Korean MPGD production and contribution plan toward ECT

2024 / 07 / 02

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4th EIC-Asia workshop @ Fudan Univ

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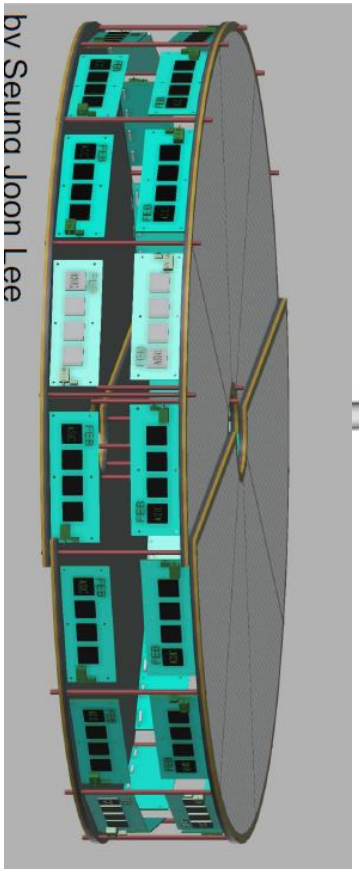
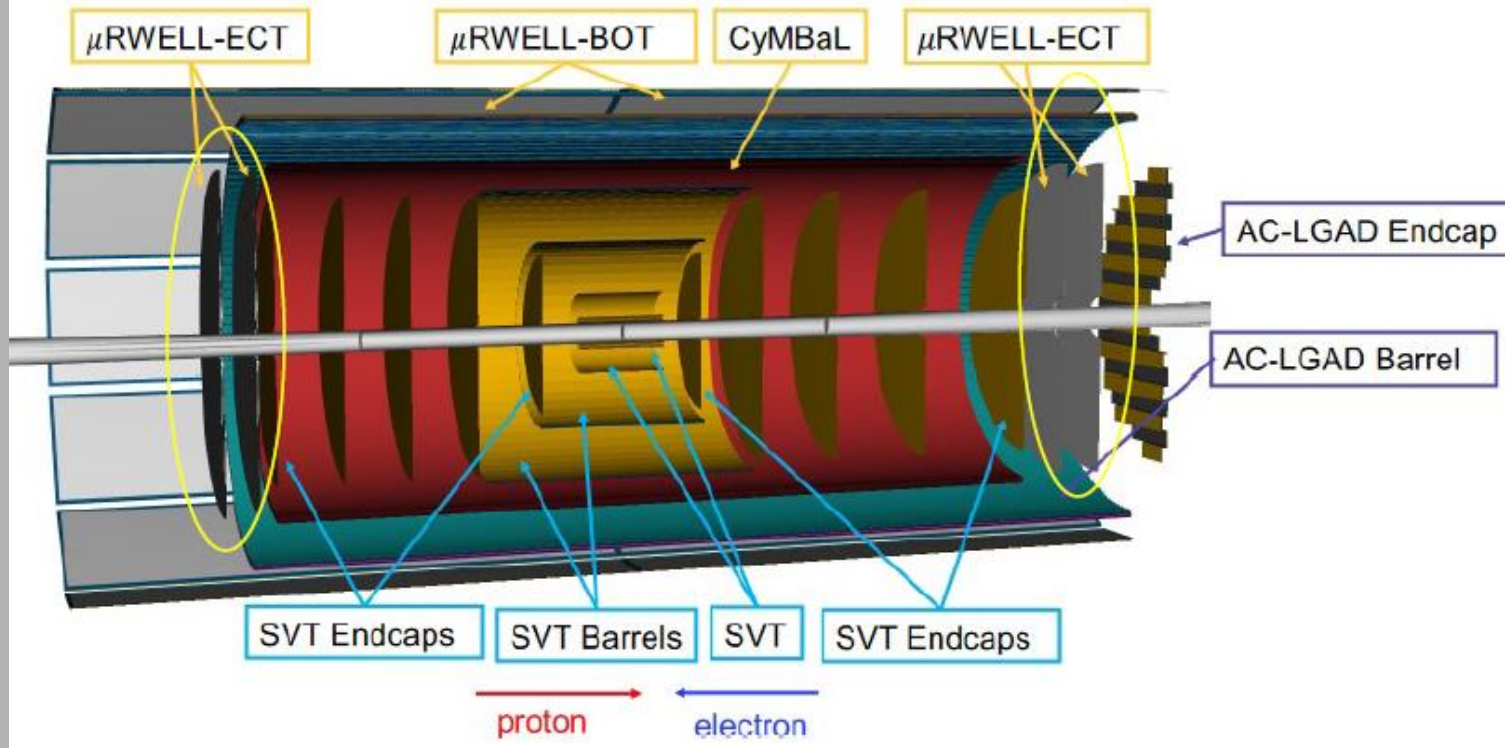
- ePIC MPGD trackers
- Introduction to GEM & μRWELL
- KCMS GEM production
- μRWELL production processes
- R&D plan & budget status

1. ePIC MPGD Trackers

- To increase hits in $|\eta| > 2$ where high Bkg. is expected for better pattern recognition

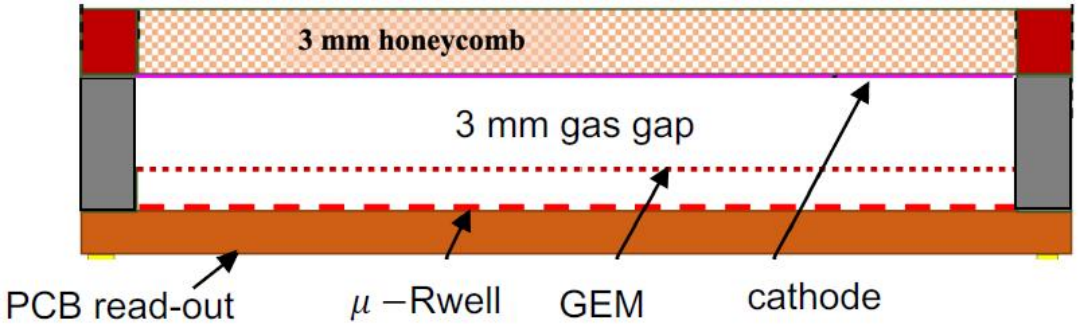


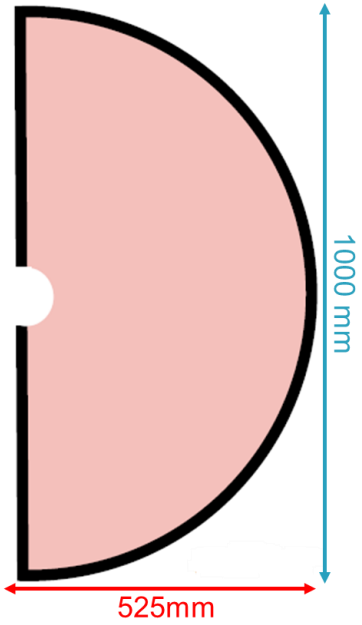


1. ePIC MPGD Trackers – ECT

- GEM+μRWELL detector

From Annalisa's slide





- Good time resolution: $10\ ns$, $< 8\ ns$
- Low material budget: $1-2\ \%\ X/X_0$, $< 0.4\ \%\ X/X_0$
- Good position resolution: $150\ \mu m$, obtainable with $500\ \mu m$ pitched RO & μTPC
- High efficiency: $96-97\ \%$, $\sim 97\ \%$ with 3 mm gas gap

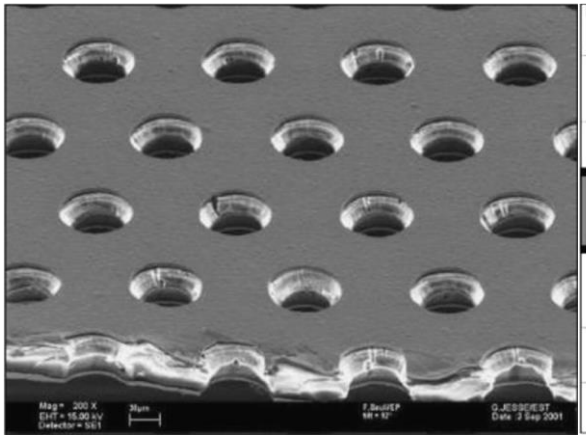
- *"Main risk is related to CERN being the unique producer of μRWELL detector layer"*

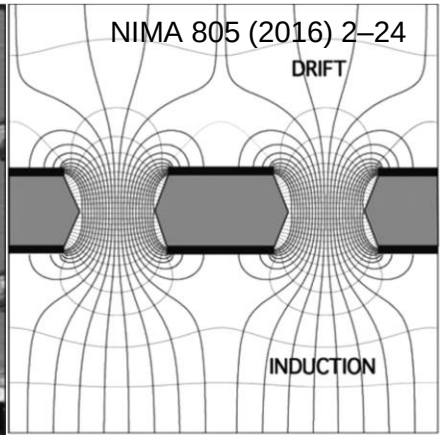
- Annalisa, Incremental Design and Safety Review of the EIC Tracking Detectors, Mar. 20-21, 2024

⇒ Korea can mitigate this risk by participating in the development of the ECT and supplying GEM & μRWELL

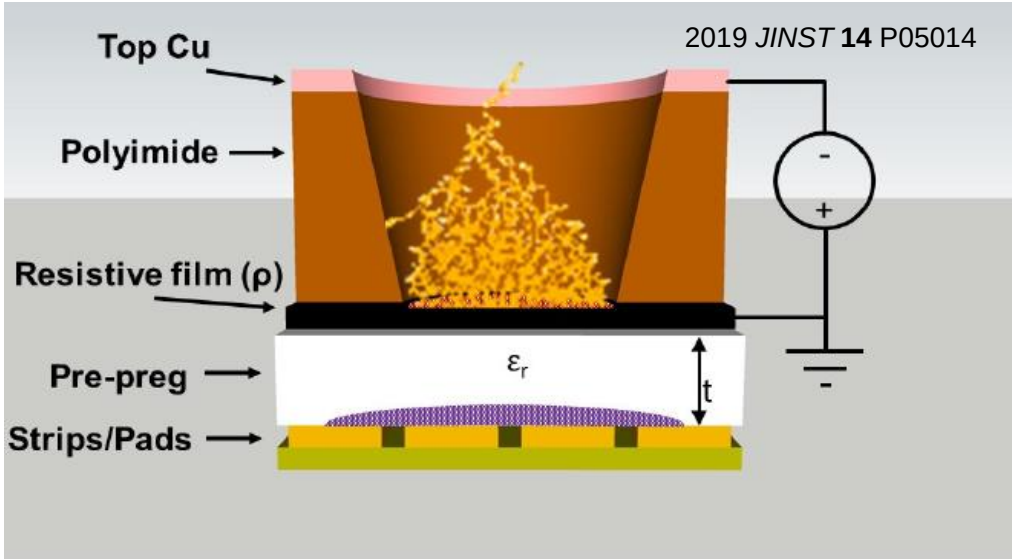
2. Introduction to GEM & μRWELL

- GEM
  - Good position resolution
  - Fair time resolution
  - Extremely robust to classical aging
  - Extremely high rate capability





- μRWELL; resistive version of GEM
  - Share many of the characteristics of GEM
  - Spark protected
  - Simpler structure
  - Rate capability is limited

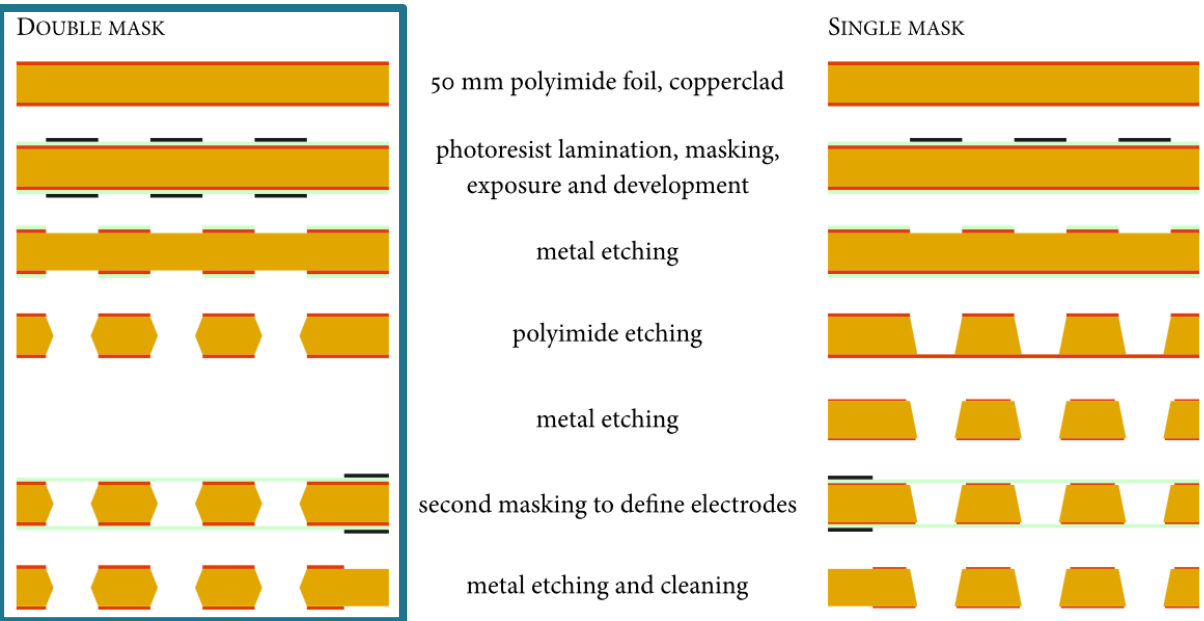


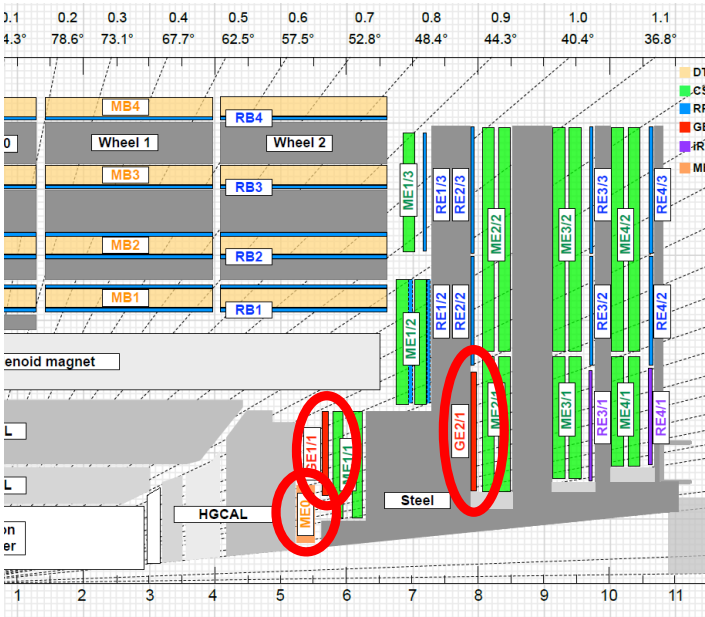
3. KCMS GEM Production

- For HL-LHC, CMS GEM upgrades are ongoing
  - GE1/1, GE2/1, and ME0 stations

- Main risk of the upgrades was procurement of large GEM foils $\sim 1 \times 0.5\ m^2$
  - KCMS became the second supplier, mitigating this risk

- KCMS produces GEM foils using the double-mask
  - Suitable for mass production
  - Bipolar UV exposure becomes limiting factor of maximum producible size





3. KCMS GEM Production

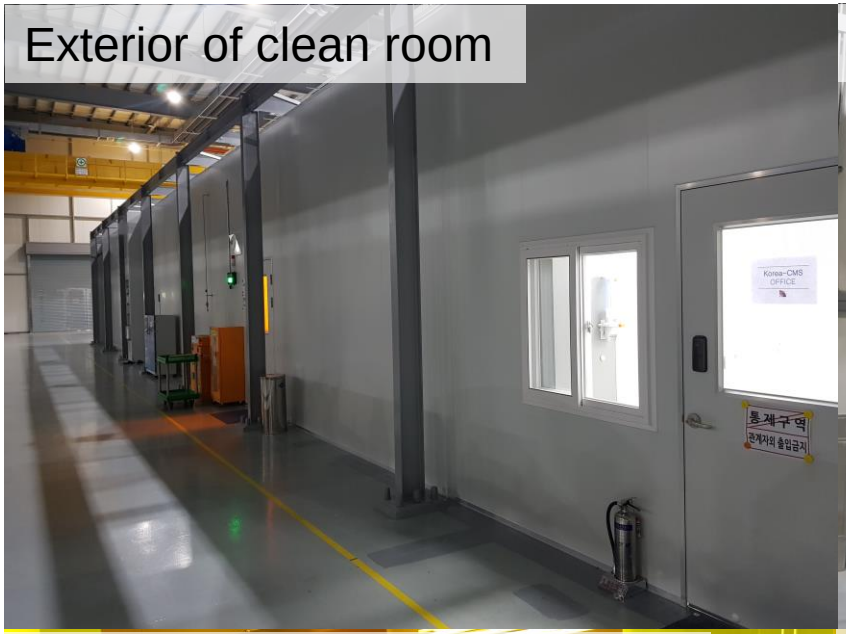
- KCMS had formed a consortium with Mecaro Ltd. to produce GEM foils
  - Mecaro had provided site & technicians
  - This consortium was over during production of the GE2/1

- Site relocation & getting green light again
  ~ 2023. 12
  - ME0 production is ongoing smoothly

- Photo process, QA/QC @ IBS
  Chemistry process @ PnF (PCB maker)
  - Not possible to get chemical handling license in IBS area due to environmental regulation
  - 2 h 30 min

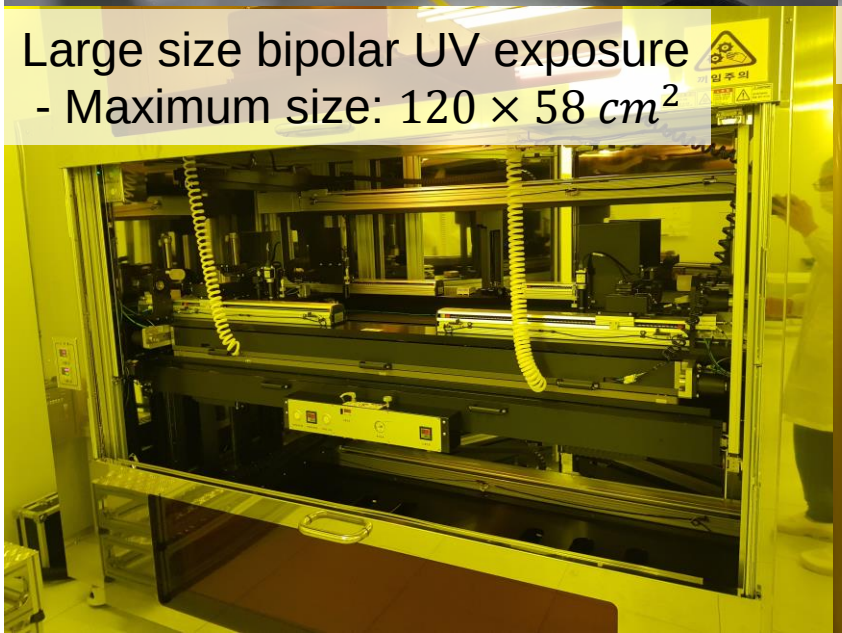
3. KCMS GEM Production – Photo Site

Exterior of clean room



Environment controller of clean room

Large size bipolar UV exposure
- Maximum size: $120 \times 58\ cm^2$



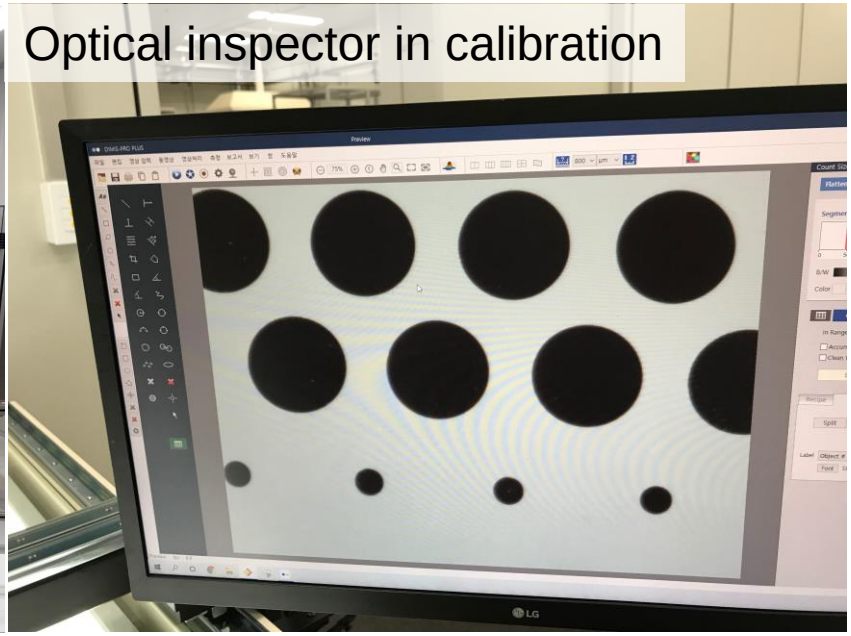
DFR laminators and worktables

3. KCMS GEM Production – Photo Site

QA/QC room
- E-cleaning and validator
- Optical inspector

Can be used for assembly as well

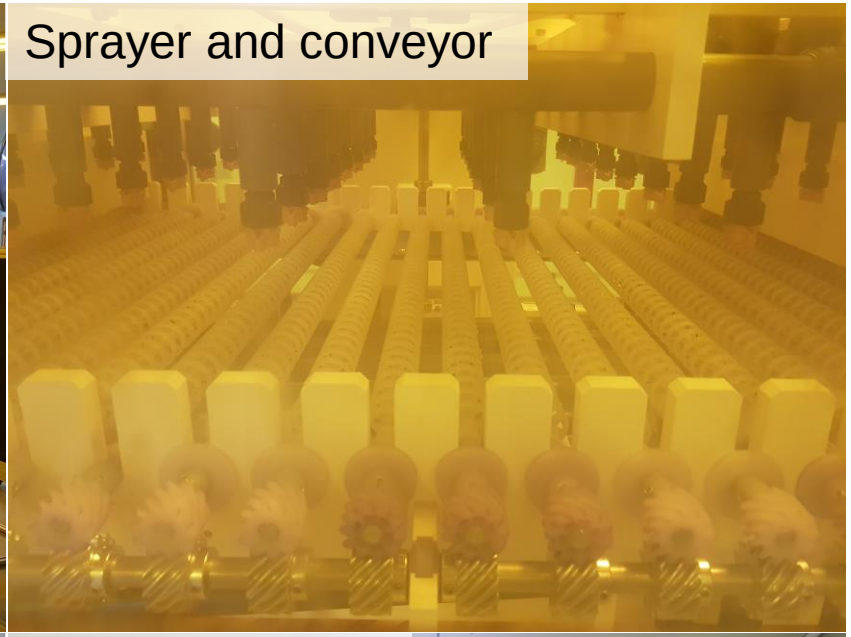
Optical inspector in calibration



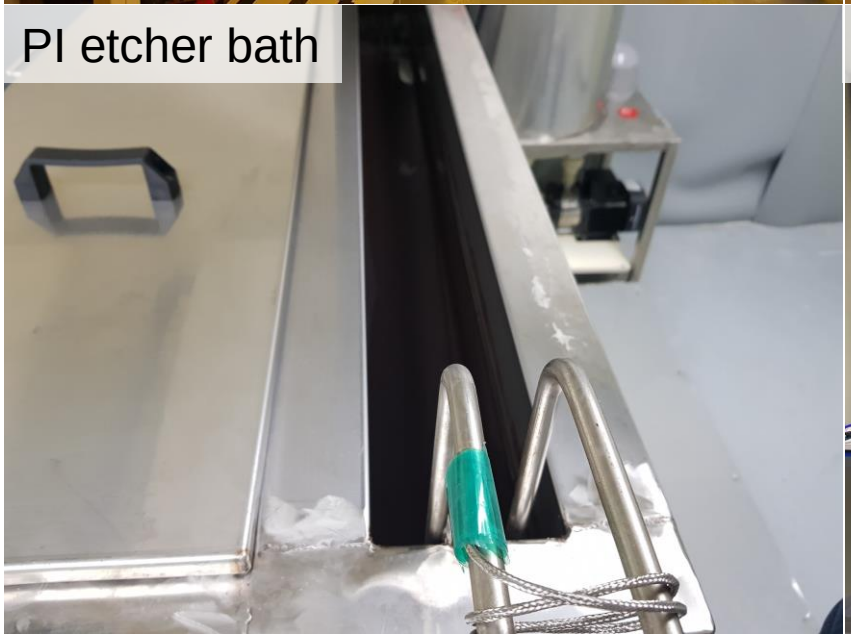
3. KCMS GEM Production – Chemistry Site

Develop & Cu etcher

Sprayer and conveyor



PI etcher bath



Optical inspector

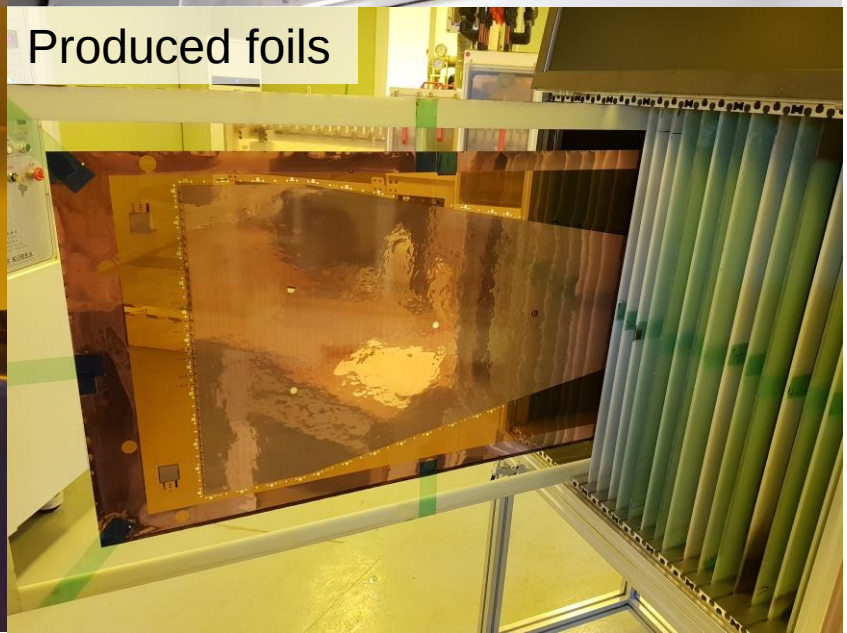
3. KCMS GEM Production – Chemistry Site

Soldering SMD resistors & making via holes

Chemical cleaning bath

DI water generator

Produced foils



3. KCMS GEM Production

- Production R&D and validation
  - 2023 *JINST* **18** C06010, NIMA 1057 (2023) 168723

- GE2/1 mass production
  - Mass produced chambers assembled with the Korean foils works well

- ME0 mass production
  - Ongoing smoothly
  - Will be done around middle or end of 2025

→ Looking for the next contribution site

ME0 Production Status

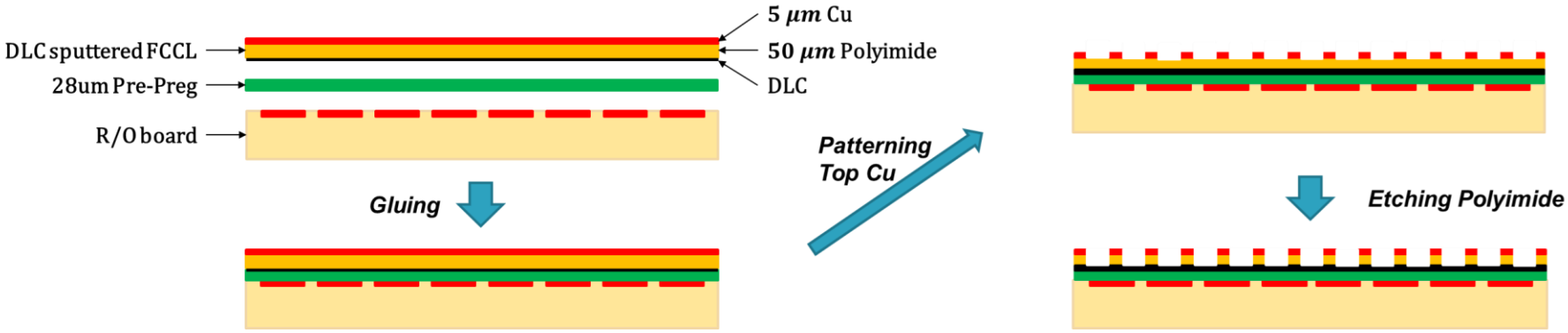
Foils produced	108
Foils in QC @ IBS	33
Foils being produced	55
Foils delivered	85
Chambers assembled	5
Chambers validated	2

From Annalisa's slide

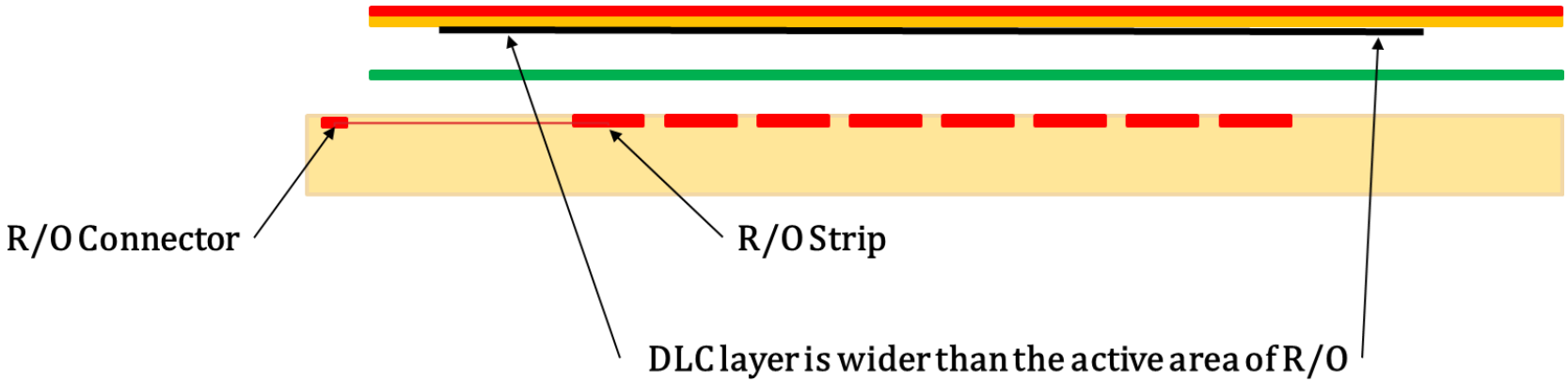
MPGD Timeline			DURATION (years)
START DATE	END DATE	DESCRIPTION	
3/1/24	12/31/24	Detectors Overall Design	<1
1/1/25	12/31/26	Pre - Production	2
1/1/27	31/12/29	Production & QA	3
1/1/30	6/1/30	Commissioning & Installation	0.5

4. μRWELL Production Processes

- GEM and μRWELL share production processes



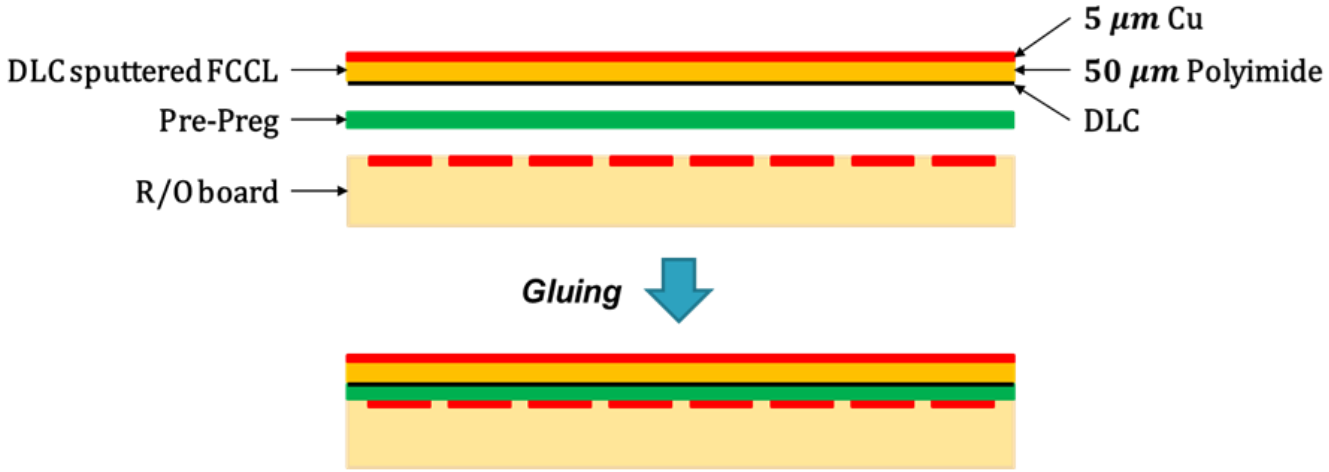
- The DLC layer is formed by a sputtering process
  - DLC-FCCL will be procured from CERN or company



4. μRWELL Production Processes

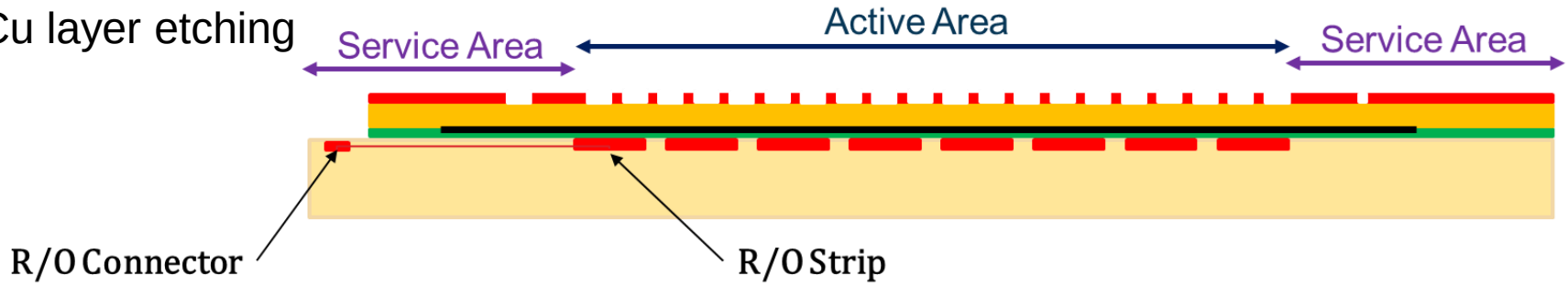
• Gluing

- Pressing DLC FCCL, pre-preg and RO PCB at high temperature in a vacuum chamber
- Will be done by domestic PCB company. Common technique in PCB maker
- Detail parameters and know-how have been secured from CERN MPT



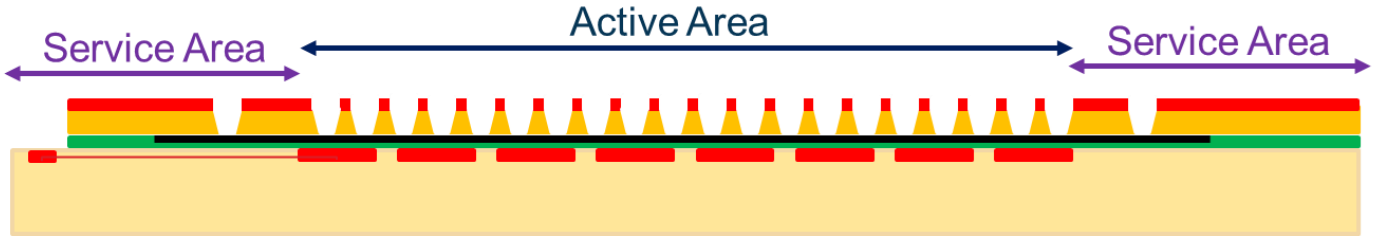
4. μRWELL Production Processes

- 1st Cu layer etching

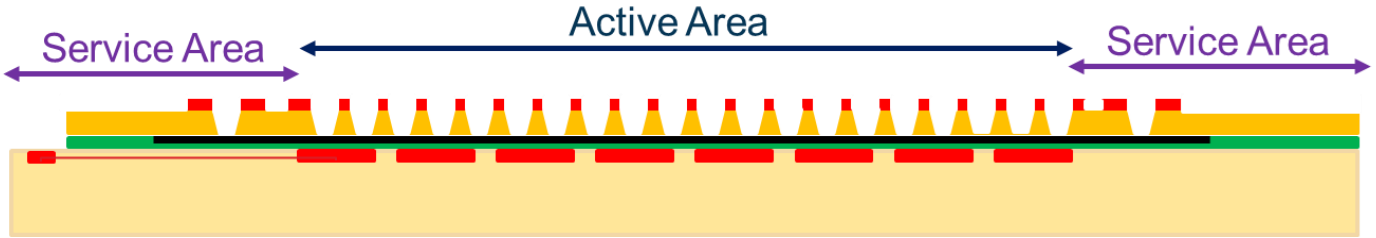


- Seed layer etching

- PI layer etching; choking point of MPGD production
  - KOH, amine (MEA for Korea, EDA for CERN)
  - By adjusting KOH to amine ratio, taper can be tuned

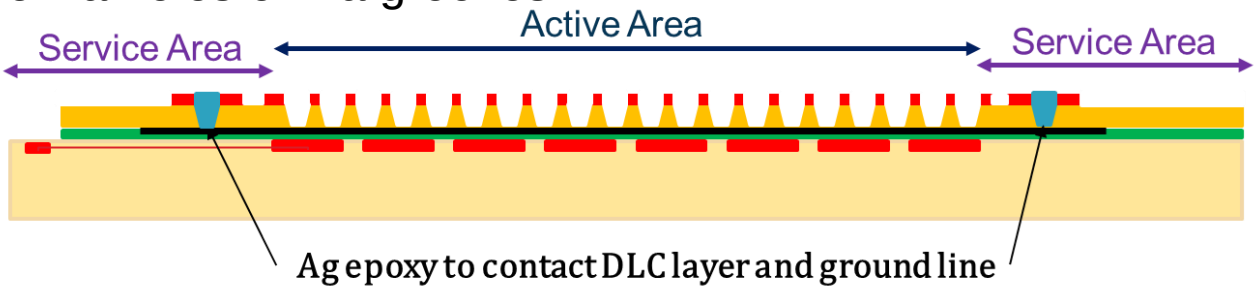


- 2nd Cu etching



4. μRWELL Production Processes

• Ag epoxy pasting to make via holes or via grooves



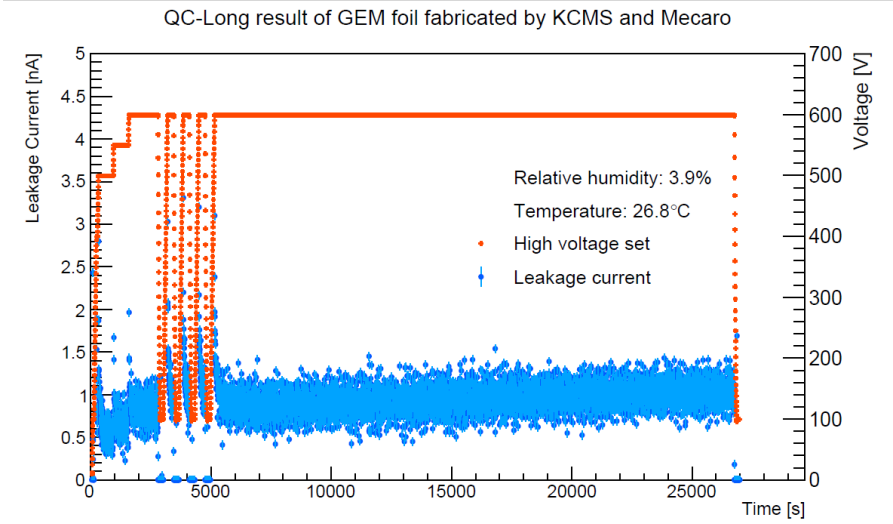
• Cleaning: 2nd choking point of MPGD production

- Chemical: surface treatment → micro etching → neutralization → passivation → high pressure DI water shower

- Electrical cleaning: controlled burning of contaminants in dry or hot environment

- If GEM or μRWELL become short or sparking due to contaminants, it needs additional cleaning

• We have a good understanding of the μRWELL production and the critical technology is already secured



5. R&D Plan and Budget Status

- $10 \times 10\ cm^2$ μRWELL to test production feasibility
  - Plan to finish by the end of this year or early next year
  - DLC-FCCL, RO PCB and other detector parts have been ordered and in production
  - Small budget for this small R&D is secured
  - Based on the experience of GEM production R&D, if we can make a small μRWELL, it will not be difficult to scale up to full-size μRWELL

- We would like to participate ePIC real scale ECT prototyping via in-kind contribution of GEM & μRWELL
  - Even if we don't finish the μRWELL feasibility study in time, we can still contribute to GEM
  - Beside the feasibility test, securing budget is critical

- We has submitted proposal on MPGD contribution toward ePIC to Korean MSIT
  - The proposal covers in-kind contribution of GEM & μRWELL for ECT, assembly and QA/QC
  - Report for research policy maker by 3rd party has been submitted as well

Summary

- MPGD detector safely satisfies ePIC requirements for central tracker
  - Main risk is procurement of GEM & μRWELL
  - Korea can mitigate this risk by supplying GEM & μRWELL

- KCMS is supplying GEM foils for the CMS GEM upgrades
  - Plenty experience on R&D, and mass production
  - Large pool of person power
  - CMS production will be done around middle or end of 2025

- We are willing to contribute to GEM + μRWELL ECT
  - In-kind contribution of GEM & μRWELL
  - The feasibility study of μRWELL production is ongoing

- We has submitted proposal on MPGD contribution toward ePIC to Korean MSIT
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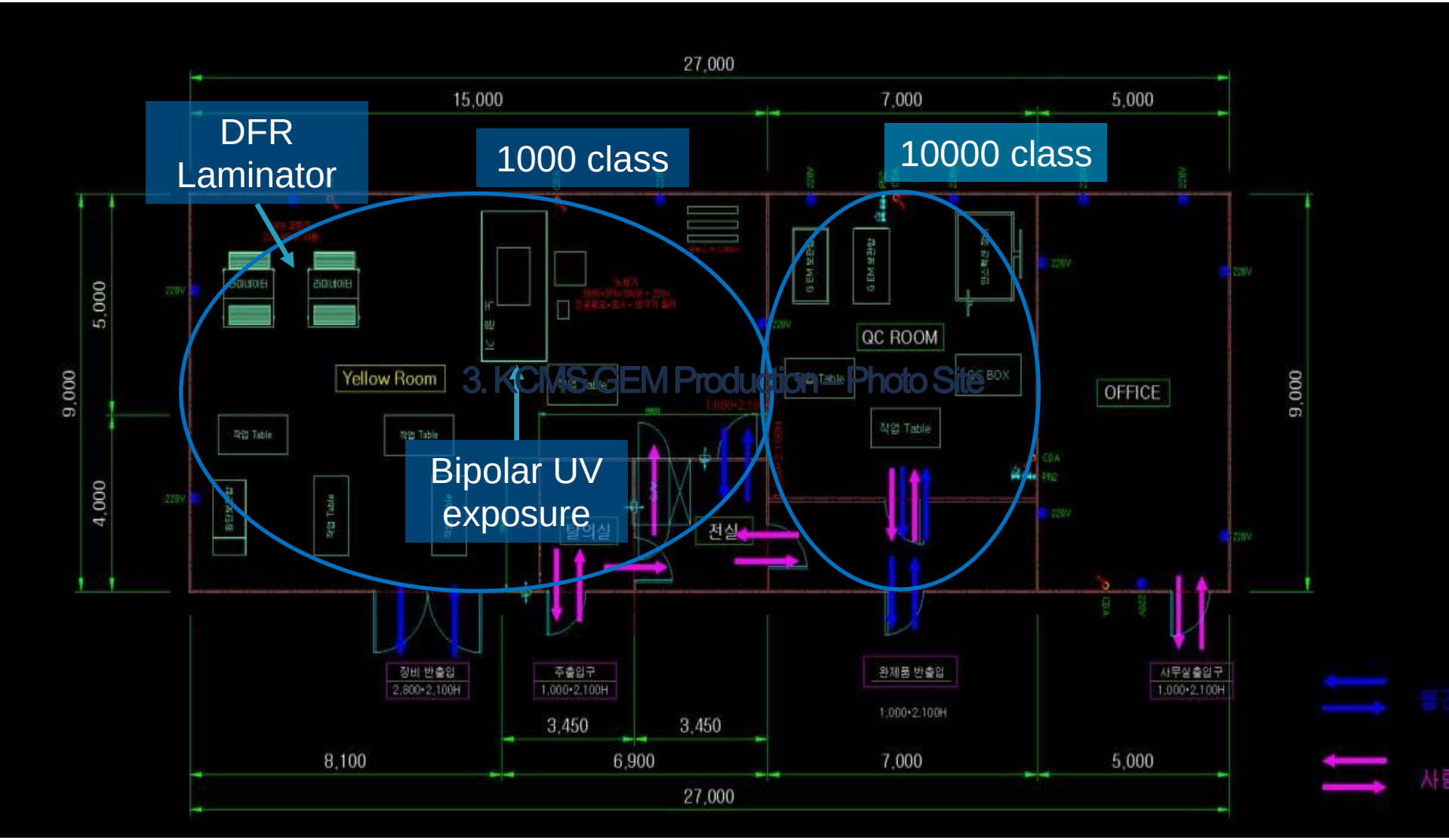
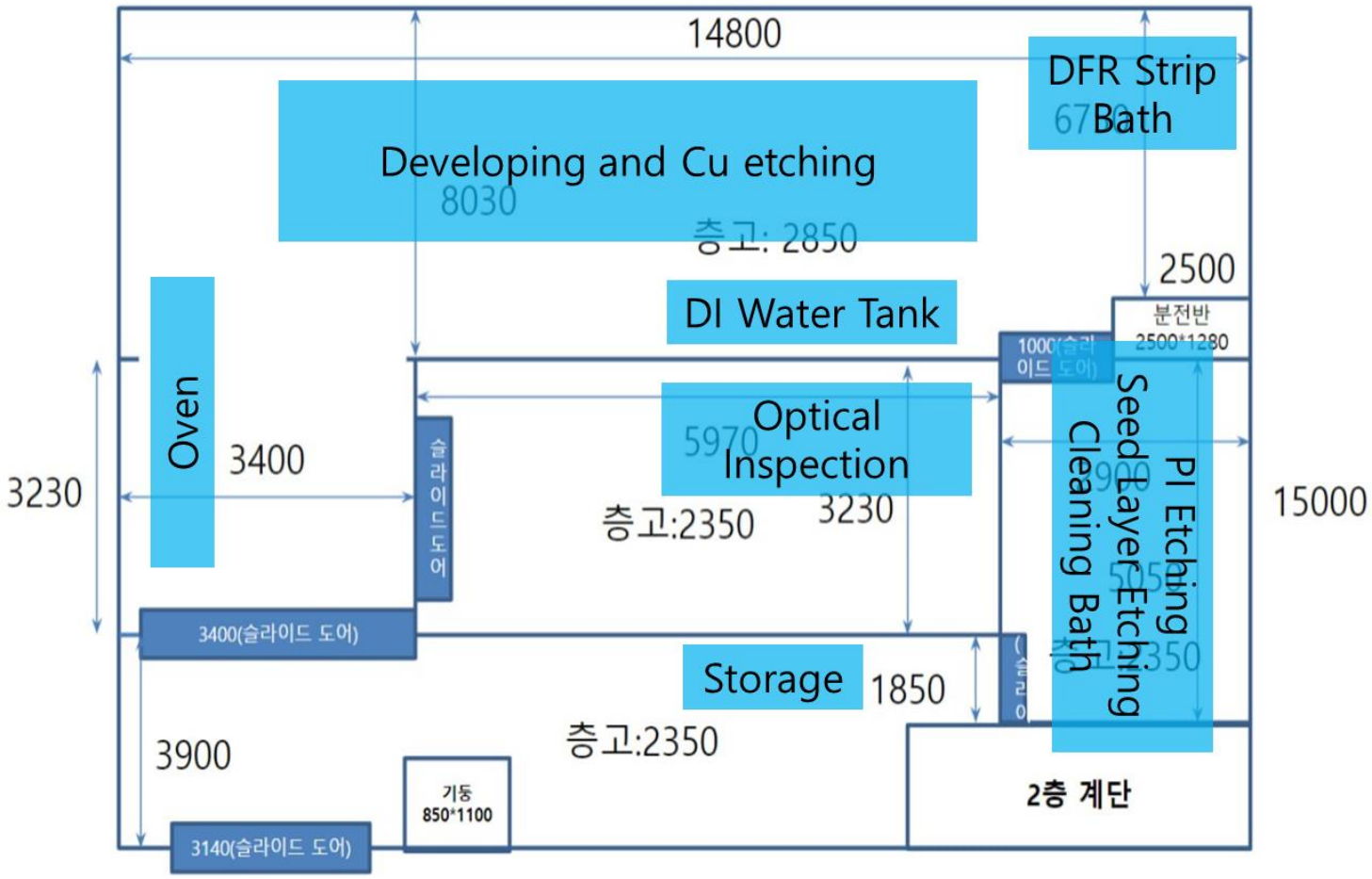
Back Up

3. KCMS GEM Production – Photo Site



3. KCMS GEM Production – Chemistry Site



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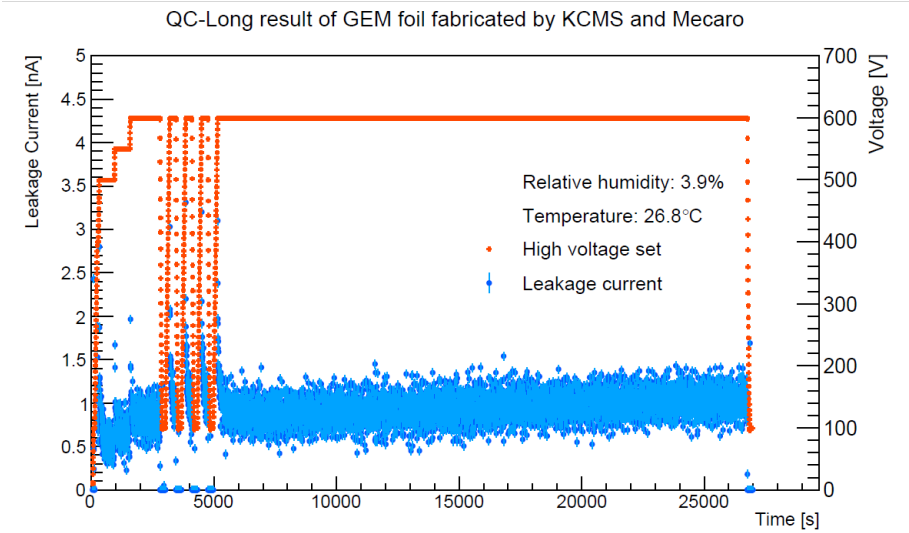

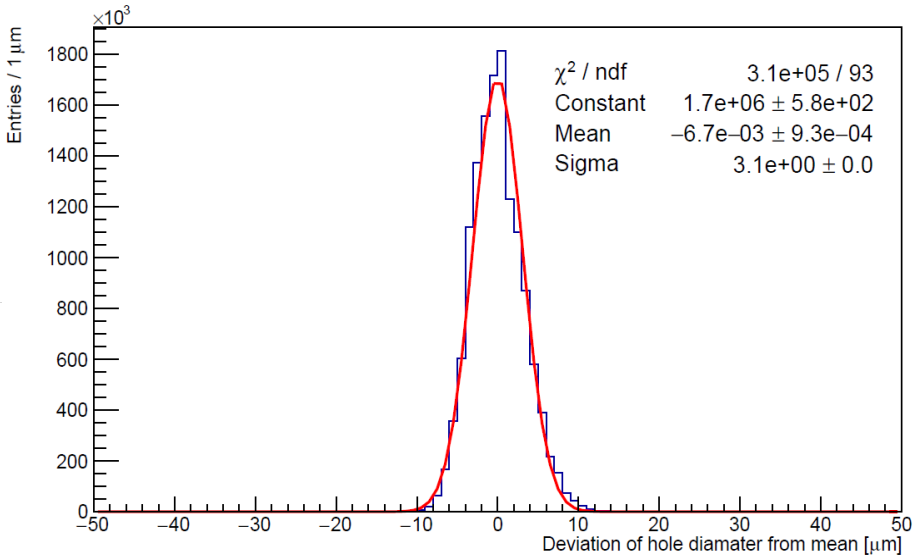

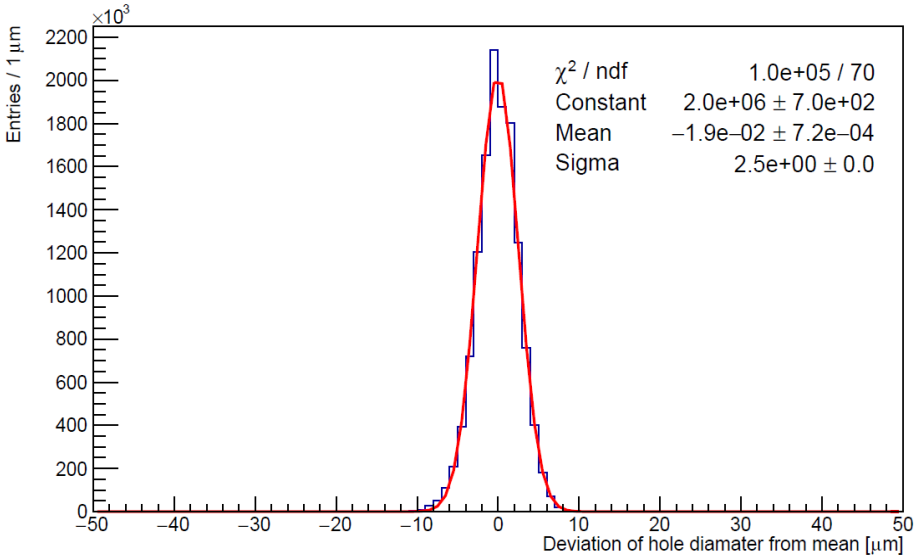

Matt Posik (Temple Univ.), private communication

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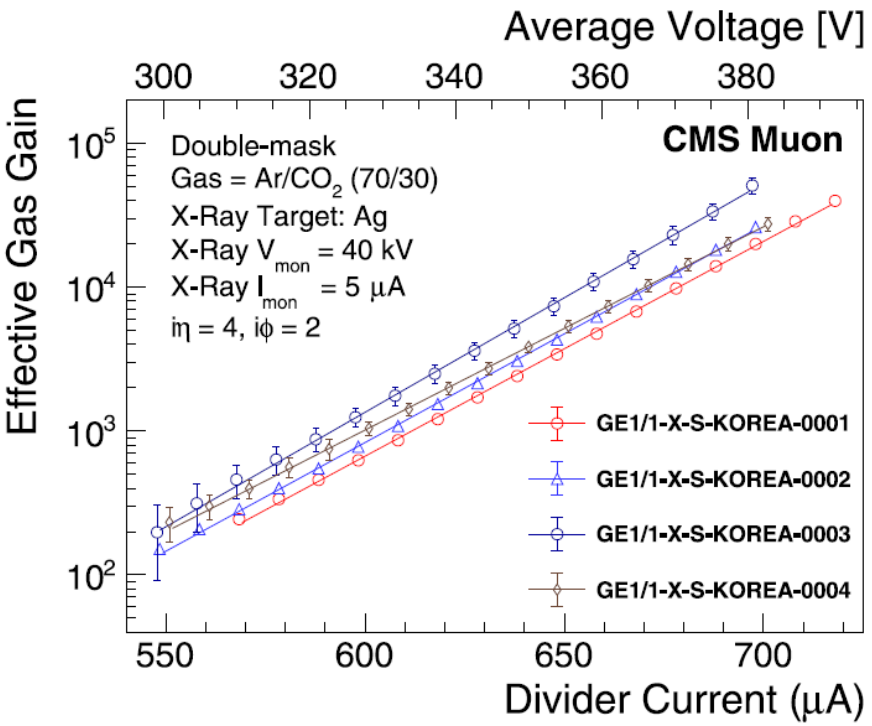

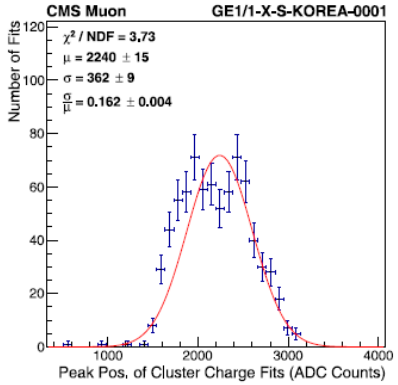

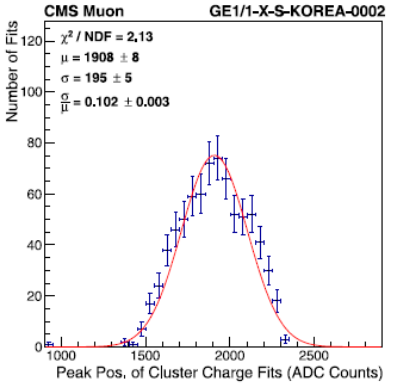

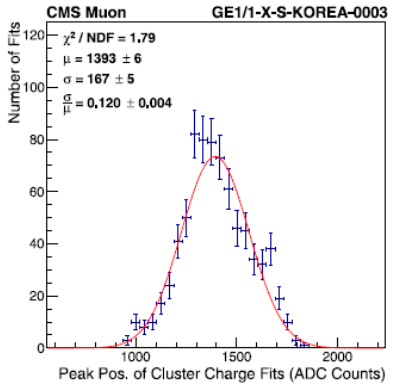

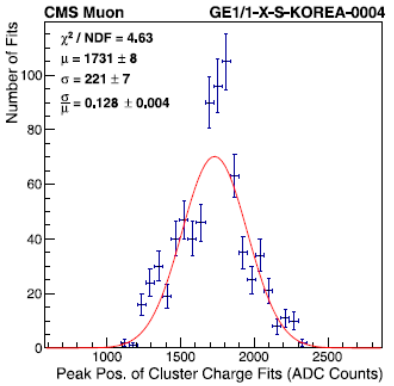

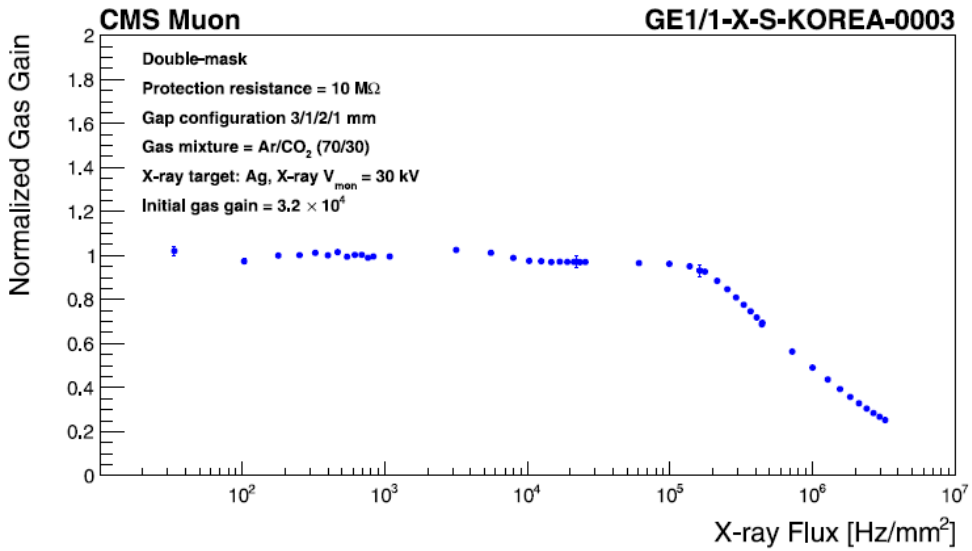

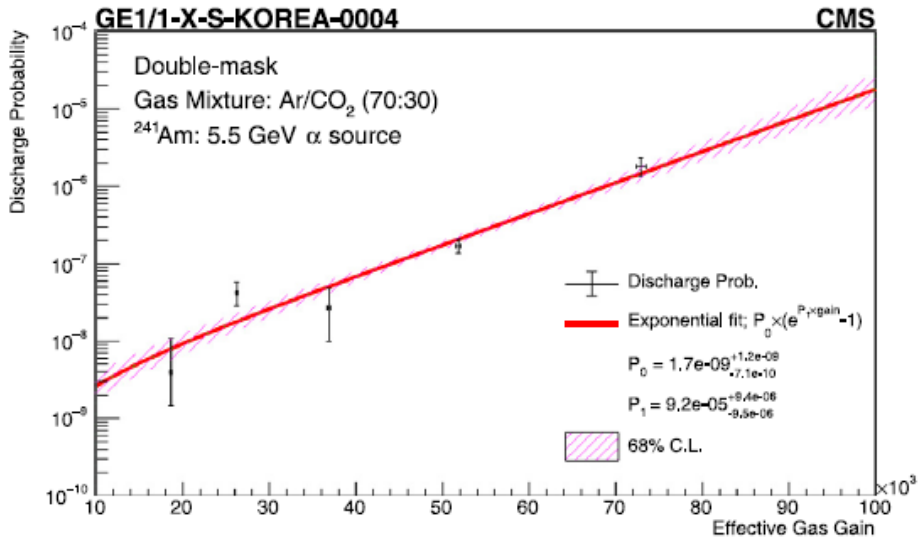

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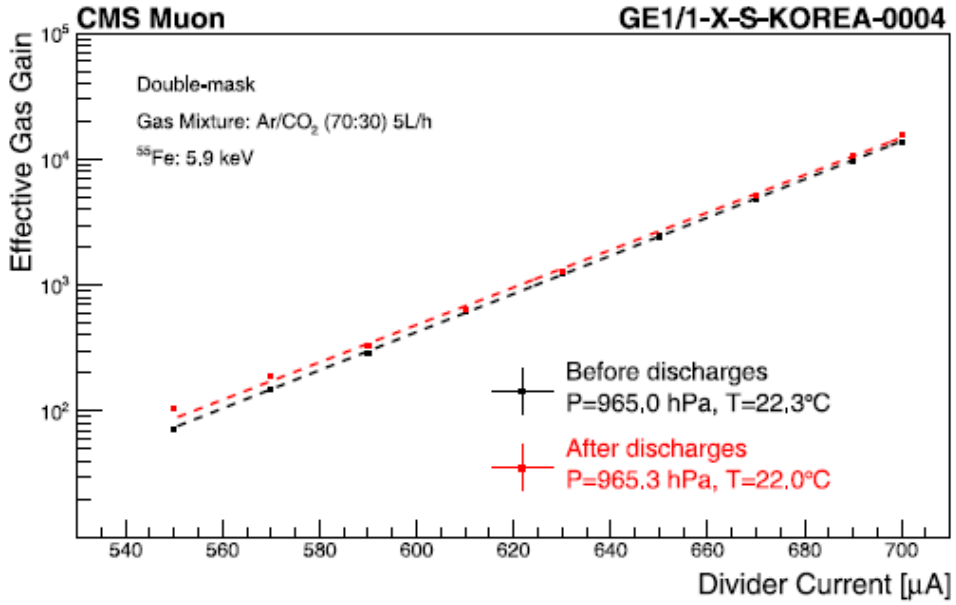

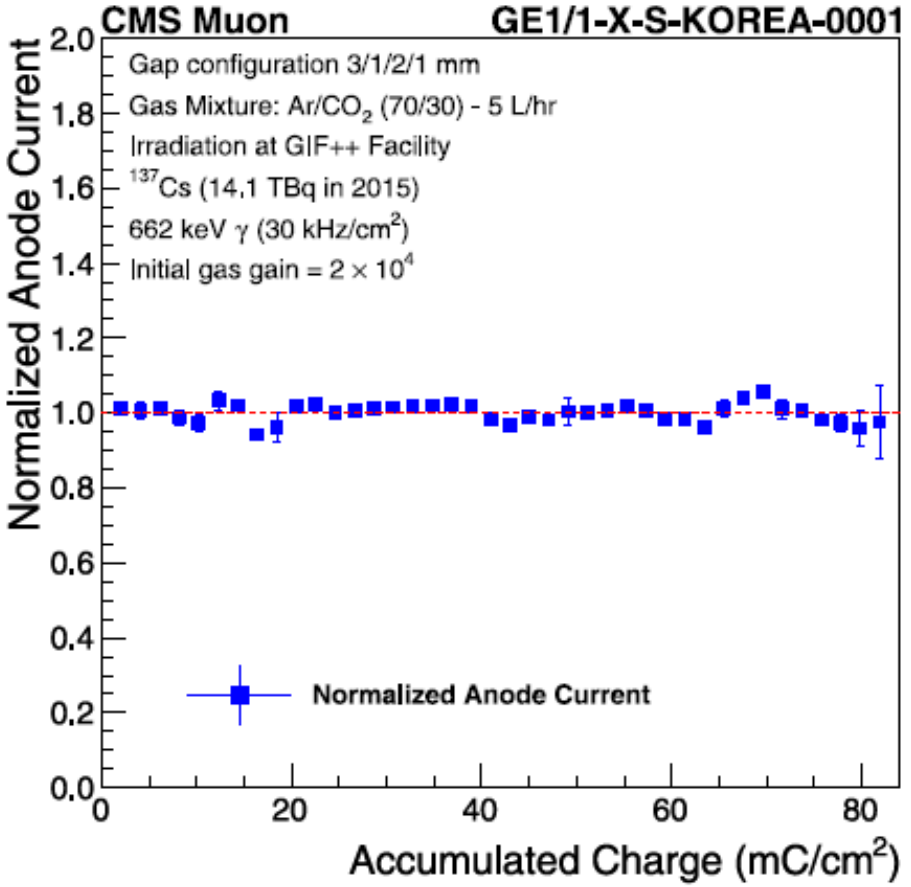

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