Commissioning and analyzing of TPC prototype integrated with UV laser

Huirong Qi

ZhiYang Yuan, Yiming Cai, Yue Chang, Zhi Deng, Yulan Li, Hui Gong, Wei Liu

Institute of High Energy Physics, CAS

Tsinghua University

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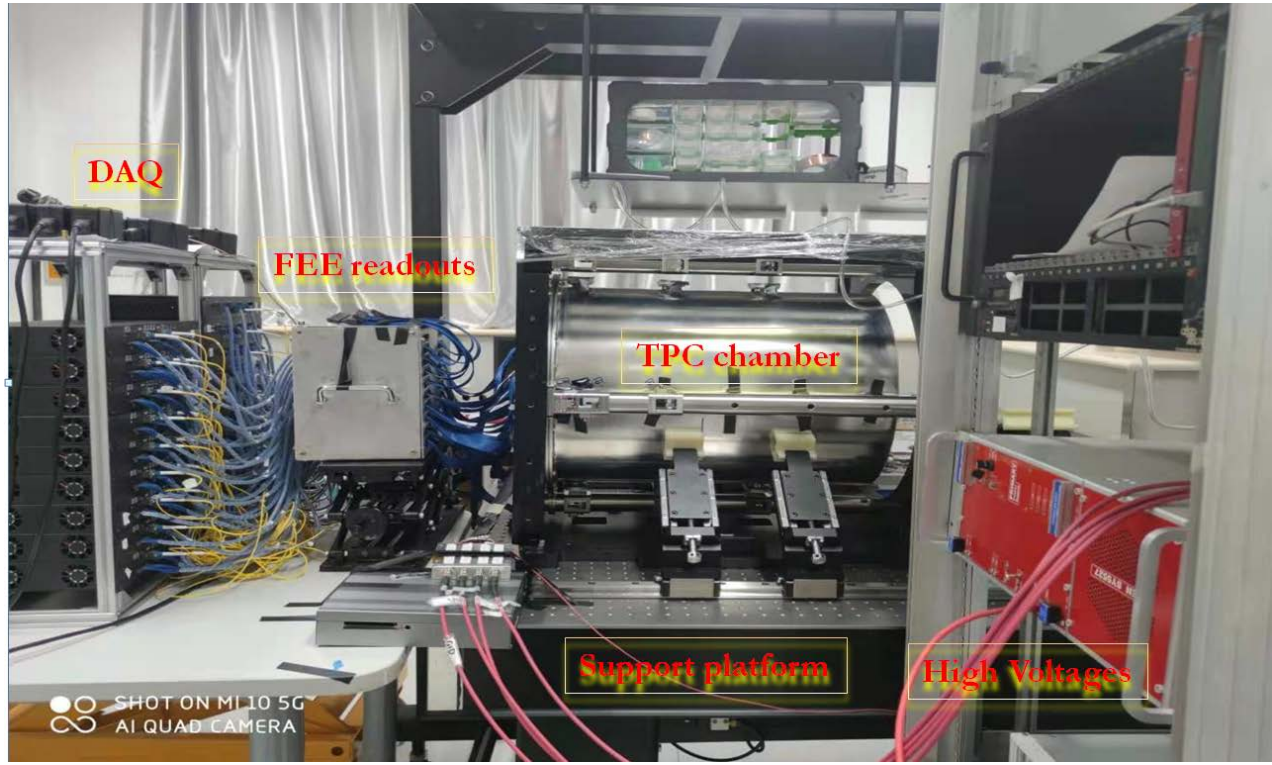
Outline

- Status of TPC prototype
- Update results
- Plan and summary

Update of the TPC prototype

Status of TPC prototype

- Detector prototype was almost perfectly done and working well
- Commissioning: Huirong Qi, Zhiyang Yuan, Yiming Cai, Yue Chang, Jiang Zhang, Yulan Li, Zhi Deng
- Data taking: the same, plus: Hongyu Zhang, Ye Wu
- Data taking and more analysis on going

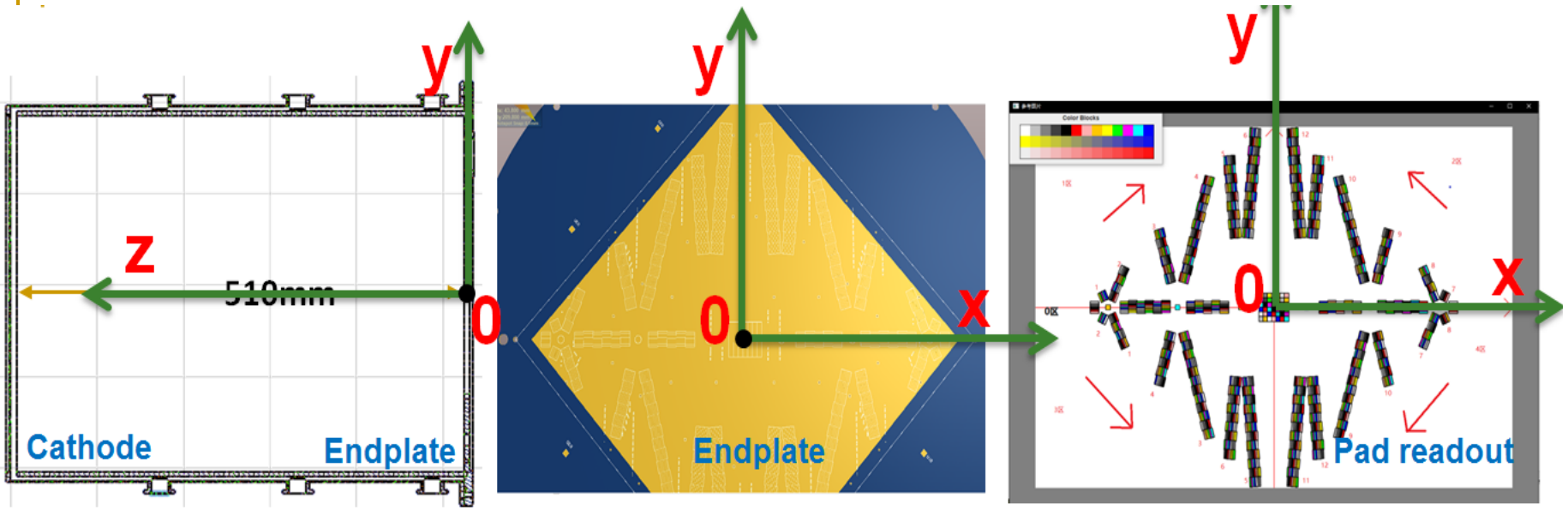


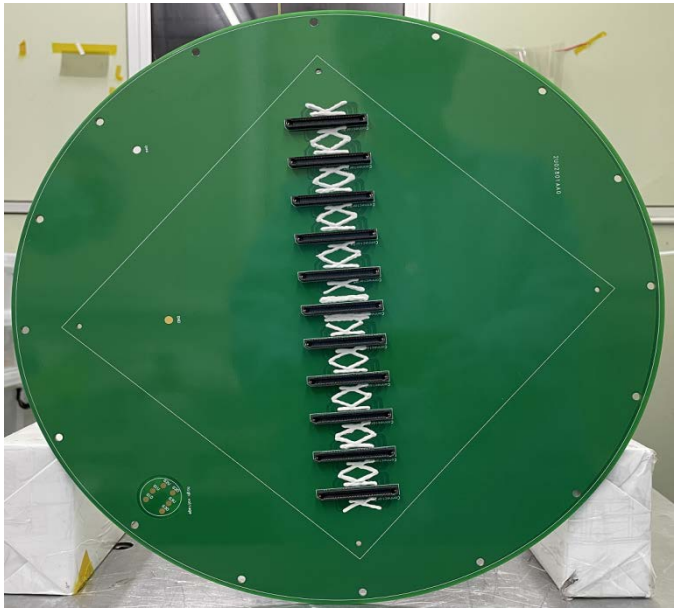
TPC prototype in the lab

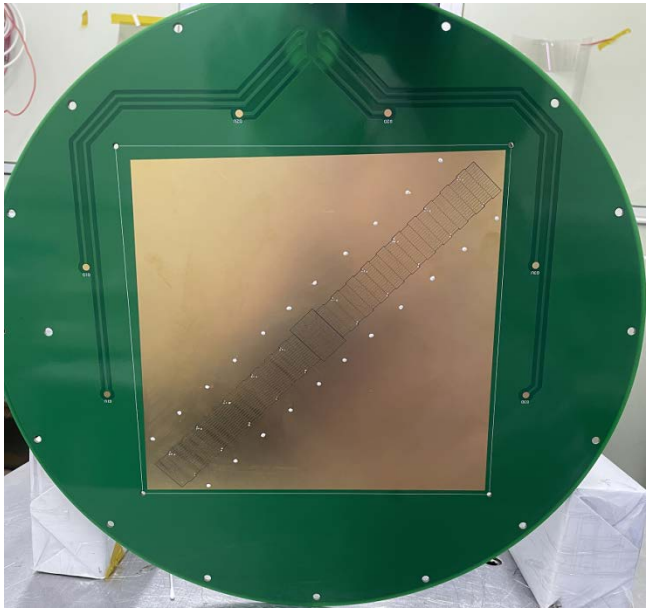
Optimization of TPC prototype

- Based on the update studies of TPC prototype
- High voltage of Field cage
  - Needed up to >300V/cm
  - No discharge more than 12 hours
  - New designed soft PCB
- Effective coverage of the PCB readout
  - Needed increasingly effective coverage
  - New designed PCB board
- More testing ongoing with the optimization

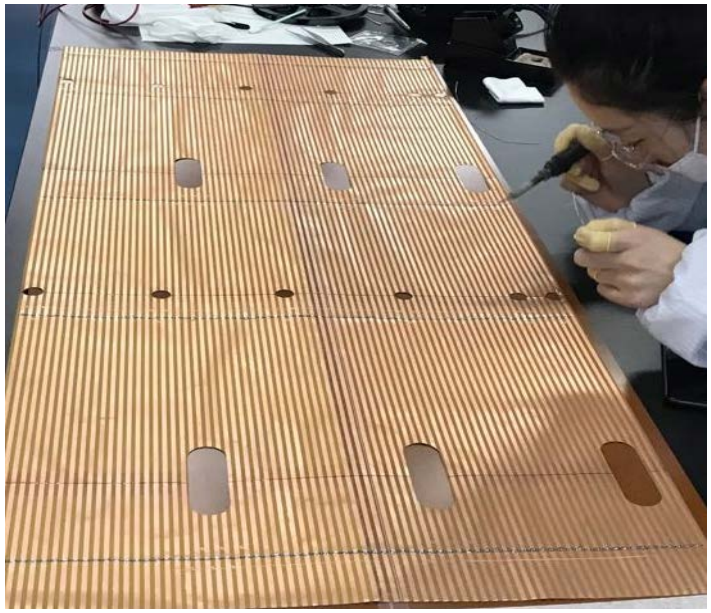
New readout PCB board assembled (Done)

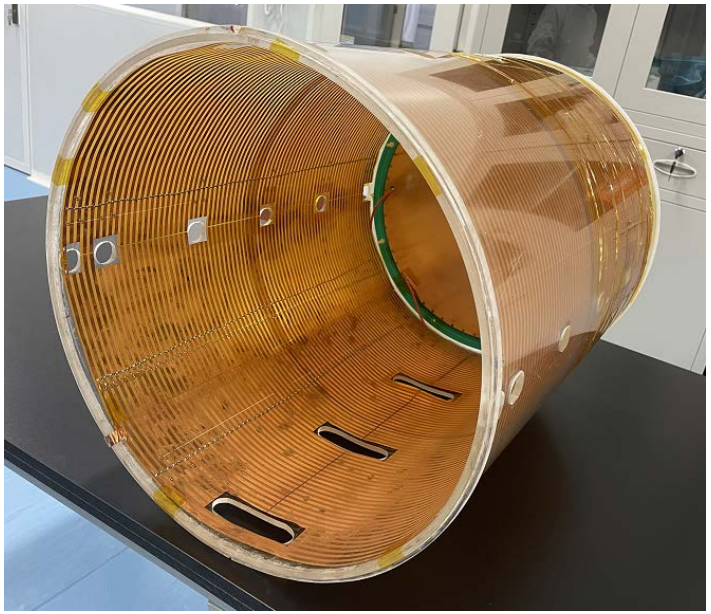






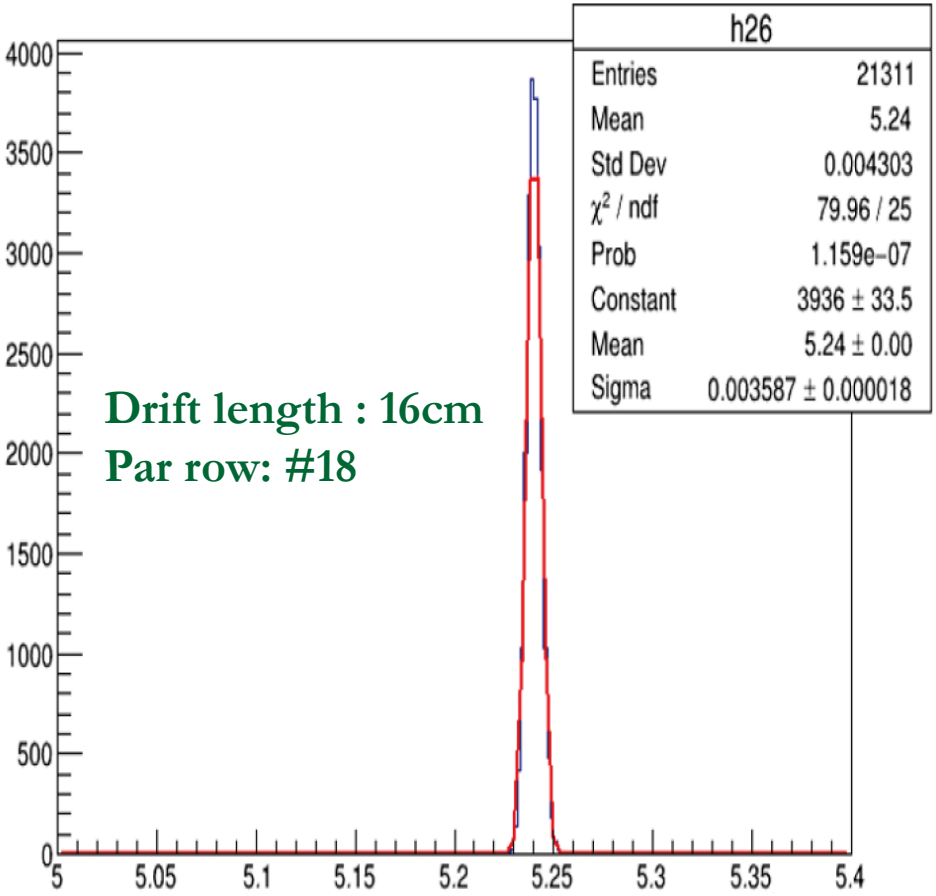
New fieldcage assembled (Done)

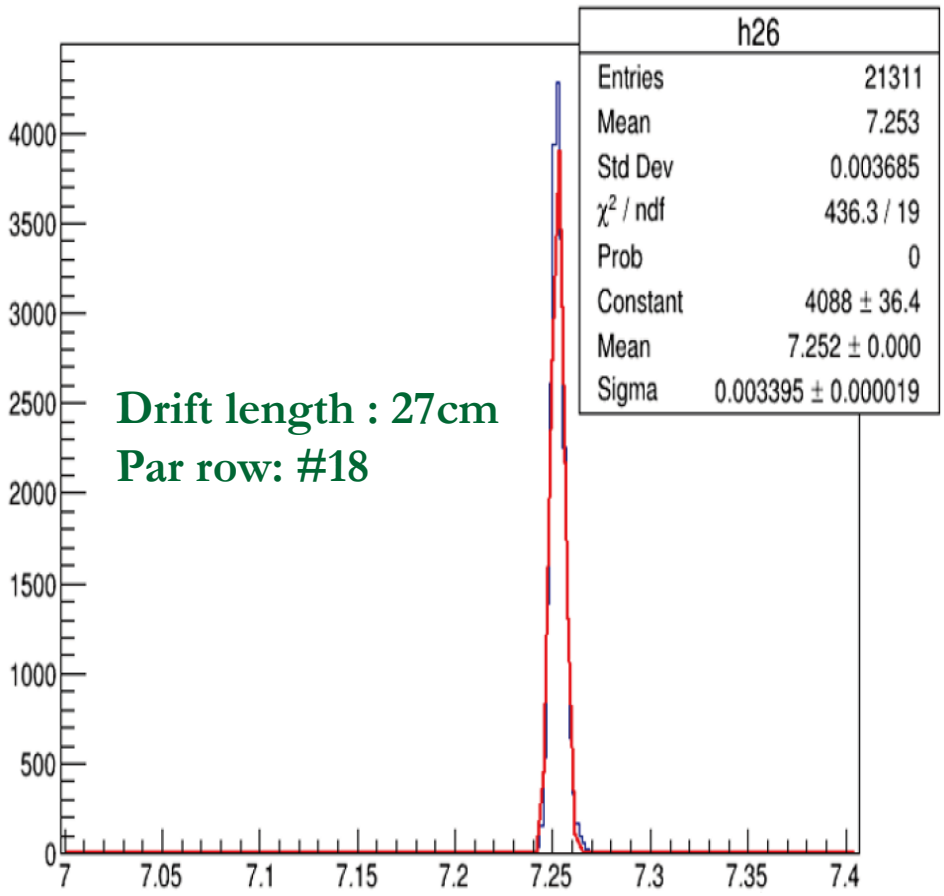




Update results

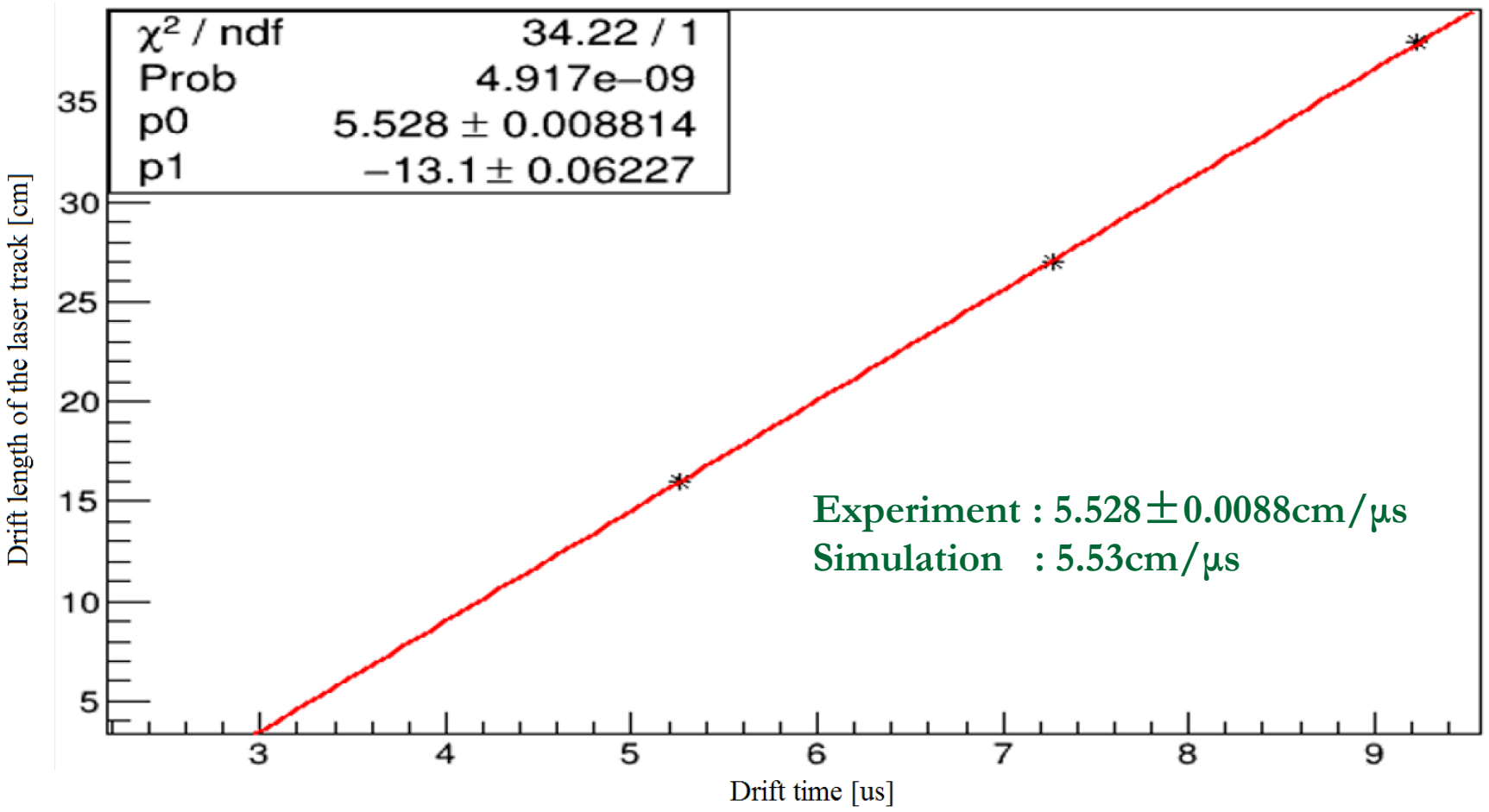
Drift time @400MHz





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

Drift velocity



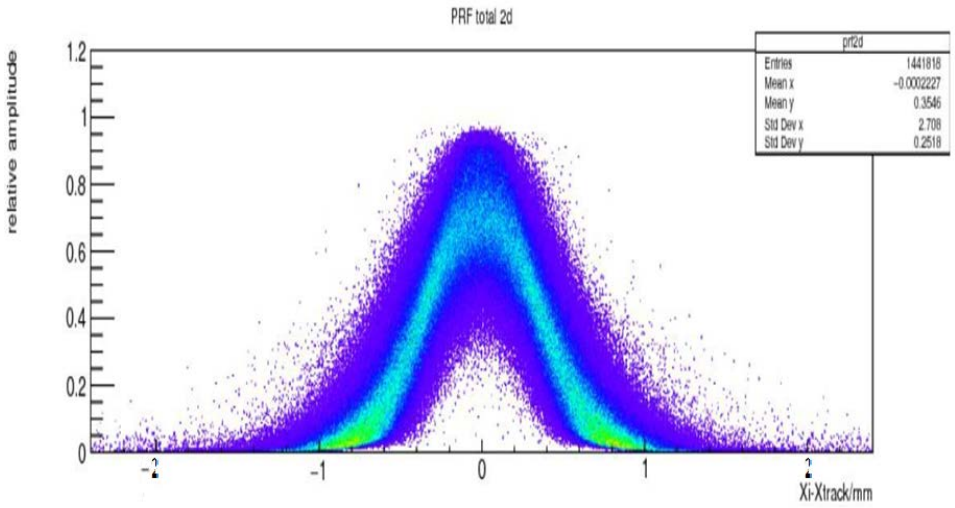
Drift velocity of the electron at 150V/cm in T2K

PRF analyzing of the spatial resolution (update)

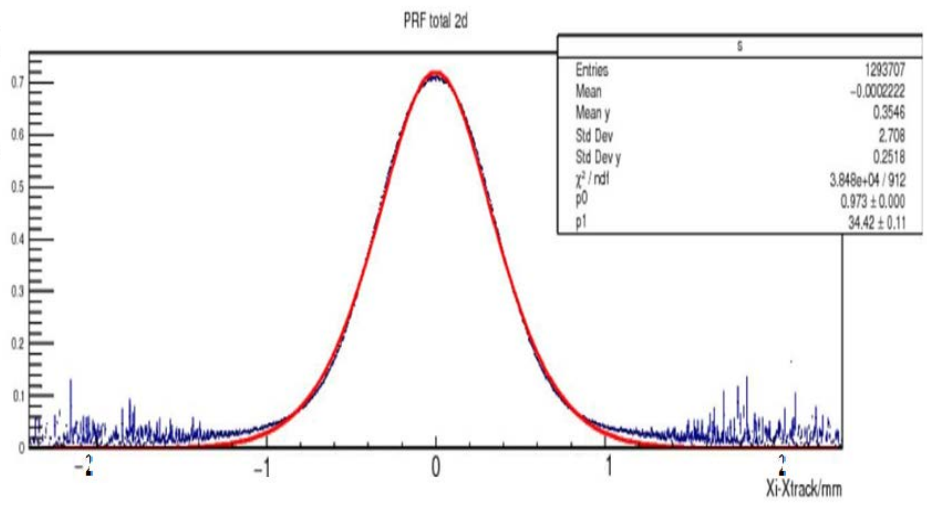
- **Pad Response Function** (PRF): a function used to describe the charge distribution and to determine the hit position via Pad

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

  - 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)



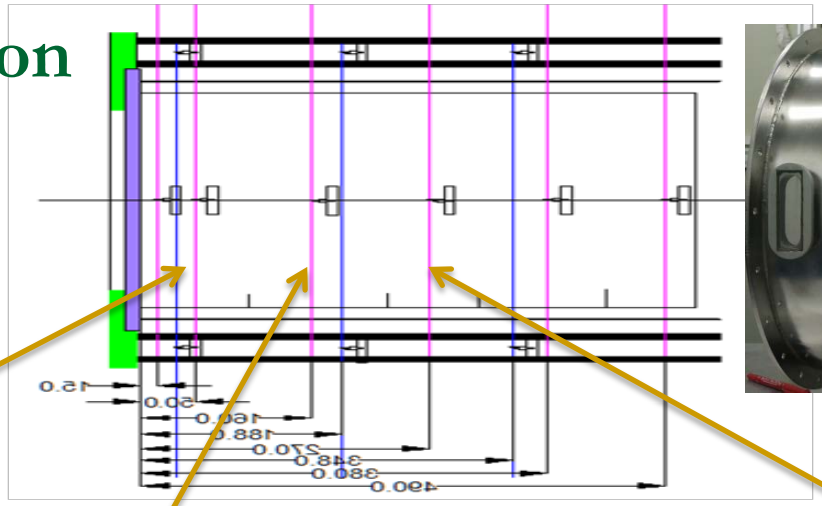
PRF total of all data

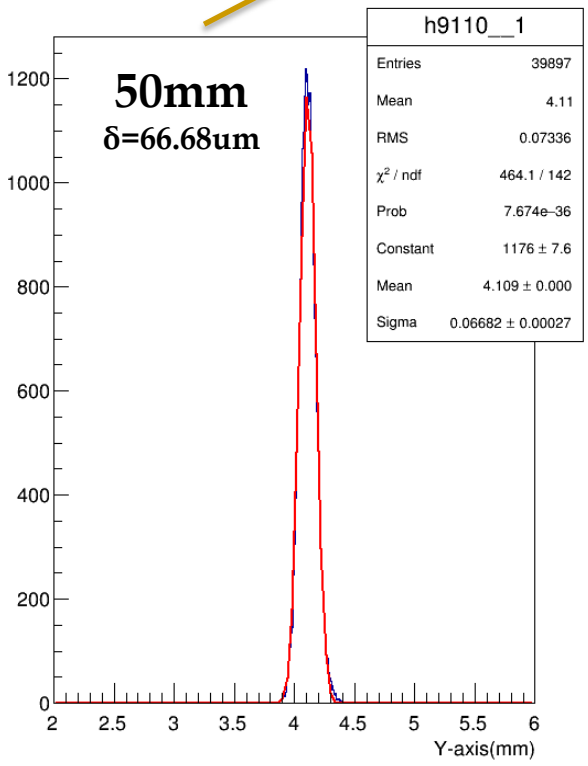


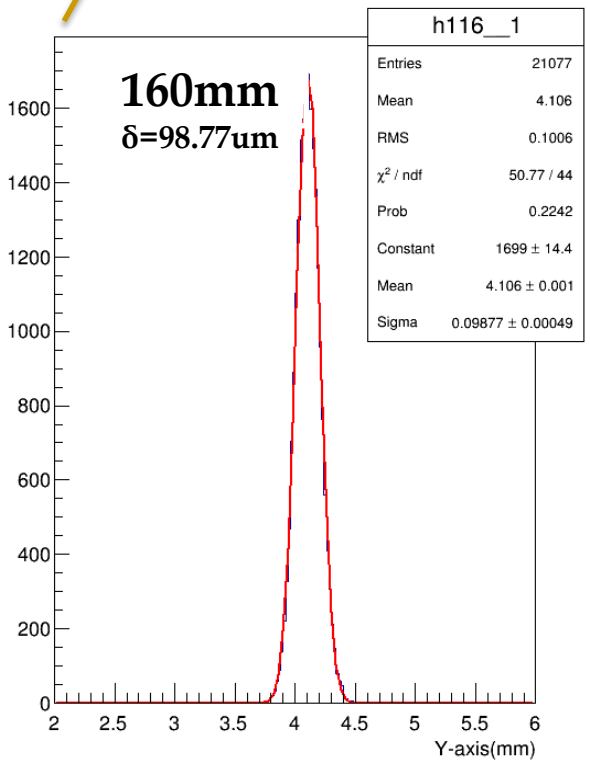
Profile of PRF from one pad row

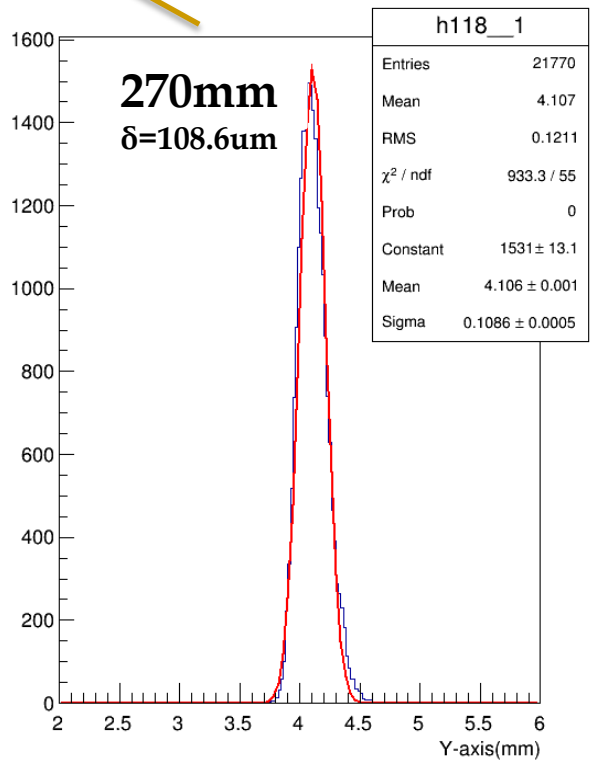
Space resolution

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









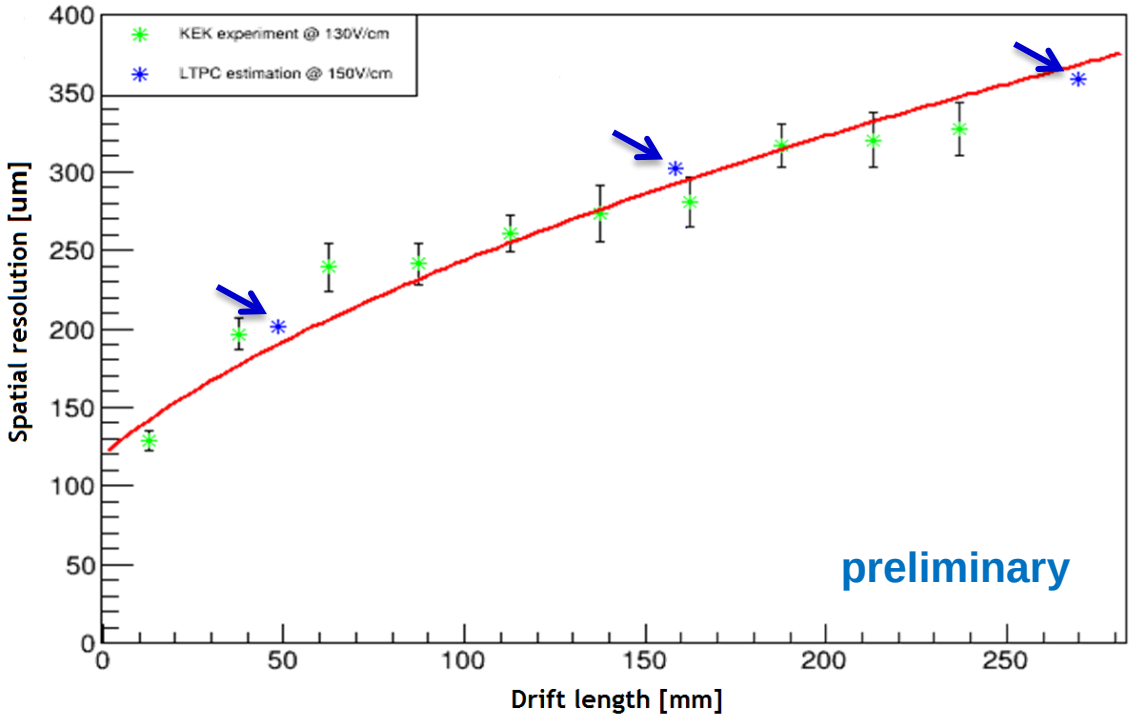
Space resolution at the different drift length

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

Plan studies of TPC prototype

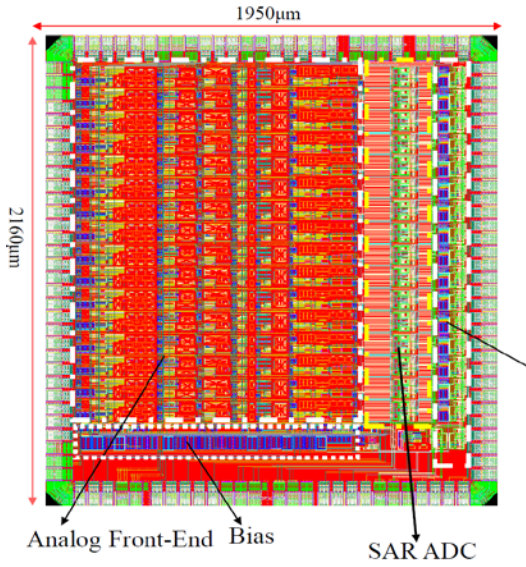
more studies are ongoing…

- dE/dx
- track distortion
- gain uniformity

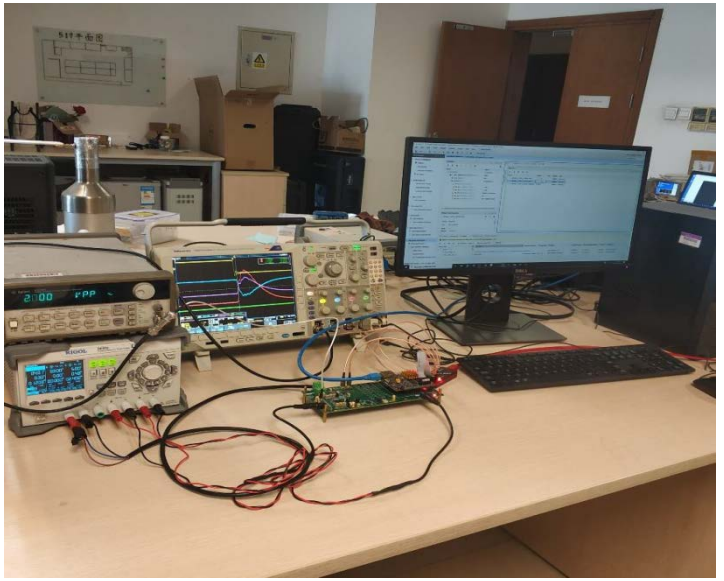
and …

Joint of new ASIC chip R&D

Deng Zhi, Liu Wei and Yuan Zhiyang

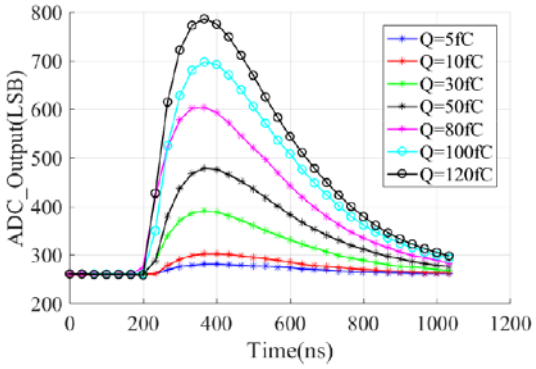


- The floor plan in layout ：
  - The die size of 1950 μm x 2160 μm
  - Analog Front-End , SPI, SAR ADC, LVDS driver are supplied by separate power
- The ASIC have been taped out in November, 2019 and is being evaluated

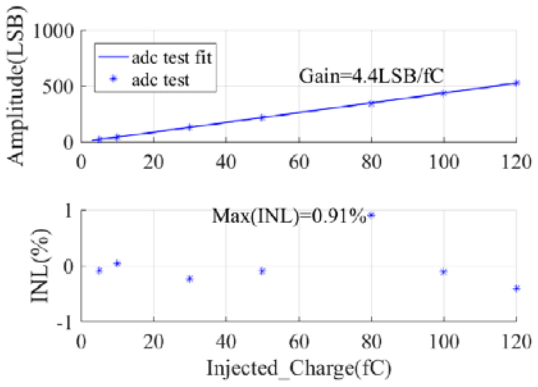


Layout of ASIC chip

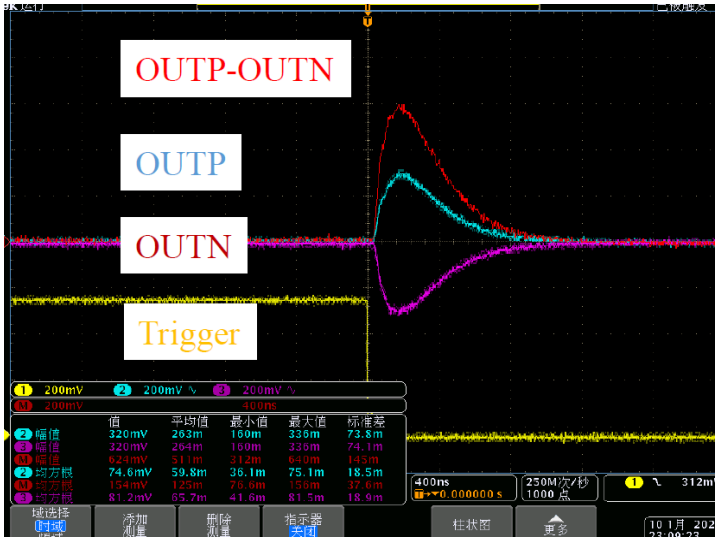
- Transient outputs



- The linearity @ gain = 10 mV/fC



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



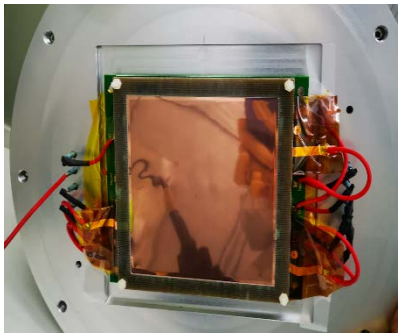
Test of the signals

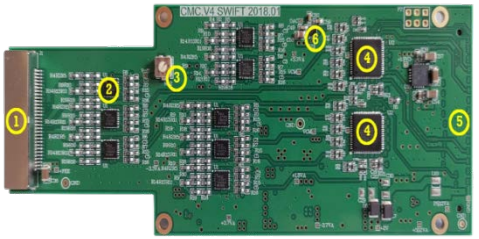
New electronics commissioning

- 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 mW/channel
    - P_{ADC} = 0.9 mW/channel @ 40M/s
  - ENC =852e @Cm = 2pF, gain =10 mV/fC and can be reduced to 474e using digital trapezoidal filter





Detector and ASIC

- 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

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.
- The TPC detector module and prototype will designed, assembled and commissioned with the new low power consumption ASIC chip from this month.
- More studies are ongoing and the update analyzing will been done.

Thanks for your attention.