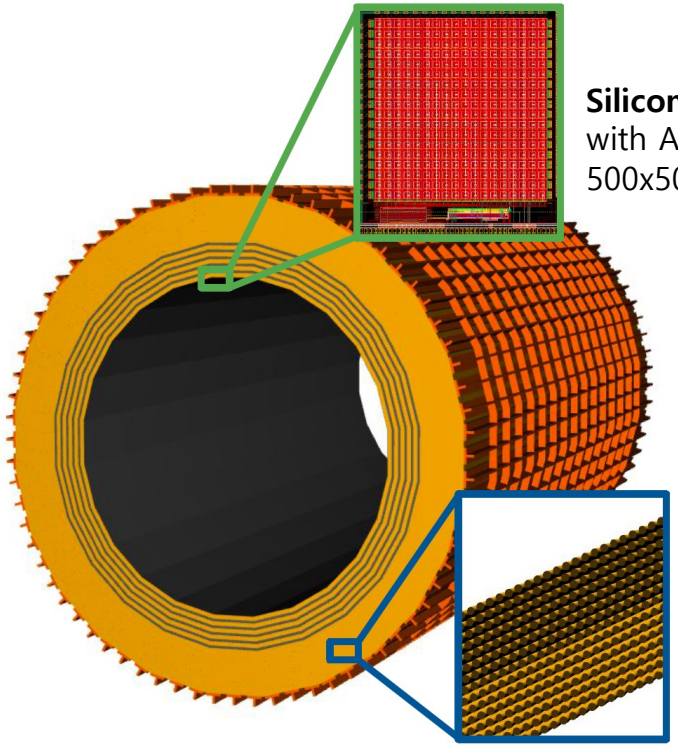
Introduction from Korean groups

Sanghoon Lim
Pusan National University

ePIC Collaboration Meeting @ ANL

Korean institutions for the BIC



Silicon layers
with AstroPix
500x500 μm^2 pixel size

Pb/SciFi layers
with two-sided
SiPM readout

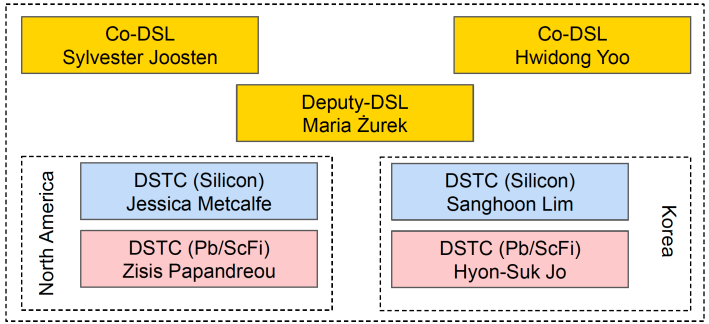
USA
Argonne National Laboratory
NASA Goddard Space Flight Center
Oklahome State University
University of Connecticut
University of California Santa Cruz

Canada
University of Manitoba
University of Regina
Mount Allison University
NSERC
Canada Fund for Innovation

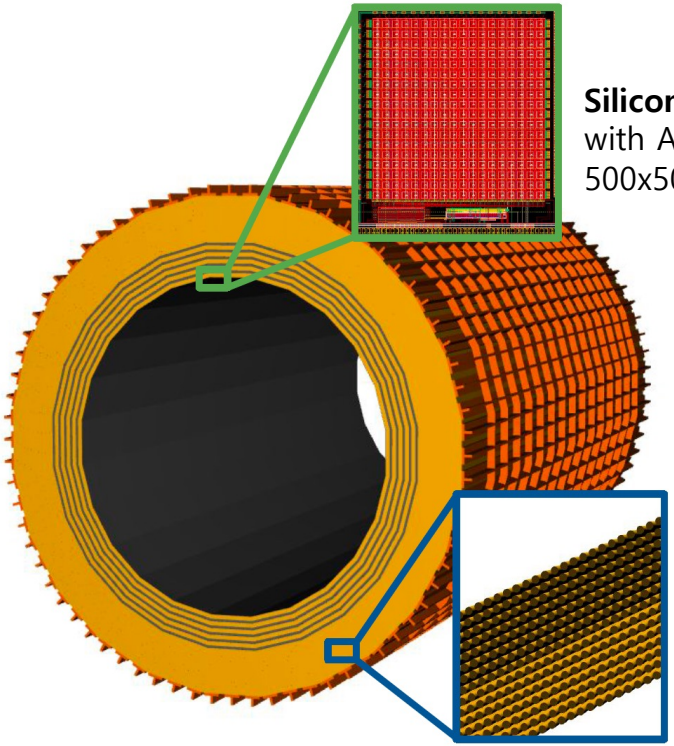
Korea
Kyungpook National University
Yonsei University
University of Seoul
Pusan National University
Korea University
Sungkyunkwan University
Hanyang University
Gangneung-Wonju National University

Germany
Karlsruhe Institute of Technology
University of Giessen

ePIC BIC Detector Subsystem Collaboration



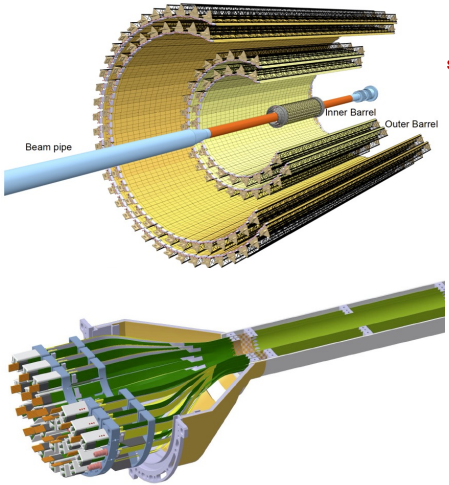
Korean institutions for the BIC

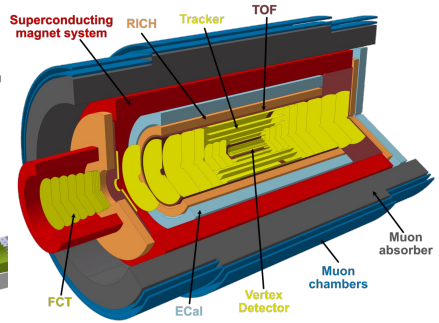


Silicon layers
with AstroPix
500x500 μm^2 pixel size

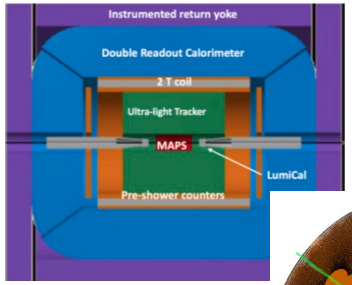
Pb/SciFi layers
with two-sided
SiPM readout

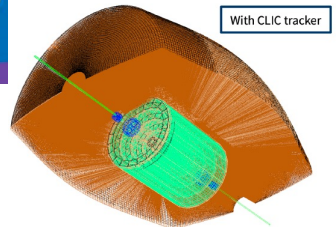
Silicon trackers for ALICE

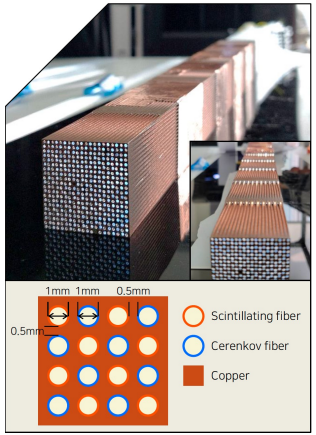




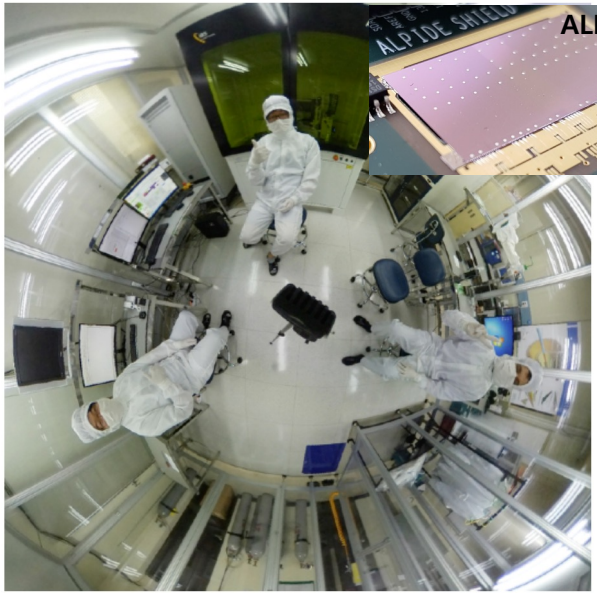
Dual-Readout Calorimeter

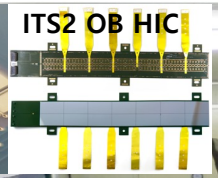






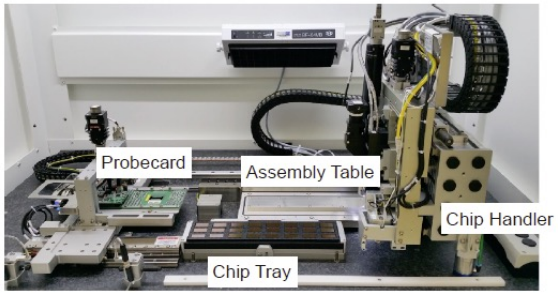
Silicon detector R&D for ALICE ITS2





PNU/Inha University

Yonsei University



- **Design of Pixel Sensor Chip**
- **Characterization of Pixel Sensor Chip**
- **Chip production (thinning & dicing)**
- **Chip test**
- **Detector module production and test**

The ALICE collaboration presents the

ALICE Industry Award 2020

to

C-ON Tech

NamdongGu Incheon, South Korea

in recognition of the exceptional commitment to the development of a high-precision automated system for the mass production visual inspection and electrical tests of the ALPIDE monolithic pixel sensor ASIC. The extraordinary dedication of C-On Tech contributed to the successful production of the ALICE Inner Tracking System and Muon Forward Tracker.

CERN

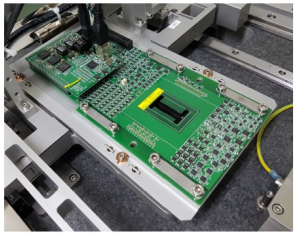
Chair of the ALICE management board

Chair of the ALICE collaboration board

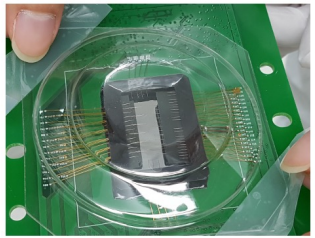
ALICE

Silicon detector R&D for ALICE ITS2

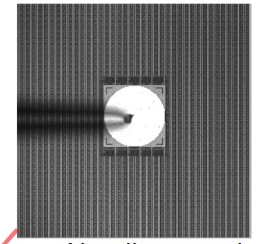
- **Mass chip test**
  - **Dimension inspection**
  - **Electrical test**
  - **Total test: ~5 min/chip**
  - **Yonsei and PNU**



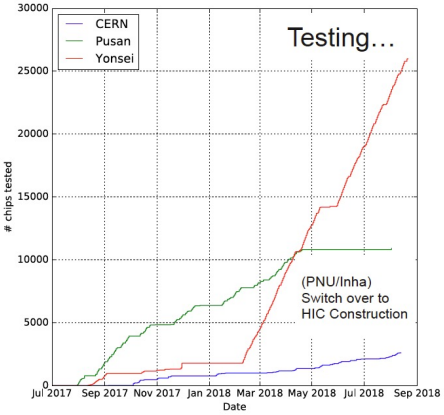
Probecard



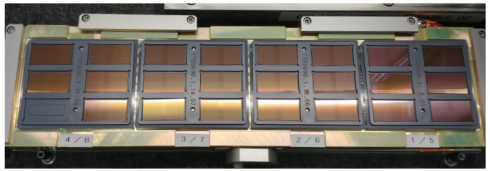
Needles of Probecard
67 needles to contact



Needle on pad



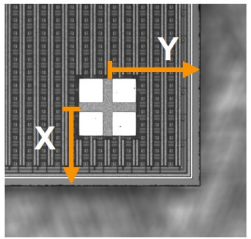
Accumulated number of tested chips
M.Mager (CERN) / 27AUG2018 / ITS Plenary



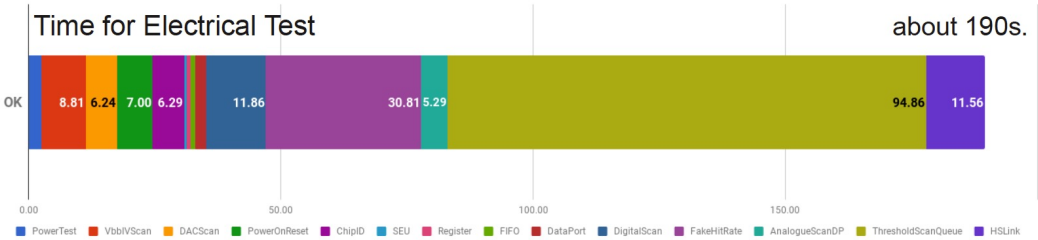
23 of ALPIDE Chips in Tray

Pads on ALPIDE

Dimension Inspection



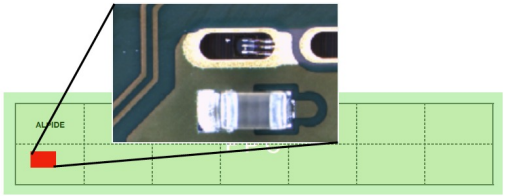
Measuring
Dimensions



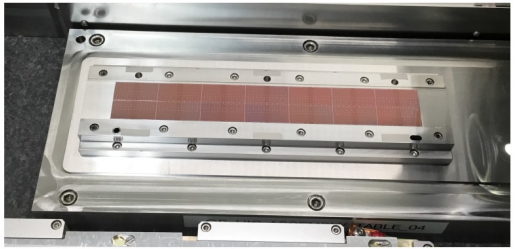
- **HIC Production**
  - **PNU (one of 5 production sites)**

Aligning ALPIDEs
in Position precision < 5μm

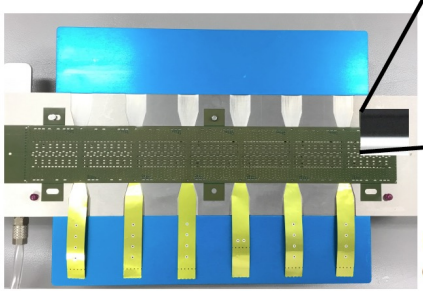
Gluing FPC to chips
Mechanical connection



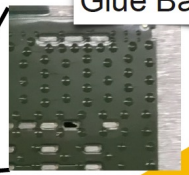
Wire-bonding
Electrical connection



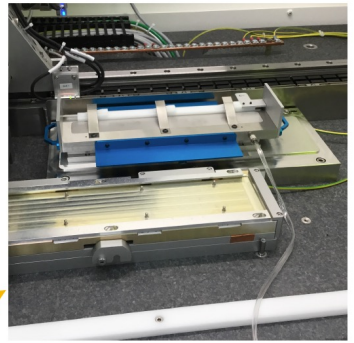
ALPIDE Aligned in ALICIA



Glued FPC on Gripper

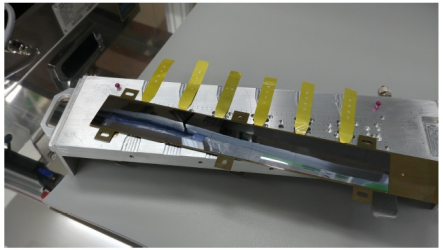


Put upside down
on aligned ALPIDEs



Pre-Curing in ALICIA
(min.) 5 hrs

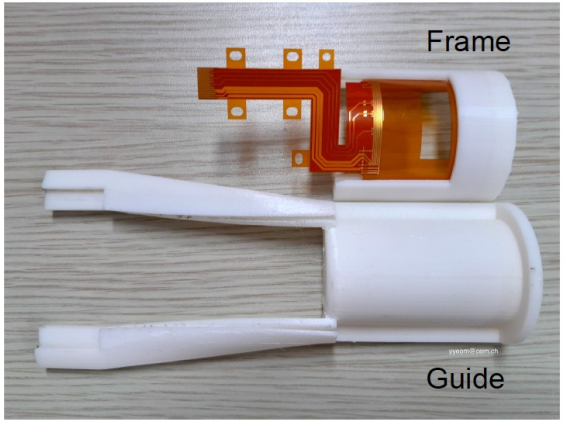
Detach HIC
from ALICIA

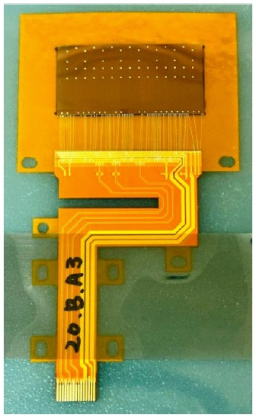


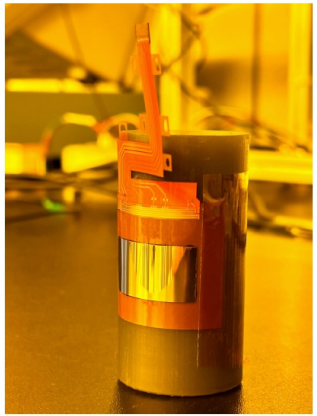
Glue HIC (Opposite side)

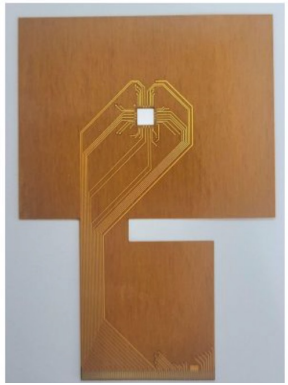
In Pusan/Inha Team, wire-bonding is being done by out-sourcing company, MEMSPACK

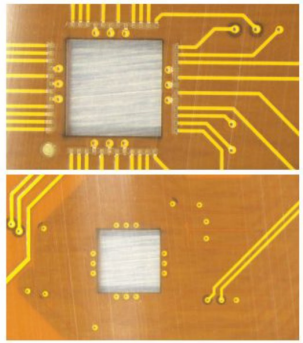
Bent chip (ALPIDE and ATPS)



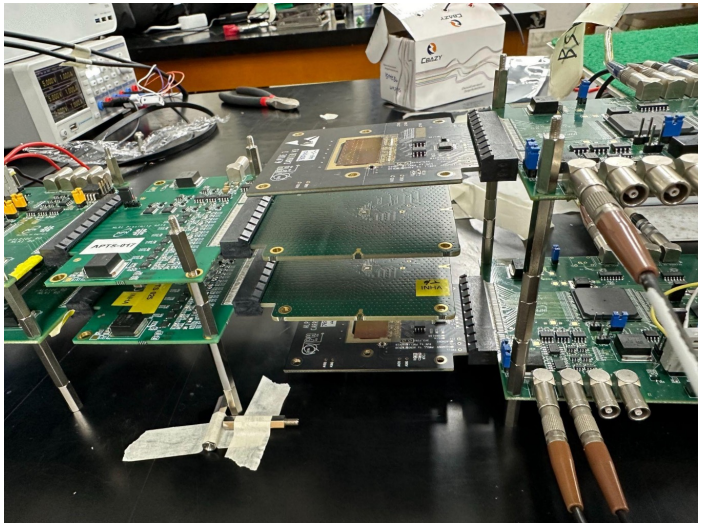








Mini-telescope with ALPIDE and ATPS



- **Working on building a telescope for testbeam at KEK (1-5 GeV electrons) in March**
  - **6 ALPIDE layers + 2 APTS layers (or 1 bent ALPIDE)**
  - **Possibility to integrate other DUTs later (AstroPix)**

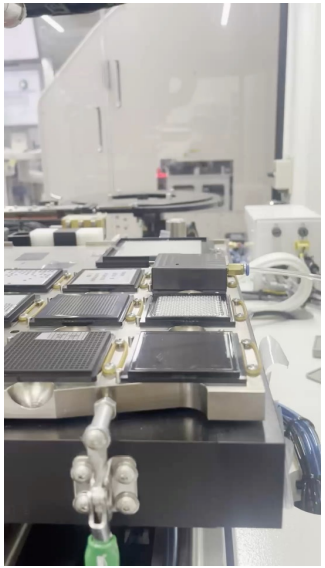
Collaboration with MEMSPACK

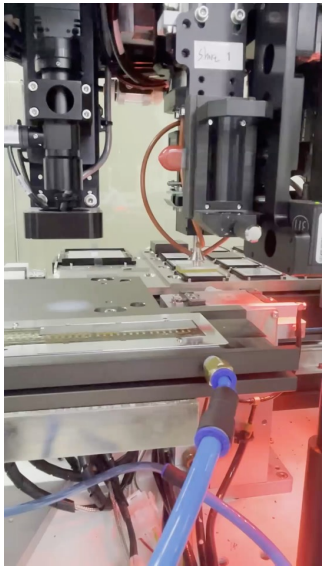
- **Automatization and industrialization of module assembly**
  - **60 m^2 of silicon sensor**
  - **x5 more modules (12500) than the ITS2 (2500)**
  - **Collaboration with a local company (MEMSPACK) for ALICE 3 Module assembly with a multi-purpose machine die bonder**

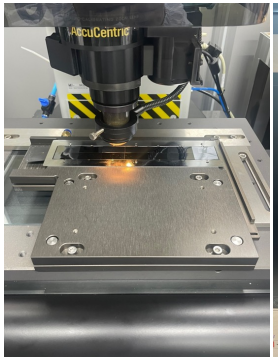
Datacon 2200 evo+

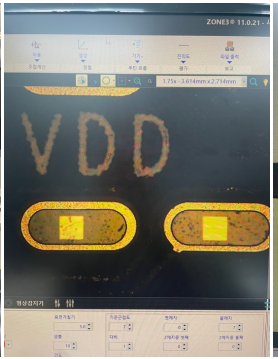
MRSI 705

General purpose die attach machine



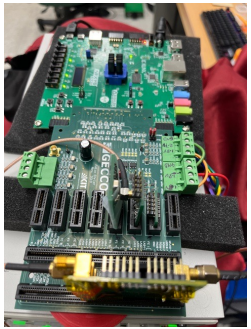


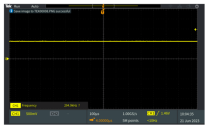




Collaboration with MEMSPACK

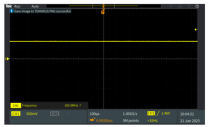
- **Testbench with AstroPix v2**
  - Built a testbench and performed a basic operation with charge injection



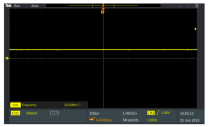


Apply LV

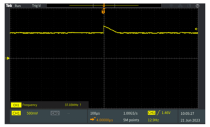
Apply LV+HV



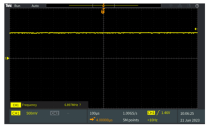
Apply LV+HV, FPGA board ON



Program firmware

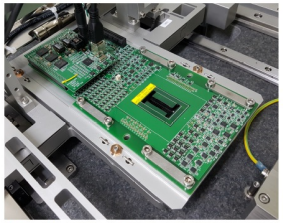


Charge injection code run

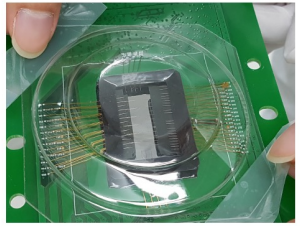


Code end

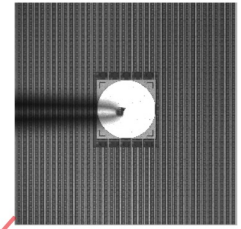
- **Chip test machine**
  - Initial discussion with C-ON Tech
  - When single chips, wafers are available, a protype machine and probe card can be designed



Probecard

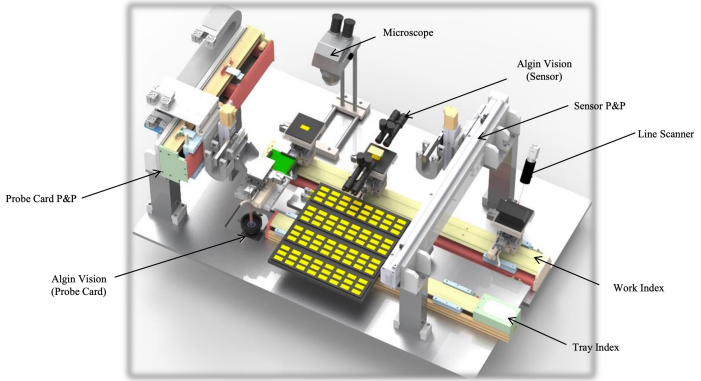


Needles of Probecard
67 needles to contact

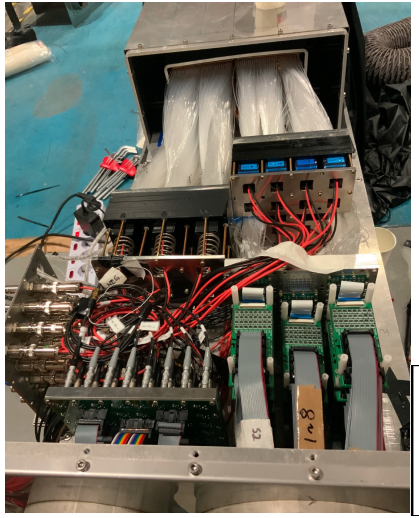


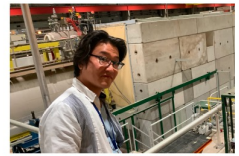
Needle on pad

- **Testbeam with ALPIDE telescope**
  - 6 ALPIDE layers for reference track: Excellent tracking with position resolution of 5 um
  - DUT (AstroPix v3 or v4): Position resolution and tracking efficiency
  - DAQ with a common external trigger
  - Possibly having a regular testbeam at KEK with Japanese institutions in ALICE

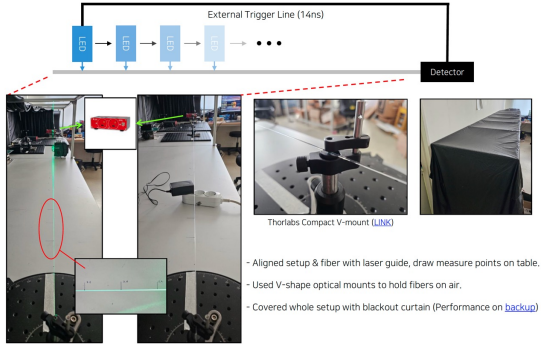


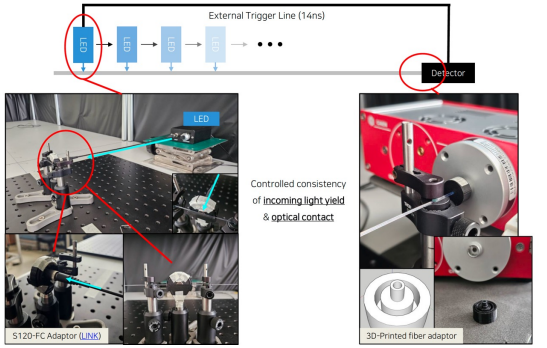
- **Testbeam with various module types: 2022 (CERN SPS), 2023 (CERN PS), 2024 (CERN SPS)**

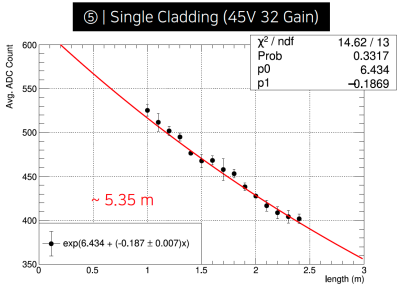


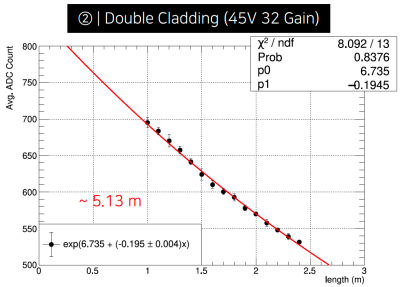


- **Fiber attenuation measurement**
  - **Comparison between single and double cladding**
  - **Under development of automated process**





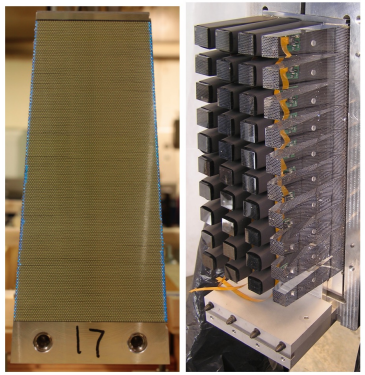


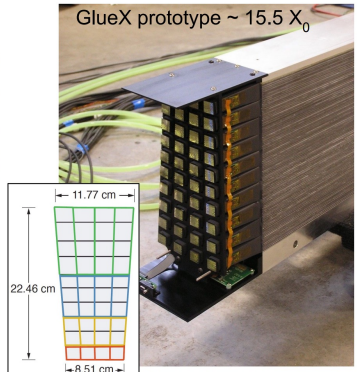


	SC	DC
Avg.	5.19 m	4.87 m
Stdev.	0.45 m (~9%)	0.18 m (~4%)

Measured Attenuation length

- **Prototype Pb/SciFi production**
  - **Similar design of the GlueX prototype**
  - **Under development of processing Pb layers**
  - **Prototype can be used for further developing read-out box and testing with silicon layers**

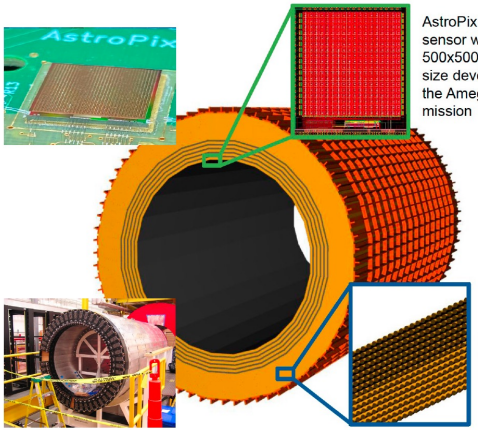


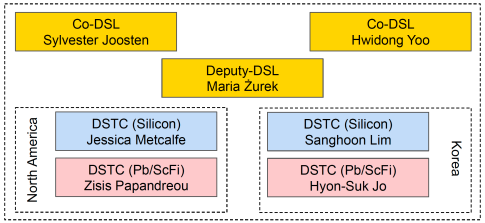


- 60-cm long prototype
- 40 light guides on either side
- 40 SiPMs per side

Summary

- Korea-bECAL group aim to make a significant contribution to the construction and relevant R&D
- We are closely communicating with the Korean government for the funding of the barrel ECAL R&D and construction, and very promising progress is expected in 2024

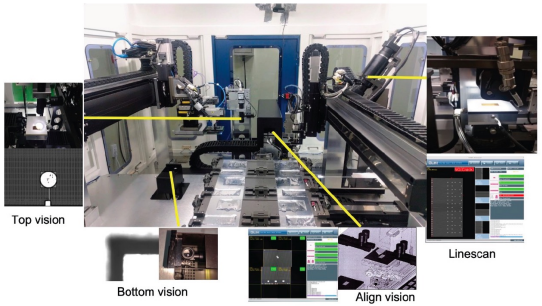




K-bECAL members: 8 institutions and 10 faculties

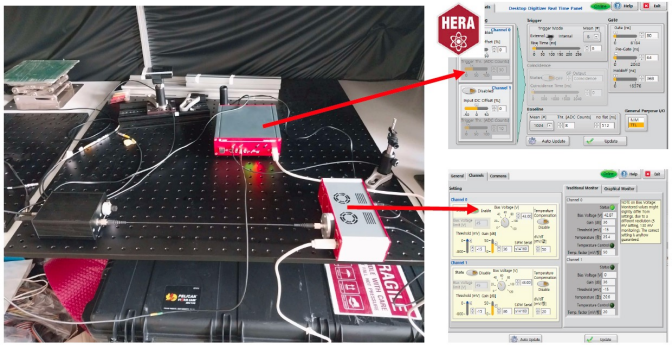
Kyungpook National University | Yonsei University | University of Seoul | Pusan National University | Korea University | Sungkyunkwan University | Hanyang University | Gangneung-Wonju National University

Silicon chip test & module assembly



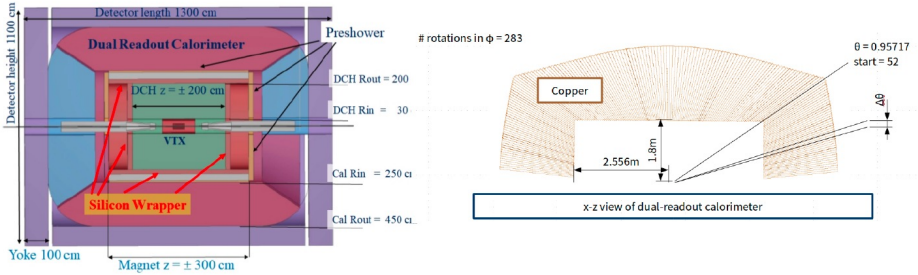
Collaborate with local companies:
C-ON Tech, MEMSPACK

Optical fiber test setup

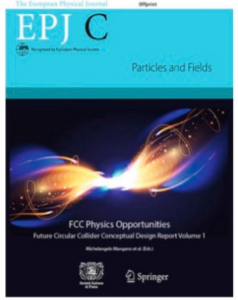


BACKUP

- **Korean team led the design of the Dual-Readout Calorimeter (DRC) for IDEA detector**
  - **Included in the CDRs of both FCC-ee and CEPC, published at the end of 2018**

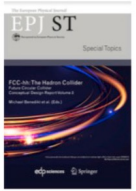


4 CDR volumes submitted to EPJ in December 2018.

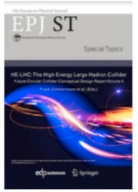


FCC Physics Opportunities

FCC-ee:
The Lepton Collider

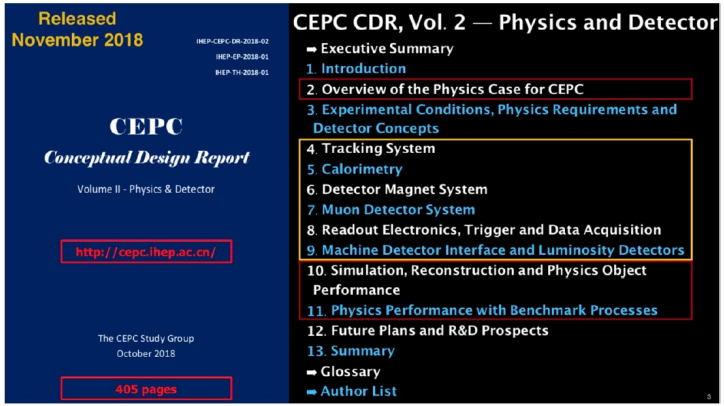


FCC-hh:
The Hadron Collider

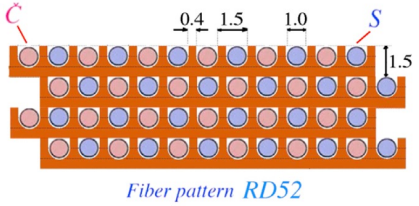


HE-LHC:
The High Energy Large Hadron Collider

Copies can be requested at
http://get-fcc-cdr.web.cern.ch



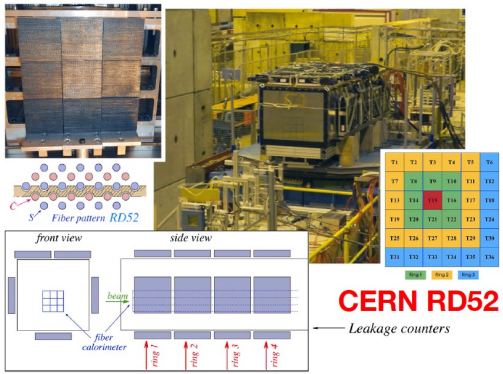
- **DRC offers high-quality energy measurement for both EM particles and hadrons**
  - **DRC consists of two different optical fibers (S, C) in a single component**
  - **The main culprit of poor hadronic energy resolution is fluctuations of the EM shower components of hadron showers (f_{em})**
  - **f_{em} can be determined using the measured values of scintillation and Cerenkov signals**



Fiber pattern RD52

$$S = E\left[f_{\rm em} + \frac{1}{(e/h)_S}(1 - f_{\rm em})\right],$$
$$C = E\left[f_{\rm em} + \frac{1}{(e/h)_C}(1 - f_{\rm em})\right],$$

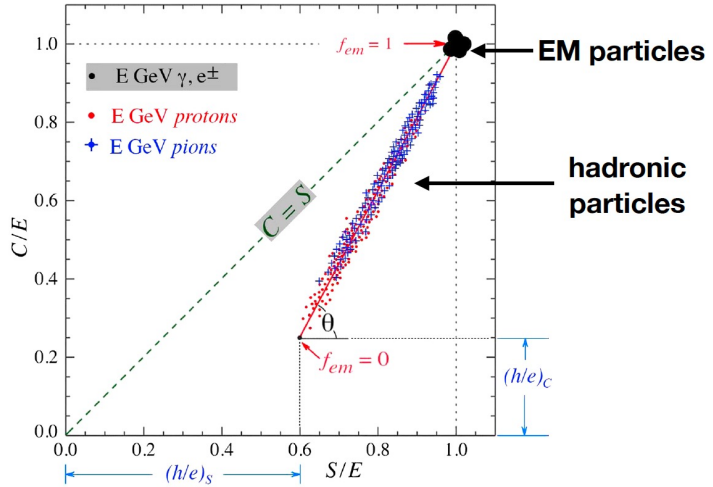
$$f_{\rm em} = \frac{(h/e)_C - (C/S)(h/e)_S}{(C/S)[1 - (h/e)_S] - [1 - (h/e)_C]}.$$



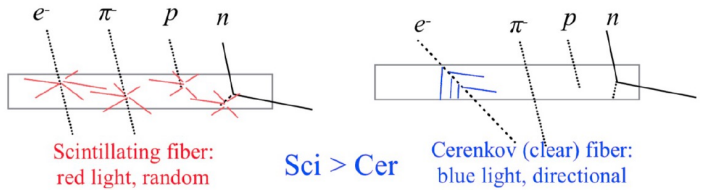
CERN RD52 experiment

$$E = \frac{S - \chi C}{1 - \chi}.$$

$$\cot\theta = \frac{1 - (h/e)_S}{1 - (h/e)_C} = \chi,$$



Signal generation: Scintillating & Cerenkov fibers

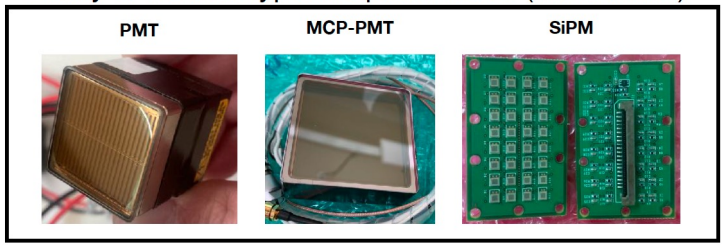


Dual-Readout Calorimeter R&D: TB2022

- **Duration : Aug. 4th ~ 24th**
- **Measurement Goal**

Module 1	- Shower depth - Longitudinal shower profile - Light attenuation length
Module 2	- Position resolution - Lateral shower profile - EM energy resolution - Uniformity study

- **Location : CERN North area (H8)**
- **R&D Goal**
  - Readout system test (MCP-PMT & SiPM)
  - Study of various type of optical fibers (scintillation)

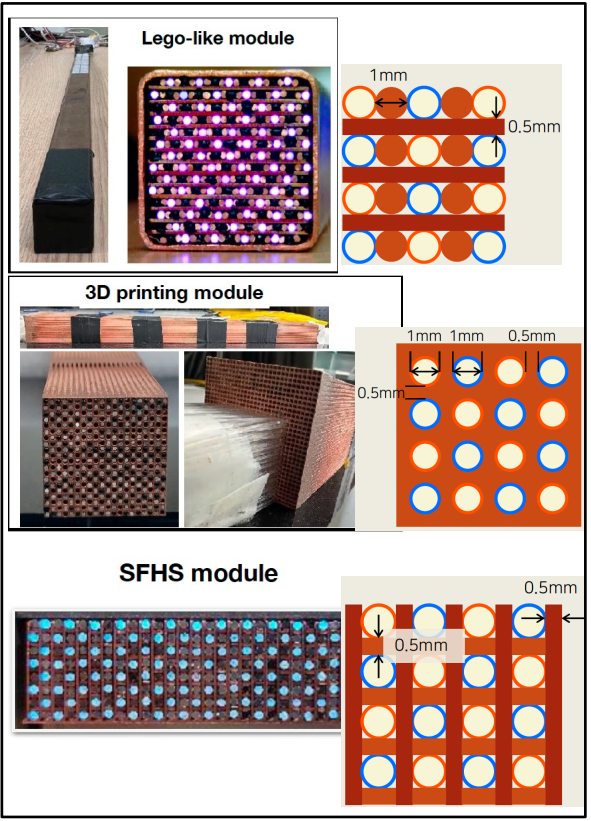


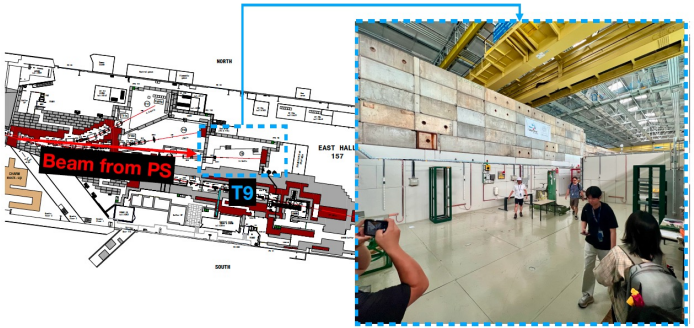
- **Training Goal**
  - Training next generation experts for DRC HW

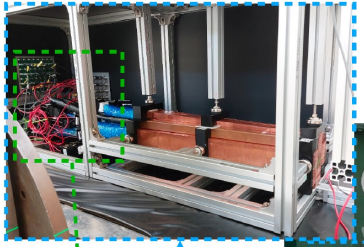
- **Schedule of test beam preparation**

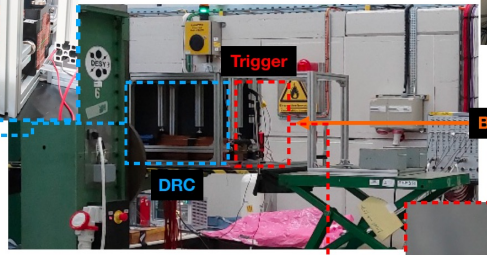
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	
Module	Building Module (fiber+Cu)		Attach readout			Test Commissioning	Packing/ Shipping	Install @ CERN(H8)	-
DAQ	Test Mutichannel operation						Packing/ Shipping	Install @ CERN(H8)	-
Test beam							Packing/ Shipping	8/3 ~ install	Preparation & commissioning @ cern (~8.16) / Taking test beam (8.17~8.24)

- **Test beam experiment at T9 (CERN PS): June 28 - July 13**
  - **New prototype modules**









- **Build full-size prototype module**
  - Contain almost full energy of a jet
  - Achieve the goal of the jet energy resolution
- **Develop an engineering solution for 4 pi detector**
  - Using Skiving Fin Heatsink