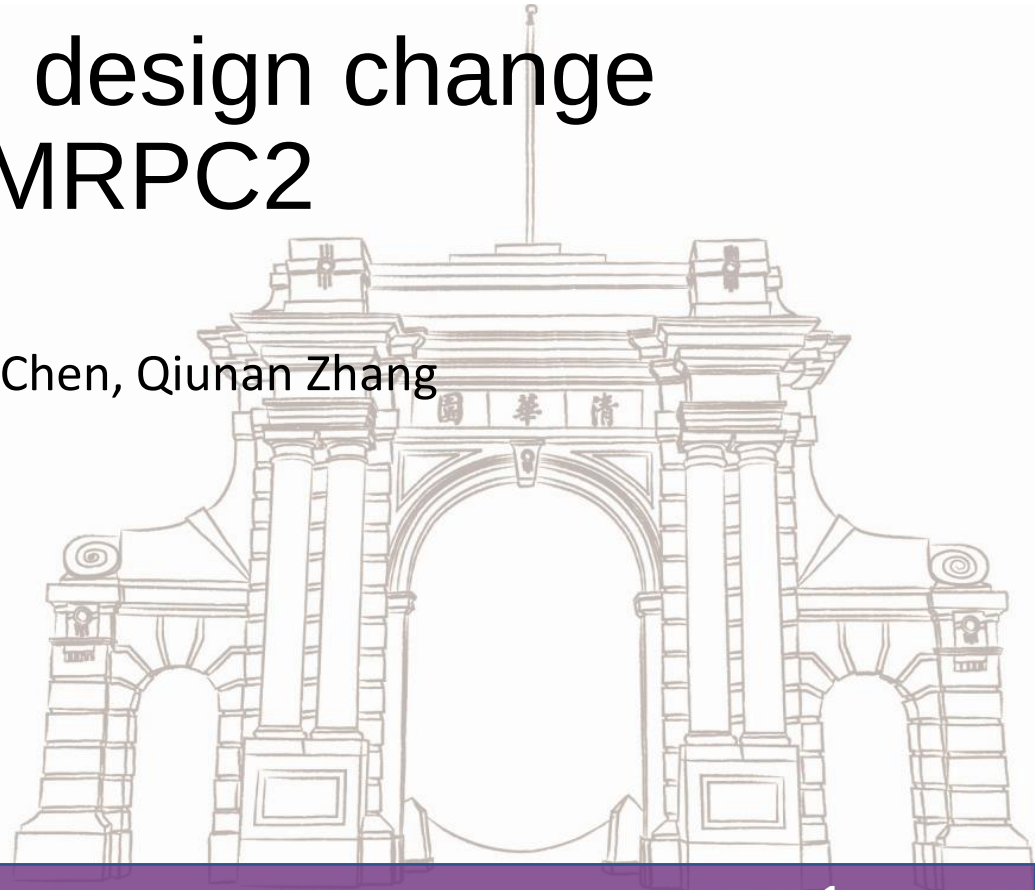
Aging studies and resulting design change considerations for MRPC2

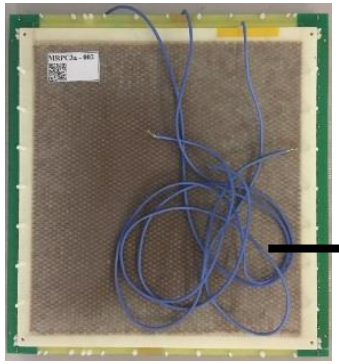
Botan Wang, Yi Wang, Dong Han, Xiaolong Chen, Qiunan Zhang

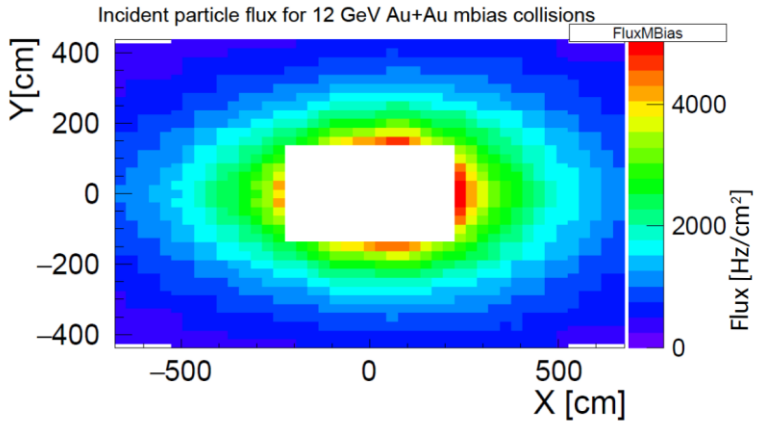
Tsinghua University

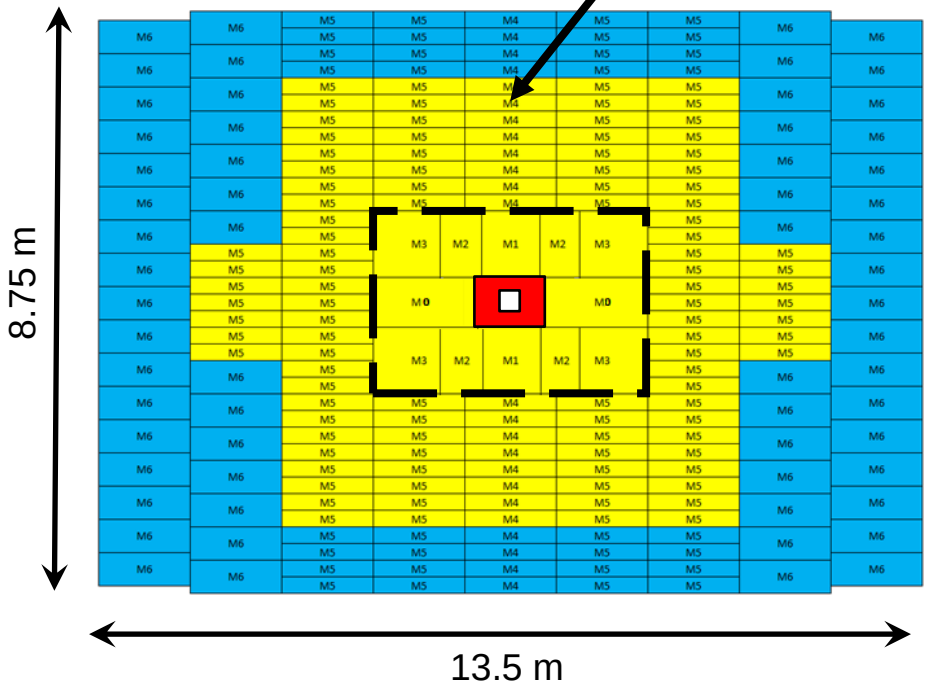


MRPC2

Parameters of outer wall MRPC	MRPC2
Number of gas gaps	8 (4 in each stack)
Gas gap width	0.25 mm
Thickness of glass electrodes	0.7 mm
Electrodes	Low resistive glass
Rate requirement	5 kHz/cm^2
Strip length (active)	270 mm
Strip width	7 mm
Strip pitch	10 mm
Strip impedance	50 Ω
Strip number	32
Quantity demand	580





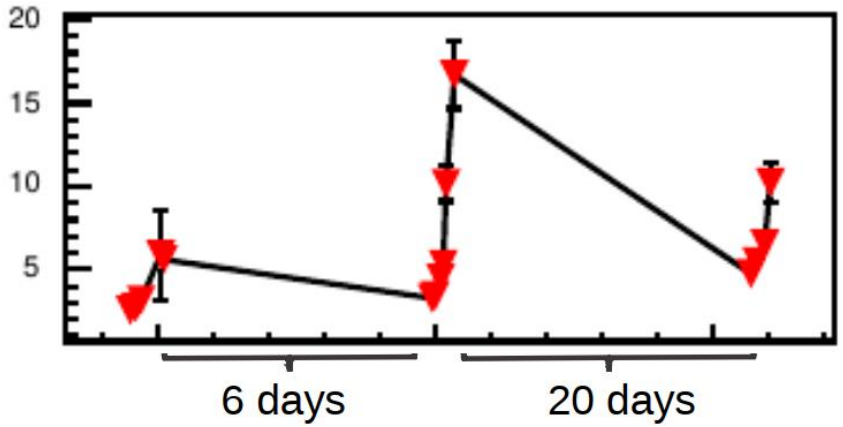


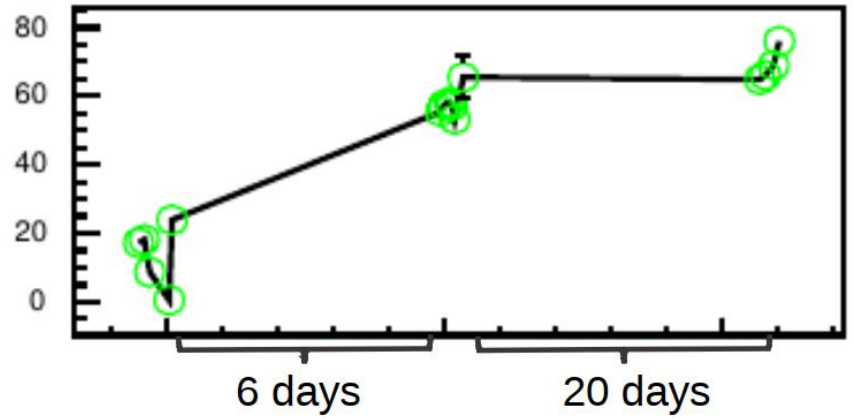
- **A module contains several MRPC counters**
- **Region containing counters equipped with thin float glass, $\rho \approx 10^{12}\ \Omega$ cm**
- **Region containing counters equipped with low resistivity glass, $\rho \approx 10^{10}\ \Omega$ cm**
- **Region containing counters equipped with ceramic material $\rho \approx 10^{9}\ \Omega$ cm**

Ingo Deppner

Aging effect

Dark rate of MRPC2 at mCBM (Hz/cm^2)



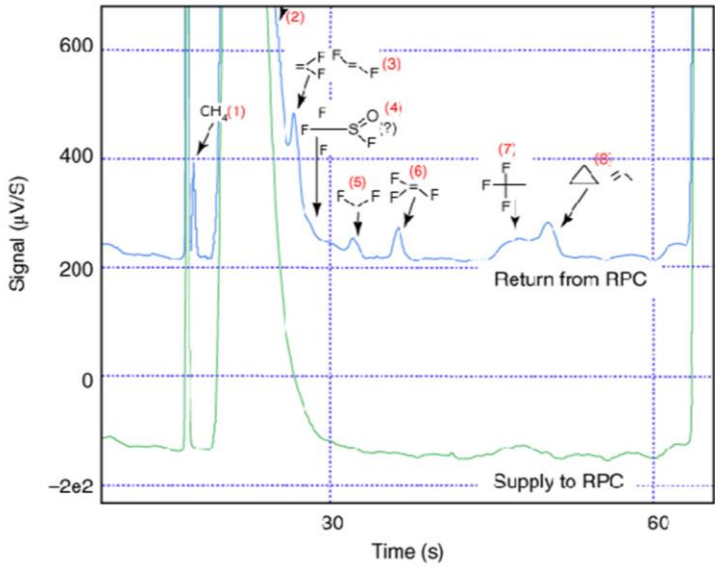


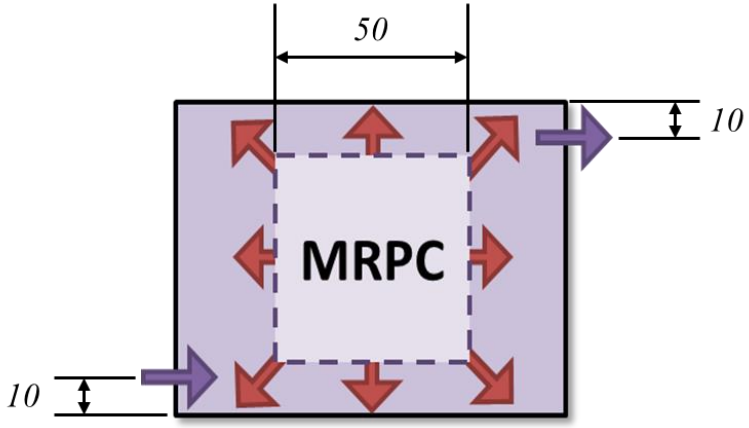
Potential radiation response: increased dark rate(off-spill) compared to cosmic tests(~ 1Hz/cm$_2$).
Big difference among counters.
→Insights into aging effects: gas pollution, glass aging.

Q. Zhang. 36th Collaboration meeting.

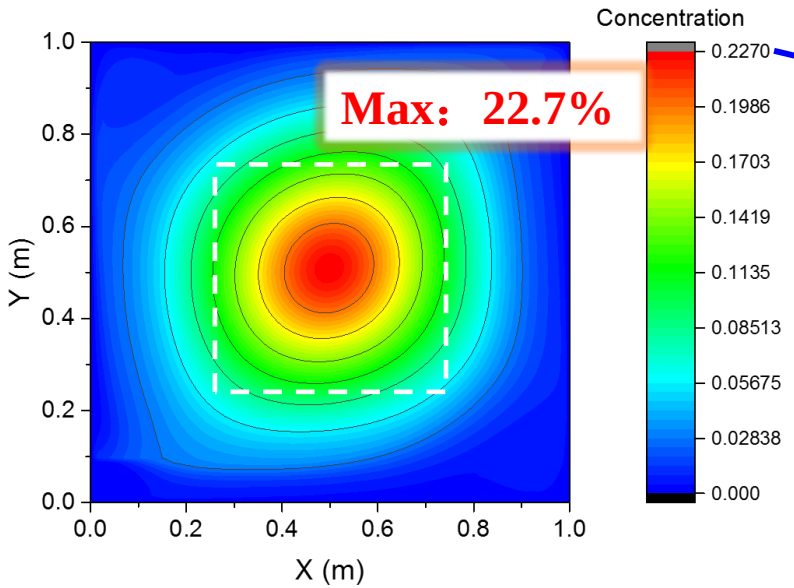
Gas pollution effect

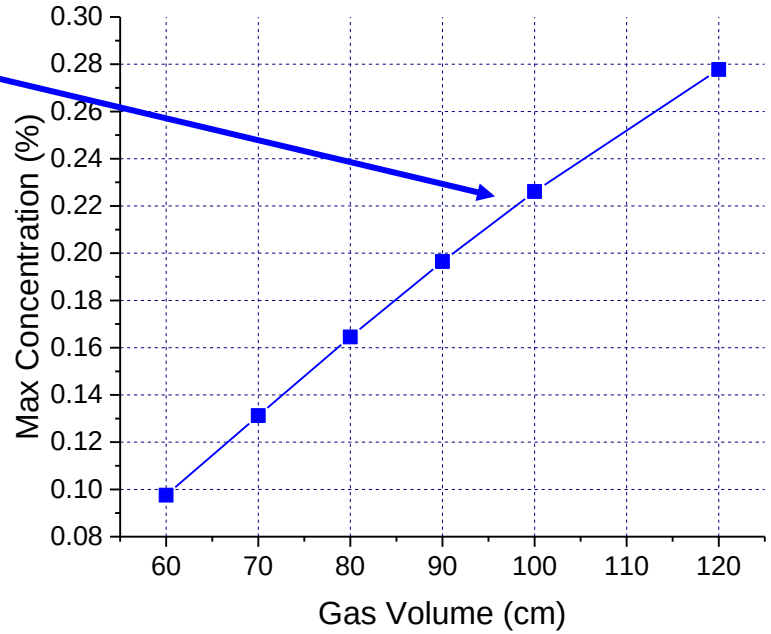
- ✓ The operation of MRPC ionizes the working gas (mainly Freon) and produces pollutants.
- ✓ The current method to supply the gas is through a **gas-streaming box**.
- ✓ With narrow gaps, the mechanism of gas exchange is **diffusion**.
- ✓ Lower volume will help promote the gas exchange.





A simplified gas-streaming model for ANSYS Fluent simulation





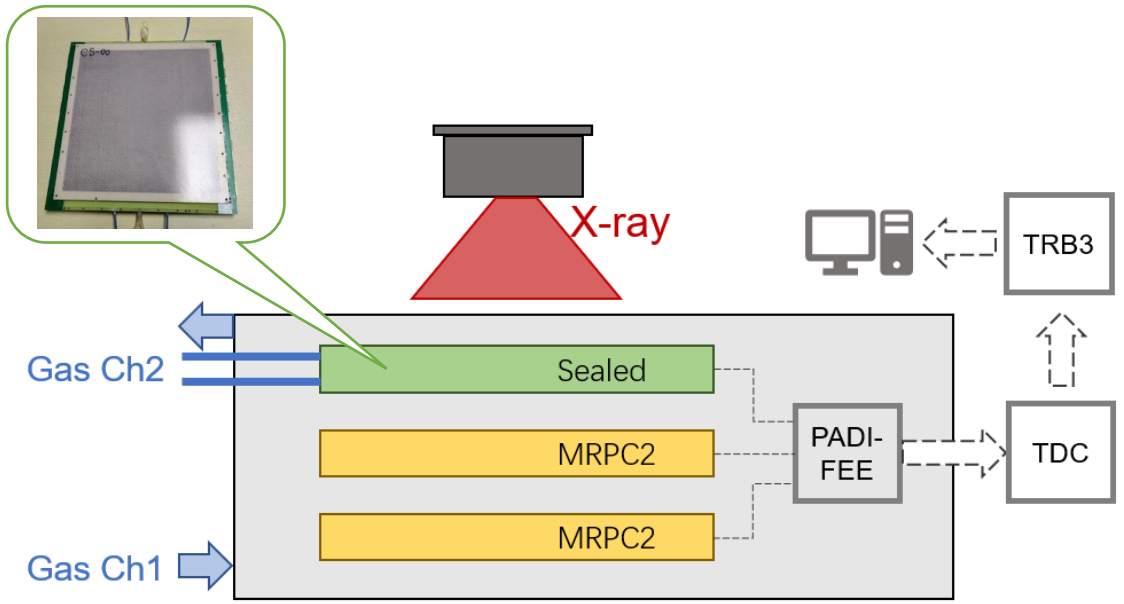
Gas pollution effect

A ‘sealed’ MRPC prototype built for a comparative study.

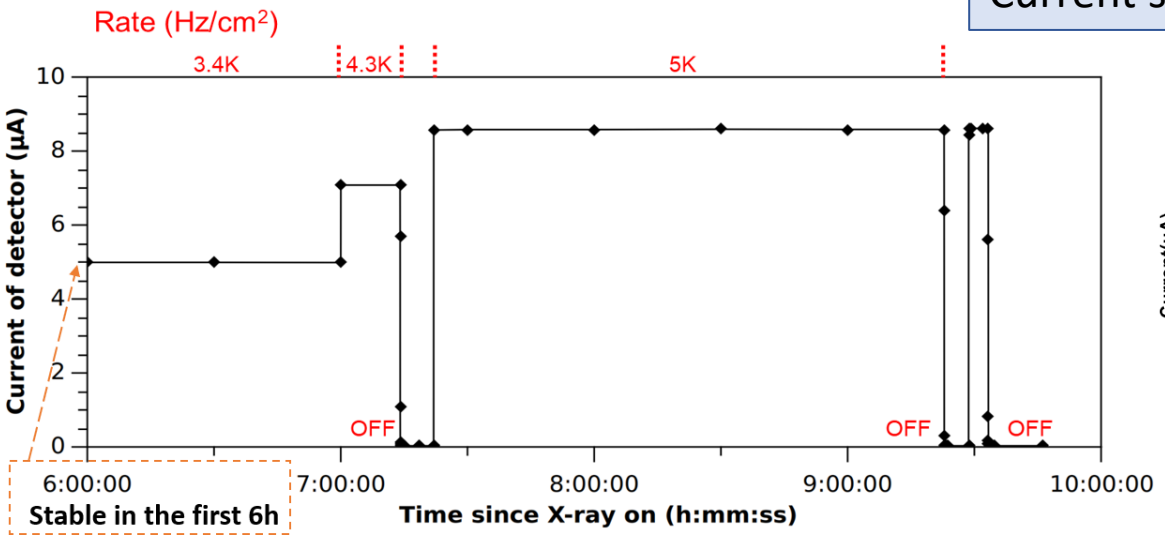
- 200 mL gas volume per counter

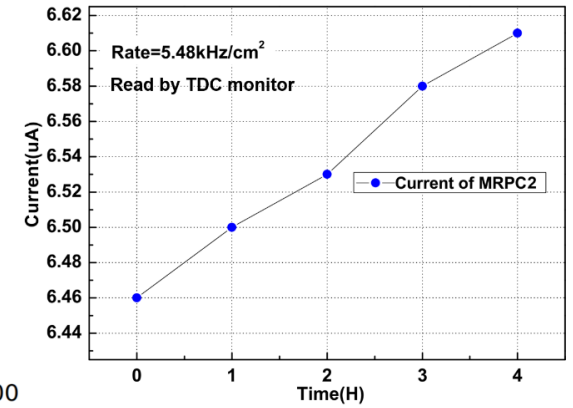
X-ray test finds the gas pollution effect:

- Current rise in constant flux rate
- Slow exchange of pollutant.

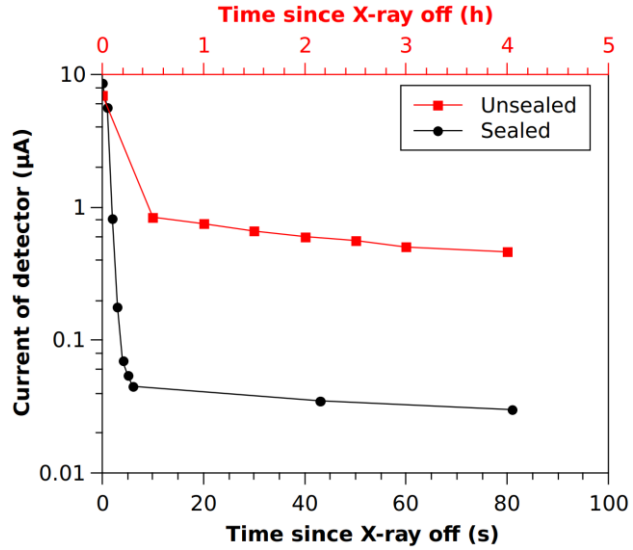


Current stability





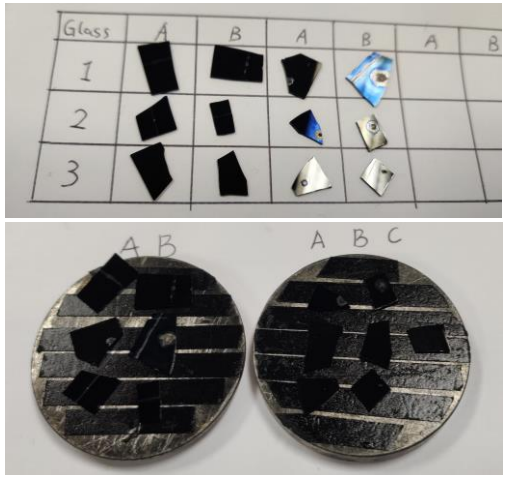
Dark current relaxation

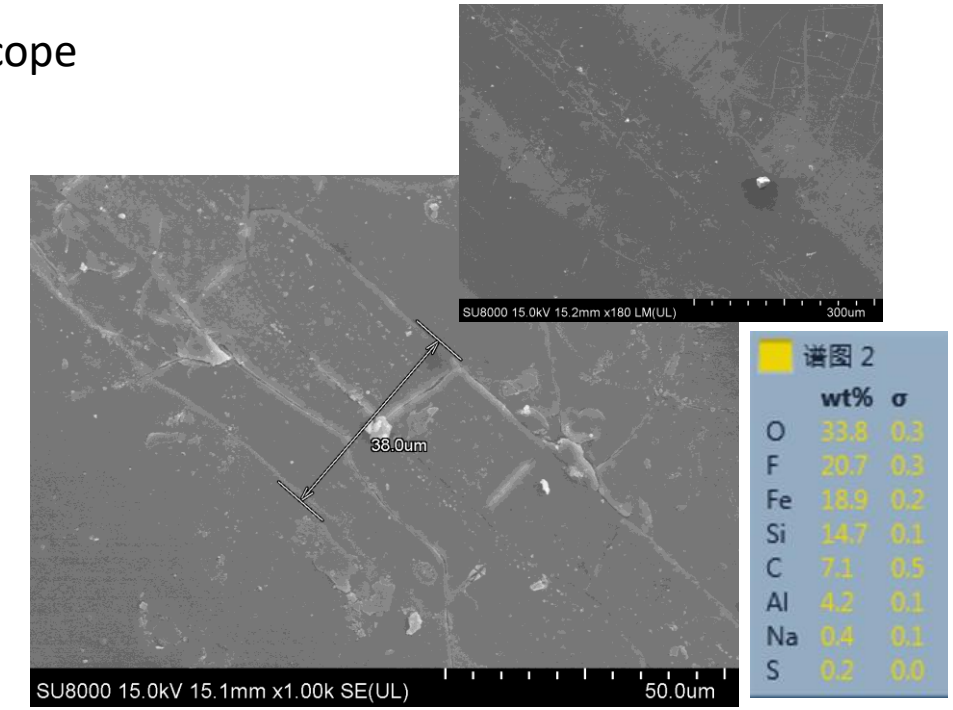


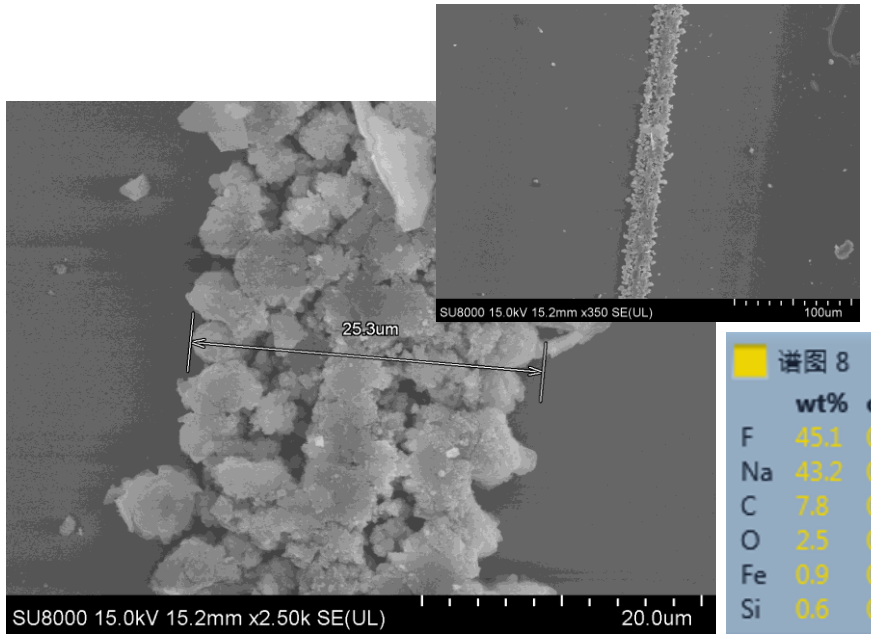
Glass aging study with SEM

Scanning Electron Microscope

Samples of regions with interest collected from MRPC2-005







A comparison of fishline region at anode (left) and cathode (right) side.

Findings:

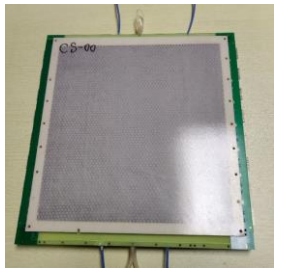
Damage of glass —— crack along the fishline, at sparking spots. The reason why those visible structures cannot be removed.

Na —— positive ion, move under electric field, concentrate at fishline

F —— found at both sides. High fraction at damaged zones.

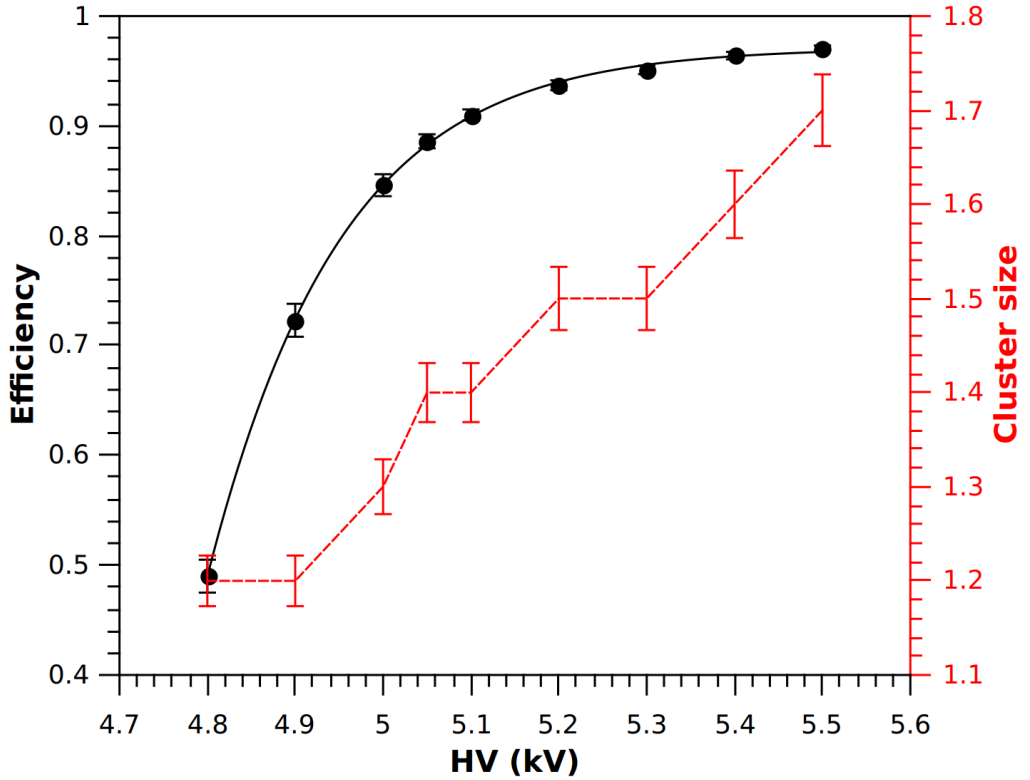
Dark current must be controlled in MRPC operation to mitigate the aging effect.

Performance of the sealed MRPC prototype

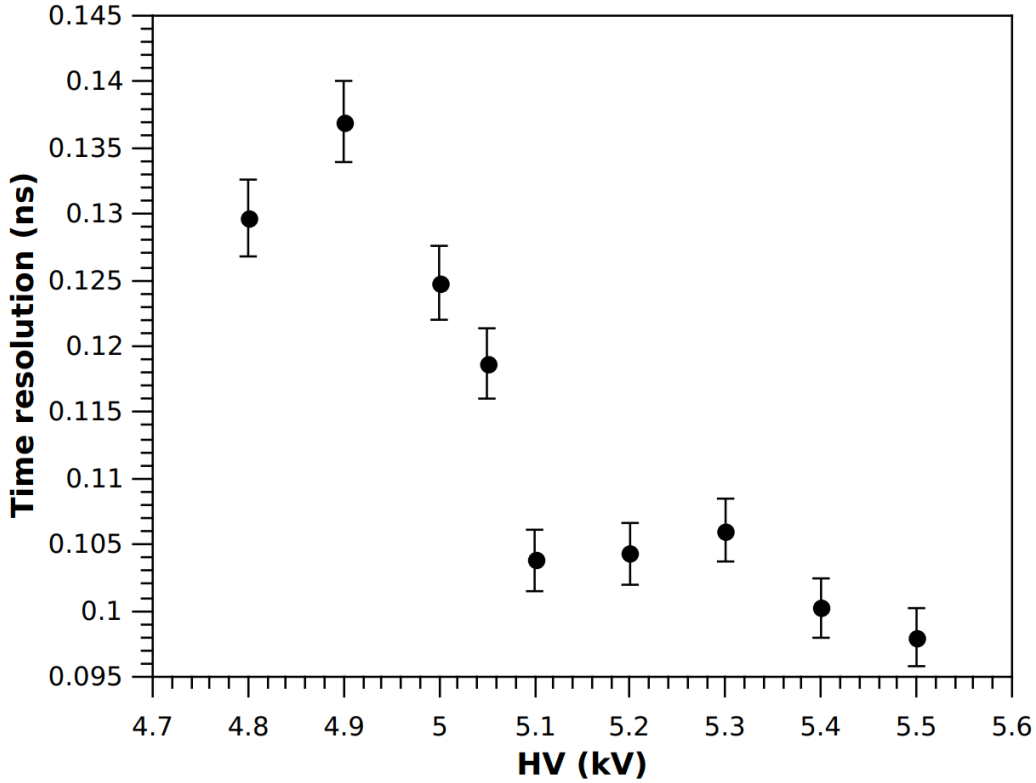


Active area:
280*250 cm^2

Cosmic test with TRB3 system:



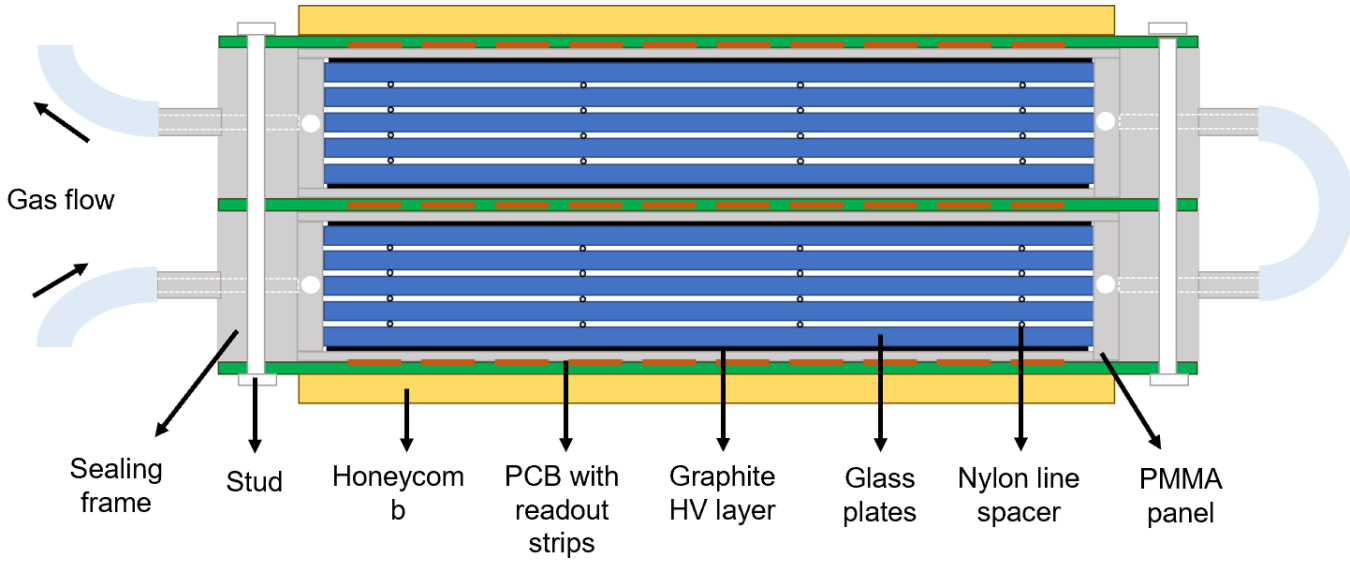
The working point and efficiency is the same as the former MRPC2

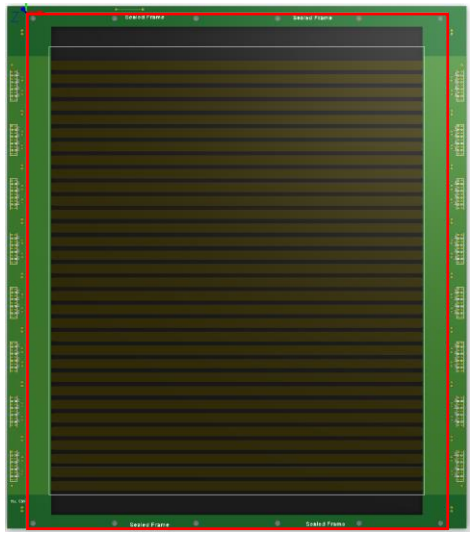


Time resolution: $100/\sqrt{2} \sim 70$ ps

Structure design of sealed MRPC2

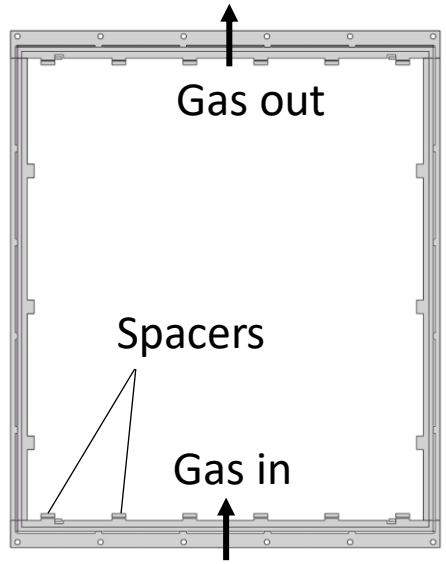
- Sealed by frame and PMMA panels
- With full active area: 330 × 276 mm^2
- 2 × 4 gas gaps
- 32 strips with 7 + 3 mm interval, 27 cm length

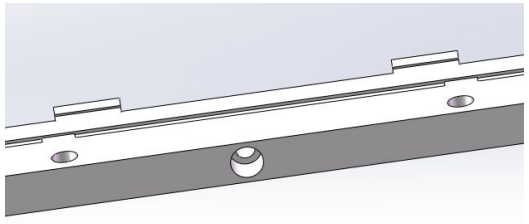


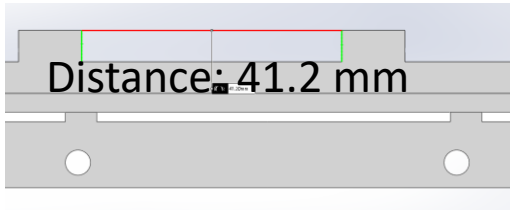


Dimension: 338 × **385** × 30 mm^3

Former MRPC2: 338 × **360** × 26 mm^3

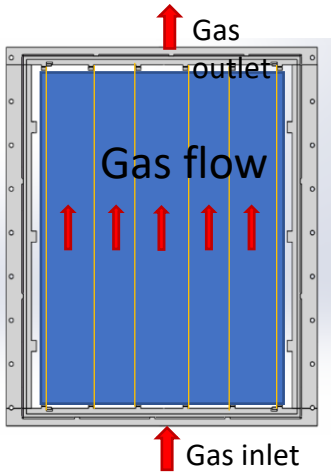


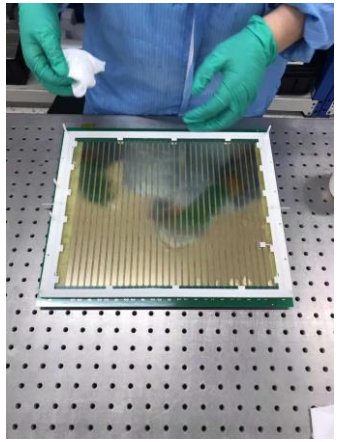


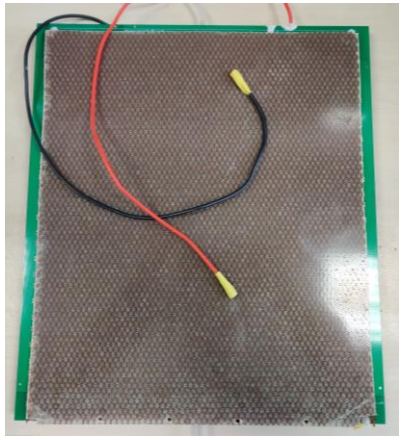


Chamber with parallel fishline routing

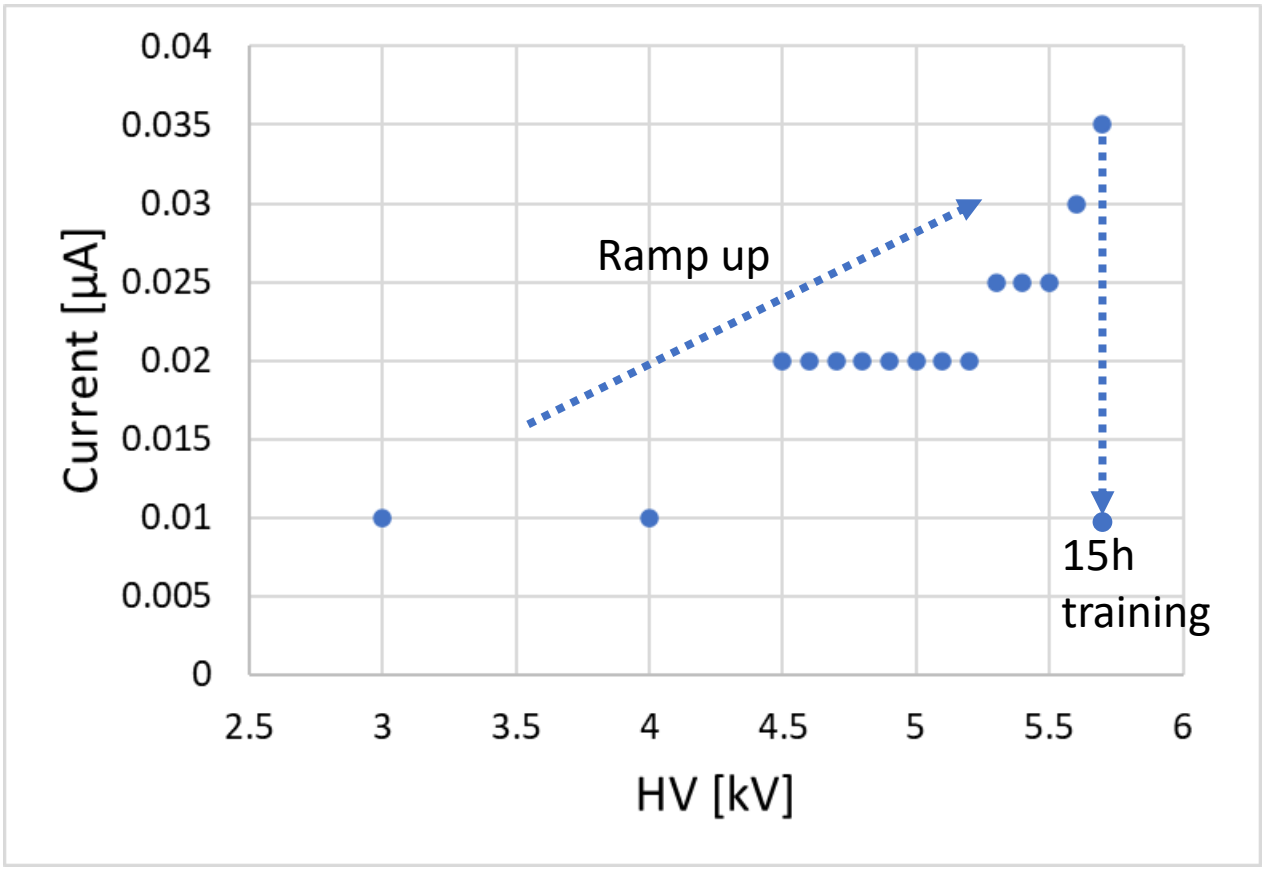
One chamber (stack) assembled and applied with HV
Not strictly parallel but open at both sides.







Flow: 20mL/min, 90/5/5 gas mixture



Reasonable dark current. Dark current relaxes slowly.

Next step

- The primary target for now is to prepare the sealed MRPC2 prototype for the next mCBM beamtime
- A complete detector is being assembled for test.
- Laboratory test to check:
  - Long time operation stability.
  - Test with less flow rate.
  - X-ray test expected.
  - Gas route management.

Thank you!