

Beam Test of High Rate MRPC In Jlab

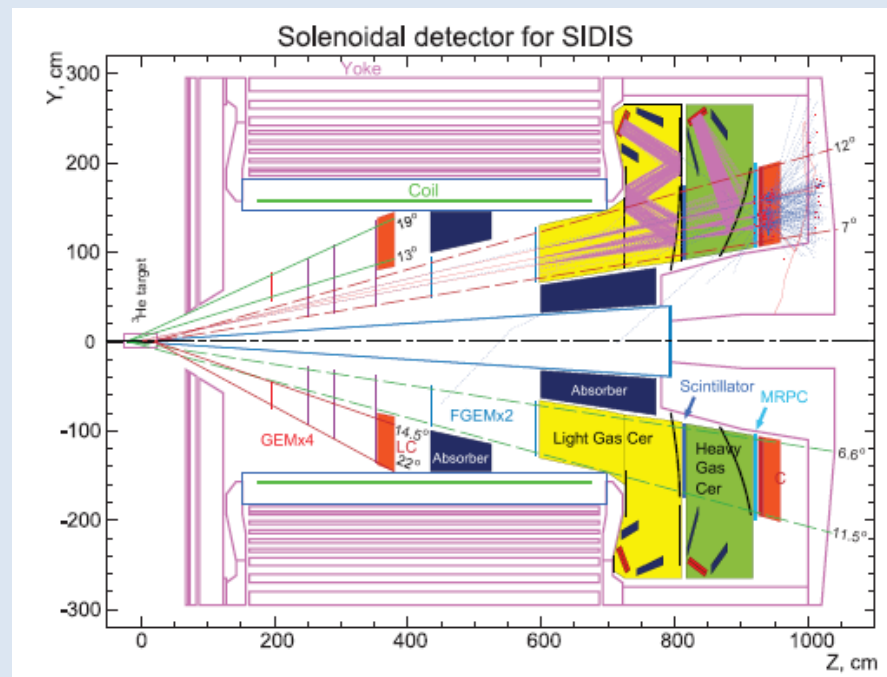
Xingming Fan

Department of Engineering Physics

Tsinghua University, Beijing, China

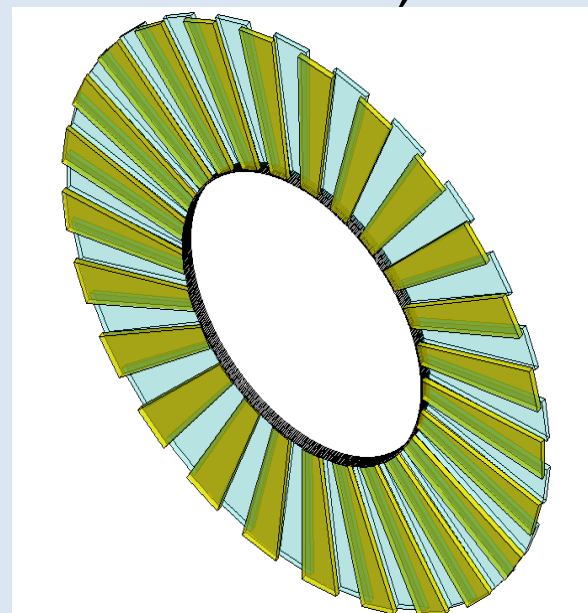
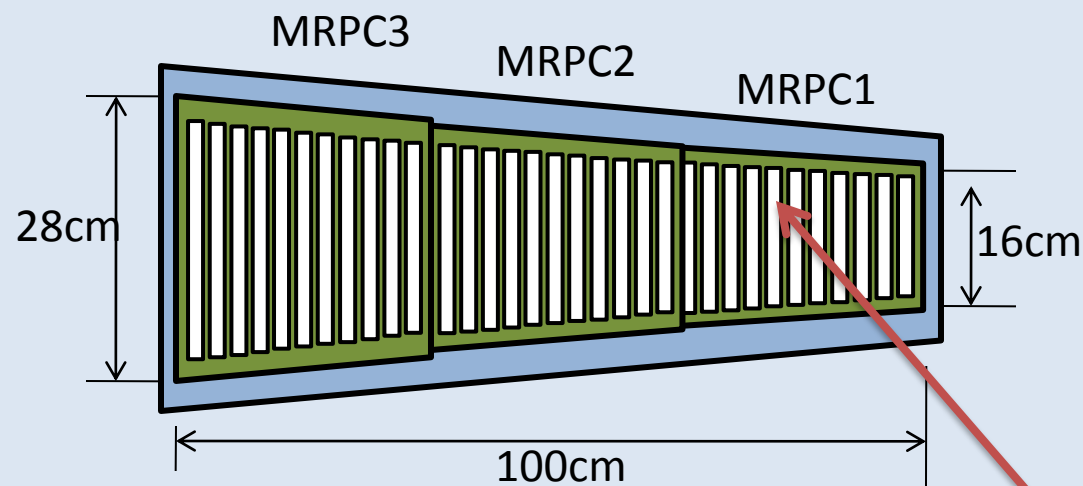
Outline

- Introduction
 - TOF and MRPC
 - Experiment Overview
- Beam Test Setup
 - Test System
 - Process
 - Some Details on Setup
- Results & Conclusion
 - Test Results
 - Comparison
 - Conclusion



1.Introduction: MRPC TOF Wall

- The MRPC is developed for the TOF wall of SoLID Experiment
- Main Requirements for TOF:
 - π/k separation up to 2.5GeV/c
 - Time resolution < 80ps
 - Rate capability > 10kHz/cm²
- MRPC TOF wall we designed contain 150 MRPC modules in total, with 50 gas boxes and 3 counters in each box, covering the area of 10m².



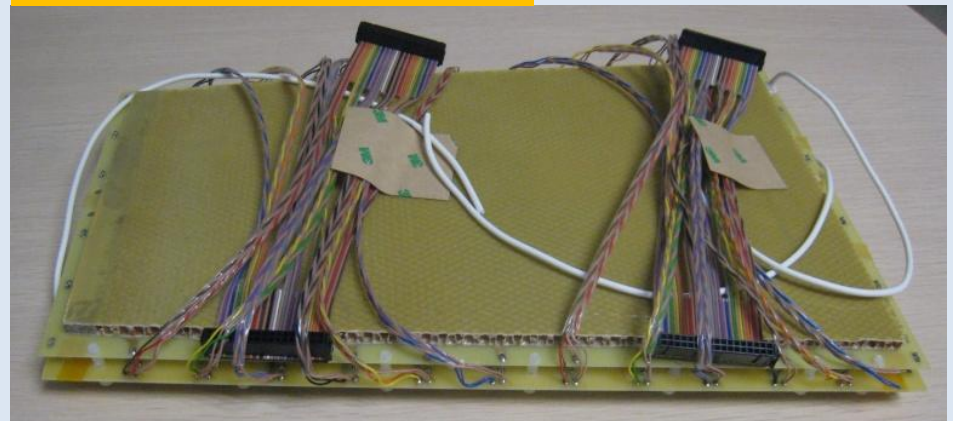
The MRPC module we tested is the prototype of inner module.

1.Introduction: MRPC module

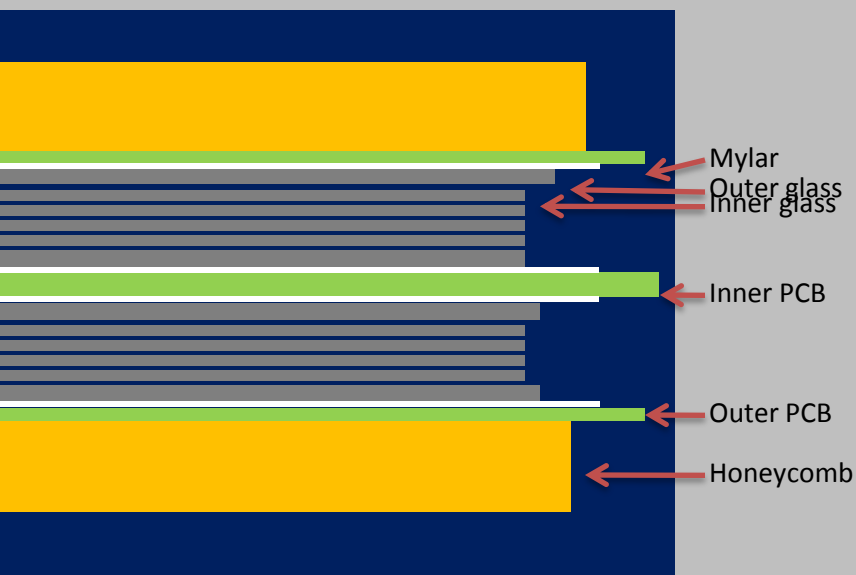
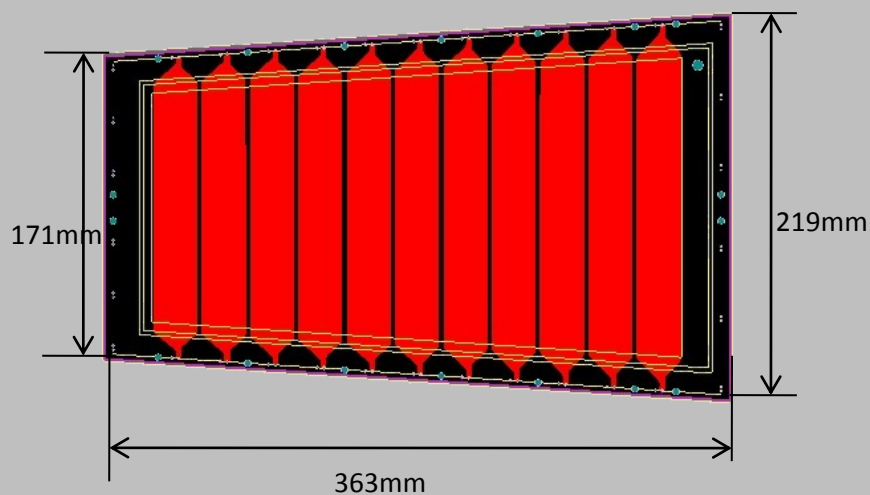
- The prototype of high rate MRPC modules low resistivity glass electrodes can work under the flux of $>25\text{kHz}/\text{cm}^2$ in previous test in HZDR and GSI.
- Low resistivity glass is black in color, and the volume resistivity can reach $\sim 10^{10}\Omega\cdot\text{cm}$. (For float glass, the volume resistivity is $\sim 10^{12}\Omega\cdot\text{cm}$)



Volume resistivity:
 $\sim 10^{10}\Omega\cdot\text{cm}$



1.Introduction: MRPC module



Gas Mixture(Pre-mixed)	Freon 90% iso-butane 5% SF6 5%
Working Voltage	$\pm 6800V$
Electrical field	$\sim 108.8kV/cm$

The design of MRPC readout

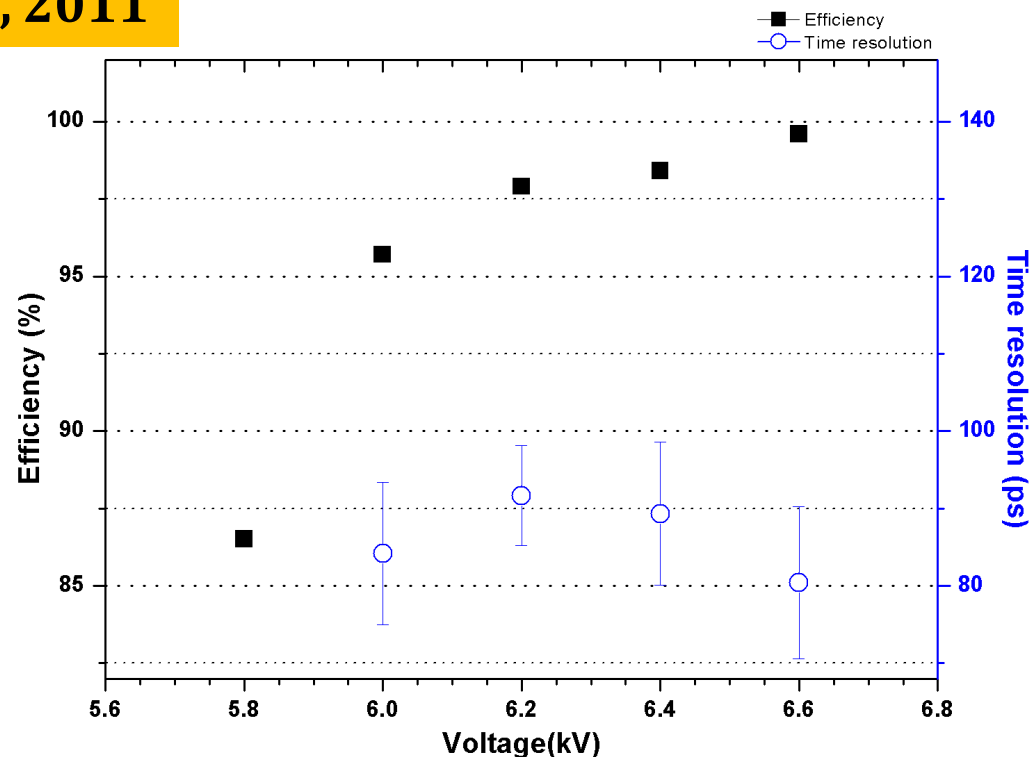
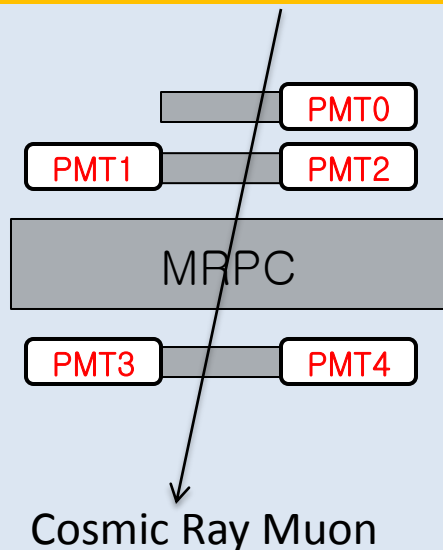
Interval	3mm
Strip width	25mm
Readout mode	Differential

Dimensions

	Length/mm	Width/mm	Thickness/mm
Gas gap	-	-	0.25×10
Inner glass	320	130-171	0.7
Outer glass	330	138-182	1.1
Mylar	335	153-198	0.15
Inner PCB	350	182-228	1.6
Outer PCB	350	172-218	0.8
Honeycomb	330	153-198	6

1.Introduction: Cosmic Ray Test

Cosmic ray test@Tsinghua August, 2011



Efficiency > 95% @ 96kV/cm (6.0kV)
Time resolution: 80ps ~ 90ps

1.Introduction: Experiment Overview

- The experiment took totally 3 months, contains several process. The MRPC is tested both with cosmic ray and beam.
- Brief Timetable :

Setting Up Feb 7 th - Apr 7 th	Preparation(Feb 7th-Mar 26th)			Setting in Hall A(Mar 26th-April 10th)	
	MRPC module and electronics; Placing High Voltage cable & gas supply; Work on DAQ and Decoding program; Pre-test with cosmic ray.			Building test system in Hall A; Upgrading of DAQ system; Finish cable connection; Pre-test with beam.	
Beam Test May 12 th -May 17 th	May 12th	May 13th	May 14th	May 15th	May 16-17th
	Begin the test; Voltage Scan. Detector is 10m from Target with shield.	Replace LTD with CFD; continue test. Add T0 into calibration.	Place the MRPC 5m from Target with shield. Add scaler.	Test continue. Changed another HV.	Take out the shield and continue testing

- The MRPC material is activated, which increases dark current and noise signal, as the test goes.
- We got the time resolution of 75-80ps

2. Beam Test Setup: Preparation

MRPC

10% Freon
3% iso-butane
5% SF₆

6 ADC Channels
6 TDC Channels

Pre-Amp

Trigger

PMT0

PMT1

Gas Out

sis3320 Flash ADC

775 TDC

LTD

Stop

fadc_ch1:Iteration\$

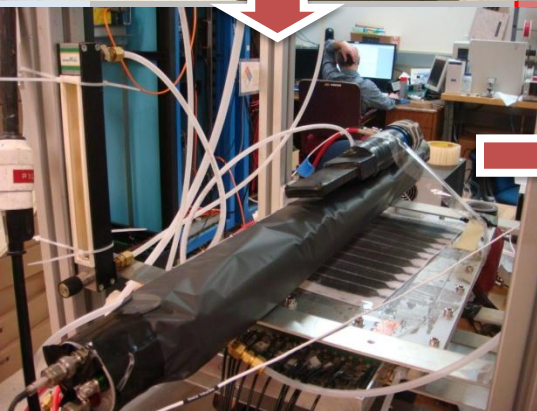
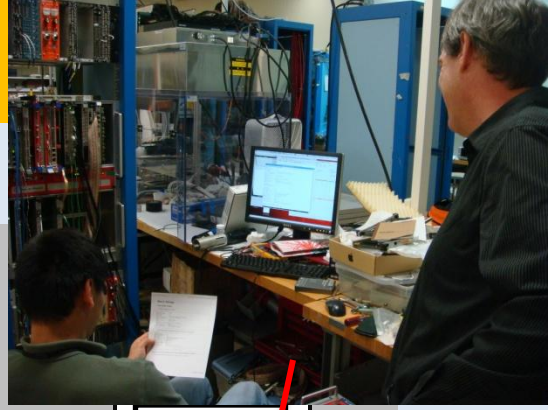
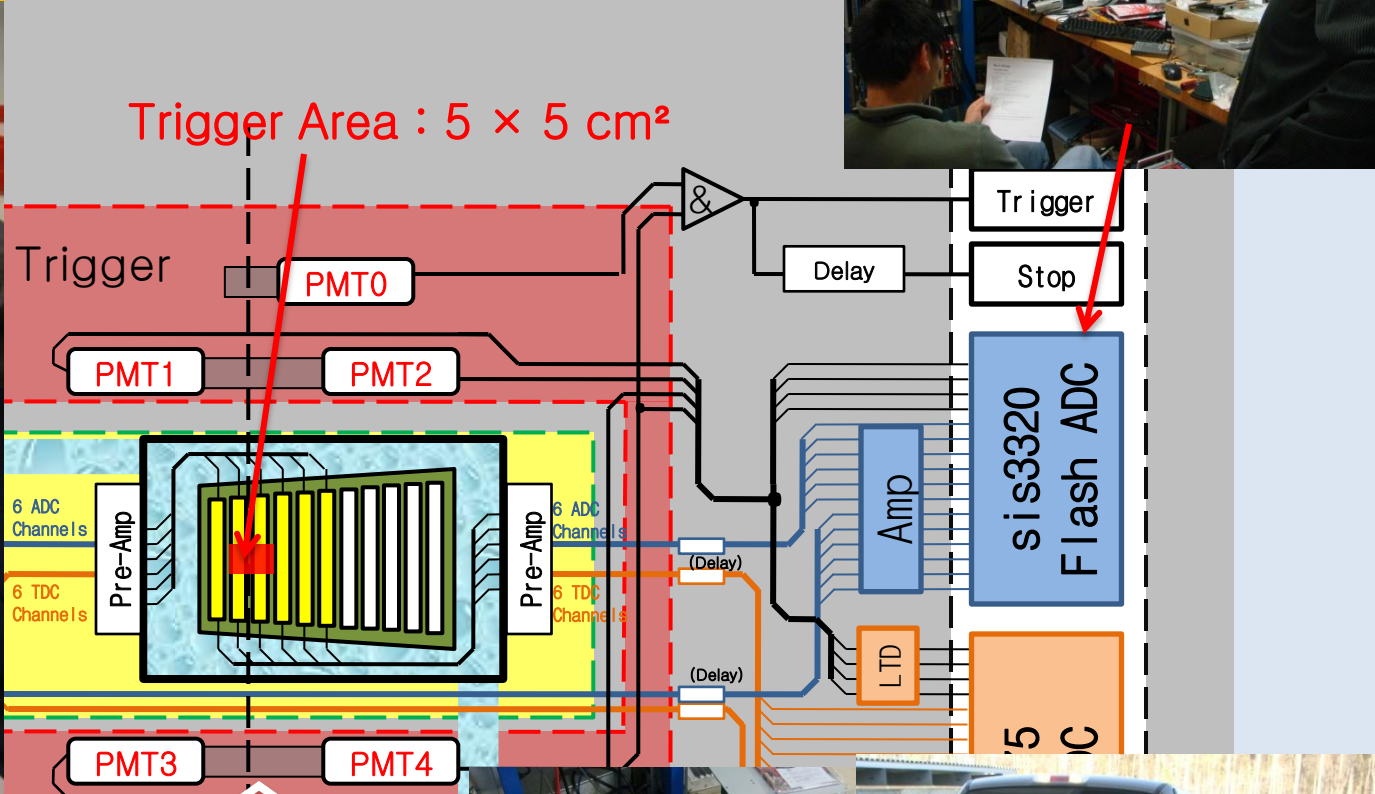
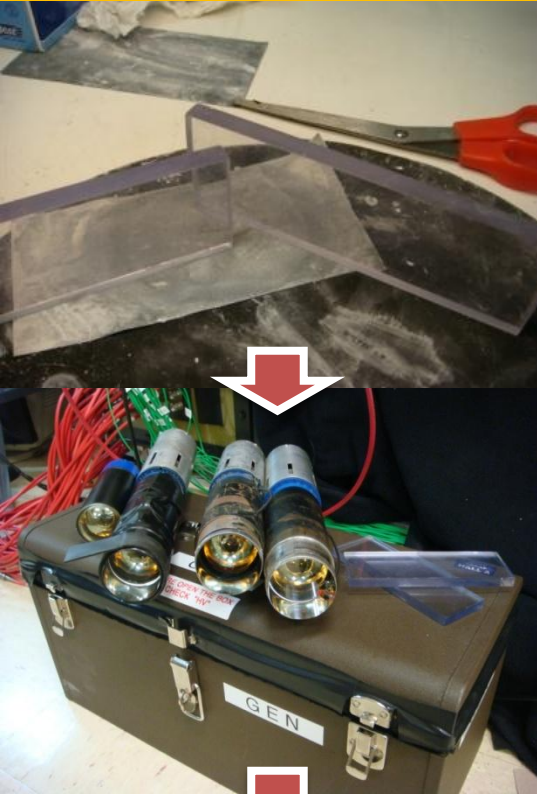
Signal

Iteration\$

MRPC TEST
Fragile equipment
Do not disturb
Contact :
Alexandre Camsonne
Cell 660 3342

2. Beam Test Setup: In Hall A

Fast Scintillator ($5 \times 15 \text{ cm}^2$)

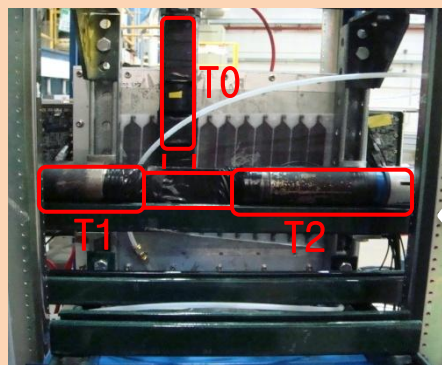


Taking all stuffs to Hall A

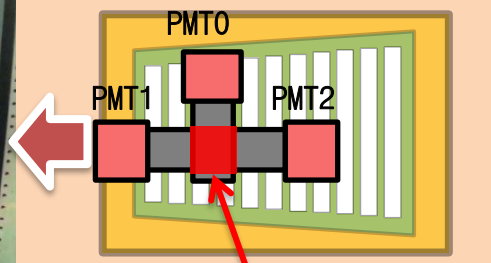
2.Beam Test Setup: In Hall A

- What is the beam like?
 - 3 GeV electrons hitting the target
 - **Uniformed** particle(electron) and photon irradiation
 - Large background and high flux

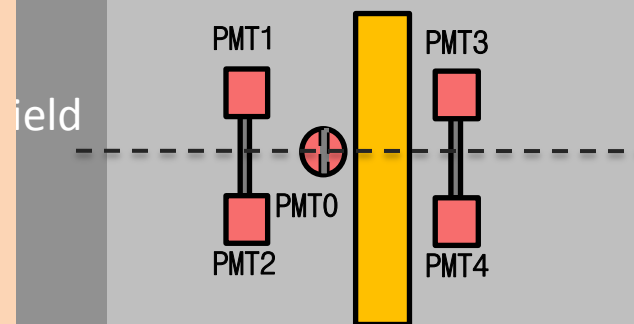
Schematic top view of the test setup



Front View



Trigger Area : $5 \times 5 \text{ cm}^2$



Top View

Time calibration of 4 PMTs: $\sim 300\text{ps}$

	Distance & Shielding	Current
Before May 13th	10m , shielded	$\sim 500\text{-}3500\text{nA}$
May 13th – 16th	5m, Shielded	$\sim 8\mu\text{A}$
After May 16th	5m, not shielded	$\sim 15\mu\text{A}$

2.Beam Test Setup: In Hall A

2012-08-14



Target

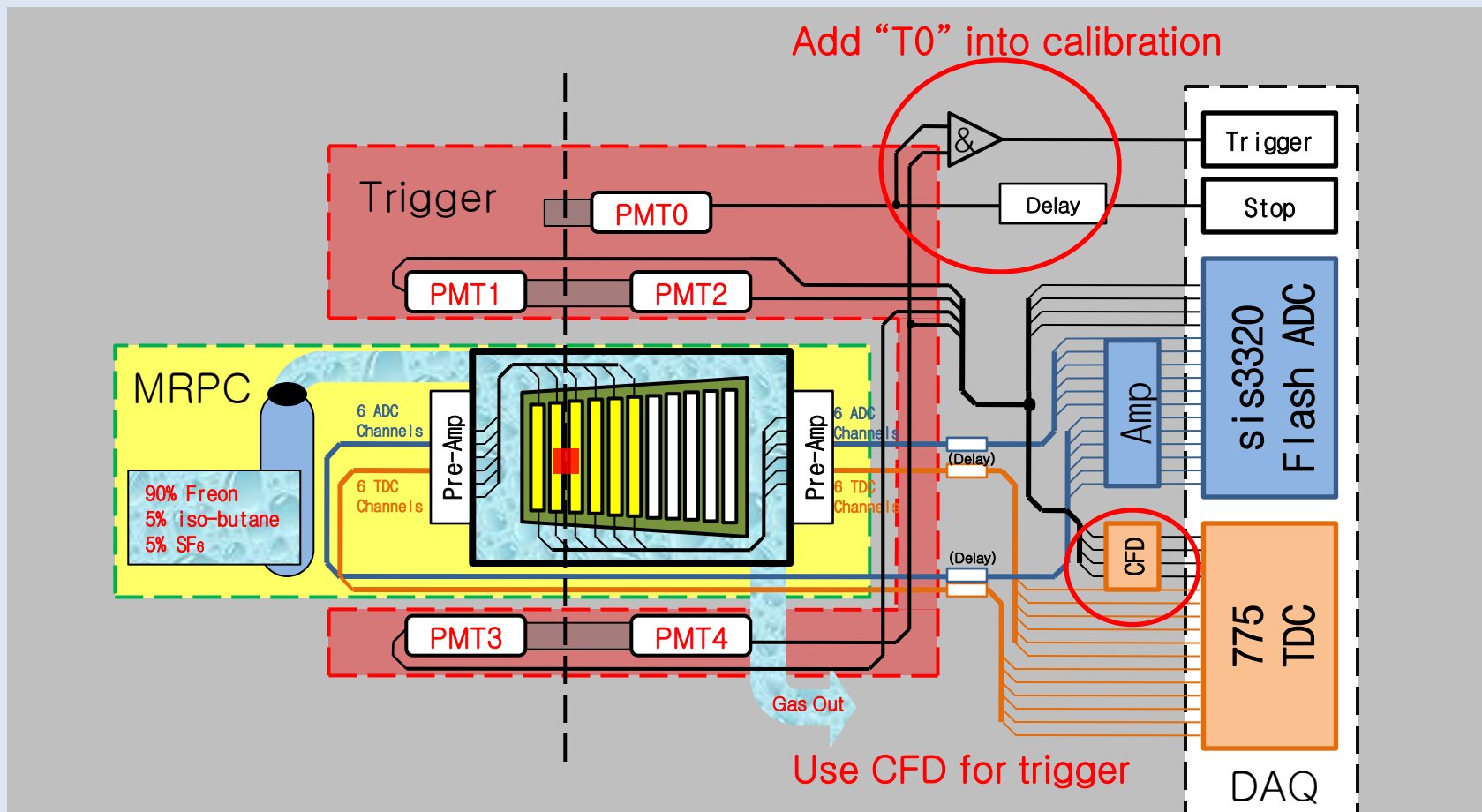
Shield

MRPC



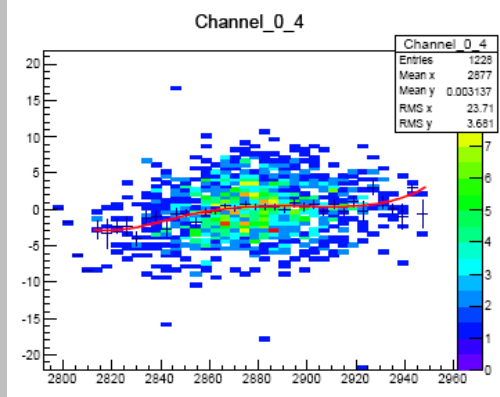
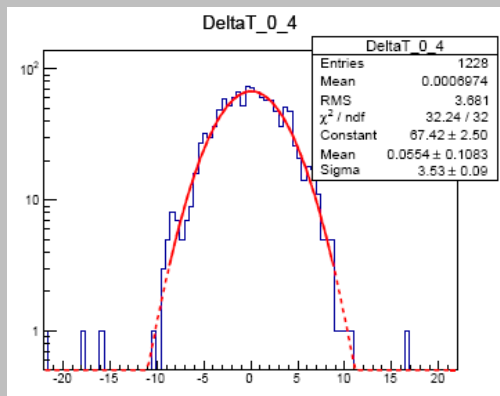
2.Beam Test Setup: Upgrade

- Improvements
 - The stop signal is changed into delayed T₀
 - LTD is changed into **CFD**

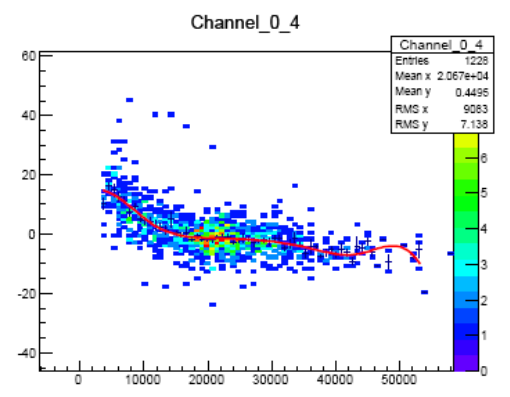
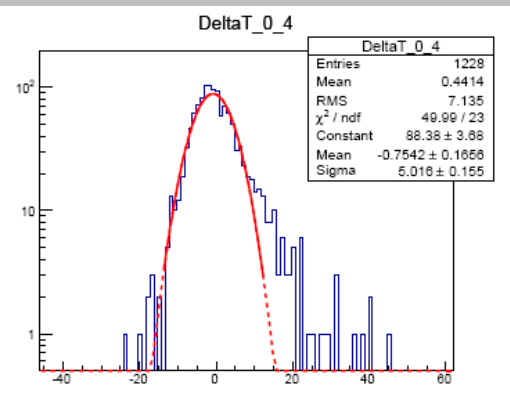


3.Results & Comparison: Calibration

Example: r175
 Operated on May 13th
 High Voltage: $\pm 6800V$
 Condition: 10m from target, shielded

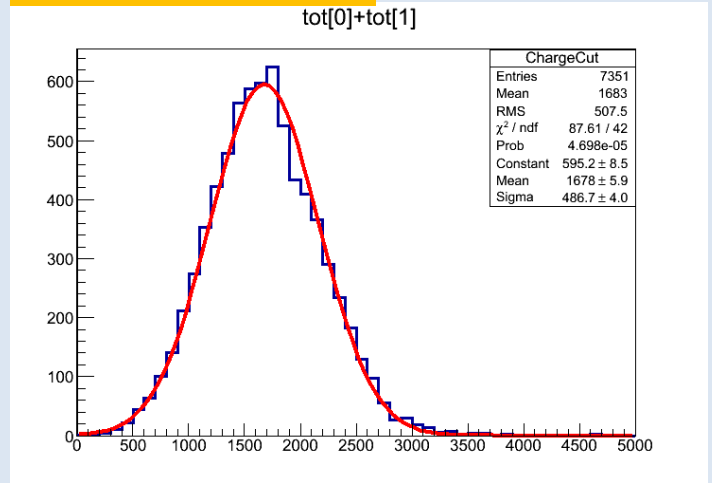


PMT before calibration

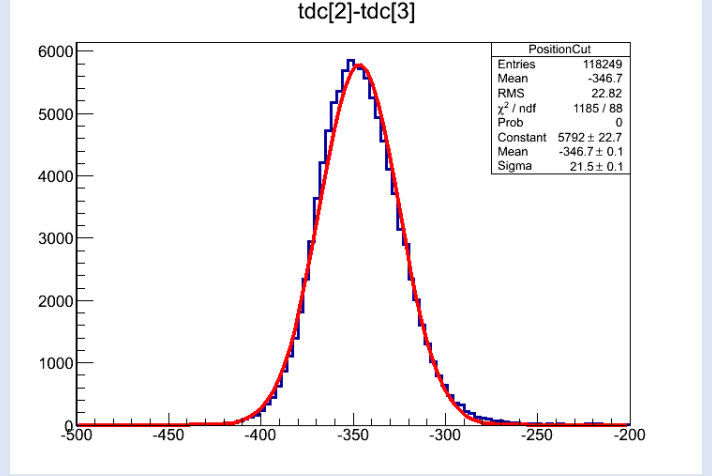


MRPC before calibration

Charge Cut: 2σ



Position Cut: 2σ



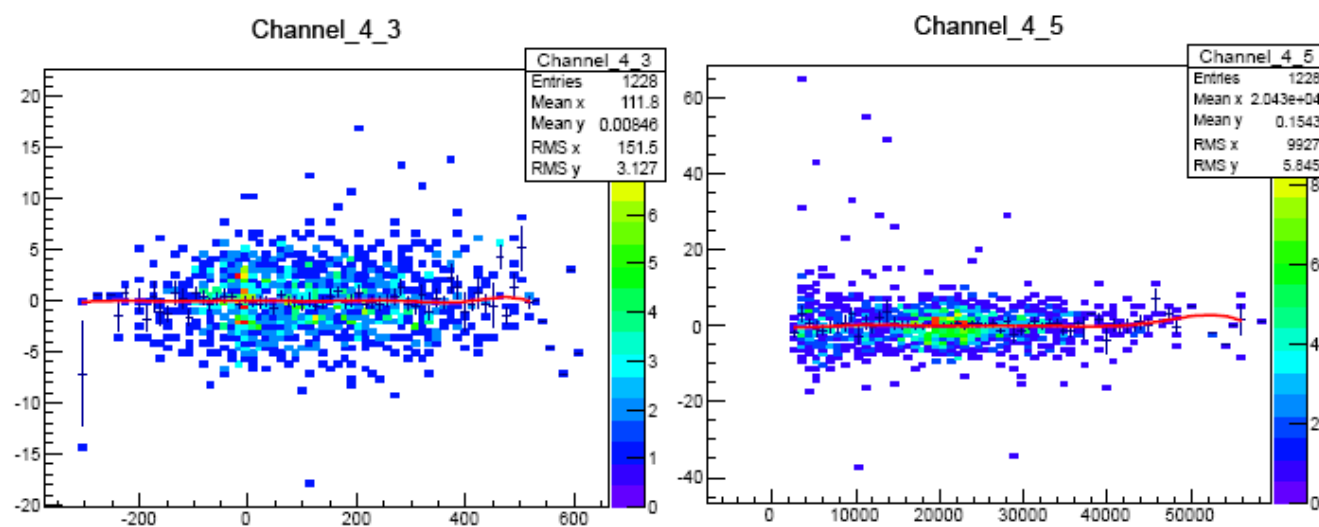
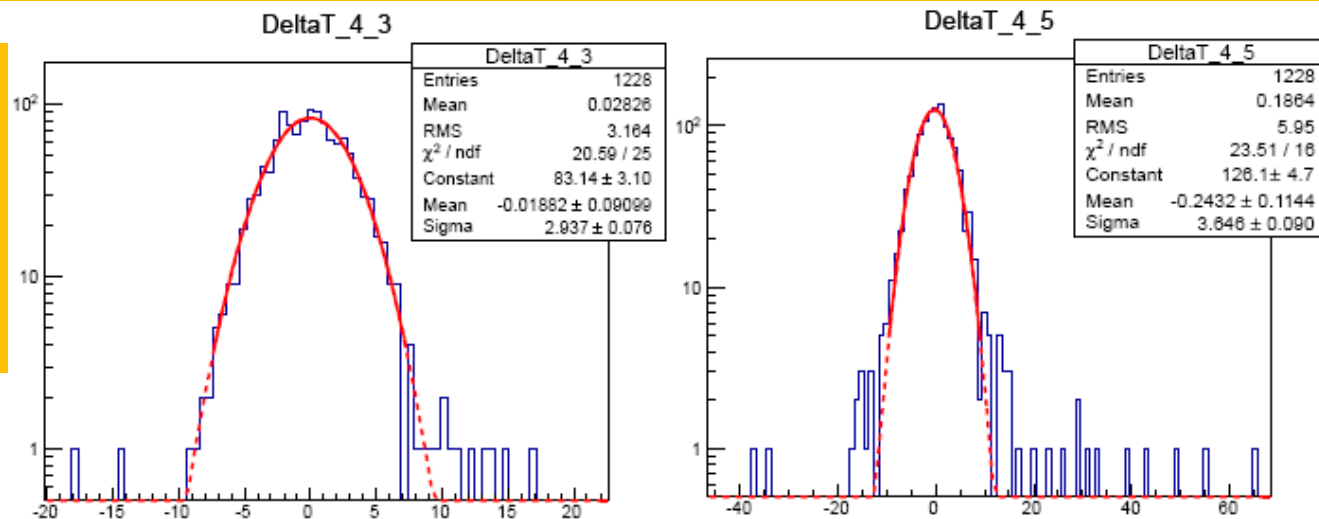
4 calibrations

3.Results & Comparison: Calibration

Example: r175
Operated on May 13th

High Voltage: $\pm 6800V$
Condition: 10m from
target, shielded

Time resolution: 76ps



Calibration of PMT

Calibration of MRPC

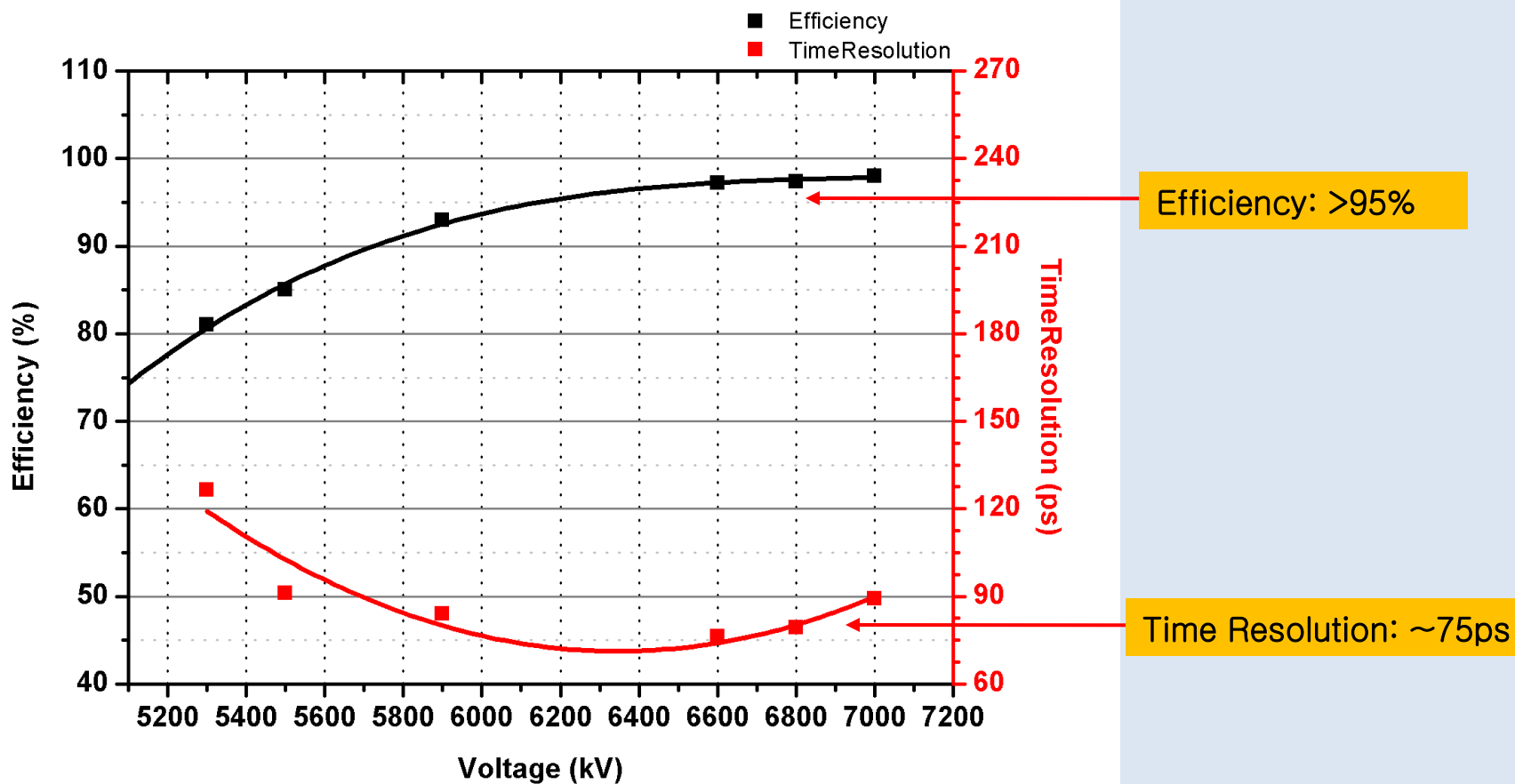
$$\sigma_{\text{PMT}} = 2.937(102.8\text{ps})$$

$$\sigma_{\text{MRPC}} = 3.646(127.6\text{ps})$$

$$\sigma_{\text{MRPC}} = 2.16(75.6\text{ps})$$

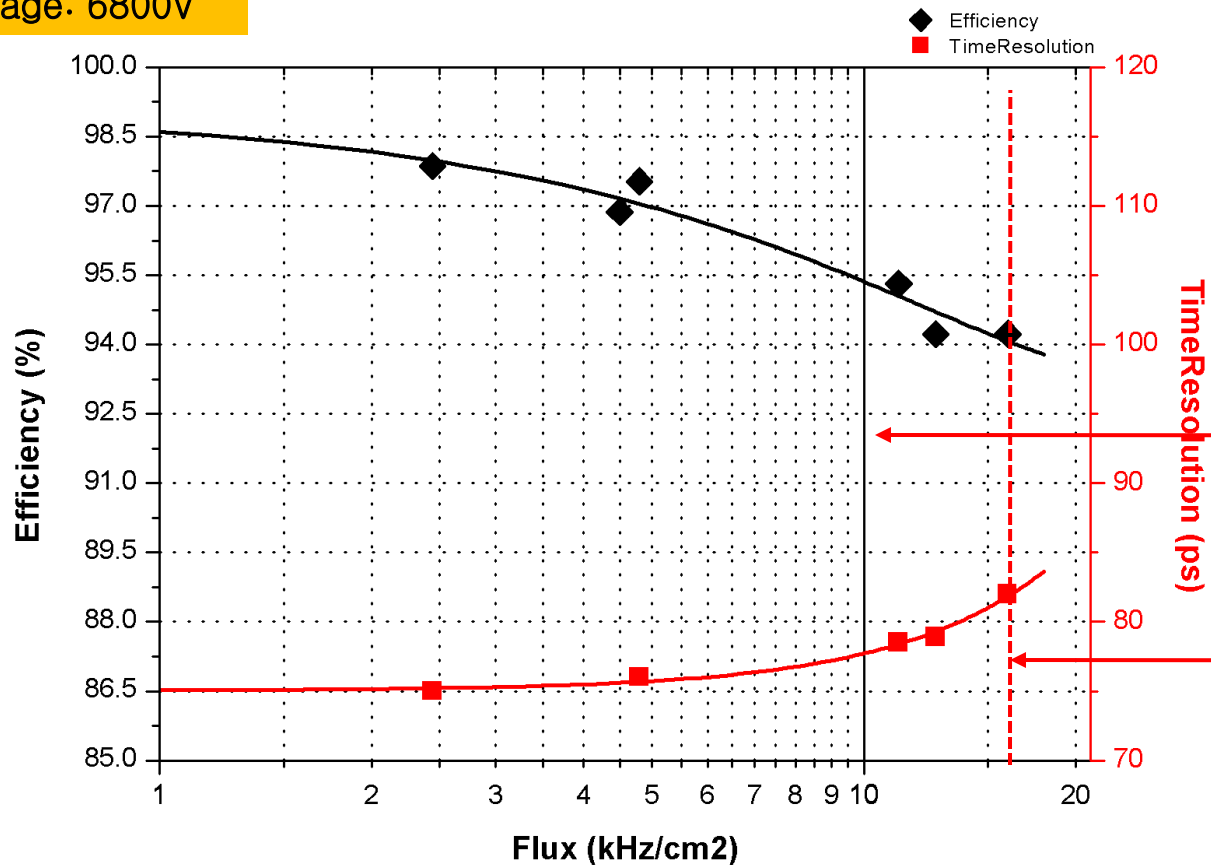
In this test, T_0 is about 100ps, the time resolution is deteriorated.

3.Results & Comparison: HV Scan



3.Results & Comparison: Rate Scan

Voltage: 6800V

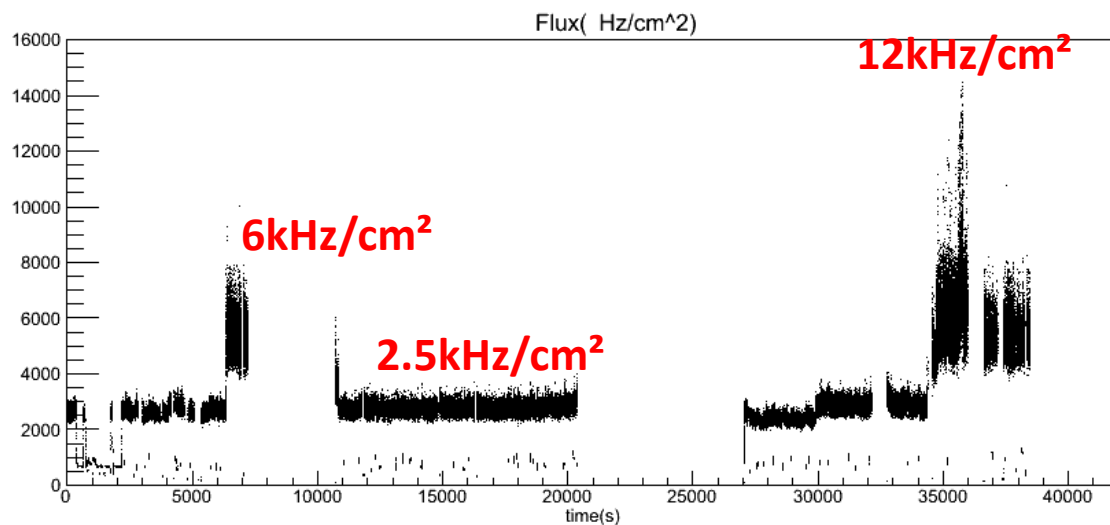


Flux: 11kHz/cm²
 Efficiency: ~95%
 Time Resolution: 78ps

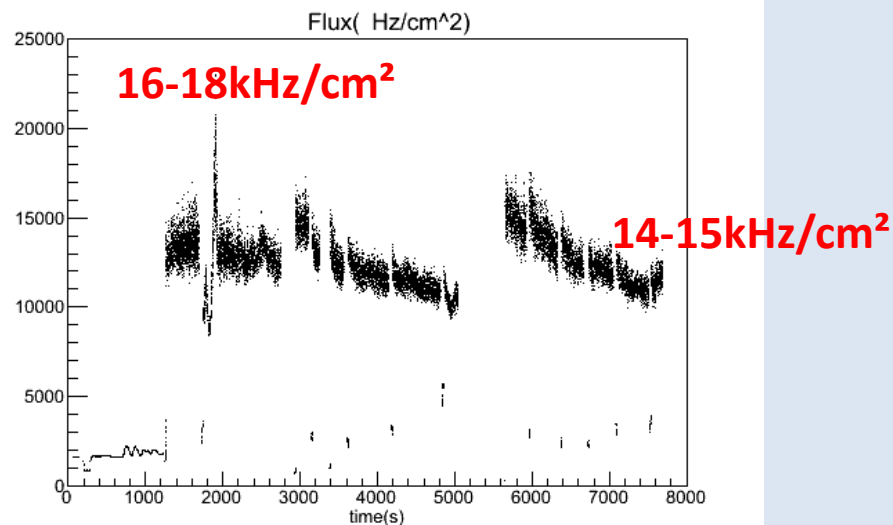
Flux: 16kHz/cm²
 Efficiency: ~95%
 Time Resolution: 82ps

3.Results & Comparison: Flux vs. Time

Run188, 6800V (5m to target, shielded)

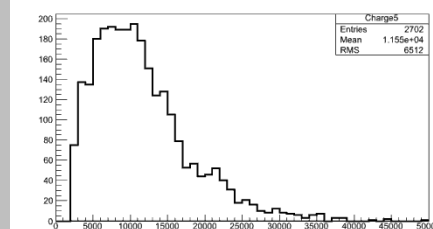
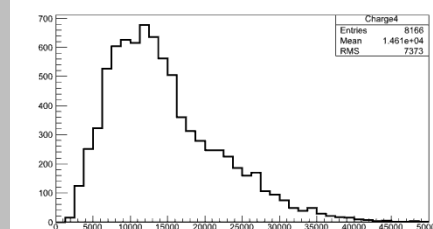
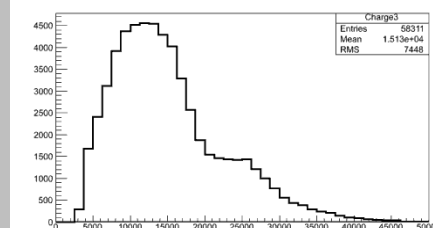
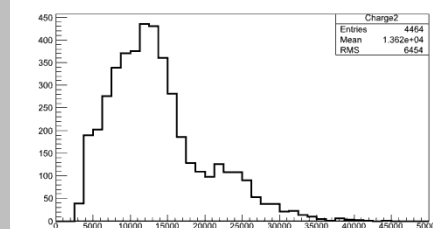
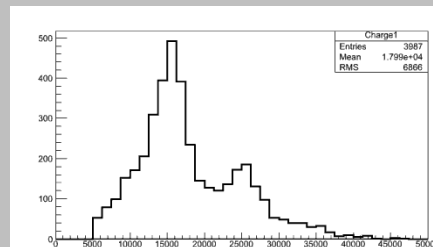
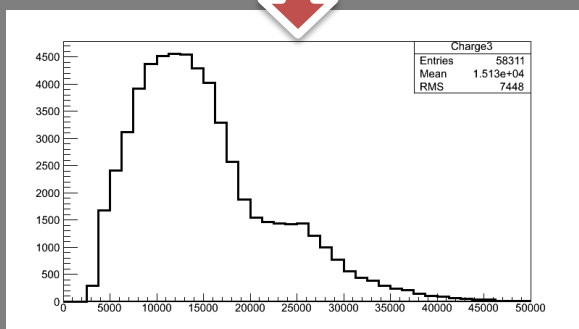
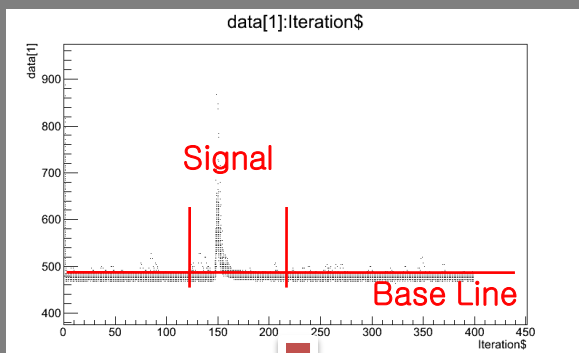


Run193, 6800V (5m to target, not shielded)



- During a run, flux is not on a stable level, which from less than 3kHz/cm² to 16kHz/cm².
- We can observe the performance by selecting data from different flux.

3.Results & Comparison : Charge Distribution



Flux is small
10m, shielded

Flux~2.5kHz/cm²
5m, shielded

Flux~6–10kHz/cm²
5m, shielded

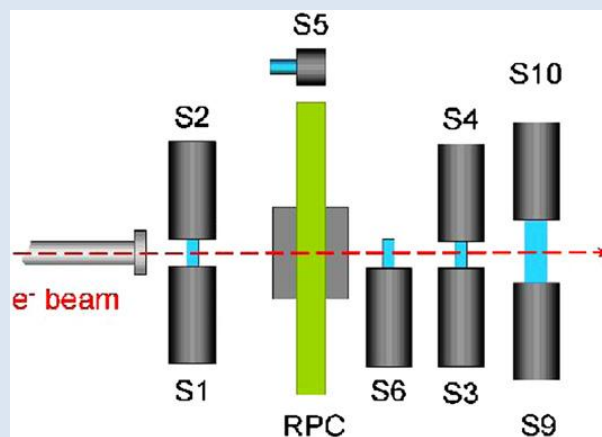
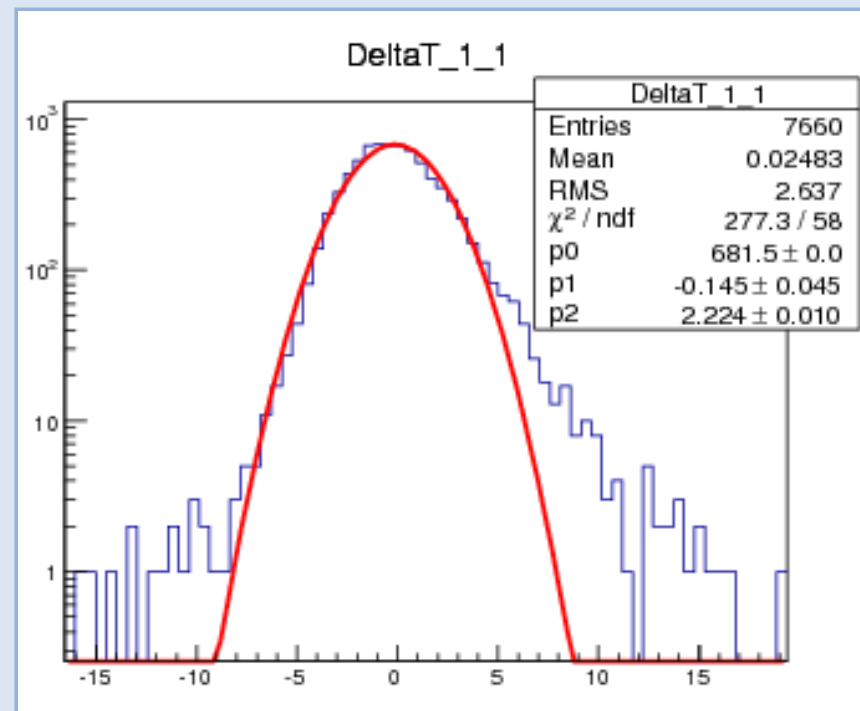
Flux~4kHz/cm²
5m, not shielded

Flux~15kHz/cm²
5m, not shielded

- Significant reduction of charge distribution can be seen as the background rate increases.
- The reduction of electrical field is caused mainly by both background irradiation and electron beams.
- Rate capacity is higher than 15kHz/cm².

3.Results & Comparison : Beam Test@HZDR

Beam Test@HZDR June, 2012



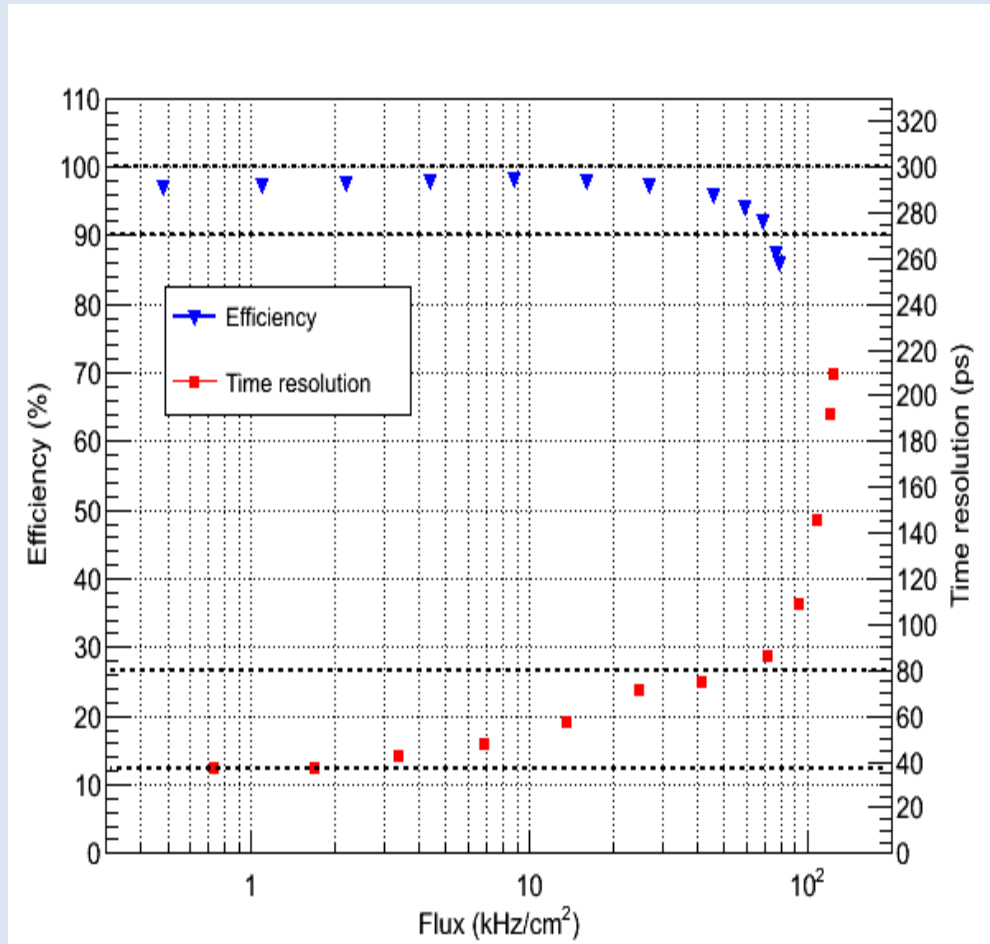
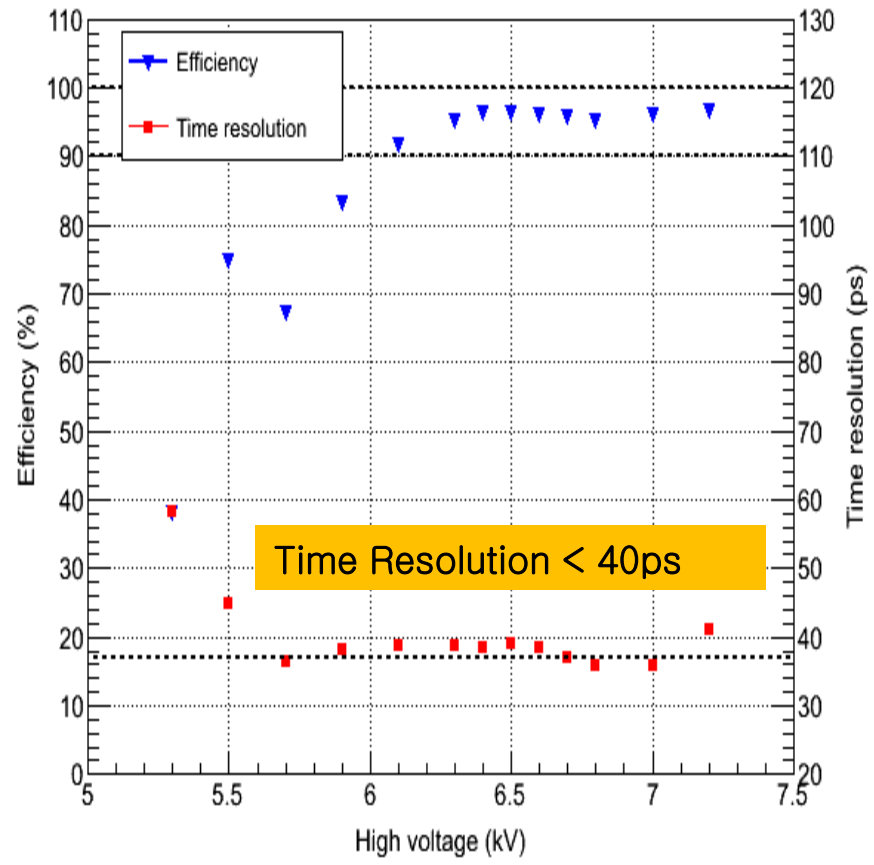
$$\sigma_{RF} = 39.2 \text{ ps}$$

$$\sigma_{RPC} = 54.4 \text{ ps}$$

$$\sigma_{RPC} = \sqrt{\sigma_{TOF}^2 - \sigma_{RF}^2} = 37.8 \text{ ps}$$

3.Results & Comparison : Beam Test@HZDR

Beam Test@HZDR June, 2012



4. Conclusion

- Performance of MRPC is measured. The time resolution can reach 70-80ps and the efficiency is higher than 95%. The flux is up to 16kHz/cm².
- The MRPC module is placed within 10m to the Target for 2 months, without significant performance reduced, representing a high capability to irradiation.
- The Irradiation is uniformed. During Test, the current is large even when the rate is not very high, which means the photon background(photon) irradiation is very strong.

Thank you!

Xingming Fan
Department of Engineering Physics
Tsinghua University, Beijing, China