Report from the ePIC Technical Coordinator Office

by the TC-Office:
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EICUG / ePIC meeting
Lehigh, July 22-27, 2023

Overview of the TC-office in shortform

- Facilitate the **finalization/completion of the ePIC detector design**

- **Support the (pre)TDR effort, detector sector**
  - It includes the parallel path to the **ePIC detector published paper**
  - One of the of the **major** present activity that will be extensively presented/discussed during the dedicated talk at the ePIC Collaboration meeting on Saturday morning
    → *not included in this talk*

- **Contribute to the integration EIC Project – ePIC Collaboration**
  - Bilateral contacts are ongoing:
    - DSCs – CAMs (IP6, needs in term of space and infrastructure)
    - DSCs – project engineers
  - InterDSC contacts at TIC meetings: an overall picture known to the whole collaboration in all its components (subsystems, analysis and physics, software and computing) is not easily available → **TC-office initiative aim at overcoming this difficulty**

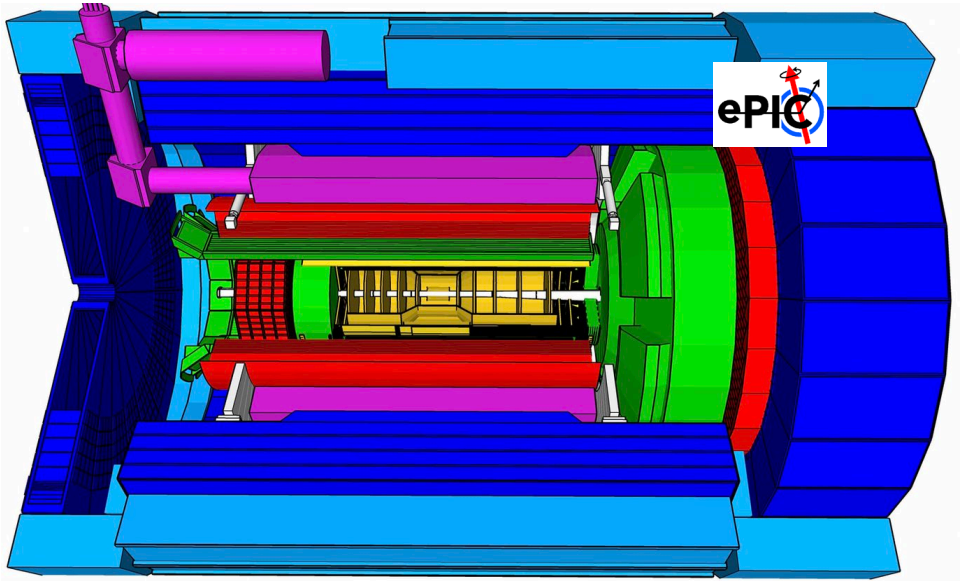
OUTLOOK of this report

- **The ePIC detector, an introduction**
- **ePIC detector aspects deserving emphasis**
  - **Synergistic aspects and efforts within the ePIC detector (by relevant examples)**
  - **Open questions in the detector design**
- **Other TC-office actions to support DSCs**

The ePIC DETECTOR:

the combined EIC PROJECT and ePIC COLLABORATION efforts

ePIC (designed for IP6 at EIC) is the **Project Detector**



ePIC is the detector to which the **ePIC Collaboration** is dedicated

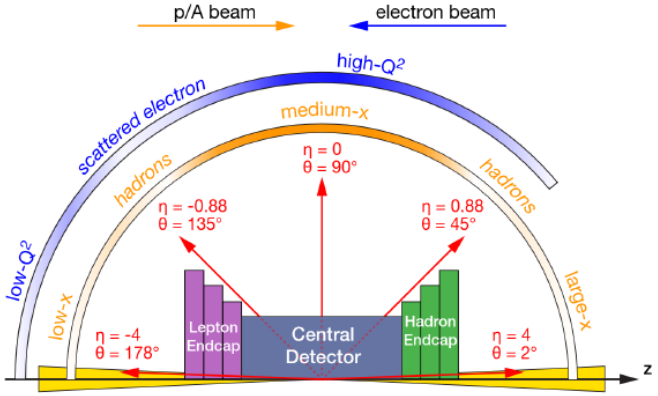
The community (Project and Collaboration) has turned the challenge arising from this dual nature of the ePIC detector into the opportunity for a highly coherent and effective effort.

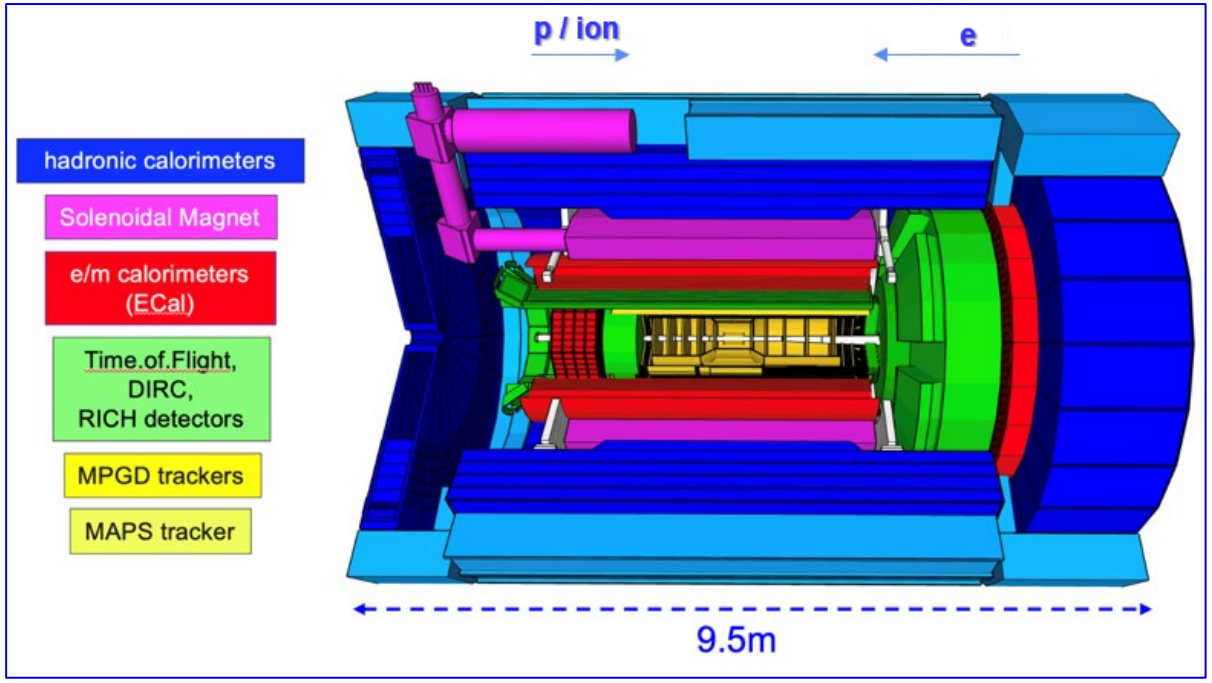
There are **specific missions**:

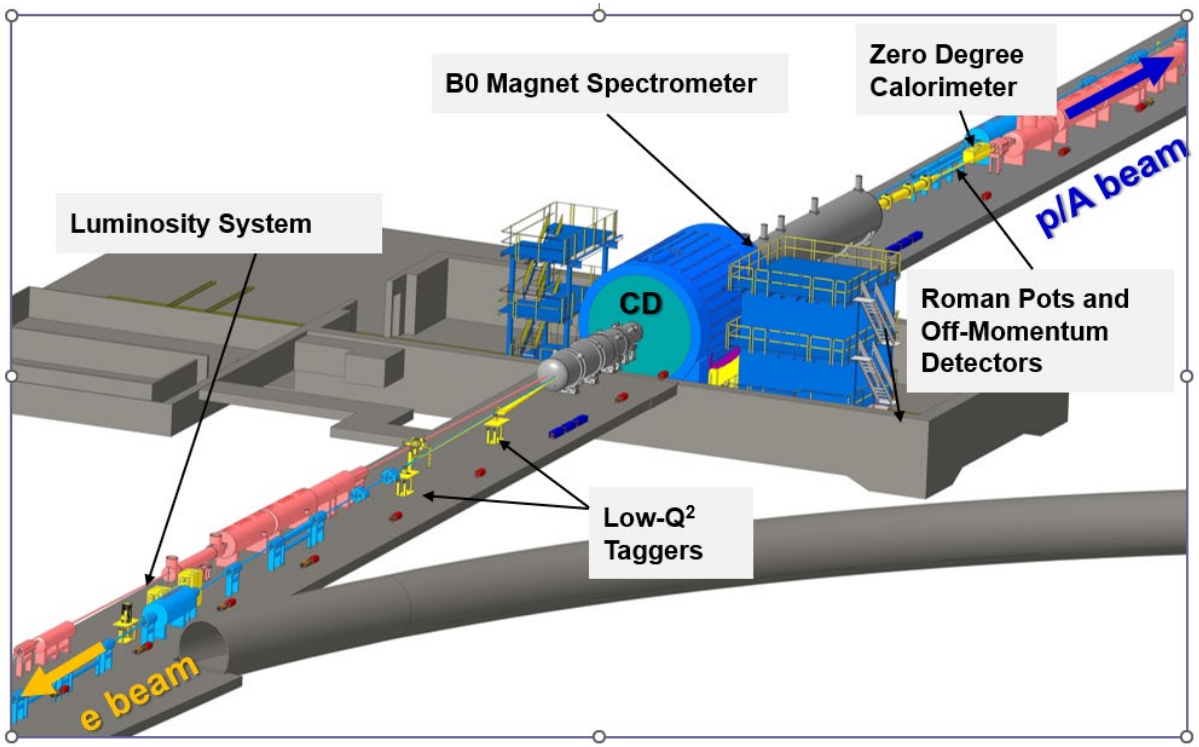
- Project: ensure that all aspects related to the EIC project realization and completion are satisfied;
- Collaboration: optimize the physics reach of the detector and manage the Collaboration to make it functional, effectively operative and a professionally sound environment

Beyond these specificities, **Project and Collaboration are synergistically cooperating** across the two missions towards the common goal:
a detector matching the overall EIC physics scope.

The ePIC detector, gross features well-known







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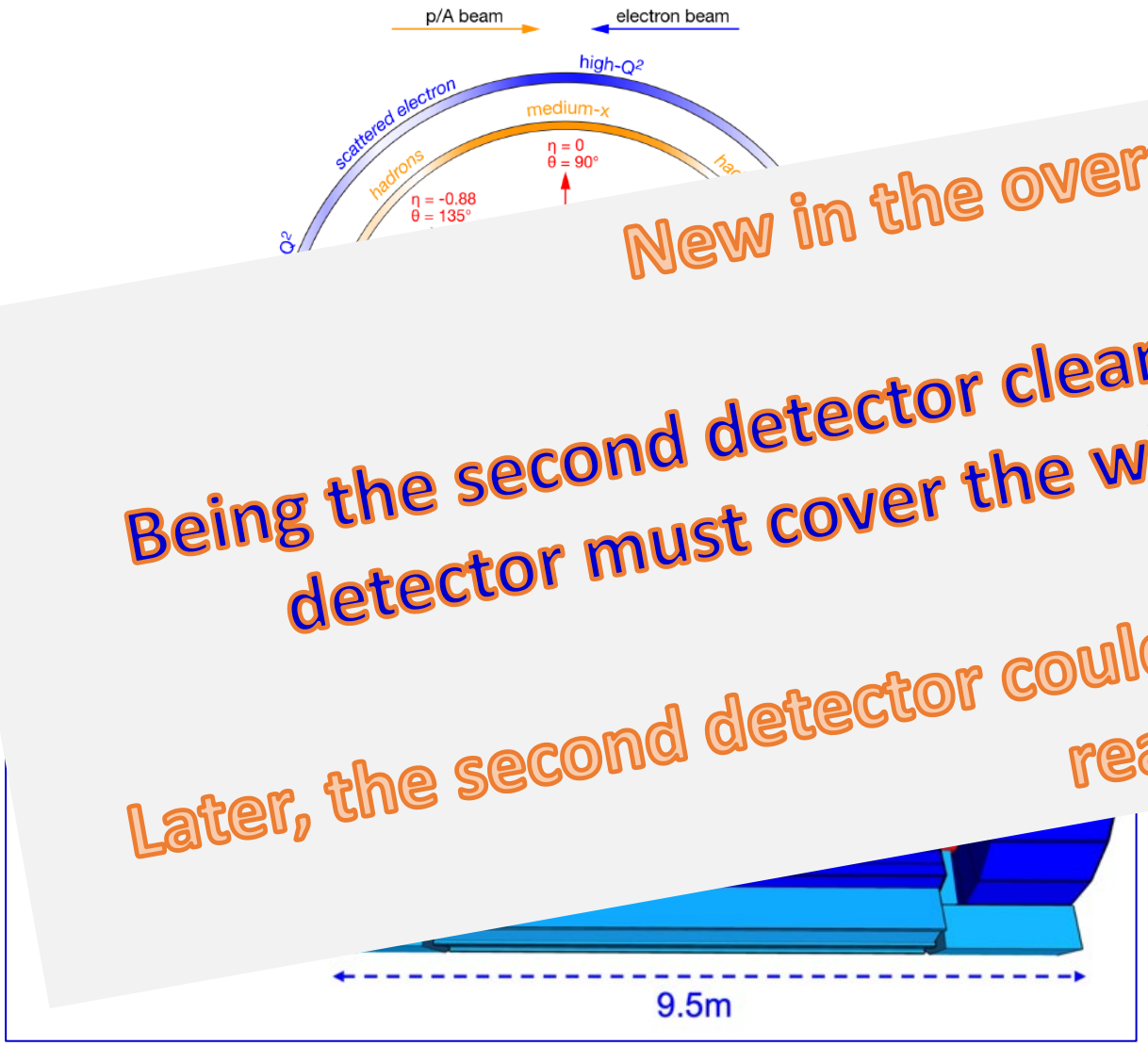

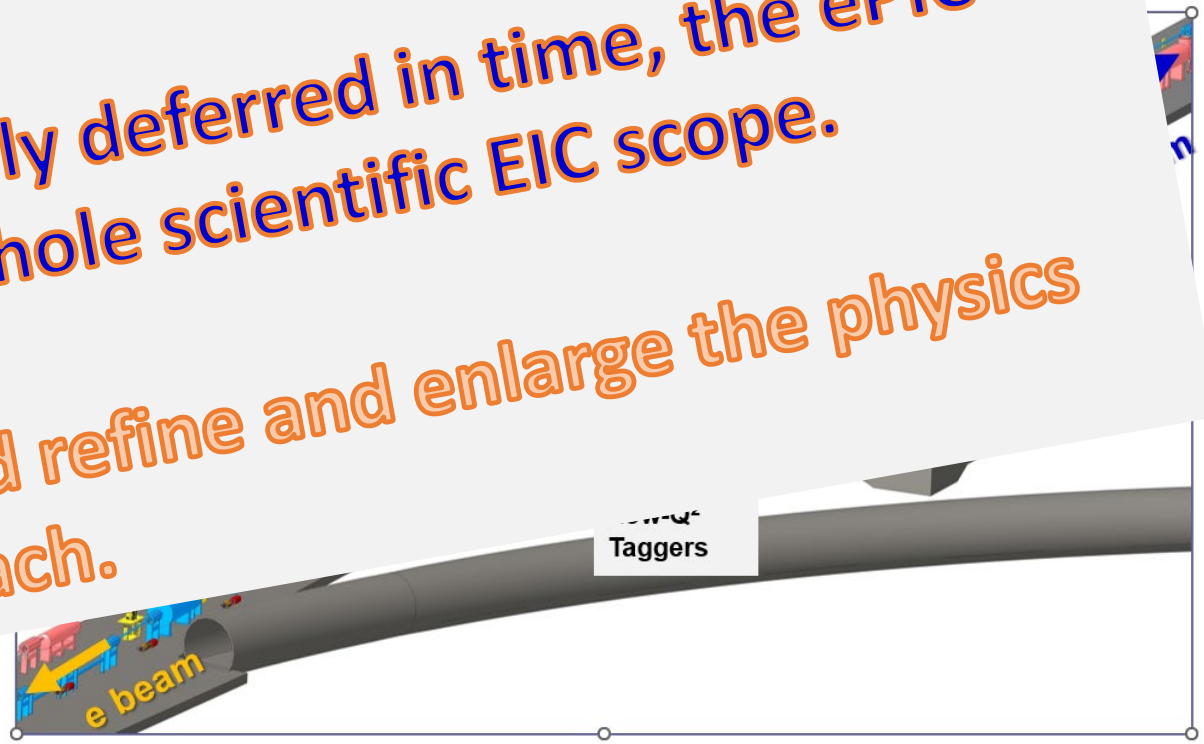

New in the overall context:

Being the second detector clearly deferred in time, the ePIC detector must cover the whole scientific EIC scope.

Later, the second detector could refine and enlarge the physics reach.

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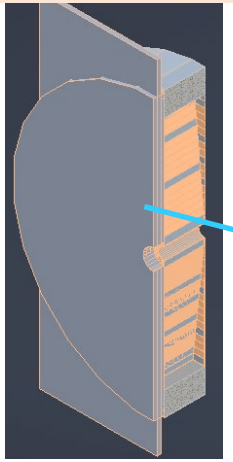
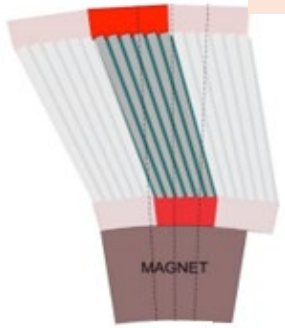
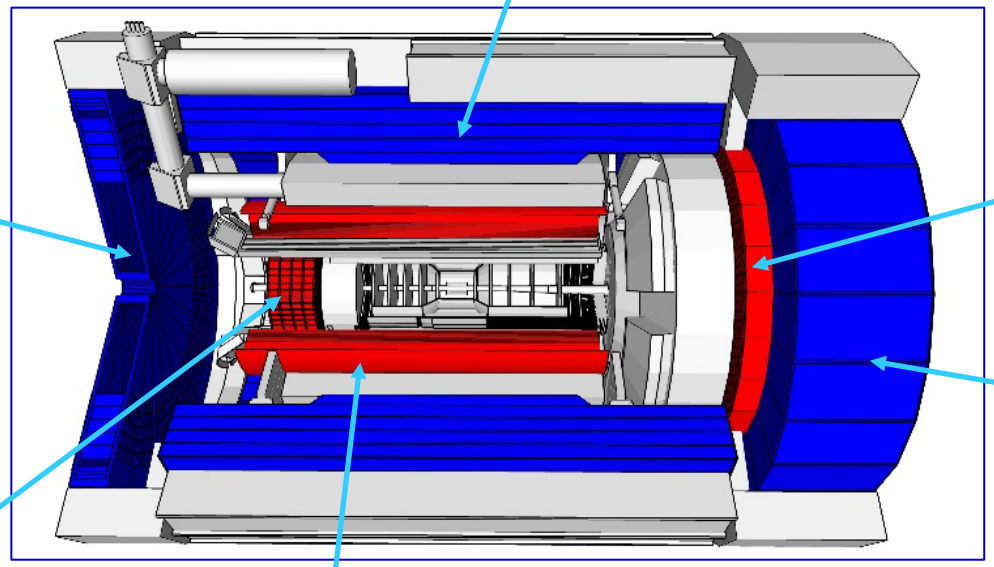
ePIC Calorimetry

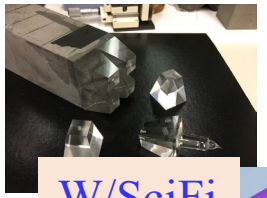
Steel/scintillator



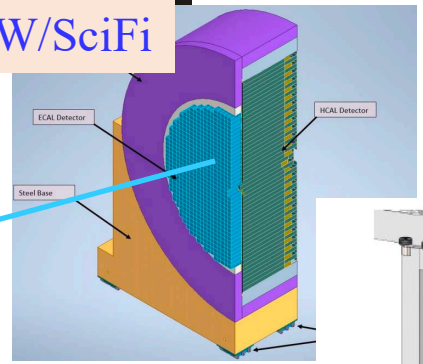


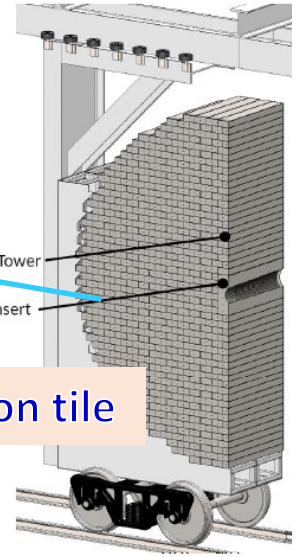
Steel/scintillator





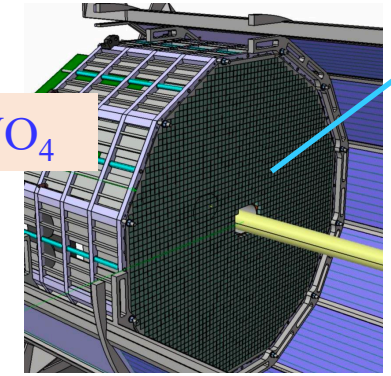
W/SciFi



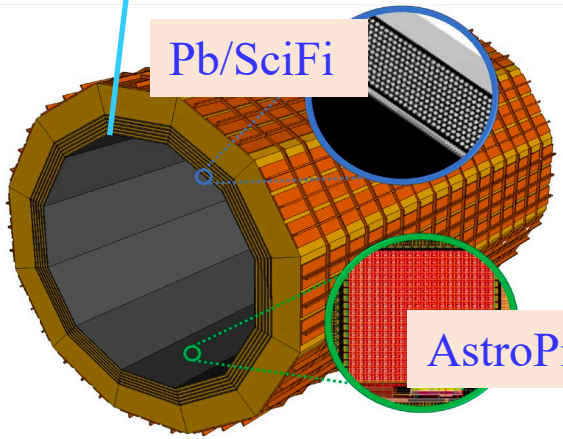


SiPM on tile

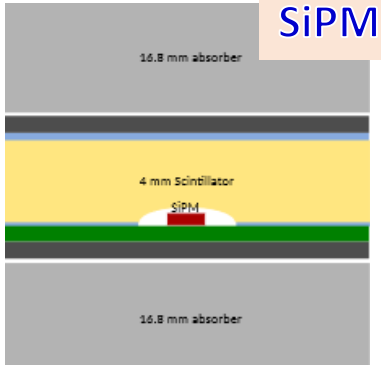
$PbWO_4$

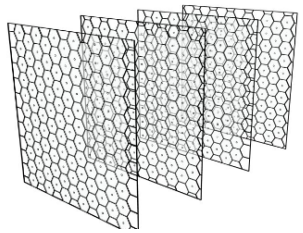


Pb/SciFi



AstroPix





Synergies in ePIC Calorimetry

SiPM sensors for all Calorimeters in ePIC

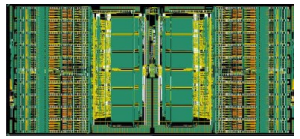
- **SiPMs recently introduced in calorimetry**
- direct experience from the applications in GlueX, STAR and sPHENIX

Relevant SiPM features for ePIC calorimetry

- **Cost-effective** technology
- Operation in **magnetic field**
- Wide **dynamic range** with tuned parameters
- Low noise with **appropriate thresholding**

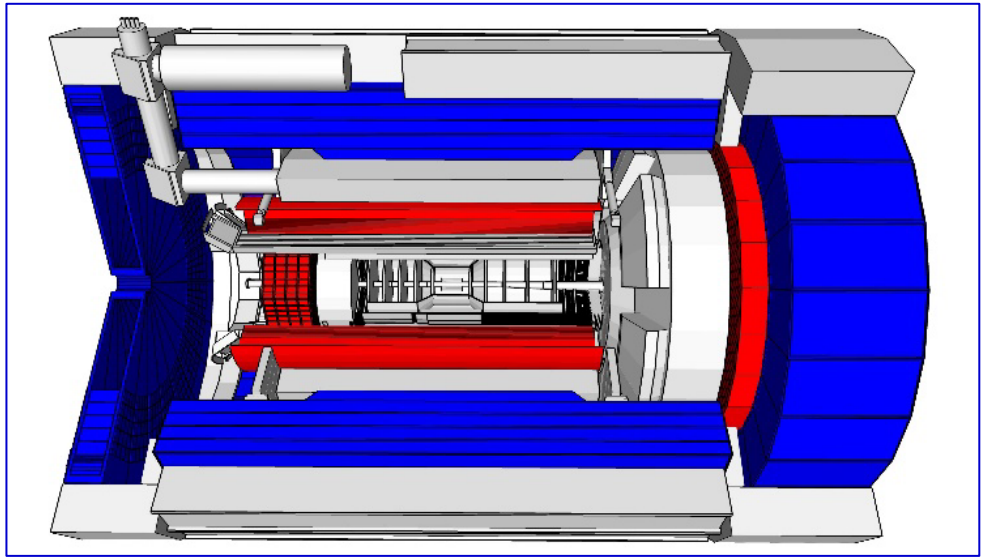
- Effect of the radiation: Irradiation campaigns on-going
  - **Fully synergistic: validation of SiPMs for all the calorimetry applications (a ref.:** B. Schmookler, TIC mtg, July 8, 2024)

SiPM type	Number Irradiated	Proton fluence range ($1/cm^2$)	Under consideration for which ePIC Calorimeter(s)
S14160-6050HS	20	$10^8 - 10^{13}$	PECal, FHCal(Insert), ZDC, BECal
S14160-6015PS	16	$10^8 - 10^{13}$	PECal, EEEMC, BECal
S13360-6050VE	10	$10^8 - 10^{12}$	BEMC
S14160-3015PS	18	$10^8 - 10^{13}$	FHCal(Insert), ZDC, EEEMC
S14160-3010PS	8	$3.5x10^8 - 5.4x10^{10}$	EEEMC
S14160-1315PS	15	$10^8 - 10^{13}$	FHCal(Insert), ZDC
S13360-1350CS	6	$10^9 - 10^{11}$	None (comparison)



→ The same FEE ASIC for all calo SiPMs

- **HGCROC → CALOROC**
  - To be confirmed for EEEMC, testbeam in October-November 2024



Calo SOFTWARE

- **At present, 2 main development lines:**
  - Implementation of cluster merging tuning both ECal/HCal parameters
  - Improving Truth-cluster association

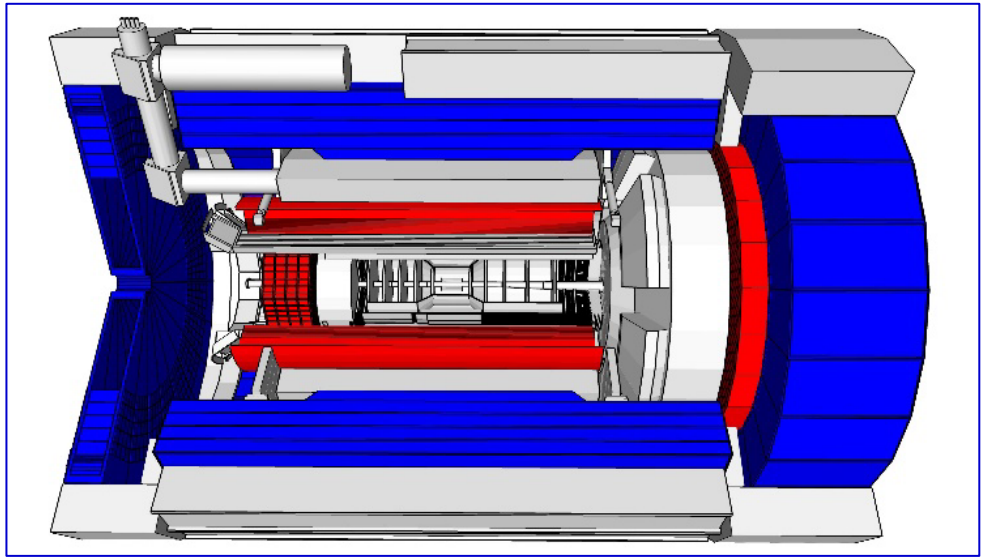
- **These developments are synergistic for all calorimeters**
  - Each progress step is tested on the different devices

A ref.: F. Bock, TIC mtg, July 15, 2024

Synergies in ePIC Calorimetry, more

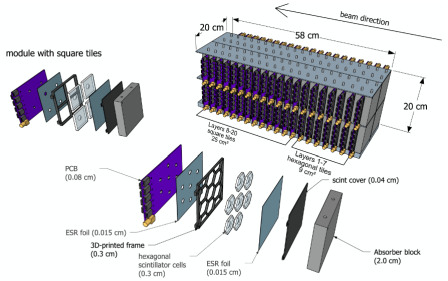
The approach by “SiPM on Tile” also for the backward HCAL?

- **LFHCAL + Backwards HCAL Work Fest** at the ePIC mtg, Thursday afternoon

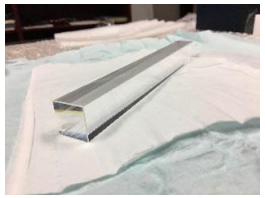


LFHCAL insert for the HCal section of the ZDC

- Test beam in view of both applications ongoing at STAR

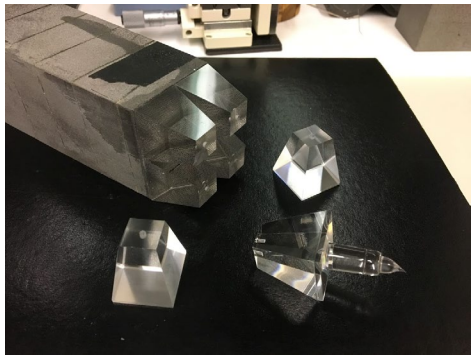


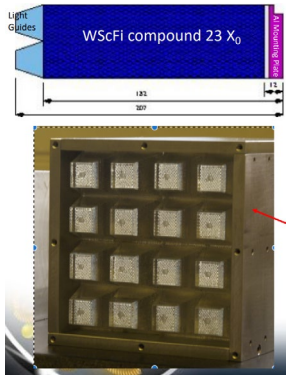
$PbWO_4$ crystal for EEEMC and calorimetry in B0



FEMCAL technology also adopted for the far detectors

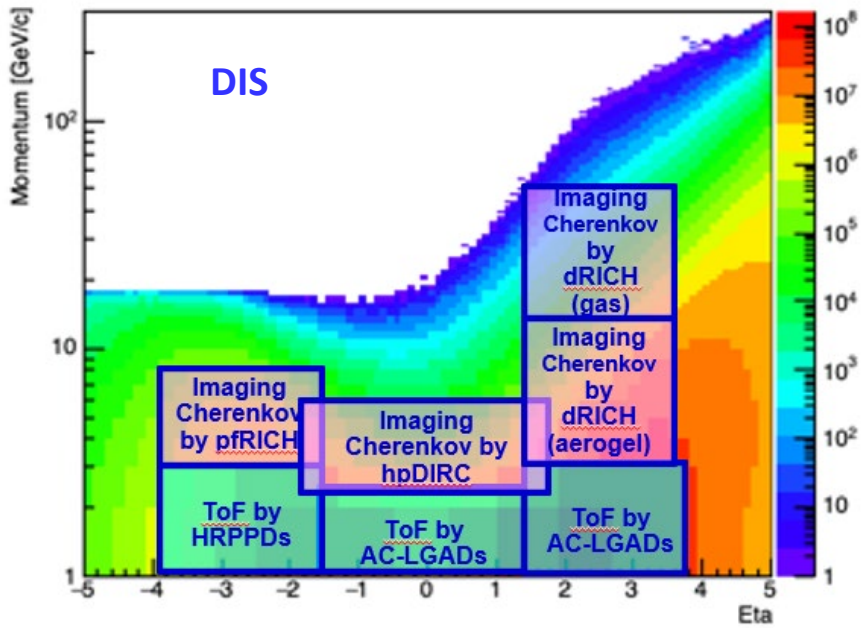
- Luminosity System: Both for Pair Spectrometer and High-Rate Ecal
- Calorimetry elements of the low Q^2 taggers

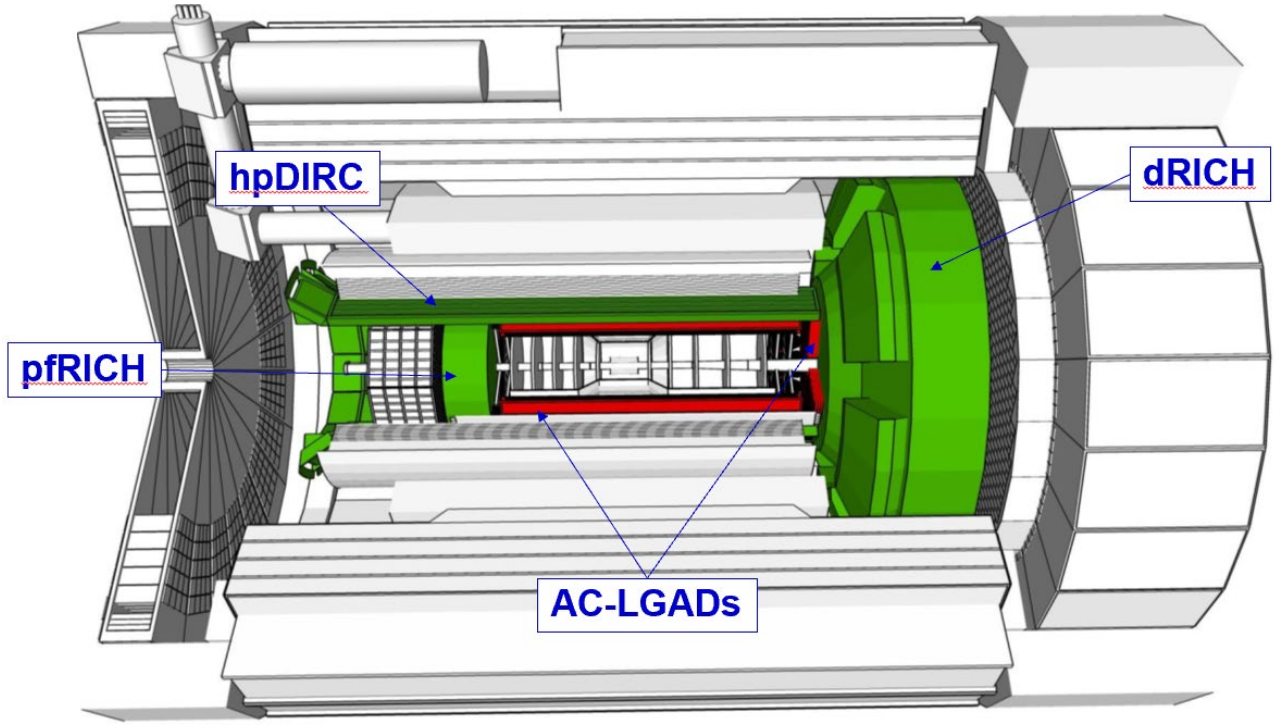




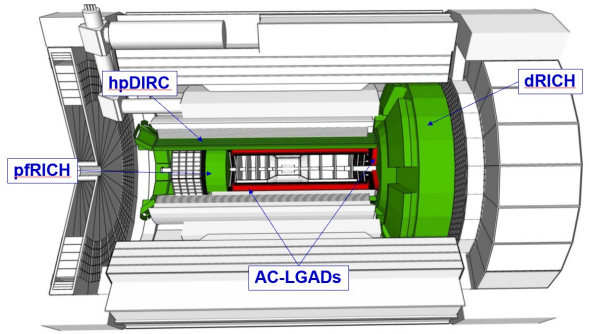
ePIC PID

Here performance areas are with reference to 3 σ π/K separation

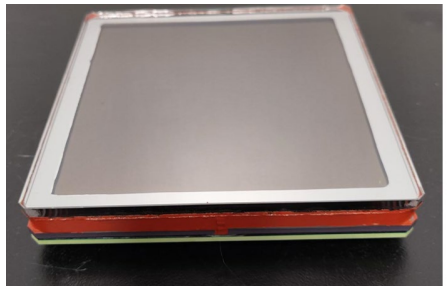




Synergies in ePIC PID and beyond



MCP photosensors



- **pfRICH baseline: HRPPDs by INCOM**
- **hpDIRC baseline: MCP-PMTs by Photek**
  - hpDIRC is seriously considering the use of HRPPDs
  - pfRICH has defined important parameters of the engineered HRPPDs so to make them compatible with hpDIRC requirements:
    - Size, now 12 x 12 cm^2
    - Pad size: 3 x 3 mm^2
- Common approach for the FEE ASIC is also been considered

Aerogel in dRICH, pfRICH

- Different refractive index values
  - dRICH is considering 1.02 → 1.026
  - pfRICH has as reference ~1.04
- Full synergies for **aerogel QA**
- Synergies pursued within the **RICH Consortium**

AC-LGADs, the sensors of the ToF layers, have wide applications in the far detectors

- Pixelized AC-LGADs for **tracking in B0, RMs** and **OMDs**
- Strip or pixel AC-LGADs for tracking in the **Luminosity Pair spectrometers**

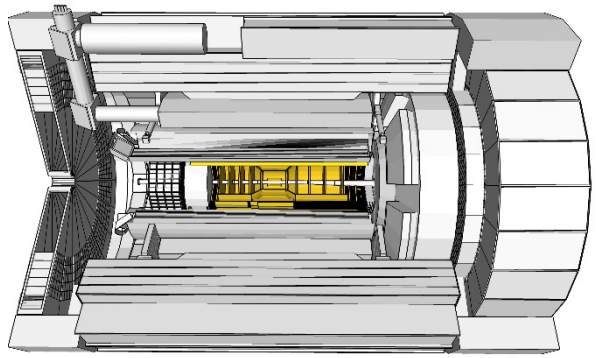
PID SOFTWARE for RICHes

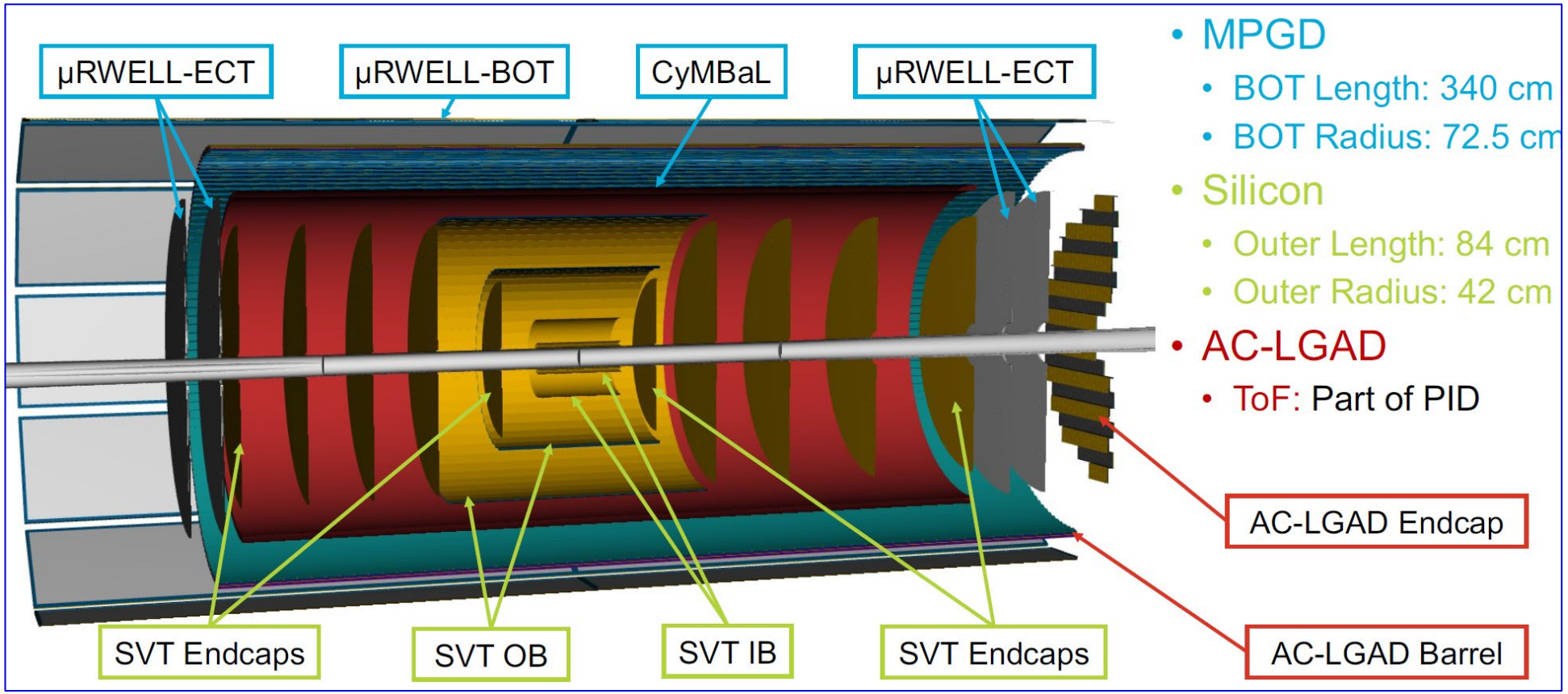
- **dRICH, pfRICH**

- IRT1, initially used for both
- IRT2: substantial set forward not yet working within EICRecon

- Synergies pursued within the **RICH Consortium**

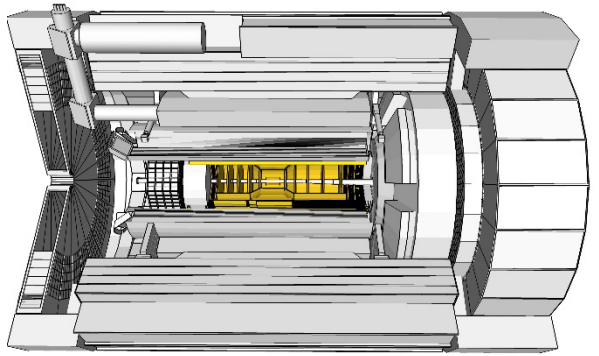
ePIC tracking



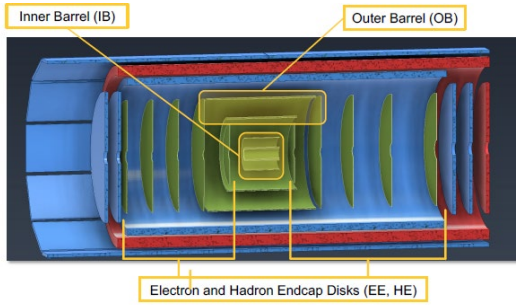


- MPGD
  - BOT Length: 340 cm
  - BOT Radius: 72.5 cm
- Silicon
  - Outer Length: 84 cm
  - Outer Radius: 42 cm
- AC-LGAD
  - ToF: Part of PID

Synergies in ePIC tracking



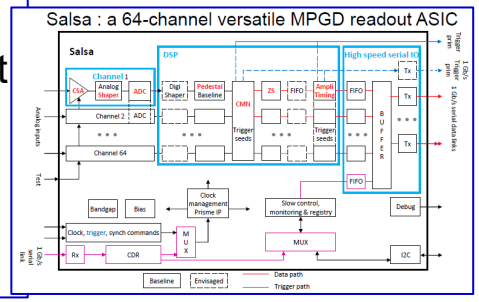
Inside SVT



- **Synergy is straight forward evident**
  - MOSAIX (ITS3) will evolve in the SV
  - For the larger surfaces: EIC-LAS is also an evolution, more articulated, from MOSAIX
  - → **a single DSC!**

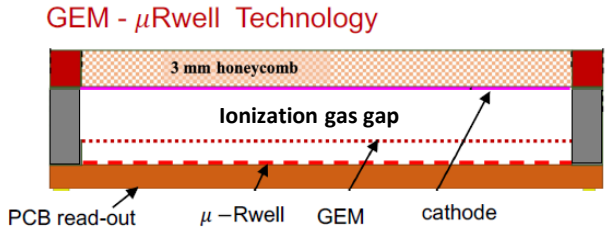
MPGD read-out

- **A single FEE ASIC, SALSA**, under development by to be adopted by all the ePIC MPGDs (CyMBaL, mRWELL-BOT and mRWELL-ECT)



μRWELL-BOT and μRWELL-ECT

- Both selecting the hybrid architecture with **μRWELL** complemented by a **GEM** preamplification layer



ToF layer by AC-LGADs complementing tracking information

- Already included in the present reconstruction

Tracking reconstruction

- A single major effort (> 10 contributors) based on ACTS

ALL MPGDs

- 2-D read-out architectures and related challenges

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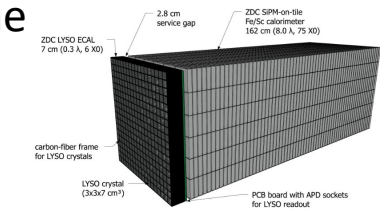
Main open questions in the detector design

- **Requiring mainly simulation studies:**
  - simulations dedicated to soft gamma and to vector meson production in order to optimize the **ZDC configuration**
    - UCR and Regina U. robustly at work;
    - Self-proposed contribution at this meeting
  - motivation and requirements for the **backward HCal**
    - the activity needs to move towards a better focus and more robust organization;
  - needs in term of space resolution for the **outer MPGD**
    - In progress (typically discussed at the MPGD-DSC-Simulation meetings);
  - impact on physics of **dRICH with single vessel vs dRICH with split vessel**
    - In an extremely preliminary status; now (just last week!) the geometrical parameters have been consolidated so to make

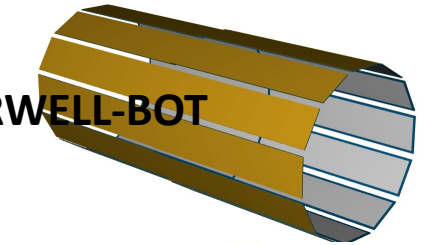
- **Requiring mainly hardware studies:**
  - Technology and architecture for the **backward HCal** (Work Fest on Thursday afternoon)
  - Use of **FEE ASICs** (CALOROC) **for EEEMC** ? (testbeam Ott.-Nov. 2024)
  - Selection of **AC-LGADs for the luminosity PSs** (pixels vs strips)
  - HRPPDs for **hpDIRC** ?

- **Requiring starting decisions:**
  - An **event tagger** is assumed within the streaming r-o model; not yet any reference model: a dedicated Work Fest on Friday afternoon

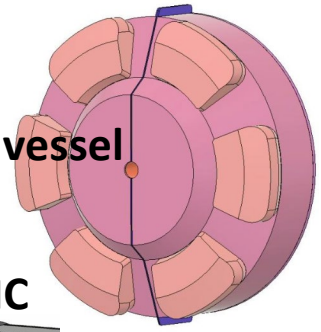
ZDC



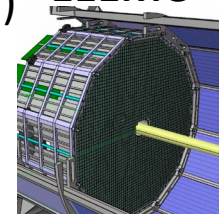
μRWELL-BOT

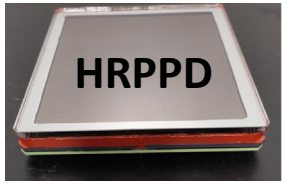


dRICH vessel



EEEMC





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More actions to support the DSCs

Detector DB, more and more needed by the DSCs

- **Requirements finalized on May 16:** https://docs.google.com/document/d/1ow1nfy8dsrI1CfTBkG6kUJ0Oy2MZONhAktLy-zevJ1E/edit
- **The selection of the implementation tool is on the way**

Collecting and advertising main hardware steps

- Reports at TIC meeting about **testbeams, rad-hard campaigns, major steps in the labs**
- Recently:

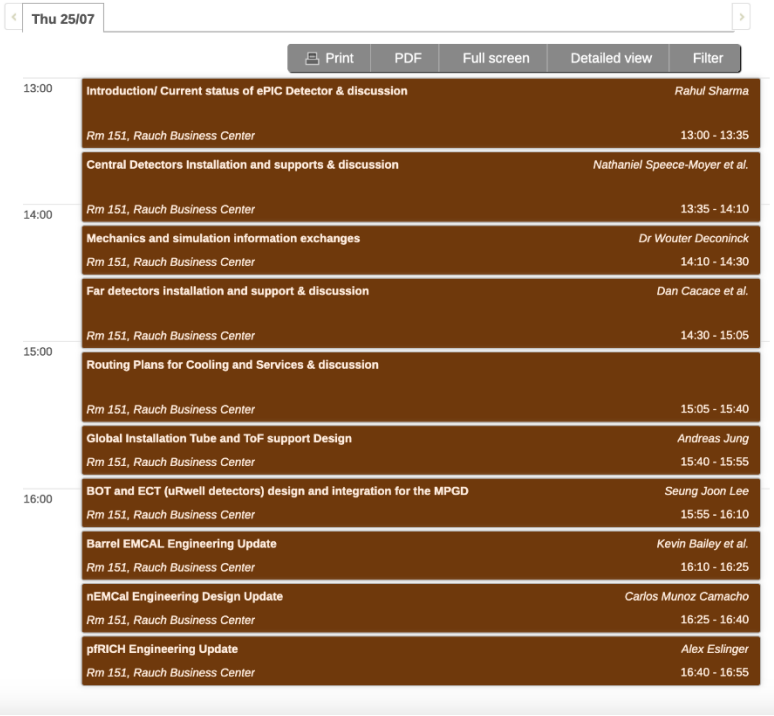
5/13: **photosensors for PID Cherenkov subsystems**, updates of hardware studies
Constant progress in establishing SiPms for these applications
Initial characterization of the first HRPPD units
5/20: progress of **ASTROPIX** development
6/3: a report concerning the delivery of the **BaBar quartz bars** at Jlab
6/17: news from the **first ITS3 testbeam**
6/24: news from the **dRICH test beam; TimePix4** news
7/8: forward **HCal insert/ZDC prototype** testbeam at STAR; **rad-hard studies** for the calorimetry SiPM, an update

More actions to support the DSCs, cont.

MECHANICS and INTEGRATION

- **A link between project and ePIC collaboration, Project engineers reports at TIC meeting, recently**
  - TIC meeting, March 11, 2024
  - TIC meeting, June 3, 2024

- New approach: **INTEGRATION and INSTALLATION WORK FEST** (Thursday afternoon)
- **Inspired by the successful**



- Participation of Several Project Engineers confirmed

- Mechanics and simulation information exchanges

From subsystems:

- BOT and ECT (uRwell detectors)
- EEEMCAL
- pfRICH
- BIC (Barrel Imaging Calorimeter)
- TOF support/ GST/ IST (Andy)

More actions to support the DSCs, cont.

Slow control, monitoring, calibration

- a dedicated TIC meeting with initial indications from DSCs on **built-in calibration systems** on January 22, 2024
- A **slow control session** at the TIC meeting on July 1, 2024
- Resulting **status:**

- **Project proposal:**
  - **Slow Control based on the opensource EPICS software tools**
  - **the hart of the hardware is a set of PLCs, which will**
    - **issue interlock**
    - **apply slow control commands**
    - **monitoring and storage of detector parameters (T, currents, magnetic filed, pressures, …)**
  - **Data from the Slow Control system also be acquired by the DAQ system to be included in the output data stream.**

- **Needed to progress**
  - **A more advanced conceptual model**
  - **A centralized PLC software development**
  - **A centralized selection of the PLC family**
  - **A better-defined model of interplay between Slow Control and DAQ architecture**

- **Following steps, after a more advanced model is made available:**
  - **Form a slow control-dedicated task force with contributors from DSCs ?**

Summarizing

- The **TC-office is at work to support the ePIC detector** with complementary actions respect to the project detector activity

- The **subsystems are progressing** thanks to the dedication and expertise of the ePIC Collaboration Institutions
  - There are great potential of synergistic collaboration, in several cases already ongoing
  - DSCs are invited to more and more implement synergies, being this a beneficial path for the ePIC detector

- The TC-office is following the technical/technological open points **and invites DSCs to discuss about together to progress towards detector finalization**

- Dedicated **efforts are ongoing**:
  - Integration
  - Detector DB
  - Slow control system
  - Shared hardware information

Thank you

Backup