



中国科学技术大学  
University of Science and Technology of China



# A Novel Anti-Aging TBS MRPC

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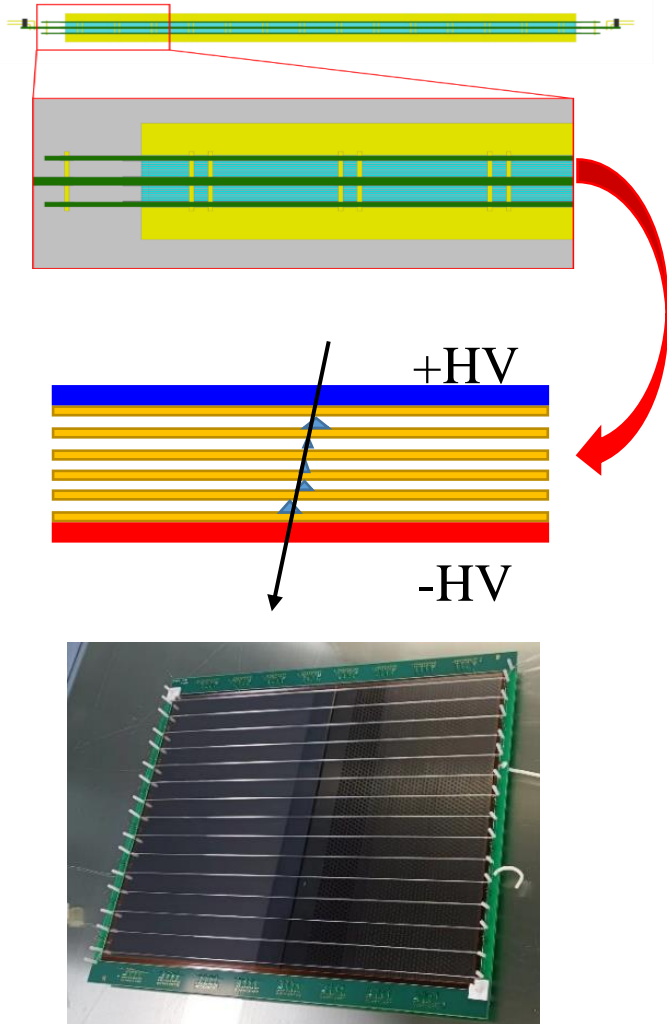
Department of Modern Physics, USTC

- Introduction
- TBS MRPC
  - Design and simulation
  - Performance test
- Summary



# CBM-TOF

## MRPC3/4

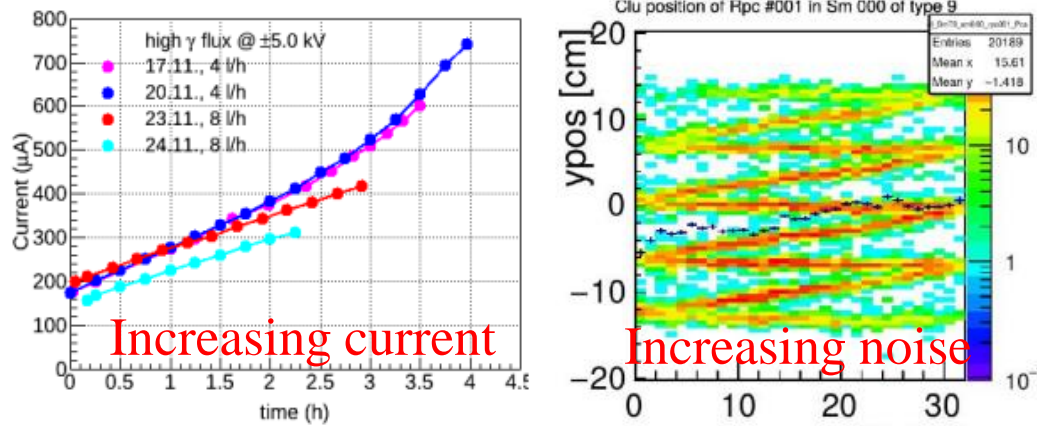


		MRPC 3	MRPC 4
		<b>Double-stack</b>	
Glass	Type	<b>ultra-thin float</b>	
	Size	353 x 276 x 0.23 mm	353 x 540 x 0.23 mm
Gaps	Size	<b>0.230 mm</b>	
	Number	<b>5 x 2</b>	
Readout strips		(0.7 cm + 0.3 cm) x 32 ,double-end strip readout	
Impedance		50 $\Omega$ differential signal to PADI	
Active area		320 mm x 270 mm	320 mm x 540 mm
Detector size		377 x 324 mm	377 x 588 mm

Facing **aging** challenges under the high radiation flux.

# Detector aging effect

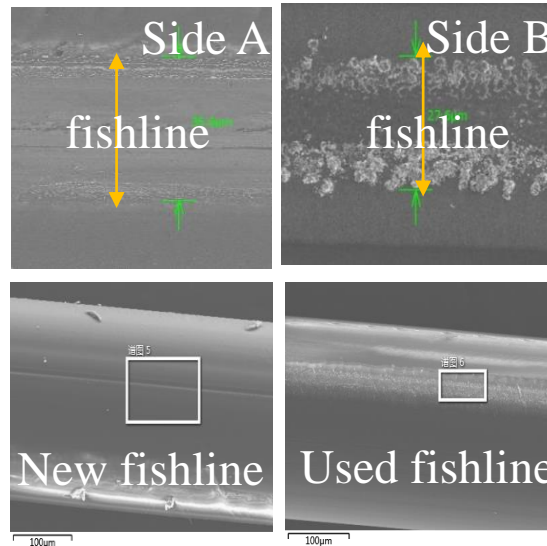
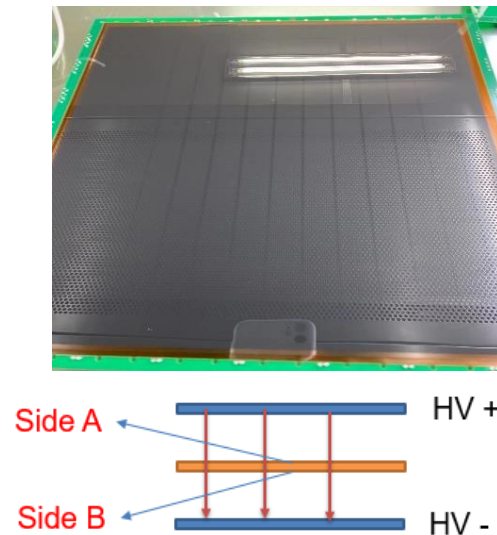
## ■ Aging effect observed under high beam intensity



*I. Deppner, 38<sup>th</sup> CBM collaboration Meeting*

- Lead to electric field break down
- Decline of efficiency and time resolution

## ■ Inspection of MRPC from STAR-eTOF

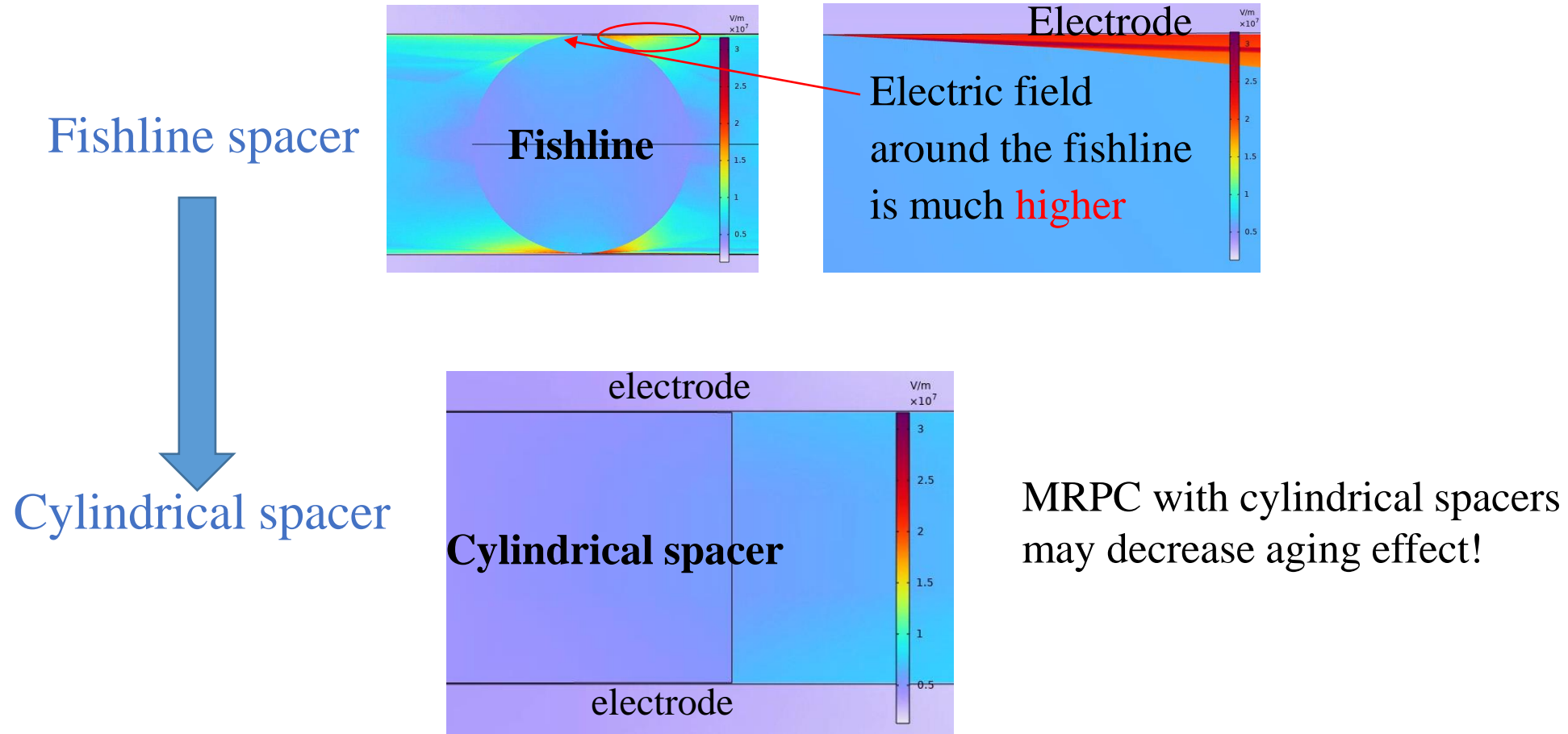


	wt%
C	1.77
O	27.14
F	21.28
Na	12.48
Si	26.92

Aging may correlated with fishline

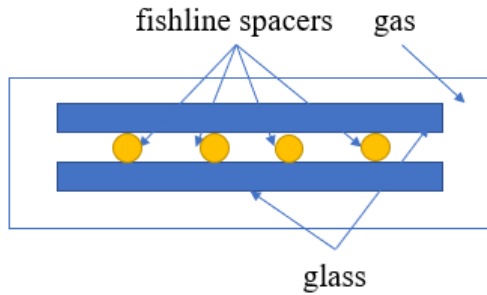
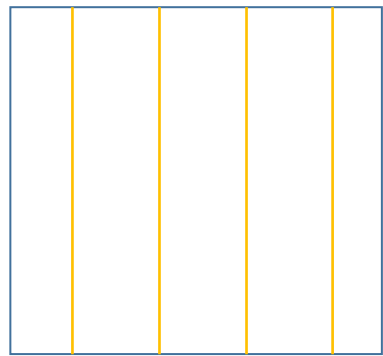
# Electric field simulation

- Using the electromechanical coupling physics module in COMSOL.



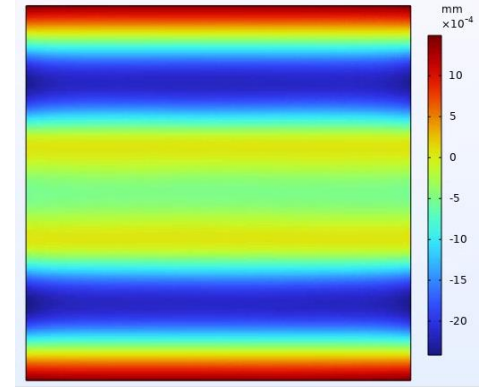


# TBS MRPC



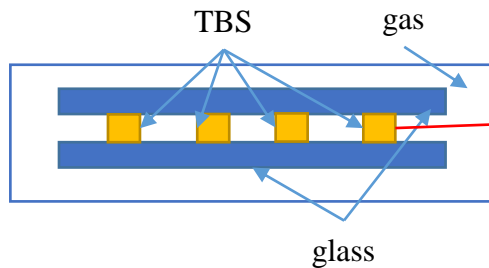
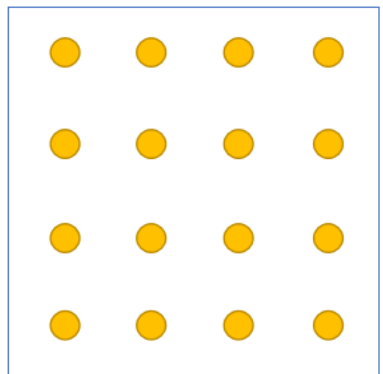
Structural design of a fishline MRPC for CBM-TOF

**Fishline:** 0.23 mm diameter, 19 mm interval

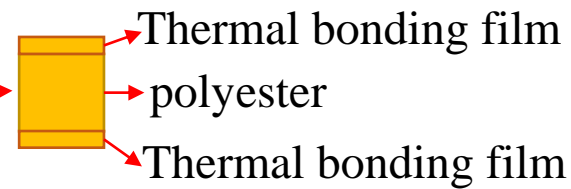


fishline structure  
Max deformation ~ 2  $\mu\text{m}$

Replace fishline with TBS

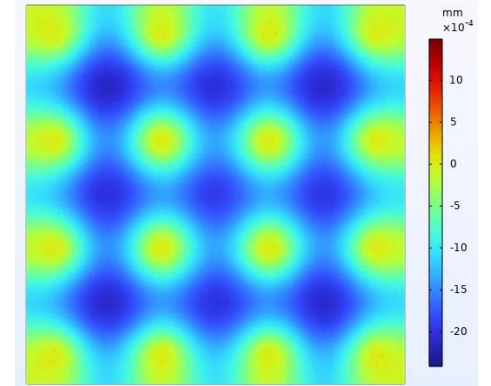


*Z. Zhang et. al JINST. 9 (2014) C10028*



**Thermal Bonding Spacer(TBS)**

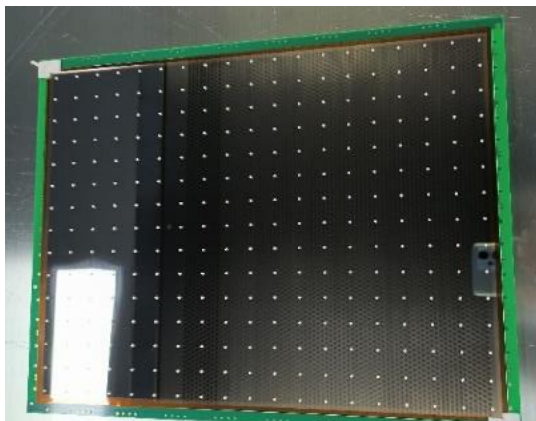
**TBS:** 2 mm diameter, 0.24 mm thickness, 19 mm interval



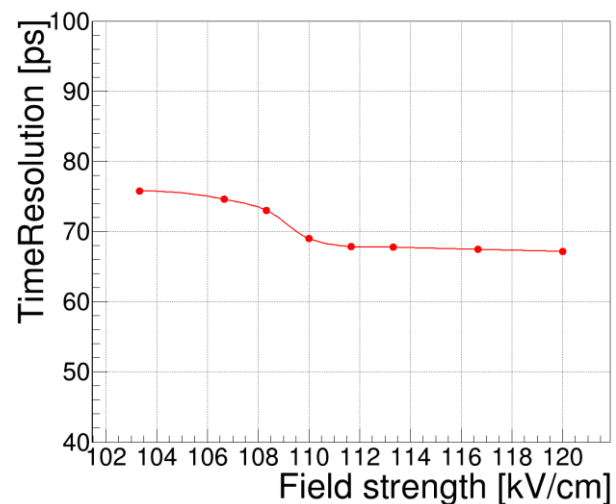
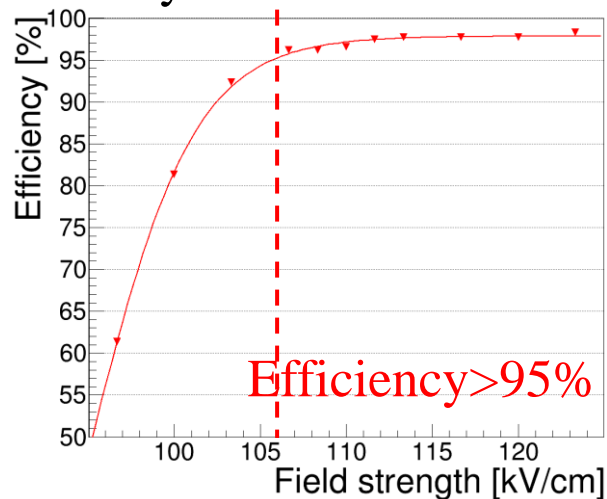
TBS structure  
Max deformation ~ 2  $\mu\text{m}$

# Performance test

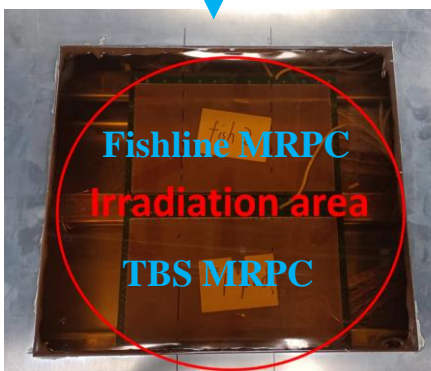
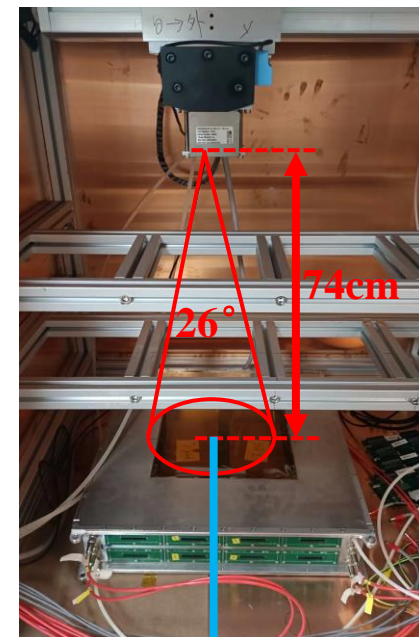
## ■ Performance under cosmic ray



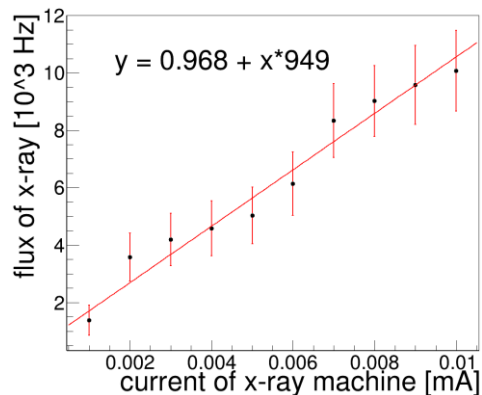
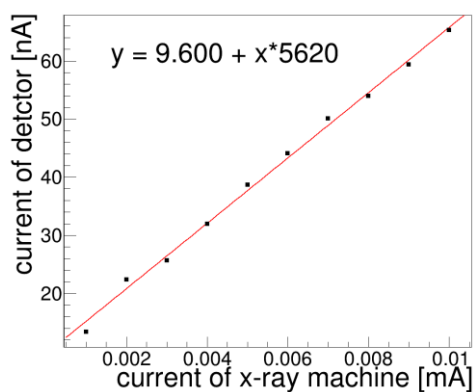
TBS MRPC



## X-ray test system



## ■ Flux calibration



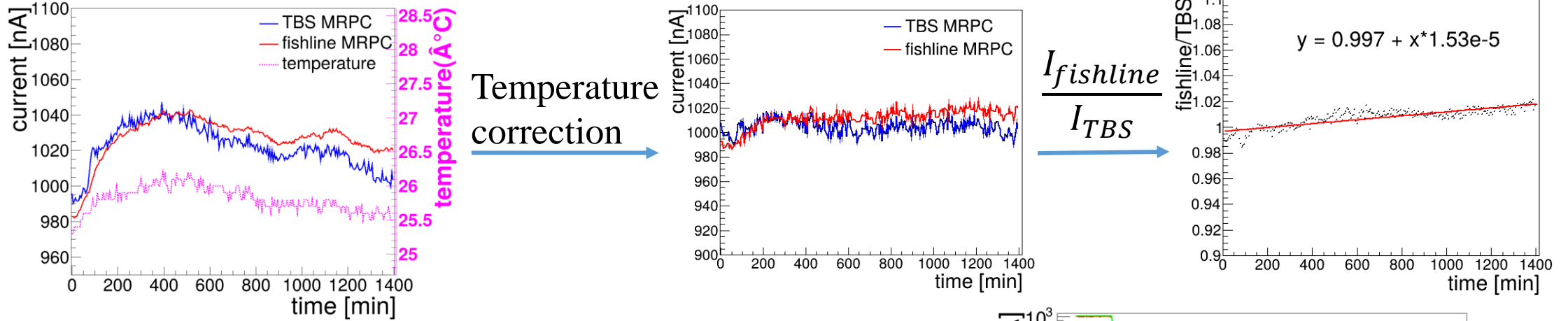
X-ray machine at 30 kV, 1.0 mA :  
4 kHz/cm<sup>2</sup> (High irradiation)

Two prototypes placed side by side for same intensity of X-ray irradiation

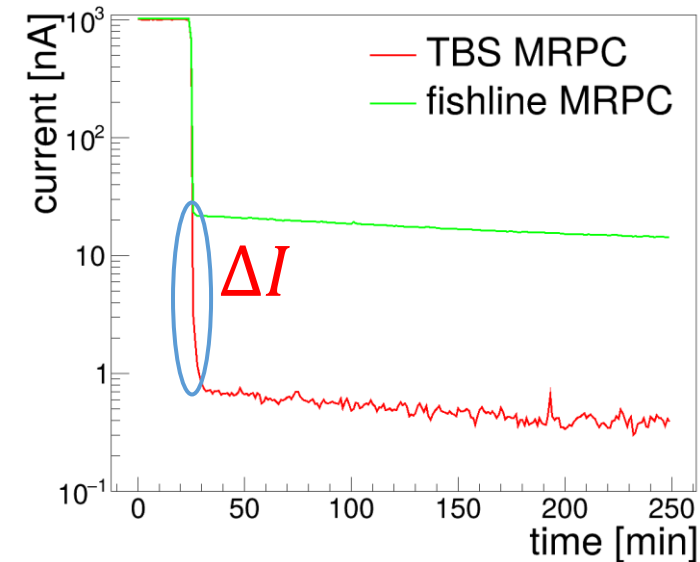


# Result analysis

## ■ Comparison of dark currents of two prototypes during X-ray irradiation



- $I_{TBS\_init} \approx I_{fishline\_init} \approx 1000 \text{ nA}$
- $I_{accumulated} = 1000 \times 1.53 \times 10^{-5} \times 1400 \approx 21 \text{ nA}$ .
- $\Delta I = I_{fishline} - I_{TBS} \approx 20 \text{ nA}$ .
- ✓  $I_{accumulated} \approx \Delta I$
- ✓ TBS MRPC → neglectable dark current
- ✓ Fishline MRPC → increasing dark current

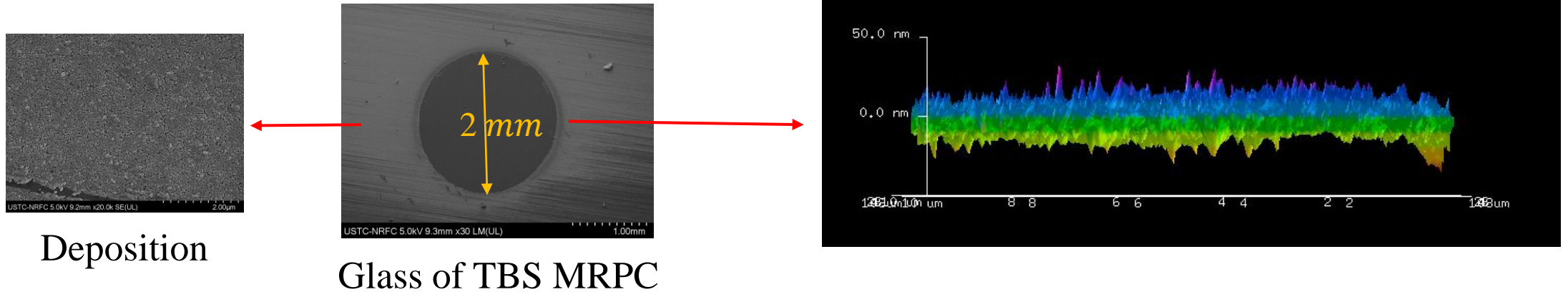
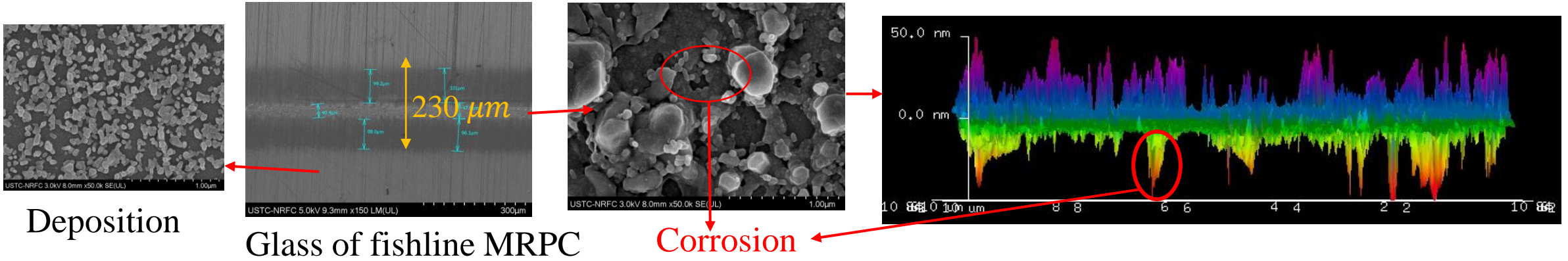


Current decrease after turning off X-ray

# SEM after irradiation

SEM(Scanning Electron Microscope)

AFM(Atomic Force Microscope)

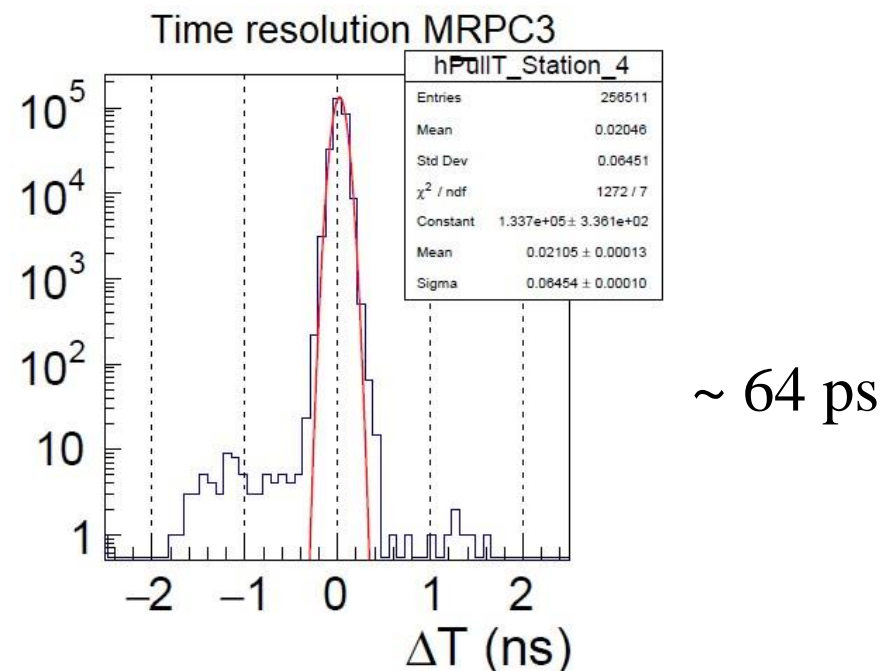
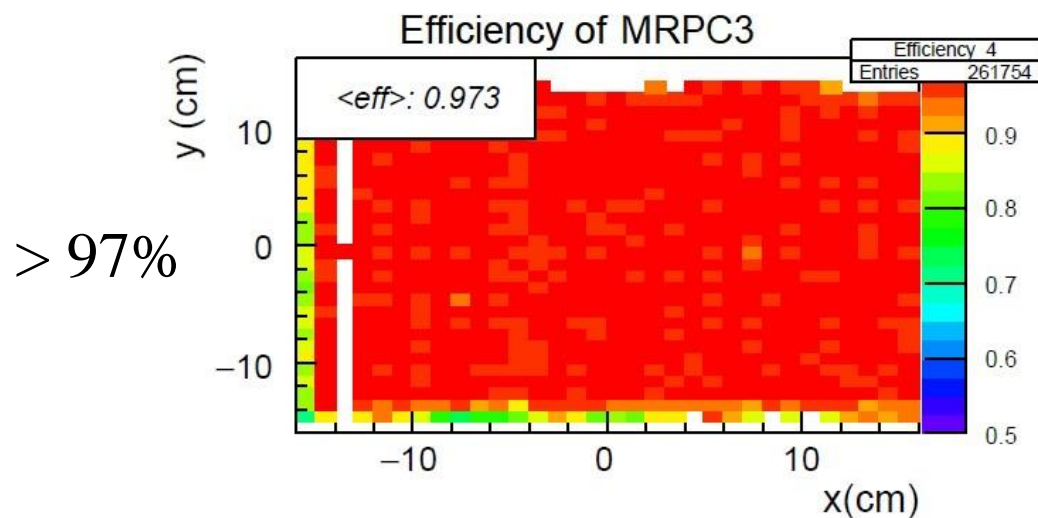


- ✓ Deposition and corrosion found in the fishline MRPC.
- ✓ Corrosion → increased dark current.

# Background noise

	Dark current(nA/cm <sup>2</sup> )	Noise(Hz/cm <sup>2</sup> )
Normal fishline MRPC	0.0045	0.31
Aged fishline MRPC	0.14	31.77
Normal TBS MRPC	0.0092	0.49
Aged TBS MRPC	0.0064	0.40

## ■ TBS MRPC beam test in miniCBM





# Summary

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- Novel TBS MRPC for solving aging effect has been developed.
- Comparative tests indicate that TBS MRPC shows potential for long-term stability in high irradiation environments.
- Preliminary exploration on aging effects through SEM and AFM scanning.

*Thank you!*

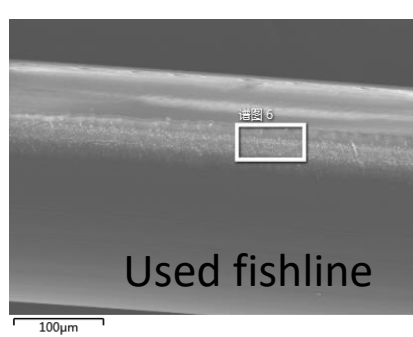


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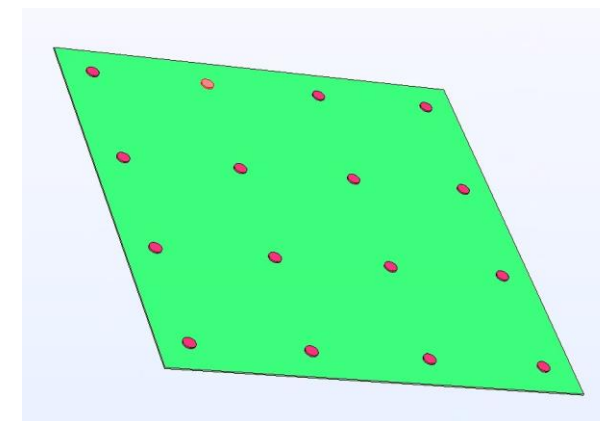
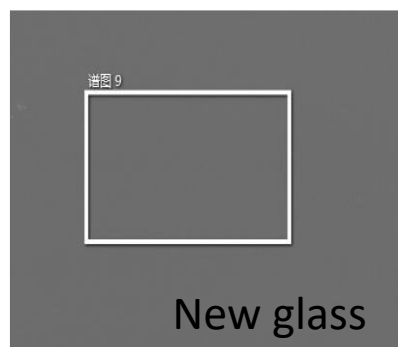


# Back up

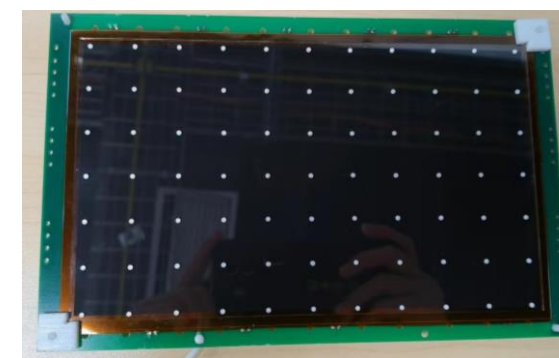
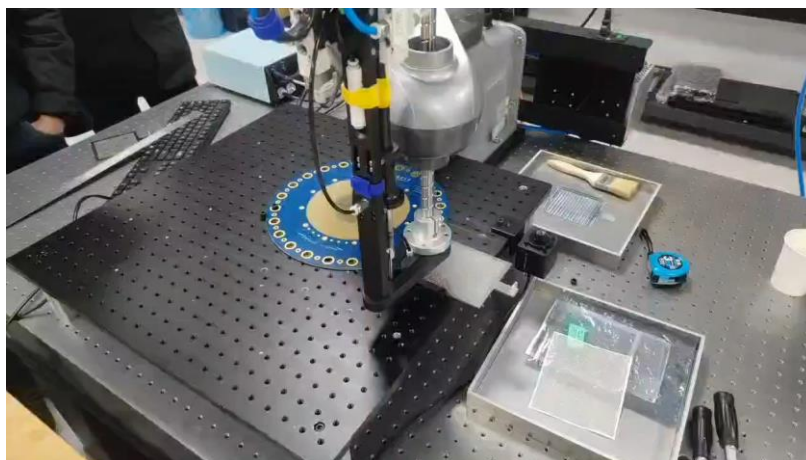
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	wt%
C	42.93
O	9.03
<b>F</b>	<b>31.99</b>
Na	13.4
Si	2.36
Pt	0.28



### Machine to paste pad

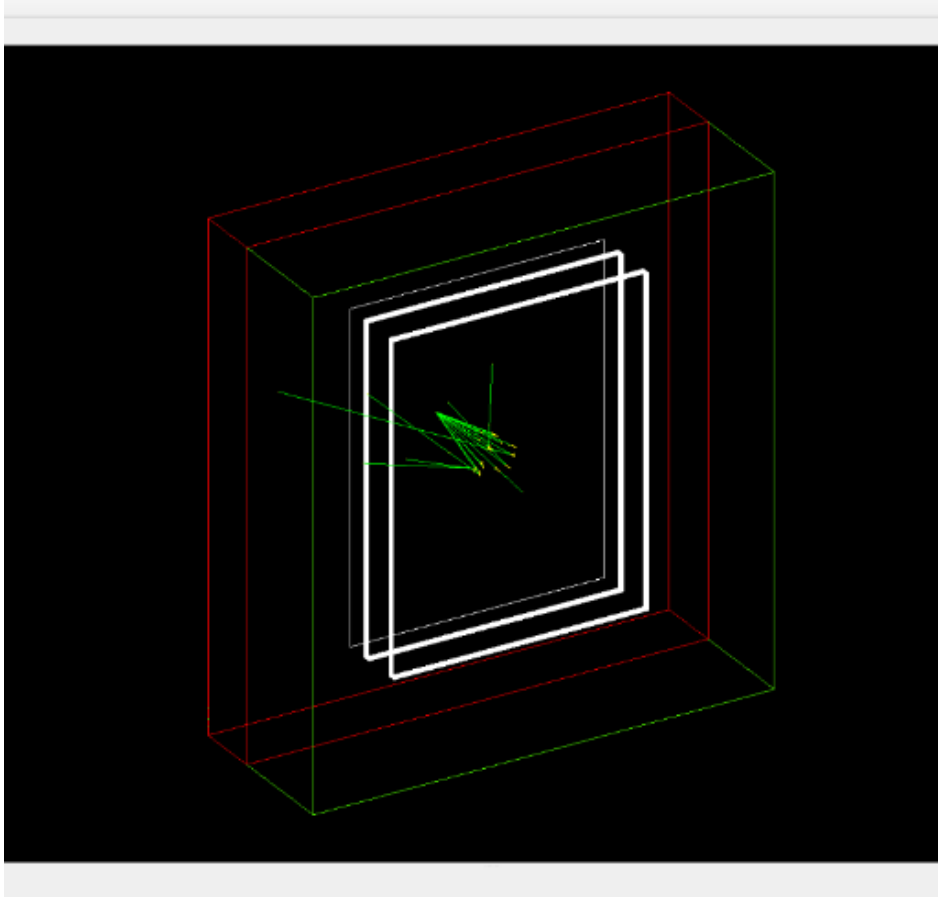


Prototype for x-ray test  
Effective area: 12 cm × 20 cm

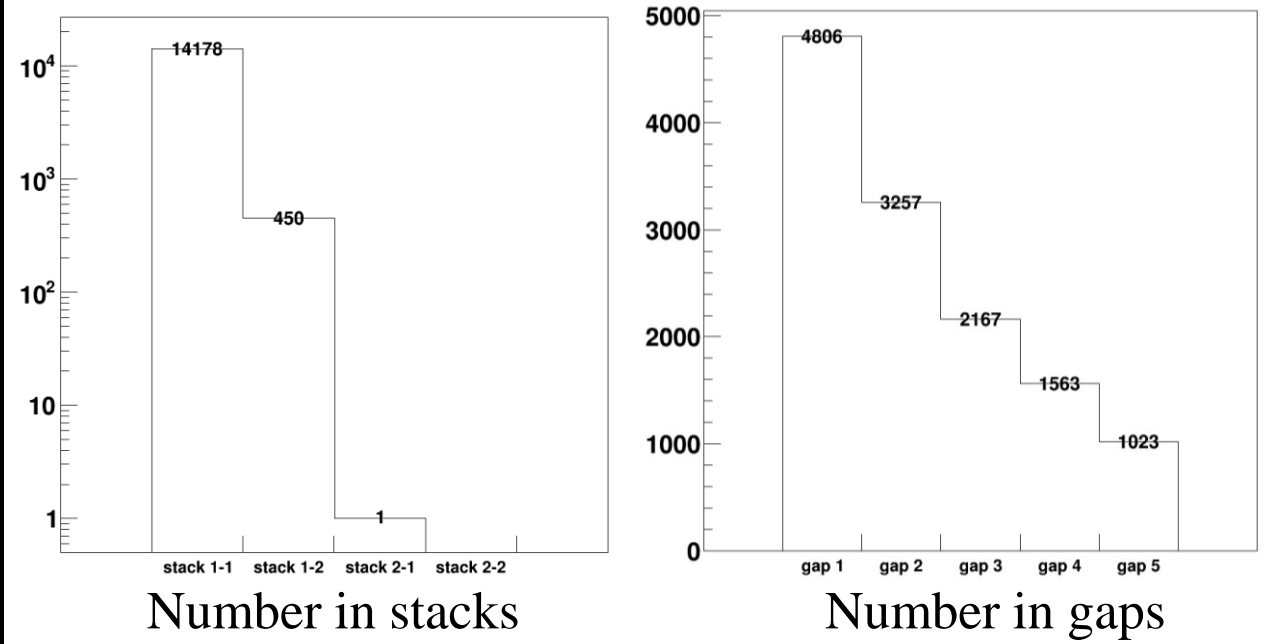


# Geant4

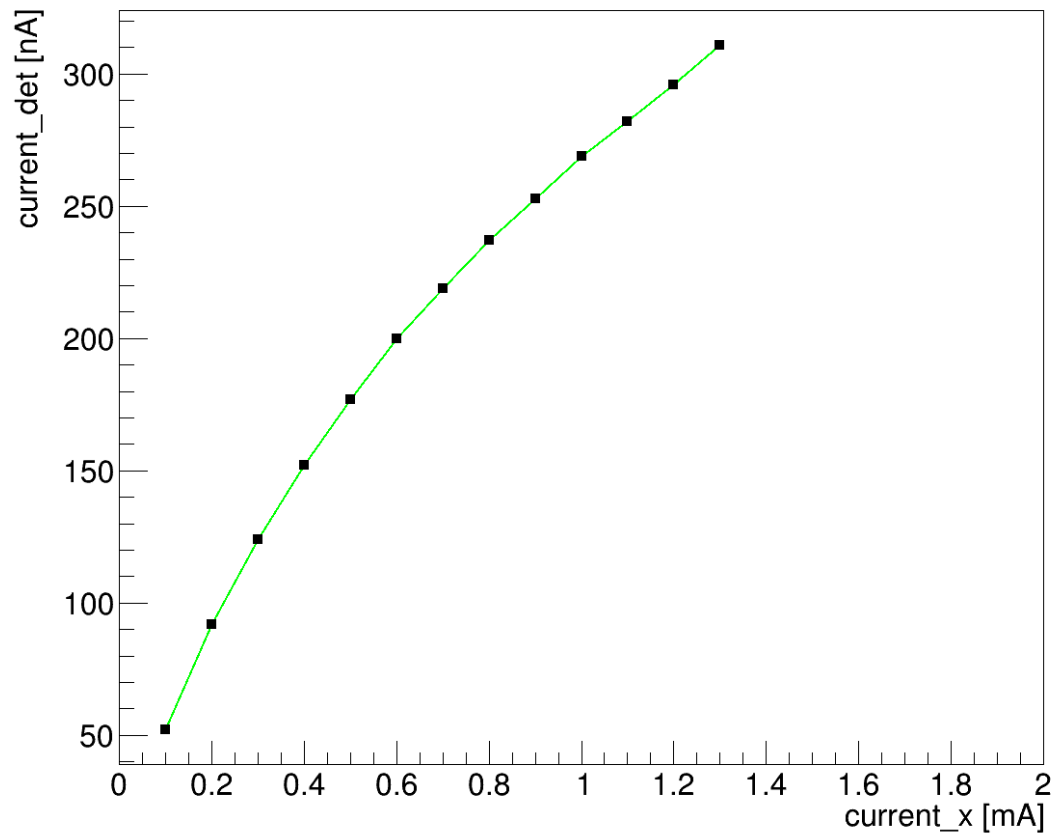
To simulate the penetration of X-ray in detector



Total events: 100,000

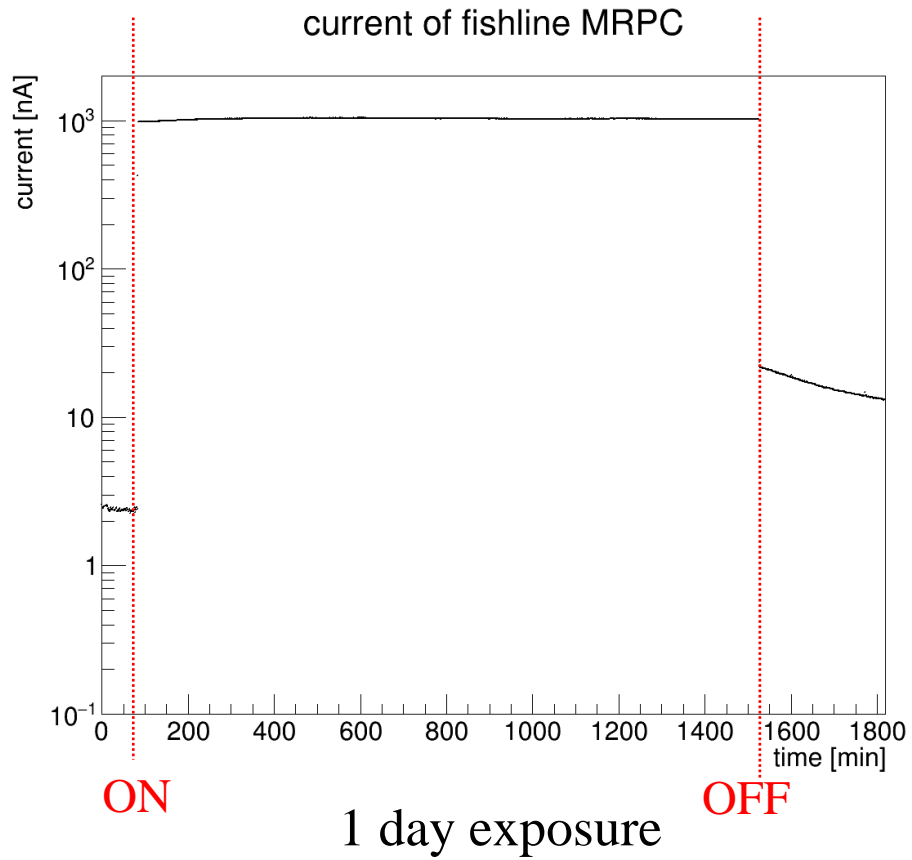


Most X-ray absorbed in the first stack.

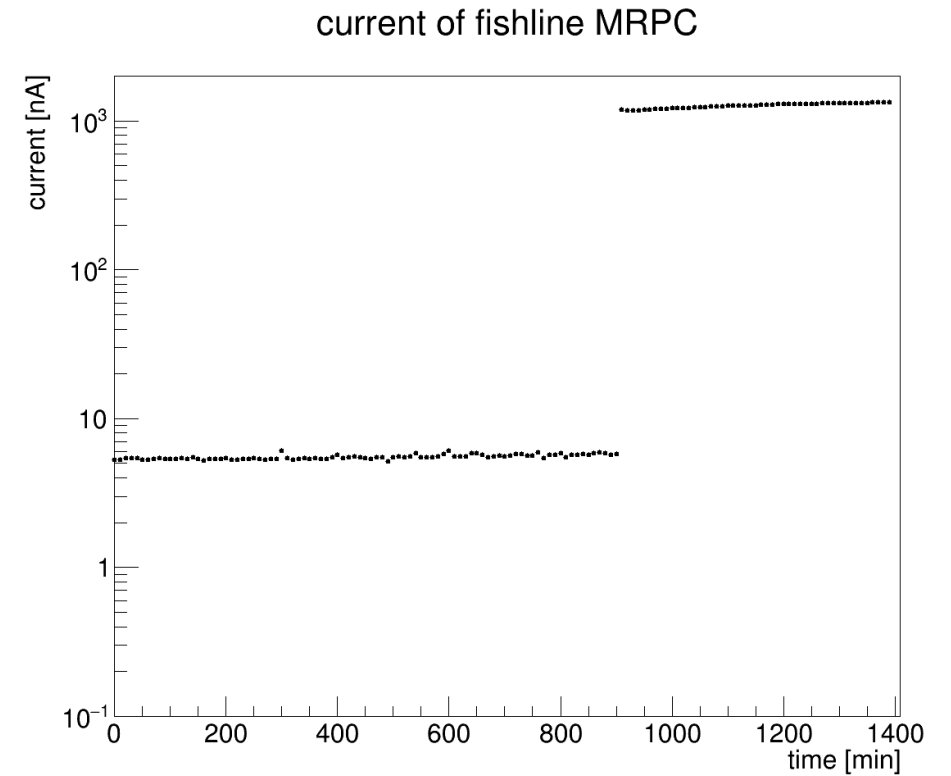


Polarity	Grounded Cathode
Flange Type	(6) 8-32 thread
High Voltage Range	4-60 kV <sup>1</sup>
Anode Current	1-3mA <sup>1</sup>
Continuous Rating	50-100 W <sup>1</sup>
Focal Spot	50 μm, 100 μm
Filament Current, max.	1.7 A
Filament Voltage, (nominal)	2.5 V
Flow Rate - Water	0.79 gallon/min (3 liters/min)
Inlet Water Temperature, max.	21°C
Stabilization Time	< 5 minutes
Weight	3.5 lbs (1.59 kg)
Inherent Filtration	0.005 inch Be
Target Materials	Cu, W Others available on request
Target Angle	20°
Radiation Coverage	26°
Radiation Leakage	<2 μSv/hr @ 50 mm (60 kV, 1 mA)

## Current of fishline MRPC



1 month



Counter	MRPC3	MRPC4
Name	910	700
Area [cm <sup>2</sup> ]	862	1696
Current [μA]	7.5	17
Current density [μA/cm <sup>2</sup> ]	0.0087	0.010
Rate [Hz/cm <sup>2</sup> ]	750	
Current [μA]	13	29
Current density [μA/cm <sup>2</sup> ]	0.015	0.017
Rate [kHz/cm <sup>2</sup> ]	1.3	
Current [μA]	20	48
Current density [μA/cm <sup>2</sup> ]	0.023	0.028
Rate [kHz/cm <sup>2</sup> ]	2.0	
Current [μA]	40	100
Current density [μA/cm <sup>2</sup> ]	0.046	0.059
Rate [kHz/cm <sup>2</sup> ]		
Current [μA]	50	50
Current density [μA/cm <sup>2</sup> ]		
Rate [kHz/cm <sup>2</sup> ]		

