Simulation of Gate GEM

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reported by A.Sugiyama

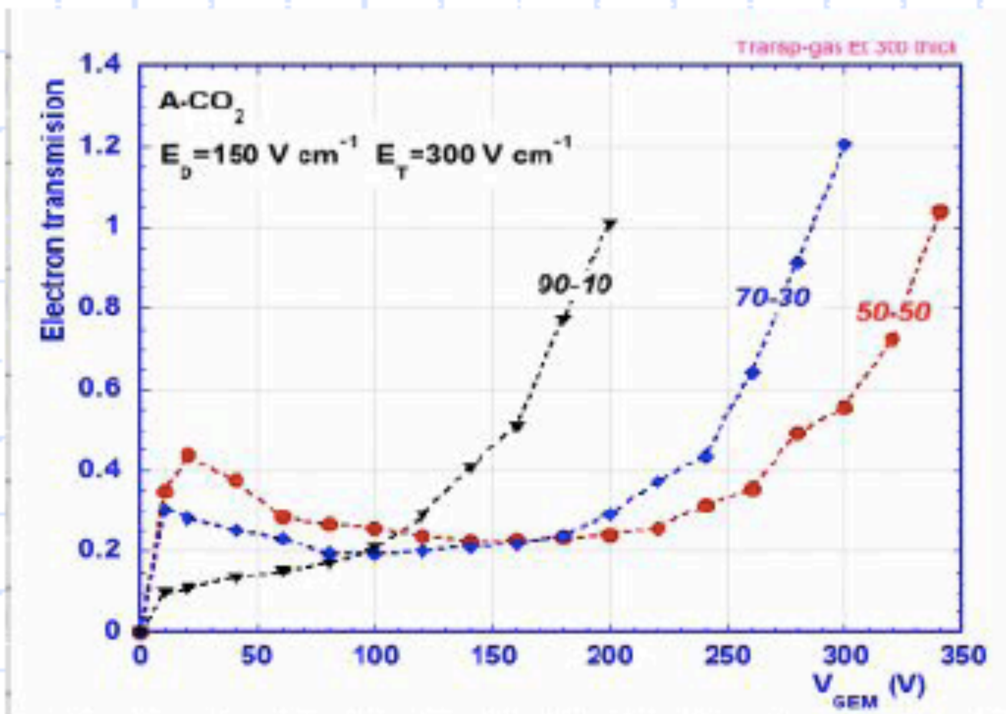
Why GEM for Gate ?
What has been done?
How much GEM can do ?
What will we do?

Original motivation was given by Sauli

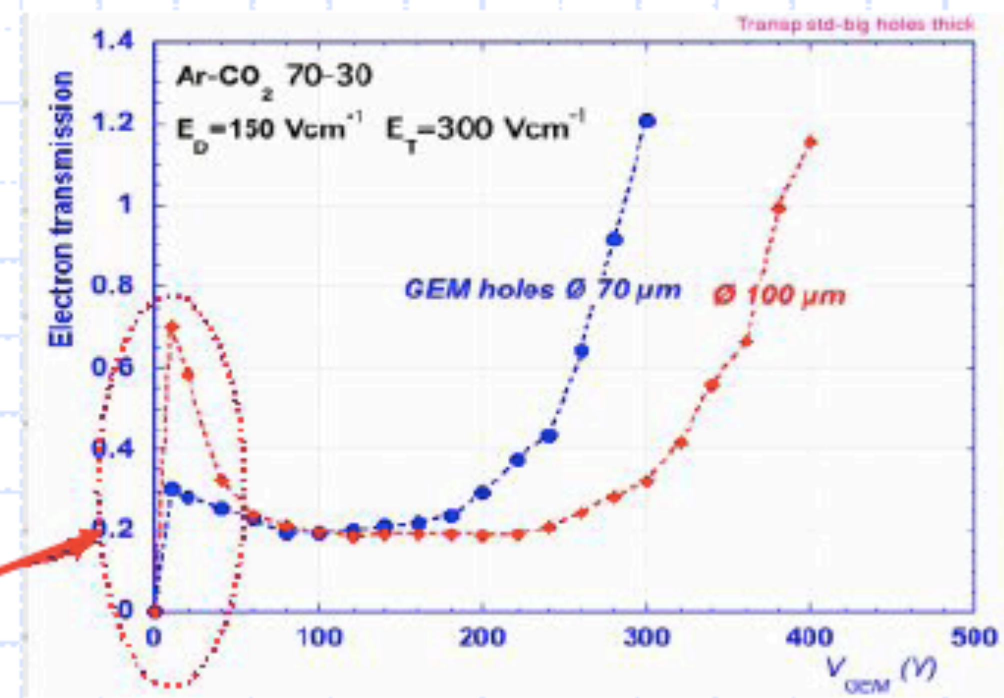
F.Sauli had proposed GEM gating @LBLTPC WS' 06

These figures are picked up from his slides.

GAS EFFECT



HOLE DIAMETER EFFECT



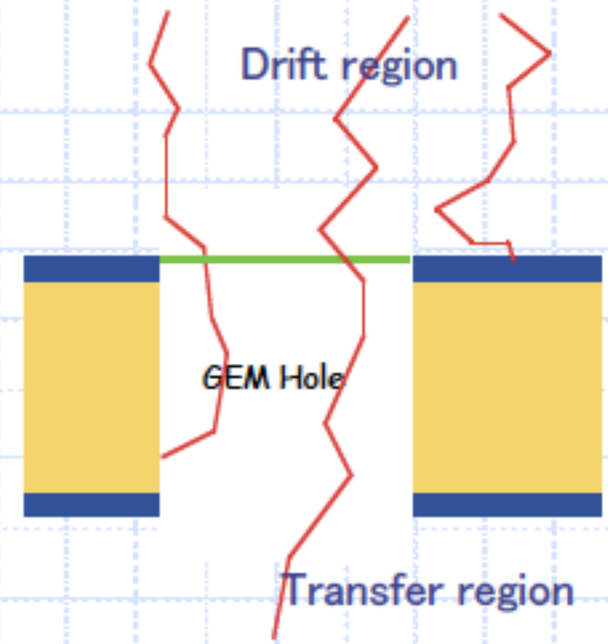
10 V/50 μm ~ 2 kV/cm!

Why low voltage operation give us higher transmission ?
Is this true for LC TPC gas ?
How much electrons will be lost ? -> resolution
This affects to Gas choice of LC-TPC

We have tried to understand behavior at low V_{GEM} using Maxwell3D + Garfield

How do we understand his data ?

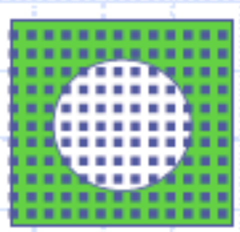
Garfield help us to understand it !!



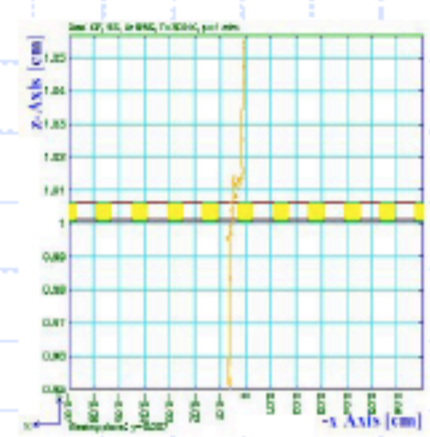
Transmission = Collection eff. x Extraction eff.

$$\text{Collection eff.} = \frac{\#\text{electrons arrived at Hole entrance}}{\#\text{ produced electron}}$$

$$\text{Extraction eff.} = \frac{\#\text{electrons coming out from GEM hole}}{\#\text{electrons arrived at Hole surface}}$$



In the simulation electrons are generated 500um above the GEM surface, at 20x20 different positions covering the hole part of GEM.

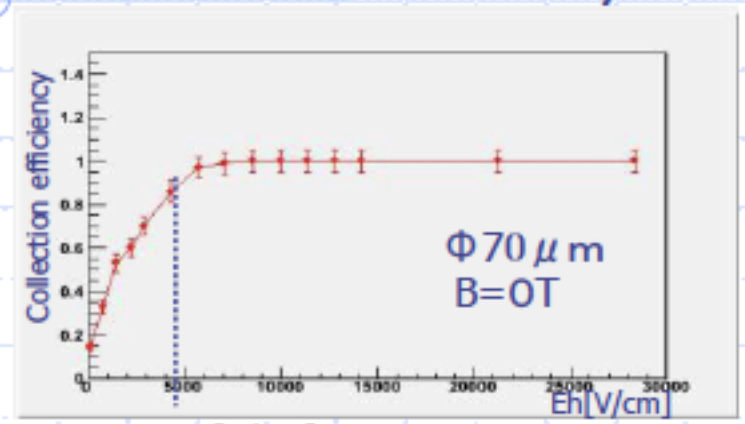


Simulation results are compared to Sauli's measurement

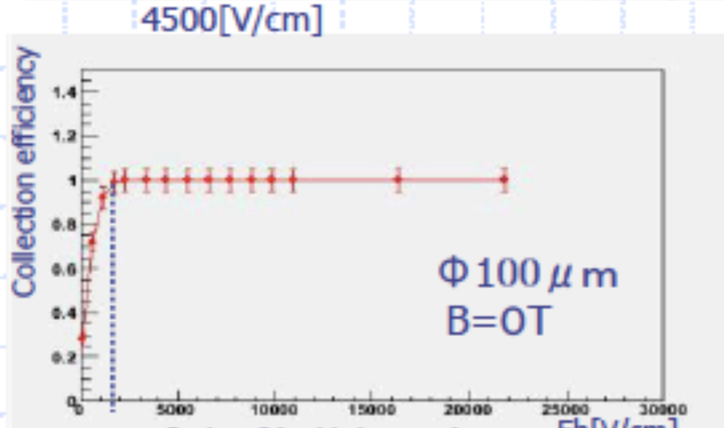
*remarks: you have to choose proper "step size"
we finally chose 2um as step length

Simulation could reproduce data (partially) and taught us a lot !

collection efficiency



4500[V/cm]



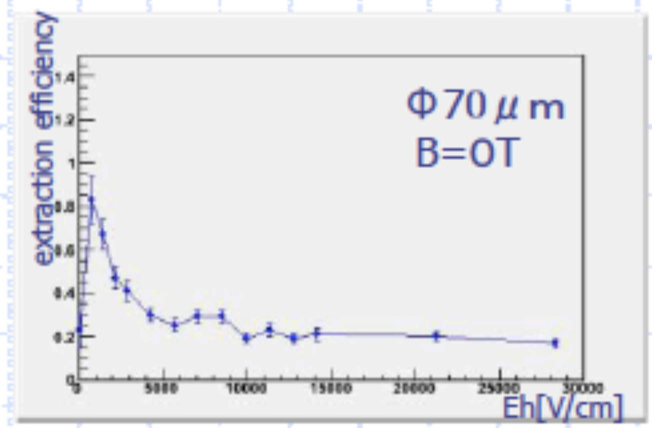
1500[V/cm](Ed/Eh=0.1)

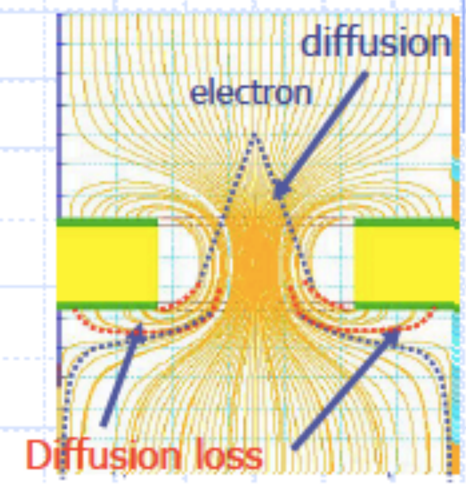
Collection efficiency has been studied by many groups and is known to be 1 at Ed/Eh<~0.03

Which almost corresponds to 4500V for 70um hole.

In 100um phi case, collection efficiency reach to 1 at Ed/Eh<0.1.

extraction efficiency





In the case of extraction efficiency, the area of pass-through field lines from drift region would shrink as Electric field in the hole.

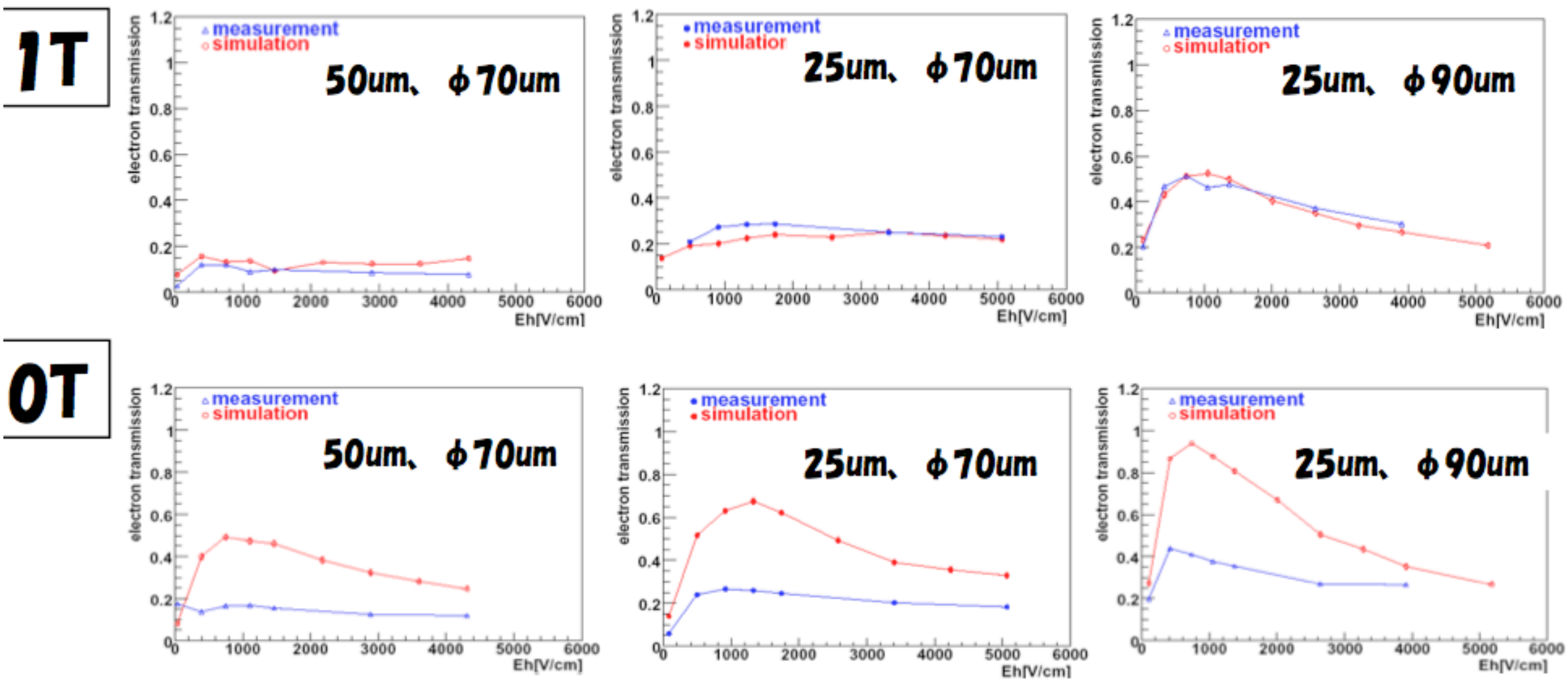
And Diffusion under high electric field becomes larger and electrons may escape into return line.

Effects of shrinking electric filed lines and diffusion may determine this behavior.

However it could not reproduce all of data

due to artificial parameter "step size"

Compare with simulation



Experimental result is not consistent with simulation without magnetic field.

Tokubetsu suisin allow us to use

ANSYS

which can fit to garfield++

which has no "step size"

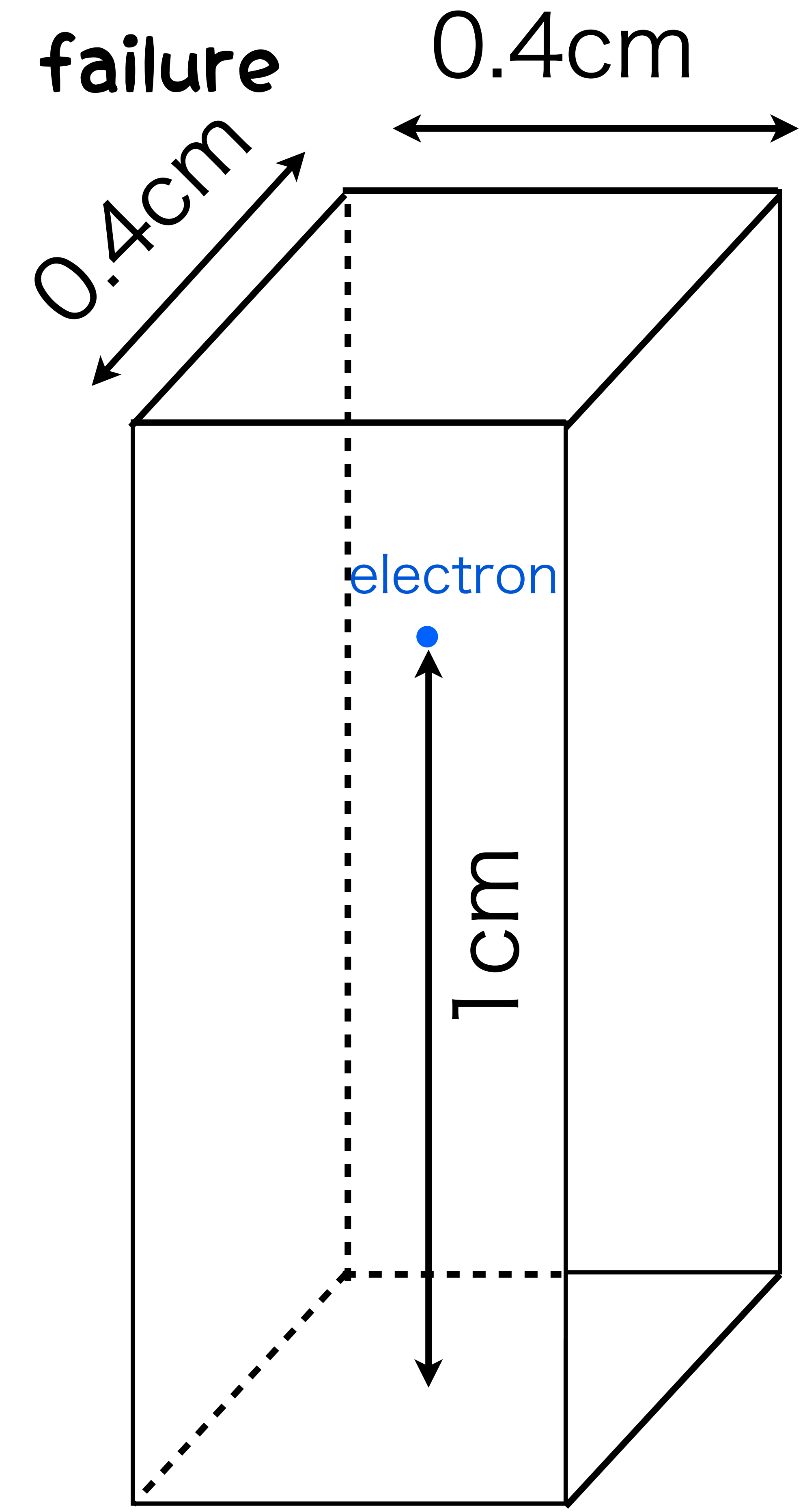
We have started to simulate old data ..... again

In order not to go into the same failure

Validity check is important.

simple test of gas property
by garfield++ simulation

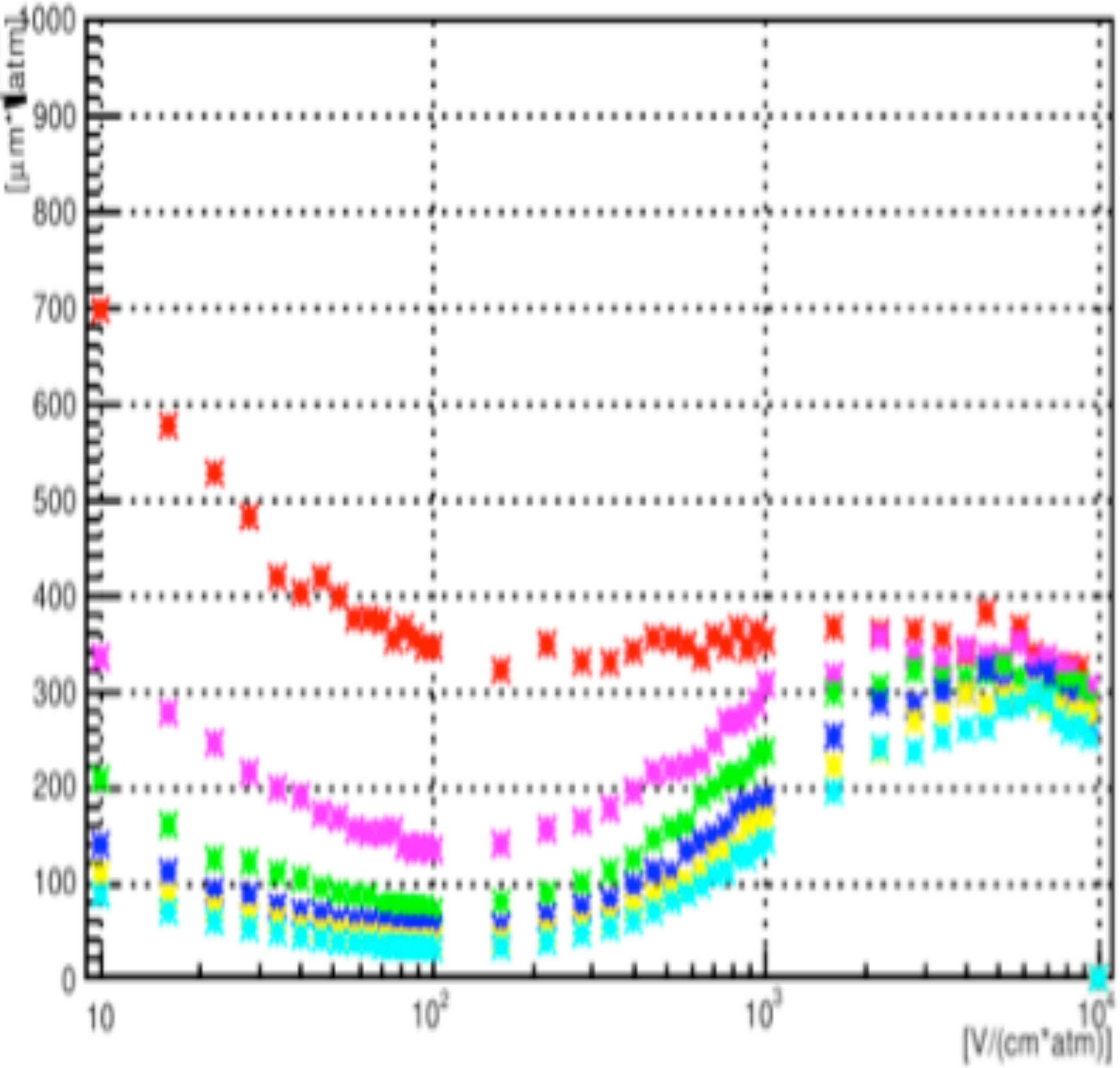
simulate diffusion under
various E/B fields



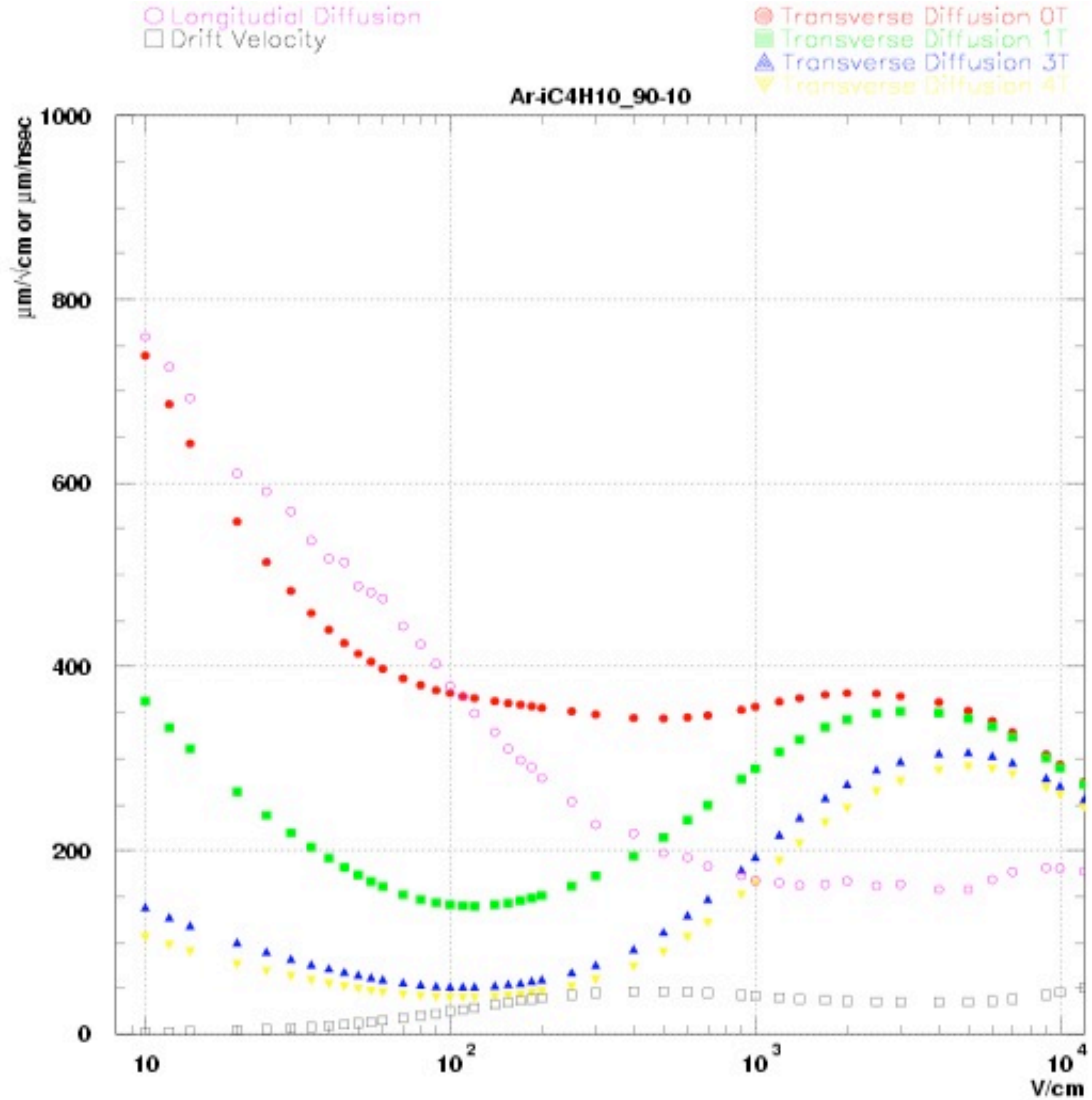
Diffusion

Ar:iC4H10

Garfield++使ったsimulation



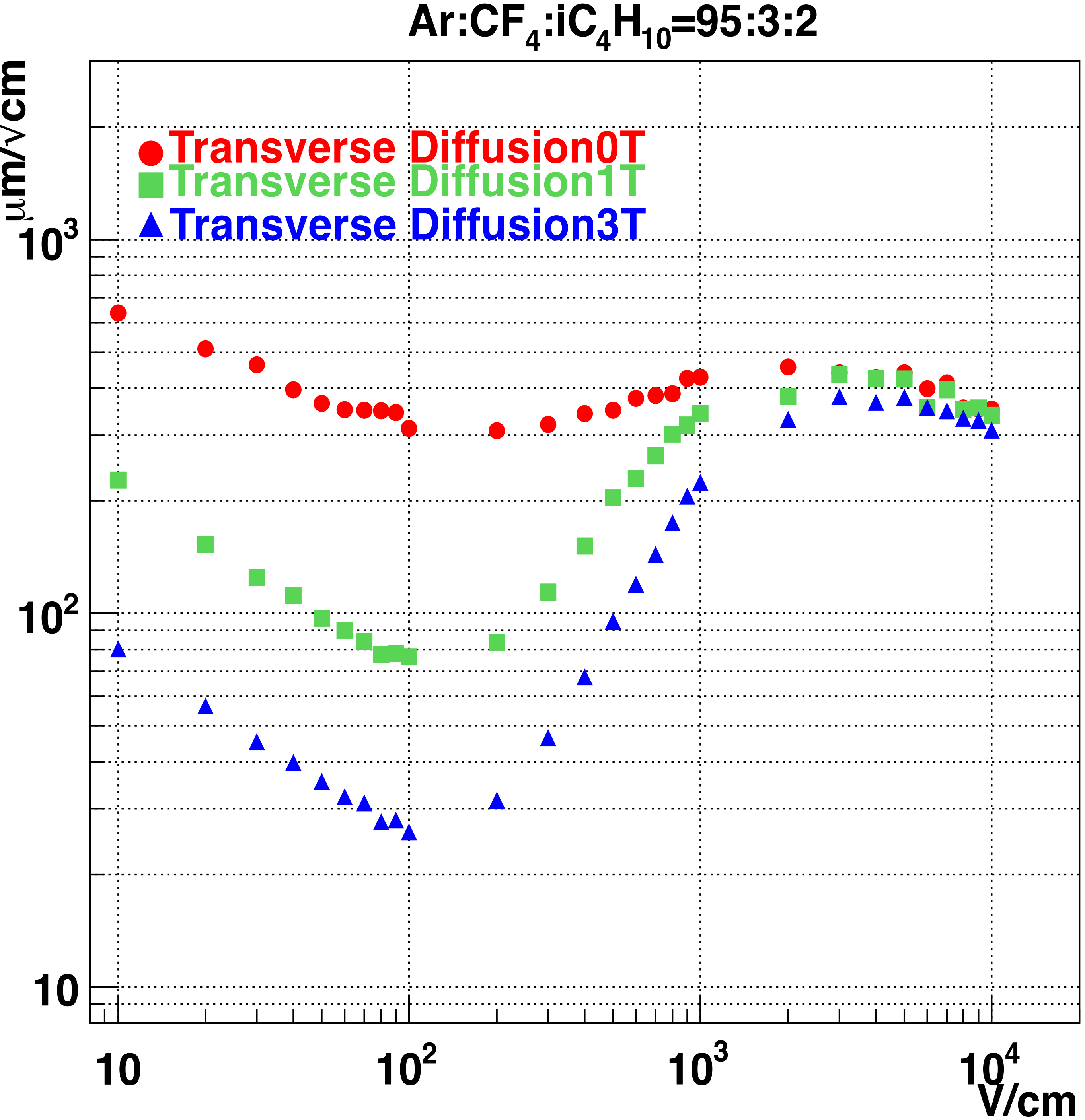
Garfield使ったsimulation



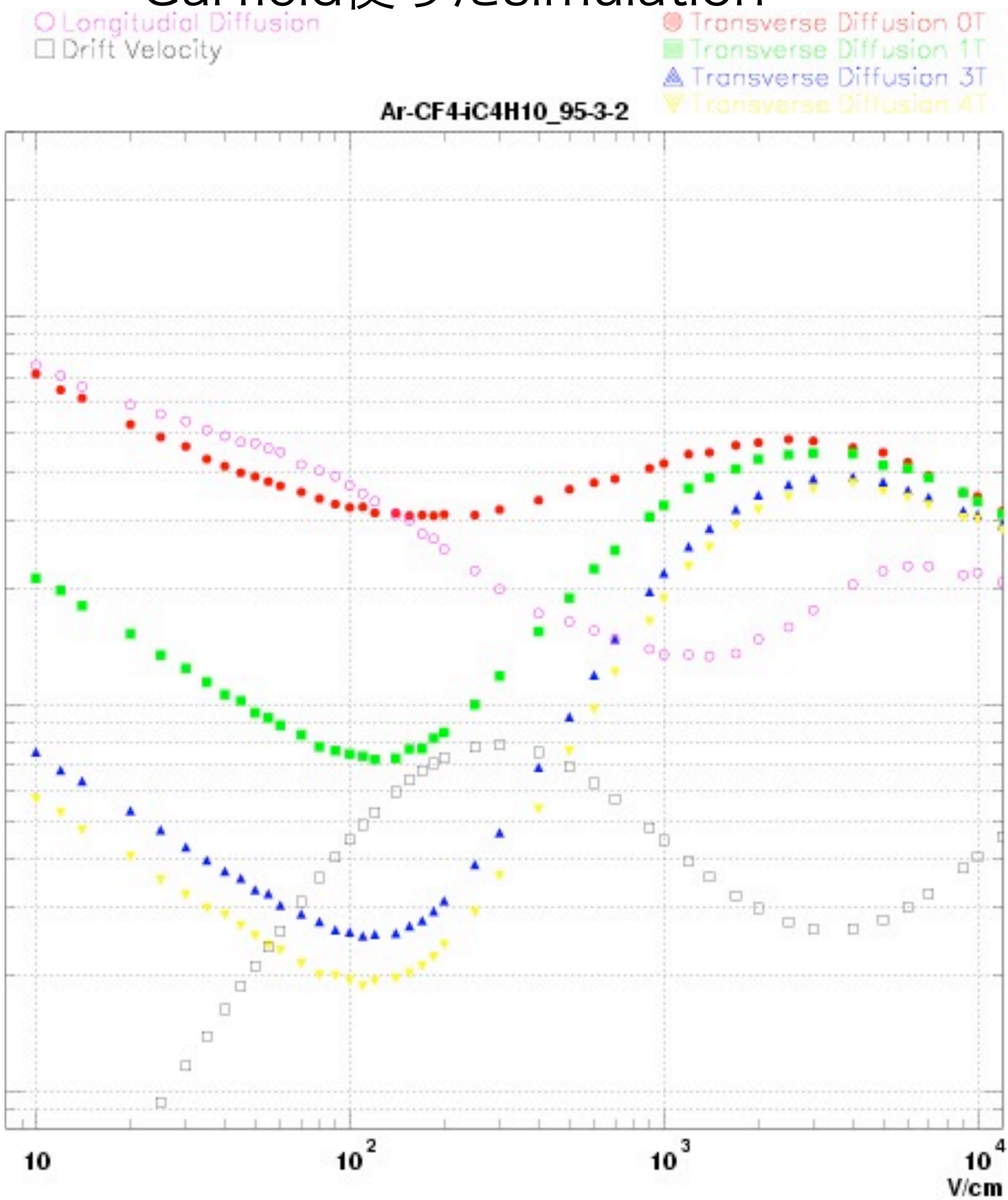
ILC TPC Wiki -Gas Study with Magboltz-
http://www-hep.phys.saga-u.ac.jp/ILC-TPC/gas/index.html

Diffusion

Garfield++使ったsimulation



Garfield使ったsimulation



ILC TPC Wiki -Gas Study with Magboltz-
http://www-hep.phys.saga-u.ac.jp/ILC-TPC/gas/index.html

garfield++を使ってgasの拡散の振る舞いを再現できた

↓

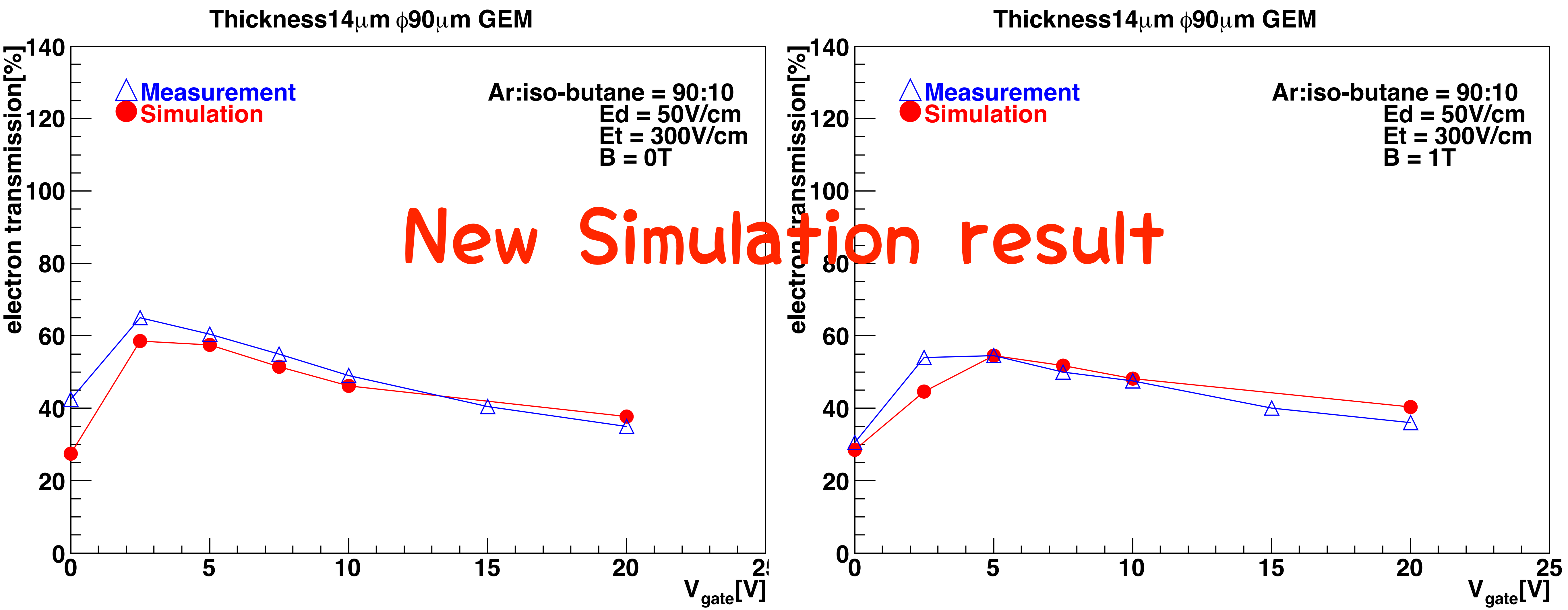
Garfield++で電子の透過率をsimulationしてみる

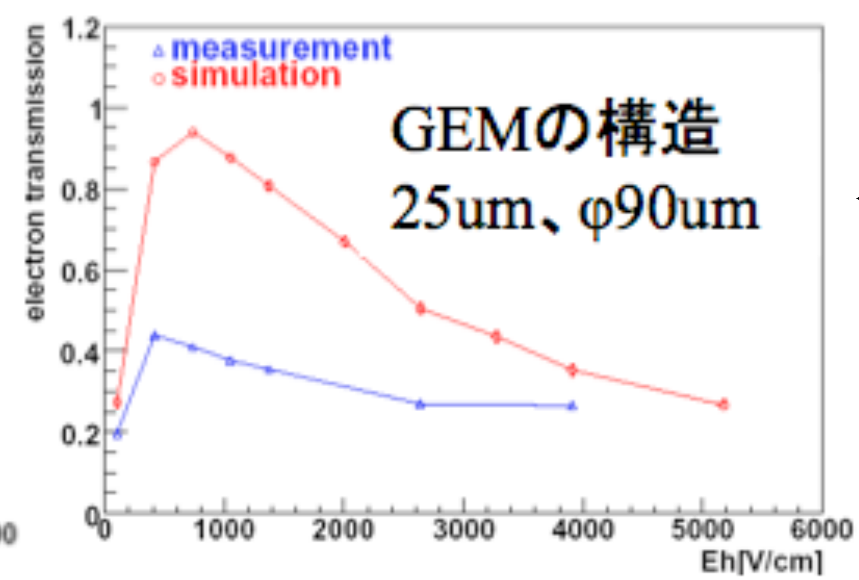
Simulate Old data

with Garfield++ w/ ANSYS

Result

garfield++を使ったsimulationの結果





← garfieldを使ったsimulation（磁場なし）の結果

Old Simulation

→ 磁場なしでのsimulationの結果は測定結果の近くなっている。

Garfield++ w/ ANSYS

does work properly

We can use this for feasibility study of Gate GEM

though we' ve already expected
Gate must have large aperture as big as transmission efficiency
under high B filed operation

it was just a guess but it became ......

ILCに使えるためのGate GEMの最適化

ILCで使用する予定のゲートは、3.5Tの磁場中にT2K gasでの中で動作させる。
またドリフト領域の電場は230V/cmとする

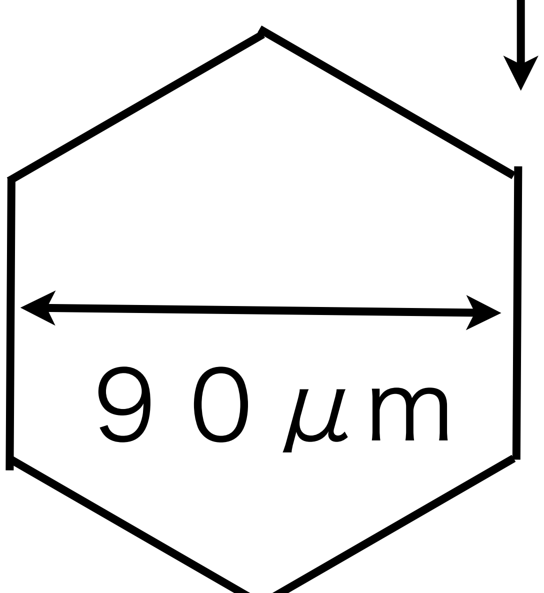
セットアップ条件
ドリフト領域の電場２３０V／cm
ガス T2k(Ar:CF4:iC4H10=95:3:2)

← 他の要求からきまり自由に変更できない

トランスファー領域の電場 ← ゲート～増幅GEM間の電場は調整可能だが、高電場をかけると増幅GEMへの収集効率の低下を招く

銅部分5μｍ → １μｍ
穴の径＝９０μｍ
Thickness(絶縁体)＝１０μｍ ← ゲートの厚さは調整可能なパラメーターであり、薄ければ薄いほど製作が困難になる
Gate GEMの構造 Honeycombタイプ

開口率を80%程度にした蜂の巣構造でsimulationしてみる

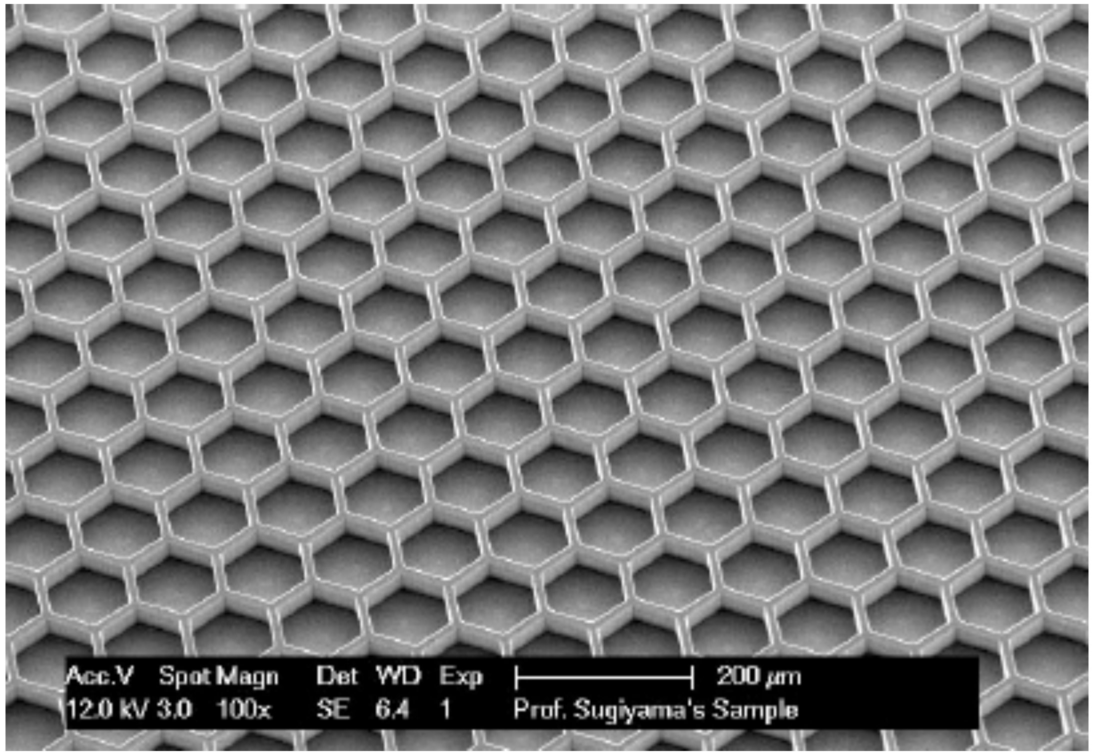


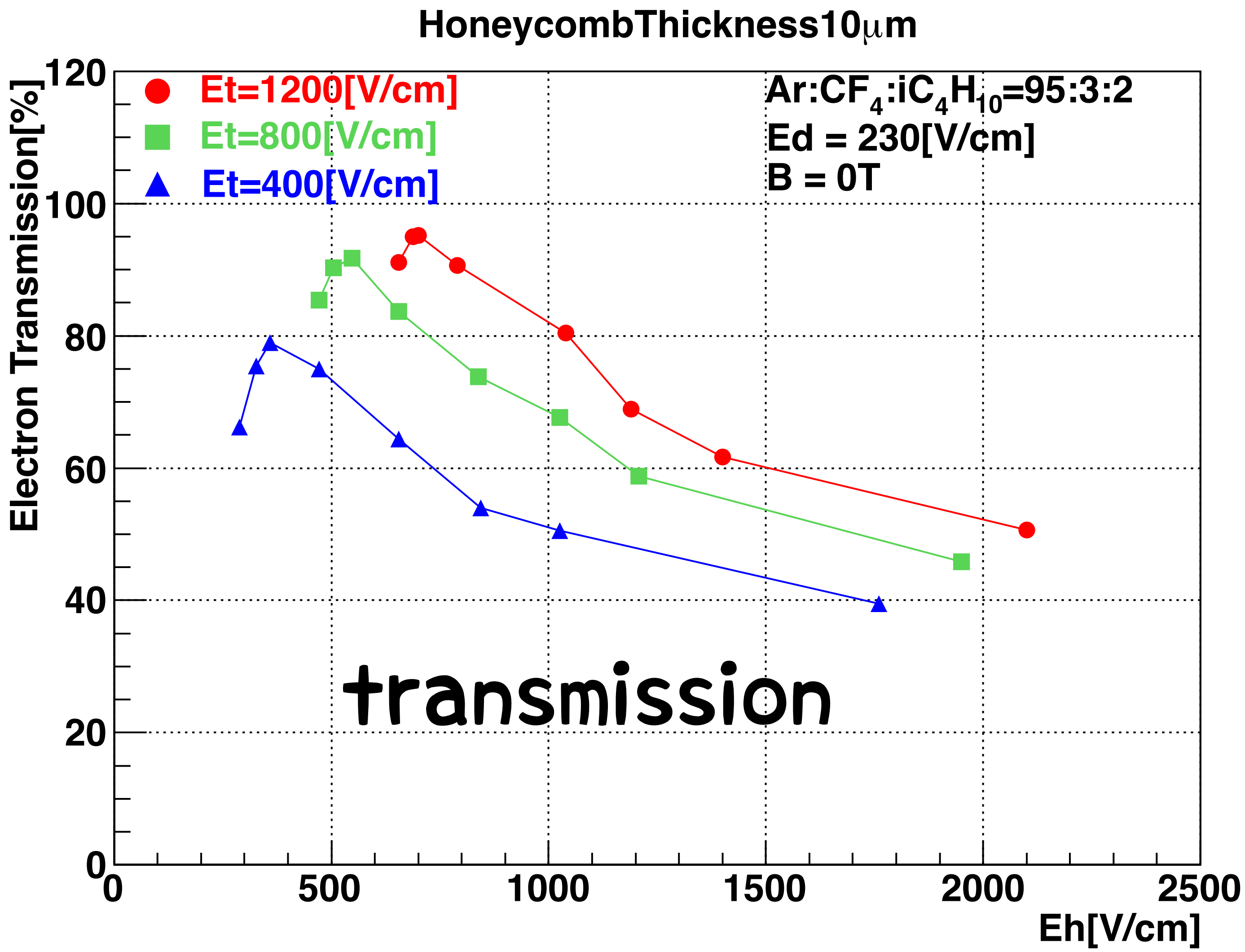
まずは、ansysで電場の計算をします

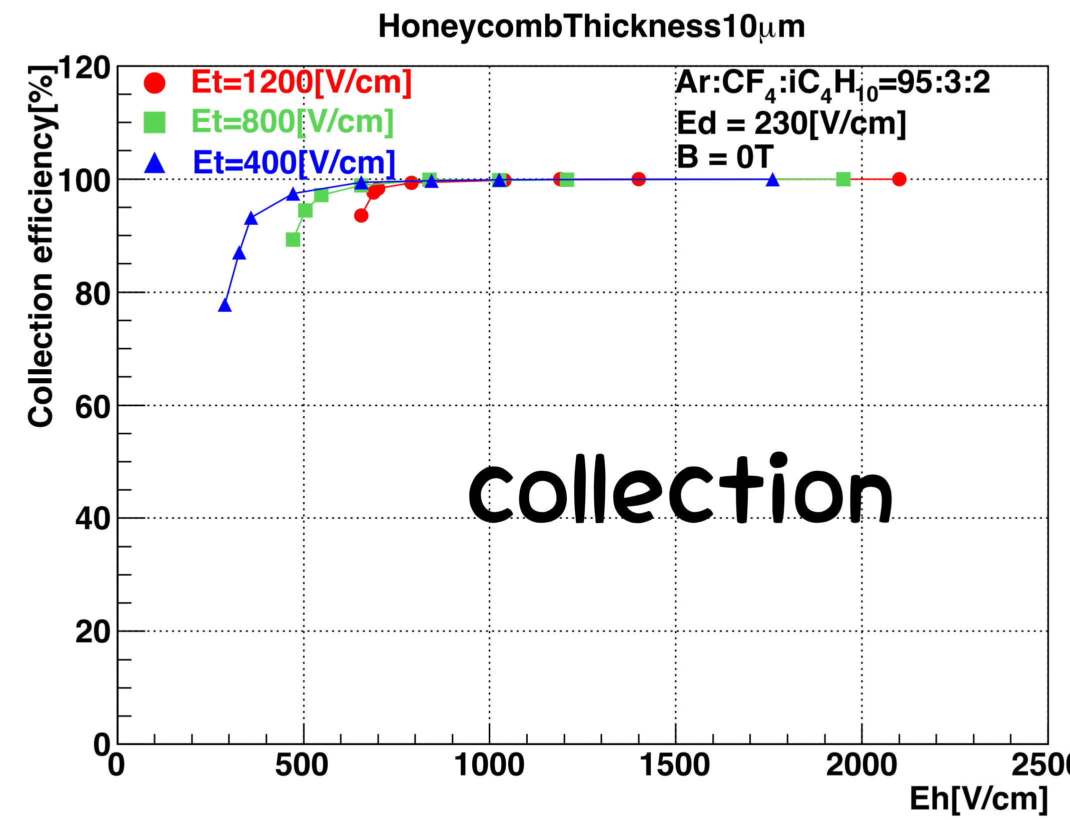
in order to achieve high aperture

Honeycomb shape was chosen

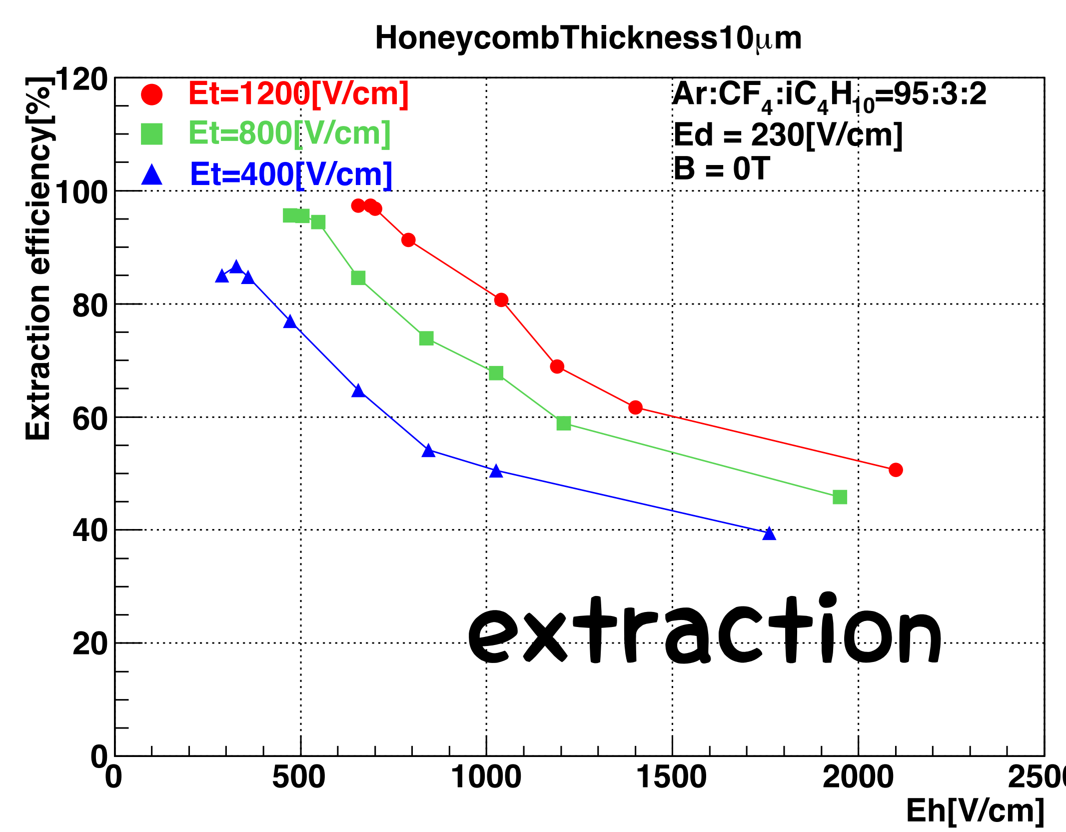
to get 80% aperture
width of lib is 10 um in 100um pitch

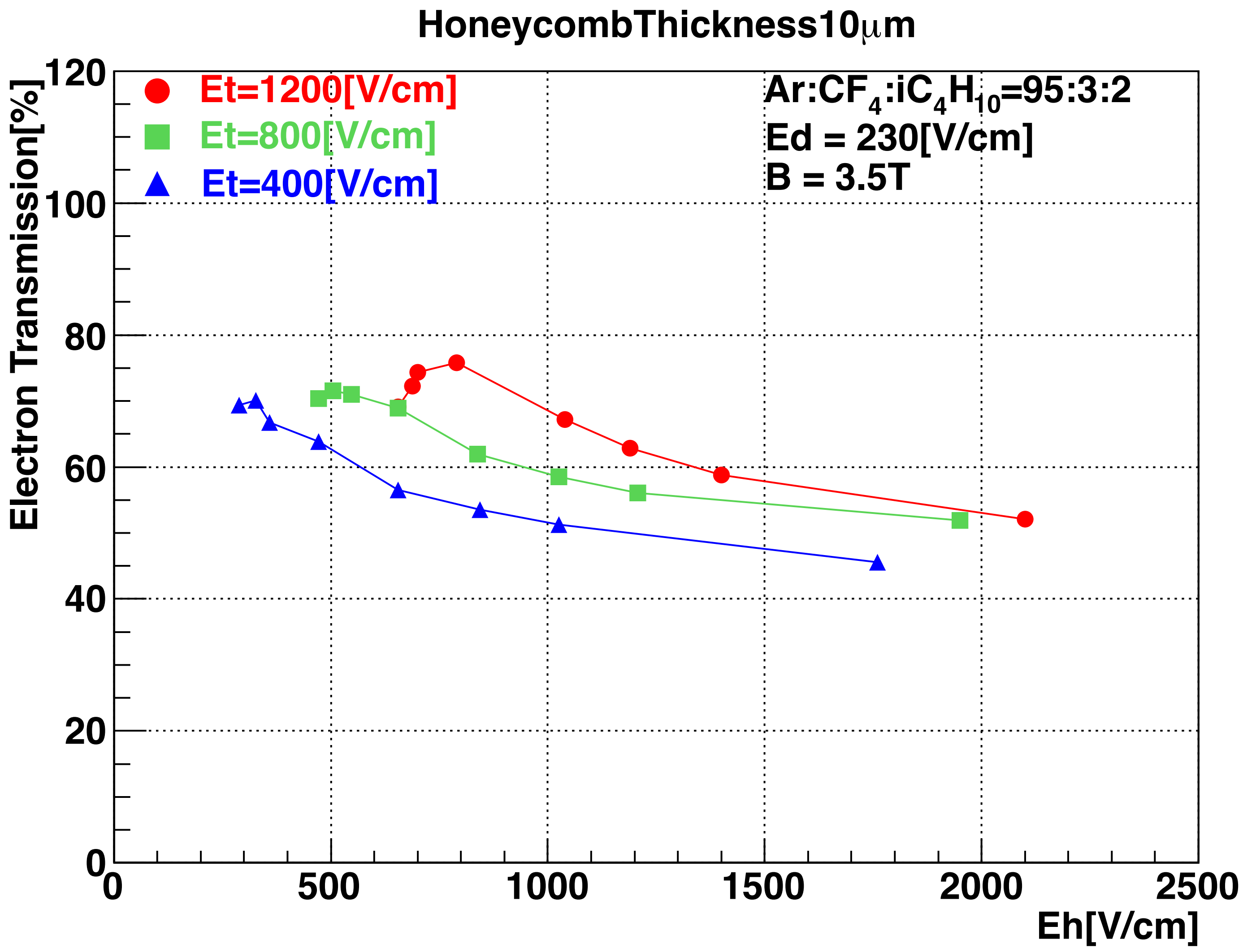



HoneycombThickness10μm
Electron Transmission[%]
Et=1200[V/cm]
Et=800[V/cm]
Et=400[V/cm]
Ar:CF$_4$:iC$_4$H$_{10}$=95:3:2
Ed = 230[V/cm]
B = 0T
transmission
Eh[V/cm]
0
20
40
60
80
100
120
0
500
1000
1500
2000
2500

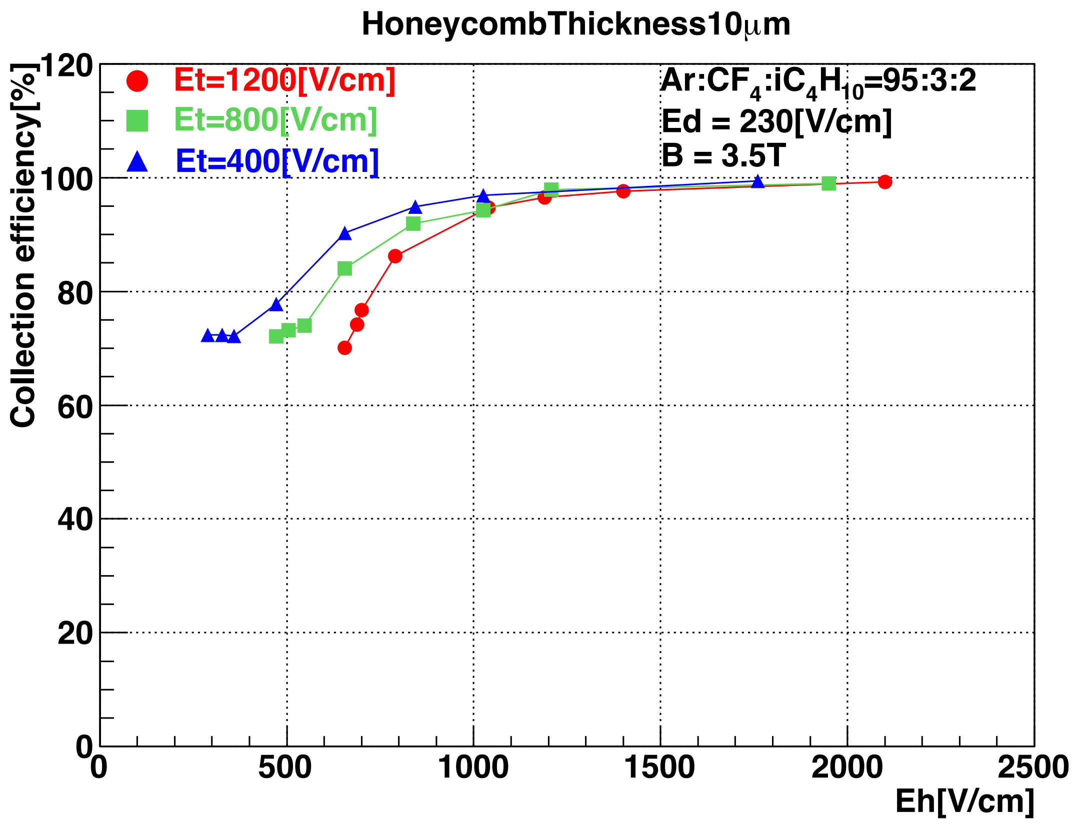

HoneycombThickness10μm
Collection efficiency[%]
Et=1200[V/cm]
Et=800[V/cm]
Et=400[V/cm]
Ar:CF$_4$:iC$_4$H$_{10}$=95:3:2
Ed = 230[V/cm]
B = 0T
collection
Eh[V/cm]
0
20
40
60
80
100
120
0
500
1000
1500
2000
2500

B=0T


HoneycombThickness10μm
Extraction efficiency[%]
Et=1200[V/cm]
Et=800[V/cm]
Et=400[V/cm]
Ar:CF$_4$:iC$_4$H$_{10}$=95:3:2
Ed = 230[V/cm]
B = 0T
extraction
Eh[V/cm]
0
20
40
60
80
100
120
0
500
1000
1500
2000
2500



HoneycombThickness10μm
Electron Transmission[%]
Et=1200[V/cm]
Et=800[V/cm]
Et=400[V/cm]
Ar:CF4:iC4H10=95:3:2
Ed = 230[V/cm]
B = 3.5T
Eh[V/cm]



HoneycombThickness10μm
Collection efficiency[%]
Et=1200[V/cm]
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Et=400[V/cm]
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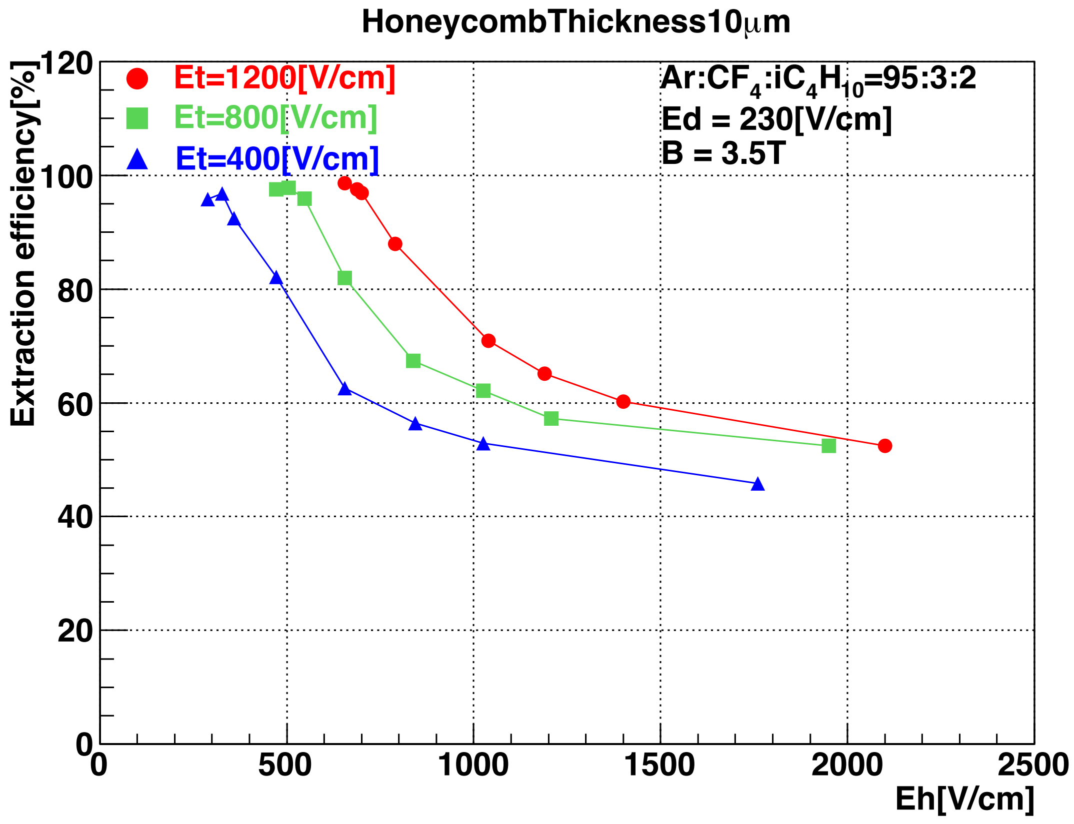
Ed = 230[V/cm]
B = 3.5T
Eh[V/cm]

B=3.5 T



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Extraction efficiency[%]
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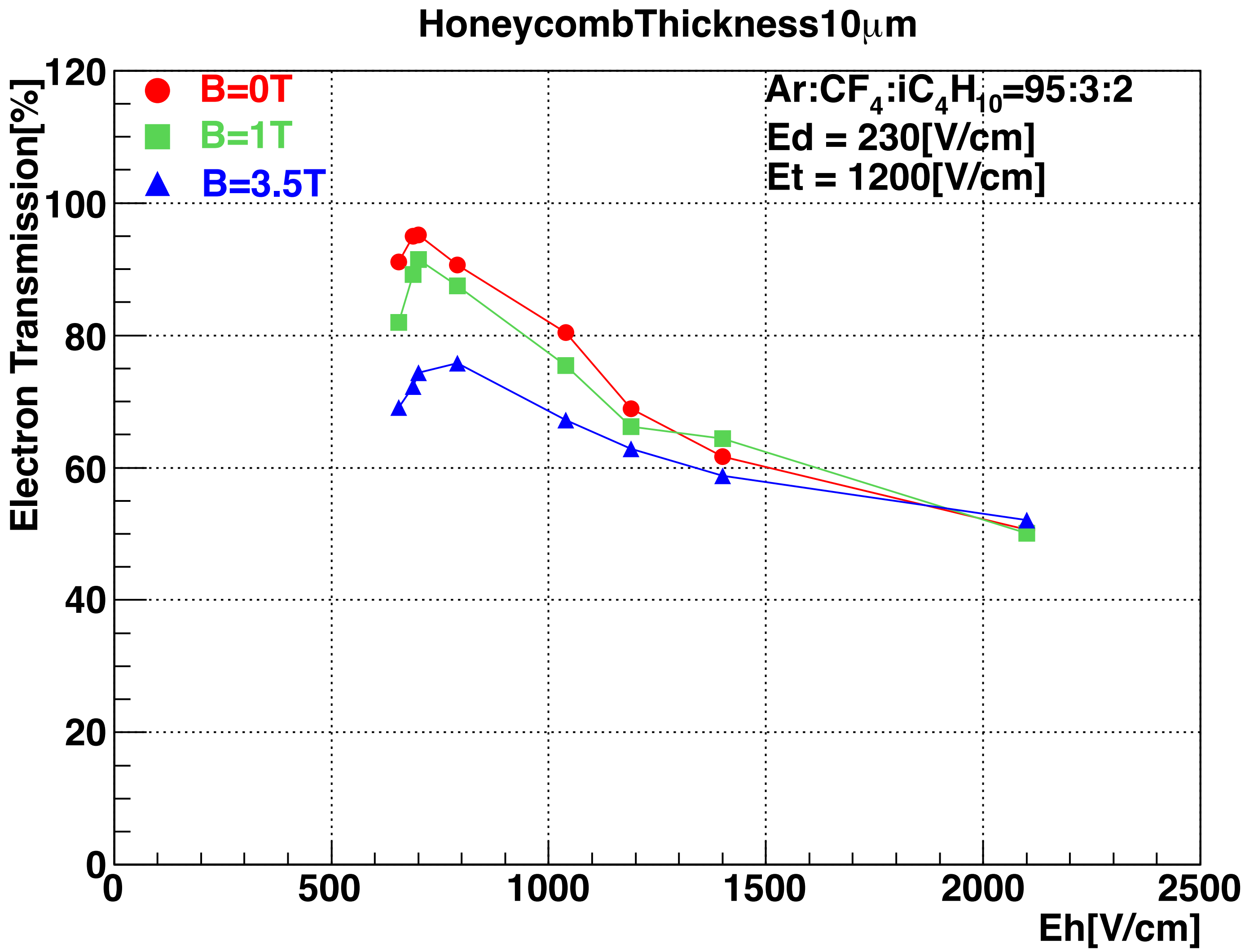
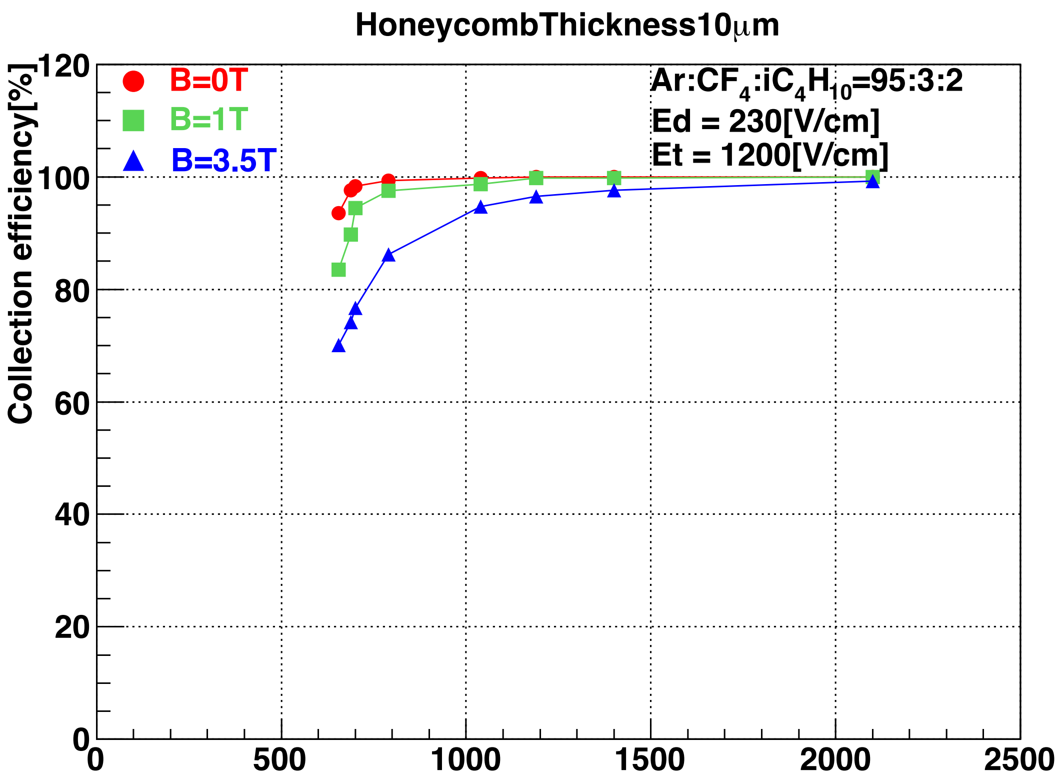


HoneycombThickness10μm
B=0T
B=1T
B=3.5T
Ar:CF4:iC4H10=95:3:2
Ed = 230[V/cm]
Et = 1200[V/cm]
Electron Transmission[%]
Eh[V/cm]
0
20
40
60
80
100
120
500
1000
1500
2000
2500



HoneycombThickness10μm
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Ar:CF4:iC4H10=95:3:2
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0
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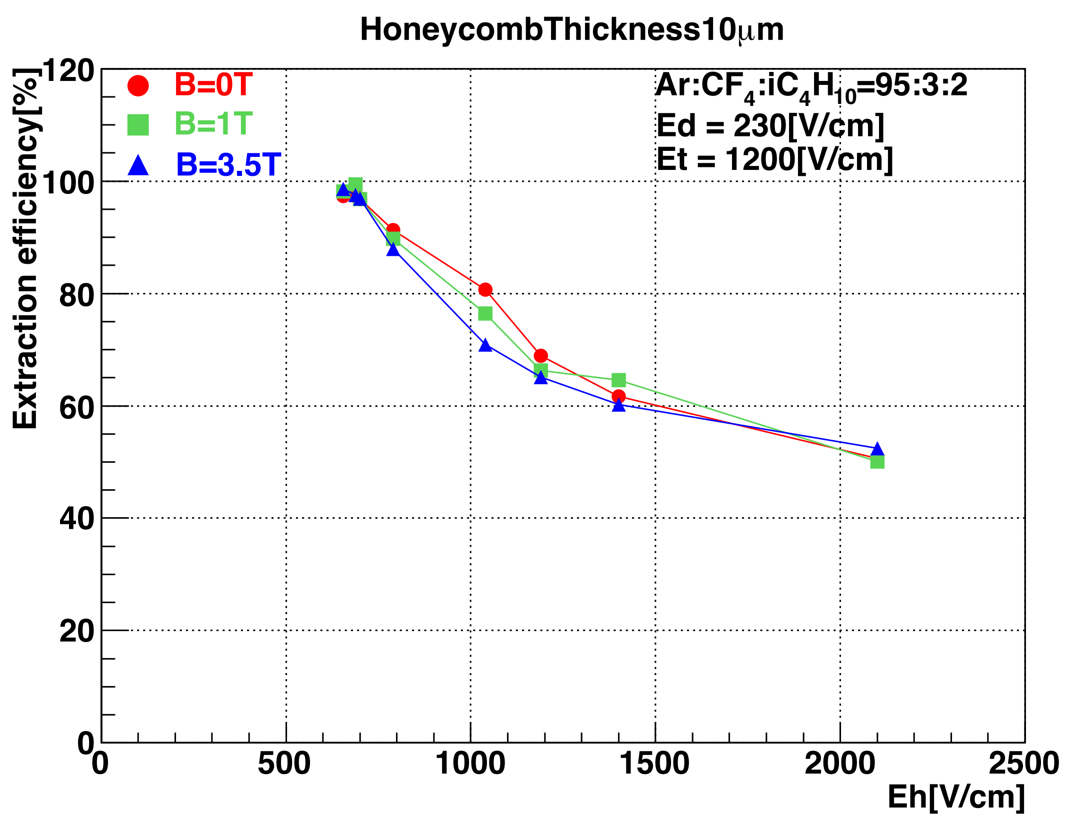

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Ar:CF4:iC4H10=95:3:2
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Et = 1200[V/cm]
Extraction efficiency[%]
Eh[V/cm]
0
20
40
60
80
100
120
500
1000
1500
2000
2500

summary

Tools are prepared

Next thing to do is

find optimum condition
to provide

Higher transmission
without deteriorating resolution
so much

and find a method to produce this GEM