

Korean Capability in GEM production and μ RWELL R&D Plan

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MPGD DSC Meeting

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1. CMS Phase-2 GEM upgrades

- Three GEM stations: GE1/1, GE2/1, and ME0
 - Too many GEM foils for CERN MPT to produce alone
- KCMS responsibility: production of half of GE2/1 and all of ME0 foils
 - ~ 1100 foils



Korea University (2007-)

Faculties: B. Hong, S. Choi, J. Yoo



Kyungpook National University (2007-)

Faculties: S.W. Lee, C. Moon



Sungkyunkwan University (2007-)

Faculties: I. Yu



Chonnam National University (2007-)

Faculties: D. Moon



University of Seoul (2009-)

Faculties: I. Park, J. Lee



Seoul National University (2013-)

Faculties: U. Yang



Sejong University (2015-)



Hanyang University (2016-)



Kyung Hee University (2019-)

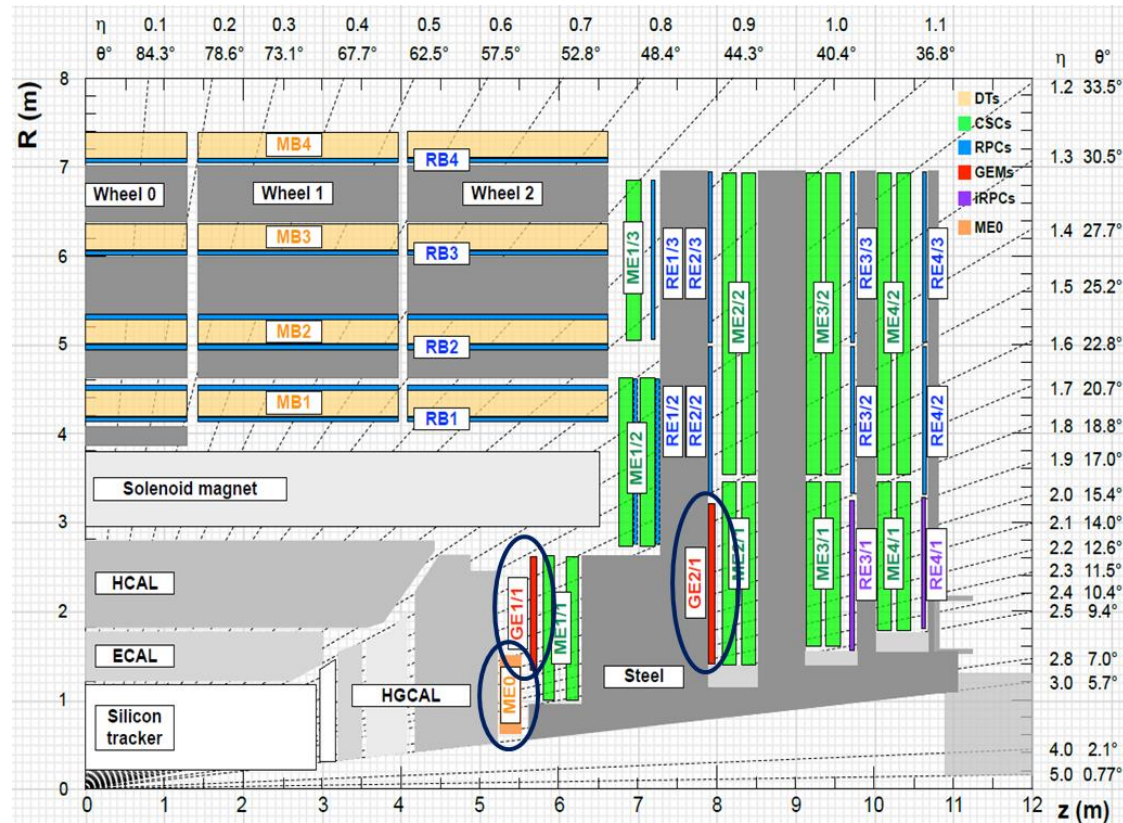


Yonsei University (2020-)



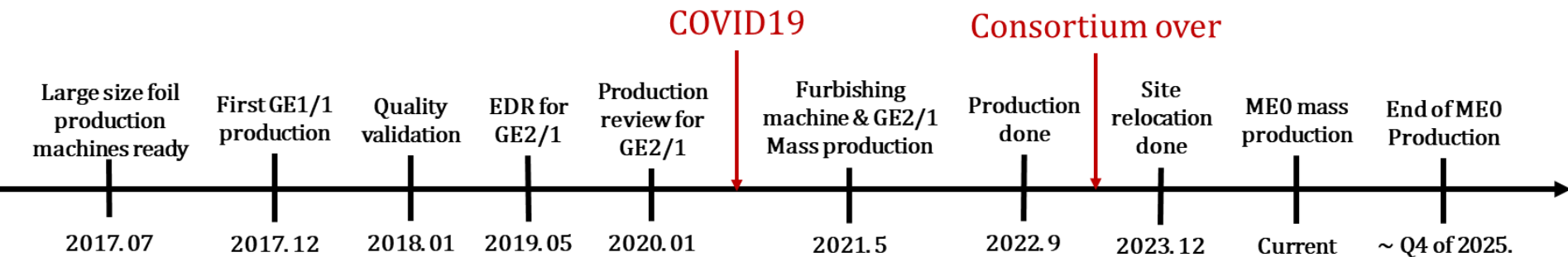
Gangneung-Wonju National

<https://www.cms-kr.org/>



2. Timeline of GEM production in Korea – Overview

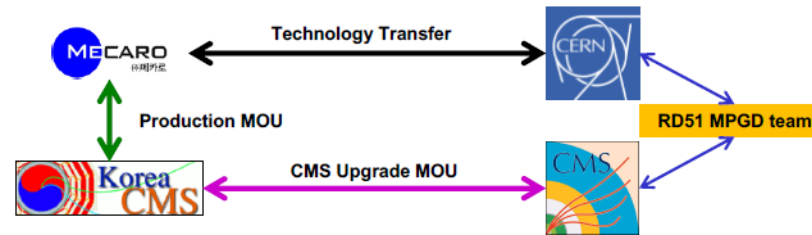
- KCMS is one of the only two vendors of large size GEM foils
 - Maximum size: $120 \times 58 \text{ cm}^2$
 - The double-mask technique for faster production
 - Mask alignment is crucial
 - Glass mask (expensive) is needed
 - ⇒ KCMS facility is suitable for mass production not R&D



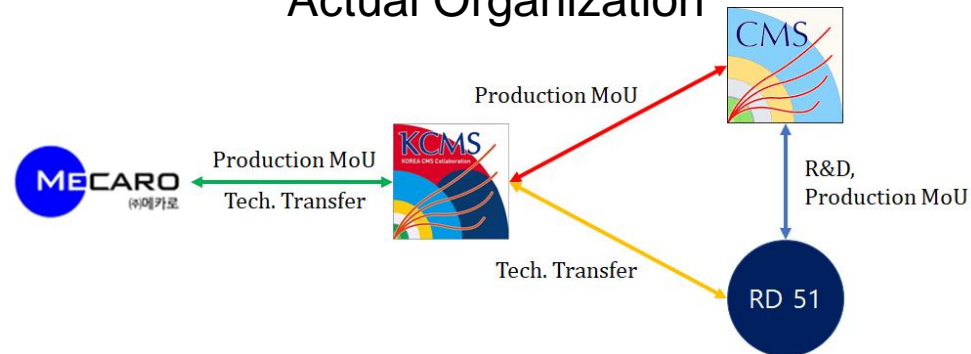
2. Timeline of GEM production in Korea – R&D

- KCMS had made consortium with Mecaro Co., Ltd.

Designed Organization



Actual Organization



- KCMS had moderated all discussion, performed production R&D and even coordination of mass production

⇒ Reason why the production smoothly handed over to KCMS

2. Timeline of GEM production in Korea – R&D

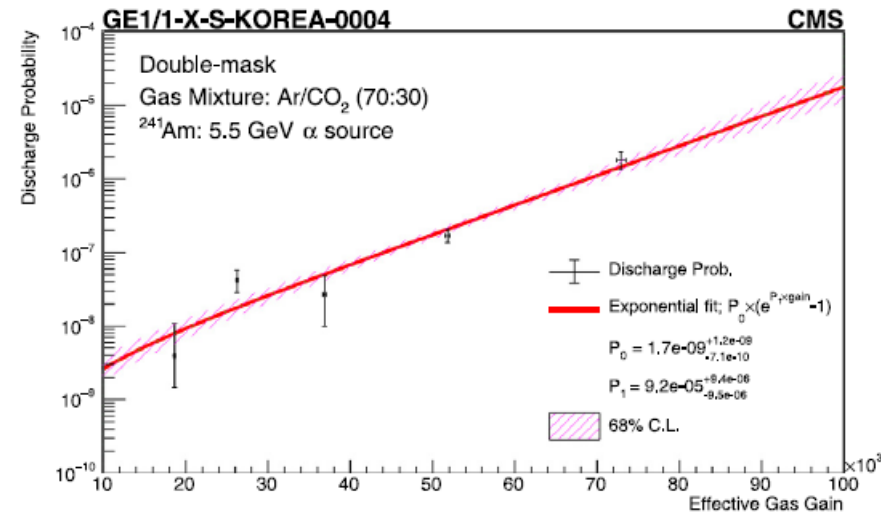
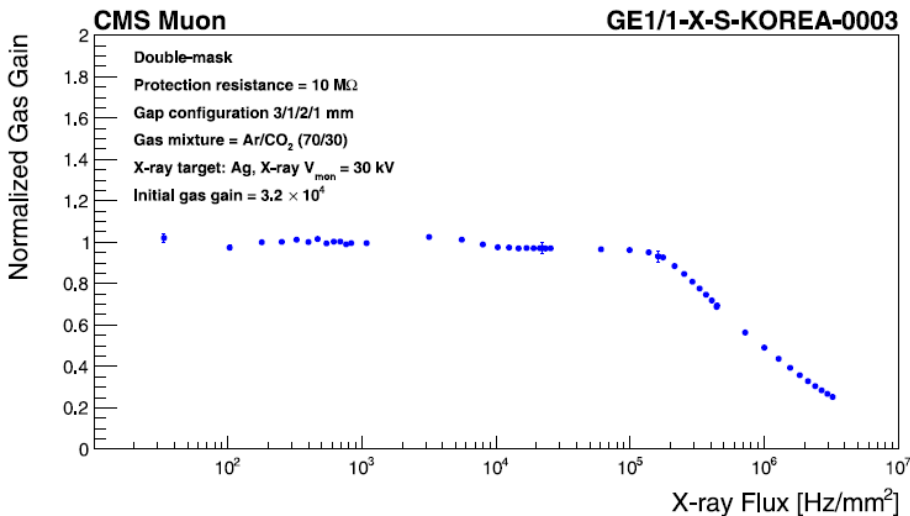
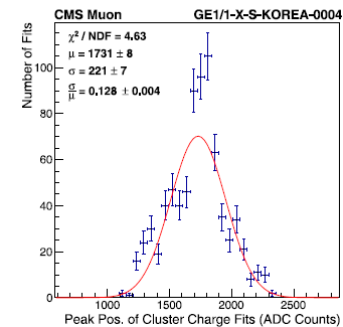
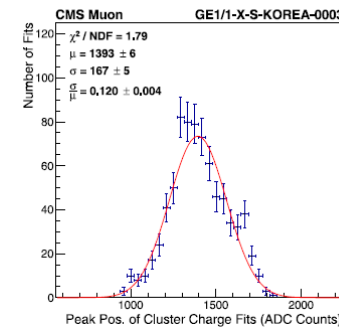
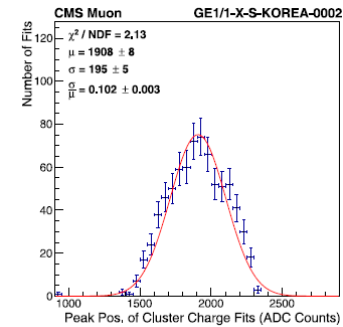
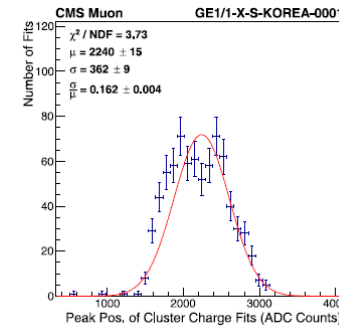
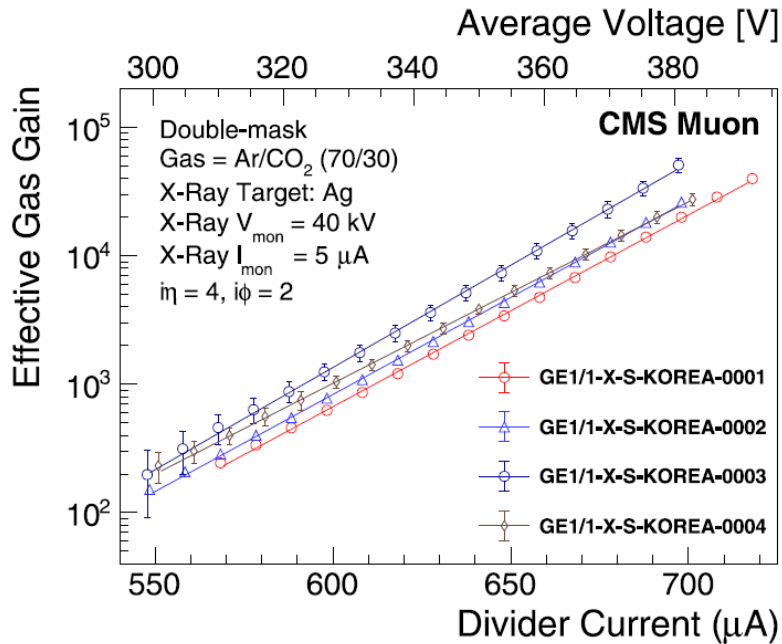
- Production R&D and vendor qualification were done with CMS GE1/1 detectors
- After optical inspection, 4 GE1/1 detectors were assembled with Korean GEM foils and properties of those were measured
 - Results were consistent with CERN detectors and satisfied CMS TDR requirements
 - NIMA 1057 (2023) 168723

Key technician
KCMS



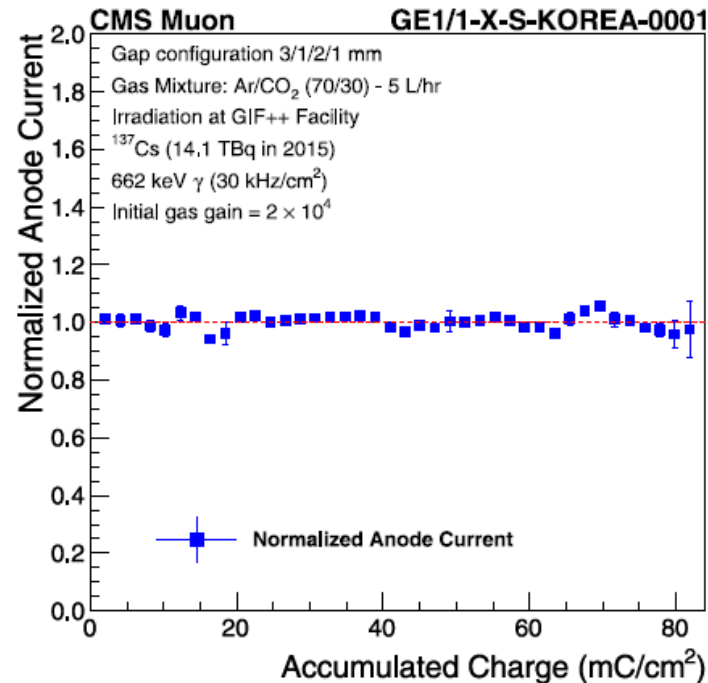
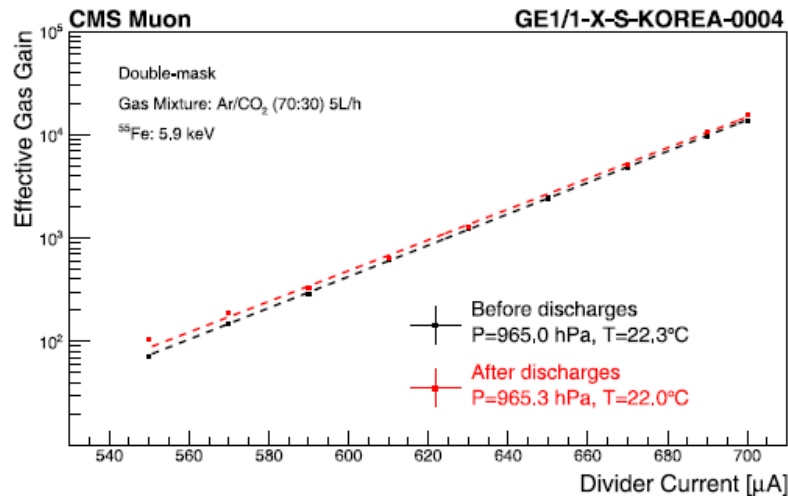
2017, Dec, 2nd
@ Geneva airport

2. Timeline of GEM production in Korea – R&D



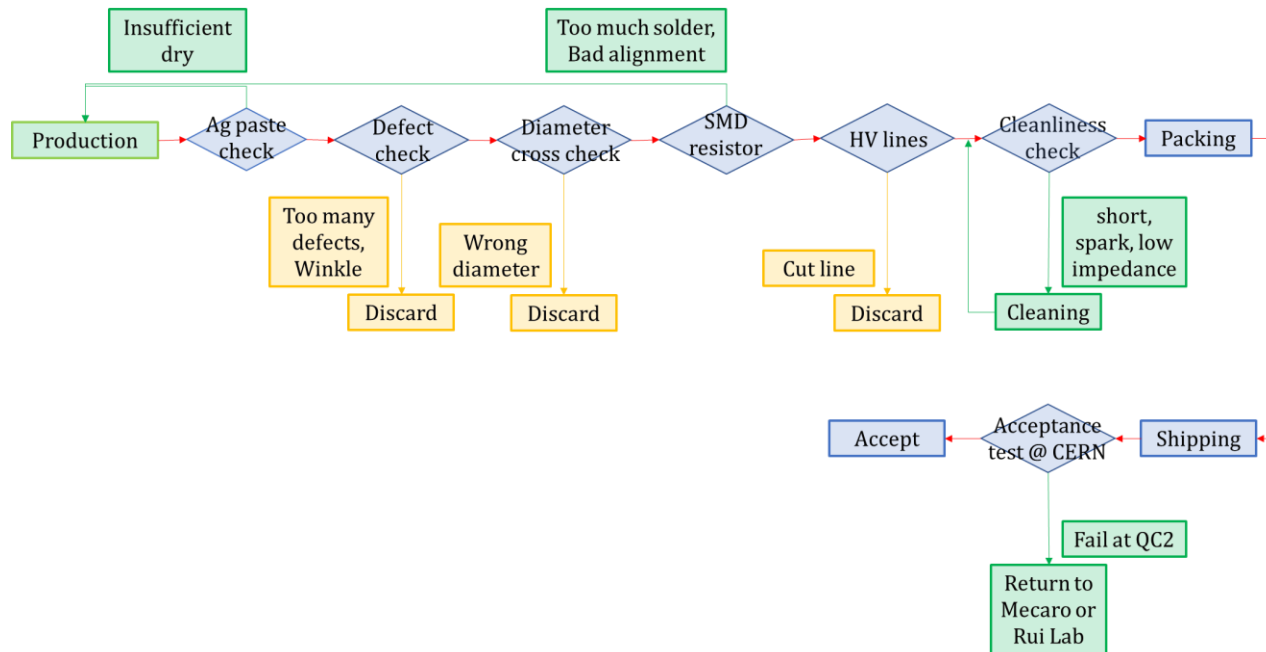
2. Timeline of GEM production in Korea – R&D

- Throughout the R&D phase, we've accumulated a lot experience not only in production R&D but also in detector R&D
 - Large pool of person power



2. Timeline of GEM production in Korea – Mass production

- 292 foils have been produced and passed QC/QA criteria
 - From 2021 May to 2022 Sep.
- Experience in mass production has been accumulated
- The produced foils are inspected by KCMS personnel through well-defined QA/QC protocol before shipping **at Mecaro**
 - Critical process to save budget and time on air transportation and pin down responsibility



2. Timeline of GEM production in Korea – Mass production

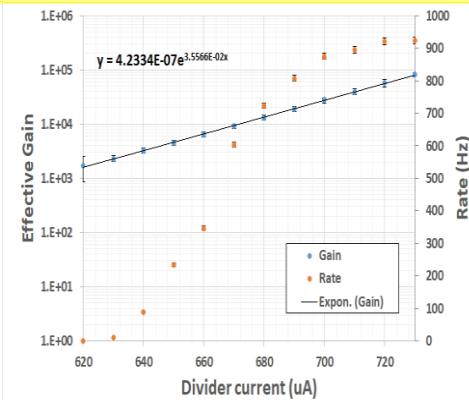
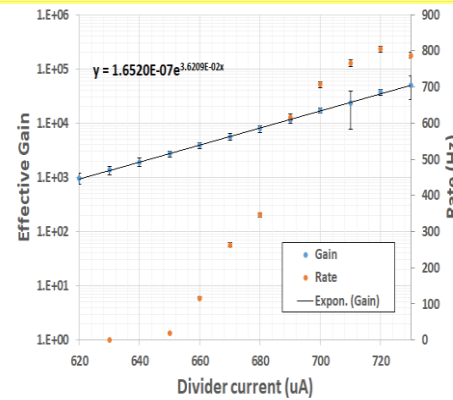
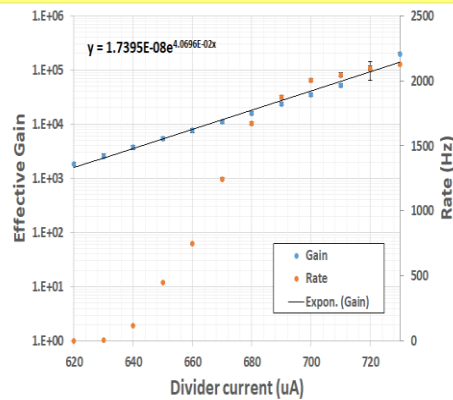
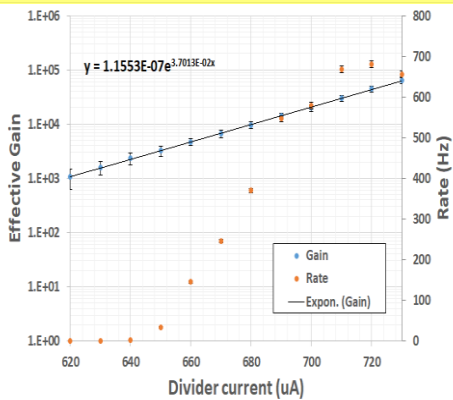
M2

M3

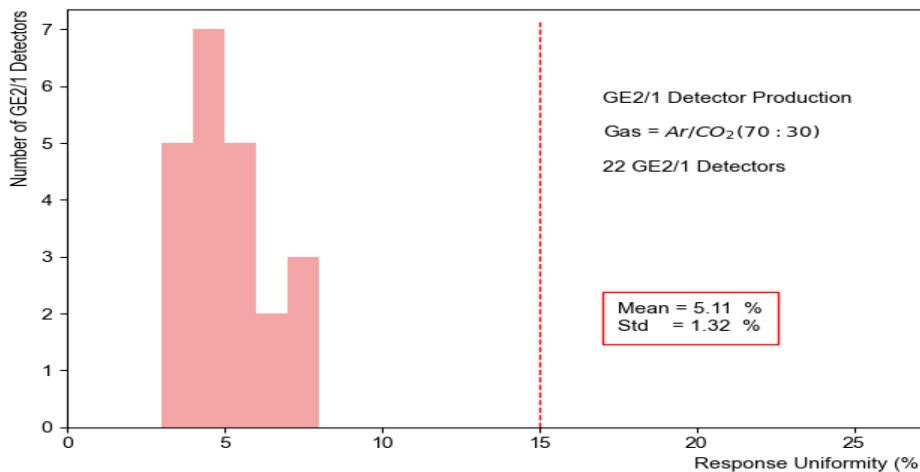
M6

M7

Effective Gain



Gain Uniformity



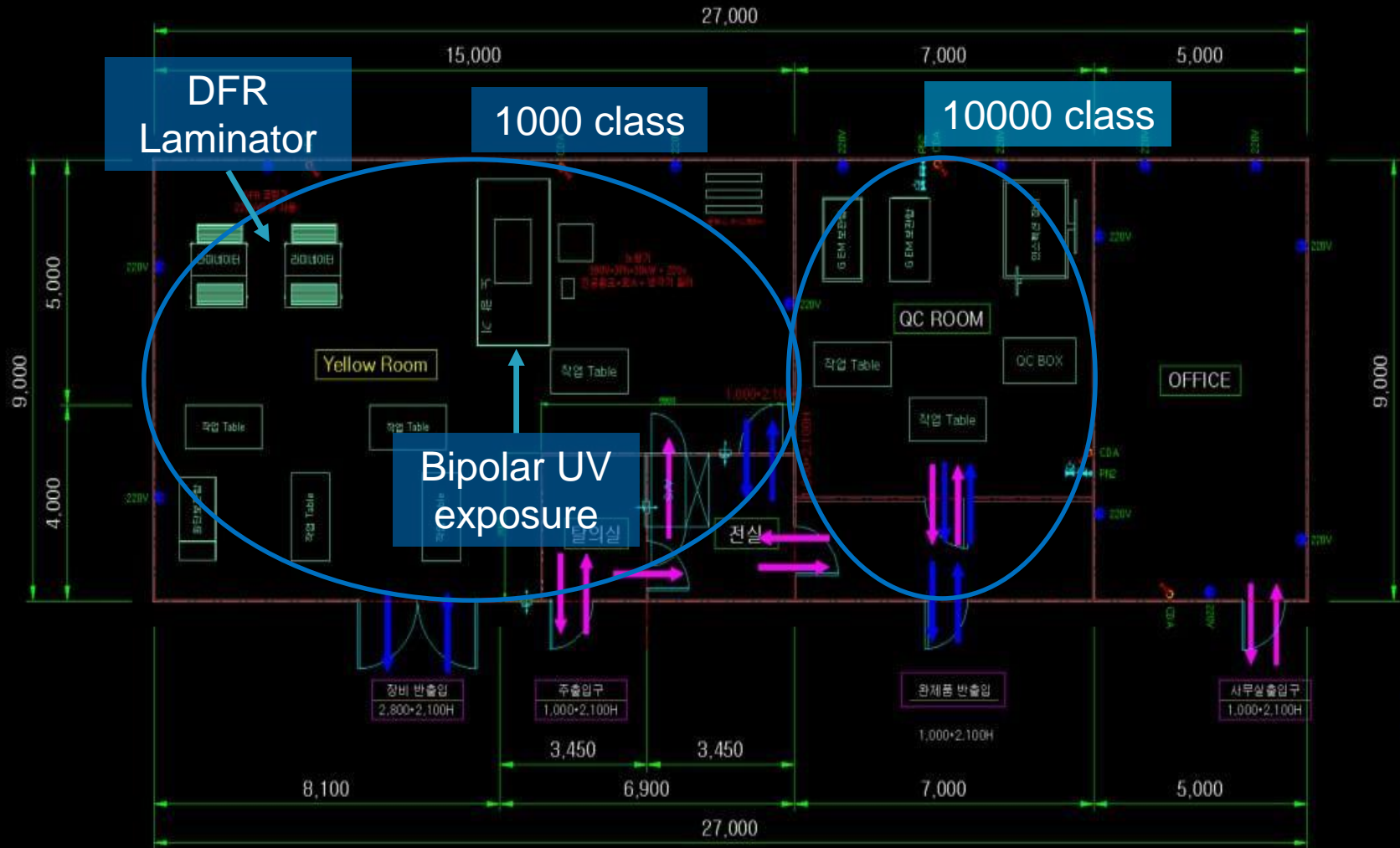
Observed RU: 5.11%
 TDR requirement:
 <15%

2. Timeline of GEM production in Korea – Site relocation

- Unfortunately, Mecaro gave up GEM production
- Photo process @ IBS
Chemical process @ PnF (PCB maker), site has been rented
 - 2 h 30 min
 - Not possible to get chemical handling license in IBS area due to environmental regulation
- Site relocation & getting green light ~ 2023. 12
 - Validation batch was produced at the new site, Delivered to CERN and checked



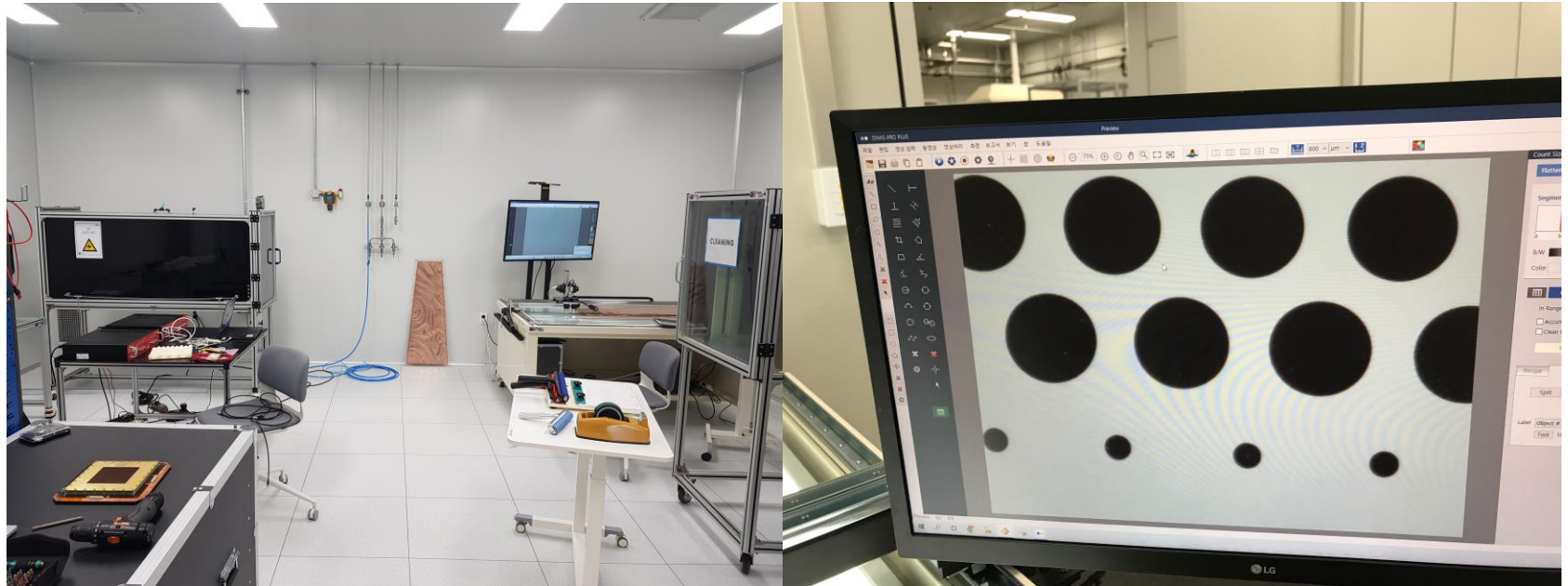
3. Facilities – Photo site



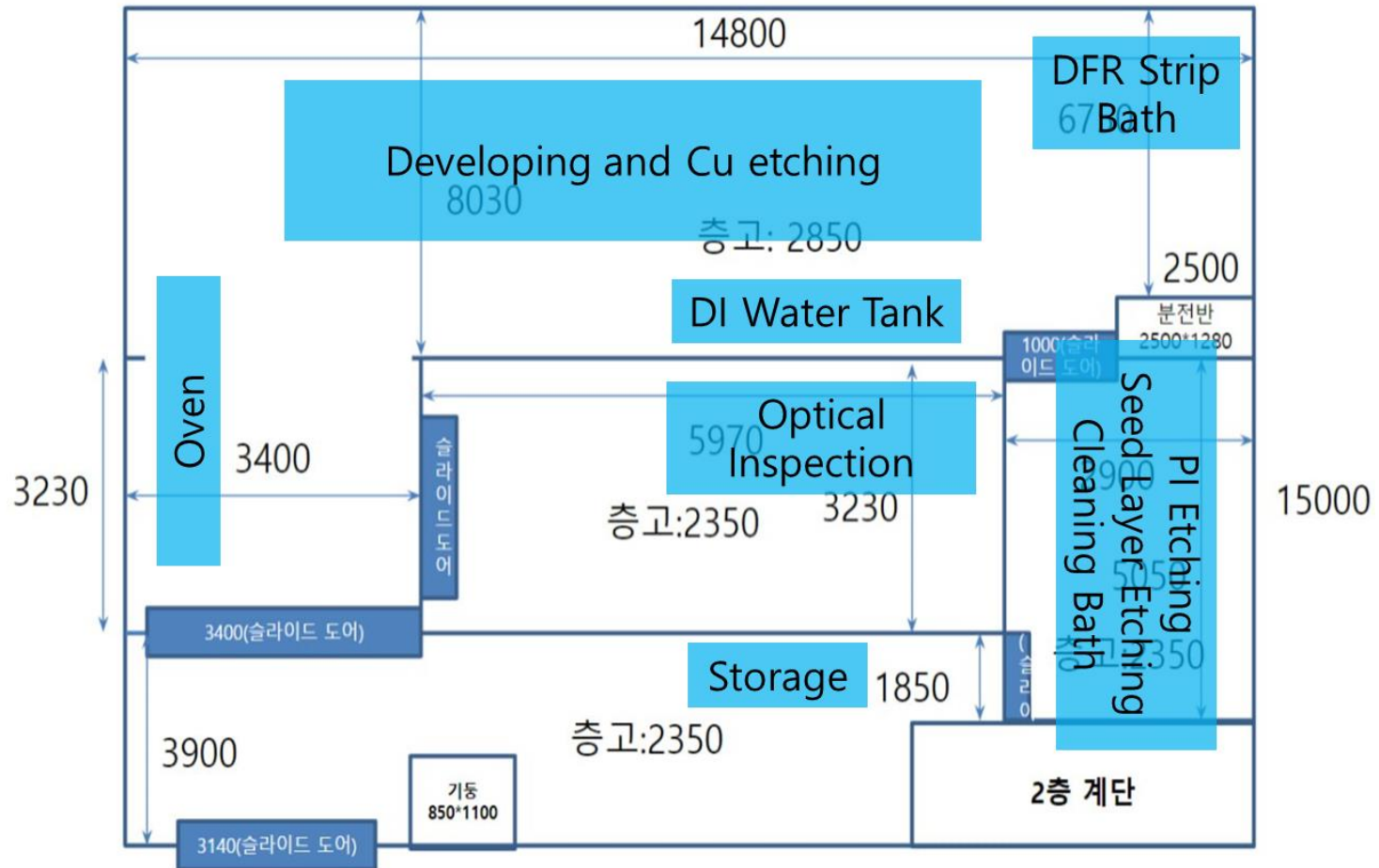
3. Facilities – Photo site



3. Facilities – Photo site

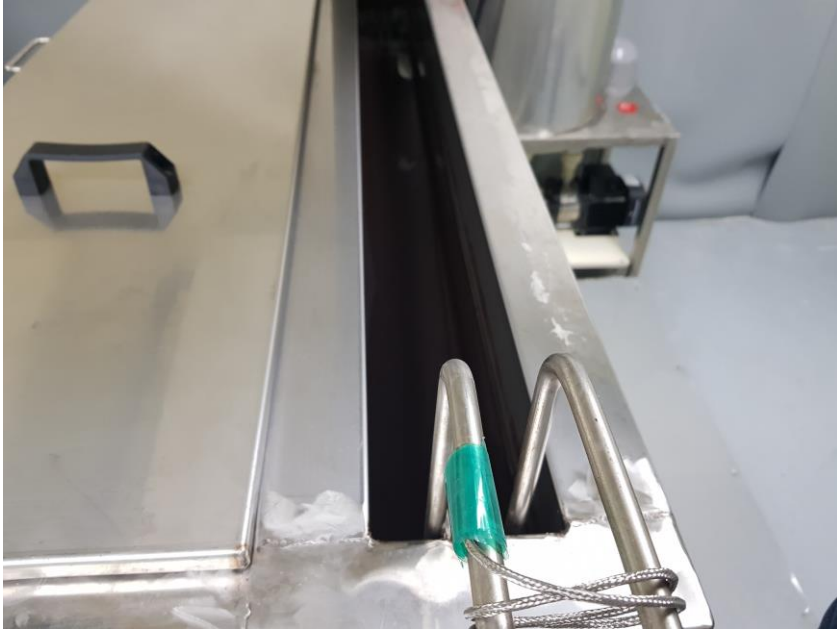
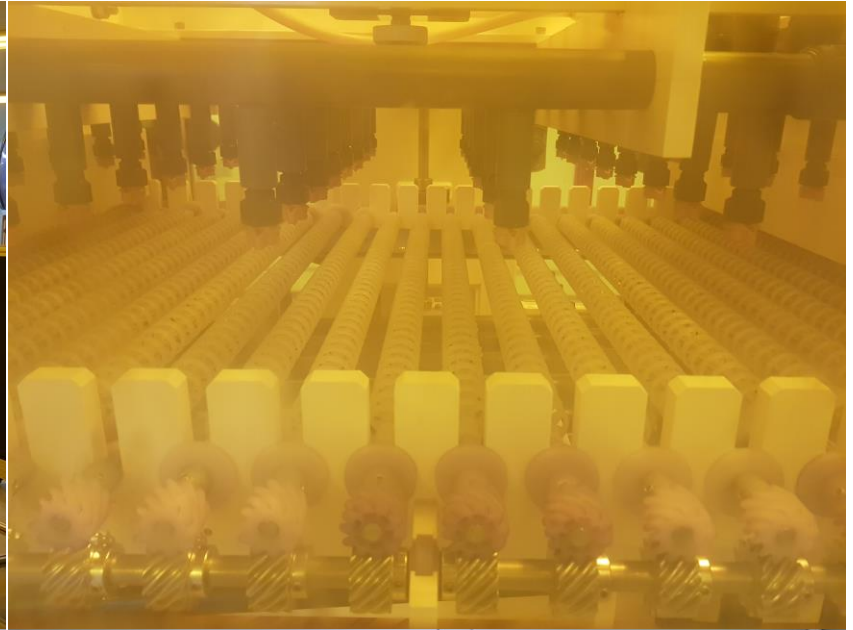


3. Facilities – Chemical site

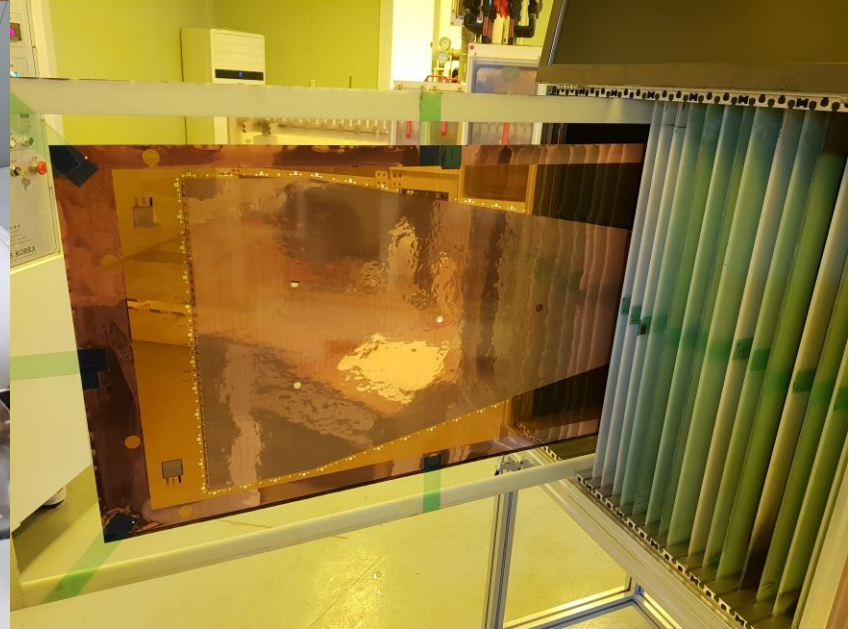


- Making via, soldering SMD, packaging ETC are done in 2nd floor

3. Facilities – Chemical site

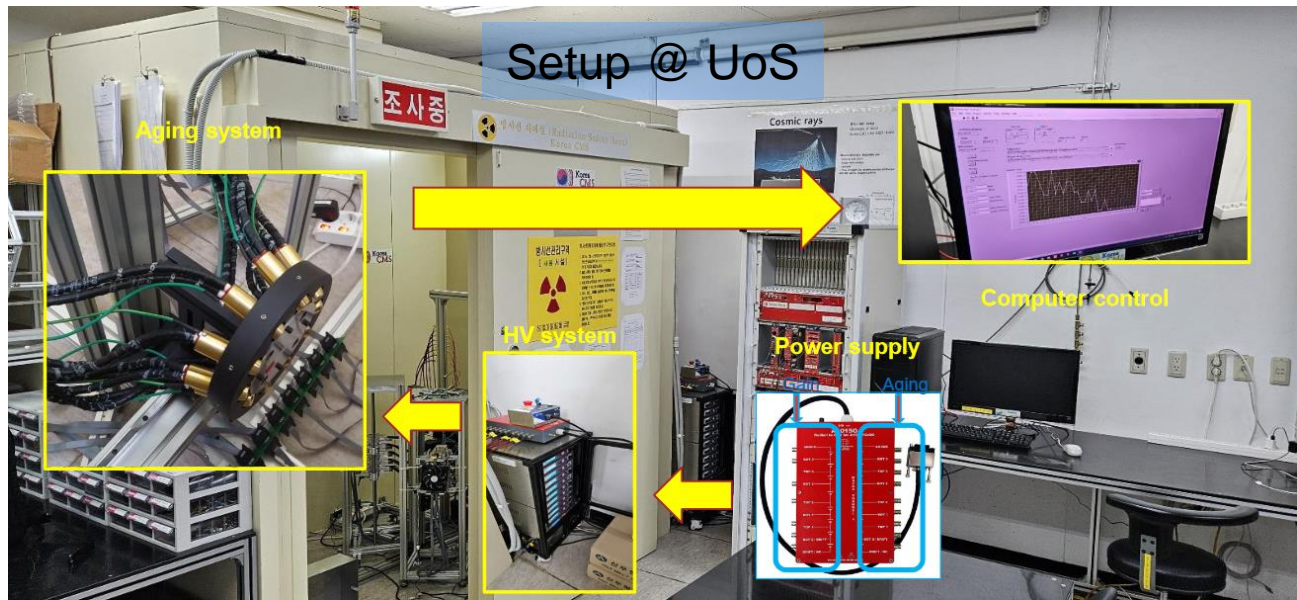


3. Facilities – Chemical site



4. Current status

- Mass production of CMS ME0 just starts
- The production will be ended by Q4 of 2025 (strict deadline due to LHC schedule)
→ and after that?
- Aging experiment targeting charge accumulation of 8 C/cm^2 or more
 - Using 10 array of 4W x-ray tubes



5. R&D plan for μ RWELL production

- We would like to expand KCMS' expertise to μ RWELL production
 - Korea is strong at RPC. Resistive GEM would be natural extension
 - μ RWELL itself is very charming; self-rigidity
 - To preserve facilities and person-power, the next contribution site is needed
 - For ePIC, and DAMSA experiment (FCC-ee)
- Trying to convince domestic community that μ RWELL R&D is needed
 - It looks like the community is being persuaded
 - Korean GEM community is fully convinced, of course

5. R&D plan for μ RWELL production

- DAMSA experiment: Search for $a \rightarrow \gamma\gamma$ and $A' \rightarrow e^+e^-$ using beam dump of Fermi Lab PIP II

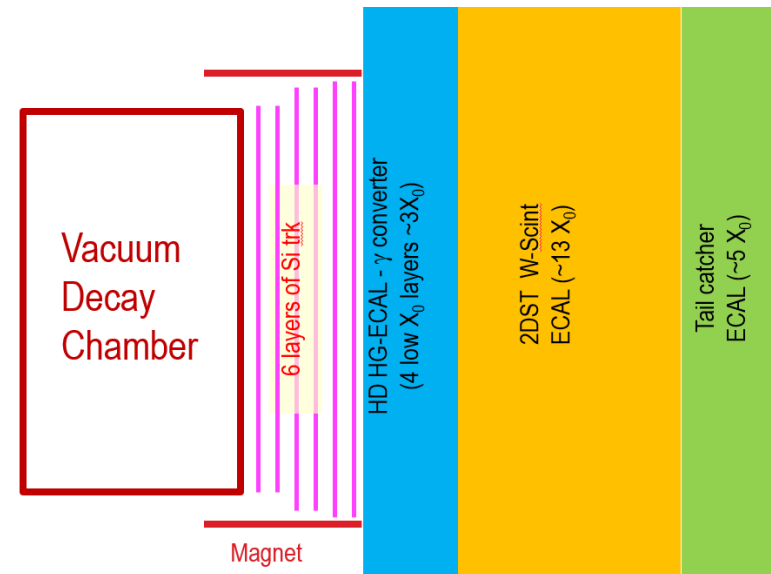
- PRD **107**, L031901 (2023)

- To veto Bkg. and to detect $A' \rightarrow e^+e^-$, tracker is needed

- μ RWELL would be cheaper and harder to neutron Bkg. than Si

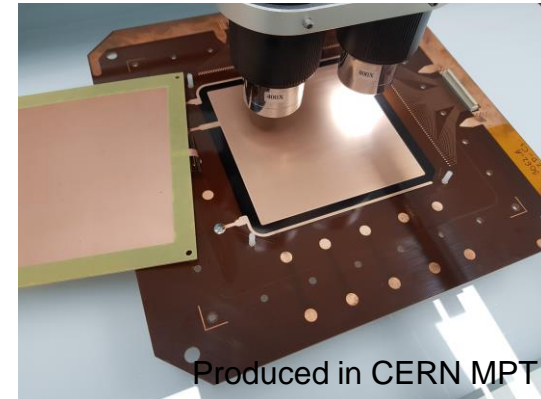
- ⇒ Consolidate R&D efforts for both of ePIC and DAMSA!

- DAMSA is a small experiment, it will not a burden on production



5. R&D plan for μ RWELL production

- R&D is just launched
 - Production of $10 \times 10 \text{ cm}^2$ μ RWELL
 - Discussion with technicians is initiated
 - Seeding budget is secured
- Missing technology
 - DLC sputtering: planning to purchase DLC sputtered FCCL
 - PCB process:
 - not going to do every part of PCB production
 - planning to purchase pre FCCL pressed PCB and do downstream processes
 - PnF (contractor, PCB maker) are very helpful
- In late Apr. or early May, I and technician of KCMS will visit CERN MPT to learn exact production process
 - E-mail discussion with Rui is ongoing



5. R&D plan for μ RWELL production

- We would like to participate ePIC real scale μ RWELL prototyping and contribute to ePIC GEM and μ RWELL tracker
 - Securing budget is critical
- We'll submit proposal on MPGD contribution toward ePIC to Korean MSIT in this year
- It'll be great to converge contribution strategy before the proposal submission

6. Concerns on possible conflicts with CMS production

- CMS production will be done around the end of 2025
- CMS production and μ RWELL R&D can run parallel
- Overlapping CMS production and ePIC production requires careful management, including hiring more technicians
 - When the full scale procurement should start?
- From 2026, we can dedicate to ePIC
- The good news is that the technicians are very motivated
 - They are willing to tolerate a few months of overlap

Summary

- For CMS Phase-2 GEM upgrade, KCMS is producing large-sized GEM foils
 - Fully qualified through CMS GE1/1 and GE2/1 projects
- After the consortium with Mecaro over, facilities have been relocated
 - Photo processes: IBS
 - Chemical processes: PCB making site
 - Green light has been obtained and mass production is ongoing
- We are willing to expand our expertise to μ RWELL
 - Production of $10 \times 10 \text{ cm}^2$ μ RWELL
- We would like to join ePIC real scale μ RWELL prototyping for the MPGD contribution toward ePIC