

ePIC Activities in Taiwan

ePIC General Meeting

December 19, 2024

Po-Ju Lin

Department of Physics, National Central University

On behalf of Taiwan Collaborators

Groups in Taiwan



NTU



NCU



AS



NTHU

- Academia Sinica
- National Taiwan University
- National Central University
- National Tsing Hua University

August 28-30, 2023
**TIDC Autumn School
On Electron-Ion Collider (EIC)**
Department of Physics, National Taiwan University
Registration Deadline June 15, 2023

INVITED LECTURERS

Dr. Rolf Ent / Jefferson Lab, USA
Prof. Jamal Jalilian-Marian / CUNY, USA
Prof. Zhongbo Kang / UCLA, USA
Dr. Ralf Seidl / RIKEN, Japan

Organizing Committee

Wen-Chen Chang (AS)
Pai-hsien Jennifer Hsu (NTHU)
Chiang Wan-Kuo (NYCU)
Chia-Ming Kuo (NCU)
Hsiang-Nan Li (AS)
C.-J. David Lin (NYCU)
Rong-Shyang Lu (NTU)
Yi Yang (NCKU)

Info registration & contact

<https://neurl.cc/4Q8RXv>
Email: tidca.phys.ntu.edu.tw
Tel: +886-2-35668648

Sponsors

Academia Sinica
Center for Theory and Computation, NTHU
National Yang Ming Chiao Tung University

**THE 2ND
TIDC EIC WORKSHOP**
January 3, 2023
Institute of Physics, Academia Sinica
Registration Deadline December 15, 2022

INVITED SPEAKERS

- ✓ Jiunn-Wei Chen (NTU)
- ✓ Chia-Yu Hsieh (AS)
- ✓ David Lin (NYCU)
- ✓ Po-Ju Lin (AS)
- ✓ Cheng-Wei Shih (NCU)
- ✓ Rong-Hwei Yeh (Asia Univ.)

ORGANIZERS

- Wen-Chen Chang (AS)
- Chia-Ming Kuo (NCU)
- Rong-Shyang Lu (NTU)
- Yi Yang (NCKU)

SPONSORS

Taiwan Instrumentation and Detector Consortium
Institute of Physics, Academia Sinica
Division of Particles and Fields, The Physical Society of Taiwan

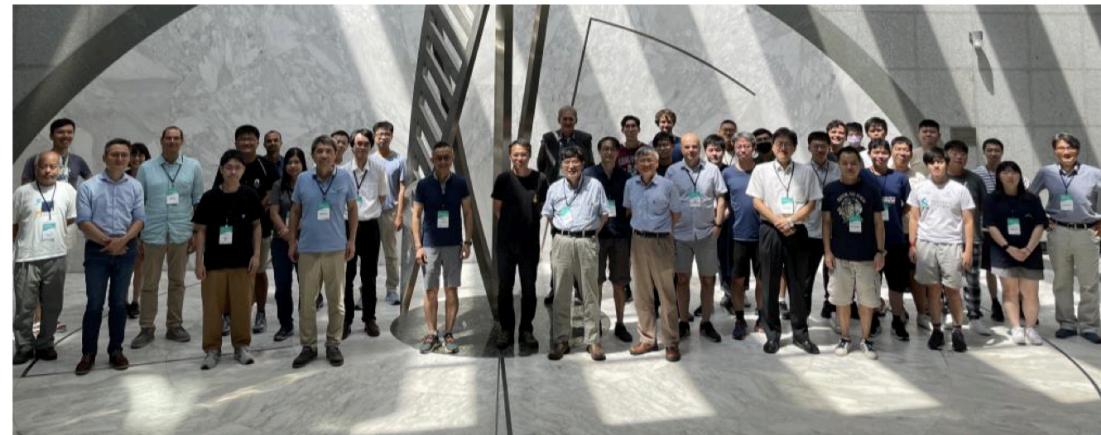
Info & Registration

<https://tidc.phys.sinica.edu.tw/Workshop/2nd.html>
2023 eid-workshop/

Contact Us

02-33668648
chhuang@phys.ntu.edu.tw

January 3, 9 AM to 6 PM
Conference Room 1, 5F, Institute of Physics, Academia Sinica



The 3rd EIC-ASIA Workshop



2024
JAN
29-31 **EIC** Asia Workshop

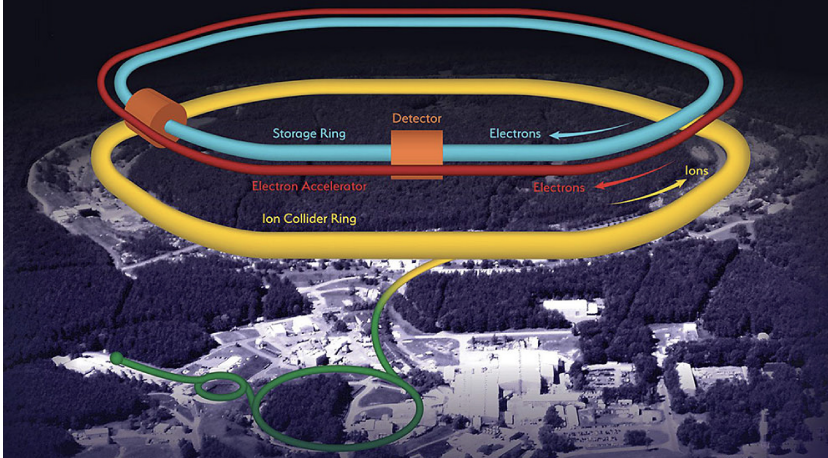
National Cheng Kung University
Department of Physics, Rm 36169 (1F)
No.1, University Road, Tainan City, Taiwan

International Advisory Committees

Elke Aschenauer (BNL)
Wen-Chen Chang (AS)
Jinhui Chen (Fudan)
Shuddha Shankar Dasgupta (NISER)
Abhay Deshpande (SBU)
Yuji Goto (RIKEN)
Taku Gunji (CNS, UTokyo)
Yongsun Kim (SJU)
Seung-II Nam (PKNU)
Ent Rolf (JLab)
Bowen Xiao (CUHK)
Qinghua Xu (SDU)
Yi Yang (NCKU)
Yifei Zheng (USTC)

Local Committees

Wen-Chen Chang (AS)
Jiunn-Wei Chen (NTU)
Kai-Feng Chen (NTU)
Pai-hsien Jennifer Hsu (NTHU)
Chung-Wen kao (CYCU)
Chia-Ming Kuo (NCU)
Chi-Jen David Lin (NYCU)
Po-Ju Lin (NCU)
Rong-Shyang Lu (NTU)
Jen-Chieh Peng (UIUC, NCU)
Zhangbu Xu (BNL, NCKU)
Yi Yang (NCKU)

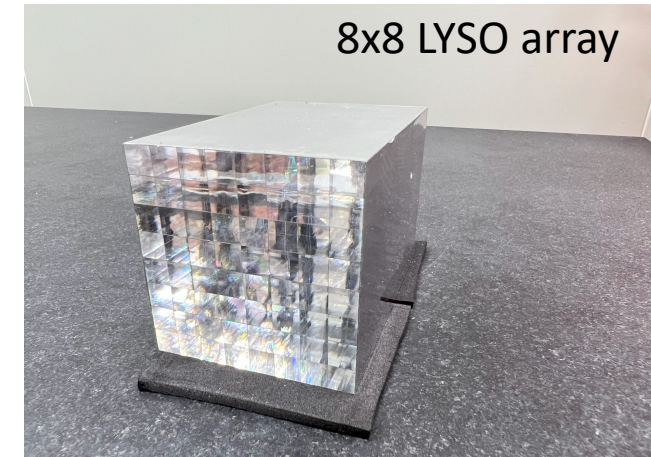


- NCKU - Jan. 29-31, 2024
- Actively collaborating with Asian colleagues

Lutetium Yttrium Orthosilicate (LYSO)



- A Candidate of the ZDC ECAL
- Higher light yield
- Lower temperature dependence
- Manufactured by Taiwan Applied Crystal



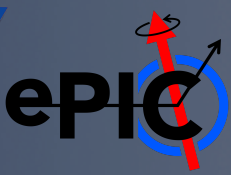
8x8 LYSO array

One crystal : 7.12mm*7.12mm*88.3mm
Array size : 56.96mm*59.96mm*88.3mm

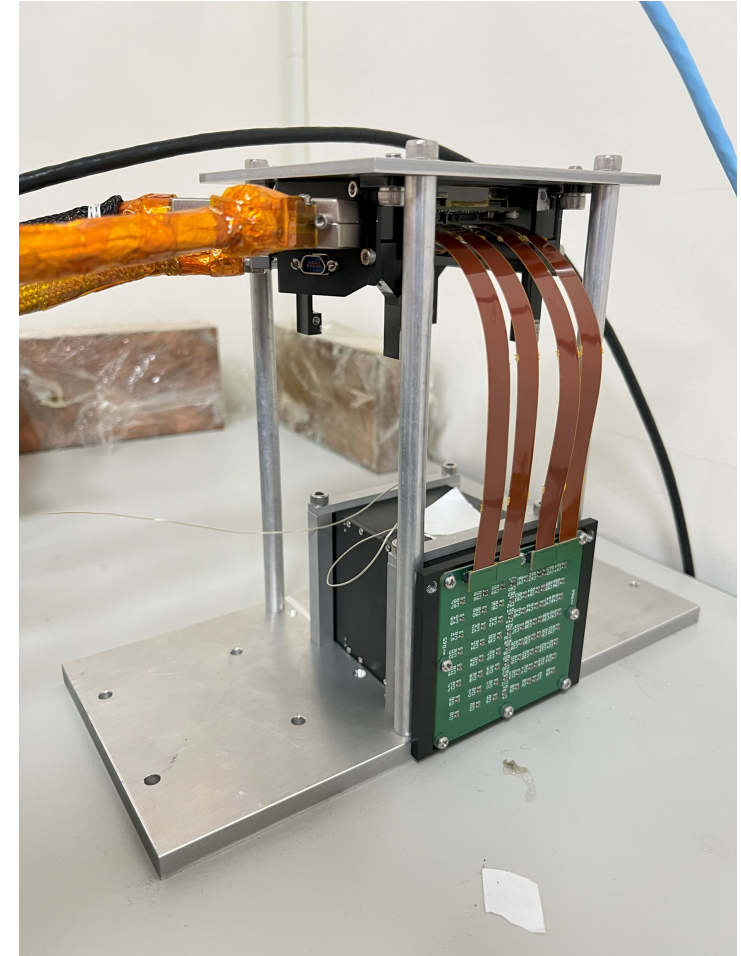
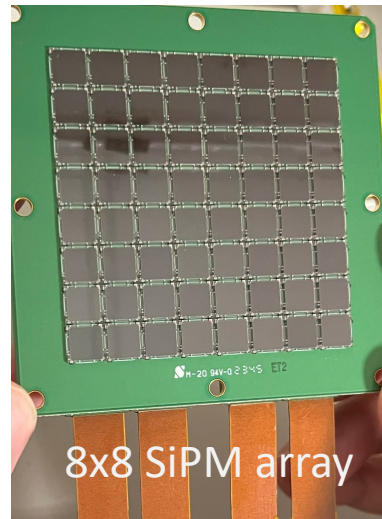
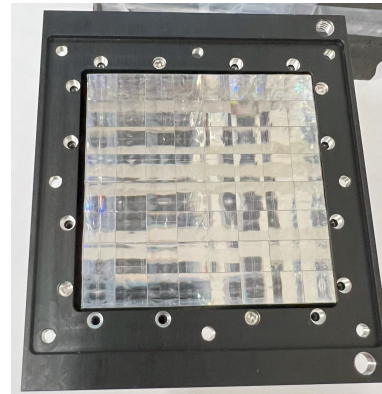
Crystal	X_0 (cm)	LY(#/MeV)	T dep.	Decay time(ns)	λ_{em}
PbWO ₄	0.89	200	-1.98% / °C	5(73%) 14(23%) 110(4%)	420nm
LYSO	1.14	30,000	-0.28% / °C	39	420nm
GAGG	1.59	40,000~ 60,000		50~150	520nm



First Prototype



- **LYSO**
 - 8x8 array
 - Each crystal : 7.1mm*7.1mm*88.3mm ($8X_0$)
 - ESR reflection layer
- **SiPM**
 - Radiation tolerance
 - SiPM : 2×10^{14} n/cm² (CMS ECAL)
 - MICROFC-60035
- **GTM Readout board**
 - 2 Citiroc1A (2 x 32 channels)
 - Separate voltage adjustment
 - Self-triggered



First Beam Test



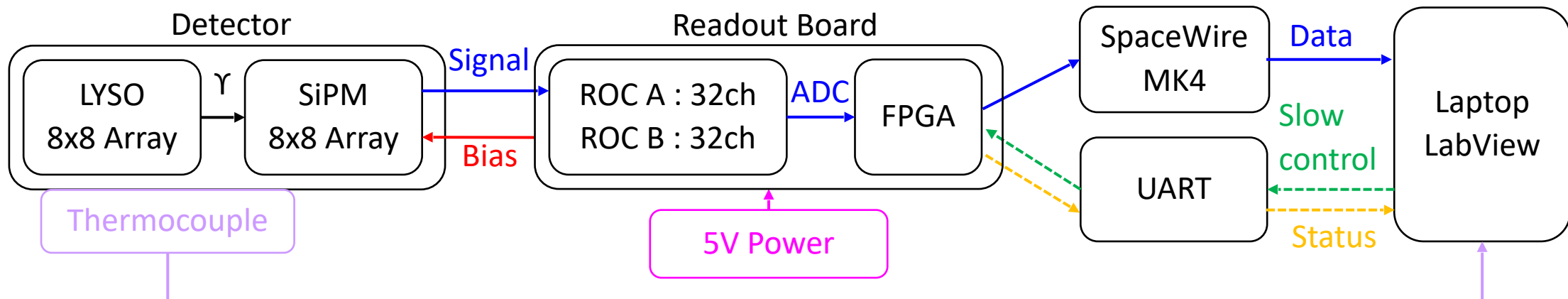
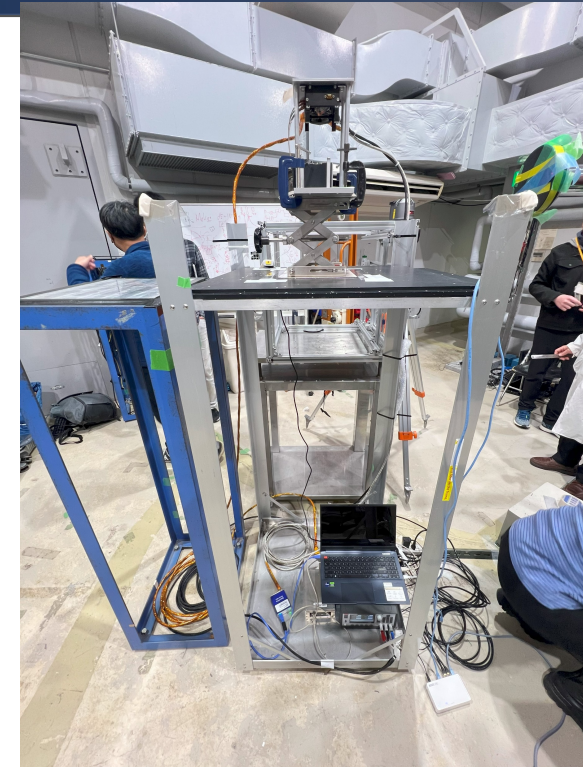
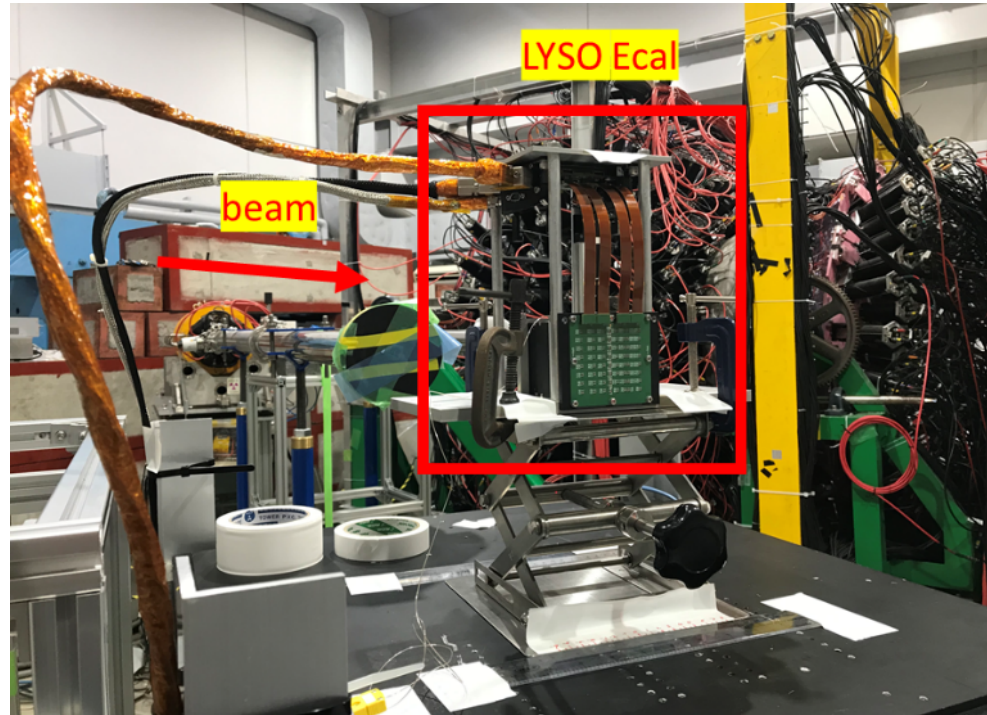
- **Time**
 - 2024 Feb. 15th to Feb. 21th
- **Location**
 - ELPH@Tohoku, Japan
- **Participants**
 - RIKEN, Tsukuba University, Tsukuba University of Technology, Sejong University, EIC-Taiwan
- **Beam**
 - 47.18 MeV to 823.36 MeV positron beam
- **Scan list**
 - SiPM HV Scan, Beam energy scan, detector rotation, etc.



Setup in Beam Test



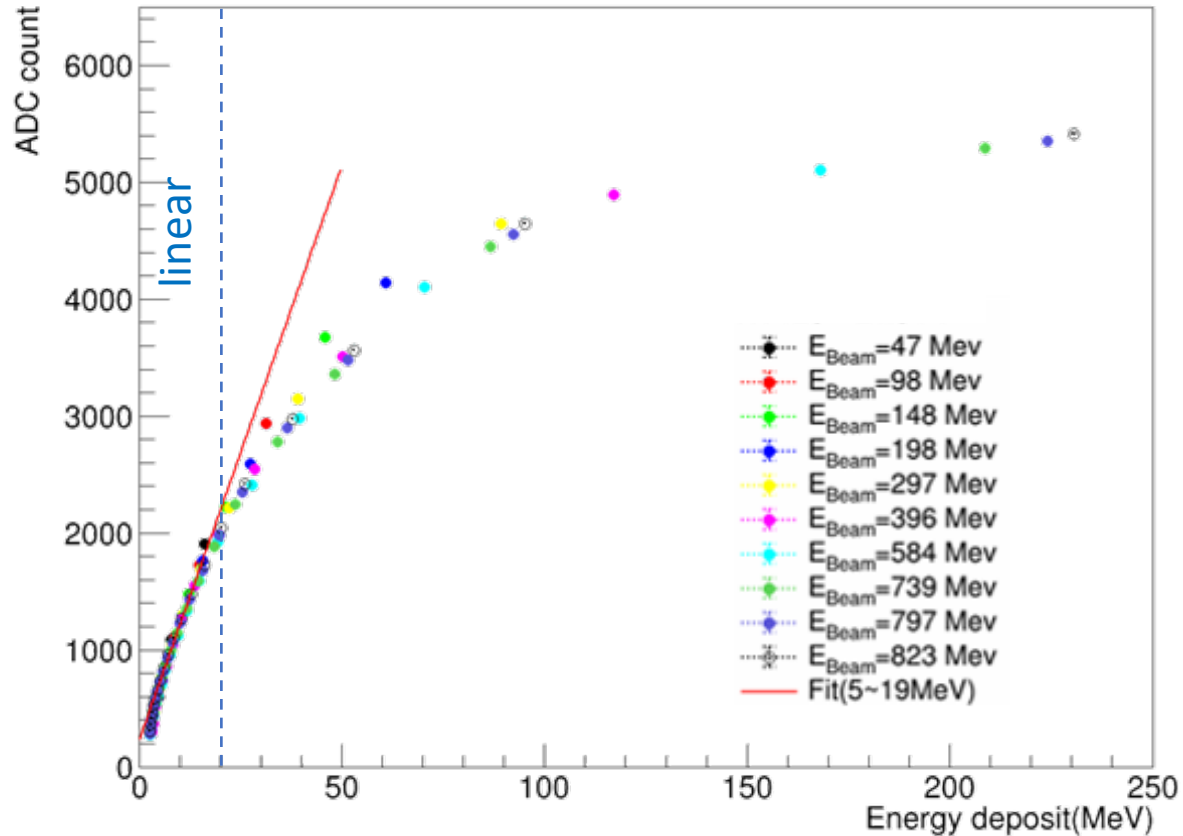
Setup @ ELPH



Beam Test Result



- Measured ADC value versus energy deposit.

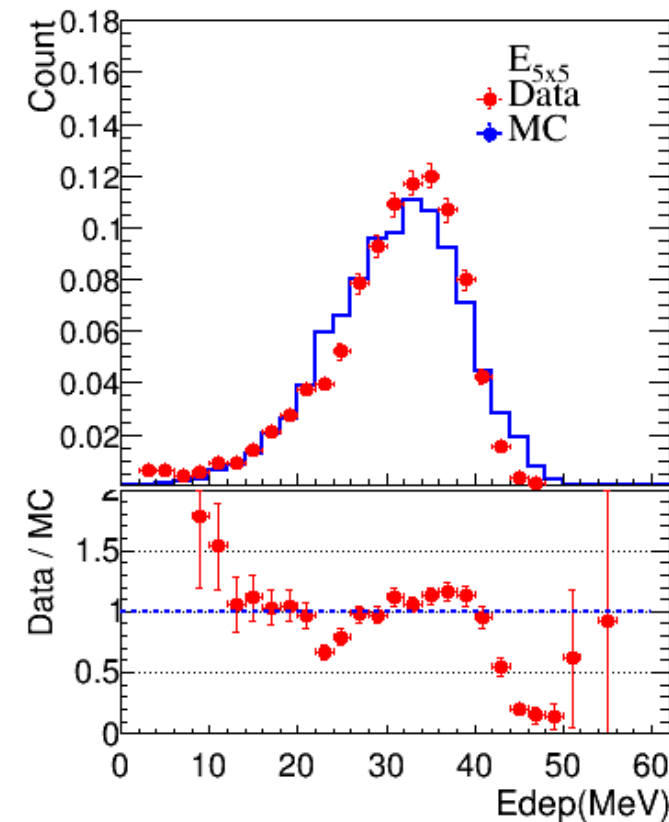
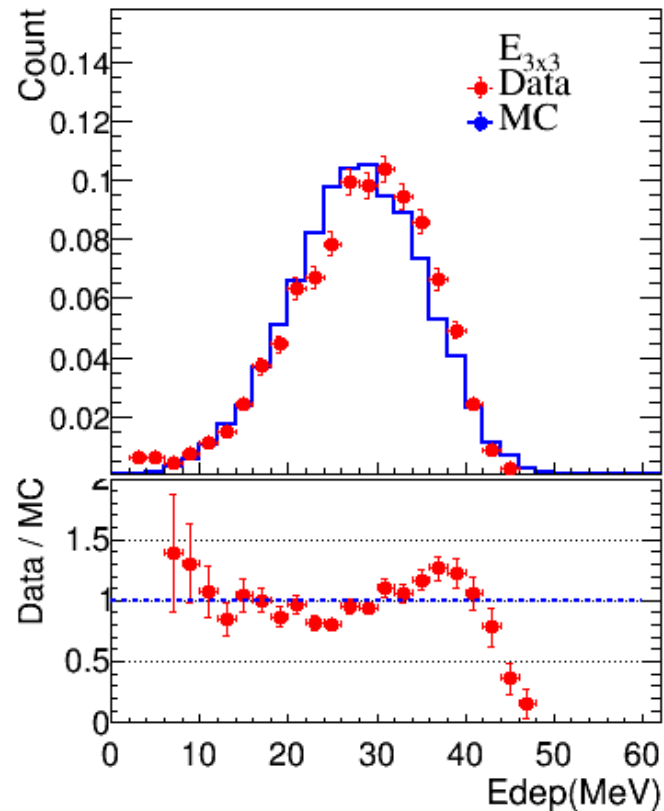
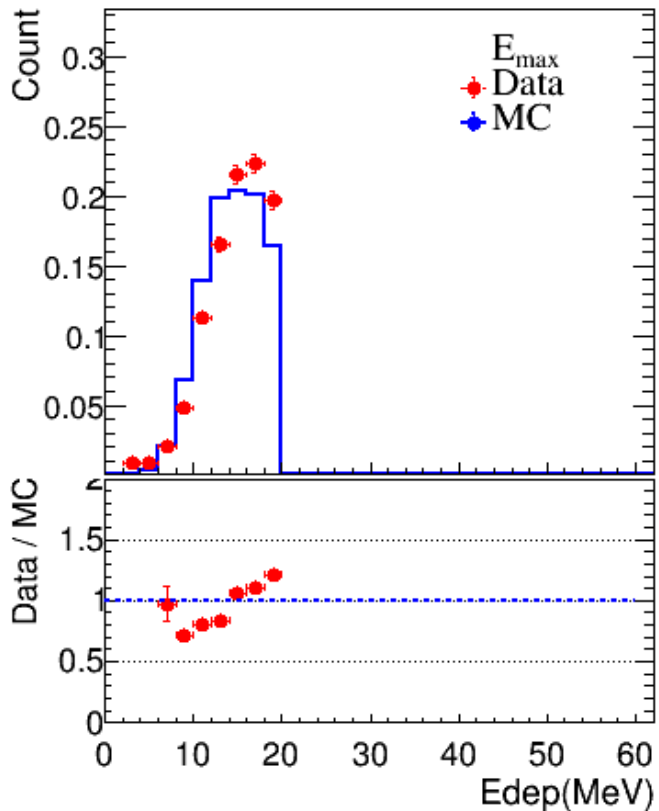
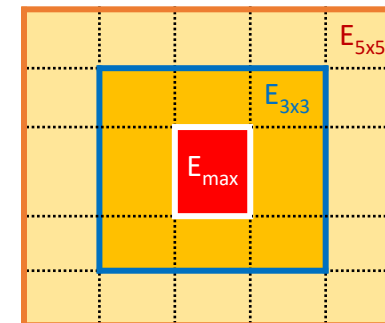


- Energy deposit deduced from the Monte Carlo simulations.
- Most of the data shows nonlinear behavior. About 60% of the data from the 47 MeV beam remain in the linear range.
- Focus on the very low-energy-deposit part of the data for a preliminary energy resolution study.

Data-MC Comparison



- Comparisons with different E-deposit clustering at 47MeV
- Energy selection : [2.5MeV, 20MeV]
- $E_{3\times3}$, $E_{5\times5}$: E-deposit sum with the clustering of 3x3 or 5x5 crystals

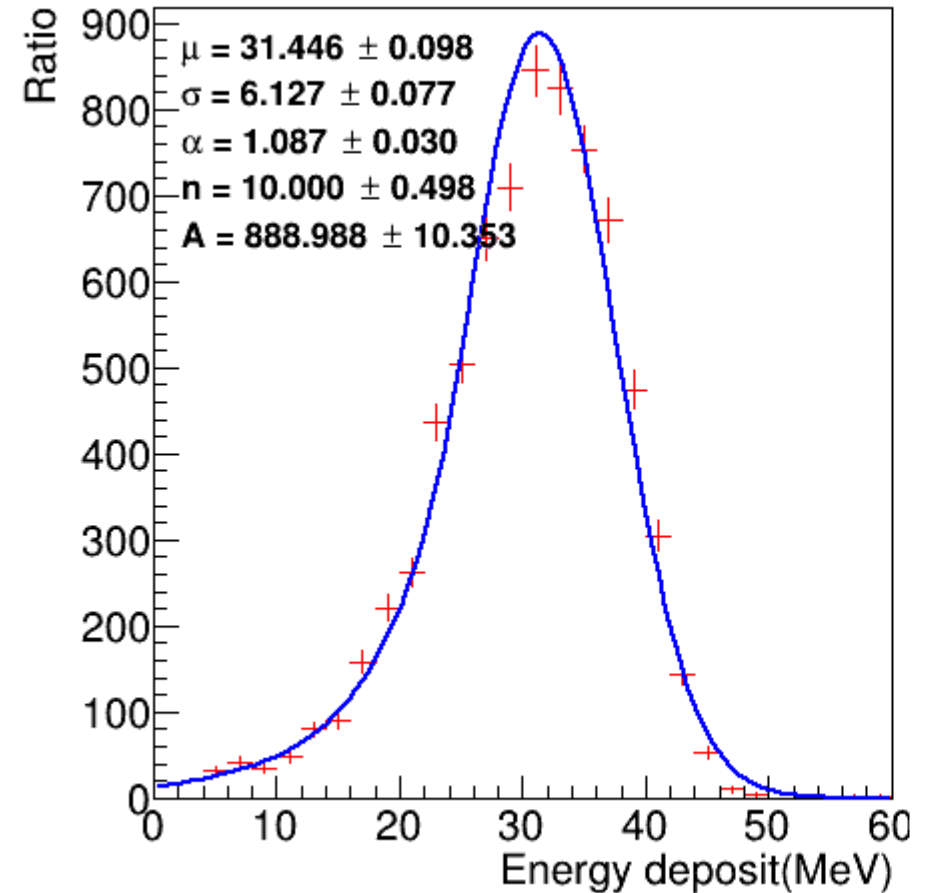


Preliminary Energy Resolution



- $E_{5 \times 5}$ energy deposit with 47 MeV beam
- Crystal ball fitting:
 - Mean = 31.446 ± 0.098 MeV
 - Sigma = 6.127 ± 0.077 MeV
- 19.5% energy resolution for 47 MeV positron beam
- Convoluted with the 11.6% uncertainty of the beam momentum. The energy resolution is about 15.6% with the beam-momentum uncertainty removed.

$E_{5 \times 5}$ @ 47 MeV



Data with Higher Beam Energies



- Try to describe the nonlinear relationship between ADC values and deposited energies using a function describing the saturated SiPM behavior.

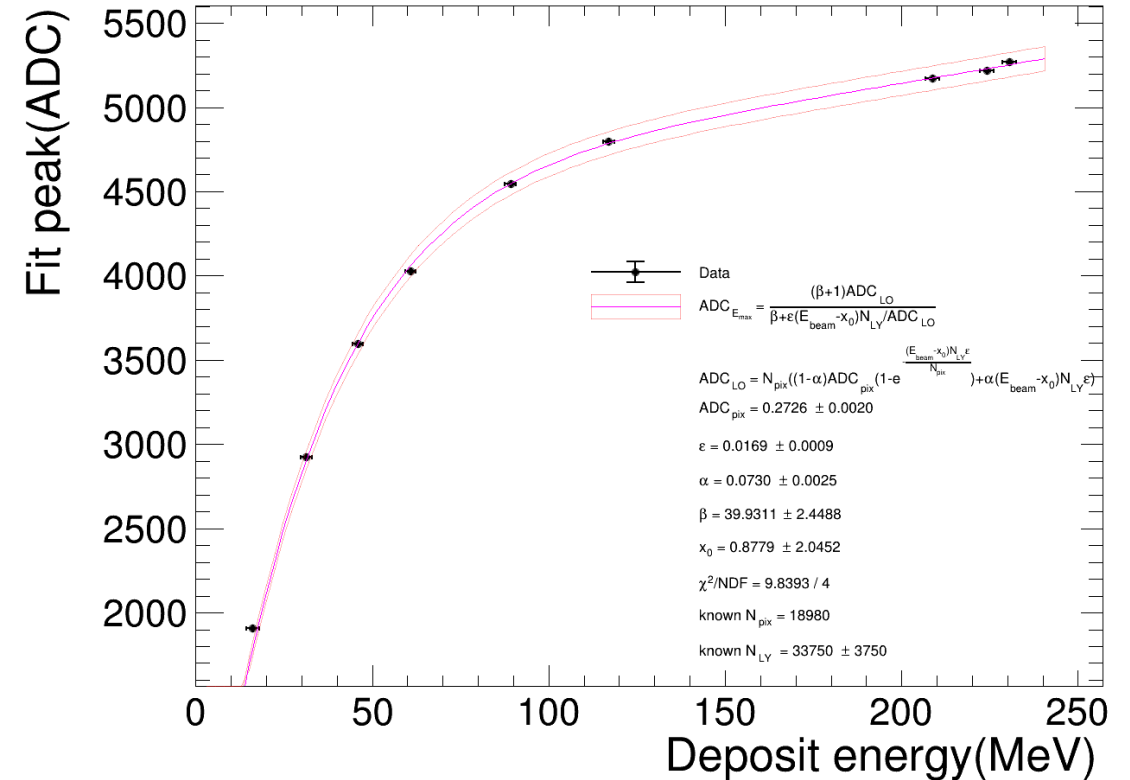
- **SiPM saturation function¹:**

- $$ADC = \frac{(\beta + 1)ADC_{LO}}{\beta + \epsilon LE_{dep}/ADC_{LO}}$$

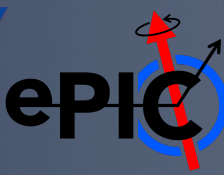
- $$ADC_{LO} = N_{pix} \left[(1 - \alpha)ADC_{pix} \left(1 - e^{-\frac{\epsilon LE_{dep}}{N_{pix}}} \right) + \alpha \epsilon LE_{dep} \right]$$

- α represent contribute factor of remaining photons
- β represent decay factor of hit channels
- ϵ represent factor photon collection

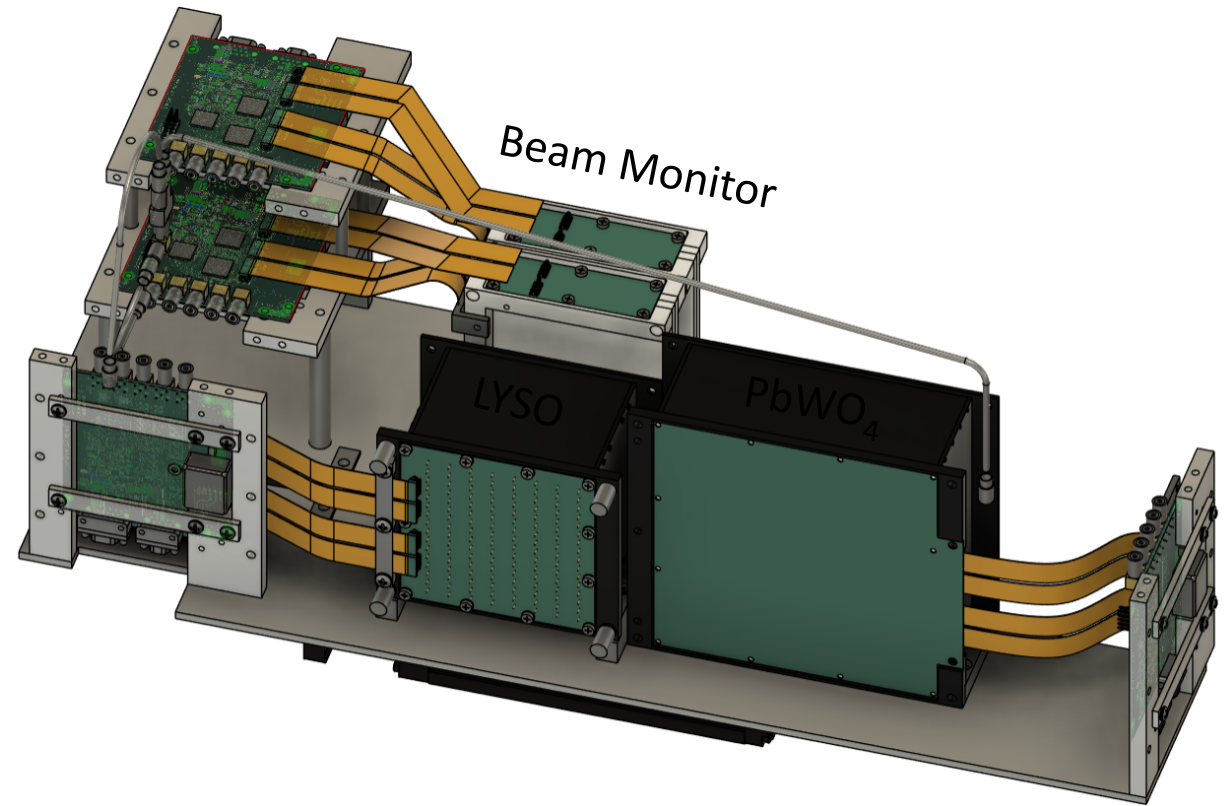
¹Katsushige Kotera, <https://arxiv.org/abs/1510.01102v4>



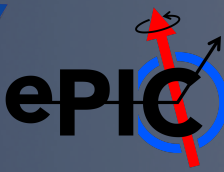
2nd Beam Test



- 2025 Feb. 17th to Feb. 20th at ELPH
- 2nd Prototype:
 - Radiation length $8X_0 \rightarrow 6X_0$
 - 64ch LYSO + APD
 - 36ch PbWO_4 + SiPM / APD
 - 2*Beam monitor (2mm scintillator bar arrays)
- Goal
 - Test the performance of LYSO with APD
 - Compare with PbWO_4
 - Study the position resolution
 - Improve the event selection



Status of the 2nd Prototype



	Parts	Progress@2024/11/18	Progress@2024/12/17
1. LYSO 1cm*1cm*6.6cm 8x8 array	LYSO Cryatal	ready	ready
	APD (C30739ECERH)	ready	ready
	APD Readout PCB	production	ready
	LYSO Housing	ready	ready
	LYSO Base support	ready	ready
2. PbWO4 2cm*2cm*5.3cm 6x6 array	PbWO4	designing	production
	SiPM (MICROFC-60035)	ready	ready
	APD (C30739ECERH)	production	ready
	SiPM Readout PCB	designing	designing
	APD Readout PCB	designing	designing
	PbWO4 Housing	designing	designing
3. Trigger 2mm*2mm*8cm 32ch in X 32ch in Y XY layers/set Two sets	scintillator	ready	ready
	SiPM	ready	ready
	SiPM Readout PCB	production	ready
	scintillator Housing	production	ready
	trigger Base support	production	ready
4. GTM	GTM firmware	designing	ready (continuing updating)
	GTM base support	production	ready
	cable	production	ready
5. Moving stage	base plate	designing	designing
	slide rail	ready	ready
	remote control	ready	ready

Testing

Testing

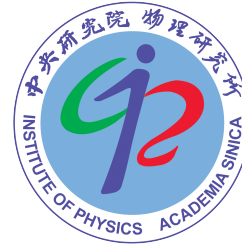
Barrel TOF Mechanical Structure



○ Yi Yang (AS), Wen-Chen Chang (AS):

design, simulation, testing, assembly(?), final production(?)

- Experiences with the AMS-02 UTTPS radiator and lead the project of the mechanical structure of STAR FST
- Excellent machine shop



Yu-Tang Wang
(NCKU Ph.D. student)



○ Andreas Jung (Purdue):

design, simulation, prototype, final production(?)

- Experienced in R&D for low mass support structures.
- Working on the light-weight composite tracker support structures for CMS

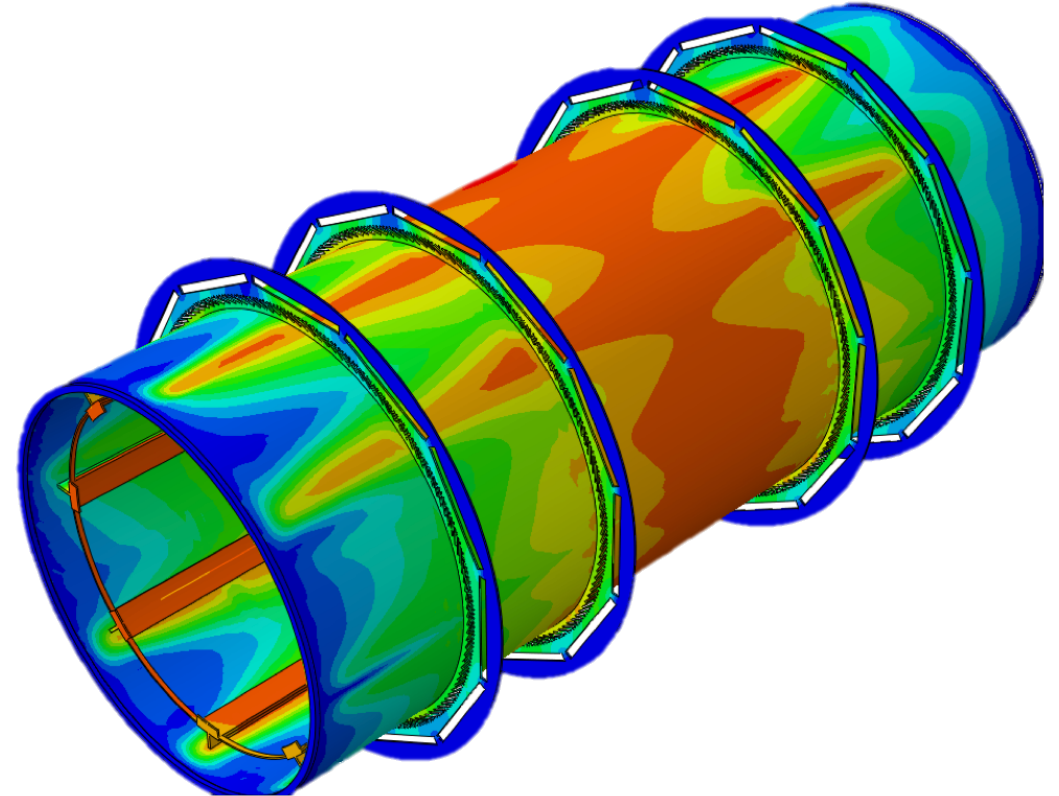
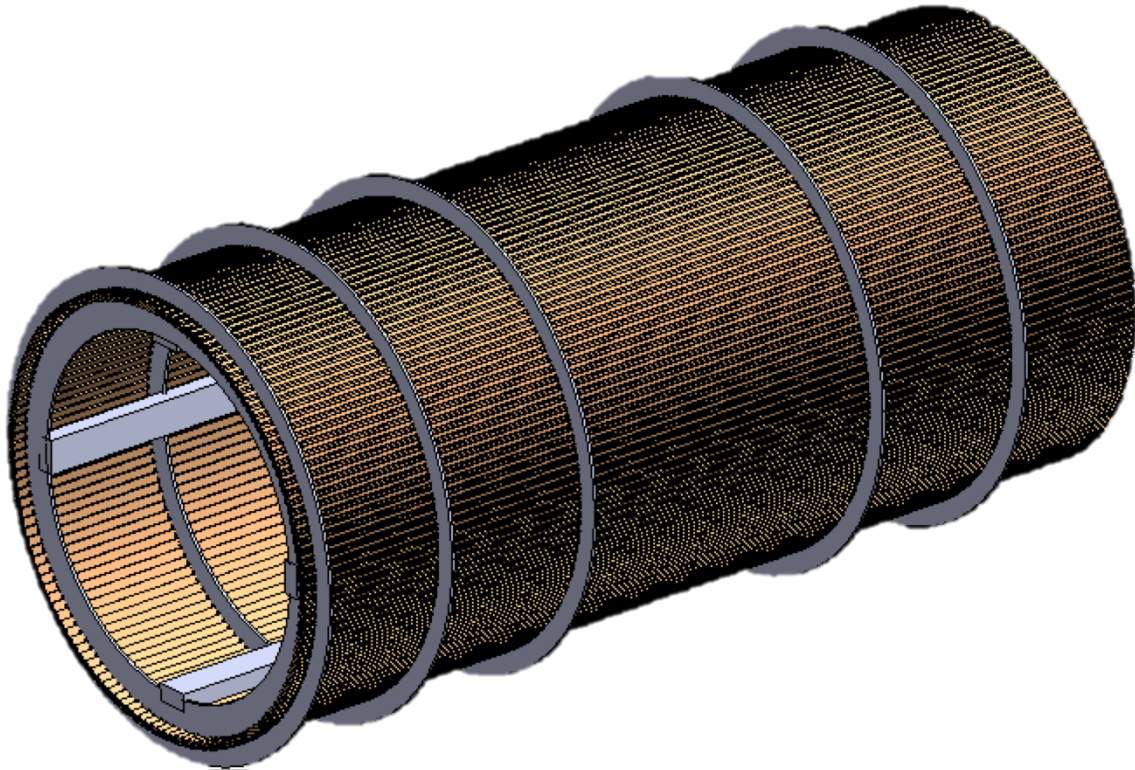


Latest Support Structure of BTOF

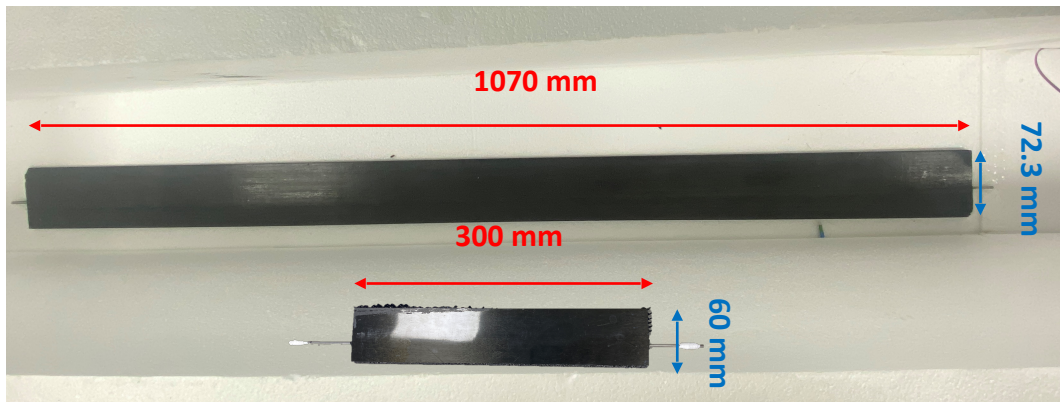
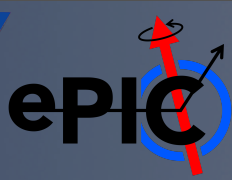


From Purdue group

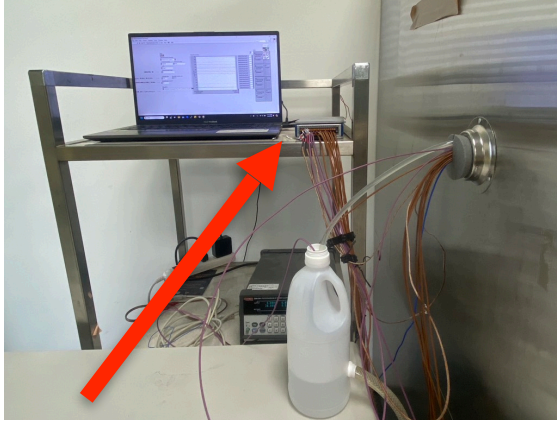
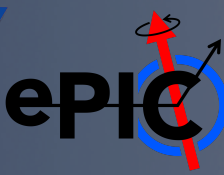
- Radius is 63 - 66 cm from the beam pipe covering $-1.42 < \eta < 1.77$ (Area: 10 m²)
- Total material budget in acceptance is $\sim 0.01 X/X_0$



Prototypes from Purdue



Thermal Test Setup @ NCKU



NI 9213 DAQ

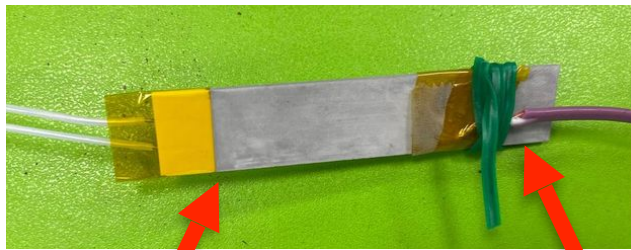
16 channels

Accuracy:



High-resolution mode : $<0.02\text{ }^{\circ}\text{C}$

High-speed mode : $<0.25\text{ }^{\circ}\text{C}$



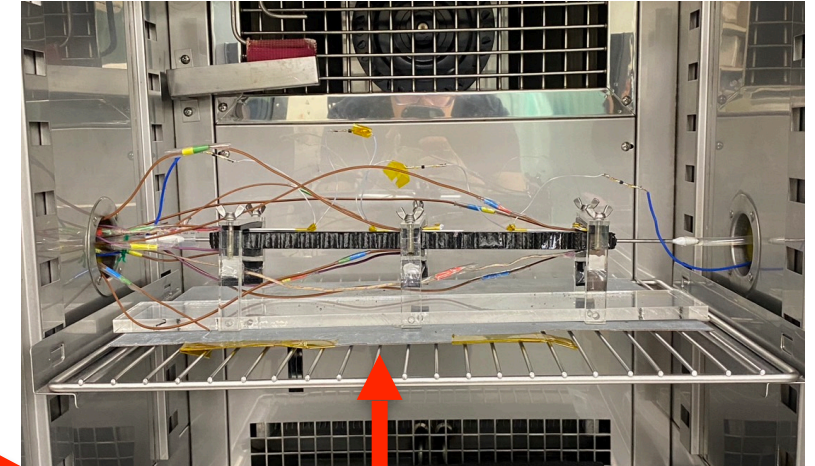
Heat source (x 9)

Ceramic plate (5 Ω): $\sim 500^{\circ}\text{C}$



Thermocouple (x 16)

○ Type E: $-250^{\circ}\text{C} \sim 900^{\circ}\text{C}$



Environmental chamber

- Inner dimensions: $40 \times 50 \times 60\text{ cm}^3$
- Temperature: $-40\text{ }^{\circ}\text{C} \sim 100\text{ }^{\circ}\text{C}$ ($\pm 0.2\text{ }^{\circ}\text{C}$)
- Humidity: $10\% \sim 98\%$ ($\pm 2.5\%$)

Flow meter

- 20 – 300 cc/min

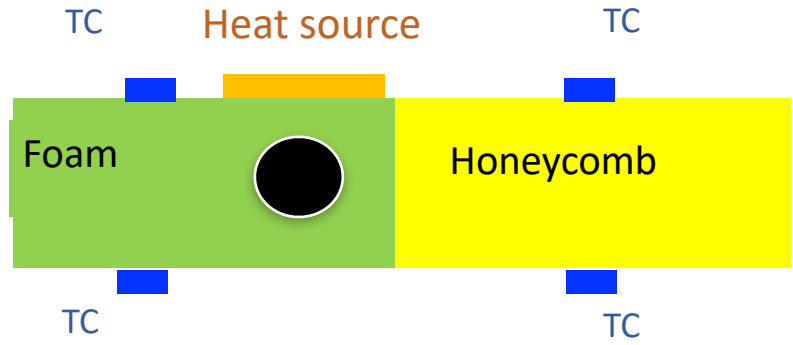
Cooling system

- Temperature: $3\text{ }^{\circ}\text{C} \sim 32\text{ }^{\circ}\text{C}$

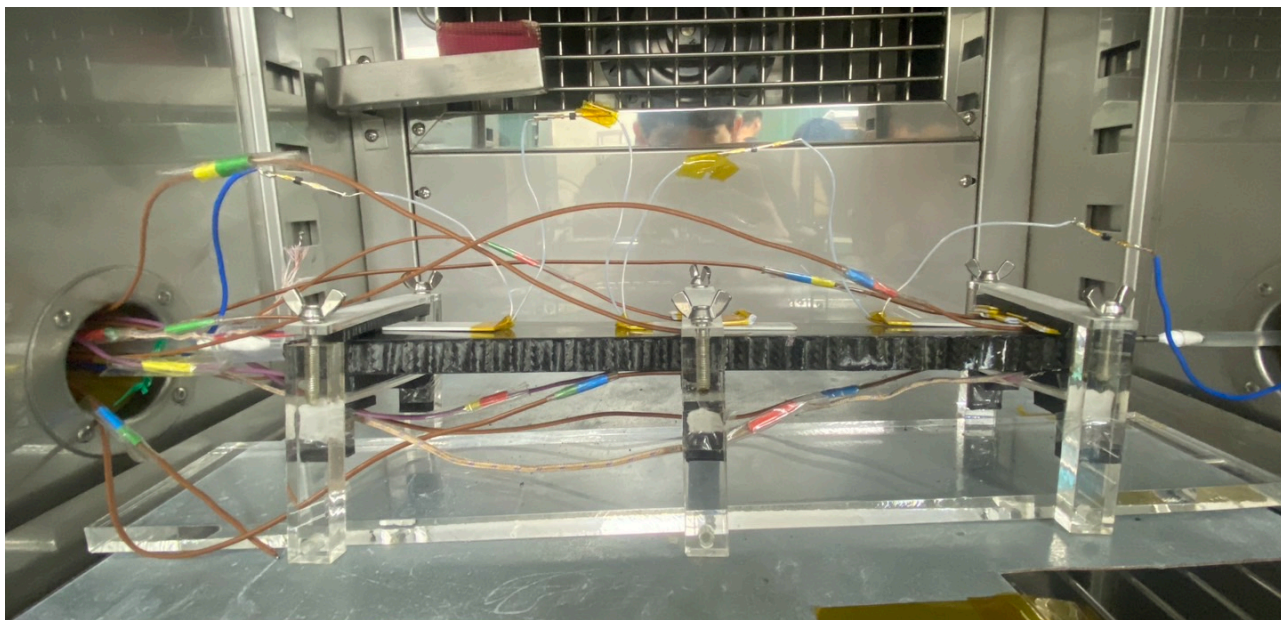
Thermal Test Setup @ NCKU



3D-printed holder



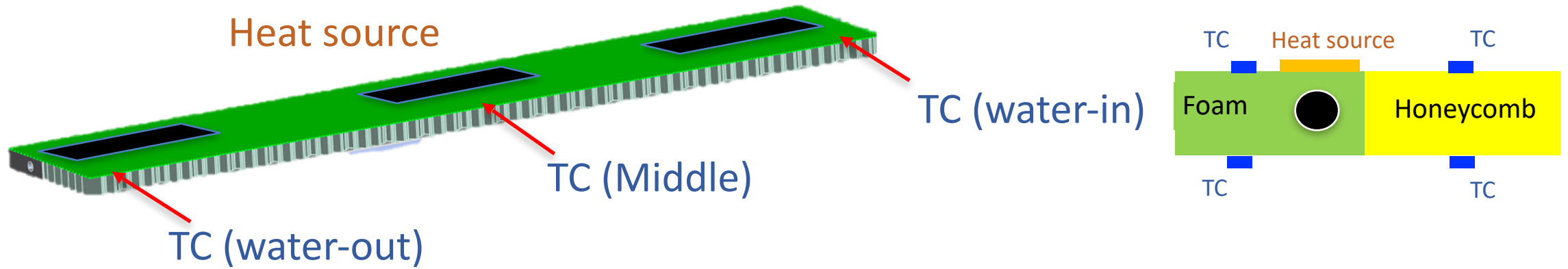
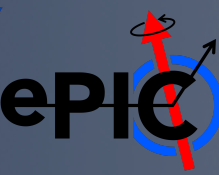
Output power of the heat source can be adjusted by the input current



Water out ←

← Water in

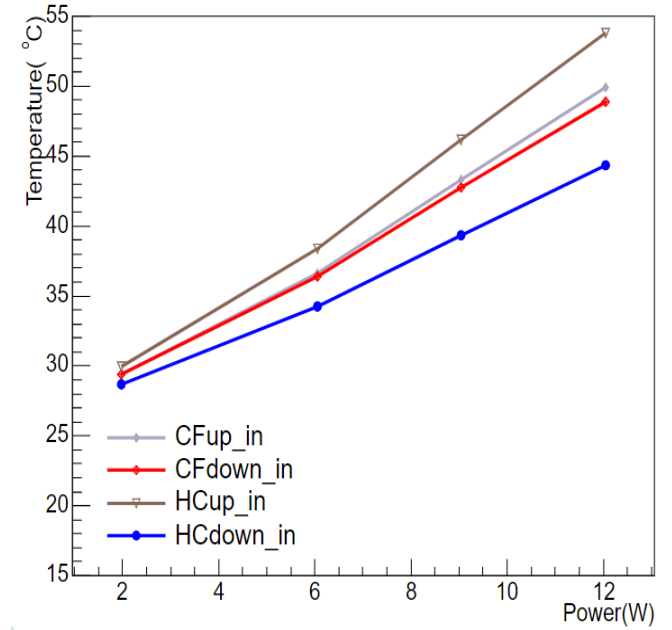
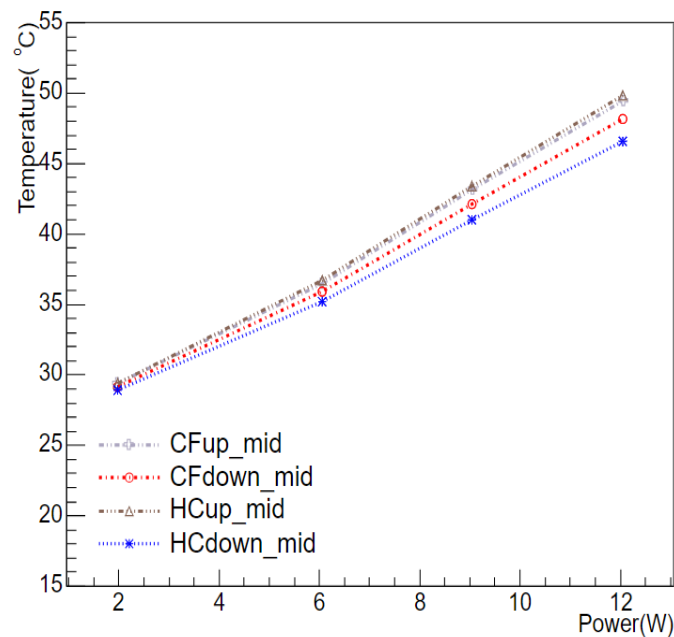
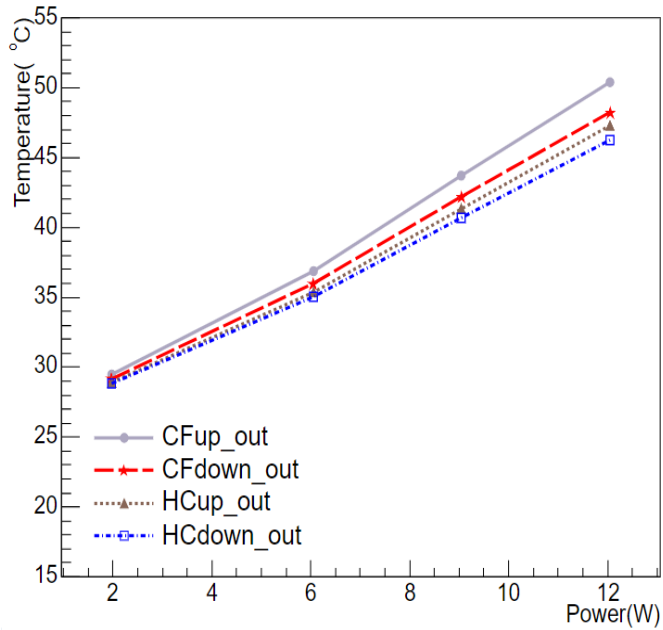
No Cooling Water



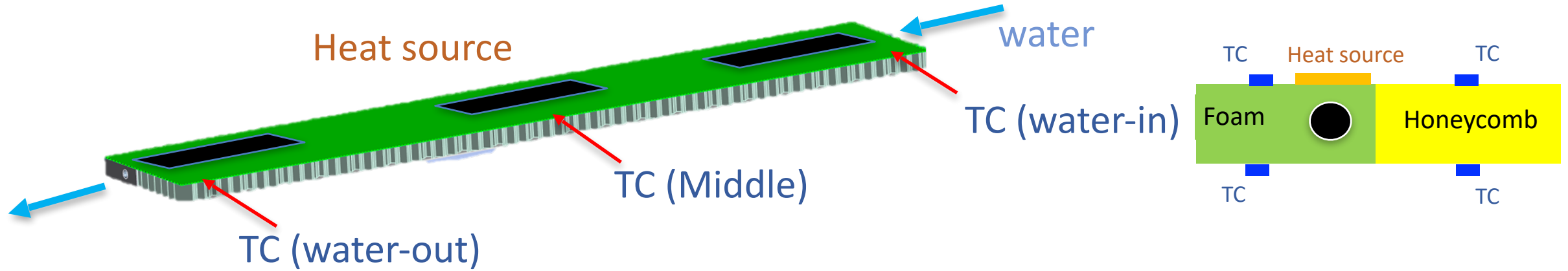
Water-out

Middle

Water-in



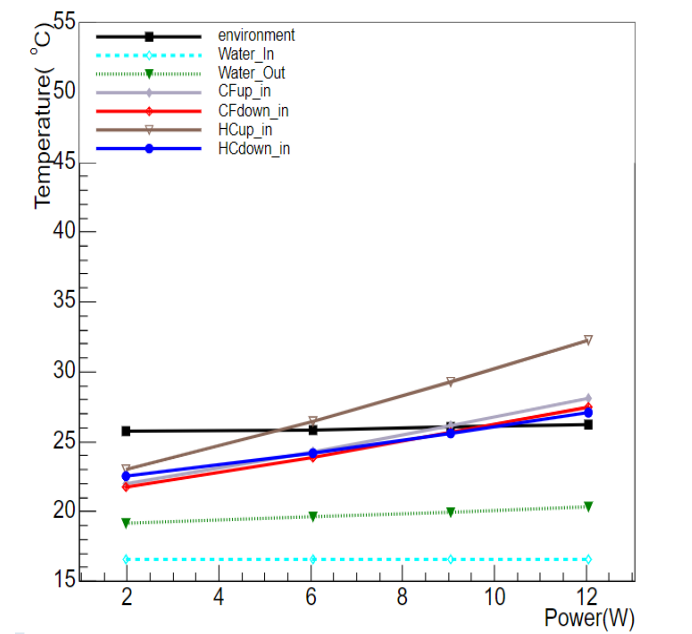
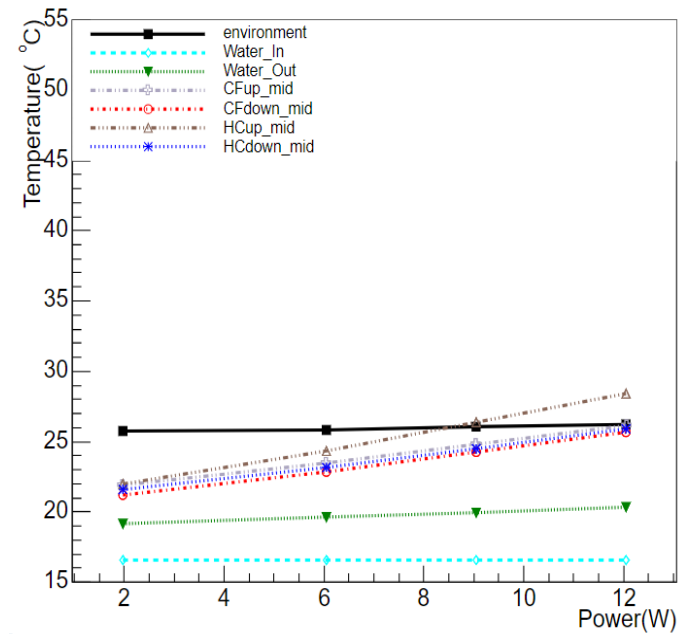
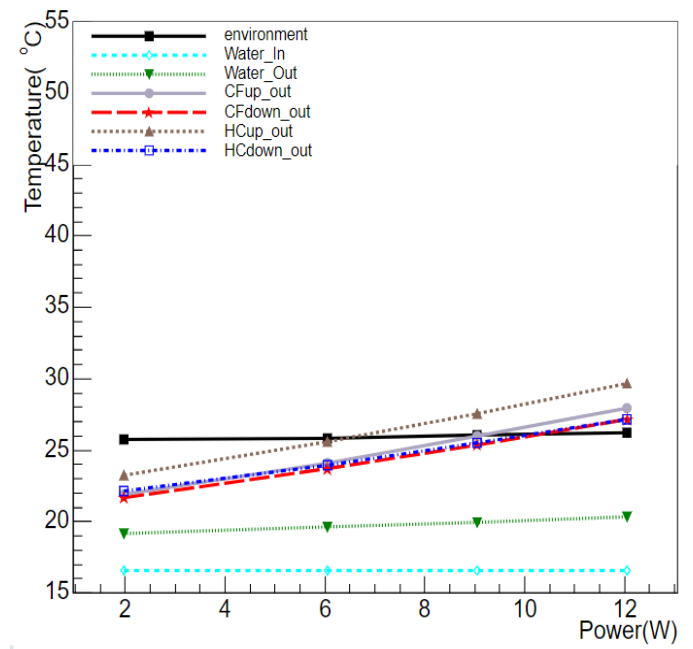
Coolingn Water at 15 °C, 100 c.c./min



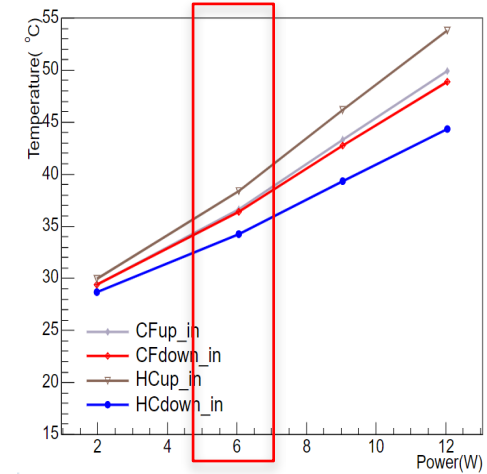
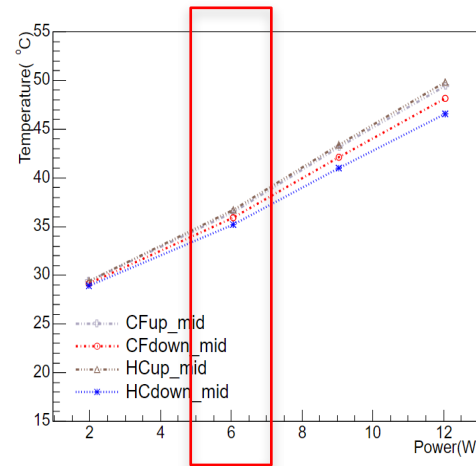
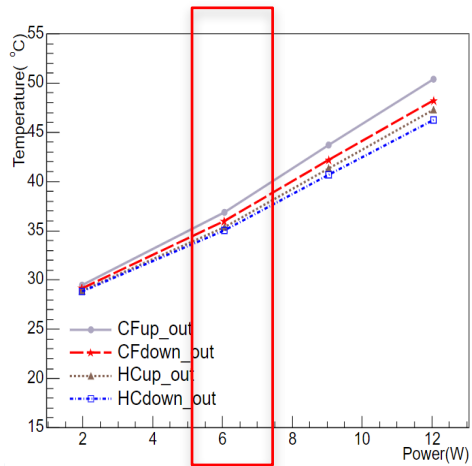
Water-out

Middle

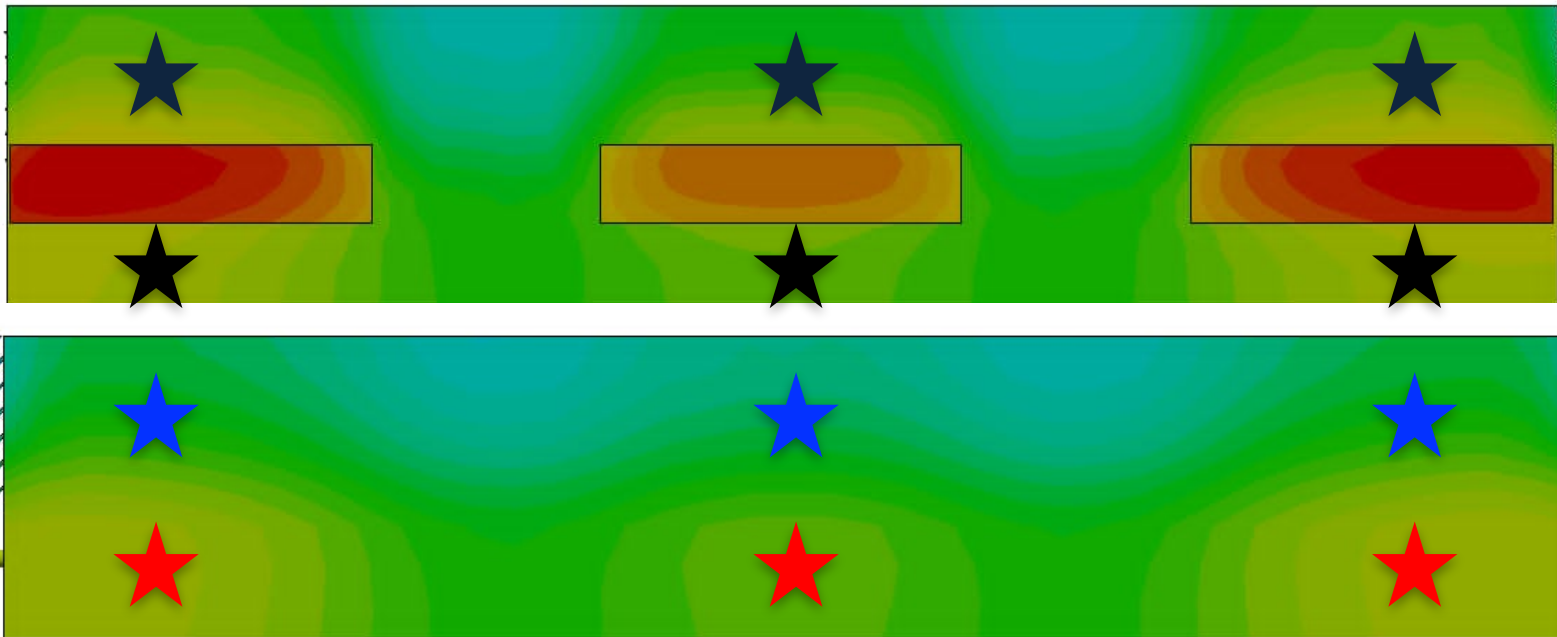
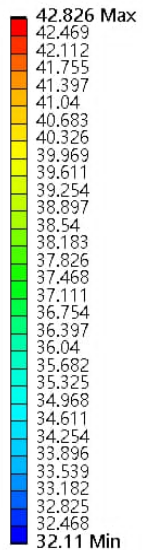
Water-in



Simulation: No Cooling Water, 6 W

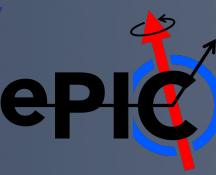


A: Transient Thermal
 Temperature
 Type: Temperature
 Unit: °C
 Time: 1 s
 2024/5/29 下午 04:26



Very preliminary results done by undergrad student of NCKU, need to double check

Test Setup for Half Stave (1070 mm)

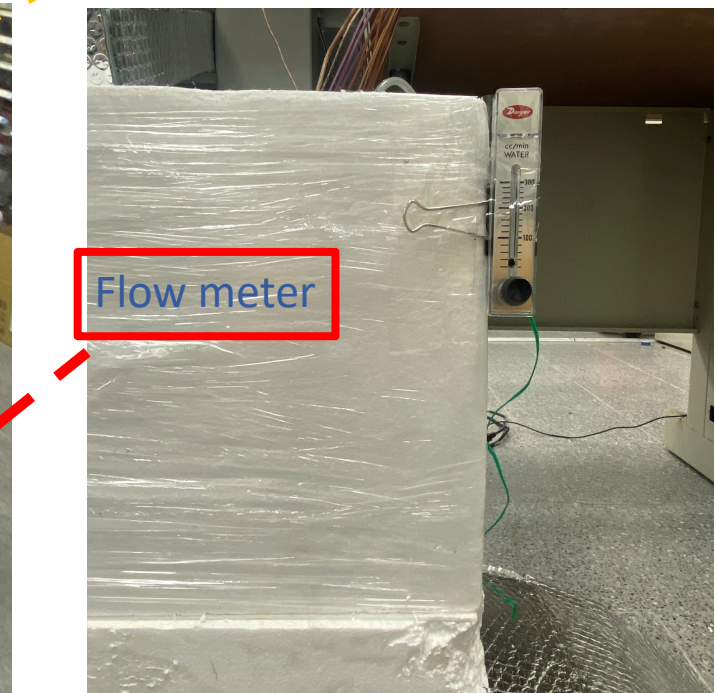


Power supply

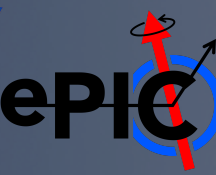
Cooling system

Computer and DAQ 1

Flow meter

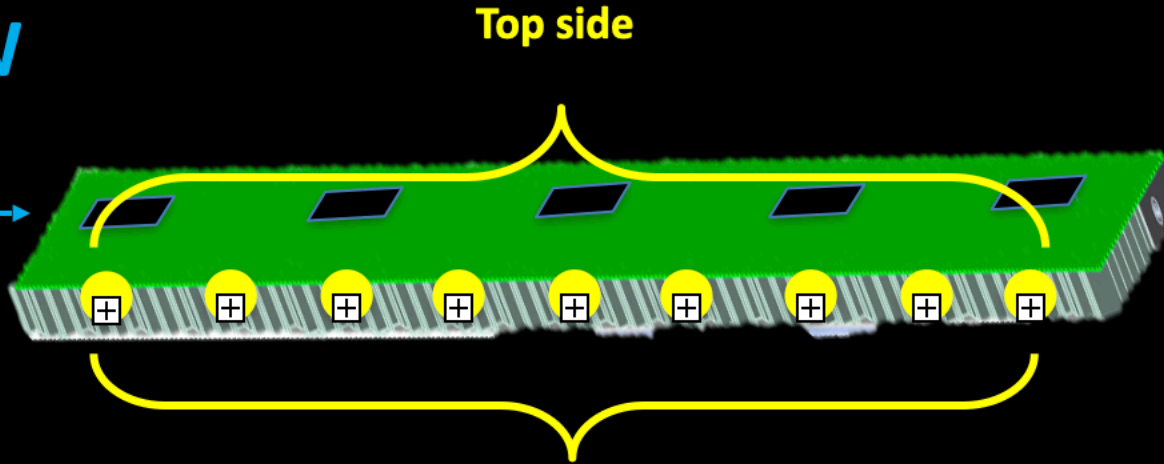


Temperature Distribution

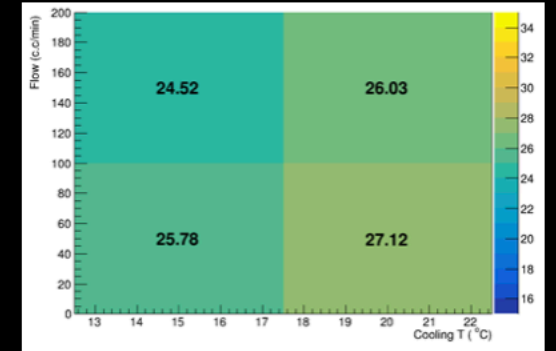


Power: 20.1 W

Water in



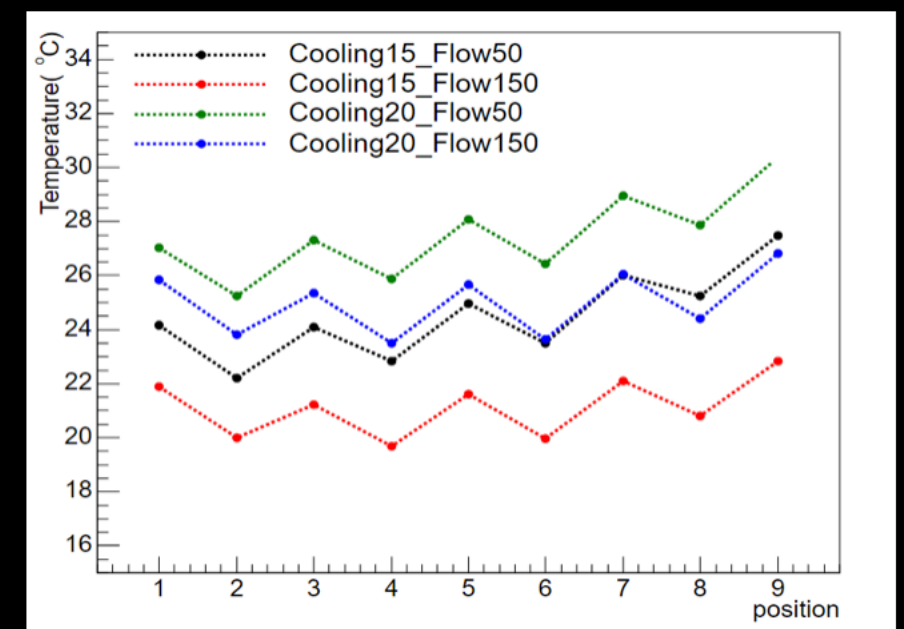
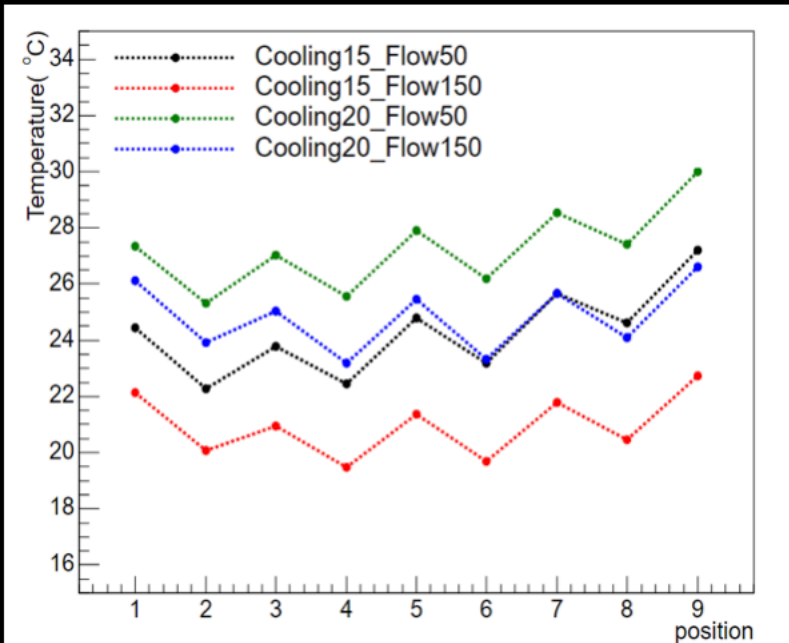
Environmental temperature



Top side

Bottom side

Bottom side



- ❖ Events to broadcast EIC physics in Taiwan and to strengthen the collaboration with Asian colleagues.
- ❖ Crystal for the ZDC ECAL
 - On-going effort on the analysis of data collected in the 1st beam test.
 - 2nd beam test in next February
- ❖ Barrel TOF Mechanical Structure
 - Thermal performance tests on the prototypes shows expected behavior. Confidence to produce longer staves with similar technology.
 - Will carry out further tests including deformation, and the simulation.