Physics activities and 2026 budget requests

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Istituto Nazionale di Fisica Nucleare

Structure of the Physics Working Groups

PHYSICS ANALYSIS COORDINATORS
Salvatore Fazio (Cosenza)
Rachel Montgomery (Glasgow)
Deputy PAC: Rosi Reed (Lehigh)

INCLUSIVE PHYSICS
Win Lin (Stony Brook)
Stephen Maple (Birmingham)

SEMI-INCLUSIVE PHYSICS
Anselm Vossen (Duke)
Ralf Seidl (RIKEN)

JETS AND HEAVY FLAVOR
Shyam Kumar (Bari)
Rongrong Ma (BNL)

EXCLUSIVE, DIFFRACTION AND TAGGING
Stephen Kay (York)
Zhoudunming Tu (BNL)

BSM AND PRECISION EW
Zuhal Seyma Demiroglu (Stony Brook)
Juliette Memmei (Manitoba)

INFN people's involvement

- Each PWG convener is for a two-years term staggered
- Conveners in blue are just appointed in July 2025
- **S. Fazio (CS) is one of the two Physics Analysis Coordinators**
  - Ex officio member of the **ePIC Executive Board**
  - **5k€ requested (CS) to support travel for PAC's role:**
    - TDR readiness + Early Science Workshops
    - Networking meetings (e.g. synergy, technical and topical workshops, EIC community meetings abroad)
- **S. Kumar (BA) nominated as JETS+HF PWG convener this July**
  - **Awaiting official endorsement by the Collab. Council**
- Involvement of Italian groups in physics analysis activities is growing at a fast pace!
  - Activities and and requests are outlined in following slides

Technical Design Report

pre–TDR (60% design completion) ⟹ December 2025

TDR (90% design completion) ⟹ ~ late 2026

- (pre)TDR are a deliverable of the EIC Project (project manager acts as editor)
  - describes the ePIC experiment
  - Technical Chapter: (hundreds of pages)
    - Focus on the ePIC Detector Description, basic performance, Software, and data preservation
  - Physics Chapter: (~60 pager)
    - Focus on physics performance and science reach
    - We envision the **publication of a spin—off physics performance paper(s)**
    - Sep. 2025 – Physics Readiness workshop, Institute of Physics, London (UK)

EIC Early Science Report

- **Charge** from Directors of Science:
  - David Dean (JLab) and Abhay Deshpande (BNL)
- **Goal of this exercise:**
  - **Highlight *meaningful* and *impactful* science within early years of running without undermining the importance of achieving full EIC capabilities**
- **Deliverables:**
  - **Report to Science Directors by May 1st, 2026**
  - **Journal Publication by the ePIC Collab. by Fall 2026**
- **Dedicated workshops:**
  - Sep. 13, 2024 (online)
  - Apr. 2025, CFNS @ Stony Brook (USA)
  - Sep. 2025, Institute of Physics, London (UK)
  - **Planned follow-ups:**
    - Feb. 2026 (Cosenza, Italy), Apr. 2026 (CFNS, USA)

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

EIC Early Science Matrix

- What machine capabilities can we expect for Early Science?
  - See Sergei Nagaitzev's talk in the first Early Science Workshop: https://indico.bnl.gov/event/24432/
- Matrix based on latest news by the Project:
  - See Elke Aschenauer's talk at the Collab. Meeting in Frascati: https://agenda.infn.it/event/43344/contributions/250126/

	Species	Energy (GeV)	Luminosity/year (fb-1)	Electron polarization	p/A polarization
YEAR 1	e+Ru or e+Cu	10 x 115	0.9	NO (Commissioning)	N/A
YEAR 2	e+D e+p	10 x 130	11.4 4.95 - 5.33	LONG	NO TRANS
YEAR 3	e+p	10 x 130	4.95 - 5.33	LONG	TRANS and/or LONG
YEAR 4	e+Au e+p	10 x 100 10 x 250	0.84 6.19 - 9.18	LONG	N/A TRANS and/or LONG
YEAR 5	e+Au e+3He	10 x 100 10 x 166	0.84 8.65	LONG	N/A TRANS and/or LONG

Note: the eA luminosity is per nucleon

NB: ePIC installation plan calls for the full ePIC to be installed year-1 (exception for roman pots and OMD)

ePIC science document for the inputs to the EPPSU 2025

March 28, 2025

Synergies between a U.S.-based Electron-Ion Collider and European Research in Particle Physics

Contact Persons: Stefan Diehl[1], Raphaël Dupré[2], Olga Evdokimov[3], Salvatore Fazio[4], Ciprian Gal[5], Tyler Kutz[6], Rongrong Ma[7], Juliette Mammei[8], Stephen Maple[9], Marco Radici[10], Rosi Reed[11], Ralf Seidl[12], Zhoudunming Tu[13]

On behalf of the ePIC Collaboration and the EIC User Group

Abstract

This document is submitted as input to the European Strategy for Particle Physics Update (ESPPU). The U.S.-based Electron-Ion Collider (EIC) aims at understanding how the complex dynamics of confined quarks and gluons makes up nucleons, nuclei and all visible matter, and determines their macroscopic properties. In April 2024, the EIC project received approval for critical-decision 3A (CD-3A) allowing for Long-Lead Procurement, bringing its realization another step closer. The ePIC Collaboration was established in July 2022 around the realization of a general purpose detector at the EIC. The EIC is based in U.S.A. but is characterized as a genuine international project. In fact, a large group of European scientists is already involved in the EIC community: currently, about a quarter of the EIC User Group (consisting of over 1500 scientists) and 29% of the ePIC Collaboration (consisting of ∼1000 members) is based in Europe. This European involvement is not only an important driver of the EIC, but can also be beneficial to a number of related ongoing and planned particle physics experiments at CERN. In this document, the connections between the scientific questions addressed at CERN and at the EIC are outlined. The aim is to highlight how the many synergies between the CERN Particle Physics research and the EIC project will foster progress at the forefront of collider physics.

- **The Science document submitted to the European Strategy for Particle Physics panel**
  - arXiv:2504.01236
  - **ZENODO:** https://zenodo.org/records/15102075
  - **Jointly submitted by EICUG and ePIC**
  - **Main editors:**
    - S. Fazio (CS) [ePIC PAC]
    - M. Radici (PV) [past EICUG Chair]
    - Key contributions by PWG Conv.s

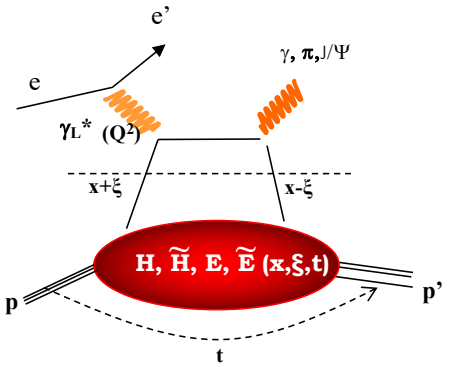
How can we help?

- **Italy has some potential to exploit (and help with the TDR cause):**
  - Leading experience with TMDs and SIDIS (3D imaging in momentum space)
  - Leading experience with diffractive PDFs at HERA (onset of gluon saturation)
  - Leading experience with exclusive processes and GPDs (partonic spatial tomography)
  - and more…
- Opportunity for M.Sc. and Ph.D. students -> analysis of reconstructed root trees
- Opportunity for experienced Ph.D.s and postdocs
  - Holistic detector performance
  - Event reconstruction
  - TDR and Early Science Report – physics performance and impact studies

10 k€ SJ requests to support **physics analysis activities** for y26 – centralized to Resp. Nazionale

- participation of S. Kumar (jets+HF conv.) and key Italian analyzers to **physics readiness** and **early science Workshops,** and eventual other technical meetings (e.g. INT and ECT*)

GPDs impact studies – exclusive+diff+tag PWG



- **Generalized Parton Distribution Functions (GPDs)**
  - **via exclusive processes: DVCS, HEMP, TCS**
  - **lead to proton tomography in impact parameter space**
- **INFN Institutes: Cosenza (S. Fazio) - Milestone y23**
- Collaborating Institutions: BNL, Saclay, Warsaw, Mainz, Zagreb

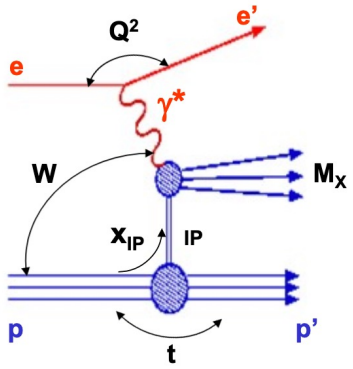
✓ INFN Milestone y23 [100%]: Use the novel E*p*IC generator [Eur. Phys. J. C 82 (2022) 9, 819] to produce DVCS, TCS and mesons physics benchmarks

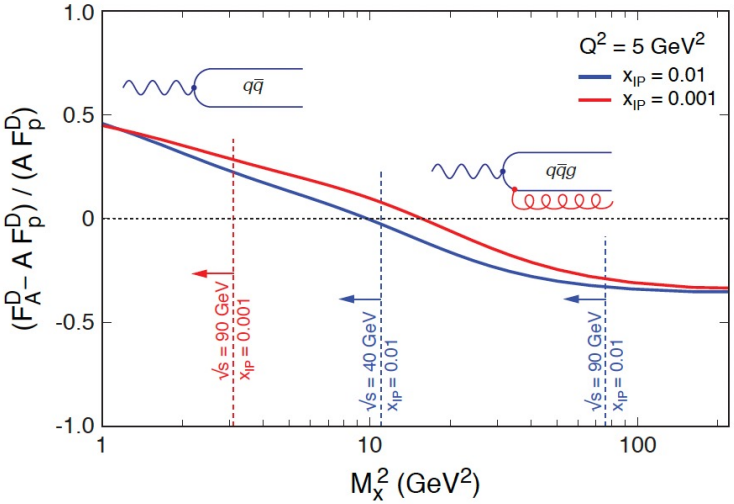
- Goals: Extract GPDs by performing global NLO fits of various models in order to quantify the impact of ePIC in constraining CFFs and GPDs, from DVCS measurements

→ paper just (yesterday) accepted for publication on PRD, preprint: arXiv:2503.05908

No budget requests specific for this activity for y26

Diffractive PDFs - exclusive+diff+tag PWG

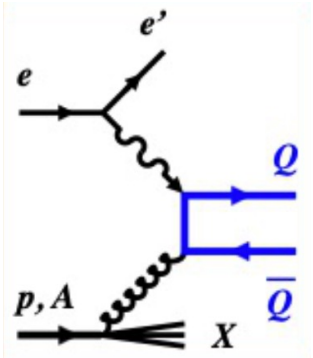




E.C. Aschenauer, S. F., J.H. Lee, *et al.* [*Rept.Prog.Phys.* 82 (2019) 2, 024301]

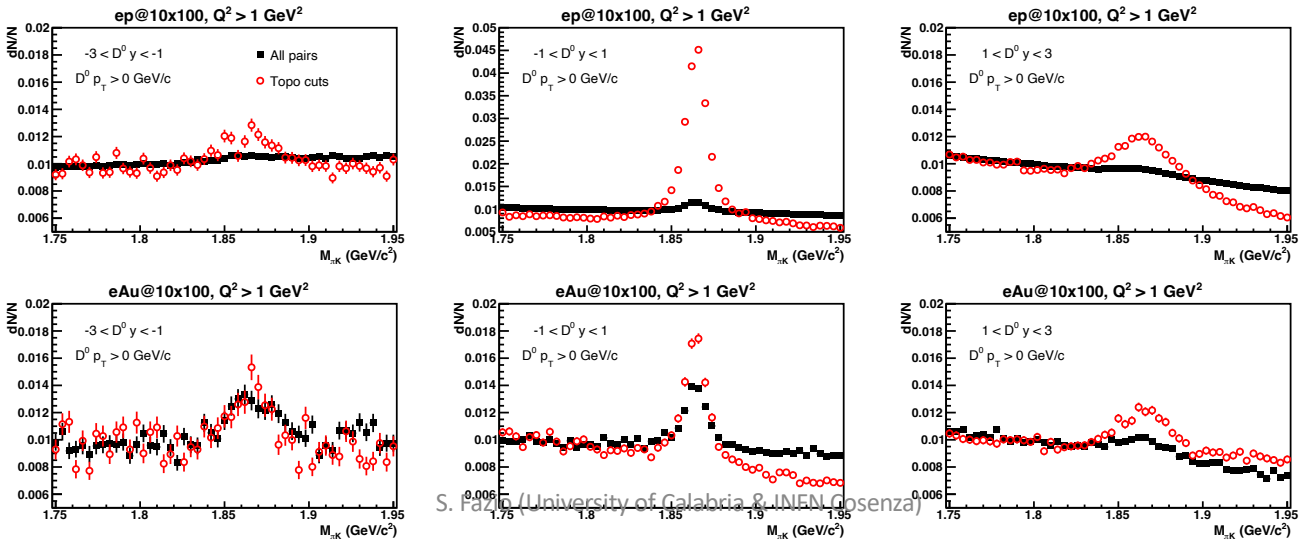
- **INFN Institutes: Torino (M. Ruspa), Cosenza (M. Capua, S. Fazio, H. Hashamipour, E. Tassi)**
- **Extraction of diffractive PDFs from protons and nuclei**
  - **not yet exploited for the EIC!**
  - good constrain on the gluon densities → saturation effects
- **PLAN: Evaluate ePIC's capability to:**
  - Investigate the transition into saturation regime **[Critical for the Collaboration!]**
  - Evaluate the impact on EIC early science
- ❑ **Requests: 2 k€ TO, 2 k€ CS (for Physics and simulation)**
  - **Collectively support networking on MC simulation of dRICH, SIDIS, Diffraction…**
  - hands-on working meetings between TO and early career collaborators at CS

Heavy Flavor Tagging – jets+HF PWG

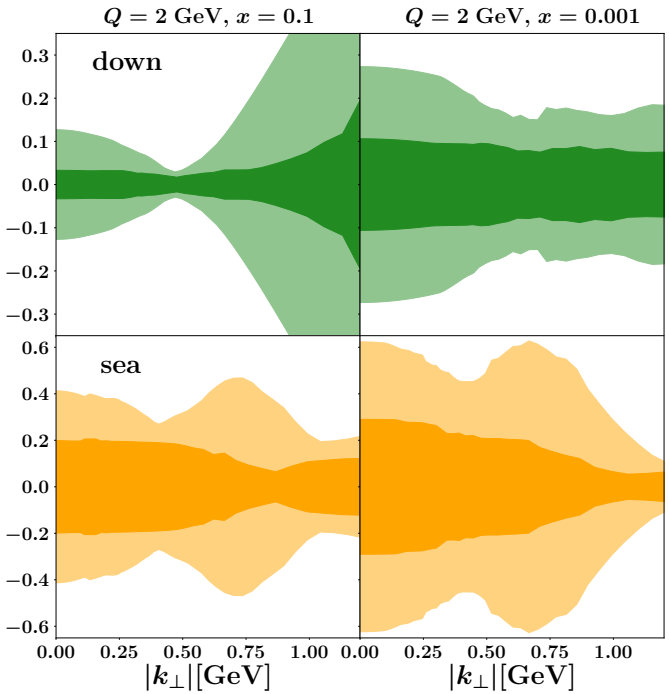


- **INFN Institutes: Bari (S. Kumar, A. Mastroserio), Pavia (G. Boca)**
- **Shyam Kumar just appointed JETS+HF PWG Conveners**
- **GOALS:**
  - Quantify the impact for the tracker into heavy flavor physics
  - Develop secondary vertex reconstruction for heavy flavor tagging
    - One of the defined **reconstruction priorities**

❑ Support for this activity is part of dedicated **"RN: Tasca indivisa"** – see slide 12



TMDs - SIDIS PWG



- **Transverse Momentum Dependent distribution functions (TMDs) lead to transverse tomography of the proton in momentum space**
- **INFN Institutes: BO, CT, FE, GE, PV, SA, TO, TS, LNS** (support from CS)
  - **Susanna Costanza (PV)** coordination the efforts
- **Close collaboration with theorists in CA+PV+TO**
- **Close ties with the INFN's lead in the construction of the dRICH**
  - Aim at seeding an INFN leadership in the SIDIS
- **PLAN:**
  - Investigate PID performance in the different kinematic regions
  - quantify the impact of ePIC on the extraction of TMDs
- **Milestone 2025**
  - "*Realizzazione di studi di performance dei PID detectors nella estrazione delle TMDs, che costituiranno input al Cap. 2 del TDR e relativo articolo esteso sulla fisica di ePIC*"

- **One In-person meeting per year** planned every year, **first was in Pavia in May 2025**
- **Requests:** 1.5k€ (BO), 1.5k€ (CT), 1k€ (FE), 1k€ (GE), 2k€ (LNS), 1€ (SA), 2k€ (PV), 2k€ (TO)

blue are shared with other activities as: **«Fisica and simulation»**

Milestone 2026

"Contributo a studi di physics performance per Early Science Report: documento iniziale dovuto per maggio 2026, con ulteriori elaborazioni in ottica pubblicazione nei mesi successivi"

- La milestone non è limitata ad uno specifico canale di fisica.
- Raggruppa, tra tutte le attività di fisica dei gruppi INFN, quelle che dimostreranno un impatto significativo sulla fisica dei primi 5 anni di presa dati
  - impatto in termini di «current knowledge»
  - impatto in termini di «analysis readiness»
- A supporto della milestone si propone, sub iudice, una tasca indivisa, per partecipazione ai due workshop previsti sull'early science.
  - 10k€ sj - RN: Tasca indivisa partecipazione gruppi a workshops Early Science e meeting Italiano su milestone 2026
    - Sub iudice a organizzazione workshops e partecipazione dei gruppi

Summary

Il coinvolgimento dei gruppi INFN nelle attività di fisica ed analisi è in rapida crescita

- **Leadership in crescita:** 1 PWG Convener in aggiunta al PA Coordinator
- Coordinamento SIDIS interno ad ePIC Italia

- **Milestone 2026:** «*Contributo a studi di physics performance per Early Science Report: documento iniziale dovuto per maggio 2026, con ulteriori elaborazioni in ottica pubblicazione nei mesi successivi*»
- **Richieste per il 2026:**
  - **5 k€** (CS) **– supporto ruolo Analysis Coordinator**
  - **9.5 k€** (2k€ CS, 1.5k€ CT, 1k€ FE, 1k€ GE, 1k€ LNS, 1k€ SA, 2k€ TO) **– fisica e simulazione**
  - **3.5 k€** (1.5k€ BO, 2k€ PV) **– attività SIDIS (networking)**
  - **10k€ sj** - RN: Tasca indivisa partecipazione gruppi a E.S. workshops e meeting su milestone