ePIC Barrel TOF Mechanical Structure

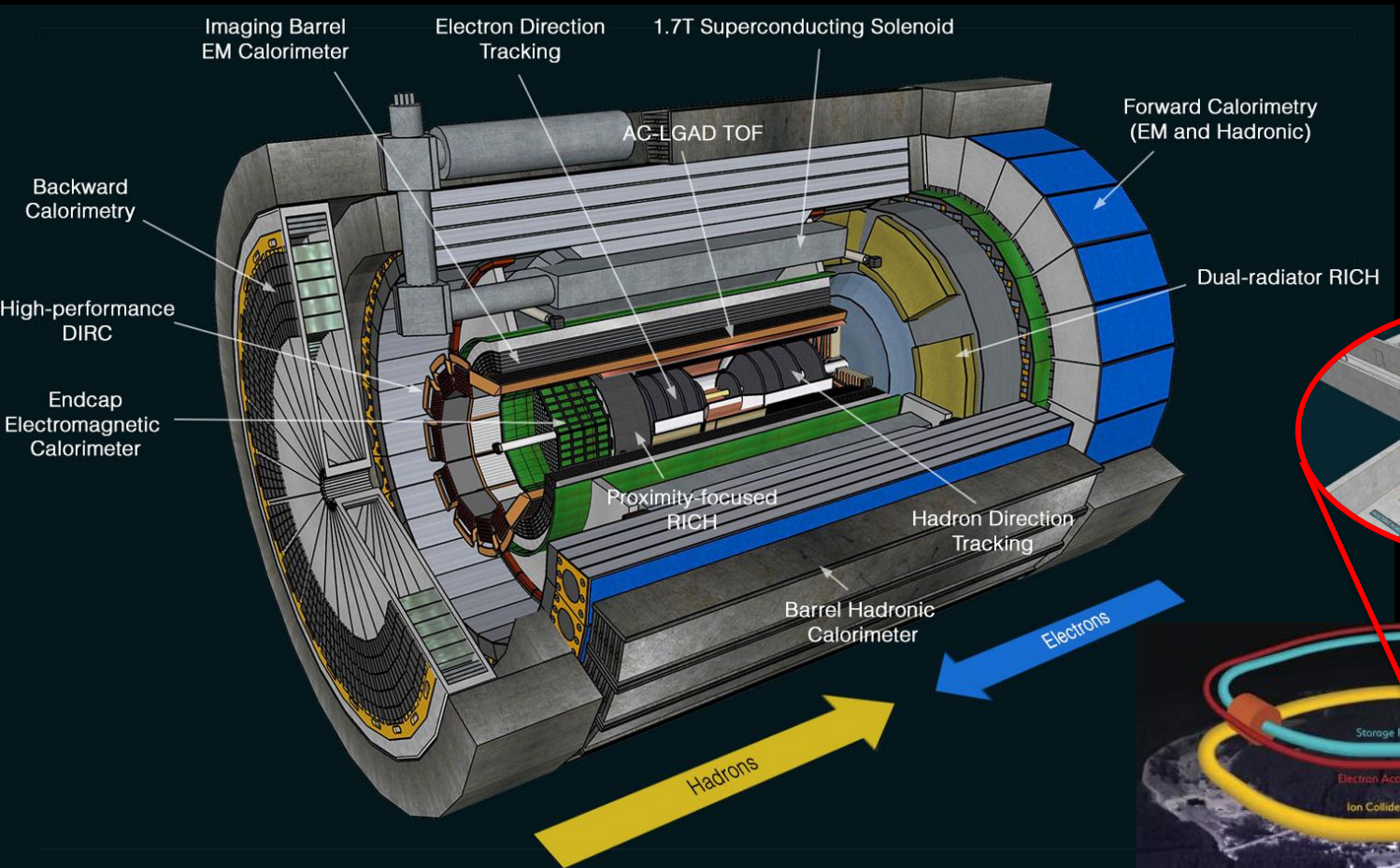
22 November 2024

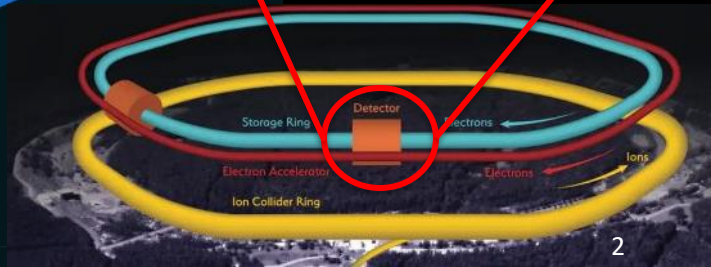
TIDC Annual Meting 2024

Yi Yang

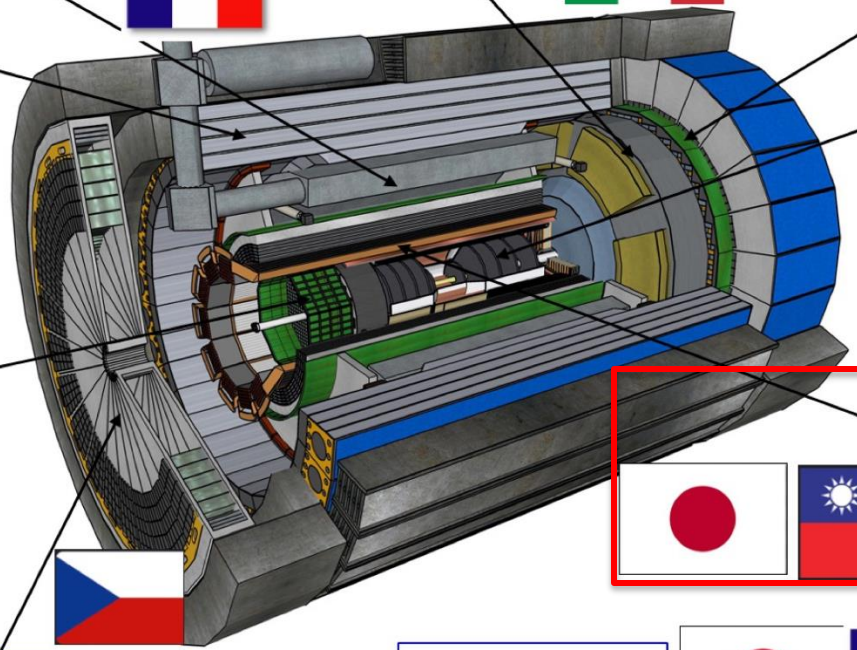
Academia Sinica

ePIC Detector





Barrel TOF Participation



Superconducting Solenoid

Dual-radiator RICH

Forward Electromagnetic Calorimeter

Barrel Electromagnetic Calorimeter

Tracking Detectors

Backward Electromagnetic Calorimeter

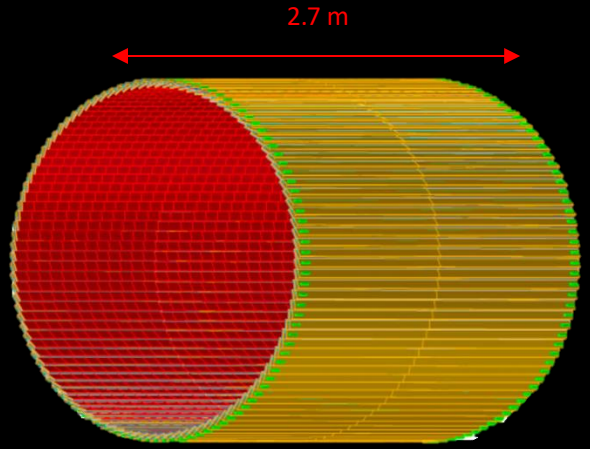
Time-of-Flight

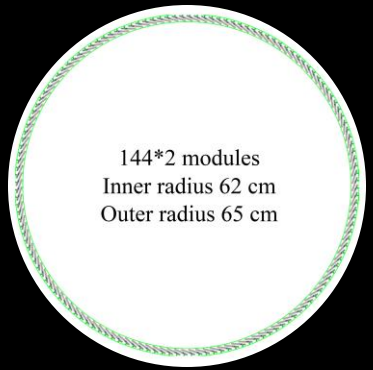
Backward Hadronic Calorimeter

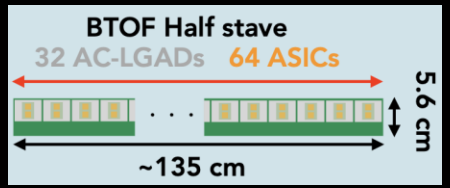
Data-Acquisition Electronics

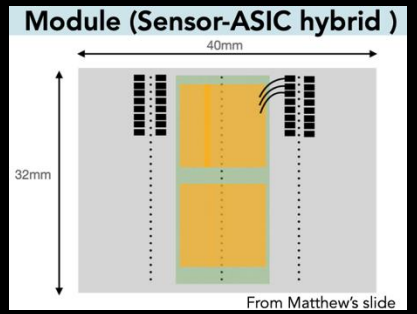
Basics of Barrel TOF

- BTOF is composed of 288 half staves (symmetric/asymmetric?)
- 32 AC-LGAD **strip-type** sensors on one half stave
  - Timing Resolution: 35 ps
  - Spatial resolution: 30 μm in r・ϕ
- Radius is 63 - 66 cm from the beam pipe covering $-1.42 < \eta < 1.77$ (Area: 10 m^2)
- Total material budget in acceptance is ~0.01 X/X0









AS-NCKU-Purdue Collaboration

- **Yi Yang (AS), Wen-Chen Chang (AS) & Po-Ju Lin (NCU):**
  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



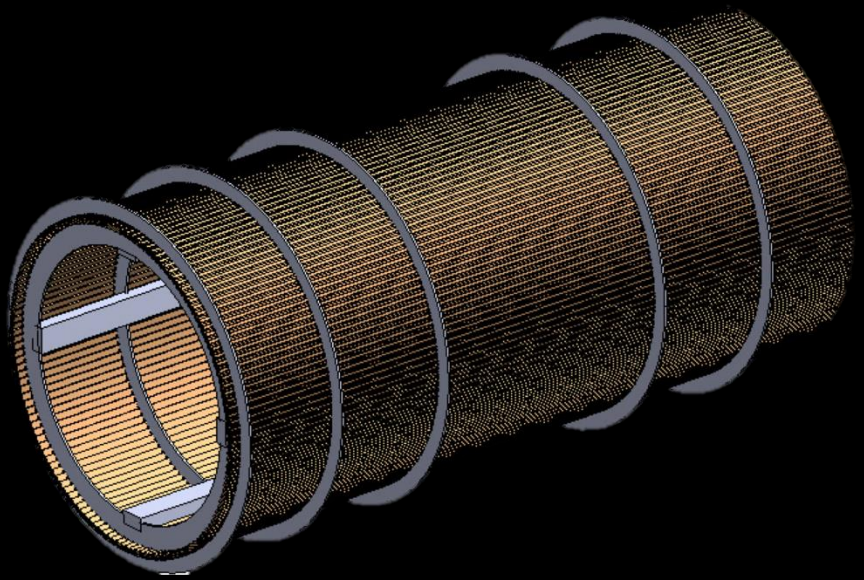
- **Andreas Jung (Purdue):**
  design, simulation, prototype, final production(?)
  - Experienced in R&D for low mass support structures.
  - Working on the light-weight composite tracker support structures for CMS

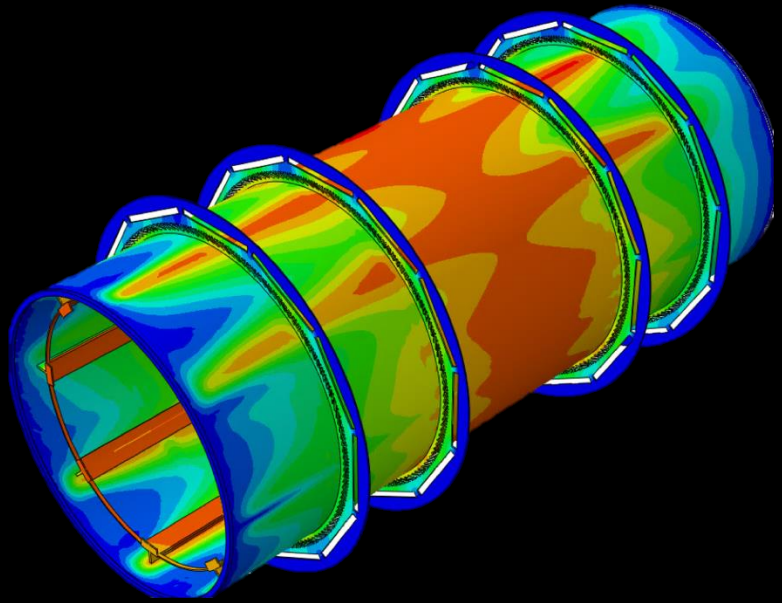
PURDUE UNIVERSITY

Yu-Tang Wang
NCKU Ph.D. student)

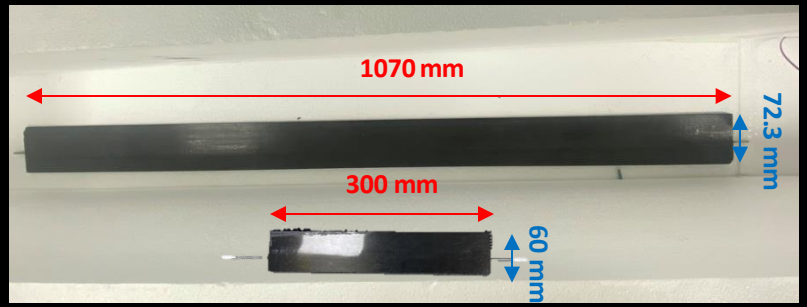
Latest Structure Support of BTOF

From Purdue group

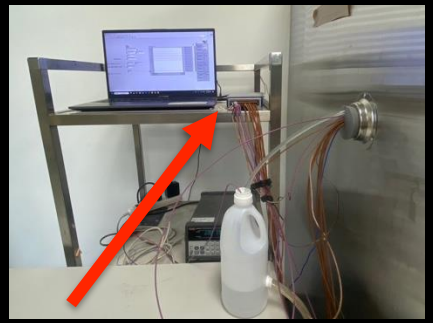




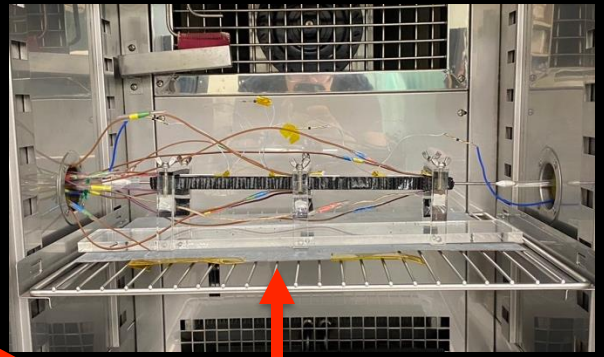
Prototypes from Purdue



Thermal Test Setup @ NCKU (300 mm)



NI 9213 DAQ
- 16 channels
- Accuracy:
  - High-resolution mode : <0.02 ˚C
  - High-speed mode : <0.25 ˚C



Environmental chamber
- Inner dimensions: 40 x 50 x 60 cm^3
- Temperature: -40 ˚C ~ 100 ˚C (± 0.2 ˚C)
- Humidity: 10% ~ 98% (± 2.5%)

Flow meter
- 20 – 300 cc/min

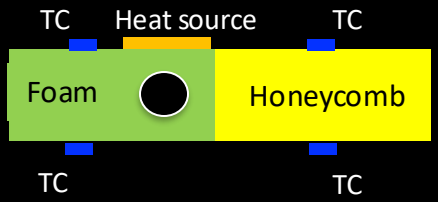
Heat source (x 9)
- Ceramic plate (5Ω): ~500˚C

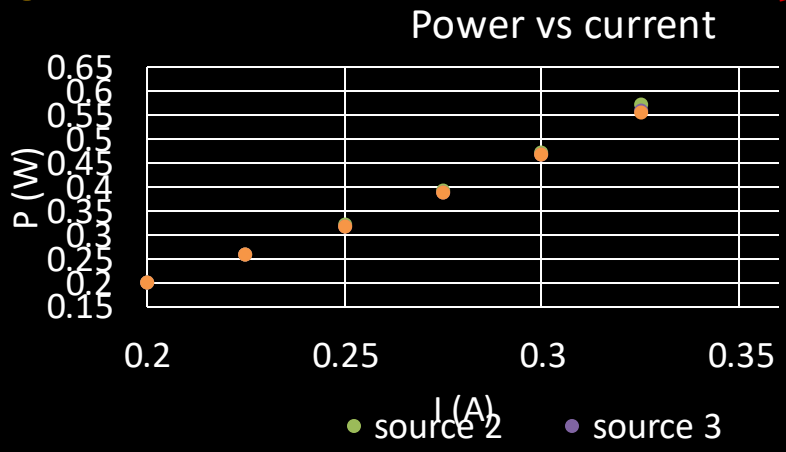
Thermocouple (x 16)
- Type E: -250˚C ~ 900˚C

Cooling system
- Temperature: 3 ˚C ~ 32 ˚C

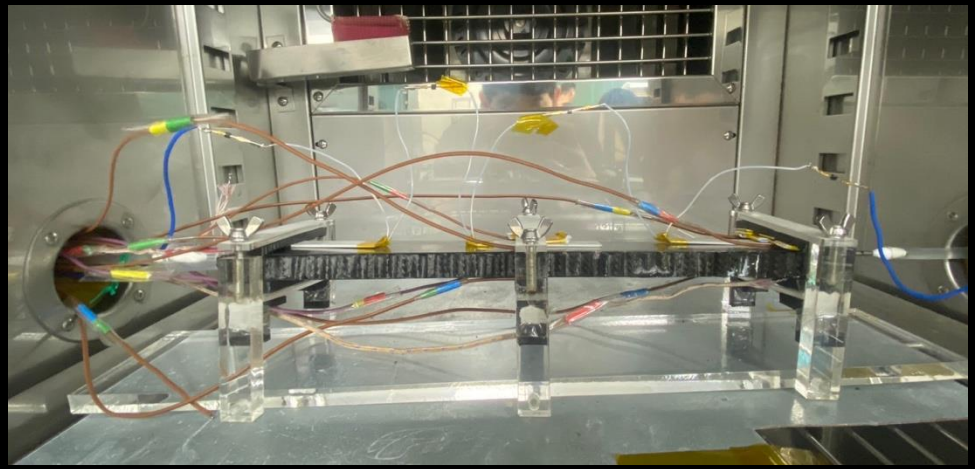
Thermal Test Setup @ NCKU

3D-printed holder



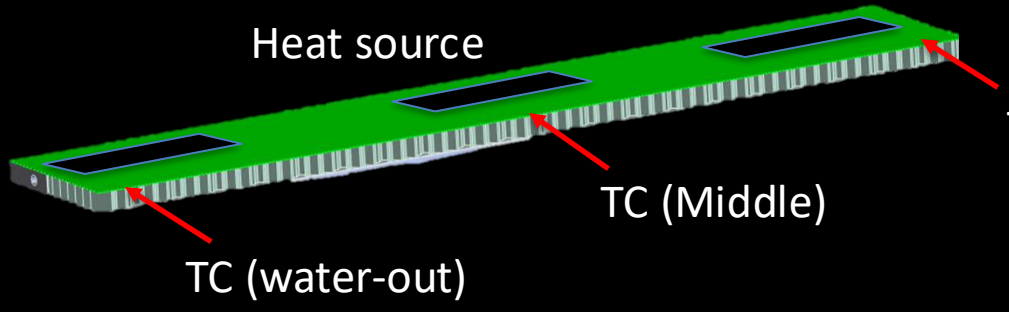


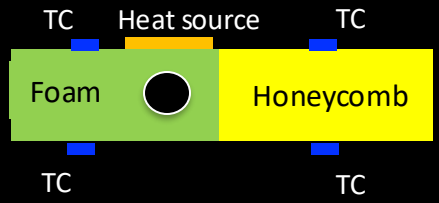
Water out ←



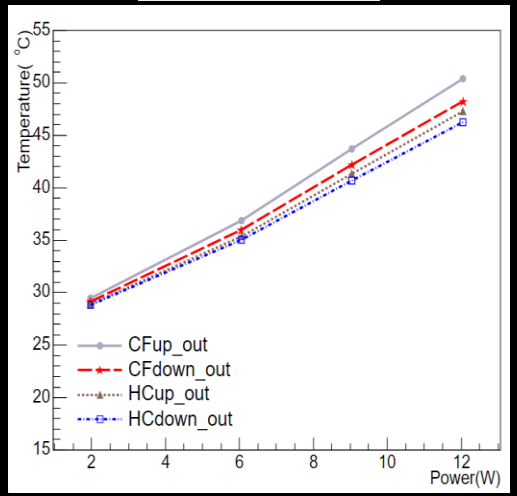
← Water in

No Cooling Water

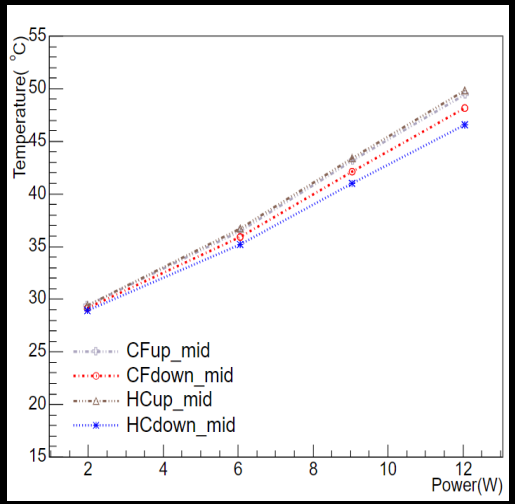




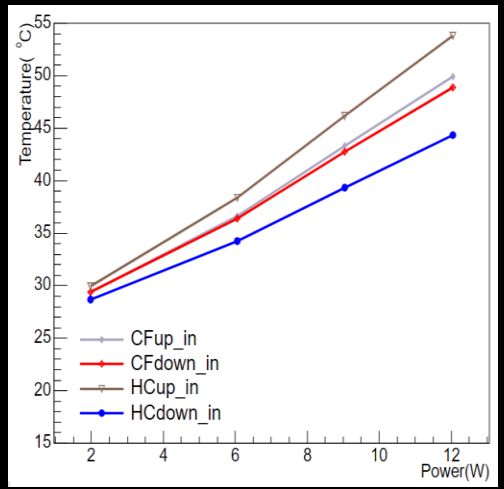
Water-out



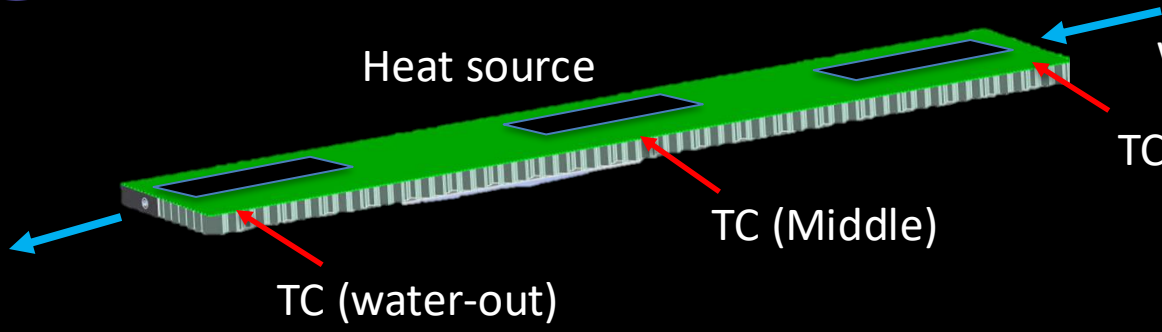
Middle

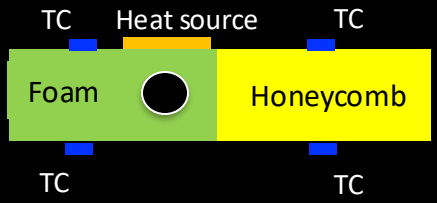


Water-in

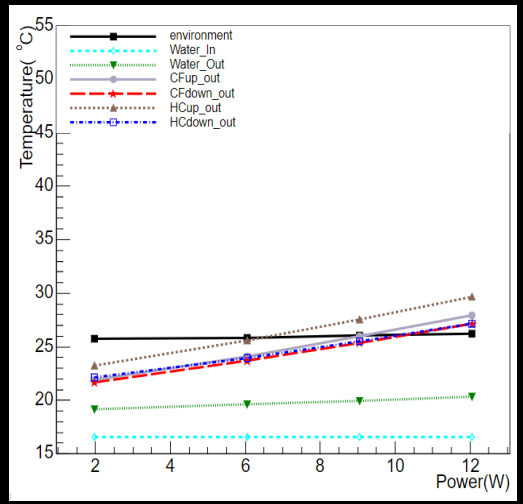


Cooling Water @ 15 °C, 100 c.c./min





Water-out



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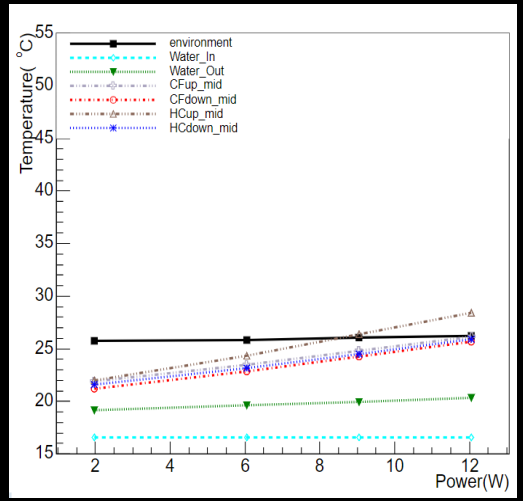
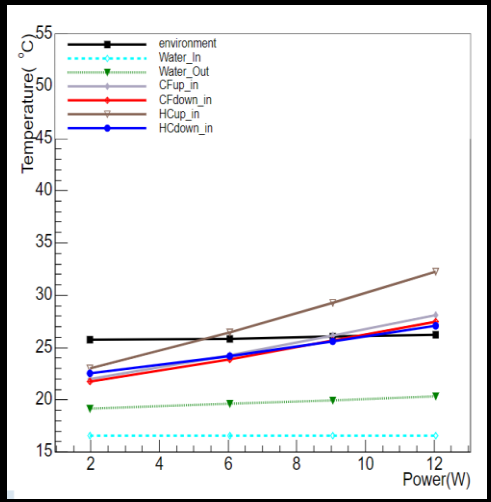
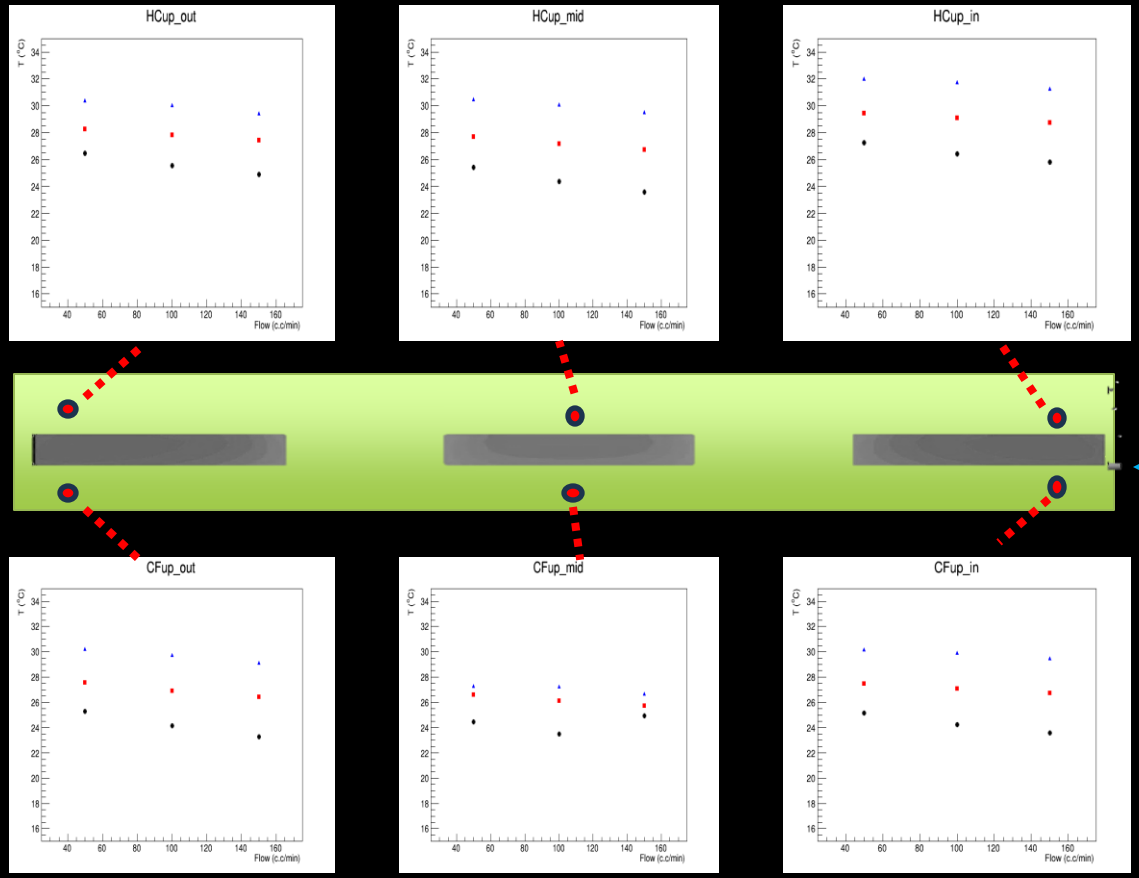


Water-in



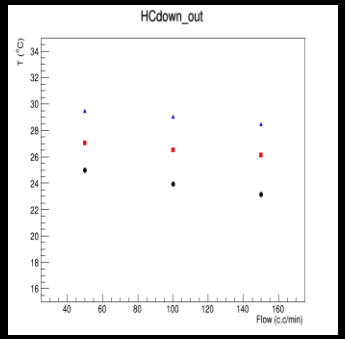
Fixed Power @ 6W vs Flow Rate: Top

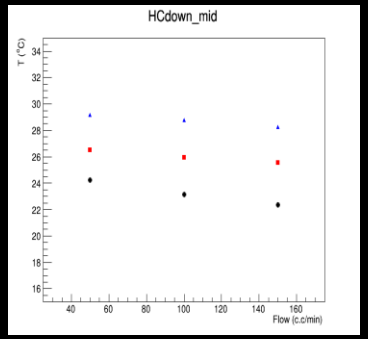


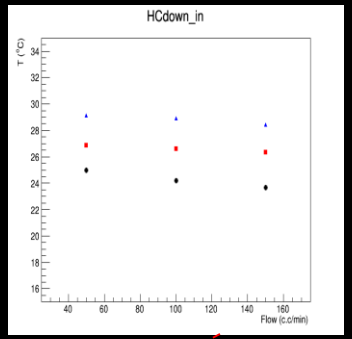
- Best cooling performance
  - High flow rate
  - Lower cooling temperature

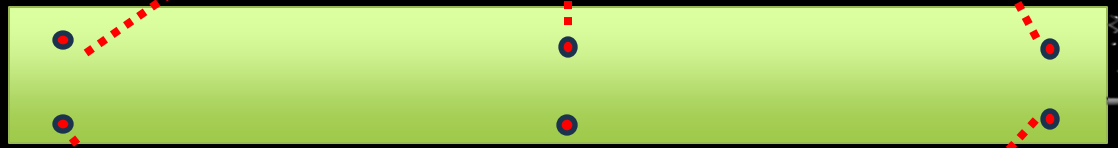
Cooling = 25°C
Cooling = 20°C
Cooling = 15°C

Fixed Power @ 6W vs Flow Rate: Bottom

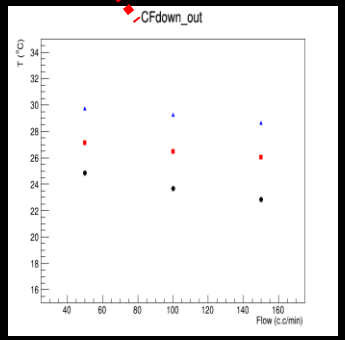


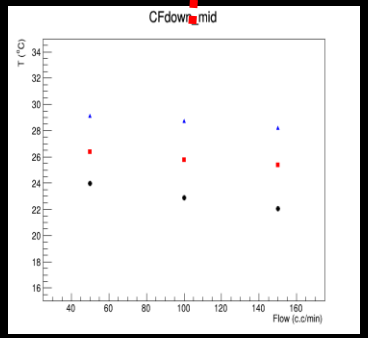


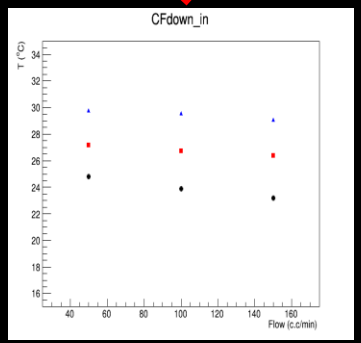




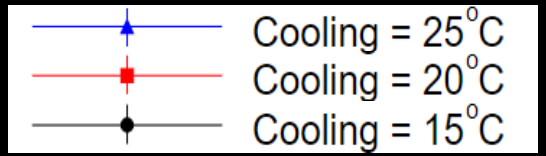
water



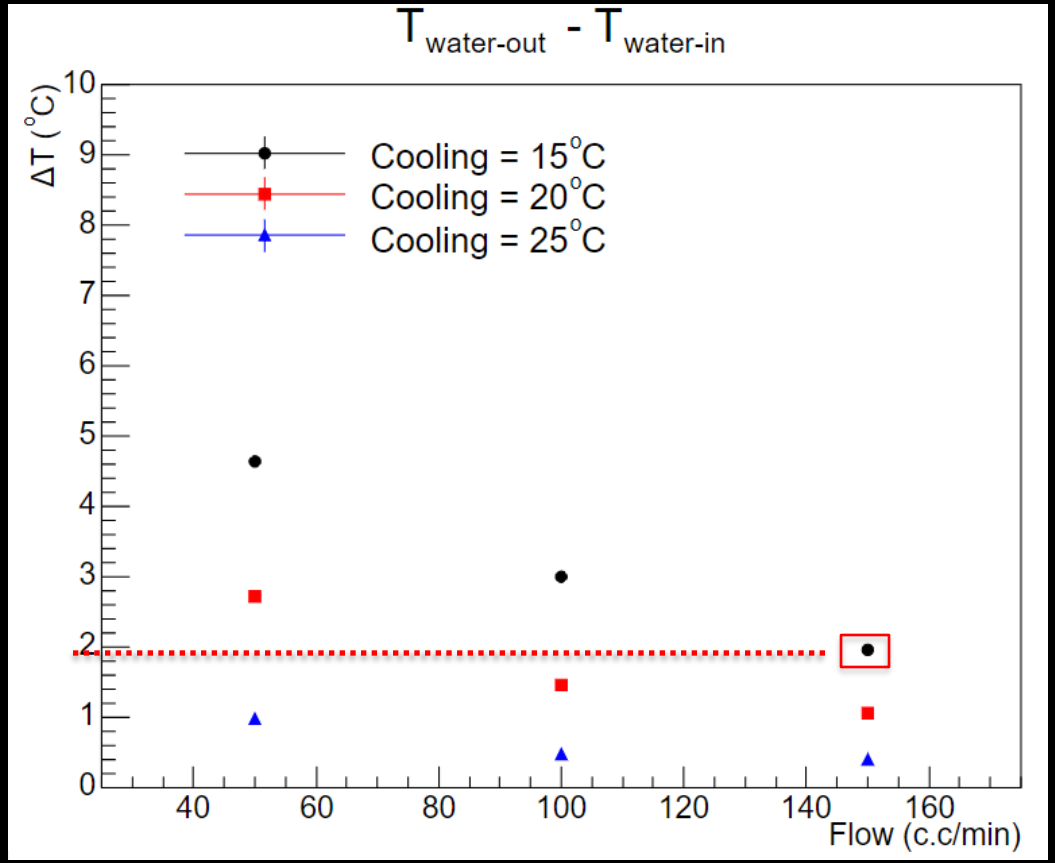




- Best cooling performance
  - High flow rate
  - Lower cooling temperature

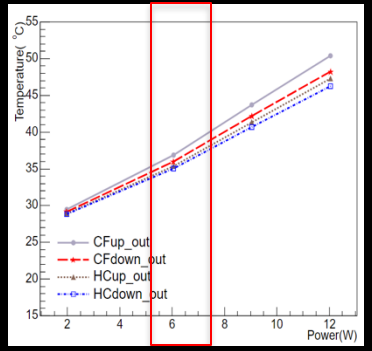


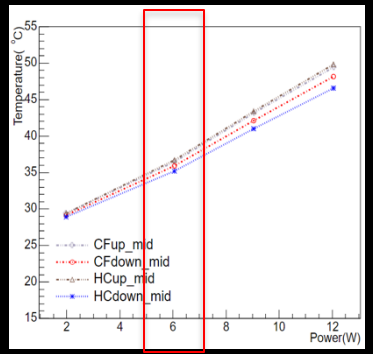
ΔT between Water-in and Water-out

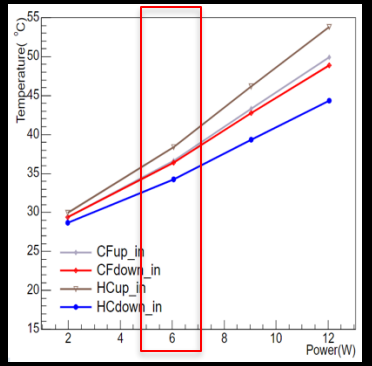


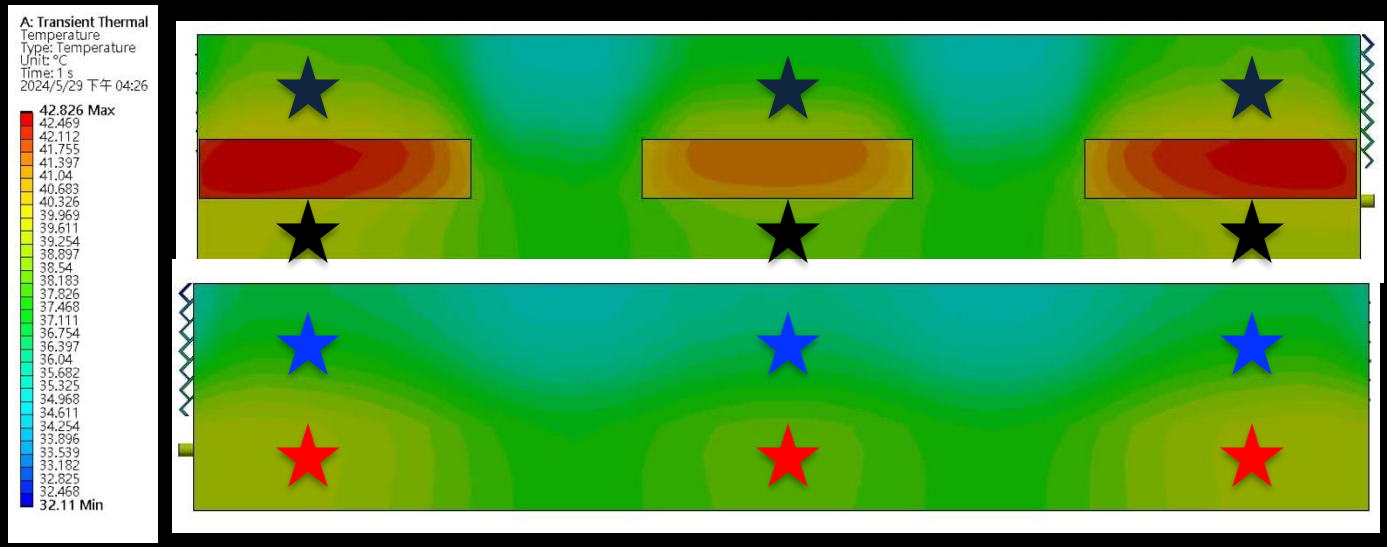
1.96

Simulation: No Cooling Water, 6 W









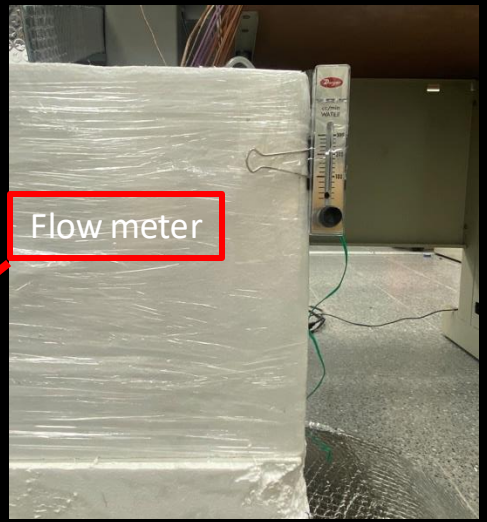
Very preliminary results done by undergrad student of NCKU, need to double check

Test Setup for Half Stave (1070 mm)

Cooling system

Power supply

Computer and DAQ 1

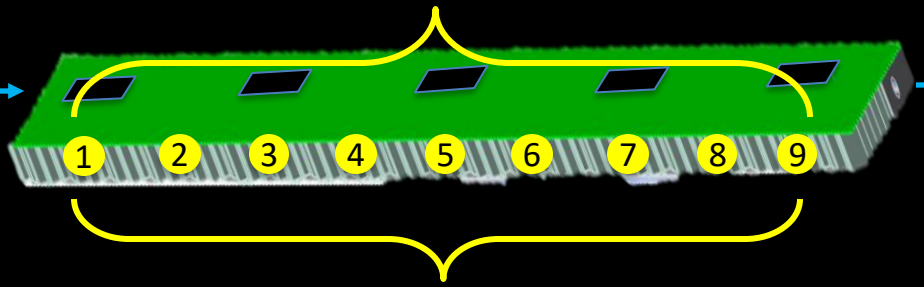


Flow meter

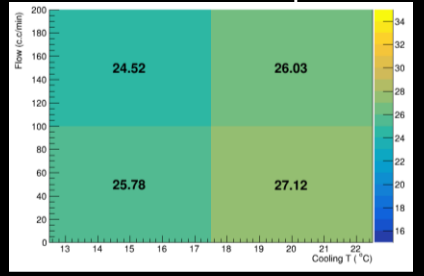
Temperature Distribution (no pipe side)

Power: 20.1 W

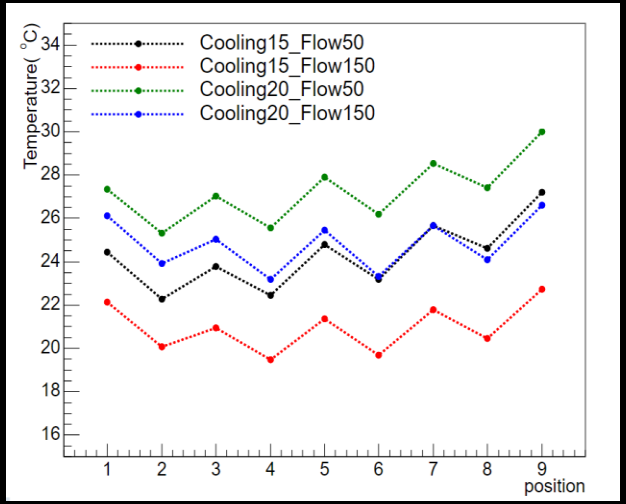
Water in



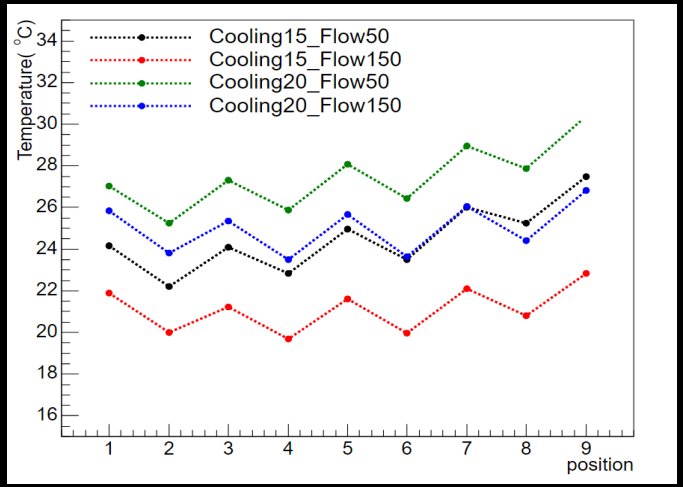
Environmental temperature



Top side



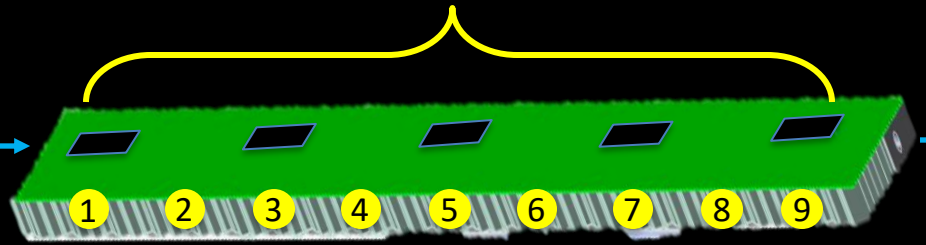
Bottom side



Temperature Distribution (pipe side)

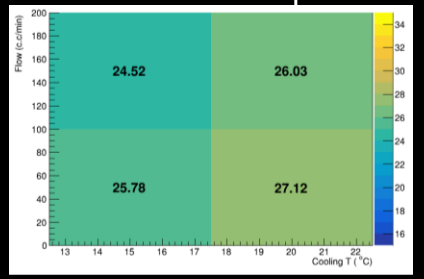
Top side

Water in

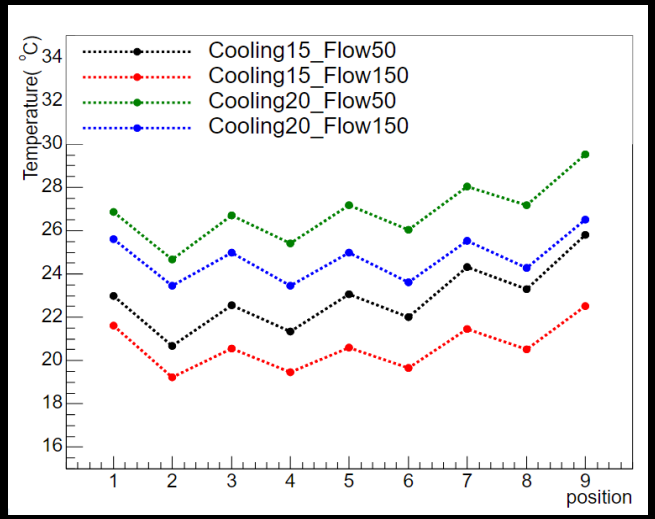


Bottom side

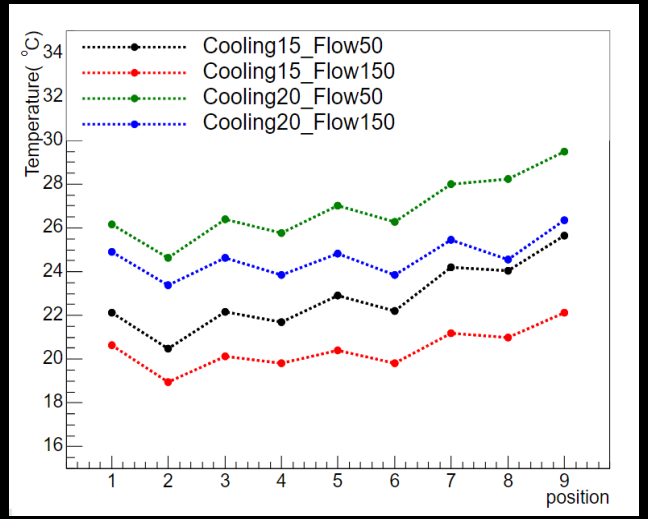
Environmental temperature



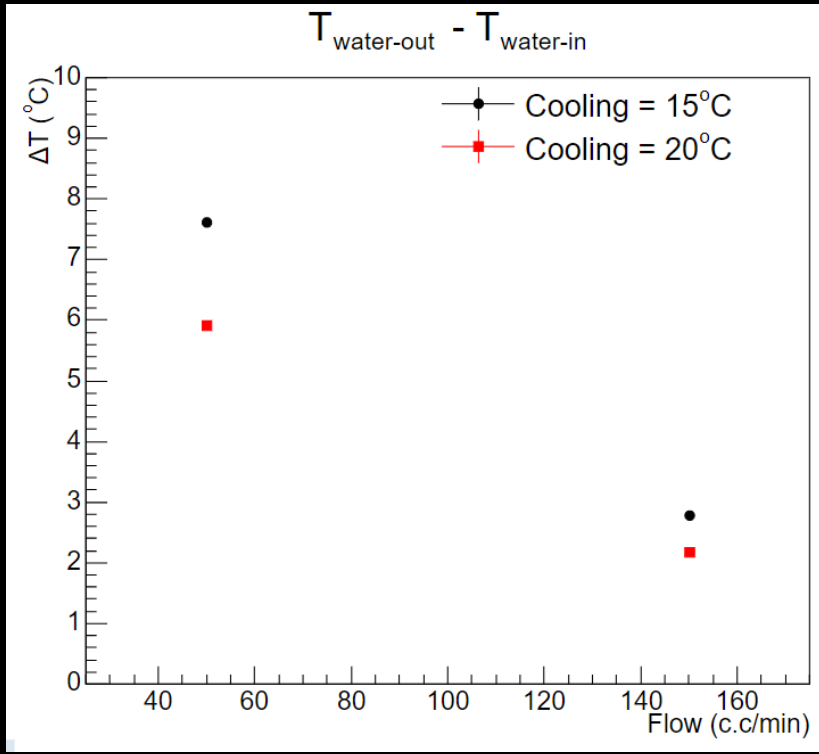
Top side

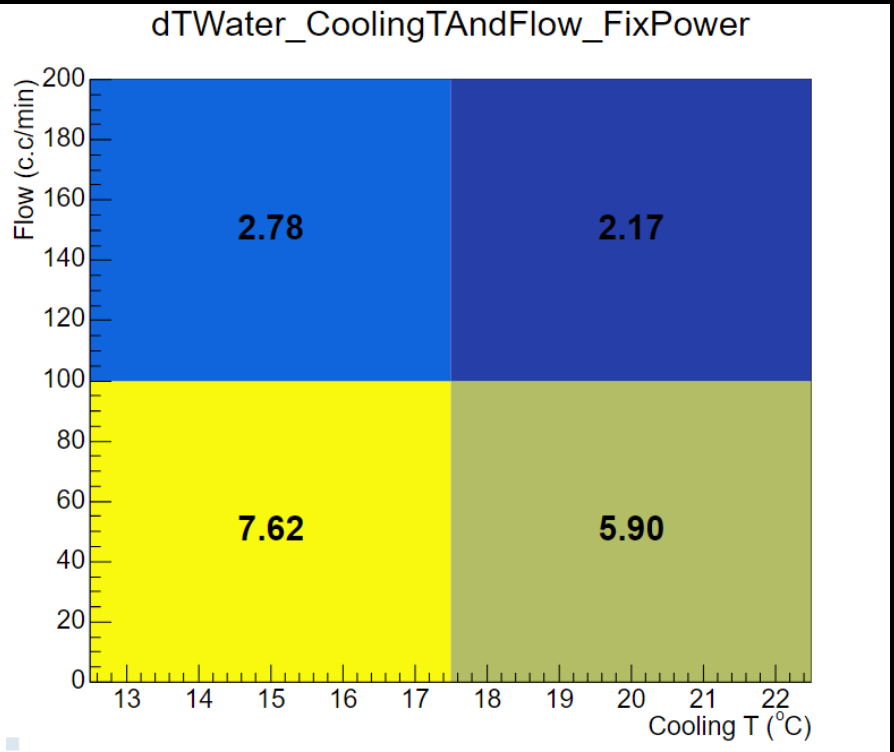


Bottom side



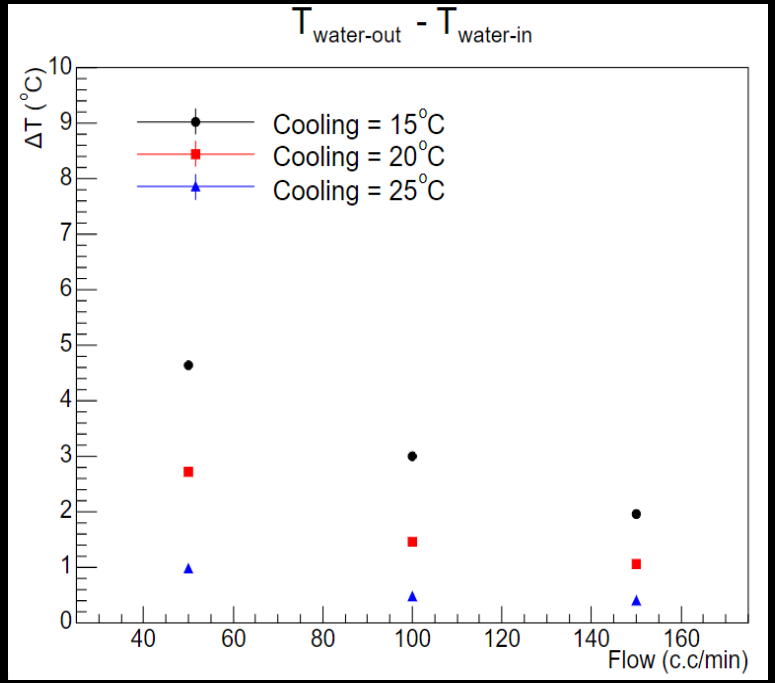
ΔT between Water-in and Water-out



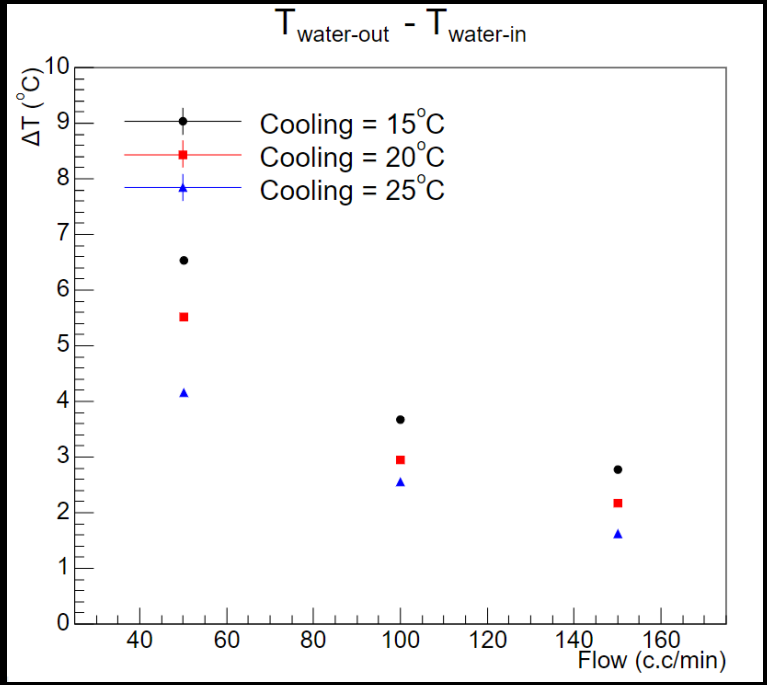


ΔT between Water-in and Water-out

- Half stave has larger ΔT



300 mm stave



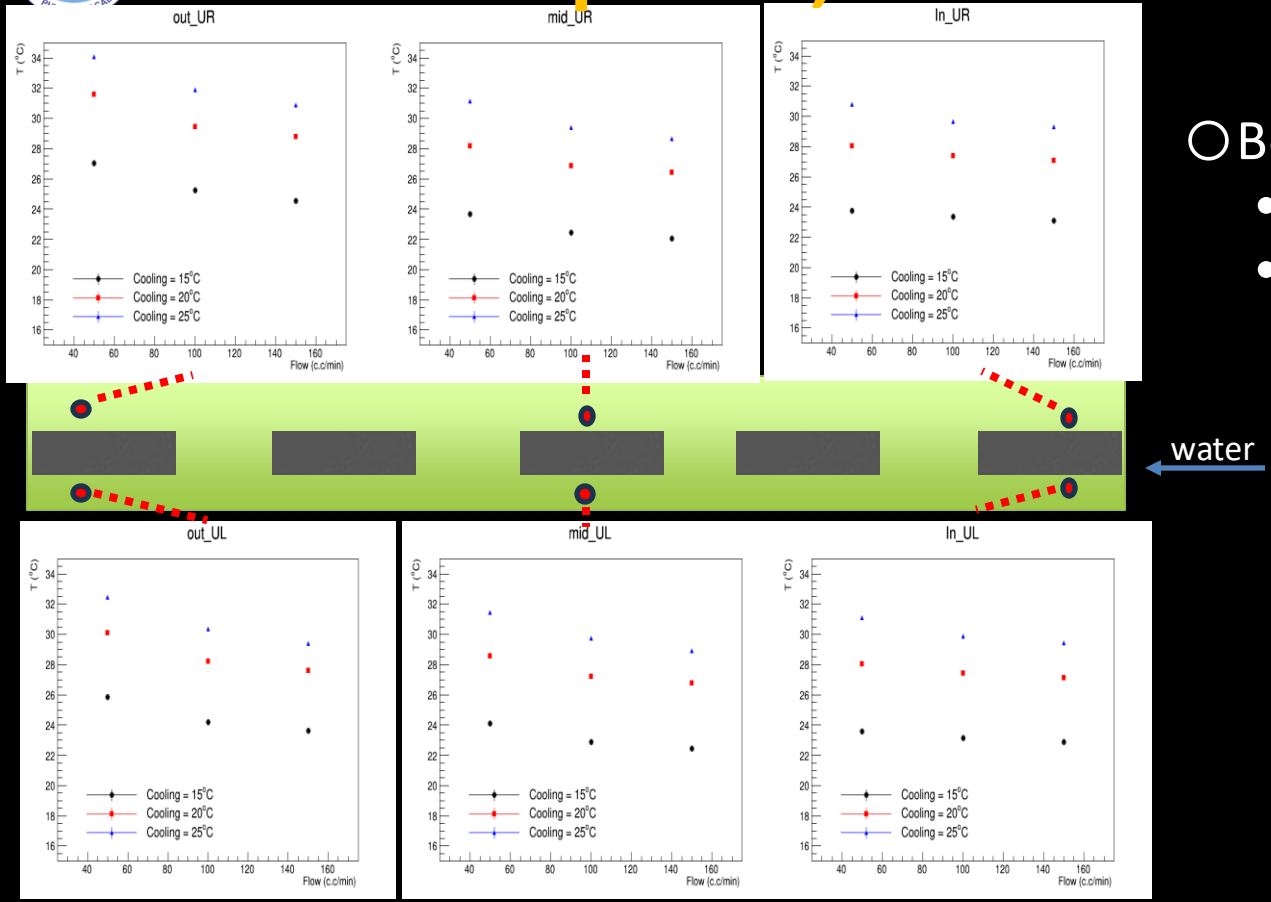
1070 mm stave

Summary and Next Steps

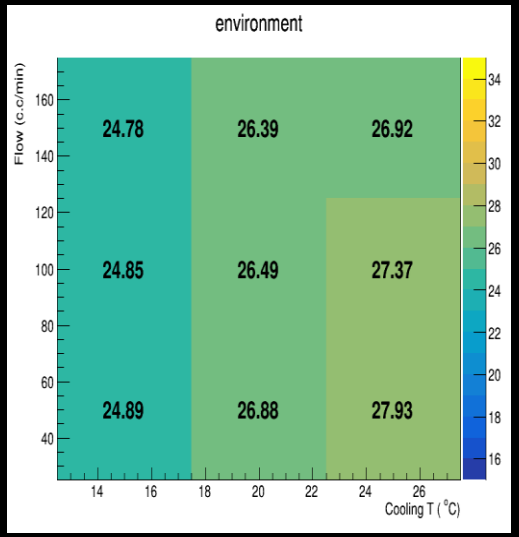
- Prototypes of the supporting structure for ePIC Barrel TOF detector are designed and manufactured by the Purdue group (300 mm and 1070 mm)
- AS/NCKU team worked on the thermal performance test.
- Thermal performances are all expected that cooler cooling temperature and higher flow rate for the cooling water can take more heats and provide the uniform temperature distribution
- The results provide confidence of making a long stave (~ 1.3 m) with similar technology
- More configurations will be tested
- Simulations are needed
- Flatness vs temperature needs to be measured

Back up

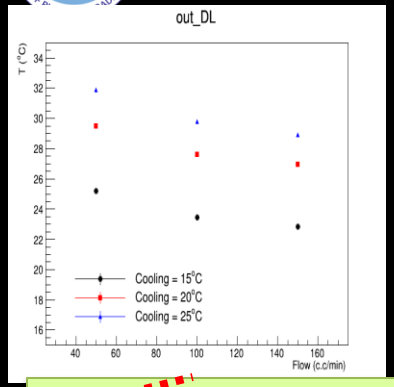
Top Side, Power: 20.1 W

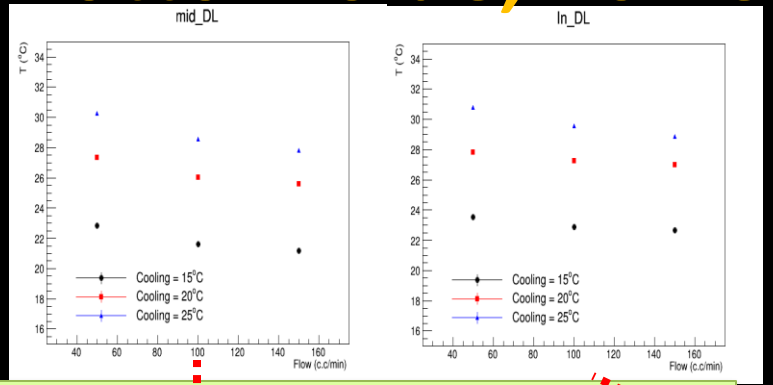


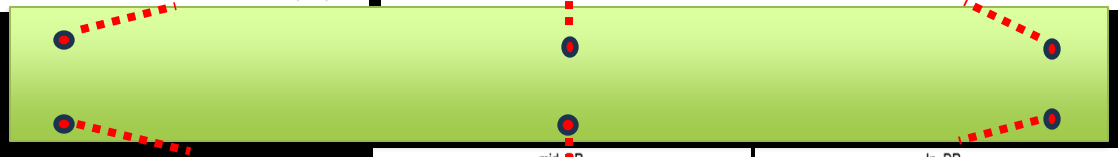
- Best cooling performance
  - High flow rate
  - Lower cooling temperature



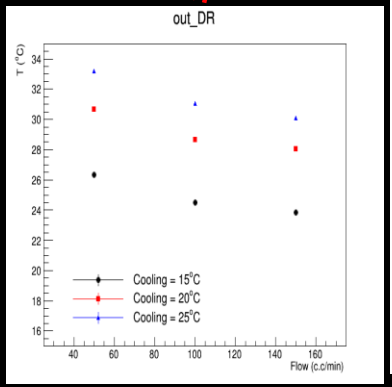
Bottom Side, Power: 20.1 W

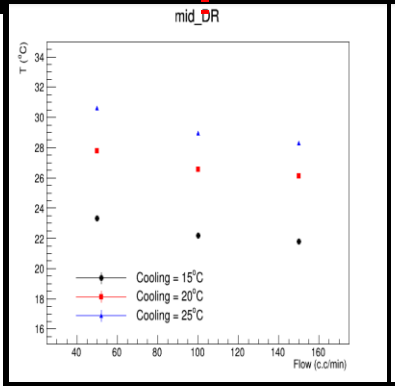


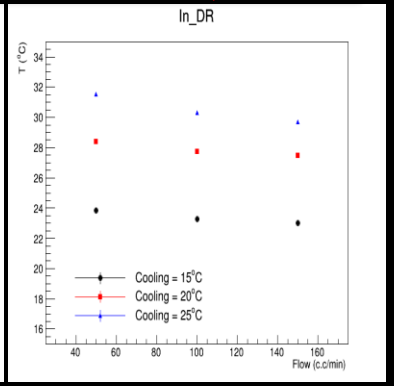




water







- Best cooling performance
  - High flow rate
  - Lower cooling temperature