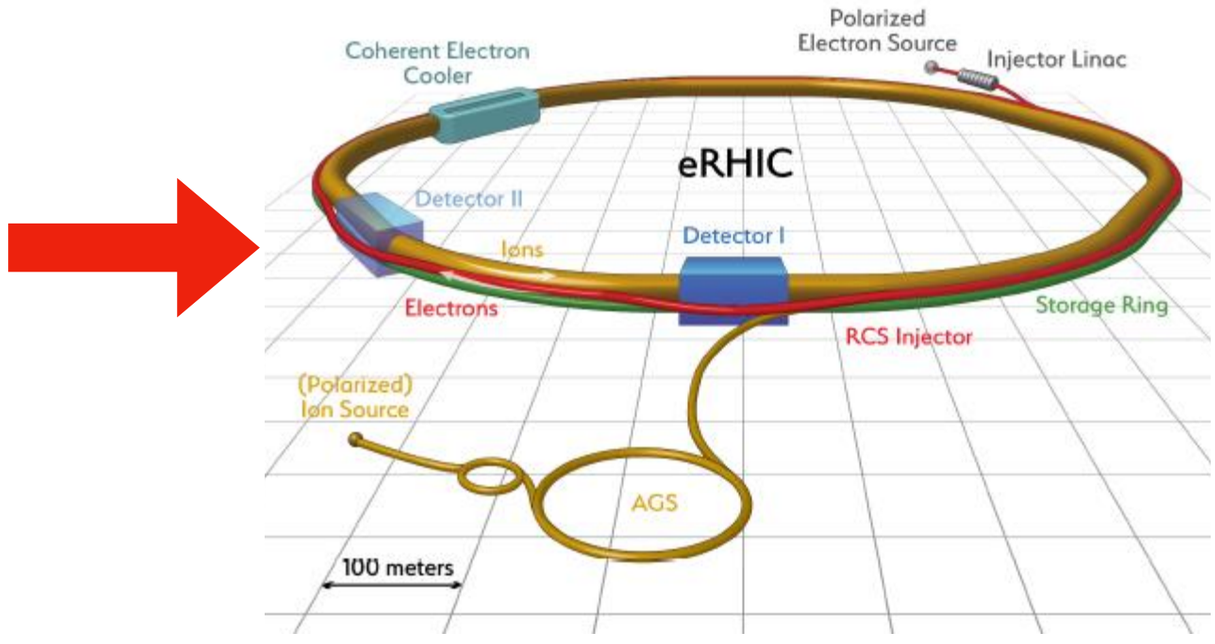

Case for a 2nd IR

Marco Radici
(for the EICUG Steering Committee)

EICUG Quarterly meeting, Oct. 28th 2021

- During last EICUG annual (Summer) meeting, Richard Milner and Rolf Ent reported on discussion within the EICUG Steering Committee about the case for **2** independent experiments:
  => **2** Interaction Regions (IR)
  => **2** complementary Detectors

- Draft has been revised according to the output of the discussion within the Users Group. The final document is titled

  Maximizing the Scientific Output of the EIC

  and can be found at the following link

  http://www.eicug.org/web/sites/default/files/Arguments%20for%20Two%20EIC%20Experiments%20Sep23.pdf

Maximizing the Scientific Output of the EIC

Based on presentation and discussion at EIC Users Group Summer Meeting 2021

EICUG Steering Committee

The Electron-Ion Collider (EIC) is an ambitious, novel particle accelerator being built at Brookhaven National Laboratory to unlock the secrets of the "glue" which binds protons and neutrons, the building blocks of matter in the visible universe. It will be a discovery machine that addresses fundamental questions like the origin of mass and spin as well as probing, for the first time, dense gluon systems in nuclei. The EIC Project was launched by the U.S. Department of Energy in January 2020 and is making good progress towards realization. The EIC is expected to begin operation in the early 2030s. The EIC attracts expertise and interest from around the world. The international community organized itself late in 2015 as the EIC Users Group (EICUG), which now consists of almost 1300 physicists at more than 250 institutions in 35 countries worldwide, working together to realize and utilize the EIC.

Over more than two decades, the scientific case for EIC has been developed and articulated by the nuclear physics community: in the 2002, 2007, and 2015 U.S. nuclear physics long range plans; the 2014 EIC White Paper; the 2018 Assessment of EIC Science by the National Academy of Sciences; and most recently in the 2021 Yellow Report of the EICUG. Throughout, the desire for multiple interaction regions and experiments has been highlighted and the EICUG has consistently articulated the necessity for two EIC experiments.

Due to constrained resources, the EIC Project supports only one interaction region and detector, but a deliverable of the EIC Project is the possibility for a second interaction region and detector. It is recognized by all stakeholders that a second EIC experiment is essential to fully exploit the science potential of the EIC. Timeliness of a second experiment is crucial: two experiments should be approximately *similar* in time for scientific validation to make sense. Timescales more than 5 years apart negatively affect formation of scientific collaborations. The purpose of this document is to succinctly state the arguments that support maintaining the path to two EIC experiments in a timely way. These arguments will be essential to securing the necessary, additional resources to realize two EIC experiments.

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Five good arguments

Argument #1 increase scientific output

Scope of the scientific program

EIC has a broad scientific goal to comprehensively explore QCD using the full range of available ion beams with polarization across the accessible x and Q^2 range via measurement of different hadronic final-states. Even when two experiments will share the same beam and the available luminosity, it does allow simultaneous data taking to address different scientific questions, and greatly increases the scientific productivity of EIC. EIC operating with one experiment is a diminished scientific return on such a large investment and, due to lack of complementary science reach, limits the EIC discovery potential.

complementarity

validation

redundancy

Argument #2

Complementarity of scientific focus and detector instrumentation

Two EIC experiments can provide both a complementary scientific focus and also implement complementary detector technologies. EIC is a unique accelerator with significant discovery potential. History teaches us that scientific discoveries must rely on independent experimental verification. When unexpected results are observed, two experiments are essential to establish a consensus. Discoveries resulting from EIC operating with one experiment would face significant external scrutiny and skepticism if there is no ability to provide an independent confirmation. Any claimed discovery would immediately motivate construction of a second EIC experiment. Multiple detectors also enhance science reach. Systematic uncertainties can be dramatically reduced by alternate detector technology choices and redundancy. The final HERA results are clear proof that this goes well beyond statistical improvement. This is especially relevant for EIC science that relies on the capability both to detect different particles over a large range of energies and to identify them. The impact of complementarity of detectors is further highlighted in dedicated sections of the Yellow Report. Complementarity can be further optimized with appropriate accelerator and detector R&D.

Argument #3 EIC@RHIC natural layout for two IR

RHIC/EIC collider layout

The RHIC/EIC collider has the impressive ability to locate experiments at both IP6 and IP8 interaction regions. These two interaction regions differ due to both the interweaving character of the various EIC beams and the physical geometry (size of hall, tunnel). This can be straightforwardly configured to have complementary electron-ion collision characteristics that emphasize different aspects of the EIC scientific program. Thus, the EIC collider can accommodate two complementary experiments in a very natural way, enhancing discovery potential and independent scientific verification. EIC operating with only one experiment would constitute a significantly diminished utilization of the opportunities being presented.

Argument #4 friendly competition → efficiency

Competition

It is accepted that competition between multiple experiments is essential for success in large-scale, frontier scientific research. Competition is a driver and engine of science. It motivates the large collaborations to be efficient, timely and effective in utilization of precious resources, the taking of data, analyzing the data and publishing the scientific results. One experimental collaboration at EIC would have less pressure to produce scientific results in a timely way and, without competition, would not be efficient in utilizing available resources.

Argument #5 EICUG growing community

Size of the international user community

EICUG has nearly 1300 members of which 800 are experimentalists. The EICUG membership roughly doubled over the last four years, and growth is expected to continue with the EIC Project progressing. We estimate that the EIC user community at EIC science turn-on will have doubled again and grown to above 2500 members. The successful H1 and ZEUS collaborations at DESY had between 450 and 500 collaborators each. The scientific findings of the LHCb experiment with ~1000 scientific collaborators further underscore the relevance of complementarity in detectors. Projecting forward, the EICUG can comfortably support two experiments. Having the entire EIC experimental community work on one experiment is beyond the scale of the effort required and diminishes scientific productivity.

- **Task force** of the EICUG Steering Committee:
  - Rolf Ent
  - Olga Evdokimov
  - Renee Fatemi
  - M. R.
  - Daria Sokhan

- **Goal:** re-organize previous document into a glossy brochure (with visuals and sidebar text) to be submitted to DOE and International Agencies.
  Brochure organized in **four sections**.

Four sections

1. The Electron-Ion Collider - The Need for Two Detectors

Independent confirmation with multiple detectors is a standard for large-impact scientific discoveries:

- ATLAS & CMS for Higgs ;
- LIGO & Virgo for gravitational waves ;
- BRAHMS + PHOBOS + PHENIX + STAR evidence of jet quenching as signature of QGP ;
- TASSO + JADE + MarkJ + PLUTO for gluon ;
- etc…

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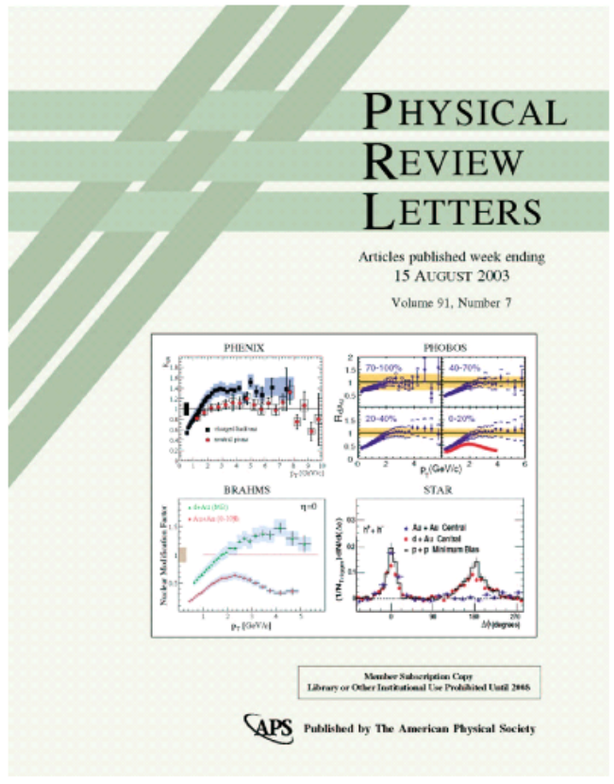
sidebar

Science Discovery Relies on Independent Experimental Confirmation



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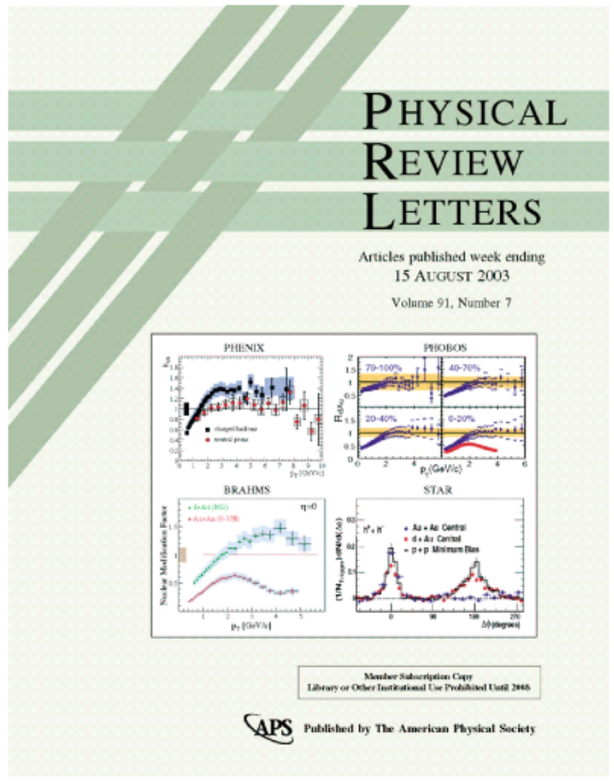

Also, occasion for diverse and international effort.

Four sections

2. The Electron-Ion Collider's Golden Opportunity for Two Detectors

Two detectors to validate discoveries → well utilize investments
EIC@RHIC naturally suited to two complementary IR → golden opportunity

3. Two Detectors - A Gateway to Innovation and International Collaboration

EICUG already large enough for two independent collaborations, *especially* when projected to time of starting EIC operations
Opportunities for new generation and international leadership
Friendly competition that opens a natural dialogue → innovation, efficiency

Four sections

4. Two Detectors - Why Worth the Investment

Growing number of benefits from Nucl. Phys. in:

- **medical applications**
  (imaging, diagnosis, therapy,..)
- **technology**
  (new materials, chips, electronics,..)
- **computing** (AI, "big data",..)
- **security** (screening, space radiation,..)
- **education and training**
- etc..

Understanding nuclear matter's structure at sub-femtometer scale = 10^6 x smaller scale than nanotechnology → future leadership

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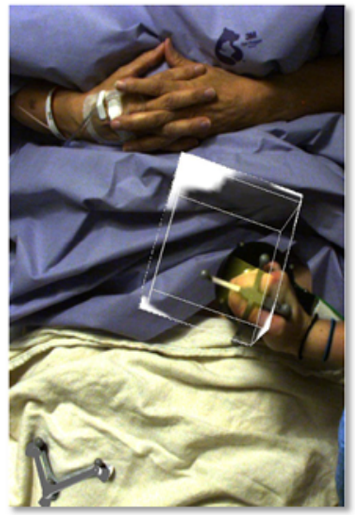
Radiation Therapy - Pushing the Envelope of Nuclear Physics Technology



Wireless and wire-free handheld SPECT gamma camera with position tracking, for detection of sentinel lymph nodes in preoperative cancer surgery setting.
Based on Silicon Photomultipliers, largely used at **GlueX (Hall D - JLab)**

Summary

- Strengthen the case for two EIC experiments
- How to realize the optimal set for two experiments at EIC
- Start searching for required additional resources beyond those identified in the EIC Project

because the time for investment
in Nuclear Physics and the EIC
is **NOW**