Sabato Stefano Caiazza

Universität Hamburg

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Marie Curie Fellow

- Initial Training Network MCPAD
- Early Stage Researcher
- Contract Started June 1st 2009

Home country: Italy

Host Institute: Desy

My MCPAD Project

- To develop a TPC readout system based on the GEM technology
- Supervisor: Ties Behnke
- PhD Supervisor for HH Uni: Johannes Haller

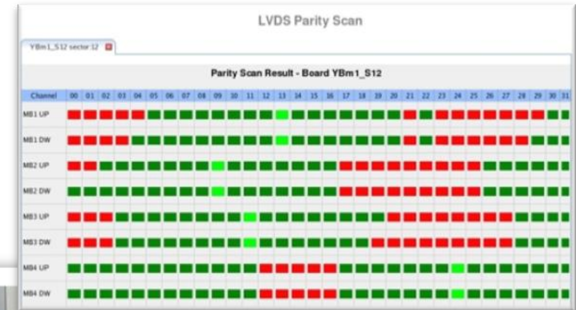
Scientific Background

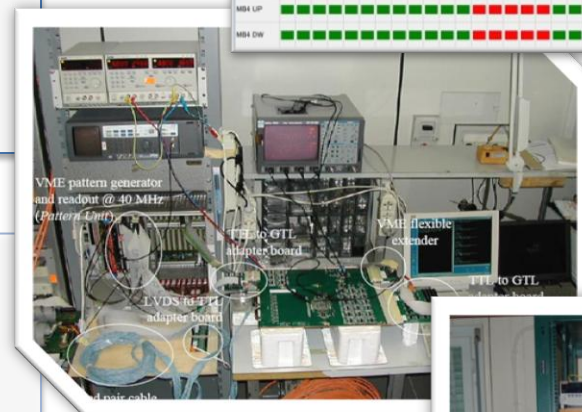
Master Degree in Physics

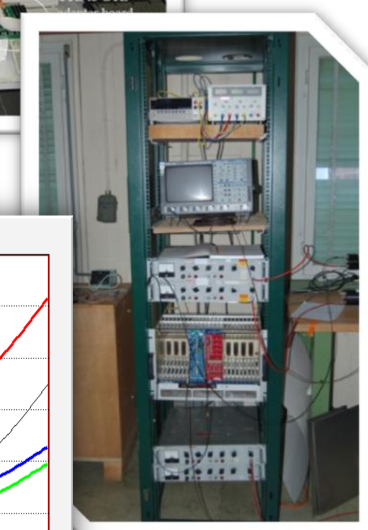
- October 2008
- Bologna University
- Final Vote: 110/110

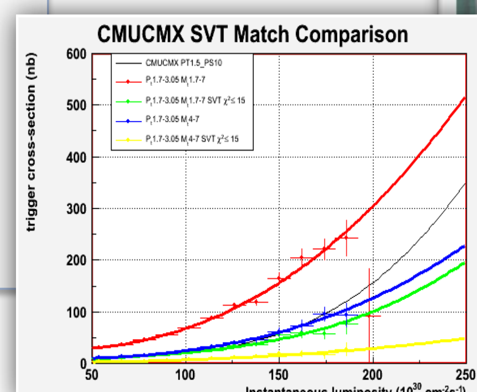
Focus on Detector development

- Experimental study curriculum
- Undergraduate work on the commissioning of the CMS detector
- CERN Summer Student: working on the development of the Alice experiment
- Fermilab Summer Student: working on the Trigger algorithms of the CDF detector









The FLC group and my project framework

FLC group @ DESY

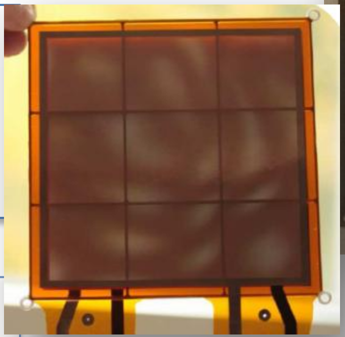
- Developing detector technologies for the next generation Linear colliders
- Focusing on the R&D for a GEM TPC

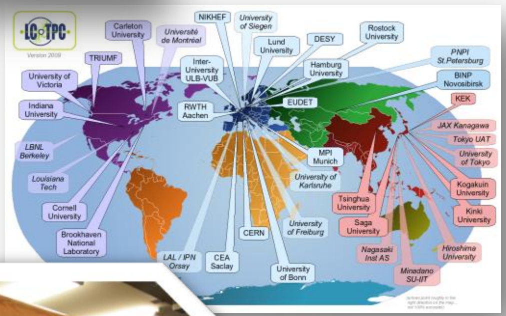
LCTPC Collaboration

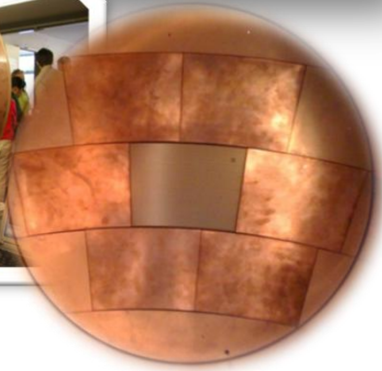
- Worldwide R&D collaboration for a TPC of an ILC experiment
- A large TPC prototype (LP) to achieve this goal
- 7 slots for 7 independent readout modules

My project

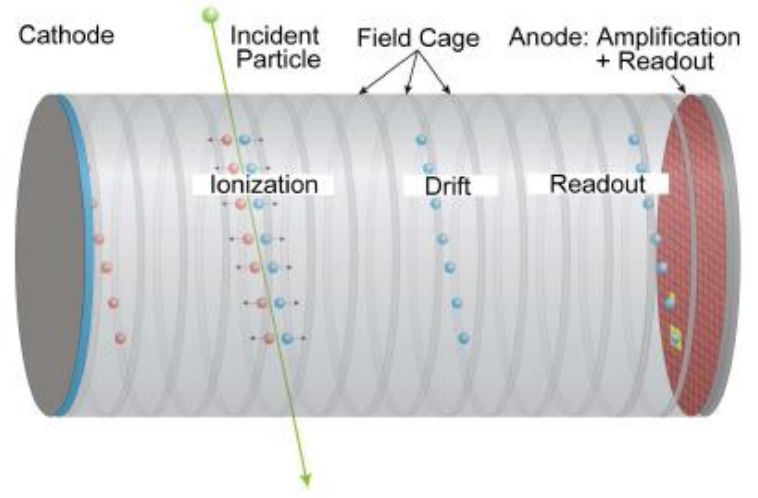
- To develop a GEM readout module for this prototype
- To operate the module in the LP
- To optimize my readout system to achieve the ILD performance goals
- To demonstrate a GEM system is a valid candidate for the readout of a TPC in a linear collider experiment







How does a TPC work



Main components

- Ionization volume
- Well known electric field
- Amplification & readout system on the anode

Goal

- 3-dimensional reconstruction of the particle trajectory

Physic processes in a TPC

Ionization → Drifting → Gas Amplification → Readout → Analysis and reconstruction

Gas amplification structures

Multi Wire Proportional Chambers

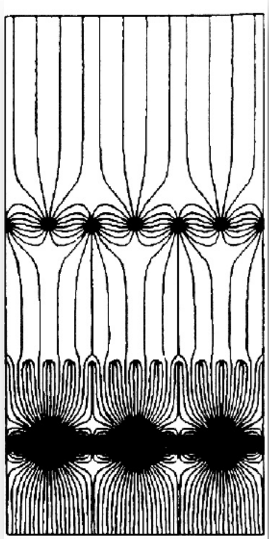
- Gas amplification system used for the last several decades

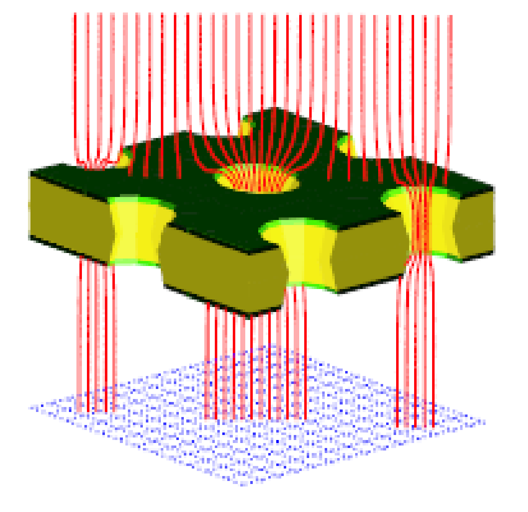
Micro Pattern Gas Detectors (MPGD)

- Modern development of the MWPC
- Resolution and rate are usually improved compared to MWPC

Gas Electron Multiplier (GEM)

- A specific type of MPGD
- Parallel plate capacitor pierced with micrometric holes
- They can be stacked over one another





Step 1: Design

Design Goals

- Three GEM stack
- Maximum sensitive area, limited by the dimension of the module itself
- Develop a self support structure
- Better than 100 µm point resolution
- Best possible gain uniformity

Assembly Backframe

GEMs

Four new components designed

Ceramic Mounting Structure

Anode Pad Plane

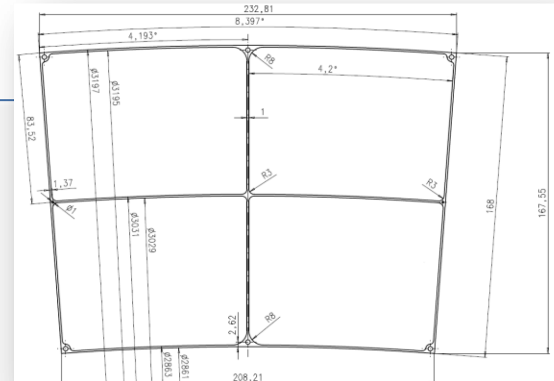
The GEM and the ceramic mounting

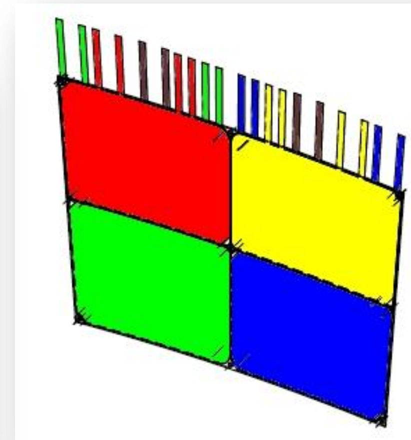
GEMs

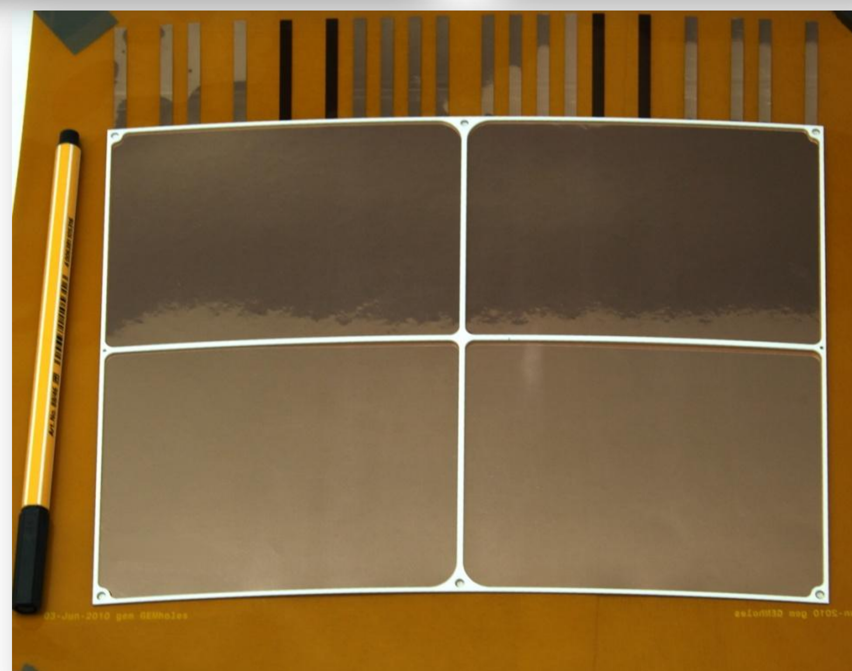
- Custom designed together with the mounting structure
- Designed to allow for a 4 GEM stack
- Produced by CERN and delivered in July

Ceramic mounting

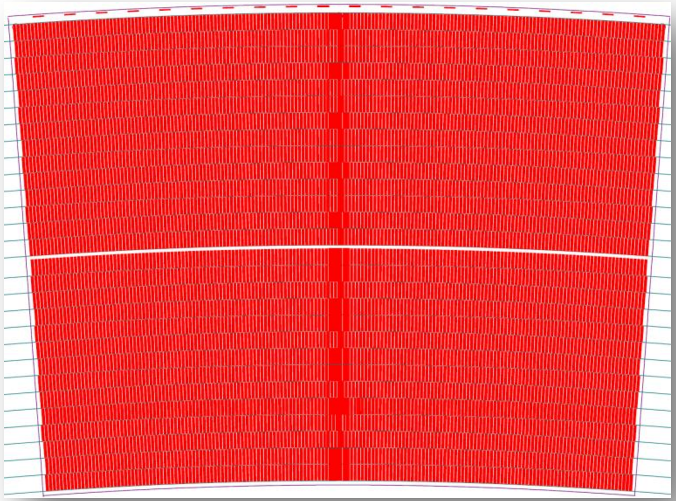
- Development on previous work by my group
- The ceramic mounting frame, supports and space the GEMs at the same time
- Final Laser cutting and delivery in June

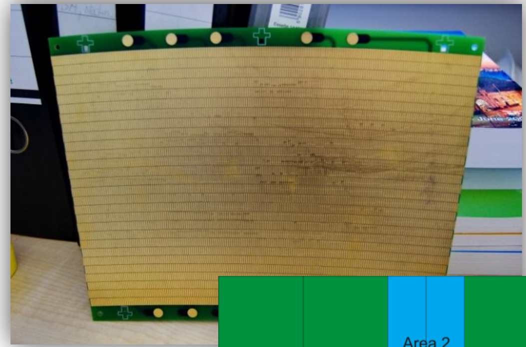


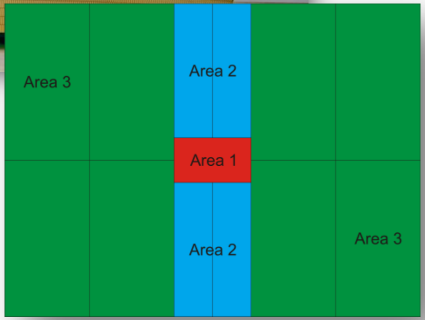




Anode pad readout plane







Challenges

- Small pad size, 1.26 x 5.85 mm, to achieve better than 100 µm resolution
- No analog electronics small enough

Board layout

- 4839 signal channels + 20 power lines
- About 150 connectors on the backside plugged in external electronics cards

Collaborative effort

- Designed by Jochen Kaminsky from Bonn University (Helmholtz Alliance)
- Lengthy process still under way

Backup plans

- Spare pad plane from Tsinghua university (part of LCTPC).
- Simplified pad plane with only 512 in a central strip

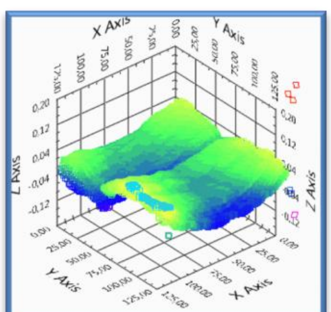
Future plans & milestones

Full module assembly

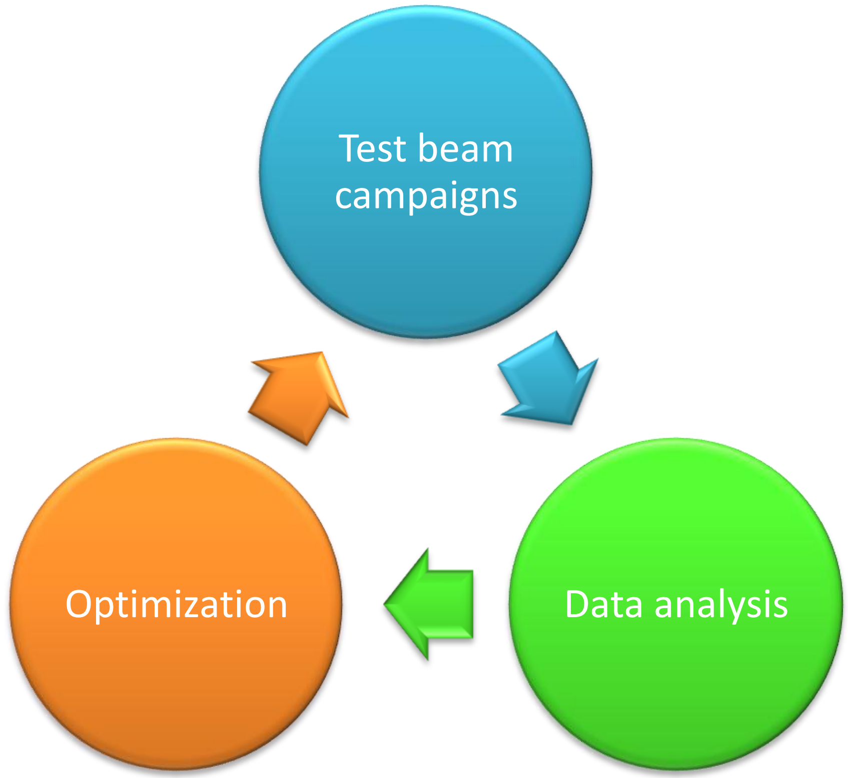
- Glue the GEMs and the ceramic units
- Prepare a GEM stack
- Install it on the readout board
  - First on the Tsinghua board than on the others when ready
- Commissioning in a custom made chamber
- Test beam planned in December

Quality control

- HV stability tests
- Profile measurements
- Notes by the end of the year



LP measurements



Data for a publication by mid 2011

Overview: Training

MC training

- Readout electronics
- Detector simulation and data analysis

Schools and courses

- A1-2 German language course
- Terascale Statistic Tools School
- Phenomenology of physics beyond the SM (HH Uni course)
- Hadron Collider Physics 2010 Summer School
- HCPSS10 Montecarlo Workshop

Tutoring

- 3 high school student during their "practikum" activities
- 1 DESY Summer Student

Conferences I attended

- DESY weekly seminars
- RD51 Meetings
- Physics at the LHC 2010
- European Science Open Forum 2010 (Main event and MC satellite event)

Organizing and convening

- FLC-TPC Strategy Review Workshop 2010

Overview: Results

Publications

- ILD Letter of Intent
- Hopefully this will soon change

Posters

- Poster at the 1st MCPAD Training in Cracow (2009)
- Poster at the MC Satellite event of the ESOF 2010 conference in Torino

Presentations

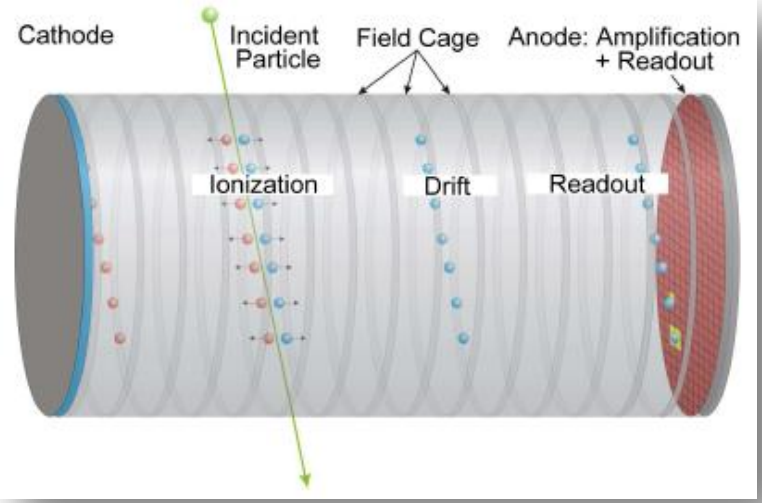
- LCTPC Collaboration meeting (DESY 21-09-2009)
- FLC Group weekly meeting (DESY 12-10-2009)
- FLC-TPC Strategy Workshop 2010 (DESY 21-01-2009)
- RD-51 Mini Week (CERN 22-02-2010)
- DPG Annual Meeting (Bonn 18-03-2010)
- FLC Group Weekly Meeting (DESY 12-04-2010)
- DESY Student Seminar (DESY 29-04-2010)

Acknowledgements

This work is a collaborative effort of many people in and outside my group

Backup Slides

How does a TPC work



Main components

- Ionization volume
- Well known electric field
- Amplification & readout system on the anode

Goal

- 3-dimensional reconstruction of the particle trajectory

Physic processes in a TPC

1. Charged particles, curved in the B field, ionize the TPC gas
2. The ionization electrons drift along the E-field lines
3. The B field reduces the transversal diffusion
4. The electrons are amplified and readout at the anode side
5. Data analysis to reconstruct the track of the incoming particle

Gas amplification structures

Multi Wire Proportional Chambers

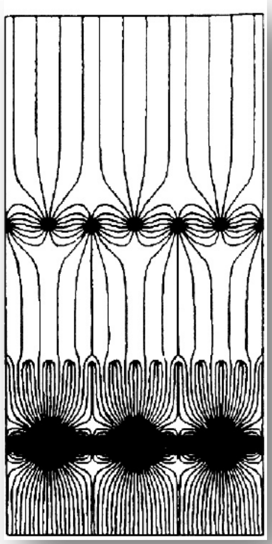
- Gas amplification system used for the last several decades
- Resolution limited by the minimum distance between wires (~ 1 mm)

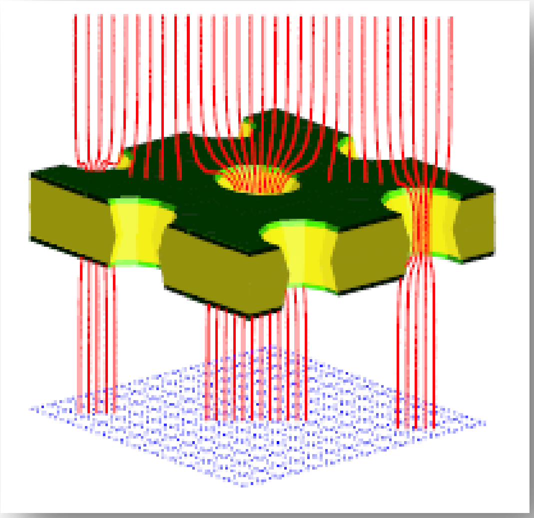
Micro Pattern Gas Detectors (MPGD)

- Modern development of the MWPC
- The size of the amplifying structures is about a 100 μm or less
- The amplifying structures are usually distributed homogeneously on the amplifying surface
- Resolution and rate are usually improved compared to MWPC

Gas Electron Multiplier (GEM)

- A specific type of MPGD
- Parallel plate capacitor pierced with micrometric holes
- The electron avalanche takes place in the holes
- They can be stacked over one another





Commissioning test box

Dedicated chamber

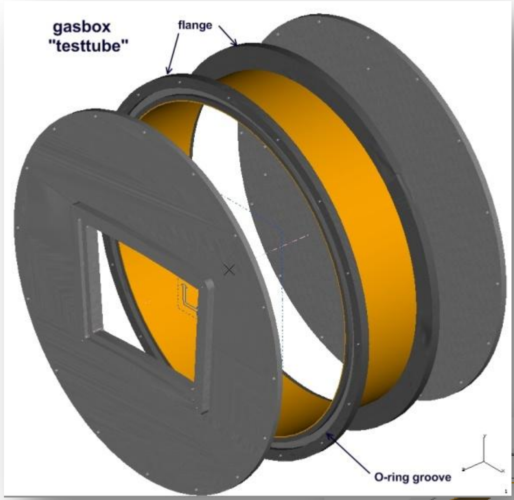
- House a single module
- Drift length up to 10 cm
- Mechanical and electrostatic simulations to validate the project

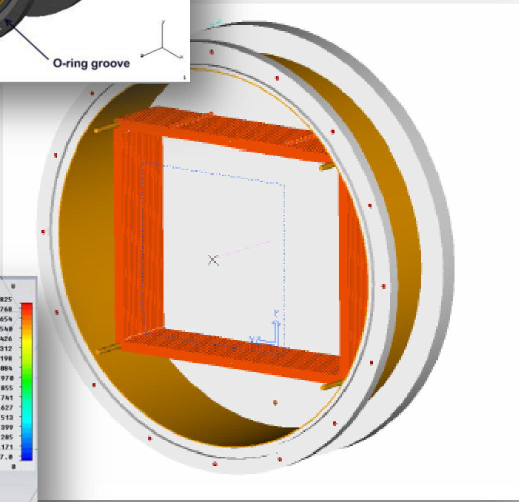
Commissioning program

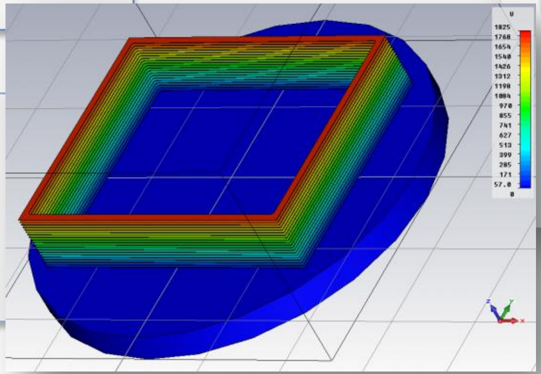
- Working point determination
- Energy resolution
- Gain uniformity
- Point and track resolution

DAQ and electronics integration

- Similar to the one used in the LP
- Will allow me to get experience on the system







Future plans

Quality Control

- HV tests
- Profile measurements

Full module assembly

- Gluing GEMs and ceramic units
- Installing the assembled GEM on the pad planes

Commissioning

- Dedicated chamber designed and under production
- Measurement with radioactive sources and cosmics
- Electronic integration

Optimization

- Stack layout optimization
- Work point determination
- GEM comparisons (e.g. production technology and producing companies)

LP Measurements

- Test Beams at DESY
- Single module first then up to 7 modules

Data analysis

- Stand alone measurements
- Comparison with the results of other groups in the collaboration
- Using and developing the MarlinTPC framework

Future plans

LP Measurements

DESY test beam campaigns

- At first using a single module
- Afterwards possibly increasing the number of module installed at the same time up to the maximum of 7

Optimization

GEM stack parameters

- Distance optimization
- Optimal work point determination

GEM comparisons

- Production technology
- Producers

Data Analysis

Stand alone Analysis

- Point and track resolution measurements
- dE/dx resolution measurement
- The analysis will be performed using and developing the Marlin TPC framework

Comparative analysis

- Comparison with the Asian LP GEM module
- Comparison with the Micromegas LP module

GEM gating R&D

The GEM and the ceramic mounting

GEMs

- 4 independent sectors to increase the reliability
- Powering scheme to allow up to 4 GEMs (e.g. 3 amplification + 1 gate) to be stacked
- Standard hole pitch (140 μm) and size (70μm) used in most GEM applications
- Produced by CERN and delivered in July

Ceramic mounting

- 1 mm thickness plates
- Central grid to support the GEM, and space them, 1 mm wide
- Grid elements aligned with the GEM section dividers
- Each Gem+grid is an independent device that can be added or removed from a stack
- Lengthy consulting and research to design and produce this piece
- Final Laser cutting and delivery in June