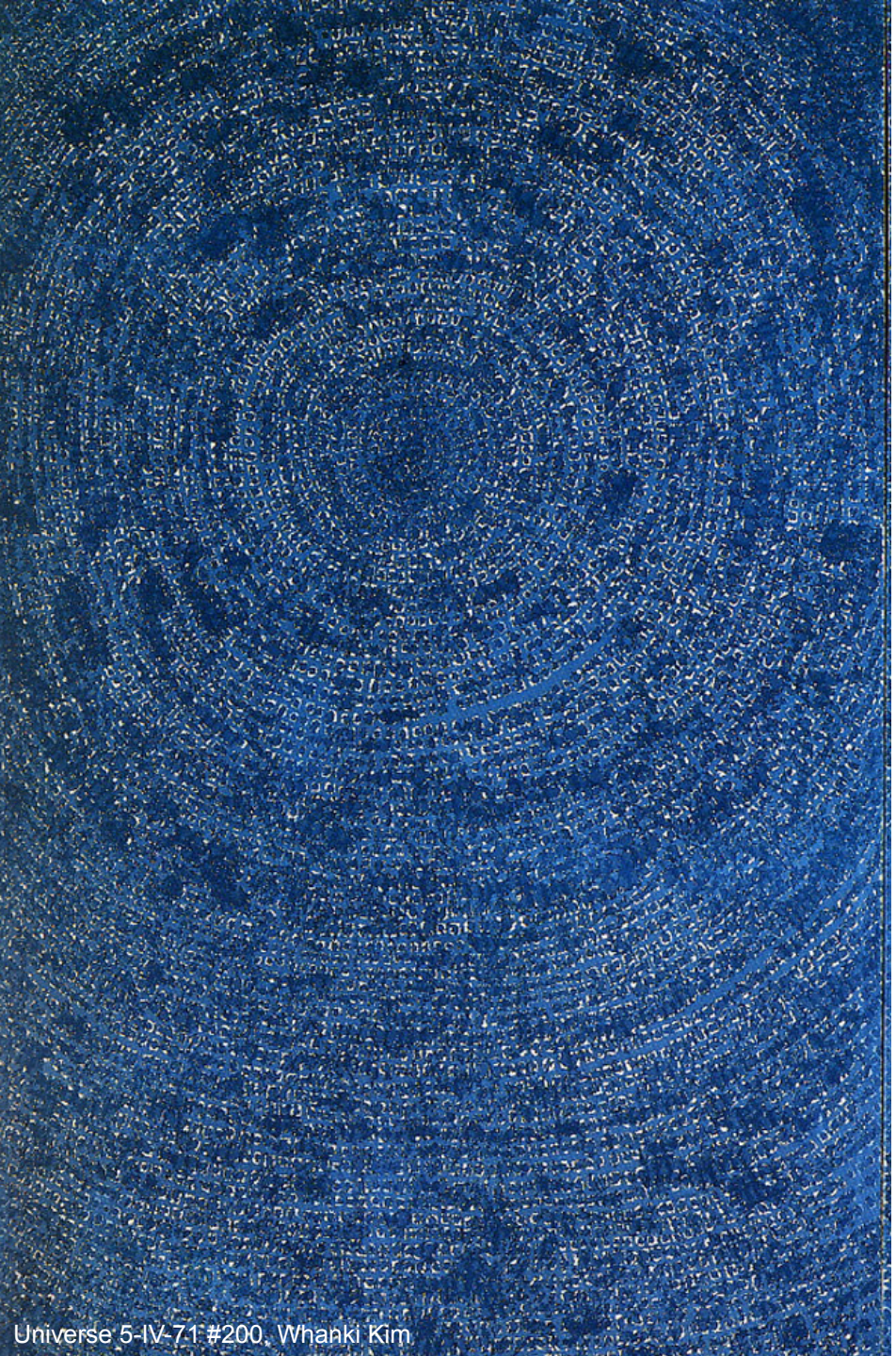


Prospective Korean Activity for EIC detector

Yongsun Kim (Sejong Univ.)

APCTP workshop on the Physics of EIC

2022.11.02

CENuM

Experimental nuclear physics groups in Korea

CNU
KNU
KU
IBS
Inha
JBNU
PNU
SJU
SKKU
SNU
UOS
Yonsei

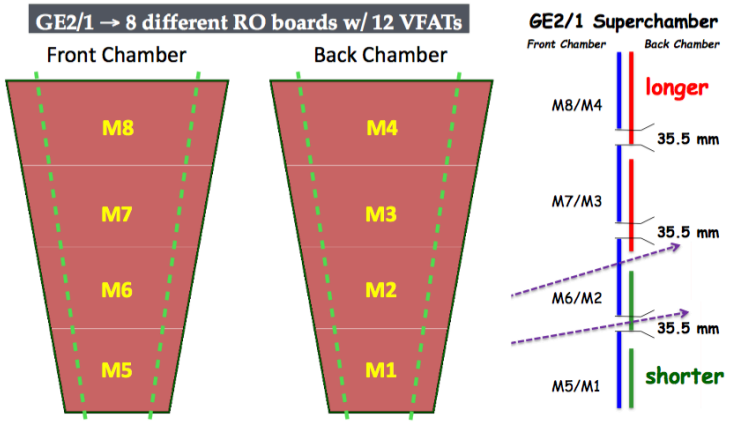
~10 institutes

~100 active members

Precedent contribution for international collaboration

RPC gap production for CMS

- A longstanding hardware activity from 1990s by Korean high energy & nuclear physics groups

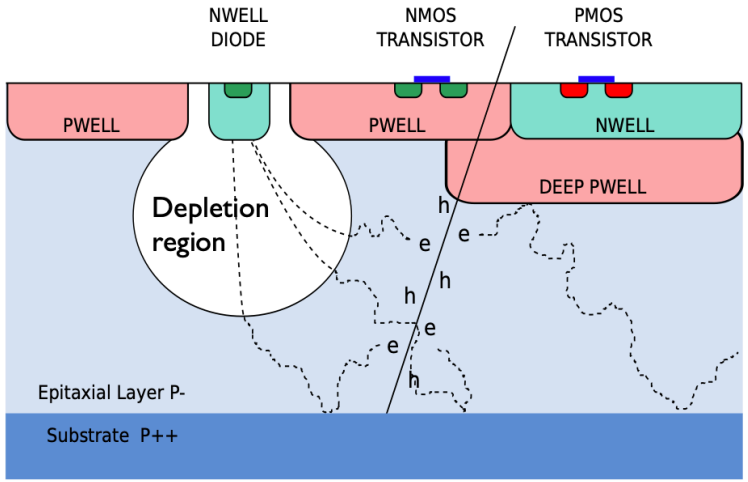


Mass production of GEM foils

- CMS upgrade
- R&D from 2014 by K-CMS group
- GE1/1, ME0

MAPS upgrade for ALICE ITS

- R&D for Pixel chip design and beam test
- Ko-ALICE groups
  - Inha U., Yonsei U., PNU



Potential Korean involvement for EIC

To maximize productivity

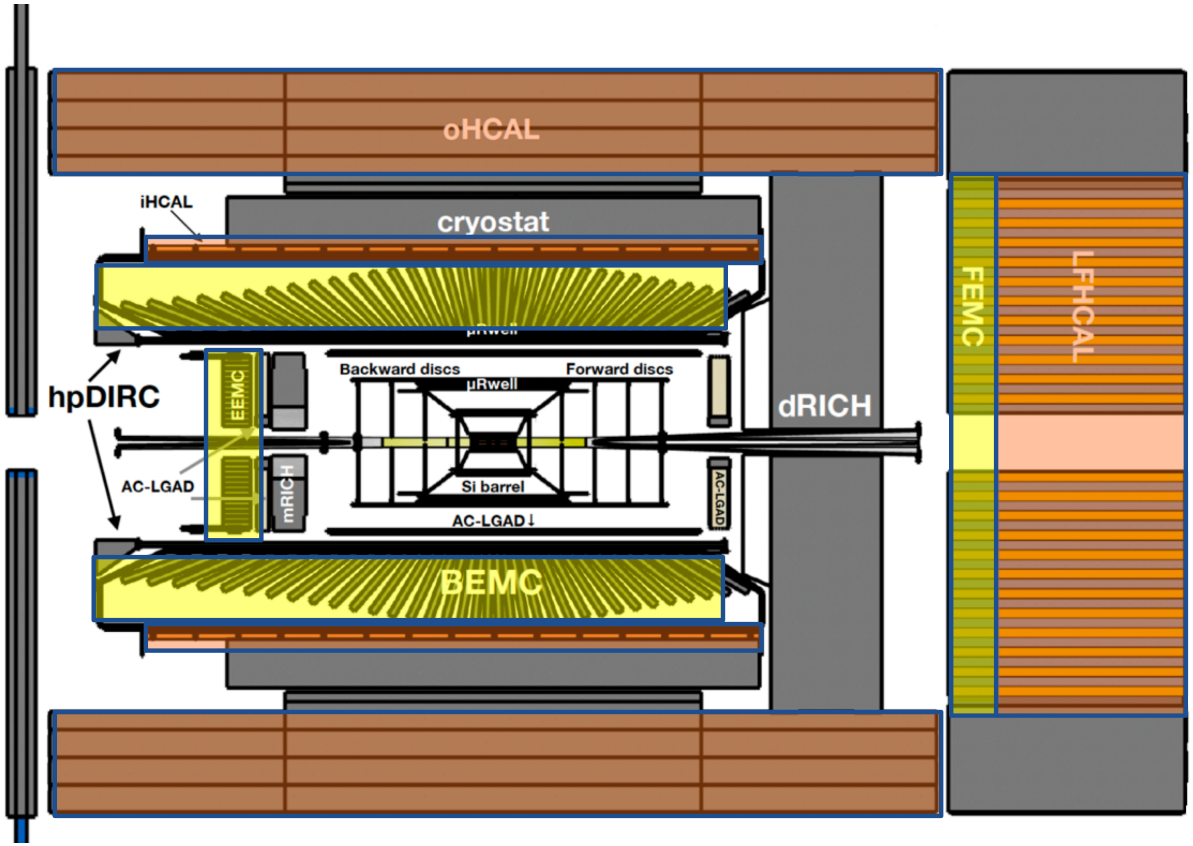
Extension of ongoing hardware developments for EIC detectors

- ALICE ALPIDE, Focal -> EIC vertex tracker and calorimeter
- CMS MTD, GEM -> EIC LGAD, μRWELL
- FCC DRC -> EIC calorimeter (upgrade)

Active collaboration with foreign groups

- BNL, ORNL, LANL, RIKEN, and more…
- Allows concentrating on well defined tasks and minimizes risks

EIC Detector-1 reference design



Tracking:

- Si MAPS (65nm)
- AC-LGAD
- µRWELL

PID:

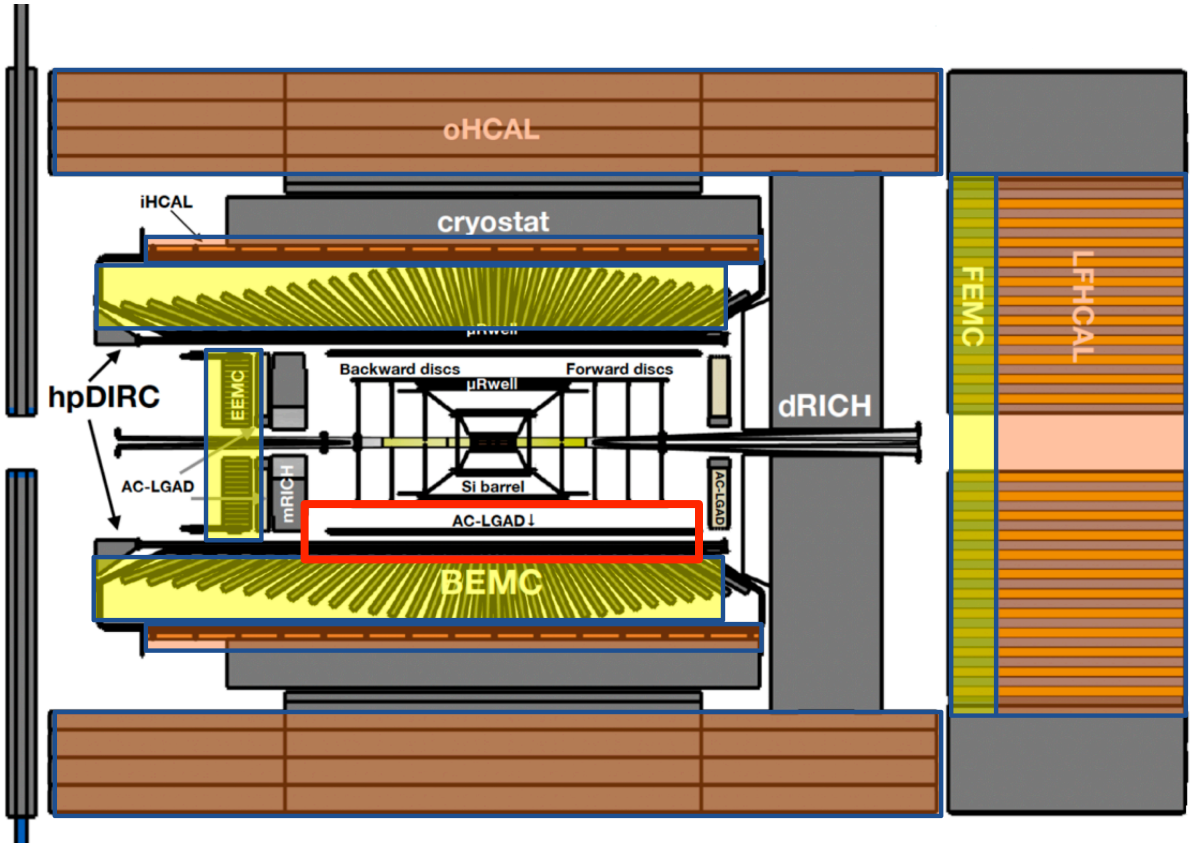
- hp-DIRC
- mRICH
- dRICH
- AC-LGAD (~30ps TOF)

Calorimetry:

- SciGlass Barrel EMCal
- PbWO EEEMCal
- Longitudinally separated EM+Hcal
- Inner HCal (instrumented frame)
- Outer HCal (sPHENIX re-use)

J. Lajoie, ORNL seminar

EIC Detector-1 reference design



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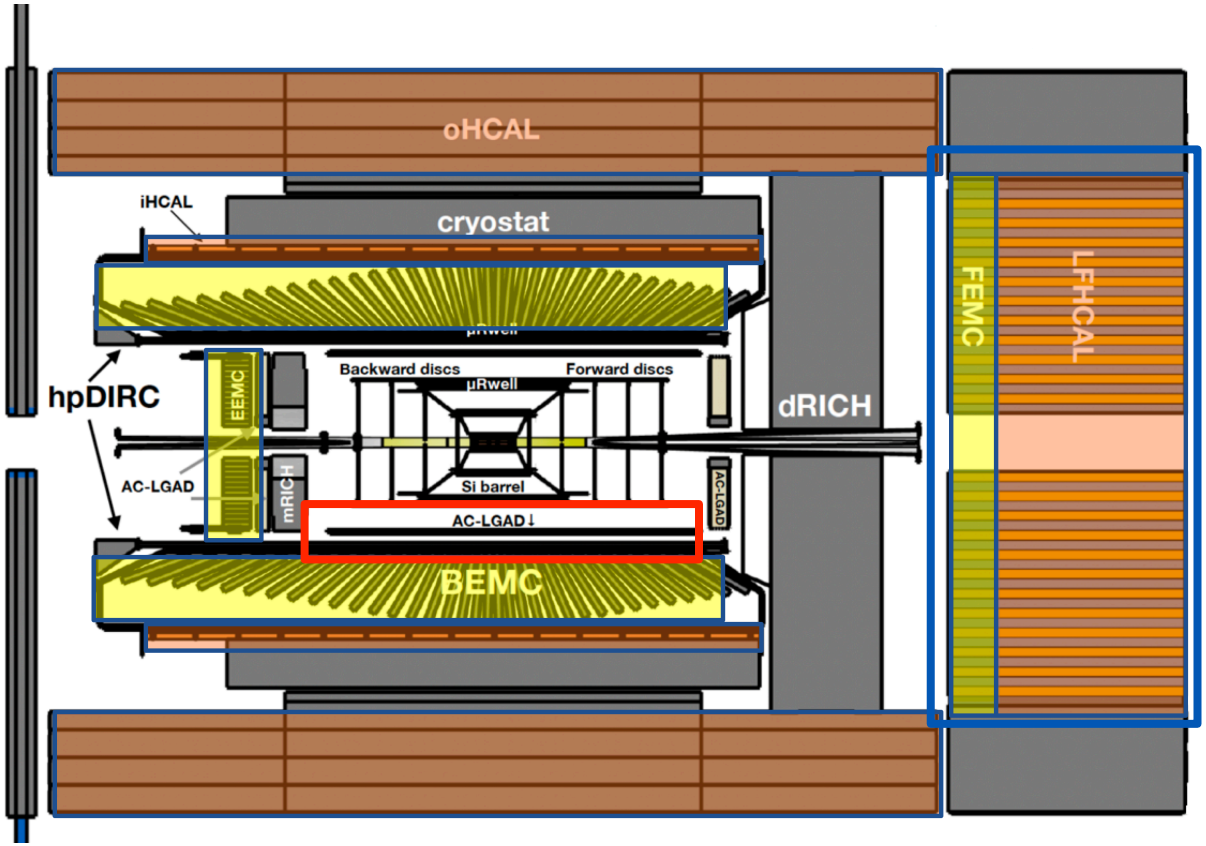

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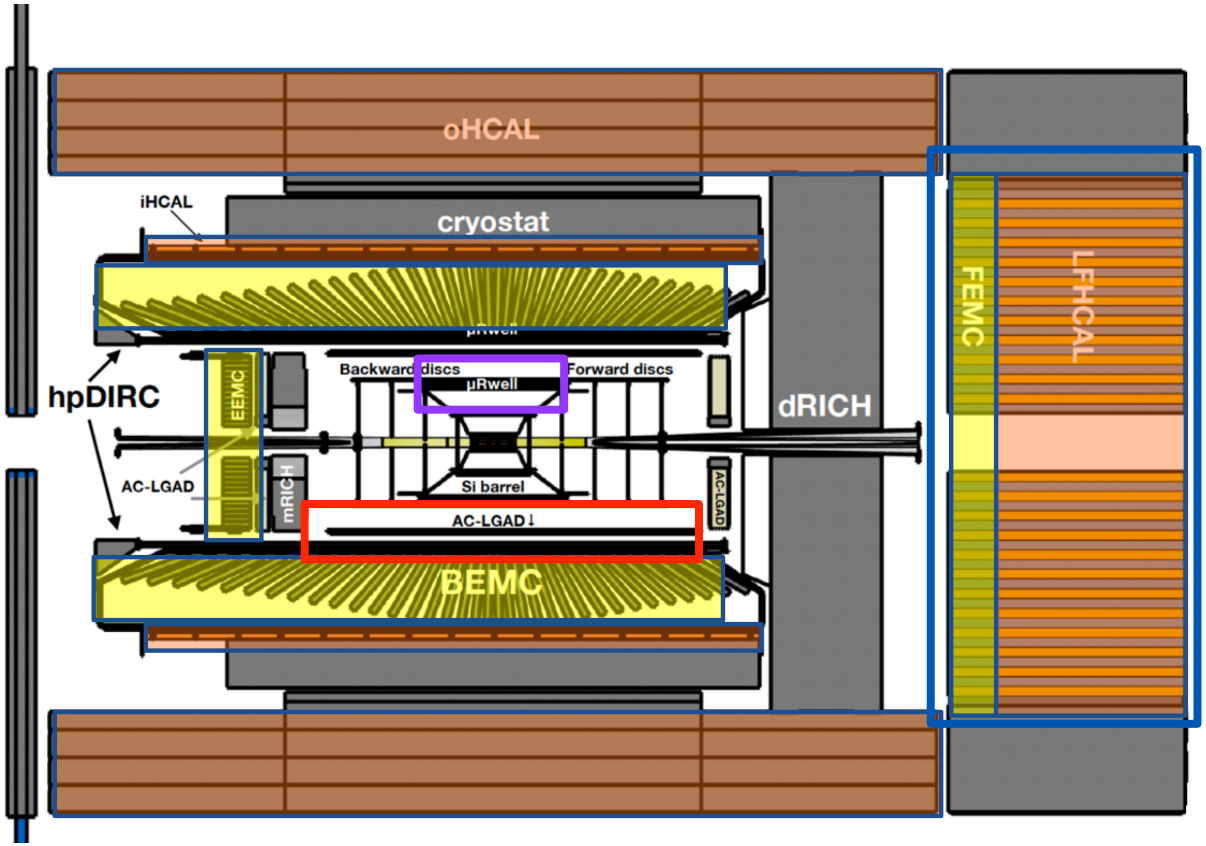

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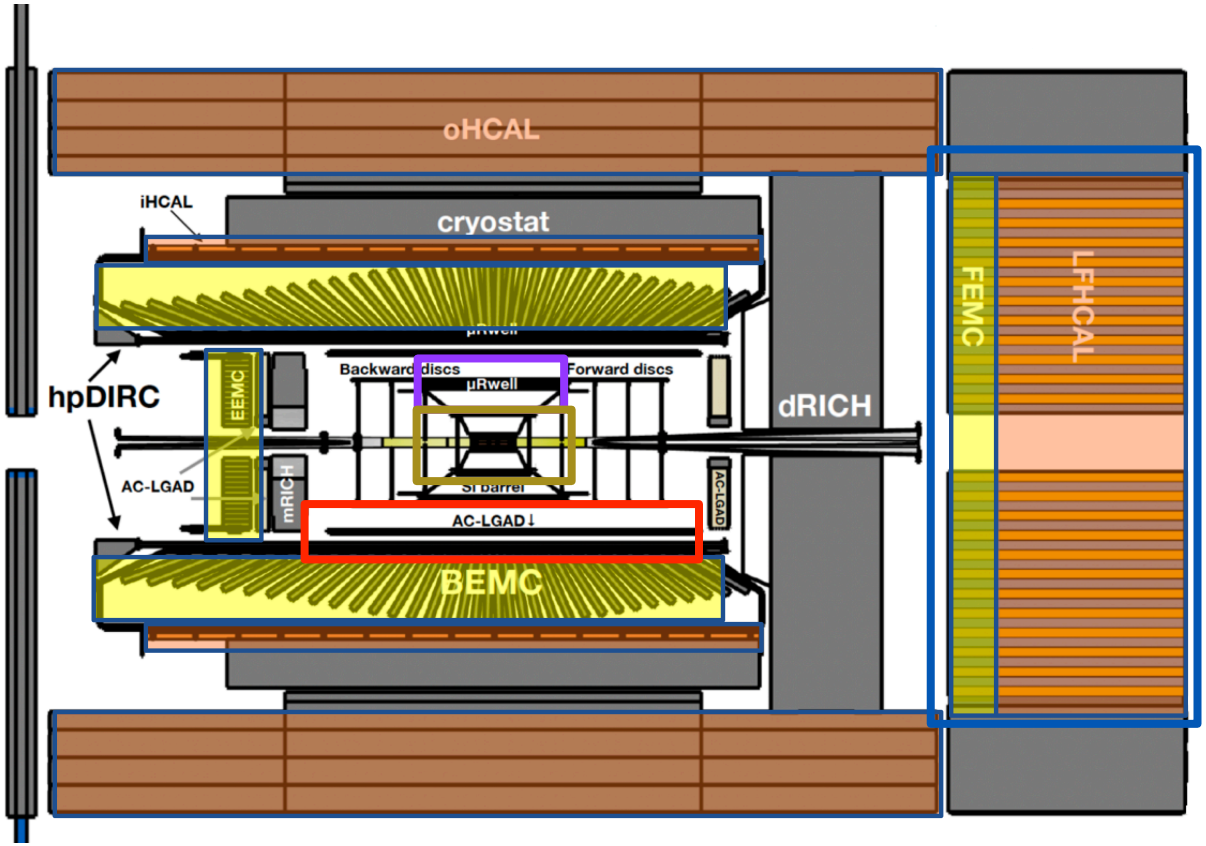

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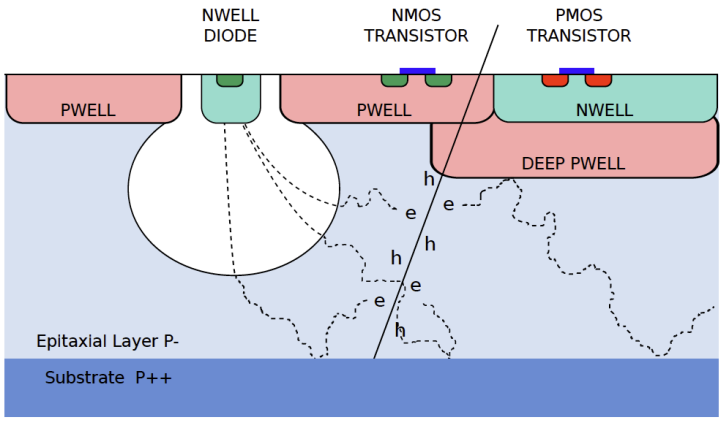
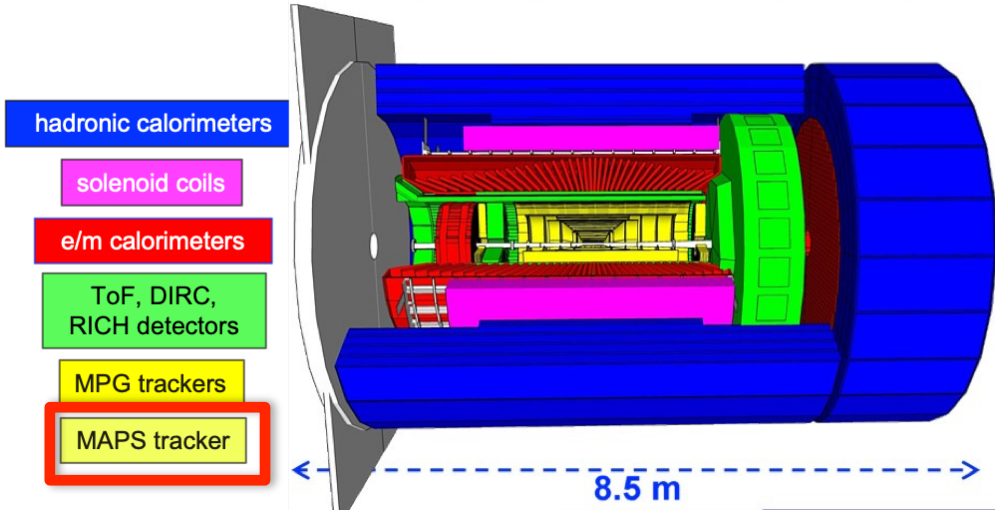
1. Silicon vertex tracker

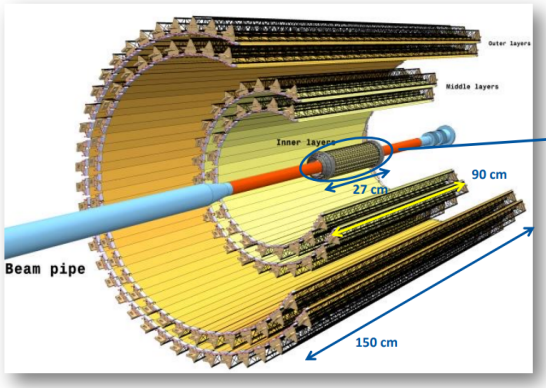




- Precise tracking and vertexing
- MAPS based silicon (STAR HFT, ALICE ITS2, sPHENIX MVTX)
- R&D for the EIC detector is in parallel with R&D for ALICE ITS3
  - ~ 10 μm pitch and improved rate capability
- KoALICE group – Inha U. , PNU, Yonsei U., JNU

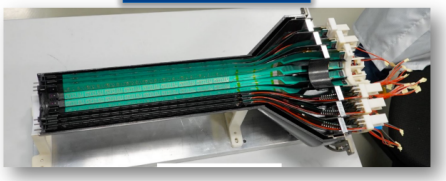
1. Silicon vertex tracker

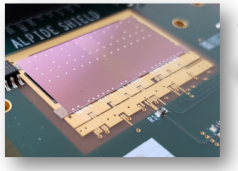
Involvement in post-processing for ALICE ITS2, ITS3

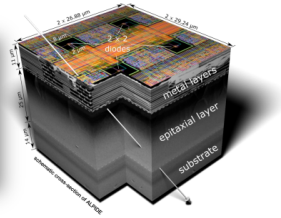


~12.5 Gpixels, 10 m² sensitive area
24120 **ALPIDE** Pixel Sensors (CMOS 180 nm)

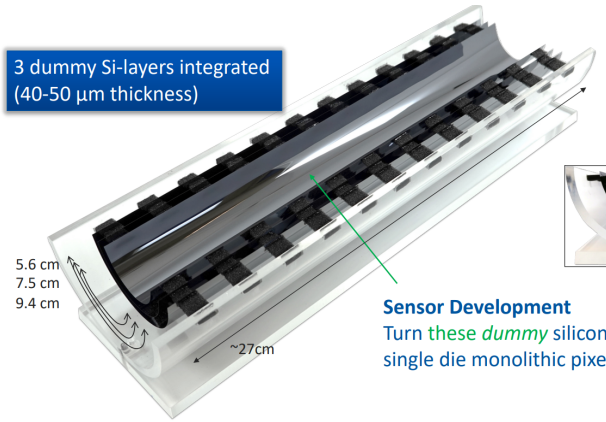
ITS2 Half Inner Barrel

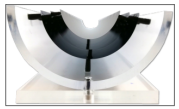






3 dummy Si-layers integrated
(40-50 µm thickness)

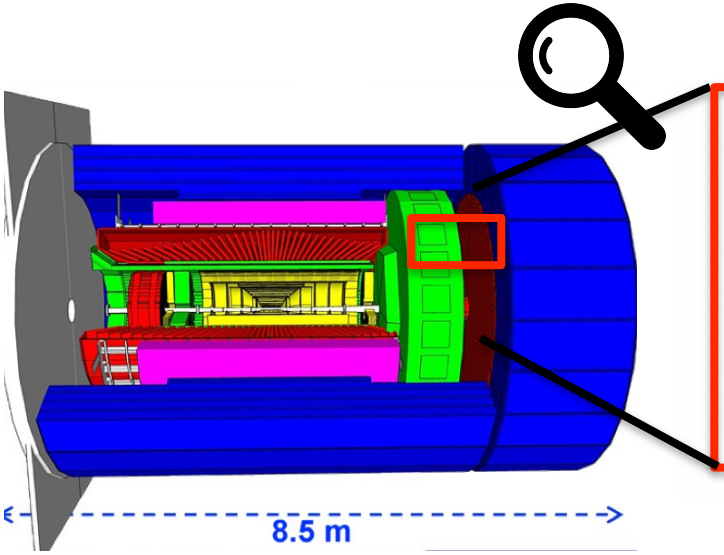


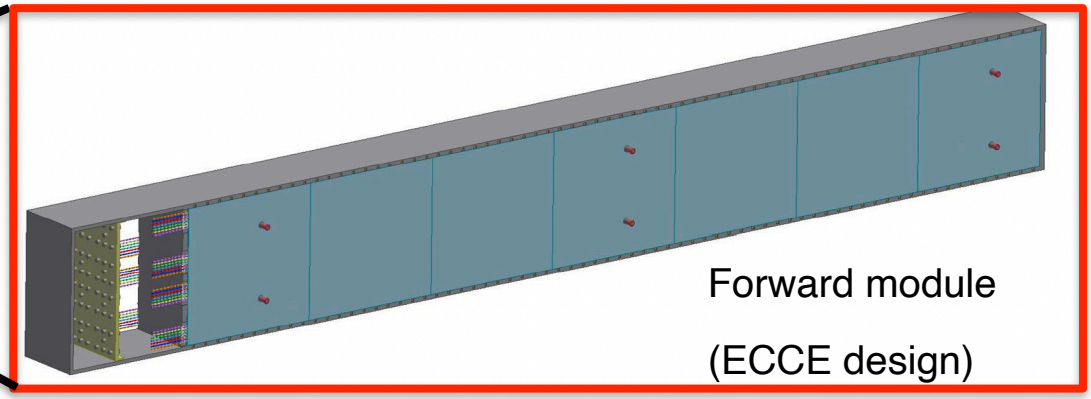


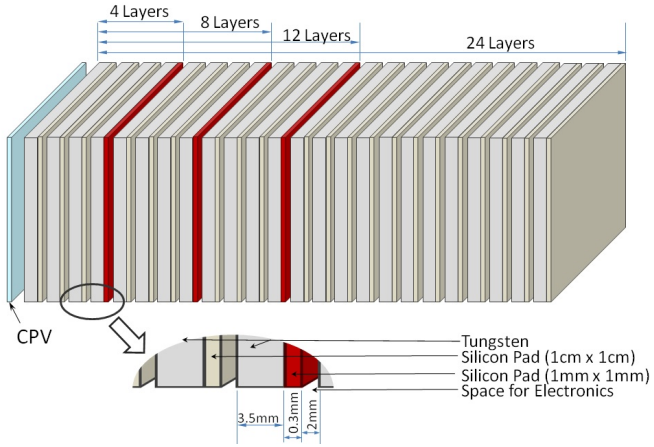
Sensor Development
Turn these *dummy* silicon chips into *true* single die monolithic pixel sensors

- Thinning & Dicing by a Korean company FUREX
- Mass production test
  - probe-card, NOTICE/EQENG
  - Automatic test equipment, C-On
- Module assembly
  - Wire-bonding by a Korean company Sejung
- Also participating in ITS3 design team

2. Longitudinally Segmented EMcal





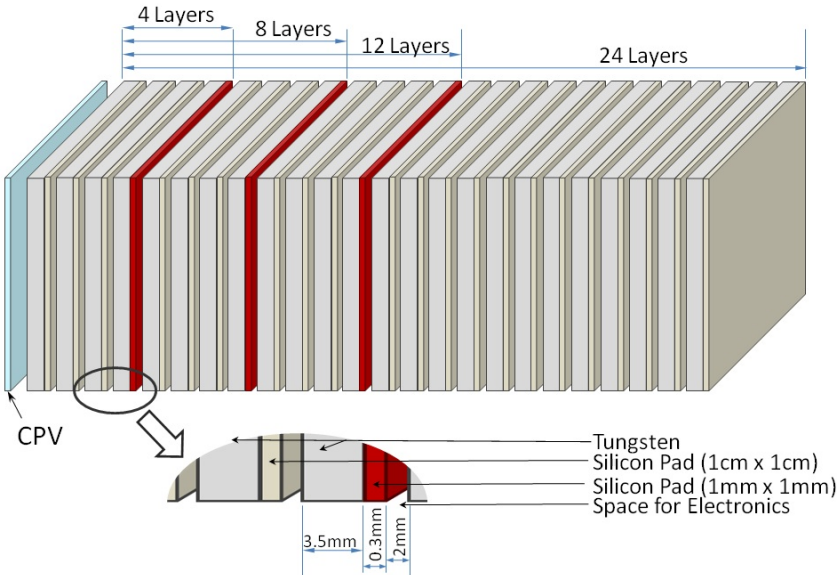


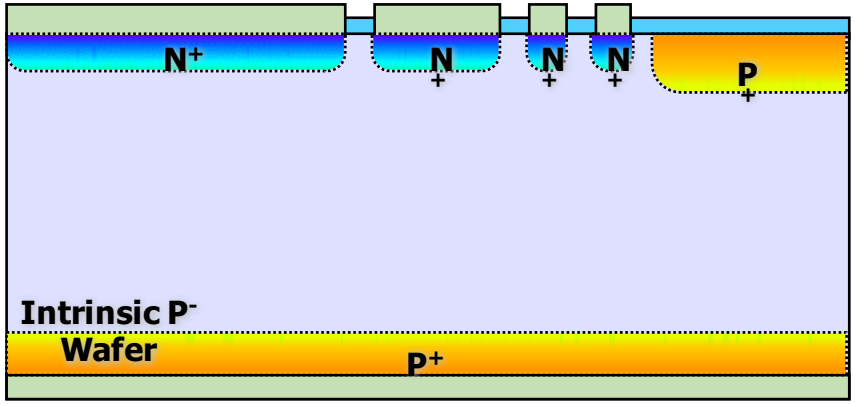
(Ref.) ALICE FoCal

- Measure longitudinal profile of EM shower to enhance e/γ/π^0 separation
- Similar technique with ALICE FoCal
- Kinematics range
  - Δz = 37 cm, 20 < r < 183 cm
  - $1.24 < |\eta| < 3.5$
- Korea Univ., Sejong Univ.

2. Longitudinally Segmented EMcal

Involvement of ALICE FoCal



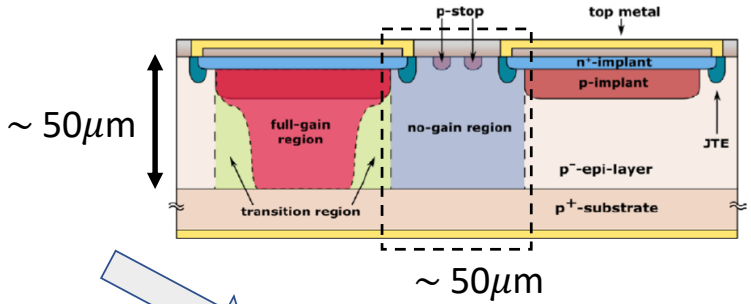


- Medium scale production record ~400 units of 6x6 cm^2
- Design and fabrication process are well understood
- Readout ASIC has to match the ever-developed back-end
- Yonsei U and SJU are involved in R&D to adapt HGCROC (High granularity calorimeter readout chip) for general purpose

3. LGAD (low gain avalanche detector)

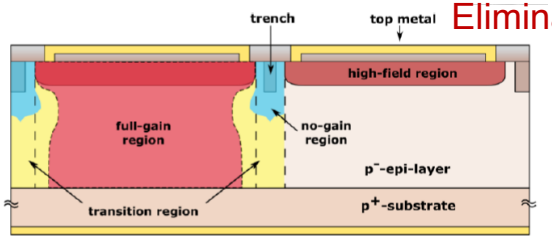
Standard LGADs at HL-LHC

- **Pixel: 1.3x1.3 mm²**
- ~ 50 μm intrapad dead zone

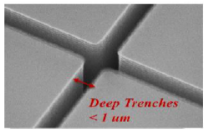


W. Lie

(1) Trench-Isolated (TI) LGADs

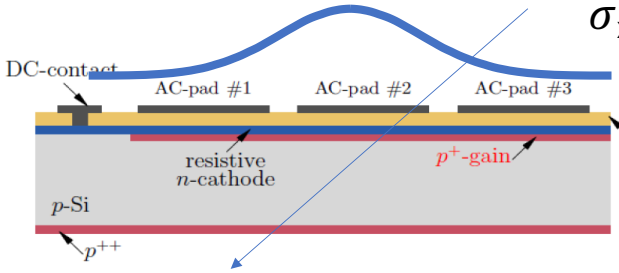


Eliminate dead zone

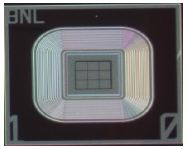


(2) AC-coupled LGADs

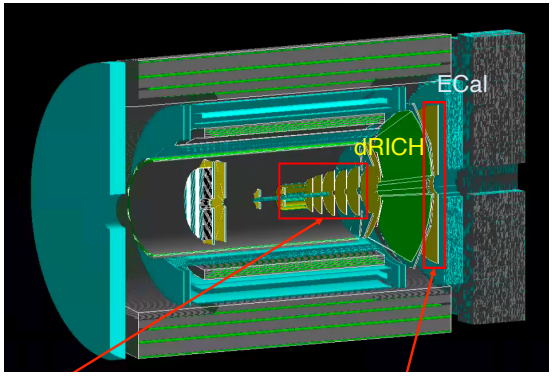
$$\sigma_x < \frac{\text{Pitch}}{\sqrt{12}}$$



BNL



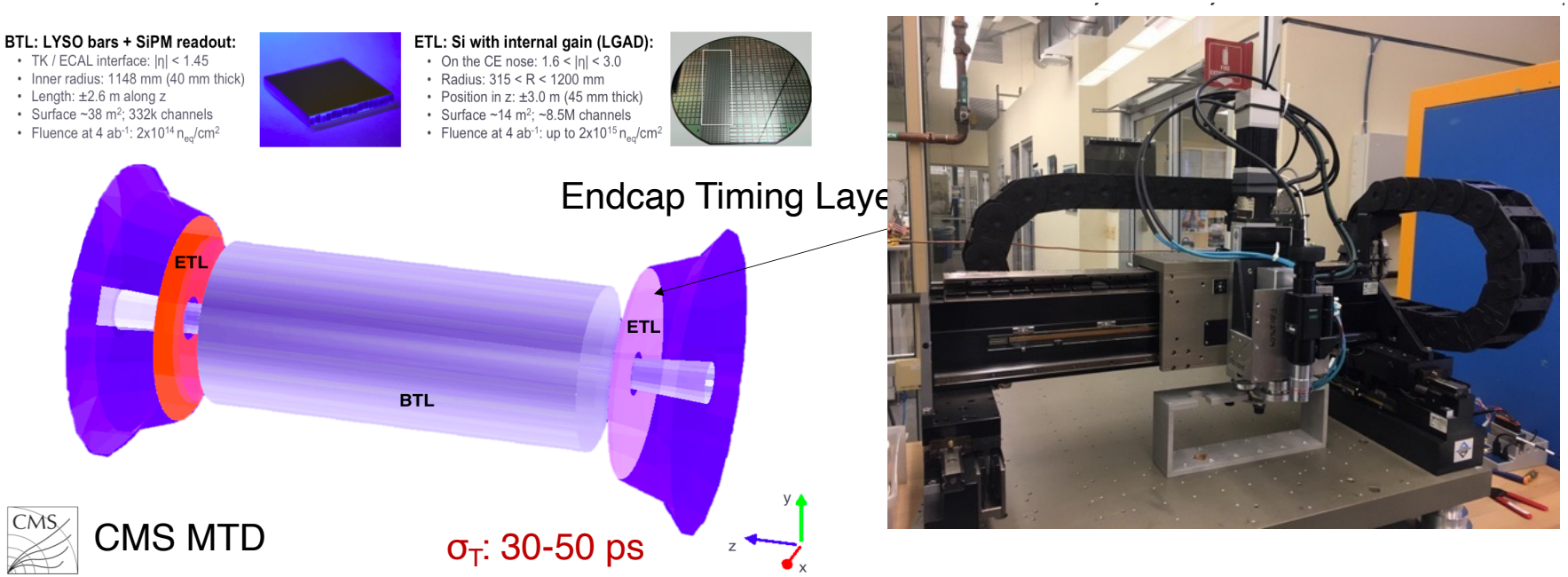
Fine pixelization (~ 100-200 µm) achievable for tracker



- Fast timing silicon detectors for EIC tracking system
- Key element for particle PID

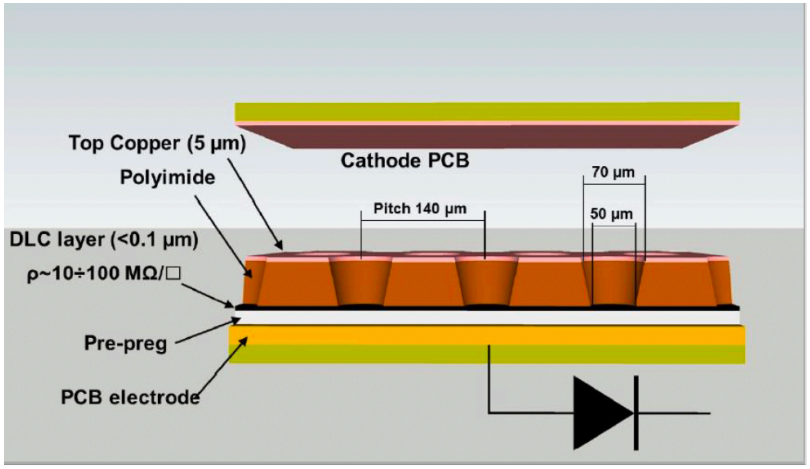
KCMS contribution for LGAD in CMS

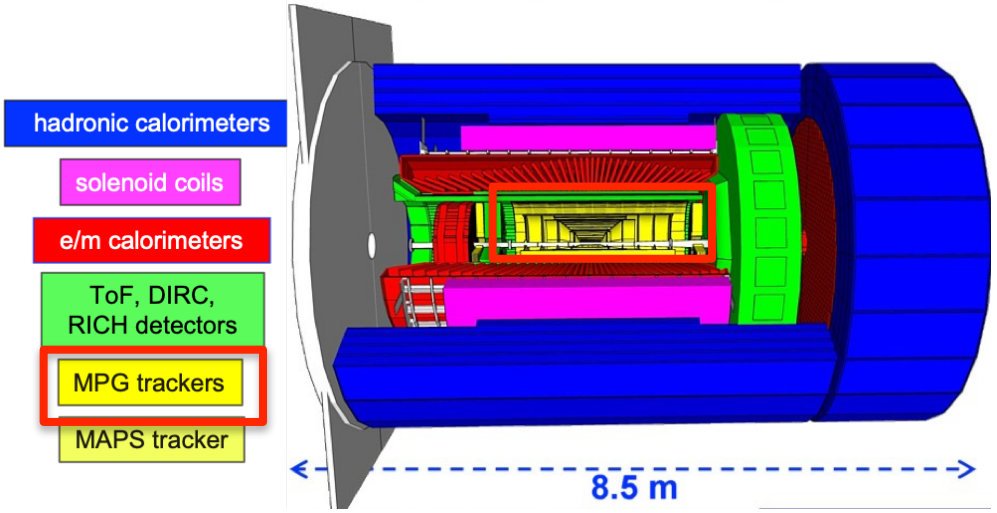
LGADs at the HL-LHC (2028)



- Endcap layers for CMS MIP Timing Detector (MTD) to be made of LGAD
- KCMS groups – KNU, CNU, KU – are actively involved
  - Prototype assembly, sensor tests with beams and lasers
- A huge synergy can be expected by collaboration with EIC-Japan

4. μRWELL micro pattern gas detector (MPGD)

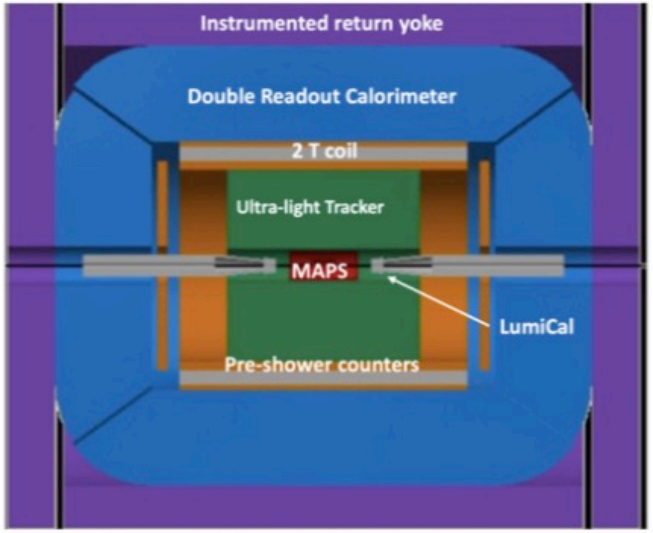




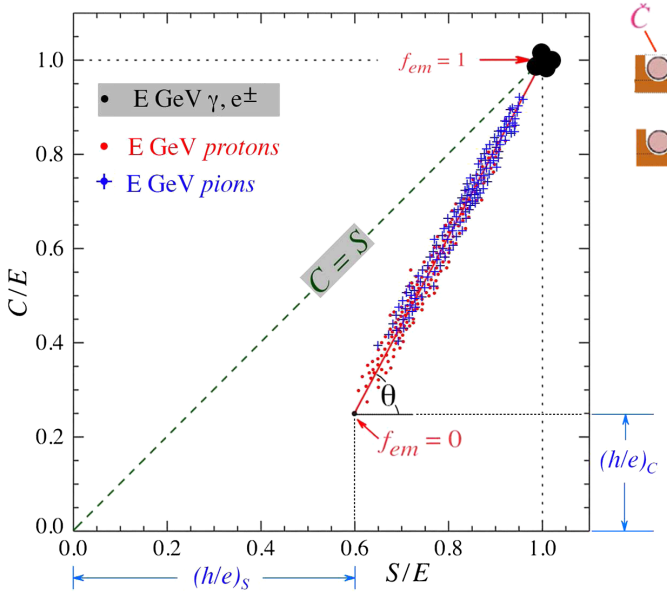
- Used for charged particle tracking
- Operating principle is combination of GEM and RPC, both of which are the world best expertise of Korean groups
- The infrastructure of KCMS is the great opportunity for mass production of MGPD
- Seoul Nat'l Univ., Univ. of Seoul

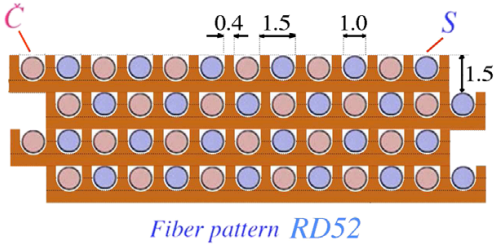
5. Daul Readout Calorimeter

- Cherenkov and scintillation fibers combined in **dual**
  - offers high-quality energy measurement for both EM particles and hadrons
  - The main culprit of poor hadronic energy resolution is fluctuations of the EM shower components of hadron showers (f_{em})
- Proposed for FCC and CEPC
- KNU, Yonsei U. PNU, Sejong U.
- Possible candidate for detector 2?

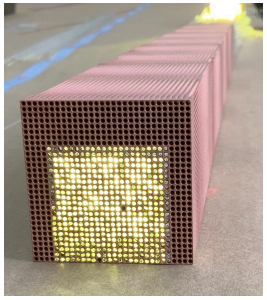


IDEA



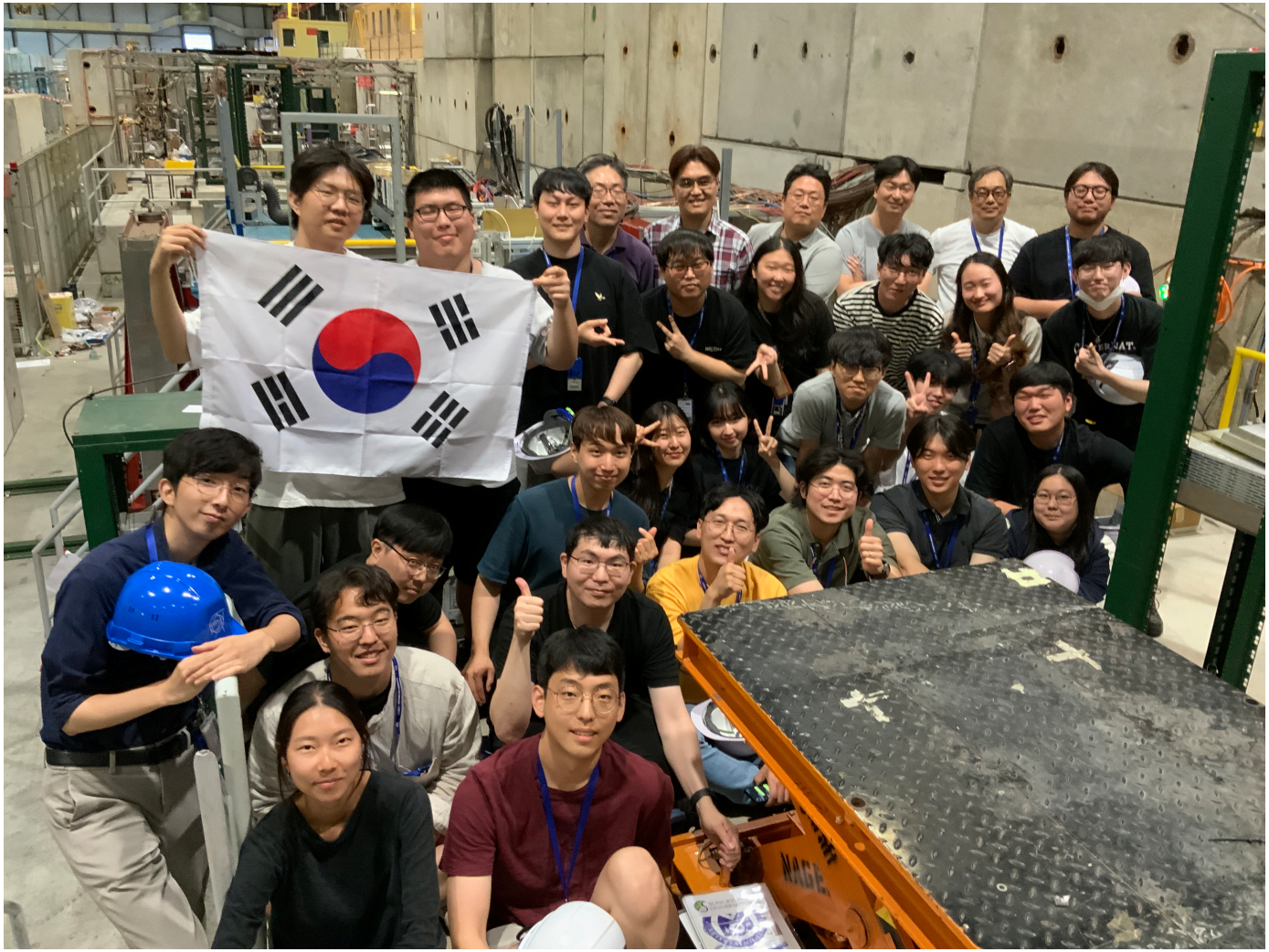


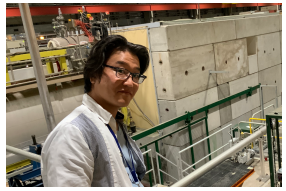
Fiber pattern RD52

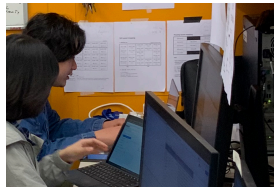


5. Beam test at CERN

- 13 institutes 34 participants (including 23 students)







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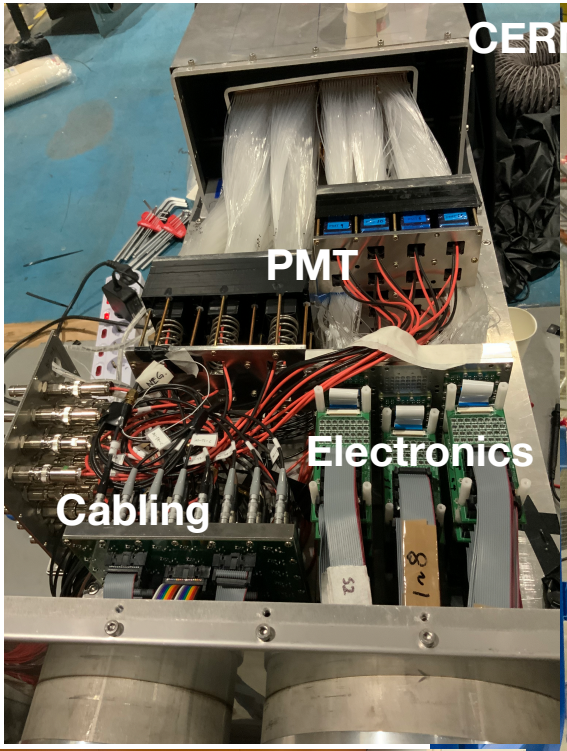
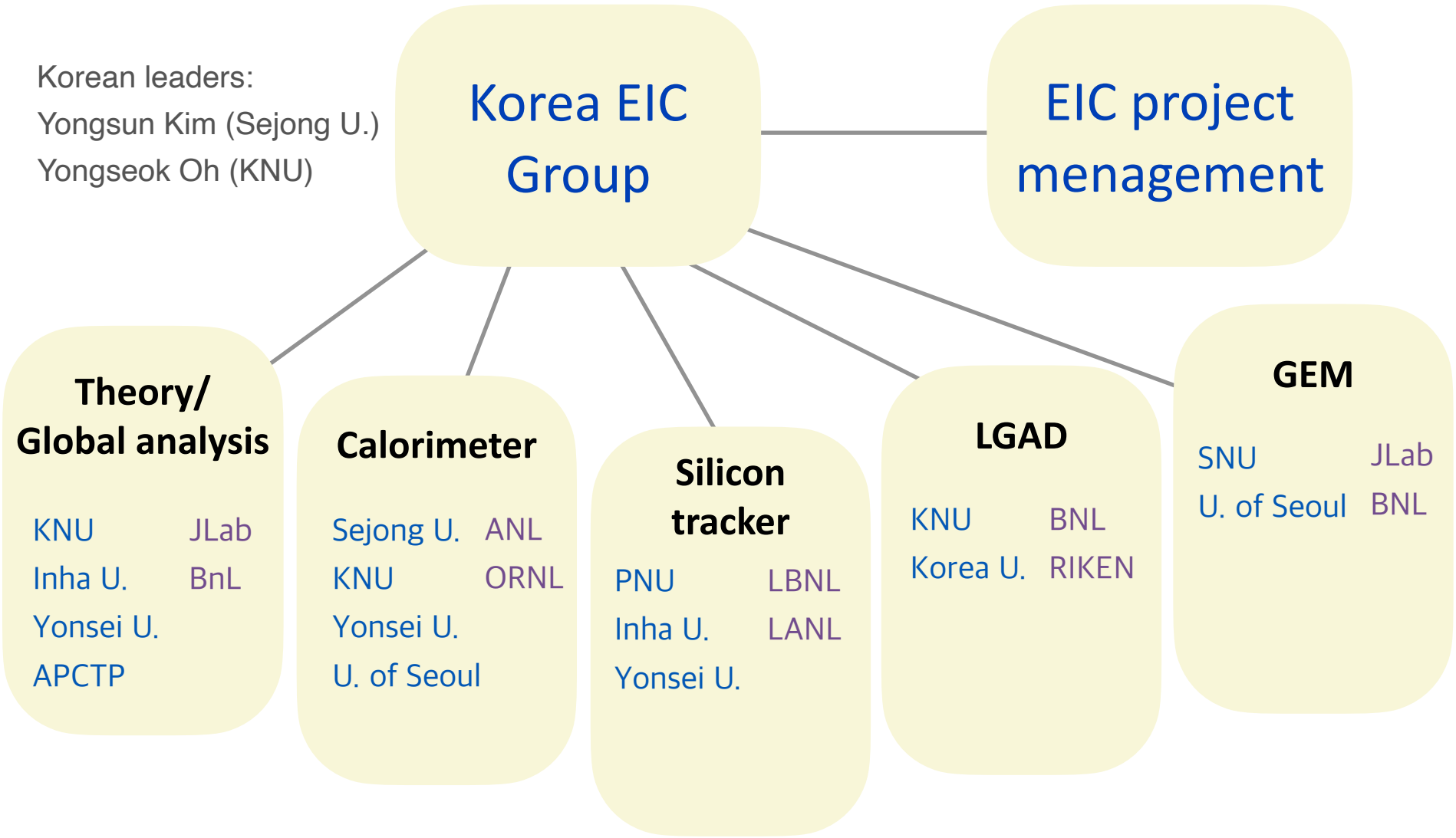


International Partnership Proposal



Summary

- **Korean groups are very interested in the involvement of EIC program**
  - Active discussion ongoing among nuclear, high energy, hadron physics societies
- **For EPIC, we are interested in contribution of following projects**
  - Electronics for calorimeters (HGCROC)
  - μRWELL gas detector
  - Silicon pixel tracker
  - LGAD sensor
  - Dual readout calorimeter
- **To realize the involvement, we are …**
  - constructing the concrete goal and plan to be achieve with limited manpower and funding
  - open for international collaboration particularly with labs in the US and nearby countries
  - seeking for substantial long-term support for R&D and detector construction

backup