A Micromegas-based TPC for the International Linear Collider

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Introduction

One of the two detector concepts for the ILC is the International Large Detector (ILD). The central tracking at the ILD [1] is foreseen to be accomplished by a TPC (the ILD-TPC). A TPC has the benefits of truly continuous 3-D tracking and robust pattern recognition. In the baseline design, the length and the diameter of the ILD-TPC are 4.6 m and 3.6 m respectively. It will work in a 3.5 T magnetic field.

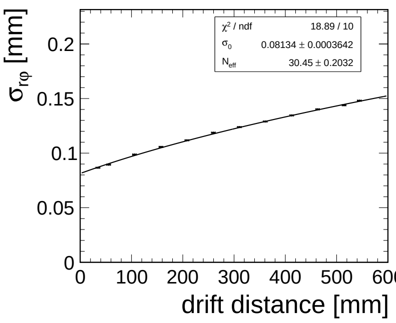

FIG. 1: Variation of space resolution in $r\phi$ (anode) plane with drift distance.

A Micromegas-based Large TPC Prototype for the ILC:

As the Micro-pattern Gaseous Detectors (MPGDs) have low material budget, high-rate capability, good spatial and temporal resolutions, they are considered as the candidate for the ILD-TPC. A Large Prototype of the TPC for the ILC (LPTPC) is installed at DESY, Hamburg since 2008 to test different MPGD technologies under comparable conditions (the technology choice is yet to be done). Upto seven MPGD modules of identical shape and size can be mounted on the end plate. This discussion is focused on the results of MICRO-MEsh GAseous Structure (Micromegas) [2] which is one among the more prominent MPGDs. At the DESY synchrotron facility, seven resistive Micromegas (MM) modules have been tested at the LPTPC with an electron beam of energy ranging from 1 GeV to 6 GeV, under a magnetic field of 1 T.

Performance of the LPTPC

The accuracy on the track sagitta corresponds to a $r\phi$ resolution at the ILD-TPC which is required to be better than 100 μm over the full drift length under a magnetic field of 3.5 T. We have studied in detail the performance, e.g., the space resolution in $r\phi$ and along the drift axis of the LPTPC using resistive Micromegas for gas amplification. The $r\phi$ and z resolutions of the Micromegas-based LPTPC, in a 1 T magnetic field, within 60 cm drift distance are measured as $\sim$ 150 μm and $\sim$ 400 μm respectively (fig 1) [3], which

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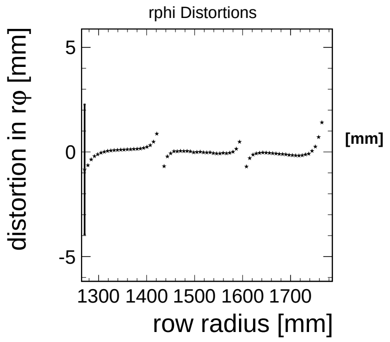

FIG. 2: Residual of the pad hits along the track as obtained in experiment at B = 1T.

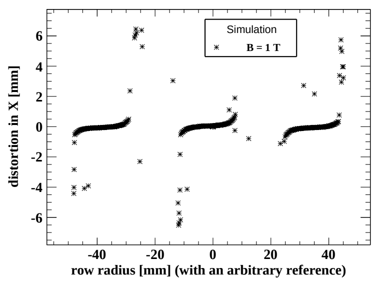

FIG. 3: Residual of the pad hits along the track as obtained in numerical simulation at B = 1T.

fulfill the requirements of the ILD-TPC. However, like any other MPGD-based TPC, there are few challenges in track reconstruction in a Micromegas-based LPTPC.

Track Distortion

Track distortion occurs due to electric field inhomogeneity near the gaps between modules. A copper frame closely surrounds the micro-mesh in order to provide support to the readout plane. The inhomogeneity arises since the copper frame is kept at ground potential where as the the micro-mesh is kept at a few hundred volts. This not only affects track reconstruction but also causes signal loss for the pad rows which are close to the boundaries. The $r\phi$ resolution for those pad rows worsen due to the non-uniform electric field. Thus, the resolution averaged over all the pad rows degrades. However, distortion effect is partially overcome during analysis. We have performed a detailed numerical study on this. The nature of the residuals of the hits on individual pad rows as obtained from numerical calculations (fig 3) are very similar that observed in the experiment (fig 2) for both B=0T and B=1T. The study helps to identify the cause and the effects of non-uniformity of the electric field around the Micromegas modules. I have also studied the possibilities to mitigate the problem by raising the potential of the peripheral copper frame. As the potential is raised to mesh voltage, the magnitude of the residuals are found to be notably reduced.

Conclusion

Micromegas is a promising candidate for the ILD-TPC. Like any other MPGD, track reconstruction at the LPTPC with Micromegas has challenges. The electric field inhomogeneity near the gap between the modules results in track distortion and affects the performance of the TPC. The causes and effects of this distortion have been throughly studied by numerical methods. The results match closely with experiment. Possible hardware modifications to mitigate distortion effect have been explored in simulation.

Acknowledgments

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