ePIC Collaboration
Technical Coordinator Report

Silvia Dalla Torre
on behalf of the TC-office

ePIC Collaboration Meeting
ANL, January 8-13, 2024

OUTLOOK

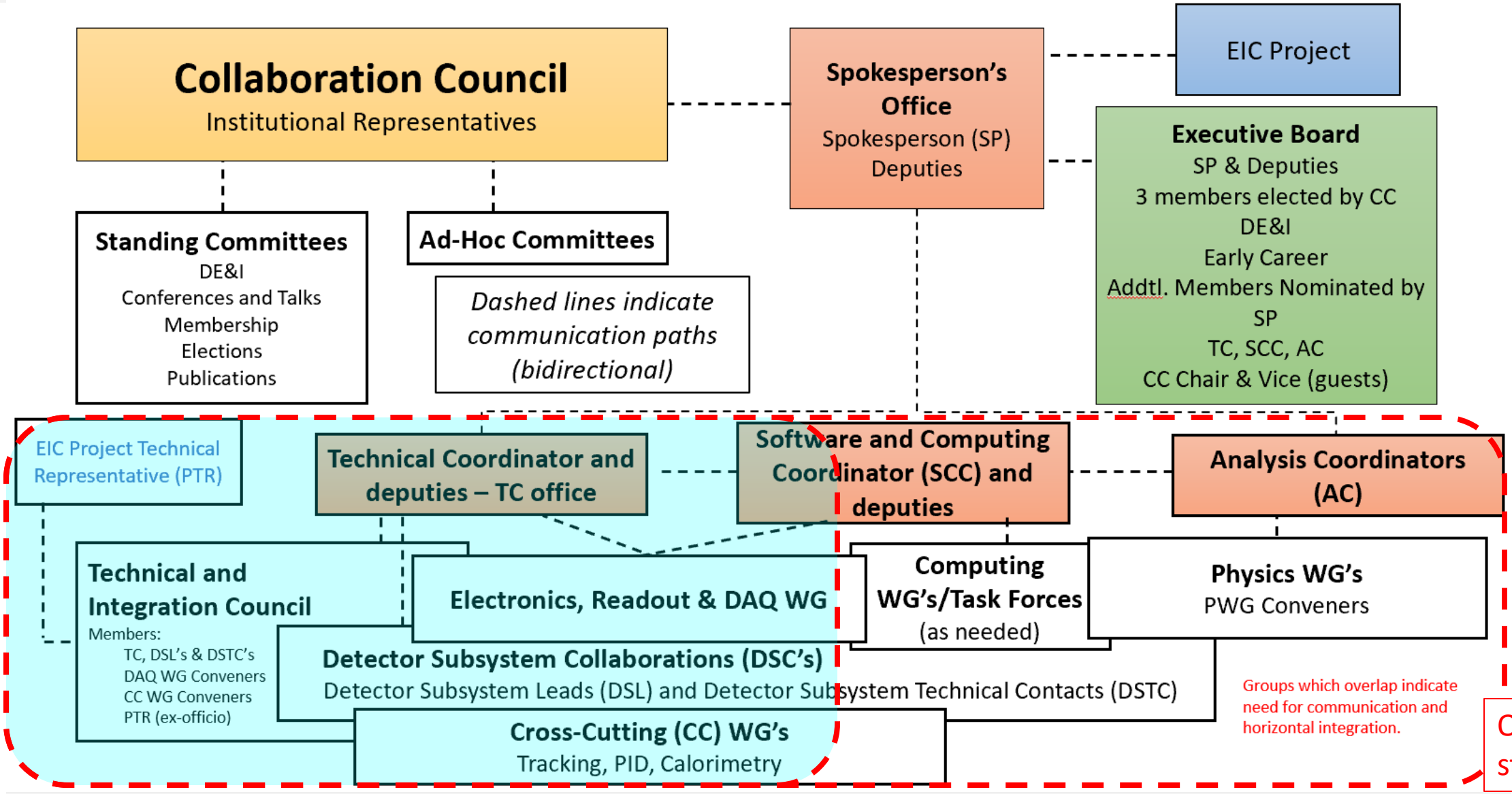
- The ePIC structure to address the detector activity
- Developing the Technical Design Report
- The major ePIC detector challenges in front of us

TC and TIC, a historical note

- **TC and TIC is in operation since April 2023**

- **An important legacy from the GD/I (Global Detector/Integration) WG**
  - Active in period May 2022- April 2023
  - GD/I conveners:
    - Silvia Dalla Torre, Jin Huang, Richard Milner, Carlos Munoz Camacho, Joe Osborn, Thomas Ulrich
  - It contributed to the design of the global detector during the first year of ePIC's life
  - **This WG is the pre-cursor of TC and TIC, which have largely built-up on this basis**

Focus on the operative structure of the ePIC Collaboration



Focusing on the operative structure

An update to the structure suggested by a deeper analysis of the ePIC collaboration

TC-office members

Silvia Dalla Torre
Acting as TC

Prakhar Garg (Yale)

Oskar Hartbrich (ORNL)

Matt Posik (Temple)

EIC Project Technical Representative (PTR)

Technical Coordinator and deputies – TC office

Software and Computing Coordinator (SCC) and deputies

Analysis Coordinators (AC)

Technical and Integration Council
Members:
- TC, DSL's & DSTC's
- DAQ WG Conveners
- CC WG Conveners
- PTR (ex-officio)

Electronics, Readout & DAQ WG

Computing WG's/Task Forces
(as needed)

Physics WG's
PWG Conveners

Detector Subsystem Collaborations (DSC's)
Detector Subsystem Leads (DSL) and Detector Subsystem Technical Contacts (DSTC)

Cross-Cutting (CC) WG's
Tracking, PID, Calorimetry

Groups which overlap indicate need for communication and horizontal integration.

Focusing on the operative structure

Weekly TIC meetings:

- The forum where the collaboration is addressing the detector needs to cope the whole EIC physics scope and proposing the path to the ePIC management

September 2023

- 25 Sep TIC meeting - status of RO/DAQ information from DSCs; Feedback from recent DAC reviews
- 18 Sep TIC meeting - Update on MPGD's
- 11 Sep TIC meeting - FEE (non-HGCROC/EICROC), Cooling
- 07 Sep TIC meeting - Backgrounds

August 2023

- 21 Aug TIC meeting - Far Backward Detectors and Integration
- 14 Aug TIC meeting - gaseous trackers
- 07 Aug TIC meeting - ASIC Discussion

December 2023

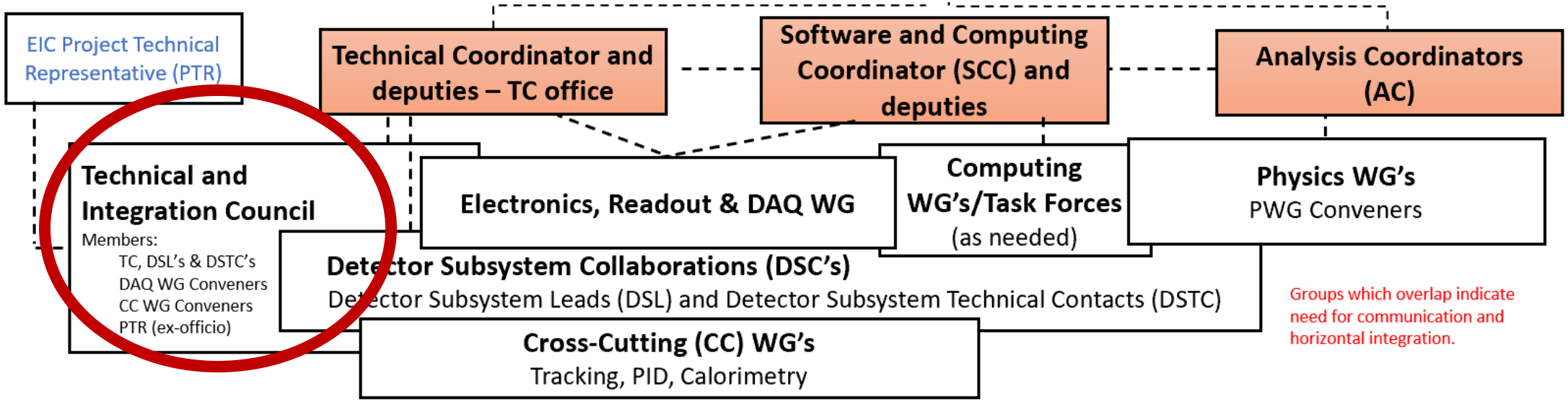
- 18 Dec TIC meeting - ZDC updates, converge towards Design definition
- 11 Dec TIC meeting - integration update from the project engineers; collect information for radhard studies
- 04 Dec TIC meeting - electronics status; photon sensor update for Cherenkov devices

November 2023

- 27 Nov TIC meeting - Update about electronics open points (transceivers, HGCROC)
- 20 Nov TIC meeting - EIC R&D for 2024; ZDC: requirements, radiation dose, updates
- 13 Nov TIC meeting - NO TIC MEETING THIS WEEK
- 06 Nov TIC meeting - photosensors for Cherenkov subsystems and risk mitigation

October 2023

- 30 Oct TIC meeting - Tracking Risk Mitigation Plan
- 23 Oct TIC meeting - Test Beam Needs, Simulation Thresholds
- 16 Oct TIC meeting - detector description in simulations; far backward
- 09 Oct TIC meeting - ZDC
- 02 Oct TIC meeting - barrel ECal



Focusing on the operative structure

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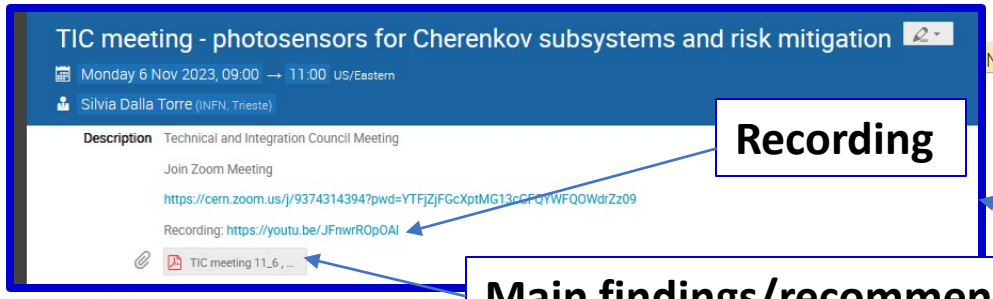

Recording

Main findings/recommendations

December 2023

- 18 Dec TIC meeting - ZDC updates, converge towards Design definition
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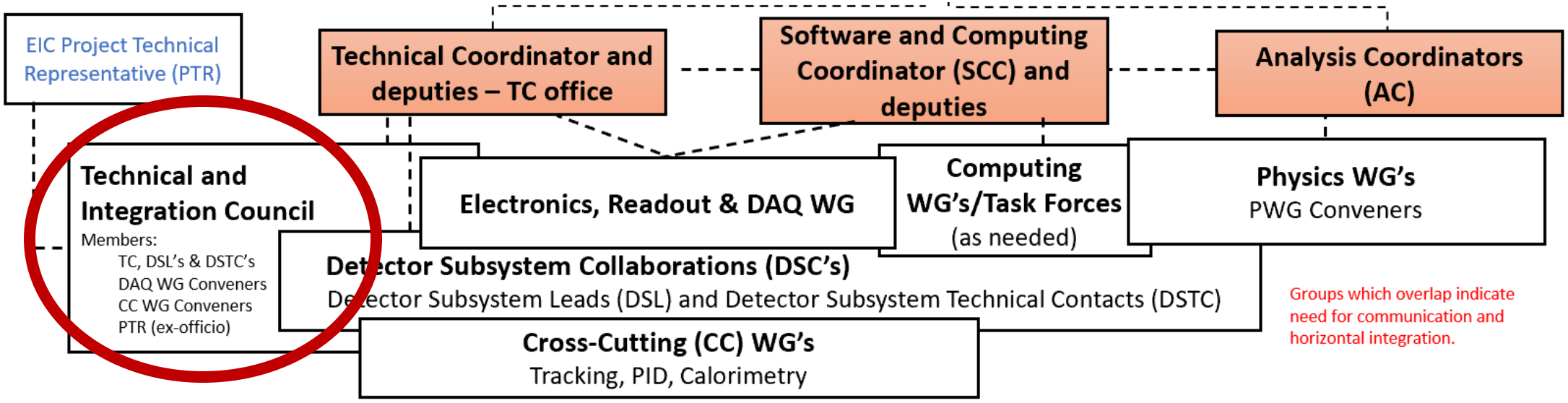


Groups which overlap indicate need for communication and horizontal integration.

Focusing on the operative structure

Weekly TIC meetings:

- The forum where the collaboration is addressing the detector needs to cope the whole EIC physics scope and proposing the path to the ePIC management

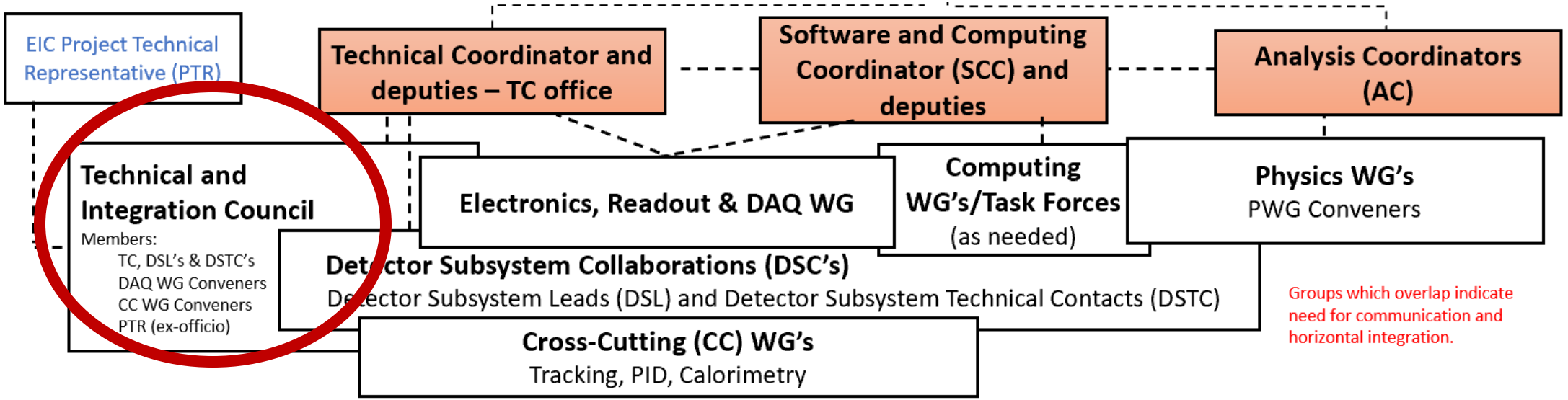
Coming TIC meetings

February 2024

- 12 Feb TIC meeting - Tracking update
- 05 Feb TIC meeting - Cooling

January 2024

- 29 Jan TIC meeting - DB for detector information
- 22 Jan TIC meeting - Update on radiation hardness studies - built-in calibration systems/tools;

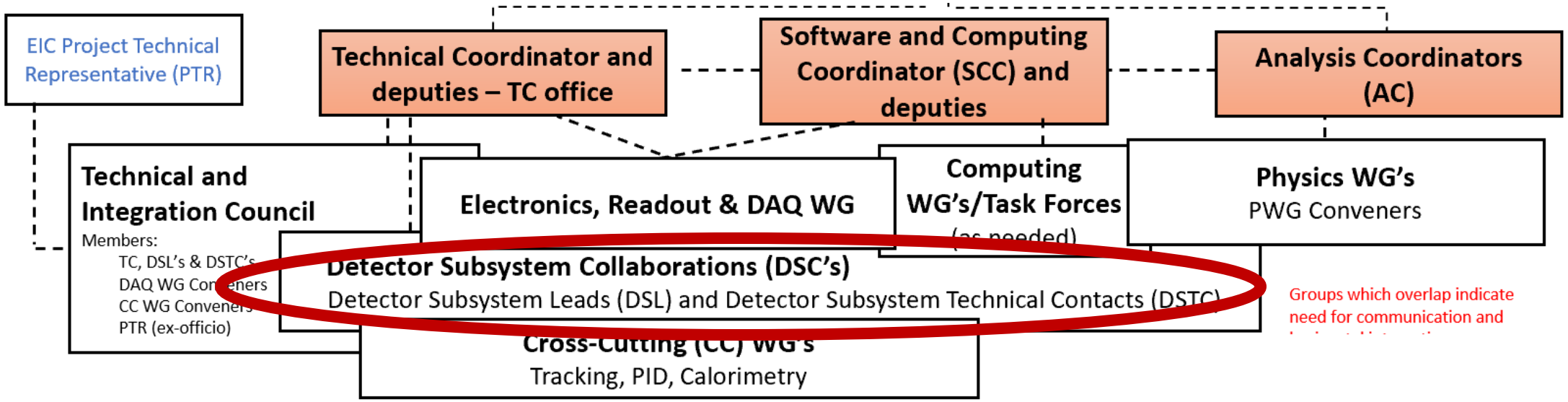


Focusing on the operative structure

The DSCs (Detector Subsystem Collaborations)

- DSC's in ePIC are organized around the **design, R&D and construction of specific subsystems in the ePIC detector**. The collaborations themselves are comprised of the people and institutions committed to realizing a particular subsystem

- **DSC activity coherence with EIC Project** ensured integrating key DSC persons in the Project structure: DSC leaders integrated in the project management at level 4, task coordinators in DSCs at level 5

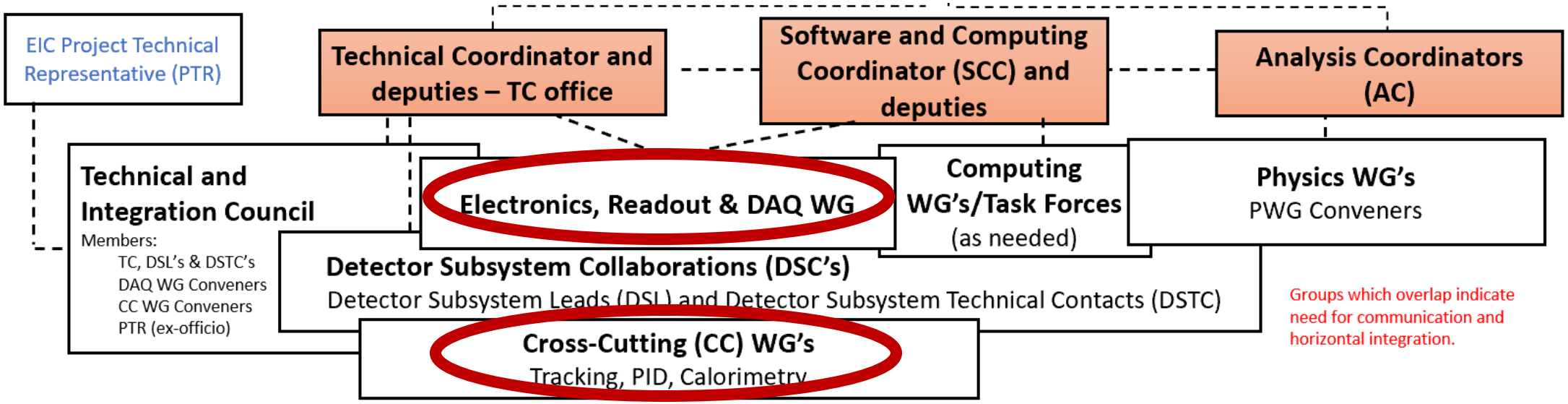


Focusing on the operative structure

The Working Groups

- ***Electronics, readout & DAQ:***
  where the whole read-out chain is designed, up to the streaming r-o DAQ making the bridge with data analysis (SCC's report)

- ***Tracking, Calorimetry, PID, Far Forward/Far Backword CC WGs:***
  a forum for synergies among subsystems with communalities

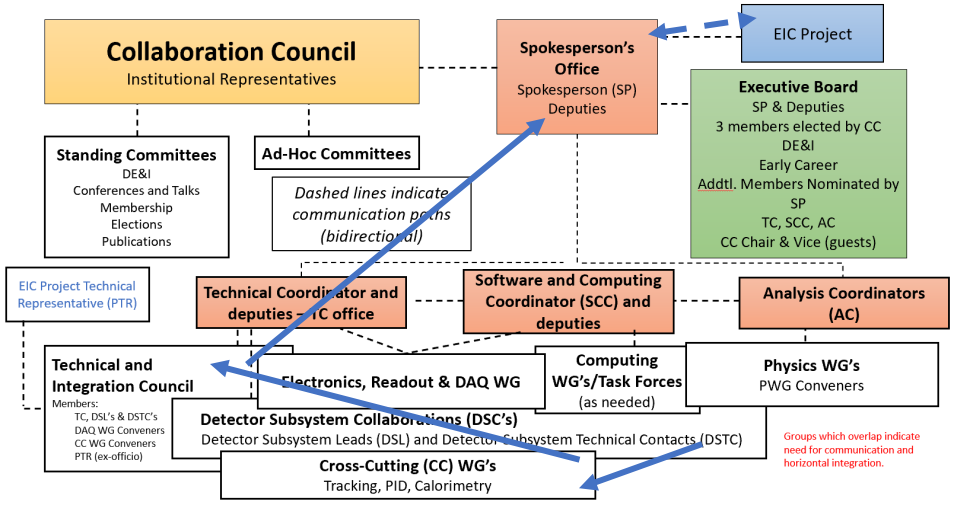


An effective structure for technical detector design

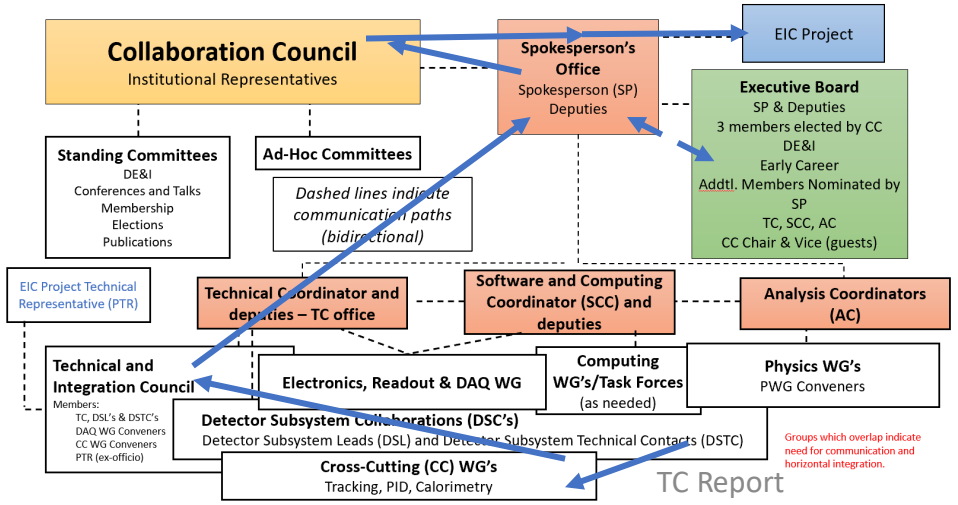
Decision flow

1. Proposed steps for detector consolidation/optimization initially **elaborated within DSCs**
2. Discussed within **the pertinent Cross-Cutting Working Group**
3. Presented and discussed at **TIC meetings** (iterating when improved proposal maturity may be beneficial) → **TIC MEETING RECOMMENDATION**
4. **Different paths** according to the modification entity:

- *Modest modifications:*
  - SP-office approval, in consultation with the Project Management feedback



- *Substantial modifications:*
  - SP-office collects Executive Board feedback and submits to Collaboration Council for decision
  - SP-office requests to Project management to start a **Change Control Process**



OUTLOOK

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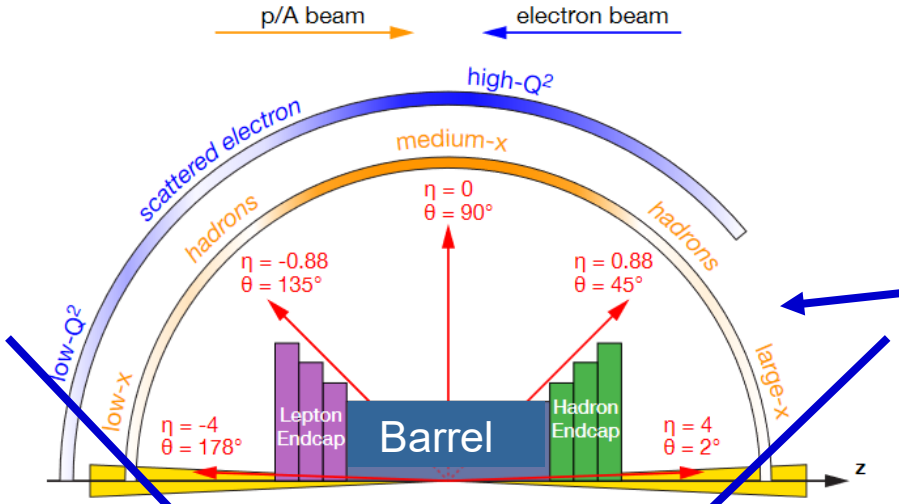
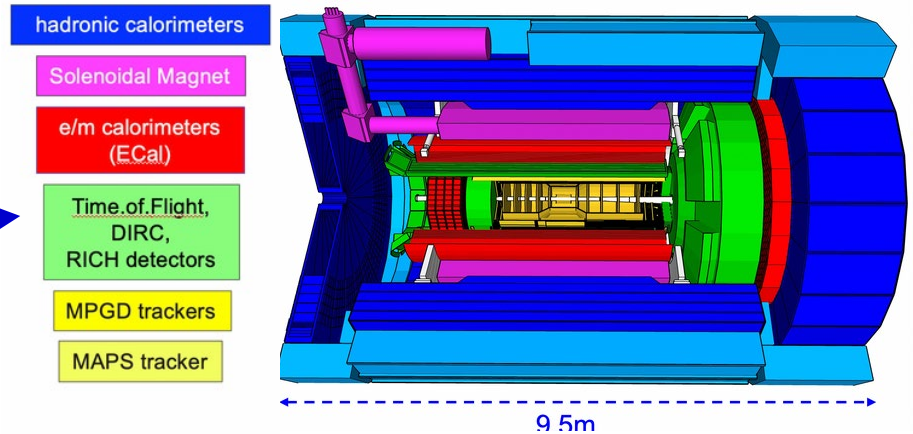
- Developing the Technical Design Report
- The major ePIC detector challenges in front of us

THE COMPLETE ePIC DETECTOR

A reminder



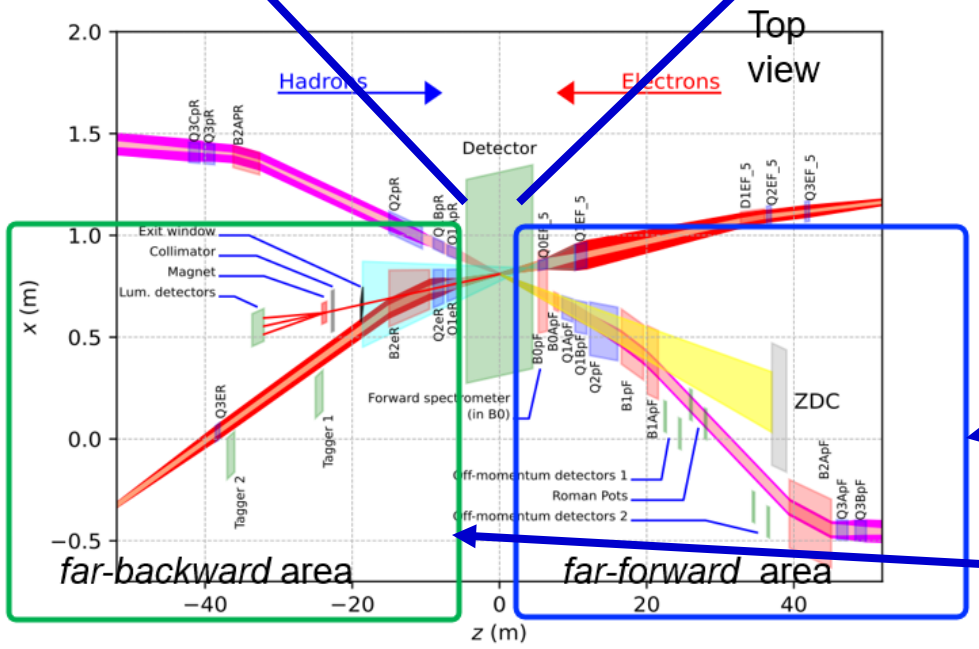


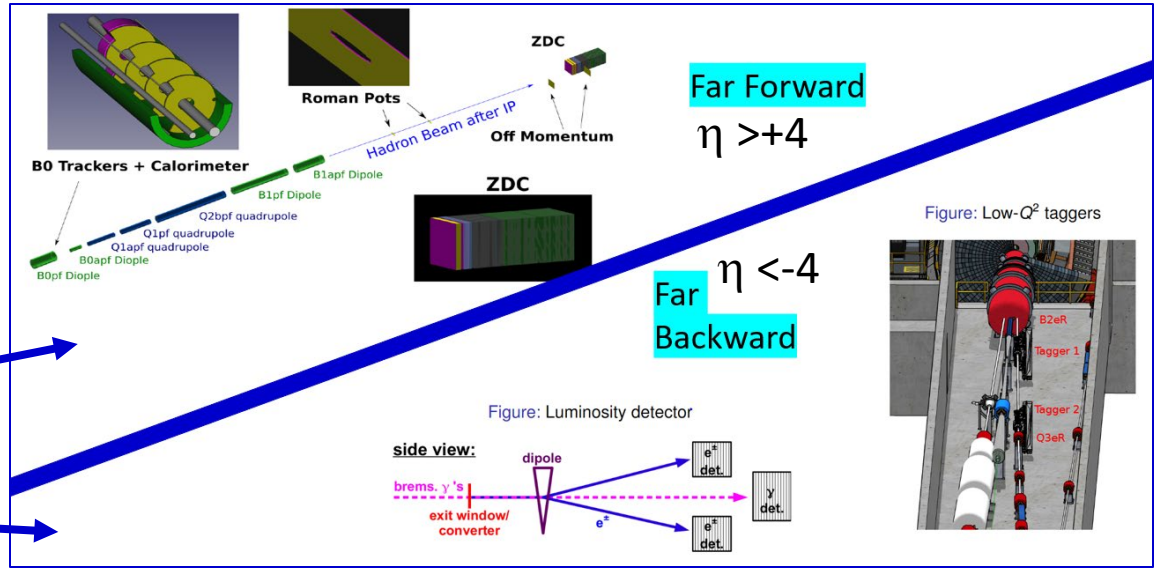
Central Detector (CD):

$-4 < \eta < +4$

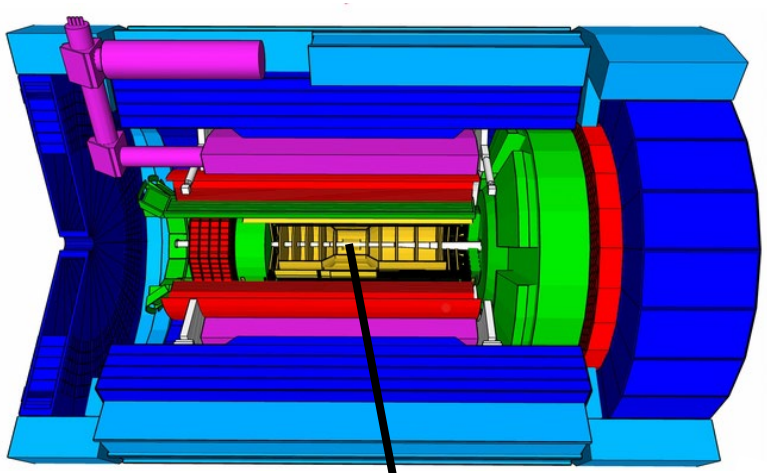
Formed by:

- Backward endcap
- Barrel
- Forward endcap





TRACKING CONFIGURATION



Complementary tracking technologies characterized by light materials

Si trackers based on ALICE ITS3 65 nm MAPS sensors

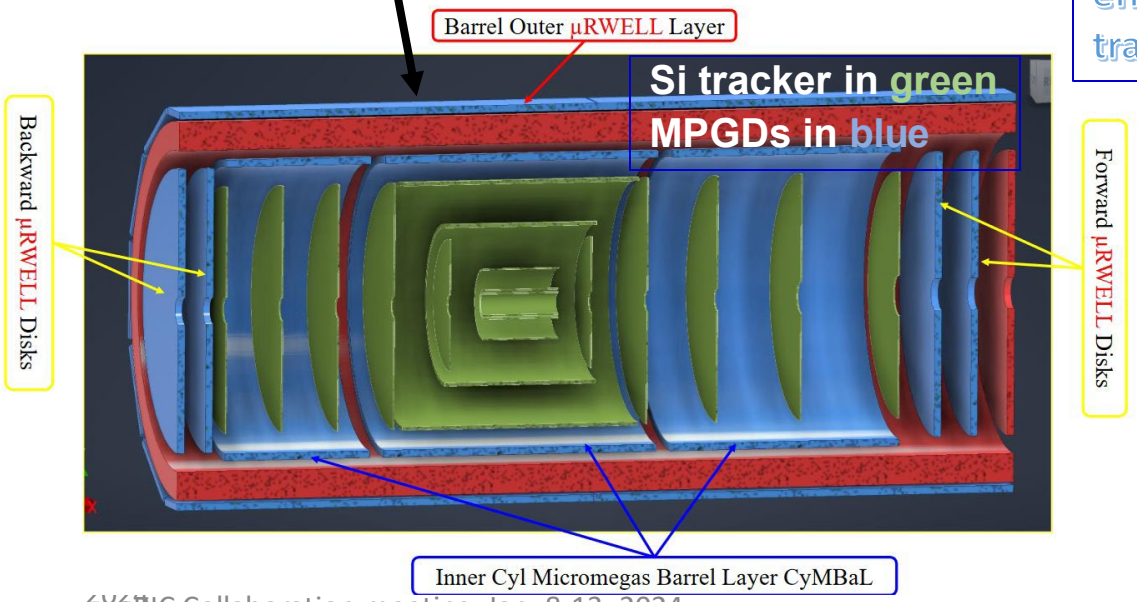
- **Five layers in the barrel and in the endcaps**

MPGD trackers

- **Cylindrical MICROMEGAS**
- **Planar μR-WELL**

Via ePIC decision process

The global tracking layout is based an ePIC software effort for simulation and track reconstruction



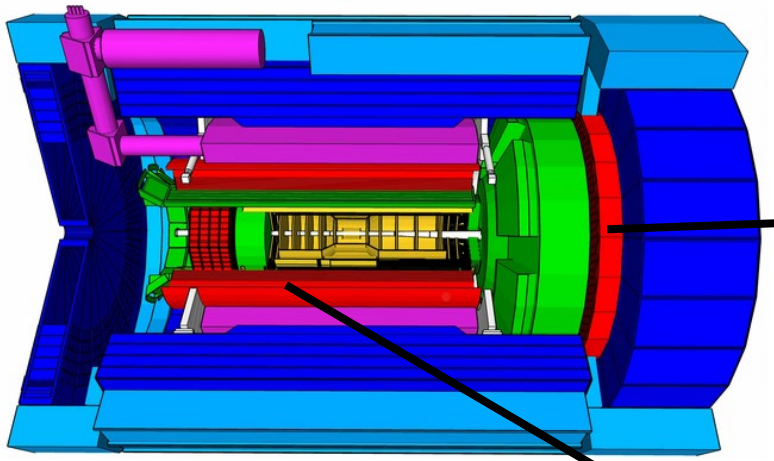
TRACKING remains one of the most demanding and challenging subsystems with a set of open questions

- **Overall performance**
- **MAPS timelines (ITS3 development is largely dictated by development within ALICE**
- **Definition of the Planar μR-WELL architecture**
- **Refinement of the service integration; cooling of the vertex layers**

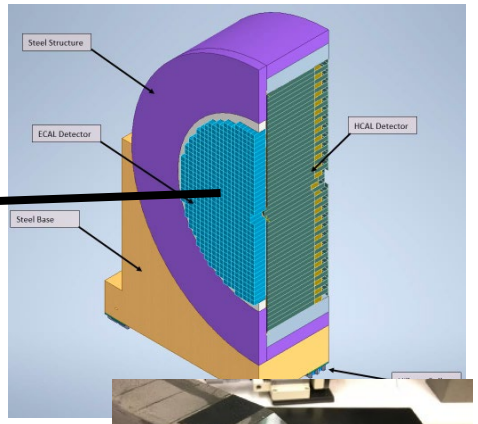
EVOLVING ELECTROMAGNETIC CALORIMETRY

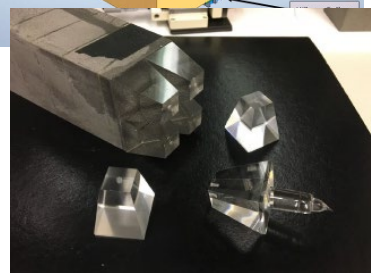
SiPM sensors for all Calorimeters

An effective option consolidated by sPHENIX experience, optimized also for operation in duet with HCal

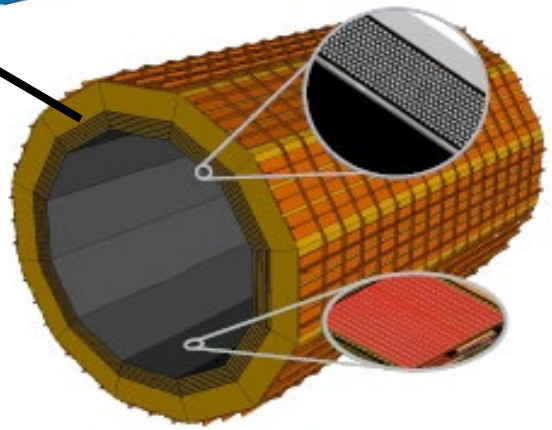


WSciFi is a unique technology allowing to achieve e/h ~1 (response to hadrons)





Via ePIC decision process



Optimization via ePIC decision process

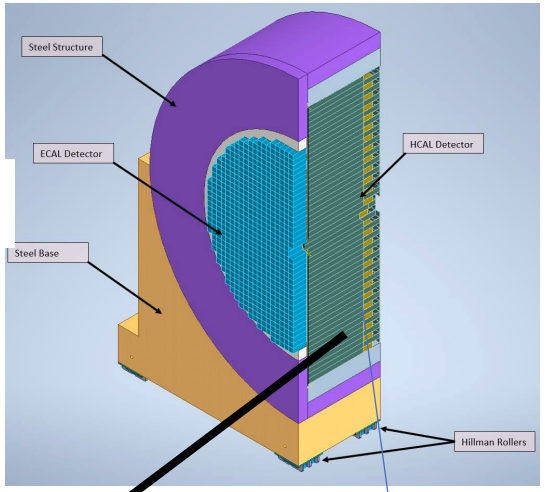
4 (6) layers of imaging calorimetry by Astropix MAPS,
and sampling calorimetry by Pb/SciFi
both in between Astropix layers and in the pure sampling section

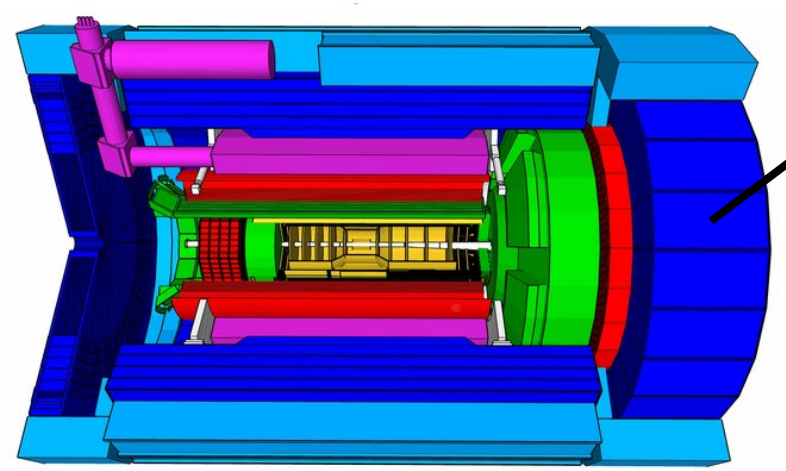
A novel hybrid approach inspired by imaging calorimetry at CERN and sampling calorimetry at GlueX

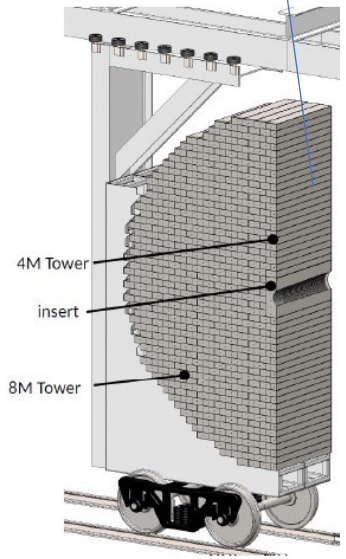
EVOLVING HADRONIC CALORIMETRY

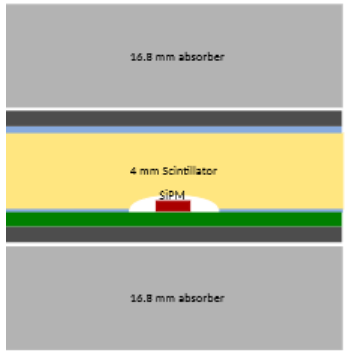
Via ePIC decision process

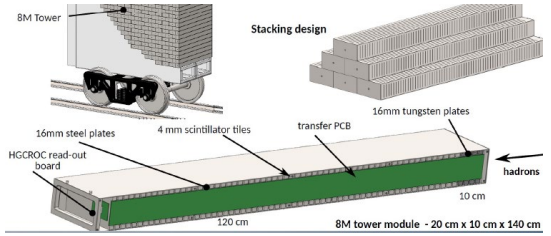
Barrel Hcal
(re-use from sPHENIX)







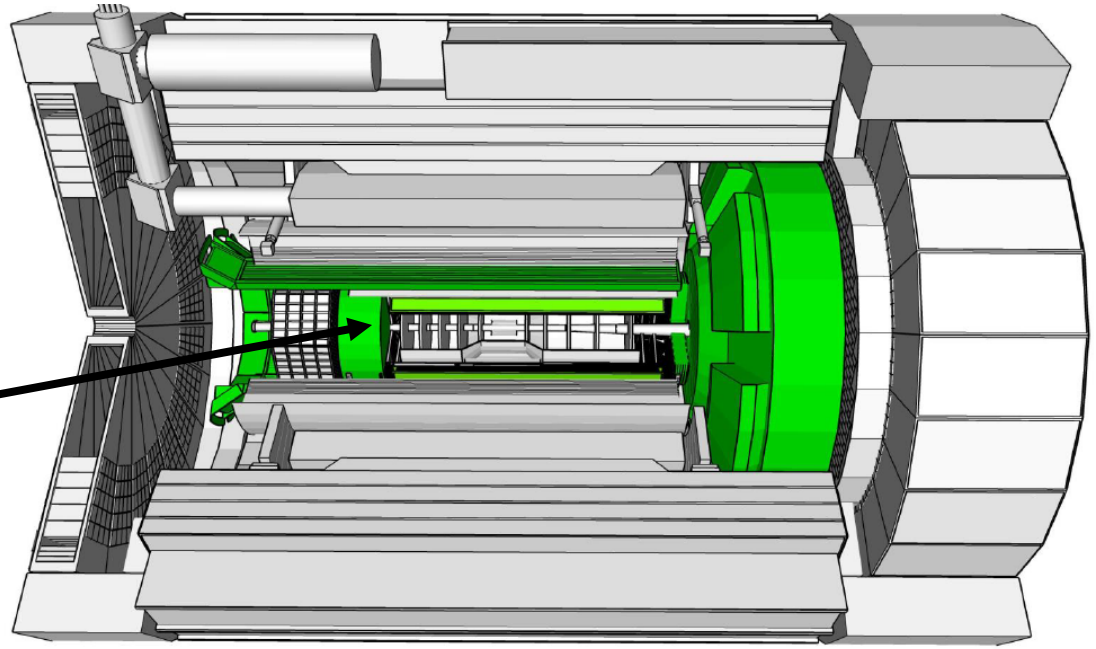


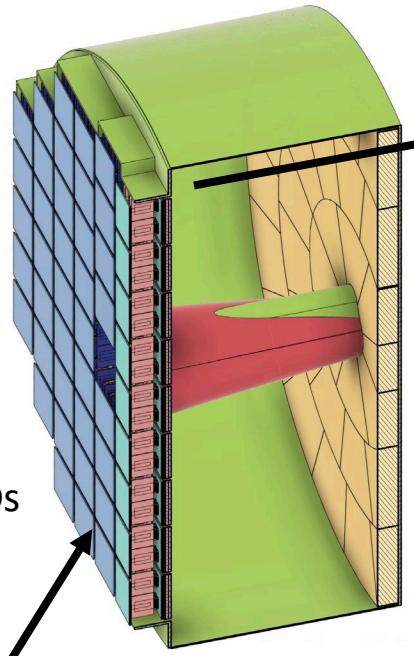


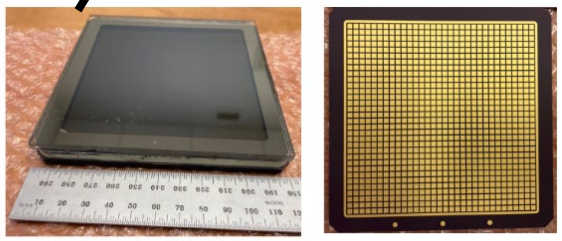
"SiPM on tile": An original innovative design inspired by CALICE developments adopted by ePIC; high granulkarity insert in the center (hiugh occupancy)

EVOLVING PARTICLE IDENTIFICATION

pfRICH: An original evolution of the focusing RICH approach by ePIC groups: long proximity gap for improved resolution







DC-coupled HRPPDs by Incom Inc.

HRPPDs: Large-size MCP-PMTs by INCOM

- Engineering contribution by ePIC
- 10 x 10 cm^2
- DC-DC coupled
- Being established within ePIC

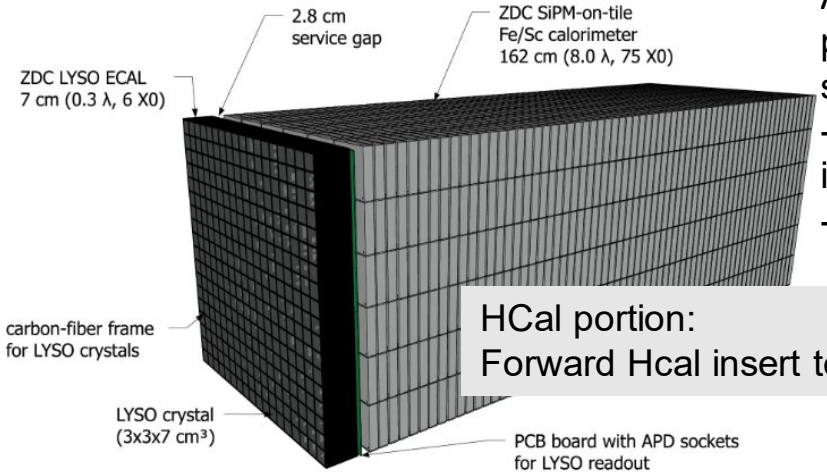
Via ePIC decision process

Using HRPPDs pfRICH is both a Cherenkov PID device and provides ToF

Establishing LAPPDs/HRPPDs as devices for RICHes and, at the same time, as adequate for ToF measurements, as well as and cooperating with industry for the correct engineering of the sensors

EVOLVING THE FF AND FB DETECTORS

ZDC layout



New baseline:

An original proposal by ePIC

A different technology to reduce cost and risks while preserving performance, and increase synergies with other subsystems:
- Hadron section by SiPM-on-tile (the technology for the insert of the forward HCAL)
- short ECal section by Lyso crystals

HCal portion:
Forward Hcal insert technology

Optimization via ePIC decision process

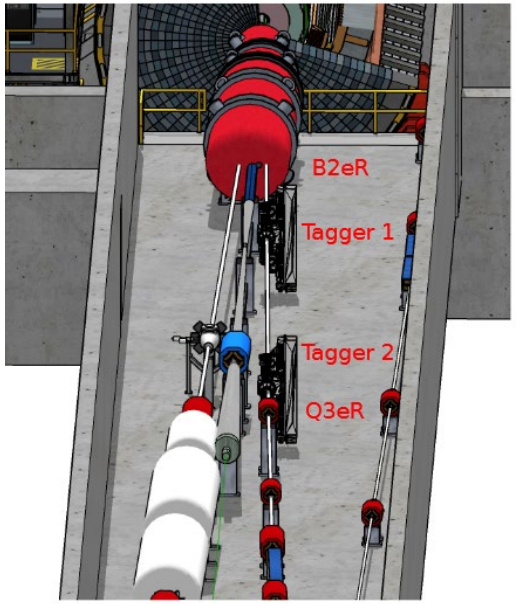
Low-Q2 taggers

- Two tagger stations with 4 Si-stations 30 cm apart and a calorimeter behind. Dimensions: 16cmx18cm

Tracker: Timepix technology
- Good timing (~200ps)
- Rate capability is very high ~20kHz per 55um pixel , 10ns shaping time

Calorimeter: PbWO4 (or similar to PS-lumi) — allows essential cross calibration of tracker and luminosity system during low current runs

Figure: Low-Q^2 taggers



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INPUTS

The major ePIC detector challenges in front of us

- A miscellanea from review close-outs
  - CD-3A Design Review by DAC (Aug. 29-30, 2023)
  - CD3A Director's Review (Oct. 10-12, 2023)
  - EIC CD-3A Status Review (Nov. 14-16, 2023)
- Adding the ePIC management assessment

Disclaims

- **Only detector issues** considered here; challenges related to organization, in-kind contributions, collaboration size and integration of the international participation, … not considered in the following
- IMPORTANT: in the next slides focus on challenges; **the many positive comments from the reviews are skipped**!

A single example of what is skipped:
*"**The detector group has made impressive progress since CD-1**. A rather mature project management for this stage exists. International detector collaboration ePIC has been established and the project and the collaboration have good coordination."*

ePIC DETECTOR CHALLENGES - 1 general considerations

- Projected **timelines** are aggressive, but appear feasible
  - *Primary risk in delays of*
    - *Magnet*
    - *Si tracker*
  - *Also iterated in the report :* "The magnet and SVT remain high risk items"

- **All central detector technologies have been chosen and appear appropriate.**
- Several technologies still **require significant further R&D, prototyping/production cycles** in order to confirm that they will provide the required performance
  - *Silicon Tracker*
  - *μRWELL tracker*
  - *Imaging Sci/Fi tracking calorimeter*
  - *AC-LGAD Tracker*
  - *pfRICH prototype*

- **Less advanced systems**:
  - *the dual RICH*
  - *the far forward and backward detectors*
  - *the TOF detectors.*

ePIC DETECTOR CHALLENGES - 2 general considerations, cont.

- There **remains concern** that **radiation hardness and background rate** issues may still affect detector performance (and design), with time-dependent rate and noise dependences. We urge the incorporation of the machine background expectations into the detector simulations as well as attempting to provide conservatively large safety margins.
- A comprehensive description of the **survey/alignment/monitoring and calibration strategy** for the hardware components of all detector systems is needed.
- **Development of contingency plans** would be useful for understanding the effects of delays which occur in the schedule. Flexibility in the schedule should be maintained as much as possible to minimize risk to the project.

ePIC DETECTOR CHALLENGES - 3

- "**Tracking** detector systems still have many key elements that are not finalized: ITS3 not being available in time, may have significant implications."
    - The overall tracking configuration requires attention and further simulation studies (more workforce needed here!)
    - The several options open for the μR-WELL detectors is a source of concern
    - About IT3, constant attention by PM and ePIC management; key meeting at CERN about technical and agreement matter, Apr. 23-24, 2023

- "Since **Astropix** production for the EM calorimeter is probably the largest silicon detector production for EIC, and one of the largest in the field, there should be more detail about its organization, planning and production in the subdetector presentation."
- "How long it would take to **procure sufficient Astropix** detectors and what services/conditions they require for reliable operation."
- **BCal** "requires significant further R&D in order to confirm the required performance and prototype needs validation with beam test"
    - The size and complexity of the barrel ECal subsystem requires sustained attention to the overall detector aspects.

ePIC DETECTOR CHALLENGES - 4

- **dRICH:** “Less advanced **design”**
- “The **cooling infrastructure for the SiPM** needs some further study, as unforeseen issues could impact the interface to nearby detector systems.”
  - An integrated approach to mechanics, cooling, mirror supports and gas system is needed.
  - Assessing the detector resolution including SiPM dark noise is urgent.

- **pfRICH:** “prototype needs validation with beam test”
  - HRPPD validation is still an open question as well as production yield

- **hpDIRC:**
  - Urgency in understanding the BABAR bar disassembly challenge;
  - Urgency in integrating the detector simulation in the overall ePIC frame

- **AC-LGADs:** “Requiring significant further R&D; Requiring prototyping and beam tests; Less advanced design”
  - Cooling issues also open

- **ASICs:** “ASIC development should be closely monitored as it has often taken significantly more time and effort than originally planned”
  - Development monitoring needed

DETECTOR CHALLENGES AND THE TC-OFFICE/TIC ROLE

In front of the detector challenges, TC-office and TIC role:

- **Identify** and continuously **update** the challenge list;
  - as done for the above analysis
- **Support the DSCs** in identifying the key issues and strategies to overcome them;
  - f. i., constantly following the tracking evolution
- **Help DSC proposals to reach maturity, evaluate them and, when appropriate, recommend them;**
  - As for all the detector design modifications recalled in this talk
- Support the **collection of information** of help for
  - the detector integration;
  - the sensor/FEE ASIC coupling;
  - the subsystem read-out integrated in the global streaming read-out scheme;
- **Services of support to the DSCs**;
  - As collecting test beam needs, as facing the need of a detector DB
- **TDR-specific activities in cooperation ACs, SCCs and DSCs (**to be further discussed at the TDR-dedicated session)
  - **Stimulate the needed lab/test beam studies and prototyping**
  - **Stimulate the simulation studies** of subsystem performance and the holistic detector performance

CONTINUATION

NEW

summarizing

- ePIC has built-up a **solid structure to address the detector activity**; goals:
  - to complete detector R&D and design for the TDR
  - to be ready for the construction phase in 2025
- The ePIC **detector design**
  - Via its structure, ePIC has effectively addressed technical detector design items assuming key decisions, then made effective in the cooperation with the Project Management
- The major **ePIC detector challenges:**
  - Identified (all of them ?) also with important input from recent reviews
  - TC-office and TIC engaged in following the related issues and supporting the required effort

Thank you