Characterization of Static Distortions in the sPHENIX TPC with a Steerable Laser System

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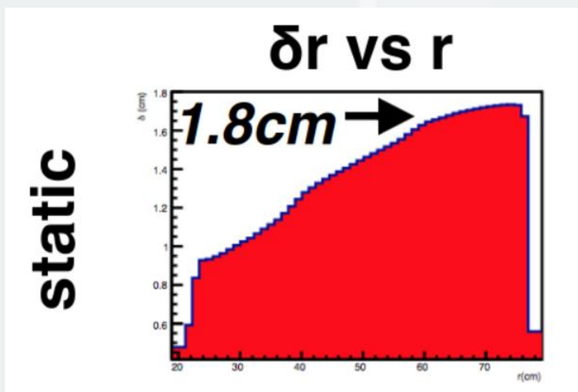
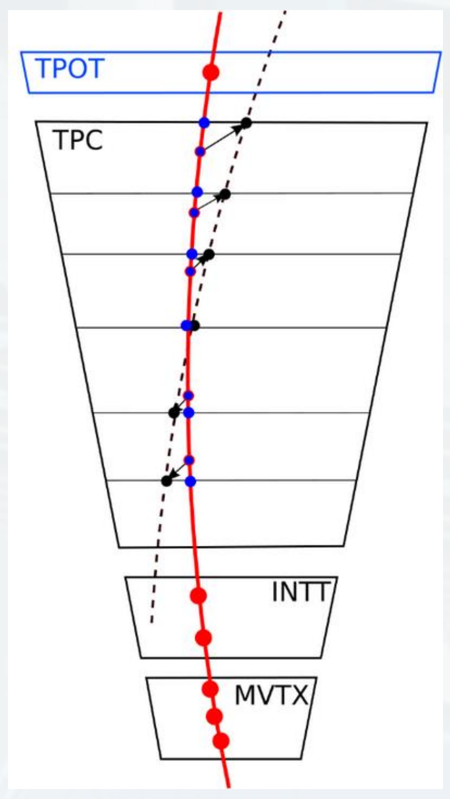
Abstract

The sPHENIX Time Projection Chamber (TPC) is a gaseous drift detector designed to measure charged particle tracks. It is filled with Argon/CF_4 and uses Gaseous Electron Multiplier (GEM) foils at readout for electron amplification and ion back-flow suppression. The electrons at readout are measured, converted to digital current, and their wave forms are processed to reconstruct the track. At this stage, the positions of hits and clusters along the track can be measured. However, a successful measurement of these hits and clusters must correct for distortion effects present in the TPC. There are 3 sources of distortion: static distortions from E and B fields, average distortion from space charge, and event by event distortions from fluctuations in space charge. This poster focuses on a novel technique to measure the static distortions using a system of steerable ionizing lasers. These provide straight tracks at many different angles with an ability to sample the entire TPC volume between periods when beam is present. These laser tracks are used measure the distortions from non-uniform and slightly misaligned drift electric fields and solenoidal magnet fields in single voxels of the TPC. From these measurements, one can determine the static distortion correction. This poster presents the methodology by which the TPC volume is sampled by steering the laser and how the distortions are measured from reconstructed laser data.

Introduction

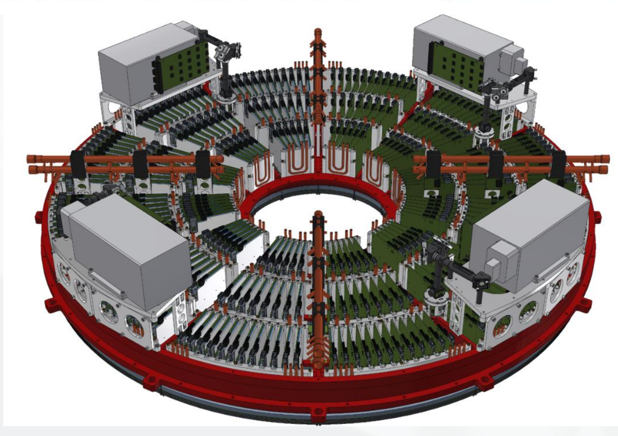
Static distortions are caused by non-uniformity and misalignment of drift and magnetic fields. They displace hits/clusters from their true location. **Static distortions are expected to be on the on the order of ~ 1-2 cm.**



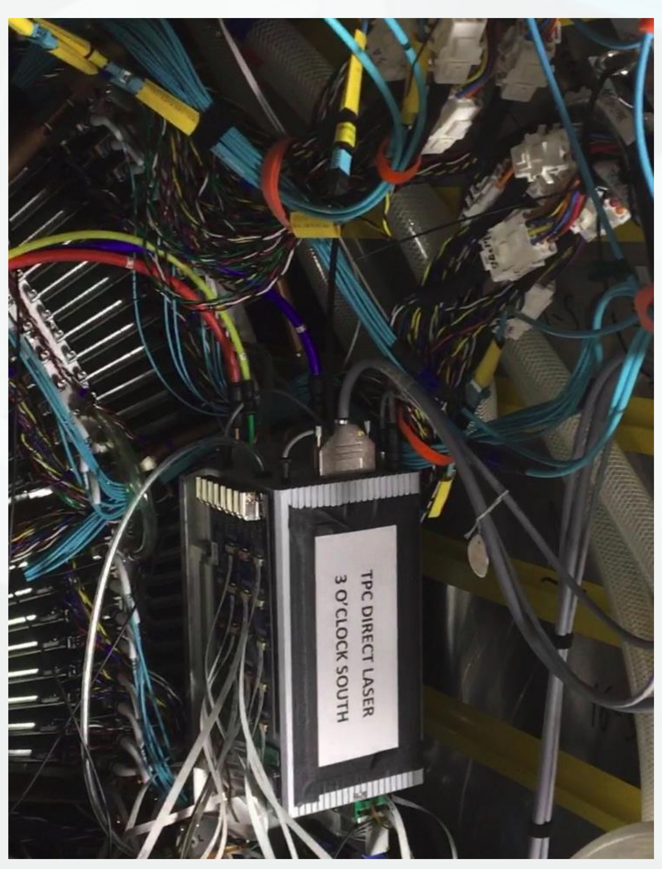


Hardware

The sPHENIX TPC uses a system of steerable lasers to produce straight-line tracks at a multitude of angles. These straight line tracks can be used to calculate the static distortions. The lasers are Cr:YAG and use a system of pizeo-electric motors for primary and secondary steering.

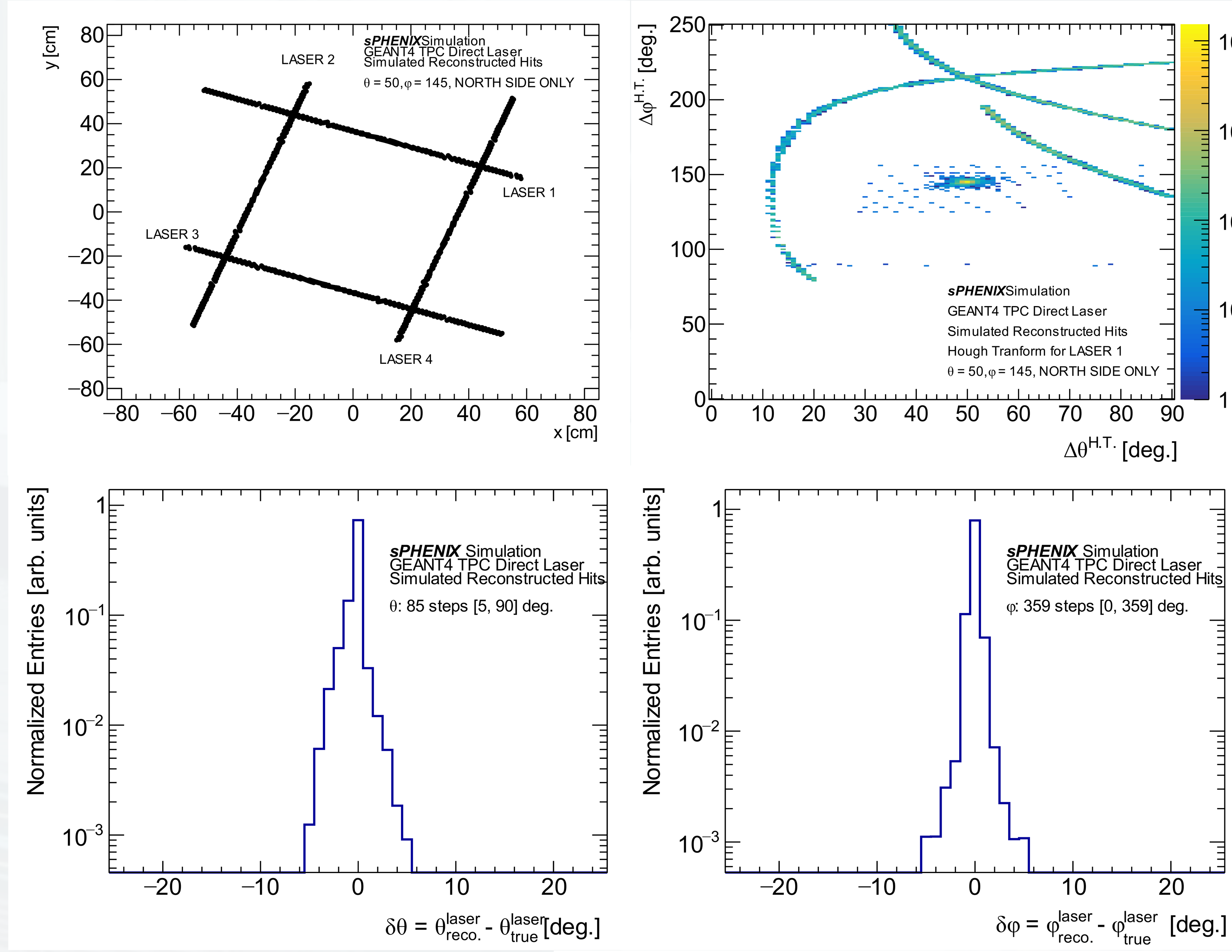


The lasers are mounted at the wagon wheel of the TPC – 4 on each side. Laser light is produced in the optical bench (shown on the right), sent through the two-stage steering, and then enters the TPC gas volume.



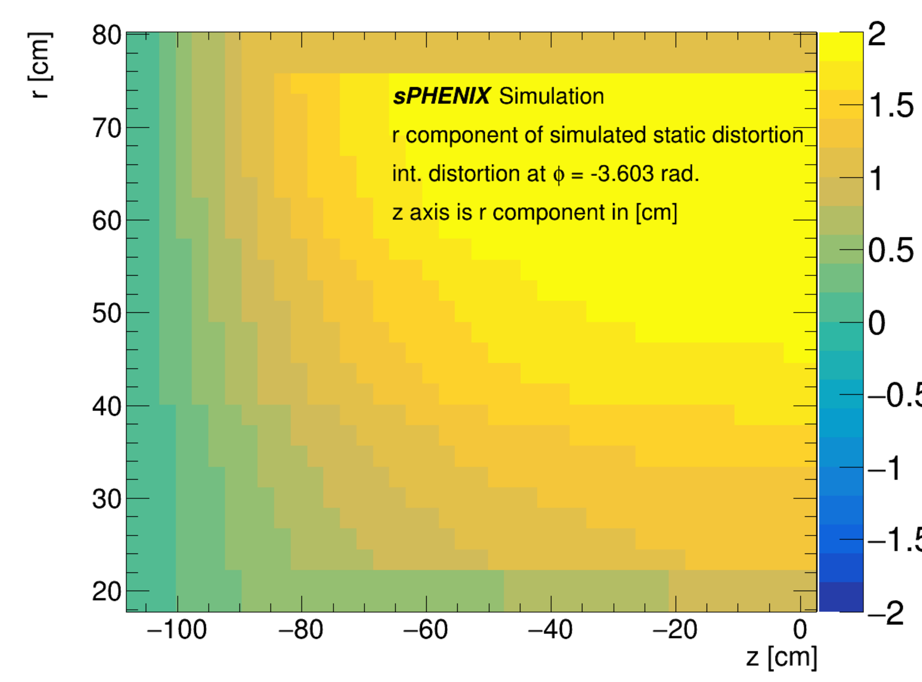
Reconstruction of Laser Trajectory: Hough Transform

Knowing the direction of the laser trajectory is crucial to measuring the static distortions. Direction can be learned from data by finding the maximum of the Hough transform of the XYZ positions of laser hits.

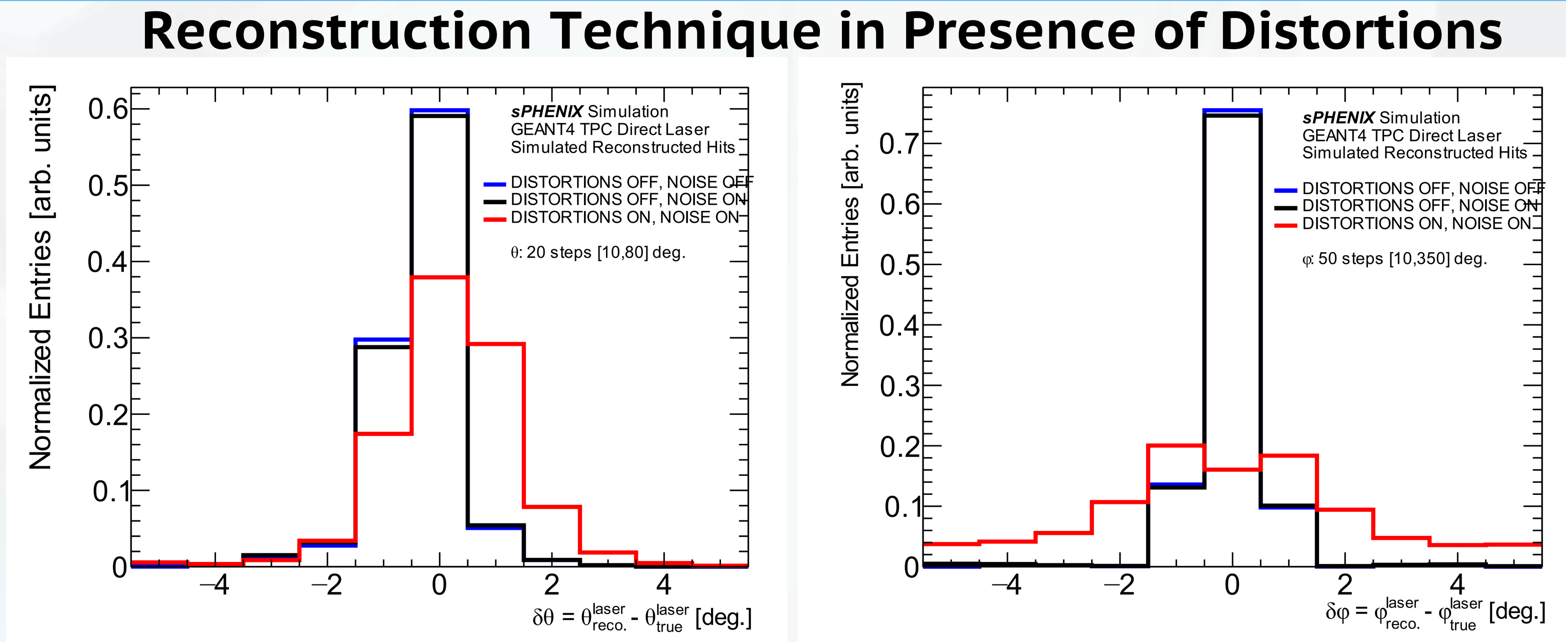


The maximum of the Hough transform method reconstructs 90 % of angles within < 1° error without noise/distortion.

Next, distortions are simulated (right) and the technique is performed with noise and distortion. Performs worse as expected – suggesting next step is only performing technique close to readout (95 <|z| <105 cm) - where distortion is less.



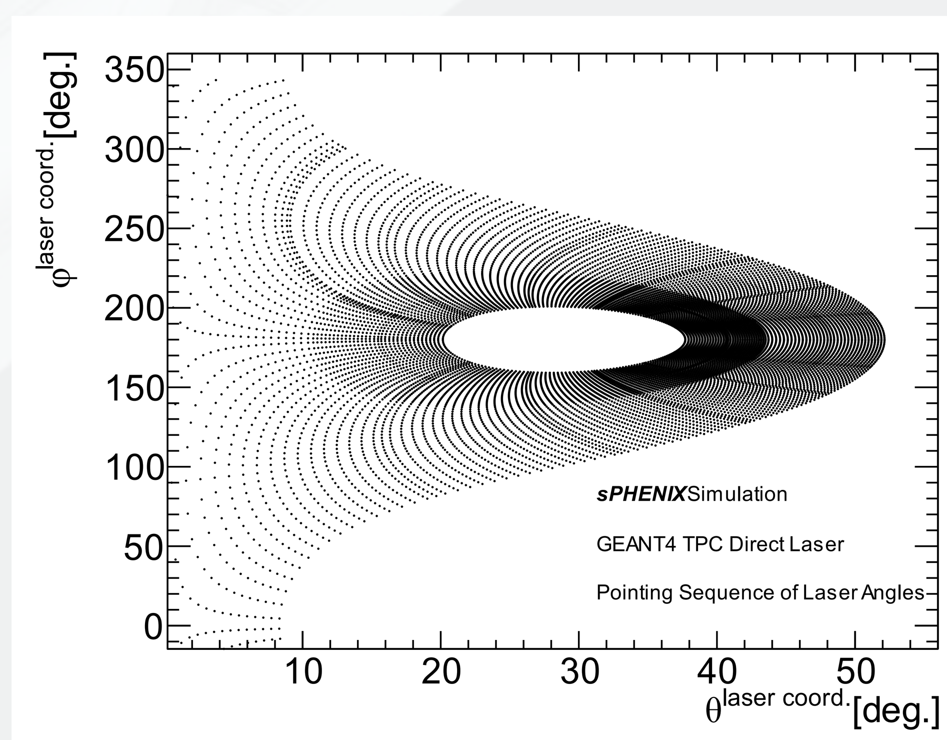
Reconstruction Technique in Presence of Distortions



Spatial Sampling Technique

Important to get granular static distortion map (voxelization).

Need to efficiently sample TPC volume by picking laser angles which sample uniform (r,ϕ) grid at, e.g., z=0 evenly. (Right) Each dot is an angle in laser fire coordinates needed to do just that. Hole is TPC Inner Field Cage (cannot hit).



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