Status of TPC prototype integrated with UV laser

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Outline

- Motivation
- IBF suppression R&D
- TPC prototype R&D
- Summary

Motivation

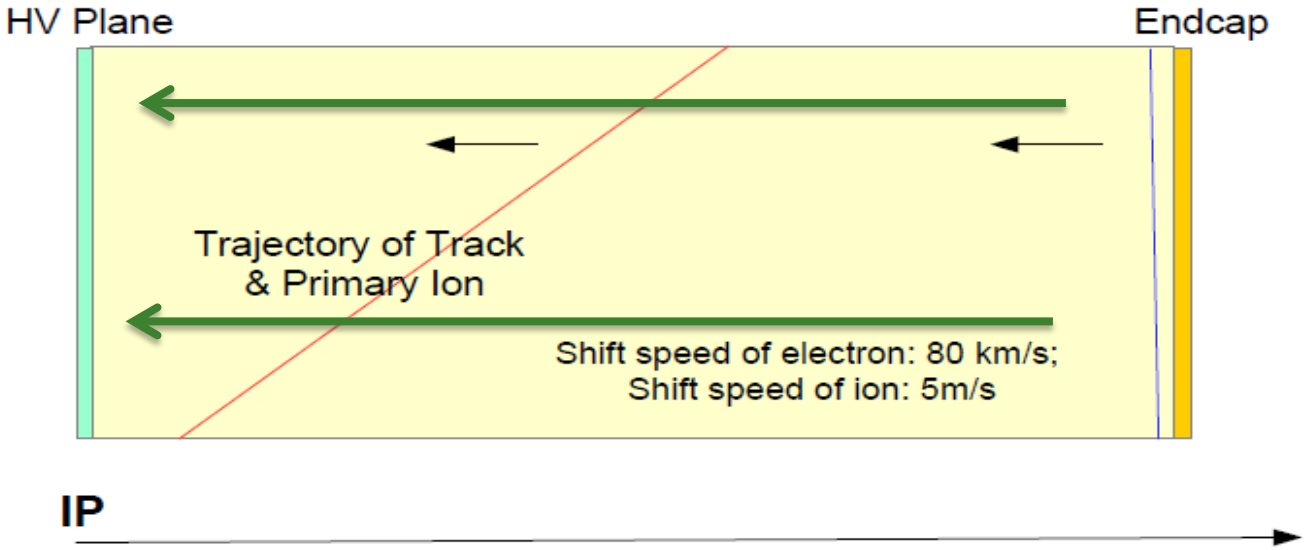
TPC limitations for Z

- Ions back flow in chamber
- Calibration and alignment
- Low power consumption FEE ASIC chip

Updated Parameters of Collider Ring since CDR

	Higgs		Z (2T)	
	CDR	Updated	CDR	Updated
Beam energy (GeV)	120	-	45.5	-
Synchrotron radiation loss/turn (GeV)	1.73	1.68	0.036	-
Piwinski angle	2.58	3.78	23.8	33
Number of particles/bunch N_e (10^{10})	15.0	17	8.0	15
Bunch number (bunch spacing)	242 (0.68μs)	218 (0.68μs)	12000	15000
Beam current (mA)	17.4	17.8	461.0	1081.4
Synchrotron radiation power /beam (MW)	30	-	16.5	38.6
Cell number/cavity	2	-	2	1
β function at IP β_x^* / β_y^* (m)	0.36/0.0015	0.33/0.001	0.2/0.001	-
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	1.21/0.0031	0.89/0.0018	0.18/0.0016	-
Beam size at IP σ_x/σ_y (μm)	20.9/0.068	17.1/0.042	6.0/0.04	-
Bunch length σ_z (mm)	3.26	3.93	8.5	11.8
Lifetime (hour)	0.67	0.22	2.1	1.8
Luminosity/IP L (10^{34} cm^{-2}s^{-1})	2.93	5.2	32.1	101.6

Luminosity increase factor: × 1.8 × 3.2

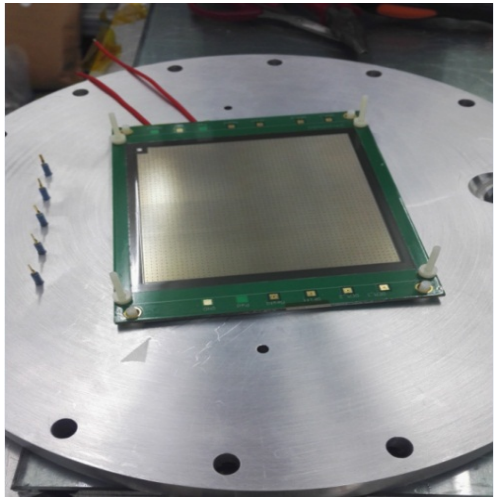


TPC detector concept

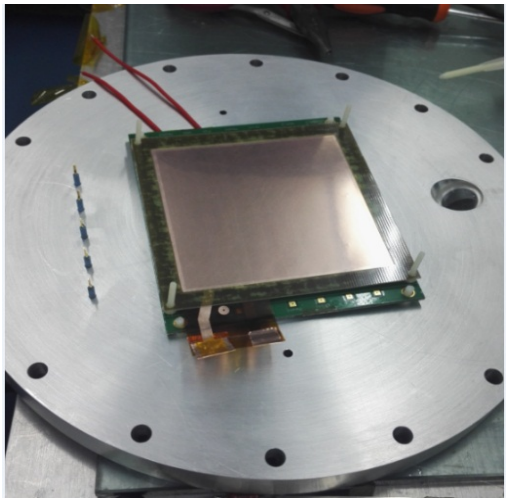
- IBF suppression R&D

TPC detector module@ IHEP

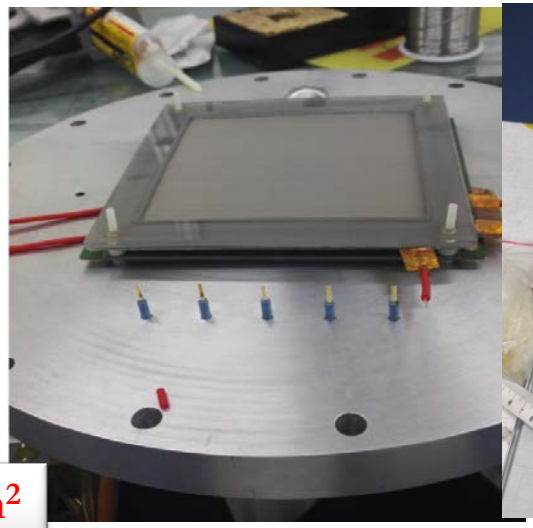
- Study with GEM-MM module
  - New assembled module
  - Active area: 100mm×100mm
  - X-tube ray and 55Fe source
  - Bulk-Micromegas assembled from Saclay
  - Standard GEM from CERN
  - Avalanche gap of MM:128μm
  - Transfer gap: 2mm
  - Drift length:2mm~200mm
  - pA current meter: Keithley 6517B
  - Current recording: Auto-record interface by LabView
  - Standard Mesh: 400LPI
  - High mesh: 508 LPI



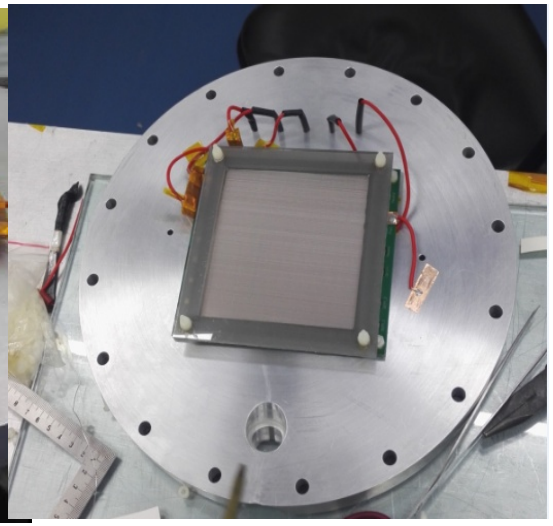
Micromegas



GEM



Cathode with mesh

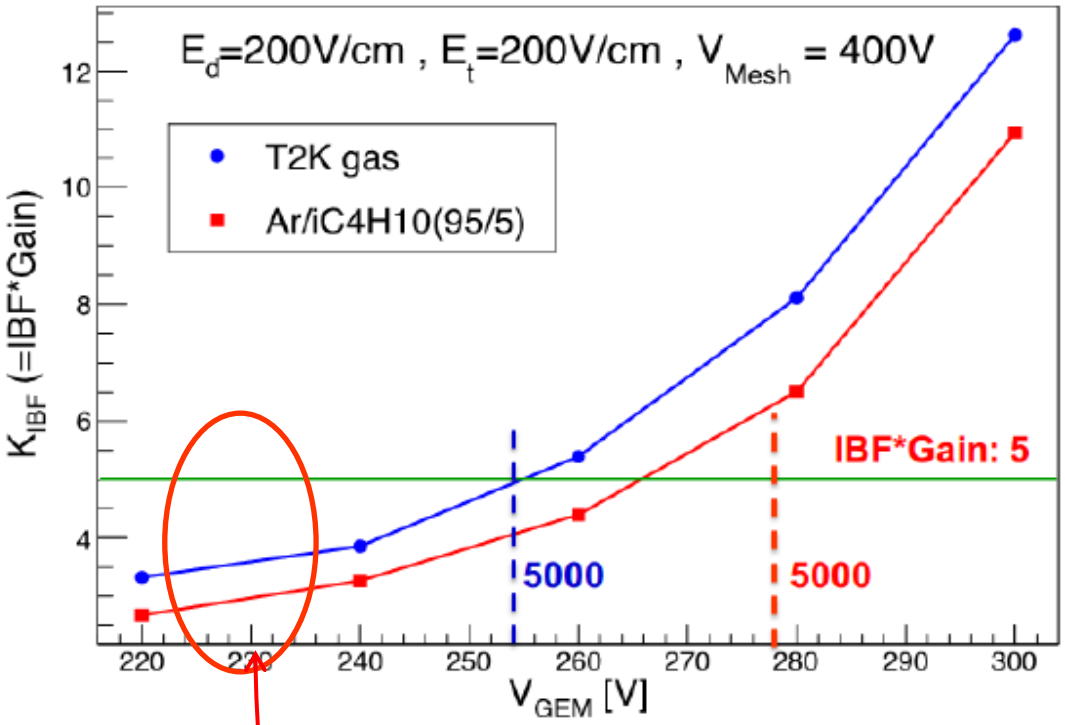


GEM-MM Detector

$50\times50mm^2$	$100\times100mm^2$	$200\times200mm^2$
2015-2016	2017-2018	2019-

GEM+MM

Micronegas + GEM detector module @IHEP



- IBF×Gain has the limitation ratio from the detector R&D at high gain.
- Lower gain and lower IBF ratio

IBF suppression R&D

- UV lamp measurement
  - Added a new voltage controller
  - pA current meter from Keithley
  - First step test about the current in mesh
  - E_drift: 10~175V/cm
  - ~43pA@175V/cm
  - Stable current with UV light
  - ~200V/cm@T2K operation gas

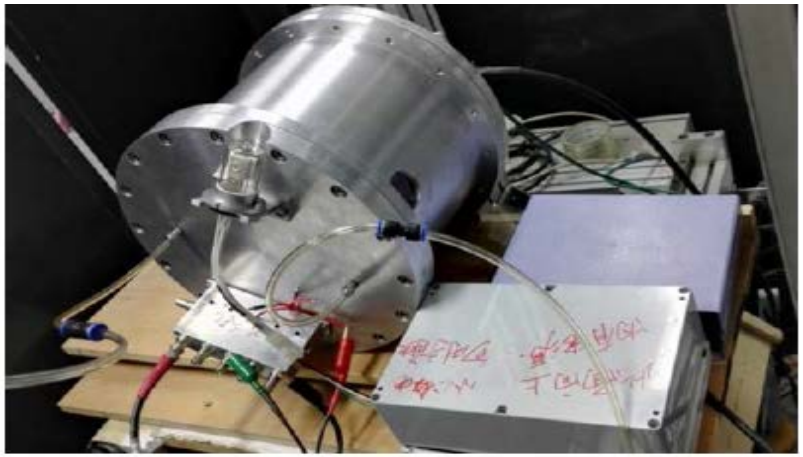
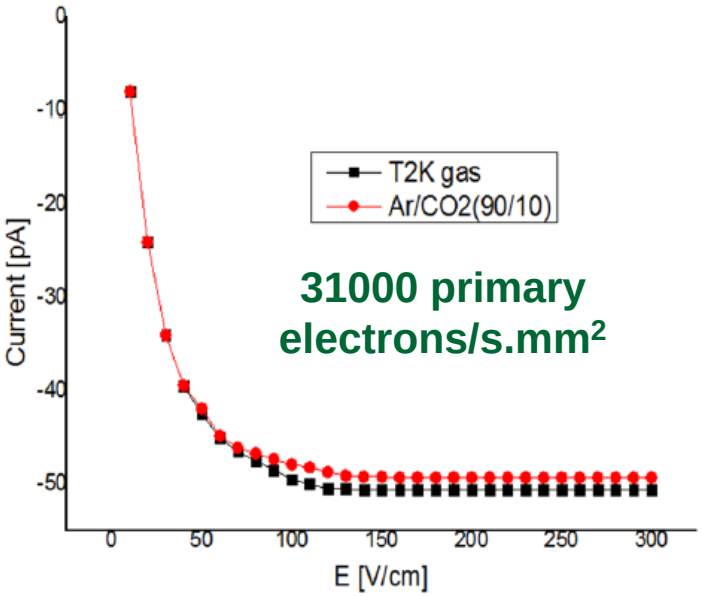
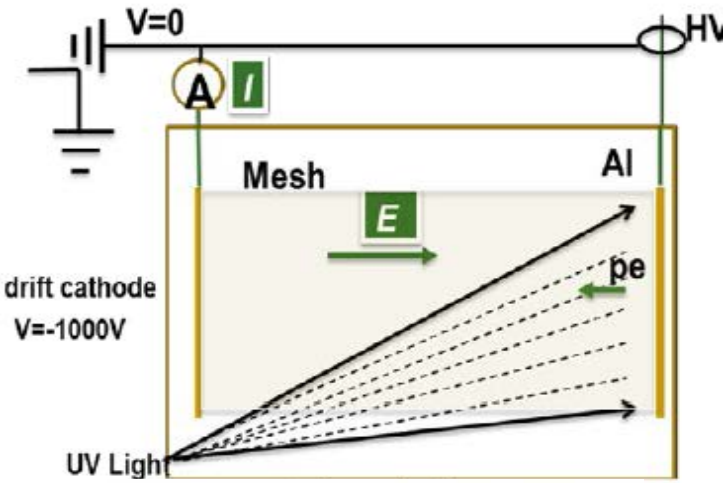


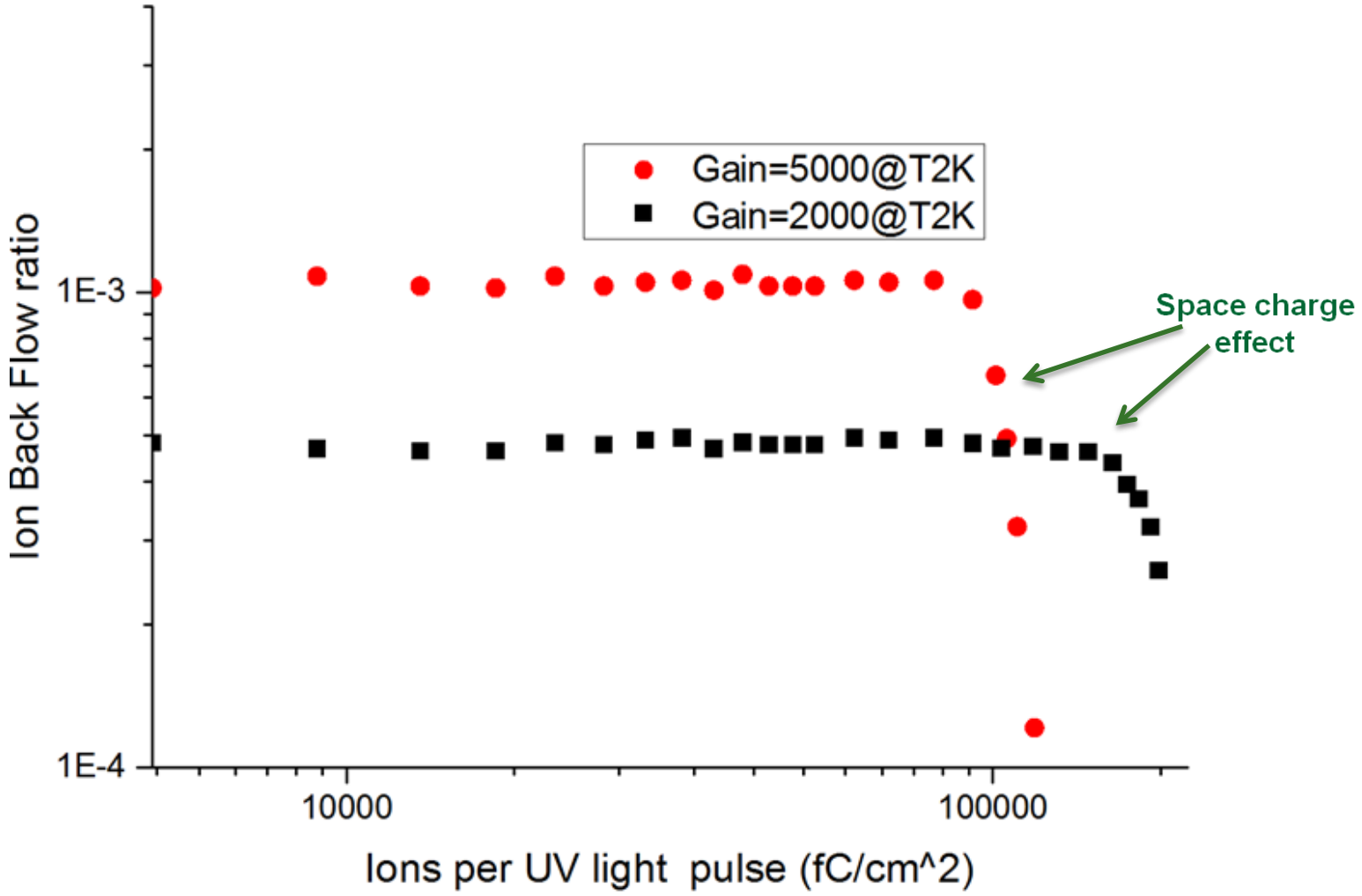
Photo of the test



Current with UV light



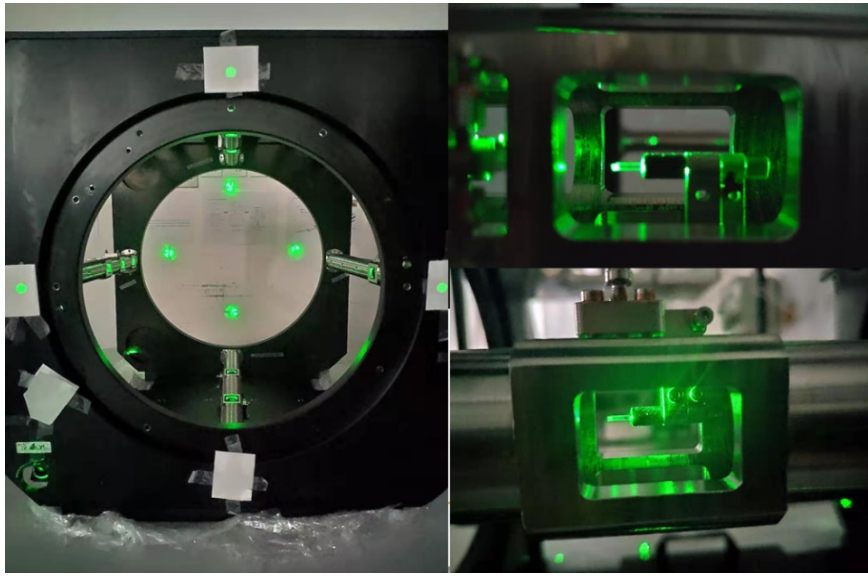
Space charge effect at the different gain

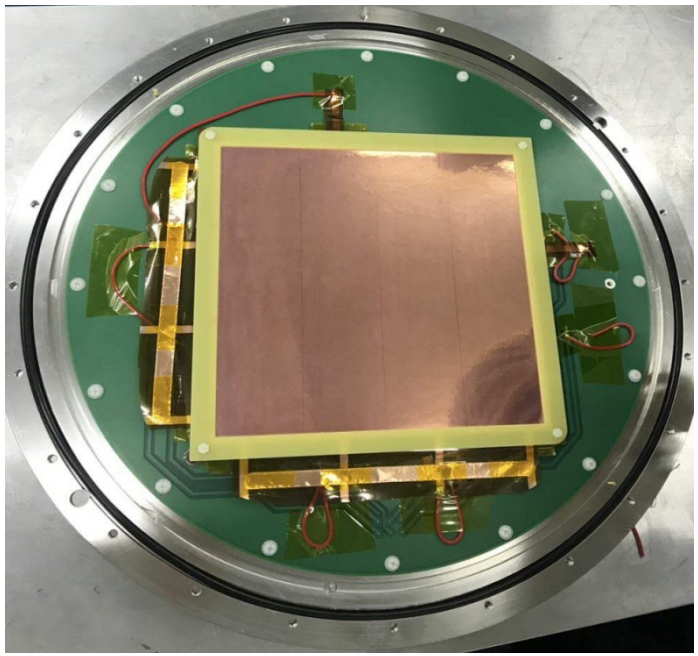


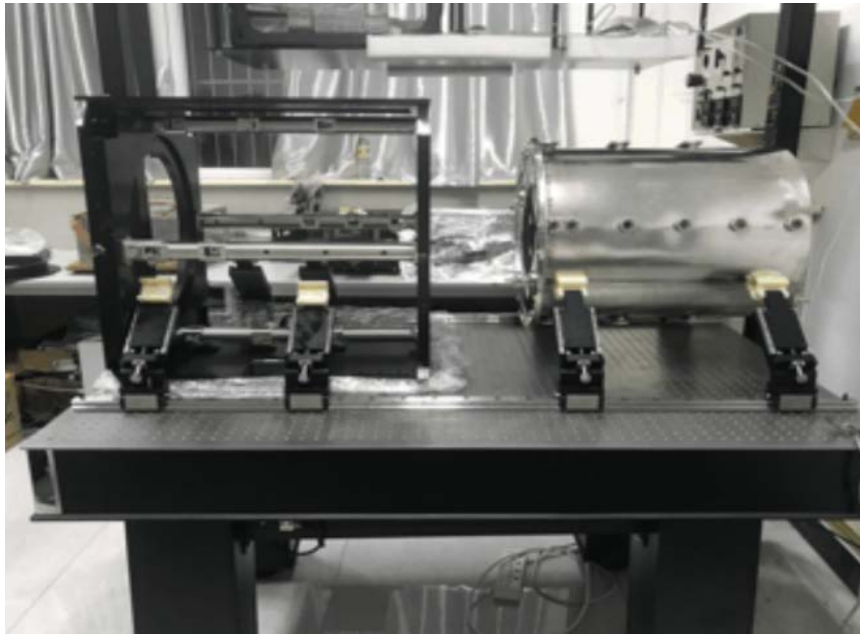
- **TPC prototype R&D**

TPC detector prototype

- Study of TPC prototype with 42 UV laser beams
- Main parameters
  - Drift length: ~500mm, Active area: 200mm^2
  - Integrated 266nm laser beam
  - GEMs/Micromegas as the readout





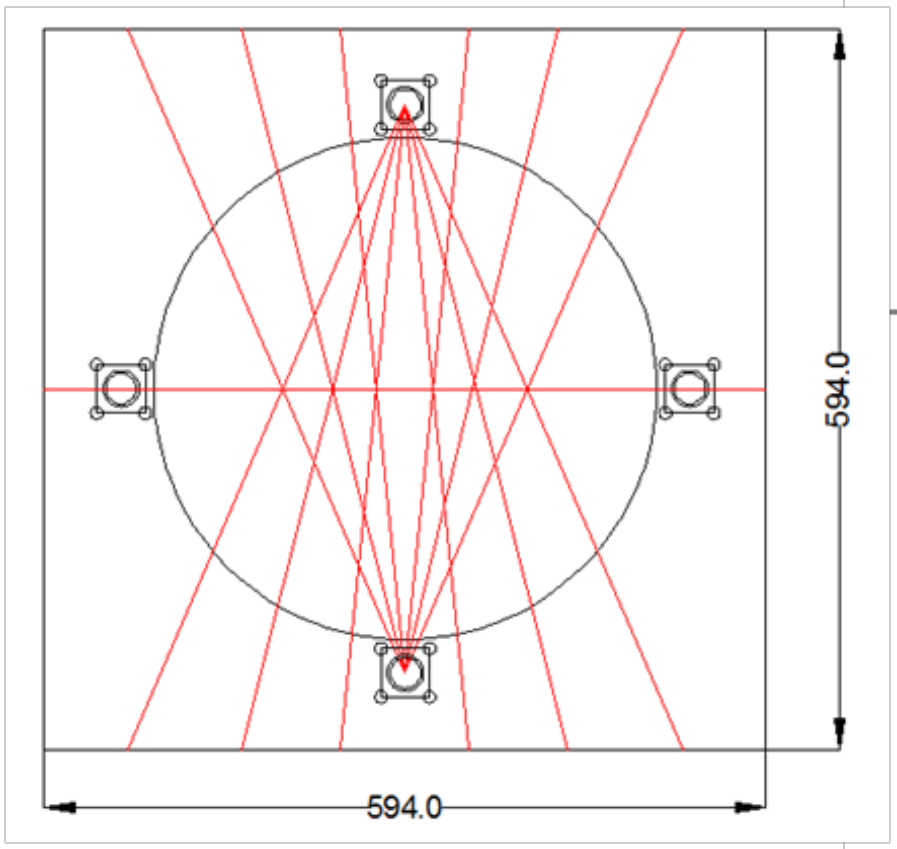


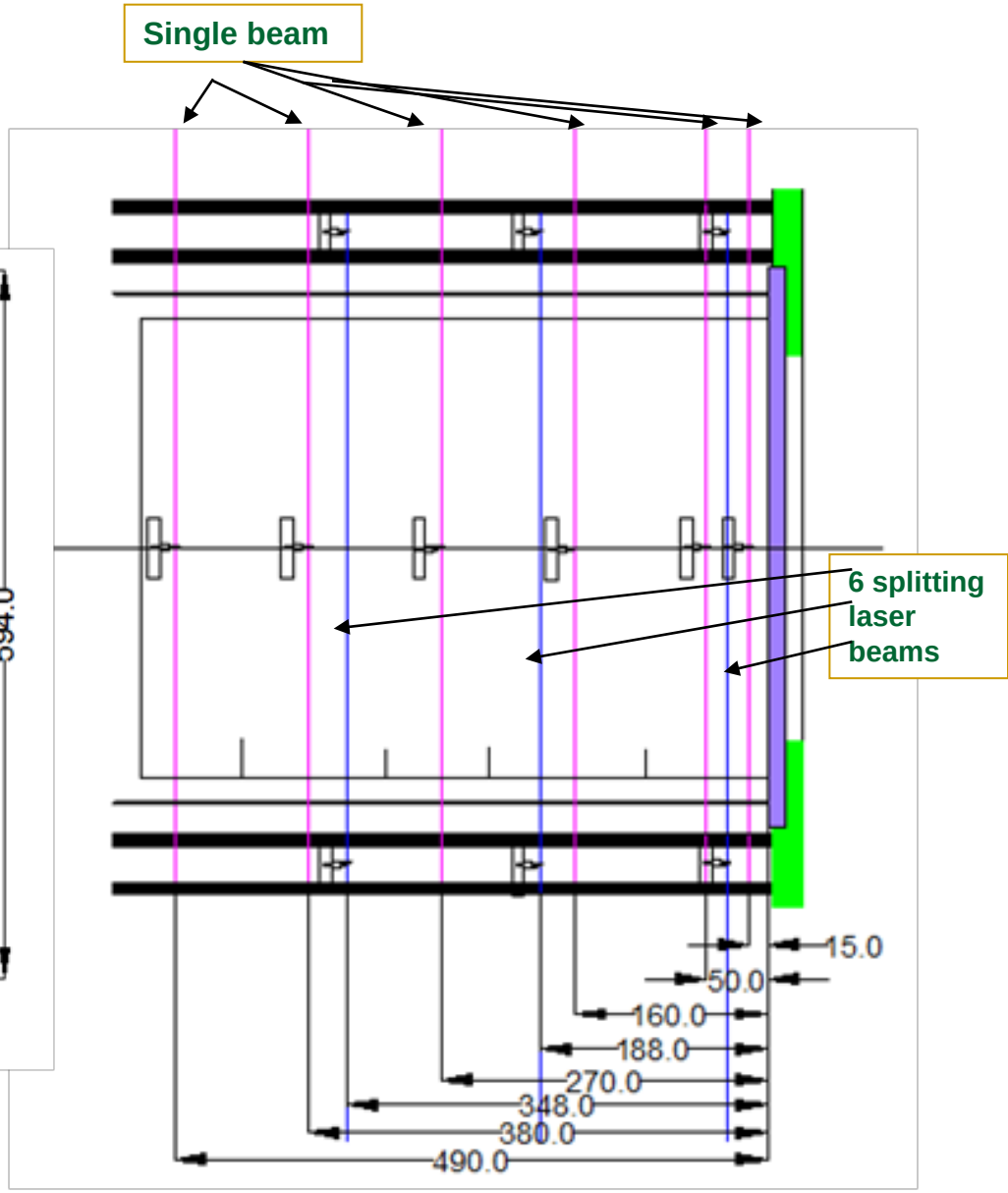
Electronics and DAQ

- Amplifier and FEE
  - CASAGEM chip
  - 16Chs/chip
  - 4chips/Board
  - Gain: 20mV/fC
  - Shape time: 20ns
- DAQ
  - FPGA+ADC
  - 4 module/board
  - 64Chs/module
  - Sample: 40MHz
  - 1280chs

FEE Electronics and DAQ setup photos

Layout of UV beams

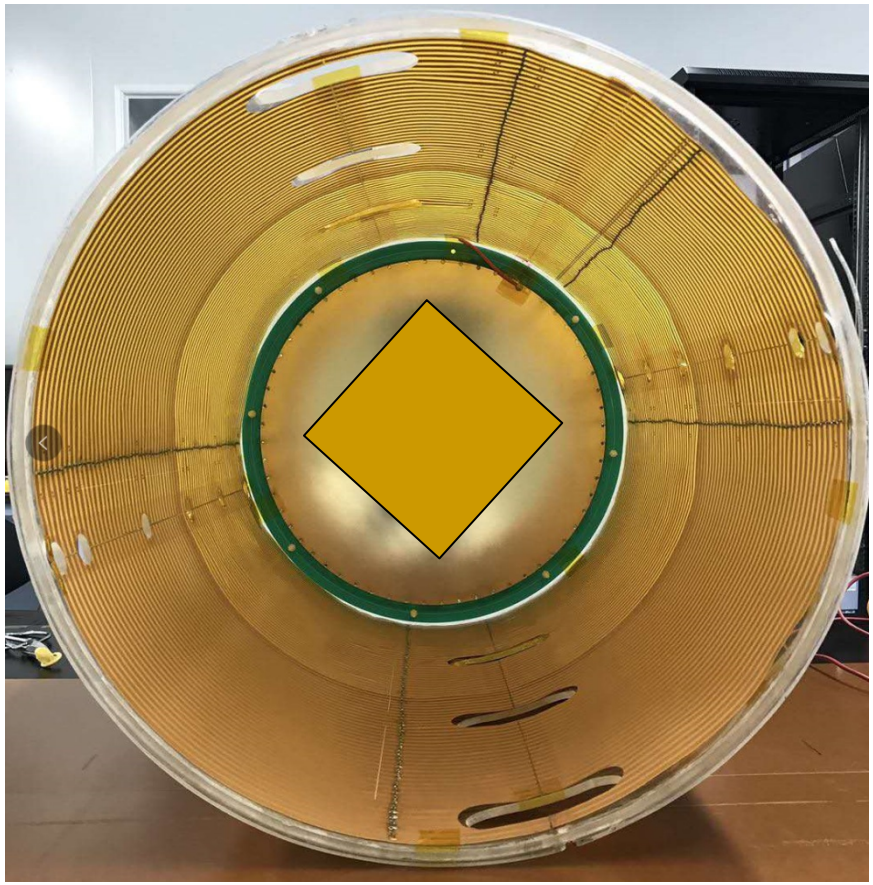




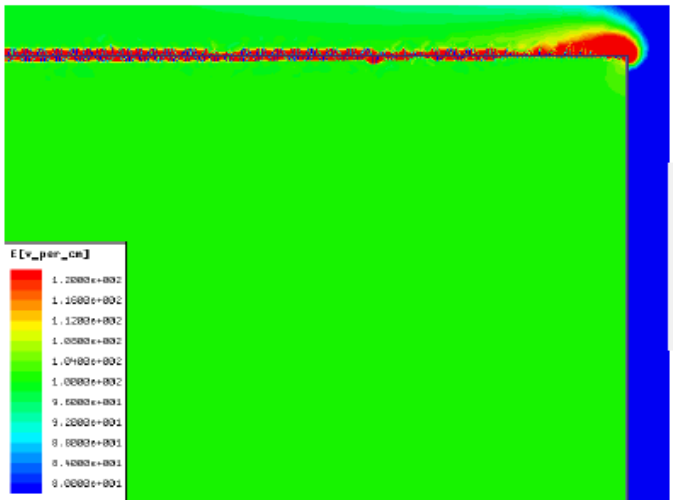
Laser map in X-Y direction

Laser map along drift length

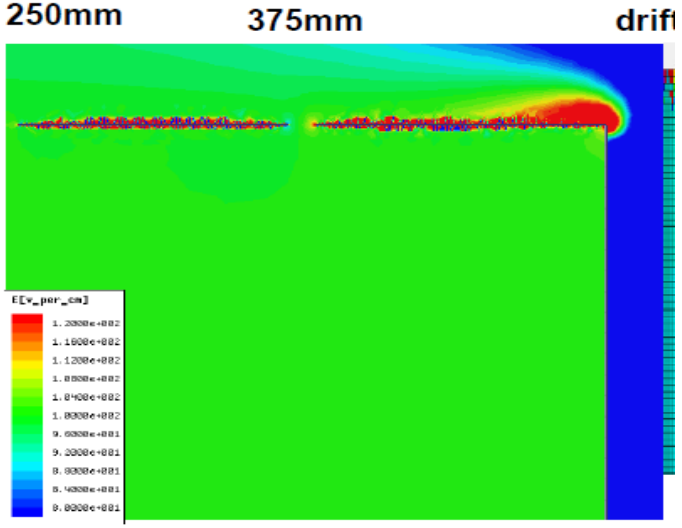
Fieldcage-1



Without hole along drift length



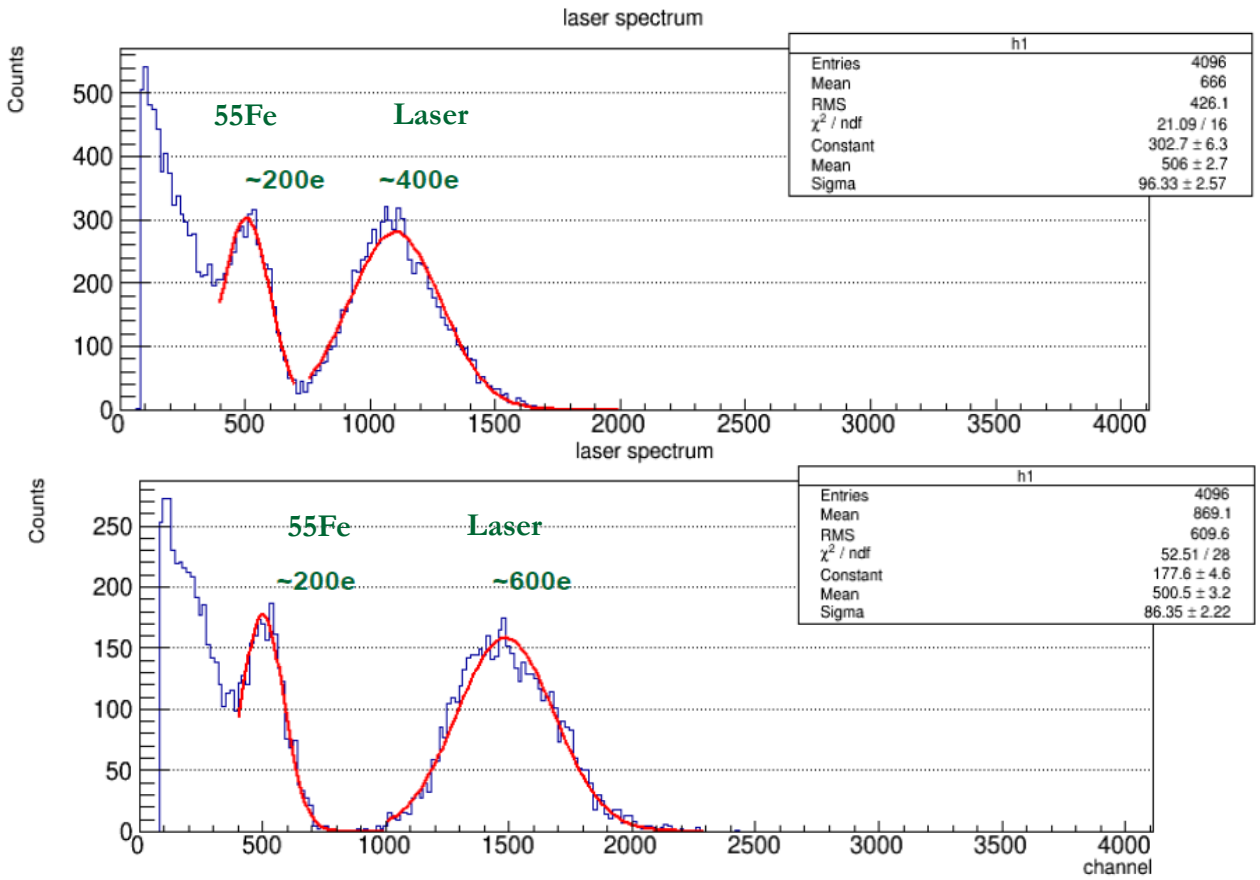
With Ø20mm hole along drift length



Simulation

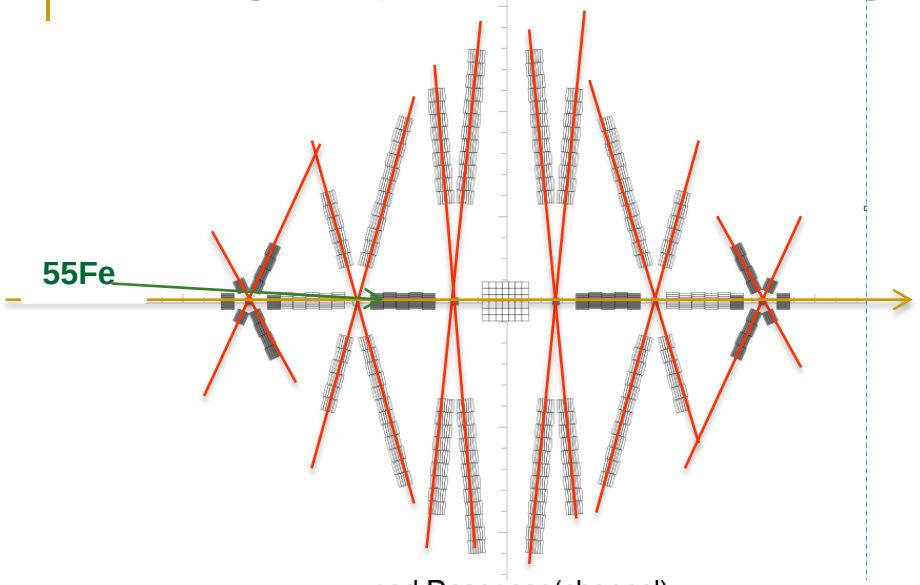
- Hole size VS length of less than 99% of electric field
- <12mm of hole size in this prototype along drift length

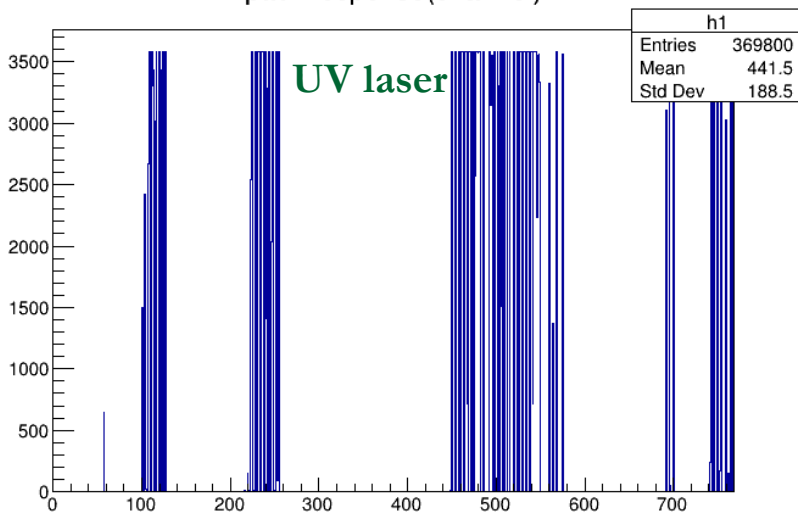
Comparison of UV laser and 55Fe



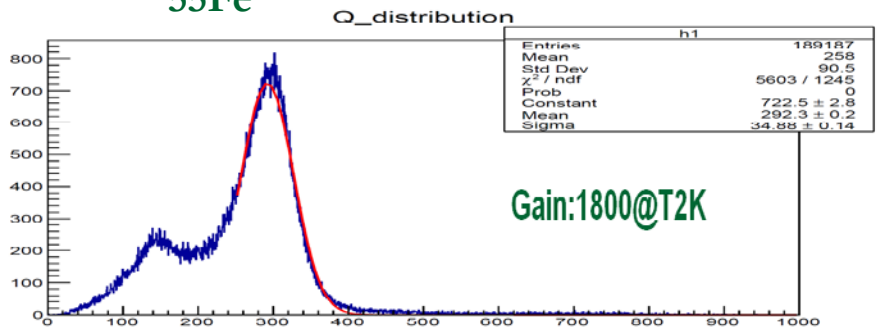
- Same test conditions:
  - Working gases:T2K
  - High voltage

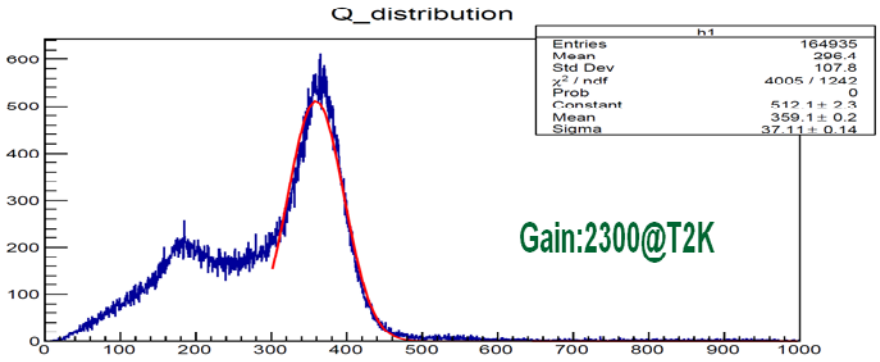
Energy spectrum@T2K gas

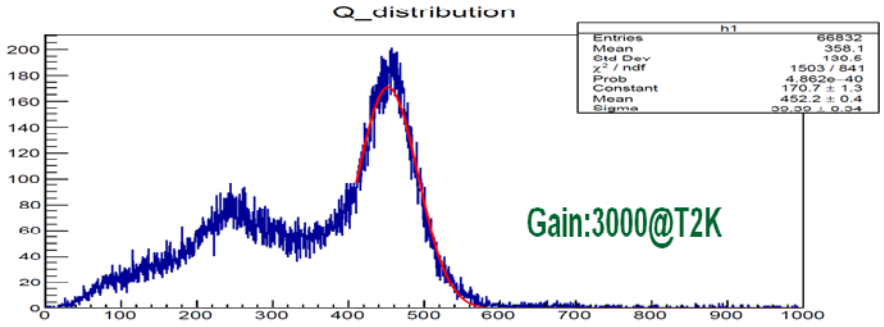




55Fe

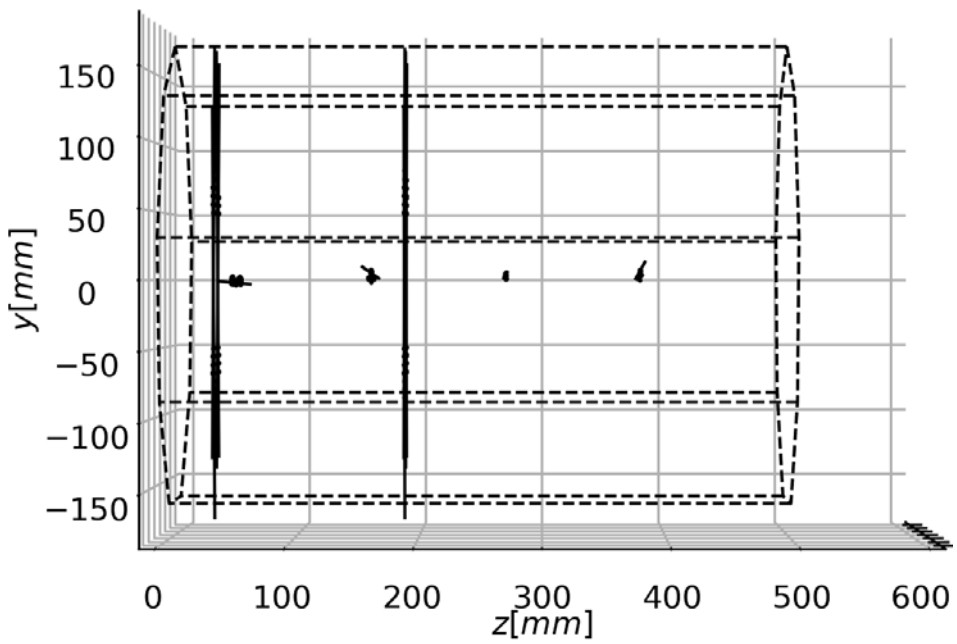


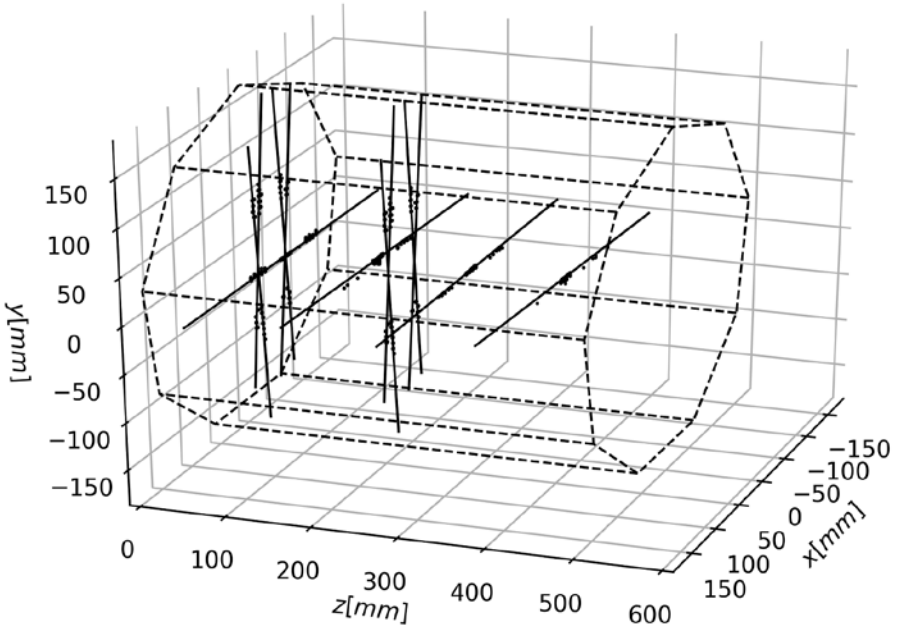




All pads response and energy spectrum @laser and 55Fe

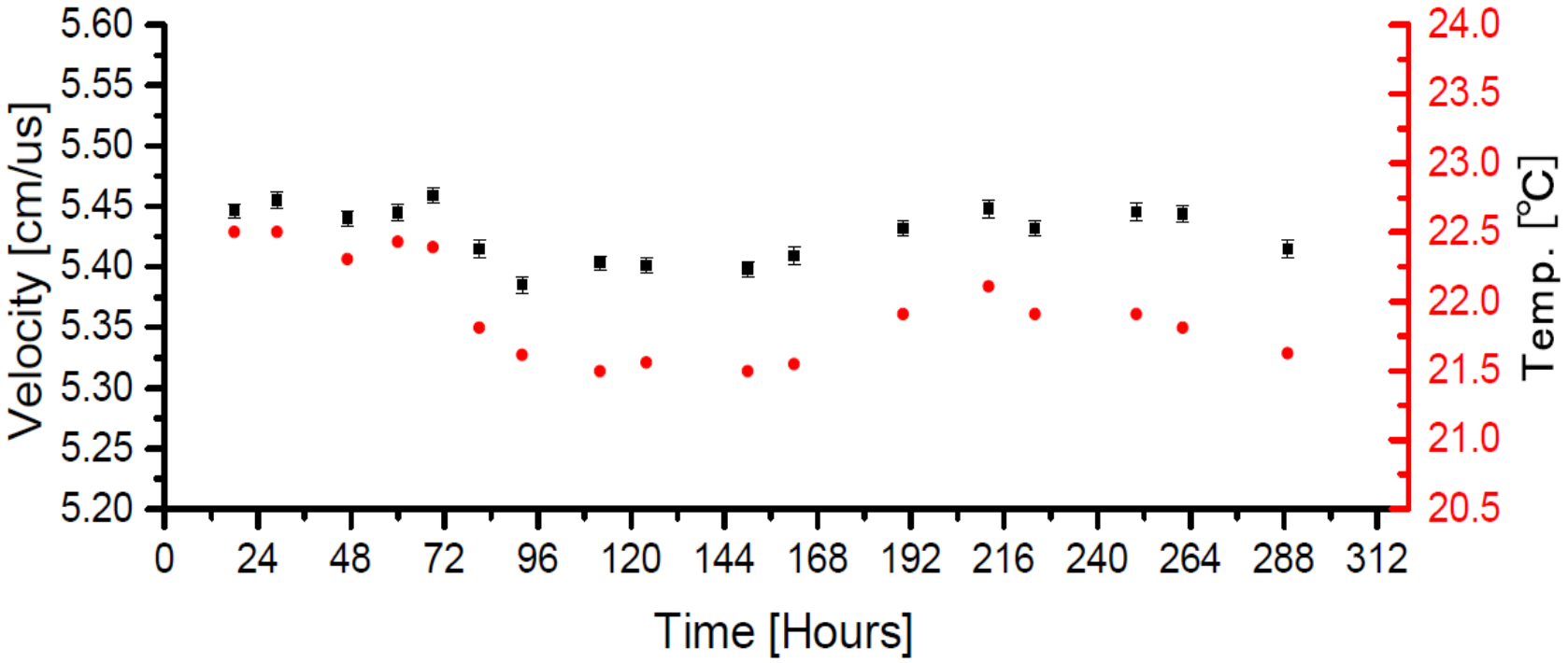
Laser tracks in chamber@T2K gas





- Same of working gas@T2K, same of high voltage, same of test conditions
- Different of GEMs@ 320V
- Triple GEMs to double GEMs
- No discharge

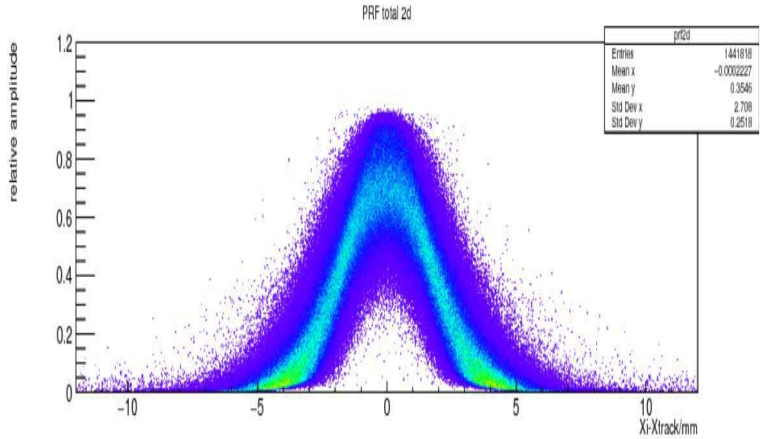
Drift velocity

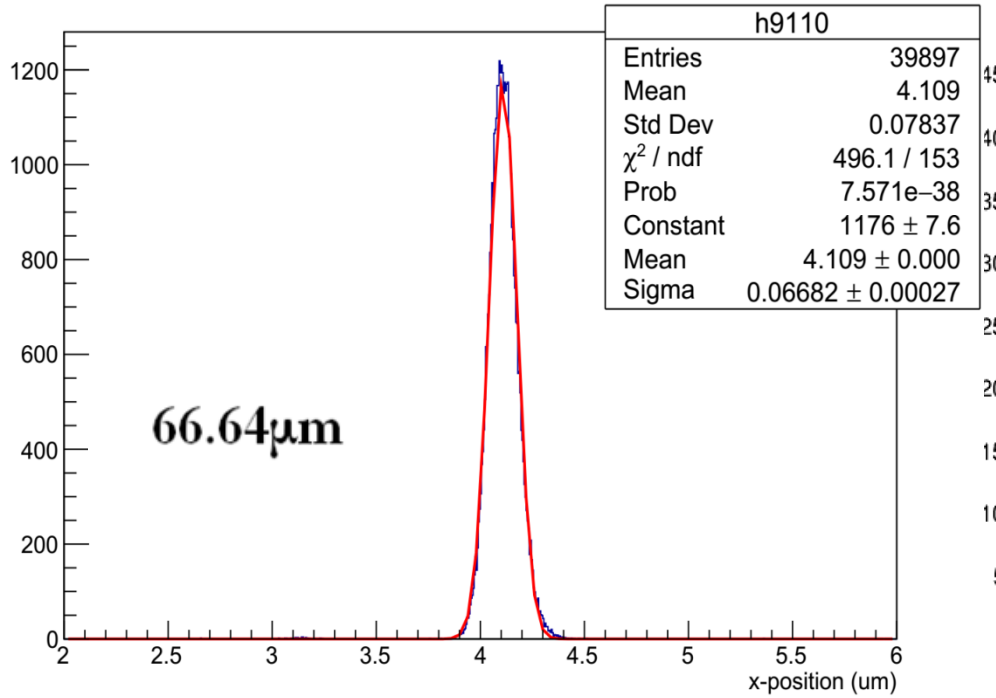


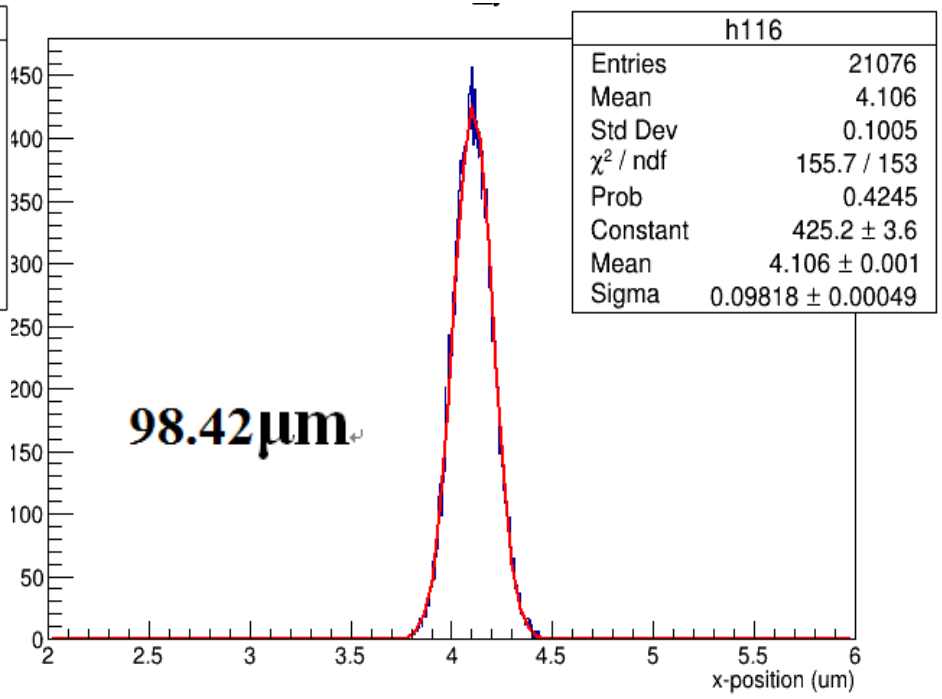
- Two weeks of continuous testing
- Room temperature recorded
- Comparison of the drift velocity and the temperature

Space resolution

$$PRF(x,r,w) = \frac{\exp[-4\ln 2(1-r)x^2/w^2]}{1+4rx^2/w^2}$$

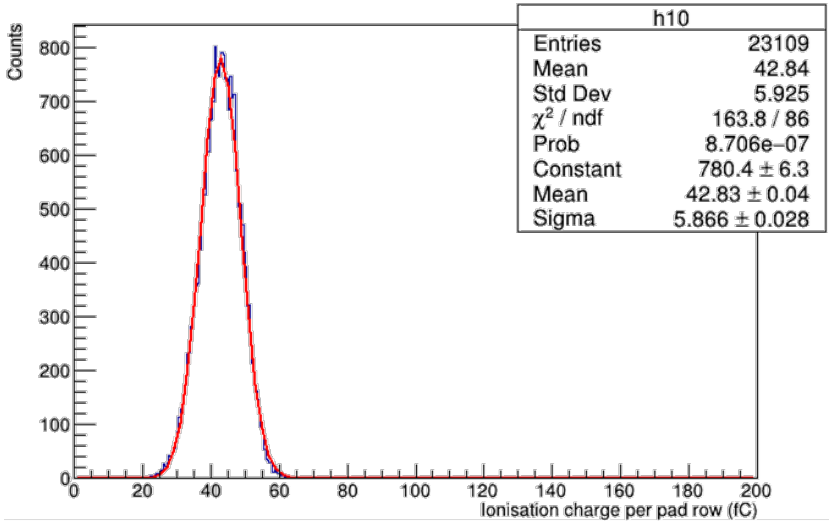




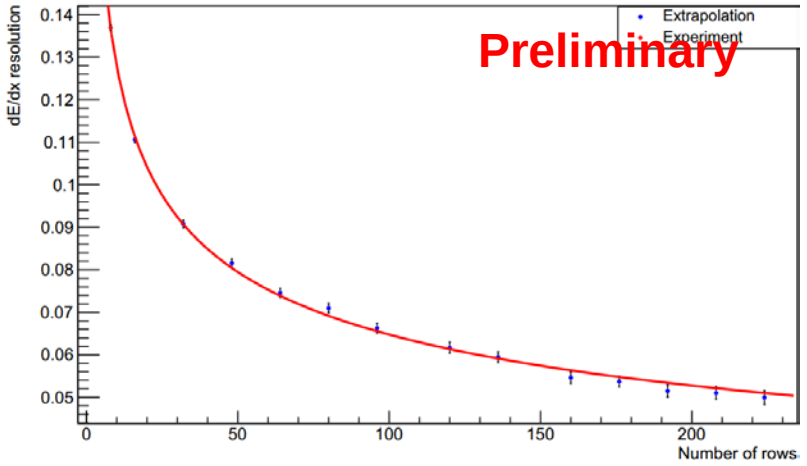


Space resolution at the different drift length

dE/dx by 266nm UV laser @IHEP



Energy spectrum of the Gaussian UV laser



Experimental study result using laser and expanded to CEPC TPC

4.91% by UV laser

Summary

- Some motivations of TPC detector for collider at Z pole run listed.
- Some update results and performance of IBF, dE/dx, drift velocity listed.
- UV laser will be very helpful in the TPC module and prototype R&D .

Thanks for your attention.