Development and production of a GEM based TPC readout module

By

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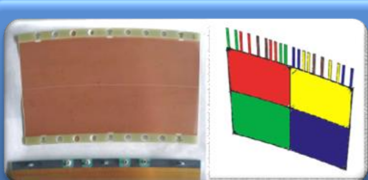
Overview

Introduction to the Large Prototype TPC (LPTPC)



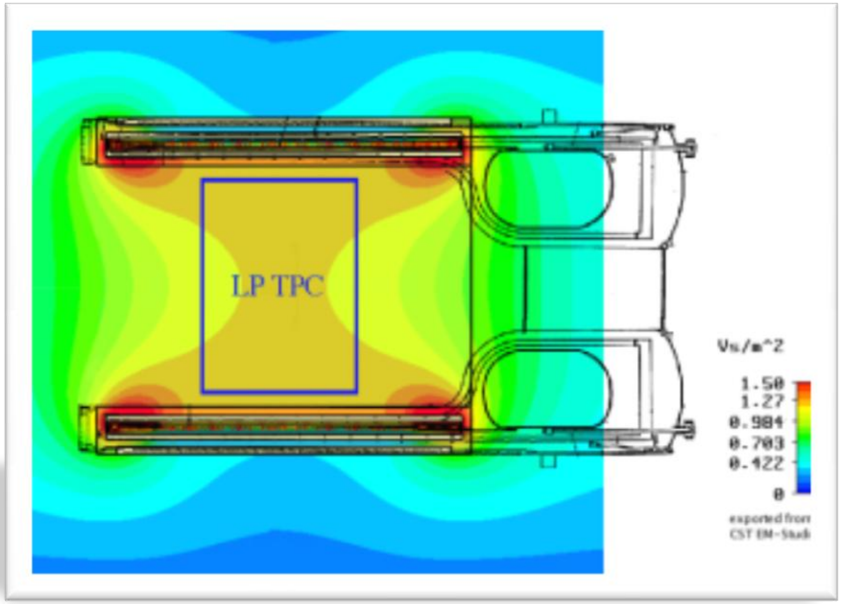
Motivation & goals of a new readout module

Design and production of the module

- Backframe
- Mounting structure
- GEMs
- Pad readout plane

Future plans & conclusions

Basics – Some features of the LPTPC



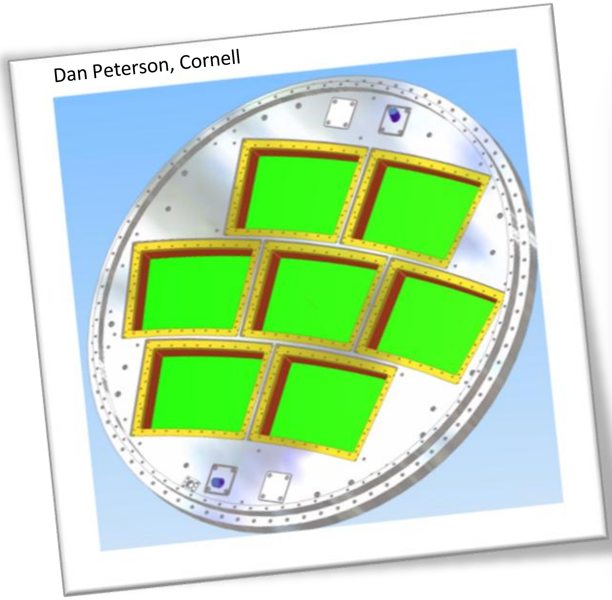
Field cage designed and produced by DESY

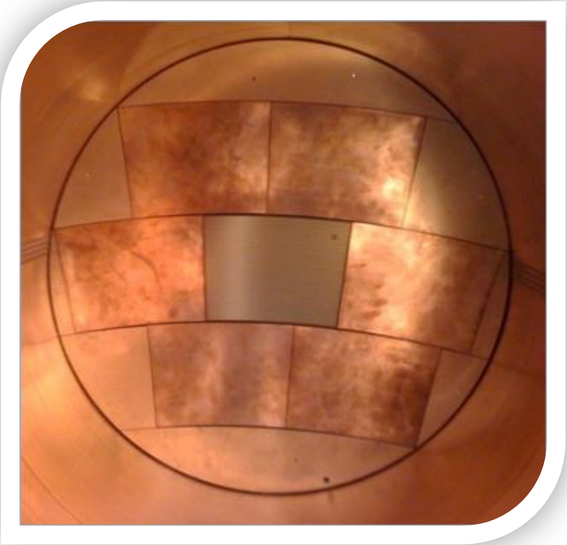
- 60 cm drift length, 72 cm inner diameter
- Field quality: $10^{-4} < \Delta E / E < 10^{-3}$
- Operational since the end of 2008
- Designed to fit inside PCMAG

PCMAG

- Superconductive solenoidal magnet with standalone liquid He cooling and low mass coil supplied by KEK.
- 1 Tesla magnetic field

Basics – LP Anode Side Endplate





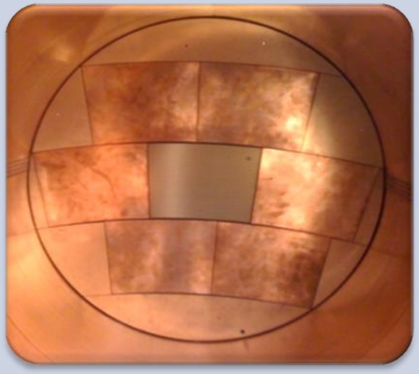
LPTPC endplate – some features

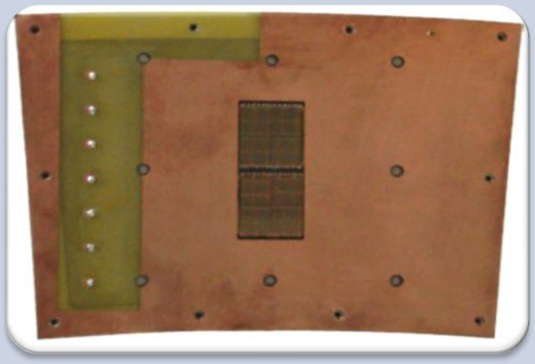
- Designed and produced at Cornell
- Aluminum alloy
- Accomodates 7 identical modules that can be equipped with different technology solutions

The modules

- Cornerstone shape , 20-24 cm wide, 17 cm high

Basics – Modules already tested





Micromegas

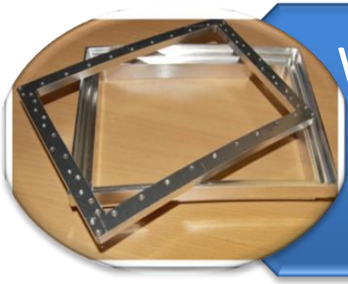
- Built at Saclay, FR
- Pad readout
- Full size module

Asian GEM

- Built in Japan and China
- 2 GEMs stretched from the top and bottom
- Pad readout

Bonn GEM

- Developed at Bonn university
- Stack of 3 10X10 cm^2 GEMs
- Pad or silicon pixel readout



We want to test a large area 3-GEM stack module with an optional gating element, and a self supporting mounting structure minimizing the dead space.

New solutions for mounting the GEMs

- The usual framing solution maybe unstable for large area GEMs
- The stretching solution (Asian GEMs) require high tension on the GEM foil and a robust, and thick, support structure
- We want to achieve a better dead space reduction
- We want to avoid or reduce the stretching of the GEM foils

Large area triple GEM

- Asian GEM: 2 Large Area GEM + optional gating
- Bonn GEM: 3 10x10 cm^2 GEM

Test of gating strategies

- It will be done also on the Asian GEM modules. Useful comparison between the technologies

DESY Module – Main Design Features

Large area three GEM stack + possible gate (GEM or otherwise)

- Use a custom designed GEM as big as the module itself
- GEMs designed to allow for a 4-GEM stack (3 amplification and an optional gate).

Self supporting ceramic mounting structure

- Each GEM is mounted in a ceramic structure, smaller than traditional frames, with an internal grid to avoid excessive stretching

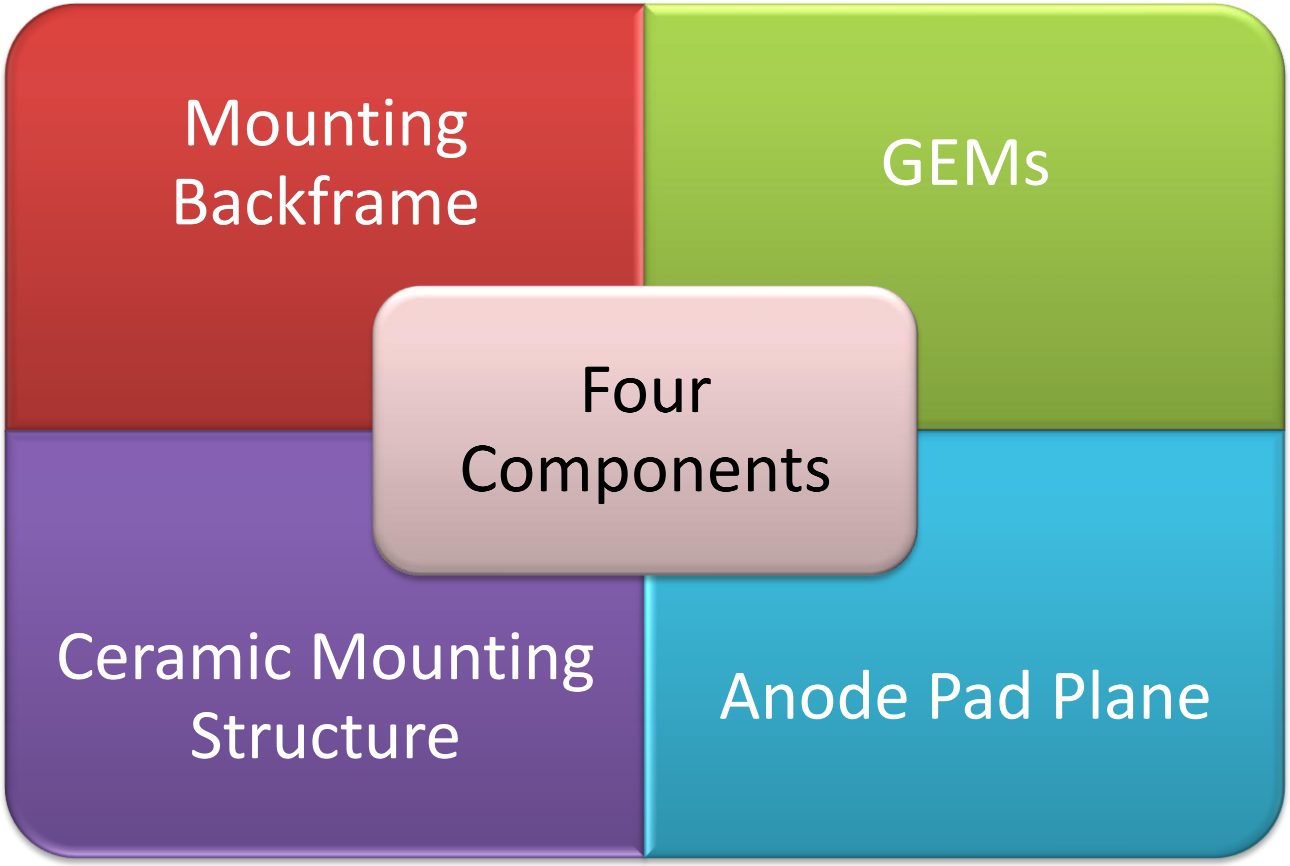
Pad readout system

- Traditional pad readout system with analogic electronics (ALTRO)
- Flexible design, may allow for use of different readout systems in future
- Power supply for the GEM routed through the pad plane PCB

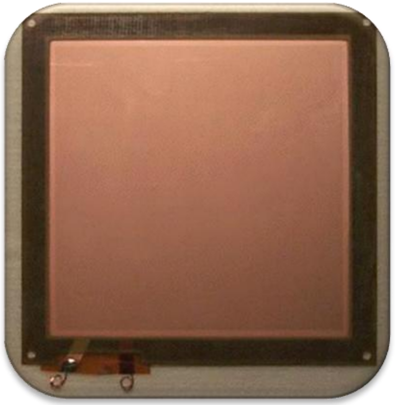
Modular system

- Each piece of the module has been designed to be independent from the others to ease and reduce the costs of the testing phase.

DESY Module – Components



GEM mounting structures: Goals



GDD Group @ CERN

CDC Group, Tsinghua

Existing solutions

- GRP Frame
- Top-bottom stretching

Avoid or reduce the necessity of stretching the GEM foils

- Eliminate or reduce the tension in the GEM foils. Leads to smaller and simpler supporting structures
- Ease of production. The stretching is a delicate procedure. Is important for large area detectors like the ILC TPC.

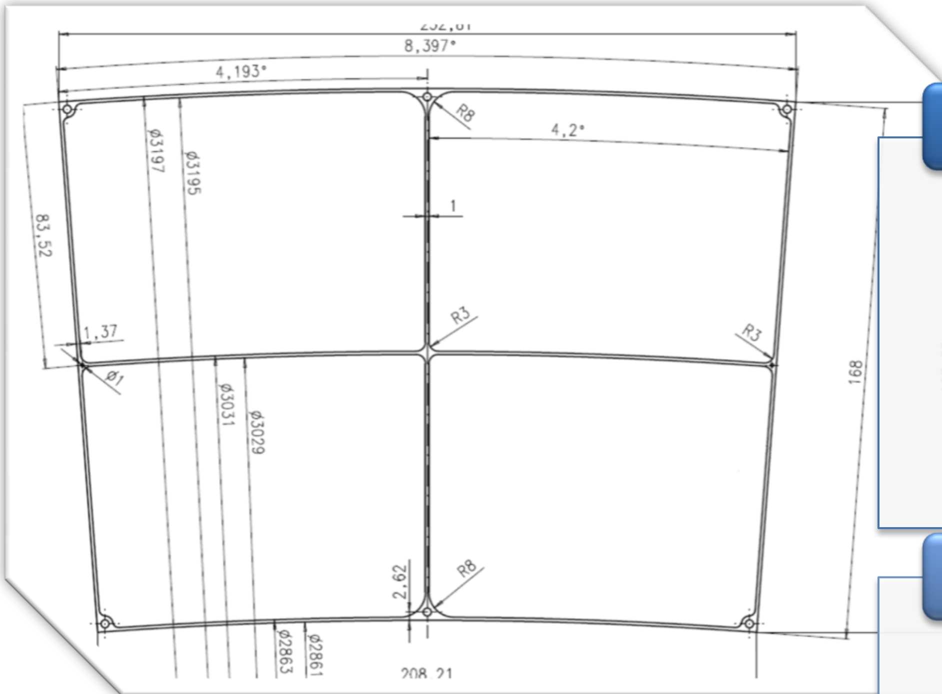
Decrease the amount of dead space

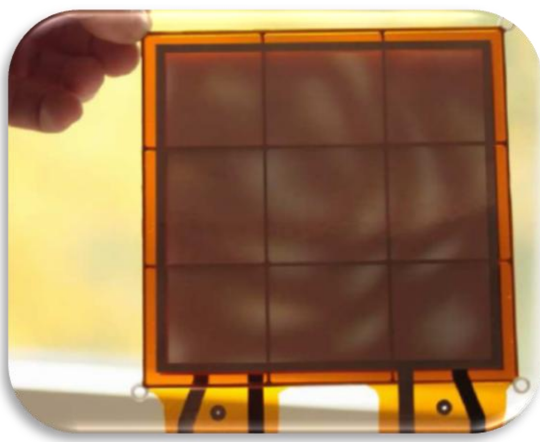
- More problematic if the dead space is pointing to the interaction point

Achieve a uniform flatness of the GEM foils

- Previous studies (previous talk in this session) demonstrate the feasibility.

GEM mounting: Our Solution





Full frame system with internal cells

- GEM supported on all sides and from the inside
- To increase the sensitive area we need to reduce the width of the mounting and supporting structure
- Reduction of the amount of unsupported area on the GEM foil

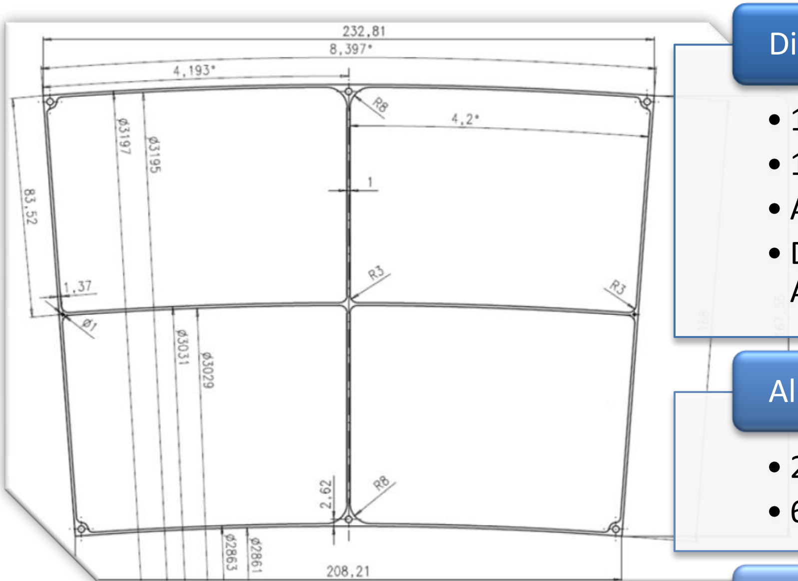
Solution: ceramic structures

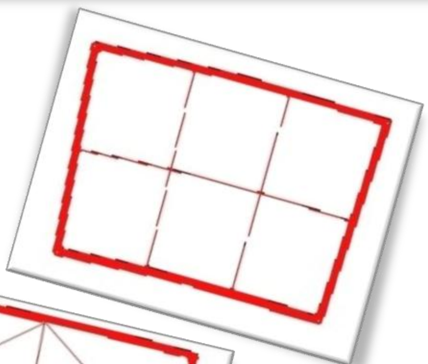
- To meet both requirements we need an insulating material which can be made thinner remaining as resistent as a normal GRP frame
- Alumina ceramics is almost 4 times stiffer than GRP

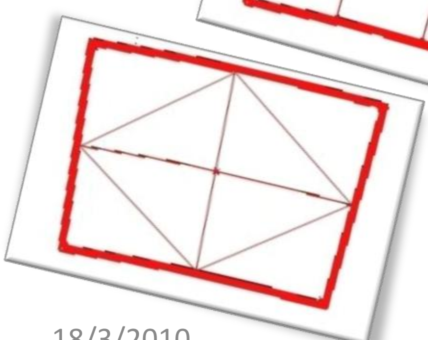
Previous studies

- We already tested at DESY standard GEM foil mounted on ceramic grids (see previous talk)

GEM mounting grid: Design







Dimensions

- 1.0 mm substrate thickness
- 1.0 mm widths of the frame beams
- As big as the module itself (~22 x 17 cm)
- Dead material surface: ~10 cm^2 (e.g. the dead material surface of the Asian GEM is 44 cm^2)

Aligning and fixing the structure

- 2 dowel holes for alignment
- 6 screwholes for fixing with nylon screws

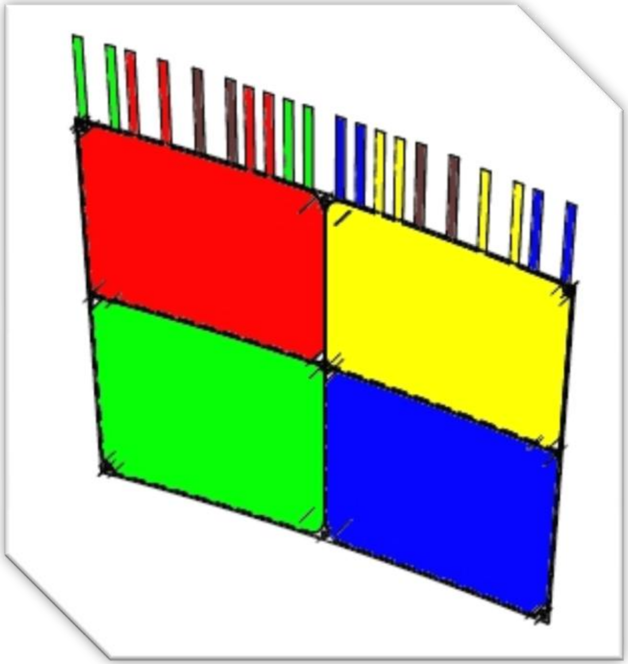
Internal Grid Pattern

- We evaluated many different patterns
- We choose a simple cross-like structure
- We can test the effect of both vertical and horizontal bars on the detector efficiency
- Other grid pattern will be tested later

Production

- Raw ceramic tiles are sent to specialized companies for laser cutting.
- Production tests are in progress

The GEMs: Design



Main features

- Hole size, 70 μm
- Hole pitch, 140 μm
- 50 μm kapton foil

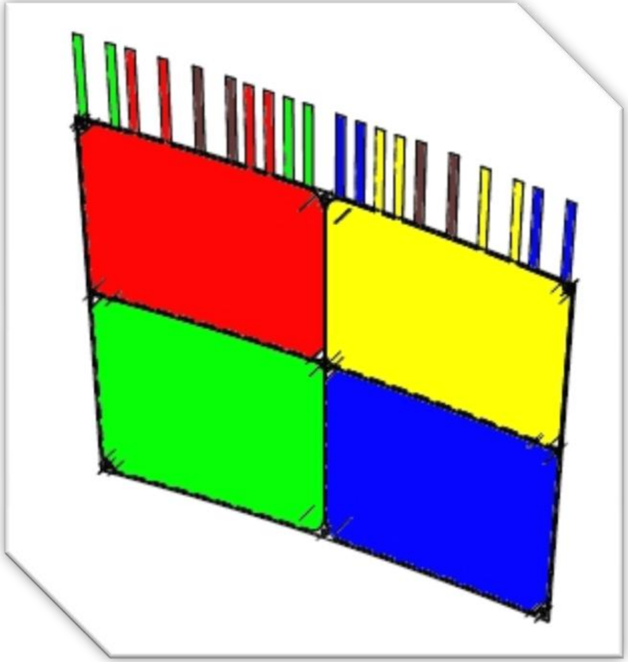
Segmentation

- 4-fold segmentation on one side
- Segmentation avoids destructive sparks
- Section gaps aligned with the frame grid patterns
- Gaps dimension chosen to match the grid size

Production

- 5 GEMs have been ordered for production

The GEMs: Power scheme



5 electrical contacts per GEM layer

- Each section (4 on 1 side, 1 on the other side) must be powered independently

20 power channels

- We need to stack up to 4 GEMs onto one another

Powering from the upper side

- We cannot power up the GEM from the side to save space
- We cannot use both the upper and lower side to avoid sparks between modules

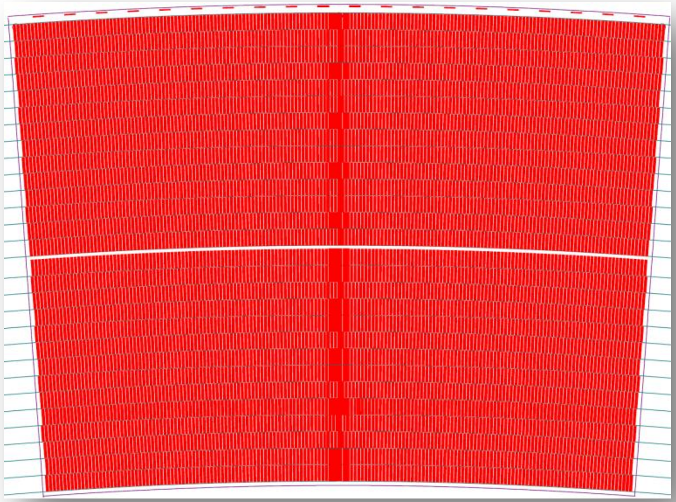
Single layout for all GEM layers

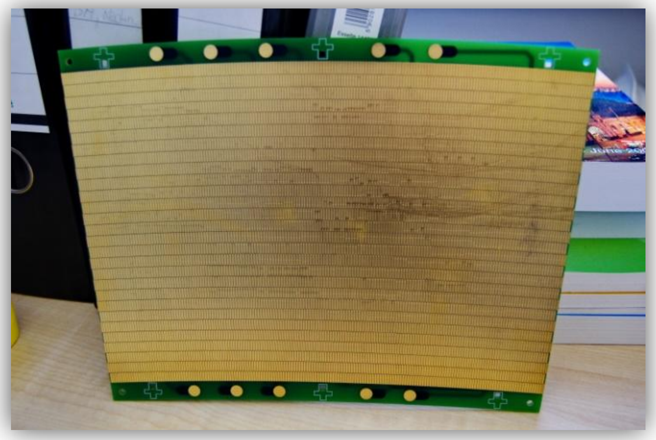
- Reducing the costs
- Allows the use of each GEM in each layer

Design Features

- 20 Electrodes on the upper side
- Upon delivery we will cut away the unnecessary ones

Anode Readout Plane: Design





In collaboration with Bonn university

- Mechanical layout complete
- Electrical routing in progress

Pad size

- 1.26 x 5.85 mm
- 28 rows
- 4839 pads
- Row gap between row 14 and 15 aligned with the GEM segmentation gap

GEM power supply

- Supplied from power pads 4 x 0.50 mm on the PCB itself
- Using the ceramic structure to separate the power from the readout pads

A spare pad plane to start

- The chinese colleagues of Tsinghua university kindly gave us a spare pad plane for the Asian GEM module that we are going to use for the first tests

Conclusion

What has been done

- The GEM frame has been design and it’s in production
- The GEM foil design is complete and the devices are in production
- The anode pad plane layout is in progress

What is to do

- Cutting of the ceramic frames
- Testing the framing procedures with dummy material
- Test the power scheme
- Frame the complete GEM foils in the ceramic frames
- Mount everything on the spare pad plane and start measurements
- Develop and produce our own pad plane

A time schedule

- By the end of April we could have the GEM and the ceramic grid delivered
- By the end of the spring we may start measurements in the TPC
- In the summer we may have our own pad plane and start measurements on the final prototype