

**Measurements of the electron transmission rate  
of a full-size gating GEM  
in the absence of magnetic field**

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**Aiko Shoji ( Iwate University )**

**on behalf of**

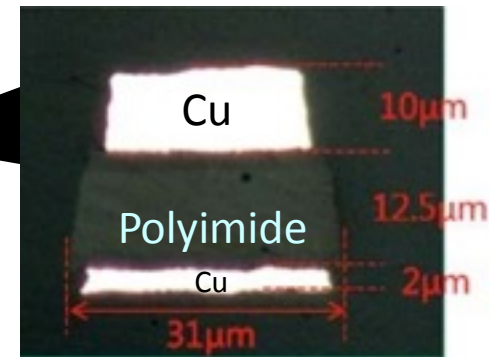
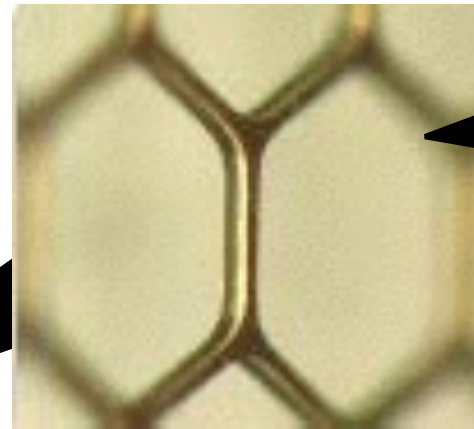
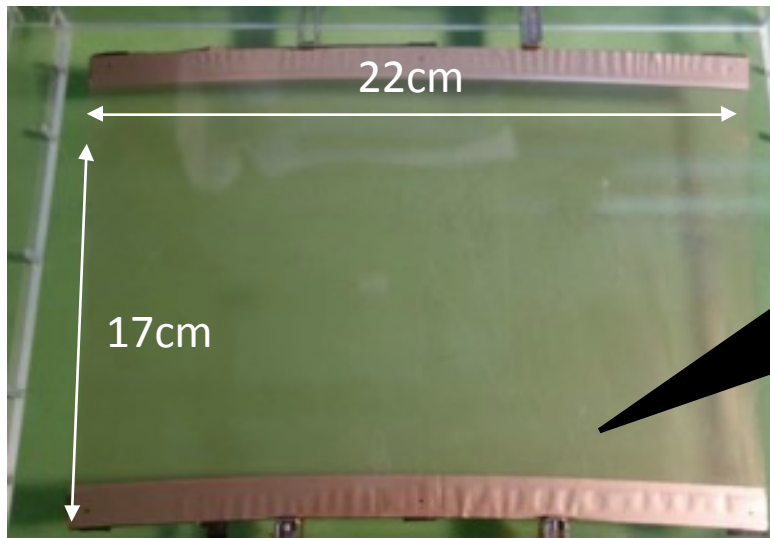
**the LC-TPC Asian group**

## Outline of My Talk

1. Brief Introduction
2. Measurement Technique
3. Measurement using an  $^{55}\text{Fe}$  Source
4. Measurement using a UV Laser
5. Summary and Outlook
6. Brief Discussion

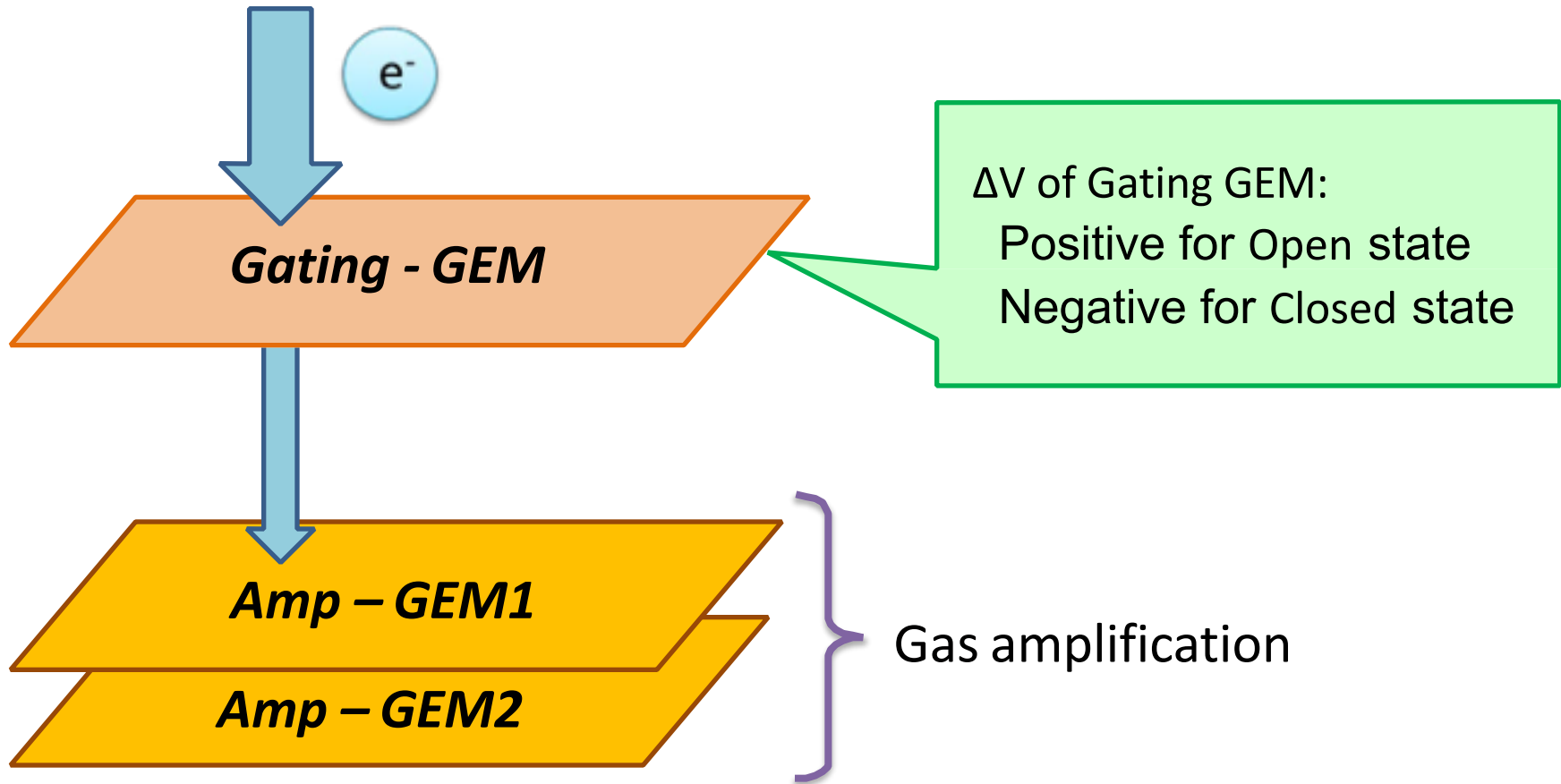
# Introduction

- ILC TPC problem: Ion Back Flow -> Distortion of reconstructed tracks
- Expected Function of Gating GEM for ILC-TPC:  
High Transparency for drift electrons at the OPEN state, and high blocking power for positive ions at the CLOSED state.



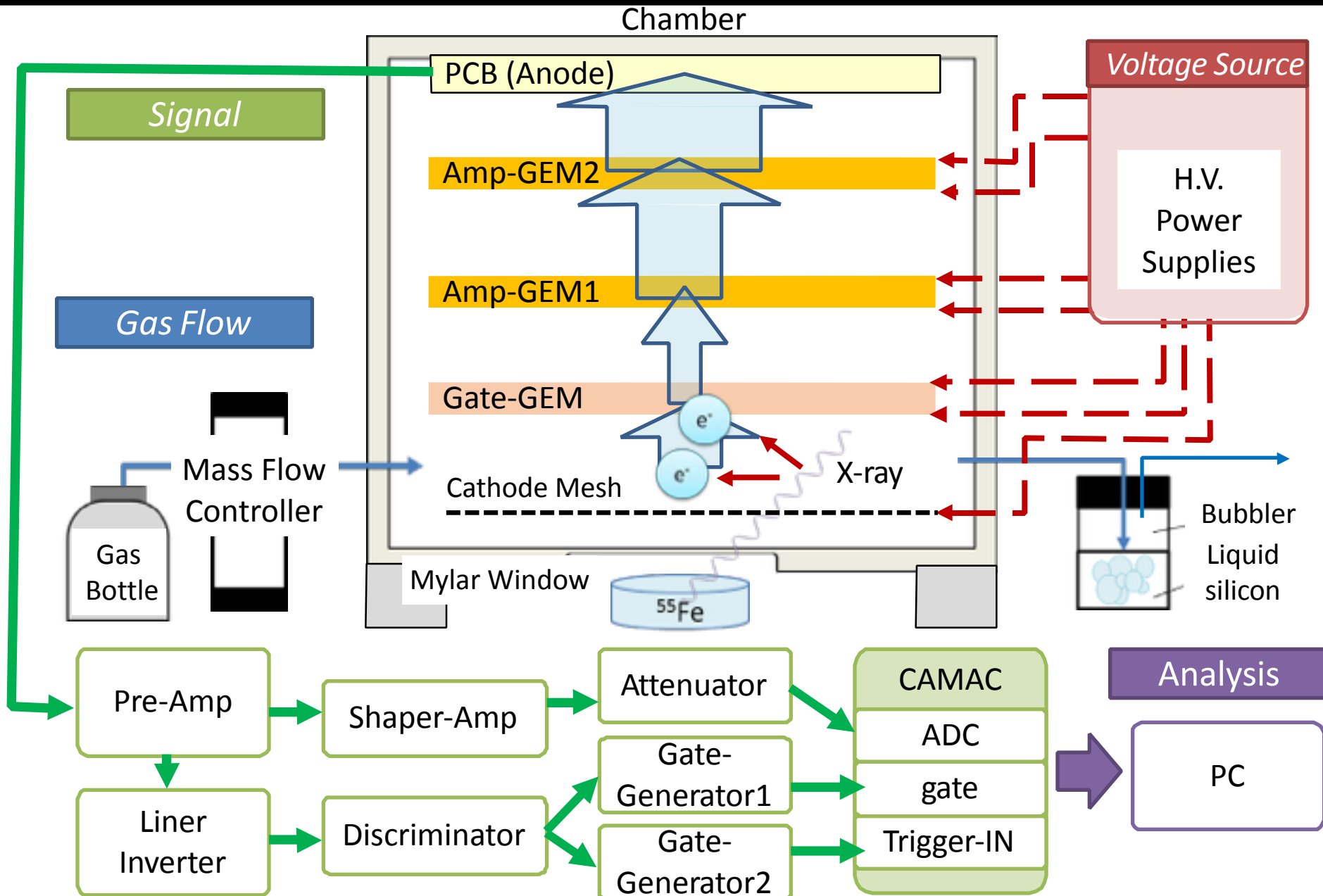
We measured the ELECTRON blocking power at the closed state as well the transmission rate at the open state using a full-size gating GEM in order to

- estimate the lower limit for the blocking power for positive ions, and
- study possibility for the application to TPCs, for which drift electrons needs to be efficiently prevented from entering the gas amplification region.

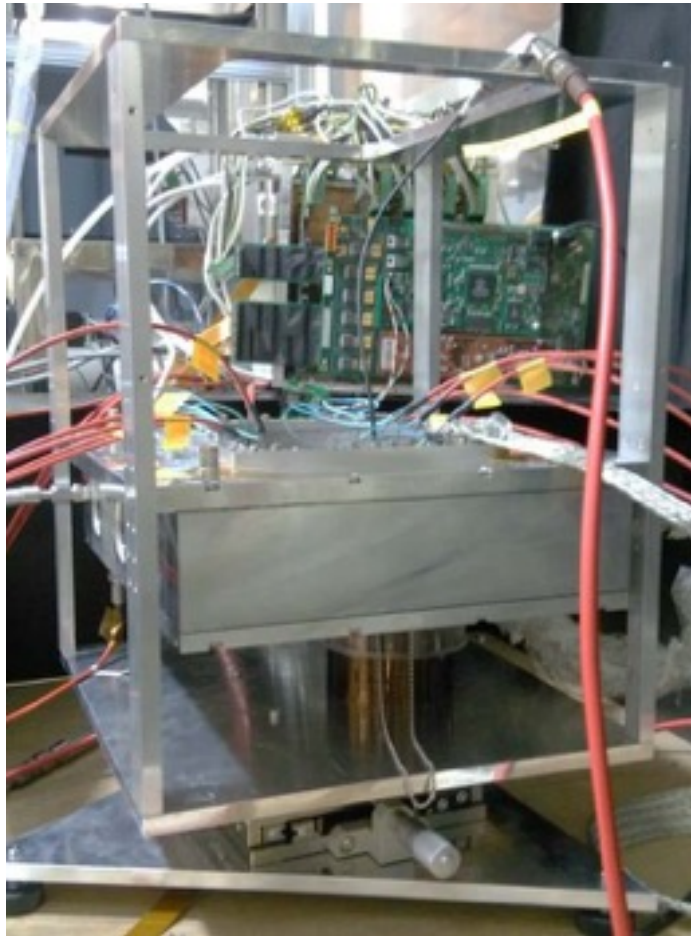


We measured the electron transmission (blocking) rate as a function of  $\Delta V$  by observing the gas-amplified signals generated by an  $^{55}\text{Fe}$  source or a UV laser.

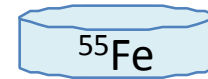
# Experimental Setup using an $^{55}\text{Fe}$ Source



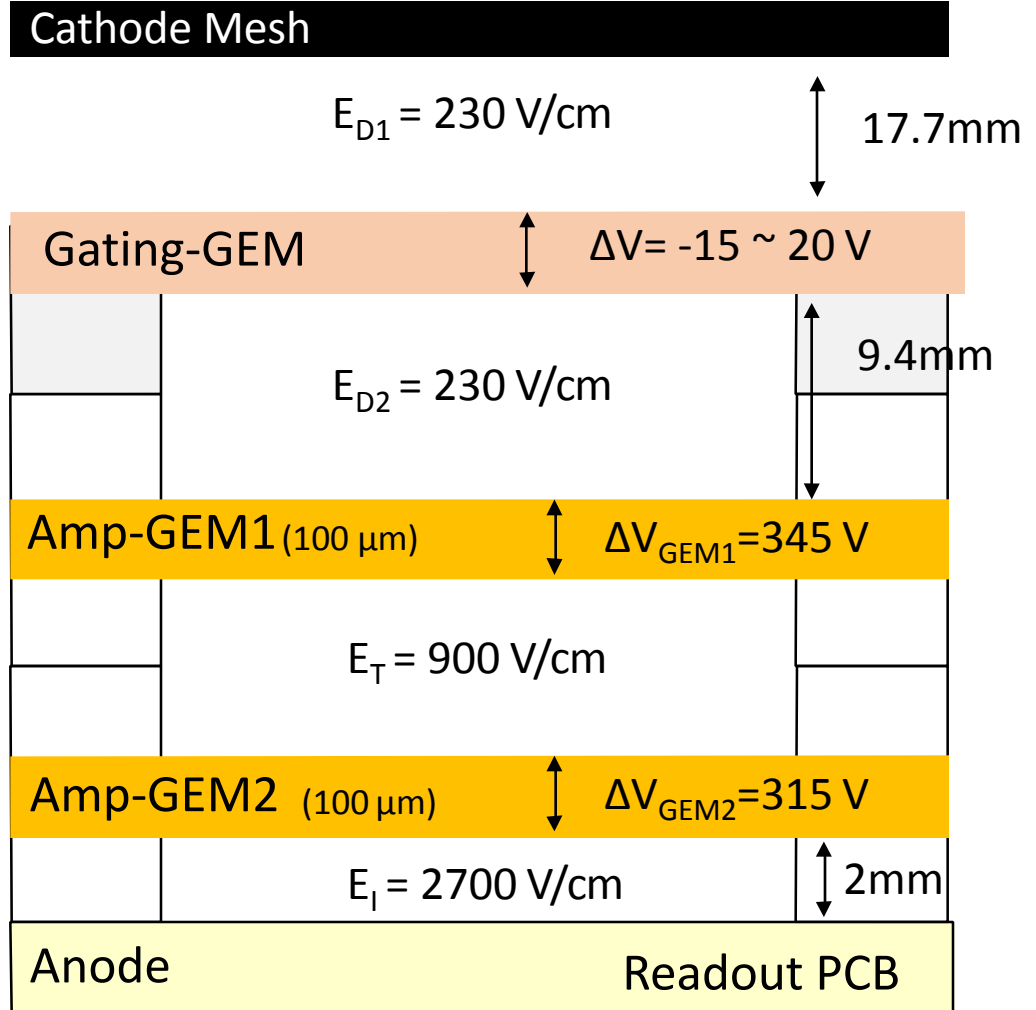
# Experimental Setup using an $^{55}\text{Fe}$ Source



Chamber



X-ray ( $E=5.9\text{ keV}$ )

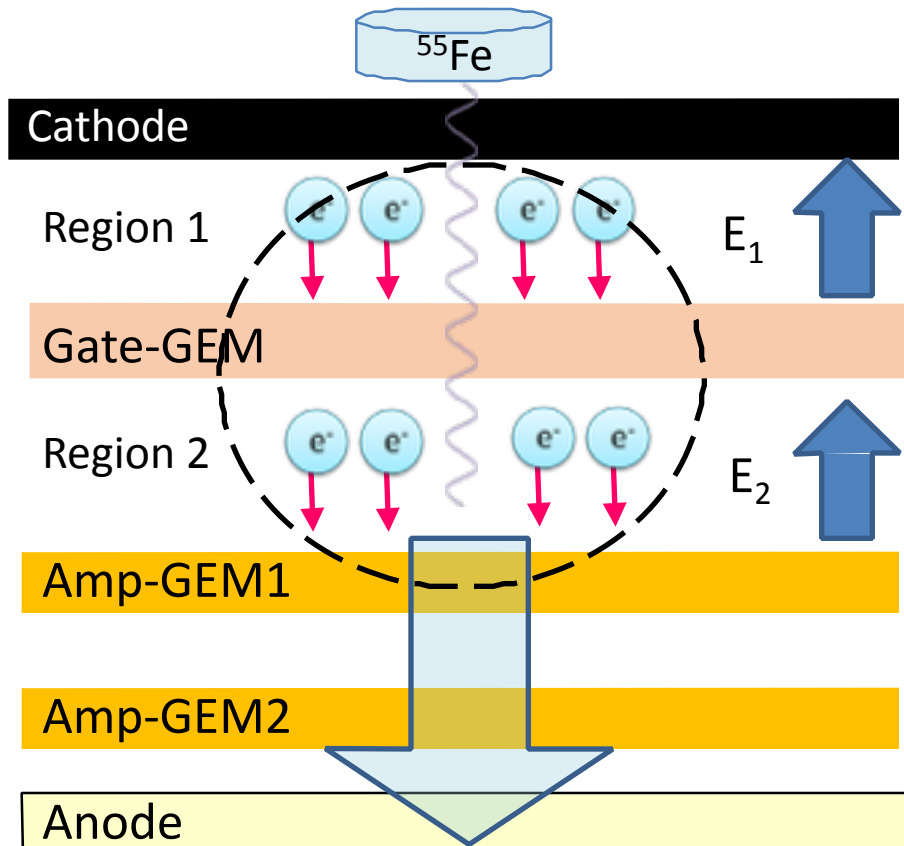


- Used gas  $\rightarrow$  Ar :  $\text{CF}_4$  : Iso- $\text{C}_4\text{H}_{10}$  = 95 : 3 : 2 [%] (T2K gas)

# Measurement using $^{55}\text{Fe}$

We measured the signals with the normal and reversed drift fields for each  $\Delta V$ .

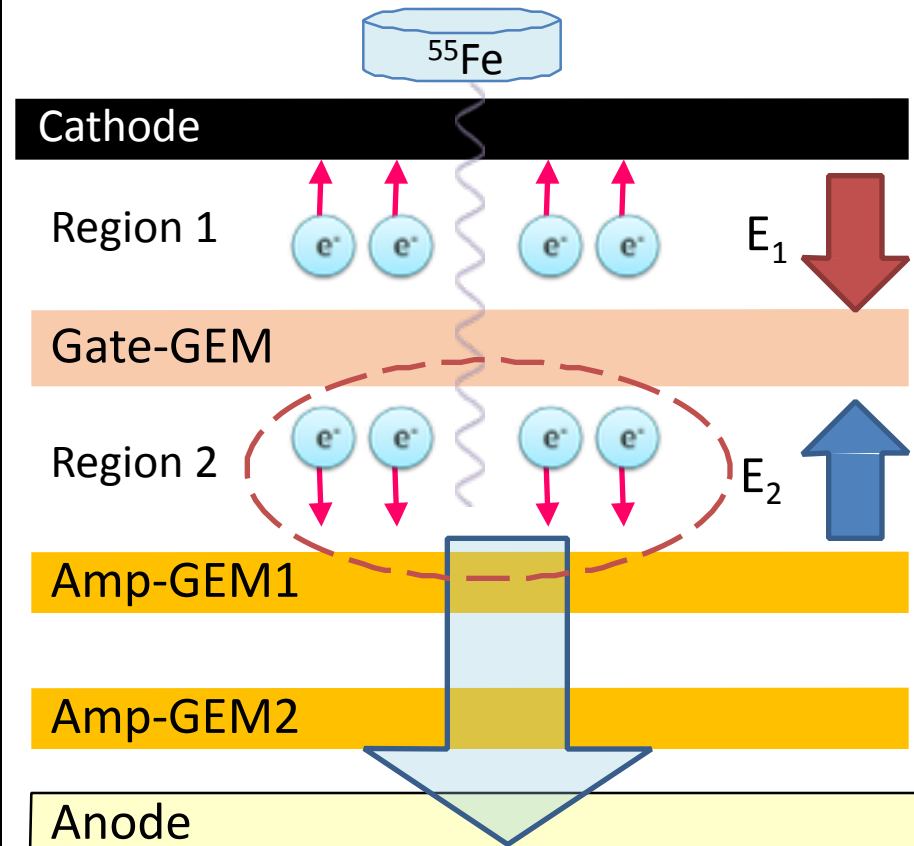
## Normal Drift Field



Signal :

electrons from both region 1 and region 2

## Reversed Drift Field



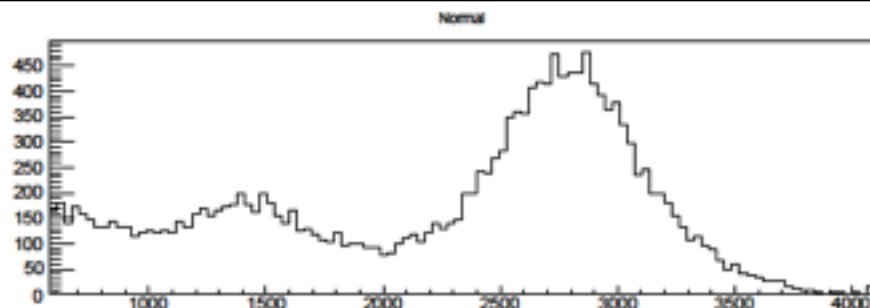
Signal :

electrons only from region 2 (full signal)

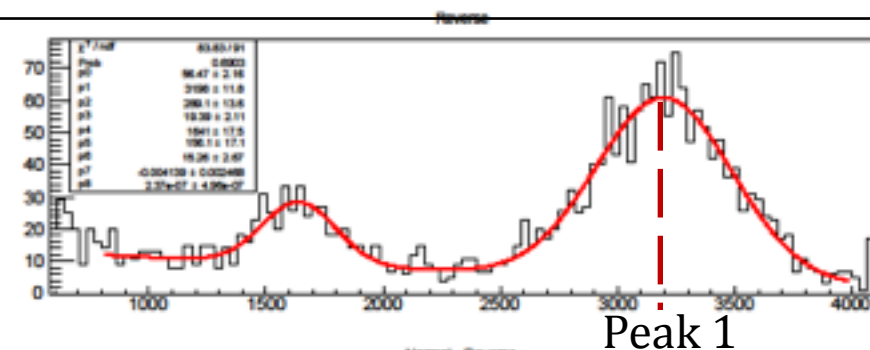
# Measurement using $^{55}\text{Fe}$

Examples of the pulse height distribution ( $\Delta V_{\text{Gate-GEM}} = +2.5\text{V}$ )

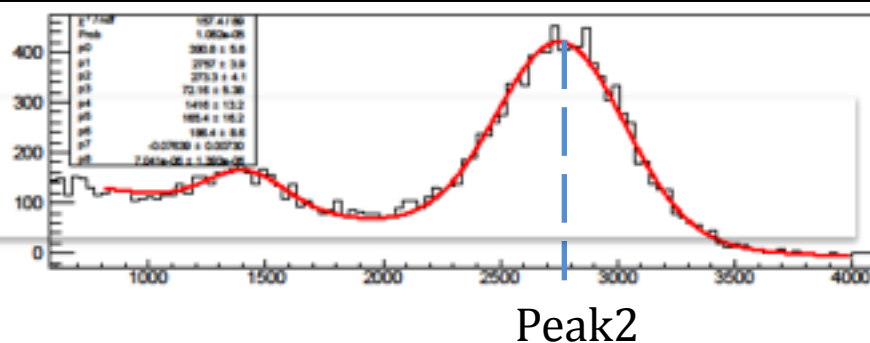
(1) Normal Drift Field  
signals from the both regions  
10-minute run



(2) Reversed Drift Field  
signals only from region 2  
(full signal charge)  
10-minute run

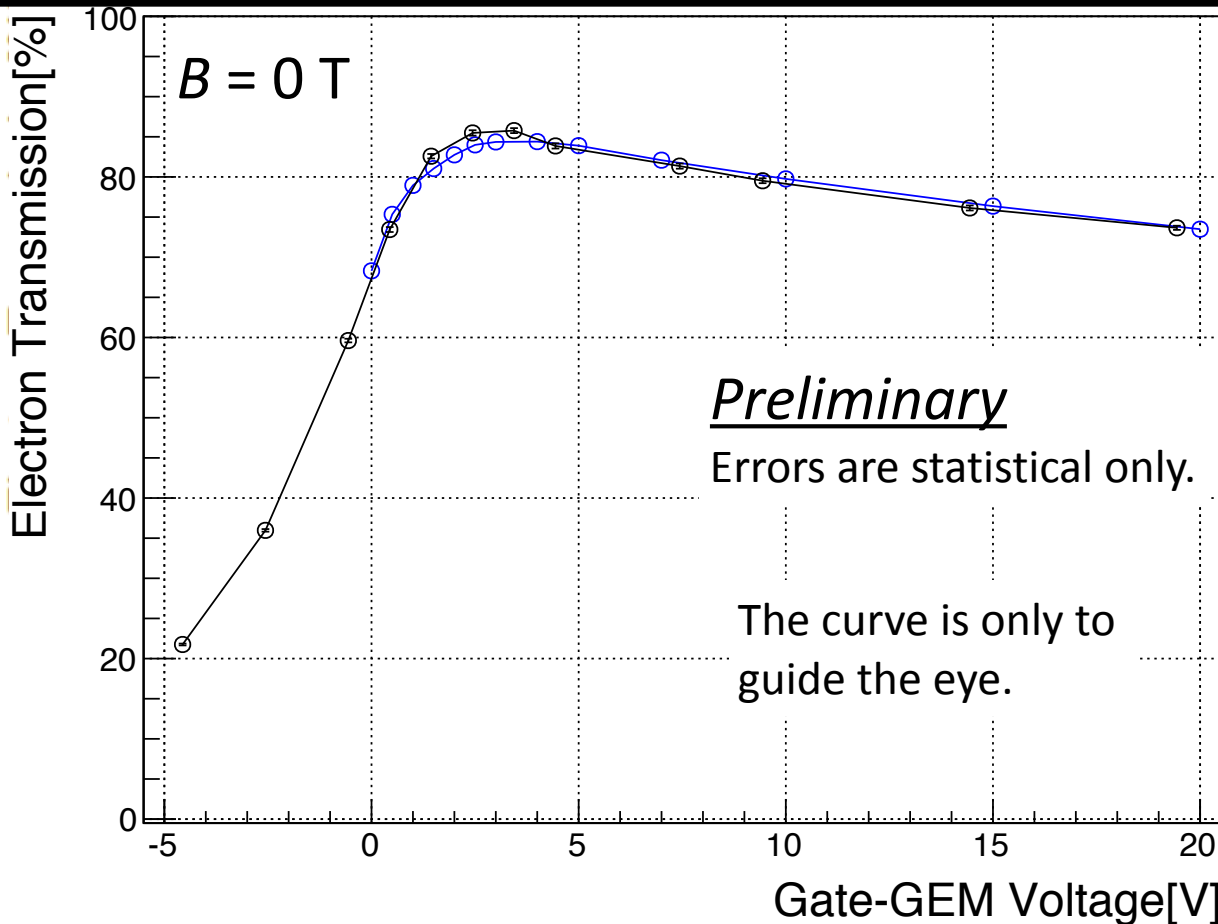


(1) - (2):  
signals only from region 1



$$\text{Transmission rate} = \frac{\text{Peak 1} - \text{Pedestal}}{\text{Peak 2} - \text{Pedestal}} \times 100 \quad [\%]$$





black circle :

Data points

blue circle :

K. Ikematsu,

Conference Record

DOI: [10.1109/NSSMIC.2014.7431237](https://doi.org/10.1109/NSSMIC.2014.7431237)

- The maximum transmission rate is about 86% at around  $\Delta V = +3.5 \text{ V}$ .
- The transmission rate decreases slowly above +3.5 V.
- It decreases rapidly with increasing negative  $\Delta V$ .
- The measurement is difficult below  $\Delta V = -4.5 \text{ V}$  because of small signals.

# Experimental Setup using a Laser

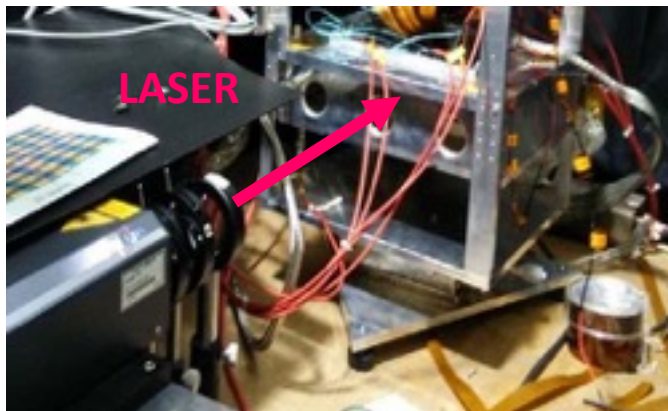
We measured the electron transmission rate at negative  $\Delta V$  using a laser.

Laser

Nd:YAG ( $\lambda = 266 \text{ nm}$ )

Rep. 20 Hz PFN. 95 %

Primary electrons: about 600 / pad row



Cathode

$E_{D1} = 230 \text{ V/cm}$

Gate-GEM

$\Delta V = -1 \sim -15 \text{ V}$

$E_{D2} = 230 \text{ V/cm}$

Amp-GEM1 (100  $\mu\text{m}$ )

$\Delta V_{\text{GEM1}} = 345 \text{ V}$

$E_T = 900 \text{ V/cm}$

Amp-GEM2 (100  $\mu\text{m}$ )

$\Delta V_{\text{GEM2}} = 315 \text{ V}$

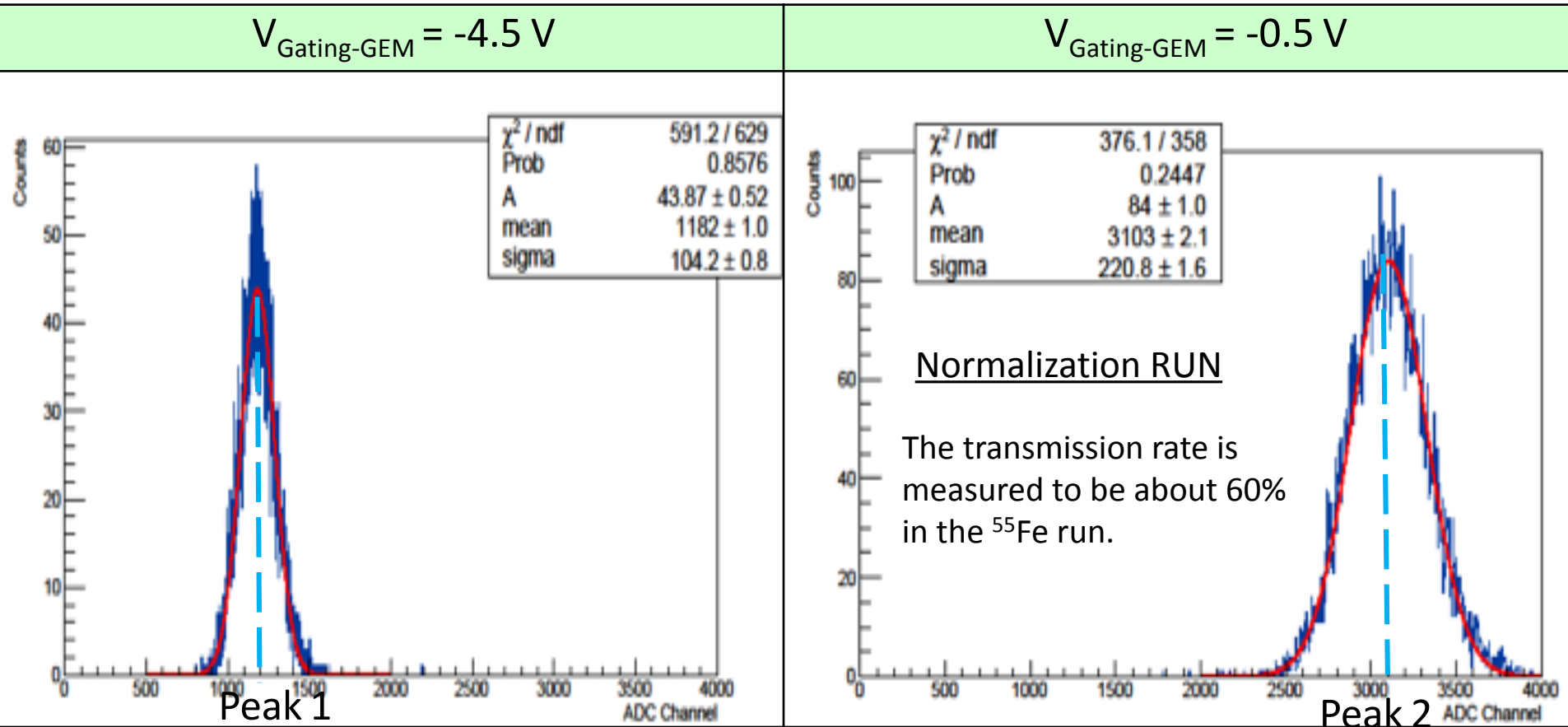
$E_1 = 2700 \text{ V/cm}$

$\updownarrow 2\text{mm}$

PCB

# Measurement using a Laser

## Examples of the pulse height distribution



Normalization RUN

The transmission rate is measured to be about 60% in the  $^{55}\text{Fe}$  run.

$$\text{Transmission rate} = \frac{\text{Peak 1} - \text{Pedestal}}{\text{Peak 2} - \text{Pedestal}} \times \underline{0.6} \times 100 \text{ [\%]} \quad \text{Pedestal} = 55.0$$

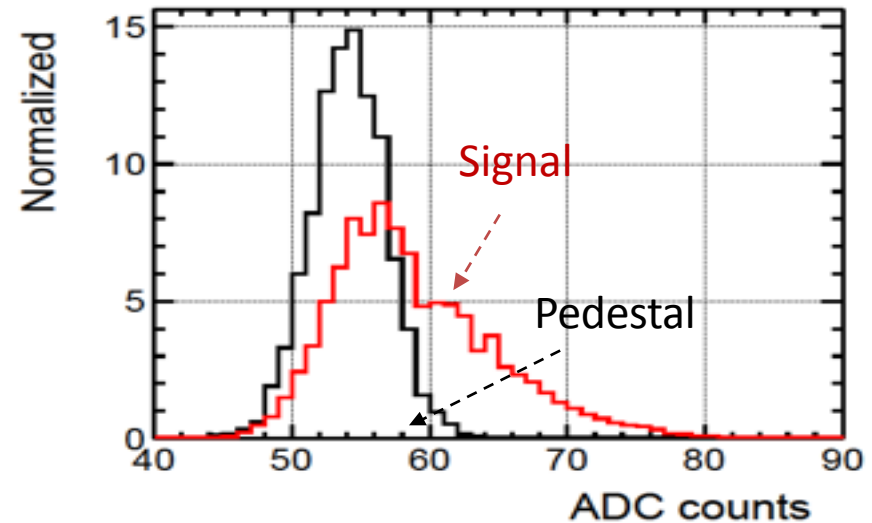
Transmission rate at  $V_{\text{Gating-GEM}} (\Delta V) = -0.5 \text{ V}$  measured with  $^{55}\text{Fe}$

Example:  $V_{\text{Gating-GEM}} = -14.5 \text{ V}$

## Raw Pulse Height Distributions

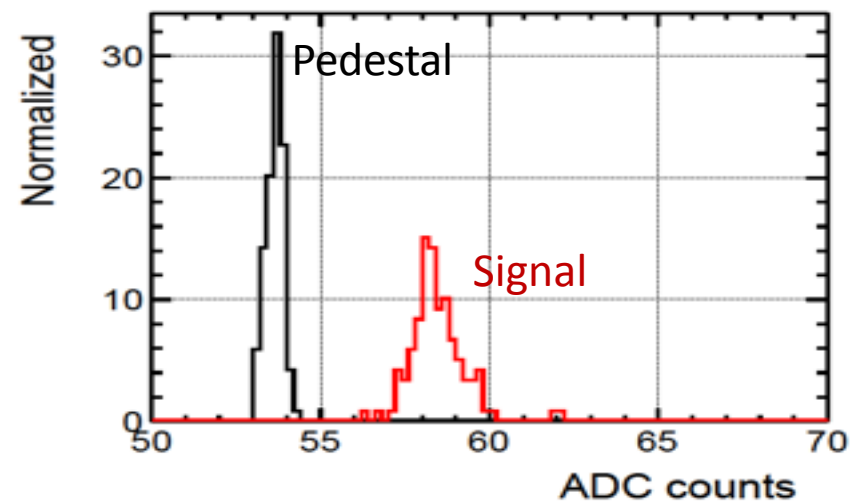
The signal is not well separated from the pedestal (noise) distribution.

The average laser signal can be obtained by taking the average of the distribution.



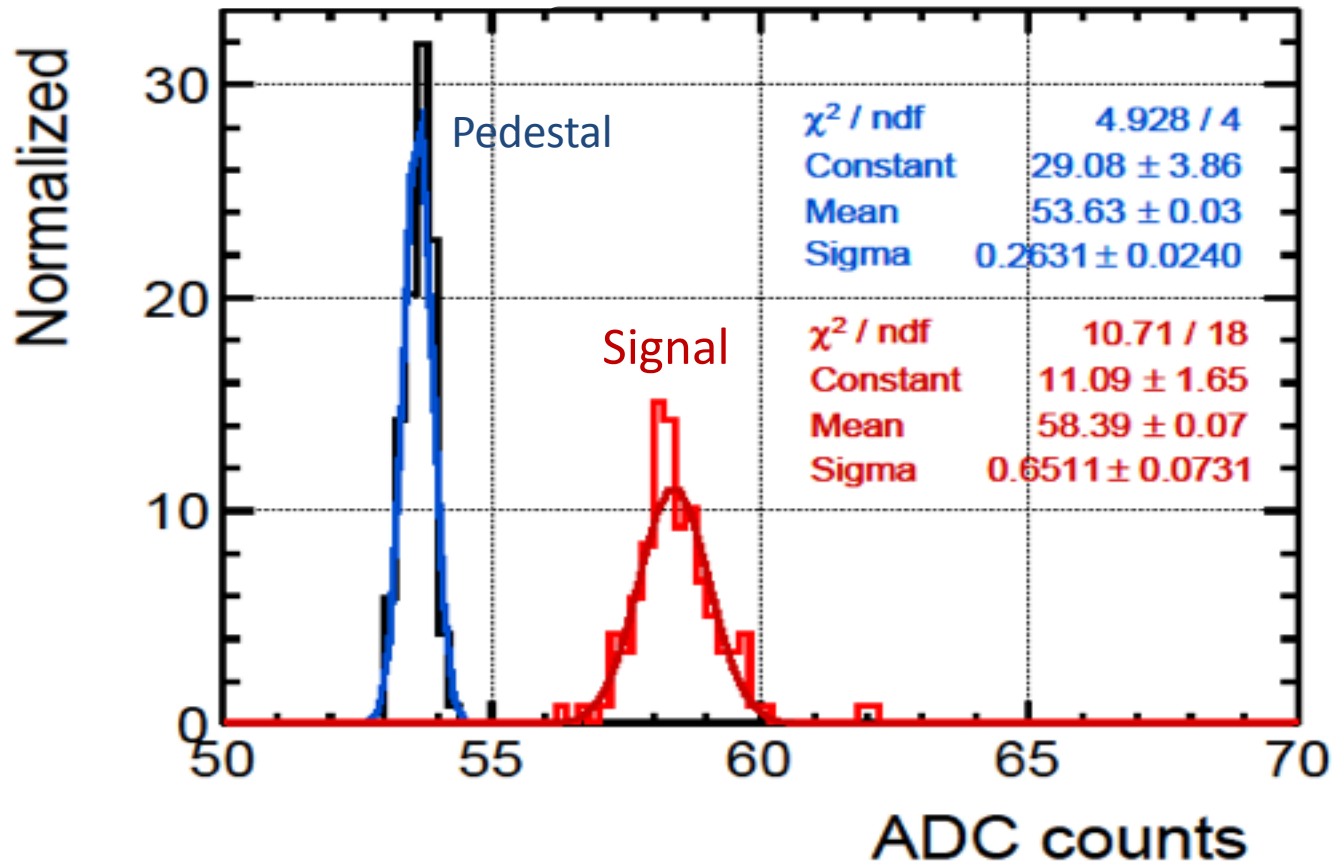
## Distribution of the averages taken for several hundreds of signals (pedestals).

The existence of the laser signal is clear, and the average signal can be estimated by Gaussian fitting.



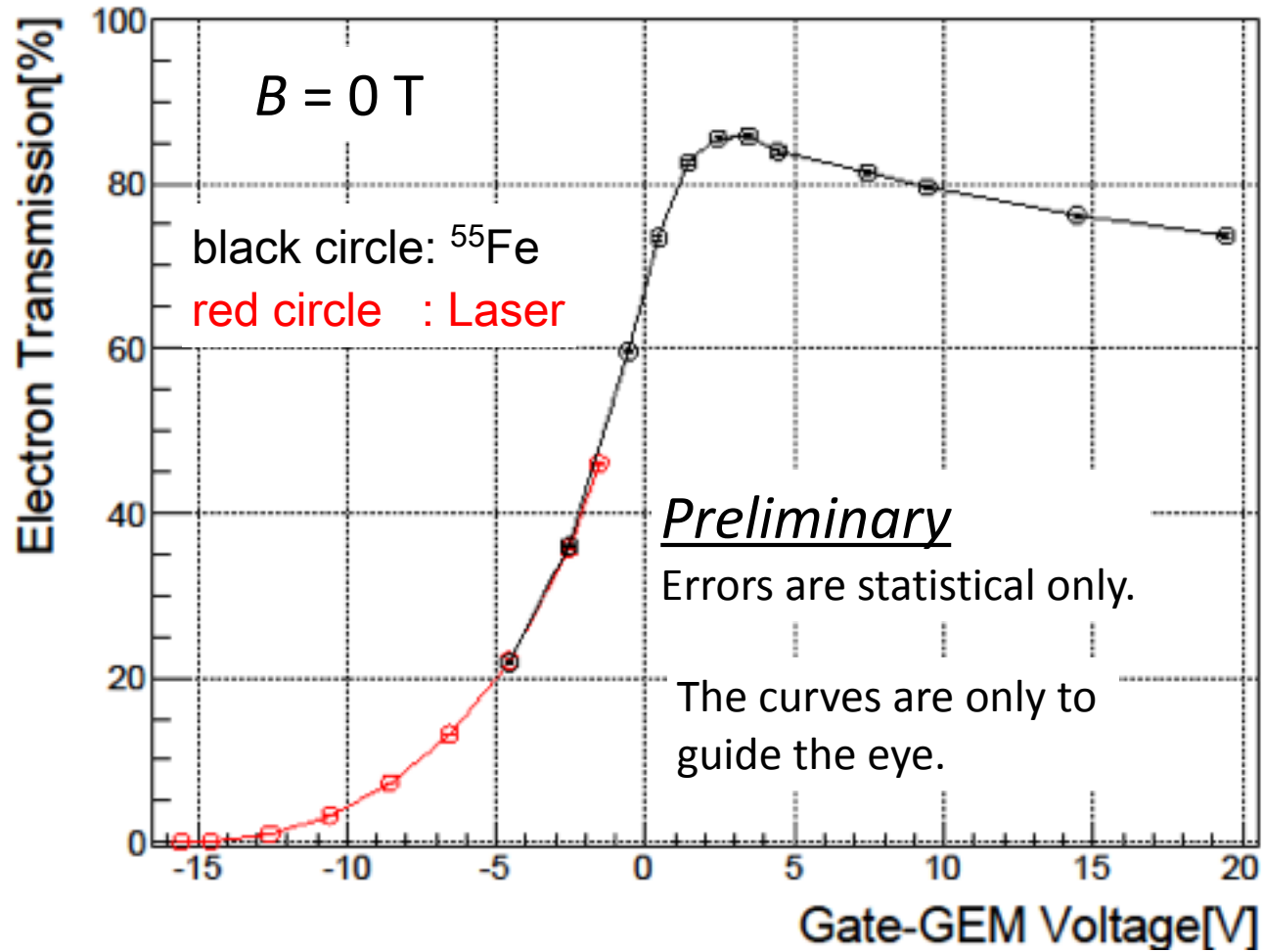
# Measurement using a Laser (for Negatively High $\Delta V$ )

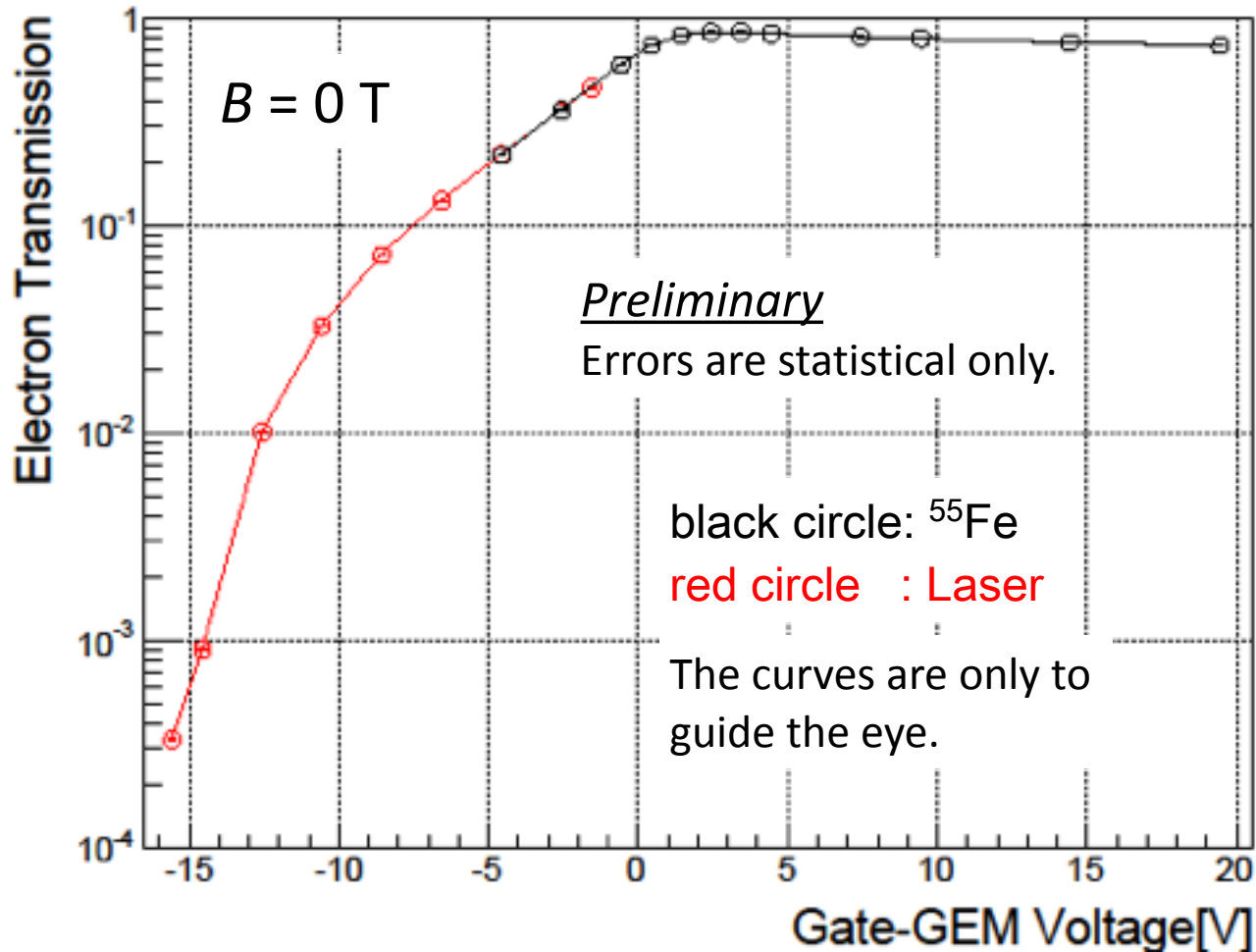
Example:  $V_{\text{Gating-GEM}} = -14.5 \text{ V}$



$$\text{Transmission rate} = \frac{\text{Peak 1} - \text{Pedestal}}{\text{Peak 2} - \text{Pedestal}} \times 0.6 \times 100 \text{ [\%]}$$

with Peak 2 at  $V_{\text{Gating-GEM}} = -0.5 \text{ V}$





- The transmission rate is measured to be as low as  $3.3 \times 10^{-4}$  at  $\Delta V = -15.5 \text{ V}$ .

We have measured the electron transmission rate of a full-size gating GEM as a function of the potential difference ( $\Delta V$ ) for  $\Delta V$  between -15.5 V and +20 V in the absence of axial magnetic field.

- The maximum transmission rate is about 86% at around  $\Delta V = +3.5$  V.
- The transmission rate is measured to be as low as  $3.3 \times 10^{-4}$  at  $\Delta V = -15.5$  V.  
We can expect adequate ion blocking power for the ILC-TPC with the present gating GEM (see discussion below).
- Gating GEM may be applicable to TPCs for which drift electrons needs to be stopped.  
A measurement in an axial magnetic field is necessary in order to prove it.

## Future plan

Direct measurements of the ion back-flow with/without a gating GEM.



If we assume 2000 for the gas gain and define  $F$  as the ion back-flow rate of the amplifying GEMs, the number of positive ions entering the drift volume is expected to be about  $0.66 \cdot F$  per drift electron with a gating GEM at  $\Delta V = -15.5$  V.

It should be noted that the positive ions are thermal, i.e. the diffusion is small. Therefore it is (much) easier to block positive ions than electrons.

In addition, their motion is hardly affected by the presence of a magnetic field.

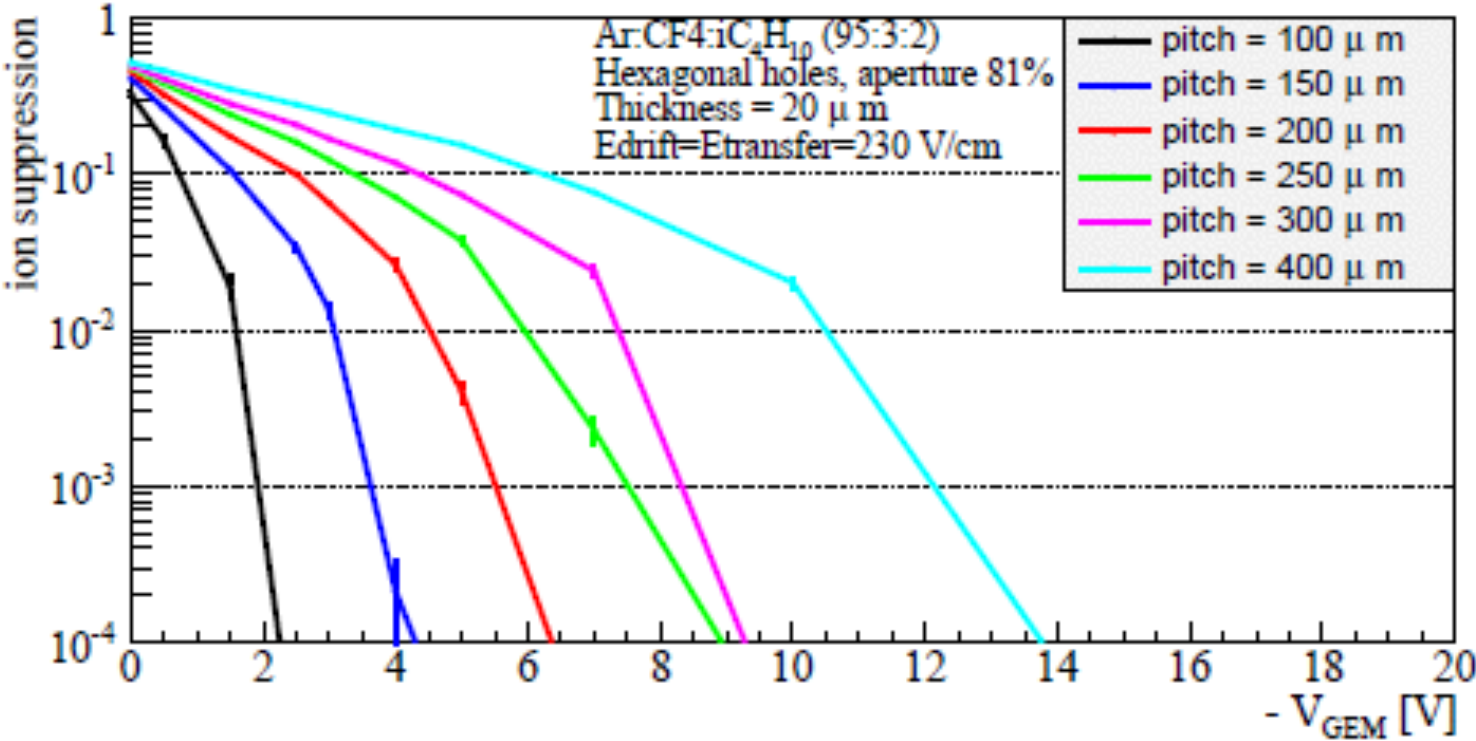
Consequently, the blocking power measured for electrons without magnetic field gives the lower limit for positive ions with a sufficient margin.

For example, if we assume (tentatively) 10% for  $F$  (with respect to the effective gain) the total ion back flow is expected to be (much) less than 0.07 per drift electron at  $\Delta V = -15.5$  V.

See also the next slide for the result of a simulation for the ion back-flow suppression.

**Simulation of the ion suppression (ANSYS + Garfield)**

**P. Gros et al., JINST 8 (2013) C11023**

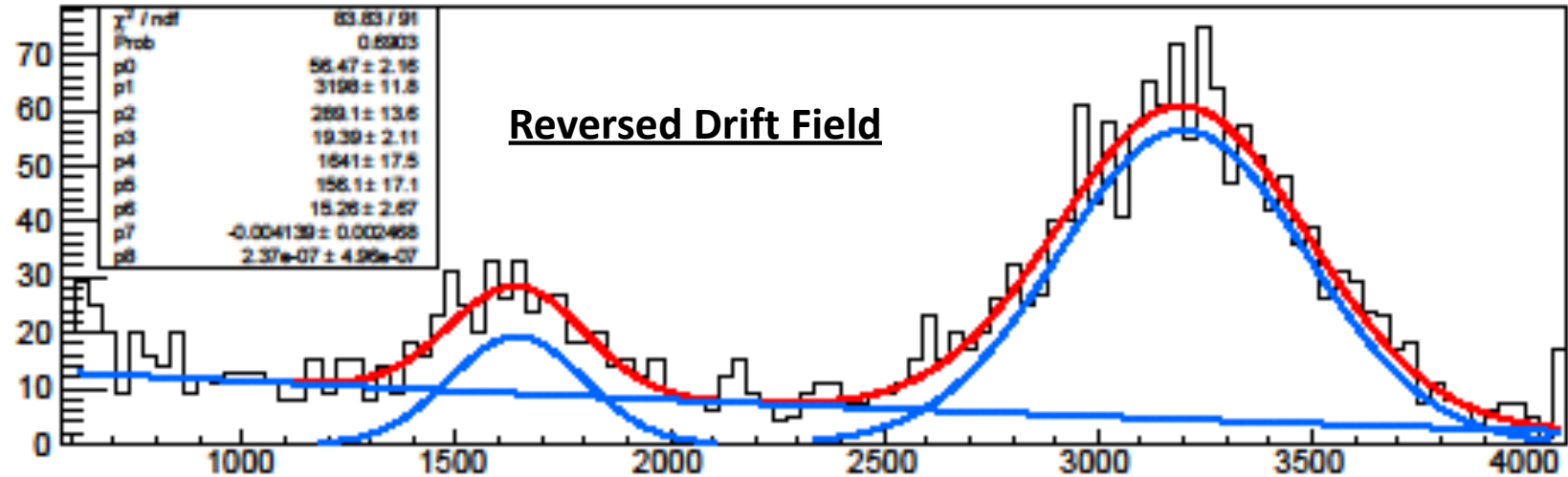


***FIN***

**Thank you for your attention.**

# Fitting of the pulse height distribution of <sup>55</sup>Fe signals with 2 Gaussians and a polynomial (background)

$\Delta V = + 2.5 \text{ V}$



Normal - Reverse

