

**RADIATION PROTECTION PROGRAM INTERNAL ASSESSMENT SUMMARY FOR THE CY 2014-
CY 2016 TRIENNIUM**

FERMILAB RADIOLOGICAL CONTROL ORGANIZATION

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SUMMARY

During this triennium, the accelerator technology and physics research programs at Fermilab continued to evolve. New facilities were developed as part of the development of the intensity frontier program. During this period, the Laboratory made great strides toward the design of its premier large scale project, the Long Baseline Neutrino Facility (LBNF), being designed to deliver neutrinos to the Deep Underground Neutrino Experiment (DUNE). Fermilab operations during this period centered on the exploitation of the neutrino sector of particle physics in the form of both short baseline and long baseline experiments, the latter with “far” detectors located in Minnesota. Other experiments and R&D efforts also exploiting accelerated proton beams were also conducted. The development of the Muon Campus facilities, first for the Muon g-2 experiment and for the later Mu2e experiment, was ongoing during the latter half of this period.

The most recent Fermilab Radiation Protection Program (RPP) was approved by the DOE FERMI Site Office on October 21, 2013. The current RPP is posted at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=88>. No exemptions to the requirements of 10 CFR Part 835 have been requested by Fermilab and none are anticipated to be needed in the foreseeable future. The RPP is anticipated to be revised early in the next triennium to incorporate changes being made to accommodate the evolving Fermilab research and operational program and also the “leased space” for the far detector of the DUNE experiment at the Sanford Underground Research Facility (SURF) in Lead, South Dakota.

During the CY2014-CY2016 triennium, all elements of the Radiation Protection Program (RPP) implemented at Fermilab were reviewed as required by 10 CFR 835.102. The implementation of radiation protection requirements continues to be effective as judged by the radiation exposures received, reported annually on time and as required to the DOE Radiation Exposure Monitoring System (REMS), the ALARA efforts documented, and the limited number of non-compliances that warranted submission to the DOE NTS system.

This 2014-2016 triennial report is the latest in a series of such triennial reports that are posted on the ESH&Q docdb at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=1557>.

REORGANIZATION OF OVERALL FERMILAB ENVIRONMENT, SAFETY, HEALTH, AND QUALITY (ESH&Q) PROGRAM

During this triennium, a major reorganization of this program has occurred. In accordance with the Laboratory Director’s stated objective of moving toward a more unified “One Laboratory” approach to overall Fermilab management, the Fermilab ESH&Q organization has moved from a system based upon both a central organization, the ESH&Q Section, working with administratively

separate ESH&Q departments within individual Divisions and Sections, toward having all ESH&Q personnel based in the ESH&Q Section. This was done in two stages, with the first step taken in July 2015 with the remainder reorganization being completed in June 2016. The June 2016 reorganization also restructured major portions of the Radiological Control Organization in order to enhance efficiency, promote career development, and provide for a greater level of succession planning.

In the area of radiation protection, in this reorganization advantage is being taken of this excellent opportunity to review procedures, consolidate policies, improve backup support for program functions, and promote lab-wide service in radiation protection. One result is the institution of a complete revision of the Fermilab Radiological Control Manual (FRCM), the document that as part of the Fermilab ES&H Manual system constitutes the Laboratory's set of policies on radiation protection. At the time of writing, this task is approximately 50 per cent complete. Already, numerous program improvements have been incorporated. This effort is taking the form of a comprehensive assessment of the radiological control program and will further guide the aforementioned revision of the RPP to be submitted during 2017.

As part of the reorganization, the majority of the Radiological Control Organization (RCO) personnel were relocated in a newly renovated central location. This will promote more effective leadership and coordination of staff efforts.

SPECIALIZED EFFORTS CARRIED OUT DURING THIS TRIENNium

This section of the report summarizes many of the lab-wide efforts initiated, and mostly completed, during this triennium to improve the radiological protection performance of the Laboratory. Some of these efforts are intrinsically "ongoing" by their nature. While some of these initiatives are restricted to the management of keeping occupational radiation exposures ALARA under the auspices of the Radiation Protection Program, others are more general and also implement important aspects of the Laboratory's Environment, Safety and Health Management System under the Fermilab Contractor Assurance System (CAS) program. At Fermilab, a holistic approach is taken in the ESH&Q program.

1. Long Term Storage of Highly Activated Components

During the previous triennium, work toward addressing the problems posed by the long term storage of highly activated components was discussed in the detail. See documents posted at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=1872>. In response to those efforts it is appropriate to report that the first stage of the proposed two-stage solution has been completed and is now in use. The dominant highly activated components, at least in terms of the spatial volume required, that motivate solving this long term problem are the focusing "horns" used to produce the focused neutrino beams that are a keystone of the Laboratory's physics research program because they become highly radioactive and are also physically large in size. In autumn 2016, the first such horn was successfully safely disposed of offsite as radioactive waste and represents a major success given the fact that heretofore all such focusing horns of the Intensity Frontier era have been stored on the Fermilab site. It is now clear that while the management,

including disposal, of these components will present ongoing challenges, a pathway for their disposal has now been successfully navigated.

2. Tritium Management Efforts

The efforts discussed in the report for the CY2011-CY2013 triennium to manage the tritium produced as a result of accelerator operations were carried over into this triennium. During much of this period, the efforts of the Tritium Working Group established by the Fermilab Director continued. Given the high profile importance of this topic, the Laboratory Director commissioned two reviews of these efforts in June 2016, one comprised of Fermilab personnel and the other comprised of invited external subject matter experts. The result of these reviews was the chartering by the Laboratory Director of a new Tritium Task Force in July 2016 chaired by the Chief Safety Officer. The documentation of these efforts, including the results of the independent reviews are found, for FY2016 on: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=2146> and for FY2017 on <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3309>. The Tritium Task Force continues to address the recommendations from both of these reviews.

3. Improvements in Radiological Training

As part of the reorganization and review of the entire ESH&Q program, an assessment of radiological training was conducted during 2016. This assessment was largely conducted by members of the Radiation Safety Subcommittee. It addressed the following classes: Radiological Worker – Classroom (RW), Radiological Worker – Practical Factors (RWPF), Material Move Survey (MMR), and Fermilab Controlled Access (CA). The assessment of Controlled Access Training was intensified subsequent to the Controlled Access Incident of March 1, 2016, discussed further below. The report is found on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3285>. It is entered into iTrack as Review ID # 45886 at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=45886. This assessment resulted in 5 corrective actions, all of which are now complete.

EVENTS MOTIVATING FOLLOW-UP INVESTIGATIONS

During this triennium, three DOE-reportable events occurred that merited further investigation as to their radiation protection implications and thus constitute assessments of the Radiation Protection Program.

1. 2014 Controlled Access Incident at the NuMI Beam Line (February 2014)

On February 5, 2014 a team of four vacuum technicians, their supervisor, and a member of the radiation safety staff assembled in the Main Control Room (MCR) to discuss repairs of a vacuum problem in the NuMI beam line area. As the supervisor discussed the needed equipment for the repairs, each member of the repair team was asking for and being issued access keys for the NuMI Pre-Target and Target Hall enclosure. The supervisor inadvertently asked for and was issued a NuMI Elevator key, unintentionally confused with the correct NuMI Pre-Target and Target Hall enclosure access keys. The result was that the supervisor entered the enclosure without possession of the correct controlled access key. While no radiation exposures resulted from this event, this

incident was investigated in considerable detail. The iTrack entry for this investigation is at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=39088. Important documents related to the details of the investigation are posted on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=2737>. All five of the corrective actions are now closed.

2. 2016 Controlled Access Incident at the Fermilab Booster (March 2016)

On March 1st, 2016, there was a Controlled Access violation in the Booster accelerator enclosure. Four employees were assigned as part of a crew to perform Radio Frequency (RF) maintenance work. All four employees entered the enclosure at the same time via Controlled Access. After they had completed their work, two of the four employees exited the enclosure via Controlled Access, leaving the other two employees inside the enclosure. When they were finished with their work, the final two employees attempted to exit the enclosure via Controlled Access and discovered that one employee did not have the correct key. They then exited the enclosure, dropping the interlocks as per training, and reported the incident to the Main Control Room (MCR) Crew Chief who subsequently notified the AD Division Safety Officer (DSO). While no radiation exposures resulted from this event, this incident was investigated in considerable detail. The iTrack entry for this comprehensive investigation based upon Human Performance Improvement (HPI) techniques is at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=45246. Important documents related to the details of the investigation are posted on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3237>. All but one of the eight corrective actions associated with this incident are now closed. The remaining corrective action involves some considerable technical and cost challenges to be considered on the longer term and thus has a due date of September 30, 2019.

3. Human Performance Improvement (HPI) Investigations of Radiological Events

During this triennium two events aside from those described above were judged to merit further investigation using HPI as a tool. While these two events did not rise to the level of DOE-reportability, the investigations motivated self-examination of program improvement.

The first such event involved the improper handling of a sealed radioactive source in June 2014 at Lab A. It is noted that the personnel involved in the event recognized it and properly reported it using the Fermilab emergency response phone number X3131. As a result of the HPI investigation, it was determined that no contamination resulted from this event. However, source issuance instructions to such users was updated and labeling of such sources was improved.

The second such event occurred at the Liquid Argon Test Facility (LArTF). In this event, it was believed that required access controls to the area, inclusive of the access to sealed radioactive sources, were not being properly adhered to. The result of the HPI investigation was to improve the training of the individuals involved with work in this location. No radiation exposures or contamination resulted from this event. The integrity of the sealed sources was not challenged in this event.

Consistent with overall ESH&Q policy, future events of this type will continue to be investigated using the HPI technique.

EXTERNAL ASSESSMENTS

1. DOE Focused Review of Radiological Postings and Controls of Accelerator Access Points (May 2014)

The Department of Energy Office of Science performed, as part of an assist visit to the Fermi Site Office, a focused review of the radiological conditions posting of Accelerator access points. The review team found that the Laboratory is posting Accelerator access points in accordance with the requirements of 10 CFR 835, "Occupational Radiation Protection". The team identified one Level 2 Finding, as defined in the report, relating to ineffective maintenance of outdoor radiation hazard signage. Even though the team reviewed only a small sample of areas, there were a significant number of faded, obscured, and deteriorating radiation signage and barriers noted, which warrants a complete follow-up and correction by Laboratory personnel. This assessment report was entered into iTrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=39826 and is available on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=2804>. Both findings are now closed.

2. DOE Periodic Safeguards and Security Survey (May 2014)

DOE conducted the subject survey. This survey addresses a wide breadth of site security issues including those related to the Materials Control and Accountability Program (MCAP), that addresses nuclear materials management at Fermilab. The assessment identified one Opportunity for Improvement relating to inventories, and one Finding relating to the Foreign National Visitors and Assignments (FNV&A) program. This assessment was entered into iTrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=40266. The Opportunity for Improvement and Finding have both been addressed and are now closed. The terms "Opportunity for Improvement" and "Finding" are defined by DOE within the assessment report.

3. DOELAP On-site Assessment of the External Dosimetry Program (July 2015)

DOE conducted this assessment in July 2015. This assessment reviewed Fermilab's External Dosimetry Program in detail, including training, oversight, reporting, quality assurance, etc. Three findings and one Opportunity for Improvement (as defined by the DOELAP assessment protocols), were identified in this assessment. This assessment report was entered into iTrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=46546. All these items are now closed.

4. DOE Fermi Site Office Assessment of the Occupational Radiation Protection Program – Written Authorizations (September 2015)

The Department of Energy (DOE) Fermi Site Office (FSO) conducted an assessment of the Fermi National Accelerator Laboratory's (Fermilab's) Occupational Radiation Protection Program on Work Authorizations as part of its Operational Oversight Program. The review also allowed FSO to review key aspects of the program for weaknesses identified at other Laboratories by the DOE Enterprise Assessment group, to promulgate these learned lessons. The assessment identified three Level 3 Findings, as defined in the report as well as six Program Strengths. This assessment report

was entered into ITrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=45366 and is available on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3248>. All three Findings are now closed.

5. External Review of Main Control Room Controlled Access Procedures (October 2016)

As one of the corrective actions developed in response to the March 1, 2016 controlled access incident (see above), an external review of Main Control Room Controlled Access Procedures was conducted in October 2016. The iTrack entry for this review is at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=46246. The report is also on ESH&Q DocDB at <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3237>. There were 12 Recommendations that resulted from this review that are presently being given further study for implementation. As of this date, five are now closed and the other seven are all within their initially scheduled implementation dates in the iTrack system.

INTERNAL ASSESSMENTS

1. Reviews of Shielding Assessments to Match Upgrades in Accelerator Operations and Delivery of Beam to New Facilities (Ongoing)

The review of shielding assessments is an ongoing task assigned to the Shielding Assessment Review Panel (SARP) of the Radiation Safety Subcommittee of the Fermilab ES&H Committee and is connected to the requirements of FRCM Chapter 8 (see discussion of the entire subcommittee's activities below). The SARP maintains a Sharepoint™ Site containing all of the shielding assessments reviewed and recommended for approval since April 2011, including those performed during this triennium;

ASTA 12/2014

P1 and P2 Beamline 4/2016

Cryo Module Test Stand 6/2016

All shielding assessments are currently up-to-date and consistent with the approved Fermilab Accelerator Safety Assessment Document (SAD) which in turn supports the current version of the DOE-FSO approved Fermilab Accelerator Safety Envelope (ASE). The SAD and ASE are found at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=1066>.

2. Internal Assessment of Safeguards and Security: The Nuclear Materials Program - Fermilab Nuclear Materials Control and Accountability (MC&A) Plan (April 2014)

This program was comprehensively reviewed in an assessment led by Fermilab's Quality Assurance team. The report was entered into iTrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=39386. It is also posted on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=2773>. One Recommendation was identified. The Recommendation is now closed.

3. Internal Assessment of Fermilab's External Dosimetry Program (November 2014)

An internal audit of the External Dosimetry Program at Fermi National Accelerator Laboratory (Fermilab) was conducted. The objective of this internal audit was to confirm that; routine practices comply with the requirements stated in 10CFR835, all related documents are up-to-date, all requirements on the "DOELAP On-Site Assessment Requirements Checklist" are demonstrated, and that all findings and recommendations from the previous DOE assessments are closed. The assessment report was entered into iTrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=41546. It is also posted on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=2773>. There were five Findings and six Recommendations identified in this assessment. All the Findings and Recommendations are now closed.

4. Accelerator Readiness Review (ARR) of ASTA (January 2015)

An ARR of the Accelerator Division (AD)/Advanced Superconducting Test Accelerator (ASTA) Injector was conducted in January 2015. This ARR was compliant with the requirements of DOE 420.2c, "Safety of Accelerator Facilities". There were four pre-start Findings, one post-start Finding, three Recommendations, and four Noteworthy Practices from this review. The documentation is provided on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3020>. All Recommendations from this review have been addressed. Note that the ASTA facility has since been renamed the Fermilab Accelerator Science and Technology Facility (FAST).

5. Self Assessment of Fermilab's Nuclear Materials Program (June 2016)

The Fermilab Nuclear Materials Control and Accountability (MC&A) Plan was assessed against internal Fermilab requirements and DOE requirements derived from applicable DOE Orders and Standards. Fermilab's Nuclear Materials Program was found to be compliant with all requirements. The assessment was entered into iTrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=45627. It is also posted on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=128>. The assessment identified six Opportunities for Improvement, no Nonconformities, and three Best Practices. The program is working efficiently and is effective in managing Fermilab's nuclear materials. The Opportunities for Improvement had now been addressed and are considered closed.

6. Assessment of Technical Division Waste Handling Procedures (July 2016)

The goal of this assessment is to review the waste program within Technical Division (TD) against Fermilab requirements as outlined in FRCM Chapter 4, Part 4, and FESHM Chapters 8020 and 8021 to identify any gaps, weaknesses, opportunities for improvement, and best practices. The assessment report was entered into iTrack at: https://www-esh.fnal.gov/pls/cert/eshtrk_common.audit_details?rid=46286 and the assessment report is also posted on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3320>. Six Opportunities for Improvement and two Best Practices were identified. One Opportunity for Improvement is closed while work is ongoing to address the

remaining five. All corrective actions remaining to be done are within their schedule iTrack completion dates.

ONGOING PROGRAM STRENGTHS

1. FESHCom and Its Subcommittees

The Fermilab Environment, Safety, and Health Committee (FESHCom) and its subcommittees provide an integrated committee structure for coordinating the Laboratory's program in environment, safety, health and quality. The monthly FESHCom meetings, with periodic presentations by the Chair of each of its subcommittees, are a venue for sharing information in a multidisciplinary manner. The Radiation Safety Subcommittee of this body continues to serve as a valuable forum for both technical experts and citizen members in promoting improvements to the Laboratory's program in radiation protection and thus comprises part of this internal assessment program. The monthly meetings of the Radiation Safety Subcommittee constitute an important part of program implementation, provide a forum for ongoing identification and resolution of problem areas, and give a connection to the overall Fermilab ESH&Q program. FESHCom minutes, including the reports of its subcommittees are available at: <http://esh.fnal.gov/xms/Resources/FESHCom>. All subcommittee minutes are available to the entire Fermilab community.

The charter for the Radiation Safety Subcommittee is found at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=812>. The minutes of this subcommittee that extensively document its work during FY2016 is posted at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=3299>, with links to reports of previous fiscal years provided therein. As mentioned above, this subcommittee now includes the Shielding Assessment Review Panel, formerly known as the Shielding Assessment Review Subcommittee.

2. Maintenance of Lists of Facilities Containing Radioactive Materials and Radiation Generating Devices

In accordance with FRCM Chapter 2, Article 242, the Radiological Control Organization maintains a comprehensive and current list of facilities containing radioactive materials for all Fermilab Divisions/Sections. There is no DOE requirement mandating these lists. However, they continue to provide useful information about such facilities in a single location. Likewise, in accordance with FRCM Chapter 3, Article 362, the Radiological Control Organization maintains a comprehensive and current list of Radiation Generating Devices. This list also satisfies a requirement of FESHM Chapter 2010 that is implicit in DOE Order 420.2C, "Safety of Accelerator Facilities". These lists are maintained on ESH&Q DocDB at: <https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=1004>.

3. Effectiveness of ALARA Efforts

The implementation of radiation protection requirements continues to be effective as judged by the radiation exposures received, reported annually on time and as required to the DOE REMS system, and the lack of significant noncompliances, or potential noncompliances, with radiation

protection requirements or radiation-related environmental protection requirements. The efforts to maintain radiation doses ALARA is one that is carried out by many people at Fermilab well beyond the staff of the Radiological Control Organization, including; engineers throughout the Laboratory, accelerator physicists, Accelerator Division leadership in planning for extensive shutdowns in which to effect improvements, the Accelerator Division Operations Group and many personnel of other Laboratory divisions. Partnerships with other groups in the ESH&Q Section are also very fruitful in achieving these objectives. Specific ALARA plans are documented and maintained by the Radiation Safety Officer(s) (RSOs) and/or the Radiological Control Technician(s) (RCTs) involved with the work.