THGEMs: very recent results towards applications in DHCAL & LXe detector readout

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Work within CERN-RD51

Weizmann:
A. Breskin, R. Chechik, R. Budnik,
CERN:
V. Peskov
Coimbra & Aveiro:
J. Veloso, C. Azevedo, J. dos Santos,
H. Natal da Luz, A. Coimbra
Nantes:
S. Duval, D. Thers
UTA:
A. White, S. Park

THGEM Recent works:
Review NIM A **598** (2009) 107
2010 *JINST* **5** P01002
2009 *JINST* **4** P08001

Thick Gas Electron Multiplier (THGEM)

~ 10-fold expanded GEM

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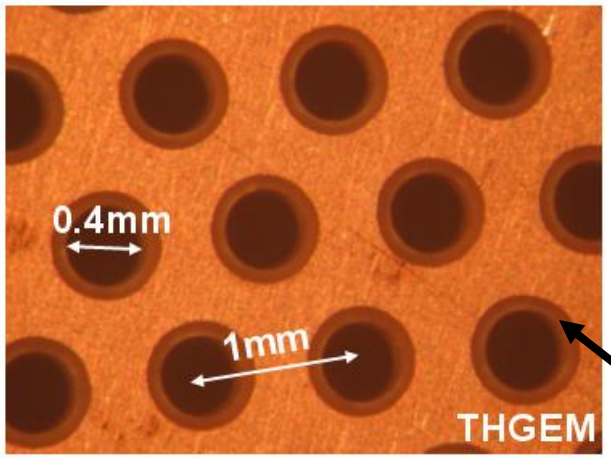
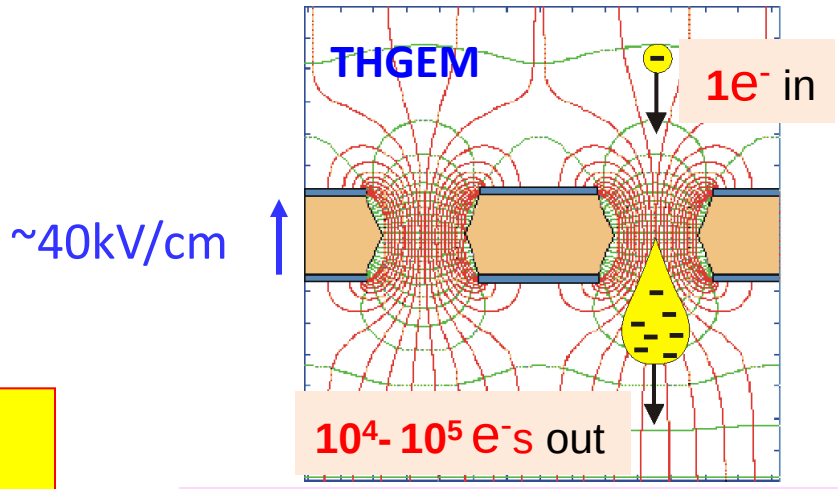


small rim prevents discharges

Thickness 0.5-1mm



Double-THGEM: 10-100 higher gains

SIMPLE, ROBUST, LARGE-AREA
Printed-circuit technology

➔Intensive R&D
➔Many applications:
- THGEM/CsI UV detectors for RICH
- Neutron imaging
- Charge sensors for DCAL
- Cryo detectors for Dark Matter

Effective single-electron detection
Few-ns RMS time resolution (MIPs/UV)
Sub-mm position resolution
MHz/mm^2 rate capability
Cryogenic operation: OK
Gas: molecular and noble gases
Pressure: 1mbar - few bar
Magnetic fields: OK

Ne-based mixtures

➔ Comparatively **low operation voltages**
reduced discharge probability,
discharge energy and charging-up effects

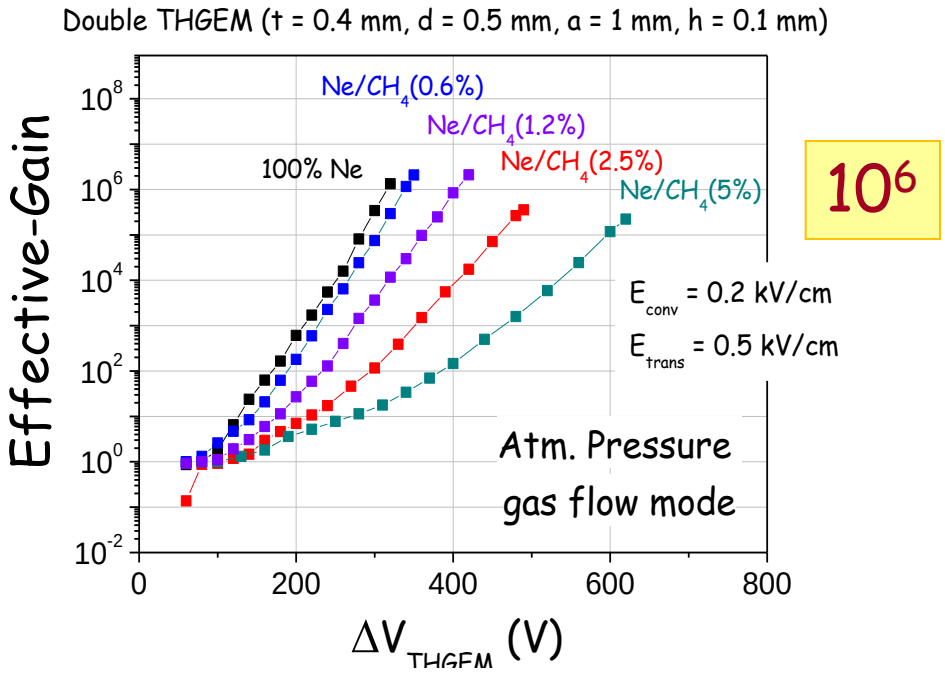
➔ **High gains**, even with single-THGEM
lower detector thickness (Important for DHCAL)

➔ High single-photoelectron gains even in the presence of ionizing background
(**higher dynamic range** **compared to Ar-mixtures**)

Gain: Single/Double THGEM in Ne-mixtures

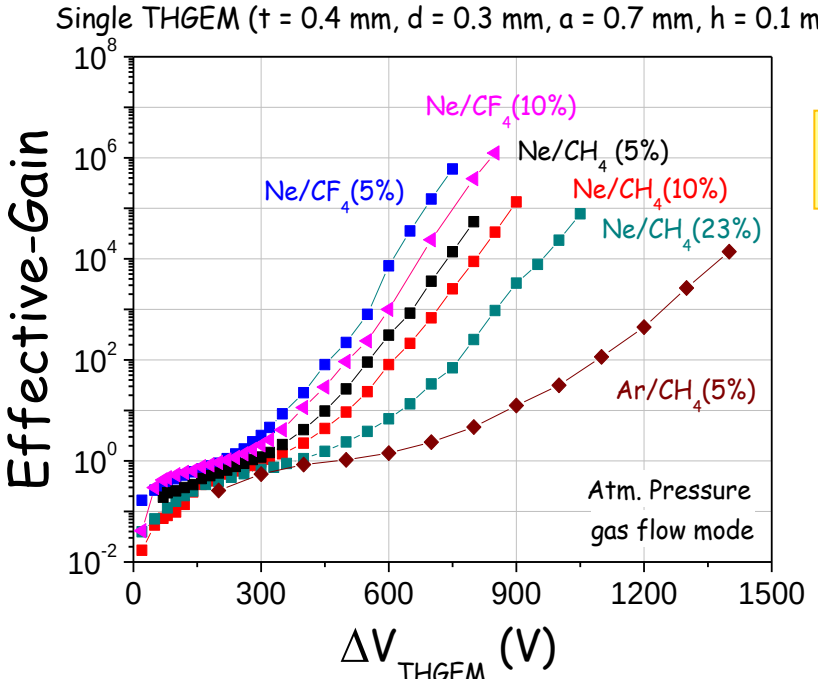
2009 *JINST* 4 P08001

Double-THGEM
9 keV X-rays



10^6

Single-THGEM
CsI PC + UV-light (180 nm)



10^6

Very high gain in Ne and Ne mixtures, even with X-rays

At very low voltages **!!**

X-rays: 2-THGEM 100% Ne: Gain 10^6 @ ~300V

UV: 1-THGEM $Ne/CF_4(10\%)$: Gain > 10^6 @ ~**800V**

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DHCAL applications

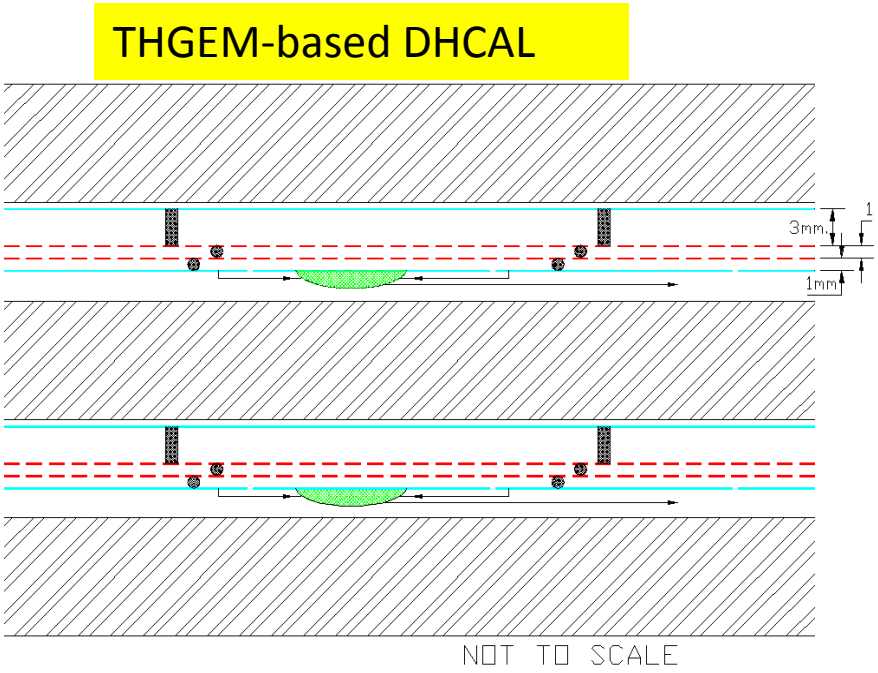
THGEM: sampling elements in Digital Hadron Calorimetry @ ILC

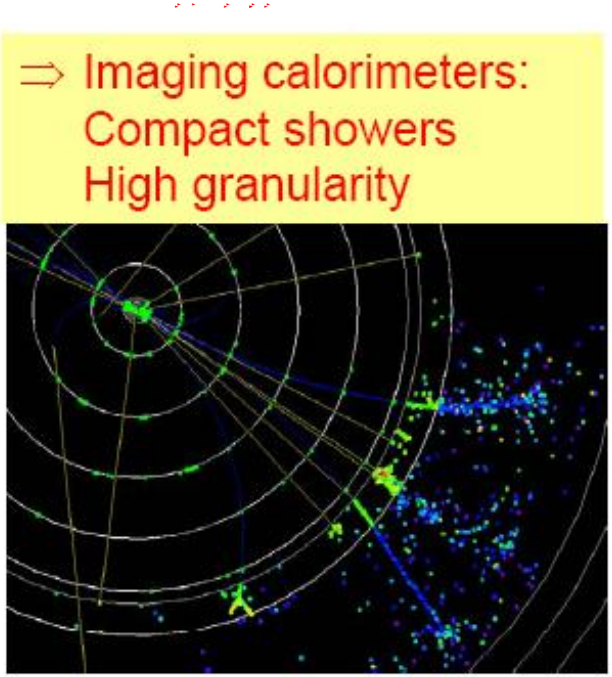
Digital Hadron Calorimetry: Different concepts proposed for the active sampling elements: GEM, RPC, Micromegas…

THGEM: a new solution proposed by Univ. Texas @ Arlington (UTA) & Weizmann

➔ Interlaced steel-plates and THGEM multipliers.

➔ Simple, robust, thin, compact, stable, high gain





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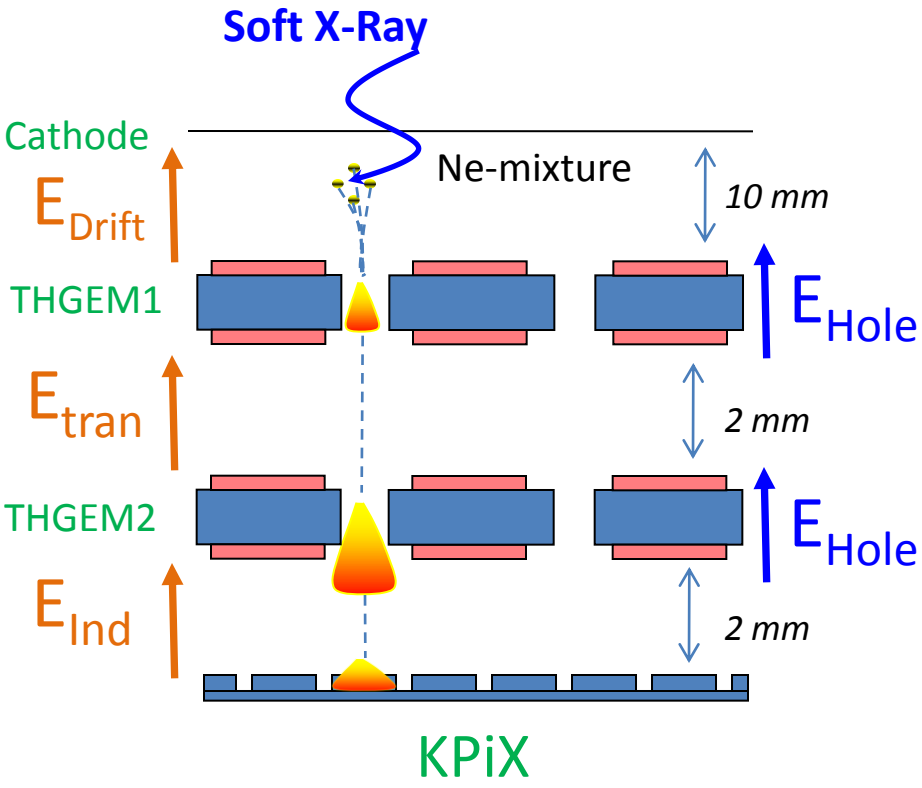
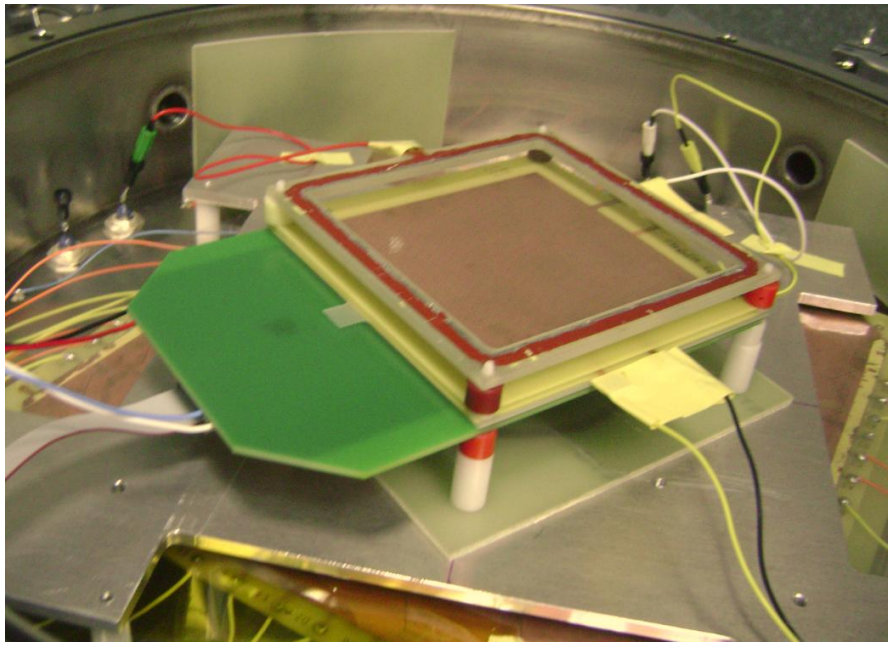
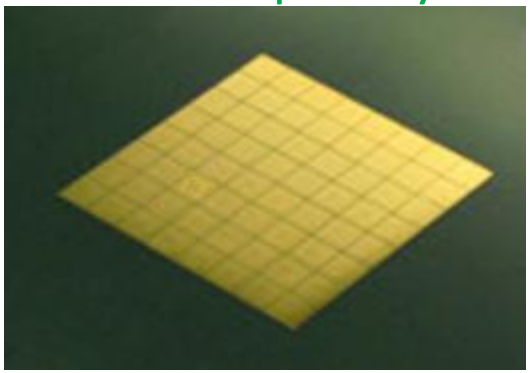
May 2010: Chamber Prototype – test with X-rays





8x8 anode pad layout

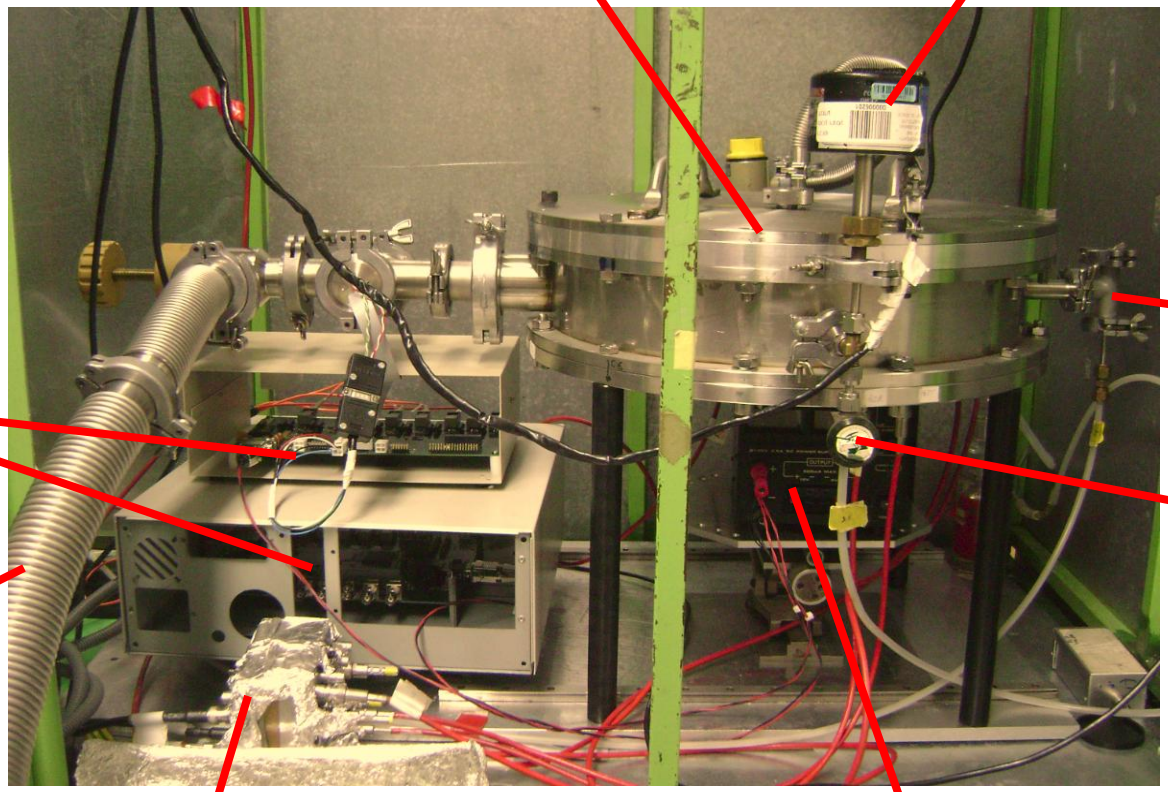


100x100mm² THGEM

Thickness → 0.4 mm
Hole diam. → 0.5 mm
Pitch → 1.0 mm
Rim → 0.1 mm

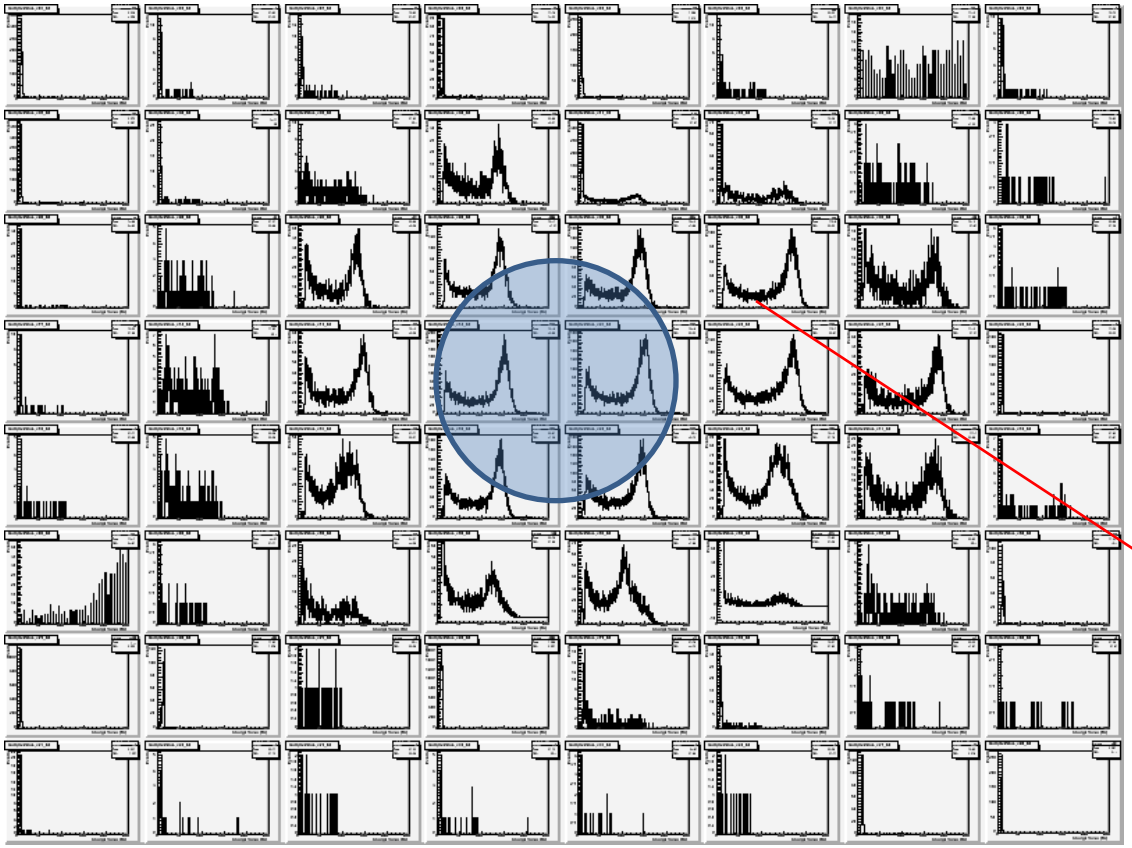
ore info about kpix-readout from. hi te talk

THGEM Chamber Setup 2



THGEM + KPiX: Preliminary results 1

Double THGEM detector – Self Trigger operation
Irradiation: 6keV non-collimated x-rays



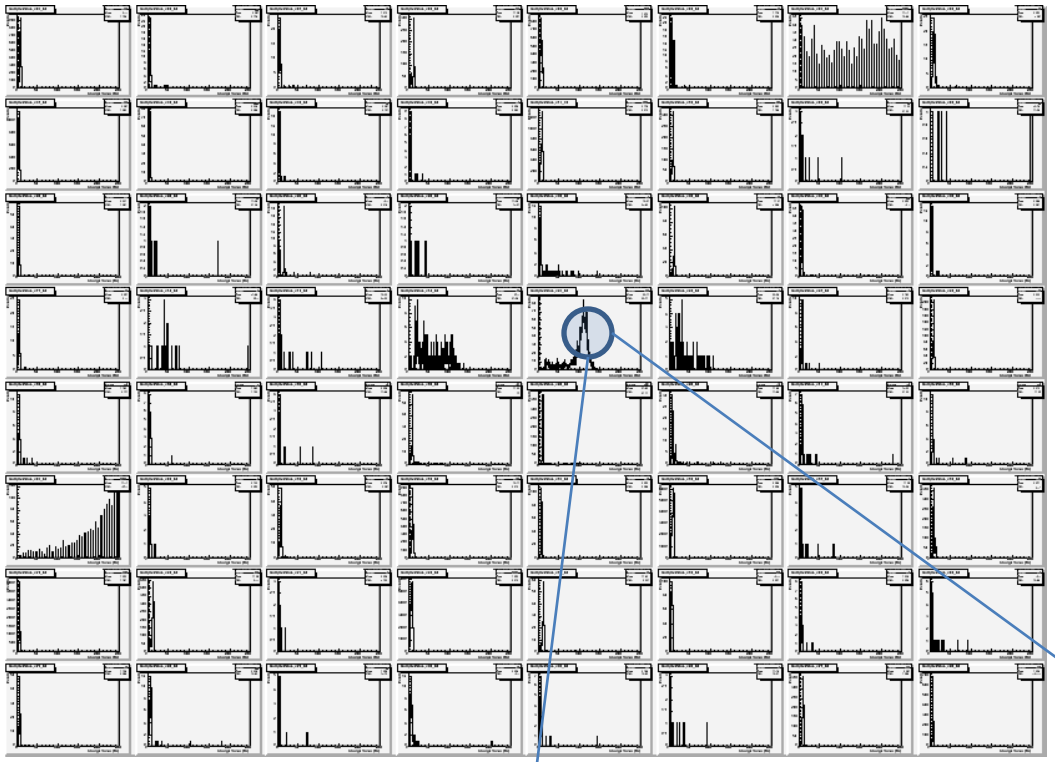
$NE/5\%CH_4$
Gain ~ **$2x10^3$**
100 fold below max!

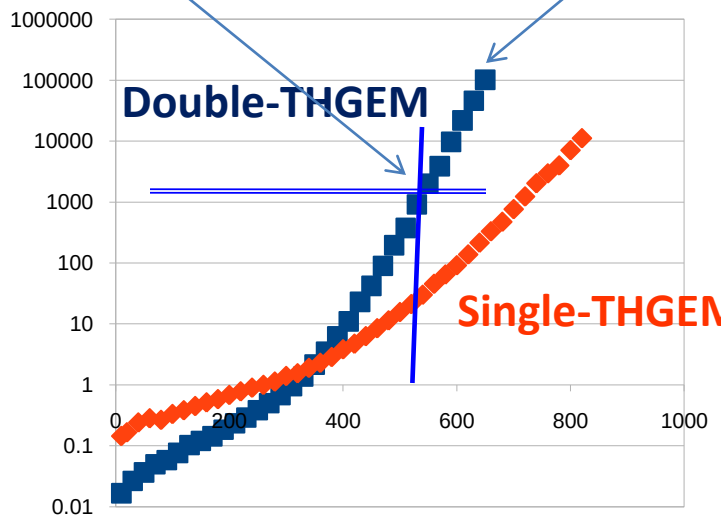
Tails due to charge sharing between neighbor pads

THGEM + KPiX: Preliminary results 2

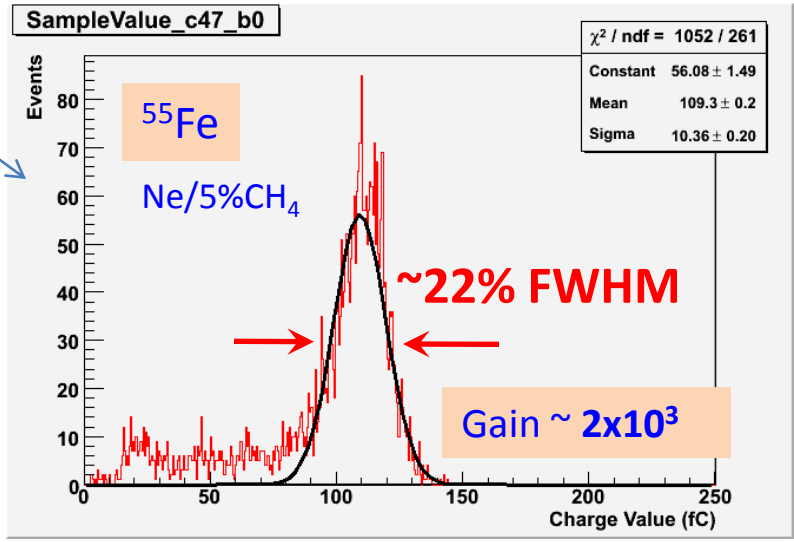
Ne/5%CH_4, operation Gain ~ **$2x10^3$**

Max Gain ~ **10^5**





^{55}Fe X-rays (5.9 keV) **COLLIMATED**



STABLE LONG-TERM OPERATION WITH ^{55}Fe

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DHCAL/THGEM: Future plans

1) Characterization and optimization of the small (10x10 cm^2) THGEM-based detector prototype with MIP (beta/cosmic rays)

2) Test beam with small (10x10 cm^2) THGEM-based detector prototype (CERN/FNAL)

3) Production of large (30x30 cm^2) THGEM electrodes (in cooperation with local industry)

4) Design and construction of large-THGEM based detector (30x30 cm^2; 33x100 cm^2)

5) Characterization and optimization of large-THGEM based detector in DHCAL (CALICE)

Cryo-THGEM applications

Noble-gas detectors

Charge &/or scintillation-light detection

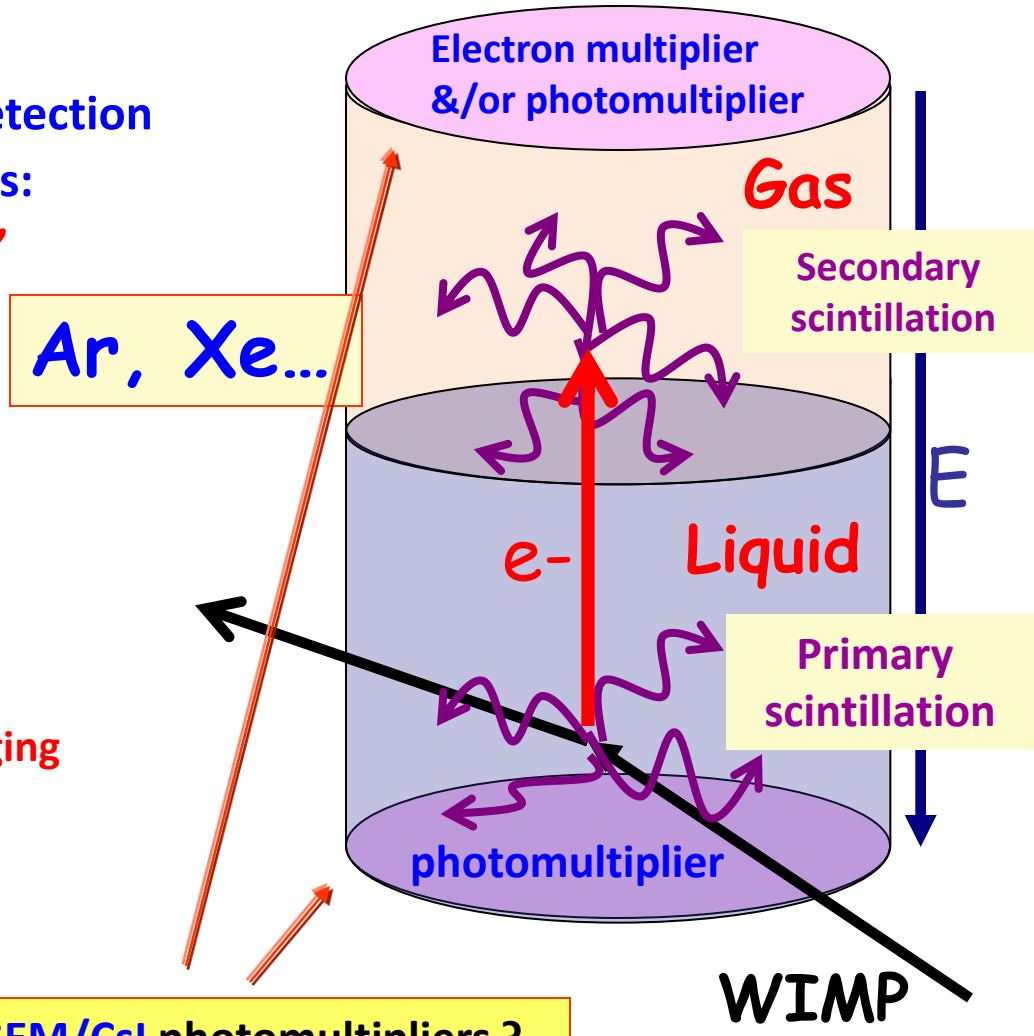
in liquid phase

or

Charge &/or scintillation-light detection

In gas phase of noble liquids:

"TWO-PHASE DETECTORS"



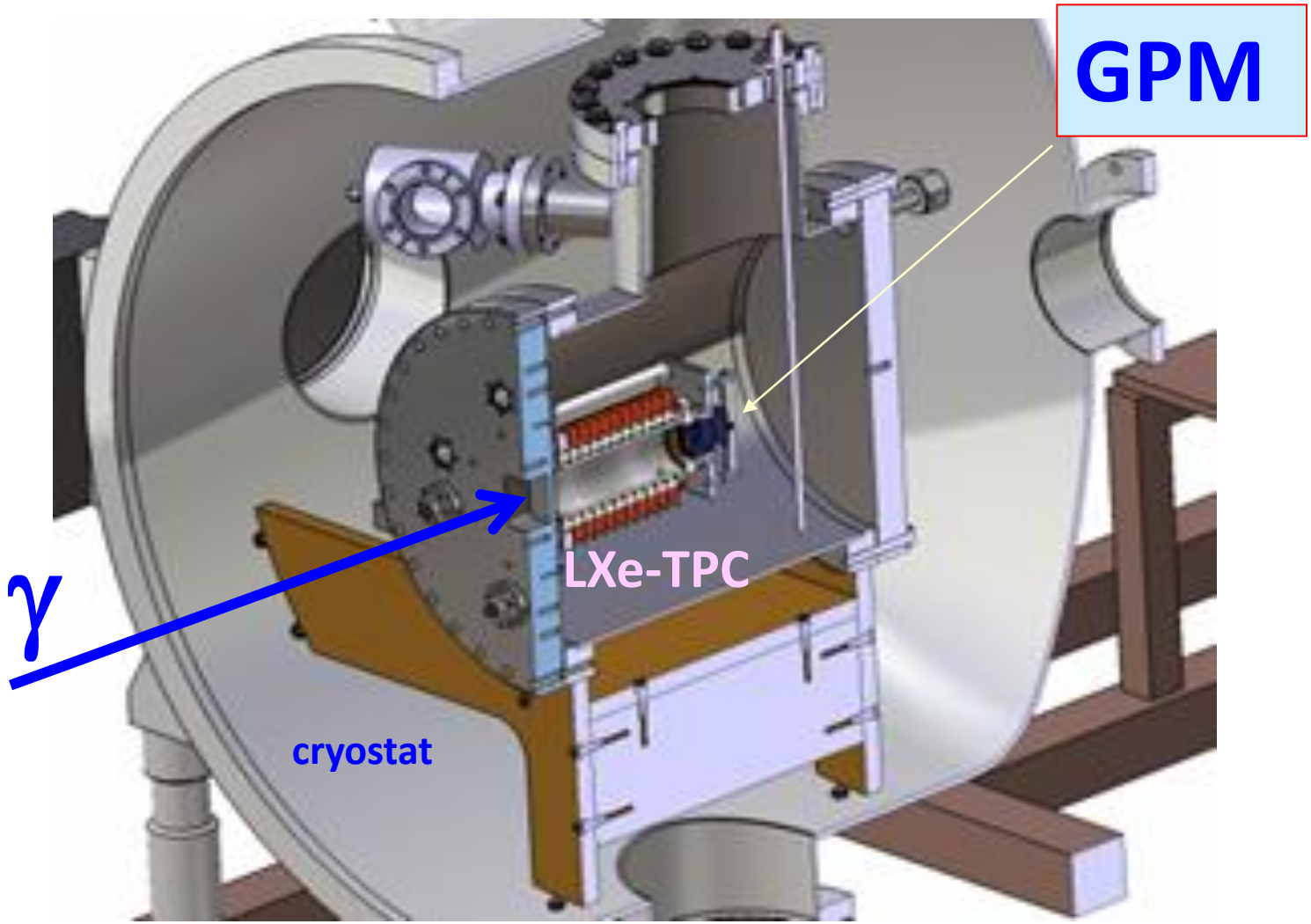
Possible applications:

- Noble liquid ionization **calorimeters**
- Noble-Liquid **TPCs** (**solar neutrinos**)
- Two-phase detectors for **Rare Events**
  (WIMPs, ββ-decay, ν …)
- **Noble-liquid γ-camera for medical imaging**
- Gamma astronomy
- Gamma inspection
- .....

Use THGEM electron multipliers & THGEM/CsI photomultipliers ?

XEMIS LXe Compton Camera

Nantes/Weizmann



Tests in LXe: May 2010 @ Nantes

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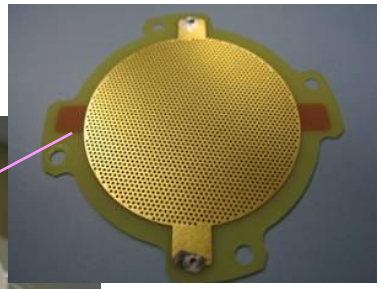
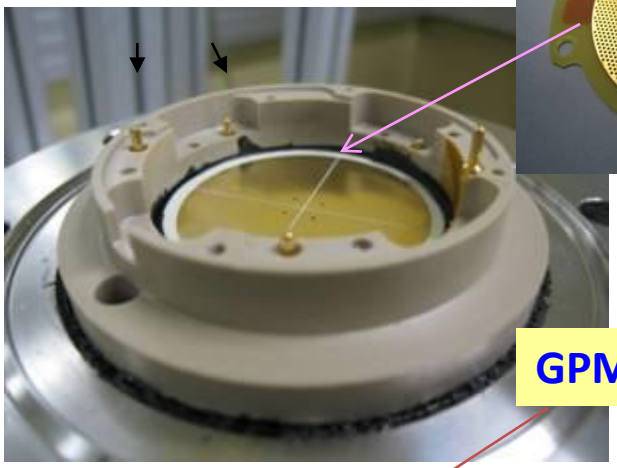
Cryo-GPM for LXe Medical Compton Camera

Subatech-Nantes/Weizmann

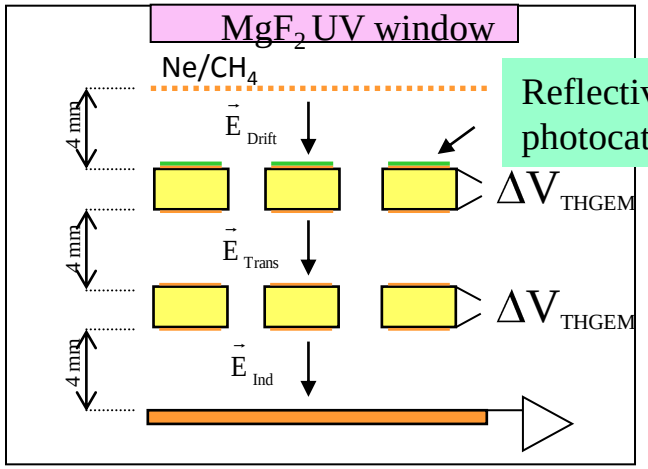
2009 *JINST* 4 P12008





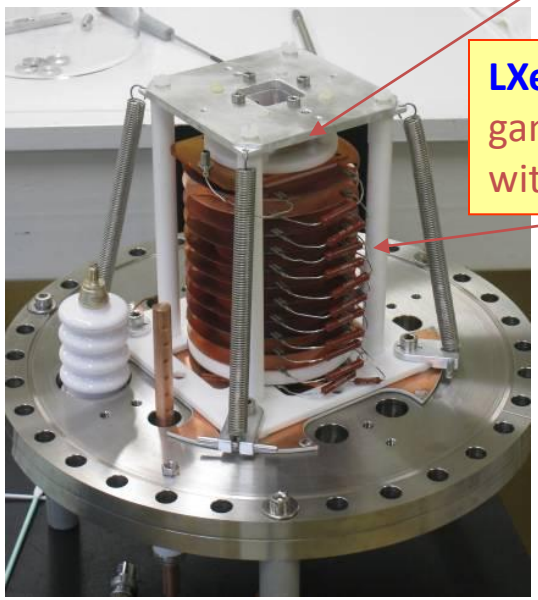
GPM location

THGEM : thickness = 400 μm
hole Ø = 300 μm
hole spacing = 700 μm
rim size = 50 μm

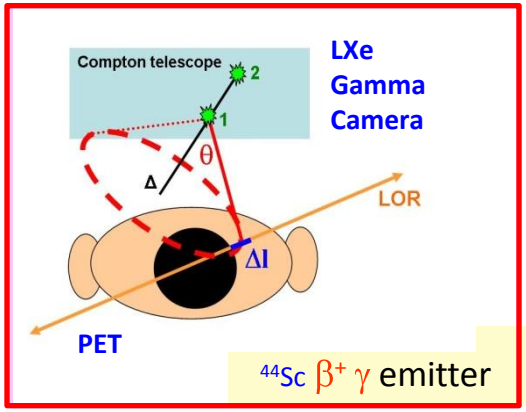


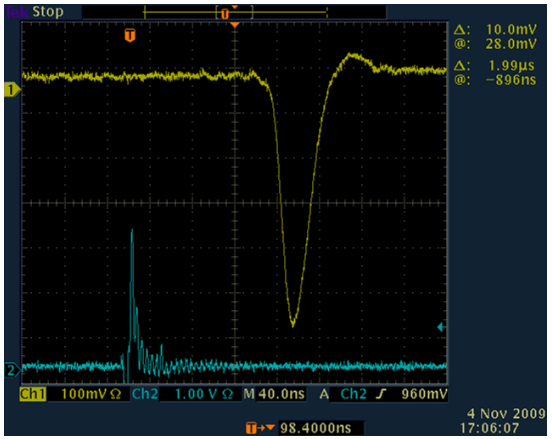
Reflective **CsI** photocathode

Double-THGEM layout



LXe TPC
gamma-converter
with field shaping





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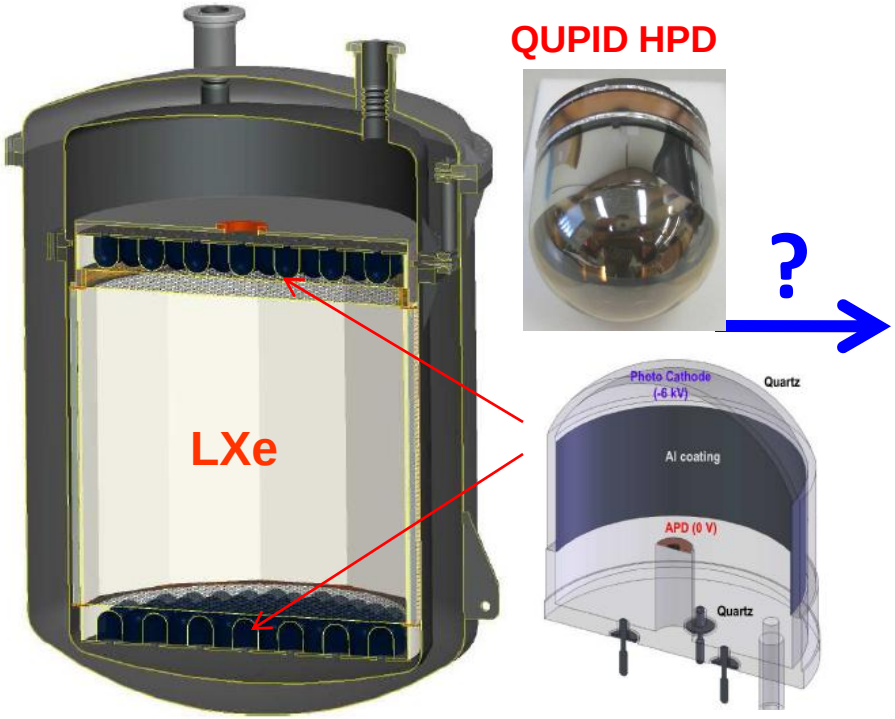
2-phase DM detectors

Aprile/XENON

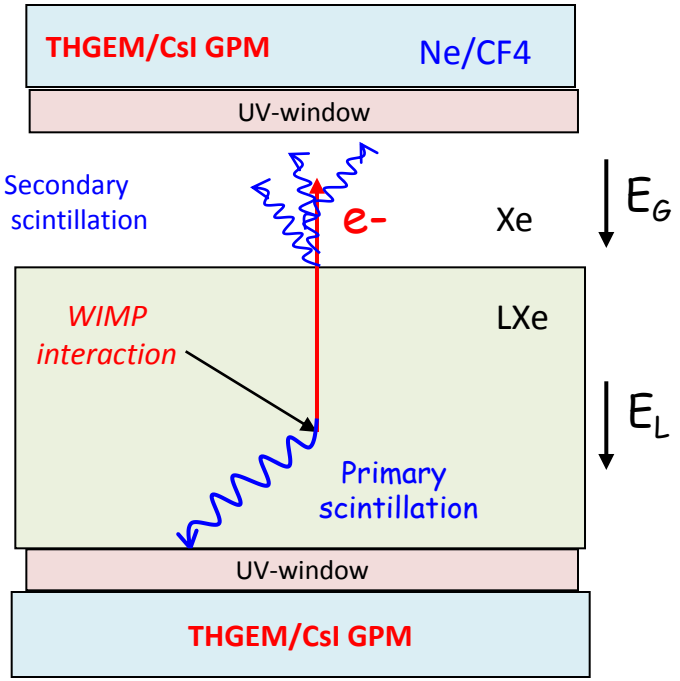
Proposed design of XENON 1ton



Possible design of the XENON 1 ton two-phase LXe DM TPC detector with ~ 121 **QUPID** vacuum photon detectors. Background: **1mBq/tube**

Expectation: < 1 WIMP interaction/Kg/Day

RD51: Weizmann/Nantes/Coimbra



THGEM-GPM (gas photomultiplier):

- Simple, flat (save LXe), robust
- Low-cost
- Can be made Radio-clean ?
- Lower thresholds ?

XENON100Kg: running with PMTs!

PROBLEM: cost & natural radioactivity of multi-ton detectors!

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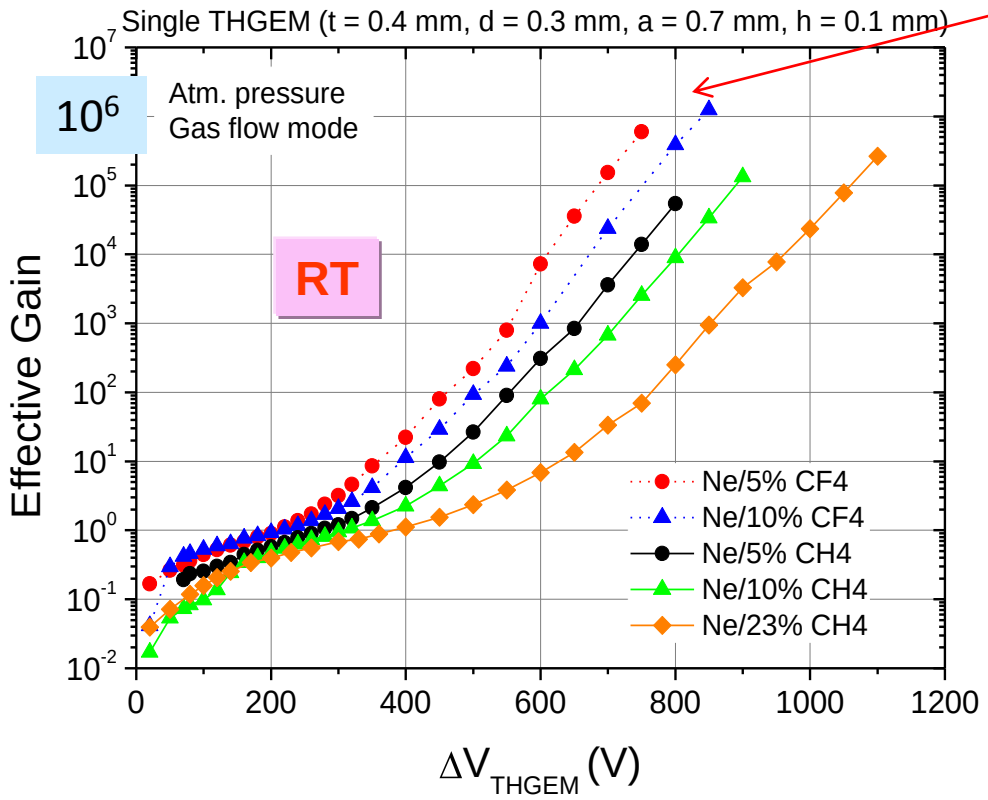
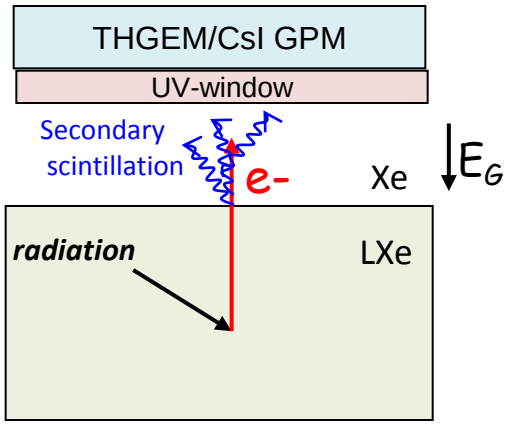
Cryo-GPM with windows

2-phase or liquid scintillators

Best operation, confirmed at **RT**: **Ne/CH_4 or Ne/CF_4**

Higher gain & lower HV





GPM in noble-gas: gain affected by lack of impurities **arXiv:1001.4741**

GPM w window: better control of counting gas / stability

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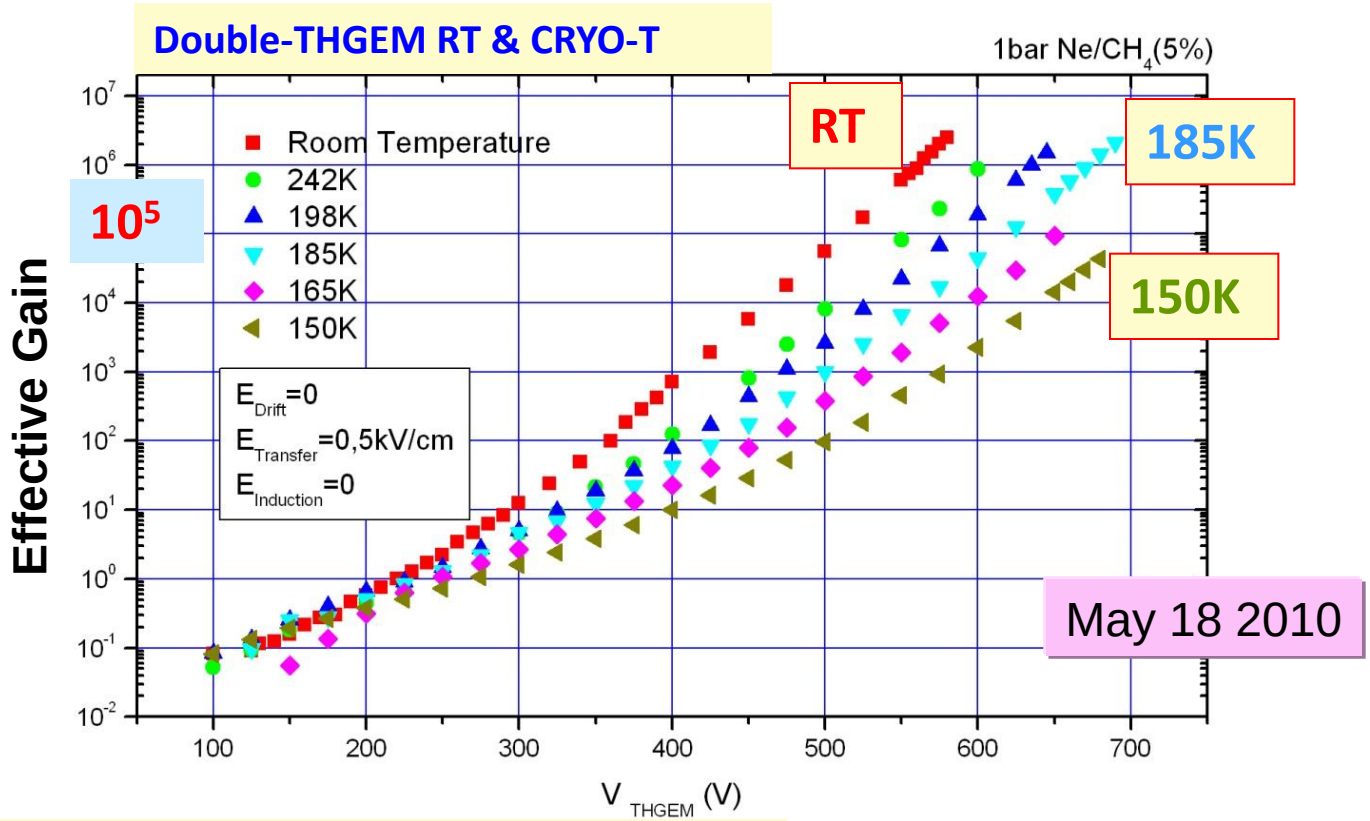
Double-THGEM/CsI at RT & CRYO-T

Preliminary results @ CRYO-T in "improvised" setup at Weizmann
Cryo-medium: LN_2/ethanol
Soon: studies at Nantes with LXe TPC



Samuel Duval, Ran Budnik, Artur Coimbra & Marco Cortesi (WIS)

Preliminary results in Ne/CF4 @ Coimbra: at RT, similar gain @ 1-3 bar

Cryo-THGEM : Future plan

1) Characterization and optimization of the small (3x3 cm^2) THGEM-based detector prototype in cryogenic conditions (LN_2/ethanol; LXe)

2) Design and construction of a 100mm diameter GPM and tests in scintillation & double-phase detector modes
(in double-phase: using XENON10 TPC)

3) R&D for design and production of radio-clean THGEM (Cirlex, Teflon, …) for Dark Matter

4) Characterization and optimization of THGEM-based pixilated GPM readout schemes.

SUMMARY

- **THGEM** a versatile robust electron multiplier
- Good suitability for photon detection with **Ne-mixtures**
  - **-) Low voltage → Better stability, No demage induced by discharges**
  - **-) High Gain, even with single THGEM → small detector thickness**
  - **-) Larger dynamic range → Good stability in background enviroment**
- Potential applications @ **RT & low-T**

Sampling elements for Digital Hadron Calorimeters

Cryogenic UV-photon detectors for medical imaging and dark matter

UV-photon detectors for RICH

Neutron-imaging detectors

Large-area moderate-resolution tracking detectors