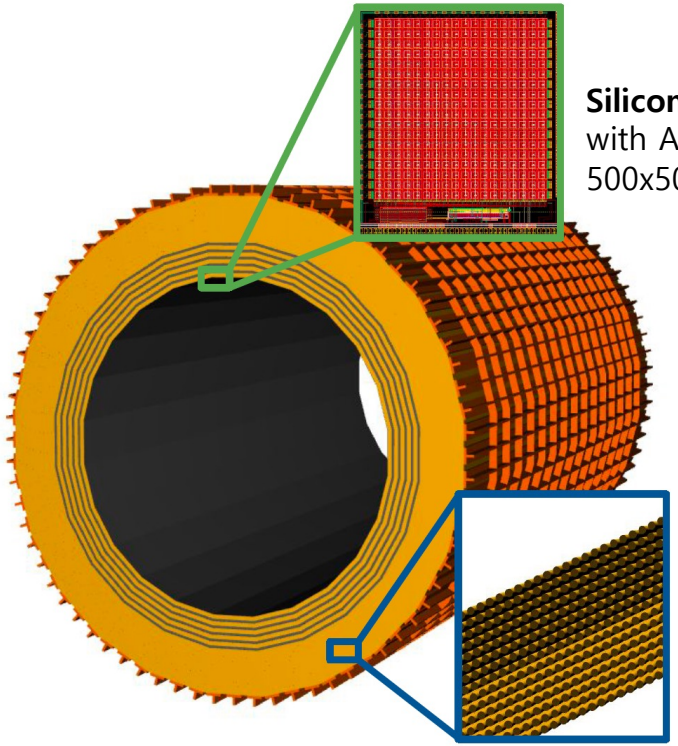
# Activity in Korea on the Barrel Imaging Calorimeter

Sanghoon Lim
Pusan National University

ePIC General Meeting

# Korean institutions for the BIC



**Silicon layers**
with AstroPix
500x500 $\mu m^2$ 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

Co-DSL
Sylvester Joosten

Co-DSL
Hwidong Yoo

Deputy-DSL
Maria Żurek

North America

DSTC (Silicon)
Jessica Metcalfe

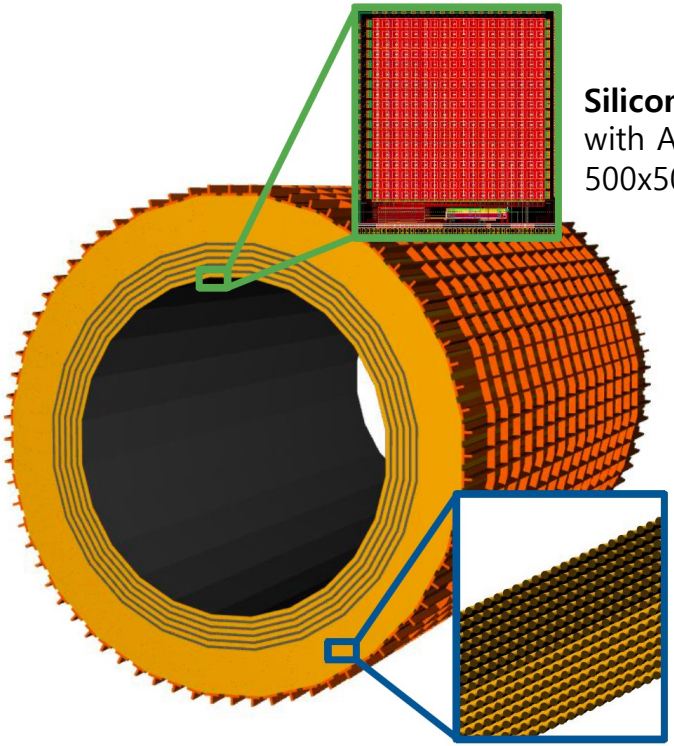
DSTC (Pb/ScFi)
Zisis Papandreou

Korea

DSTC (Silicon)
Sanghoon Lim

DSTC (Pb/ScFi)
Hyon-Suk Jo

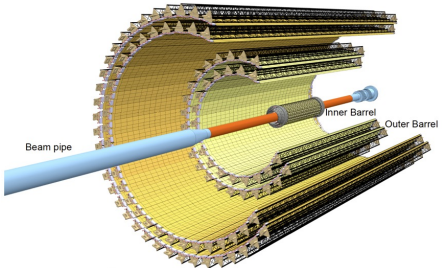
# Korean institutions for the BIC

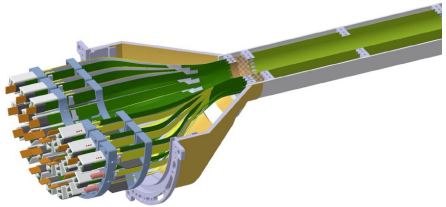


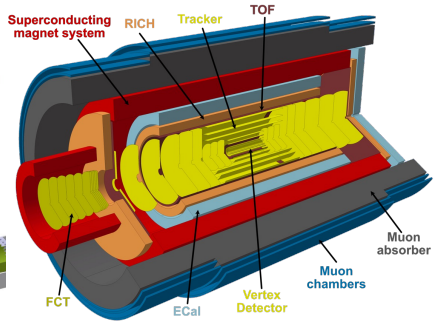
**Silicon layers**
with AstroPix
500x500 $\mu m^2$ pixel size

**Pb/SciFi layers**
with two-sided
SiPM readout

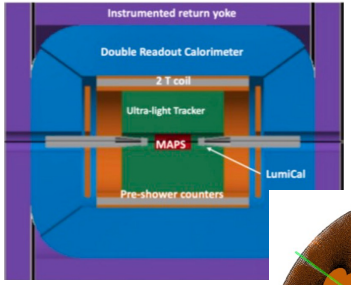
## Silicon trackers for ALICE

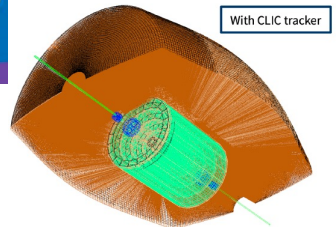


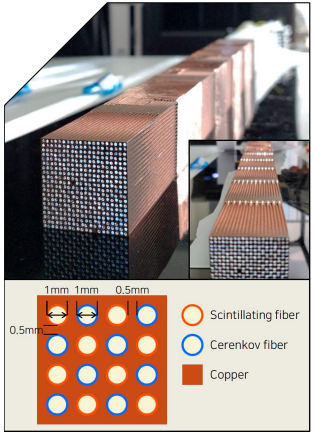





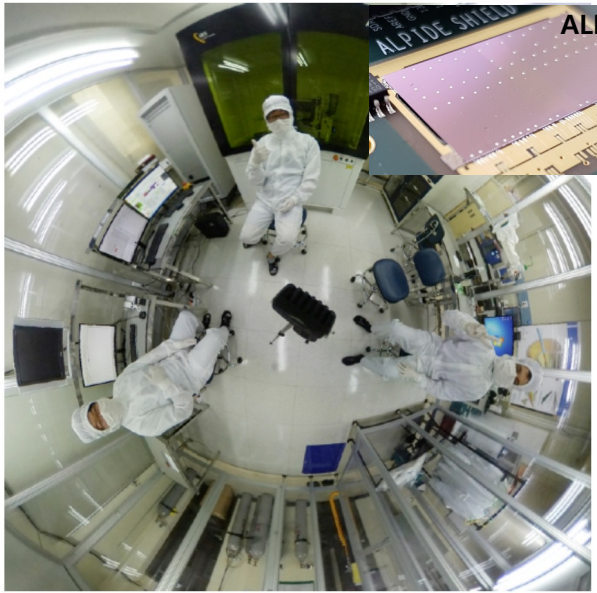

## Dual-Readout Calorimeter



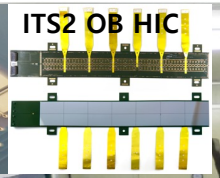



# Silicon detector R&D for ALICE ITS2



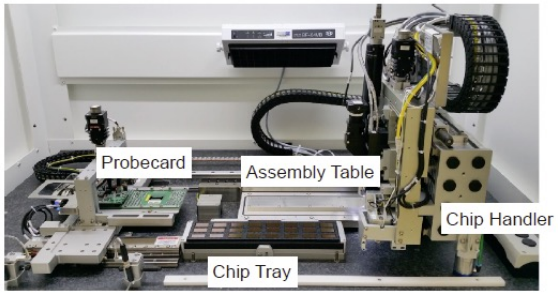





PNU/Inha University

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

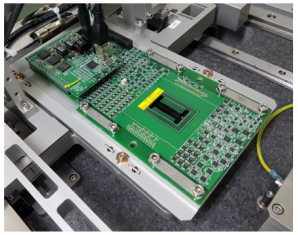
Chair of the ALICE collaboration board

ALICE

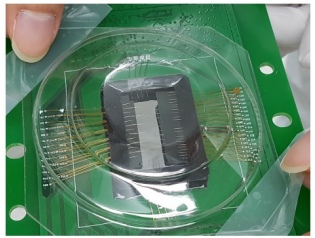
# Silicon detector R&D for ALICE ITS2

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

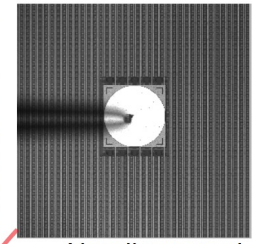
  - **Note: wafer-level chip test for the BIC AstroPix**



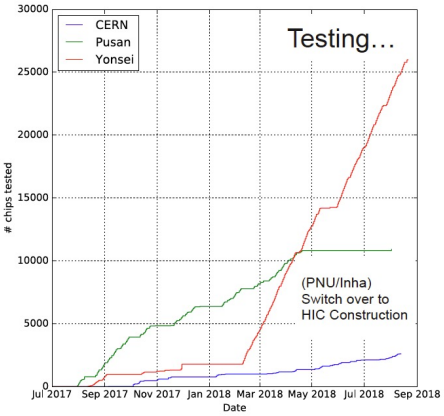
Probecard



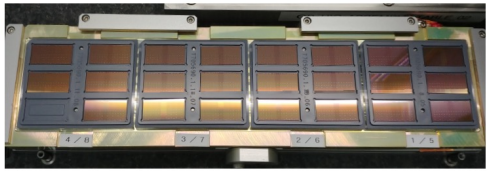
Needles of Probecard
67 needles to contact



Needle on pad



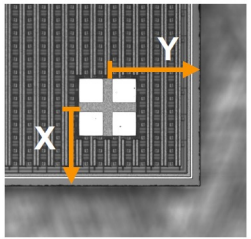

Accumulated number of tested chips
M.Mager (CERN) / 27AUG2018 / ITS Plenary



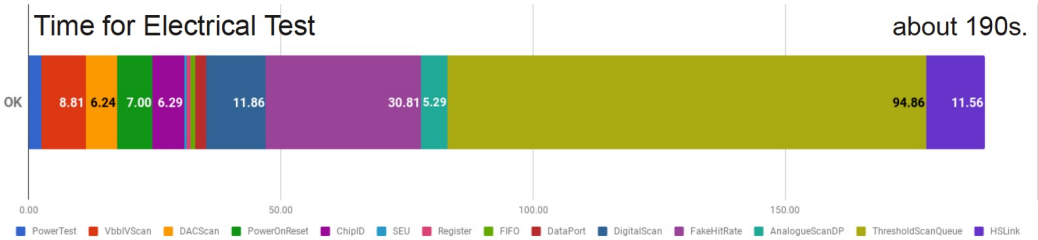
23 of ALPIDE Chips in Tray

Pads on ALPIDE

Dimension Inspection



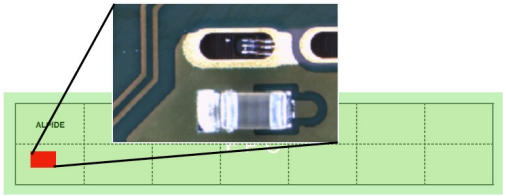

Measuring
Dimensions



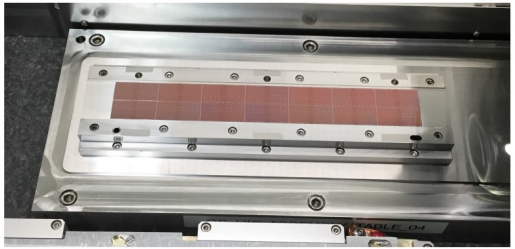
- **HIC Production**
  - **PNU (one of 5 production sites)**


**Aligning ALPIDEs**
in Position precision < 5μm

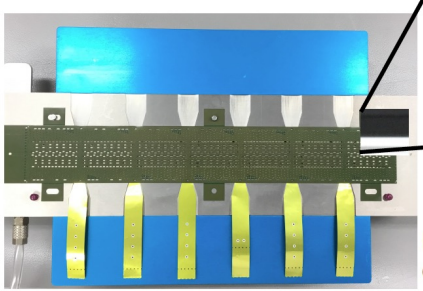

**Gluing FPC to chips**
Mechanical connection



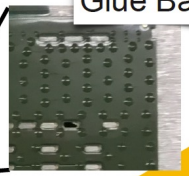

**Wire-bonding**
Electrical connection



ALPIDE Aligned in ALICIA

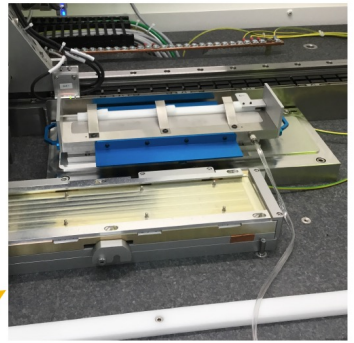


Glued FPC on Gripper



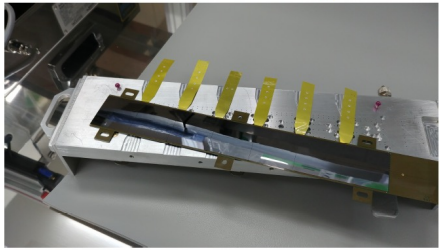

Put upside down
on aligned ALPIDEs

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



Pre-Curing in ALICIA
(min.) 5 hrs

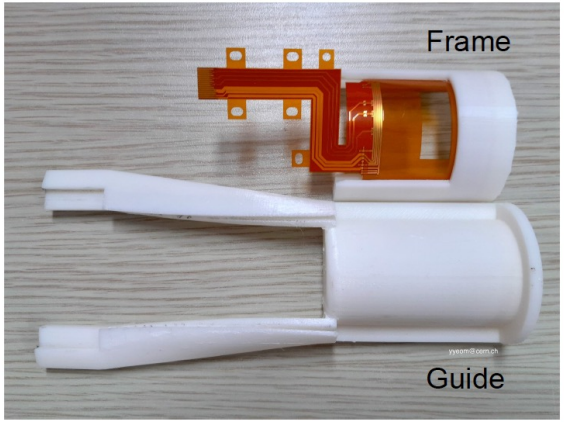
Detach HIC
from ALICIA

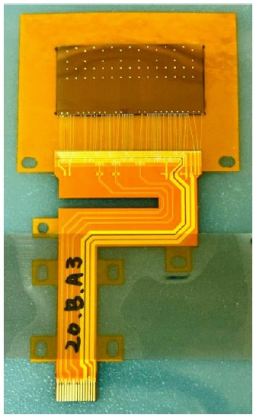


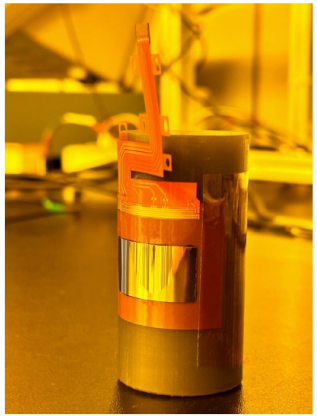
Glue HIC (Opposite side)

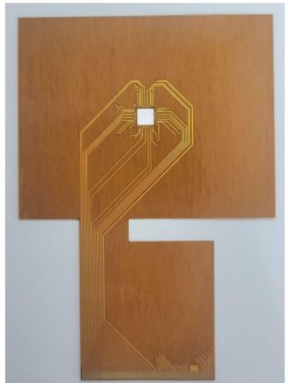
# Silicon detector R&D for ALICE ITS3

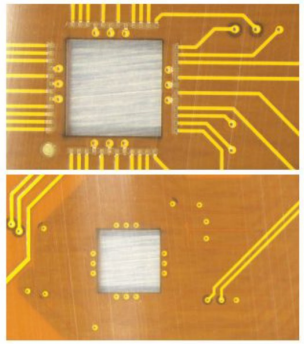
## Bent chip (ALPIDE and ATPS)



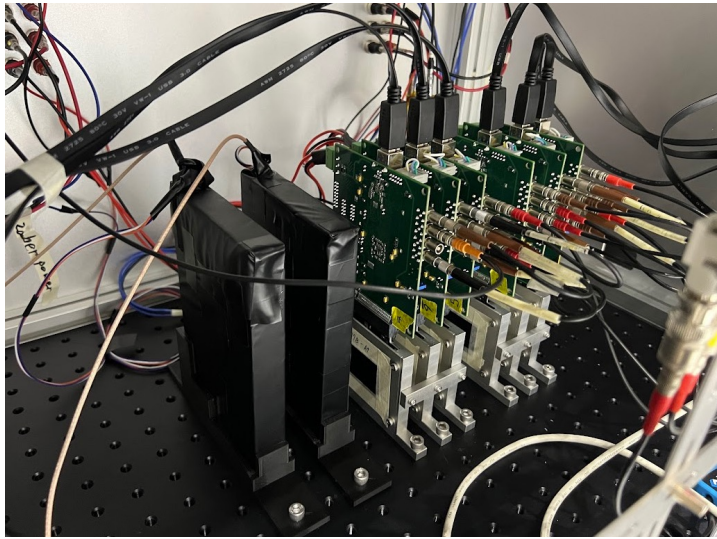









## Telescope with ALPIDE



- **Successfully built a telescope with 6 ALPIDE layers and just finished test beam at KEK PF-AR (1-6 GeV electron beam) on March 11-18**
  - **6 ALPIDE layers + 2 APTS layers (or 1 bent ALPIDE)**
  - **Possibility to integrate other DUTs later (AstroPix)**

**Collaboration with MEMSPACK**

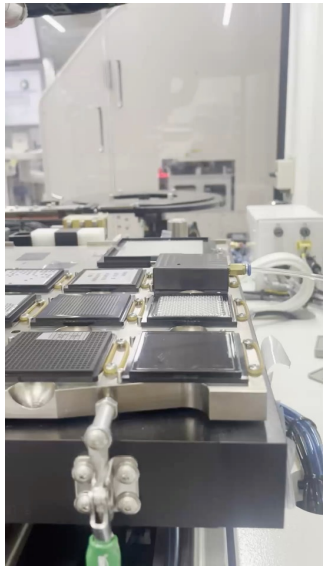
# Silicon detector R&D for ALICE 3 Outer Tracker

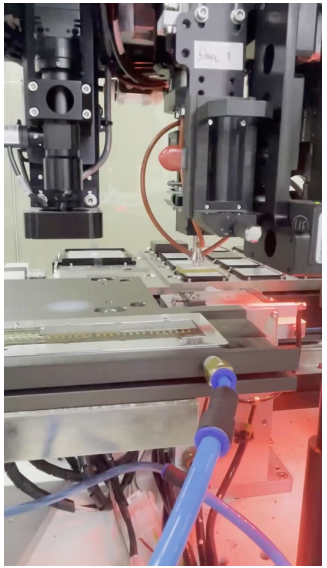
- **Automatization and industrialization of module assembly**
  - 60 $m^2$ of silicon sensor
  - x5 more modules (12500) than the ITS2 (2500)
  - Collaboration with a local company (MEMSPACK) for ALICE 3 Module assembly with a multi-purpose machine die bonder

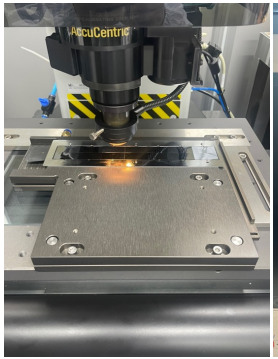
Datacon 2200 evo+

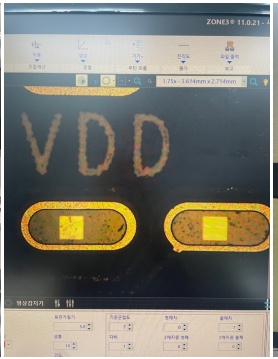

MRSI 705

General purpose die attach machine





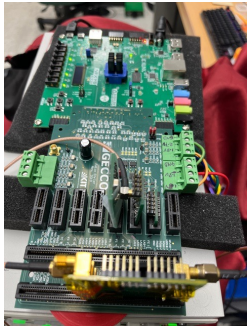


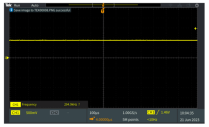




Collaboration with MEMSPACK

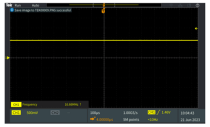
# Activity & plan for the BIC

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

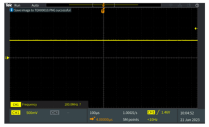




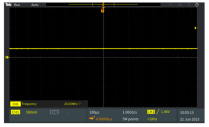
Apply LV



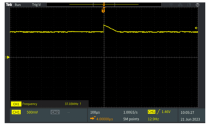
Apply LV+HV



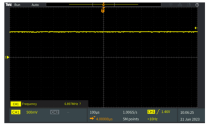
Apply LV+HV, FPGA board ON



Program firmware

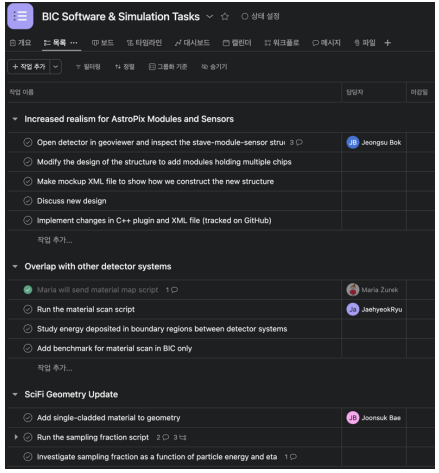


Charge injection code run

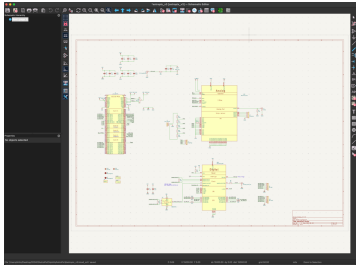


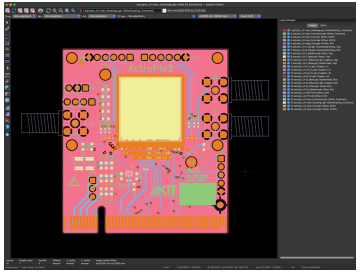
Code end

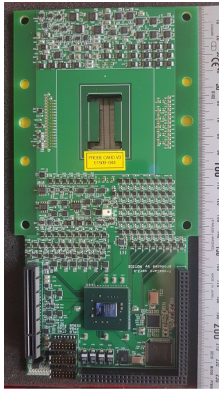
- **Testbeam with ALPIDE telescope**
  - 6 ALPIDE layers for reference tracks:
    Excellent tracking with position resolution of 5 um
  - DUT (AstroPix v3 or v4):
    Position resolution and hit efficiency
- **Simulation development for TDR**
  - Detailed geometry implementation and performance study




- **Chip test machine**
  - Initial discussion with C-ON Tech and NOTICE
  - Based on the design files of the single-chip carrier board of AstroPix v3, a probe card design will be started in April
  - Plan to make a probe card for AstroPix chip as the exact dimension of ITS2 ALPIDE to utilize the probe station

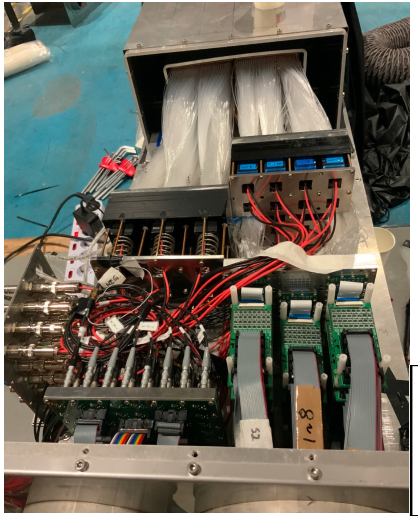


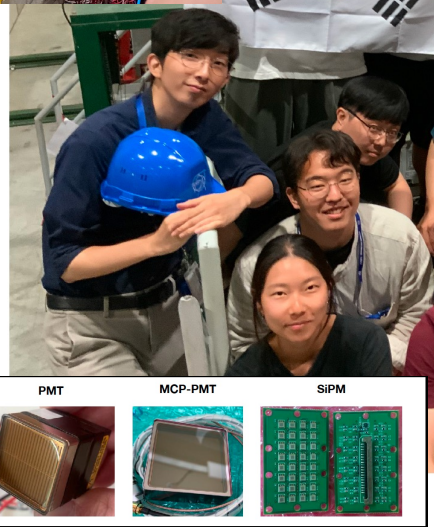


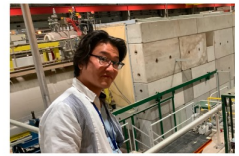


# Dual-Readout Calorimeter R&D

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

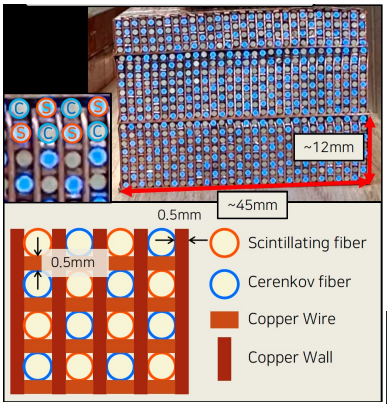


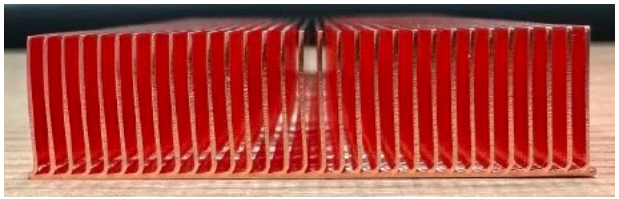


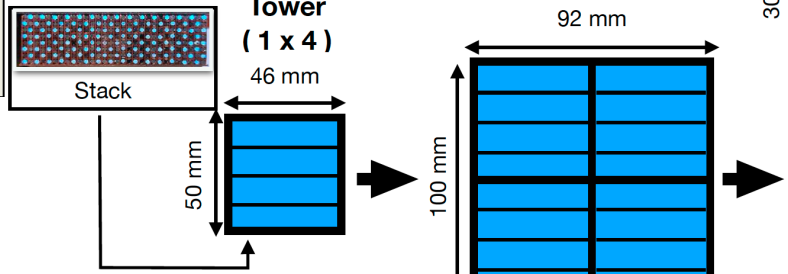



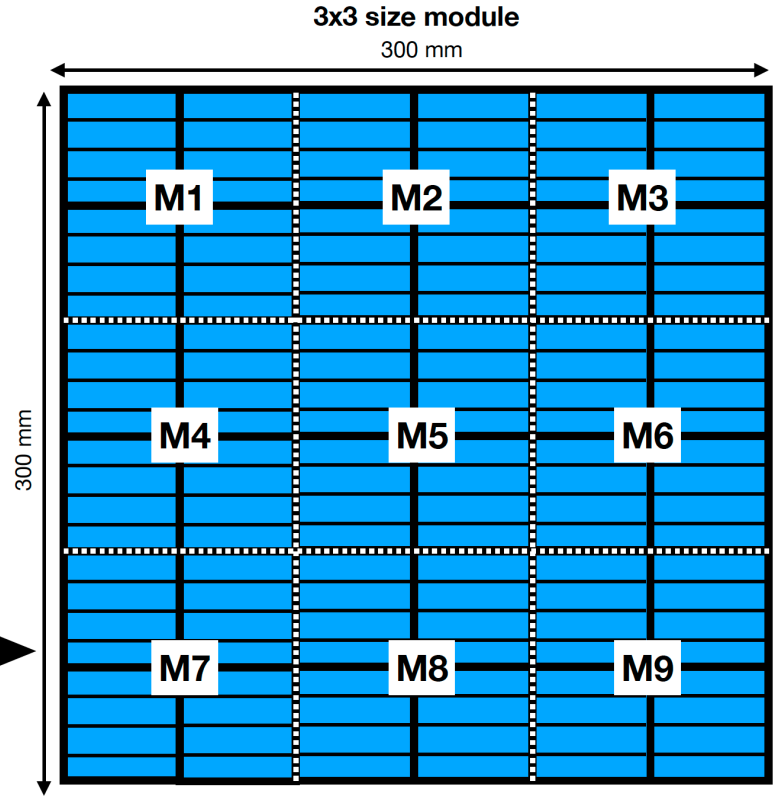
# Dual-Readout Calorimeter R&D: TB2024

- **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



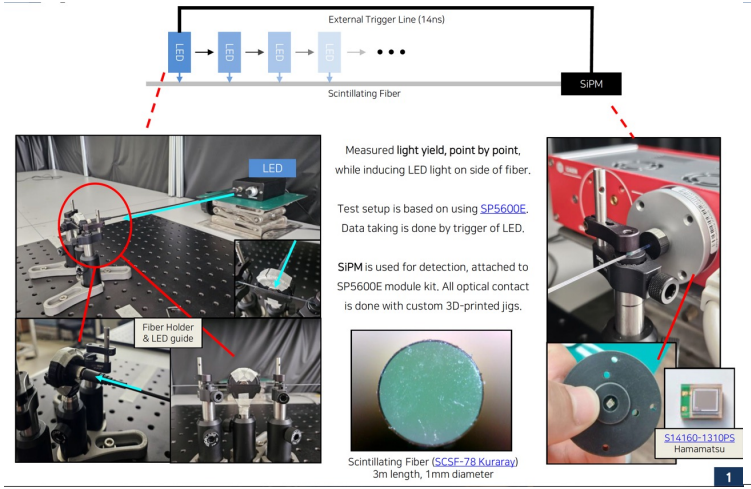



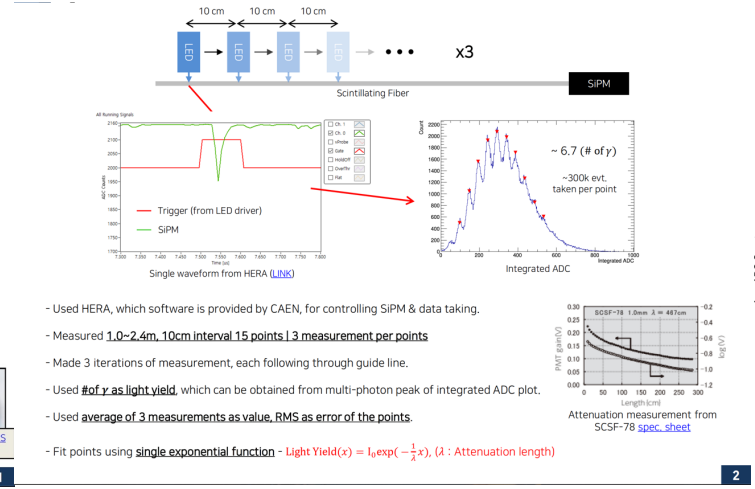


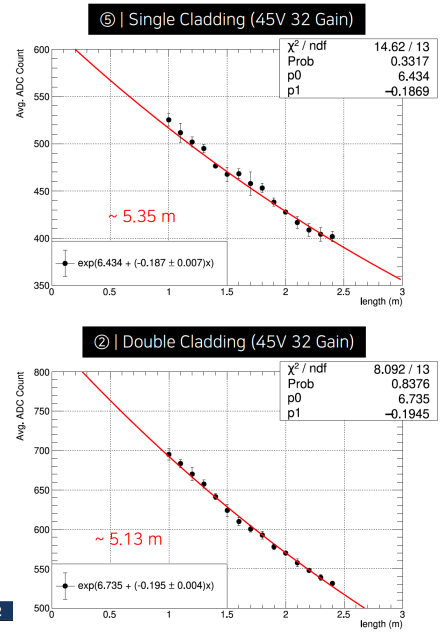



# Activity & plan for the BIC

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



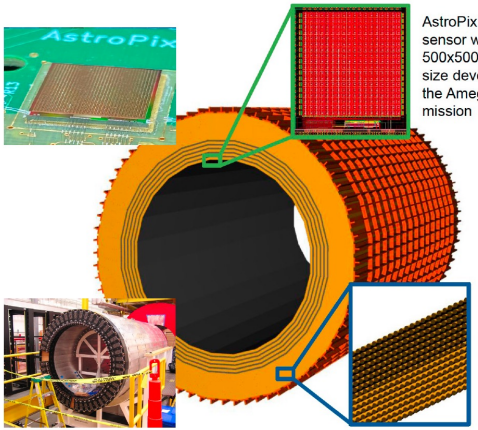

| | SC | DC |
|---|---|---|
| Avg. | 5.19 m | 4.87 m |
| Stdev. | 0.45 m (~9%) | 0.18 m (~4%) |

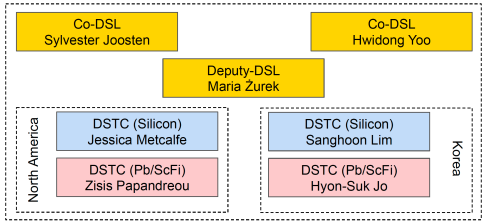
Measured Attenuation length

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

# Summary

- Korean BIC group aims 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

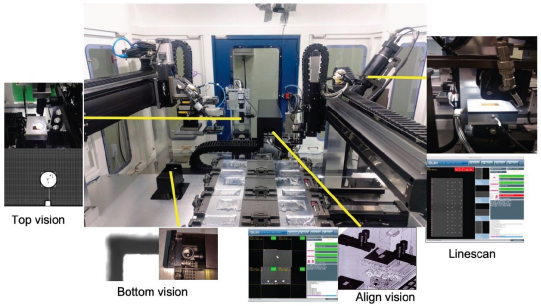


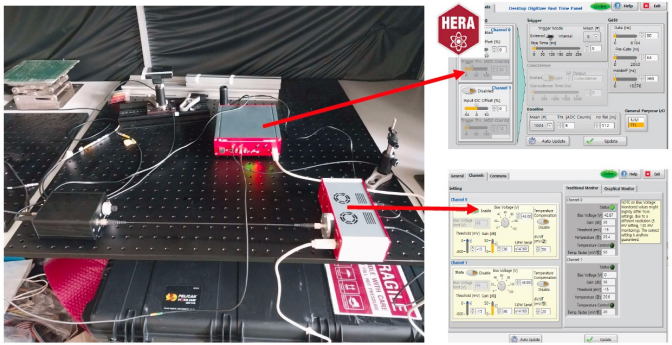

## K-BIC members: 8 institutions and 10 faculties

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




## Optical fiber test setup

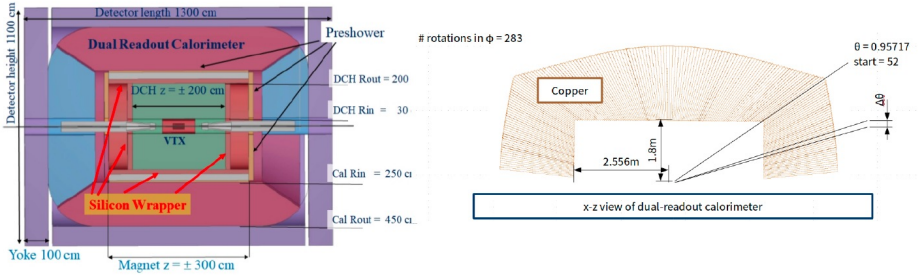



**Collaborate with local companies: C-ON Tech, MEMSPACK**

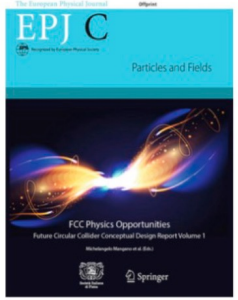
# BACKUP

# Dual-Readout Calorimeter R&D in Korea

- **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**



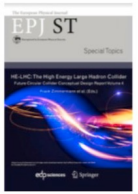

**4 CDR volumes submitted to EPJ in December 2018.**




**FCC Physics Opportunities**

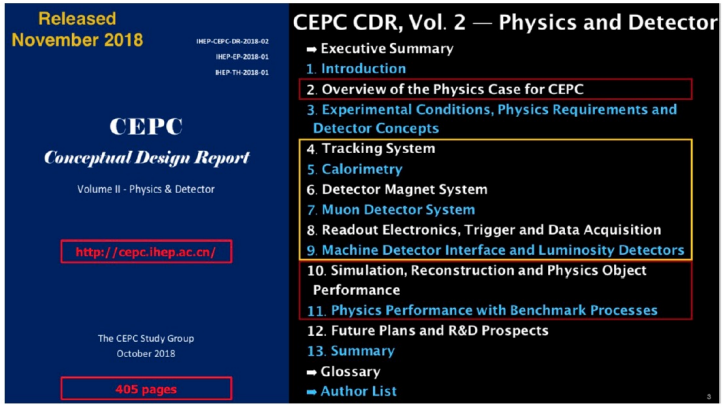

**FCC-ee: The Lepton Collider**


**FCC-hh: The Hadron Collider**

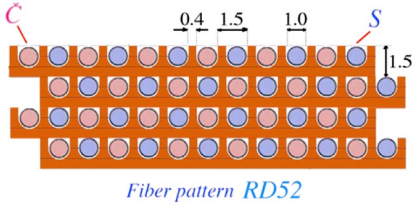



**HE-LHC: The High Energy Large Hadron Collider**

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

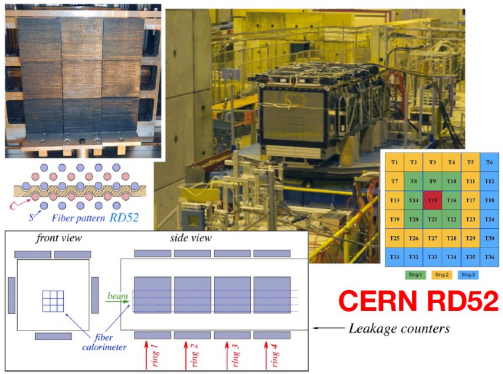



- **DRC offers high-quality energy measurement for both EM particles and hadrons**
  - DRC consists of two different optical fibers (S, C) in a single component
  - The main culprit of poor hadronic energy resolution is fluctuations of the EM shower components of hadron showers ($f_{em}$)
  - $f_{em}$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




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

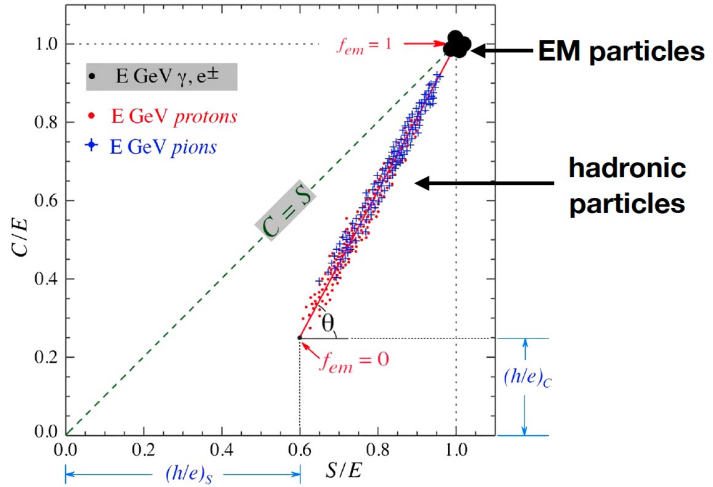
$$f_{em} = \frac{(h/e)_C - (C/S)(h/e)_S}{(C/S)[1 - (h/e)_S] - [1 - (h/e)_C]}.$$



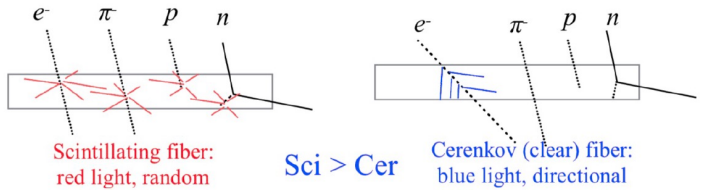

CERN RD52 experiment

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

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




Signal generation: Scintillating & Cerenkov fibers

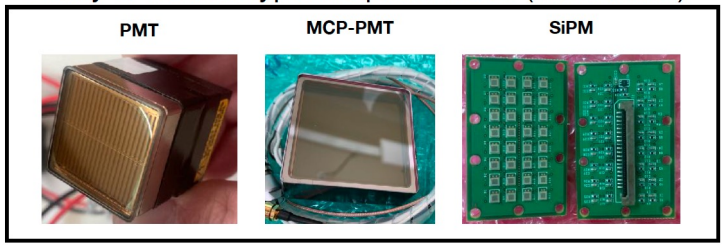


# Dual-Readout Calorimeter R&D: TB2022

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

| | |
|---|---|
| Module 1 | - Shower depth<br>- Longitudinal shower profile<br>- Light attenuation length |
| Module 2 | - Position resolution<br>- Lateral shower profile<br>- EM energy resolution<br>- 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) |

# Dual-Readout Calorimeter R&D: TB2023

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