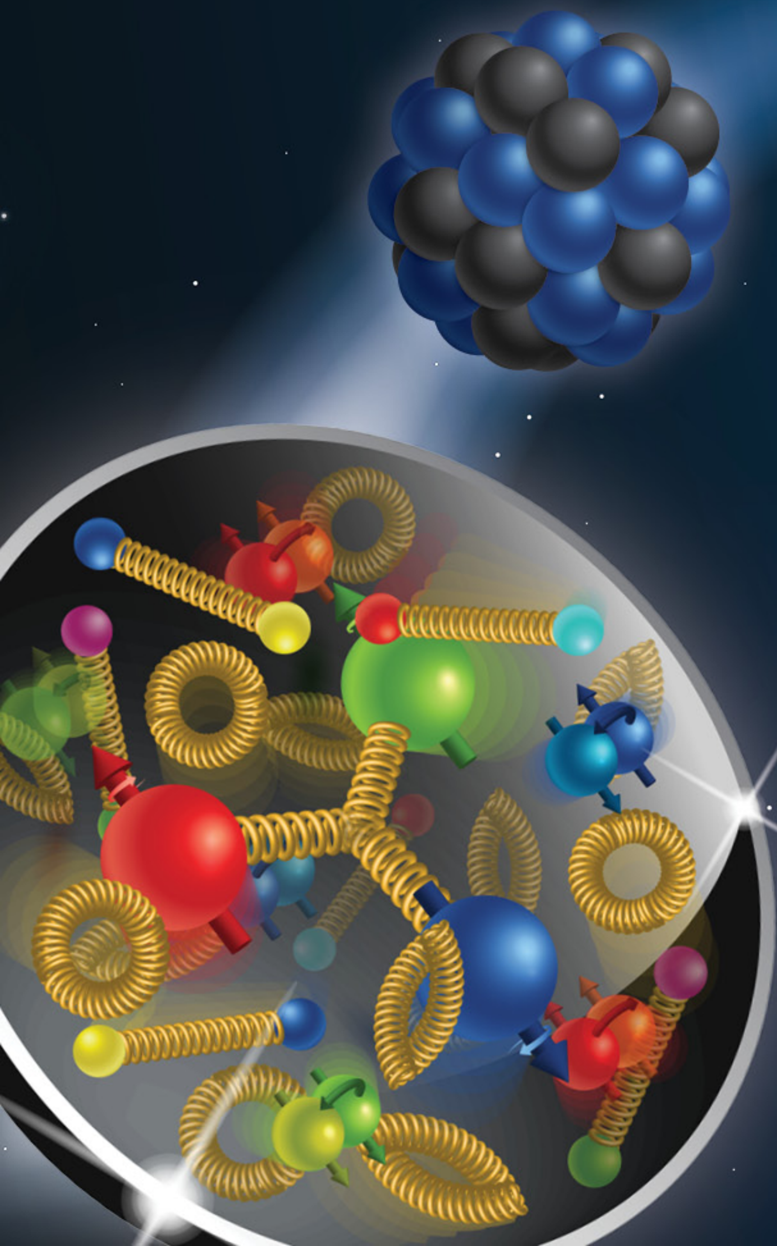


EIC Project & Two Detector Scenario

Jim Yeck, EIC Project Director

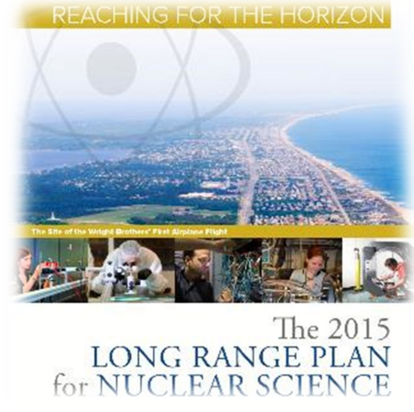
CORE Workshop

March 30, 2021

Electron-Ion Collider

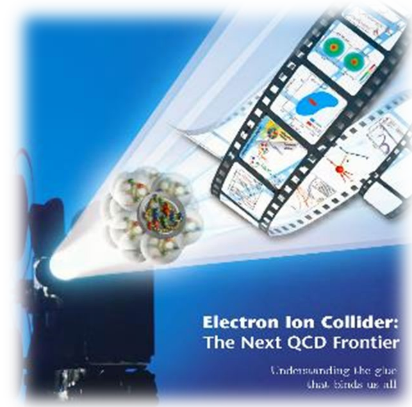
BROOKHAVEN NATIONAL LABORATORY
Jefferson Lab
U.S. DEPARTMENT OF ENERGY | Office of Science

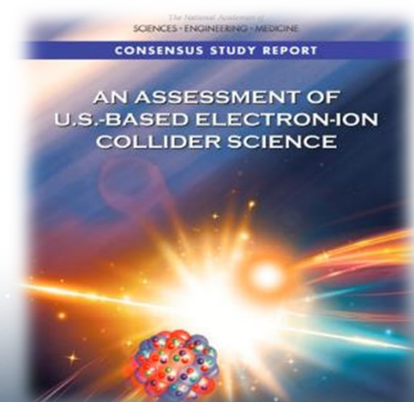
Project Requirements



Project Design Goals

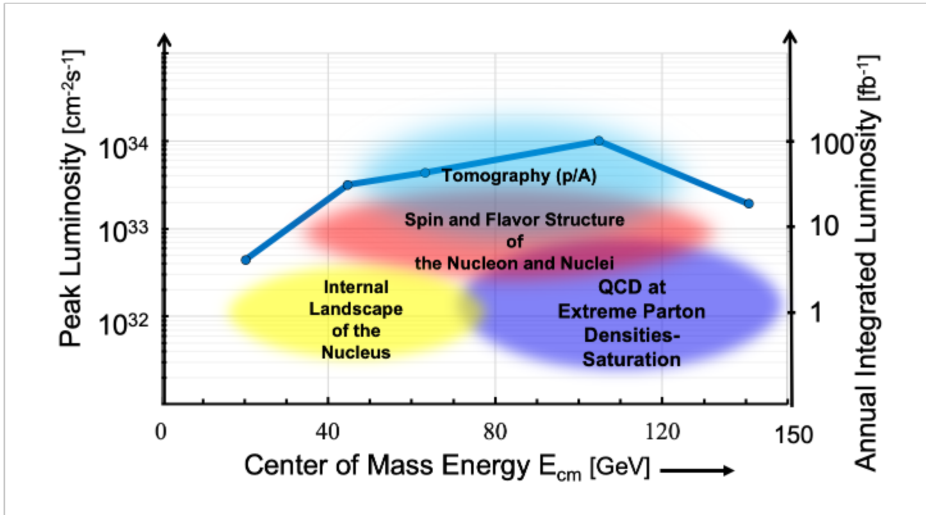
- High Luminosity: $L = 10^{33} – 10^{34} \mathrm{cm}^{-2}\mathrm{sec}^{-1}$, 10 – 100 fb^{-1}/year
- Highly Polarized Beams: ~70%
- Large Center of Mass Energy Range: E_{cm} = 20 – 140 GeV
- Large Ion Species Range: protons – Uranium
- Large Detector Acceptance and Good Background Conditions
- Accommodate a Second Interaction Region (IR)

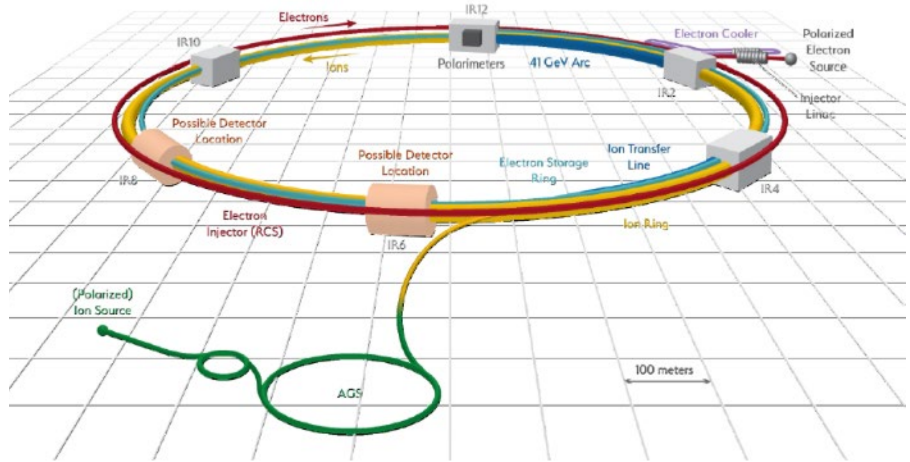




Conceptual design scope and expected performance meets or exceed NSAC Long Range Plan (2015) and the EIC White Paper requirements endorsed by NAS (2018)

EIC Machine Parameters





Double Ring Design Based on Existing RHIC Facilities	
Hadron Storage Ring: 40 - 275 GeV	**Electron Storage Ring: 2.5 - 18 GeV**
• RHIC Yellow Ring and Injector Complex	• Many Bunches, Large Beam Current - 2.5 A
• Many Bunches, 1160 @ 1A Beam Current	• 9 MW Synchrotron Radiation
• Bright Beam Emittance ε_{xp}= 9 nm	• Superconducting RF Cavities , 10MW Power
• Flat Beam, Requires Strong Cooling	
High Luminosity Interaction Region(s)	**Electron Rapid Cycling Synchrotron**
• 25 mrad Crossing Angle with Crab Cavities	• Spin Transparent Due to High Periodicity

EIC Recent History

Event	Date
DOE Mission Need Statement Approved	January 22, 2019
DOE Independent Cost Review	July 2019
DOE Electron Ion Collider Site Assessment	October 2019
Critical Decision – 0 (CD-0) Approved	December 19, 2019
DOE Site Selection Announced	**January 9, 2020**
BNL TJNAF Partnership Agreement	May 7, 2020
DOE Office of Science Status Review	September 9-11, 2020
Independent EIC Conceptual Design Review	November 16-18, 2020
DOE Office of Science CD-1 Review	January 26-29, 2021
DOE Independent Cost Review	January - February 2021
CD-1 Approval Target Date	***April/May 2021***

Project Organization

- BNL/TJNAF Partnership
  - BNL and TJNAF partnering agreement signed in May 2020.
  - Executive Management Team established that integrates BNL and TJNAF into project leadership roles.
  - EIC Council, chaired by BNL Director, established in June 2020. TJNAF Director is a founding member. Major international partners will also join the Council.

- Established standing advisory committees with international membership
  - Machine Advisory Committee: 08/26/20, *TBD*
  - Project Advisory Committee: 08/27/20, 12/01/20, *04/29/21*
  - Detector Advisory Committee: 09/28-29/20, 12/18/20, 03/24-26/21

Project Organization

BROOKHAVEN NATIONAL LABORATORY
D. Gibbs
Laboratory Director
R. Tribble
Deputy Director for Science & Technology
J. Anderson
Deputy Director for Operations

Electron Ion Collider Council
D. Gibbs, Chair

Project Advisory Committee
T. Glasmacher, Chair

ELECTRON-ION COLLIDER PROJECT
J. Yeck (BNL), Project Director
F. Willeke (BNL), Deputy Project Director and Technical Director

R. Ent (TJ), Co-Associate Director for the Experimental Program
E. Aschenauer (BNL), Co-Associate Director for the Experimental Program

A. Lung (TJ), Deputy Project Director for TJNAF Partnership
A. Seryi (TJ), Associate Director for Accelerator Systems & International Partnership

D. Hatton (BNL), Project Manager

EIC User Group Steering Committee
B. Surrow, Chair
R. Milner, Vice Chair

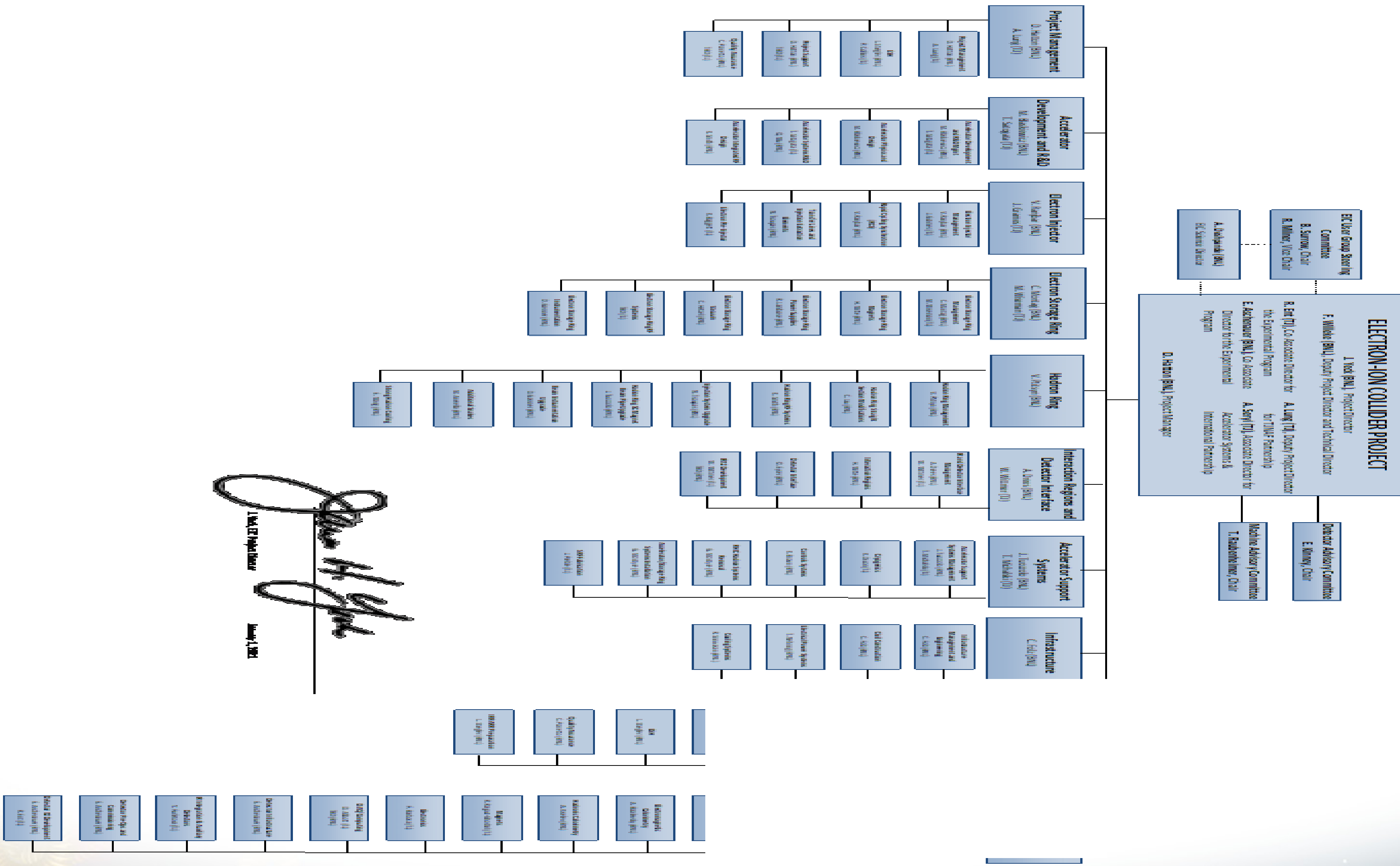
A. Deshpande (BNL)
EIC Science Director

Detector Advisory Committee
E. Kinney, Chair

Machine Advisory Committee
T. Raubenheimer, Chair

Interaction Regions and

Accelerator Support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A. Dashpande (BNL)
EIC Science Director
Detector Advisory Committee
E. Kinney, Chair
Machine Advisory Committee
T. Raubenheimer, Chair
Project Management
D. Hatton (BNL)
A. Lung (TJ)
Accelerator Development and R&D
M. Blaskiewicz (BNL)
T. Satogata (TJ)
Electron Injector
V. Ranjbar (BNL)
J. Grames (TJ)
Electron Storage Ring
C. Montag (BNL)
M. Wiseman (TJ)
Hadron Ring
V. Ptitsyn (BNL)
Interaction Regions and Detector Interface
A. Dovis (BNL)
W. Wittmer (TJ)
Accelerator Support Systems
J. Tuozzolo (BNL)
T. Michalski (TJ)
Infrastructure
C. Folz (BNL)
J. Yeck, EIC Project Director

EIC Partnership Plans

- Bi-lateral meetings with potential partners are underway to discuss opportunities in the accelerator and experimental areas.
- Accelerator Partnership Activities (~5-10% In-kind)
  - In-kind contributions to accelerator design and hardware expected
  - Workshop hosted by UK Cockcroft Institute in October 2020
    Promoting Collaboration on the Electron-Ion Collider
- Detector Partnership Activities (Project Detector ~30% In-kind)
  - Expressions of Interest submitted in November 2020
  - Call for proposals for detectors issued in March 2021
- Regular meetings among the international funding agencies organized by DOE Office of Nuclear Physics.
- New York State is a partner in the EIC infrastructure ($100M).

Experimental Program Preparation

Yellow Report and EIC Conceptual Design Report are both available and include the reference detector concept.

BNL and TJNAF Jointly Leading Process to Select Project Detector		
2020	Call for Expressions of Interest (EOI)	May 2020
	EOI Responses Submitted	November 2020
	Assessment of EOI Responses	On-going
2021	Call for Collaboration Proposals for Detectors	March 2021
	BNL/TJNAF Proposal Evaluation Committee	Spring 2021
	Collaboration Proposals for Detectors Submitted	December 2021
✔	Decision on Project Detector	March 2022

CD-1 Reviews

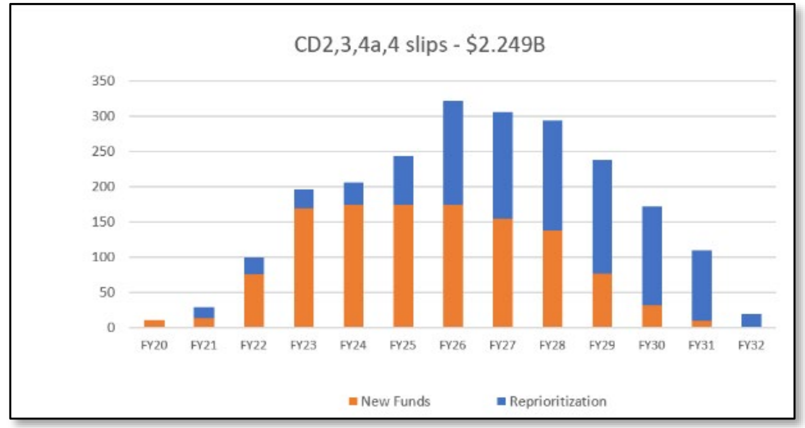
- CD-1 Preparation Reviews
  - Independent Design Review – November 2020 ✔
  - Director's Review – December 2020 ✔

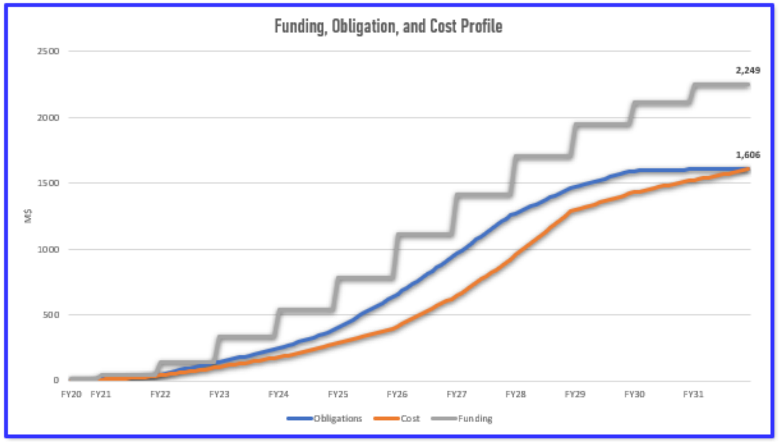
- DOE CD-1 Reviews
  - DOE Office of Science, Office of Project Assessment CD-1 Readiness Review – January 26-29, 2021 ✔
  - DOE Office of Project Management Independent Cost Review – Jan/Feb 2021 ✔

DOE reviews recommend proceeding with CD-1!

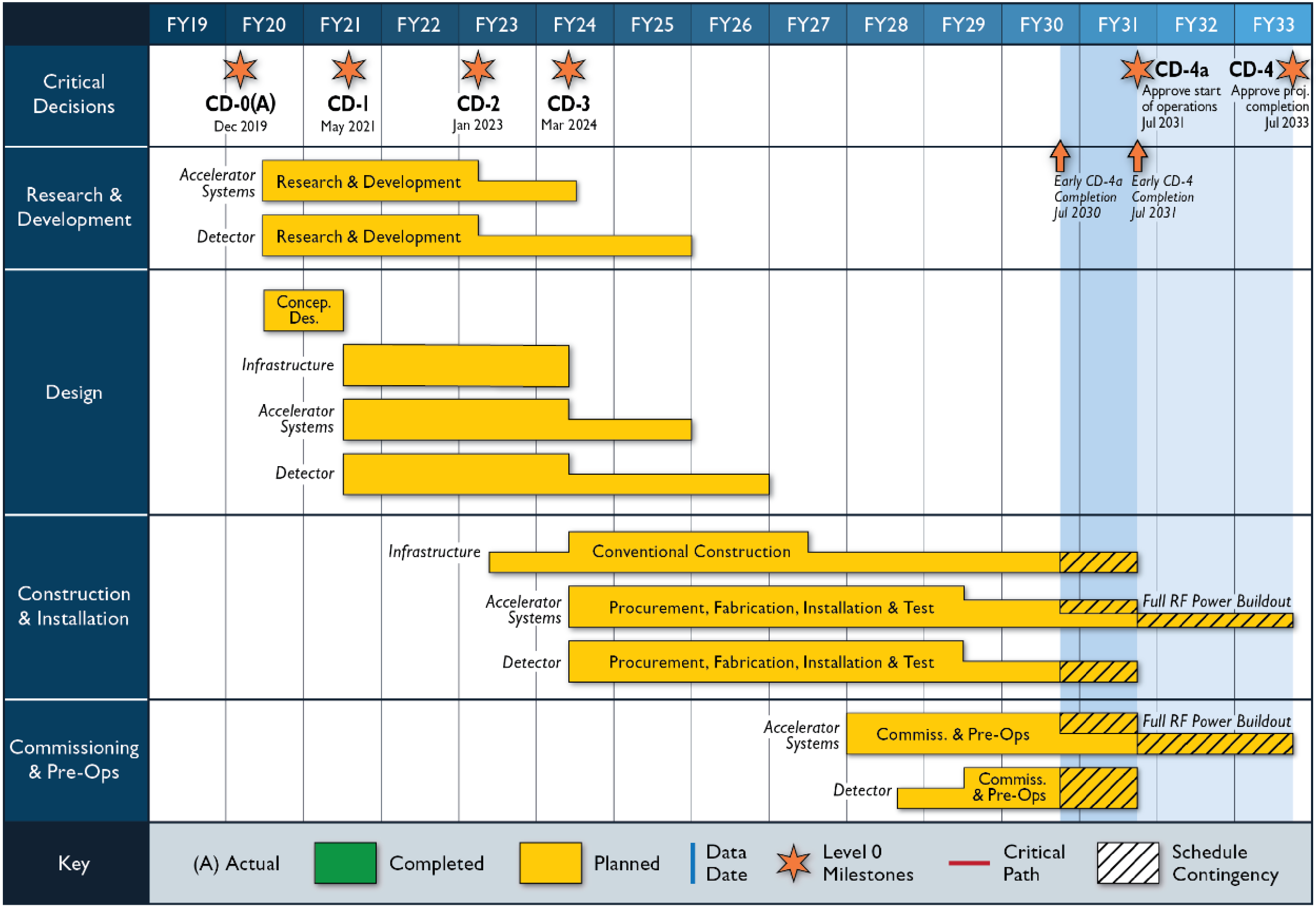
CD-1 Plan Revised – Ref. Profile v2

- DOE TPC $2,249M
- Proposed DOE PMB $1,606M
- Contingency $643M (40%)
- Revised Milestones
  - CD-2 January 2023
  - CD-3 March 2024
  - CD-4a Early Finish Jul 2030
  - CD-4a Jul 2031
  - CD-4 EF Jul 2031 (no change)
  - CD-4 Jul 2033 (24-month schedule contingency)
- Notes
  - Funding profile consistent with financial obligation plans
  - Revised timeline for Critical Decisions
  - Reasonable schedule and cost contingencies





	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
FUNDING:	11	41	141	337	543	787	1109	1415	1709	1947	2119	2249
OBLIGATION:	11	41	137	234	383	633	936	1255	1459	1593	1606	1606
COST:	8	37	100	168	274	398	620	924	1286	1423	1518	1606



FY19 FY20 FY21 FY22 FY23 FY24 FY25 FY26 FY27 FY28 FY29 FY30 FY31 FY32 FY33
Critical Decisions
CD-0(A) Dec 2019
CD-1 May 2021
CD-2 Jan 2023
CD-3 Mar 2024
CD-4a Approve start of operations Jul 2031
CD-4 Approve proj. completion Jul 2033
Early CD-4a Completion Jul 2030
Early CD-4 Completion Jul 2031
Research & Development
Accelerator Systems
Research & Development
Detector
Research & Development
Design
Concep. Des.
Infrastructure
Accelerator Systems
Detector
Construction & Installation
Infrastructure
Conventional Construction
Accelerator Systems
Procurement, Fabrication, Installation & Test
Full RF Power Buildout
Detector
Procurement, Fabrication, Installation & Test
Commissioning & Pre-Ops
Accelerator Systems
Commiss. & Pre-Ops
Full RF Power Buildout
Detector
Commiss. & Pre-Ops
Key
(A) Actual
Completed
Planned
Data Date
Level 0 Milestones
Critical Path
Schedule Contingency

Key Milestones

DOE Critical Decision (CD)	CD-1 Review (2020)	Change (Months)	Proposed (03/21)
CD-1, Alternative Analysis	April 2021	+1	May 2021
CD-2, Performance Baseline	October 2022	+3	**January 2023**
CD-3, Construction Start	July 2023	+8	March 2024
		Construction Start to Early Ops = 6 ¼ Years	
Early Start of Operations (CD-4a)	July 2029	+12	**July 2030**
Late Start of Operations (CD-4a)	January 2031	+6	July 2031
CD-4 Early Project Completion	July 2031	=	July 2031
		Schedule Contingency = 2 Years	
CD-4 Late Project Completion	January 2033	+6	July 2033

- Revised funding profile including actual FY2021 (\$30M vs \$43M)
- DOE Total Project Cost with 40% contingency
- Additional year of schedule contingency on project completion

Post CD-1 Timeline

Accelerator Technical Reviews	Spring/Summer 2021
Call for Detector Proposals	March 2021
Start Preliminary Design	April 2021
Detector Proposals Submitted	December 2021
Selection of Project Detector	March 2022
Start Earned Value Tracking	Summer 2022
Clarify In-kind Deliverables - Agreements	Summer/Fall 2022
Goal for CD-2 Approval	January 2023
Goal for CD-3 Approval	March 2024

Two Detector (Two IR) Scenario

- EIC with two interaction regions and detectors
  - Ensures a robust EIC physics program and enhances the science reach.
- Detector concepts needed now
  - Informs strategies towards achieving two detectors and IRs
  - Influences project decisions
  - EIC project schedule is an important planning constraint
- Major effort needed to secure resources (~$500M)
  - Possibly a DOE Major Item of Equipment (MIE) project
  - Significant international engagement will be required

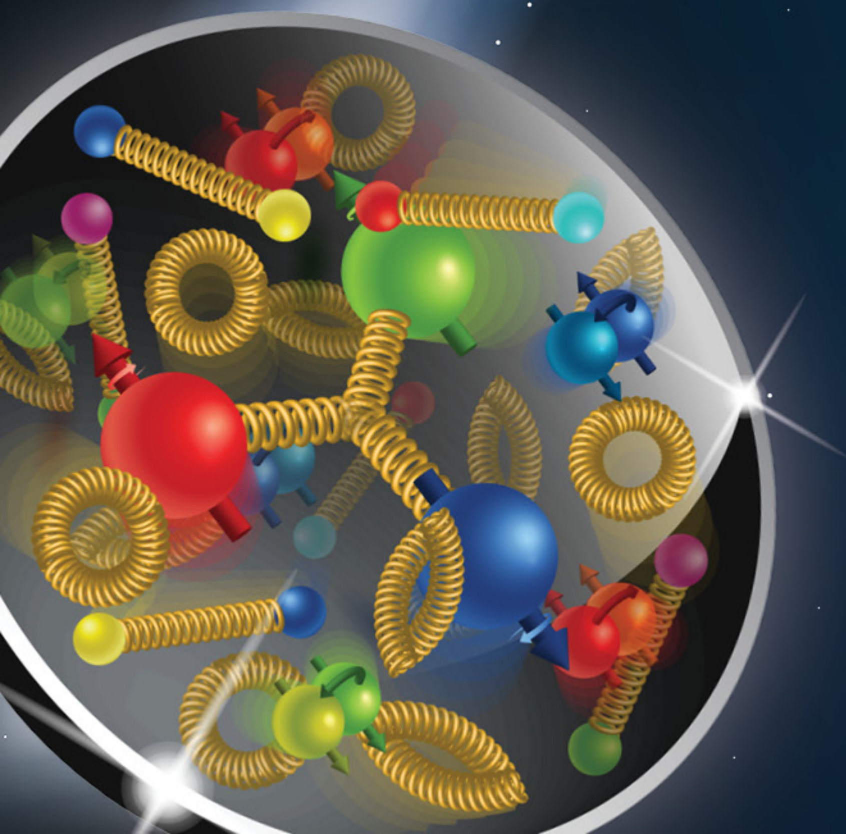
EIC Challenges and Opportunities

- Affordability – EIC is very large project for DOE Office of Nuclear Physics (NP) and Office of Science (SC)
  - Requires reprioritization of RHIC funding and new funding
  - Significant ramp up of project funding required to maintain schedule
  - Most cost-effective project follows a technically driven schedule
- Partner Engagement – Expectations and Implementation
  - International engagement is highly desirable and expected
  - In-kind contributions to the accelerator and detector are being pursued
  - Partners must engage now given the technically driven schedule
  - Collaboration proposals should include in-kind contribution plans

Summary

- Excellent progress in 2020 - congratulations on the Yellow Report and Conceptual Design Report!
- Ready for CD-1, DOE approval expected in May 2021.
- CD-2 preparations underway and approval milestone in less than two years, January 2023.
- DOE and the EIC project promoting international collaboration and partnership in the EIC and exploring possibilities for in-kind contributions.
- Response to the Call for Collaboration Proposals for Detectors at the EIC is critical to CD-2 and project success.

Electron-Ion Collider Overview & Machine-Detector Interface Considerations



EIC Calorimeter Workshop
March 15 2021

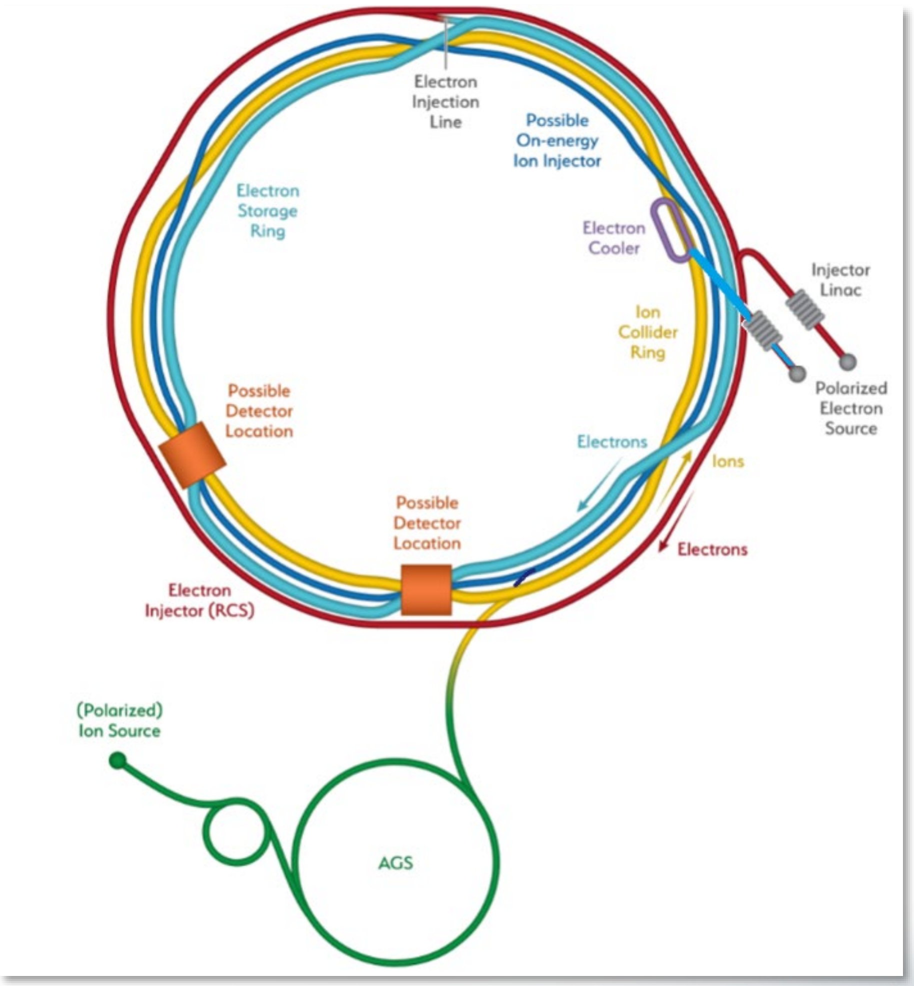
F. Willeke, BNL
EIC Technical Director
EIC Deputy Director

Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY
Jefferson Lab
U.S. DEPARTMENT OF ENERGY | Office of Science

Overview

- Requirements
- EIC Accelerator Design
- IR overview
- IR magnets
- IR set up for low E_{cm}
- 2 IR's
- IR 8
- Summary



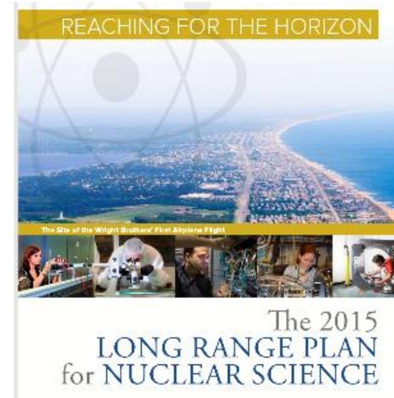
Requirements

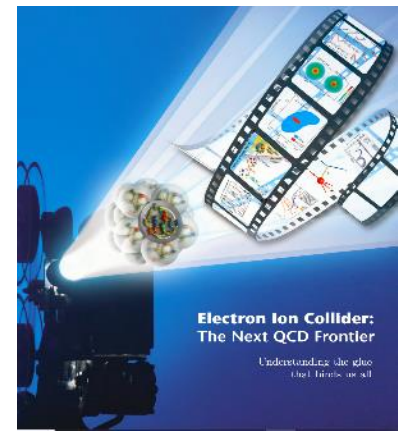
EIC Design Goals

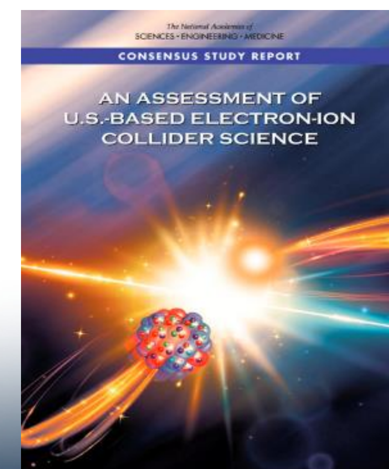
- High Luminosity: $L=(0.1\text{-}1)\cdot 10^{34} cm^{-2} sec^{-1}$, (need 10 -100 fb^{-1})
- Collisions of highly polarized e and p (and light ion) beams with flexible spin patterns of bunch structure: 70%
- Large range of center of mass energies: E_{cm} = (20-140) GeV
- Large range of Ion Species: protons – Uranium
- Possibility to accommodate a 2^{nd} detector and IR
- Large detector acceptance
- Good background conditions (hadron particle loss and synchrotron radiation in the IR)

These goals match or exceed the requirements of the **Long-Range Plan for Nuclear Science** and the **EIC White Paper,** endorsed by the **National Academy of Science**

EIC Design meets or exceeds goals and requirements



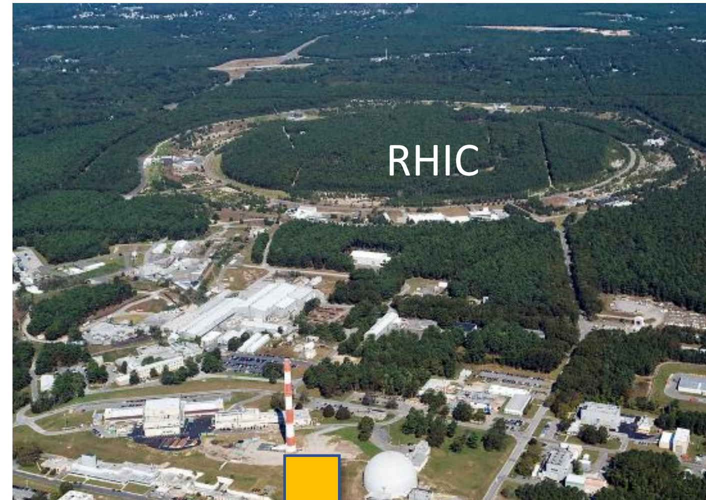


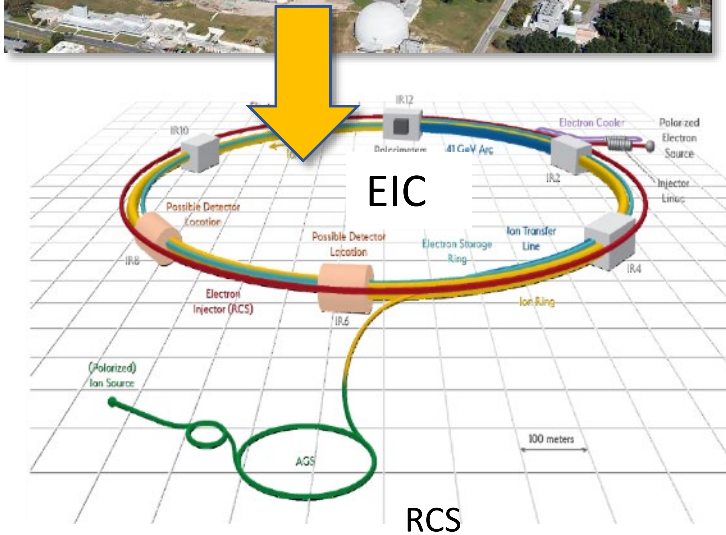


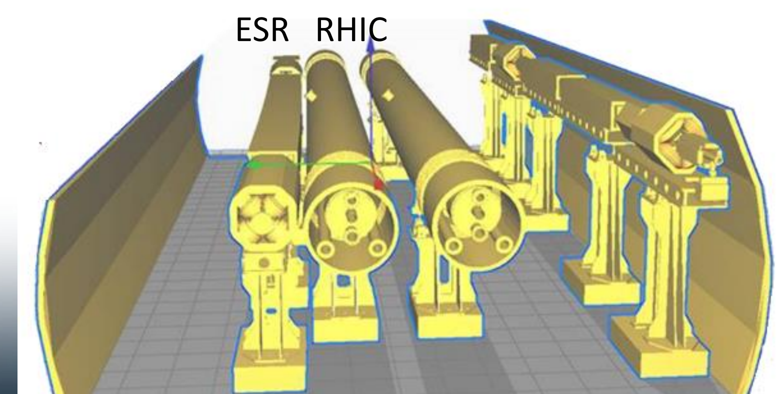
EIC Collider Concept

Design based on **existing** RHIC,
RHIC is well maintained, operating at its peak

- **Hadron storage ring 40-275 GeV** (existing)
  - RHIC Yellow Ring
  - many bunches, 1160 @ 1A beam current
  - bright beam emittance ε_{xp}= 9 nm, flat beam
  - need strong cooling
- **Electron storage ring (2.5–18 GeV, new)**
  - many bunches,
  - large beam current (2.5 A) ➔10 MW S.R. power
  - s.c. RF cavities
  - Energy independent radiation damping
- **Electron rapid cycling synchrotron** (new)
  - 1-2 Hz
  - Spin transparent due to high periodicity
- **High luminosity interaction region(s)** (new)
  - L = 10^{34}cm^{-2}s^{-1}
  - Superconducting magnets
  - 25 mrad Crossing angle with crab cavities
  - Spin Rotators (longitudinal spin)
  - Forward hadron instrumentation







High Luminosity Concept

- Highest luminosity in the center of mass energy (E_{cm}) range of the EIC requires strong hadron cooling
- Strong hadron cooling for hadron energies up to 275 GeV is very challenging and requires new techniques and demanding technologies

➔ **Maximize Luminosity while keeping hadron cooling requirements modest**

Implies:

- Maximize total e, p currents: 2.5 A e @10 MW RF; 1A p (3 x RHIC)
- Chose maximum bunch population compatible with collective effect $N_e = 1.7 \times 10^{11}$ e
- Number of bunches minimized $N_b = 1160$
- Luminosity maximized with maximum (p) beam emittance ε_{px}= 9.5 nm,1.5 nm
- Minimum strong hadron cooling requirement τ_{cool} = 2-3 h
- 25 mrad Crossing Angle

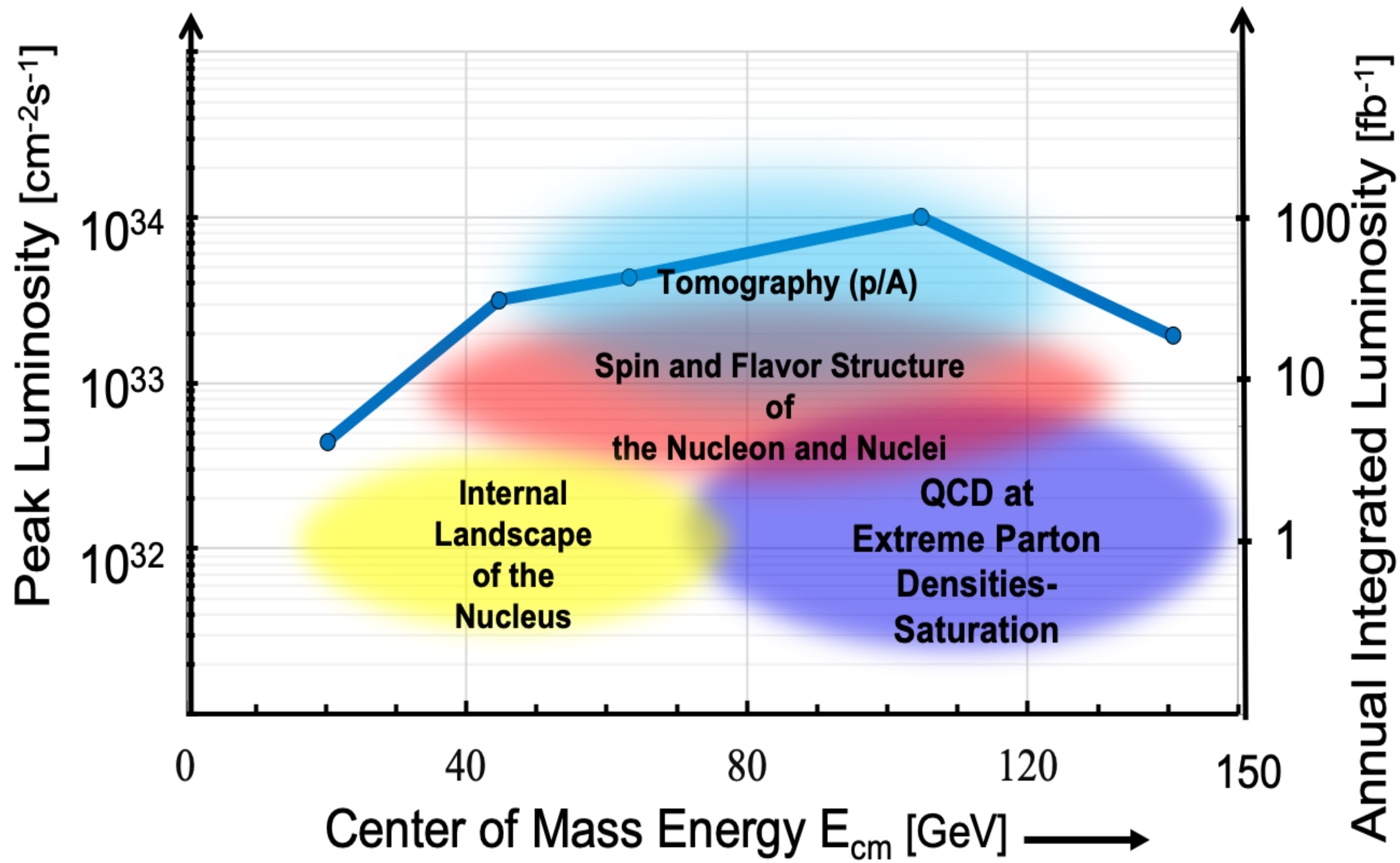
- Modestly strong focusing, Small β^*_y = 5 cm
  - Manageable dynamic aperture issues (+/- 15 σ_x, 10 σ_e)

EIC CDR Parameters for E_{cm} and Luminosity

	Electrons	Protons
Beam energies	2.5 - 18 GeV	41- 275 GeV
Center of mass energy range	E_{cm} = 20-140 GeV	

	Electrons	Protons
Beam energies	10 GeV	275 GeV
Center of mass energy	E_{cm} = 105 GeV	
number of bunches	nb =1160	
crossing angle	25 mrad	
Bunch Charge	$1.7 \cdot 10^{11}$e	$0.7 \cdot 10^{11}$e
Total beam current	2.5 A	1 A
Beam emittance, horizontal	20 nm	9.5 nm
Beam emittance, vertical	1.2 nm	1.5 nm
β- function at IP, horizontal	43 cm	90 cm
β- function at IP, vertical	5 cm	4 cm
Beam-beam tuneshift, horizontal	0.073	0.014
Beam-beam tuneshift, vertical	0.1	0.007
Luminosity at E_{cm} = 105 Gev	$\mathbf{1 \cdot 10^{34} cm^{-2} s^{-1}}$	

Luminosity versus E_{CM} center of mass energy



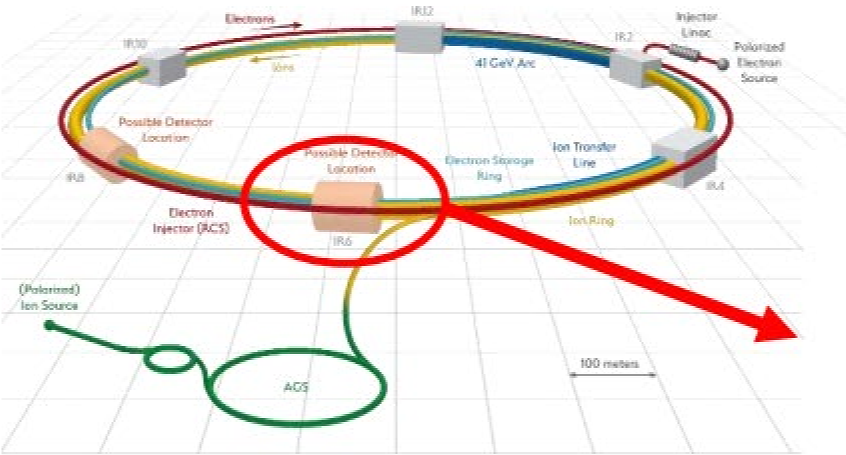
Interaction Region & Machine Detector Interface

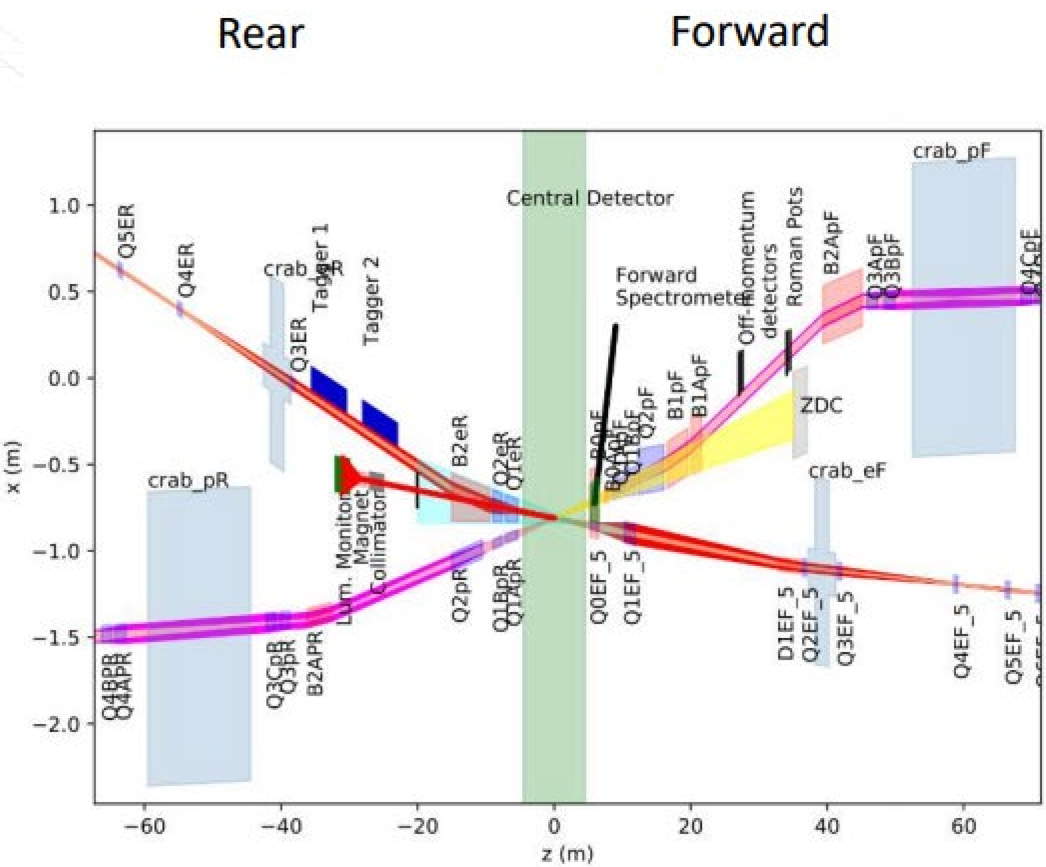
Most constraint part of the collider. Multiple requirements, most are conflicting:

- Space requirement for detectors L=-4.5/+5m (<u>note:</u> luminosity~1/L)
  detector radius limited to 3.4m by building , need to bypass detector with RCS
- Forward hadron apertures determined by forward neutron and scattered ion beams +/- 4mr neutrons, proton p_t =(1.3-0.2) GeV/c, accommodate Roman pots in vacuum system, beam orbit geometry which provides free path for neutrons from IP to ZDC
- Provide space for luminosity measurements and local polarization measurements
- High luminosity, small β^* high chromaticity generated in final focus
- Total chromaticity is limited as its necessary compensation caused dynamic aperture limitation
- Meets beam optical constrains to be able to compensate chromaticity
- Novel s.c. magnet technology required for implementation
- Synchrotron radiation emitted from final quadrupoles does not hit detector beam pipe.
- Optimized vacuum geometry minimizes impedance and beam heating
- Crossing angle 25 mrad required to accommodate large number of bunches
- Accommodate crab-cavities to compensate detrimental crossing effects: crab crossing
- Accommodate spin rotators and keep IR beam optics spin transparent
- Fits inside the existing straight section (at least for IR 6) and matches adjacent hadron and electron arcs
- Compensate detector solenoid field without anti-solenoid for spin, crabbing, beam dynamics

Interaction Region (WBS 6.06)

EIC IR: Overview





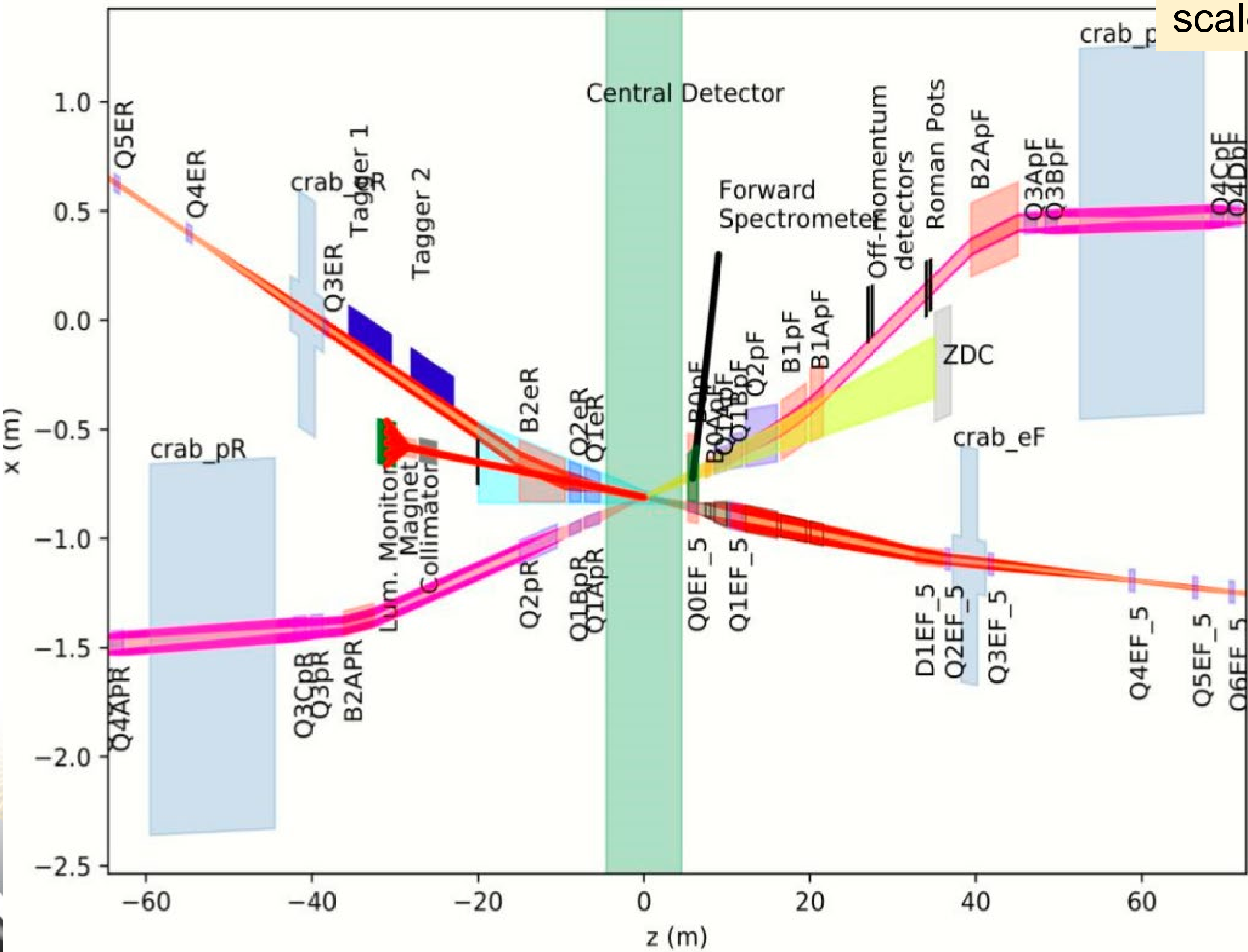
RHIC yellow ring: EIC hadron ring

Add electron storage ring in existing tunnel (and the RCS)

IR location: IR6

Interaction Region Layout

IR Top view (with stretched vertical scale)



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EIC High Luminosity with a Crossing Angle

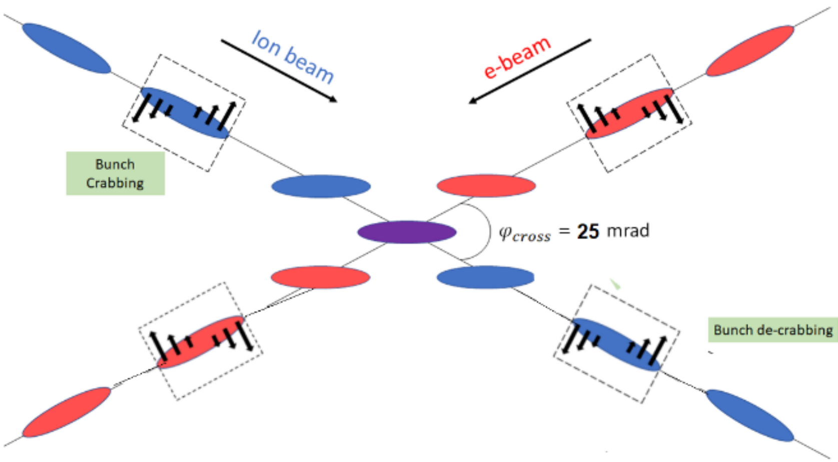
Modest crossing angle of 25 mrad

- avoid parasitic collisions due to short bunch spacing,
- for machine elements, to improve detection
- reduce detector background,

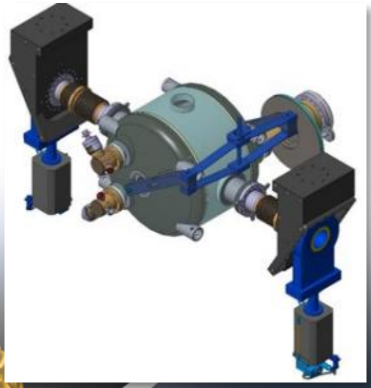
<u>Note</u>: IP moves radially by 75 microns (long: 3 cm) during collisions of 100 ps

However, crossing angle causes
- Low luminosity
- Beam dynamics issues

avoided by Crab Crossing

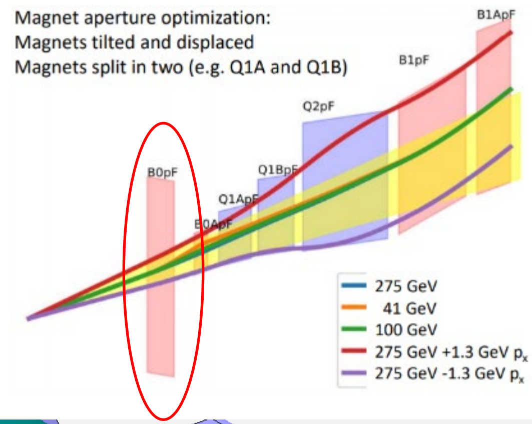


Consequently:
Effective head-on collision restored
beam dynamic issues resolved (mostly)

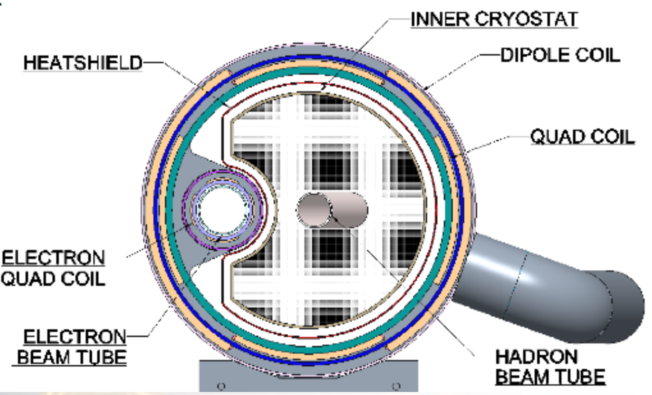


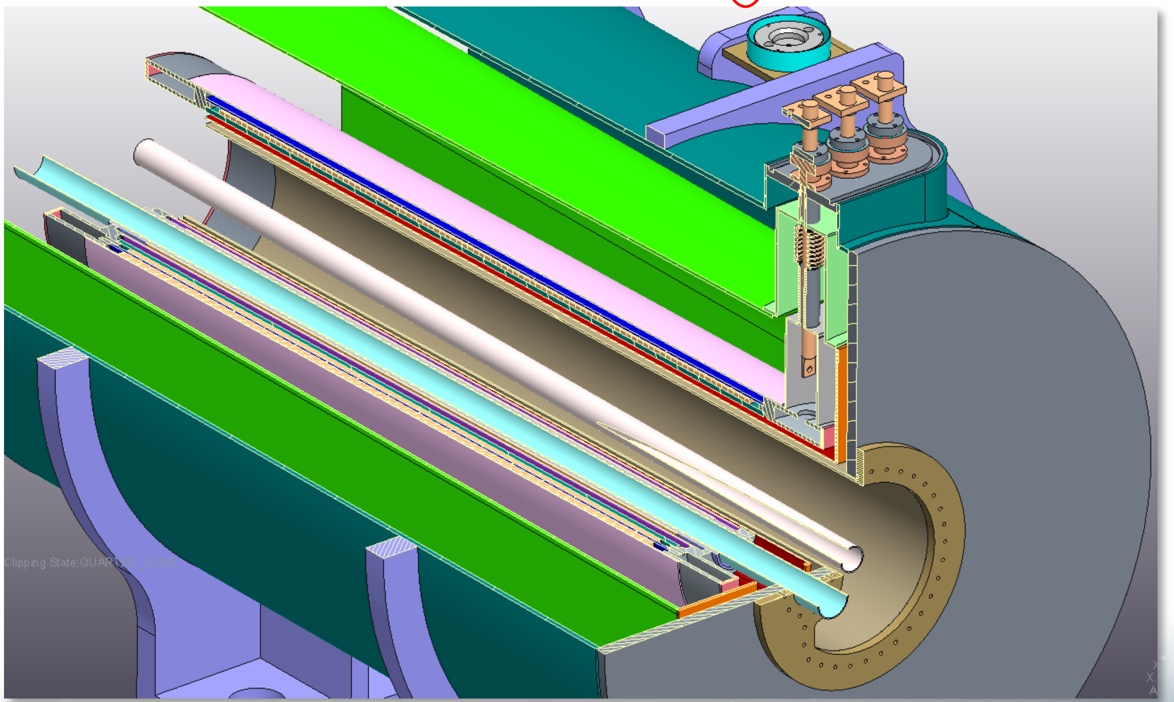
Several transverse RF resonator (crab-cavity) prototypes built
- tested with proton beam in the CERN-SPS

Magnet Technology

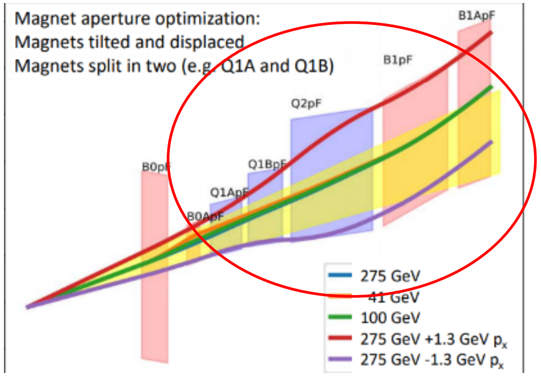


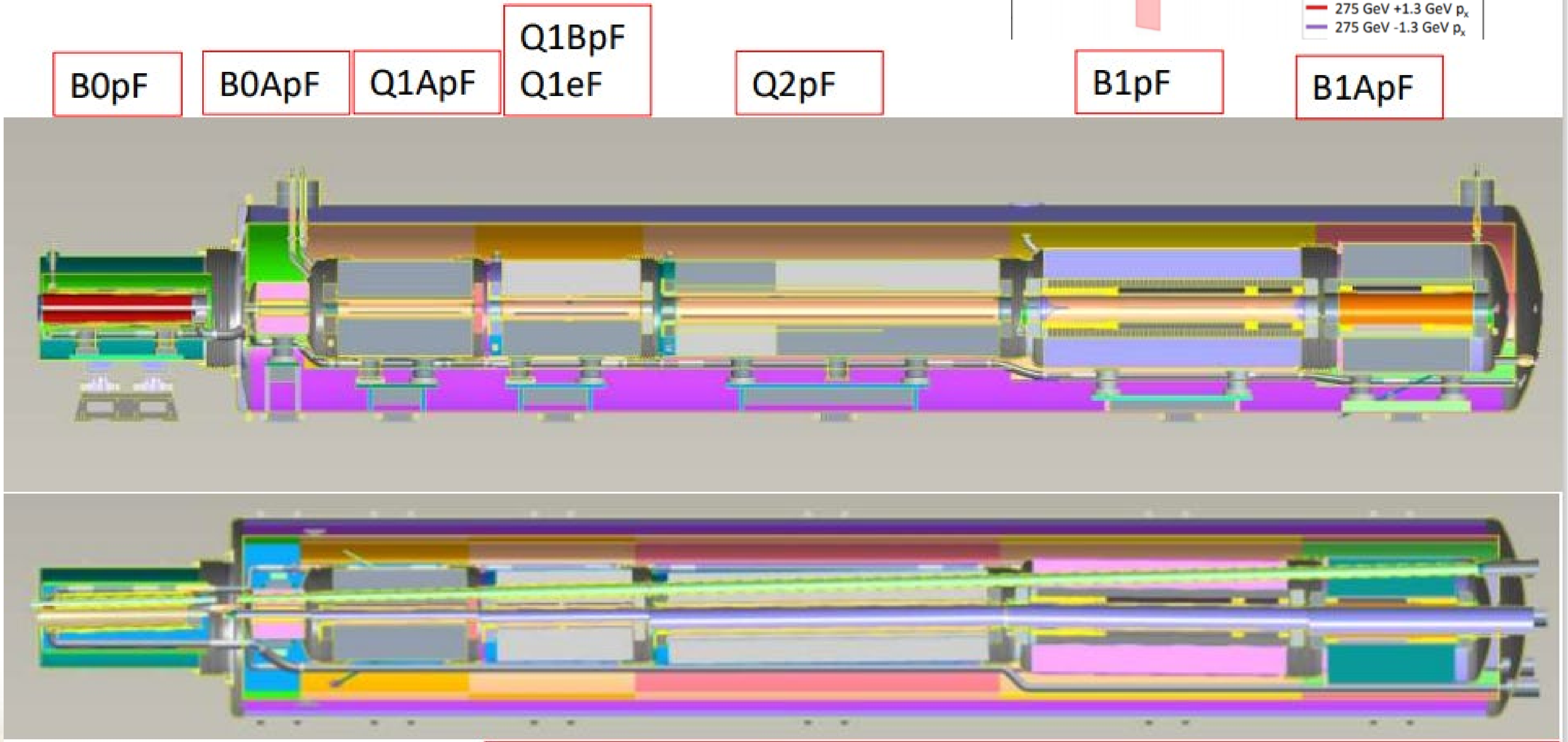
B0 spectrometer magnet





Magnet Technology

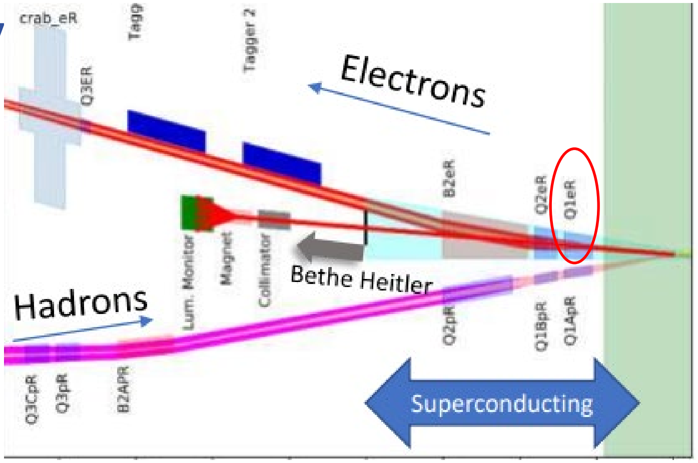




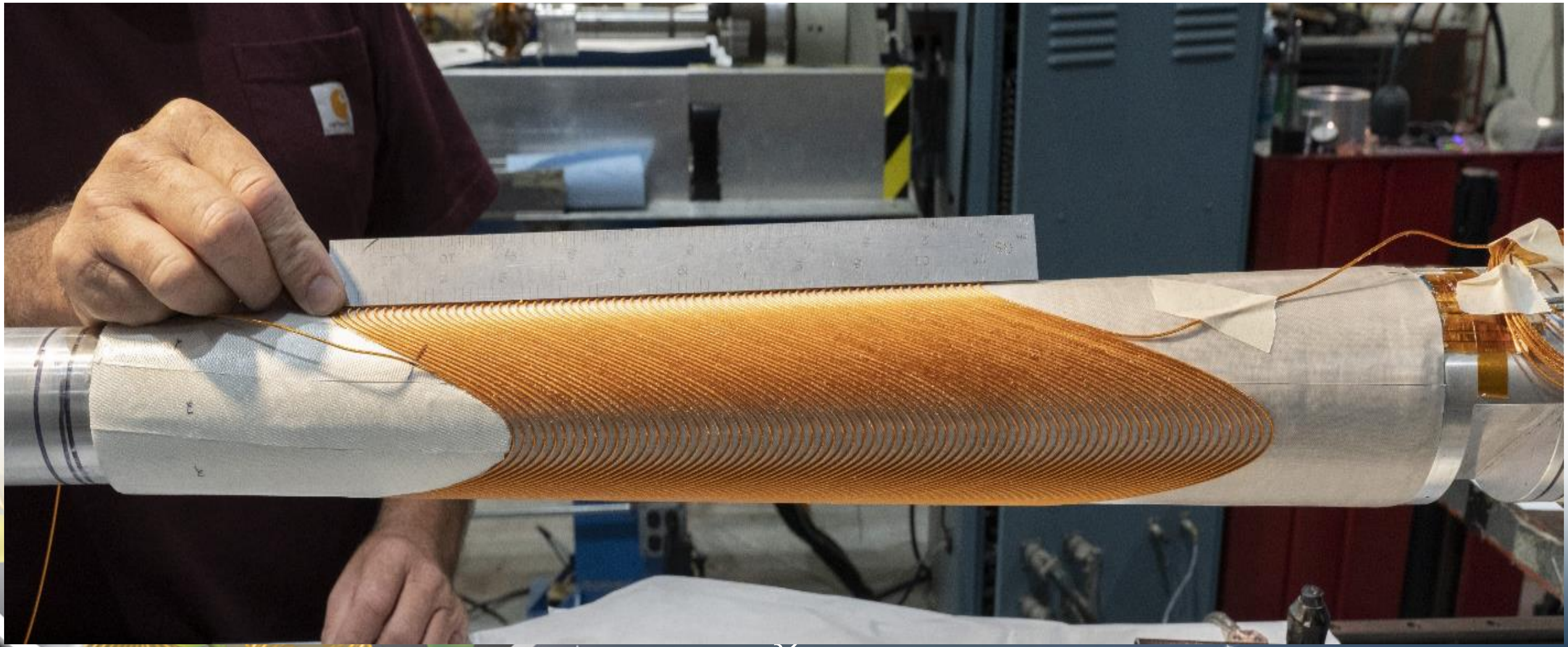
Standalone
48” cryostat

- Common split cryostat
- Cold mass adjustments within cryostat
- Each cold mass independently anchored
- Common helium vessel, with bellows between all magnets

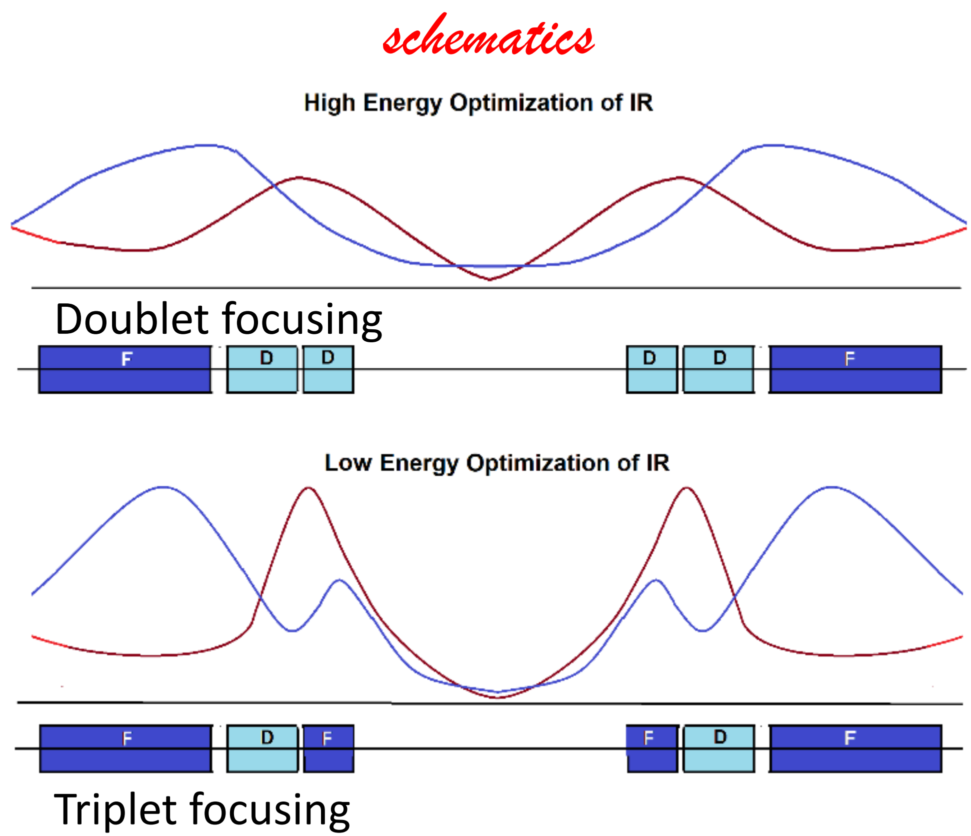
Magnet Technology

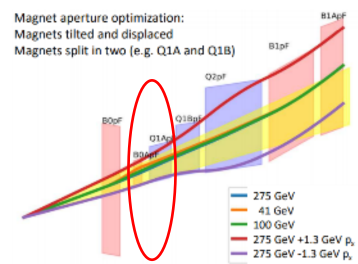


Successful prototype of a direct wind double helix quadrupole magnet with tapered aperture during the winding process.
This technology will be used for **Q1eR**



How to get more luminosity at lower E_{cm}?

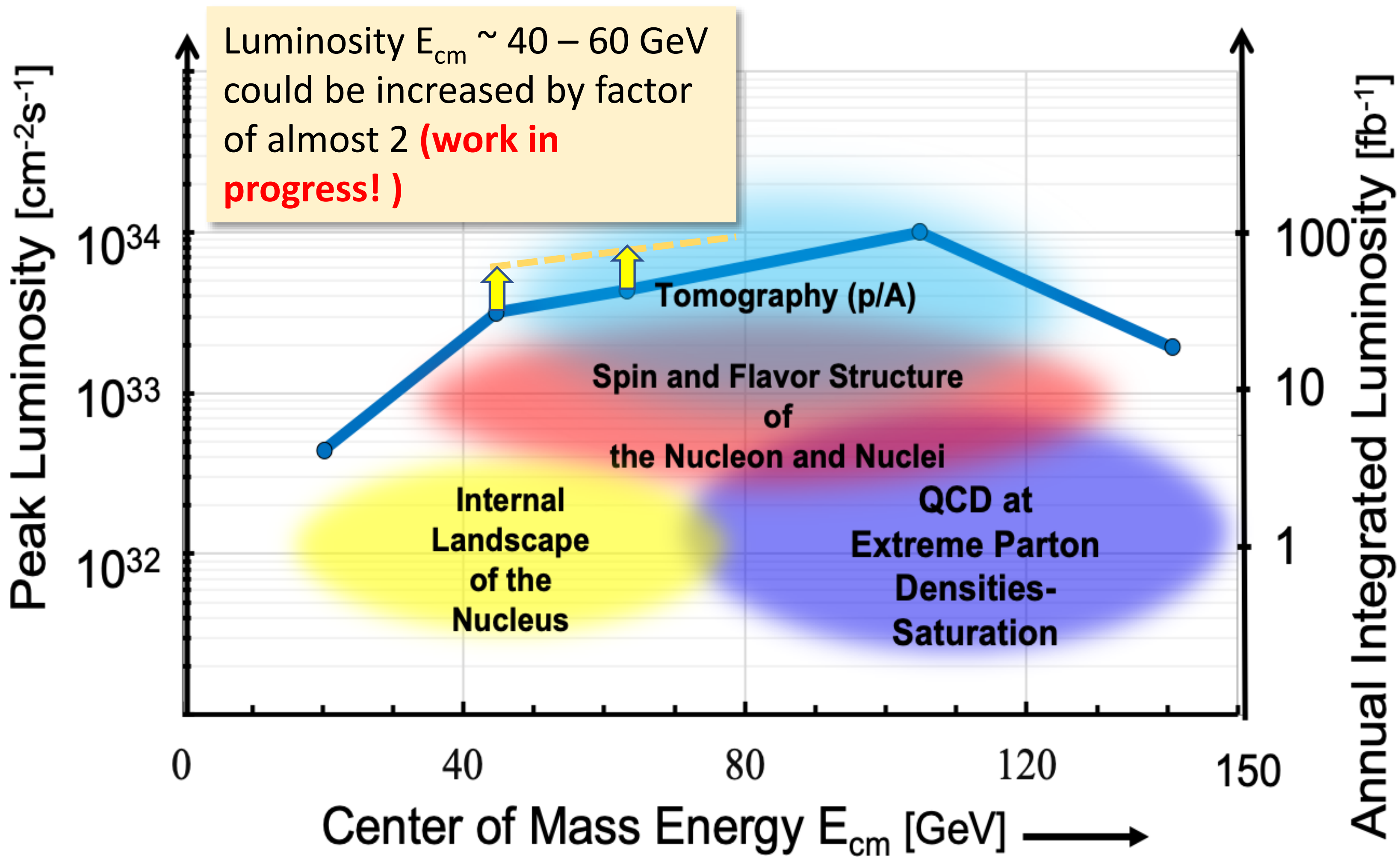




For hadrons, final focus lens (vertical) is split into two magnets (tapering the aperture that way). Doublet focusing for E_{cm} ~100-140 GeV.

For low hadron beam energy (E_{cm} =60 GeV) can rewire into triplet focusing, reduce β^* ➔ Increase L by factor of 2

Luminosity at lower E_{CM}



Operation with two Detectors

- Only one detector and one IR is in the EIC budget. The project is working on accommodating a second IR and detector. Required funding of ~500M$ is unclear at this point
- The bunches cannot collide in two IRs with maximum intensity.
- Simultaneous collisions of all bunches in 2 Irs most likely requires to reduce the intensities by up to a factor of 2:

L ➔ 2 x L/4

- Instead, we arrange for half of the bunches collide in one IR the other half in the second IR (luminosity sharing)

L ➔ 2 x L/2

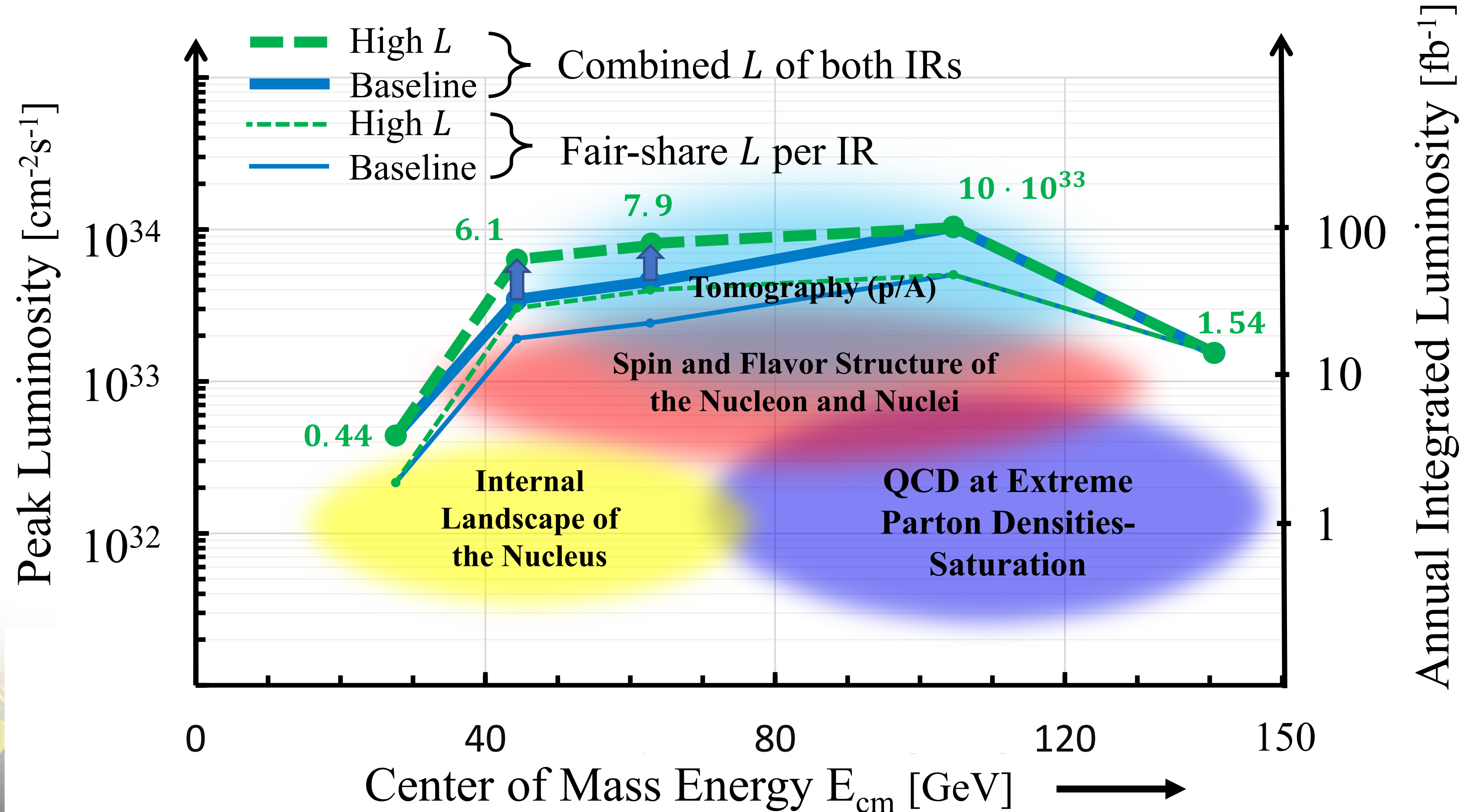
- So far, we don’t have (**yet**) a satisfactory solution for operation with 2 IRs, too much chromaticity, to much deterioration of polarization!
- What works: Run collisions in one IR at a time and alter Irs

L ➔ 2 x L/2

Nota bene: Two IRs as compared to one will most likely **not increase** the sum of the (integrated) luminosity

Luminosity Sharing

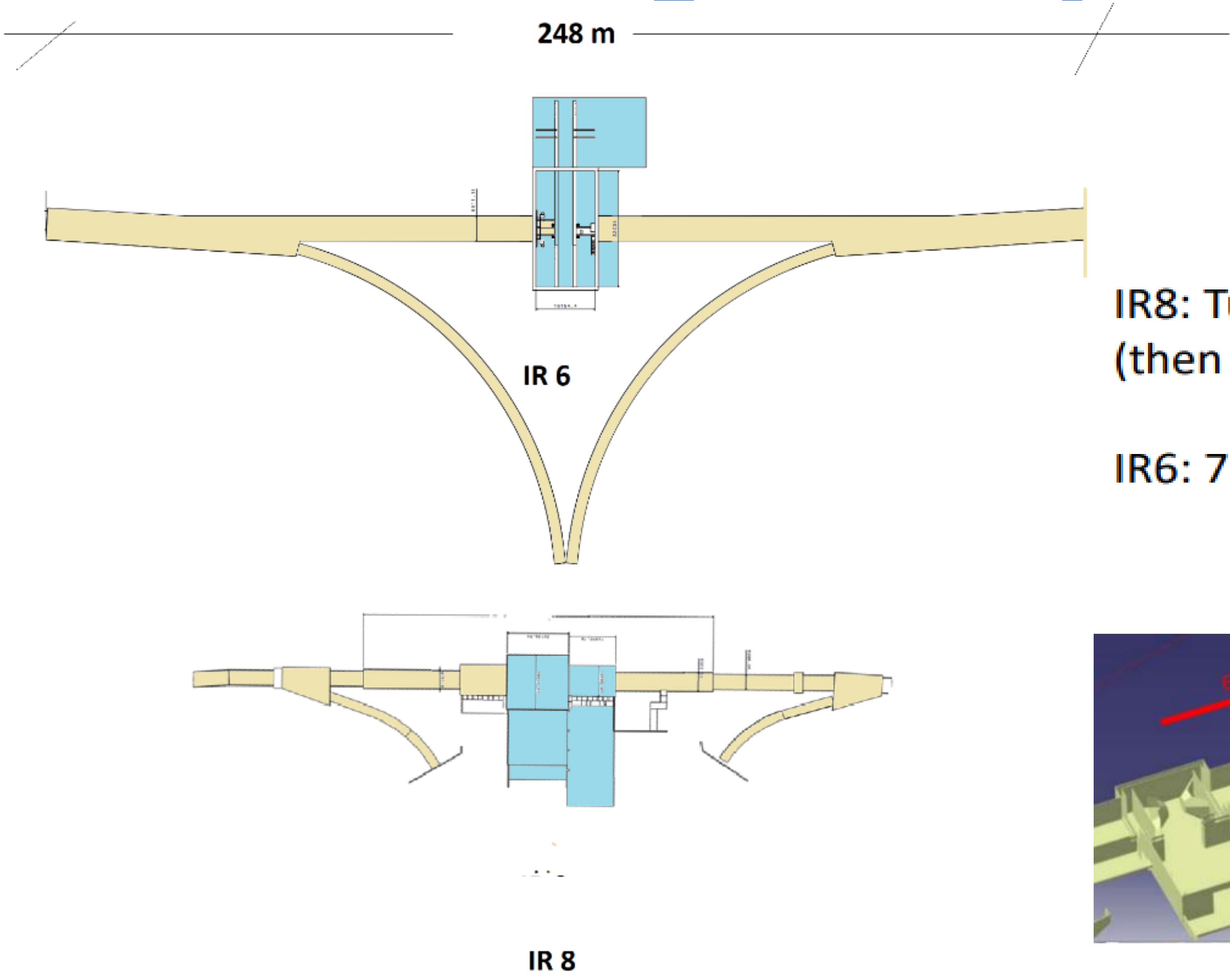
- Conservative assumption: luminosity is shared between two detectors, different bunch pairs collider at different IPs
- Luminosity in the medium rage can pushed at the expense of acceptance



IR 8

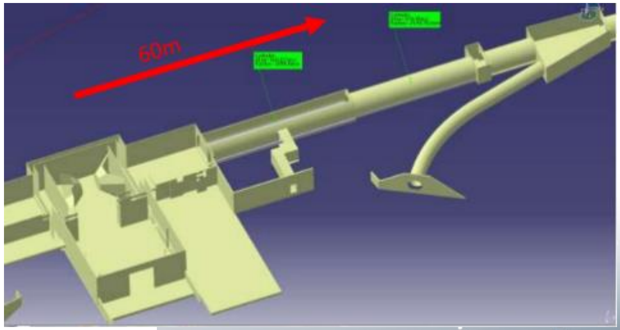
- The first interaction region of EIC is at IR 6
- Present RHIC offers IR8 as a possible second IR and detector location.
- IR 8 has significantly less space than IR6.
- A much larger crossing angle (35 mrad seems possible) in IR 8 compared with the present 25 mrad crossing angle in the first IR is most likely not possible without a major effort in civil construction.
- The tunnel end in **IR 6** is **6.9 m** wide over a length of **284 m**. In IR8 it is only **6.4 m** wide over a length of **117 m**. Further out it is only **5.27 m** wide.
- A detector bypass for the RCS limits the detector radius to **3.4 m**
- At present, we are planning the hadron and electron pathlengths in IR 8 similarly to the ones in IR6. This will constrain the differential pass length for electrons and hadrons in a later full IR8 layout, as any pathlength difference between hadron and electrons might not be able to be compensated any more by already existing accelerator arcs.
- IR8 centerline needs to be moved at least 85 cm from present midline of the tunnel (outwards)
- Work in progress to lay out reference design for IR with larger crossing angle and stronger emphasis on forward detection

IR6 vs IR 8 geometry



IR8: Tunnel dia. 6.3m to 60m (then 5.3m dia)

IR6: 7m dia. +/- 140m



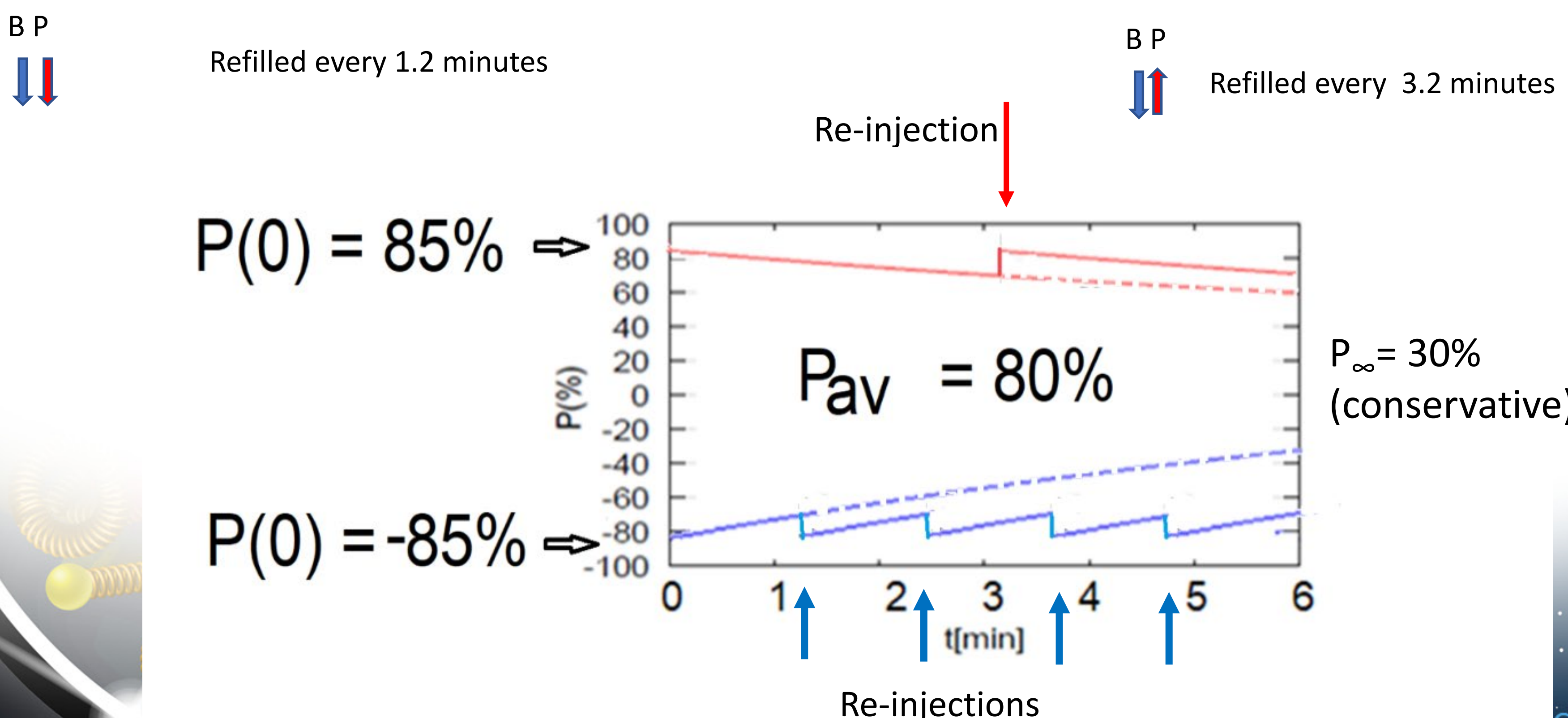
Summary

- The EIC has challenging performance goals
- The EIC conceptual design supports these goals
- The design effort is well organized, and challenges are under control
- The EIC conceptual design has achieved CD1 maturity
- The interaction region has progressed well
- SC Magnet design has matured as well as vacuum systems and other important hardware systems
- A possibility of increasing the luminosity for lower center of mass energies <100 GeV is being pursued and looks possible
- Operation with 2 IRs being worked out and challenges are being addressed

Backup

80% average polarization at electron storage ring by frequent on-energy injection of highly polarized (85%) electron bunches

- Equilibrium polarization in ESR is too slow and only ~50%
- Frequent injection of bunches with high initial polarization of 85%
- Initial polarization decays towards P_∞ < ~30-60%
- At 18 GeV (worst case) every bunch is refreshed in 2.2 min with RCS cycling rate of 2Hz.



EIC CDR Parameters for E_{cm} and Luminosity

	Electrons	Protons
Beam energies	2.5 - 18 GeV	41- 275 GeV
Center of mass energy range	E_{cm} = 20-140 GeV	

	Electrons	Protons
Beam energies	10 GeV	275 GeV
Center of mass energy	E_{cm} = 105 GeV	
number of bunches	nb =1160	
crossing angle	25 mrad	
Bunch Charge	$1.7 \cdot 10^{11}$e	$0.7 \cdot 10^{11}$e
Total beam current	2.5 A	1 A
Beam emittance, horizontal	20 nm	9.5 nm
Beam emittance, vertical	1.2 nm	1.5 nm
β- function at IP, horizontal	43 cm	90 cm
β- function at IP, vertical	5 cm	4 cm
Beam-beam tuneshift, horizontal	0.073	0.014
Beam-beam tuneshift, vertical	0.1	0.007
Luminosity at E_{cm} = 105 Gev	**$1 \cdot 10^{34} cm^{-2} s^{-1}$**	

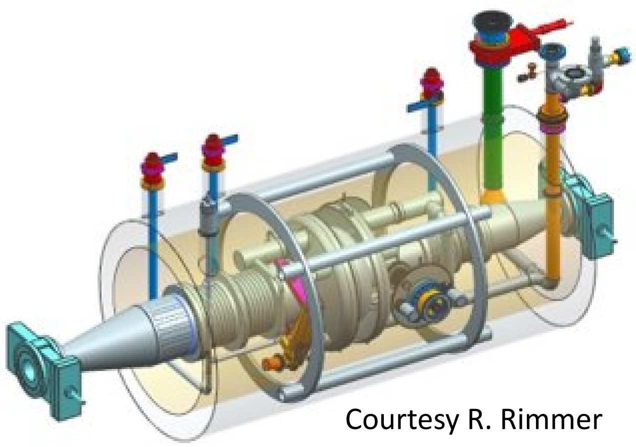
Electron Storage Ring (WBS 6.04)

- FODO-cell design, normal conducting magnets
- Superconducting RF 591MHz 1-cell
- 14 MW installed RF power (solid state)
- Vacuum system extruded OFE Copper

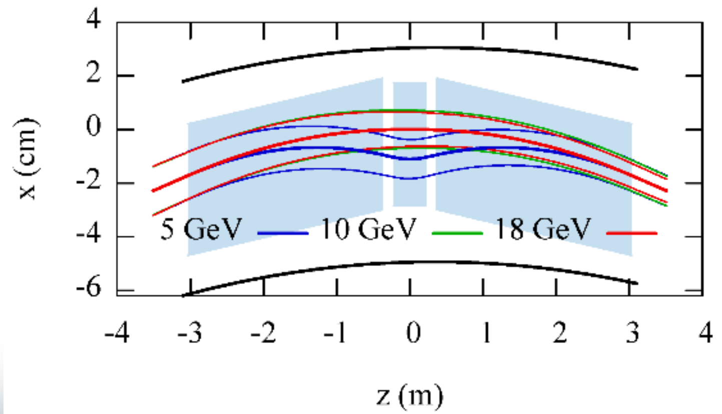
  NSLS-II type Bellows
- Radiation damping maintained <10 GeV

Control radiation damping and emittance super-bends (all dipoles split in 3 with center bend can be reversed)

- High spin polarization by frequent injection of 85% polarized bunches, fast kickers (10ns)

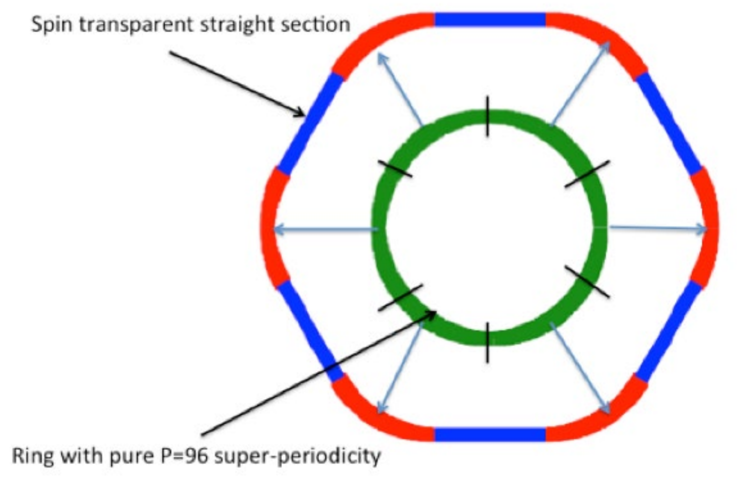


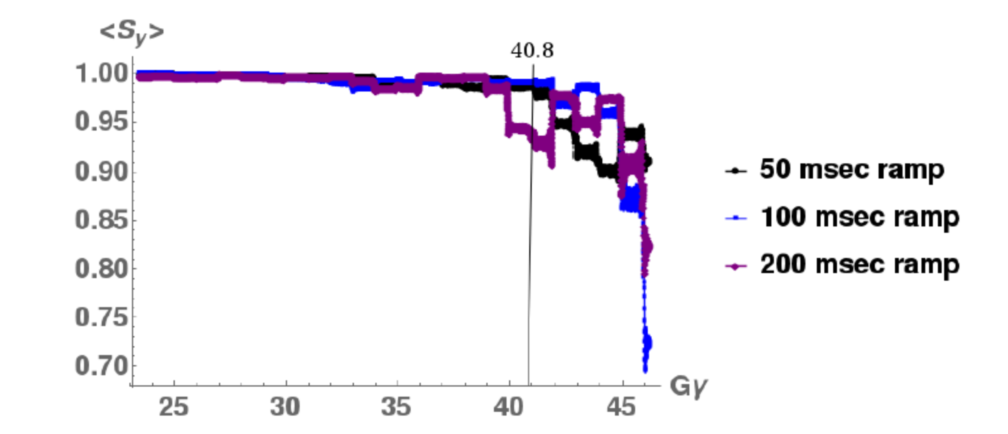
Courtesy R. Rimmer



Electron Injector (WBS 6.03)

- Electron Injector consists of:
  - polarized electron source (**existing**, being commissioned, SLAC/JLAB design)
  - 400 MeV s-band injector LINAC (**new**)
  - spin transparent Rapid Cycling Synchrotron (RCS) (**new**)
- RCS spin transparency achieved by high quasi symmetry due to periodic arcs with unit transformation straight section: all systematic depolarizing resonances suppressed, and imperfection resonances weakened



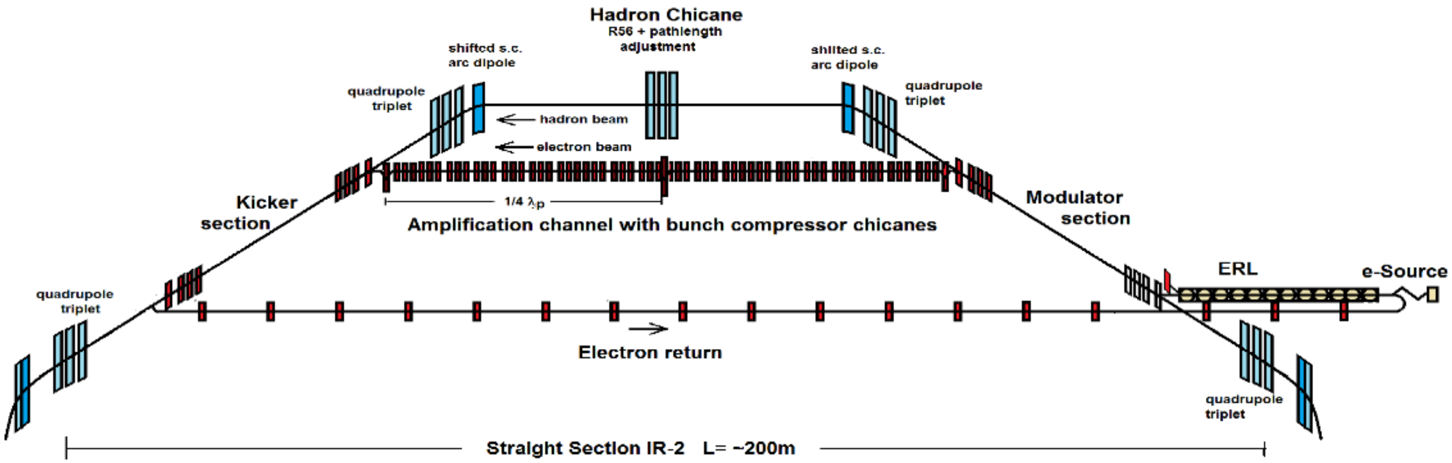


Hadron Storage Ring (WBS 6.05)

- RHIC Yellow Ring is the Hadron Storage Ring of the EIC
- Existing hadron injectors incl. polarized p and ion sources support EIC beam parameters
- Large energy range 41GeV -275 GeV
- Use Blue Ring sector IR2 to IR12 as a bypass for low energy running (41GeV), sector IR6-IR4 as injection channel
- Increase beam current by factor of 3 to 1A (1160 bunches)
- Insert a Cu- and aC-coated liner into cold beam pipe to limit thermal loads and suppress e-cloud
- Insert 4 more Siberian snakes (2➔ 6) to improve polarization performance for protons and He-3
- To obtain/maintain flat beam emittance, short bunches(6 cm), introduce strong hadron cooling in longitudinal and horizontal plane by coherent electron cooling with plasma enhanced microbunching amplification

EIC Strong Hadron Cooling (WBS 6.05.08)

Coherent Electron Cooling with μ-bunching amplification



- Design Cooling Rate R_{cool}= 1-2 h^{-1}
- Electron beam current I_e=100 mA (1nC/bunch), electron emittance ε_{xyN}= 2.5/0.5μm

<u>Scope</u>

- 400 keV DC gun
- 149 MeV, 120 mA ERL, e-beam dump
- Transfer lines to connect to hadron orbit and to return electrons to ERL
- Amplification sections with strong quadrupole triplet focusing and bunching chicanes
- Hadron chicane using existing s.c. magnets
- 2 K He sub-cooler, RF and power infrastructure, e-beam diagnostics
- Shared tunnel with e-injector LINAC