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

XIII Collaboration Meeting of the MPD Experiment at the NICA Facility

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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)

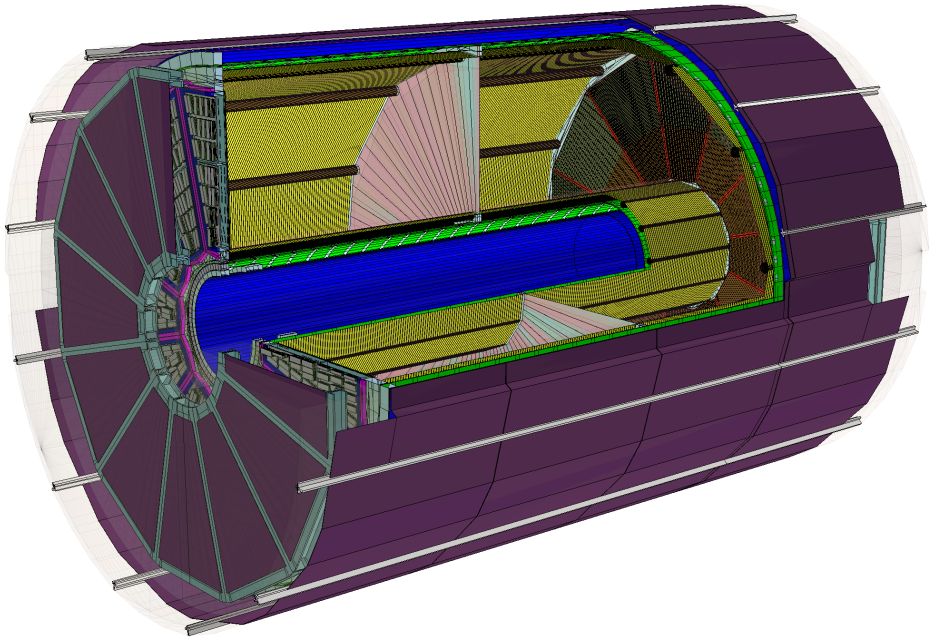
Temperature 25 °C

stability < 0.5 °C

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

~5.53291 cm/μs +/- 0.01%

(Garfieg++ simulation)

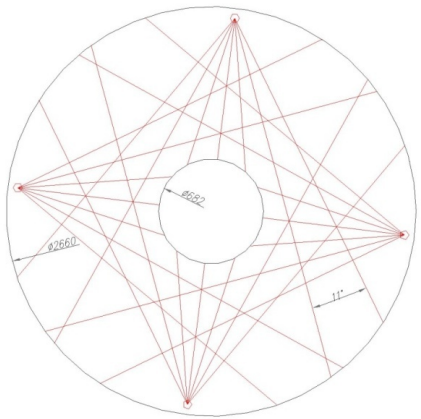


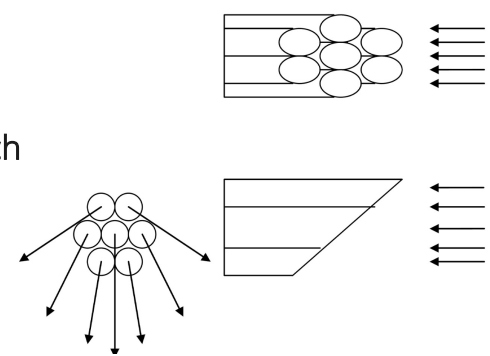
According to TPC TDR v7

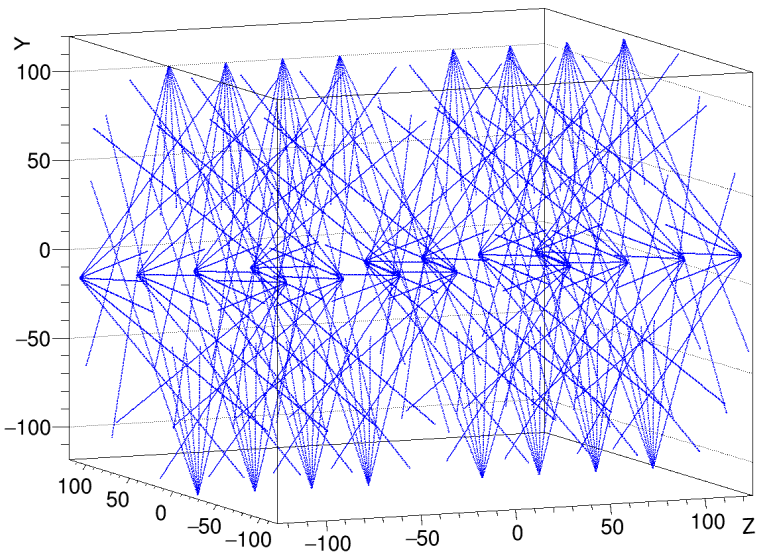
Laser Calibration System

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







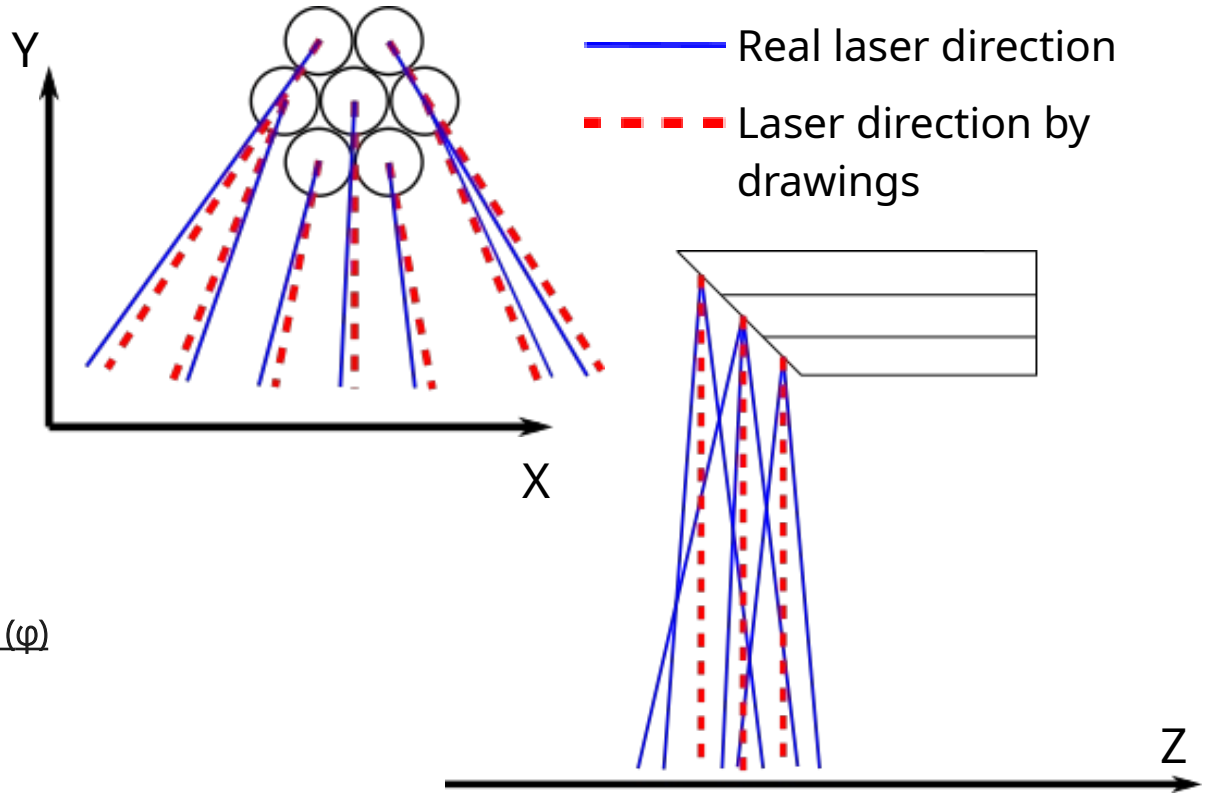
Laser Calibration System (2)

Impact on drift velocity

- Temperature
- Pressure
- Charged areas in gas volume

Problems of real mirrors bundles

- Deviations of laser beams
  - Drawings → 90° to Z axis (θ)
  - Drawings → 11° between beams in XY palne (φ)
- Positioning errors in TPC tubes



Laser micro mirrors bundles

32 mirrors bundles needed for the TPC

16 per half

4 in tube (1 bundle for each laser pane)

37 mirrors bundles produced in total

Each bundle with its frame produced as one

4 types of holding frames → 4 types of bundles

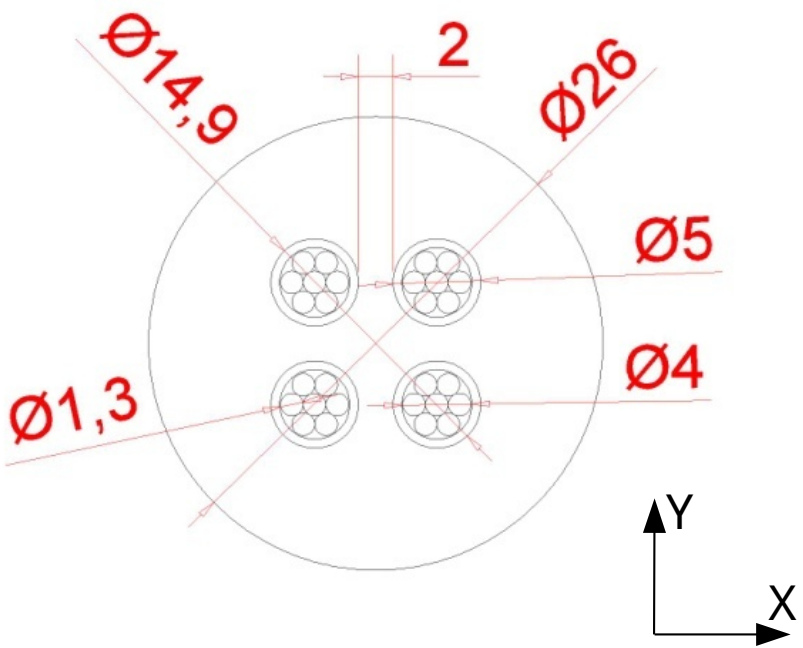
90° direction frame – 9 bundles

0° direction frame – 9 bundles

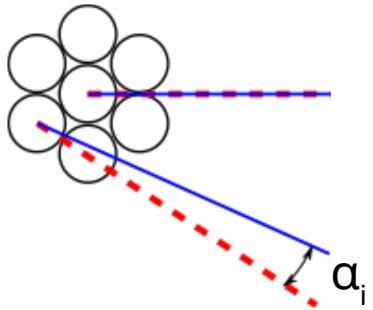
180° direction frame – 9 bundles

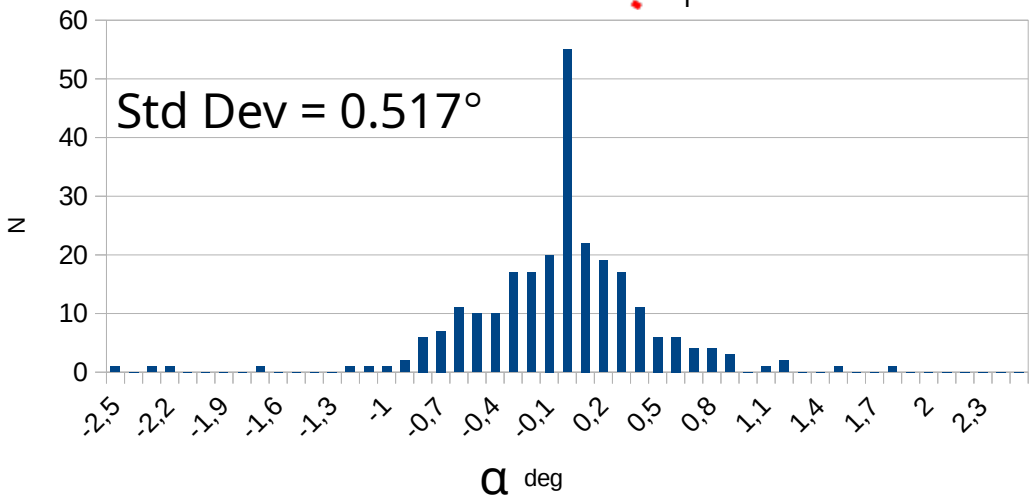
360° direction frame – 10 bundles

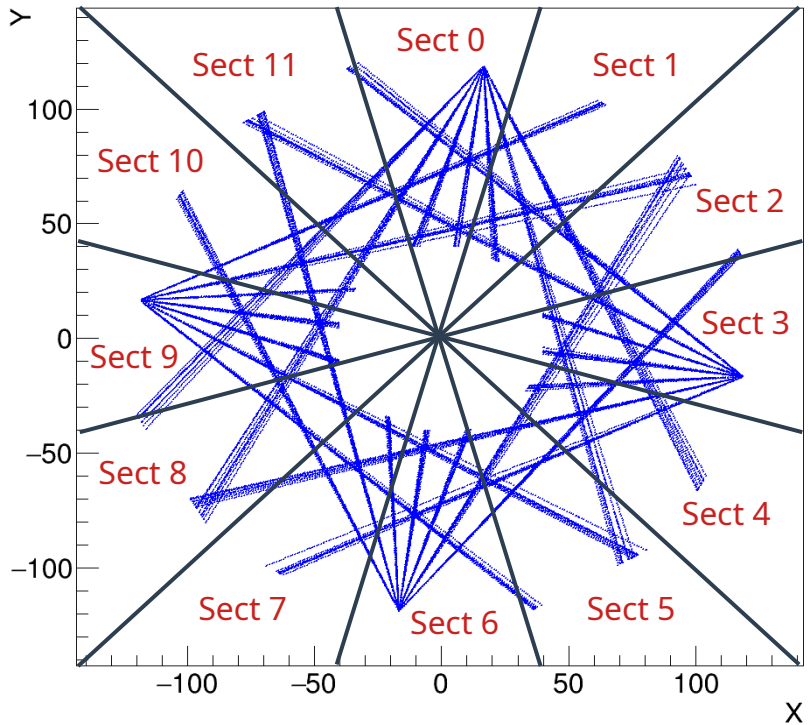
<u>In single tube should be placed only bundles with different types of frames</u>



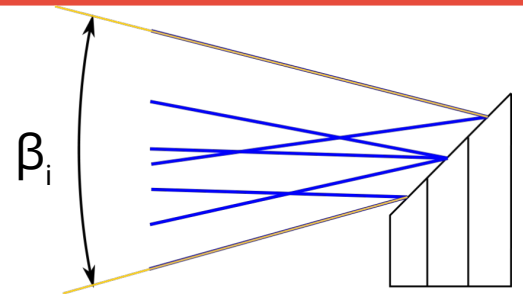
Measurements of real micro mirrors bundles (ϕ angles)

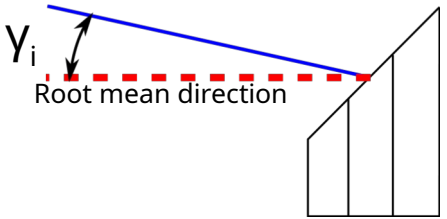


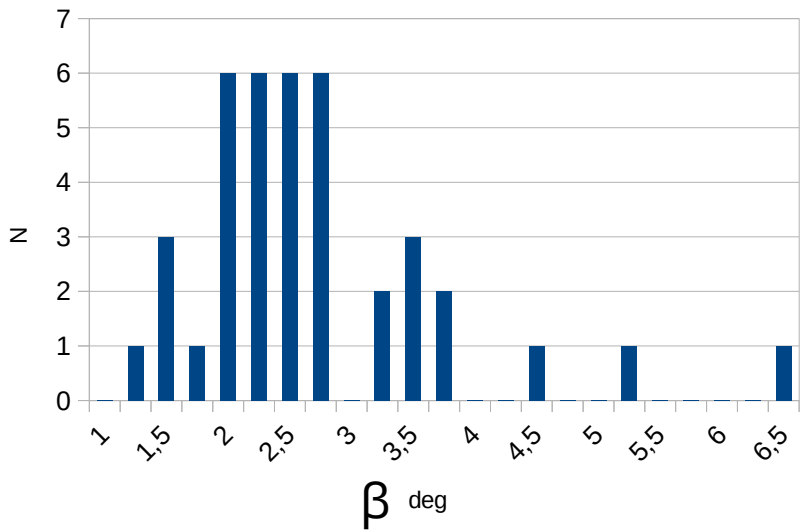


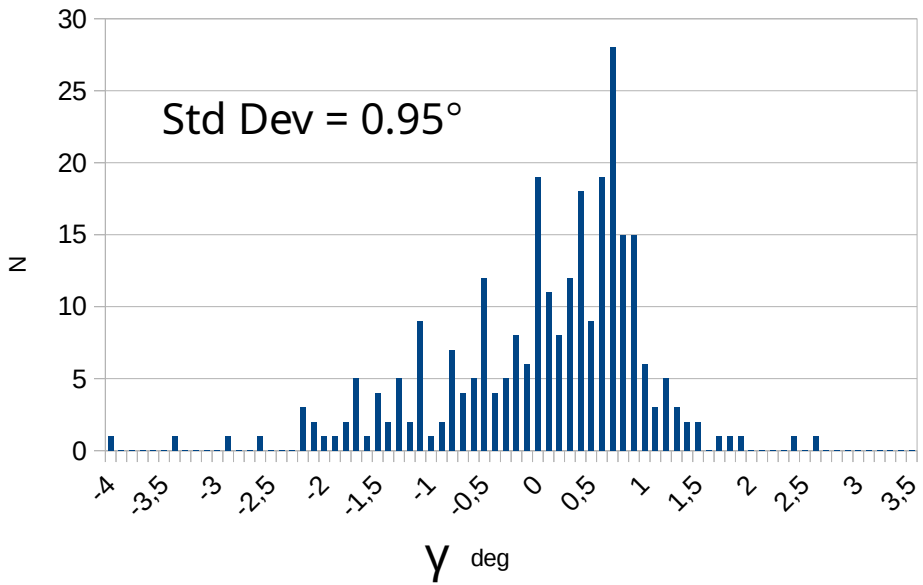


Measurements of real micro mirrors bundles (θ angles)

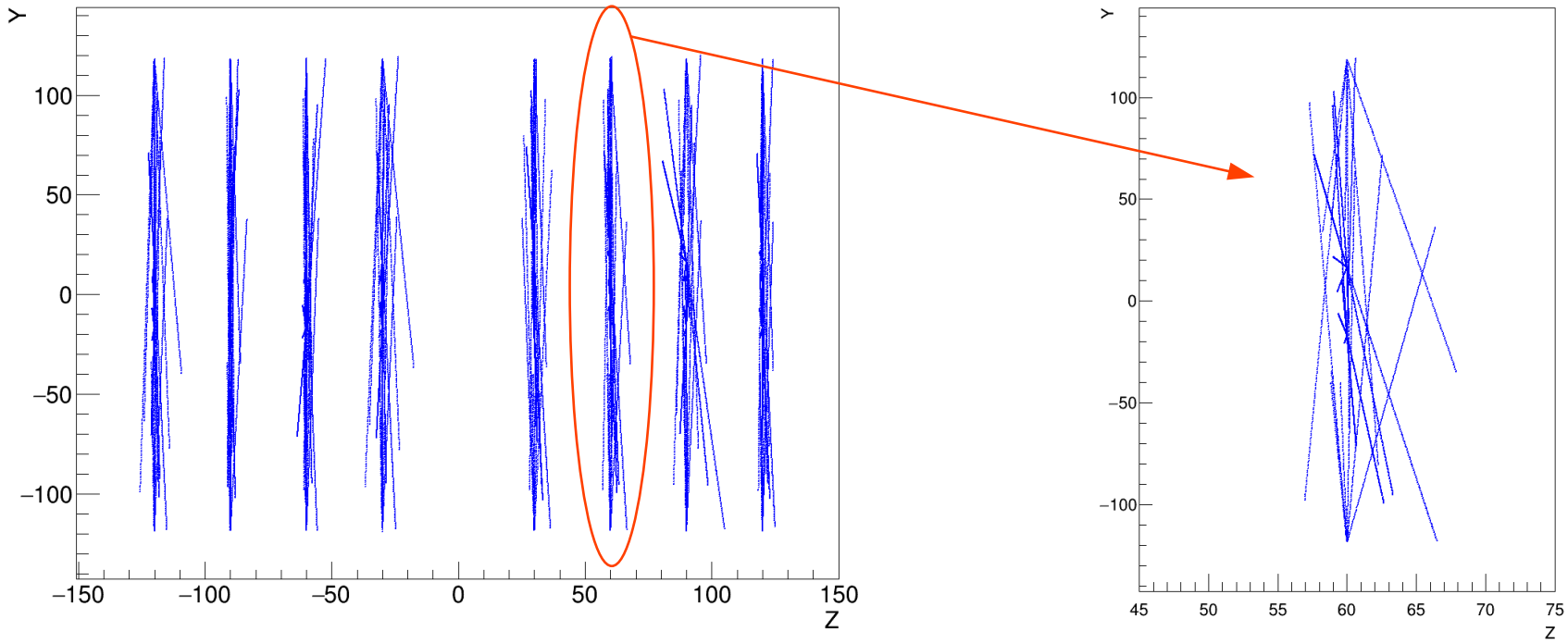






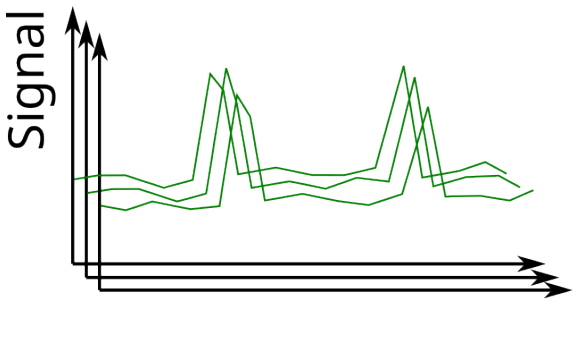


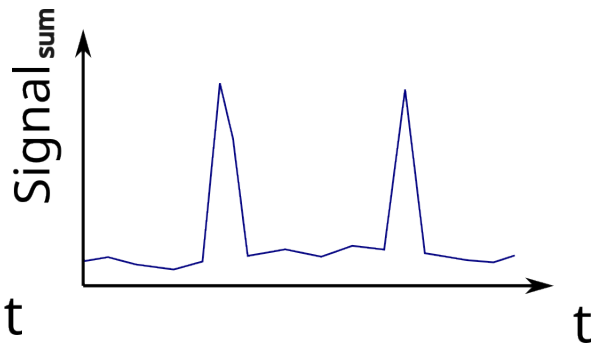
Example of simulation of laser calibration system



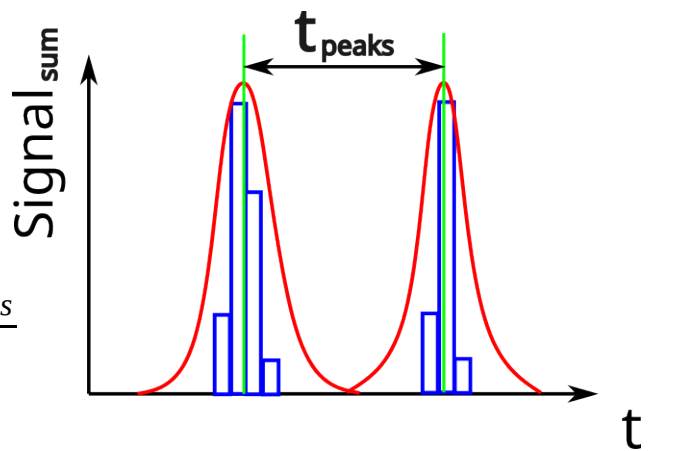
Drift velocity calculation algorithm

- 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





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



Bundles position optimization

Point of interest for each TPC sector

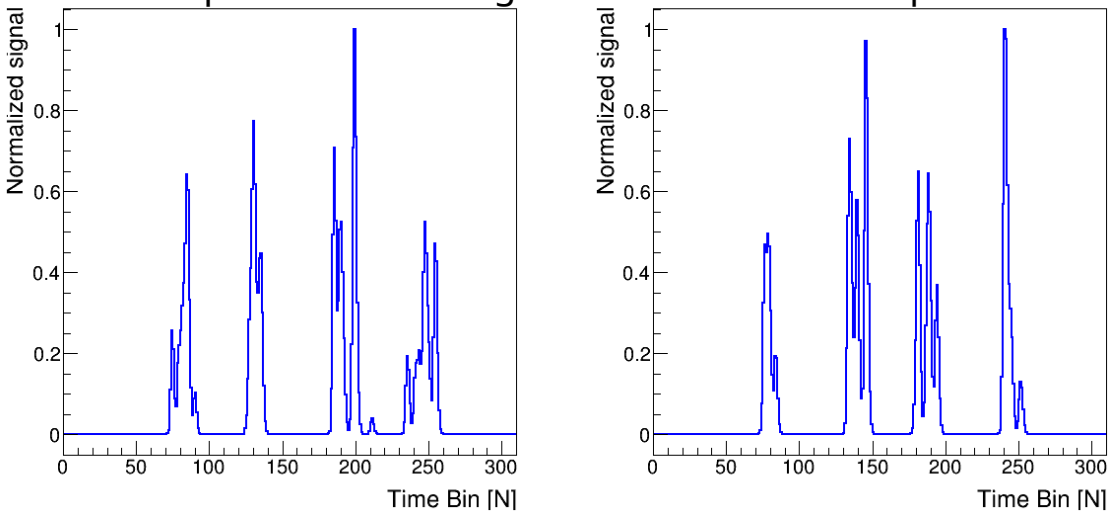
3 points between pairs of laser planes

interpolated/extrapolated velocity value for each hit

or

average velocity in halves

Examples of sectors signal distributions w/o optimizations



Problems

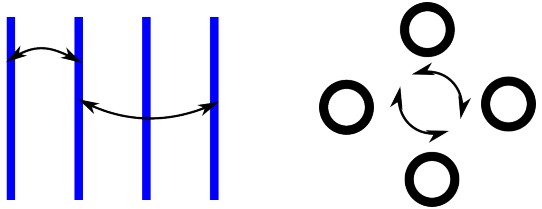
No «proper» peaks

Multiple peaks individual pattern for each plane

Optimization of bundles position

Optimization task of bundles position

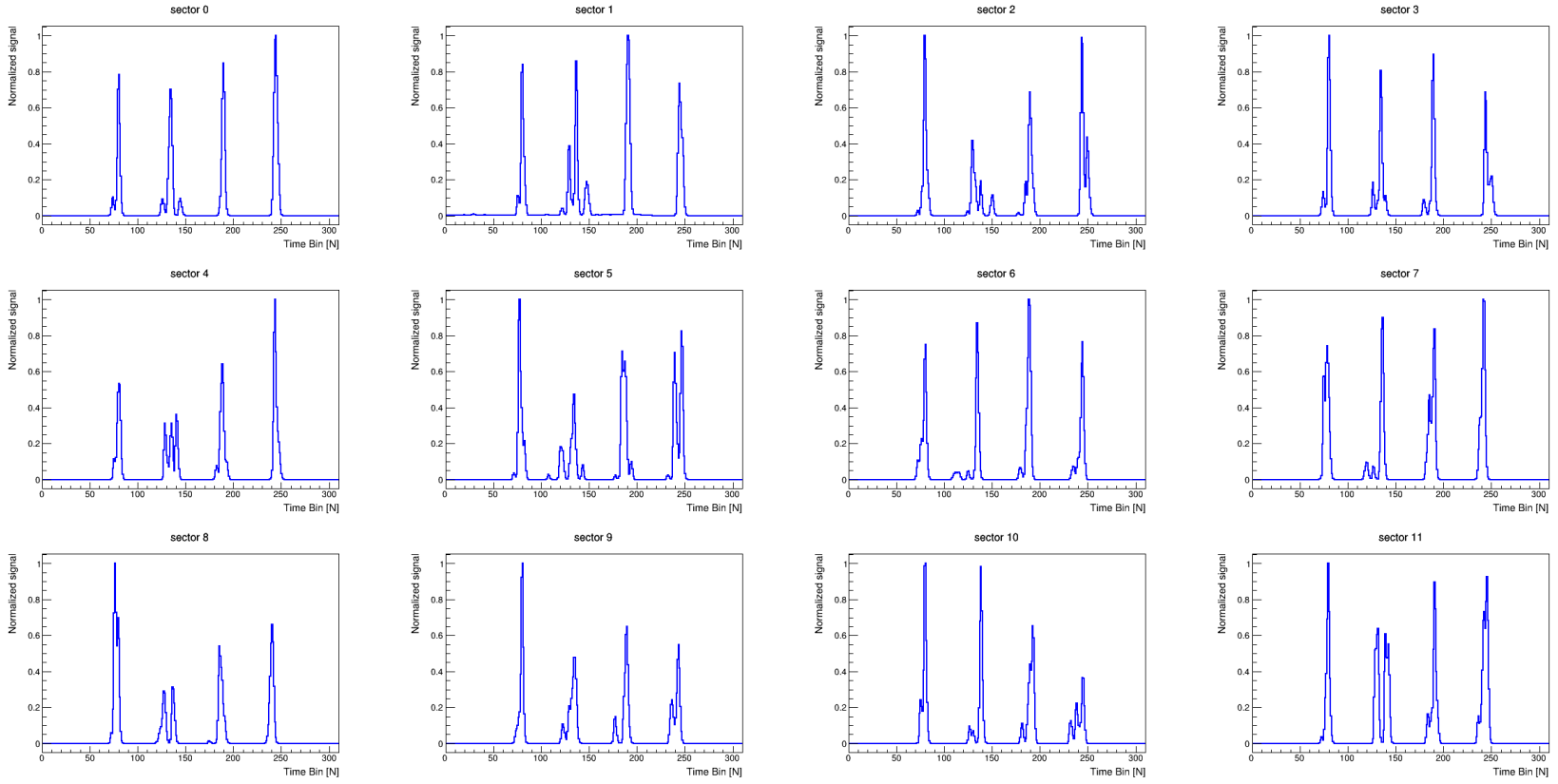
- 4 tubes for each half of TPC
- 4 different bundles per tube
- Things that not impact on velocity calculation quality
  - Rotation of tube position
  - Switching laser planes



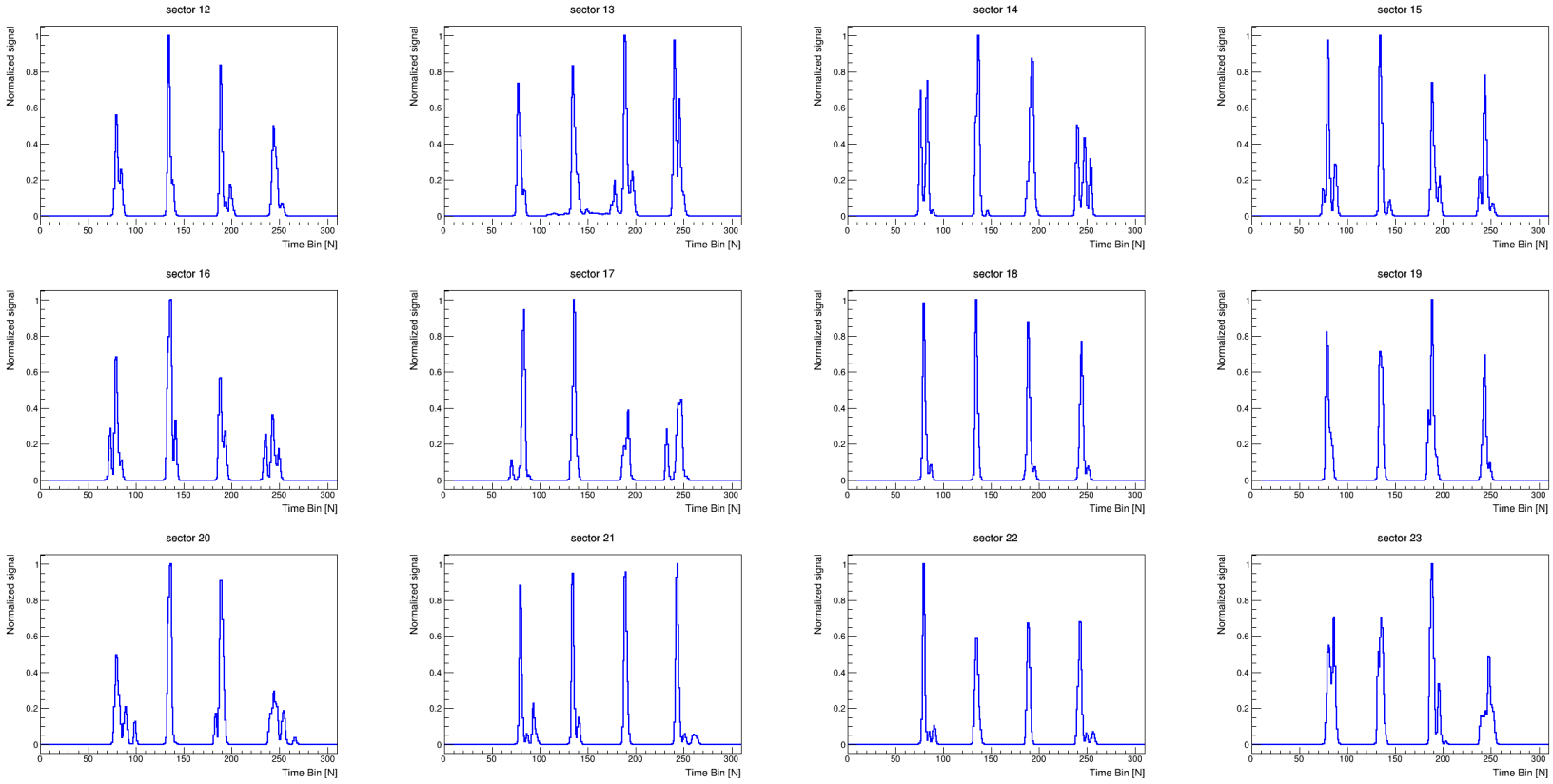
Genetic algorithm optimization (OpenGA library)

- Optimization function – minimization of peaks in bundles position configuration
- There are many equivalent solutions of bundles placement

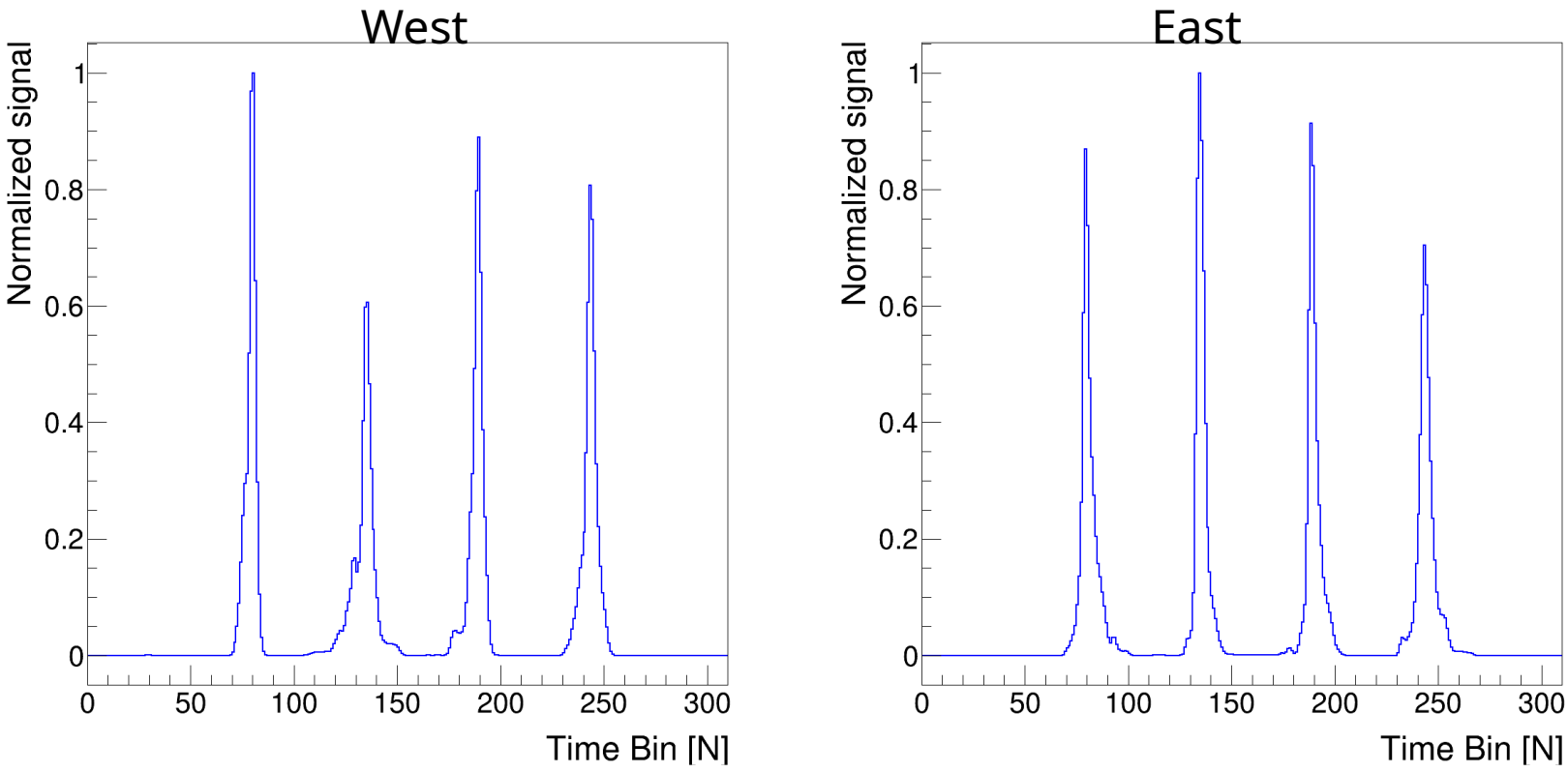
West side of TPC



East side of TPC

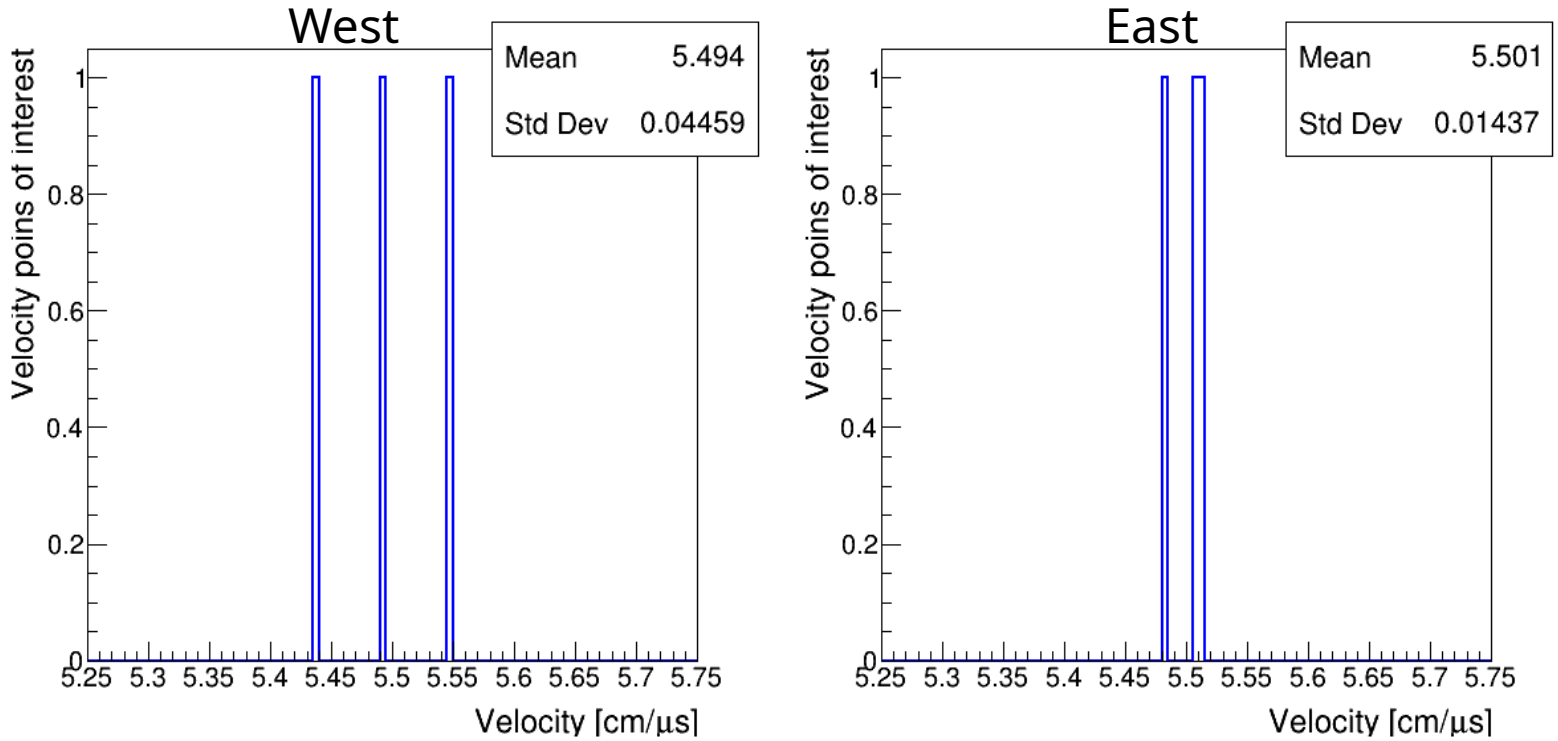


Halves of TPC



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

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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