Simulation Study of GEM gating for LC-TPC

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Gating for back-drift ions

ILC case : ions feedback must be smaller than 10^{-3}(ie. no ions from MPGD)

Gate can be open for 1 msec and be closed following 199 msec.

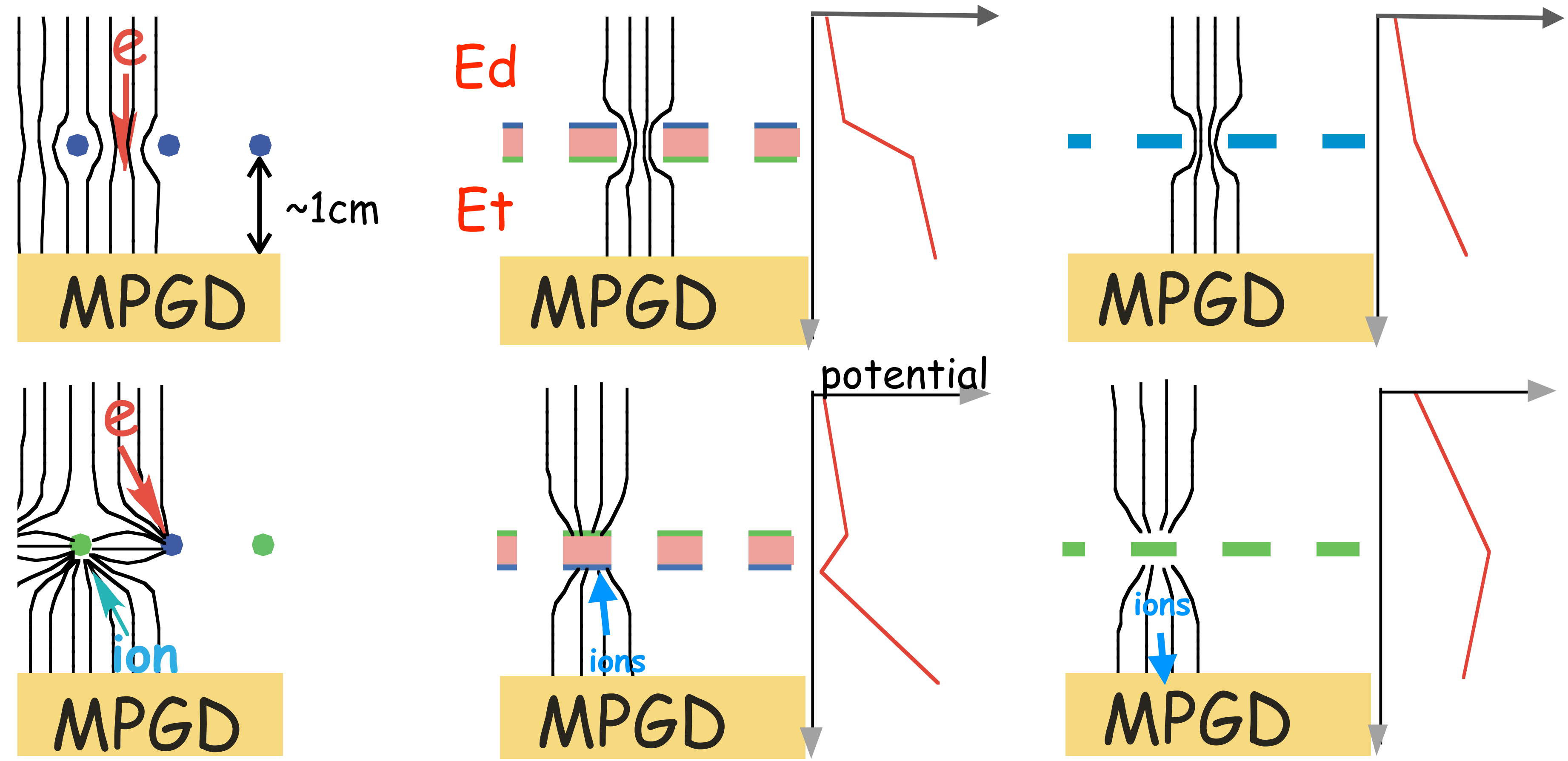
ion can dirft < 1cm

Gate: wire GEM micromesh

3 candidates

open

close



wire: local change of E, wire tension, ExB

GEM: local change of E, electron transmission

micromesh: change of drift E, electron transmission

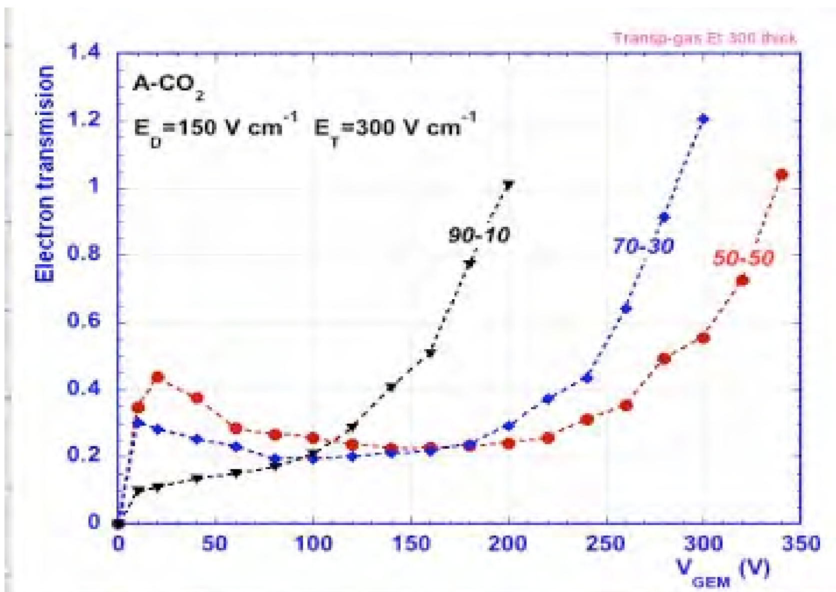
GEM gating

F. Sauli had proposed GEM as gating device @LBLTPC'06

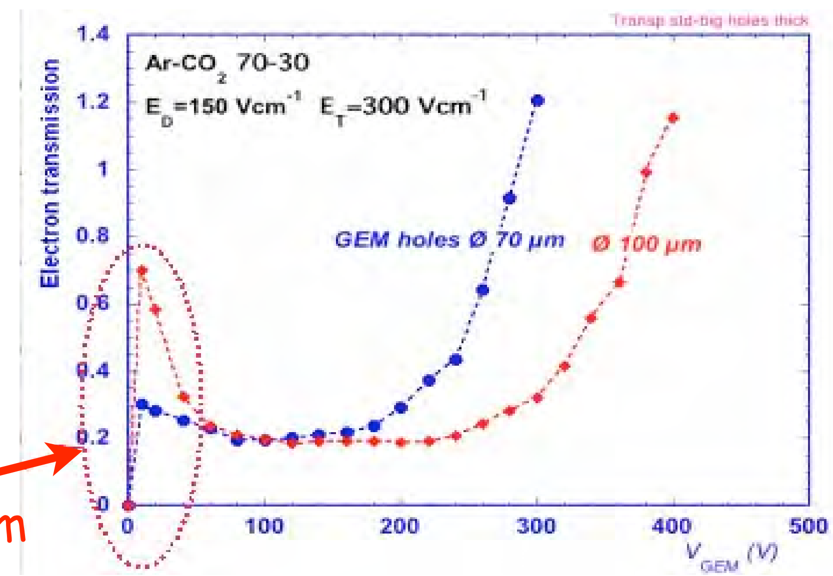
electron transmission is the key issue here !!

Electron transmission had been measured as a function of V_{GEM}

for different Gas mixture



for different hole size



10V/50um
~ 2kV/cm

Low voltage operation may give us good electron transmission:
where no gas amplification happen.

We hope to understand this mechanism and optimize GEM for ILC gate

E field calculation and electron simulation in gas help us to do this.

Maxwell3D Garfield

BUT We have to make sure these tools provide correct answer

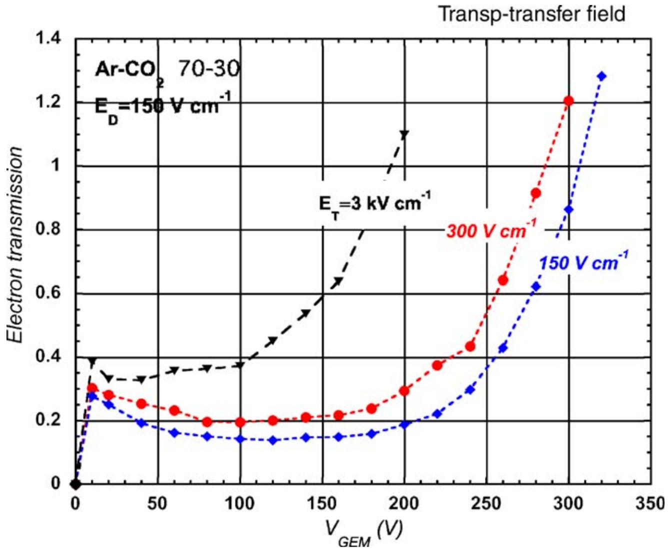


Fig. 4. Electron transmission of a standard GEM foil, measured in the pulse mode, for standard high ($3\,\mathrm{kV\,cm^{-1}}$) and low transfer fields (150 and $300\,\mathrm{V\,cm^{-1}}$), as a function of GEM voltage. Drift field: $150\,\mathrm{V\,cm^{-1}}$, gas filling A–CO_2 70–30 at STP.

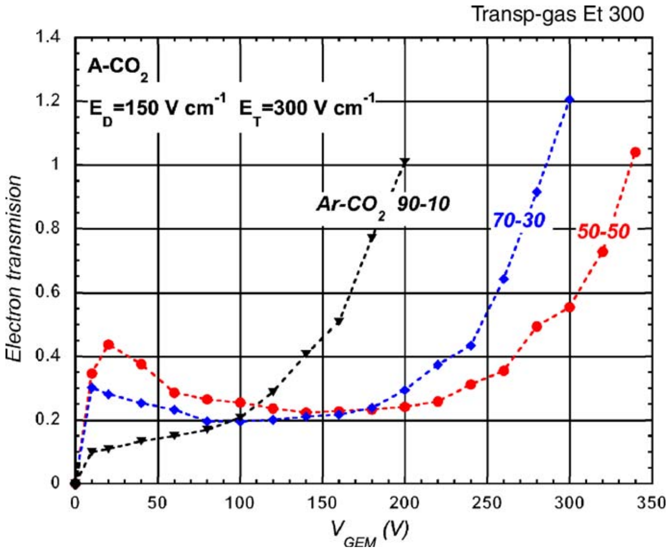
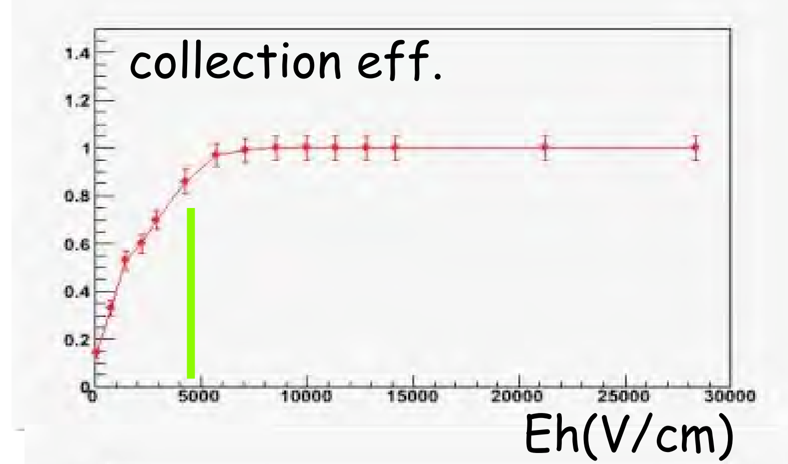


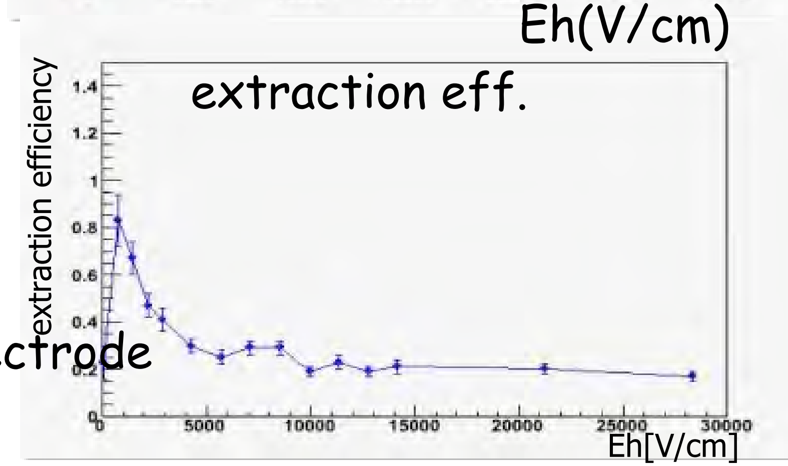
Fig. 5. Electron transmission of a standard GEM, for low transfer field ($300\,\mathrm{V\,cm^{-1}}$), as a function of GEM voltage and for three A–CO_2 mixtures: 90–10, 70–30 and 50–50.



Collection eff. has been studied by several groups as a func. of Ed/Eh

and known to be ~1 @Ed/Eh < 0.03 (ie 4.5kV/cm here)

it is relaxed when hole become larger.



Extraction eff. behave more complicatedly

- area of penetrating field line become small as Eh
- electron can spread due to diffusion(Eh)
- some electron follow returned filed line to GEM electrode

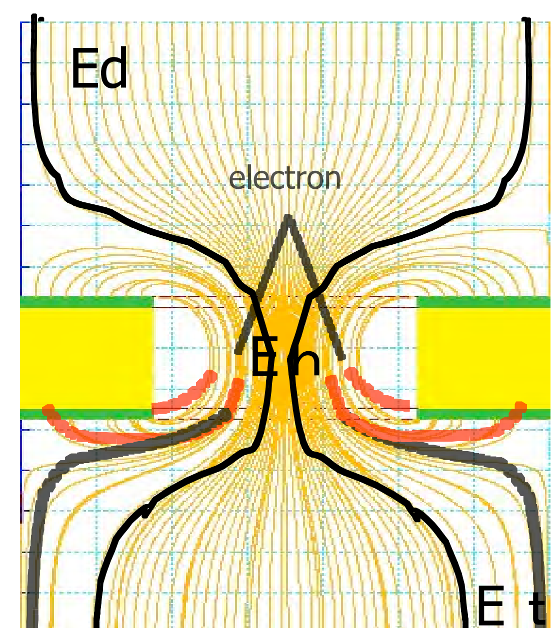
area of penetrating field line is larger @ low Eh

higher extraction

diffusion behavior is also important !

This means "transmission is largely depend on gas"

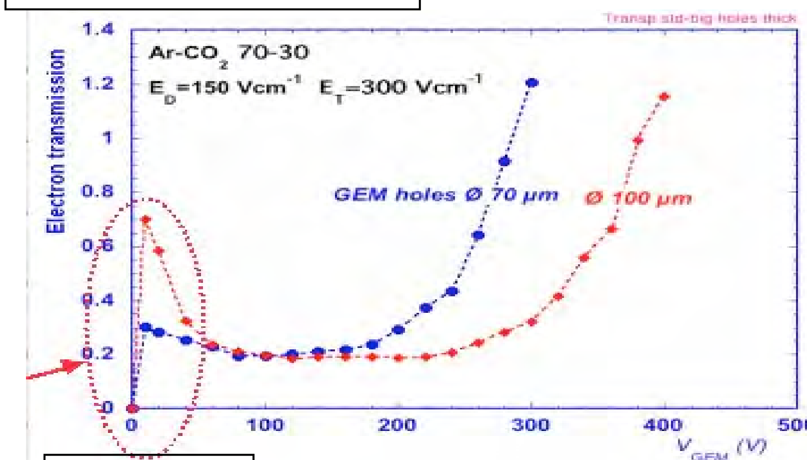
LC also requires High Magnetic Field (3~4 T)



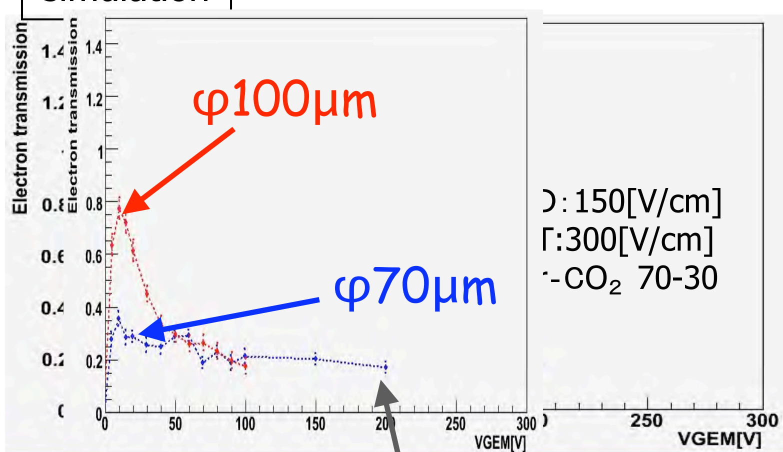
Comparison to exp. results

Electron transmission
Hole size dep.

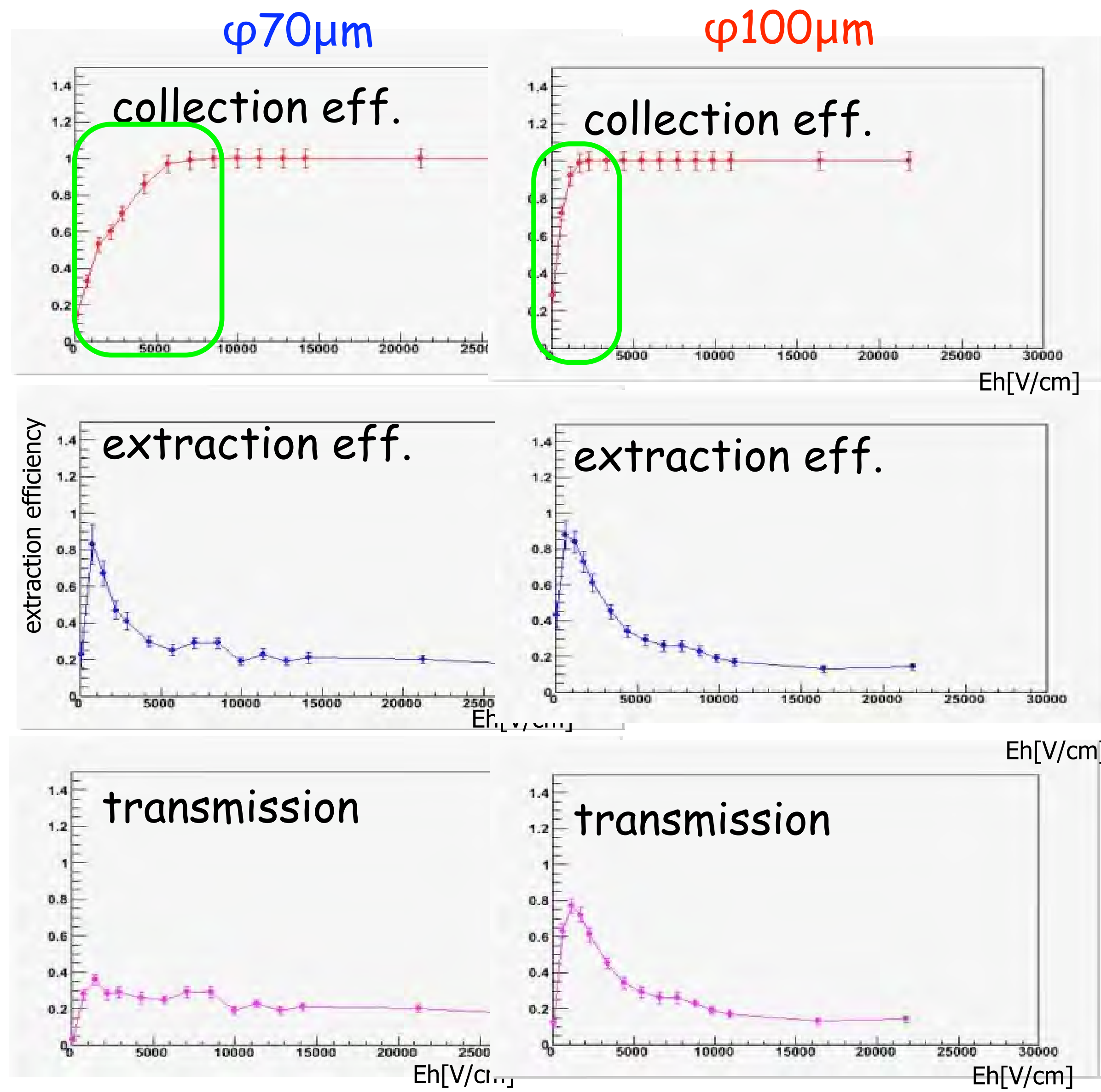
Measurement by Sauli



simulation



Gas gain is not included



Collection eff. improve transmission
due to large aperture

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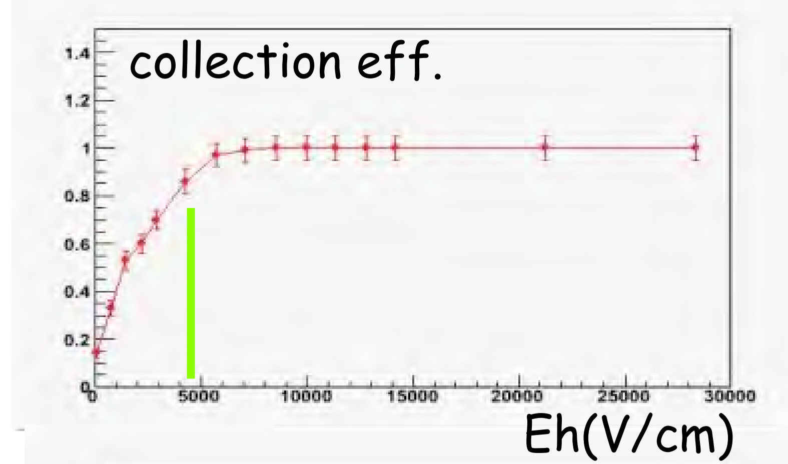

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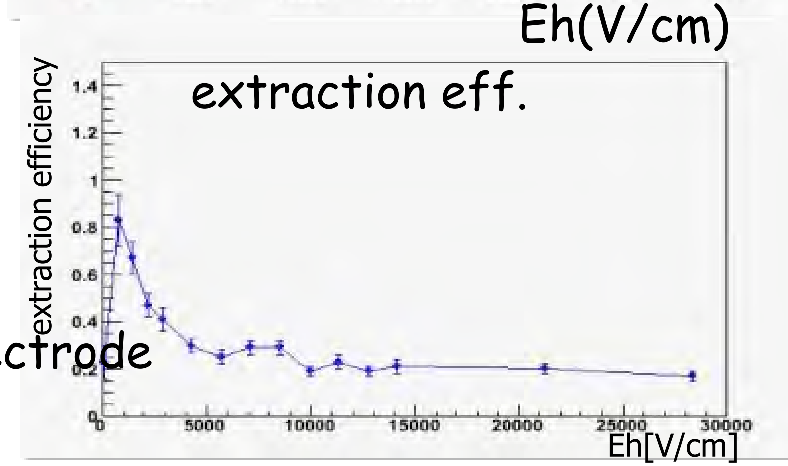

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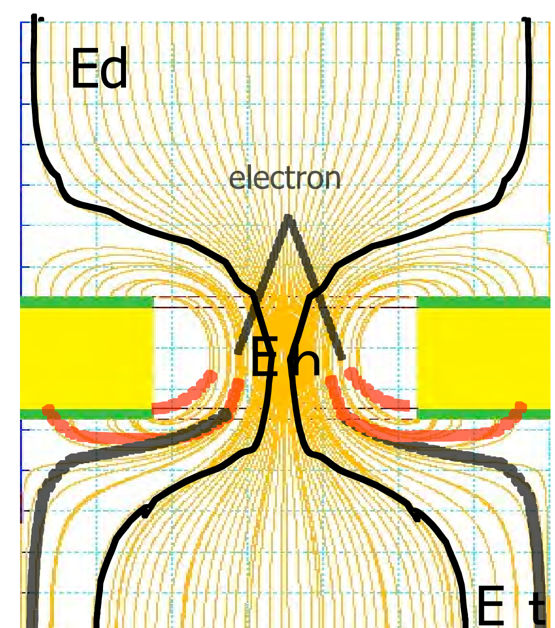


Optimization of GEM Gating for LC-TPC

High Magnetic Field (3 ~ 4 Tesla)
High $\omega\tau$ gas

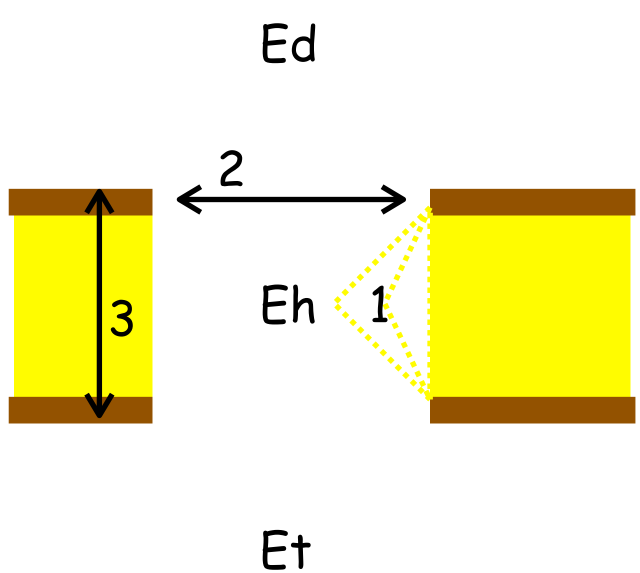
Ar:CF4 is the first candidate for this (w/ iso-C4H10)

Optimization of GEM itself

1. Hole shape
2. Hole Size/pitch
3. thickness

Optimization of operation condition

1. Drift E field : Ed
2. Hole E field (V_{GEM}) : Eh
3. transfer E field : Et



Summary of simulation study

If GEM would be used for GATE, it must be

Aperture must be large (larger hole size)
Thinner GEM is better for Gating
Field shaping around hole
Eh need to be kept low (diffuion)
Ed must be low (50V/cm)
Et must be high (300V/cm) (but just below diffusion rise)

We may be able to achieve 70% transmission @25um thick GEM in simulation.
(10% error may exist)

Do you accept this number ??

Confirmation is necessary ! especially under High B field

Need to establish how to measure.
25um thick GEM is available (though hole diameter is 90 um)
Do we try 12.5um for 10% improvement ?

DESY 5T magnet is necessary for this

Let's do together