



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

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December 17, 2024
Dubna, Russia

MPD TPC

TPC gas

Gas mixture 90% Ar + 10% CH₄

Operating pressure 2.0±0.1 mbar

(relative to atmospheric)

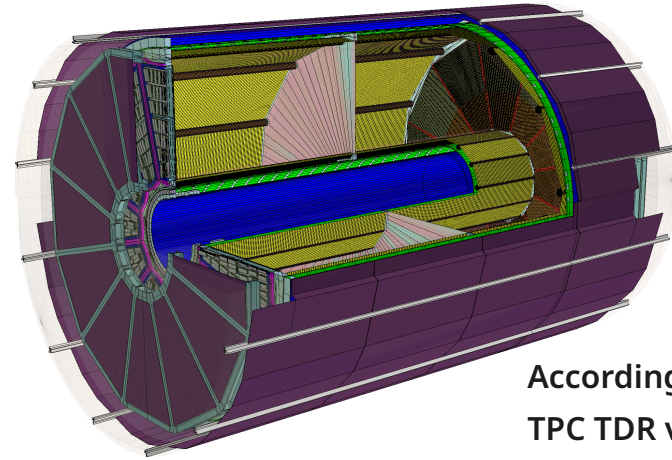
Temperature 25 °C

stability < 0.5 °C

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

~5.53291 cm/μs +/- 0.01%

(Garfie++ simulation)



According to
TPC TDR v7

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

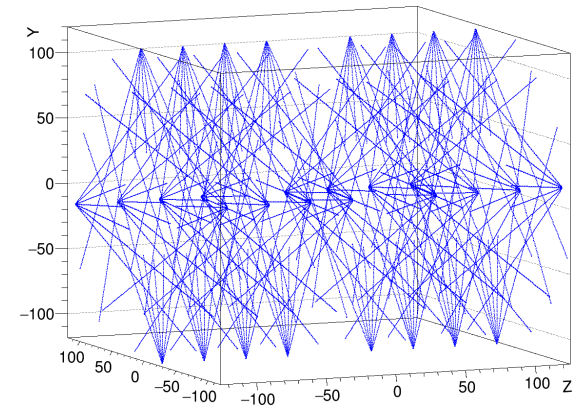
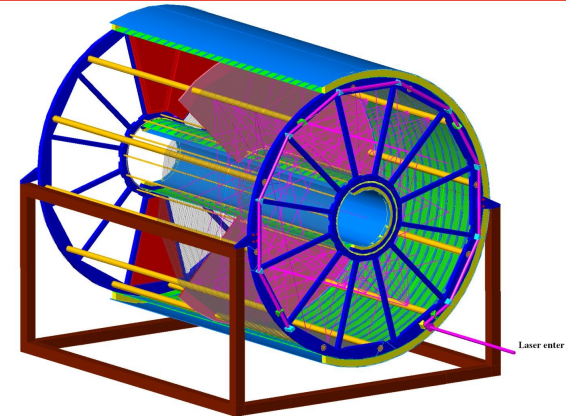
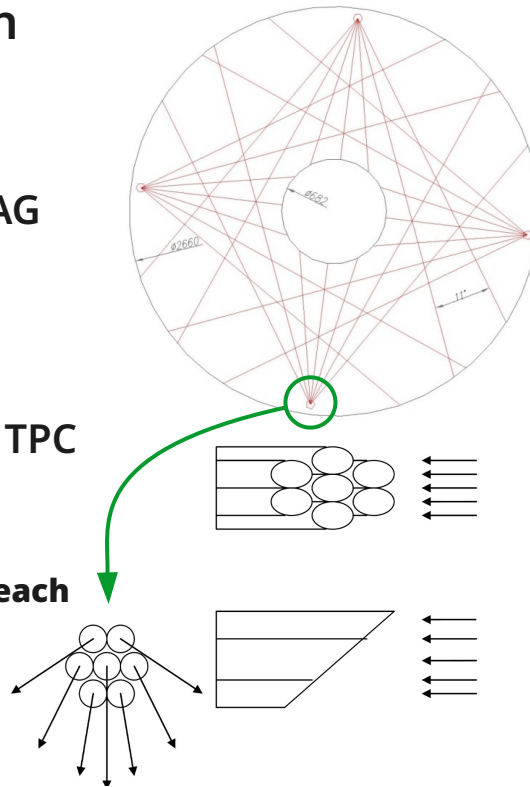
4 planes of laser beams

30cm between planes

16 bundles with 7 micro mirrors each

4 tubes with 4 bundles

10 Hz impulses



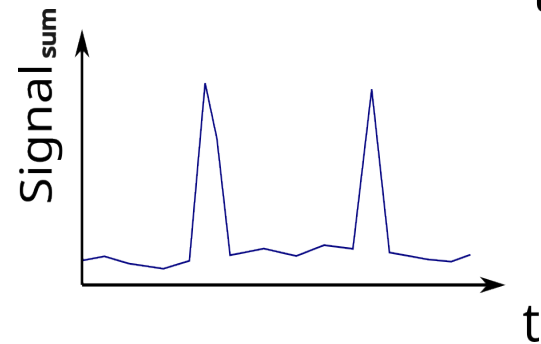
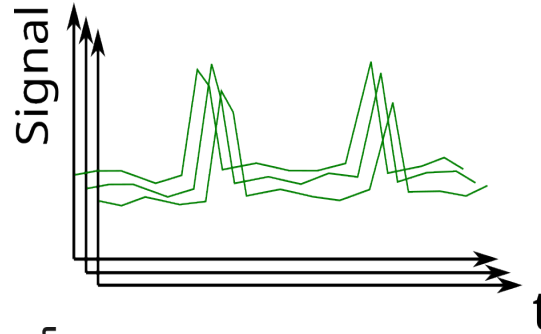
Drift velocity calculation algorithm

Based on cumulative signal-in-time distribution from all channels in sector
Laser grid planes forms high peaks in the distribution

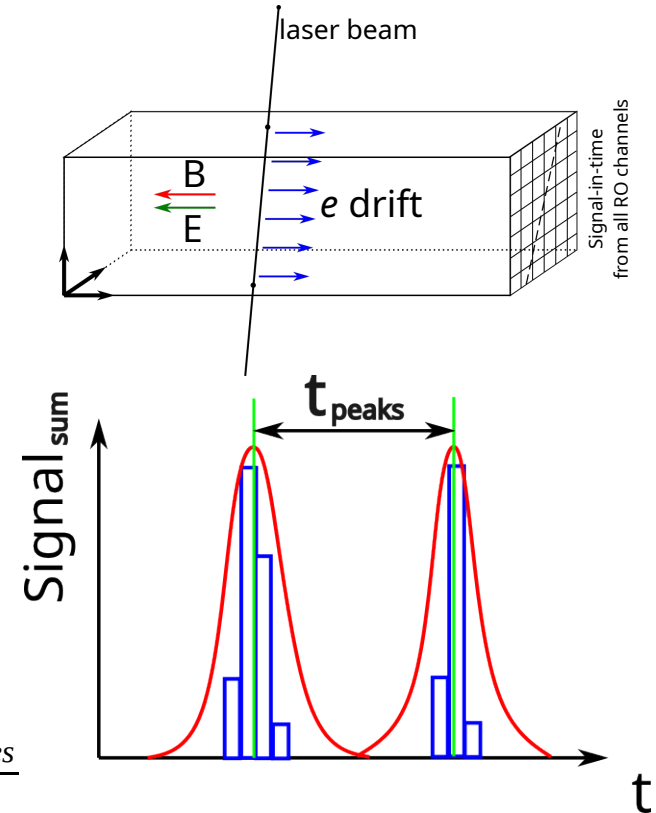
The peaks determines position of laser grid planes

Drift time between positions of laser planes provides velocity information

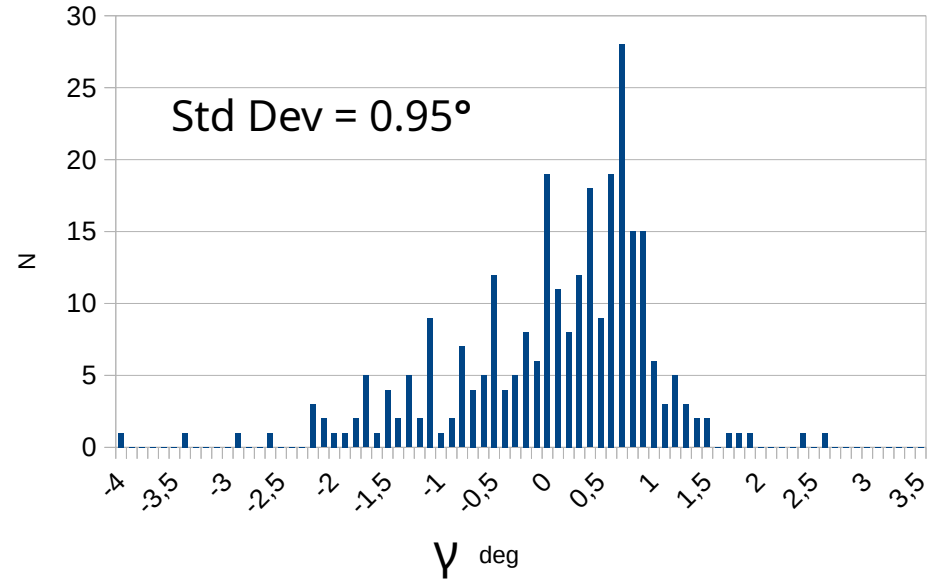
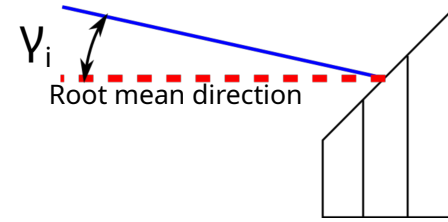
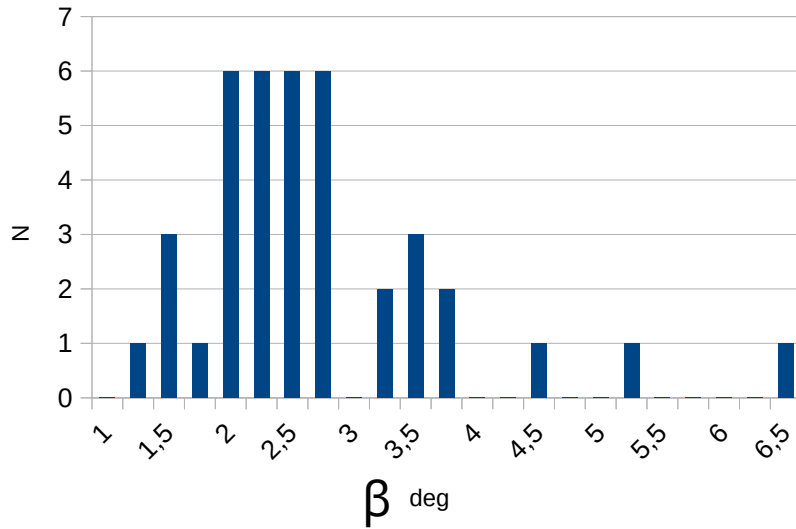
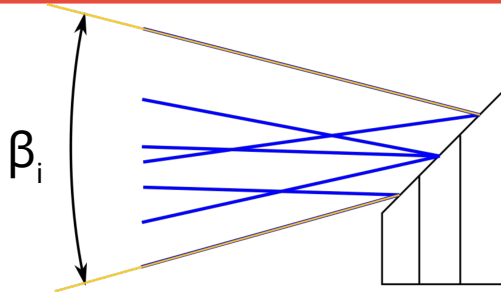
Difference between measured and «expected» position of laser grid provides trigger delay information



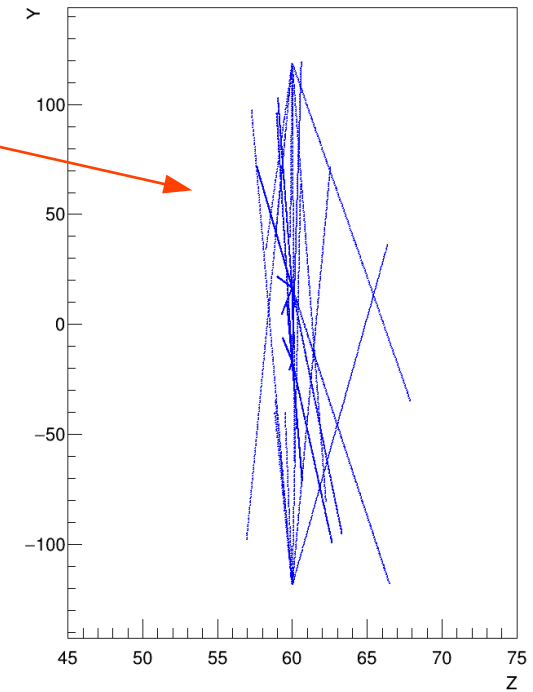
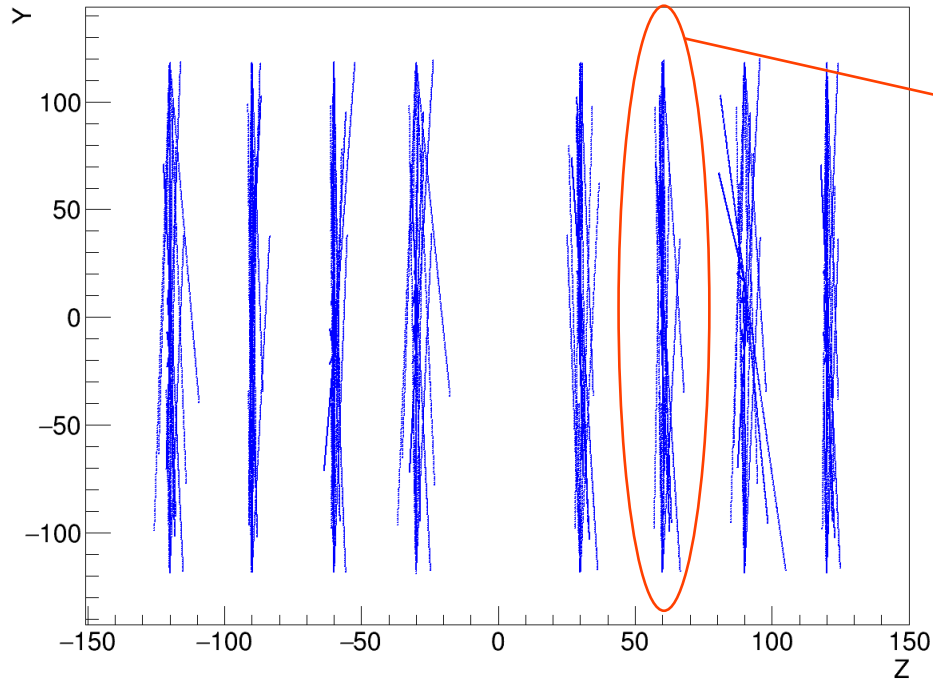
$$V_{drift} = \frac{Z_{between\ laser\ planes}}{t_{peaks}}$$



Measurements of real micro mirrors bundles (θ angles)



Example of simulation of laser calibration system



Bundles position optimization

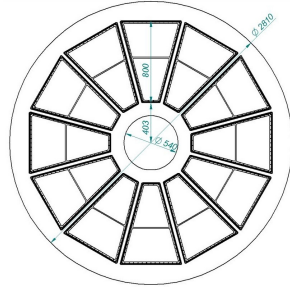
12 sectors per half of TPC
Point of interest for each
TPC sector

3 points between pairs of
laser planes

interpolated/extrapolated
velocity value for each hit

or

average velocity in halves

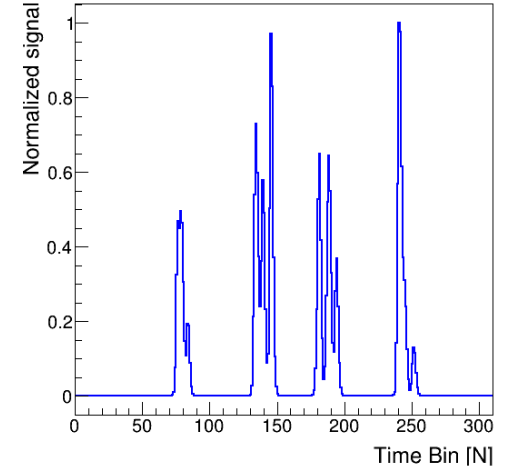
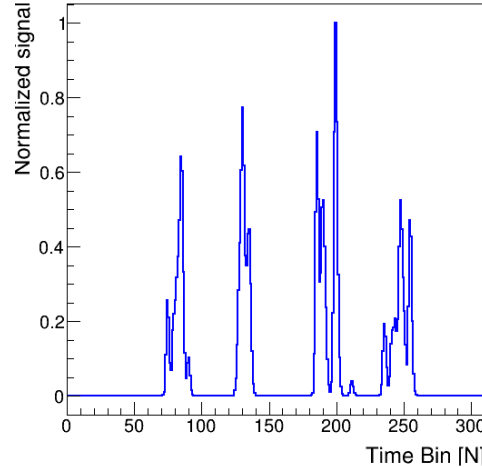


Problems

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

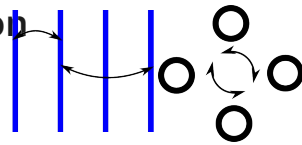
Genetic algorithm optimization
(OpenGA library)

Optimization function - minimization
of peaks in bundles position
configuration

There are many equivalent solutions
of bundles placement

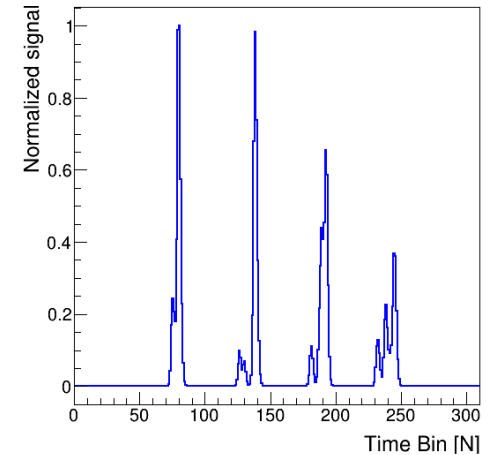
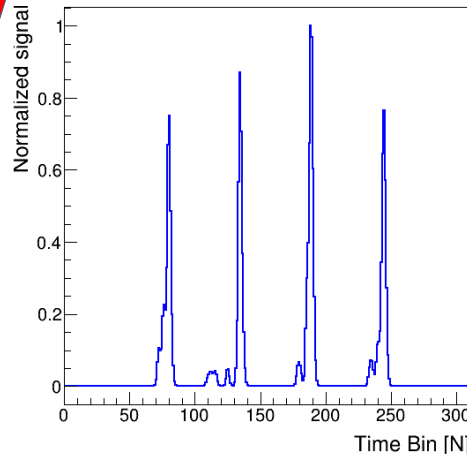
Rotation of tube position

Switching laser planes

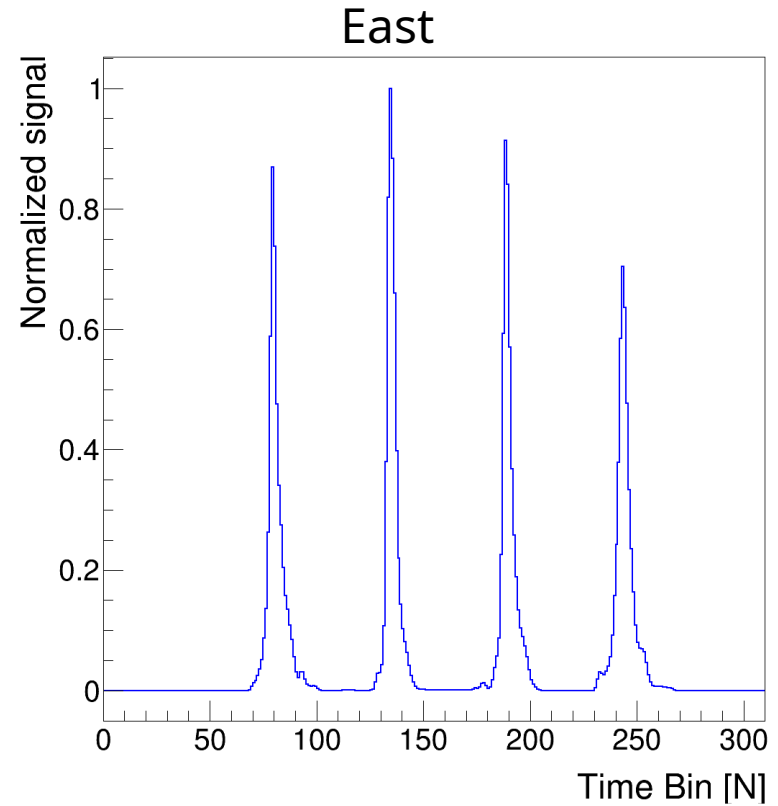
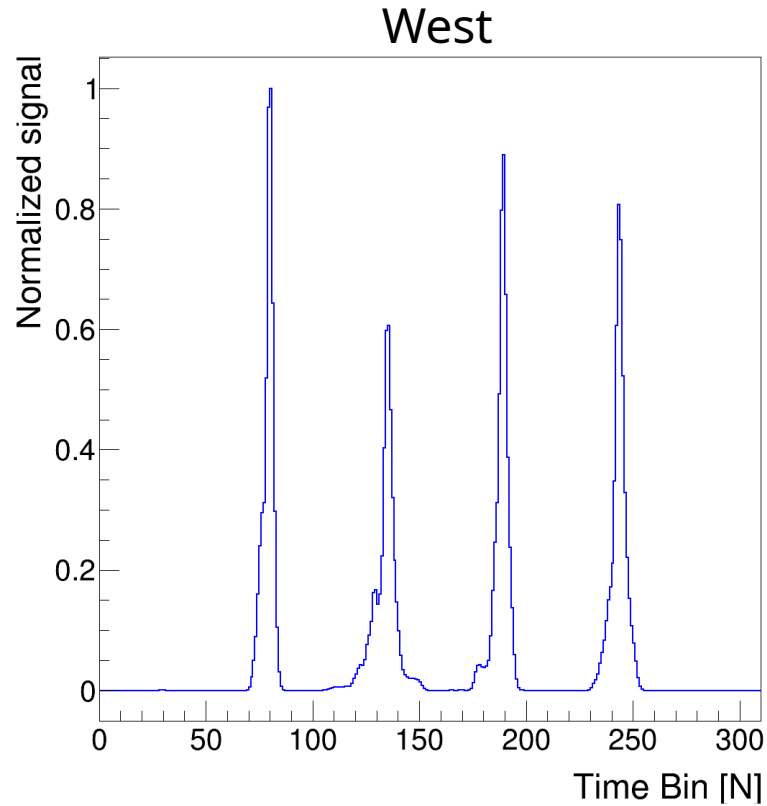


Still there is no single peaks
for every sector

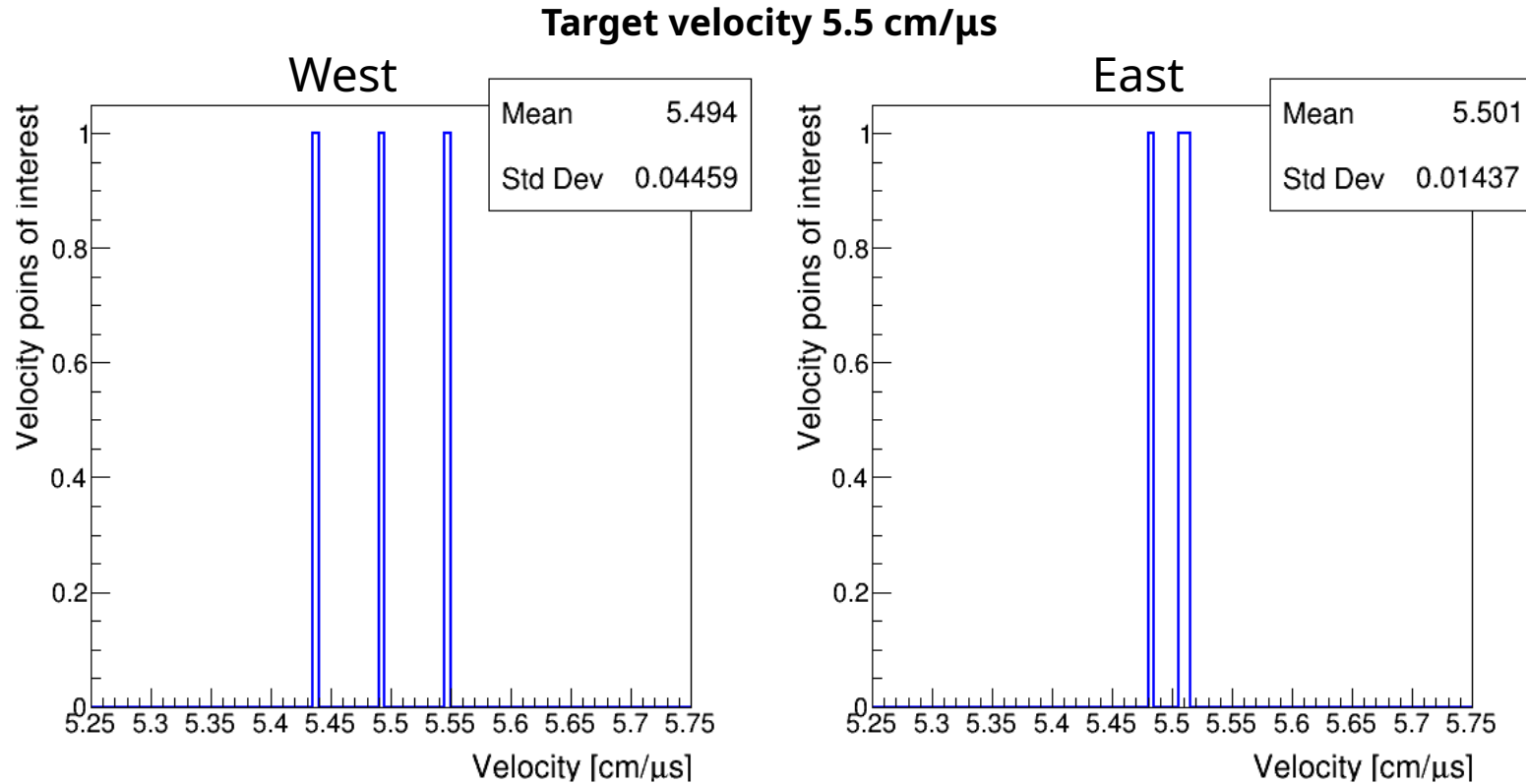
Examples of sectors signal distributions
with optimizations



Halves of TPC



Velocity calculations for halves (500 events)



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

Velocity calibration problems (new)

Expected ionization length for each laser ~1m

problems of micro-mirrors quality → convex surface → beam scattering
beam become more than ~1 cm in diameter → unable to gas ionization

Less impact from laser beams with big θ angle deviation

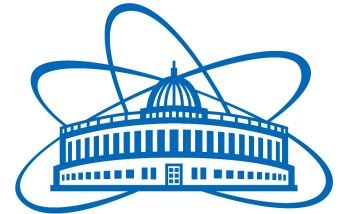
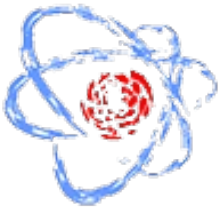
Better form of peaks by laser planes

better quality of drift velocity calculations
easier detection and fitting of the peaks

Effects should be verified and measured on test bench before implementation in simulations

That`s it

Thank you
for attention!



Articles corresponded to a general task of simulations of MPD TPC laser calibration system:

1. Bychkov A., Rogachevsky O. Simulations of a Laser Calibration System and Electron Drift Velocity Determination for the MPD TPC // Phys. Part. Nuclei — 2021. — Vol. 52, No. 4. — pp. 779–782.
2. Bychkov A., Rogachevsky O., Hnatic S. Implementation of task for calibration of MPD TPC electron drift velocity // Phys. Part. Nuclei Lett. — 2024. — V. 21, no. 4. — P. 711–714.



Personal conference participation corresponded to the task of simulations of MPD TPC laser calibration system:

1. RFBR grants for NICA – Simulations of a laser calibration system and electron drift velocity determination for MPD TPC – Dubna – JINR – 2020 – oral presentation
2. IX Collaboration Meeting of the MPD Experiment at the NICA – Simulation and reconstruction of electron drift velocity for MPD TPC – Dubna – JINR – 2022 – oral presentation
3. XII Collaboration Meeting of the MPD Experiment at the NICA – Implementation of task for calibration of TPC gas drift velocity – Serbia – Vinča Institute of Nuclear Sciences – 2023 – oral presentation
4. AYSS-2023 – Implementation of task for calibration of TPC gas drift velocity – Dubna – JINR – 2023 – oral presentation
5. Alushta-2024 – Simulation and position optimization of real laser emitters for TPC calibration system – Alushta – Hotel Dubna – 2024 – oral presentation
6. XIII Collaboration Meeting of the MPD Experiment at the NICA – Simulation and position optimization of real bundles of micro mirrors for TPC laser calibration system – Dubna – JINR – 2024 – oral presentation