Test Beam Results for the sPHENIX TPC Prototype

Henry Klest, for the sPHENIX Collaboration
Department of Physics and Astronomy, Stony Brook University, SUNY, Stony Brook, New York 11794-3800, USA

Abstract
A Time Projection Chamber (TPC) will be the central tracking detector in the sPHENIX experiment. Its main task is to provide a high tracking efficiency and excellent momentum resolution for precise upsilon spectroscopy and jet measurements. The TPC will cover the full azimuth and a pseudorapidity range of up to |η| < 1.1.

An A small-scale prototype TPC with a radial extension of 40 cm and a similar drift length has been manufactured which can accommodate a full-size amplification module as for the sPHENIX TPC. The prototype has been exposed to a 120 GeV proton beam at the Fermilab Test Beam Facility (FTBF). The results of the test-beam campaigns including SAMPA readout electronics will be presented.

2019 sPHENIX TPC Test Beam Goals
- Demonstrate stable operation of GEMs in low ion backflow mode, sPHENIX requires <1%
- Test almost final frontend electronics
- Explore Ne:CF4 50/50 mixture
- Maintain or improve spatial resolution

Spatial Resolution
- sPHENIX physics goals require spatial resolution < 220 µm from TPC
- sPHENIX magnet will provide ~1.4T
- Measurement of resolution as a function of drift length in prototype TPC requires extrapolation to value with magnetic field
- Ne:CF4 50/50 gas mixture provides a significant improvement over 90/10, likely due to reduced electron attachment

dE/dx Resolution
- Measuring the energy loss for different particle species enables particle identification in a TPC, critical measurement for EIC
- sPHENIX TPC is compact, covers 20 < r < 78 cm
- dE/dx measurements generally use long baseline: STAR radial drift volume 150 cm, ALICE 162 cm
- Due to large ratio of primary ionization to total ionization, CF4 enables high dE/dx resolution in a smaller TPC

Low Ion Backflow Configurations
- Prototype employs almost-final FEE
- 80 ns peaking time required for sPHENIX
- SAMPA v5 coming soon!
- Streaming readout performed well, aside from some event chopping issues

Readout Electronics
- Continuous readout via 8 SAMPA per front-end card
- 8 FEE cards for prototype TPC
- 256 Channel SAMPA Optical readout

sPHENIX Prototype TPC
- 40 cm long, one-sided TPC
- Exposed to 120 GeV protons at Fermilab Test Beam Facility
- 400 V/cm drift field
- Ne:CF4 50/50 gas mixture
- Single module, 1/36 of an endcap
- Quad-GEM with zig-zag pads
- Moving stage allows for movement simulating tracks inclined in z,φ
- No magnetic field, realistic momentum resolution requires extrapolation
- Free parameters: GEM voltages, cathode voltage, gas mixture, TPC position, beam species

SPHENIX needs to run in low IBF configuration due to high rate and occupation, makes dE/dx more difficult, but for EIC IBF is not as large of a concern
- Projection of test beam data to full TPC provides a possible dE/dx resolution of α = 6.6%
- sPHENIX TPC is a capable day-one detector for EIC!