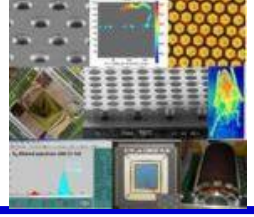
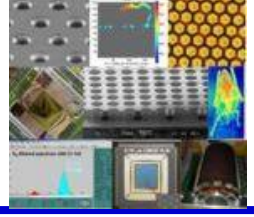


The gain in THGEM multipliers and its time-evolution

M. Alexeev[a], R. Birsa[b], F. Bradamante[c], A. Bressan[c], M. Büchele[d], M. Chiosso[a], P. Ciliberti[c], S. Dalla Torre[b,*], S. Dasgupta[c,†], O. Denisov[e], V. Duic[c], M. Finger[f], M. Finger Jr[f], H. Fischer[d], B. Gobbo[b], M. Gregori[b], F. Herrmann[d], K. Königsmann[d], S. Levorato[b], A. Maggiora[e], N. Makke[c], A. Martin[c], G. Menon[b], K. Novakova[b,g,‡], J. Novy[f], D. Panzieri[h], F.A. Pereira[i], C.A. Santos[b], G. Sbrizzai[c], P. Schiavon[c], S. Schopferer[d], M. Slunecka[f], F. Sozzi[b], L. Steiger[b,g,§], M. Sulc[g], S. Takekawa[a], F. Tessarotto[b] and J.F.C.A. Veloso[i]

based on the M. Alexeev *et al.* 2015 *JINST 10* P03026
also published as RD51-NOTE-2015-001

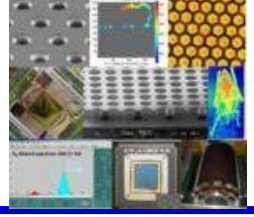


INTRODUCTION

It is a SUMMARY of our studies about gain in THGEMs

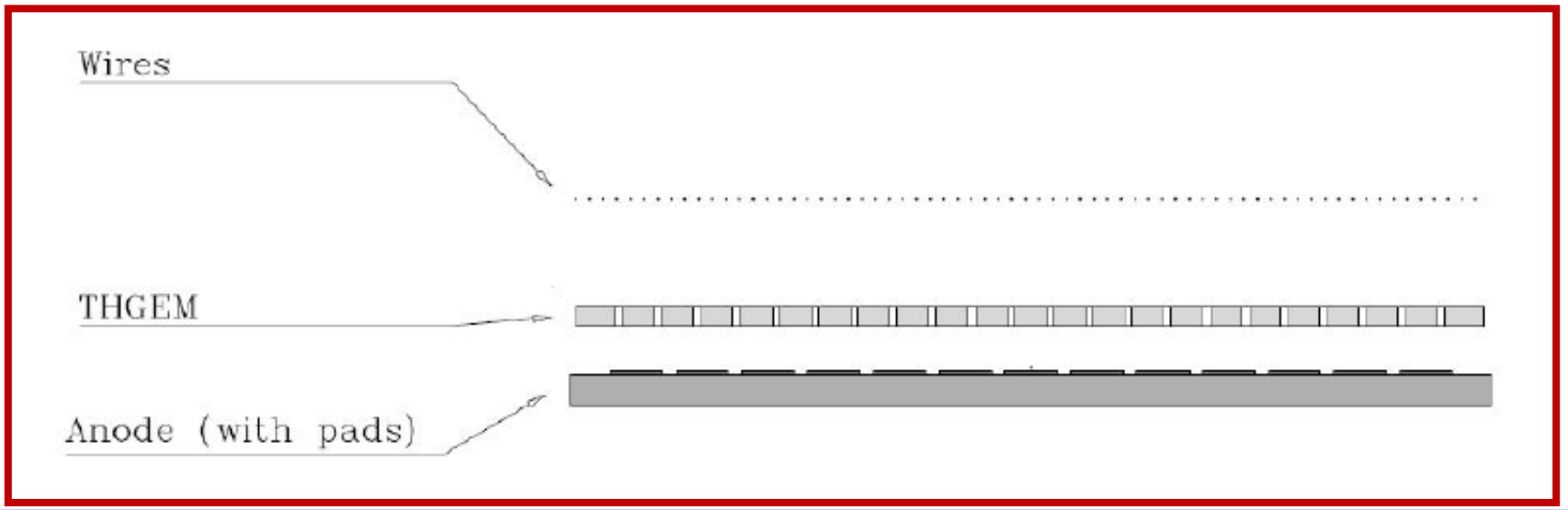
- **Its dependence on geometrical parameters**
- **Its time evolution**
  - **Relevant to evaluate its impact in experiments**
  - **Gain time-evolution observed in detectors with open insulator surfaces (Iarocci tubes, MSGCs, GEMs, …)**

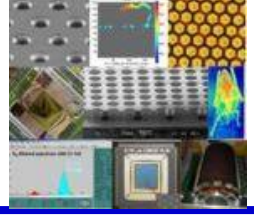
Part of the material has already been shown in past RD51 meetings



METHOD

- Single layer
- Gas: Ar : CO_2 = 70 : 30
- X-ray source
- measuring anode amplitude and/or
- the current absorbed by all the electrodes
- ~50 different geometries studied over yaers → here a summary of the conclusions with examples



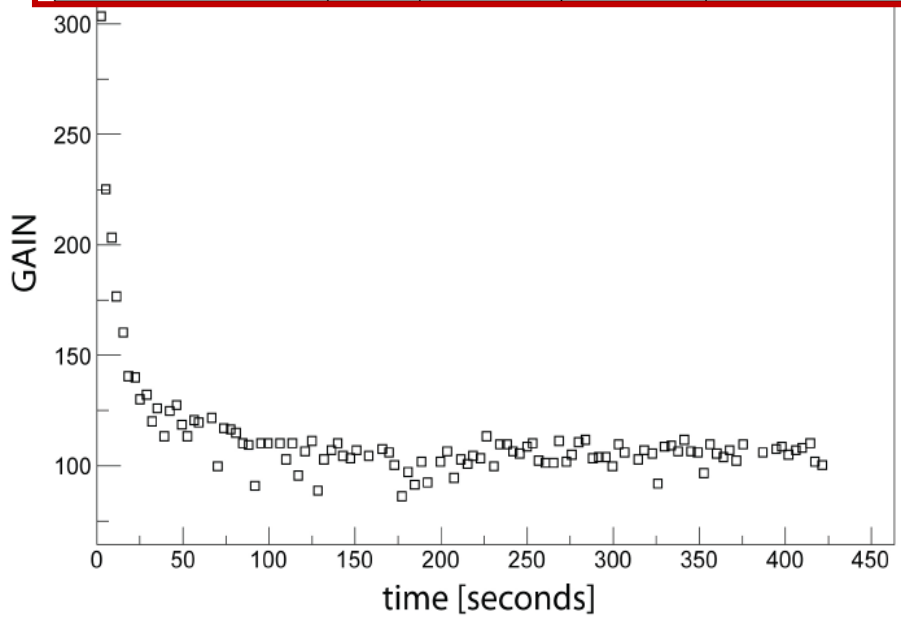


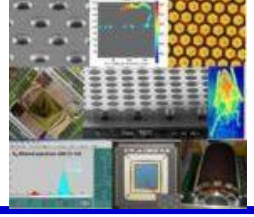
TIME-EVOLUTION OF THE GAIN: 2 DISTINCT PHENOMENA

1. Fast evolution (~ 1'-20')

- **Due to charge accumulation at the free dielectric surface**
- **Time duration depends on open surface, HV, irradiation rate**
- **Due to the accumulated charge: E reduction**
  - **If HV is applied too quickly, discharges at switching on**
- **Qualitatively understood**
- **Quantitatively: simulation approaches started**
  - M. Alfonsi et al., Nucl. Instr. and Meth. A671 (2012) 6
  - P.M.M. Correia et al., JINST 9 (2014) P07025.

THGEM geometry: type	pitch mm	diameter mm	thickness mm	rim annulus width μm
A	0.2	0.4	0.2	40





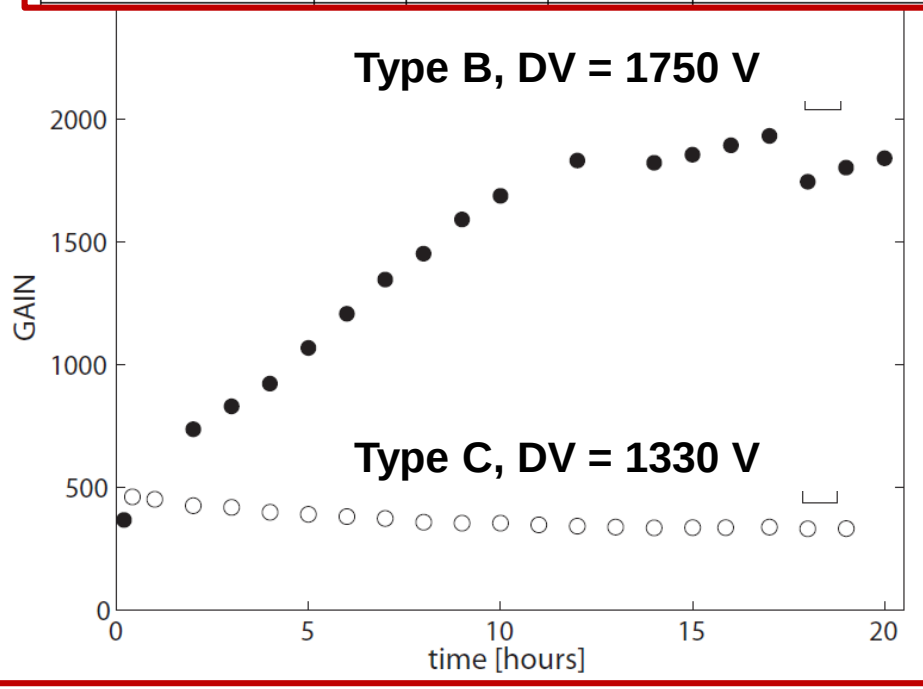
TIME-EVOLUTION OF THE GAIN: 2 DISTINCT PHENOMENA

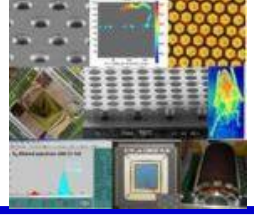
2. Long-term time-evolution (d)

- It takes one or more days
- Δ Gain covers a large range:
  x 1.2 - 5
- The gain can rise/decrease vs time
- Understanding ?
  - Due to <u>charge mobility inside the dielectric</u> (?)
  - See later

Continuos irradiation (X-ray)

THGEM geometry: type	pitch mm	diameter mm	thickness mm	rim annulus width μm
B	0.8	0.4	0.4	100
C	0.8	0.4	0.4	0



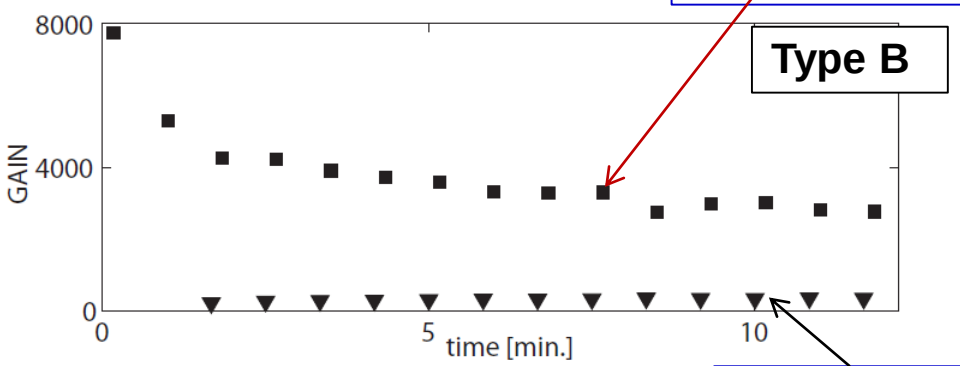


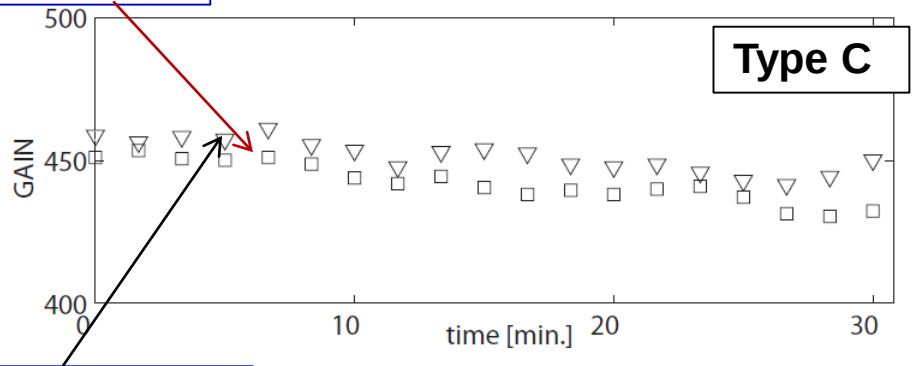
GAIN & RIM

- **Large rim : ~ 100 μm**
  - **introduced to obtain large gains, up to 1 order of magniture more !**
- **Small rim (< 20 μm) or no rim**
  - **Largely reduced gain-evolution**

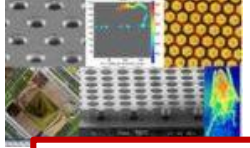
THGEM geometry: type	pitch mm	diameter mm	thickness mm	rim annulus width μm
B	0.8	0.4	0.4	100
C	0.8	0.4	0.4	0

irradiating with X-ray after keeping nominal voltage for 10 h without irradiation



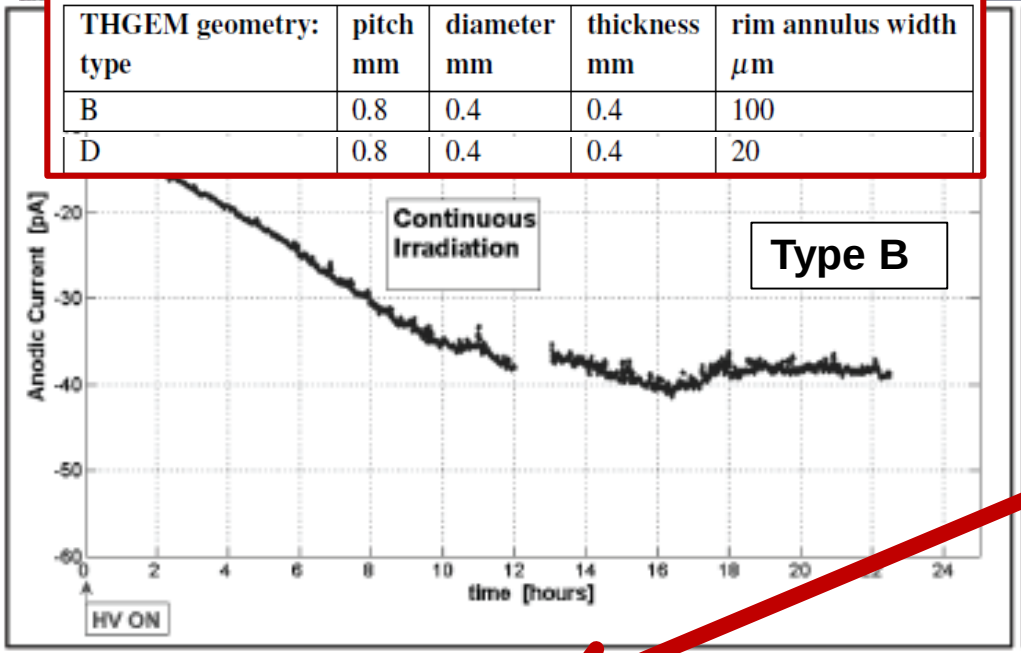


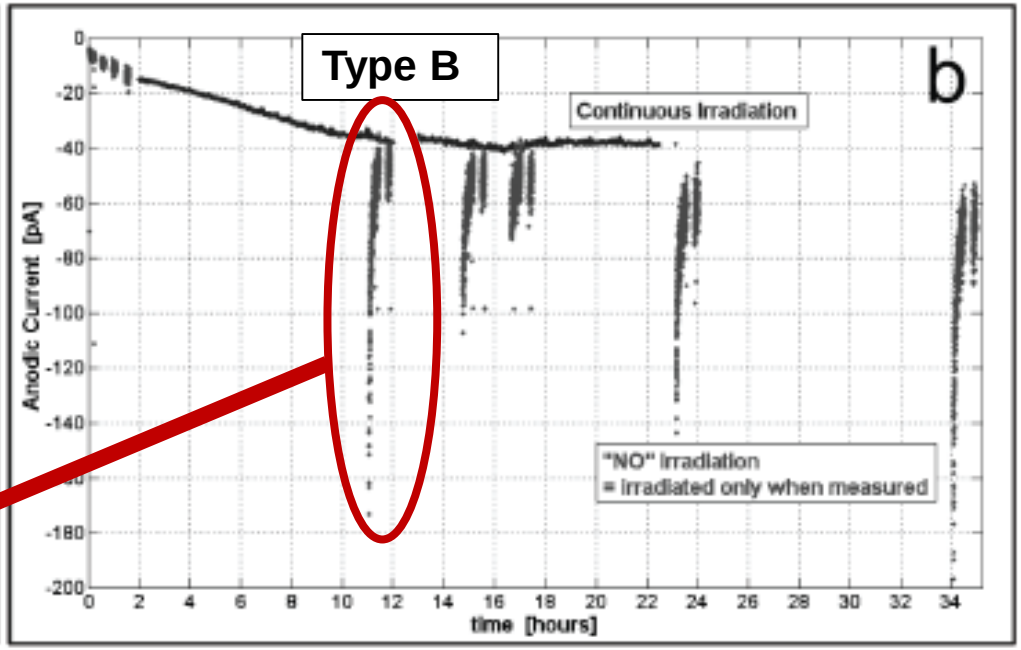
exposing to X-ray irradiation at voltage switching on, after 24 h off

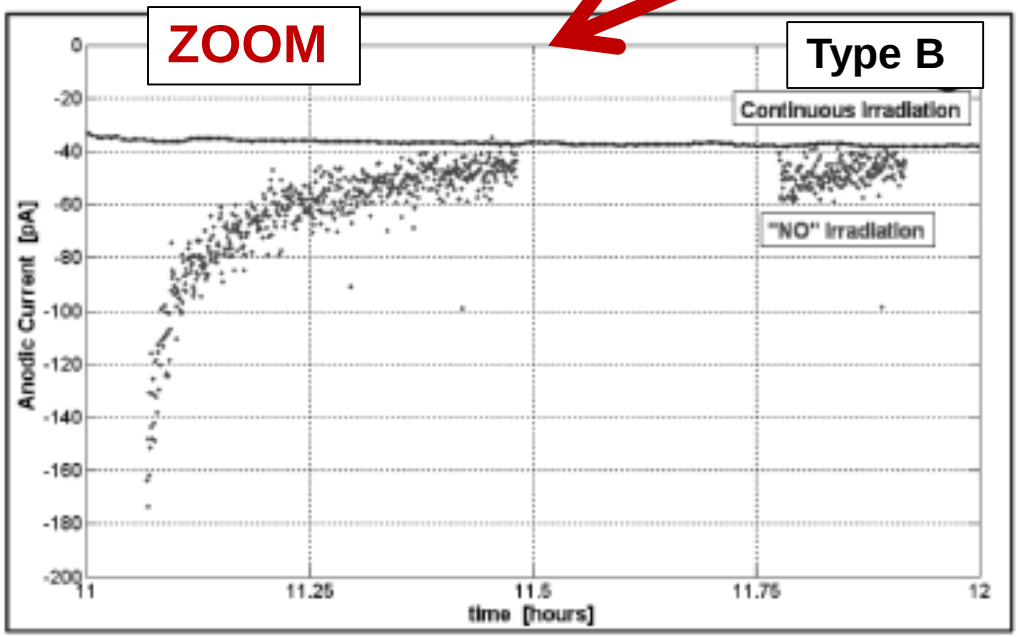


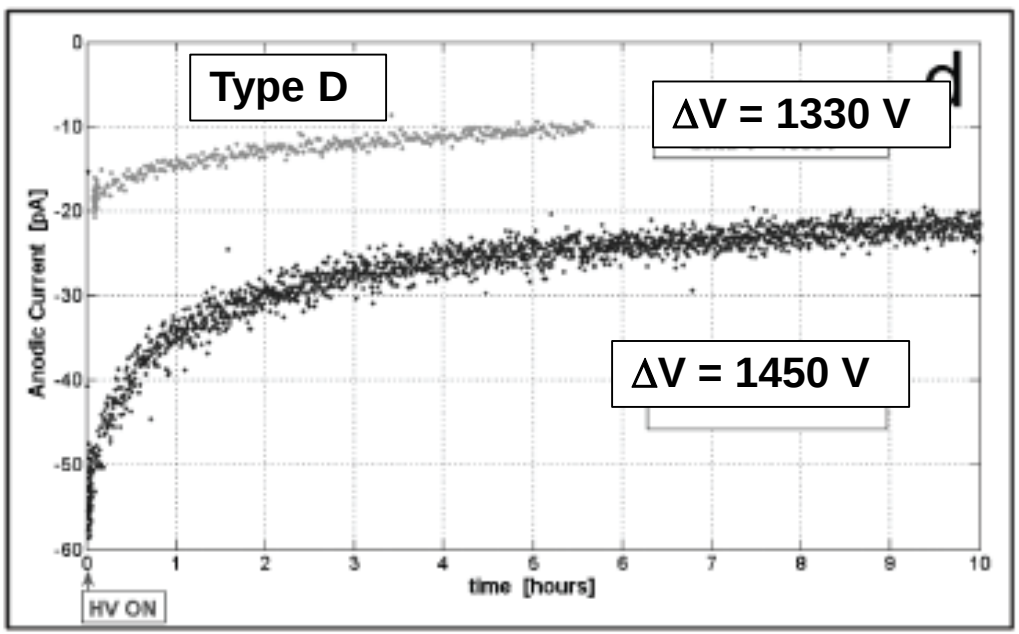
MONITORING BY CURRENTS

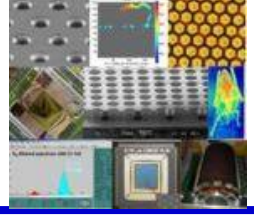
THGEM geometry: type	pitch mm	diameter mm	thickness mm	rim annulus width μm
B	0.8	0.4	0.4	100
D	0.8	0.4	0.4	20









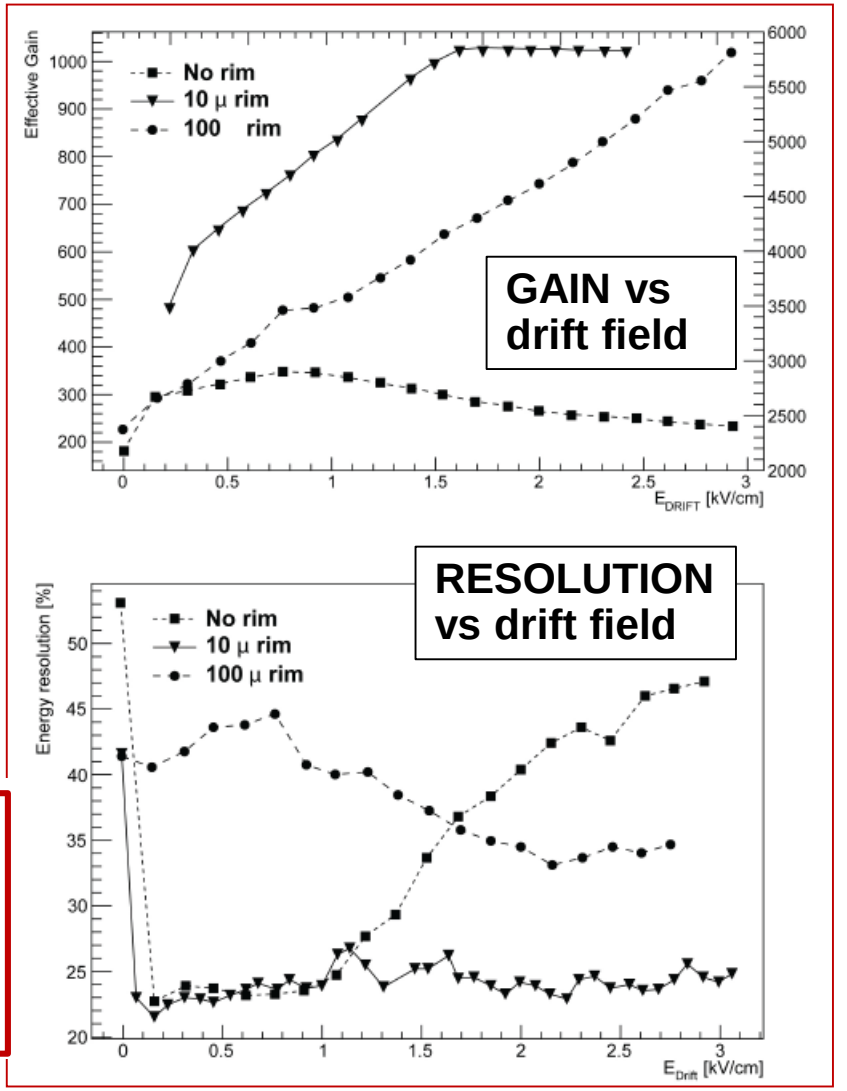


RIM & CHARGE COLLECTION

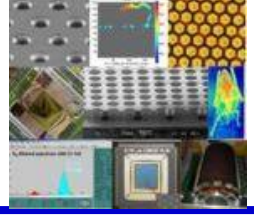
Up to E_drift as high as 3 kV/cm good resolution is not reached in spite of the large gain

→

incomplete electron collection is suggested

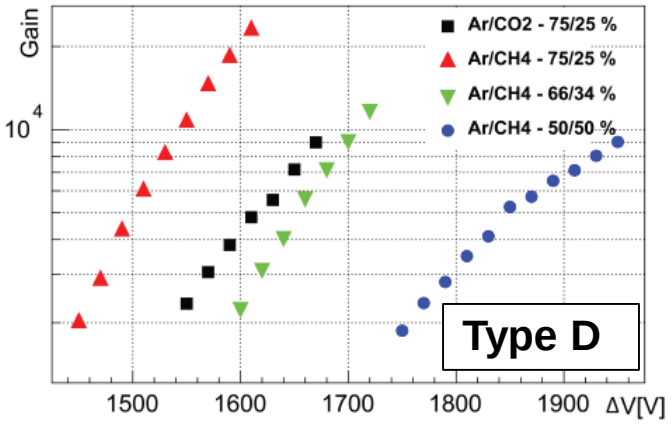


THGEM geometry: type	pitch mm	diameter mm	thickness mm	rim annulus width μm
B	0.8	0.4	0.4	100
C	0.8	0.4	0.4	0
E	0.8	0.4	0.4	10

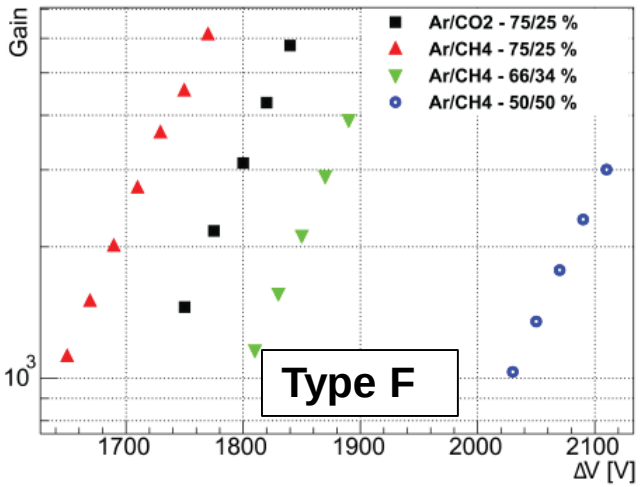


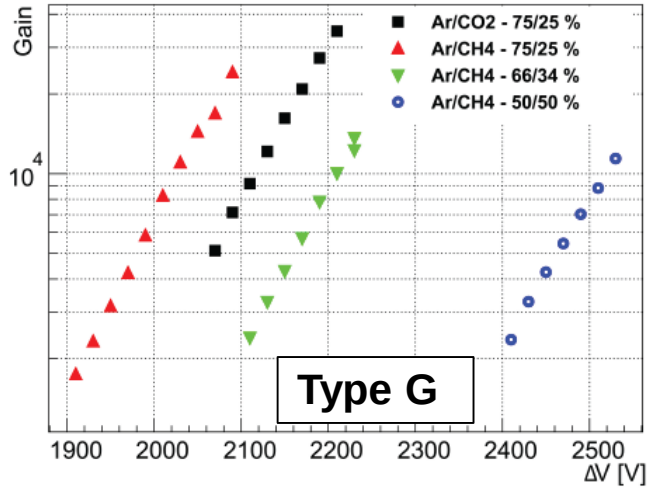
GAIN & THICKNESS

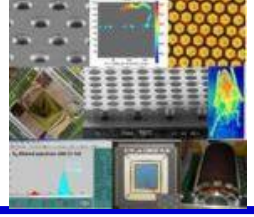
increasing the THGEM thickness, larger maximum gain can be obtained



THGEM geometry: type	pitch mm	diameter mm	thickness mm	rim annulus width μm
D	0.8	0.4	0.4	20
F	0.8	0.4	0.6	0
G	0.8	0.4	0.8	0







LONG-TERM GAIN-EVOLUTION: A QUALITATIVE MODEL

- **A SLOW movement of ions in the PCB fibreglass when power is applied (not dielectric polarization)**
- **EFFECTS:**

i. The field inside a THGEM hole is modified due to the presence of a net charge distribution along the cylindrical hole wall

ii. at the PCB faces, charge migration from the uncoated rim region toward the metallized area takes place

  - **REMARK:** the charge accumulation is screened in the metallized region, not at the uncoated rim annulus and along the hole wall

- no rim or small rim THGEMS: the charge distribution due to (i) generates an electric field opposite to bias one, while effect (ii) is absent or non dominant → gain decreases versus time
- large rim THGEMS: the net charge at the rim surface due to effect (ii) reinforces the bias electric field → gain increases vs time
  - When the detector is irradiated, the accumulated charge distribution partially compensates this gain