Status of the ePIC-ZDC development

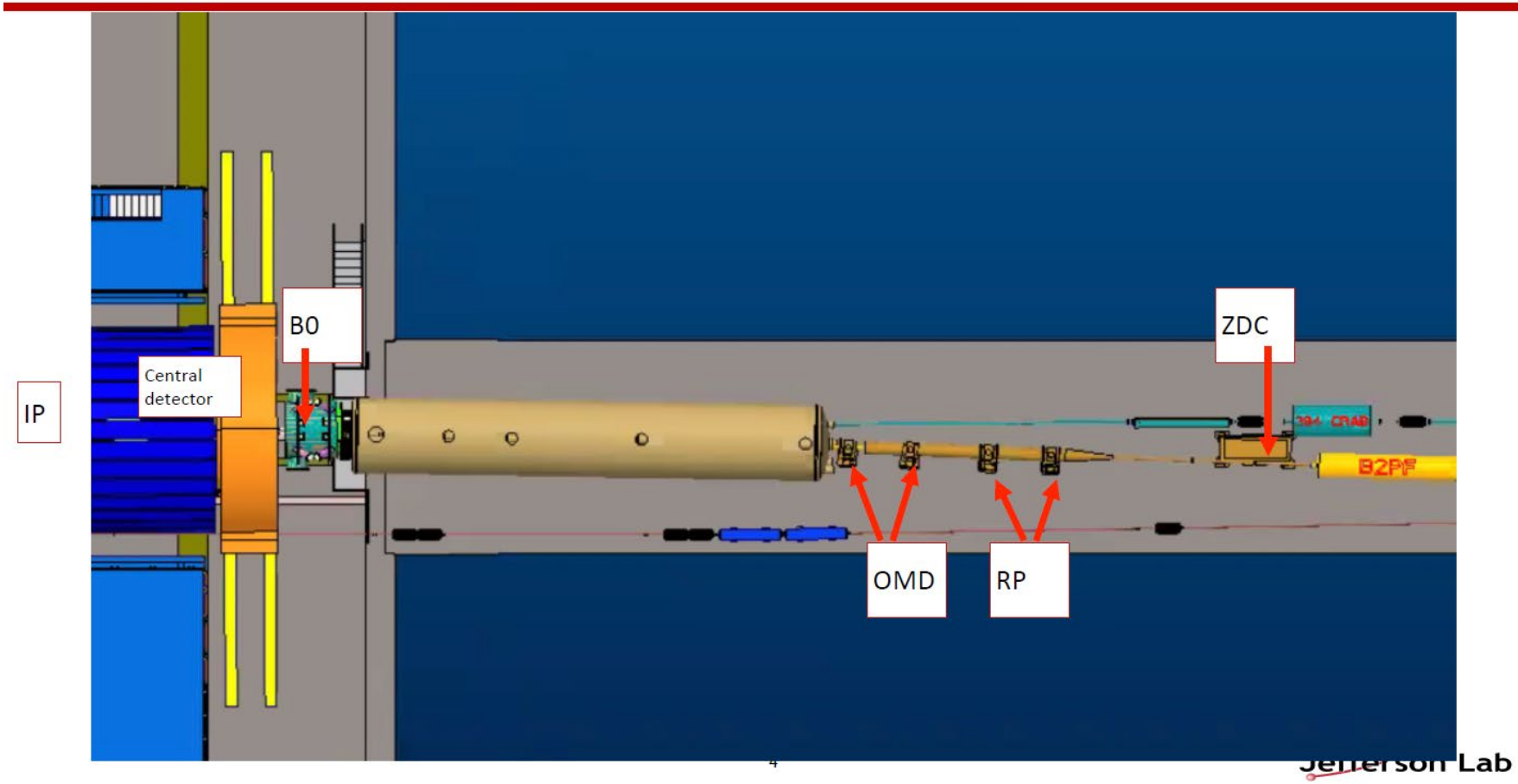
RBRC exp. group meeting

July 4th, 2023

Yuji Goto

Far-Forward detectors

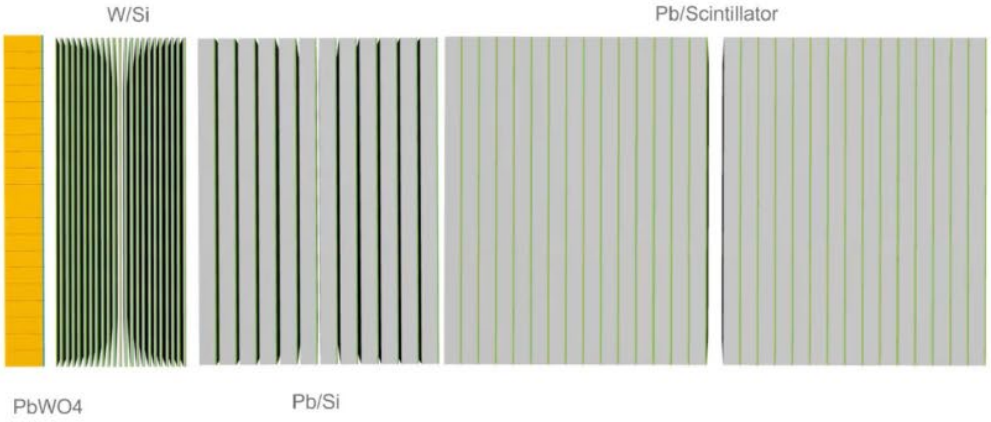
FAR-FORWARD DETECTORS

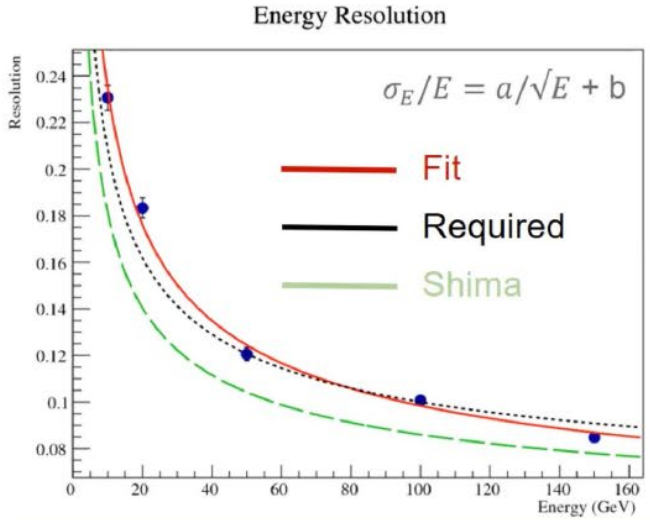


ZDC simulation by Po-Ju

ZDC RESOLUTION (NEUTRONS)

Po-Ju Lin (CEA- Université Paris-Saclay)





- Fit: $\frac{63\%}{\sqrt{E}} + 3.6\%$
- Required: $\frac{50\%}{\sqrt{E}} + 5\%$
- Shima: $\frac{44\%}{\sqrt{E}} + 4.2\%$

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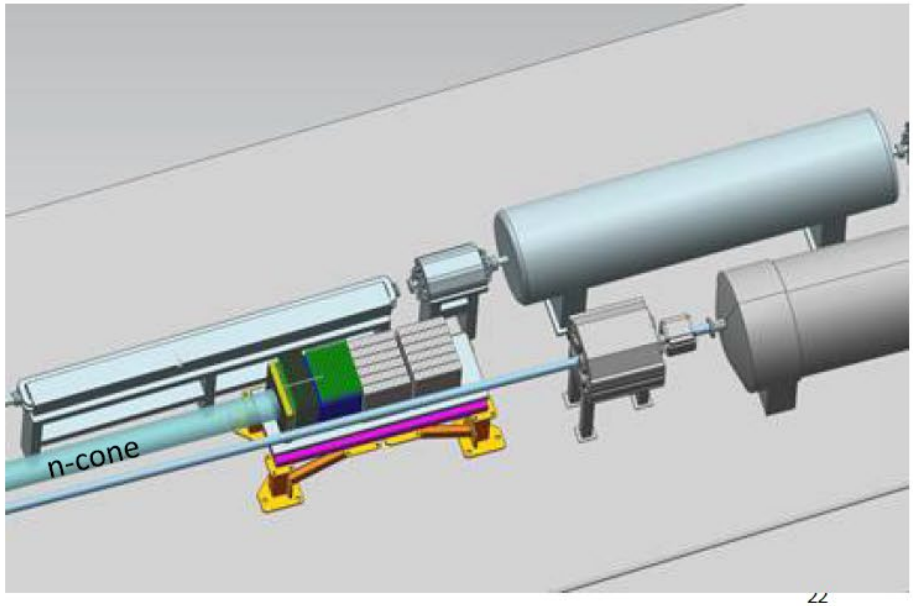
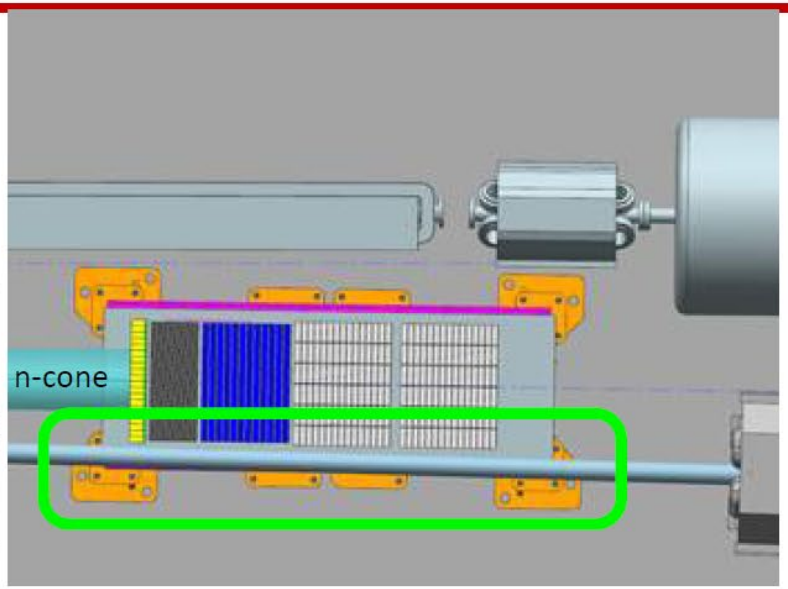
ZDC integration

ZDC

"Stay-clear" zone around the beam-pipe (1.5-3cm)
Placement of readout boards

Z-placement , transverse size





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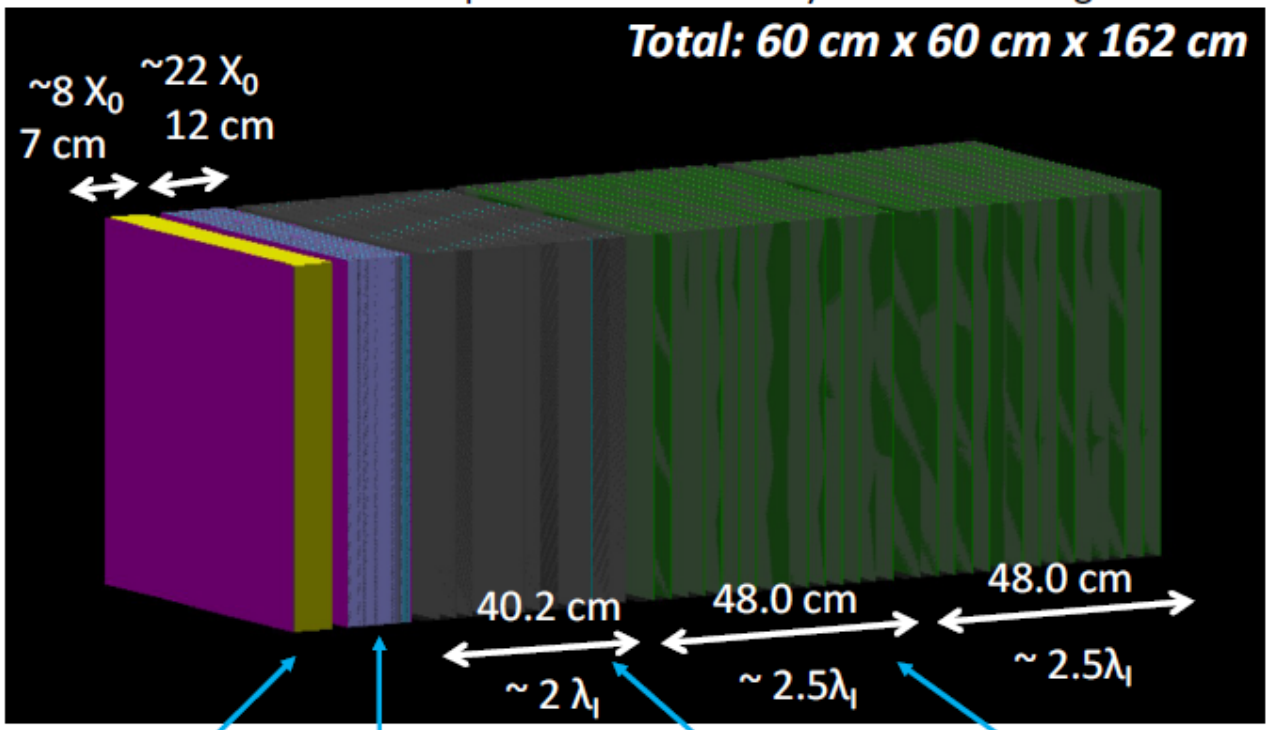
Task Assignment

- Timeline and goals
  - Pre-TDR → CD3a (2024.1)
    - No need because of no Long Lead-time Procurements
  - TDR → CD2/3 (2025.4)
    - Final design (80% ready): 2024.4?
    - Specs/docs/first article, etc.
  - Construction: 2025-2030?
    - Start: 2025.5?
  - Integration: 2030-2031?
- Review the detector design
  - Optimization including cost review
- Integration & Mechanical design
- Readout devices, electronics, DAQ
- Prototype production, test & evaluation
- Software development & simulation studies

ePIC-ZDC 1st design

Current ZDC design

*note: space for readout may extend the longitudinal length.



Crystal ($PbWO_4$) + Silicon Pixel layer

W/Si calo. 3 Pixel layers are inserted.

Pb/Si calo.

Pb/Sci. calo.

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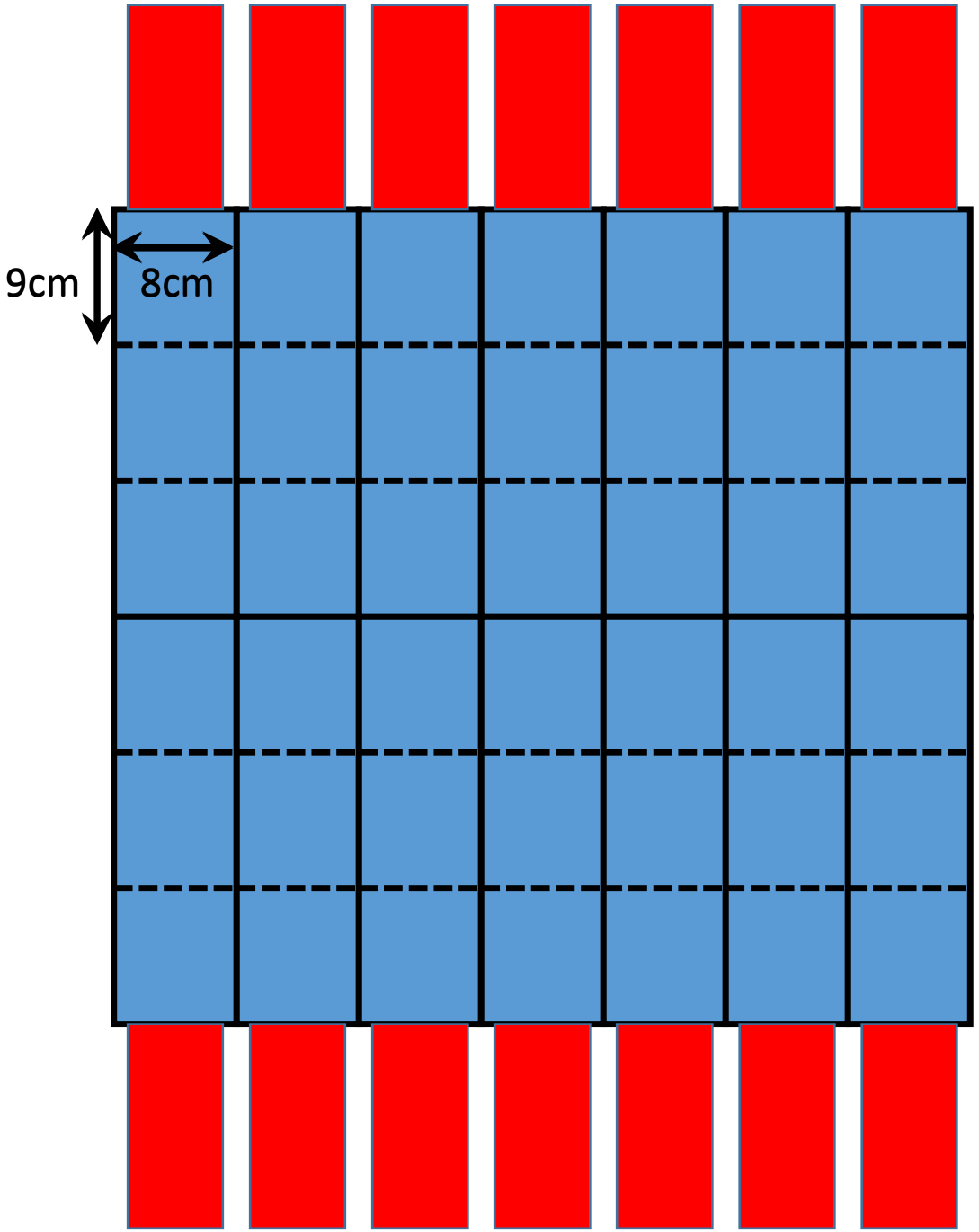
2023 task plan

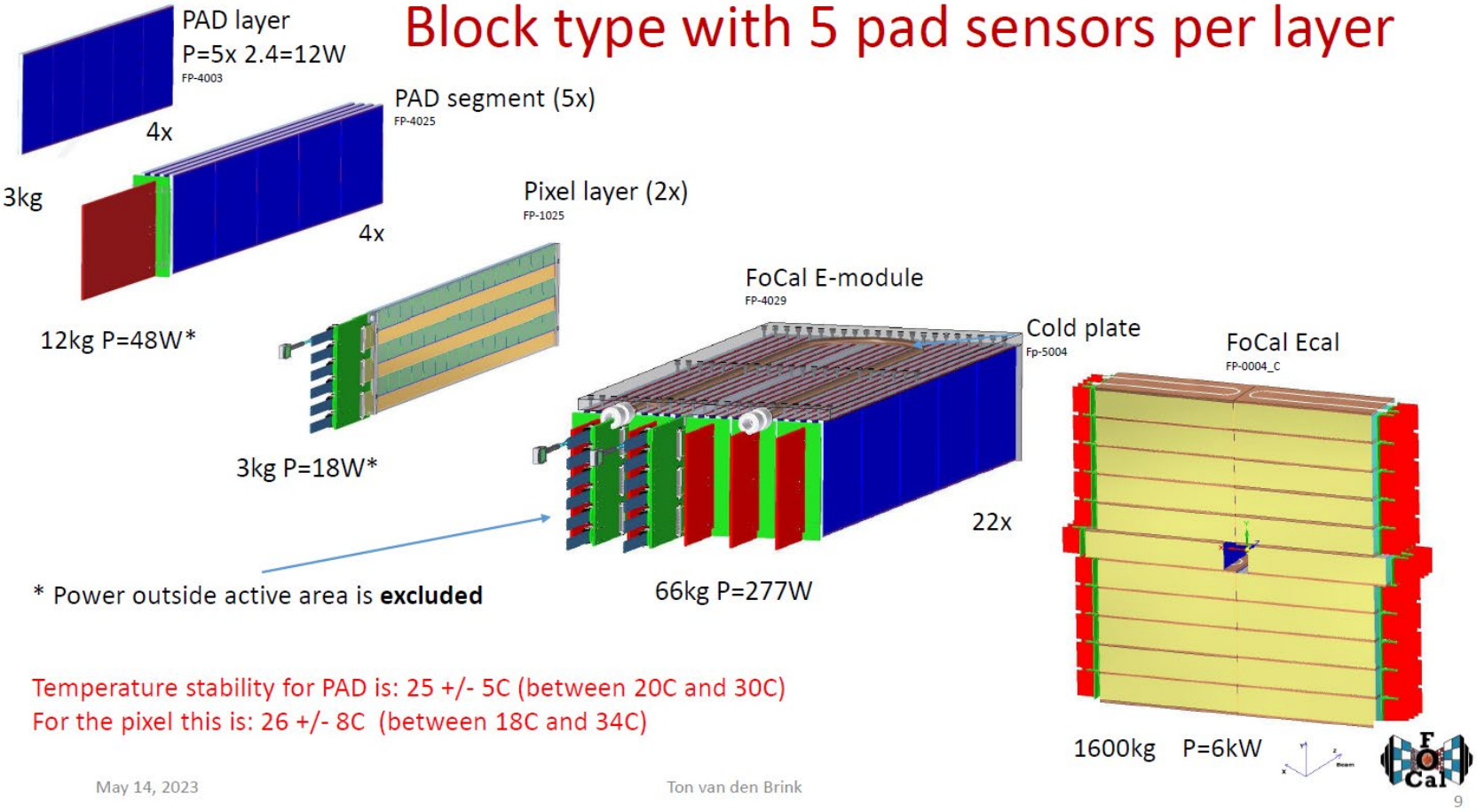
- Plan for “timeline & goals”
  - Plan and discussion for each task assignment
- Software development
  - Cooperation between US (PNNL) & Asia groups
- Simulation studies
  - Revisit radiation dose
  - Comparison with FLUKA result
- Prototype production
  - Crystal + Imaging calorimeter (W-Si)
- Test beam at ELPH, Tohoku Univ.
  - 2023 Autumn beam time
  - Participation of Asia (Taiwan) group
- Radiation tolerance test (neutron irradiation) @ RIKEN RANS
  - Comparison of new & old ALICE-FoCal-E Pad sensors

Review the detector design

- Crystal calorimeter
  - 1st design: 60cm x 60cm PWO crystal $8X_0$
  - Design update option:
    - Smaller lateral dimension? 60cm x 60cm necessary to cover lateral hadron shower leakage (EM shower leakage smaller)
- W-Si imaging calorimeter
  - 1st design: 60cm x 60cm W-Si $22X_0$ (22 layers)
  - Design update option:
    - Smaller lateral dimension? e.g. ALICE-FoCal-E Pad size 9cm x 8cm $\rightarrow$ 6 x 7 = 54cm x 56cm?
    - Smaller number of layers? e.g. $1X_0$ x 22 layers $\rightarrow$ $2X_0$ x 11 layers?
- Hadron calorimeter
  - 1st design:
    - Pb-Si $0.16\lambda_I$ x 12 layers (40cm)
    - Pb-Scintillator 10cm x 10cm x 48cm ($2.5\lambda_I$) tower, 10 x 10 x 2
  - Design update option:
    - No imaging (Pb-Si) layers?
    - Pb-(Scintillator + Fused silica) 10cm x 10cm x 48cm tower 4 x 4?


9cm
8cm

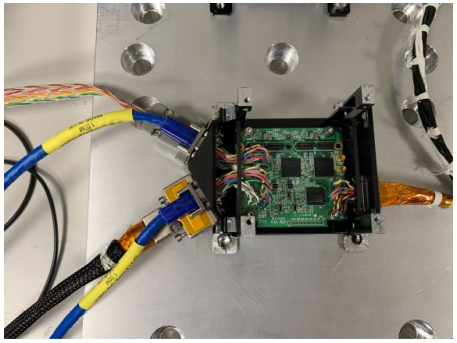
Block type with 5 pad sensors per layer



Temperature stability for PAD is: 25 +/- 5C (between 20C and 30C)
For the pixel this is: 26 +/- 8C (between 18C and 34C)

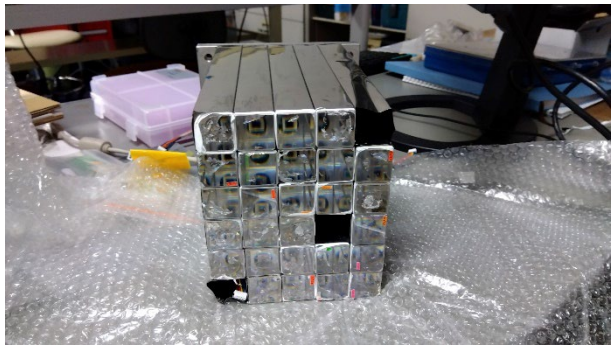
Crystal calorimeter prototype

- Plans by Taiwan group
  - Discussed today in the ePIC-ZDC discussion meeting
- Place the order for LYSO crystals
  - Need to determine the cross section area
  - Worry: large LY of LYSO so that saturation→ smaller cross section can be better (6mm x 6mm ?)
  - G4 study is underway to estimate the energy deposit with the beams at Tohoku university
- Purchase SiPM
- Design an adapted board
  - Readout board designed by Chih-Hsun Lin of Academia Sinica

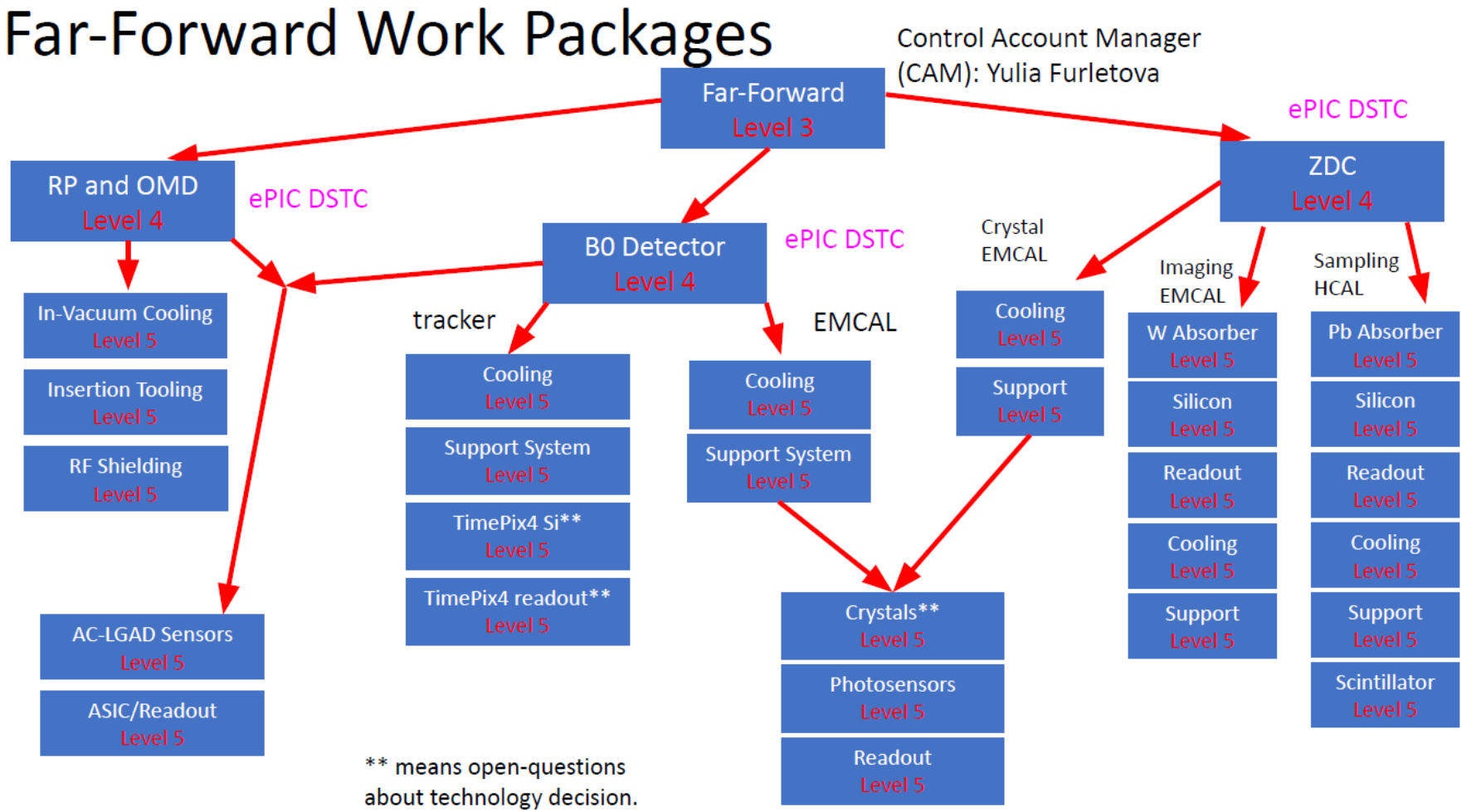


Crystal calorimeter prototype

- ALICE-Phos PWO prototype
  - Hiroshima Univ.
  - 2cm x 2cm x 18cm
  - APD readout
  - Shipped to RIKEN
  - Some towers to be sent to Taiwan for prototype module
- Evaluation using a test beam with FoCal-E W/Si-Pad



Far-Foaward Work Packages



ZDC Work Packages

- Crystal EMCAL
  - Taiwan group - NCU (Ming Kuo), Academia Sinica
  - Crystals (Common with B0 EMCAL)
    - Compare and select the type of crystal; PWO, LYSO, or else (incl. glass scintillator)
    - Optimize the size of the crystal by simulation calculations
    - Radiation hardness
  - Photosensors (Common with B0 EMCAL)
    - Compare and select the type of photo sensors; SiPM, APD, or else
    - Evaluate light yield and optimize design with crystal and photosensor combination
    - Radiation hardness
  - Readout (Common with B0 EMCAL)
    - Design readout scheme; ASIC and downstream; FPGA, bus, cable, etc.
    - Radiation hardness
    - Electrical engineer needed
  - Cooling
    - Evaluate how much cooling power required
    - Design the cooling system
  - Support
    - Evaluate how much support required and design modules
    - Design how to integrate modules as a detecgtor subsystem
    - Mechanical engineer needed

ZDC Work Packages

- Imaging EMCAL
  - RIKEN (Goto), Kobe (Yamazaki), Tsukuba (Chujo, Inaba)
  - W absorber
    - Simulation calculations to be performded to determine thickness and number of layers, or radiation length incl. the crystal EMCAL
    - Determined the size of the W plate and how to fix it
  - Silicon
    - Determine if ther are any changes to the FoCal-E Pad sensor
    - Consider how to realize the Pixel layer; small-Pad sensor, LYSO-SiPM (with timing information), or else
    - Radiation hardness
  - Readout
    - Consider whether to use HGCROC as well as FoCal-E Pad, dynamic range, etc.
    - Design readout scheme downstream from ASIC (HGCROC); FPGA, bus, cable, etc. (from top side or bottom side?)
    - Radiation hardness
    - Electrical engineer needed
  - Cooling
    - Evaluate how much cooling power required
    - Design the cooling system
    - Mechanical engineer needed
  - Support: Taiwan group
    - Evaluate how much support required and design modules
    - Design how to integrate modules as a detector subsystem
    - Mechanical engineer needed (Taiwan group?)

ZDC Work Packages

- Sampling HCAL
  - Korea group - Sejong (Yongsun Kim)
  - Absorber
    - Compare and select material; Pb, Cu, or else
    - Evaluate and optimize absorber + active (sampling) material to get correct ratio for compensation (e/h around 1)
  - Sampling method
    - Compare and select material; silicon, plastic scintillator, fused silica, dual-readout, etc.
    - Radiation hardness
  - Readout
    - Silicon sensor or photosensor, etc.
    - ASIC and downstream; FPGA, bus, cable, etc.
    - Radiation hardness
    - Electrical engineer needed
  - Cooling
    - Evaluate how much cooling power required
    - Design the cooling system
  - Support
    - Evaluate how much support required and design modules
    - Design how to integrate modules as a detecgtor subsystem
    - Mechanical engineer needed

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