Prototype of a TPC (EUDET and LCTPC collaboration)
- Two MPGD technologies (with three electronics techniques) have been tested:
  - Micromegas (AFTER electronics)
  - GEM (ALTRO, TimePix)
- Infrastructure for Large Prototype has been constructed
- e^- test beam (DESY) in conjunction with PCMAG (*1T* magnet)
- Preliminary results are looking very promising
- Accomplishment of assigned goals

Summary & Outlook

- Items not yet completed:
  - Alignment system for LP within PCMAG to be tested/installed
  - Slow control to be (further) developed
  - Automation of processes
  - DESY GEM module
- Further test beam campaigns for this year:
  - Backplane integrated 10,000 channel readout system, based on ALTRO electronics
  - Seven Micromegas modules with AFTER electronics attached to the modules (?)
  - DESY-GEM module with ALTRO electronics
- PCMAG modifications in 2011