Recent studies of LCTPC-Asia group

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on behalf of LCTPC-Asia group

LCWS14, Oct. 6-10 @ Belgrade

outline

- towards a gating device for TPC @ ILC
  - primary & secondary positive ions
  - prototypes of GEM gate & wire gate
  - experiments using Fe55 & laser
  - results & simulation
- better understanding of distortion
- test of GEM discharge & gain stability
- summary & plan

space charge in a TPC @ ILC

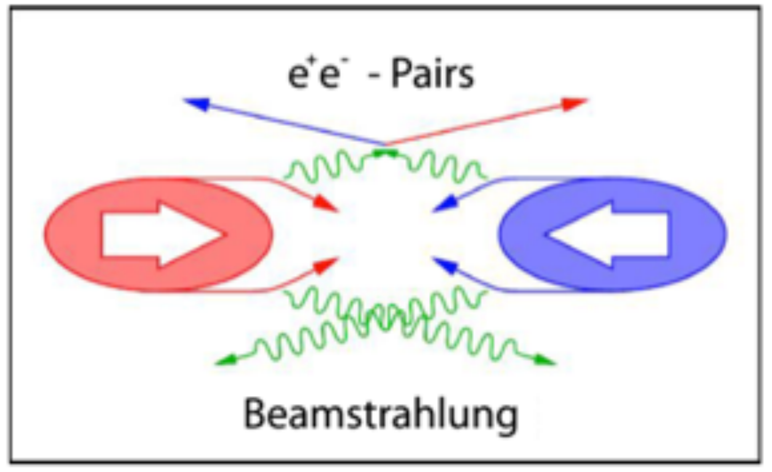
- primary ions

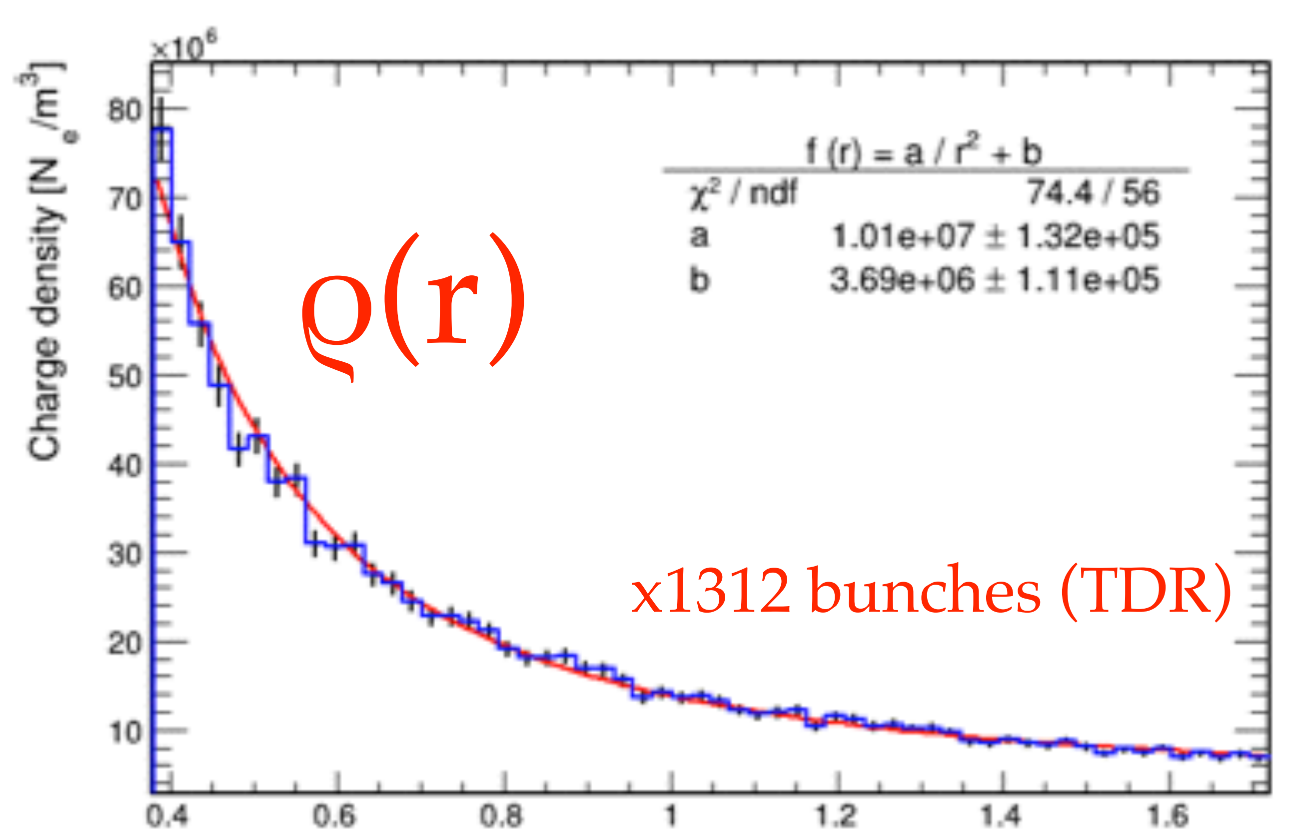
  from primary track ionization

- secondary ions

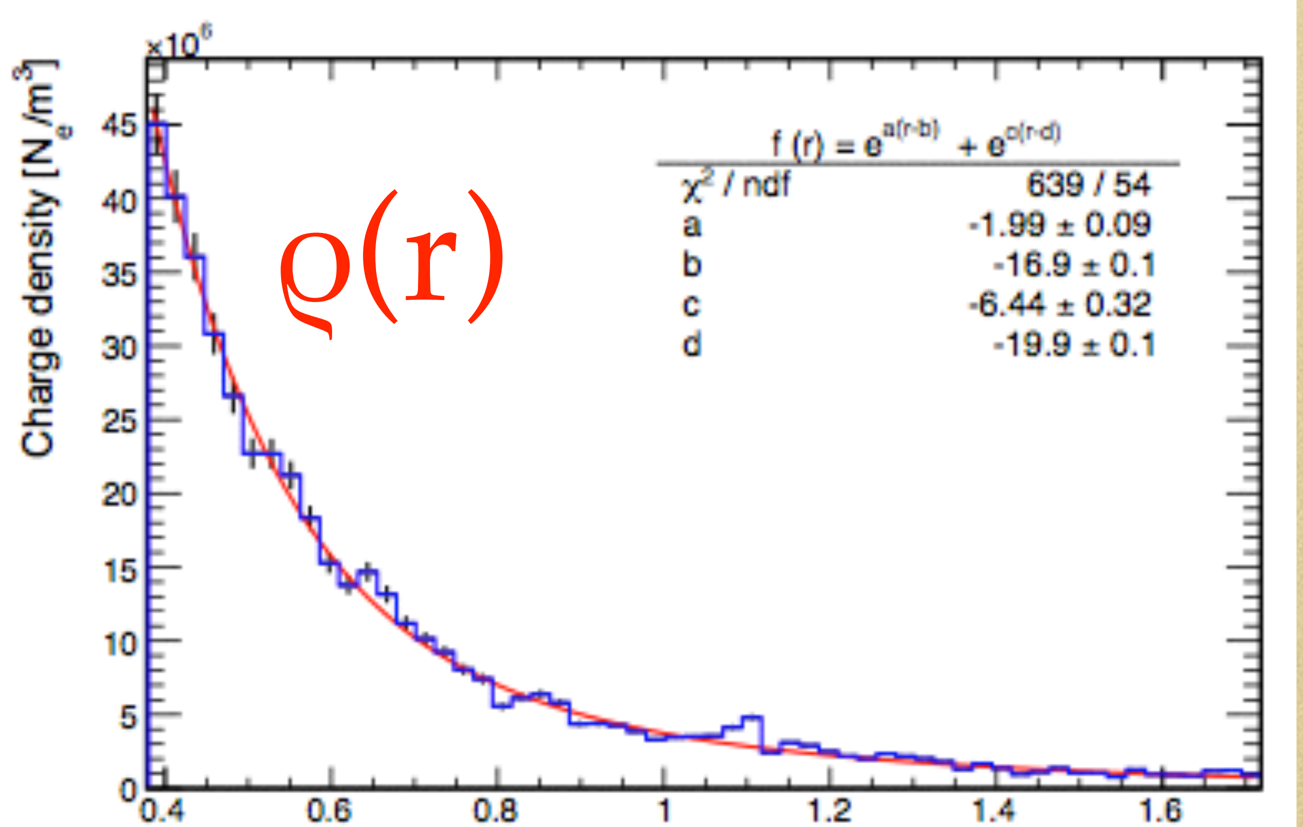
  from MPGD feedback

beam induced background





(pair background)



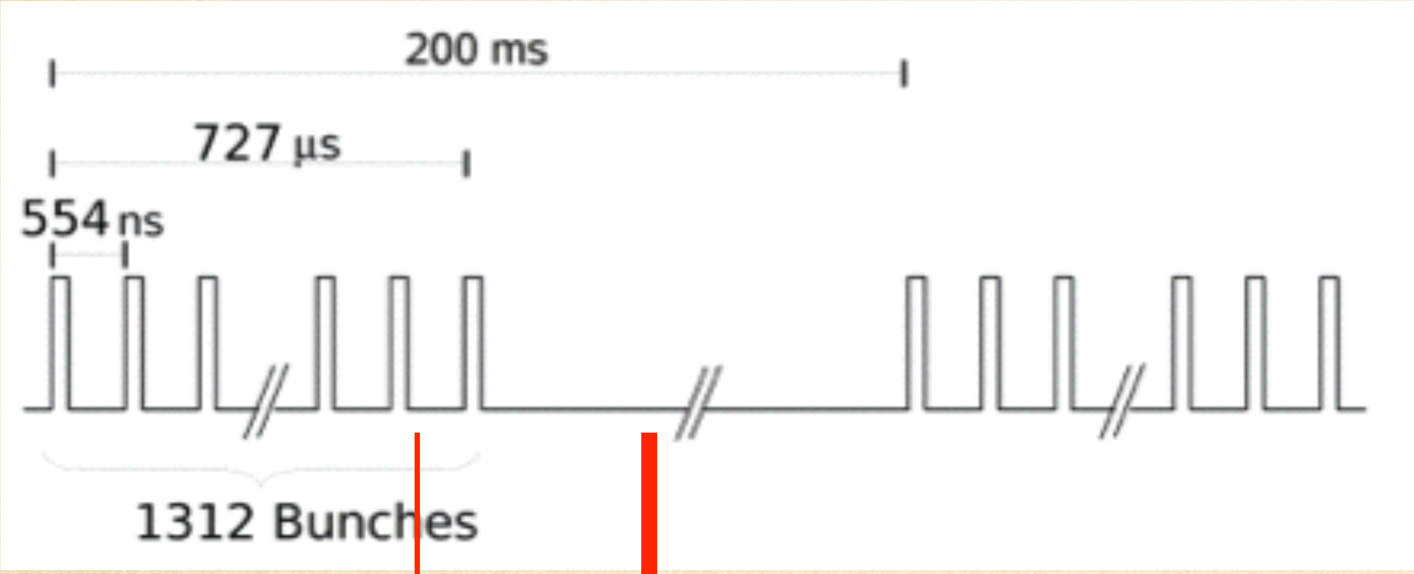
(γγ—>hadrons)

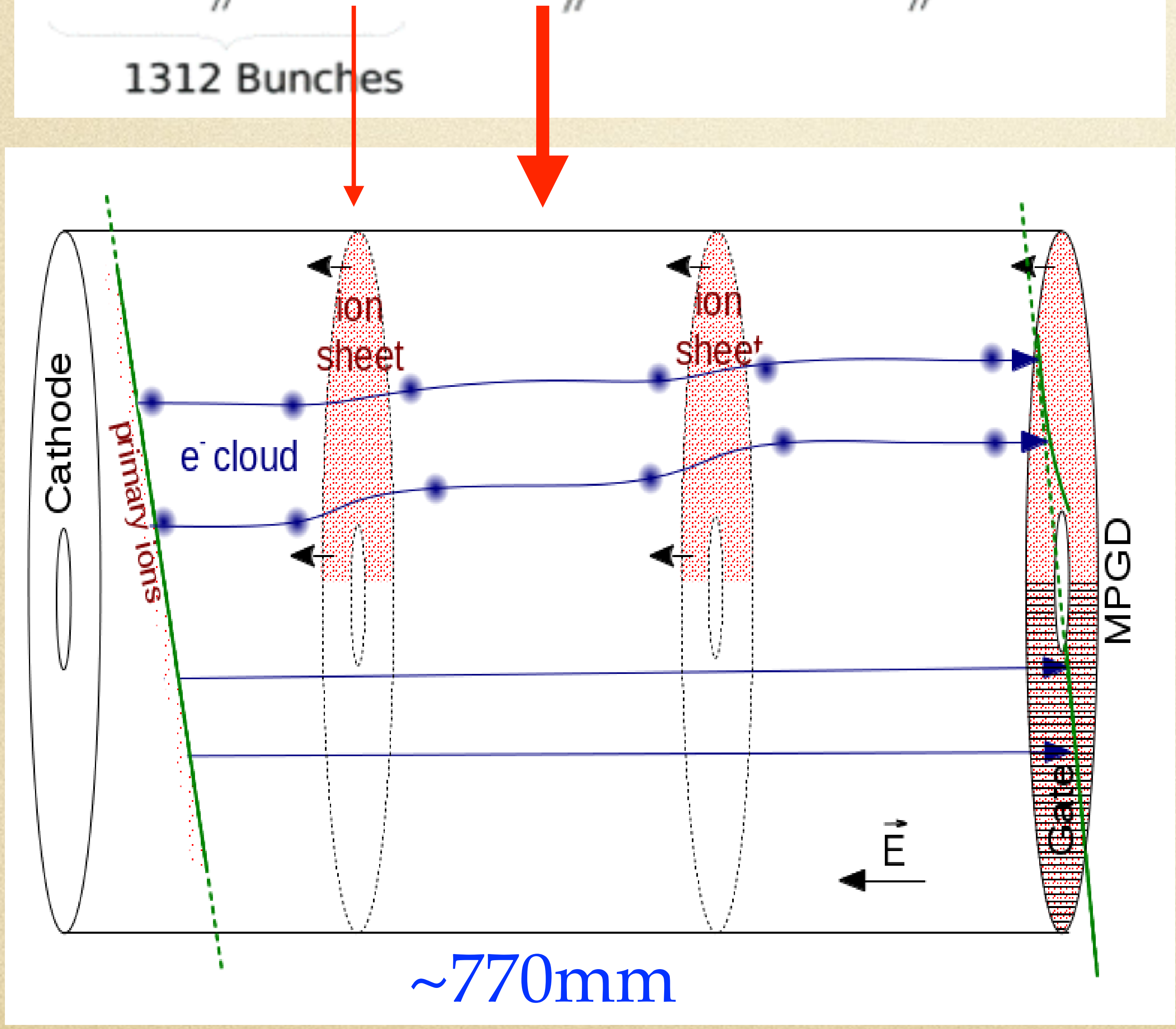
T. Krautscheid, LCTPC Collaboration Meeting, June 2013

D. Arai, LCTPC workpackage meeting #145

space charge in a TPC @ ILC

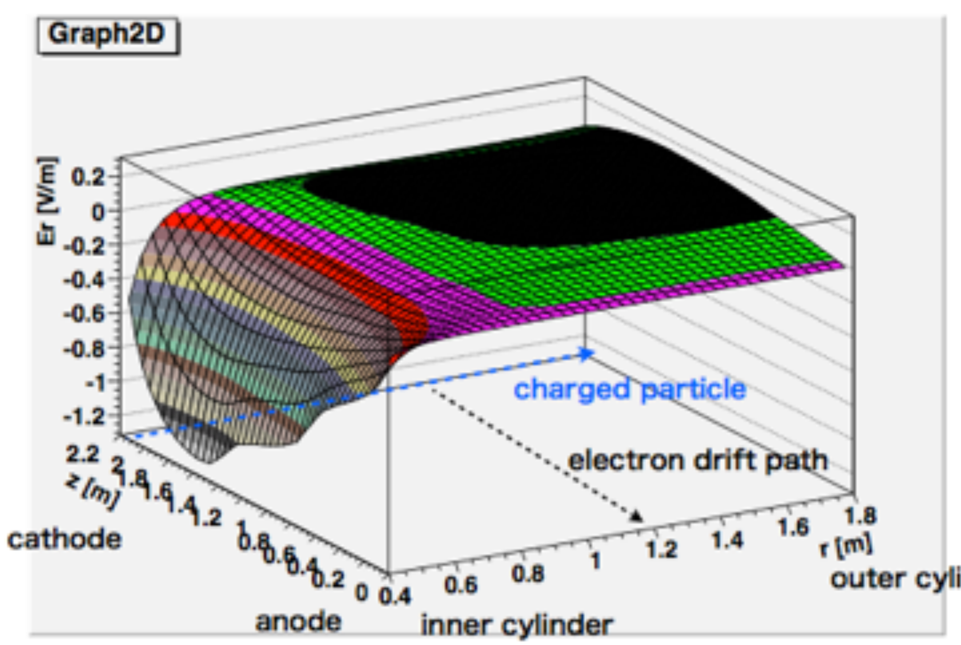
ILC beam bunch structure



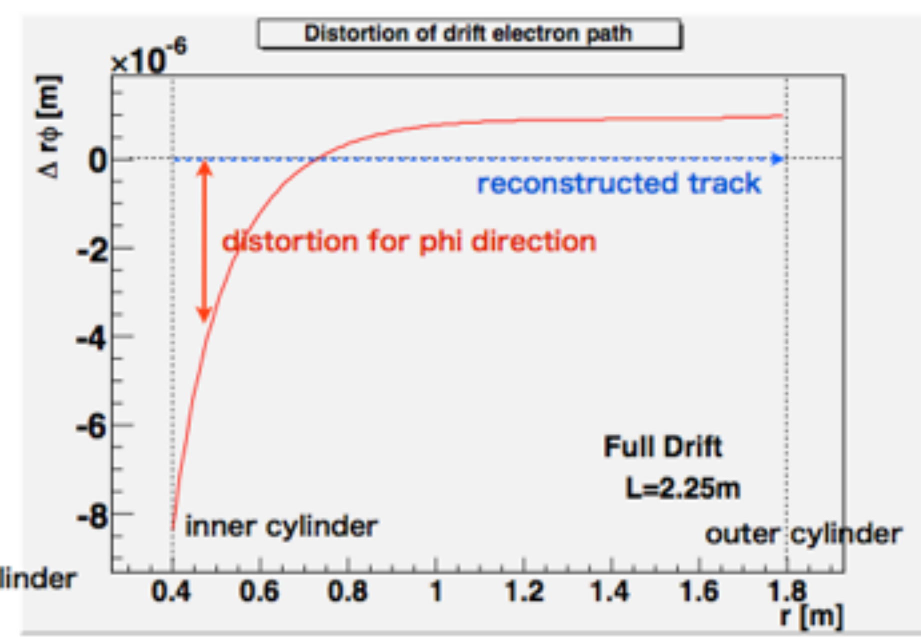


- one ion sheet is formed after one bunch train (thickness ~4mm)
- charge density depends on ion feed back ratio
- 3 discs co-exist in drift area and distorted the path of seed electrons

distortion due to positive ions



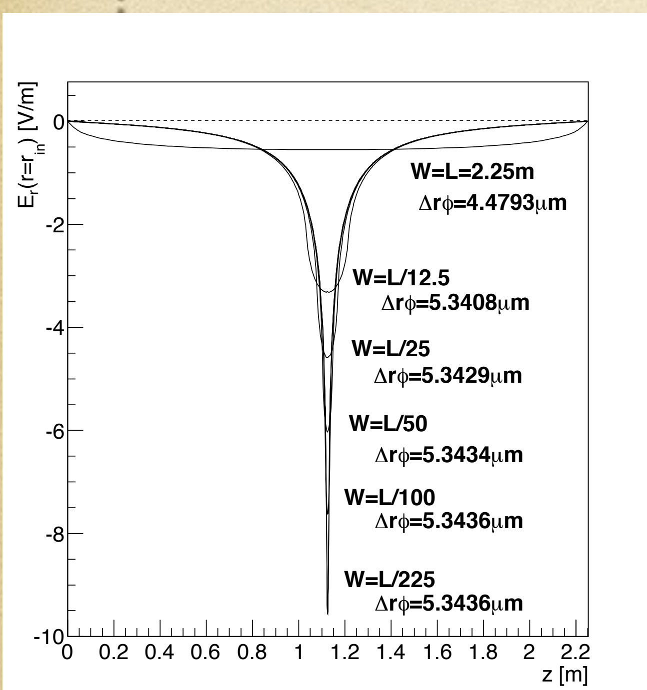
Efield map

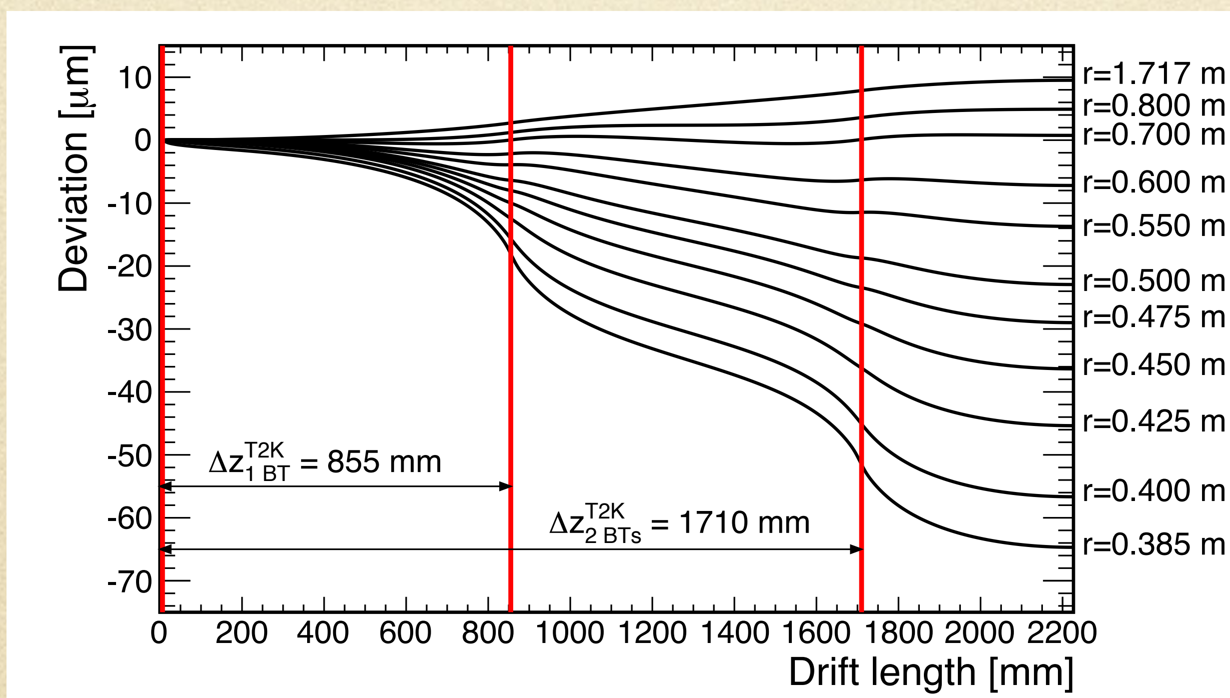


Distortion of drift electron path (Full drift)

- primary ions

  max (inner TPC) ~ 8.5 μm





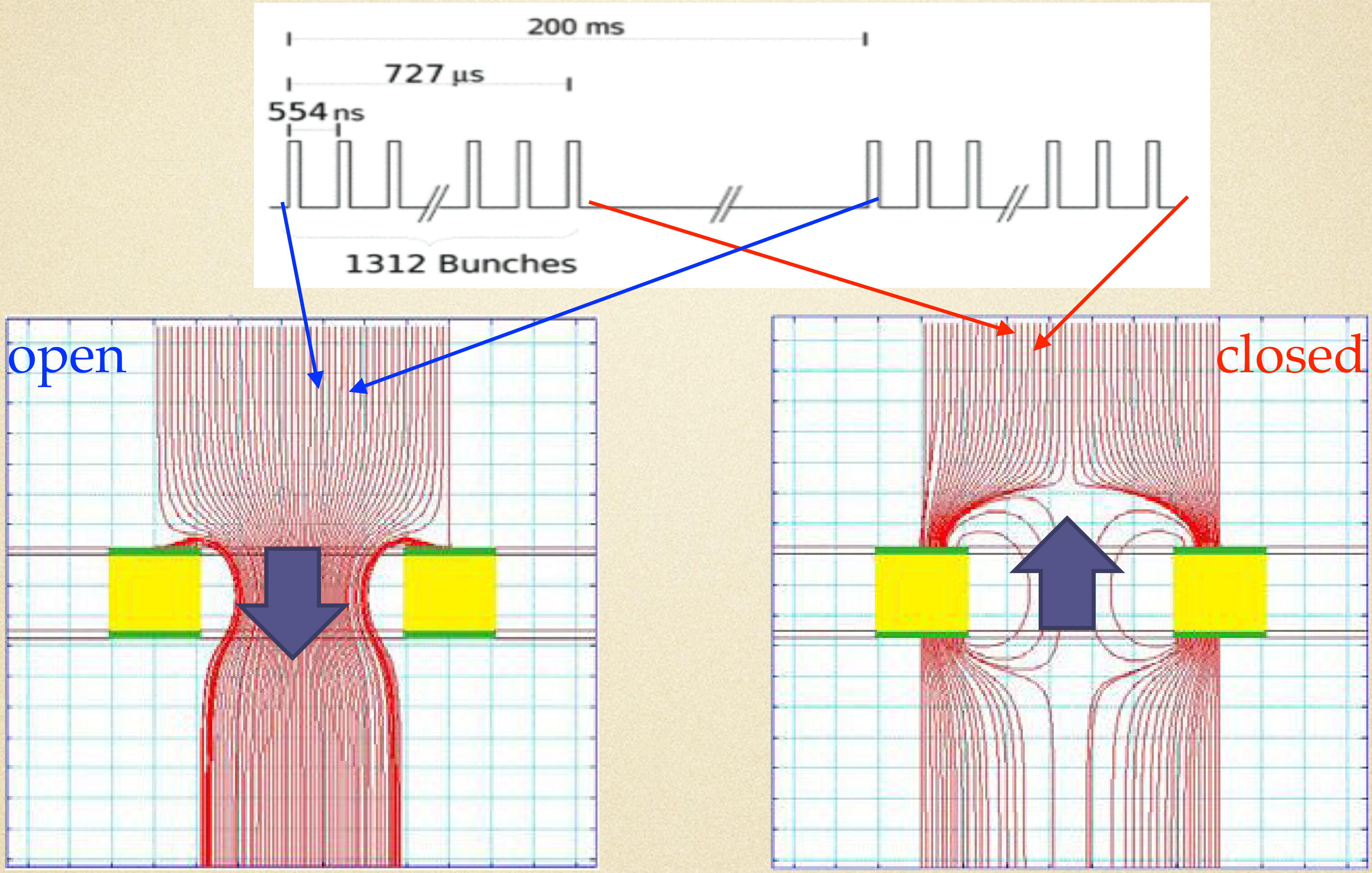
- secondary ions

  max ~ 60 μm (pair BG)

  max ~ 30 μm (γγ—>hadrons)

point resolution ~ 100 μm —> we need a gate to suppress back flow of 2nd ions

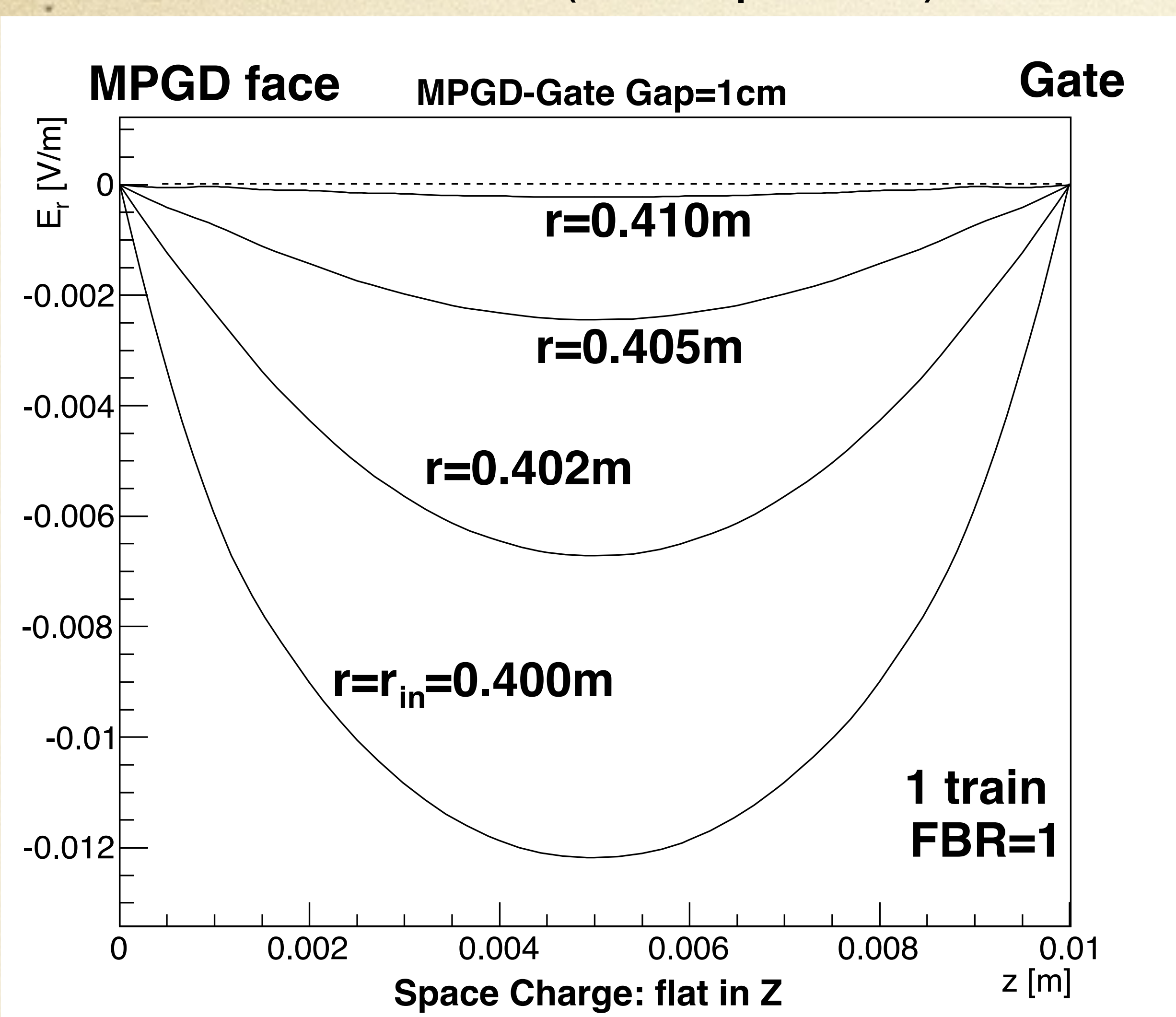
gating devices to suppress secondary ion feedback



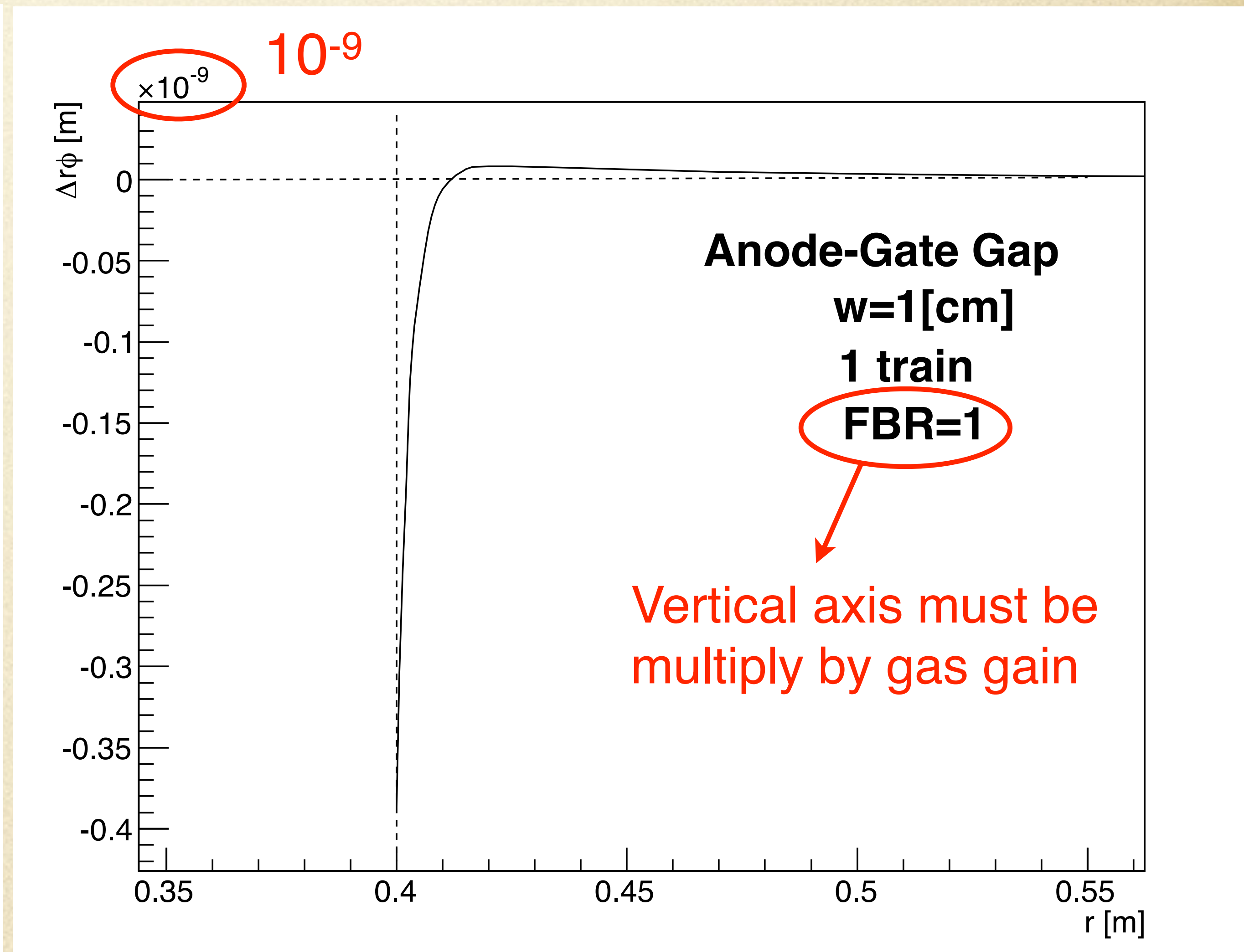
- open gate during one train, ~ 1cm above MPGD; gate potentials are set correspondingly to keep electric field line
- close gate between two trains, just flip the voltage on gate, positive ions are mostly sucked into electrodes
- 1312 bunches in one train, there still will be positive ions between gate-MPGD

between bunches in one train: ions in the gate-MPGD gap

E-field distortion (r-component)



Distortion (rphi)



For FBR = 1000, the maximum distortion is less than 1um, completely negligible if the distance from the inner cylinder becomes > 2cm!

K.Fujii, LCTPC collaboration meeting 2012

two types of gating devices

conventional wire gate (an option)

- need be operated at HV, provided that wires are only ~mm apart and very close to MPGD
- large mechanical and electrical complication, not very feasible
- field distortion, ExB effect

GEM gate (originally by F. Sauli, 2006)

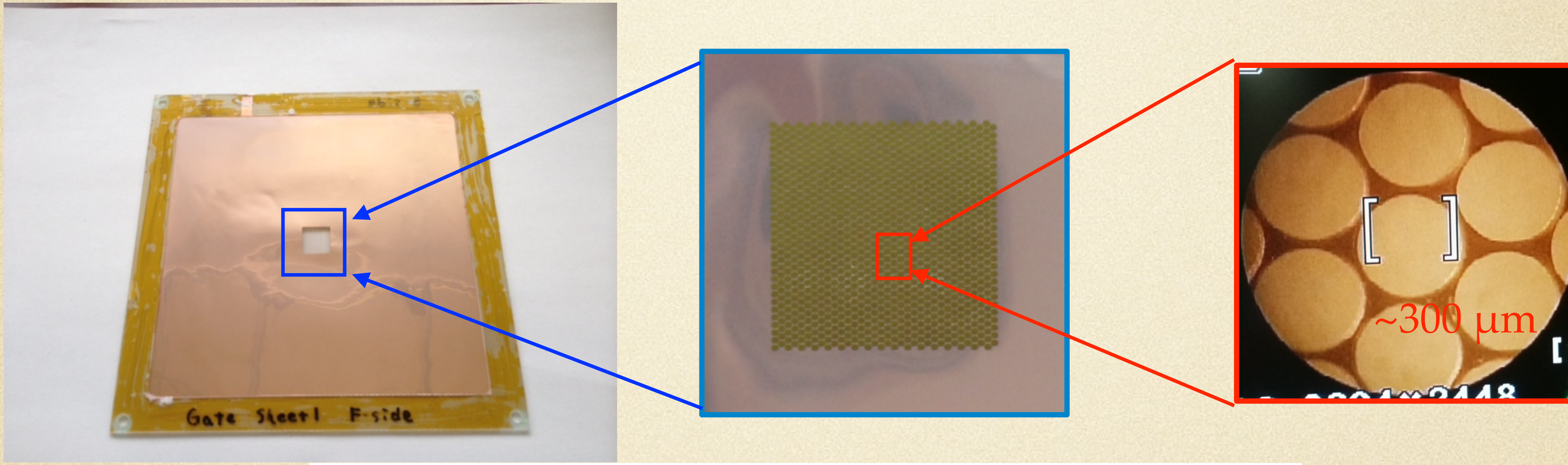
- operated at low voltage, easy to open and close gate
- much more robust, can be conveniently integrated with MPGD
- requirements: large aperture to achieve high electron transmission efficiency, under high B field

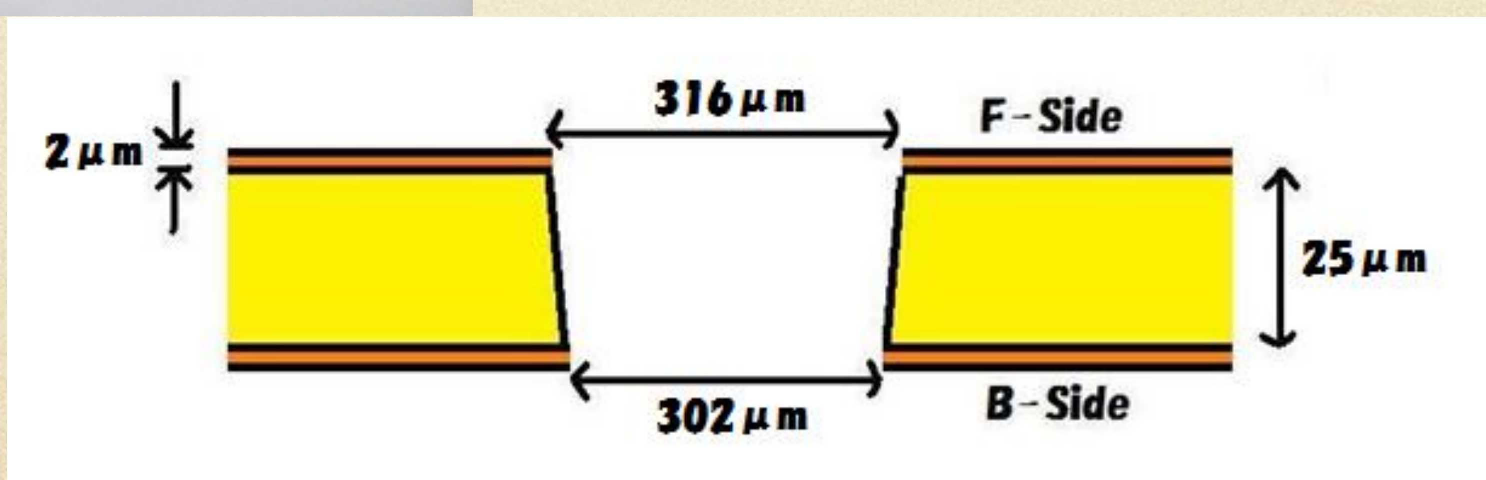
prototypes of both types have been produced and tested

prototype of GEM gate

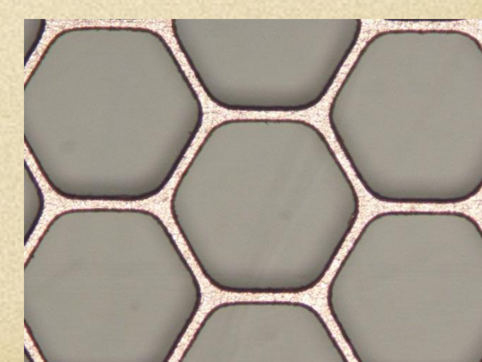
by Fujikura

- type 0 (1cm x 1cm): aperture ~75%, results in this talk

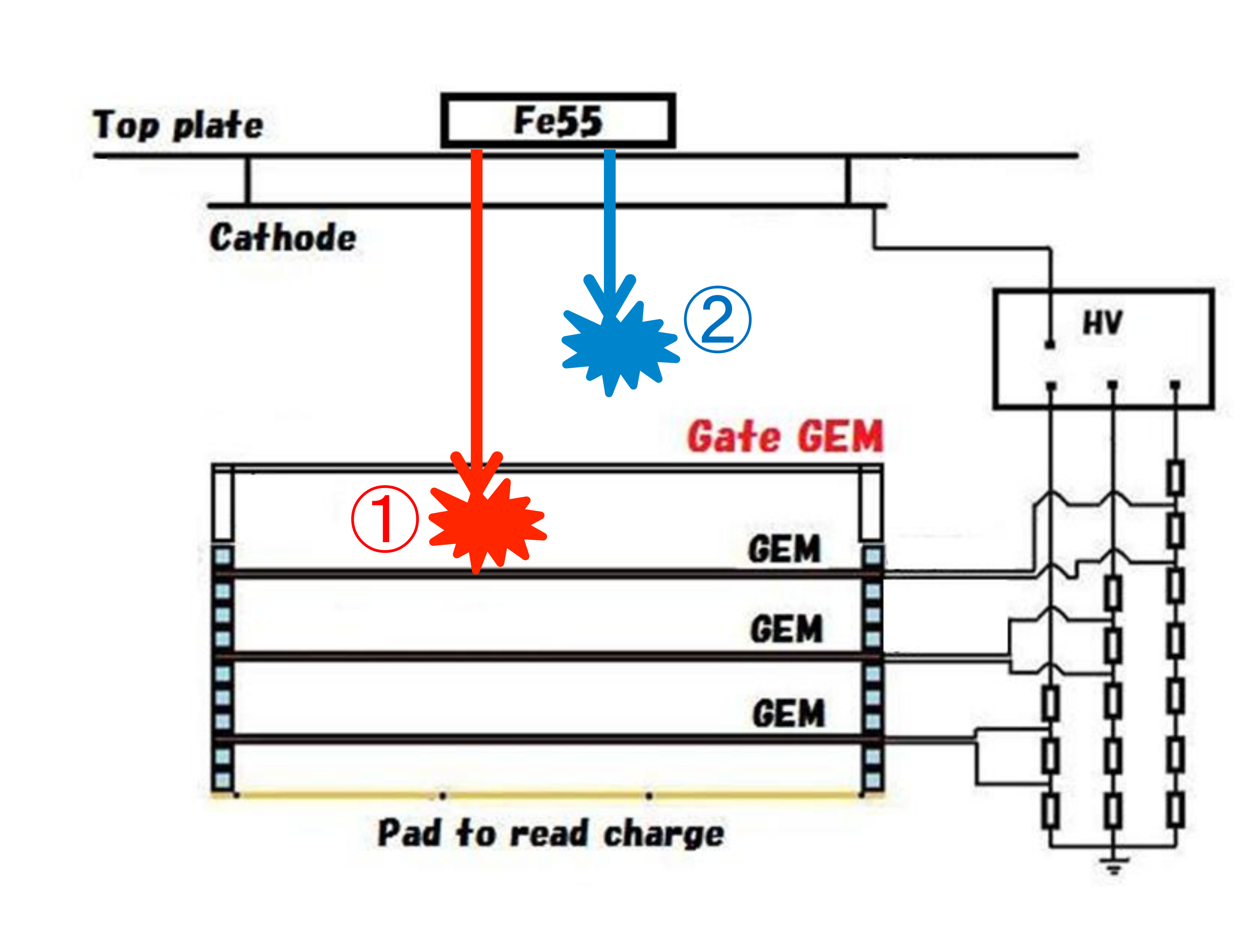


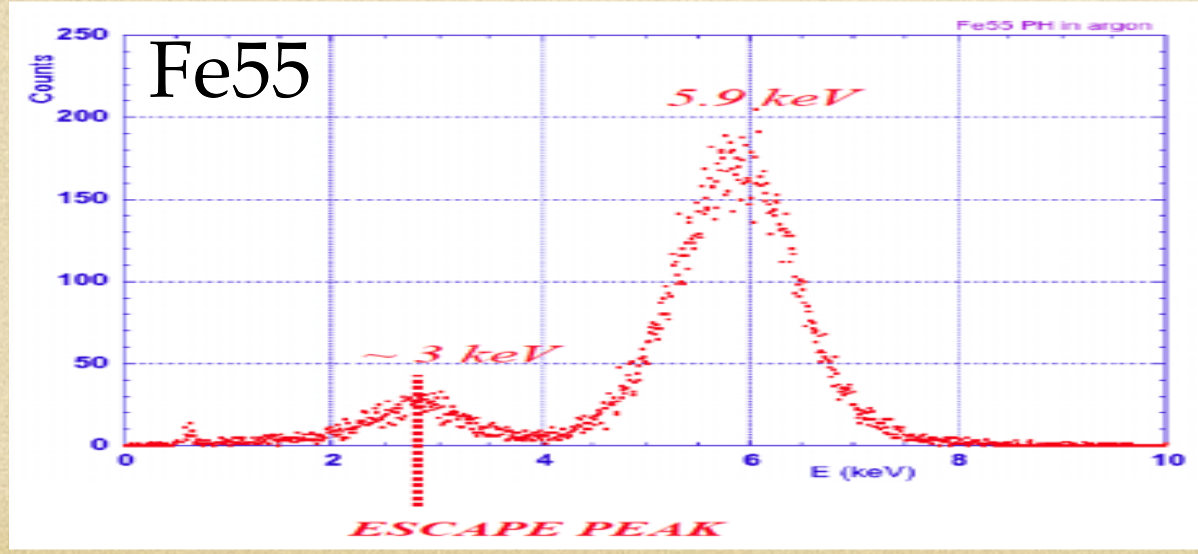


- new types with aperture ~85%, 10cm x 10cm ongoing



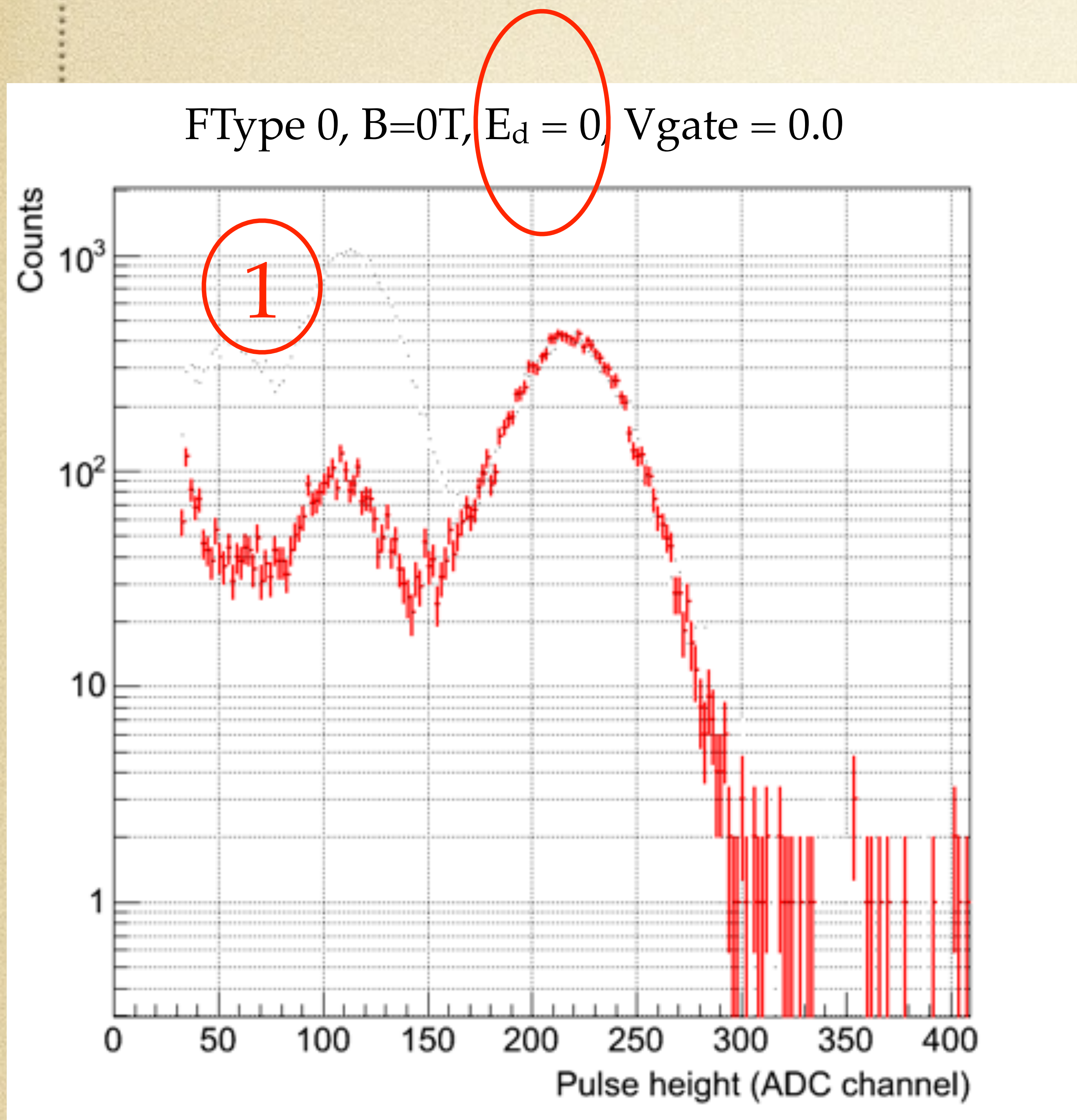
transmission efficiency measurement using Fe55

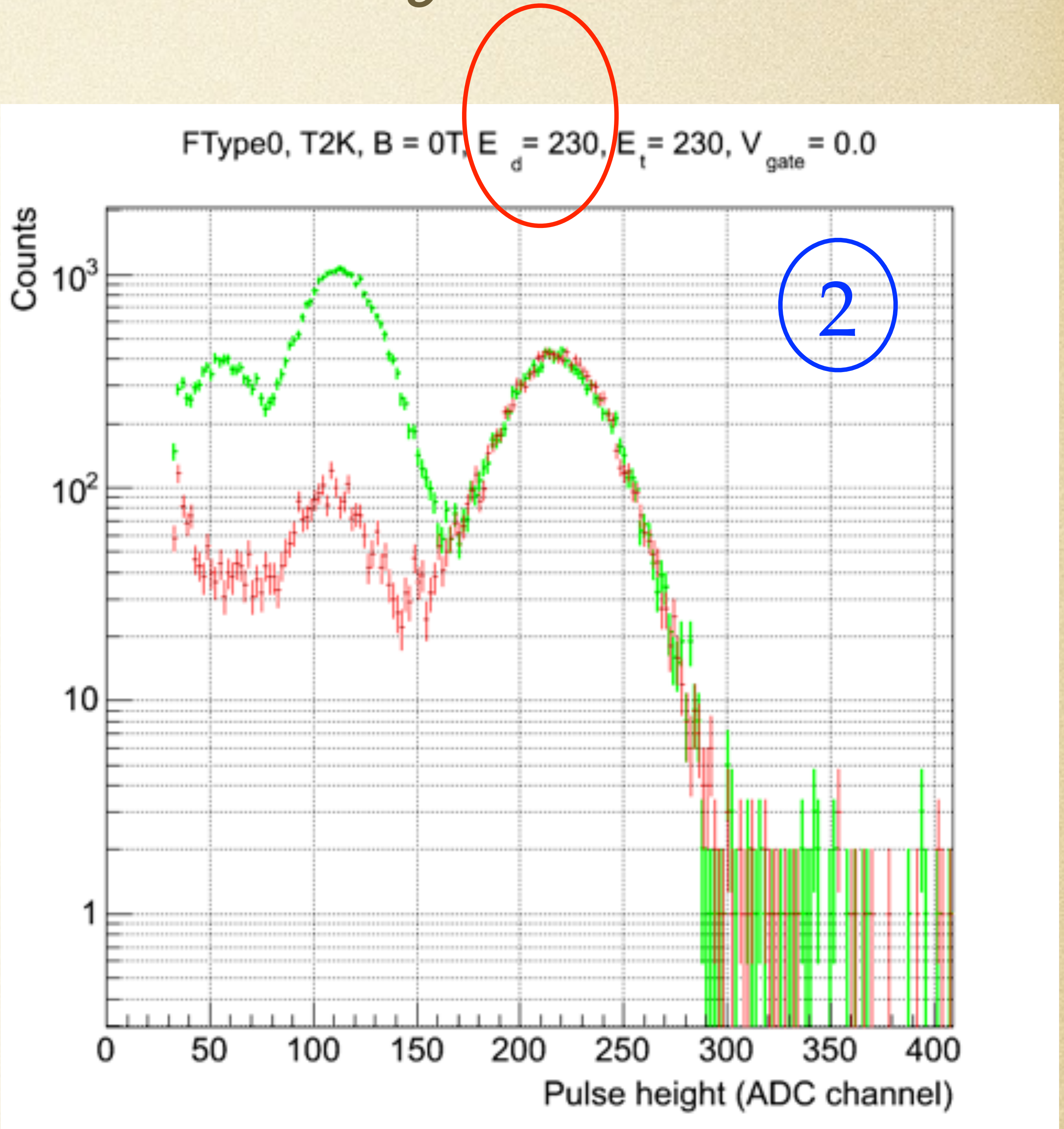




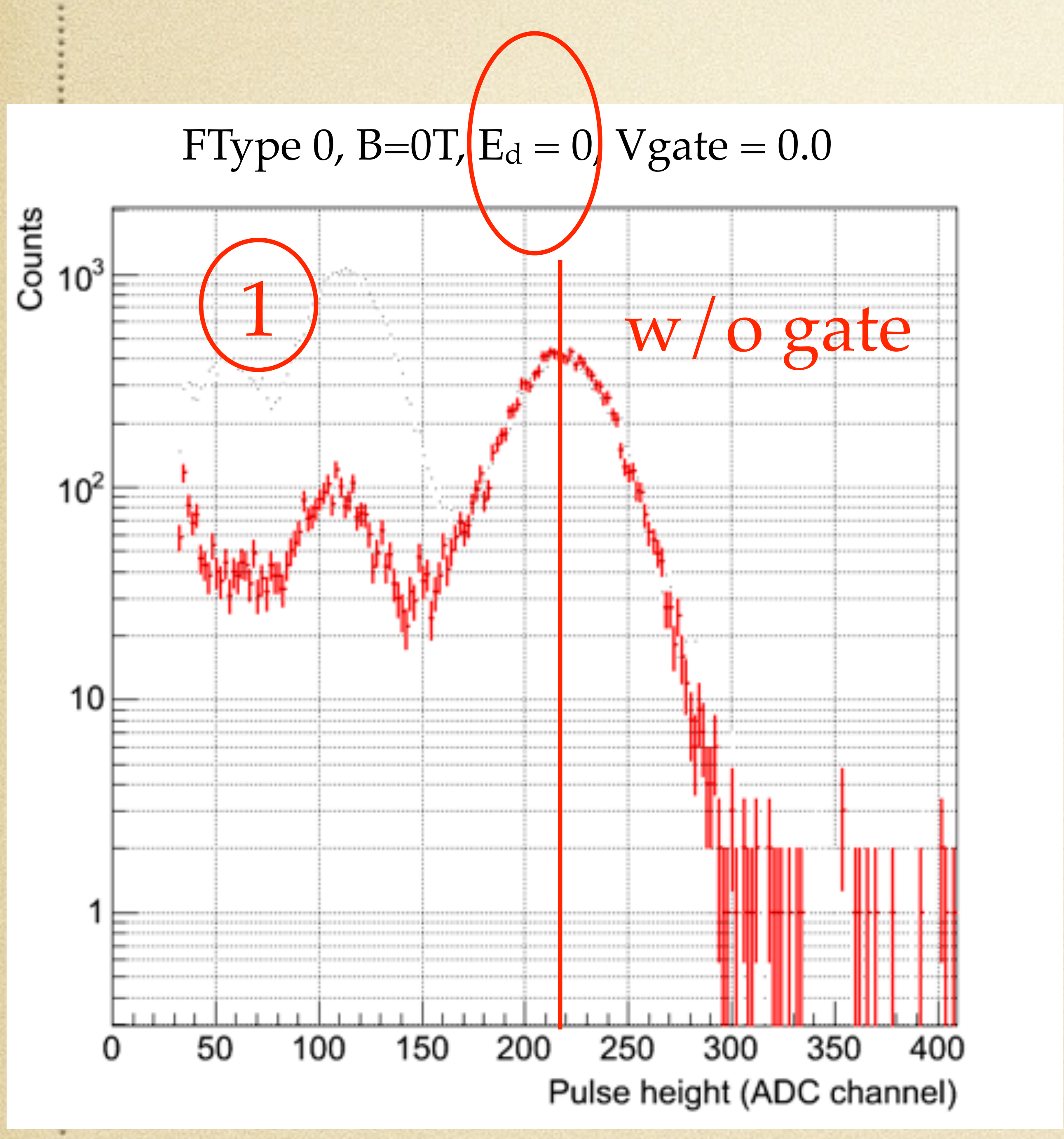
- basic idea: measure the charge without (1) and with gate (2), ratio is transmission efficiency
- first to measure the charge without gate, we switched off drift field —> only electron from convention at (1) can reach amplification GEM and be collected
- then drift field is switched on —> electron at both (1) and (2) can be collected —> subtract charge at (1) using data at previous step —> get the charge from (2)

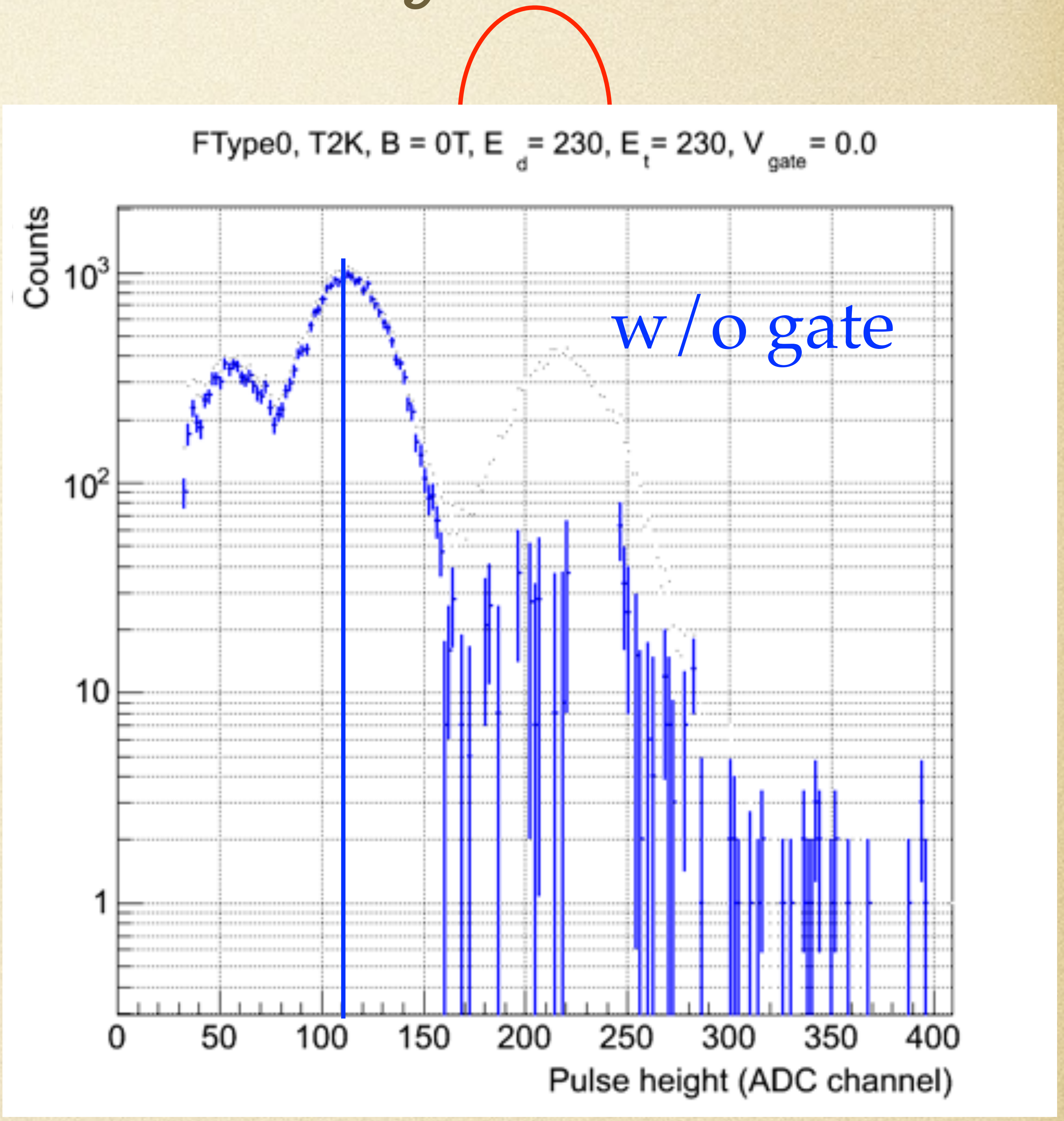
measure transmission efficiency with Fe55



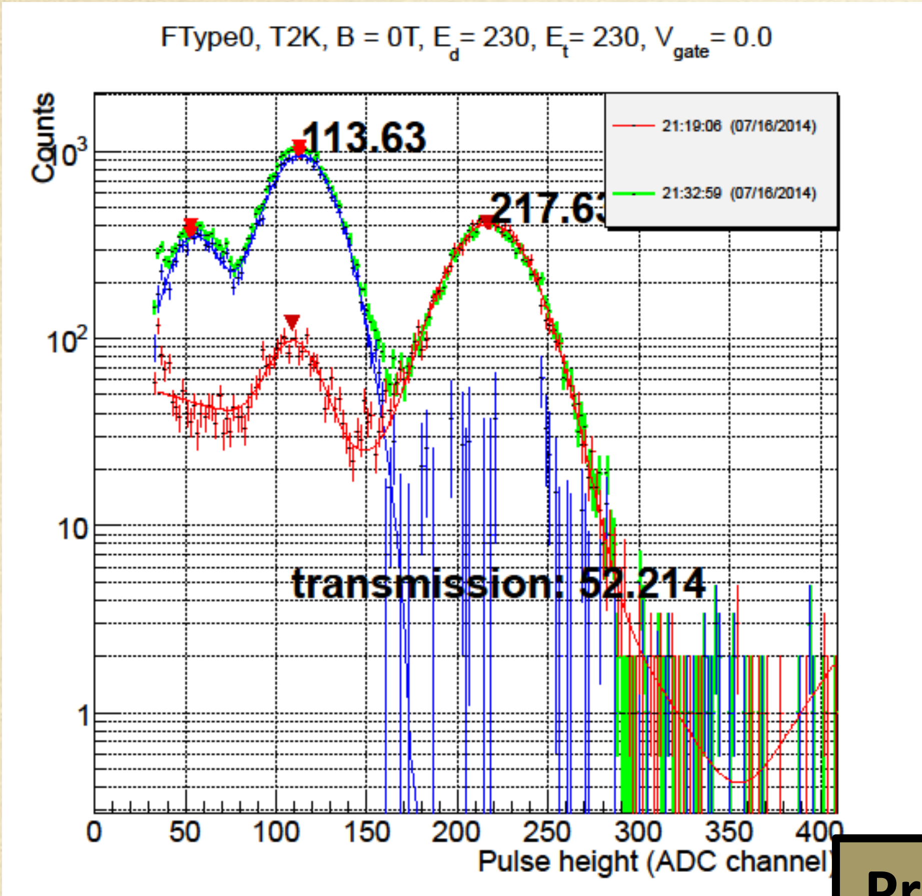


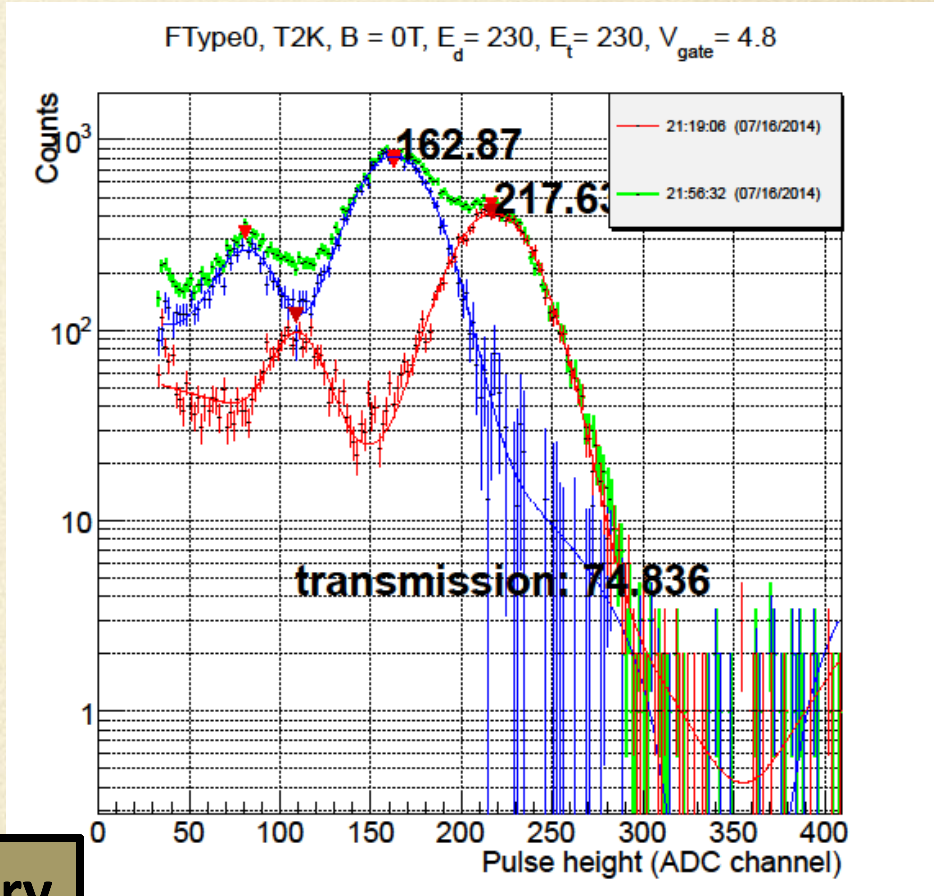
measure transmission efficiency with Fe55



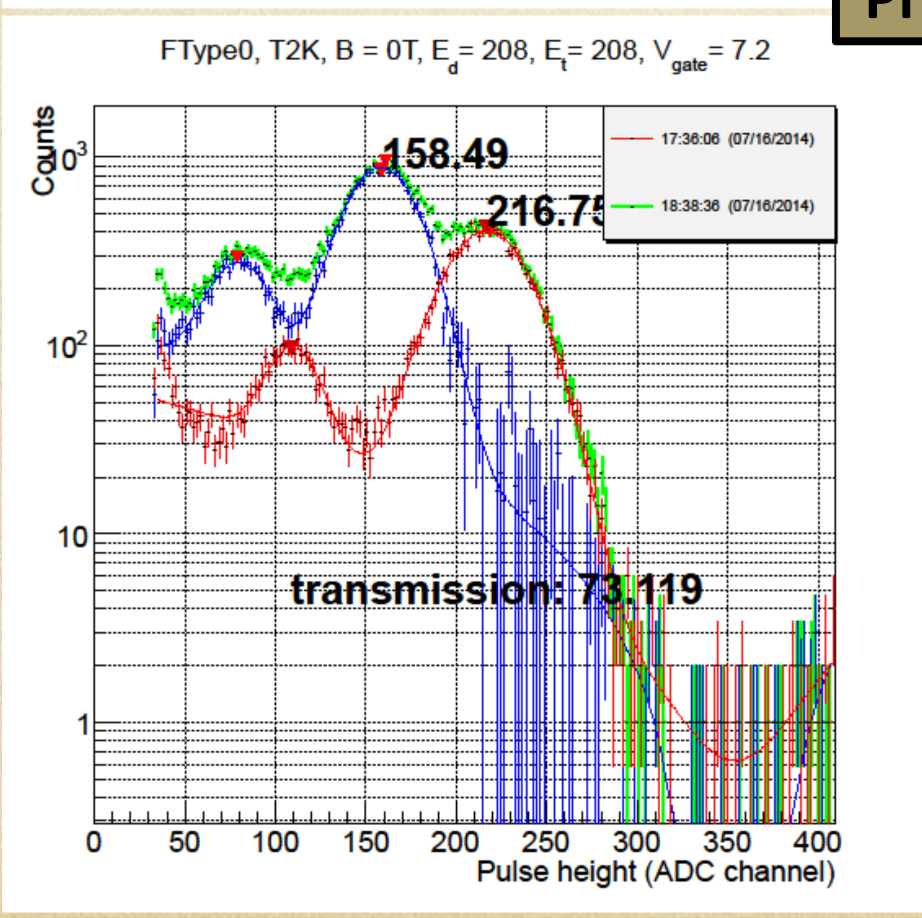


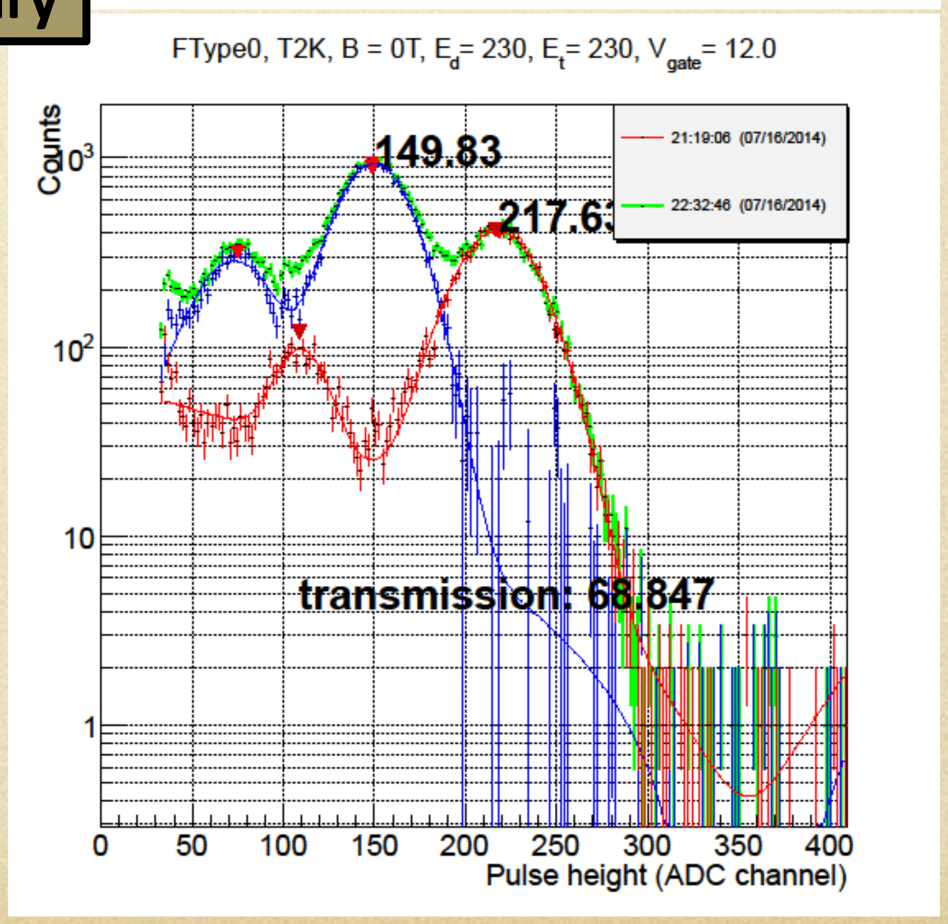
transmission efficiency versus voltage on gate (B=0T)



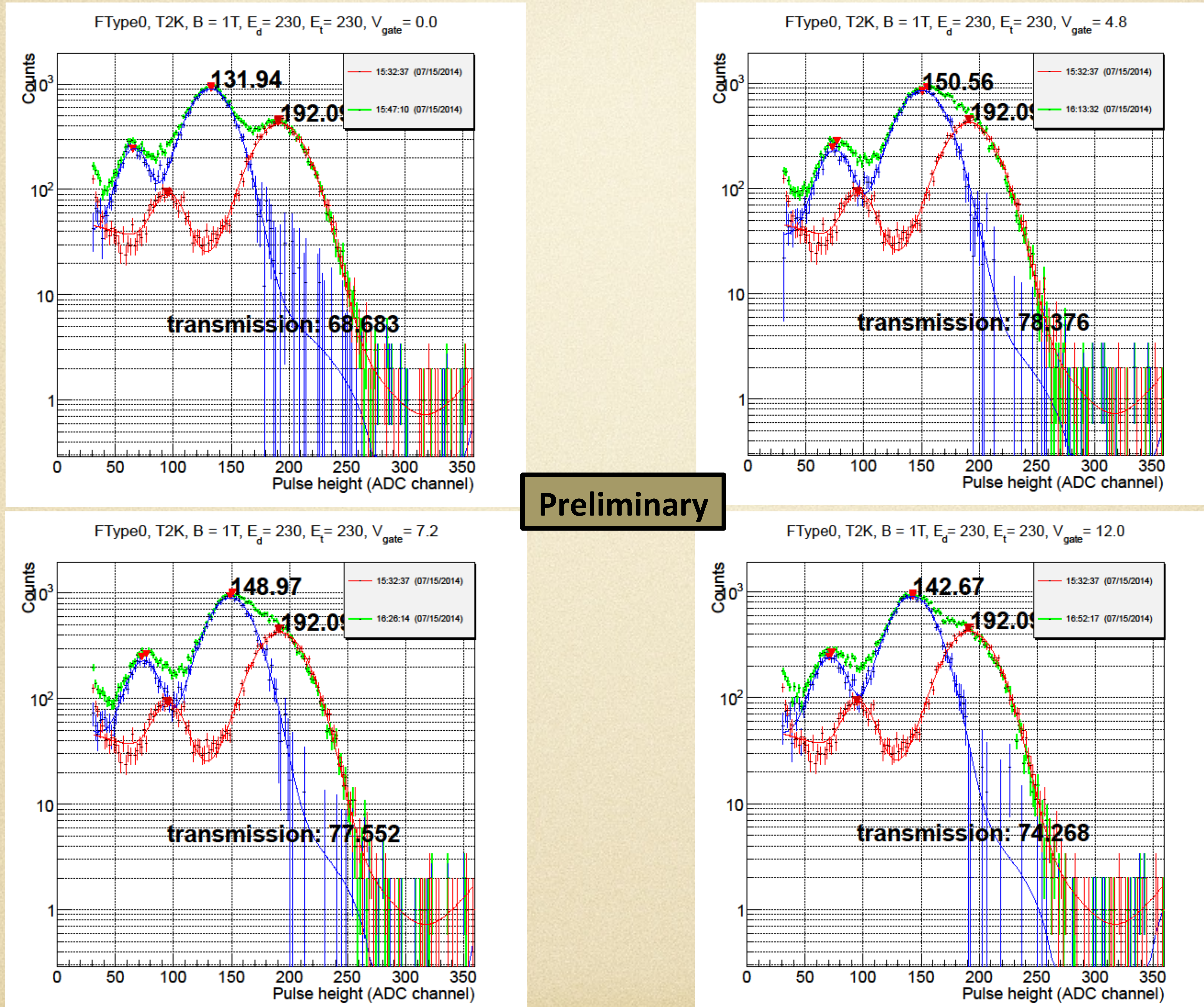


Preliminary

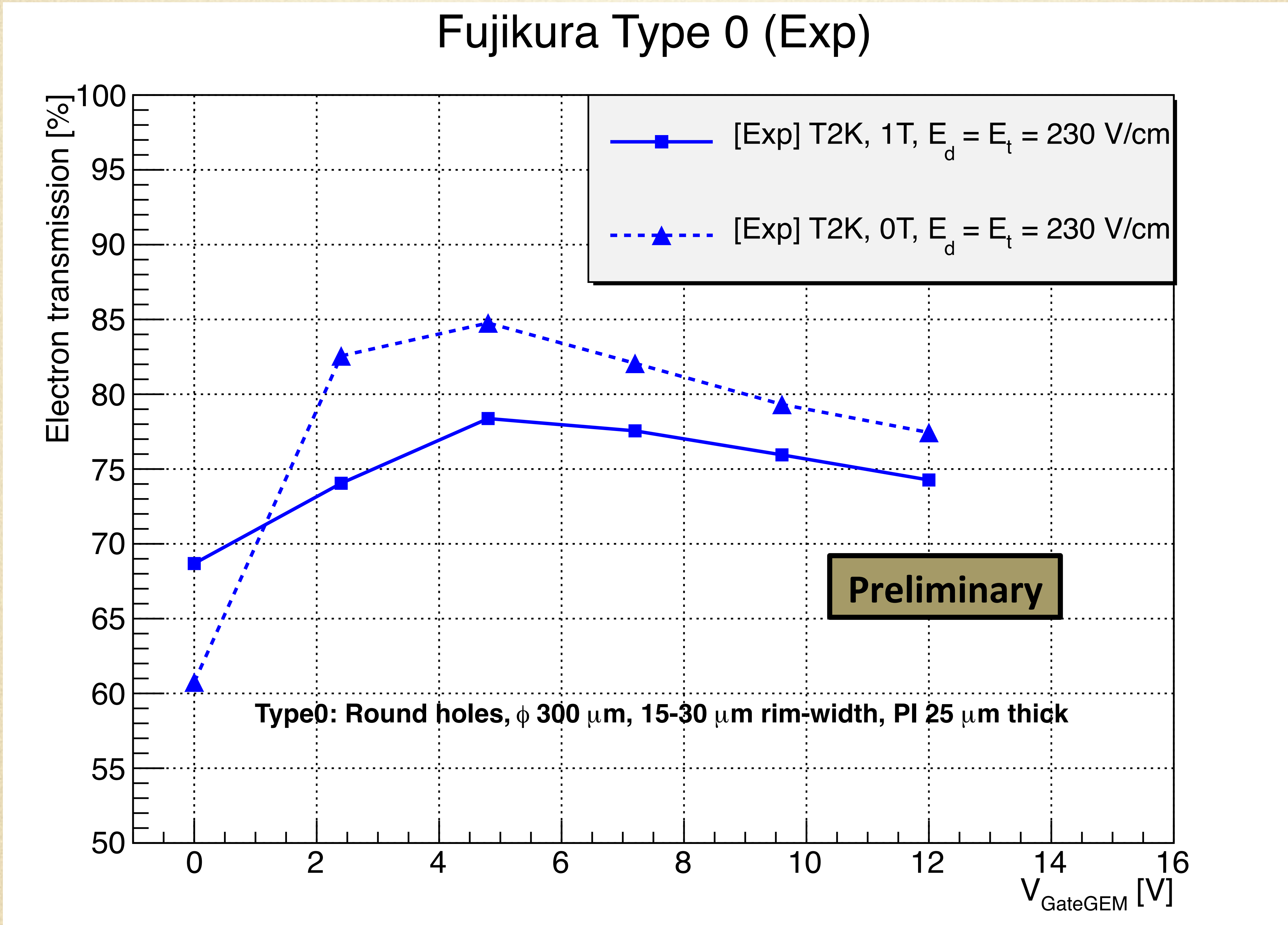




transmission efficiency versus voltage on gate (B=1T)



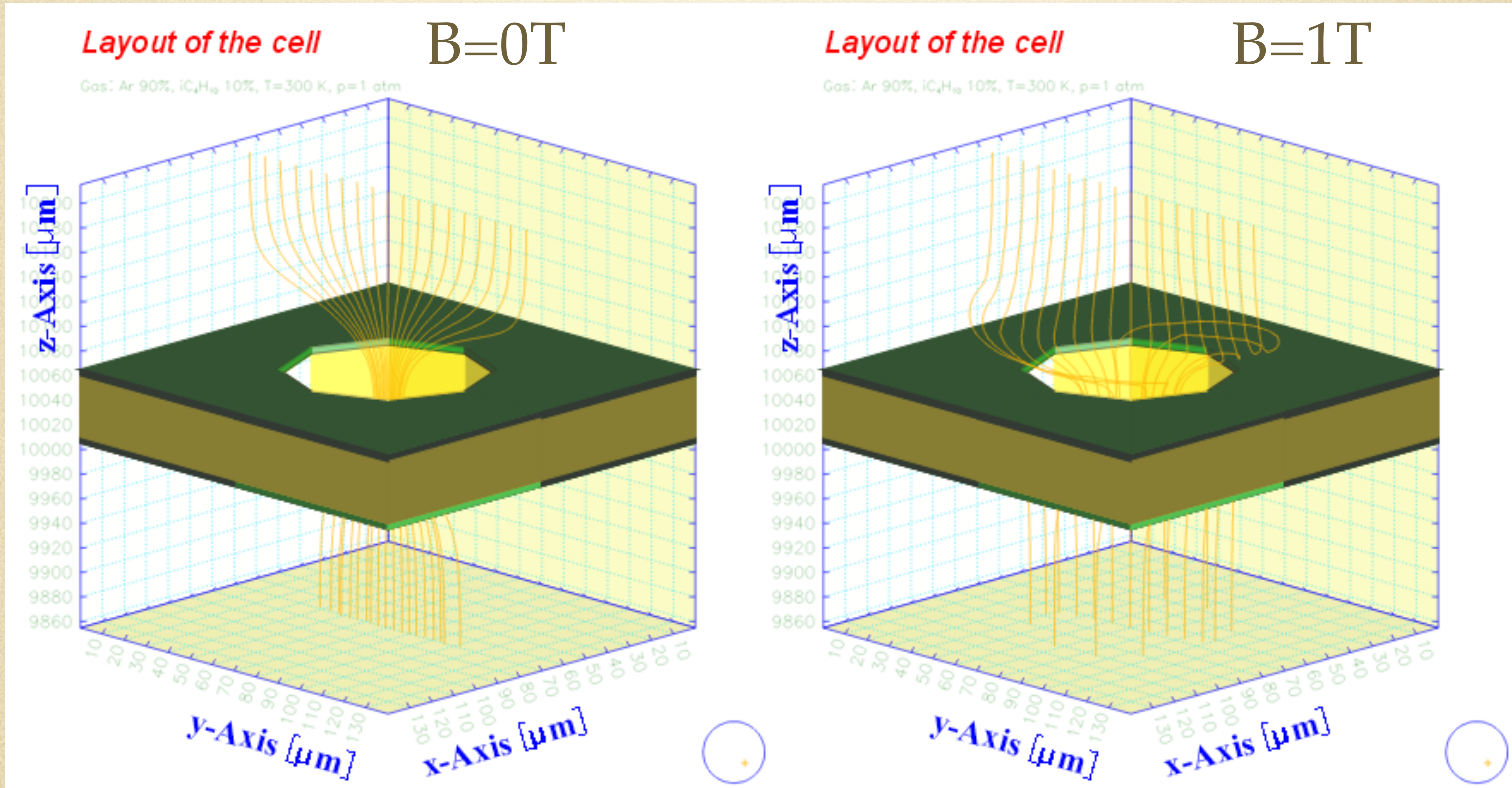
transmission efficiency: result



75-85% transmission efficiency achievable

comparison with simulation (ANSYS + Garfield++)

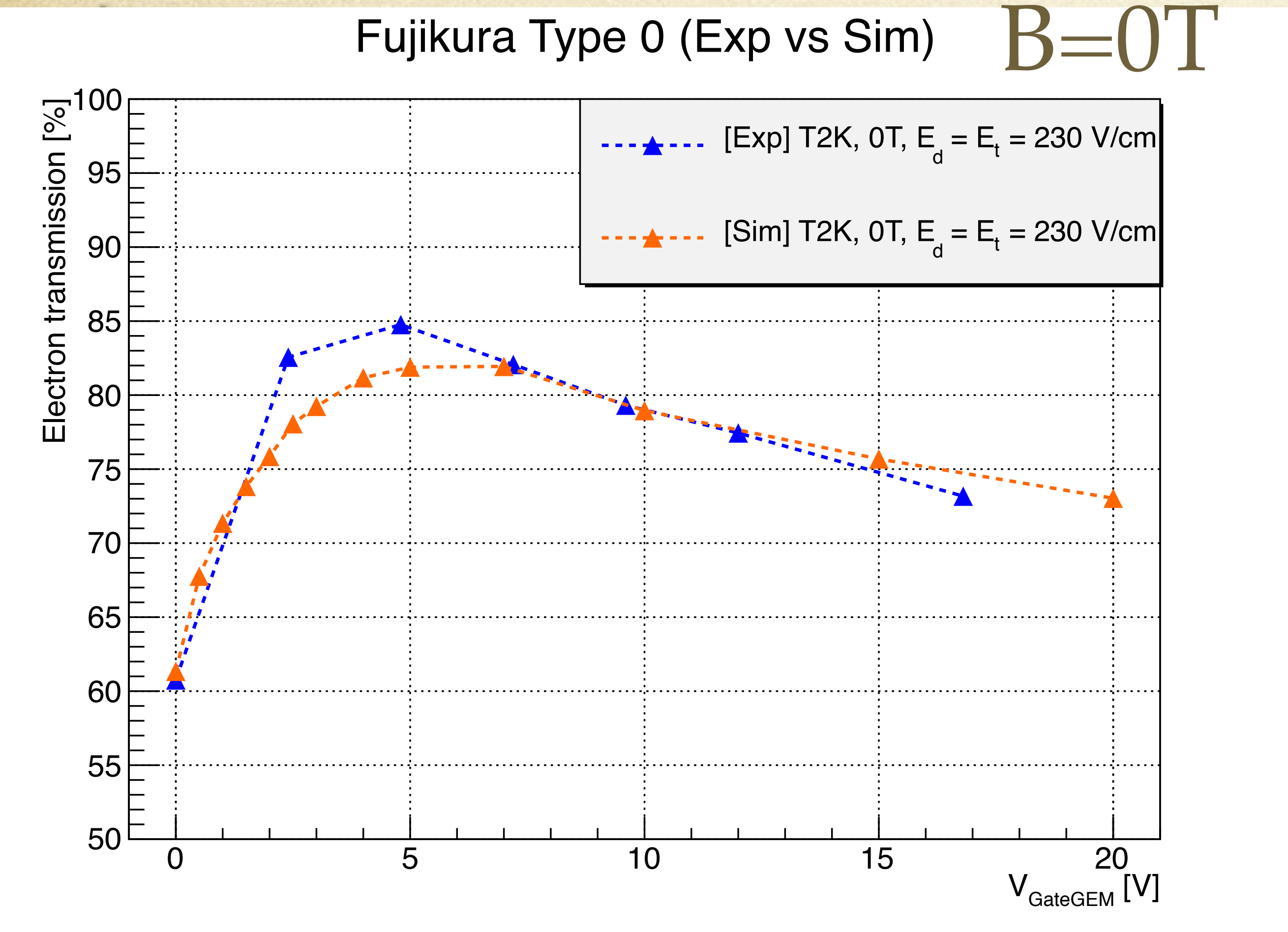
effect of B-Field



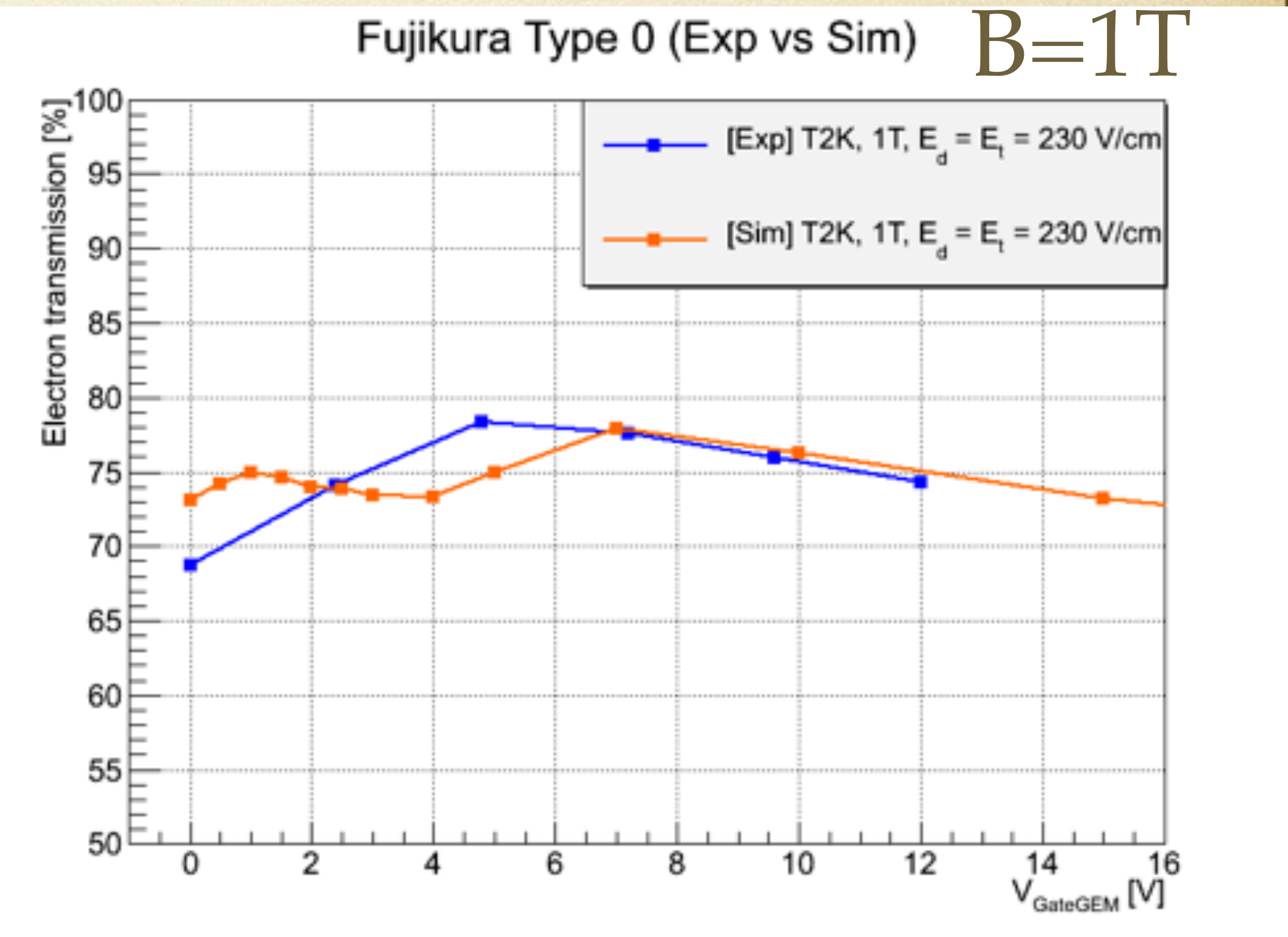
comparison with simulation (ANSYS + Garfield++)

Preliminary

B=0T

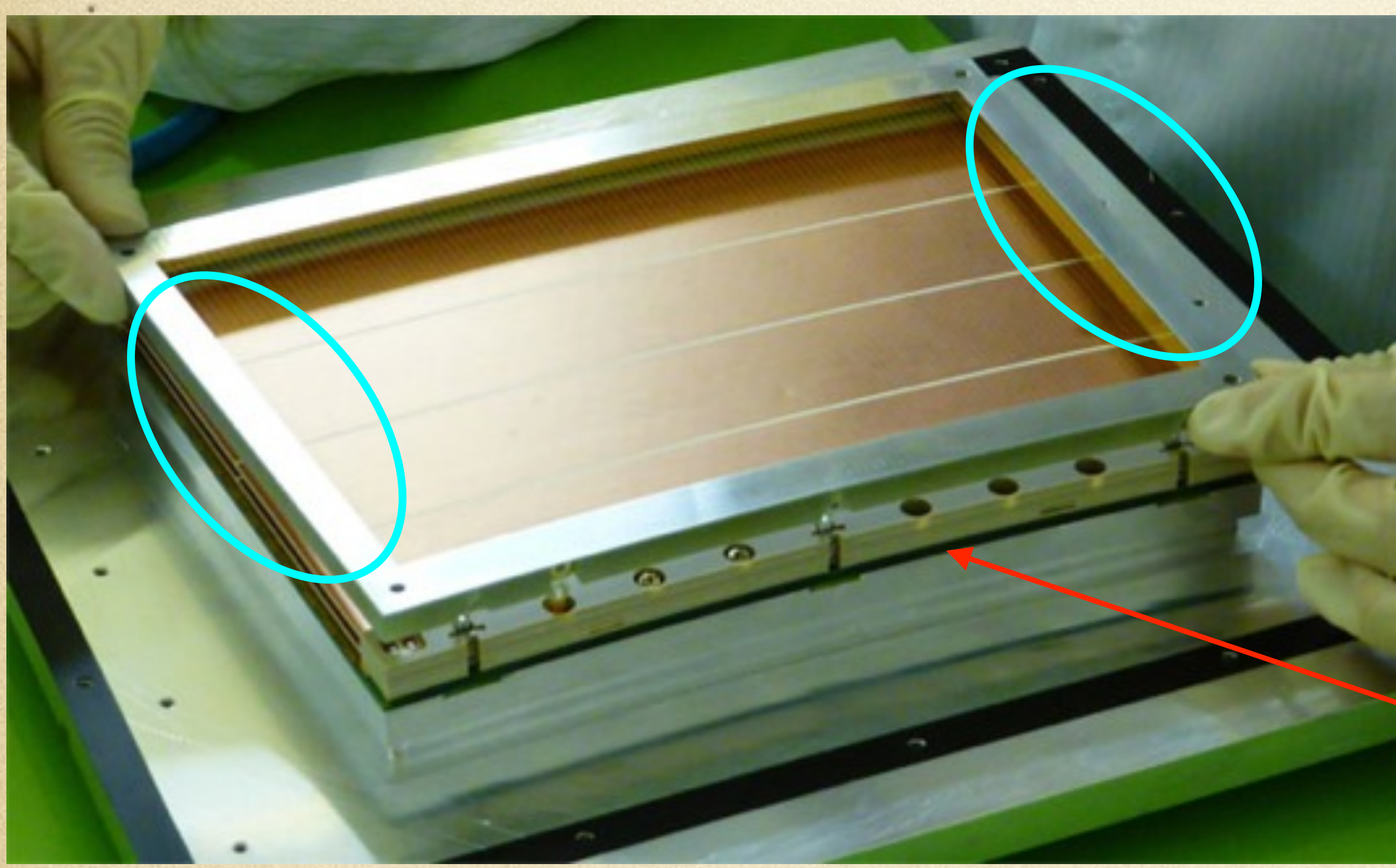


B=1T



efficiency = E(collection) X E(extraction)

prototype of wire gate: test with UV laser system

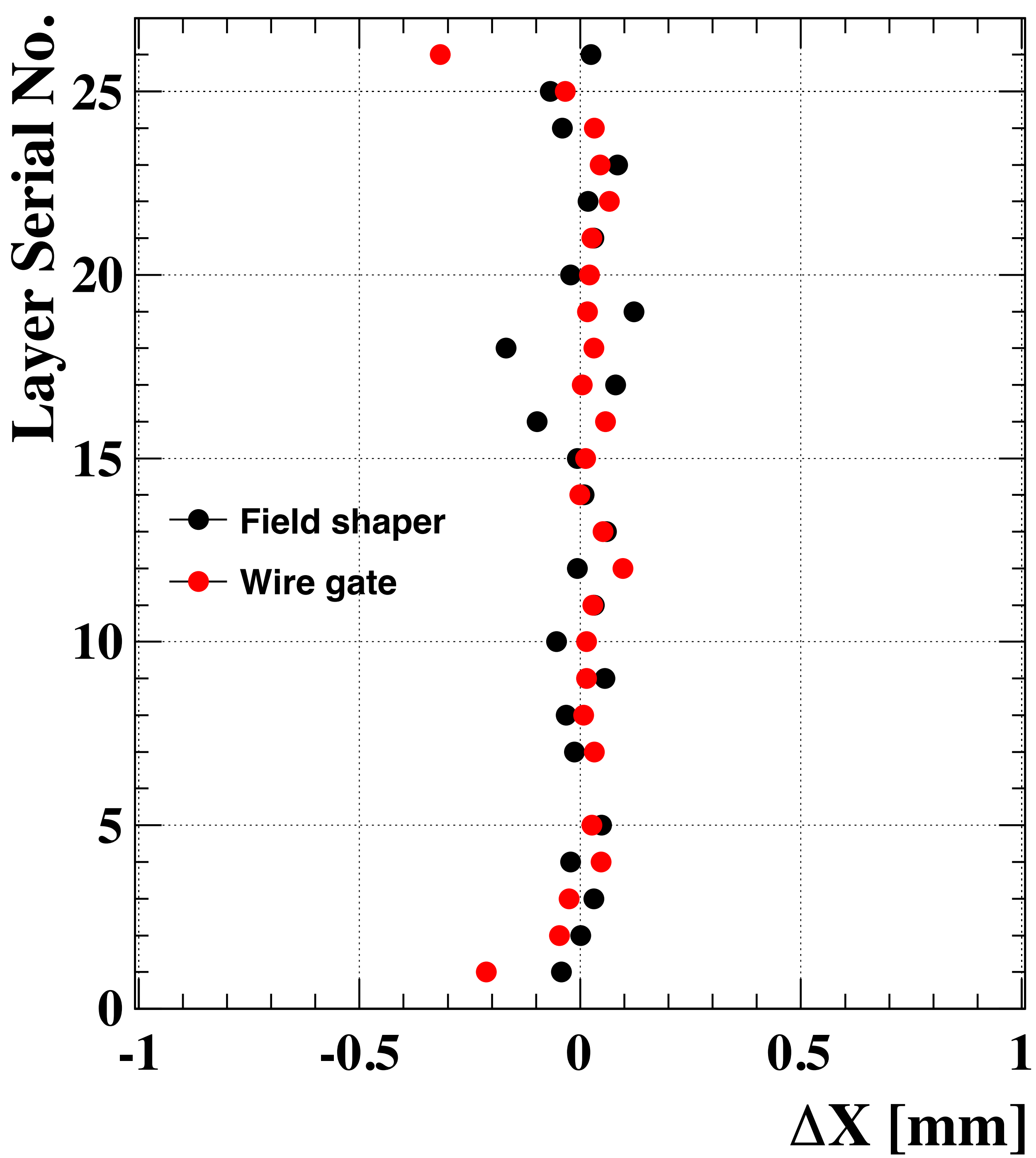


the first radical type wire gate!
30μm wire, 2mm pitch

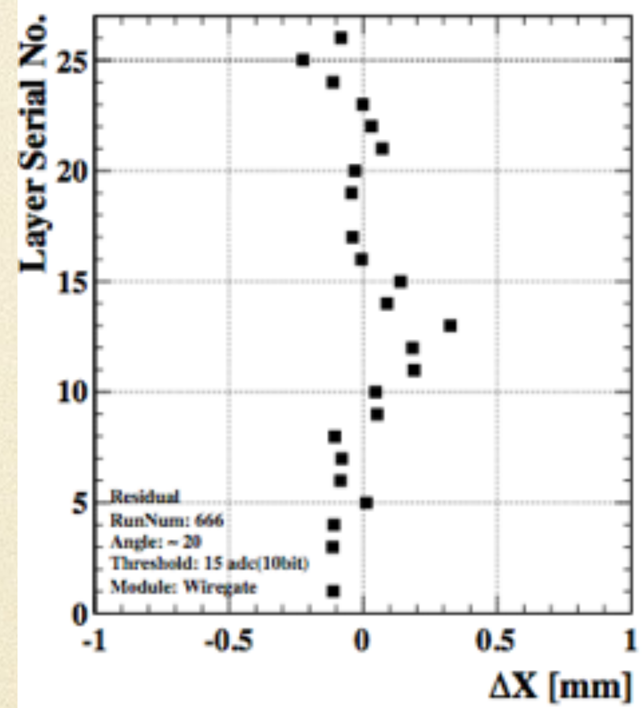
(first look at distortion due to wire gate)

result by laser test (distortion)

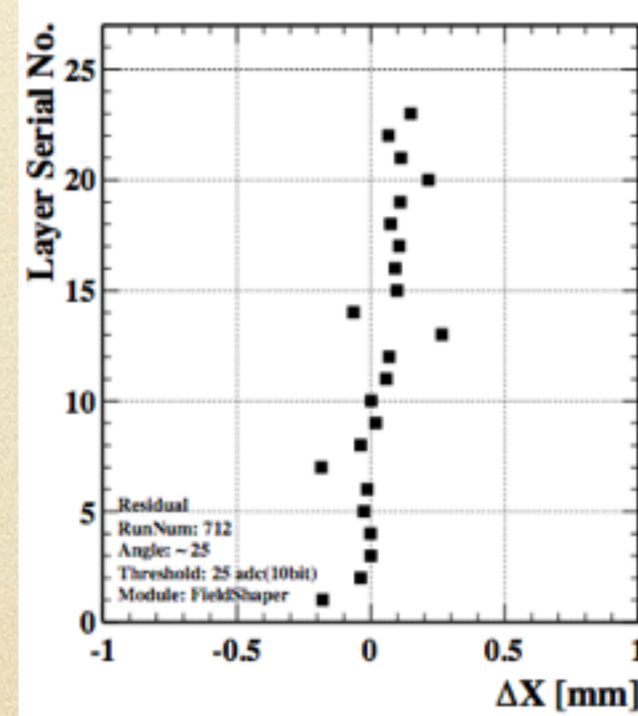
0 degree



20 degree



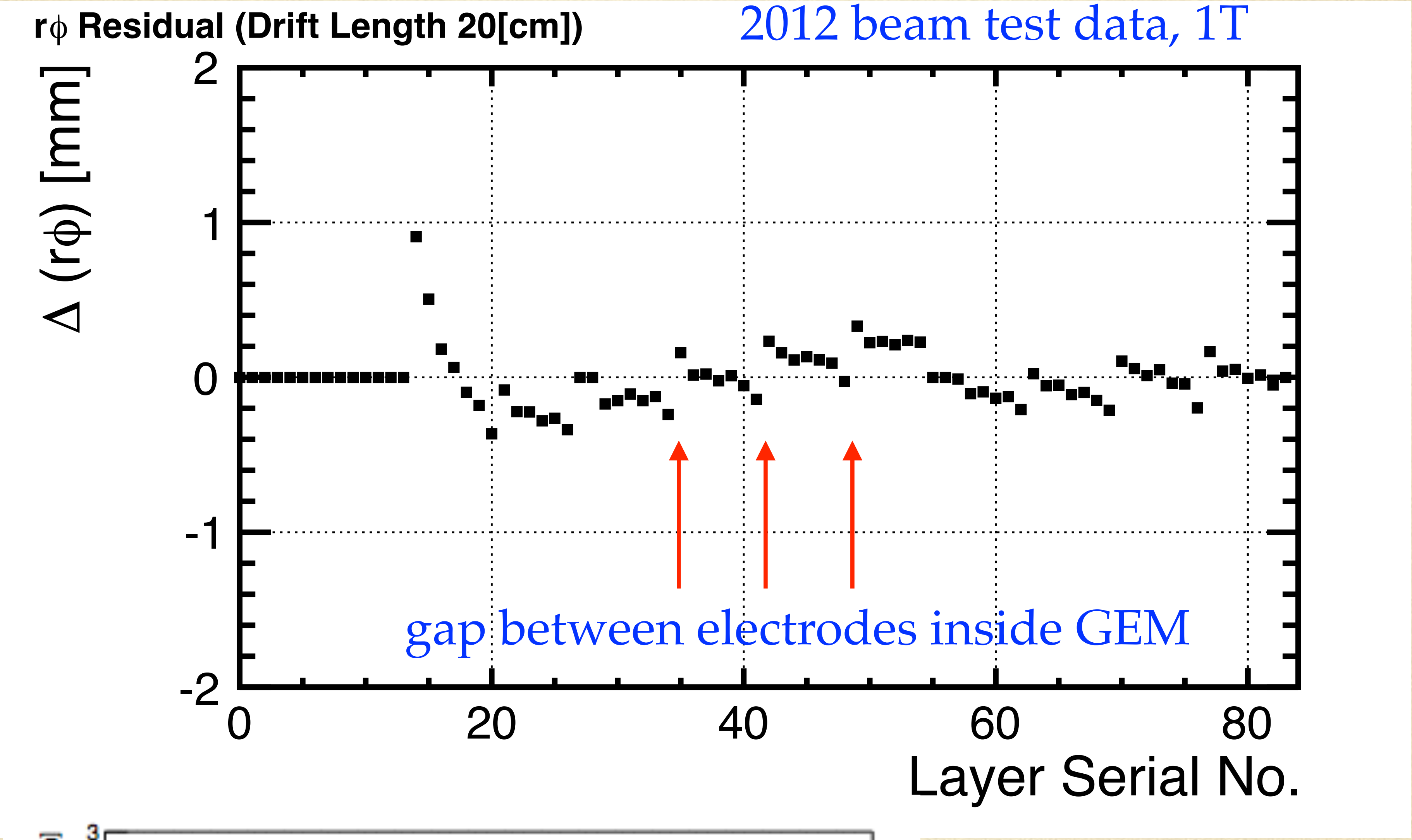
wire gate

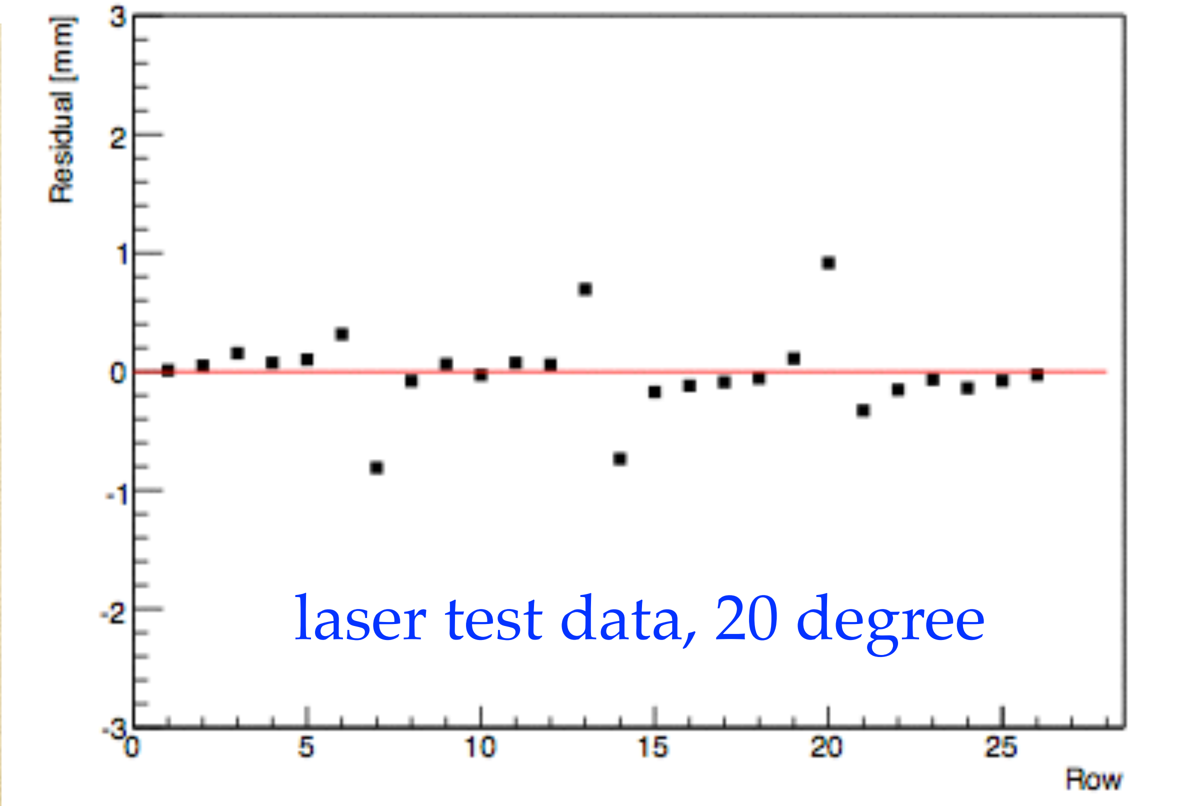


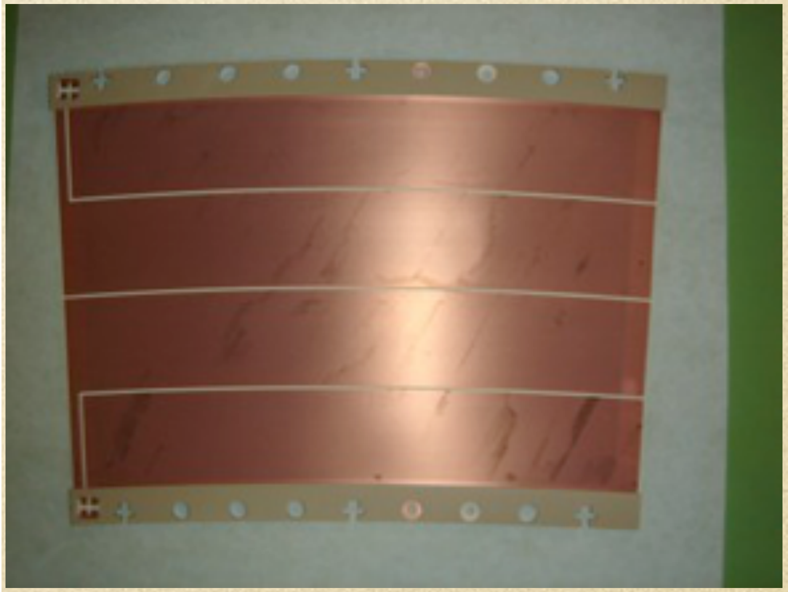
field shaper

very preliminary! more careful analysis and difference of experimental conditions need be checked

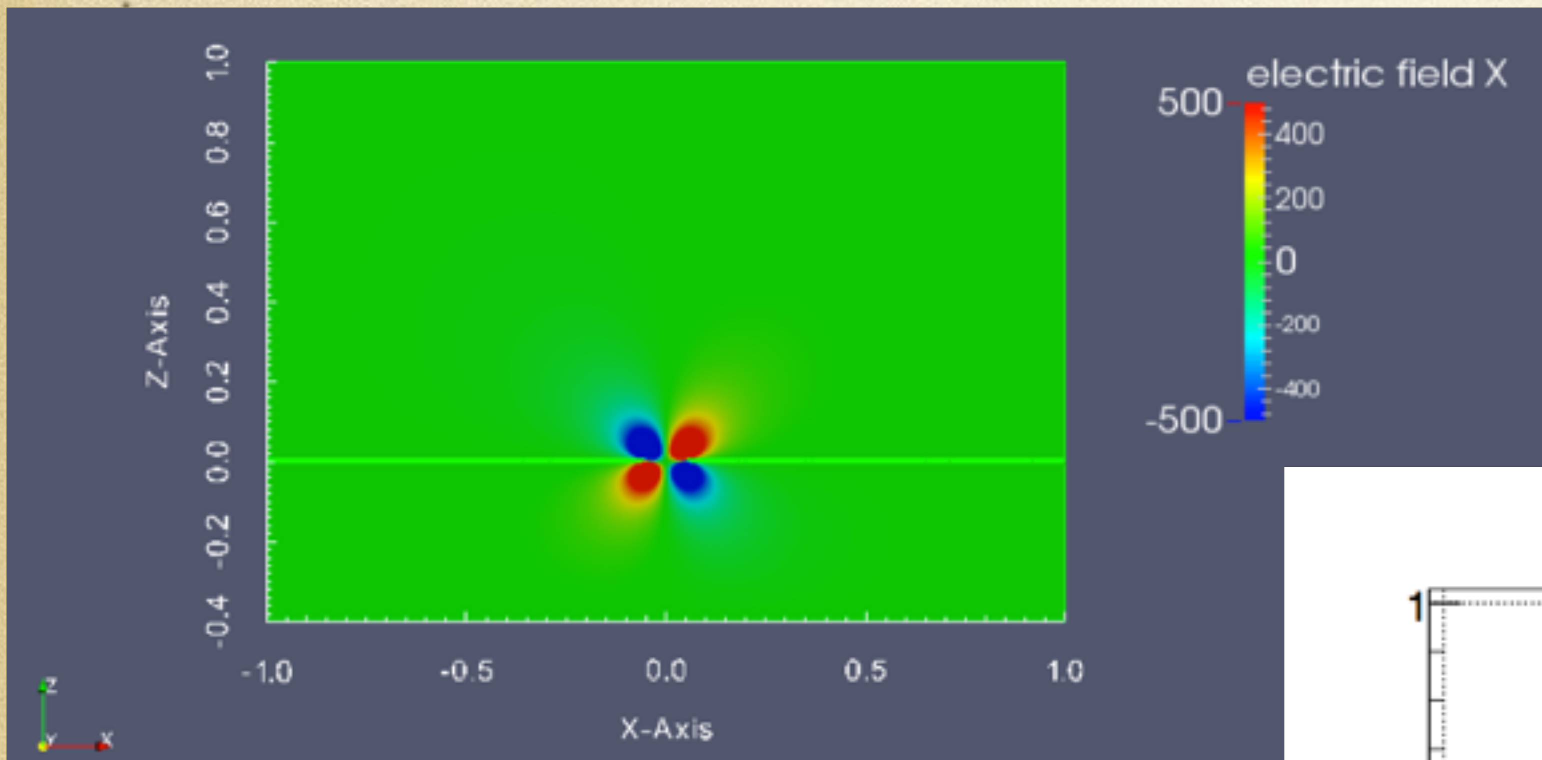
(II) better understanding of distortion



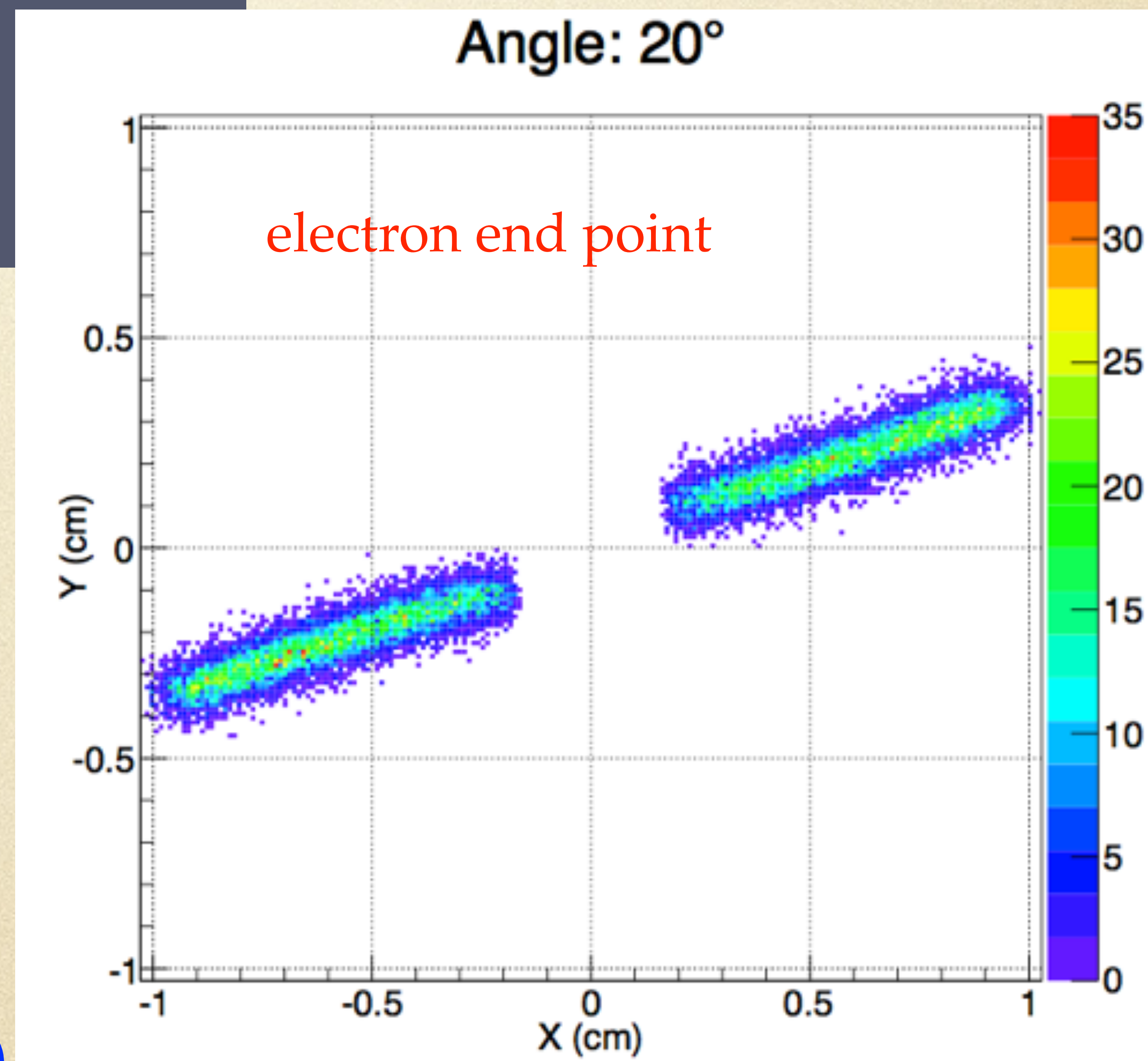




(II) distortion simulation (Elmer + Garfield++)

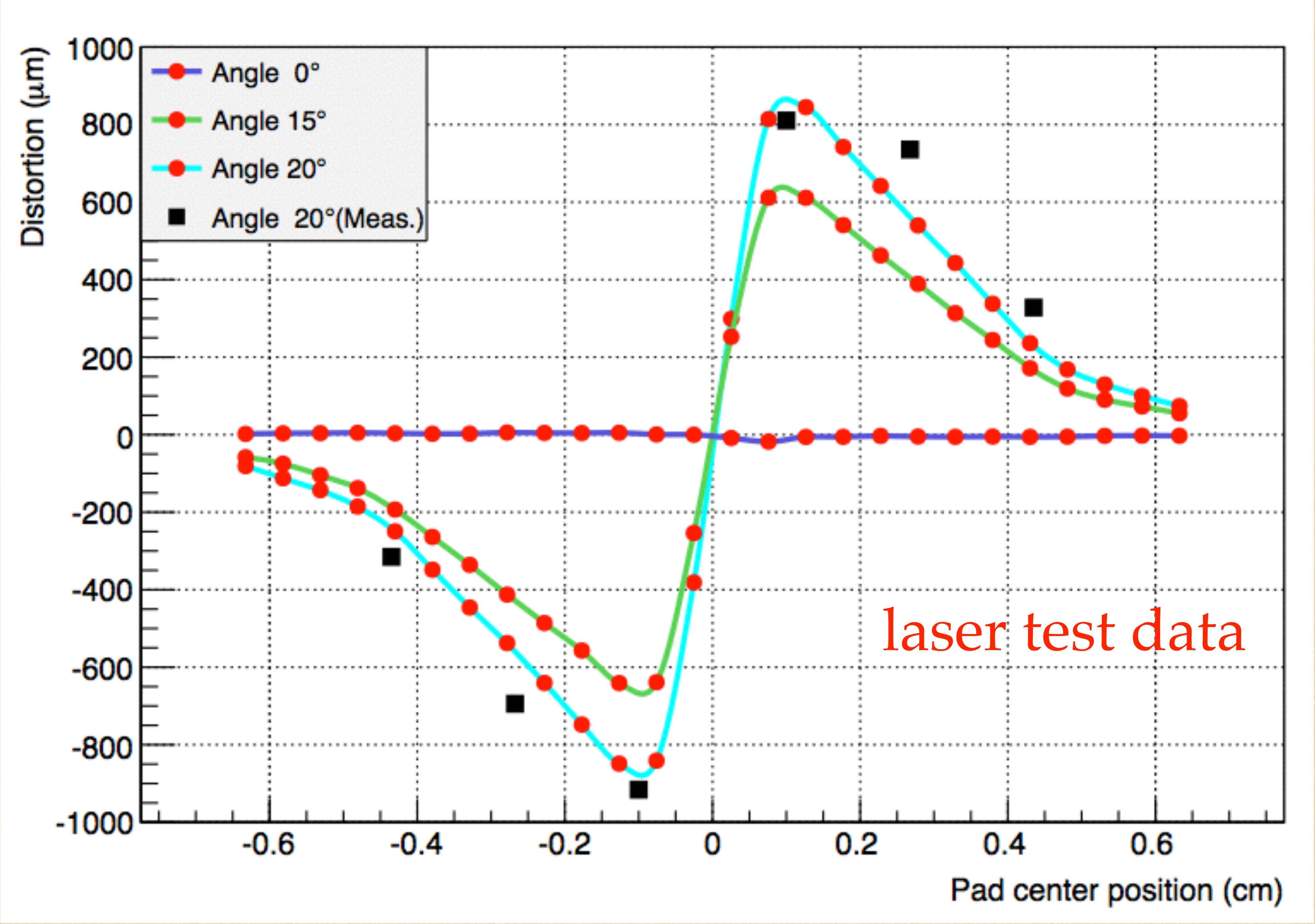


1. calculate E-Field around gap (Elmer): note the force along x-direction pointing to gap

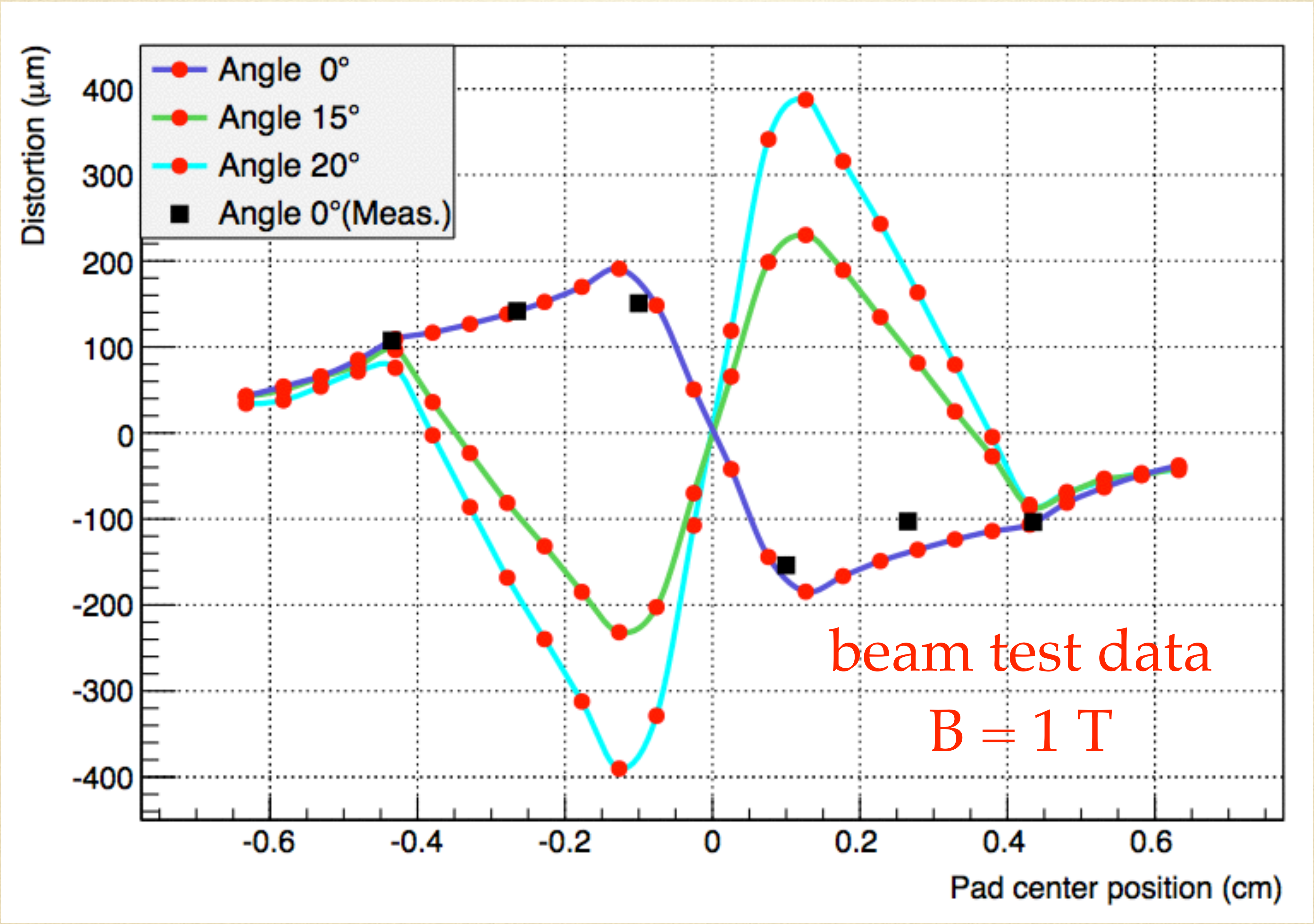


2. simulate electron drift and get end point (Garfield++)
3. based on relative position between gap and pad plane, charge are deposited
4. center-of-gravity to get hit position and residual (-truth)

(II) distortion simulation: comparison with data



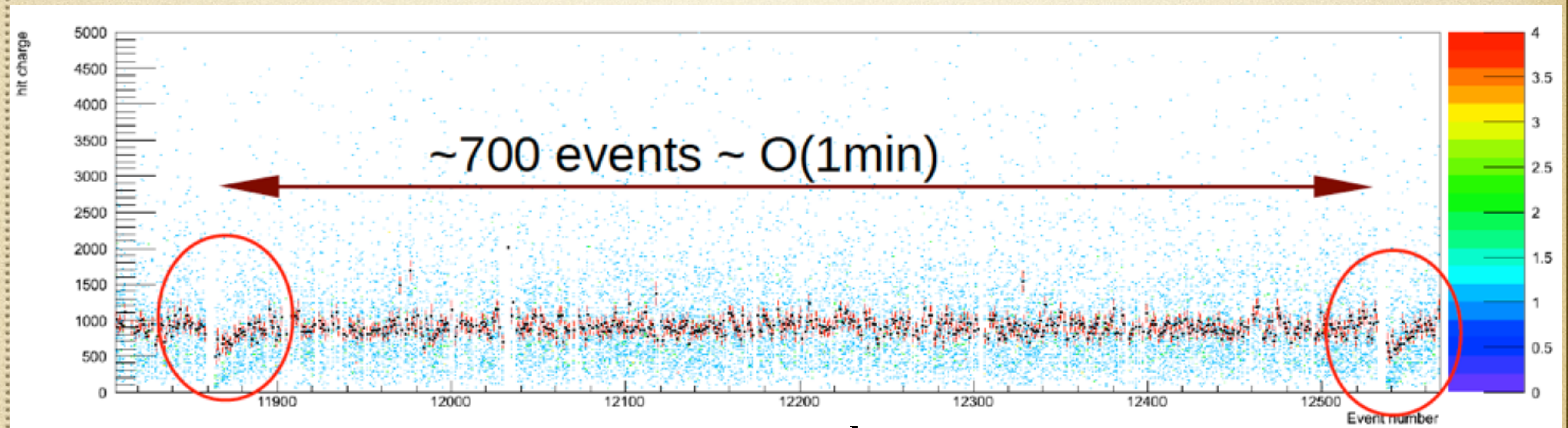
(II) distortion simulation: comparison with data



(III) GEM gain stability and discharge test

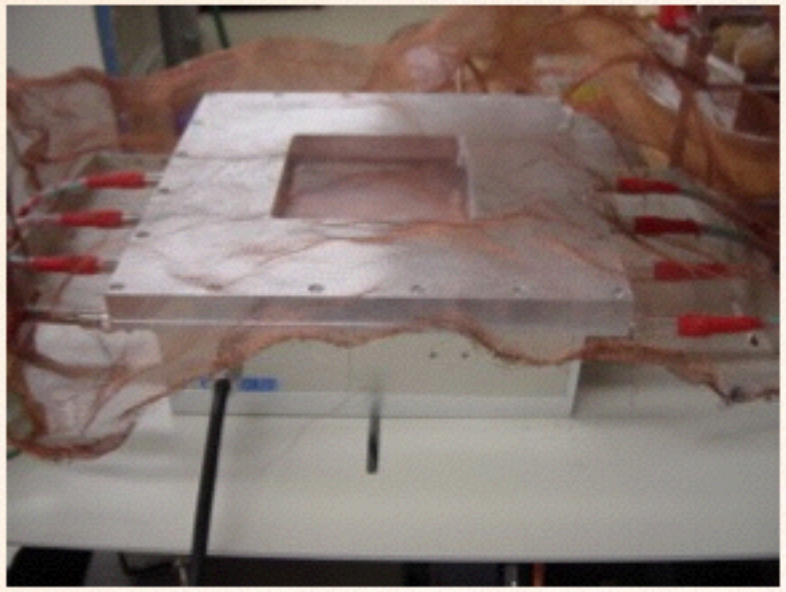
micro discharge was observed during 2012 beam test

Average of hit charge

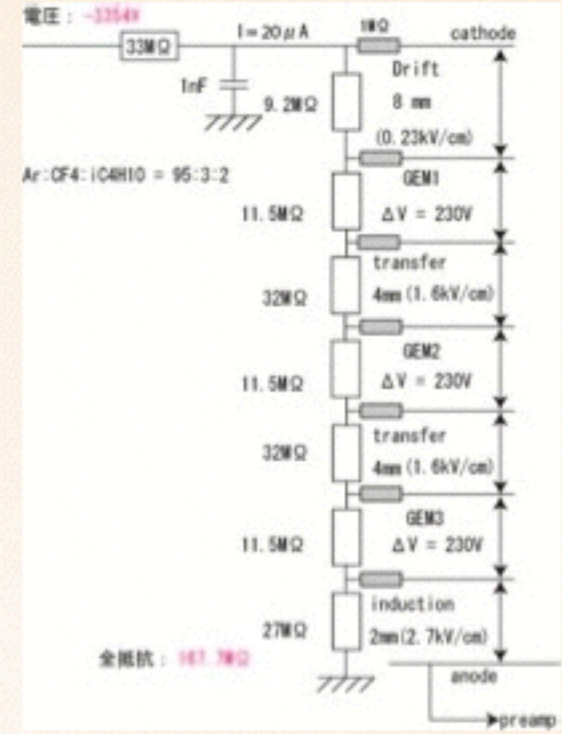


Event Number

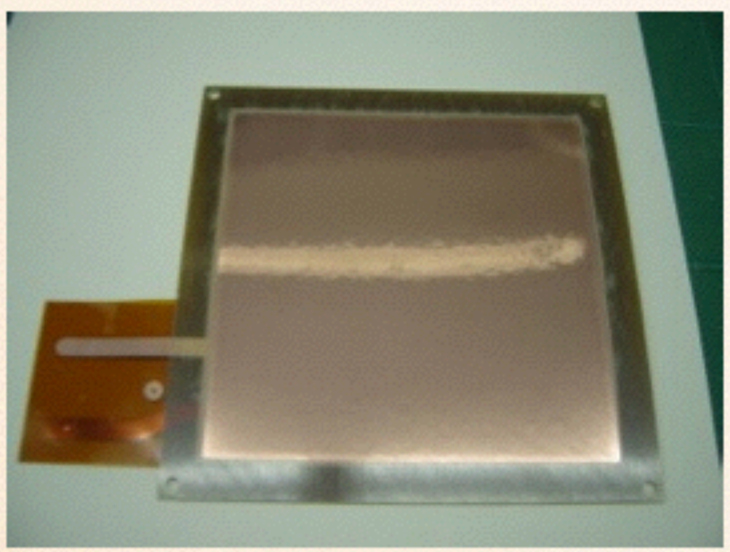
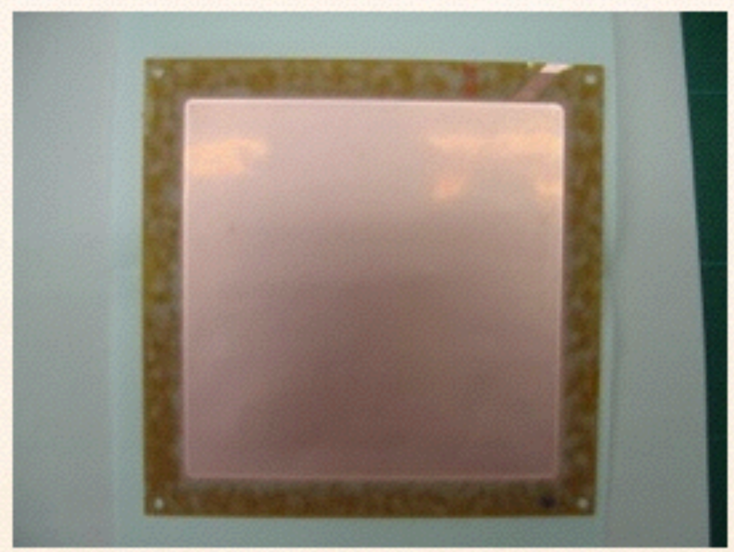
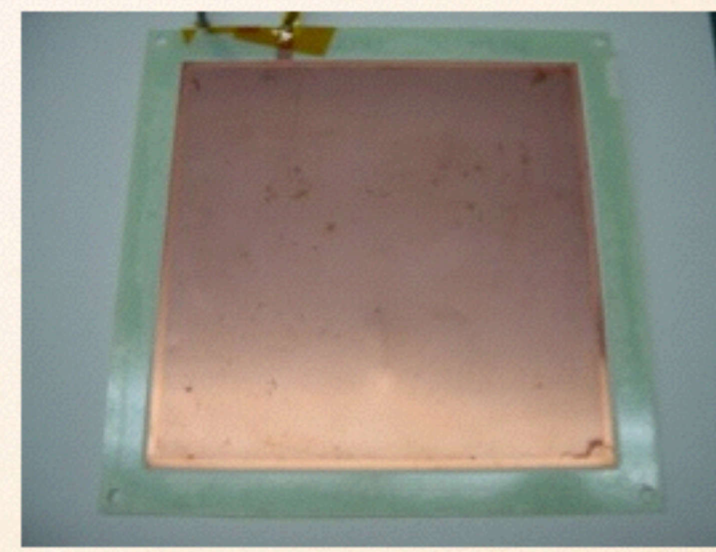
New chamber and GEM's



- chamber size is almost same as previous
- good airtightness



Chamber setup

CERN GEM	Raytech GEM	Sciernergy GEM
		

- Size is same (10cm X 10cm, t=50μm).
- Surface luster is different (CERN GEM has most luster)

Average of hit charge

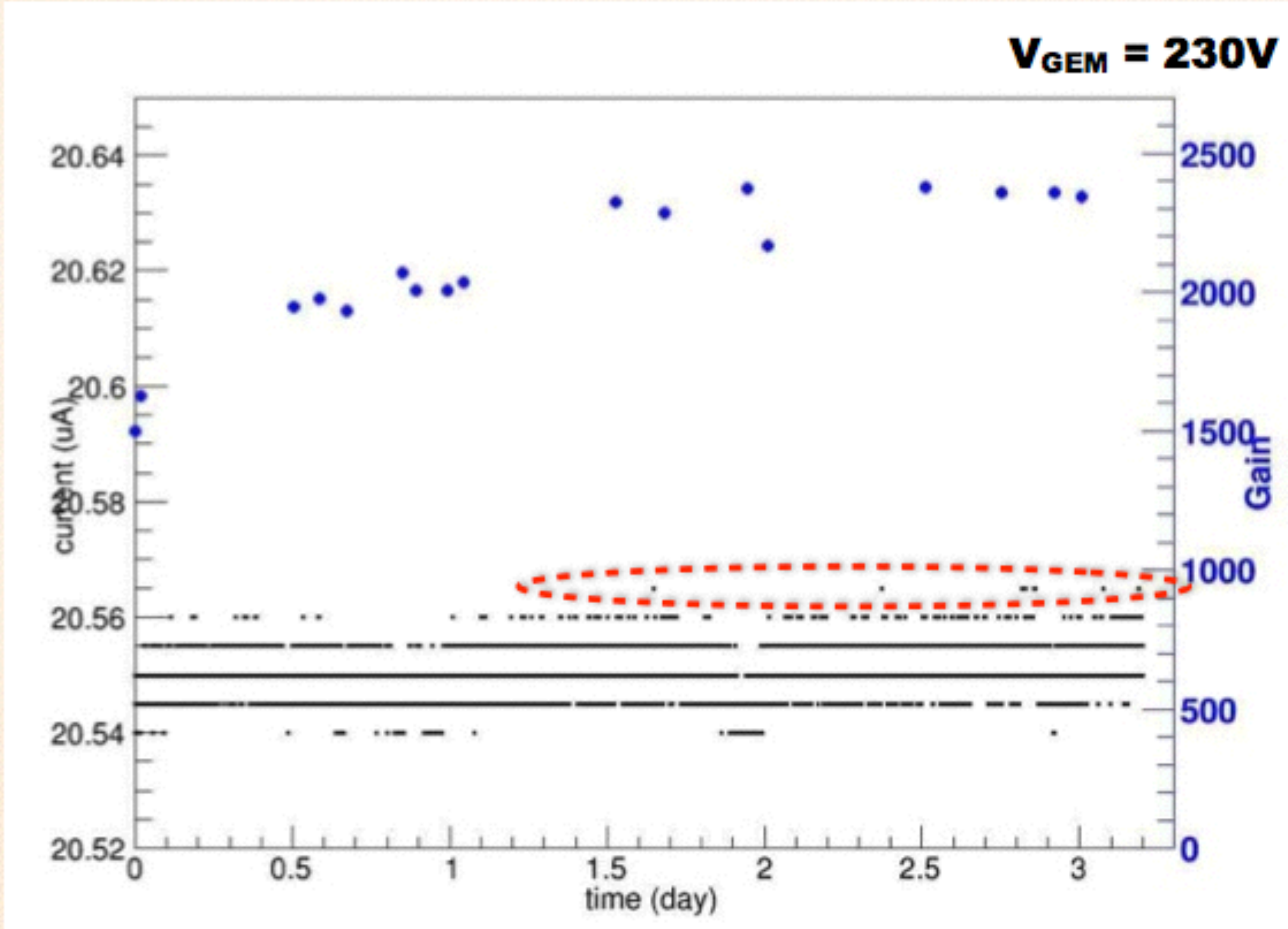
hit charge

4 3.5 3 2.5 2 1.5 1 0.5 0

hence we set up some experiment to test GEM gain stability and discharge rate

(III) GEM gain stability and discharge test

Discharge Measurement of Raytech GEM



Nominal current
20.550 μA

Current by discharge
> 20.560 μA

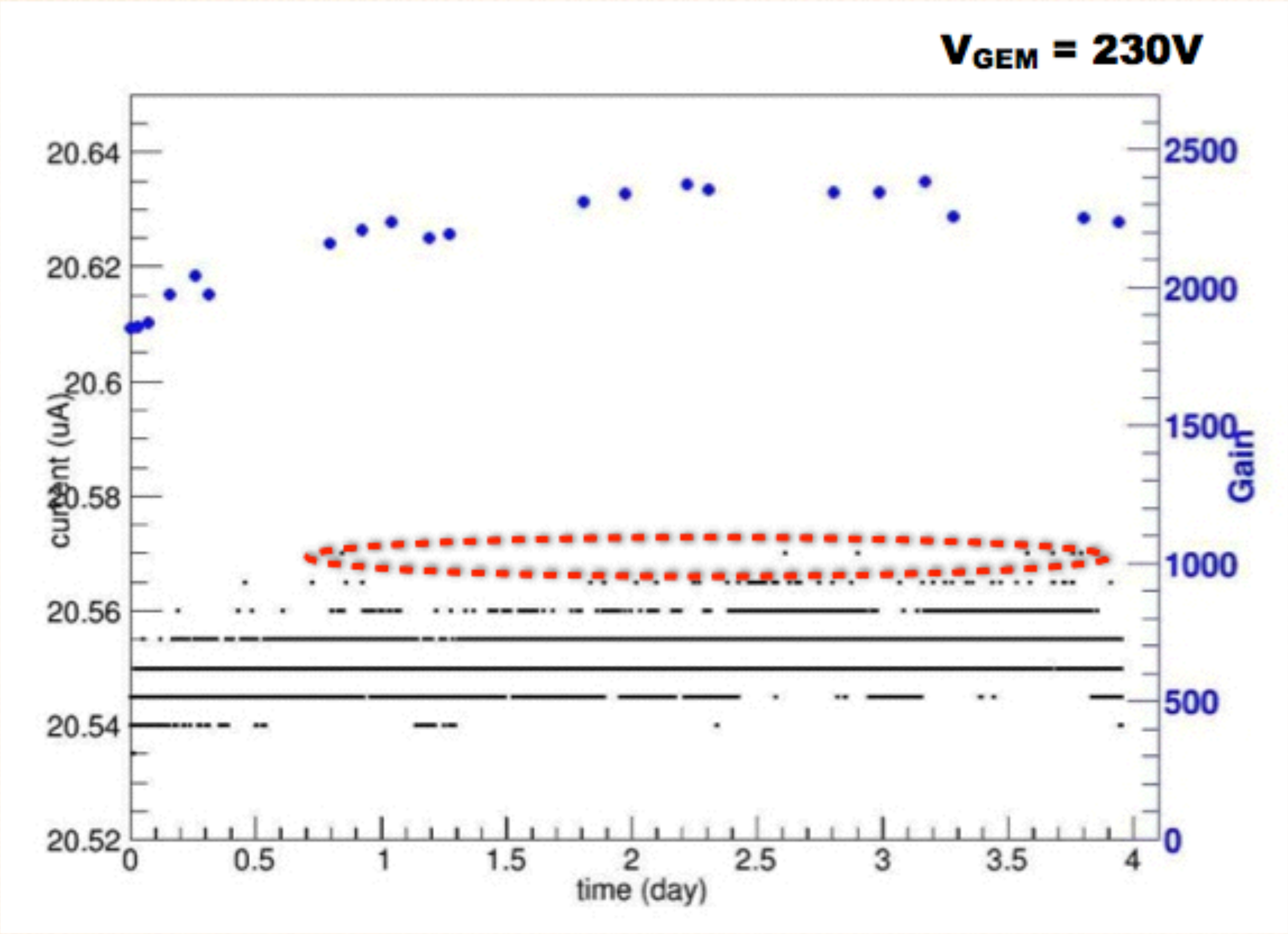
Discharge rate

2.9×10^{-5} Hz

(8 tims/276431 sec)

(III) GEM gain stability and discharge test

Discharge Measurement of CERN GEM



Nominal current
20.550 μA

Current by discharge
> 20.565 μA

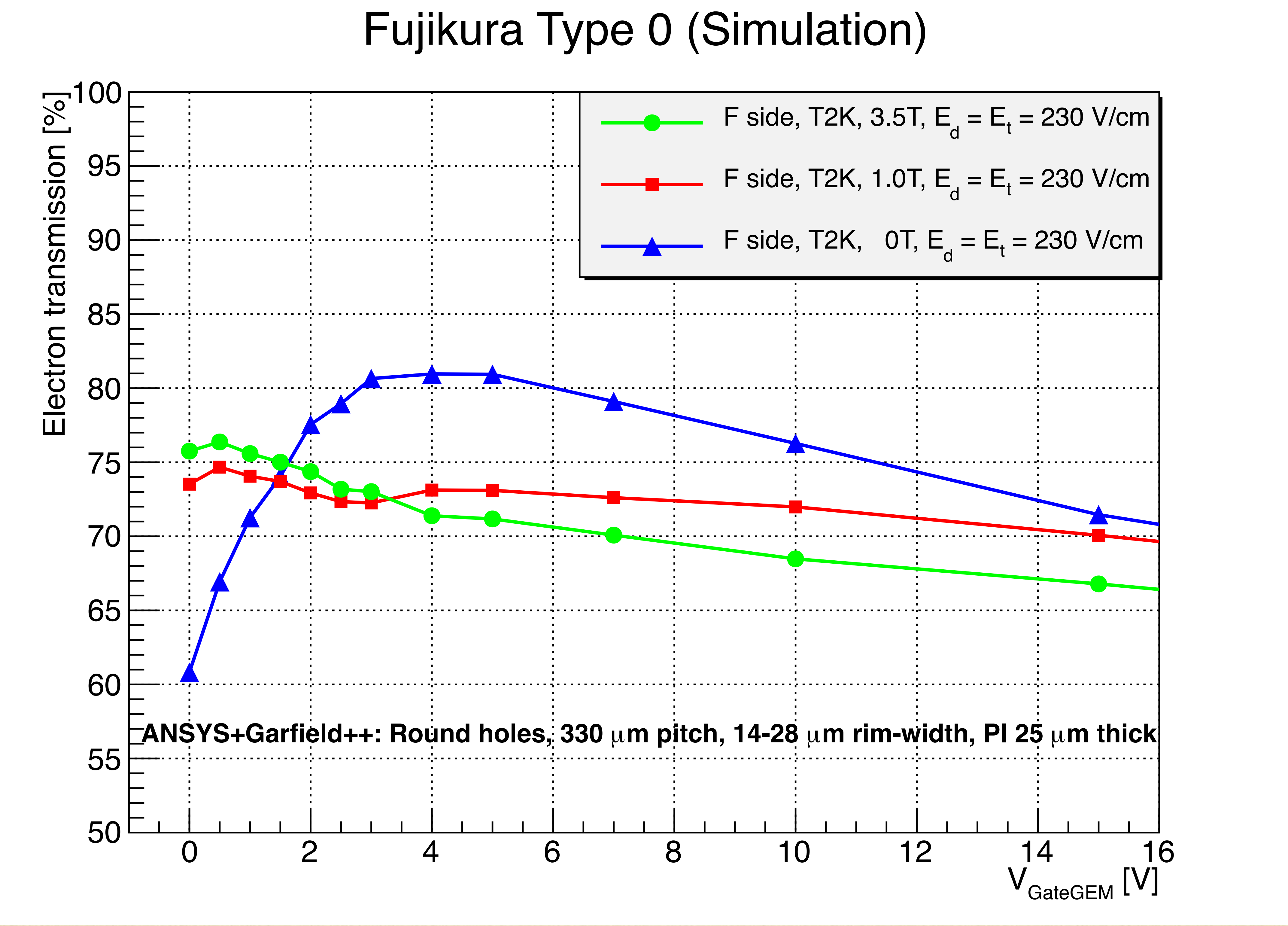
Discharge rate
2.1 x 10^{-5} Hz
(7 tims/341301 sec)

Current by discharge
> 20.560 μA
Discharge rate
1.6 x 10^{-4} Hz
(56 tims/341301 sec)

summary and plan

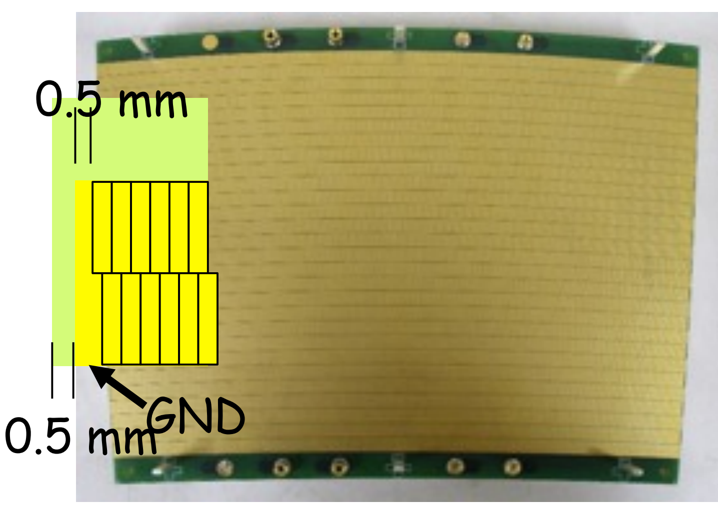
- distortions due to ion feedback and back flow have been learned, ~60 μm; a gating device is needed to achieve 100 μm point resolution.
- GEM gate is more preferred to be integrated to current MPGD; prototypes of both GEM gate and wire gate have been produced and tested.
- preliminary results show quite promising electron transmission efficiencies for GEM gate.
- more data analysis and test for wire gate are needed.
- GEM discharge rate test is ongoing.
- test of larger aperture GEM gate is ongoing, production of larger GEM foil (17cm x 22 cm) is planned, which will be mounted on LP1 module.

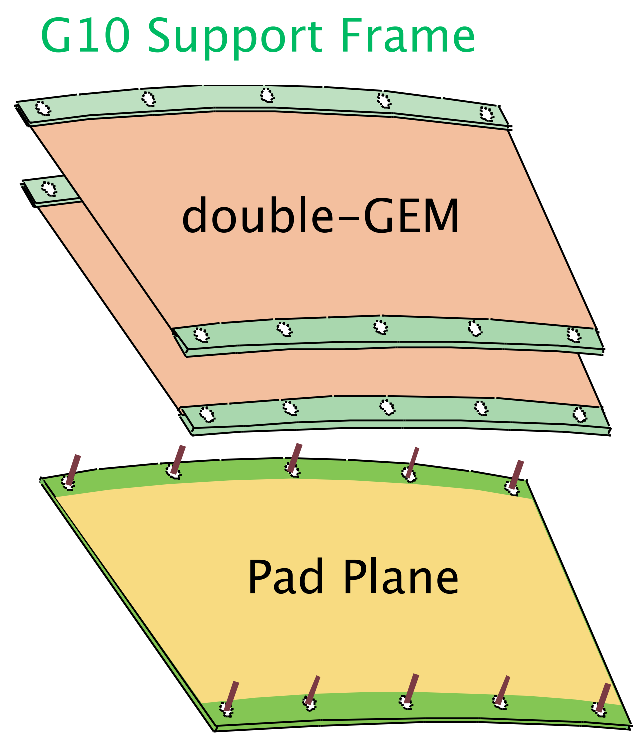
back up

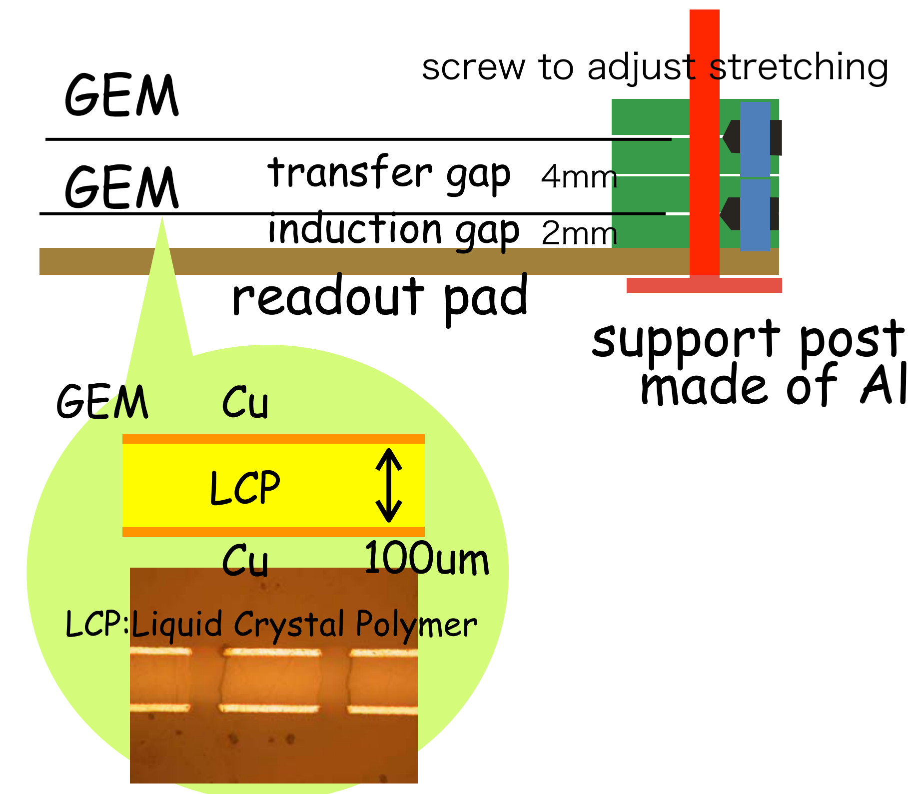

Fujikura Type 0 (Simulation)
Electron transmission [%]
F side, T2K, 3.5T, E_d = E_t = 230 V/cm
F side, T2K, 1.0T, E_d = E_t = 230 V/cm
F side, T2K, 0T, E_d = E_t = 230 V/cm
ANSYS+Garfield++: Round holes, 330 μm pitch, 14-28 μm rim-width, PI 25 μm thick
V_GateGEM [V]
100
95
90
85
80
75
70
65
60
55
50
0
2
4
6
8
10
12
14
16

Concept of Asian-GEM module

- **Small pad** **+** **Thick double-GEM** + GEM-gate device + up-downside support fame



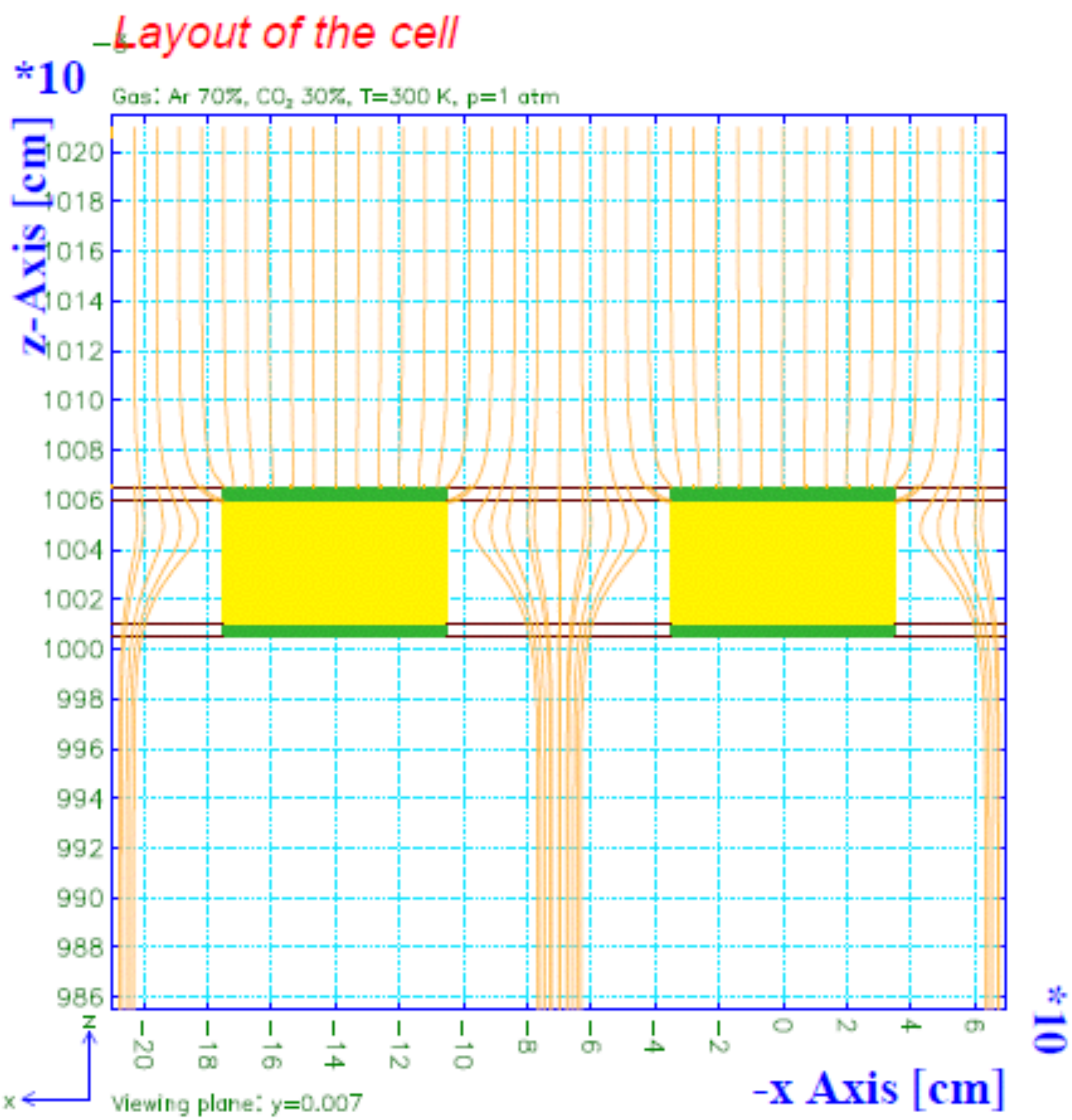




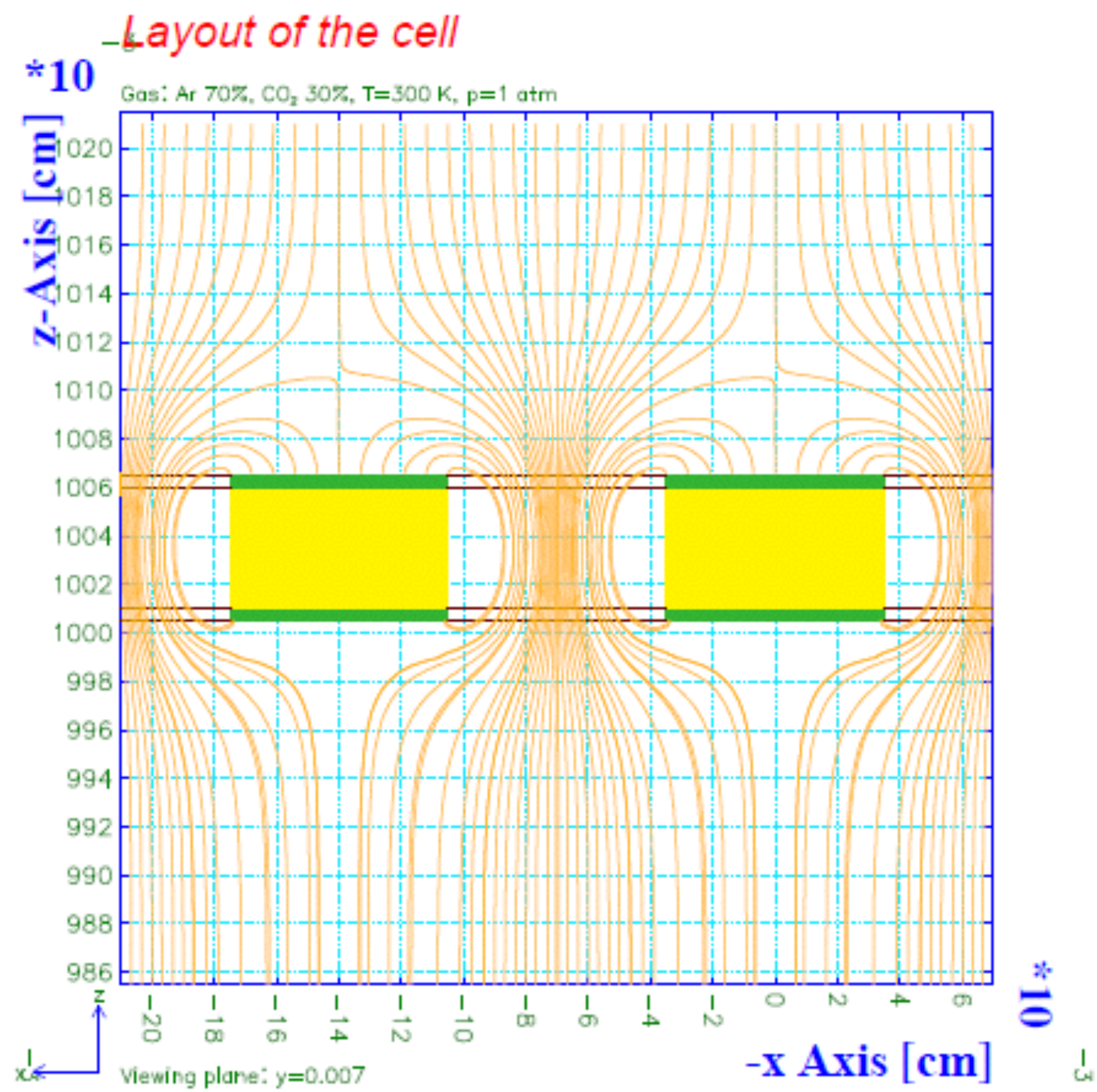
- **Pad plane**
  - Designed and fabricated at Tsinghua Univ.
  - 5152 pads / PCB (module)
  - 28 layers
  - 192 pads at outer
  - 176 pads at inner
  - 1.15~1.25 mm width
  - 5.26mm height
  - Staggered layout

- **Thick double-GEM for amplification**
  - 100 μm thick LCP (Liquid Crystal Polymer)
  - Hole: 70 μm φ、140 μm pitch
  - Produced by SciEnergy (Japanese company)
  - Gas mixture: Ar-CF4-isoC4H10 (95:3:2) = T2K gas
  - Gas Gain: ~3000 at V_{GEM} = 360V
  - (Drift field: 230V/cm)

comparison with simulation (ANSYS + Garfield++)



E_h 低の場合の電気力線の様子



E_h 高の場合の電気力線の様子