ITA Experimental program -- Overview

Evan Niner

Accelerator Readiness Review for the 400 MeV Test Area

9 September 2020

Demand for a FNAL based Irradiation Facility

Broad experimental interest going back a number of years in having an onsite facility available to study the effects of radiation on materials and detector components.

- Achieve “HL-LHC type” fluences of 10^{16} protons/cm^2 in a few hours

Survey to potential users in 2018

- Not comprehensive but indicative of extent of the need for this type of beam facility
- https://www.dropbox.com/s/z4lfshhl7b2lrqw/Responses_All_180522.pdf?dl=0
- CMS, ATLAS, Mu2e-II, DUNE, LHC-B, sPHENIX, TOTEM, RD50, RD53, CubeSats

Onsite location allows for rapid development cycle in conjunction with the Fermilab Test Beam Facility (FTBF) to perform beam tests before/after devices are placed in the ITA.

Recommendations from DOE Reviewers

- 2018 HL LHC CMS CD-1 Director's Review -- Outer Tracker Recommendation, Page 8 of Final report:

1. The review committee recommends that Fermilab work with the DOE to establish a proton irradiation facility at Fermilab. This is particularly important during LS2 when the CERN PS facility will be down. This is critical not only for the CMS Outer Barrel but also for all the HL-LHC projects.

- 2018 HL LHC CMS CD-1 Review, Outer Tracker Comments, Page 8 of Final Report
  - (now also IPT Tracking item R06)

The Committee encouraged FNAL to establish a proton irradiation facility. This will be of great use for the upgrade program and beyond. In case this facility will not be realized or not be available in time, an alternative needs to be developed. An analysis that supports the preferred alternative needs to be performed.

- 2019 HL LHC CMS CD-1 Review, Final Report

-- The irradiation facility at Fermilab is a critical resource for the project and should be completed as soon as possible to support the needs of CMS and other projects.

-- The establishment of an irradiation facility at FNAL will certainly be helpful and we congratulate the lab for this decision.

- 2018 HL LHC ATLAS CD-1 Review, Pixel Recommendation #3 (available on request)

3, Work with DOE to pursue a dedicated proton irradiation facility in the U.S., e.g. by supporting the proposed irradiation facility at FNAL.

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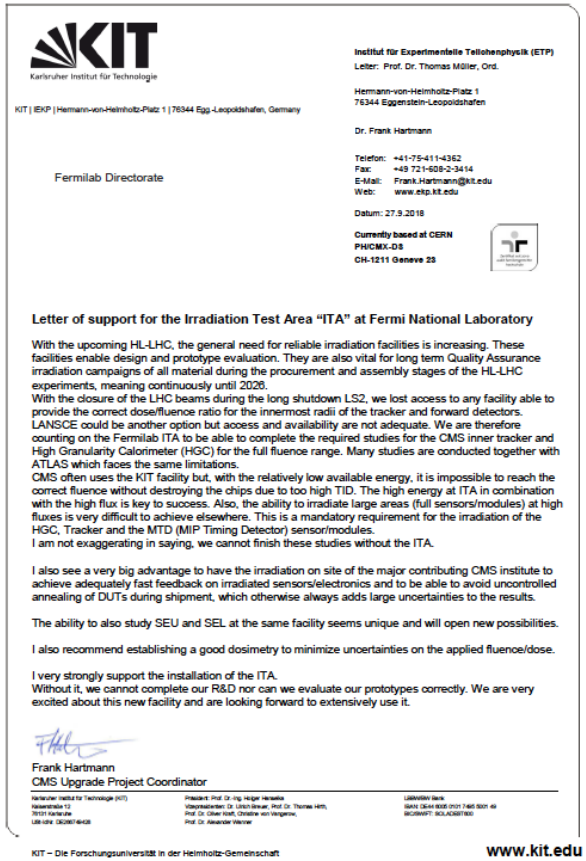
Letter of Support from CMS Upgrade Coordinator



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Letter of support for the Irradiation Test Area "ITA" at Fermi National Laboratory

With the upcoming HL-LHC, the general need for reliable irradiation facilities is increasing. These facilities enable design and prototype evaluation. They are also vital for long term Quality Assurance irradiation campaigns of all material during the procurement and assembly stages of the HL-LHC experiments, meaning continuously until 2026.
With the closure of the LHC beams during the long shutdown LS2, we lost access to any facility able to provide the correct dose/fluence ratio for the innermost radii of the tracker and forward detectors. LANSCE could be another option but access and availability are not adequate. We are therefore counting on the Fermilab ITA to be able to complete the required studies for the CMS inner tracker and High Granularity Calorimeter (HGC) for the full fluence range. Many studies are conducted together with ATLAS which faces the same limitations.
CMS often uses the KIT facility but, with the relatively low available energy, it is impossible to reach the correct fluence without destroying the chips due to too high TID. The high energy at ITA in combination with the high flux is key to success. Also, the ability to irradiate large areas (full sensors/modules) at high fluxes is very difficult to achieve elsewhere. This is a mandatory requirement for the irradiation of the HGC, Tracker and the MTD (MIP Timing Detector) sensor/modules.
I am not exaggerating in saying, we cannot finish these studies without the ITA.

I also see a very big advantage to have the irradiation on site of the major contributing CMS institute to achieve adequately fast feedback on irradiated sensors/electronics and to be able to avoid uncontrolled annealing of DUTs during shipment, which otherwise always adds large uncertainties to the results.

The ability to also study SEU and SEL at the same facility seems unique and will open new possibilities.

I also recommend establishing a good dosimetry to minimize uncertainties on the applied fluence/dose.

I very strongly support the installation of the ITA.
Without it, we cannot complete our R&D nor can we evaluate our prototypes correctly. We are very excited about this new facility and are looking forward to extensively use it.

Frank Hartmann
CMS Upgrade Project Coordinator

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Letter of Support from the US-ATLAS Project Manager

From: "Kotcher, Jonathan" <kotcher@bnl.gov>

Subject: Radiation testing

Date: September 28, 2018 at 3:41:47 PM CDT

To: Vivian O'Dell <odell@fnal.gov>

Dear Vivian:

The U.S. ATLAS institutions participating in the High Luminosity LHC (HL-LHC) Upgrade Project are developing many different devices that require verification of radiation tolerance to significant levels. The Application-Specific Readout Circuits (ASICs) for the ATLAS inner trackers and calorimeters are good examples of this. Currently operating facilities that can reach the required fluences have limited availability, which often leads to prohibitively long wait times (up to 1 year). Such wait times can have a significant impact on the overall construction schedules. Access to a facility that can meet the highest radiation tolerance test levels required with high availability would significantly reduce the risks associated with ensuring that our designs meet the radiation tolerance specifications. Such a facility available at Fermilab will enhance our ability to meet our international obligations.

If there are any additional details we can provide, please don't hesitate to let us know.

Sincerely,

Dr. Jonathan Kotcher
Senior Scientist
Brookhaven National Laboratory
Project Manager, U.S. ATLAS HL-LHC Upgrade Project

Professor Gustaaf Brooijmans
Professor of Physics
Columbia University
Deputy Project Manager, U.S. ATLAS HL-LHC Upgrade Project

Professor Harold Evans
Professor of Physics
Indiana University
Deputy Project Manager, U.S. ATLAS HL-LHC Upgrade Project

Professor Michael Tuts
Professor of Physics
Columbia University
NSF Principal Investigator, U.S. ATLAS HL-LHC Upgrade Project

Letter of Support from sPHENIX group at BNL

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October 15, 2018

Dr Joe Lykken

I am writing to you to express my support for a proton irradiation facility at Fermilab. One of the many challenges facing the experimental heavy-ion and nuclear physics programs is designing detectors and electronics that can operate in the radiation environments that are present in the experimental areas. While the effects of ionizing radiation can be studied using radioactive sources such as ^{60}Co, it is also important to understand the effects from charged hadrons on the electronics. A facility at Fermilab that would allow the performance of electronics in a controlled radiation environment to be studied would be extremely beneficial to the community. The ability to monitor the operation of prototype boards, and characterize the degradation of the performance as a result of irradiation would allow for optimization of component selection and board design. In addition to electronics, studies of the effects of radiation on materials used in detector construction (e.g. glues, plastics) will also be of value. These combined studies will result in improved detector designs that will enhance the physics programs in heavy-ion and nuclear physics.

Should Fermilab pursue implementing a proton irradiation facility in the coming year, the sPHENIX calorimeter electronics group would be interested in conducting tests on electronics that has been design for the sPHENIX calorimeters to understand the long term effects on the the electronics.

Sincerely,

Eric J. Mannel, Ph.D.
PHENIX Group
Physics Department
Brookhaven National Laboratory

Fermilab

Experimental Space

Provide flexible infrastructure to safely accommodate a wide variety of user tests.

Shielding cave will house user devices in the path of the beam both on the “front porch” or inside the cave using the trolley.

Small counting house in adjacent service building for monitoring.

Basic support infrastructure for cabling, cooling, holding/positioning of devices under test (DUT), monitoring, provided.

Typical Experiments

Most experiments will fall into two categories:

Passive DUTs – Materials/devices are placed in the path of the beam to receive a desired dose of radiation. The DUTs are not powered or connected to external equipment and little to no monitoring is needed beyond knowing the total fluence delivered to the samples.

Active DUTs – Devices placed in the beam are powered and/or cooled and require active monitoring/data collection while beam is operated such as for Single Event Upset (SEU) studies.

Operations Process

Users will propose experiments by submitting a Technical Scope of Work (TSW) to the facility, noting the samples being placed in the beam and their destination/purpose at the conclusion of the beam run. Adjustments have been made to add administrative control from the Senior Radiation Safety Officer to this process.

Each experimental installation will undergo an Operations Readiness Clearance (ORC) before beam.

Experiments are operated, removed, stored, and shipped in close coordination with Radiation Safety.

ITA is managed jointly with the Test Beam (FTBF). Many scheduling requests are anticipated to utilize both facilities.

Initial Experimental Plans

We will be typically operating one experiment and beam request per week.

- Beam will operate about 12 hours per week with 10^{16} protons/cm^2 achievable in about four hours.

Initial use will alternate weeks between CMS and ATLAS to test a variety of materials, sensors, and readout chips for the HL-LHC upgrade.

Initial runs will involve silicon samples in the front porch area. Passive samples to start but active tests requiring cooling and power are anticipated within the first couple months of operations.

Representatives from CMS and ATLAS are filling out TSWs now, broader scheduling to follow.

Conclusions

The ITA will support experiments studying the radiation effects on material. Material will be intentionally irradiated; however the facility is not intended to be used as an isotope production facility and any radionuclides produced are incidental to the radiation effects studies.

Broad experimental interest in seeing the ITA at Fermilab. This facility will fill a critical need for the HL-LHC CMS and ATLAS upgrades and more.

We have added an experimental shielding cave, counting house, and basic support infrastructure for initial user needs with the flexibility to adapt.

We have developed a process with Radiation Safety to control the experimental approval, installation, operation, retrieval, storage, and shipment activities.

Initial user operations starting this Fall will focus on CMS and ATLAS studies for the HL-LHC upgrade.

Questions and Comments