

Date: 12/29/17

EIC Detector R&D Progress Report

Project ID: eRD21

Project Name: EIC Background Studies and the Impact on the IR and Detector Design

Period Reported: from 10/01/2017 to 12/29/2017

Project Leader: Latifa Elouadrhiri and Charles Hyde

Contact Person: Latifa Elouadrhiri

Project members

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Vasiliy Morozov (Jefferson Lab)

[Nick Markov \(University of Connecticut\)](#)

[Christine Ploen \(Old Dominion University\)](#)

Marcy Stutzman (Jefferson Lab)

[Mike Sullivan \(SLAC National Accelerator Laboratory\)](#)

Mark Wiseman (Jefferson Lab)

Pavel Degtiarenko (Jefferson Lab)

Note: [The project members listed in blue are supported by the eRD21 funds for their work on this project.](#)

Abstract

This document describes the progress made since the start of our R&D project eRD21 (October 1, 2017). The goal of our proposal is to perform detailed simulations of the EIC machine related backgrounds generated in the interaction region (IR). The first phase of the project is to create realistic simulation tools and procedures and a validation method using HERA background data. The second phase is to apply this to the JLEIC configuration keeping in mind that the developed tools and procedures are of general applicability to any EIC IR design. This requires close collaboration between the accelerator and detector groups to support an iterative design process which maximizes the capabilities of the physics program at the EIC. The focus of this past quarter has been on the completion of the HERA benchmarking studies and the development of the engineering and simulation modeling of the JLEIC beam pipe design as described in section 6: Project Deliverables of the original proposal.

Past

What was planned for this period?

The items listed below are the project deliverables for FY2018 first and second quarter as stated in section 6 of our proposal.

- Complete and document the HERA benchmarking studies.
- Model the current baseline design of the JLEIC IR beam pipe concept in GEMC/GEANT4 simulations.
- Benchmark synchrotron radiation rates produced within GEANT4 and compare with SR code simulations.
- Develop an interface of the SR code to GEMC.
- Model the current baseline design of JLEIC IR beam pipe concept in a 3D CAD model.

What was achieved?

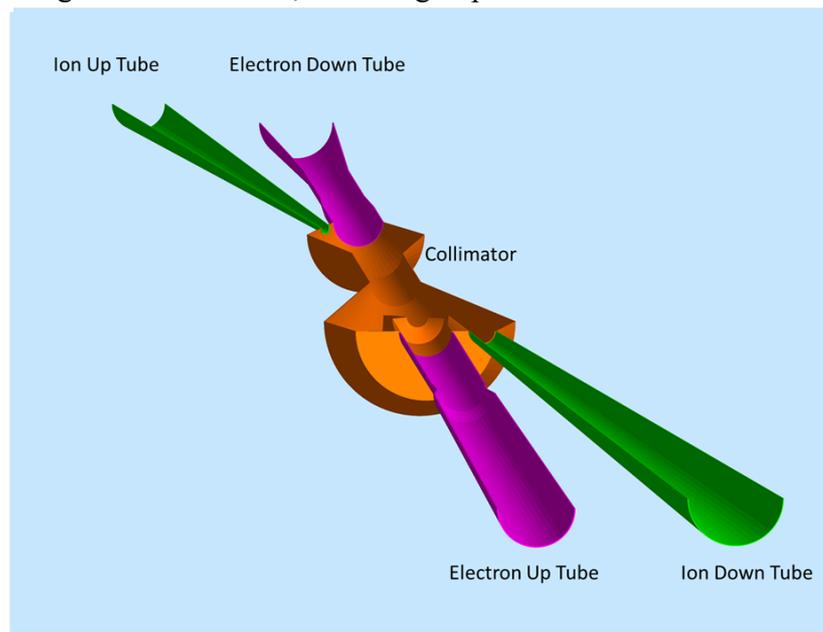
We have made good progress since the start of our project eRD21 (October 2017) on all the project deliverables listed above. We are on track to meet the deliverables of FY2018 and we are discussing plans for beyond FY2018. We quickly put a collaboration between Jefferson Lab, Old Dominion University, University of Connecticut and SLAC National Accelerator Laboratory in place. The team members are from physics, accelerator, and engineering groups. We have established weekly meetings and additional technical meetings as needed to discuss the project status and next steps. Starting January 2018, the BNL team will also join these meetings. We had our first in-person meeting with collaborator Mike Sullivan (SLAC) at Jefferson Lab this December to discuss and finalize a baseline concept of the IR beam pipe.

The focus of this period was on the completion of the HERA benchmarking and the preparation of the JLEIC modelling and simulation. Below we report on the status of each one of the deliverables.

- **Complete and document the HERA benchmarking studies:**
We completed the benchmarking of the background rates generated by beam-gas interactions in our simulation framework. This was achieved by reproducing or scaling the HERA configuration and parameters for simulation in GEMC/GEANT4. Additional variations on the HERA configuration, such as varying the length and density of the deteriorated vacuum, beam pipe material, beam energy, as well as variations due to reference physics list were analysed and further confirmed the reliability of the simulation. The studies performed using HERA conditions established the validity of modeling hadronic beam-gas interactions in GEMC and Geant4 for future studies of background produced near the IR of an EIC. A draft paper has been produced and will be finalized by end of January.

- **Model the current baseline design of JLEIC IR beam pipe concept in GEMC/GEANT4 simulations.**

The engineering design of the IR beam pipe is performed in a Computer Aided Design (CAD) program, and the background simulations are done with a Geant4-based program. In this project, we used tools to automate importation of the IR and machine design's engineering models into Geant4-based simulation programs which supports rapid, iterative cycles of detector design, simulation, and optimization. Below is an example of the interaction region produced using this technique. The framework is ready for detailed modelling, background simulation, and design optimization.

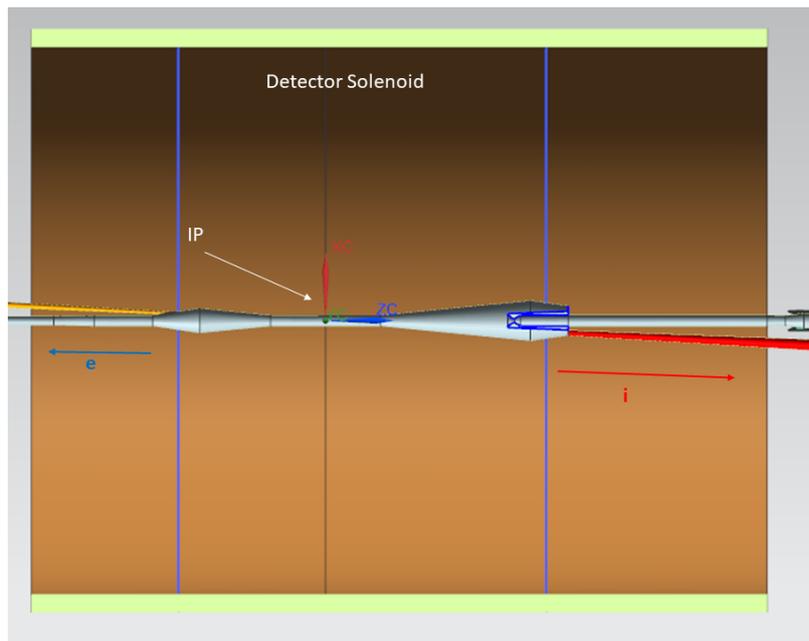


- **Benchmark synchrotron radiation rates produced within GEANT4 and compare with SR code simulations and develop an interface between the SR code and GEMC**

The Synchrotron Radiation (SR) program developed at SLAC by our collaborator Mike Sullivan is ready for our use. The SR program creates a photon file that is read into a Geant4 model as a background source, at which point the detector model then tallies the number of background hits and occupancy of various subdetectors and beamline components. The interface has been tested on previous IR designs. The results from the SR program will be compared to Synrad+ output for benchmarking and validation.

- **Model the current baseline design of the JLEIC IR beam pipe concept in a 3D CAD model**

A concept of the IR beam pipe has been developed, an EIC note has been written, and close collaboration with our engineers is in place. The first CAD model has been developed as illustrated in the figure below. The CAD model becomes input to our simulation.



Future

What is planned for the next funding cycle and beyond? How, if at all, is this planning different from the original plan?

Our plans are consistent with eRD21 project deliverables as stated in the section 6 of the proposal:

1. Complete FY2018 second quarters deliverables. Focusing on the benchmark synchrotron radiation rates produced within GEANT4 and compare with SR code simulations using realistic engineering design. This is necessary for all forthcoming physics simulations, background studies, support structure design, and vacuum pressure distribution studies.
2. Complete FY2018: Third and fourth quarters deliverables:
 - a. Determine background rates as a function of vacuum levels for the JLEIC configuration.
 - b. Determine the intensity and distribution in the beam pipe and in the various detectors using GEMC interfaced with SR code
 - c. Interface CAD drawings with Molflow+ and Synrad+.
 - d. Using validated software tools and result of beam pipe design, evaluate background contributions from hadron beam/gas interactions under nominal vacuum levels. Deliver quantitative analysis of amount and distribution of this background source using EIC parameters. At this stage, vacuum is not yet simulated.

3. Develop FY2019 project proposal: Use Molflow+ and Synrad+ to realistically simulate vacuum conditions. Initially, this will be for static conditions. Next, the SR level determined in year 1 will be used to determine the level of dynamic vacuum due to the SR. The vacuum levels thus determined then will be used in GEMC to update the beam gas boundaries. Finally, the result will be compared to the HERA experience
4. Address the comment from the committee about neutron rates estimates. This will require the use of programs such as Fluka/GEANT3 in comparison with GEANT4 to accurately estimate neutron rates. To address this important comment, we started discussion and collaboration with experts from the JLab radiation group, in fact Pavel Degtiarenko is now consultant on our project.

What are critical issues? Completion of the paperwork for the funding of Nick Markov post-doc from UConn.

Additional information: None

Manpower

Include a list of the existing manpower and what approximate fraction each has spent on the project. If students and/or postdocs were funded through the R&D, please state where they were located, what fraction of their time they spend on EIC R&D, and who supervised their work.

The team members are from physics, accelerator, and engineering groups.

1. Simulations for background: Latifa Elouadrhiri, Christine Ploen (Student) and Nick Markov(Post-doc)
2. IR design contact person: Vasilij Morozov
3. Beam pipe design: Charles Hyde
4. Synchrotron radiation simulations using SR code: Mike Sullivan

5. Vacuum calculation: Marcy Stutzman and Nick Markov (Post-doc)

6. 3D CAD modeling of JLEIC IR and beam pipe and GEANT4 implementation: Mark Wiseman, Christine Ploen (Student) and Nick Markov (Post-doc)

We recruited a replacement for the Jefferson Lab post-doc Kijun Park, originally assigned to this project, by Nick Markov a post-doc from University of Connecticut. Kijun left Jefferson Lab in August for a position in the medical field. Nick comes with an extensive experience in GEANT modeling, electromagnetic background simulations as well as an extensive expertise in data analysis.

There is one student from ODU on the project: Christine Ploen, she is stationed full time at Jefferson Lab. Her home supervisor is Charles Hyde and JLab supervisor Latifa Elouadrhiri. She is assigned 75% to work on the project. Christine took leadership role in the HERA benchmarking studies and has started on the SR benchmarking studies.

There is one post-doc on the project, Nick Markov he is assigned 40% of his time on the project. He is full time stationed at Jefferson Lab. Latifa Elouadrhiri is his supervisor on this project.

External Funding

Describe what external funding was obtained, if any. The report must clarify what has been accomplished with the EIC R&D funds and what came as a contribution from potential collaborators.

The completion of the HERA benchmarking, the IR implementation in GEANT and the synchrotron radiation simulations and interface with GEANT, are funded by the project. The CAD drawing and the detailed concept of the IR beam pipe are contributions.

No external funding was obtained.

Publications

Please provide a list of publications coming out of the R&D effort.

Two EIC notes are in developments:

1. Benchmarking hadronic beam-gas in GEANT4-based GEMC for an EIC (L. Elouadrhiri et al.)
2. Interaction Region Optics and Beam Stay Clear for Ion Injection: Impact on Central Vacuum Pipe Design (C. Hyde et al.)

