13. Conventional Facilities for the Neutrino Factory

13.1 Introduction

The Conventional Facilities for the proposed Neutrino Factory include all necessary civil construction components required to house the beam facilities and on-site physics detectors including below grade enclosures, access shafts, halls, and surface support buildings. In addition, Conventional Facilities includes site improvements such as grading, roadways, utilities, heat rejection facilities such as cryogenic plants and cooling ponds, and high voltage electrical supply.

We have included the incorporation of some of the existing Fermilab infrastructure into the preliminary design of this study. The Collaboration has assumed that the existing Proton Physics program would most likely not be viable at that time in the future when the Neutrino Factory would be complete and ready for operation. This makes available the existing Fermilab infrastructure including; roadways, utilities, heat rejection facilities, high voltage electrical supply, office buildings, and mechanical support facilities for use in this proposed facility.

The following pages describe the preliminary conceptual design for the Conventional Facilities portion of the proposed Neutrino Factory and Muon Storage Ring at the Fermi National Accelerator Laboratory (Fermilab) site in northeastern Illinois. Conceptual Drawings and Sketches are presented in the following pages to reflect the design assumptions that were made and to represent the level of design development that was performed for this report.

13.2 Description of the Proposed Conventional Facilities

The technical components of the facility include the 16 GeV Booster, Target Hall, Decay Drift Channel, Induction Linac, Bunching, Cooling, 2 GeV Linac, Recirculating Linear Accelerators 1 and 2 (RLA 1 and RLA 2, and finally the Muon Storage Ring (MuSR) which houses beamline components to direct the neutrino beam to its final destination. Several layouts for the Fermilab site were derived. Constraints for these layouts included the size of the elements and their respective adjacencies, site radiation requirements, existing environmentally sensitive areas and existing developed areas. Existing developed areas and wetlands were avoided to minimize cost and environmental impact.

The layout shown in Figure 1 meets all the criteria mentioned above and is relatively close to existing cooling ponds and electrical distribution systems. This layout utilizes the existing 400 MeV H-minus Linac, includes a new 16 GeV Booster around the existing Antiproton Source, includes a beamline to carry 16 GeV protons to the existing Main Ring beam enclosure, and eventually to the infield of the Main Ring (currently undeveloped) where the remaining machine elements would be constructed. Figure 2 through Figure 8 show design sketches in plan and section.

We anticipate improving and expanding the existing Fermilab infrastructure as it relates to mechanical and electrical systems, grading, paving and parking. The following sections outline the current required improvements for each.

13.3 Mechanical Systems

We anticipate a total cooling load of approximately 150 MW for this proposed facility. We assume 80% (120MW) is technical component power and 20% (30MW) is conventional power for cooling, lights, etc. In addition, 75% of technical component cooling is chilled due to high klystron concentrations and cryogenic facilities and 25% is exchanged pond cooling (95LCW). At the 150MW level pond-water circuiting would not interfere with other current operations on site, if they were to remain. Pond-water cooling would be circuited through equipment in a Central Cooling Plant (CCP) and spray discharged into Lake Logo, on the eastside of RLA2. Following natural site topography pond-water would cascade from Lake Logo (20 acres remaining), through Main Ring Lake (42 acres), through Lake Law (45 acres), and through the AE Sea (49 acres), where a 100,000 gpm pump station would be located ahead of the outfall to the Sea of Evanescence and Ferry Creek. The pump station would return pond-water through dual 48" HDPE lines to the CCP and out to the Lake Logo spray headers. For additional cooling the Tevatron and Main Injector Ring ponds can be used for an additional 50MW if the physics program is not using this capacity. This involves additional chillers, pumps, piping, etc. in the same proportions as above.

13.4 Electrical Systems

The anticipated electrical load required for this facility is 150 MW. The existing Kautz Road substation has a capacity of between 160 and 200 MW. We anticipate using this substation with upgrades for the proposed study including rehabilitation of the existing transformers, installation of a new 50 MW transformer, concrete duct bank and feeder from the Kautz road substation to the Main Ring infield.

13.5 Grading

We anticipate utilizing earthen berms for radiation shielding above most cut and cover enclosures. Fermilab currently has over 7 miles of earthen shielded cut and cover enclosure of a similar type. General site grading for drainage and wetland mitigation would also be required. An attempt would be made to balance cut and fill volumes to minimize earth excavation and hauling costs.

13.6 Paving

Paving would be required to create access roadways on the Main Ring infield.

13.7 Parking Areas

New parking areas would be required at all new facilities. Existing parking at such areas as Wilson Hall and Industrial Center will remain. The above systems design and construction requirements are very familiar to the Fermilab Engineering and Operation Personnel.

13.8 Surface Buildings

The Collaboration does not anticipate requiring any additional office or manufacturing buildings. However, beamline support buildings and klystron galleries above the enclosures will be required. Figure 2 shows a site overview of these surface buildings, and Figure 3 through Figure 5 show the relationship of the surface buildings to the beam enclosures. We estimate as much as 300,000 sf of these low-rise industrial type buildings will be necessary. Below grade facilities for this study include cut and cover type enclosures and sloping enclosures constructed with tunneling technology.

The estimated 18,500 lineal feet of near surface enclosures constructed with the cut and cover construction would vary in width from 10 feet in the 16 GeV Booster beam enclosure to as much as 60 feet in the RLA arcs. Heights will range from 8 to 10 feet. These underground areas will be used to house beamline elements starting with the 400 MeV H-minus beam and ending with the extraction of the muon beam from the second recirculating linac. Earthen cover of between 15 and 25 feet will be typical for these enclosures. The majority of this accelerator complex would be constructed at or near the surface with cut and cover construction. The near surface enclosures are shown in Figure 3 through Figure 5. Sloping enclosures for the Muon Storage Ring (MuSR) will be constructed with methods including cut and cover at the shallow arc, soft tunneling in the glacial moraines and drill and blast methods in the lower shale and dolomite rock. Figure 6 shows cross sections of the MuSR tunnel in these two regions indicating the difference in construction techniques. The MuSR consists of 5800 lineal feet of enclosure sloping at 13% pointed nearly due West to deliver Neutrinos to a detector located somewhere on the West Coast of the United States. Tunnel enclosure cross sections for the proposed MuSR are expected to be approximately 10’ wide and 13’ high as shown in Figure 6. Fermilab is currently constructing a tunneled below grade enclosure for the Neutrinos at Main Injector (NuMI) project that is very similar to this proposed construction.

We believe the Fermilab Geology provides an excellent media for constructing such an enclosure. Based on our research the proposed 13 degree slope creates an acceptable environment for the required mucking of the drill and blast tunneling method. Figure 7 shows the Muon Storage Ring in an elevation view with the Fermilab Geology represented. Figure 8 shows the lower end of the Muon Storage Ring.

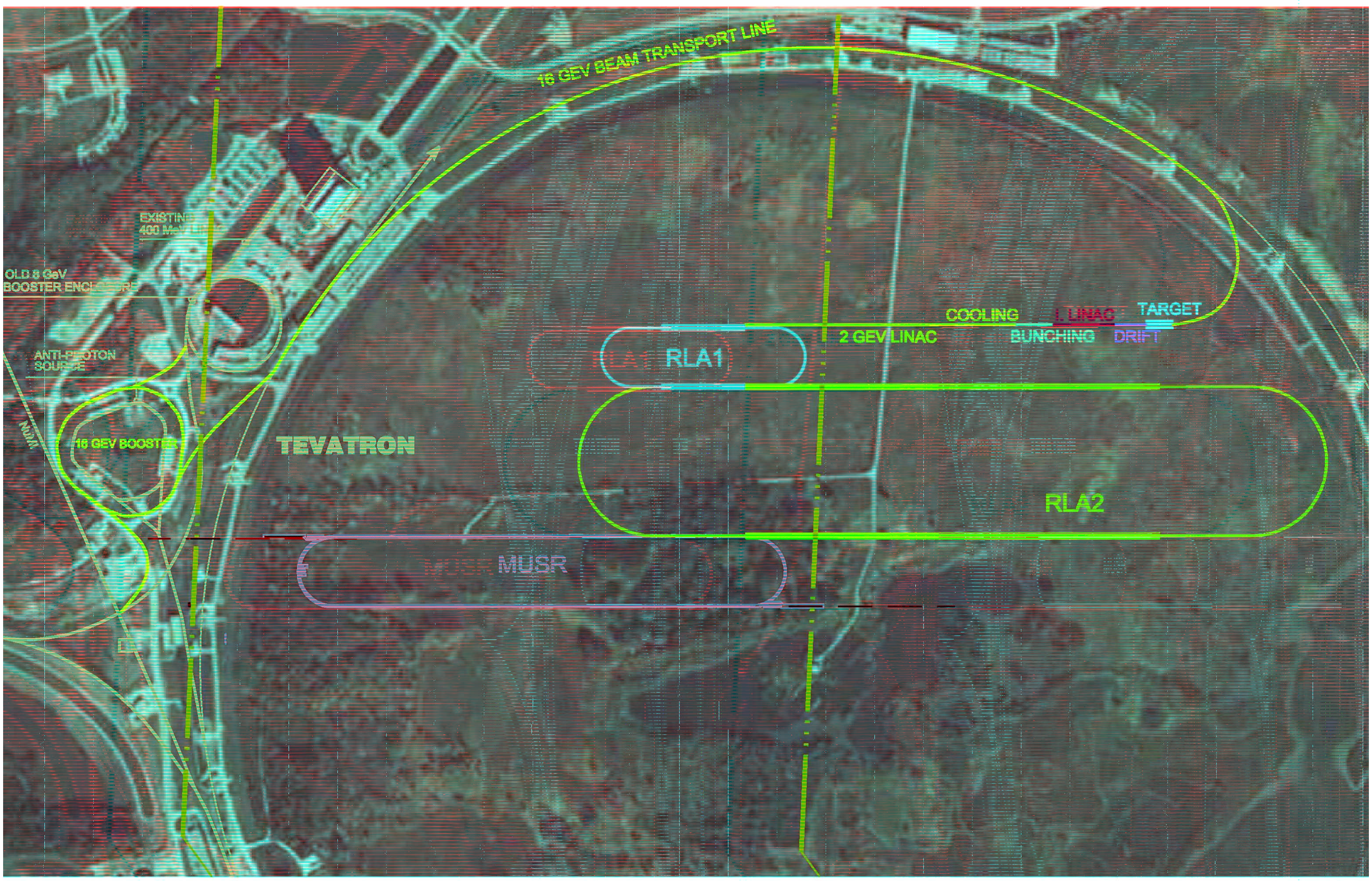

Figure 1: Layout of the Neutrino Factory on a photograph of the Fermilab site.

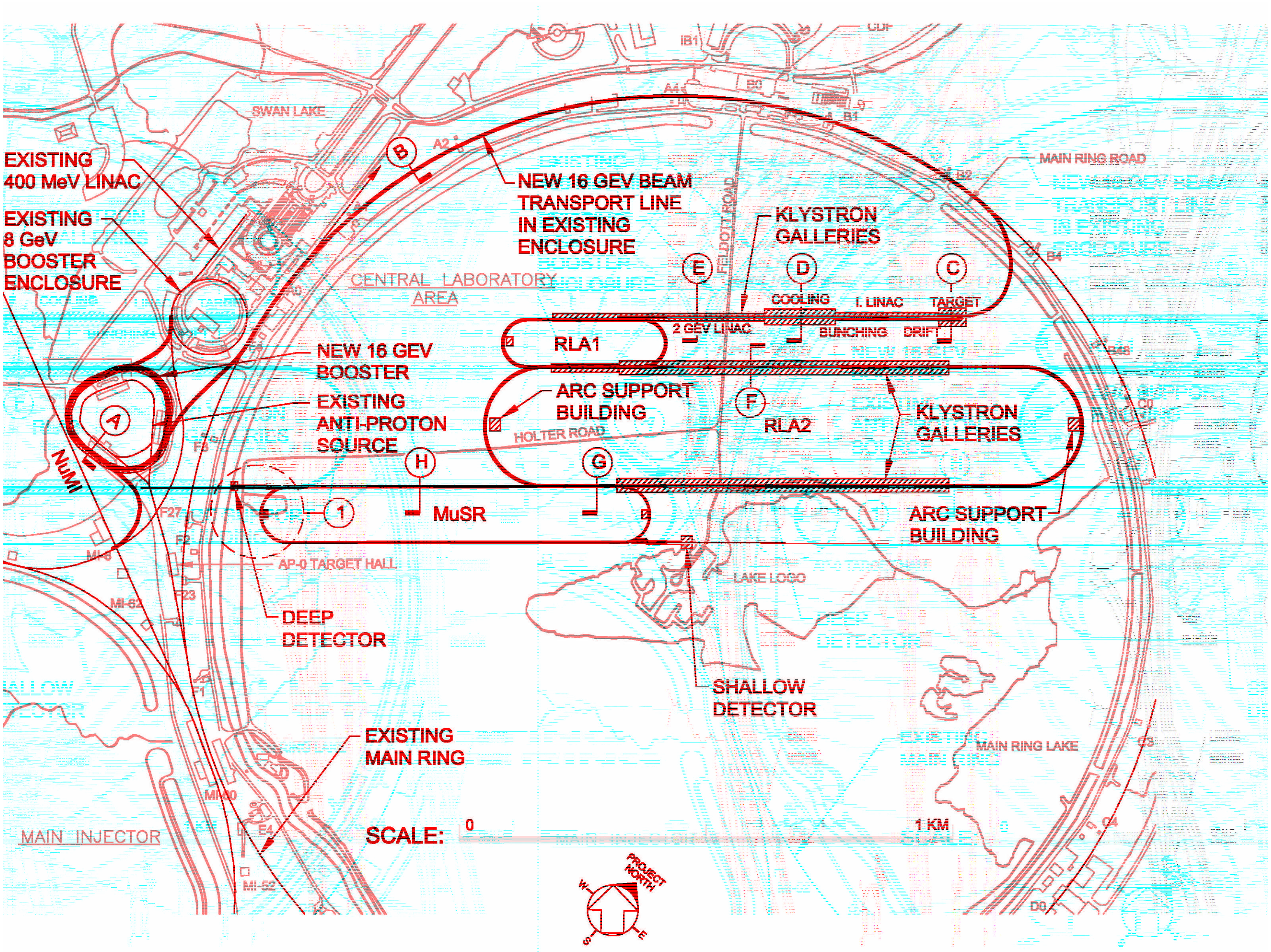

Figure 2: Sketch of the Neutrino Factory layout on the Fermilab site. The sections (A through F) and details (1 and 2) are shown in the Figures which follow. The hashed areas indicate new surface buildings.

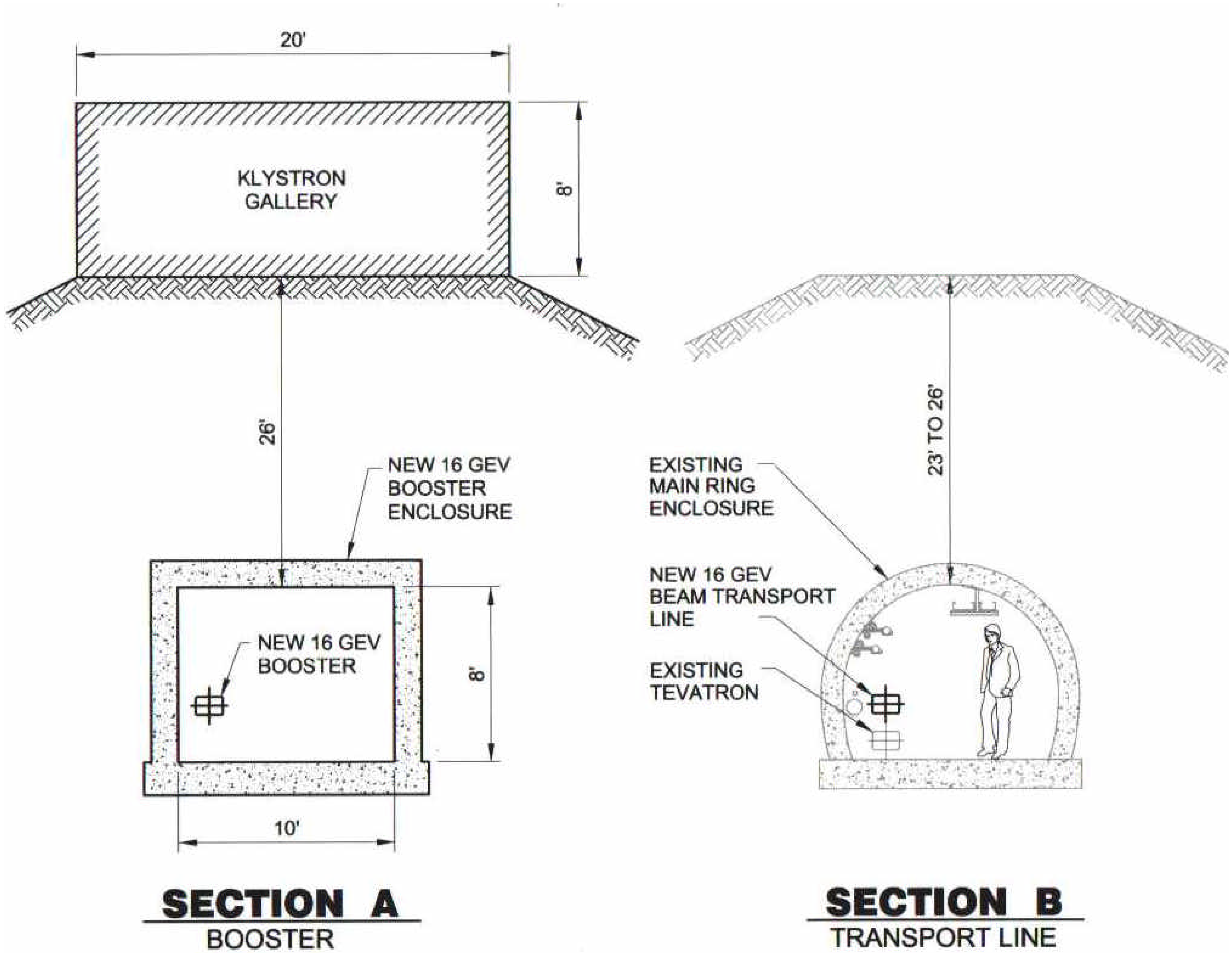

Figure 3: Section A shows the 16 GeV Booster klystron gallery over the beam enclosure with a sketch of a magnet cross section. Section B shows the existing Main Ring beam enclosure with a Tevatron magnet below the 16 GeV permanent magnet beam transport line.

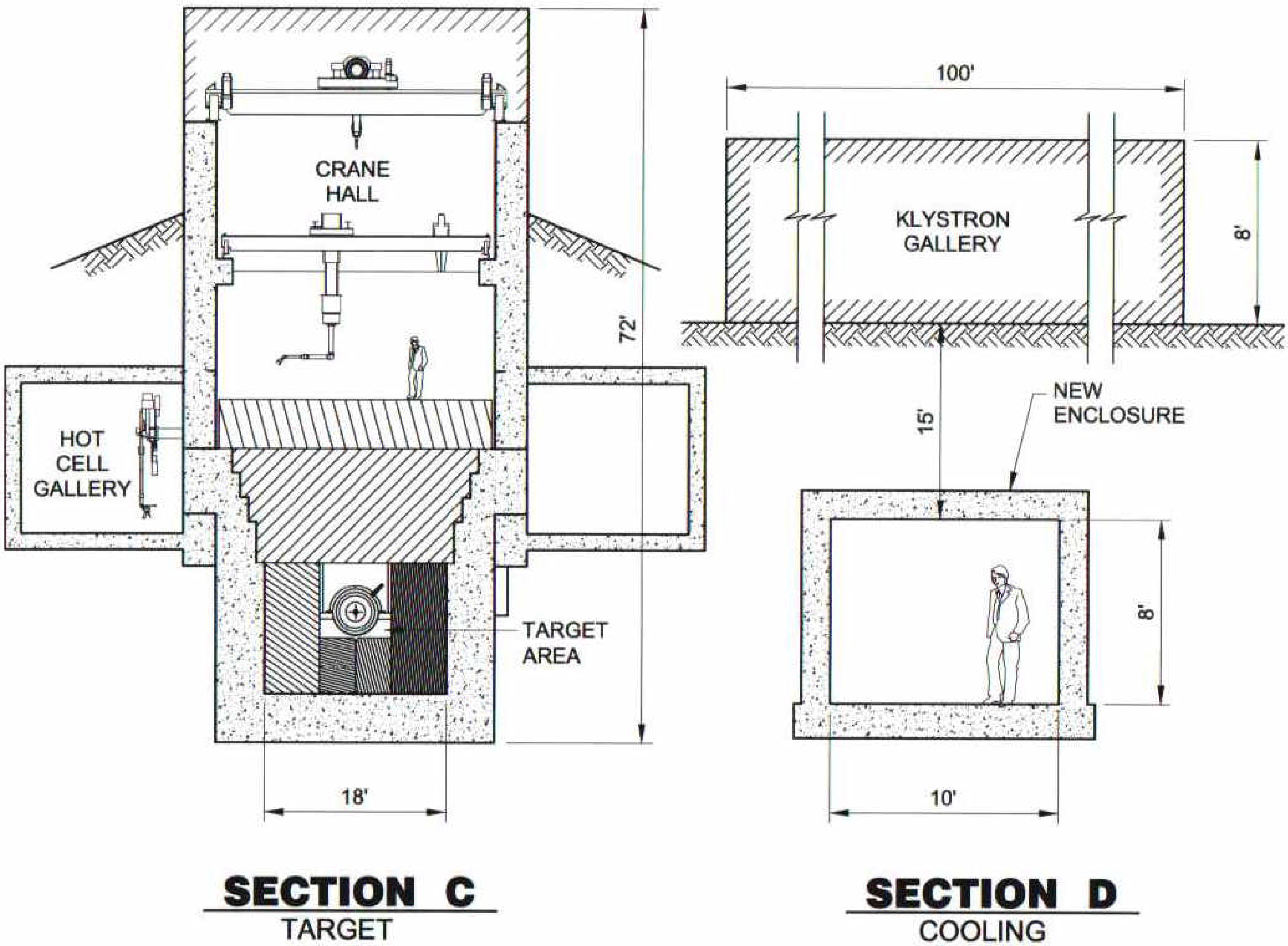

Figure 4: Section C shows a cross section of the Target facility building. Section D shows a cross section of the Cooling facility with the klystron gallery above the beamline enclosure.

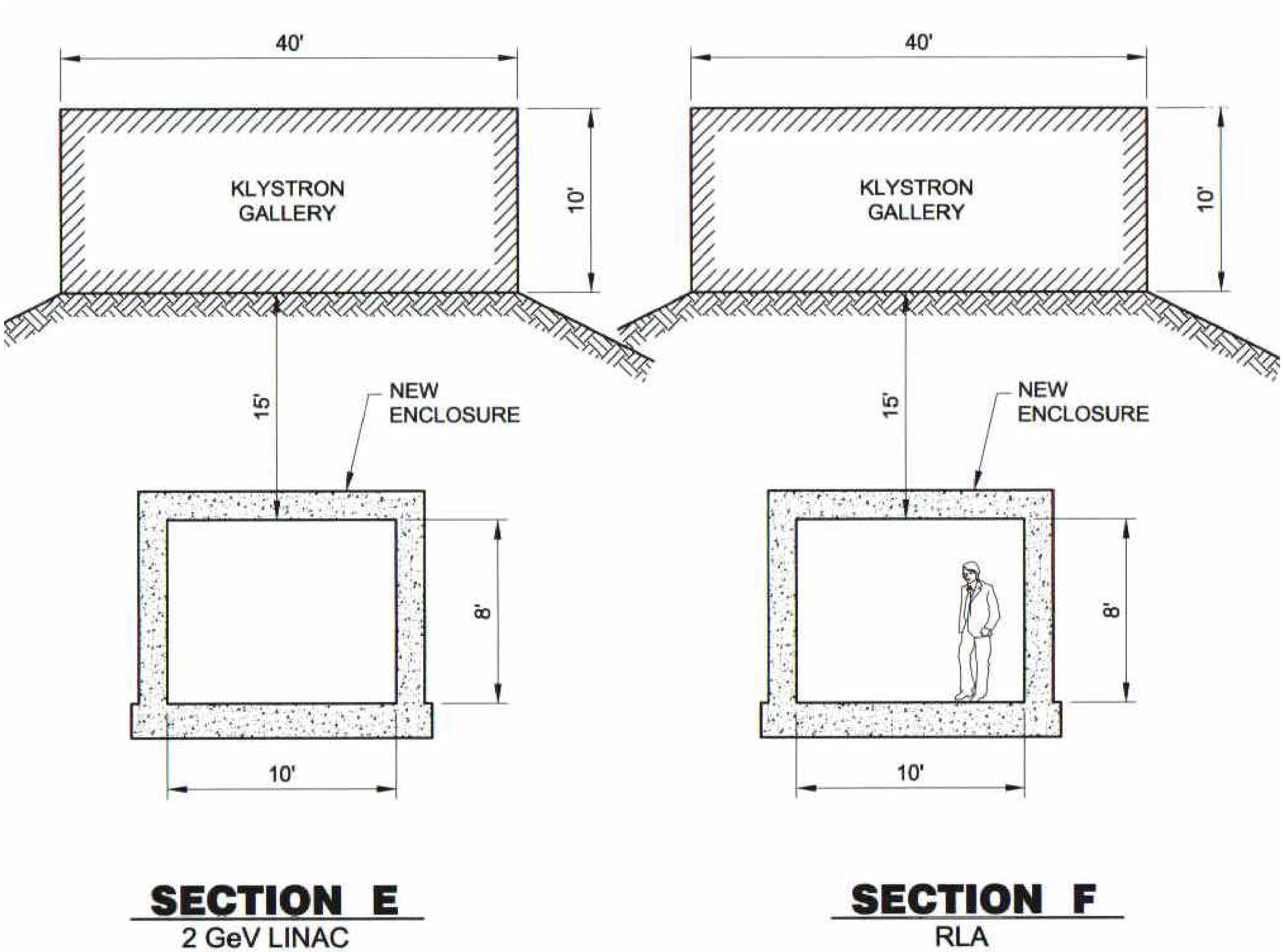

Figure 5: Section E shows the muon linac klystron gallery and beam enclosure. Section F shows the klystron gallery and beam enclosure for a Recirculating Linac.

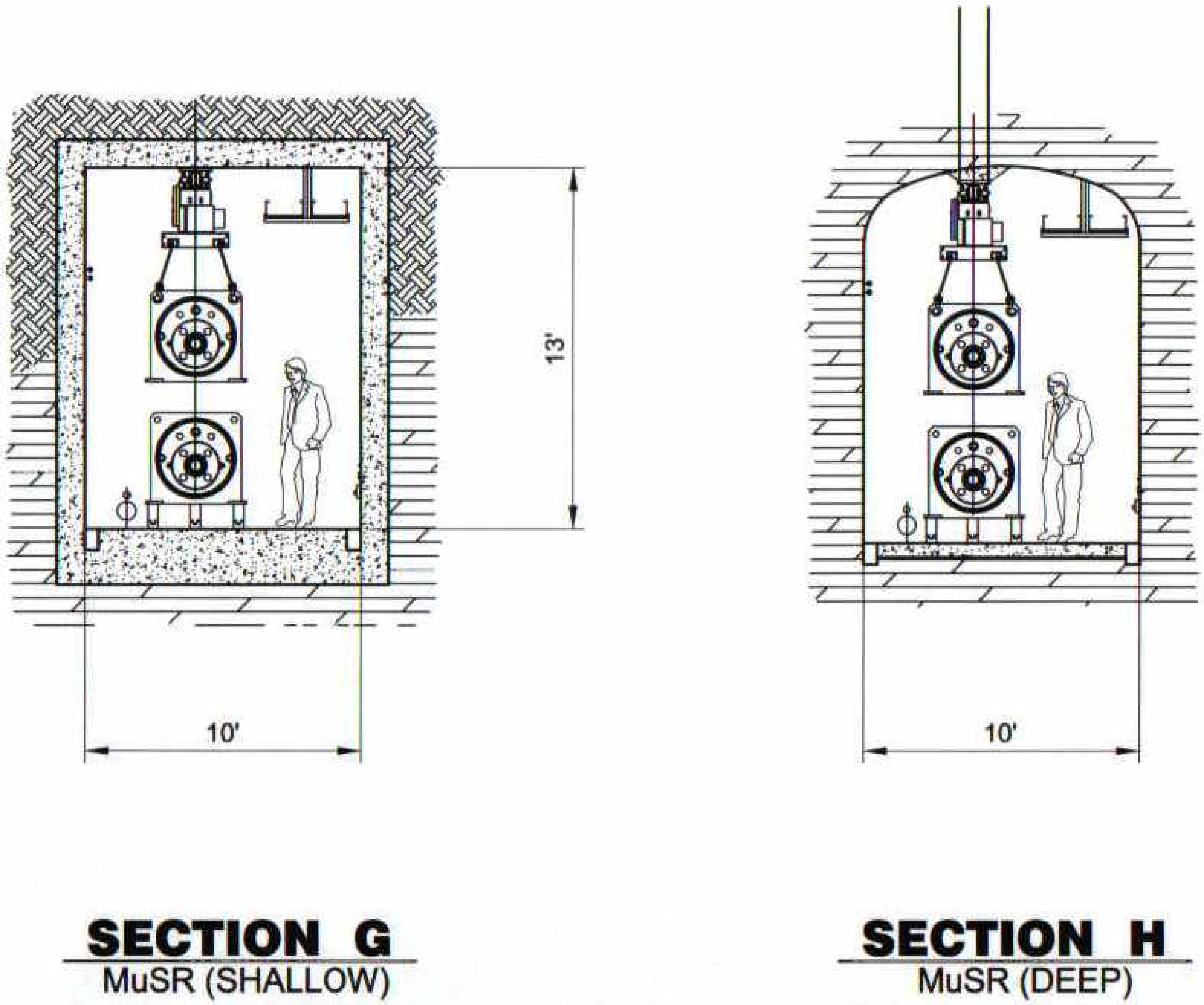

Figure 6: Section G shows the Muon Storage Ring in its beam enclosure near the top of the tunnel where soft tunneling or cut and cover will be used. Section H shows the beam enclosure where drill and blast through dolomite or shale will be used.

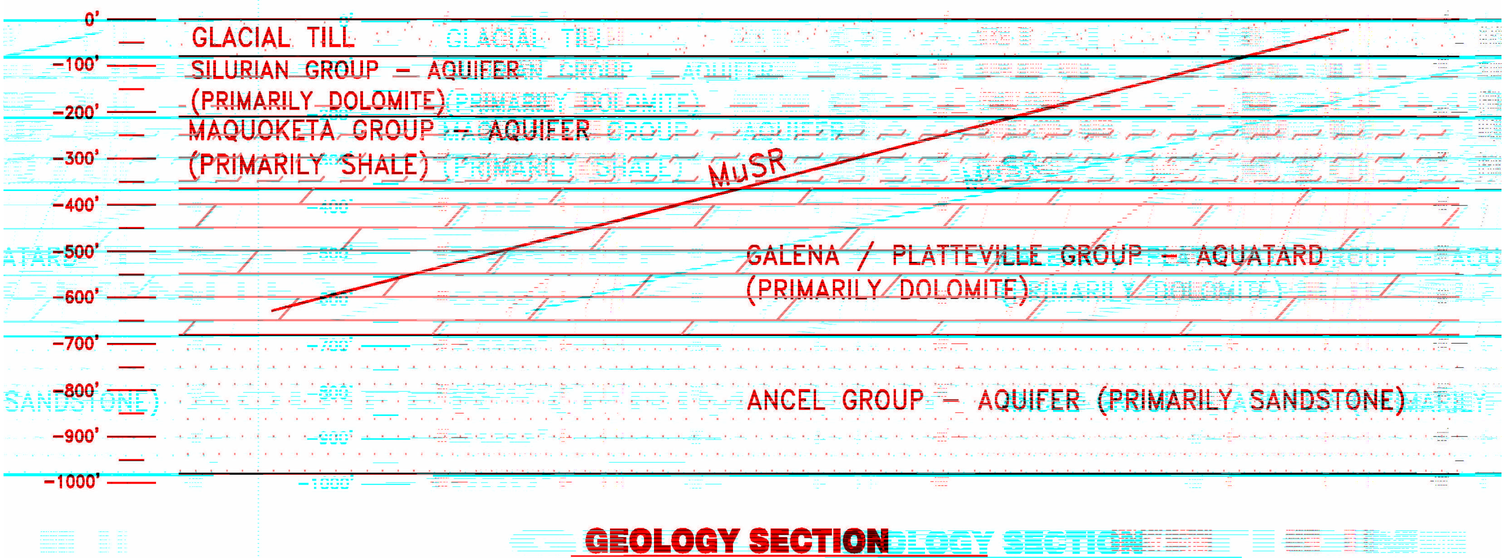

Figure 7: The above shows the geology beneath the Fermilab Site.

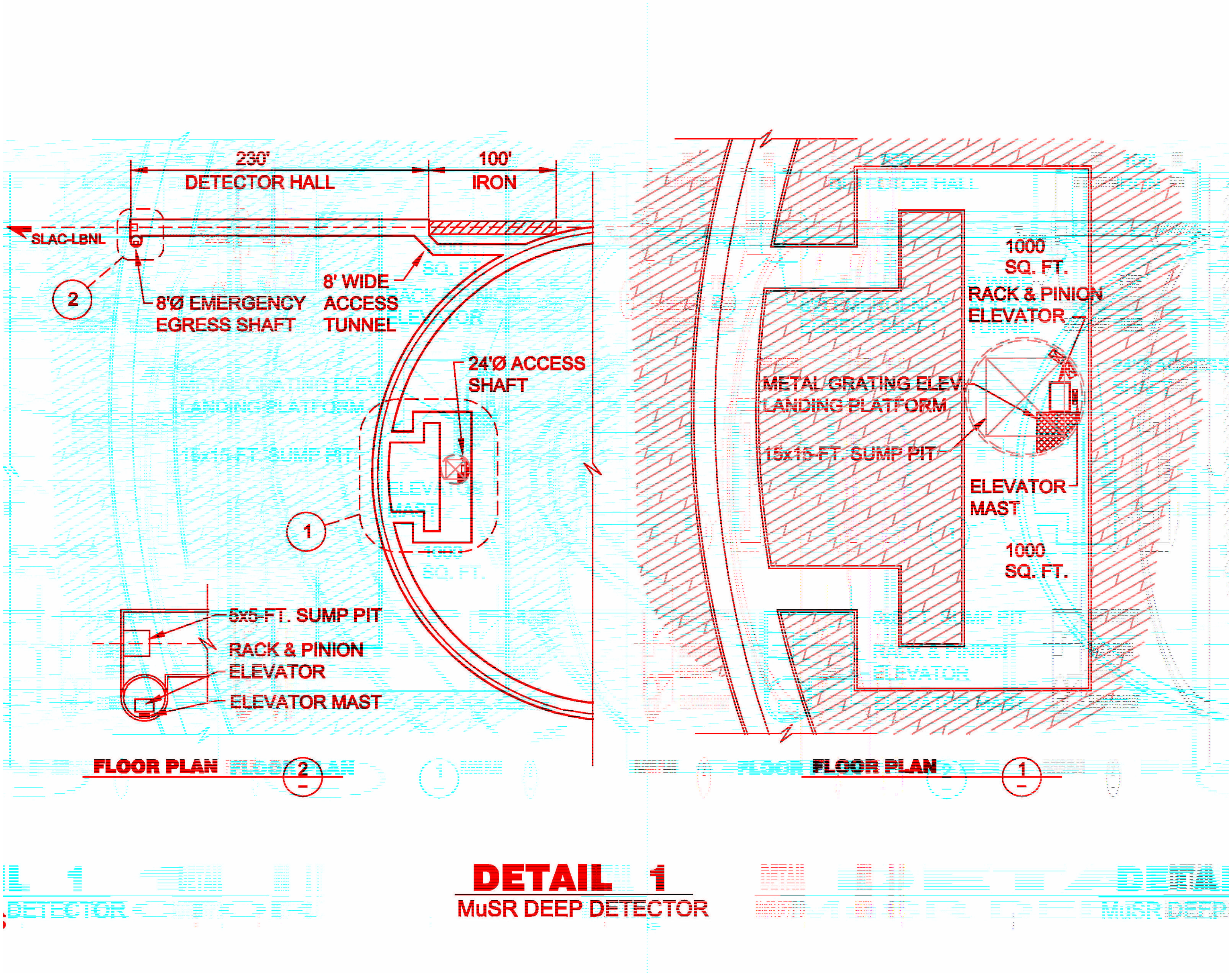

Figure 8: Detail 2 shows the lower end of the Muon Storage Ring and its relationship to the lower physics detector. The two 1000 sq.ft. areas indicated on the floor plan are for accelerator support equipment such as power supplies and cryogenic plant.