Aging test of high rate MRPC

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Outline

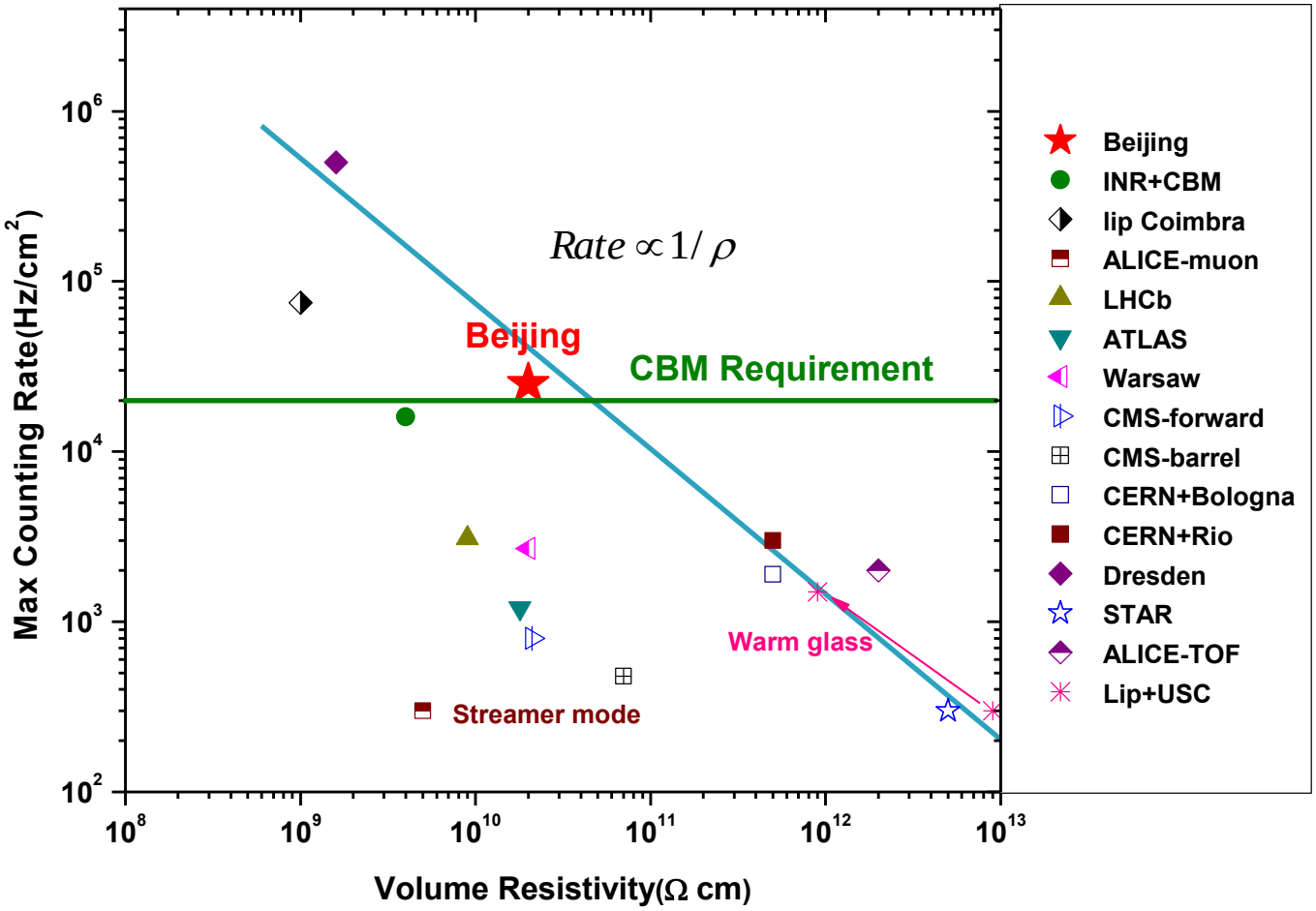
- Introduction
- Related Research
- Experimental Setup
- Simulation
- Results & Discussion
- Conclusions

World map of MRPC's rate capability

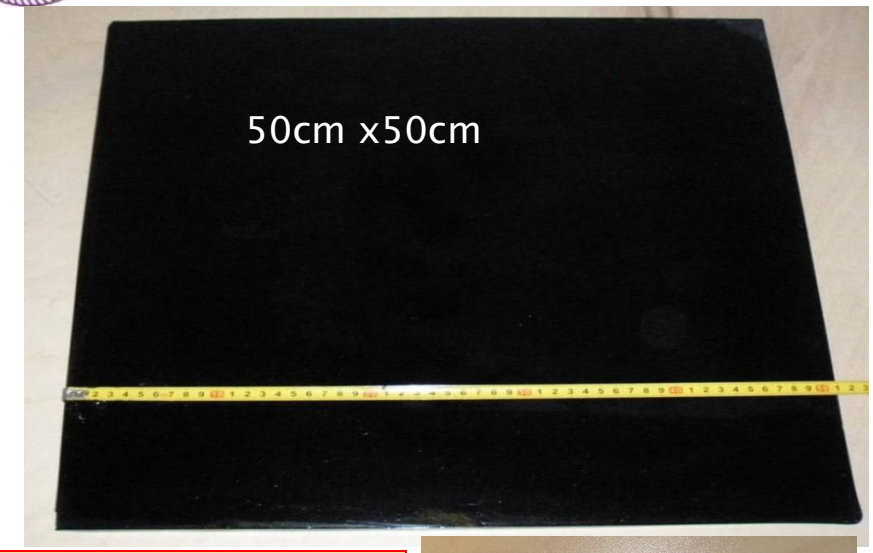
Ceramics

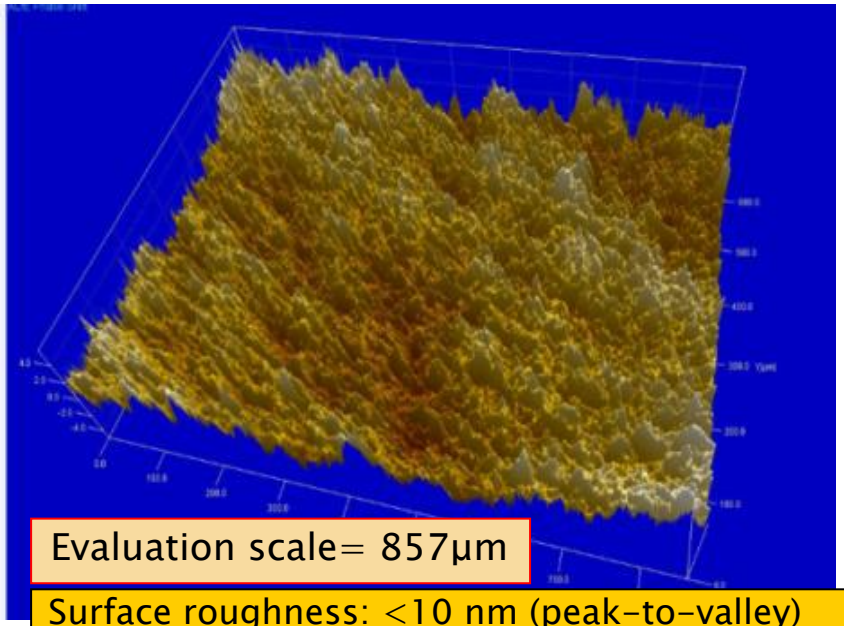
Semi-conductive glass

Float glass



Performance of Low-resistive glass



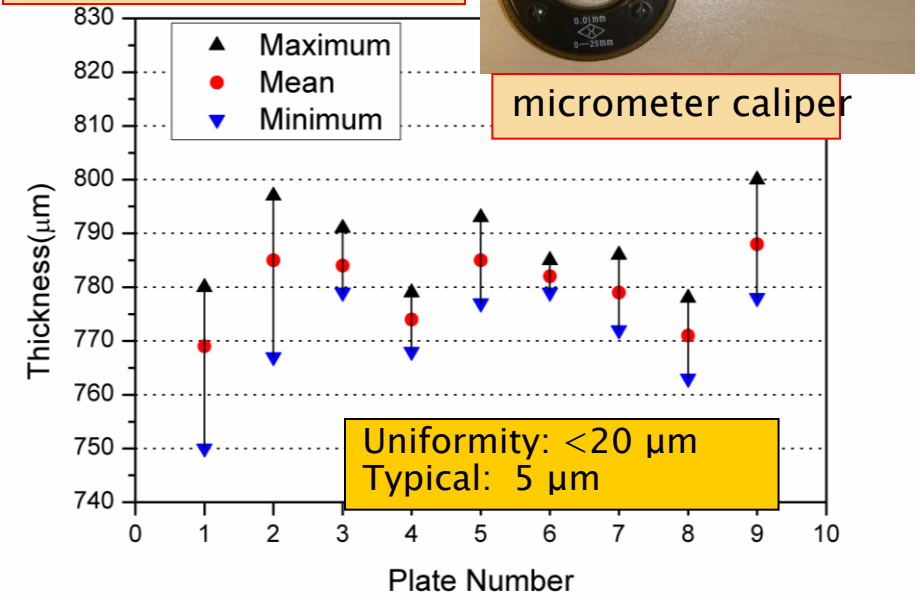


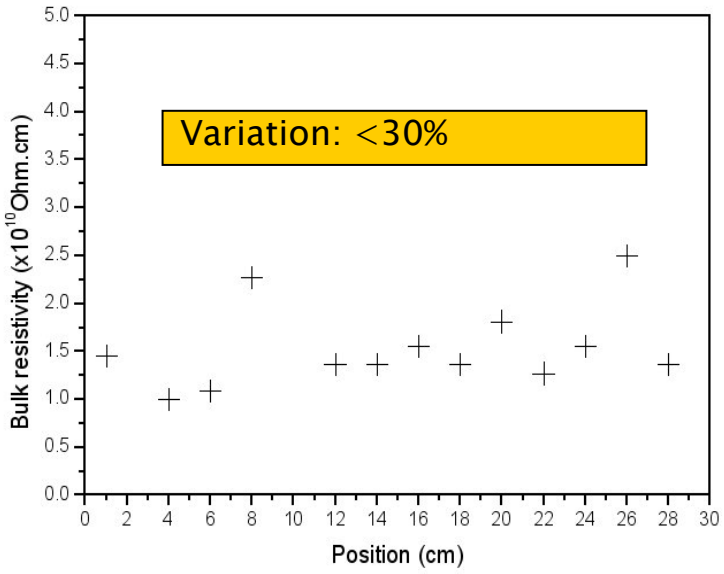
Evaluation scale= 857μm

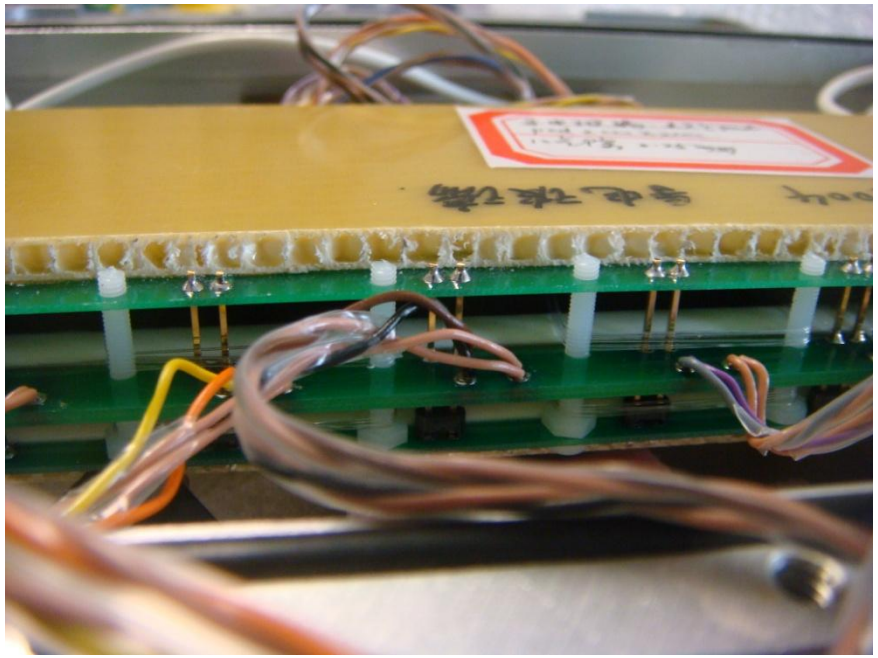
Surface roughness: <10 nm (peak-to-valley)

Thickness distribution
(Evaluation scale= 30cm)

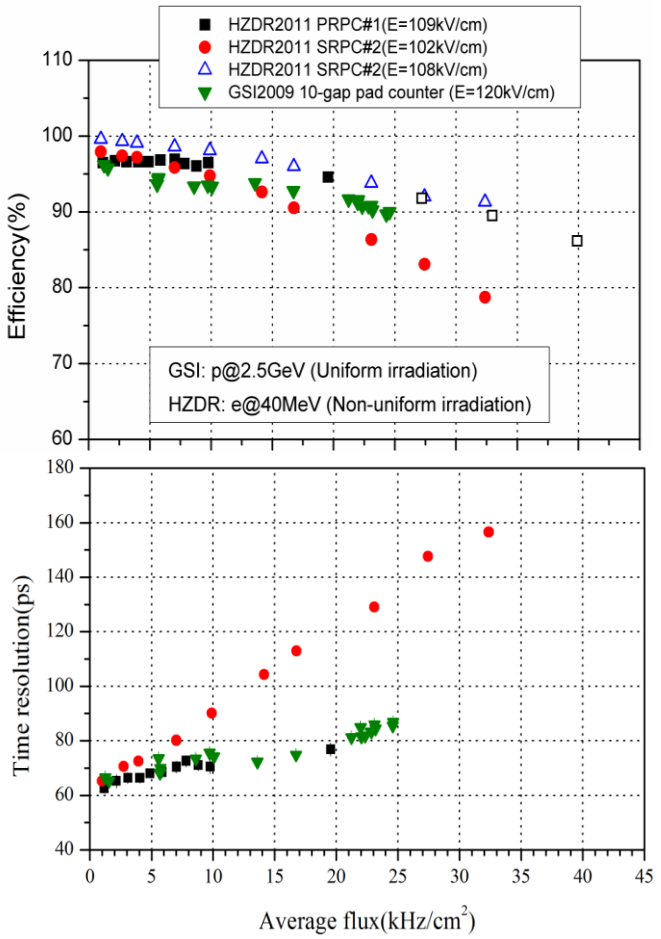
micrometer caliper







Time Resolution:<80ps
Efficiency:>90%
Rate Capability:>25kHz/cm^2



Aging effect:

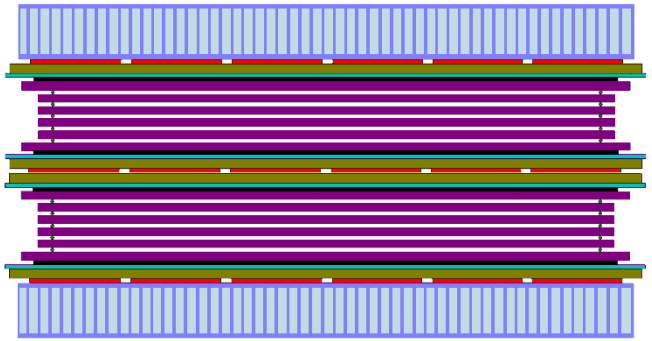
- Performance degradation of material, glass, mylar, et al.
- Performance degradation of detector.

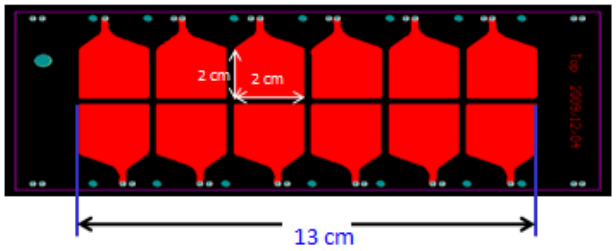
Introduction of Aging Test

- X-Ray source: X-ray Generator
- Gas Mixture:
  - 90% Freon, 5% iso-butane, 5% SF_6
- Irradiation Area: $2 \times 2\ cm^2$

- Dose Rate: 2.16×10^{-3} Gy/h
- Irradiation Time: 300h
- Total Charge: 0.22C

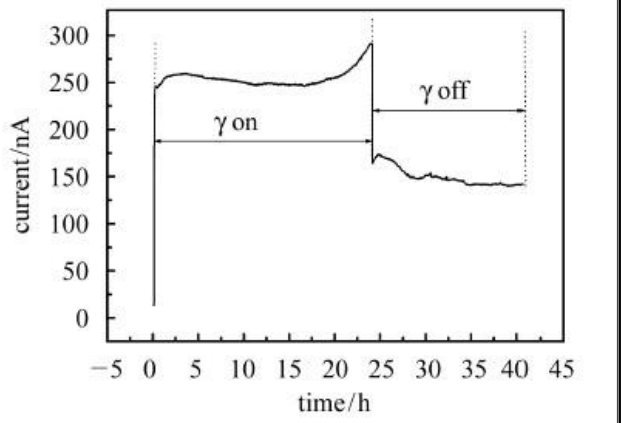
MRPC Module: 12pad high rate





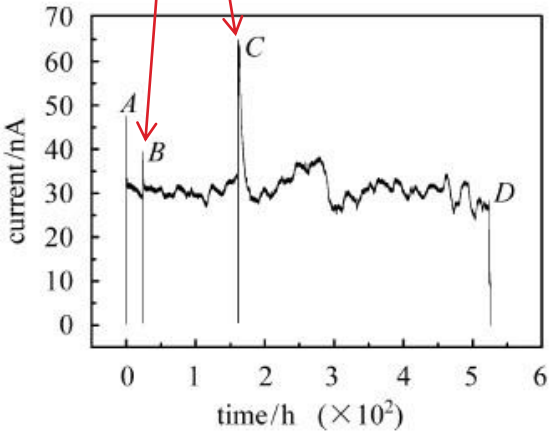
Glass type: Low-resistive glass
Gas gap (×10) : 0.25mm
Readout Pad (×12) : 2cm×2cm
Active area: 13cm×4.2cm

Related Researches



Efficiency →
Time Resolution ↗↗
Noise Rate ↗↗
Dark Current ↗↗

Turn off for a while



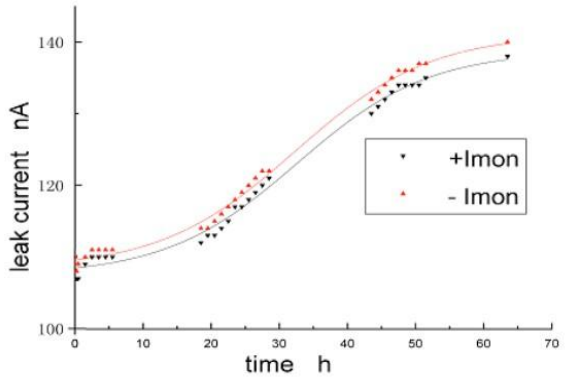
Low Dose Rate Test

Dose Rate:
Irradiation

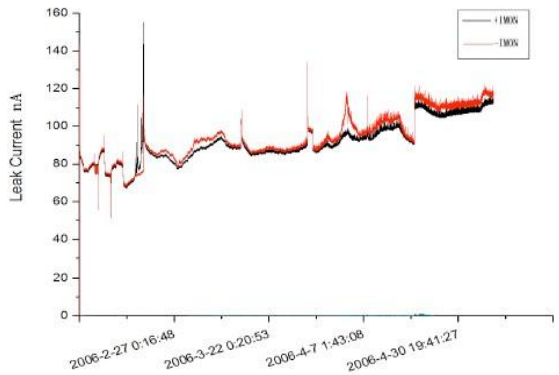
No significa
degradatio

Wang Yi, Kang Ke-Jun, Cheng-Jian-Ping et al.,
Aging Test of Multi-Gap Resistive Plate Chambers. HEP & NP 30(

Related Researches



Efficiency →
Time Resolution ↗↗
Noise Rate ↗↗
Dark Current ↗↗



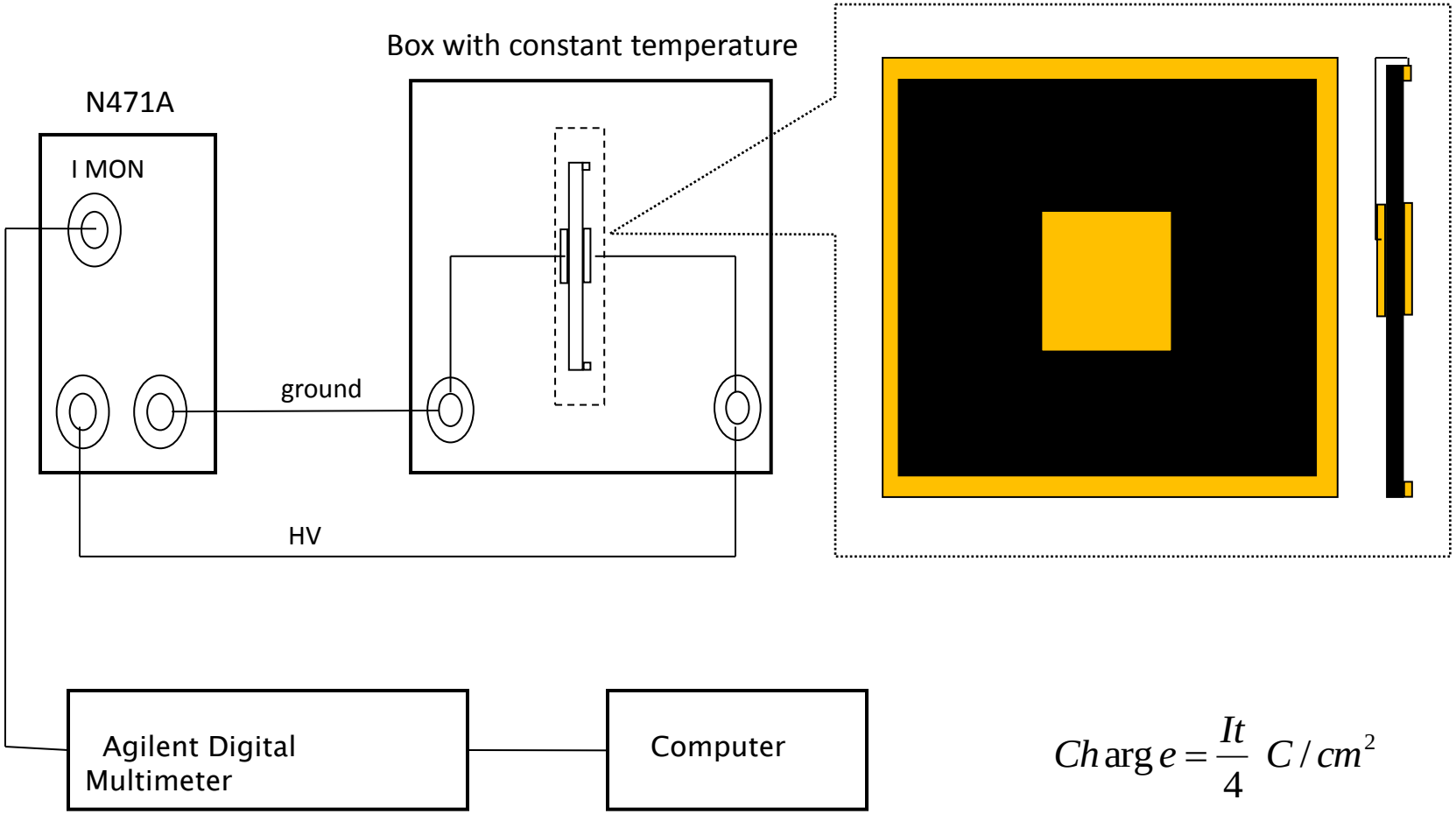
Low Dose Rate Test

Dose Rate: ~10^{-3}Gy/h
Irradiation Time: ~4 Months

No Obvious Aging Effect.

Wu Yuelei, et al.,
Aging Effect of Multi-Gap Resistive Plate Chambers, USTC, May 2005

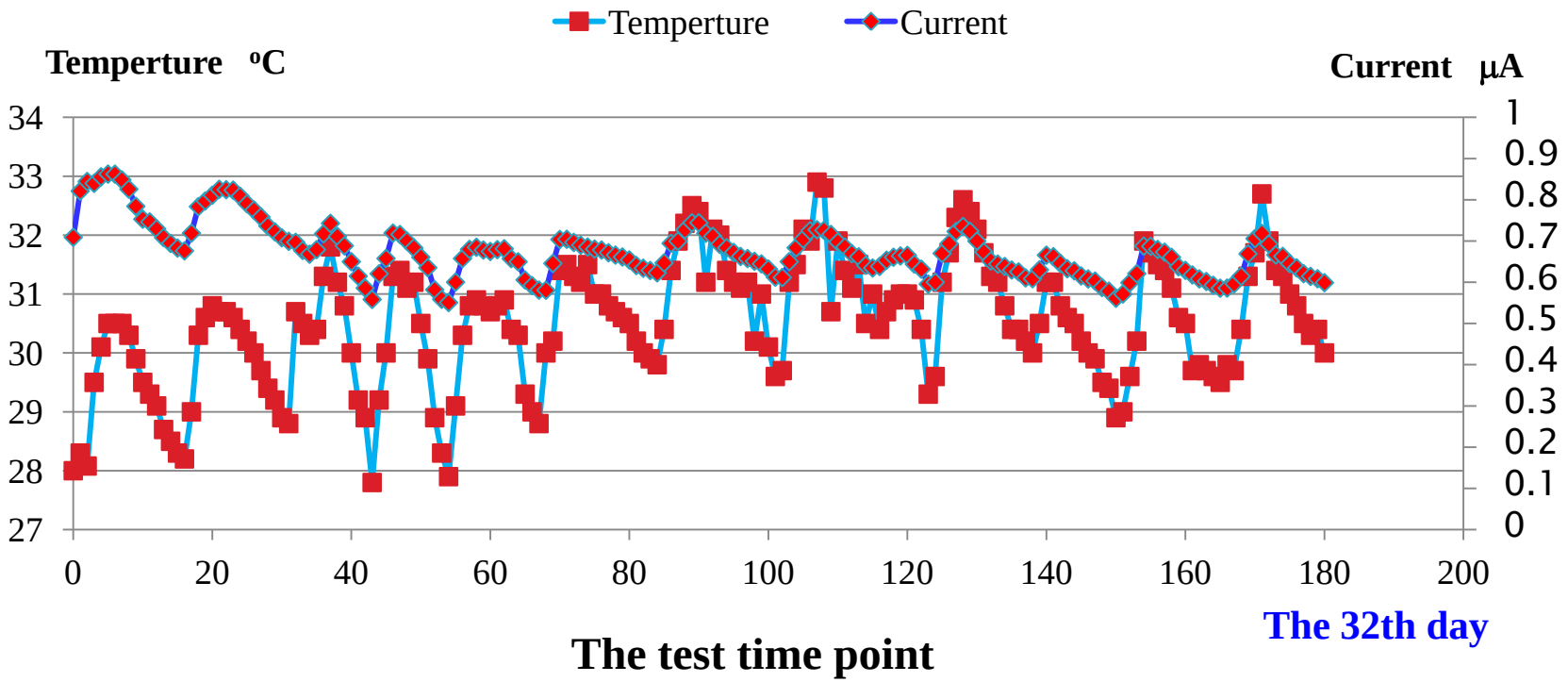
HV aging test of glass



$$Charge = \frac{It}{4}\ C/cm^2$$

The current was monitored in the interval 0f 30s

Current changes with test time



This glass was applied with 1000V for about 32days, integrated charge: 1 C/cm^2
--roughly corresponding to the CBM life-time over 5 years operation at the maximum particle rate.

Experimental Setup

- X-ray Generator
- MRPC Setup
- Gas System
- Monitoring System

During aging test,
the X-Ray Tube is closed for 30 minutes every 8-10 hours in order to prevent damage and study the responding behavior.

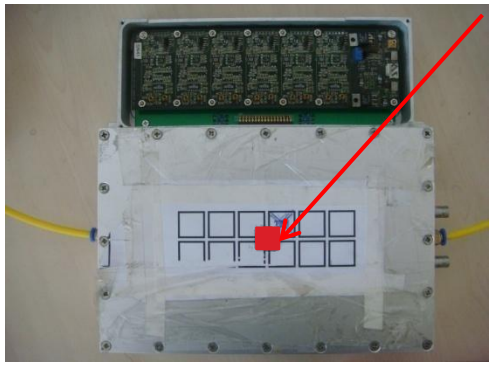
Spellman™ XRB80
High Voltage: 60kV
Current: 0.5mA
Dose Rate: 2.16×10^{-3}Gy/h (at 1m)

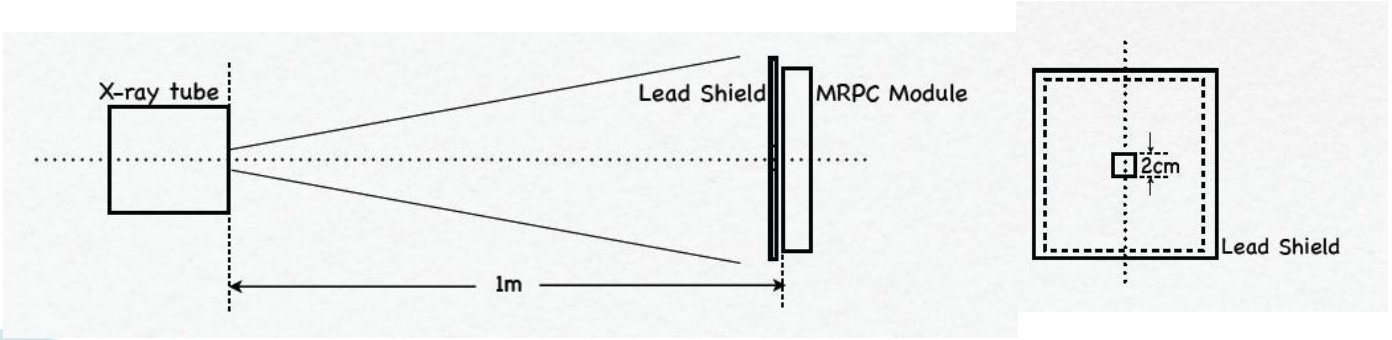
Experimental Setup

- X-ray Genarator:
- MRPC Setup
- Gas System
- Monitoring Sy

High Voltage: ±6600V
Dark Current: ~7nA
Noise Rate: ~150Hz/Pad

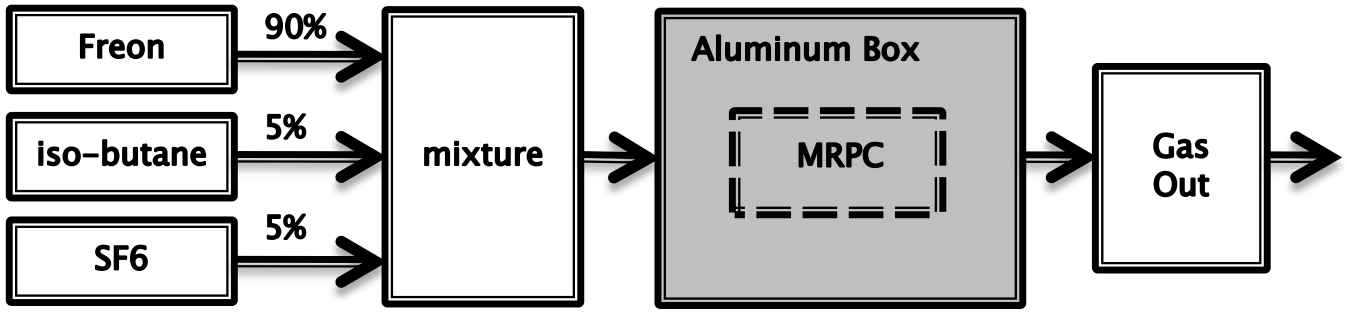
Irradiation Area





Experimental Setup

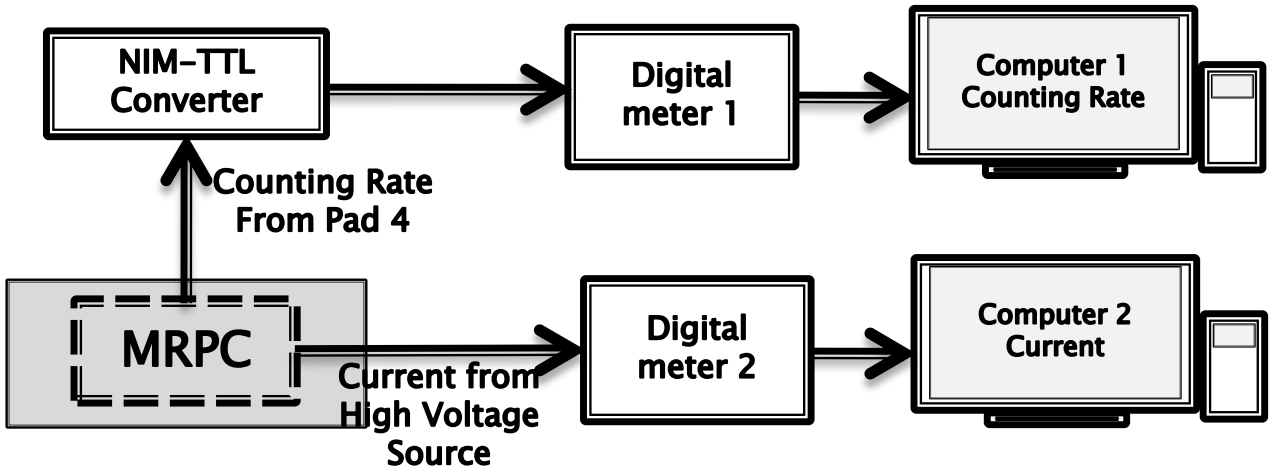
- X-ray Genarator:
- MRPC Setup
- Gas System
- Monitoring System



Experimental Setup

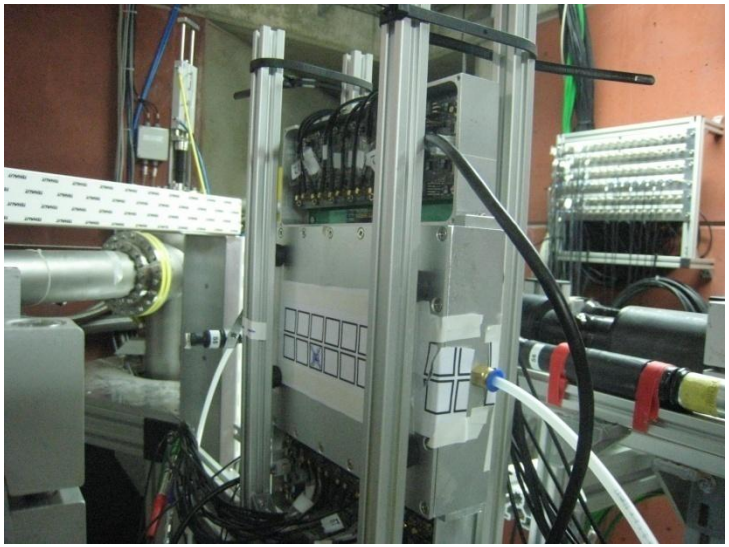
- X-ray Genarator:
- MRPC Setup
- Gas System
- Monitoring System

Monitoring Interval: 1min

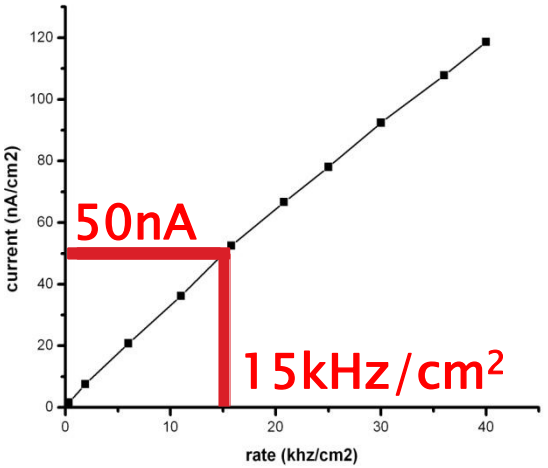


Experimental Setup

- During irradiation, the current of the MRPC module is 50nA/cm^2, this intensity is comparable to 15 kHz/cm^2 electron beam (tested at HZDR).



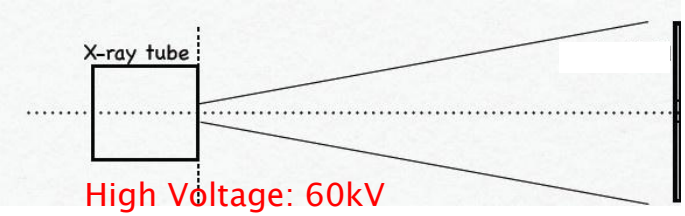
Beam test layout @HZDR



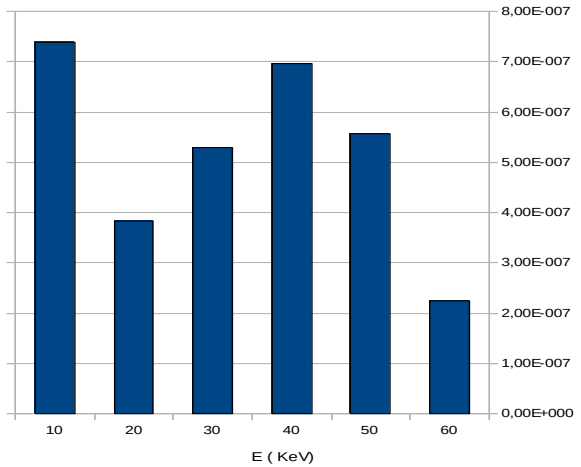
Rossendorf Beam Test Data

Simulation

- The energy deposition distribution caused by X-Rays.(MCNP)



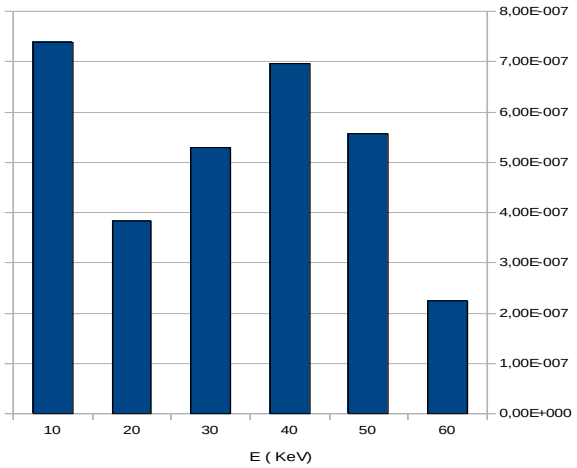
High Voltage: 60kV

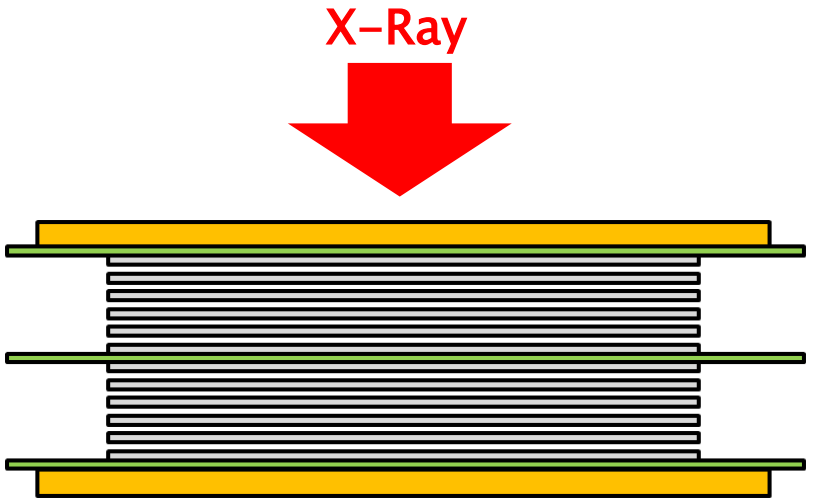


Energy spectrum of X-ray machine

Simulation

- The energy distribution of X-Rays generated.
- The number of electrons produced in each gap.(MCNP)

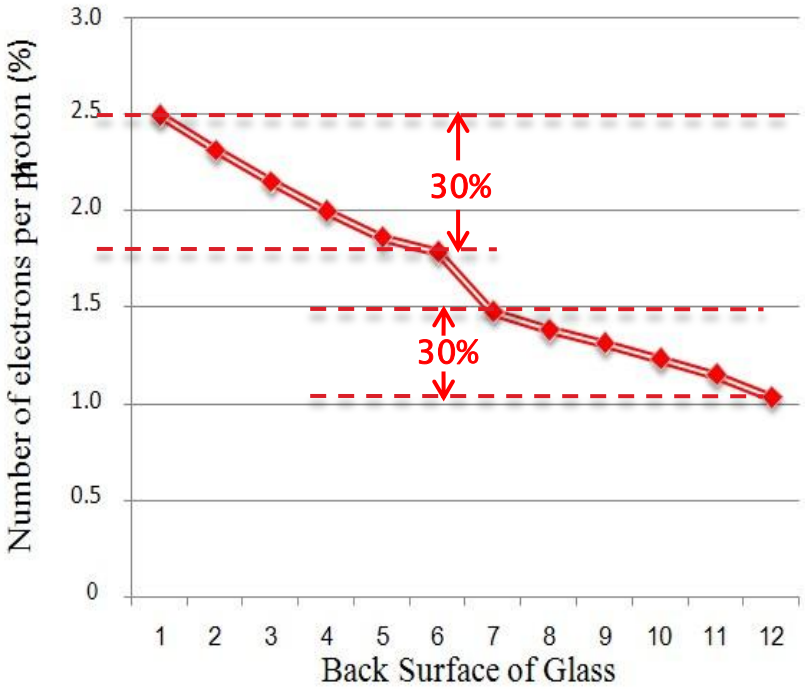




Glass type: Low-resistive glass
Gas gap (×10) : 0.25mm
Readout Pad (×12) : 2cm×2cm
Active area: 13cm×4.2cm

Simulation

- The energy distribution of X-Rays generated.
- The number of electrons produced in each gap.

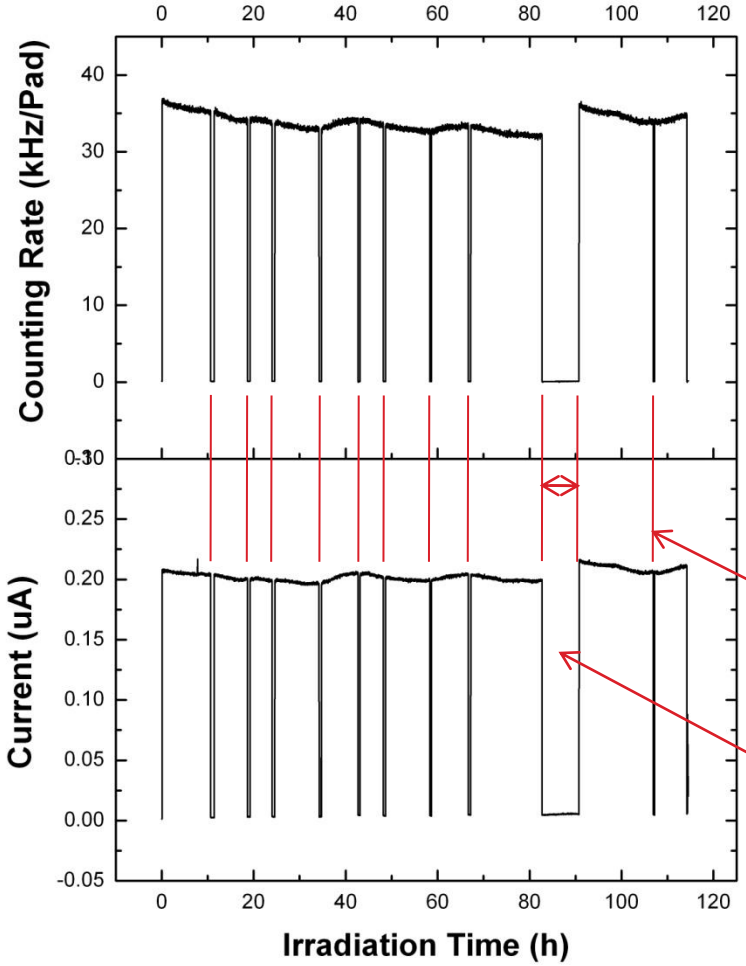


There is 30% less electrons in the the last gap of each half, compared to the first one.

The upper half ages twice than the lower half. (However, ×2 error is reasonable in aging test.)

Results & Discussion

- 1st run



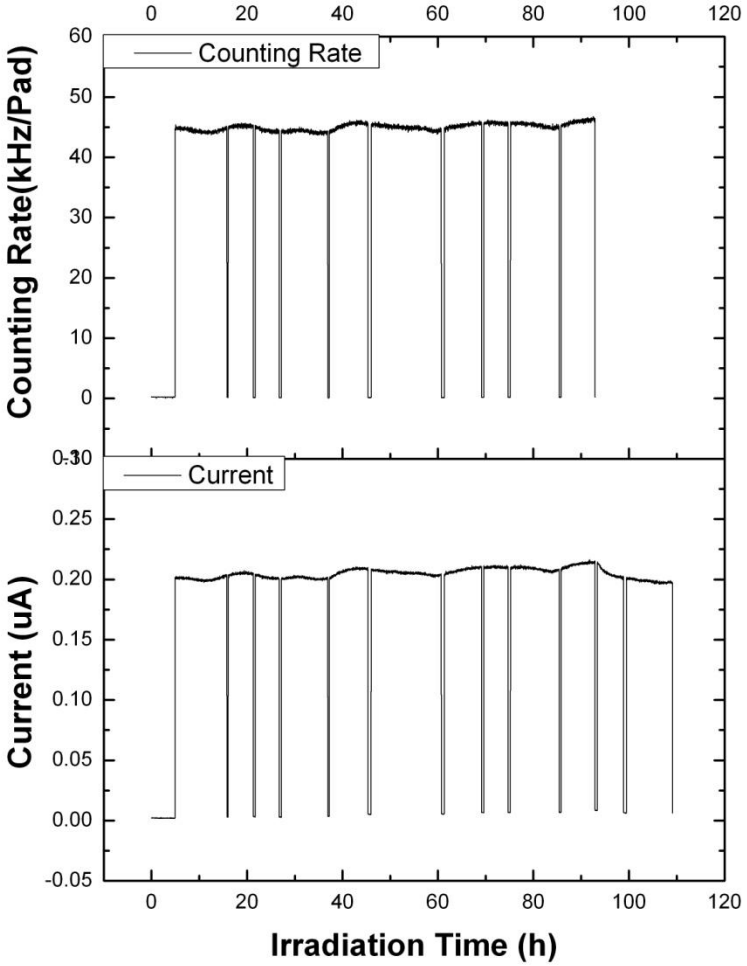
Irradiation Time: 101.3h
Noise rate: ~130Hz/Pad
Dark current: ~7nA

X-ray is turned of for 30min

A long time without X-ray

Results & Discussion

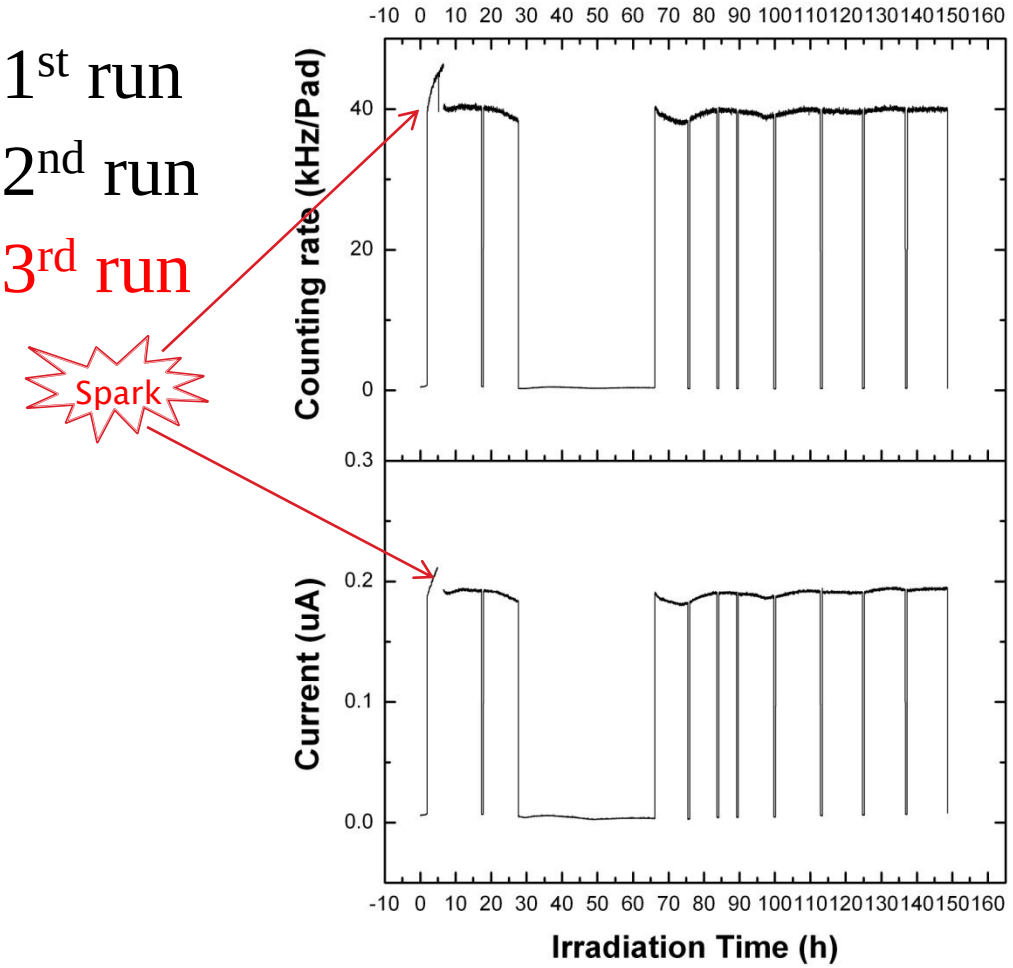
- 1st run
- 2nd run



Irradiating Time: 99.0h
Noise rate: ~200Hz/Pad
Dark current: ~7nA

Results & Discussion

- 1st run
- 2nd run
- 3rd run



Irradiating Time: 104.1h
Noise rate: ~300Hz/Pad
Dark current: ~8nA

Results & Discussion

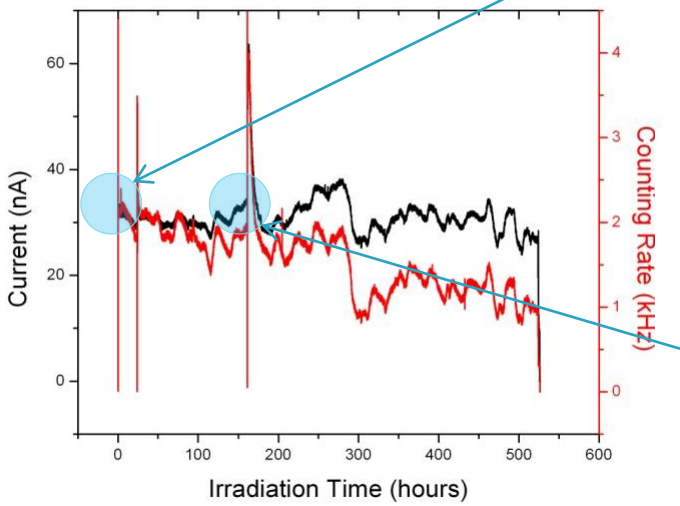
- Time Resolution

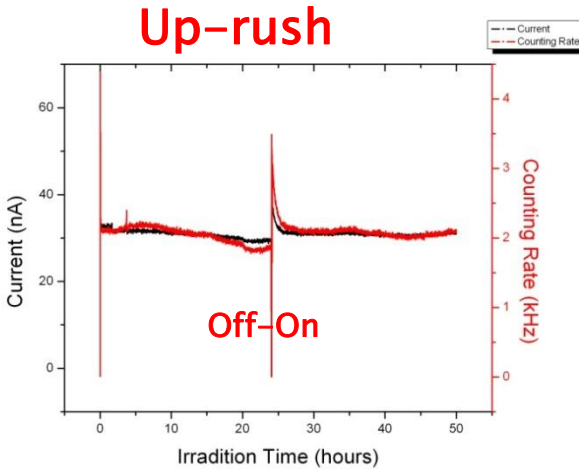
	Time Resolution(ps)
Before irradiation	90.0
After 100h's irradiation	94.5
After 300h's irradiation	87.5

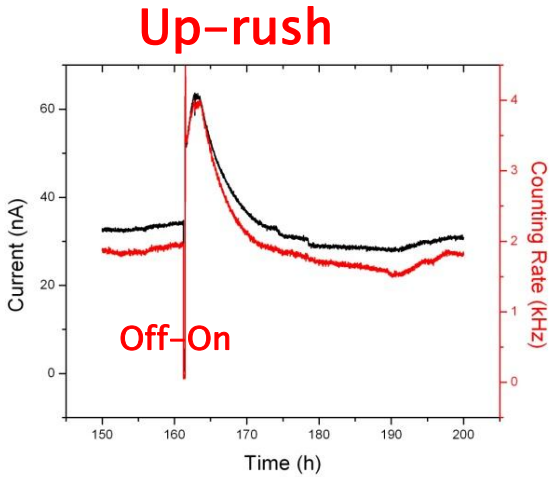
Results & Discussion

- Response Experiment

Common Glass MRPC





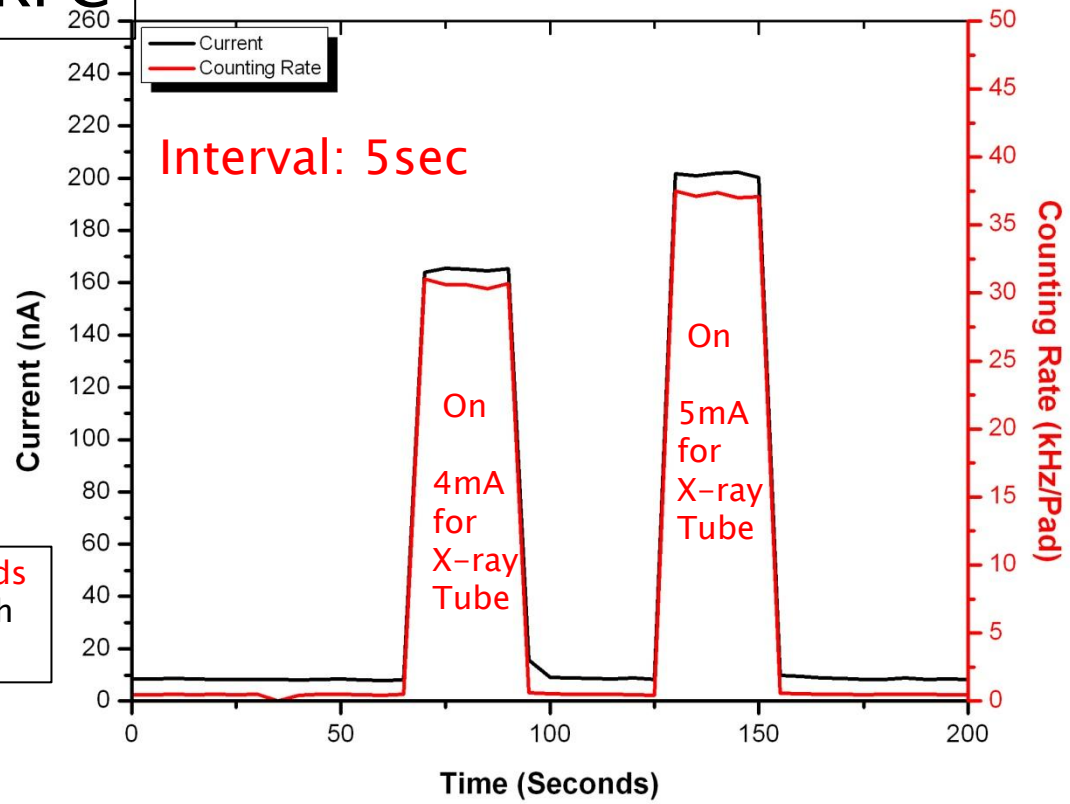


Wang Yi, Kang Ke-Jun, Cheng-Jian-Ping et al.,
Aging Test of Multi-Gap Resistive Plate Chambers. Chinese Physics C30(2006) 1-5

Results & Discussion

- Response Experiment

High Rate MRPC



The high rate MRPC responds very fast without an up-rush of signal.

Conclusions

- The low resistive glass shows very promising performance and passed HV aging test.
- Within 300h's operation, the performance of high rate MRPC module has shown the hardiness against irradiation. A dose rate of 2.16×10^{-3}Gy/h or a counting rate of 15kHz/cm^2 does not cause obvious aging effect.
- Compared to common glass MRPC, high rate MRPC responds and reaches a stable state faster.
- Further study will be done.

Thank You!