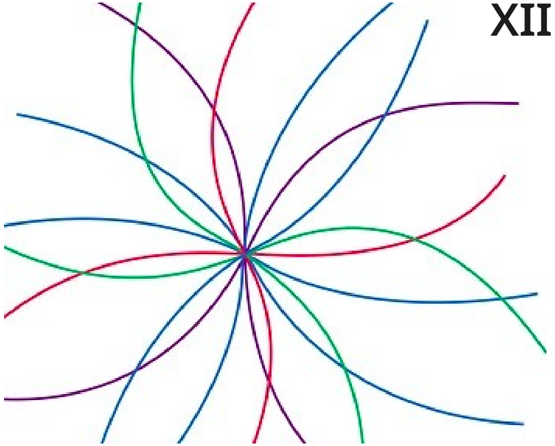
Implementation of task for calibration of TPC gas drift velocity

XII Collaboration Meeting of the MPD Experiment at the NICA Facility



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October 5, 2023
Belgrade, Serbia

MPD TPC

TPC gas

Gas mixture 90% Ar + 10% CH_4

Operating pressure 2.0±0.1 mbar

(relative to atmospheric)

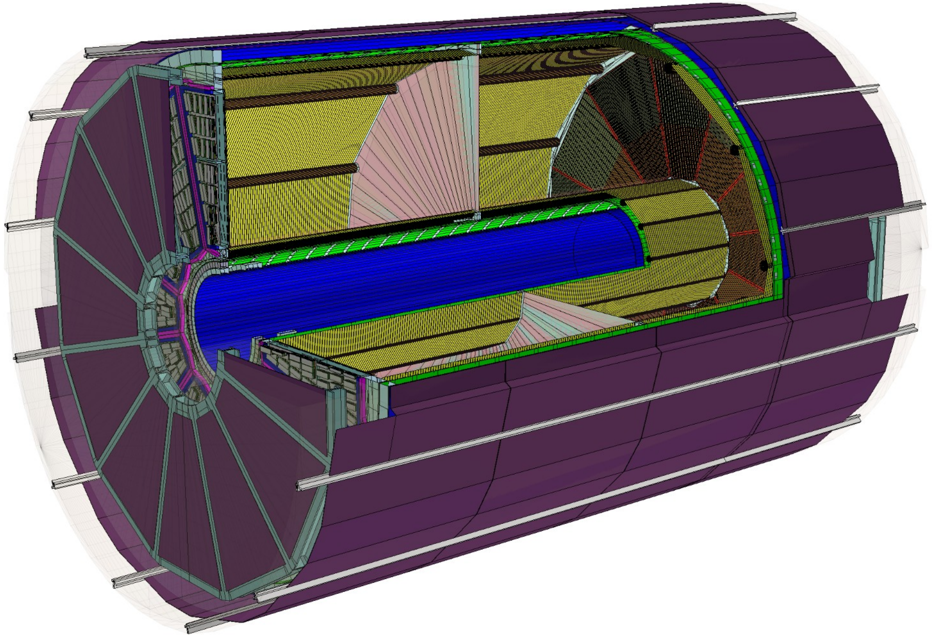
Temperature 25 °C

stability < 0.5 °C

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

~5.53291 cm/µs +/- 0.01%

(Garfieg++ simulation)



According to TPC TDR v7

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 happens and starting of gathering data by ROC
- Time offset of all data

Read-Out Cameras (ROC)

24 sectors — 24 ROCs

>95000 read-out channels in total

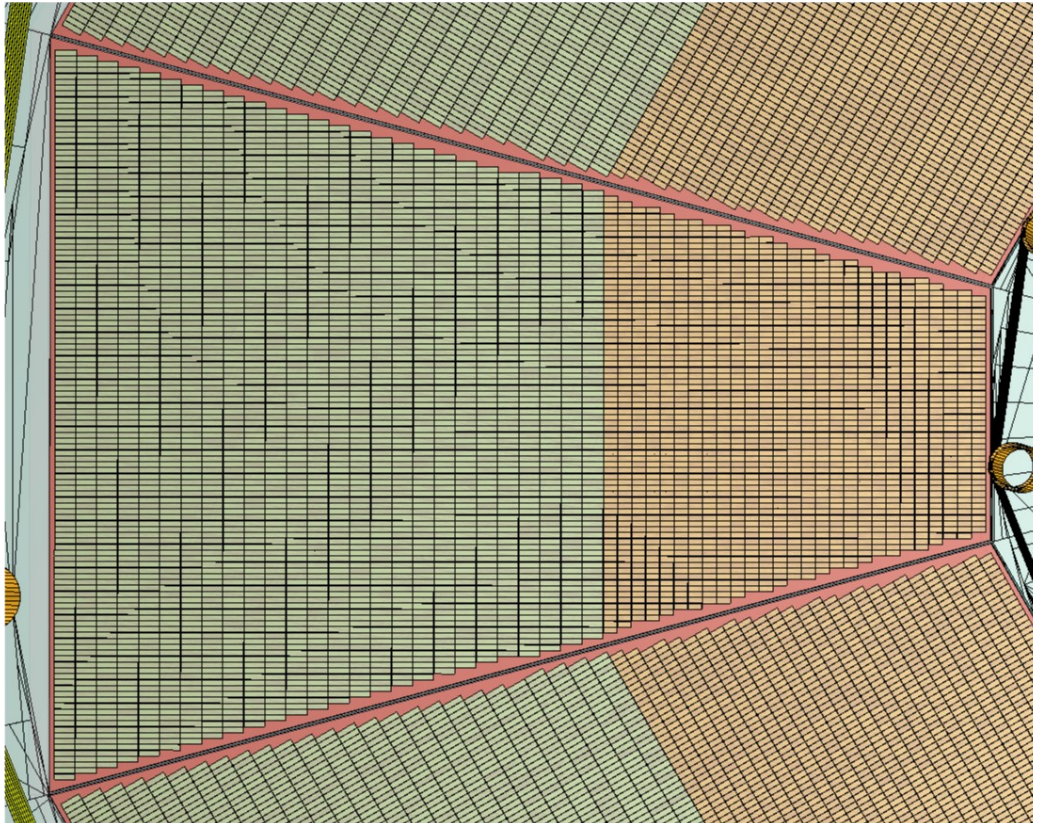
Each ROC

~4000 active pads — read-out channels

Each read-out channel

310 time buckets

10 MHz — 100 ns per bucket



SAMPA electronics (Read-out Cameras)

Read-out channel parameters

100 ns – time bucket, 310 time buckets

>95000 read-out channels in total

SAMPA impulse shape function

$$f(x) = \left(\frac{x-t}{\tau}\right)^N e^{-N\left(\frac{x-t}{\tau}\right)} + Bl$$

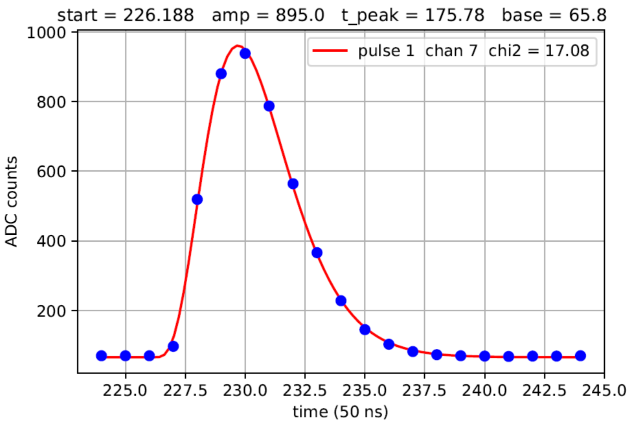
N = 4 — shaping order

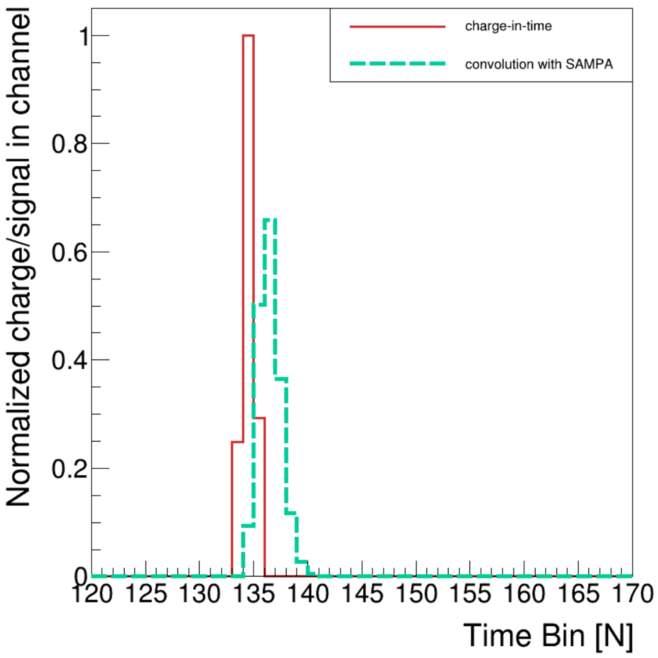
τ = 160 — peaking time (ns)

Bl = 0 — baseline

t — start time

Ae^{-N} = 20 (30) — amplitude (fC per mV)





According article **SAMPA Based Streaming Readout Data Acquisition Prototype**

Simulation features for testing velocity calculations

Electrons drifting + ROC response

«Digitizing» task in MPDRoot software

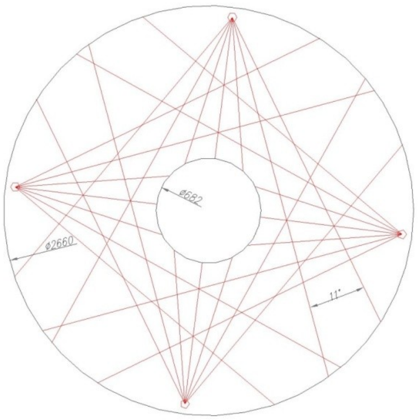
- Forming charge-in-time distributions for each pad of the TPC
  - Transferring electrons from MC track to Pad Plane of ROC with desired electron drift velocity
  - Adjust electron drift times taking into account read trigger delay
  - Remove electrons that reach ROCs plane before read trigger occurs
- Simulation of SAMPA electronics
  - Convolution of each charge-in-time distribution with SAMPA impulse shape function

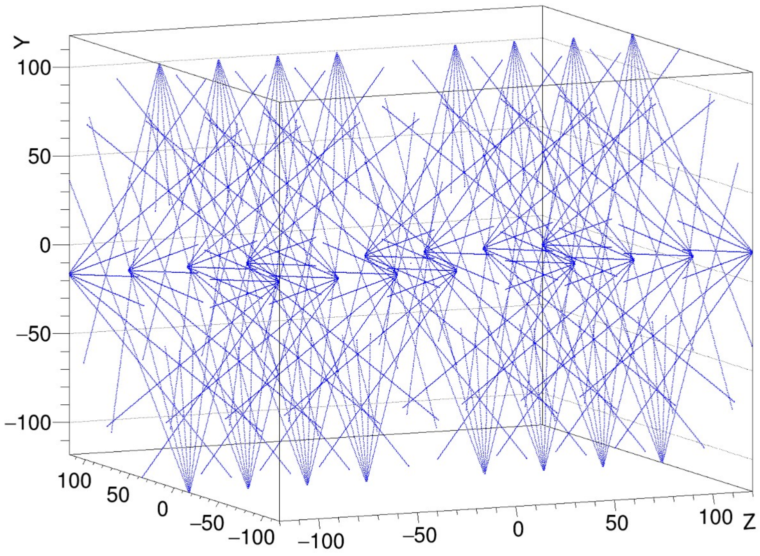
Correction each SAMPA channel output data for peaks shift

- Always 160 ns for current simulations
- Should be pre-measured on test stands for real hardware

UV laser system

- Two pulsed 130 mJ 5-7 ns Nd:YAG lasers
- ~1mm diameter
- 224 laser beams in total
- 112 “tracks” in each half of the TPC
  - 4 planes of laser beams
  - 30cm between planes
- 10 Hz impulses





Drift velocity calculation algorithm

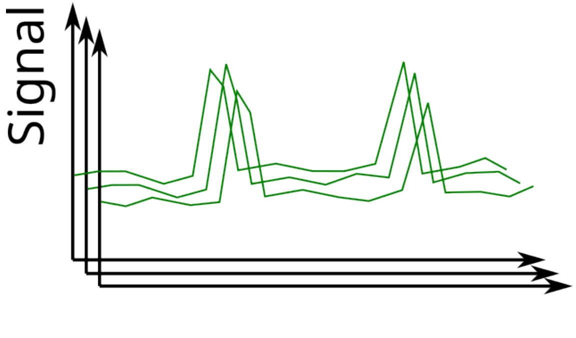
Based on cumulative signal-in-time distribution from all channels in sector

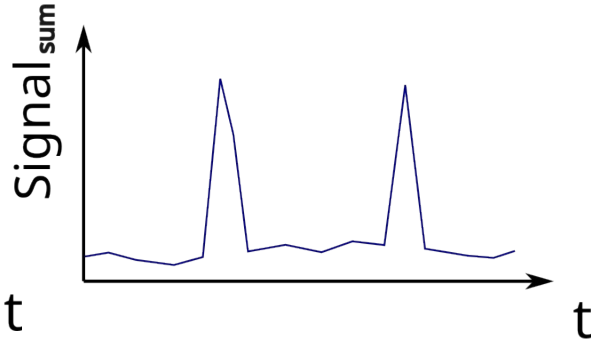
Laser grid planes forms high peaks in the distribution

The peaks determines position of laser grid planes

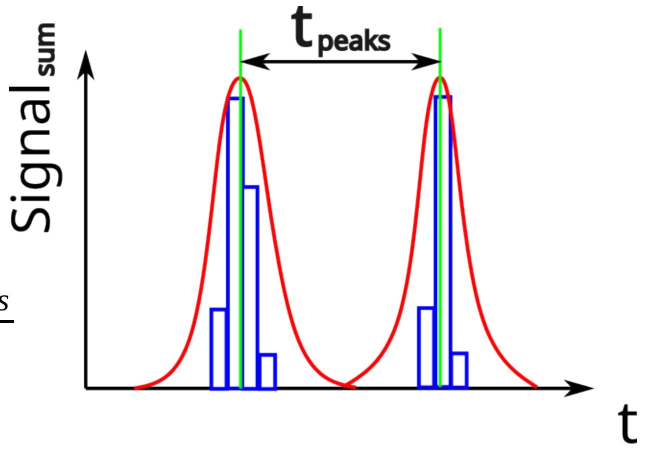
Drift time between positions of laser planes provides velocity information

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





$$V_{drift} = \frac{Z_{between\,laser\,planes}}{t_{peaks}}$$



Drift velocity calculation codes

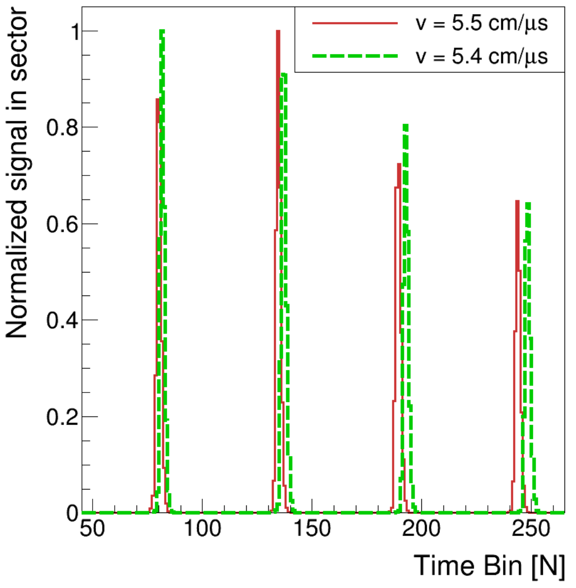
Points of interest for each TPC sector

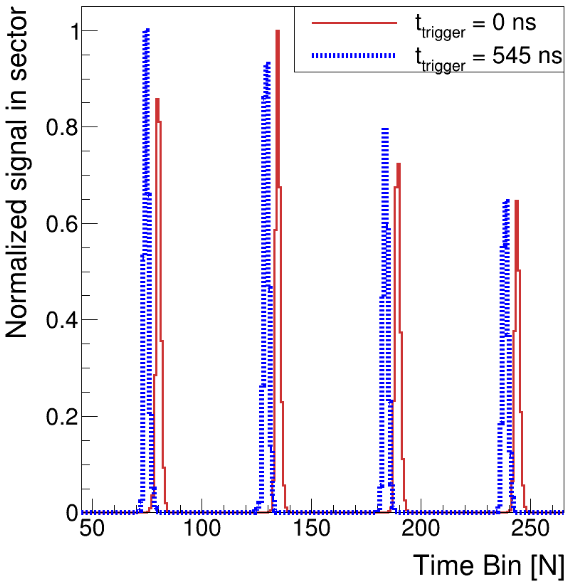
- Drift velocity calculation along all drift length
  - 3 points between pairs of laser planes
  - interpolated/extrapolated velocity value for each hit
- Read trigger offset calculation
  - with taking into account actual drift velocity

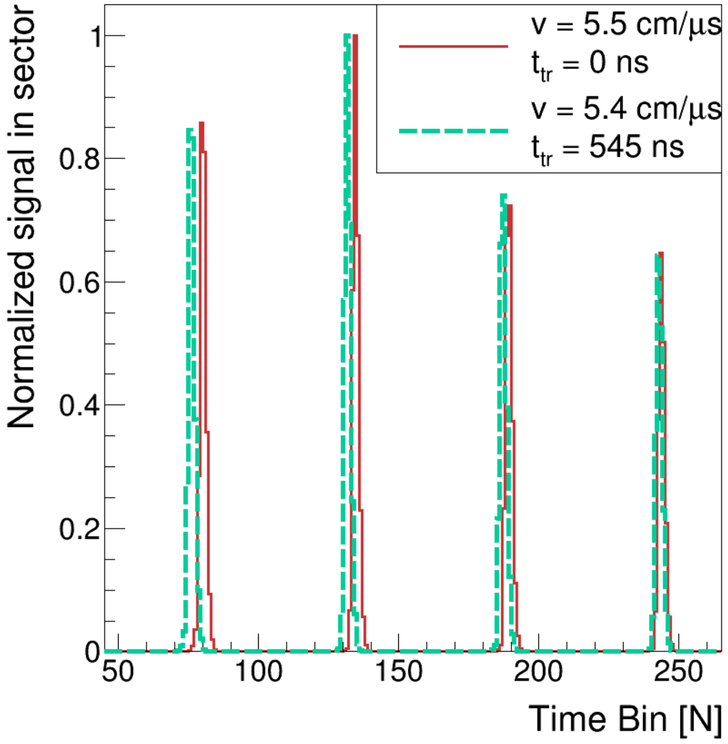
Fast algorithm

- Real time calculations for slow control and based on RAW data
- Calculations of velocity map of each event less than 100 ms (10Hz)
  - now ~70-75 ms, single thread for all sectors (Intel Core i7-8700), codes allow multi-thread per sector

Simulations – laser grid only







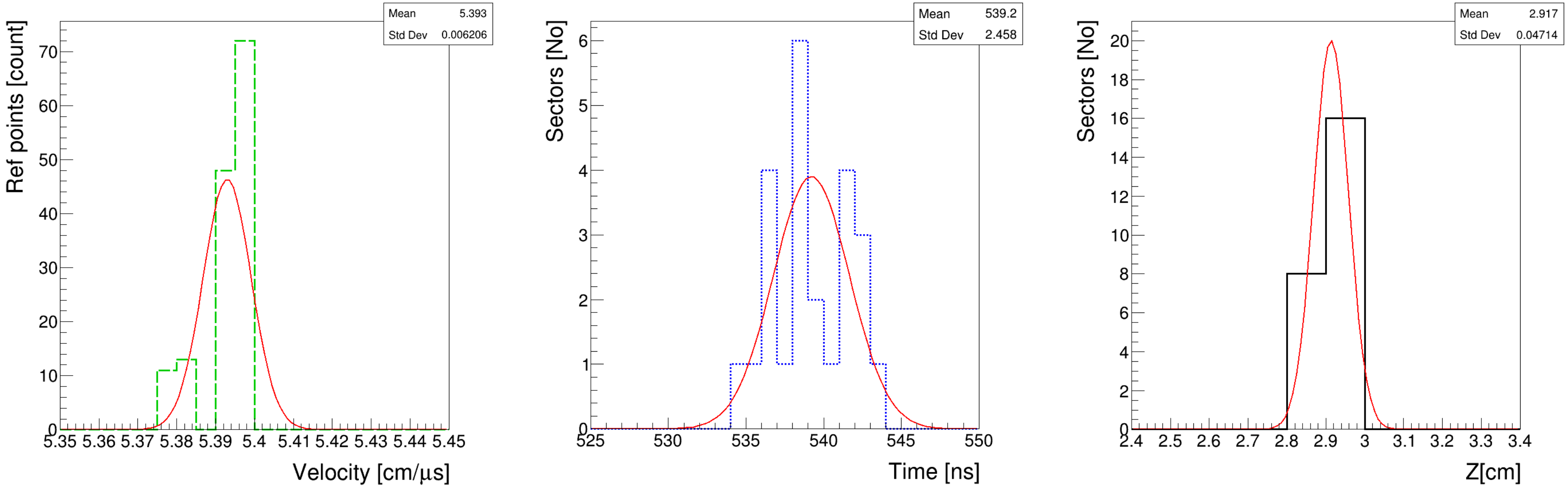
Simulations – laser grid only (2)

Statistics - 500 events of laser grid

V_{drift} = 5.4 cm/μs $t_{trigger}$ = 545 ns (~ 3 cm offset)

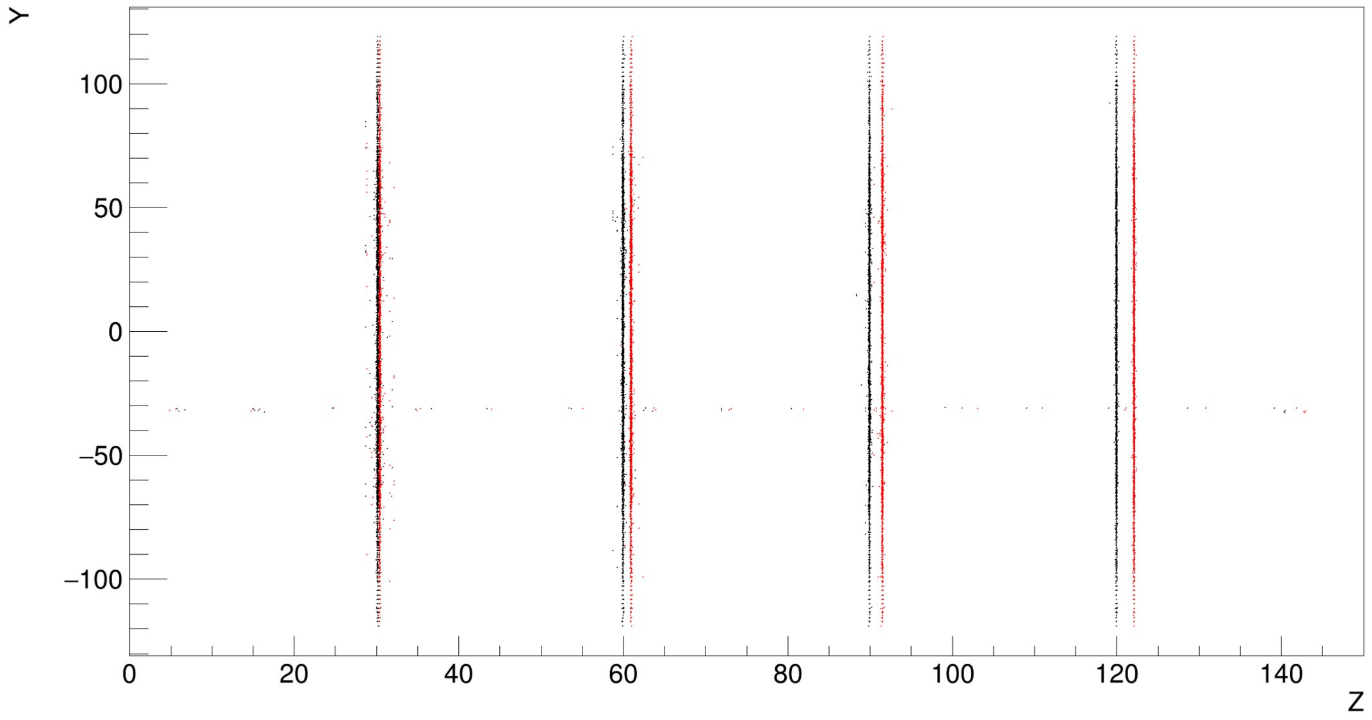
144 velocity reference points = 24 sectors * 6 reference points

4 points — each laser plane, 1 point — HV electrode, 1 point — ROC pad plane

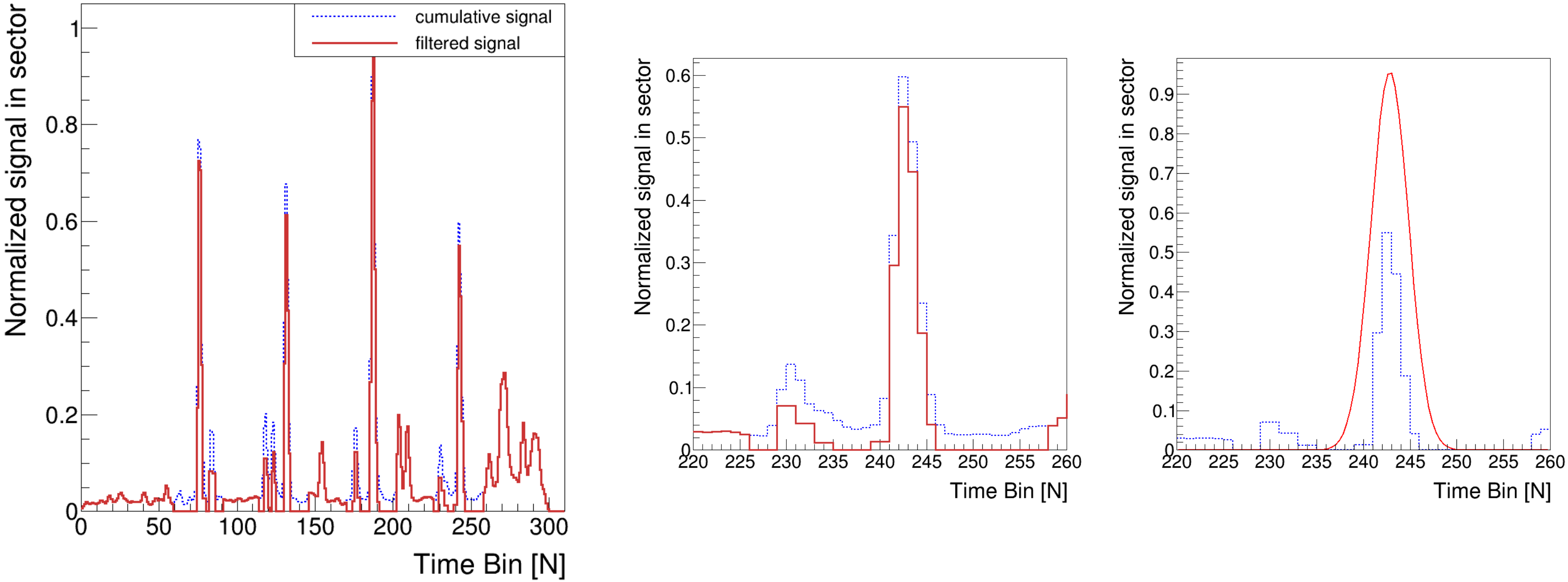


Simulations – laser grid only (3)

Example correction V_{drift} = 5.4 cm/μs $t_{trigger}$ = 545 ns



Simulations – laser grid mixed with event



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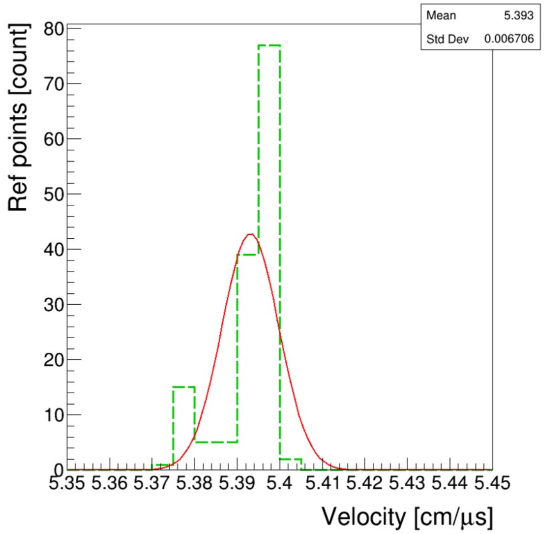

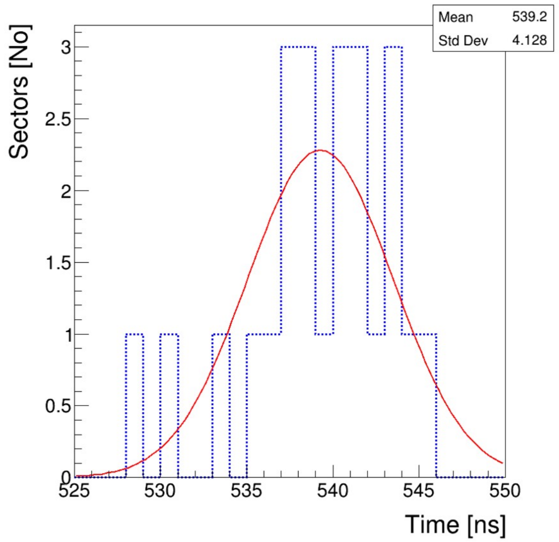

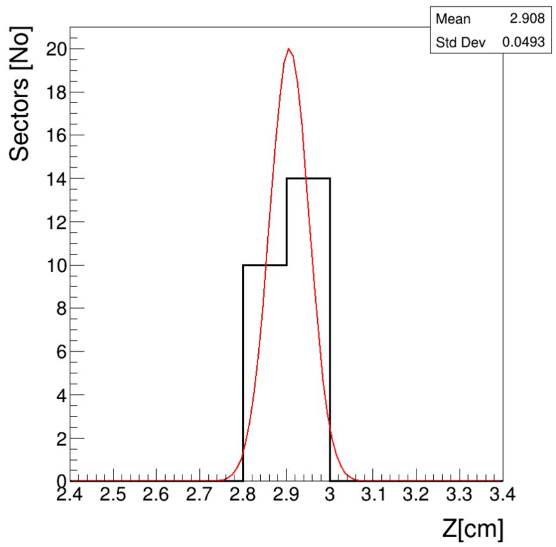

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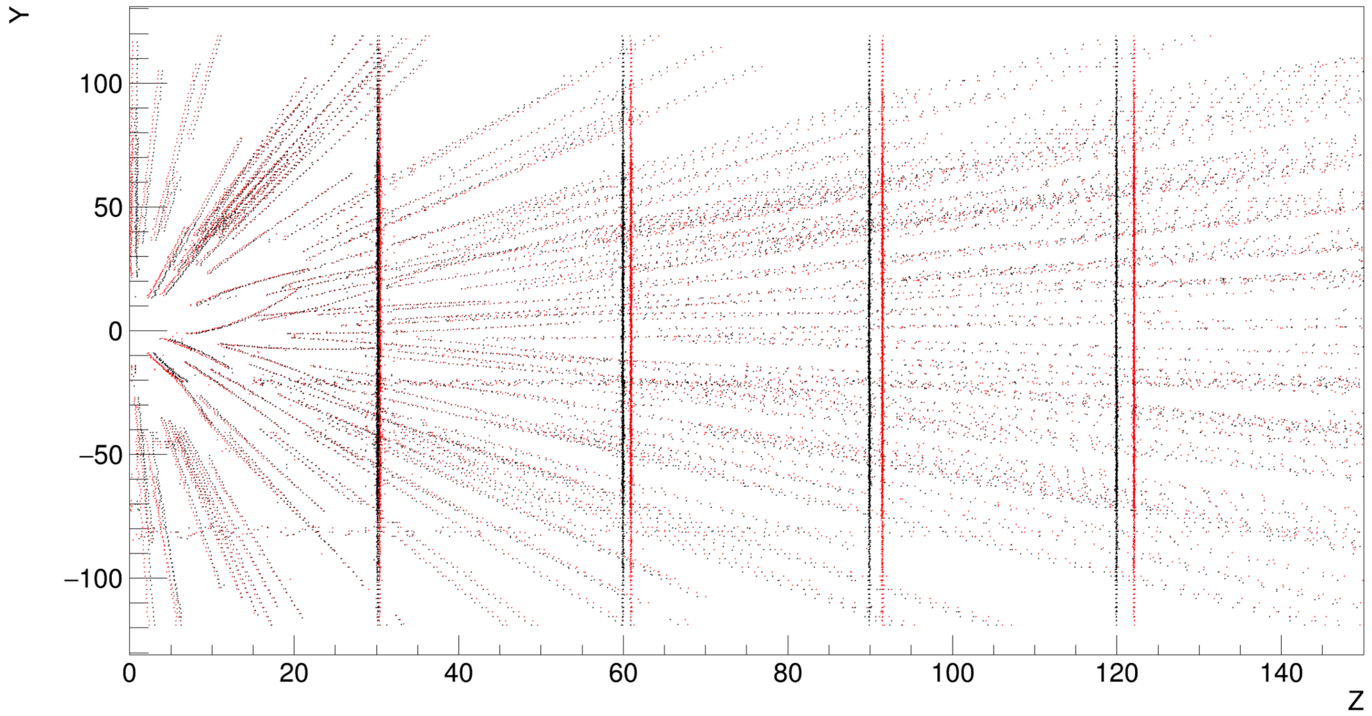

Future Plans

Near

- Read-Write velocity calibration parameters to DB (now in XML)
- Quantity estumations of how calibration impacts on track reconstruction

Medium-far

- Study impact of charged areas on drift velocity
- Correction of ZR distortions of drift velocity
  - According papers of STAR experiment velocity near inner tube is different from velocity in most of volume of TPC
- Codes adaptation to real hardware (there is no working experimental ROC now)

Thank you
for attention!

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