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EIC Physics and Detector Concepts: The Path to a Yellow Report

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Purpose

Advance the state of documented (i) physics studies (White Paper, INT program proceedings) and (ii) detector concepts (Detector and R&D Handbook) in preparation for the EIC. This will provide both the basis for further development of concepts for experimental equipment best suited to the EIC science needs, including complementarity of the two detectors/interaction regions, and input towards future Technical Design Reports (TDRs) of the experimental equipment.

Strategy

- Quantify **physics measurements** for existing or new physics topics and implications for detector design
 - This will be a more technical description than exists in the White Paper (WP). Focus not so much on physics motivation of measurements (especially if they are in the WP) but implication for detector requirements: PID, kinematic coverage, backgrounds, systematics. Where is room for compromises, what is critical?
 - What could be the main physics considerations for two independent but complementary detectors?
- Study **detector concepts** based on the requirements defined above, and quantify implications for the physics measurements
 - In the absence of a site and collaboration this needs to be more general looking at multiple possible concepts.
 - Since compromises may be dependent on actual detector concepts, the impact on physics measurements will differ, so this provides a feedback loop.
 - Complementarity between different concepts should also be considered. Complementary concepts should attempt to minimize overall systematics.
- **Optional:** Study opportunities for **accelerator physics experiments** at a future EIC
 - The accelerator scope is to deliver an EIC for nuclear science experiments.
 - The EIC will be one of the most complex and sophisticated collider accelerators ever built. The machine requirements push the state-of-the-art on many fronts including the high degree of beam polarization, high luminosity, beam cooling, beam dynamics, crab cavities for both beams, and an interaction region with

complex magnets. Accelerator physics experiments at this unique facility could further push the frontiers of accelerator science and technology.

- Engage the EIC community independent of laboratories or hosting site
 - The current accelerator and detector concepts are now in a state that with the simulation and software tools developed by the EICUG quantitative physics and detector studies can be done.
 - EIC community engagement may, based on common interest, naturally evolve into proto-collaboration formation.
 - It is vital for this effort that a large fraction of the active participants come from university groups. If it ends up with the labs carrying out the lion share of the work the effort will miss its goals.
- The output will be documented in reports (equiv. to CERN Yellow Reports¹). If this becomes one document or two separate ones can be decided later.

Approach

- Effort is limited in time to ~1 year. April 2021 is considered a feasible deadline.
- Form working groups on physics measurements and detector concepts.
- Each should have 3 conveners (= editors of final Reports). Likely, more than 2 conveners are required to have backup for various tasks. One could have 4 conveners but only if it is the right combination as there is concern people could “hide”.
- For the detector group the conveners need to be mainly experimentalists, but could integrate 1 theorist. This could be important to ensure we would have an integrated theory and experiment approach.
- For the physics group the conveners could be a mix of theorists and experimentalists.
- Each group has 1 Steering Committee (SC) observer that follows progress and reports the status of the effort to the SC.
- The two groups should have regular meetings (preferably weekly) via video conference/phone. At regular intervals (preferably monthly) both groups should have a joint meeting.
- The SC reserves the right to replace conveners detrimental to the effort (e.g. inactivity).
- Each group (physics and detector) will need to be divided in sub-groups. If we have an optional third accelerator group they likely can stay as one.
- Subgroups/Subdivisions:

¹ The CERN Yellow Reports series provides a medium for communicating CERN-related work where publication in a journal is not appropriate. Reports include material having a large impact on the future of CERN, as well as reports on new activities which do not yet have a natural platform. The series includes reports on detectors and technical papers, criteria being that the audience should be large and the duration of interest long. The term Yellow Reports is now used frequently for documents with similar purpose in various physics communities unrelated to CERN.

- Topics should be defined from the beginning by the SC following the analysis of the “Request of Information”. This can be adjusted later, if needed, by conveners in collaboration with the SC.
- Subgroups are headed by a sub-convener appointed by the respective working group conveners in collaboration with the SC
- Subgroups do not need to be all-covering but should address key topics

Possible Subdivisions:

- Detector

Following the EICUG *Request of Information* call:

- Tracking
- Vertexing
- Calorimetry
- Particle ID
- Forward instrumentation / Backward instrumentation
- IR design / Background studies
- Ancillary Measurements: Polarimetry, Luminosity
- Software / Computing
- DAQ / Slow Controls / Readout
- Other

The three areas below have been added as they are important to study and document in the Yellow Reports:

- Magnetic field options (configuration, strength, impact on machine, IR compatibility)
- Arguments for 2 complementary detectors
- Overall design/integration

After analysis of EICUG *Request of Information* the above scheme can be adjusted if needed.

- Physics

Following the EICUG *Request of Information* call:

- Longitudinal (spin) nucleon structure
- 3D nucleon / nucleus structure
- High density parton physics
- Beyond Standard Model / Electro-weak physics
- Hadronization and fragmentation
- Nuclear Structure / Short-range correlations
- Origin of nuclear force
- Collective effects
- Spectroscopy
- Origin of mass
- Other (Entanglement, Jet studies, ...)

Also this subdivision should be adjusted later based upon analysis of the EICUG *Request of Information* input.

Manpower

For this to be successful each study group needs ≥ 30 active members (and likely ≥ 4 active members for any subgroup). For reference, the present EIC User Group has over 900 members, and we should aim to engage at least 10% in this effort. The SC will have to be proactive in the recruitment phase.

This effort needs *substantial* participation from universities willing to invest some amount of their time to this project. It should be clear from the very beginning that people need to engage (more doers, less bystanders).

Integration of detector concepts with the ongoing EIC detector R&D program, presently supporting 11 projects from 49 institutions with over 190 participants, is required. Many, but not all of these are member of the EIC User Group. This could form a core basis of the detector group. To enhance a strong synergy the following steps should be taken: (1) Specifically inform the R&D projects of the planned effort and encourage their participation; and (2) Invite detector group conveners to give brief updates of ongoing efforts and status at the EIC detector R&D meetings in January and July. The detector group conveners should further balance presentations of ongoing R&D projects and their status, which can be highly beneficial for the planned series of workshops, with encouragement of groups to come in with different detector concepts, keeping in mind two complementary full detectors.

Meetings

- Efforts will start with 2-day kick-off meeting
 - Summarize current status on physics (WP + new efforts) and detector concepts.
 - Summarize software and simulation tools available describing the current detector and interaction region concepts.
 - Split in parallel sessions (physics, detector, optional accelerator) for further organization sessions. Discuss who is doing what, and what are the foreseen timelines and activities of the subgroups.
- Have 3-4 workshops every ~ 3 months of physics and detector groups alternating between locations (EIC², CFNS, Universities, West/East coasts, Europe). Workshops should be Video/BlueJeans enabled. Workshop should include plenary and parallel sessions with enough time to actually “work”. Meeting location should be able to accommodate break-out/working sessions.
- Final meeting to finalize Yellow Reports

- The SC will support the conveners in requesting financial support from the two EIC centers (EIC² and CFNS) as well as labs for these meetings.

Timeline

September 20, 2019: Distribute (web/email) purpose and idea behind the Yellow Report efforts as introduced as User-Group driven activity (see Appendix) at the EIC Users Group Meeting in Paris.

October 10, 2019: Pre-announce effort/plan at quarterly EICUG Institutional Board phone call, fold in input of IB on plan and possible location for workshops.

October 2019: SC decides on structure, subgroups, and picks conveners. Work with conveners to get tentative dates/locations for workshops.

October 24, 2019: Pre-announce effort/plan at quarterly EICUG phone call, fold in input of community.

Early November 2019: Announce final effort/plan through mailing lists, invite/ask for participation for workshops (perhaps by mechanism that people can pre-sign up for some meetings)

Late November 2019: SC and Conveners decide on subconveners

December 2019: 2-day Kick-off Meeting

February/March 2020: 1st Workshop

May/June 2020: 2nd Workshop

August 2020: Include session on (short) status reports of main groups (physics, detector and possible accelerator) in EICUG meeting

September/October 2020: 3rd Workshop

November/December 2020: 4th Workshop (drafts of subgroup reports should be available at this point)

January 2021: Final Meeting and assembling of Yellow Reports

February 2021: review team to look at the reports and comment, independent of editors and authors.

April 2021: Release of Yellow Reports, assign editors that keep report up-to-date.

Appendix

Timeline as shown at the 2019 EIC Users Group Meeting in Paris for discussion of Future Planning of user-group driven activities accompanying DOE-driven activities.

