

No track without errors

M. Berger^{1,2} and the *GEM-TPC Collaboration*^{1,2,3,4,5,6}

¹Physik Department E12, Technische Universität München, Garching, Germany; ²Excellence Cluster 'Origin and Structure of the Universe', Garching, Germany; ³GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany; ⁴Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany; ⁵Universität Heidelberg, Heidelberg, Germany; ⁶Stefan Meyer Institut für Subatomare Physik, Wien, Austria

In past experiments, Time Projection Chambers (TPCs) have been equipped with a gating structure to prevent the migration of avalanche ions created during gas amplification – traditionally realized with Multi Wire Proportional Chambers (MWPCs) – in order to maintain drift field homogeneity. This, however, limited the application of TPCs to experiments with trigger rates smaller than $\mathcal{O}(10^3 \text{ Hz})$. To overcome this limitation a TPC with GEM (Gas Electron Multiplier) foils [1] exploiting their intrinsic ion backflow suppression, has been built [2]. This GEM-TPC has a drift length of 728 mm, an inner radius of 50 mm and an outer radius of 155 mm. For the readout a padplane with hexagonal shaped pads with 1.5 mm radius was used. For tests with cosmic tracks and different heavy ion beams as well as for a physics experiment with a pion beam the GEM-TPC was employed together with the FOPI spectrometer [3].

To reduce the data rate and to introduce the possibility of an early noise suppression, pad hits are collected in entities called clusters which are defined by an amplitude, a position and an uncertainty. This is done by a full 3D local minima search which is independent of the pad shape or pad plane geometry. The clusters are then passed to the pattern recognition algorithm performing track finding employing a conformal mapping method [4]. Finally, a track can be fitted to these clusters. For this the Kalman Filter implementation provided by the GENFIT [5] framework is used.

For track fitting it is mandatory to have a precise knowledge of the uncertainty on the cluster position. The uncertainty of this position is strongly dependent on the track topology. For example, along the track the pad hits are uniformly distributed while perpendicular to the track the pad hit distribution is broadened by diffusion. Therefore the uncertainty has to take the track topology into account.

In order to avoid a completely model dependent uncertainty a new method is implemented using only measured values. In order to incorporate the track topology a prefit has to be performed. After this prefit the new clusters are created by stepping through the track and collecting the pad hits. These pad hits are projected onto a plane perpendicular (see left side of Fig.1) to the track and fitted with a two dimensional Gaussian function. The new cluster position is then calculated by the position of the plane and the position of the mean from the fitted function. The position uncertainty is simply the uncertainty on the mean also given by

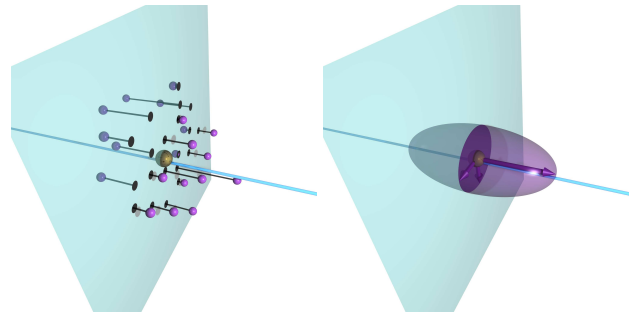


Figure 1: Left panel: Pad hits (purple spheres) projected onto a plane (turquoise) perpendicular to the track (light blue). The projected pad hits are depicted as black disks and the resulting cluster position is shown in gold. Right panel: Final resulting uncertainty of the cluster is shown as transparent purple ellipsoid. The eigenvectors (scaled by the eigenvalue) are shown as purple arrows and the uncertainty ellipse from the fit is shown in dark purple.

the fit which is a 2×2 matrix defined in the coordinate system of the plane. To extend the uncertainty into 3D space a new covariance matrix is created using equation 1 where \mathbf{V} is a 3×3 matrix containing the two eigenvectors of the original matrix and an vector along the track. \mathbf{S} is a 3×3 diagonal matrix with the corresponding eigenvalues. Figure 1 (right side) shows the resulting uncertainty ellipsoids and the eigenvectors of the final covariance matrix.

$$\text{COV} = \mathbf{V}\mathbf{S}\mathbf{V}^{-1} \quad (1)$$

This method however may treat several detector intrinsic features not properly, like the different types of measurements of X-, Y- and Z-coordinates. X and Y are measured on a pad plane while the Z coordinate is reconstructed with a drift time measurement. The proper treatment of such features is investigated at the moment.

References

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