Progress on IBF measurement and TPC prototype R&D

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Outline

- Motivation
- Status of TPC module R&D
- Status of TPC prototype R&D
- Summary

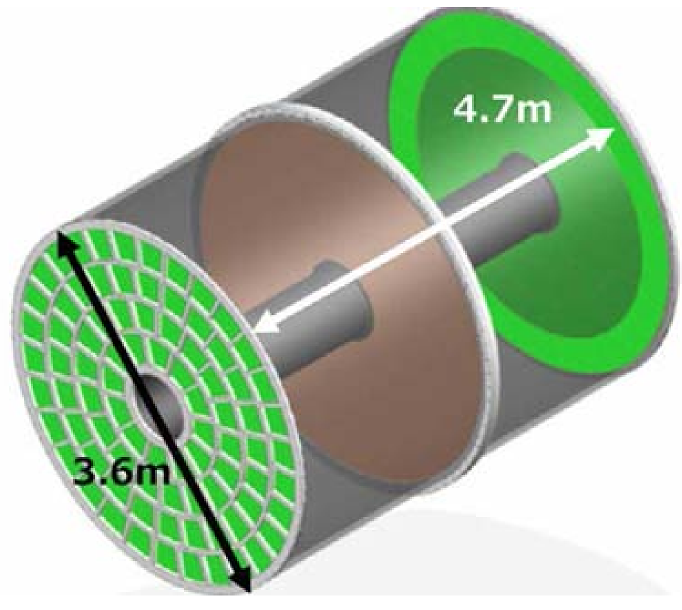
TPC requirements for collider concept

TPC could be as one tracker detector option for CEPC, 1M ZH events in 10yrs E_{cm} ≈240 GeV, luminosity ~2×10^{34} $cm^{-2}s^{-1}$, can also run at the Z-pole

TPC detector concept:

- Motivated by the H tagging and Z
- ~3 Tesla magnetic field
- ~100 μm position resolution in rφ
  - ~60μm for zero drift, <100μm overall
  - Systematics precision (<20μm internal
- Large number of 3D points(~220)
- Distortion by IBF issues
- dE/dx resolution: <5%
- Tracker efficiency: >97% for pT>1GeV
- 2-hit resolution in rφ : ~2mm
- Momentum resolution: ~10^{-4}/GeV/c
- TPC material budget
  - 0.05 X_0 including outer fieldcage in r
  - 0.25 X_0 for readout endcaps in z

from MoA document of LCTPC@2018

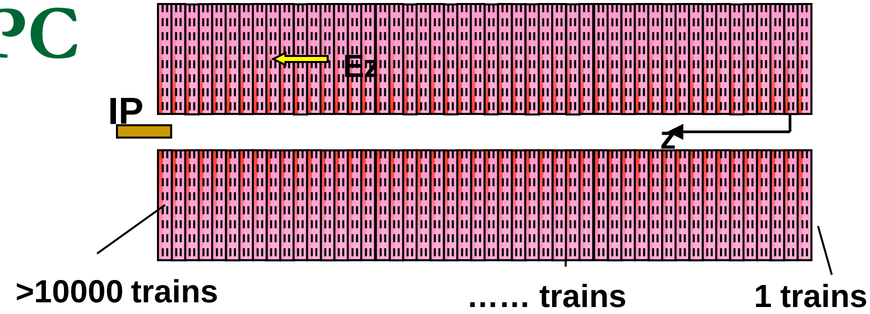


Overview of TPC detector concept

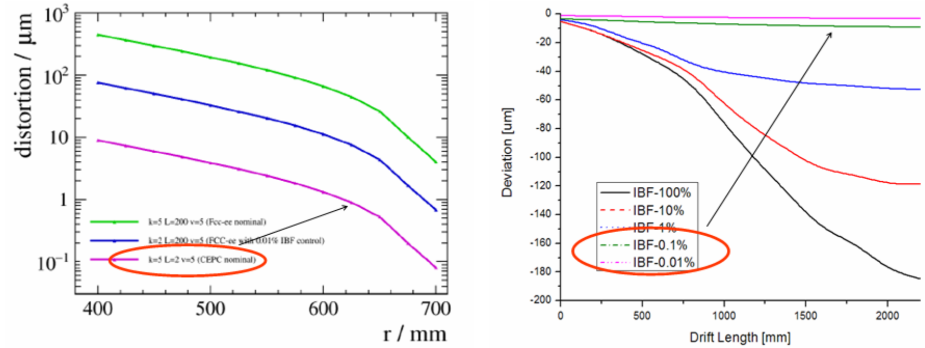
Technical challenges for TPC

Ion Back Flow and Distortion :

- ~100 μm position resolution in rφ
- Distortions by the primary ions at CEPC are negligible
- More than 10000 discs co-exist and distorted the path of the seed electrons
- The ions have to be cleared during the ~us period continuously
- Continuous device for the ions
- Long working time



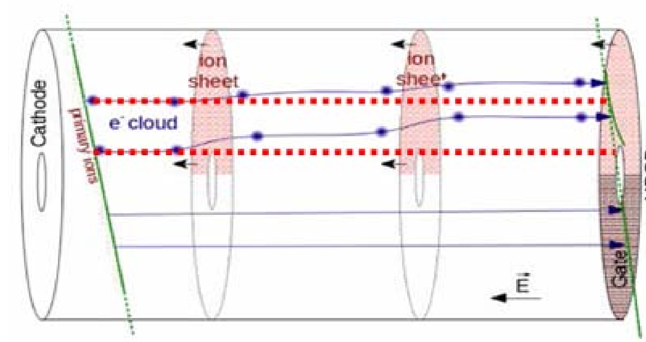
Amplification ions @CEPC



Evaluation of track distortions

Calibration and alignment:

- Calibrated drift velocity, gain uniformity, ions back in chamber
- Geometry and mechanic of chamber
- Modules and readout pads alignment
- Track distortions due to space charge effects of positive ions



Ions backflow in drift volume for distortion

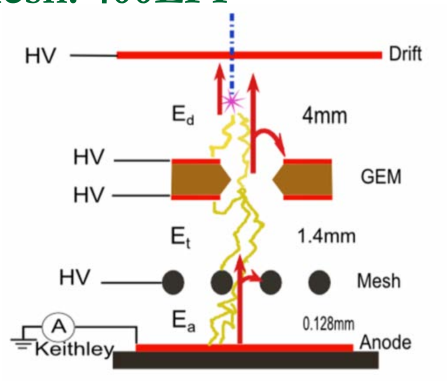
Investigation of IBF study with module

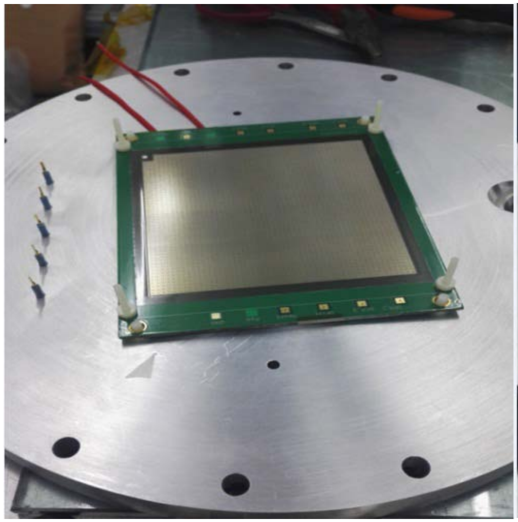
Combination detector

IBF control measurement

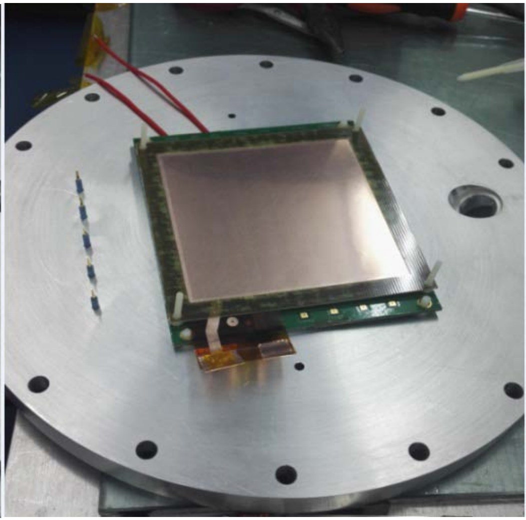
Test of the new module

- Test with GEM-MM module
  - New assembled module
  - Active area: 100mm×100mm
  - X-tube ray and 55Fe source
  - Bulk-Micromegas from Saclay
  - Standard GEM from CERN
  - Additional UV light device
  - Avalanche gap of MM:128μm
  - Transfer gap: 2mm
  - Drift length:2mm~200mm
  - Mesh: 400LPI

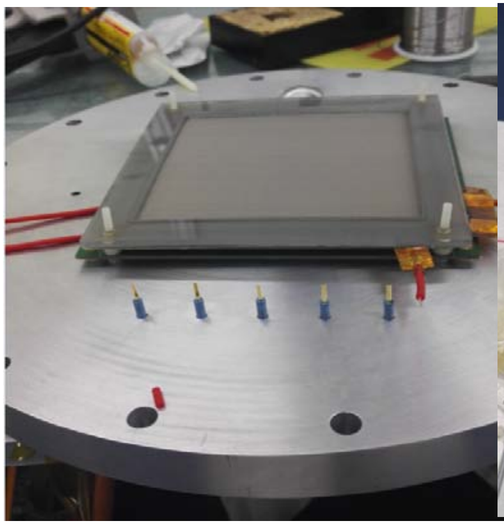




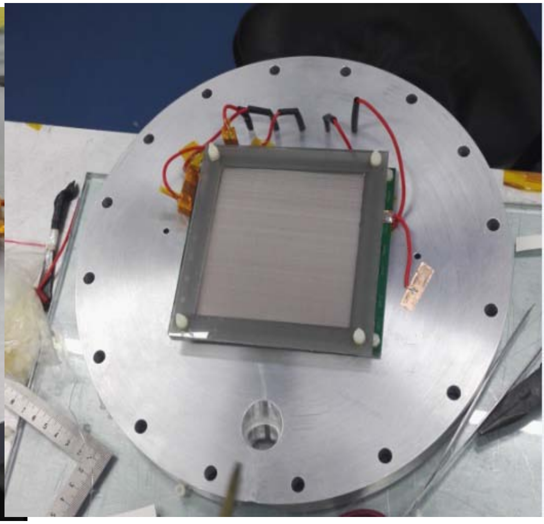
Micromegas(Saclay)



GEM(CERN)



Cathode with mesh



GEM-MM Detector

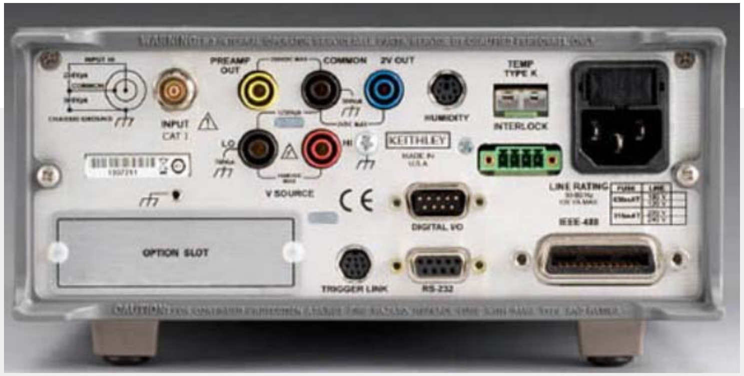
Electrometer/High Resistance Meter

Keithley 6517B

Electrometer/High Resistance Meter, 100aA - 20mA, 10μV - 200V, 100Ω - 10PΩ

Brand:	Keithley
Model No:	6517B

KEITHLEY
A Tektronix Company

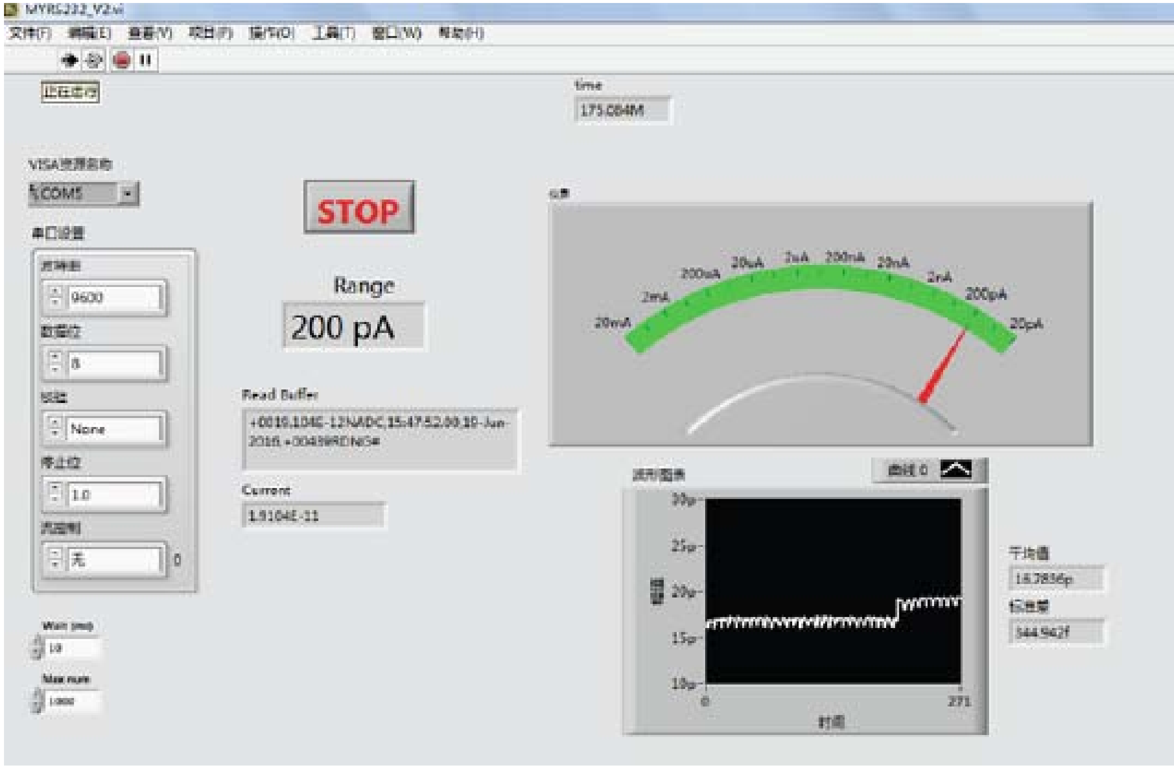


Product Features:

- Measures resistances up to 1018O
- 10aA (10×10-18A) current measurement resolution
- Less than 3fA input bias current
- 6 1/2-digit high accuracy measurement mode
- Less than 20μV burden voltage on the lowest current ranges
- Voltage measurements up to 200V with >200TO input impedance
- Built-in +/-1000V voltage source
- Unique alternating polarity voltage sourcing and measurement method for high resistance measurements
- Built-in test sequences for four different device characterization tests, surface and volume resistivity, surface insulation resistance, and voltage sweeping
- Optional plug-in scanner cards for testing up to 10 devices or material samples with one test setup

Measuremnt of GEM-MM module

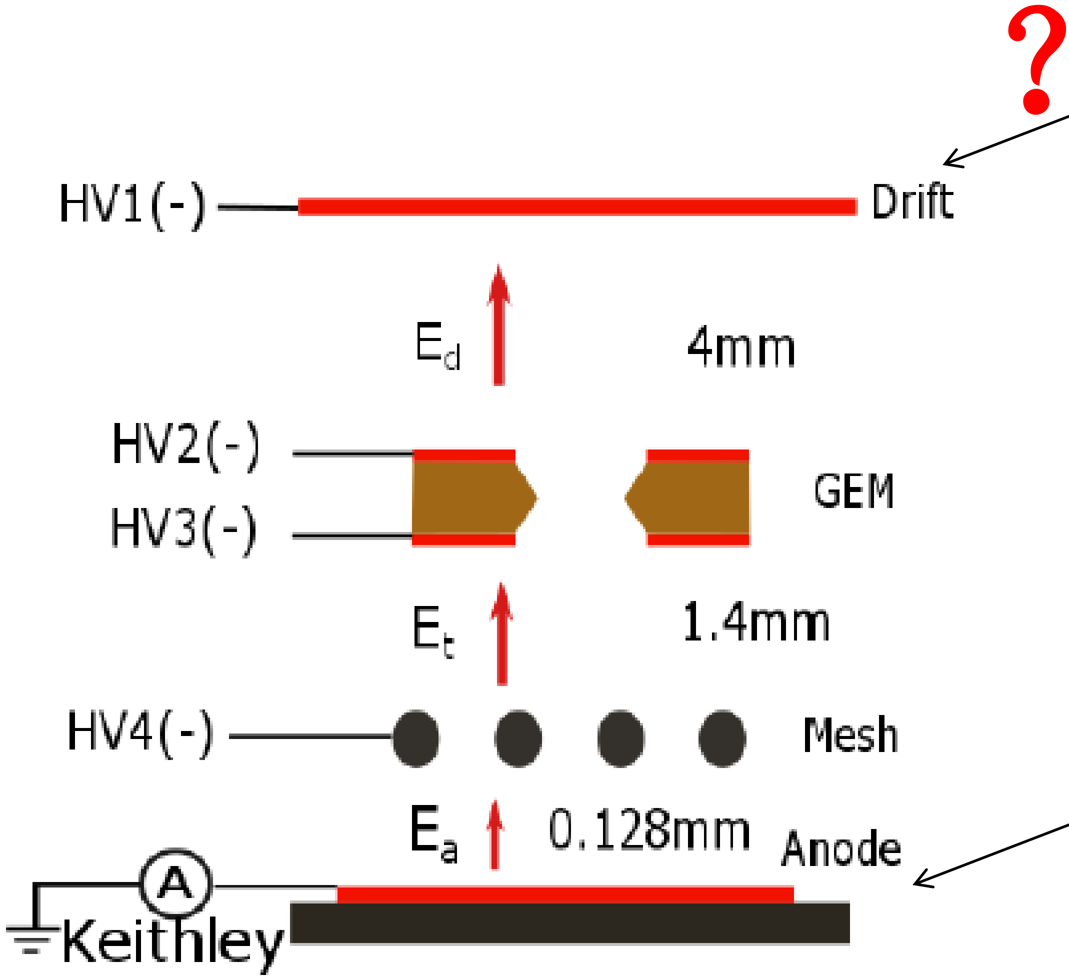
- Test with GEM-MM module
  - Keithley Electrometers for Ultra-Low Current Measurements: pA~mA
  - Keithley: 6517B
  - Test of cathode of the module
  - Test of readout anode of the module
  - Labview interface of the low current to make the record file automatically



Labview interface of the current with Keithley

$$IBF = \frac{I_C - I_P}{I_A}$$

pA current – How to measure?



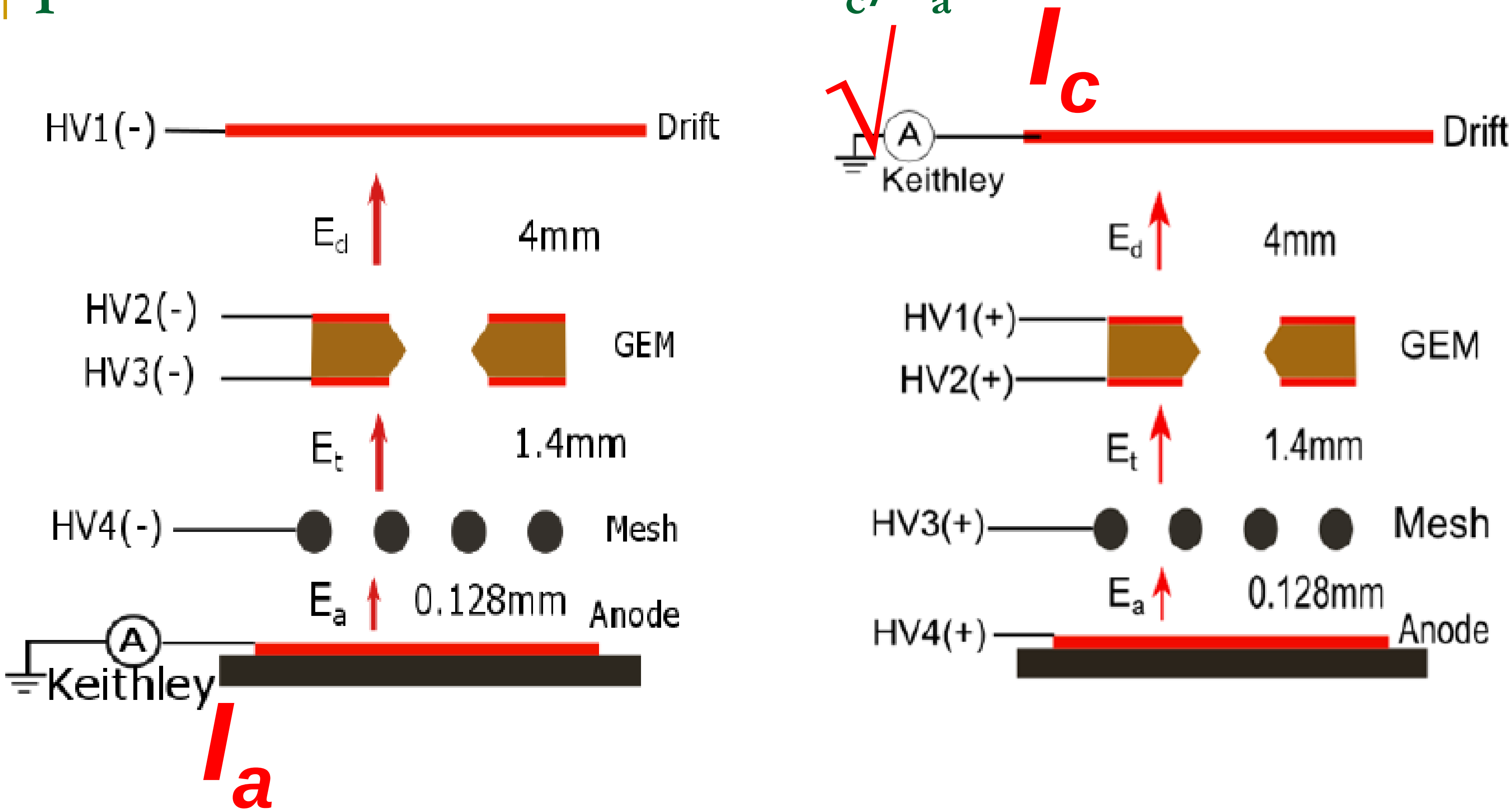
To -2600V high voltage

Can not connect with Keithley meter

To ground with Keithley meter

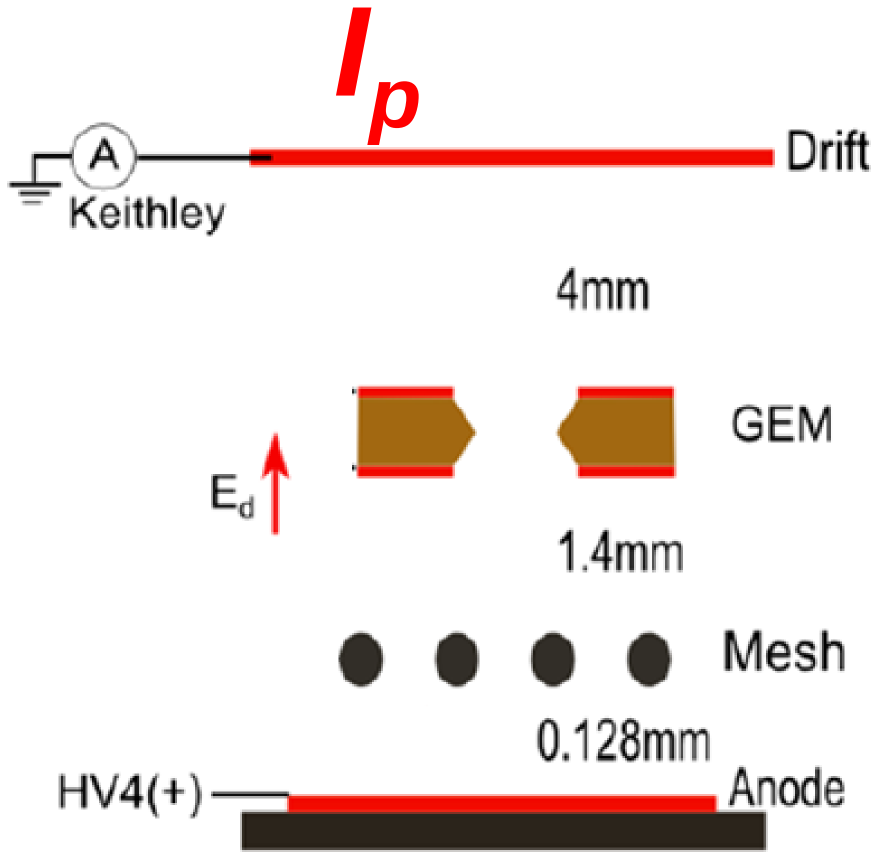
Rang: ~nA

pA current measurement – I_c/I_a



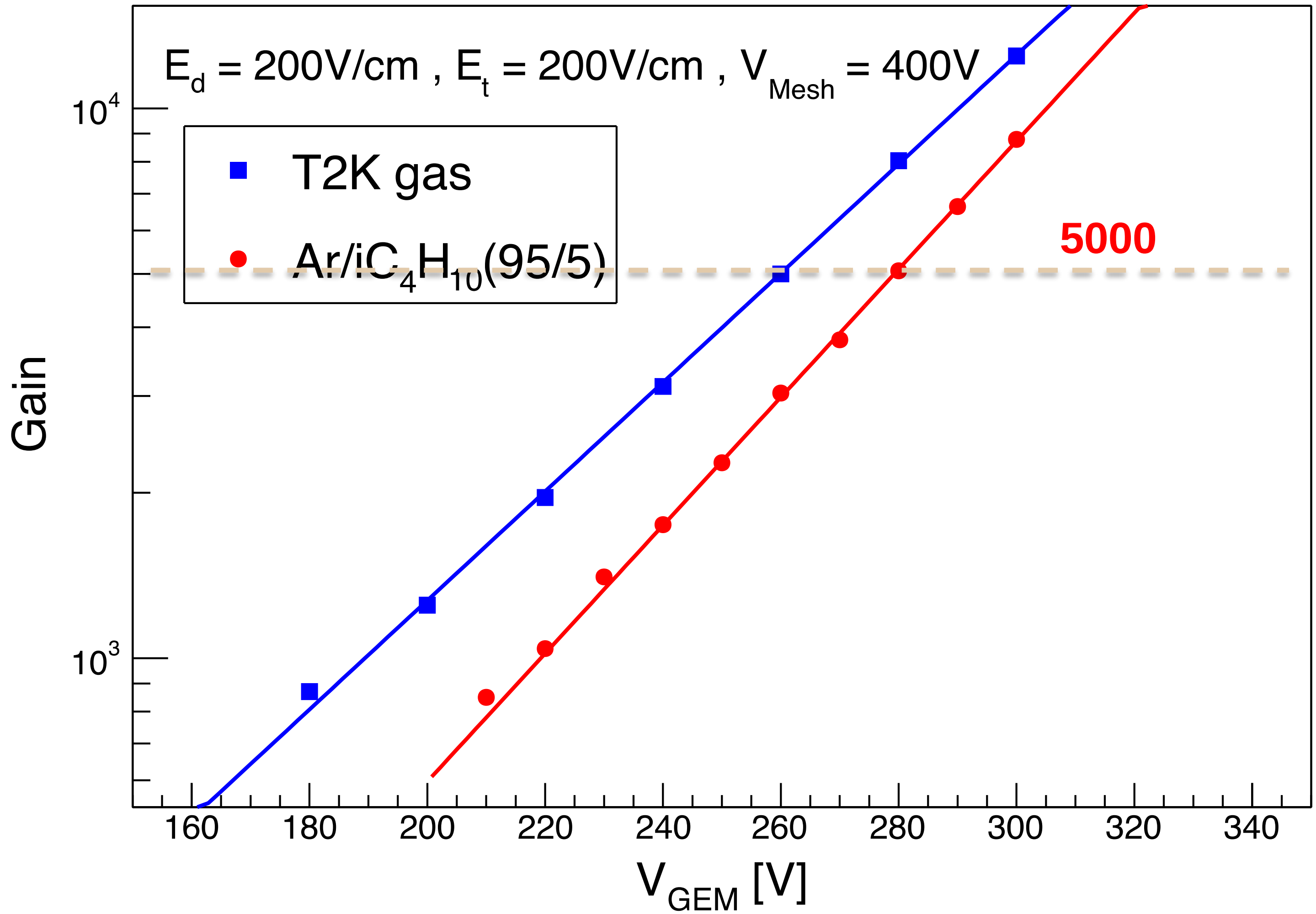
- Different polarity
- Same electric filed
  - Ed=Ed; Et=Et; Ea=Ea

Primary electrons current - I_p



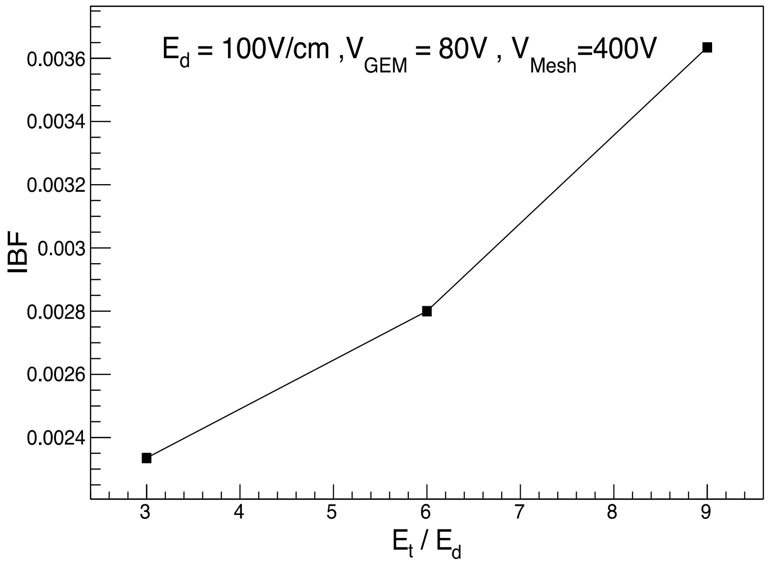
- No operation voltage of the GEM-MM detector
- Just test current of the primary electrons (~pA)

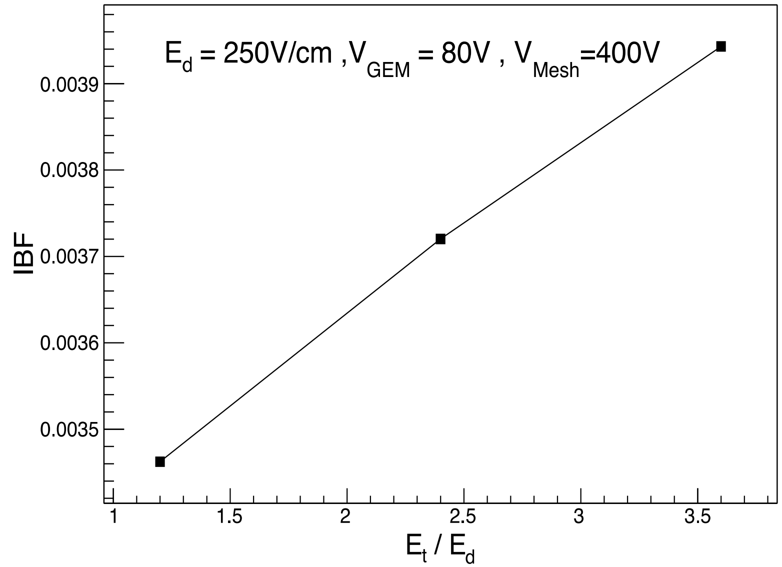
Gain of the hybrid structure detector

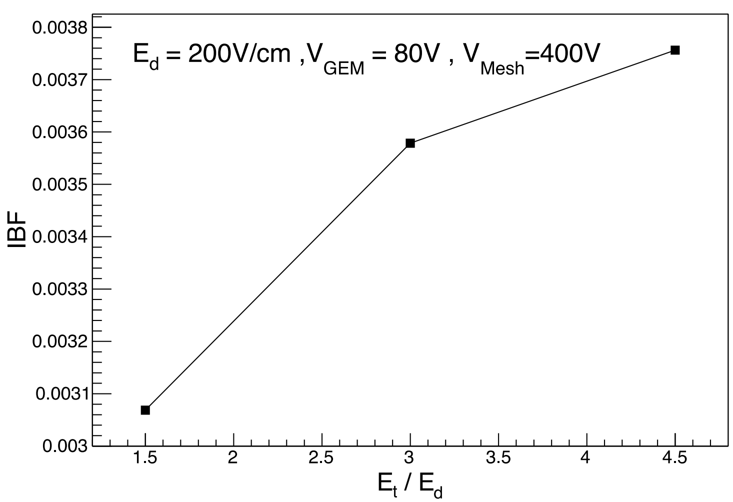


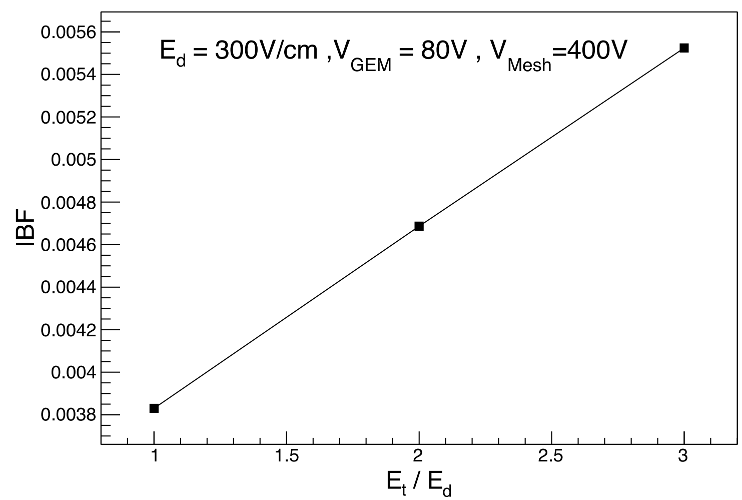
Optimization of Et/Ed

- Et/Ed set to 1-1.5 to control the IBF
- Ed=200V/cm for T2K at the saturation velocity

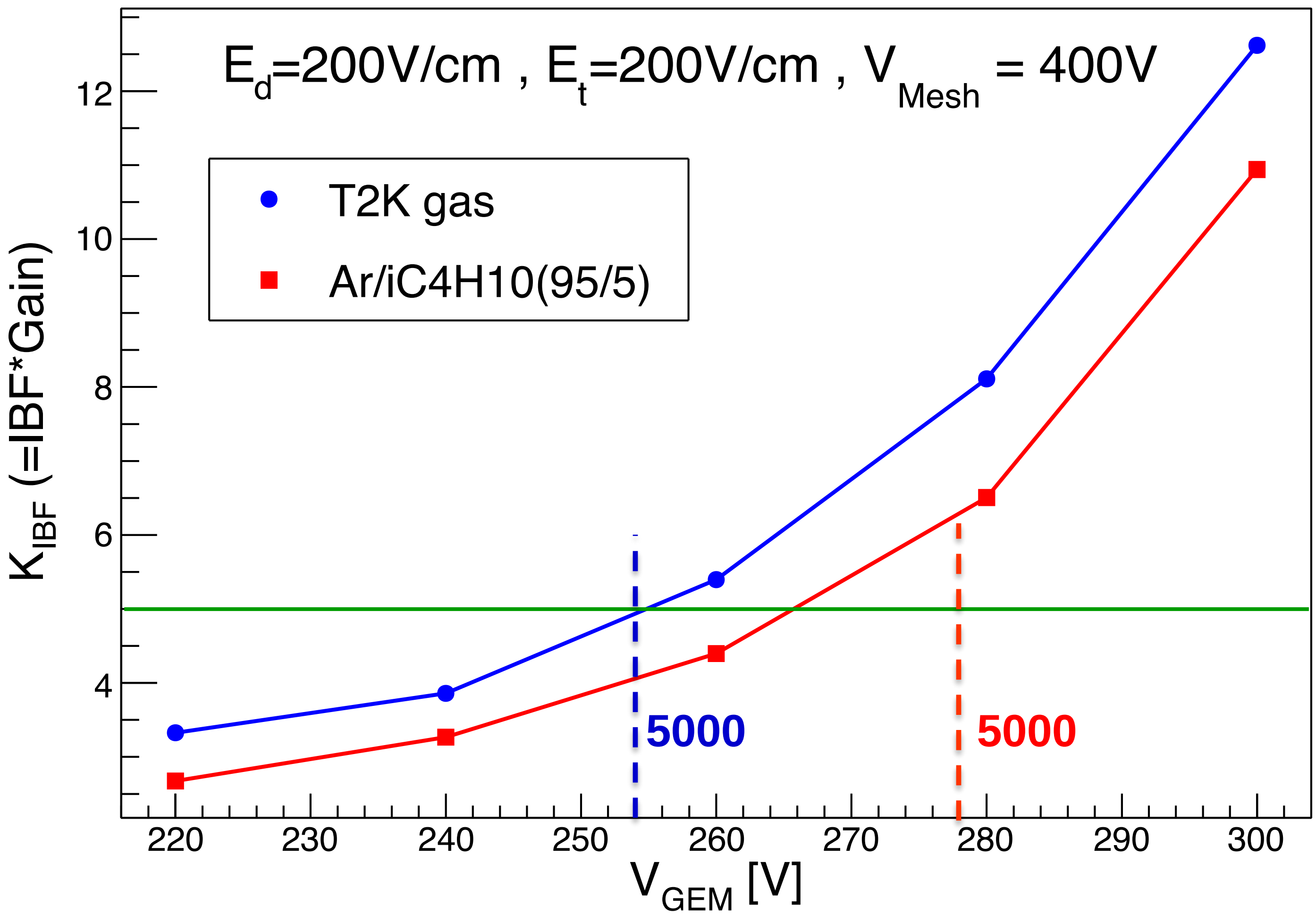








Key IBF factor: IBF × Gain



Status of TPC prototype R&D

Drift velocity @Gas/P/T

Uniformity

Calibration and alignment

Distortion

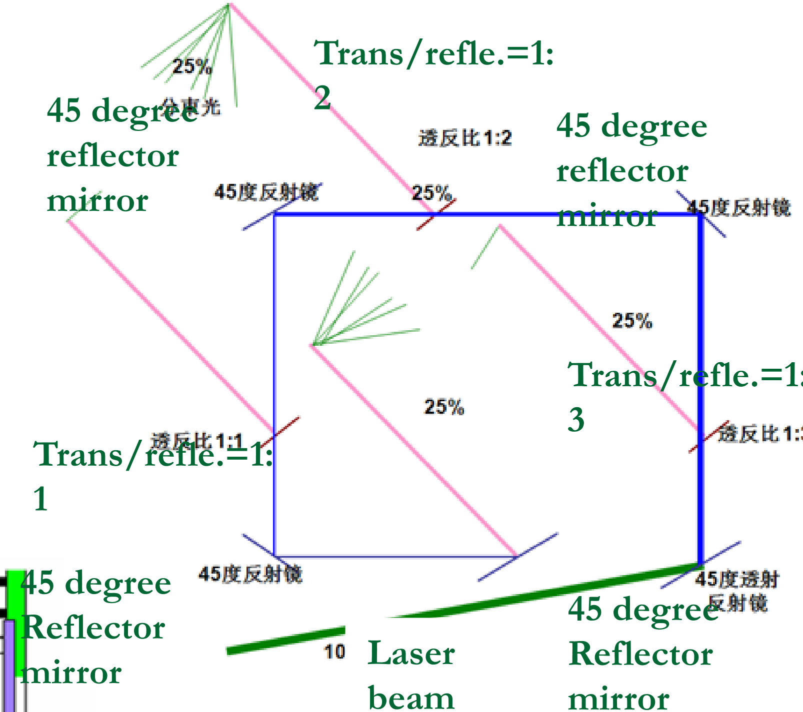
Parameters of the TPC prototype

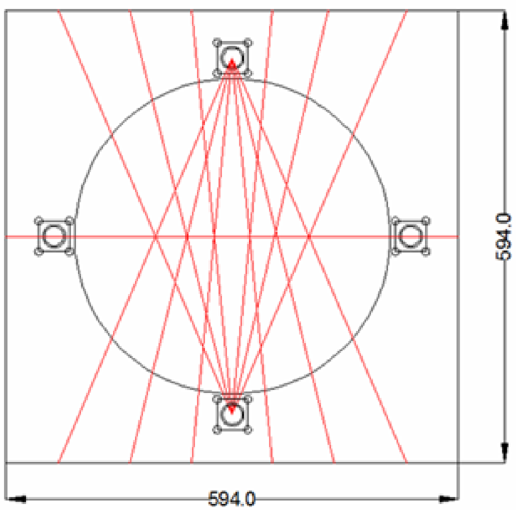
- To aim that the small TPC prototype for the estimation of the distortion due to the IBF, and the study of related physics parameters
- To mimic the bunch structure & the ions distortion with UV light and laser split beam

- Main parameters
  - Drift length: 510mm
  - Readout active area: 200mm×200mm
  - Integrated the laser and UV lamp device
  - Wavelength of laser: 266nm
  - GEMs/Micromegas as the readout
  - Materials: Non-magnetic material (Stainless steel, Aluminum)

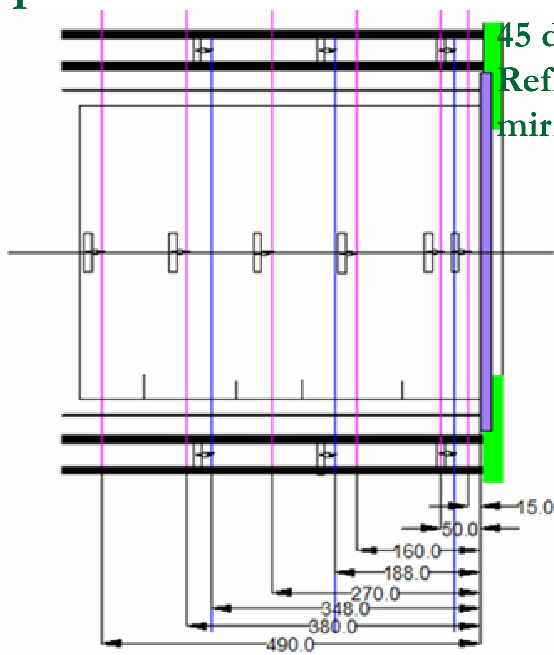
Laser map in drift length

- Size: ~0.85mm×0.85mm
- Transmission and reflection mirrors
- Aluminum board integrated the laser device and supports
- Drift velocity in Z
- Uniformity in X-Y plane

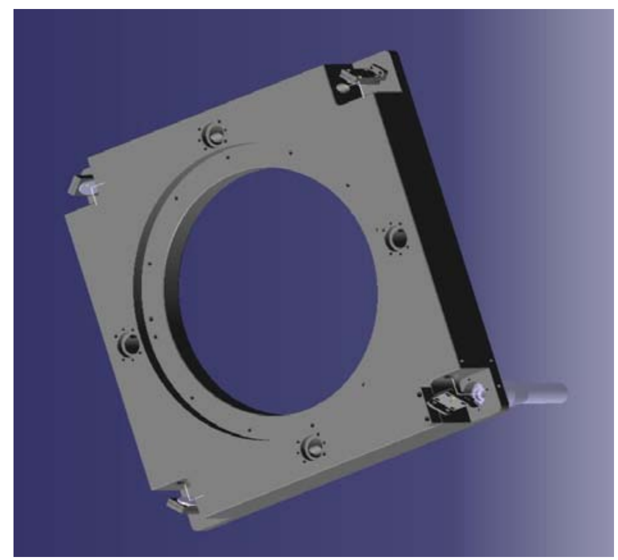




Laser map in X-Y plane



Laser map along Z

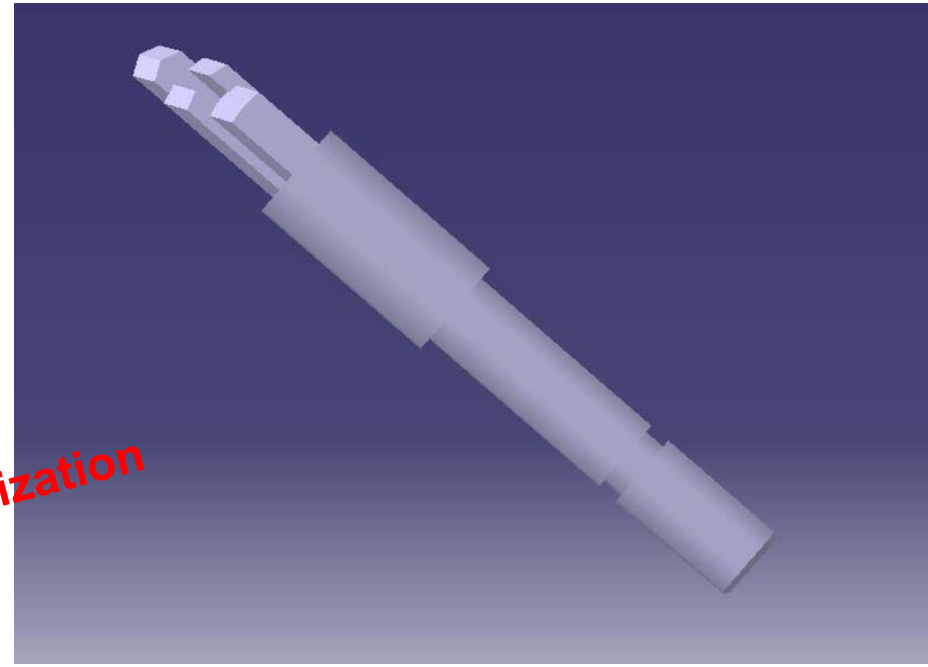


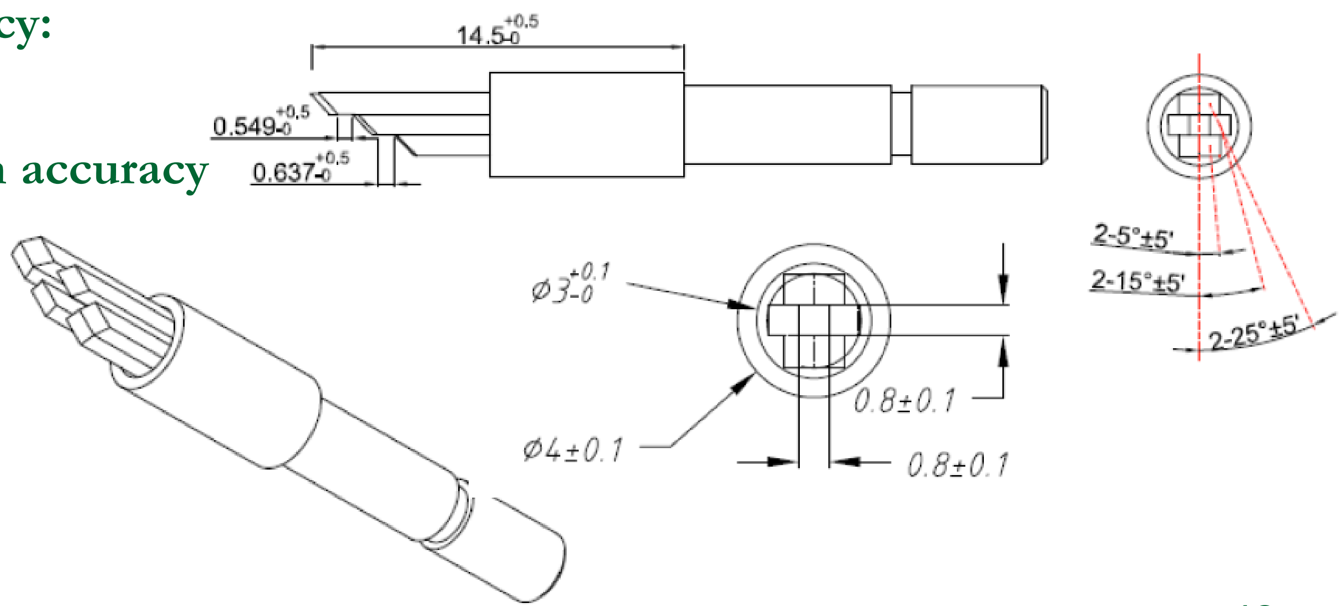
Detector with the laser system

Divide and reflection mirrors

- Laser wave for the divide and reflection mirrors: 266nm
- Size: ~0.8mm×0.8mm
- Number of the divide trackers: 6
- Stainless steel support integrated the laser mirrors
- Reflection efficiency:
  >99%@266nm
- Reflection position accuracy
  1/30 degree

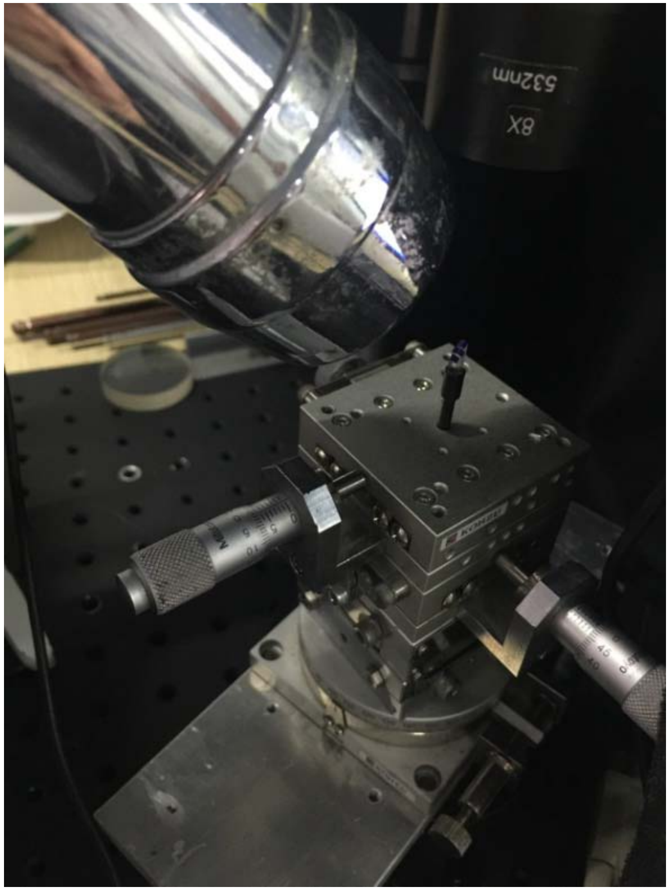
Optimization



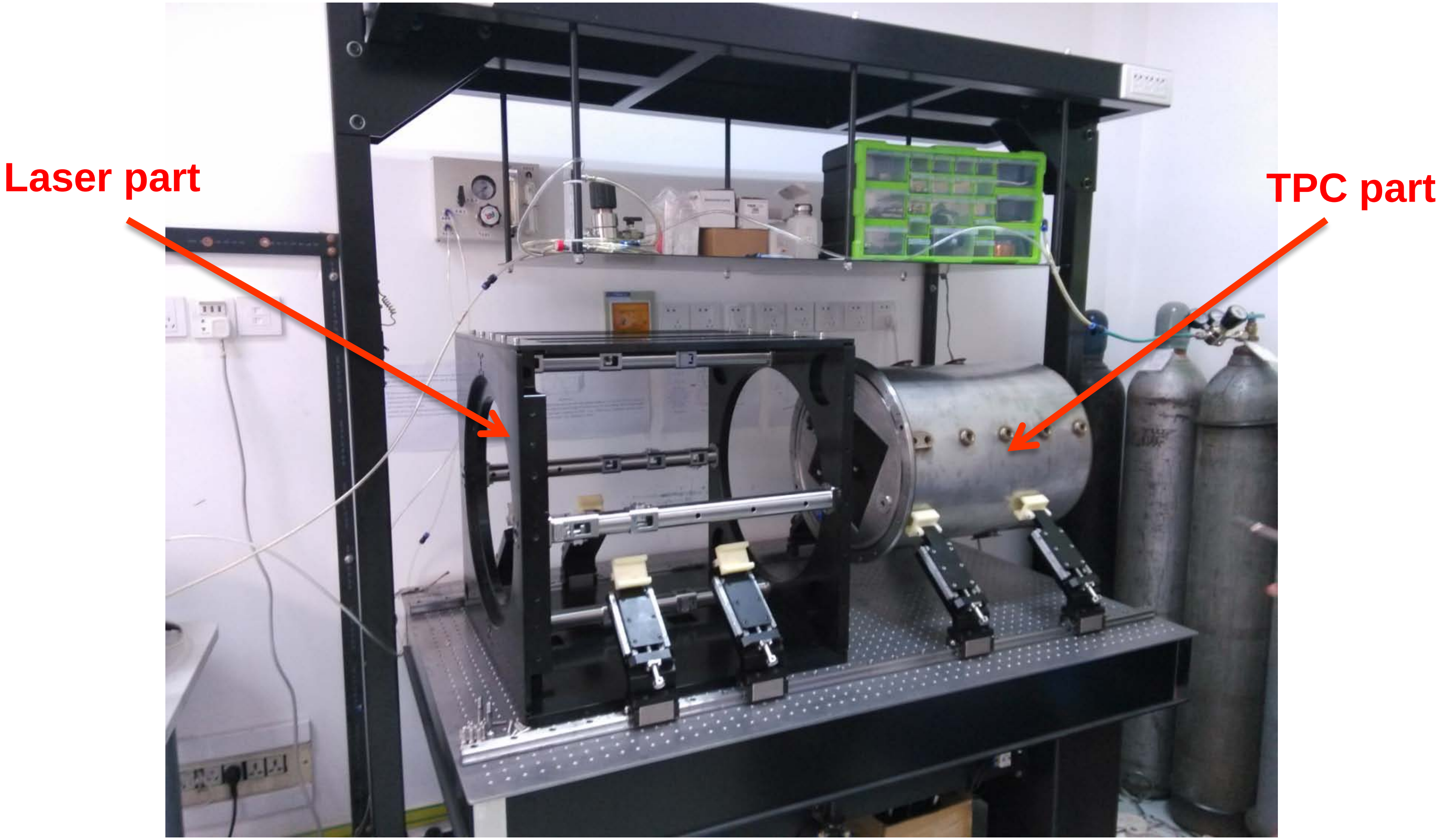


Laser splitting mirrors

Angle accuracy: ~1/60 degree
1 minnte



Design of the prototype

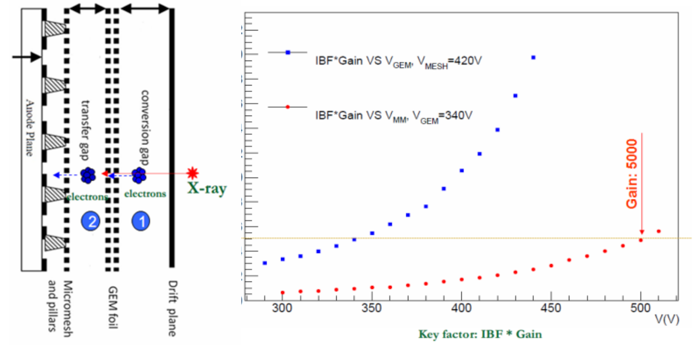


- Support platform: 1200mm×1500mm (all size as the actual geometry)
- TPC barrel mount and re-mount with the Auxiliary brackets
- Readout board (Done), Laser mirror (Done), PCB board (Done)

Summary

Continuous IBF module:

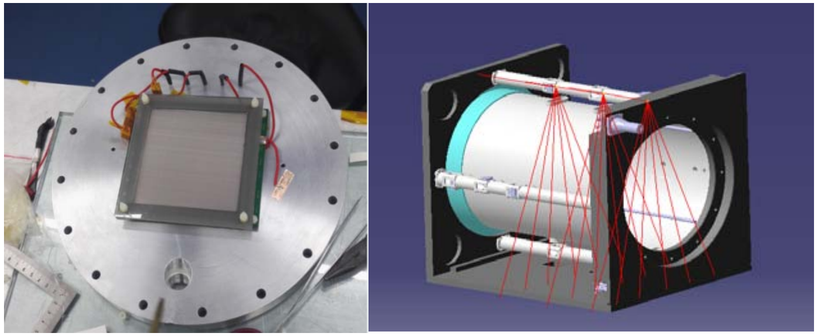
- No Gating device options used for Higgs/Z pole run
- Continuous Ion Back Flow due to the continuous beam structure (Developed in IHEP)
- ~100 μm position resolution in rφ
- Key factor: IBF×Gain=5 and leas than (R&D)
- Low discharge and spark possibility



Continuous IBF prototype and IBF×Gain

Prototype with laser calibration:

- Laser calibration system integrates UV lamp
- Calibrated drift velocity, gain uniformity, ions back in chamber
- Prototype has been developed with laser (IHEP and Tsinghua)_
- Nd:YAG laser device@266nm, 42 separated laser beam along 510mm drift length



TPC prototype integrated with laser system

Thanks.