# Study of the IBF of Double/Triple THGEM

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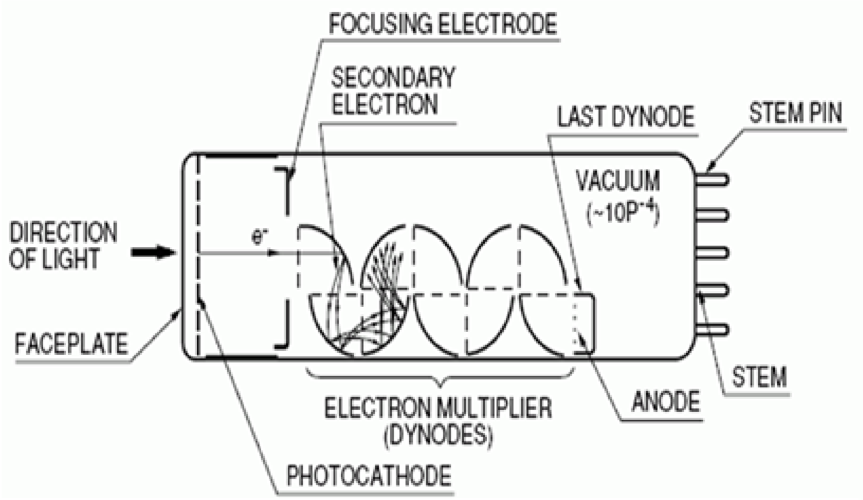
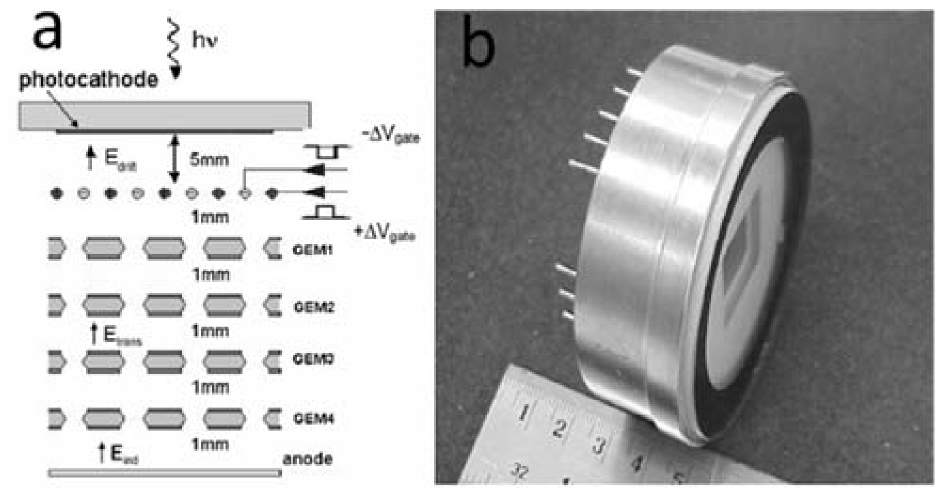
# Outline

- PMT/Gas PMT
- THGEM introduction
- IBF of DTHGEM study
- Triple THGEM study
- Combined analysis
- Conclusion

# Photo Multiplier Tube (PMT)



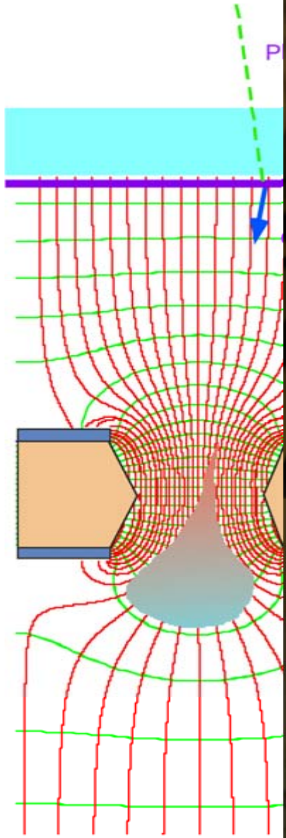

## PMT

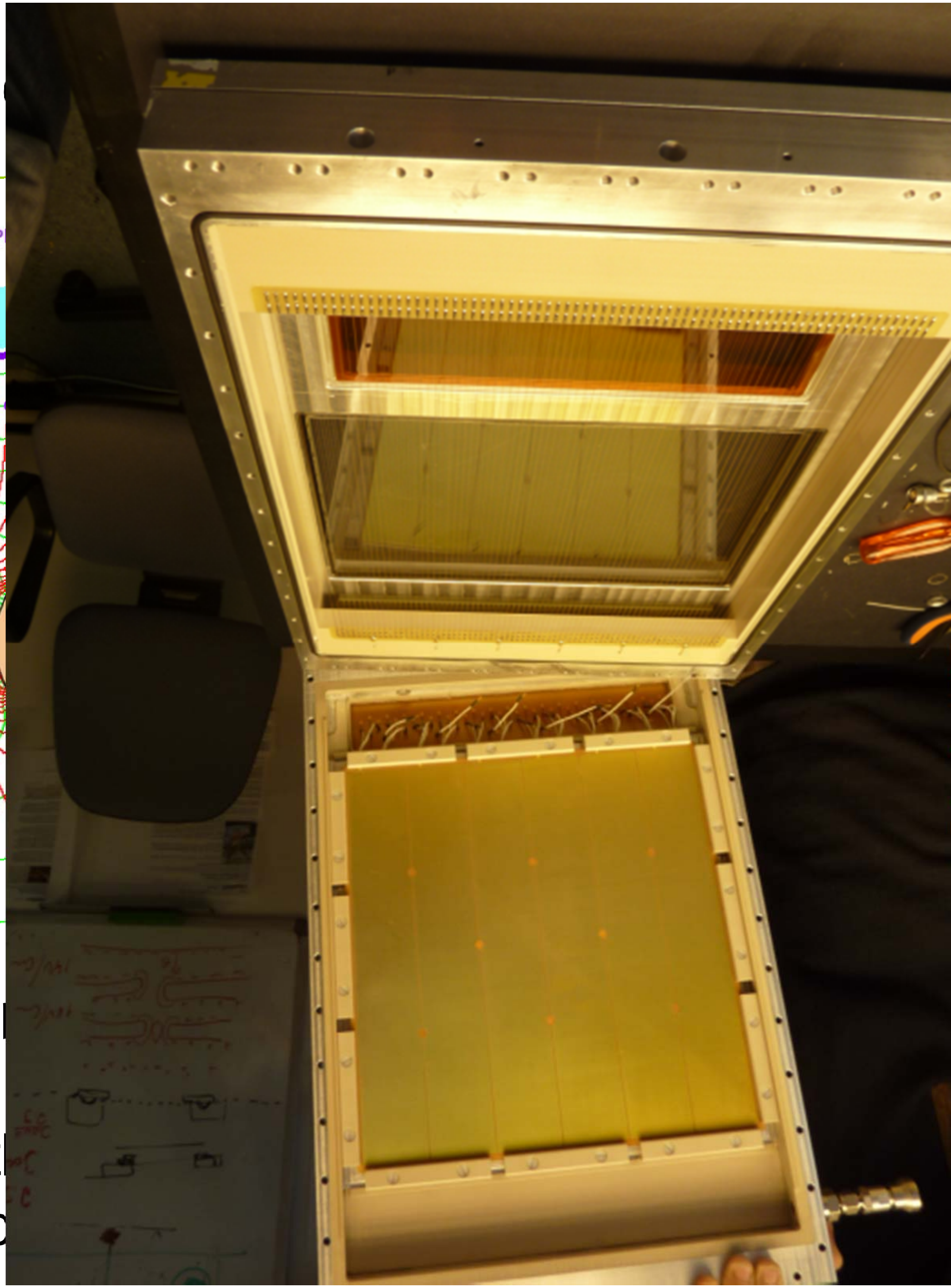
1. High Gain
2. Excellent time resolution (ps)
3. Output channel limited
4. Magnetic field deflected
5. Expensive

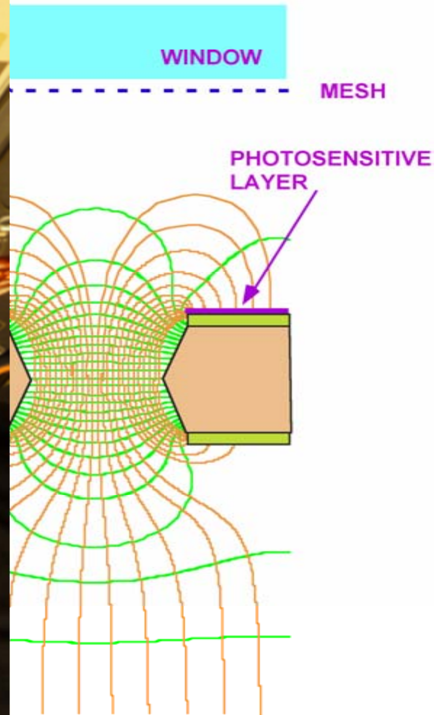
## Gas PMT

1. High Gain
2. Good time resolution (ns)
3. Multi-Channel output
4. Magnetic field tolerated
5. Radiation hard
6. Relatively cheap
7. Compact

# Prin… oating








Tra… ct

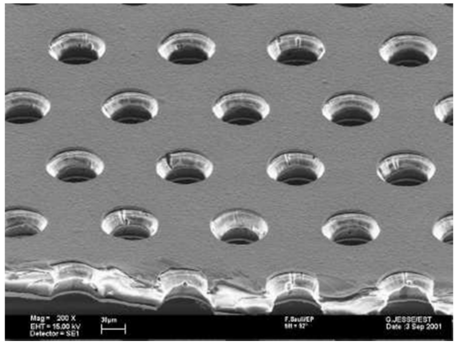
In both met… tric field and
hit on photo…

# Thicker Gas Electron Multiplier (THGEM)

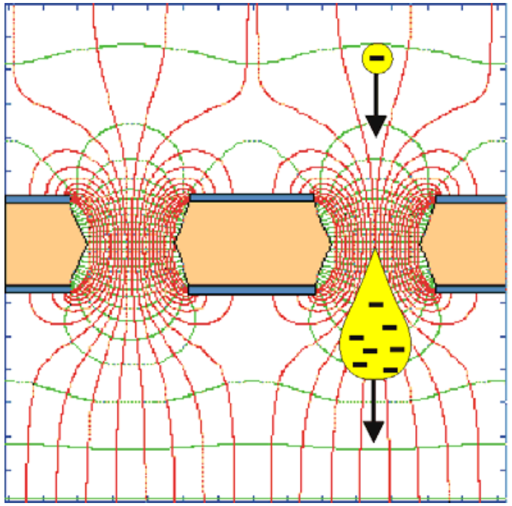
**Standard GEM**

**Developed from 1997 by F. Sauli (CERN)**

Typical parameters:
- 50μm Kapton
- Ø60μm holes
- 100-200μm pitch



F. Sauli NIM A 433 (1997) 531

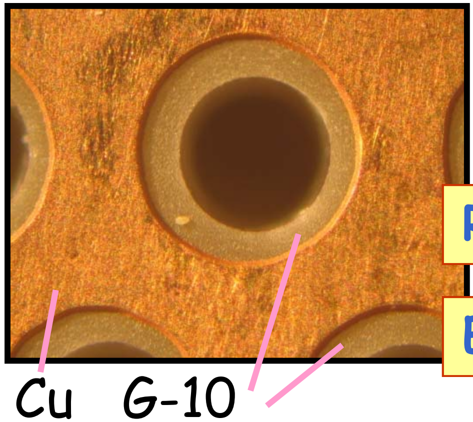


**THGEM**

**Developed from 2004 by A. Breskin (Israel, CERN) :**

Parameters:

| | |
|---|---|
| Thickness | t = 0.2~0.5 mm |
| Hole diameter | d = 0.2 - 1 mm |
| Pitch | a = 0.5- 1 mm |

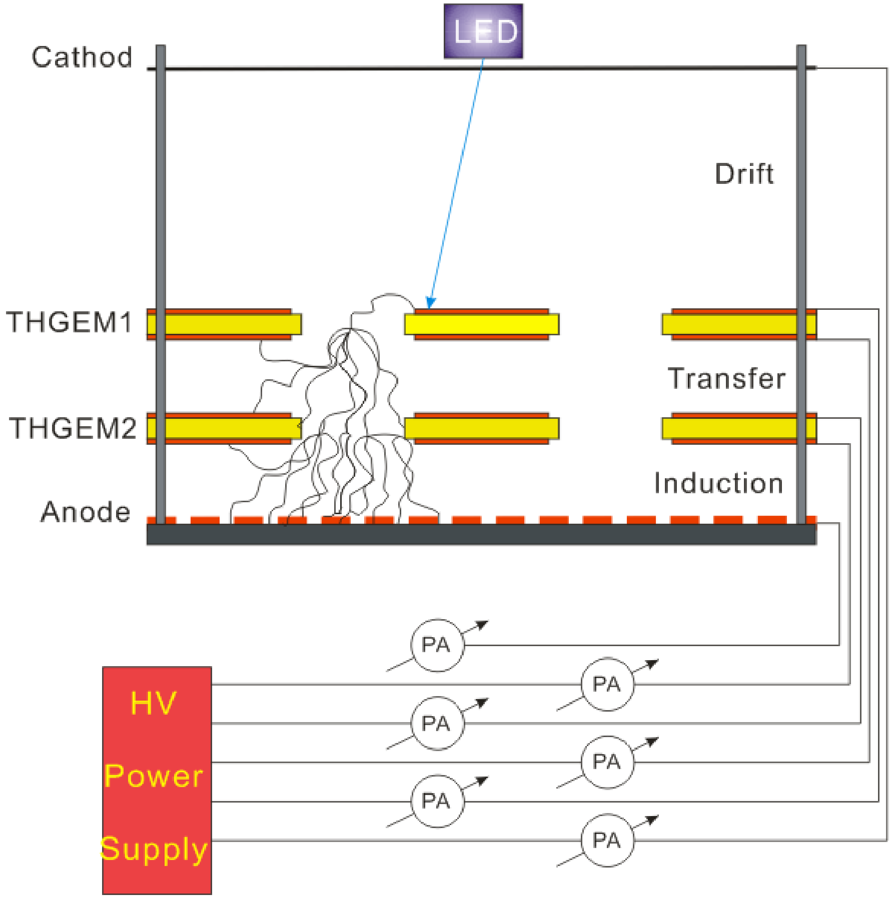


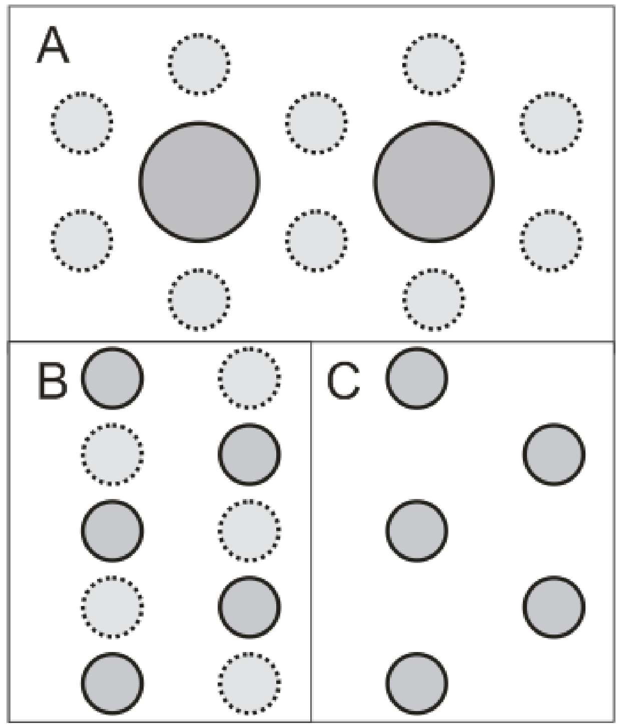

**ROBUST !**

**Easy produced**

Chechik et al. NIM A535 (2004) 303

# Experiment setup



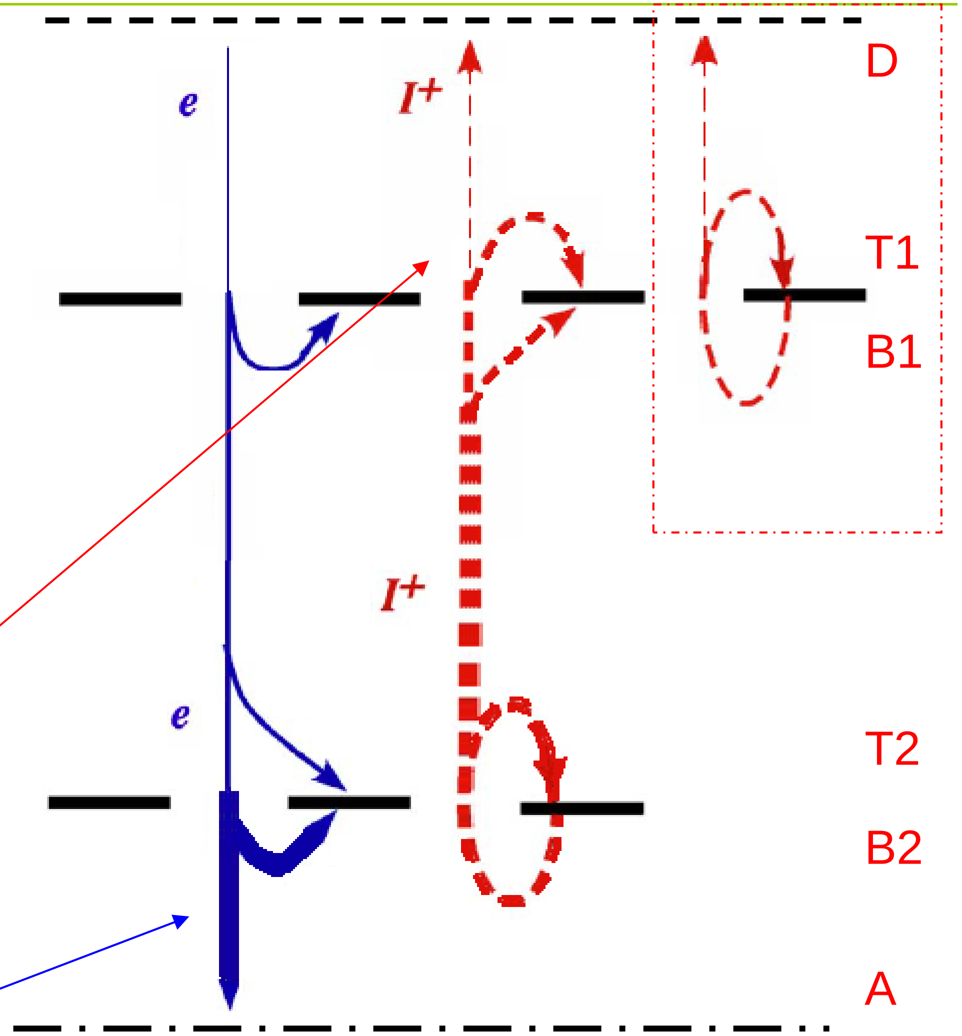




Different pattern designs of THGEM

# Test procedure

1. We tested them with aligned/not aligned configuration.

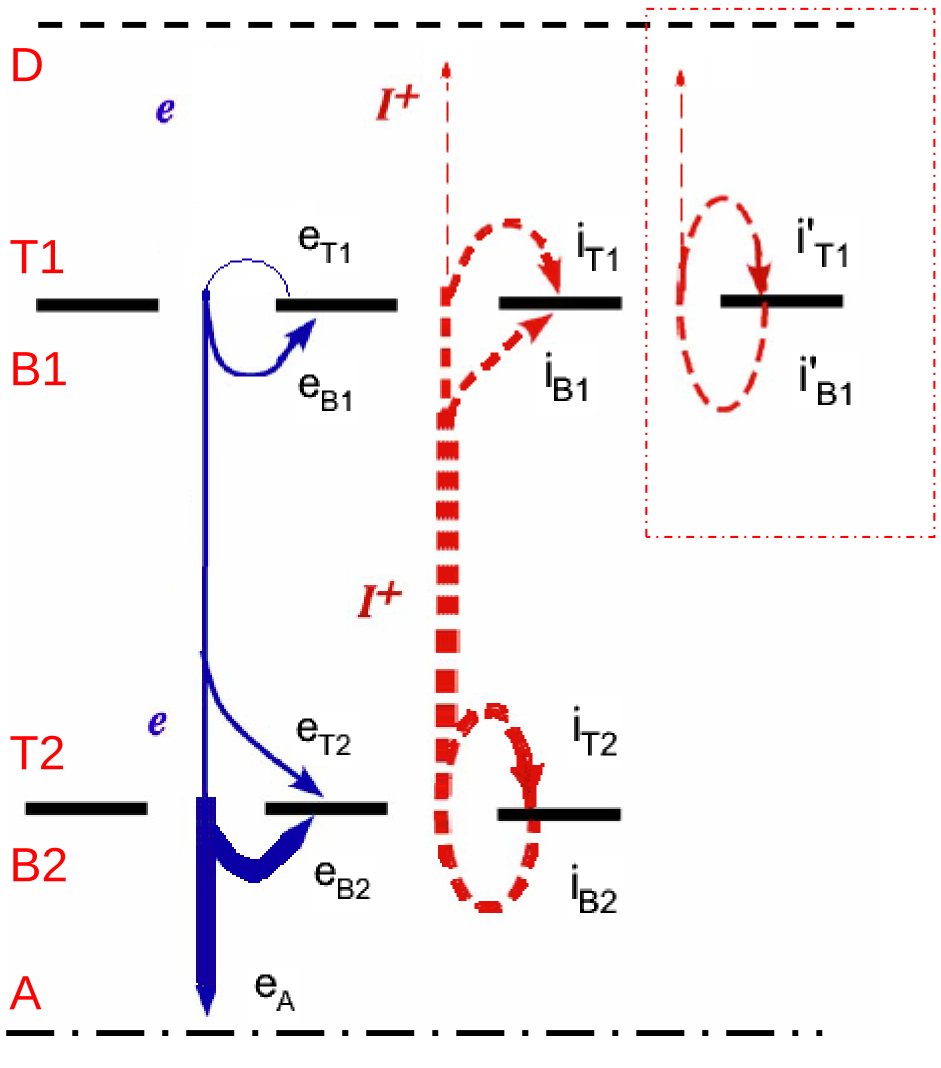
2. The current of each layer are measured and the following parameters are calculated:




$\Sigma(I_i)/I^e_{total}$

$I_{T1}/I^e_{total}$

$I_{Anode}/I^e_{total}$




$e_{B1}, e_{T2}, i'_{T1} \propto$ Gain

$e_{B2}, e_A, i_{T1}, i_{B1}, i_{T2}, i_{B2} \propto$ Gain$^2$

Almost 0

negligible

$I_{T1} = i_{T1} + i'_{T1} - e_{T1}$

$I_{B1} = i_{B1} - e_{B1} + i'_{B1}$

$I_{T2} = i_{T2} - e_{T2}$

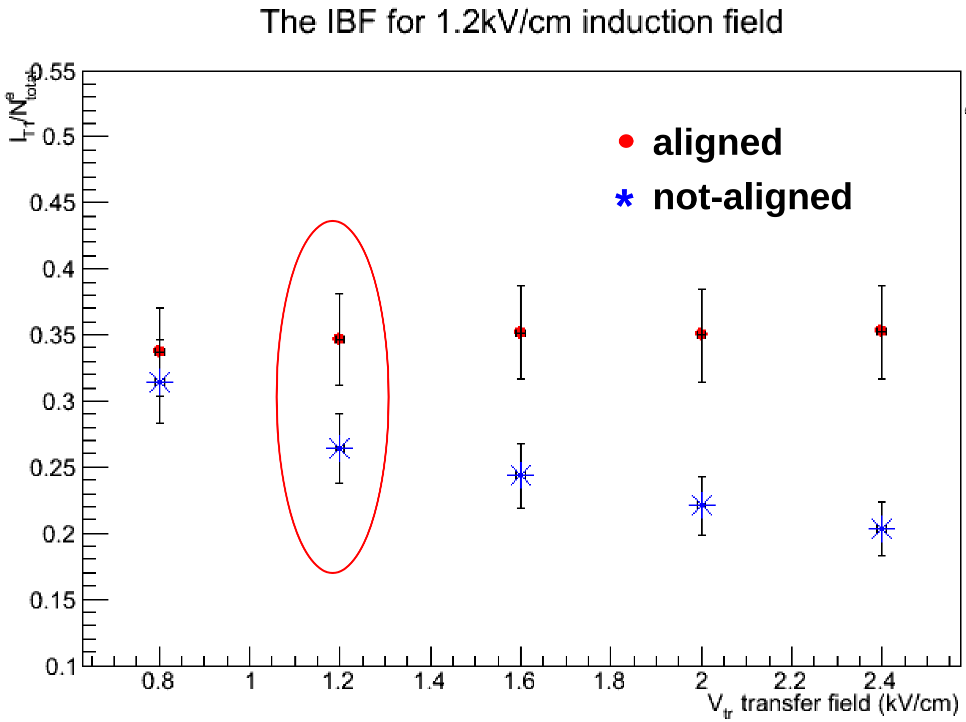
$I_{B2} = -e_{B2} + i_{B2}$

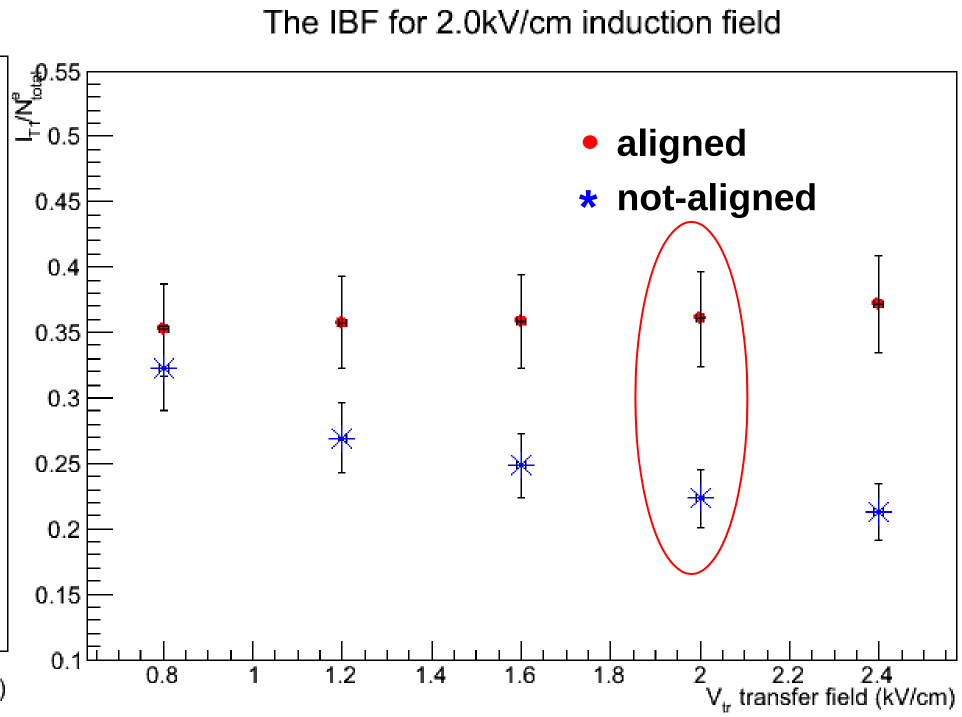
$I_A = -e_A$

$I^e_{total} = |e_A + e_{B2} + e_{T2} + e_{B1}|$

$\rightarrow \ |I_A + I_{B2}| = |e_A + e_{B2} - i_{B2}|$

# IBF measurement (T1/Tot) for Conf. B/C

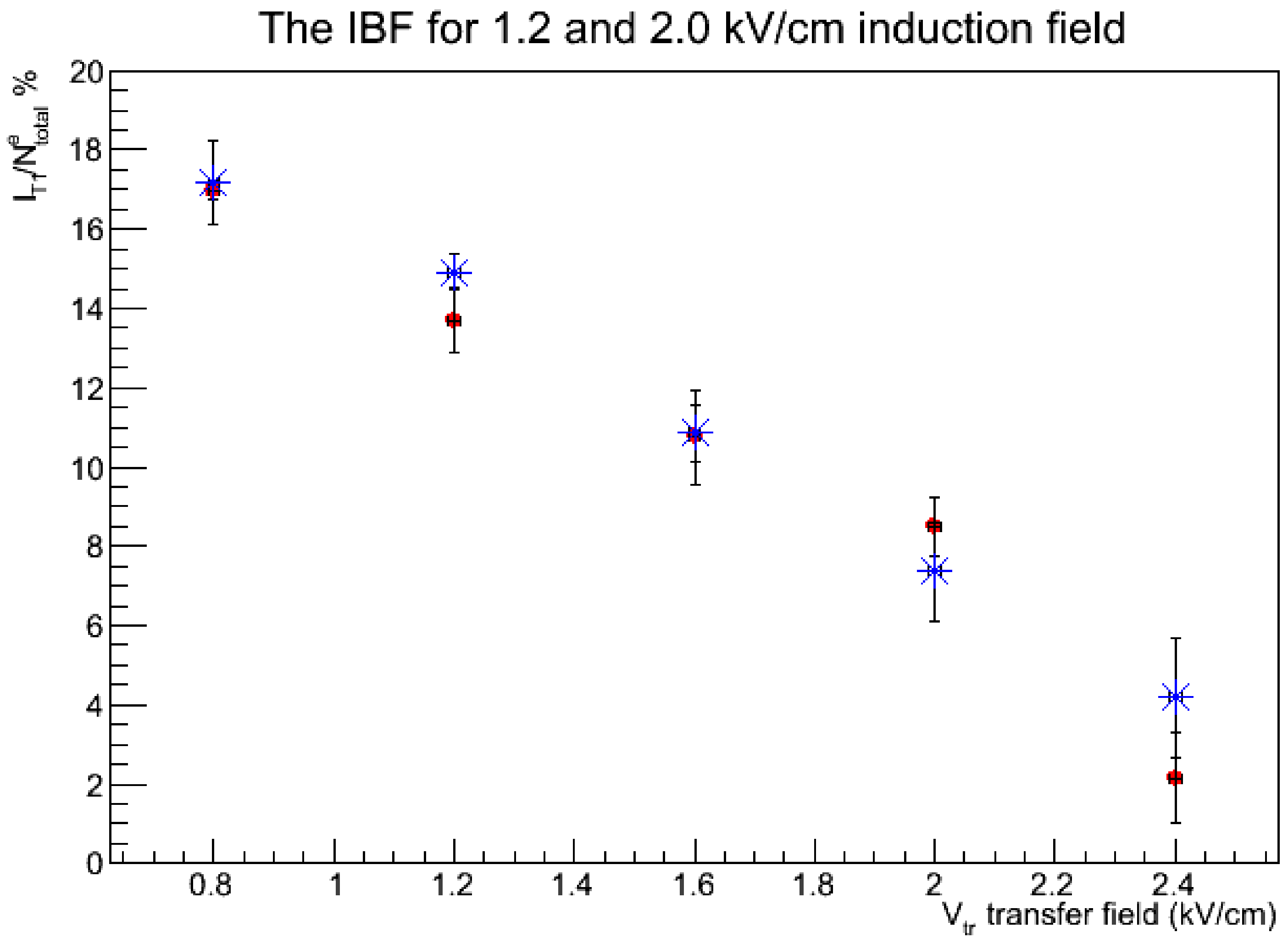



For aligned DTHGEM, the IBF is not related to the transfer field.

For not-aligned DTHGEM, the IBF decreases while transfer field increases.

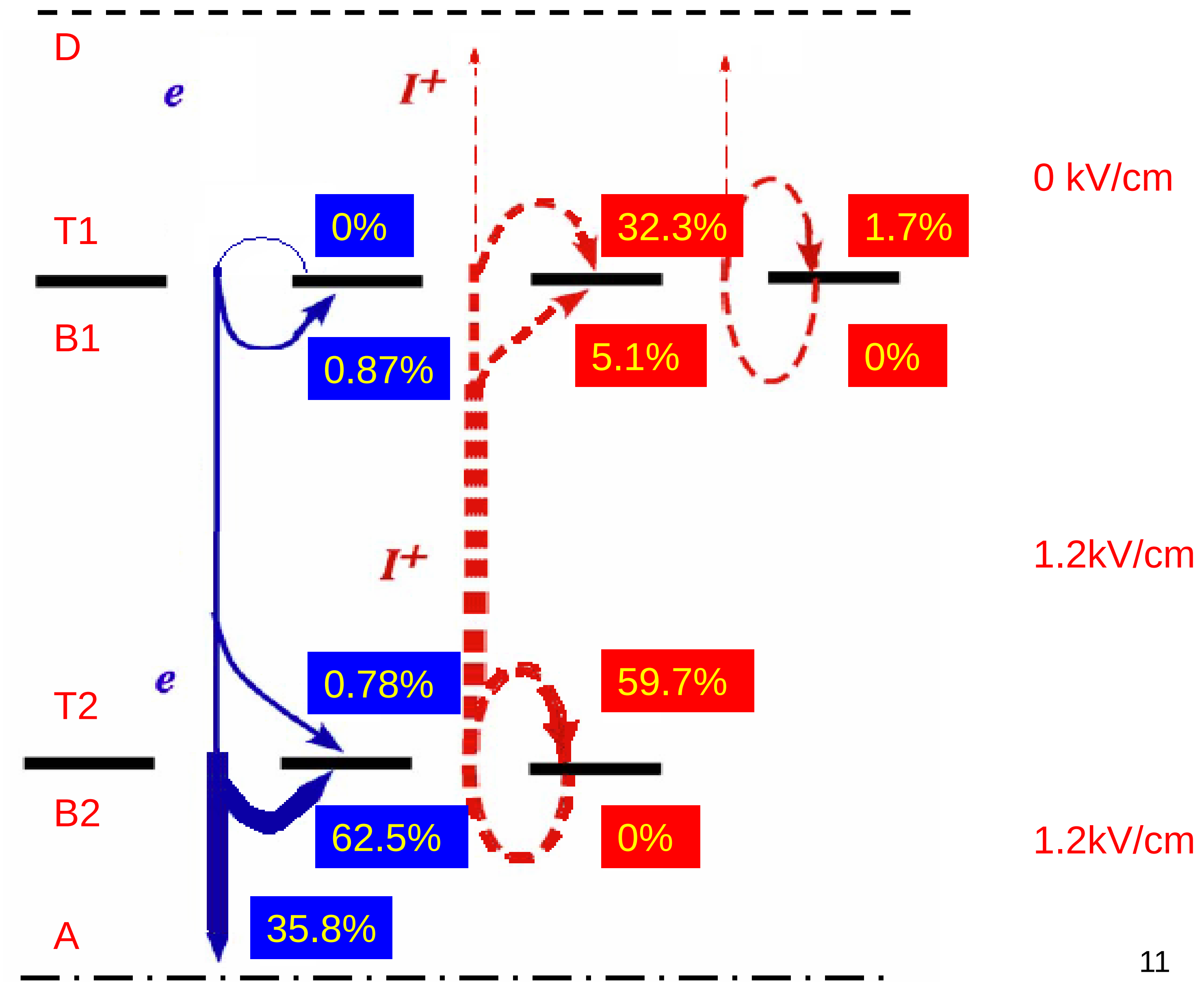
# IBF measurement for conf. A(T1/Tot)




The IBF decreases dramatically while transfer field increases.

Errors are calculated using the error propagation function.

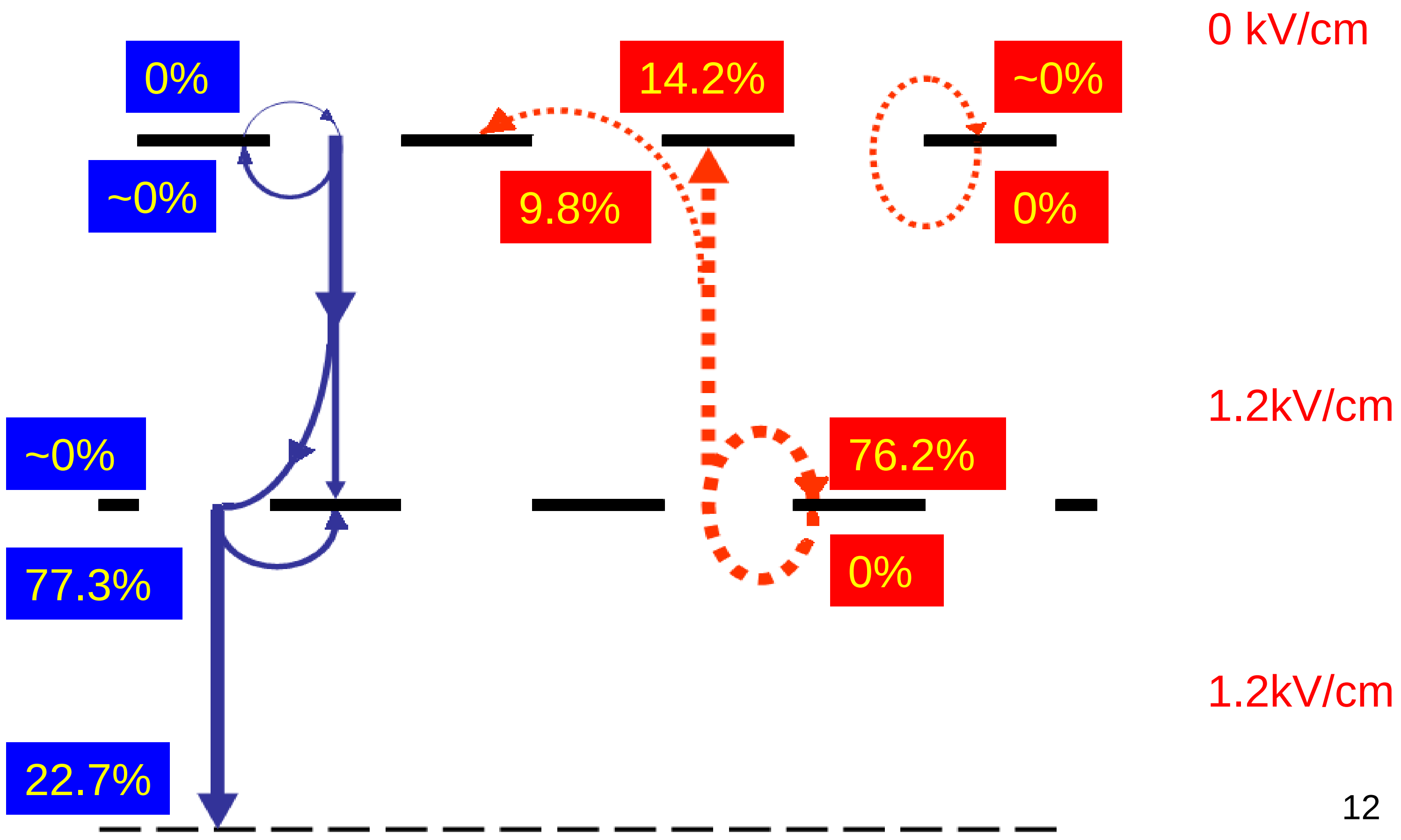
# IBF analysis for conf. C (aligned)



# IBF analysis for conf. A

Gain was pushed to the second THGEM,

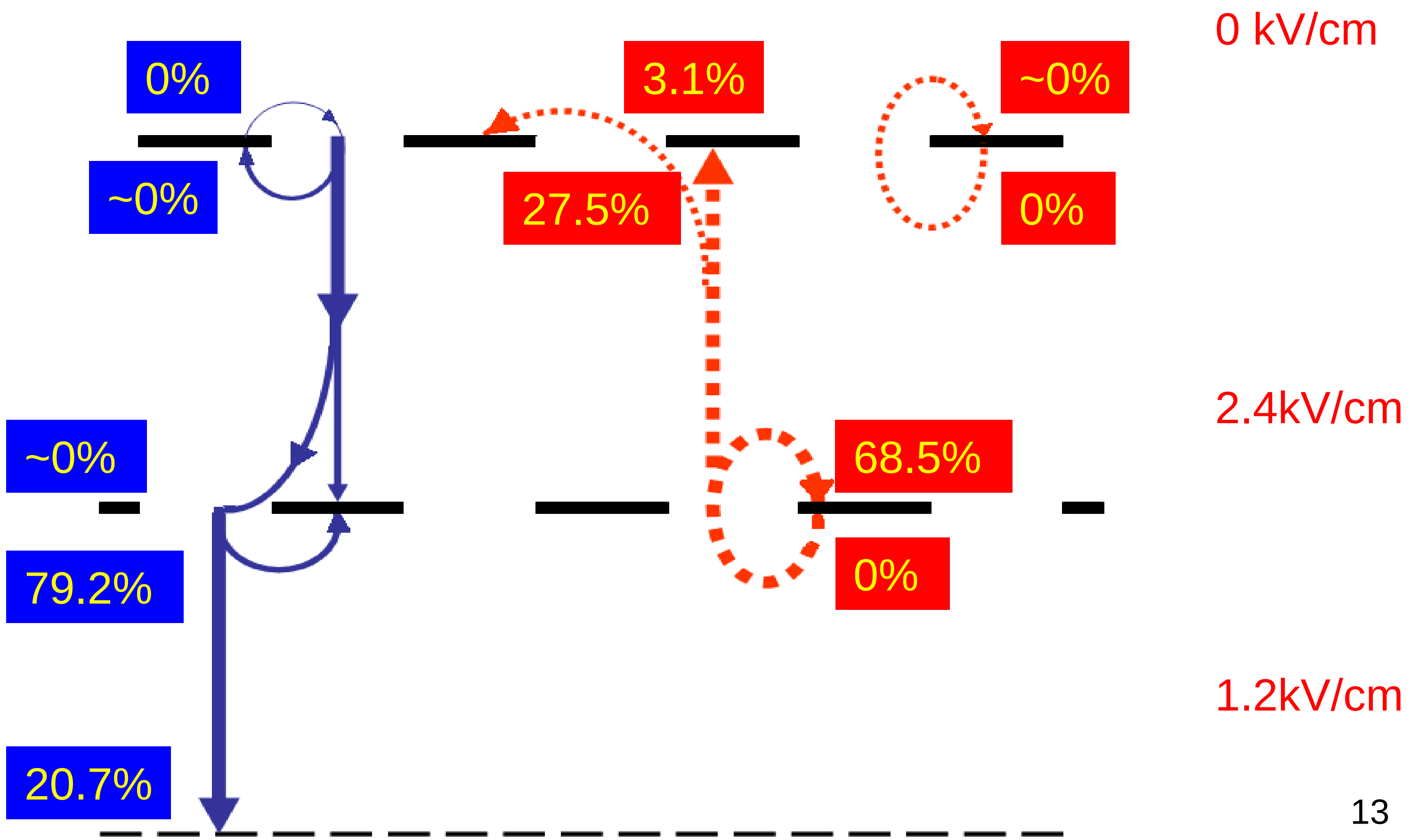
so the electrons and ions from the first layer of THGEM are almost negligible.



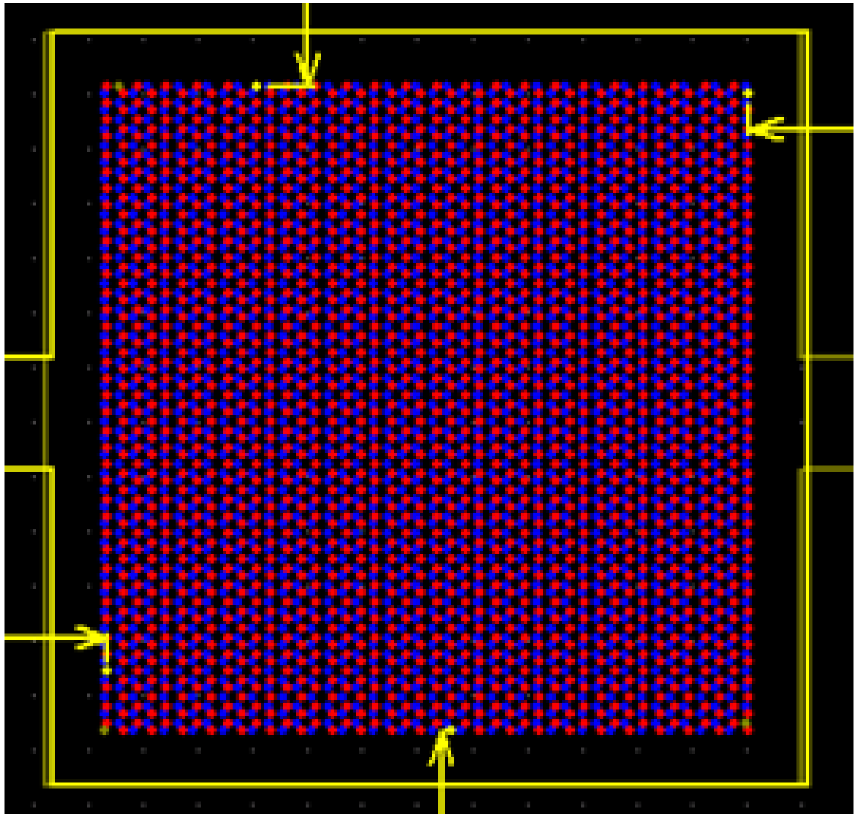
# IBF analysis for conf. A

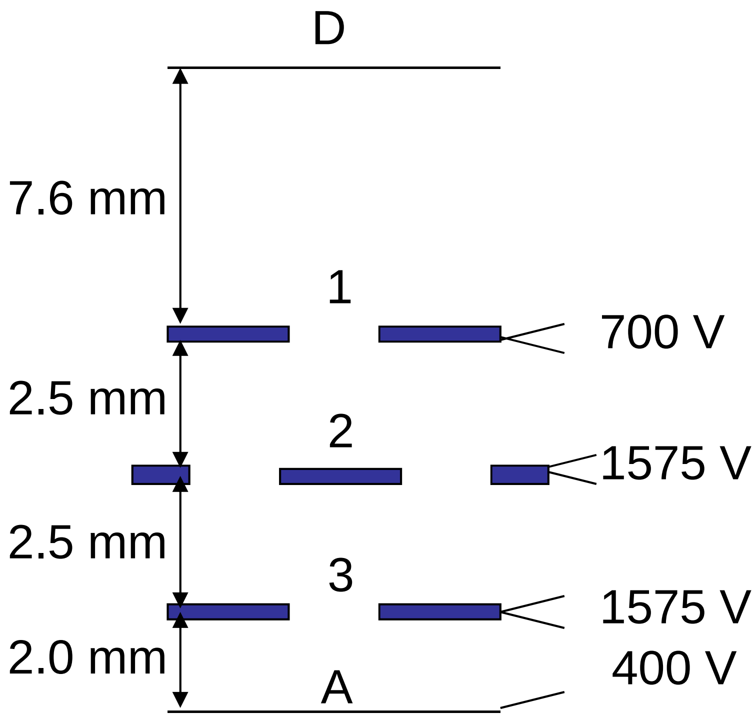
Double the transfer field, the ions will hit B1 instead of drifting to T1.

But the ions from bottom are still mainly collected by T2.



# Triple THGEM configuration

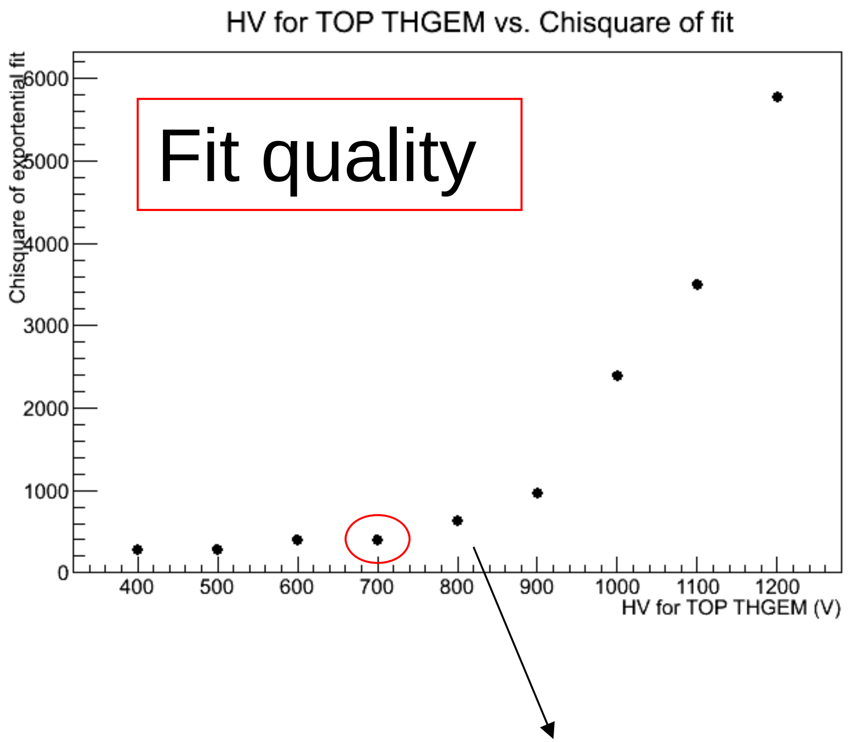


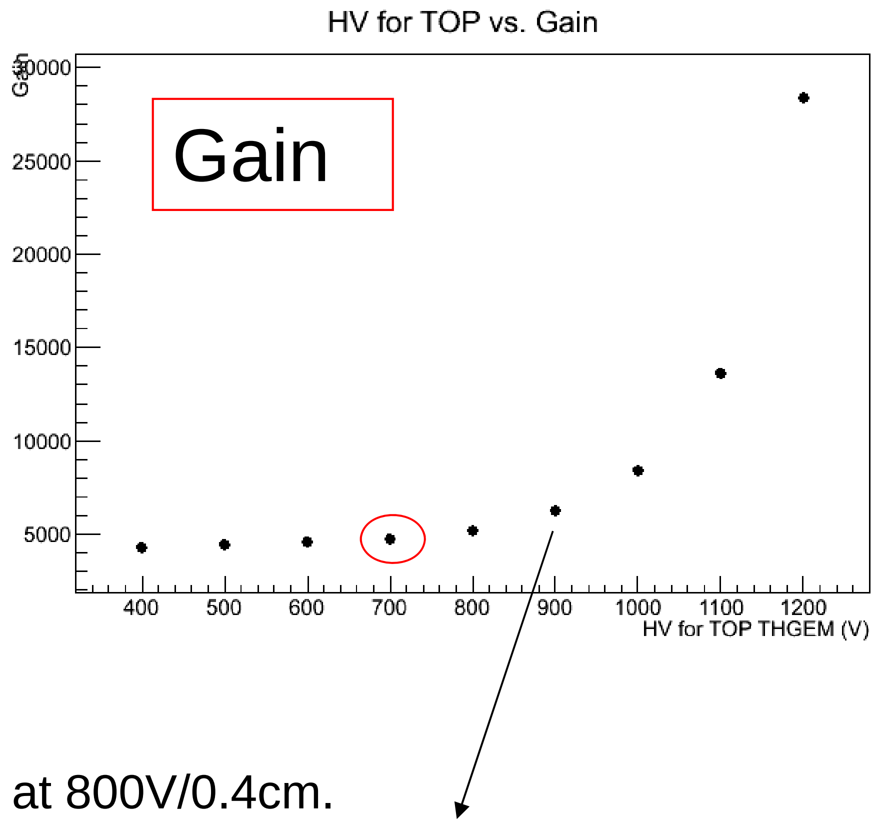



Conf. B is used for triple THGEM. The middle one is not aligned to the others two.

# Scan the top THGEM HV

To push the gain to the bottom two, TOP THGEM high voltage is set to 700V.



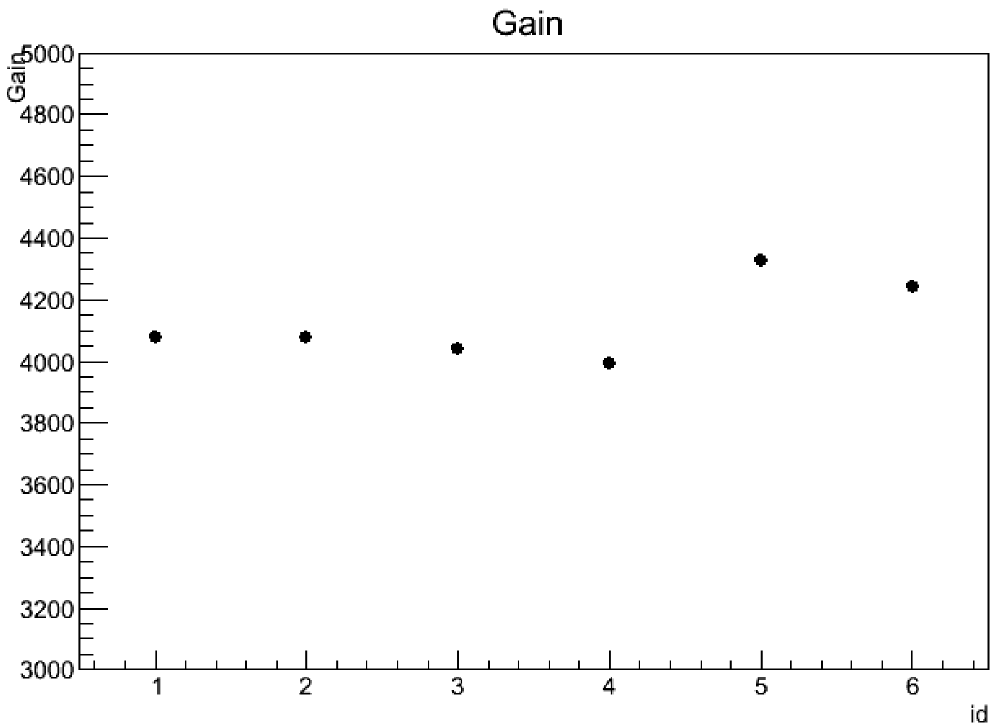




- The quality of the fit starts to get worse at 800V/0.4cm.
- The gain shows lower than 900V/0.4cm, the single photon is dominated. Starting at 900V/0.4cm, the multiple photons are dominated, and the top THGEM starts to work.

# UV light stability

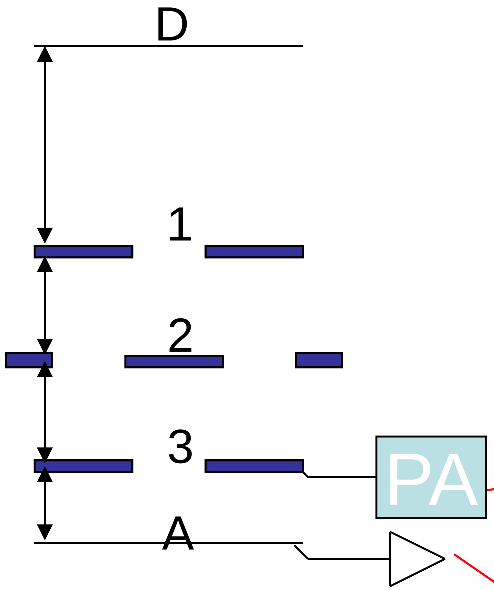
Motivation: during DTHGEM test, the current of anode decreased when induction field increased. One probability is the UV light intensity decreased.

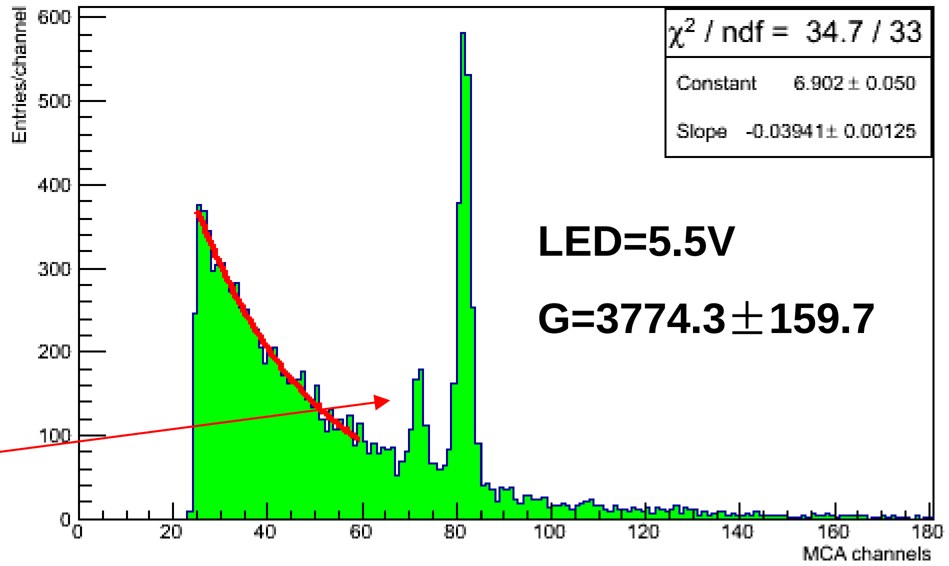
Method: Applying 6.5 V to UV light, turn it on for 1 min which is approximately the same time period for IBF measurement, then turn it off for another 1 or 2 minutes.

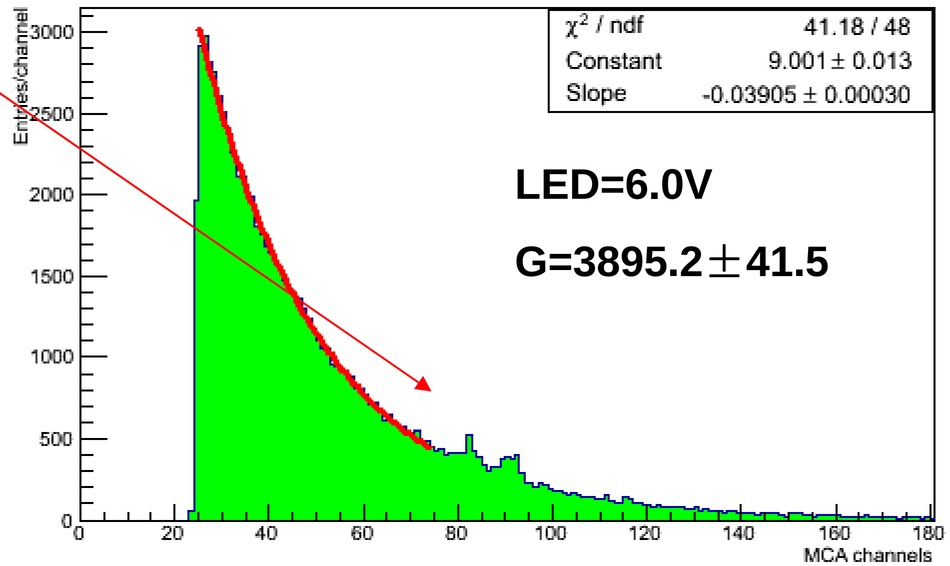



The light source should be quite stable during the IBF measurement!

# UV light vs. PA Meter



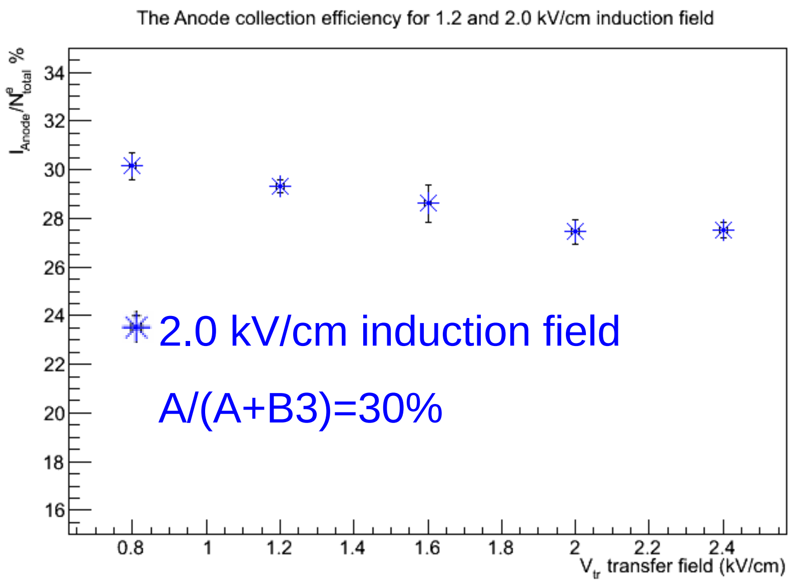

The noise from PA contribution can be avoid by chose a different fit range.

# UV light vs. PA Meter

The anode current can be estimate by:

$$I_{Anode} = e \times Gain \times Rate / e^{-Thres/(e \times Gain)}$$

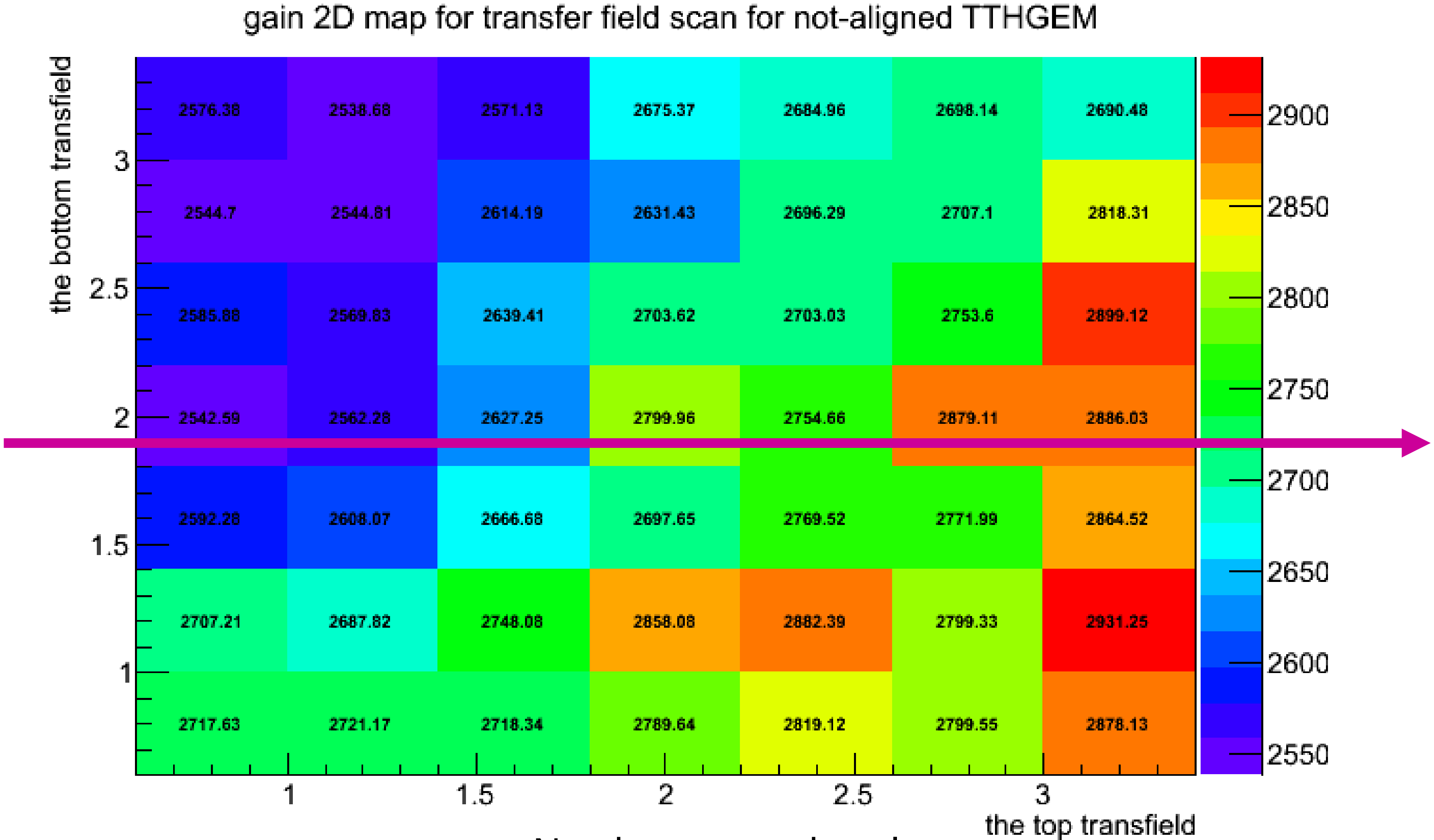
| LED | Thres./fC | Rate/Hz | Gain | I_Anode | I_Anode' | I_B3 |
|---|---|---|---|---|---|---|
| 5.5 | 1.12 | 550 | 3774.3 | -2.12 | -3.0 | -7 |
| 6.0 | 1.12 | 6975 | 3895.2 | -26.22 | -37.7 | -88 |
| 6.5 | 1.12 | 27947 | 4172.2 | -99.87 | -165 | -385 |




Measured from PA Meter

# Gain 2D scan for not-aligned TTHGEM

Gain doesn’t change much. But with larger bottom transfer field, the gain is smaller.

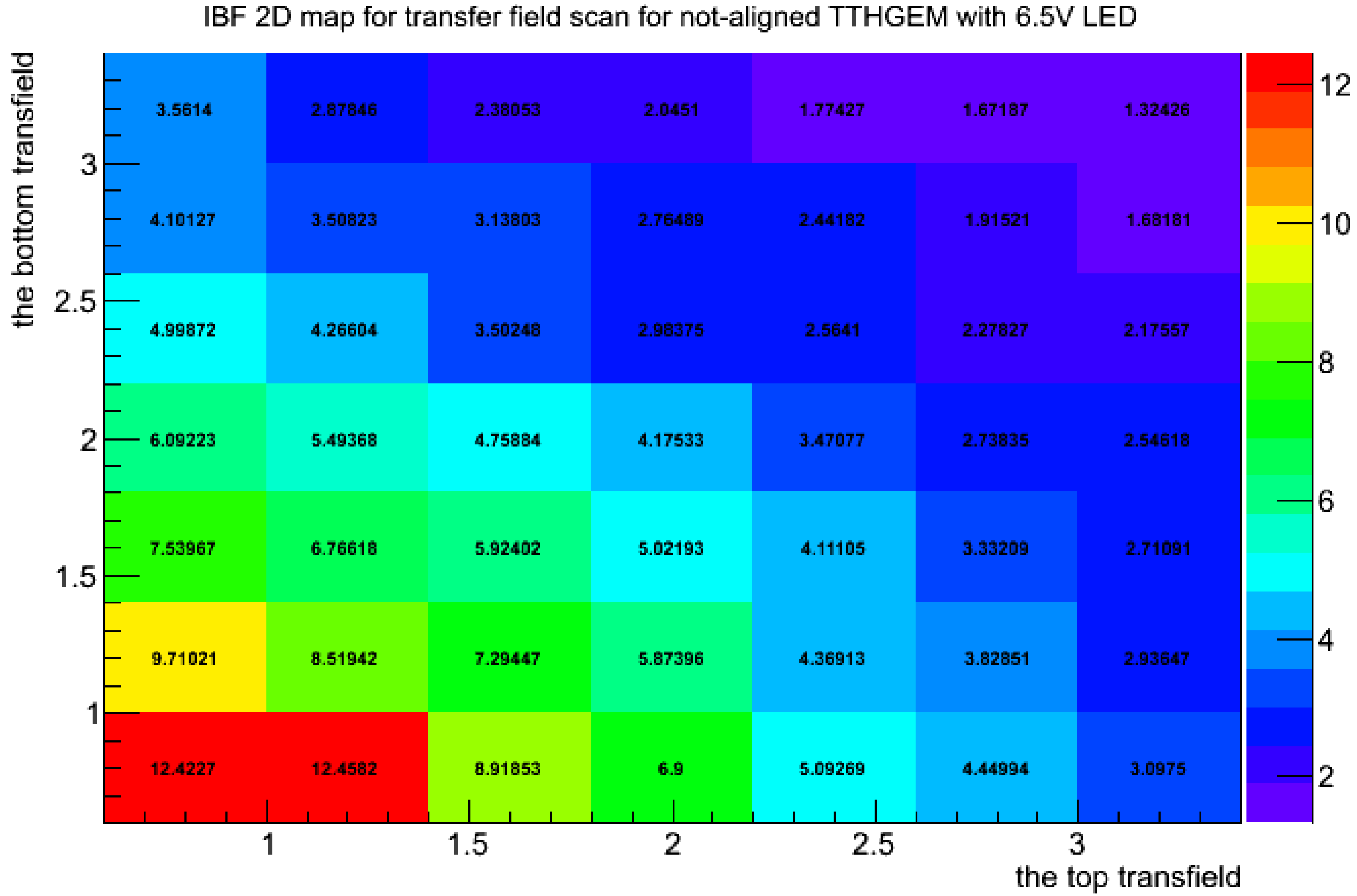



Numbers are gain value.



The test has been done with LED=5.5V

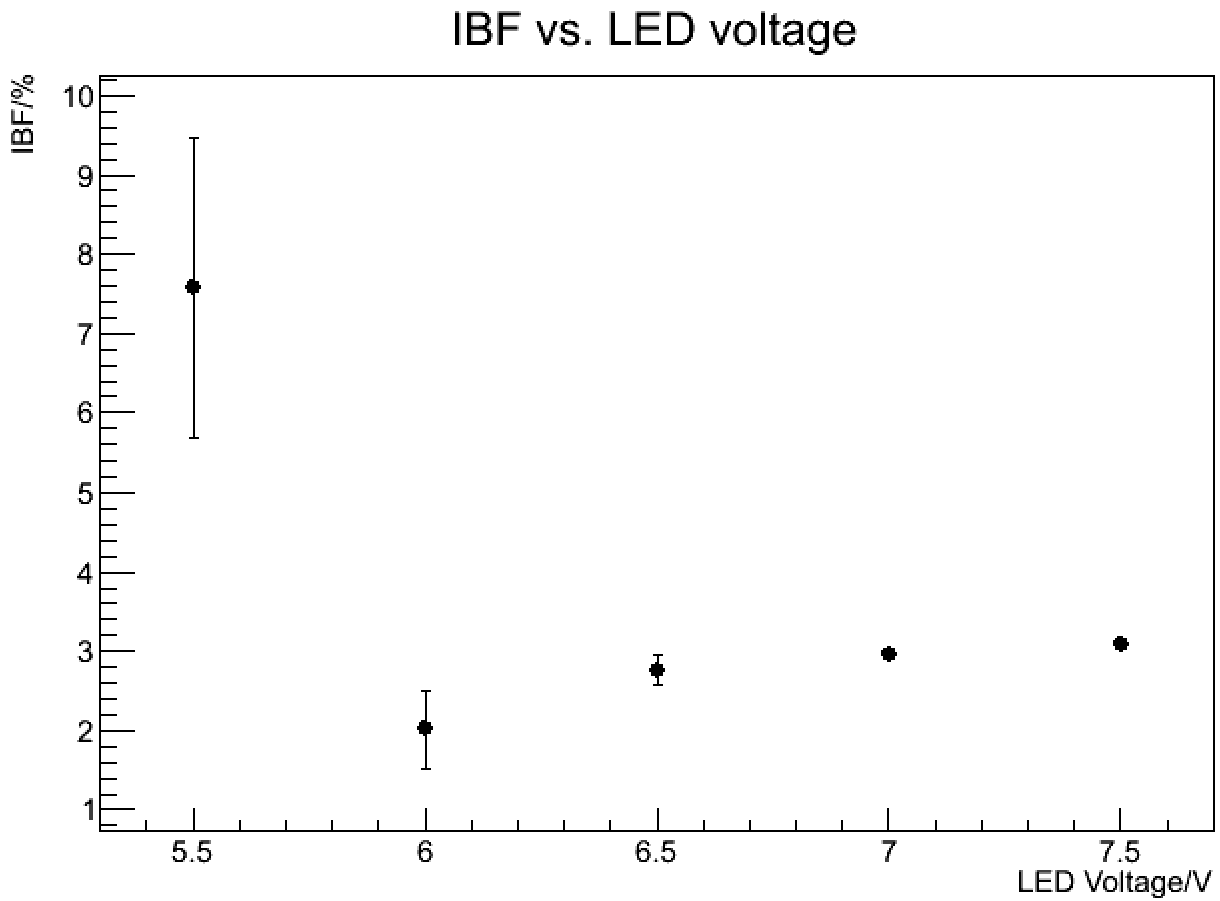
# IBF 2D scan for not-aligned TTHGEM




Numbers are IBF%

# IBF vs. LED for not-aligned TTHGEM

The top transfer field = 3.0kV/cm The bottom transfer field = 2.0kV/cm




The error are calculated by error propagation.

By increasing LED voltage, the uncertainty of IBF decreases

because the current is bigger and more stable

The IBF 2D scan result for 5.5V LED can be found in the backup slices.

# discussion

- The not-aligned conf. can decrease 93.3% IBF, while only lose 17% gain.
- Question followed:
  1. will this not-aligned conf. decrease the max counting rate?
  2. will this not-aligned conf. decrease the efficiency?

- Due to the PA meter, IBF is measured for LED=6.5 V;
- To have "single" photon-electron signals, gain is measured for LED=5.5V

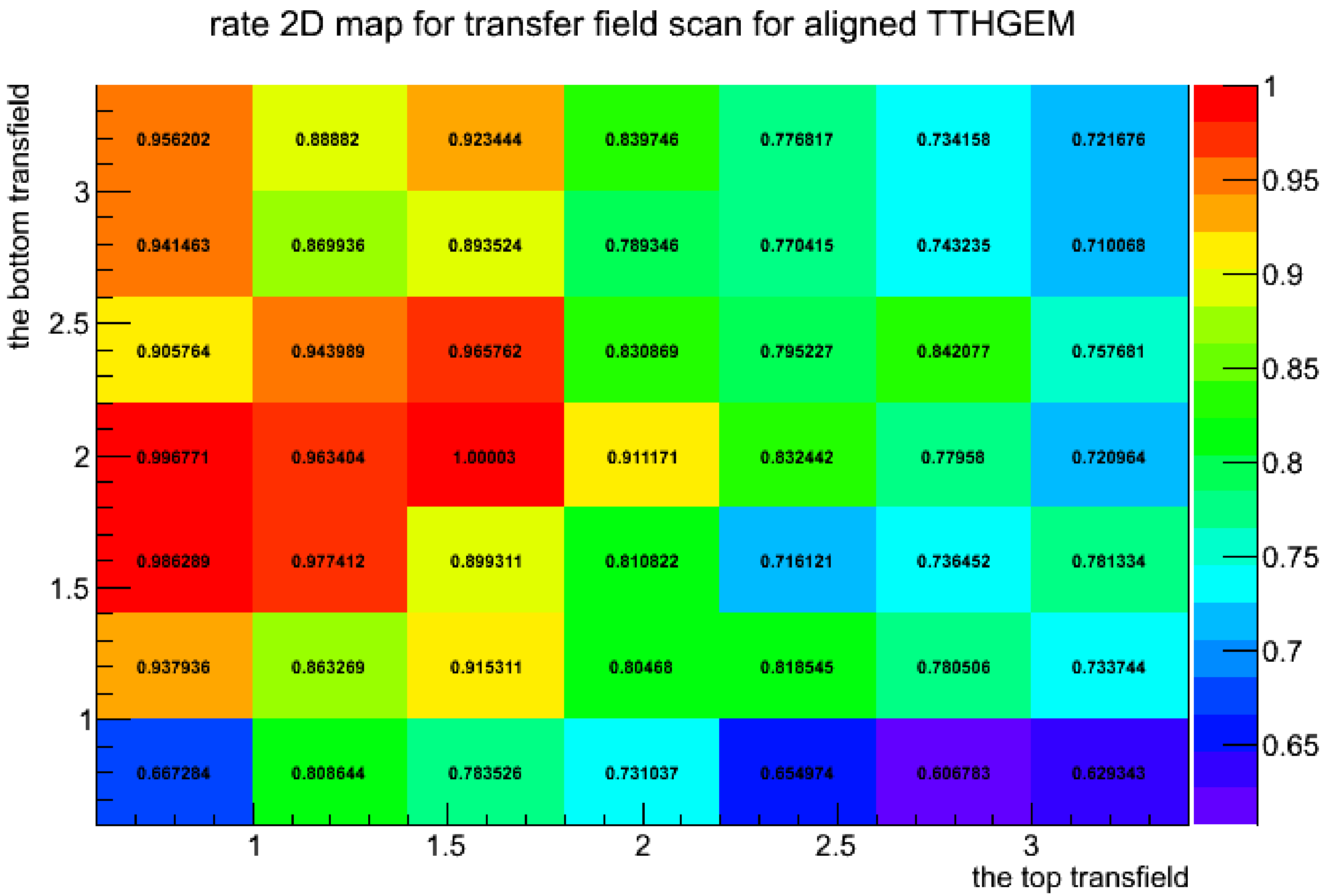
$$I_{Anode} = e \times Gain \times Rate / e^{-Thres/(e \times Gain)}$$

If we assume the gain will not change much, and the LED intensity will be the same if the same voltage is applied, we can define the relative efficiency by:

$$\varepsilon_i = \frac{R_i}{R_0} \qquad R_i = Rate_i / e^{-Thres/(e \times Gain_i)}$$

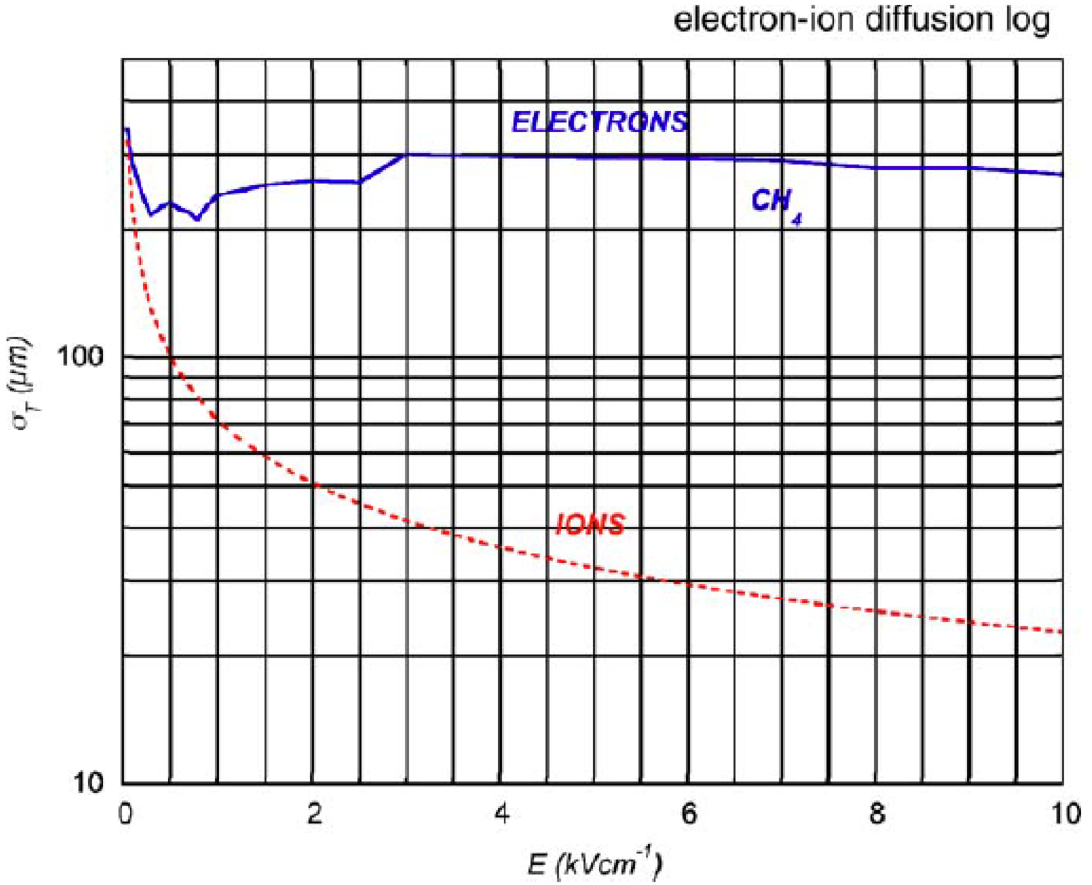
The "R" here can be get from gain MCA files, or by solving the function above.

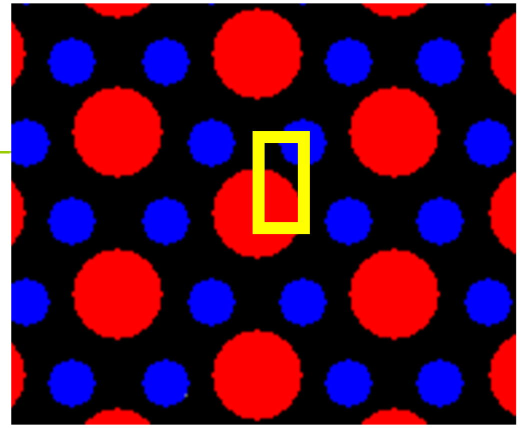
# Efficiency of aligned 2D distribution

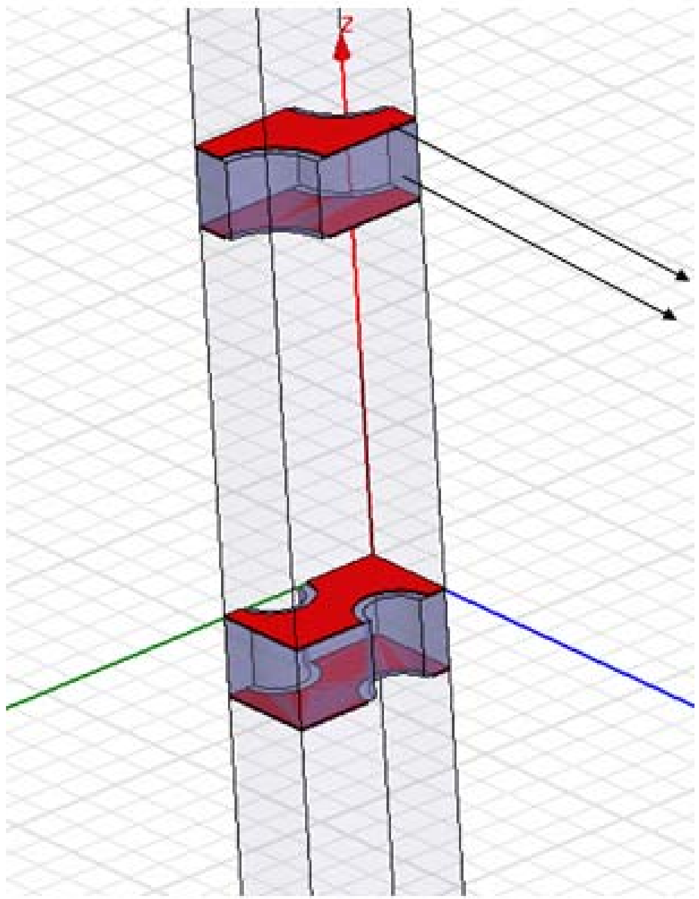



The result gives a same behavior as not-aligned configuration.
The result is got from MCA.

# MC Simulation

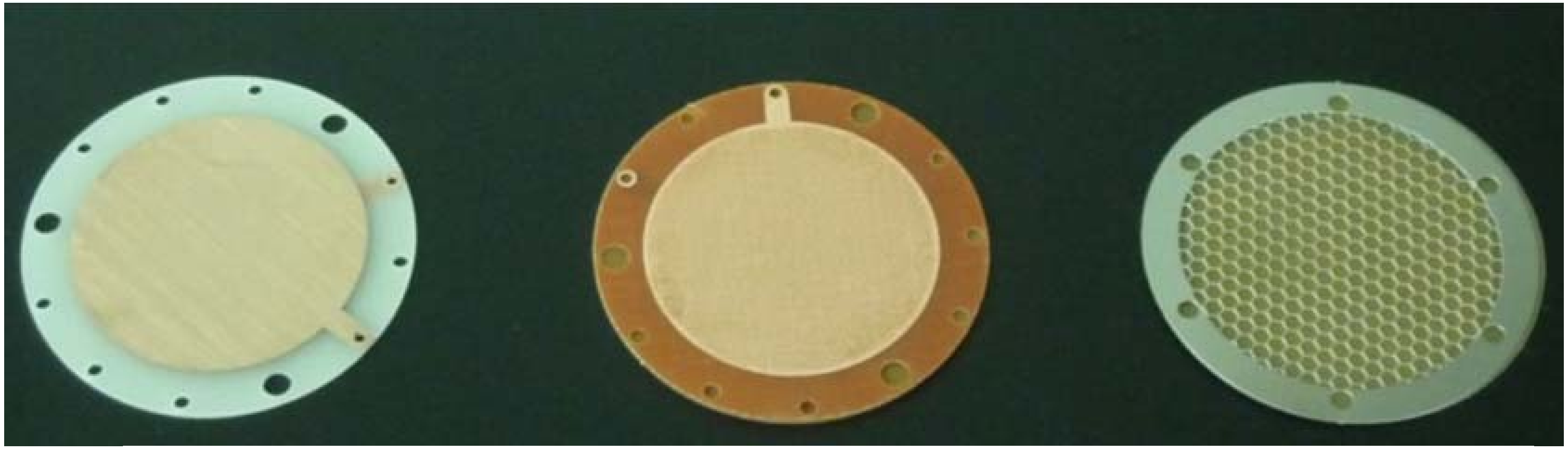


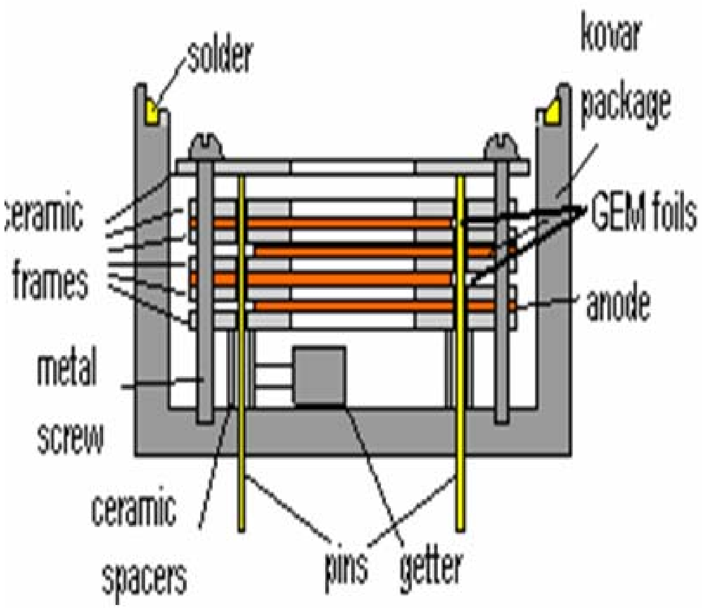






Ions diffusion is much less than electrons which proves this mis-aligned configuration is effective to the IBF.

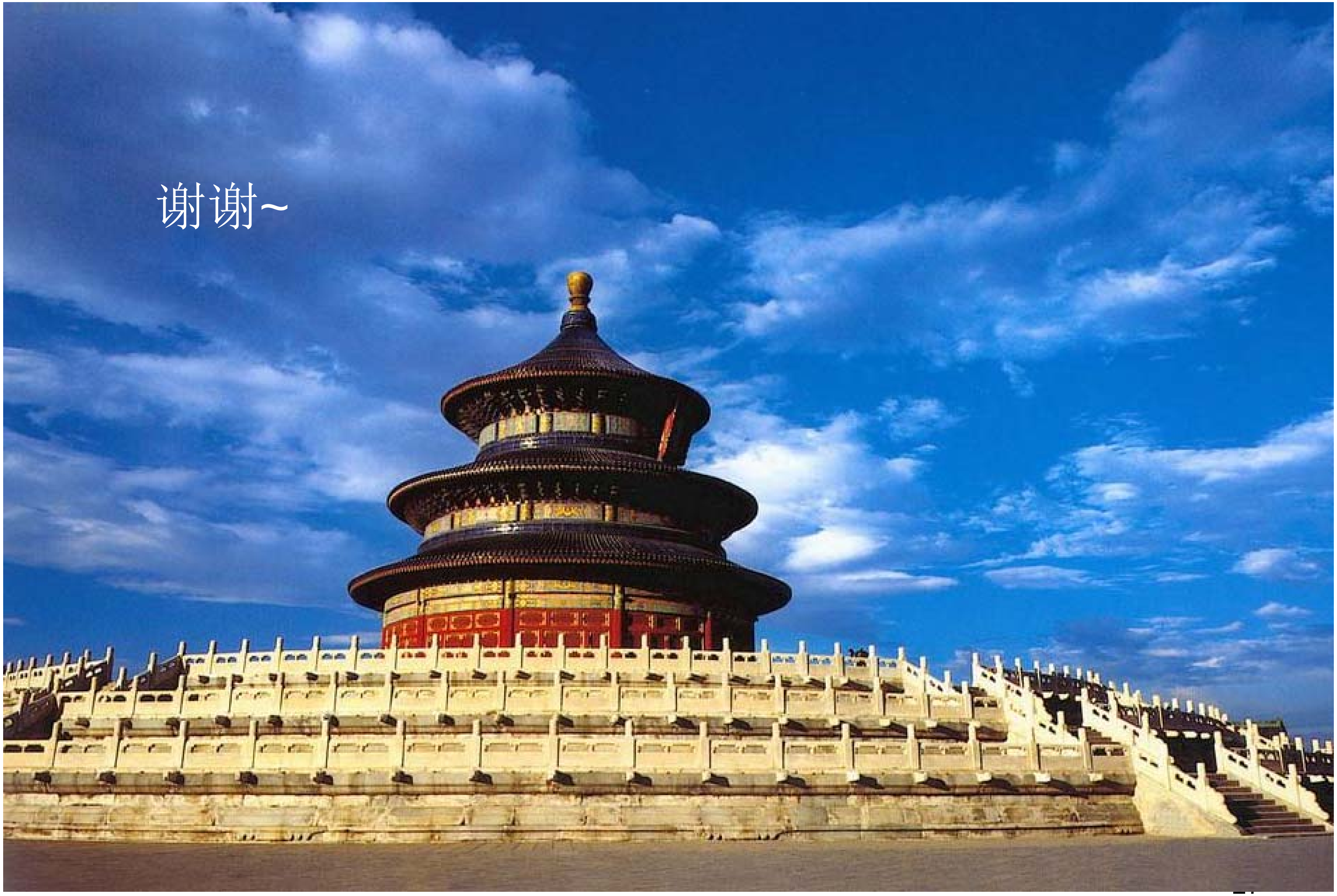
# What've done in GUCAS






# Conclusion

1. 93% of the IBF can be reduced by not-aligned configuration while the gain only decreased 17%.
2. The ions will mainly collected (60%~70%) by the layer where those ions are generated. So working under the minimum gain of the first layer THGEM is also important.


谢谢~