Simulation and position optimization of real micro mirrors bundles for TPC laser calibration system

JINR Association of Young Scientists and Specialists Conference "Alushta-2024"

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MPD TPC

TPC gas

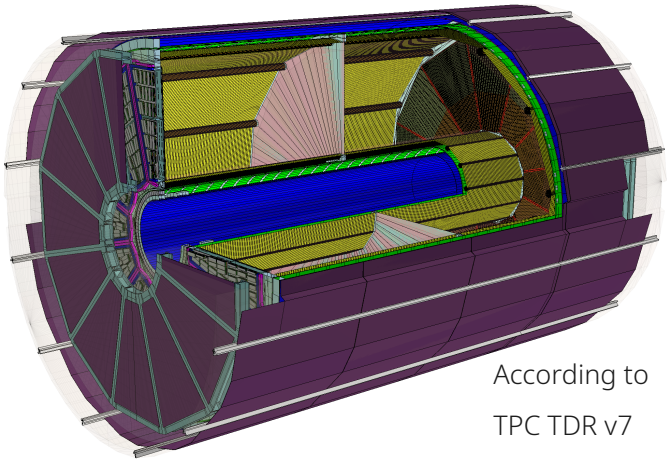
Gas mixture 90% Ar + 10% CH_4

Operating pressure 2.0±0.1 mbar

(relative to atmospheric)

Temperature 25 °C

stability < 0.5 °C



According to TPC TDR v7

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

~5.53291 cm/μs +/- 0.01%

(Garfieg++ simulation)

Impact on drift velocity

Temperature

Pressure

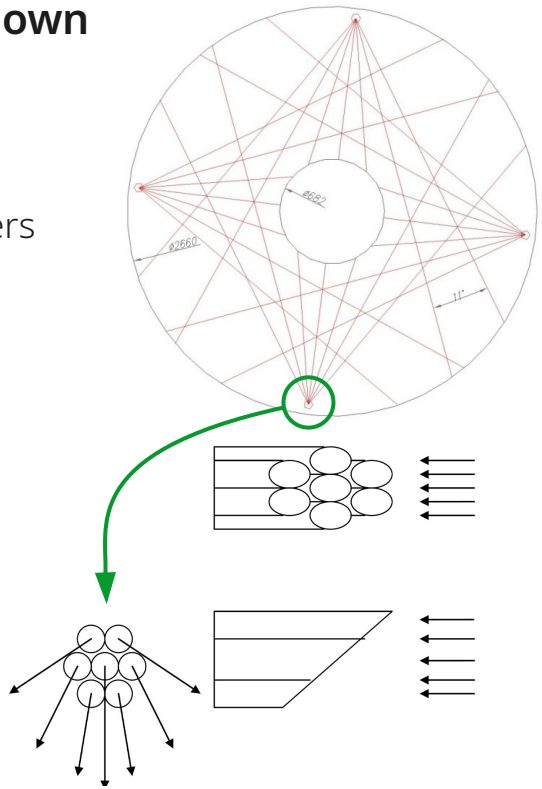
Charged areas in gas volume

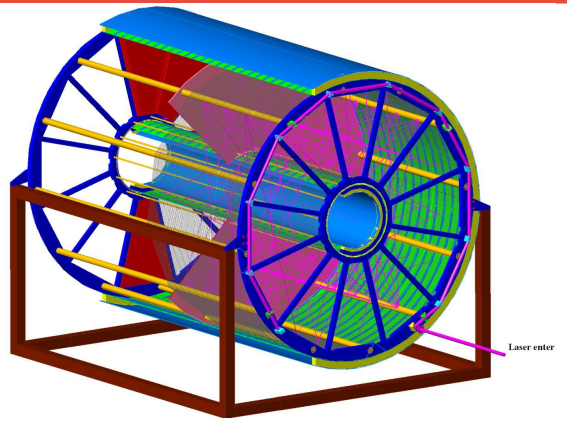
Laser Calibration System

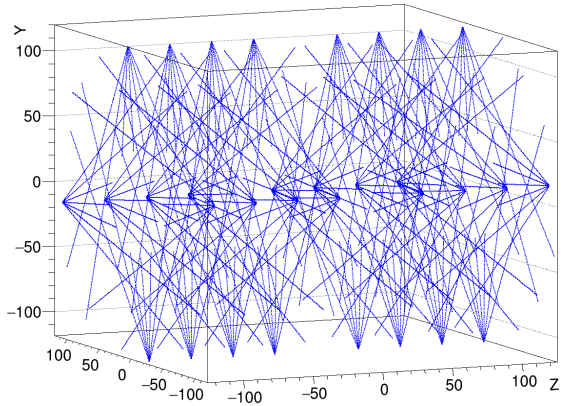
Should provide «tracks» with known position

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
  - 16 bundles with 7 micro mirrors each
    - 4 tubes with 4 bundles
- 10 Hz impulses

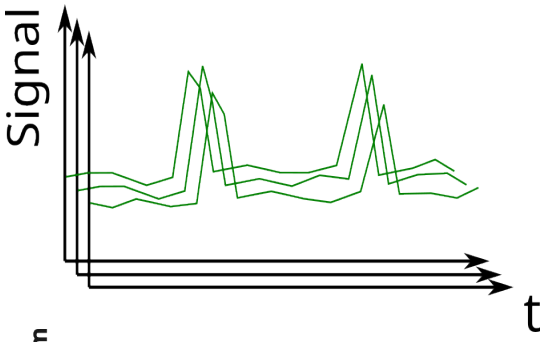


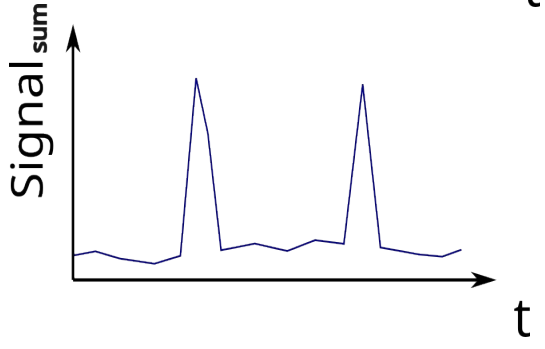


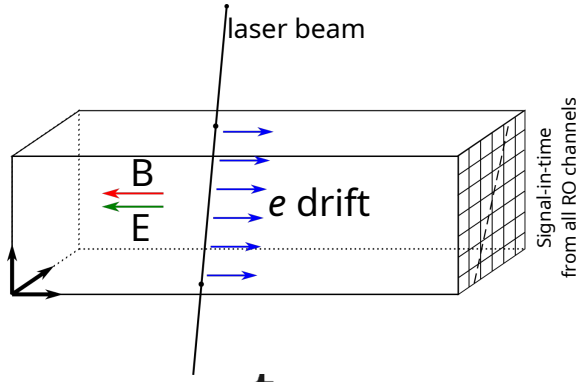


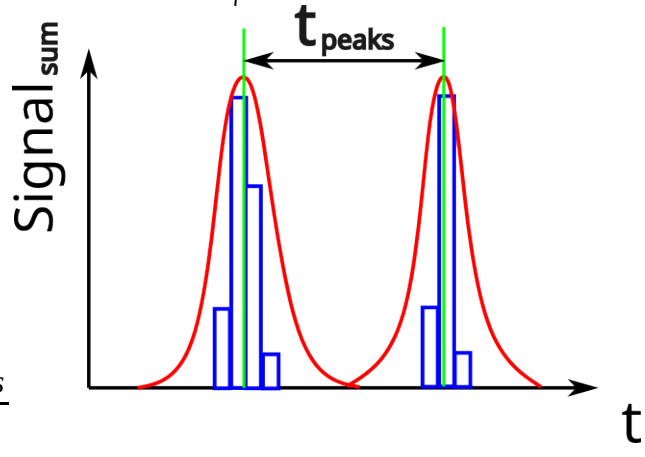
Drift velocity calculation algorithm

- 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



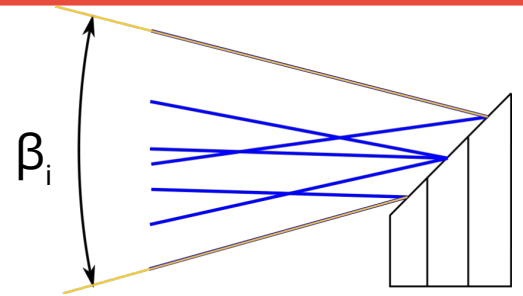


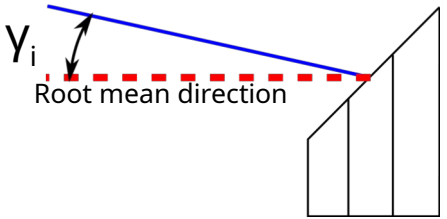


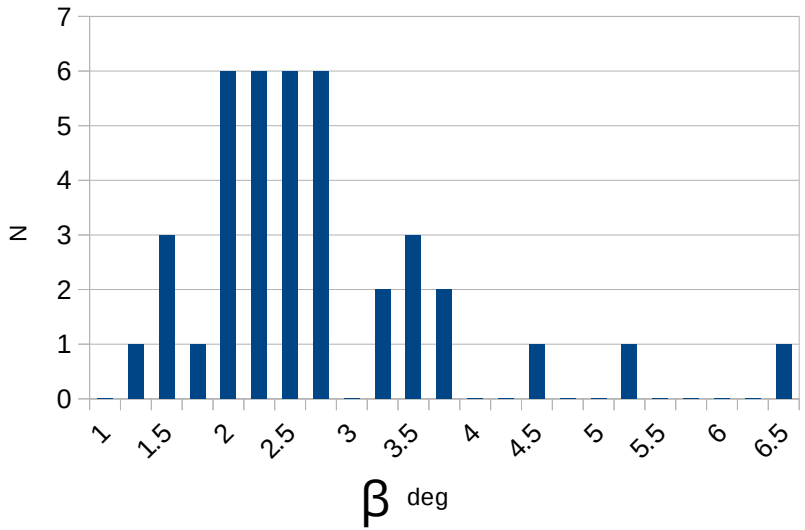


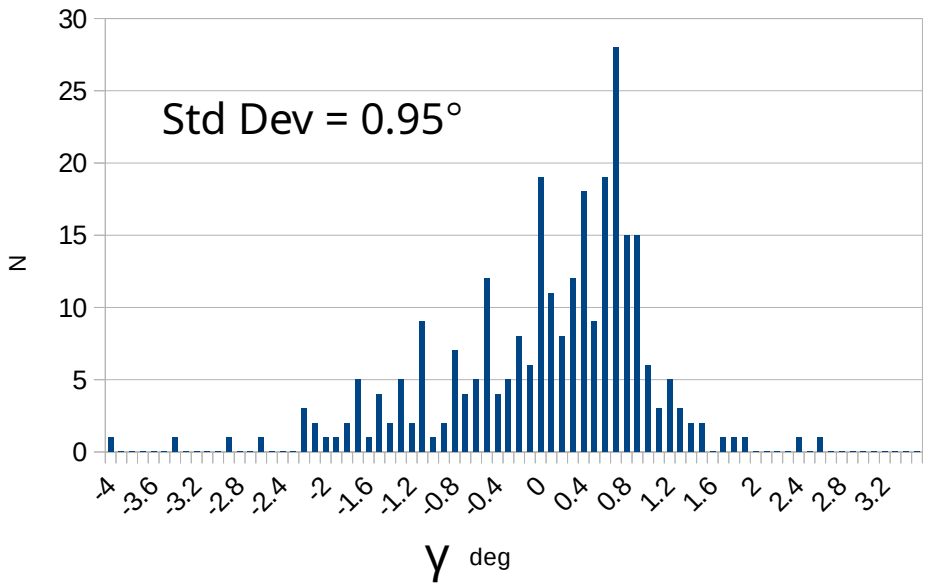
$$V_{drift} = \frac{Z_{between\ laser\ planes}}{t_{peaks}}$$

Measurements of real micro mirrors bundles (θ angles)

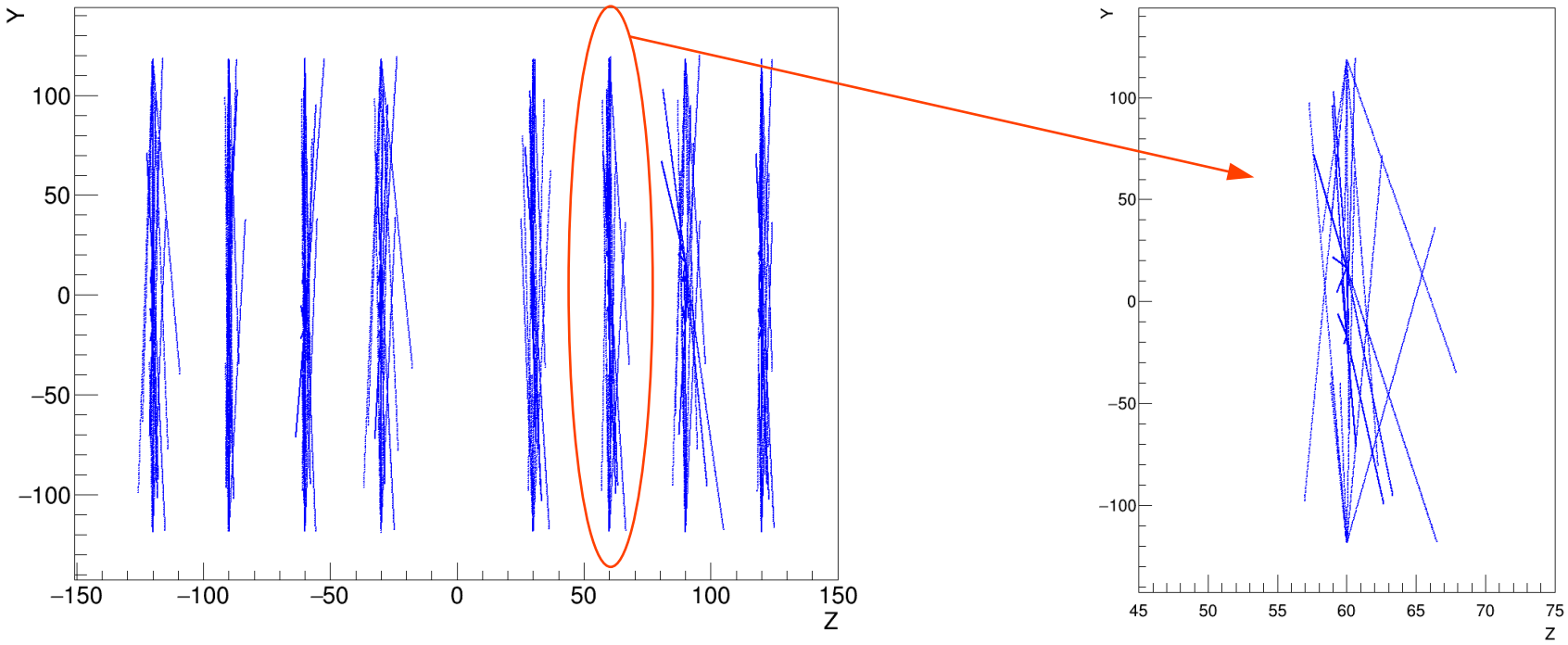








Example of simulation of laser calibration system

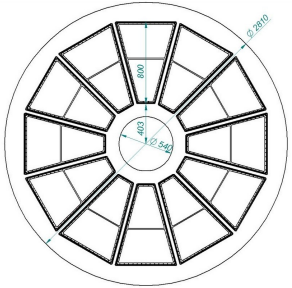


Bundles position optimization

12 sectors per half of TPC

Point of interest for each TPC sector

3 points between pairs of laser planes



interpolated/extrapolated velocity value for each hit

or

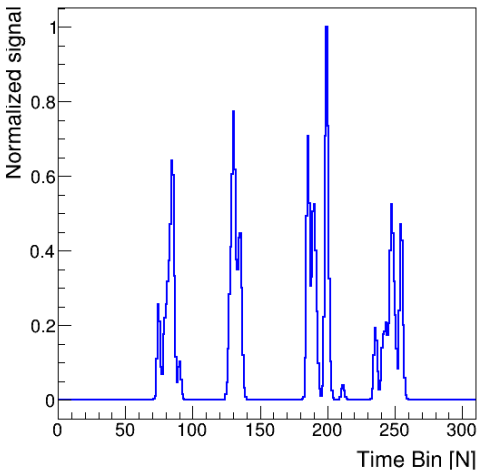
average velocity in halves

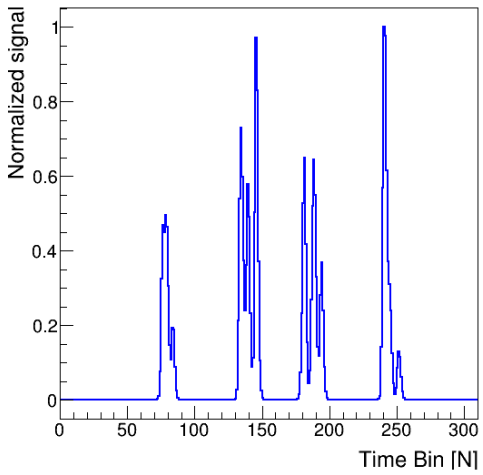
Problems

No «proper» peaks

Multiple peaks individual pattern for each plane

Examples of sectors signal distributions w/o optimizations





Optimization of bundles position

Optimization task of bundles position

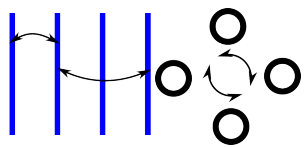
Genetic algorithm optimization (OpenGA library)

Optimization function – minimization of peaks in bundles position configuration

There are many equivalent solutions of bundles placement

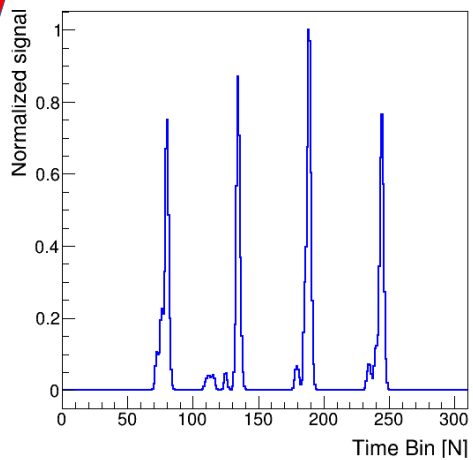
Rotation of tube position

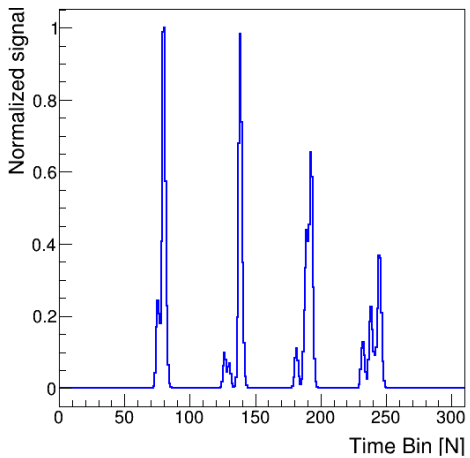
Switching laser planes



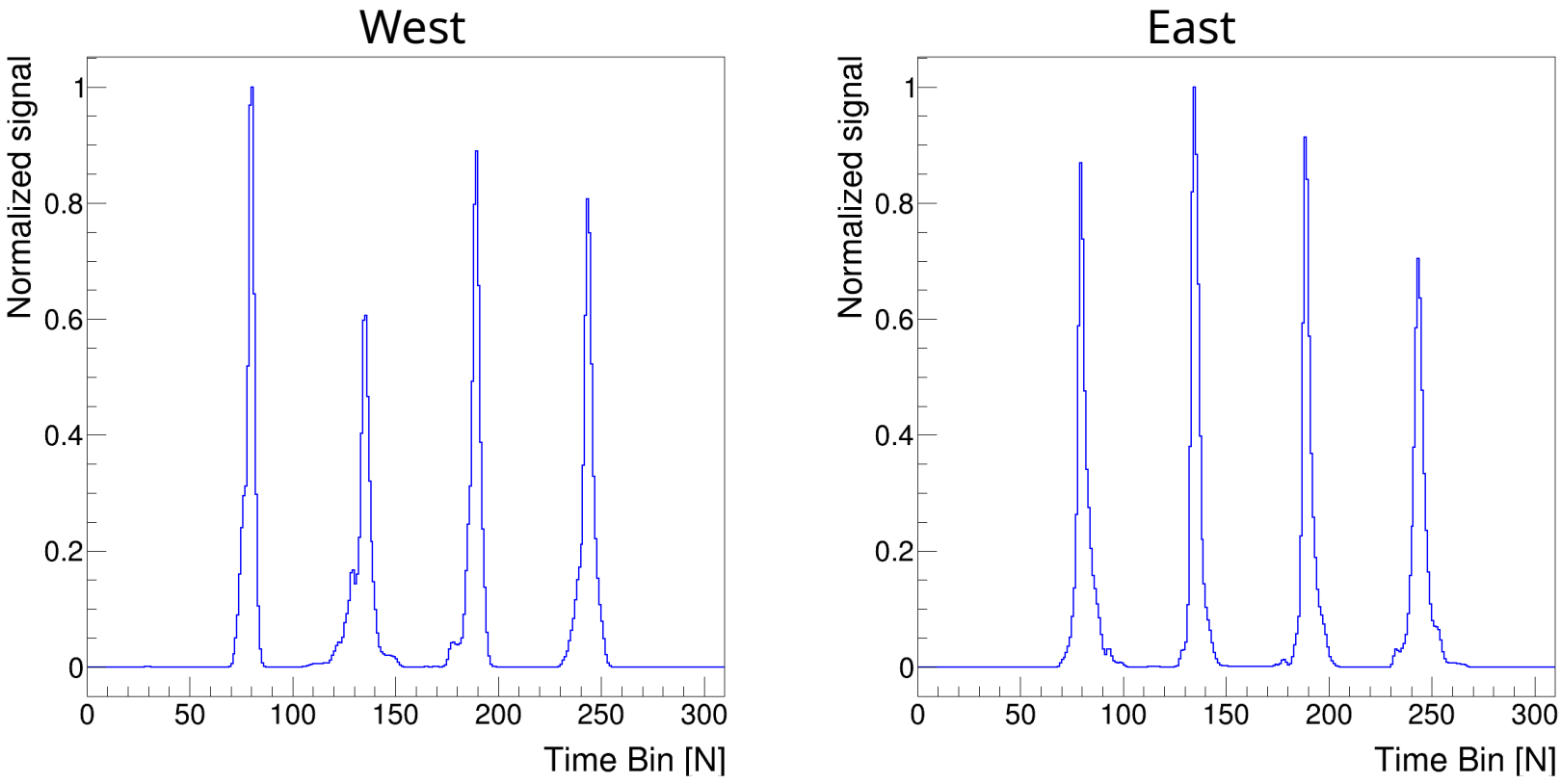
Still there is no single peaks for every sector

Examples of sectors signal distributions with optimizations



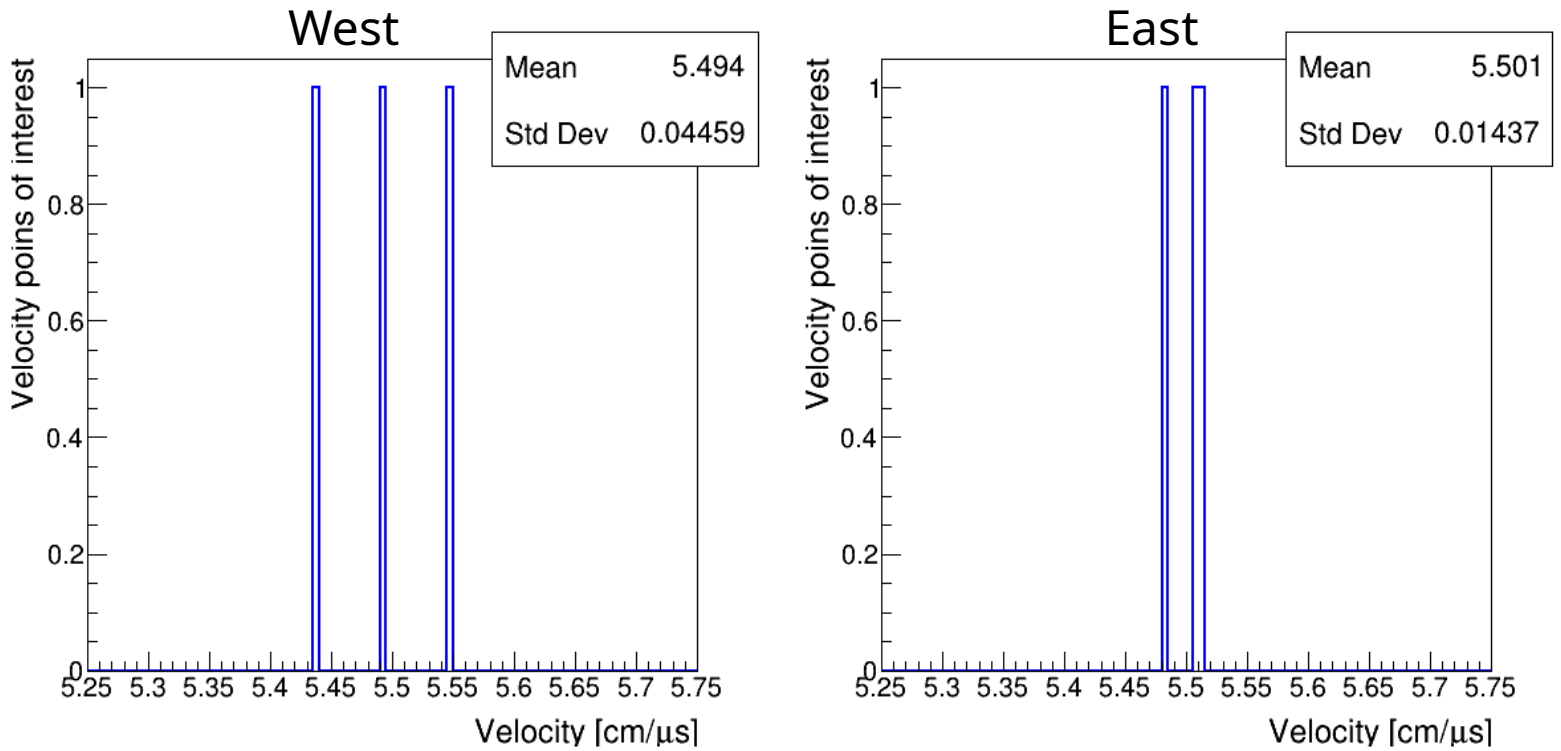


Halves of TPC



Velocity calculations for halves (500 events)

Target velocity 5.5 cm/µs



Results of simulations and optimizations

Velocity map for sectors

Quality of bundles producing not allows to calculate velocity with algorithm based on cumulative signal-in-time distributions w/o additional investigations

Velocity in halves

Deviations of laser beams leads to systematic errors in velocity calculations between planes

Average velocity in a half can be calculated

Systematic errors can be corrected after choosing of micro mirrors bundles placement

That`s it

Thank you
for attention!

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