MREFC Education and Public Outreach Strategy for US ATLAS

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Contents

1 Introduction

The excitement and fascination generated by research being conducted at the LHC has provided the basis for many valuable and far-reaching programs and activities that promote and develop education and public outreach (EPO). Goals of these efforts include, to promote and ensure a greater diversity of scientists in STEM fields and, to involve and share with a broad spectrum of audiences the societal value and necessity of the research we do. The success of these objectives is vital to securing the future strength and health of not only particle physics, but to science in general.

The HL-LHC project offers a unique opportunity to develop a coherent EPO strategy that leverages MREFC funding to promote and enhance our current EPO programs and objectives. The MREFC proposal can not include funding directed at EPO activities, however, the institutional HL-LHC activities generated by the proposal can take advantage of existing institutional EPO projects and infrastructure for the mutual benefit of both the HL-LHC project and EPO.

Here we outline a strategy for how the opportunities generated within the NSF scope of the US ATLAS upgrade project can be used to promote EPO objectives. This strategy is also being coordinated with the US CMS upgrade EPO plan in order to exploit synergies and common goals between our respective collaborations.

A major focus of this plan is to utilize the scale of the HL-LHC project across multiple institutions, involving on the order of a hundred undergraduate students, to establish a meaningful strategy to develop and retain a STEM workforce of greater diversity, together with a robust assessment plan to quantitatively evaluate the effectiveness of our education and mentoring program. Such a coordinated and focussed effort for EPO (and together with CMS) is taking EPO to a whole new level for US ATLAS and is spawned from the MREFC HL-LHC project in which students will gain experience with cutting-edge technologies that will lead to a broad spectrum of possible future STEM careers.

2 General Considerations

Our HL-LHC EPO strategy is guided by some general considerations and desired outcomes that will tie together the various institutional activities and plans into a coherent overall scheme. Here we summarize these goals, with further details in the sections following.

- **Exploit the scope of the HL-LHC project.**

  MREFC funding for the HL-LHC project will be used for the design, construction, and testing, of particle detectors and data acquisition systems using cutting-edge technologies. This enables a broad range of unique educational and public outreach

activities that are synchronized with the design and construction phase of an upgraded experiment that will expand the horizons of our understanding of the universe. In addition, the scale of the project across many institutions provides unique opportunities to promote inclusion and diversity retention by developing communities in which under-represented groups in particular can identify themselves as being an integral part of. The estimated numbers of undergraduate and graduate students from the 18 US ATLAS MREFC institutions who will be involved in the MREFC project are as follows for each fiscal year of the project [1].

	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	10	17	33	12	0
Graduate Students	8	15	11	8	5

In addition there will be a number of high-school students (of order 20 across the project) and technical staff involved. Together with those from CMS, these represent the population involved in our workforce development plan. In Sections 3.1 and 4 we give details of how we will establish a meaningful and impactful EPO program based on the MREFC activities.

- **Leverage and build upon existing infrastructures.**

  Numerous US ATLAS institutions participating in the MREFC project have established and developed EPO programs and infrastructures that will be utilized for HL-LHC EPO activities. The most common are the REU programs and Quarknet which will need to be coordinated when viable across institutions for HL-LHC projects. These programs are independent from MREFC EPO, but have resources we can utilize. It is envisioned that the increased US-LHC contributions to Quarknet will provide an opportunity to involve Quarknet management in an HL-LHC EPO committee (chaired by the HL-LHC EPO coordinator) charged with formulating meaningful metrics, milestones, outcomes, comparisons, etc.. Quarknet trains high-school teachers, who then go back to their schools to teach/train high-school students. We are considering using this (or a similar mechanism) to address pipeline diversity by including these HS students in the broader URM networks we plan to establish, and which is a major component to our EPO plan. Since the implications for the increased HL-LHC contributions to Quarknet are still evolving we are still woking on how best to utilize resources from these existing programs.

  There are also a number of valuable institutional programs utilizing opportunities, resources, interests, and local student populations, that are unique to a particular institution. We discuss this further in Section 3.1.

[1] These numbers were calculated assuming an undergraduate will contribute 0.25FTE and a graduate student 0.50FTE in a given year.

- **Workforce development.**

  One of the greatest impacts we can have is to increase the diversity in STEM fields at all levels. The HL-LHC project enables the promotion of this objective that is essential to the future health and strength of our field. We discuss in Section 3.1 specifics of how existing programs and planned enhancements will help realize this objective.

- **Evaluation of EPO effectiveness.**

  In order to determine the effectiveness of our EPO efforts we need to establish a concrete plan for evaluation. Our overall EPO strategy needs to be flexible enough to adapt as necessary to data from our evaluation schemes. Furthermore, our evaluation schemes will be closely linked to, and will help prioritize, our desired EPO outcomes. For the outcome of increased diversity mentioned above it is understood that meaningful evaluation will be an ongoing endeavour over many years. We discuss evaluation further in Section 3.2 along with specific avenues we have developed together with US CMS.

The following sections expand upon these points and how they have guided the development of HL-LHC EPO program.

3 Developing an HL-LHC EPO Strategy

Our EPO plan for involving and distributing students across our HL-LHC research projects will be based on; projected HL-LHC project needs, existing and planned US ATLAS HL-LHC institutional involvement, and determining those activities that can best be applied for generating undergraduate (and high-school) research projects.

In Section 4 we detail the EPO activities of US ATLAS institutions that are part of the MREFC proposal. It is apparent that a huge resource of EPO experience and expertise exists across these institutions that can be used to mutually benefit both their HL-LHC research and their EPO programs. Based on the HL-LHC research projects of these institutions, and the projected personnel needs of the project, we will coordinate the students available from each institutional program for each HL-LHC task.

Other components of this plan include the following objectives.

3.1 Workforce Development

One of the overarching objectives for EPO is to increase the diversity of scientists in STEM fields. The US ATLAS HL-LHC project enables a broad range of unique education and outreach activities coupled to institutional undergraduate and graduate programs which

form a program of workforce development that is aligned with the NSF goal of STEM workforce development. A summary of these activities is shown in Table 1. From grade school to graduate programs, US ATLAS institutions are contributing to greater workforce diversity in the following ways that will incorporate their HL-LHC projects.

Several US ATLAS institutions run programs designed to inspire the younger generation to pursue STEM education with a focus on underrepresented groups. The pipeline for underrepresented groups pursuing STEM fields is very "leaky", so intervening as early as possible to both inspire and show strong role models is critical in helping reduce the leaks. Grade school and high school programs are key for that sort of future workforce development. In addition to inspiring URMs to pursue STEM education we must also be committed to assessing and working on the changes required for an environment more conducive to maintaining greater diversity.

On the issue for improving pipeline diversity, we will make recommendations for how to increase connections with minority physics chapters, colleges, high schools, and conferences, in order to more effectively recruit a more diverse group of students.

One of the unique aspects of the HL-LHC project is its scale across many institutions. This provides an opportunity for developing communities among the participants from the various institutions in which URMs in particular can identify themselves as being an integral part of. This will be an important endeavor for promoting inclusion and diversity retention in our field. Specific plans for supporting this goal include informal weekly video/skype chats for under-represented groups across all participating institutions. This will allow URMs to identify within a larger group, make contacts with other students, discuss their respective projects in an informal way, and to talk generally about their experiences. The plan is for these chats to be organized by a mentor from one of the institutions, or possibly by a participating student and facilitated by a mentor. In addition, we plan to organize more formal weekly or biweekly undergraduate meetings for presentations on the work they are doing, and to have regular reports scheduled at US ATLAS meetings. The latter will be designed to give students a better sense of the importance of their roles in a much larger overall effort.

Beyond the technical training students will receive, we are also planning on biweekly meetings (attended by all participants via video) to discuss career development, interviewing skills, STEM career opportunities, etc., where we will on occasion invite a speaker expert on a chosen career topic. These meetings will be designed to give guidance to students along their career path beyond just their research experience. We may also consider expanding these meetings to include graduate students and postdocs working on the project, for whom these issues are also important.

The Quarknet program is supported by many US ATLAS institutions. This program to "teach the teachers" at the high school level has a large multiplier effect when taking into account that one inspired teacher can influence hundreds of high school students. In addition, it now also supports high school students to carry out HL-LHC research under

the direction of faculty mentors. In addition, as part of our HL-LHC EPO strategy we will facilitate involvement from institutions who have not traditionally been involved with Quarknet but who are heavily involved with the HL-LHC.

Undergraduate programs, including a number of REU summer programs and semester at CERN programs have excited undergraduates by affording them the opportunity to spend a summer or a semester at CERN working on ATLAS. This unique and rewarding experience makes a strong impression on these students from smaller undergraduate institutions, many of whom go on to study science at the graduate level. Several US ATLAS HL-LHC institutions are planning to extend existing REU programs, or apply for new programs, that will involve REU students in their respective HL-LHC projects.

The graduate student experience at CERN is unique and highly complementary to the "usual" graduate experience. Besides developing the skills of a physicist by working on the cutting edge of physics, these US ATLAS students are immersed in a global environment, learning to work with an international and diverse workforce. Whether they continue in physics or move on to other fields, that experience is key to forming international connections that will serve them well in their future careers in an ever more globalized world.

In order to ensure we follow best practices for inclusiveness and diversity in the workforce, we are working with the US ATLAS Diversity and Inclusion Committee who are now familiar with our EPO plan and goals. The US ATLAS D&I committee can provide resources and recommendations on best practices for fostering inclusive environments. This committee contains significant expertise in the challenges faced by URMs and the strategies for creating more inclusive environments. The US ATLAS HL-LHC EPO co-coordinator will be responsible for discussing agreed upon strategies with L2 managers and institutional contacts to ensure they are aware of issues faced by URMs and how to mitigate insensitive (and often not conscious) behaviors. We also plan to enact regular (annual) meetings with the US ATLAS D&I committee, the EPO coordinator(s), L2 managers, and institution contacts, to discuss any issues and questions, and to reinforce these strategies.

3.2 Evaluation

An important component of our EPO strategy is the meaningful evaluation of its impact, both in terms of STEM diversity at all levels and, societal impact more generally. An effective approach to evaluating our EPO strategy will allow us to demonstrate how well it is performing for our EPO objectives, and to be able to make informed decisions as to how it might be improved in the future.

We have developed our assessment plan together with CMS, which will be based on entry/exit surveys and follow-up interviews. Working with Prof. Natasha Holmes of Cornell, a STEM education professional, we have devised a set of surveys, the data from which will be analyzed and interpreted by interns working with Prof. Holmes. Further details of these surveys is provided in Appendix A. These surveys are designed to obtain data

on demographics, quality of research experience, and retention in STEM fields. Studies of correlations in this data will guide us to the effectiveness of our workforce development. As we also mention in the management plan, this will require careful oversight and ongoing review. In addition, privacy and confidentiality will be ensured using well-established protocols, and only aggregate data and anonymized quotes will be used in publications and other publicly accessible materials.

There are several other NSF programs that we could potentially make beneficial connections with. For example, STELAR (STEM Learning and Research Center Instruments), OERL (Online Evaluation Resource Library), and DEVISE (Developing, Validating, and Implementing Situated Evaluation Instruments) are all NSF programs dedicated to the development of instruments, data collection techniques, and resources for evaluating education and learning outcomes. Furthermore, we are looking into the NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) program as a possible funding opportunity to better enable our development of the evaluation approaches and techniques that will prove immensely valuable to our HL-LHC EPO programs.

In addition, we are continuing to pursue connections with departments and programs at our institutions that are actively involved in the research of evaluation metrics. One example is the work being done at Columbia Teachers College in gauging the impact of teaching innovations. We are exploring how we may mutually benefit from integrating some of their ideas and expertise for HL-LHC EPO assessment.

Our plan for EPO evaluation has made significant progress over the past several months with the bulk of its structure now in place. In addition we are exploring some other avenues to build upon and extend our evaluation system for it to best serve the HL-LHC project well into the future. We are also developing our evaluation plan in coordination with US CMS in order to have a common system from which we can compare and analyze data.

3.3 Management Structure

Both US ATLAS and US CMS have EPO coordinators who oversee projects funded by their respective entities. These positions are assumed by physicists from US LHC institutions. Due to the constraints of MREFC funding we anticipate redefining the responsibilities of the existing US ATLAS EPO coordinator, and appoint an additional associate EPO coordinator to provide coordination and oversight to the US ATLAS HL-LHC EPO strategy. An important responsibility of this role will be to monitor and ensure the requisite institutional involvement and conduct regular (two per year) review meetings with institutional representatives to discuss issues, successes, and possible modifications to their implementation of the plan.

The HL-LHC EPO coordinator will also be expected to build on the communities of students that develop across the MREFC project as a result of the regular discussion groups

and meetings outlined in Section 3.1. What specific steps to take will likely evolve once we get a better sense of how these get-togethers are working, but the goal will be to facilitate the creation of ongoing student networks to serve as a resource and mentoring avenue for current and prospective students from a given under-represented group(s). Besides the more straightforward step of establishing a platform/website for communication, news, advice, resources, etc., we might also envision connecting with organizations devoted to diversity, such as SACNAS, and offer opportunities for students to give talks and make further connections at events run by these organizations.

As of February 2020, US ATLAS has approved a second EPO co-coordinator position to oversee the HL-LHC strategy discussed in this document. The HL-LHC EPO activities and strategies of the US ATLAS EPO plan will be part of the institutional reporting to the L2 managers overseeing a particular institutional responsibility. Each MREFC institution will either appoint a dedicated EPO contact to assembled and submit their reports, or have their level-3 or level-4 managers include EPO as part of their project responsibilities. Each institution will regularly report student numbers, survey data, and participation in the planned project-wide student meetings. The L2 managers will collate this information to report to the HL-LHC US ATLAS EPO co-coordinator who will oversee the analysis of survey data (together with CMS) and keep track of diversity and inclusion goals across the project. These links and expectations will be made clear in the new US ATLAS EPO co-coordinator charge and in the US ATLAS organizational chart.

4 Current and Planned Institutional EPO Involvement

There are numerous US ATLAS institutions involved with the HL-LHC that have established EPO programs and infrastructure that can be leveraged to exploit the opportunities offered by the HL-LHC project. As discussed we will coordinate these efforts according to the general strategic guidelines listed in Section 2 to establish a strong and coherent US ATLAS HL-LHC EPO program.

Table 1 summarizes the primary focus areas of current and planned EPO activities at each institution involved in the NSF scope of the HL-LHC upgrade. Listed are those activities that can be leveraged and expanded upon using their respective HL-LHC project work. Further details of individual institutional activities and plans is given in the Appendix B.

5 Summary

US ATLAS institutions on the MREFC proposal are engaged in both agency-supported EPO programs such as REU and Quarknet, and their own initiatives that take advantage

Institution	Audience			
	Grade School	High School	Undergraduate	General Public
Arizona			REU	
Boston		Projects for URMs	CERN semester	
Chicago	Projects, Lectures	Projects, Lectures	REU	Lectures, Film
Columbia	Presentations	Student mentoring	REU (@Nevis)	Lectures, Visits
Indiana			Firmware projects	Science Festival
Michigan			REU (@CERN), CERN semester	Virtual Visits
MSU			Hardware projects	Planetarium Show, Film Festival
NIU		Quarknet	Mentoring program, REU	
Oregon		Projects	Projects	Radio
Pennsylvania		Quarknet	Hardware projects	
Pittsburgh		Lectures	URM program	
Stony Brook		Quarknet	Hardware projects, REU	
SMU		Quarknet	Hardware projects	Symposia, Community/HS Lectures
U Mass			Hardware projects	Festivals, Lectures
UT Austin		Lectures, Projects, Women in STEM	Hardware projects	

Table 1: Summary of EPO activities for US-ATLAS MREFC institutions.

of university-specific opportunities, interests, and support.

For the undergraduate and high-school educational component of our EPO strategy we have developed a plan to incorporate the HL-LHC projects of these institutions into these EPO programs in a meaningful and coordinated way to optimally benefit both the HL-LHC project and the associated EPO programs. This involves; a detailed assessment of the personnel needs for each project per institution and the students available from each program, a management structure to coordinate and oversee this plan, and a structure for determining the effectiveness of our plan toward our EPO objectives. This latter point is being developed with US-CMS EPO for more uniform evaluation data to be used for follow-up studies and comparisons.

In addition, we are involved in a variety of public outreach activities that can be of valuable support for the HL-LHC project. Evaluation of these activities is trickier but also important, so we are contacting professionals in the field of outreach assessment to work

with us in developing ideas that we can implement.

A Evaluation surveys: further details

We are working closely with CMS to formulate a consistent EPO assessment plan and evaluation metrics. As part of this plan we have created a set of surveys that will be required to be filled out by project participants. These surveys are designed to evaluate the effectiveness of our workforce training and diversity efforts.

There will be three surveys administered:

1. Entry survey: administered shortly before starting one's research experience
2. Exit survey: administered immediately upon completion of one's research experience
3. Follow-up survey: administered at least one year after the completion of one's research experience

Surveys will be administered by local project leaders and overseen by the appropriate L2 manager. We have been working with CMS and Prof. Natasha Holmes (Cornell), a STEM education researcher, in developing the surveys. In addition Prof. Holmes is interested in recruiting students for analyzing and interpreting the data from the surveys for use in evaluating our HL-LHC EPO program.

The following pages provide the current drafts of these three surveys.

A.1 Entry survey

HL-LHC project: Entry survey

In order to gauge the effectiveness of our HL-LHC educational efforts we would greatly appreciate your time in filling out this short survey. All responses will be kept anonymous.

PART 1: Regarding your upcoming research experience

1. **University or Lab at which you will work:**

   _____

2. **Is this your first LHC research experience?**
   ○ Yes ○ No

3. **Start date (MM/YY):** _____ **End date (MM/YY):** _____

4. **What is your *main* reason for participating in this research project? (select one)**
   - ○ To determine if this is a field I might be interested in pursuing
   - ○ To fulfill a research requirement for my degree
   - ○ To gain experience in research methods and/or data analysis
   - ○ This was my only offer for a research experience
   - ○ My other research options appealed to me less
   - ○ Other: _____

Please rate the following:

5a. **Your understanding of what your project entails is:**
poor ○—○—○—○—○ excellent

5b. **Your excitement regarding particle physics at the Large Hadron Collider is:**
low ○—○—○—○—○ high

5c. **Your desire to pursue a career in physics or a related field is:**
low ○—○—○—○—○ high ○ not applicable

Regarding physics as your major or intended major:

6a. **Are you a physics major, or intend to be a physics major?**
○ Yes ○ No ○ not applicable

6b. **Are you a physics minor, or intend to be a physics minor?**
○ Yes ○ No ○ not applicable

Please turn over...

Part 2: Demographic Information

1. **Current position and institution (e.g. Year 2 undergrad at University of X):**

   _____

2. **Preferred pronouns:**

   ☐ He/him/his
   ☐ She/her/hers
   ☐ They/them/theirs
   ☐ Other: _____
   ☐ Prefer not to answer

3. **Ethnicity to which you identify:**

   ☐ Asian
   ☐ Black/African
   ☐ Hispanic/Latino
   ☐ Native American
   ☐ Pacific Islander
   ☐ White/Caucasian
   ☐ Other: _____
   ☐ Prefer not to answer

4. **Are you the first generation in your family to attend an undergraduate institution?**
   ☐ Yes ☐ No ☐ not applicable

5. **Please feel free to make any further comments and/or suggestions regarding your upcoming research project:**

   _____
   _____
   _____
   _____

Thanks for your time in filling out this survey.

A.2 Exit survey

HL-LHC project: Exit survey

In order to gauge the effectiveness of our HL-LHC educational efforts we would greatly appreciate your time in filling out this short survey. All responses will be kept anonymous.

PART 1: Regarding your completed research experience

1. **University or Lab at which you worked:**

   _____

2. **Was this your first LHC research experience?**
   ○ Yes ○ No

3. **Start date (MM/YY):** _____ **End date (MM/YY):** _____

4. **What was your *main* reason for participating in this research project? (select one)**
   - ○ To determine if this is a field I might be interested in pursuing
   - ○ To fulfill a research requirement for my degree
   - ○ To gain experience in research methods and/or data analysis
   - ○ This was my only offer for a research experience
   - ○ My other research options appealed to me less
   - ○ Other: _____

Please rate the following:

5a. **Your preparation/knowledge before starting your project was:**
poor ○—○—○—○—○ excellent

5b. **During your project the instruction and mentorship provided was:**
poor ○—○—○—○—○ excellent

5c. **During your project you were excited by the work you were doing:**
never ○—○—○—○—○ always

5d. **During your project you felt included and respected by your colleagues:**
never ○—○—○—○—○ always

5e. **Your excitement regarding particle physics at the Large Hadron Collider is:**
low ○—○—○—○—○ high

5f. **If applicable, your desire to pursue a career in physics or a related field is:**
low ○—○—○—○—○ high

Part 1 continued next page...

Please rate the following regarding what you gained from your research experience:

1a. A better understanding of the limitations of research methods:
no gain □—□—□—□—□ great gain □ not applicable

1b. A better understanding of the research and development required for the LHC:
no gain □—□—□—□—□ great gain □ not applicable

1c. Problem solving in general:
no gain □—□—□—□—□ great gain □ not applicable

1d. Comfort in working collaboratively with others:
no gain □—□—□—□—□ great gain □ not applicable

1e. Confidence in my ability to contribute to science:
no gain □—□—□—□—□ great gain □ not applicable

1f. Understanding what everyday research work is like:
no gain □—□—□—□—□ great gain □ not applicable

1g. Anything else you would like to mention that you gained from your project?

_____

2. Please comment on the effect of this research experience on your plans for pursuing a career in physics or a related field:

_____

_____

_____

Regarding physics as your major or intended major:

3a. Are you a physics major, or intend to be a physics major?
□ Yes □ No □ not applicable

3b. Are you a physics minor, or intend to be a physics minor?
□ Yes □ No □ not applicable

Please turn over...

Part 2: Demographic information

1. **Current position and institution (e.g. Year 2 undergrad at University of X)**

2. **Preferred pronouns:**
   - ☐ He/him/his
   - ☐ She/her/hers
   - ☐ They/them/theirs
   - ☐ Other: _____
   - ☐ Prefer not to answer

3. **Ethnicity to which you identify:**
   - ☐ Asian
   - ☐ Black/African
   - ☐ Hispanic/Latino
   - ☐ Native American
   - ☐ Pacific Islander
   - ☐ White/Caucasian
   - ☐ Other: _____
   - ☐ Prefer not to answer

4. **Are you the first generation in your family to attend an undergraduate institution?**
   ☐ Yes ☐ No ☐ not applicable

Please feel free to make any further comments and/or suggestions regarding your research project:

Thanks for your time in filling out this survey.

A.3 Follow-up survey

HL-LHC project: Follow-up survey

In order to gauge the effectiveness of our HL-LHC educational efforts we would greatly appreciate your time in filling out this short survey. All responses will be kept anonymous.

PART 1: Research experience and outcomes

1. **University or Lab at which you conducted your research project:**

   _____

2. **Was this your first LHC research experience?**
   ○ Yes ○ No

3. **Project start date (MM/YY):** _____ **End date (MM/YY):** _____

4. **Today's date (MM/YY):** _____

Please rate the following from your recollection of your research experience:

5a. During your project the instruction and mentorship provided was:
poor ○—○—○—○—○ excellent

5b. During your project you were excited by the work you were doing:
never ○—○—○—○—○ always

5c. During your project you felt included and respected by your colleagues:
never ○—○—○—○—○ always

5d. Your excitement regarding particle physics at the Large Hadron Collider was:
low ○—○—○—○—○ high

Please rate the following regarding the impact of your research experience:

6a. Do you feel your LHC research experience assisted you in your career path?
Not at all ○—○—○—○—○ To a large degree

6b. Your excitement regarding particle physics at the Large Hadron Collider is:
low ○—○—○—○—○ high

Part 1 continued next page...

Please rate the following regarding what you gained from your research experience:

1a. A better understanding of the limitations of research methods:
no gain □—□—□—□—□ great gain □ not applicable

1b. A better understanding of the research and development required for the LHC:
no gain □—□—□—□—□ great gain □ not applicable

1c. Problem solving in general:
no gain □—□—□—□—□ great gain □ not applicable

1d. Comfort in working collaboratively with others:
no gain □—□—□—□—□ great gain □ not applicable

1e. Confidence in my ability to contribute to science:
no gain □—□—□—□—□ great gain □ not applicable

1f. Understanding what everyday research work is like:
no gain □—□—□—□—□ great gain □ not applicable

1g. Anything else you would like to mention that you gained from your project?

Please feel free to make any further comments regarding your LHC research experience:

Please turn over...

Part 2: Demographic Information

1. **Position and institution at time of research experience (e.g. Year 2 undergrad at University of X)**

   _____

2. **How would you best characterize your current position:**

   - ☐ Graduate Student in Physics
   - ☐ Graduate Student in another discipline. Please specify: _____
   - ☐ Postdoctoral researcher. Please specify area: _____
   - ☐ Technical position at an academic institution
   - ☐ Technical position outside of academia
   - ☐ Nontechnical position outside of academia
   - ☐ Other: _____
   - ☐ Prefer not to answer

3. **Preferred pronouns:**

   - ☐ He/him/his
   - ☐ She/her/hers
   - ☐ They/them/theirs
   - ☐ Other: _____
   - ☐ Prefer not to answer

4. **Ethnicity to which you identify:**

   - ☐ Asian
   - ☐ Black/African
   - ☐ Hispanic/Latino
   - ☐ Native American
   - ☐ Pacific Islander
   - ☐ White/Caucasian
   - ☐ Other: _____
   - ☐ Prefer not to answer

5. **Are you the first generation in your family to attend an undergraduate institution?**
   ☐ Yes ☐ No ☐ not applicable

Thanks for your time in filling out this survey.

B Further Details of Institutional EPO Activities

B.1 University of Arizona

Arizona is planning on involving undergraduate students through a summer bridge program (REU) with a local community college that is expected to participate in their HL-LHC program in the near future. They are planning to use undergraduates for testing of the HTT-RTM.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students						
Graduate Students						

B.2 Boston University

Boston University offers the BU Geneva program (`http://physics.bu.edu/pages/show/geneva-program`), where 10-15 undergraduate physics students a year (roughly half from BU and half from other universities) partake in a research semester abroad in Geneva. The physics students who are part of the program take classes at the University of Geneva and do research at CERN. Students have contributed to both studies and hardware projects, such as the HL-LHC upgrade at ATLAS. The program has been active since 2009, with 15 of a total of 75 students working on the ATLAS experiment. It is expected that several students will have the opportunity to participate in hardware projects connected to the HL-LHC upgrade for both ATLAS and CMS

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	0	1	2	2	1	0
Graduate Students	1	1	1	1	1	1

B.3 University of Chicago

The ATLAS group, together with Chicago's Electronics Development Group (EDG), has a long history of outreach to Chicago students, the greater Chicago community, and an even larger audience that they reach through research opportunities, summer programs, lectures, and films. The Chicago ATLAS group (Mark Oreglia, David Miller, Mel Shochet

and Jim Pilcher) is involved in a number of subsystems for the HL-LHC project which they will leverage to provide outreach and education opportunities.

The Enrico Fermi Interns summer program for Chicago Public Schools teaches 6 and 7th graders how to build electronics and use computers. The EDG participates in this program. For the Oreglia group working on the Tile calorimeter, Chicago undergraduate students and REU undergraduates from other institutions (a summer program for women and URM students), participate in the R&D by testing prototypes and helping make measurements during test beam experiments at CERN. Graduate students will participate in system testing and design, learning circuit design and use of tools such as Mentor Graphics (which are valuable skills for workforce development).

For work on the Hardware Track Trigger (HTT), the Shochet group expects to follow a similar program that was used for the Phase-I FTK project. Their outreach focus was getting young people, especially women and minority students, involved in the group's work. This ranged from simple simulation studies and board testing for undergraduates to complex simulation studies, writing firmware, and detailed testing and commissioning for graduate students and postdocs. The undergraduates (about a half dozen, almost all women and minorities) came from; the Chicago physics program, the Chicago summer REU program focusing on women and minorities and, Chicago State University which is a largely minority serving neighboring institution. About half of the graduate students have been women (4 of them), and there have been 2 women postdocs.

The Miller group has undertaken performance studies for the HL-LHC with the help of Chicago undergraduates, and as the HL-LHC project evolves, he expects to involve undergrads in prototyping algorithms and performance studies for the trigger. He also plans to include the data challenges posed by the HL-LHC as part of outreach and broader undergraduate and graduate training. The undergraduates include URMs (in this case a transgender undergraduate who is planning to go on to graduate school).

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students Graduate Students						

B.4 Columbia University

For the past 17 years, Columbia's Nevis Labs has operated a NSF-supported Research Experience for Undergraduates (REU) Site (`https://www.nevis.columbia.edu/reu/`), with typically 10 undergraduates from around the country each summer spending 10 weeks at Nevis Labs (and some at CERN) doing research. They select a very diverse group, actively recruiting women and minority candidates. Of the 166 REU participants to date, over

two-thirds are from under-represented minority (URM) groups. Also, to provide opportunities to those who cannot find them at their home institution, over 40% were selected from schools without a physics Ph.D. program; for the past several years at least 50% have been selected from undergraduate-only institutions. REU research can include physics analysis, hands-on experience with instrumentation, or R&D for future experiments such as the ATLAS HL-LHC project. Of the past REU participants who have since graduated, about 80% went on to graduate school in STEM fields. This is an important measure of the success of the program. Replies to the survey that the students fill out also confirm that they are succeeding in increasing student interest in research. John Parsons is the PI of the REU program. In addition to the REU Site, which is required to be mostly for students from other schools, they regularly involve Columbia undergraduates in their research.

High school (HS) students are regularly mentored in research at Nevis. The students often use their research to enter nation- or state-wide science contests, and a number have competed very successfully in events such as the Regeneron (previously Intel) Science Talent Search and the Siemens Competition. For example, Gustaaf Brooijmans has mentored a HS junior who helped test ADC chips for the ATLAS upgrade. Postdocs Ochoa and Crespo-Anadon are teaching high energy physics courses to HS students enrolled in the Columbia Science Honors Program that operates on campus on Saturday mornings during the academic year. This provides an excellent opportunity to gain valuable teaching experience, and a number of our previous postdocs and senior graduate students have enthusiastically done so. This provides a valuable element of workforce development.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	3	3	3	3	3	3
Graduate Students	3	3	3	3	3	3
High School Students	1	1	1	1	1	1

B.5 University of Illinois

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students						
Graduate Students						

B.6 Indiana University

The Indiana University ATLAS group, led by Hal Evans, is an active participant in the annual Indiana University Science Fest (`https://scienceoutreach.indiana.edu/news-events/science-fest/more-information.html`). A total of 3,050 visitors attended the event in 2017, including a large number of children from under-served school districts in Indiana. IU ATLAS group members were among the original proposers of the event and serve on the organizing committee. An "Activity Room" at the event is devoted to the ATLAS experiment, where the group's activities on the HL-LHC upgrades are presented and where visitors can discuss LHC science with group members.

Graduate students and approximately two undergraduates per year in the IU ATLAS group participate in the design and testing of firmware algorithms, gaining valuable skills and understanding in the areas of high-speed data transfer and in the design of firmware for big-data processing, which is a valuable skill that enhances workforce development.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	1	1	2	2	2	2
Graduate Students	1	1	1	2	2	2

B.7 University of Michigan

Junjie Zhu (L3 TDC Manager) is the PI for the NSF-supported summer REU program at Michigan. Each year the program picks up to 15 undergraduate students across all US universities and sends them to CERN to work with people there for nine weeks. Students work on a variety of physics and hardware projects at CERN. Many recent students have been working on Michigan's HL-LHC-related projects. As an example, in the summer 2016 program (`https://indico.cern.ch/event/538492/`), REU students, Greg Ottino and Mitchell Kerver, worked on HL-LHC related upgrade studies.

Tom Schwarz (L2 Muon Manager for Muons) is the PI for a Research Semester at CERN program funded by the Lounsbery Foundation. This program is intended to provide talented undergraduate students from all over the country with the opportunity to spend a semester at CERN. Students participate in ongoing research after being assigned a mutually agreed upon project chosen from a wide range of high energy research topics, such as assisting with Higgs boson analysis, supersymmetry searches, trigger studies, detector development and upgrade, and many other physics and engineering projects. Roughly two dozen students have passed through the program with a majority working on the ATLAS or CMS experiments and roughly half of those working on hardware projects such as the HL-LHC upgrade. Many students chose to remain at CERN during the summer – several of which continued working on hardware projects.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students						
Graduate Students						

B.8 Michigan State University

During the ATLAS MREFC HL-LHC construction period, undergraduate students will be employed at MSU for the burn-in and testing of the ELMB++ motherboards.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students						
Graduate Students						

B.9 Northern Illinois University

Dhiman Chakraborty leads the NIU group on the HL-LHC project. They have programs for both undergraduate and high school students. The undergraduate program has a number of programs to promote undergraduate research, from department-administered semester-long courses, to university-supported student-mentor research ranging in duration from a semester to a year (some are repeatable). NIU has submitted a proposal to host a REU site, that is awaiting an agency decision. NIU hosts a highly active QuarkNet center that attracts students and science teachers from several nearby high schools into hands-on HEP experimentation (`1http://nicadd.niu.edu/quarknet/`). Participation in each of its many activities ranges typically from 15-30 each year.

In the future, during the HL-LHC project period, NIU plans to leverage their work on the Tile LVPS to provide undergraduate research opportunities in two types of activity; course-based and "freelance". The HEP group has an excellent record of involving undergraduates in construction projects in the past. If the REU proposal is awarded, then NIU would welcome the involvement of suitably qualified undergraduates from participating institutions. The high school program is expected to continue, where one component of the QuarkNet program provides a stipend for student summer research (full time for 4-8 weeks) under faculty supervision. The MREFC project would be an excellent fit for this.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students Graduate Students High School Students						

B.10 University of Oregon

Stephanie Majewski has a group working on the HGL-LHC trigger. Besides graduate students, her group engages undergraduates and high school students in research. This is planned to continue for planned MREFC activities.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students Graduate Students						

B.11 University of Pennsylvania

The University of Pennsylvania instrumentation group runs a QuarkNet program which includes four high-school students and two high-school instructors each summer. The students work together on a project advised by the same engineering team that will be directly involved in the HL-LHC development. They also participate in a series of lectures by engineers, faculty, and graduate students that include the broad context of high-energy physics including the upgrade programs active at the university.

The instrumentation group also takes 5-10 undergraduates each summer primarily from University of Pennsylvania to work on technical projects. These have already included HL-LHC ITk projects and will include the NSF funded trigger projects in the near future. In addition, undergraduate students have worked on HL-LHC sensitivity studies.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students Graduate Students						

B.12 University of Pittsburgh

The University of Pittsburgh ATLAS Group is involved in the following programs and events, both formal and informal, that involve students and the public. The events involve discussion of HL-LHC as part of the bigger picture, but none are exclusively targeting HL-LHC.

For the past few years, Hong involved a large number of students at the University of Pittsburgh in his research group. On average, between four and six students are engaged with about half of them being female students. While they engage in a large number of projects, some of them have been involved in Phase-I Upgrade studies that have implications for the ATLAS HL-LHC upgrade. Also, the trigger rate estimation tool that one of them developed for L1Topo has the potential to be used in the context of the HL-LHC upgrade. The recruitment of freshman/sophomore students from his introductory physics course to engage in research seeks talented females and members of underrepresented groups.

Given this experience, for the MREFC US ATLAS HL-LHC project Hong plans to support undergraduates to assist the group in the firmware project. One task could be running mock software that mimics firmware. Another task could be to help with the input format to the firmware simulation.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students						
Graduate Students						

B.13 SUNY Stony Brook

Stony Brook typically has one or two undergraduates per year doing base grant related research and testing for Phase I. Stony Brook plans to follow this model to leverage testing opportunities for their HL-LHC project activities. These students typically receive research credit during the academic year and are paid during the summer. Not all academic year students work during the summer.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	3	3	3	3	3	3
Graduate Students	1	1	1	1	1	1

B.14 Southern Methodist University

The ATLAS-SMU group plans for 2020-2025 to involve two graduate students in the ATLAS upgrade projects for the Phase-1, Phase-2 and in R&D projects. In addition, several undergraduate students and a couple of high students are typically involved in testing of electronics components for the detector. That number varies with the number of ASICS to be tested and averages to about 5 per year.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	3	3	3	3	3	3
Graduate Students	2	2	2	2	2	2
High School Students	2	2	2	2	2	2

B.15 UC Irvine

The ATLAS-UCI group plans for the period 2020-2024 to involve graduate and undergraduate students in the ATLAS HL-LHC projects. The work typically involve development of software to test trigger algorithms performances and generate test vectors, development of associated firmware for trigger algorithms and monitoring, setting up test benches and testing of firmware with simulation and hardware.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	2	2	2	2	2	2
Graduate Students	2	2	2	2	2	2

B.16 University of Massachusetts

The UMass group is involved in various public outreach activities in addition to undergraduate education involving the HL-LHC.

UMass also involve undergraduates in their HL-LHC hardware projects. About half a dozen undergraduate students in Physics and Electrical Engineering work on hardware projects for the LHC and on upgrades for the HL-LHC. The work typically involves testing of detectors and/or electronics, programming for DAQ and monitoring systems, and firmware development. These students range from freshmen to seniors. About two dozen undergraduate students in Physics also work on data analysis projects at the LHC and HL-LHC. The work typically involves studies of detector performance, event selection, and

sensitivity studies for the large integrated luminosity that will be available at the HL-LHC. The UMass group also conducts seminars for freshmen and talks for seniors. Topics are particle physics, research opportunities, and career prospects. Recent examples include the REU program at UIUC in the summer of 2017 (funded by NSF), the freshman seminar series at UMass Amherst, and the seminar series for undergraduates at UIUC.

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students						
Graduate Students						

B.17 UT Arlington

Anticipated student involvement (numbers, not FTE) in MREFC activities broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students						
Graduate Students						

B.18 UT Austin

The ATLAS group at UT Austin engages local high school and undergraduate students with programs that include public talks and research opportunities. First, Andeen is helping to create a platform for facilitating communication between UT faculty and Austin area school teachers in order to schedule guest lectures at nearby schools. We are starting this with a small core group of faculty and teachers, and the first lectures will occur in the spring of 2018. Some of these lecture will highlight HL-LHC upgrade activities and we expect to reach about 100 students per year.

Secondly, we benefit from an existing program for high school women interested in majoring in STEM: UT Austin's "Alice in Wonderland" summer internships. This program has existed since 2005 and we were happy to be able to take a student during the summer of 2017. We anticipate taking one high school student per year. This last year the student worked with us creating event displays, and in the future we expect these students to participate in HL-LHC related projects.

Finally, we have a (necessarily short) history of involving undergraduate students in research with the ATLAS experiment. Since the start of the UT Austin group in 2015 we have had eight students participate in research with us. Two of the eight are women (specifically, joining us as summer researchers in 2017), and one of the eight is hispanic (in

fact one of the women students). Two of the students are currently working on HL-LHC sensitivity studies. Another student, double majoring in EE, helped lay out a test chip for HL-LHC upgrade R&D. Going forward we plan to include undergraduate students in testing, particularly in the MREFC period when the large-scale testing will begin.

Anticipated student involvement (numbers, not FTE) broken down per fiscal year is as follows.

	FY20	FY21	FY22	FY23	FY24	FY25
Undergraduate Students	2	3	4	2	2	2
Graduate Students	3	3	4	2	2	2
High School Students	1	1	1	1	1	1