Implementation of task for calibration of TPC gas drift velocity

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Alexander Bychkov
VBLHEP, JINR
abychkov@jinr.ru
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Reconstructed coordinates in 3D

XY – pad position

Z – calculates by electrons drift time and velocity
Electron Drift Velocity calculation problem

Impact on drift velocity

Temperature
Pressure
Charged areas in gas volume

Read trigger delay

Cumulative delay of all triggers before Read-Out Camera (ROC) starts gathering data

Delay between moment when collision event or laser pulse happens and starting of gathering data by ROC

Time offset of all data
TPC gas

- Gas mixture 90% Ar + 10% CH₄
- Operating pressure 2.0±0.1 mbar (relative to atmospheric)
- Temperature 25 °C
  - stability < 0.5 °C

Electron drift velocity in electric field
140 V/cm and magnetic field 0.5T

~5.53291 cm/µs +/- 0.01%

(Garfiege++ simulation)

According to TPC TDR v7
Simulation features for testing drift velocity calculations

Read-out channels details

100 ns – time bucket, 310 time buckets
>95000 read-out channels in total
24 Read-out Cameras - sectors

Electrons drifting + ROC response («Digitizing» task in MPDRoot software)

Forming charge-in-time distributions for each pad of the TPC

Transferring electrons from MC track to Pad Plane of ROC with desired electron drift velocity
Adjust electron drift times taking into account read trigger delay
Remove electrons that reach ROCs plane before read trigger occurs
Laser Calibration System

UV laser system

Two pulsed 130 mJ 5-7 ns Nd:YAG lasers

~1 mm beam diameter

224 laser beams in total

112 “straight tracks” in each half of the TPC

4 planes of laser beams

30 cm between planes

10 Hz impulses
Drift velocity calculation algorithm

Based on cumulative signal-in-time distribution from all channels in sector (or half of TPC)

Laser grid planes forms high peaks in the distribution

The peaks determines position of laser grid planes

Drift time between positions of laser planes provides velocity information

Difference between measured and «expected» position of laser grid provides trigger delay information

\[ V_{\text{drift}} = \frac{Z_{\text{between laser planes}}}{t_{\text{peaks}}} \]
Drift velocity calculation codes

Points of interest

Drift velocity calculation along all drift length

3 points between pairs of laser planes
interpolated/extrapolated velocity value for each hit (quadratic polynomial now)

Read trigger offset calculation
with taking into account actual drift velocity

Fast algorithm

Real time calculations for slow control and based on RAW data

Calculations of velocity map of each event should takes less than 100 ms (10Hz)

now ~70-75 ms (Intel Core i7-8700) - single thread (codes also allow multi-thread per sector), velocity per sector, all sectors
Simulations – laser grid only

![Graphs showing normalized signal in sector against time bin for different velocities and trigger times.](image-url)
Simulations – laser grid mixed with event

![Graphs showing normalized signal in sector over time bins.](image-url)
Simulations – laser grid mixed with event (2)

Statistics - 500 events of laser grid

\[ V_{\text{drift}} = 5.4 \text{ cm/μs} \quad t_{\text{trigger}} = 545 \text{ ns (~ 3 cm offset)} \]

144 velocity reference points = 24 sectors * 6 reference points

4 points — each laser plane, 1 point — HV electrode, 1 point — ROC pad plane
Simulations – laser grid mixed with event (3)

Example correction \( \nu_{\text{drift}} = 5.4 \text{ cm/\mu s} \quad t_{\text{trigger}} = 545 \text{ ns} \)
Conclusions

Main results

- Developed and implemented algorithm of electron drift velocity calculation
  - Calculations of drift velocity map (velocity per sector) or drift velocity in half of the TPC
  - Implementation adapted for real-time/offline execution

Additional results

- Extended features of MPD TPC response simulation algorithms
  - New additional features for electron transferring in sensitive volume
Thank you for attention!

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