Micro-Pattern Gas Detector

Technology and Application

Development of MPGD

New MPGD

Read out method

New techniques

Application and new requirement

RD51 collaboration

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蓬勃发展的位置灵敏气体探测器

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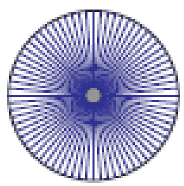
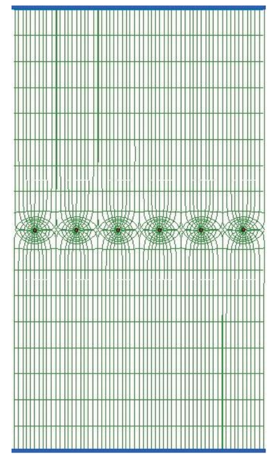
摘要: 介绍了近年来气体位置灵敏探测器的发展, 简要描述了几种新型的高位置分辨、高计数率的探测器: MSGC、MGC、MICROMEGAS、GEM 等。

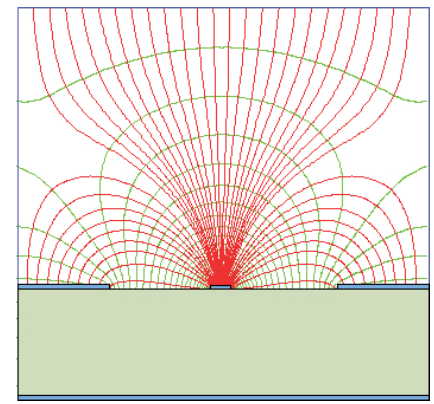
关键词: 位置灵敏; 高计数率; 气体探测器

中图分类号: TL815; TL816　**文献标识码**: A　**文章编号**: 0258-0934(2001)01-0070-06

Development of MPGD







Single tube

↓

Proportional tube
GM
Streamer tube
…..

MWPC

↓

Drift chamber
CSC
TPC
….

MSGC

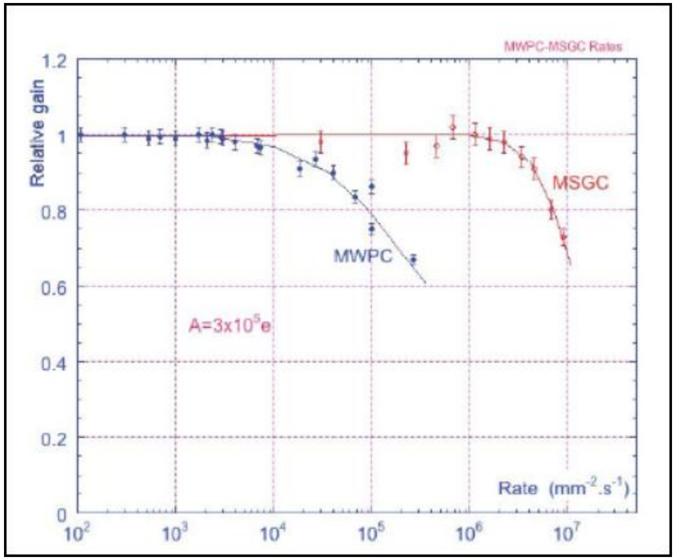
↓

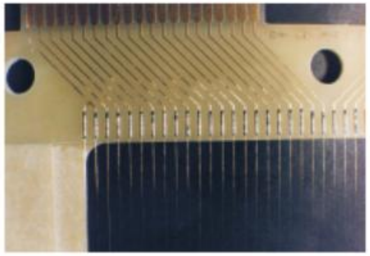
Glove
GEM
Micromegas

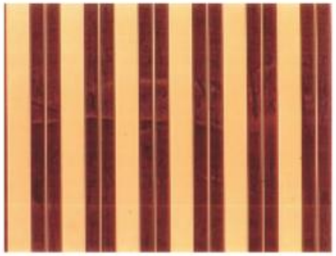
Signal， counting Function → Track , Counting Drift → Image Read out

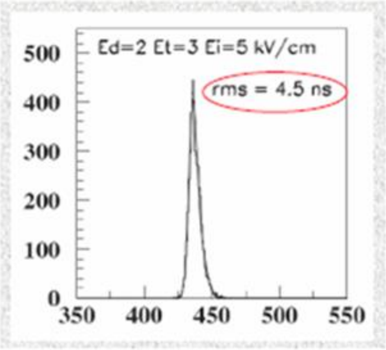
Main improvement

- Gain of gas
- Event rate
- Position resolution
- Time response
- Robust
- Read out independent
- Man power

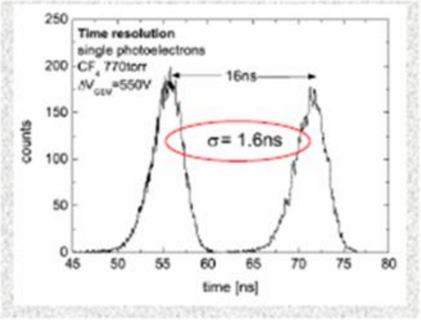






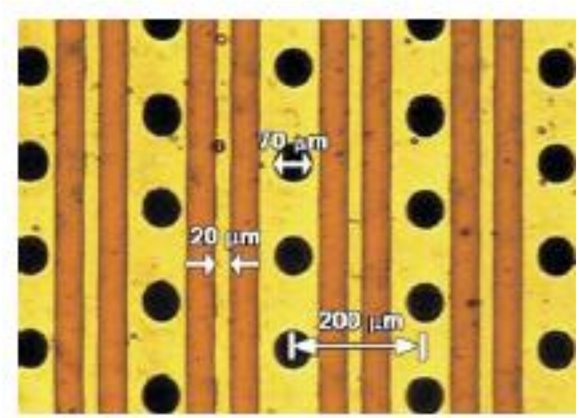


(a)

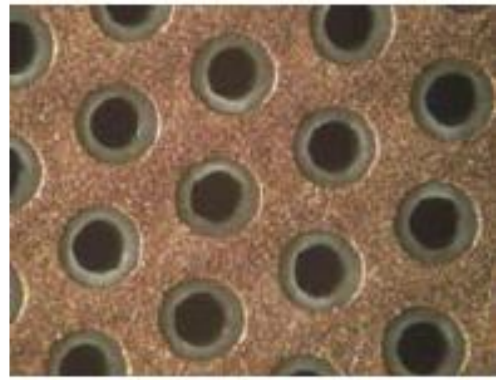


(b)

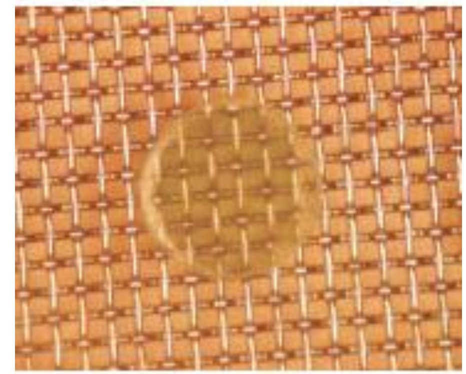
New MPGD



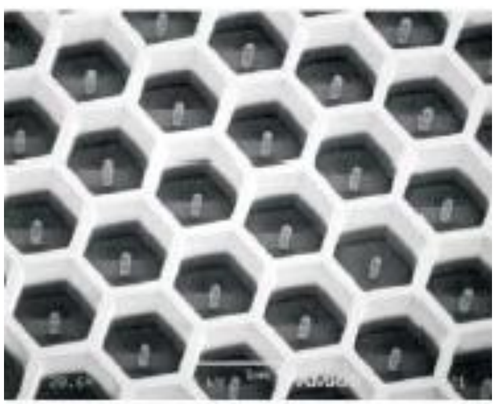
Micro hole & strip plate



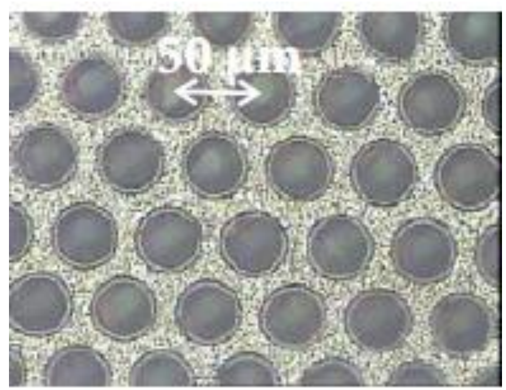
Thick GEM



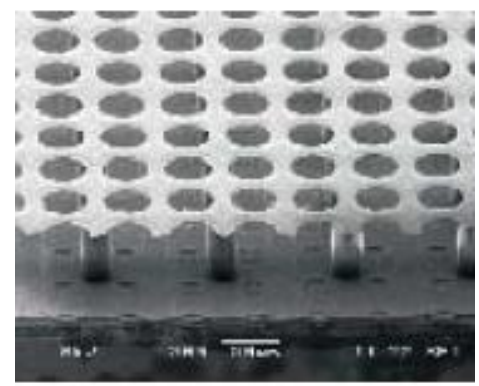
Bulk Micromegas



Micropin array

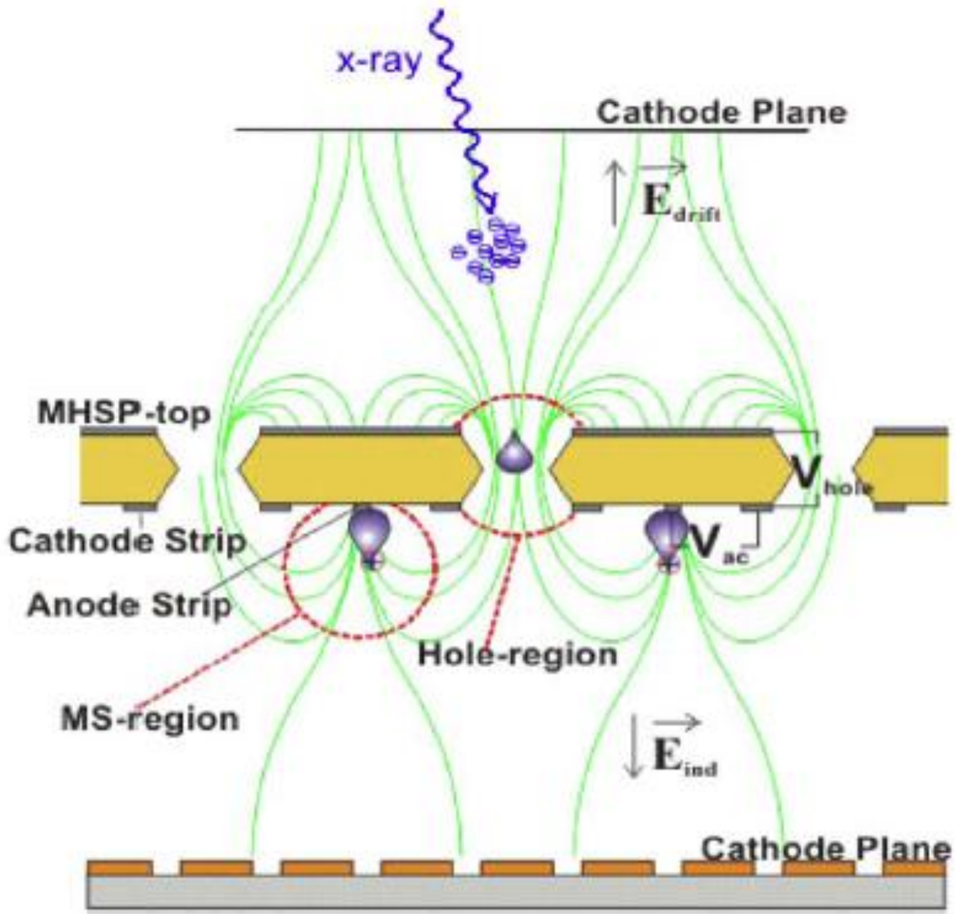


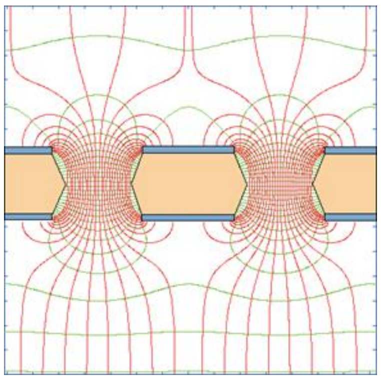
Fine pitch GEM



InGrid on pixel chip

Micro hole & strip plate : Ar+Xe





Micromegas in a bulk

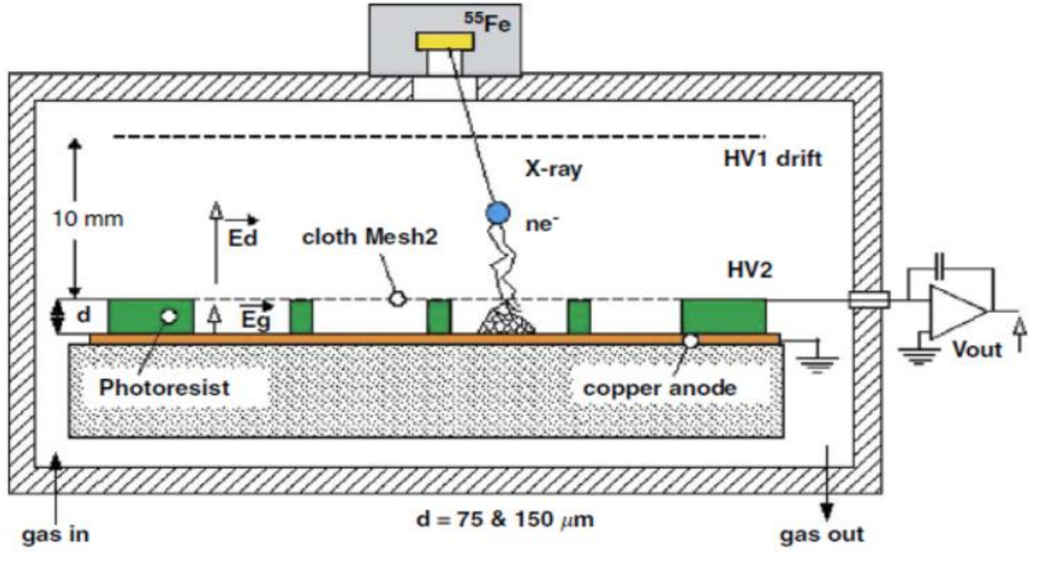
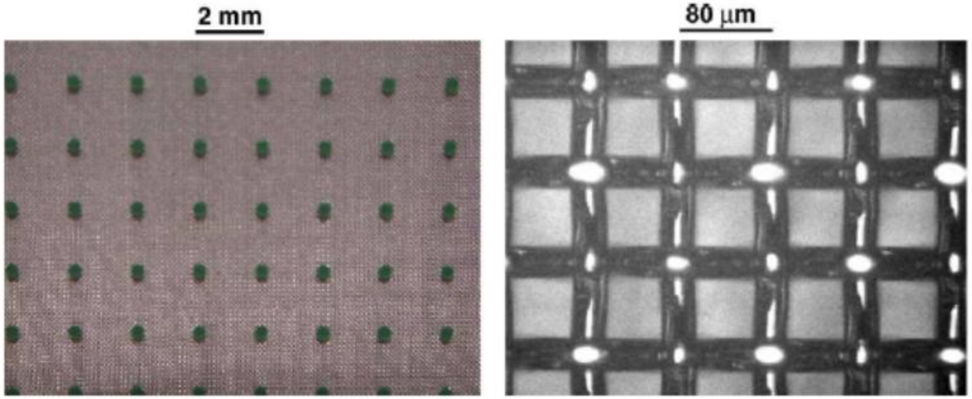
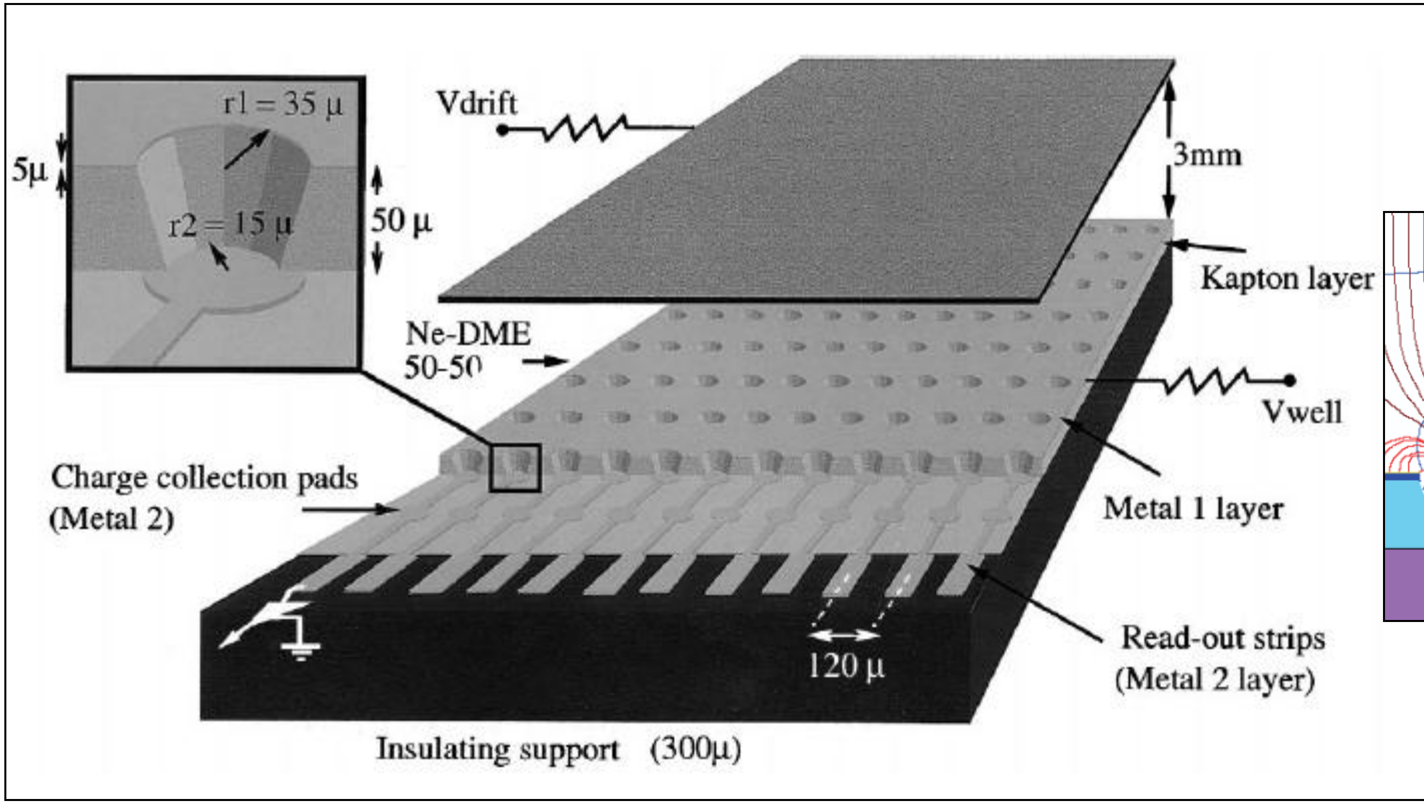
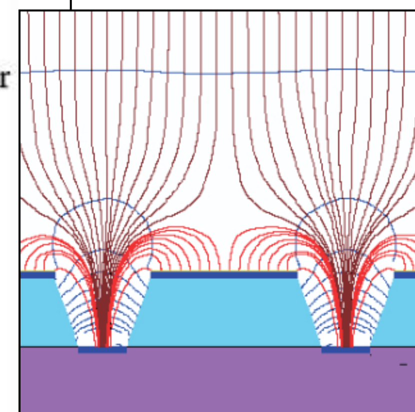


Fig. 3. Schematic drawing of the test chamber.

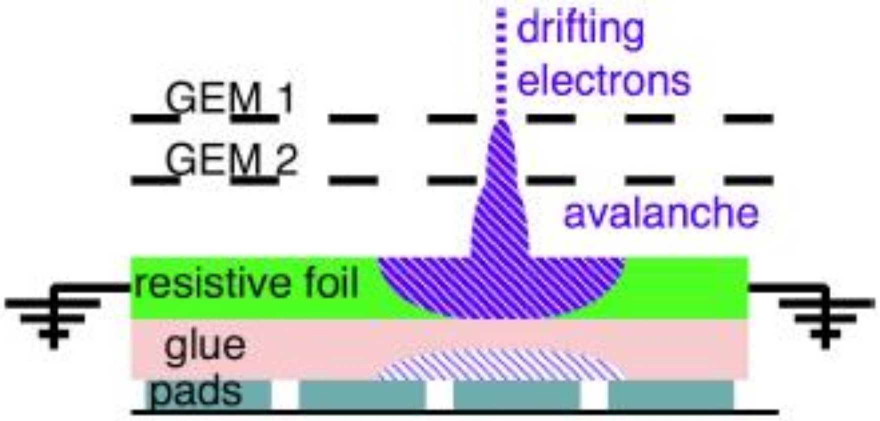


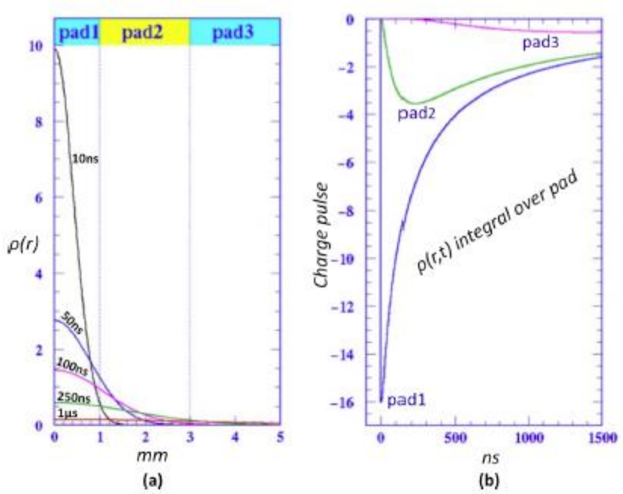
WELL detector

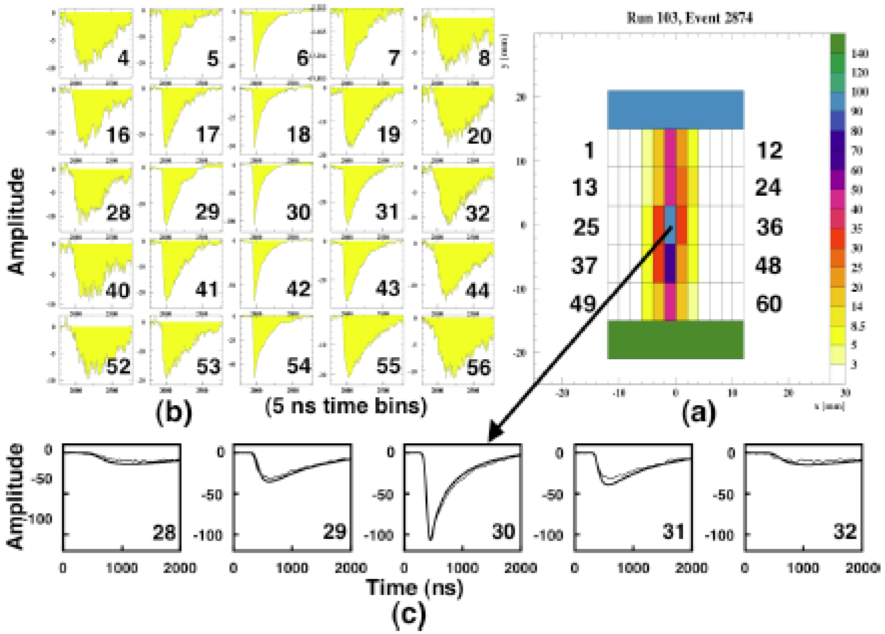




Read out with Resistive layer



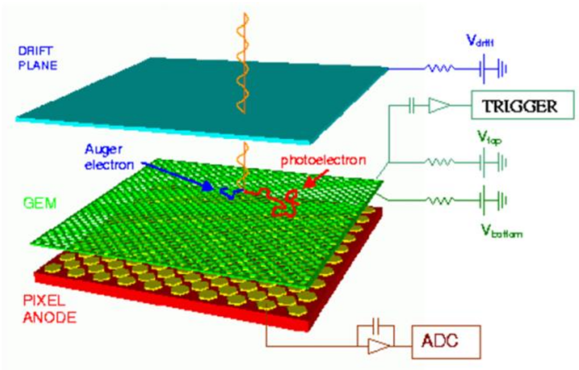




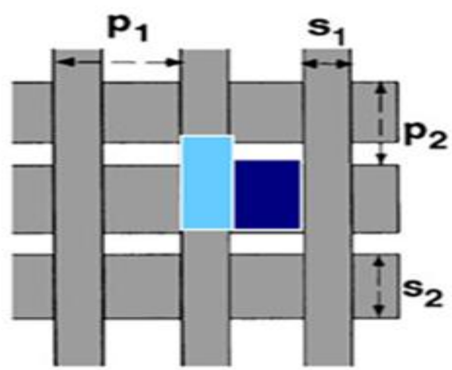
Read out method

- 1，Parallel Strips， Pads Array，
- Wedge Strip Anode（WSA)
- 2，TFT（Thin Film Transistor）Arrays
- 3，CMOS Readout Chip
- 4，CCD（Charge Coupled Device）
- 5，Delay line，

Strip or Pad read out



Read out pad independent



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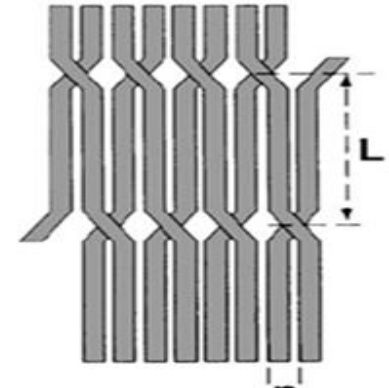

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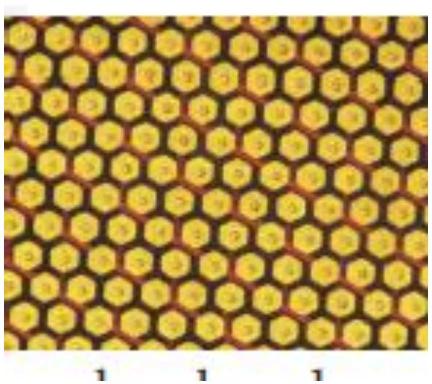
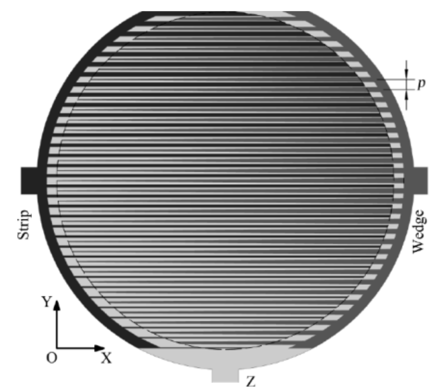




TFT and CCD

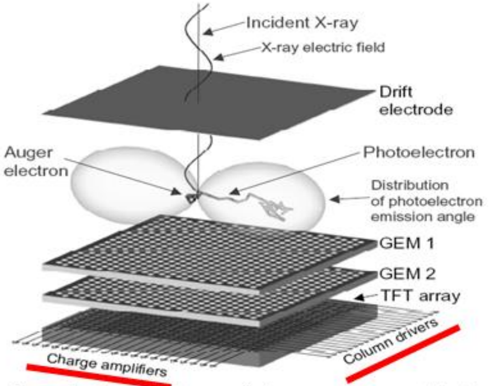


Figure 1. Schematic diagram of detector geometry used in these measurements. The $\sin^2\theta\cos^2\phi$ distribution of photoelectron emission for normally incident X-rays is projected onto the detector plane and observed as $\cos^2\phi$.

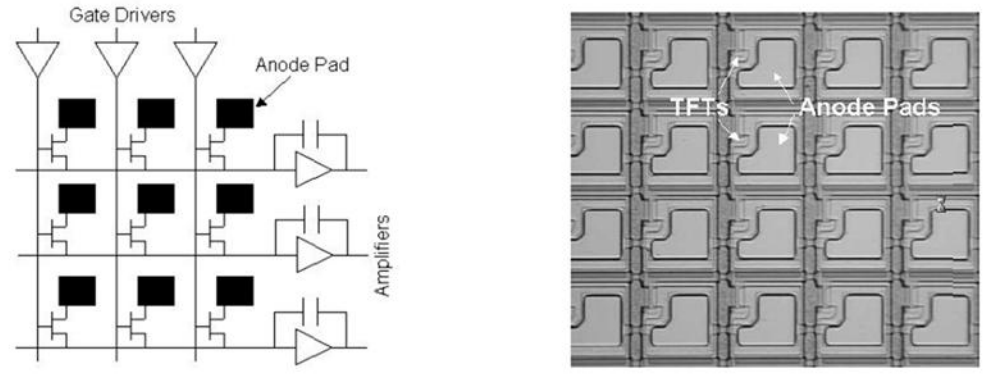


Figure 2. (Left) The TFT active-matrix readout scheme is highly scalable. (Right) Optical microscope photo of the array used in these measurements. The pixels are on a 100 micron spacing.

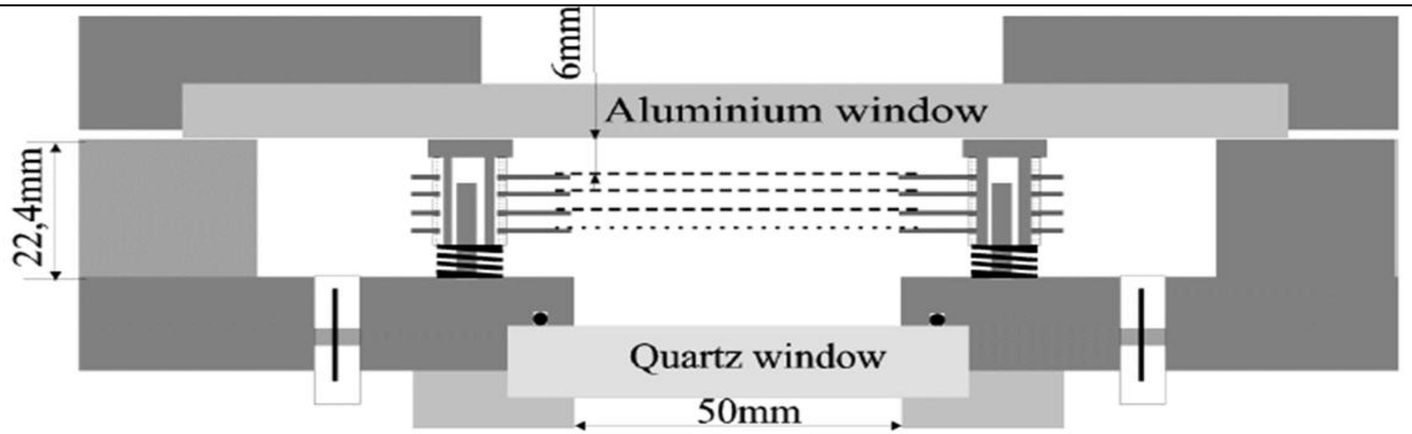


Fig. 5 Schematic cross-section of the detector. The CCD (not shown) was placed 30 cm away from the glass window.

CMOS read out

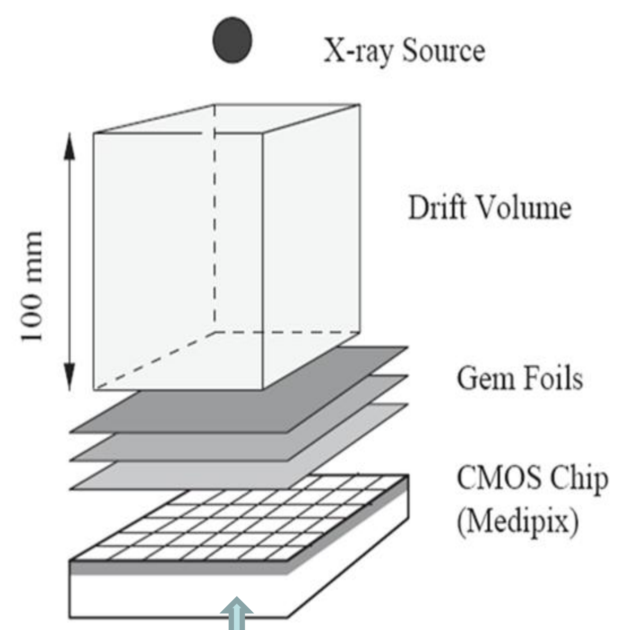


Fig. 1. The layout of the drift space, triple GEM and Medipix2 in the prototype test TPC.

No circuits for control o or amplification

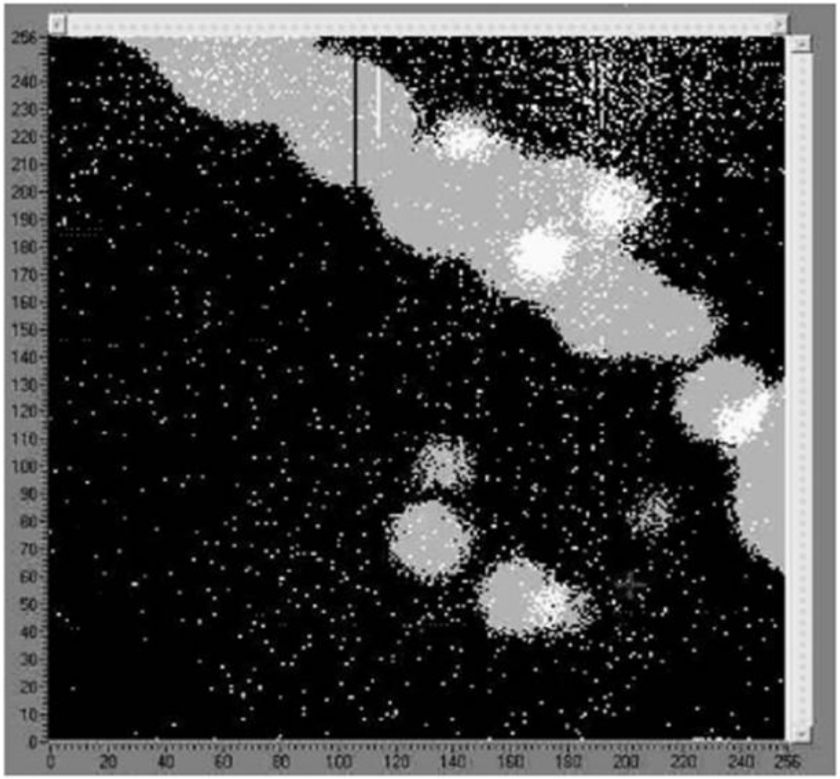
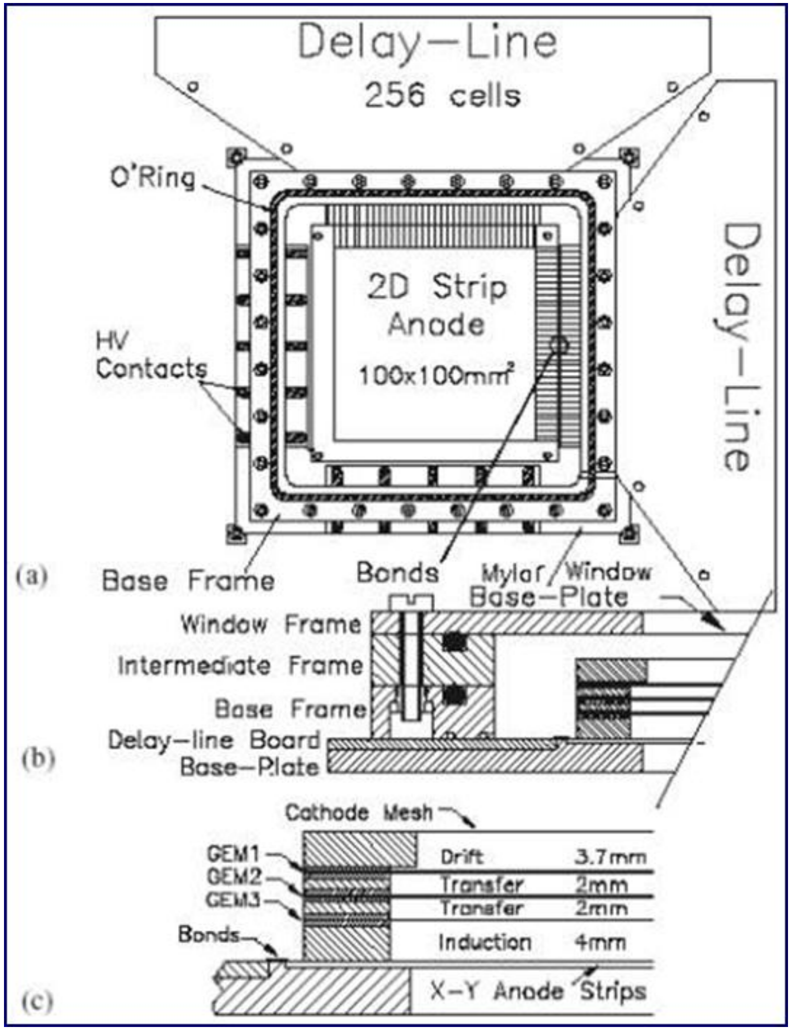
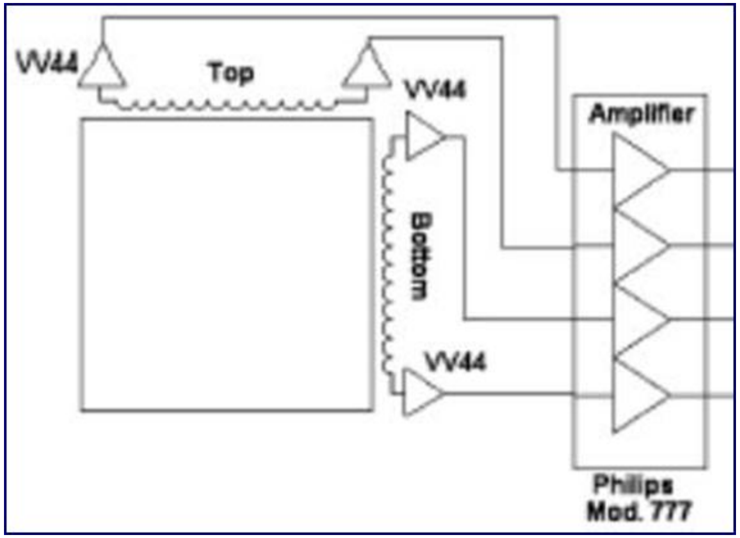


Fig. 3. As Fig. 2, but with Ar/isobutane 95/5, gain 18k, no radioactive source present and a 2s acquisition time. A non-typical image of a cosmic-ray track is visible.

Delay line


Delay–Line
256 cells
O'Ring
HV
Contacts
2D Strip
Anode
100x100mm²
Delay–Line
(a)
Base Frame
Bonds
Mylar Window
Base–Plate
Window Frame
Intermediate Frame
Base Frame
Delay–line Board
(b)
Base–Plate
Cathode Mesh
GEM1
GEM2
GEM3
Drift 3.7mm
Transfer 2mm
Transfer 2mm
Bonds
Induction 4mm
(c)
X–Y Anode Strips


VV44
Top
VV44
Amplifier
Bottom
VV44
Philips
Mod. 777

Techniques

Base on the industry of micro-electronics and printed circuits

光刻技术, 金属蚀刻，丝网印刷， 聚酰亚胺蚀刻，光可成像聚酰亚胺；光刻胶阻焊层

1，Photolithographic techniques– glass plates used (very thin metal easy discharge)

2，Printed circuits photolithographic, metal etching and screen printing : thicker metal, low cost. Large area, manufacturing of metal and insulator separate , robust

3，Etching of polyimide

4，Photo-imageable polymers ; photoresist solder masks

5，Resistive layer or patterns used to quench discharge to control the spreading of signal over readout channels

New technology

- Refinement of polyimide Etching used to made GEM also detector which read out and amplification at same plane (WELL, Groove);
- Microhole and strip plate combines

- Thick GEM normal PCB plate and automatic drilling
- Micromegas detector with new fabrication method a woven metal micromesh is laminated to the readout board between layers of photo-imageable solder mask. The solder mask layer can subsequently be patterned by uv-exposure to create the supporting pillar structure, the material are inexpensive and processes are industry standard. scale large, homogeneity is better, robust.

- The micro-pin array, microdot chamber based on microelectronics.
- Post-wafer processing techniques makes the introduction of MPGD with pixel read out

New Fabrication Method

(photoresistive film + solder mask layer)

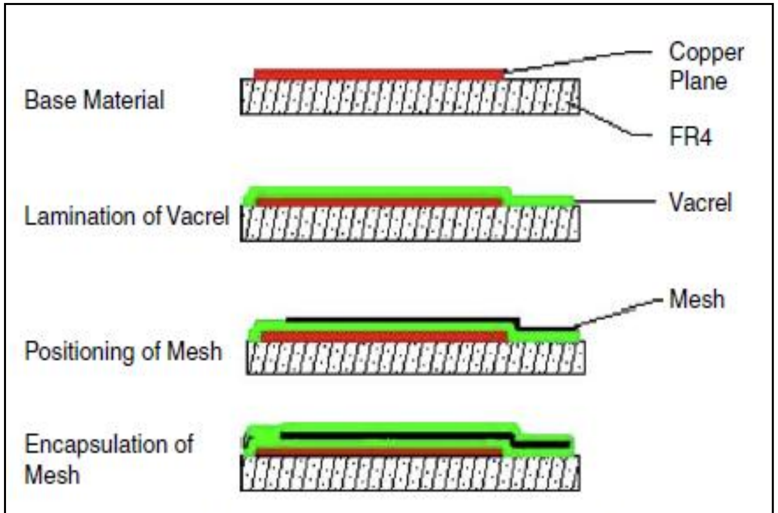


Fig. 1. Schematic of the fabrication procedure of the bulk Micromegas.

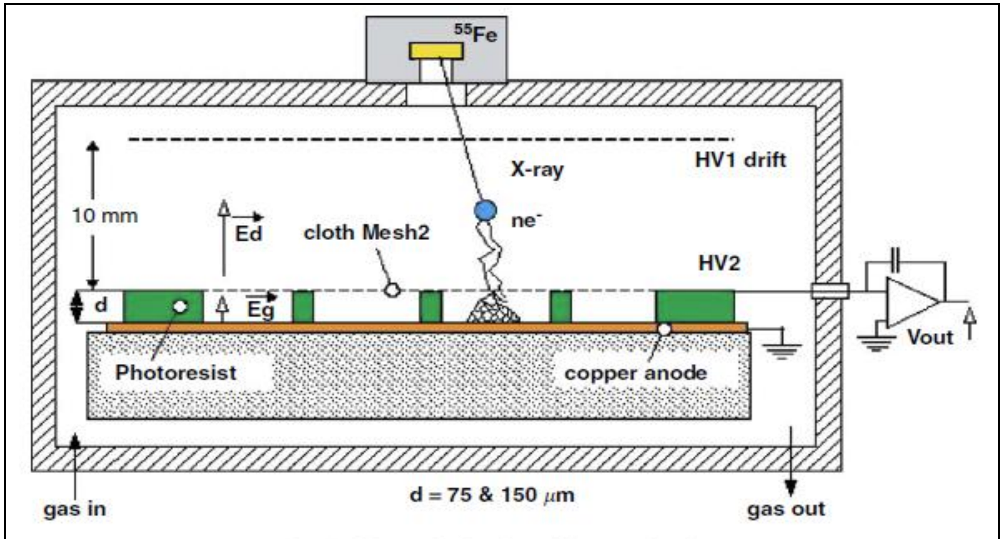
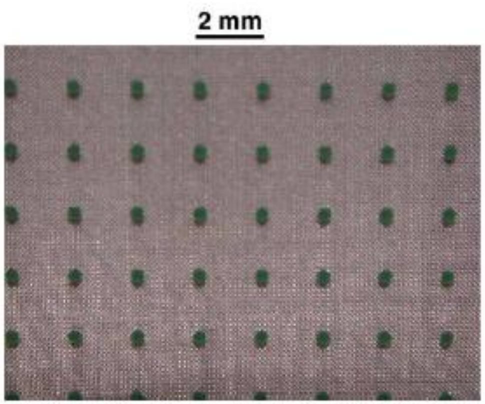
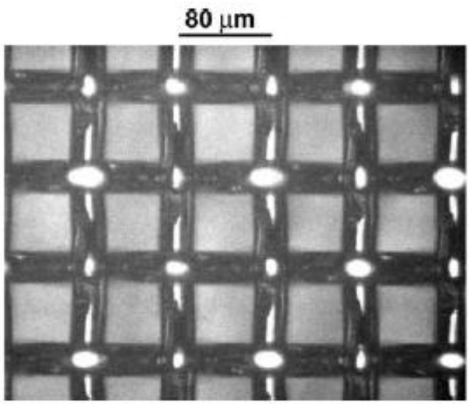
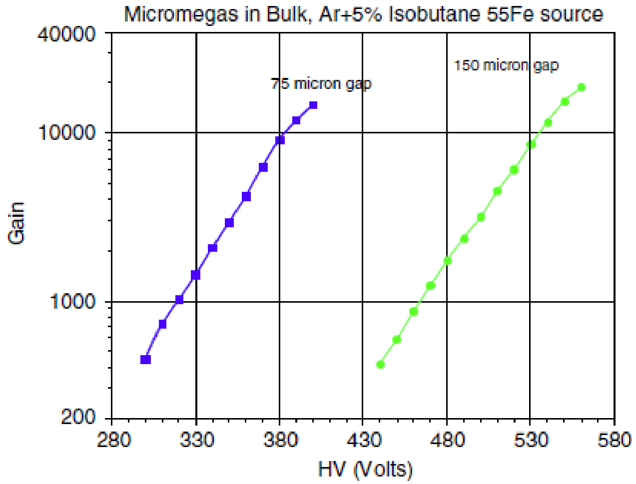


Fig. 3. Schematic drawing of the test chamber.







Simulation tool

- Simulation software :

Heed :primary ionization;

Magboltz :electron transport property in the gas mixture in electric and magnetic field :

Garfield: gas avalanches and induction of signal on readout electrodes .Garfield has interface to Heed and Magboltz and need to be supplied with a field map and detector configuration.

Electric field map can be generated by commercial finite-element method program such as **Ansys, Maxwell, Tosca, Quick Field and FEMLAB .**

- Recent development:

Simulation of the Penning transfer mechanism in the modeling of ionization and avalanche processes, greatly improving estimations of gas gain.

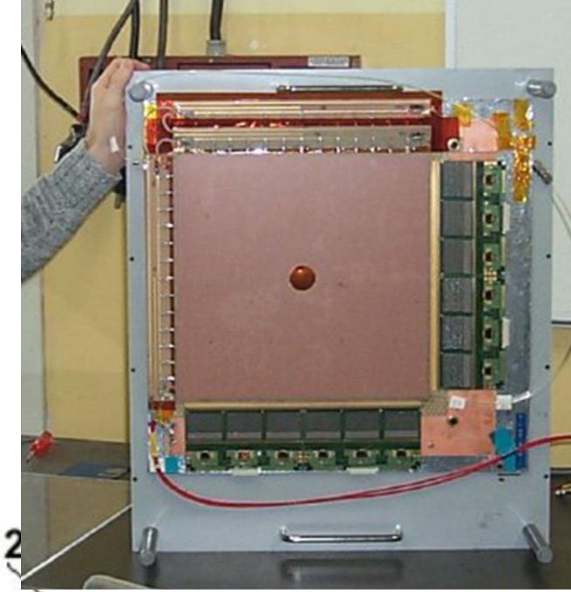
Application

Instrument and experiment both by science and industry

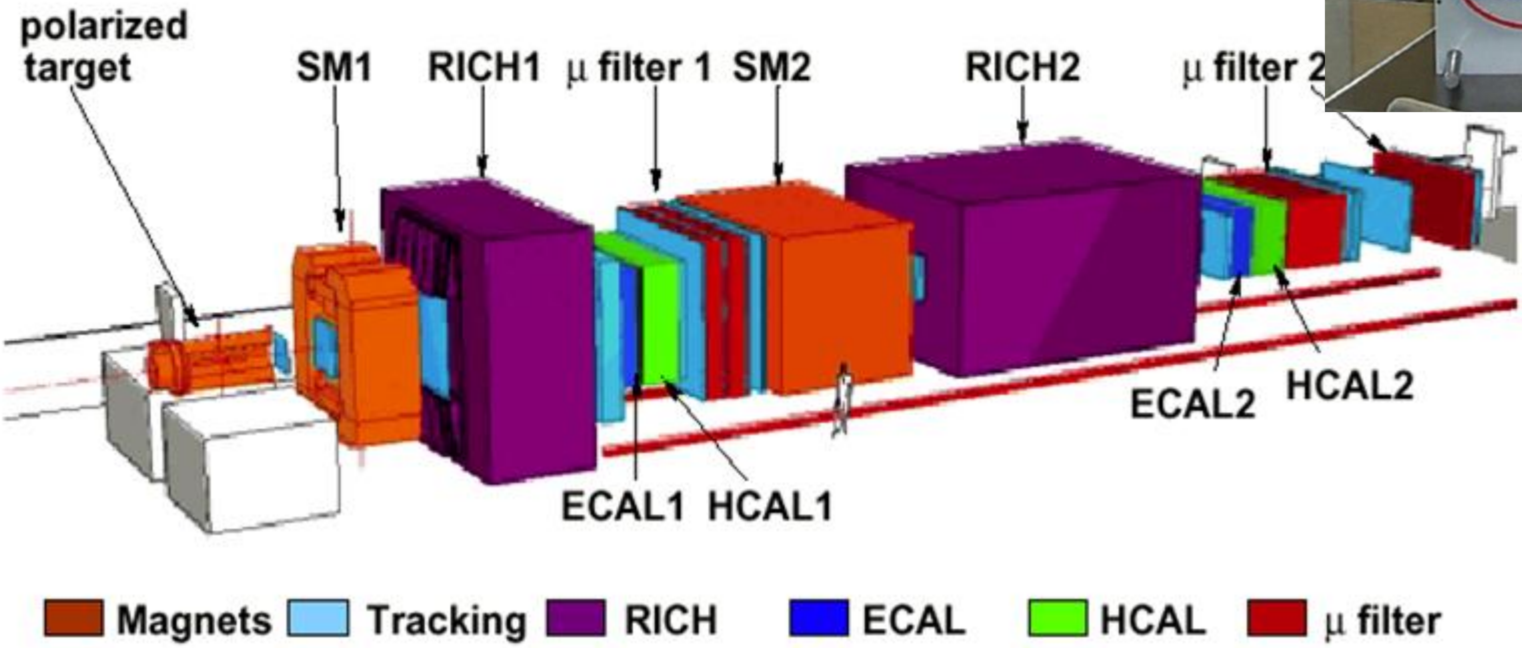
high energy physics ;nuclear physics; synchrotron neutron research; medical image ; homeland security;

- High rate tracking of charge particles (COMPASS,LHCb,TOTEM),LHC upgrade program use MPGD replace wire chamber ,RPC, DC.
- Both GEM and Micromegas used for read out of TPC have ion feedback suppression.
- One project use large area GEM to detect nuclear fission materials or waste in cargo containers by tomography of cosmic ray muons
-

TRIPLE GEM TRACKER FOR COMPASS AT CERN (NA58)



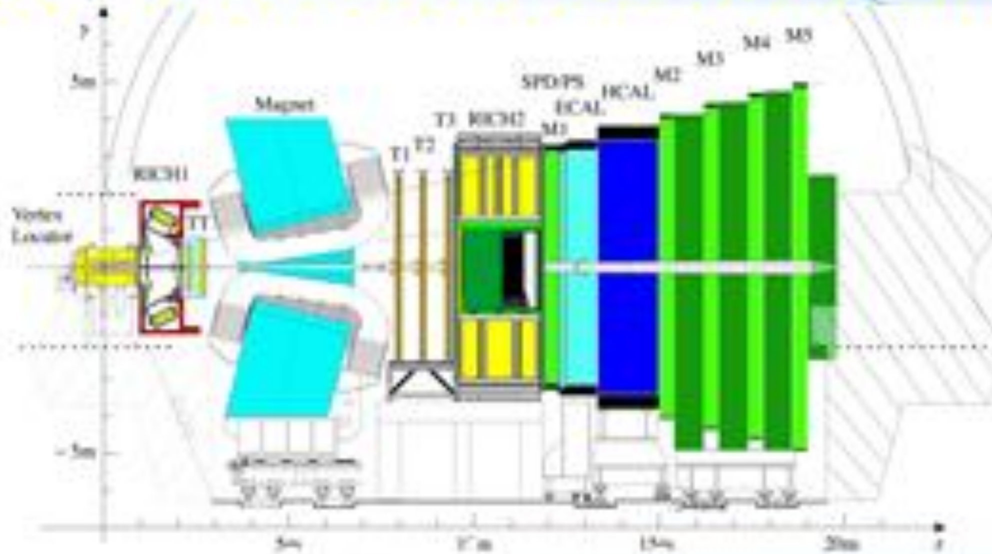
High rate forward spectrometer:
~ 5.10^{7} polarized 160 GeV μ^{+}/s on polarized ^{6}LiD target



22 Triple-GEM detectors, mounted in pairs on 11 stations

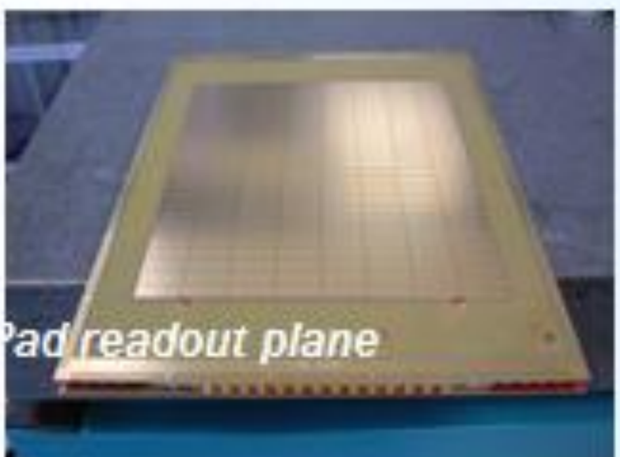
LHCB MUON TRIGGER

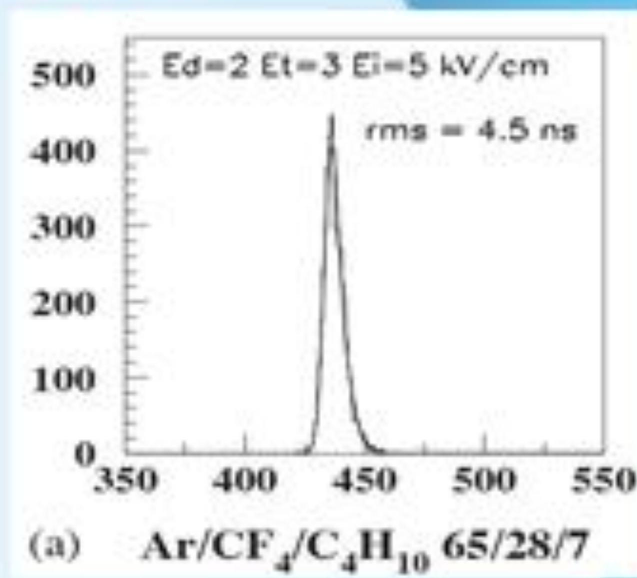
FAST TGEM DETECTORS FOR LHCb MUON TRIGGER



12 double TGEM detectors operated with fast gas mixture (Ar-CO_2-CF_4)

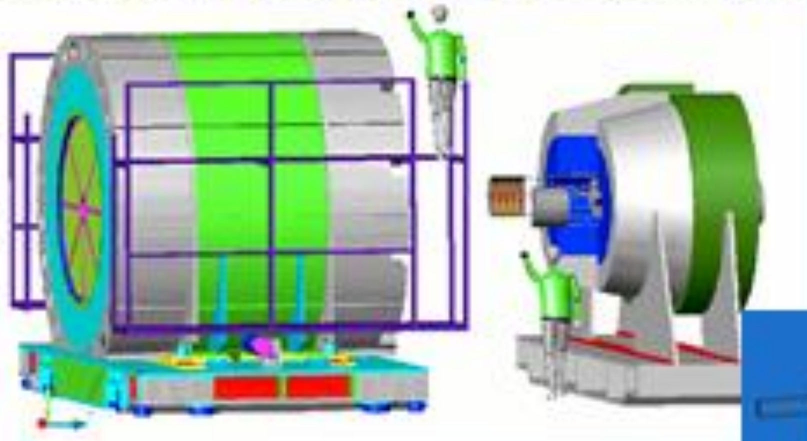
Rate - 5 kHz mm^{-2}
Time resolution 4.5 ns rms
Radiation hard up to integrated charge of 20 mC mm^{-2} (15 LHCb years)



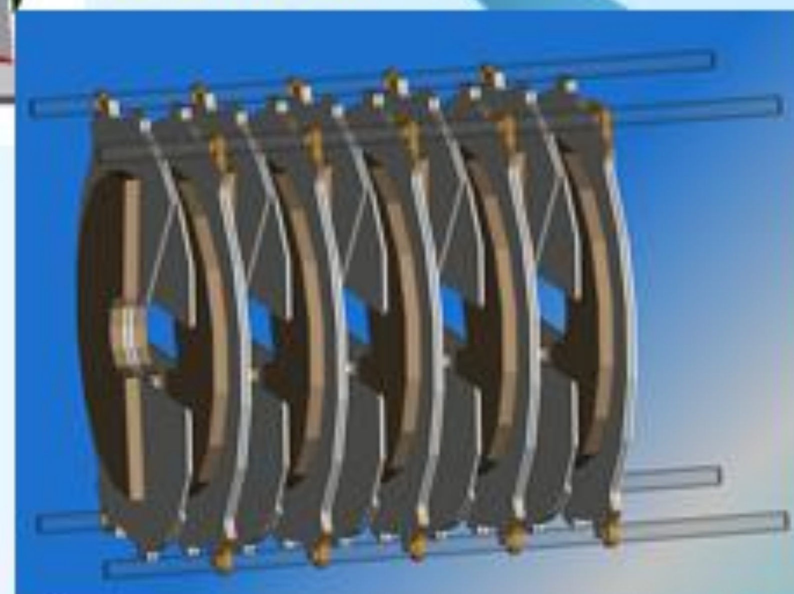


TOTEM

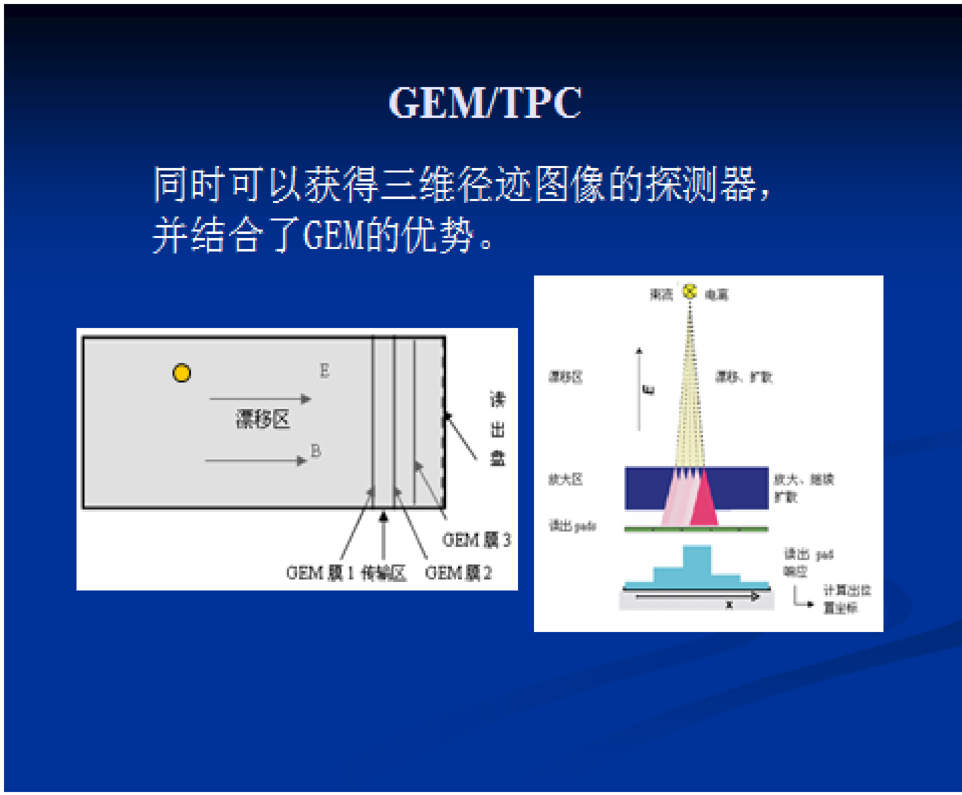
TOTEM EXPERIMENT AT CERN LHC:
Total Cros Section, Elastic Scattering and Diffraction Dissociation

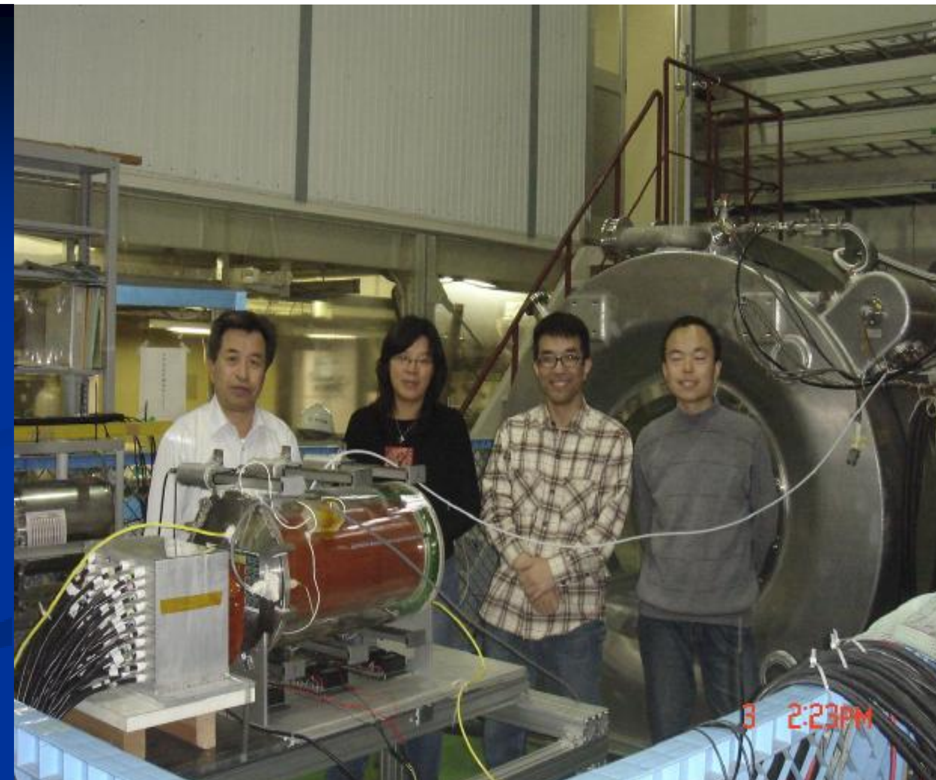


2x10 half-moon T-GEM detectors on each arm:

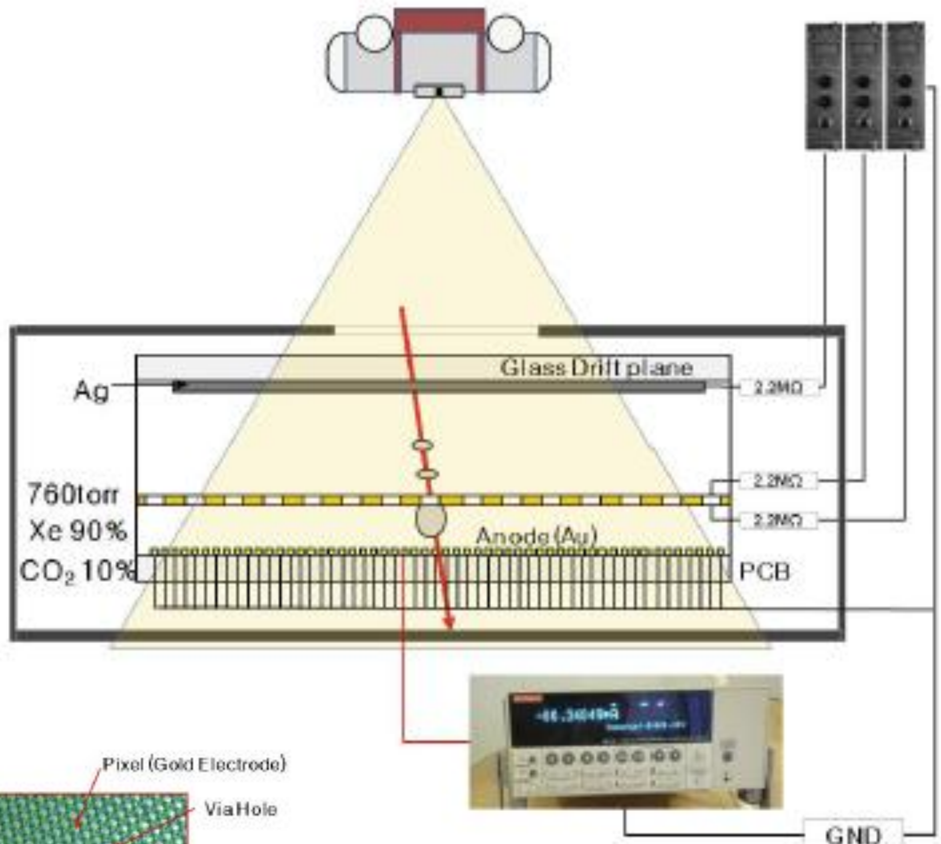


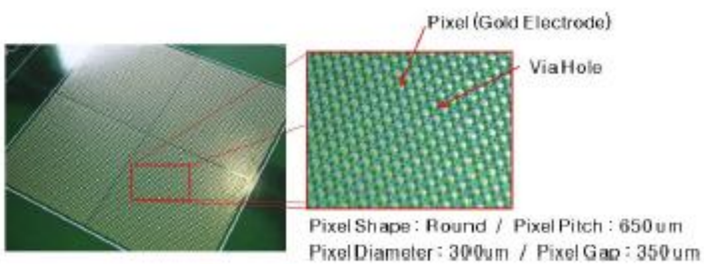
TPC with GEM


GEM/TPC
同时可以获得三维径迹图像的探测器，
并结合了GEM的优势。
E
漂移区
B
读
出
盘
GEM 膜 3
GEM 膜 1 传输区
GEM 膜 2



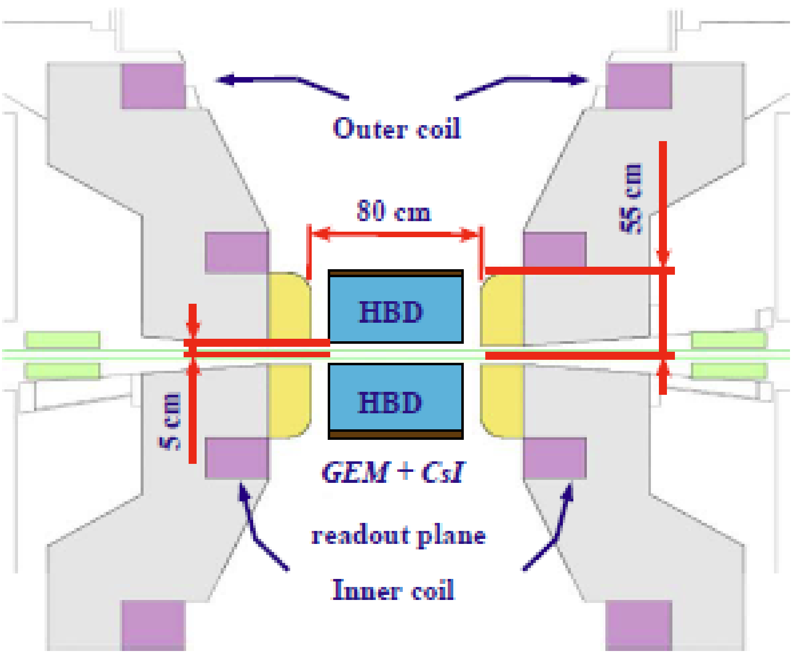
MPGD with Pixel read out for X-ray imaging

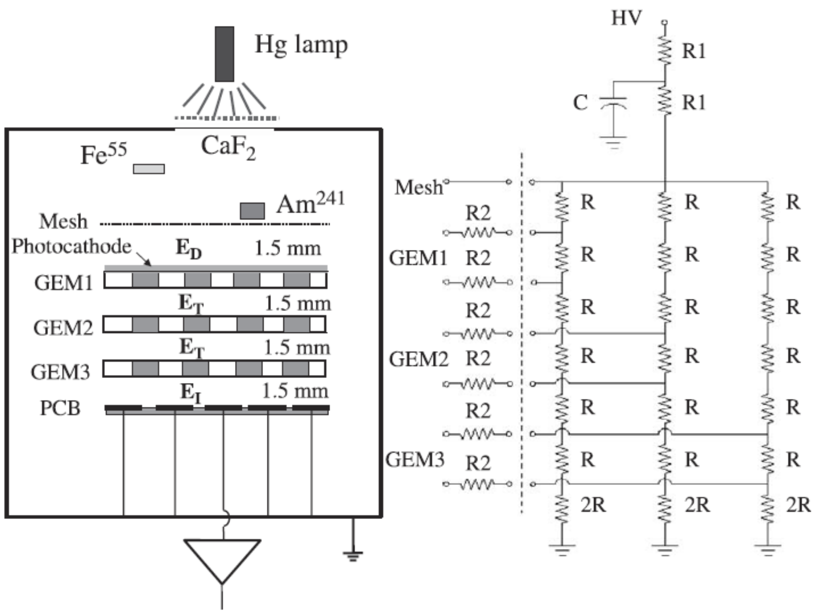




Gas : Xe + CO2,90:10
Pixel：Φ50um， 50×50mm2

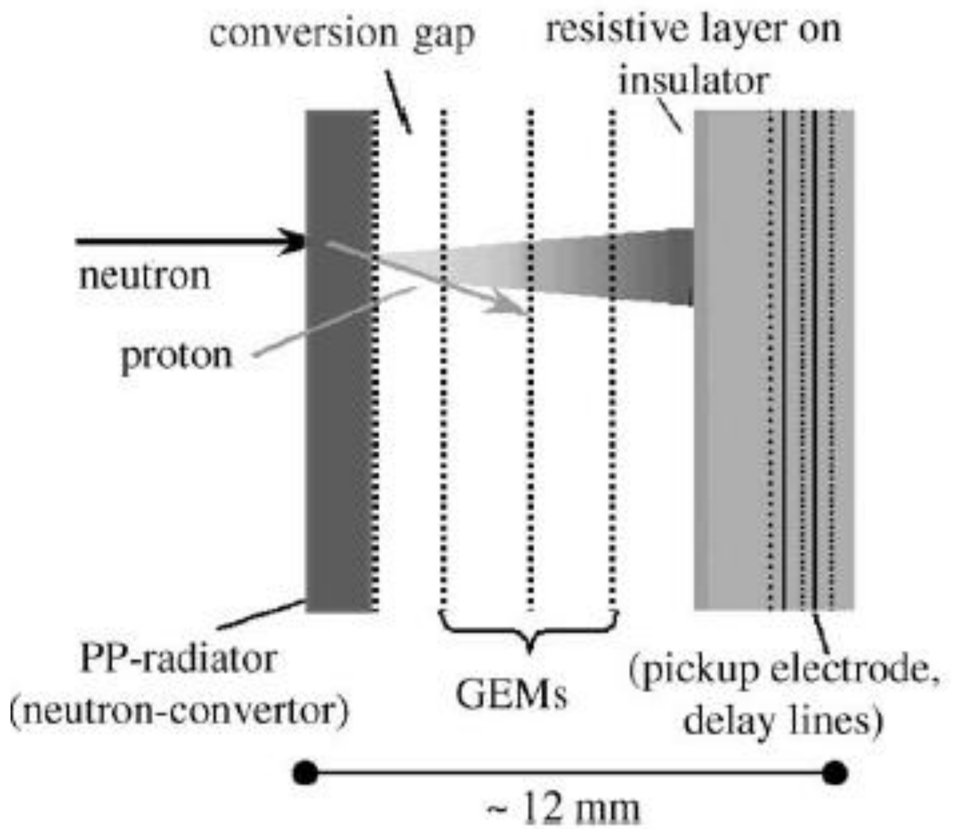
Cherenkov radiator with pure CF4 coupled in windowless to Triple-GEM with CsI photocathode





Inner part of the PHENIX detector
HBD : Hadron Blind Detector

Fast neutron detector



Fast neutron imaging,100×100mmGEM, 1mm convertor, 5MeV neutron , 0.2%

Current trends in MPGS

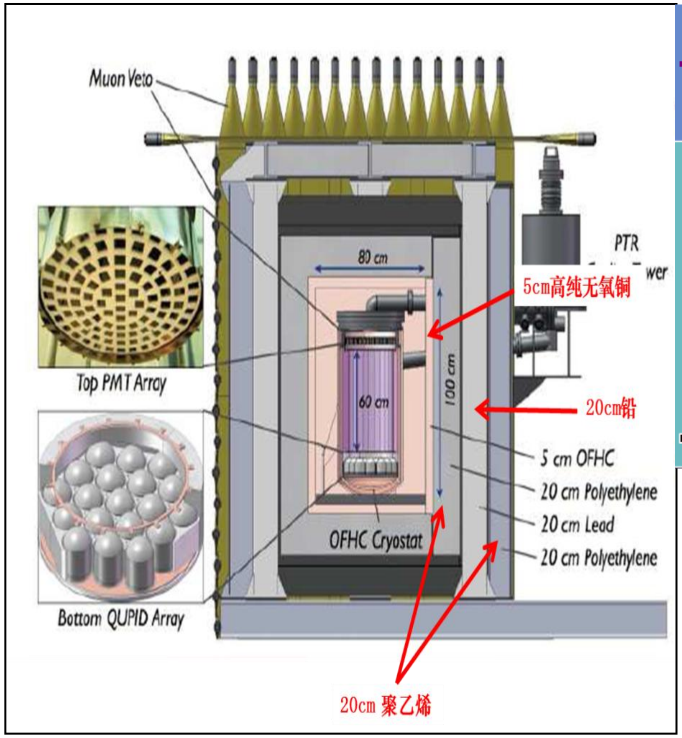
- Higher rate capability
- Excellent time and position resolution
- Resistance of aging
- Intrinsic ion and photon feedback suppression
- New way to make new structure for wider rage of application

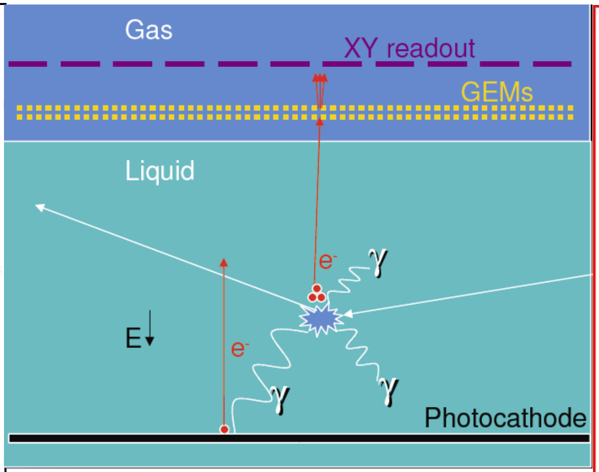
Develop new detector

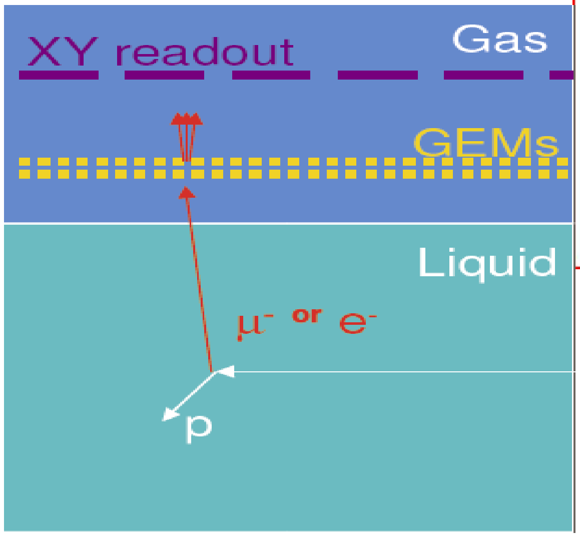
1. Master physics principle of gas detector
2. Use simulation tool exactly
3. Understand the goal of application
4. Following the New technology of industry

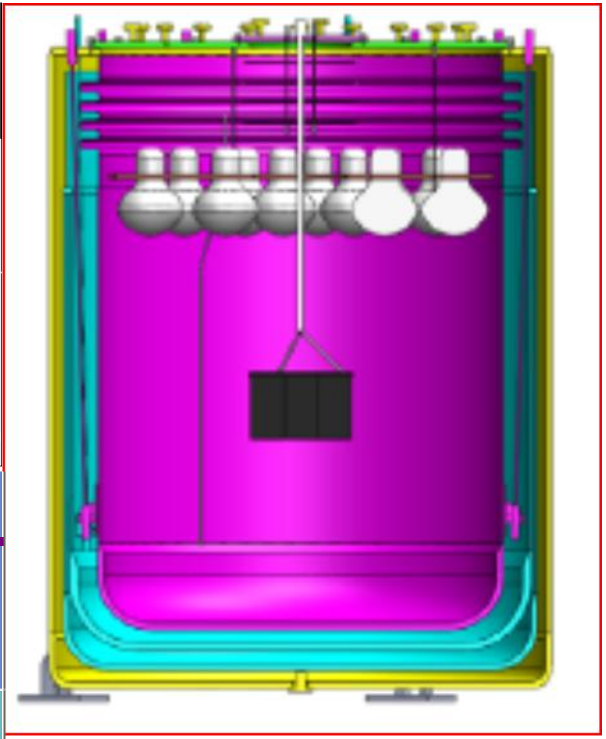
New requirement and develop new MPGD

- MPGD : in pure noble gas Xe, Ar ,Neon , H …and low temperature
- MPGD : in liquid Xe, Ar,…

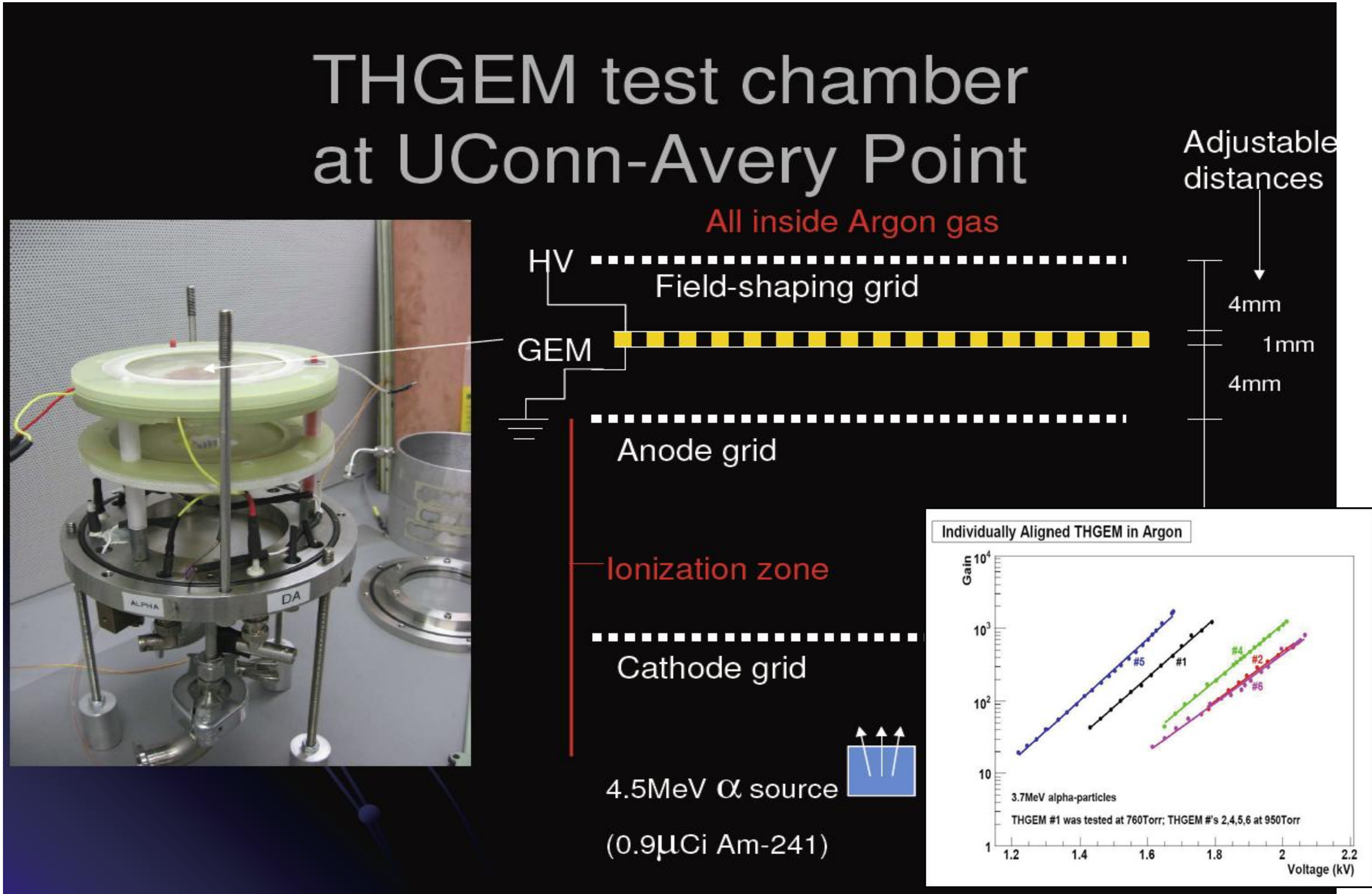








THGEM in Argon



RD51 collaboration

430peaples ,75 institutes, 25 country

	WG1 MPGD technology & new structures	WG2 Characterization & physics issues	WG3 Applications	WG4 Software & simulation	WG5 Electronics	WG6 Production	WG7 Common test facilities
OBJECTIVES	Design optimization. Development of new geometries and techniques	Common test standards. Characterization of physical phenomena in MPGDS	Evaluation and optimization for specific applications	Development of common software and documentation for MPGDS	Readout electronics optimization and intergration with MPGDS	Development of cost-effective technologies and industrialization	Sharing of common infrastructure for detector characterization
TASKS	Large area MPGDS — Design optimization New geometries Fabrication — Development of rad-hard detectors — Development of portable detectors	Common test standards — Discharge protection — Aging and radiation hardness — Charging-up and rate capability — Avalanche statistics	Tracking and triggering — Photodetection — Calorimetry — Cryogenic det. — X-ray & neutron imaging — Astroparticle physics appl. — Medical appl. — Plasma diagn. Homeland sec.	Algorithms — Simulation improvements — Common platforms (ROOT, Geant4) — Electronics modeling	FE electronics requirements definition — General purpose pixel chip — Large area systems with pixel readout — Portable multi-channel system — Discharge protection strategies	Common production facility — Industrialization — Collaboration with industrial partners	Testbeam facility — Irradiation facility

New Application push development of MPGD
New Technology promote development of MPGD