CY2007 Fermilab As Low As Reasonable Achievable Project Description
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At the Fermi National Accelerator Laboratory (Fermilab), a policy consistent with integrated safety management and in accordance with 10 CFR Part 835 requirements is to conduct activities in such a manner that worker and public safety, and protection of the environment are given the highest priority. Fermilab senior management is committed, in all its activities, to maintain any safety, health, or environmental risks associated with ionizing radiation or radioactive materials at levels that are As Low As Reasonably Achievable (ALARA). Likewise, Fermilab management supports related work planning and review activities in support of Fermilab's ALARA program.

During CY2007, the primary activities at Fermilab that resulted in occupational radiation exposures were associated with maintenance activities of the accelerator. Nearly all dose to personnel was due to exposures to items activated by the accelerated beams. Many maintenance activities were necessary as the Fermilab accelerator complex was challenged to meet the scientific objectives of the Tevatron Run II Collider Program while simultaneously operating the proton beam needed for the Neutrinos at the Main Injector (NuMI) and Booster Neutrino (MiniBooNE and SciBooNE) experiments. Fermilab safely accomplished many essential accelerator upgrades during the summer of 2007 shutdown. These upgrades included but were not limited to replacement of the antiproton target, lithium lens transformer assembly rebuild and drive shaft replacement, replacement of Booster long corrector magnets and quadrupole magnets, and work on NuMI target chase ventilation system. Additionally, Main Injector large electron-positron magnet upgrades were completed, Main Injector collimators were installed, and sections of beam pipe were replaced. Extensive ALARA pre-job planning, implementation of specific ALARA activities during radiological work, and post-job analyses were integral to all work conducted during calendar year 2007.

The following activities highlight Fermilab's continued commitment to keeping exposures ALARA.

1. Preliminary Assessment of Potential Absorbed Dose to Complete Tasks

A preliminary assessment of potential collective dose that would be incurred as a result of the summer 2007 shutdown was projected prior to the shutdown. This preliminary collective dose assessment to completed tasks slated for shutdown 2007 was estimated to be approximately 22.5 person-rem. The number of personnel available to complete the proposed work was viewed to be less than what would be required to properly complete several of the tasks. As a result of this information, it was determined that numerous shutdown tasks should be scaled back and/or postponed in order to maintain exposures ALARA. Successful planning with ALARA at the forefront of upper management's decision-making process resulted in a collective dose reduction of approximately 10 person-rem.

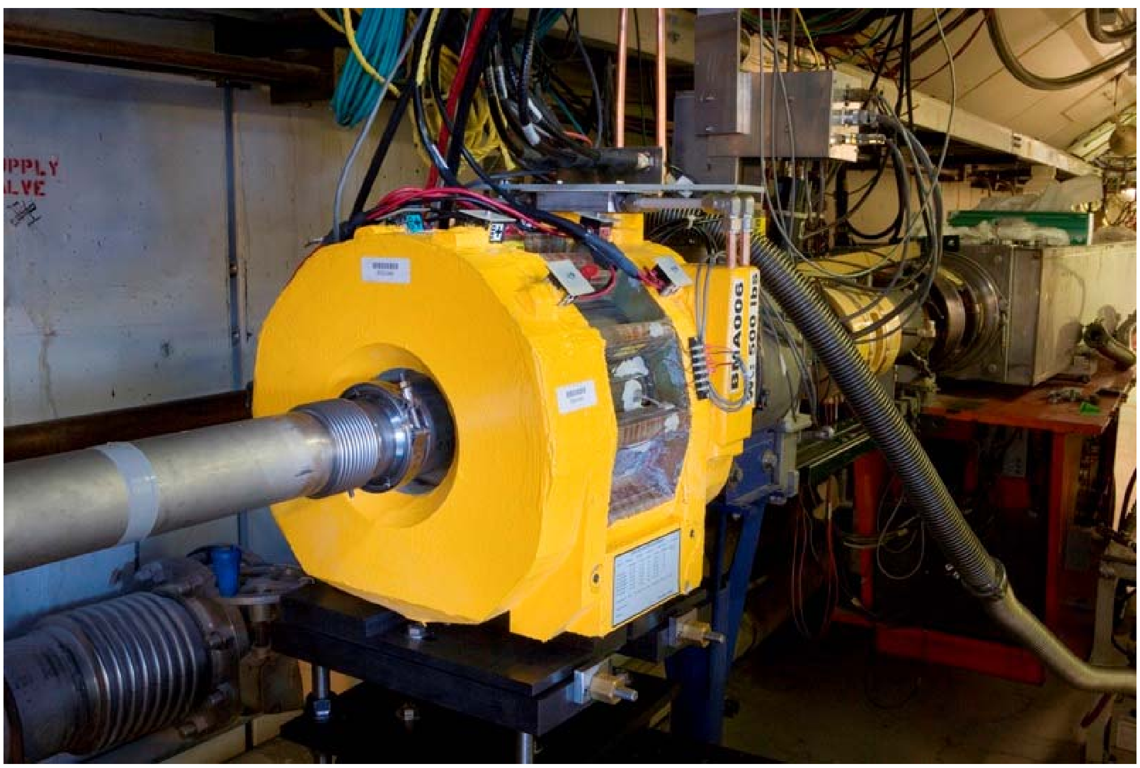
2. Main Injector Large Electron-Positron (LEP) Magnets Replacement and Multiwire Chamber Repair

Replacement of the weak LEP corrector magnets and repair of the 851 multiwire proportional chamber improved the performance of the Main Injector 8 GeV collimator system. The small aperture LEP dipole magnets were replaced with rebuilt LEP corrector magnets that can run more current than the previously installed LEP magnets. This improvement will help to reduce losses in the Main Injector. The multiwire at 851 measures the transverse beam prior to injection into the Main Injector. The mechanical system that moved the multiwire into and out of the beam was repaired. This job required radiological control technician (RCT) coverage and radiation surveys were conducted as needed to monitor exposure rates during the work. There were five persons assigned to this job in addition to the RCT. The job went as planned, so the estimated collective dose of 64 person-mrem matched extremely well with the actual collective dose received of 61 person-mrem. This LEP magnet replacement and multiwire repair is estimated to reduce future doses by 300 person-mrem annually.

Main Injector Multiwire Paddle

3. Booster Long 4 Prototype Corrector Magnet Replacement

The Booster is the first circular accelerator, or synchrotron, in the chain of accelerators at Fermilab. It consists of a series of magnets arranged around a 75-meter radius circle. A prototype corrector magnet was installed in the Booster during the summer of 2007. A total of 15 people participated in this work. The estimated collective dose for this job was 310 person-mrem and the actual collective dose received was 163 person-mrem. Actual doses were lower than estimated for several reasons. First, the general area exposure rates were estimated to be 10 mR/hr. In actuality, general area exposure rates were less than half of the estimate. Also, the surveyors and electricians completed their work much faster than estimated in the ALARA plan. A third reason for actual doses being lower is that the shielding placed in the 8 GeV beamline was more effective than the ALARA plan had estimated. This task was very successful because basic radiation dose reduction principles of time and shielding were integrated into the work.



Booster Corrector Prototype Installation

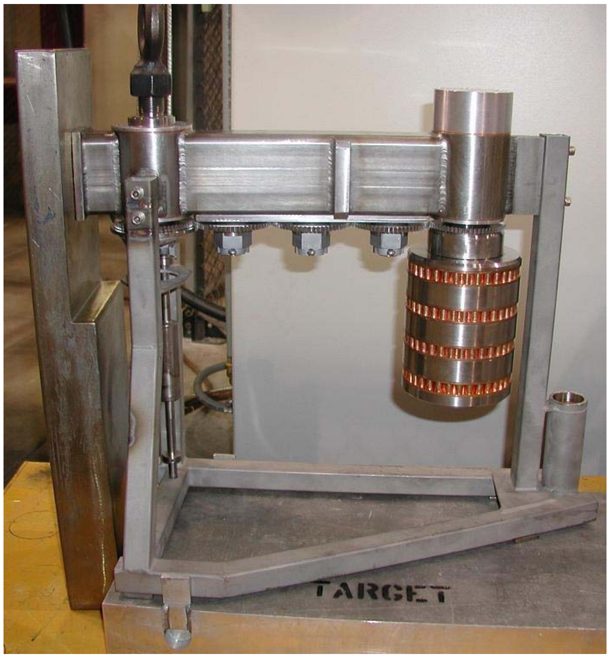
4. Neutrinos at the Main Injector (NuMI) Ventilation System High Efficiency Air Filter Replacement

During the summer 2007 shutdown, work was performed to change out high efficiency air bank filters in the NuMI target chase inside the NuMI target hall. The air filter banks consisted of four levels of filters with each containing three pre-filters, and three high efficiency filters. The three pre-filters measured approximately 20 mR/hr at one foot. The other filters read about 2 mR/hr at one foot. The procedure used a bag-in bag-out procedure to prevent airborne contamination. Because the air filters were known to be highly contaminated, workers wore forced-air hoods, personal air monitors, and full anti-contamination clothing. The collective dose estimate for this work was 100 person-mrem and the actual collective dose received was 34 person-mrem. The reason the actual dose was much lower than estimated is that the workers were very efficient in their work despite the difficult conditions of the job. Also, the bag-in bag-out procedure for changing the filters proved to work well because no airborne radioactivity was created. Analysis of the worker's personal air monitors showed no detectable airborne activity.

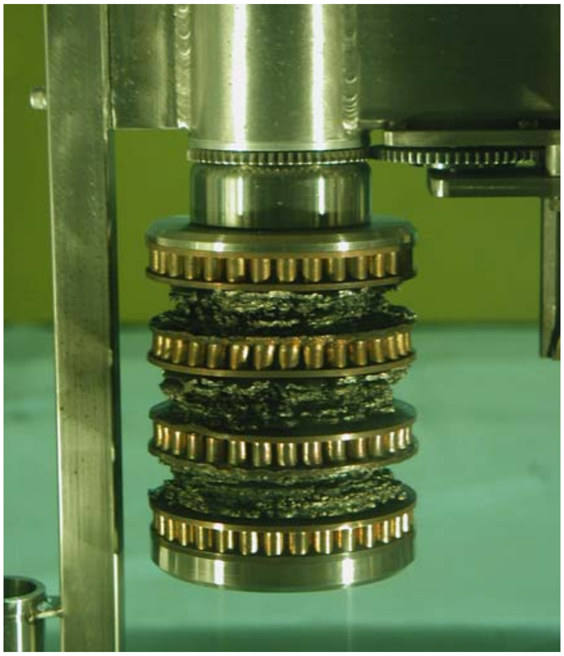
NuMI Target Chase Ventilation Bank

5. Antiproton Area (AP0) Target and Drive Shaft Replacement

Fermilab creates antiprotons by striking a nickel target with protons. It takes 100,000 to a million protons to make an antiproton. Over time, these nickel targets become damaged by the proton beam and must be replaced. In May of 2007, work was performed to replace a target and also replace a drive shaft. Before the work began, the Accelerator Division ordered beam to be shut off from the area approximately four hours to allow for cool down. Plastic was placed on the floor and the alcove before the target module was moved. When the used target was removed and placed into the alcove, it measured approximately 300 R/hr at one foot from the upstream side of the target. It is interesting to note that several pieces of the target were observed on the antiproton target stand frame. When the target was placed into the coffin, it measured about 150 mR/hr at one foot. The coffin was wrapped in plastic to contain any highly activated material fragments. Once the work was completed, the plastic on the floor between the alcove and the lower vault was placed into a bag. The bag measured approximately 700 mR/hr on contact from highly activated particles. Next, the drive shaft on the target module was replaced. Plastic was placed over the old shaft and the shaft was transferred to the storage vault. The drive shaft measured about 600 mR/hr at one foot. All areas were carefully surveyed to ensure that there were no highly activated material fragments present. During this work, pictures of the lithium lens and the pulsed magnet were also taken. Unexpected difficulties in obtaining photos of these items added 16 person-mrem to the overall collective dose. The collective dose estimate for the target and drive shaft replacement was 285 person-mrem and the actual collective dose was 290 person-mrem. This actual dose was well within the contingency estimate of 340 person-mrem. This job was carefully planned, well-executed, and workers diligently followed ALARA. The time estimated for this work was twelve hours, but it was completed in ten hours.



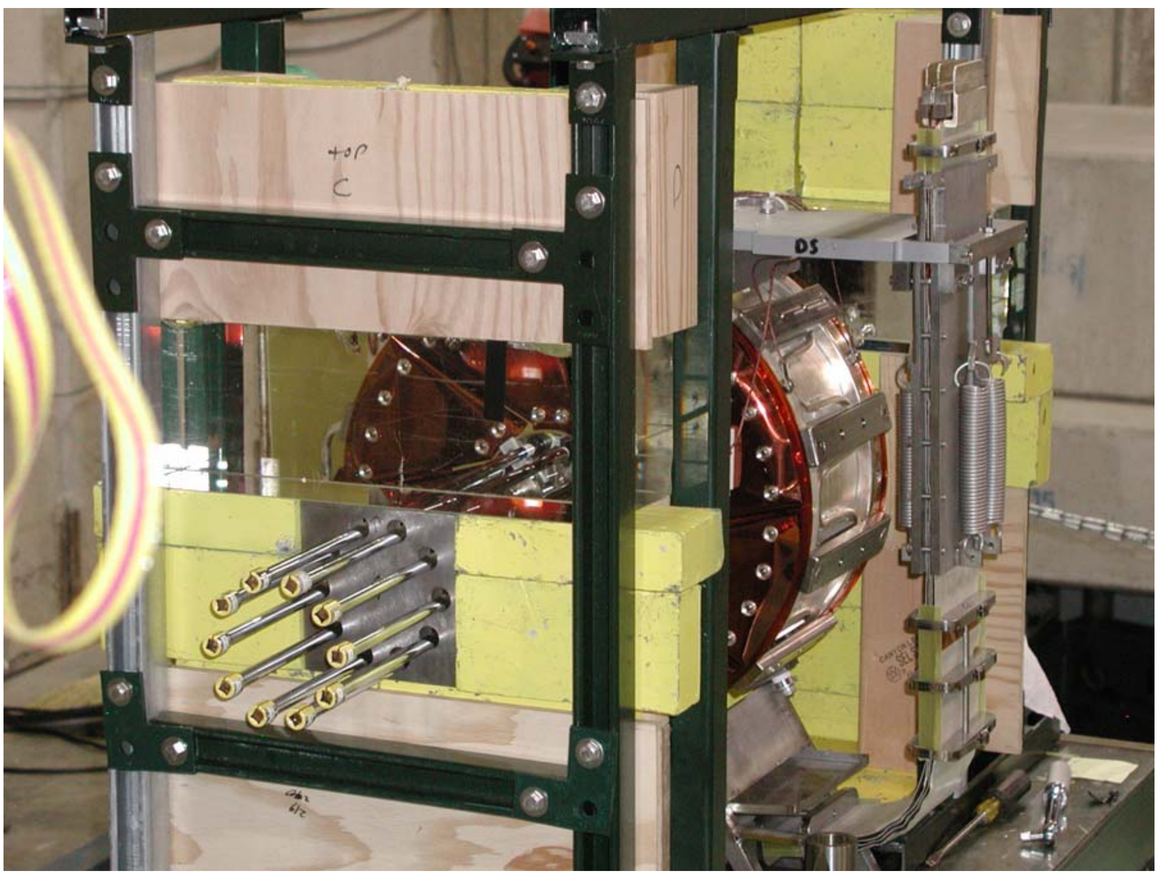
New Nickel Antiproton Target



Used Nickel Antiproton Target

6. Antiproton Area (AP0) Lithium Lens Installation in New Transformer Assembly

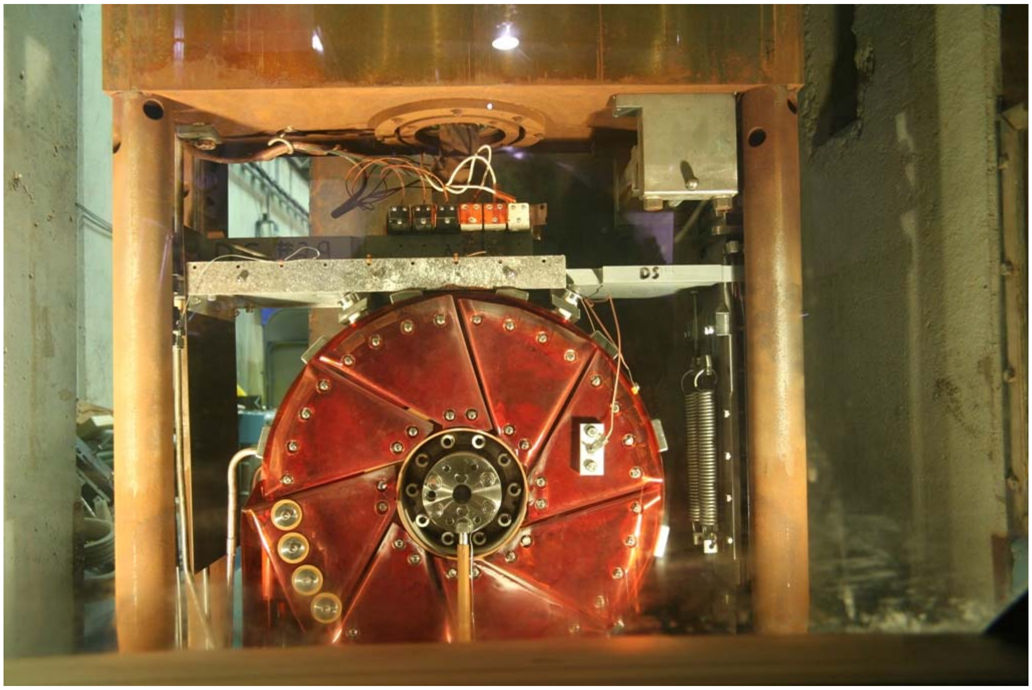
The purpose of a lithium lens is to focus newly created antiprotons into a beam. In September of 2007, a used lithium lens was placed into a new transformer. This work required continuous Radiological Control Technician coverage and an extensive, detailed ALARA plan. The dose rate on contact with the lithium lens was approximately 10 R/hr (2.8 mR/sec). The dose rate at one foot upstream and downstream of the lens was approximately 2.8 R/hr (0.8 mR/sec). Due to the high exposure rates, ALARA plan time estimates were made in seconds rather than minutes. The work was completed in about five hours. During the work, circles were drawn on the floor to indicate the lowest exposure rates in each of the work areas. The workers were very careful to stand inside these circles to minimize their exposure. The collective dose estimate for this job was 114 person-mrem and the actual collective dose received was 65 person-mrem. The workers practiced installing the new transformer on a mock setup of the lens assembly prior to performing the work. The primary reasons the actual doses were almost half of the dose estimate were due to thorough prior job planning, successful use of a mock-up, and conscientious ALARA work practices.



Lithium Lens in New Transformer Assembly

7. Antiproton Area (AP0) Spare Lithium Lens Module Replacement with New Pre-Attached Lithium Lens

A spare lithium lens module was refurbished complete with a replacement lens already attached. In the past, when a lithium lens failed, the lens was replaced with a new lens on the same highly radioactive lens module. In this case, a new lens was attached to a previously used spare lens module. In the future, when a lens failure does occur, the entire lens module will be switched out by remote crane operations and replaced with another less radioactive lens module. In this ALARA job, the highly radioactive lens module was placed directly in the storage vault for cool down. The exposure rate at the downstream side of the lithium lens was about 200 R/hr at one foot. The estimate for this job was 257 person-mrem and the actual collective dose received was 234 person-mrem. Another unique ALARA feature of this job was fabrication of a screwdriver with long extension to reduce exposure. Additionally, there was effective use of temporary shielding in the AP0 alcove. A third feature of this work was careful pre-planning and use of a mock-up to practice the job before it was performed. The mock-up work was performed on radioactive spare module with a much lower exposure rate than the lens module being replaced. The highest dose rate on the spare mock-up lens module was about 4 R/hr at one foot. The use of a spare lithium lens module will save both time and dose in future lens replacements. It is anticipated that the refurbishment of a spare replacement lens module will require about 50 person-mrem. A typical lithium lens replacement job results in a collective dose of approximately 300 person-mrem. Therefore, a spare lens module with a new lens will save an estimated dose of about 250 person-mrem.



Lens Module Replacement with New Pre-Attached Lithium Lens

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