

Feasibility and Distortion study of TPC detector prototype with the laser calibration

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Outline

- Distortion requirements
- Status of Laser calibration
- Status of TPC prototype R&D
- Summary

Distortion requirements

Motivation of TPC prototype

Focused on the smaller TPC prototype

Motivation of the TPC prototype

1. TPC chamber
2. Laser calibration

- Study and estimation of the distortion from the IBF and primary ions with the laser calibration system
- Main parameters
 - Drift length: $\sim 510\text{mm}$, Readout active area: $200\text{mm} \times 200\text{mm}$
 - Integrated the laser calibration with 266nm
 - GEMs/Micromegas as the readout
 - Matched to assembled in the 1.0T PCMAG

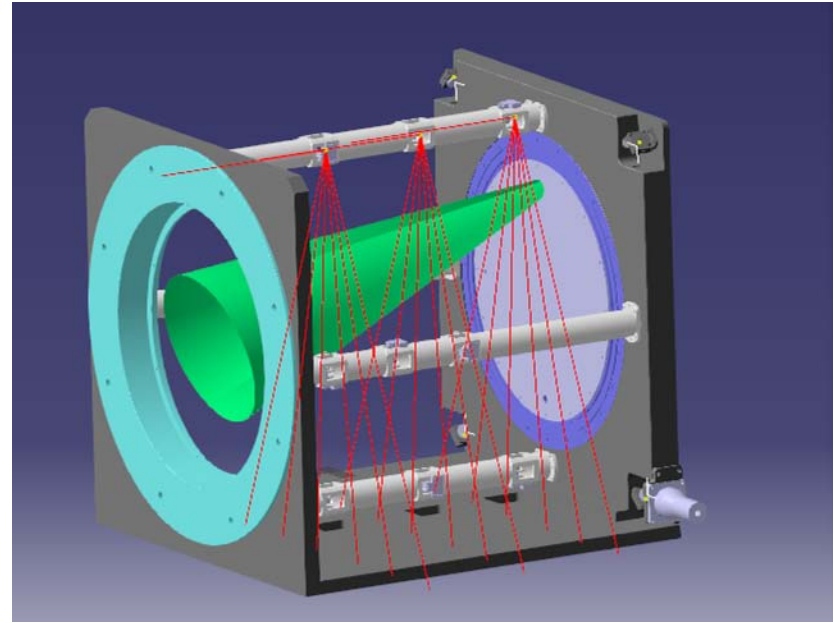
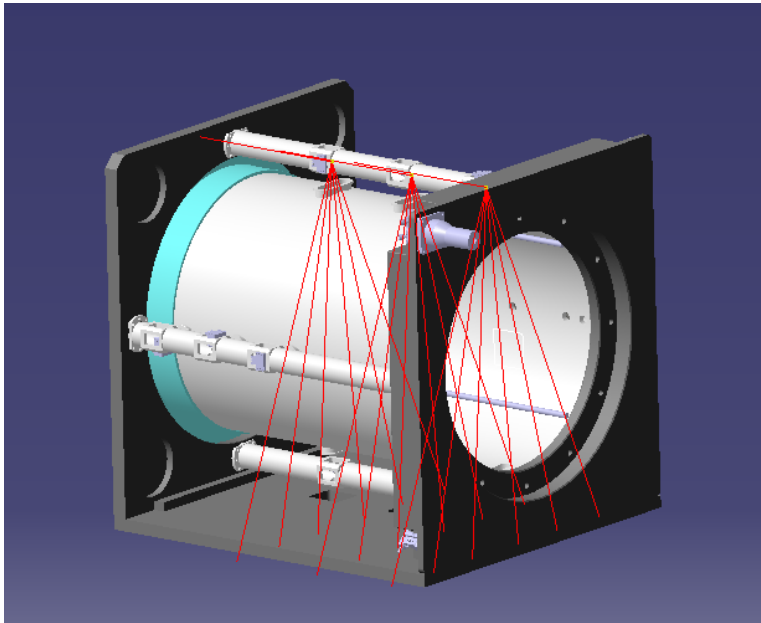
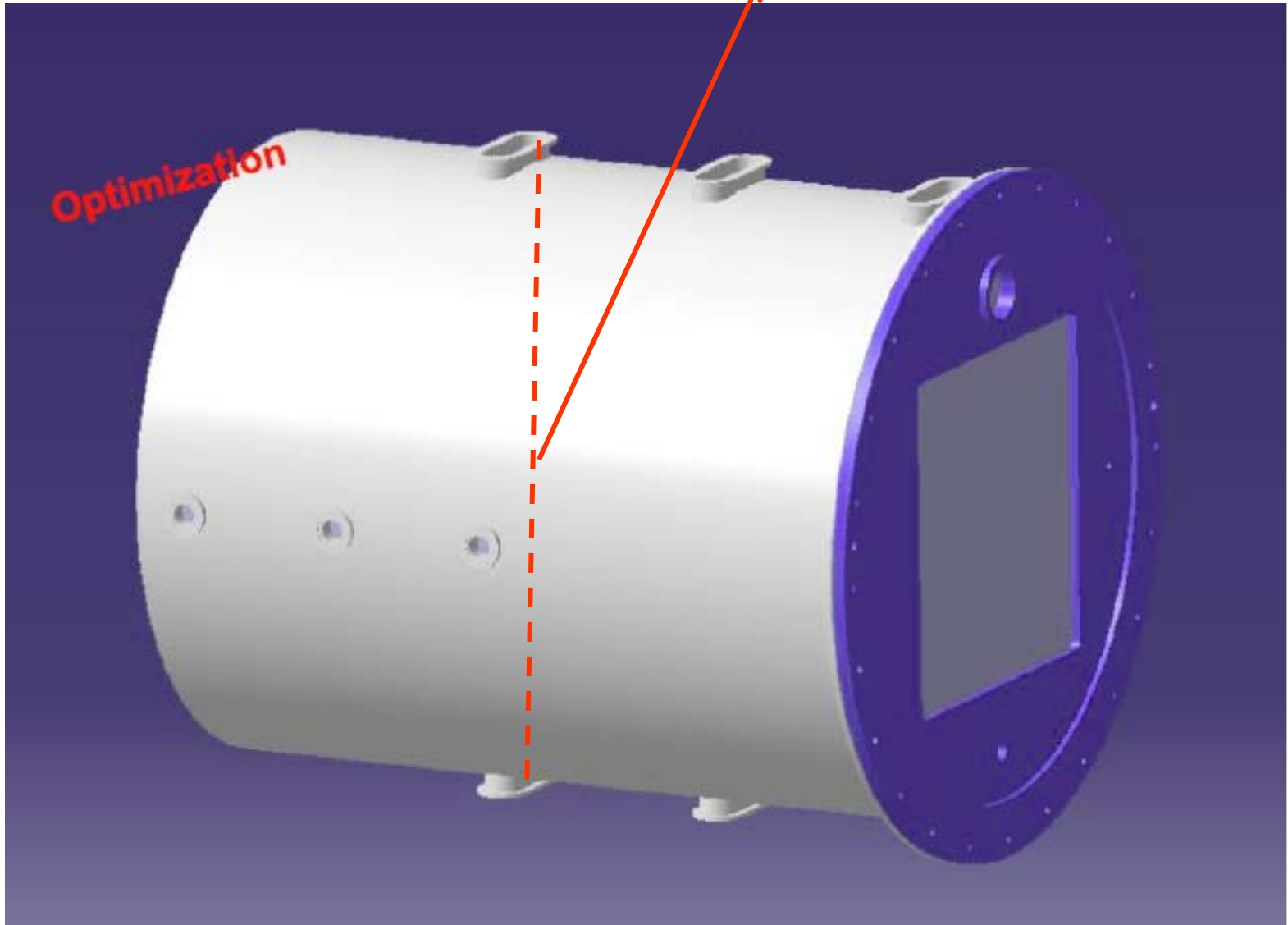


Diagram of the TPC prototype with the laser calibration system

TPC chamber

Diameter: ~400mm

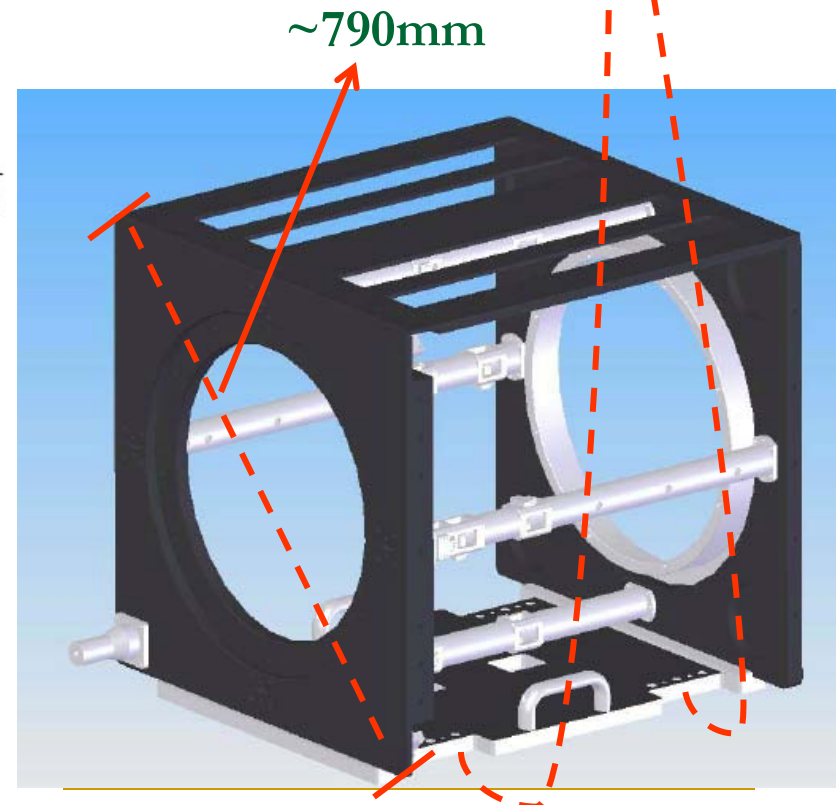
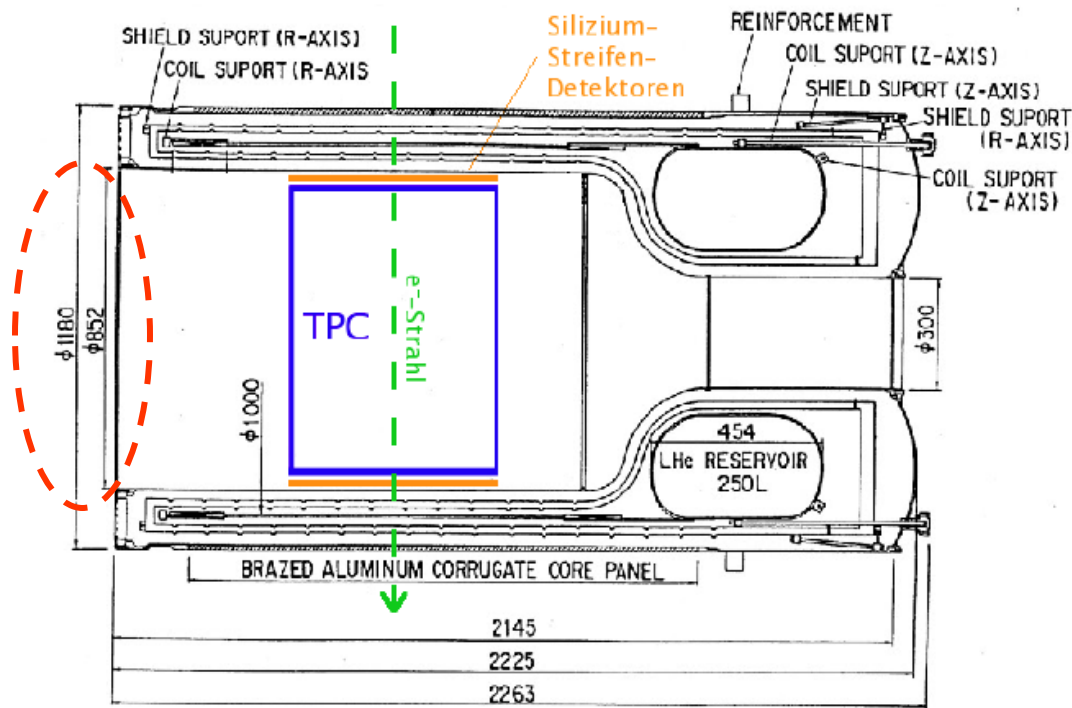


TPC barrel with the 266nm laser transmission windows

Laser calibration system

■ Main parameters

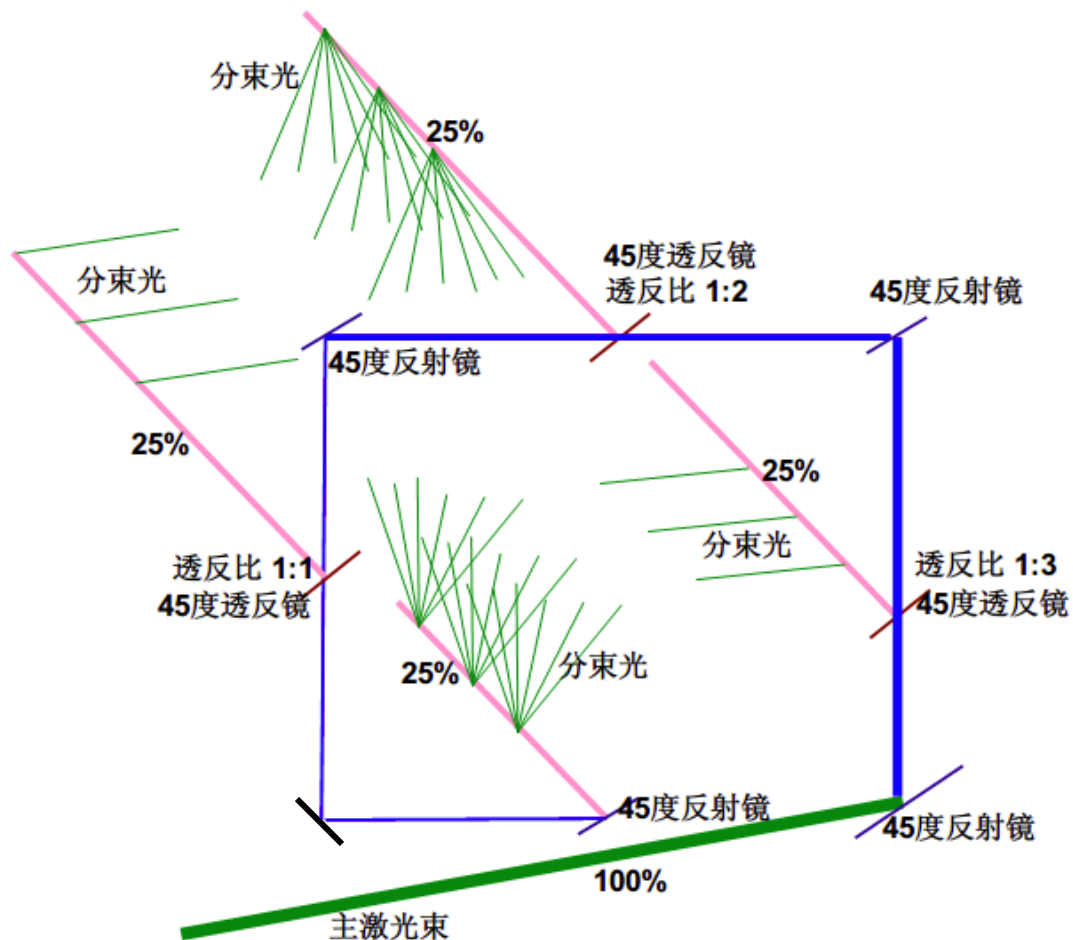
- ❑ Easily to move with the support platform
- ❑ Designed to assemble in Magnet
- ❑ **Separable parts: TPC+ Laser system**
- ❑ Cosmic and electron beam test



Dimension of the TPC prototype according to the PCMAG

Laser map design

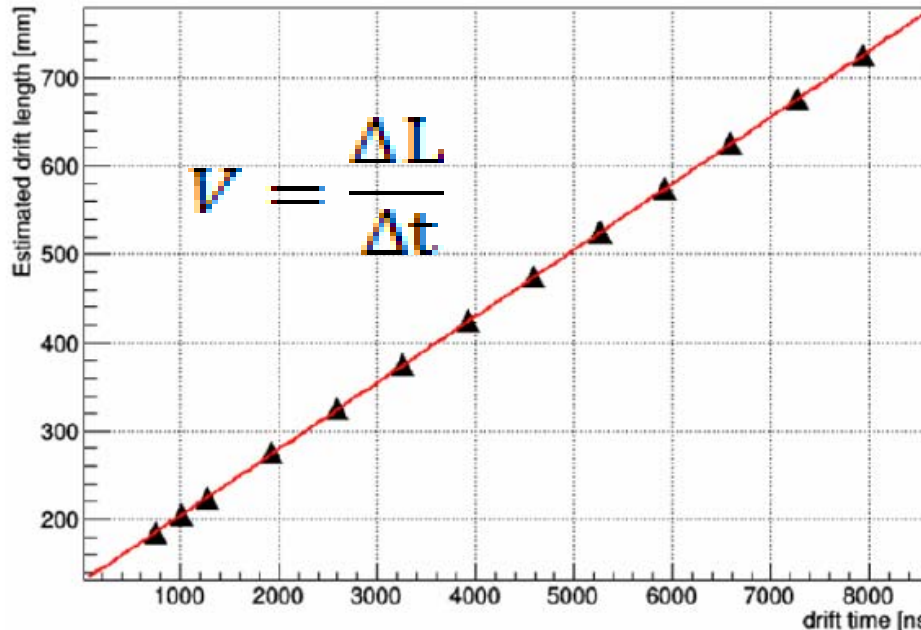
- Number laser beam in chamber: 42
- Transmission and reflection mirrors



Drift velocity calibration

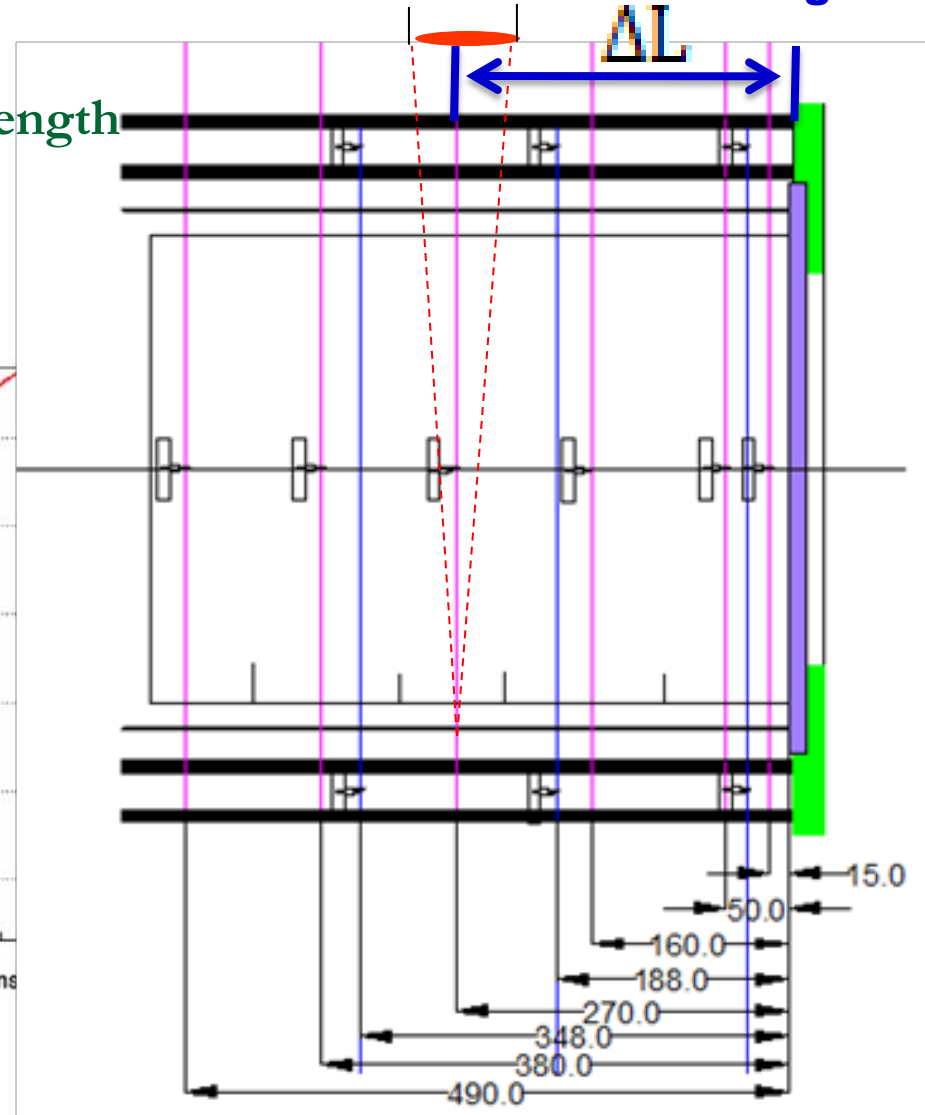
■ Parameters

- 9 layers laser beam along drift length
- X Direction: 4 layers
- Y Direction: 4 layers



Drift velocity from KEK GEM module

Key questions:
Center of the laser beam range!

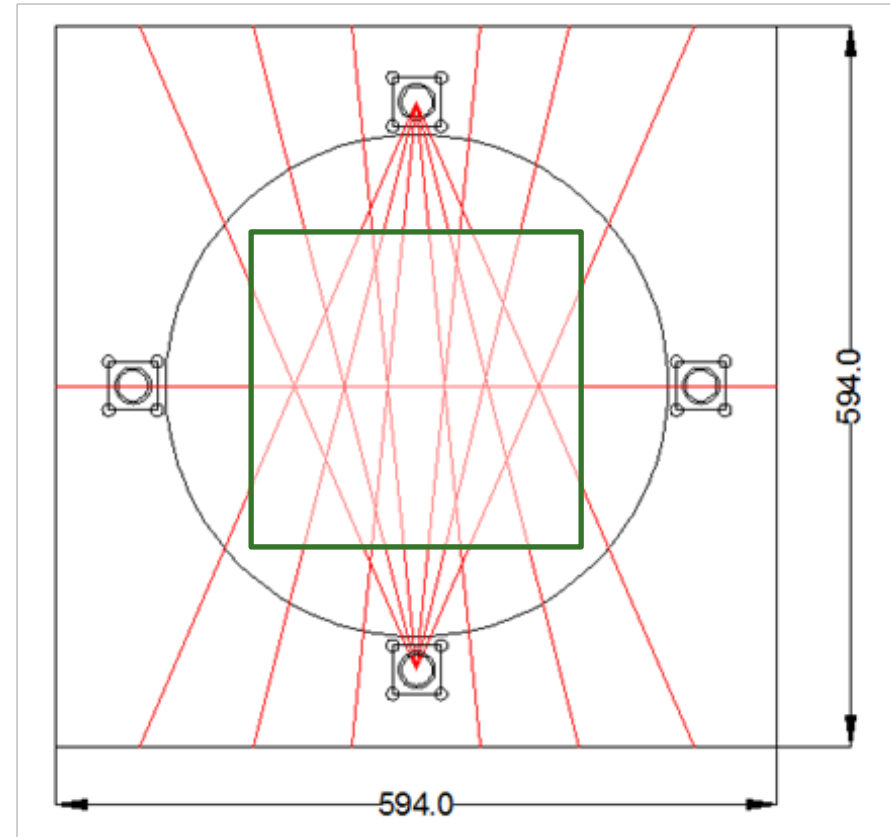


Drift velocity design along drift chamber

Uniformity of Gain calibration

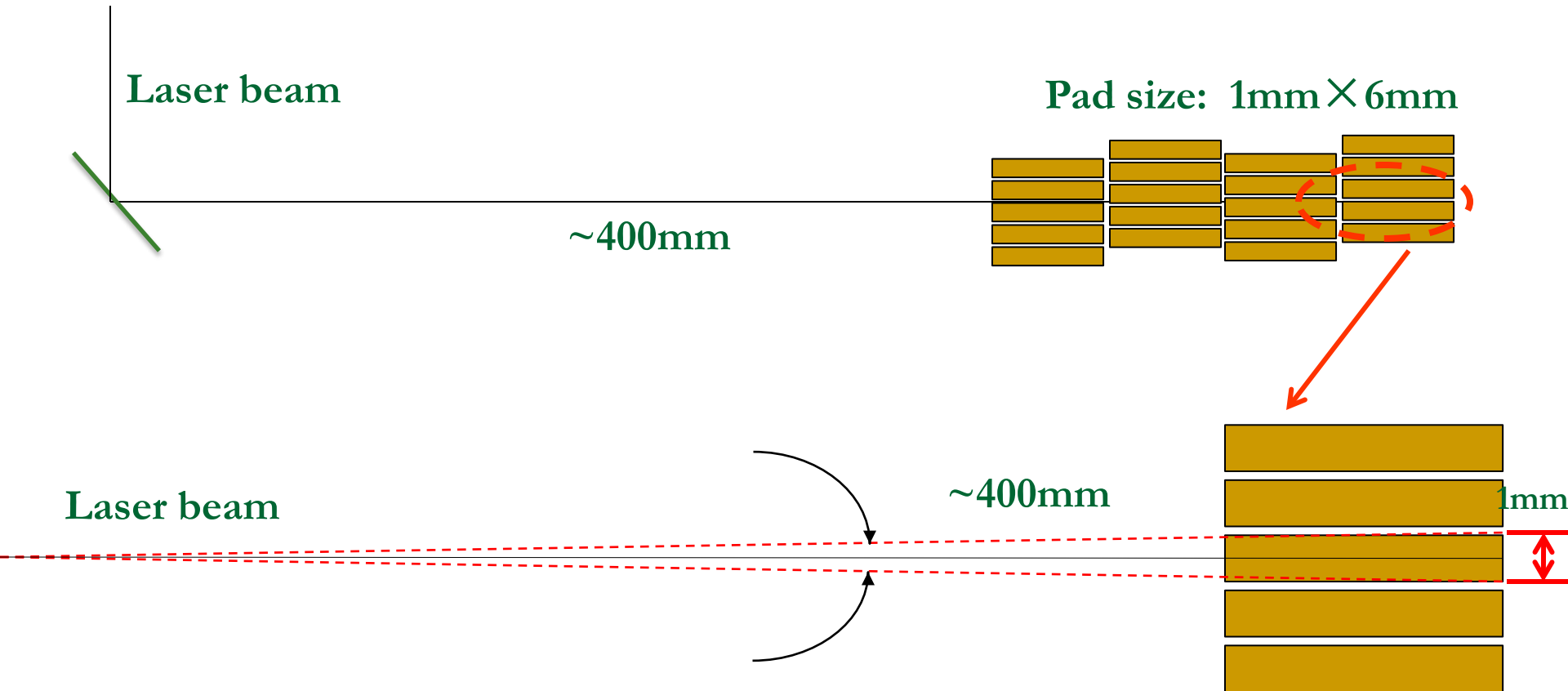
■ Parameters

- ❑ 42 laser beams along drift length
 - 6 laser beams (UP) * 3 layers
 - 6 laser beams (DOWN) * 3 layers
 - 3 laser beams (LEFT)
 - 3 laser beams (RIGHT)
- ❑ Cover all the active area
 - Drift velocity
@Gas/P/T/Operation
 - Uniformity
 - Online calibration
 - Distortion



Uniformity design in X-Y plane

Laser beam position requirement



Requirement:

Center of the laser beam will in the range of one pad

Laser beam position precision: $< \pm 5$ minutes

1 minutes = $1/60$ degree

Status of TPC prototype R&D

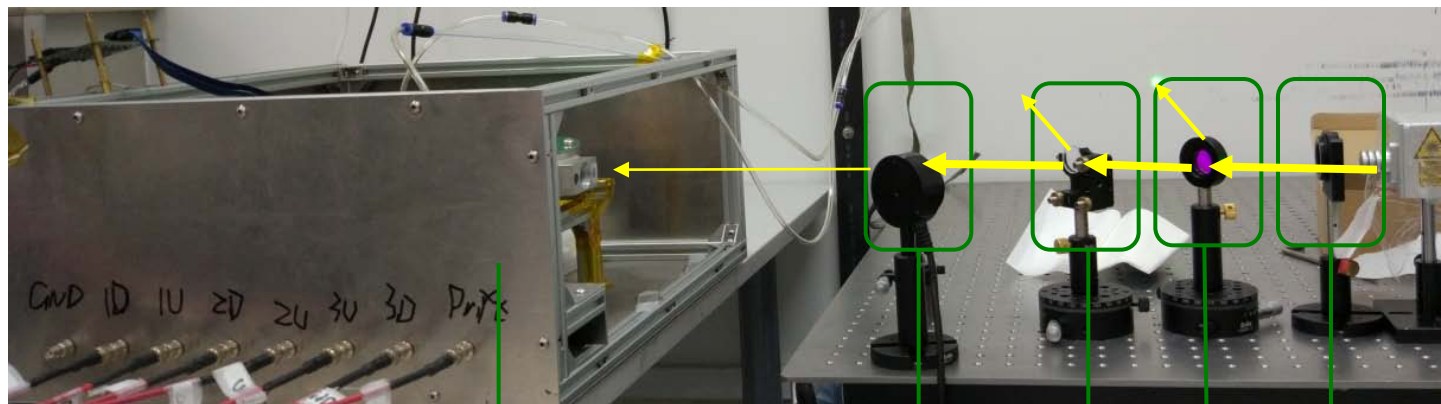
Drift velocity @Gas/P/T/Operation

Uniformity

Online calibration

Distortion

Signal of the laser with $\Phi 1\text{mm}$ @266nm



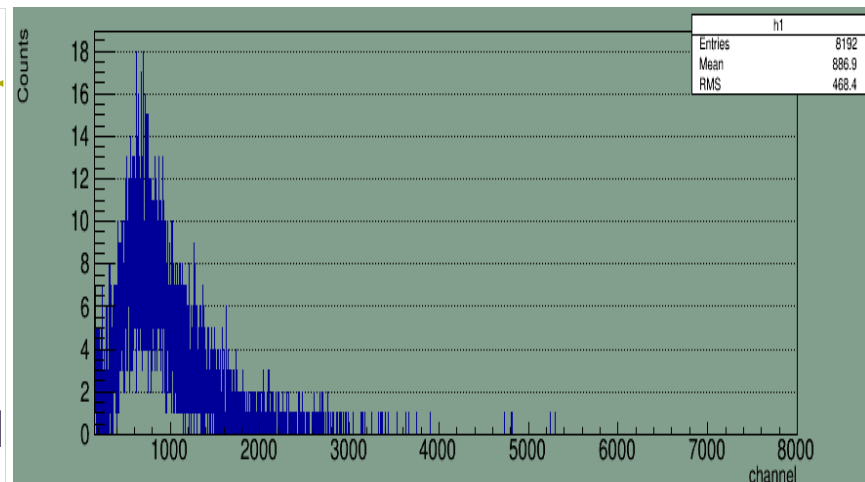
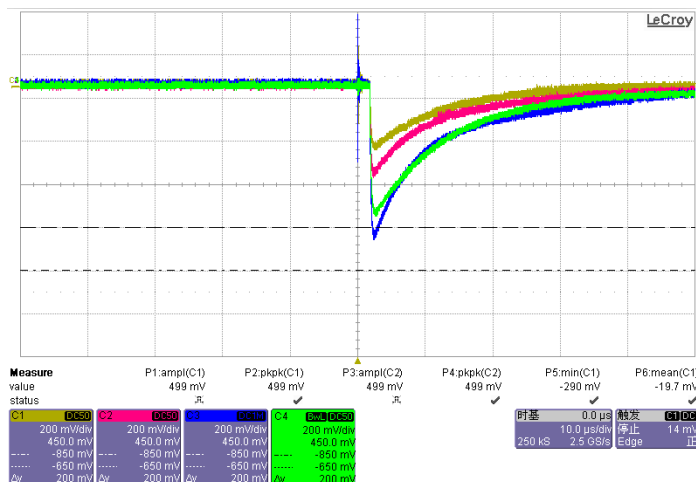
Triple GEMs
detector

Hole collimator
 $\Phi 1\text{mm}$

Trans/refle.
=1:99

Transmission
mirror

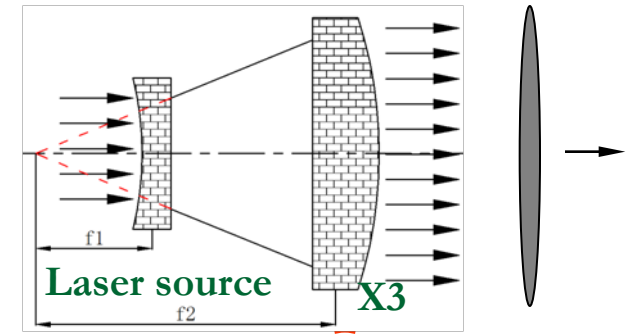
Transmission mirror



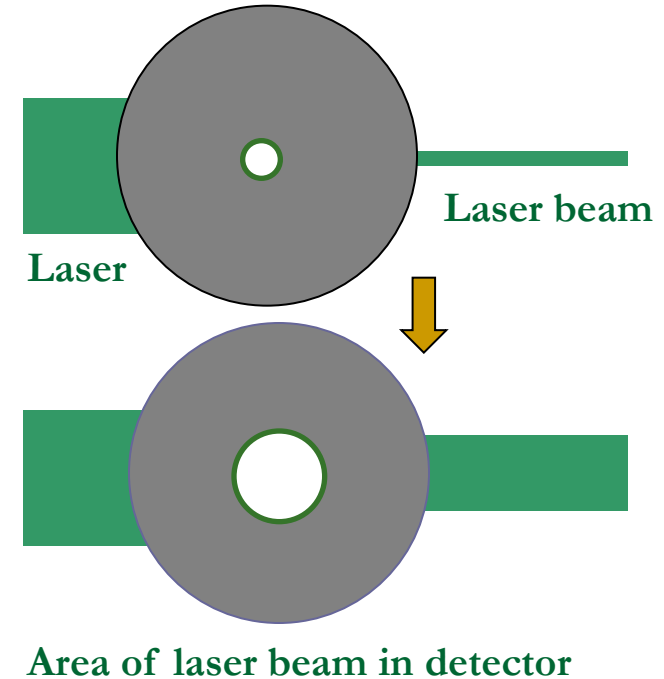
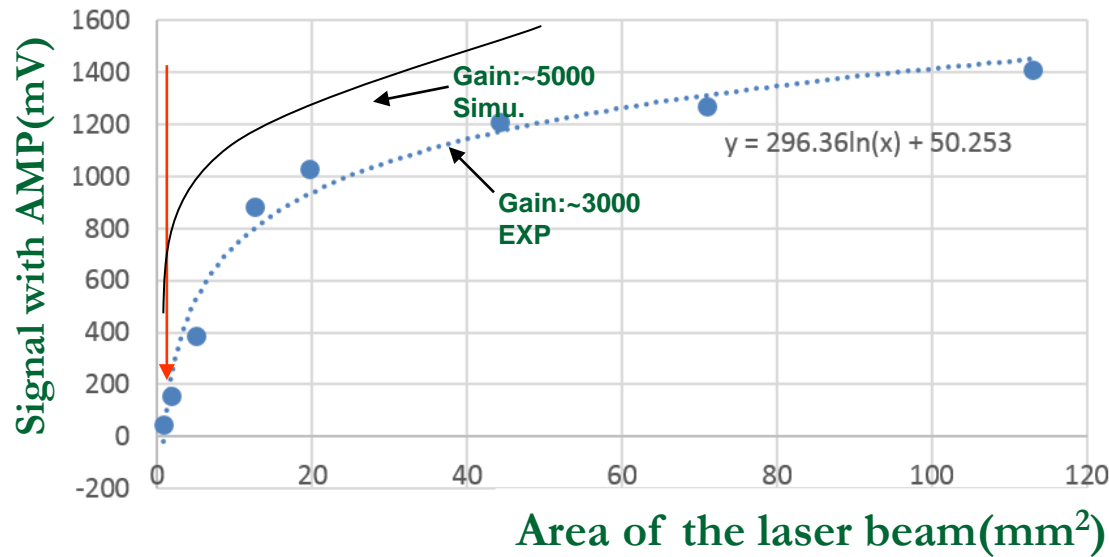
Signal of the laser with $\Phi 1\text{mm}$ @ Charge sensitive AMP/12mV/fC

Collimator@ $\Phi 1 \sim \Phi 12\text{mm}$

- ❑ Laser beam with expander mirror: $5\text{mm} \times 3$
- ❑ Primary laser power: $170\mu\text{J}$
- ❑ Gain: ~ 3000



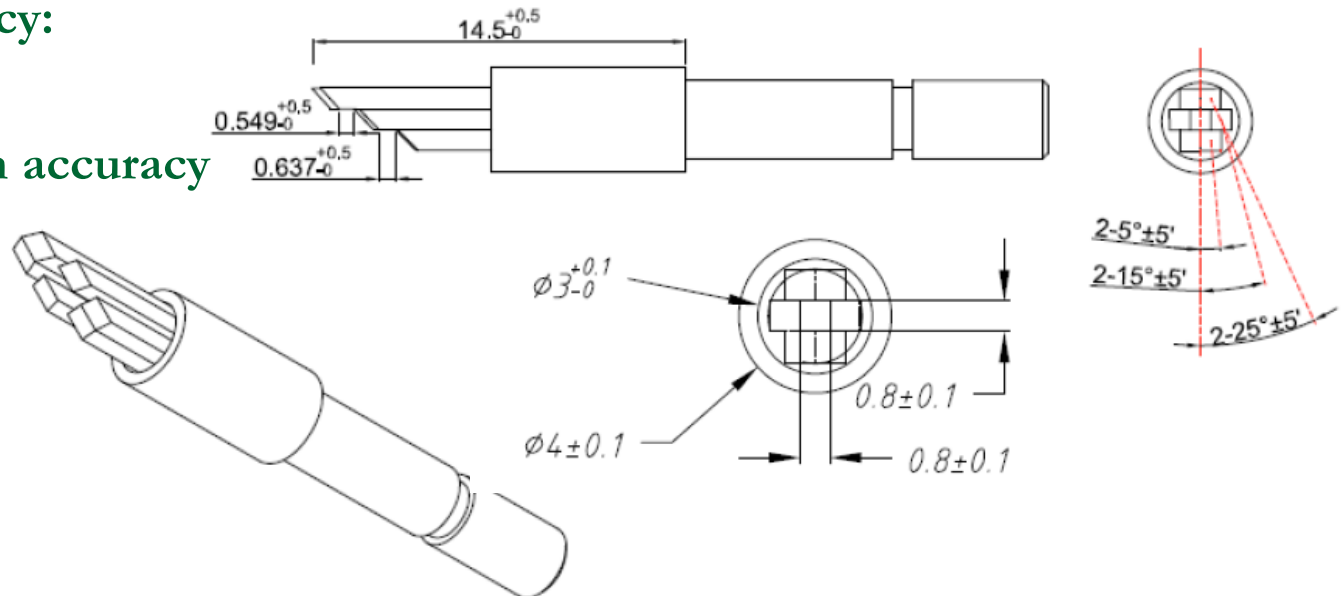
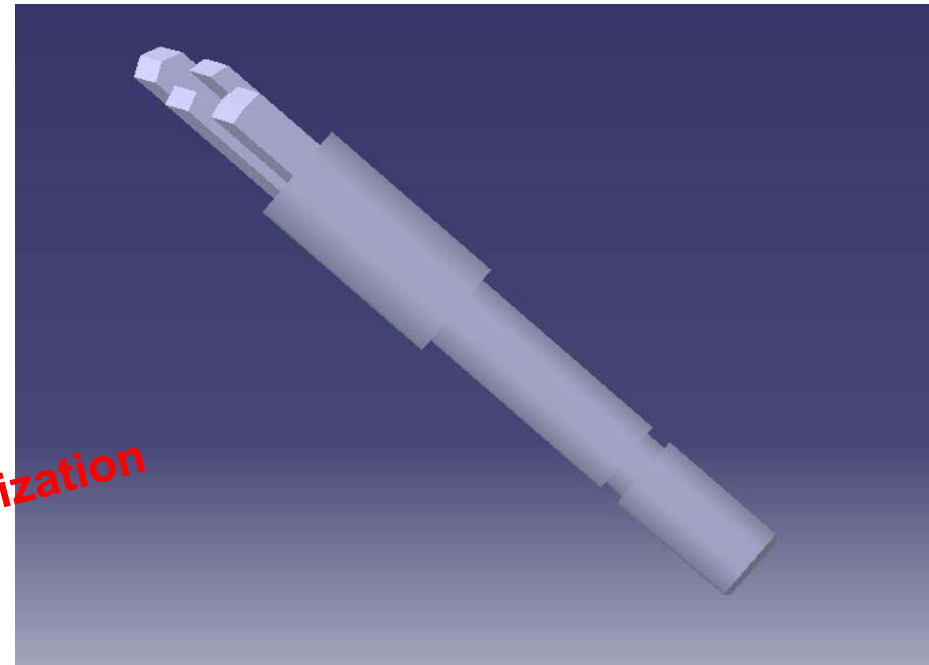
直径/mm	12	9.5	7.5	5	4	2.5	1.5	1
面积/mm ²	113.1	70.882	44.179	19.635	12.566	4.9087	1.7671	0.785
道数	6648	5990	5717	4856	4177	1853	779	267
幅度/mV	1411.5	1270.6	1212.2	1027.8	882.47	384.9	154.96	45.34



Divide and reflection mirrors

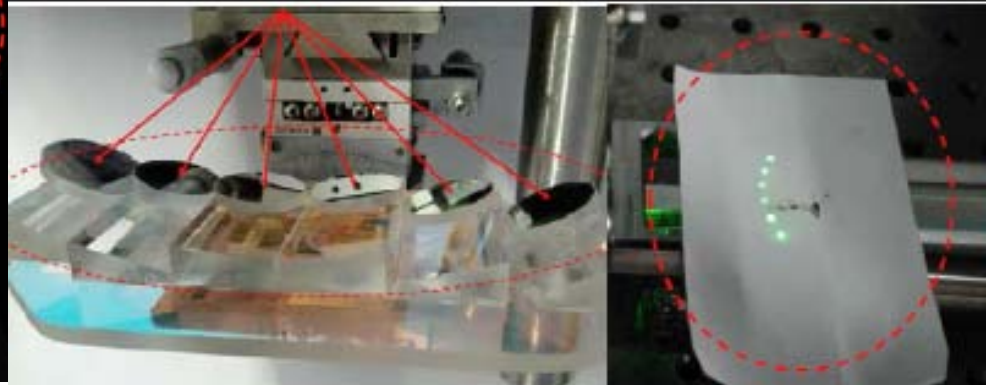
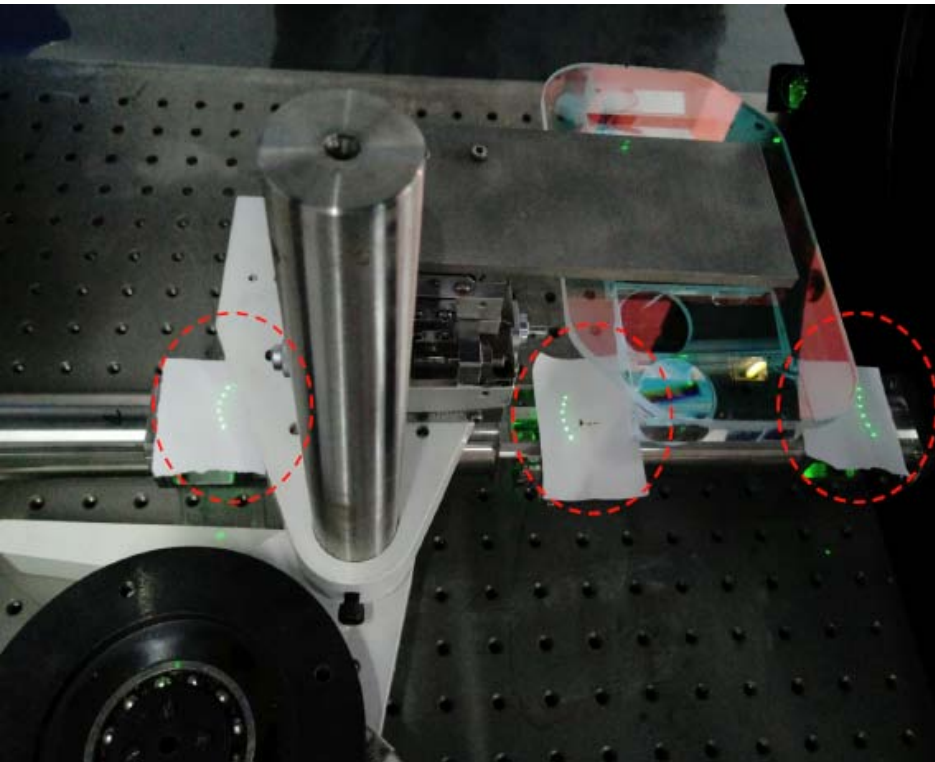
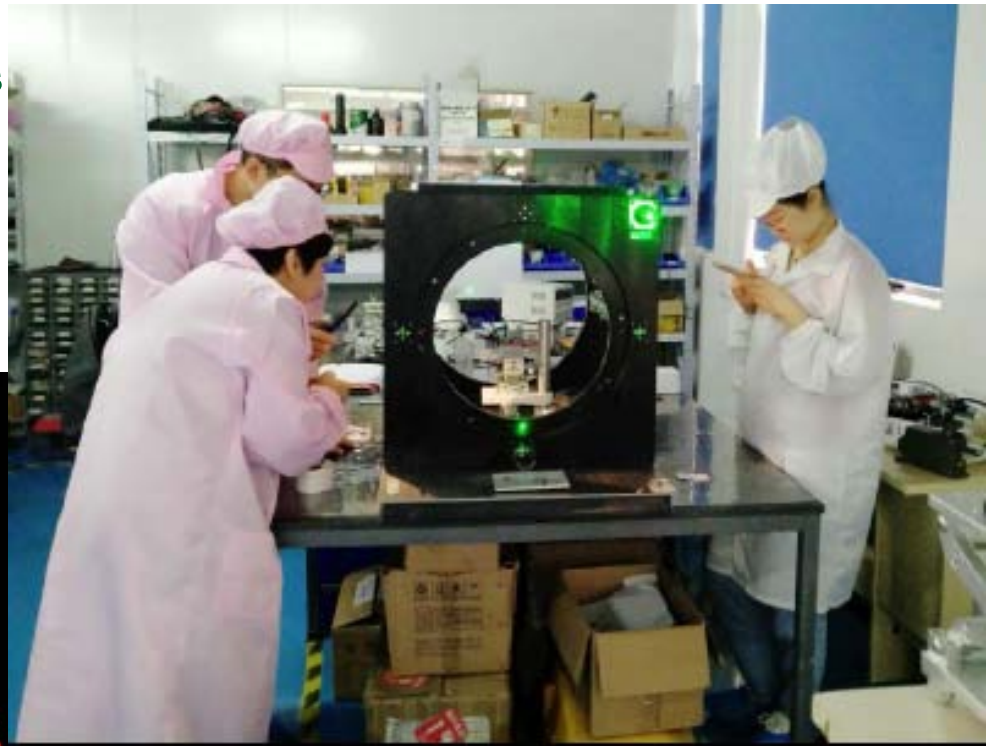
- ❑ Laser wave for the divide and reflection mirrors: 266nm
- ❑ Size: $\sim 0.8\text{mm} \times 0.8\text{mm}$
- ❑ Number of the divide trackers: 6
- ❑ Stainless steel support integrated the laser mirrors
- ❑ Reflection efficiency:
 $>99\% @ 266\text{nm}$
- ❑ Reflection position accuracy
 $1/30 \text{ degree}$

Optimization



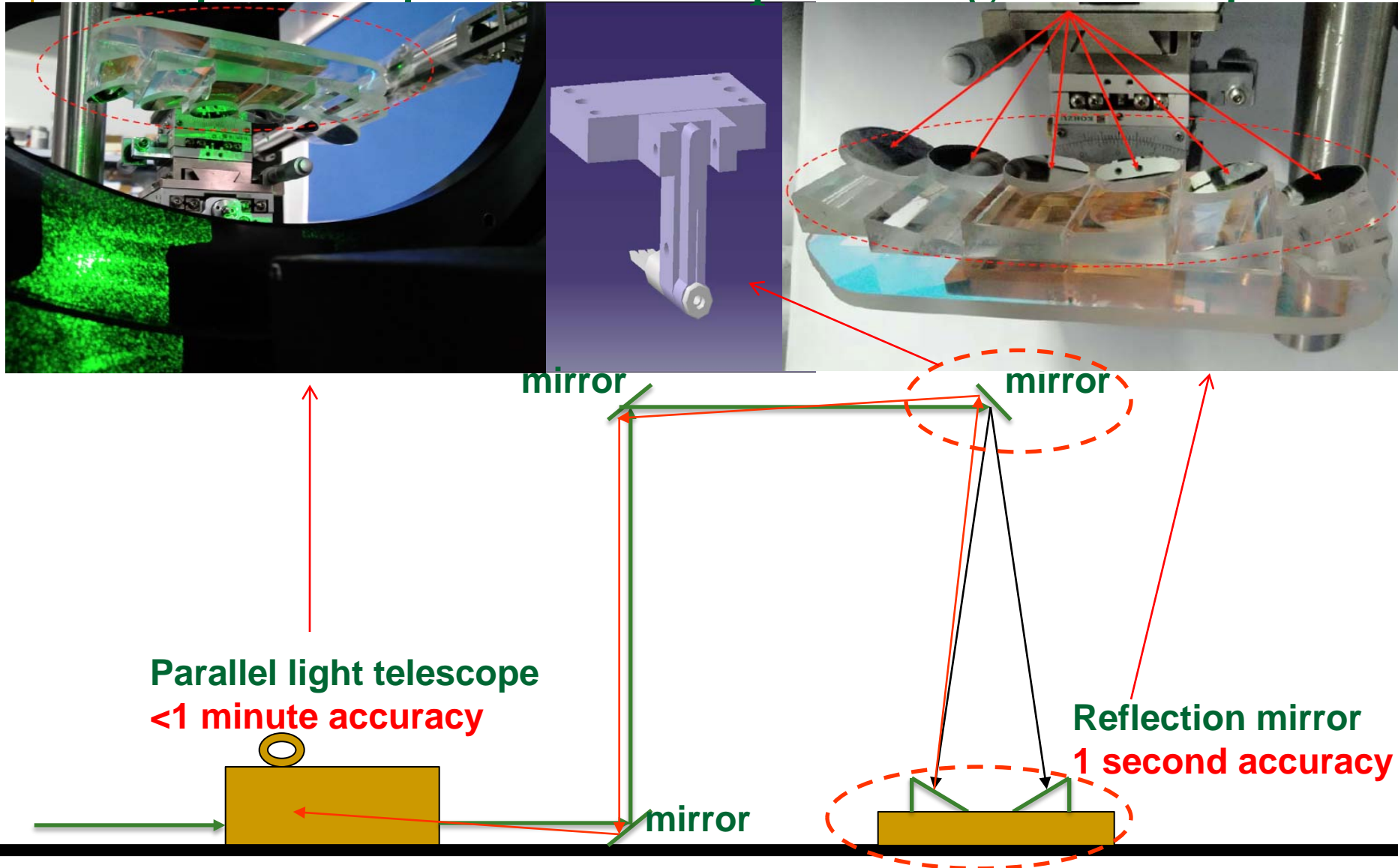
Laser calibration system assembled

- ❑ Transmission and reflection mirrors
- ❑ Aluminum board integrated the laser device and supports
- ❑ **All works finished**



Detector with the laser system

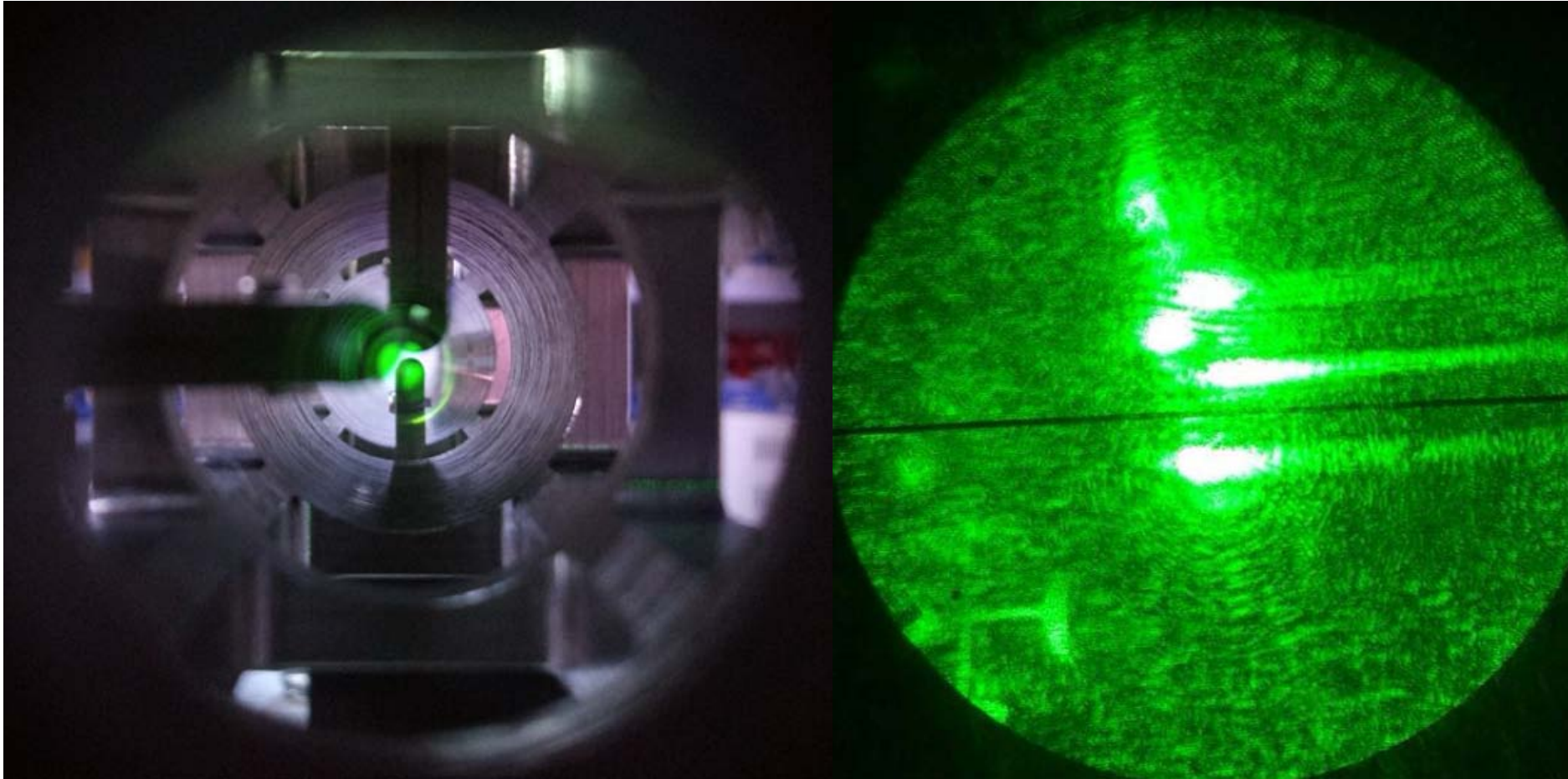
Laser position precision with parallel light telescope



High precision optical platform

Details of the laser calibration system 1 minutes = 1/60 degree

Precision (parallel light telescope test) : $< \pm 5$ minutes



Split mirrors of the laser system and the position of the laser

Design of the prototype with laser



- ❑ Support platform: 1200mm×1500mm (all size as the actual geometry)
- ❑ TPC barrel mount and re-mount with the Auxiliary brackets
- ❑ Readout board (Done), Laser mirror (Done), PCB board (Done)

Summary

TPC prototype with laser calibration :

- ❑ Calibrated drift velocity, gain uniformity, ions back in chamber
- ❑ Prototype has been designed with laser (Developed by IHEP and Tsinghua)
- ❑ Nd:YAG laser device@266nm, 42 separated laser beam along 510mm drift length
- ❑ The prototype will be assembled and tested

More simulation based on this prototype:

- ❑ Need discussion to make more efficient ?
- ❑ Manpower: Cai Yiming (Tsinghua), Wang Haiyun (IHEP), Yuan Zhiyang (IHEP)

Thanks.