Status of the Early Science Report

The ESR editorial team
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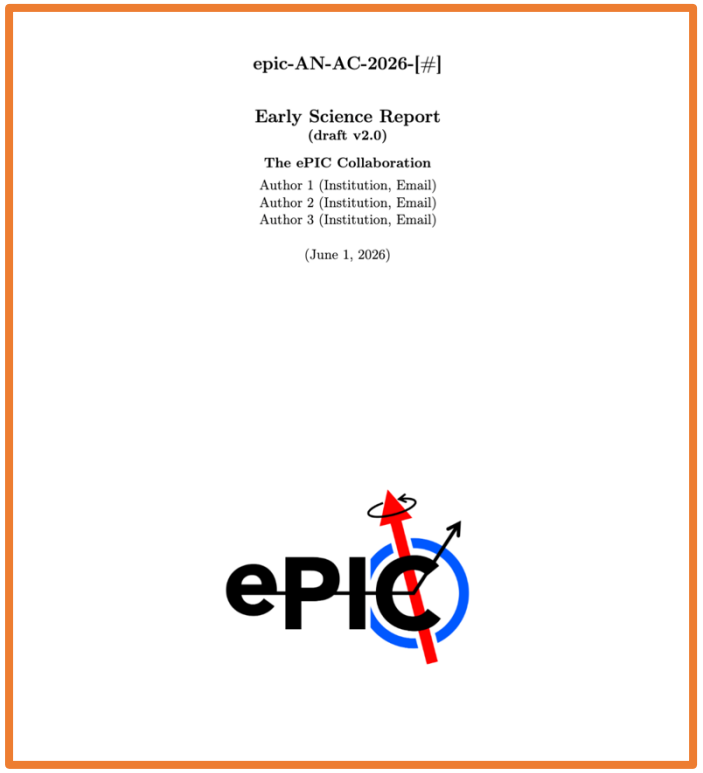
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Early Science Report
(draft v2.0)

The ePIC Collaboration

Author 1 (Institution, Email)
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Author 3 (Institution, Email)

(June 1, 2026)

ePIC General Meeting

June 5th, 2026

The Charge and the Opportunity

- The EIC will ramp up gradually — luminosity, beam energies, species and polarization arrive in stages during the early years of running
- In June 2025 BNL & JLab Associate Lab Directors charged ePIC to summarize the science achievable with early data, before full machine capability
  - The initial deadline of May 1 -> **July 1**
- This report answers that charge using the **full Geant4 detector ePIC simulation** and **official ePIC event reconstruction**

○ **Goal of this exercise:**

- Highlight *meaningful* and *impactful* science within early years of running without undermining the importance of achieving full EIC capabilities

Jefferson Lab

Brookhaven National Laboratory

June 13, 2025

Subject: ePIC Collaboration: Early Science Document

John Lajoie and Silvia Dalla Torre
Spokespeople, ePIC Collaboration

Dear John, Silvia and the ePIC Collaboration,

As the EIC construction plan becomes more mature, it is apparent that there will be a period of about five years when there will be collisions at the ePIC and early data could be recorded. The EIC Project team has released their expectations for the beam parameters (polarization, luminosity, energy and nuclear species) and their ramp-up during that early operating phase. We are writing to you – the ePIC collaboration - to develop a short document summarizing the science that would be possible from those early data.

Based on the early commissioning beam parameters released by the EIC project [1,2], the ePIC collaboration should summarize for the broader nuclear physics community, the funding agencies, and for the Labs, what exciting scientific results would be possible from this perid. The results in the document should be based on the most recent understanding of the ePIC detector including the acceptances, efficiencies of each detector subsystem, and off-line reconstruction capabilities the collaboration has developed so far. We believe this document will also serve to help in the preparation of the ePIC TDR currently under preparation by the collaboration with the EIC Project, as input to CD2/3 milestone for the EIC. Beyond the physics of interest, we think that this ePIC early physics document would also be useful to demonstrate the collaboration's engagement and getting prepared for physics at the EIC and capture the status of ePIC collaboration's activities at this stage. We are happy to support this activity through in-person or hybrid workshops or topical meetings should they be needed.

We recognize that this is an additional exercise for the ePIC community. At the same time, many previous such exercises (like the Yellow Report) were focused on full EIC machine capability. This report should focus on the science that could be produced before the ramp up to the full EIC machine capability.

We suggest that the collaboration prepares this report by May 1, 2026.

1 of 2 ePIC Early Science

How the Idea Started?

- Even **before the charge**, the EIC machine ramp up phase prompted ePIC collaborators to assess the scientific impact achievable with early data
  - The EIC early science program **must engage the collaboration**; it must get the collaboration excited about working hard for the future. It must have a balance of *breadth* and *depth*
  - The EIC early science program must take the first steps towards realizing the EIC science goals
- **E.C. Achenauer's talk** @ ePIC Collab. Meeting (Lehigh) [link] kick started the discussion
- **Dedicated "early science" and "physics readiness" workshops:**
  - **Sep. 13, 2024 – online [link]**
  - **Jan. 2025, plenary at Coll. Meeting [link]**
  - **Apr. 2025, CFNS @ Stony Brook [link]**
  - *ESR charge received on June 13*
  - **Sep. 2025, IoP in London [link]**
  - **Mar. 2026, University of Calabria & INFN Cosenza [link]**

EIC Early Running Conditions

9 GeV electron beam (at 10 nC) collides with a staged sequence of hadron and ion beams

Stage 1 — Commissioning

Unpolarized mid-weight ions (e+Ag, 9×115 GeV) for technical stability in the RHIC→EIC transition

Stage 2 — e^- polarization

Longitudinal electron polarization via spin rotators; far-forward proton detectors (RPs) commissioned when beam conditions permit

Stage 3 — hadron polarization

Hadron spin rotators enable longitudinal proton polarization

Species	Beam energy (GeV)	Integrated luminosity	Electron-beam polarization	Hadron-beam polarization
e+Ag	9×115	1.0 fb^{-1}	NO	N/A
e+D	9×130	1.5 fb^{-1}	LONG	NO
$e+p$	9×130	1.0 fb^{-1}	LONG	TRANS and/or LONG
$e+p$	9×275	2.5 fb^{-1}	LONG	TRANS and/or LONG
e+Au	9×100	1.0 fb^{-1}	LONG	N/A
$e+{}^3\text{He}$	9×166	1.5 fb^{-1}	LONG	TRANS and/or LONG

The e+A luminosity is per nucleon

- Matrix based on Project's assessment for early running conditions:
  - See Elke's talk [link]
- **For comparison:** HERA delivered 0.5fb^{-1} each to H1 and ZEUS in its lifetime

EIC Early Running Conditions

- **Early Science -> the new Matrix**
  - **Assumptions:**
    - Running 30 weeks/year
    - 2.5 hour turn around time
    - 80% facility availability
  - **Other Config's also possible:**
    - ep 5x100: 0.5 fb-1/year
    - eAu 5x110: 2 fb-1/year
    - eAg 5x110: 2 fb-1/year
- **Simulations:**
  - ESR: Use April campaign, just rescale the lumi
  - NIM-A: July, new energies!

Species	Beam energy (GeV)	Integrated luminosity	Electron-beam polarization	Hadron-beam polarization
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Table 1: EIC Early Science Matrix. The eA luminosity is per nucleon.

Remember: we are not making a run plan

- **Updated Roadmap to ESR**
  - May 29 – v2.0 draft handed over to the referees
  - June 10 - feedback from referees
  - June 16 – circulation to Collaboration. Request feedback by June 23
  - **July 1** – hand over to ALDs prior to Collab meeting in Glasgow

The NAS Science Pillars

Identified in the 2018 **National Academy of Sciences assessment** of the EIC science case

Origin of nucleon mass

How does the mass of the nucleon arise?

Gluon dynamics, gravitational form factors, and the QCD mechanisms behind visible mass

Origin of nucleon spin

How does the spin of the nucleon arise?

Quark & gluon helicity, transversity, and orbital angular momentum via polarized beams

Dense gluonic matter

What are the emergent properties of dense gluon systems?

Nuclear gluon densities, nuclear structure, and the search for gluon saturation

Every early running measurement presented in ESR maps to one or more of these pillars

- A draft will be shared with the collaboration on **June 16**

  -> we look forward to you input!
- ESR deadline July 1

  -> we will present a summary in Glasgow!

Preview of Our Take Aways

Even before full design parameters, ePIC will deliver world-leading insights, and lay the foundation for the complete EIC science mission

Main takeaways:

- Early ePIC running takes the first decisive steps on all three NAS pillars — not a commissioning exercise, but globally competitive QCD science
- The program is staged by machine capabilities: with unpolarized inclusive DIS yielding the first impactful and precision measurements
- Early running also establishes the validated reconstruction, calibration and analysis methods for the full EIC program

❖ We are working with the publication committee on an ePIC author list and on how to list theorist collaborators

Delivered early

- F_2, F_L & proton PDFs
- α_s at world-class precision
- Meson structure
- g_1^p, g_1^n spin structure
- Initiate Sivers/Collins/transv.
- Nuclear gluon imaging
- Charm & jet R_eA in nuclei