2^{nd} detector working group of the EIC user group and science goals for detector 2

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EIC UG SC: path forward for Detector II/IP8 and WG charge

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.

EIC UG SC – comments from the DPAP report shown at UG meeting

- "A strong case for ***two complementary general-purpose detectors*** has been made during the panel review"
- "…requires a ***well-chosen balance between optimization as general-purpose detector versus partial specialization*** and the ability to cross check the other detector for a broad range of measurements. The design of a second detector should be chosen with these criteria in mind."
- "The time required for its design and construction may offer ***opportunities for benefiting from technological progress***."
- "As laid out in the section 2.1 on physics performance, ***an IR with a secondary focus can significantly broaden the physics scope and output of the EIC***."

2nd detector working group – conveners, mailing list, and wiki

1. Sangbaek Lee (ANL) - experiment
2. Simonetta Liuti (UVA) – theory
3. Pawel Nadel-Turonski (SBU) – experiment
4. Thomas Ullrich (BNL/Yale) – experiment
5. Anselm Vossen (Duke) – experiment
6. Walter Wittmer (JLab) – accelerator

Everyone is welcome to participate!

The mailing list is: mailto:eic-det2-l@lists.bnl.gov
You can subscribe here: https://lists.bnl.gov/mailman/listinfo/eic-det2-l
There is also a wiki page: https://wiki.bnl.gov/eic-detector-2/

2nd detector WG – meetings and workshops

Detector-II Working Group Kick-Off Meeting

Friday Sep 2, 2022, 10:30 AM → 12:00 PM US/Eastern

Description **Connection Information:**

To join please click on the link here (https://stonybrook.zoom.us/j/99391353912?pwd=UzNsVVQ4bVh0QjdZUnFUdTNva0lyUT09)

10:30 AM	→ 10:40 AM	**Charge and Aim of WG** 10m **Speaker**: Renee Fatemi (University of Kentucky)
10:40 AM	→ 10:50 AM	**Project View of Det-2** 10m **Speaker**: Jim Yeck
10:50 AM	→ 11:00 AM	**Status and Plans** 10m **Speaker**: Anselm Vossen (member@duke.edu;faculty@duke.edu)
11:00 AM	→ 11:20 AM	**IP8: Design, options and opportunities** 20m **Speaker**: Walter Wittmer (employee@jlab.org;member@jlab.org)
11:20 AM	→ 11:35 AM	**IP8: Infrastructure** 15m **Speaker**: E. C. Aschenauer (BNL)

- Meeting time: Fridays at 10:30 EST
- First meeting: September 2

- Future meetings will focus on user presentations covering topics in nuclear and accelerator physics, detector technologies, and engineering

- Starting in November there will also be a series of CFNS workshops related to the 2nd detector.

The initial focus will be on formulating the science goals for the 2nd detector.

EIC call for detector proposals – science goals

Detector 1 Collaboration Proposals: Experiments must address the EIC White Paper and NAS Report science case. The collaboration should propose a system that meets the performance requirements described in the EIC CDR and EICUG YR.

Detector 2 Collaboration Proposals: Experiments should address science goals described in the EIC White Paper and possibly science beyond that and enable some complementarity to Detector 1.

Please note that the charge for the evaluation of both detectors rested on the 2012 White Paper. In the case of Detector 1, it also included the NAS report, while in the case of Detector 2, possible science beyond the white paper. The Yellow Report was only referred to in the context of performance requirements for Detector 1.

2012 White Paper - physics deliverables of the EIC

- **Proton spin:** Within just a few months of operation, the EIC would be able to deliver decisive measurements, which no other facility in the world could achieve, on how much the intrinsic spin of quarks and gluons contribute to the proton spin.

- **The motion of quarks and gluons in the proton:** Semi-inclusive measurements with polarized beams would enable us to selectively probe with precision the correlation between the spin of a fast moving proton and the confined transverse motion of both quarks and gluons within. Images in momentum space are simply unattainable without the polarized electron and proton beams of the proposed EIC.

- **The tomographic images of the proton:** By measuring exclusive processes, the EIC, with its unprecedented luminosity and detector coverage, would create detailed images of the proton gluonic matter distribution, as well as images of sea quarks. Such measurements would reveal aspects of proton structure that are intimately connected with QCD dynamics at large distances.

2012 White Paper - physics deliverables of the EIC

- **QCD matter at an extreme gluon density:** By measuring the diffractive cross sections together with the total DIS cross-sections in electron+proton and electron+nucleus collisions, the EIC would provide the first unambiguous evidence for the novel QCD matter of saturated gluons. The EIC is poised to explore with precision the new field of the collective dynamics of saturated gluons at high energies.

- **Quark hadronization:** By measuring pion and D^0 meson production in both electron+proton and electron+nucleus collisions, the EIC would provide the first measurement of the quark mass dependence of the hadronization along with the response of nuclear matter to a fast moving quark.

DPAP report - key science questions that the EIC will address

- How do the nucleonic properties such as mass and spin emerge from partons and their underlying interactions?

- How are partons inside the nucleon distributed in both momentum and position space?

- How do color-charged quarks and gluons, and jets, interact with a nuclear medium? How do the confined hadronic states emerge from these quarks and gluons? How do the quark-gluon interactions create nuclear binding?

The accelerator design foresees two interaction regions, IR6 and IR8. The interaction region IR6 is designed to meet the physics requirements of, *e.g.*, the White Paper and will host Detector 1. A pre-conceptual layout exists for IR8, with a larger crossing angle compared to IR6 and possibly using a 2^{nd}, downstream focus, if feasible. It is supposed to host Detector 2.

The 2^{nd} focus option would expand the physics capability, thereby adding to the complementarity between the two detectors, as discussed in Section 2.1 below.

DPAP report – assessment of physics capabilities - complementarity

The CORE studies for DVCS and exclusive meson production find that the reaction kinematics can be reconstructed from the central detector alone. This allows the extension of the parton imaging program from the proton to nuclei, and it may increase the precision of measuring *t* in *ep* collisions. The panel regards this as a good example of specialization/optimization to enhance the complementarity between two detectors, discussed below.

Please note that the nuclear DVCS studies relied on both a 2nd focus and an extension of the high-resolution $PbWO_4$ EMcal to cover the full outgoing electron hemisphere ($\eta < 0$). Electron beam energies of 5-10 GeV were assumed, as these are best suited for 3D structure measurements.

DPAP report – assessment of physics capabilities - complementarity

The CORE proposal makes a convincing case for the significant gain in physics reach achievable with a secondary focus:

- kincreased acceptance in the invariant momentum transfer t of the scattered proton in ep collisions, which directly translates into an increased resolution power for imaging partons in the transverse plane,
- significantly improved abilities to detect nuclear breakup in exclusive and diffractive scattering on light and heavy nuclei. The distinction between coherent and incoherent scattering is essential for the physics interpretation of these processes,
- prospects for a program of low-background γ gamma spectroscopy with rare isotopes in the beam fragments.

Complementarity in the proposal for the upcoming CFNS workshop

Complementarity 1: cross checks and detector synergies

- The second detector should be able to cross check results from Detector 1, presumably with an emphasis on the common White Paper goals.
- The combined data from Detector 1 and 2 could reduce systematic uncertainties in key channels (*cf*. H1 and ZEUS).

Complementarity 2: new opportunities

- The second detector can provide opportunities to carry out measurements that cannot be undertaken with IR6/Detector 1 combination or significantly extend the capabilities, for instance as outlined in the DPAP report.
- Note that some new capabilities could provide direct extensions of the White Paper goals (*e.g*., studies of the 3D structure of nuclei), while others could be physics beyond the WP (e.g., BSM).