Fermilab: Accelerator Division

TLM and Chipmunk Response to Controlled Beam Loss at Booster

Report on data set collected in March 2015

Anthony Leveling, Keith Gollwitzer

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NOTE: 11-8-16, corrected references to Figures 1 through 6 in the text.

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INTRODUCTION

The Booster Total Loss Monitor System (TLM) [2, 4, 5] installation began in September 2014 and became fully functional in March 2015. At a minimum, the new TLM Safety System is intended to supplement the existing array of Chipmunk connected to the Radiation Safety System (RSS). If it can be shown that the TLM system provides equivalent or better protection, the TLM System consisting of 8 detectors can replace the array of 48+ Chipmunks.

As a part of the Proton Plan and the Proton Improvement Plan upgrade (PIP), a set of 96, high strength, ramped, trim magnets replaced an earlier version of trim magnet. These horizontal and vertical trim magnets are located at each of the 24 Booster Long and Short straight sections. The peak current on the ramp of each of the 96 magnets are periodically and systematically adjusted to improve beam transmission while reducing beam loss through the Booster. As a consequence, the setting of any Booster trim magnet is subject to change at the discretion of Booster experts and the Accelerator Operations Department. It is expected that the orbit of the Booster beam will change on an ongoing basis in response to these actions.

Study periods made available on 3/10/15, 3/18/15, and 3/30/15 were used to collect data sets for 197 unique cases.

STUDY TIMELINE

The collection of such a large dataset required the cooperation of the Program Planning Office, the AD Run Coordinator, AD Operations and ES&H Departments. The study required dedicated Booster machine operation with no beam delivery to any other programs. The imposition of quiet machine conditions was necessary to eliminate the possibility of non-study related beam loss interferences which would have been impossible to separate from the cases to be studied.

The study timeline was a continuous series of 180 second time windows. Beam was delivered at a 1 Hz rate for the first 10 seconds of the 180 second period. The start of each 3 minute period was synchronized with the start of the RADMUX front end of ACNET. The outputs of the Chipmunks and TLMs are integrated over 60 second periods. In this way, the 3 data points related to each study case were unambiguously isolated and could not contain detector response from an adjacent study period. The Chipmunk and TLM electrometers have 20 second time constants. In the 170 second period following the cessation of beam delivery, 8.5 electrometer time constants have elapsed. The fraction of charge remaining in the electrometer integrating capacitor after 8.5 time constants is 0.02%. The beam intensity delivered for the 400 MeV studies was nominally about 3.8E12 ppp, which provided sufficient sensitivity for TLMs as well as Chipmunks.

BEAM ENERGY

Studies at 2 beam energies were conducted.

400 MeV

Beam was injected at 400 MeV, the present Booster injection energy, while one of the 96 trim magnets had its flat top magnet current set to + or – 39 amps, the nominal upper/lower limit of the current range. The nominal current at the time for each magnet was also noted to allow the difference for the local nominal and abnormal condition to be recorded. 192 datasets resulted from the 400 MeV injection energy. The setting of a trim magnet at its maximum or minimum current during beam injection was expected to cause all of the beam to be lost at 400 MeV, nominally within a single turn, but in every case before the start of beam acceleration. In order to avoid interruption of the study, the Booster beam loss monitoring system had to be bypassed.

8 GeV

Five beam loss cases were established at the end of the acceleration cycle. The radial position of the beam was moved in the positive and negative positions. This resulted in the beam hitting apertures around the Booster causing distributed Chipmunk and TLM responses. In a third study the Booster extraction kickers' strengths were reduced. The fourth study was made with the magnetic septum MP02 turned off. In the fifth study, a single extraction kicker (MKS05) was turned off. For each of these cases, Booster experts detuned the Booster to create extreme beam loss conditions. Once the parameters for these accident conditions were established, the beam was turned off for several minutes to allow detector responses to return to background levels. Then, 10 beam pulses were delivered at 1 Hz for the first 10 second of a three minute study window as described for the 400 MeV studies.

DETECTORS

A total of 48 Chipmunks have been installed at Booster since about 1998. The detectors (with one exception) are located outside the Booster tunnel, nearby the limiting horizontal and vertical apertures at the long and short straight sections. A total of 8 TLM detectors are installed inside the Booster tunnel. Each TLM cable covers three periods of the Booster. The 8 TLM detectors, the periods covered by each one, and the associated Chipmunks are listed in the following table.

TLM#/ACNET name	Covers Periods	Chipmunk ACNET name	Location
1/G:RD2024	23, 24, and 1	G:RD0234	Long 23
		G:RD0235	Short 23
		G:RD0236	Long 24
		G:RD0237	Short 24
		G:RD0238	Long 1
		G:RD0239	Short 1 - booster exit stairway
2/G:RD0252	2, 3, and 4	G:RD0240	Long 2
		G:RD0241	Short 2
		G:RD0242	Long 3
		G:RD0243	Short 3
		G:RD0244	Long 4
		G:RD0245	Short
3/G:RD0253	5, 6, and 7	G:RD0246	Long 5
		G:RD0247	Short 5

TLM#/ACNET name	Covers Periods	Chipmunk ACNET name	Location
		G:RD0248	Long 6
		G:RD0249	Short 6
		G:RD0192	Long 7
		G:RD0193	Short 7
4/G:RD0205	8, 9, and 10	G:RD0194	Long 8
		G:RD0195	Short 8
		G:RD0196	Long 9
		G:RD0197	Short 9
		G:RD0198	Long 10
		G:RD0199	Short 10
5/G:RD0206	11, 12, and 13	GLRD0200	Long 11
		G:RD0201	Short 11
		G:RD0202	Long 12
		G:RD0203	Short 12
		G:RD0209	Long 13
		G:RD0210	Short 13
6/G:RD0220	14, 15, and 16	G:RD0211	Long 14
		G:RD0212	Short 14
		G:RD0213	Long 15
		G:RD0214	Short 15
		G:RD0215	Long 16
		G:RD0216	Short 16
7/G:RD0221	17, 18, and 19	G:RD0217	Long 17
		G:RD0218	Short 17
		G:RD0244	Long 18
		G:RD0225	Short 18
		G:RD0226	Long 19
		G:RD0227	Short 19
8/G:RD2025	20, 21, and 22	G:RD0228	Long 20
		G:RD0229	Short 20
		G:RD0230	Long 21
		G:RD0231	Short 21
		G:RD0232	Long 22
		G:RD0233	Short 22

Study Results

The TLM and Chipmunk responses for each of the 197 cases were normalized to 2.7E17 protons per hour. The rate responses reported were the maximum ones achievable at this proton intensity and beam energy. During the conduct of the study, the actual beam loss was approximately 0.28% of the full beam power anticipated by the study.

The complete study results are included in an Excel spreadsheet which is a companion of this report. The study results are also summarized in the tables at the end of this document.

The trip levels of Chipmunks and TLMs are included in the summary tables. The Chipmunk trip levels in a number of unlimited occupancy locations were determined in the 1998 Booster Shielding Assessment. These areas have subsequently been reclassified as minimally occupied spaces while the trip levels for those detectors have remained at settings intended for unlimited occupancy. For purposes of this analysis, the trip levels in the summary tables have been adjusted to the nominal trip level for minimally occupied spaces, i.e., 5 mrem/hr. It is recommended that the actual trip levels be adjusted accordingly following completion of the 2015 Booster shielding assessment. The affected locations and present trip levels are listed in the following Table.

Chipmunk	Location	Present trip level mrem/hr
S21	RF room –Linac upper gallery	0.4
L20	safety portakamps	0.4
L19	safety portakamps	0.4
S18	safety portakamps	0.4

The results of each study has been plotted graphically, for example, as shown in Figure 1. The 8 TLM responses are indicated as horizontal bars while the 6 associated Chipmunk responses are indicated as filled circles. The TLM and Chipmunk responses are plotted in units of nC/min and mrem/minute, respectively. The mrem/min y scale range is locked in the range of 0 to 20 mrem/min while the nC/min y scale is allowed to float from 0 to an auto scale value determined by Excel. Blue points are resulting from the +39 amp trim setting while red points result from the -39 amp trim setting.

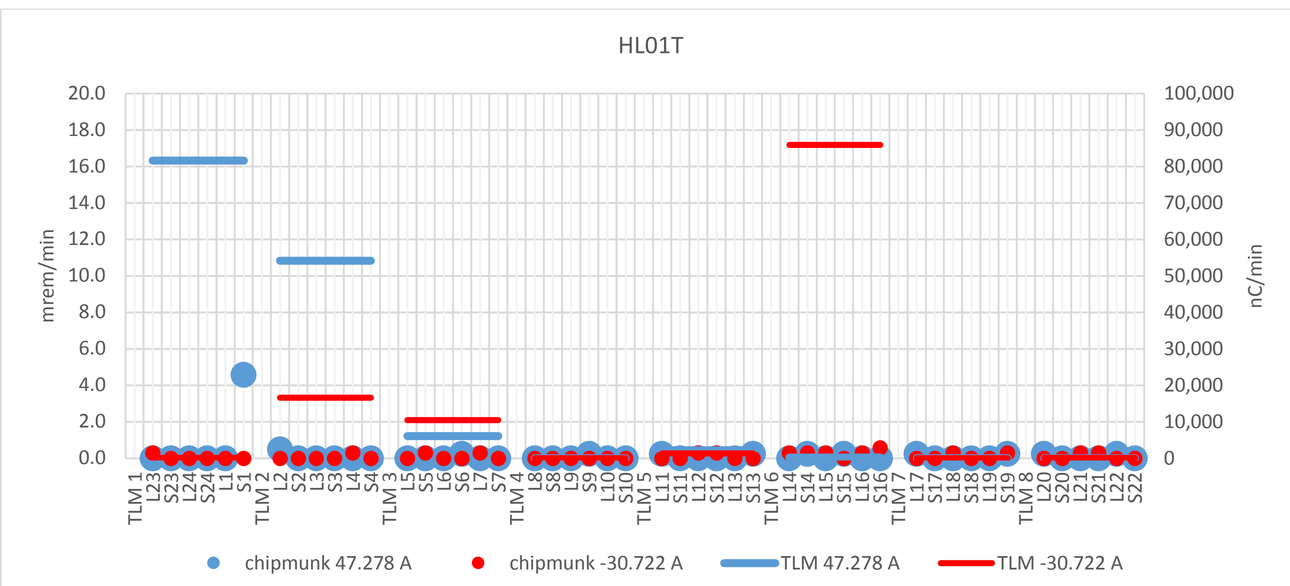


Figure 1

ELAPSED TIME ESTIMATE OF RADIATION DETECTOR TRIP FOLLOWING ONSET OF BEAM LOSS CONDITION

Chipmunk

The behavior of the Chipmunk and TLM electrometers have each been modeled in Excel spreadsheets [1]. Consequently, it is possible to predict the elapsed time to trip from the onset of a beam loss condition. Examples of Chipmunk and TLM time to trip calculations are illustrated in this section. The time to trip calculation for the most sensitive Chipmunk and TLM for the 197 cases listed in the summary table were calculated; the result is included in the summary table.

Figure 2 shows an example of the Chipmunk electrometer spreadsheet. The nominal dose rate measured by the Chipmunk for the current running condition is 0.05 mrem/hr. An unintentional beam loss condition occurs beginning at 50 seconds and persists for 300 seconds creating a dose rate of 7.5 mrem/hr. The beam loss condition is corrected at 350 seconds and radiation dose rate returns to starting level of 0.05 mrem/hr. Since the RSS sum never exceeds the 5 mrem/hr trip level, beam runs continuously without interruption.

time constant	20	seconds			**INSTRUCTIONS:**
chipmunk background	0.6	mrem/hr	0.067	counts per second	Insert user defined parameters in cyan colored cells B1 to B5.
normal losses	0.05	mrem/hr	0.006	counts per second	Enter the accident duration in cells B36 to B3636.
accident losses	7.5	mrem/hr	0.833	counts per second	0 is normal condition and 1 is the accident condition.
trip level	5	mrem/hr	500	counts per 15 minutes	
chipmunk pulse	2.5	urem/count	400	counts/mrem	All other cells are write protected with the password "chipmunk".
Total dose for the hour	0.67	mrem			

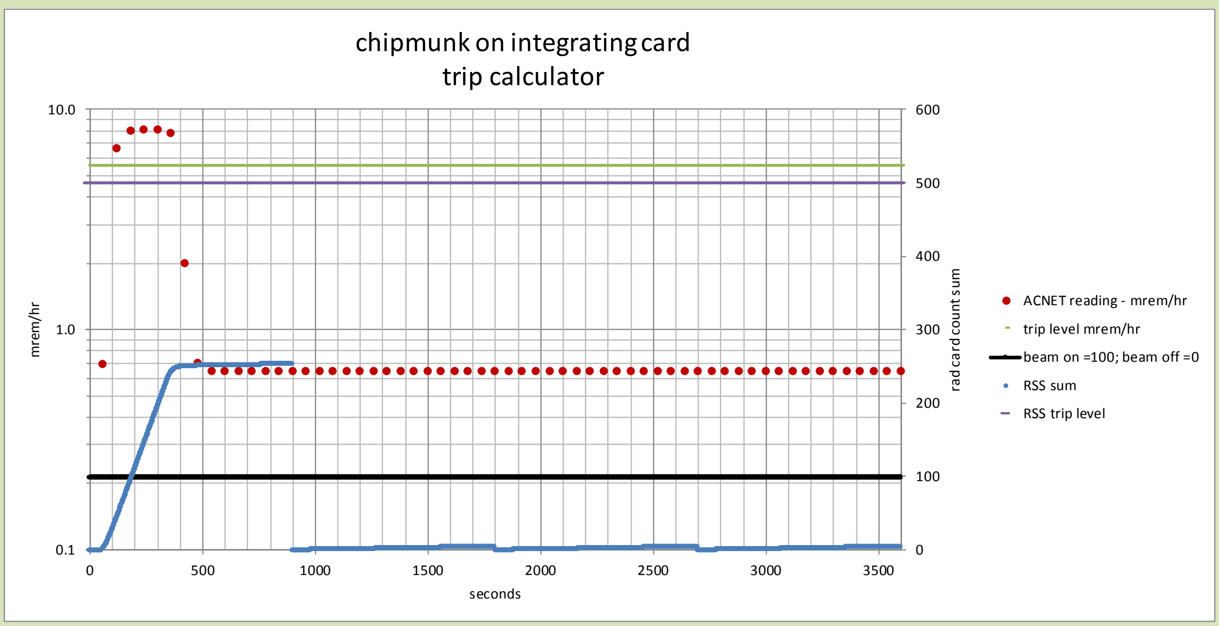


Figure 2

In Figure 3, the same conditions shown in Figure 2 exist except that the condition persists for 600 seconds. In this case, RSS sum exceeds the trip level and initiates a Radiation Safety System trip at 680 seconds. The cause of the beam loss condition is corrected after the RSS trip occurs. The beam is held off until 900 seconds when an RSS reset is permitted. The Chipmunk time to trip from the onset of the beam loss condition is 680 – 50 = 630 seconds.

time constant	20	seconds			**INSTRUCTIONS:**
chipmunk background	0.6	mrem/hr	0.067	counts per second	Insert user defined parameters in cyan colored cells B1 to B5.
normal losses	0.05	mrem/hr	0.006	counts per second	Enter the accident duration in cells B36 to B3636.
accident losses	7.5	mrem/hr	0.833	counts per second	0 is normal condition and 1 is the accident condition.
trip level	5	mrem/hr	500	counts per 15 minutes	
chipmunk pulse	2.5	urem/count	400	counts/mrem	All other cells are write protected with the password "chipmunk".
Total dose for the hour	1.30	mrem			

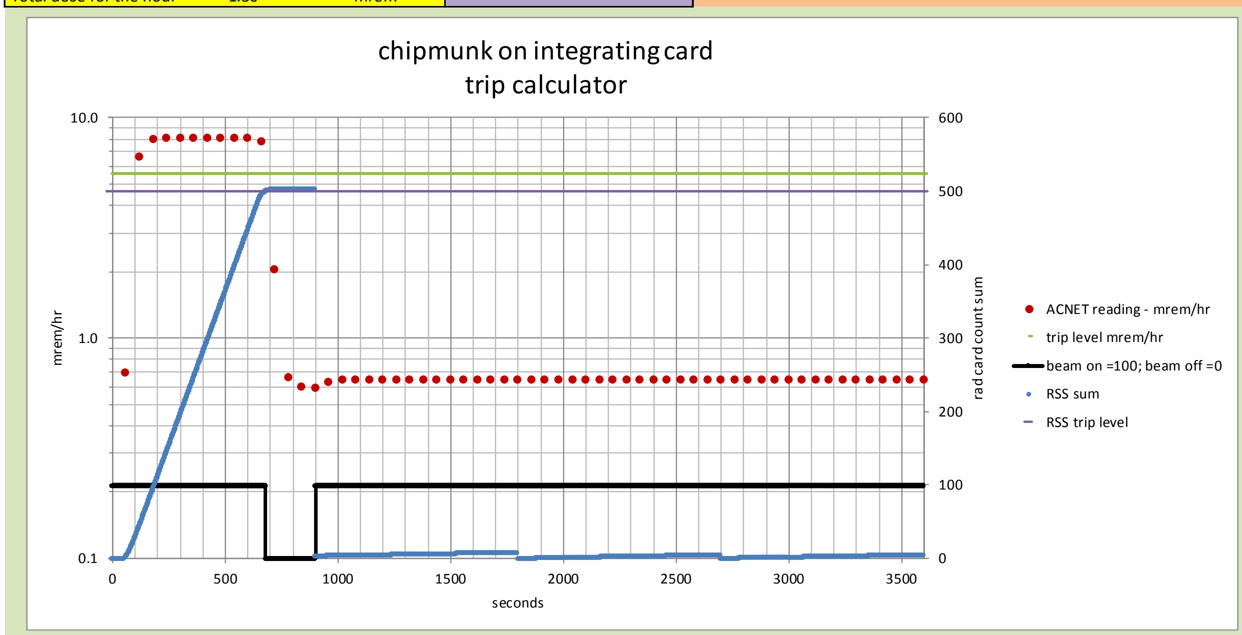


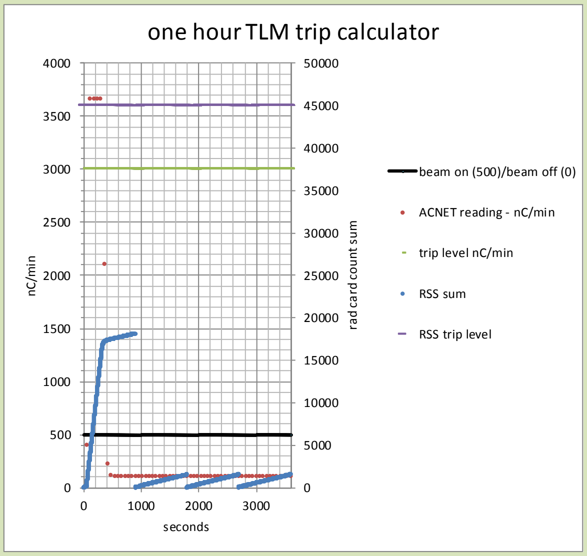
Figure 3

TLM

The TLM detection system is capable of inhibiting beam operation from either of 2 beam induced conditions. In the first condition, the TLM outputs TTL pulses in the same manner as a Chipmunk. When the limiting integral of pulses is sensed by the rad card, a trip is initiated which inhibits further beam delivery. In the second condition, referred to as “excessive charge”, a trip is initiated when the integrating capacitor of the TLM system reaches the end of its dynamic range in which linear response is possible [2].

In Figure 4, a normal beam loss condition produces a 100 nC/min charge collection rate above the 5 nC/min heartbeat signal. Starting at 50 seconds an unintentional beam loss condition occurs producing a charge collection rate of 10,000 nC/min. The unintentional beam loss condition is corrected 100 seconds after it began. The left plot in Figure 4 indicates that the RSS sum never exceeds the trip level and beam operation continues without interruption. The right plot in Figure 3 shows that the excessive charge voltage reached -2.8 volts but never exceeded the excessive charge trip level of -5 volts.

time constant	20	seconds			INSTRUCTIONS:
TLM background	5	nC/min	0.083	counts per second	Insert user defined parameters in cyan colored cells B1 to B5.
normal losses	100	nC/min	1.667	counts per second	Enter the accident duration in cells B36 to B3636.
accident losses	10000	nC/min	166.667	counts per second	0 is normal condition and 1 is the accident condition.
trip level	3000	nC/min	45000	counts per 15 minutes	
TLM pulse	1	nC/count	1	nC/count	All other cells are write protected with the password "TLM".
otal charge for the hour	22966.75	nC			Change x axis maximum up to 3600 seconds as necessary
Time required for MCR crew chief to reset excessive charge trip	300.00	seconds			excessive charge trip holds off operations until MCR crew chief reset



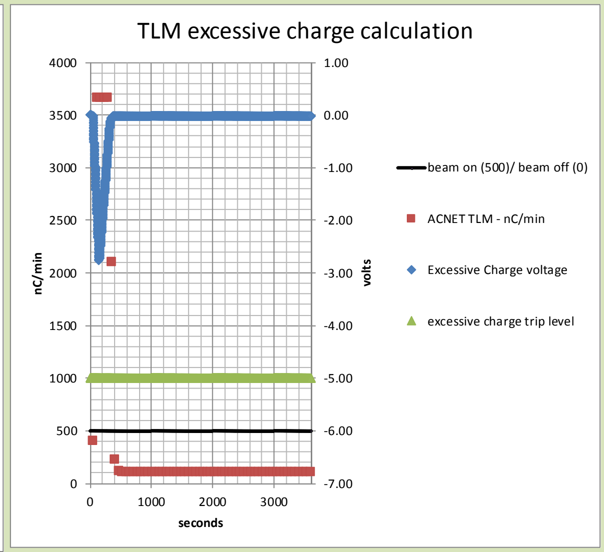


Figure 4

In Figure 5, the same beam loss condition described in Figure 4occurs, but it remains uncorrected for 200 seconds. In the left plot, it can be seen that beam operation is interrupted at 234 seconds. The RSS sum does not exceed the trip level; consequently, the beam interruption is not caused by the integrating feature of the rad card. However, in the right plot, it can be seen that the excessive charge voltage has exceeded -5 volts which has initiated a RSS trip.

time constant	20	seconds			INSTRUCTIONS:
TLM background	5	nC/min	0.083	counts per second	Insert user defined parameters in cyan colored cells B1 to B5.
normal losses	100	nC/min	1.667	counts per second	Enter the accident duration in cells B36 to B3636.
accident losses	10000	nC/min	166.667	counts per second	0 is normal condition and 1 is the accident condition.
trip level	3000	nC/min	45000	counts per 15 minutes	
TLM pulse	1	nC/count	1	nC/count	All other cells are write protected with the password "TLM".
otal charge for the hour	36465.08	nC			Change x axis maximum up to 3600 seconds as necessary
Time required for MCR crew chief to reset excessive charge trip	300.00	seconds			excessive charge trip holds off operations until MCR crew chief reset

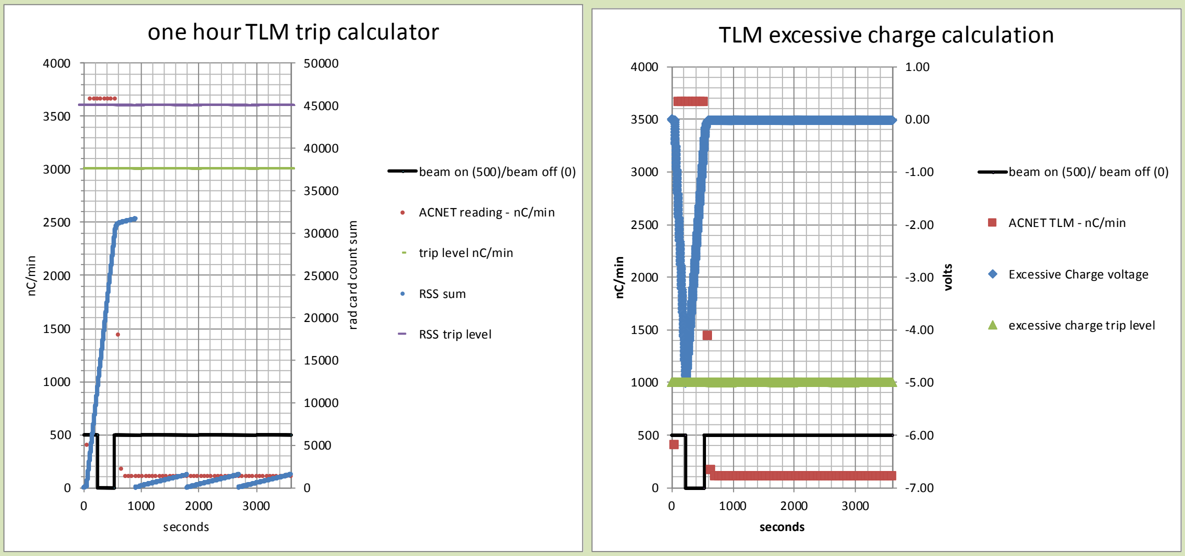


Figure 5

In Figure 6, a more complicated case is illustrated. A beam loss condition which produces a charge collection rate of 100,000 nC/min begins at 50 seconds and persists for 900 seconds. The excessive charge trip can be reset by the MCR Crew Chief as soon as the excessive charge voltage is below the trip level. In Figure 6, an arbitrarily chosen, MCR Crew Chief reset delay of 300 seconds is indicated. As can be seen in the right plot, an RSS trip is initiated on 3 occasions for excessive charge. As can be seen in the left plot, during the third beam off interval due to excessive charge, the 15 minute integrating rad card limit of 45,000 nC is exceeded; this would hold off the beam regardless of whether the MCR crew chief would attempt to reset the RSS. Note that this trip is initiated while the beam has been off for a significant period of time. This occurs because the charge collected by the TLM system integrating capacitor is bled down with a 20 seconds time constant. The RSS rad card subtraction occurs at 900 seconds, the beam loss condition is corrected at 950 seconds, and the MCR Crew Chief resets following the RSS following the third excessive charge delay at 987 seconds. The beam is restored with the normal loss condition and runs without incident for the remainder of the hour. Beam is on for just 100 seconds over the first 1,000 seconds of the hour indicated in Figure 6.

time constant	20	seconds			INSTRUCTIONS:
TLM background	5	nC/min	0.083	counts per second	Insert user defined parameters in cyan colored cells B1 to B5.
normal losses	100	nC/min	1.667	counts per second	Enter the accident duration in cells B36 to B3636.
accident losses	100000	nC/min	1666.667	counts per second	0 is normal condition and 1 is the accident condition.
trip level	3000	nC/min	45000	counts per 15 minutes	
TLM pulse	1	nC/count	1	nC/count	All other cells are write protected with the password "TLM".
otal charge for the hour	64795.08	nC			Change x axis maximum up to 3600 seconds as necessary
Time required for MCR crew chief to reset excessive charge trip	300.00	seconds			excessive charge trip holds off operations until MCR crew chief reset

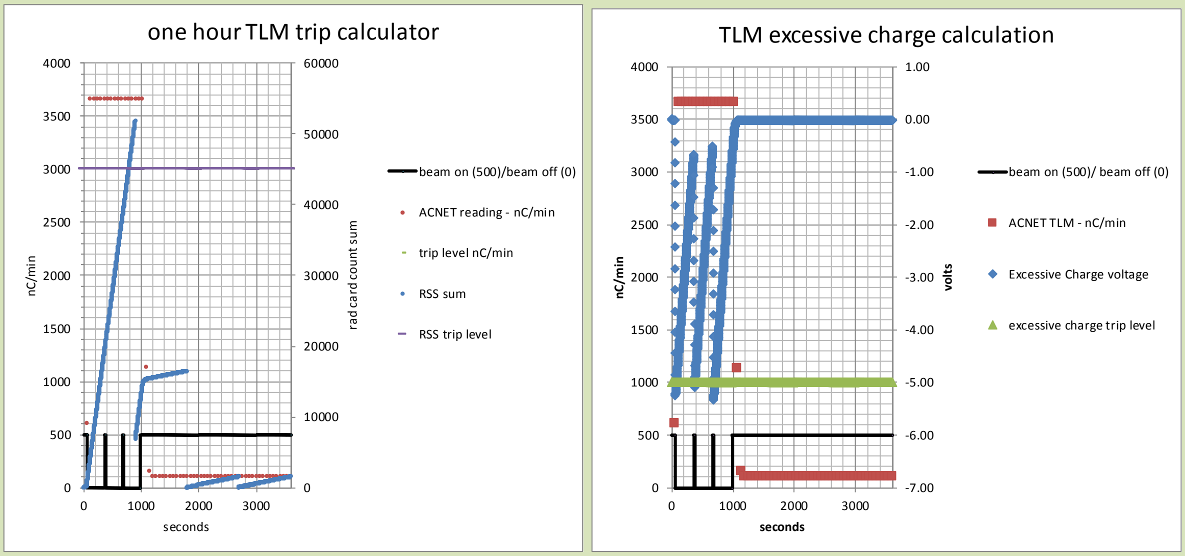


Figure 6

The Chipmunk and TLM time to trip values entered in the summary table were calculated using the spreadsheets indicated above. The nominal background counting rates were used with normal losses to set 0. The normalized rates in the “Most sensitive Chipmunk (mrem/min)” and “max TLM value (nC/min)” columns of the summary tables were set to occur beginning at 0 seconds. The resulting time to trip levels were determined by inspection of the respective spreadsheets. As described in this section, it is possible for the TLM to inhibit beam by two types of trips. Due to the severe nature of the cases studied and listed in the summary table, all TLM trips listed were due to the excessive charge trip feature. There is just one case in which a Chipmunk detector may have tripped before that of the associated TLM system.

CORRELATION OF CHIPMUNK RESPONSE WITH TLM RESPONSE

Two columns in the summary table are used to consider whether Chipmunks would have been required to interrupt beam for the cases studied. The column entitled “Chipmunk response with TLM at its trip level (mrem/hr)” gives the steady state Chipmunk response in mrem/hr which is correlated with the TLM detector response in nC/min. If the indicated Chipmunk response is greater than the presently assigned trip level, the study row is highlighted in bold red type. This indicates that the Chipmunk is complementary and required for comprehensive protection of the Booster. The column heading “Retain Chipmunk?” has a “yes” entry in those cases. For cases in which the Chipmunk response is less that the currently assigned trip level, the “Retain Chipmunk?” response is “no”. The “Retain Chipmunk?” field is intended to serve as a guideline only. The actual disposition of Chipmunks following completion of the Booster shielding assessment is at the discretion of the Radiation Safety Organization, and in particular, the AD RSO.

SUMMARY

The relative responses of TLM and Chipmunks have been measured for 192 beam loss cases involving 400 MeV proton beam and for 5 cases involving an 8 GeV proton beam in the Booster accelerator. All beam loss responses have been normalized to 2.7E17 protons per hour. Based upon analysis of this dataset, the Booster Chipmunks located at Short 1, Long 22, and Short 19 should be retained to ensure comprehensive protection of the Booster. The response of the subsurface Chipmunk located at Short 5 just slightly exceeds its trip level, but is essentially similar to its existing trip level. The remaining Chipmunk detectors would remain at the discretion of the Radiation Protection Organization.

The conditions created for this study set were not intended to be absolutely reproducible. The Booster beam orbit is continuously adjusted by Booster Operations Specialists and Accelerator Division Operations Personnel to improve beam transmission and reduce beam losses. Consequently, the studies presented here should be considered representative of other study sets which could be conducted at a later date. The set of studies presented here indicate that the 8 TLM systems currently installed at the Booster, when complemented by the Short 1, Long 22, and Short 19 Chipmunks, meet the necessary and sufficient radiation protection requirements of the FRCM.

REFERENCES

1. Chipmunk and TLM radiation detector trip calculators, Beams doc.db 4732-v2, July 21, 2015
2. TLM Electrometer Excessive Charge Interlock, Beams doc.db 4757-v2, A. Leveling, February 11, 2015
3. TLM and Chipmunk data summary and analysis for March 2015 data sets, Excel Spreadsheet, July 22, 2015
4. TLM Electrometer Preliminary Design, Beams doc.db 4491-v1, December 5, 2013
5. Preliminary Test Results, Dynamic Range Requirements, and TLM Electrometer Requirements for TLM Systems at Fermilab, Beams doc.db 4533-v1, February 6, 2014

Summary Tables of Chipmunk and TLM Response

The description of the fields in the table header are:

Condition – For the 8 GeV studies, this is the name of the accident condition for which beam loss occurred.

Trim – For the 400 MeV studies, this is the ACNET name of the trim magnet which was set to create the beam loss condition

Current – The resulting net current for the trim magnet established for the study. For example, the nominal current for the B:HL01T study was 8.3 amps.

Maximum Chipmunk response normalized by the trip level – this dimensionless value is calculated for the Chipmunk which most closely approaches or most greatly exceeds its trip level. The value reported is the Chipmunk response in mrem/hour divided by the trip level in mrem/hour.

Most sensitive Chipmunk (mrem/min) – This is the response for the Chipmunk which most closely approaches or most greatly exceeds its trip level.

Max TLM normalized response divided by the trip level – this dimensionless value is calculated for the highest responding TLM. The value reported is the TLM response in units of nC/min divided by the TLM trip level in nC/min.

Max TLM value (nC/min) – the maximum TLM response for one of 8 TLM detector systems

Which Chipmunk? – Chipmunk with the most sensitive response relative to its trip setting

Which TLM? – TLM with the most sensitive response relative to its trip setting

TLM trip level – trip level for the most sensitive TLM in nC/min

Chipmunk trip level –trip level for the most sensitive Chipmunk

Most sensitive detector input rad card device – The TLM or Chipmunk which would cause a rad trip in cases where excessive charge trips are not invoked

Chipmunk response with TLM at its trip level (mrem/hr) – peak steady state Chipmunk response when TLM is just below its trip level

Retain Chipmunk? – If the Chipmunk response is more sensitive than the most sensitive TLM response, this indicates that the Chipmunk may be required for comprehensive Booster protection. Alternative options such as increasing radiological postings and/or Chipmunk trip level settings may also exist.

Chipmunk – seconds to trip – The calculated elapsed time in seconds required for the most sensitive Chipmunk to initiate a RSS trip for the full power beam loss

TLM seconds to trip – The calculated elapsed time in seconds required for the most sensitive TLM system to initiate a RSS trip for the full power beam loss.

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:HL01T	**47.3**	**54.9**	**4.6**	**27.2**	**81611**	**S1**	**TLM 1**	**3000**	**5**	**S1**	**10.1**	**yes**	**31**	**16**
B:HL01T	-30.7	6.9	0.6	28.6	85869	S16	TLM 6	3000	5	TLM 6	1.2	no	144	15
B:HL02T	20.8	3.5	0.3	11.7	35174	S19	TLM 6	3000	5	TLM 6	1.5	no	269	38
B:HL02T	-57.2	3.5	0.3	17.4	52174	S6	TLM 2	3000	5	TLM 2	1.0	no	269	25
B:HL03T	35.2	6.9	0.6	20.0	59989	L21	TLM 6	3000	5	TLM 6	1.7	no	144	23
B:HL03T	-42.8	6.3	0.3	18.0	53979	L3	TLM 2	3000	2.5	TLM 2	0.9	no	144	24
B:HL04T	40.9	41.9	10.5	71.7	215143	L5	TLM 3	3000	15	TLM 3	8.8	no	37	6
B:HL04T	-37.1	6.9	0.3	23.3	70016	L22	TLM 3	3000	2.5	TLM 3	0.7	no	144	19
B:HL05T	50.4	6.9	0.6	19.6	58935	S16	TLM 3	3000	5	TLM 3	1.8	no	144	22
B:HL05T	**-27.6**	**10.4**	**0.9**	**9.0**	**26940**	**S1**	**TLM 6**	**3000**	**5**	**S1**	**5.8**	**yes**	**102**	**52**
B:HL06T	30.0	3.2	0.3	18.6	55766	S6	TLM 6	3000	5	TLM 6	0.8	no	269	23

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:HL06T	-48.0	6.9	2.3	65.1	195295	L7	TLM 3	3000	20	TLM 3	2.1	no	149	7
B:HL07T	26.2	9.3	2.3	12.6	37822	S8	TLM 4	3000	15	TLM 4	11.0	no	116	35
B:HL07T	-51.8	16.2	4.0	155.4	466060	L8	TLM 4	3000	15	TLM 4	1.6	no	74	3
B:HL08T	26.8	0.0	0.0	13.6	40715	L23	TLM 5	3000	5	TLM 5	0.0	no	-	33
B:HL08T	-51.2	8.8	2.2	100.2	300743	S9	TLM 4	3000	15	TLM 4	1.3	no	120	5
B:HL09T	27.1	4.6	1.2	20.1	60325	S10	TLM 4	3000	15	TLM 4	3.4	no	206	22
B:HL09T	-50.9	18.4	4.6	146.4	439202	L10	TLM 4	3000	15	TLM 4	1.9	no	67	3
B:HL10T	25.3	6.9	0.3	26.2	78577	L3	TLM 6	3000	2.5	TLM 6	0.7	no	144	16
B:HL10T	-52.7	6.9	0.6	117.0	351086	S16	TLM 5	3000	5	TLM 5	0.3	no	144	4
B:HL11T	23.0	6.9	0.3	9.6	28885	L3	TLM 3	3000	2.5	TLM 3	1.8	no	144	48
B:HL11T	-55.0	6.9	0.6	36.5	109476	L12	TLM 5	3000	5	TLM 5	1.0	no	144	12
B:HL12T	19.9	6.9	0.6	10.9	32683	S16	TLM 6	3000	5	TLM 6	3.2	no	144	42
B:HL12T	-58.1	6.9	0.3	14.4	43315	L3	TLM 5	3000	2.5	TLM 5	1.2	no	144	31
B:HL13T	15.9	3.5	0.3	34.1	102205	S14	TLM 6	3000	5	TLM 6	0.5	no	269	13
B:HL13T	-62.1	6.9	0.6	37.6	112874	S16	TLM 6	3000	5	TLM 6	0.9	no	144	11
B:HL14T	22.0	6.3	0.5	23.9	71828	S1	TLM 6	3000	5	TLM 6	1.3	no	169	18
B:HL14T	-56.0	6.9	0.6	53.7	161236	L15	TLM 6	3000	5	TLM 6	0.6	no	144	8
B:HL15T	16.7	6.9	0.6	10.5	31594	L21	TLM 7	3000	5	TLM 7	3.3	no	144	43
B:HL15T	-61.3	6.9	0.3	46.9	140725	L3	TLM 6	3000	2.5	TLM 6	0.4	no	144	9
B:HL16T	23.0	6.9	0.6	23.5	70482	S16	TLM 7	3000	5	TLM 7	1.5	no	144	18
B:HL16T	-55.0	3.5	0.3	44.2	132670	S14	TLM 7	3000	5	TLM 7	0.4	no	269	10

TLM and Chipmunk Response to Controlled Beam Loss at Booster

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:HL17T	19.4	10.4	0.9	25.0	75146	S1	TLM 7	3000	5	TLM 7	2.1	no	102	17
B:HL17T	-58.6	17.4	1.4	61.7	185045	L18	TLM 7	3000	5	TLM 7	1.4	no	72	7
B:HL18T	26.4	3.5	0.3	11.7	35198	L16	TLM 1	3000	5	TLM 1	1.5	no	269	38
B:HL18T	-51.6	6.9	0.6	55.4	166273	S19	TLM 7	3000	5	TLM 7	0.6	no	144	8
B:HL19T	30.9	6.9	0.6	31.9	95827	S19	TLM 1	3000	5	TLM 1	1.1	no	144	13
B:HL19T	-47.1	3.5	0.3	72.8	218399	L16	TLM 8	3000	5	TLM 8	0.2	no	269	6
B:HL20T	33.1	6.9	0.6	28.2	84635	S14	TLM 8	3000	5	TLM 8	1.2	no	144	15
B:HL20T	-44.9	20.7	1.7	68.7	206230	L21	TLM 8	3000	5	TLM 8	1.5	no	62	6
B:HL21T	26.0	13.8	1.2	25.2	75706	S1	TLM 8	3000	5	TLM 8	2.7	no	81	17
B:HL21T	-52.0	6.9	0.3	50.6	151714	L22	TLM 8	3000	2.5	TLM 8	0.3	no	144	9
B:HL22T	27.7	6.9	0.6	18.2	54618	L21	TLM 1	3000	5	TLM 1	1.9	no	144	24
B:HL22T	-50.3	3.5	0.3	45.6	136891	S1	TLM 1	3000	5	TLM 1	0.4	no	269	9
B:HL23T	32.0	3.2	0.3	49.8	149514	S19	TLM 1	3000	5	TLM 1	0.3	no	269	9
B:HL23T	-46.0	17.3	1.4	41.9	125619	S1	TLM 1	3000	5	TLM 1	2.1	no	72	10
B:HL24T	27.3	6.9	0.6	23.9	71847	S14	TLM 1	3000	5	TLM 1	1.4	no	144	18
B:HL24T	-50.7	17.3	1.4	21.8	65363	S1	TLM 2	3000	5	TLM 2	4.0	no	72	20
B:HS01T	**27.1**	**97.1**	**8.1**	**41.2**	**123637**	**S1**	**TLM 2**	**3000**	**5**	**S1**	**11.8**	**yes**	**22**	**10**
B:HS01T	**-50.9**	**97.1**	**8.1**	**22.8**	**68430**	**S1**	**TLM 2**	**3000**	**5**	**S1**	**21.3**	**yes**	**22**	**19**
B:HS02T	34.9	3.5	0.3	14.9	44726	S1	TLM 2	3000	5	TLM 2	1.2	no	269	30
B:HS02T	-43.1	6.9	0.3	16.7	49975	L3	TLM 2	3000	2.5	TLM 2	1.0	no	144	26
B:HS03T	27.4	39.1	13.0	253.4	760086	L4	TLM 2	3000	20	TLM 2	3.1	no	16	2

TLM and Chipmunk Response to Controlled Beam Loss at Booster

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:HS03T	-50.6	37.3	12.4	159.9	479804	L4	TLM 2	3000	20	TLM 2	4.7	no	40	3
B:HS04T	23.4	46.1	11.5	75.3	225787	L5	TLM 3	3000	15	TLM 3	9.2	no	35	6
B:HS04T	-54.6	40.5	10.1	81.9	245647	L5	TLM 3	3000	15	TLM 3	7.4	no	38	5
B:HS05T	21.6	6.9	0.6	13.1	39412	L17	TLM 3	3000	5	TLM 3	2.6	no	144	34
B:HS05T	-56.4	6.9	0.3	17.9	53573	L3	TLM 3	3000	2.5	TLM 3	1.0	no	144	24
B:HS06T	35.8	3.5	0.3	12.2	36566	L16	TLM 3	3000	5	TLM 3	1.4	no	269	37
B:HS06T	-42.2	3.5	0.3	23.3	69773	S14	TLM 3	3000	5	TLM 3	0.7	no	269	19
B:HS07T	32.5	15.1	3.8	199.9	599585	L8	TLM 4	3000	15	TLM 4	1.1	no	77	3
B:HS07T	-45.5	24.3	6.1	212.3	636882	L8	TLM 4	3000	15	TLM 4	1.7	no	54	2
B:HS08T	34.4	70.7	17.7	302.8	908360	L9	TLM 4	3000	15	TLM 4	3.5	no	26	2
B:HS08T	-43.6	29.5	7.4	218.2	654661	L9	TLM 4	3000	15	TLM 4	2.0	no	47	2
B:HS09T	38.4	35.4	8.9	361.8	1085478	L10	TLM 4	3000	15	TLM 4	1.5	no	42	2
B:HS09T	-39.6	35.5	8.9	233.8	701268	L10	TLM 4	3000	15	TLM 4	2.3	no	42	2
B:HS10T	37.1	4.7	0.4	295.8	887440	L11	TLM 5	3000	5	TLM 5	0.1	no	206	2
B:HS10T	-40.9	7.0	0.6	202.3	607014	L11	TLM 5	3000	5	TLM 5	0.2	no	144	2
B:HS11T	39.8	7.0	0.6	63.9	191752	L12	TLM 5	3000	5	TLM 5	0.5	no	144	7
B:HS11T	-38.2	10.5	0.9	41.7	125150	L12	TLM 5	3000	5	TLM 5	1.3	no	202	10
B:HS12T	**40.1**	**7.0**	**0.3**	**2.5**	**7462**	**L22**	**TLM 5**	**3000**	**2.5**	**L22**	**7.0**	**yes**	**144**	**310**
B:HS12T	-37.9	7.0	0.3	9.5	28357	L3	TLM 5	3000	2.5	TLM 5	1.9	no	144	49
B:HS13T	35.4	7.0	0.6	67.3	201922	L21	TLM 6	3000	5	TLM 6	0.5	no	144	7
B:HS13T	-42.6	7.0	0.6	42.7	128140	S23	TLM 6	3000	5	TLM 6	0.8	no	144	10

TLM and Chipmunk Response to Controlled Beam Loss at Booster

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:HS14T	39.8	3.5	0.3	73.9	221717	S6	TLM 6	3000	5	TLM 6	0.2	no	269	6
B:HS14T	-38.2	7.0	0.3	53.1	159218	L3	TLM 6	3000	2.5	TLM 6	0.3	no	144	8
B:HS15T	37.6	3.5	0.3	72.3	216922	S14	TLM 6	3000	5	TLM 6	0.2	no	269	6
B:HS15T	-40.4	7.0	0.6	56.2	168583	S23	TLM 6	3000	5	TLM 6	0.6	no	144	8
B:HS16T	34.5	3.5	0.3	55.7	166975	S23	TLM 7	3000	5	TLM 7	0.3	no	269	8
B:HS16T	-43.5	3.5	0.3	40.2	120593	L12	TLM 7	3000	5	TLM 7	0.4	no	269	11
B:HS17T	38.1	21.1	1.8	93.4	280186	L18	TLM 7	3000	5	TLM 7	1.1	no	59	5
B:HS17T	-39.9	17.5	1.5	76.8	230323	L18	TLM 7	3000	5	TLM 7	1.1	no	68	6
B:HS18T	35.1	3.5	0.3	74.3	222995	S6	TLM 7	3000	5	TLM 7	0.2	no	269	6
B:HS18T	-42.9	7.0	0.6	58.8	176399	S19	TLM 7	3000	5	TLM 7	0.6	no	144	7
B:HS19T	33.4	8.2	0.7	262.6	787917	S23	TLM 8	3000	5	TLM 8	0.2	no	127	2
B:HS19T	-44.6	3.5	0.3	163.2	489698	S19	TLM 8	3000	5	TLM 8	0.1	no	269	3
B:HS20T	31.7	21.0	1.8	92.5	277404	L21	TLM 8	3000	5	TLM 8	1.1	no	59	5
B:HS20T	-46.3	28.0	2.3	49.4	148336	L21	TLM 8	3000	5	TLM 8	2.8	no	50	9
B:HS21T	35.0	7.0	0.3	61.9	185746	L3	TLM 8	3000	2.5	TLM 8	0.3	no	144	7
B:HS21T	-43.0	14.0	0.6	52.6	157878	L22	TLM 8	3000	2.5	TLM 8	0.7	no	81	8
B:HS22T	29.8	3.5	0.3	60.6	181676	S14	TLM 1	3000	5	TLM 1	0.3	no	269	7
B:HS22T	-48.2	7.0	0.3	43.8	131257	L3	TLM 1	3000	2.5	TLM 1	0.4	no	144	10
B:HS23T	26.9	7.0	0.6	76.0	227928	S23	TLM 1	3000	5	TLM 1	0.5	no	144	6
B:HS23T	-51.1	3.5	0.3	43.2	129485	S14	TLM 1	3000	5	TLM 1	0.4	no	269	10
B:HS24T	27.0	7.0	0.6	53.5	160435	S16	TLM 1	3000	5	TLM 1	0.7	no	144	8

TLM and Chipmunk Response to Controlled Beam Loss at Booster

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:HS24T	-51.0	3.5	0.3	39.9	119564	S1	TLM 1	3000	5	TLM 1	0.4	no	269	11
B:VL01T	**47.3**	**23.3**	**1.9**	**13.2**	**39460**	**S1**	**TLM 2**	**3000**	**5**	**S1**	**8.9**	**yes**	**57**	**34**
B:VL01T	**-30.7**	**21.1**	**1.8**	**13.9**	**41625**	**S1**	**TLM 1**	**3000**	**5**	**S1**	**7.6**	**yes**	**59**	**32**
B:VL02T	42.4	8.2	0.7	15.3	45881	S2	TLM 2	3000	5	TLM 2	2.7	no	127	29
B:VL02T	-35.6	4.9	0.4	17.2	51578	S2	TLM 2	3000	5	TLM 2	1.4	no	206	25
B:VL03T	36.5	3.7	0.3	15.5	46436	S17	TLM 2	3000	5	TLM 2	1.2	no	269	28
B:VL03T	-41.5	2.8	0.2	18.8	56542	L6	TLM 2	3000	5	TLM 2	0.7	no	394	23
B:VL04T	40.7	6.7	1.7	23.2	69467	S4	TLM 3	3000	15	TLM 3	4.3	no	151	19
B:VL04T	-37.3	6.7	1.7	23.3	69783	S4	TLM 3	3000	15	TLM 3	4.3	no	151	19
B:VL05T	36.6	16.9	4.2	15.9	47616	S5	TLM 3	3000	15	S5	15.9	no	72	28
B:VL05T	-41.4	13.6	3.4	16.3	48855	S5	TLM 3	3000	15	TLM 3	12.5	no	84	27
B:VL06T	38.2	2.8	0.2	15.4	46075	L6	TLM 3	3000	5	TLM 3	0.9	no	394	29
B:VL06T	-39.8	5.9	0.5	17.0	50937	S6	TLM 3	3000	5	TLM 3	1.7	no	169	26
B:VL07T	37.5	3.3	0.3	40.9	122720	S16	TLM 4	3000	5	TLM 4	0.4	no	269	11
B:VL07T	-40.5	3.8	0.3	45.4	136122	L24	TLM 4	3000	5	TLM 4	0.4	no	269	10
B:VL08T	38.7	0.0	0.0	65.5	196501	L23	TLM 4	3000	5	TLM 4	0.0	no	-	7
B:VL08T	-39.3	7.2	0.3	62.1	186397	L22	TLM 4	3000	2.5	TLM 4	0.3	no	144	7
B:VL09T	38.4	9.5	2.4	55.3	165959	S9	TLM 4	3000	15	TLM 4	2.6	no	112	8
B:VL09T	-39.6	9.6	2.4	61.5	184563	S9	TLM 4	3000	15	TLM 4	2.3	no	112	7
B:VL10T	36.6	3.1	0.3	55.1	165242	L21	TLM 5	3000	5	TLM 5	0.3	no	269	8
B:VL10T	-41.4	3.9	0.3	56.4	169115	L24	TLM 5	3000	5	TLM 5	0.3	no	269	8

TLM and Chipmunk Response to Controlled Beam Loss at Booster

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:VL11T	31.1	11.4	0.9	35.9	107565	S11	TLM 5	3000	5	TLM 5	1.6	no	202	12
B:VL11T	-46.9	5.7	0.2	34.2	102615	L3	TLM 5	3000	2.5	TLM 5	0.4	no	207	13
B:VL12T	32.1	9.3	0.8	13.9	41746	S12	TLM 5	3000	5	TLM 5	3.3	no	112	32
B:VL12T	-45.9	5.7	0.2	14.3	42994	L3	TLM 5	3000	2.5	TLM 5	1.0	no	207	31
B:VL13T	31.7	2.8	0.2	10.6	31730	L6	TLM 5	3000	5	TLM 5	1.3	no	394	43
B:VL13T	-46.3	5.7	0.2	11.3	33819	L3	TLM 5	3000	2.5	TLM 5	1.3	no	207	40
B:VL14T	34.6	7.2	0.3	19.5	58636	L22	TLM 6	3000	2.5	TLM 6	0.9	no	144	22
B:VL14T	-43.4	3.9	0.3	20.5	61572	L24	TLM 6	3000	5	TLM 6	0.9	no	269	21
B:VL15T	31.8	2.7	0.2	19.8	59440	S24	TLM 6	3000	5	TLM 6	0.7	no	394	22
B:VL15T	-46.2	2.8	0.2	19.2	57698	S12	TLM 6	3000	5	TLM 6	0.7	no	394	23
B:VL16T	32.0	3.4	0.3	11.9	35604	L21	TLM 6	3000	5	TLM 6	1.4	no	269	38
B:VL16T	-46.0	3.0	0.3	13.4	40135	L6	TLM 6	3000	5	TLM 6	1.1	no	269	33
B:VL17T	33.6	4.5	0.4	28.6	85895	S17	TLM 7	3000	5	TLM 7	0.8	no	206	15
B:VL17T	-44.4	5.8	0.5	30.6	91713	S21	TLM 7	3000	5	TLM 7	0.9	no	169	14
B:VL18T	31.6	3.6	0.3	20.4	61334	S16	TLM 7	3000	5	TLM 7	0.9	no	269	21
B:VL18T	-46.4	2.7	0.2	20.9	62716	L11	TLM 7	3000	5	TLM 7	0.7	no	394	21
B:VL19T	**35.5**	**52.4**	**4.4**	**37.8**	**113548**	**S19**	**TLM 8**	**3000**	**5**	**S19**	**6.9**	**yes**	**32**	**11**
B:VL19T	**-42.5**	**61.9**	**5.2**	**40.5**	**121379**	**S19**	**TLM 8**	**3000**	**5**	**S19**	**7.6**	**yes**	**29**	**11**
B:VL20T	38.1	3.3	0.3	26.8	80267	L21	TLM 8	3000	5	TLM 8	0.6	no	269	16
B:VL20T	-39.9	7.8	0.3	27.3	81954	L22	TLM 8	3000	2.5	TLM 8	0.7	no	144	16
B:VL21T	36.9	4.1	0.3	18.6	55773	L24	TLM 8	3000	5	TLM 8	1.1	no	269	23

TLM and Chipmunk Response to Controlled Beam Loss at Booster

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:VL21T	-41.1	3.5	0.3	19.4	58181	L13	TLM 8	3000	5	TLM 8	0.9	no	269	22
B:VL22T	36.1	3.1	0.3	11.7	35241	L13	TLM 8	3000	5	TLM 8	1.3	no	269	38
B:VL22T	-41.9	7.2	0.3	12.4	37209	L22	TLM 8	3000	2.5	TLM 8	1.4	no	144	36
B:VL23T	33.8	3.5	0.3	20.2	60499	L14	TLM 1	3000	5	TLM 1	0.9	no	269	22
B:VL23T	-44.2	7.2	0.3	19.8	59316	L22	TLM 1	3000	2.5	TLM 1	0.9	no	144	22
B:VL24T	30.2	5.6	0.2	14.5	43424	L3	TLM 1	3000	2.5	TLM 1	1.0	no	207	31
B:VL24T	-47.8	5.9	0.5	14.9	44719	S24	TLM 1	3000	5	TLM 1	2.0	no	169	30
B:VS01T	**41.4**	**50.2**	**4.2**	**24.3**	**73011**	**S1**	**TLM 2**	**3000**	**5**	**S1**	**10.3**	**yes**	**33**	**18**
B:VS01T	**-36.6**	**30.3**	**2.5**	**26.4**	**79095**	**S1**	**TLM 2**	**3000**	**5**	**S1**	**5.7**	**yes**	**47**	**16**
B:VS02T	37.3	3.6	0.3	15.2	45493	L12	TLM 2	3000	5	TLM 2	1.2	no	269	29
B:VS02T	-40.7	5.6	0.2	17.9	53600	L3	TLM 2	3000	2.5	TLM 2	0.8	no	207	24
B:VS03T	35.2	4.0	1.3	29.3	88044	L4	TLM 2	3000	20	TLM 2	2.7	no	249	15
B:VS03T	-42.8	11.5	3.8	98.9	296788	L4	TLM 2	3000	20	TLM 2	2.3	no	97	5
B:VS04T	41.4	15.4	3.9	37.7	112952	L5	TLM 3	3000	15	TLM 3	6.1	no	76	11
B:VS04T	-36.6	24.4	6.1	45.1	135410	L5	TLM 3	3000	15	TLM 3	8.1	no	54	10
B:VS05T	42.1	5.7	0.2	14.8	44363	L3	TLM 3	3000	2.5	TLM 3	1.0	no	207	30
B:VS05T	-35.9	5.1	0.4	11.4	34324	S23	TLM 3	3000	5	TLM 3	2.2	no	206	39
B:VS06T	42.7	4.6	0.4	19.2	57617	S19	TLM 3	3000	5	TLM 3	1.2	no	206	23
B:VS06T	-35.3	6.4	2.1	26.4	79319	L7	TLM 3	3000	20	TLM 3	4.9	no	161	16
B:VS07T	41.4	4.0	1.0	52.5	157518	L8	TLM 4	3000	15	TLM 4	1.2	no	74	8
B:VS07T	-36.6	5.1	1.3	114.7	344229	L8	TLM 4	3000	15	TLM 4	0.7	no	62	4

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:VS08T	40.5	0.0	0.0	82.1	246314	L23	TLM 4	3000	5	TLM 4	0.0	no	-	5
B:VS08T	-37.5	3.8	0.9	70.4	211244	L9	TLM 4	3000	15	TLM 4	0.8	no	269	6
B:VS09T	37.4	9.1	2.3	78.1	234265	L10	TLM 4	3000	15	TLM 4	1.7	no	116	6
B:VS09T	-40.6	4.6	1.2	78.3	234997	L10	TLM 4	3000	15	TLM 4	0.9	no	206	6
B:VS10T	45.4	5.2	0.4	75.4	226251	S21	TLM 5	3000	5	TLM 5	0.3	no	206	6
B:VS10T	-32.6	7.2	0.3	80.6	241864	L22	TLM 5	3000	2.5	TLM 5	0.2	no	144	6
B:VS11T	40.9	7.0	0.6	41.2	123521	L12	TLM 5	3000	5	TLM 5	0.9	no	144	10
B:VS11T	-37.1	7.0	0.6	45.7	137073	L12	TLM 5	3000	5	TLM 5	0.8	no	144	9
B:VS12T	43.8	5.4	0.5	11.1	33285	L17	TLM 5	3000	5	TLM 5	2.4	no	169	41
B:VS12T	-34.2	3.9	0.3	10.8	32389	L24	TLM 5	3000	5	TLM 5	1.8	no	269	42
B:VS13T	43.8	4.4	0.4	27.2	81741	L1	TLM 6	3000	5	TLM 6	0.8	no	206	16
B:VS13T	-34.2	5.9	0.5	37.4	112097	S24	TLM 6	3000	5	TLM 6	0.8	no	169	12
B:VS14T	46.2	3.6	0.3	30.8	92423	L12	TLM 6	3000	5	TLM 6	0.6	no	269	14
B:VS14T	-31.8	5.7	0.2	32.0	96006	L3	TLM 6	3000	2.5	TLM 6	0.4	no	207	13
B:VS15T	47.6	5.2	0.4	24.2	72468	S23	TLM 6	3000	5	TLM 6	1.1	no	206	18
B:VS15T	-30.4	3.9	0.3	18.8	56501	L24	TLM 6	3000	5	TLM 6	1.0	no	269	23
B:VS16T	47.1	5.7	0.2	18.5	55645	L3	TLM 7	3000	2.5	TLM 7	0.8	no	207	23
B:VS16T	-30.9	2.6	0.2	33.1	99194	S20	TLM 7	3000	5	TLM 7	0.4	no	394	13
B:VS17T	41.4	5.7	0.5	49.1	147328	L18	TLM 7	3000	5	TLM 7	0.6	no	169	9
B:VS17T	-36.6	9.1	0.8	59.2	177513	L18	TLM 7	3000	5	TLM 7	0.8	no	112	7
B:VS18T	46.0	3.9	0.3	27.4	82258	L24	TLM 7	3000	5	TLM 7	0.7	no	269	16

TLM and Chipmunk Response to Controlled Beam Loss at Booster

trim	current (amps)	Maximum Chipmunk response normalized by the trip level	Most sensitive Chipmunk (mrem/min)	Max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	Most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk - seconds to trip	TLM – seconds to trip
B:VS18T	-32.0	14.8	1.2	35.7	106999	S19	TLM 7	3000	5	TLM 7	2.1	no	81	12
B:VS19T	39.0	5.7	0.2	56.0	168141	L3	TLM 8	3000	2.5	TLM 8	0.3	no	207	8
B:VS19T	-39.0	4.4	0.4	60.5	181567	L1	TLM 8	3000	5	TLM 8	0.4	no	206	7
B:VS20T	40.3	9.8	0.8	52.0	156025	L21	TLM 8	3000	5	TLM 8	0.9	no	112	8
B:VS20T	-37.7	13.1	1.1	57.4	172194	L21	TLM 8	3000	5	TLM 8	1.1	no	87	8
B:VS21T	41.9	5.7	0.2	32.6	97758	L3	TLM 8	3000	2.5	TLM 8	0.4	no	207	13
B:VS21T	-36.1	3.4	0.3	32.3	96824	S16	TLM 8	3000	5	TLM 8	0.5	no	269	13
B:VS22T	42.7	3.9	0.3	20.3	60906	L14	TLM 1	3000	5	TLM 1	1.0	no	269	21
B:VS22T	-35.3	5.7	0.2	32.6	97783	L3	TLM 1	3000	2.5	TLM 1	0.4	no	207	13
B:VS23T	43.5	3.4	0.3	33.1	99405	S16	TLM 1	3000	5	TLM 1	0.5	no	269	13
B:VS23T	-34.5	7.3	0.3	39.3	117977	L22	TLM 1	3000	2.5	TLM 1	0.5	no	144	11
B:VS24T	53.0	5.7	0.2	16.6	49758	L3	TLM 1	3000	2.5	TLM 1	0.9	no	207	26
B:VS24T	-25.0	7.2	0.3	9.4	28137	L22	TLM 1	3000	2.5	TLM 1	1.9	no	144	49

device	condition	max Chipmunk normalized response divided by the trip level	most sensitive Chipmunk (mrem/min)	max TLM normalized response divided by the trip level	max TLM value (nC/min)	Which Chipmunk?	Which TLM?	TLM trip level	Chipmunk trip level (mrem/hr)	most sensitive detector to rad card device	Chipmunk response with TLM at its trip level (mrem/hr)	Retain Chipmunk?	Chipmunk – seconds to trip	TLM – seconds to trip
B:ROFT	Radially out	121.7	40.6	678.8	2036477	L4	TLM 2	3000	20	TLM 2	3.6	no	19	1
B:ROFT	Radially in	184.4	46.1	374.3	1122986	S8	TLM 3	3000	15	TLM 3	7.4	no	15	1
B:MKS0#	8 GeV Extraction losses	21.5	7.2	839.2	2517534	L4	TLM 2	3000	20	TLM 2	0.5	no	59	1
B:MP02	8 GeV Extraction losses	29.2	9.7	915.5	2746455	L4	TLM 2	3000	20	TLM 2	0.6	no	48	1
B:MKS05	8 GeV Extraction losses	15.0	1.3	25.4	76238	S23	TLM 2	3000	5	TLM 2	3.0	no	76	17