NuMI Area Maximum Credible Incident (MCI)

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NuMI: maximum credible incident

The NuMI beam line is designed to transport as much beam intensity as the Main Injector can give us at the operating energy of 120 GeV. The maximum credible incident assumes 2.83e17 protons per hour and a one-hour duration.

The intensity is arrived at by assuming maximum Booster output (7e12 protons per batch); maximum number of Booster batches for slip-stacking injected into the recycler (12); minimum Main Injector repetition period (1.067 seconds); and 100% transmission efficiency.

One assumes that beam can be lost anywhere along the beam line or most likely strikes the target as intended in normal operation. As losing the beam along the way to the target would halt beam, the maximum credible incident is the largest beam intensity produced by the upstream proton source and accelerated through the Linac and Booster, then transmitted through the Recycler/Main Injector accelerators. That is described above: 8.40e13 ppp, 2.83e17 protons/hr at 1.067s minimum rep rate. Beam is transmitted to the target with a power corresponding to the intensity delivered from the Main Injector for one hour. This is normal operating beam behavior with an abnormally high input from upstream. The unshielded dose for this scenario is 1.03E11 mrem/hr.

Passive shielding

I use the ISA shielding spreadsheet for the maximum output of MI based on the maximum output of booster: 7e12 protons per batch. This yields out of the MI 2.83e17 protons/hr. Locations are analyzed for compliance with the 500 mrem limit on potential exposure from a MCI in accessible locations, and 5000 mrem in locked locations. From the spreadsheet, the required shielding is smaller than the existing shielding.

Location	Fixed Shielding (efd)	Movable Shielding (efd)	Current Shielding (efd)	Category	Standard (efd)	Required [1] (efd)	Difference (efd)
carrier pipe	41.5		41.5	4B	18.8	18.2	23.3
pretarget	100.0		100.0	4A	21.3	20.7	79.3
pretarget	100.0		100.0	4B	18.8	18.2	81.8
target hall	94.3		94.3	4A	21.3	20.7	73.6
decay pipe	138.1		138.1	4C	23.7	23.1	115.0
absorber	264.0		264.0	4A	21.3	20.7	243.3
alcoves >2	264.0		264.0	4A	21.3	20.7	243.3

For labyrinths and penetrations, I have recalculated by scaling the MCI from previous information in rad notes and shielding assessments for NUMI (2004 rad note 147, original, 780kW and 1.2 MW assessments documents) from the dose for normal operations to the dose for the MCI. The ratio of protons/hr is 1.26. The following were evaluated based on doses and methodology from which I calculated attenuation factors (e.g. TH labyrinth, site riser shielding plugs, TH shield door, bottom of MI65 shaft to top). Source terms were scaled as described.

Surface penetrations

SR1, 2, 3

EAV-1, 2 3

MI65 Shaft area:

target hall labyrinth shaft side door for entry/exit

outside of the target hall shield door

bottom of shaft

mi65 service building

PS room (strip line penetration)

Minos area:

Outside of Absorber Hall door to MINOS ramp

Muon alcoves (muons, neutrons, bypass tunnel)

MINOS hall (muons, neutrinos)

These areas are inside locked buildings and subject to a 5000 mrem MCI limit. Members of the public would be at least 1700 feet from MI-65 and 300 feet from the MINOS hall. MCI doses would be well below 1 mrem to a member of the public from any NuMI area.

type	location	dose (mrem/	notes		
survey riser			on surface		
	SR1	0.011	shielded		
	SR2	0.007	shielded		
	SR3	0.002	no shielding		
Exhaust air vents					
	EAV-1	0.038			
	EAV-2	0.088			
	EAV-3	0.025			
MI65 Shaft area:					
	target hall labyrinth	0.015	shaft side door for entry/exit		
	target hall shield door	0.680	shaft side door		
	shaft	0.819	bottom		
	mi65 service building	0.035			
	PS room	0.118	PS room side of strip line penetration		
Minos area:					
	Absorber door	126	MINOS ramp side		
	Muon alcoves (muons, neutrons, bypass tunnel), *mrem/hr*				
	sub-location	*distance (ft)*	*muons*	*neutrons*	*bypass tunnel (tot*
	alcove 1	0	3.33E+05	3.33E+04	6.99E+02
	alcove 2	45	9.11E+04	6.47E+01	1.76E+02
	alcove 3	110	3.63E+04	6.47E+00	2.43E+01
	alcove 4	220	3.75E+03	6.47E-01	8.82E-01
	MINOS hall	830	2.39E-02	4.09E-06	n.a.

While the sight riser shielding is not required to meet the 500 mrem/hr limit to worker/coworker, it is administrative controlled by the RSO for ALARA purposes.

MCI considerations for NuMI beam scans at low intensity with the target hall shield door not present

For alignment of target hall components, beam scans are done at low intensity with the target hall shield door not present. The same considerations of the MCI as above apply: abnormally large output from the upstream machines. For scans the following modifications apply.

- Upstream machines are configured for 1 booster batch, not 12.
- NuMI is configured for 10 s minimum between pulses (thus 360 pulses/hr not 3374).
- The shield door is not present.

These modifications change the MCI number by a factor of 1/12th (1 batch), a factor of 23 (no shield door) and a factor of 360/3374 (pulses for the special machine configuration). The dosage is given in the next table for worker or coworker at the bottom or top of the shaft (service building). It should be noted that special administrative controls and procedures are implemented for this case.

	w. shield door	wo shield door	beam scan
MCI # bottom of shaft	0.819	18.8	0.167
MCI # top of shaft	0.035	0.8	0.007