

The EIC project at BNL

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big news since last SIF:
project formally approved!

Department of Energy

U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility

JANUARY 9, 2020



[Home](#) » U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics

WASHINGTON, D.C. – Today, the **U.S. Department of Energy (DOE)** announced the selection of Brookhaven National Laboratory in Upton, NY, as the site for a planned major new nuclear physics research facility.

The Electron Ion Collider (EIC), to be designed and constructed over ten years at an estimated cost between \$1.6 and \$2.6 billion, will smash electrons into protons and heavier atomic nuclei in an

Secretary Brouillette approved Critical Decision-0, “Approve Mission Need,” for the EIC on December 19, 2019.

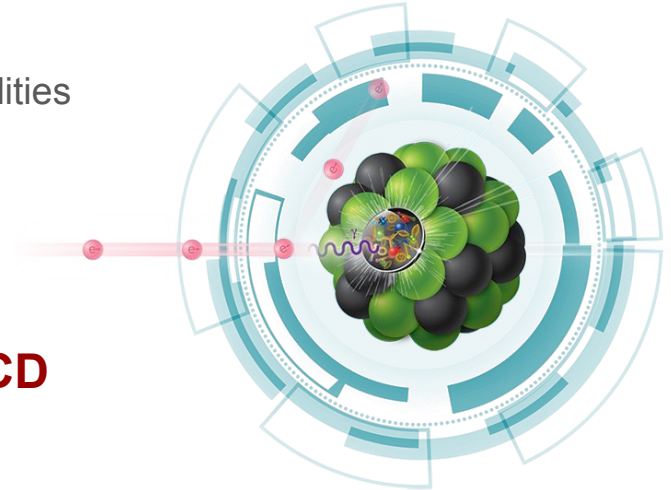
accelerator technology, critical components of overall U.S. leadership in science,” said U.S.

The Electron-Ion Collider

a machine that will unlock the secrets of the strongest force in Nature

is a future electron-proton and electron-ion collider to be constructed in the United States in this decade and foreseen to start operation in 2030

- **EIC constitutes the major US project in the field of nuclear physics**
 - and will surely be one of the most important scientific facilities for the future of nuclear and subnuclear physics
- **EIC will be the world's first collider for**
 - polarised electron-proton (and light ions)
 - electron-nucleus collisions
- **EIC will allow one to explore the secrets of QCD**
 - understand the origin of mass and spin of the nucleons
 - provide extraordinary 3D images of the nuclear structure

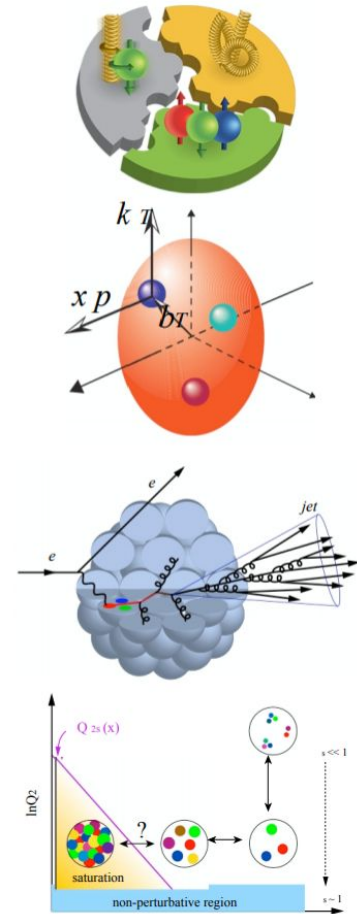


The Physics of EIC

is precision QCD Physics

investigate universal dynamics of gluons
understand the emergence of hadronic matter and its properties

- **how are sea quarks and gluons, and their spins, distributed in space and momentum inside the nucleon?**
 - how do the nucleon properties emerge from them and their interactions?
- **how do colour-charged quarks and gluons, and colorless jets, interact with a nuclear medium?**
 - how do confined hadronic states emerge from these quarks and gluons?
 - how do the quark-gluon interactions create nuclear binding?
- **what happens to the exploding gluon density at low- x in hadronic matter?**
 - does it saturate at high energy, giving rise to a gluonic matter with universal properties?

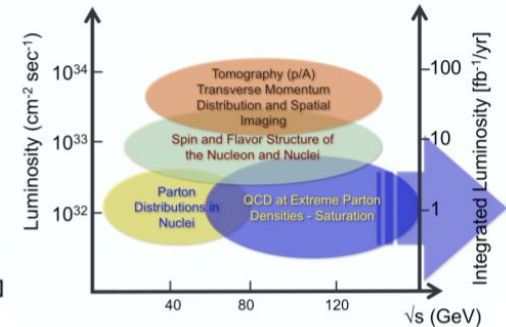
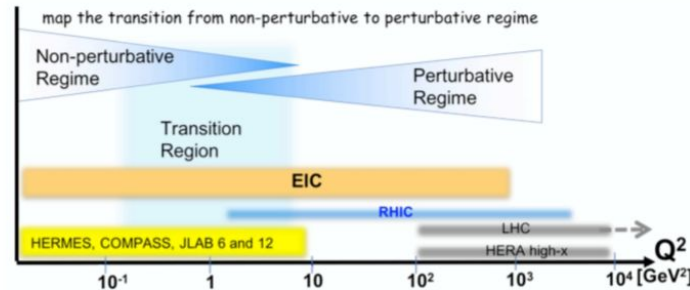
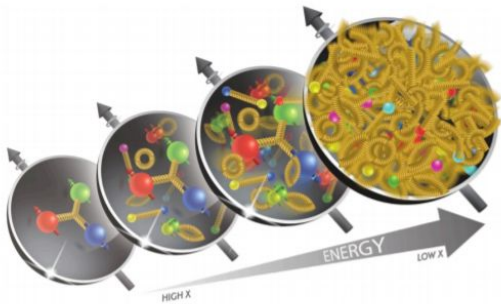


The Electron-Ion Collider aim is to answer central questions in QCD Physics

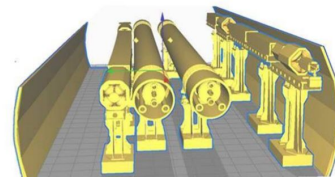
Accelerator requirements

to fulfill the rich physics programme

- **large centre-of-mass energy range, $\sqrt{s} = 20\text{-}140$ GeV**
 - access gluon dominated region and wide kinematic range in x and Q^2
- **polarized electron, proton and light nuclear beams, $\geq 70\%$**
 - access to spin structure and 3D spatial and momentum structure
- **nuclear beams with heavy ions, up to U**
 - access the highest gluon densities ($Q_s^2 \sim A^{1/3}$)
- **High luminosity (100x HERA), $10^{33\text{-}34}$ $\text{cm}^{-2} \text{s}^{-1}$**
 - study observables as a function of x , Q^2 , A , ...



Accelerator overview

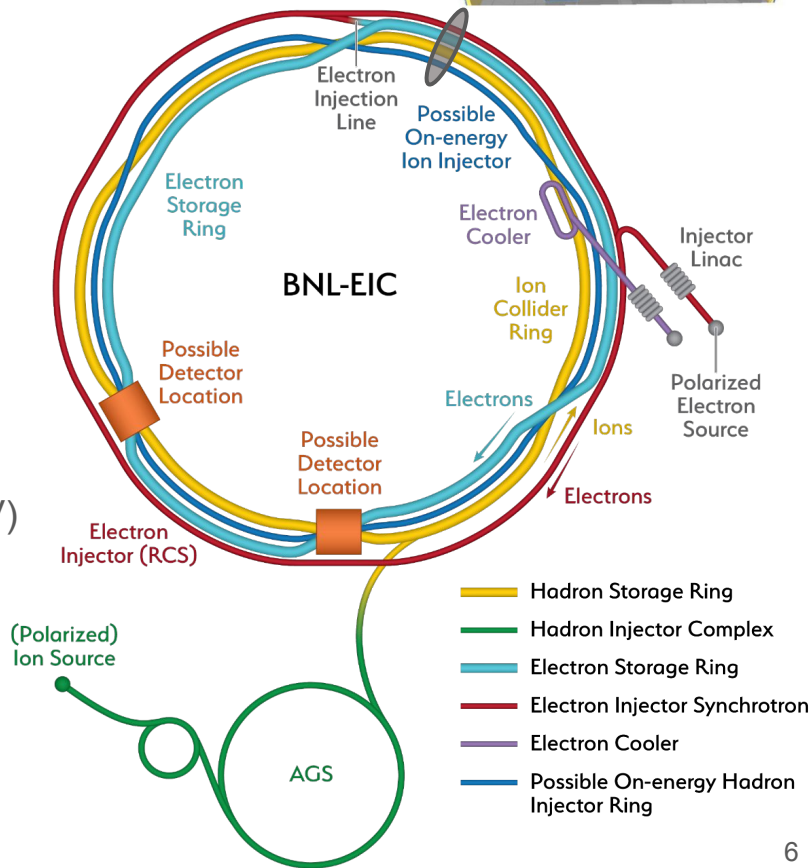


\sqrt{s}	20 – 141 GeV
\mathcal{L}_{max}	$10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
$P(e^-)$	80%
$P(h)$	80%
A	p – U

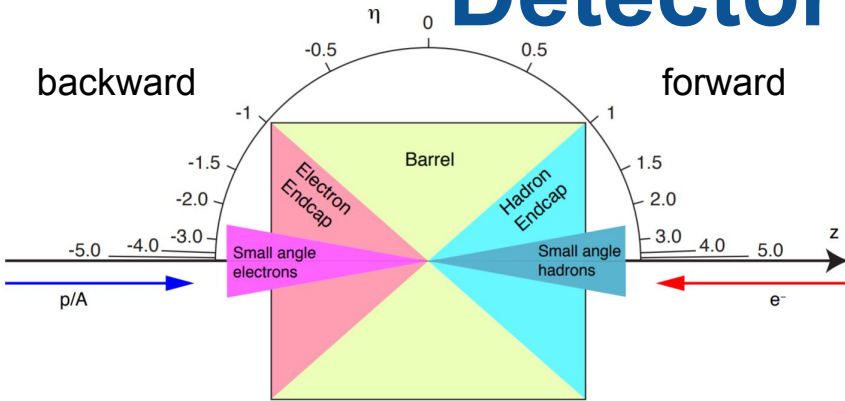
BNL-EIC satisfies the requirements

- **design using much of the RICH facility**

- three accelerator rings
 - existing RHIC ring (275 GeV)
 - new Rapid Cycling Electron Synchrotron (18 GeV)
 - new Electron Storage Ring (18 GeV)
- two injector complexes
 - existing Hadron Injectors
 - new Electron Injectors
- two detector halls
- hadron cooling facility



Detector requirements



- **hermetic detector**

- with low-mass inner tracker
- moderate radiation hardness

- **good momentum resolution**

- central: $\sigma_p/p = 0.05 \oplus 0.5 \%$
- forward: $\sigma_p/p = 0.1 \oplus 0.5 \%$

- **and impact parameter resolution**

- $\sigma = 5 \oplus 15 / p \sin^{3/2} \mu\text{m}$

- **electron and jets**

- $-4 < \eta < 4$

- **excellent EM resolution**

- central: $\sigma_E/E = 10 / \sqrt{E} \%$
- backward: $\sigma_E/E < 2 / \sqrt{E} \%$

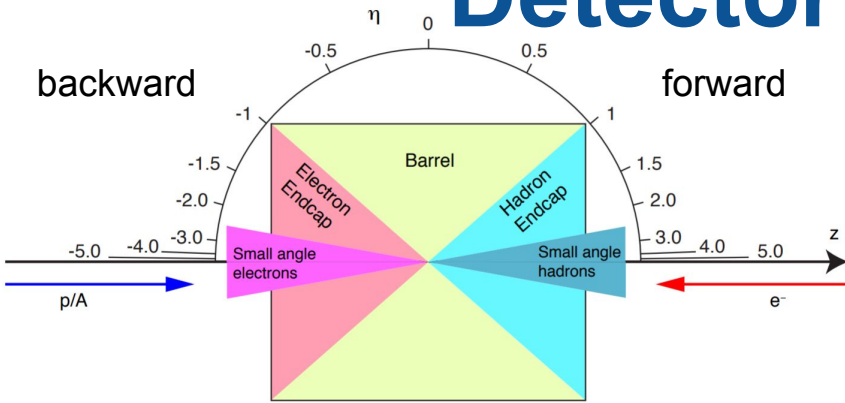
- **good hadronic energy resolution**

- forward: $\sigma_E/E \approx 10 / \sqrt{E} \%$

- **excellent PID for π , K, p**

- forward: up to 50 GeV/c
- central: up to 8 GeV/c
- backward: up to 7 GeV/c

Detector requirements



main challenges
forward PID
EM cal at $< 2\% / \sqrt{E}$ %

- **hermetic detector**

- with low-mass inner tracker
- moderate radiation hardness

- **good momentum resolution**

- central: $\sigma_p/p = 0.05 \oplus 0.5 \%$
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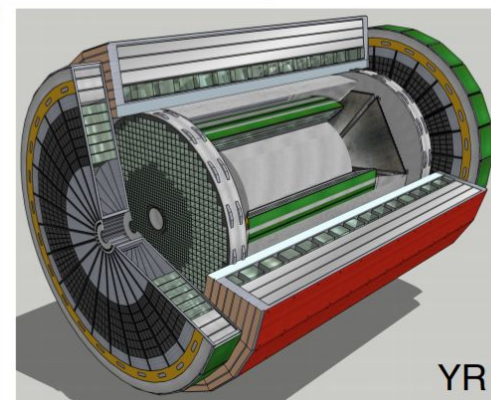
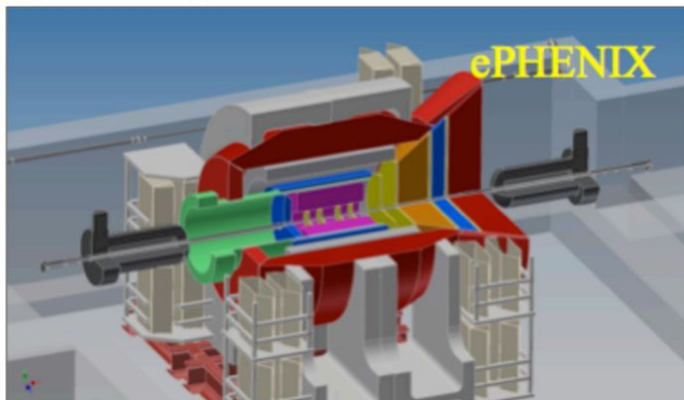
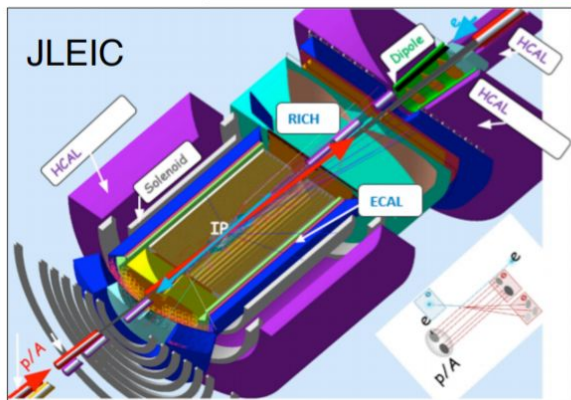
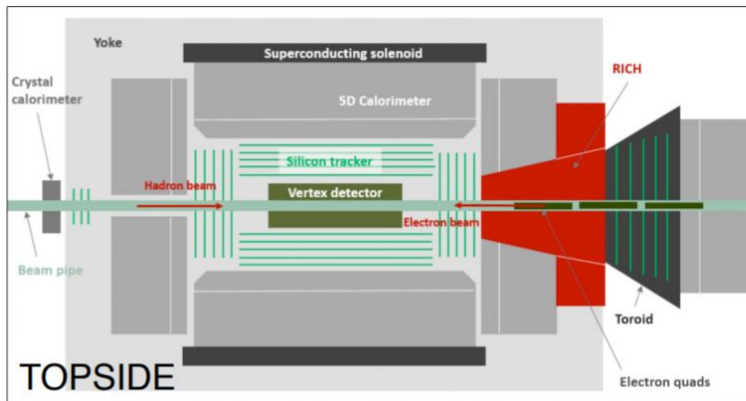
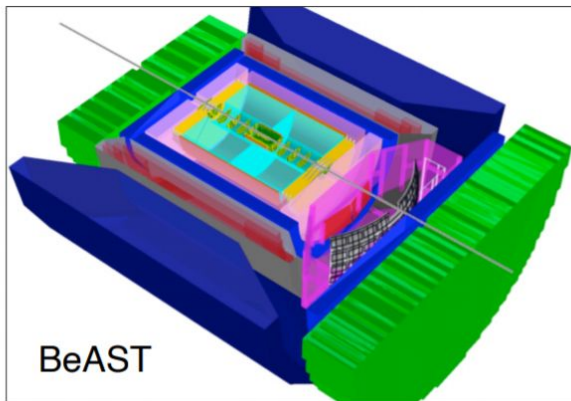
- **good hadronic energy resolution**

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- ○ forward: up to 50 GeV/c
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Detector concepts



current efforts within the Yellow Report will produce more mature concepts
final decision will be in hands of Collaborations once established

The EIC Project

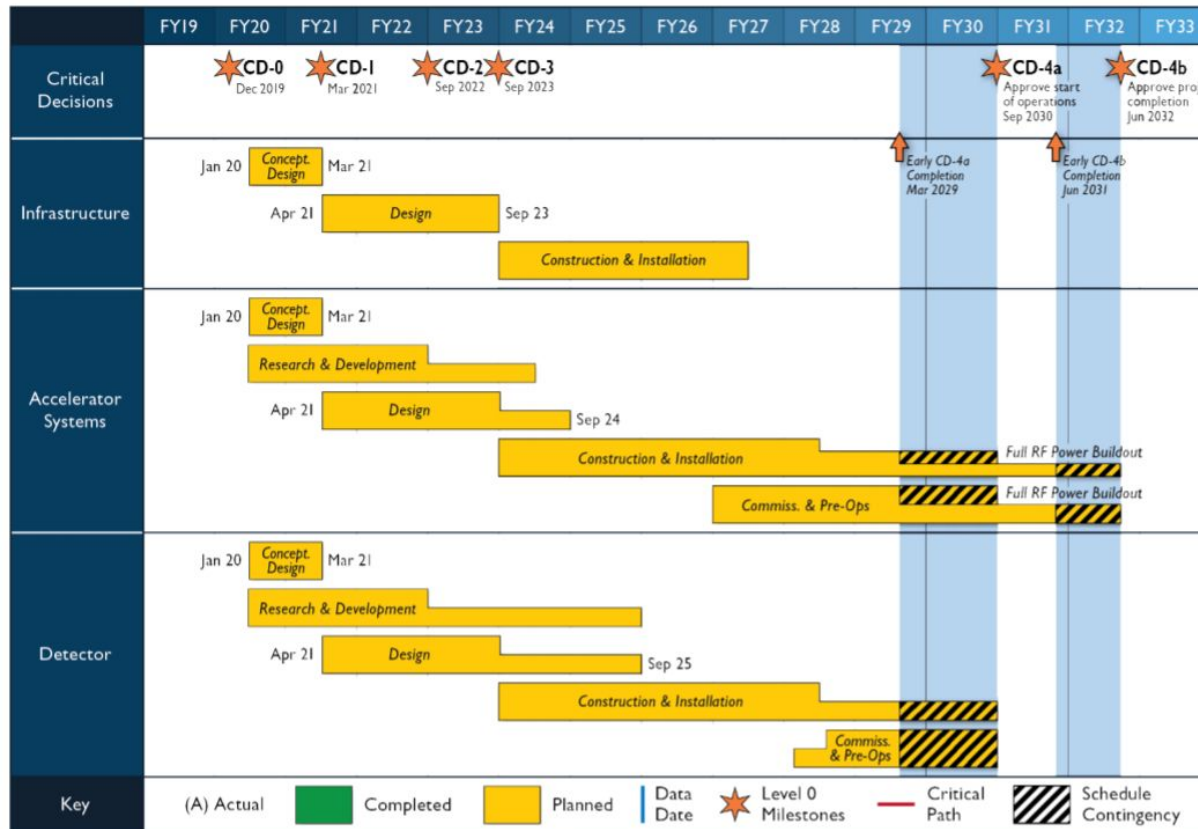
what is included in the scope of the project and in reference cost

- **full-energy, full-luminosity accelerator**
 - as per requirements (NSAC and NSA recommendations)
- **one interaction region**
 - with allowance for a second one
- **one detector ***
- **schedule**
 - completion in about 10 years
- **cost**
 - CD-0 approved within a range of 1.6 – 2.6 billion USD

* note that the EIC is capable of supporting a science program that includes two detectors and two interaction regions. The community (EIC User Group) is strongly in favor of two general purpose detectors

EIC Project Planning

US-DOE series of staged project approvals: “Critical Decision (CD)”

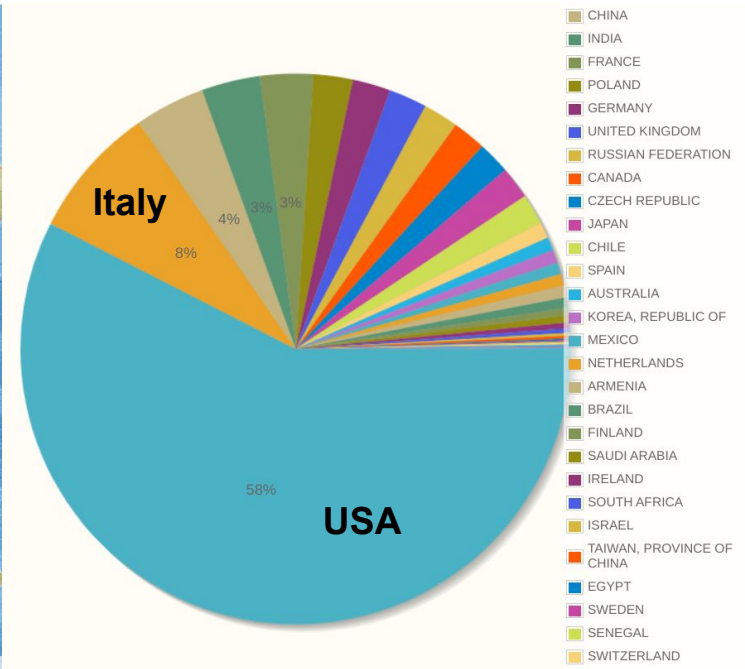


- **CD-1 March 2021**
 - alternative and cost range
 - (also machine CDR)
 - (call for detector proposals)
- **CD-2 September 2022**
 - performance baseline
- **CD-3 September 2023**
 - start construction
- **CD-4a September 2030**
 - start operation
- **CD-4b June 2032**
 - full RF Power Installed

The EIC Community

international Community organised in the EIC User Group

1162 members, 239 institutions, 33 countries



The EIC Italian Community

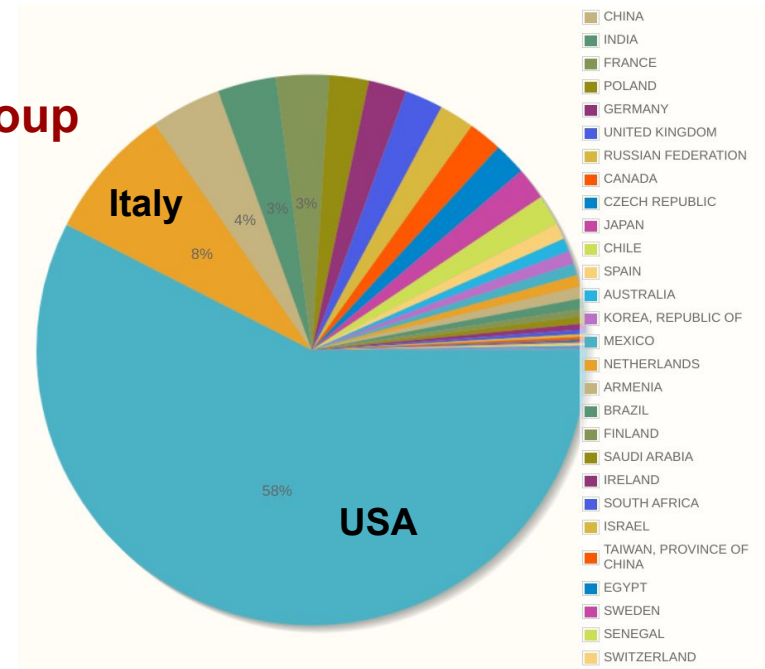
experimental Community organised in EIC_NET (INFN-CSN3)

51 members, 12 INFN divisions

plus an active theoretical Community from NIMPHA (INFN-CSN4)

● INFN members serving in the EIC User Group

- 15 Institutional Board members
- Institutional Board Deputy Chair
 - Andrea Bressan (Trieste)
- Steering Committee member
 - Marco Radici (Pavia)
- Elections and Nominating Committee member
 - Marta Ruspa (Torino)
- Conference & Talks Committee member
 - Michela Chiosso (Torino)



The User Group meeting

annual meeting of the EIC User Group

- 2014 - Stonybrook University
- 2016 - University of California/Berkeley
- 2016 - Argonne National Laboratory
- 2017 - Trieste
- 2018 - Catholic University of America
- 2019 - Paris
- 2020 - Miami

Trieste, 18-22 July 2017



Miami, 15-17 July 2017



due to COVID-19 restrictions, the last annual EIC User Group Meeting (Miami) took place in a restricted form with remote participation

Krakov will host the next EIC User Group Meeting in 2021

National EIC_NET day



first National EIC_NET day

Bari, 7-8 November 2019

perfect organisation and hospitality
from the colleagues in Bari

- **format in two half days**

- 7/11 afternoon
 - closed meeting of EIC_NET
- 8/11 morning
 - open meeting for all interested people
 - informative presentations
 - 37 registered participants

second National EIC_NET day in 2020

organisation is currently under discussion
expected towards the end of the year
in person, unless COVID-19 restrictions

09:00	Indirizzi di saluto <i>Aula multimediale INFN - I piano, Dipartimento Interateneo di Fisica - Bari</i>	09:00 - 09:15
	Stato progetto EIC <i>Aula multimediale INFN - I piano, Dipartimento Interateneo di Fisica - Bari</i>	Silvia Dalla Torre
	La fisica a EIC: base-line e nuove prospettive <i>Aula multimediale INFN - I piano, Dipartimento Interateneo di Fisica - Bari</i>	Giuseppe Bozzi
10:00	Coffee break <i>Saletta riunioni - I piano, Dipartimento Interateneo di Fisica - Bari</i>	09:50 - 10:35
11:00	L'attività italiana in EIC_NET: strumenti per la simulazione, attività di Monte Carlo e studi di fisica <i>Aula multimediale INFN - I piano, Dipartimento Interateneo di Fisica - Bari</i>	Roberto Preghenella
	L'attività italiana in EIC_NET: progetti di R&D <i>Aula multimediale INFN - I piano, Dipartimento Interateneo di Fisica - Bari</i>	Andrea Celentano
12:00	Conclusioni e fine Giornata Nazionale EIC_NET <i>Aula multimediale INFN - I piano, Dipartimento Interateneo di Fisica - Bari</i>	11:40 - 12:15
		12:15 - 12:30

The Yellow Report

an initiative of the EIC User Group

advance the state and detail of the documented physics studies and detector concepts in preparation for the realization of the EIC.

**EIC Yellow
Report**

Physics and
Detectors

- **large effort and aggressive time scale**

- 12 - 18 months of intense activity
- started with kick-off meeting in December 2019
- plus 4 dedicated workshops in 2020

- **with a clear strategy and organisation**

- Physics Working Group
 - quantify physics measurements for existing or new physics topics and implications for detector design
- Detector Working Group
 - study detector concepts based on the requirements defined above, and quantify implications for the physics measurements
- Accelerator Physics Group
 - study opportunities for accelerator physics experiments at a future EIC

The Yellow Report

large involvement of INFN Physicists

advance the state and detail of the documented physics studies and detector concepts in preparation for the realization of the EIC.

**EIC Yellow
Report**

Physics and
Detectors

- **Physics Working Group**

- 4 conveners
- 5 subgroups, 23 subconveners
 - Barbara Pasquini (Pavia)

- **Detector Working Group**

- 5 conveners
 - Silvia Dalla Torre (Trieste)
- 11 subgroups, 21 subconveners
 - Andrea Celentano (Genova)
 - Domenico Elia (Bari)

- **Software Working Group**

- 3 conveners
 - Andrea Bressan (Trieste)

- **plus active INFN contributors**

- spread in different subgroups
 - 15 experimentalists (EIC_NET)
 - 16 theorists (NIMPHA)

Expression of Interest

moving towards the formation of Collaborations

Expressions of Interest for potential Cooperation on the EIC experimental program
call by BNL in association with JLAB

- **deadline 1 November 2020**

- call formally launched on 2 June 2020

- **main purpose**

- guide expectations and to better understand the potential EIC experimental equipment scope

- **goal**

- give the EIC Project guidance on current interest for participating in the EIC experimental program

- **non binding**

- **call addressed to**

- interested groups to work together within their country, their geographical region, or as a general consortium

- **INFN Expression of Interest**

- cured by EIC_NET members (+ others)
- main items of interest
 - PID in forward region
 - silicon vertex detector
 - streaming readout
 - software tools

- **preparation for the next call**

- call for detector proposals
 - March - September 2021

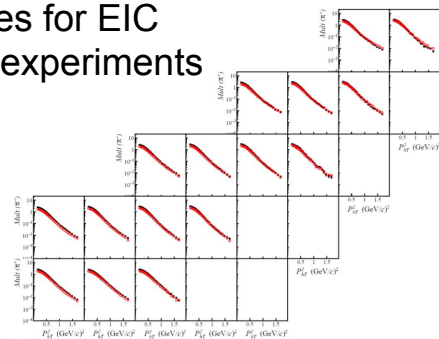
INFN R&D activities (1)

moving towards the call for Detector Proposals

cannot afford to go into the details of the many ongoing R&D activities for EIC
all benefit from experience and synergies with past, current and future experiments

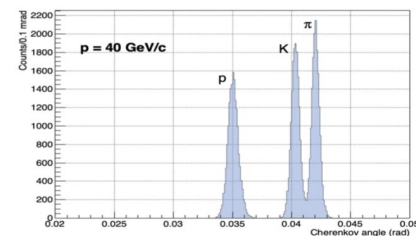
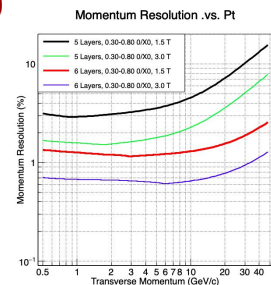
- **software tools for simulation and event generators**

- coordination of Software Working group
 - documentation and maintenance of EIC simulation tools
- development of radiative corrections for Monte Carlo event generators



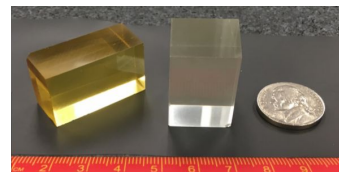
- **simulation activities focused to detector R&D**

- fast and full simulation for the Silicon Vertex Tracker
- fast and full simulation for the dual-radiator RICH
- fast simulation for a high-pressure focusing RICH
- full simulation for a proximity-focusing aerogel RICH



- **calorimetry and streaming readout**

- characterisation glass-based scintillators
- INFN is proponent of streaming RO, technology validation



INFN R&D activities (2)

moving towards the call for Detector Proposals

cannot afford to go into the details of the many ongoing R&D activities for EIC
all benefit from experience and synergies with past, current and future experiments

- **dual-radiator Ring Imaging Cherenkov (dRICH)**

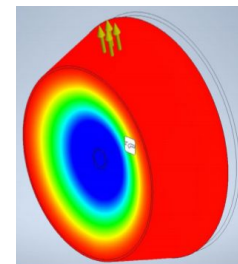
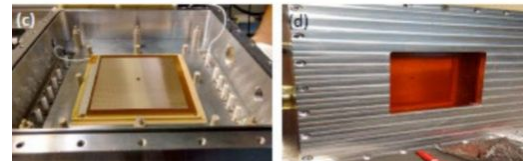
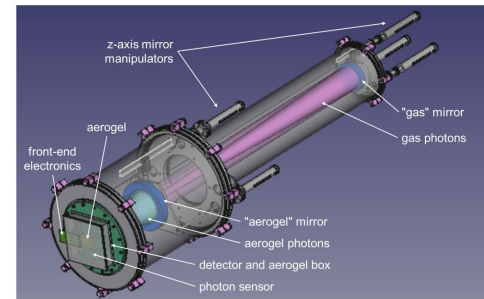
- aerogel ($n \sim 1.02$) and gas ($n \sim 1.0008$) radiators, shared photodetectors
- hadron ID in the forward hadronic endcap (3-60 GeV/c)
- prototype design almost completed

- **Cherenkov photodetectors**

- start R&D on SiPM for application in dRICH
 - proof of feasibility, radiation tolerance
 - readout electronics, ASIC (ALCOR)
- advanced R&D on MPGD single-photodetectors
 - based on COMPASS RICH upgrade
 - synergies with RD51 and IDEA

- **high-pressure RICH**

- replace use of CF-based gas with pressurised Ar @ 3.5 bar
- start study and design of low-material pressure vessel



Summary

EIC White Paper, EPJA 52 (2016) 9, 268

- **EIC project is gaining momentum**

- DOE approved Critical Decision-0
- Brookhaven National Laboratory selected to host the EIC
- start of experimentation expected in 2030

- **Physics program is rich**

- EIC is a unique machine for precision QCD
- BNL design matches the requirements for Physics

- **International Community is active**

- large User Group Community, large Italian participation
- Yellow Report initiative, Expression of Interest, ...

- **Italian Community is on the front line**

- strong participation, with important roles in the various processes
- advanced and new R&D activities on several fronts
- preparation of Expression of Interest is today
- moving towards the Call for Proposal in a year from now

