Gate

- Introduction
- Status of Gate production
- Status of Gate study w/ prototype
  - transmission
  - comparison to MC
- remaining to be done

Introduction

Why we need Gating device ?

Ion problem

Production of Ions is inevitable in gas detector.

dense ions in drift volume may deteriorate drifting electron.

Primary ions : produced by generated charged tracks/photons

Background @ ILC

mini-jets

2×10^4 tracks/train ~ 10 tracks/bunch

~O(0.3%) occupancy @ innermost raw(r=45cm)

naive estimation

low Pt tracks contribute more(curling)

these rates are dep. on BDS/IR design

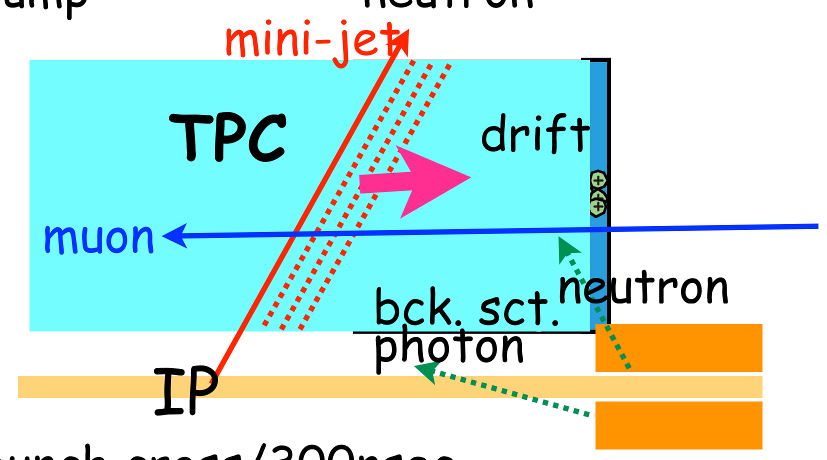
GAS in TPC (H less gas ?)

Physics background

2 photon process - mini jets

Beam background

pair background	photon, electrons
disrupted beam	muon
beam dump	neutron



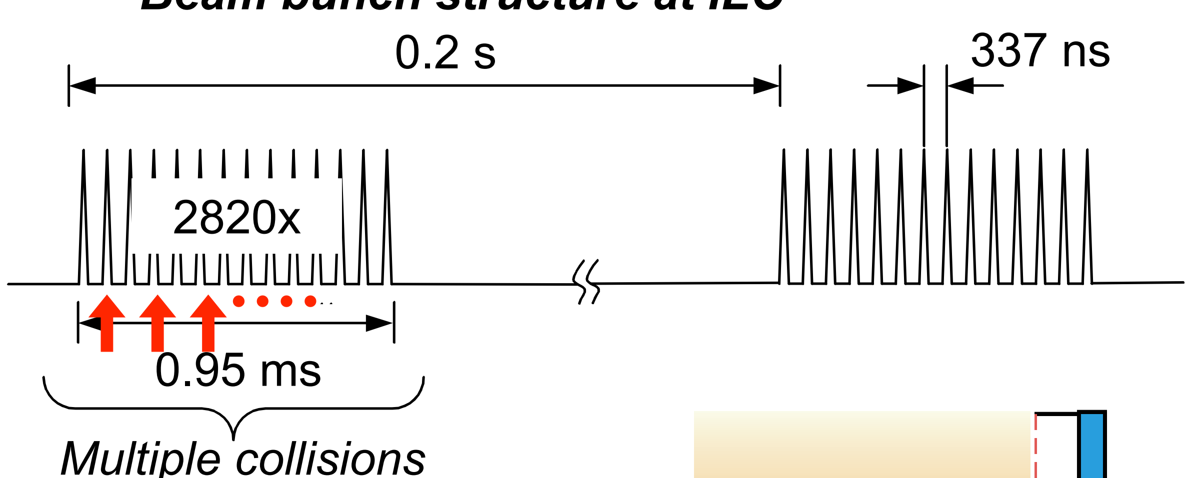
bunch cross/300nsec

ions from gas amplification(backdrift ions) :

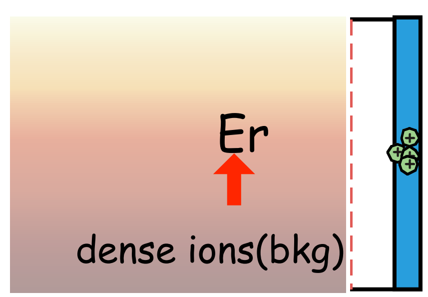
ions (dense) discs are formed due to slow drift velocity

MPGD owns inherent ability of ion absorption

Beam Structure @ ILC

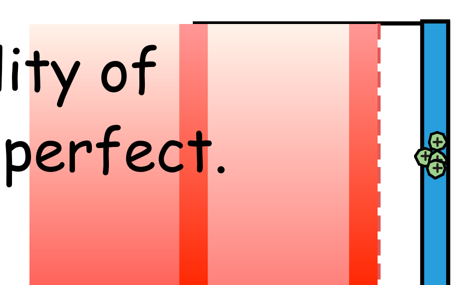


train produce back-drift ions' disk
without "Gate mechanism" for ions
as big difference of drift velocity
between electron and ion
drift velocity of ion is 10000 times slower



1st train produce prim. ion pairs in all drift volume
electron drift to MPGD(endplate)
and amplification produce more ions

MPGD has a natural ability of gating ions, but it's not perfect.

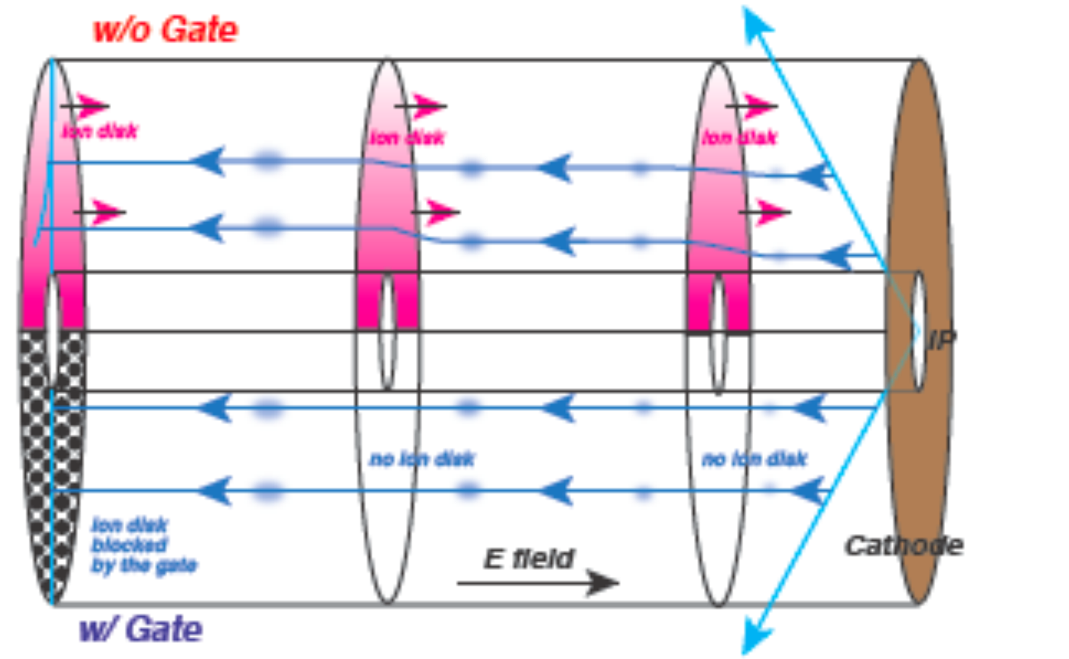


next train produce prim. ion pairs again
before ions are swept out
amp. ions by 1 train form thin disc and drift slowly

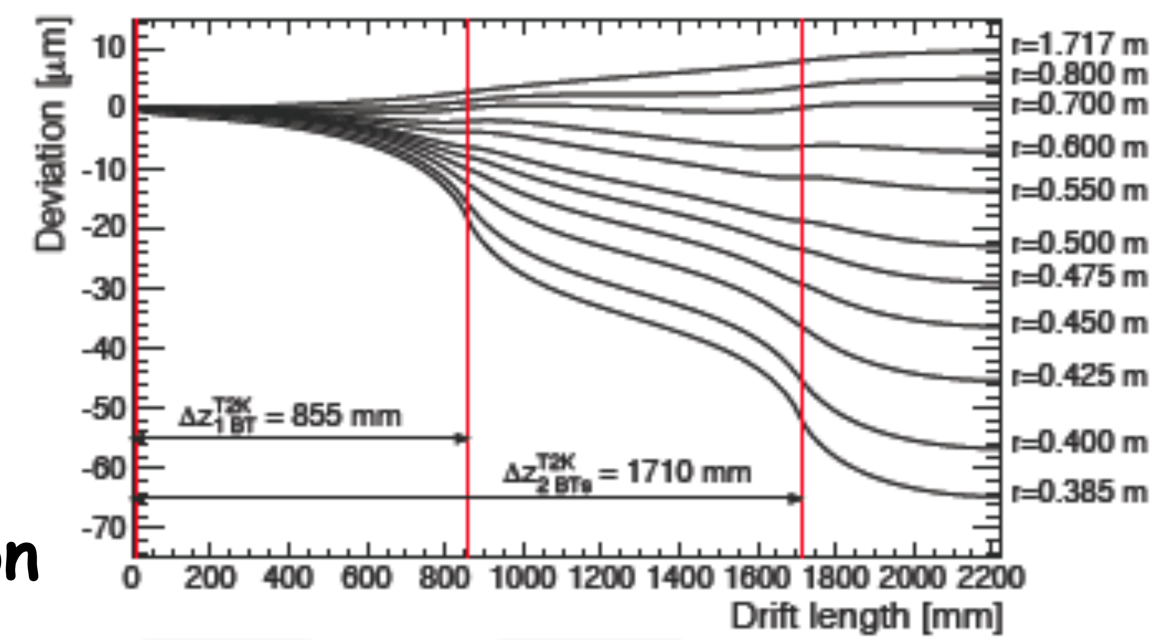
We need "GATE"ing GRID

Effect of ion (disc)

Primary ions are inevitable
  no way to recover
    but ions are spread over all volume
  effect to position measurement is
    acceptable O(10 um)

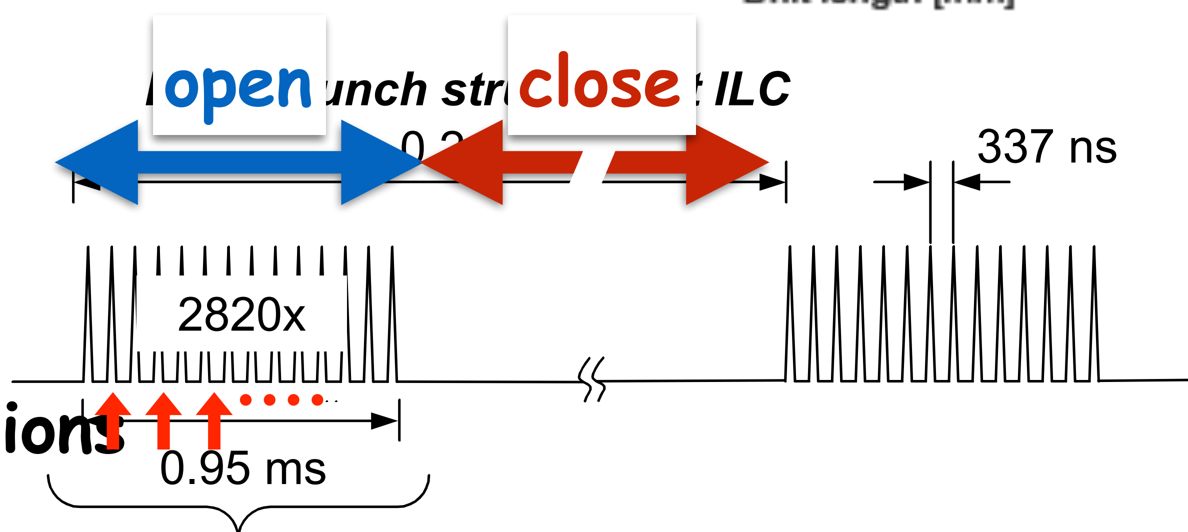


Ions produced by amplification form
  dense ion disc which deteriorate
    position accuracy ~60 um
  even 1 ion / prim. electron
    assuming φ symmetry
    two ion disc
    not negligible to 100 um resolution



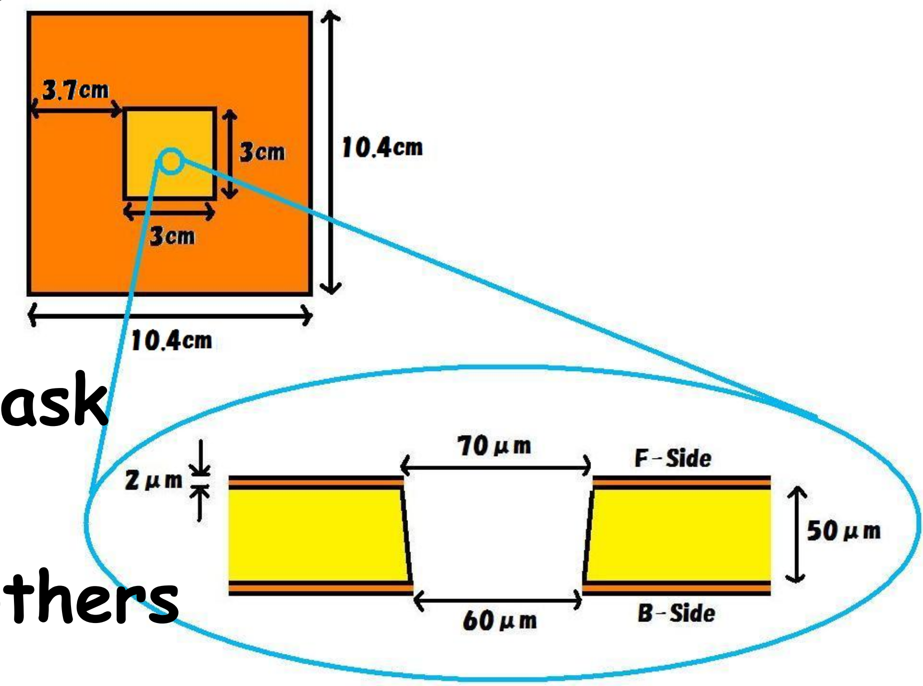
We need Ion Gate device

ILC beam structure is good for gating
  gate is open for 1ms collision
  gate is closed for 199ms between collisions



Status of Gate production

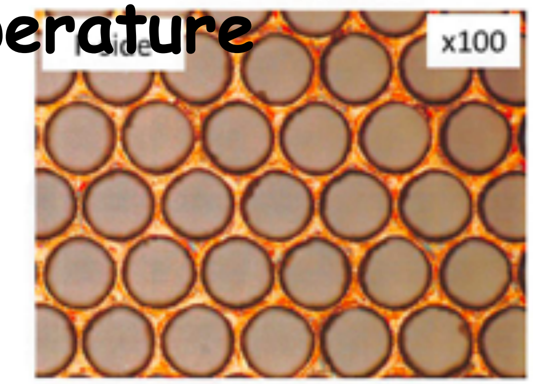
History of Fujikura Gate production



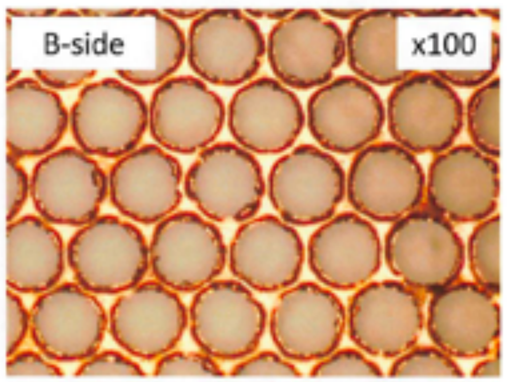
2012 Fujikura's 1st MPGD production: GEM
hole drilling : YAG Laser shot w/o mask

performance as GEM is almost same as others

2013 Fujikura's 2nd MPGD was Gate GEM 1cmx1cm 140um pitch
hole drilling : YAG Laser shot w/o mask
Laser shot may increase temperature
of PI
shape is no good,
Cu peeled off partially

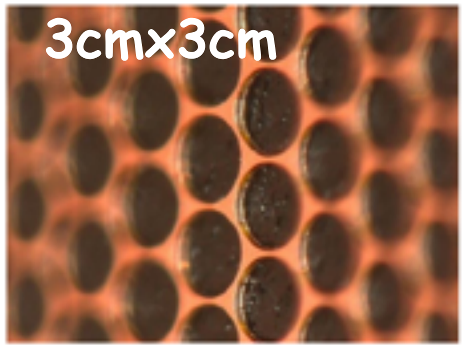


Cu : 2um, PI : 25um (F-side)

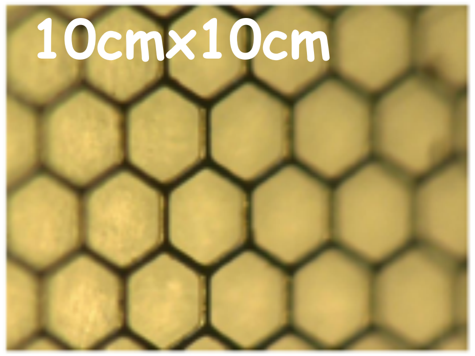


Cu : 2um, PI : 25um (B-side)

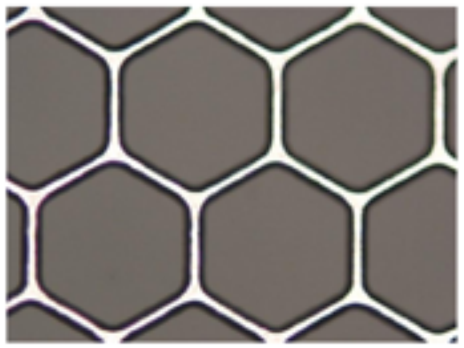
2014 relax pitch to 300um single Mask with defocused laser
Type0 circle
Type1 honeycomb
Type2 Ni coat
Type3 current procedure



Gate GEM Type 0



Gate GEM Type 1


Gate GEM Type 2

2015 Module-size Gate (geom. same as Type3)

old frame (no side frame)

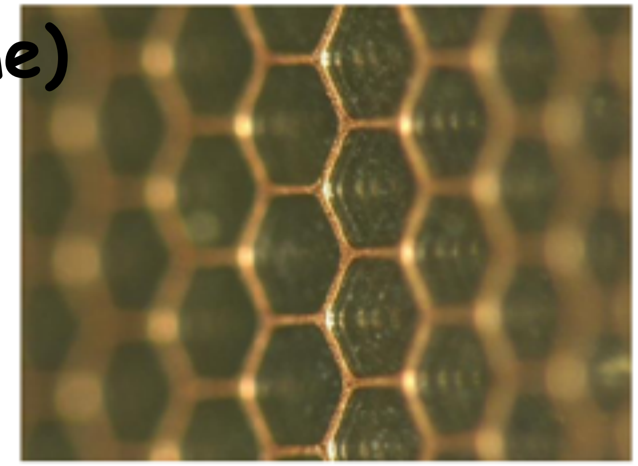


図3. F-side斜め外観

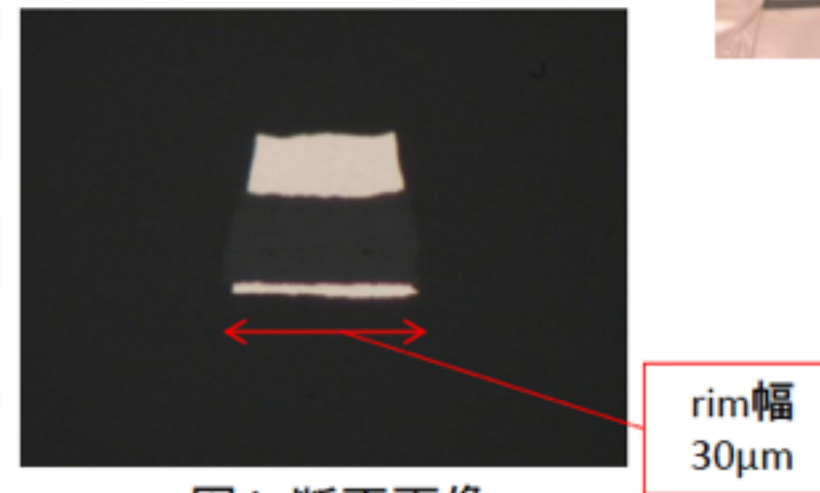


図4. 断面画像

2016 Module-size Gate

for Field-shaper frame

2 mask for electrode/boundary process

This is used at this beamiest

Design is changed every time/

need to study process condition each time

we need to order any Gate constantly

in order to let company keep/improve production skill

Size issue

Module size is not a issue to be discussed from the gating session,
but it's better to know the current obtainable size

What limit a size of Gate produced by the company

movable stage of laser system
25cm x 35cm
company has bigger system (reach to 50cm x 50cm)
need new conditioning as sept. is different

etching system for FPC
50cm x 50cm
Production line allow to accept this size but maximum is this

50cm size : difficult to eliminate broken circuit
laser shooting time increase … cost
1cm clearance is necessary from each side of sheet
-> 48cm x 48cm is the current max. size company can produce

Status of Gate study using prototype

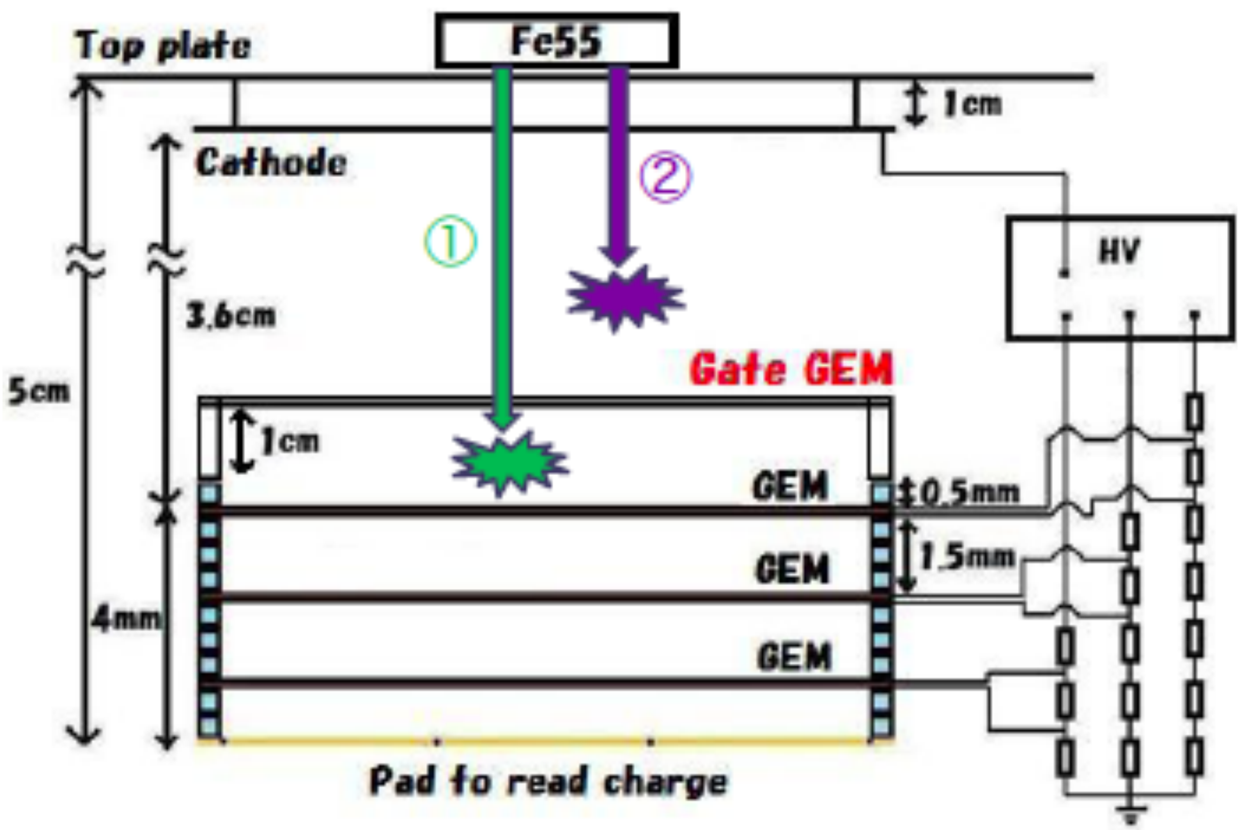
Transmission measurement

Data was taken at 2014 fall , at KEK cryo-center w/ 1T B field
…… finalizing data

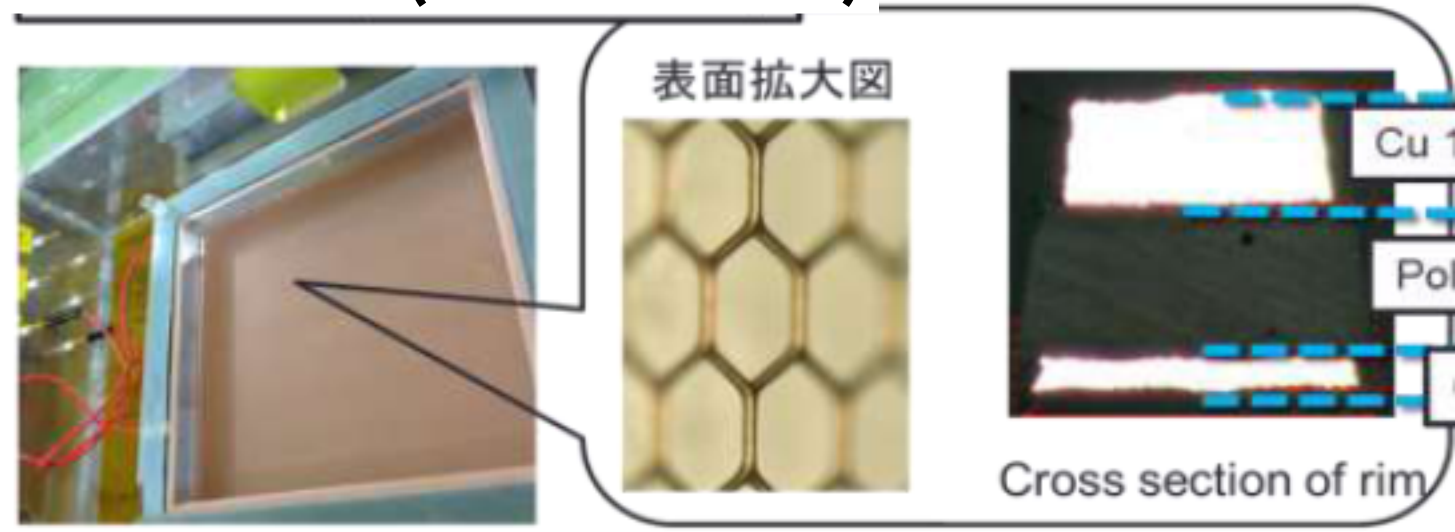
Simulation of electron transmission

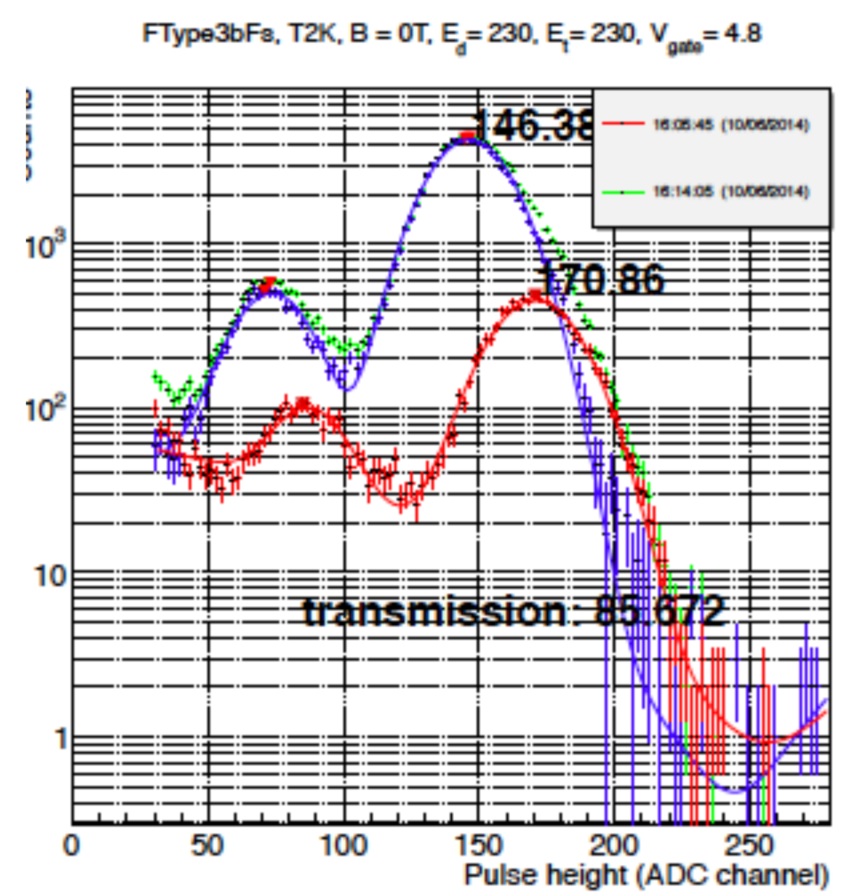
E field by ANSYS + Garfield++
we try to reproduce obtained data
in order to extrapolate performance at 3.5/4 T B field

Electron transmission measurement



Gate device(10cmx10cm)





When we measure Fe spectrum with poor Gate,
as spectrum(peak) is well separated,
so no difficulty to get transmission.

But good gate provide similar peaks overlapping each other,
how we differentiate two peaks
determine quality of transmission.

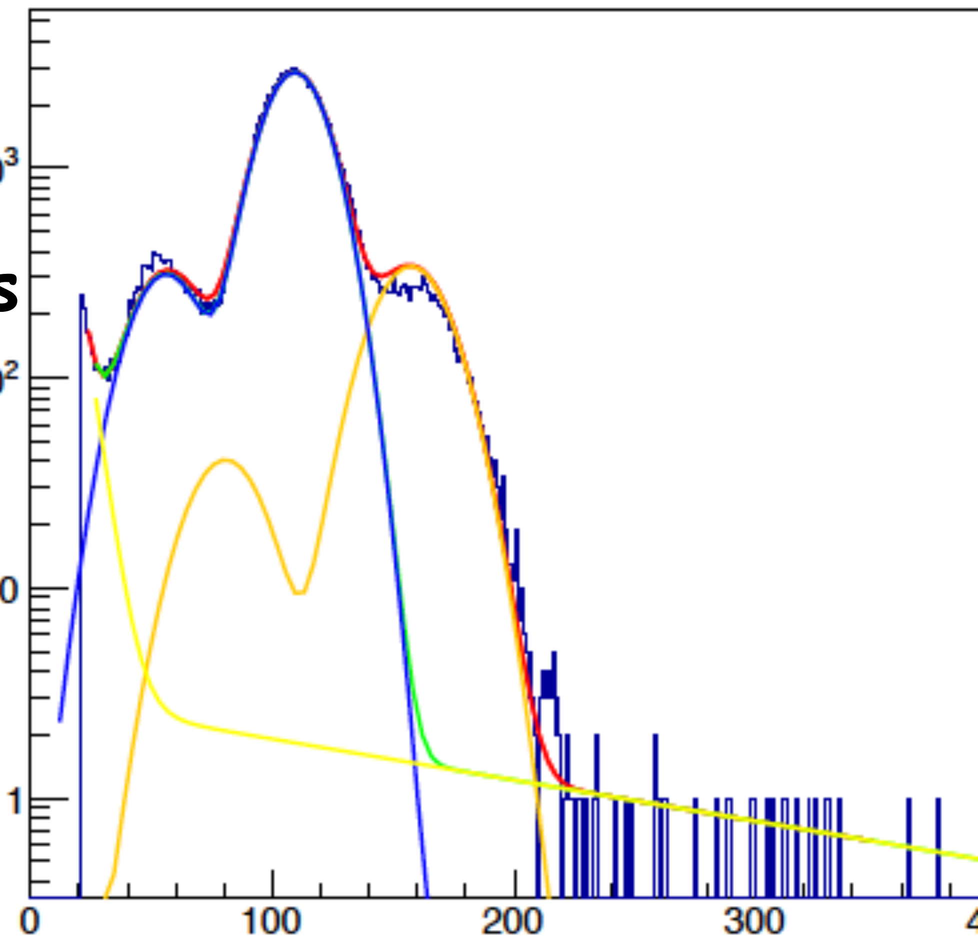
Transmission is obtained using two data sets
Edrift = 0
Edrift =230V/cm

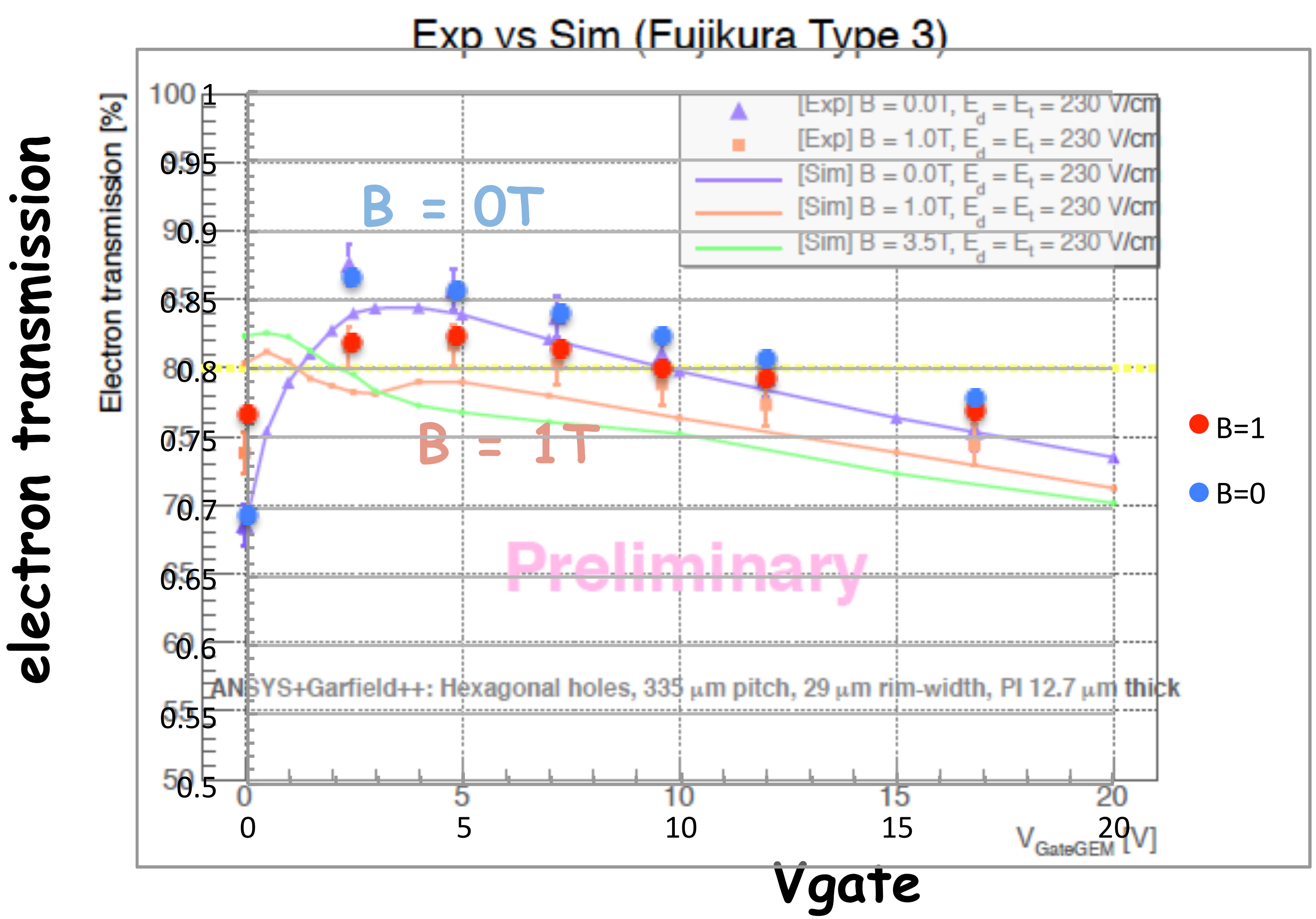
Difficulty :
gain shift
evaluation of systematic er

Electron transmission measurement

Simultaneous fit of single data using constraints can provide reasonable result

constraints:
#main to #escape ratio
Pmain to Pescape ratio
#drift to #trans. ratio
σmain to σescape ratio





Obtained results are consistent each other. we are trying to finalize data.

Do we understand well? by simulation

Simulation of transmission

Modeling @ANSYS

previous study assume straight hole though real Gate has taper holes

(ANSYS support simple geometry only)

improve the model by importing the real geometry

Cross-section of rim

Model1 : realistic model

Model2 : exaggerated model

No taper : previous model

hole pitch 335 um

hole size 304 um

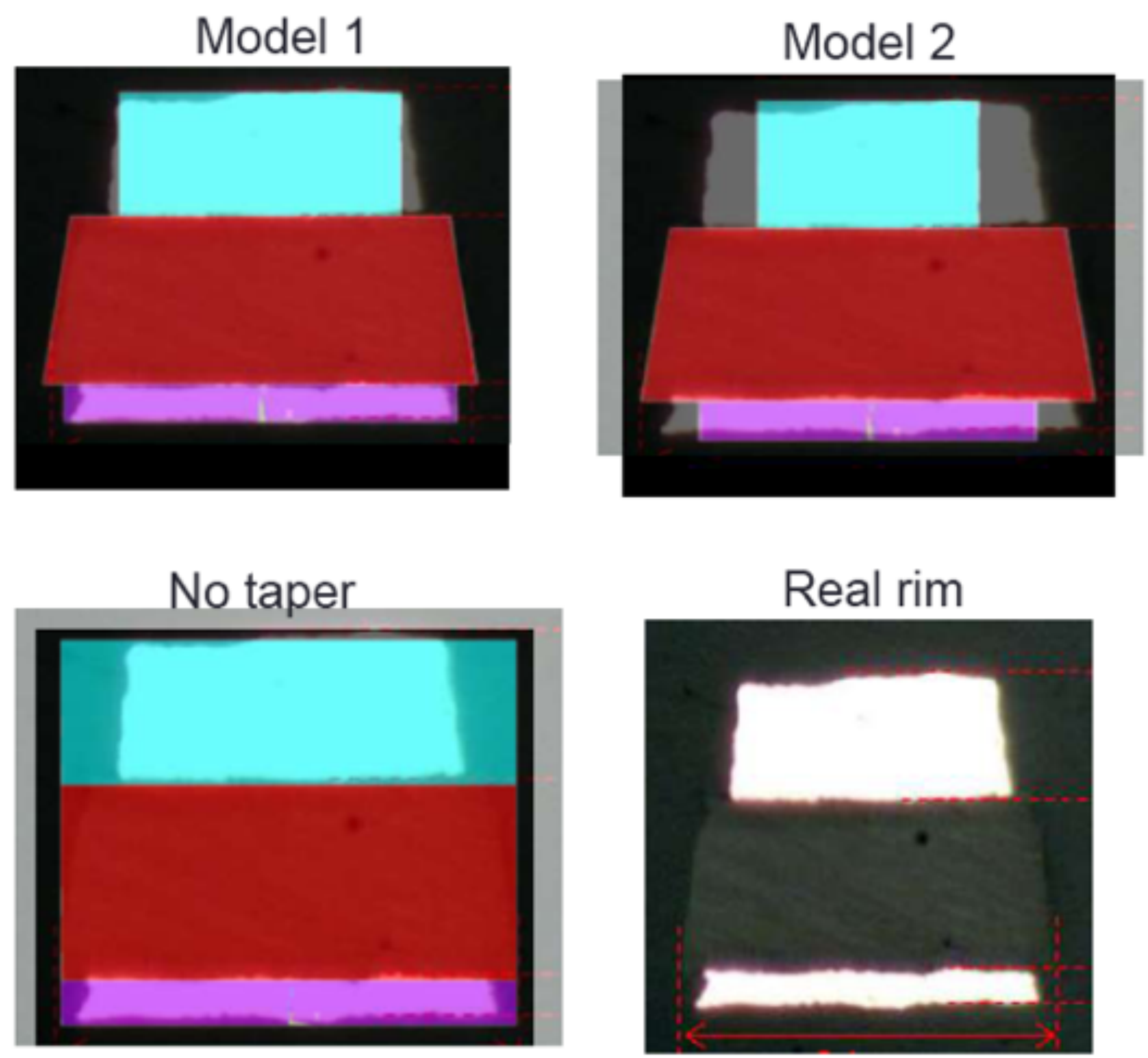
insulator thickness 12.5 um

applied drift field : 230 V/cm

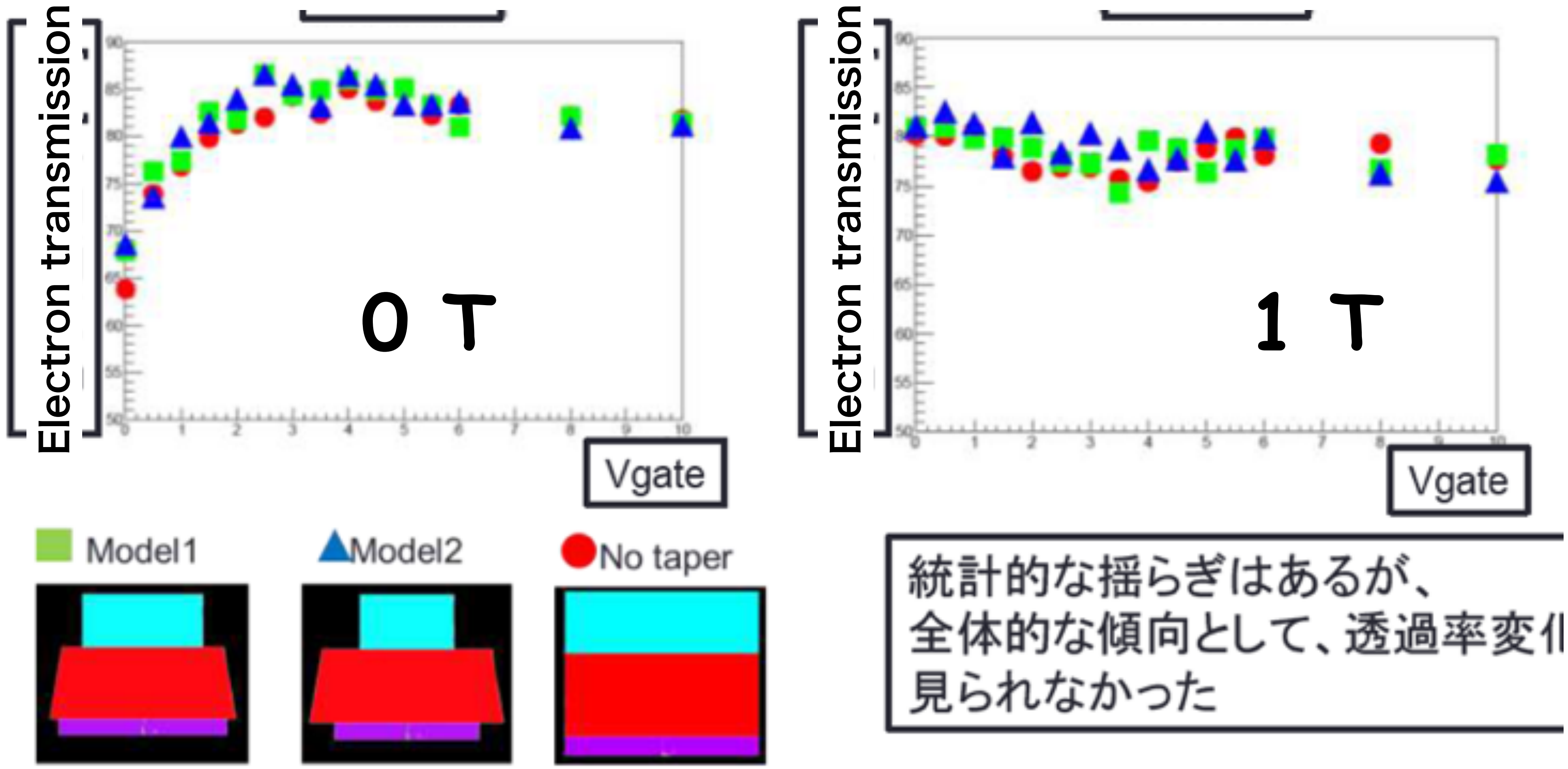
1mm above Gate

applied transfer field :230 V/cm

1mm below Gate



Simulation of transmission 2



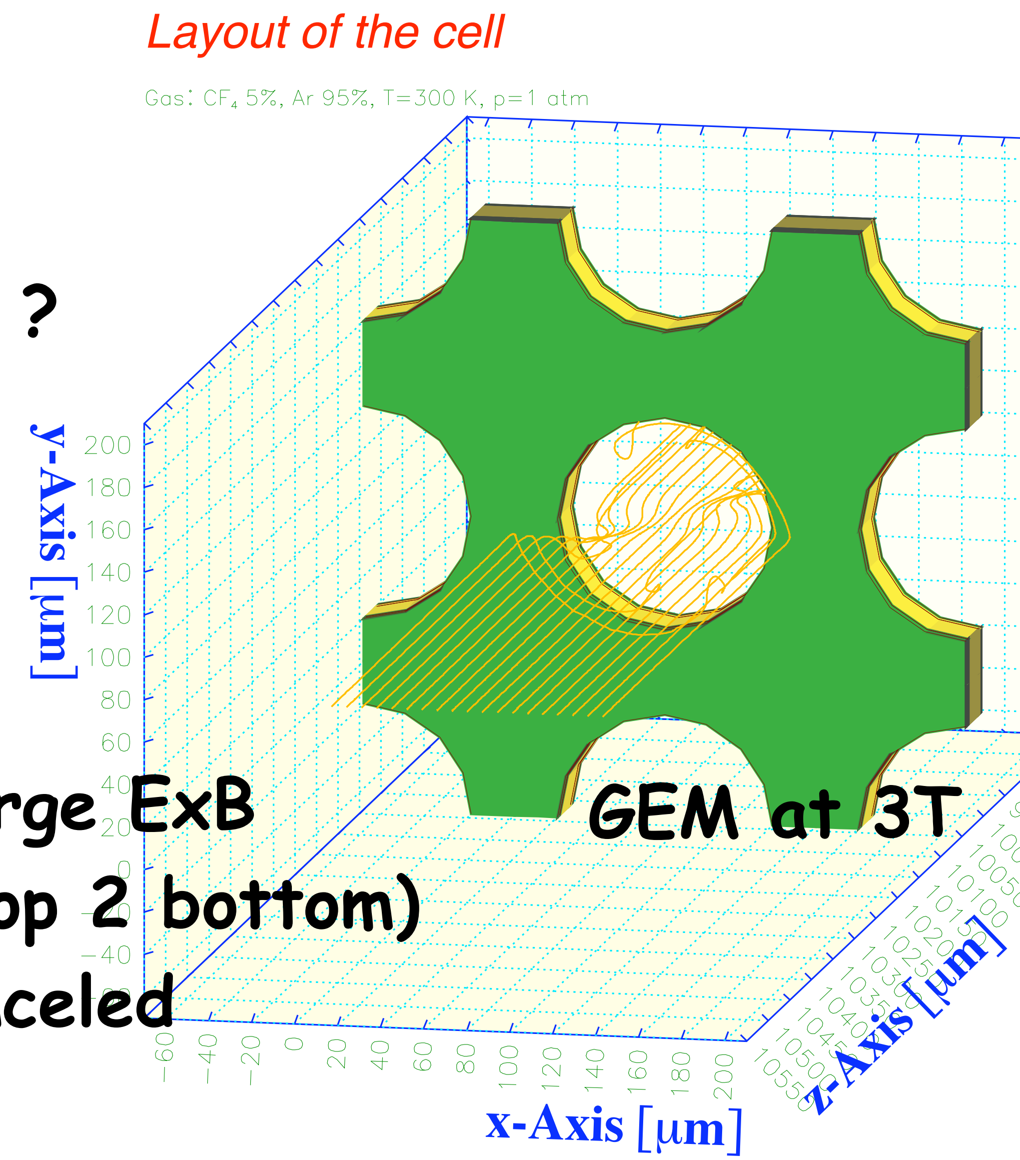
3 models behave similar within statistics (only 1000)

Modeling is not so important as far as geom. is included

We also consider the case drift/trans. field was not properly set
but 5% difference would not explain the behavior

Can we believe the behavior at 3T ?

Remaining (big) issue



Position information

Does Gate deteriorate position information ?

electron move around hole entrance

due to ExB effect

Symmetric structure of Gate

ExB effect would be canceled out

Low voltage operation would not make large ExB

But real Gate is not symmetric geometry(top 2 bottom)

there is no guarantee for ExB to be canceled

Beamtest may answer this question

Ion

Measurement of ion back-flow rate with Gate

We assume sim. is correct for ion behavior but need to check……

@ 3~4 T

together with electron transmission/resolution

Gate for other modules

GEM + Gate would be tested by this beam test

Gate must be rather easily accommodated with DESY module
technical practice is necessary for Gate production/assembly

How we integrate Gate on Micromegas module
supporting structure
HV supply

Gate for Timepix must be easier for the current module
as many space is left on the module
and be able to observe Gate behavior in 1 electron level

Japanese group will support Gate production for all group
in order to make company active
we submit budget requests for this
at lease KEK budget will be accepted

Summary

The gate for the current module seems to be
working somehow (next talks)
Some more studies in detail behavior
are necessary

Production/use of more Gate
will help to improve tech. experience
to show reliability of Gate