Integration Issues Around the TPC

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Abstract

A Large Prototype (LP) of a Time Projection Chamber (TPC) is being constructed by the LCTPC (Linear Collider TPC) collaboration. The LP is expected to be operable in the first quarter of 2008 and will be tested under e^- irradiation in a DESY II testbeam area, immersed in a magnetic field. The field-cage (FC) of the TPC as well as the testbeam facility including a superconducting magnet are provided as EUDET projects.
An overview about the integration issues for this combined effort will be presented.

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1 Introduction

The LCTPC collaboration combines an effort, which is distributed over 35 institutes in three continents. The effort concentrates on a large prototype of a TPC, which defines the consolidation phase towards a TPC for the International Linear Collider (ILC). The LP will be immersed in a magnetic field of $\sim 1\,T$, provided by a superconducting magnet, called PCMAG. The TPC will be placed within the PCMAG and the entity will be translated horizontally and vertically, as well as rotated within the horizontal plane, with respect to the beam line.
The LP will be built in a modular way, which allows to test different techniques of readout structures (GEM, MicroMegas) [1]. The FC and the PCMAG will therefore serve as an infrastructure, which is provided within the EUDET framework. In order to also test the feasibility of an envelope of Silicon detectors, modules from the SiLC (Silicon for the Linear Collider) collaboration will be incorporated and will provide precise space points for tracks at the entry as well as the exit side of the TPC [2].
Furthermore, a scintillator hodoscope is under construction to be implemented in the LP setup. With the hodoscope cosmic muon studies will be performed in order to commission and calibrate the setup.

2 Testbeam Area

The DESY II accelerator is providing electrons/positrons with an intensity of $\sim 10^{10}$ particles, with energies up to $7\,GeV$ [3]. The particles in the testbeam areas emerge from converted Bremsstrahlung beams due to $7\,\mu m$ carbon targets in the DESY II beam pipe and subsequent collisions with targets on the way to the testbeam areas. The produced electrons/positrons experience a dipole magnet, which controls the energy and spreads the beam out into a horizontal fan. Eventually a set of collimators form the beam for usage in the test areas.
The electrons in the testbeam area are minimum ionizing particles (MIP), their energy distribution is nearly flat and the Bremsstrahlung spectrum has an $1/E$ dependence. Typical particle rates in the testbeam area can be seen in Table 1.

Energy / GeV	Rate (3mm Cu) /Hz	Rate (1mm Cu) /Hz
1	330	220
2	500	330
3	1000	660
5	500	330
6	250	160

Table 1: Estimated particle rates from DESY II.

3 Superconducting Magnet PCMAG

The LP will be placed in a superconducting magnet PCMAG, which is provided by KEK. PCMAG is a rather lightweight magnet: a low mass coil and no return yoke make its weight to be 460 kg. It has a usable diameter of about 85 cm [1] and the usable length is about 130 cm. Its 3342 windings with an operating current of 480 A provide a magnetic field density of up 1.25 T in the center region of the magnet. The field is homogeneous within 3% in the region of ±30 cm of the center, whereas larger deviations are expected in the remaining region (Fig.1). This, however, allows for establishing correction tests during operation.

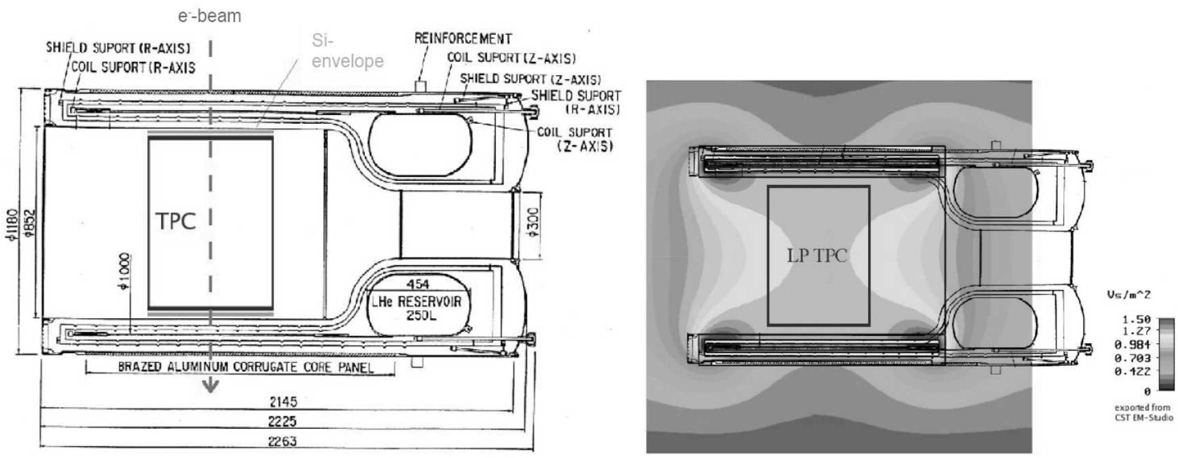

Figure 1: Schematic drawing of PCMAG and its field density distribution.

The magnet is operable and was tested twice within the DESYII T24/1 testbeam area. A field measurement was performed in July 2007 and the proper determination of the field map is under development. It is expected to be available by January 2008.

4 Large Prototype of a TPC

The LP TPC will consist of a field-cage and two closing end plates. The end plates will act as cathode and anode and the anode side will also house the gas amplification structures. The anode will be built such that two different amplification structures can be used (Fig.2), which are either based on the GEM or MicroMegas (Fig.3) principle.
The inner diameter of the field-cage will be 730 mm and its length will be 600 mm. The wall thickness will be about 20 mm and consists mainly of a honeycomb Nomex structure, thus the least amount of material will be present for particles to travel through.
The TPC has to be placed and moved within the PCMAG's volume. Due to the thin wall structure of the magnet, an independent support structure has to be considered (Fig.4). The support structure has to be stiff so that the TPC will not cause a significant

[1]The DESY survey team measured the mean diameter to be 852 mm.

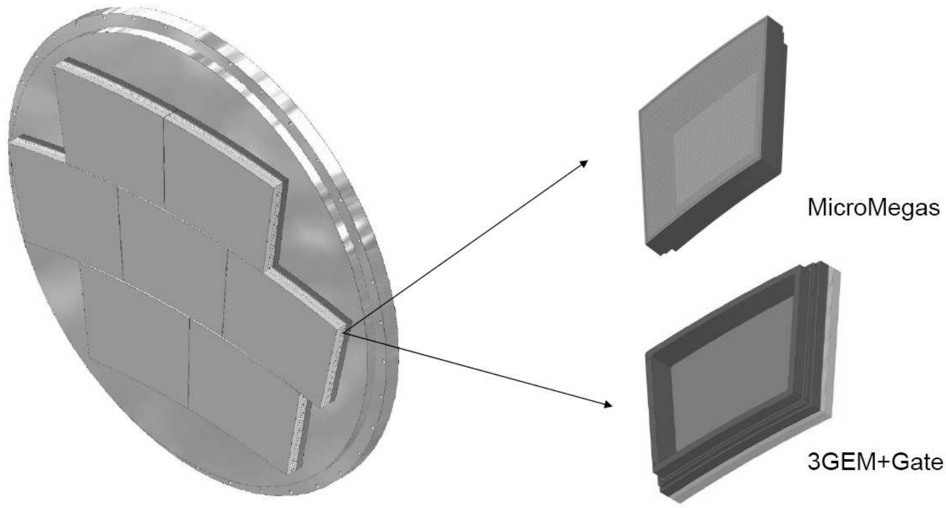

Figure 2: Modular end plate.

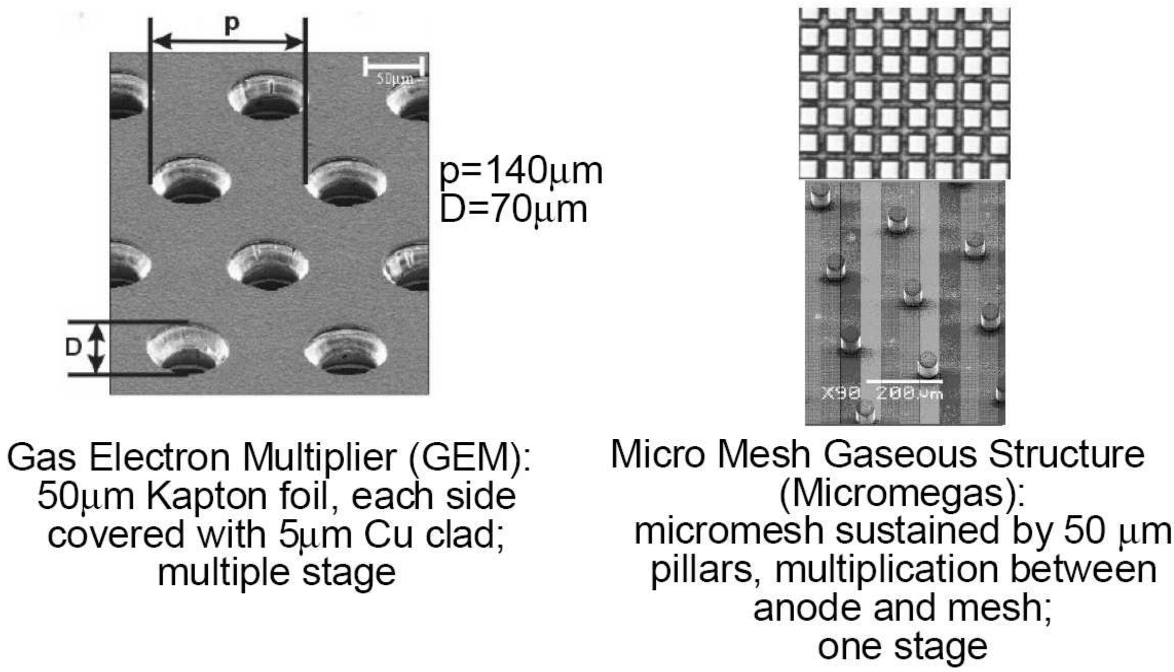

Figure 3: Zoomed excerpt of a GEM (left) and MicroMegas (right) device.

deflection and has to be non magnetizable. A support ring is foreseen for the front end electronics. This support should accommodate the needed PCBs and cables in order not to have the load at the end plate. This additional support is expected to have the maximum contingent of load for the entire TPC. Calculations about the expected deflections of the support structure are ongoing.
The support structure has to be mounted at outside positions of the magnet. The structure has to be built such that it provides no material within the region where the testbeam particles will be entering the TPC. The Si-envelope has to be mounted within this region, movable in the horizontal and vertical direction. Since the space within the magnet is limited, the above mentioned issues depict non trivial considerations about the mounting structure (Fig.5).

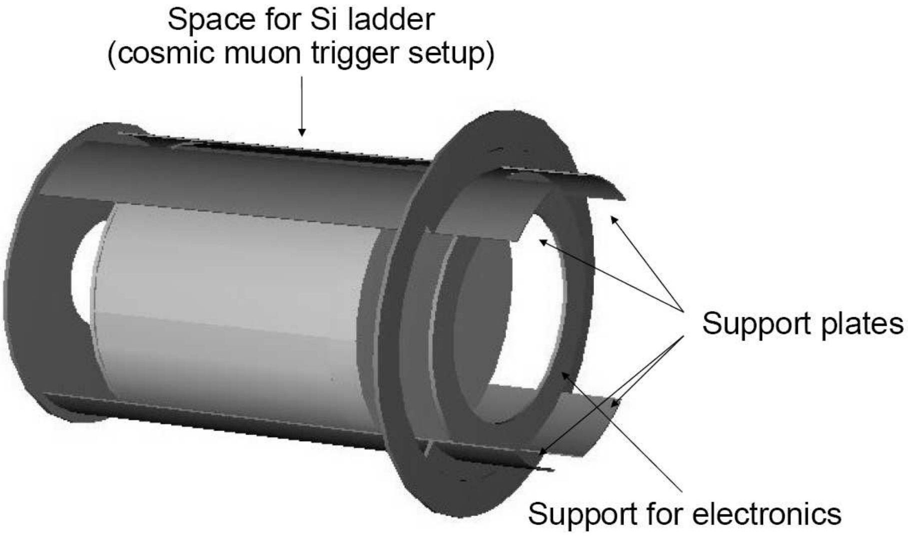

Figure 4: Support structure for the LP TPC.

In addition to the mounting structure for the inner volume of the magnet a lifting table for the entire magnet is foreseen. This allows to scan the TPC horizontally as well as vertically. Furthermore the table is foreseen to rotate within the horizontal plane. All movements will be with respect to the beam line. The table has also to consist out of non-magnetizable material.

5 Scintillator Hodoscope

For commissioning and calibration as well as for reference issues a scintillator hodoscope is foreseen to be included in the testbeam setup (Fig.7). It will be detecting cosmic muons in standalone as well as in testbeam modus. The hodoscope will consist of several layers of scintillator slabs. Five slabs, each with a size of $873 \times 175\,mm^2$ will make the layer on top of the TPC. The longer side of the slabs will be parallel to the TPC's axis. The bottom layer will be made up of two layers. One layer will have three slabs parallel, and the other layer will have four slabs perpendicular to the TPC's axis.

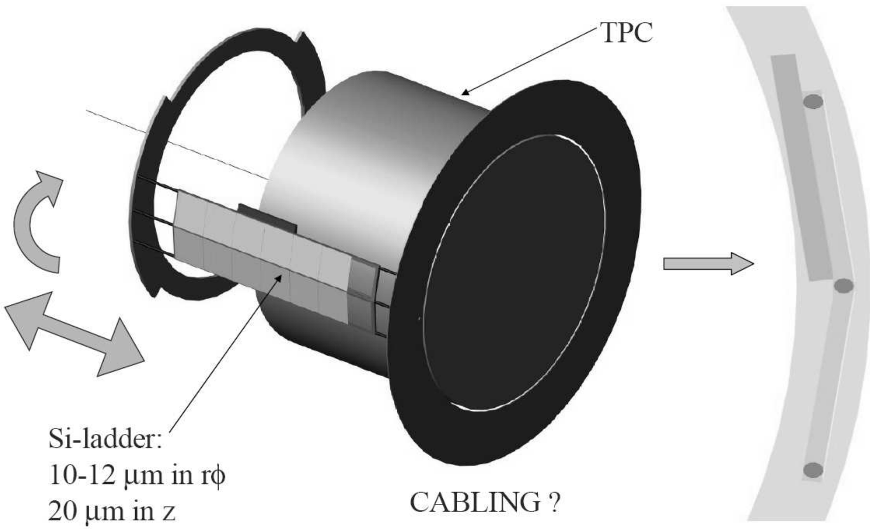

Figure 5: Silicon modules for the usage with the LP TPC. The right sketch depicts the limited space between PCMAG's inner wall and the TPC's out wall.

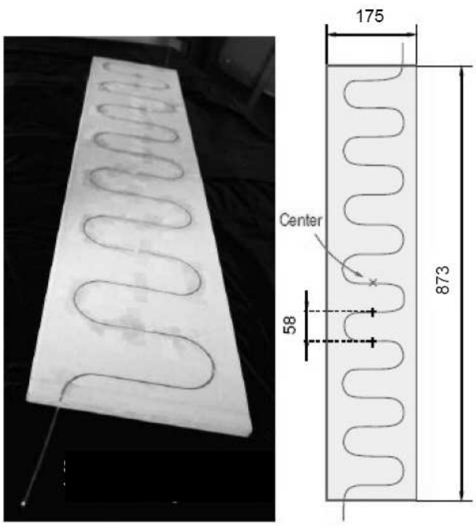

Figure 6: Scintillator slabs produced by UNIPLAST in Vladimir (Russia).

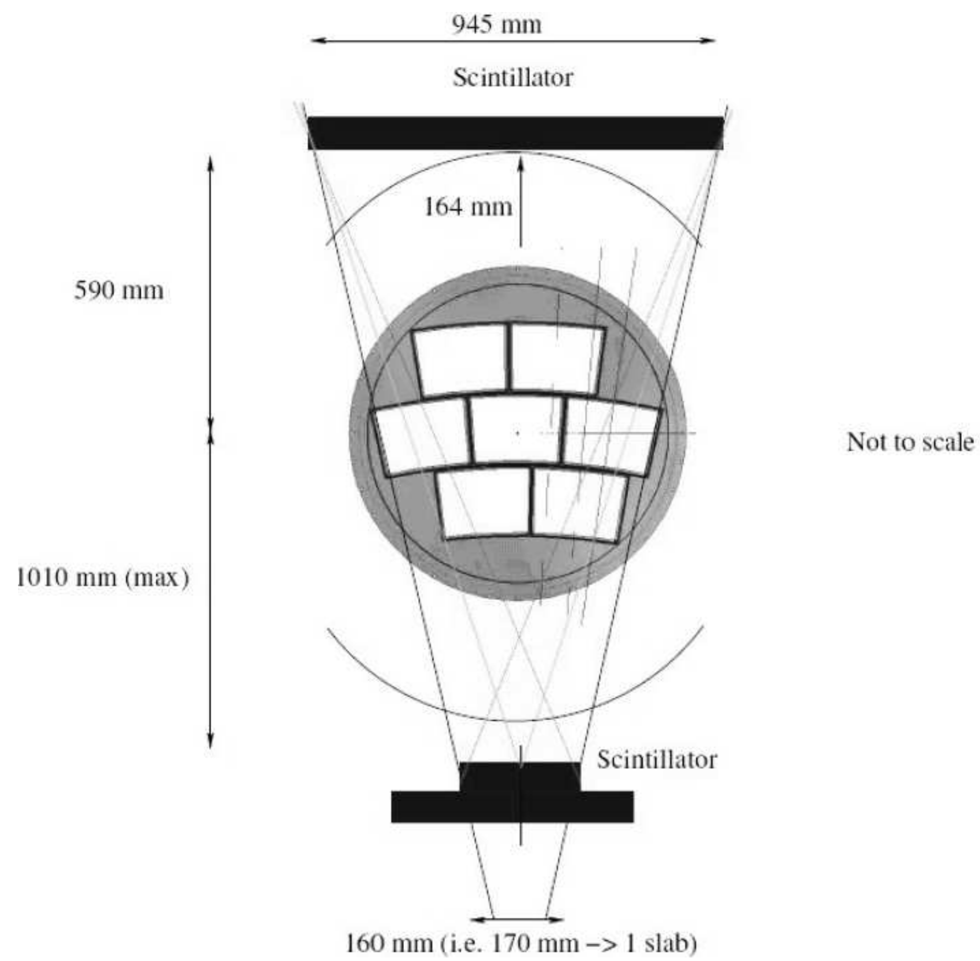

Figure 7: Scintillator hodoscope setup with the LP TPC. The central disk depicts the end plate of the TPC with the modules for amplification and readout.

The slabs will have a white chemical reflector in order to increase the light yield. In addition the slabs will be covered with tape so that light other from the signal cannot enter the scintillator. The slabs will be placed in a aluminum box with openings at the face sides. There the scintillator light will be transformed into electric charge with Multi Photon Pixel Counters (MPPC) [4] with an active area of $1 \times 1\,mm^2$ and a pitch of $100\,\mu m$. The MPPC is a novel type of photon counting device made up of multiple APD (avalanche photo diode) pixels operated in Geiger mode and available in room temperature operation. The MPPC is essentially an opto-semiconductor device with excellent photon counting capability and which also possesses advantages such as low voltage operation and insensitivity to magnetic fields, which is the case here due to operation at PCMAG.

6 Conclusion

The presented integration issues for the planned testbeam efforts of the LPTPC collaboration depict a list of tasks, which are necessary for successfully operating the LP at the DESY II testbeam. The issues describe the more technical aspects of the R&D effort. The planned start of the DESY II testbeam operation is set to August 2008 since DESY II will experience a shutdown in the first half of 2008 due to the PETRA III upgrade. In the meantime cosmic muons will be used in conjunction with the trigger hodoscope and the LP will be commissioned and calibrated with an expected startup in the first quarter of 2008.

Acknowledgement

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