Update results of TPC module and prototype

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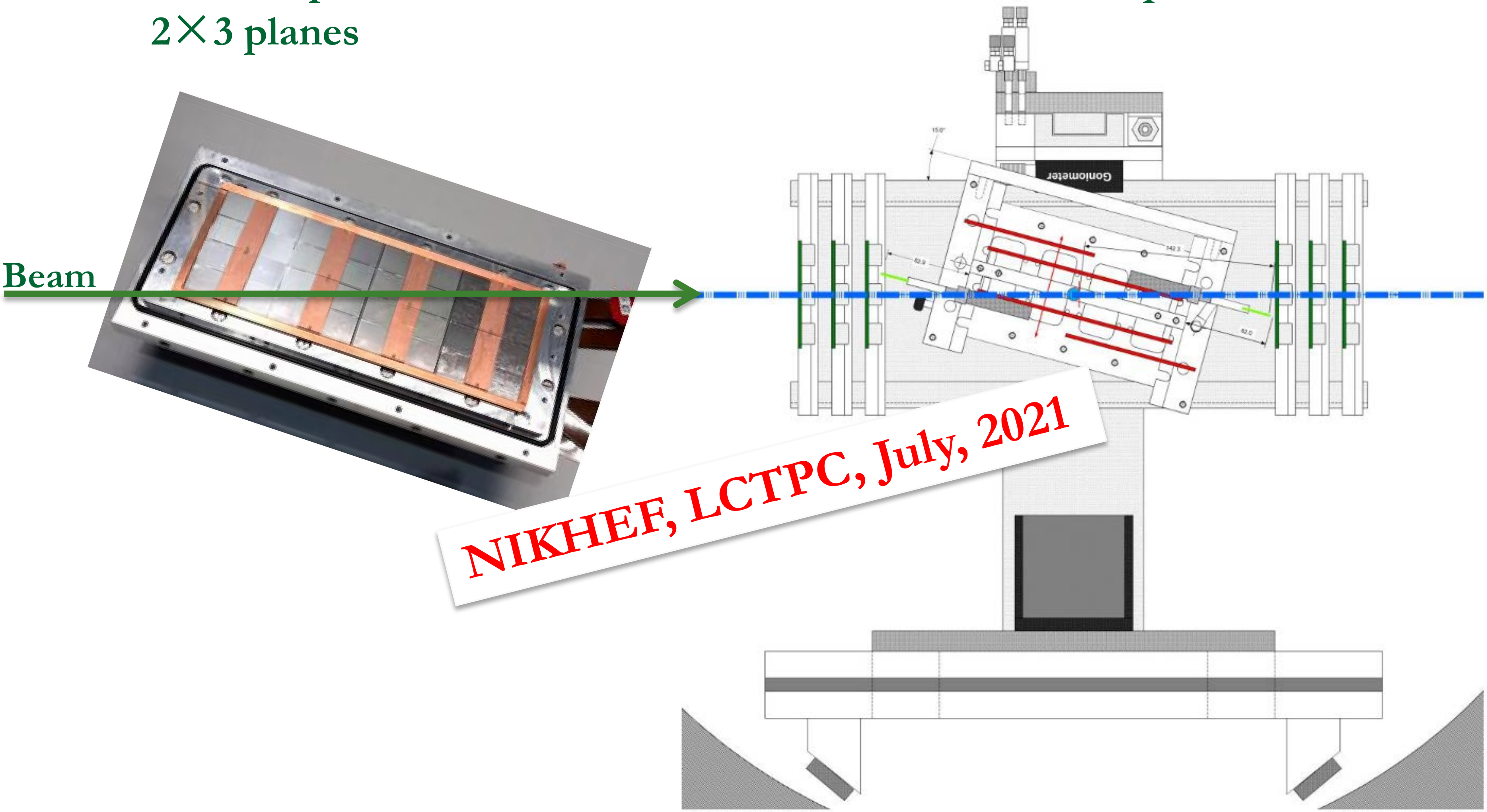
Outline

- Status of pixel TPC
- Update simulation and analysis

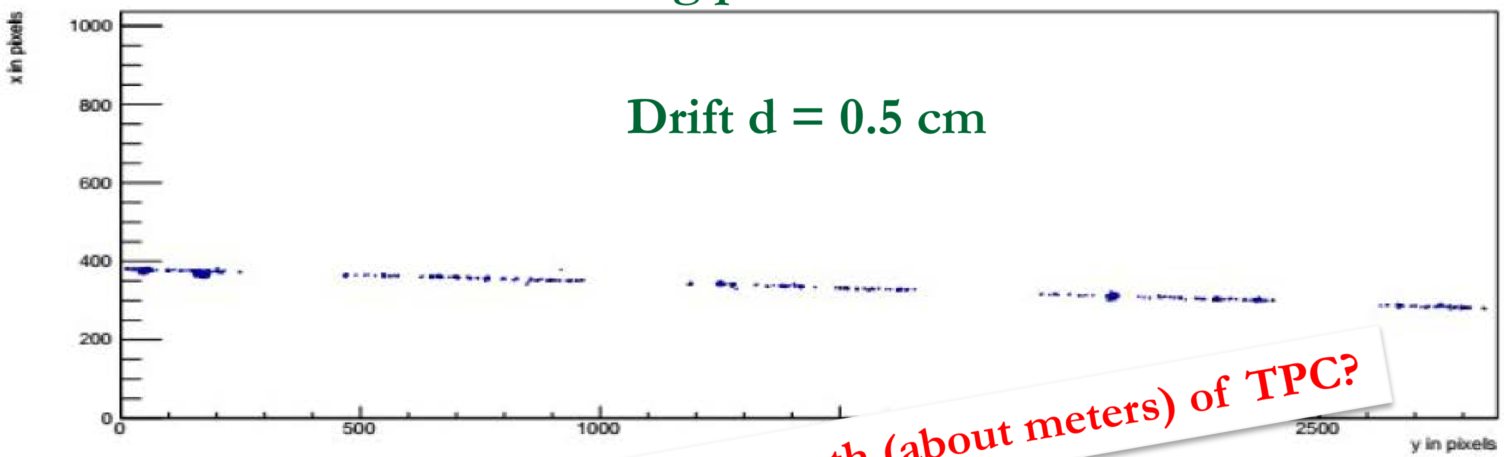
Pixel TPC@LCTPC

- 32 chip quad module in the gas envelop
- Entrance windows are 50μm kapton
- The setup at DESY includes a MIMOSA silicon telescope with 2×3 planes

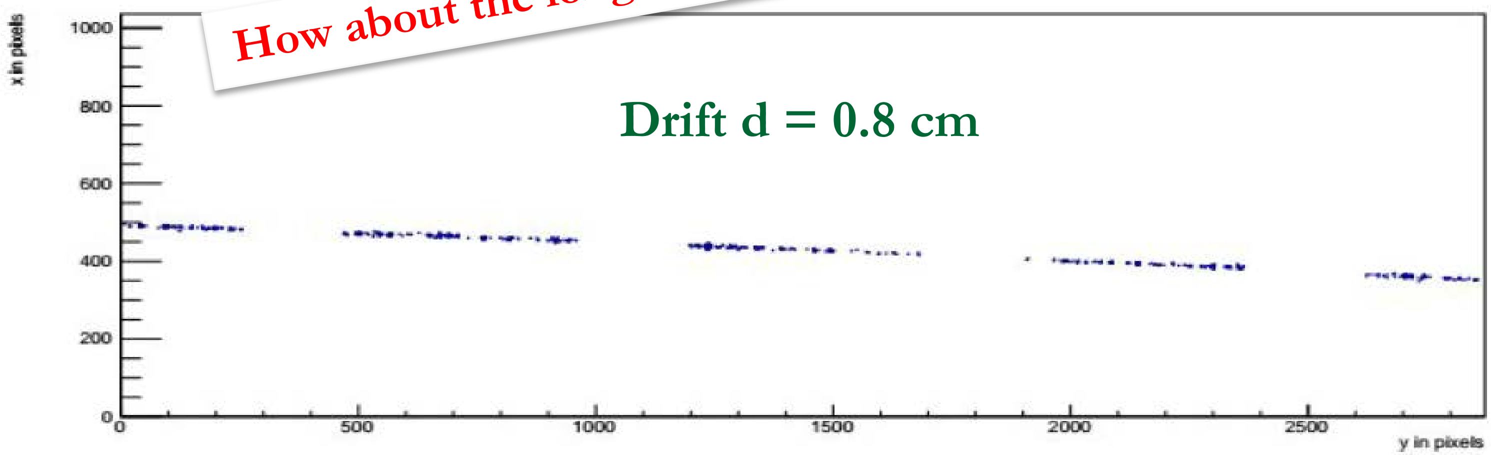


Beam test of the pixel TPC

Event Pictures using pixel readout at B = 1 T



How about the long drift length (about meters) of TPC?

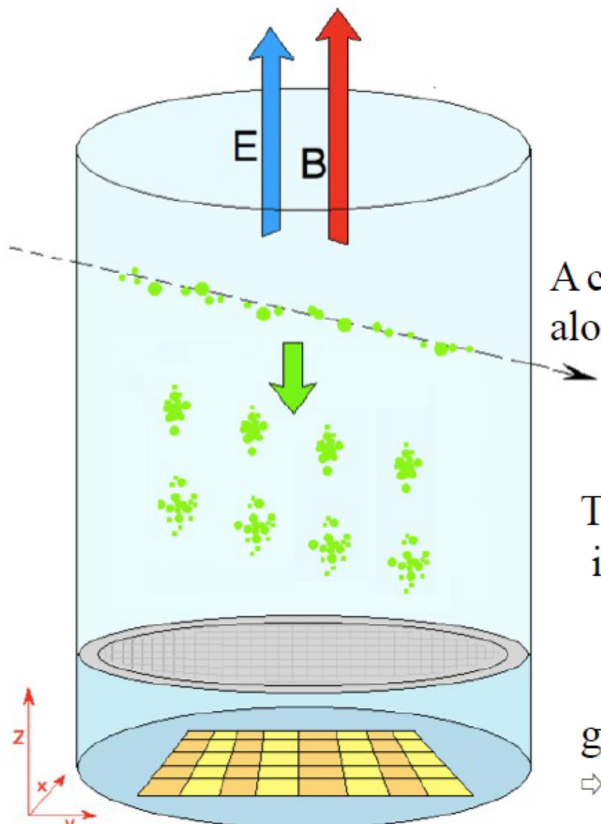


- Some interesting events reconstruction, which can either not be seen by pads or which are usually nor recorded
- Analyzing on going (dE/dx, Time walk correction…)

TPC concept

Operating principle of TPC

electric field and magnetic field are applied in parallel in the TPC



A charged particle ionizes the atoms of the gas mixture along its trajectory

The liberated electrons drift in the E-field towards the readout pad

gas-amplified and read as signal
⇨ <u>2-dimensional (x,y) information</u>

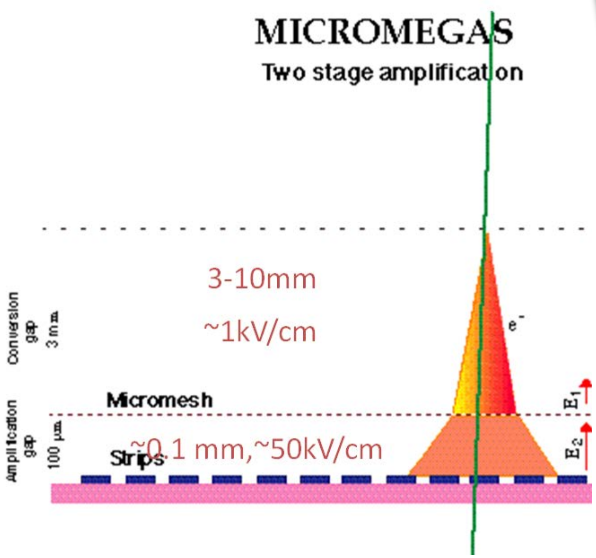
MPGD readout

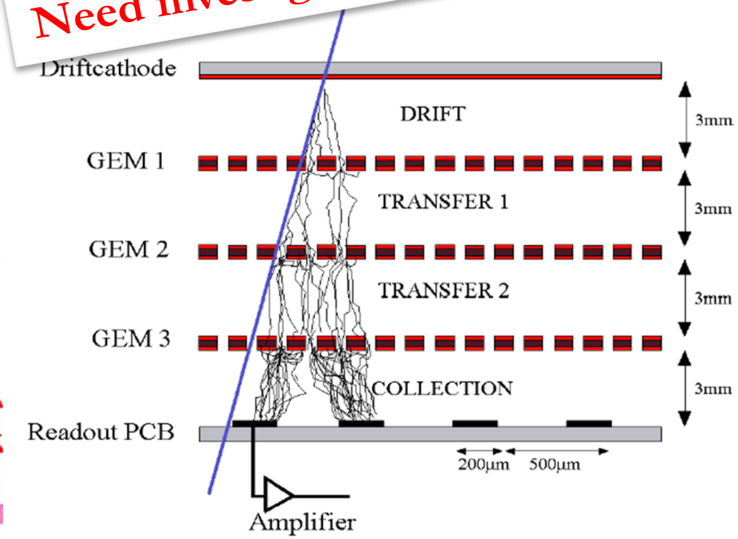
z component is obtained from drift time ⇨ <u>3-dimensional (x, y, z) information</u>

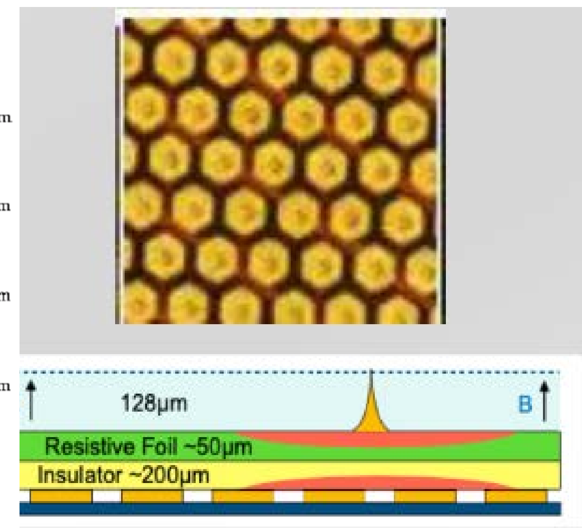
Electrons cluster profile to reach at the readout pad

- High magnetic field
  - Reduce the diffusion along the drift length
  - Cluster size limited to the pixel readout

Need investigation and analysis







Standard GEM and Micromegas

- Higher rate and position resolution
- Discharge near to readout pad

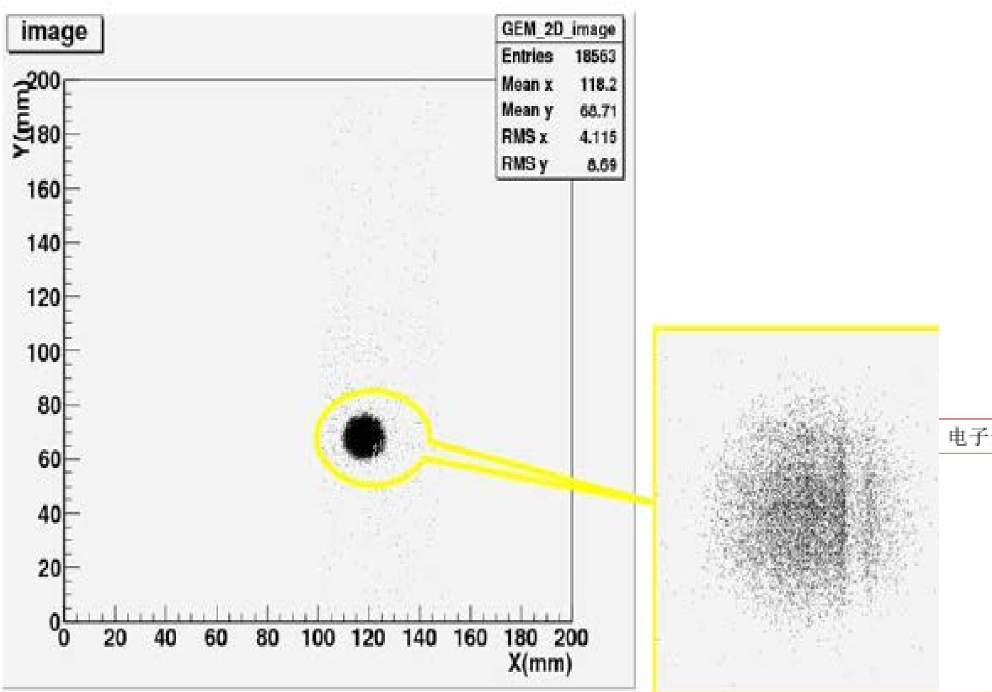
Standard resistive Micromegs

- Not reach to higher rate
- No Discharge near to readout pad

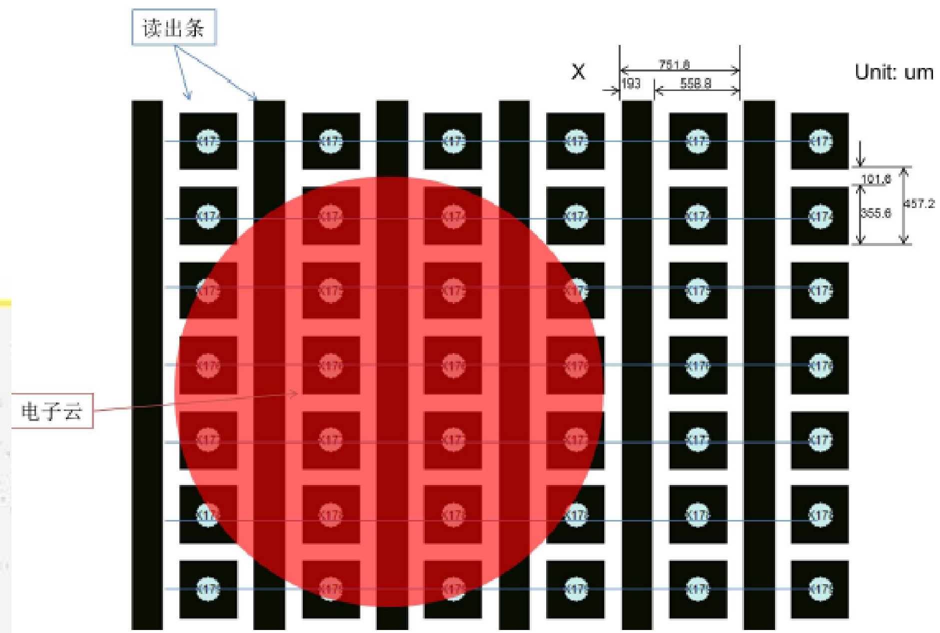
- **Update simulation and analysis**

Our triple GEM's results (previous)

- 2D detector module of Triple GEMs in 2015
- Investigation of single event's electrons cluster at the readout pads
- Drift length: 14mm (only this parameter)



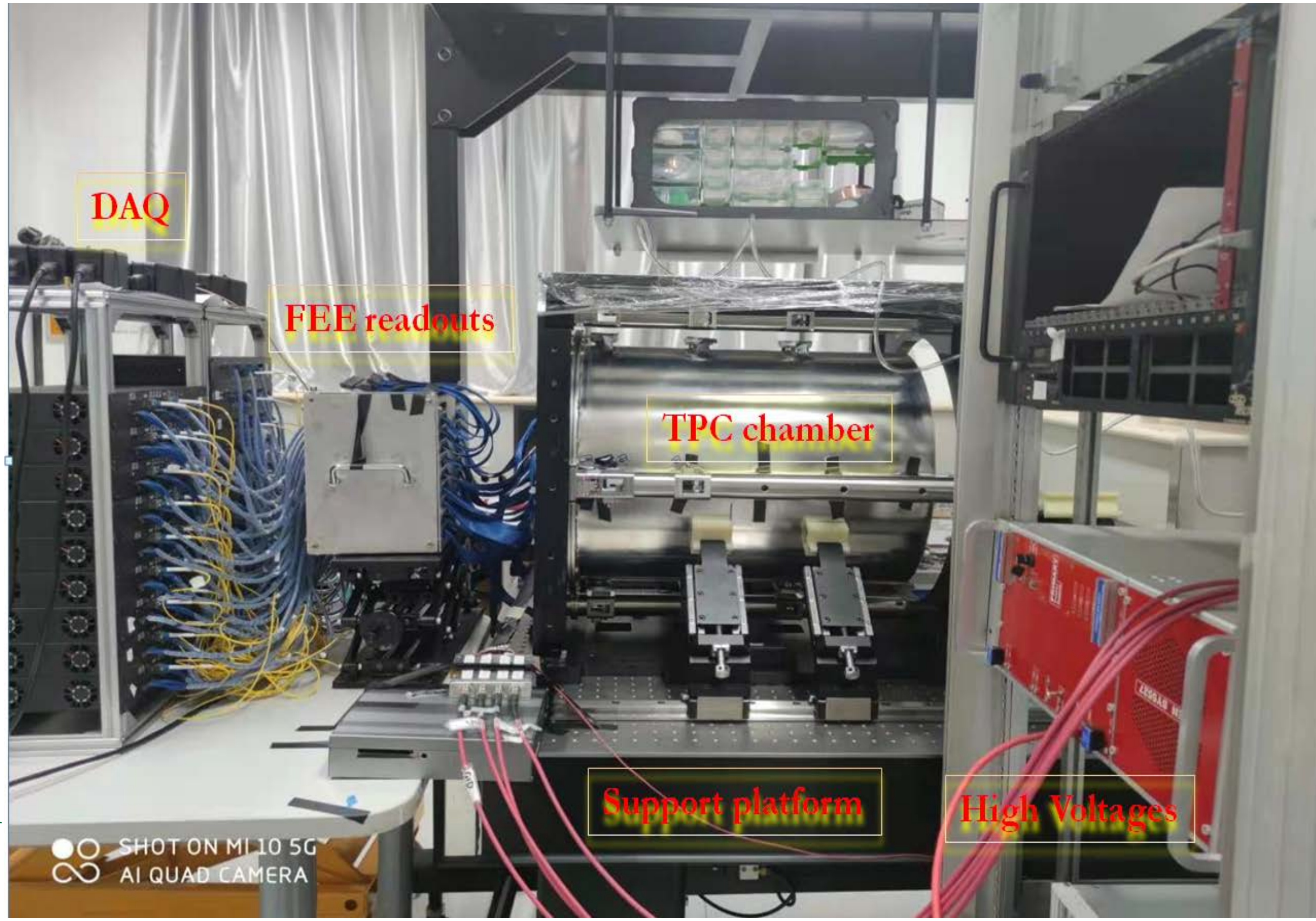
2D profile of ^{55}Fe
With Ø5.0mm collimator



2D profile of the electrons cluster size at the readout pads

Status of TPC prototype

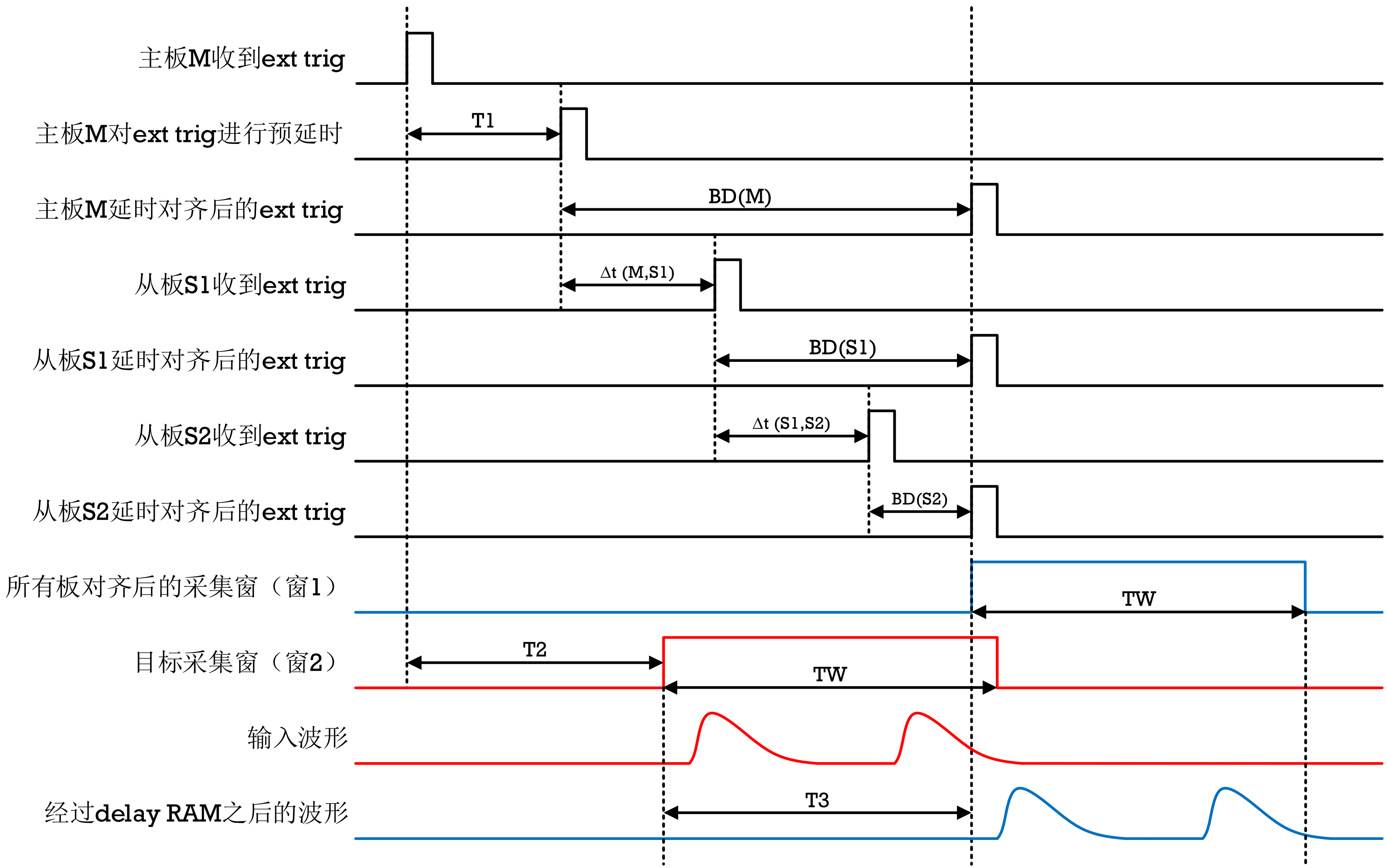
- Based on this prototype and analysis of the electrons cluster size at the readout pads
- Data taking and more analysis
- Commissioning:
  Huirong Qi, Zhiyang Yuan, Yiming Cai, Yue Chang, Jiang Zhang, Yulan Li, Zhi Deng



TPC prototype in the lab

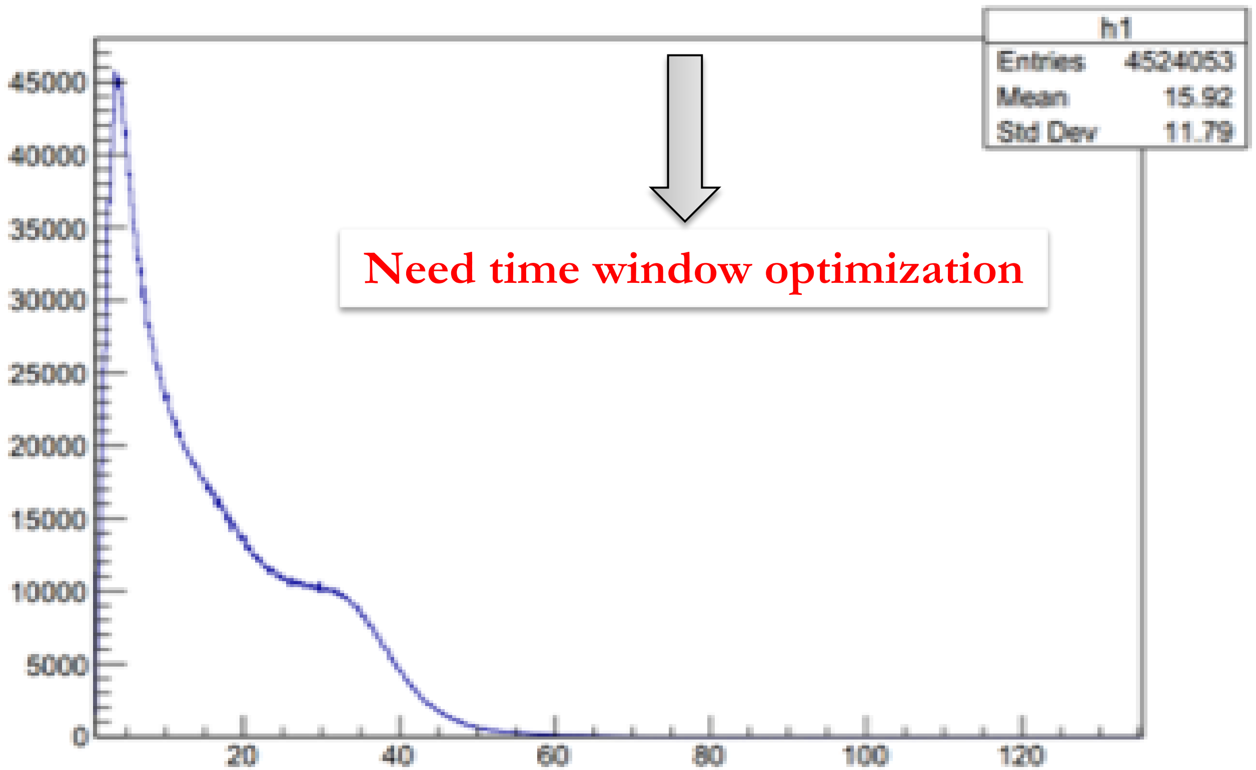
Calibration of ^{55}Fe

- Time window of self-trigger (or triggerless)



Calibration of ^{55}Fe

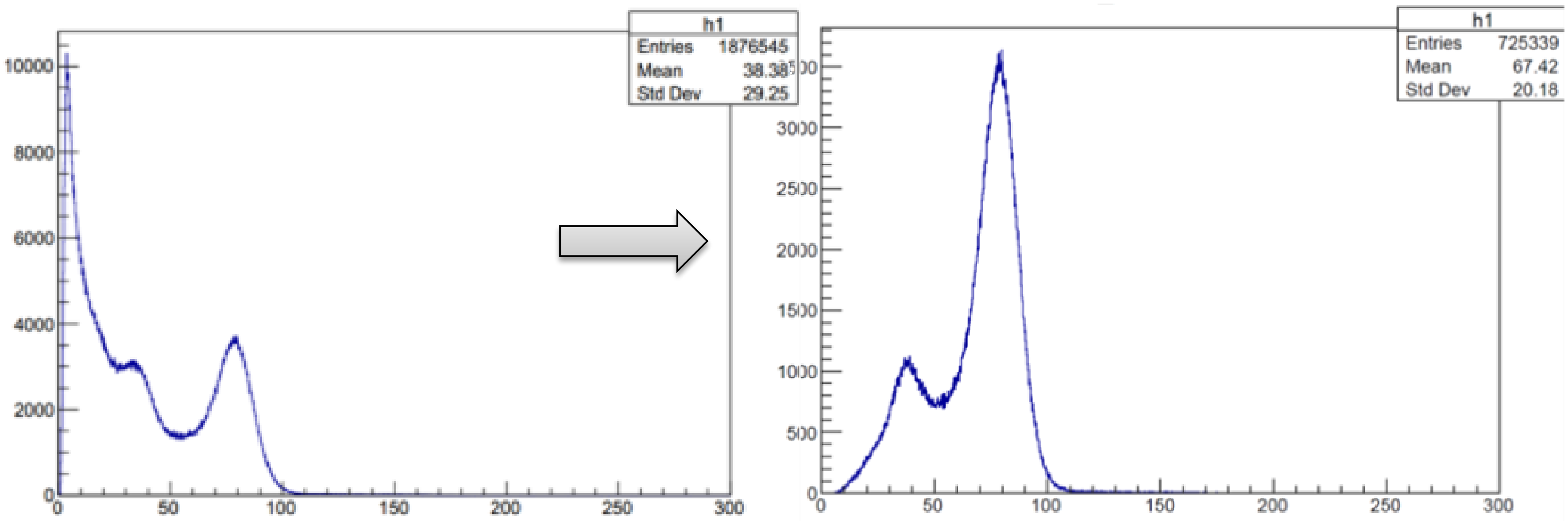
- Self-trigger (or triggerless) of TPC prototype
  - Self-trigger principle: Just consideration of the pulse time @400MHz TDC
  - Shape time: 120ns (CR^2-RC^3, CASAGEM ASIC)
  - ^{55}Fe with Ø1.0mm collimator
  - Trigger rate(every pulse): ~34550Hz



Spectrum of ^{55}Fe using TPC prototype

Calibration of ^{55}Fe

- Self-trigger (or triggerless) of TPC prototype
  - Optimization: different time window value
  - Confirmation: using ^{55}Fe energy spectrum
  - Optimization selection: eliminate incomplete or accidental coincidence event



Spectrum of ^{55}Fe using TPC prototype

Calibration of ^{55}Fe

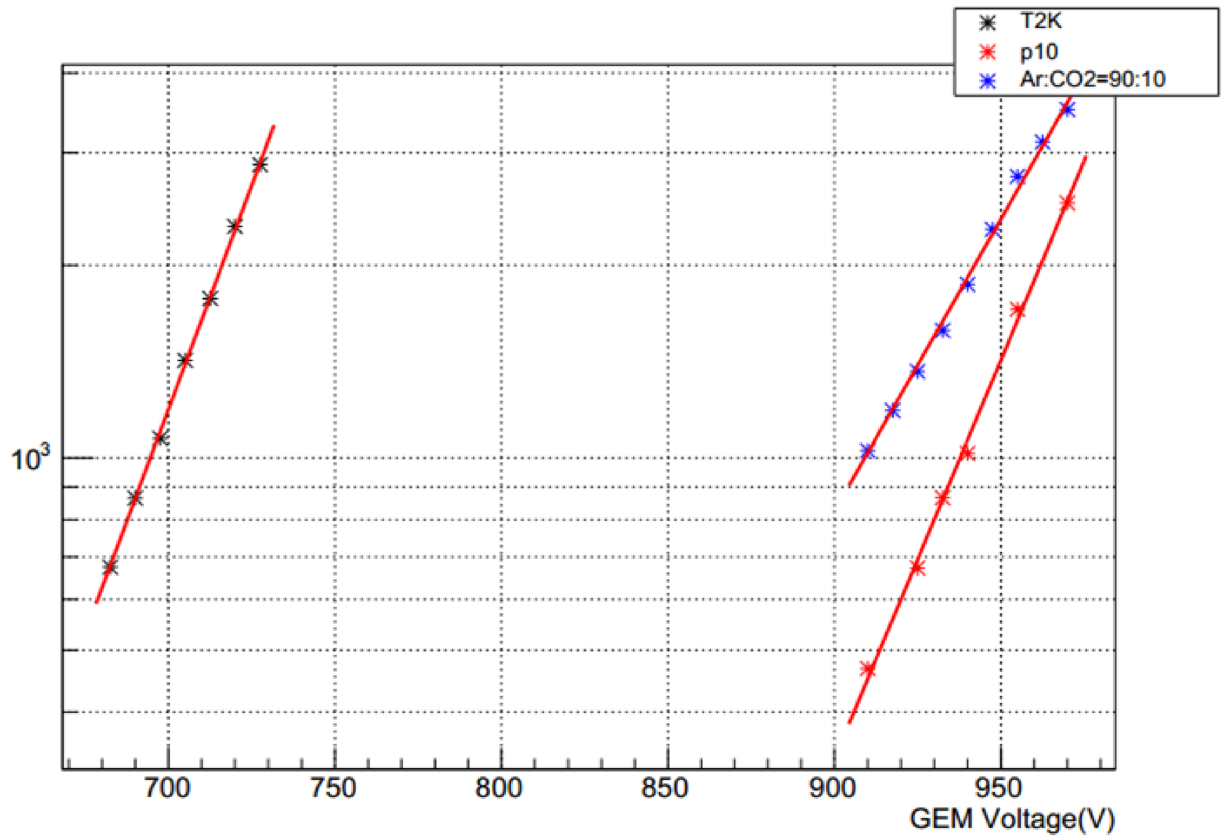
- Self-trigger (or triggerless) of TPC prototype
  - Along the different drift length
  - Setting as the optimization time window
  - Some parameters of the electron cluster size

Drift length of Z position	Profile of the electrons cluster(single event)	Minimum electrons cluster	Maximum electrons cluster
10.30mm	1.06 mm	3	6
7.30 mm	0.85 mm	3	6
5.84 mm	0.76 mm	3	6
3.65 mm	0.60 mm	2	4
1.46 mm	0.38 mm	1	4

Calibration of ^{55}Fe

Confirmation with the previous results

- Self-trigger (or triggerless) of TPC prototype
  - Setting as the optimization time window
  - Operation mixture gases: T2K. P10, Ar/CO2=90/10



Gain of ^{55}Fe using TPC prototype

- **No conclusions**
- **But, the electrons cluster size can be investigated and analyzed using UV laser beam, even without the high magnetic field**
- **And, this parameter can measured using the smaller dipole magnetic(0.1T-3T) field with our TPC module**
- **This parameter is very important for TPC technology**

Deviation of the electrons

- Electrons drifting along the drift length
  - Electromagnetic field (temperature, pressure, gases)
  - Fluctuation of gain (impact N_{eff})
  - Electronics (Shape time, amplifier, digitalized)
  - Diffusion: D_T, D_L

Langevin's formula for electronic directional drift

$$v = \mu |E| \frac{1}{1+\omega^2\tau^2}\left(\hat{E} + \omega\tau\left[\hat{E}\times\hat{B}\right] + \omega^2\tau^2(\hat{E}\cdot\hat{B})\hat{B}\right)$$

No magnetic or the electric field is parallel to the magnetic field

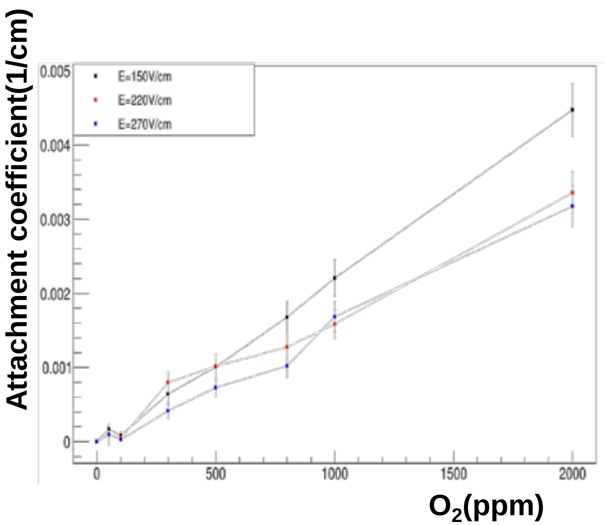
$$v = \mu E$$

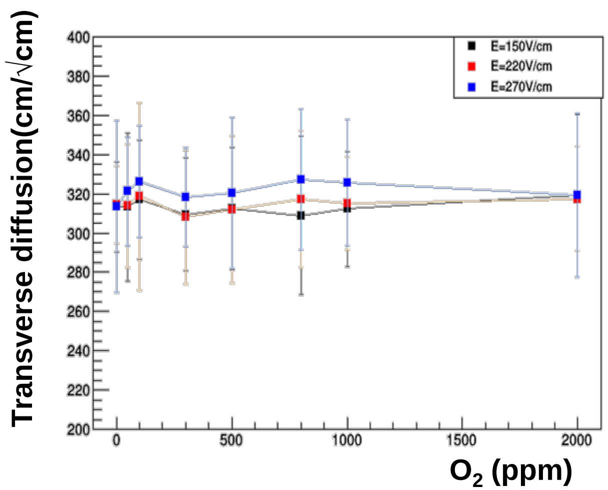
With magnetic and no parallel of E/B E×B effect

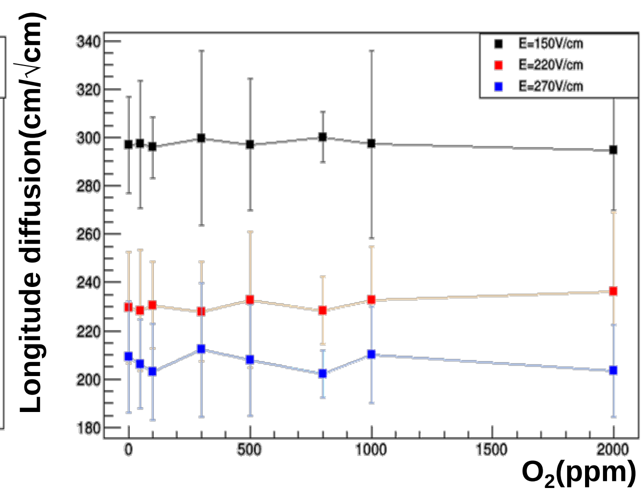
$$\begin{cases} v_x = \dfrac{\mu}{1+(\omega\tau)^2}[E_x - \dfrac{\omega\tau}{|B|}(E_y B_z - E_z B_y) + \dfrac{(\omega\tau)^2}{|B|^2}(E_x B_x + E_y B_y + E_z B_z)B_x] \\ v_y = \dfrac{\mu}{1+(\omega\tau)^2}[E_y - \dfrac{\omega\tau}{|B|}(E_z B_x - E_x B_z) + \dfrac{(\omega\tau)^2}{|B|^2}(E_x B_x + E_y B_y + E_z B_z)B_y] \\ v_z = \dfrac{\mu}{1+(\omega\tau)^2}[E_z - \dfrac{\omega\tau}{|B|}(E_x B_y - E_y B_x) + \dfrac{(\omega\tau)^2}{|B|^2}(E_x B_x + E_y B_y + E_z B_z)B_z] \end{cases}$$

Deviation of the electrons

- Electrons drifting along the drift length
  - Gas impurities: Oxygen and water







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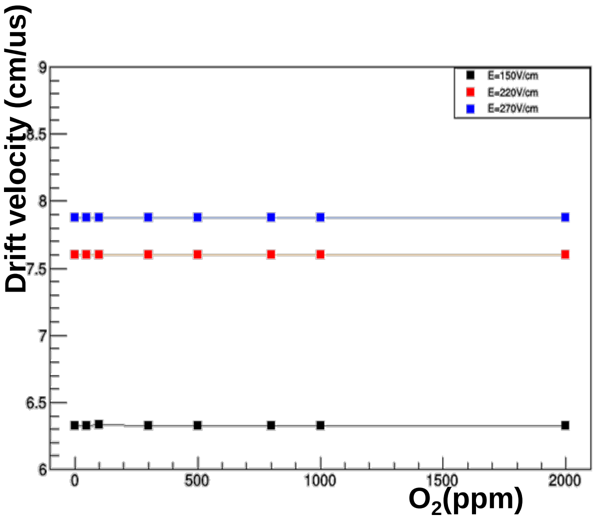
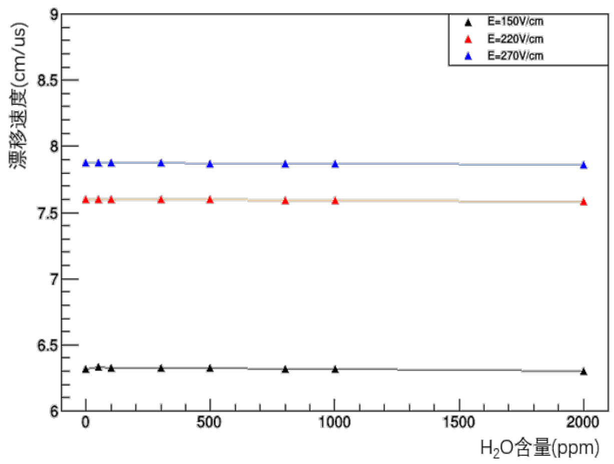
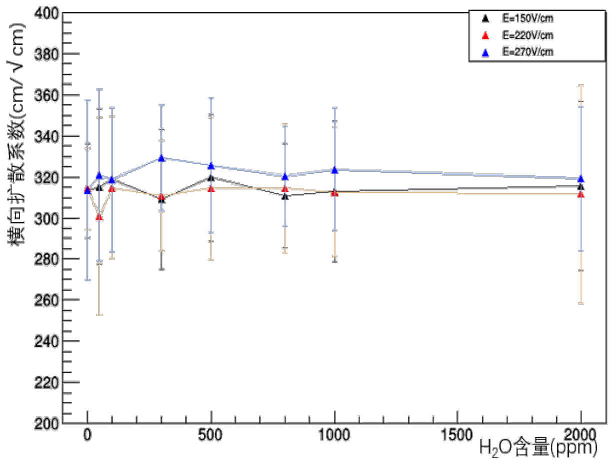




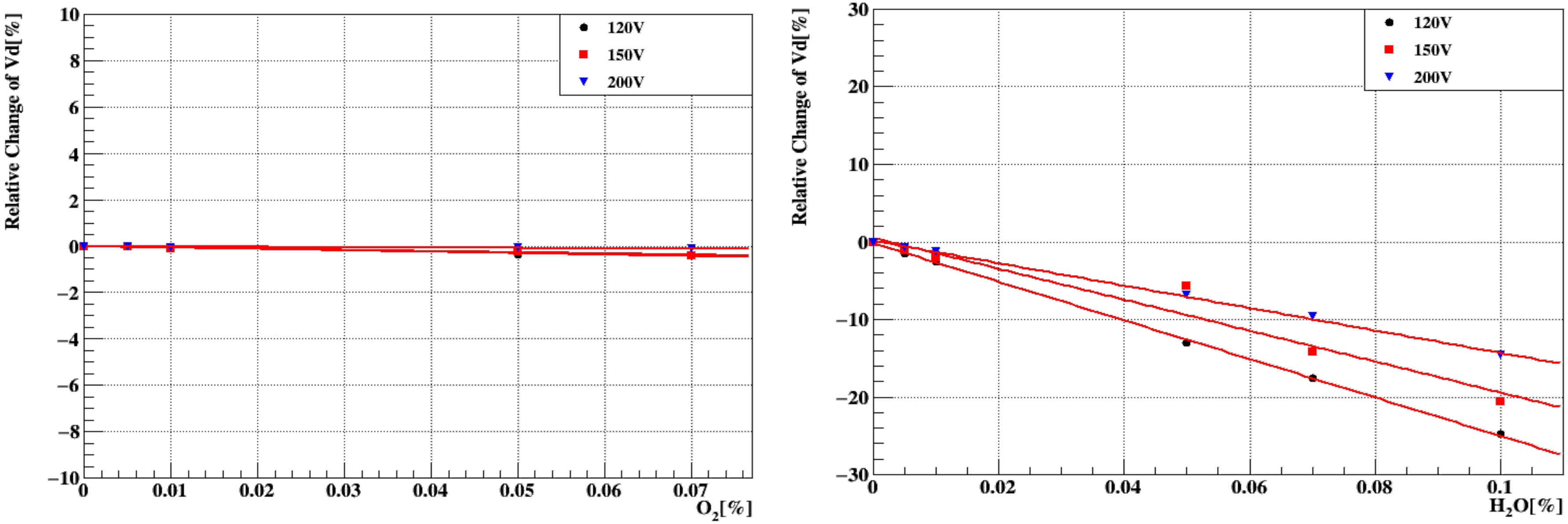


Deviation of the electrons

- Electrons drifting along the drift length
  - Gas impurities: Oxygen and water

$$\frac{\partial v_d}{\partial C_{O_2}} = -5.103 \pm 0.606\ [\%/\%]$$

$$\frac{\partial v_d}{\partial C_{H2O}} = -199.105 \pm 22.728[\%/\%]$$

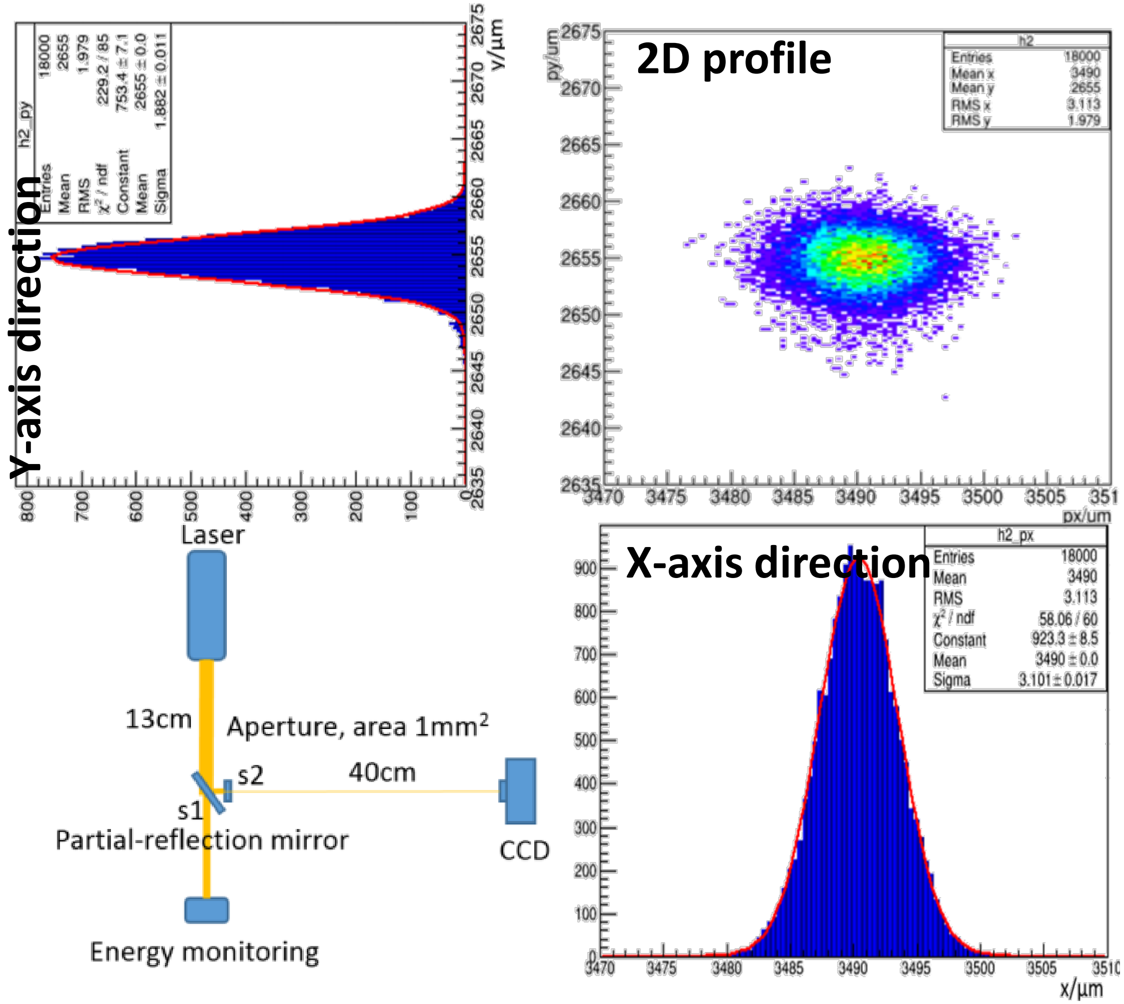


- Conclusion

  The influence of the purity(ppm) of Oxygen and water can be ignored for the previous taking data from TPC prototype.

Analysis of UV laser stability

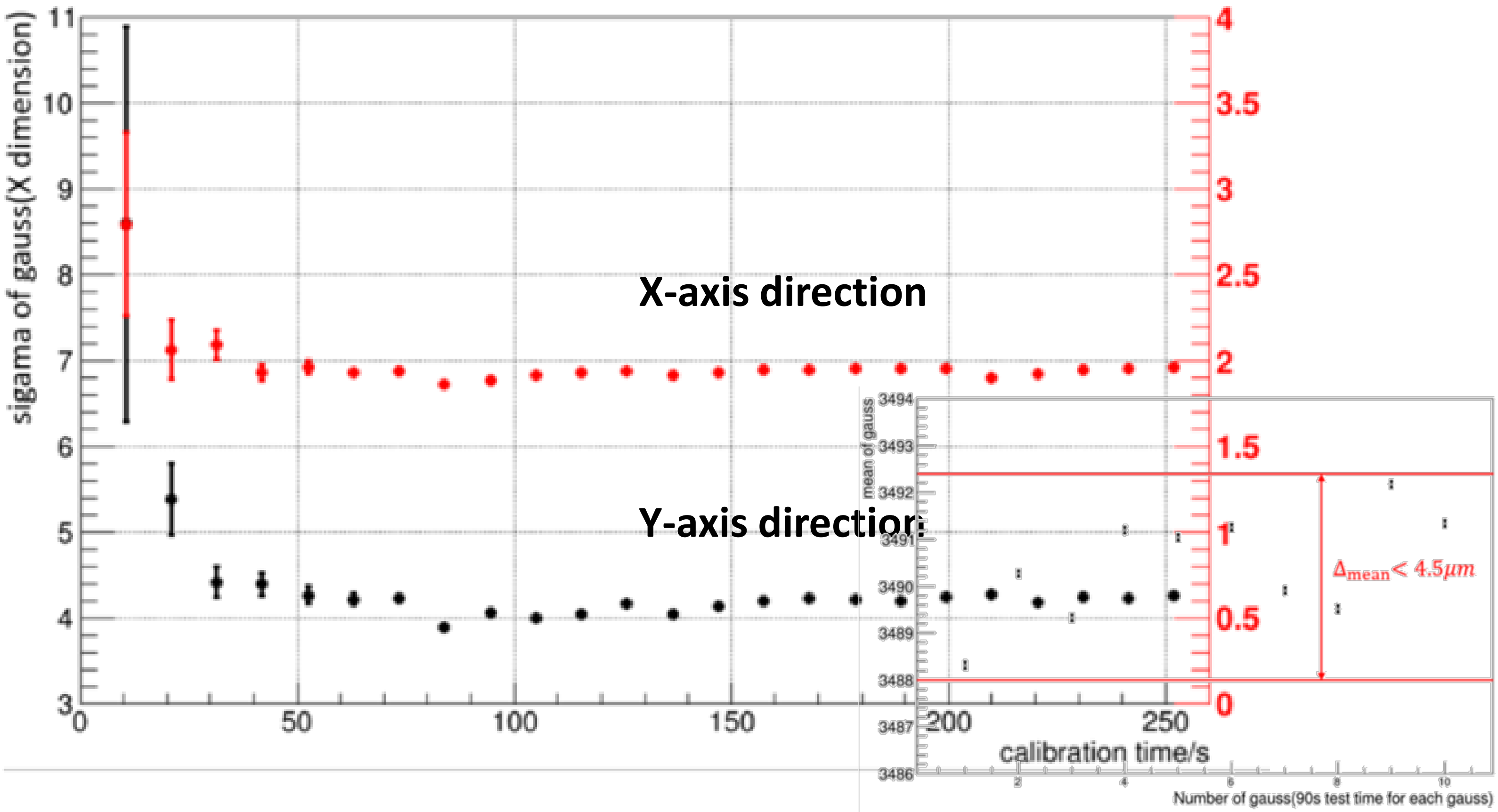
- Profile of UV laser beam
  - Update results of the UV laser stability from TPC prototype



Measurement and profile of UV laser beam for the tests

Analysis of UV laser stability

- Profile of UV laser beam
  - Profile(sigma) of the X-Y axis direction along the test duration time
  - UV laser tube need about 1 min warming up time



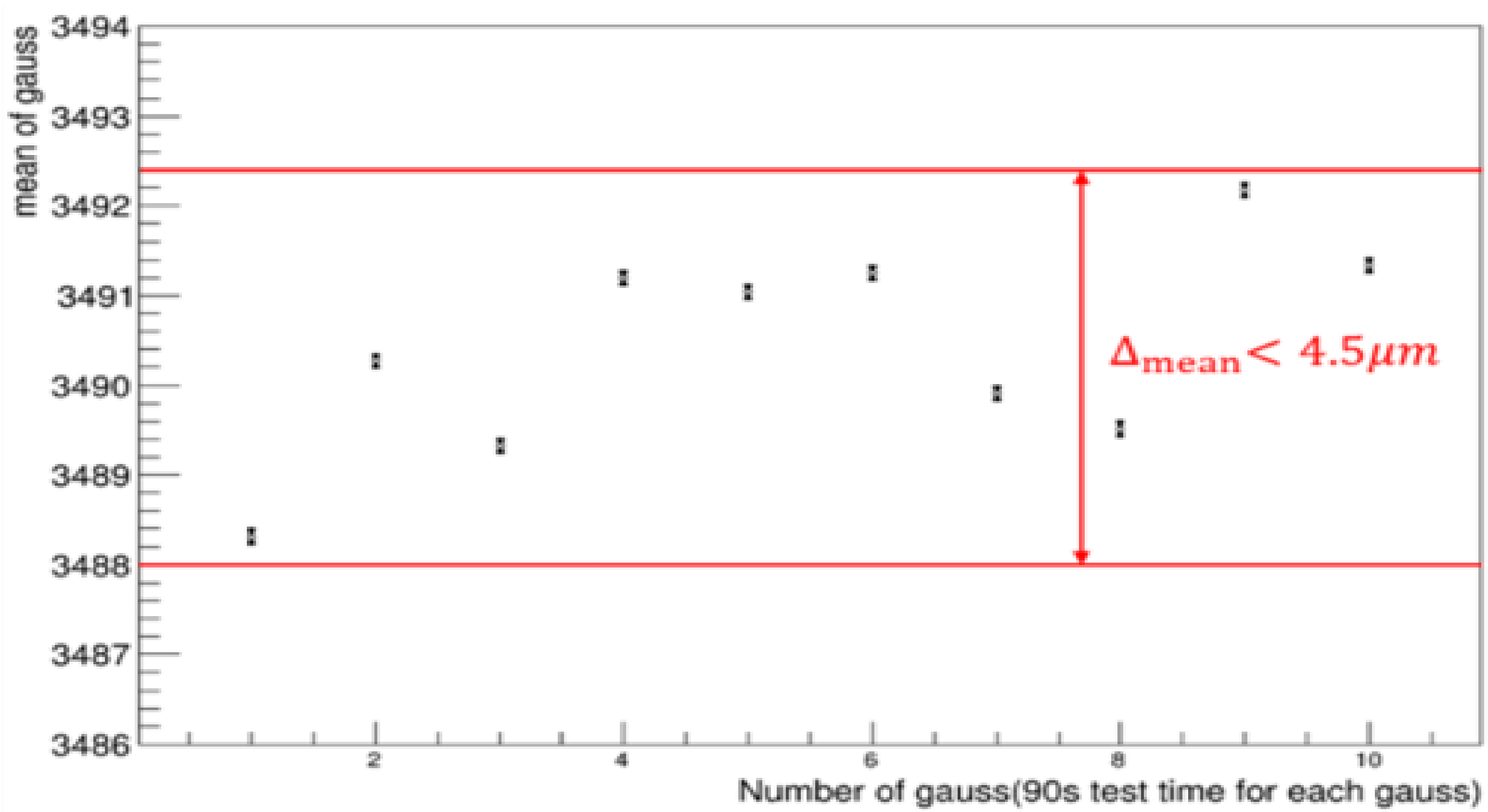
X and Y axis direction stability of UV laser beam

Analysis of UV laser stability

- **Conclusion**

  Precision value of UV laser stability can meet TPC prototype's resolution

  Qutel 266nm UV laser is very good for testing and analysis



Stability of UV laser beam

Summary

- Some update information of the pixel TPC beam test in DESY.
- Some update results of the electrons cluster size are starting to investigate and some new plan are raised for this parameter.
- Some update simulation and analysis are given here.

Thanks for your attention.