Fermilab

Requirements for the Mu2e Protection Collimator

Version 4

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6/23/2014

Mu2e-doc-2897

Change Log

Revision No.	Pages Affected	Effective Date
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Requirements for the Mu2e Protection Collimator

This document lays out the physics requirements for the Mu2e Protection Collimator. The Mu2e primary 8GeV (KE) proton beam averages 8 kW of deliverable beam power. Normally, this beam will interact with the production target located within the bore of the Production Solenoid (PS), with the remnant beam delivered to the proton beam absorber located well downstream of the production region. There are stringent limits for heat loads on components of the PS, the Transport Solenoid (TS), and the Heat and Radiation Shield (HRS). In addition, there are stringent limits on displacements per atom (DPA) for the aluminum stabilized superconductor of the Mu2e solenoid systems. In particular, beam accident conditions which result in direct interaction of primary beam protons with the HRS, cryostat walls, or coils, could result in significant heat deposition or radiation damage to these components.

To ensure that the above limits are not exceeded even during beam accident conditions, Mu2e requires a Protection Collimator (PC) to be installed between the downstream end of the final beam element, and the entrance of the proton beam through the cryostat wall. This device and its support elements must be designed to fit between the various interfacing systems, and must not interfere with them. The PC must be no longer than 1.0 m in order to fit between the last trim dipole & beam position monitor and the entrance to the PS cryostat. The material and outer diameter of the collimator shall be chosen to sufficiently contain the particle shower in any possible beam mis-steering accident condition.

During accident conditions, the PC must be able to absorb and dissipate the heat load from the full primary 8 kW (average) beam for at least 50 ms before the beam protection systems trip off the beam.

Vacuum consistent with the proton beamline vacuum condition shall be maintained within the aperture of the PC. The proton beamline vacuum specifications derive from [3].

During normal operations, the beam will have a transverse size (Gaussian profile) within the PC aperture of ~3 mm.[1] To maximize targeting flexibility, the beam aperture through the PC should be as wide as possible during normal operations. The aperture diameter may not exceed 80 mm, to protect the extinction monitor from fake signal events.[2]

During startup we will operate the primary beam at low intensity to perform targeting scans. The beam must able to move entirely off the target and must also be able to be angled about the target center. The beamline design permits motion off the target and allows 0.8 degrees of rotation about its center. Since the 80 mm requirement above restricts beam rotation to less than 0.8 degrees, the PC must be removable during target scans. The aperture does not restrict the transverse motion off the production target, which is less than one cm target diameter.[4]

Since it will be installed in close proximity to the PS, TS1, and TS2 coils, the PC must be constructed from non-magnetic materials so that it does not affect the field uniformity requirements of those systems. The PC and its supporting systems should be serviceable without removal from within the beam transport enclosure. As far as is practical, materials should be chosen to minimize residual activation for the protection of maintenance personnel, and such that the radiation cool-down time does not significantly impact the experiment sensitivity.

References:

1. M4 line magnet names, currents, lattice,Mu2e-docdb-3375-v10.
2. Extinction Monitor Status, Peter Kasper, Mu2e-docdb-2024
3. WBS 475.02.07 – M4 External Beamline Vacuum System, Mu2e-docdb-3596
4. Requirements for the Mu2e Production Target, Mu2e-docdb-887.