3rd International Conference on Micro Pattern Gaseous Detectors

Development of Au-coated THGEM for Single Photon, Charged Particle, and Neutron Detection

Yuguang Xie[a]*, Junguang Lv[a], Aiwu Zhang[a], Boxiang Yu[a], Tao Hu[a], Li Zhou[a], Xiao Cai[a], Jian Fang[a], Zhigang Wang[a], Xilei Sun[a]

a) State Key Laboratory of Particle Detection and Electronics (Institute of High Energy Physics, CAS and University of Science and Technology of China), Beijing 100049, China

*e-mail: ygxie@ihep.ac.cn

Introduction

The THGEM has been studied and promoted continually since it was reported for the first time[1]. The study of THGEMs in China has been active in recent years[2,3]. We report the development of Au-coated THGEMs produced totally from homemade industrial PCB technology in China. This development aims at producing THGEMs with high performance for a wide range of structure parameters, and feasibility of mass production with a high rate of finished products. More than 100 THGEM samples have been produced and tested. The test results using X-rays,VUV&UV lights, cosmic ray muons, and alpha particles are presented and verify that these kinds of THGEM can be used for single photon, charged particle and neutron detection.

THGEM Production [4]

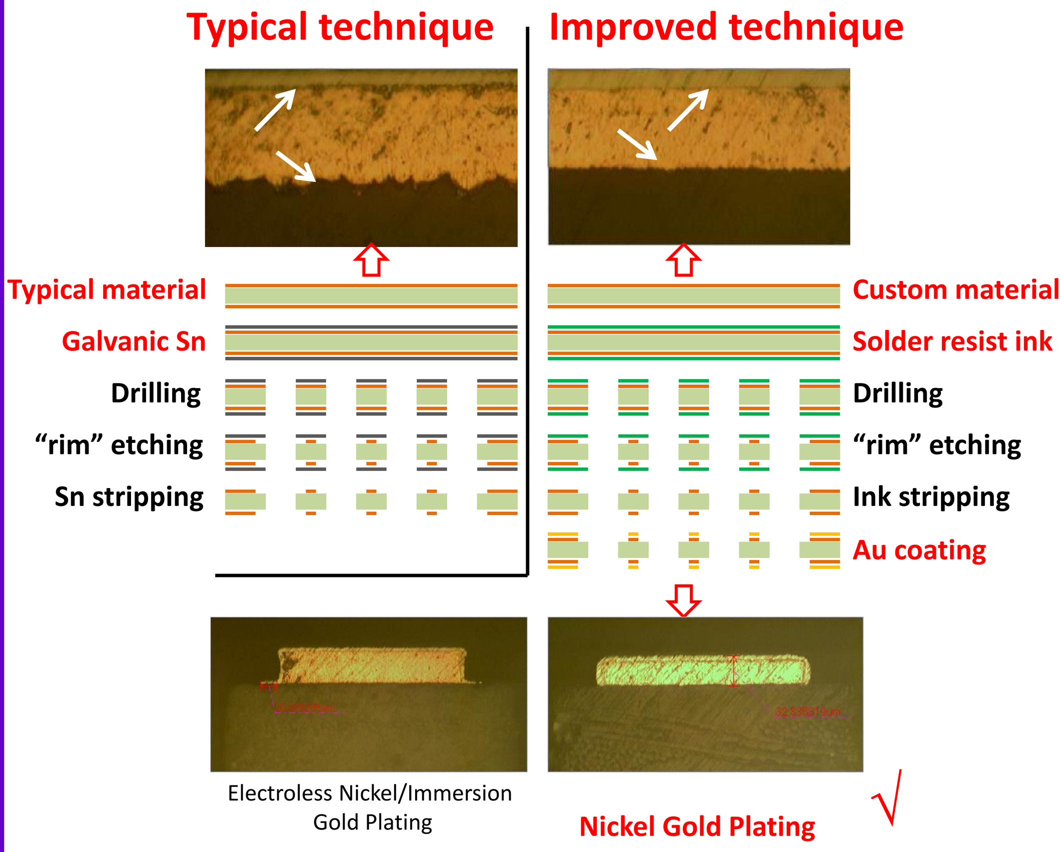


Fig. 1 THGEM production procedures.

Characteristics

- Totally based on homemade industrial PCB technology in China, all in factory.
- Sensitive area: ≤ 500 × 1000 mm²
- Minimum total thickness: 150 µm
- Minimum hole diameter: 200 µm
- Rim size: 20 – 120 µm
- Substrates: FR-4, Ceramic, PTFE, Kapton
- Cost: ≤ 40% of that by CERN
- Feasibility of mass production
- High rate of finished products: >70%

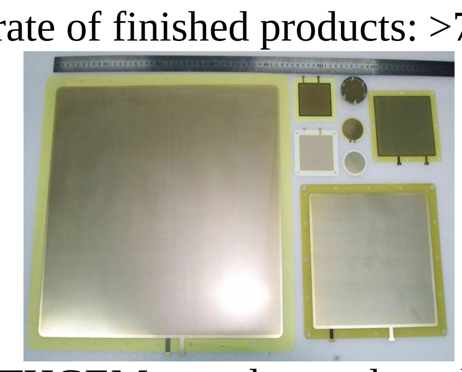
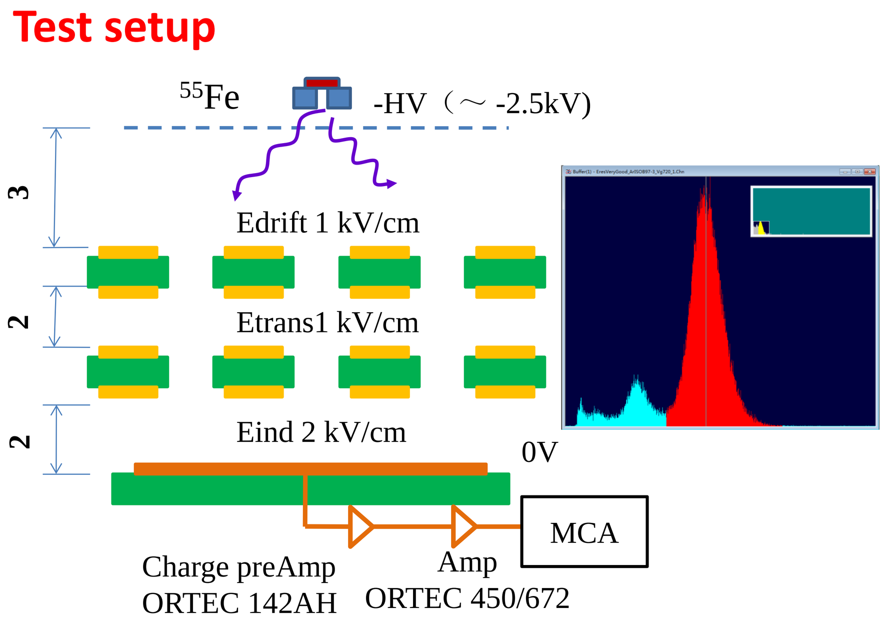


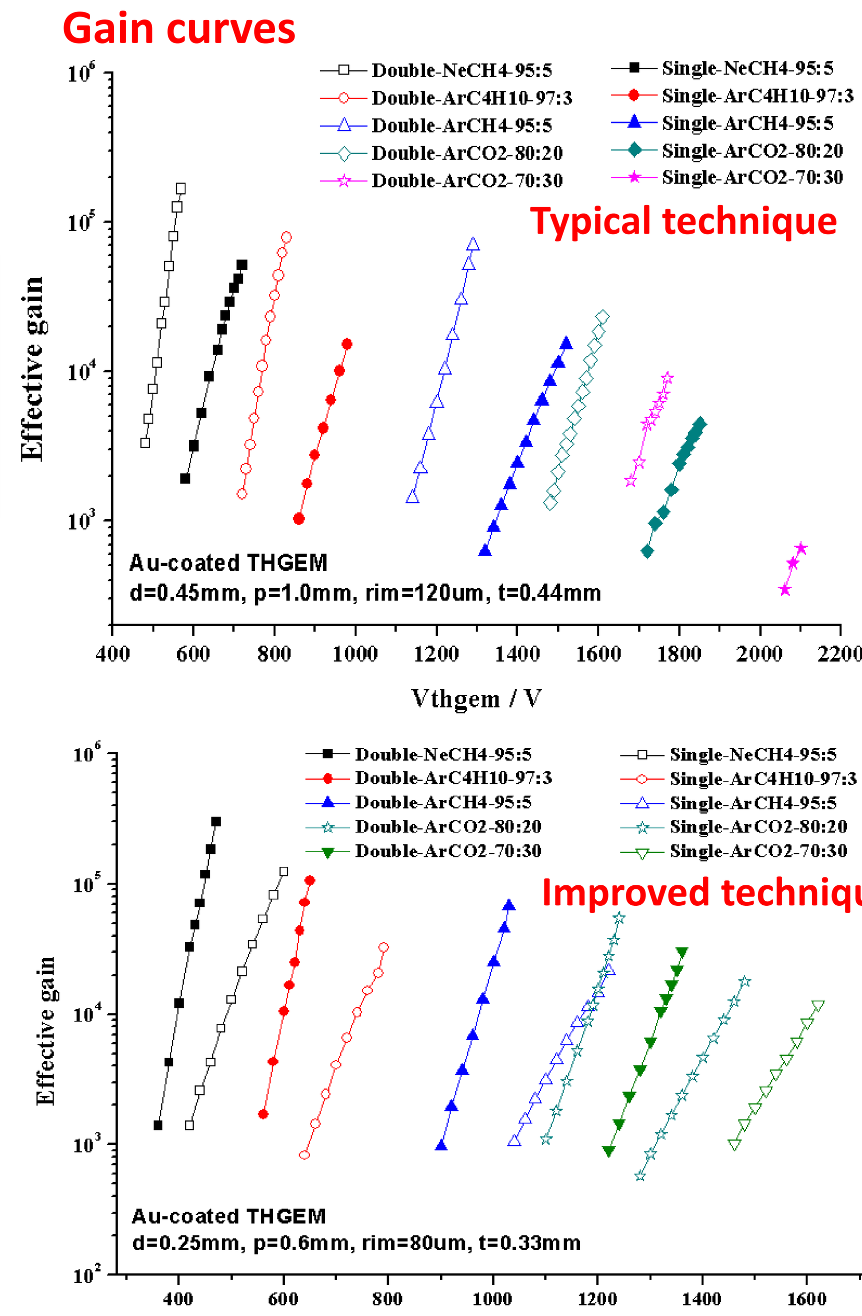
Fig. 2 THGEM samples made and tested.

THGEM Performance

Test setup



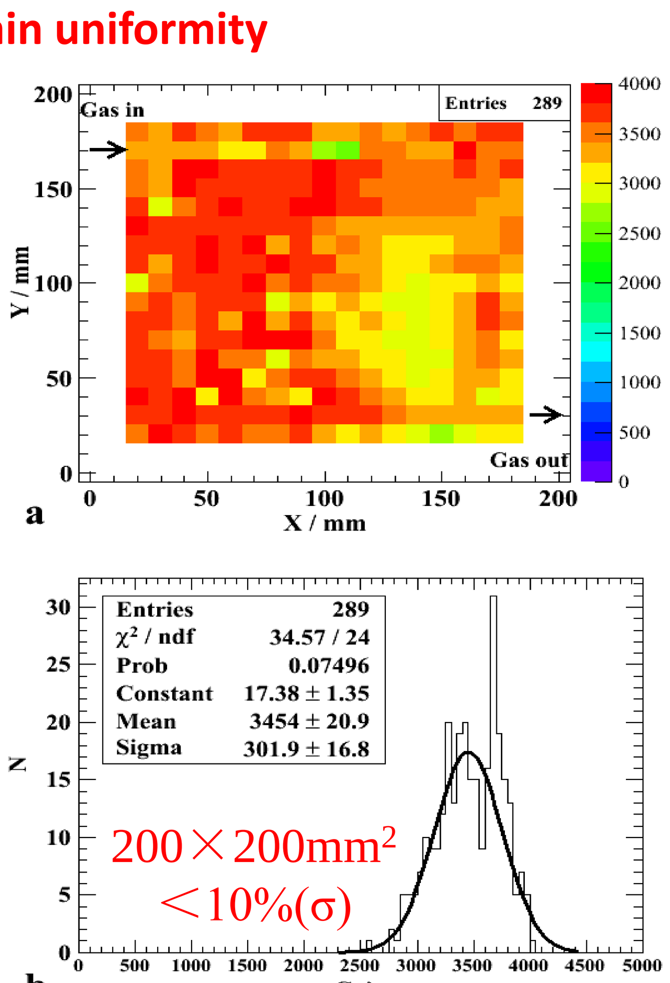
Gain curves



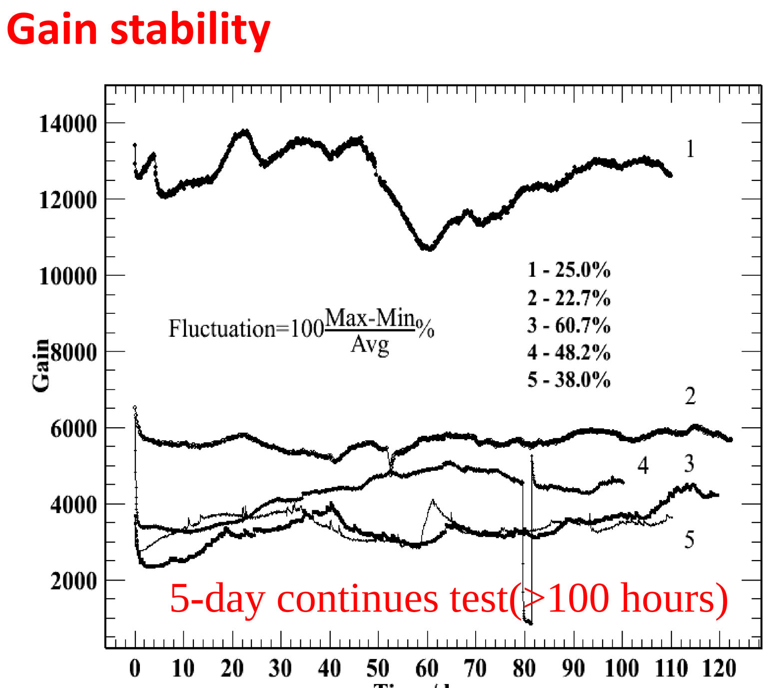
Gas	Vthgem range / V		Maximum gain			
	Single layer		Single layer		Double layer	
	General	Improved	General	Improved	General	Improved
Ne+CH4=95:5	～100	>150	5×10⁴	1×10⁵	2×10⁵	3×10⁵
Ar+ISO=97:3	～100	>150	2×10⁴	3×10⁴	7×10⁴	1×10⁵
Ar+CH4=95:5	～150	～200	2×10⁴	3×10⁴	5×10⁴	8×10⁴
Ar+CO2=80:20	～120	～200	5×10³	2×10⁴	2×10⁴	5×10⁴
Ar+CO2=70:30	～60	～200	1×10³	1×10⁴	1×10⁴	3×10⁴

↑50～100V ↑2～10 times

Gain uniformity

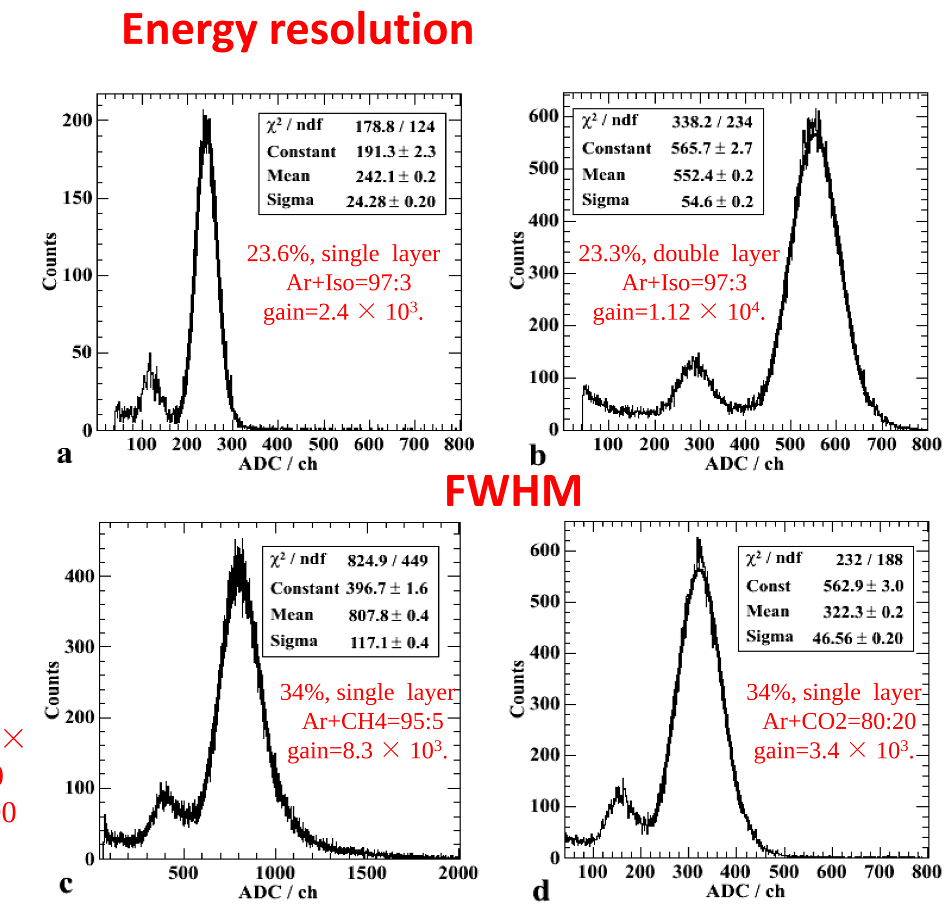


Gain stability



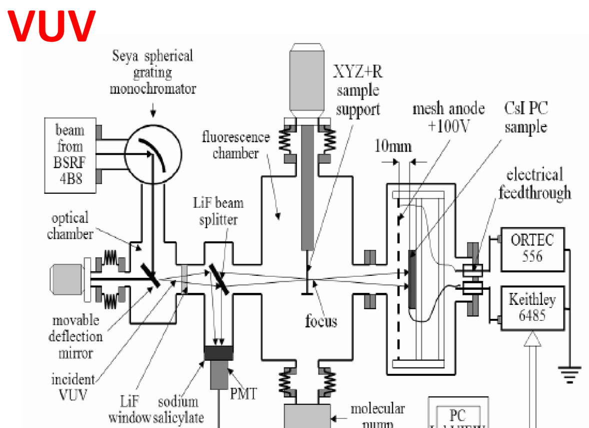
1) φ38 mm, double layer, Ne+CH4 = 95:5 @ 1.25 × 10⁴. 2) 50 × 50 mm², single layer, Ar+CH4 = 95:5 @ 5.66 × 10³. 3) 50 × 50 mm2, single layer, Ar+CO2 = 70:30 @ 3.34 × 10³. 4) 100 × 100 mm2, double layer, Ar+IsoB = 97:3 @4.2 × 10³. 5) 200 × 200 mm2, single layer, Ar+ISO = 97:3 @ 3.39 × 10³.

Energy resolution

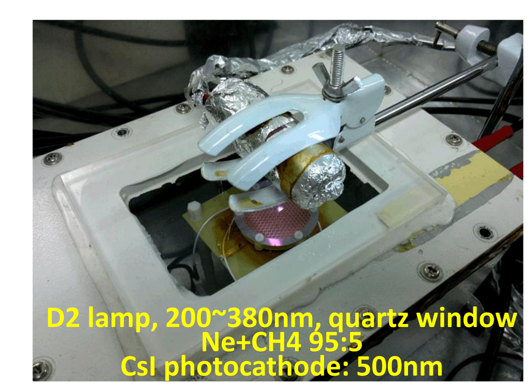


VUV&UV、Cosmic ray muon and α test

VUV



UV



Gain for single photon

- Ed contributes to gain;
- Max ETE required Ed = 0;
- High gain is necessary for single photon detection (such as gaseous photonmultiplier (GPM));
- It is shown that both high ETE and high gain(>1×10⁵) can be obtain when Ed = 0 kV/cm.

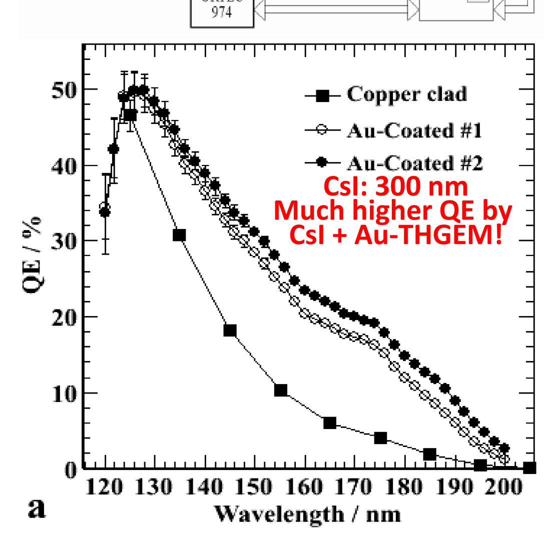


Fig. 3 VUV test and results (at BSRF).

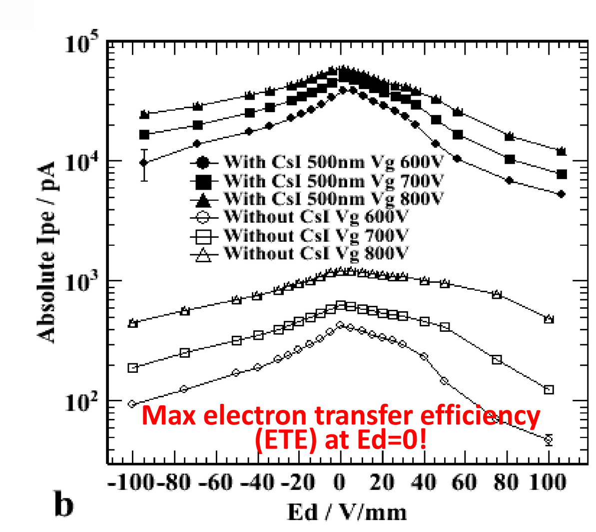


Fig. 4 UV test and results (DC mode).

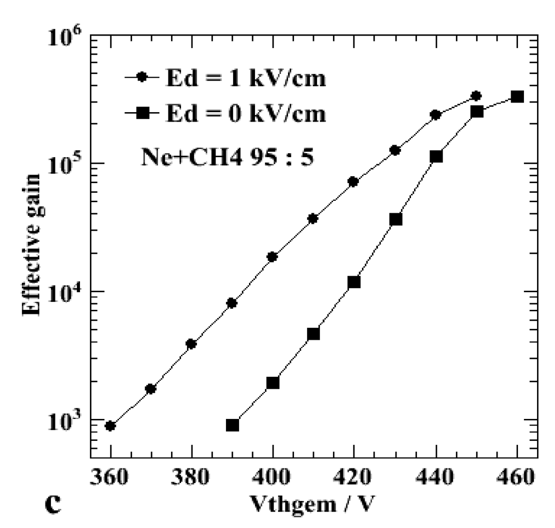
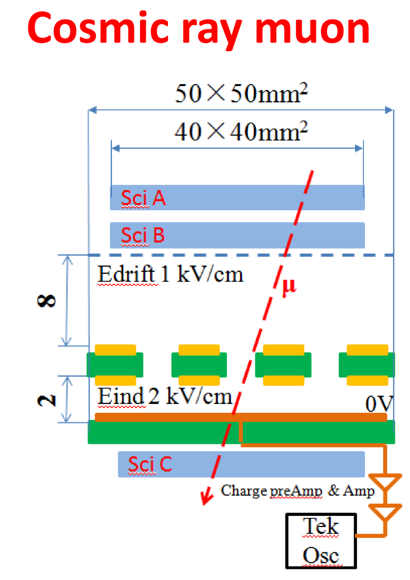
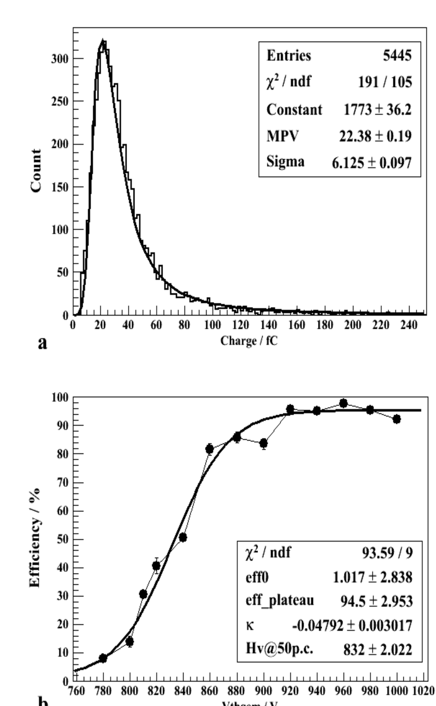


Fig. 5 Gain for single photon detection (triple THGEM).

Cosmic ray muon



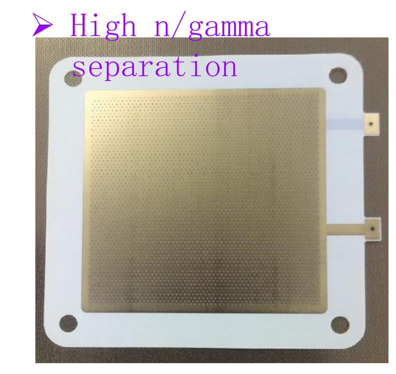
- Plateau efficiency: 94.5%;
- Deposited charge: 22.4fC at a gain of 2200 in Ar+IsoB/97:3;

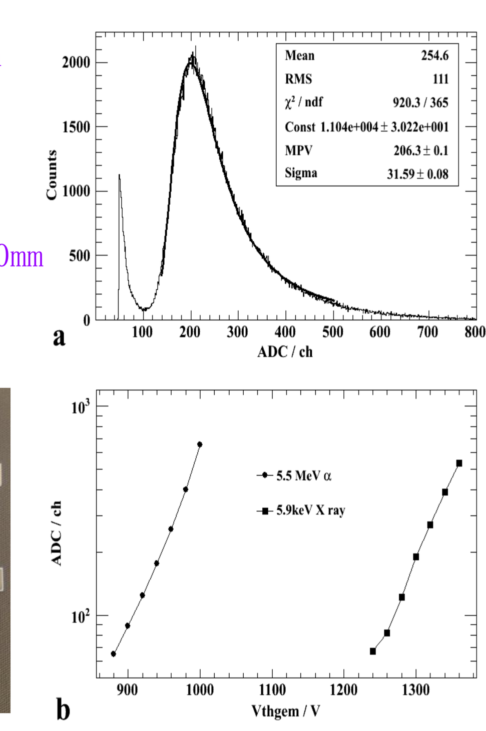


α

For neutron detection
Substrate: ceramic

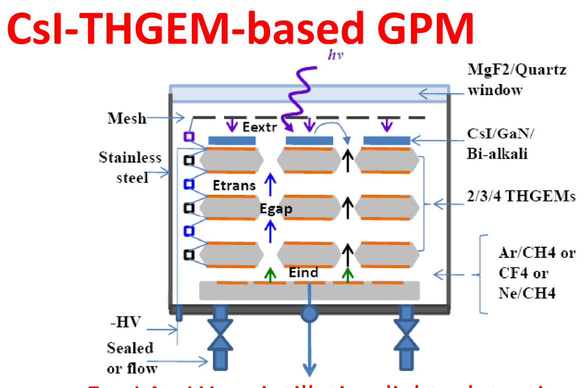
- Total thickness: 150μm
- Rim: 60~100μm
- d: 0.2mm, pitch:1.0mm
- Vthgem:800~1000V (α@Ar+CO2=70:30)
- High n/gamma separation



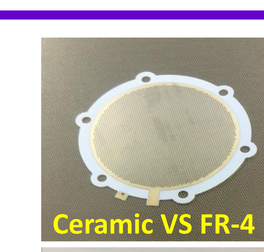


Works ongoing

CsI-THGEM-based GPM



For LAr, LXe scintillation lights detection



THGEM for e beam monitoring

一 Detection object

1. Electron：0.1～50MeV，energy dispersion：<1%;
2. Work modes（Quasi-particle）
   A. CW：1-10⁶Hz（0.1-4MeV
   B. PL：100Hz（3-50MeV
3. Beam size
   1) Small : 0.5mm;
   2) Big ： 100×100mm²。

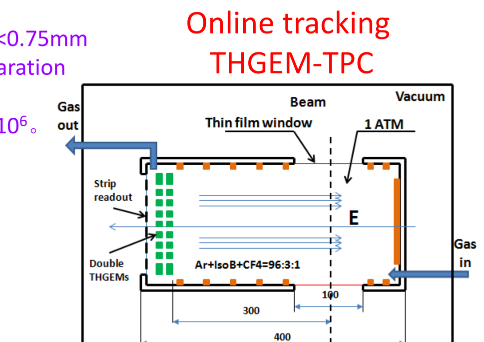
二．Requirements

1. High detection efficiency + online trigger
2. 100×100mm² sensitive area
   High E， σ_{xz}<0.2mm，Low E， σ_{xz}<0.75mm
3. Online single /double particles separation
   1）space<0.5mm 2）time <1ps
4. Counting rate :online 10⁴，offline 10⁶。

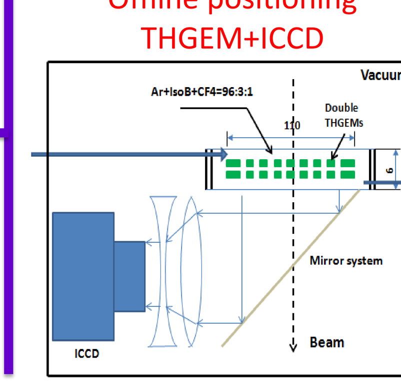
三．Operation conditions

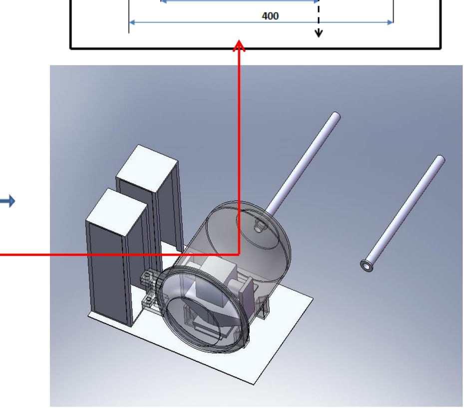
1. Pressure：10^{-3}～10^{-5}Pa (vacuum)
2. Temperature：-20±15℃

High energy range
Online tracking
THGEM-TPC



Low energy range
Offline positioning
THGEM+ICCD





B10-THGEM-based n beam monitoring

(Ref: Oral report by Jianrong Zhou, et.al., CSNS)

THGEM-based digital hadron calorimeter (DHCAL)

(Preliminary study: A.-W. Zhang et al., NIM A 722 (2013) 43–48)

Conclusion and outlook

Au-coated THGEMs with good performances were successfully developed by an improved industrial PCB technology in China. THGEMs with a wide range of structure parameters and large sensitive areas can be produced.

- ✓Effective gain: 1.0×10⁵ (single) and 3.0×10⁵ (double) in Ne+CH_4 / 95:5.
  1.0×10⁴ (single) and 4.0×10⁴ (double) in Ar-based gas mixtures.
- ✓Good gain stability (no continuous degradation) and uniformity.
- ✓Moderate energy resolution.
- ✓Application potentials: photon, charged particle and neutron detection.
- ✓New THGEMs of different substrates and new high efficiency production technology are also under development.

We are now pushing the development of CsI-THGEM-based GPM, Boron10-THGEM-based neutron beam monitor system, THGEM-based DHCAL and TPC-THGEM-based electron beam tracking detector.

Reference

[1] R. Chechik et al., NIM A 535 (2004) 303
[2] ZHANG Ai-Wu et al., CPC(HEP & NP), 2012, 36(2)
[3] H.B. Liu et al., NIM A 659(2011) 237
[4] Elena Rocco, Development of a gaseous photon detector for Cherenkov imaging applications, Ph.D. Thesis, CERN-THESIS-2010-053, Feb. 16, 2010

This work is supported by National Natural Science Foundation of China (11205173, 11205240). We acknowledge the support and cooperation of Huizhou King Brother circuit technology Co., LTD (KBC).