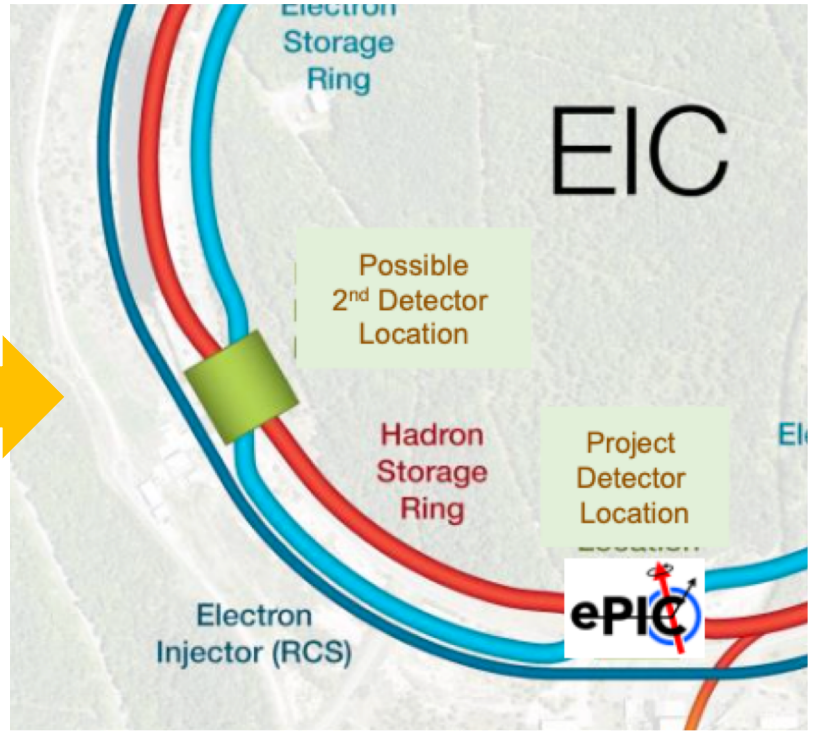
Summary from the 2nd detector WG

Conveners: Charles Hyde (ODU), Sangbaek Lee (ANL), Simonetta Liuti (UVA), Pawel Nadel-Turonski (CFNS/SBU), Bjoern Schenke (BNL), Ernst Sichtermann (LBL), Thomas Ullrich (BNL), Anselm Vossen (Duke/JLab)

The 2nd detector



EIC UG meeting, Warsaw, July 25, 2023

Motivation for a 2nd detector in addition to ePIC

- Needed to unlock the full discovery potential of the EIC
  - Cross checks of key results are essential!
  - Implies a general-purpose collider detector able to support the full EIC program

- New physics opportunities
  - Take advantage of much-improved near-beam hadron detection enabled by a 2nd focus,
  - Impacts, for instance, exclusive / diffractive physics; greatly expands the ability to measure recoiling nuclei and fragments from nuclear breakup.
  - New ideas beyond the Yellow Report and CD0 (EW and BSM)? Your input is essential!

- Complementary design features
  - Possible to reduce combined systematics (as for H1 and ZEUS)
  - Particularly important for the EIC where high statistics mean that uncertainties for a large fraction of the envisioned measurements will be systematics limited

Motivation for two detectors – a HEP perspective

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, 2023

The paper was inspired by Mont's presentation at the first 2nd EIC detector CFNS workshop in December 2022. Mont was also JLab director 2008-2017, and has been very interested in the EIC

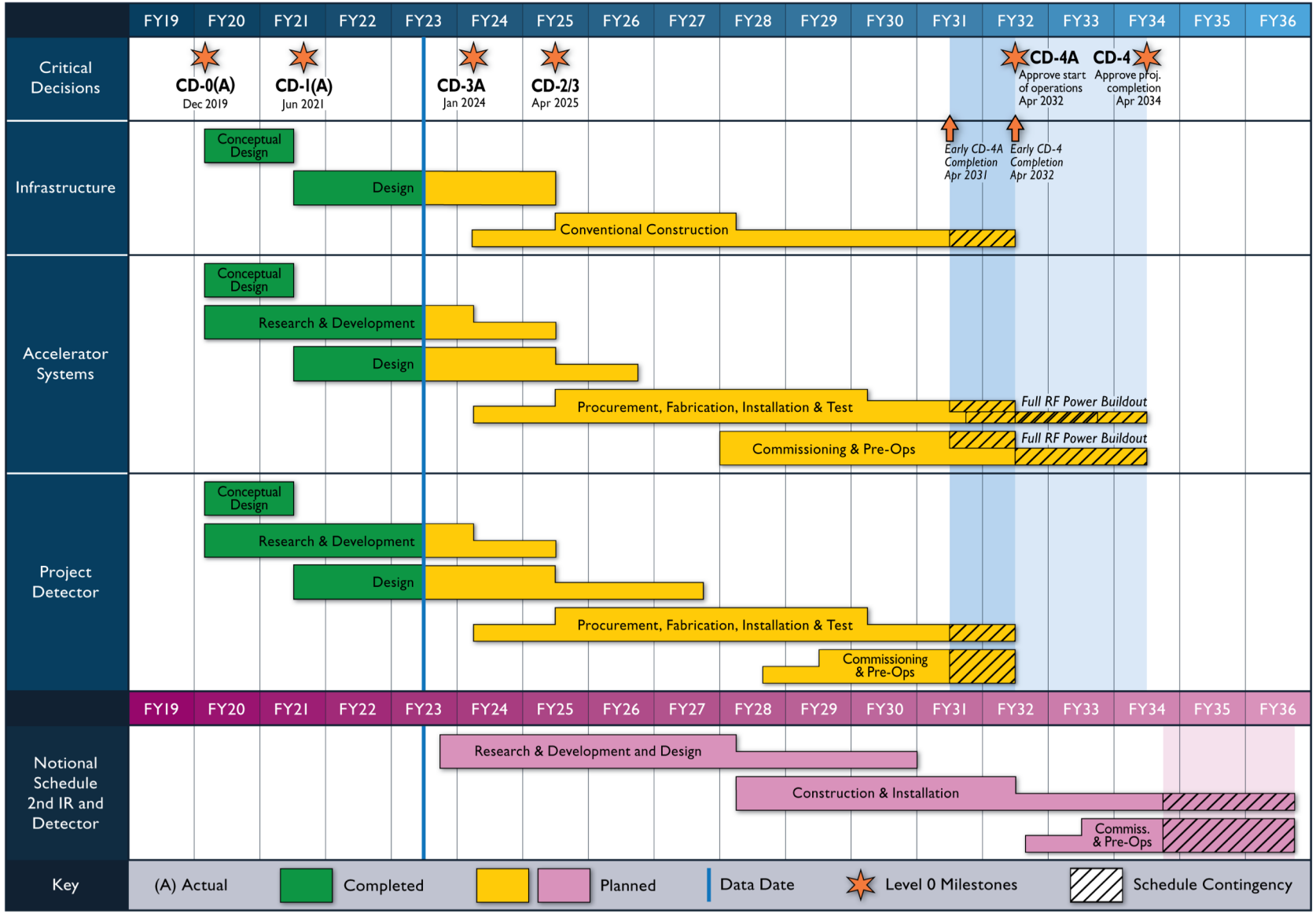
Project perspective on a 2nd Detector

- Project Design Goals
  - **Accommodate a Second Interaction Region (IR)**
- DOE, and BNL and JLab as the Host Labs, are establishing a governance structure intended to support the EIC. This includes the construction of a 2nd IR and detector.
  - EAB, RRB, DOE International Agreements
- Successful delivery of the EIC Project will be a major challenge, and the priority of the EIC project leadership team
- 2nd IR and Detector will be **installed after the EIC project** is complete
  - Science case must be compelling given resources required
  - IR and detector technologies should be state of the art
  - International engagement should be significant
- Organized effort needed now to prepare plans and build support for the 2nd IR and Detector

Jim Yeck, EIC 2nd detector WS, May 2023

Reference schedule for a 2nd IR and Detector

Jim Yeck, EIC 2nd detector WS, May 2023



Second detector

EIC UG 2nd detector / IP8 working group – a timeline

- December 2021 – DPAP review of EIC detector proposals
  - The call included criteria for proposals to be a 2nd detector
  - While the DPAP did not make a selection of a 2nd detector, it endorsed the idea

- Spring 2022 – EICUG-SC produced a brochure on a 2nd EIC detector
  - Distributed to same international funding agencies that received copies of the yellow report

- July 2022 – the Det II / IP8 WG was formed. **Everyone is welcome to join!**
  - Conveners: Klaus Dehmelt (CFNS/SBU), Charles Hyde (ODU), Sangbaek Lee (ANL), Simonetta Liuti (UVA), Pawel Nadel-Turonski (CFNS/SBU), Bjoern Schenke (BNL), Ernst Sichtermann (LBL), Thomas Ullrich (BNL), Anselm Vossen (Duke/JLab)
  - General mailing list: eic-det2-l@lists.bnl.gov
  - Convener mailing list: eic-det2-conveners-l@lists.bnl.gov

2nd detector WG workshops

- A series of CFNS workshops at Stony Brook University
  - The first was held in December 2022 - 98 participants, local and remote

- The first international workshop on a 2nd detector for the EIC was held at Temple University
  - 115 participants, local and remote

- Detector II / IP8 program at this EIC UG meeting, July 30-31

Detector II / IP8 program at the end of the EIC UG meeting

Session 1	(Sunday)			
14:30 - 14:40	Welcome	Marco Radici	INFN	in person
14:40 - 15:15	Intro to 2nd detector	Abhay Deshpande	CFNS Stony Brook	in person
15:15 - 15:40	Physics opportunities with a 2nd focus	Pawel Nadel-Turonski	CFNS Stony Brook	in person
15:40 - 16:05	2nd detector WG	Renee Fatemi	U. Kentucky	in person
16:05 - 16:30	Generic R&D programm	Dave Mack	JLab	remote
Session 2	(Sunday)			
17:00 - 17:30	DIRC - future opportunities	Roman Dzhygadlo	GSI	in person
17:30 - 18:00	A KLM for the EIC	Simon Schneider	Duke	remote
18:00 - 18:30	Timelike Compton Scattering (dileptons)	Pierre Chatagnon	JLab	remote
Session 3	(Monday)			
9:00 - 9:35	Summary of past workshops - physics / theory	Simonetta Liuti	UVA	remote
9:35 - 10:10	Summary of past workshops - experiment / detector	Ernst Sichtermann	LBL	in person
10:10 - 11:35	Low-Q2 tagger coverage	Stephen Kay	York	in person
10:10 - 11:00	A few degree calorimeter: bridging the Q2 gap	Miguel Arriata	UCR	in person
Session 4	(Monday)			
11:30 - 12:00	Reggeons	Anna Stasto	U. Penn	in person
12:00 - 12:30	gluon TMDs	Francesco Celiberto	UAH Madrid	remote
12:30 - 13:00	double parton distributions	Matteo Rinaldi	INFN	remote
Session 5	(Monday)			
14:30 - 15:00	Two detectors	Hugh Montgomery	JLab	remote
15:00 - 15:30	Synergies with the LHeC	Paul Newman	Birmingham	remote
15:30 - 16:00	Deep Exclusive Meson Production as a probe of Lambda polarization at the EIC	Zhoudunming "Kong" Tu	BNL	in person
16:00 - 16:30	Rare isotopes at the EIC	Barak Schmookler	UCR	remote
Session 6	(Monday)			
17:00 - 17:30	low-x jets / hadronic calorimetry in the electron endcap	Brian Page	BNL	remote
17:30 - 18:30	Discussion on international participation	discussion leaders: Abhay, Rolf		

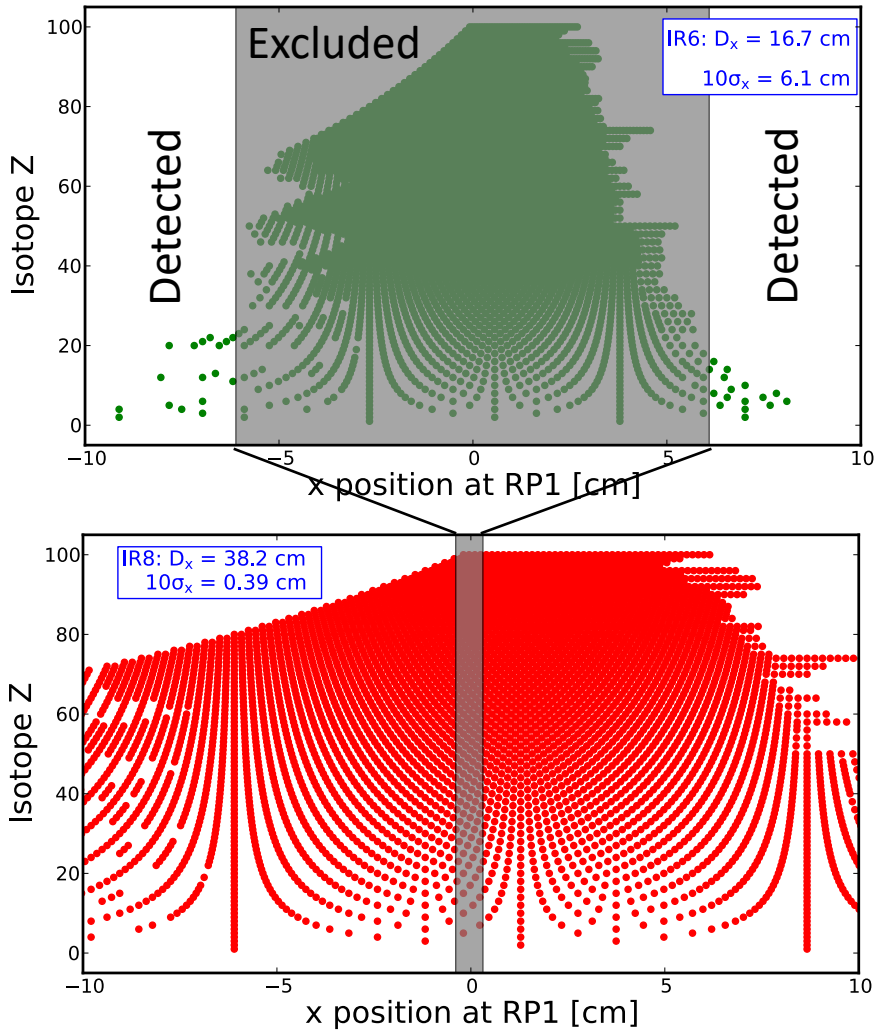
Aspirational goals for a 2nd EIC detector

- **MAGNETIC FIELD –** Solenoid field up to 3T, allowing for high resolution momentum reconstruction for charged particles.
- **EXTENDED COVERAGE** for precision electromagnetic calorimetry – important for DVCS on nuclei.
- **MUONS –** enhanced muon ID (not only MIPs) in the barrel and (possibly) backward region.
- **BACKWARD HADRONIC CALORIMETER –** Low-x physics, reconstruction of current jets in the approach to saturation.
- **SECONDARY FOCUS –** tagging for nearly all ion fragments and extended acceptance for low-p_T/ low-x protons. Enables detection of short-lived rare isotopes.

Renee Fatemi, EIC 2nd detector WS, May 2023

Example: far-forward acceptance with and without a 2nd focus

Ion fragments from ^{238}U



Without 2nd focus:
(EPIC @IR6)

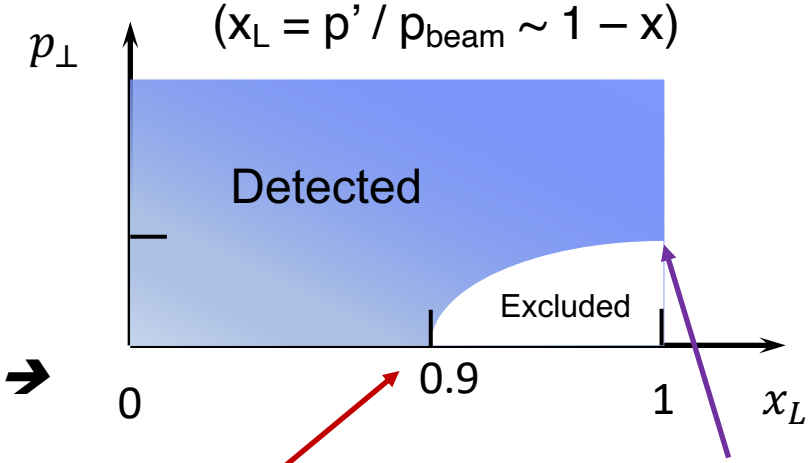
← Z' vs x_{RP}

$p_\perp$ vs x_L →

With 2nd focus:
(Detector 2 @ IR8)

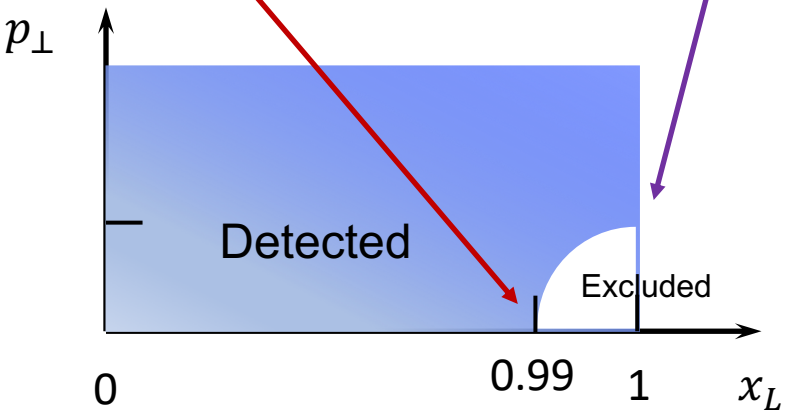
Order-of-magnitude improvement in forward acceptance

Exclusive protons
(x_L = p' / p_{beam} ~ 1 – x)



Limited by D and 2nd focus (β_2)

Limited by angular acceptance (β^*)



Five initial benchmark channels for Detector 2 simulations

CHANNEL	PHYSICS	DETECTOR II OPPORTUNITY
Diffractive dijet	Wigner Distribution	detection of forward scattered proton/nucleus + detection of low p_T particles
DVCS on nuclei	Nuclear GPDs	High resolution photon + detection of forward scattered proton/nucleus
Baryon/Charge Stopping	Origin of Baryon # in QCD	PID and detection for low p_T pi/K/p
F_2 at low x and Q^2	Probes transition from partonic to color dipole regime	Maximize Q^2 tagger down to 0.1 GeV and integrate into IR.
Coherent VM Production	Nuclear shadowing and saturation	High resolution tracking for precision t reconstruction

- Please note that these were selected to illustrate particular opportunities
- You are most welcome to add your favorite process!

Thank you!

Detector II/IP8 and WG charge

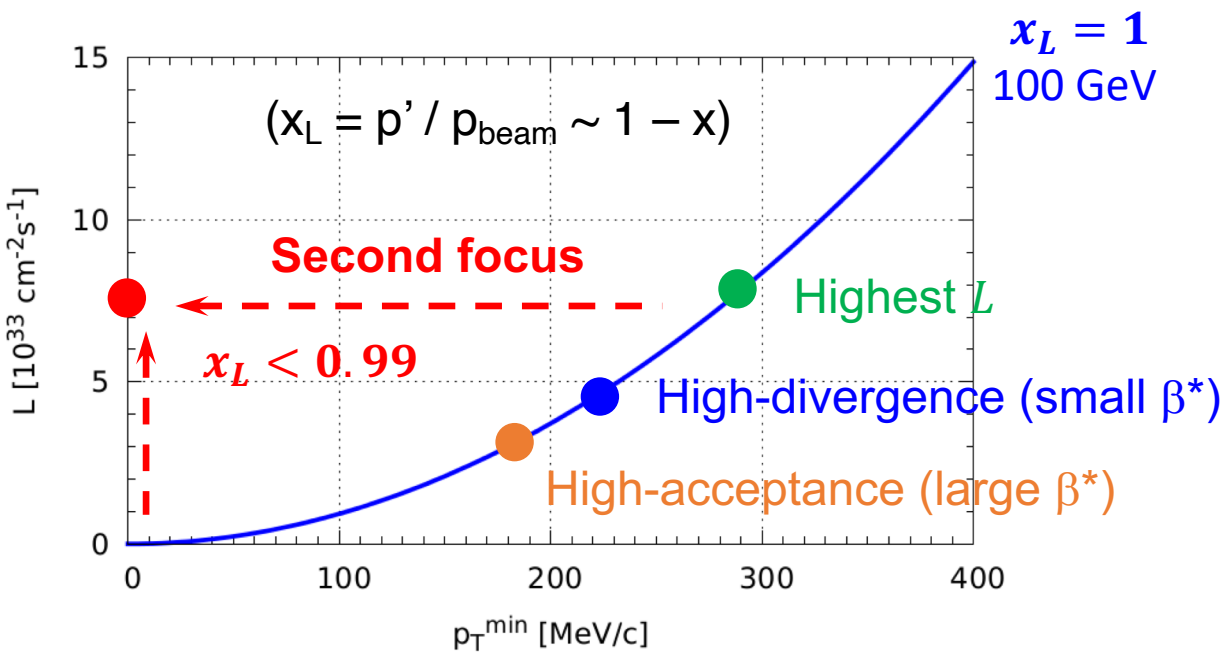
Renee Fatemi, EIC UG meeting, Stony Brook, July 2022

"With a clear mandate from DPAP and the EICUG to support and organize a Detector II/IP8 effort, the SC held discussions with Project, Detector I and CORE leadership. We agreed to form a dedicated working group that would address the following charge:"

1. Engage the broader community, ***including theorists, accelerator physicists and Detector I experimentalists***, to fully develop projections for the portfolio of measurements that are complementary to the Detector I physics program, including those that capitalize on the implementation of the secondary focus.
2. Work with the EICUG Steering Committee and Project to ***recruit new institutions*** and establish a diverse and vibrant 2nd Detector working group.
3. Utilize the extended design period for Detector 2 to identify groups that will focus on ***R&D for emerging technologies*** that could provide another aspect of complementarity to Detector 1.
4. Facilitate the development of a ***unified concept*** for a general-purpose detector at IR8. In particular, the 2nd detector should be complementary to the project detector at IR6 and may capitalize on the possibility of a secondary focus at IR8.

Luminosities in IR6 (ePIC) and IR8 (Detector 2)

18x275	10x275	5x275	10x100	5x100	5x41
1.65×10^{33}	10.05×10^{33}	5.29×10^{33}	4.35×10^{33}	3.16×10^{33}	0.44×10^{33}



- The maximum luminosity will be similar for both Detector 1 and 2.
- When operated together, they will share the *beam current* (*luminosities* can be different).
- In IR6, a higher luminosity reduces the forward low-p_T acceptance.
- Due to the 2nd focus, IR8 can operate at max luminosity without any acceptance penalty for x > 0.01, and a smaller one at lower x

This complementarity will allow for a global optimization. Detector 2 will have a natural advantage for exclusive / diffractive physics, and in particular for detection of nuclei.