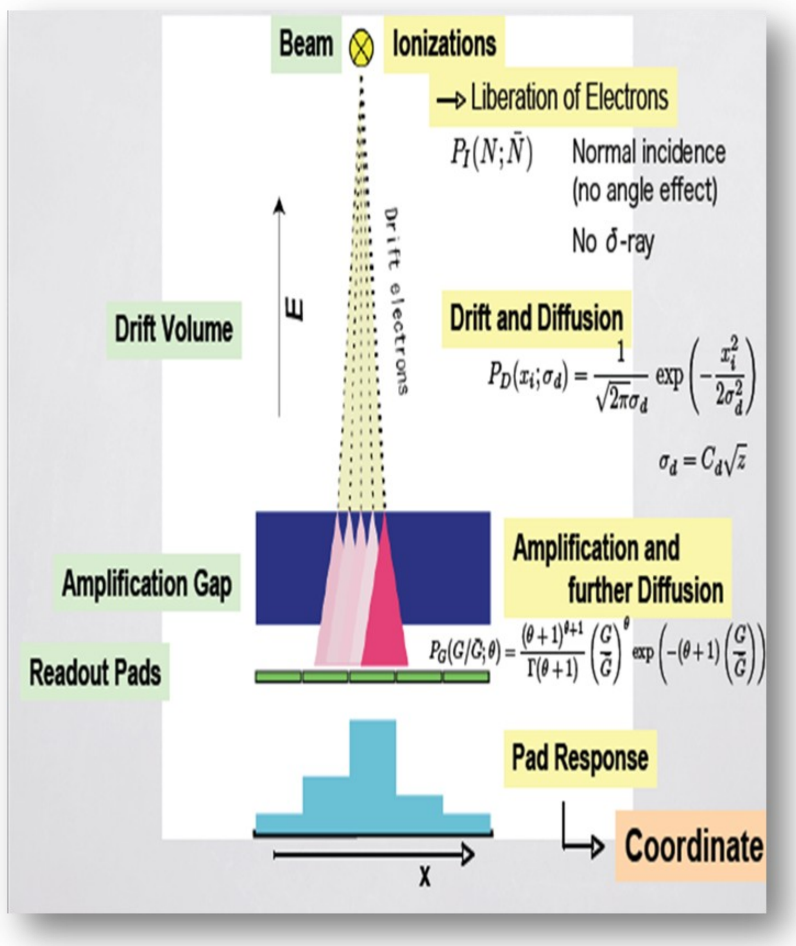
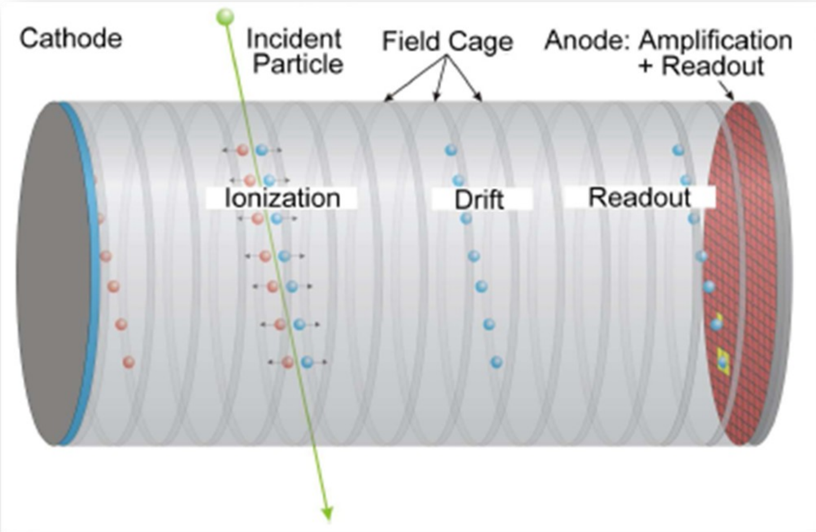
R&D of a GEM module for a TPC Readout System at DESY



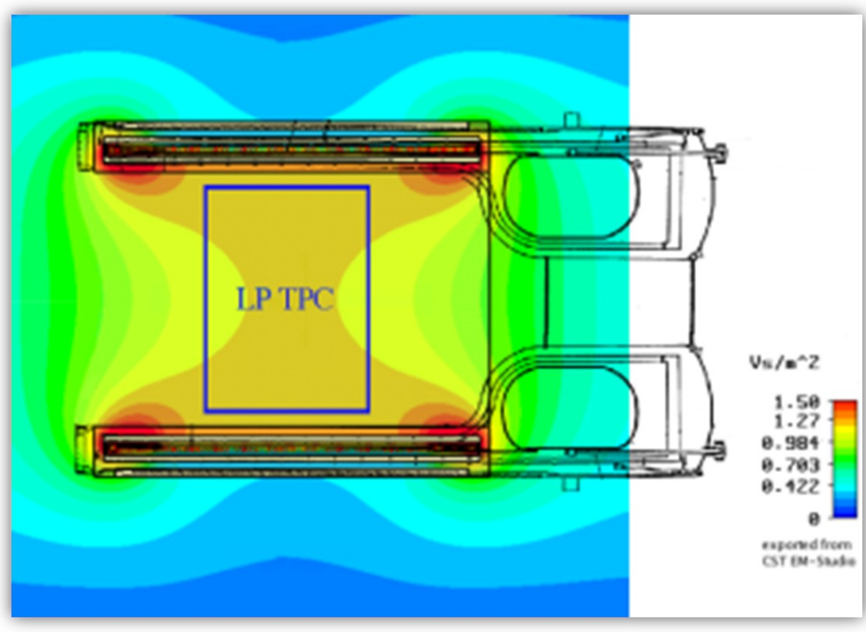
TPC Detectors

TPC stands for **Time Projection Chamber**.
The TPC is a gaseous detector with a sensitive volume up to several cubic meters which allows for a continuous tracking (~2 sample\cm) of charged particle with high spatial and momentum resolution.



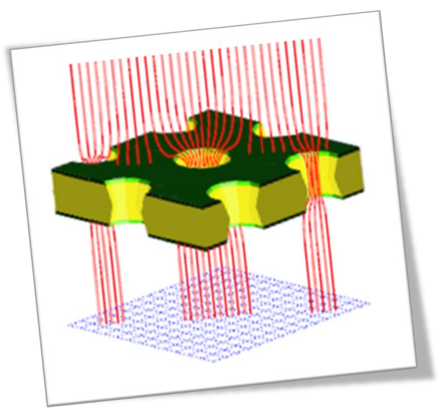
The LPTPC

To develop new technologies for the next generation TPCs, the FLC-TPC Group at DESY built a large TPC prototype (LPTPC). This device is hosted in a 1T superconductive magnet called PCMAG, donated by the Japanese institute KEK.



The Gas Amplification and Readout stage of the LPTPC is composed of seven modules that can be equipped with different devices.
This prototype has been used to test both G.E.M. and MICROMEGAS amplification systems with pad or pixel readout

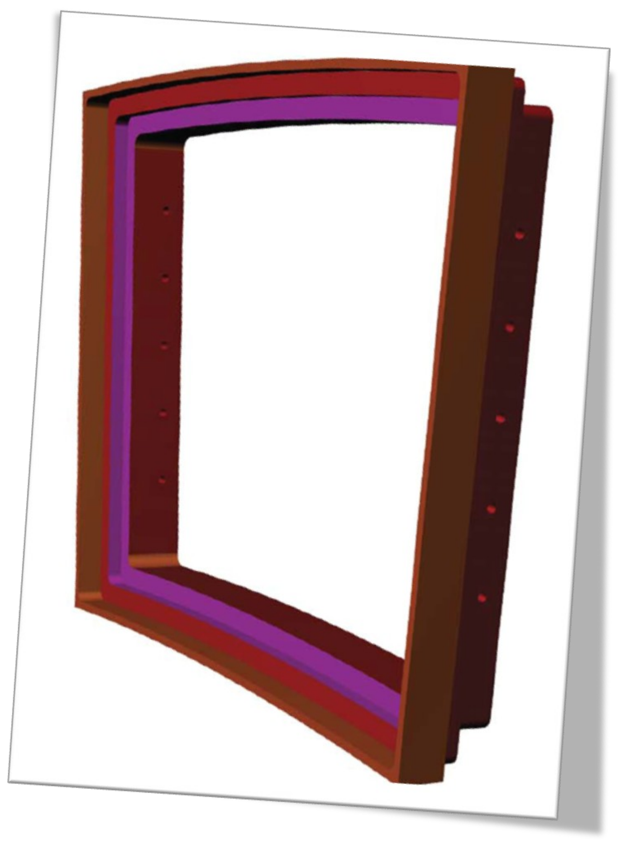
GEM: The Gas Electron Multiplier



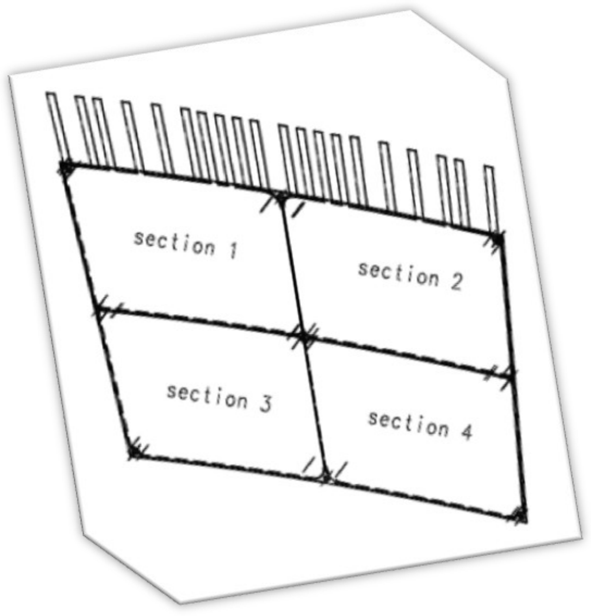
The GEM is a device used to achieve electron amplification in gas detector. It looks like a thin plane capacitor holed throughout its surface. When a potential is estabilished across the GEM, the electrons drift inside the holes where the electric field is high enough to produce an avalanche. The electron cloud thus obtained drifts out of GEM holes along the field lines and can get to the readout module or to another amplification stage. This possibility to stack GEMs over one another allows for very high gas amplification. Moreover the amount of ions backdrifting from the amplification volume to the sensitive volume is reduced by the field configuration because most of them get neutralized on the GEM electrodes.

A Triple GEM Module for the LPTPC

The main goal in designing the DESY module for the LPTPC is to build a detector element with the maximum possible sensitive area, a point resolution of less than 100 μm in the 1T magnetic field of the PCMAG , a backdrifting ion density of the same order of magnitude of the primary ion density and a dE/dx measurement resolution of the order of a few percent. The main technical choices in the development of this device are the gas amplification system and the readout system to use. We choose a GEM stack on a pad readout system. This device has different components to be optimized: the GEM and its framing structure, the pad readout system and a backframe to mount everything on.



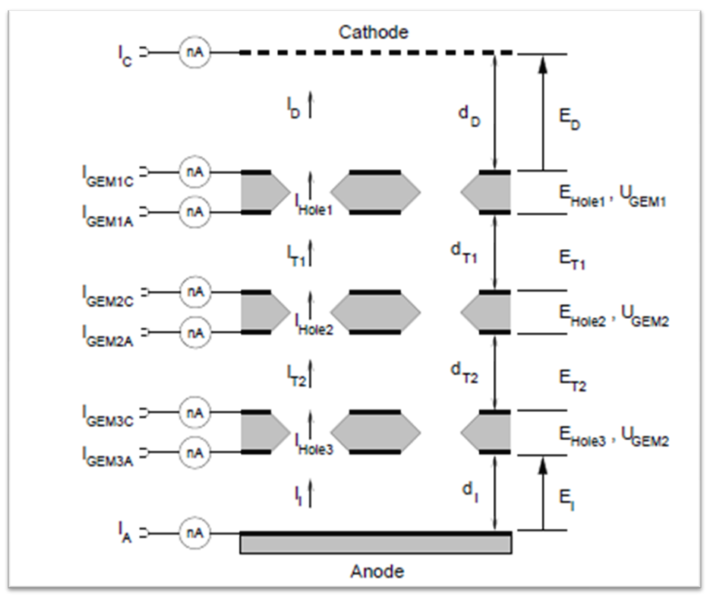
GEM Design



Because of the size of the module one side of the GEM is segmented in four section to reduce the energy stored in each capacitive structure thus reducing the damage a discharge can produce on them. Each GEM is provided with 20 electrical contacts, 4 for each of the sections on the segmented side and 4 for the unsegmented side, to allow the stacking of 4 amplification stages in each module.

GEM Stacking

The stacking of GEM allows for higher gains of the whole system while keeping the voltage across the GEM low enough to avoid dangerous discharges on a GEM and between them.
Moreover it adds versatility to the system because it's possible to fine tune the fields and potentials in each amplification stage for a better control of the detector performance (e.g. gain, ion backdrift reduction, defocussing, and so on).

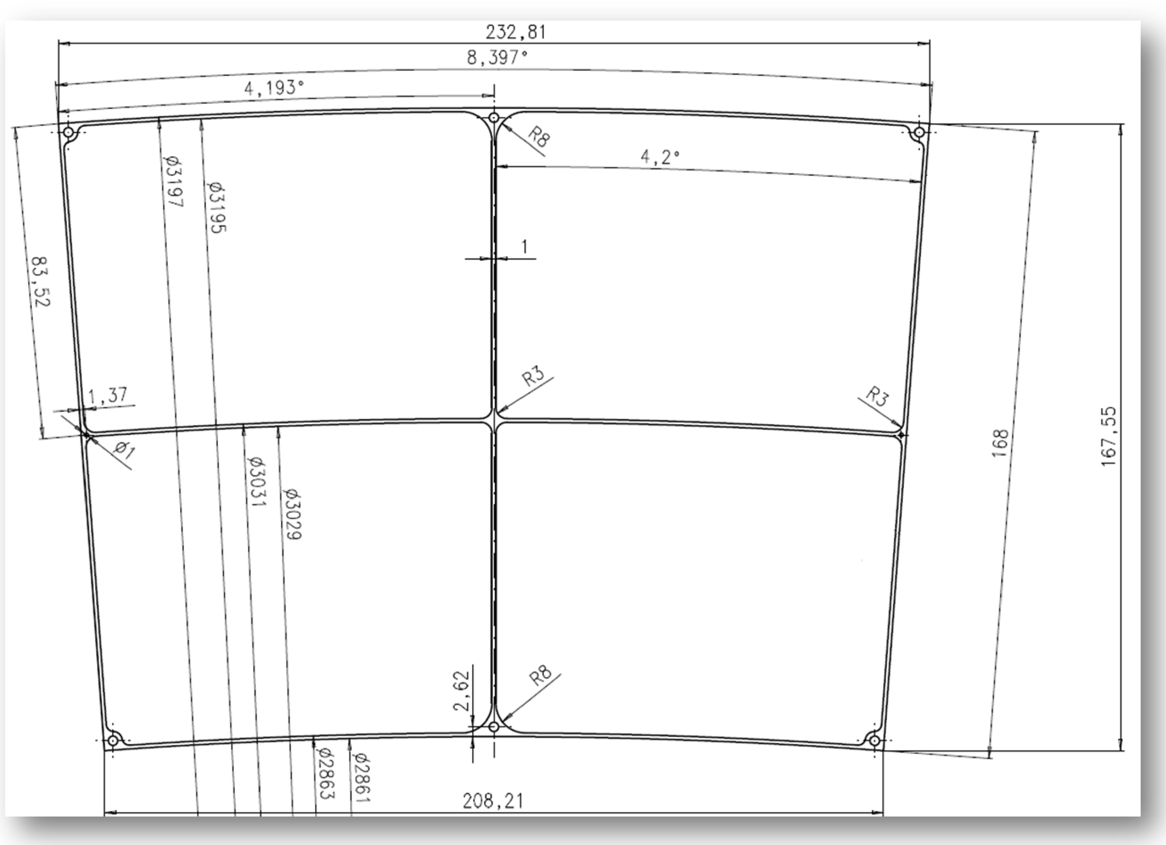


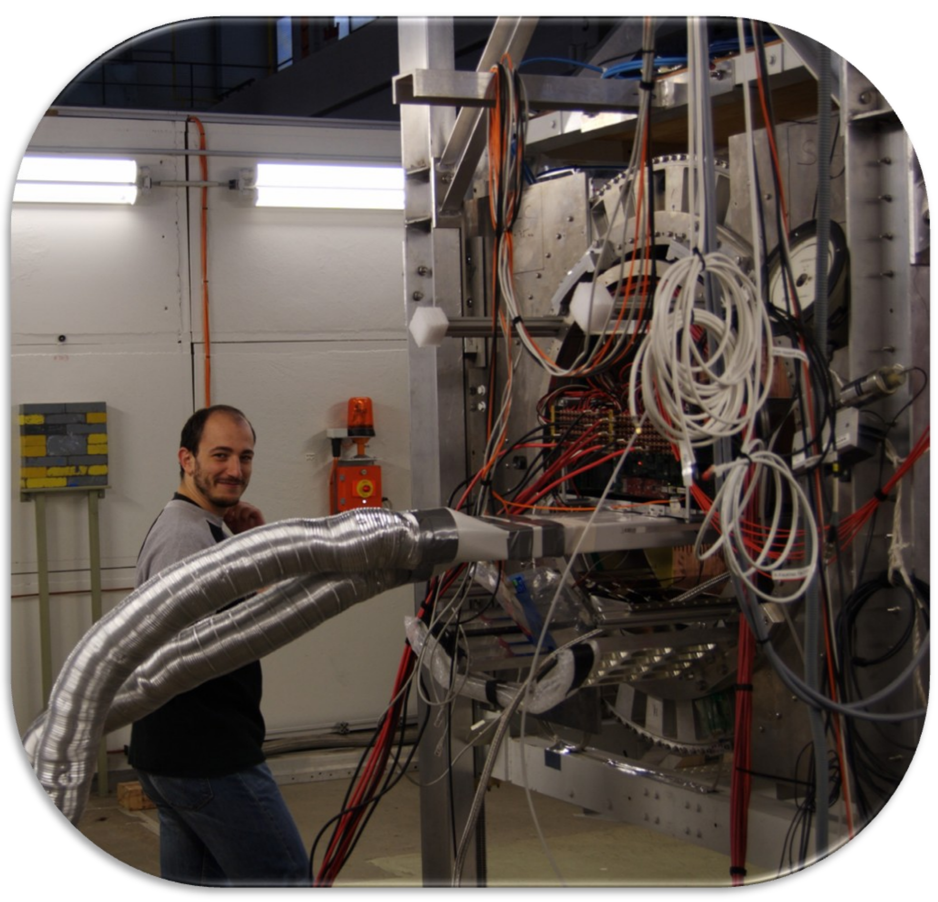
The backframe

To mount everything in the LPTPC we redesigned and produced a new support frame. Compared to the old model this has a greater surface on the connector side, external to the TPC, to plug in more easily the electronics modules. This device is also provided with dowel and screw holes to align and fix the sensitive structure

GEM Framing Structure

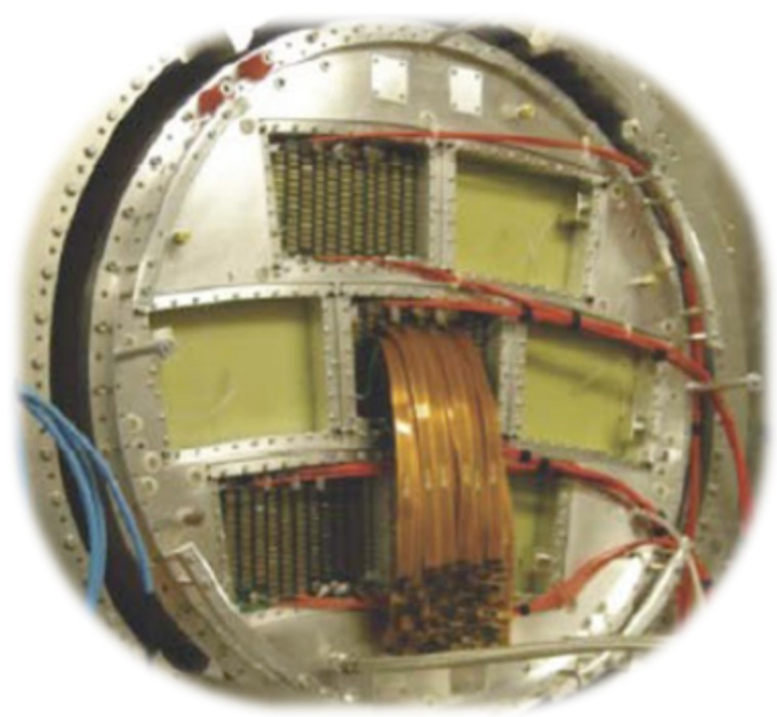
The gain of a GEM stack depends on the field between the GEMs themselves. To achieve a greater gain uniformity the GEM must be as flat as possible and they have to be mounted as parallel as possible to one another. For this reason we designed a framing structure for the GEMs built out of Alumina ceramics, a material more than 50 times stiffer than GRP which is commonly used to build GEM frames. Due to the characteristics of this material we can design elements with a width of only 1 mm.
To achieve the best precision, very flat ceramic tiles are laser cutted to obtain the desired shape. This shape includes an external frame and an internal grid structure which can be cutted in different shapes. The shape is under test now provides an horizontal and vertical bar to test the influence of this elements on the tracking efficency.





Readout System

The readout system of the LPTPC DESY module is composed of the readout plane itself and the electronics linked to it. The latter has been chosen to be based on the ALTRO chip, developed for the use with the ALICE TPC detector. This electronic system will be connected to the backside of the readout plane via flexible kapton cables.
The readout plane is segmented in 4839 staggered pads, 1.26 x 5.85 mm^2, laid out in 28 rows of different length, which will cover all the surface of the module but 2 mm on the right, left and short side, and 3 mm on the top side of the module.
On the top side of the module there will also be 20 pads 4 x 0.5 mm^2, where the GEM electrical contacts will be soldered to power them up.
8 through-holes will allow to align and fix the readout plane to the backframe on one side and to the framed GEM on the other side. The ceramic frame will be sitting between the power pads and the readout pads acting as an insulator between them avoiding dangerous discharges.



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