Drift chamber prototype and beam test plan

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On behalf of the working group

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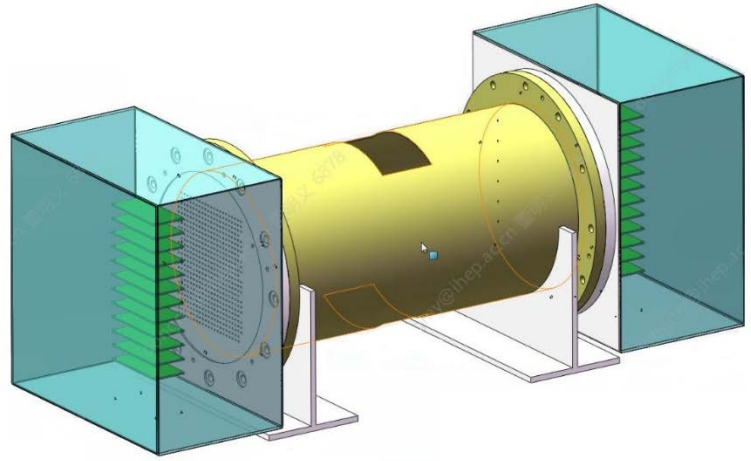
Drift chamber prototype system

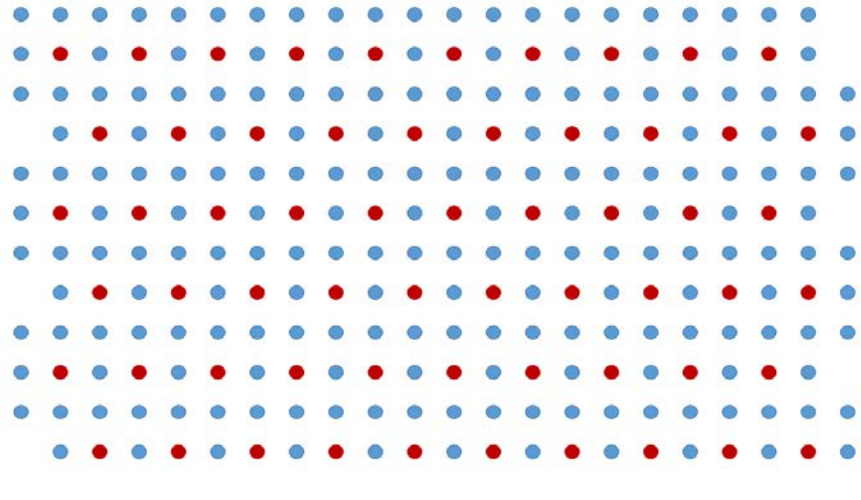
- To investigate the dN/dx based PID capability of the drift chamber, a dedicated prototype test system was developed

- Prototype test system consists of
  - A multi-layer drift chamber
  - Readout electronics
  - Data acquisition (DAQ) software
  - Trigger and control system

Multi-layer DC prototype

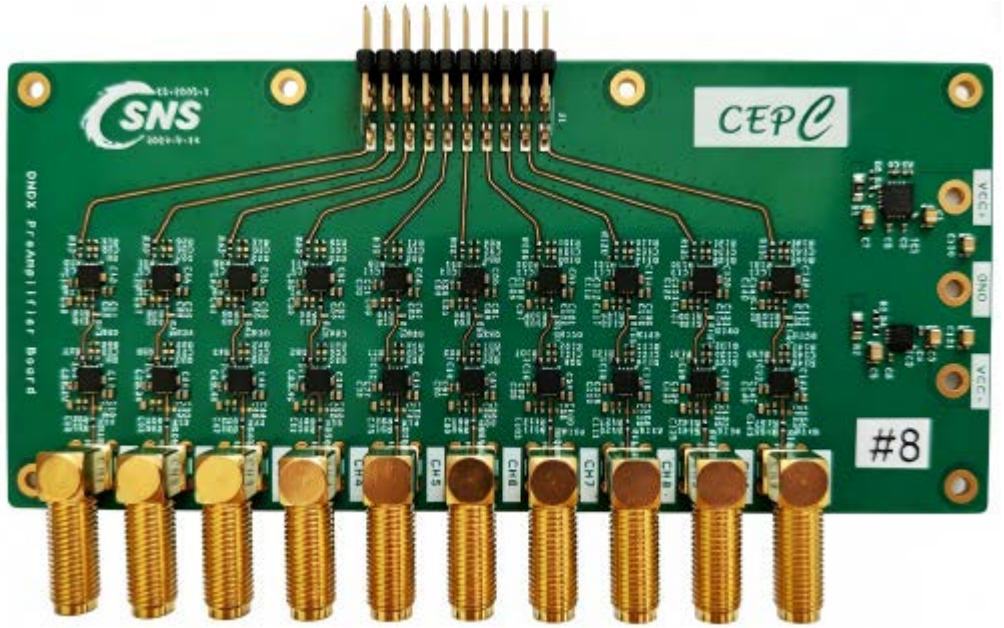
- **Parameters of the DC prototype**
  - 120 cells (12 layers, 10 cells/ layer)
  - Length: 60 cm
  - Cell size : 18 mm × 18 mm
  - Sense wire: 20 μm Au-plated tungsten
  - Field wire: 70 μm aluminum

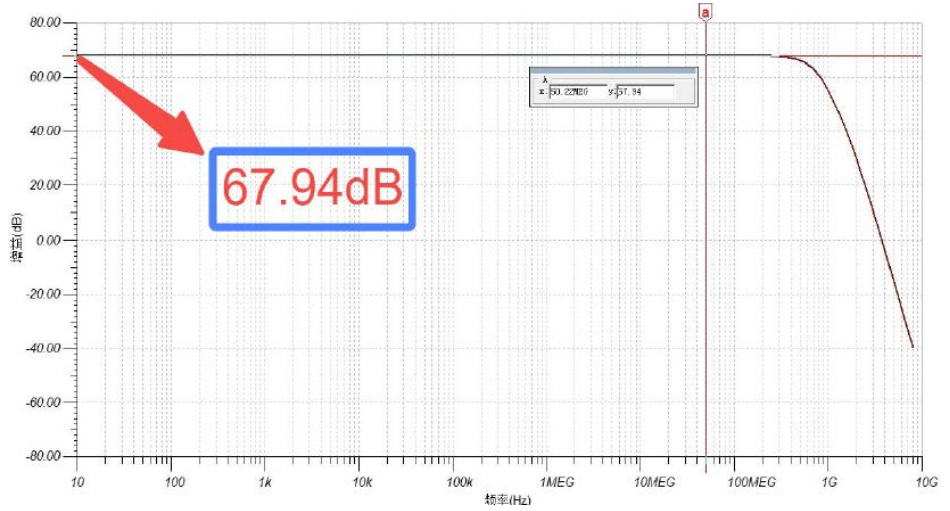




Preamplifiers

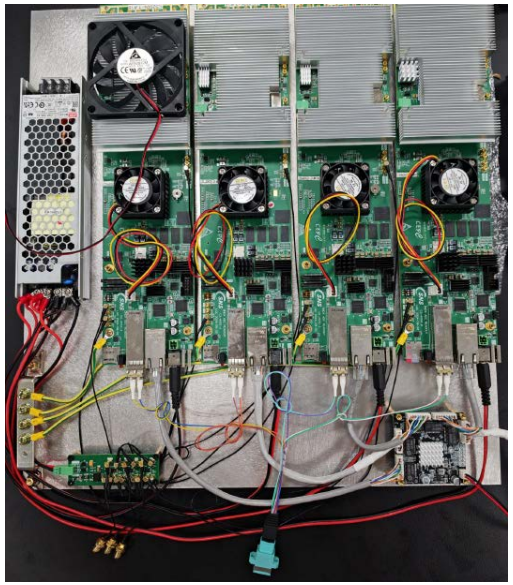
- Fast current preamplifier based on LMH6629 chips
- High gain, high bandwidth and low noise
  - Current gain：67.94 dB
  - Bandwidth: 587.74MHz @-3dB
  - Baseline noise: 1.53 mVrms





Readout electronics

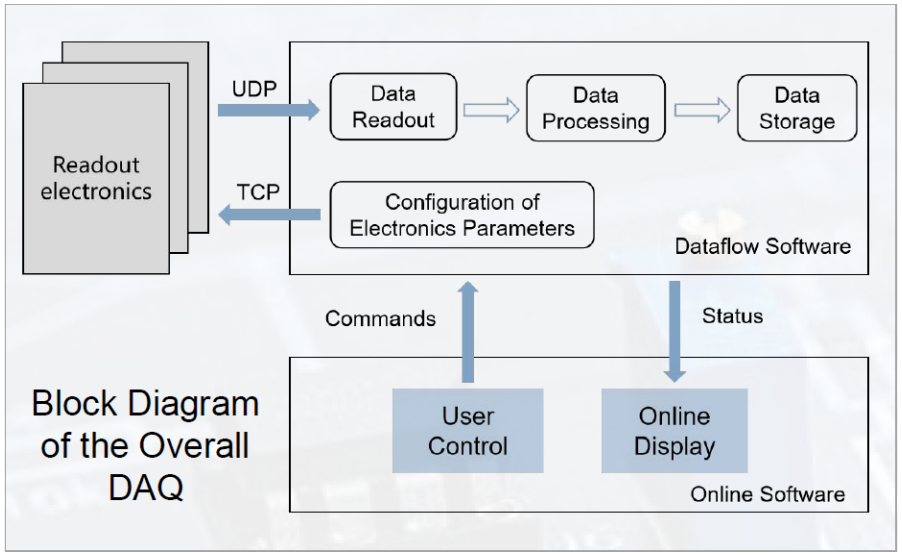
Digitization and FPGA board

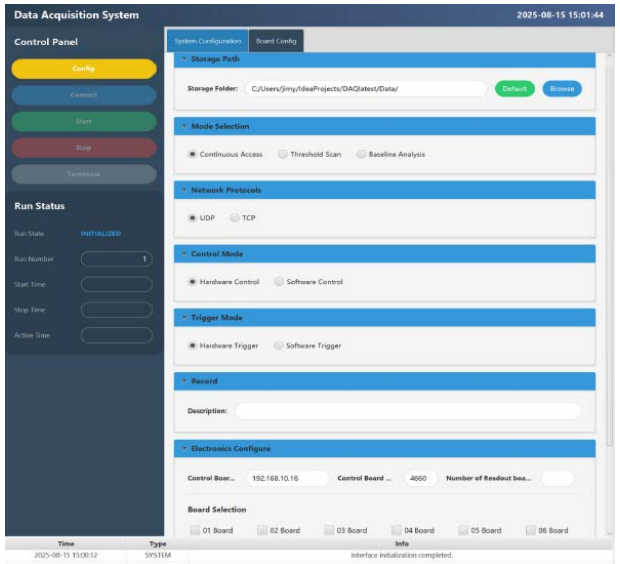


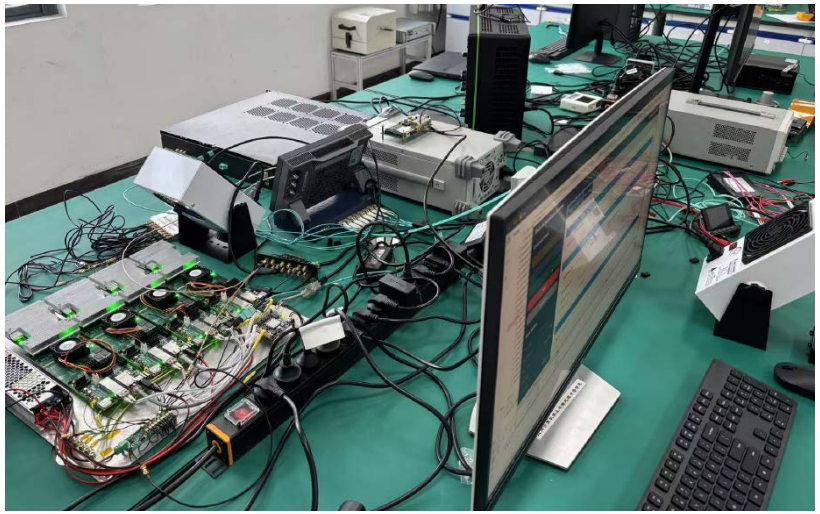
40-channels chassis

- **ADC mezzanine board**
  - Sampling rate: 1.3 Gsps,
  - Resolution: 14 bits
  - Power consumption: 750 mW/channel
- **FPGA readout board**
  - Receive data streams from five AD9695 ADCs via 13 Gbps JESD204B links
  - Send processed data to the DAQ server via 10 Gbps UDP links
- **Each chassis contains 40 digitization channels**

DAQ



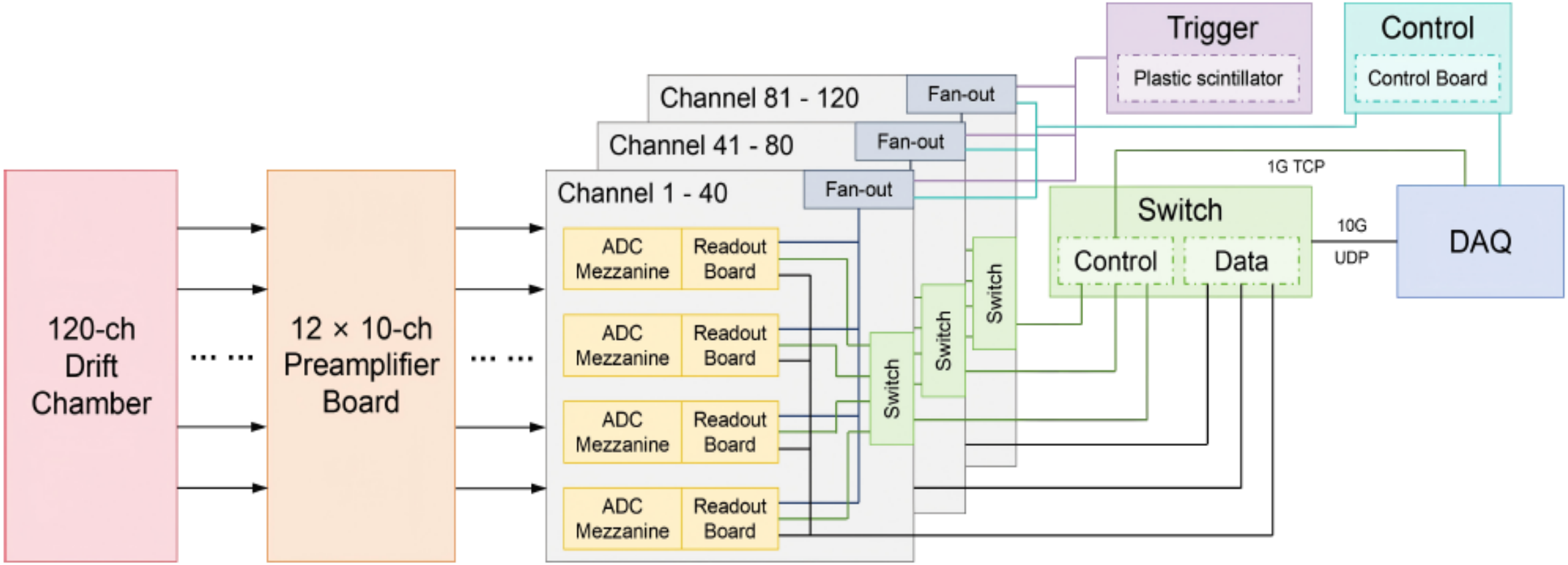




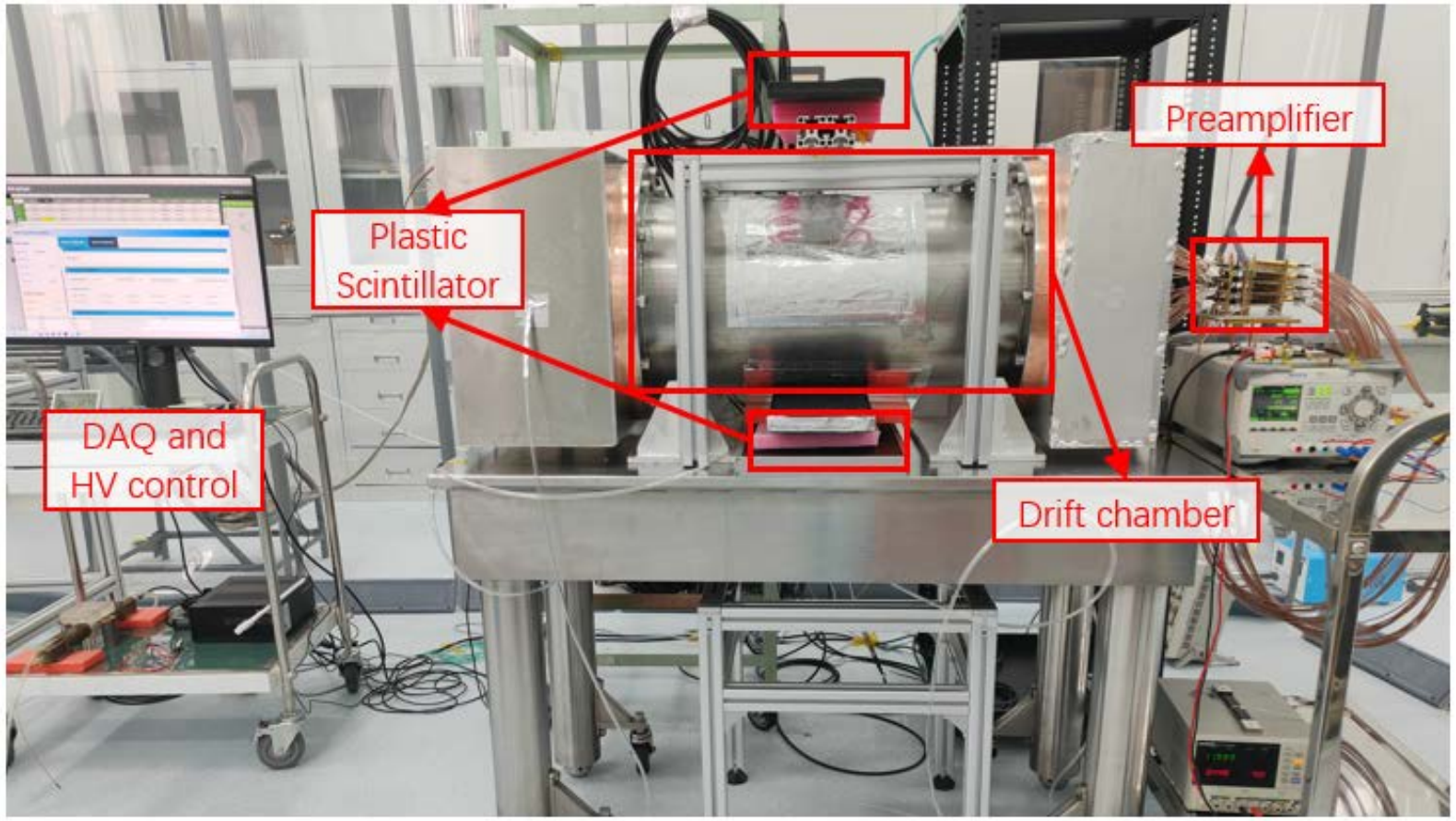
- Transmit data by 10 Gbps UDP
- Configure electronics by 1Gbps TCP

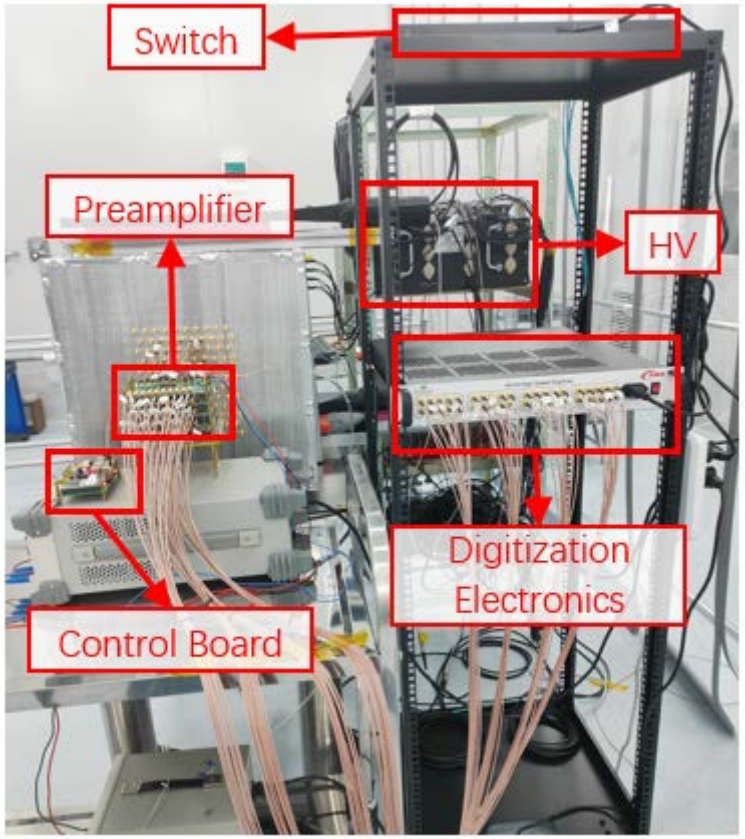
- **Dataflow Software**
  - Read out , check and save data
  - Configure the electronics, …
- **Graphical user interface**
  - Commands
  - Run information
  - Run log file
- **Online display software**
  - Online data process
  - Online waveform display

Test system setup



Prototype tested with cosmic rays

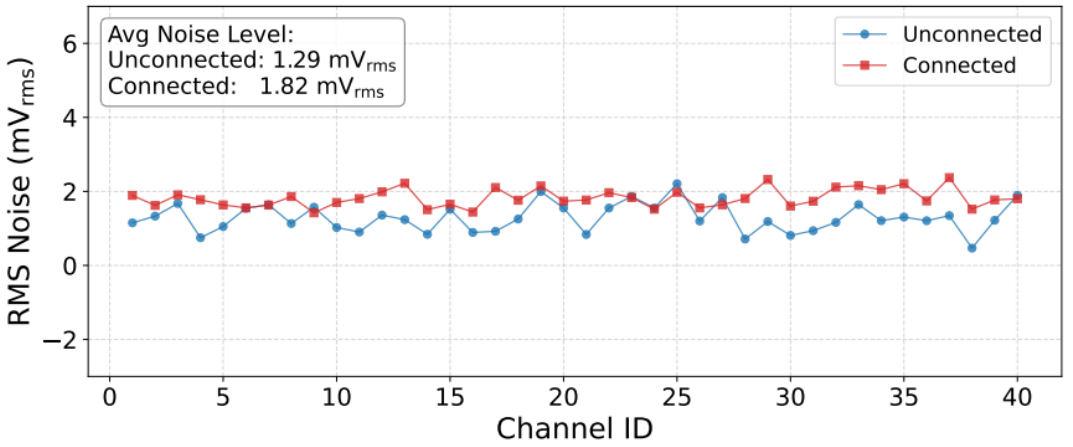


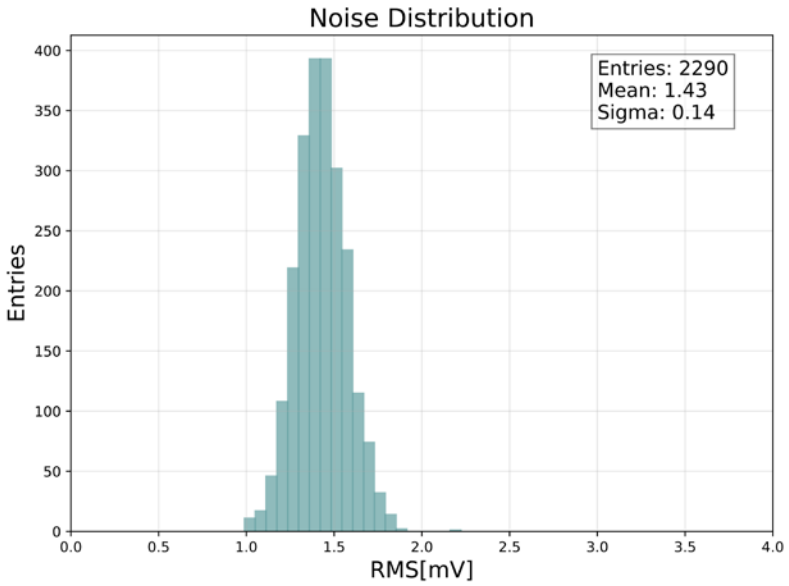


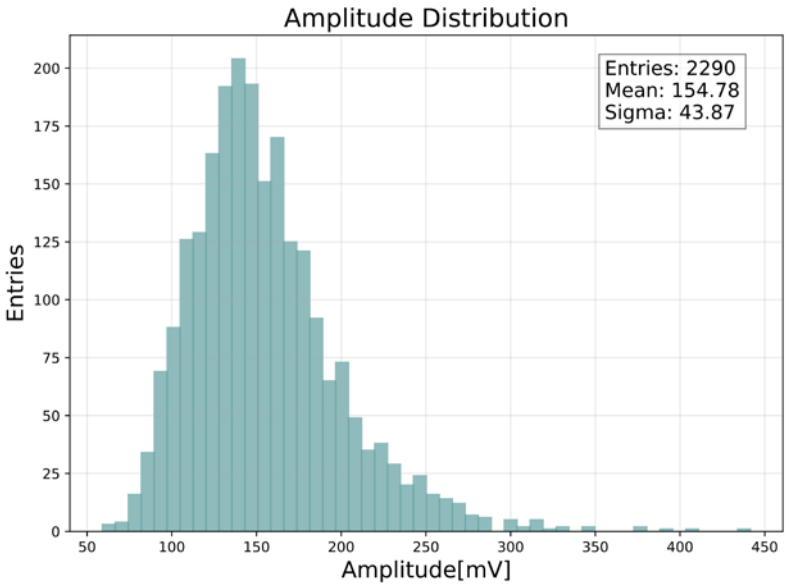
Noise characterization

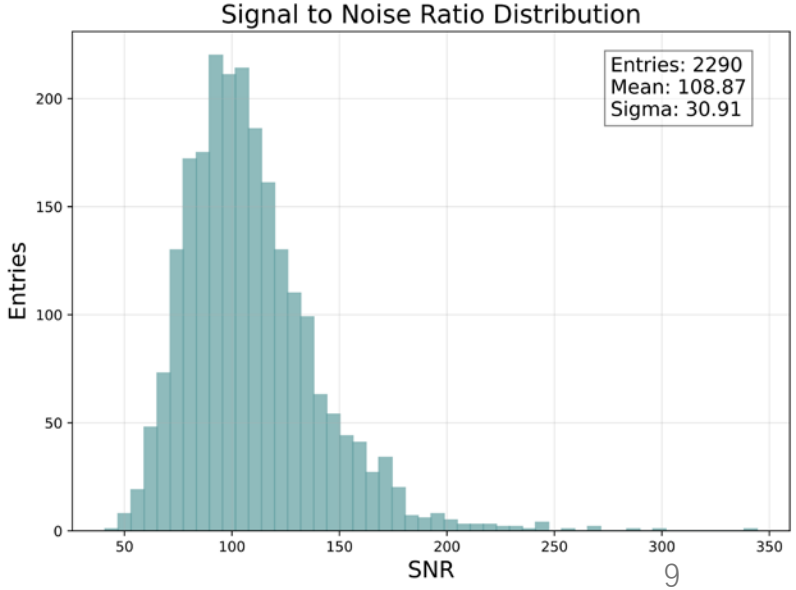
- The average noise level of 40 channels is measured to be 1.29 mV_{rms} for the unconnected configuration and 1.82 mV_{rms} with the detector connected
- The average SNR is around 108.87, with an equivalent relative noise level of 0.94%
- The system has the sensitivity necessary for testing single primary ionization electrons

RMS noise statistics of the 40-channel system



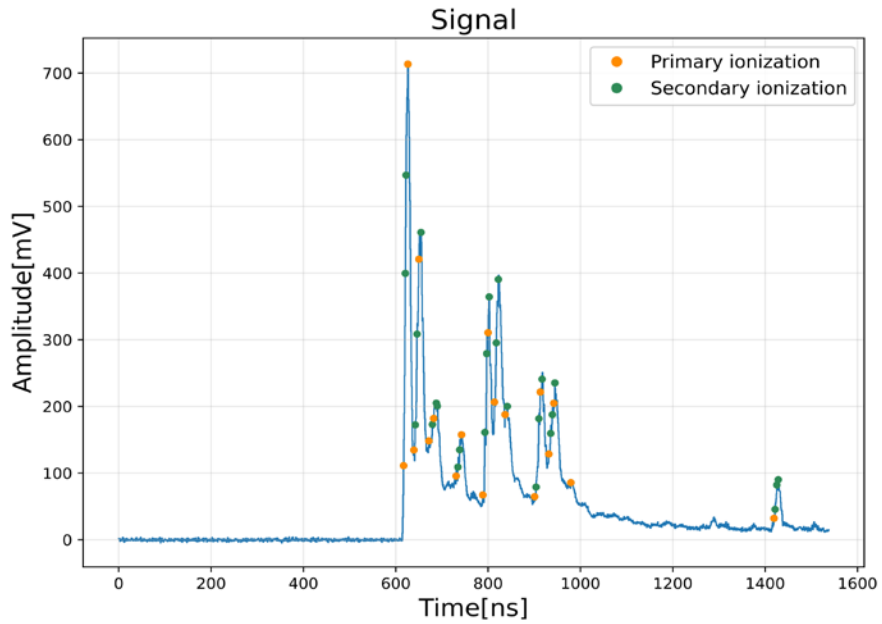




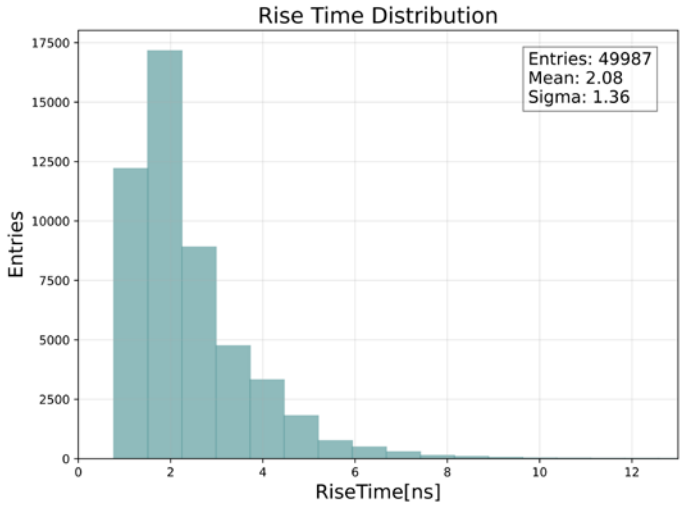


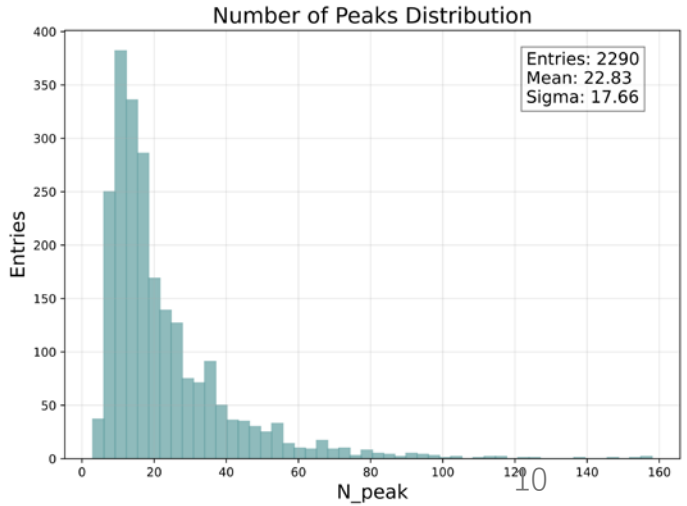
Preliminary waveform analysis

- The second derivative method is used for peak finding
  - Rise time: 2.08 ns
  - Number of peak：22.83



- Preliminary results confirm that the system is operating correctly
- The readout electronics have the characteristics of high bandwidth and low noise

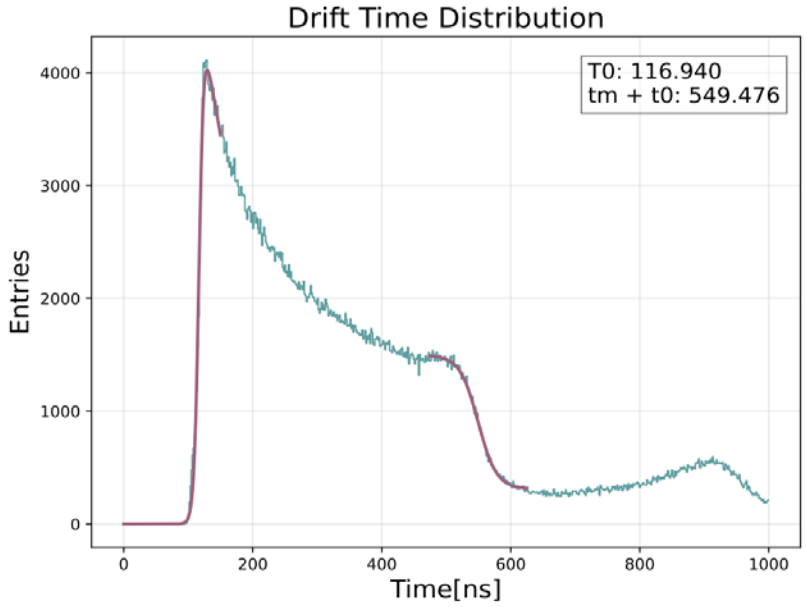




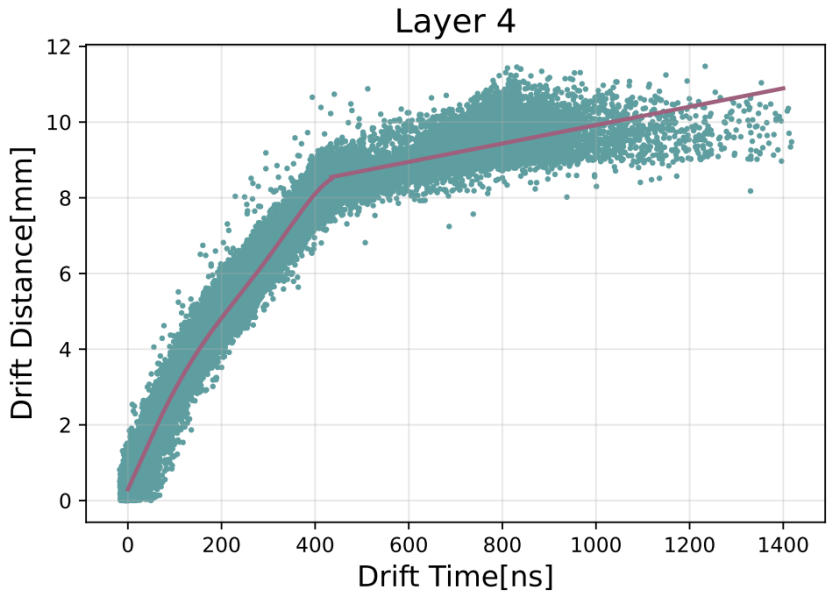
Calibration

- T0 calibration
  - The rising edge of the drift time distribution contains information about the zero point of the drift time
  - Rising edge fitting function, T0 = p4

$$f(t) = p0 + p1\frac{e^{-p2(t-p3)}}{1+e^{\frac{-(t-p4)}{p5}}}$$



- X-T calibration
  - The initial X-T calibration is obtained using the time distribution integration method
  - Based on the initial calibration, track fitting is carried out, and the actual X-T distribution is obtained
  - A segmented fitting is performed on the distribution using a fifth-order polynomial and a first-order polynomial



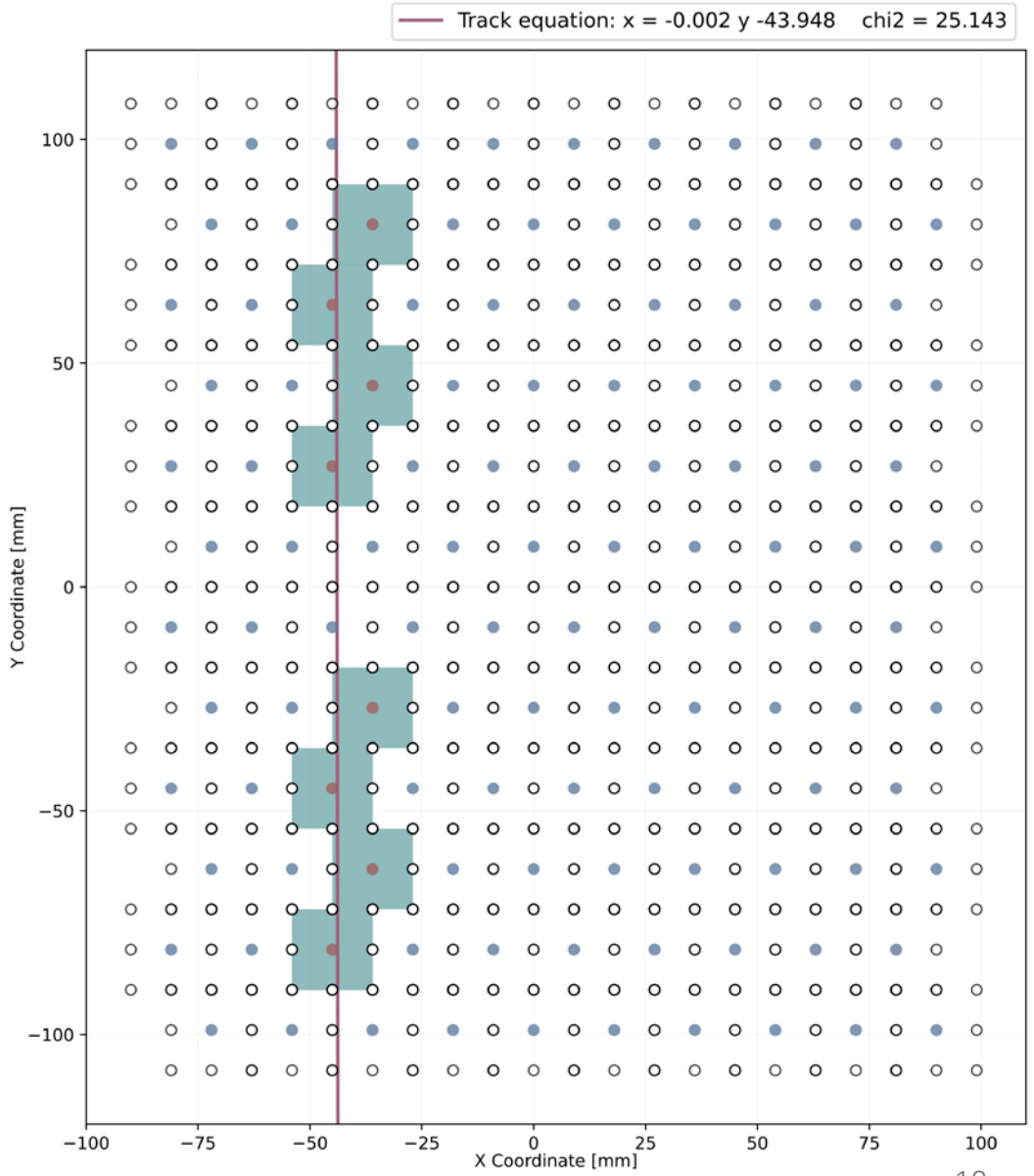
Track reconstruction

- Tracking
  - The Hough transform is used to perform tracking
  - The (k, b) with the highest vote value in Hough space is the track parameters. They will be used as initial values for fitting

- Fitting
  - Track fitting generally adopts the least squares approach, and the chi-square (χ^2) is constructed as follows:

$$\chi^2 = \sum_{i=1}^{N} \frac{\left(d_{meas}^{(i)} - d_{track}^{(i)}\right)^2}{\sigma_i^2}$$

  - The calculation of the drift distance employs T0 and X-T relationship obtained from the calibration

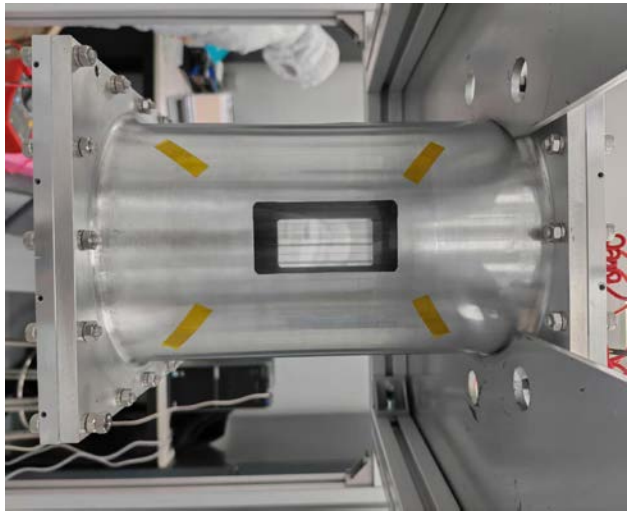


International Collaboration on the beam test

- To validate dN/dx resolution, and PID capability
- Test beam was scheduled for May 28 – Jun10, in cooperation with IDEA DC group
- CERN PS, T9 (Mixed charged particles, maximum energy: 12GeV)

- Thank Nicola and Maxim for their supports from IDEA Group and DRD1

- A new smaller DC prototype will be brought to CERN



- 10 layers, 6 cells/layer, 60 cells
- Cell size: 12 mm × 12 mm
- Length of wire: 250 mm

List of components for the beam test

Components prepared by IHEP

No.	Item	Quantity	Remarks
1	DC prototype	1	
2	Preamplifier board	6	
3	Readout electronics Chassis	1	
	Control Board	1	
4	DAQ server + disc	1	
5	Switch	1	
6	Optical Fibers, cables…		

Components prepared and shared by Italy group

No.	Item	Quantity	Remarks
1	Gas system	1	He:iC4H10=9:1, Φ6 connector on the detector
2	HV Power Supply	3 channels	>2000V, SHV connector
3	DC Power Supply	1	±3V, total current: 1.5A
4	DC Power Supply	1	12V, current: 1A
5	Trigger system	1	Coincidence output (TTL level(3.3V)), SMA connector
6	Computer monitor	1	
7	Oscilloscope	1	

Summary

- A DC prototype system was setup for dN/dx study
- The performance of the readout electronics was validated through cosmic-ray test
- Will Join the test beam at CERN from May 28 to June 10