

Fermilab Meson and Neutrino Switchyard 120 Experimental Areas

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III - 3. Fermi National Accelerator Laboratory (Fermilab) Meson and Neutrino Switchyard 120 Experimental Areas

III - 3.1 Fermilab Meson and Neutrino Switchyard 120 Experimental Areas Area Locations on Fermilab Site

The Fermilab Meson and Neutrino Switchyard 120 Experimental Area consists of four locations that house detectors that are served by three beam lines (Figure 1). These locations house permanent beam characterization equipment, long-term experiments, and are readily configurable and flexible for research and development for new detectors and detector technology.

The Fermilab Test Beam Facility (FTBF), located along the Fermilab meson line, comprises three of the test areas, including Meson Test (MTest), Meson Center 7 (MC7) enclosures and the M03 High Rate Tracking Area. These facilities allow experimenters to expose their experimental equipment to differing beam intensities and energies.

The NM4 enclosure experimental hall, located along the Fermilab neutrino line, currently houses the long-term E906 SeaQuest experiment. All together, these four locations comprise the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas and allow great flexibility for experimenters to explore new detector technologies and to characterize and improve existing technologies.



Figure 1 – Aerial view of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas

III - 3.2 Inventory of Hazards

The following table lists the identified hazards found in the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas. All hazards with an * have been adequately discussed in Chapters 1-10 of the Fermilab Safety Assessment Document and are not covered further in this section.

<p>Radiation Particle beams and prompt radiation Residual component activation Radioactive waste Radioactive sources Lasers</p>	<p>Kinetic Energy Power tools * Pumps and motors * Motion tables*</p>
<p>Toxic Materials Lead shielding* Beryllium* Other gasses *</p>	<p>Potential Energy Crane operations * Compressed gases * Vacuum / pressure vessels * Vacuum pumps *</p>
<p>Flammable & Combustible Materials Cables * Flammable gasses * Combustible and flammable liquids *</p>	<p>Magnetic Fields Fringe fields *</p>
<p>Electrical Energy Stored energy exposure * High voltage exposure * Low voltage, high current exposure *</p>	<p>Gaseous Hazards Confined spaces * ODH hazards *</p>
<p>Thermal Energy Cryogen*</p>	<p>Access / Egress Life Safety Egress *</p>

III - 3.3 Introduction

This Section III, Chapter 3 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD) covers the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas.

III - 3.3.1 Purpose of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas

The purpose of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas is to provide experimenters with flexible, equal, and open access to test beams for detector technology research and development.

III - 3.3.2 Description of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas

The FTBF is served by the meson fixed-target beamline and enables experimenters to test their detectors in an active beamline and also permits detectors for other types of research (cosmic rays, etc.) to be calibrated. Typically experiments installed at FTBF are operated for short durations (< 1 month). The NM4 enclosure experimental hall is served by the neutrino fixed-target beamline and is located approximately ¼ mile to the south of the FTBF. The enclosure houses long-term fixed-target experiments. The Neutrino line currently (2015) hosts the long-term E906 SeaQuest experiment at the NM4 enclosure experimental hall. These experiments and tests utilize target materials, charged particle tracking detectors, particle identification detectors and calorimetric detectors. Some experiments use evacuated vessels or helium filled bags to minimize the amount of material in the beam (to reduce scattering of the beam) or experiment detectors.

The character of the hazards associated with these planned experiments is similar, but may vary in magnitude, which has been the case with prior experiments, and will likely be the case in the future. New experiments are screened for hazards through the Operational Readiness Clearance (ORC)¹ process coordinated by the ORC chairperson for the respective area prior to approval. Such experiments would be similar in ES&H impact to those described here.

III - 3.3.3 Operating Modes

The Accelerator Safety Envelope (ASE)² limits operating modes of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas and describes the beam character and beam limitations delivered to these areas.

III - 3.4 Safety Assessment

Hazards of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas can vary for each scheduled experiment. Radiological hazards such as ionizing radiation, residual activation, radioactive waste and sources can be present depending upon the experiment. Lasers may also be used to align experimental equipment with the particle beam. All other

conventional/general industrial hazards are addressed by Fermilab ES&H and quality guidance documents. The unique hazards of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas are analyzed in this section.

III - 3.4.1 Radiological Hazards

Radiation safety has been carefully considered in the design of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas. All radiation hazards relating to beam operations safety are the responsibility of the Accelerator Division. The Accelerator Division, whose facilities includes all beamlines, their shielding, radiation, interlocks, beam surveys, monitors and impact of radiation on the environment and is addressed in the Fermilab Switchyard Fixed-Target Beamlines Safety Assessment Document³, the Meson Area Safety Assessment Document⁴, and the Fermilab Neutrino Area Safety Assessment Document⁵.

Fermilab protocols require that all personnel and experimenters who work in experimental halls must be trained according to Fermilab Radiological Control Manual (FRCM) Chapter 6 – Training and Qualification⁶. All radiological work, posting, labeling and monitoring in experimental halls must be conducted in accordance with requirements described in FRCM Chapter 2 – Radiological Standards. All experiments at Fermilab will participate in Fermilab’s ALARA (As Low As Reasonably Achievable) program as described in FRCM Chapter 3 – Conduct of Radiological Work.

III - 3.4.1.1 Ionizing Radiation

Prompt ionizing radiation is generated from the particle beam interaction with the materials, such as the beam pipes, beamline elements, and beamline instrumentation. The enclosures of the Meson and Neutrino 120 Experimental Areas are constructed of shielding (concrete, steel, earth, etc.). The enclosure shielding for these areas have been specifically and quantitatively analyzed through the Fermilab Shielding Assessment Process for both normal and accidental loss conditions as referenced in the 2003 Shielding Assessment for the Switchyard 120 Project⁷, the 2013 Addendum to the SY 120 Shielding Assessment for Continued Operation of the Meson Center Beam Line⁸, and the 2012 Neutrino Muon Beamline Shielding Assessment⁹.

The shielding assessment documents referenced in the Fermilab Switchyard Fixed-Target Beamlines, Fermilab Meson Area, and the Fermilab Neutrino Area Safety Assessment Documents have already addressed the ionizing radiation issues associated with groundwater and surface water activation; air activation; particle interactions in soil; radiation shielding requirements; labyrinth and penetrations; residual dose rates; and active and passive shielding

controls and monitoring according to the FRCM Chapter 8 – Accelerator Shielding and Radioactivation.

III - 3.4.1.2 Residual Activation

Positioning detector components in the path of the beam may result in activation of the components. This type of radio-activation is called residual activation. The activation level and quantity of activated material will not be unique relative to other accelerators at Fermilab.

Residual activation hazards will be managed within the ALARA program established throughout the Fermilab accelerator complex and as prescribed in the FRCM Chapter 3. All potential residual activation hazards are handled operationally as in all other primary beam enclosures. These controls include verification of training, centralized authorization, and key entry. The level of control depends on the level of residual radiation. In most cases, the typical Radiological Work Permit (RWP) as described in FRCM Chapter 3, for accesses will suffice. A job-specific RWP and an ALARA plan will be required for work on any highly activated equipment.

III - 3.4.1.3 Radioactive Waste

Radioactive waste hazards and disposal will be managed within the program established throughout the Fermilab accelerator complex and as prescribed in the FRCM. Waste minimization is an objective of both the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas design and operational procedures. Typically material in the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas does not become activated, but any activated items that cannot be reused will be disposed of as radioactive waste in accordance with the FRCM Chapter 4 – Radioactive Materials.

III - 3.4.1.4 Radioactive Sources

Radioactive sources are used extensively by experiments for calibration and testing of detectors. Radioactive sources present minimal potential hazards for onsite personnel and negligible hazards off site and are monitored according to FRCM Chapter 11 - Environmental Radiation Monitoring and Control.

Commonly used sources are Co-60, Sr-90, Cs-137, Fe-55 and Ru-106. Radioactive source controls described in the Fermilab Radiological Control Manual include requirements for 1) source accountability records to be maintained by the Environment, Safety, Health, and Quality Section (ESH&Q), Section, 2) ESH&Q Section notification and supervision for changes in use, storage, transfer, disposal or loss, 3) labeling, 4) source cabinets and source monitors

responsible for issuing sources to users, and 5) source procurement. Radioactive source monitors and source users must be trained in accordance with requirements set forth in FRCM Chapter 4. Radioactive sources pose a contamination hazard if they are not handled properly. Following policies set forth in FRCM Chapter 4 –mitigates the contamination hazard.

III – 3.4.1.5 Lasers

Lasers may be used for alignment or calibration of detectors. It is unlikely that a hazard class 1, 2, or 3A laser used for alignment of equipment would cause an inadvertent injury. On the other hand, hazard class 3B and 4 lasers have a significant potential for causing accidental injuries due to their inherently higher beam power. All laser installations (class 3B or greater) must be reviewed by the Fermilab Laser Safety Officer (LSO) prior to commencement of operations according to FESHM¹⁰ Chapter 4260 - Lasers.

III - 3.5 Credited Controls

III - 3.5.1 Passive Controls

Passive controls are accelerator elements that are part of the physical design of the facility that require no action to function properly. These passive controls are fixed elements of the beam line that take direct human intervention to remove. The Meson and Neutrino 120 Experimental Areas is designed to optimize the effect of these passive controls with permanent concrete and earth-covered radiation shields that use a combination of permanent shielding, movable shielding, and penetration shielding to protect personnel from radiological exposure during beam line operations

III - 3.5.1.1 Permanent Shielding Including Labyrinths

Permanent shielding surrounds the detector halls and enclosures. Concrete shielding blocks are used to shield surrounding work areas and create labyrinths for personnel access to enclosures. The enclosures of the Meson and Neutrino 120 Experimental Areas are constructed of shielding (concrete, steel, earth, etc.). The enclosure shielding for these areas have been specifically and quantitatively analyzed through the Fermilab Shielding Assessment Process for both normal and accidental loss conditions as referenced in the 2003 Shielding Assessment for the Switchyard 120 Project, the 2013 Addendum to the SY 120 Shielding Assessment for Continued Operation of the Meson Center Beam Line, and the 2012 Neutrino Muon Beamline Shielding Assessment.

III - 3.5.1.2 Penetration Shielding

The beamline has several utility penetrations routing between the exclusion areas and occupied areas which were analyzed for required shielding and designed to eliminate the need for additional penetration shielding. Consequently, the prompt dose rates at the exits of the penetrations are within the limits established in the FRCM Chapter 2.

III - 3.5.2 Active Controls

Active engineered controls are systems designed to reduce the risks from accelerator operations to an acceptable level. These are automatic systems that limit operations, shut down operations, or provide warning alarms when operating parameters are exceeded. The active controls in place for Meson and 120 Neutrino Experimental Areas are discussed below.

III - 3.5.2.1 Radiation Safety Interlock System

The Fermilab Meson and Neutrino Switchyard 120 Experimental Areas, the MT6 Section 1 & 2 enclosures, MC7 enclosure and NM4 enclosure experimental hall, are all protected by a radiation safety interlock system that is described in the Switchyard Fixed-Target Beam Lines, Fermilab Meson Area, and Fermilab Neutrino Area Safety Assessment Documents.

Trained and qualified personnel from the Accelerator Division Operations Department are required to search and secure the enclosure before permits from the radiation safety interlock system may be reestablished following any personnel access to the enclosure, except under strictly specified controlled access conditions. The radiation safety interlock systems including requirements for hardware and system testing, inventory of interlock keys, search and secure procedures for the beamline enclosure, controlled access procedures, personnel training requirements, and procedures for maintenance of interlock systems, are in conformance with the requirements stated in the FRCM Chapter 10 – Radiation Safety Interlock Systems.

Fermilab Radiological Worker training and Fermilab Controlled Access training are required to enter beamline areas when the particle beam has been disabled and the interlocks remain active. The Main Control Room controls access to beamline enclosures when the interlocks are active.

III - 3.5.3 Administrative Controls

All Fermilab Meson and Neutrino Switchyard 120 Experimental Areas' operations with the potential to affect the safety of employees, researchers, or the public, or to adversely affect the environment, are performed using approved laboratory, division, or department procedures. These

procedures are the administrative controls that encompass the human interactions that define safe operations. The administrative procedures and programs considered necessary to ensure safe accelerator operations are discussed below.

III - 3.5.4 Fermilab Meson and Neutrino Switchyard 120 Experimental Area Operational Readiness Clearance for Experiments

The experimental collaboration of each proposed experiment will submit a Technical Scope of Work (TSW), which describes the experiment in detail including any safety issues. Division management reviews, approves, and distributes the TSW to the appropriate ES&H review committee(s) for the operational readiness review in accordance with FESHM Chapter 2005 *Operational Readiness Clearance*. Prior to operations, the appropriate ES&H review committee(s) reviews the installation for environmental, safety and health issues. Once the committee is satisfied with the installation, the division office grants approval for operations.

III - 3.6 Summary & Conclusion

This chapter of the Fermilab Safety Assessment Document identifies and assesses specific radiological hazards associated with commissioning and operation of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas. The chapter identifies and describes designs, controls, and procedures to mitigate Fermilab Meson and Neutrino Switchyard 120 Experimental Areas' hazards. In addition to the specific safety considerations presented in this chapter, Fermilab Meson and Neutrino Switchyard 120 Experimental Areas are subject to the global and more general safety requirements, controls and procedures outlined in Section 1 of this Fermilab Safety Assessment Document.

The Fermilab Meson and Neutrino Switchyard 120 Experimental Areas have been constructed, commissioned and will be operated within the specific and general considerations of this safety assessment. The preceding discussion of the hazards presented by the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas' operations and the credited controls established to mitigate those hazards demonstrate that the experiment can be operated in a manner that will produce minimal hazards to the health and safety of Fermilab workers, researchers, members of the public, as well as to the environment.

III - 3.7 Glossary, Acronyms

AD	Accelerator Division
ALARA	As Low As Reasonably Achievable
ASE	Accelerator Safety Envelope
ES&H	Environment, Safety and Health (ESH)
FESHM	Fermilab Environmental, Safety and Health Manual
FTBF	Fermilab Test Beam Facility
FRCM	Fermilab Radiological Control Manual
LSO	Laser Safety Officer
M03	Meson enclosure number 3
MC7	Meson Center enclosure number 7
NM4	New Muon enclosure number 4
ORC	Operational Readiness Clearance
PPD	Particle Physics Division
RSO	Radiation Safety Officer
RWP	Radiation Work Permit
SAD	Safety Assessment Document
TSW	Technical Scope of Work

III - 3.8

References

- ¹ Fermilab Environment, Safety and Health Manual Chapter 2005 (FESHM 2005), *Operational Readiness Clearance*.
- ² Fermilab Environment, Safety and Health Manual Chapter 2010 (FESHM 2010), Planning and Review of Accelerator Facilities and Their Operations
- ³ Fermilab Switchyard Fixed-Target Beam Lines Safety Assessment Document, John Anderson Jr., Craig Moore, October 2013.
- ⁴ Fermilab Meson Area Safety Assessment Document, John Anderson Jr., Craig Moore, April 2014.
- ⁵ Fermilab Neutrino Area Safety Assessment Document, Thomas Kobilarcik, February 2012.
- ⁶ Fermilab Radiological Control Manual – All references to FRCM can be found here at the current web link: <http://esh.fnal.gov/xms/ESHQ-Manuals/FRCM>
- ⁷ 2003 Shielding Assessment for the Switchyard 120 Project, C. Brown, T. Kobilarcik, G. Koizumi, E. Ramberg, W. Higgins, April 8, 2003
- ⁸ Addendum to the SY 120 Shielding Assessment for Continued Operation of the Meson Center Beam Line, T. Kobilarcik, W. Schmitt, November 25, 2013
- ⁹ Neutrino Muon Beamline Shielding Assessment, T. Kobilarcik, M. Geelhoed, February 24, 2012
- ¹⁰ Fermilab Environmental Safety and Health Manual – All references to FESHM can be found here at the current web link: <http://esh.fnal.gov/xms/ESHQ-Manuals/FESHM>