# Potential Ion Gate using GEM: experiment and simulation

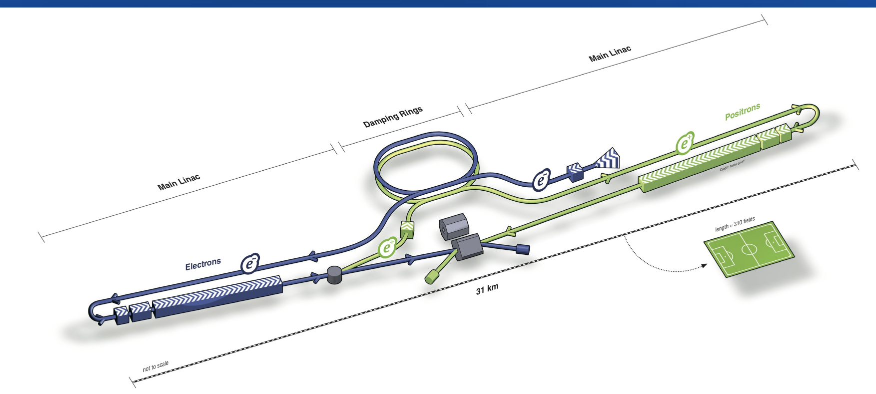
Philippe Gros

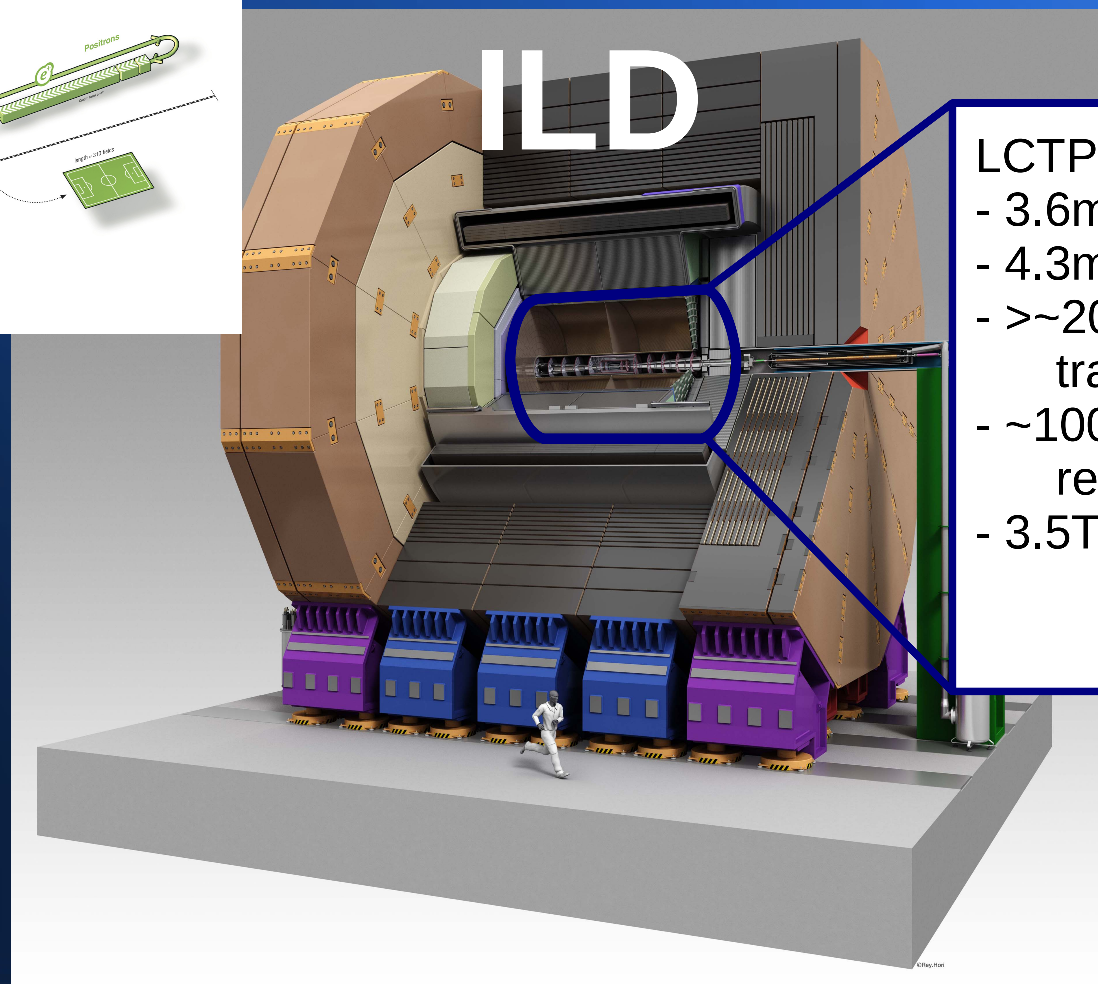
Saga University, Japan

# Outline

- A TPC for ILC
  - Structure
  - Ion backflow and gate issue
- Ion gating with GEM
  - Concept
  - Experiment
  - Simulation results
- Conclusions and outlook

# A TPC for ILD@ILC



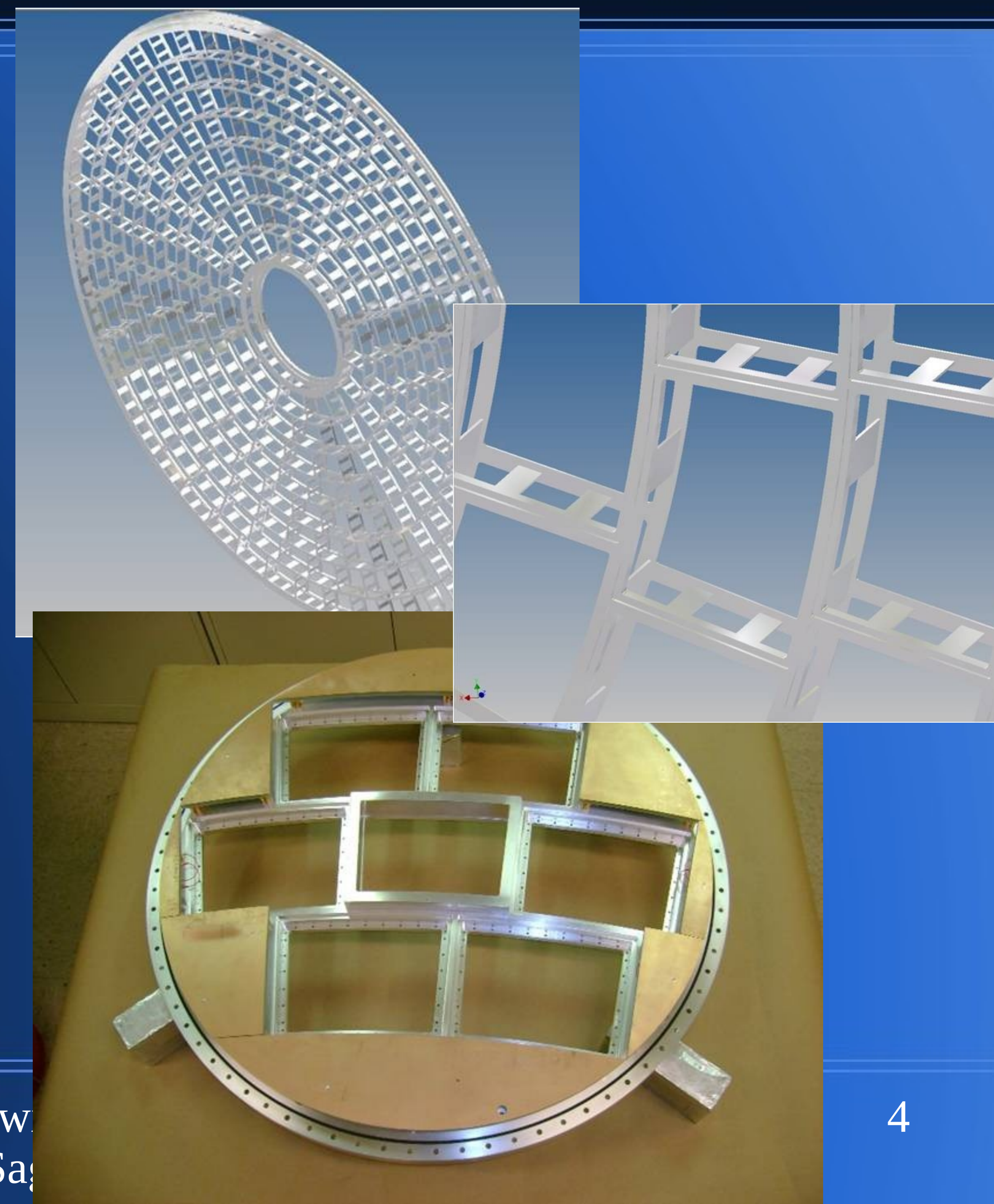




LCTPC:
- 3.6m diameter
- 4.3m long
- >~200 points per track
- ~100µm space resolution (rφ)
- 3.5T B-field

<u>ILC</u>
- ~31km long
- ~16,000 SCRF cavities
- 250-500GeV $e^+e^-$ upgrade 1TeV
- polarised beams
- 1ms train (~3000 bunch) every 200ms
- 2 Detectors (ILD, SiD) Push-pull
- Japan?
- start 2025???

# Readout plane MPGD modules

- Modular structure
- Minimises dead angles
- Tests with 7 small modules
  - ~20x20cm$^2$
  - GEM or Micromegas

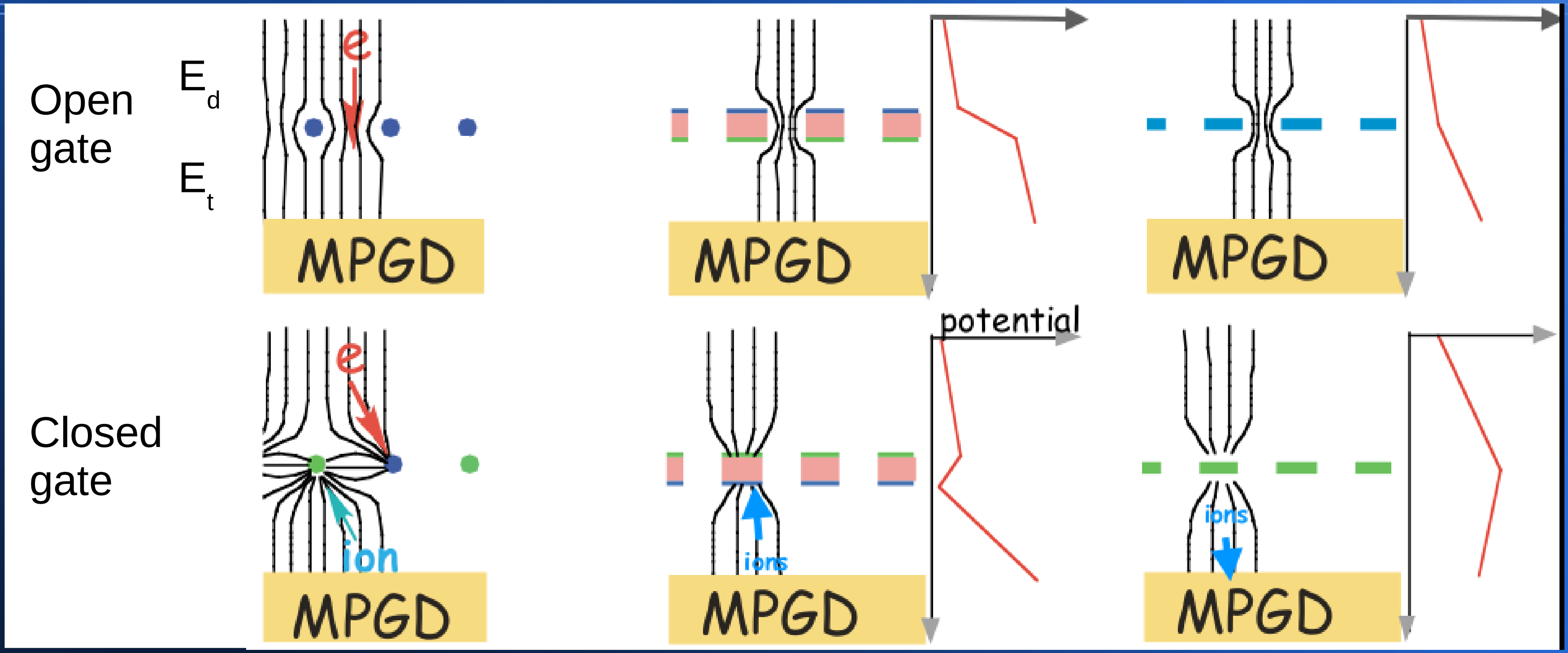


# Ion back flow in LCTPC

- ILC beam expected to produce large pair background from beamstrahlung
- Simulations by D. Arai, K. Fujii and reproduced by T. Krautscheid
- Simulations show that the positive ions in the TPC will produce non negligible distortions
  - from primary ions: ~8 µm (cannot be avoided)
  - from amplification: ~20BFR µm (back flow rate)

A gating system is necessary

# Gating options




<u>Wires</u>

+ Known technology, local E change

- Directional, wire tension, ExB, structure

<u>GEM</u>

+ Symmetry, local E change

- Electron transmission

<u>Mesh</u>

+ Symmetry, simplicity

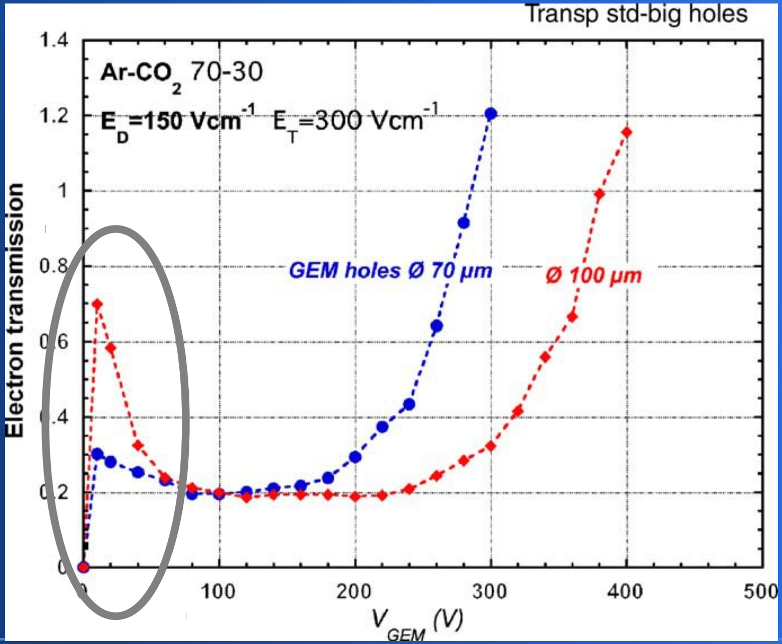
- Electron transmission, global E change

# GEM gate idea

- Suggested in 2006 by Sauli

  F.Sauli, L.Ropelewski,P.Everaerts NIM A560(2006)269-277

- Transparency peak observed experimentally
  - > Geometrical aperture
  - Relatively high GEM voltage

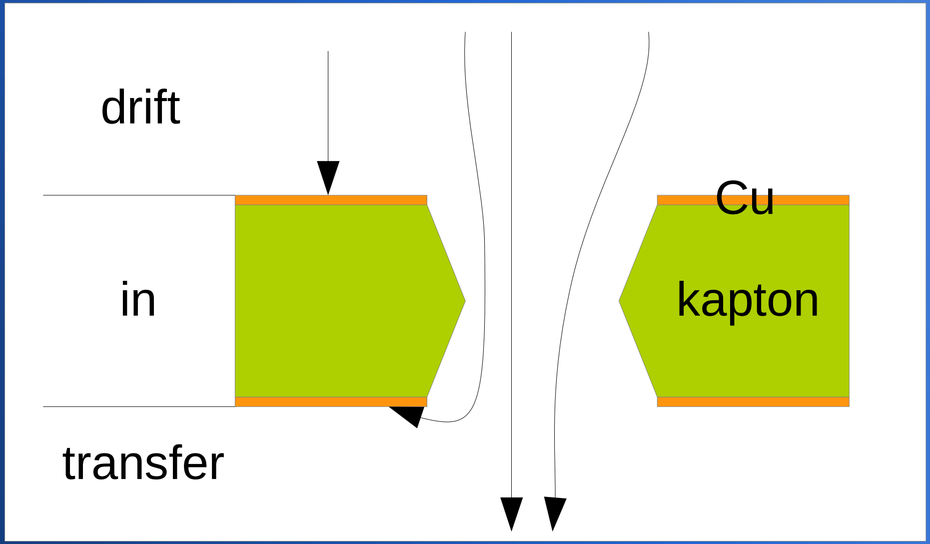


# Simulation

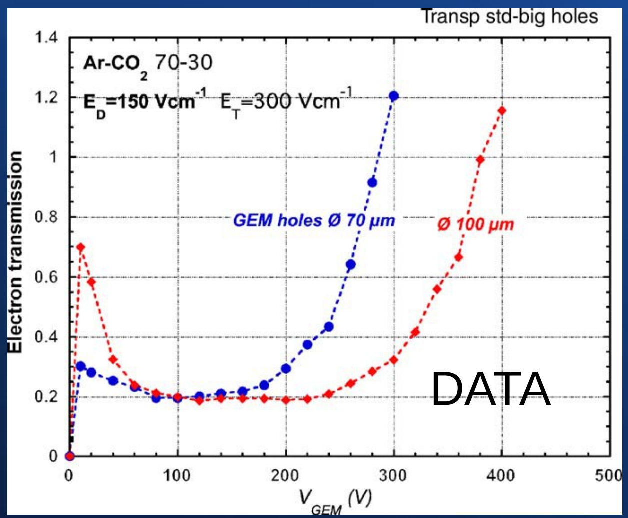
- Garfield++
  - microscopic description
  - gas cross-sections calculated with Magboltz
  - Field description from ANSYS®
- ANSYS
  - Finite elements field calculation
  - meshing with curved tetrahedra

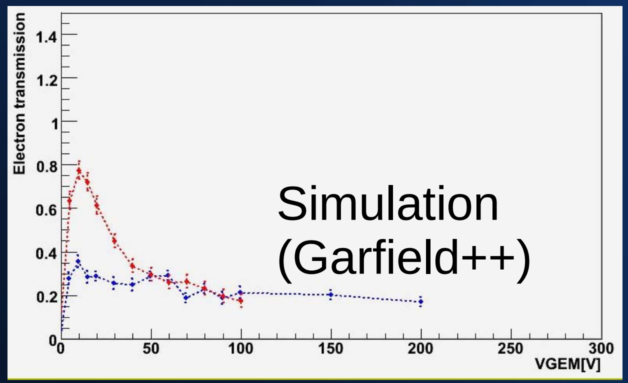
# Definitions

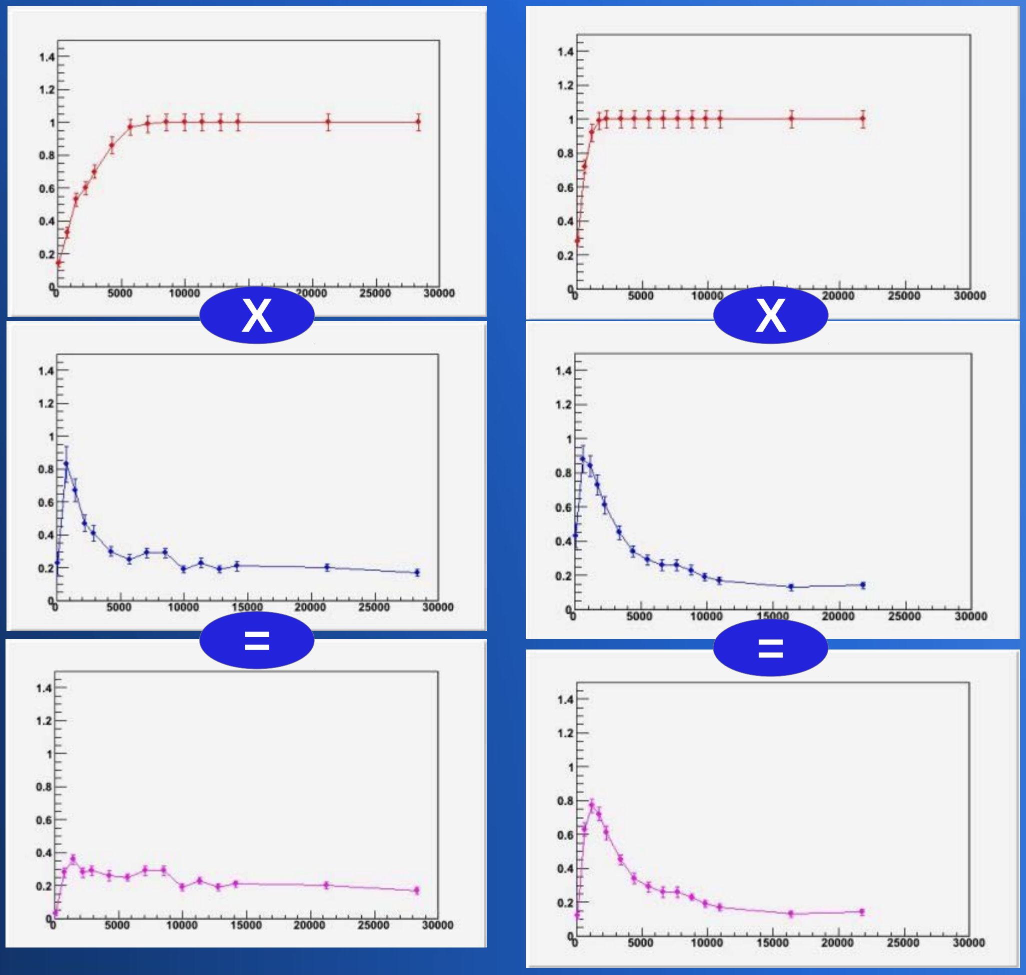
- Collection efficiency
  - $coll = N_{in} / N_{drift}$
- Extraction efficiency
  - $extr = N_{transfer} / N_{in}$
- Transmission
  - $T = N_{transfer} / N_{drift} = coll \times extr$



# Simulation of Sauli's experiment



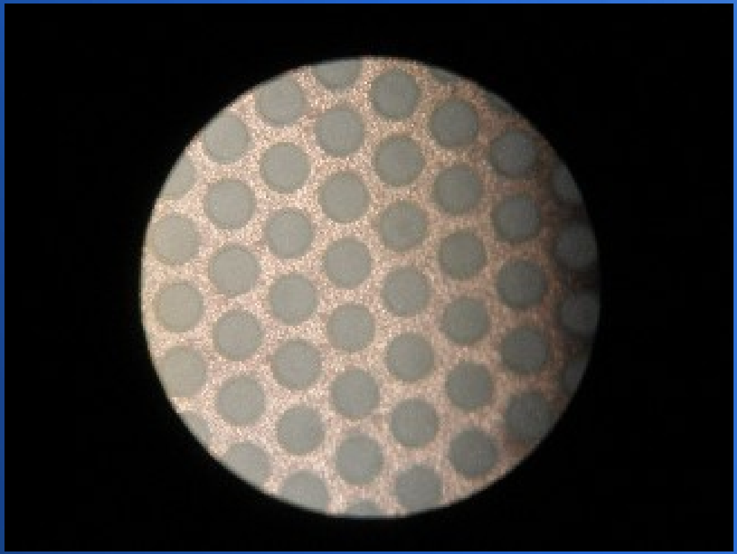



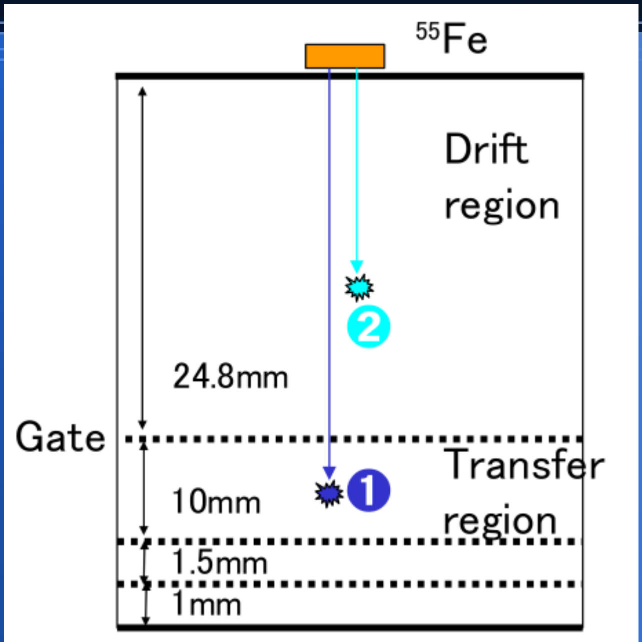
# Experiments with a thin GEM gate (14μm)

- A specific GEM gate was produced
- Thin GEM
  - 14μm kapton, 1μm copper
- Relatively large aperture
  - 90 μm diameter
  - 140 μm pitch

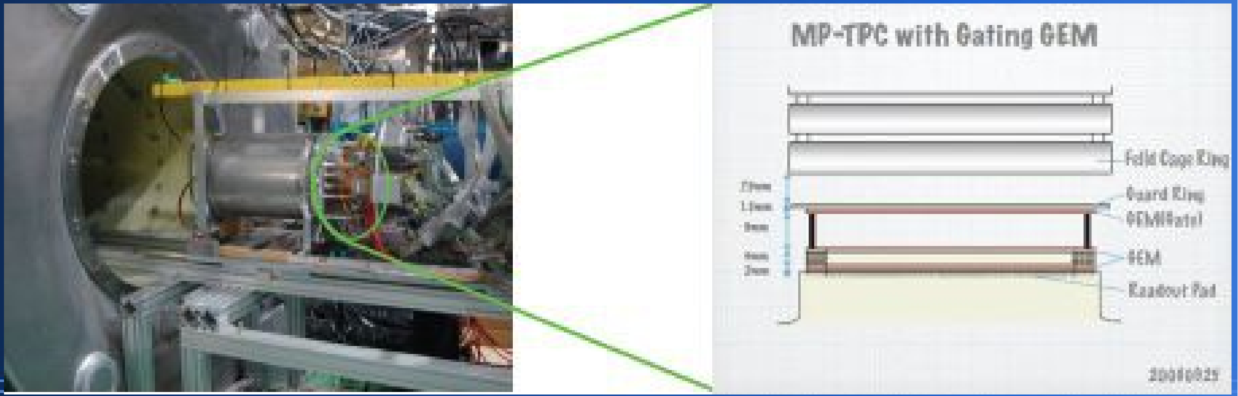
  => 37% geometrical aperture



# GEM gate experiments

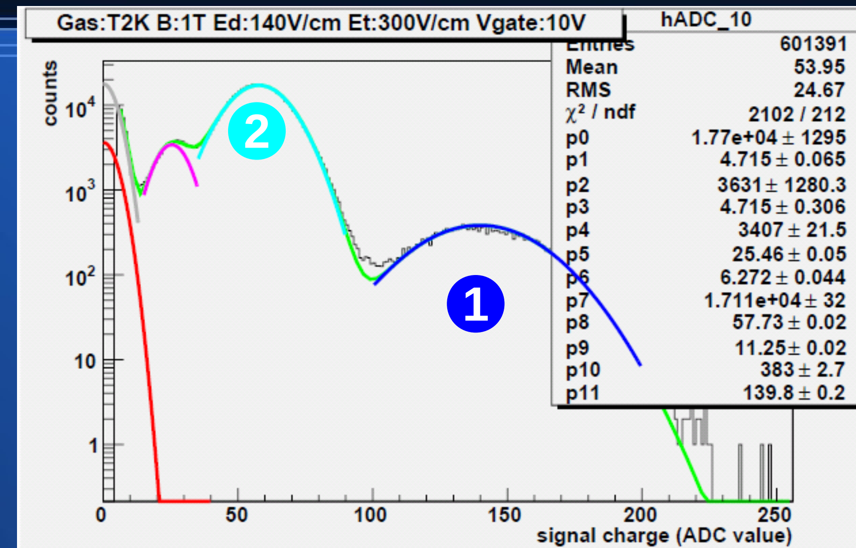



- Transparency measurement
  - Compare the signal create before and after the gate
  - Systematic effects cancel out
- Space resolution
  - 1T magnet
  - Cosmic rays
  - Evaluate $N_{effective}$

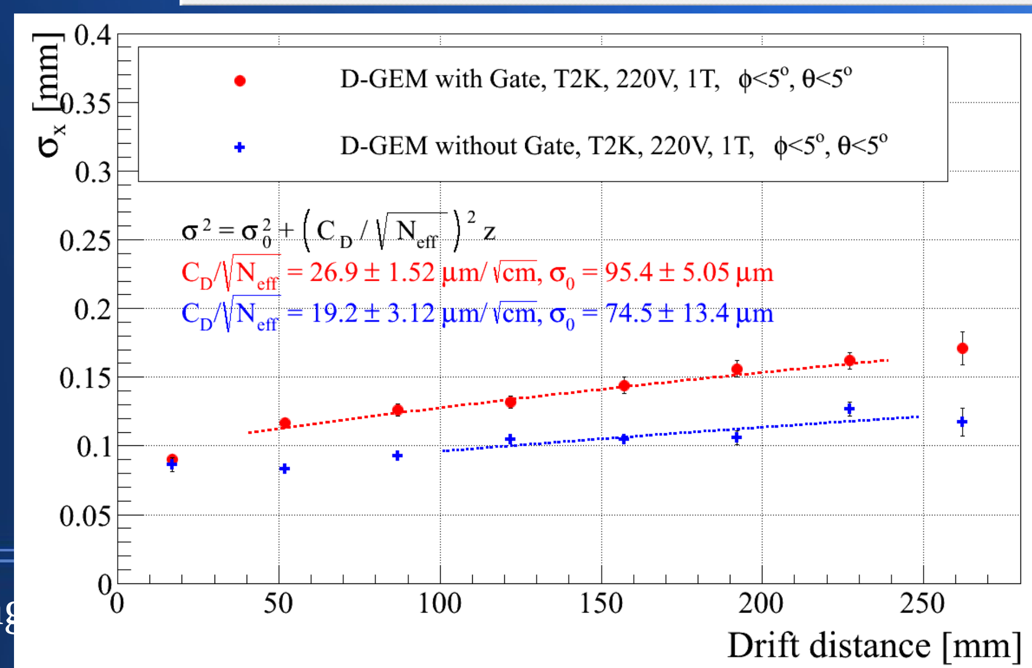


# Experiment Result

- Transparency ~50% at B=1T

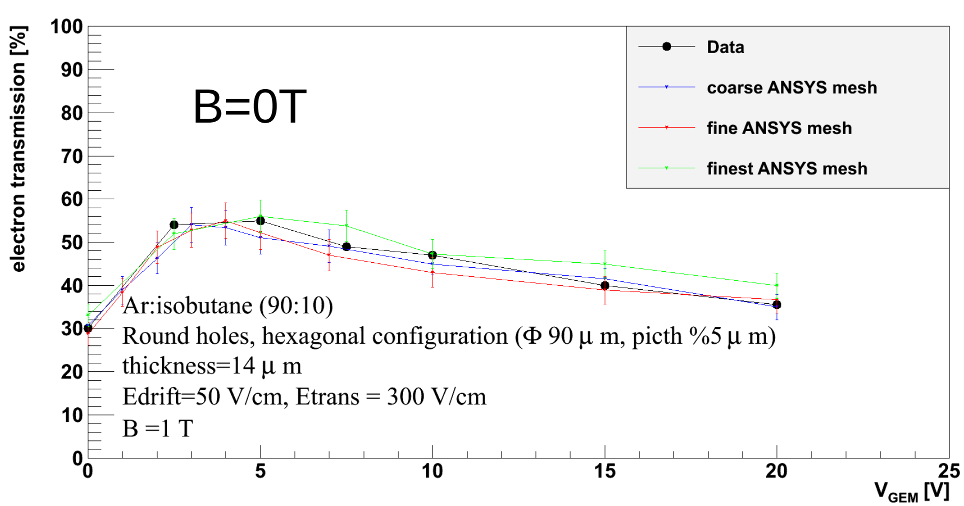


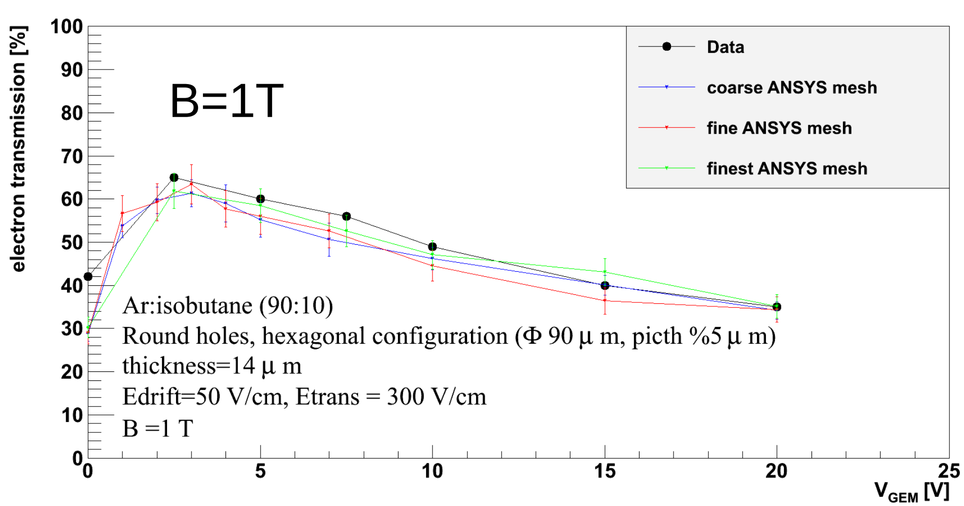

- Consistent with 50% transparency



# Simulation

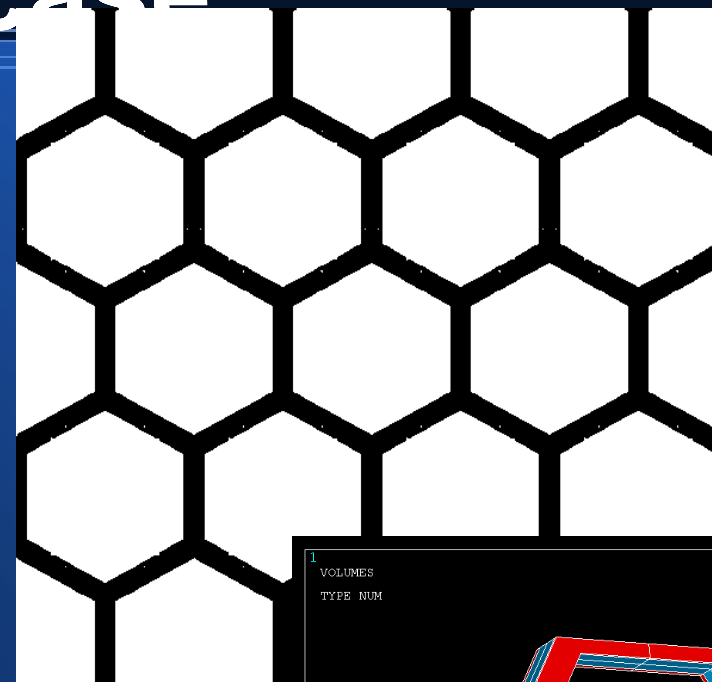
- Using Garfield++ and ANSYS
- Reproduces the experimental transparency measurement very well

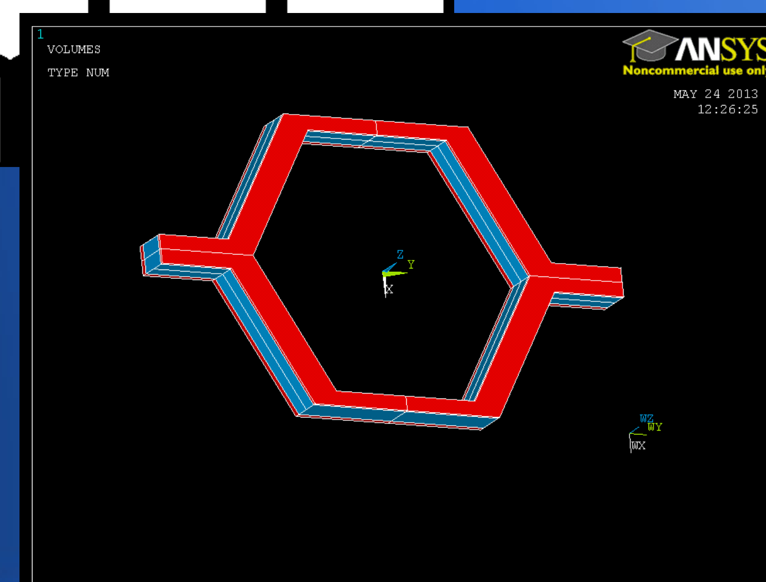


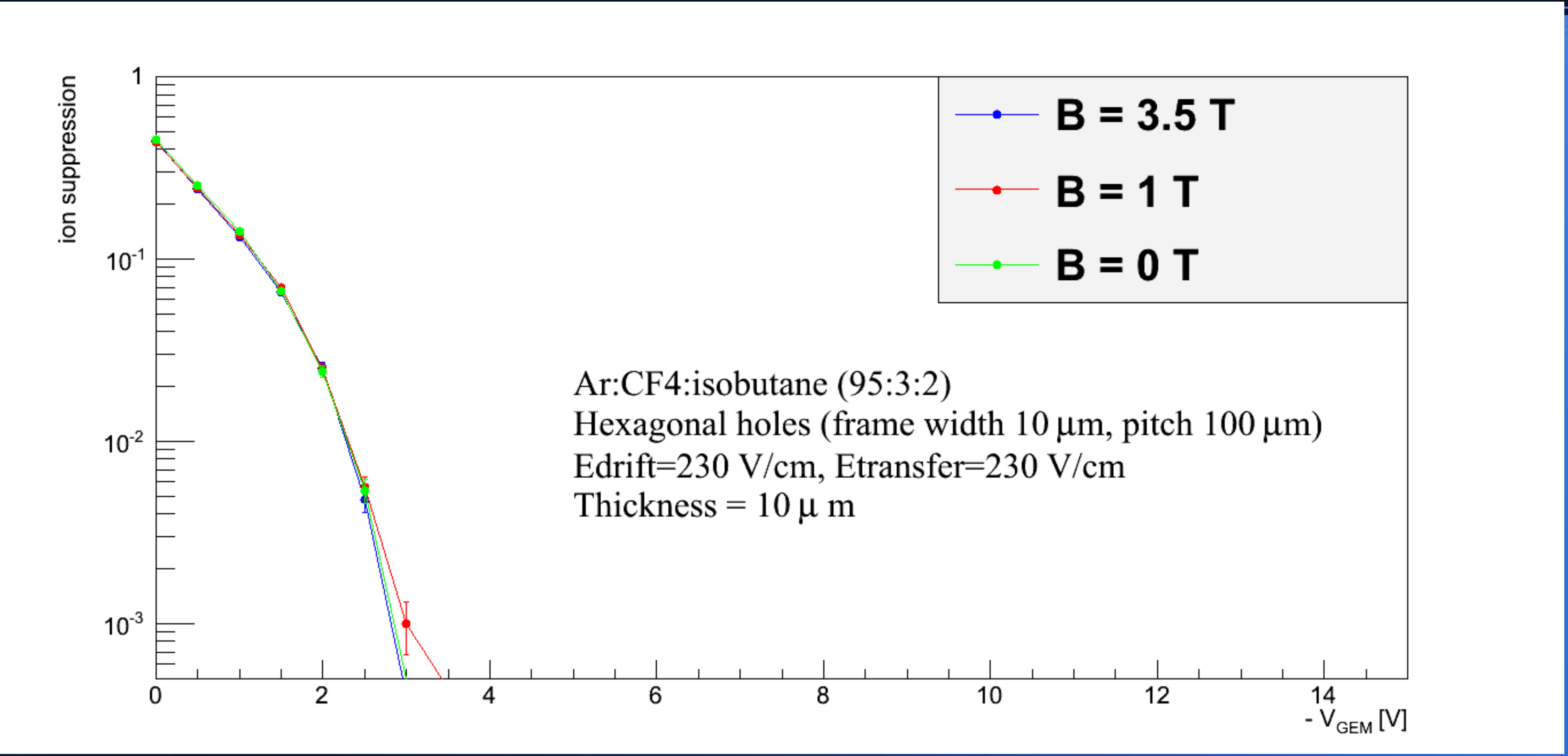
# Large aperture Simulating an extreme case

- Maximize the aperture
- Honeycomb structure
- 10µm wide, 100µm pitch
  - 81% aperture
  - difficult to build





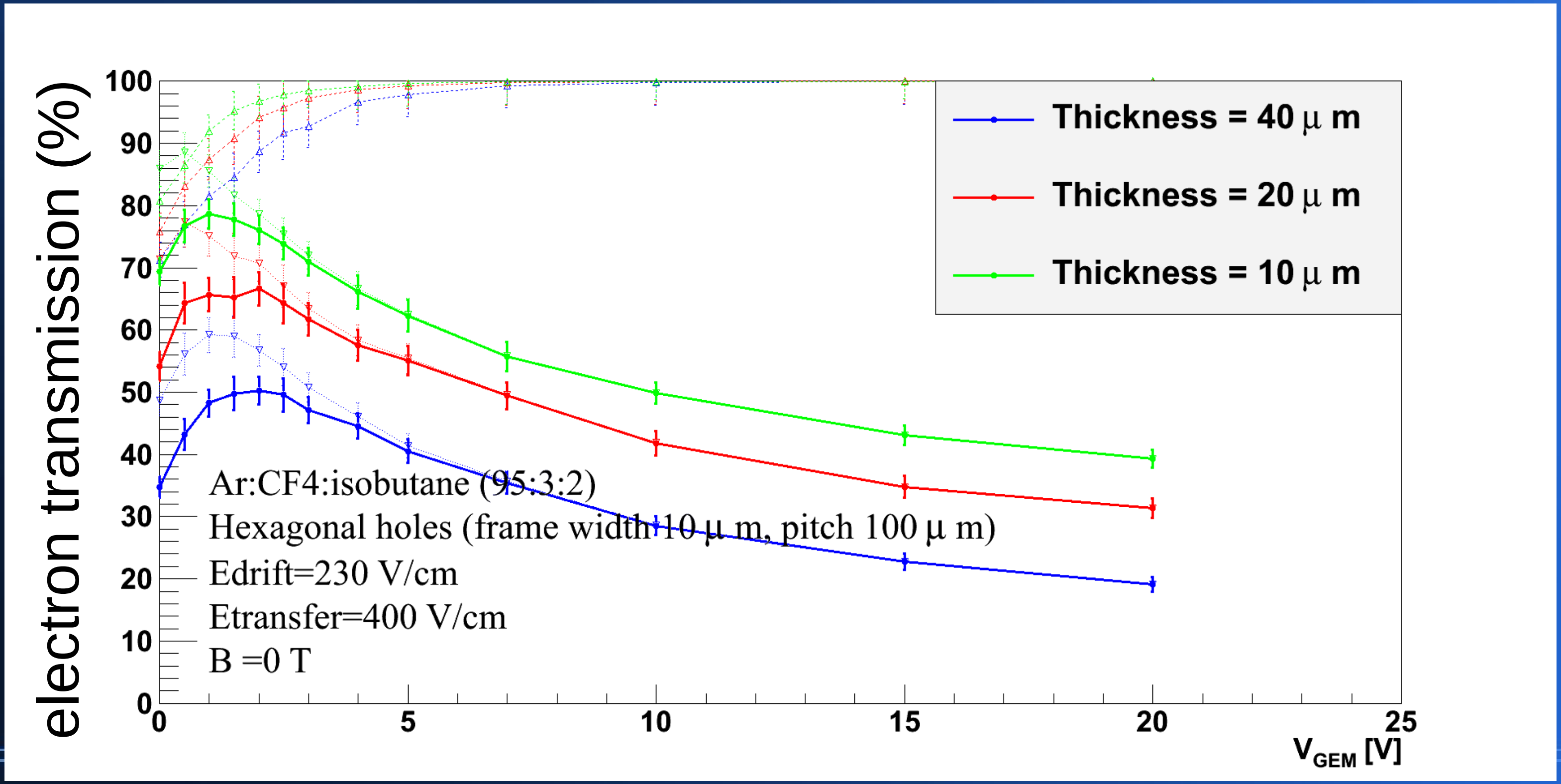
# Closing the gate




As expected, the magnetic field has little influence on the ions
A GEM voltage above **3V** already gives enough ion suppression.

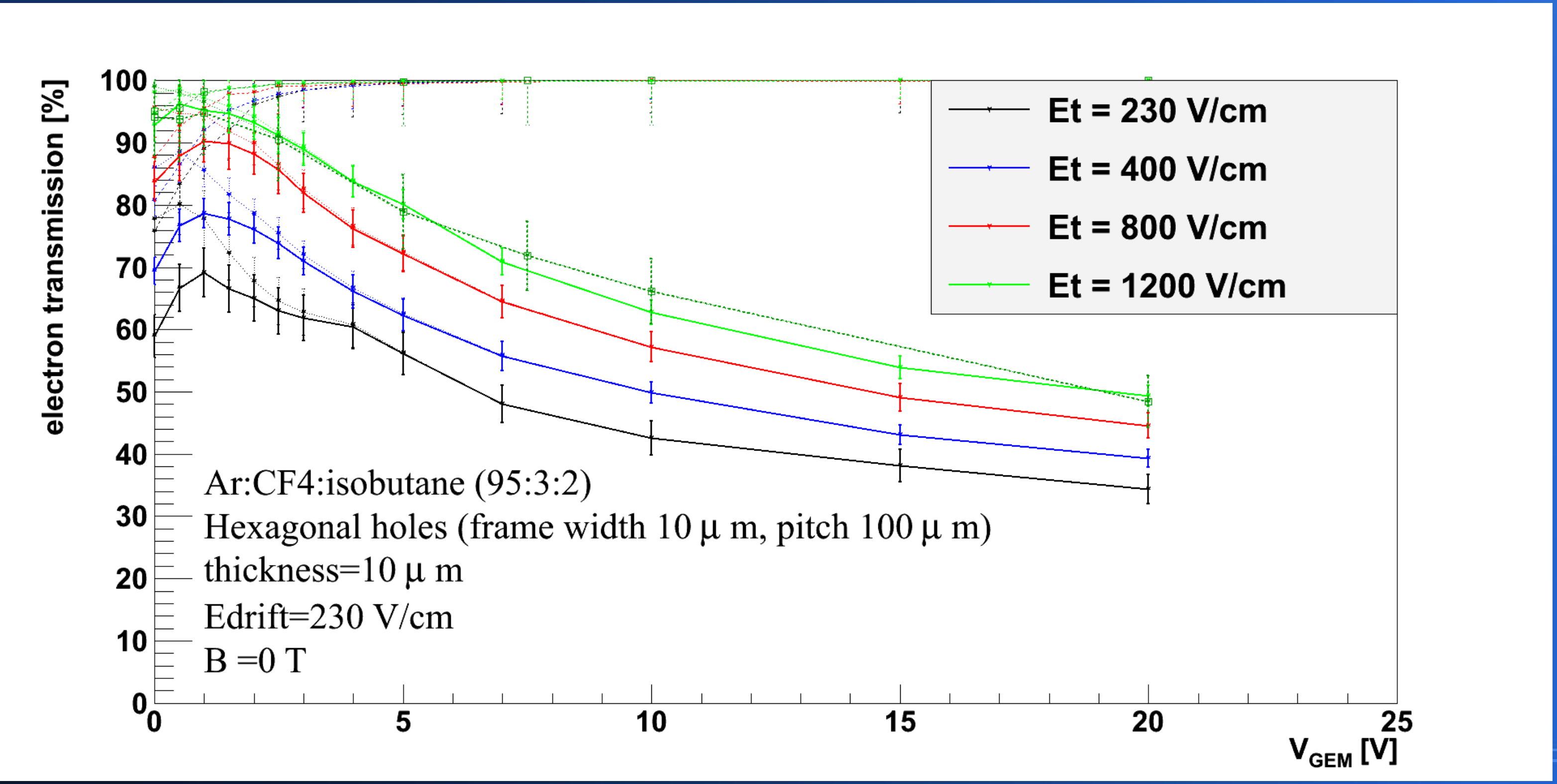
# First result

- Without magnetic field
- Good transparency requires extreme conditions



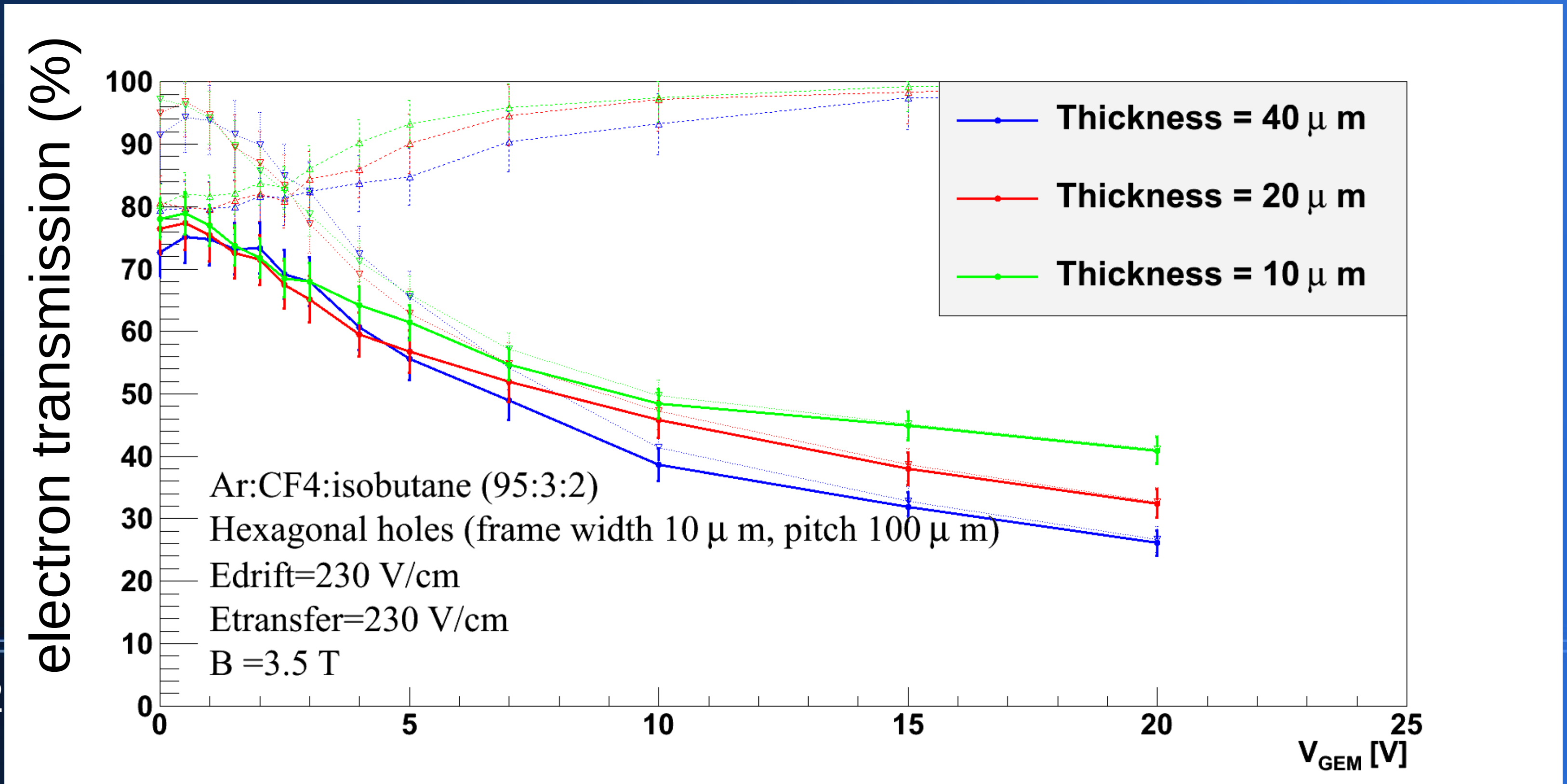
# First result

- Without magnetic field
- Good transparency requires extreme conditions



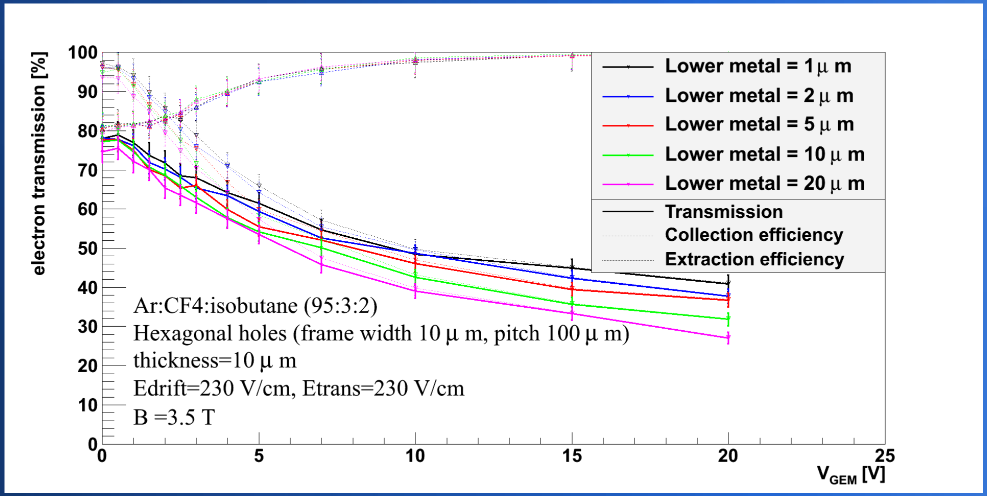
# With 3.5T B field

- ωτ~10 => the electrons follow B, little diffusion
- Electric field and thickness have little influence
- Geometric transparency (81%)

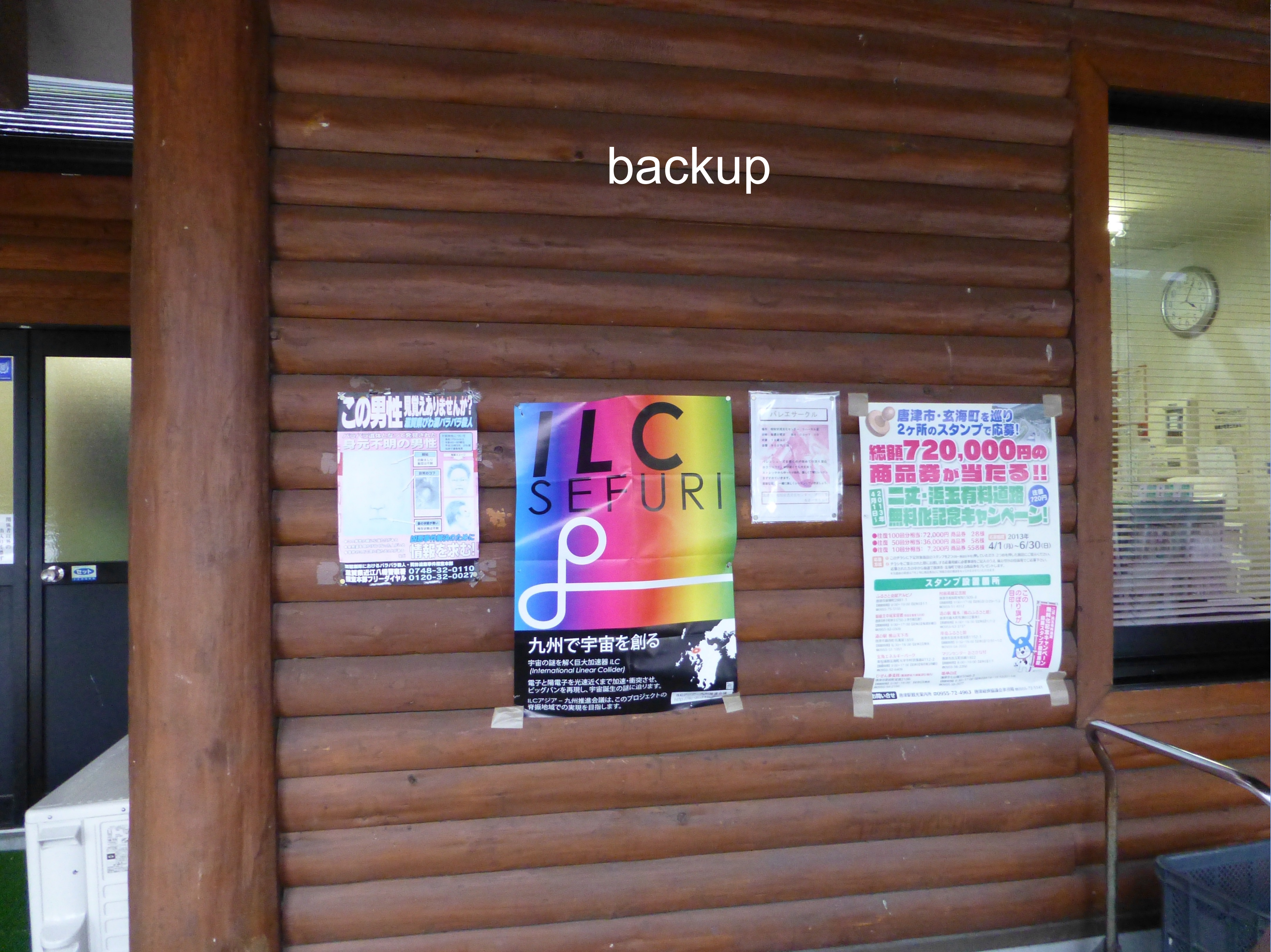


# Conclusion and outlook

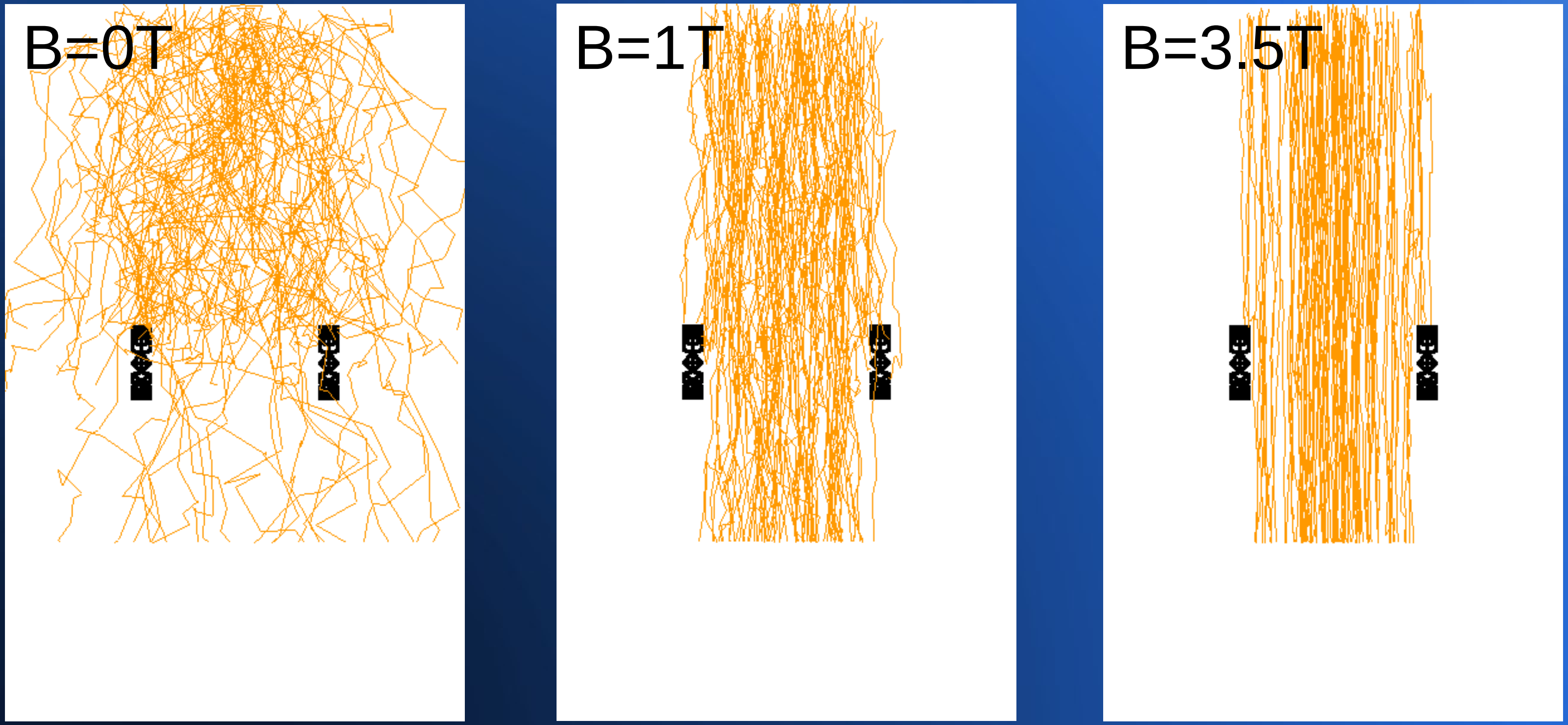
- Garfield++ simulations give a good description of GEM gate performance
- In high B field, geometrical aperture becomes the key parameter
- Difficulties are mechanical
  - How to make thin structure
  - Maybe improved with thicker metal?



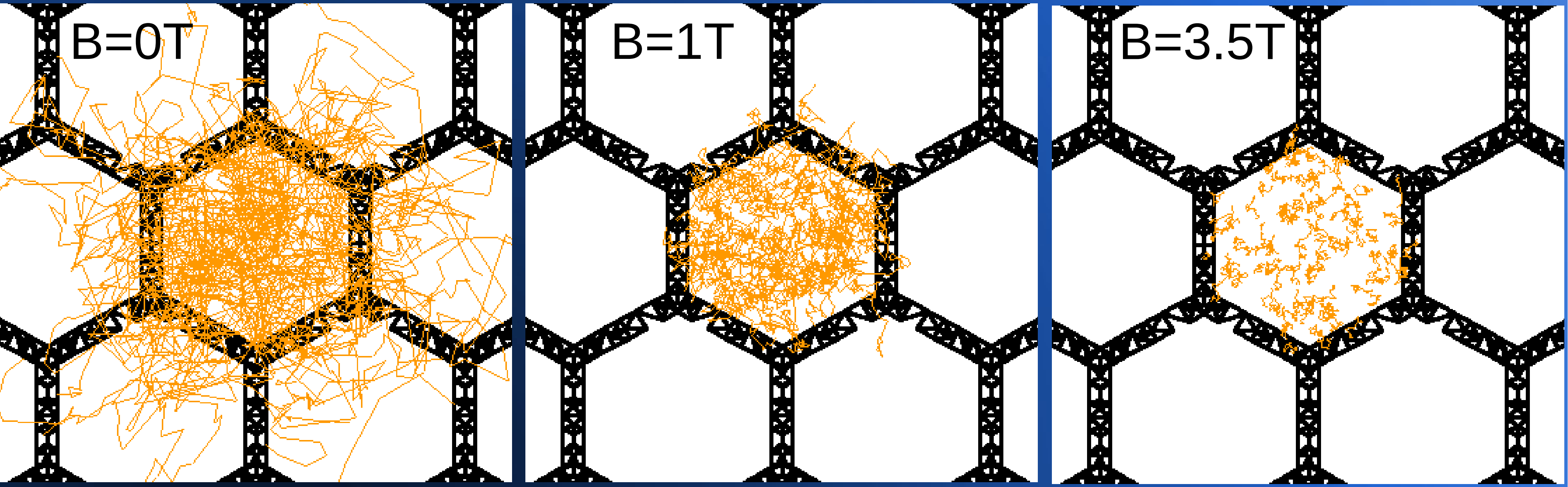
backup


この男性見覚えありませんか?
身元不明の男性
情報を求む!
0748-32-0110
0120-32-0027
ILC
SEFURI
九州で宇宙を創る
宇宙の謎を解く巨大加速器 ILC
(International Linear Collider)
電子と陽電子を光速近くまで加速・衝突させ、
ビッグバンを再現し、宇宙誕生の謎に迫ります。
ILCアジア－九州推進会議は、このプロジェクトの
脊振地域での実現を目指します。
バレエサークル
唐津市・玄海町を巡り
2ヶ所のスタンプで応募!
総額720,000円の
商品券が当たる!!
二丈・浜玉有料道路
無料化記念キャンペーン!
2013年
4/1(月)~6/30(日)
スタンプ設置箇所

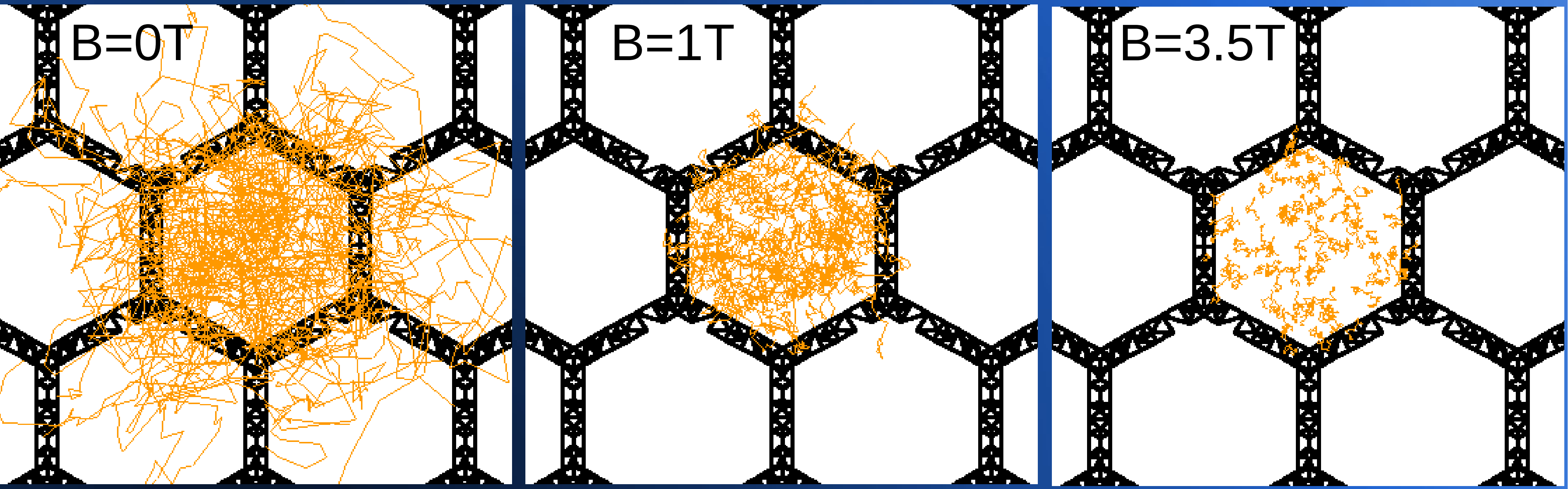
# Effect of B field



# Effect of B field



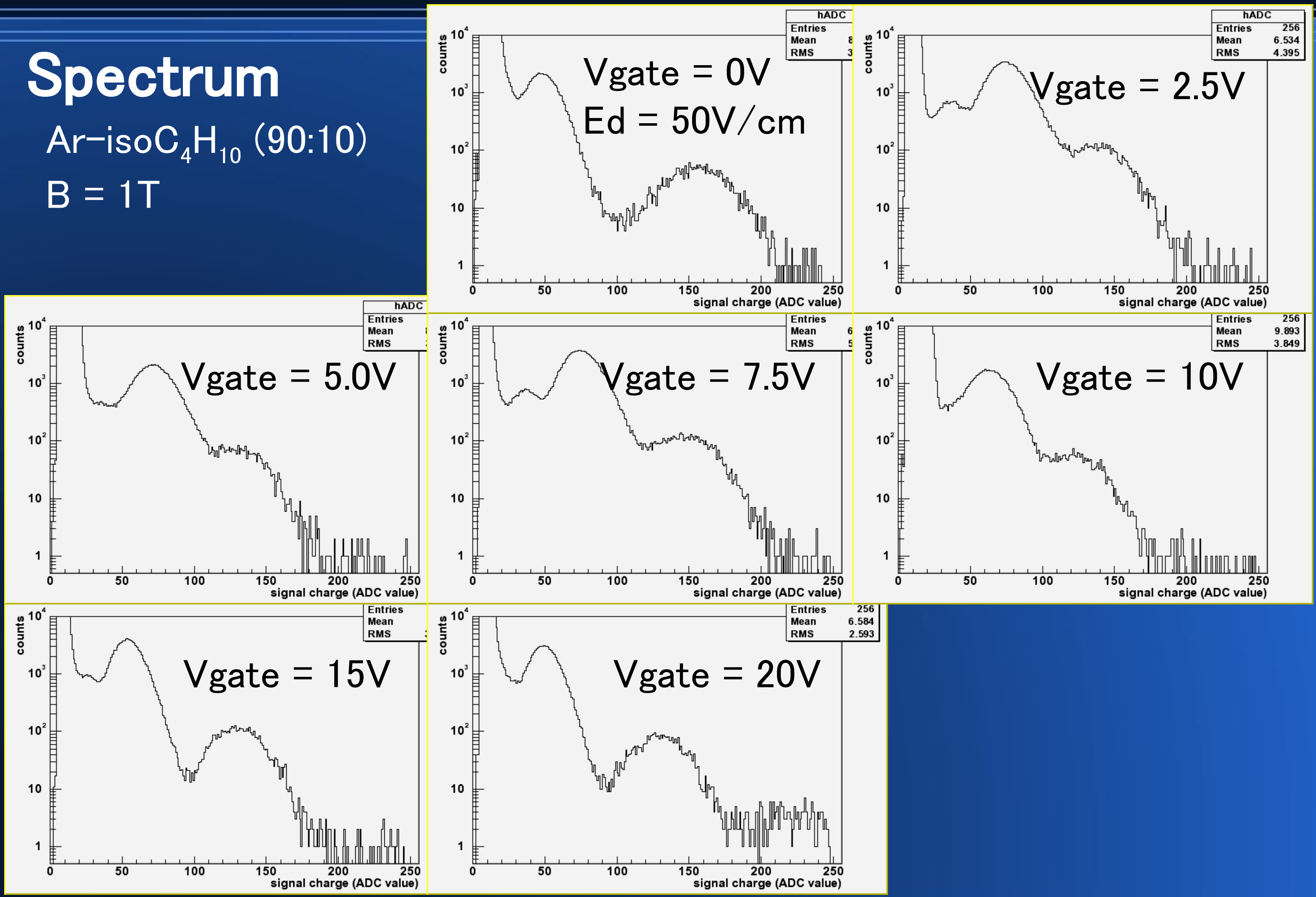
# Effect of B field



# Spectrum

Ar–iso$C_4H_{10}$ (90:10)

B = 1T



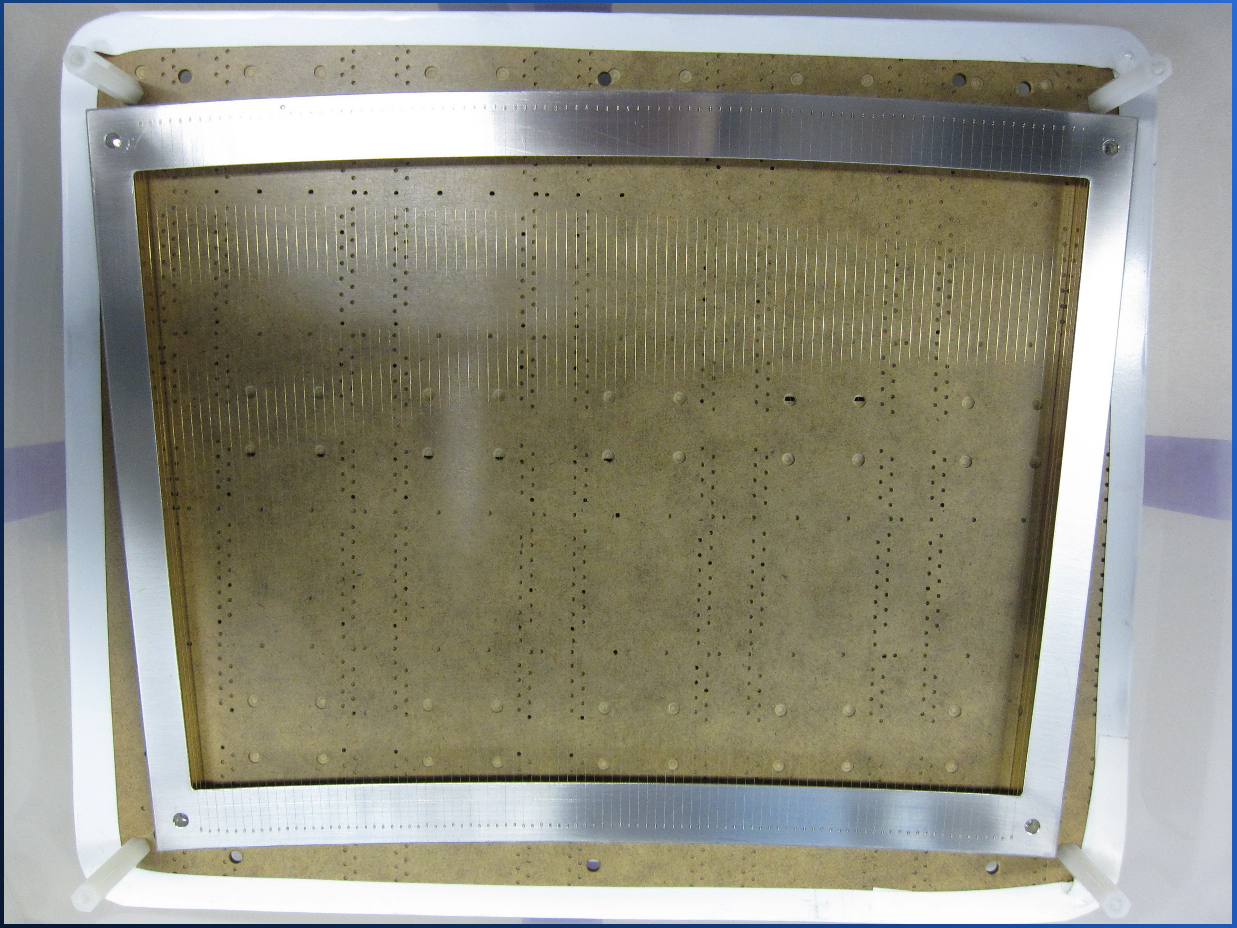
# Wire gate

- Well known technology
- Difficult to adapt to the module structure
- Possible effects of B field

  => *Radial wires*

  - No radial support structure: minimises dead regions
  - ExB in the wire direction => minimises distrotions

# Radial wire gate prototype



# Status

- 3 prototypes were built
  - 30µm wires, 2mm pitch
  - spot welded on stainless steel frame
  - only one potential: no alternate potential closed gate scheme
- Could not be tested yet
  - small design error has to be fixed
- Planned test with laser at KEK
- Needs to be tested in B field