Tevatron Beam Loss Scenarios and Mitigations for BTeV Detector

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BEAM LOSS SCENARIO	**PROBABILITY**	**POSSIBLE EFFECT ON PIXEL**	**MITIGATION**	**TIME SCALE** (turns)	**DOSE (**rad**)**
Slow quench of the nearby magnets	Medium; many possible causes	Permanent damage or degradation	QPM system pulls abort [1]; pixel detector pulls abort on integrated or instantaneous losses; local BLM's pull abort when losses pass threshold *(under construction [2])*; Collimator at B48 intercepts some losses	>800 (by definition)	Very high*
Kicker prefire or messy abort	3-4 times/year	Permanent damage, or degradation	Collimators at A11, A48 and B48 intercept kicked beam; modify A48 collimator *(ongoing studies[3]);* The solid state switches replacing the thyratrons in the abort system *(under R&D[4])*; perform beam studies to better understand location of collimators wrt beam centroid and improve collimator position readback	1-2	High
Vacuum valve fast close	Low	Permanent damage, or degradation	Beam valves are interlocked to abort system *(modifications are underway [5])*; beam valves close slowly enough so that only a relatively slow quench is possible and QPM, QPM fast buffer [11], or pixel will pull abort safely [6]	>650	Low to very high
Beam collimation Block into beam	Medium	Permanent damage, or degradation	beam loss feedback on collimators; collimators move slowly enough that only a slow quench is possible and QPM or pixel will pull abort safely [7]	>13000	Low to very high

Pixel detector run into beam	Low	Permanent damage	Interlock system, beam loss monitor on detector: local loss monitor feedback on pixel detector motion control; limit speed of pixel motion control so that only a slow quench is possible and QPM or pixel will pull abort [8]	? (depends on speed of pixel detector)	Very high
Corrector magnets trip	medium	degradation	Lattice limits missteering potential at the IR [9]; magnet inductance, power supply voltage limitation, and slew rate limit make this no worse than a slow magnet quench -- QPM or pixel will pull abort; some protection from B48 collimator	>800 (?)	Low to high
High beam loss during the store due to coherent or incoherent instability	high	Degradation	Collimation; background monitors and Tev tuning; pixel detector abort; MCR/BTeV administrative controls; fastest instabilities have growth rates of 10's of msec [10]	>1000, Up to tens minutes	low
DC beam	Every store (5~10)E9 proton	Degradation	DC beam cleaning and monitoring; pixel detector abort on integrated losses; MCR/BTeV administrative controls; B48 collimator intercepts some losses	Entire store	low
Injection loss, ramping loss, losses during study modes	high	Degradation	Precautions; inhibit injection unless pixel detector is fully out; only insert pixel detector after collimators have been inserted at the start of the store; pixel detector pulls abort on integrated or instantaneous losses; MCR/BTeV administrative controls	5~20	Low to high

Device moves into beam (not pixel, collimator, or beam valve)	low	Degradation or damage	Limit speed of all moveable devices so that losses are slow and QPM system or pixel detector pulls abort; B48 collimator provides some shielding	>5000	High
Sudden vacuum loss	low		Beam valves close when bad vacuum is detected and abort is fired when beam valves close	>5000	Low
Fast quench of nearby magnets	medium	Degradation or permanent damage	pixel detector pulls abort on instantaneous losses; QPM fast buffer pulls abort on large fast losses *(implemented and operational [11];* B48 collimator provides some shielding; local BLM's pull abort when losses pass threshold *(under construction [2])*	10 – 800 turns (by definition)	Low to high
C0 vertical 3-bump moves beam into pixel	low	Degradation or permanent damage	pixel detector pulls abort on instantaneous losses; QPM fast buffer pulls abort on large fast losses; local BLM's pull abort when losses pass threshold; *magnet control circuitry pulls abort when out-of-tolerance conditions are detected.*	>800 tuns	High
Separator sparks and voltage drop	medium	Degradation or damage	BLM may pull abort when loss are high; QPM may pull abort when quench detected;[12]	10-800 turns	Low to high

[1] Maximum response time of the QPM system is 1/60 sec, or about 800 turns. This will be improved to 2~3ms (see [11])

[2] BLM input to the abort system is normally masked during stores to prevent "false" aborts. An ongoing Run II upgrade project is building a BLM system with the possibility of unmasking the BLM input to the abort system.

[3] The A48 collimator is only .5 meters in length. A Run II project is investigating the possibility of adding tungsten layer to its beam interception block. (*Alexandr Drozhdin, Possible Modification of A48 Collimator, Beams-doc-1317-v1*)

[4] The R&D of using solid state switches pulser to replace the thyratrons in the TEV abort system is ongoing, which have the potential to eliminate abort kicker pre-firing and can be triggered within a single turn. The proposal of designing a resonantly charging abort system was abandoned.

[5] Currently, the abort is pulled when an end beam valve pulls off its limit switch and it would take at least 150ms from the time the power to the solenoid were removed to the time the valve actually came off the open micro switch. A Run II upgrade being ongoing this shut down (Oct.04) is to send the abort signal when the 110VAC power to the valve solenoid is removed. Now the time is less than 8 milliseconds from the time the power are removed to the time the abort signal is dropped. Therefore, we are gaining at least 142 milliseconds if we are closing a valve due to the loss of an interlock signal such as a pirani gage etc.

[6] A beam valve closes in about 3 seconds. This motion is ~1000 mils/sec. In the worst case, it would take a beam valve ~650 turns to intercept 1 beam sigma.

[7] Maximum collimator speed is 50 mils/sec. In the worst case it would take 13000 beam turns to intercept 1 beam sigma.

[8] Beam sigma at the C0 IP will be 33 microns. This requires a pixel motion slower than 2 mils/sec for the detector to intercept less than 1 beam sigma in 1/60 second. The estimated head-tail instability is about 100ms (P. Ivanov, et al. PAC'03). As a FY05 upgrading project, the beam will be aborted if the detected beam betatron oscillation amplitude is larger that 0.5mm.

[9] Maximum steering correction at the IP is ±3 mm. Pixel detector will be positioned ±6mm from the beam.

[10] Maximum instability growth rate needs to be verified.

[11] A fast buffer internal to the QPM was used to detect large, fast quenches and pull the abort in 2~3 msec (95 turns). The machine studies have been done successfully in Tevatron in FY04. It has been already implemented and operational.

[12] The orbit distortion caused by the separator spark may induce high loss in the machine and results in machine quench in the worst situation. It might pull abort due to the local loss.

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* Very high dose means over a few hundreds of rad instant dose. See following documents for detail:

[1] M. Church, A. Drozhdin, R. Moore, D. Still "Tevatron Abort Kicker Prefire Simulations", Beams-doc-649-v1

[2] D. Still, "Analysis of Tevatron 16 House Quench on December 5, 2003", Beams-doc-1166-v1