Some results of TPC prototype integrated with 266nm UV laser

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Outline

- **TPC prototype**

- **Analysis and results**

- **Spatial resolution and C_d/N_{eff}**

- **Cooling device for ASIC**

Achievements and prospects

❑ **Detector prototype was almost perfectly done and working in 2020**

❑ **Commissioning:**
  Huirong Qi, Zhiyang Yuan, Yiming Cai, Yue Chang, Jiang Zhang, Yulan Li, Zhi Deng

❑ **Data taking:** the same, plus: **Hongyu Zhang, Ye Wu**

❑ **Compared with some previous LCTPC R&D, good results of the drift velocity , the spatial resolution and FEE electronics were observed**
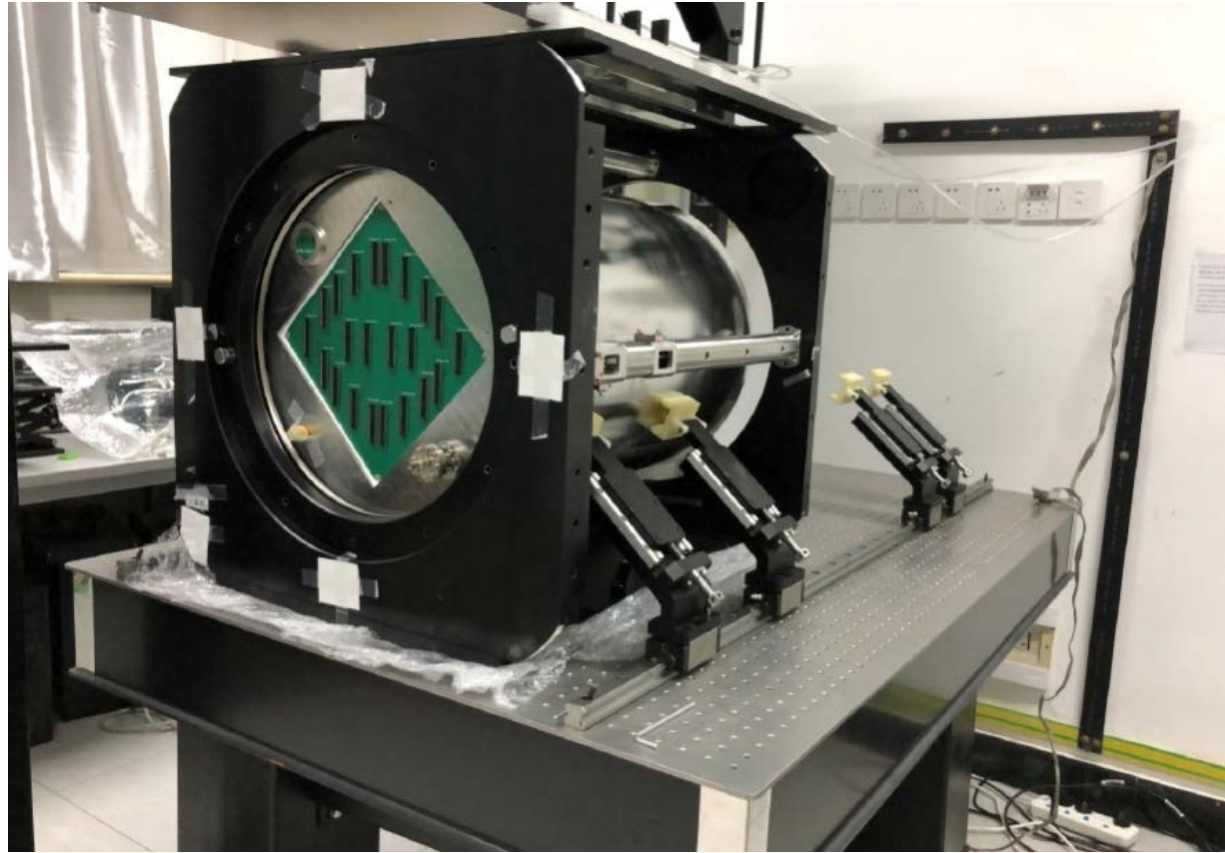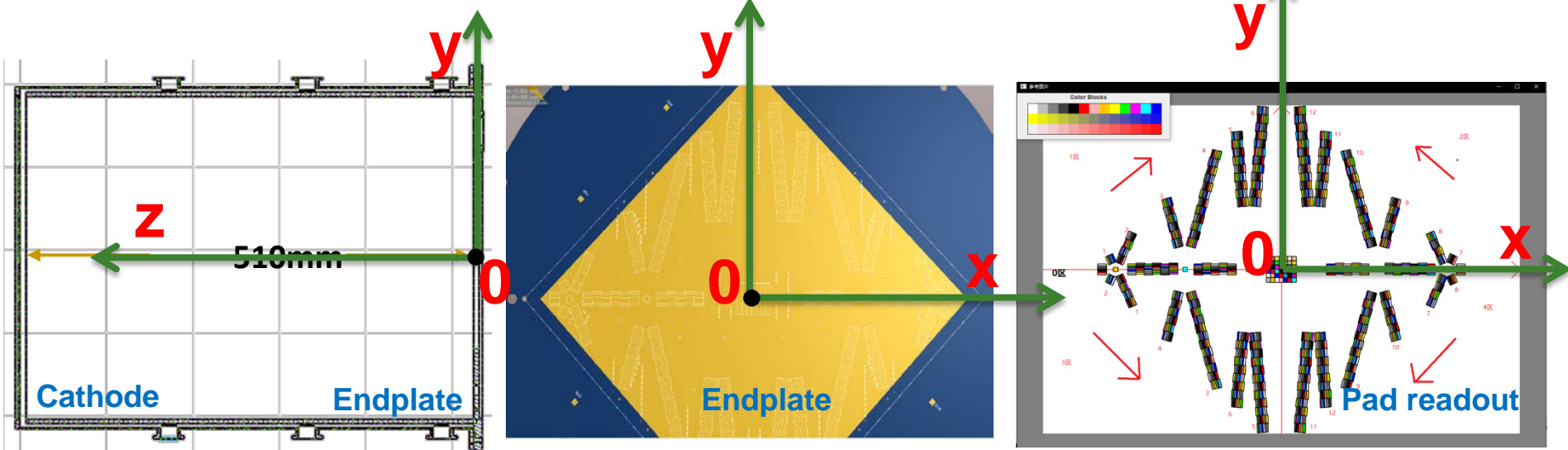

TPC prototype in the lab

Endplate and field cage
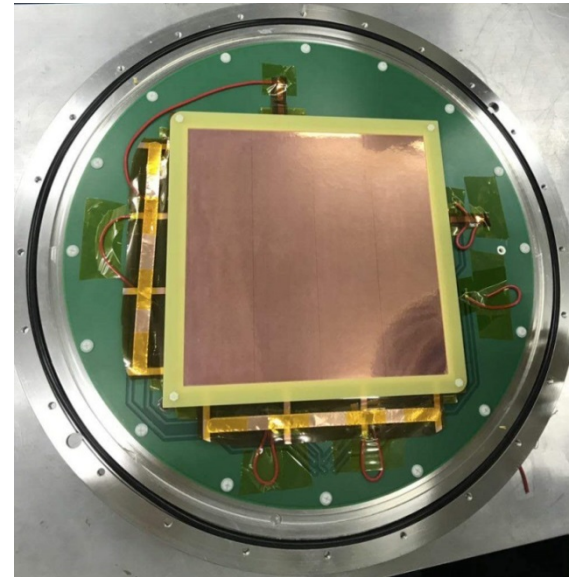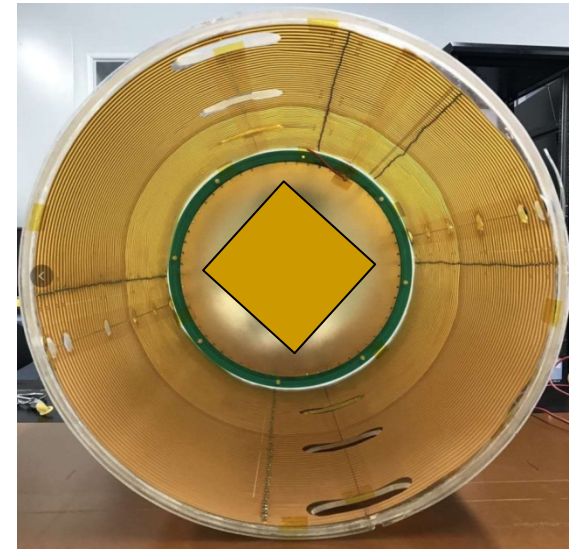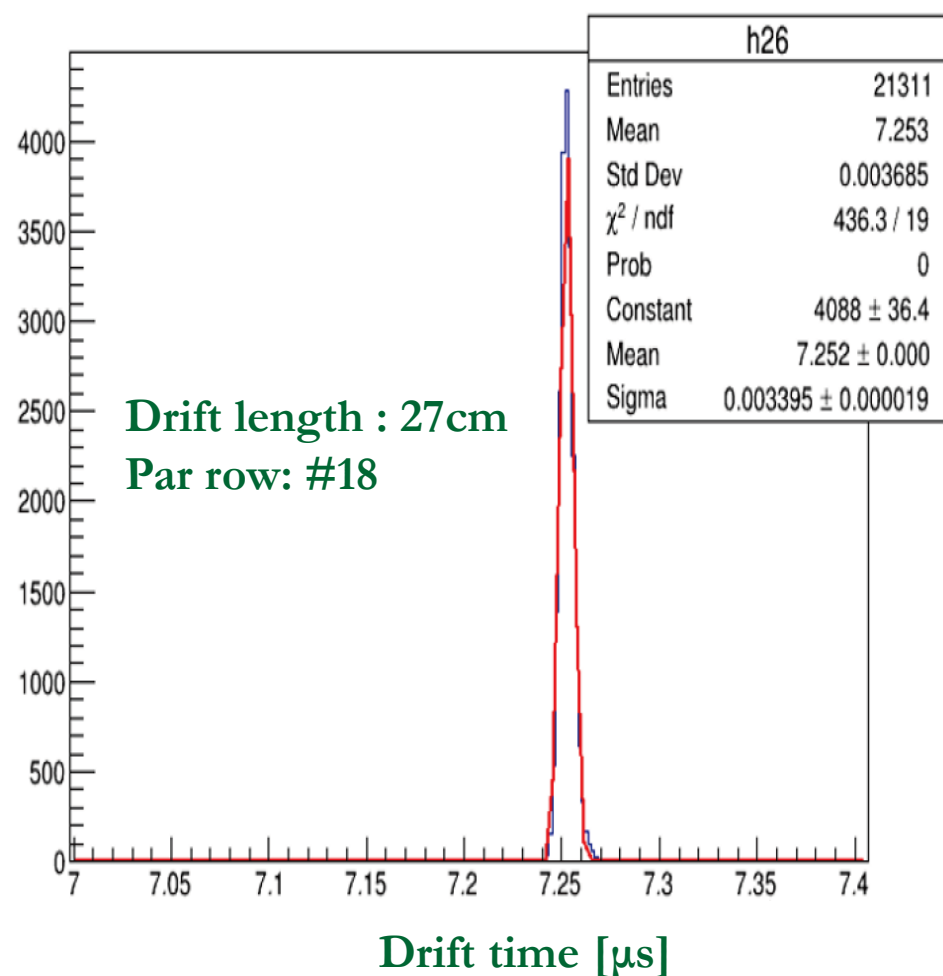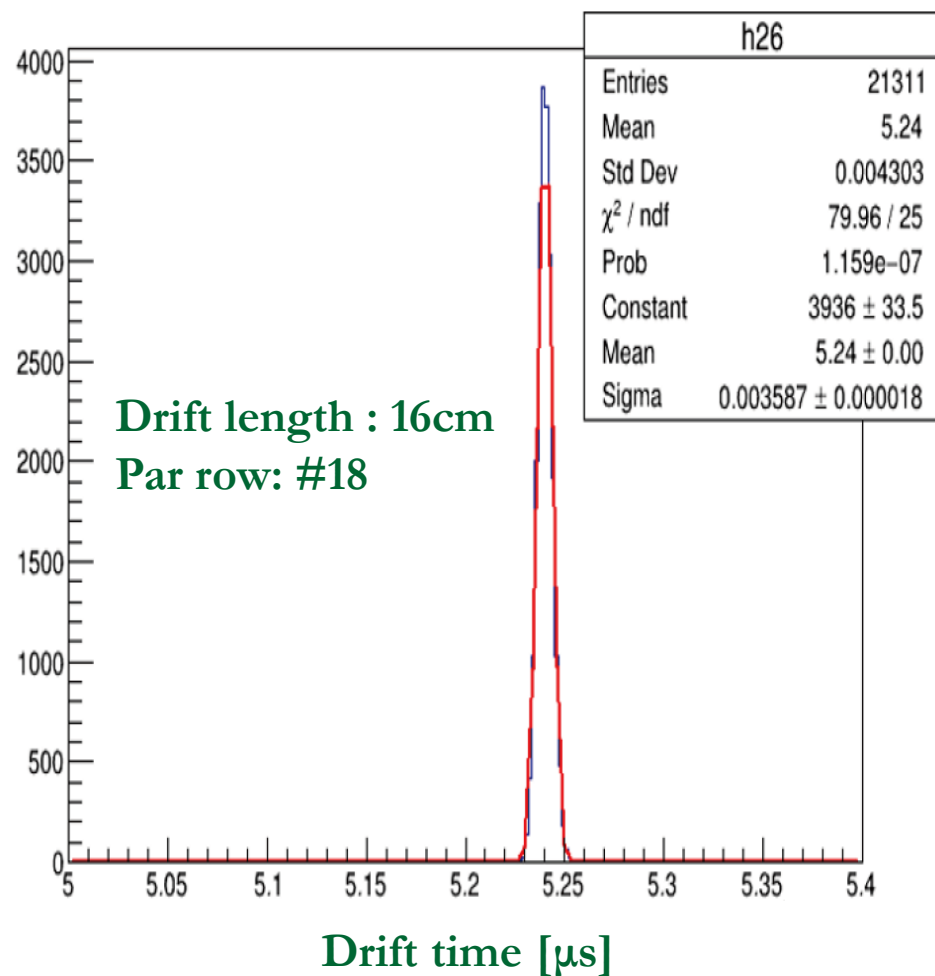

- ❑ **GEM detector as the endplate with 200mm^2**
- ❑ **Cylindrical flexible circuit board with 0.15mm thickness**
- ❑ **500mm drift length with 20000V high voltage**
- ❑ **Integration of the 266nm UV laser tracks in the chamber**

Detector coordinate definition

Cathode   **Endplate**

y

z

510mm

0

Endplate

y

0

x

Pad readout

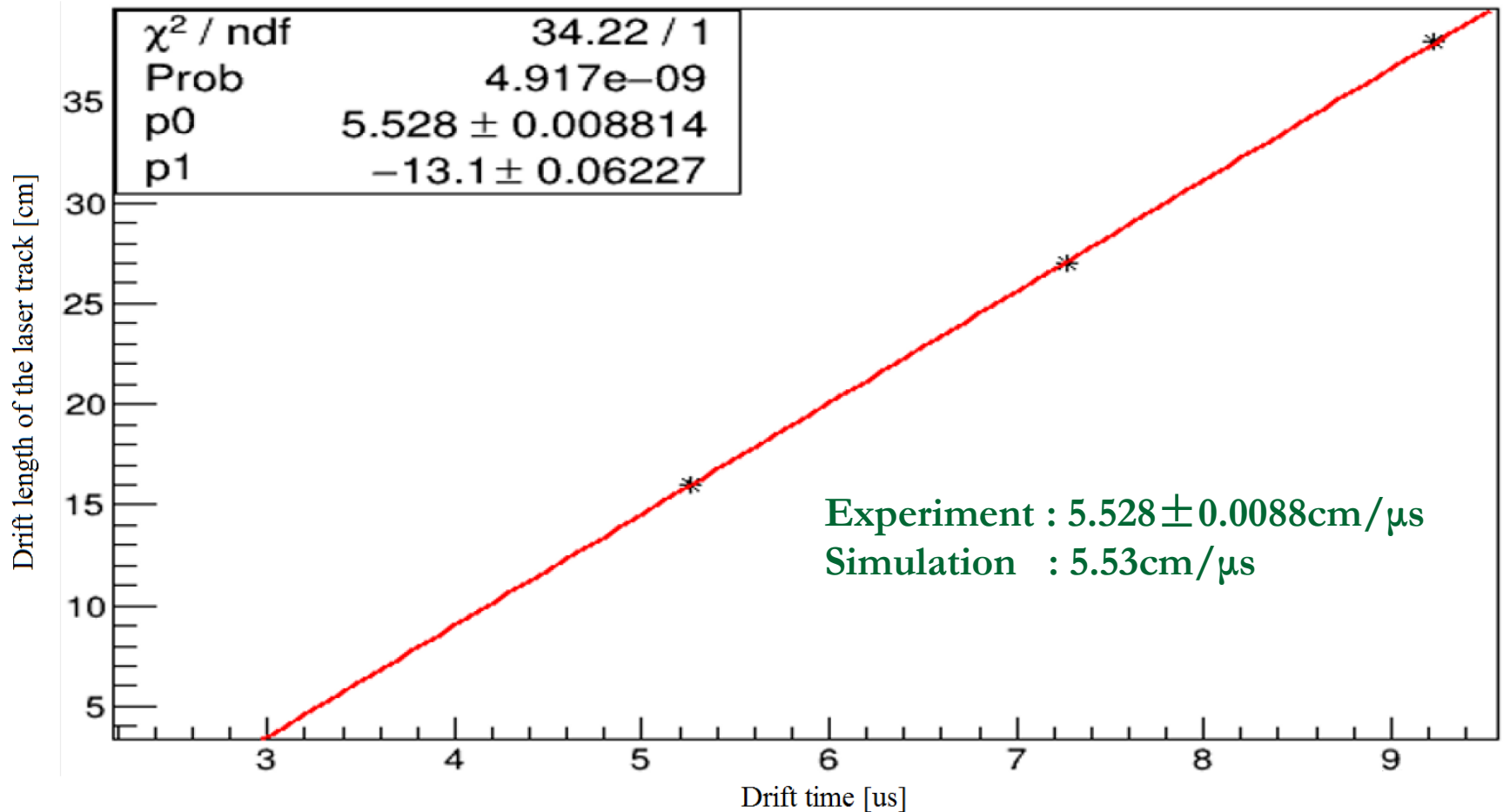y

0

x

- ❑ The origin of the coordinate **is set at the center** of the endplate board.
- ❑ X and Y plan is set as the readout plane
- ❑ Z is set along the drift length from endplate to the cathode
- ❑ Z_0 plane is set at the **first surface of the detector** from cathode to endplate plane.
- ❑ **The center of the pad** is set as the pad's coordinate, and every pad has the specific x and y.

Drift time @400MHz

Drift length : 16cm
Par row: #18

h26	
Entries	21311
Mean	5.24
Std Dev	0.004303
χ^2 / ndf	79.96 / 25
Prob	1.159e−07
Constant	3936 ± 33.5
Mean	5.24 ± 0.00
Sigma	0.003587 ± 0.000018

Drift length : 27cm
Par row: #18

h26	
Entries	21311
Mean	7.253
Std Dev	0.003685
χ^2 / ndf	436.3 / 19
Prob	0
Constant	4088 ± 36.4
Mean	7.252 ± 0.000
Sigma	0.003395 ± 0.000019

Drift time [µs]

Drift time [µs]

Drift time of the electron at 150V/cm in T2K

Drift velocity@150V/cm

Drift velocity of the electron at 150V/cm in T2K

Drift velocity@190V/cm

Experiment : 6.906±0.0102cm/μs
Simulation   : 6.91cm/μs
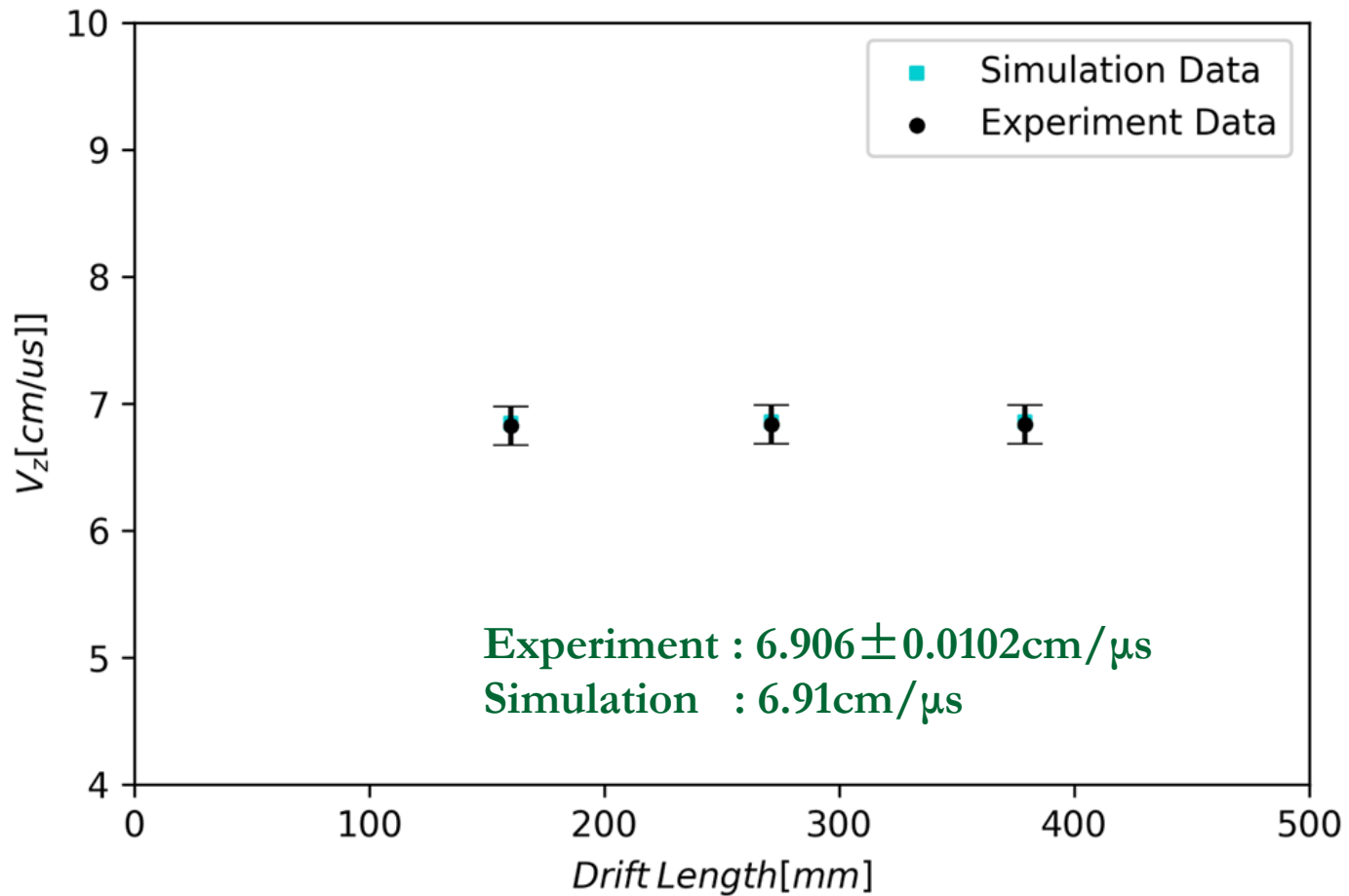
Drift velocity of the electron at 190V/cm in T2K
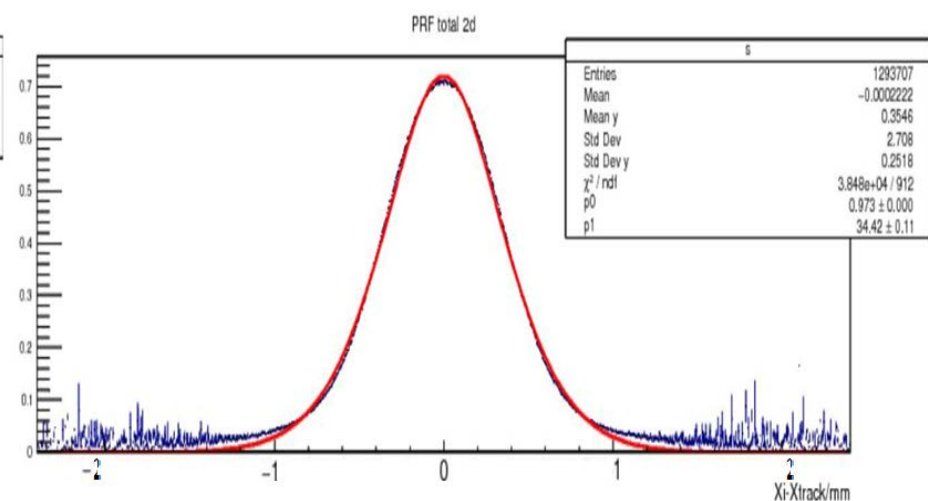
PRF analyzing of the spatial resolution (update)

❑ **Pad Response Function (PRF):** a function used to describe the charge distribution and to determine the hit position via Pad

$$PRF(x, y, w) = \frac{e^{-4ln2(1-y)x^2/w^2}}{1 + 4y \cdot x^2/w^2}$$

- ❑ x is the Pad's coordinate of the center of the corresponding Pad in x-aixs.
- ❑ y is a factor to describe Lorentzian and the Gaussian function
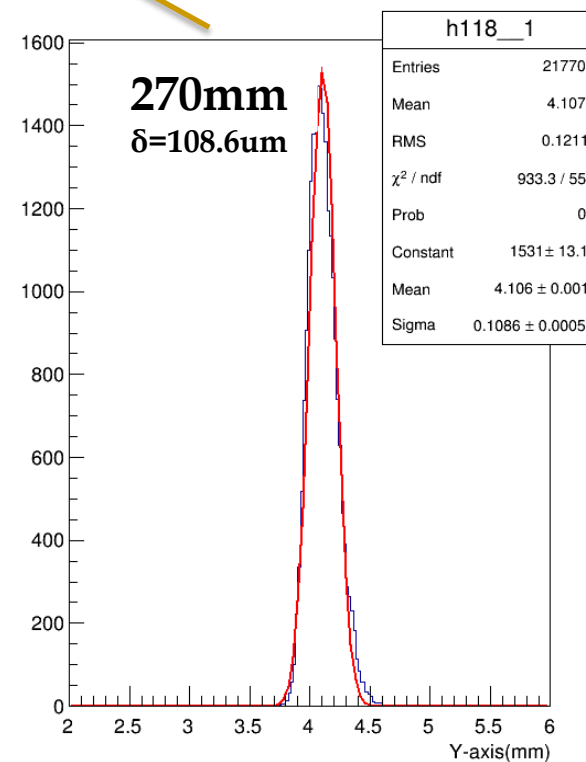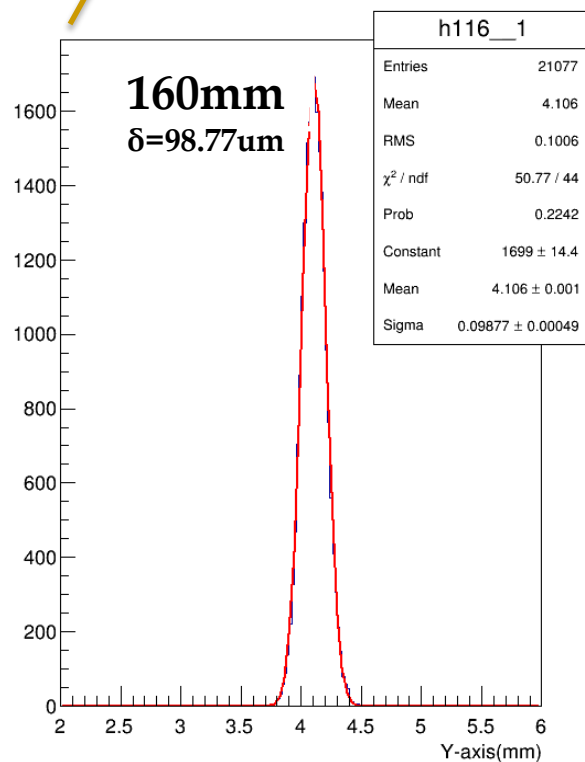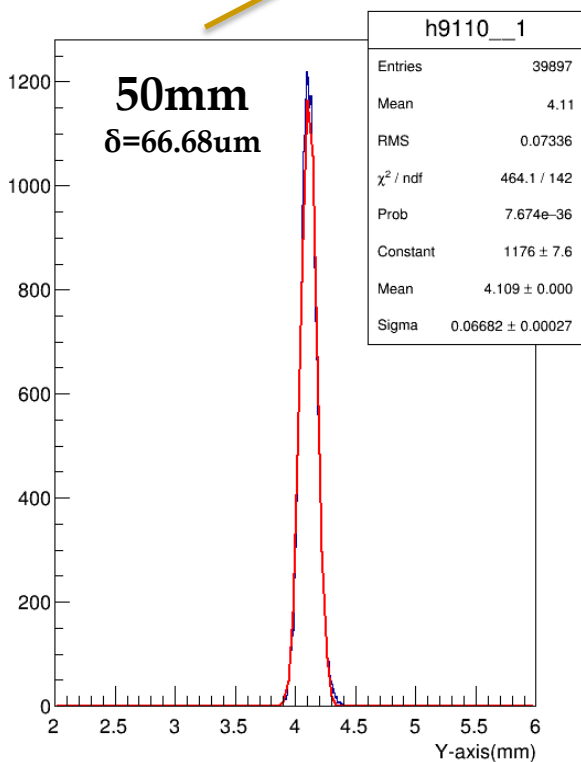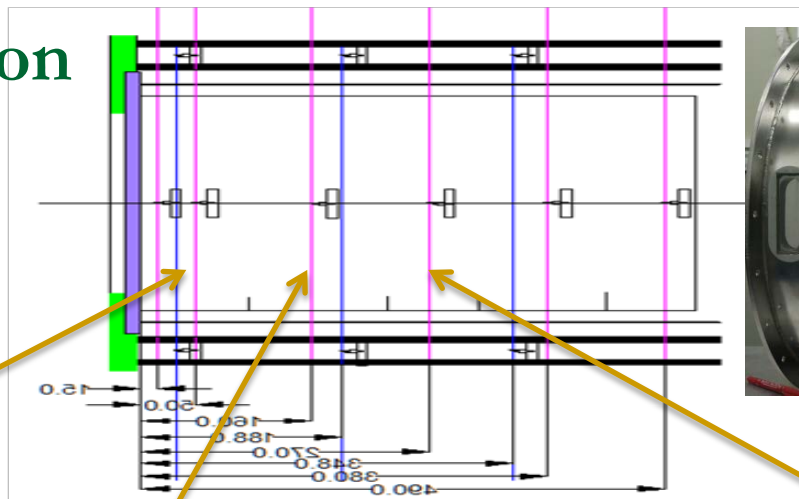- ❑ w is the width of the Pad (in here, the Pad's width is 0.9 mm)
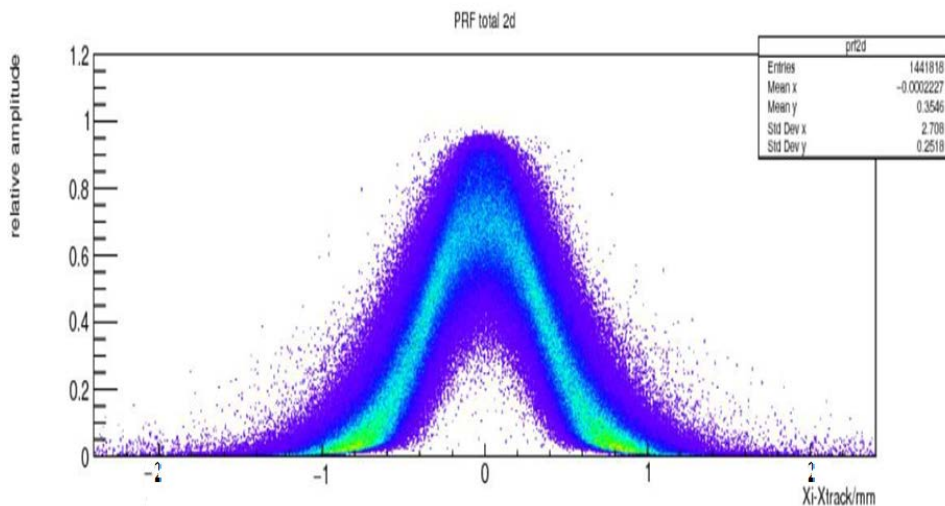
PRF total of all data

Profile of PRF from one pad row

Space resolution

N$_{eff}$ of UV laser in test: ~80

50mm
δ=66.68um

h9110__1	
Entries	39897
Mean	4.11
RMS	0.07336
χ² / ndf	464.1 / 142
Prob	7.674e−36
Constant	1176 ± 7.6
Mean	4.109 ± 0.000
Sigma	0.06682 ± 0.00027

160mm
δ=98.77um

h116__1	
Entries	21077
Mean	4.106
RMS	0.1006
χ² / ndf	50.77 / 44
Prob	0.2242
Constant	1699 ± 14.4
Mean	4.106 ± 0.001
Sigma	0.09877 ± 0.00049

270mm
δ=108.6um

| h118__1	
Entries	21770
Mean	4.107
RMS	0.1211
χ² / ndf	933.3 / 55
Prob	0
Constant	1531 ± 13.1
Mean	4.106 ± 0.001
Sigma	0.1086 ± 0.0005

Space resolution at the different drift length

Spatial resolution VS Neff（simulation）

- **Testing parameters**
  - T2K operation gases and 0T of the magnetic field
  - Drift field: 150V/cm-220V/cm
  - Pad readout option (1mm×6mm)

$$\sigma_x^2 = \sigma_0^2 + \frac{D_T^2 \cdot z + \frac{w_{laser}^2}{12}}{N_{eff}}$$

Preliminary

$$D_T = 312.71 \pm 10.87 (\ m/\sqrt{cm})$$
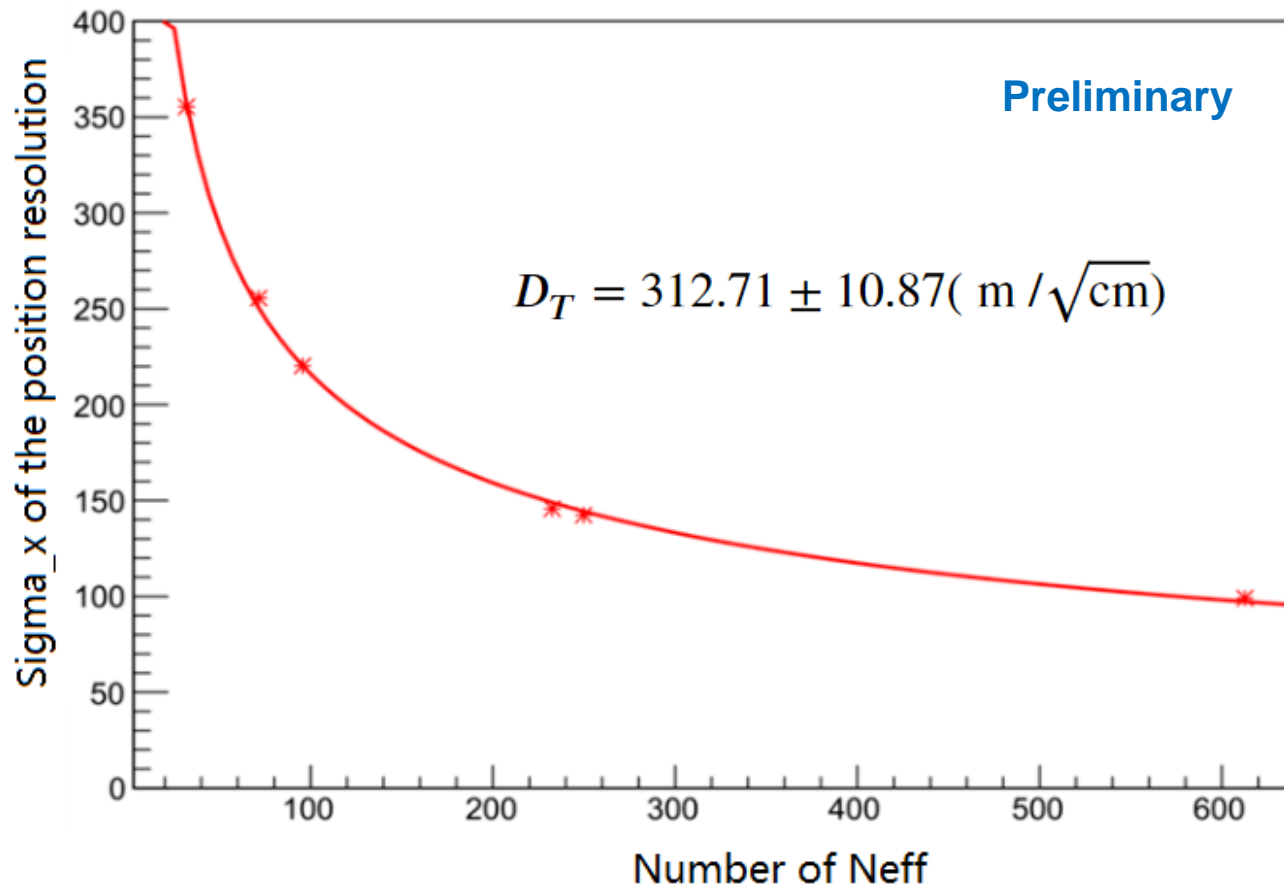
Spatial resolution VS the number of Neff

Comparison of the spatial resolution

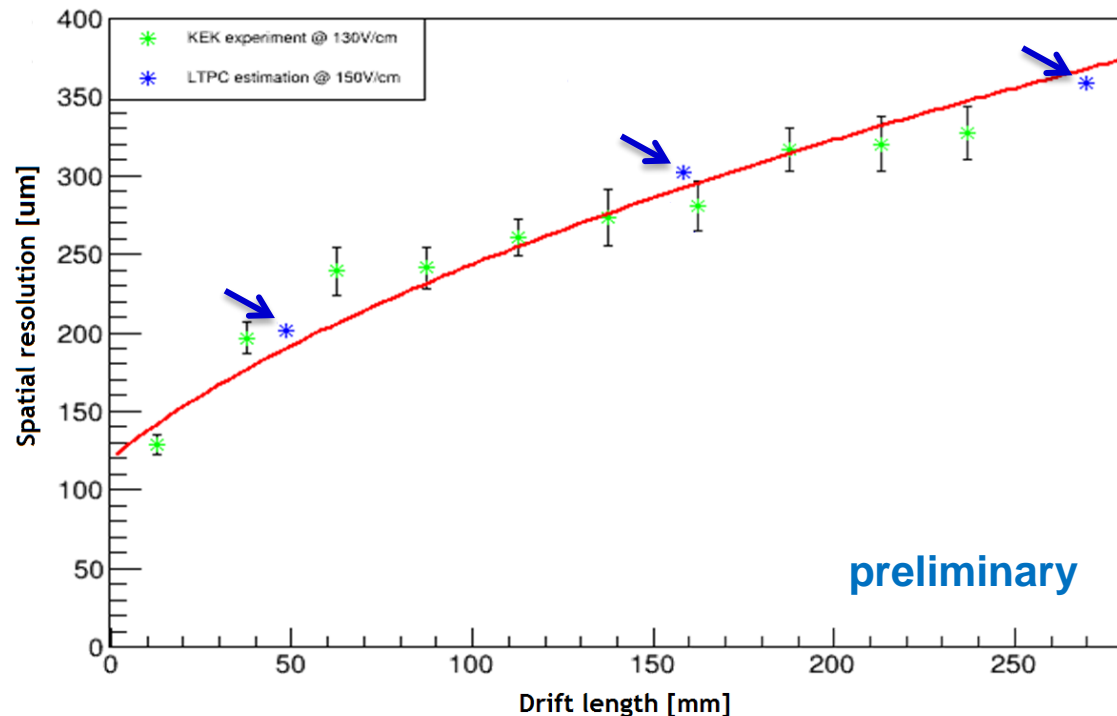- ❑ **Same testing conditions**
    - ❑ **T2K operation gases and 0T of the magnetic field**
    - ❑ **Drift field: 150V/cm-220V/cm**
    - ❑ **Pad readout option (1mm×6mm)**
    - ❑ **Framework from LCTPC software package**

Neff of Cosmic ray: ~30
Neff of UV laser in test: ~80

- ❑ **Normalized comparison** of **KEK cosmic experimental data using the same N_{eff}**
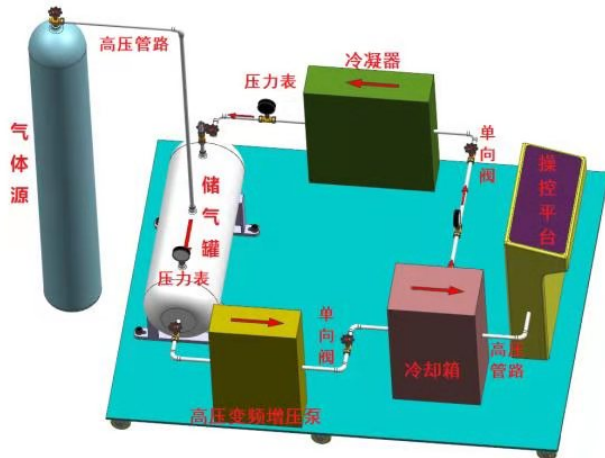   - ❑ N_{eff} **is the number of the effective electrons in chamber**

Normalized comparison of the spatial resolution

CO_2 cooling for ASIC readout at IHEP

- ❑ **Optimization of CO_2 cooling device**
    - ■ **Height: 1.6m**
    - ■ **Width: 0.6m×0.8m**
    - ■ **Integration controller interface**
    - ■ **Good anti-vibration and heat dissipation**
    - ■ **Small CO_2 gas bottle**
    - ■ **Digital temperature display**

Optimization of CO_2 cooling device

Summary

- **Some update results of TPC prototype have been studies, the prototype is working well, and the results indicated that 266nm UV laser beams system could used in the TPC prototype R&D.**

- **Spatial resolution, Diffusion constant(C_d) and Neff simulated.**

- **More analysis on going**
  - E_d: 220V/cm
  - Graduates: Yuan Zhiyang and Chang Yue

Thanks for your attention.