Expression of Interest
Canadian Participation in the Electron-Ion Collider

Please indicate the name of the contact person for this submission:
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Please indicate all institutions collectively involved in this submission of interest:
Mount Allison University, University of Manitoba, University of Regina

Please indicate the items of interest for potential equipment cooperation:
Canadian subatomic physicists have participated intensively in the planning of the EIC and we have chartered a multi-institutional EIC Canada Collaboration to coordinate participation. We anticipate that the Canadian participation will become substantial, reaching about six FTE investigators and about 20 graduate students and postdocs at the time of first beam.

We have requested research support from the Natural Sciences and Engineering Research Council (NSERC) for the Canadian participation in the Electron-Ion Collider for a period of two years, 2021-2023. This request combines the efforts that **six faculty members at three institutions** will undertake through the involvement of four M.Sc. students, and four undergraduate summer research students. In particular, we will:

- determine whether measurements of the pi+ and K^+ form factors in electroproduction at the EIC will be a feasible probe of emergent mass generation in hadrons,
- revisit earlier preliminary studies of electroweak mixing angle measurements with updated performance parameters for the anticipated EIC detectors,
- develop a conceptual design for the electron detection channel in the Compton polarimetry at the EIC,
- build event generators to study the photoproduction of XYZ states by examining channel sensitivity as a function of kinematics and calorimetry,
- contribute to simulations and the conceptual development of calorimetry for EIC,
- meaningfully engage undergraduate students in these research activities to position them well for future participation in the EIC.

At the start of a major project such as the EIC, there is unavoidably some uncertainty. In recognition of this, we anticipate that we will be requesting NSERC support in two-year intervals for the next several project cycles. This allows us to assess the actual progress and recalibrate the optimal levels of support. At this point we are primarily including M.Sc. students who have a timeline to degree completion that is more compatible with two year projects, along with undergraduates working during the summer months and on eight-month honours projects.

We are engaged in several cross-linked EOI efforts:

- Deconinck is involved in the EOI for Software,

- UManitoba is involved in the EOI for Lepton Polarimetry,
- Zisis Papandreou is involved in the EOI for Calorimetry.

This indicates our interest in potential equipment cooperation in the areas of Compton polarimetry (electron detector) and calorimetry.

The **Manitoba group** plans to apply its expertise in **Compton polarimetry** at HERA and Jefferson Lab. The development of Compton polarimetry for the EIC has significant synergies with the upgrade of the Belle II facility to use polarized electrons in their high energy ring. Due to the importance of electron polarimetry, we will attract one M.Sc. student to work on the development of electron detection in Compton polarimetry for the EIC. Over the course of the next two years, we anticipate to contribute to the conceptual design for an electron detection system, including its anticipated position along the electron ring. This project overlaps with our group's expertise in electron detection at Jefferson Lab and our participation in the polarized SuperKEKB efforts. Through hardware expertise with HV-MAPS detectors, we believe that we have a radiation-hard detector technology that will be applicable.

The **Regina-GlueX** group has joined the EIC **Calorimetry** group (with BNL and JLab participants) where the group's experience in building the 30 ton sampling fraction, electromagnetic barrel calorimeter (BCAL) for GlueX will be leveraged, as will the expertise in testing and deploying silicon photomultipliers. The Regina-GlueX calorimetry team has expertise from building the GlueX BCAL (instrumented with large area SiPMs) and is working (under Papandreou's NSERC grant) on the planned upgrade of the GlueX FCAL with a $PbWO_4$ insert, both in hardware efforts (PMT-base combination R&D) as well as in the application of Machine Learning algorithms to optimize photo cluster recognition and sorting of shower split-offs and overlaps. In parallel to the physics simulations and kinematical studies above, the effort of the group will participate in BNL-JLab Calorimetry Working group effort towards investigating calorimetry technologies and in simulation studies, following physics-driven requirements to ECAL and HCAL calorimetry. Simulations will include evaluation of calorimeter response as a function of kinematics—in particular for the physics of interest above—and as well as Machine Learning applications towards calorimeter granularity optimization.

Please indicate what the level of potential contributions are for each item of interest:
The EIC Canada Collaboration anticipates that the next five years will be a period of growth. Opportunities exist for subatomic physics groups with detector technology expertise to join the EIC Canada Collaboration. The current members are in leadership positions in the detector development and physics working groups, as well as the software working groups.

By 2026, we anticipate to have grown our number of PIs to 2.5 FTE and our number of graduate students and postdocs to 9. At that point, we will be at the start of the construction phase of a

major Canadian detector component, funded through a substantial Canadian Foundation for Innovation (CFI) investment of between **CA$1.5M and CA$6M (US$1.13M to US$4.5M)**.

Funding from CFI is awarded to "infrastructure." This typically means a detector component that can be considered to be directly associated with the Canadian contribution. Funding from CFI also requires up to 60% of the total project cost to come from other contributions (provincial financial contributions, international financial or in-kind contributions).

Please indicate what, if any, assumptions you made as coming from the EIC Project or the labs for your items of interest:
The Canadian Subatomic Physics Long Range Planning process is currently underway. Our assumptions are that the support of the Canadian Subatomic Physics community (expressed with the draft recommendation reproduced below) will result in the optimal scenario of support that we submitted to the Long Range Planning committee.

> "5. Position Canada for leadership in future international nuclear physics research
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> The Canadian nuclear physics program is grouped around several key questions that are internationally recognized as being of high priority. To advance our understanding of these key questions, it is understood that Canadians must be leading participants in the development of major international projects. These potential future flagship endeavors must receive the support needed to position Canada for key leadership roles.
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> Significant international nuclear physics projects with significant Canadian leadership contributions include Qweak and GlueX at Jefferson Lab and ALPHA at CERN. The Electron-Ion Collider (EIC) is a major international facility on the future horizon, which will uniquely address profound questions about nucleons (neutrons and protons) and how they are assembled to form the nuclei of atoms. Canadians have been involved in the planning of the EIC program for some time, and a Canadian was recently elected as International Representative on the EIC User's Group Steering Committee. A substantial involvement in the EIC project will confirm Canada's leadership role in scientific research and development." [SAP LRP draft, October 2020, exact language may change]

Please indicate the labor contribution for the EIC experimental equipment activities:
The time commitment (in FTE per year) of members of the EIC Canada Collaboration in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Prof	Research Prof	Staff Scientist	Postdoc	Grad Student	Undergrad Student	Engineer	Designer	Tech	Total Sum
U. Regina	0.15				0.50					0.65
	0.15				0.50					0.65
U. Manitoba	0.30				0.50					0.80
	0.13				0.50					0.63
	0.10									0.10
Mt. Allison U.	0.20					0.40				0.60

NOTE 1: FTE in the above tables represents the annual fractional full time equivalent. The fractions for profs are as entered in our NSERC proposal submissions.

NOTE 2: For a professor, full-time equivalent research time is based on actual research hours per month as certified in NSERC proposal submissions; for a postdoc we are able to assume 100%; for a graduate student we allocate at most 50% (on average); for an undergraduate student we allocate at most 20% (on average).

To indicate how the **EIC Canada Collaboration sees its involvement over the next 15 years**, we are including a table that was submitted to the Canadian Subatomic Physics Long Range Planning process, but with the maximum weights for grad and undergrad students applied as above. The numbers are to some extent already outdated by the process of submitting an NSERC grant for 2021-2023 where the 2.0 postdoc FTE turned into 2.0 grad students FTE (without changing the sum). However, the totals are intended to be representative of our optimal funding scenario, and indicate the scale of the increase in personnel that we anticipate.

Totals by Year	Prof	Research Prof	Staff Scientist	Postdoc	Grad Student	Undergrad Student	Engineer	Designer	Tech	Total Sum
2020 (actual)	1.0			0.2	0.0	0.0				1.2
2021-2023	1.3			2.0	0.5	0.8				4.6
2024-2026	2.5			3.0	1.0	0.8				7.3
2027-2029	4.2			4.0	2.5	1.2				11.9
2030-2036	5.6			5.0	5.0	1.2				15.8

Please indicate if there are timing constraints to your submission:
The Canadian funding cycles are aligned to the financial years, starting on April 1. We are currently on 2 year grant cycles, reflecting the ramp-up in EIC efforts. This allows us, with some frequency, to adjust and increase requests.

Please indicate any other information you feel will be helpful:
n/a