

Echelon 1 Resource Estimates and Site Requirements



Brookhaven
National Laboratory

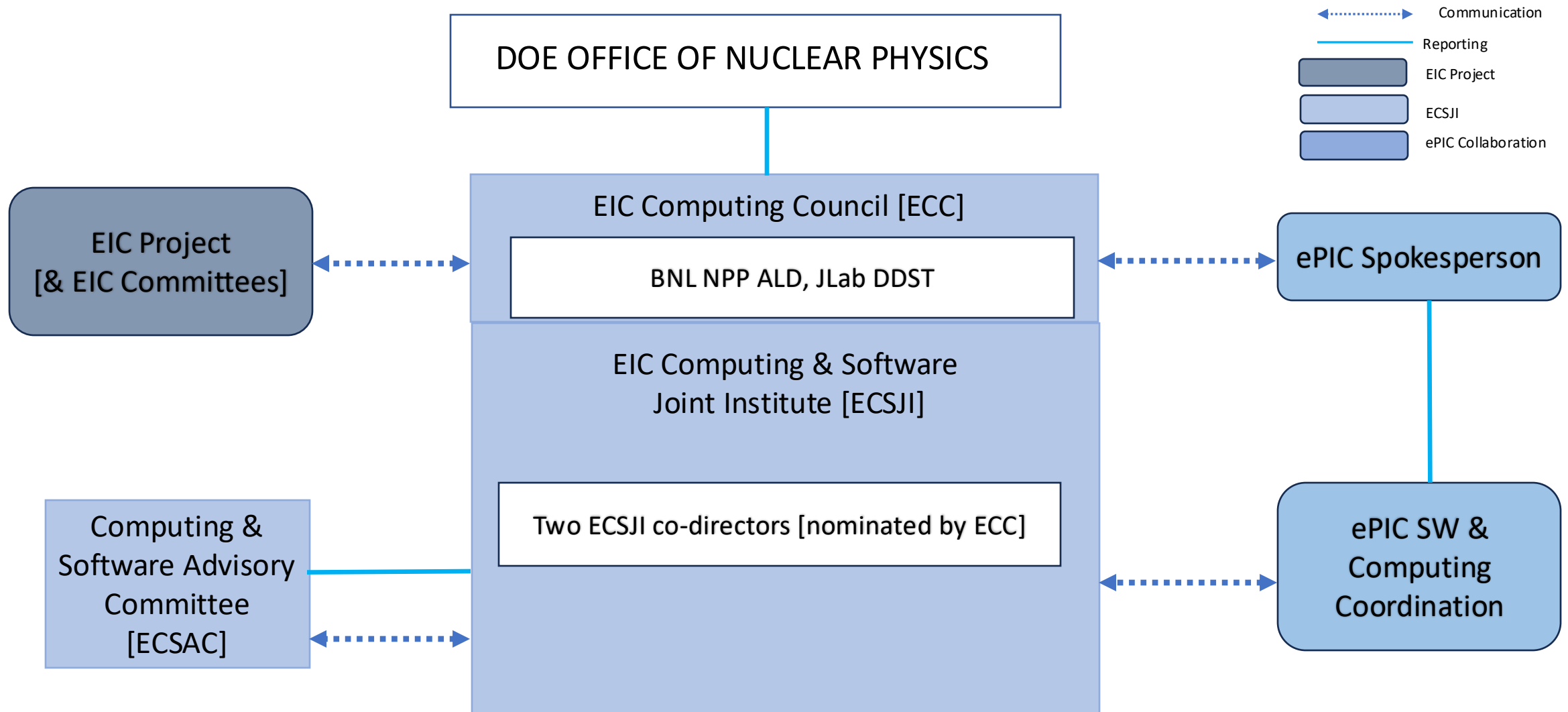
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EIC Echelon 0-1 mini-Workshop.
October 8, 2025

EIC Computing, DOE Context



v0.25 May 27, 2025

Estimating BNL and JLab Requirements for ePIC/EIC Computing in 2027–2032 (aka “white paper for DOE ONP”)

- Also to address EIC Computing and Software Advisory Committee (ECSAC) September 2024 recommendation :
 - *Assign dedicated effort to the ePIC S&C team before the next ECSAC meeting*
- *Timeline*
 - *Request from DOE ONP (P.Mantica [PM])*
 - *EIC RRB June 2025*
 - *Also comments by PM at BNL RHIC R&R review (September, 2025)*
 - *Amber, Markus, Alexei worked on draft (August – September)*
 - *September 30 : draft sent to ECC (A.Deshpande & D.Dean) and EIC Project Co-Directors (E.Aschenauer & R.Ent)*
 - *October 6 : presentation to ECSAC*
 - *October 7 : updated version was sent to ECC*
 - *comments from ECC, EIC and ECSAC are addressed*
 - *Target : send white paper to DOE ONP before EIC RRB*

Estimate of BNL and JLab requirements for the ePIC/EIC computing in 2027-2032.

Motivation

- The host laboratories for the EIC, [BNL and JLab](#) are primarily responsible for developing and implementing [EIC computing services and infrastructure](#), from online delivery of data to its processing and archiving.
 - AI will play a central role in this development, positioning EIC computing as a leader in AI for the online system and computing in general.
 - This development is being conducted in close collaboration with the EIC project and the ePIC collaboration. The ePIC collaboration is co-designing the detector and the computing of the primary experiment at the upcoming Electron-Ion Collider.
 - These systems are being developed in parallel and in close coordination to establish a distributed computing model that enables seamless data processing from the detector to the physics analysis, incorporating AI and streaming readout.
 - Current efforts focus on data transfer and processing from the detector to Echelo 1 sites at BNL and JLab, as well as collaborations with international partners on distributed computing.
- [We must be fully prepared for the early tests](#) and data challenges planned with the ePIC collaboration.
 - See [backup slides](#) for EIC, ePIC detector, Streaming DAQ & Computing schedule
- Currently, [ePIC/EIC computing](#) opportunistically uses Lab and DOE/NSF resources, which are [partly supported by the Labs' program development funds](#). Both Laboratories support the EIC program in all three core categories: compute, software infrastructure, and storage.
- We successfully completed the initial phase of the ECSJI and EIC International Computing Organization (EICO) in 2024/25, and [we are ready to start developing the EIC computing infrastructure prototype](#). This prototype will be integrated with the ePIC international computing resources in CY 2027 and will be ready for the planned DAQ challenges in 2027/2028.

Estimate of BNL and JLab requirements for the ePIC/EIC computing in 2027-2032.

Inputs and Assumptions

1. The estimates are based on the most recent version of the ePIC Streaming Computing Model Report, it is assumed that in 2034 the EIC will operate at 10% of its expected maximum luminosity of approximately $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
2. To estimate host labs contributions, we assume their share is based on the following allocation fractions.

Assumption	Computing	Storage (disk)	Storage (tape)
Host Labs fraction	100%	100%	100%

It is further assumed that Echelon 1 computing facilities will be sufficient to perform prompt and full processing of ePIC data at the EIC startup. This aligns with the expectation that two data replicas will be archived at BNL and JLab and Echelon 2 sites will not be fully operational by 2032.

3. We assume a typical 99% of uptime for the Echelon1 computing resources.
4. A common 5-year replacement cycle is assumed for computing and storage servers. Equipment can be purchased with longer warranty (at a cost) and can also be operated out-of-warrant (at a risk).

Final assumption: The final assumption concerns the EIC schedule. The execution of the current request will cover the period between 01/01/2027 until 12/31/2032. Computing procurement and deployment are aligned with the overall EIC Project schedule and the associated timelines for the development and deployment of the ePIC DAQ, computing, and AI components.

Risks

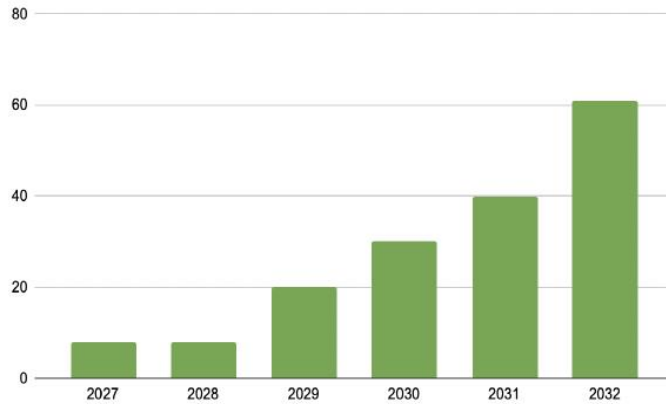
Risk 1: Given the large increase in computing and storage needs just prior to the start of the EIC program, additional schedule delays may modify the amount of funds needed in this 6-year request.

Risk 2: We assume a 10% and 5% reduction per year in the computing cost per kHS and in the disk storage per PB. External factors like supply-chain interruptions, exchange rates, and additional costs due to importing tariffs may have a large impact on the assumption of cost reduction per year. Changes in architecture (eg, GPU and FPGA computing, or NVMe storage) can also have an impact on the cost.

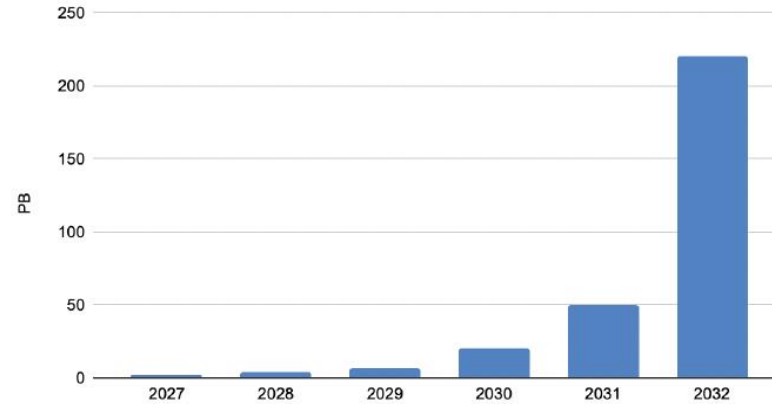
Estimate of BNL and JLab requirements for the ePIC/EIC computing in 2027-2032.

Purchase cost model and labor profile.

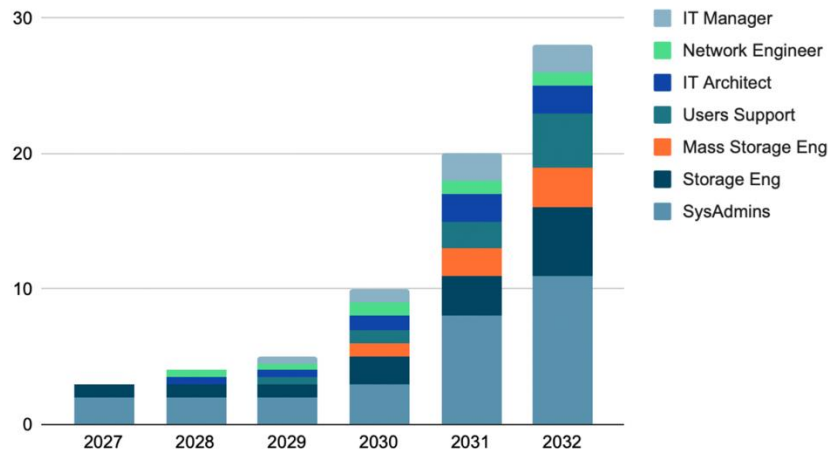
CPU [kCores] vs Year



Storage [PB] vs. Year



Labor Profile 2027 - 2032



- During the first years of data-taking, the Echelon 2 sites will be fully commissioned and integrated into the workflows, providing substantial extraordinary CPU and storage capacity.
- By that time, algorithms, including AI-based data filtering, are expected to be optimized and tuned, and experience will have been gained regarding end-user analysis needs.
- A gradual increase in CPU and storage capacity is preferred to avoid the simultaneous retirement of a large portion of resources at the end of their five-year lifecycle.
- The staffing plan initially supports system admin for procurement and deployment of the initial hardware systems. The staffing ramp adds skills each year to support the deliverables for managing the activities, designing and operating the systems including the user support.
- This estimate does not include ePIC specific software activities, but Echelon1's personnel will work on distributed computing support, including data and workload management instances at JLab and BNL, CVMFS₇ services, and collaborative tools and user support.

Estimate of BNL and JLab requirements for the ePIC/EIC computing in 2027-2032.

Timeline and milestones (preliminary).

	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
Brookhaven National Laboratory EIC scequare								c c c c
DAQ schedule		t	d	h	f		μ	
Networking & Tests	Ω		Test IP6 BNL JLab		β	λ	α	
Echelon0 enclave at BNL		6 DAQ racks		DAQ+ racks	DAQ storage		Product ion ready	
compute			10% cores		30% cores	50% cores	75% cores	Production ready 61k cores
storage		2PB		4PB	7PB	20PB	50PB	Production ready 220PB
archive (tape)				1PB		4PB	40PB	Production ready 200 PB
services		Early development & prototype				Bulk procurement	Commissioning & Installation	Production Ready

EIC timeline:
 c : no beam and cosmics commissioning run

DAQ timeline :
 t : DAQ test setup
 h : DAQ full hardware and timing chain
 d : DAQ readout detector in test stand
 f : full DAQ chain
 μ : DAQ ready for cosmics

Networking & tests timeline :
 Ω : collect and evaluate requirements for EIC/RHIC fibers
 β : BNL LAN Data Challenge
 λ : Echelon0/Echelon1 Data Challenge
 α:Full Dress Rehearsal (DAQ → <Echelon0> → Echelon1/2..)

- Timelines and milestones are aligned with those of the EIC project (DAQ) and the ePIC collaboration
- We will review the proposed timeline on a year-by-year basis. The decision to purchase bulk computing and storage in FY29 and FY31 will depend on the EIC project schedule and the readiness of the Echelon 2 sites for ePIC, which provide extraordinary computing in support of the core computing performed at the Echelon 1 sites.
- Under the current plan, we retain the flexibility to adjust our pace in response to the EIC schedule. If the EIC project experiences delays, we can slow our activities accordingly; conversely, if it accelerates, we have the capacity to expedite our efforts. The purchase and deployment schedule will be reviewed and discussed annually.

Summary and Conclusion

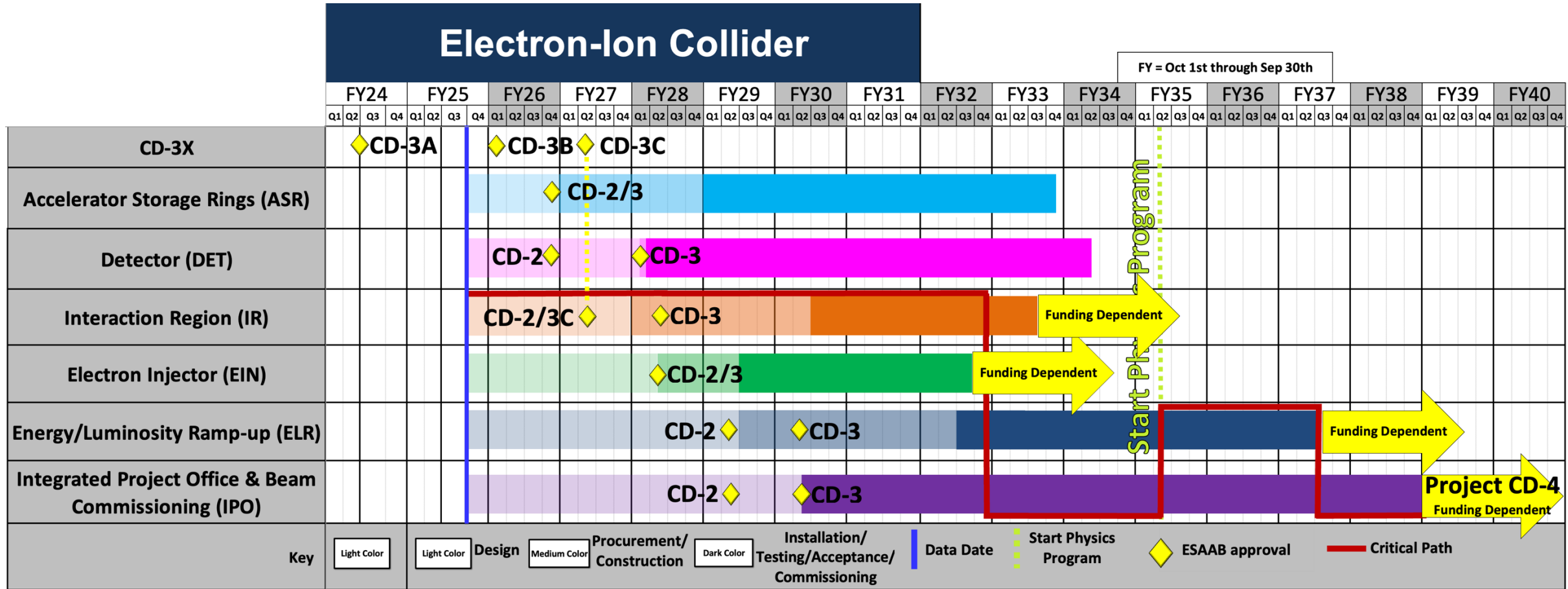
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- We successfully completed the initial phase of the EIC national and international computing organization in 2024/25, and we are ready to start developing the EIC computing infrastructure prototype. This prototype will be integrated with the ePIC international computing resources in CY 2027 and will be ready for the planned DAQ challenges in 2027/2028.
- At the request of the DOE ONP, ECSJI is preparing a document on projected computing estimates and requirements, with input from the ePIC Software & Computing Coordinator. A draft has been shared with the BNL ALD and JLab DDST for feedback. We intend to share it with the EIC Project and ePIC leadership before presenting it to the DOE ONP in October

Glossary and Abbreviations

- AHM – All Hands Meeting
- ALD – Associated Laboratory Director
- CM – Computing Model
- DDST – Deputy Director for Science and Technology
- E0, E1, E2 – Echelon0, 1, 2 sites according to ePIC computing model
- ECC - EIC Computing Council
- ECSAC – EIC Computing and Software Advisory Committee
- EICO – EIC International Computing Organization
- ECSJI – EIC Software and Computing Joint Institute
- IKC – in-kind contribution
- MB – Management Board
- NPP – Nuclear and Particle Physics
- OB – Overview Board
- ONP – DOE Office of Nuclear Physics
- OSG - Open Science Grid (NSF supported computing consortium)
- RRB – Resource Review Board
- SLA – Service Level Agreement
- SW&C – Software and Computing
- TF – Technical Forum
- WLCG – World LHC Computing Grid

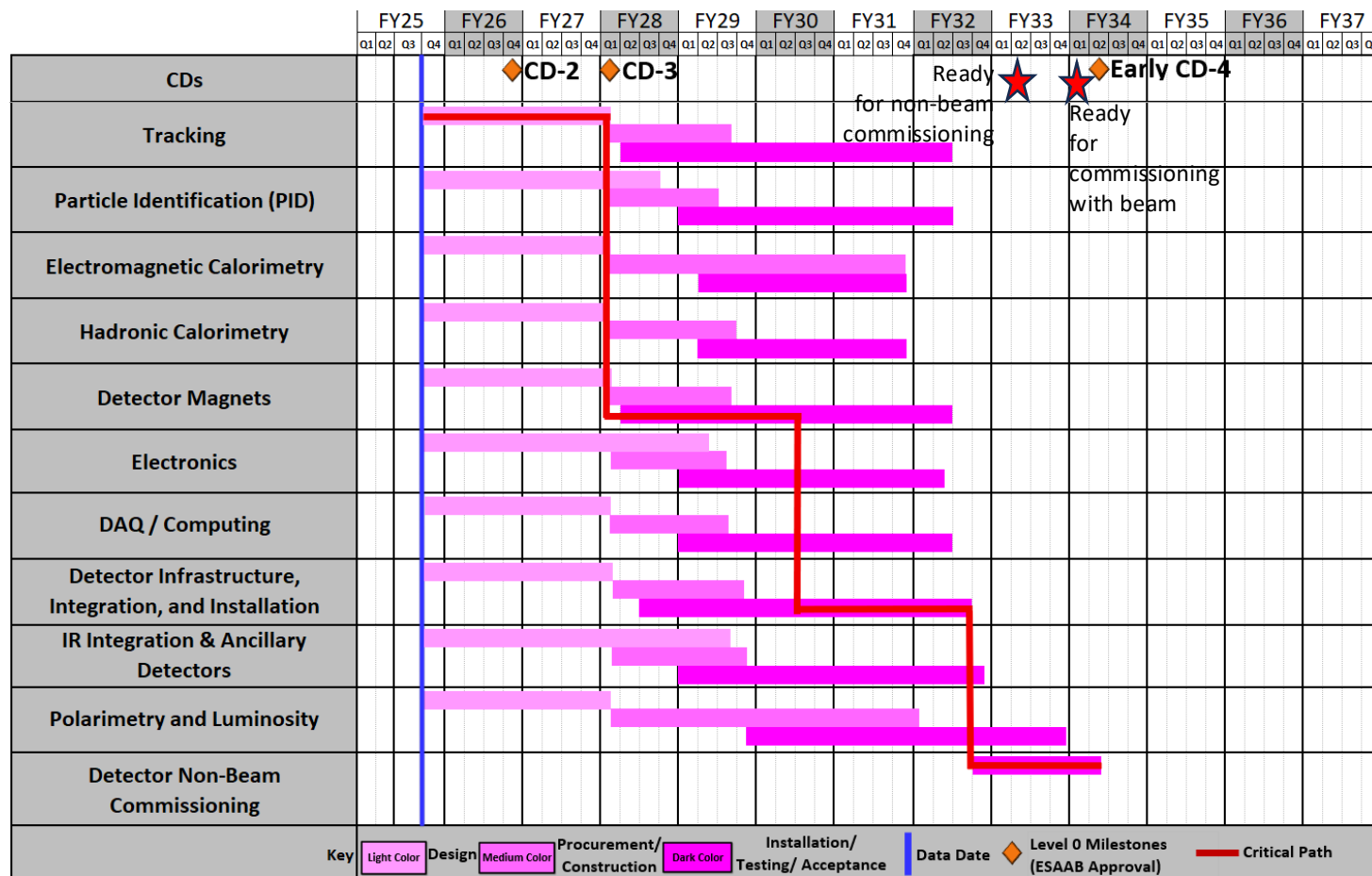
Backup slides

EIC High Level Schedule



Effect of the \$300M/y peak funding profile on the schedule

ePIC DET Subproject Schedule



Schedule Drivers:

- To hold the date for a CD-2 Independent Project Review (IPR) expected not before June 2026
- To keep the (inter)national user community engaged and limit the danger to lose groups
- all subdetectors need to be more or less ready at the same time to be assembled to ePIC
- Superconducting Solenoid → CD-3A item
- Silicon Sensors (MAPS, AC-LGAD & ASTROPIX)
- ASIC long time frames only one ASIC designed from scratch all others are modifications to existing ASICS
- Items with long production times, single vendor and complex assembly → CD-3A & CD-3B
- International agreements driving in-kind and MAPS design (agreement with CERN)

FY25	FY26	FY27	FY28	FY29	FY30	FY31	
PicoDAQ	MicroDAQ	MiniDAQ	Full DAQ-v-1	Production DAQ			DAQ
Streaming Orchestration			Streaming Challenges				Computing
AI-Empowered Streaming Data Processing			Analysis Challenges				
				Distributed Data Challenges			
AI-Driven Autonomous Calibration			AI-Driven Autonomous Alignment, Calibration, and Control				AI