KCMS activities and Plans for CMS

Tae Jeong Kim (Hanyang University)

CERN-Korea-Committee meeting

2024. 4. 22.

Discovery of New Physics

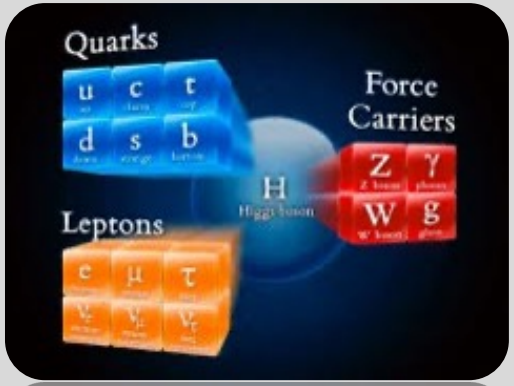
Discovery of the Higgs boson

▼

Standard model complete?

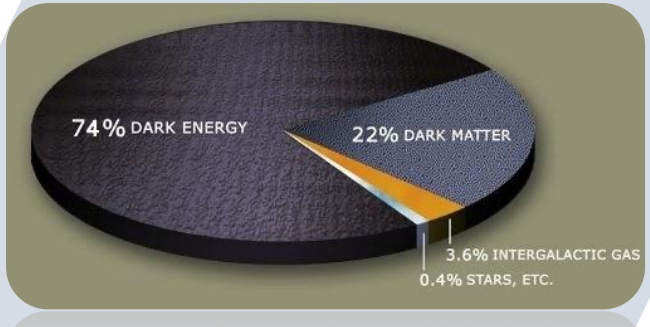
▼

Suggest another way for new physics



Unsolved problems in the Standard Model (SM)

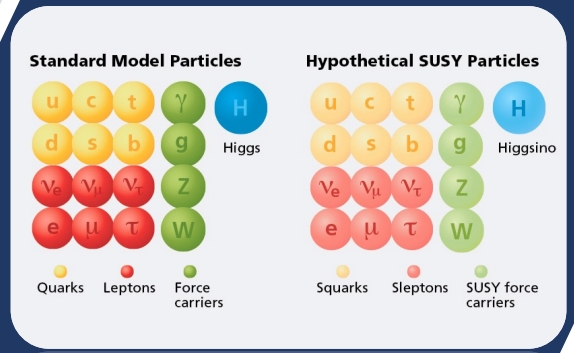
- Dark matter
- Higgs boson mass (naturalness problem)
- Matter-Antimatter asymmetry



Searching for new physics beyond SM

Search for Supersymmetry

Precision measurement - Anomaly detection



Korea-CMS (KCMS) Collaboration

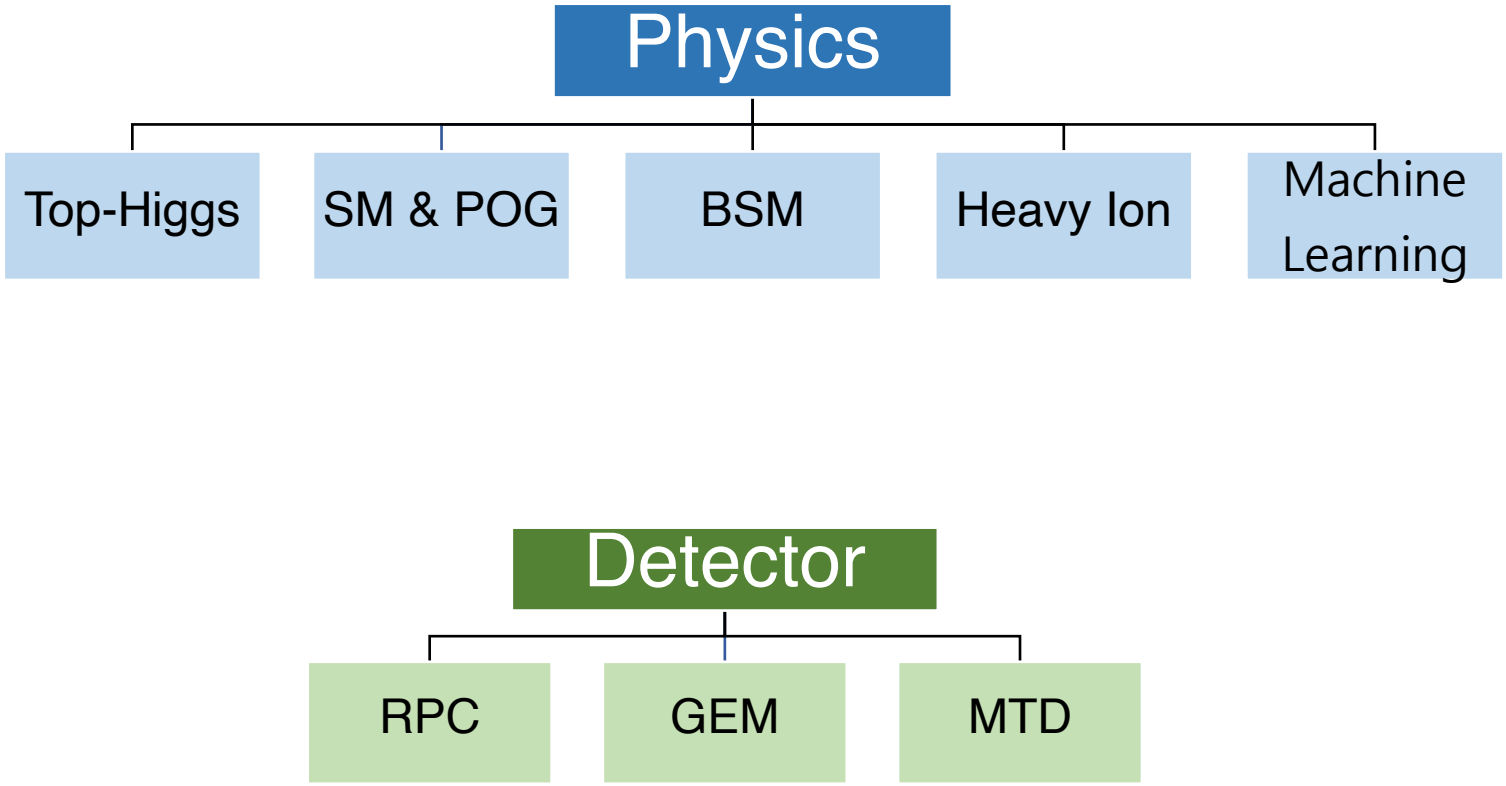
- **World-class research through international cooperation with CERN**
- **Development of detector with CERN**
- **Train next generation of researchers**

- **11 Institutes : KNU (Kyungpook), KHU (Kyung Hee), KU (Korea), SNU (Seoul National), UOS (Univ. of Seoul), SKK (Sungkyunkwan), SJU (Sejong), YU (Yonsei), CNU (Chonnam), HYU (Hanyang), GWNU (Gangneung-Wonju)**

Stage	year	budget (100 MKRW)	M&O-A	Prof.	Postdoc	Grad. students	Tech. staff	Total
4	2016	22.5	32	15	20	46	5	86
5	2021	30.6	36	17	23	73	9	122
6	2022	33.4	36	17	27	68	8	120
6	2023	40.1	35	15	23	72	8	118
6	2024	40.4	34	16	22	69	8	115

- **Around 2.4% of total CMS collaboration – 10th largest**
- **Annual Budget for 2024 – 4042 MKRW~2.6 MCHF**

Organization



- **Top-Higgs**
  - Precision measurement, search for rare production and decay, top-Higgs interplay measurement
- **SM & POG**
  - DY precision measurement, anti-symmetry, Physics Object identification
- **BSM**
  - SUSY, dark matter, heavy neutrino, long lived particle
- **Heavy Ion**
  - Nuclear effect
- **Machine learning**
  - Trigger, data analysis and data certification

- **Detector**
  - GEM GE2/1,ME0 foil production and test
  - iRPC gap (RE31, RE41) production and test
  - MIP Timing Detector sensor and bump-bonding R&D / MoU (done)

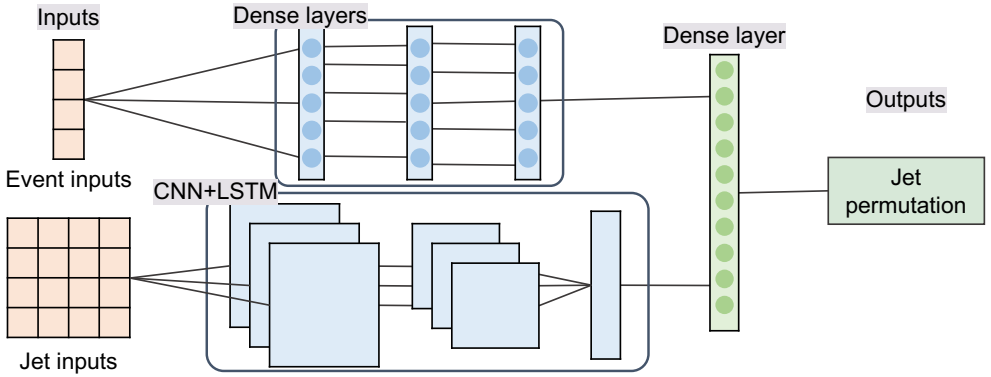
KCMS physics summary 2023

List of published and submitted papers as primary authors

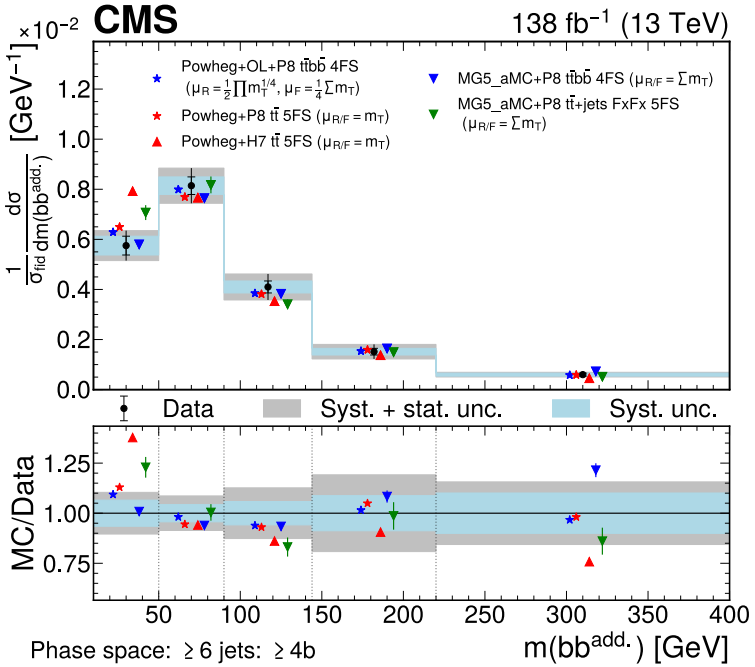
Title	Reference	Status
Azimuthal Correlations within Exclusive Dijets with Large Momentum Transfer in p+Pb collisions at. 5. 02 TeV	HIN-18-011	PRL 131 (2023) 05 1901
Search for CP violation top quark couplings in pp collisions at 13 TeV	TOP-18-007	JHEP 07 (2023) 02 3
Search for new physics in the tau lepton plus missing transverse momentum	EXO-21-009	JHEP 09 (2023) 05 1
Measurements of the azimuthal anisotropy of prompt and non prompt Charmonia in PbPb at 5.02 TeV	HIN-21-008	JHEP10(2023)115
Evidence for four-top quark production in proton-proton collisions at 13 TeV	TOP-21-005	PLB 844 (2023) 13 8076
Production and validation of industrially produced large-sized GEM foils for the phase-2 upgrade of t he CMS spectrometer muon	CMS-NOTE-2 023-00606	NIM A 1057 (2023) 168723
Search for Z prime bosons decaying to pairs of heavy Majorana neutrinos in pp collisions at 13 TeV	EXO-20-006	JHEP11(2023)181
Performance of the local reconstruction algorithms for the CMS hadron calorimeter with Run 2 data	PRF-22-001	Accepted in J. Instr um.
Inclusive and differential cross section measurements of ttbb production in the lepton+jets at 13 TeV	TOP-22-009	Submitted to JHEP
Search for long-lived SUSY with disappearing track at 13 TeV	SUS-21-006	Submitted to PRD
Study of azimuthal anisotropy of Upsilon (1S) in p+Pb at 8.16 TeV	HIN-21-001	Submitted to PLB
Observation of the Upsilon (3S) and suppression in Pb+Pb at 5.02 TeV	HIN-21-007	Submitted to PRL

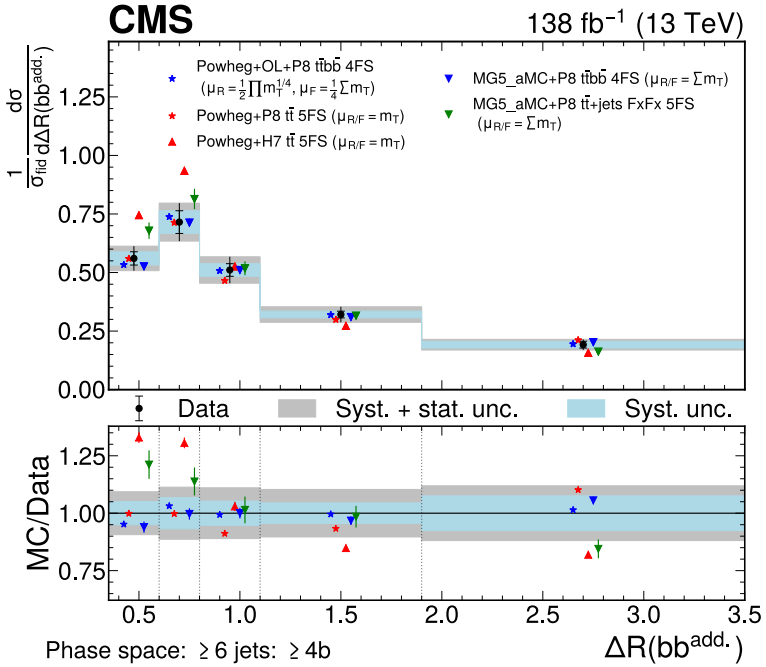
KCMS physics summary

- **Differential cross section measurement of additional two b jets in the top quark pair production**
  - **Using single lepton events**



DNN struture developed by KCMS students





TOP-22-009

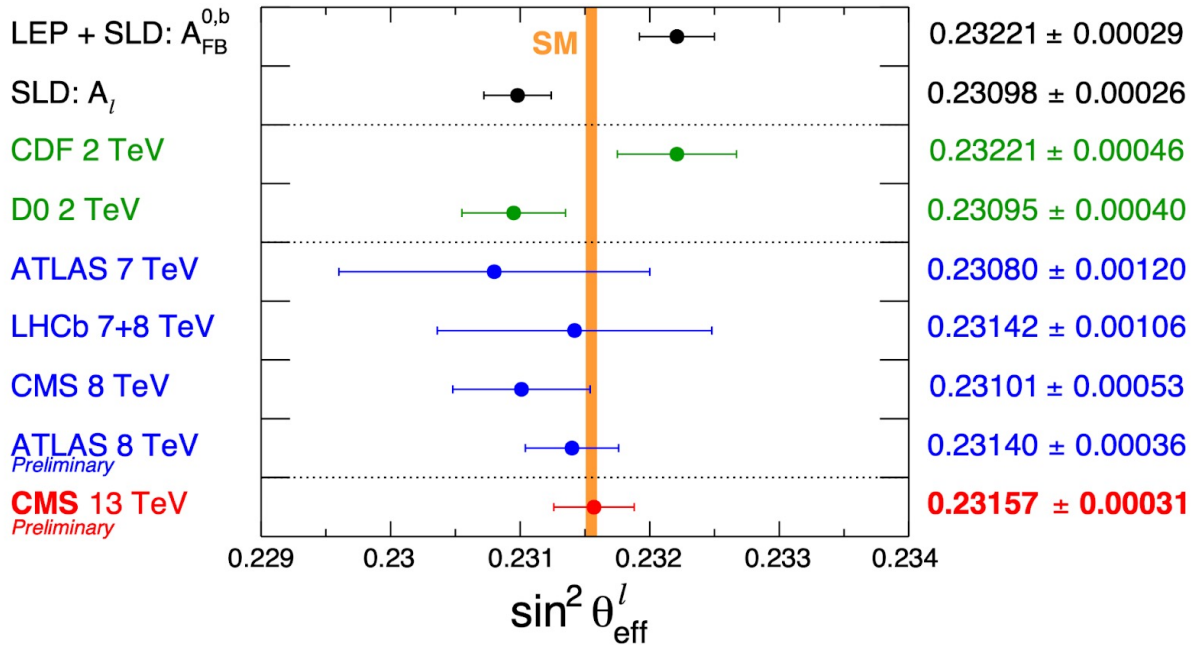
Submitted to JHEP http://arxiv.org/abs/2309.14442

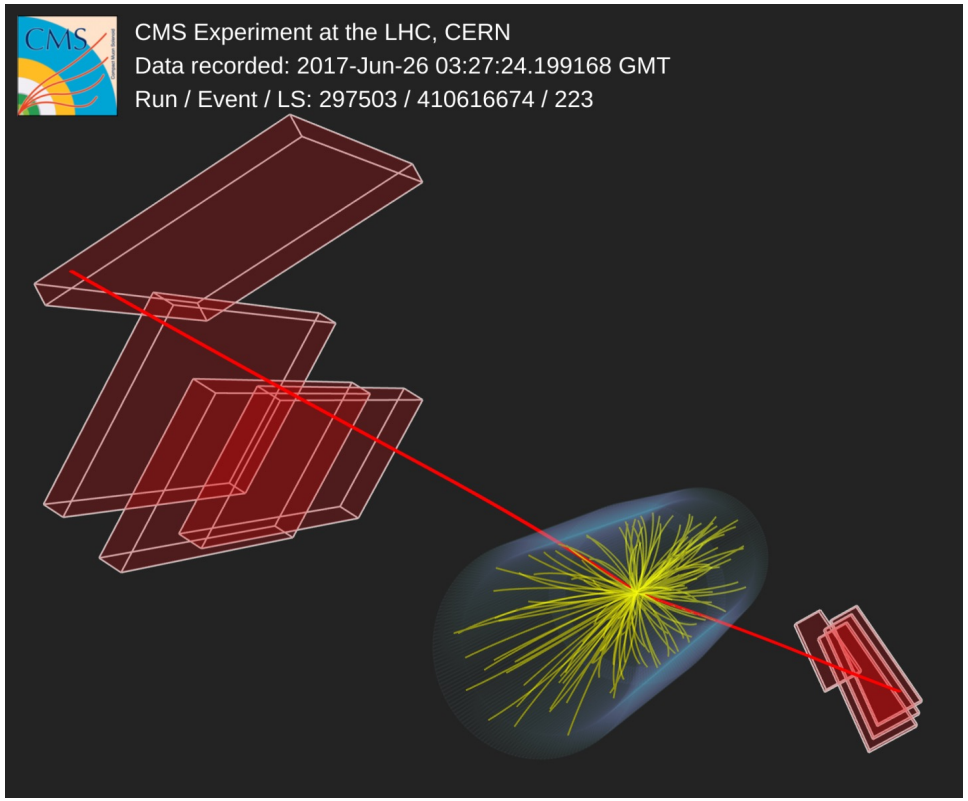
- **This analysis was performed by the KCMS members (Prof. Tae Jeong Kim, Juhee Song, Jieun Choi)**

KCMS physics summary

SMP-22-010

- **The most precise measurement on the weak mixing angle from the CMS experiment**
  - **Using the events where a Z boson decays to a pair of leptons using the forward-backward asymmetry of these two leptons**

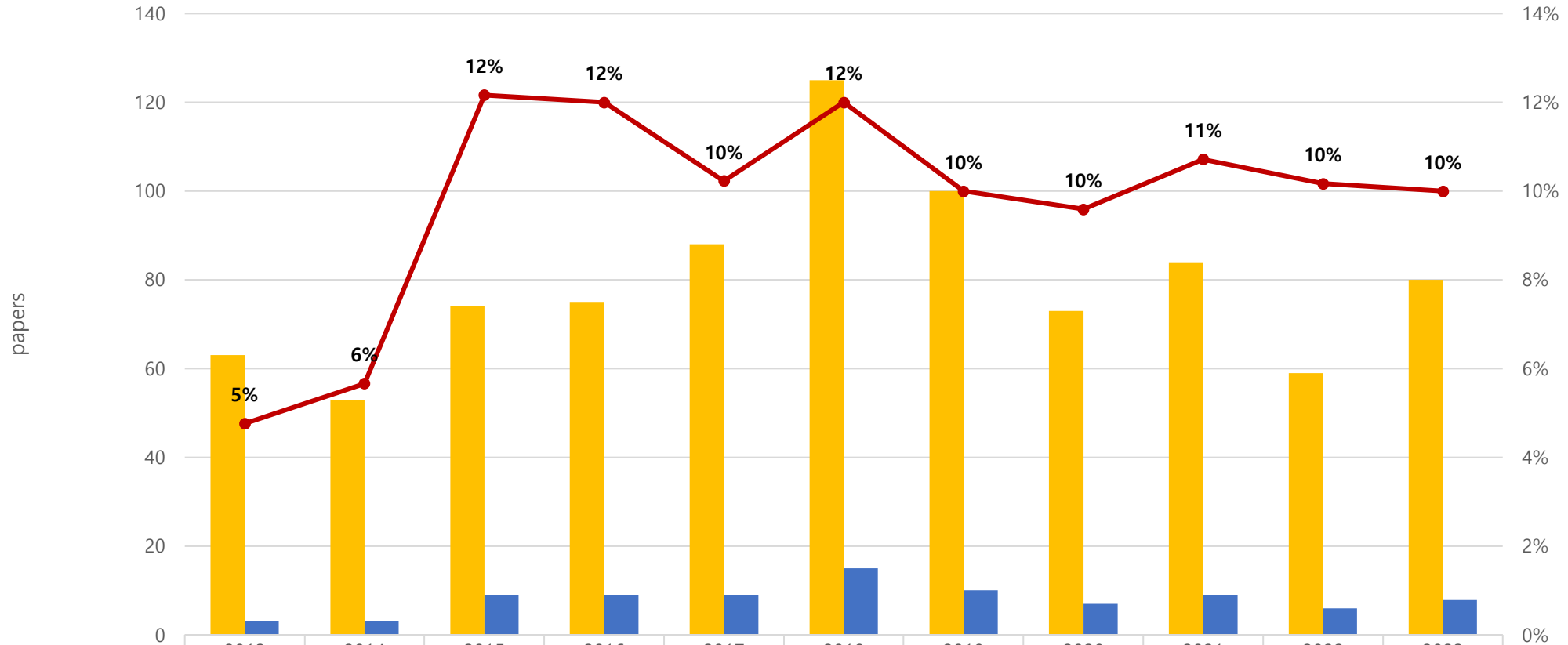




- **This analysis was performed by the KCMS members (Prof. Unki Yang, PhD students Won Jun, Hyon-San Seo)**

Papers

Goal →

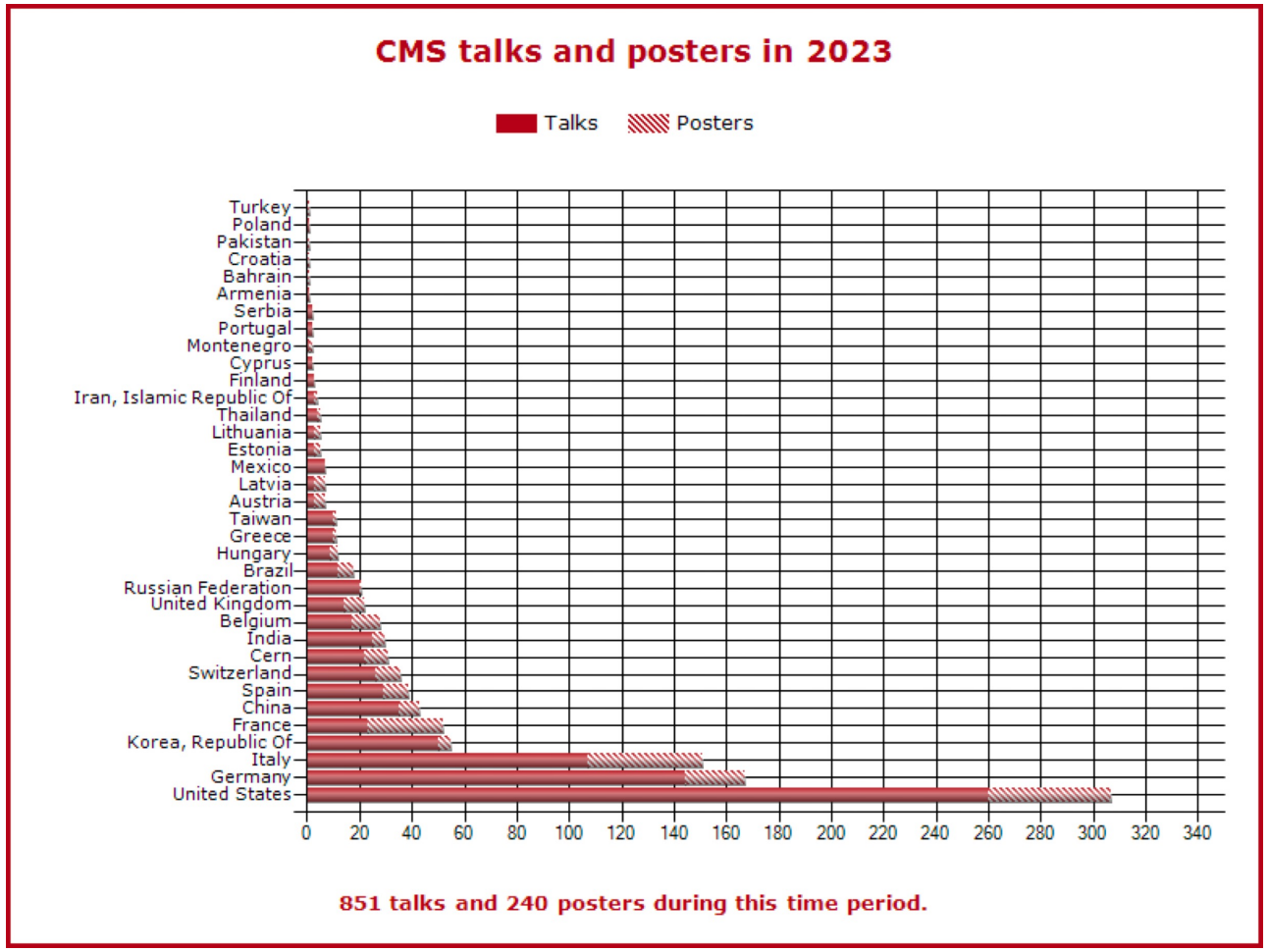


	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CMS papers	63	53	74	75	88	125	100	73	84	59	80
KCMS primary	3	3	9	9	9	15	10	7	9	6	8
KCMS ratio	5%	6%	12%	12%	10%	12%	10%	10%	11%	10%	10%

- **CMS papers with primary authorship by KCMS**
- **We expect the similar rate in 2024**

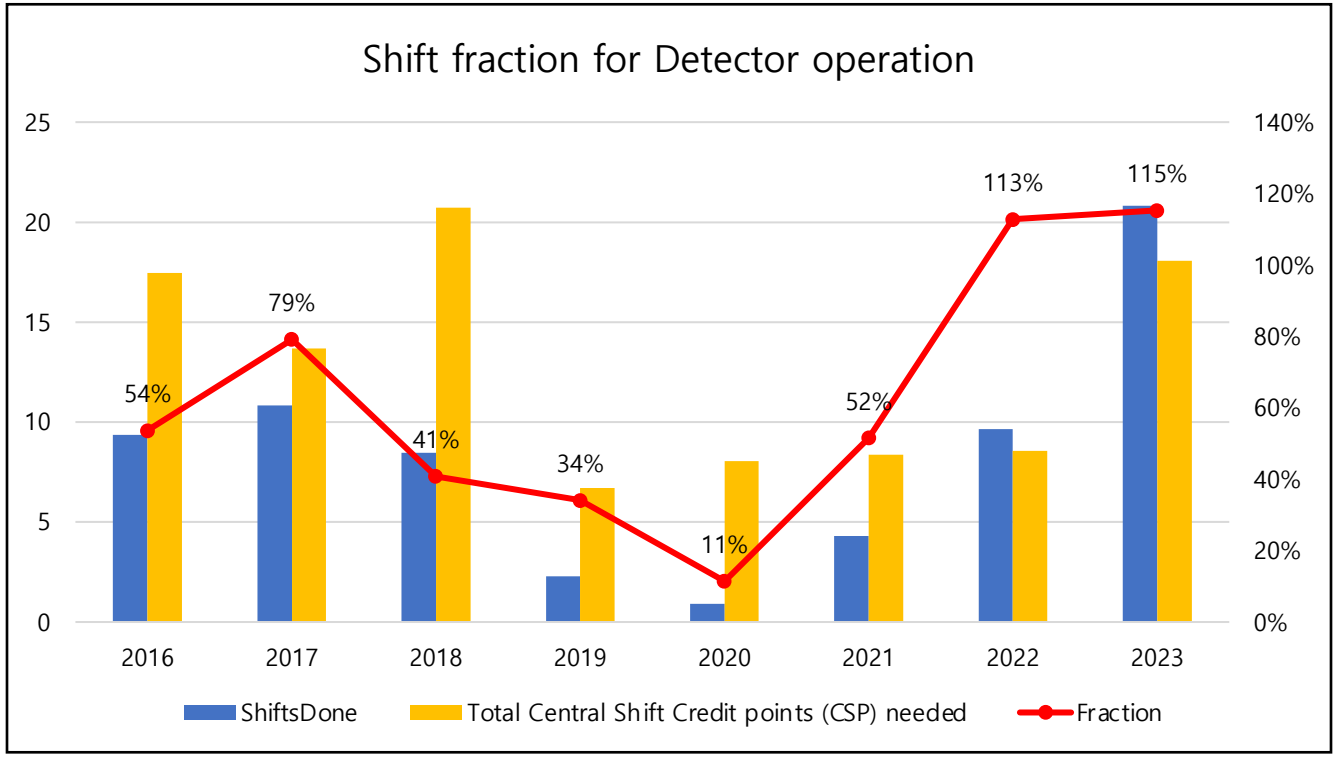
Conference talks

- 4th rank in 2023
  - International conference – 21 talks
  - National conference – 49 talks



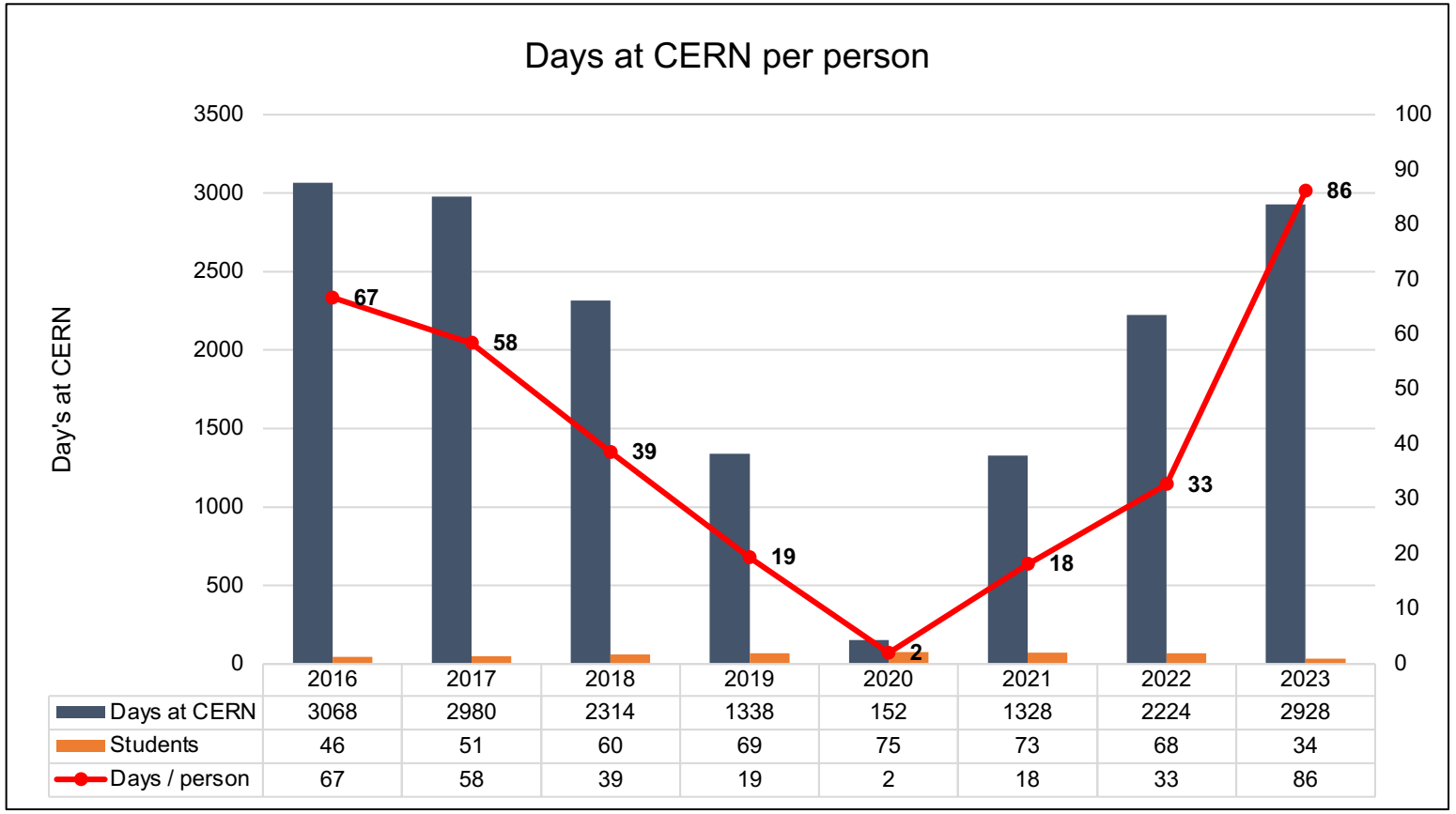
Detector operations (%)

- Since data taking in July 2022, more students and postdocs are stationed at CERN
- ShiftDone/ShiftNeeded > 100% in 2022 and 2023
- In 2024, we are aiming to reach 100% of the ratio towards the end of the year



Days of staying at CERN

- Long term stay
  - One faculty member : Junghwan Goh
  - 3 postdocs : Jeremie Alexandre Merlin, Ece Asilar, Sezen Sekmen
  - 6 students : Won Jun, Seulgi Kim, Jun-Bin Lee, Kyuyeong Hwang, Hyejin Kwon, Jieun Choi



	2016	2017	2018	2019	2020	2021	2022	2023
Days at CERN	3068	2980	2314	1338	152	1328	2224	2928
Students	46	51	60	69	75	73	68	34
Days / person	67	58	39	19	2	18	33	86

Leaderships – as of April 2024

Name	Position	CMS leadership	Period
Tae Jeong Kim	Faculty	Muon System Manager deputy (L1) → Management Board	2023.9~
Sezen Sekmen	Postdoc	SUSY Hadronic/photon subgroup convener (L3) → **SUS PAG L2 coordinator from 2024.9 (approved by CB)**	2022.9~
Soohwan Lee	Student	HIN Dilepton Physics Interest Group convener (L3) **→ FOG (Field Operations Group) (L2) from 2024.9 (approved by CB)**	2022.9~
Junghwan Goh	Faculty	RPC DPG Coordinator (L2)	2017.5~
Ian Watson	Postdoc	GEM DPG Deputy Coordinator (L2)	2023.9~
Jerime Merlin	Postdoc	GEM production coordinator (L2)	2021.6~
Ece Asilar	Postdoc	RPC technical coordinator (L2)	2022.9~
Seulgi Kim	Student	GEM production convener (L2)	2022.9~

Leaderships – as of April 2024

Name	Position	CMS leadership	Period
Seungkyu Ha	Postdoc	JME contact for Top PAG (L3)	2022.9~
Won Jun	Student	Muon HLT convener (L3)	2022.9~
Dayoung Kang	Student	GEM PreProd Manager (L3)	2022.9~
Junbin Lee	Student	GEN MC Validation convener (L3), GEM-PDF contact (2022.04~)	2022.9~
Jin Choi	Student	ME Future Generators and Acceleration convener (L3)	2022.9~
Hyejin Kwon	Student	Combine contact in SUS PAG (L3)	2023.9~
Jieun Choi	Student	B2G HLT contact (L3)	2023.9~
Sanghyun Goh	Student	EXO electron contact (L3)	2022.9~
Jihun Kim	Student	EXO muon contact (L3)	2022.9~
Taehee Kim	Student	EXO Generator contact (L3)	2022.9~
Byunghoon Oh	Student	Combine contact in B2G (L3)	2023.2~
Jihoon Shin	Student	GEN Powheg contact (L3)	2023.11~

Achievement

- New 6 PhD graduated in 2023.8-2024.2
  - postdocs (U. of Florida, Argonne Natl. Lab), KCMS postdoc
  - 2 of them went to industry
- International collaboration
  - Joint supervision for PhD degree - Lyon (Jieun Choi), VUB (Juhee Song)
- 2022 CMS award (awarded in 2023)
  - Ece Asilar (Hanyang)
  - Sihyun Jeon (Seoul National Univ.)

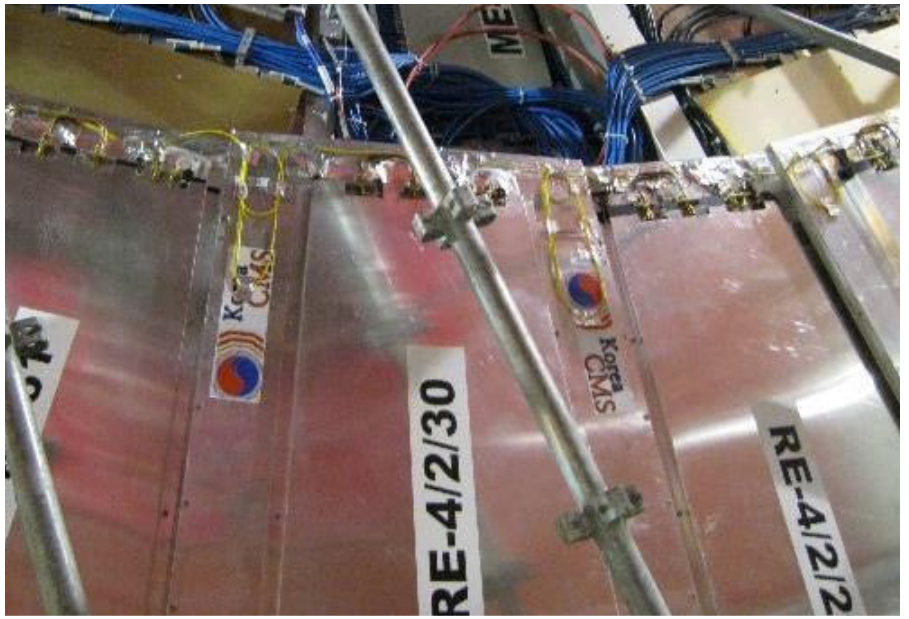

The Compact Muon Solenoid Collaboration
confers on
Sihyun Jeon
Seoul National University, Seoul, Korea
a
CMS 2022 Award
For
For his crucial and sustainable contributions to the CMS Monte Carlo production.
The Collaboration Board Chairperson (Claudia Wulz)
The Experiment Spokesperson (Patricia McBride)
June 16th, 2023


The Compact Muon Solenoid Collaboration
confers on
Ece Asilar
Hanyang University, Seoul, Korea
a
CMS 2022 Award
For
The Collaboration Board Chairperson (Claudia Wulz)
The Experiment Spokesperson (Patricia McBride)
June 16th, 2023

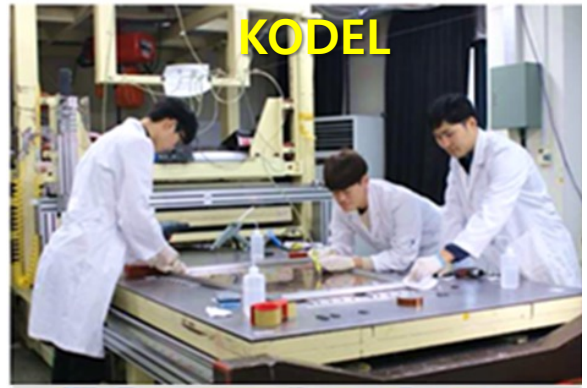
- 2023 CMS award (waiting for the official announcement)
- CMS award committee : Tae Jeong Kim (2023.9-2025.9)
- KCMS seminars once a month at CERN by Professors during sabbatical year

Contribution to phase 2 upgrade

- **GE11: 592 kCHF (Complete)**
- **GE21, ME0 (2024~2026): 2.262 MCHF**
  - 456(GE21), 666(ME0) foils:2064kCHF
  - Glass mask (5 pairs):198kCHF
- **iRPC Upgrade: 400 kCHF**
  - RPC GAP: 286 kCHF (in-kind)
  - Shipping + chammber compoents (114kCHF)
- **Common Fund (MoU:done)**
  - 560 kCHF(2018-2026)
- **MTD upgrade: 2.2 MCHF (MoU: done)**
  - LGAD sensor and Bumpdonding, etc.
- **Total contribution on the Phase 2: 6 MCHF + DUF and increased Common Fund**



Korea University lab and facilities for CMS RPCs



The current KODEL lab and facilities have been operated for

- Construction of CMS endcap RPCs (2003 -)
- PHENIX RPCs (2008-2009) and R&Ds for SHiP/BDF
- For future experiments (?)

Facilities and human resources for RPC production at KODEL will be preserved after the upgrade of CMS RPCs

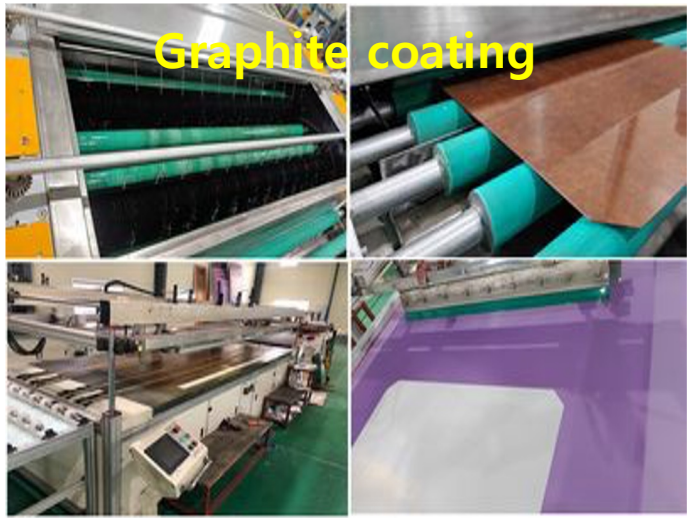
1. Human resources for gas gap production, QC tests, and detector assembly

2. Facilities of phenolic electrode gas gaps (also for glass RPCs) operated since 1999

- Gluing and curing for gas gaps
- Linseed-oil varnishing tool
- QC test for Leak and spacer bonding (QC2 at KODEL)
- QC test for stability of detector currents (DC and DC2 tests, QC2 at KODEL)

3. Utilizing dedicated facilities of company nearby Seoul for some processes (since 2020)

- Washing electrode: Damia @Goyang city
- Graphite coating: Damia @Goyang city
- Insulator coating (PET): Yurim @Goyang city



Plans for near future

Korean group → Completion of iRPC gap production for CMS upgrade

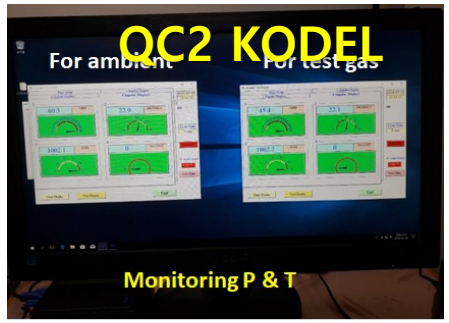
- Completion of ~ 260 iRPC gaps and QC for iRPC gaps will by the end of May 2024.
- QC2, QC3, QC4 for iRPC chambers are reliably on going.

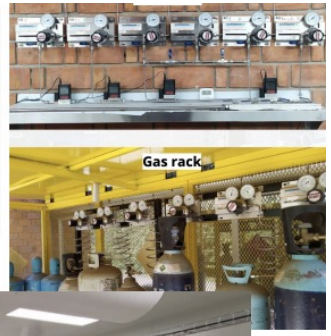
What to do for CMS RPCs in 2024-2025?

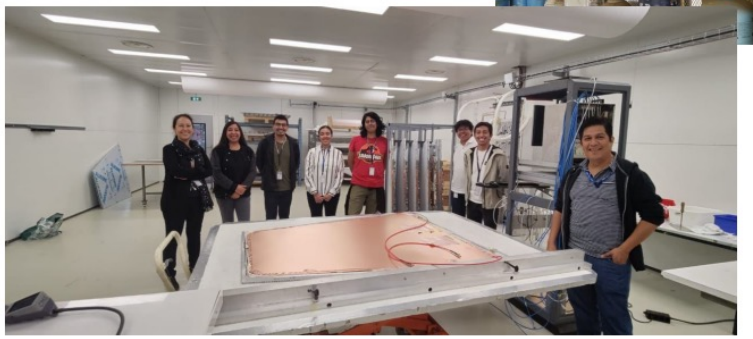
- Repair plan for iRPC gaps: The leaky gaps can be shipped to KODEL together with leaky and high current iRPC gaps.
  - ✓ Sealing again using glue.
  - ✓ Re-oil vanishing for high-current gaps
- Plan for construction of RE4/2 and RE4/3 gaps for existing 2-mm gap RPCs if necessary.

DRD1 activities (WP7) aiming for large-sized RPCs with σ_t < 200 ps

- Thin double-gap RPCs
- Thin four-gap (double bi-gap)RPCs
- Material search for RPC electrodes for high rate capability (Ceramic)







GEM foil production site in Korea well established

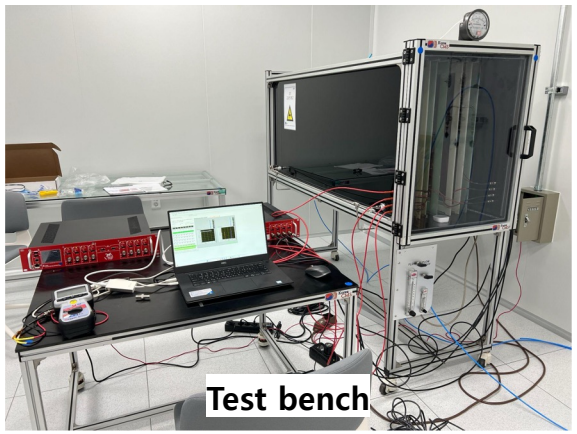
Two different location :

1. Dry process(IBS)

New GEM Foil QC & Production site

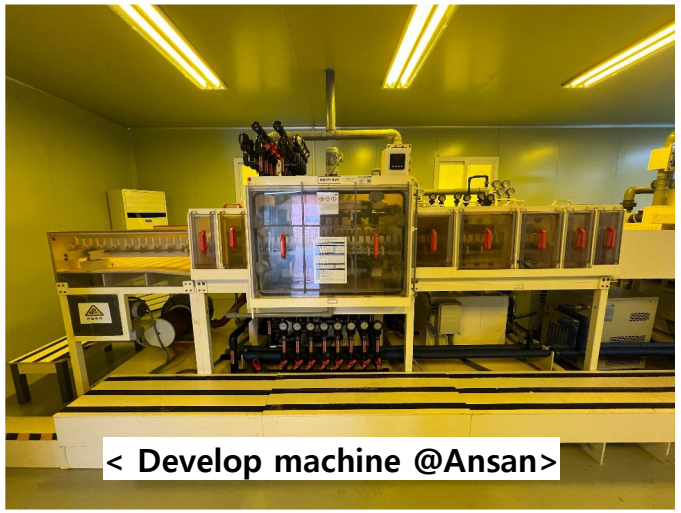
Yellow Room(Workstation)

QC Station



Test bench

2. Wet process(Ansan)

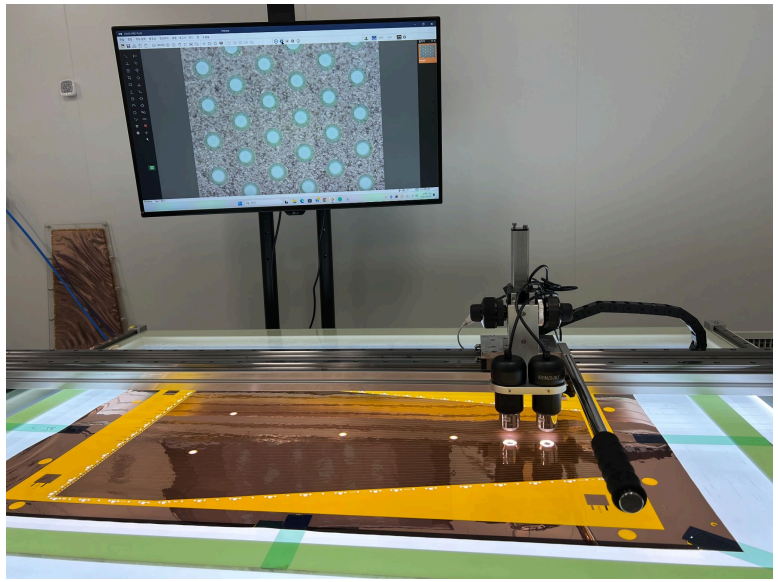


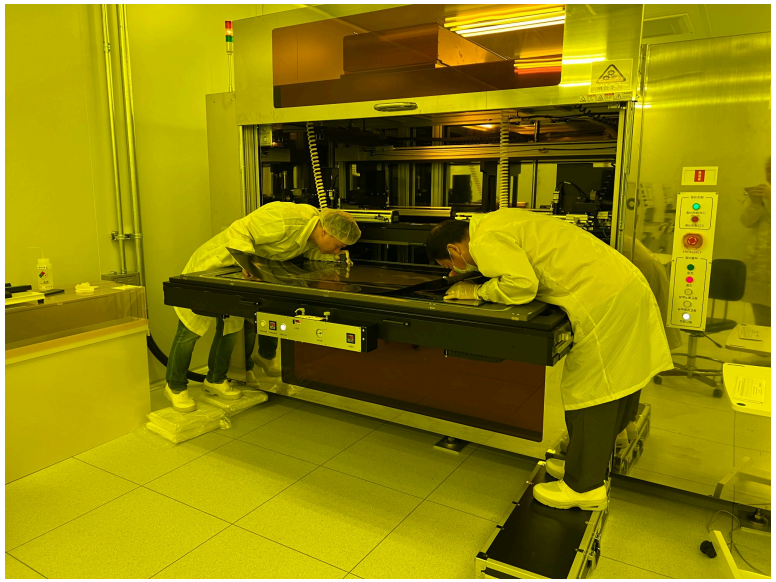
< Develop machine @Ansan>

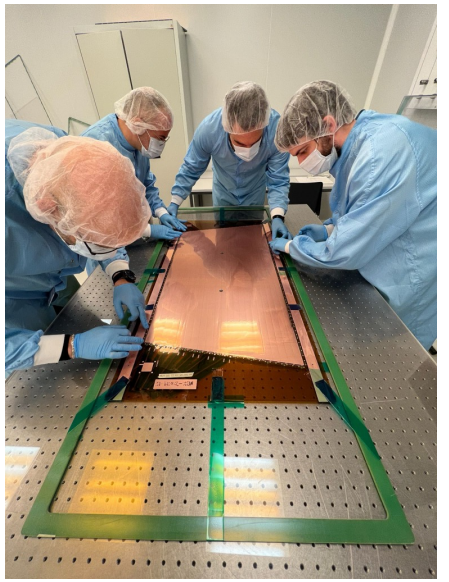
< Etching machine @Ansan>

GEM ME0 foil production status

- Since the GEM foil production facility relocation, we have produced 13 ME0 foils for validation last year in October 2023
  - 13 foils (2 rejected)
  - Successful assembly 2 ME0 modules (final-design prototypes)
- Minor modification of the mask design
- First batch for the mass production of 53 ME0 foils were delivered to CERN April 5, 2024
  - Currently QC is going on at 904
- Expect to produce more than 30 GEM foils at the GEM facility in Korea every month

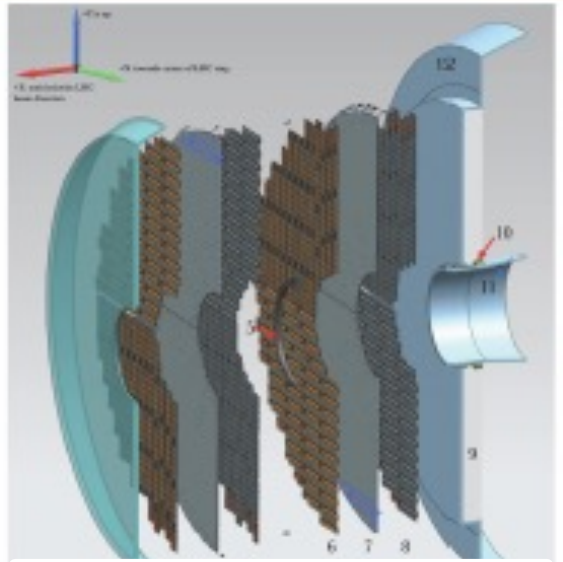


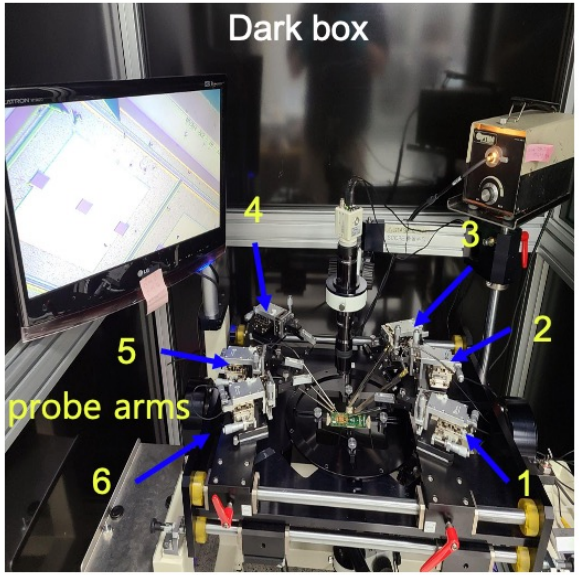




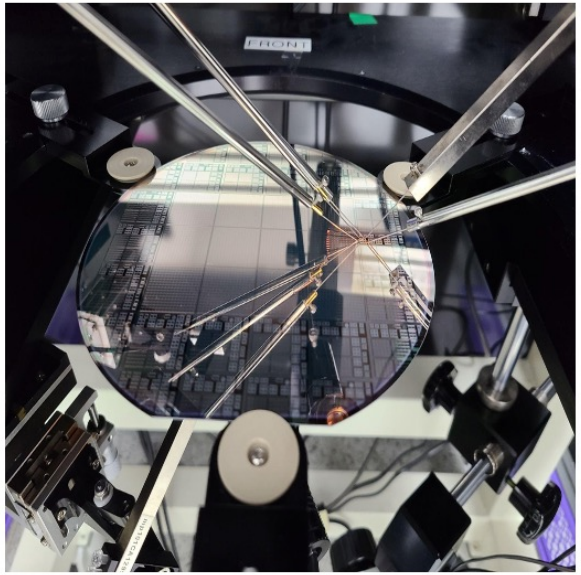
KCMS contribution for MIP Timing Detector (MTD)

- Mitigate the pileup effects at HL-LHC using precision timing information to enhance and expand the physics reach our detector performance,
- Main contributions from KCMS
  - Low Gain Avalanche Detector (LGAD) sensor development & production
  - LGAD & ETROC Bump-Bonding development & processing
  - ETL (Endcap Timing Layer) Module Assembly development & production
- KCMS contribution for MTD : 2.2 MCHF (25% of the total endcap coverage)

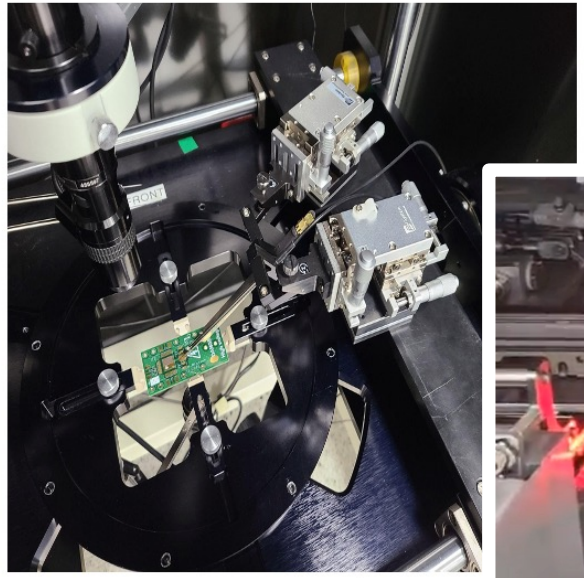




● Overview



● wafer tray



● sensor tray

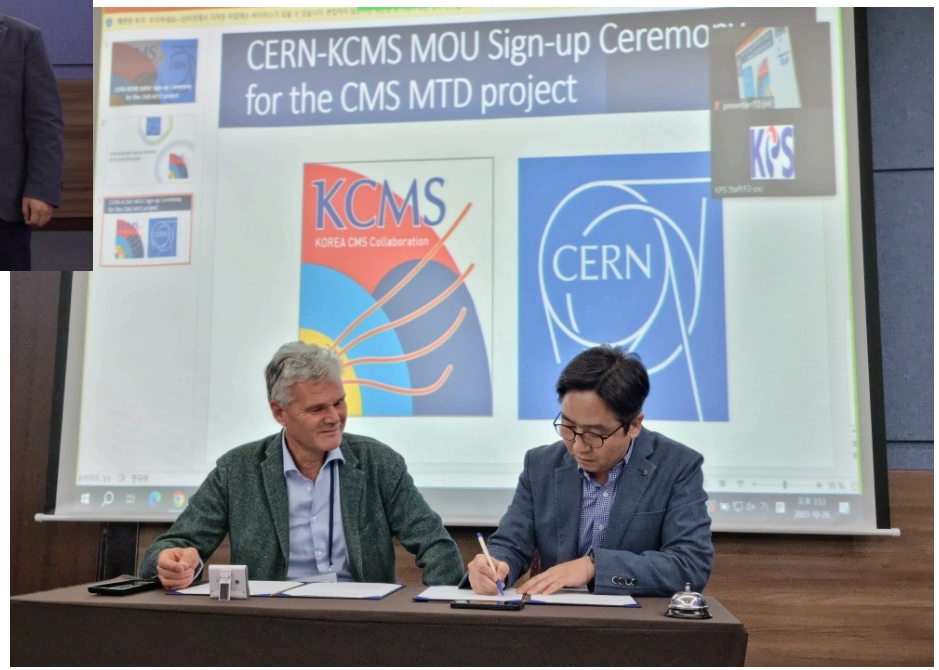
CERN-Korea CMS Sign-up Ceremony for the MTD project

Last CKC meeting on Oct 23

CMS COLLABORATION CMS-2023-006

Memorandum of Understanding (MoU)
for Korea-CMS contribution
towards the MIP timing detector (MTD)
for the Phase-2 CMS Upgrade

Last KPS meeting on Oct 26



- **Korea CMS group** will contribute to the **LGAD production (25%), bump bonding process, front-end ASICs and module structures**, etc.
- Total budget: **2.2M CHF** supported by National Research Foundation of Korea (NRF)

KPS Pioneer session – Present and Future of the LHC Program at CERN

- **Korean Physics Society, Changwon, Oct 24-27 in 2023**
- **Pioneer session**
  - **Present and Future of the LHC programs at CERN**

KPS Pioneer session - Present and Future of the LHC Program at CERN

Thursday 26 Oct 2023, 14:00 → 20:00 Asia/Seoul

Room: 602 (Changwon Exhibition Convention Center)

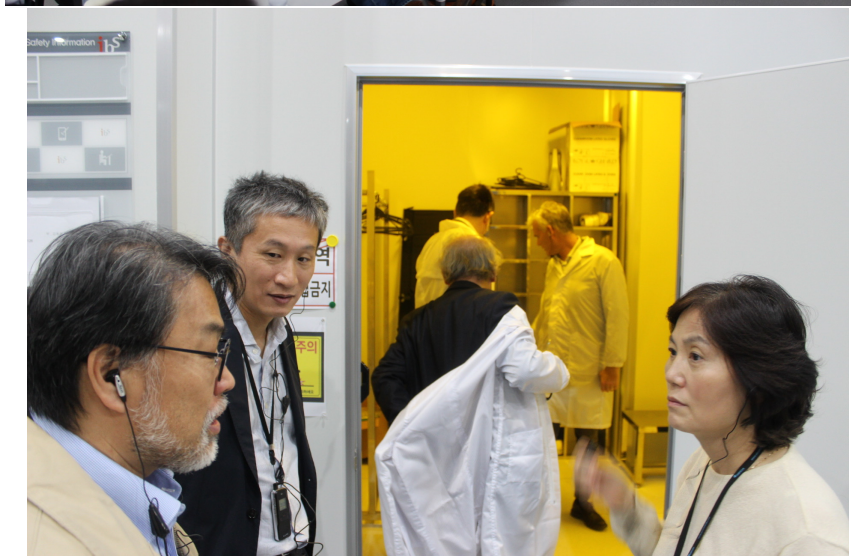
Chang-Seong Moon (Kyungpook National University (KR)), Hyung Do Kim (Seoul National University (KR)), Min Jung Kweon (Inha University (KR)), Tae Jeong Kim (Hanyang University (KR))

Description

LHC started more than 10 years ago, and CERN will turn 70 years old soon. Ever since then, the Higgs boson was discovered, and the properties of the fundamental particles has been measured precisely. The standard model seems to be complete. However, nature such as dark matter and matter-antimatter asymmetry is still out there to be discovered. Furthermore, through heavy-ion collision experiments, we have confirmed the existence and basic properties of quark-gluon plasma, known as the primordial matter of the universe. However, understanding its characteristics from various perspectives is still necessary. LHC is the unique machine that allows us to probe these unknown phenomena. We will discuss the present and future of the LHC in this session.

KPS and Visiting RAON and GEM facility

Visiting GEM facility@RAON

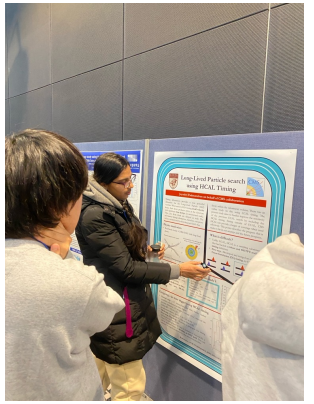


Discusss on possible extension of the CERN-Korea program@RAON

Workshops and conference

- High Energy Physics and Machine learning workshop@Hanyang, Dec 1
- We had an annual Korea CMS workshops in December 27-30, 2023 @ Ski resort

First time for the poster session



- We can have more CERN and/or CMS related workshop and schools more in Korea
  - Proposal to have the CMS Muon week in 2024, CMS week in 2025
  - already CERN school in Korea in 2022, computing school maybe in coming future(?), etc.

Thank you