EIC 2nd Detector : Vision and Realization

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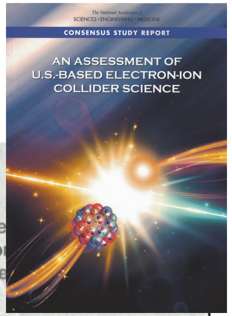
More in Jim Yeck's talk



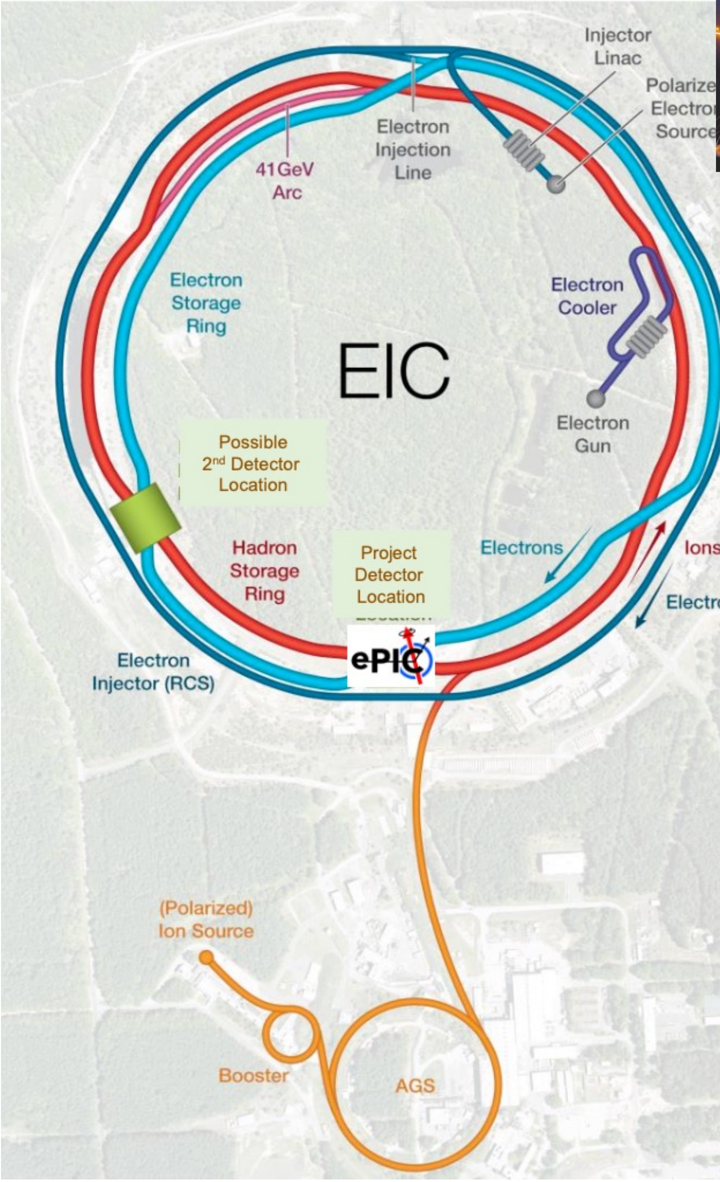
Electron Ion Collider Project: Accelerator & ~70% 1st detector

Physics of EIC ➔ Elements of CD0 (Science Need) from DOE

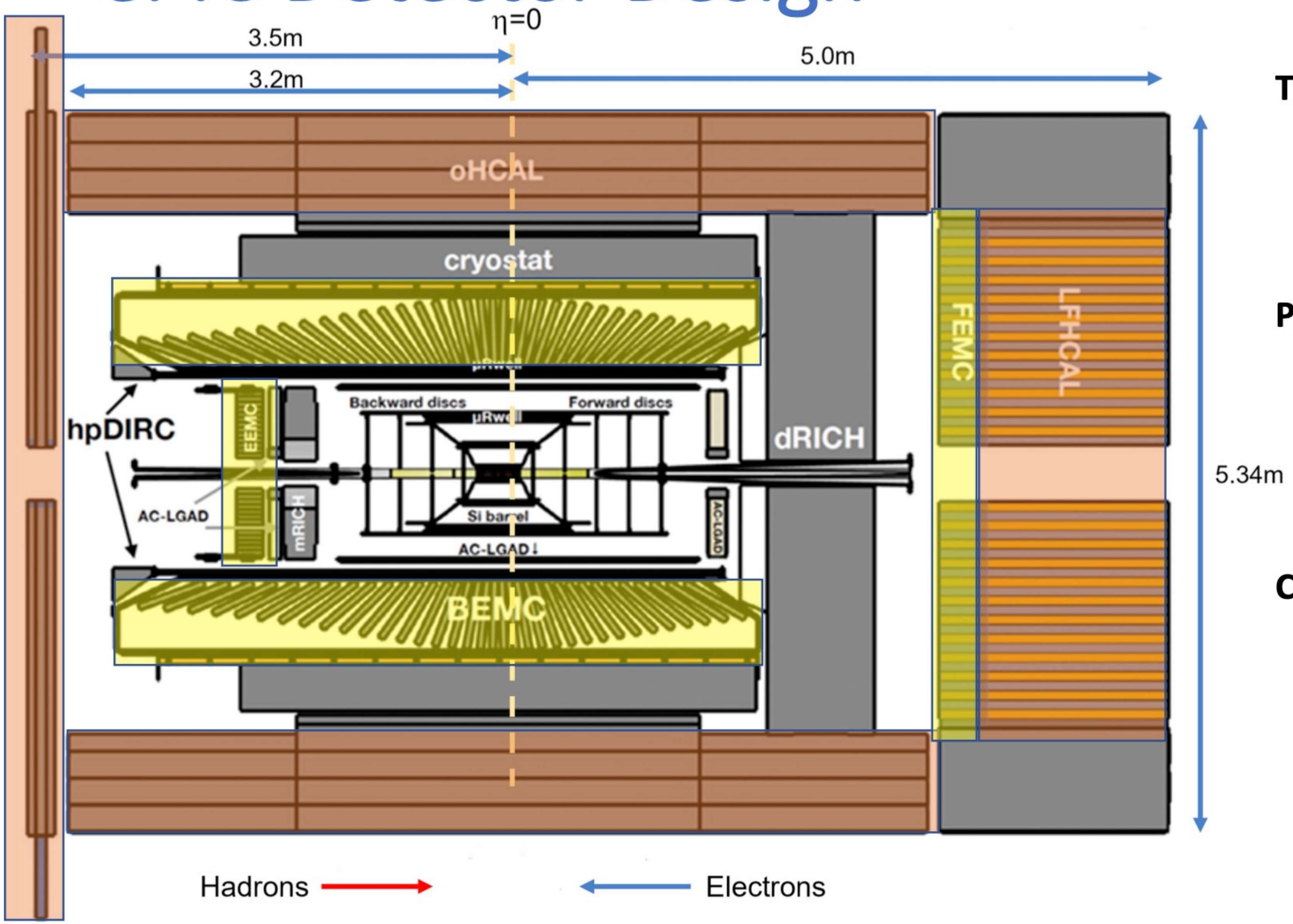
- Emergence of Spin
- Emergence of Mass
- Physics of high-density gluon fields

Machine Design Parameters:

- High luminosity: up to 10^{33}-10^{34} cm^{-2}sec^{-1}
  - a factor ~100-1000 times HERA
- Broad range in center-of-mass energy: ~20-140 GeV
- Polarized beams e-, p, and light ion beams with flexible spin patterns/orientation
- Broad range in hadron species: protons…. Uranium
- Up to two detectors well-integrated detector(s) into the machine lattice



ePIC Detector Design



Tracking:

- New 1.7T solenoid
- Si MAPS Tracker
- MPGDs (μRWELL/μMegas)

PID:

- hpDIRC
- mRICH/pfRICH
- dRICH
- AC-LGAD (~30ps TOF)

Calorimetry:

- SciGlass/Imaging Barrel EMCal
- PbWO4 EMCal in backward direction
- Finely segmented EMCal +HCal in forward direction
- Outer HCal (sPHENIX re-use)
- Backwards HCal (tail-catcher)

Slide from John Lajoie

Value of more than 1 detector

Two documents: with overlapping arguments

Ent and Milner et al for the EICUG SC

JLAB-PHY-23-3761

Motivation for Two Detectors at a Particle Physics Collider

Paul D. Grannis* and Hugh E. Montgomery†
(Dated: March 27, 2023)

It is generally accepted that it is preferable to build two general purpose detectors at any given collider facility. We reinforce this point by discussing a number of aspects and particular instances in which this has been important. The examples are taken mainly, but not exclusively, from experience at the Tevatron collider.

arXiv: 2303.08228v2 March 24, 20234

Case for two detectors being made from **Nuclear** and **Particle** Physics

History: Discoveries established with **more than one** detectors in Nuclear Science

- Discovery of gluon : TASSO, JADE, Mark J, and PLUTO @ DESY
- H1 and ZEUS at Rise of F_2 and hence the gluon dominance at low-x
- BRAHMS, PHOBOS, PHENIX and STAR Discovery and establishing the existence of Quark Gluon Plasma
- Measurements at DESY and JLab eventually led to “parton imaging”
- EMC discovered and then SMC/CERN and EXXX/SLAC established nucleon spin crisis (low-x) & EMC discovered and then NMC established nuclear effects on nucleon PDFs (also low-x)

Two detectors (independent cross checks) builds trust in novel discoveries and prevents historical mistakes

Building Trust

- Quark Gluon Plasma: RHIC Experiments
- Discovery of Top Quark D0/CDF
- Discovery of Higgs Boson: ATLAS and CMS
- Gravitational Waves: LIGO and VIRGO
- Neutrino oscillations

Mistakes or misinterpretations:

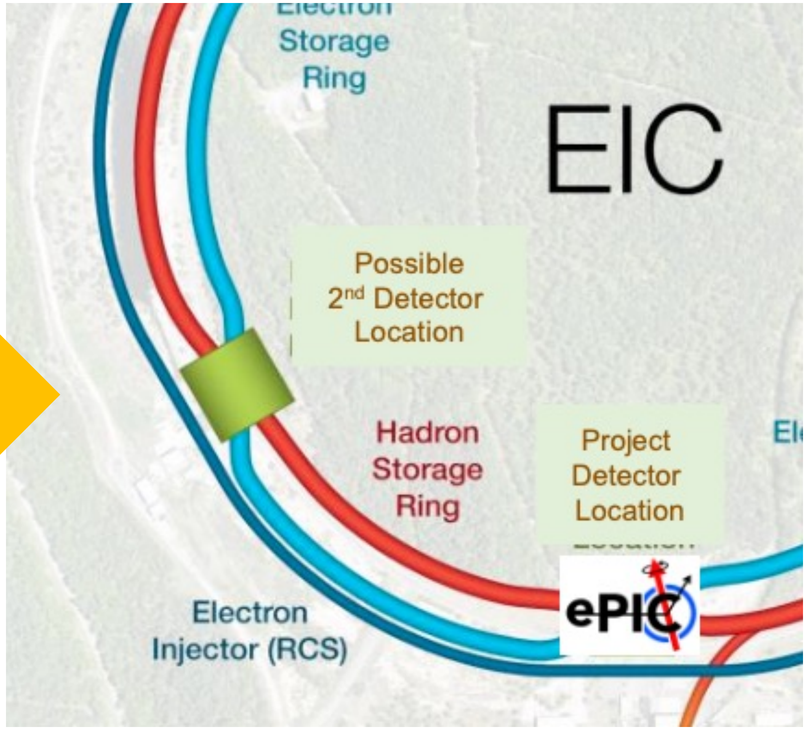
- Cold fusion
- 17 KeV neutrinos in Tritium
- Superluminal neutrinos
- Leptoquarks
- Pentaquarks from 2000's

Complementary detectors (collaborations): 1 + 1 > 2

More than one detectors with different acceptances, optimizations and technologies: **Redundancy, cross-calibration and independent validation** of important results

- Complementary acceptance -- confirming or refuting discoveries – studying from different "point of views"
- Complementary Technologies – multiple examples of systematic uncertainties improvement due to different Particle ID, Calorimetry, Tracking, magnetic field strengths and orientations. H1/ZEUS, PHENIX/STAR, CDF/D0 and ATLAS/CMS vs. LHCb
- Impact of different perspectives that different collaborators bring to the same problem.
  - Complementary analyses strategies build confidence in conclusions

The 2nd detector



NSAC documents talk about possibly ~4 detectors

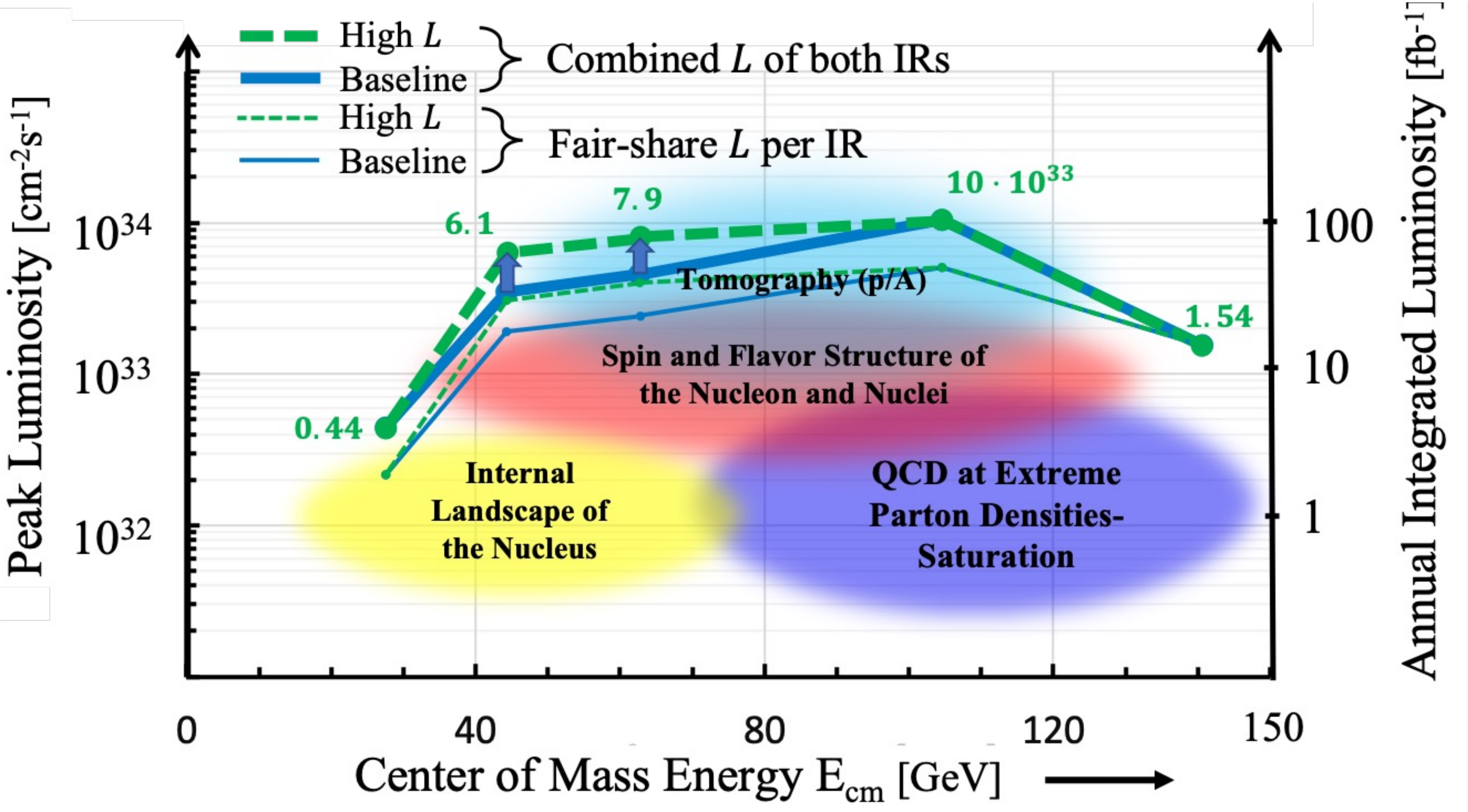
NAS Report: planning for up to 2 well-integrated detectors

EICUG desires 2 Detectors

EIC Project has 1 Machine, 1 IR and ~1 Detector

without negating the possibility of the 2nd IR/Detector

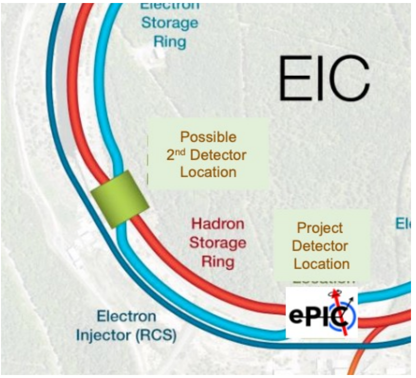
Adding IRs : Luminosity gets shared
(at beam-beam limit)



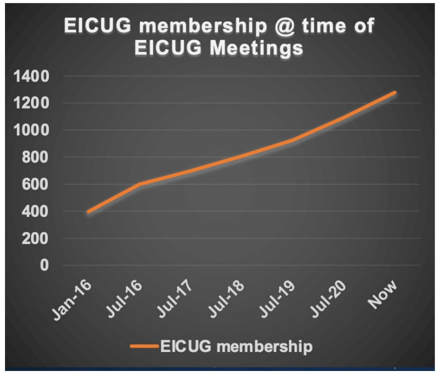
While EIC project (machine and 1st detector) have to succeed….

I think we have everything we need to sow the seeds for a 2nd detector

EIC Layout and International EIC Users Group



- EIC layout allows for more than one interaction point
- EIC Users Group is large & growing
  - 700 in 2016 to 1400 in 2023 – potential to grow further

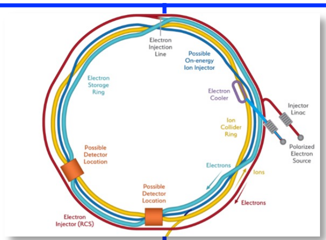


- Have we explored the potential of all countries and subgroups in the UG?
- Is there (not) significant potential growth in international contribution?

Opportunity for complementary detector designs for different IRs exists!

Complementarity for 1st-IR & 2nd-IR

	1st IR (IP-6) ePIC	2nd IR (IP-8)
Geometry:	ring inside to outside	ring outside to inside
	tunnel and assembly hall are larger Tunnel: ⦸ 7m +/- 140m	tunnel and assembly hall are smaller Tunnel: ⦸ 6.3m to 60m then 5.3m
Crossing Angle:	25 mrad	35 mrad secondary focus



different blind spots
different forward detectors and acceptances
different acceptance of central detector

Luminosity:

More luminosity at lower E_{CM} ?
Optimize Doublet focusing FDD vs. FDF
→ impact of far forward p_T acceptance

Experiment:

1.7 Tesla or 3 (?) Tesla
different subdetector technologies

Potential Physics topics beyond Core EPIC detector's mandate exist

Focus first on Physics beyond the EIC's core (CD0) science

(there will be others: some overlapping, some exclusive due to different IR design)

Physics with nucleons and nuclear targets:

- Quark **Exotica**: 4,5,6 quark systems…? Much interest after recent **LHCb** led results.
- **Nuclear Fragments** from light and heavy nuclei : e-A – Connecting to low energy nuclear physics (exotic nuclei), studying the shapes of nuclei and their nternal substructure; entanglement, entropy, fragmentation, hadronization and such phenomena

New Studies with proton or neutron target: (mostly overlapping?)

- Impact of precision measurements of unpolarized PDFs at high x/Q^2, on LHC-Upgrade results(?)
- Precision calculation of α_S : higher order pQCD calculations, twist 3
- Heavy quark and quarkonia (c, b quarks) studies with 1000 times lumi of HERA (and polarization)

Precision electroweak and BSM physics:

- Electroweak physics & searches beyond the SM: Parity, charge symmetry, lepton flavor violation
- LHC-EIC Synergies & complementarity: (**muon detectors** were of particular interest)

Vision for the 2^{nd} detector: C^3

- Complementary (IR, detector technologies & design)
  - Continue to explore complementary ready and not-yet-ready technologies
  - Generic detector R&D program – Run through JLab
- Complementary (physics)
  - A significant list of physics topics (some-exclusive to 2^{nd} IR, some-overlapping) exists: drill down and see which of those can *develop into strong pillars of science for the 2^{nd} detector.*
  - New physics developing around the world : we need to monitor constantly
- Complementary (people)
  - New non-US/outside groups who may bring new interests & funding in future
  - New US groups – other than those with significant responsibilities in ePIC

Center for Frontiers in Nuclear Science

EIC²
EIC Center at Jefferson Lab

Path forward: focused workshops and detector studies on new physics topics:

- ✓Look at **complementary detector technologies** (to ePIC) and attract groups that are experts in them to the EICUG
- ✓Focused discussions on **new physics topics** (not just listed in this talk but also beyond) to try to make a unique case complementary to ePIC/EIC White Paper
- ✓**Build community** – new groups/faces/resources needed to contribute and become part of new detector effort

Resources:

Generic detector R&D – supported by DOE administered from JLab

Center for Frontiers in Nuclear Science @ Stony Brook (& EIC – Theory Institute at BNL) and the EIC² at JLab

Observation and Remarks:

- EIC project's path is well understood. Its success is paramount.
- 2nd detector is essential for completing the Vision of EIC
  - C^3 : Complementary physics, technology and people
- It is time to march forward developing a design and case for the 2nd detector: Detailed studies through series of workshops, outreach and critical evaluation for each developing argument
  ➔ Plan an INT- Program in ~2025 like we had in 2010

I look forward to discussions in this workshop