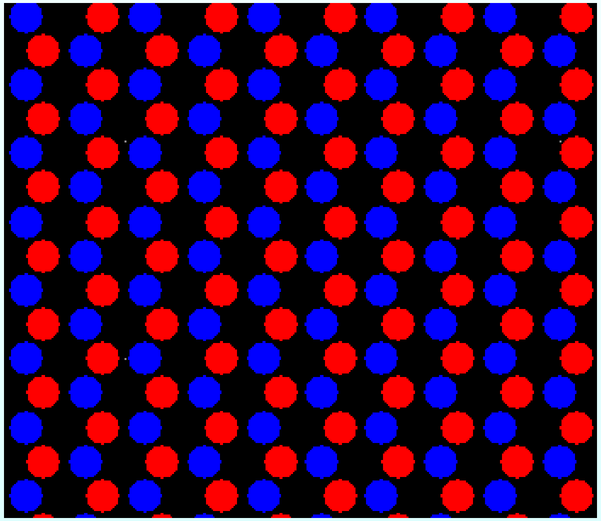
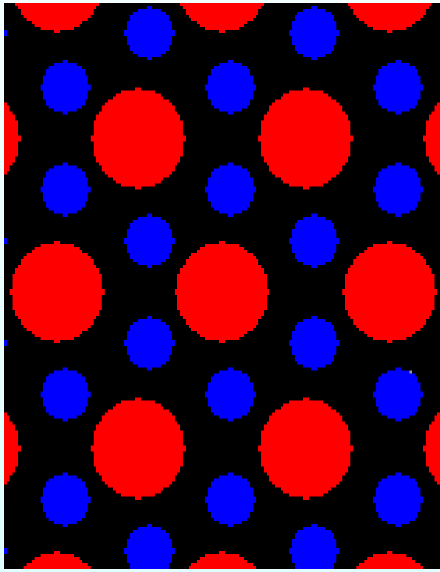
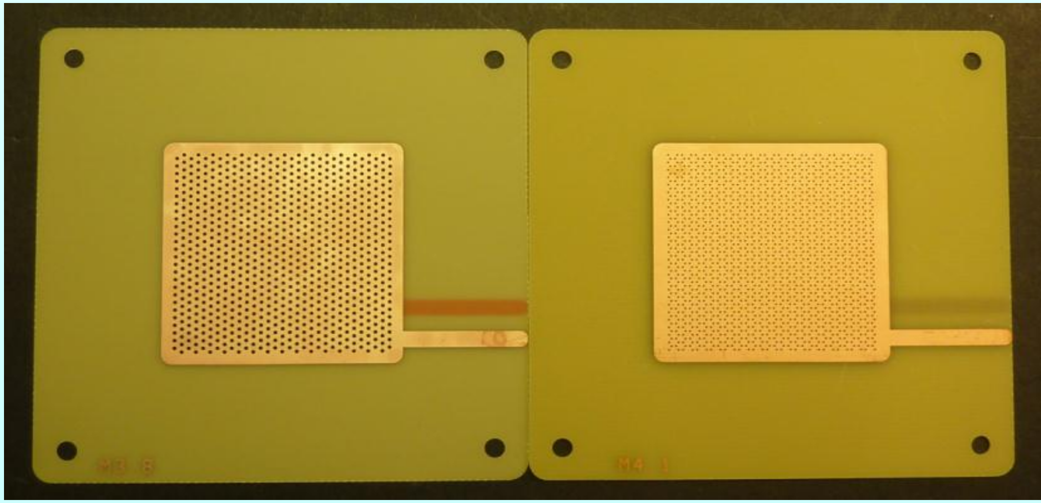
IBF in aligned, misaligned and FLOWER THGEMs

Fulvio Tessarotto

(I.N.F.N. – Trieste)







The IBF problem

Standard THGEM configuration

COBRA and extra electrode

Misaligned holes

FLOWER THGEM solution

THGEM + Micromega

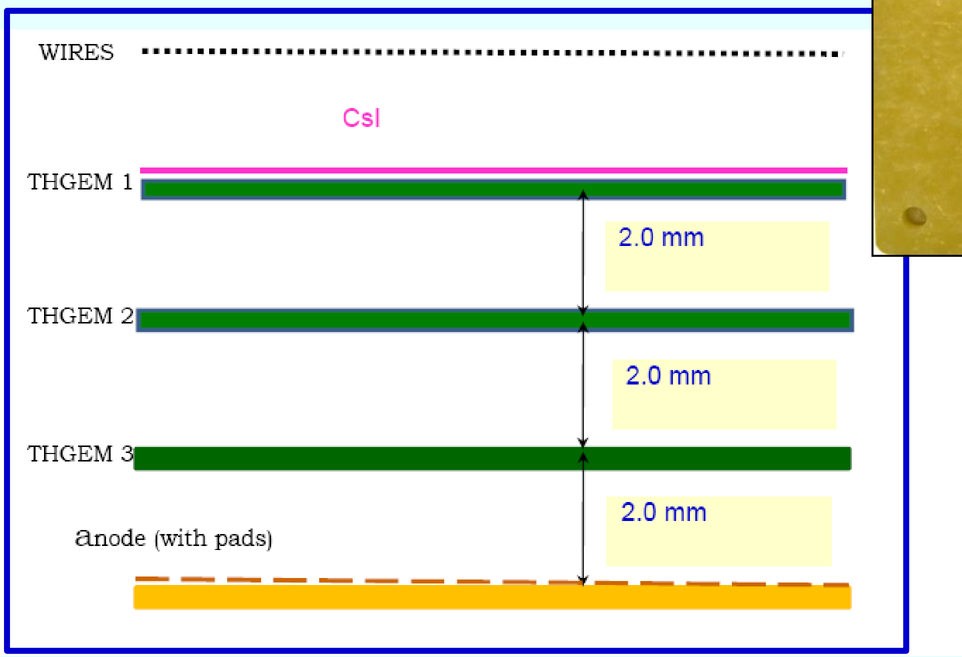
Conclusions

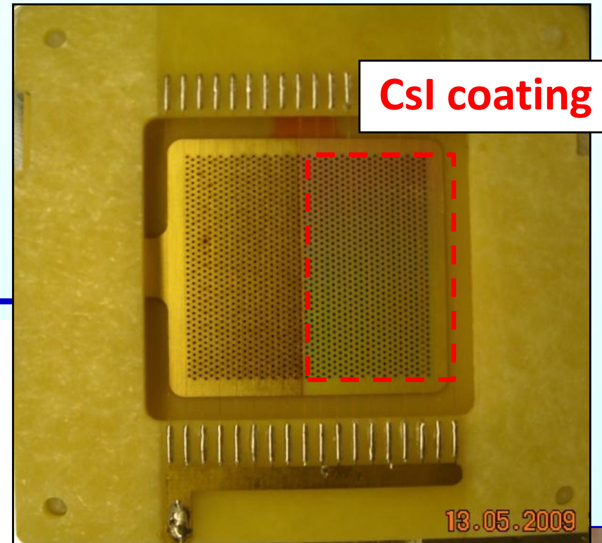
OUR FIRST THGEM-BASED PDs

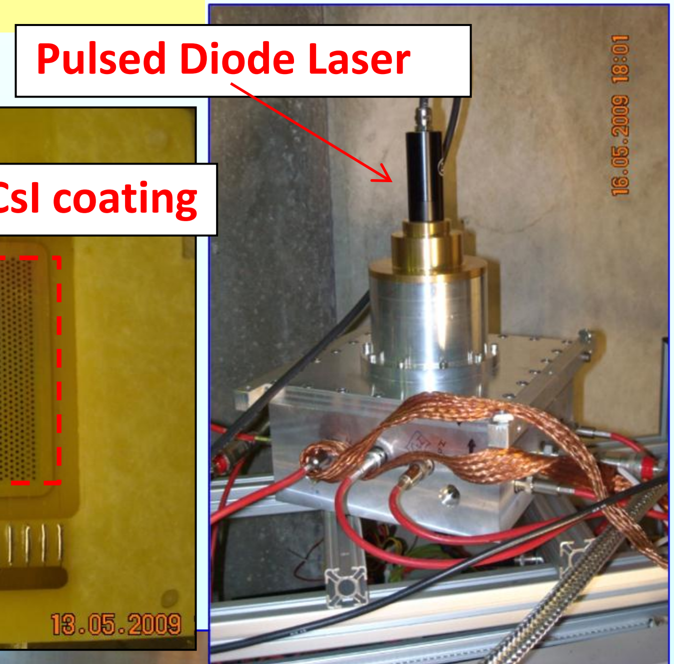
Triple THGEM (CsI) Ar/CH_4

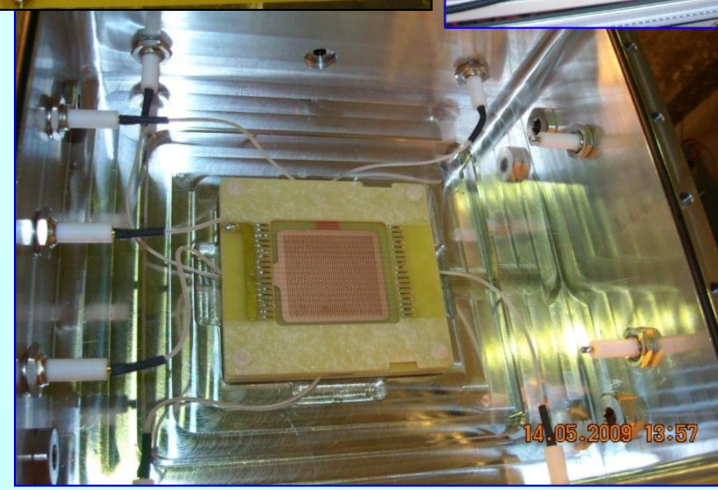
Active area = 30 mm x 30 mm

Diam=0.4 mm, pitch =0.8,
Thick=0.4, rim ≤10 μm



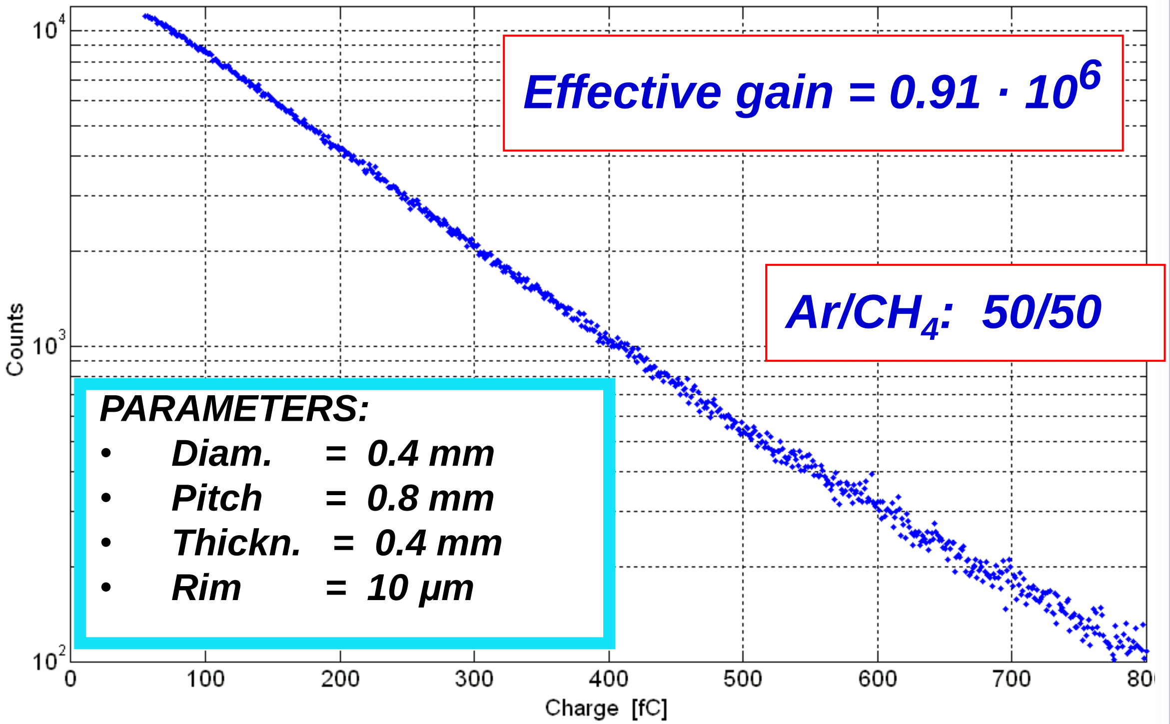






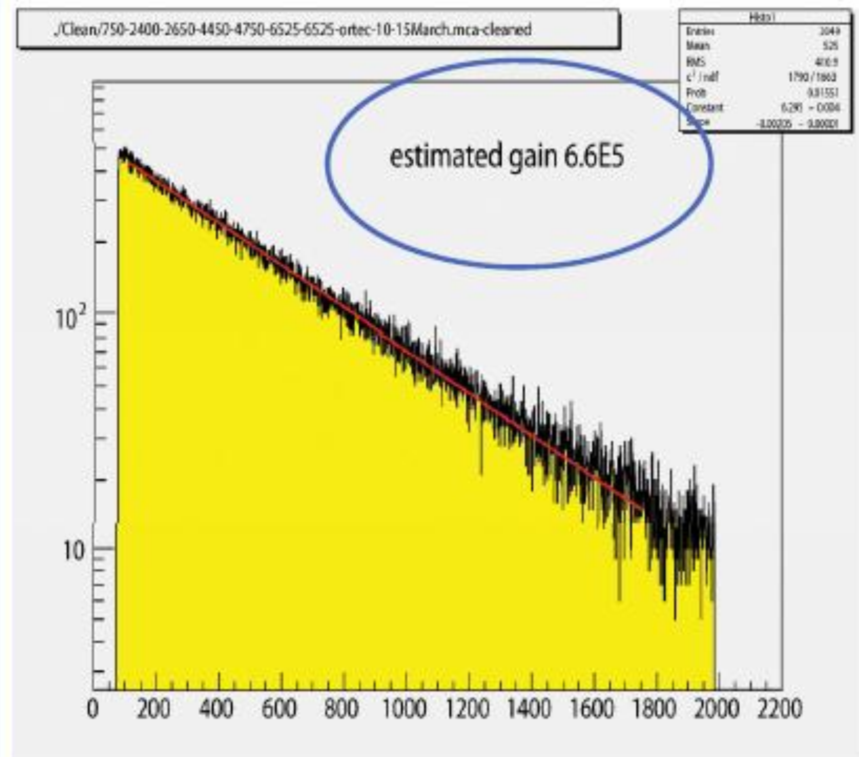
Gain around 1 M

Triple THGEM

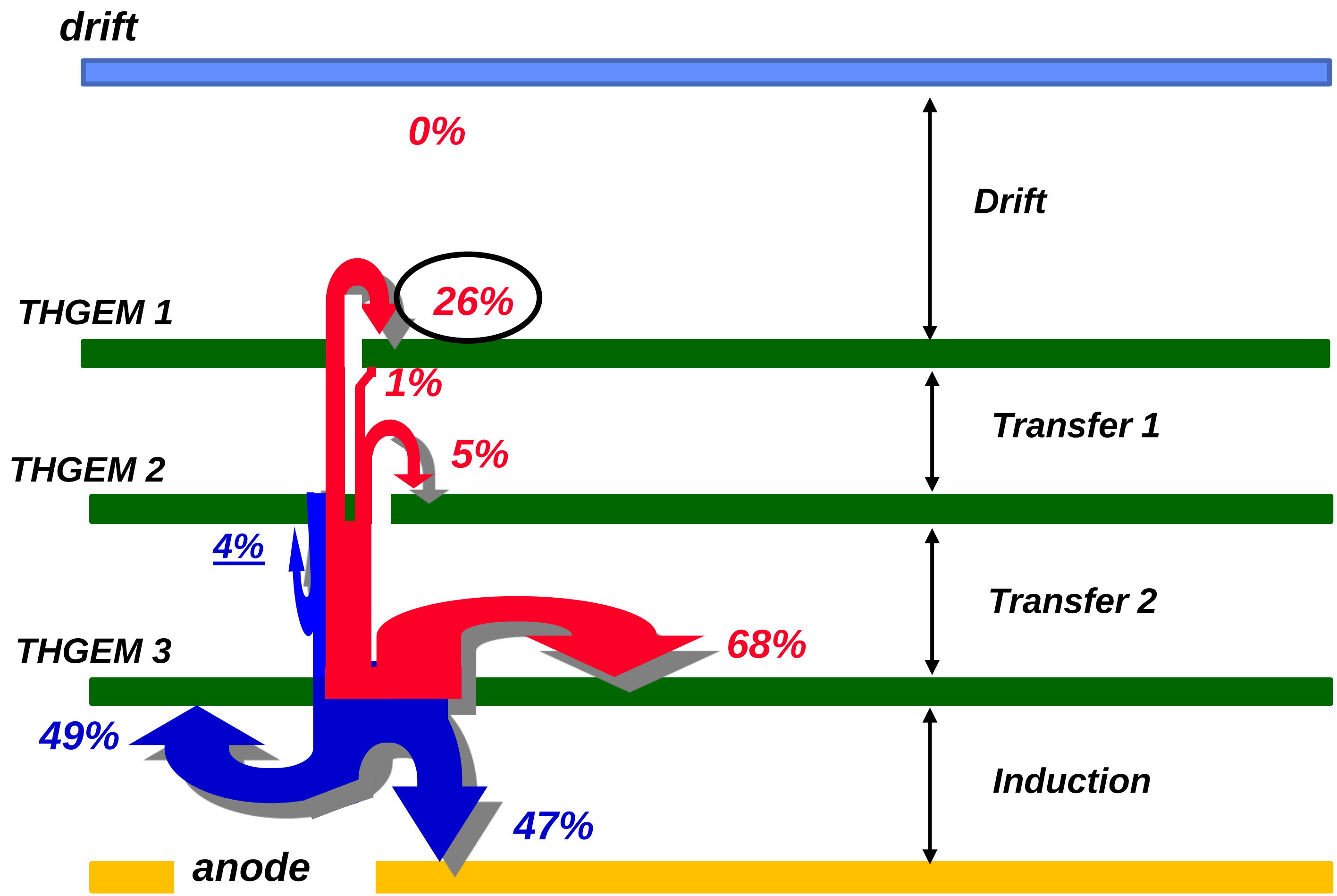


3 layers:

hole diameter	0.4 mm
pitch	0.8 mm
thickness	0.8 mm
rim	0



typical charge sharing, no optimization

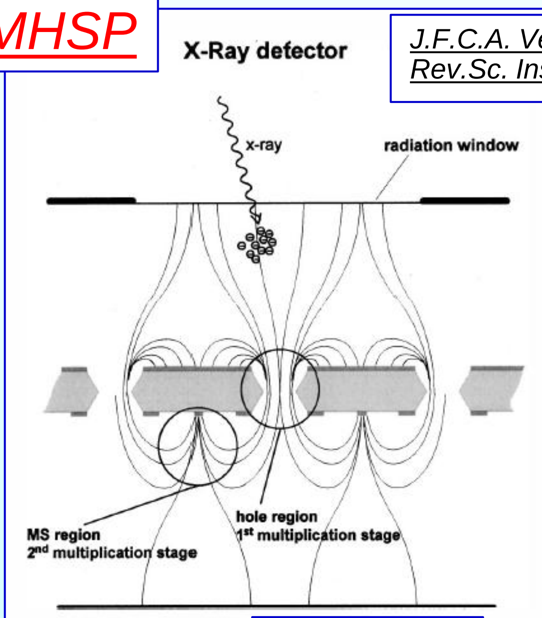


field values optimization could reduce IBF by a factor 2 at most

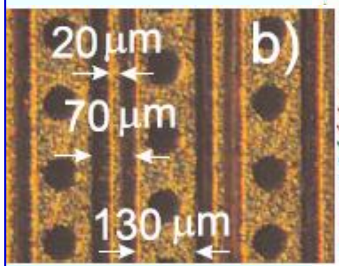
Reducing the ion backflow is possible

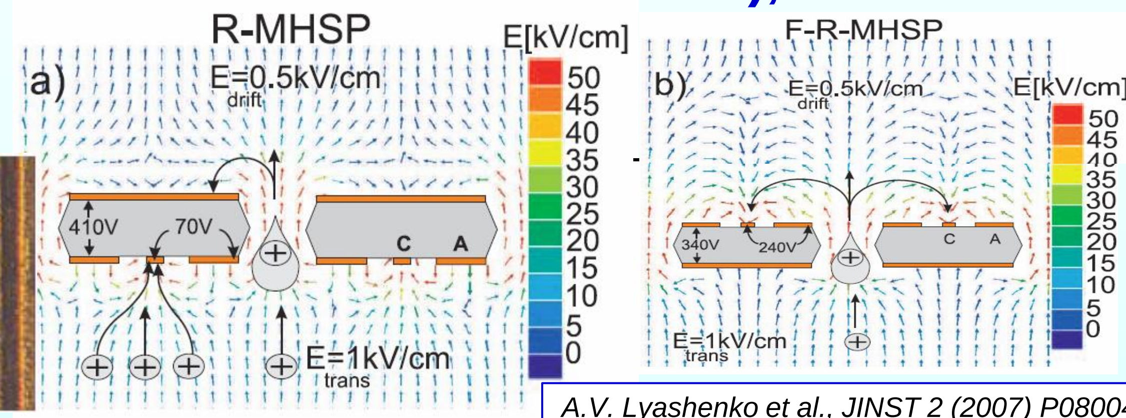
with more complex geometries: Micro-Hole & Strip Plate (MHSP), COBRA

MHSP



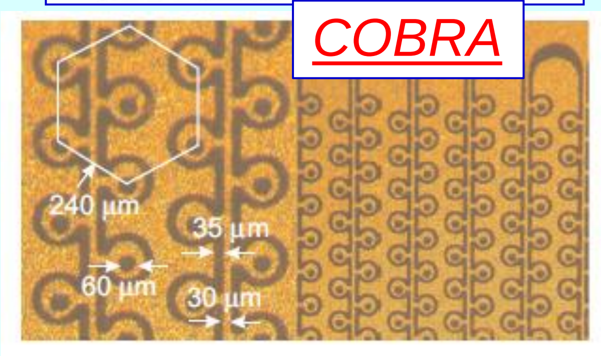
J.F.C.A. Veloso et al., Rev.Sc. Instr. 71 (2000) 2371

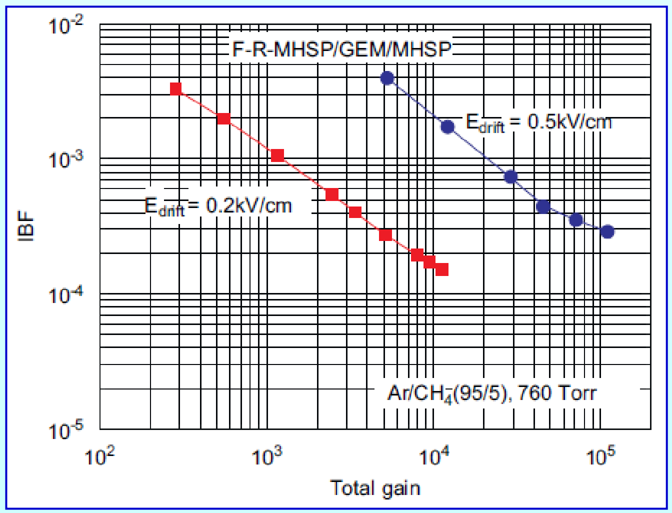


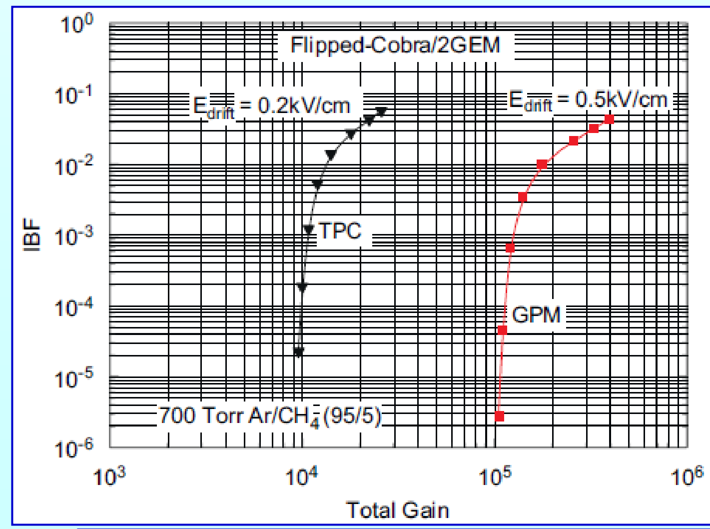


A.V. Lyashenko et al., JINST 2 (2007) P08004

COBRA



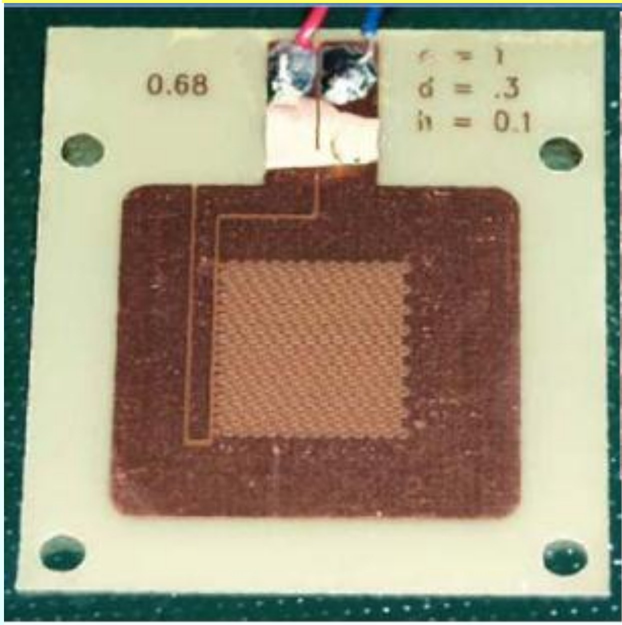


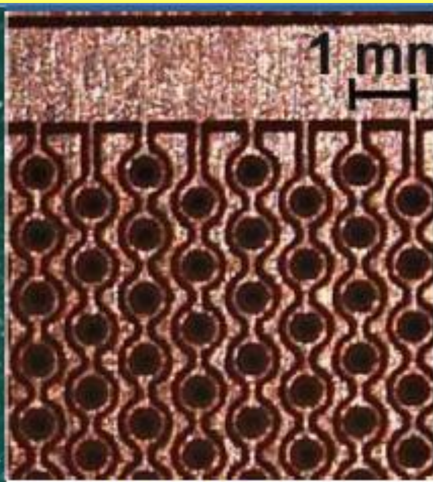


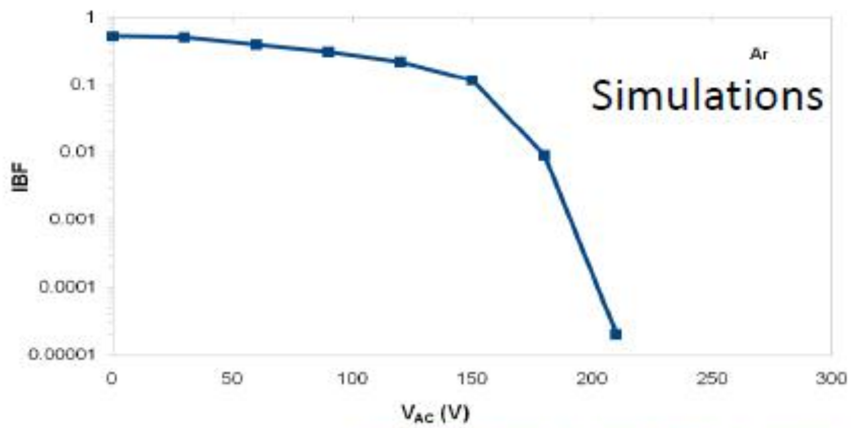
A.V. Lyashenko et al., NIMA 598 (2009) 116

A.V. Lyashenko et al., NIMA 598 (2009) 116

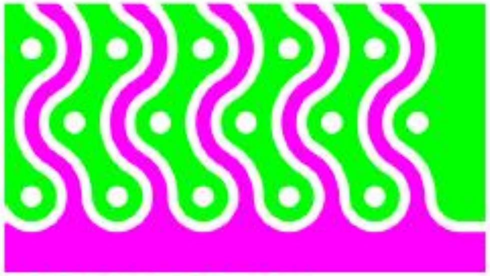
The COBRA way







New Thick Hole-Structures for Gaseous Detectors, João Veloso RD51



Single photon detection efficiency strongly affected by

Active area (electrode) / Dead area (holes) → limits on the geometry of 1th THGEM

E field on the surface → geometrical parameters of the 1th THGEM

$E_z \sim \exp(\text{diam.})$

$E_z \sim 1/(\text{pitch})^4$

Impose constrains on the maximum space between electrodes for THCOBRA → pitch and hole size

Hole	Ering	Clearance	Cobra Electrode	Pitch
400	2X80	2X80	80	800

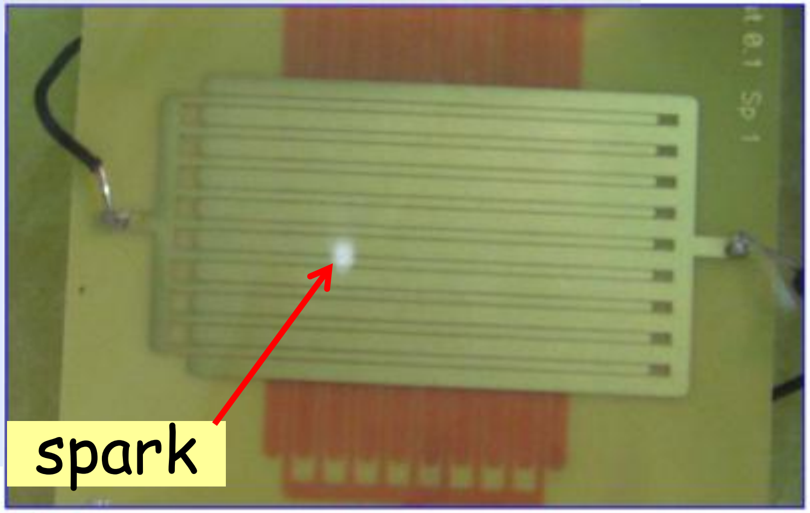
Loosing robustness and constraining too much the geometry

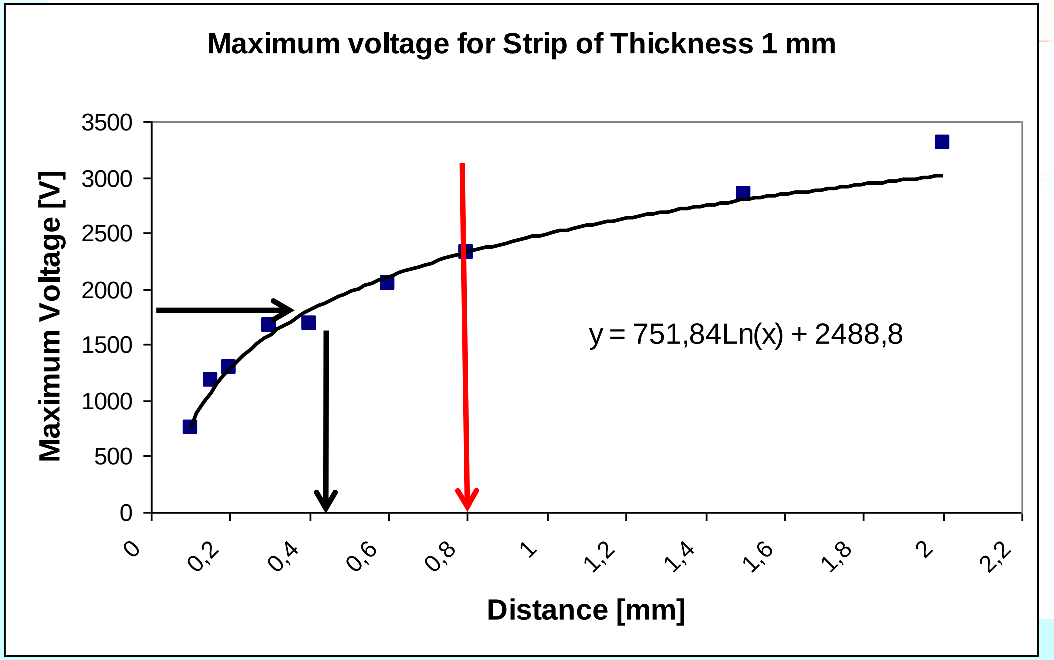
Sparks may damage tiny pists

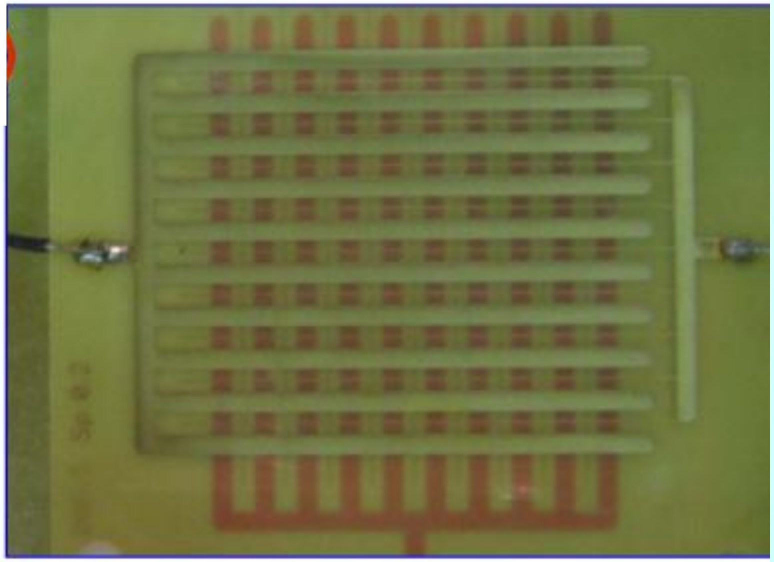
Samples of 20 different types

Determine the breakdown voltage

Use this information to properly design the THGEM segmentation



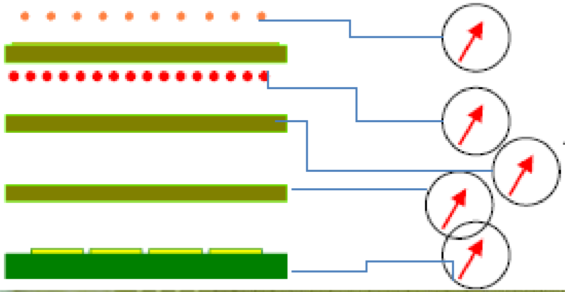




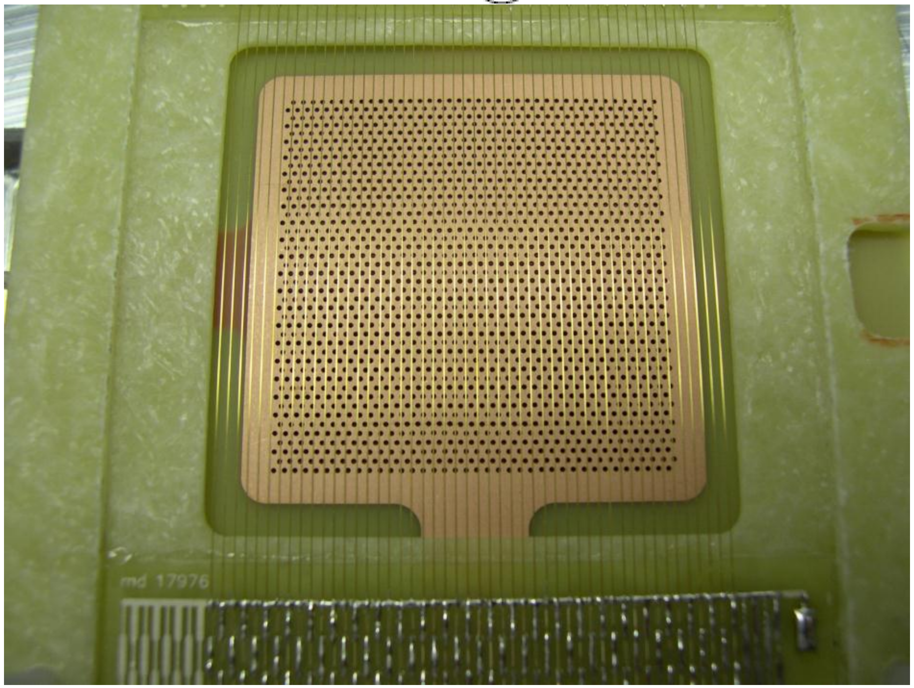
Inserting a dedicated electrode

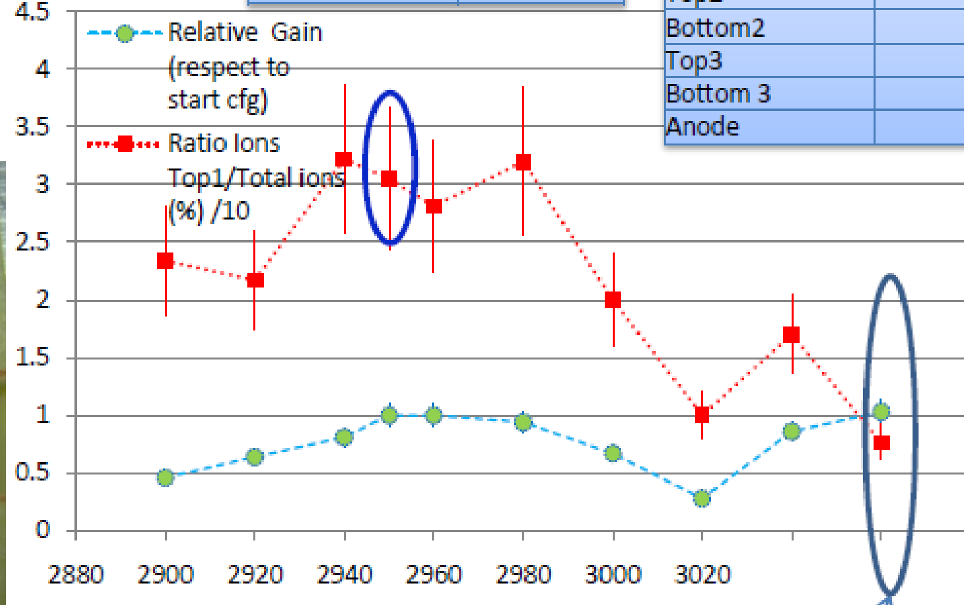
HV	Volt
Drift	4100
Top1	4100
Bottom 1	2956
Cobra wires	3020
Top2	2807
Bottom2	1650
Top3	1510
Bottom 3	490

Anode	0
Drift	4100
Top1	4110
Bottom 1	3150
Cobra wires	3220
Top2	3000
Bottom2	1650
Top3	1510
Bottom 3	500
Anode	0



1 pA for each layer,
2mm spacing





Increasing Second THGEM ΔV (200V)

Reduces by a factor 4 the ion feed-back without gain losses

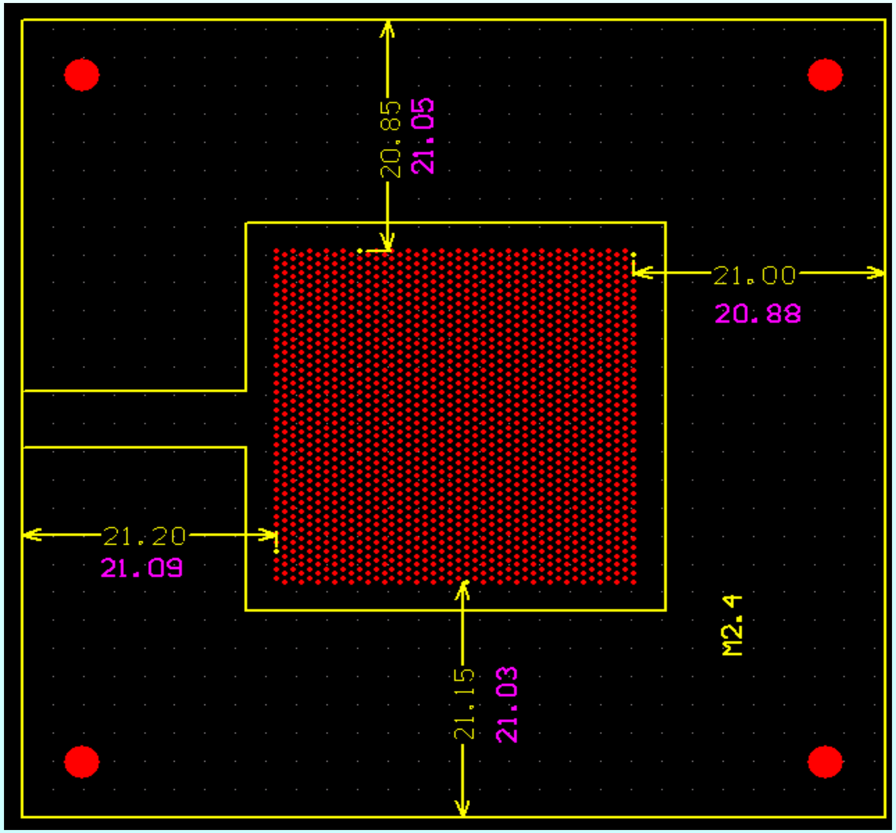
Hole alignment

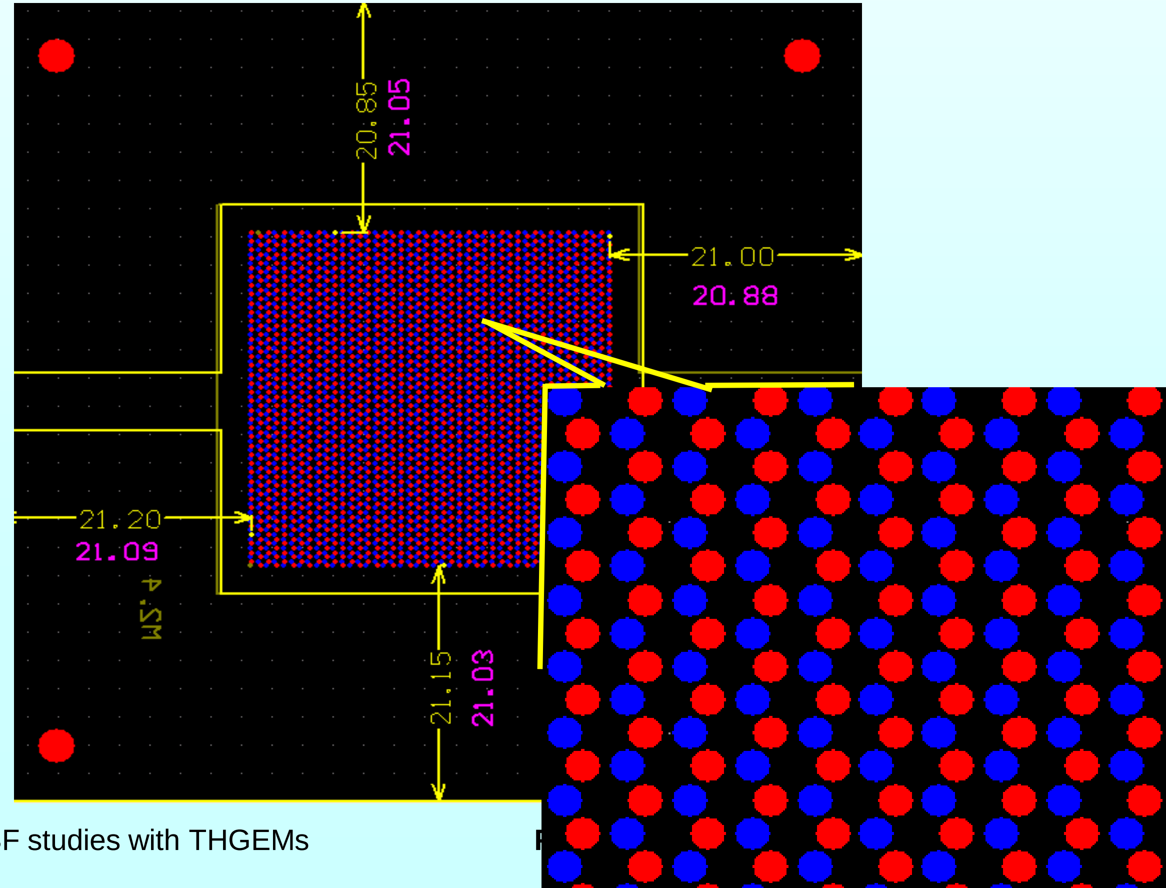
Inspired by the study of F. Sauli, L. Ropelewski, P. Everaerts on GEM IBF: NIM A 260 (2006) 269, we decided to study the effect of THGEM hole alignment on IBF.

we produced (ELTOS) THGEMs with a special symmetry:

the holes of the flipped THGEM are displaced by p·√3/3

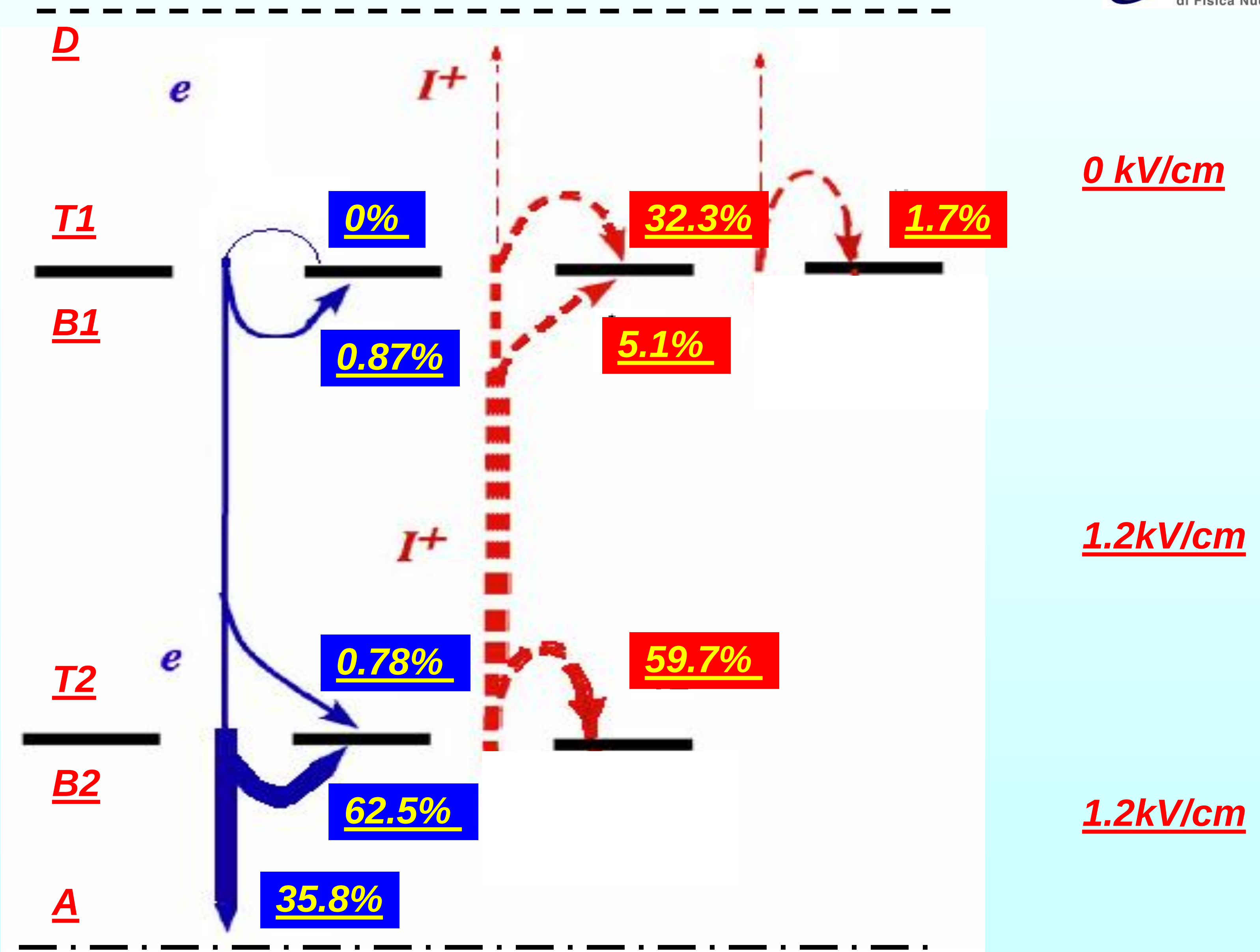
with respect to the holes before flipping





IBF of Aligned DoubleTHGEM

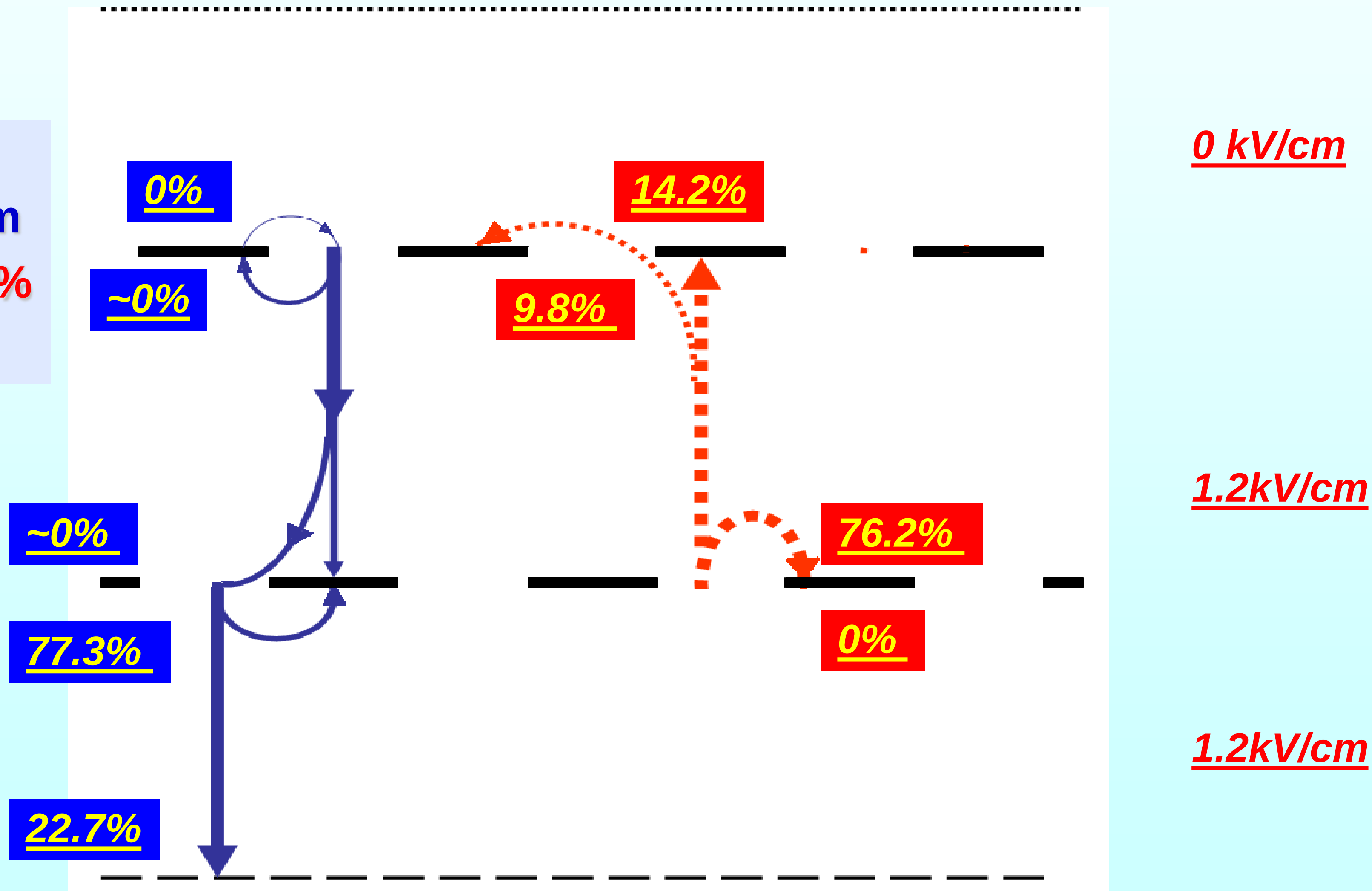
a case study:
low gain on the first THGEM,
high gain on the second THGEM
T1 IBF = 32 %



IBF of Misaligned DTHGEM

Staggered holes provide lower IBF

for 1.2 kV/cm
T1 IBF = 14 %

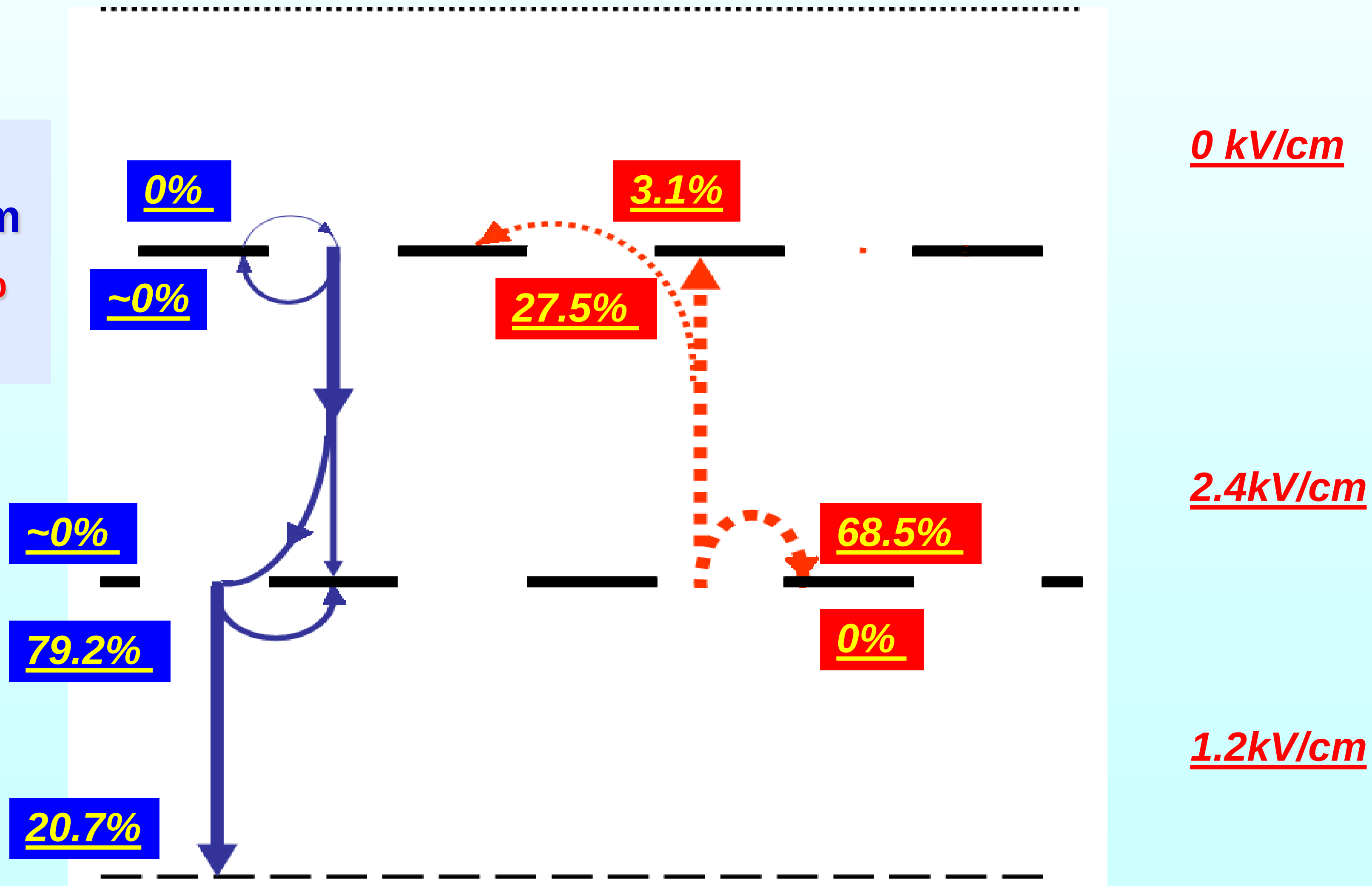


IBF of Misaligned DTHGEM study

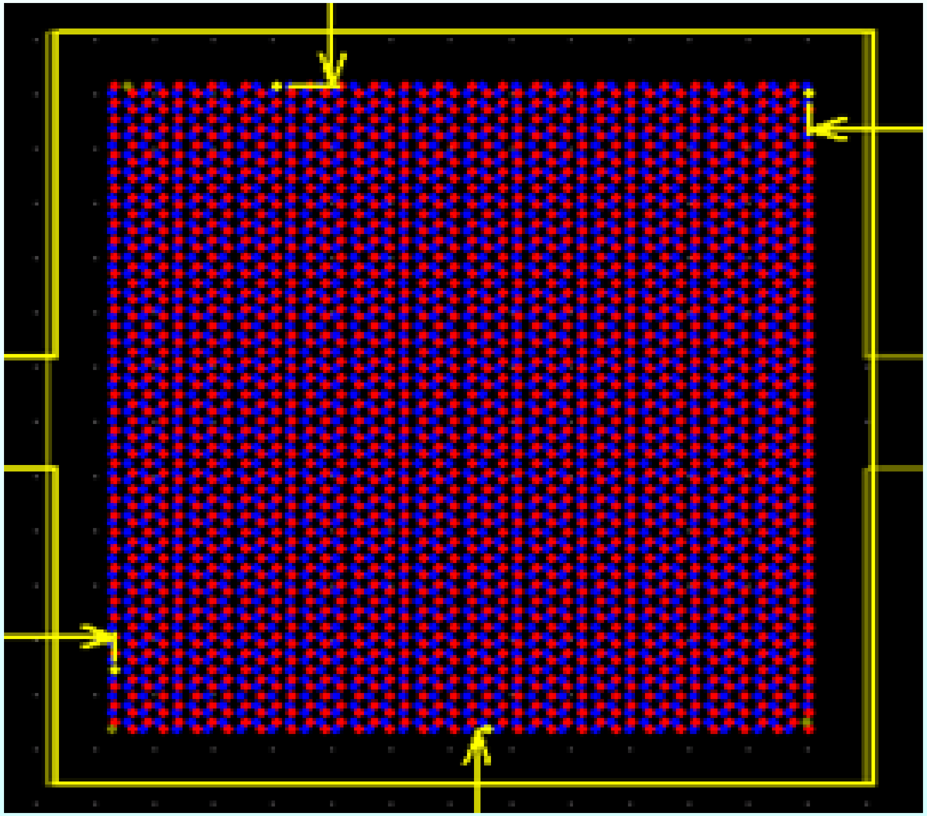
Doubling the transfer field, the ions will hit B1 instead of drifting to T1.

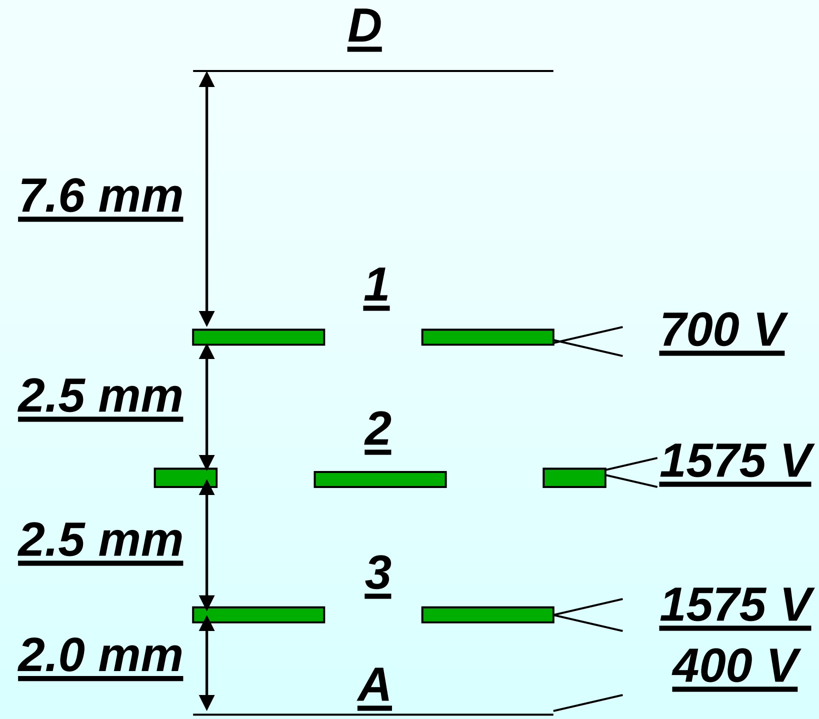
for 2.4 kV/cm

T1 IBF = 3 %



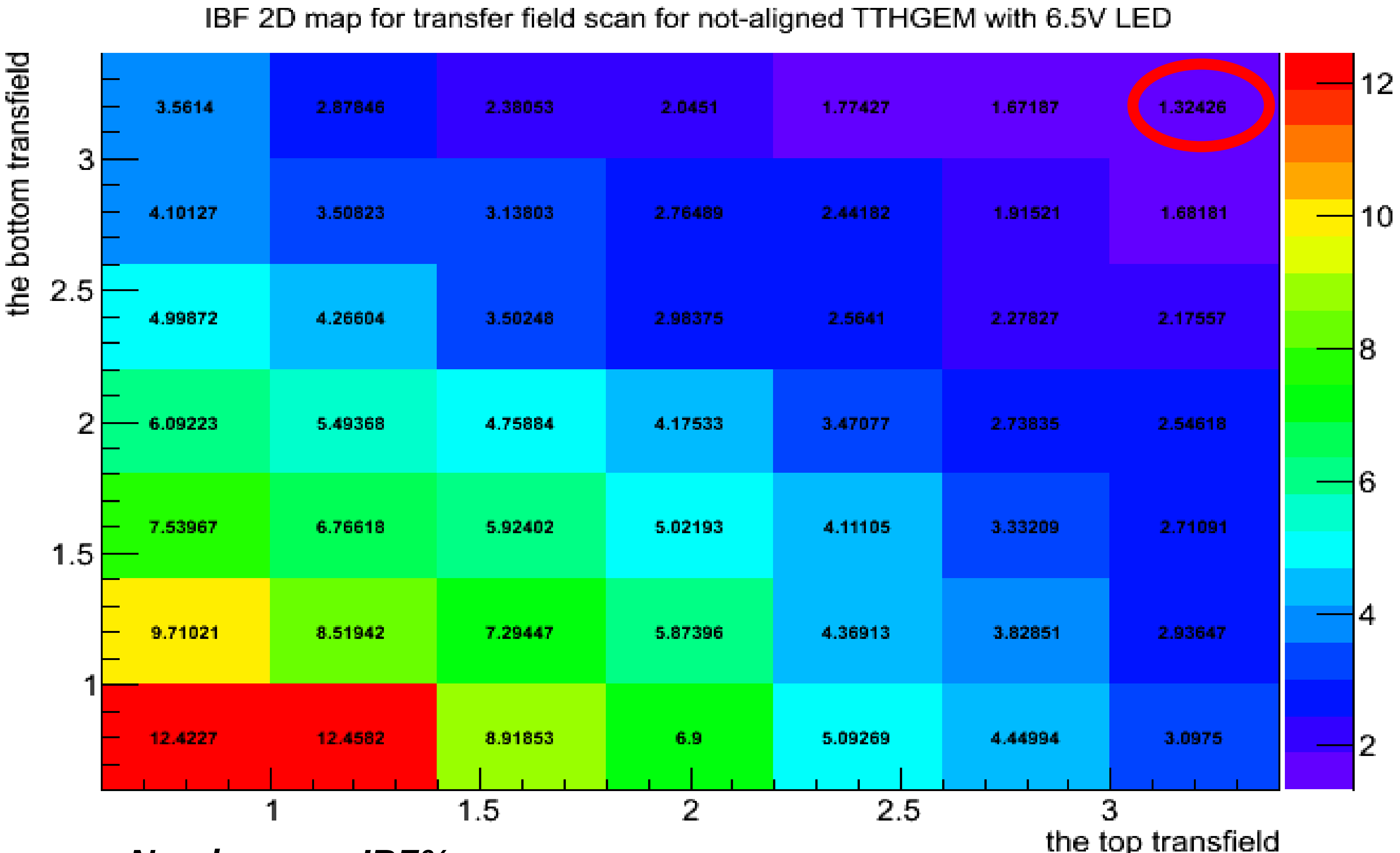
Triple THGEM configuration





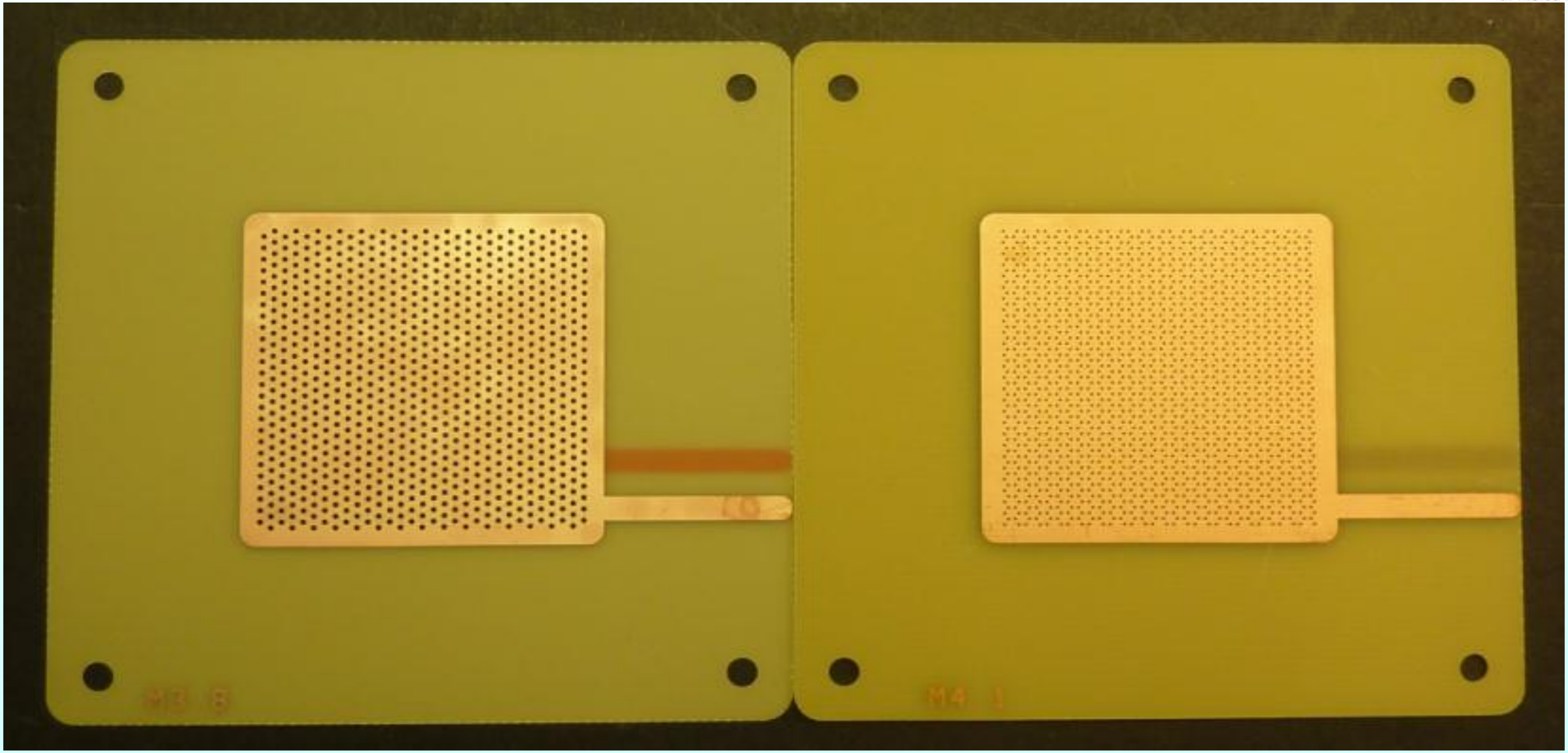
- ***Flipping the central M2.4 provides the maximally misaligned configuration***
- ***tests performed in aligned and misaligned configuration***
- ***all parameters have been varied, all currents + signal amplitudes measured***

IBF for misaligned THGEMs



Numbers are IBF%

"FLOWER" THGEM



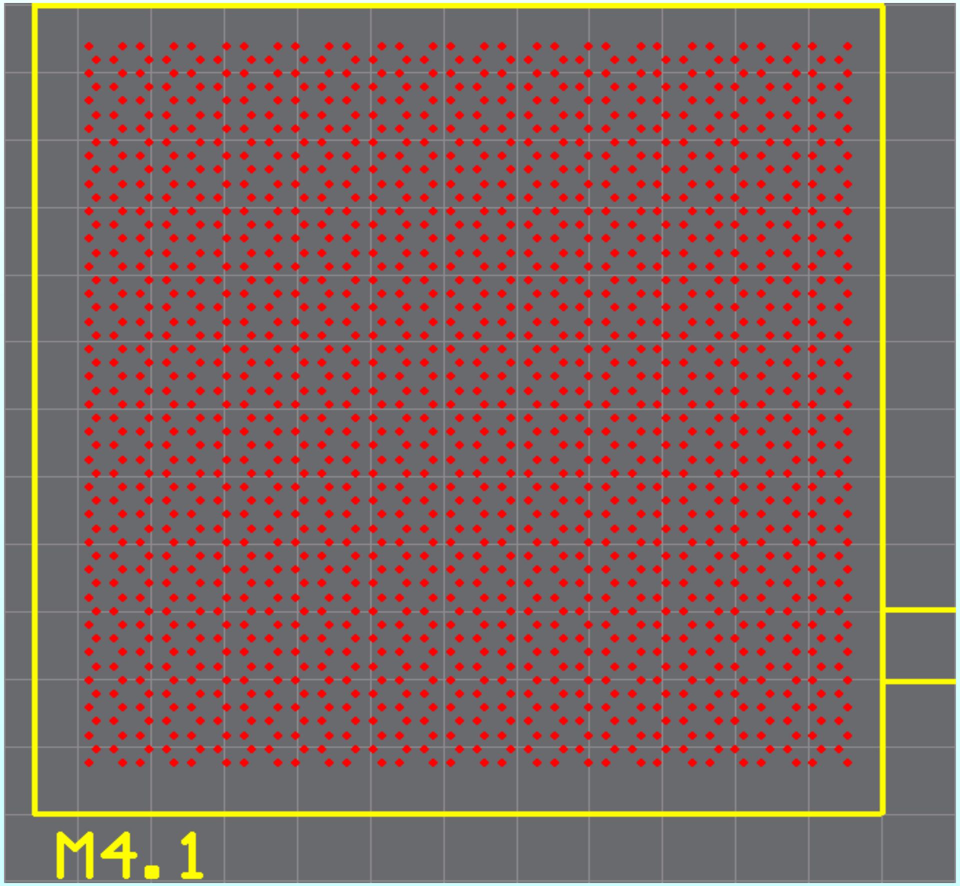
M3.9: T=0.4mm,R=0.6mm,P=1.2mm

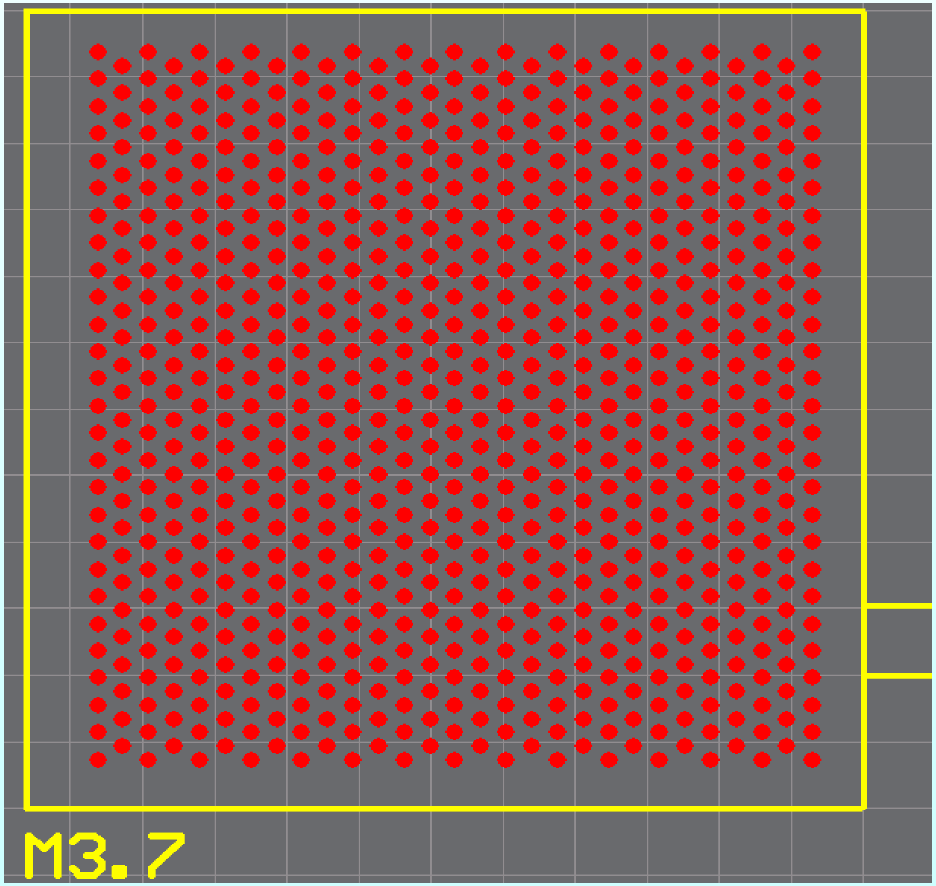
M4.1: T=0.8mm,R=0.3mm,P=0.6mm

Drift dis. 10.6mm
Transfer dis. 2.5mm
Induction dis. 2.5mm

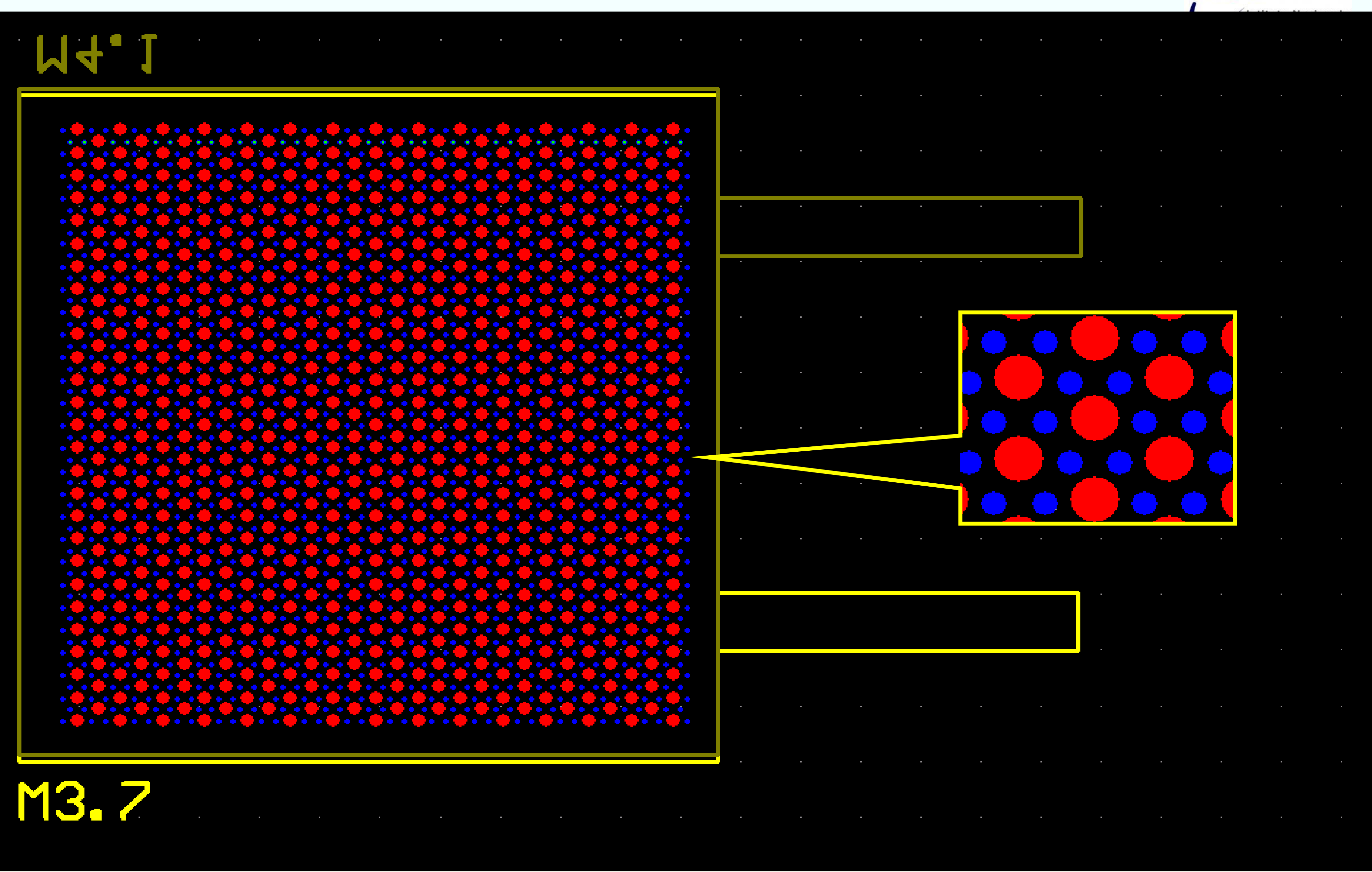
FLOWER”   THGEM

4. Check the IBF effect using M4.1 / M3.7 configuration.

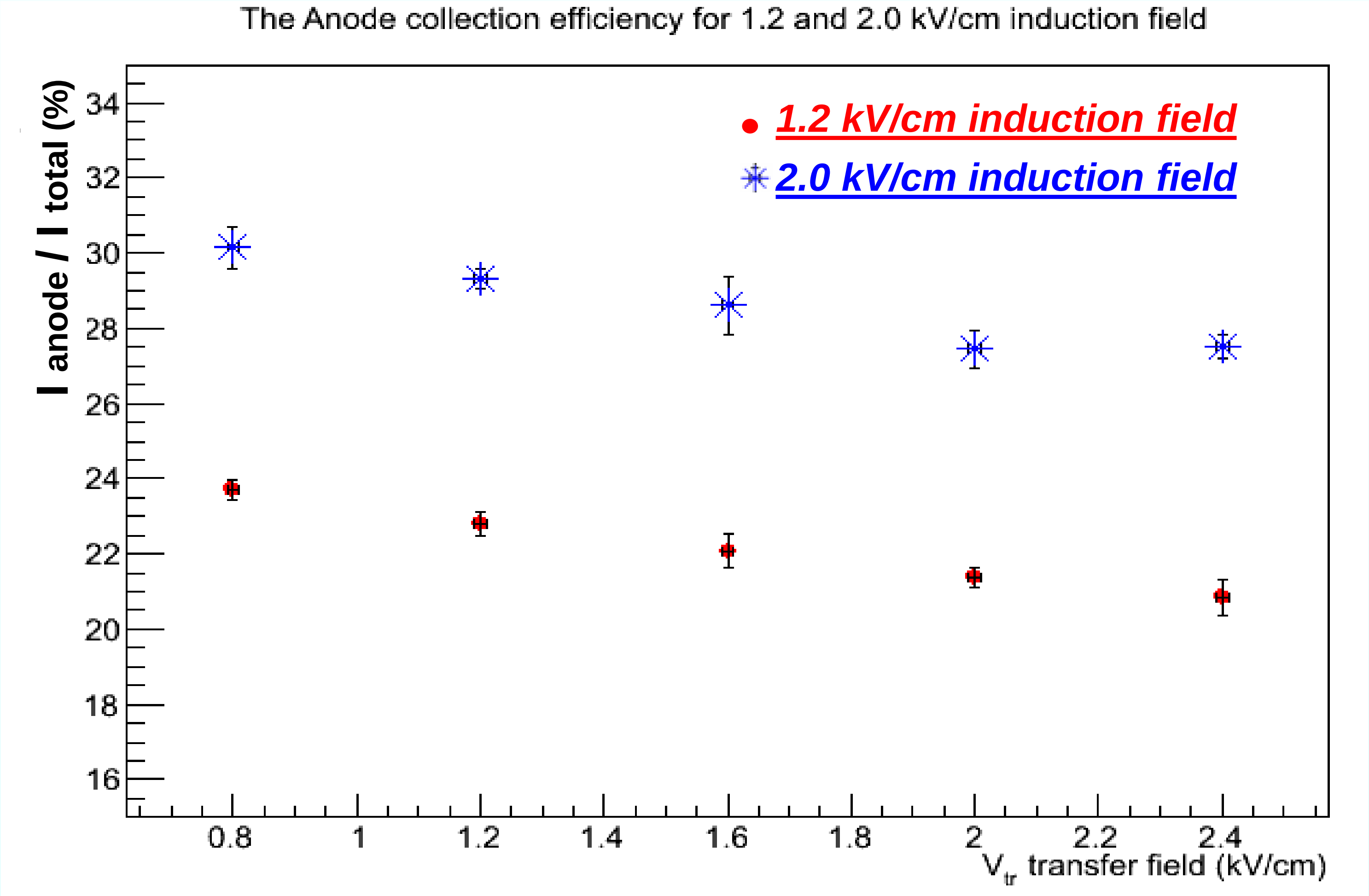




"FLOWER" THGEM

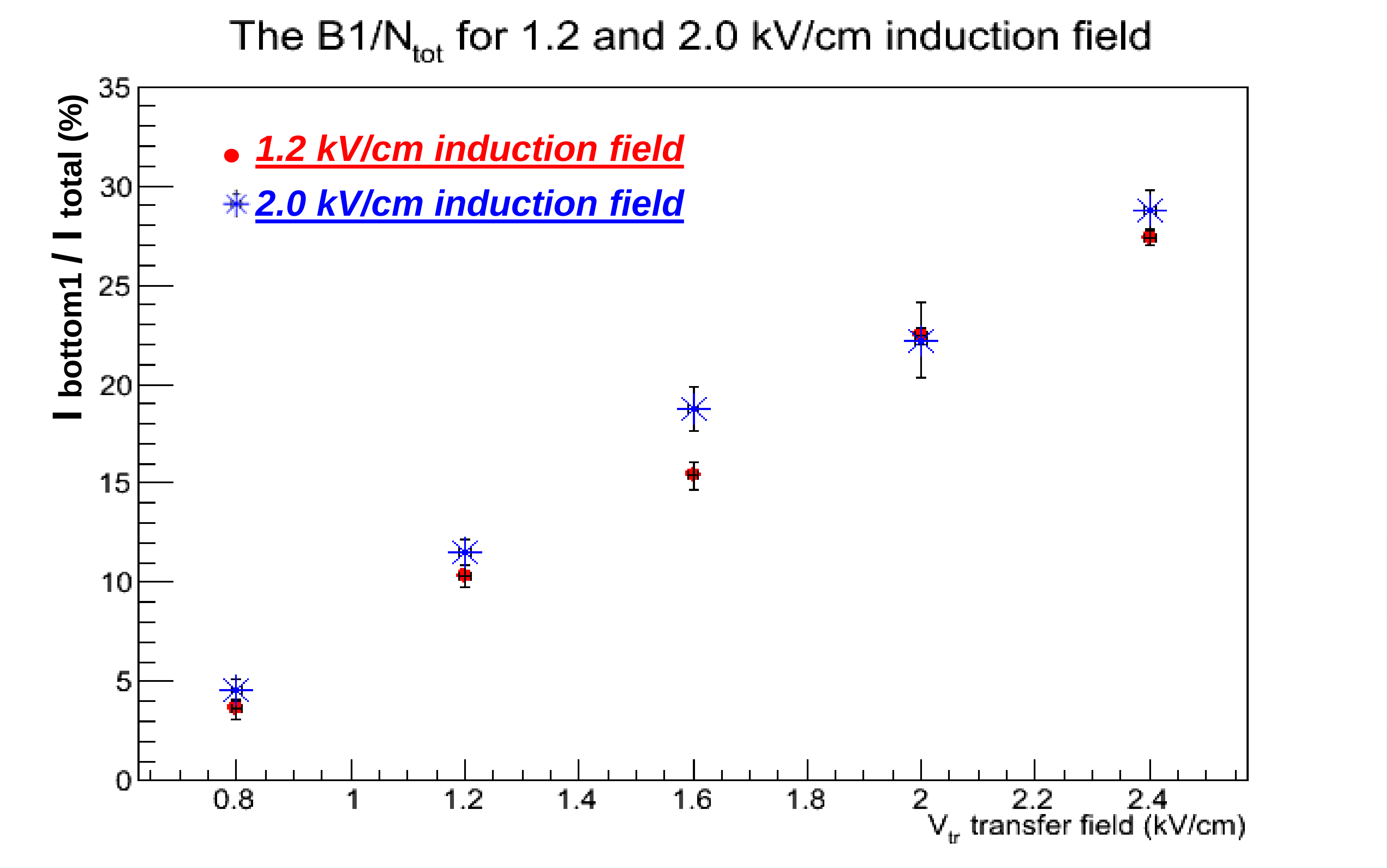


Anodic current (A/Tot)



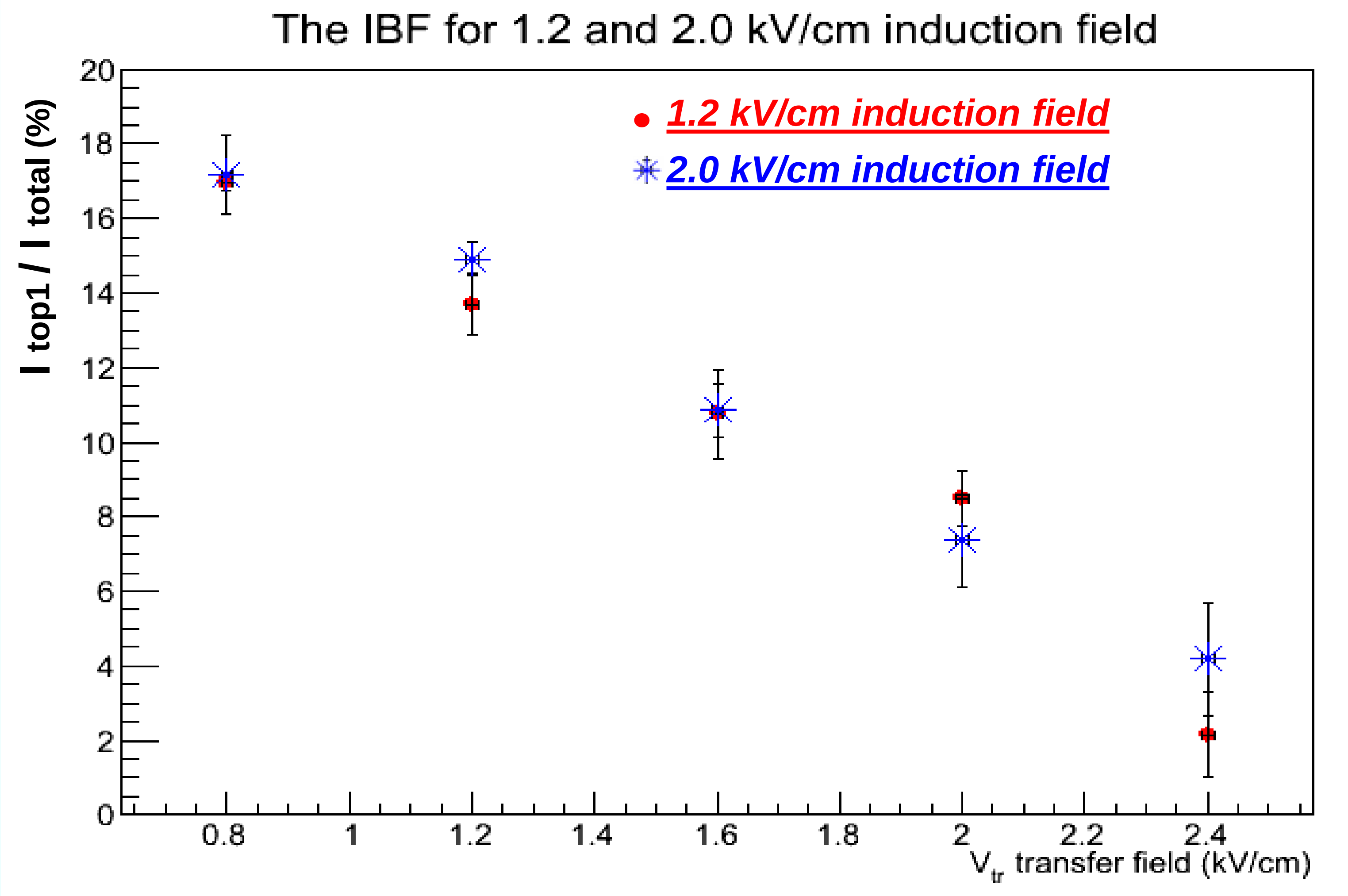
Anode current is almost not affected by the transfer field value

The ions collected at B1 (B1/Tot)



More ions are collected at B1 when transfer field increases

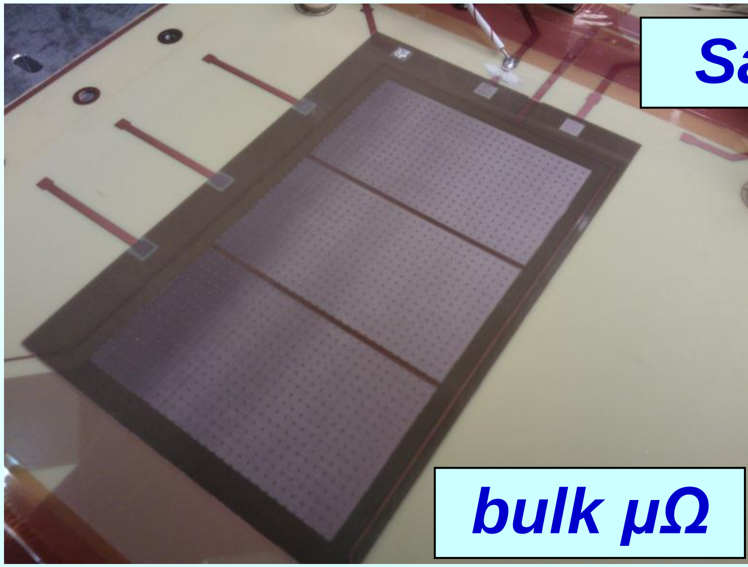
IBF measurement (T1/Tot)



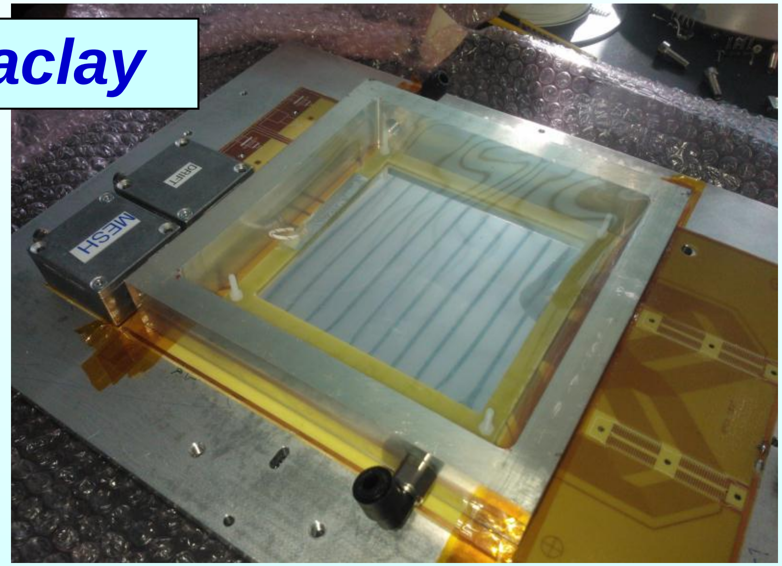
The IBF decreases dramatically when the transfer field increases.

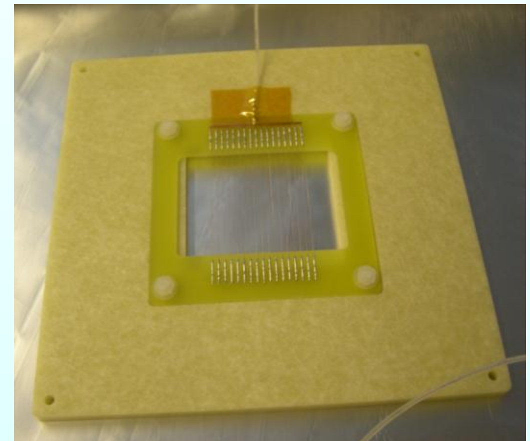
Courtesy of COMPASS CEA-Saclay colleagues:
(many thanks to Damien Neyret)
we could mount one THGEM on top of their Micromega

Saclay

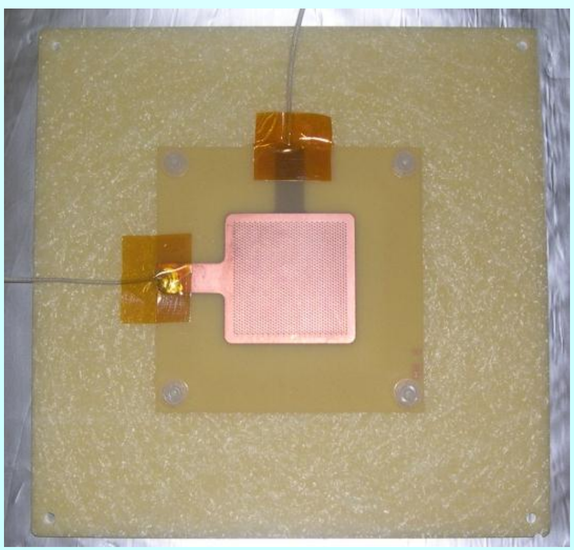


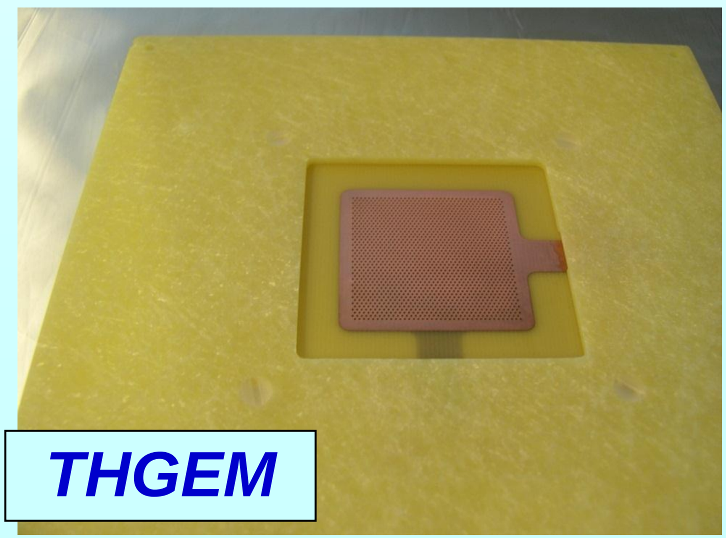
bulk μΩ



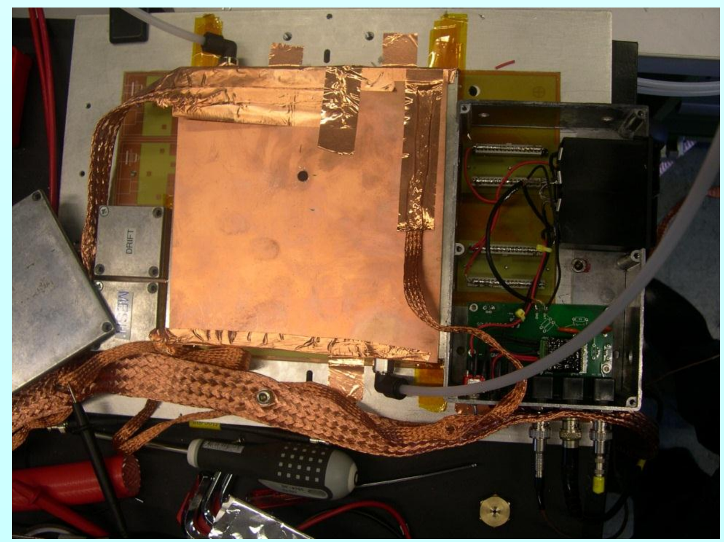


Drift wires

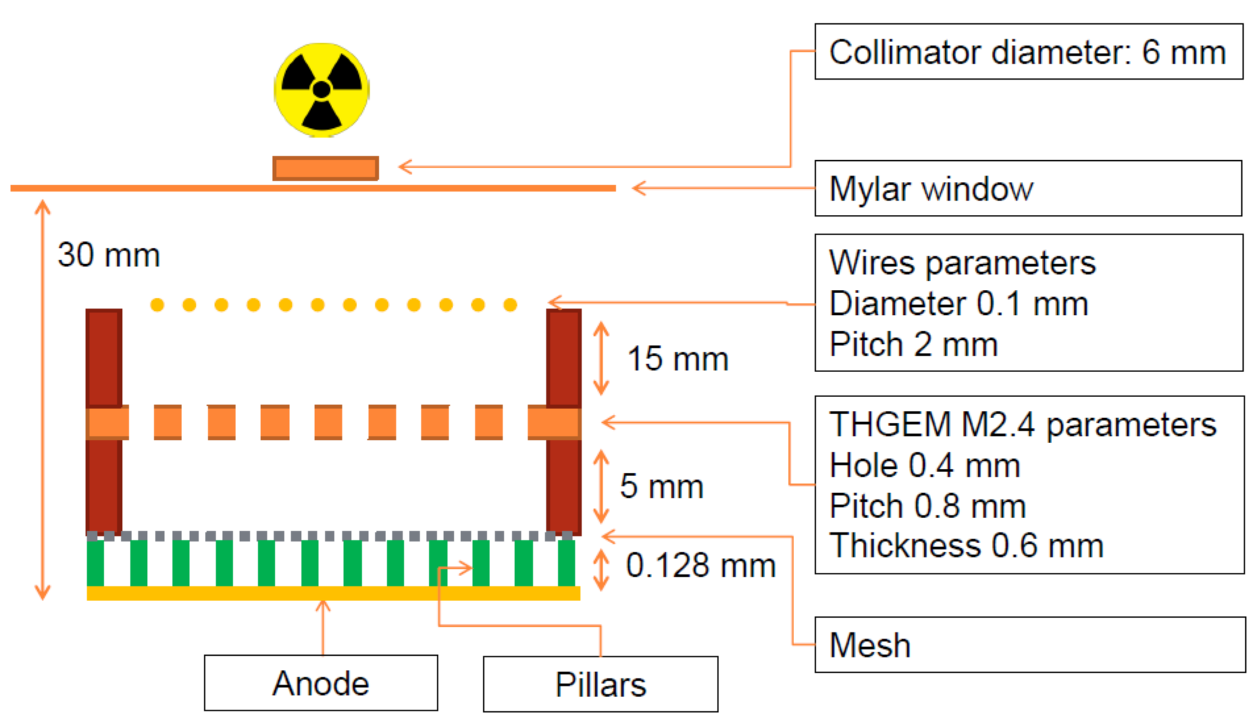


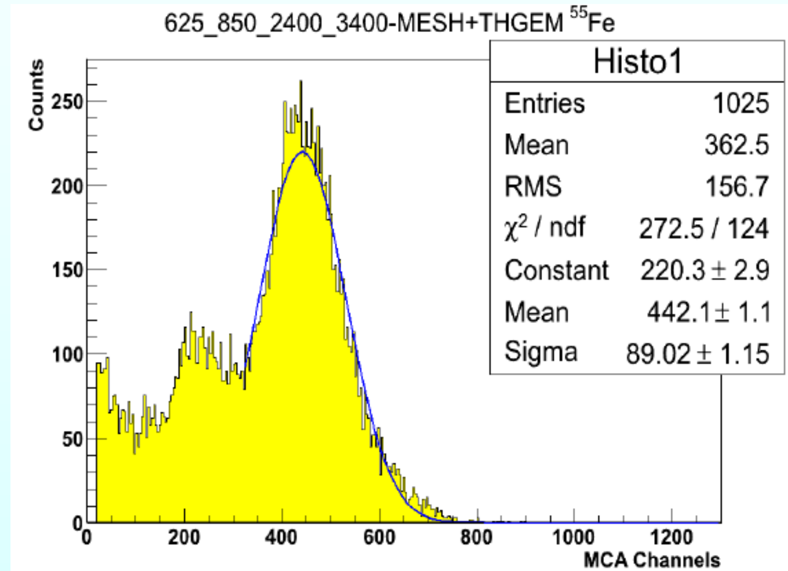


THGEM

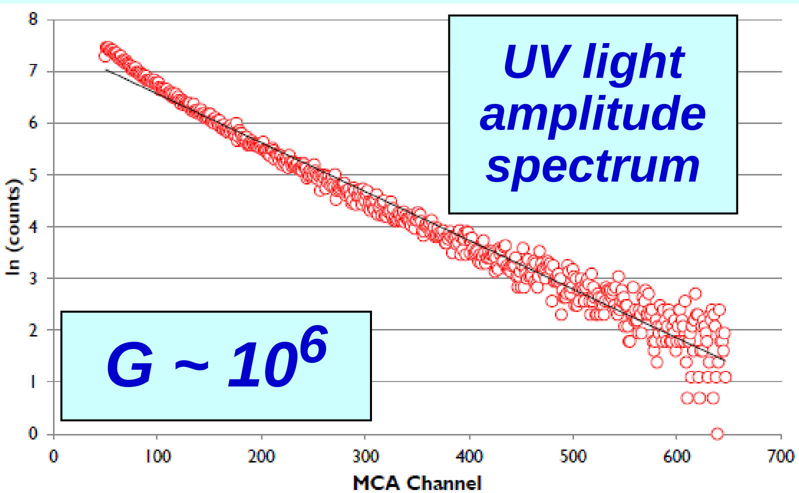


IBF: Very promising preliminary results from hybrid detector: THGEM + Micromega





^{55}Fe source, G ~ 250000



gas: Ar/CO2 70/30, source: 55Fe or UV LED (245 nm)
r/o Cremat CR100 + spark protection
Signal amplified (ORTEC) and read by MCA

Electrode:	drift	THGEM top	THGEM bottom	mesh	anode
charge:	**0 %**	**4 %**	**0%**	**96%**	**-100%**

SUMMARY OF THGEM IBF STUDY

- **IBF reduction is of utmost importance for large gain, large rate THGEM – based PDs operation**
- **Field optimization in standard geometry allows to go from 30% to 15%**
- **Complex geometries ("COBRA" like) are very effective but compromise the basic simplicity, robustness, low cost characteristics**
- **Adding a dedicated electrode for ion intercept provides IBF ~ 7% but adds engineering complications**
- **Misaligned holes configurations (staggered holes or "FLOWER") may reduce IBF by one order of magnitude**
- **Very promising results from THGEM + Micromega structure : IBF ~ 4%**