Remarks About GEM + Micromegas Structures

Leading Idea:
Fabio Sauli

Measurement Support (GDD team):
Eraldo Oliveri, Dorothea Pfeiffer, Filippo Resnati, Leszek Ropelewski, Miranda van Stenis, Patrick Thuiner

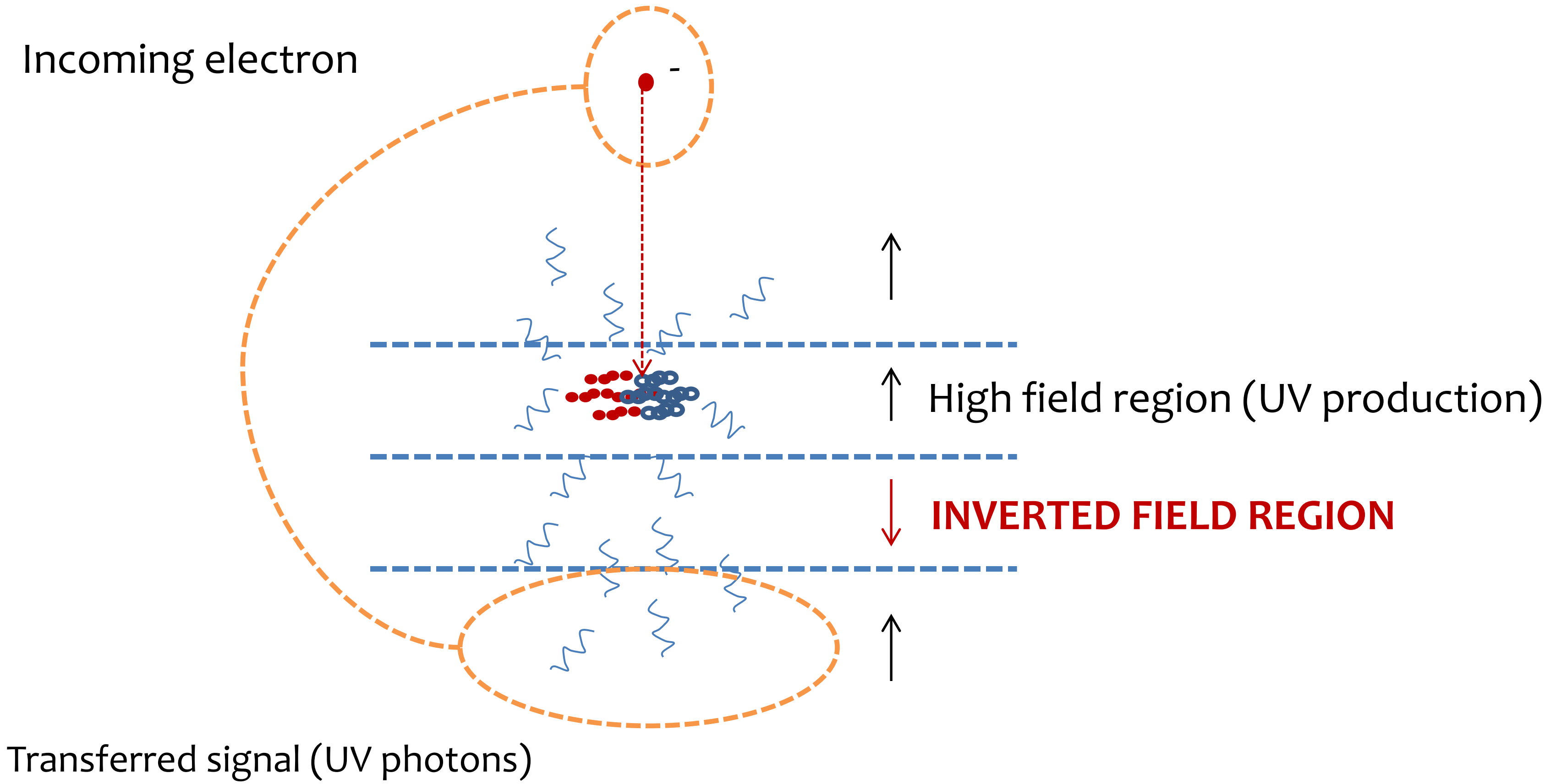
Technical Support(MPGD workshop):
Olivier Pizzirusso, Rui De Oliveira

outline

- The subjects of the talk are IBF and Energy Resolution measurements performed using a double GEM detector with a parallel field pre-amplification and transfer stage on top (PA-GEM, Pre-Amplified GEM)
- The aim is to share what has been observed up to now and provide additional inputs on possible methods to improve detector performances (not necessarily related to ALICE)
- An accurate optimization of the available parameters is missing
- No measurements available (as far as we know) to compare/cross check our results

The starting point: photoelectric gate

Transfer of the signal from above to below the gate without charge transfer but with UV photons due to secondary scintillations in the noble gas



photoelectric gate and solid converter (CsI)

Gaseous Photodetectors with Solid Photocathodes

A. F. Buzulutskov

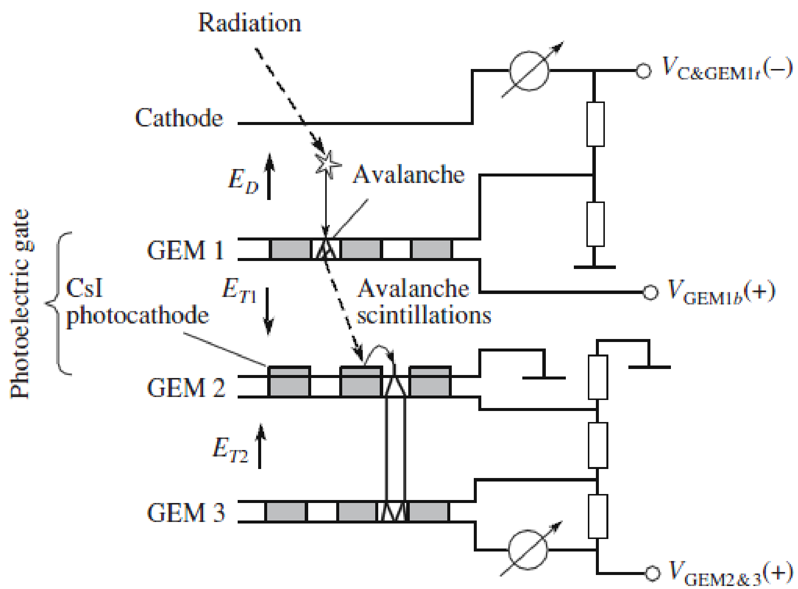


Fig. 6. Multistage GEMs with the photoelectric gate based on opaque CsI photocathode deposited on the second GEM [66]. The photoelectric gate suppresses the ion feedback due to electric field inversion between the first and the second GEMs.

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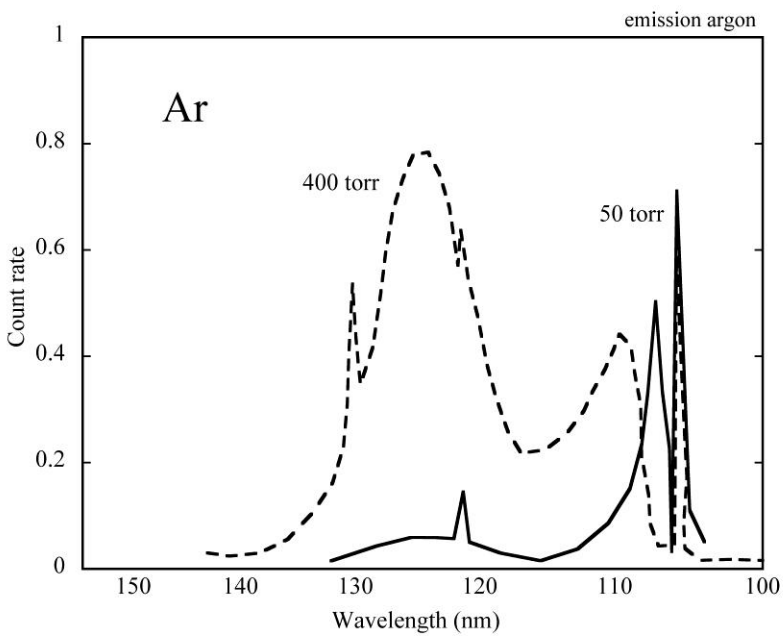
J. F. C. A. Veloso, F. D. Amaro, J. M. F. dos Santos, et al., “The Photon-Assisted Cascaded Electron Multiplier: A Concept for Potential Avalanche-Ion Blocking,” J. of Instrumentation **1, 08003 (2006).**

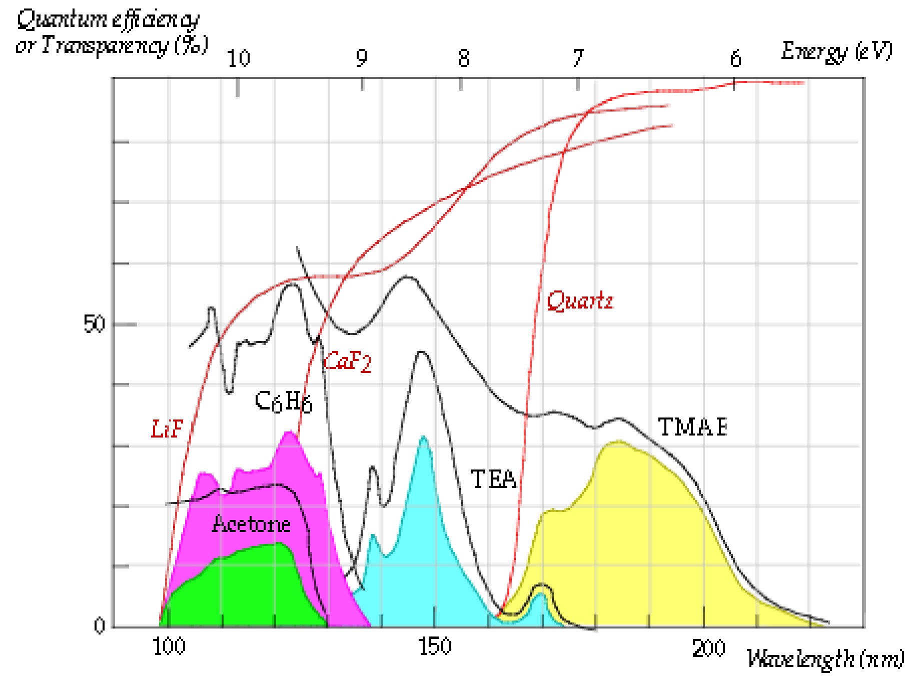
A. Buzulutskov and A. Bondar, “Electric and Photoelectric Gates for Ion Feedback Suppression in Multi-GEM Structures,” J. of Instrumentation **1, 08006 (2006).**

Fabio’s Idea: photoelectric gate and photosensitive vapours

Argon Scintillation Emission

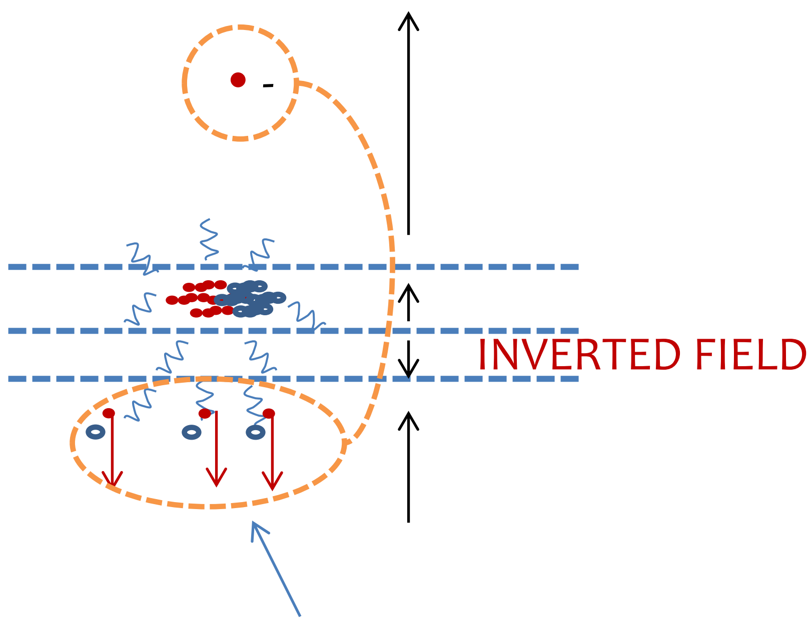


Photosensitive Vapours



Fabio's Idea: photoelectric gate and photosensitive vapours

Transfer of the signal across the meshes without charge but with photons



UV photon detection with photosensitive vapours

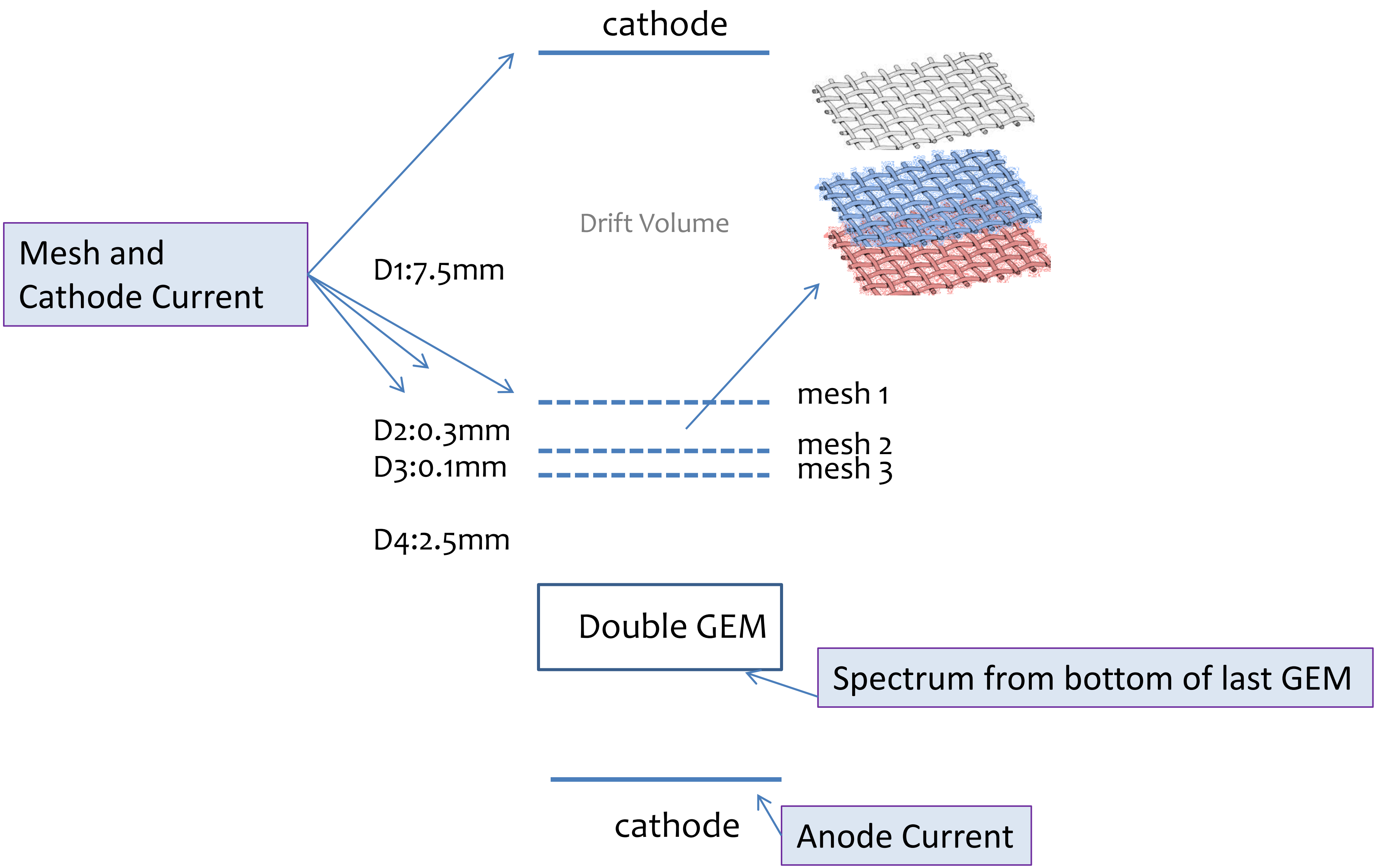
Preliminary result
(TEA and Acetone tested):

A sort of "failure"...

Due to the poor quality of the gas system we cannot state if the idea and the vapours tested are basically wrong.

Measurements have been postponed but we started a set of measurements after the observation of good properties in standard charge transfer mode

Use of our floating meshes as a standard Parallel Field Pre-amplification and transfer stages



Parallel Field Pre-amplification and transfer stages

Volume 78B, number 4 PHYSICS LETTERS

**THE MULTISTEP AVALANCHE CHAMBER:
A NEW HIGH-RATE, HIGH-ACCURACY GASEOUS DETECTOR**

G. CHARPAK and F. SAULI
CERN, Geneva, Switzerland

Received 14 September 1978

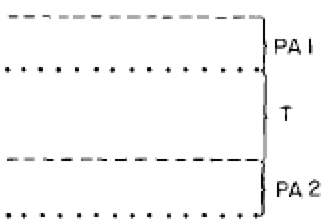
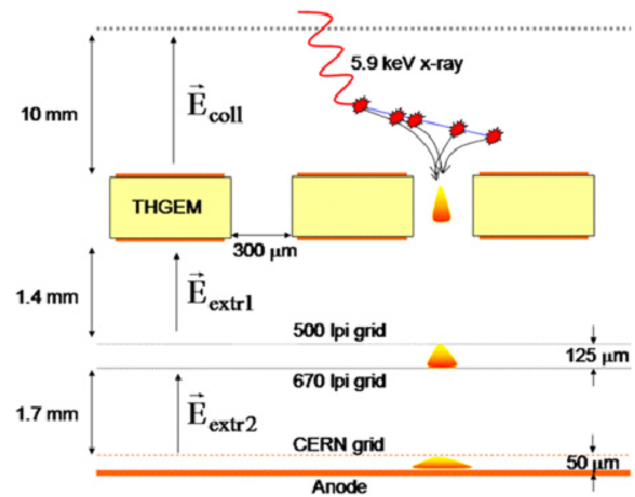


Fig. 1(d)

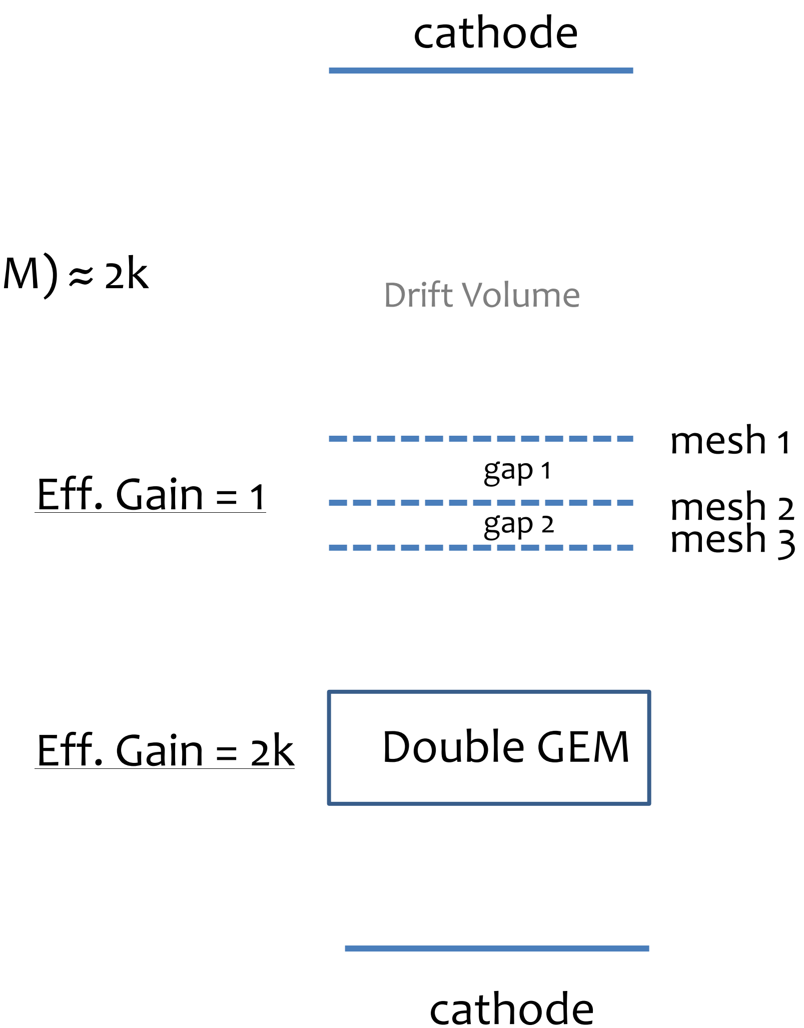
S. Duval et al. / Nuclear Instruments and Methods in Physics Research A 695 (2012) 163–167

The main objective of combining three different micro-pattern detectors was to reach a high gain and efficient photo extraction with a low avalanche ion-backflow to minimize photocathode ageing.



The PIM consisted oftwo5 mm thick electroformed nickel grids with different mesh parameters (500 and670lpi) isolated from each other by a Kapton spacer defining an amplification gap of 125 mm.

IBF measurements



Gas Mixture: Ar/CO 2 90/10

Total effective Gain (three meshes + double GEM) ≈ 2k

Three meshes Effective Gain ≈ 1

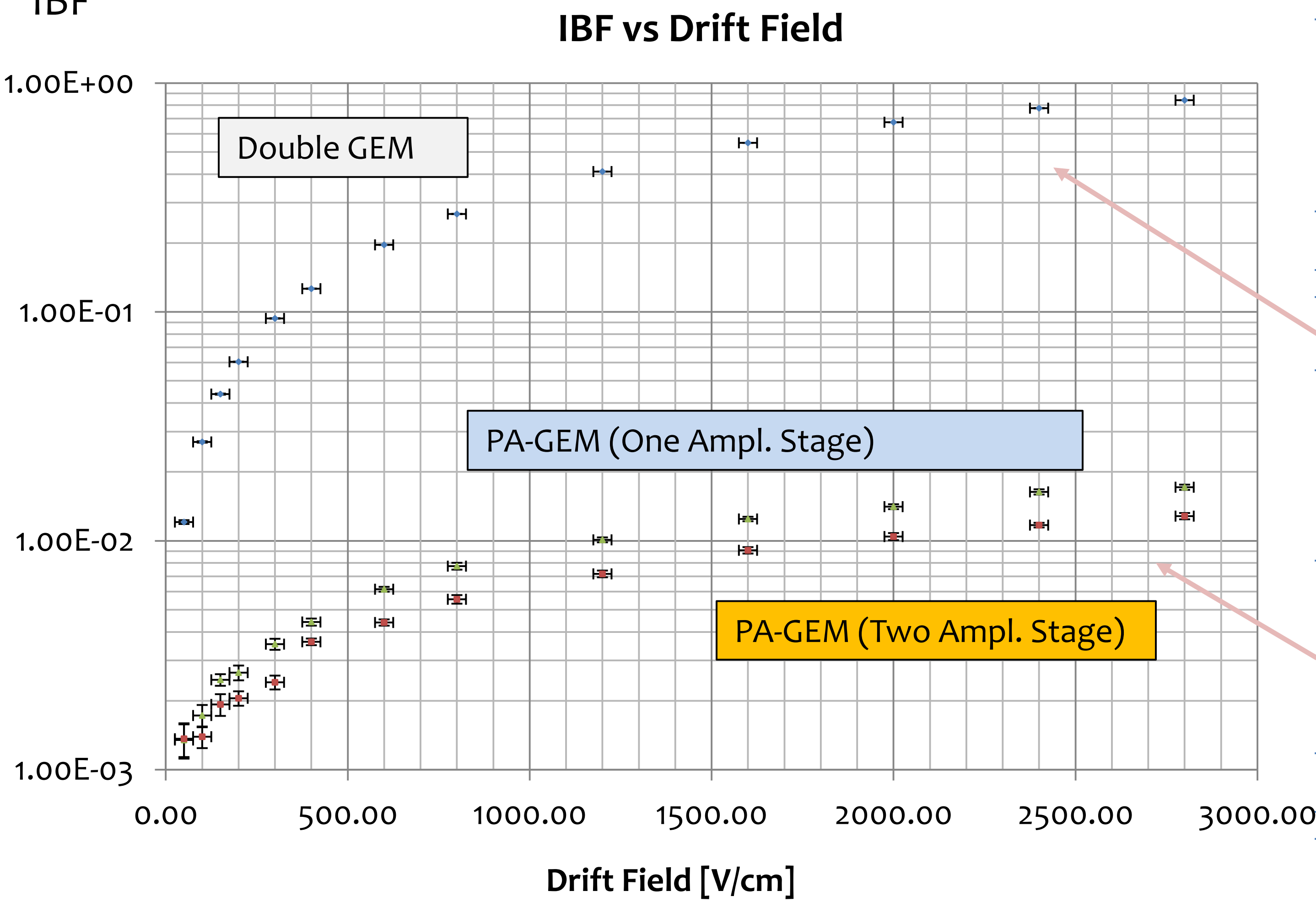
(No Reason to stay with this configuration.
Chosen as a starting point of our investigation to have smaller gain in the meshes' gaps)

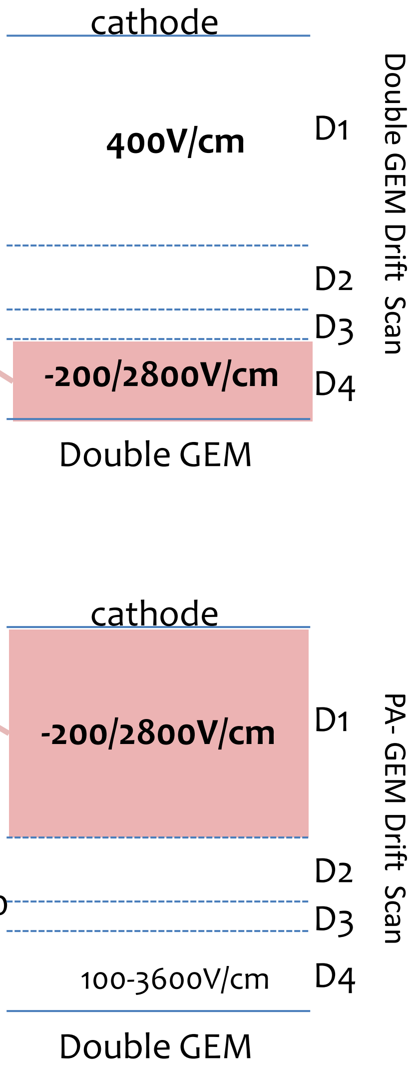
Two different configurations tested:

1. Amplification in gap 1 and transfer in gap 2

2. Amplification in gap 1 and gap 2

IBF





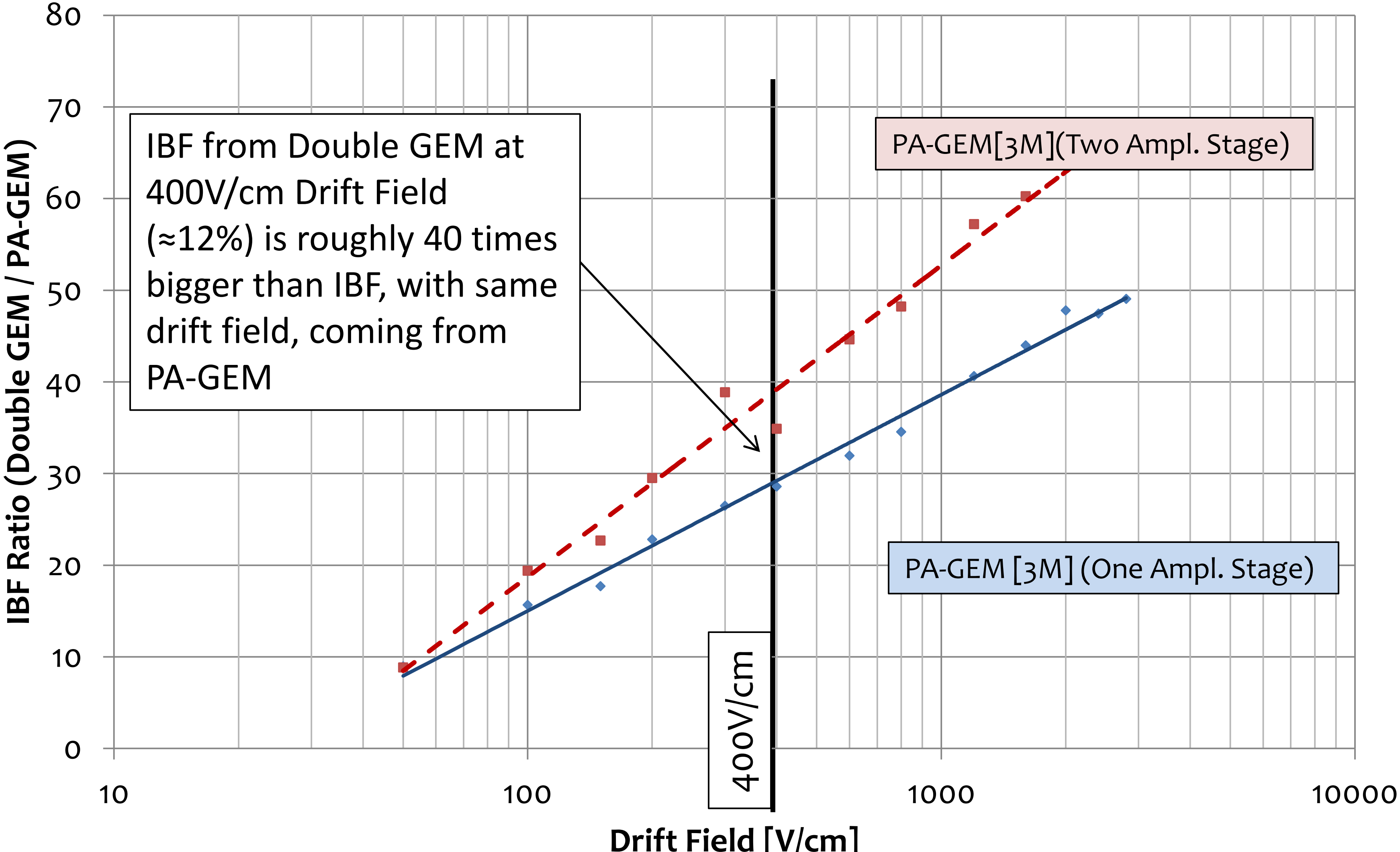
Transfer field between meshes and double GEM = 1.6kV/cm

FIELD CONFIGURATION:
DG: -200/2800
PA-GEM(1AmpStage): -200/2800,21875,3200,1600
PA-GEM(2AmpStage): -200/2800,21200,21200,1600

Source: Cu X-Ray Tube
Collimator: 10 mm diameter
Anode Current ~ 150nA

IBF

IBF ratio between Double GEM and PA-GEM

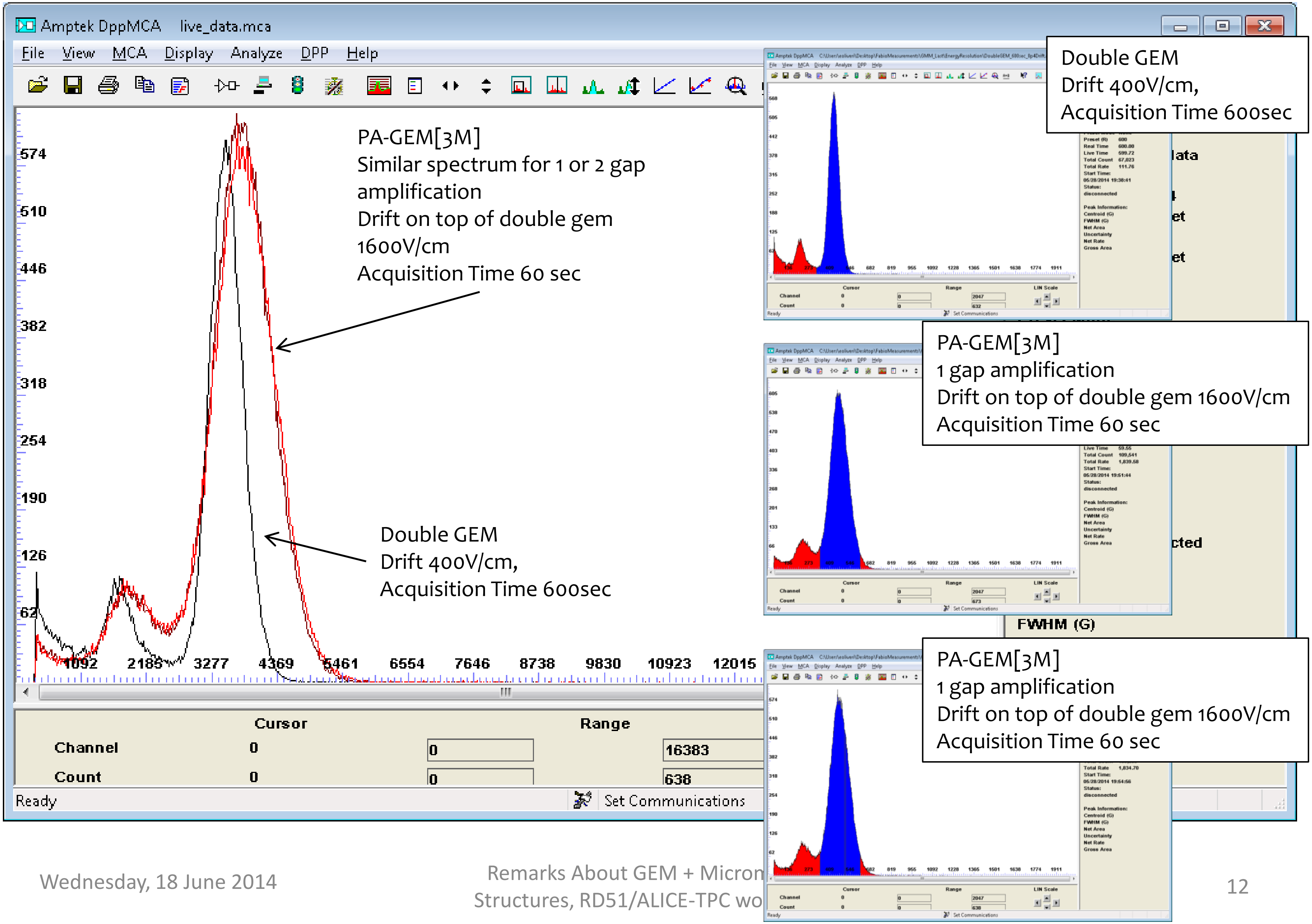


Transfer field between meshes and double GEM = 1.6kV/cm

result referred to the specific field configuration used

Energy Resolution

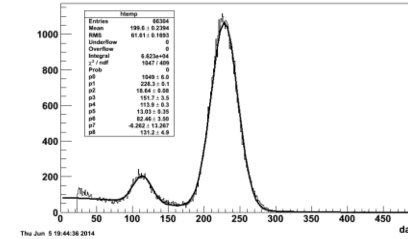
Standard Configuration with PA effective GAIN≈1



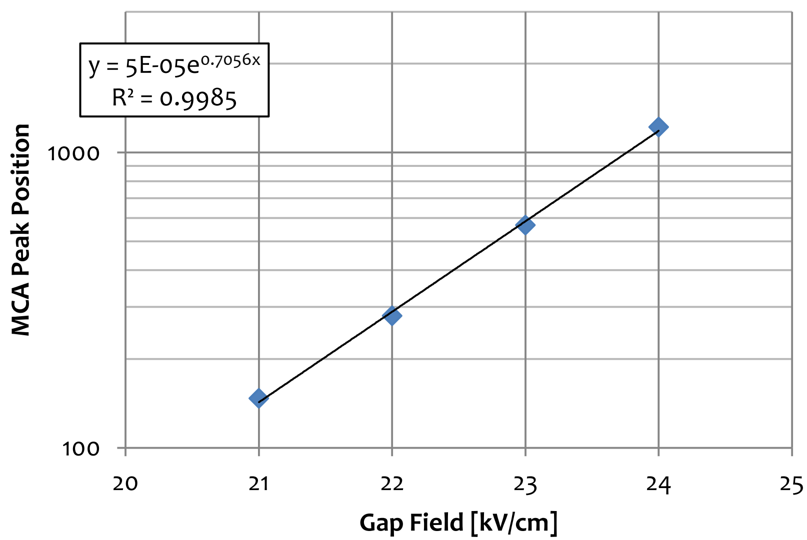
Energy Resolution

PA-GEM (Two Amplification Stages)

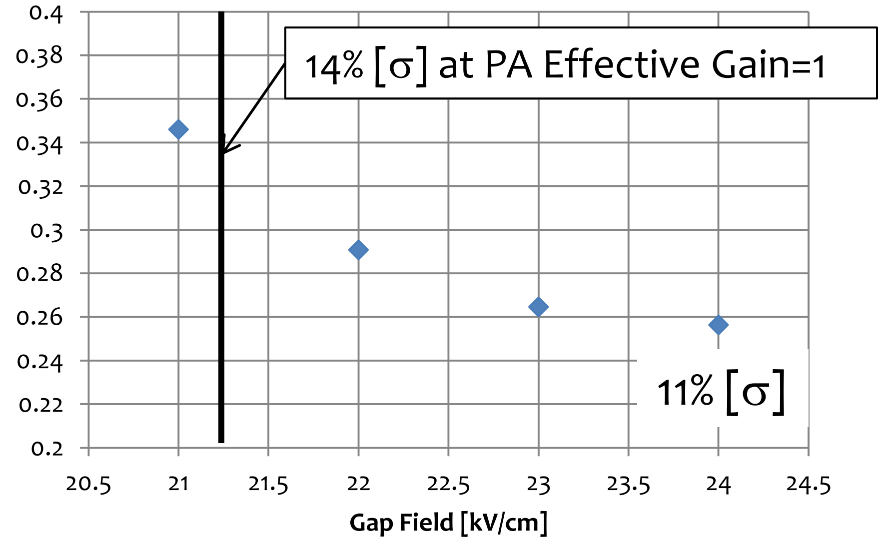
Energy Resolution Double GEM
≈ 19% FWHM [8% σ]

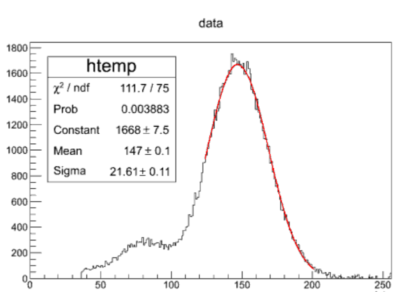


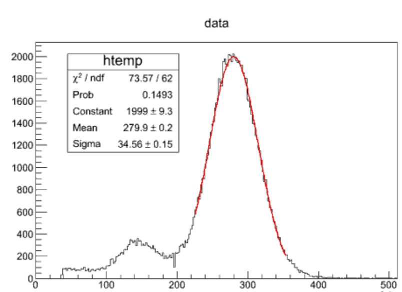
Fe55 Main Peak

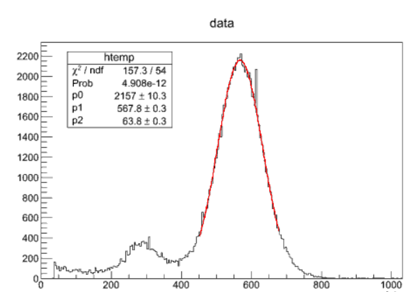


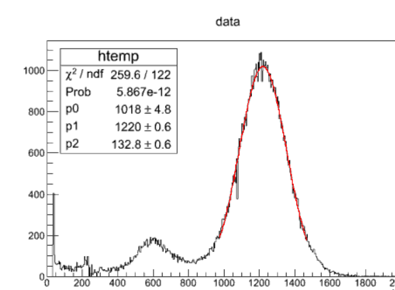
Energy Resolution [FWHM]



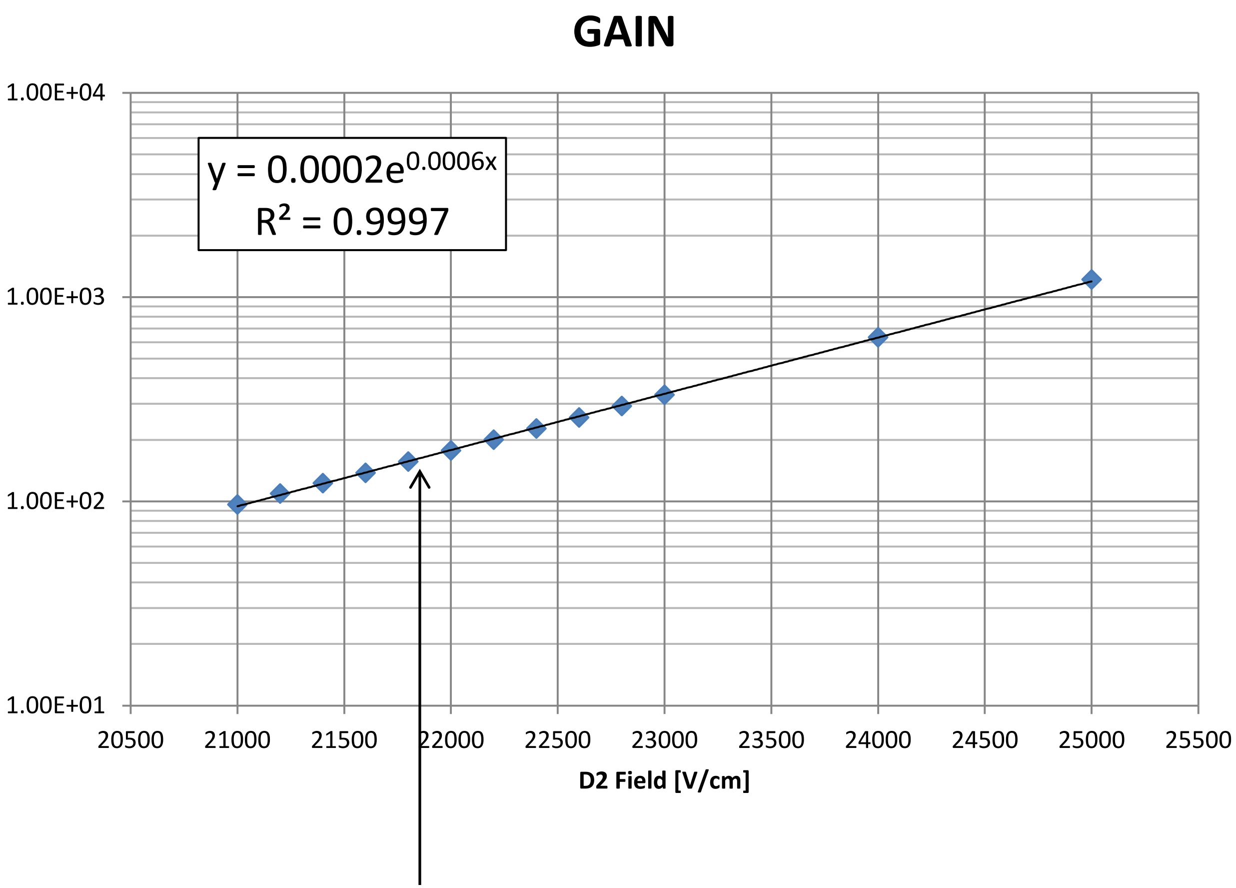


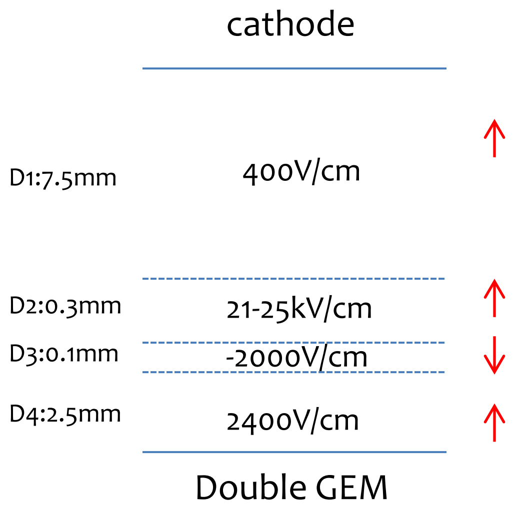






PA (one amplification Stage) Gain Calibration



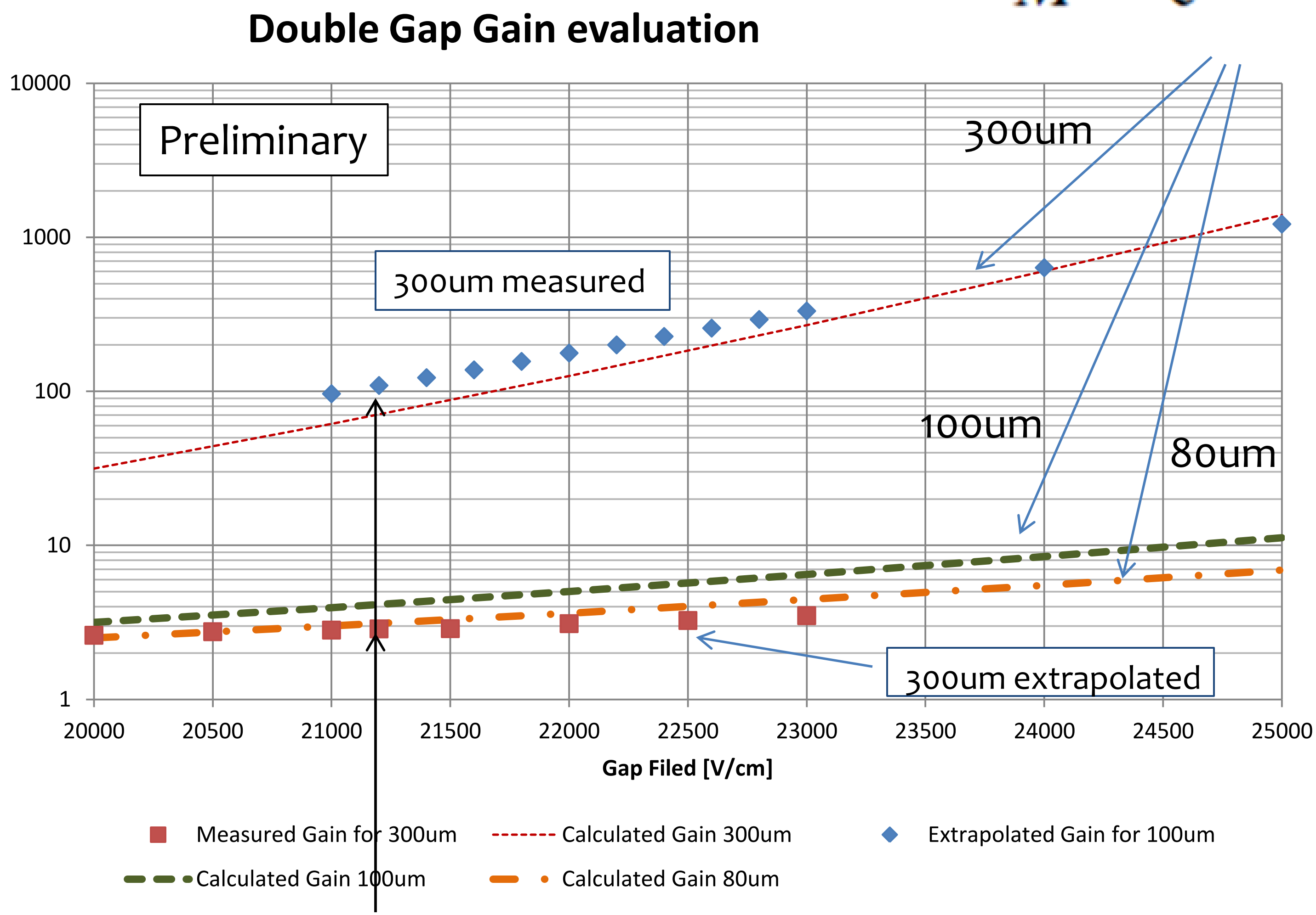


VGEM1top=750V, I divider=205uA

Working point (PA effective gain=1) :
D1=400V/cm, D2= 21875V/cm, D3=3200V/cm, D4=1600V/cm

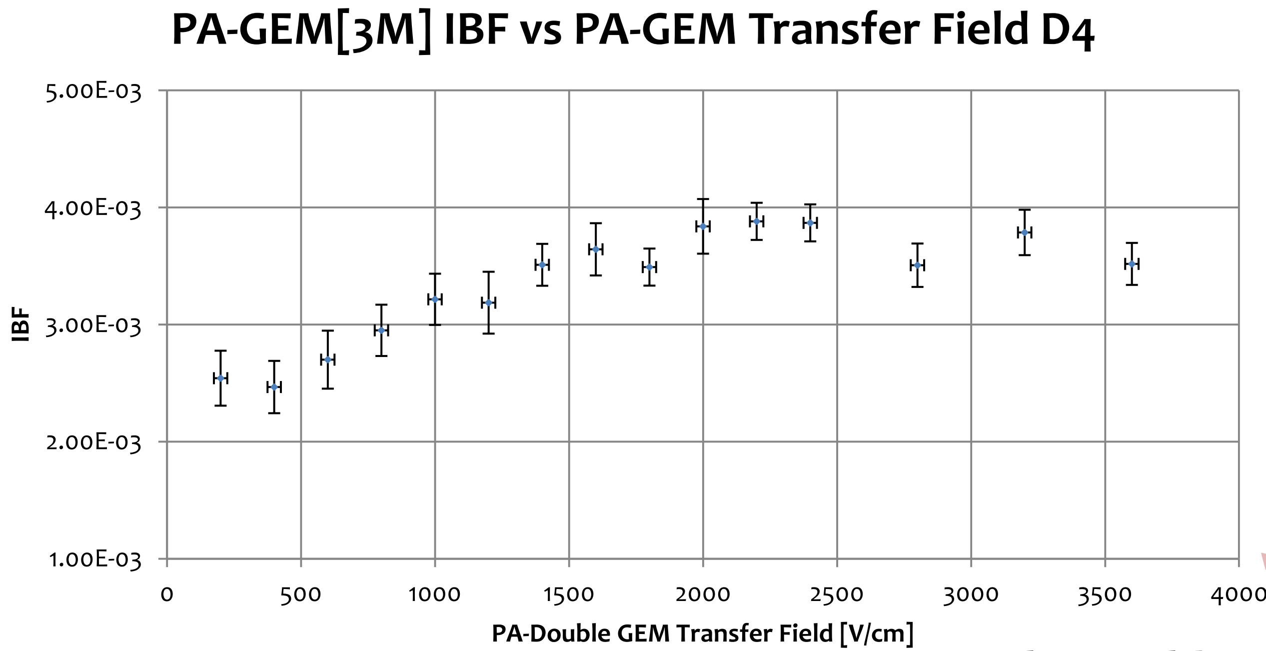
Gain Calibration

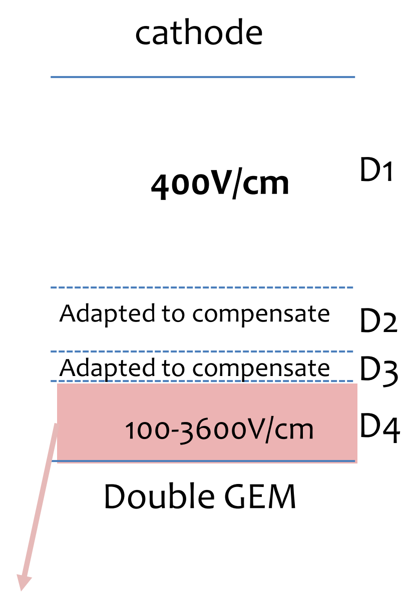
$$M = e^{Apde^{-Bpd/V}}$$



Working point (PA effective gain=1) :
D1=400V/cm, D2= 21200V/cm, D3=21200V/cm, D4=1600V/cm

A first step on optimization…

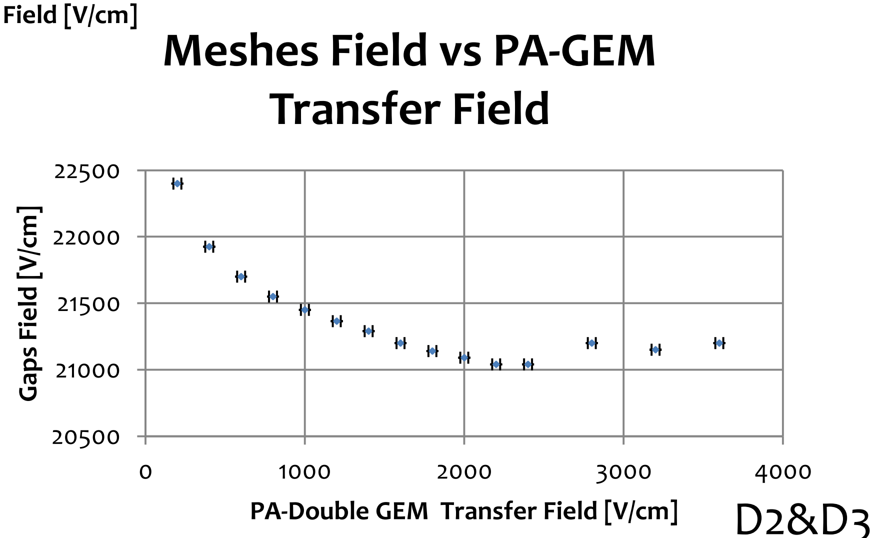




Two Amplification Stages Configuration

D1=400V/cm
D2&D3 adapted to have same anode current
D4=200-3600V/cm

Gap field changed in order to compensate the loss of signal from the PA extraction mesh

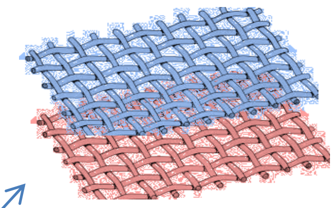


Double Mesh

cathode

D1:7.5mm

Drift Volume



D2:0.5mm

mesh 1

mesh 2

Eff. Gain = 1

D3:2.5mm

Double GEM

Eff. Gain = 2k

cathode

Two “drift framed meshes” have been used with a spacer of 0.5mm in between.

Measurements performed suggest that we don’t have a properly defined gap.

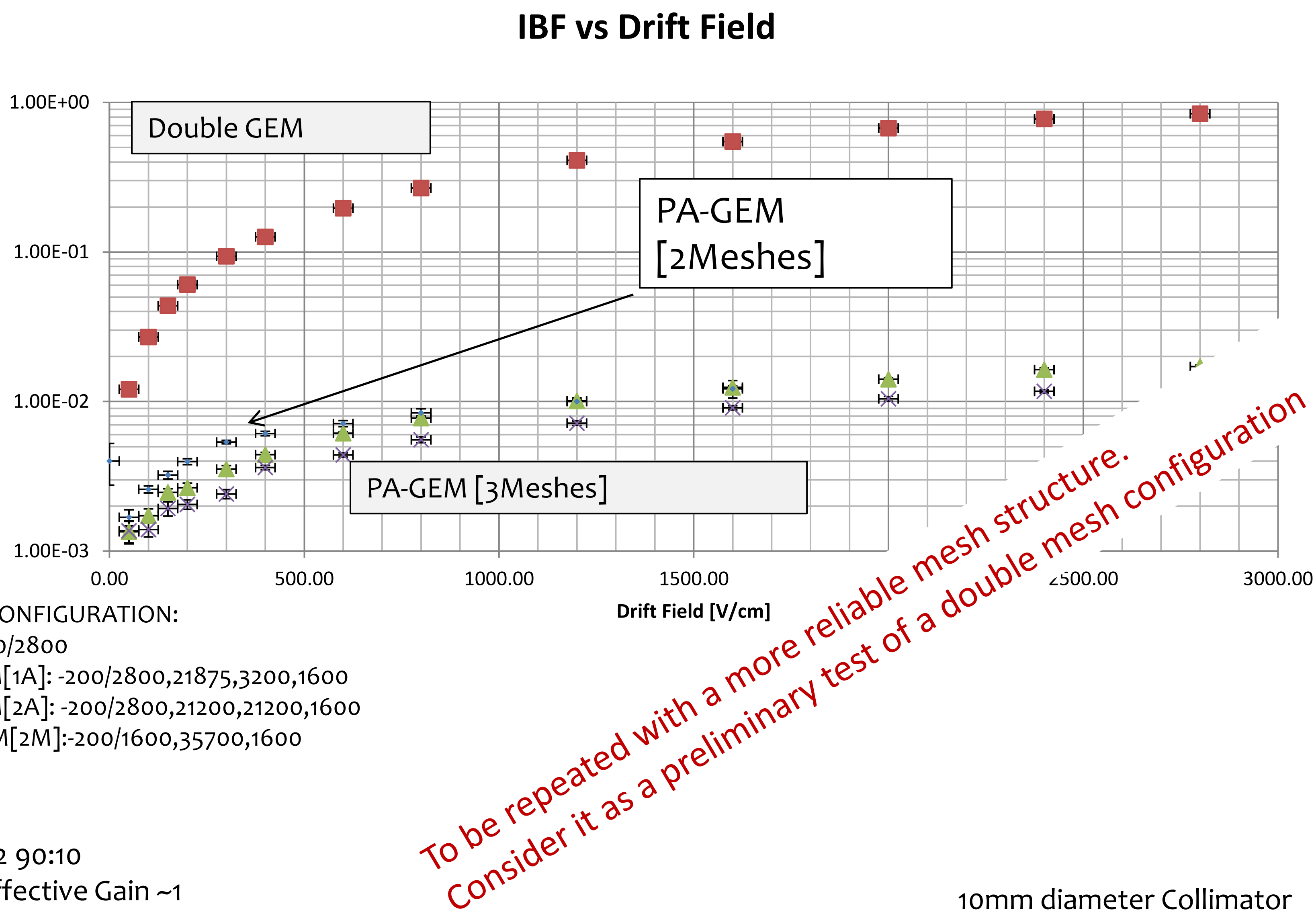
A new double mesh will be produced soon where the gap is better defined.

Nevertheless we performed measurement to test the new configuration [but all the measurements have to be repeated]

Gas Mixture: Ar/CO 90/10

Total effective Gain (PA-GEM) ≈ 2k

PA Effective Gain ≈ 1

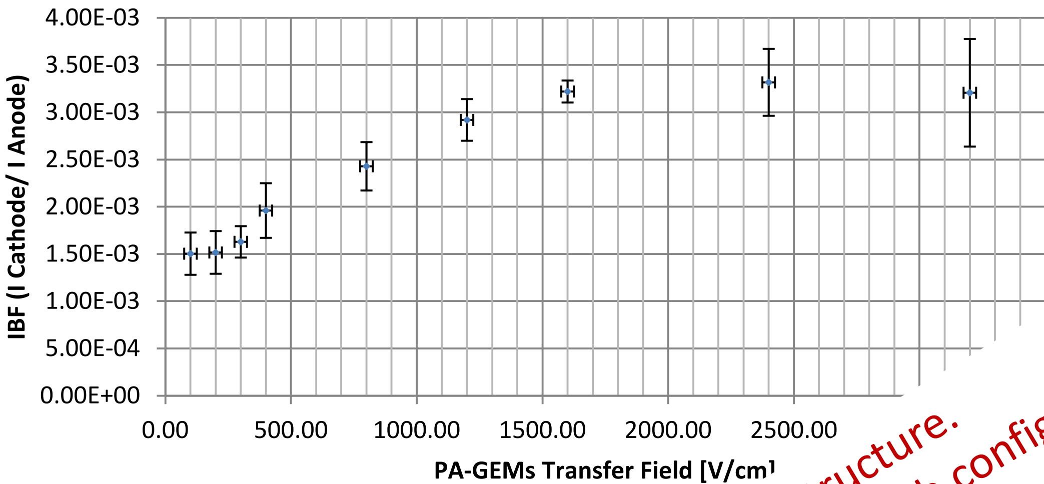


FIELD CONFIGURATION:
DG: -200/2800
PA-GEM[1A]: -200/2800,21875,3200,1600
PA-GEM[2A]: -200/2800,21200,21200,1600
PA_GEM[2M]:-200/1600,35700,1600

Ar/CO2 90:10
Mm effective Gain ~1
Transfer field between meshes and double GEM = 1.6kV/cm
Drift Field 400V/cm

10mm diameter Collimator
Anode Current ~ 150nA

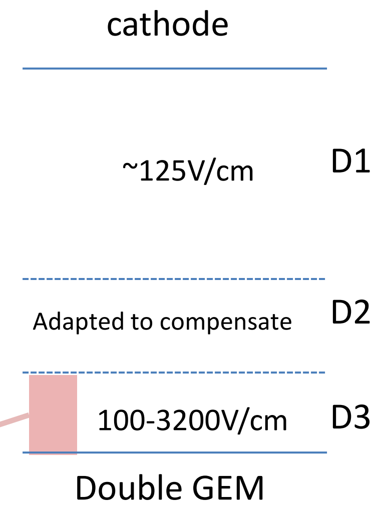
IBF PA-GEM (Two Meshes) vs PA-GEM Transfer Field



D1=123.3V/cm (transparency peak)

D2 adapted to have same anode current

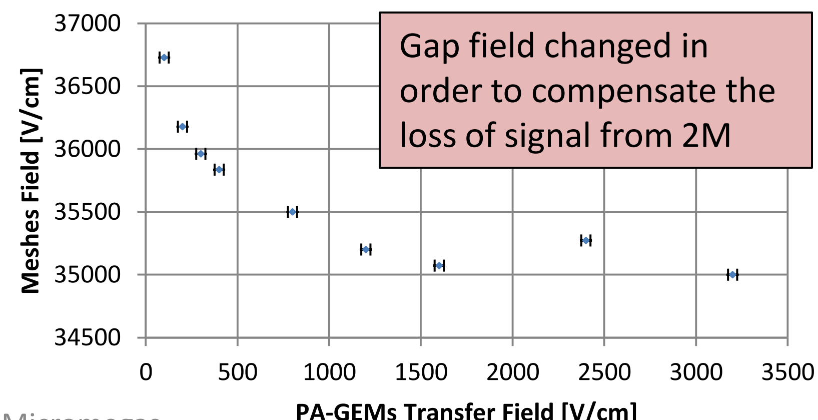
D3=100-3200V/cm



To be repeated with a more reliable mesh structure.

Consider it as a preliminary test of a double mesh configuration

Meshes Field vs PA-GEM Transfer Field

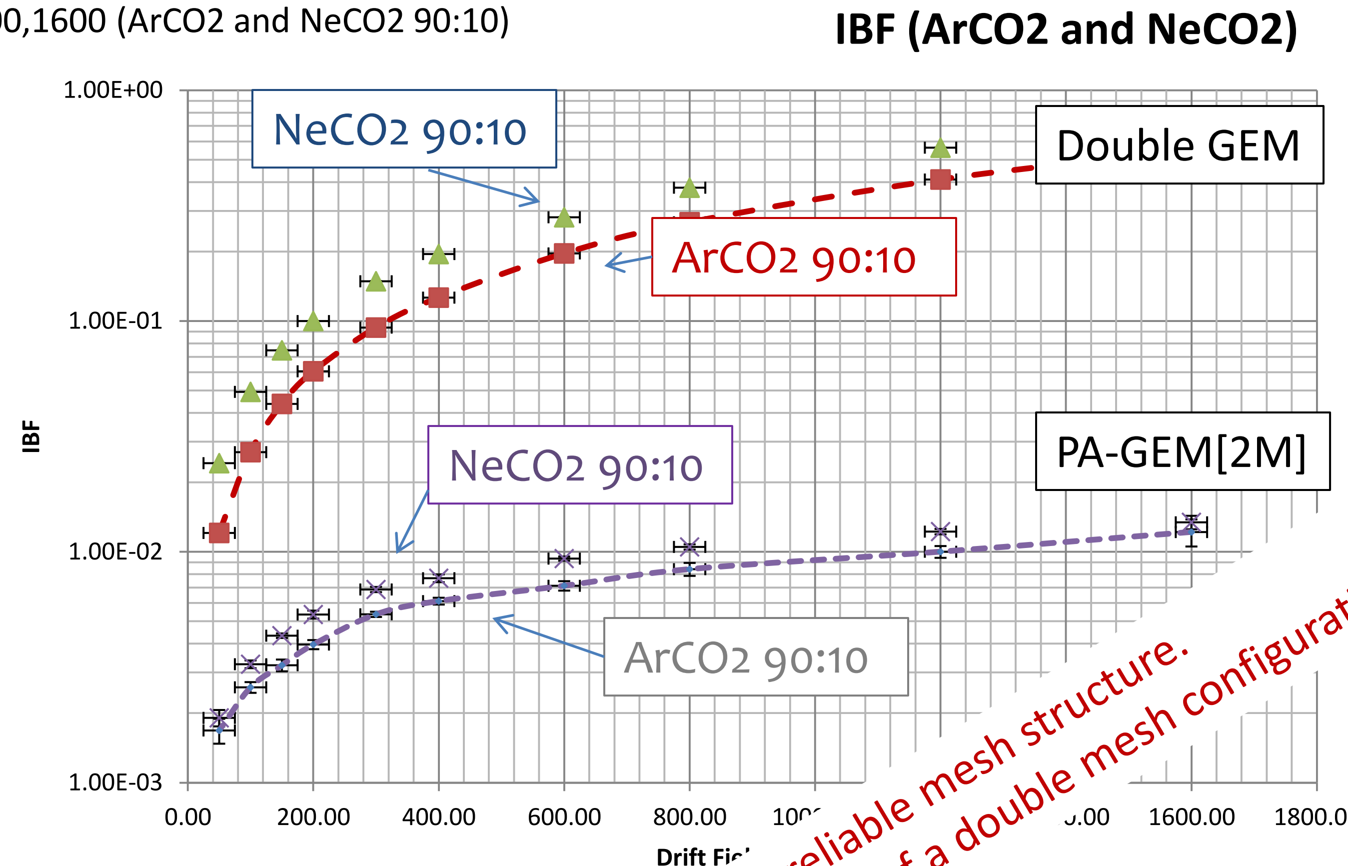


Argon – Neon mixtures performance comparison

DG: 50/1600 (ArCO2 and NeCO2 90:10)

2M: 50/1600,35700 and 20200,1600 (ArCO2 and NeCO2 90:10)

Preliminary



To be repeated with a more reliable mesh structure.

Consider it as a preliminary test of a double mesh configuration

ArCO2 and NeCO2 90:10

PA effective Gain ~1

Transfer field between meshes and double GEM -

10mm diameter Collimator

Anode Current ~ 150nA

Gap field for the new meshes (500um ga ...e used with the previous meshes (100, 300um gap).

Rate (Flux) effects

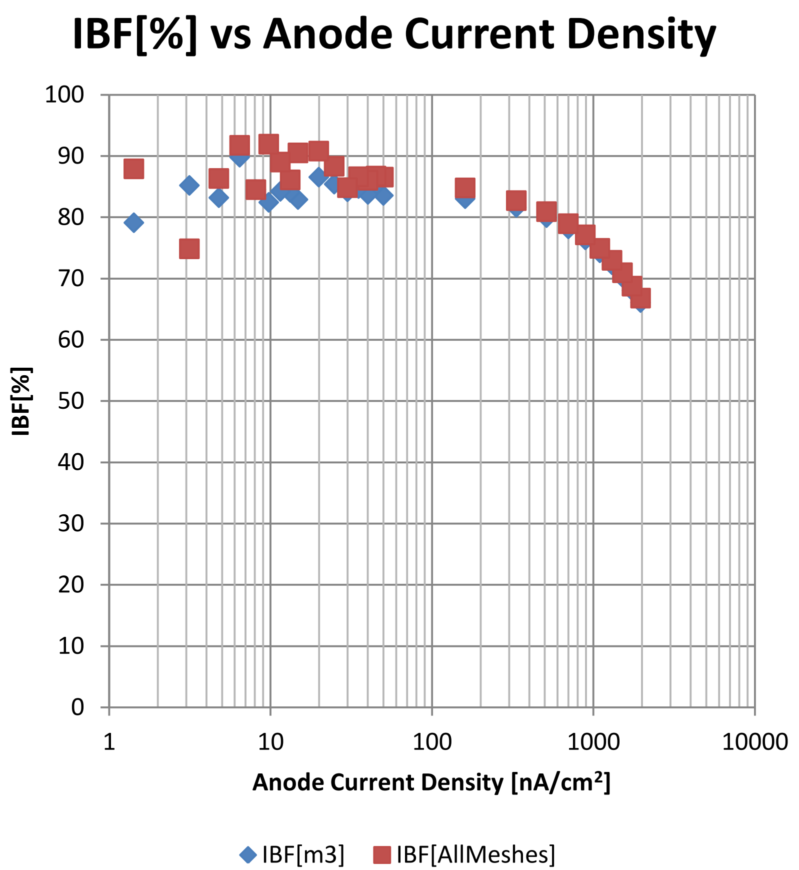
Concerning this talk, we want to be in region where rate effects are negligible/small

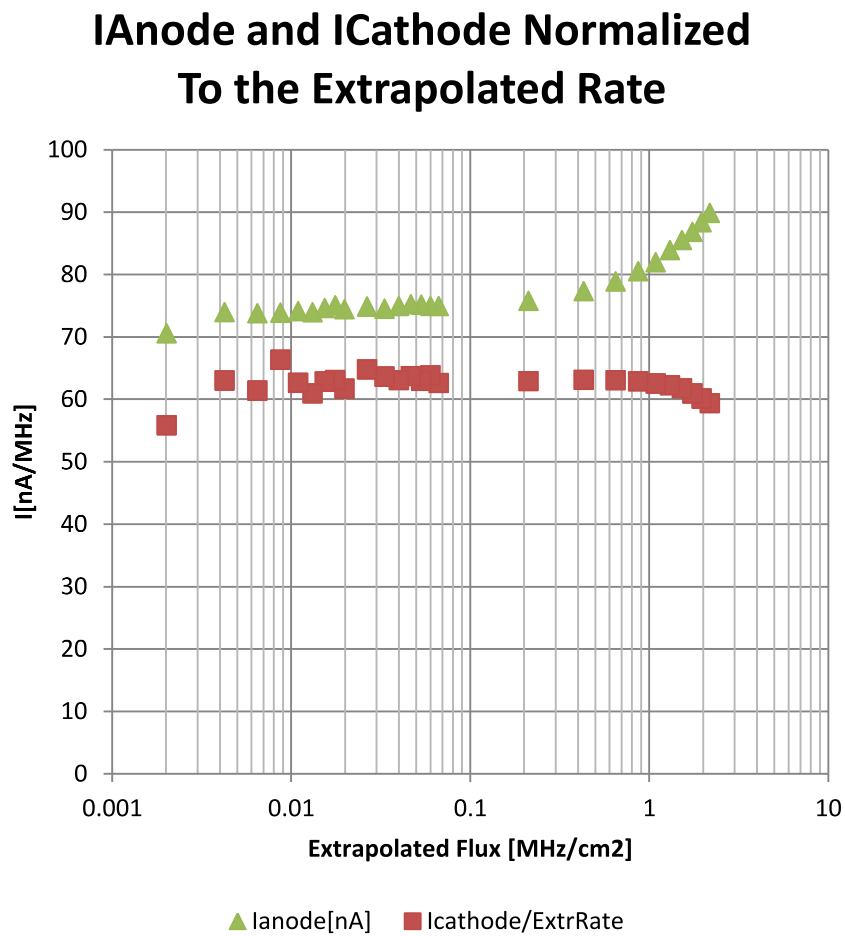
- GAIN increase at higher flux for GEMs based detector
(Pieter Everaerts Thesis, L. Ropelewski, F. Sauli,… Measurements)

- IBF is reduced increasing the rate
(ALICE collaboration. Measurements and simulation)

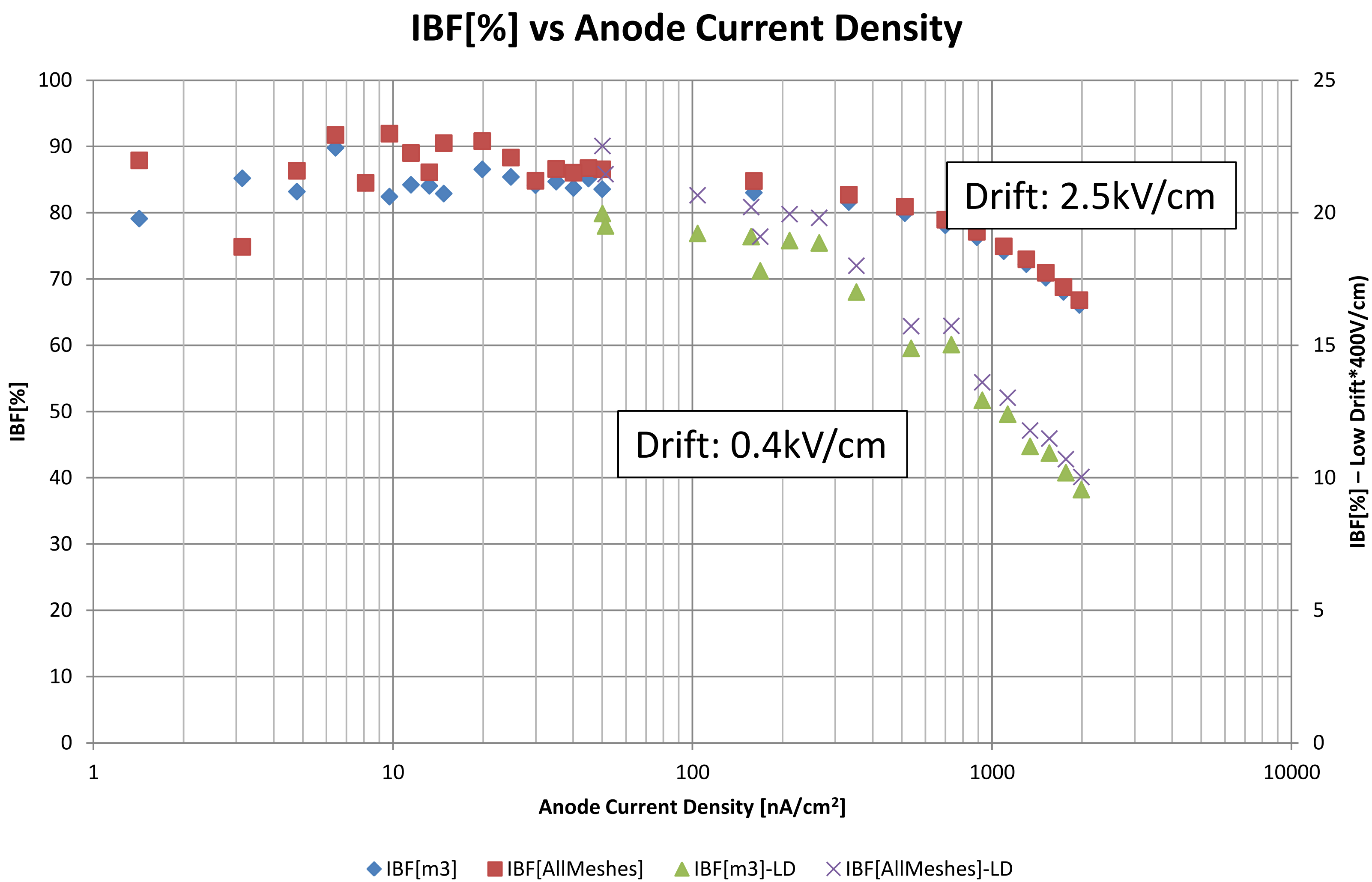
- Mesh Transparency increase at higher rate
(Patrick Thuiner and Filippo Resnati. Measurements and simulation)

Double GEM (high IBF config)

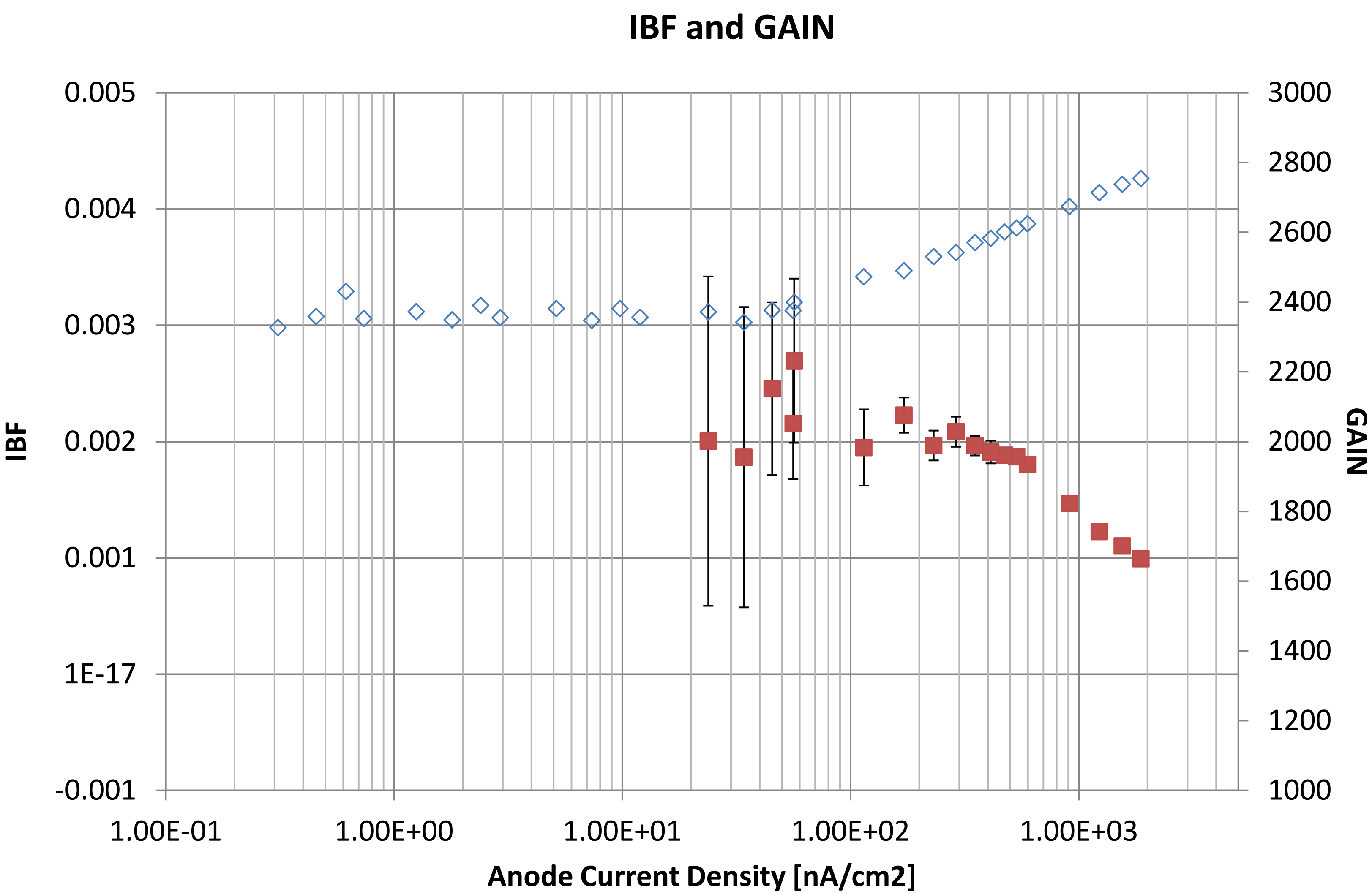




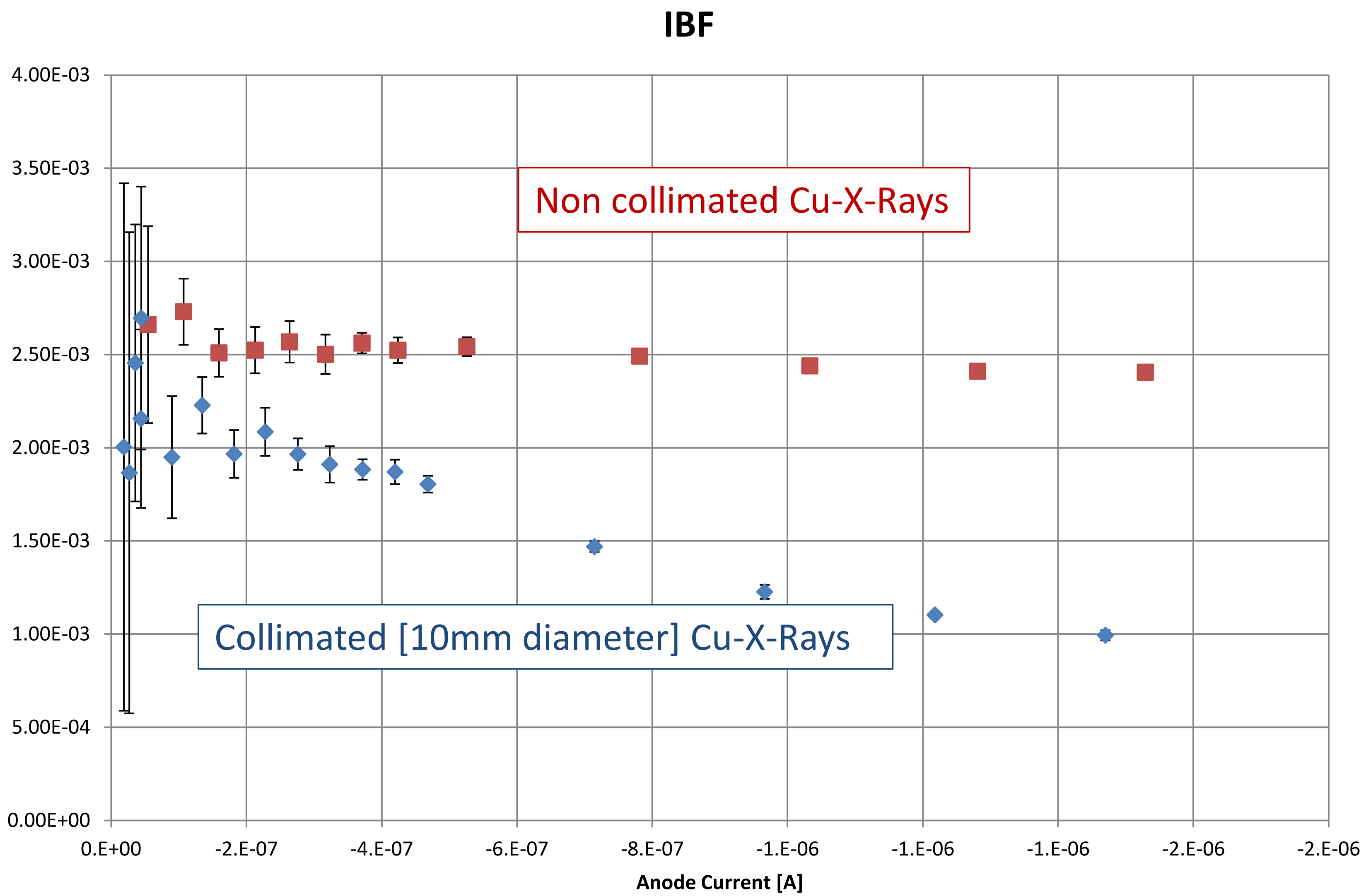
Double GEM (high IBF config)



PA-GEM[2M] (after Gluing)

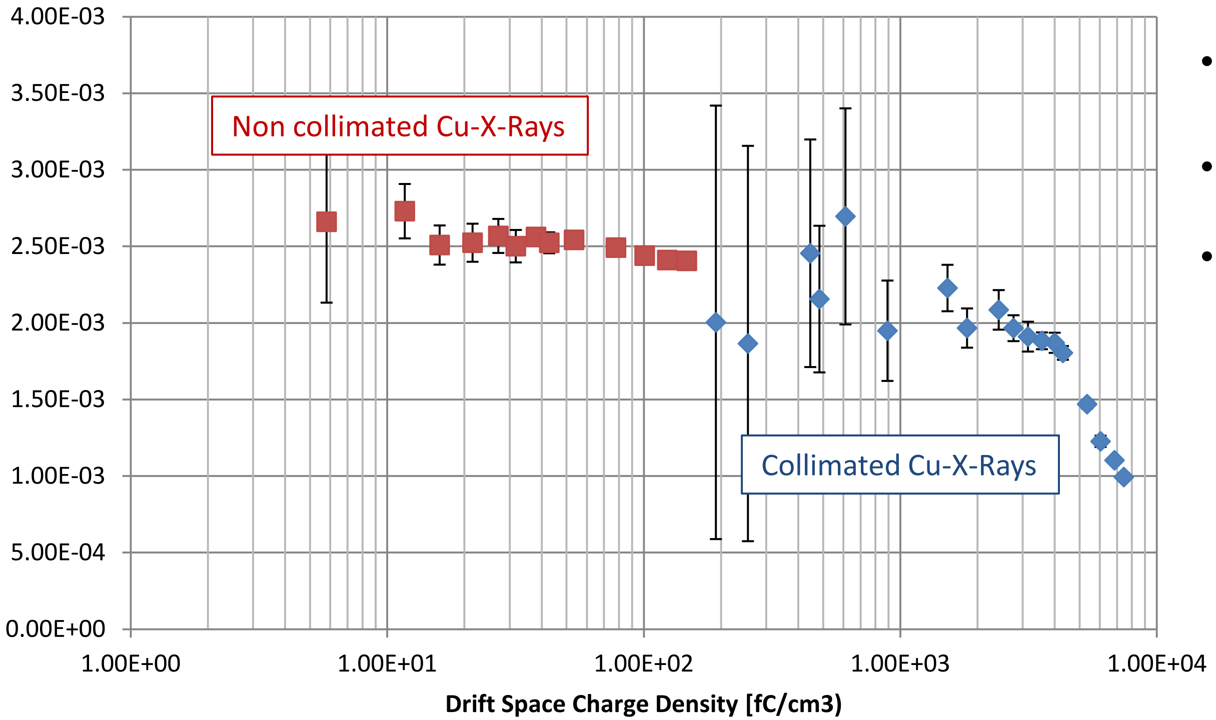


PA-GEM[2M] (after Gluing)



PA-GEM[2M] (after Gluing)

IBF



- μ(Ions Mobility) = 2 cm^2/V sec [in Ar/CO2 90/10]
- E = Drift Field
- $\rho = I / (\mu * E)$

Ion Backflow studies for the ALICE TPC upgrade with GEMs

Markus Ball[a]*, Korbinian Eckstein[a], Taku Gunji[b] for the ALICE TPC Collaboration

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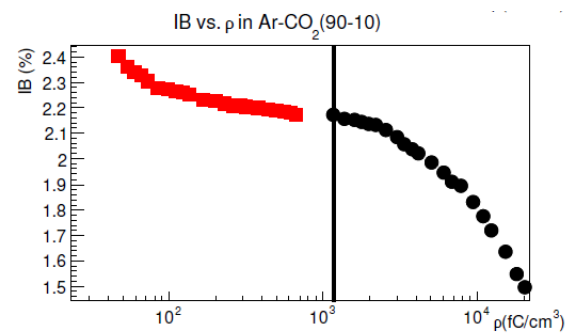

Figure 5. IB as a function of the space-charge density with the drift length fixed to 3 mm. The black dots show a range of 130 μA to 5 μA X-ray current at an X-ray voltage of 30 kV. The red dots indicate the behavior when a 1 cm aluminum absorber has been placed in front of the X-ray tube. The black line indicates the current of the X-ray tube and the corresponding charge density that has been used for the field scans of Sec. 5.1. For both gas mixtures no bias of the ion backflow is expected at this point.

possible advantages
(to be carefully proved)

- Pure electrons signal
  (no ions tail)
- Parallel field amplification stage as a first
  (better energy resolution achievable in principle)
- Readout decoupled from amplification stages
  (simpler protection circuits and no specific requirements on the readout pcb)
- More discharge-sensitive stage as a first
- Intrinsically better IBF suppression stage as a first

conclusions/remarks

- hybrids of different mpgd technologies can boost detector performances

- a parallel field pre-amplified GEM detector can be a solution where IBF improvements are requested

- additional measurements will be done in order to understand where and how the actual solution can be optimized (meshes gap, pitch)

- Exportability to large area… will follow the previous step