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The Electron-Ion Collider project

Raphaël Dupré, Adam Hoballah, Dominique Marchand, Carlos Muñoz, Silvia Niccolai, Eric Voutier

(IJCLab)

We describe herein our current activities related to the Electron-Ion Collider project and present a plan for a stronger involvement of IN2P3 in this activity. Two technical contributions are outlined: the participation in the R&D, design and construction of the electromagnetic calorimeter for the electron endcap, and the development of the readout electronics for the Roman Pots. They both match well the expertise of the institute, and will allow our group to have high visibility in the community by taking a lead on these two important detector components. A summary of the resources required in the next few years is also presented.

Contents

1 Introduction

Understanding of protons and neutrons, or nucleons—the building blocks of atomic nuclei—has advanced dramatically, both theoretically and experimentally, in the past half century. It is known that nucleons are made of fractionally charged valence quarks, as well as dynamically produced quark-antiquark pairs, all bound together by gluons, the carrier of the strong force. A central goal of modern nuclear physics is to understand the structure of the proton and neutron directly from the dynamics of their quarks and gluons governed by the theory of their interactions, quantum chromodynamics (QCD), and how nuclear interactions between protons and neutrons emerge from these dynamics.

Three central scientific issues that will be addressed by the Electron-Ion Collider (EIC) are as follows. The first is to understand in detail the mechanisms by which the mass of nucleons, and thus the mass of all the visible matter in the universe, is generated. The problem is that while gluons have no mass, and quarks are nearly massless, the nucleons that contain them are heavy; the total mass of a nucleon is some 100 times greater than the mass of the valence quarks it contains. The second is to understand the origin of the internal angular momentum or spin of nucleons. How the angular momentum, both intrinsic as well as orbital, of the internal quarks and gluons gives rise to the known nucleon spin is not understood. And third, the nature of gluons in matter—that is, their arrangements or states, and the details of how they hold matter together—is not well known. The EIC will potentially reveal new states resulting from the close packing of many gluons within nucleons and nuclei. These issues are fundamental to an understanding of the matter in the universe.

To pursue these questions requires peering into nucleons and nuclei with very-high-energy electrons. The high energy is required to achieve the needed resolution, and the only practical way of reaching the needed energies is to collide counter-rotating beams of electrons with protons or atomic nuclei (ions). To carry out the scientific investigations, such a machine must be capable of colliding a beam of polarized electrons of energies from 5 GeV up to 18 GeV with a beam of polarized ions of energies from 40 GeV up to 250 GeV at high luminosity.

The immediate science that the EIC will enable is manyfold. It will permit "tomography" of nucleons and nuclei, in which one builds together many high-resolution, lower-dimensional slices, to arrive at a composite multidimensional picture of their quark and gluon components. It would also be a laboratory for studying QCD with unprecedented depth, opening the study of the collective behavior of quarks and especially gluons. Understanding the collective physics of gluons offers the opportunity for the most surprises, including new phases of matter and deep insights about quantum field theory.

2 The EIC group at IJCLab

The Jefferson Lab (JLab) group at IJCLab has developed a very fruitful physics program investigating the three-dimensional structure of the nucleon and nuclei in terms of the Generalized

Parton Distributions (GPDs). The GPDs offer the exciting possibility of the first ever spatial images of the quark waves inside hadrons, as a function of their wavelength [1–2]. GPDs are accessible experimentally through the measurement of exclusive reactions, where the final state is fully determined.

The high-luminosity fixed-target experiments at JLab have started probing the high x_B region[1], where the scattering occurs primarily on the quarks that make up the nucleon. In order to probe the gluon structure of hadrons, a much higher center-of-mass energy is needed than what is currently available in fixed-target setups.

A new facility dedicated to the study of QCD at low x_B is currently planned at Brookhaven National Lab (NY, USA): the Electron-Ion Collider (EIC). The EIC project has received CD-1 approval in July 2021 from the US Department of Energy (DoE). CD-1 approval marks the completion of the project Definition Phase and the conceptual design. It provides the authorization from DoE to begin the project Execution Phase and allows Project Engineering and Design (PED) funds to be used. The current project schedule aims at a start of operations in 2034.

3 Ongoing activities

Our group intends to continue the exploration of 3D imaging of nucleons and nuclei at EIC in order to investigate the role of gluons in hadronic matter. Our focus will be on the study of exclusive reactions, such as Deeply Virtual Compton Scattering (DVCS) and Deeply Virtual Meson Production (DVMP). The final state of these reactions includes the scattered electron and proton/ion, which remain intact, and the production of an additional particle, such as a photon (in the case of DVCS) or a meson (in the case of DVMP). At high momentum transfer, all 3 particles in the final state are emitted at very small angles. The scattered electron and the created photon/meson go typically into the (electron-going) endcap of the detector, whereas the scattered proton/ion can only be measured in far-forward detectors outside the interaction region (such as Roman Pots).

3.1 Simulations and event generators

Our group is involved in several simulation and event generator activities related to the development of the EIC physics program and more recently in connection to the accelerator and detector designs within the preparation of the EIC Yellow Report released in March 2021 (https://arxiv.org/abs/2103.05419, see Appendix B-a, page 13).

Historically, the first event generator developed in our group and used for the EIC physics is PyQM, a Pythia based generator developed to include several nuclear effects. This generator was used to highlight the physics possibilities to study quark hadronization in nuclear material and processes such as quark energy loss in cold nuclear matter at the EIC. This software was merged four years ago into the Beagle package developed at Brookhaven National Laboratory (BNL) as the generic electron-ion event generator. This software was largely used for the development of

[1] The Bjorken variable x_B is defined from the initial virtual photon (q) and proton (p) 4-momenta as $x_B=-q^2/2p\cdot q$. In Deep Inelastic Scattering (DIS), it corresponds to the momentum fraction carried by the struck quark.

the EIC Yellow Report, in particular for tagged processes in which soft nuclear recoils are detected in addition to the hard scattered particles. More recently, we developed a new event generator for nuclear DVCS with collaborators from the University of Perugia, named TOPEG. This code was also employed in the EIC Yellow Report exercise. These event generators are also used to prepare and analyze JLab experiments on similar topics and a large part of the funding on this effort comes from the ERC Partonic Nucleus.

3.2 High resolution electromagnetic calorimetry R&D

In synergy with our hardware activities at JLab we have started an R&D program on high resolution, homogeneous materials for the electromagnetic endcap of an EIC detector.

In addition to our physics interests in exclusive reactions, nearly all physics processes require the detection of the scattered electron in the electron endcap (backward rapidities). The requirement of high-precision detection is driven mainly by inclusive Deep Inelastic Scattering (DIS) where the scattered electron is critical for all processes to determine the event kinematics. Excellent electromagnetic calorimeter resolution of better than $2\%/\sqrt{E}$ is required at small scattering angles. The highest resolution in electromagnetic calorimeters can be provided by homogeneous materials, e.g. lead tungsten (PWO) crystals.

4 Proposed future involvement

4.1 Software and simulations

In terms of software projects, we intend to pursue the existing effort by maintaining and continuously improving the event generators already developed. This effort will be carried on in parallel to support the analysis of JLab experiments and to refine the EIC studies. Some of these developments will be done in common, while others are planned specifically to improve the generators at high energy for the EIC. Another event generator is also being developed in the field of nuclear TMDs, in particular with the contributions from a postdoc associate funded by the ERC Partonic Nucleus.

Our group will thus be placed to contribute in three important event generators. We propose to reinforce this activity and move its focus from JLab to EIC. We feel that this task is particularly suitable in the field of 3D distribution functions, where phenomenology is a complex but critical activity. It appears as a natural extension of the past contributions by our group to the field of GPD extraction, in a context where phenomenology will become increasingly important as the EIC project progresses.

4.2 Electron-endcap electromagnetic calorimeter

Our group plans to participate in the design and construction of the electromagnetic (EM) calorimeter in the electron-going direction covering a pseudo-rapidity region between -4 and -1, in collaboration with other international institutions also currently involved in the necessary R&D. Our team has a long-standing track record with the construction of homogeneous EM calorimeters at JLab. Our experience spans a wide range of activities including detector design and construction, technical support and infrastructure, readout electronics, and crystal characterization. Figure 1 shows the current design for the electromagnetic calorimeter of the electron endcap, consisting of 2932 lead tungsten crystals. IJCLab has developed the conceptual design for its support structure and integration into the barrel detector, as shown in Fig. 1 (bottom).

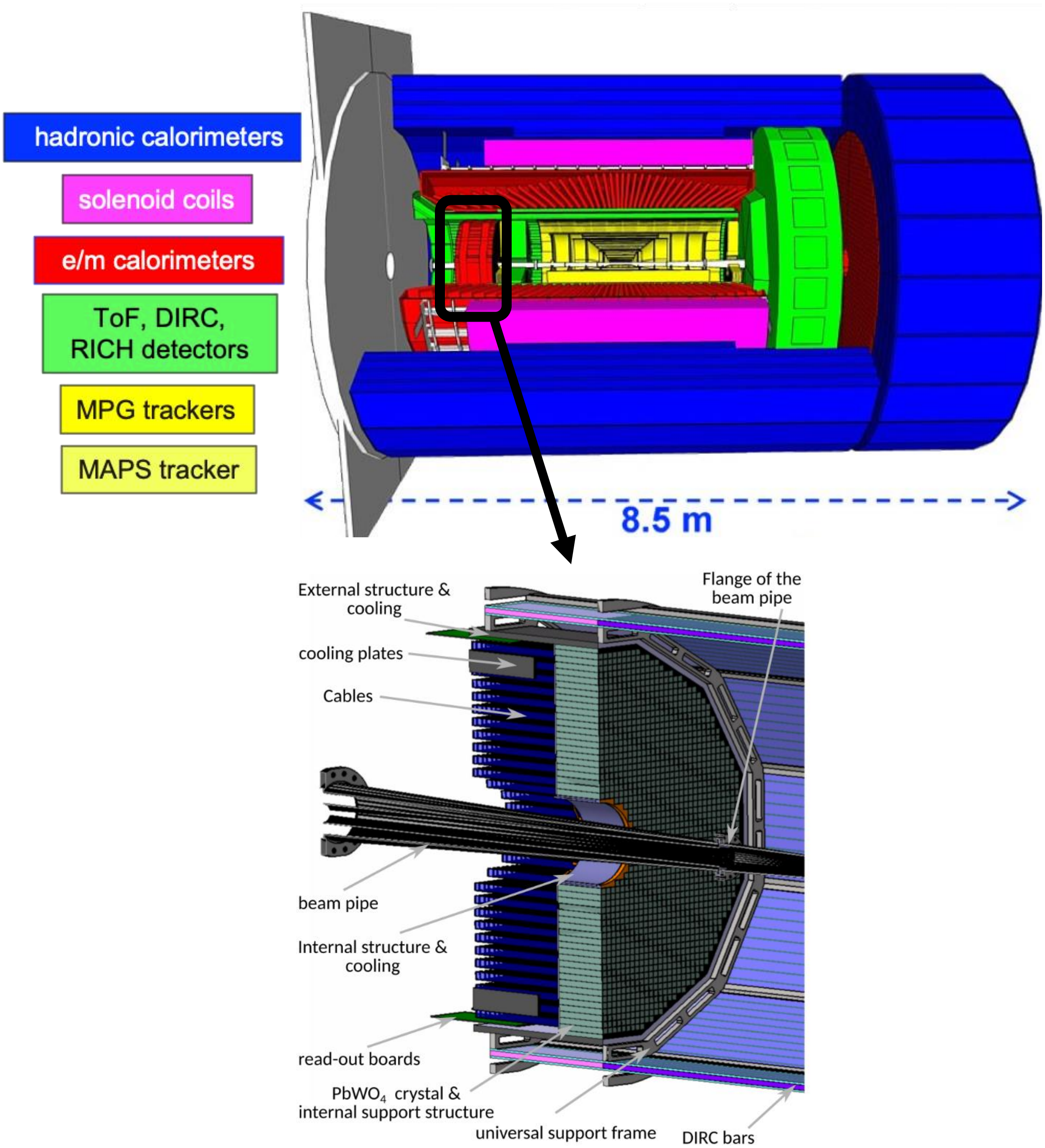


Figure 1: Top: current reference design of the EIC detector, showing its different subsystems. The electron EM calorimeter endcap consists of an assembly of 2932 PWO crystals around the beam pipe (r_{in}=8.5 cm; r_{out}=64 cm). Bottom: conceptual design of the electron endcap EM calorimeter support structure, developed by IJCLab.

In addition to contributions to the mechanical design of the calorimeter, we intend to perform R&D studies oriented towards possible readout systems. An R&T project funded be IN2P3 (2022-2024) will study the combination of PWO and Silicon Photo-Multipliers (SiPM) for the first time, addressing some of the issues that have prevented a straightforward use of the two so far. An optimized readout extended to the UV range will allow increasing the PWO light yield (LY) and therefore its intrinsic resolution. An optimized analog electronic could exploit the full SiPM dynamical range and fast response to make the combination of the two suitable for the EIC. Together with recent developments in readout sensors and electronics, we will be able to improve the energy and time resolution of current calorimeters to the high levels of demand required by the future EIC in particular in the environment of large magnetic fields.

We detail below some concrete activities that we intend to develop in the next 2-3 years, before the actual construction of the calorimeter begins.

4.2.1 Crystal characterization

Crystal detectors have been used widely in total absorption electromagnetic calorimeters made of inorganic materials and have been employed for decades because of their excellent energy resolution and detection efficiency for photon and electron measurements. PWO has been used at hadron colliders and electron accelerators because of its energy and timing resolutions and its radiation hardness. Its high density allows building compact detectors and its fast response provides timing resolution of <100 ps. Finally, its radiation hardness makes it possible to stand high luminosities and long periods of experimental running. Crystals for CMS at LHC were commercially available from 2 manufacturers: BTCP in Russia and SICCAS in China. BTCP produced crystals using the Czochralski method whereas SICCAS uses the Bridgeman method. Basically, all high quality crystals have been produced at BTCP using the Czochralsky method. However, BTCP is now out of business and the worldwide availability of high quality PWO crystals has changed dramatically. Recent studies of crystals from SICCAS seem to indicate major problems maintaining good crystal quality for large scale production and to reach high quality in all relevant parameters simultaneously. Thus, there is a clear need to develop an alternative supplier of PWO. The company CRYTUR in the Czech Republic has started developing a manufacturing process of PWO crystals using the Czochralsky method and the raw material left from BTCP.

The crystal quality will be controlled in close collaboration with the provider. The facilities available at IJCLab and other laboratories in the Paris-Saclay campus will allow the quality control of crystals produced by the suppliers. Thus, the optical transmission will be measured longitudinally as well as perpendicularly to the crystal axis in order to control the homogeneity. The light yield will be determined from the number of detected photoelectrons per MeV deposited energy with a standard bi-alkali photo-multiplier. The signal from gamma rays from a ^{137}Cs-source is typically used. Finally, the radiation damage will be measured by the lateral and longitudinal absorption coefficient. Crystals will be irradiated by strong ^{60}Co sources to determine the degradation of the wavelength-dependent longitudinal transmission as a quantitative measure of the radiation hardness. The details of the spectral distributions give a sensitive hint to impurities and the concentration of defect centers. All these measurements will be essential to define and control the specifications required for EIC calorimeter crystals. The infrastructure developed at IJCLab for crystal characterization can also be used for other scintillating materials currently planned for other subsystems in the EIC detector (eg. scintillating glass for the barrel electromagnetic calorimeter).

4.2.2 Silicon PMT readout

Silicon photomultipliers have developed rapidly in the last 15 years. Their insensitivity to magnetic fields makes them very attractive as a readout solution for scintillating crystals and may be able to provide a measurement of the light output combined with a timing signal with high resolution only limited by the scintillation mechanism. However, there are several outstanding challenges that need to be addressed before they can be used for high-resolution homogeneous calorimetry at medium and high-energy physics. Firstly, their present size is relatively small, which does not allow the collection of most of the scintillating light, in particular relevant for PWO due to its moderate luminescence yield. Secondly, the sensor would need to be capable of covering a large dynamic range over more than 3 orders of magnitude when the electromagnetic shower is laterally deposited over a large number of detector modules. Therefore, the active area of the SiPM has to be composed of a sufficient number of pixels to avoid saturation. Finally, the high rate of dark noise, temperature dependence and so far not yet reached radiation hardness are additional challenging aspects.

Within the framework of an IN2P3 R&T project and in collaboration with colleagues at INFN and JLab we plan to investigate the use of SiPM with PWO crystals. Due to the limited light yield provided by PWO crystals, a high quantum efficiency (QE) readout is required in an extended spectral region (down to 300-350 nm) where the light emission peaks. Standard SiPMs show a sizable QE in the range of interest and prototypes of optimized sensors without the epoxy coating have shown a significant QE down to the UV range (up to 15% at 150 nm). We will study the energy and time response of a PWO crystal equipped with a UV-enhanced SiPM readout. Despite the significant gain (~10^6) of the SiPM, the signal produced in the few photo-electrons range requires a dedicated analog amplification for further processing. A custom analog trans-impedance preamplifier has been developed by the Electronic Service of IJCLab and successfully used to read the 232 channels of the CLAS12-FT Hodoscope at JLab. The current version of the SiPM+preamp system produces a binary (on/off) signal necessary to identify a MIP[2] detector crossing. A modified version of this preamp could provide a signal proportional to the number of pixels excited in the SiPM and indeed proportional to the light produced in a PWO crystal.

For the backend electronics, we could use a system based on the DALTON (Digitizer from ALTO to Narval) board developed at IJCLab and used at the Tandem/ALTO facility. The electronics board consists of a mother board developed at IJCLab and 2 industrial daughter boards (FMC standard) hosting ADC functions, differential amplifiers, etc. The heart of the motherboard is a Virtex 6 FPGA and an ARM processor. This digital system will allow the energy and time measurements of signals with a high sampling rate (ADC 14 bits 250 Msamples/s).

[2] Minimum Ionizing Particle

4.2.3 Gain monitoring and radiation damage

Ultimately, the energy resolution of the calorimeter is dominated at high energy by the control of the relative response of each module. A system to accurately monitor the gain of each channel should be developed and tested. Despite the high radiation hardness of crystals, a significant loss of transmittance is expected in crystals positioned at small angles. Methods to cure the crystal damage produced by the high radiation doses foreseen need to be investigated. The injection of blue light is a possibility that has proved effective for shallow doses and will be explored in the configuration of EIC.

4.2.4 Prototype construction and beam tests

We plan to build a 5×5 (or 6×6) prototype instrumented with different combinations of readout systems (PMT, SiPM, APD) in order to establish the limiting energy and position resolution, as well as the uniformity of the response. The performance of different online calibration and radiation curing systems could also be evaluated. Beam tests could be performed at JLab or another high energy beam facility such as Fermilab.

4.3 Readout electronics of the Roman Pots

The Roman Pots will be essential detectors for the study of exclusive reactions at EIC. As mentioned before, the scattered proton can only be measured by detectors far away from the interaction region. They will also be crucial for the study of all sorts of diffractive processes, which are expected to be one of the cleanest signatures of the gluon saturation regime, a new state of matter predicted by QCD and that the EIC could observe for the first time.

In order to achieve an excellent time resolution (30-40 ps) and be able to be placed as close as possible to the beam axis, new sensors known as LGAD (Low Gain Avalanche Diodes), in their AC-coupled variation, are being studied at BNL. In addition, a pixel size of $0.5\times0.5\ \text{mm}^2$ is necessary to ensure a p_T resolution of 10 MeV/c. LGADs are recent detectors not yet used in high energy experiments, but DC-coupled LGADs are currently planned in the HGTD (High Granularity Timing Detector) upgrade project of the ATLAS experiment at LHC with a pixel size of $1.3\times1.3\ \text{mm}^2$ and a readout ASIC partially developed by OMEGA[3]. The upgrade of CMS also includes LGAD technology.

In synergy with the ATLAS group at IJCLab and in collaboration with OMEGA, our group has started a project to develop and characterize an ASIC to read AC-LGADs at EIC. This project has been funded by a 2-year grant (2021-22) of the P2IO Labex ('*Projets émergeants*' call). The goal of the project is to produce and characterize a first prototype of ASIC for a 4×4 AC-LGAD pixelated sensor with a 0.5 mm pitch. The designed is based in ALTIROC developed for HGTD. However, with a pixel capacity 7 times smaller, the preamplifier of the ASIC developed for the HGTD needs to be redesigned for EIC, taking into account the constraint of low dissipation. While

[3] OMEGA is a CNRS-IN2P3-Ecole Polytechnique microelectronics design center located in the Ecole Polytechnique Campus in Palaiseau.

the signal amplification in the sensor is essential to reach a fast timing response, the design of an ASIC remains a second challenge. In collaboration with OMEGA, the ATLAS team at IJCLab and our colleagues from IRFU/CEA-Saclay, we have produced the first prototype of ASIC dedicated to EIC (see Fig. 2). While our interest is primarily on the Roman Pots, the same AC-LGAD technology is currently considered for other detectors, such as time-of-flight (TOF), trackers and preshowers. It can also find applications in other colliders (FCC, ILC…).

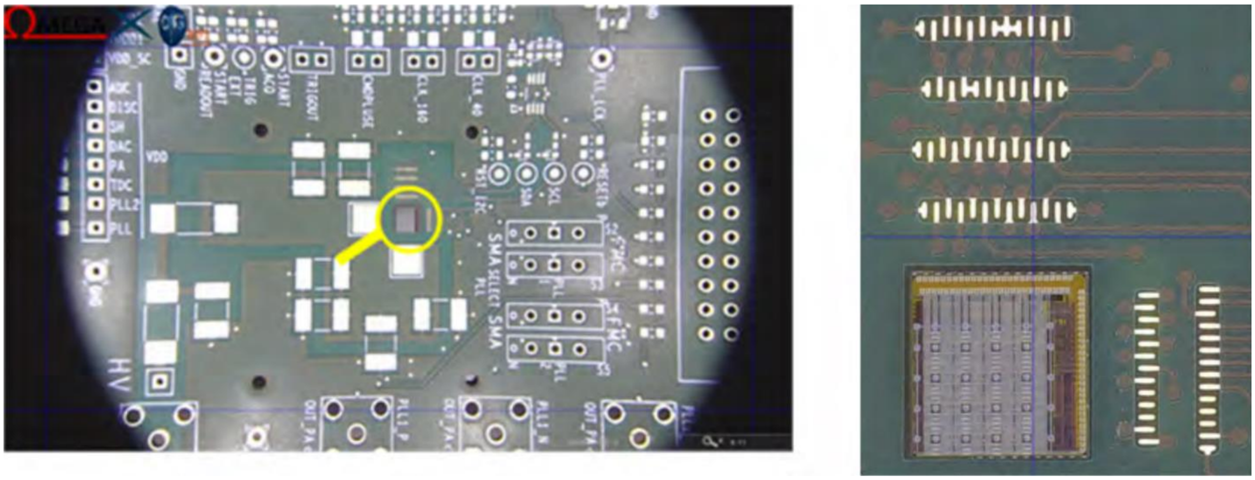


Figure 2: Microscope views of EICROC0 in the test board used for its readout. The picture in the right shows a zoom around the ASIC position.

We are currently charactering the performances of EICROC0, which we received last July. Initial measurements of an AC-LGAD sensor with ALTIROC that our group have performed over the last year indicate a good compatibility of the ASIC architecture. In particular, we have performed measurements of the signal sharing among neighboring pixels using a ^{90}Sr source and we have setup a laser test bench in order to evaluate the response as a function of the impact position of the incoming particles.

A second iteration of this ASIC is planned in 2023 with R&D funds from the EIC project, which will permit the submission of EICROC1 as a Multi-Project Wafer (MPW). We have requested funds from IN2P3 for an R&T project to accompany these external funds while we seek for a longer-term funding (eg. ANR).

EICROC1 will have close to the real-detector size along one direction (16×4) and will aim to reduce its power dissipation by including a new ADC recently designed at IJCLab. The goal for the Roman Pots of EIC is a power dissipation of 1-2 mW/channel, as the detector is in vacuum and is very difficult to cool.

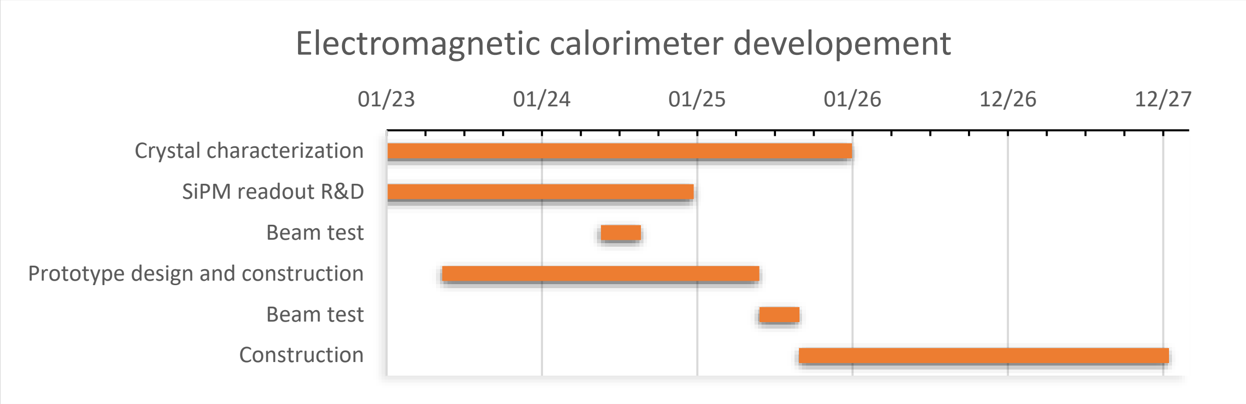
5 Additional opportunities

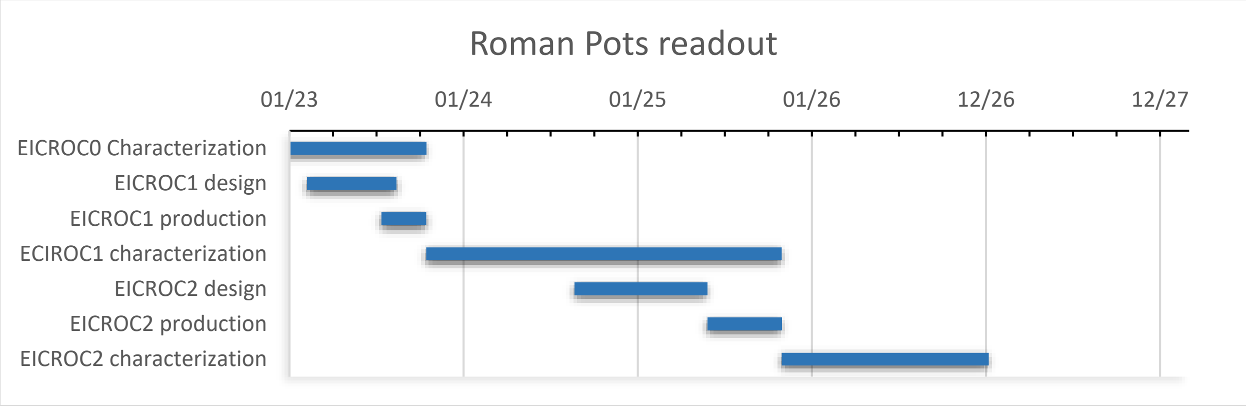
The EIC project presents ambitions technological challenges in several fronts and will provide an excellent opportunity to deploy a large number of innovative accelerator technologies. In particular, the EIC plans to include an Energy Recovery Linac (ERL) for hadron cooling, which will be crucial to achieve the energy and luminosity required. Thus, synergies with the PERLE project would be extremely interesting.

In addition, an accurate measurement of the polarization of both electron and proton/light-ion beams is of paramount importance for the physics of EIC. In particular, for the study of GPDs, the measurement of the cross sections of exclusive processes as a function of the polarization of the beams allows to pin down different combinations of GPDs. The Accelerator Division of IJCLab, in synergy with a Compton polarimetry upgrade of SuperKEKB, could contribute to the design of a Compton Polarimeter for the electron beam of EIC. Specifically, its expertise would be key to the laser system for which a precise control of the polarization is critical. If this avenue is pursued, our group would be interested in collaborating with the Accelerator Division to help define the polarimetry requirements needed to deliver the science program of EIC.

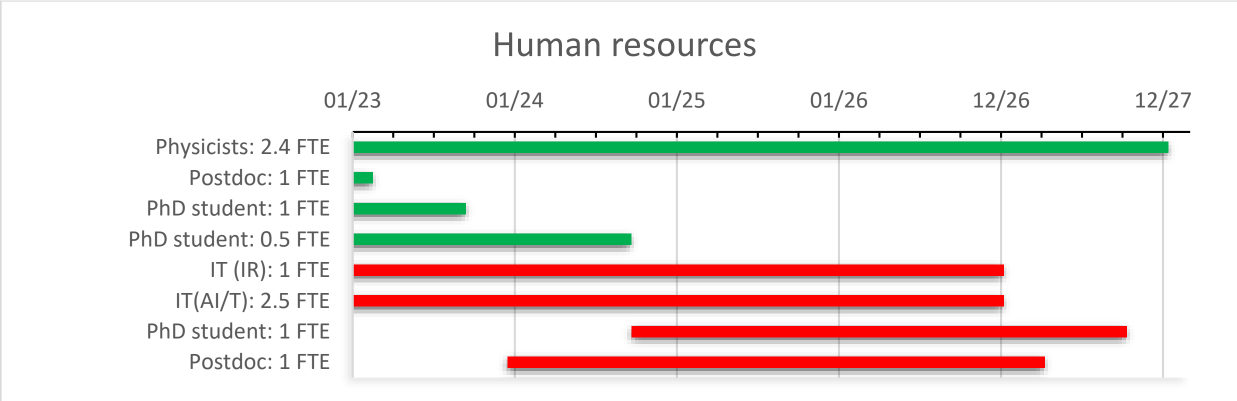
6 Request of resources

The charts below indicate the timelines planned for the projects mentioned above.





The following chart summarizes an estimate of the human resources required. We indicate in green the resources currently available in our group, and in red our needs for technical staff and future PhD and postdoc positions.



Finally, the following table includes our budget estimate in order to accomplish the projects above. It expands over the next few years. If the projects are successfully pursued, we anticipate the need of about 100-200 k€/year after 2024 in order to have a visible impact in the construction of the EM calorimeter (in collaboration with other institutions), and the development of the final readout chip for the Roman Pots.

Year	EM Calorimeter	k€	Roman Pots	k€	Total (k€)
2023	R&D & prototype	40	EICROC1 prototype	95	**135**
2024	R&D & beam tests	30	EICROC1 characterization	20	**230**
2025	Design/engineering (parts)	30	EICROC2 prototype	200	**~100-200**
2026	Start of construction		EICROC characterization		**~100-200**
2027					**~100-200**

Table 1: Budget estimate

7 Conclusion

We have presented our activities in relation to the EIC project and proposed to maintain our strong involvement by actively participating in two technical contributions, in addition to continuing our developments in software and simulations.

The electromagnetic calorimeter of the electron endcap is a crucial part of the EIC detector, and the technology choice is settled. Our expertise with crystals in previous calorimeters and our capabilities of detector design and construction puts us in a very good position to have a strong impact with minimal risk.

The use of LGAD technology for the Roman Pots of EIC is a very promising avenue of development. IJCLab, in collaboration with OMEGA, can play a leading role in the readout of these detectors if the current R&D is successful and this technology choice is selected. It also opens the possibility of application to other EIC detectors and in other accelerator facilities. While there is a technological risk, we consider it is worth pursuing the proposed R&D during the next 2-3 years to assess the feasibility of the readout.

Appendix

A. Coordination with the JLab activities of the group

Our group has currently 2 ongoing hardware projects for JLab experiments, at different levels of development:

- The NPS (Neutral Particle Spectrometer) calorimeter construction is completed and the detector is currently being tested at Jefferson Lab. The commissioning will take place in June 2023 and the experiment will take data from July 2023 to March 2024 in Hall C.
- The ALERT (A Low Energy Recoil Tracker) detector is in the final stages of construction and its assembly is planned for 2023. The experiment will take data during 4-5 months in 2024 in Hall B.

In addition, there is interest in the group to engage with the Accelerator Division of IJCLab in order to develop a polarized positron source (PEPPo, standing for Polarized Electrons for Polarized Positrons) to be implemented at JLab.

The NPS project will require about 0.5 FTE from the Engineering Division of IJCLab during 2023 for its commissioning. The involvement of physicists will mostly take place in 2023-25 for the data taking and their analysis. We plan to recruit a PhD student in 2023 in order to take the lead on those tasks.

The ALERT project will require about 1 FTE of engineer, 0.5 FTE of designer and 2 FTE of technicians from the Engineering Division of IJCLab in 2023 for the completion of the detector project locally. An additional 0.5 FTE is expected to be needed in 2024 for the installation and commissioning of the detector at JLab. A moderate involvement of physicists is constant in the project, but will significantly increase when the experiment runs and afterwards, when data are analyzed.

The PEPPo project is developing within a collaboration between the Center for Injectors and Sources of JLab and our group at IJCLab with the short term goal of achieving a CDR (Conceptual Design Report) for a polarized positron source at JLab over the 2 coming years. A TDR (Technical Design Report) and prototyping phase would follow before actual implementation at JLab. In this context, a collaboration with the Accelerator Division of IJCLab has been discussed to involve up to 0.4 FTE over the CDR period. The IJCLab team also comprises a PhD student working full-time on PEPPo (since 10/2020).

Aside from the technical projects cited above, the data-taking and data-analysis activities at JLab will continue for the next ~5 years, with in particular the participation in two Hall-B experiments with polarized targets of which our group is spokesperson. A PhD student, sharing her time between Hall-B analysis and EIC-related studies, has joined the group in 10/2021.

B. Timeline of the EIC project and Users Group activities

Since the official start of the EIC project, the activities to accomplish its realization have been rapidly organized and actively pursued. Figure 3 shows the project schedule as recently presented by its management [3].

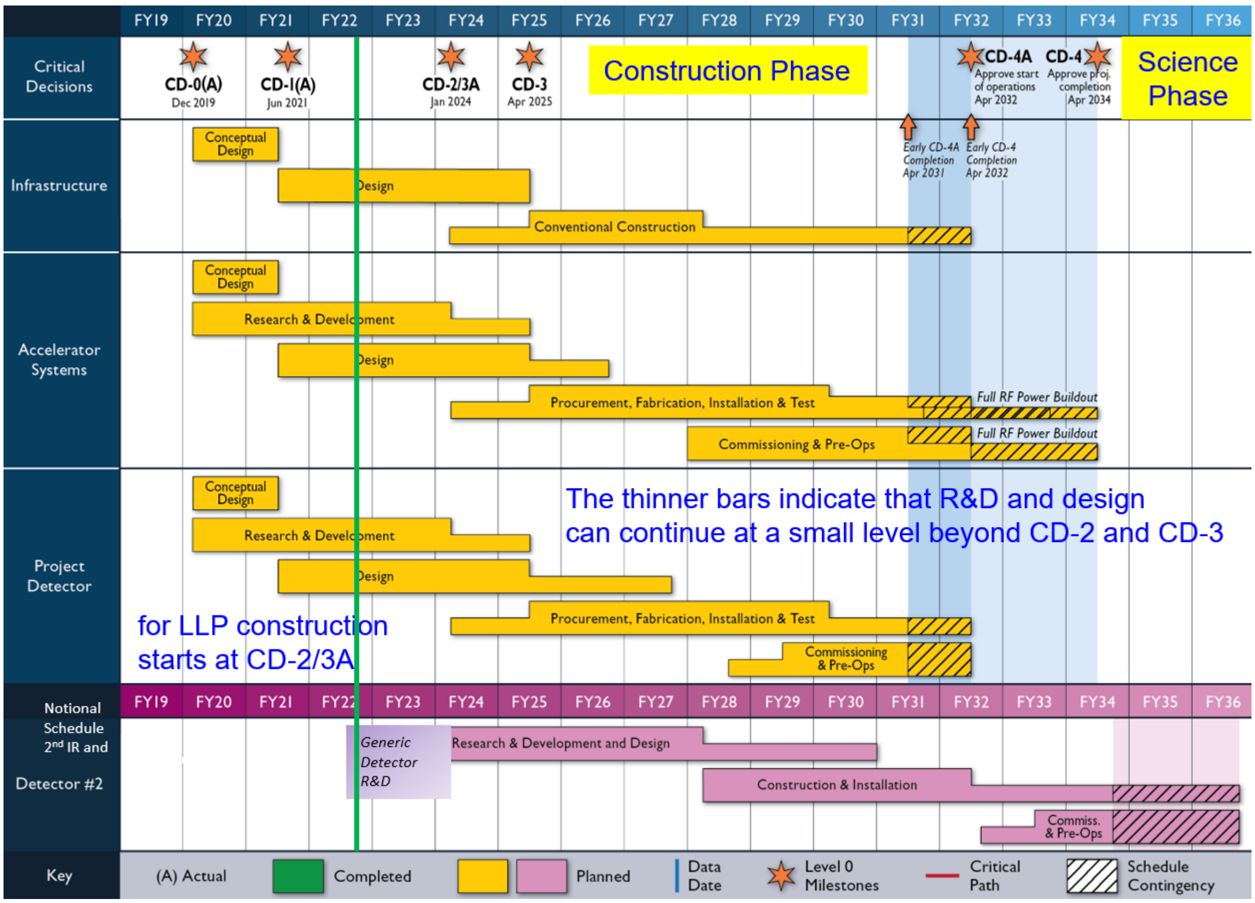


Figure 3: EIC project schedule

In parallel, the EIC Users Group [4] have started a process to organize the community towards the creation of collaborations and the construction of detectors. Some important steps in the process are described below.

a. The EIC Yellow Report Initiative

The purpose of the Yellow Report Initiative was to advance the state and detail of the documented physics studies and detector concepts in preparation for the realization of the EIC. The effort aimed to provide the basis for further development of concepts for experimental equipment best suited for science needs towards future Technical Design Reports (TDRs).

Two working groups were organized, one on physics requirements and one on detector concepts. Each group had four conveners and one Steering Committee (SC) observer that followed progress and reported the status of the effort to the SC. Each group was further subdivided in smaller groups each with its own sub-conveners. The effort concluded with the release of a comprehensive Yellow Report in March 2021 [5].

Our group at IJCLab actively participated in this initiative, and co-led several of the working groups.

b. Expressions of Interest for Potential Cooperation on the EIC Experimental Program

BNL, in association with JLab, made a call for a non-binding Expression of Interest (EOI) for potential cooperation on the experimental equipment as required for a successful science program at EIC [6]. Our group, together with other IN2P3 institutions, responded to the call, following discussions started within the national 2020 Long Range Plan initiative (*Exercice de prospective nationale en physique nucléaire, physique des particules et astroparticules*). Our contribution can be found in Ref. [7].

c. Call for detector proposals

In March 2021, there was be a call for EIC detector proposals, with a deadline in December 2021. A Detector Proposal Advisory Panel (DPAP) met in December 2021 and January 2022 to select one of the detector concepts proposed. Our group actively participated in the process, including leading roles in the proposal which was finally recommended as the reference design for the EIC detector.

d. EIC detector collaboration formation

A new experimental collaboration was formed soon after the DPAP recommendation was released: the Electron Proton and Ion Collider (EPIC) experiment. It was formed to realize the physics program at the first detector of the Electron-Ion Collider and is making fast progress towards the detector technical design, with the goal of having a TDR by 2024. Our group also participates strongly in the EPIC collaboration, with several leading roles within the different working groups.

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