SiLC Sensors for the Large Prototype TPC at DESY

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Abstract

The Silicon for the Linear Collider (SiLC) collaboration will participate at the Large Prototype TPC (LPTPC) at the EUDET facility in DESY. SiLC will design, build and install position sensitive detector modules around the LPTPC made of silicon microstrip sensors that can be used as telescope. The design of it will allow a simply exchange of the modules to enable tests of different sensor- and chip- designs. This setup will also help to verify if a silicon envelope for a future linear collider TPC is reasonable.

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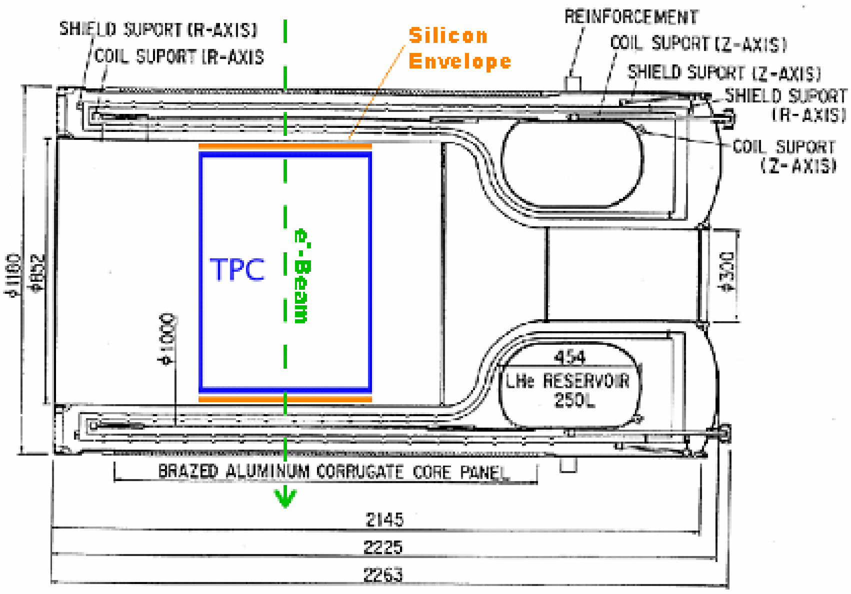
1 Introduction

The Linear Collider TPC (LCTPC) collaboration is formed of several groups world-wide and stands in close relation to the ILD detector concept. Their goal is to evaluate different TPC designs for the ILC [1]. At the moment the second R&D phase has started – the so-called Consolidation Phase. The goal of this phase is to design, build and operate a Large Prototype TPC (LPTPC) at the EUDET facility in DESY [2]. The Silicon for the Linear Collider (SiLC) collaboration will design, build and install silicon modules for the LPTPC with the primary goal to design and test sensors and readout chips. Additionally, these position sensitive detectors will act as a telescope to provide precise tracking information for the TPC. It will also be possible to experimentally inspect how reasonable a silicon envelope around a future ILC TPC would be.

2 The Setup

The overall setup, the magnet and the TPC are described in details in [3]. Here, only short updates to some parts are given. The most emphasis is given to the design and the present status of the silicon modules.

2.1 Overall Design

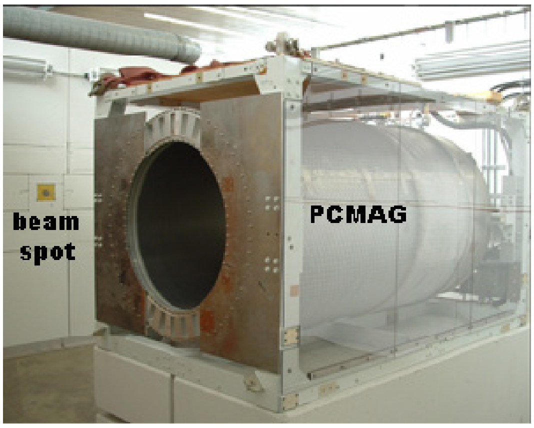


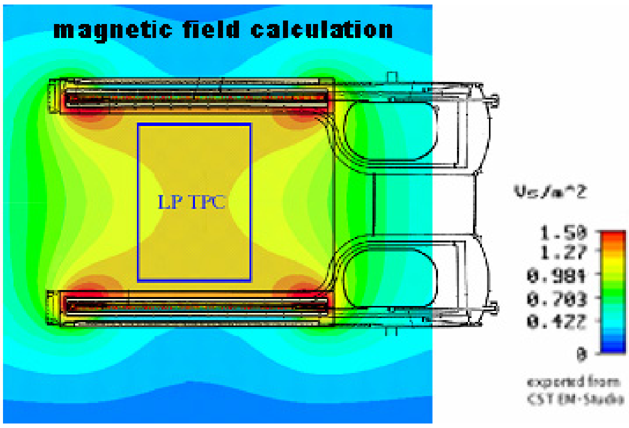
The TPC (in blue) and the silicon modules (orange) inside the magnet are shown in the picture above (top view, from [4]). DESY will provide an electron beam of up to 6 GeV electrons (spread ~5%, divergence ~2mrad) which will be used for the TPC and silicon module tests. The radial dimensions of the different parts inside the magnet are shown in the next table:

inner diameter of the magnet (measured min.)	850	mm (846 mm)
SiLC detectors	2 x 35	mm
clearance inside of SiLC	780	mm
extra clearance	2 x 5	mm
outer diameter of field cage	770	mm
field cage wall	25	mm
inner diameter of field cage	720	mm

2.2 The Magnet

A PCMAG coil built by KEK was already installed in the DESY test beam in December 2006 and in July its field was measured. The field of the magnet is inhomogeneous and reaches a maximum of about 1.25 T. A picture of the magnet and its field distribution is shown in the pictures below (from [4]).

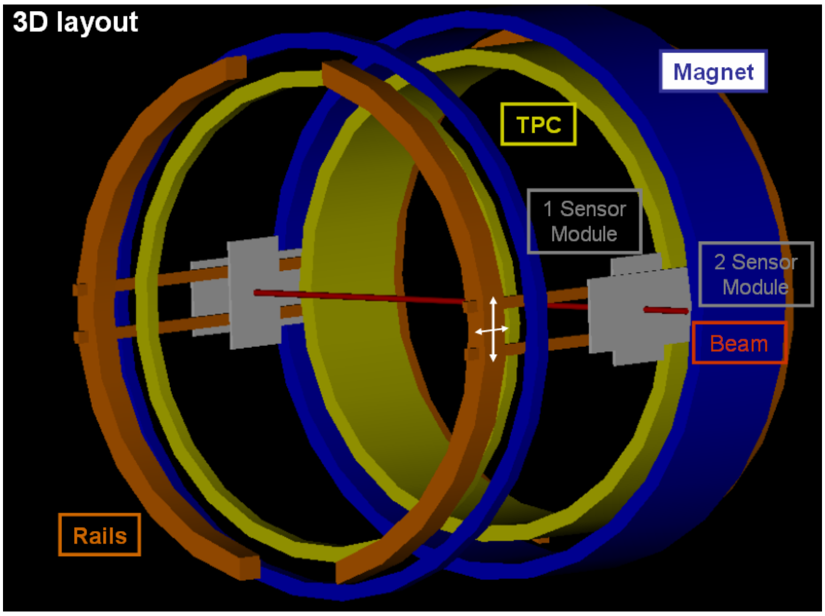




2.3 The LPTPC

The TPC field cage design was made on the basis of smaller prototypes. It has a length of 610 mm and an outer diameter of 775 mm, including the end cap [6]. The field cage design is in its final phase and the TPC will be fully functional in the beginning of 2008. An important feature is the possibility to rather easily change the endplate of the TPC to enable tests of different endplates. The status of the endplates can be found in [5].

2.4 The Silicon Modules

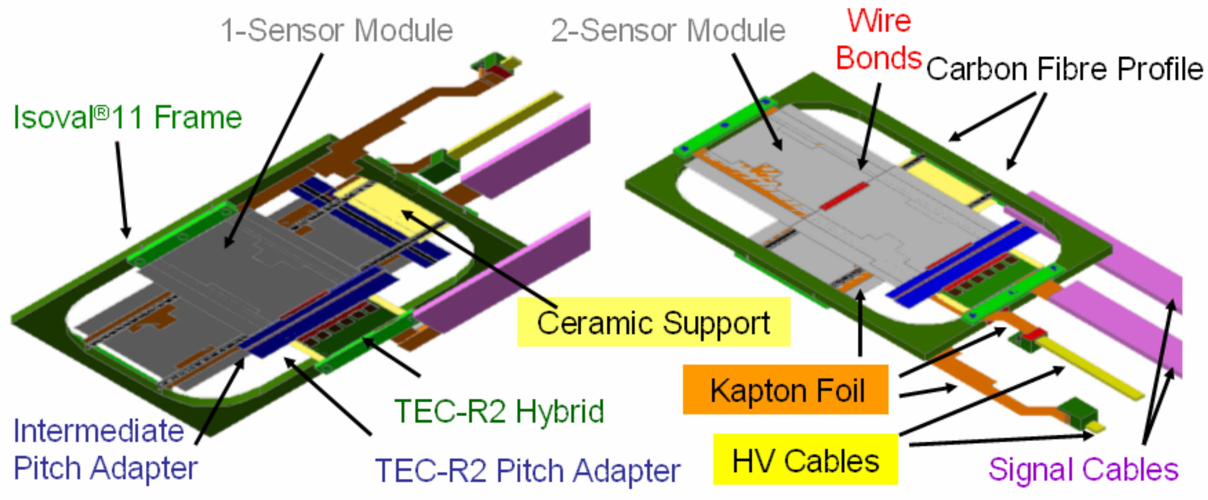


The Silicon Modules will provide very precise 3D points just outside the TPC and will work as telescope for the track reconstruction. The point resolution of the silicon sensors will be better than 15 µm in phi and 15 µm in z-direction. This is possible by using two silicon microstrip sensors with very narrow pitch crossed at an angle of 90 degree. These sensors have been designed by the SiLC collaboration and were delivered by Hamamatsu Photonics,

Japan. Since the financial conditions are not sufficient to build a full 360 degree silicon envelope, only four silicon modules, two in front and two behind the TPC, with respect to the e^--beam, will be installed. On each side of the TPC, a support frame will hold two modules, where one module consists of two daisy-chained sensors while the other module is installed perpendicular and consisting of one sensor only.
Since the magnet will be moveable w.r.t. the beam and the TPC will be moveable inside the magnet the modules have to compensate these movements to keep the readout areas inside the beam spot. In addition the two modules have to move independently from each other to compensate different deviations of the beam due to different magnetic fields. This, and the very limited space, makes the design of the modules and their support very challenging.

2.5 The Modules

Two one-sensor and two two-sensor silicon microstrip modules will be built. They get mounted in pairs onto an Isoval®11 frame:

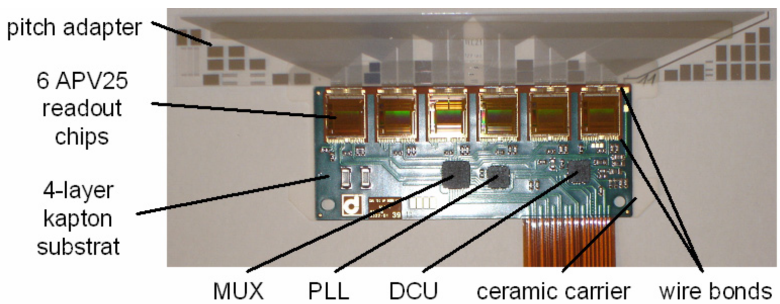


2.5.1 The Sensors

Single sided AC coupled sensors with a thickness of 320 µm and a size of 91.5 x 91.5 mm are used. They have 1792 readout strips with a strip pitch of 50 µm. In the first setup only 768 of these channels will be read out reducing the readout sensitive area to 38.4 x 38.4 mm (only the intersecting readout area of the two modules on top of each other is interesting). All details about these sensors can be found in [7].

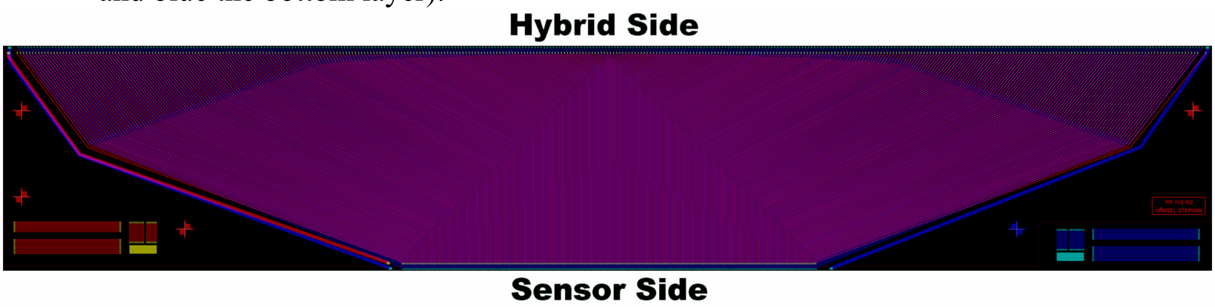
2.5.2 The Front-End Hybrids and Pitch Adapter

Front end (FE) hybrids leftover from the CMS Tracker End Cap module production will be used in the beginning. Later on, these hybrids will be replaced by others containing newly developed FE chips



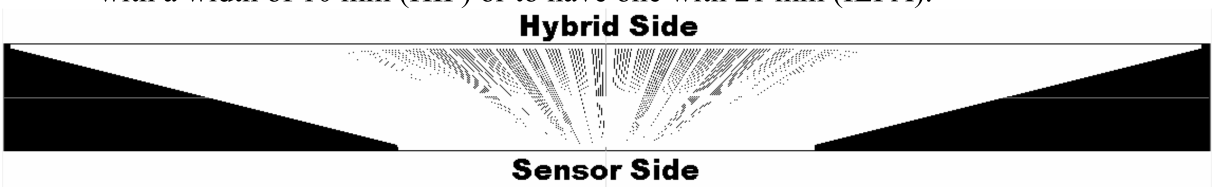
These hybrids are already connected to the appropriate pitch adapter for specific CMS sensors with a pitch of 143 µm. Since it is impossible to remove this pitch adapter (PA), an additional PA has to be designed. This so-called intermediate PA connects 768 channels with a pitch of 143 µm on one side and a pitch of 50 µm on the sensor side. It is currently being built in two different versions:

A) ILFA GmbH produces such a pitch adapter on a 4-layer printed circuit board (PCB). For ILFA, the minimum pitch of two lines is 100 µm. Nevertheless it is possible to design two layers of Cu-lines with 100 µm pitch on two different layers with different sizes and glue them on top of each other shifted by 50 µm. With this design a 50 µm pitch on the sensor side can be reached (in the picture below red indicates the top layer and blue the bottom layer):



This is a very challenging task for the company, but if it is successful, it would be a cheap alternative to glass pitch adapters for future prototypes. Since ILFA does this for the first time, a backup solution is foreseen (point B).

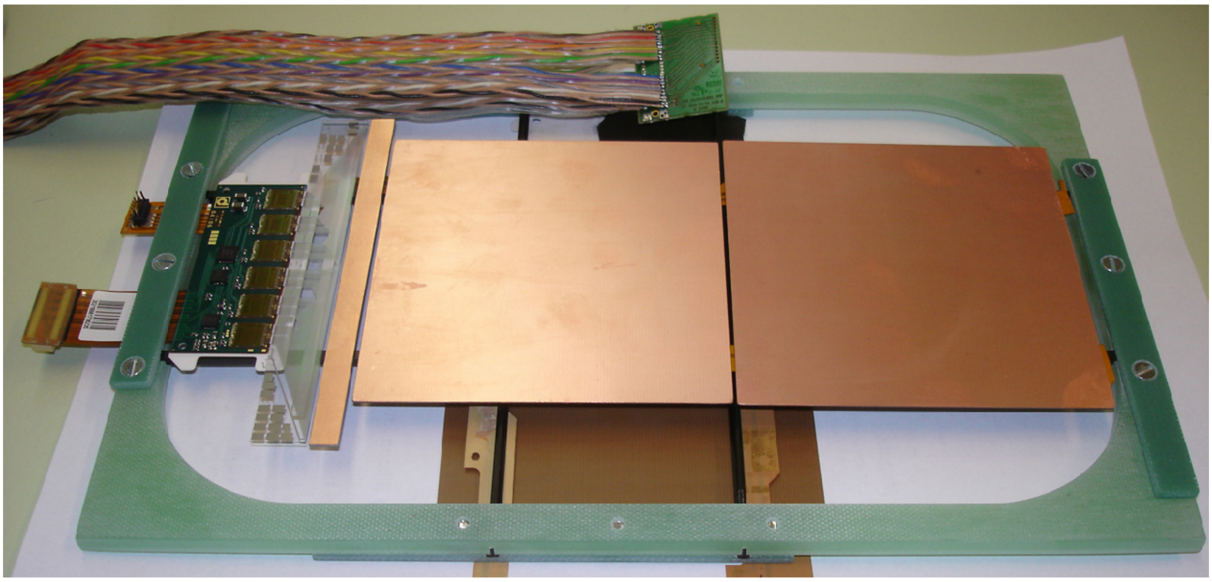
B) Helsinki Institute of Physics (HIP), Academy of Finland, will design and produce Aluminium on quartz PA. The big advantage of this technology is the very minimum width of the conductive lines and the consequential smaller needed dimensions of the PA. Because of the constraints in space it is a big advantage to have a pitch adapter with a width of 10 mm (HIP) or to have one with 21 mm (ILFA).



2.5.3 The Isoval®11 Frame

Isoval®11 is a composite of a resin epoxy reinforced with a woven fibreglass mat. It was chosen because of its high rigidity, its low mass and its insulating properties. Moreover, it is easy to mechanically process. A first prototype was already built and will soon be assembled with two prototype modules containing dummy intermediate pitch adapter and electronically broken FE hybrids. With the appropriate cables it will be a first geometrical prototype (see picture below).

A requirement on the support frame is the possibility to exchange modules. For this reason the modules are not glued onto the frame but each gets clipped to the frame with the help of two 3 mm thick Isoval®11 pads. These pads get screwed to the frame. This system will also be used to fix the HV- and signal-cables to the frame (not implemented in the picture).

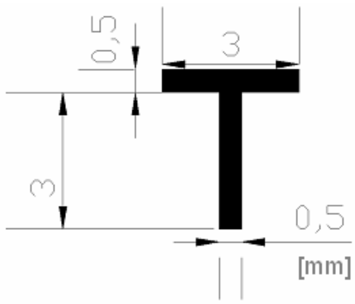


2.5.4 The Kapton Foil

To deliver the HV bias voltage to the sensor backplane and to isolate the sensor backplane from the carbon fibre profiles, Kapton foils are used. They are modified leftovers of the CMS sensor recuperation campaign. These Kapton foils contain already a RC circuit to stabilize voltage fluctuations and to filter out high frequencies in the HV line.

2.5.5 The Carbon Fibre Beams

The backbone of each module consists of two carbon fibre T-beams. Although there are companies which can produce carbon fibre U-, I- and T-profiles, it is not affordable for a low quantity. SECAR Technologie GmbH provided rectangular beams. These beams do not have the highest possible Young's modulus but are still sufficient for the lightweight modules. Two such beams are glued together with a thin film of glue[2] to form a T-beam which is rigid enough to support the sensors, pitch adapter and the front-end hybrid. These support structures are not maximised in terms of radiation length and rigidity, but are a first approach for future silicon strip modules for the ILC.



2.5.6 Status of the Front-End Electronics

Until the new SiLC readout electronics including the FE chip developed by LPNHE Paris [8] is available, the CMS front-end electronics based on the APV25 chip will be used together with a CMS readout system. This so-called XDAQ system with PCI FED and PCI FEC [9] will be made available by IEKP Karlsruhe in the beginning of 2008.

2.5.7 Sliding Carriage for the Silicon Modules

A support system is being build by IEKP that allows the movement of the two diagonally arranged frames containing the silicon modules independently in both, phi and in z direction. It is foreseen to use an Aluminium sledge that slides on two round rods with a threaded rod for the z-movement. The phi movement is realized via curved rails mounted at the outside of the magnet and at the beginning of the magnets bottleneck. With only 35 mm space between the magnet and the TPC this is a challenging design.

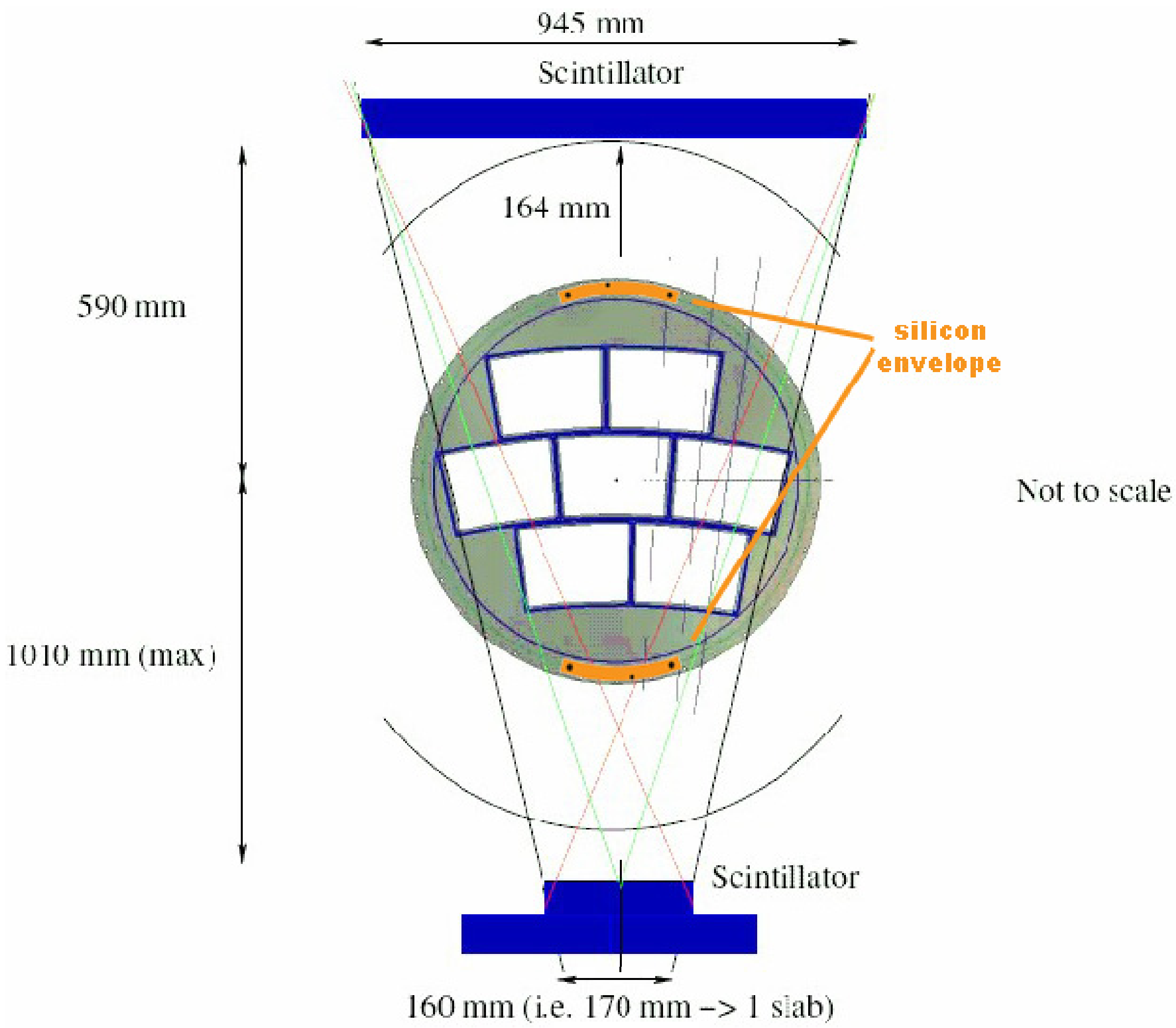
[2] Epoxy AW 106: 2011 ARALDITE, Huntsman

3 The Cosmic Run

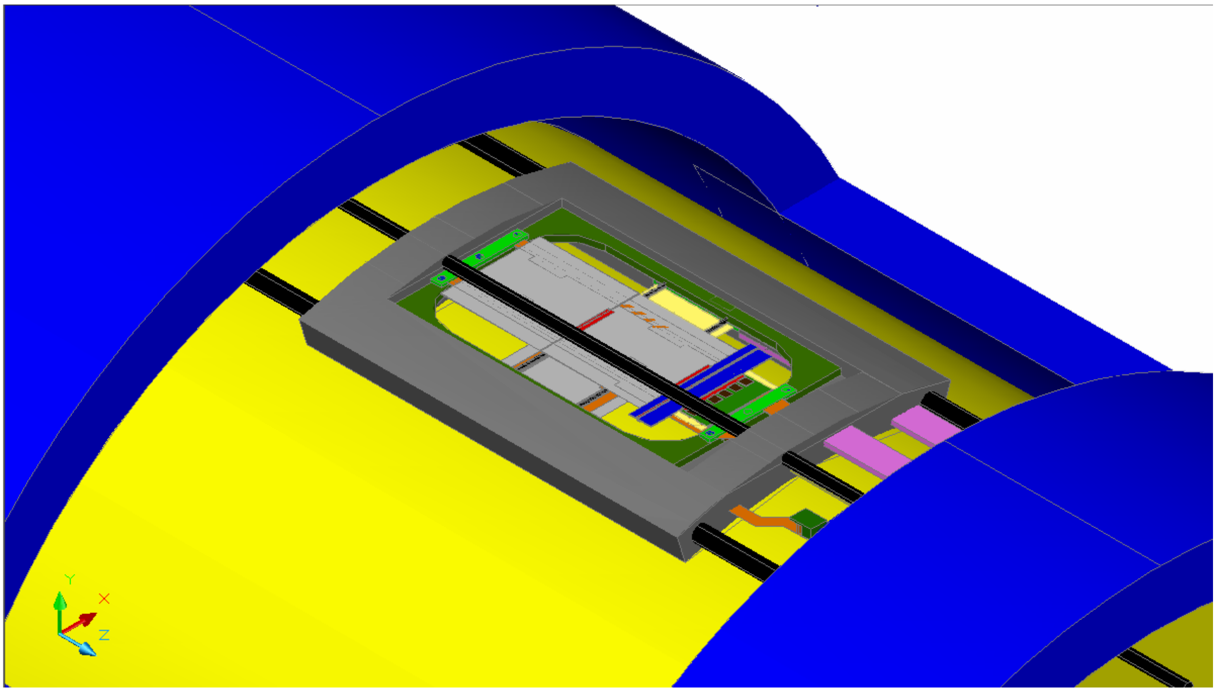
Since there will be a shutdown at DESY in the first half of 2008, the test beam will not be available before August 2008. It was decided to use the time before to perform first tests with cosmics. A very rough estimation expects only about 20 Muon coincidences per day in the intersecting readout areas of all four silicon sensors. However, this test will help to gain experience in operating the readout systems of the silicon modules and the TPC together. For the cosmic run the design of the silicon envelope has to be changed:

1) the modules will be installed at the top and bottom of the TPC which interferes with the support plates of the TPC
2) for this setup the sliding carriage for the silicon envelope only needs to be moveable in z-direction, to move the silicon envelope inside the gap between the magnet and the TPC and out again. (the phi movement and hence the curved rail system is not needed)

No changes are needed on module level. The cosmic run is a great possibility to make first experiences with the modules, the readout system and a simplified module support system. A sketch of the cosmic run setup can be seen here:



The following picture shows a detailed view of the top frame containing the silicon modules. It is located between PCMAG magnet (blue) and the TPC field cage (yellow).



4 Conclusion

According to the schedule, the first cosmics will be measured in the beginning of 2008. The following six month will be used to fully understand the readout and to combine the XDAQ readout system with the TPC system to provide tracking information. In August 2008 the silicon modules will be installed in the original position inside the beam line with the final version of the sliding carriage that enables additional phi movement of the modules. Additionally, it is foreseen to replace parts of the CMS readout system with newly developed electronics containing the SiLC readout chip in the future.

References

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