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Determination of Interlock Gate Locations at E35, F47, and A25

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INTRODUCTION
The Main Injector and its associated beam lines will provide for significantly improved operating flexibility. In order to achieve this flexibility, the Tevatron safety system configuration will need to be modified to accommodate the new operating modes.

The Tevatron tunnel is to be divided into three major sections for electrical and radiation safety system purposes. The proposed sections are E35 to F47, F47 to A25, and A25 to E35. Three additional sub-systems, the CDF collision hall, DØ collision hall, and CØ interaction region will be included within the A25 to E35 section. The purpose of this Note is to demonstrate that the placement of interlocked gates at E35, F47, and A25 will meet the radiation safety requirements of the Fermilab Radiological Controls Manual (FRCM) for the required operating scenarios.

CALCULATIONAL APPROACH

A series of measurements were made in the Main Injector 8 GeV Tunnel to study the dose attenuation as a function of distance downstream of the beam absorber at cell location 833. The specific dose in mrem/p was determined at locations 49, 140, 200, 250, 311 and 410 feet downstream of the end of the absorber with 8 GeV protons incident upon it. Multiple measurements were made at the 140, 311, and 410 locations. Figure 1 is a plot of this data along with a curve fit.

The data from the measurement has been compared with a labyrinth attenuation program commonly know as Exit2A. The program was refitted to work in the Excel environment and has been documented[2]. Specifically, the source term was examined to determine the distance along the tunnel for which any agreement might exist between it and experimental data. Plotted on Figure is the output from the spreadsheet indicated as “source term”. It can be seen that the agreement is reasonably good between experimental data and the source term in the region from 49 to about 200 feet. A physical explanation for this agreement is that the line-of-sight distance from the downstream end of the absorber to a point further downstream in the MI8 enclosure was a little more than 200 feet.

A second comparison is made between a CASIM run made for the 8 GeV beam absorber illustrated in reference 1 and the source term of reference 2. From the Casim run, the star density at the downstream end of the absorber is taken to be about 5E-7 stars per incident proton per cc. The dump core is iron and is followed by about 16 inches of concrete. If we ignore the relatively thin concrete at the downstream end of the absorber core, and use the conversion factor for a thick iron shield from reference 3 (420 E-3 mrem/star-cc), we obtain a source term at 0 feet from the downstream end of the absorber of 2.1E-7 mrem/incident proton. The curve fit obtained when this Casim result is plotted with data generated with the source term portion of the labyrinth spreadsheet show very good agreement.

A third comparison can be made between experimental data obtained from 200 to 410 feet downstream of the absorber and the labyrinth calculation. Attachment 5 shows that attenuation in this region is in fair agreement with the calculation when the region is treated as a first leg. The slope of the these two curves suggests that the calculation is probably conservative, but the range of data available doesn't allow a more firm conclusion.

The agreement among the CASIM result, source term calculation, and experimental data in the first 200 feet plus the experimental data in the region from 200 to 410 feet suggest an approach to use for determination of the adequacy of the placement of the gates in question. For the distance from the downstream-most element on which beam can be lost to the end of line of sight, we can use the source term portion of the labyrinth attenuation sheet to determine an initial dose rate. In the region beginning the end of the line of sight and ending at the region of interest (i.e., where the gate is to be placed), we can estimate attenuation by treating the remainder of the enclosure as the first leg of a labyrinth.

The cross-sectional area of the Tevatron is a maximum of 6.3 m^2. The actual area is somewhat less because of the presence of cable tray and other equipment. The cross-sectional area of the MI8 line is about 7.3 m^2 and was relatively free of installed cable tray and equipment while experimental data was collected.

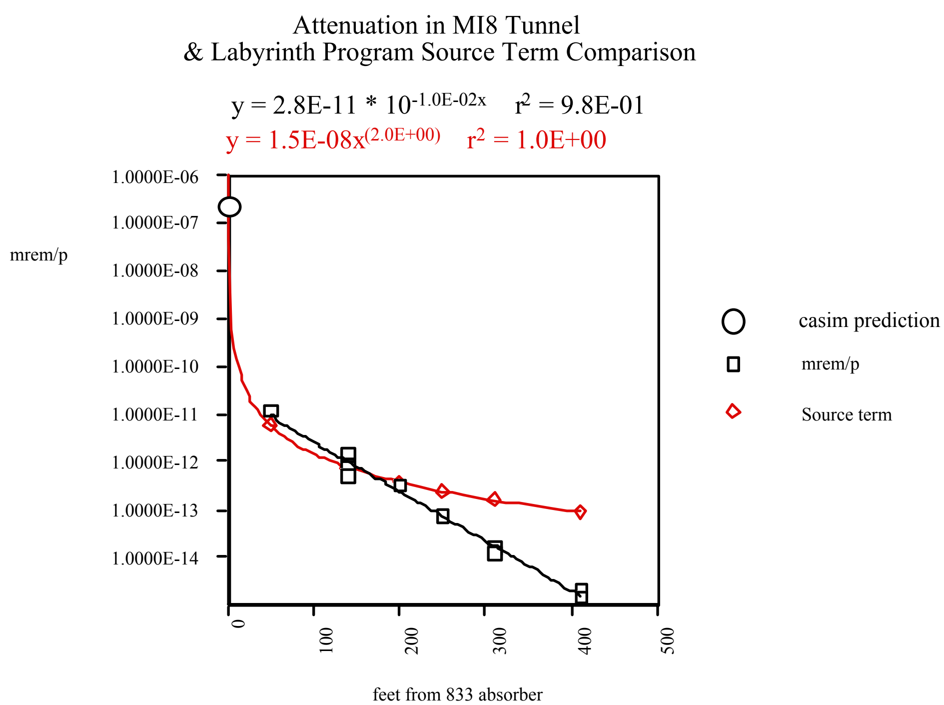

Figure 1

A25 Gate

The purpose of the interlocked gate at A25 is to prevent personnel access to the F47 to A25 region of the Tevatron tunnel during the transport of 120 GeV beam from the Main Injector through the Main Ring remnant (FØ to AØ) and to Enclosure B of Switchyard. The worst case accident considered for the A25 gate is a loss of full beam power (120 GeV, 3.9E16 protons per hour) near the downstream end of the AØ straight section. A sketch showing the line of sight source-term distance and the remaining first-leg distance to the A25 gate is included in Attachment 1. The worst case accident dose rate is estimated to be 6 mrem/hr and is illustrated in Attachment 2.

F47 Gate

The purpose of the interlocked gate at F47 is to prevent personnel access to the E35 to F47 region during various type of beam transport between the Main Injector and the pbar source. The worst case accident for this gate is anticipated to be due to the transport of 1.2E16 protons per hour at 120 GeV beam to the pbar source. A sketch showing the line-of-sight source-term distance and the remaining first-leg distance to the F47 gate is included in Attachment 1. The worst case accident dose rate is estimated to be <1 mrem/hr and is illustrated in Attachment 3.

E35 Gate

The purpose of the interlocked gate at E35 is prevent personnel access to the E35 to F47/A25 region during beam transport between the Main Injector and the pbar source or Transfer Hall.

The worst case accident anticipated at the E35 gate is due to back-scattered radiation resulting from full beam power loss in the FØ region due to Meson 120 operation (120 GeV, 3.9E16 protons per hour). In the case of the A25 and F47 gate, we are concerned about forward-scattered radiation. The possible loss points in the FØ region are beneath the Tevatron and below the Tevatron enclosure floor grade, factors which are not considered in the calculation. As a consequence, the calculation for the E35 gate is thought to be very conservative.

A sketch showing the line-of-sight source-term distance and the remaining first-leg distance to the E35 gate is included in Attachment 1. The worst case accident dose rate is estimated to be 11 mrem/hr and is illustrated in Attachment 4.

Conclusion

The dose rate for three accident scenarios has been calculated for three interlocked gates to be placed in the Tevatron enclosure at locations A25, F47, and E35. The resulting worst-case accident dose rates for all three are below those permitted by Reference 3 since the areas are to be posted as Radiation Areas. A set of measurements in the F17 to F47 region of the Tevatron during pbar stacking would be a useful proof of the method described in this paper.

References

[1] "Groundwater, Airborne, and Soil Activation from the Operation of the Temporary Beam Absorber in the MI-8 GeV Beamline", C. M. Bhat & A. F. Leveling, January 25, 1997

[2] "Approximate Technique for Estimating Labyrinth Attenuation of Accelerator-Produced Neutrons", J. D. Cossairt, Radiation Physics Note 118, September 1995

[3] Fermilab Radiological Controls Manual