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A high rate and high timing photoelectric RPC detector

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Introduction

Future high-energy and high-luminosity physics experiments pose new challenges to the performance of particle detectors, such as time resolution and counting rate. Photosensitive gaseous detectors have advantages over other types of photodetectors mainly in terms of size and cost. We have developed a photodetector with RPC (resistive plate chamber) structure. The detector exhibits excellent time resolution ($\sigma_{NPE=1} < 30$ ps) and high rate (~ 100 kHz/cm^2) by using low-resistivity float glass electrodes ($\rho \sim 1.4 \cdot 10^{10}\ \Omega \cdot cm$) and narrow gas gap ($\mathrm{T}_{gap} = 215\ \mu m$).

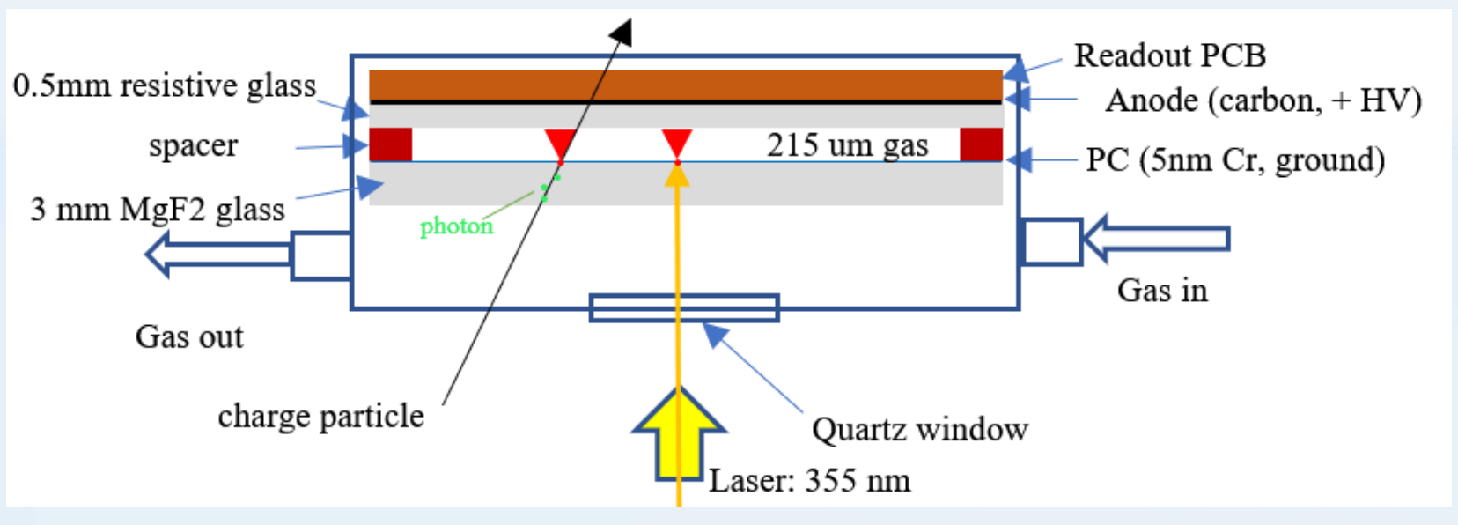
☐ The rate capability of the resistive gas detector is constrained by the material's resistivity. Generally, a lower resistivity leads to a higher rate. However, excessively low resistivity can shield the signal induction and deteriorate the detector's function.

☐ In order to further improve the rate capability, we used float glass with a resistivity of $\rho \sim 1.6 \cdot 10^{9}\ \Omega \cdot cm$. This work focuses on:

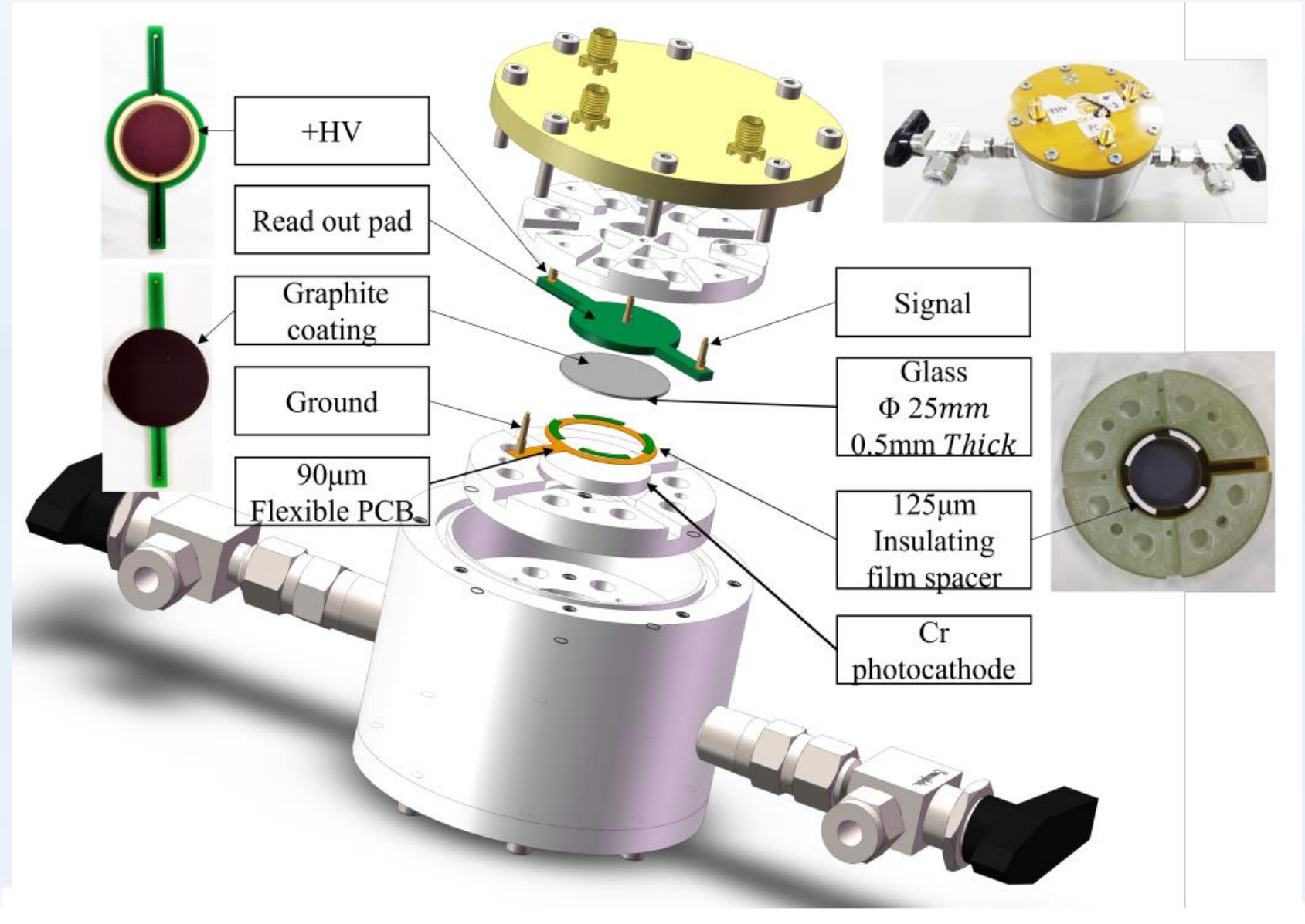
- Can the detector work properly with the low-resistivity electrodes?
- How dose the rate capability improved?
- How does the performance of the detector change?

Photoelectric RPC structure

- The detector was fixed in a closed stainless steel chamber with ventilation
- Gas gap: 90 µm flexible PCB +125 µm kapton film
- Float glass thickness: 500 µm



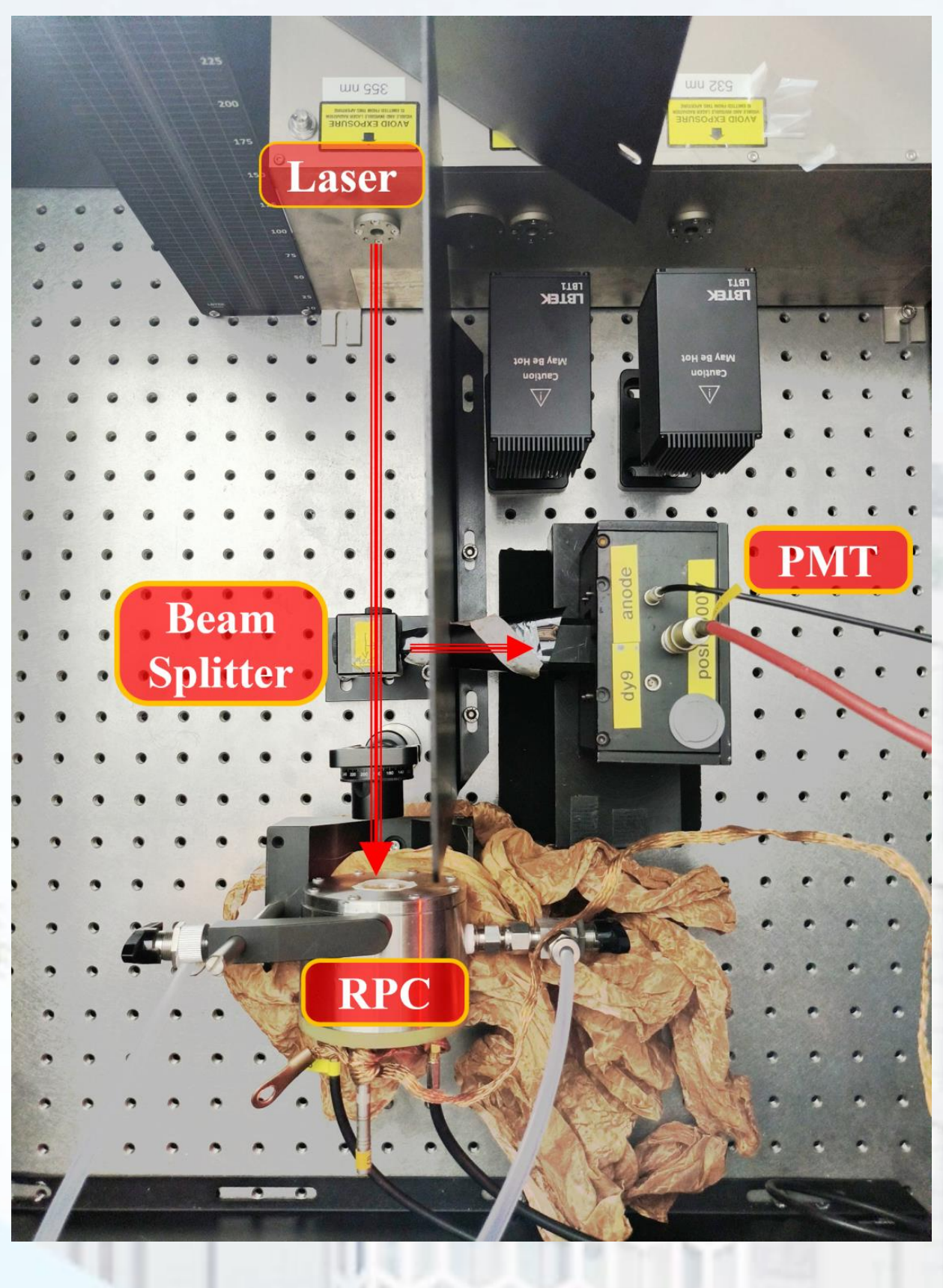
A schematic layout of the photoelectric RPC chamber

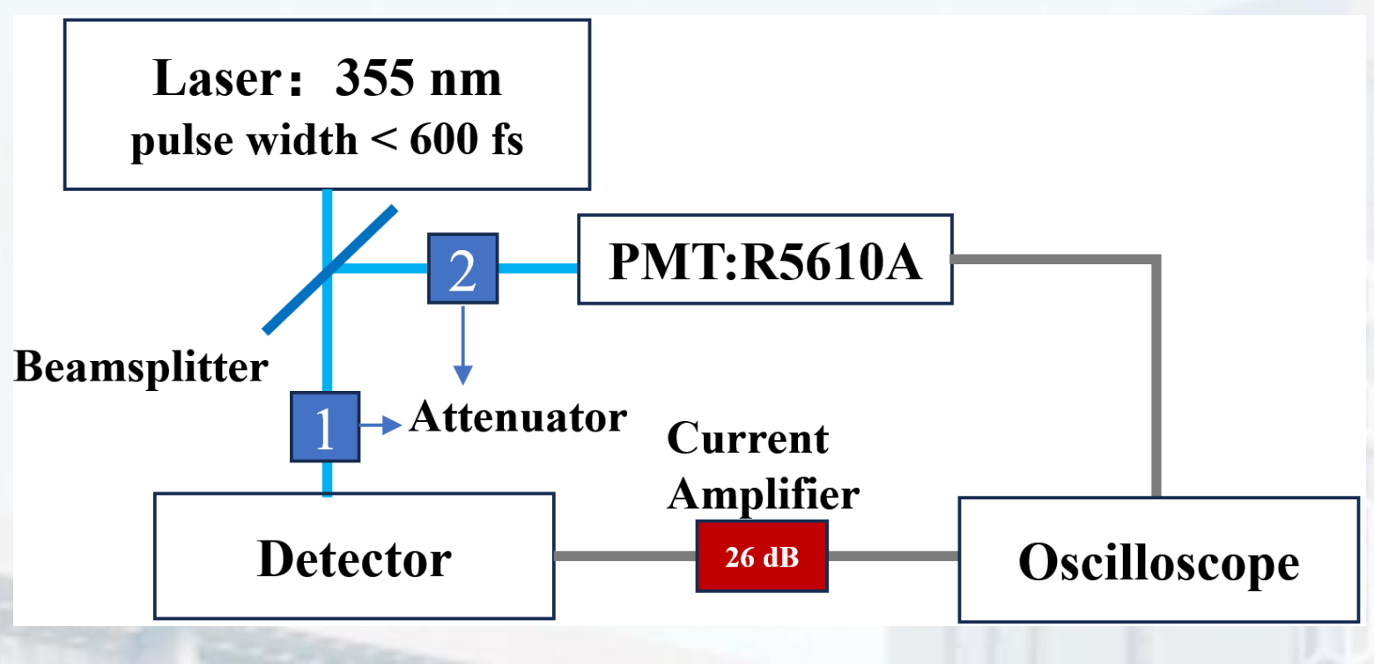


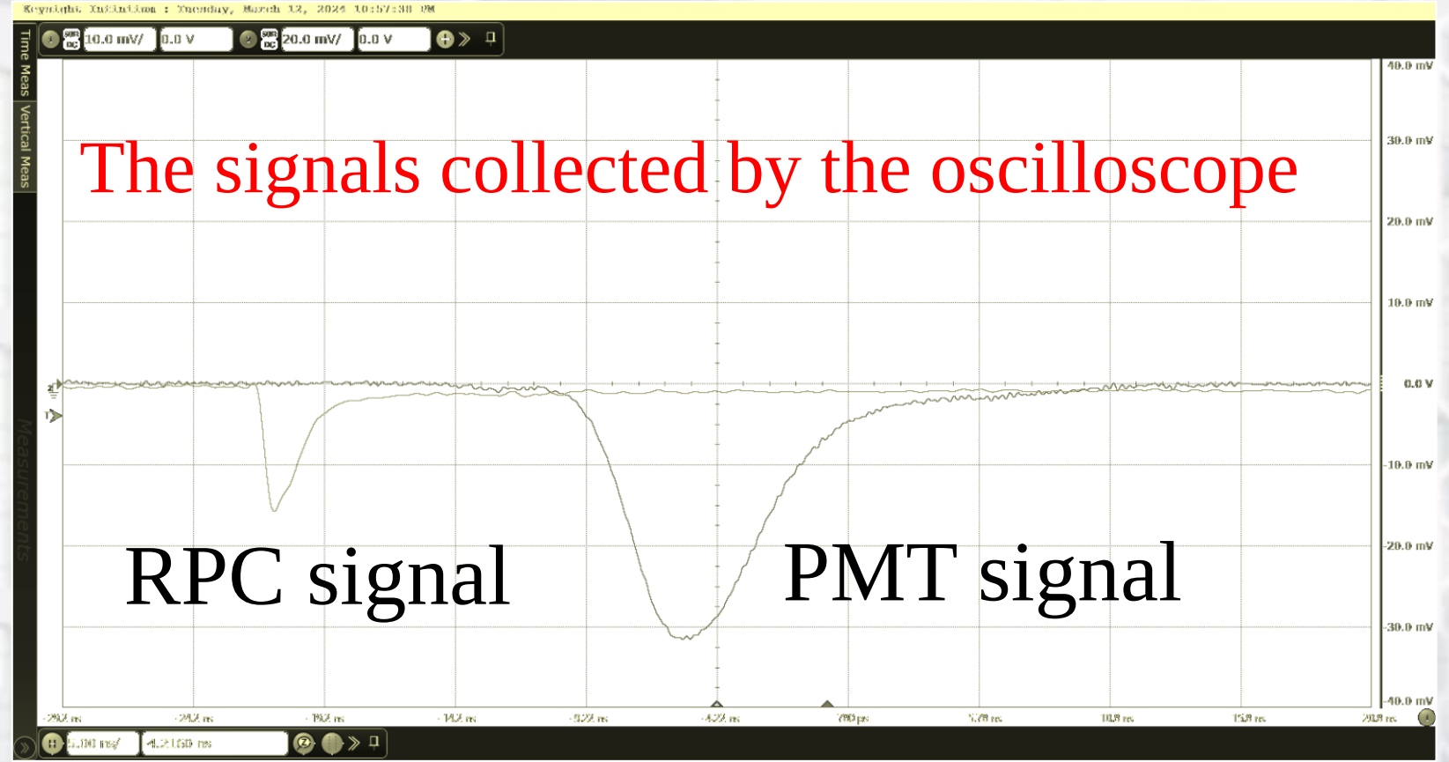
The mechanical structure of the photoelectric RPC chamber

Test setup

- High precision test platform: $\sigma_{system} < 10$ ps

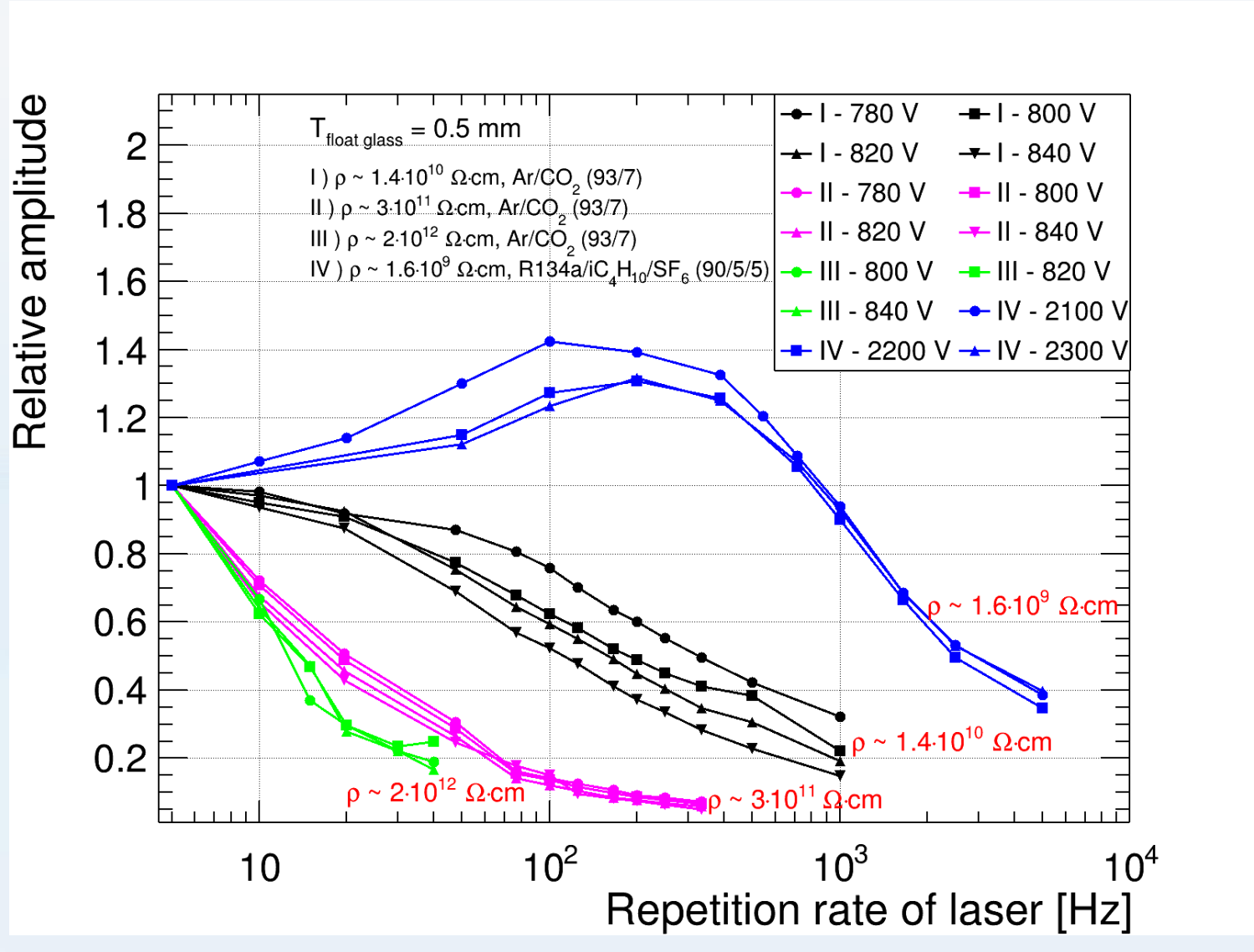





The signals collected by the oscilloscope

Low-resistivity float glass

- The magnitude of RPC signal as a function of laser repetition rate.
- In the resistivity range of $10^{12} \sim 10^{10} \Omega \cdot cm$, the smaller ρ, the slower magnitude decreases, the better rate capacity.

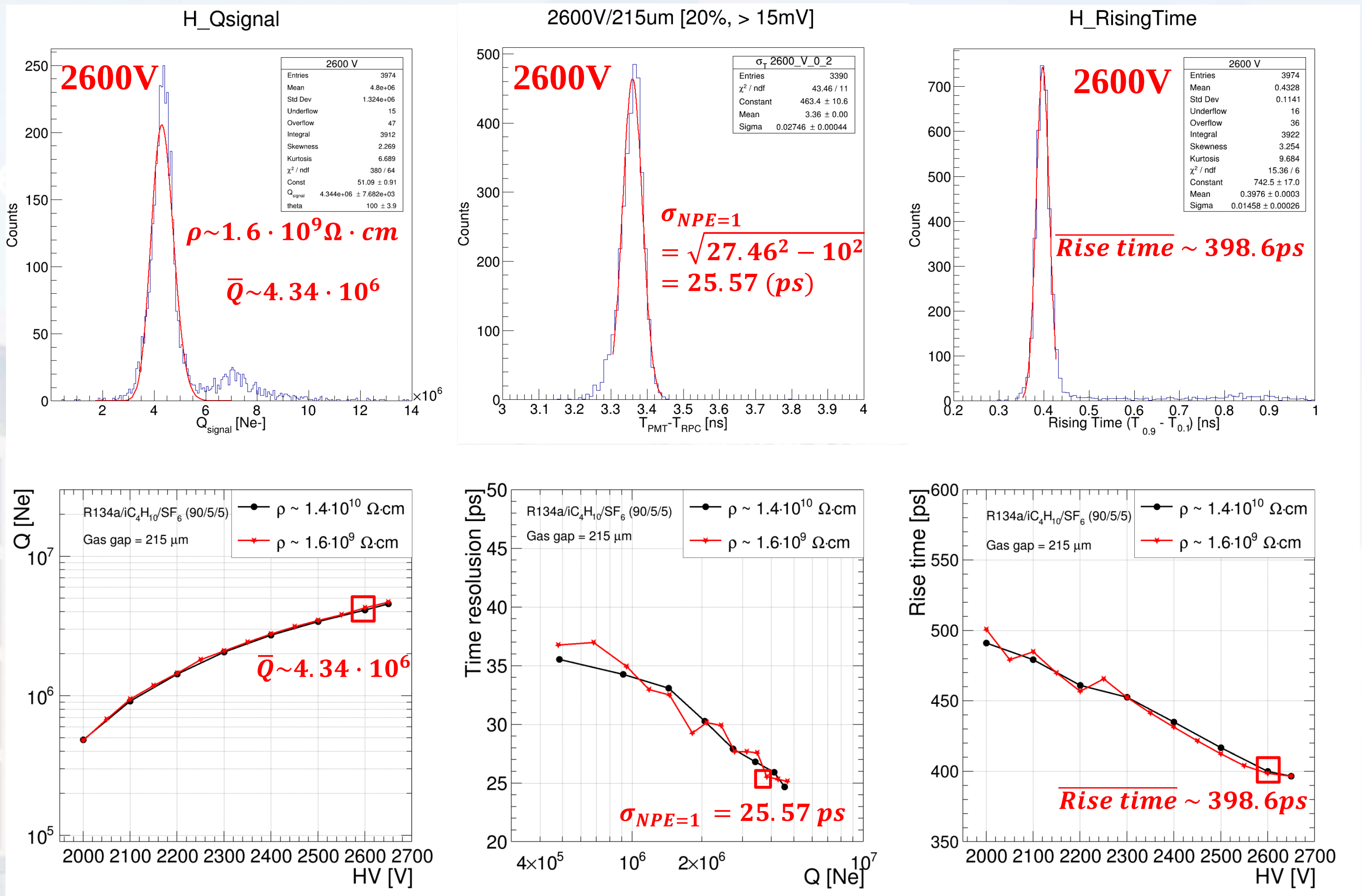


For $\boldsymbol{\rho_{float\ glass} \sim 1.6 \cdot 10^{9} \Omega \cdot \mathrm{cm}}$

The magnitude initially increases and subsequently decreases as the repetition rate of the laser increases. **The rate capacity is much better than that of higher ρ chamber.**

Performance of RPC

- Time resolution, gain, signal rise time of single photoelectron
- Standard RPC gas: $R134a\backslash \mathrm{iC}_4H_{10}\backslash \mathrm{SF}_6$ (90\5\5)



✓ The timing performance of detector with $1.6 \cdot 10^{9} \Omega \cdot \mathrm{cm}$ resistivity float glass is as good as those with higher resistivity.

Conclusions

- Developed a photoelectric RPC detector
- Tested with several types of float glass $\boldsymbol{\rho_{float\ glass} \sim 1.6 \cdot 10^{9}\ \Omega \cdot cm,\ 1.4 \cdot 10^{10}\ \Omega \cdot cm,\ 3 \cdot 10^{11}\ \Omega \cdot cm}$
- Rate capability is improved and timing performance is good: $\sigma_{NPE=1} = 25.6$ ps **@(Gain~4.3· 10^6, RPC gas, 2600V)**.

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