Gain measurements of GEM detectors with Korean foils

Laura Franconi – Alma Mater Studiorum - Università degli Studi di Bologna (IT)

Andrey Marinov – Universiteit Gent (BE)

Michal Zientek – Wroclaw University of Technology (PL)

Christopher Armaingaud – University of Strasbourg (FR)

Krina Mehta – University of Manchester (GB)

Jeremie Merlin – University of Strasbourg (FR)

On behalf of the GEMs for CMS Collaboration

Outline

- Why use GEMs from Korea
- Gain measurements of detectors with Korean GEMs
  - Single GEM chamber
  - Triple GEM chamber
- Comparison with results of detectors with CERN GEMs
- Conclusion and future plans

Why use Korean GEMs

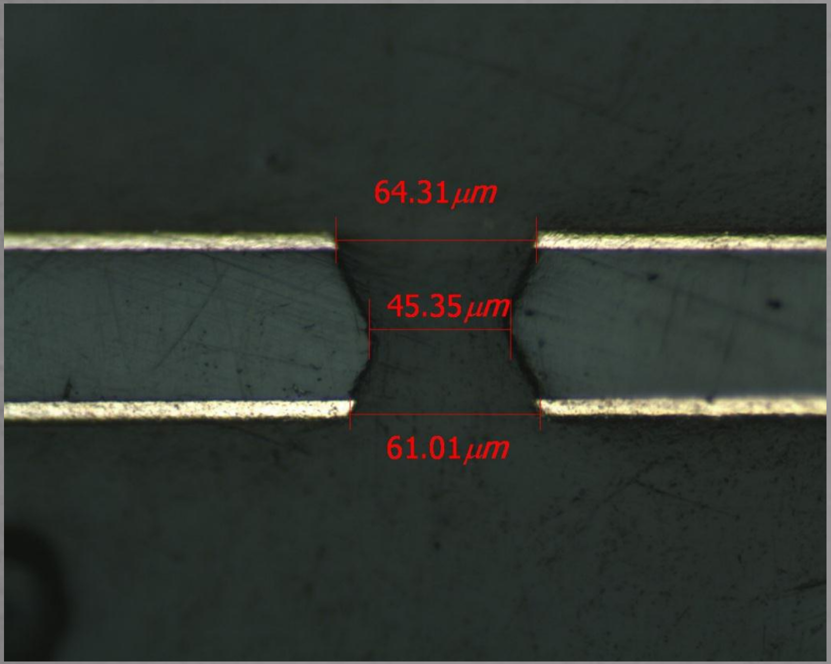
- CERN is not able to have a big production (time and machines)
- Purpose: transfer CERN technology to an external company
- Possible candidate for production: NewFlex Technology, Ansan, South Korea
  - Large production capability of Flexible PCB since 1996
  - Master of the whole production process
  - Have facilities for large area circuits

We have tested

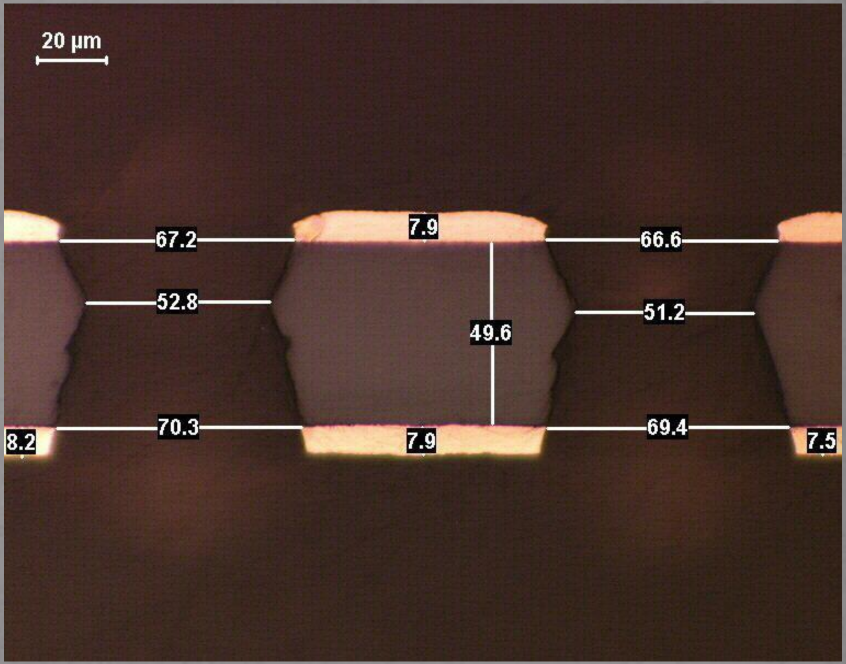
small prototypes ($6x6cm^2$)

GEMs from Korea

- Produced using the Double Mask technique
- Size of the foils: 6x6 cm^2

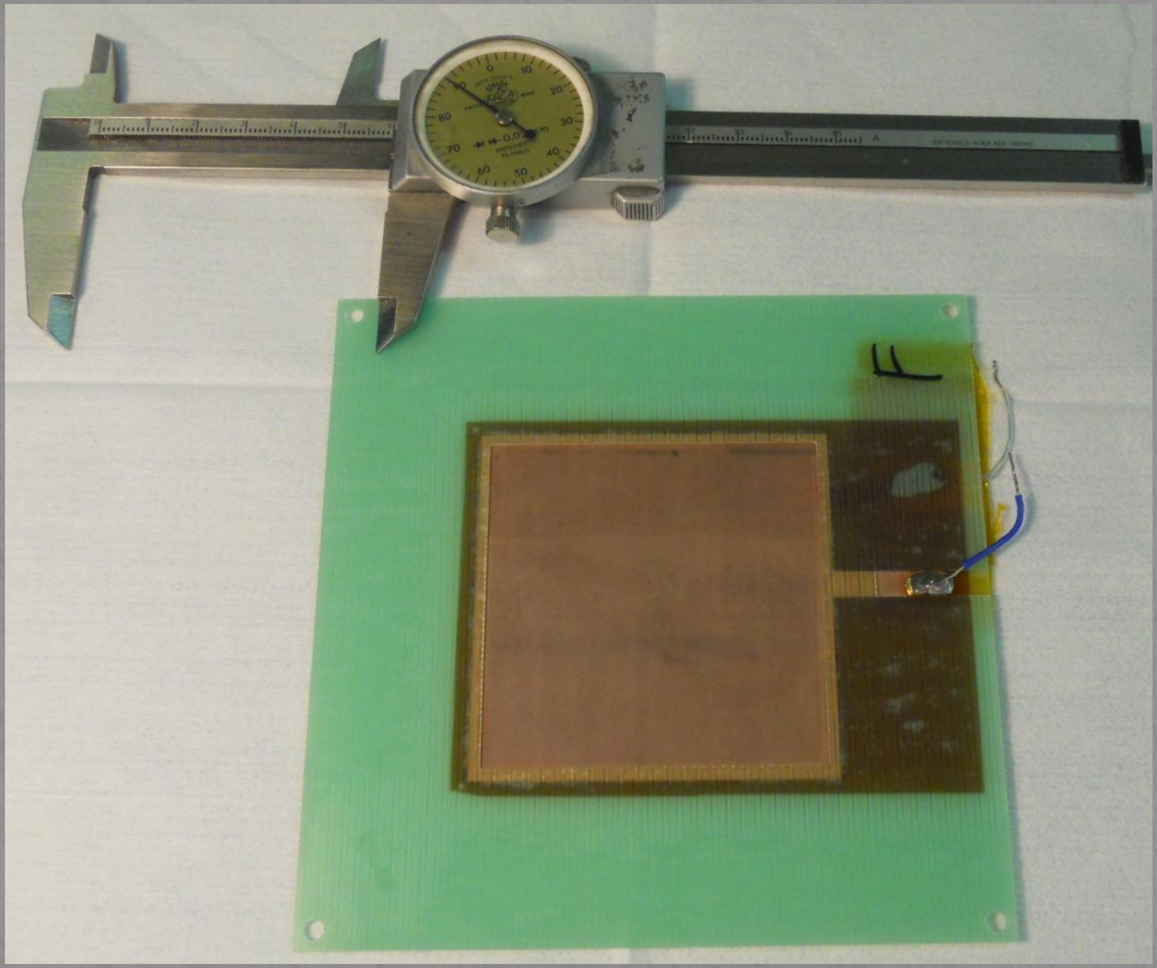


Korean GEM cross section (double mask)



CERN GEM cross section (single mask)

What a 6x6cm² Korean GEM looks like



Single GEM detector (Korea)

Configuration: 3-2

Gas: Ar+CO_2 (70-30) or (80-20)

How to compute the gain

$$G = \frac{i_{anode} \cdot \Delta t}{e \cdot \#_{p/\gamma}} \left(\frac{\#_\gamma(L,w)}{\#_\gamma(L,w/o) \cdot \#_\gamma(H,w)} \right)$$

G =effective gain

$\#_\gamma$ = number of photons

$\#_{p/\gamma}$ = number of primaries per photon

i_{anode} = readout current

e = electric charge

Δt = time of counts measurement

$$\#_{p/\gamma} = E_\gamma \left(\sum^{gases} \frac{\%(gas)}{w(gas)} \right)$$

Where

E_γ = energy of photons

w = ionisation energy of the gas (found in literature)

$$\frac{\#_\gamma(L,w/o)}{\#_\gamma(L,w)} = \frac{\#_\gamma(H,w/o)}{\#_\gamma(H,w)}$$

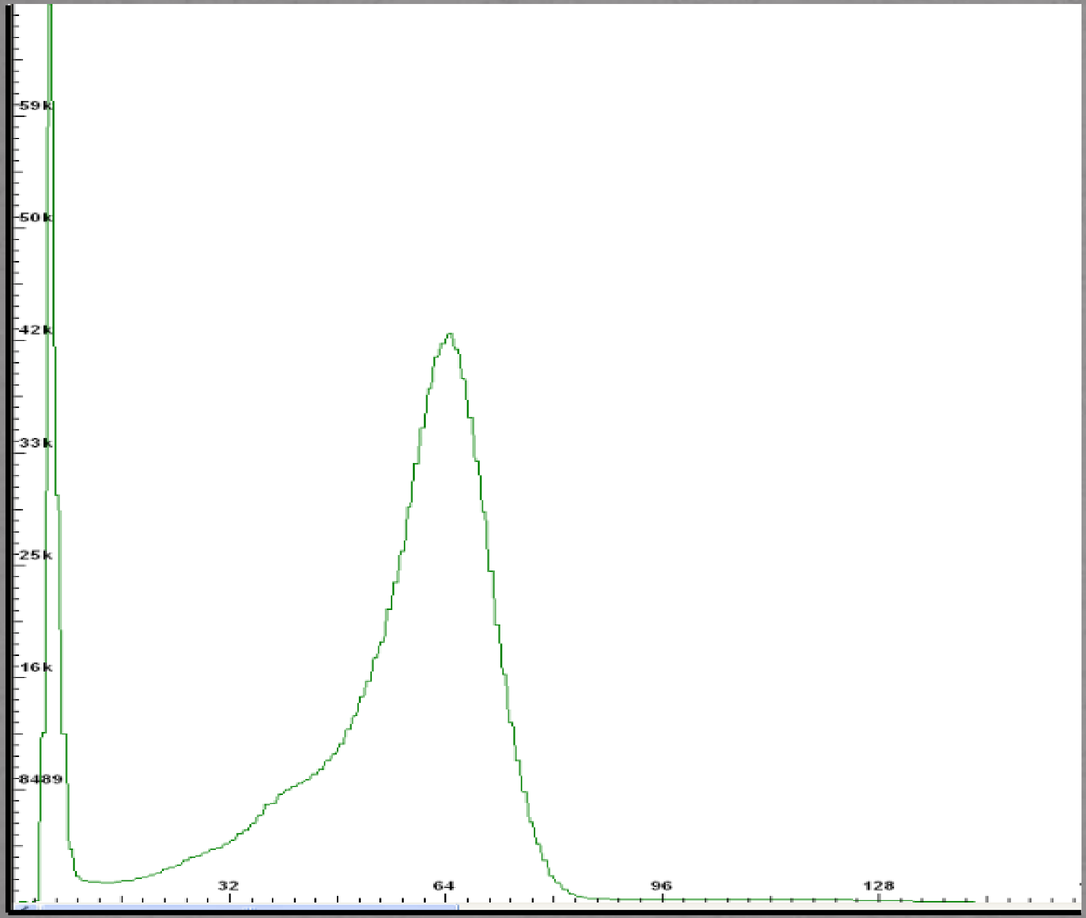
Ratio used to calculate the number of photons at high current without the absorber to measure the gain

What we need to compute the gain

- Compute the number of counts in condition of high current on the x-rays filament, without any absorber
  - This count cannot be straight measured (x-rays rate too high)
  - It is computed using the attenuation factor's formula, measuring
    - counts in low current with the absorber
    - counts in low current without the absorber
    - counts in high current with the absorber
- Measure the anode current from the PCB readout with a picoamperemeter

Single GEM detector (Korea): Pulse height spectrum (example)

Counts



ADC channels

Single GEM (Korea)
Config: 3-2
E_{drift} = 2kV/cm
$E_{induction}$ = 3kV/cm
Ar+CO_2 (70-30)

Cu X-rays: V= -10kV, i = 1.6mA
Collimator 2mm (diameter)
Rate: 95 kHz/mm^2
Absorber:135 µm Cu

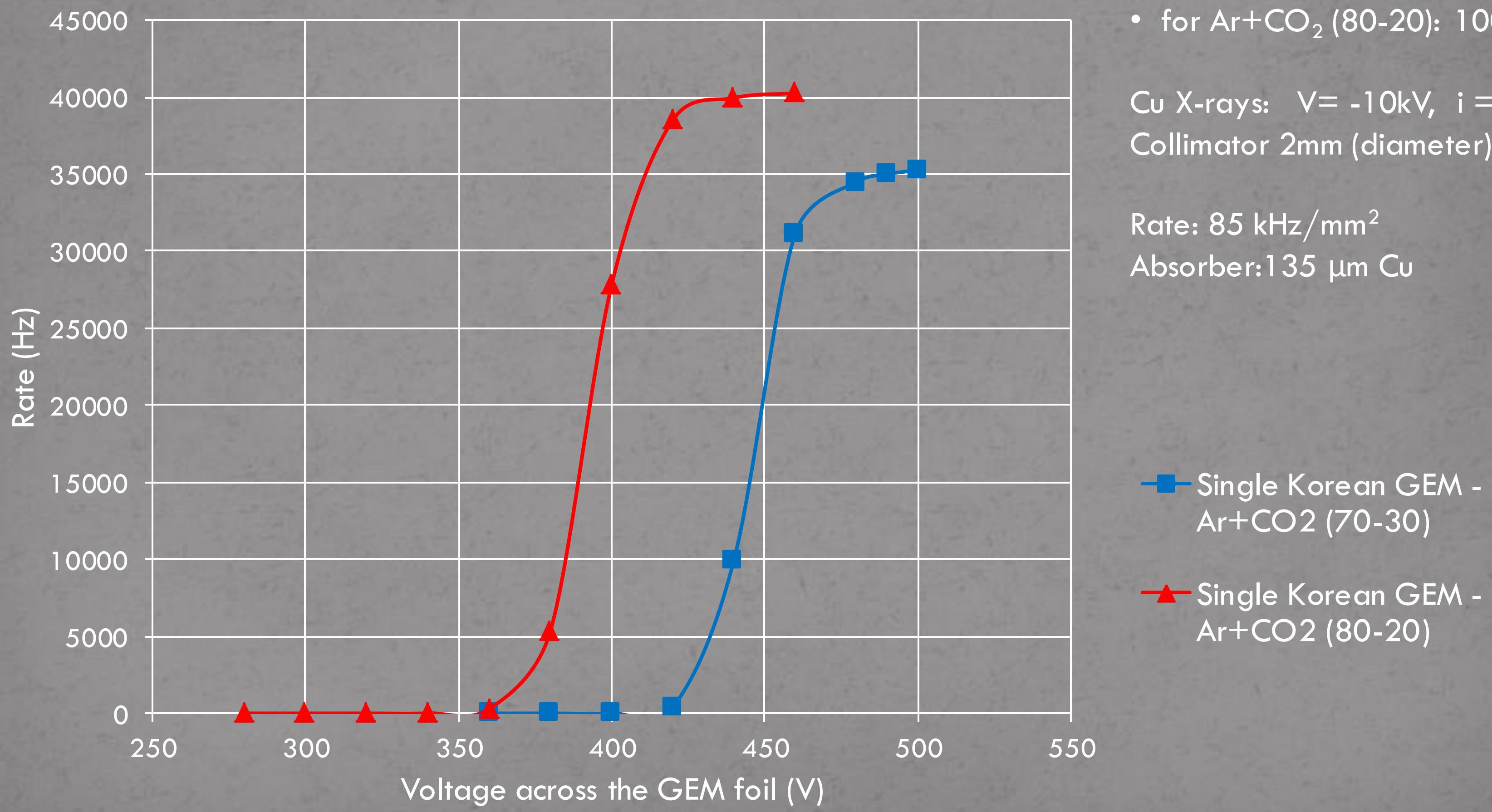
Single GEM detector (Korea): Plateau region

Single GEM (Korea)
Config: 3-2
E_{drift} = 2kV/cm
$E_{induction}$ = 3kV/cm
Ar+CO_2 (70-30) or (80-20)
Amplification factors:

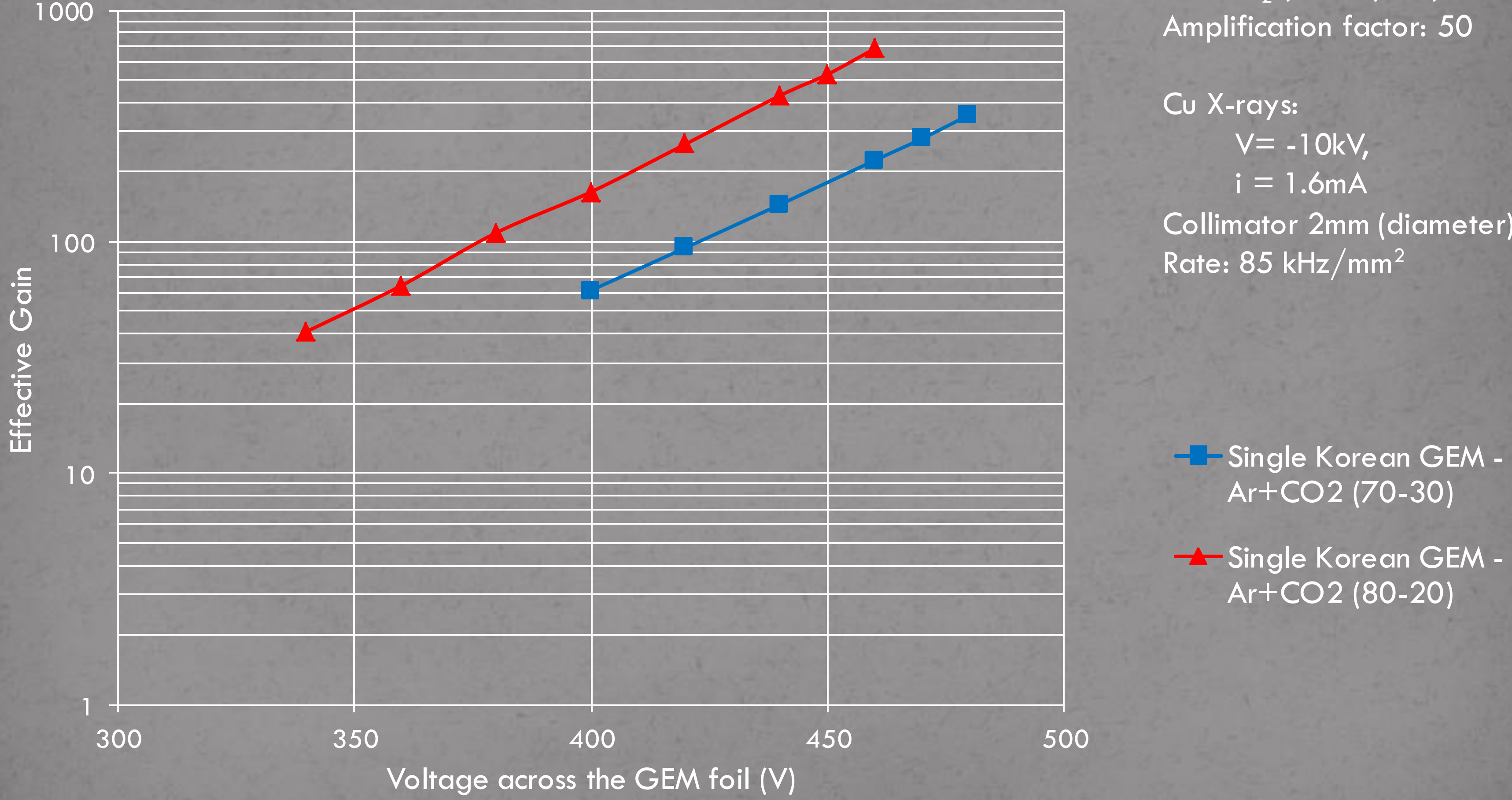
- for Ar+CO_2 (70-30): 50
- for Ar+CO_2 (80-20): 100

Cu X-rays: V= -10kV, i = 1.6mA
Collimator 2mm (diameter)

Rate: 85 kHz/mm^2
Absorber:135 µm Cu



Single GEM detector (Korea): Gain calibration



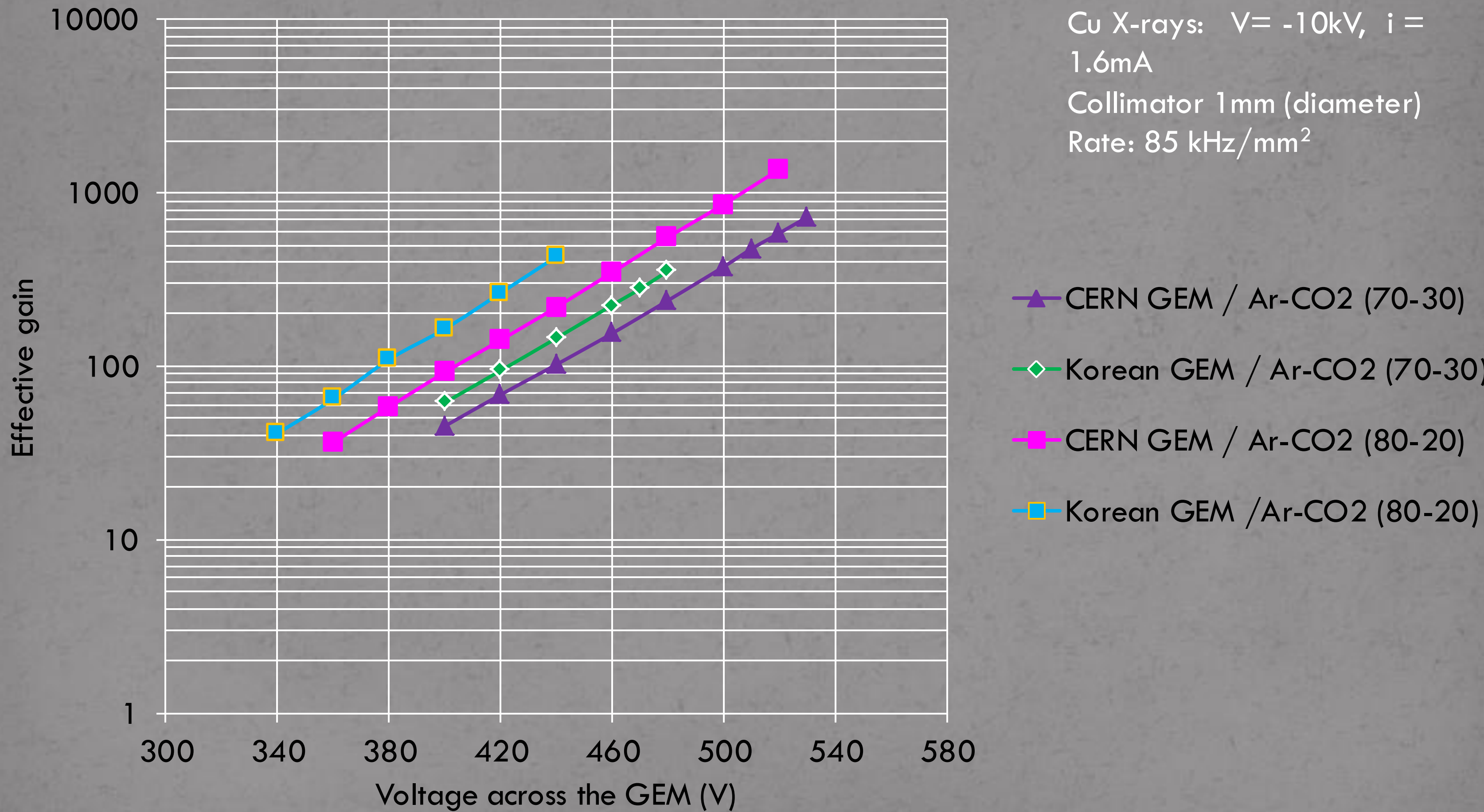
Single GEM (Korea)
Config: 3-2
E_{drift} = 2kV/cm
$E_{induction}$ = 3kV/cm
Ar+CO_2 (70-30) or (80-20)
Amplification factor: 50

Cu X-rays:
V= -10kV,
i = 1.6mA
Collimator 2mm (diameter)
Rate: 85 kHz/mm^2

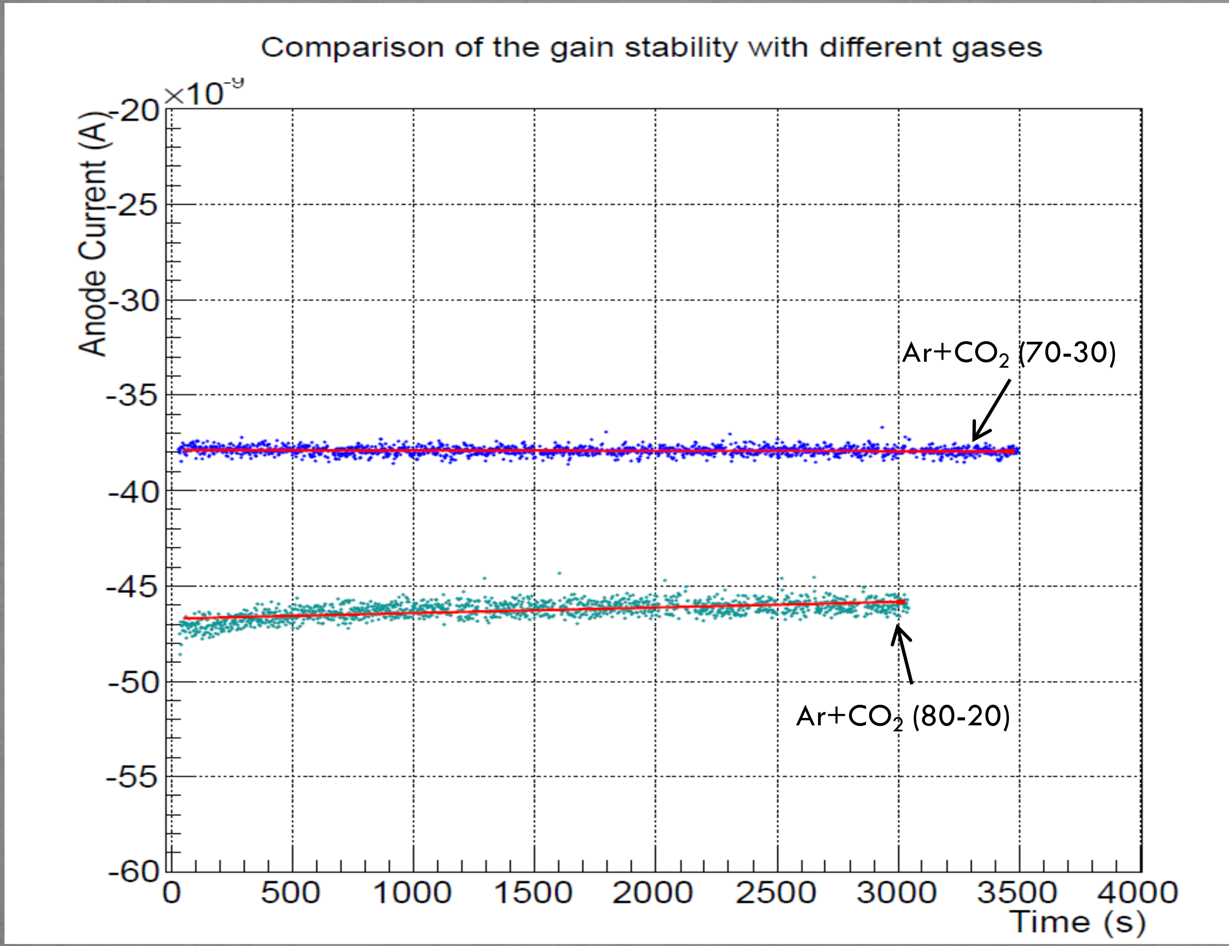
Single GEM detector (Korea): Gain calibration comparison Korean and CERN GEMs

Single GEM (Korea and CERN)
Config: 3-2
Ar+CO_2 (70-30 or 80-20)
E(drift) = 2kV/cm
E(induction) = 3 kV/cm

Cu X-rays: V= -10kV, i = 1.6mA
Collimator 1mm (diameter)
Rate: 85 kHz/mm^2



Single GEM detector (Korea): Gain stability



Single GEM (Korea)
Config: 3-2
E_{drift} = 2kV/cm
$E_{induction}$ = 3kV/cm
Ar+CO_2 (70-30) or (80-20)
Amplification factor: 50

Cu X-rays: V= -10kV, i = 1.6mA
Collimator 6mm (diameter)
Rate: 9.6 kHz/mm^2

Maximum variation
(relative difference between the maximum and the minimum points of the whole range):

- for Ar+CO_2 (70-30): 5.0%
- for Ar+CO_2 (80-20): 8.8%

Triple GEM detector (Korea)

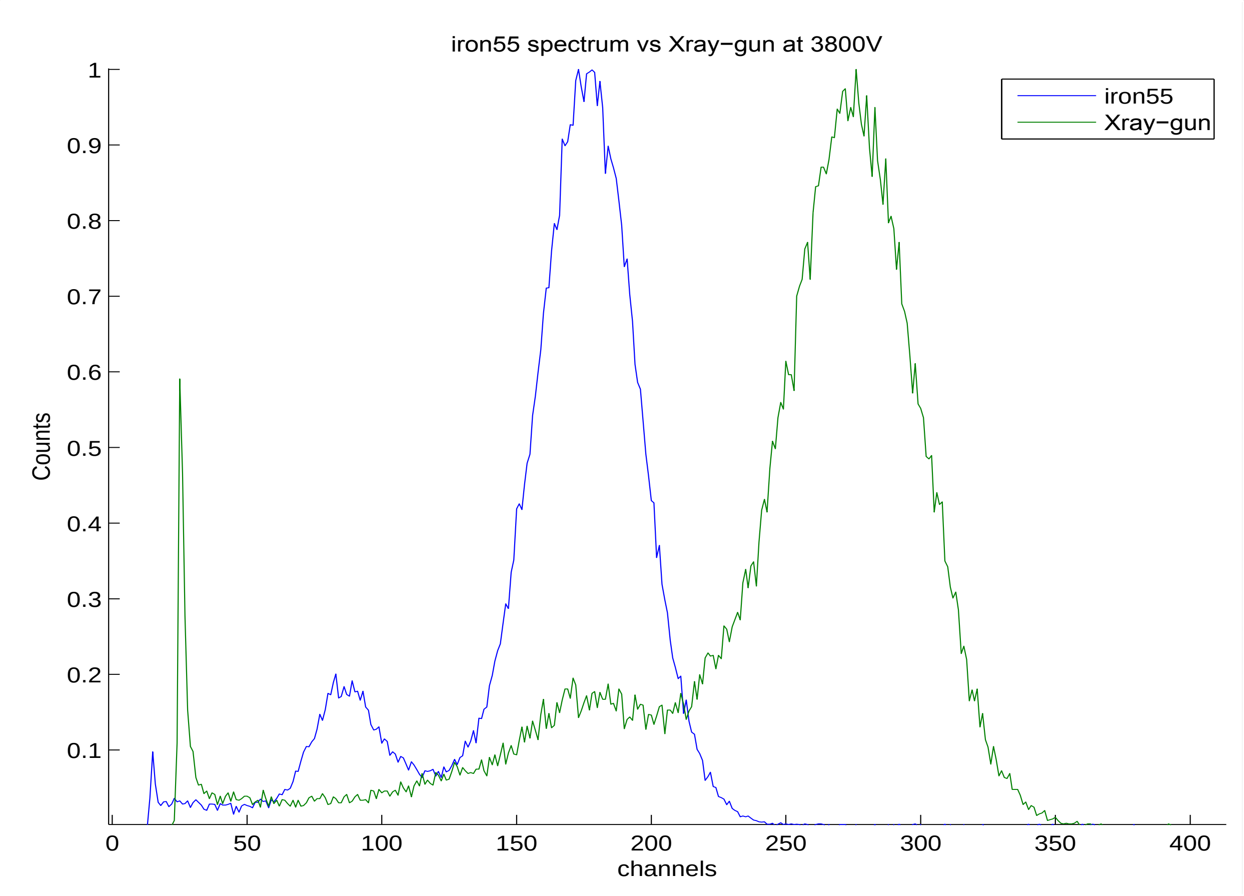
Ceramic HV divider

Configuration: 3-2-2-2

Gas: Ar+CO_2 (70-30)

Readout: pads

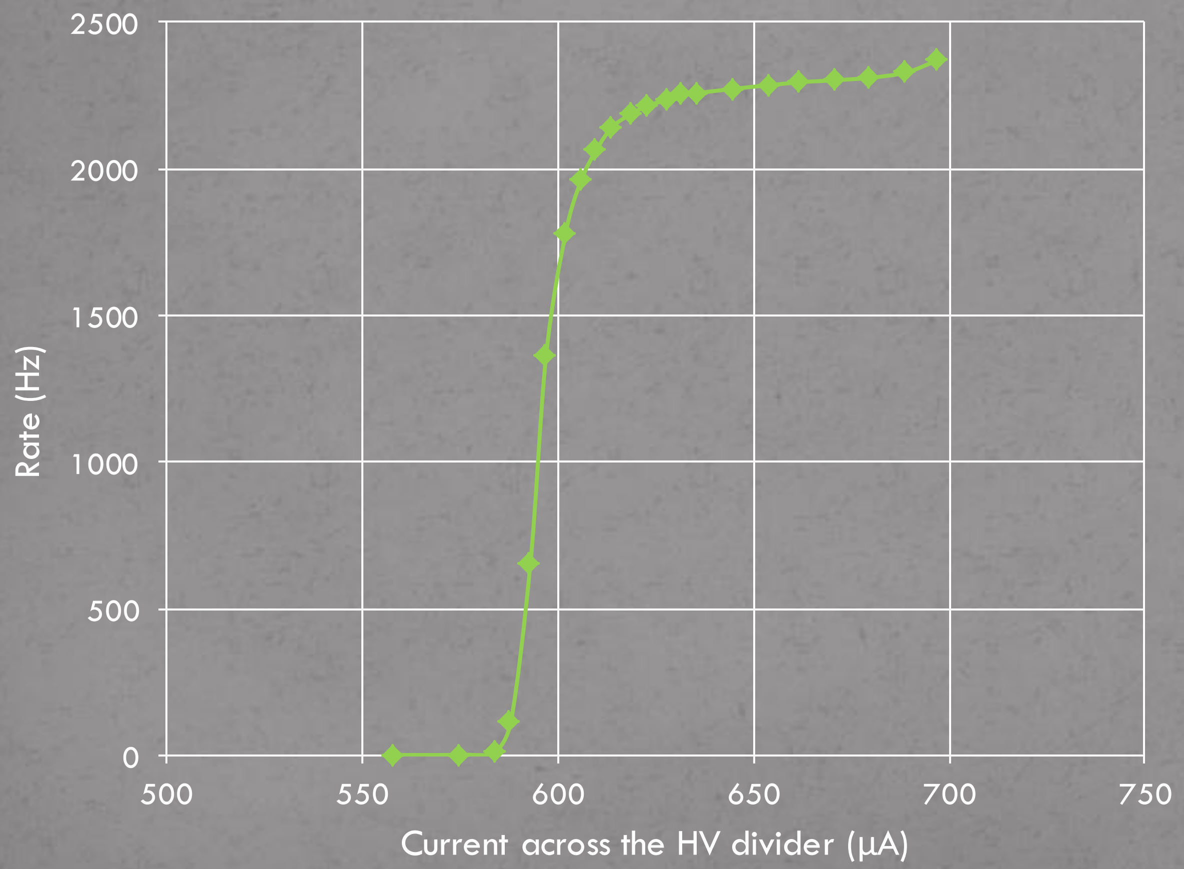
Triple GEM detector (Korea): Pulse height spectra (example)



Triple GEM (Korea)
Config: 3-2-2-2
Ar+CO_2 (70-30)

Cu X-rays: V= -10kV, i = 1.5mA
Collimator : 1mm (diameter)

Triple GEM detector (Korea): Plateau region

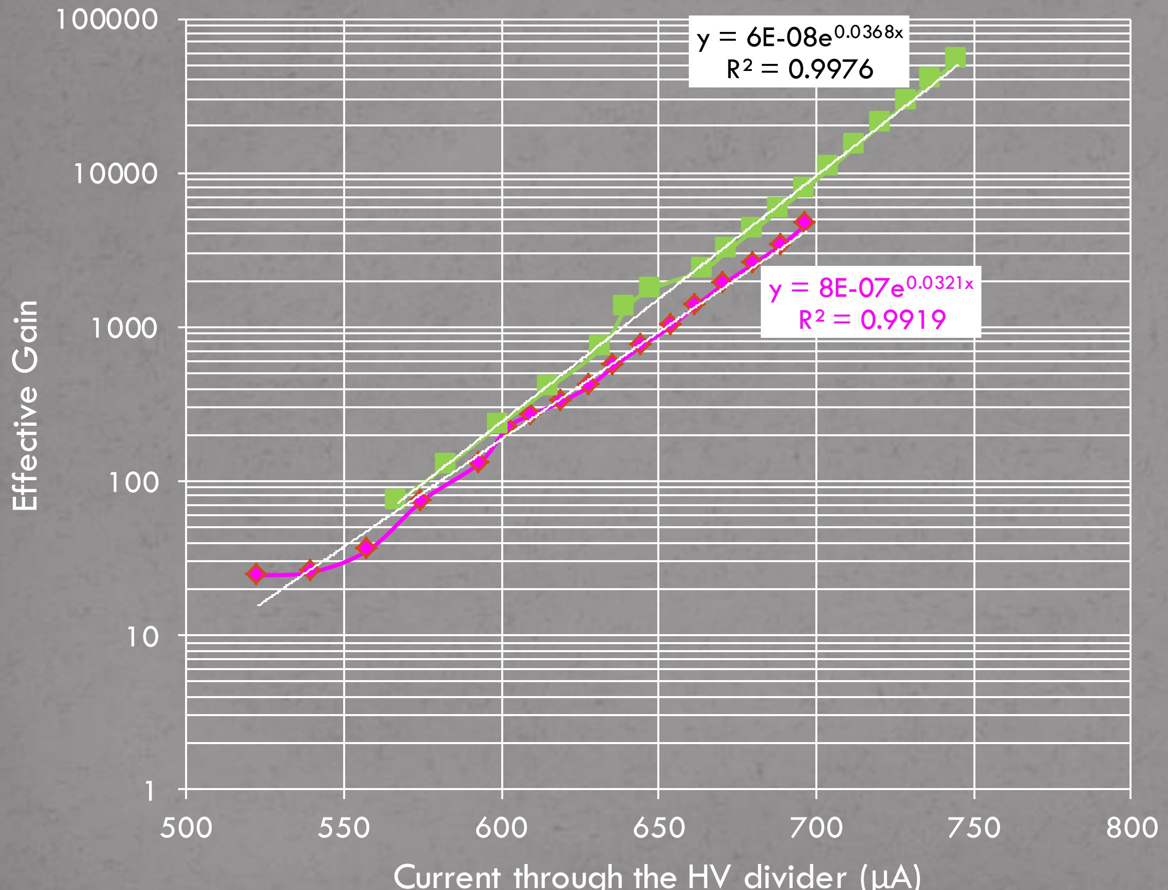


Triple GEM (Korea)
Config: 3-2-2-2
Ar+CO_2 (70-30)

Cu X-rays: V= -10kV, i = 1.5mA
Collimator: 1 mm diameter

Errors are too small to be seen in the plot

Triple GEM detector (Korea): Gain calibration



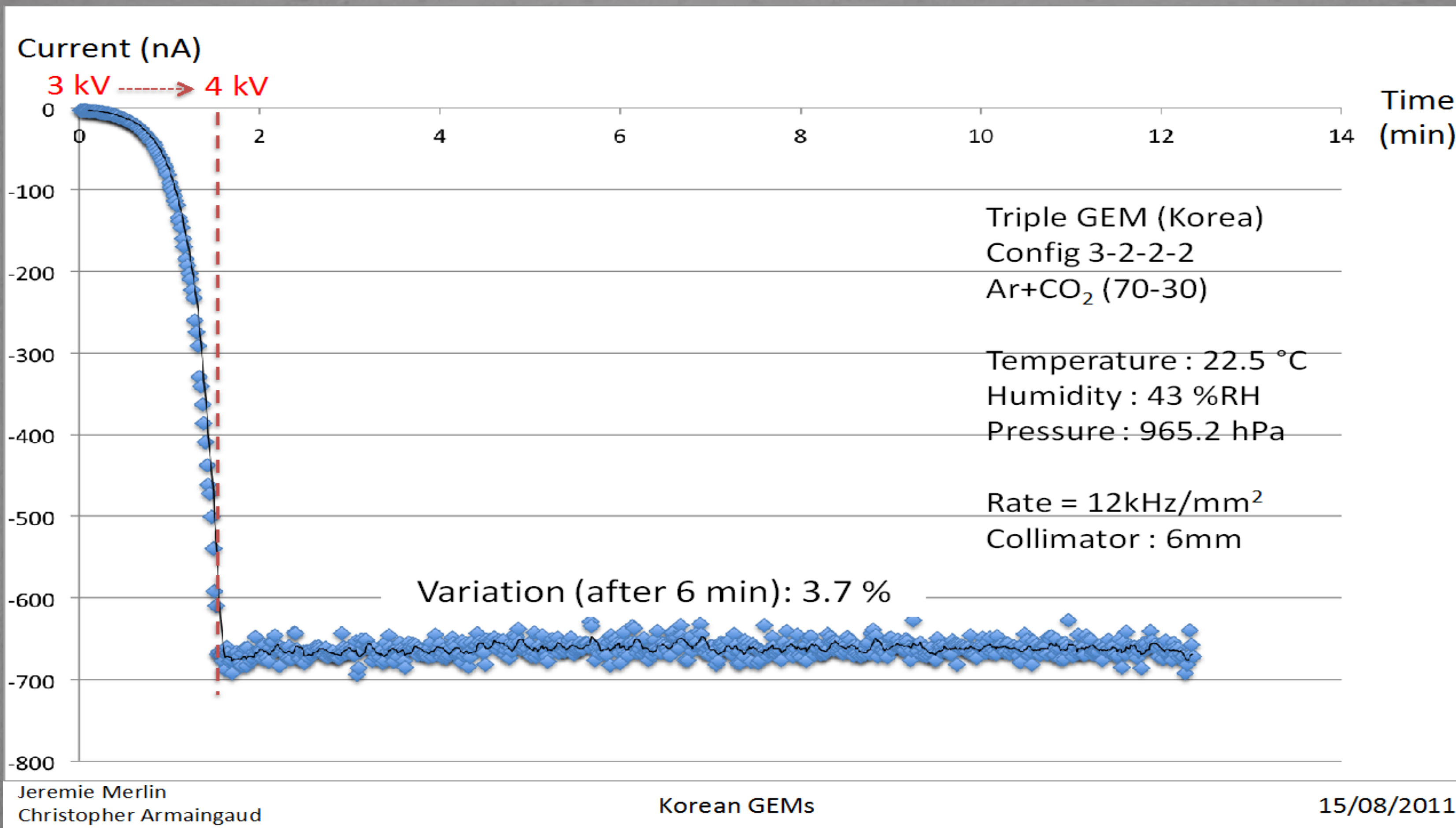
Triple GEM from Korea and CERN
Config: 3-2-2-2
Ar+CO_2 (70-30)

For CERN GEM detector
Cu X-rays: V= -10kV, i = 1.6mA
Collimator 1mm (diameter)
Rate: 56kHz/mm^2

For Korean GEM detector
Cu X-rays: V= -10kV, i = 1.5mA
Collimator 1mm (diameter)
Rate: 442 kHz/mm^2

% variations:
600μA : 26%
650 μA : 59%
700 μA : 101%

Triple GEM detector (Korea): Gain stability



Conclusion

- Korean GEMs have been tested and validated to be as good as CERN standard GEMs

Future plans

- 30x30 cm2 Korean GEMs being fabricated
- Test large sizes in view of CMS production

Thank you

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