

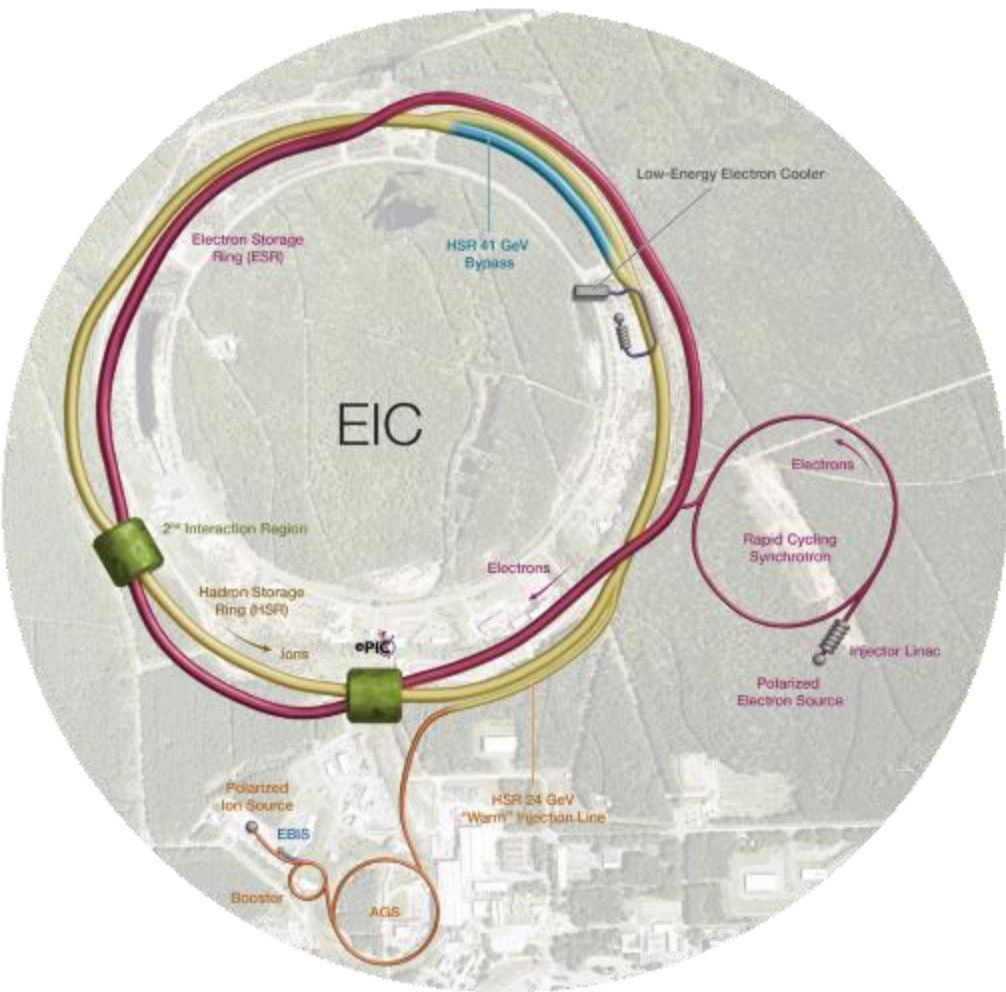


# ePIC software training and development support

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ePIC Software User Learning Co-Conveners

7 May 2025  
WLCG/HSF Workshop 2025  
IJCLab, Paris

# Electron-Ion Collider



## World's first collider of:

- Polarized electrons and polarized protons
- Polarized electrons and light ions (d,  $^3\text{He}$ )
- Electrons and heavy ions (up to Uranium)

The EIC will enable us to embark on a **precision study of the nucleon and the nucleus** at the scale of sea quarks and gluons, over a large kinematics range.

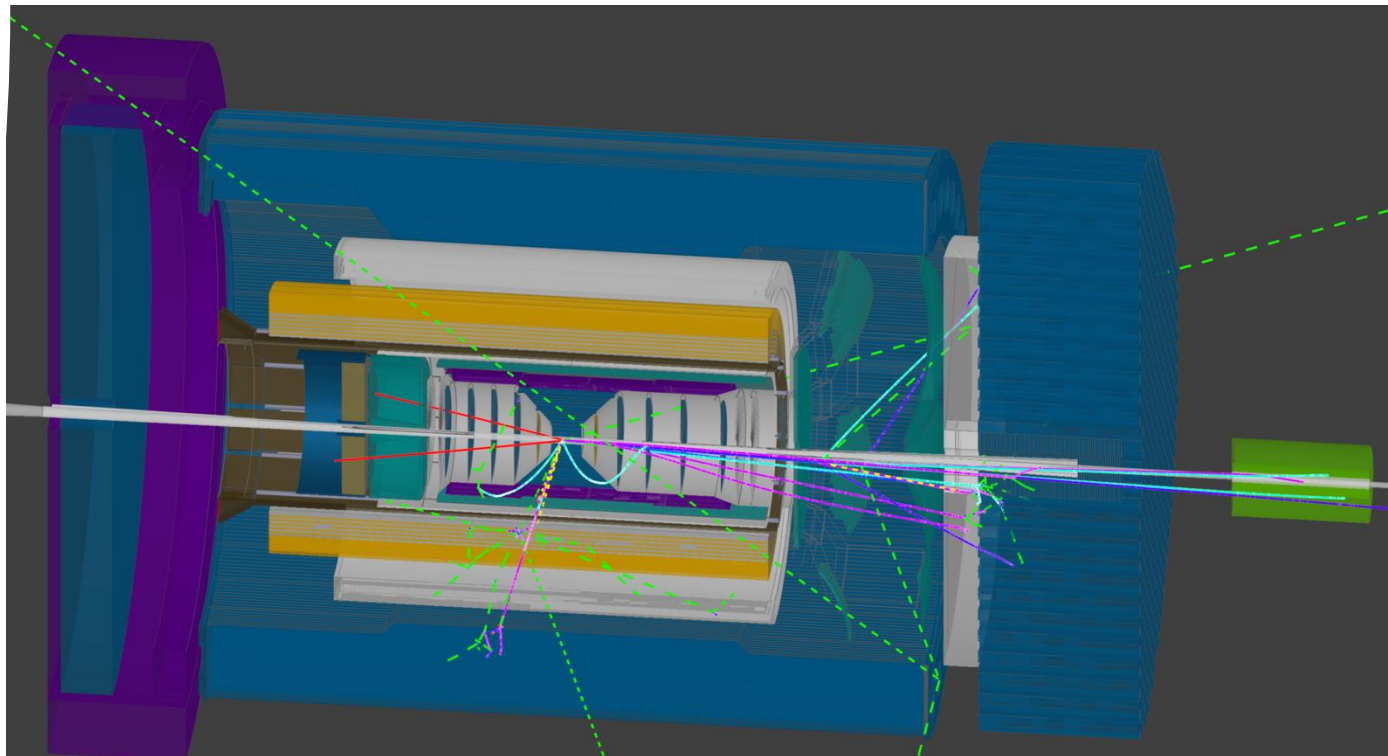
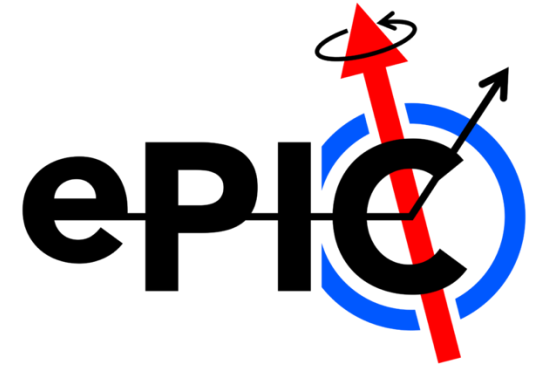
The **EIC Yellow Report** ([Nucl. Phys. A 1026 \(2022\) 122447](#)) describes the physics case, the resulting detector requirements, and the evolving detector concepts for the experimental program.

Brookhaven National Lab and Jefferson Lab will be the host laboratories for the EIC program. Leadership roles in the EIC project are shared.

EIC operations will start in about a decade.

# ePIC Experiment

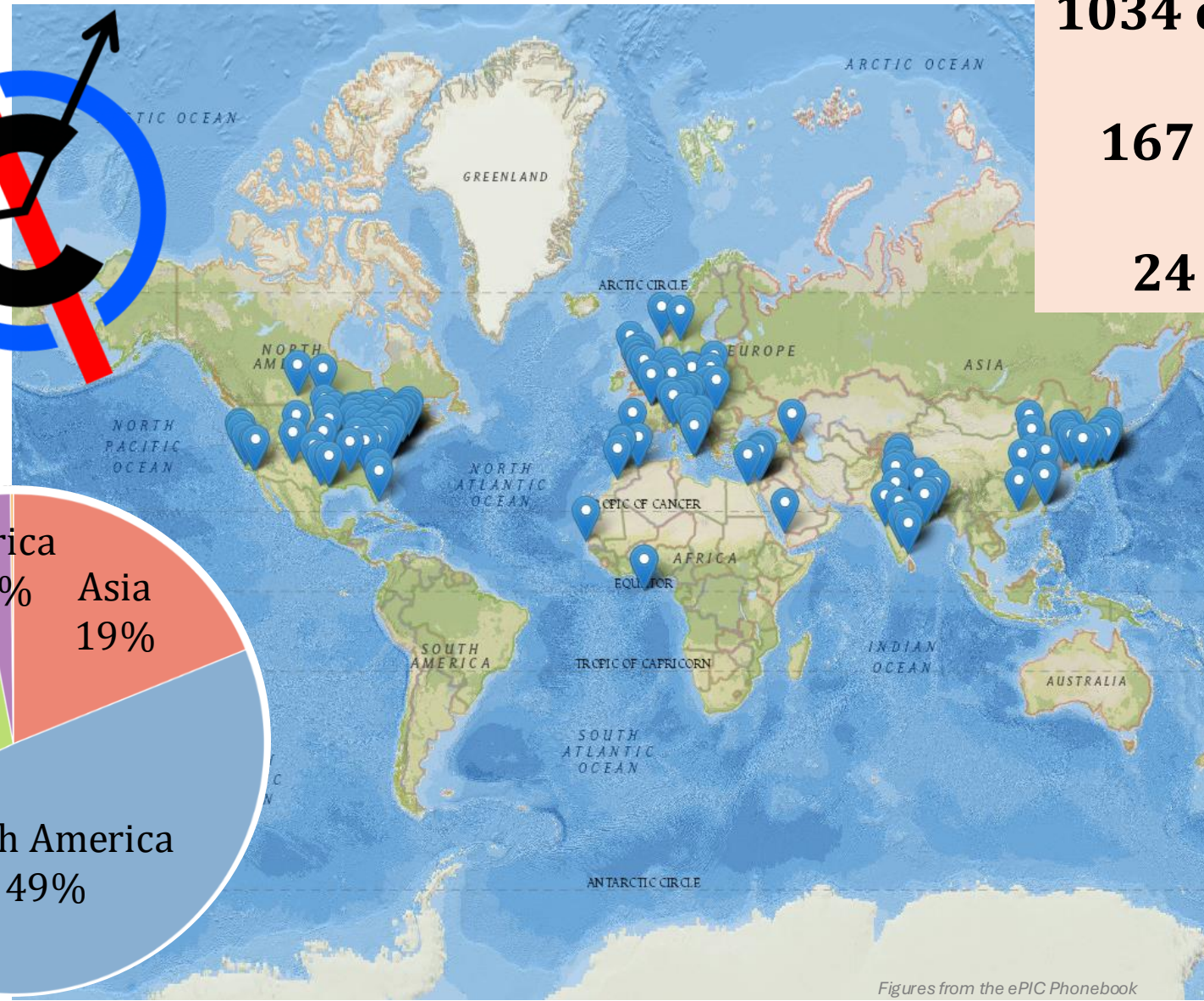
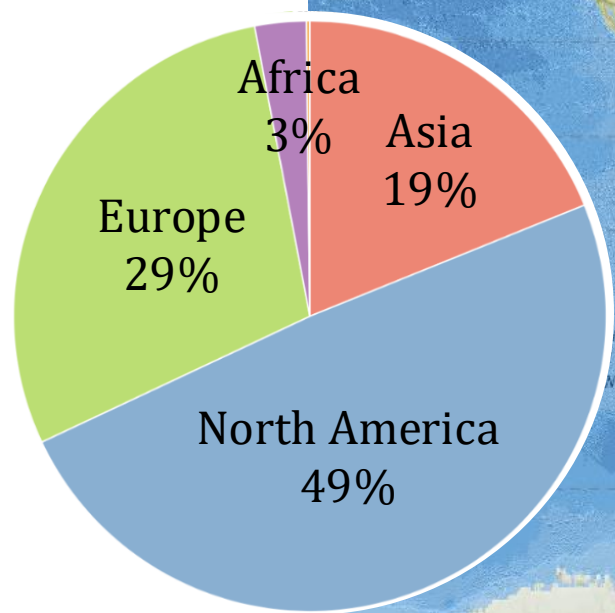
- ePIC is the primary experiment at the EIC
- It is a highly integrated, multi-purpose experiment
- The experiment is being developed by the ePIC collaboration in partnership with the EIC Project



# ePIC collaborators from all over the world!



**1034 collaborators  
from  
167 institutions  
from  
24 countries!**



Figures from the ePIC Phonebook

# Central ePIC Detector

## Magnet

- New 1.7 T SC solenoid, 2.8 m bore diameter

## Tracking

- Si Vertex Tracker MAPS wafer-level stitched sensors (ALICE ITS3)
- Si Tracker MAPS barrel and disks
- Gaseous tracker: MPGDs ( $\mu$ RWELL, MMG) cylindrical and planar

## PID

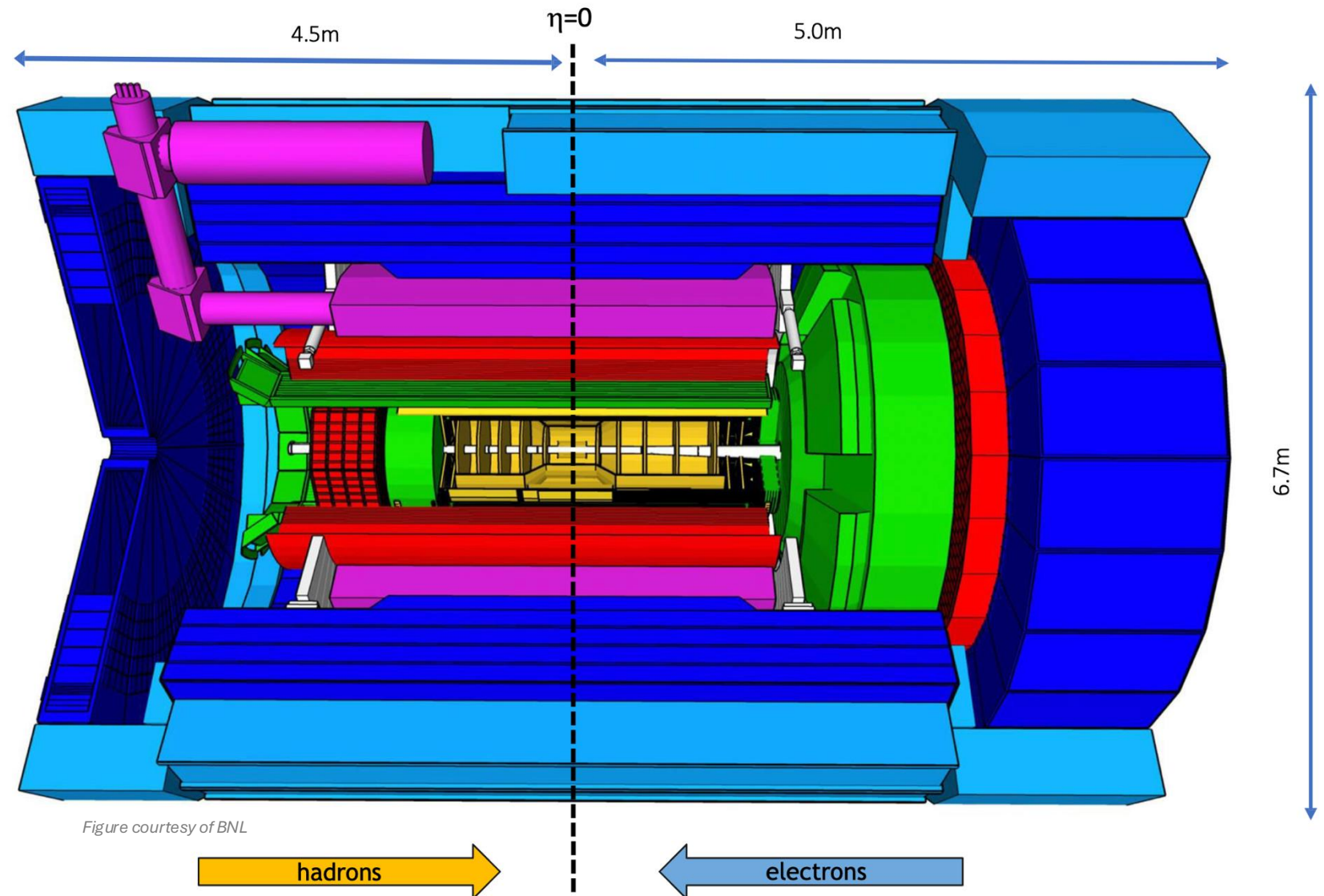
- high performance DIRC (hpDIRC)
- dual RICH (aerogel + gas) (forward)
- proximity focussing RICH (backward)
- ToF using AC-LGAD (barrel+forward)

## EM Calorimetry

- imaging EMCal (barrel)
- W-powder/SciFi (forward)
- $\text{PbWO}_4$  crystals (backward)

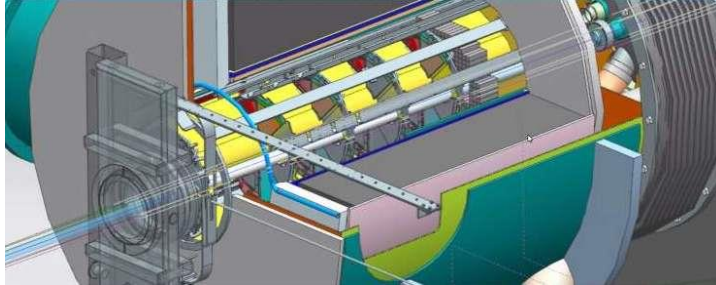
## Hadron calorimetry

- FeSc (barrel, re-used from sPHENIX)
- Steel/Scint – W/Scint (backward/forward)



# Far-Forward/Far-Backward System

ePIC detector is 90 meters long! The central, far-forward, and far-backward regions are **integrated with the IR**

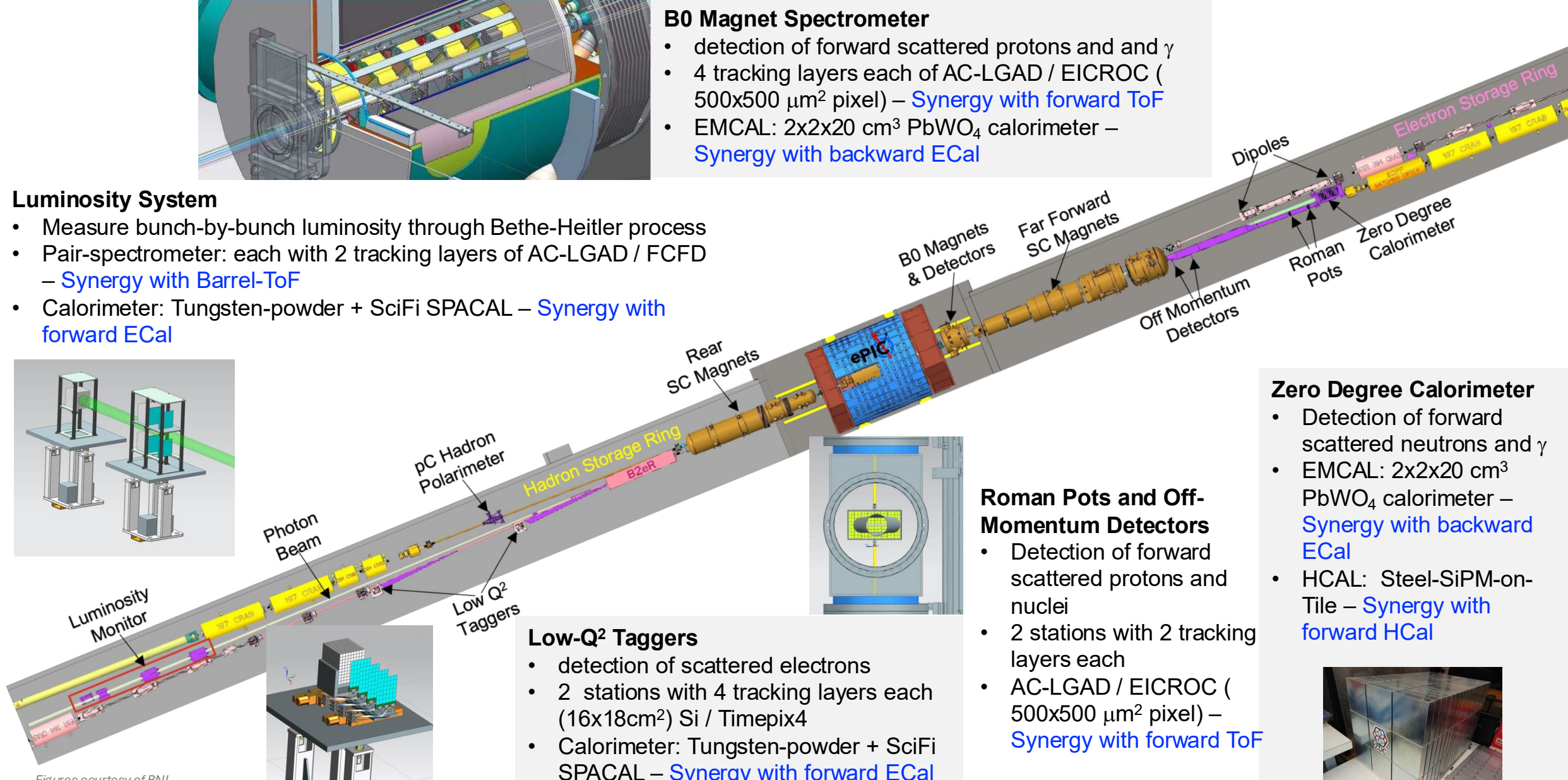
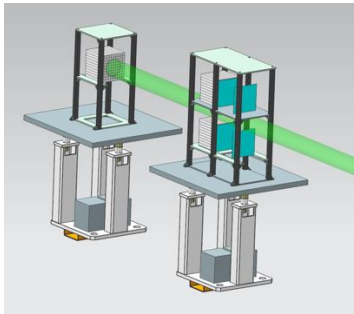


## B0 Magnet Spectrometer

- detection of forward scattered protons and  $\gamma$
- 4 tracking layers each of AC-LGAD / EICROC (  $500 \times 500 \mu\text{m}^2$  pixel) – **Synergy with forward ToF**
- EMCAL:  $2 \times 2 \times 20 \text{ cm}^3$   $\text{PbWO}_4$  calorimeter – **Synergy with backward ECal**

## Luminosity System

- Measure bunch-by-bunch luminosity through Bethe-Heitler process
- Pair-spectrometer: each with 2 tracking layers of AC-LGAD / FCFD – **Synergy with Barrel-ToF**
- Calorimeter: Tungsten-powder + SciFi SPACAL – **Synergy with forward ECal**



## Low-Q<sup>2</sup> Taggers

- detection of scattered electrons
- 2 stations with 4 tracking layers each (  $16 \times 18 \text{ cm}^2$  ) Si / Timepix4
- Calorimeter: Tungsten-powder + SciFi SPACAL – **Synergy with forward ECal**

## Roman Pots and Off-Momentum Detectors

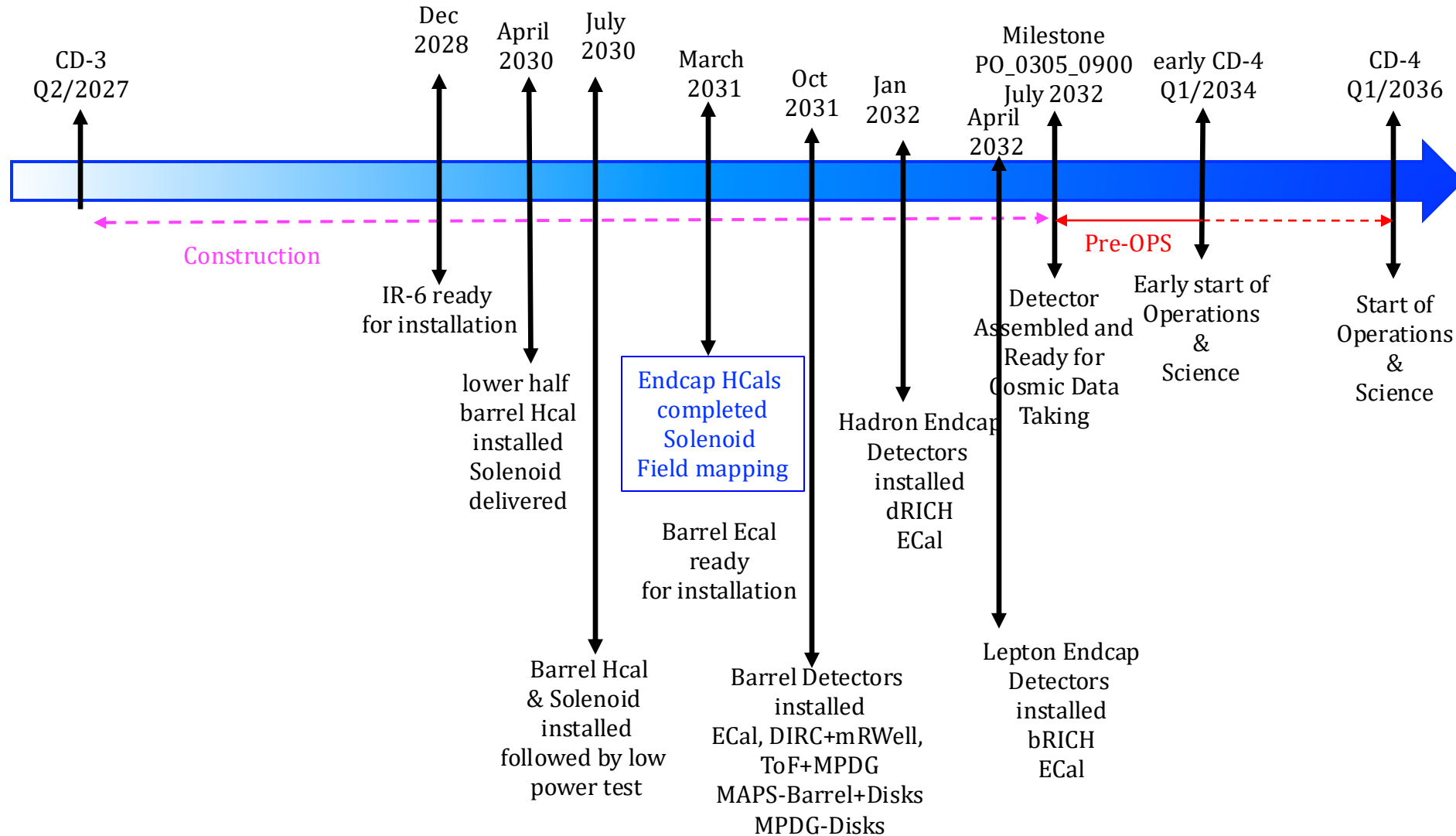
- Detection of forward scattered protons and nuclei
- 2 stations with 2 tracking layers each
- AC-LGAD / EICROC (  $500 \times 500 \mu\text{m}^2$  pixel) – **Synergy with forward ToF**

## Zero Degree Calorimeter

- Detection of forward scattered neutrons and  $\gamma$
- EMCAL:  $2 \times 2 \times 20 \text{ cm}^3$   $\text{PbWO}_4$  calorimeter – **Synergy with backward ECal**
- HCAL: Steel-SiPM-on-Tile – **Synergy with forward HCal**

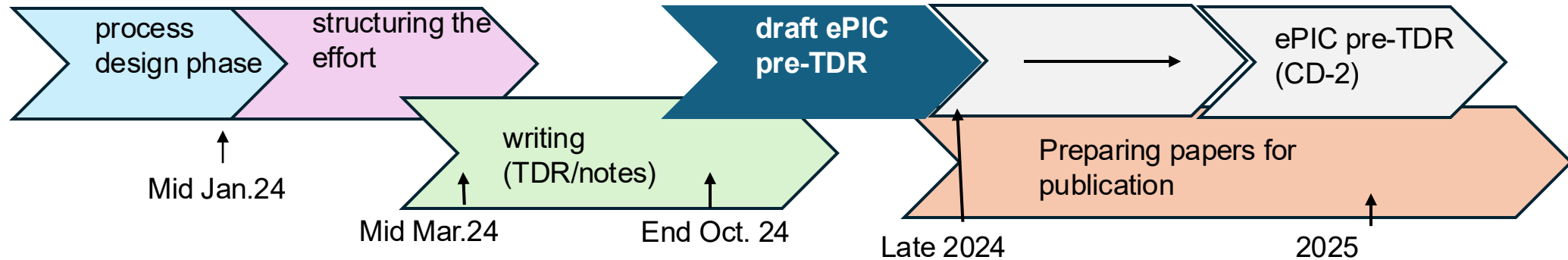


# Current installation schedule



(Assumes the present best-known schedule)

# Software deliverables



ePIC Software & Computing is essential to the Technical Design Report, providing advanced **software and simulation productions** that are the input for **detector and physics studies**

# Organization structured around user's needs



## Guiding Principles:

- *Statement of Software Principles*
- *Sustainability*



**Software and Computing Coordinator**  
Markus Diefenthaler (Jefferson Lab)

## Cross-cutting Working Group:

- *Data and Analysis Preservation*



**Deputy Coordinator (Operations)**  
Wouter Deconinck (U. Manitoba)

## Operation Working Groups:

- Production
- User Learning
- Validation



**Deputy Coordinator (Development)**  
Dmitry Kalinkin (U Kentucky)

## Development Working Groups:

- Physics and Detector Simulation
- Reconstruction Framework and Algorithms
- *Analysis Tools (not yet activated)*



**Deputy Coordinator (Infrastructure)**  
Torre Wenaus (BNL)

## Infrastructure Working Groups:

- Streaming Computing Model
- *Multi-Architecture Computing (not yet activated)*
- *Distributed Computing (not yet activated)*

# User-centered design

## EIC SOFTWARE: Statement of Principles

### 4 We will aim for user-centered design:

- We will enable scientists of all levels worldwide to actively participate in the science program of the EIC, keeping the barriers low for smaller teams.
- EIC software will run on the systems used by the community, easily.
- We aim for a modular development paradigm for algorithms and tools without the need for users to interface with the entire software environment.

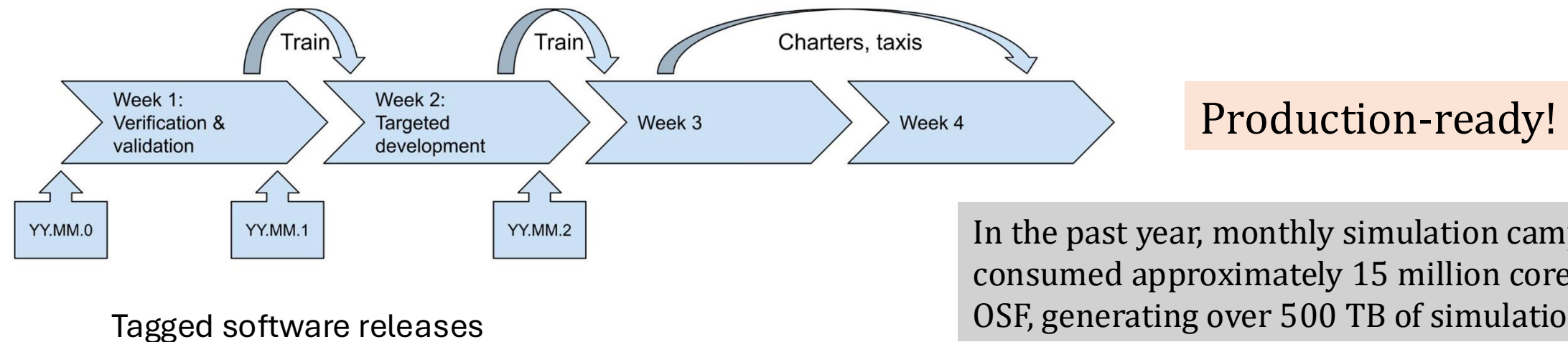
### 7 We will embrace our community:

- EIC software will be open source with attribution to its contributors.
- We will use publicly available productivity tools.
- EIC software will be accessible by the whole community.
- We will ensure that mission critical software components are not dependent on the expertise of a single developer, but managed and maintained by a core group.
- We will not reinvent the wheel but rather aim to build on and extend existing efforts in the wider scientific community.
- We will support the community with active training and support sessions where experienced software developers and users interact with new users.
- We will support the careers of scientists who dedicate their time and effort towards software development.

# Simulation Campaign Strategy

## Objectives:

1. Achieve continuous deployment of the software used for detector and physics simulations
2. Ensure regular updates of simulation productions for detector and physics studies, and for geometry and algorithm development
3. Implement timely validation and quality control for simulation productions on datasets that require substantial time and resources



In the past year, monthly simulation campaigns consumed approximately 15 million core hours on the OSF, generating over 500 TB of simulation data.

# User Learning

- Supports the users by providing training, documentation and support
- Preliminary Technical Design Report (deliverable) is upcoming
- User Learning supports the user's needs (i.e. simulation, analysis....)

**Eic-shell** Easy to get started locally... in only 1 line!

```
curl -L get.epic-eic.org | bash
```

Based on container images, the same images are used for simulation campaigns.

- Organize hybrid (live/virtual) tutorials every 1-2 months
- Support the trainers in developing engaging material and documentation
- Goal to develop discoverable software



# Past year training events

## 2025

May: HSF India/ePIC Workshop

April: Inclusive kinematics reconstruction tutorial

March: Getting started with a physics analysis tutorial

February: Analysis and working the simulation output,  
Understanding the simulation output

## 2024

October: Validation and benchmarking tutorial

September: Working with simulation output

April: ePIC Software tutorials at CERN

Overview of ePIC software,  
working with simulation output,  
simulating detectors and their readout,  
reconstruction algorithms



Software ▾

Resources ⚙ ▾

Activities 💡 ▾

Organization 🏢 ▾

Policies ⚙ ▾

Get Started 📖 ▾

About 💡 ▾



## Landing Page

Get started

ePIC Tutorials

HEP Software  
Training Center

FAQ

ePIC Image  
Viewer

Welcome to the **ePIC Landing Page!**

Our mailing list: ✉ [eic-projdet-comp-sw-l@lists.bnl.gov](mailto:eic-projdet-comp-sw-l@lists.bnl.gov)

Subscribe here: <https://lists.bnl.gov/mailman/listinfo/eic-projdet-comp-sw-l>

# Independent user onboarding



Software >

Resources >

Activities >

Organization >

Policies >

Get Started >

About >



## Get Started

Welcome to the **Get Started** section. This page will guide you through the steps to get setup for contributing and working in our software framework.

1. Join GitHub: <https://github.com/eic>
  - GitHub serves as a central platform for version control, code review, issue tracking, and documentation. We maintain the EIC organization on GitHub for collaborative development of all software related to the EIC.
  - **Read Access:** Contact ✉ [eic-software-l-request@lists.bnl.gov](mailto:eic-software-l-request@lists.bnl.gov) from your institutional email address. Include in your email your GitHub username and confirmation of whether you or your sponsor/advisor is a member of the EICUG or ePIC.
  - **Write Access:** For access to specific repositories, you can request to join various GitHub teams. For example, join 'EPIC Devs' for software development within the ePIC collaboration.
2. Join Mattermost: <https://chat.epic-eic.org/>
  - We use Mattermost for our main communication channel.
  - You can join by emailing any group member to be added.
3. Sign up for our mailing lists:
  - Collaboration mailing list ([subscribe here](#)): ✉ [eic-projdet-collab-l@lists.bnl.gov](mailto:eic-projdet-collab-l@lists.bnl.gov)
  - Software mailing list ([subscribe here](#)): ✉ [eic-projdet-comp-sw-l@lists.bnl.gov](mailto:eic-projdet-comp-sw-l@lists.bnl.gov)
4. Join a project! Checkout the [ePIC wiki](#) to get involved:
  - [Physics Working Group](#)
  - [Detector Subsystems](#)
  - [Software Working Group](#)
5. Refer back to the [landing page](#) to checkout [HEP Software](#) and [ePIC tutorials](#)

Refer to HSF training Center for common tools

# Current documentation of tutorials



Software

Resources

Activities

Organization

Policies

Get Started

About



Please join the [Mattermost Software Tutorials](#) channel for updates/announcements and questions about tutorials.

Note that the tutorials as presented below are not intended to be followed in a strict sequence. New users should start with the "Setting up an environment" tutorial. Beyond this, we encourage users to pick and choose the tutorials on topics they want to explore.

Current tutorials are summarised in the table below -

Tutorial	Difficulty	Tags	Description	Resources
<a href="#">Setting up an environment</a>	Beginner	[Setup] [Environment]	Get started with the ePIC software environment	<a href="#">Video 1</a> • <a href="#">Video 2</a>
<a href="#">Analysis and simulation output</a>	Beginner/Advanced	[Analysis] [Data]	Learn how to analyze simulation data	<a href="#">Video</a> <a href="#">Video2</a>
<a href="#">Simulating detectors</a>	Expert	[Simulation] [Detector] [DD4hep]	Development of detector geometry using DD4hep	<a href="#">Video</a>
<a href="#">Modifying geometry and digitization</a>	Advanced	[Geometry] [Digitization]	Learn to customize detector configurations	-
<a href="#">Understanding simulation output</a>	Advanced	[Simulation] [Data]	Deep dive into simulation data structure	<a href="#">Video</a>
<a href="#">Getting started with physics analysis</a>	Advanced	[Physics] [Analysis]	Physics analysis introduction	<a href="#">Video</a>
<a href="#">Inclusive kinematics reconstruction</a>	Advanced	[Reconstruction] [Kinematics]	Learn kinematics reconstruction techniques	<a href="#">Video</a>
<a href="#">Reconstruction algorithms</a>	Expert	[Algorithms] [Reconstruction]	Study different reconstruction approaches	<a href="#">Video 1</a> • <a href="#">Video 2</a>

# Tutorials use standard format

[Home](#)[Code of Conduct](#)[Setup](#)[Episodes ▾](#)[Extras ▾](#)[License](#)[Improve this page !\[\]\(2b0f02b4a70afa75816b328a8d32ffe7\_img.jpg\)](#)

## EIC Tutorial: Geometry Development with DD4hep

### Prerequisites

This tutorial forms part of the [EIC tutorial series](#):

- [Setting Up Your Environment](#)
- [Geometry Development with DD4hep](#)
- [Simulations Using Ddsim and Geant4](#)
- [Reconstruction Algorithms in JANA2](#)
- [Analysis of Reconstructed Data](#)

### Schedule

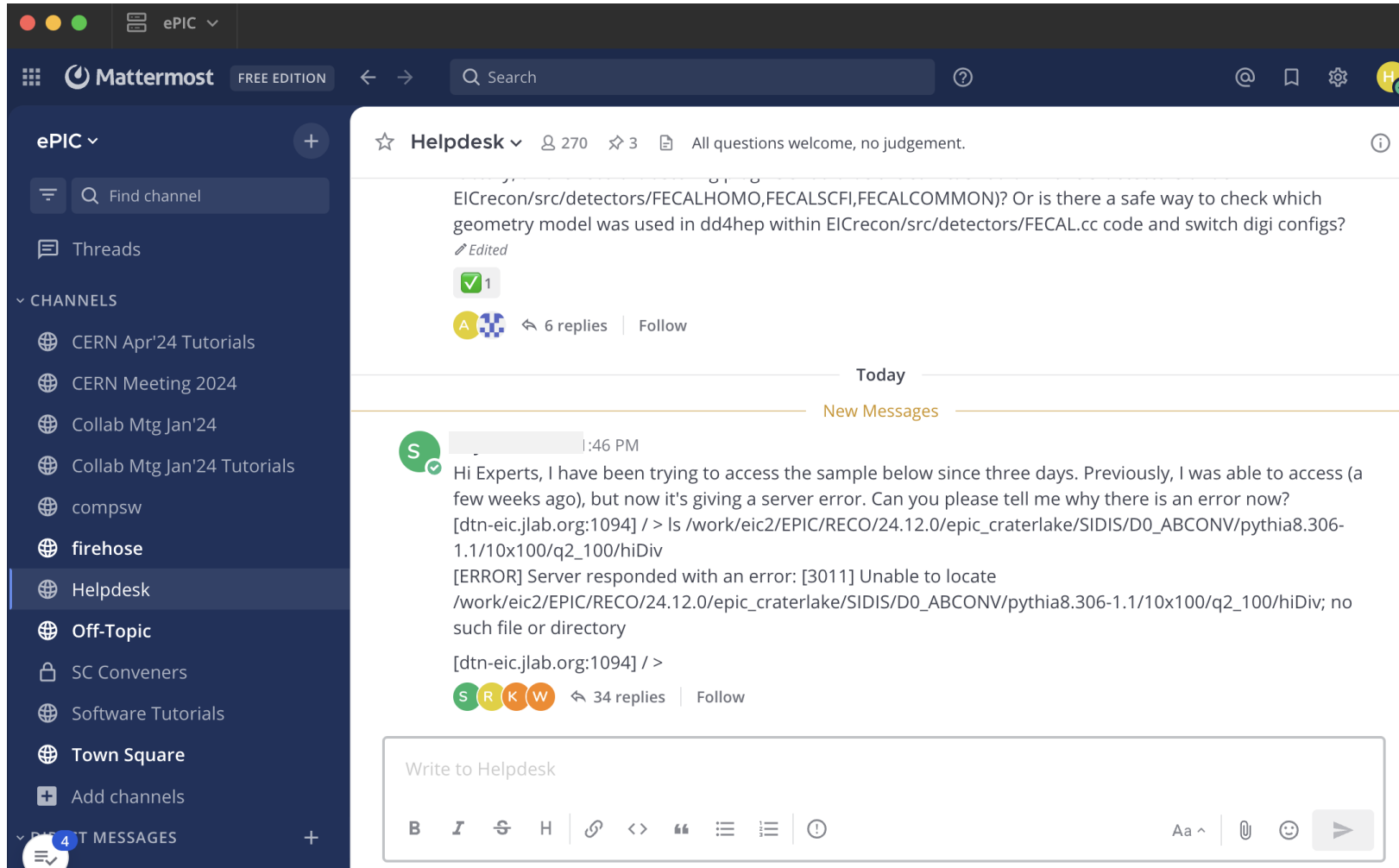
	Setup	Download files required for the lesson
00:00	1. <a href="#">Geometry Definition</a>	How do we define geometry using DD4hep?
00:25	2. <a href="#">Viewing the geometry</a>	How can we view the geometry?
00:45	3. <a href="#">Modifying geometry</a>	How do we modify or add geometry defined in DD4hep?
01:45	Finish	

The actual schedule may vary slightly depending on the topics and exercises chosen by the instructor.

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# User support



**Helpdesk** channel provides crucial near/real-time support to users

**Software Tutorials** channel for tutorial announcements and information

**firehose** for simulation production files and information

# Goal: discoverable software

- Structure focus groups to better understand how users interact with the software.
  - Evaluate students and postdocs, all users
  - Evaluate what software is used, barriers to work
  - Understand research goals
- Implement “message of the day” in eic-shell to share news and updates about the software
- Creative idea: Table-top role-playing trainer to teach about the software

# Summary

- The ePIC software stack is a modern and modular toolkit built from NP/HEP community tools and components from HPC and Data Science; ePIC is an active member of the software & computing community in NHEP
- **User Learning** is critical for onboarding new collaboration members, training them to successfully use software and simulations, and supporting their transition from users to developers.
- High level milestones ensures that the agile development process is continuously confronted with real world exercising of the software and the developing realization of the computing model:
  - Priority always given to meeting **near-term needs**. ePIC leverages monthly production campaigns, benchmarks, and timeline-based prioritization to ensure timely completion of the simulation studies for the Technical Design Report.
  - **Longer range timeline** progressively exercising the streaming computing model to deliver for the needs of the Critical Decision process, for specific applications, e.g. test beams, for scaling and capability challenges, and ultimately for the phases of data taking.

Many thanks to the **ePIC Collaboration**, my User Learning co-convener **Stephen Kay**, our Software & Computing Coordinator **Markus Diefenthaler**, and our software deputies **Wouter Deconinck**, **Dmitry Kalinkin**, and **Torre Wenaus**