

CMS GEM development in Korea & μ RWELL contribution idea to ePIC

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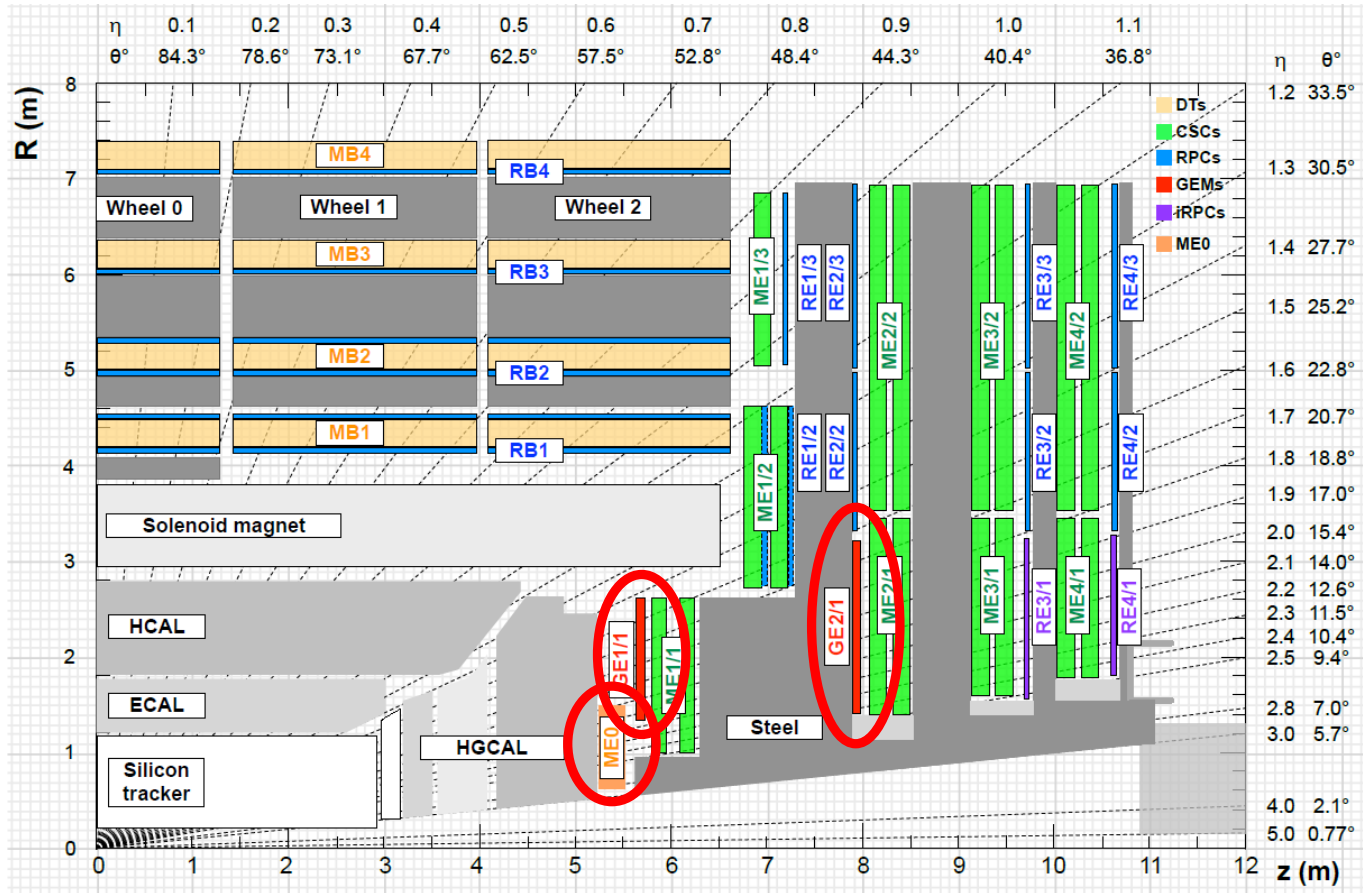
Inseok Yoon (Seoul National University)

EIC Asia Workshop @ RIKEN

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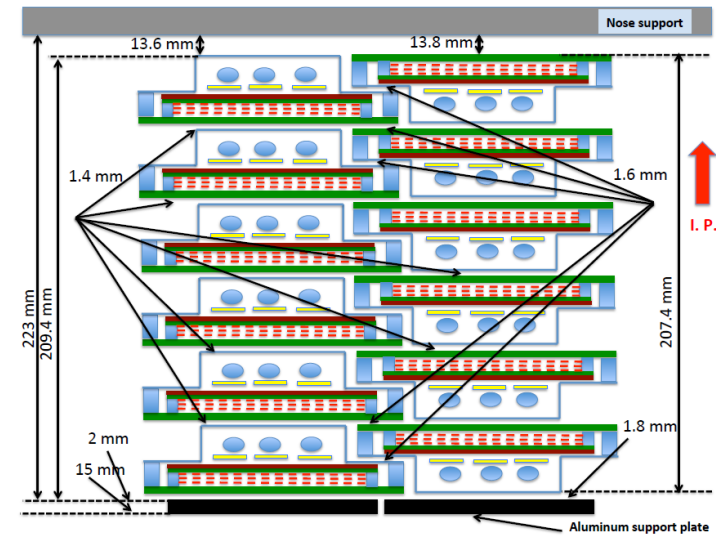
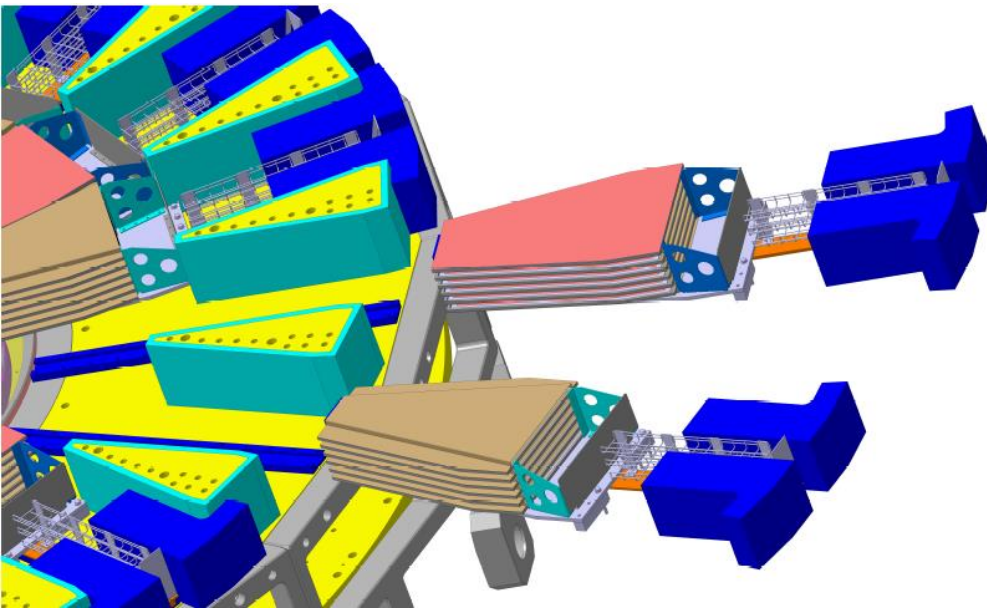
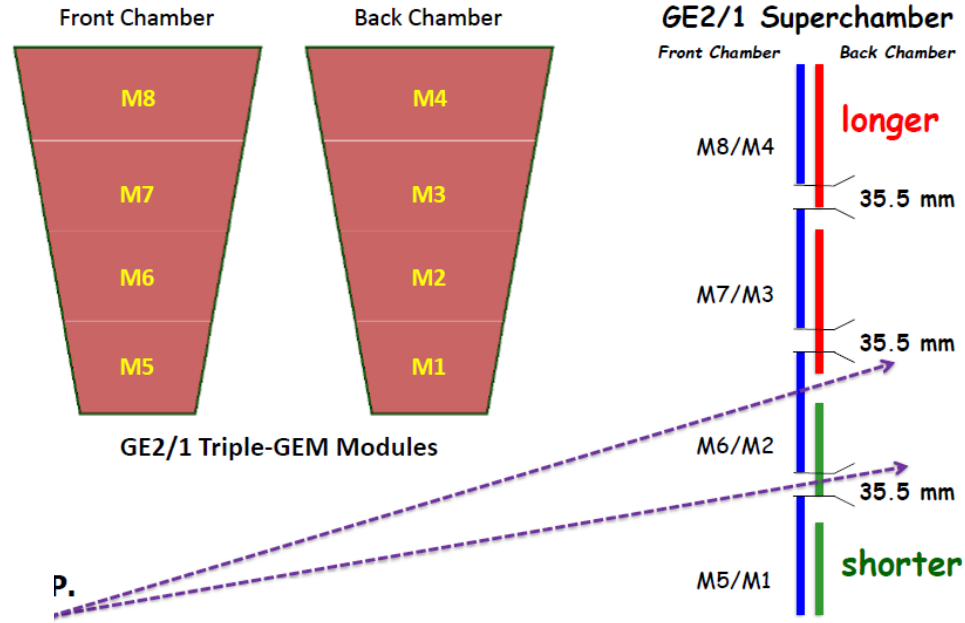
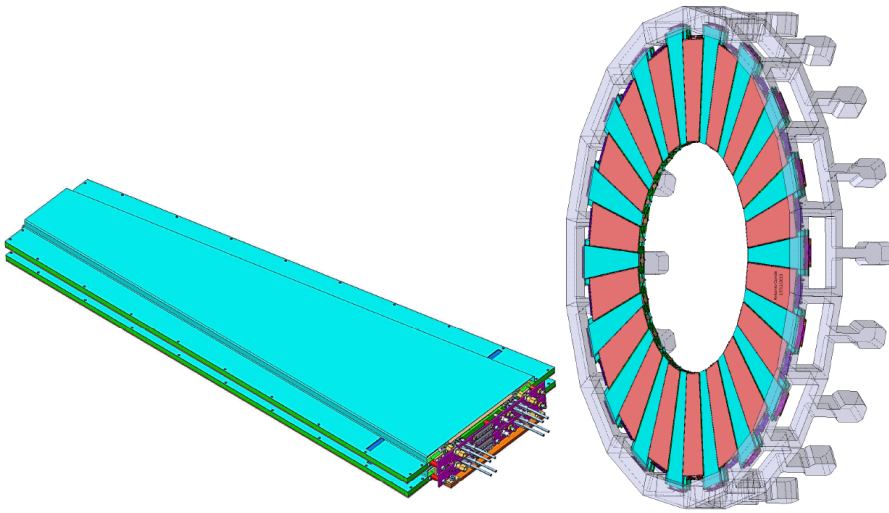
- CMS GEM upgrades for HL-LHC
- KCMS GEM projects
 - Overall
 - Production
 - Validation results
 - Mass production results
 - Current status and production plan for ME0
- Contribution idea for μ RWELL tracker of ePIC
 - Feasibility
 - Production plan for prototype μ RWELL

1. CMS GEM upgrade for HL-LHC



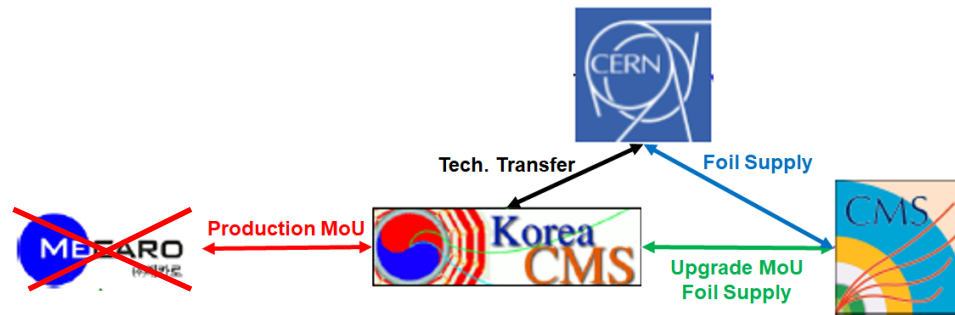
- GE1/1: installed in 2020
- GE2/1: production ongoing, will be installed during YETS 23/24 and 24/25
- ME0: will be installed during LS3 (26-28)

1. CMS GEM upgrade for HL-LHC



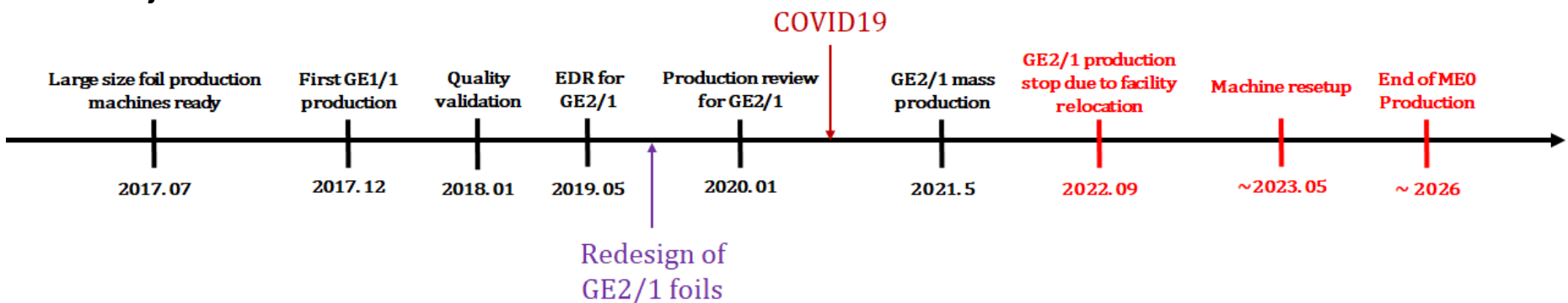
2. KCMS GEM projects – Overall

- KCMS: **In-kind contribution of the large-size GEM foils**
 - Second supplier of the large-size GEM foils together with CERN MPT
 - Half of GE2/1 and all of ME0 foils = $114 \times 4 + 666$ foils

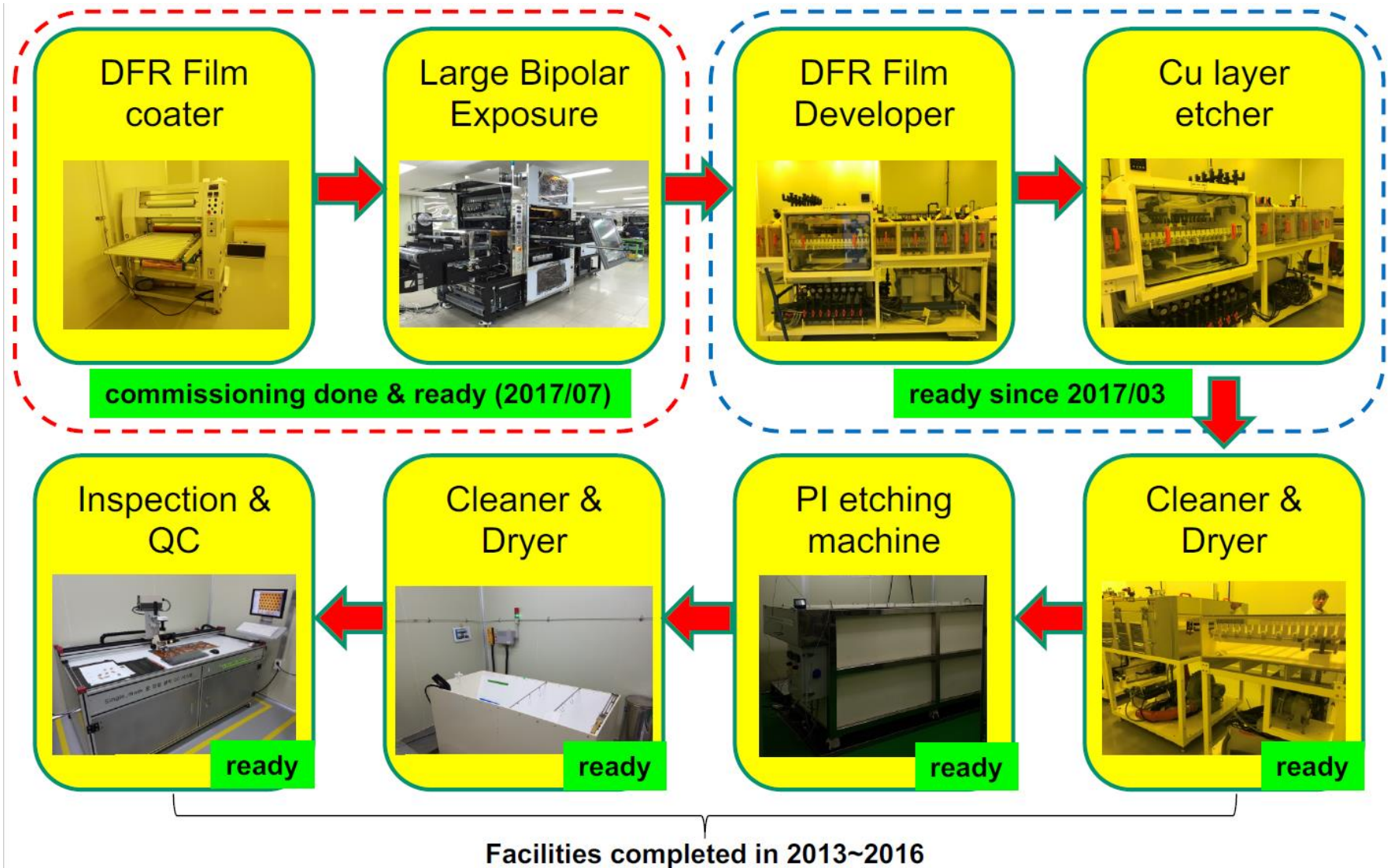


- Tight relationship with CERN MPT

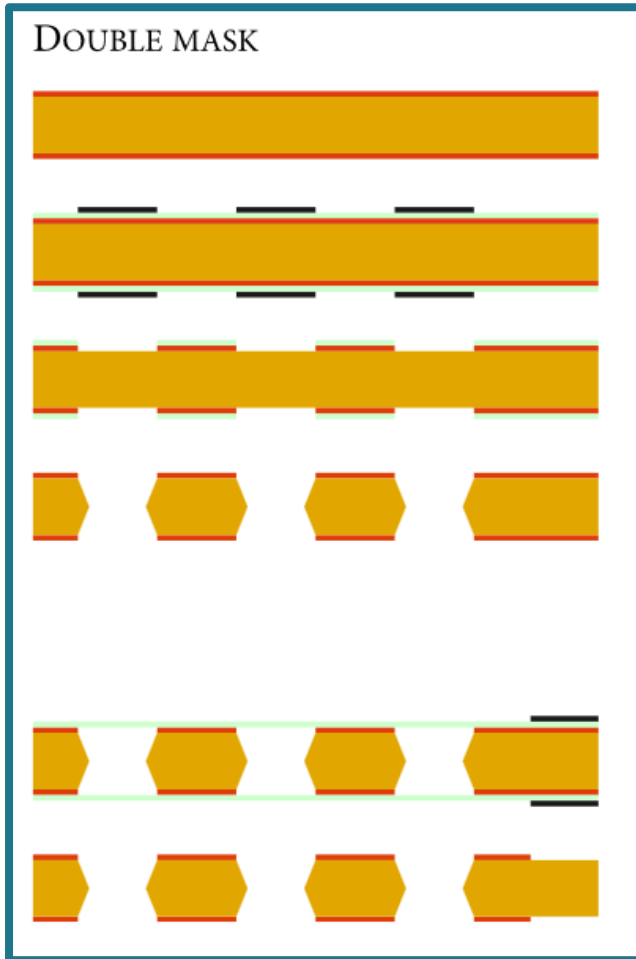
- Project timeline



2. KCMS GEM projects – Production



2. KCMS GEM projects – Production



50 mm polyimide foil, copperclad

photoresist lamination, masking, exposure and development

metal etching

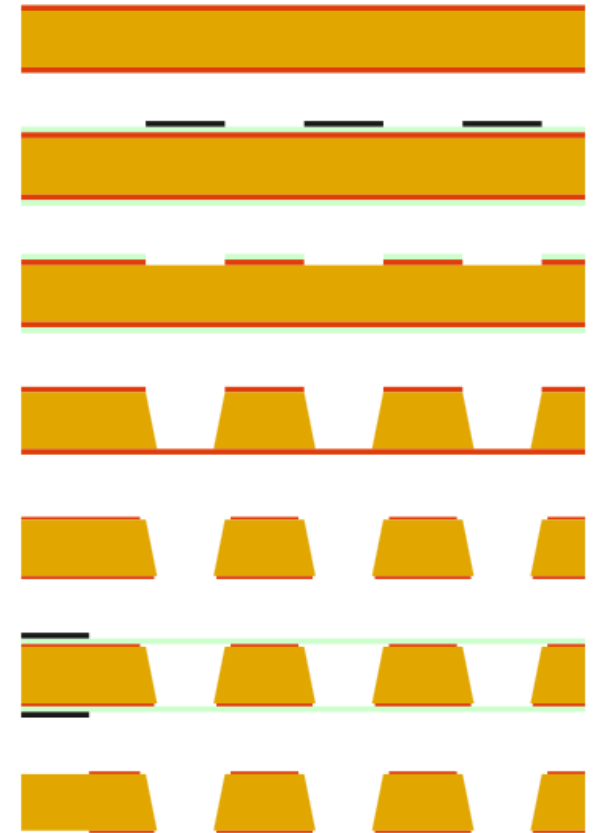
polyimide etching

metal etching

second masking to define electrodes

metal etching and cleaning

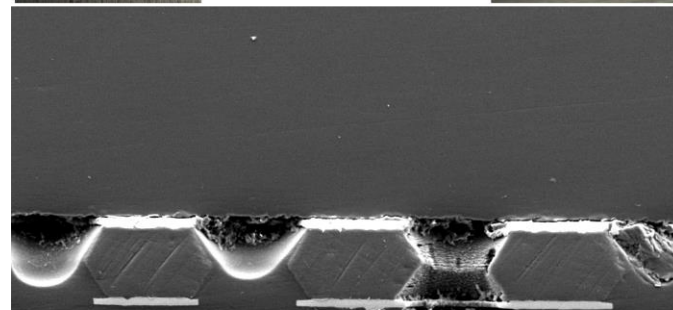
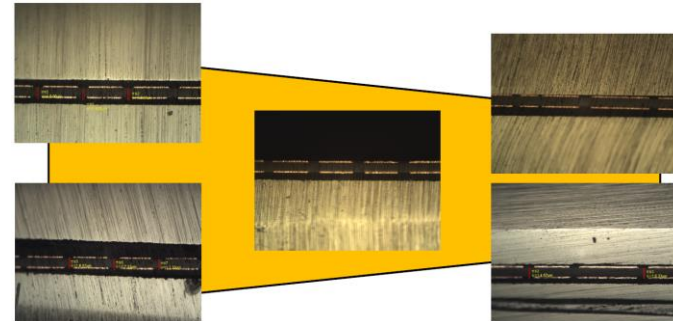
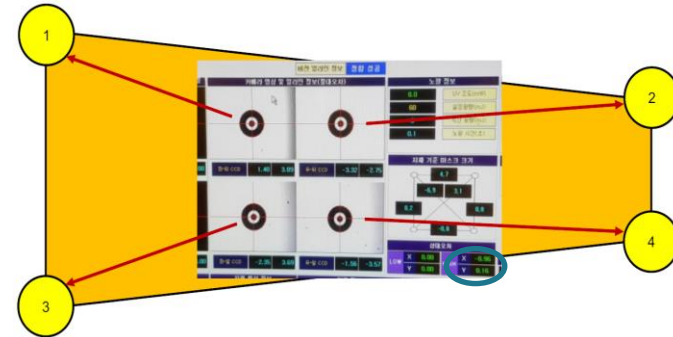
SINGLE MASK



KCMS adopts the double-mask technique

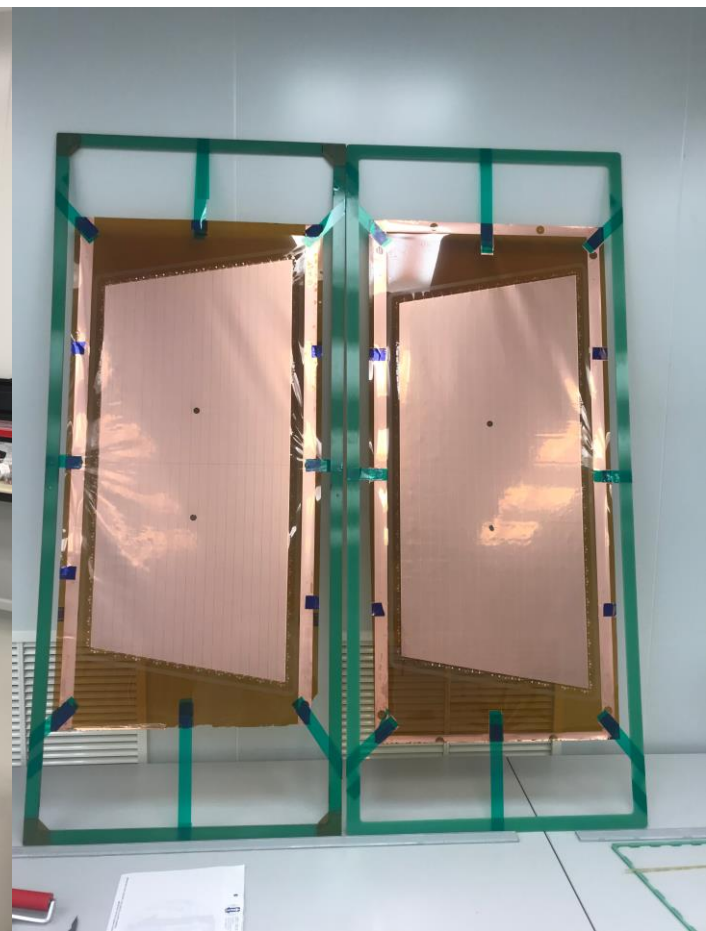
2. KCMS GEM projects – Production

- **Concept: faster production**
 - **Double-mask technique**
 - Automated conveyering machine from development to Cu etching
 - NaOH for DFR stripping
 - Low cost fast soldering technique
- Large bipolar UV exposure
 - **$125 \times 58 \text{ cm}^2$**
 - Residual misalignment $< 5 \mu\text{m}$
(emulsion glass mask)
- PI etching
 - MEA which has less inhalation toxicity
 - Tunable geometry by adjusting KOH/MEA



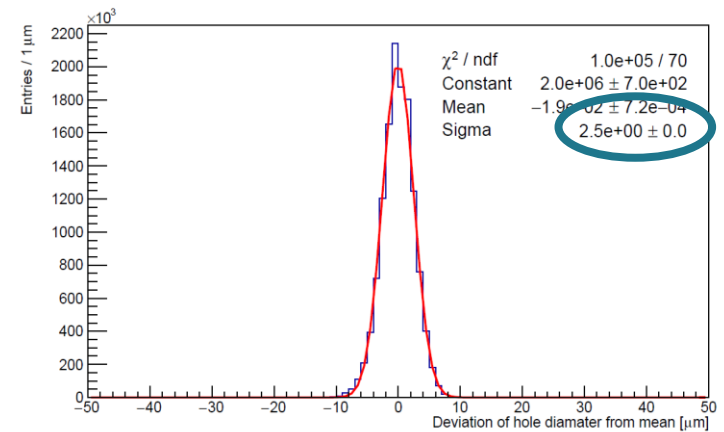
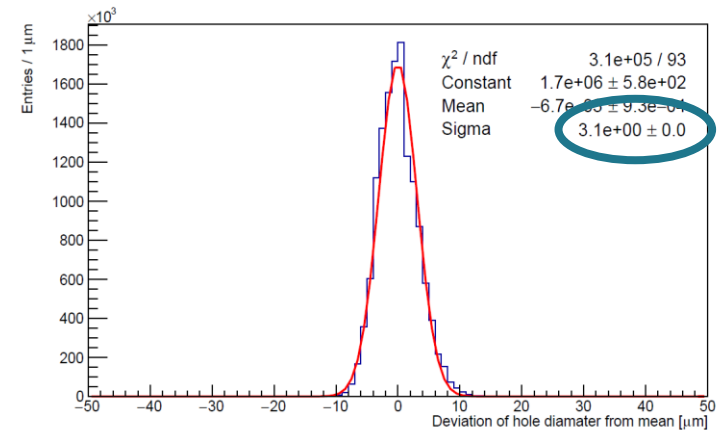
2. KCMS GEM projects – Production

- Korean GEM foils under QC

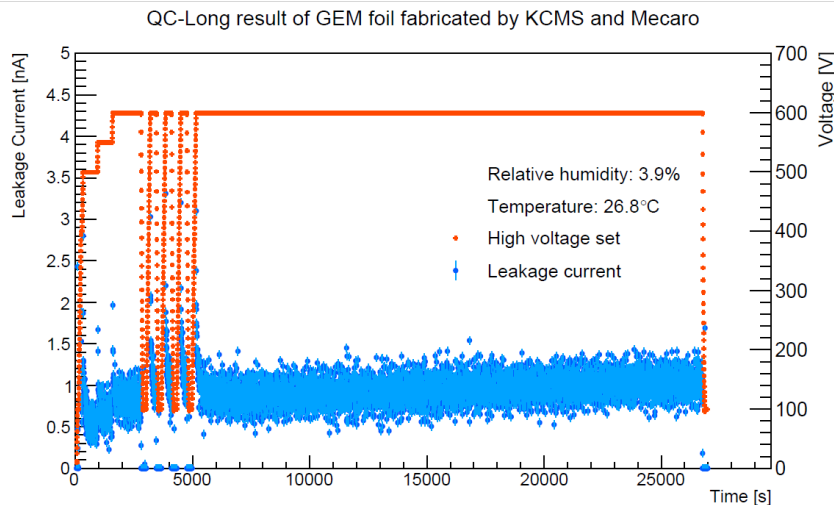


2. KCMS GEM projects – Validation

- Optical etching uniformity check
 - as Good as CERN double-mask foils
(Measured by Matt Posik (Temple Univ.))
- Long-term measurement of leakage current and applied voltage in dry condition

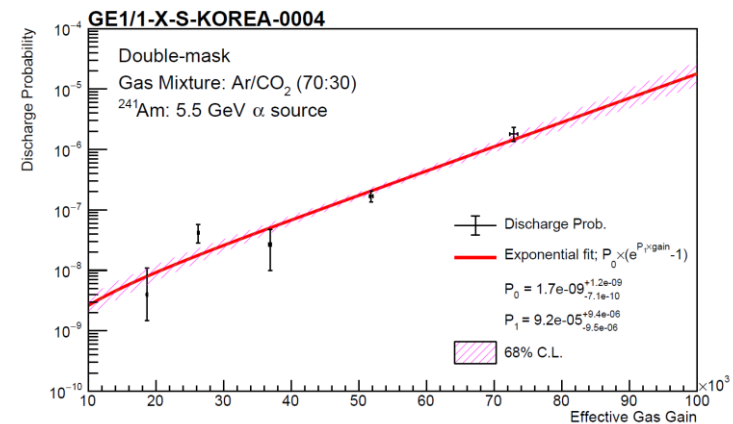
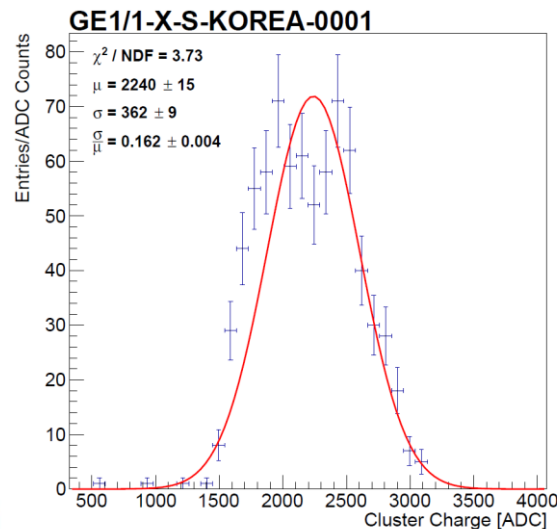
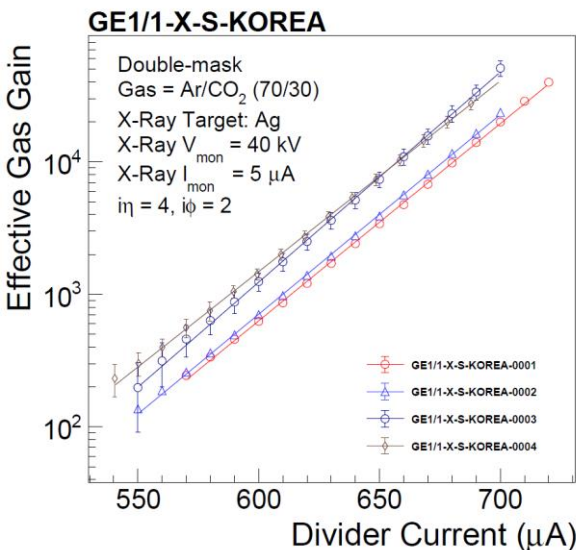


Matt Posik (Temple Univ.), private communication



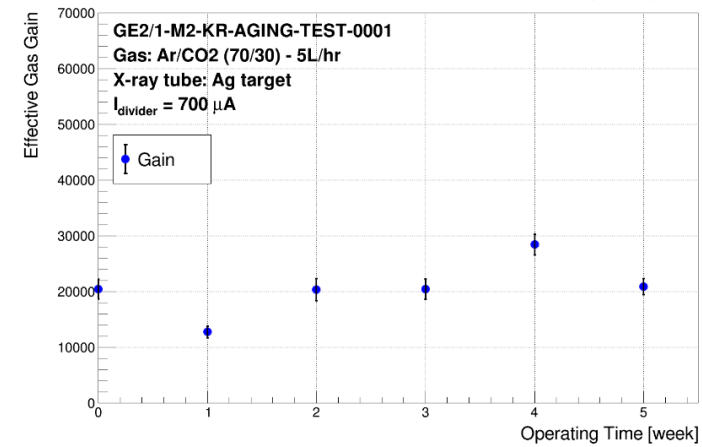
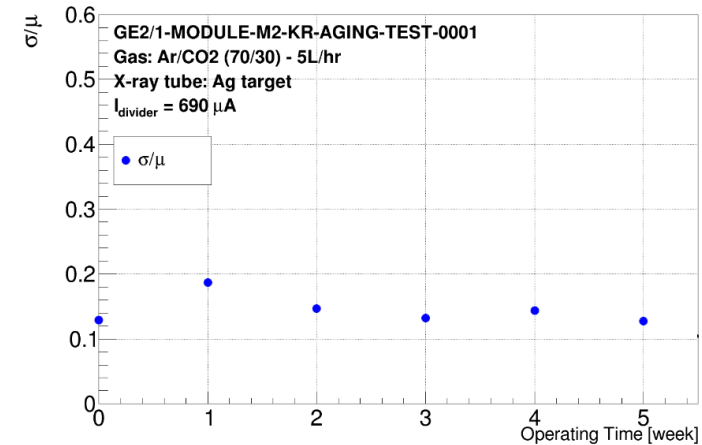
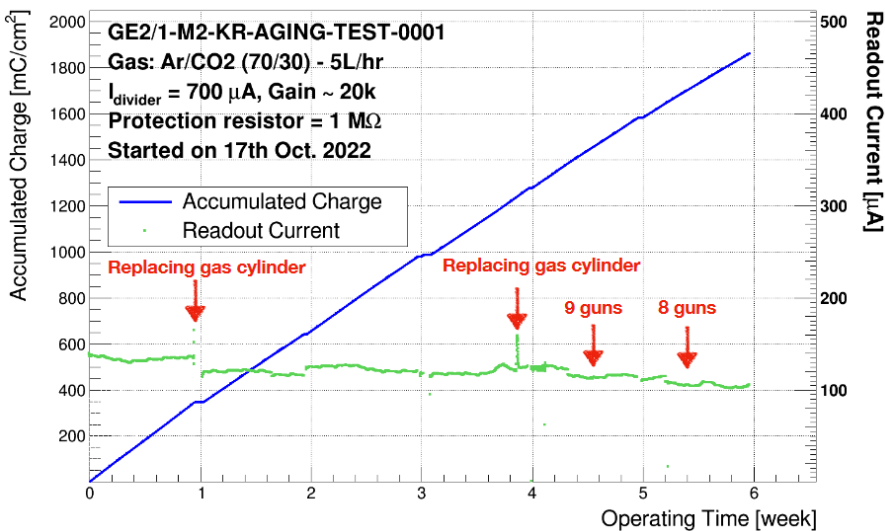
2. KCMS GEM projects – Validation

- Validation with GE1/1 detectors and measure properties of those
 - ⇒ Detector properties were as good as CERN chambers in term of gain, gain uniformity, rate capability, classical aging, discharge properties, hardness to discharges, ETC
 - ⇒ Production ability of KCMS is **validated!**



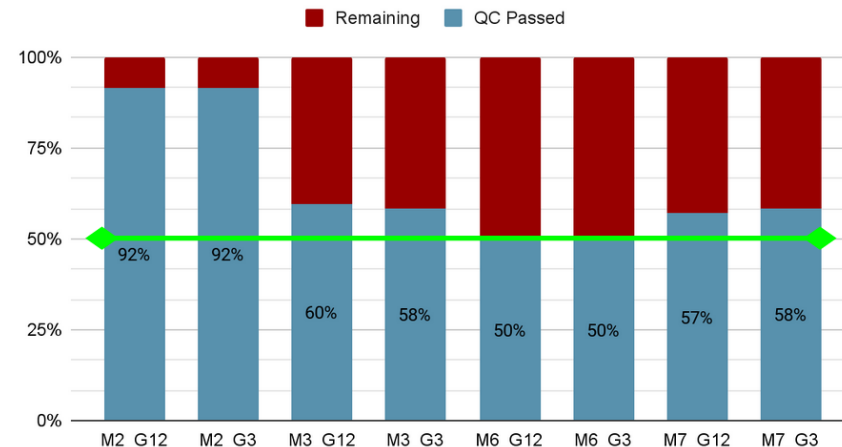
2. KCMS GEM projects – R&D

- R&D to measure the aging properties of GEM detector for unprecedentedly large charge accumulation
 - Host: University of Seoul
 - Target: $7.9 C/cm^2$ (= 10 years of ME0 operation at HL-LHC)
 - Up to $1.8 C/cm^2$, no sign of degradation is observed



2. KCMS GEM projects – Mass Production Results

- From May. 2021 to Sep. 2022, **292 foils** have been produced and passed QC criteria established by the CMS upgrades
 - GE2/1 detectors are being assembled with the Korean foils and under QC/QA



2. KCMS GEM projects – Current Status and Plan for ME0

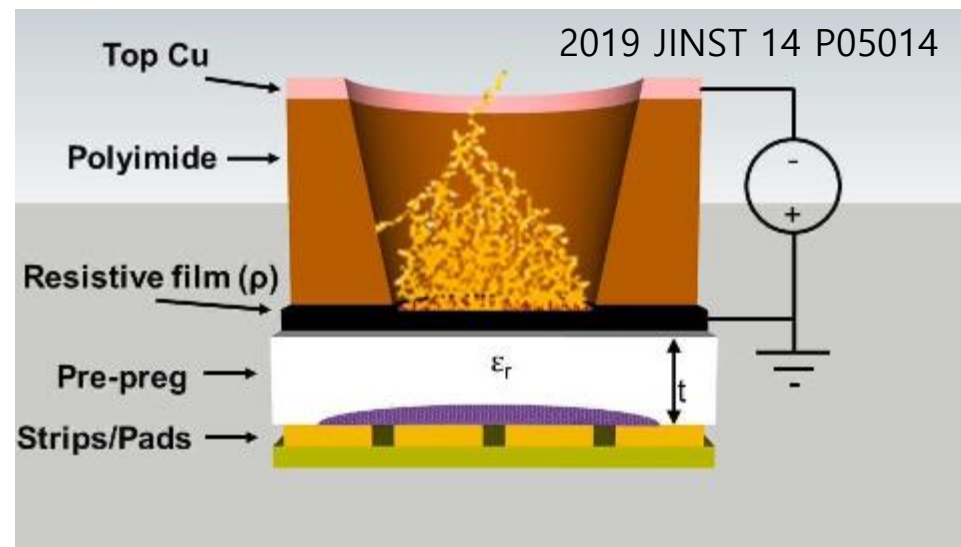
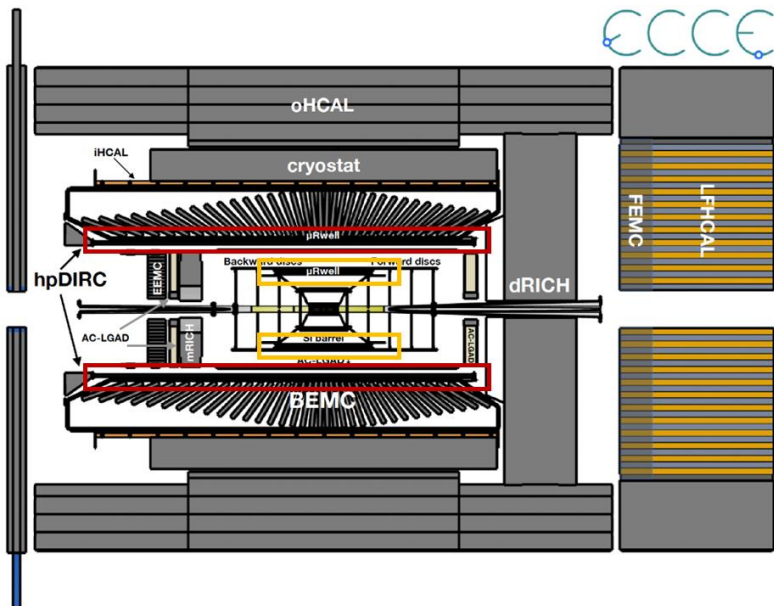
- Facility relocation is ongoing
 - Consortium with Mecaro has been over
 - New sites are secured (Raon facility, IBS)
 - Machine re-setup will be done around middle of 2023
- If machine re-setup done, we can start production again wo/ major problems
 - Production processes were transferred via KCMS or invented by KCMS
 - KCMS engineers were heavily involved in the mass production so far
- KCMS will focus on producing ME0
 - Mass production will be done around 2026



3. Contribution Idea to μ RWELL tracker of ePIC

- We are looking for the next experiment we can contribute to
 - μ RWELL tracker of ePIC
 - Charmed by the physics motivation of ePIC as well
- μ RWELL is very attractive detector
 - Need single board to achieve enough gain
 - Own rigidity

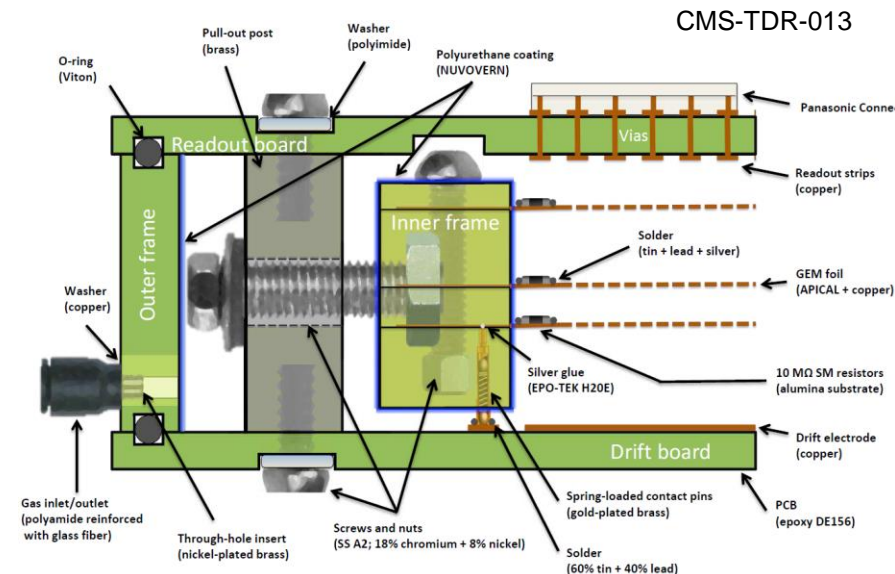
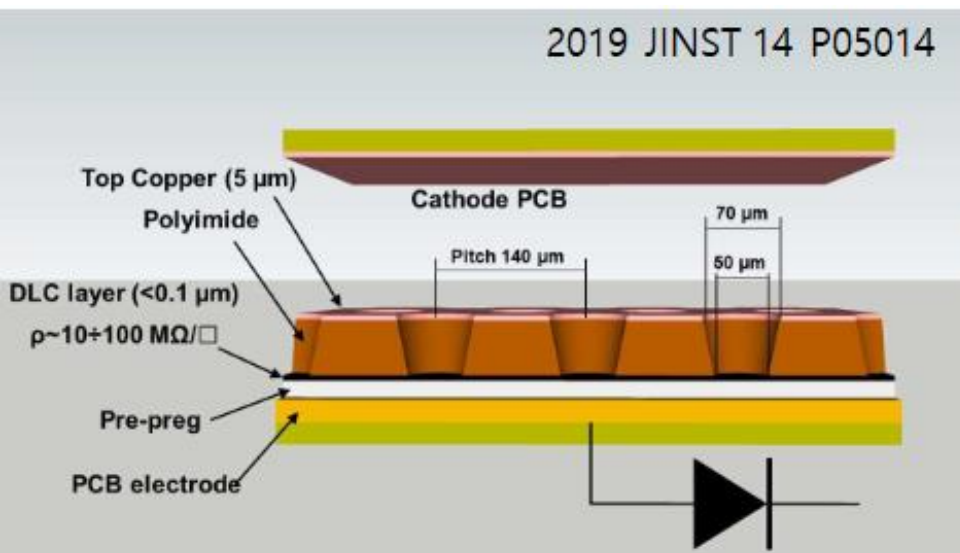
⇒ Cheaper and easy to assemble



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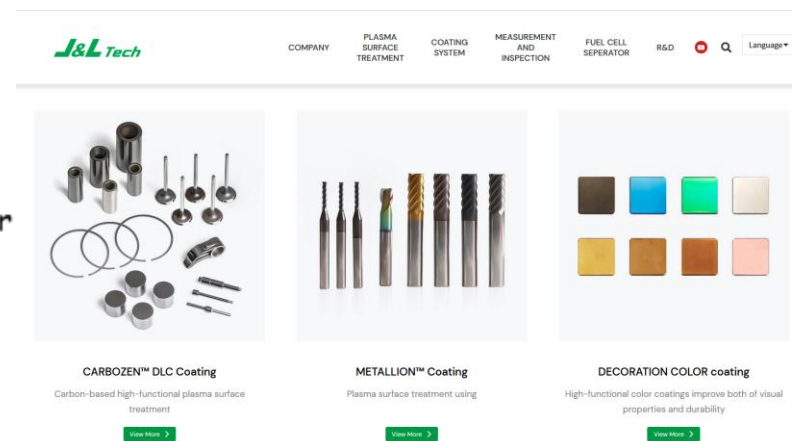
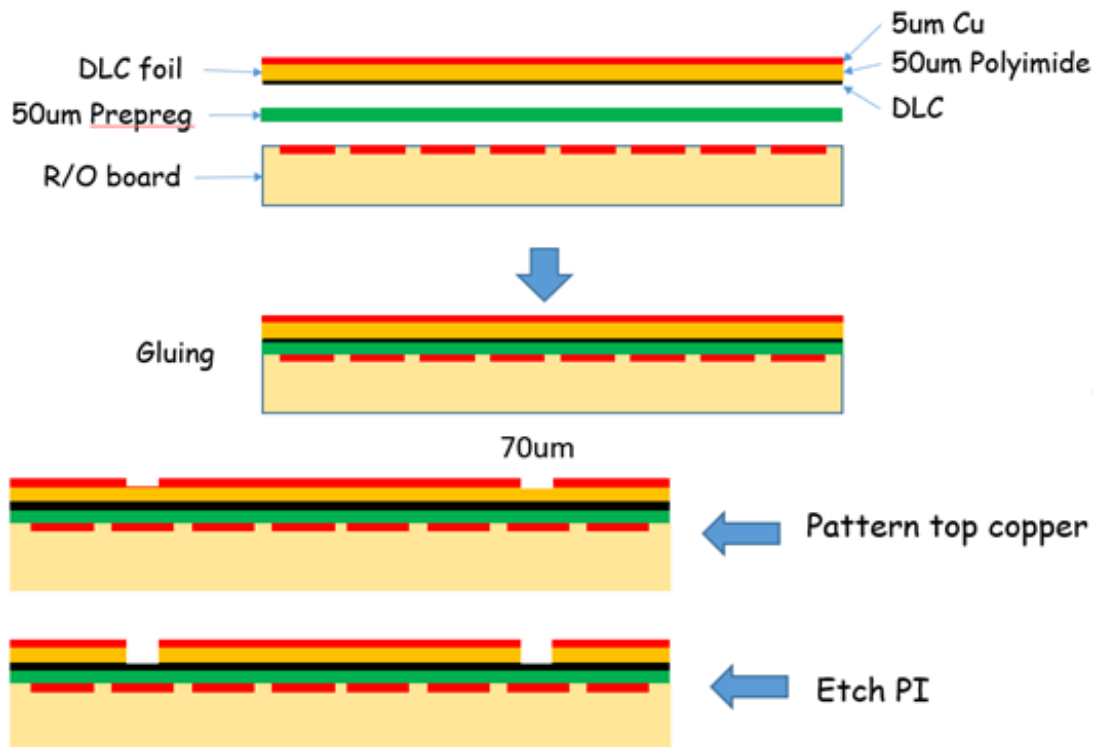
⇒ Cheaper and easy to assemble



3. Contribution Idea – Technical Feasibility

- μ RWELL and GEM are similar in structure and manufacturing processes
 - Only one missing technique is DLC sputtering
 - DLC sputtering is common technique in industry. Market is matured

• When we started the GEM projects, CERN MPT suggested to produce μ RWELL also



3. Contribution Idea – Prototyping plan

- To check producibility, $10 \times 10 \text{ cm}^2$ μ RWELL will be produced for prototyping
 - After facility re-setup and urgent things done, it can start
 - μ RWELL study kit for training of technician is being delivered
- If it's possible to make the small μ RWELL, it's not problem to make it large for planar types
 - Through the CMS upgrade, uniform etching ability for large area is proven
- In case, ePIC adopts cylindrical shape μ RWELL, further R&D will be needed
 - Gluing fully processed FCCL to RO might work

Summary

- KCMS GEM group is playing important role in the CMS upgrades by supplying the large-size GEM foils
 - First mass production done
 - Second mass production for CMS ME0 will start after facility relocation and re-setup
- We are looking for the next experiment we can contribute to
 - ePIC μ RWELL
 - μ RWELL is charming technology and so is ePIC physics
 - Since it's technically adjacent, human resource and infrastructure can be used
- Our contribution idea is feasible and timely
 - Mass production can start after CMS ME0 production done (~ 2026)
- Prototyping $10 \times 10 \text{ cm}^2$ will start in this year