



SOKENDAI



# The first beam test of a GEM-readout TPC module with a large aperture GEM-like gating device

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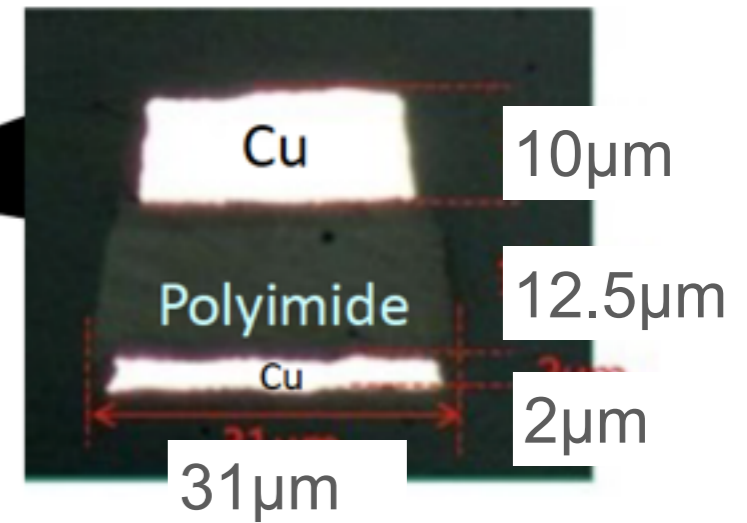
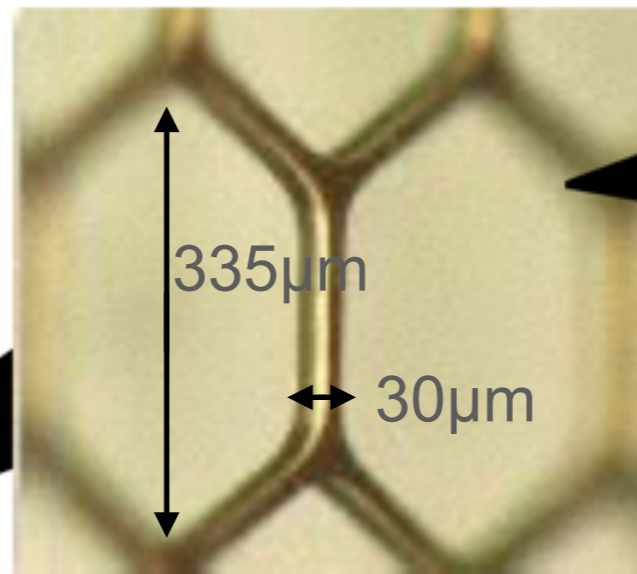
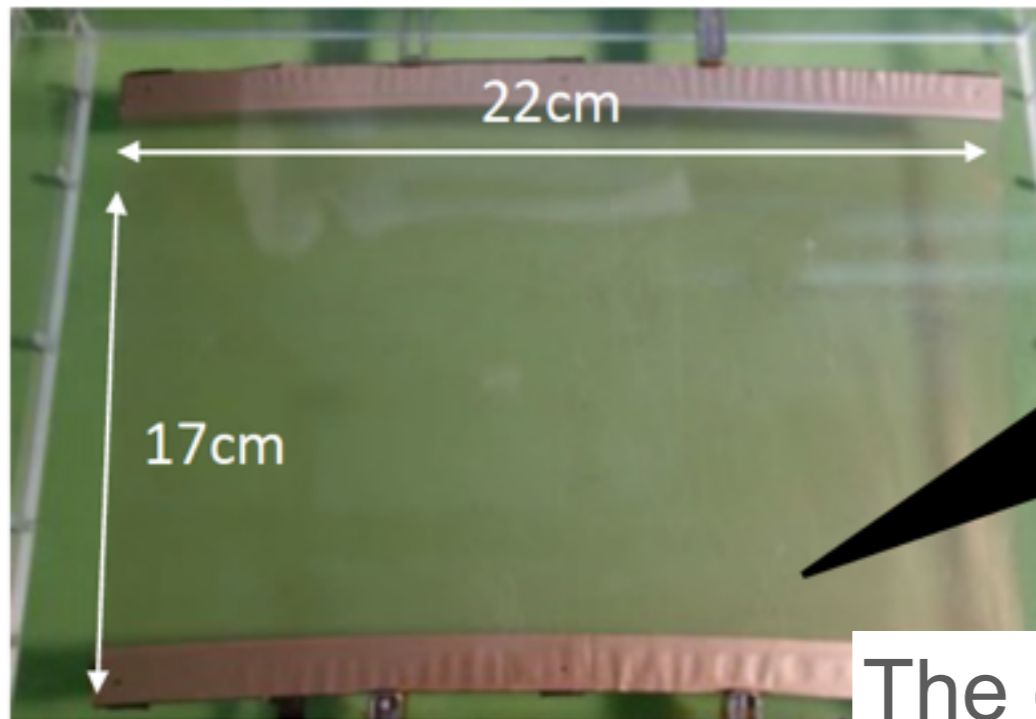
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# A large aperture GEM-like gating device



GEM as a gate = a large aperture GEM-like gating device  
(gating GEM)

The joint development with FUJIKURA



honeycomb structure

The optical transparency = 82 % 25 μm thick

Though gating GEM stop positive ions, should not stop electron too. → Electron transmission rate is important

To achieve 100 μm of position resolution, We need 80% electron transmission rate

Electron transmission rate in the attainable high electromagnetic field = Optical transparency

→ We checked by beam test



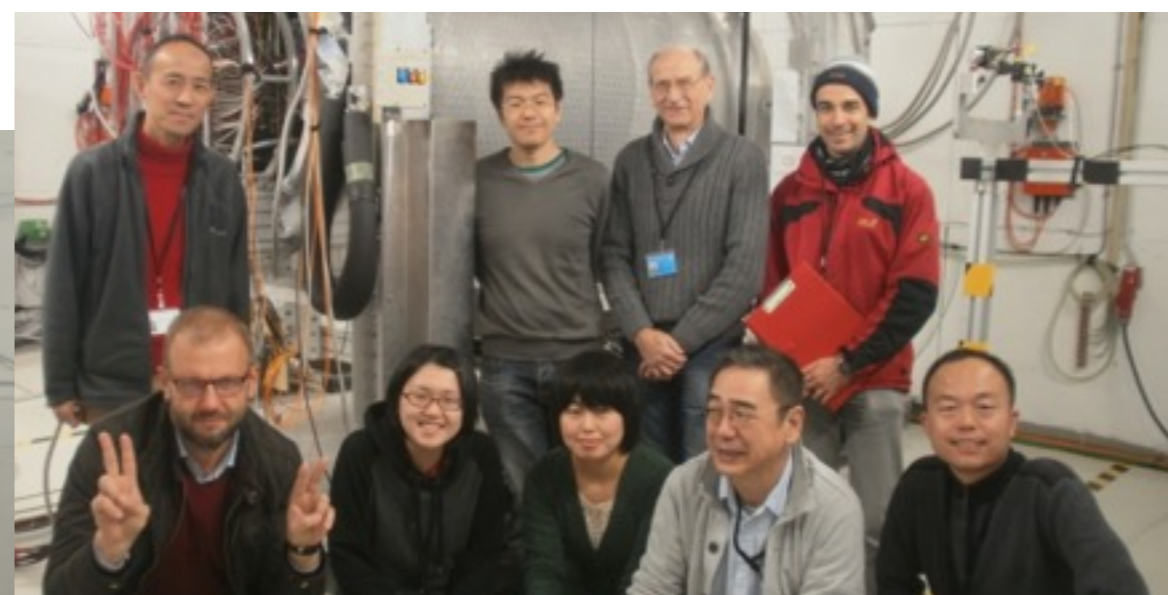
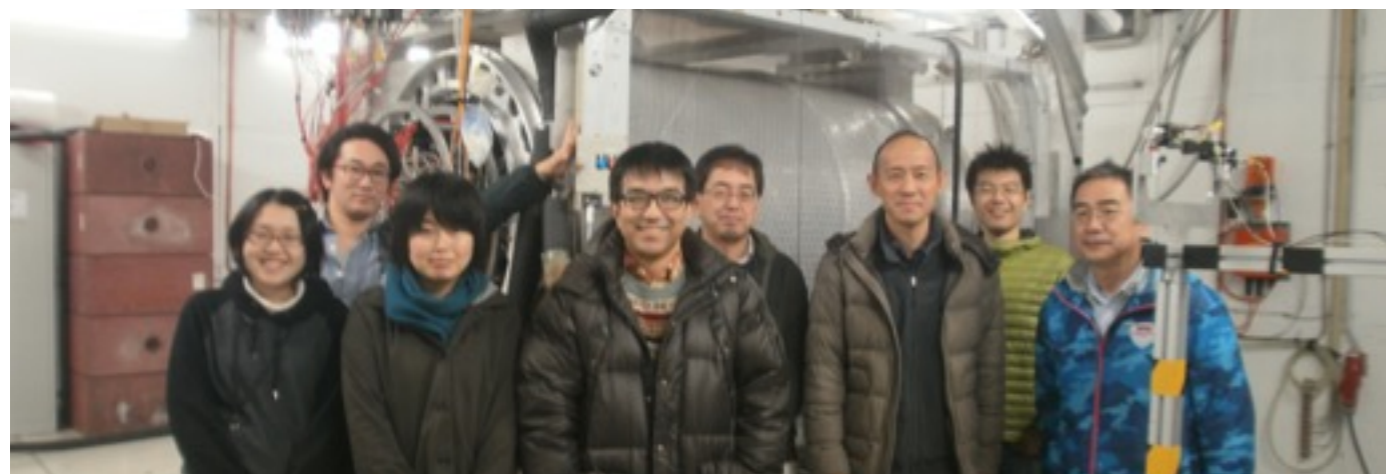
# Beam test



2016.10.31~11.13 (beam time)  
@DESY TPC large prototype  
The first beam test  
of a GEM-readout TPC module  
with a gating GEM



15 participants from Japan,  
France, Germany, China

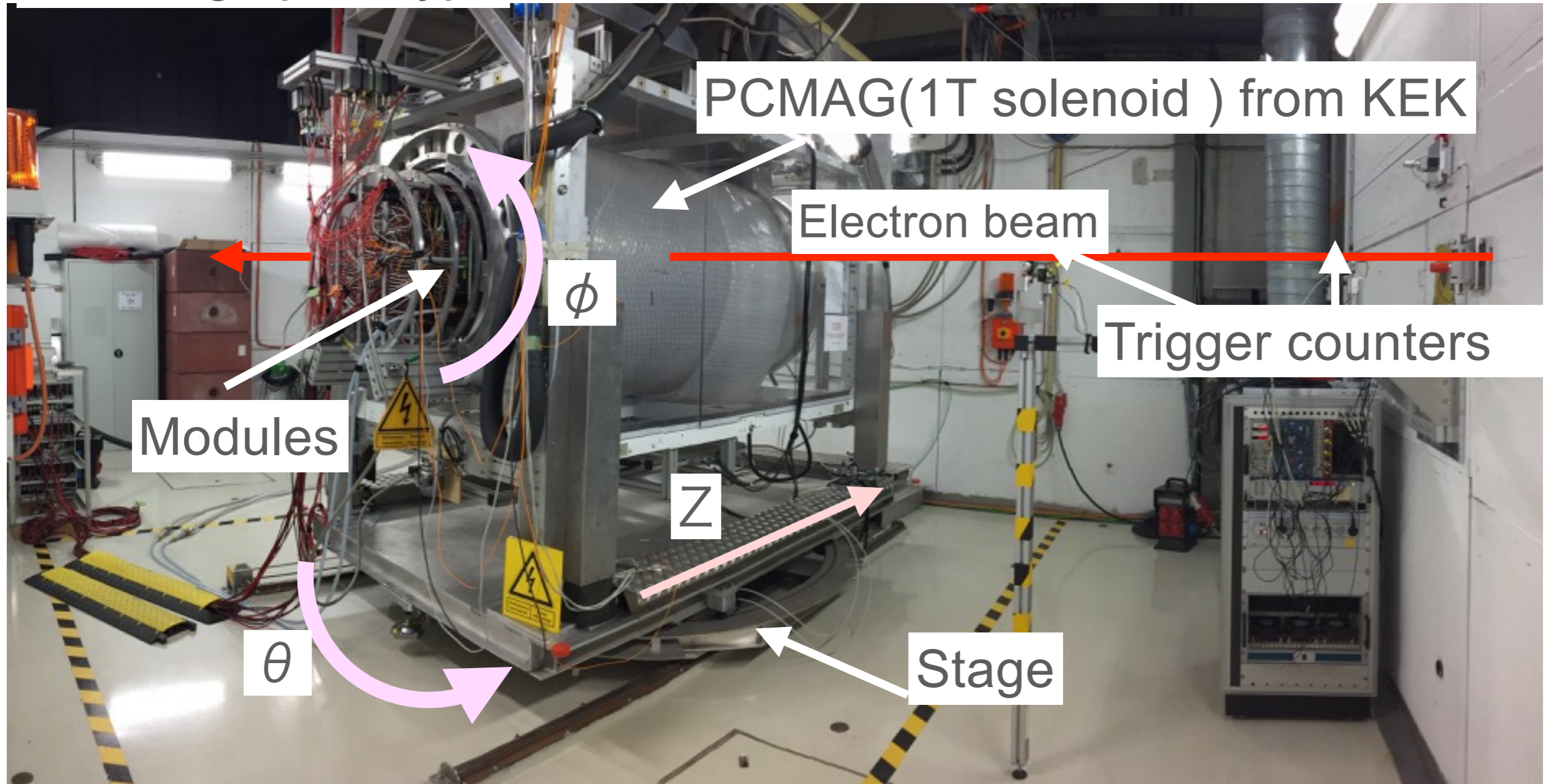




# Setup

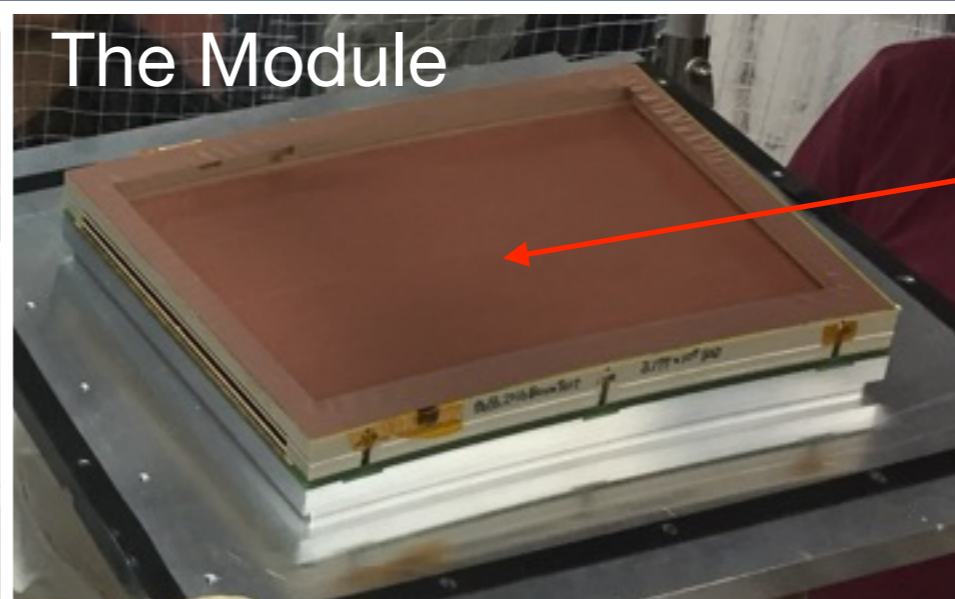
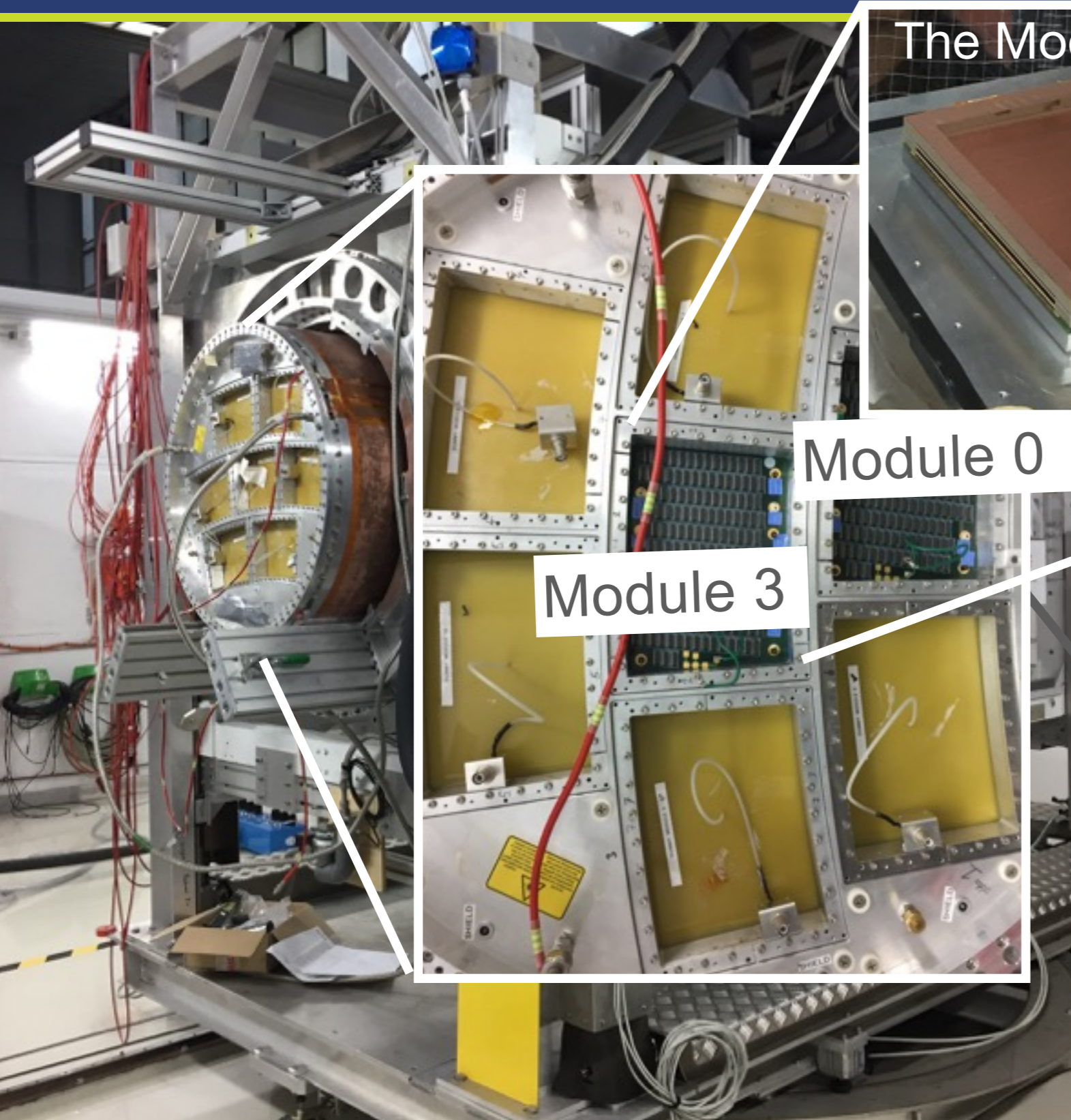


## TPC large prototype





# Module with Gating GEM

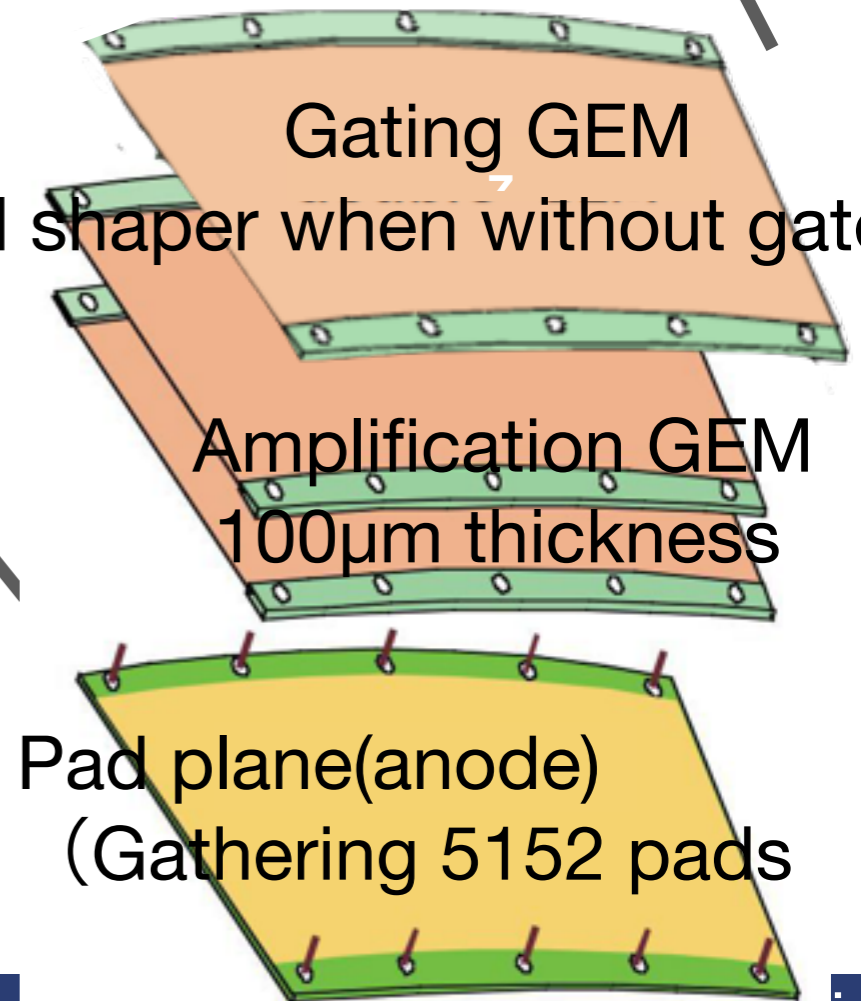


Gating GEM

Module 0

Module 3

(A field shaper when without gate)



Gating GEM

Amplification GEM  
100 μm thickness

Pad plane (anode)  
(Gathering 5152 pads)

# 実験条件



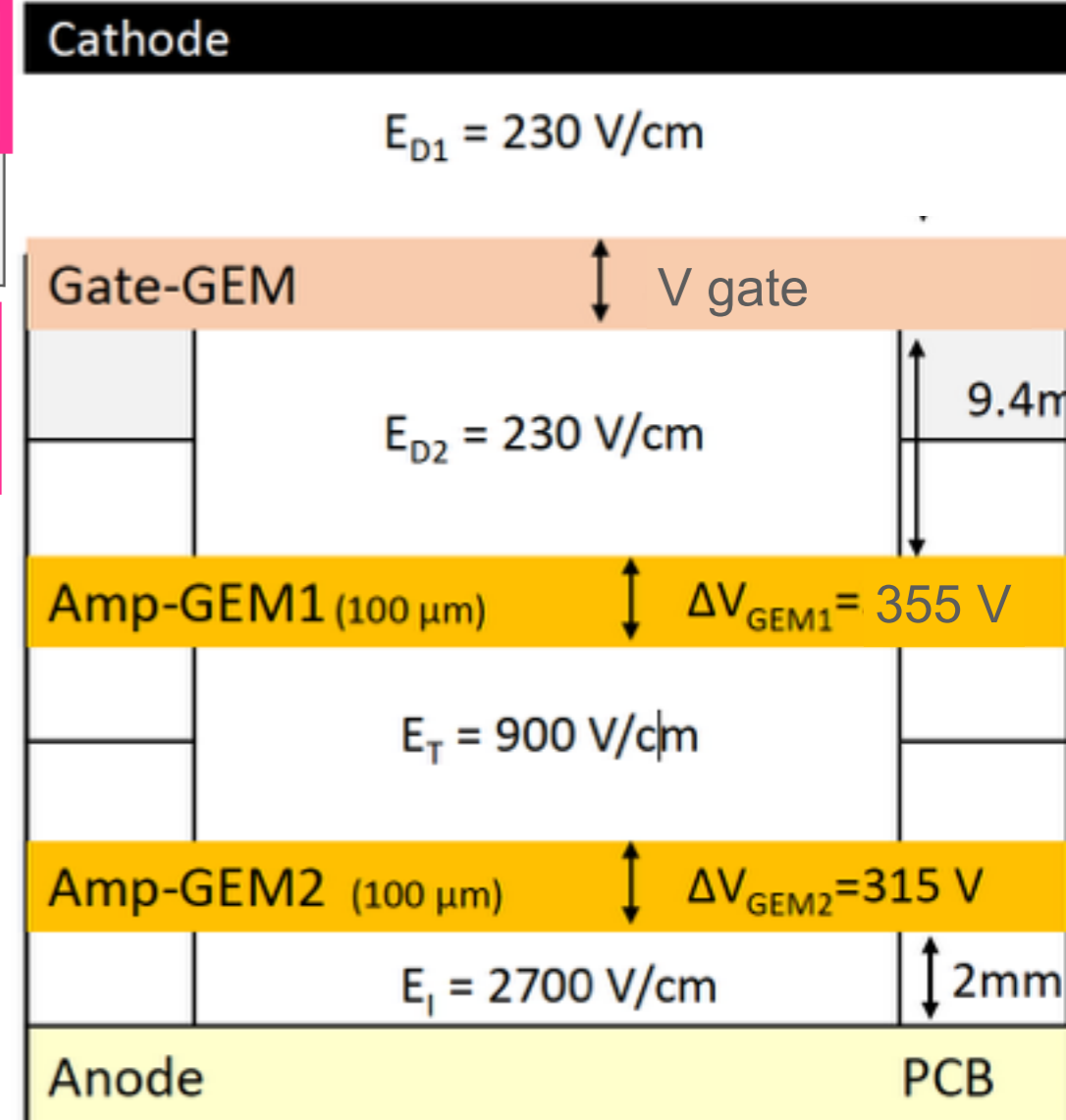
Module 3	With Gating GEM	Without Gating GEM
Module 0	Without Gating GEM	Without Gating GEM
Z[cm] (Drift length)	1.25,2.5,5,7.5,10,12.5,15,20 25,30,35,40,45,50,55	
$\phi$ [degree]	0,10,20	
$\theta$ [degree]	-20,-10,0,10,20	
$V_{\text{gate}}$ [V]	-3.5,0,3.5	
B[T]	0,1	

Analyze condition of

Beam: 5 GeV electron

Gas:T2K gas (Ar : CF<sub>4</sub> : Iso-C<sub>4</sub>H<sub>10</sub> = 95 : 3 : 2 [%])

Analytics framework:MarlinTPC (Analysis 20000 event/1 run)

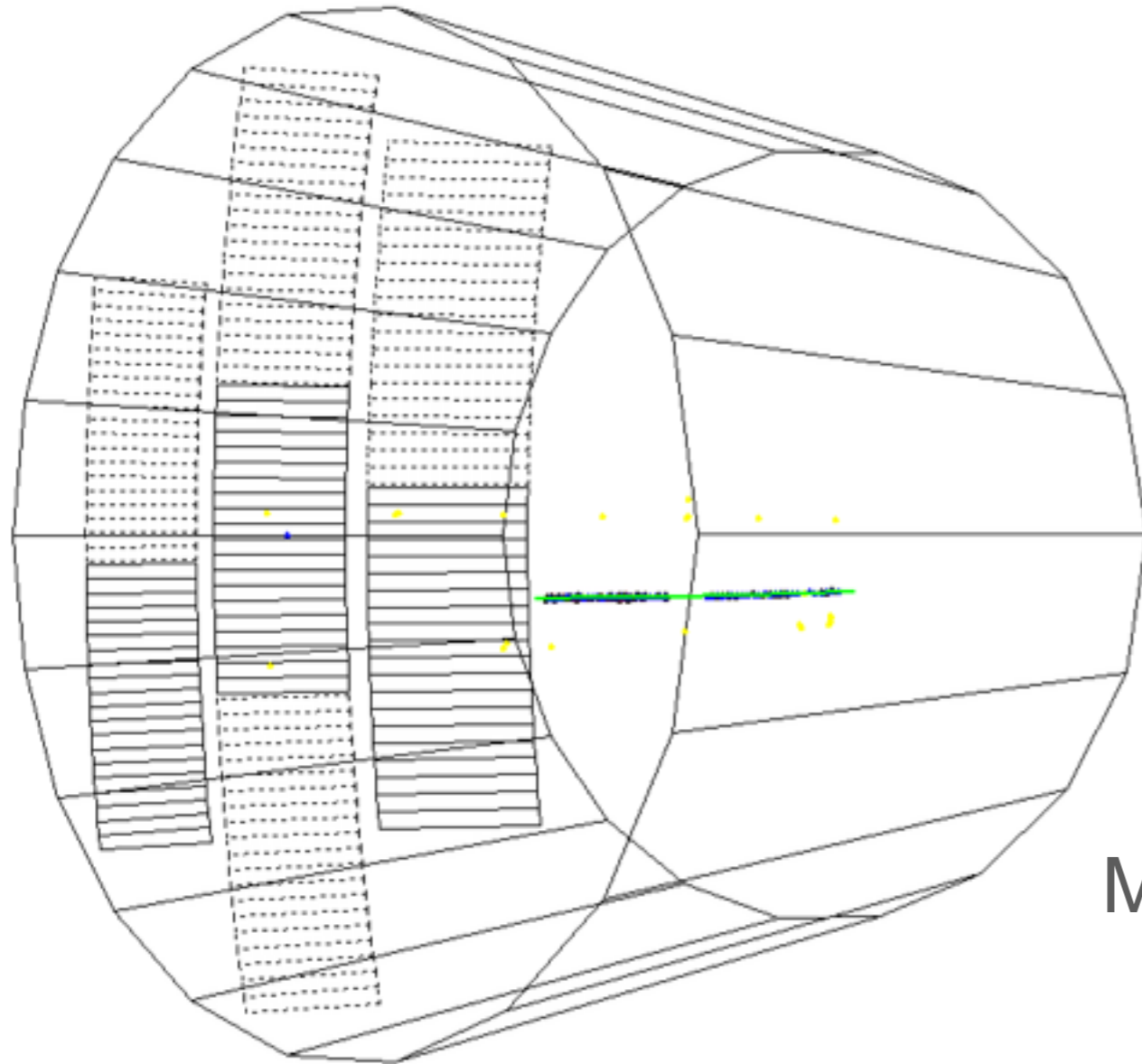




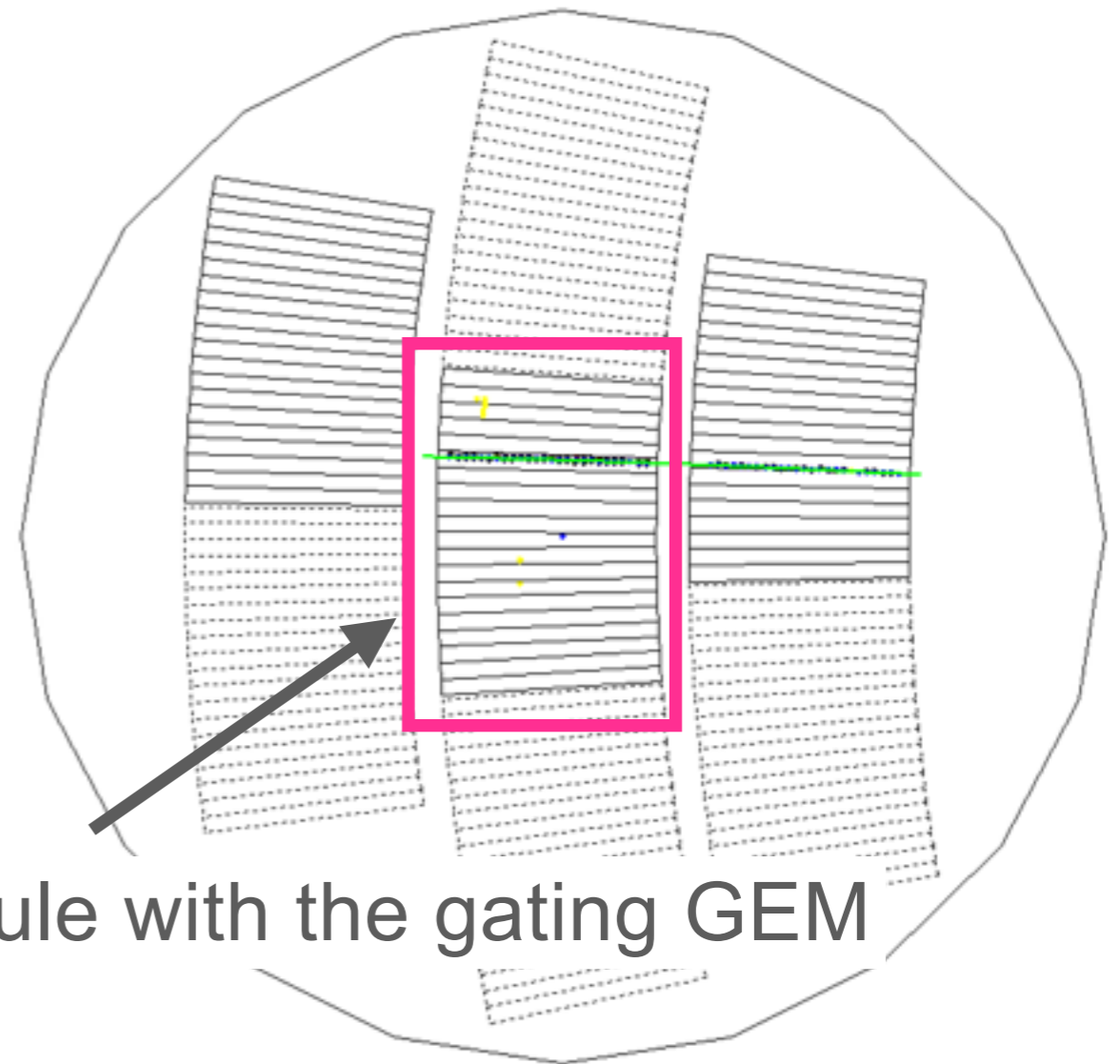
# Typical event



From side



From top



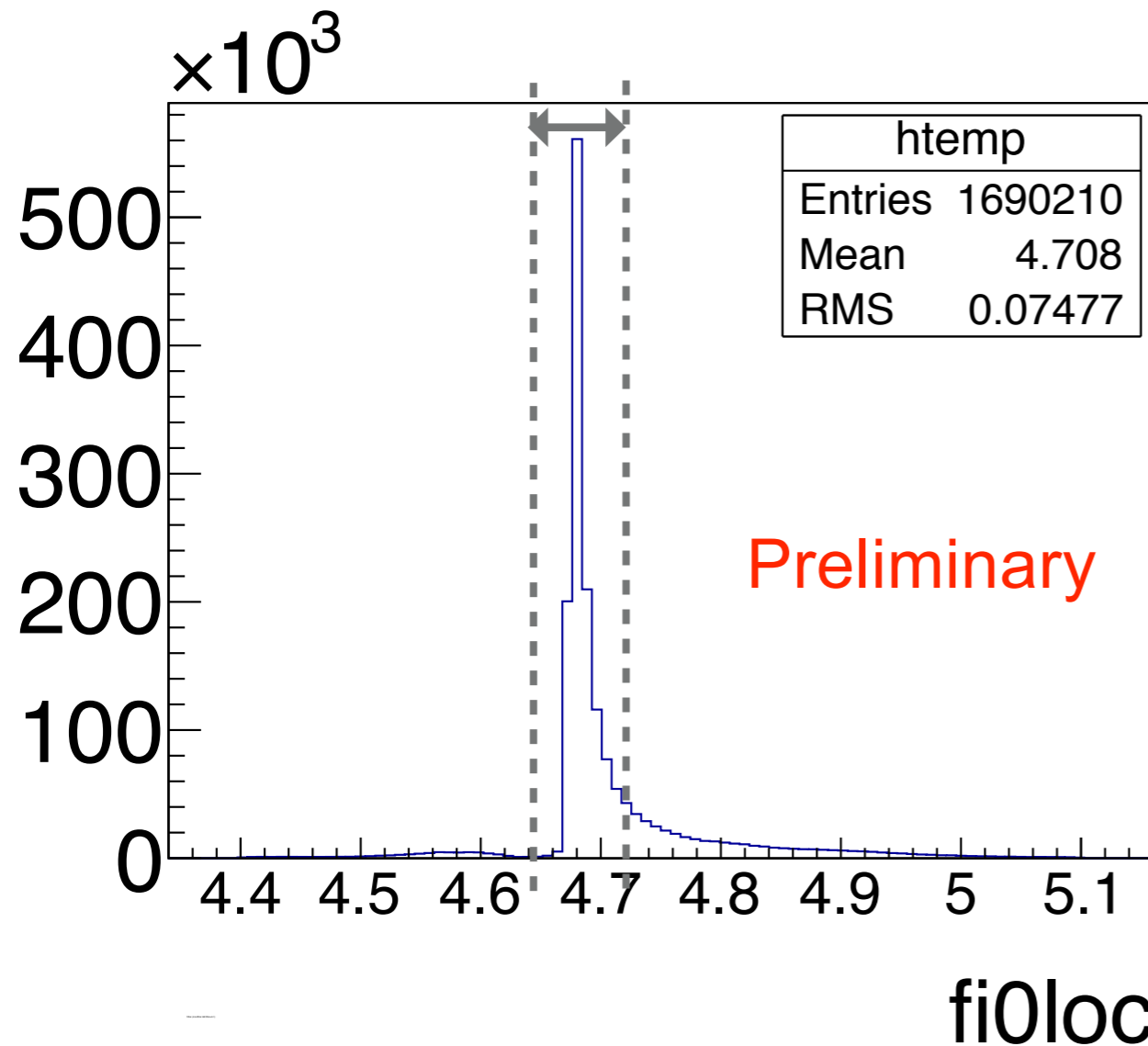
Module with the gating GEM

An electron goes through our module with our gating device far from edge.

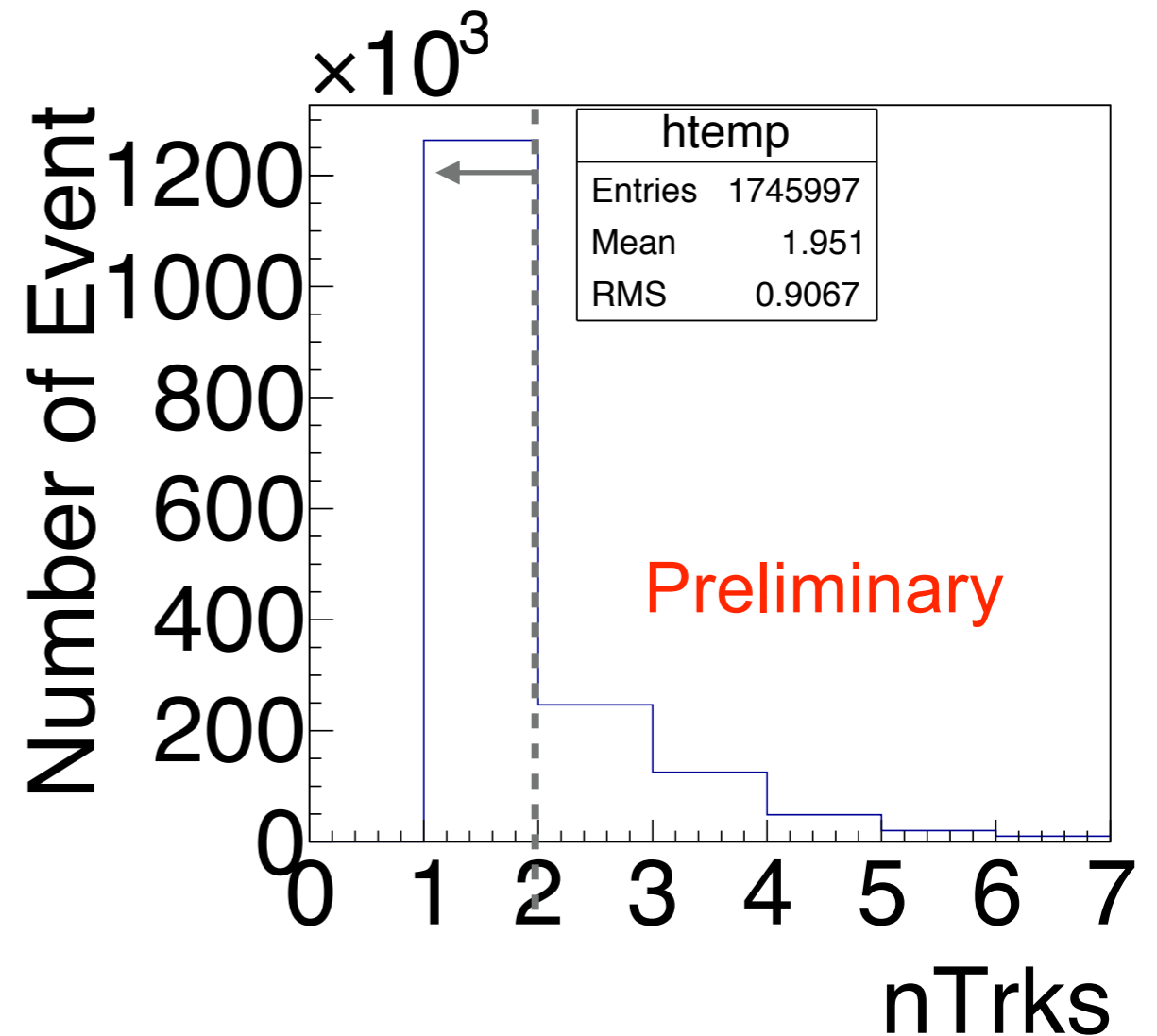
# Event Selection



Track angle cut[rad]  
 $4.64 < \phi_0 < 4.72$



# of tracks per event  
 $nTrks = 1$



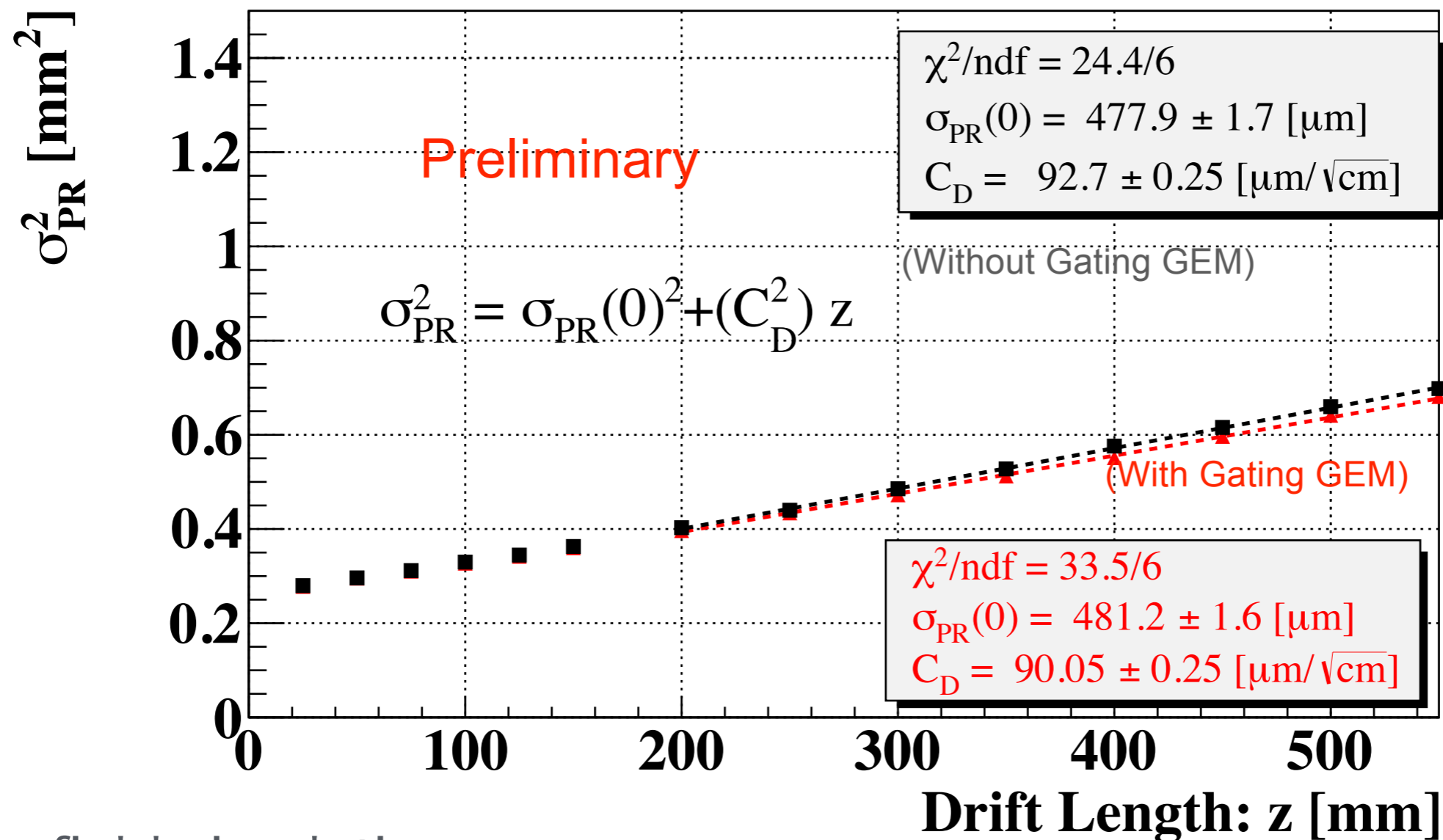
I applied a track angle cut to exclude angled tracks and a cut on nTrks to eliminate events with multiple tracks caused by electromagnetic shower in the upstream.



# Pad response



## Pad Response (Module3 Row16)



Garfield simulation

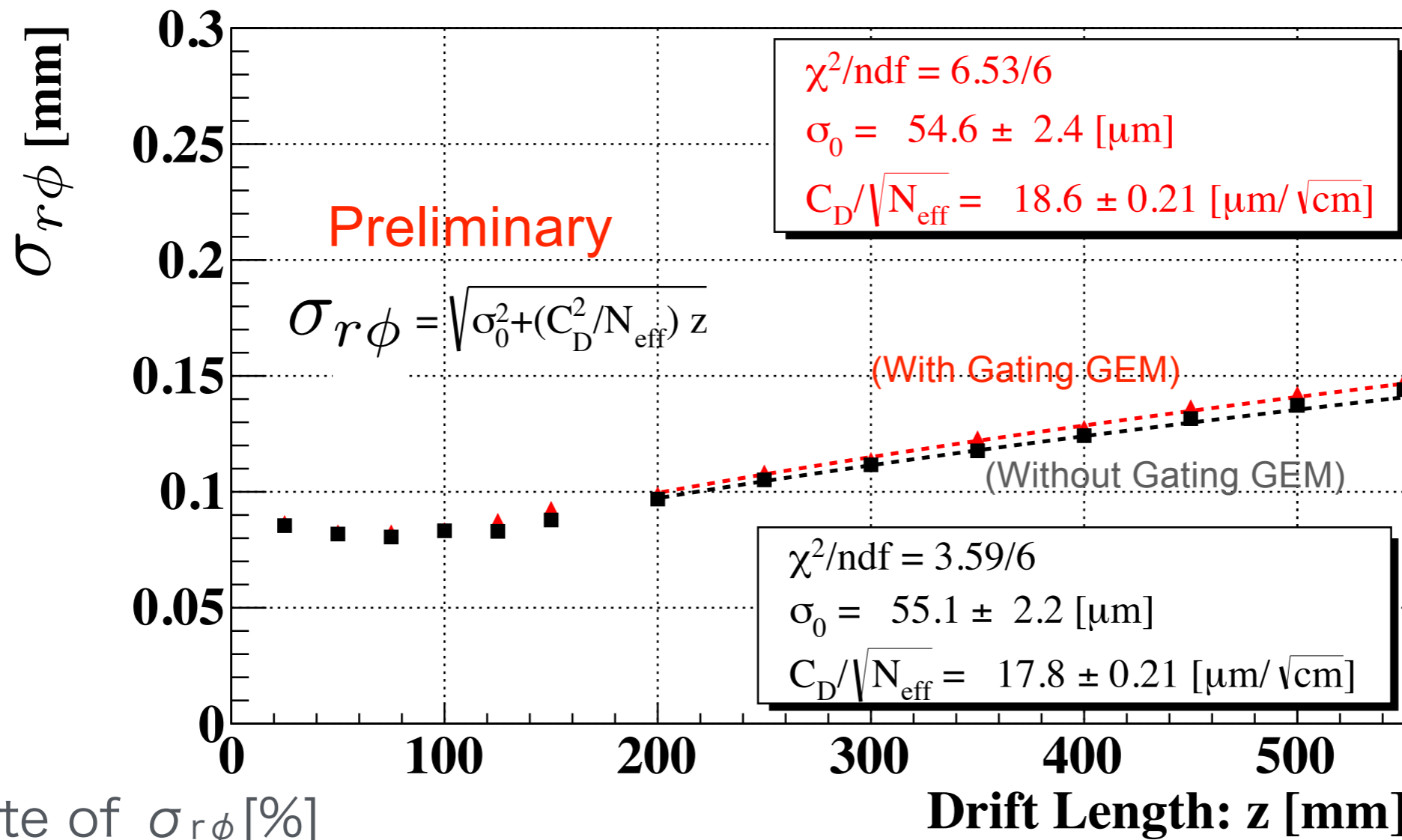
Cd(condition with gating GEM) 94.0  $\mu\text{m}/\sqrt{\text{cm}}$  +/- 0.2%

Cd(condition without gating GEM) 94.2  $\mu\text{m}/\sqrt{\text{cm}}$  +/- 0.3%

# GM resolution ( $r\phi$ )



## GM Resolutin (Module3 Row16)



	2.5	5	7.5	10	12.5	15	20	25	30	35	40	45	50	55
Ratio /%	101.7 ±0.1	101.2 ±0.1	102.9 ±0.1	100.7 ±0.1	105.8 ±0.1	105.8 ±0.1	102.4 ±0.1	103.3 ±0.1	102.1 ±0.1	104.8 ±0.1	103.0 ±0.1	104.0 ±0.1	103.8 ±0.1	102.7 ±0.2

Expected rate : 110 %

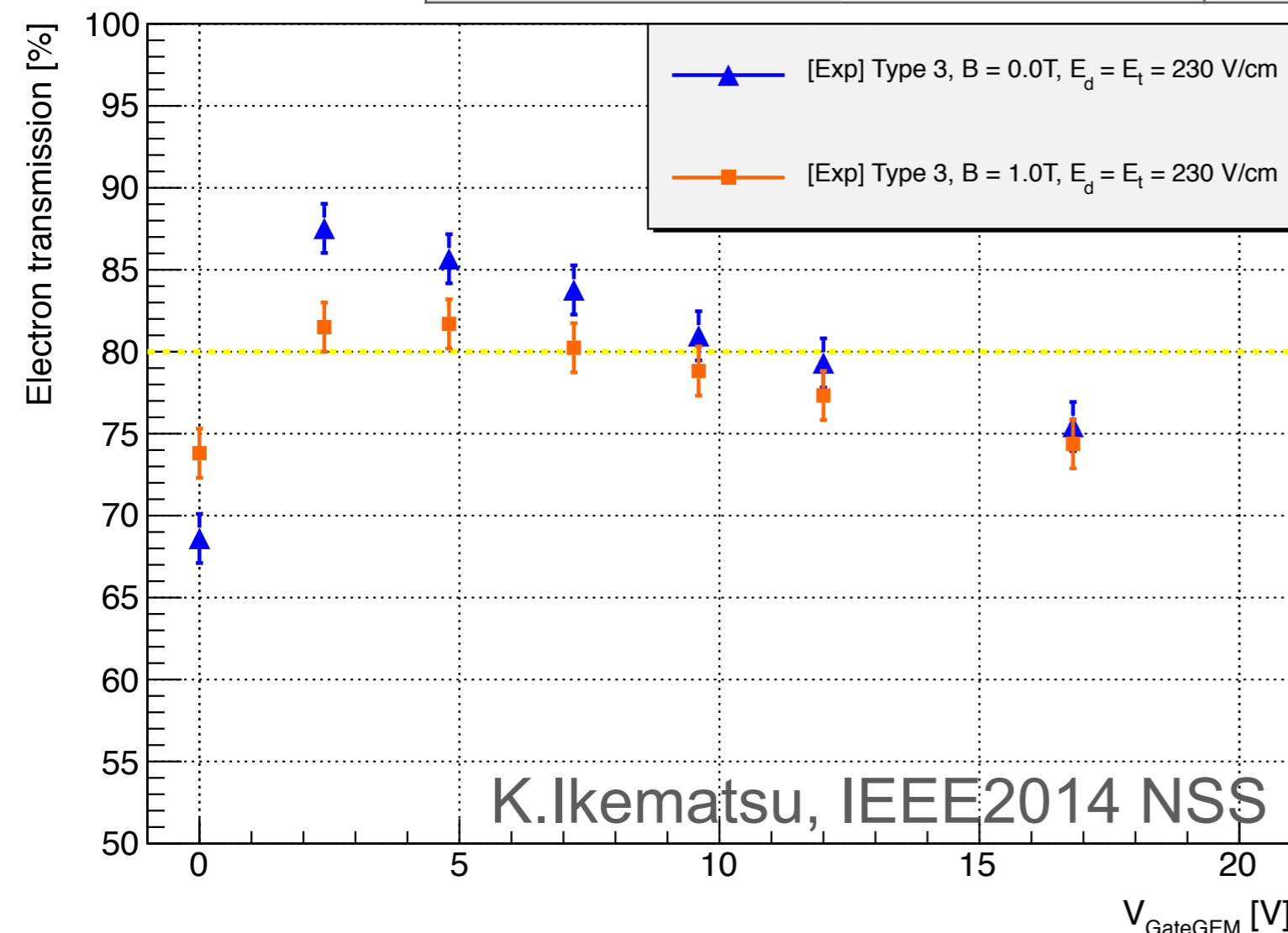
Preliminary(Stat. only)



# Electron transmission rate



Used Cd values [ $\mu\text{m}/\sqrt{\text{cm}}$ ]	$N_{\text{eff}}$ (With gate)	$N_{\text{eff}}$ (Without gate)	rate[%]
measurement	$23.4 \pm 0.6$	$27.1 \pm 0.7$	$86.4 \pm 3.0$
Simulation	$26.7 \pm 0.7$	$30.0 \pm 0.9$	$89.1 \pm 3.3$



The electron transmission rate estimated by  $N_{\text{eff}}$  is more than 80%

$N_{\text{eff}}$  used the measurement Cd value is more nearer the measurement result of the small prototype  $\approx 82\%$ .

The electron transmission by using Fe55 source 10cm $\times$ 10cm prototype(1 T)

We succeeded the first beam test of a GEM-readout TPC module with a large aperture GEM-like gating device



The electron transmission by using the measurement is  $86.4 \pm 3.0\%$

We achived the electron transmission rate benchmark.

The problem

The difference of Cd with/without gating GEM

We pursuit of causes by comparison of the result of module 0 which measured in same time.