Development of large area spatial resolution MRPC for muon tomography

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XIII WORKSHOP ONRESISTIVE PLATE CHAMBERS AND RELATED DETECTORS Belgium

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Outline

- **Introduction**
- **MRPC module and experimental setup**
- **MRPC working in standard gas and pure R-1314a**
- **Conclusions**

Introduction

Cosmic ray muon tomography is a newly developed method based on scattering theory which can be applied in nuclear material discrimination because of its sensitivity to high Z material.
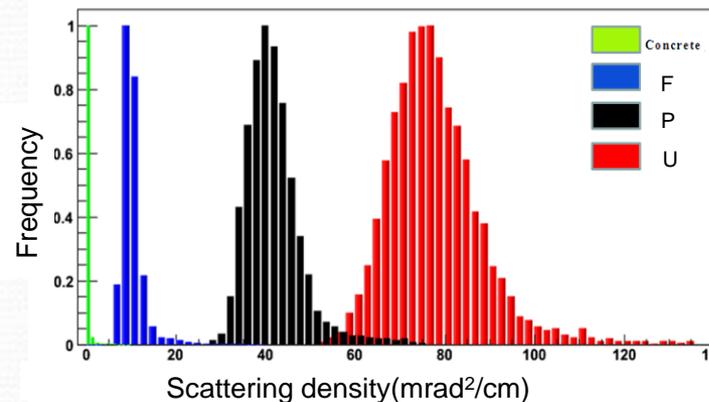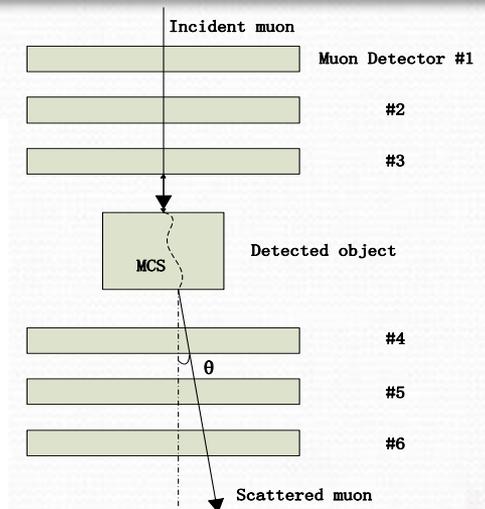
Muon

Mass: $105.7 MeV/e^2$

Electric charge: $-e$

Rate: $\approx 1/cm^2*min$

Advantages used for imaging:

1、 Natural

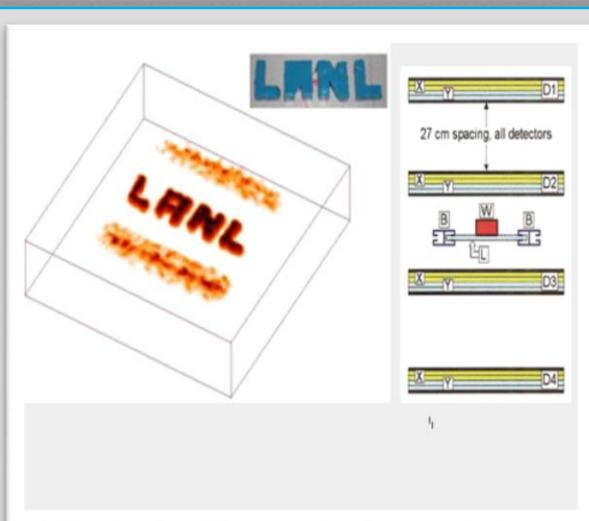2、 Stable

3、 High energy

4、 Continuously bombard the Earth

The scattering densities of different materials

Layout of muon tomography system

Tomography facility

Lab: LANL
Detector: drift tube
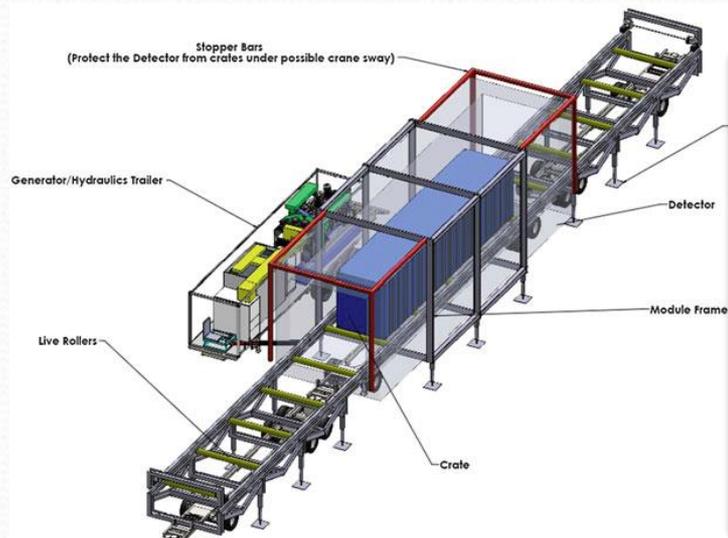Pitch:400μm
Spatial resolution:200μm

Company : Atomic Energy of Canada Limited
Detector: Sliver scintillator
Area : 4m^2

Institute**:** Florida Institute of Technology
Detector: GEM
Area : 30cm$\times$30cm
Spatial resolution:130μm

Cosmic Ray Generated Charged Particles for Cargo Inspection

Times to clear most non-threat cargo range from 30s to 60s, with suspicious scenes (for instance heavy shielding, gamma emitting materials) being held longer to confirm the presence of and identify the material. Extended scanning of suspicious scenes typically takes 2–10 min.
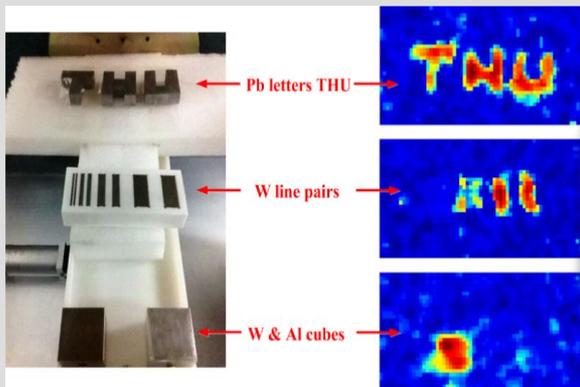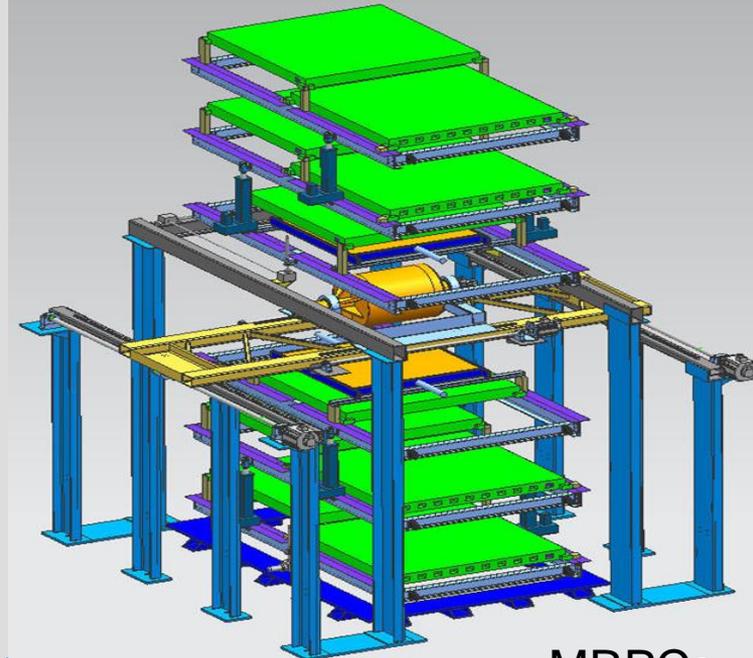
TUMUTY and the future

Lab: Tsinghua
Detector: MRPC
Sensitive area:
720mm×720mm

TUMYTY system

Pb letters THU
W line pairs
W & Al cubes

Test kits and MAP Reconstruction

MRPCs

Container inspection system

Why choose MRPC

➢ The key technique to achieve this application is to develop detectors with sub-millimetre position resolution to achieve an angular resolution in the order of micro-rad .

➢ Compared with other detectors, MRPC can not only give the track but also the ToF between two detectors which can estimate the energy of particles.

➢ Low cost and easy to produce large detector

➢ Very stable, fit industrial application

Structure of MRPC
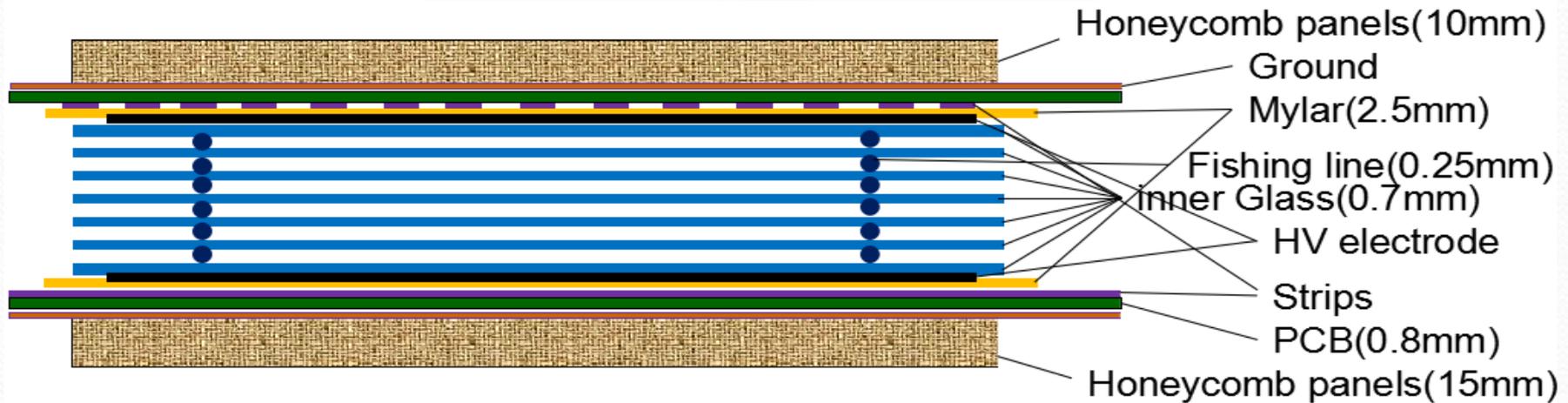
| Pats of MRPC	Size（mm）
PCB	1160*1160
Sensitive area	1072*1072
Mylar	1110*1110
Honeycomb panels	1100*1100
Inner glass	1100*1100
Outer glass	1100*1100
Carbon film	1092*1092
Read out strip	1.44
Gap	1.1
Gas gap	0.25

Setup of experiment

MRPC need 432 electronics one dimensional, in order to reduce the number of the electronics, the multiplexer board was connect to the MRPC detector via the samtec connector, after multiplexer, the number of the electronics reduced to 64 for one dimensional.
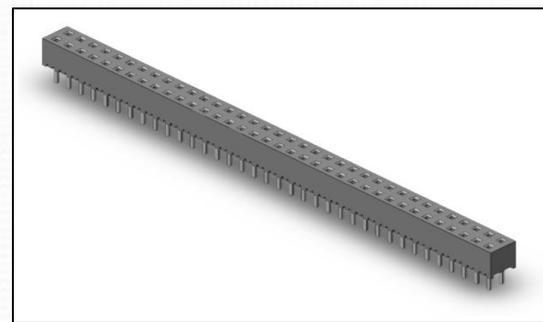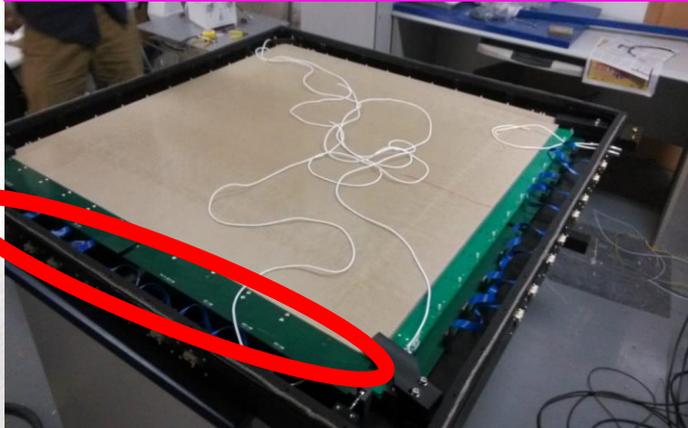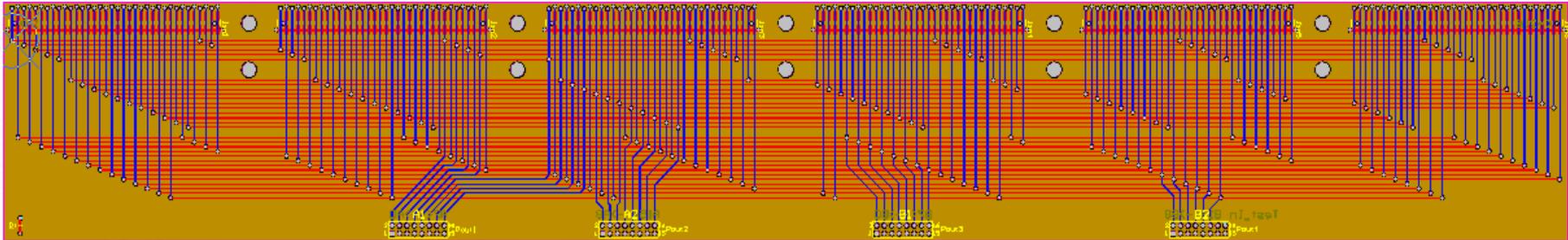

MMS-136-01-L-DV
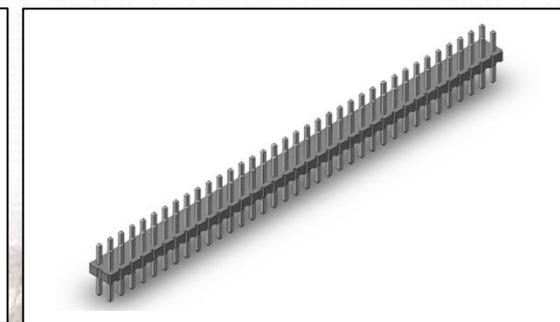
TMM-136-01-L-D

Setup of cosmic ray test

Desktop module housing 16 Channels. Default sampling frequency is 5GS/s. As a trigger signal arrives, all analog memory buffers are frozen and subsequently digitized with a 12bit resolution into a digital memory buffer. The available digital memory versions are 1024 events per channel allowing to store subsequent events.
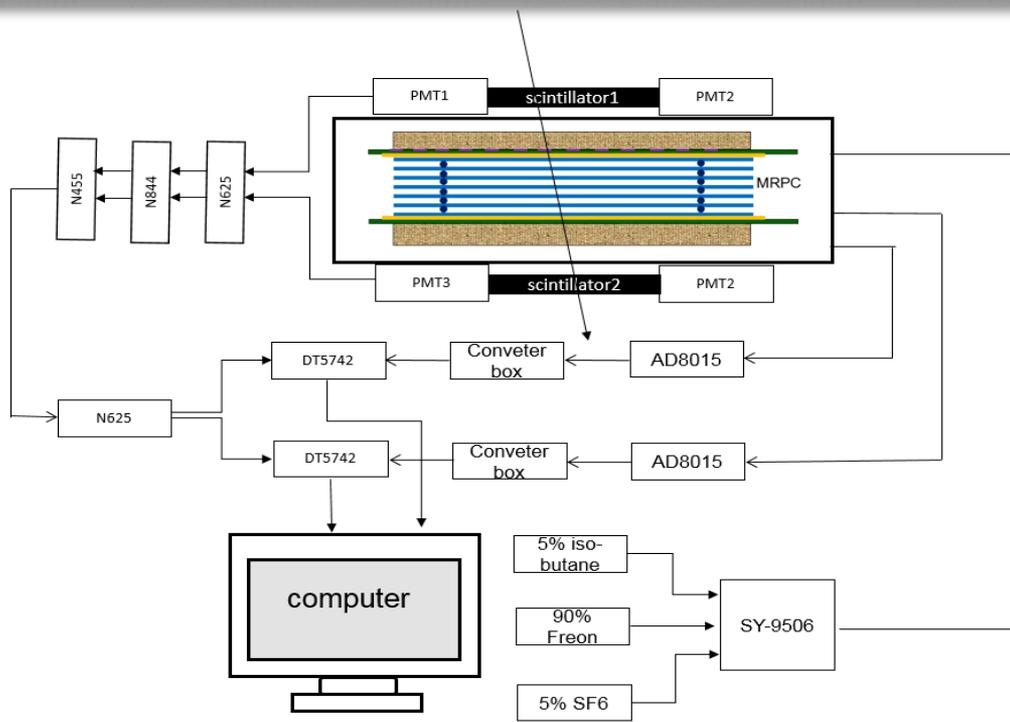
AD8015

DAQ: DT5742
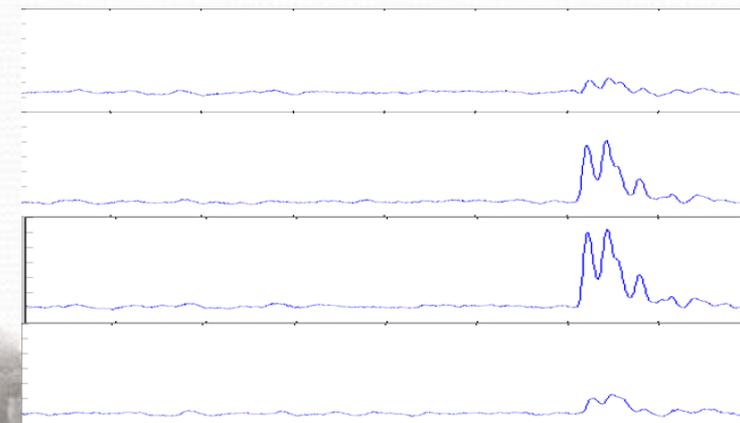
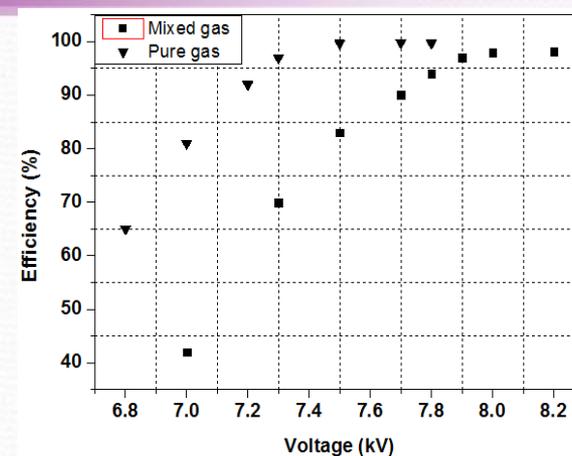# Setup of the X ray experiment

Slotted tungsten plate
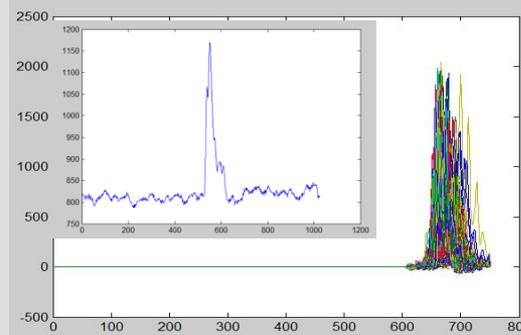
X ray generator:
HV: 60kV
Current:0.8mA

Some results
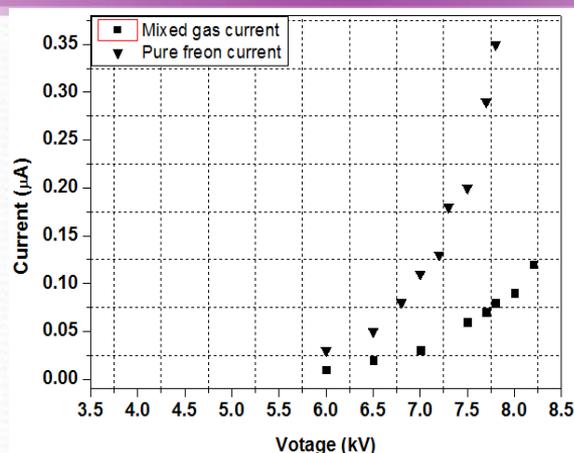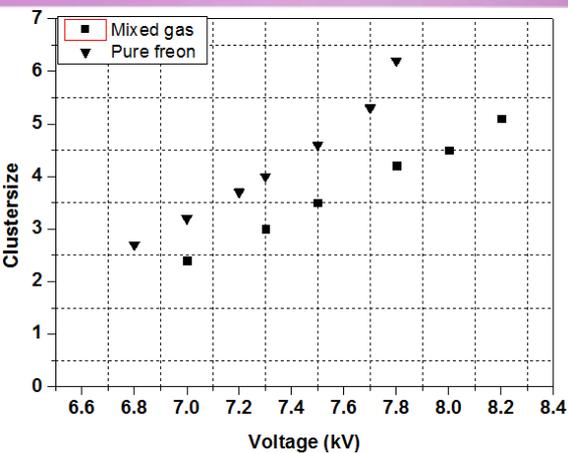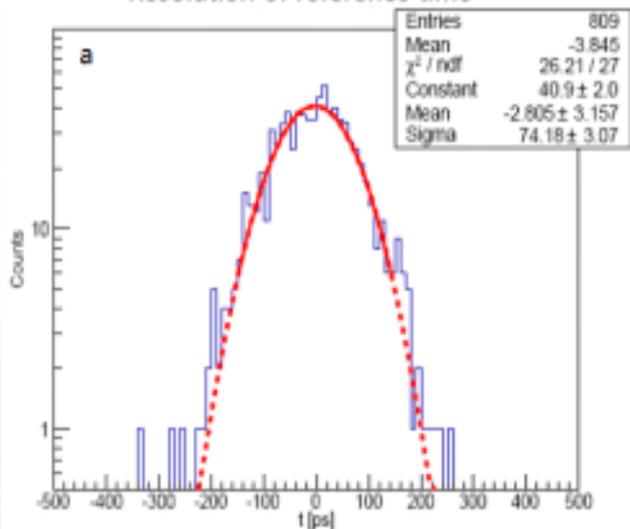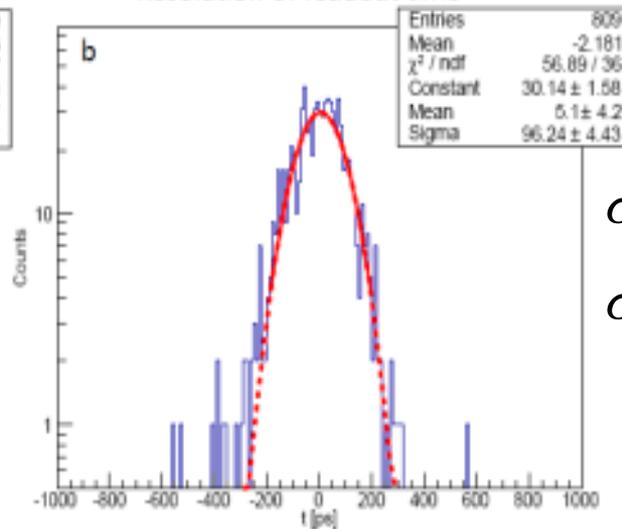
$$\sigma_{MRPC} = \sqrt{\sigma_{t-MRPC}^2 - \sigma_{t-ref}^2}$$

$$\sigma_{MRPC} = 65ps$$

The reconstructed position distribution
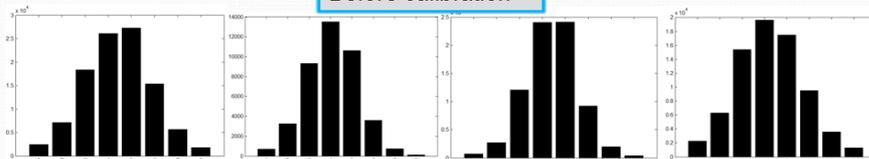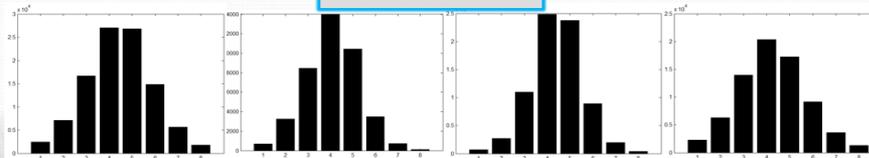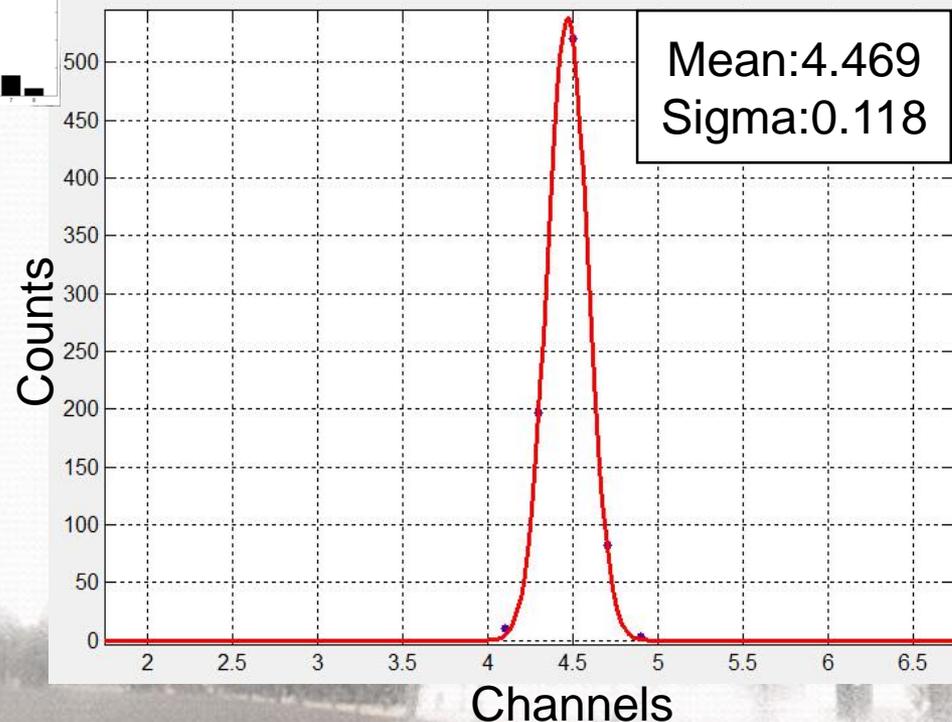

Before calibration

After calibration

Via the charge calibration eliminate the difference of the each electronics.

Mean:4.469
Sigma:0.118

$$\sigma_{MRPC} = \sqrt{\sigma_{all}^2 - \sigma_{slit}^2}$$

Before calibration:

$$\sqrt{(0.13 \times 2.54)^2 - 0.126^2} = 0.278$$

After calibration:

$$\sqrt{(0.118 \times 2.54)^2 - 0.126^2} = 0.272$$

Amplitude and position resolution

Voltage	Average amplitude(standard)	Average amplitude(pure)
±7000V	80	113
±7500V	125	178
±7800V	138	316

Table1. Amplitude in standard gas and pure R-1314a in different voltage

	Voltage	Efficiency	Spatial resolution
Standard gas	±8000V	98.8%	272μm
Pure R1314-a	±7000V	81%	246μm
	±7200V	92%	215μm
	±7500V	97%	210μm

Table2. Spatial resolution in different gas

Conclusions

➢ 1072mm×1072mm two dimension MRPC is developed for muon tomography system.

➢ The results show that the efficiency is higher than 98% and the spatial resolution can reach 272μm. When the detector work in the pure Freon, the efficiency and the spatial resolution seems better than work in the standard gas.

➢ Next to study the MRPC performance in sealed gas (flush gas intermittently) . So the MRPC muon tomography system will fit industrial application greatly.

Thanks for your attention!