
Some results of TPC prototype integrated with 266nm UV laser

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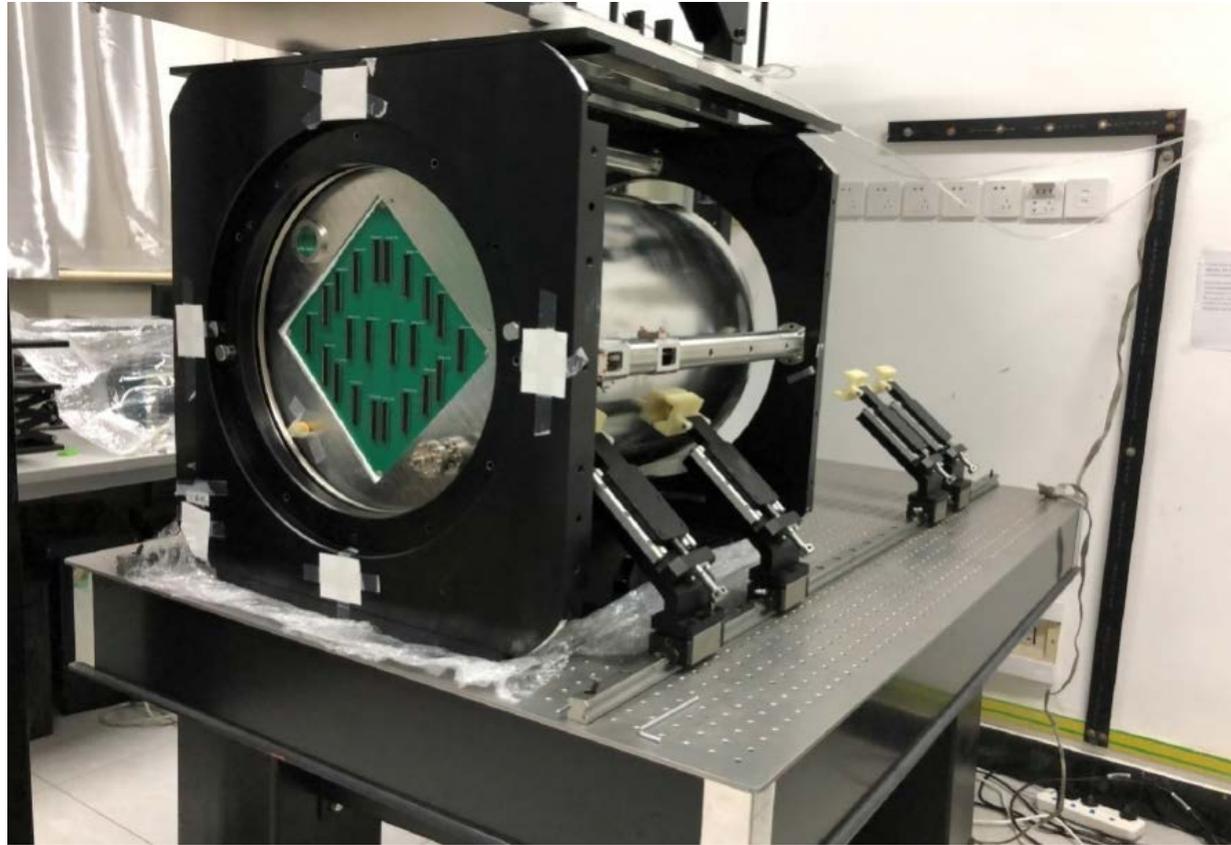
Outline

- **TPC prototype**
- **Analysis and results**
- **Plans of studies**
- **Summary**

Status of TPC prototype

Achievements and prospects

- ❑ Detector prototype was **almost done and working well** in 2021
- ❑ **Commissioning:** Huirong Qi, Zhiyang Yuan, Yiming Cai, Yue Chang, Jiang Zhang, Yulan Li, Zhi Deng
- ❑ **Data taking:** the same, plus: Hongyu Zhang, Ye Wu
- ❑ **Some analyzing results of the drift velocity, the spatial resolution and FEE electronics were observed**

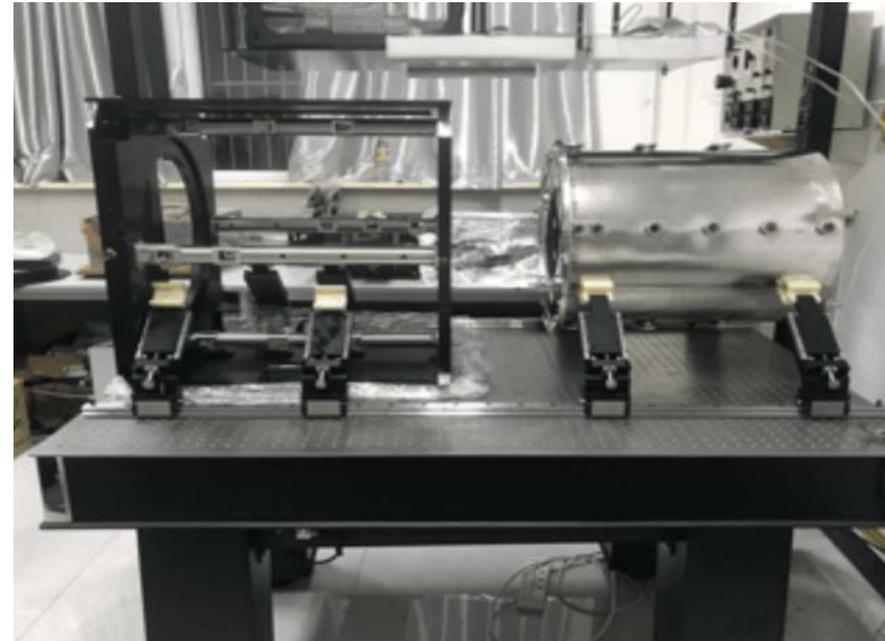
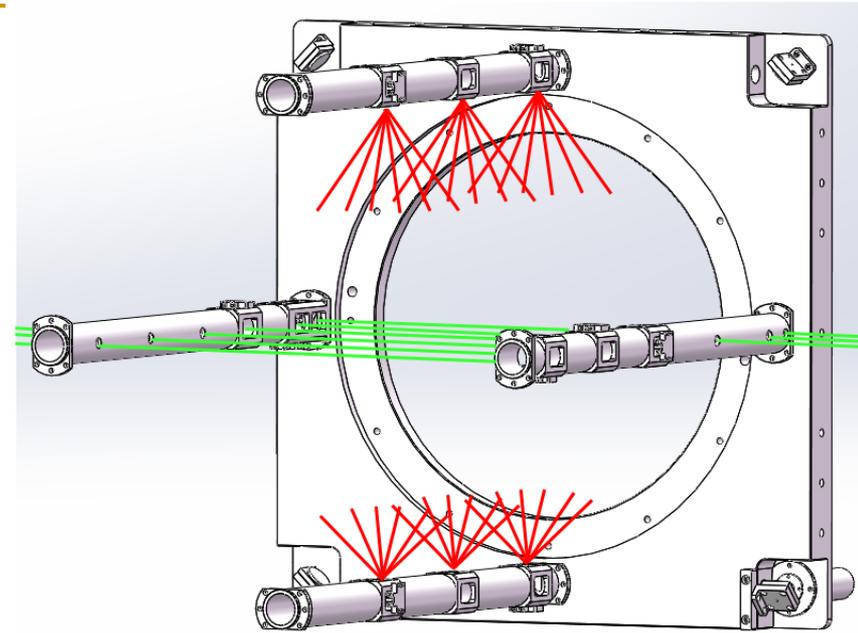


TPC prototype in the lab

TPC Prototype sketch

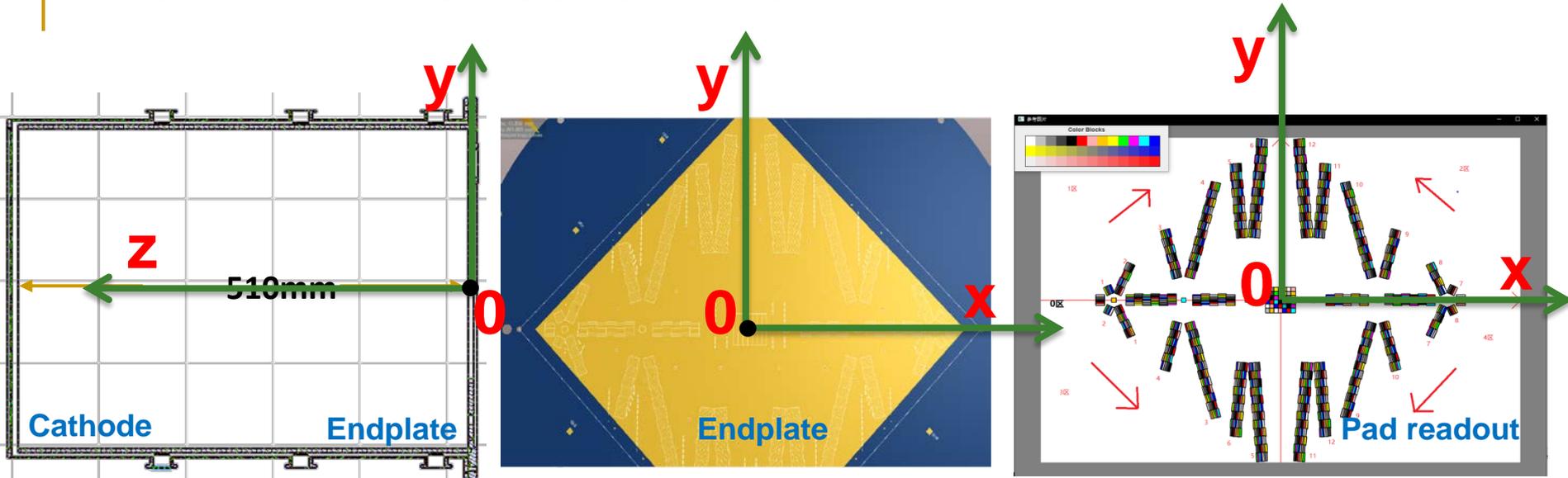
- Main parameters
 - Same test parameters in CEPC
 - Drift field=200V/cm
 - Relative gain: ≥ 2000
 - Readout pad(anode) is designed to 0V (Ground)
 - TPC detector system: Fieldcage+ Pads readout
 - Working mixture gas:
 - Ar/CF₄/iC₄H₁₀=95/3/2
 - Same purity
 - Specific prototype parameters
 - Drift length: ~500mm
 - Active area: 200mm²
 - Integrated 266nm laser beam
 - MPGD detector as the readout
 - TPC cathode: -10kV
 - Readout Pads: 1280 channels

preliminary



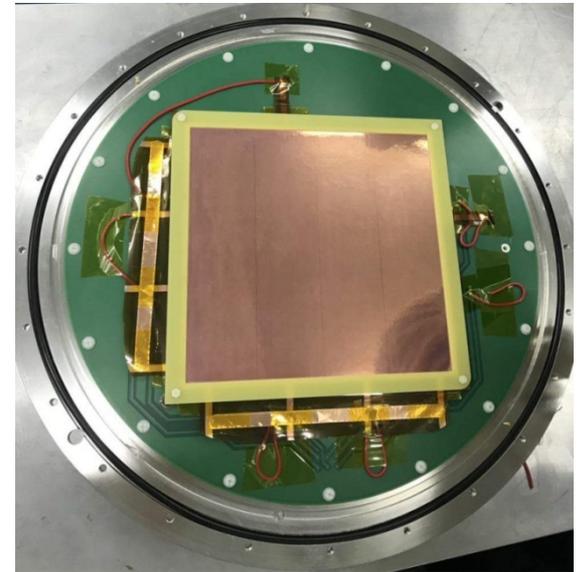
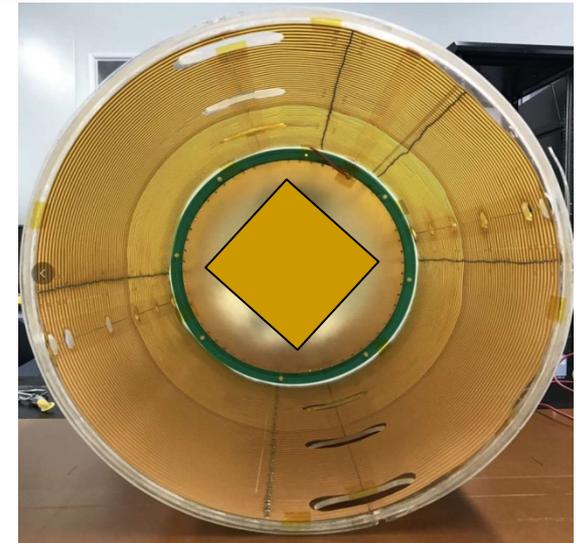
TPC prototype

Detector coordinate definition



- ❑ 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.

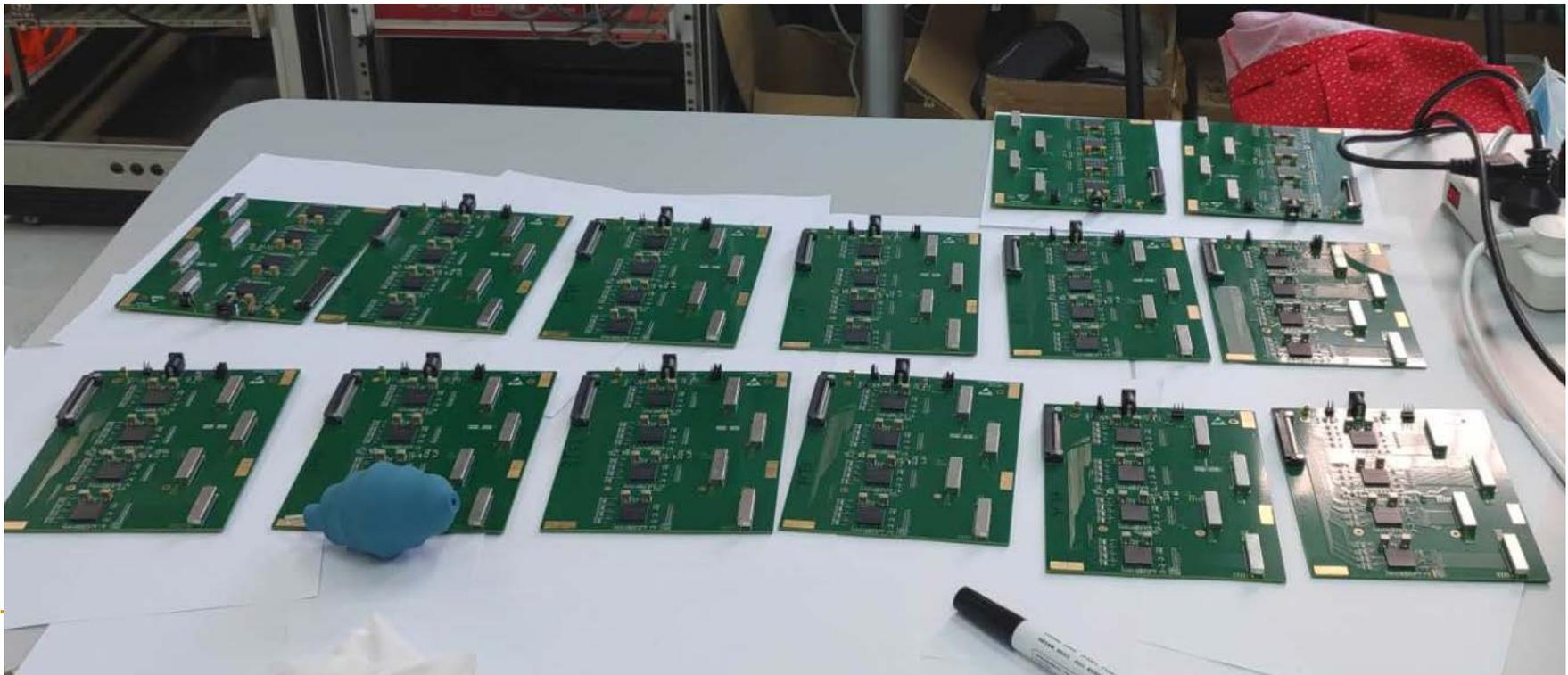
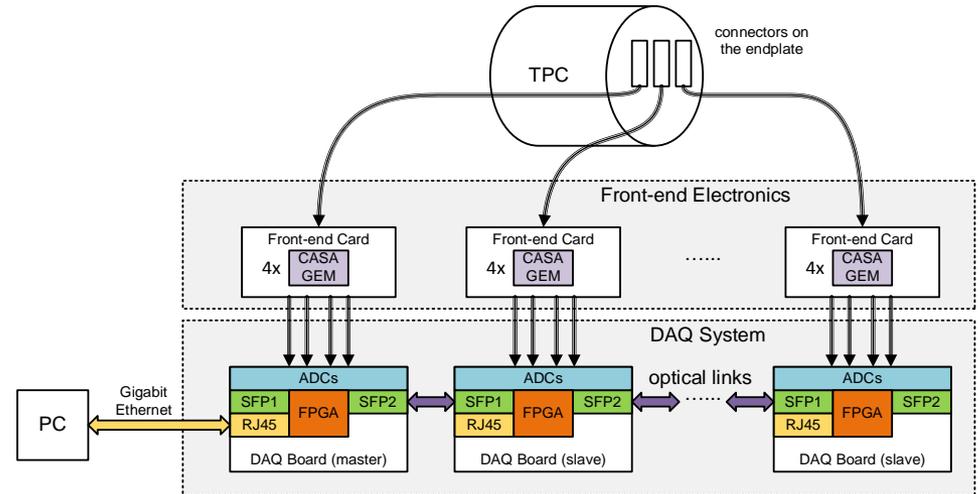
Endplate and field cage



- ❑ 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

Electronics

- ❑ Amplifier and FEE
 - ❑ CASAGEM chip
 - ❑ 16Chs/chip
 - ❑ 4chips/Board
 - ❑ Gain: 20mV/fC
 - ❑ Shape time: 20ns



Electronics and DAQ

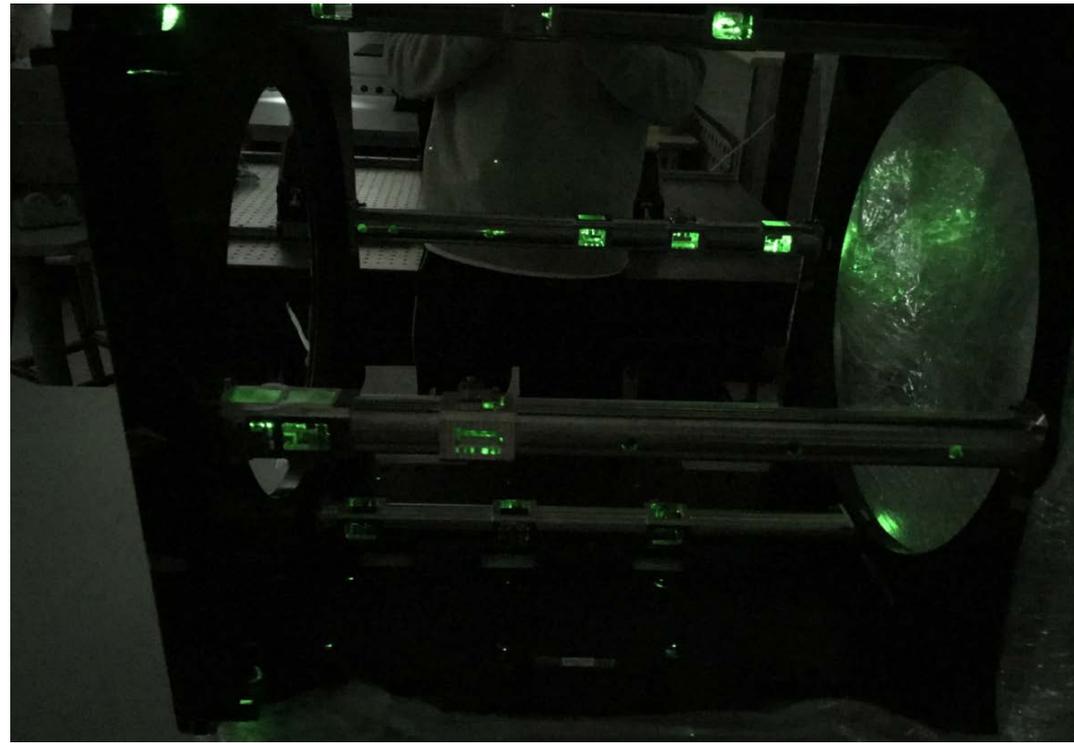
- DAQ Commissioning
 - FPGA+ADC
 - 4 module/board
 - 64Chs/module
 - Sample: 40MHz
 - 1280chs
 - Signal: >16 sample points
 - **Zero suppression**
 - 1280 readout channels
 - Noise: <10mV@pp
 - **Run mode: trigger and triggerless**



FEE Electronics and DAQ setup photos

UV laser device

- Gaussian laser device
 - Nd-LAG UV laser
 - Wave length: 266nm
 - Quantel Q-smart Lasers
 - Frequency: 20Hz
 - Power: <20mJ/pulse
 - Trigger: BNC output



UV laser along the drift length



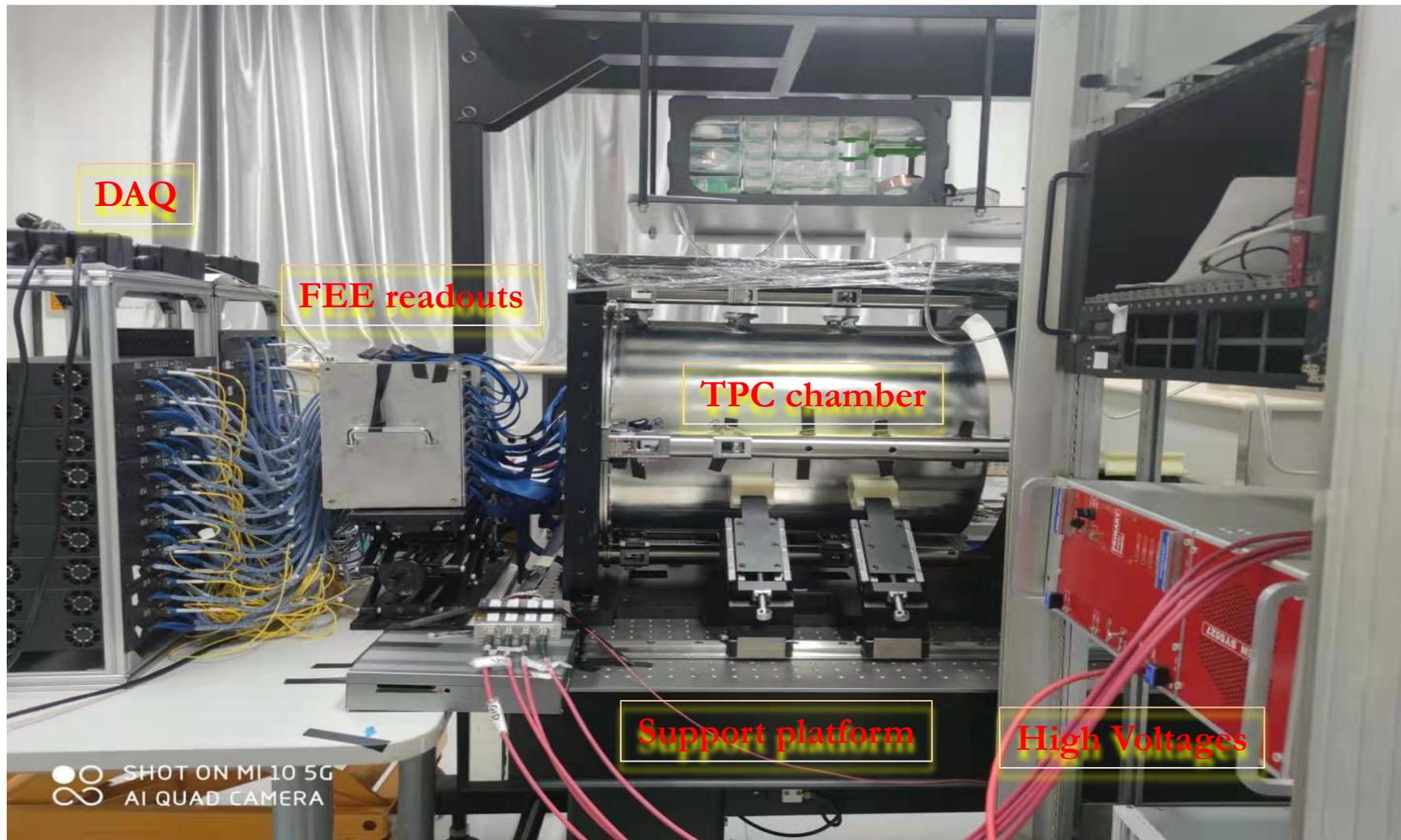
灯泵脉冲激光器头

倍频模块

激光器电源

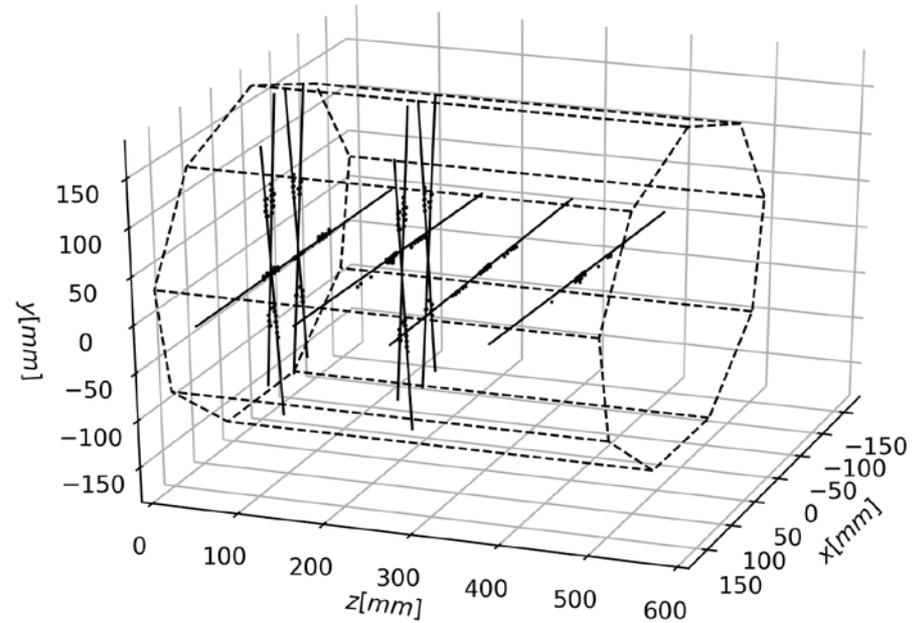
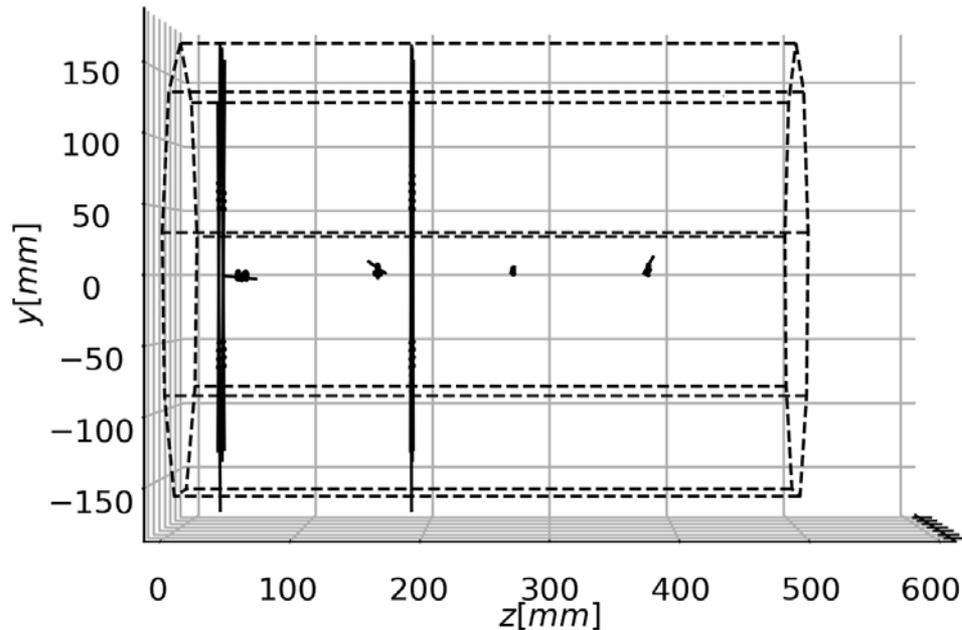
Parameters of the UV laser device

Commissioning and studies



Prototype working well

Laser tracks reconstruction@T2K gas



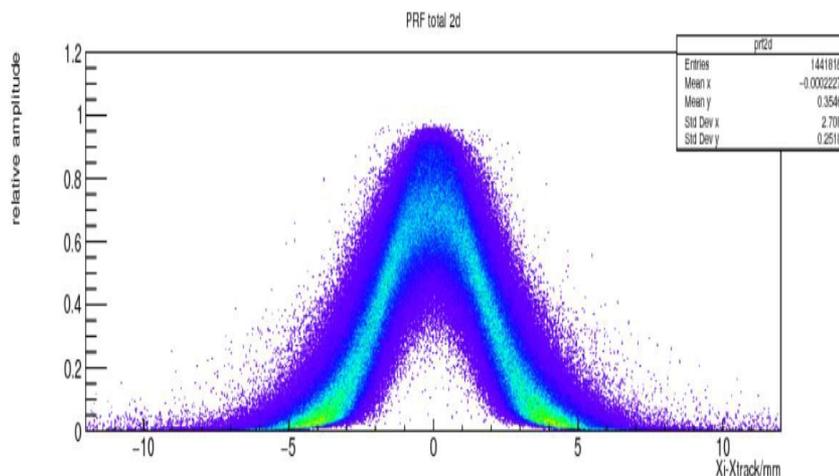
- ❑ Same of working gas@T2K, same of high voltage, same of test conditions
- ❑ Different of GEMs@ 320V
- ❑ No any discharge to damage the detector
- ❑ Conclusion
 - All of the triple GEMs, double GEMs and GEM+Micromegas could be as the readout option for TPC prototype
 - 2000 of gain is fine to study UV laser
 - The spatial resolution and the drift velocity could be analyzed

PRF analyzing of the spatial resolution

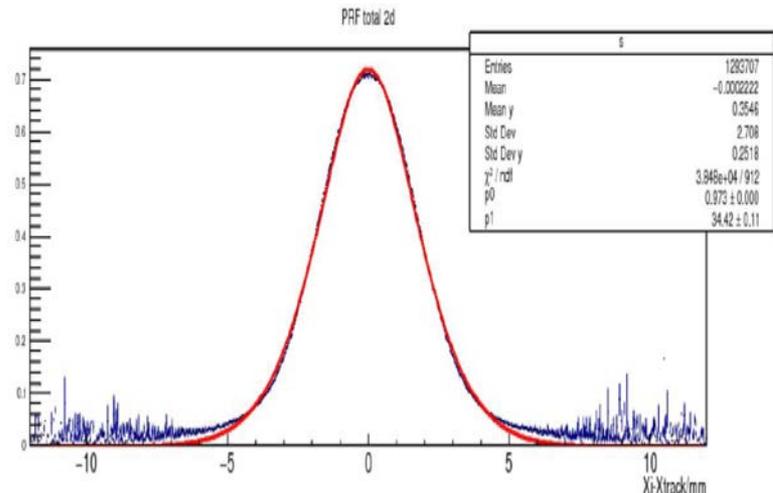
- ❑ **Pad Response Function (PRF):** a function used to describe the charge distribution and to determine the hit position via Pad

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

- ❑ **x** is the Pad's coordinate of the center of the corresponding Pad in x-axis.
- ❑ **y** is the Pad's coordinate of the center of the corresponding Pad in y-axis.
- ❑ **w** is the width of the Pad (in here, the Pad's width is 0.9mm)



PRF total of all data



Profile of PRF from one pad row

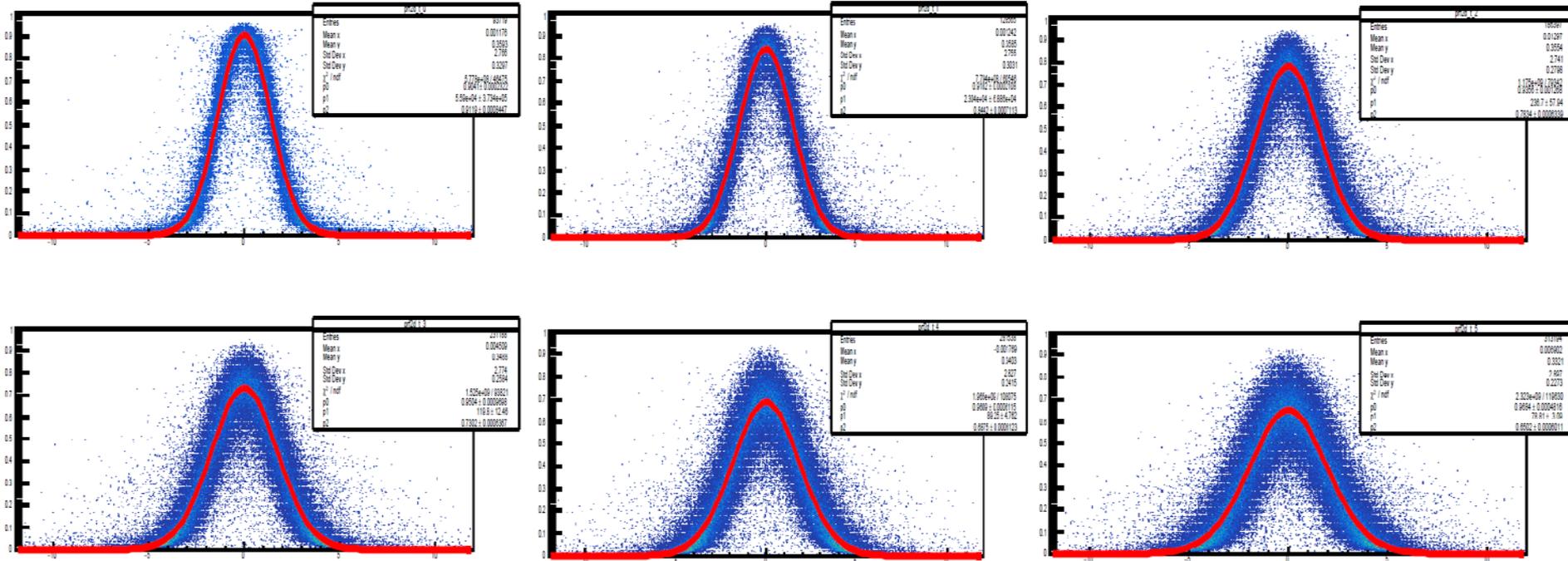
PRF analyzing – iteration calibration

- ❑ X-track: reconstruction by the double fits
- ❑ Pad Response Function (PRF): need the iteration calibration with $\mathbf{X}_i - \mathbf{X}_{\text{track}}$

PRF v.s. drift time
without iteration

PRF v.s. drift time with
iteration(1st)

PRF v.s. drift time with
iteration(2nd)

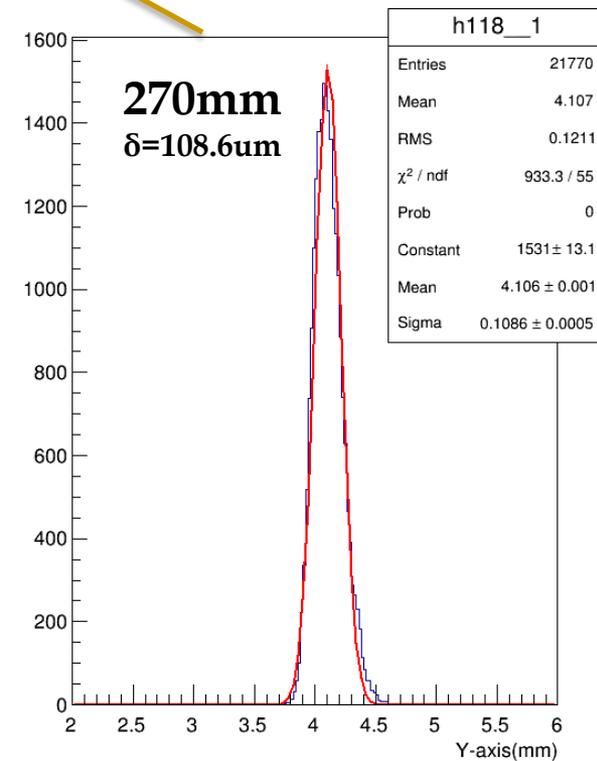
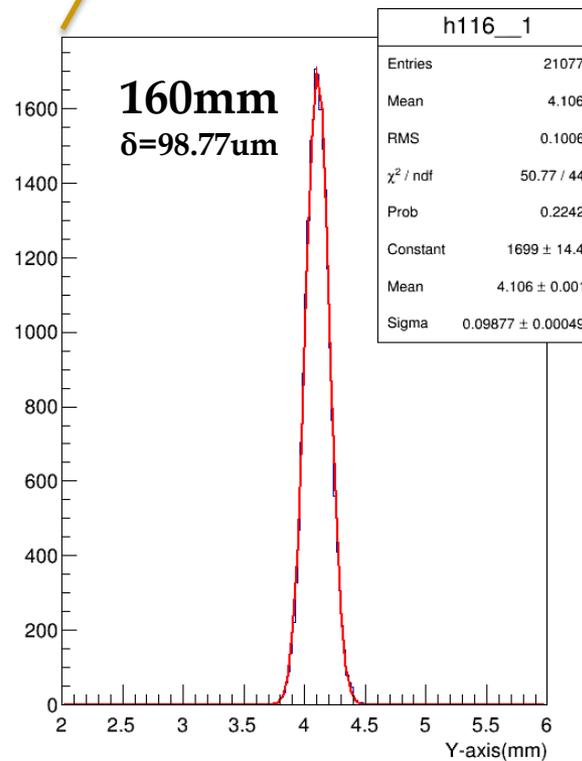
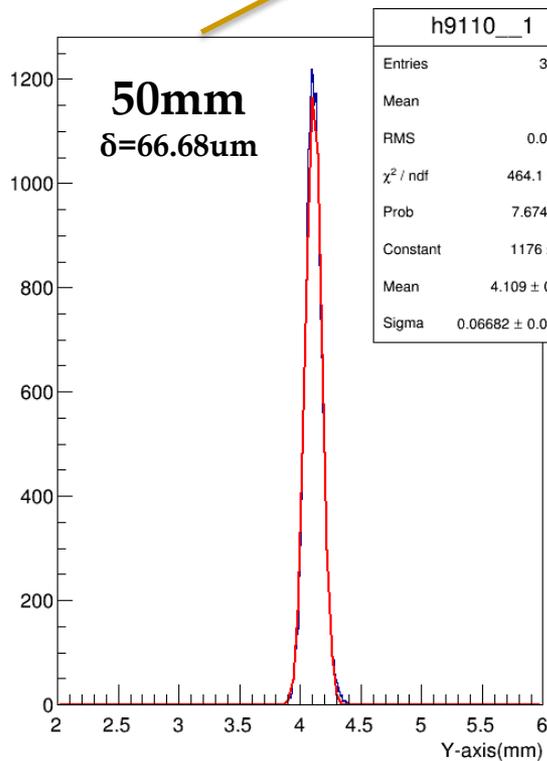
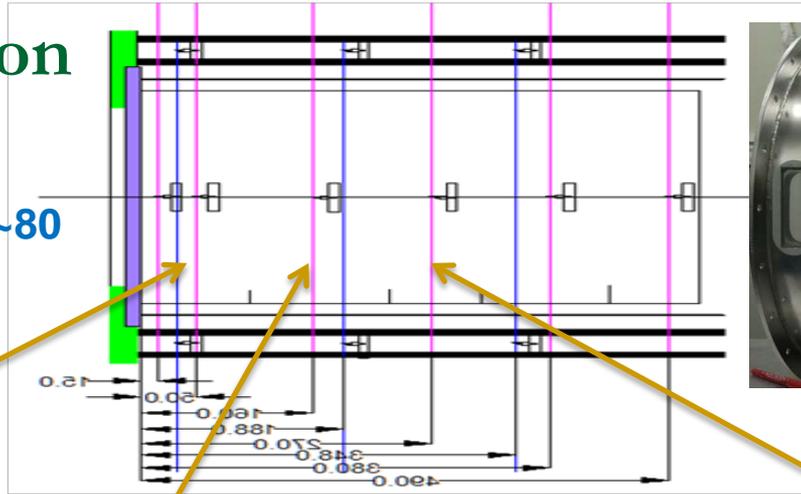


Example of the two rows using iteration calibration

Space resolution

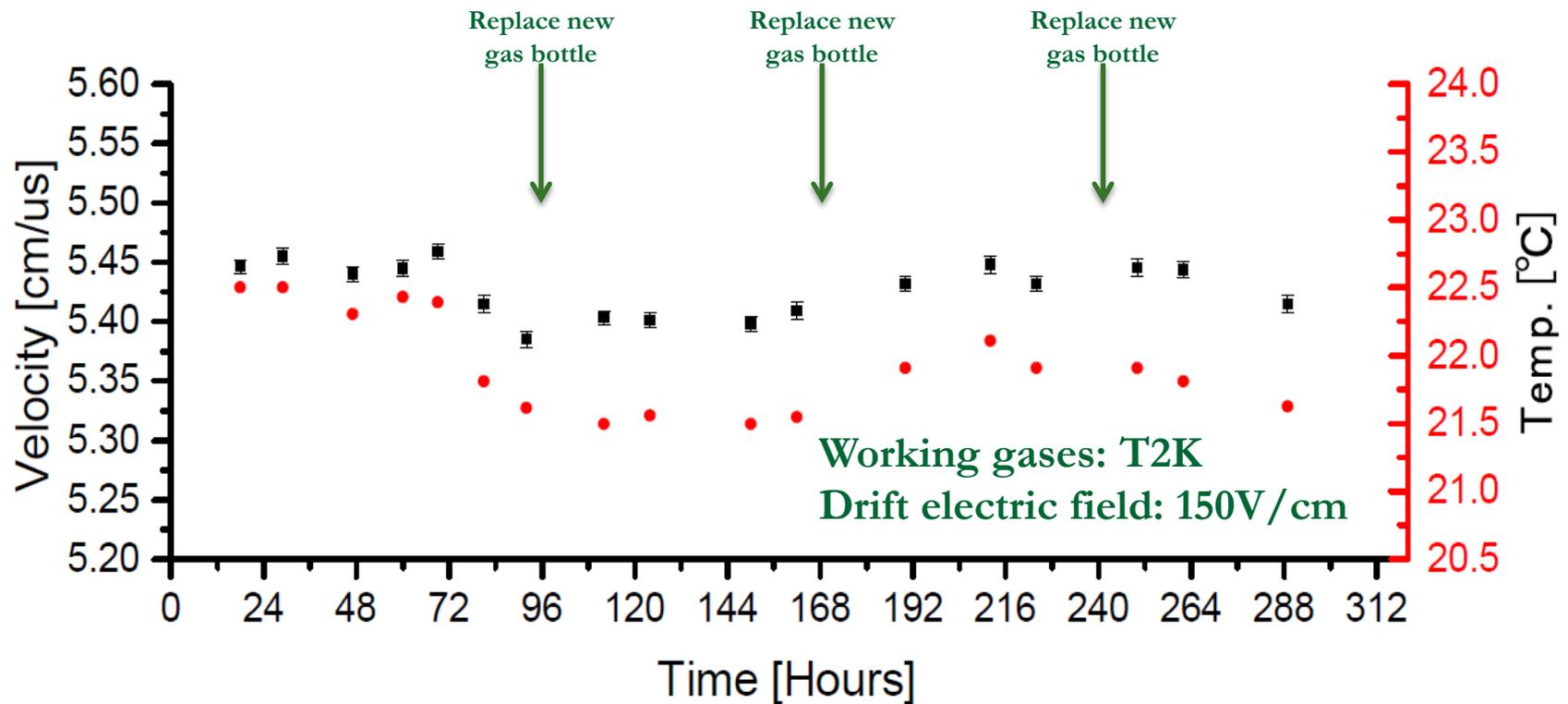
N_{eff} of UV laser in test: ~80

Testing continuing



Space resolution at the different drift length

Drift velocity measurement



- Two weeks of continuous testing (Data of $E_{\text{drift}}=220\text{V/cm}$ is still taking)
- Room temperature recorded
- Comparison of the drift velocity and the temperature
- Simulation of some influencing factors using Garfield/Garifield++ software

Conclusion: 266nm UV laser can work well when it can be as the online monitor option.

Plan studies of TPC prototype

more studies are ongoing...

dE/dx

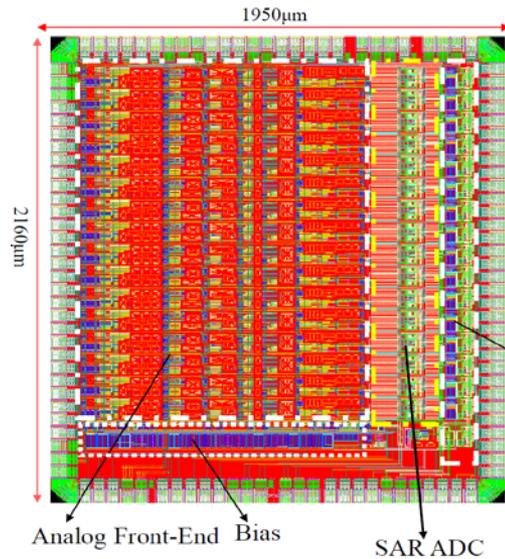
track distortion

gain uniformity

and ...

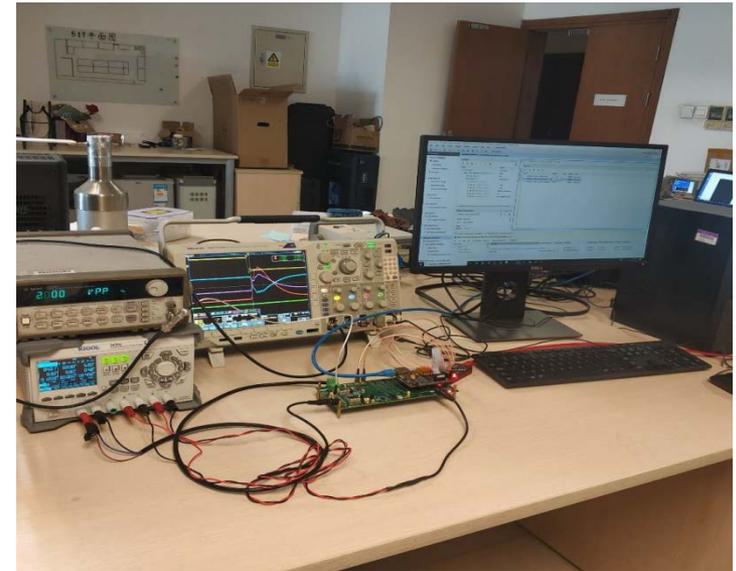
Joint of new ASIC chip R&D

Deng Zhi, Liu Wei and Yuan Zhiyang

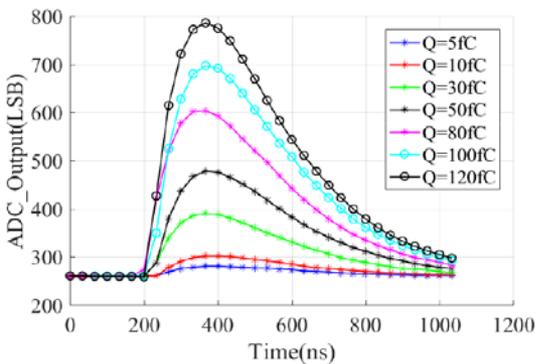


- The floor plan in layout :
 - The die size of 1950 µm x 2160 µm
 - Analog Front-End , SPI, SAR ADC, LVDS driver are supplied by separate power
- The ASIC have been taped out in November, 2019 and is being evaluated

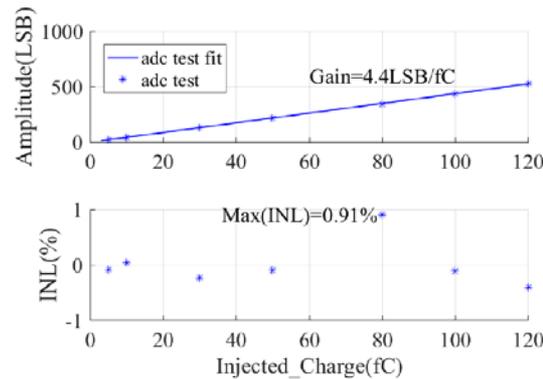
Layout of ASIC chip



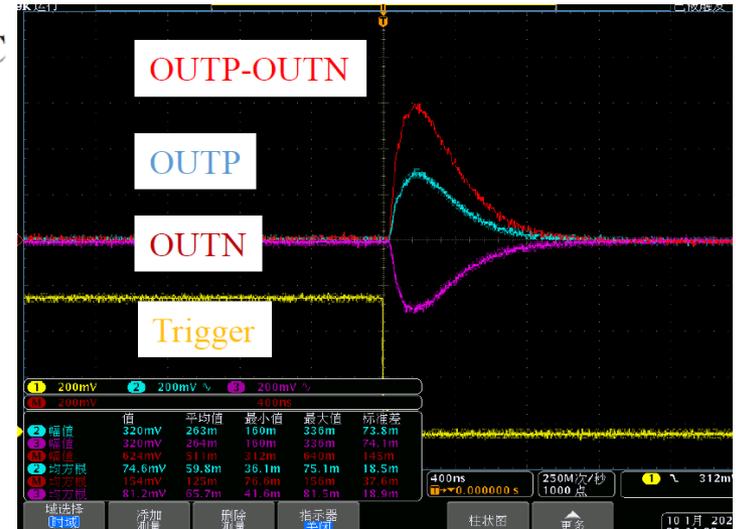
- Transient outputs



- The linearity @ gain = 10 mV/fC

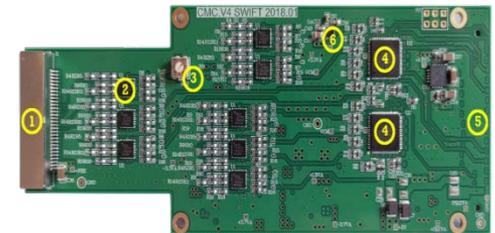
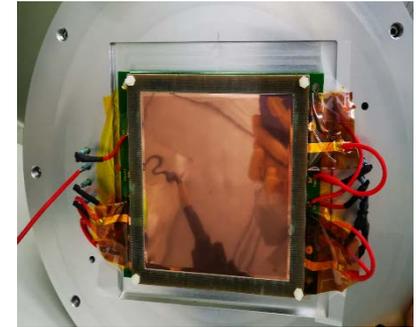


Gain = 4.4 LSB/fC = 4.4 x 2.34 mV/fC = 10.3 mV/fC



New electronics commissioning

- A 16 channels low power consumption readout ASIC chip for TPC readout have been developed
 - The power consumption is **2.33 mW/channel**
 - $P_{AFE} = 1.43 \text{ mW/channel}$
 - $P_{ADC} = 0.9 \text{ mW/channel @ } 40\text{M/s}$
 - $\text{ENC} = 852e @ C_m = 2\text{pF}$, gain = 10 mV/fC and can be reduced to 474e using digital trapezoidal filter
- Future studies
 - More ASIC evaluations: Higher sampling rate, more detailed noise test, test with detectors ...
 - Low power digital filter and data compression in FPGA/ASIC
 - **Commission of ASIC chip board and the detector** to test in the laboratory



Detector and ASIC

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 will be **very useful in the TPC prototype R&D**.
- More studies are ongoing and the update analyzing will be done.
- The TPC detector module and prototype will **designed, assembled and commissioned** with the new low power consumption ASIC chip from this month.

Thanks for your attention.