JENAS-2022

JENAA EoI 6: “Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments”

Daniël Boer, Van Swinderen Institute for Particle Physics and Gravity
University of Groningen, The Netherlands

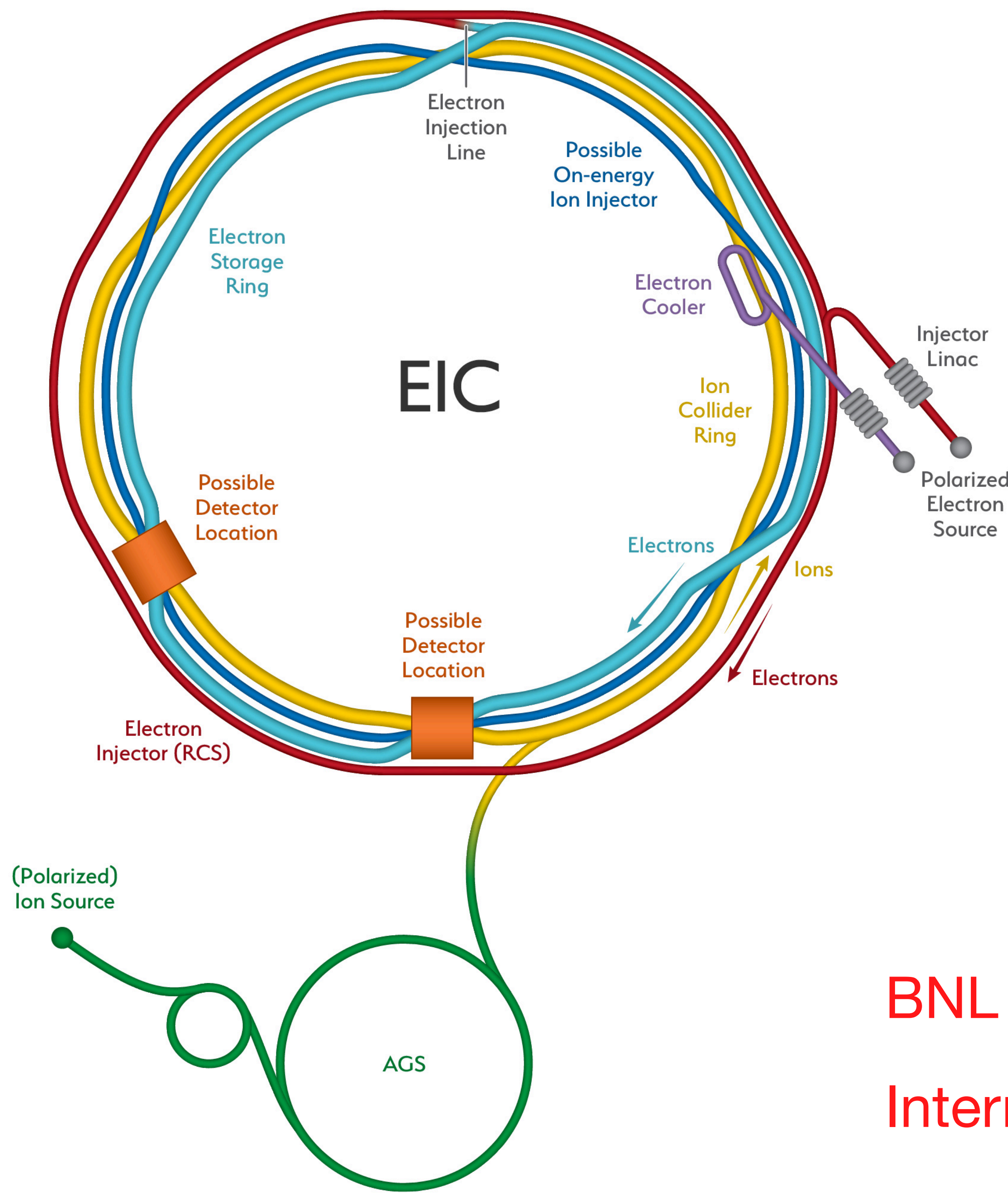
Also on behalf of Franck Sabatié, CEA Saclay

2nd Joint ECFA-NuPECC-ApPEC JENAS-Seminar, Madrid, May 4, 2022

Brief outline

- EIC - brief introduction & status
- EIC in the European strategy (ESPPU)
- JENAA EoI & Kick-off meeting at CERN
- Examples of synergies EIC & (HL-)LHC

U.S.-based Electron-Ion Collider



EIC will be constructed at Brookhaven National Laboratory

EIC is well on its path towards realization (CD-1 in June 2021)

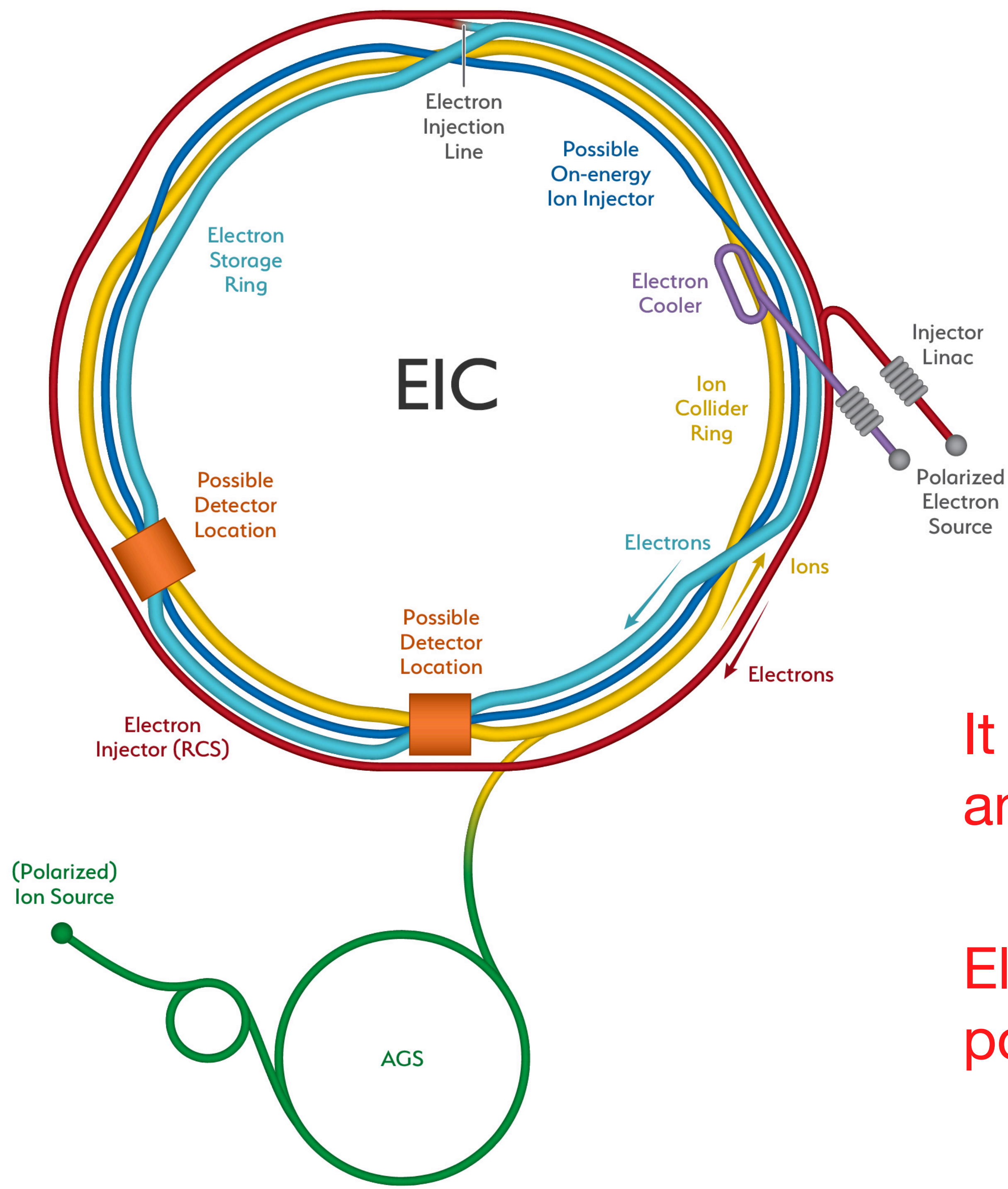
Now in the detector design and collaboration formation phase

Start of operation expected ~2031

BNL & TJNAF (Jefferson Lab) partnership

International facility, large EU involvement

U.S.-based Electron-Ion Collider



EIC will have a center of mass energy between 20 and 140 GeV and a luminosity of ~10^{-34} cm^{-2} s^{-1}

For comparison:

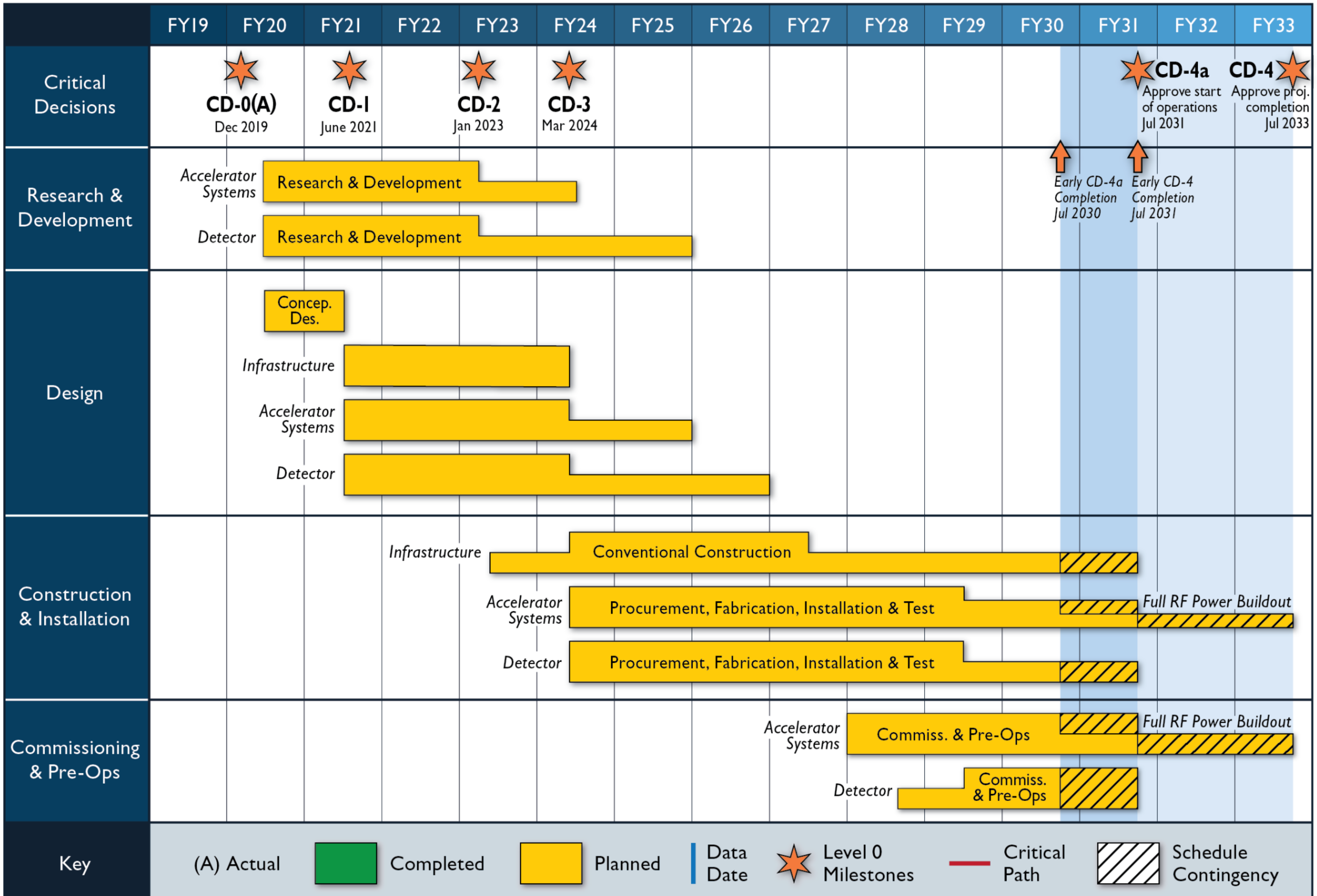
HERA energy ~320 GeV

Luminosity ~10^{-31} cm^{-2} s^{-1}

It will collide electrons with protons and nuclei up to U

Electrons, protons and light nuclei with polarization

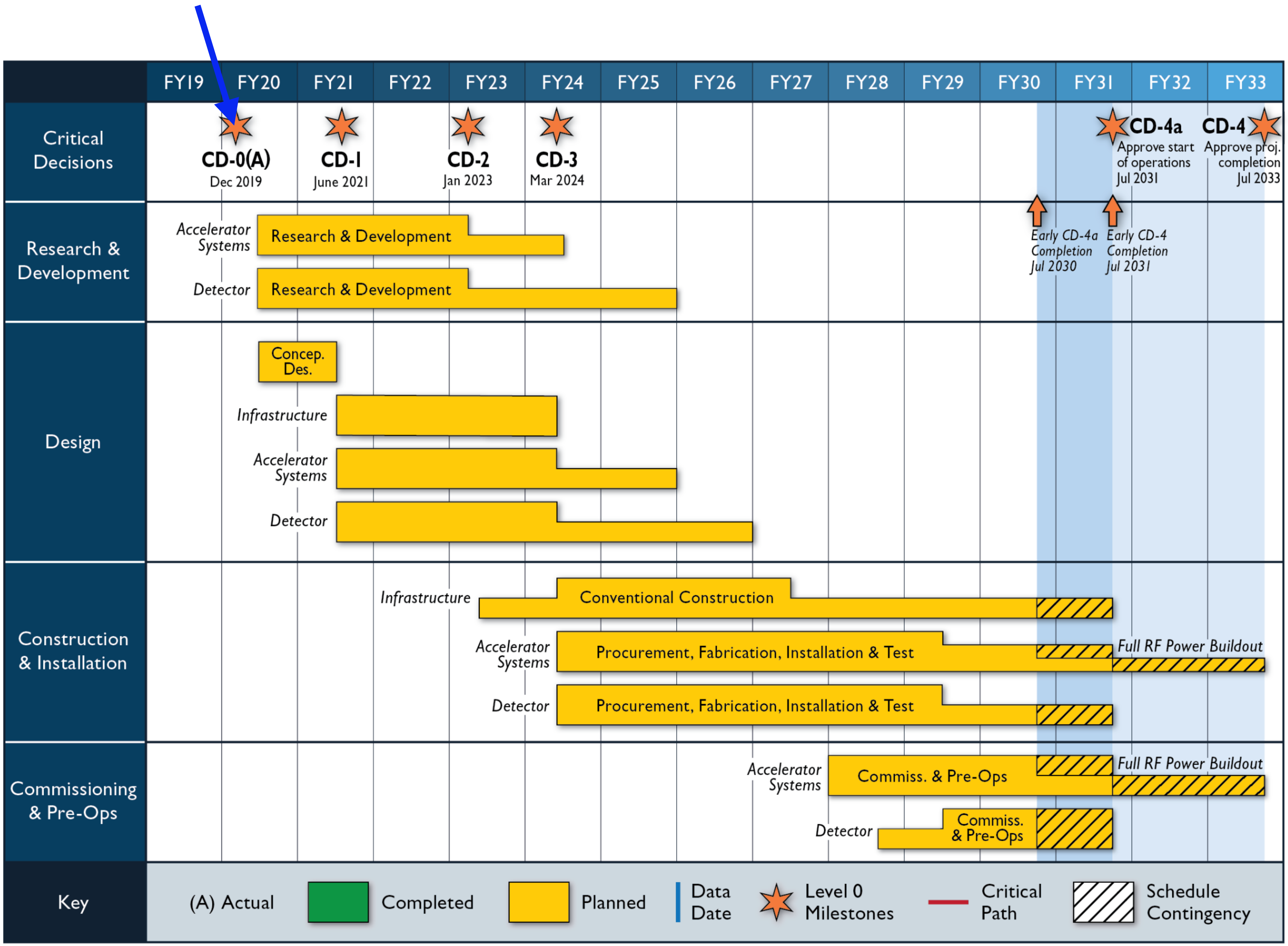
EIC prelim. schedule (revision foreseen by April 30, 2022)



As shown by T.J. Hallman (DoE) on August 2, 2021

EIC prelim. schedule (revision foreseen by April 30, 2022)

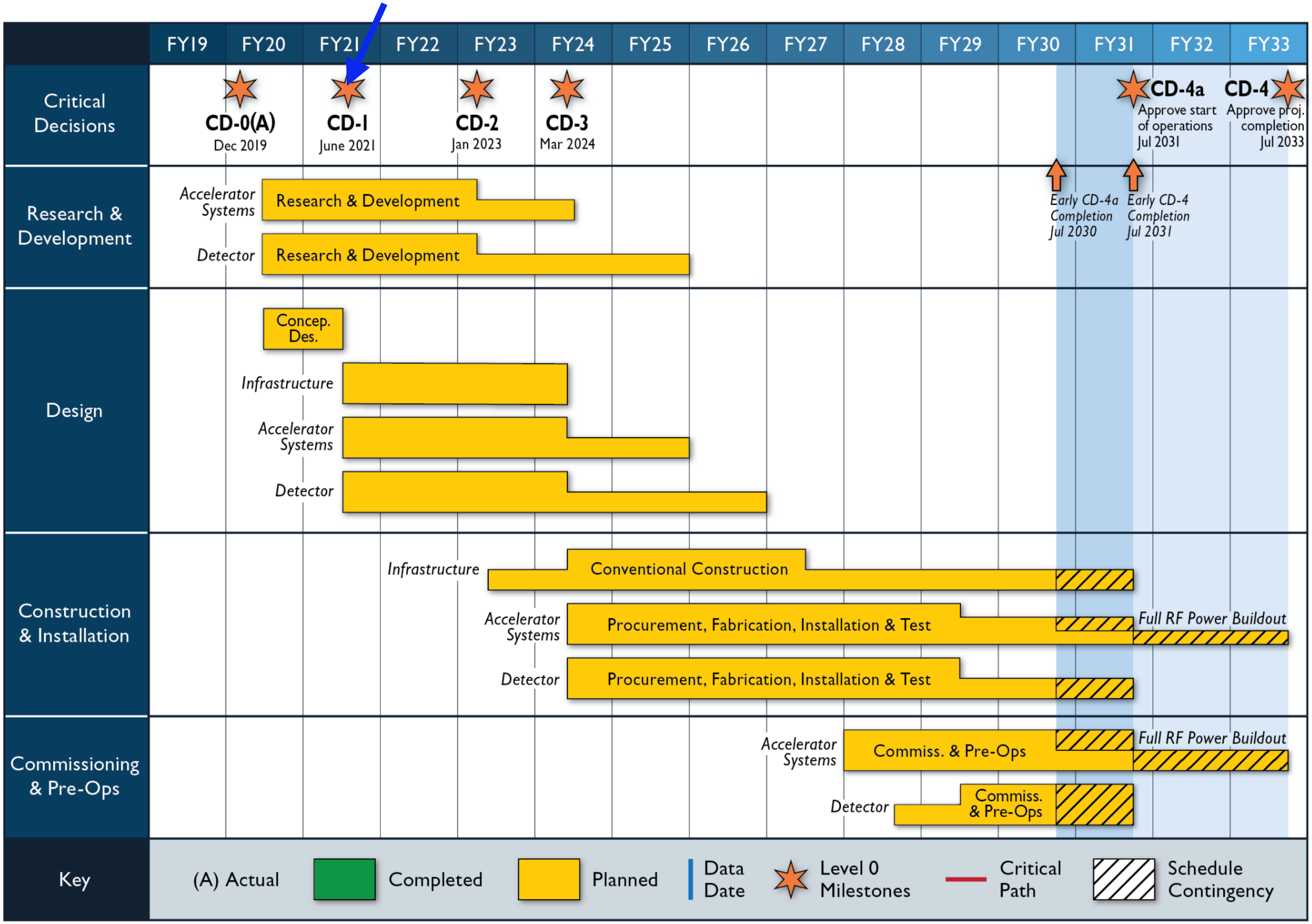
Critical Decision level 0: 'Mission Need'



As shown by T.J. Hallman (DoE) on August 2, 2021

EIC prelim. schedule (revision foreseen by April 30, 2022)

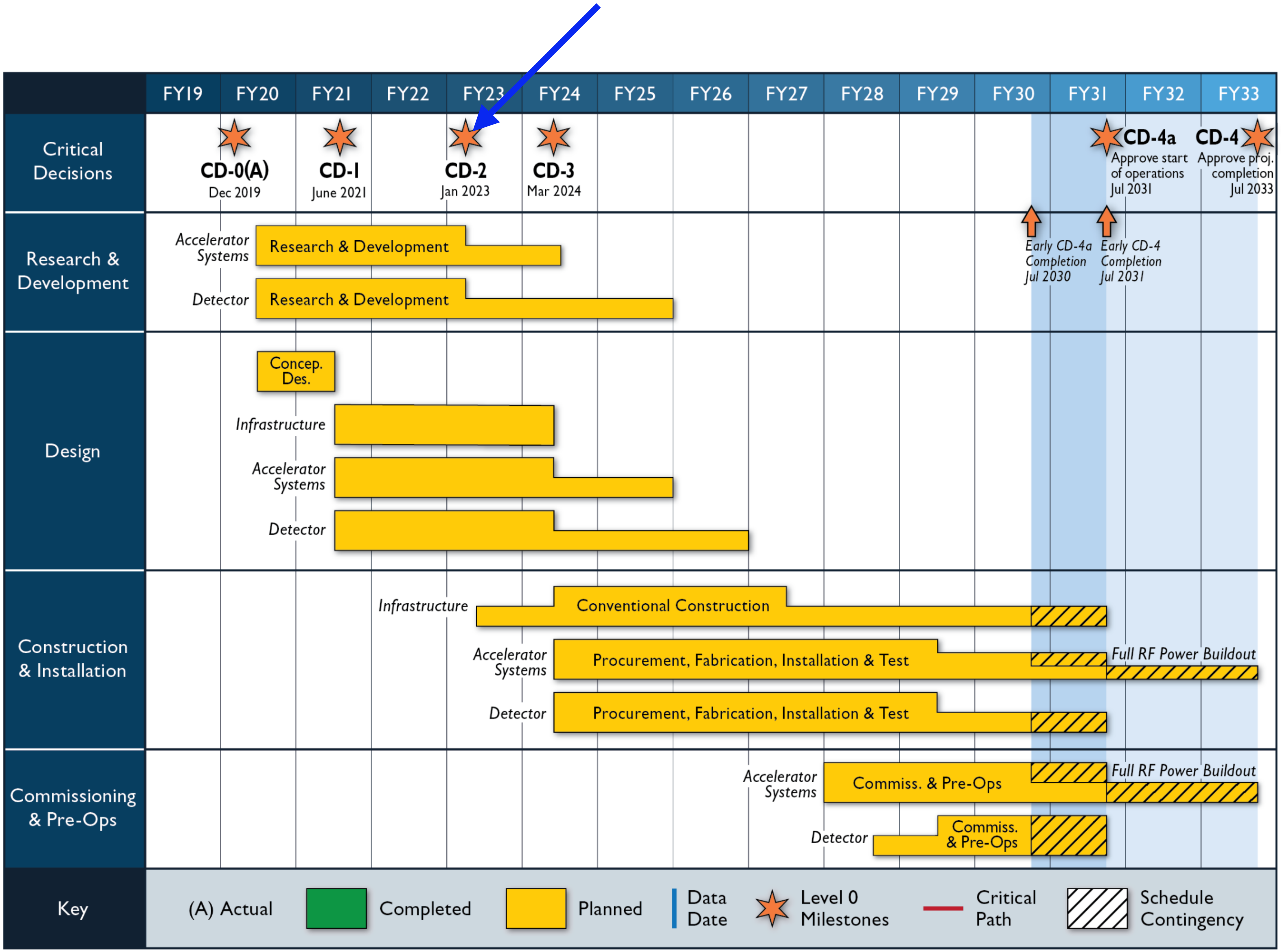
start of project execution phase



As shown by T.J. Hallman (DoE) on August 2, 2021

EIC prelim. schedule (revision foreseen by April 30, 2022)

approval of the preliminary design



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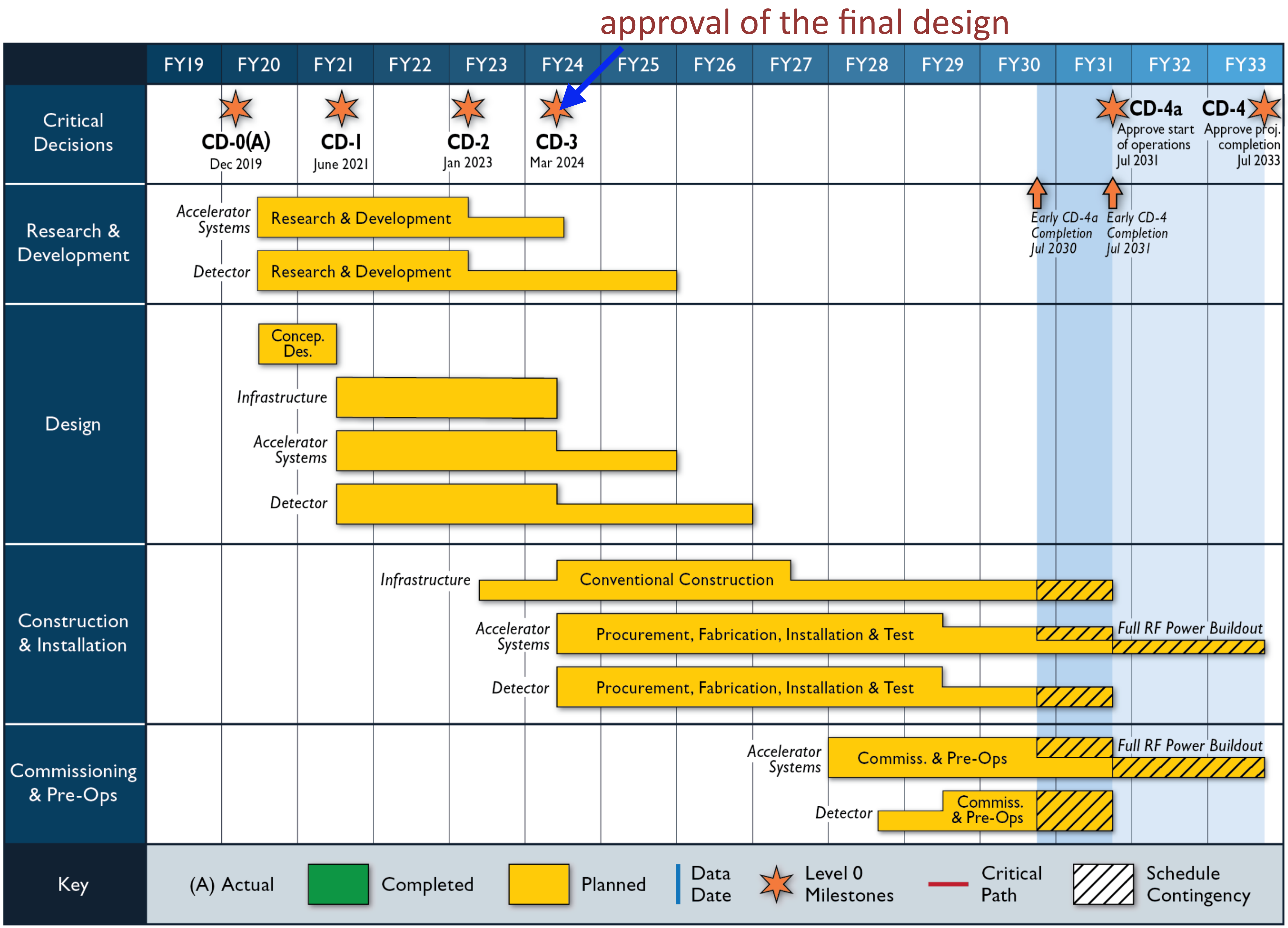

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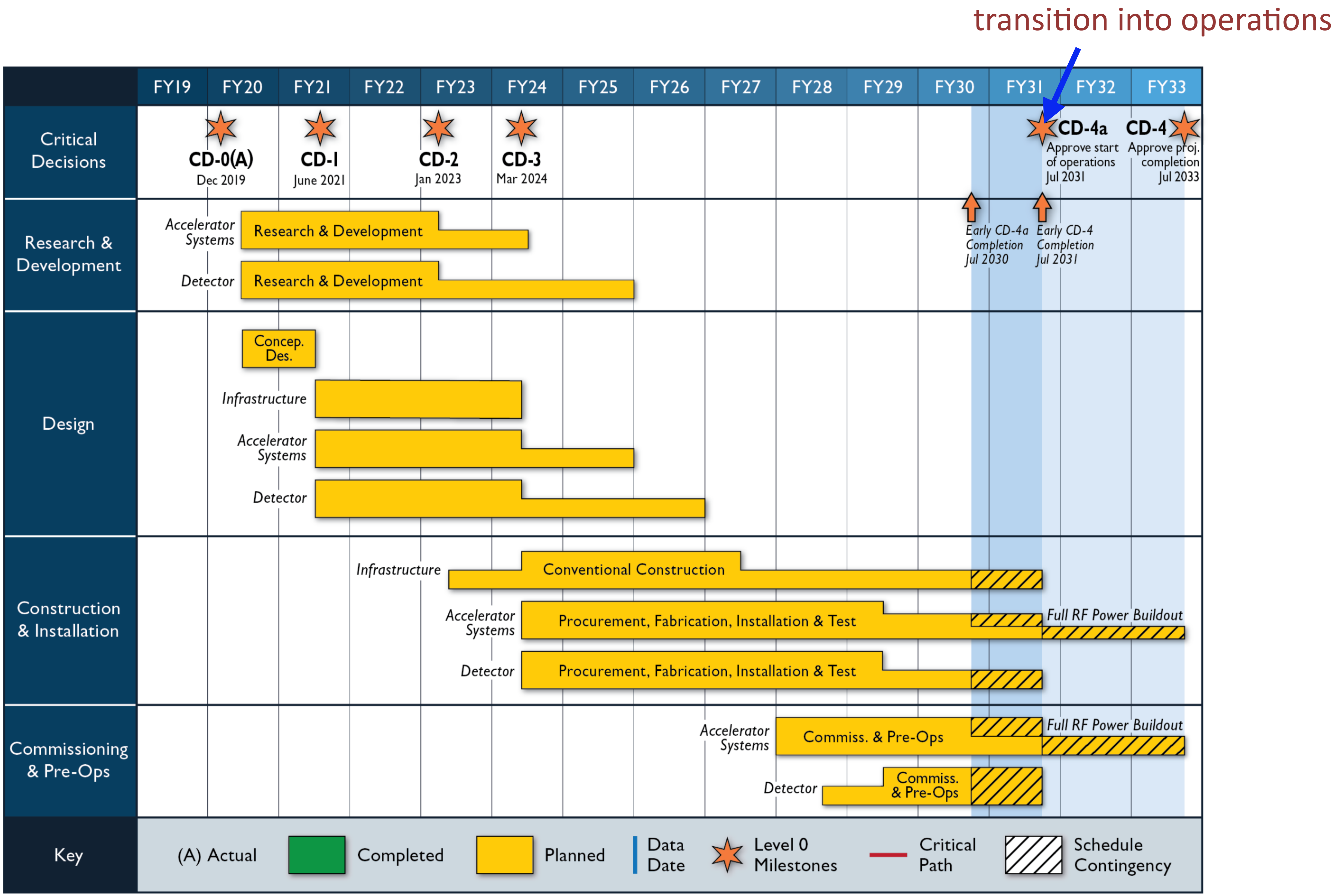

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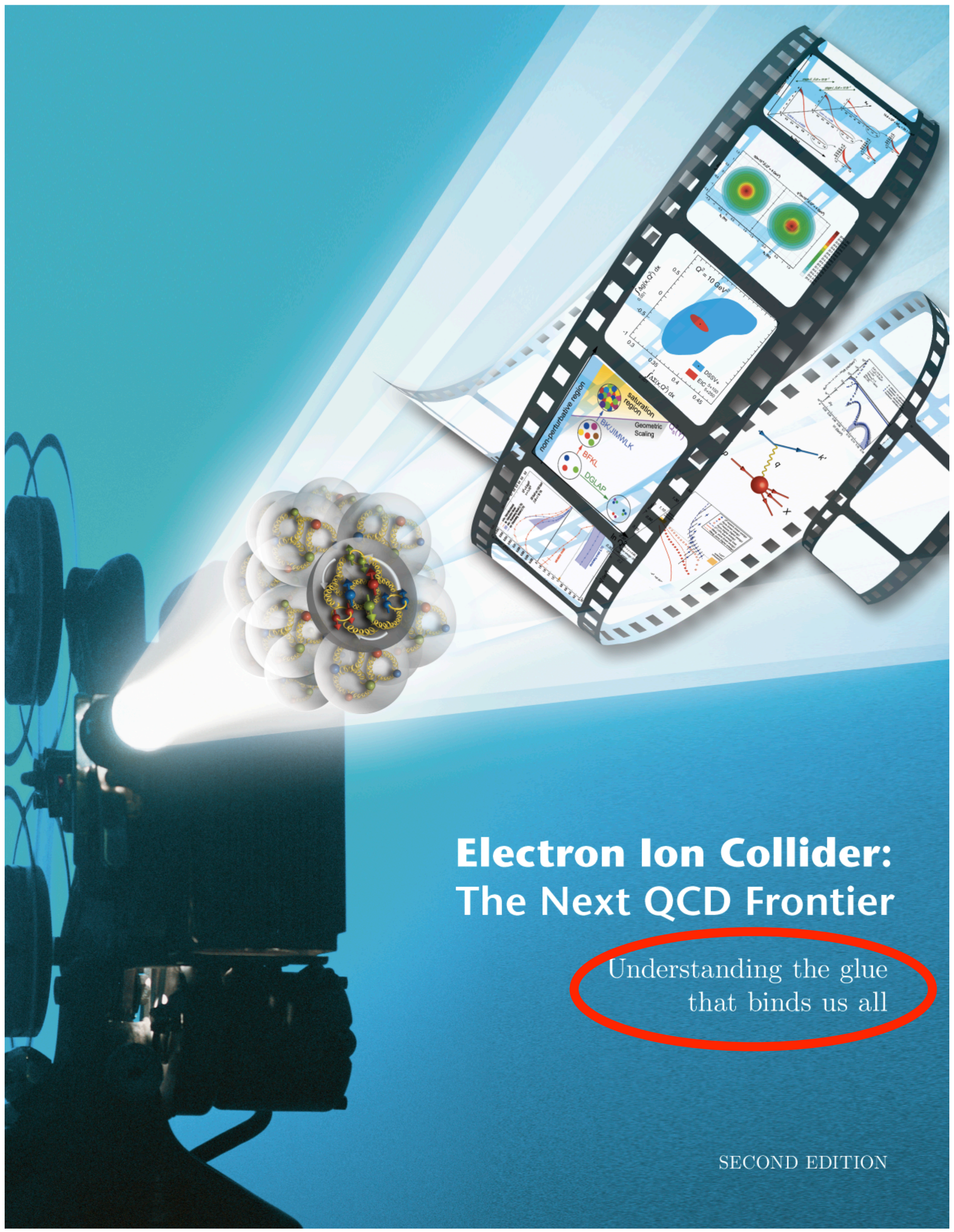
HL-LHC operation: 2027-2040

EIC will operate for about a decade concurrently with HL-LHC

White paper of the U.S.-based Electron-Ion Collider, 2016



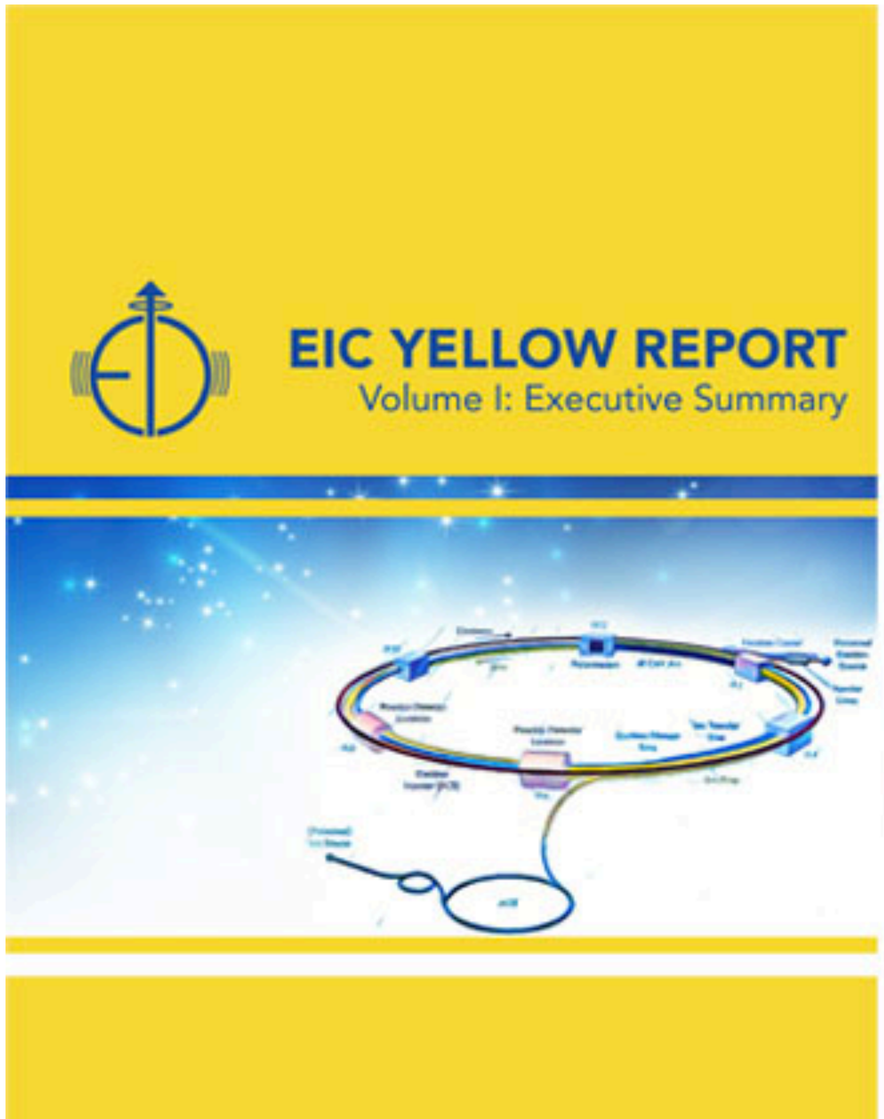
The Electron-Ion Collider (EIC) aims to address three key questions:

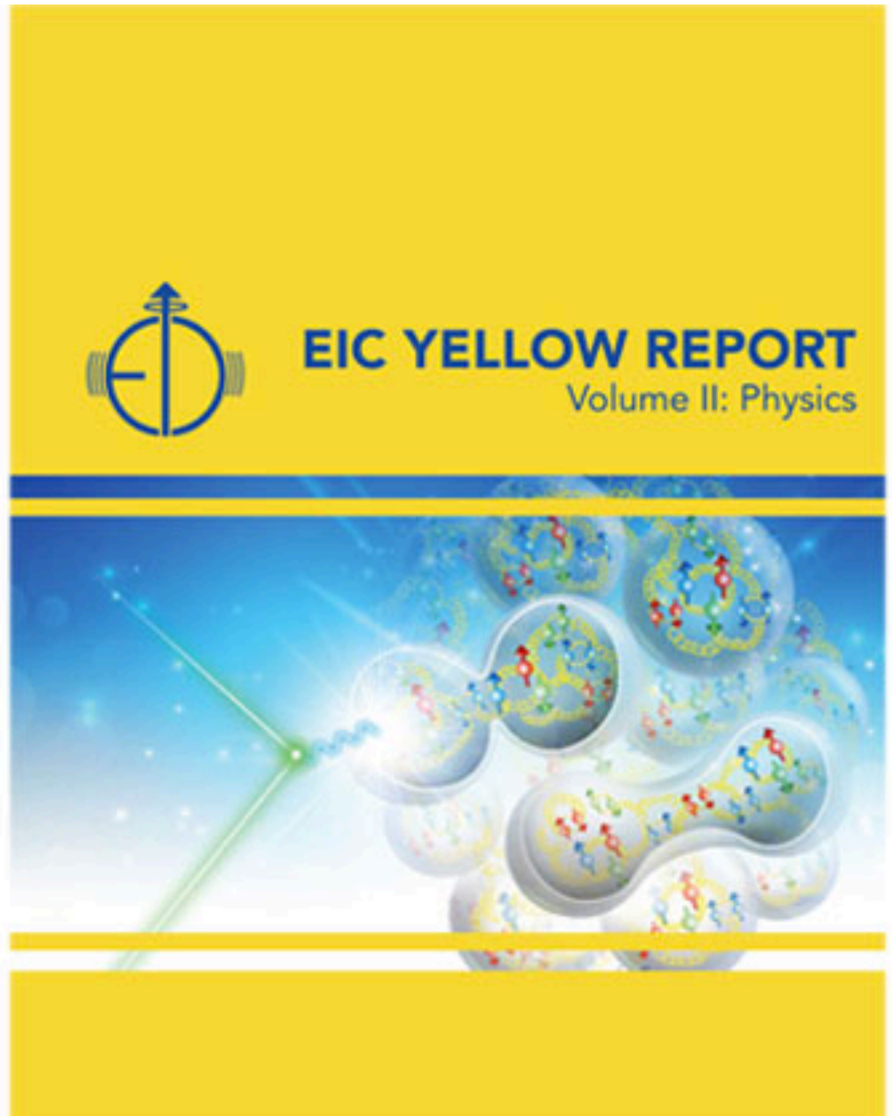
- How does the mass of the nucleon arise?
- How does the spin of the nucleon arise?
- What are the emergent properties of a dense system of gluons?

The EIC physics case is to a large extent aimed at understanding the physics of gluons

Physics based detector requirements described in great detail in Yellow Report

EIC Yellow Report 2021





900+ page document
arXiv:2103.05419

Following these detector requirements there was an open Call for Collaboration Proposals for Detectors

EIC detector requirements

- Unambiguous identification of the scattered electron and precise measurement of its angle and energy is essential, as it determines x & Q^2
- Semi-inclusive processes require excellent hadron identification over a wide momentum and rapidity range, from 200 MeV/c to 10 GeV/c in the barrel region and up to 50 GeV/c in the forward (hadron going) region, with full 2π acceptance for tracking and momentum analysis and excellent vertex resolution by a low-mass vertex detector
- Exclusive reactions require accurate particle tracking with high spatial and momentum resolution
- Complete hermeticity of the setup: very forward detectors (e.g. Roman pots), and large-acceptance zero-degree calorimetry to detect neutrons from breakup of nuclei
- Precise measurement of luminosity
- Highly accurate electron, proton, and light nucleus polarimetry

Detector Proposal Advisory Panel Report March 2022

DPAP report

- The final DPAP report was released on 21 March and can be downloaded from the DPAP Panel Meeting web site. Based on the DPAP recommendations, the EIC project has confirmed that the ECCE detector design will serve as the reference in developing a technical design for CD-2/3a.

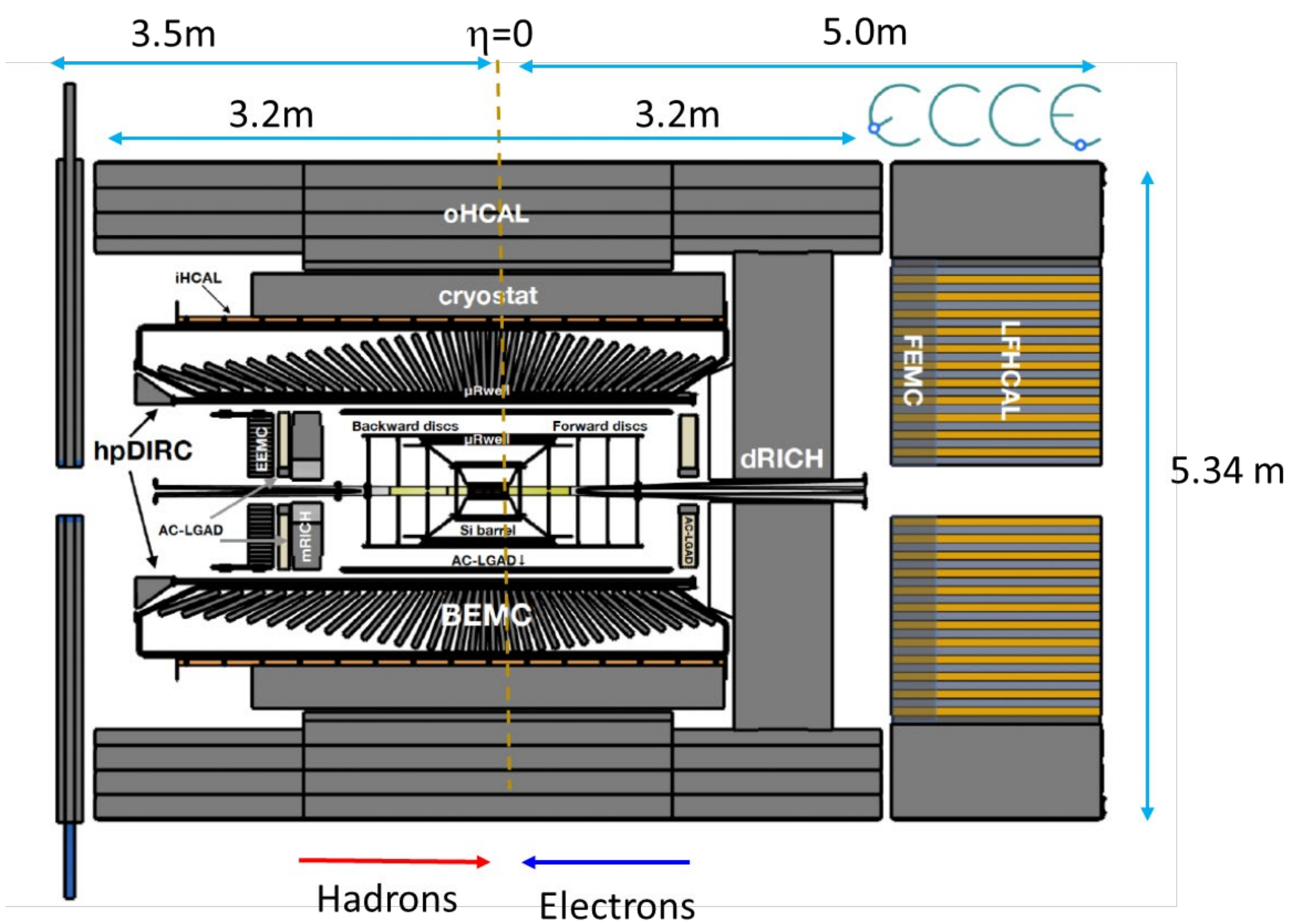
> *"The EIC Project recognizes that the panel recommended ECCE as the Project Detector. As described in the panel report, we will urge the proto-collaboration to: (1)* ***integrate new collaborators*** *in a manner that enables them to make contributions that impact the capabilities and success of the experiment in significant ways, including new collaborating individuals and groups into positions of responsibility and leadership; and (2)* ***integrate new experimental concepts*** *and technologies that improve physics capabilities without introducing inappropriate risk.* ***ECCE is the reference design for this optimization and consolidation so that the Project Detector can advance to CD2/3a in a timely way****"* – email communication from the EIC Project Team on 13 March 2022.

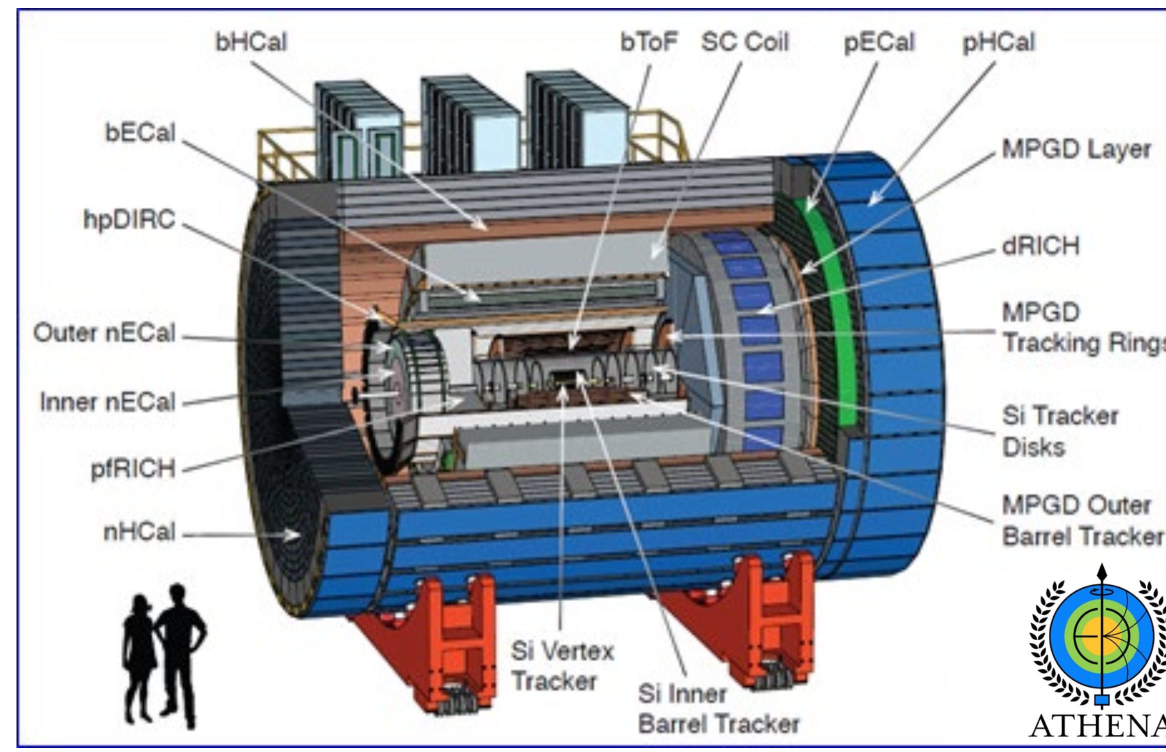
- From the DPAP report: "….none of the three proto-collaborations is yet large enough or strong enough for successful development of a detector for Day 1 of the EIC". → wise to combine efforts

Slide shown by Tanja Horn at EICUG quarterly meeting, March 31, 2022

Selected reference detector

The ECCE Detector Design



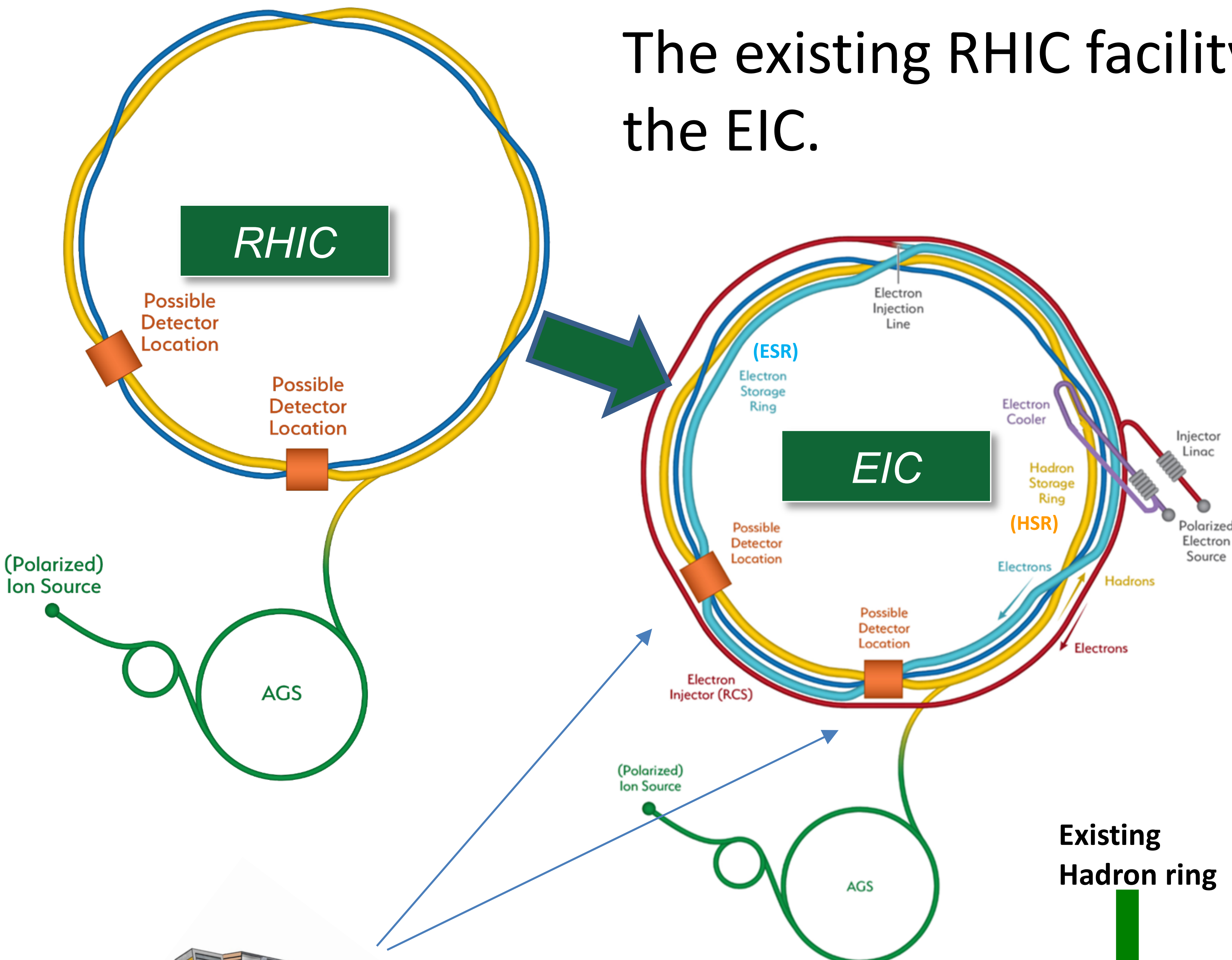


Also need to include:
+ Far-Forward/Far-Backward
+ DAQ/Electronics and Software

Now in the optimization/consolidation phase need to also compare with ATHENA detector solutions

Slide shown by Tanja Horn at EICUG quarterly meeting, March 31, 2022

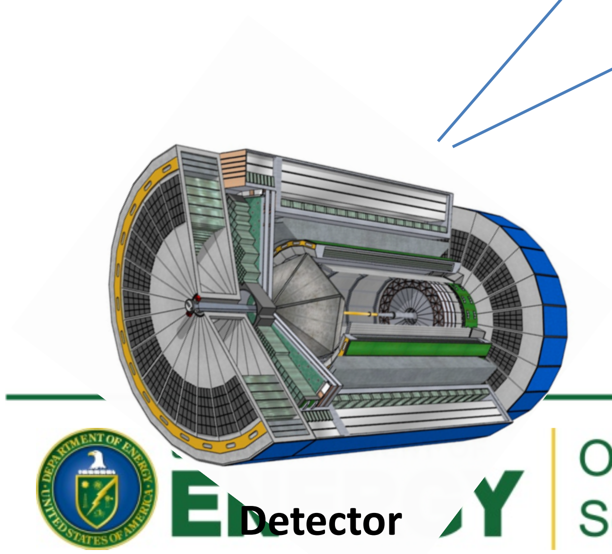
Preliminary Scope Overview



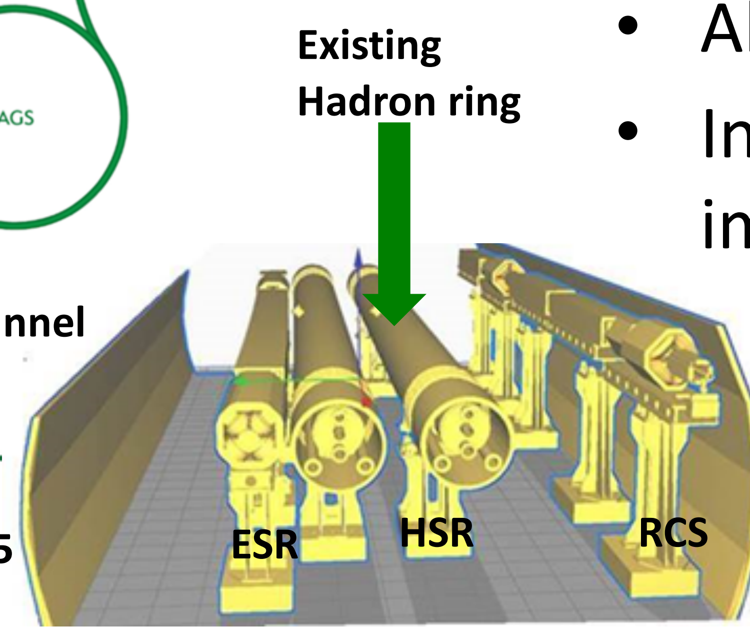
The existing RHIC facility will be modified into the EIC.

New systems include:

- Polarized electron source,
- Injector linac,
- Electron cooler complex,
- Rapid Cycling Synchrotron(RCS)
- Electron storage ring (ESR),
- Interaction region (IR) with 1 detector,
- Allowance for 2nd IR,
- Infrastructure improvements.



Section thru tunnel



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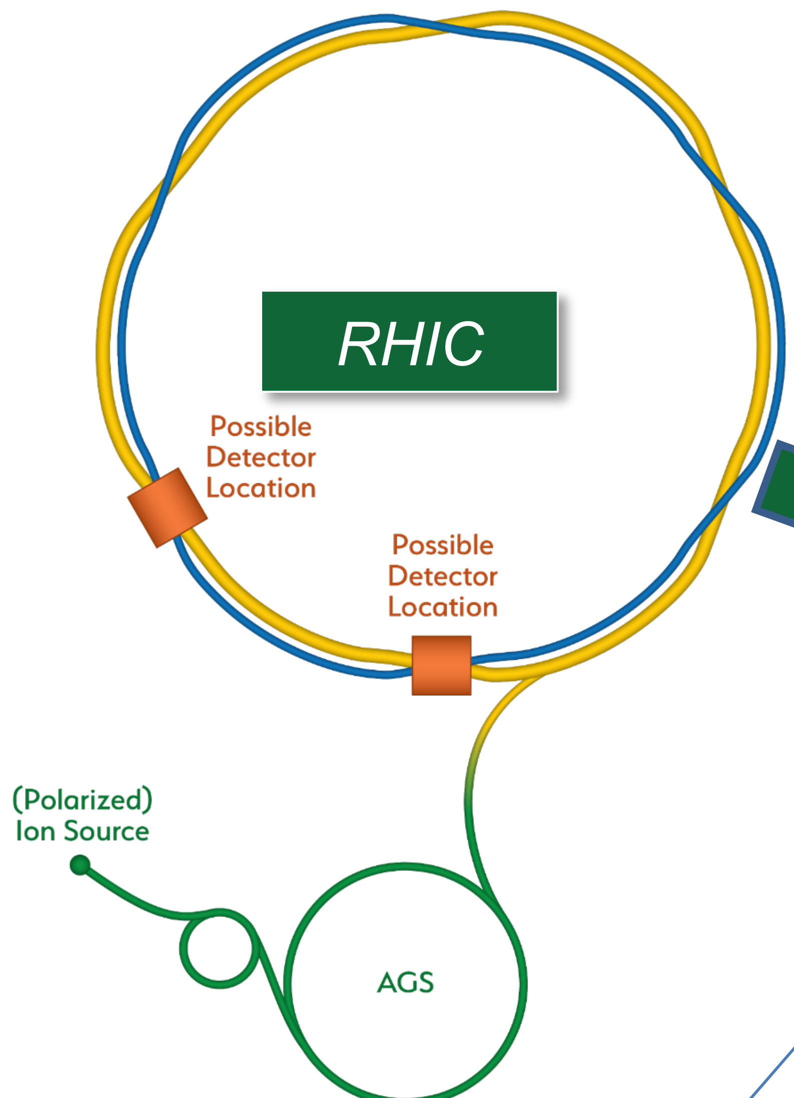

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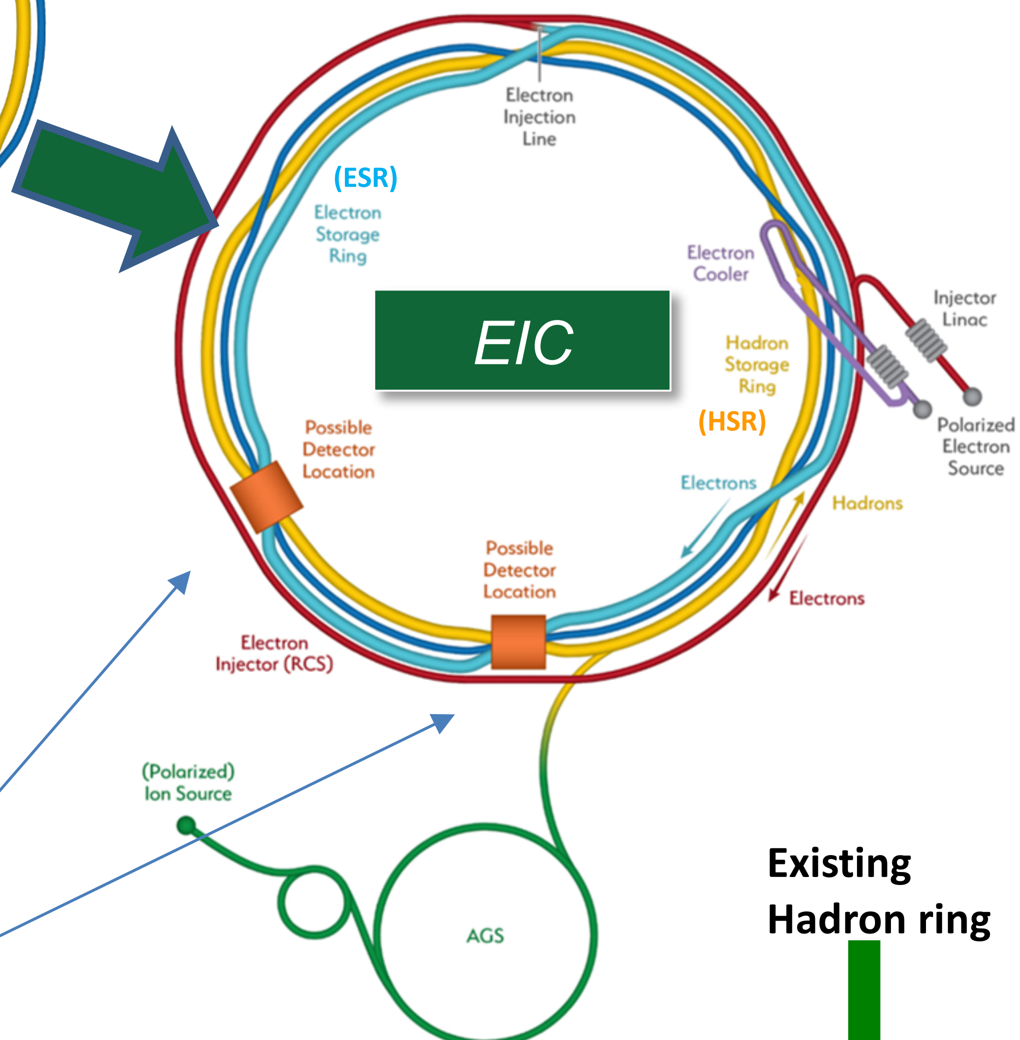

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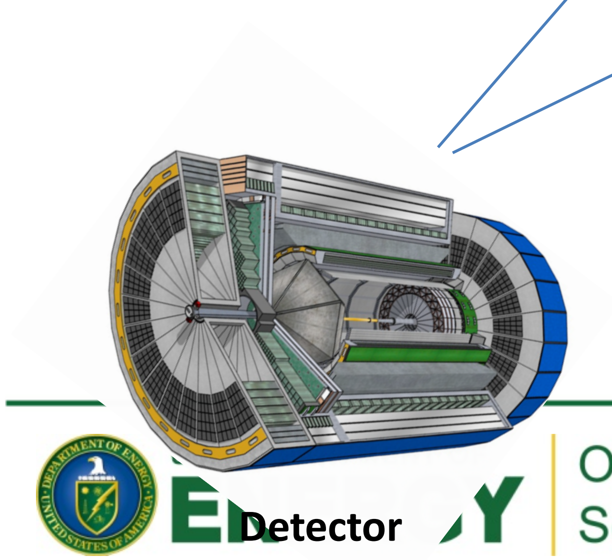

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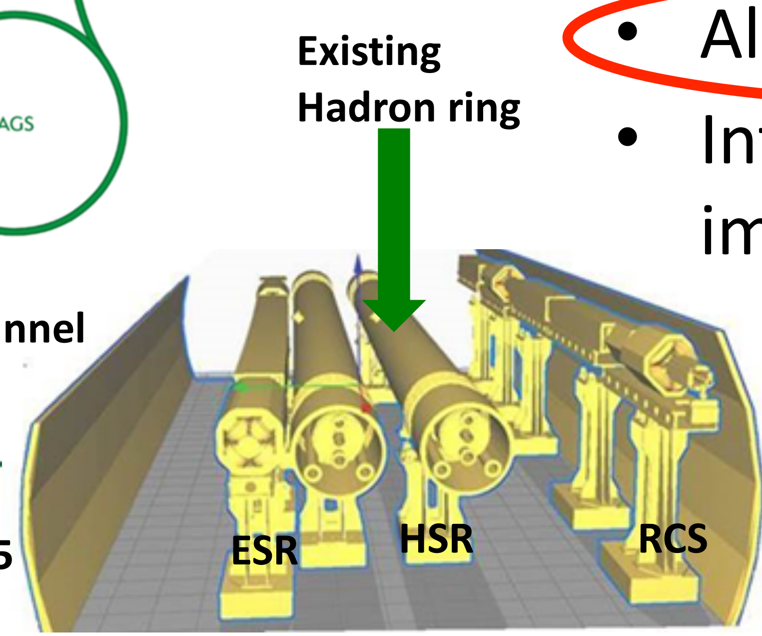


Detector Proposal Advisory Panel Report March 2022

"A pre-conceptual layout exists for IR8, with a larger crossing angle compared to IR6 and possibly using a 2nd, downstream focus, if feasible.

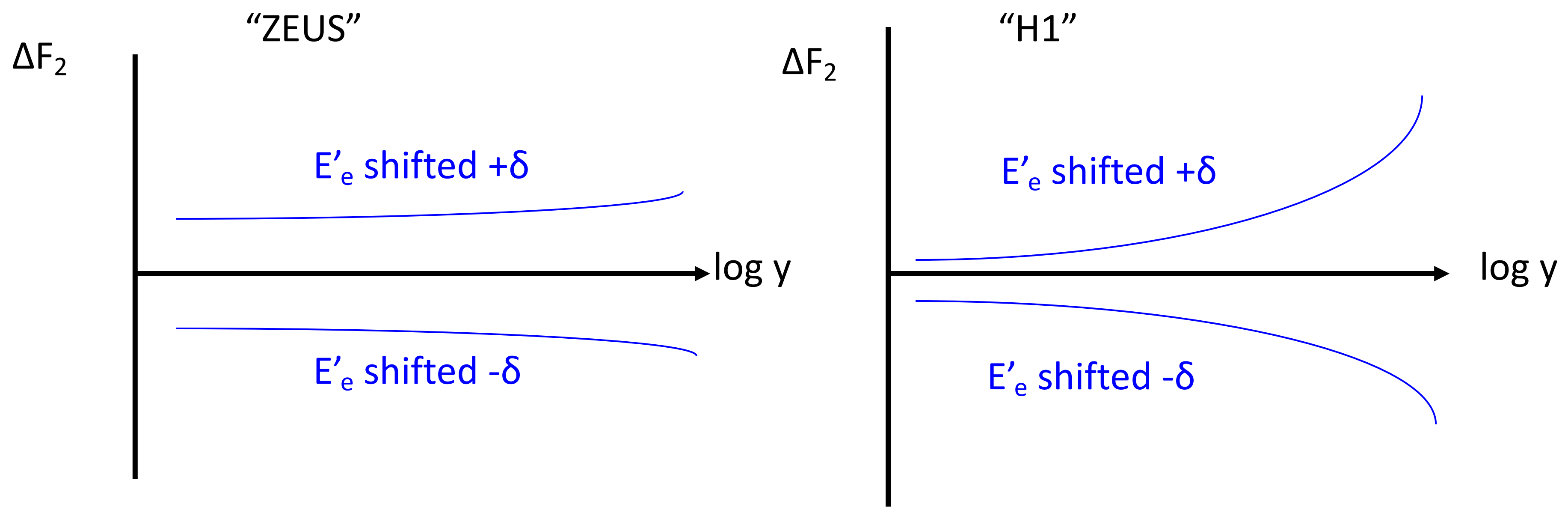
The 2nd focus option would expand the physics capability, thereby adding to the complementarity between the two detectors […]

Resources for Detector 2 are not included in the scope of the project, nor is the construction of the second interaction region (IR8). Detector 2 is supposed to be ready for data taking several years after the start of data taking in IR6. It could be a complementary detector e.g. by using different technologies, by optimization for particular science topics or by addressing science topics beyond those described in the White Paper.

Such a second detector could be envisioned to be realized up to 3-5 years after Detector 1."

Advantages of complementarity of H1 and ZEUS

What happens to systematic uncertainties.



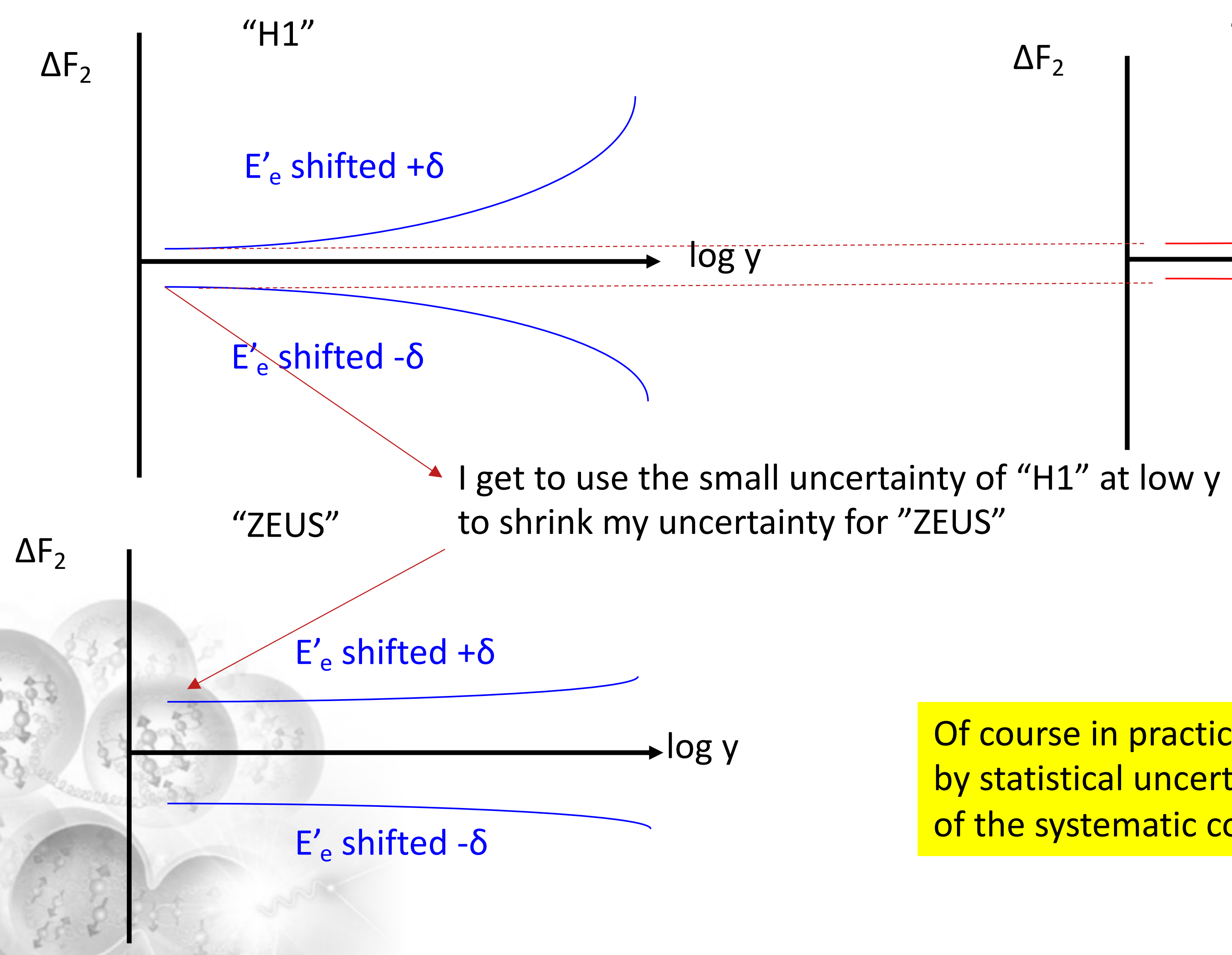
- ZEUS and H1 have similarly sized uncertainties.
- ZEUS and H1 have differently "shaped" uncertainty correlations—different detector and different reconstruction of kinematic quantities.
- ZEUS and H1 have different best measured regions.

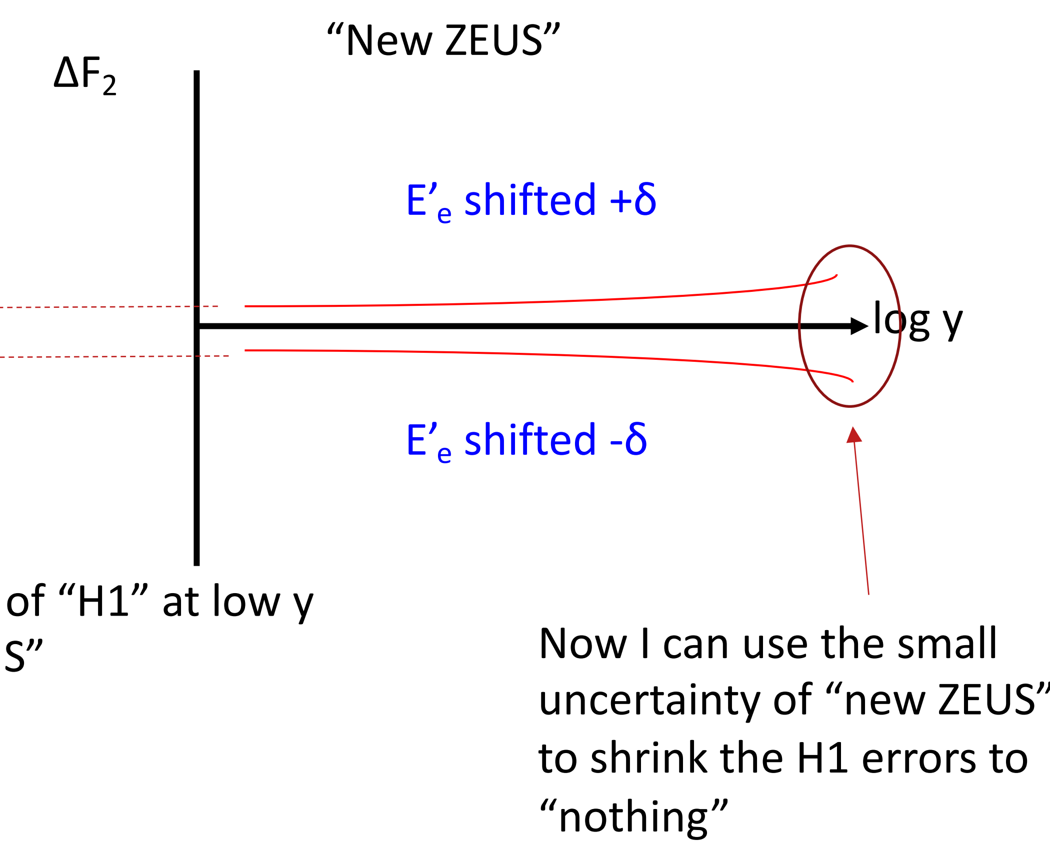
➔ You win big from the fit

By R. Yoshida, EIGUG meeting Paris, 2019

Advantages of complementarity of H1 and ZEUS

Consider the case if there is no statistical uncertainty





Of course in practice, the improvement is limited by statistical uncertainties, and our imperfect knowledge of the systematic correlations.

By R. Yoshida, EIGUG meeting Paris, 2019

Detectors & EU involvement

DoE supports the machine construction and one "project detector"
CD-0 approved with a cost range of $1.6B-$2.6B

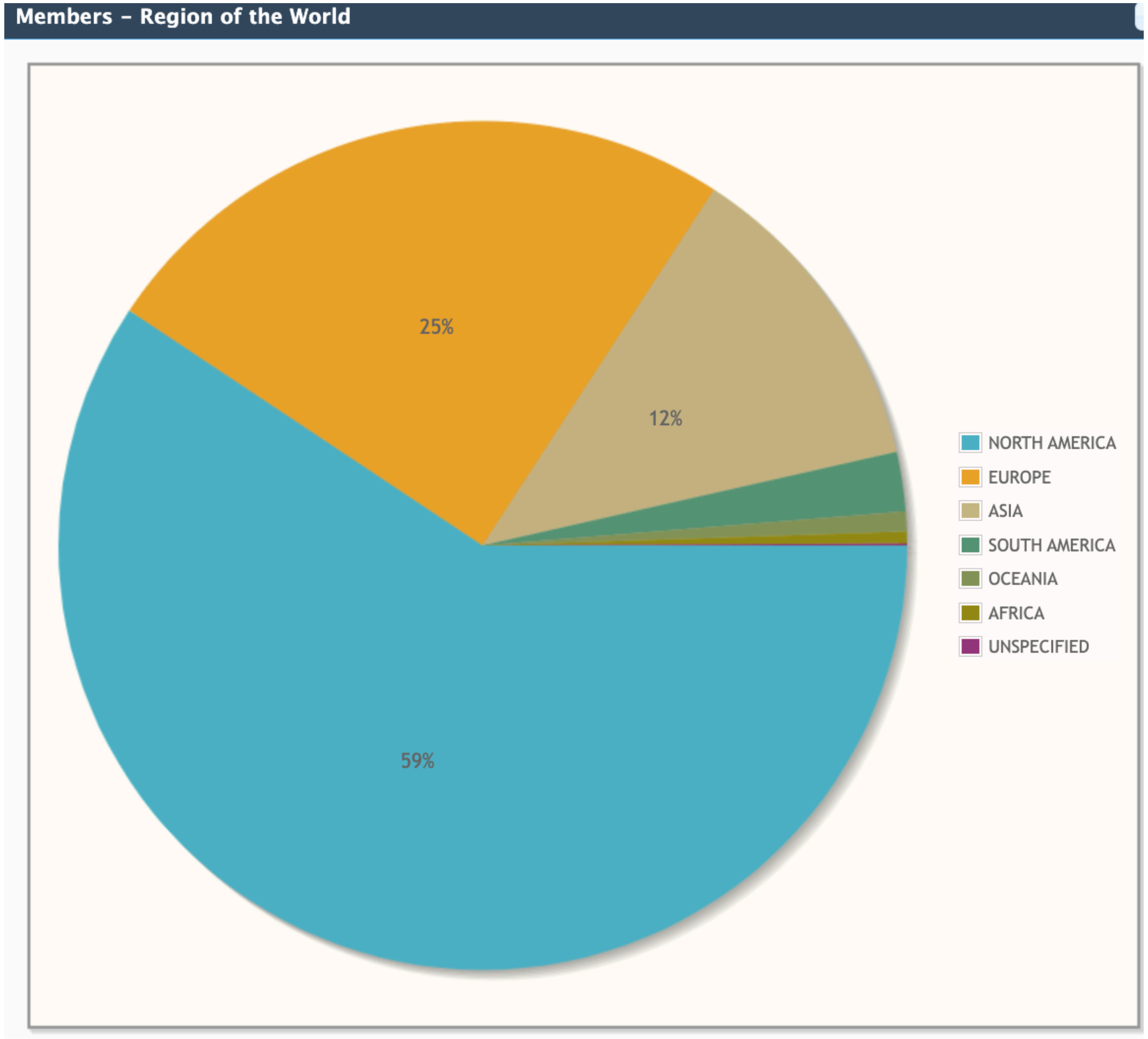
The EIC community wishes to have two complementary detectors (2nd "off-project detector")
HERA case (H1 & ZEUS) shows complementarity goes well beyond statistical improvements

International participation in **both** detectors/experiments is highly desired
Ideally by means of agreements between DoE and national funding agencies (requires approval on government level)

Many agreements with DoE already exist

Country Institution Funding Agency	Gov. to Gov. Agency to Agency Implementing Agreement
CERN	✓
France - IN2P3	✓
France – CEA	✓
Italy	✓
United Kingdom	✓
Czech Republic	✓
Germany	✓
Poland	➢X

European involvement in EIC



EICUG currently has 1327 members, ~25% from Europe, about 30% theorists
EU representative in Steering Committee, as of August 2021: Daria Sokhan (Glasgow)

EICUG input to ESPPU

December 18, 2018

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

Contact Persons: Daniël Boer[1], Marco Radici[2]

On behalf of the Electron-Ion Collider (EIC) User Group[3]

The EIC physics case has many goals in common with part of the (HL-)LHC program

Abstract

This document is submitted as input to the European Strategy for Particle Physics Update (ESPPU). The U.S.-based Electron-Ion Collider (EIC) project recently received strong endorsement by the U.S. National Academies of Sciences, Engineering, and Medicine, bringing its realization another step closer. A large group of European scientists is already involved in the EIC project. Currently, more than a quarter of the EIC User Group (consisting of over 800 scientists) is based in Europe. This European involvement is not only an important driver of the EIC, but can also be beneficial for 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, as well as the shared interest regarding detector R&D. The aim is to highlight how the synergies between the European Particle Physics research and the EIC project offer ample opportunities to foster progress at the forefront of collider physics.

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Marco Radici is Vice-Chair of the Steering Committee, as of August 2021

EIC in EU country input to ESPPU

Countries that included EIC activities in their input to the ESPPU: France, Italy, UK, Czech Rep.
Germany puts it as the "second highest priority of the European hadron physics community" after FAIR

Initial contribution of the INFN Hadron Physics Community to the ESPPU 2018–2020

DE LA RECHERCHE À L'INDUSTRIE
cea

CEA-Irfu contribution to the 2020 update of the European Strategy for Particle Physics

UK input to the European Strategy for Particle Physics Update

Inputs to European Strategy Update 2018-2020 by the Czech particle physics community

NuPECC input to ESPPU

Nuclear physics and the European Particle Physics Strategy Update 2018

NuPECC Working Group
A. Bracco, J.J. Gaardhøje, M. Guidal, B. Sharkov, H. Ströher, J. Wambach, E. Widmann*

December 18, 2018

Abstract

This document provides input to the update of the European Strategy for Particle Physics in fields that are related to Nuclear Physics as described in the NuPECC Long Range Plan 2017.

EIC The Electron-Ion Collider (EIC) currently considered in the US (JLab or BNL) is a very attractive facility with a large European community. EIC aims at colliding, for the first time, spin-polarized beams of electrons and light ions, with center-of-mass energies in the range of 20 to 140 GeV and a luminosity of 10^{34} cm^{-2} s^{-1}. The scientific motivation is to study issues at the intersection of nuclear and particle physics such as the origin of the saturation of gluon densities, the evolution of partonic structure functions between free nucleons and nucleons within a nucleus, the propagation of colour charges through nuclear matter and hadronisation, the quark-gluon origin of the nuclear force, etc. From physics issues to detector techniques and R&D, there are many common and mutual interests in the EIC related to the particle and nuclear physics communities, which shall motivate strong collaboration, cooperation and involvements of both fields.

ESPPU about NuPECC

“CERN should continue to coordinate with NuPECC on topics of mutual interest”

This prompted installation of the NuPECC EIC Task Force and contacts between EICUG (via EU representative) and NuPECC

Synergies with neighbouring fields

A variety of research lines at the boundary between particle and nuclear physics require dedicated experiments and facilities. Europe has a vibrant nuclear physics programme at CERN, including the heavy-ion programme, and at other European facilities. In the global context, a new electron-ion collider, EIC, is foreseen in the United States to study the partonic structure of the proton and nuclei, in which there is interest among European researchers. ***Europe should maintain its capability to perform innovative experiments at the boundary between particle and nuclear physics, and CERN should continue to coordinate with NuPECC on topics of mutual interest.***

NuPECC EIC Task Force & JENAA EoI

NuPECC EIC Task Force: Dave Ireland, Eugenio Nappi & Franck Sabatié

We decided to start a Joint ECFA-NuPECC-APPEC Activity

Requires an Expression of Interest that we (an initial group of proponents) prepared mid-2021 for the ENA chairs, which was later on approved

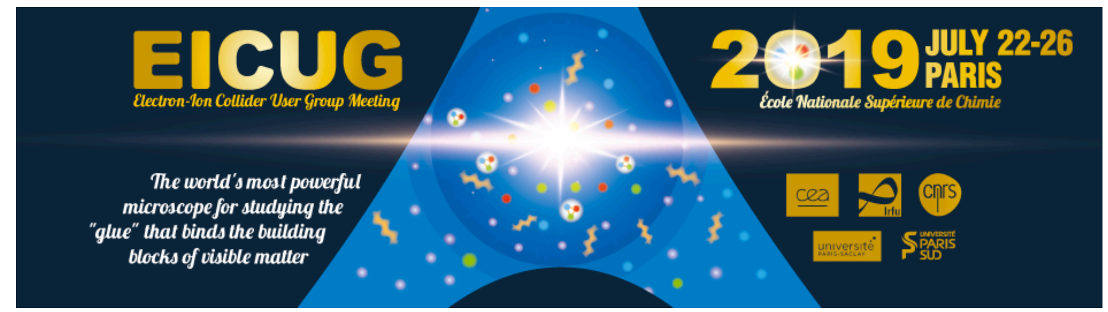
JENAA EXPRESSION OF INTEREST (EOI)

"Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments"

Objectives:
To stimulate and strengthen collaboration among the European nuclear, particle and astroparticle physics communities, to mutually benefit from the many synergies between experiments at the planned U.S.-based Electron-Ion Collider (EIC) and the Large Hadron Collider (LHC) at CERN.

Existing activities in Europe covering both EIC & LHC

- The annual EICUG meeting (alternatingly held in Europe)



- The annual DIS conference, the REF (Resummation, Evolution, Factorization) and POETIC (Physics Opportunities at an ElecTron-Ion-Collider) workshops
- LHC community meetings, such as in the PDF4LHC, LHC ElectroWeak, and LHC forward physics working groups
- Relativistic heavy-ion collision community meetings (e.g. Initial Stages, Hard Probes, Quark Matter)
- STRONG2020 - many workpackages include EIC and LHC in their scope

Snowmass 2021

Snowmass 2021 White Paper:
Electron Ion Collider for High Energy Physics

R. Abdul Khalek,[1] U. D'Alesio,[2,3] Miguel Arratia,[4,5,*] A. Bacchetta,[6] M. Battaglieri,[7,1] M. Begel,[8] M. Boglione,[9] R. Boughezal,[10] Renaud Boussarie,[11,*] G. Bozzi,[12,3] S. V. Chekanov,[10] F. G. Celiberto,[13,14,15] G. Chirilli,[16] T. Cridge,[17] R. Cruz-Torres,[18] R. Corliss,[19,20] C. Cotton,[21] H. Davoudiasl,[8] A. Deshpande,[8,19] Xin Dong,[18,*] A. Emmert,[21] S. Fazio,[8] S. Forte,[22] Yulia Furletova,[1,*] Ciprian Gal,[23,20,*] Claire Gwenlan,[24,*] V. Guzey,[25] L. A. Harland-Lang,[26] I. Helenius,[27,28] M. Hentschinski,[29] Timothy J. Hobbs,[30,31,*] S. Höche,[32] T.-J. Hou,[33] Y. Ji,[18] X. Jing,[34] M. Kelsey,[35,18] M. Klasen,[36] Zhong-Bo Kang,[37,38,20,*] Y. V. Kovchegov,[39] K.S. Kumar,[40] Tuomas Lappi,[27,28,*] K. Lee,[41,42] Yen-Jie Lee,[43,44,*] H.-T. Li,[45,46,47] X. Li,[48] H.-W. Lin,[49] H. Liu,[40] Z. L. Liu,[50] S. Liuti,[21] C. Lorcé,[51] E. Lunghi,[52] R. Marcarelli,[53] S. Magill,[54] Y. Makris,[55] S. Mantry,[56] W. Melnitchouk,[1] C. Mezrag,[57] S. Moch,[58] H. Moutarde,[57] Swagato Mukherjee,[8,†] F. Murgia,[3] B. Nachman,[59,60] P. M. Nadolsky,[61] J.D. Nam,[62] D. Neill,[63] E.T. Neill,[53] E. Nocera,[64] M. Nycz,[21] F. Olness,[61] F. Petriello,[46,47] D. Pitonyak,[65] S. Plätzer,[66] Stefan Prestel,[67,*] Alexei Prokudin,[68,1,*] J. Qiu,[1] M. Radici,[6] S. Radhakrishnan,[69,18] A. Sadofyev,[70] J. Rojo,[71,72] F. Ringer,[73,19] Farid Salazar,[37,38,74,75,*] N. Sato,[1] Björn Schenke,[8,*] Sören Schlichting,[76,*] P. Schweitzer,[77] S. J. Sekula,[78,*] D. Y. Shao,[79] N. Sherrill,[80] E. Sichtermann,[18] A. Signori,[6] K. Şimşek,[81] A. Simonelli,[9] P. Sznajder,[82] K. Tezgin,[83] R. S. Thorne,[17] A. Tricoli,[8] R. Venugopalan,[8] A. Vladimirov,[84] Alessandro Vicini,[22,*] Ivan Vitev,[85,*] D. Wiegand,[86] C.-P. Wong,[48] K. Xie,[87] M. Zaccheddu,[2,3] Y. Zhao,[88] J. Zhang,[89] X. Zheng,[21] and P. Zurita[84]

24 Mar 2022

ABSTRACT

Electron Ion Collider (EIC) is a particle accelerator facility planned for construction at Brookhaven National Laboratory on Long Island, New York by the United States Department of Energy. EIC will provide capabilities of colliding beams of polarized electrons with polarized beams of proton and light ions. EIC will be one of the largest and most sophisticated new accelerator facilities worldwide, and the only new large-scale accelerator facility planned for construction in the United States in the next few decades. The versatility, resolving power and intensity of EIC will present many new opportunities to address some of the crucial and fundamental open scientific questions in particle physics. This document provides an overview of the science case of EIC from the perspective of the high energy physics community.

Snowmass 2021

Snowmass 2021 White Paper:
Electron Ion Collider for High Energy Physics

This document has sections on:

- Beyond Standard Model Physics at EIC
- Tomography of Hadrons and Nuclei at the EIC
- Jets at EIC
- Heavy Flavors at EIC
- Small-x physics at the Electron-Ion Collider

This Snowmass exercise involved many Europeans

JENAA

Despite these existing activities by various parts of the community, we believe there is interest to have more structured community wide activities that are more specifically focused on the potential synergies

That is what the JENAA EoI aims to achieve with activities like:

- Workshops on the topics of the EoI and other community building activities
- Initiate articles directed to the communities represented by ECFA, NuPECC and APPEC that report and showcase results and activities that are of mutual interest
- Initiate ERC Synergy grant applications between the interested European parties

EoI website

https://indico.ph.tum.de/event/7004/

JENAA Expression of Interest: "Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments"

Jun 20 – 21, 2022
CERN
Europe/Berlin timezone

Enter your search term

Overview

Endorse this Expression of Interest

List of Endorsers

108 participants

You are all welcome to check out the EoI and endorse it

Contact persons: Daniël Boer & Franck Sabatié

Kick-off meeting at CERN, June 20 & 21, 2022

Kick-Off Meeting - Synergies between the Electron-Ion Collider and the Large Hadron Collider

Jun 20 – 21, 2022
CERN
Europe/Berlin timezone

https://indico.ph.tum.de/event/7014/

Enter your search term

Overview
Registration

Participant List
51 participants

STRONG 2020

We (together with David D'Enterria) are still working on the program

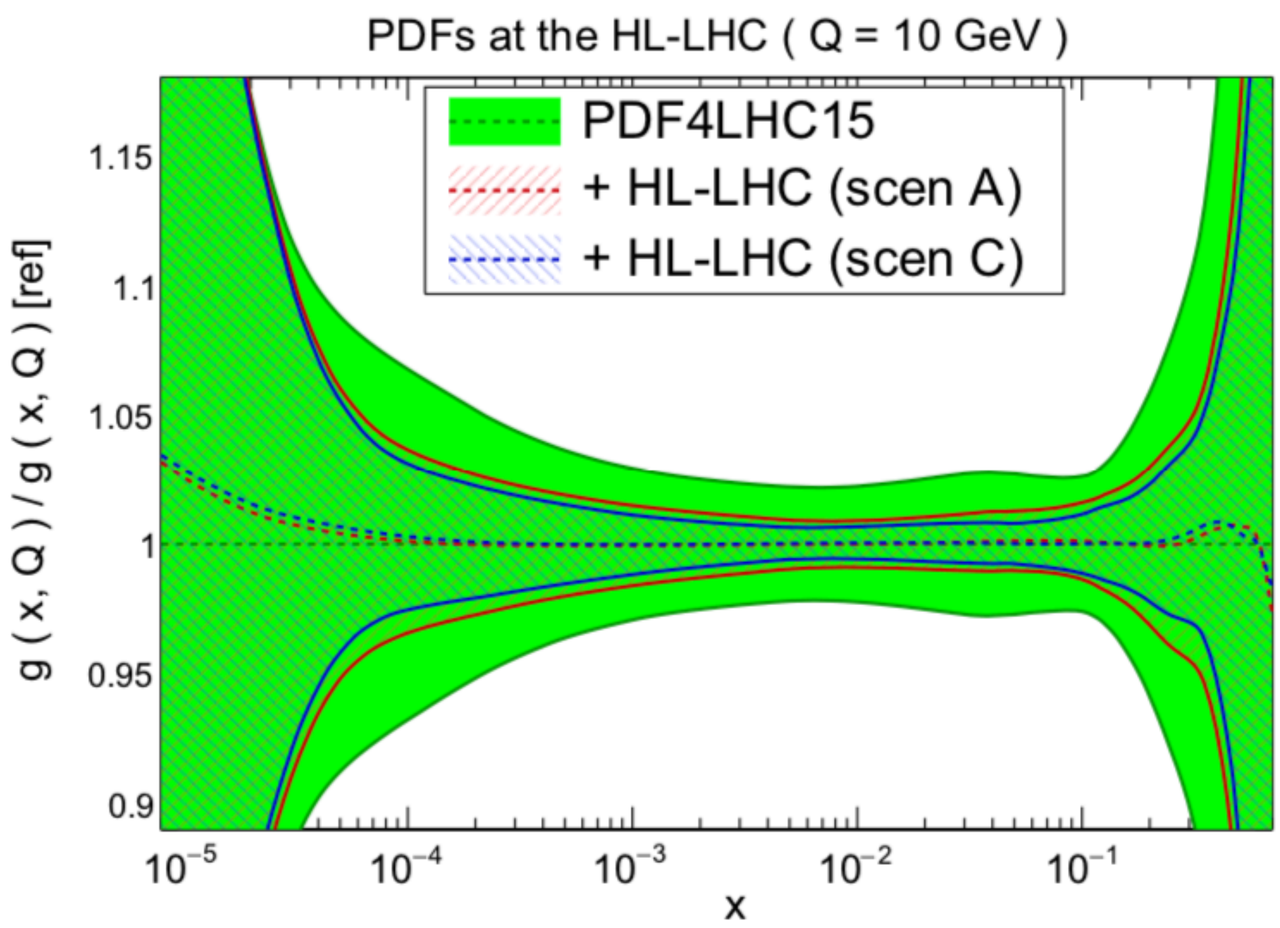
Confirmed speakers: Alessandro Bacchetta, Silvia Dalla Torre, Abhay Deshpande, Stefano Forte, Maria Vittoria Garzelli, Cynthia Hadjidakis, Lucian Harland-Lang, Jamal Jalilian-Marian, Jean-Philippe Lansberg, Magnus Mager, Heikki Mäntysaari, Juan Rojo, Ignazio Scimemi

Synergies - topics of mutual interest

- The flavor and spin structure of the proton: PDFs
- Three-dimensional structure of nucleons and nuclei in momentum and configuration space (TMDs, GPDs, GTMDs) and their evolution
- QCD in nuclei: nuclear PDFs and gluon saturation phenomena
- Heavy Ion Collisions: Quark-Gluon Plasma studies & Ultra-Peripheral Collisions
- Diffractive processes and distributions
- Jet physics, Jet substructure
- Heavy flavor physics, quarkonia, exotic states
- Electroweak physics and beyond the Standard Model physics
- EFT studies, SMEFT
- Neutrino cross-sections at low and high-energy
- High energy cosmic rays and Dark Matter
- Detector R&D
- Computational physics, Monte Carlo simulations, machine learning techniques

Prime example of synergy: parton densities

g



Khalek, Bailey, Gao, Harland-Lang, Rojo, EPJC 78 (2018) 962

HL-LHC expected to reach % level accuracy of proton and Pb PDFs down to $x\sim10^{-4}$

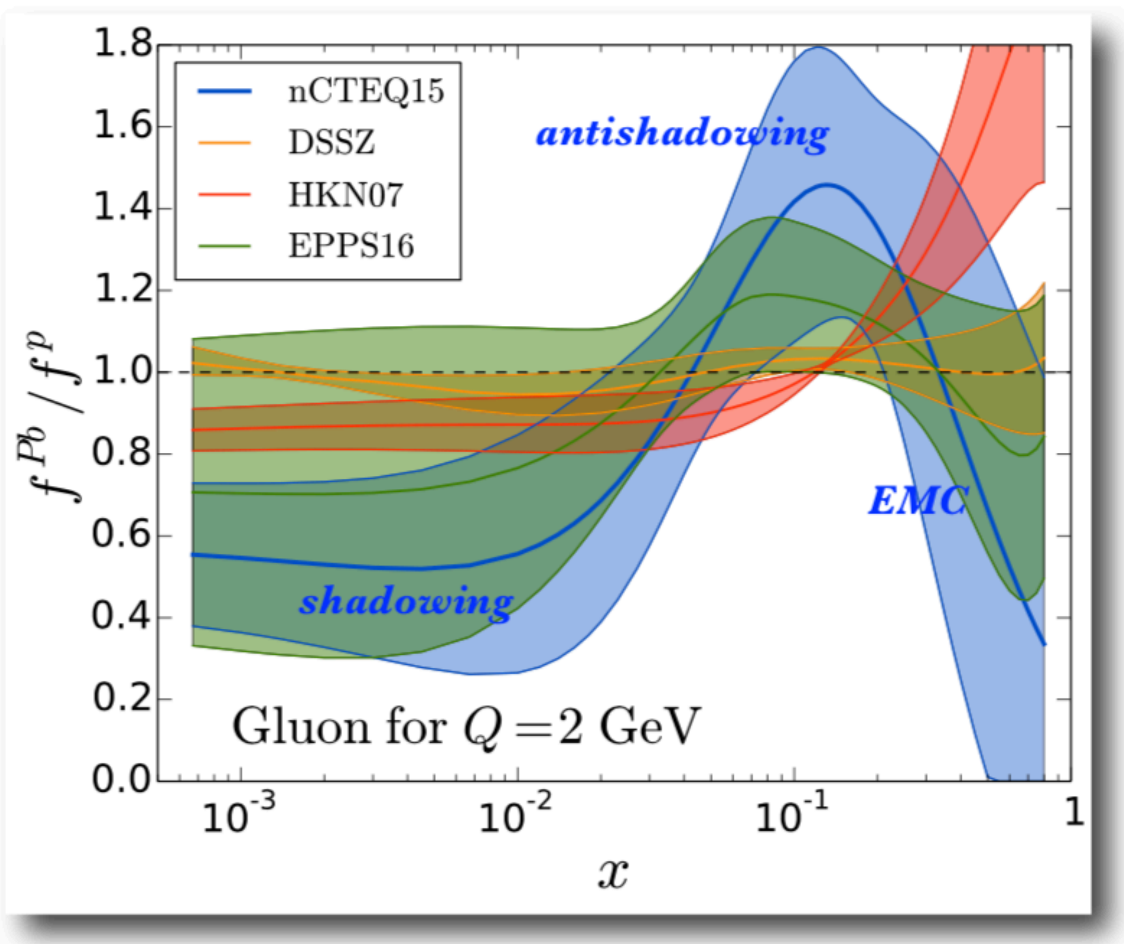
EIC will cover a similar region and can study PDFs for many other nuclei

At small x signals from (the onset of) parton saturation are expected, due to nonlinear QCD effects, here ep/eA provides the baseline for pp, pA and AA

Nuclear PDFs

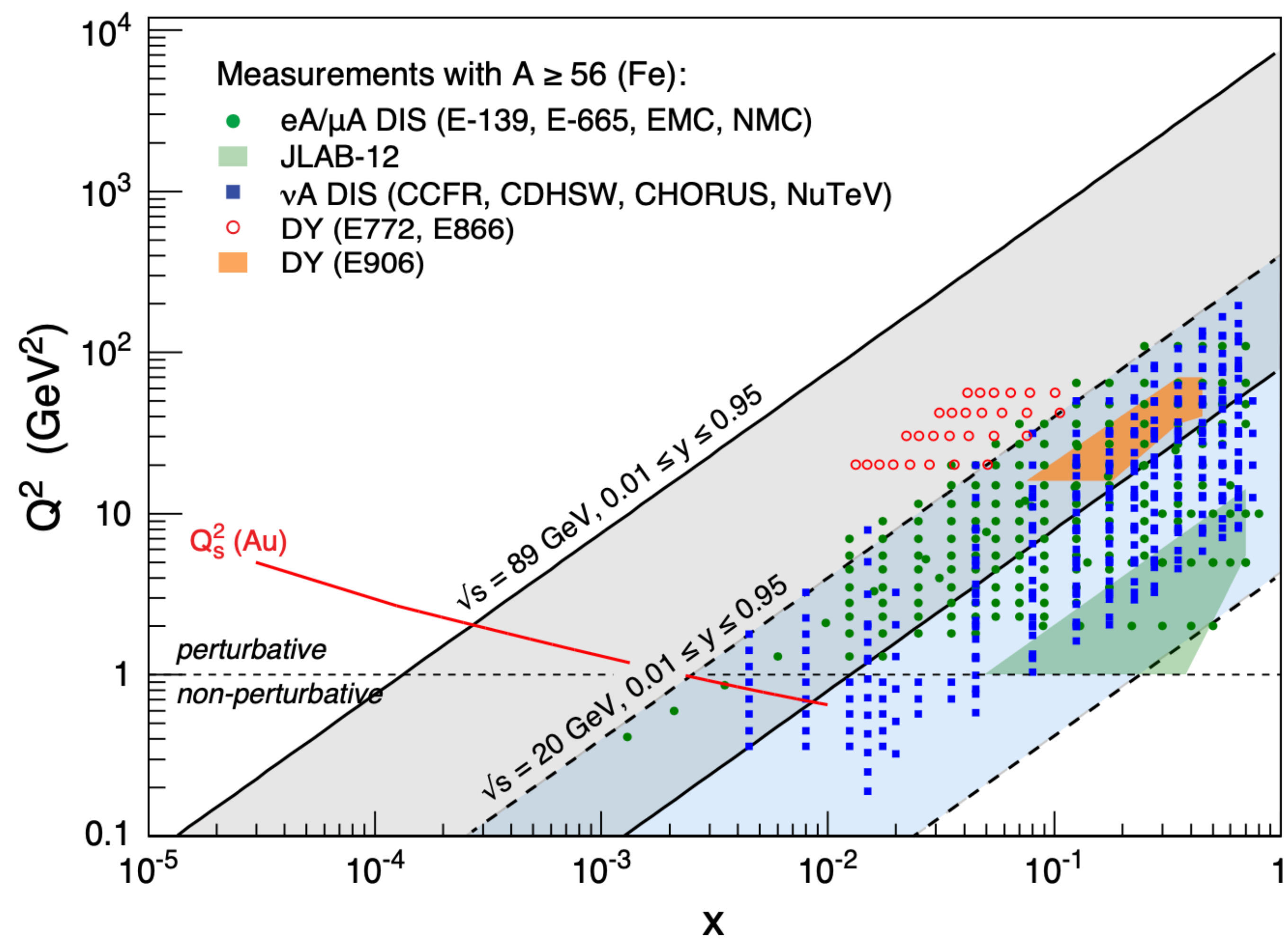
Nuclear PDFs are not well constrained over the entire x region, which displays various effects: EMC effect, anti-shadowing & shadowing

gluon nuclear PDF (Pb)



From M. Echevarria, DIS2019 & 1807.00603

EIC kinematic coverage in eA & existing FT data



EIC Yellow Report, arxiv:2103.05419

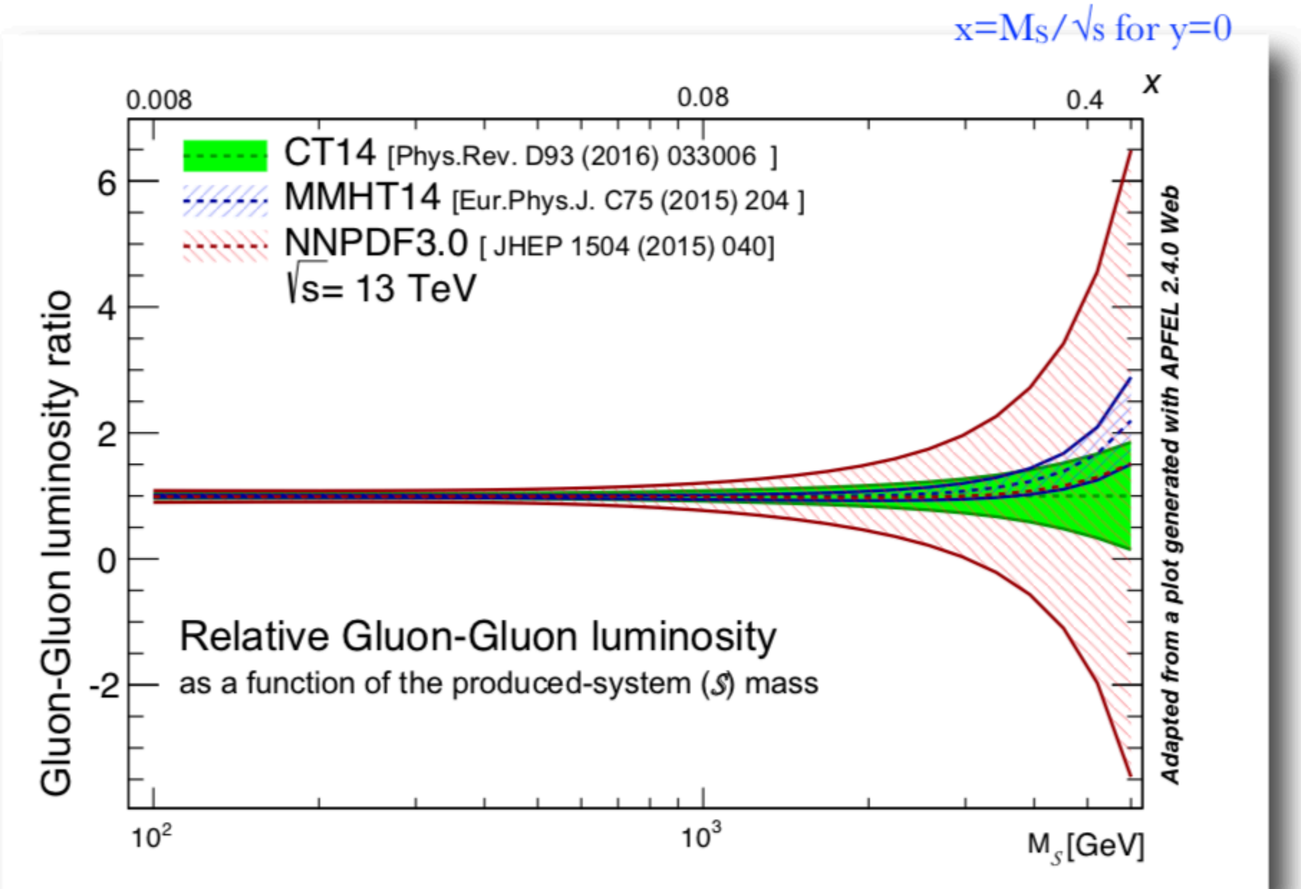
Saturation effects at small x need cross validation between pA/AA and eA, to study the initial conditions for QGP formation in heavy ion collisions

PDFs at large x

EIC will improve PDFs mostly at large x

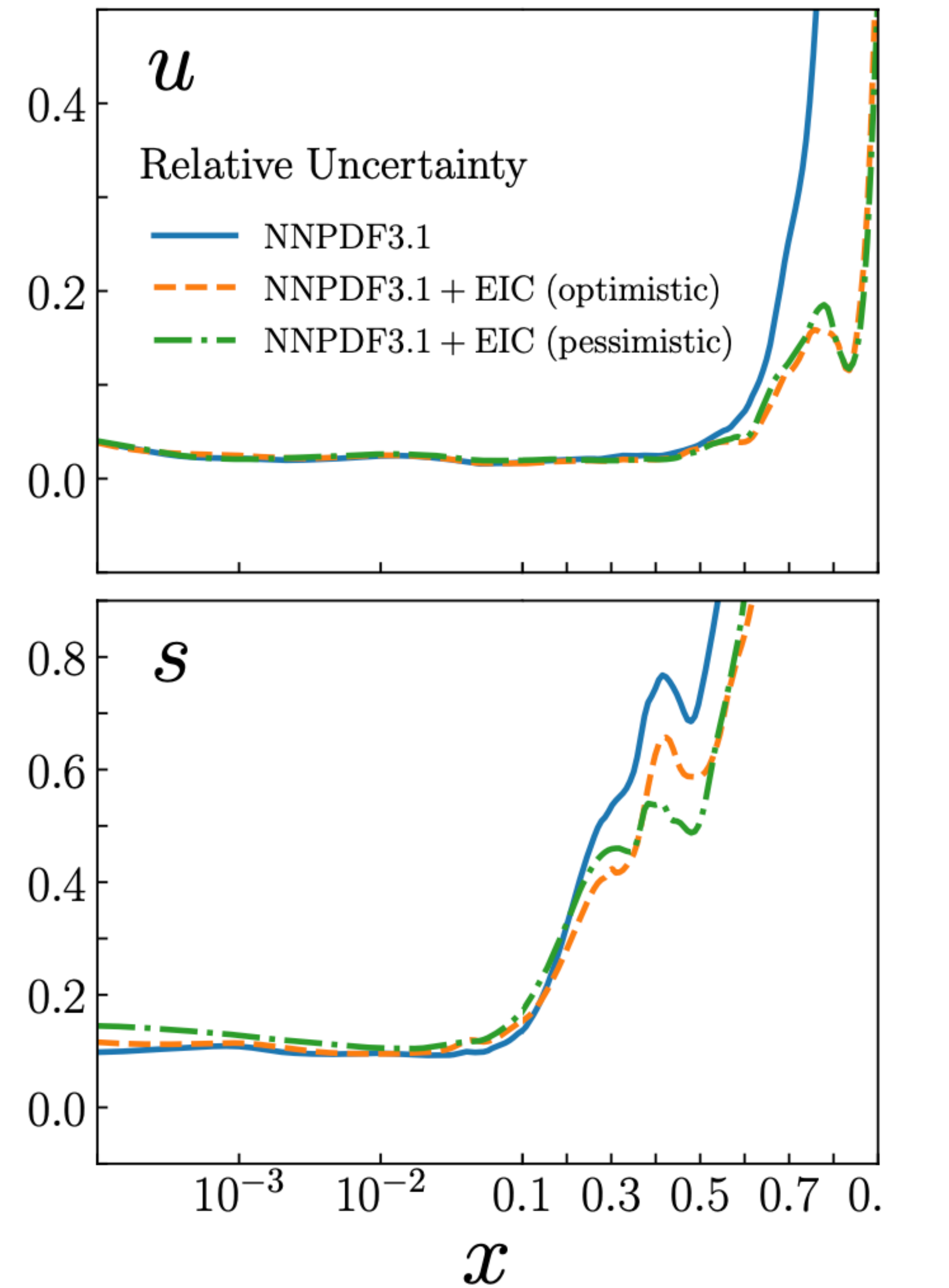
Complementary to HL-LHC and relevant for high-energy BSM searches at the LHC

gg luminosity



$$\frac{\partial \mathcal{L}_{ab}}{\partial \tau} = \frac{1}{s}\int_{\tau}^{1}\frac{dx}{x} f_a(x, M_S^2)\, f_b(\tau/x, M_S^2), \qquad \tau = M_S^2/s$$

From M. Echevarria, DIS2019 & 1807.00603

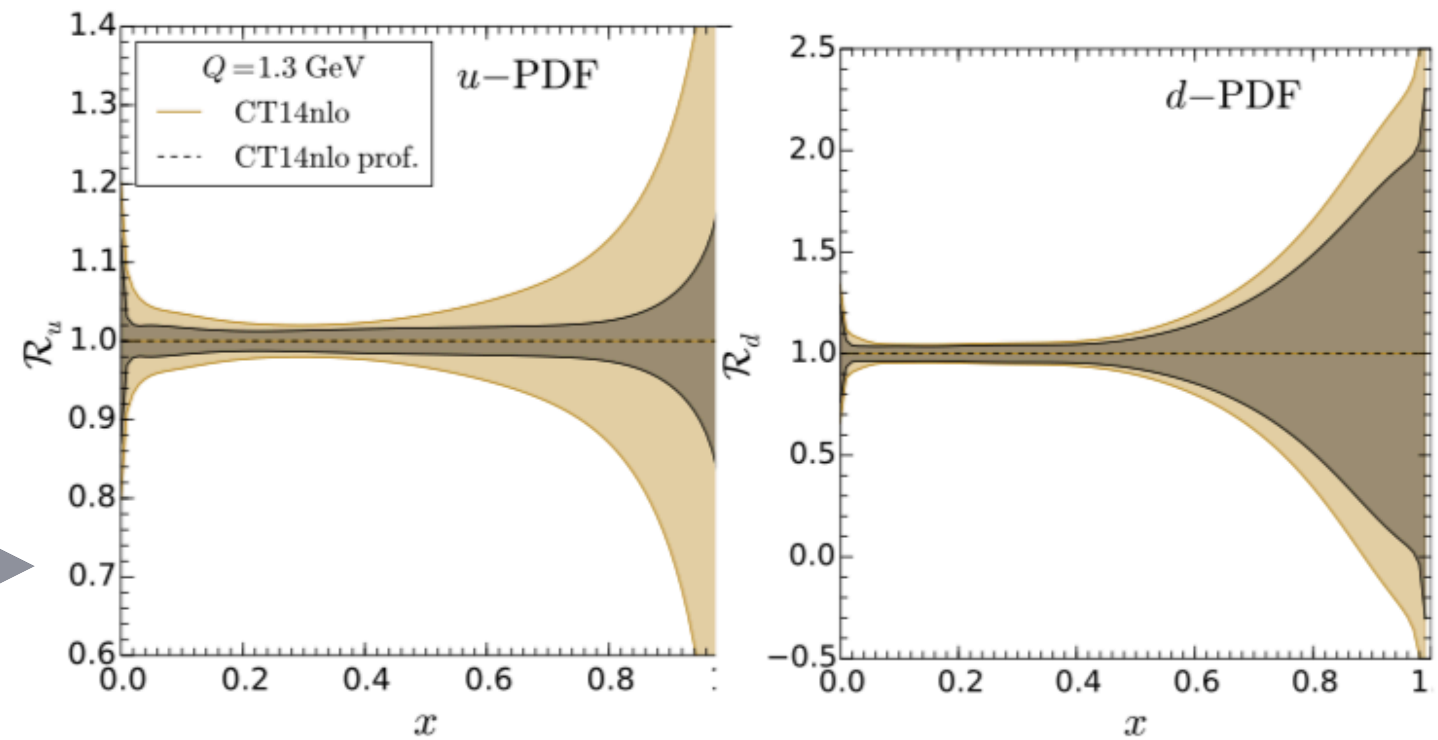


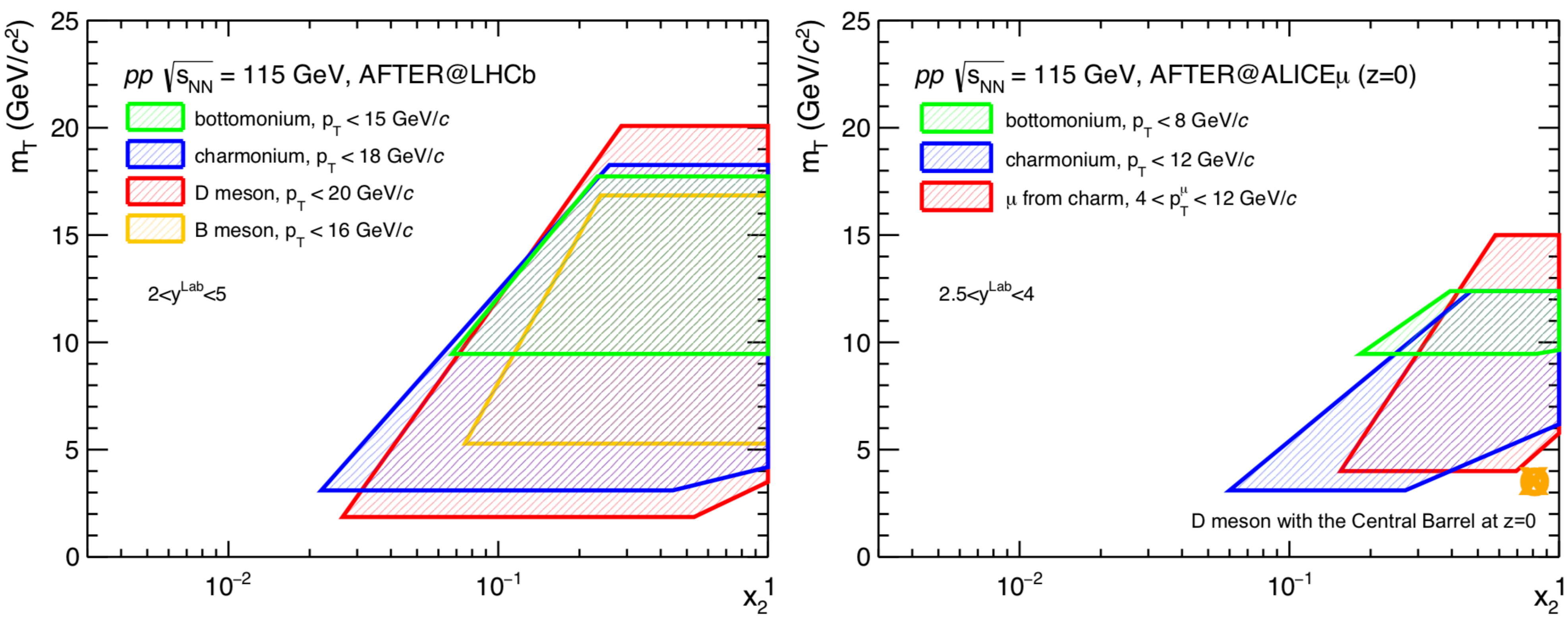
Khalek, PhD thesis (2021) based on Khalek, Ethier, Rojo, EPJC 79 (2019) 491

Large x studies in Fixed-Target experiments at LHC

Recent upgrade of the LHCb detector includes a storage cell system (SMOG2) that provides access to unpolarized gas fixed-target collisions at high energy

Projections for FT experiment at LHCb (10 fb^{-1}) [1807.00603]





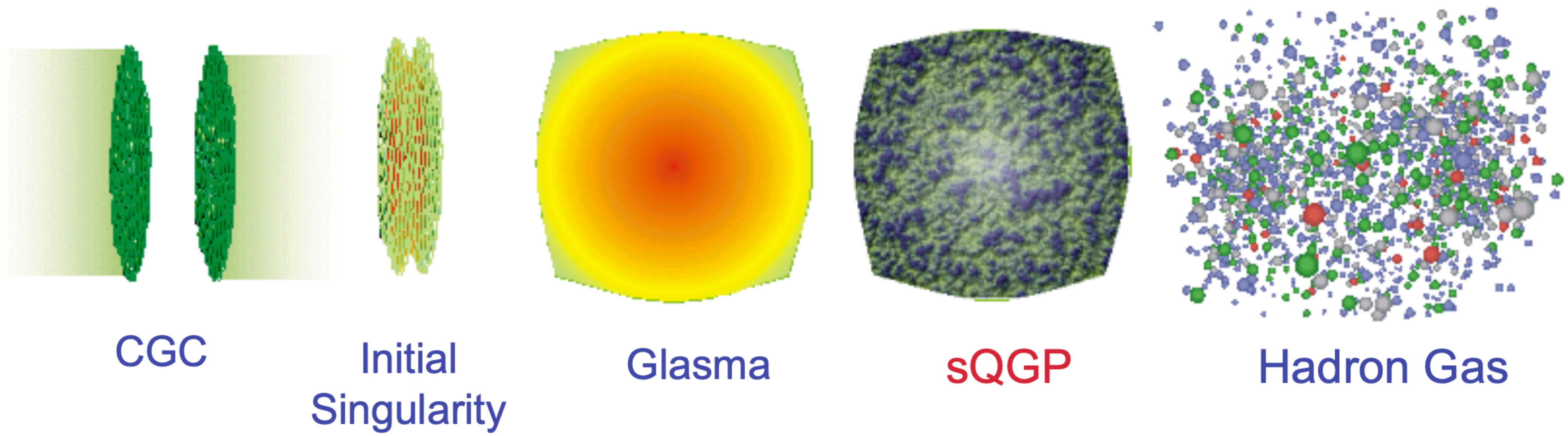
At ALICE an unpolarized solid target system is under study

Large-x gluon studies in heavy quarkonium production

Other objectives with nuclei

- Jet energy loss, medium modifications of jets: studies of deconfined QCD matter will form an important part of the nuclear collision program at HL-LHC

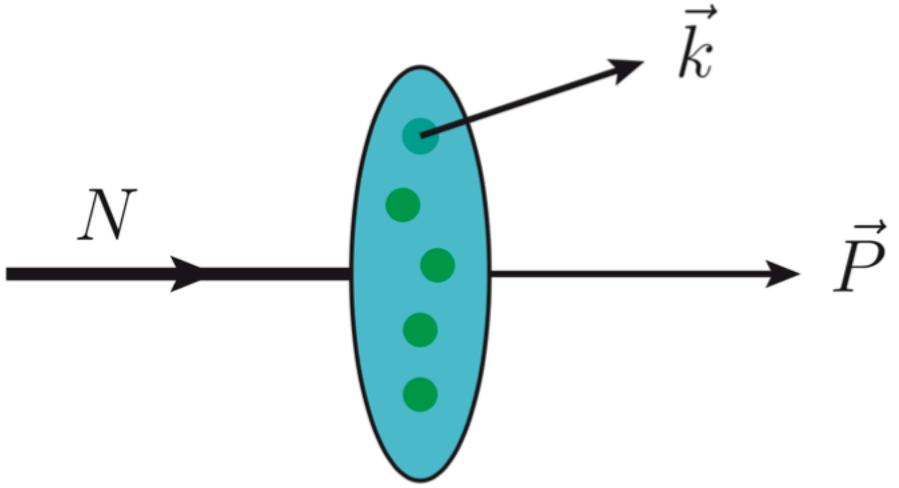
- Evolution from initial conditions via the Glasma to the Quark-Gluon Plasma
Necessary to understand collective behavior in nuclear collisions (elliptic flow, the ridge), EIC provides necessary baseline to go from CGC to Glasma to QGP



By S. Bass

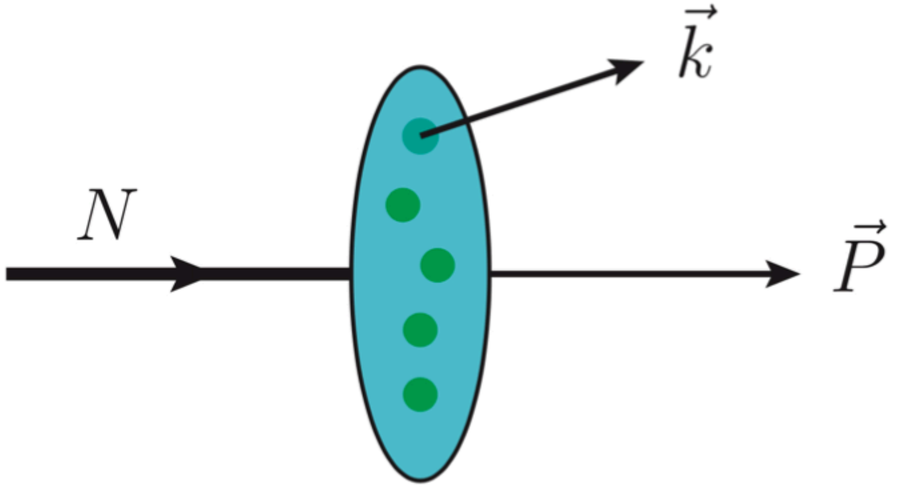
- Ultra-Peripheral Collisions (UPCs), e.g. in exclusive vector J/ψ and Υ production, comparison to photon-nucleus scattering at EIC.
Gives a handle on the nuclear geometry and its fluctuations

Beyond inclusive DIS: TMDs

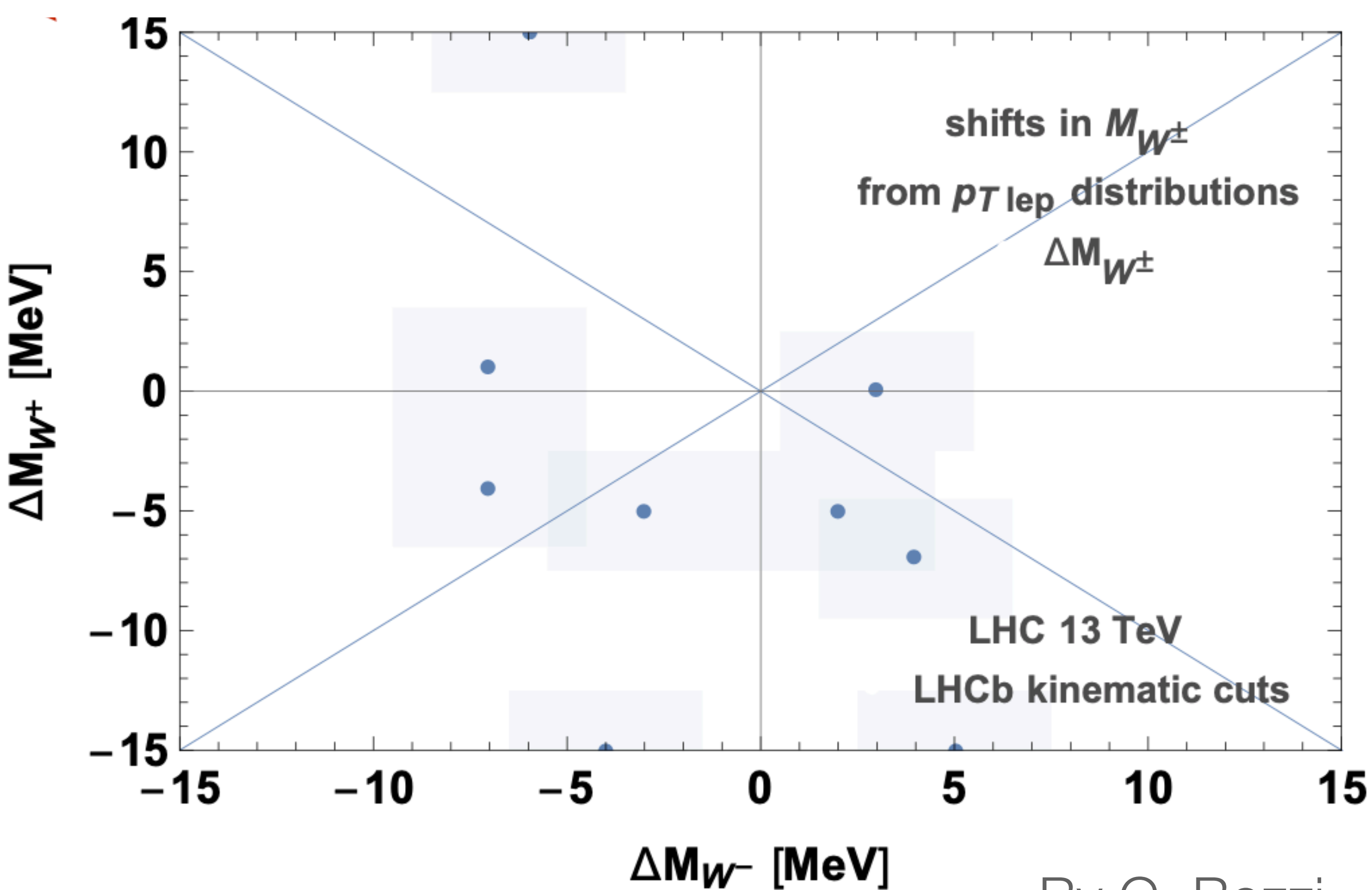


- When more aspects of the final state are measured, one can become sensitive to the 3-D momentum distributions: Transverse Momentum Dependent PDFs
- Many TMD studies foreseen at EIC, especially spin dependent ones and gluon TMDs: e.g. gluons inside unpolarized protons can be linearly polarized
- Objectives:
  - (non-)universality of TMDs (Higgs p_T spectrum, quarkonium production, …)
  - understanding azimuthal asymmetries
  - TMD evolution (quarkonium pair production, photon-jet production, …)
  - matching high and low p_T descriptions (Drell-Yan, W & Z production, …)
  - TMD factorization breaking (dijet production, …)
- There are also proposals for future TMD studies at CERN: AMBER (COMPASS++) and AFTER@LHC

Beyond inclusive DIS: TMDs

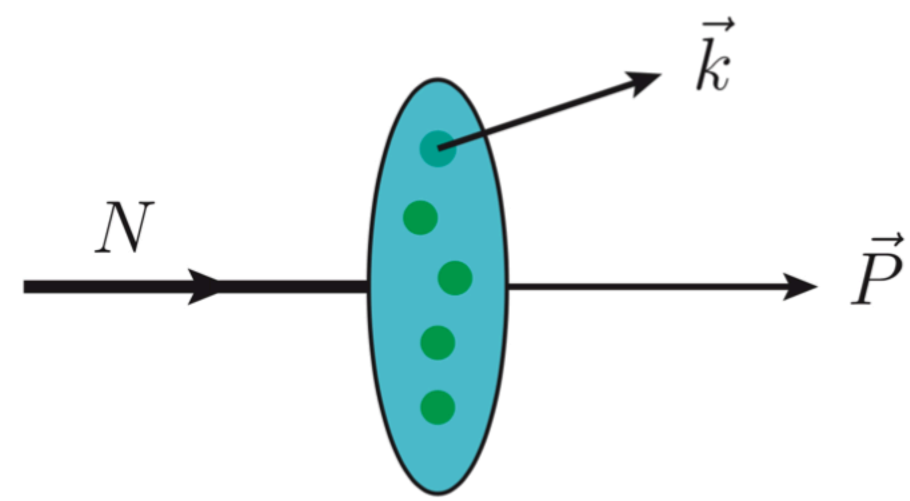


- Semi-inclusive DIS data of EIC can help reduce the uncertainties in the determination of the W mass from its p_T spectrum due to the flavor dependence of the parton intrinsic transverse momenta



By G. Bozzi

Beyond inclusive DIS: TMDs



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HOME > SCIENCE > VOL. 376, NO. 6589 > HIGH-PRECISION MEASUREMENT OF THE W BOSON MASS WITH THE CDF II DETECTOR

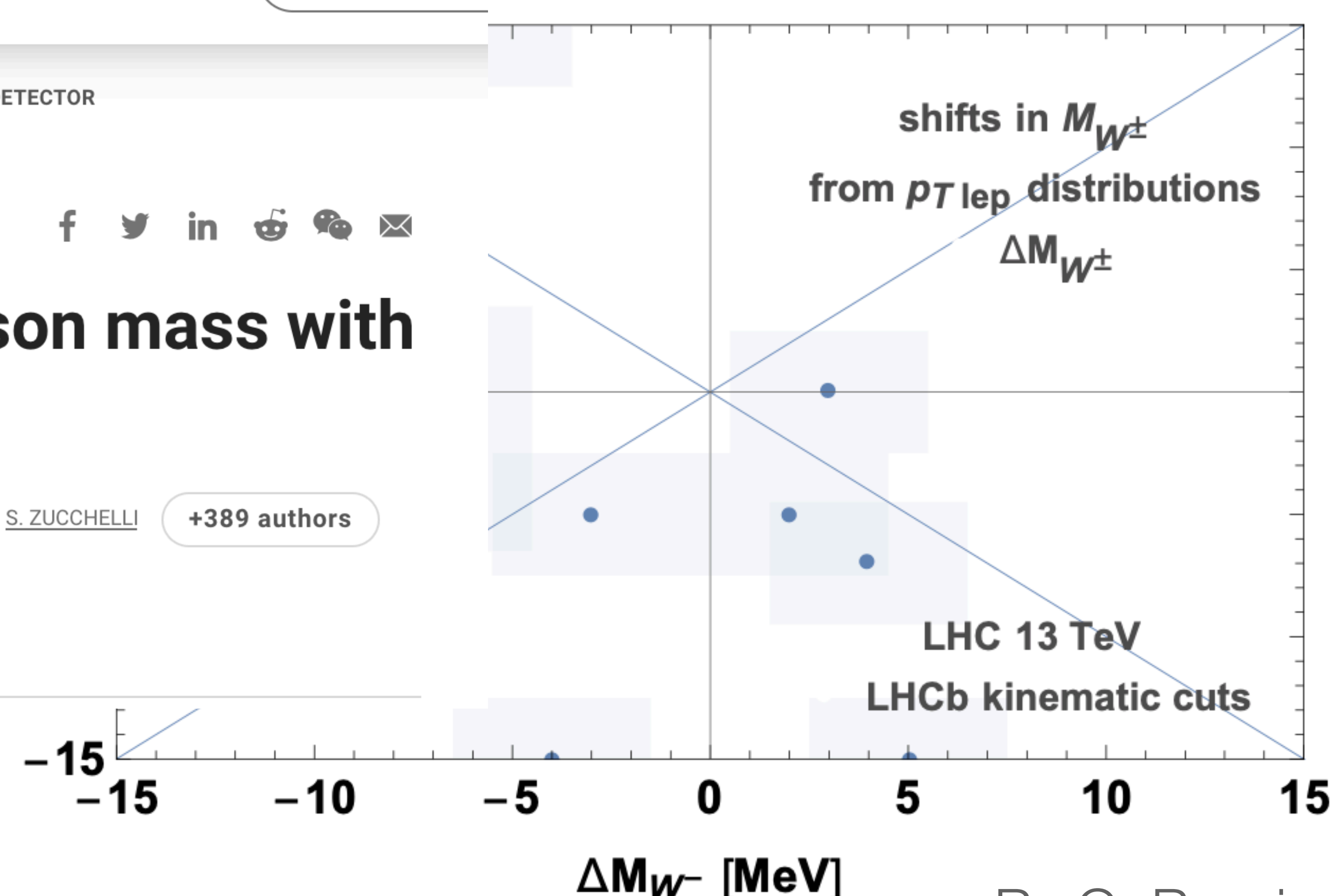
RESEARCH ARTICLE | PARTICLE PHYSICS

High-precision measurement of the *W* boson mass with the CDF II detector

CDF COLLABORATION†‡, T. AALTONEN, S. AMERIO, D. AMIDEI, A. ANASTASSOV, A. ANNOVI, J. ANTOS, G. APOLLINARI, J. A. APPEL, [...] S. ZUCCHELLI +389 authors

Authors Info & Affiliations

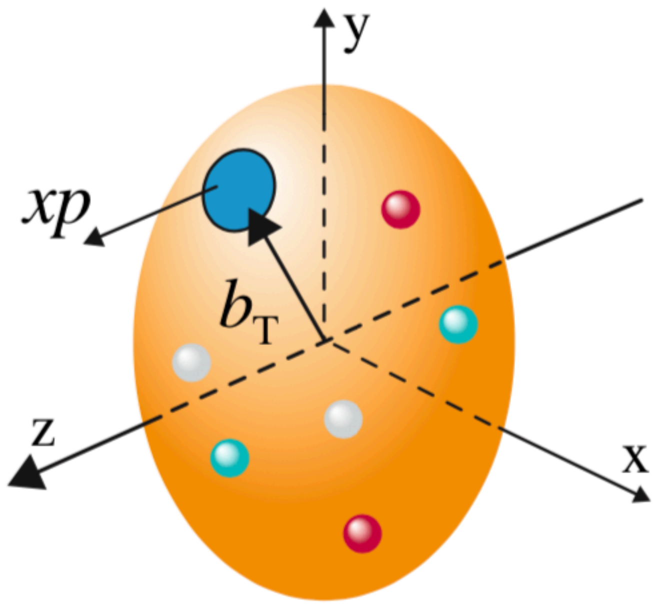
SCIENCE • 7 Apr 2022 • Vol 376, Issue 6589 • pp. 170-176 • DOI: 10.1126/science.abk1781



By G. Bozzi

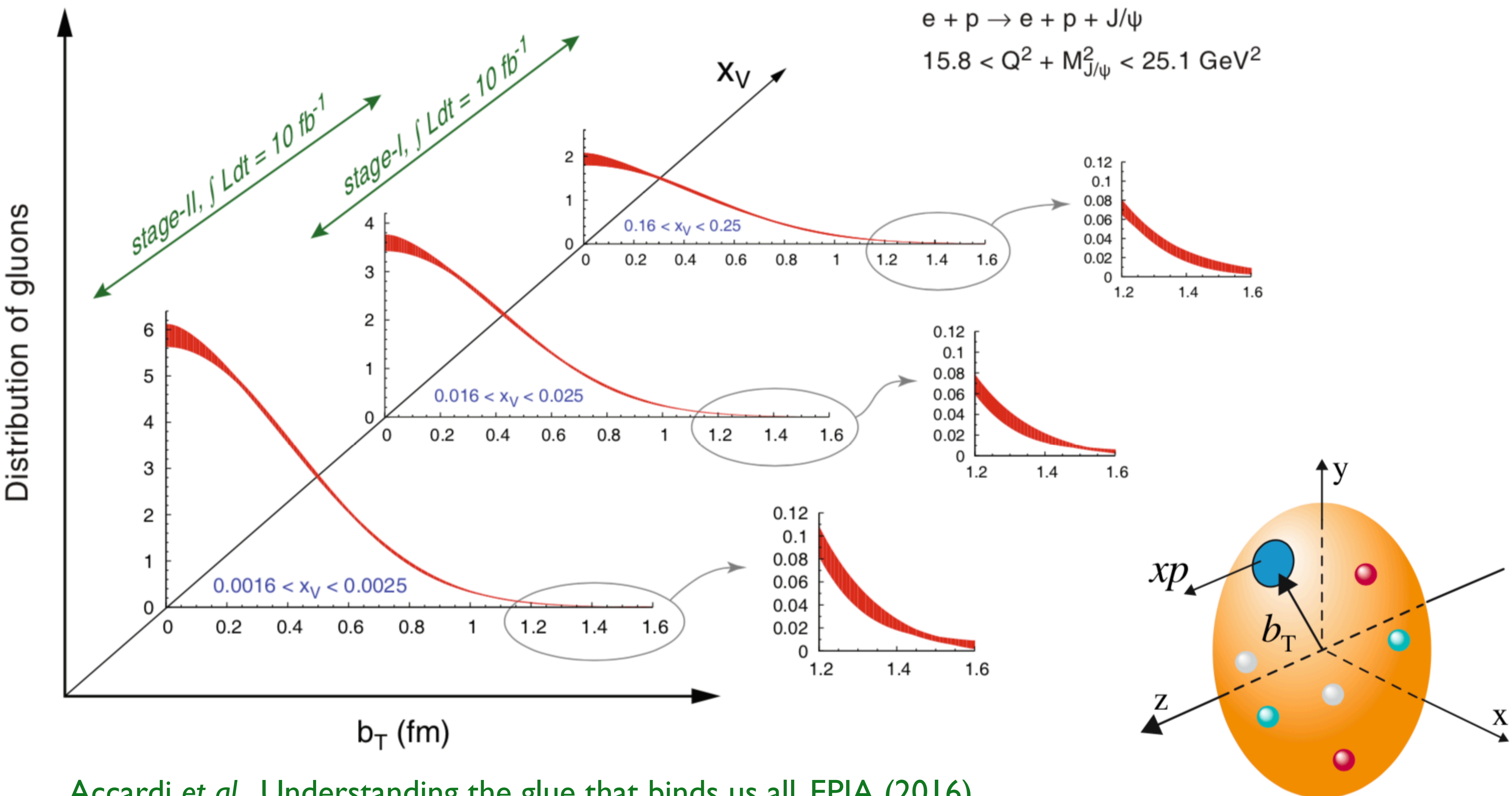
GPDs and MPI

- Exclusive and diffractive processes allow one to probe transverse spatial distributions, Generalized Parton Densities (GPDs)
- Exclusive reactions like DVCS or DVMP have been studied extensively by the COMPASS experiment for instance
- GPDs provide a quantitative baseline expectation for the correlations between different partons. This is relevant for studies of multiparton interactions (MPI) and underlying events in pp, pA and AA collisions



Gluon GPD from exclusive J/ψ production

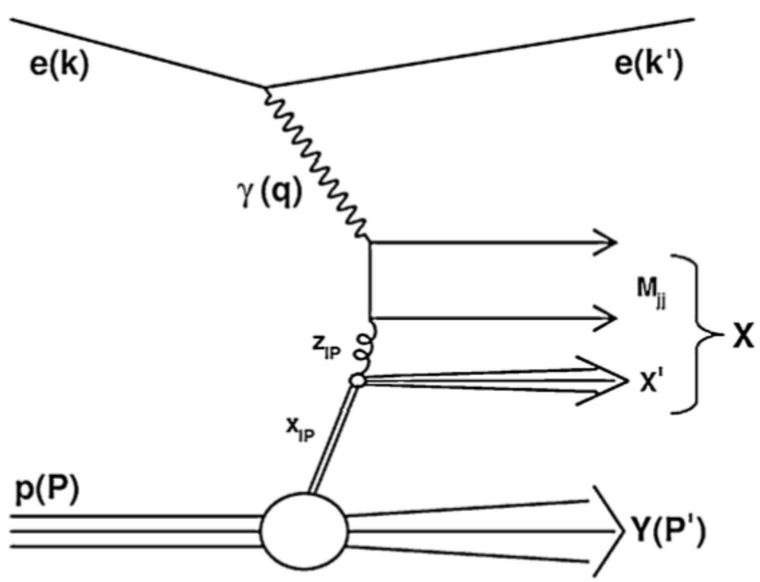
Projected precision of the transverse spatial distribution of gluons

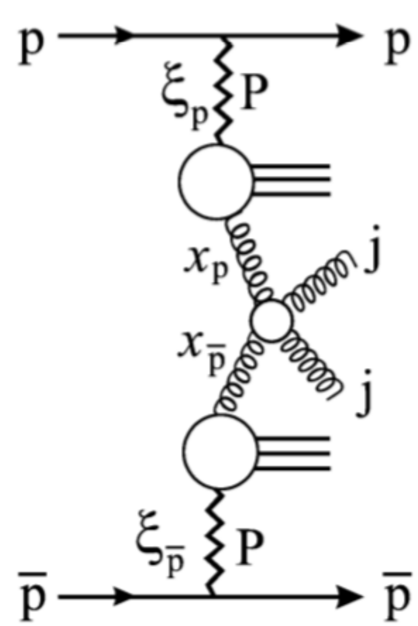


Accardi *et al.*, Understanding the glue that binds us all, EPJA (2016)

Diffractive PDFs & Factorization Breaking

Diffractive dijet production indicates **non-factorization** in pp and $p\bar{p}$ collisions [$Sp\bar{p}S$, Tevatron, LHC] compared to ep [HERA]





Inclusive dijet observables in pp that probe TMDs (transverse momentum dependent PDFs) are also expected to be **non-factorizing**

Understanding of the origin and magnitude of the **non-factorization** is needed for **global analyses of multi-dimensional PDFs**

Multi-dimensional parton distributions: GTMDs

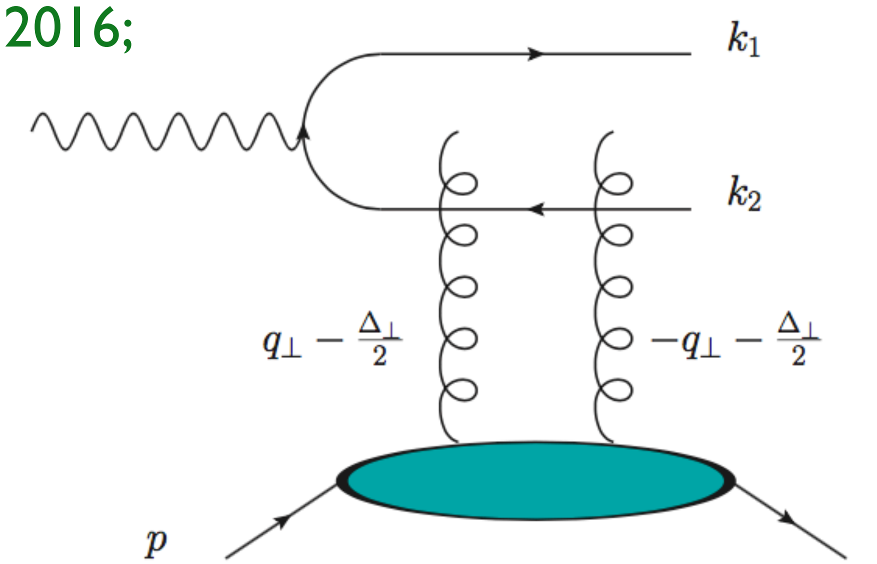
TMDs: transverse momentum dependent PDFs

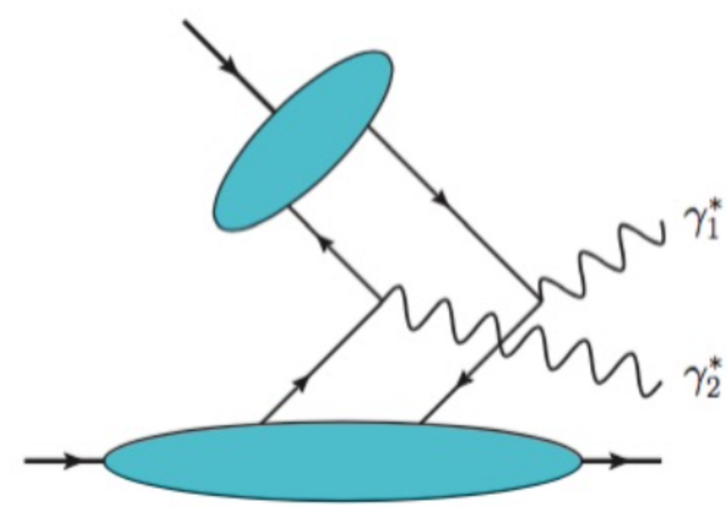
GPDs: off-forward PDFs

GTMD = off-forward TMD = transverse momentum GPDs $G(x, \boldsymbol{k}_T, \boldsymbol{\Delta}_T)$

Diffraction dijet production in eA at EIC allows to probe GTMDs

Altinoluk, Armesto, Beuf, Rezaeian, 2016;
Hatta, Xiao, Yuan, 2016





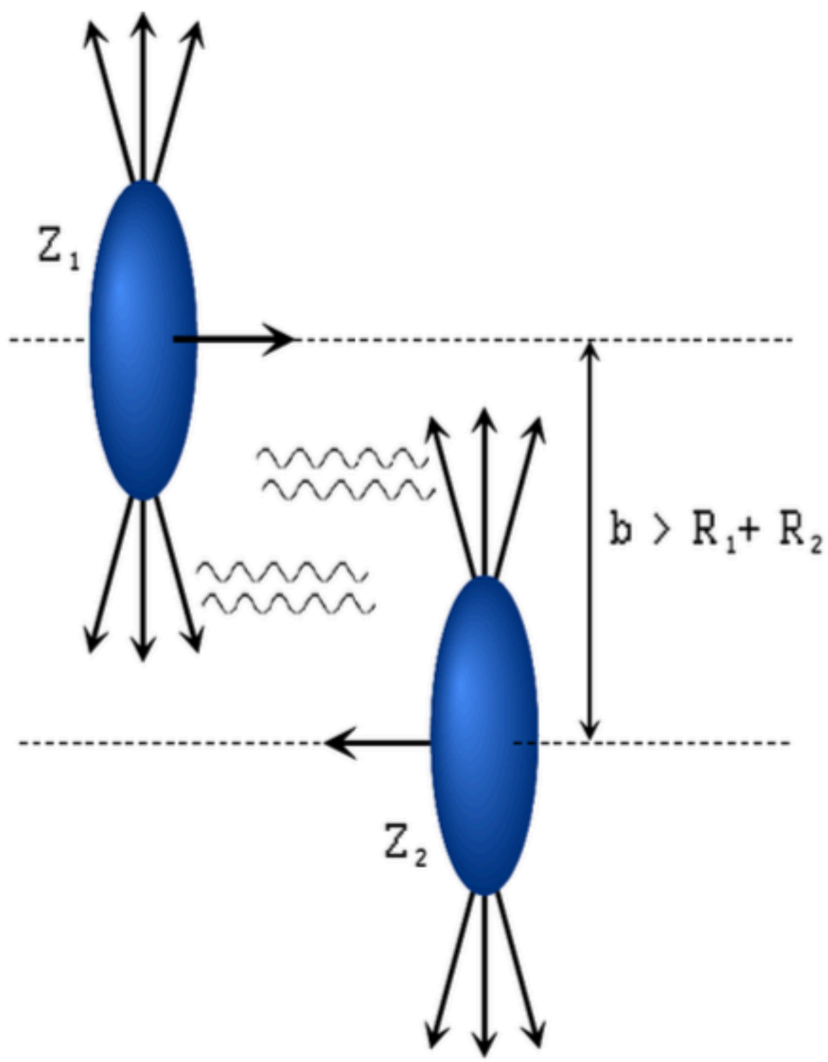
Double parton scattering allows to access GTMDs at LHC

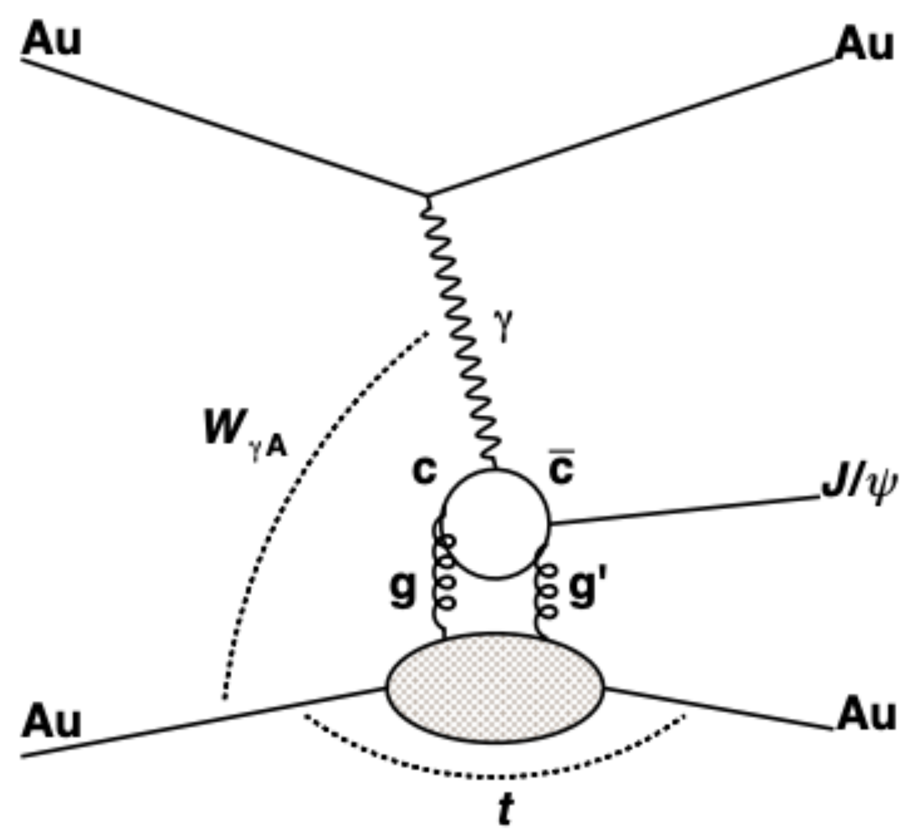
Lappi, Schenke, Schlichting, Venugopalan, 2016;
Bhattacharya, Metz, Jian Zhou, 2017

GTMDs

Exclusive diffractive processes can be used to study GTMDs at EIC in photo- and electro-production

UPCs at RHIC and LHC can do the same

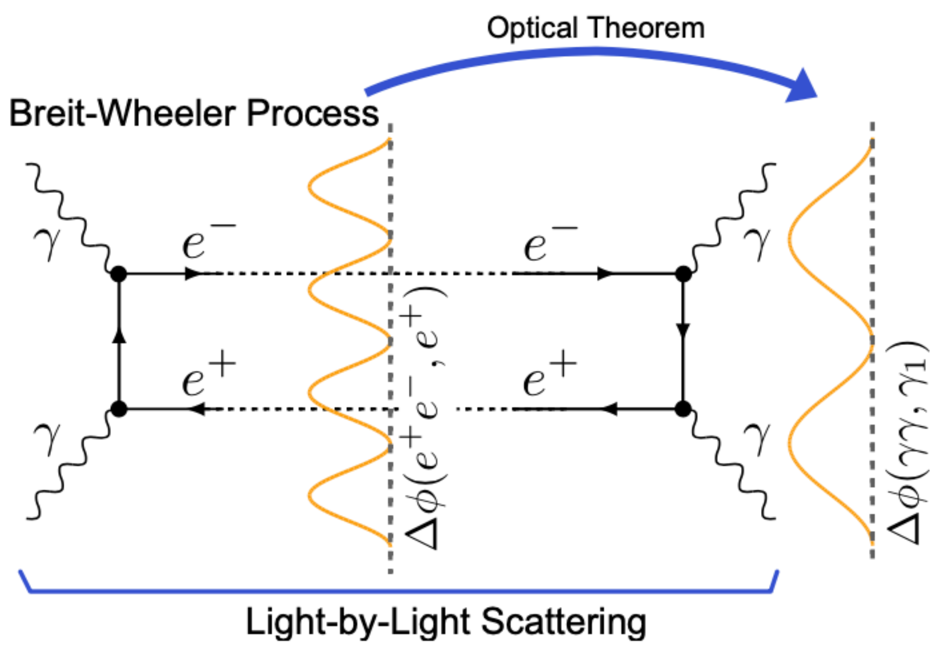


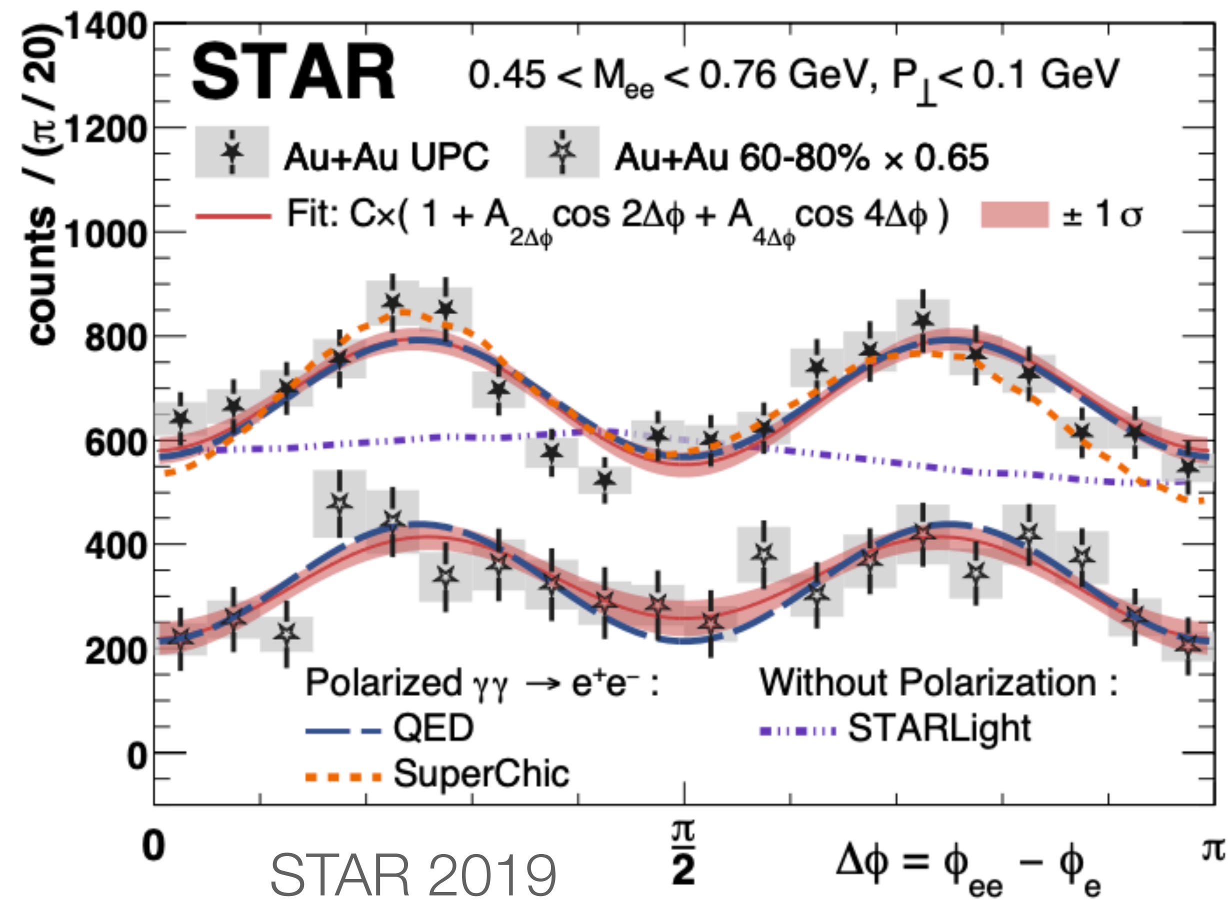


Figures taken from a presentation by Jaroslav Adam

Linear polarization distributions

UPCs also lead to photon-photon collisions
RHIC measured azimuthal asymmetries in such collisions

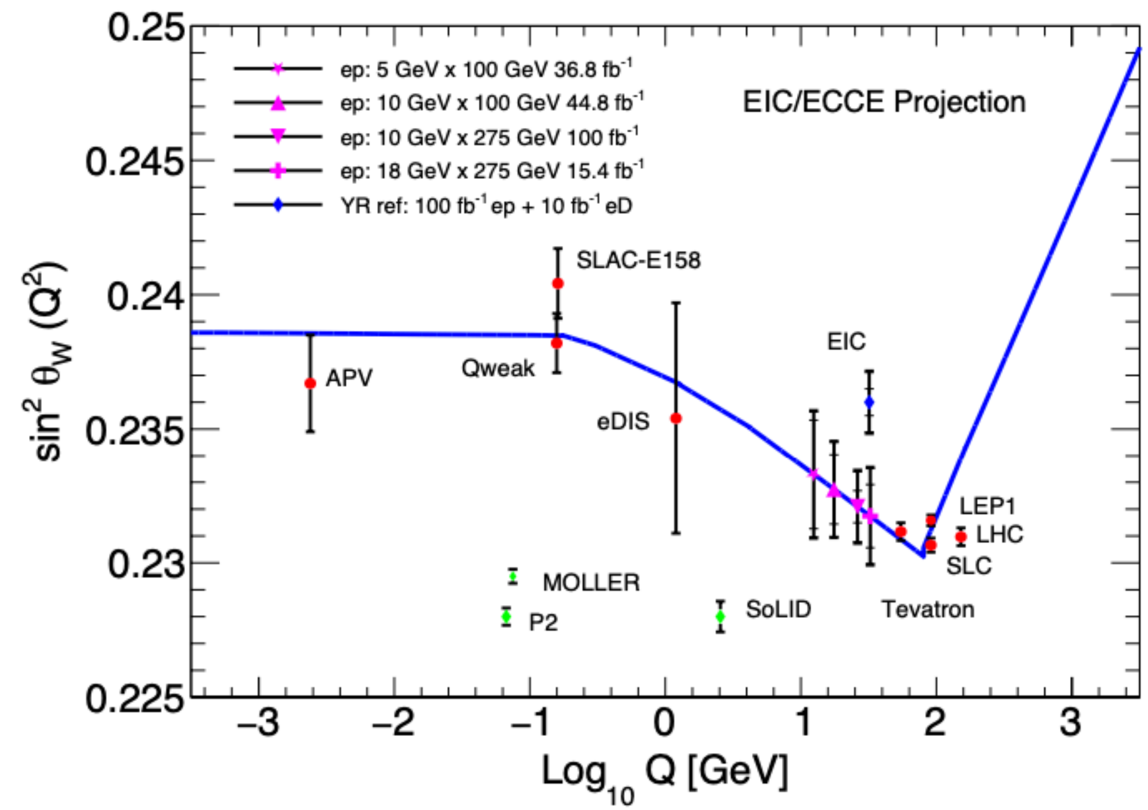




STAR 2019

QCD analogues of these asymmetries can be studied at EIC & LHC

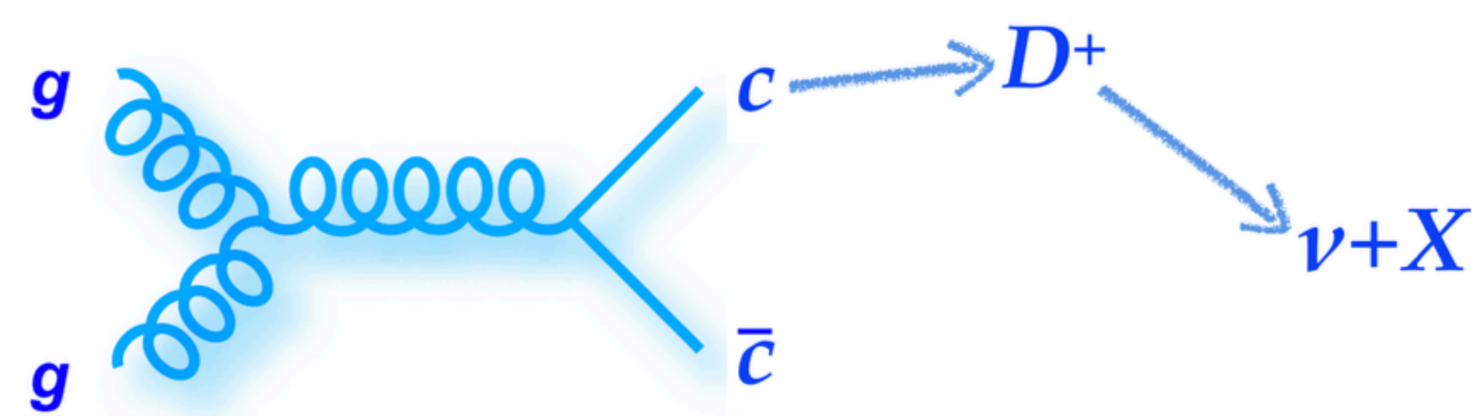
Electroweak and BSM physics



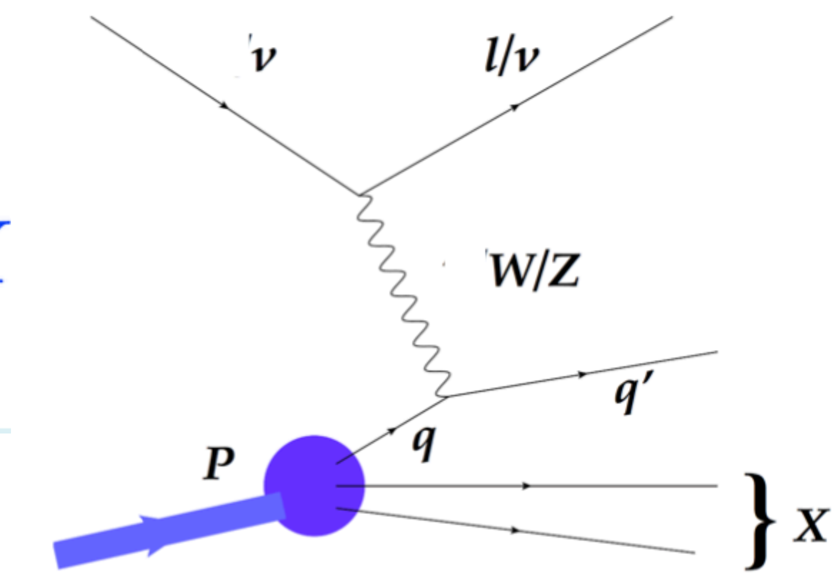
- Precision determinations of the weak mixing angle $\sin^2\theta_W$ in collisions of polarized electrons and unpolarized deuterons. Deviations from the SM running would signal BSM physics, e.g. “dark” Z bosons
- EIC can put further constraints on lepton flavor violating (electron→τ) transitions, improving on an earlier limit set by HERA and complementing the limits from τ decays at B-factories and lepton flavor violation studies at LHC
- Tensor interactions at the TeV scale can be constrained better with help of tensor charge measurements on polarized protons

Synergies with Astroparticle Physics

- Particle production at high-x_F and in diffractive collisions are relevant for cosmic ray air showers - Charm production and neutrino cross sections are especially of interest, but also antiproton production cross sections, oxygen cross sections



background to astrophysical neutrinos



- Nuclear PDF errors currently form the dominant theory error in the description of high-energy neutrino-nucleus cross sections. Improved knowledge on the required nuclear PDFs at very small x will come from both the LHC and EIC

- Cross sections at energies above the collider experiments, e.g. total pp cross section. Could lead to a better understanding of the observed over-abundance of muons in air showers above LHC energies. Odderon physics.

Detector R&D in Europe for LHC & EIC

- Detector R&D in Europe for both LHC & EIC already done in many places

- State-of-the-art detector technologies were developed in various European projects for CERN experiments. Examples:
  - large high-rate TPC with GEM readout and the light-mass vertex detector for ALICE
  - gaseous RICH detectors of LHCb
  - high-momentum hadron identification capabilities of COMPASS
  - large-size gaseous trackers using MPGD technologies in various LHC experiments

- EIC detector R&D program in the U.S. involves European groups from e.g. the University of Birmingham, GSI, INFN Genova, INFN Ferrara, INFN Roma, INFN Trieste and IPN Orsay. They address calorimetry, particle identification by Cherenkov imaging techniques, silicon tracking and vertexing, development of simulation and analysis tools, and streaming read-out data acquisition

Opportunities for synergies also described in the ECFA Detector R&D Roadmap

Shared detector components and requirements

- Tracking and vertexing using ultra-light silicon detectors is a must at EIC. The currently favored (MAPS) technology is aligned with the needs for ALICE-3 (a joint development program is already in place)
- Tracking using Micro-Pattern Gaseous Detectors (MPGDs) such as Micromegas or GEMS nicely complements silicon detectors to cover larger areas. They are used in most LHC experiments already and are planned for both barrel and forward/backward tracking at the EIC
- Particle identification in a wide momentum range is also essential at both EIC and LHC, e.g. for spectroscopy studies at LHCb or for the identification of low momentum hadrons at ALICE
- Silicon detectors offering extremely high time resolution O(10 ps), such as LGAD or ARCADIA, are needed at the EIC (for time-of-flight applications) and at the LH-LHC (for mitigating the 'pile-up' overlap of events)
- The development of novel ASICs for Front-End detector readout such as MPGDs, matching both the sensor characteristics and the needs of largely streaming-readout-based data acquisition systems

For more details ask e.g Franck Sabatié or Silvia Dalla Torre indico.cern.ch/event/1063927/

proxy | Inbox (12) - d.boe... | University of Gron... | Inspire | Google Scholar | Natuurtijdschriften | Proxy

Public | Europe/Zurich

EP R&D Day 2021

11 Nov 2021, 09:00 → 12 Nov 2021, 18:00 Europe/Zurich

Description

CERN's Experimental Physics department has defined a strategic R&D programme on Technologies for future experiments which was officially launched in January 2020.

The 2021 EP R&D day will serve to review the progress and plans of the 11 work packages after almost 2 years of research activities.

In view of gradual approval of the EIC project in the US, we devote the second half day to technological needs and possible cooperation with groups involved in detector R&D for the EIC.

We hoped that the event can be run in mixed mode, however we finally decided to run it via zoom only.

Videoconference

zoom EP R&D Day 2021 Join

Thursday, 11 November

09:00 → 12:30 **Session 1 (EP R&D status and plans)**

09:00 **Welcome and introduction** 10m

Speaker: Christian Joram (CERN)

R&D Day Nov 2021.... | R&D Day Nov 2021....

Separate ongoing activities on R&D synergies will not be duplicated in our JENAA, of course

Posters of EoI 6

- Lisa Walter (Regenburg U.): “Lattice Calculations for Quark Transversity Distributions for the Nucleon”
- Patricia Andrea Gutierrez Garcia (Universidad Complutense de Madrid): “QCD Factorization of Exclusive Processes to probe GTMDs”
- Aleksandra Lelek (Antwerp U.): “The Parton Branching method: collider predictions with Monte Carlo based on TMDs”
- Sara Taheri Monfared (DESY): “Back-to-back azimuthal jet correlation in pp and ep”

Next steps

- Advertise more broadly the Indico page for the JENAA “Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments” https://indico.ph.tum.de/event/7004/

- Ask more colleagues to endorse the EoI on the webpage

- Kick-off meeting at CERN, June 20-21, 2022: https://indico.ph.tum.de/event/7014/

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Thank you for your attention!