Status of Large TPC Prototype Field Cage

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Four concepts for detectors at the International Linear Collider (ILC) have evolved. One of these proposals is the Large Detector Concept (LDC) [2]. It contains a large continuous gaseous tracker surrounded by a highly granular calorimeter all embedded in a solenoidal 4 T magnetic field. Within the LDC concept and in the framework of the EUDET programme, the FLC TPC group at DESY in collaboration with the Department of Physics of the University of Hamburg develops a field cage for a large Time Projection Chamber (TPC) prototype. In the following, the status of its design and construction will be described.

1 The Large Prototype Proposal

The EUDET project [3] is an EU supported project to develop an infrastructure for detector R&D for the ILC. The construction of a Large Prototype (LP) for an TPC is part of it. This prototype is designed and will be operated by the LCTPC collaboration. With the LP studies of e.g. amplification systems, readout structures and electronics will be performed. A first series of tests is planned at the electron test beam at DESY.
A superconducting magnet (PCMAG) from KEK is installed at the test beam area since winter 2006. Together with a high precision silicon telescope and the LP this will become a powerful research infrastructure for the development of TPC detectors at the ILC.

2 Field Cage Design

The dimensions and the field homogeneity of the magnet constrain the field cage dimensions. The LP will be 60 cm long and will have an outer radius of 77 cm. This leads to a gap of 4 cm all around between the field cage and the magnet, where silicon strip detectors will be mounted. In Figure 1 the LP is shown inside the inner region of PCMAG, where the field deviations are smaller than 3 %.
The walls of the prototype will consist of composite material to obtain a lightweight but stable structure with the smallest possible amount of dead material. A technical drawing of the field cage is shown in Figure 2.

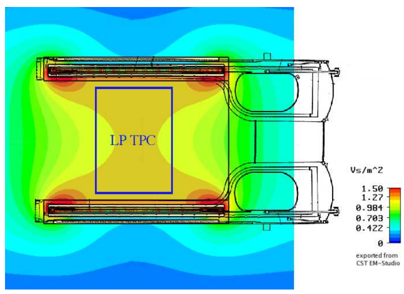

Figure 1: LP in simulated magnetic field of PCMAG

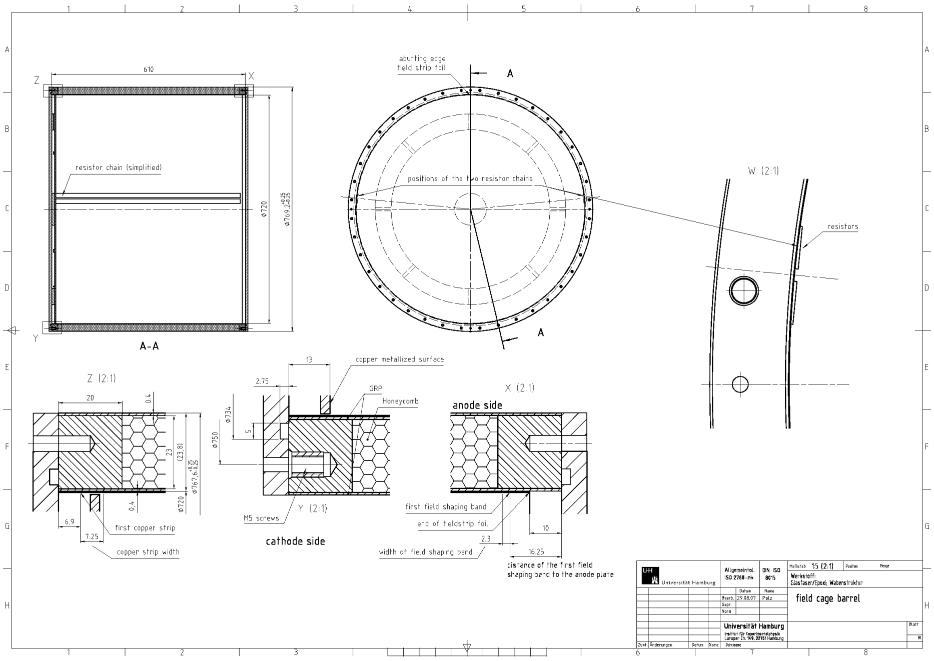

Figure 2: Technical drawing of field cage. All dimensions are preliminary.

2.1 Wall Structure and Mechanical Calculations

The field cage wall will consist of two thin layers of glass-fibre reinforced plastic (GRP) with a honeycomb Nomex layer in-between. On the inner side, an insulation layer of Kapton and the field strip foil will be attached. The outer wall consists of another Kapton foil and a Copper layer for electrical shielding.
Mechanical calculations with a finite element program were performed to find optimal values for the thickness of the different layers of the wall. The result of these computations is a structure of two 0.4 mm GRP layers with a 23 mm Nomex layer in-between. A simulation of such a field cage that is supported only by the end plates demonstrated its stability. Even an overpressure of 0.1 bar or an additional load of 5 kg on the barrel of the field cage resulted in only minor deviations (sub μm regime) well within the limits.

2.2 Field Strip Foil

The homogeneity of the drift field in the field cage is a critical parameter for the measurements. The deviations of the field should be smaller than 0.1 per mill ($\Delta E/E \leq 10^{-4}$). A calculation of the electrical field with finite element methods resulted in a field strip foil design which contains mirror strips on the other side of the foil. This mirror strips are lying on the intermediate position and potential of the strips on the inner surface. The field strips have a pitch of 2.8 mm and the potential is divided down from the cathode to the anode by a chain of $1\,\mathrm{M}\Omega$ resistors. The intermediate potential for the mirror strips is provided by feedthroughs.

2.3 Drift Field Quality

Besides the design of the field strip foil, the accuracy of the used resistors and a potential tilt of the end plates will influence the drift field quality. The chosen surface mount device (SMD) resistors provide deviations of less than 0.1% at 1 MΩ. This yields slightly modified potentials on the strips. The resulting electrical field, which was calculated with a randomly generated set of these resistors, showed only deviations of $\Delta E/E < 10^{-4}$.
A tilt of the cathode of 0.2 mm leads to field deviations, which are shown in Figure 3. In the corners near the cathode, on the right hand side of the plot, the deviations are remarkably high but within 25 cm towards the anode the field strips level this out and the field reaches the aspired quality with $\Delta E/E < 10^{-4}$.

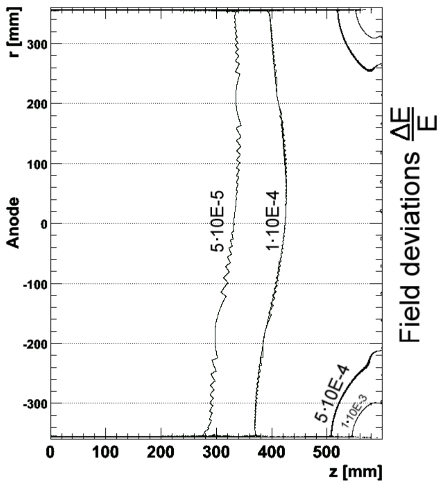

Figure 3: Calculated field deviations caused by tilted cathode. The figure shows a longitudinal cut through the LP.

3 Field Cage Production and Silicon Strip Detectors

The field strip foil as well as the field cage itself will be built by external companies, which are specialised in production of circuit boards respectively composite materials. The anode for the LP with the readout structure will be designed and built by the LCTPC collaboration. The silicon strip detectors will be mounted on the support structure between magnet and field cage. They are used to get independent reference points for particle tracks. The SilC collaboration will install two perpendicular layers of silicon strips on both sides of the field cage. These modules will have a size of 10×10 mm^2 and are expected to provide a resolution of $10 - 12$ μm in $r\varphi$ and 20 μm along the z axis.

4 Acknowledgments

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5 Bibliography

References

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[3] http://www.eudet.org