Imperial College London

MICE Particle Rate and ISIS Beam Loss

Adam Dobbs, CM28, 4th October 2010

Outline

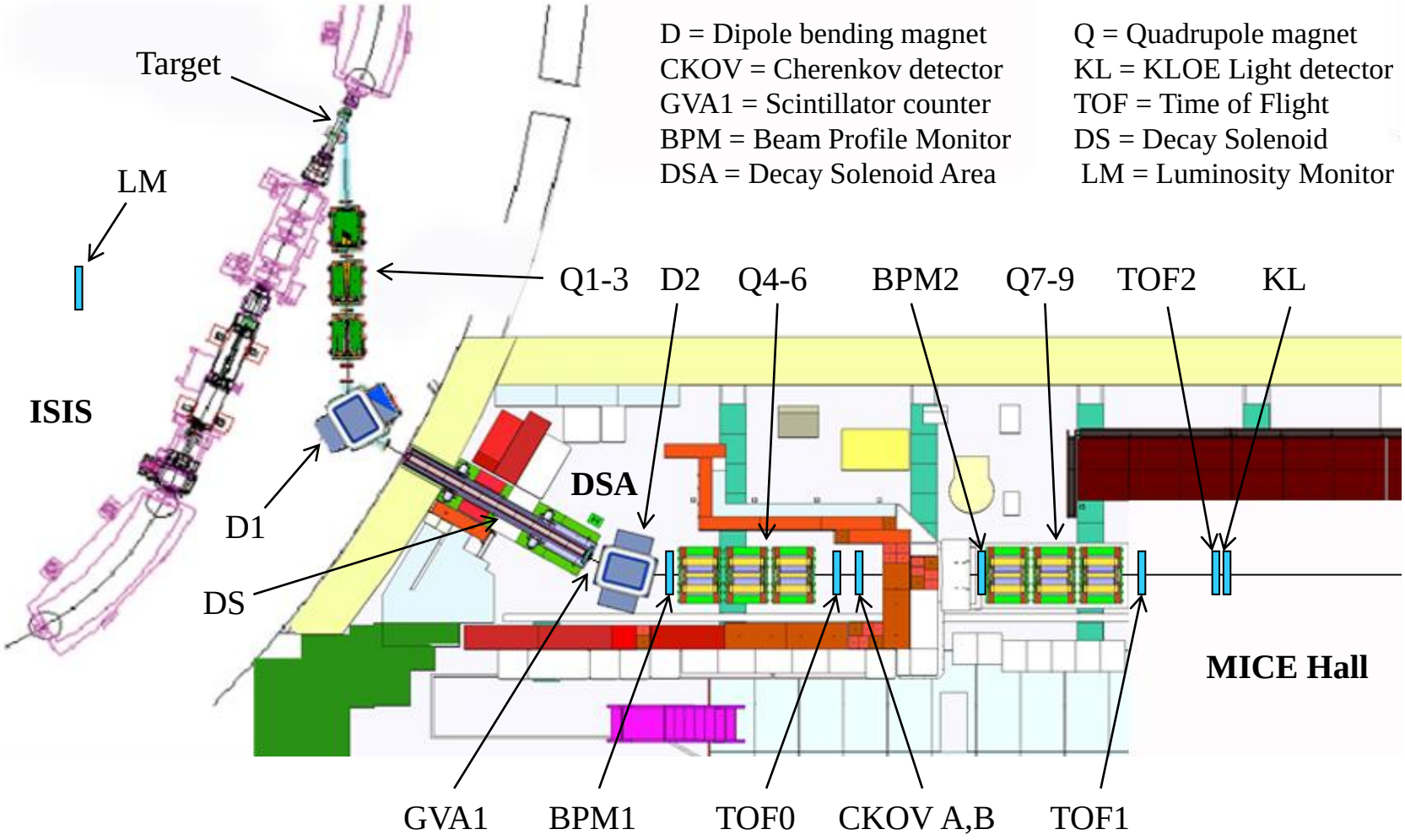
I. Introduction
   I. Beamline
   II. Analysis Methodology
   III. Study Conditions
II. Results
   I. November 2009
   II. June 2010
   III. August 2010
III. Conclusion

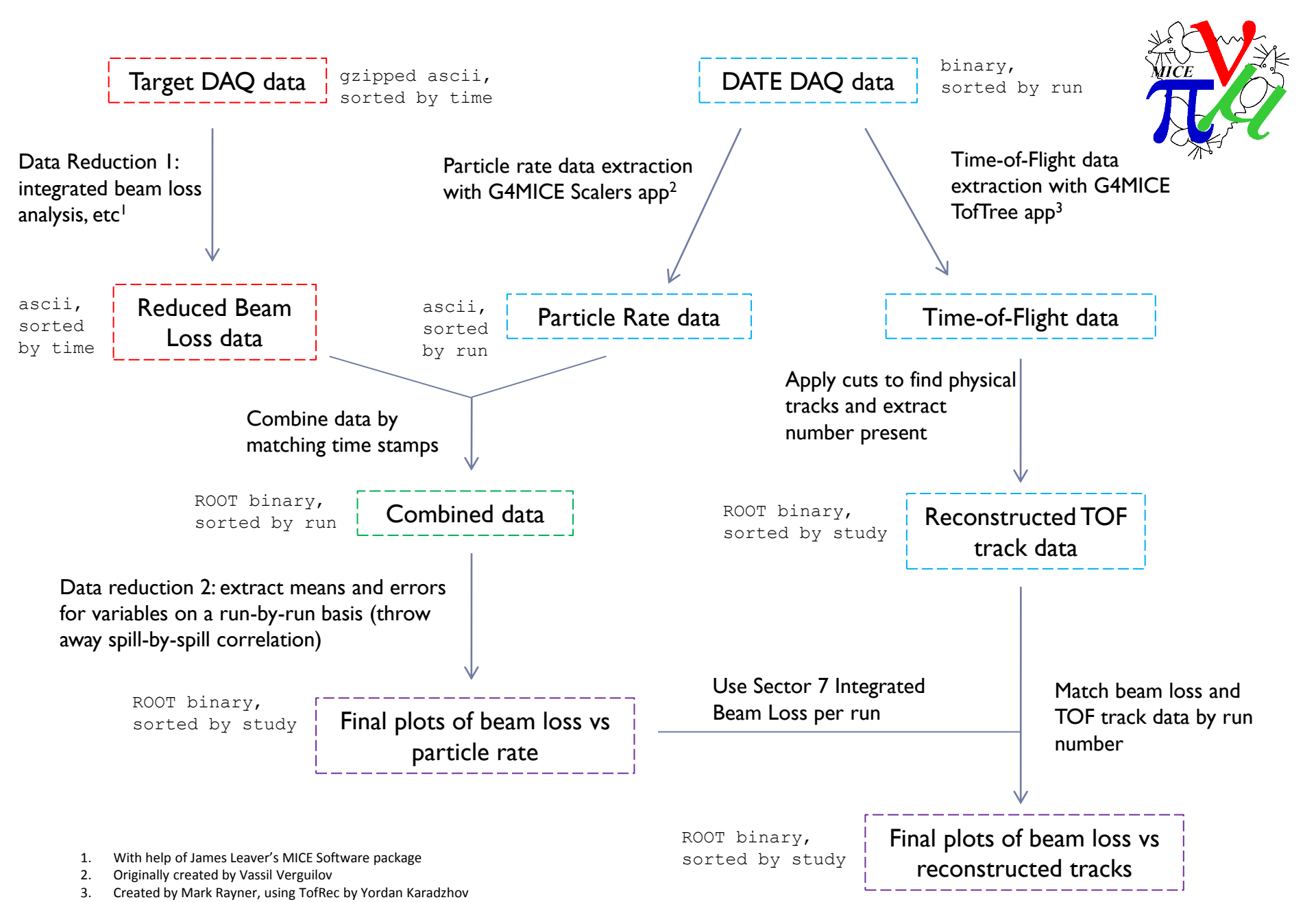
1. Introduction

The MICE Beamline

Analysis Methodology

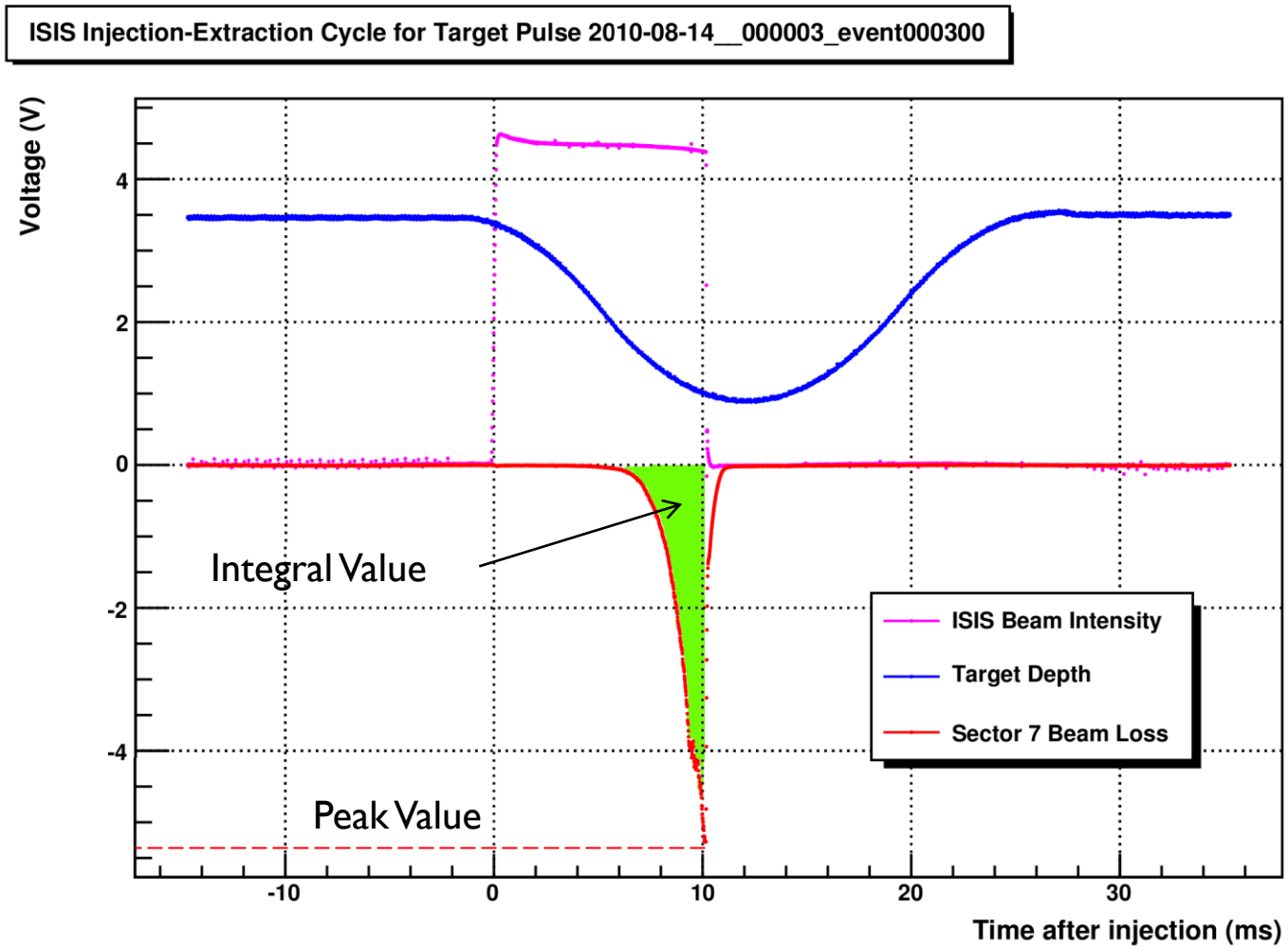
Current MICE beamline





1. With help of James Leaver's MICE Software package
2. Originally created by Vassil Verguilov
3. Created by Mark Rayner, using TofRec by Yordan Karadzhov

Beam Loss Analysis Methods



Target DAQ data

Data Reduction I – fitted peak beam loss analysis, etc

Reduced Beam Loss data

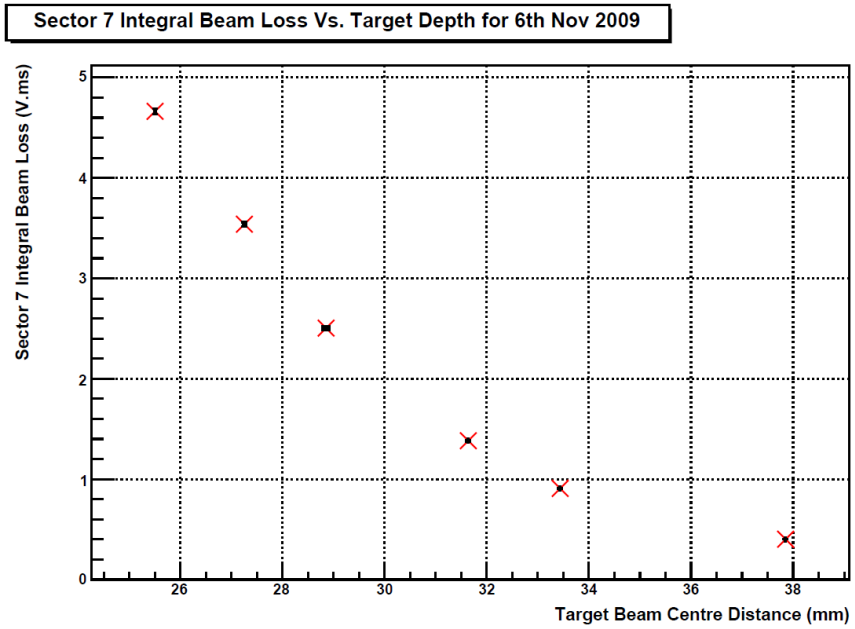
Study Conditions

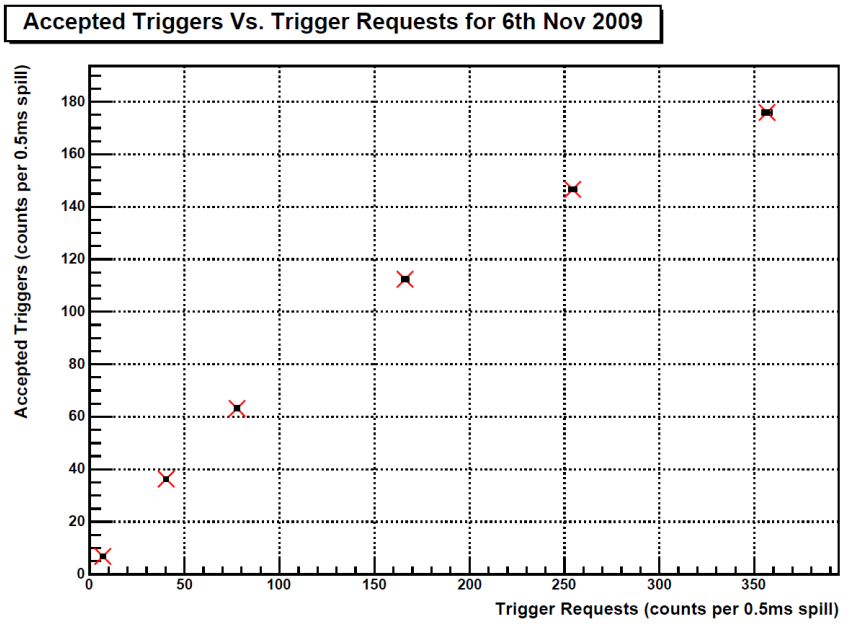
Parameter	6 Nov 09	15 June 10	16 June 10	14 Aug 10
Max Beam Loss (mV.ms)	4700	2800	3400	6000
Target Delay Setting	0010001011	0010000011	0010000011	0010000000
Optics	$+\ \pi$	$-\ \pi \rightarrow \mu$, no Q3	$+\ \pi \rightarrow \mu$, no Q3	$+\ \pi \rightarrow \mu$
Proton Absorber	No	No	No	83mm
Detectors	GVA1 BPM1 BPM2 TOF0 TOF1 x	GVA1 x BPM2 TOF0 TOF1 LM	x x x TOF0 TOF1 LM	GVA1 x BPM2 TOF0 TOF1 LM
DAQ Gate Width (ms)	0.5	3.2	1	0.5
DAQ Trigger	TOF1	TOF1	TOF1	TOF1
Approximate pulses per run	200	400	400	200

2. Results

November 2009
15th June 2010
16th June 2010
August 2010

Nov 09: Target Depth and Deadtime

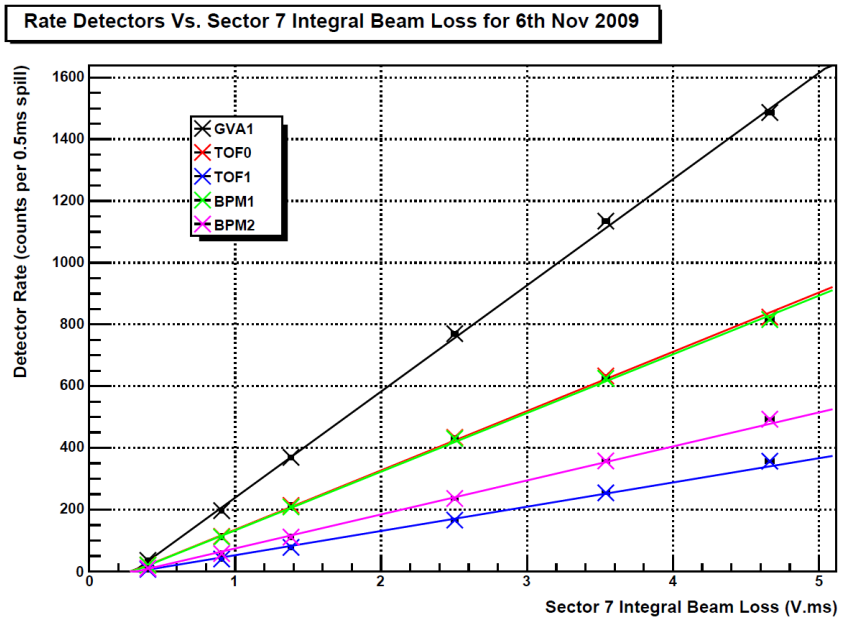




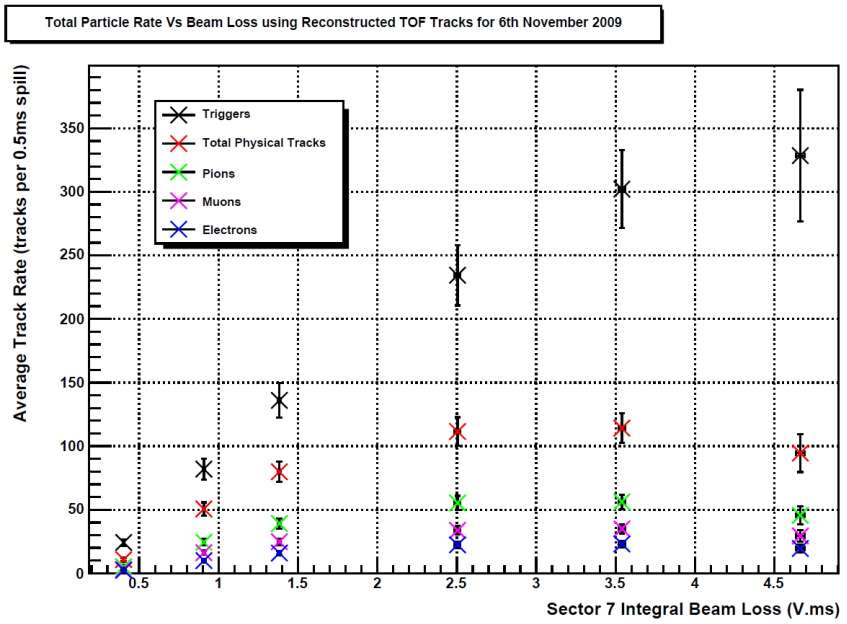
Exponential? Or linear once through the beam halo?

Very large deadtime ~ 50% of trigger requests lost at highest beam losses

Nov 09: Rate Vs. Beam Loss

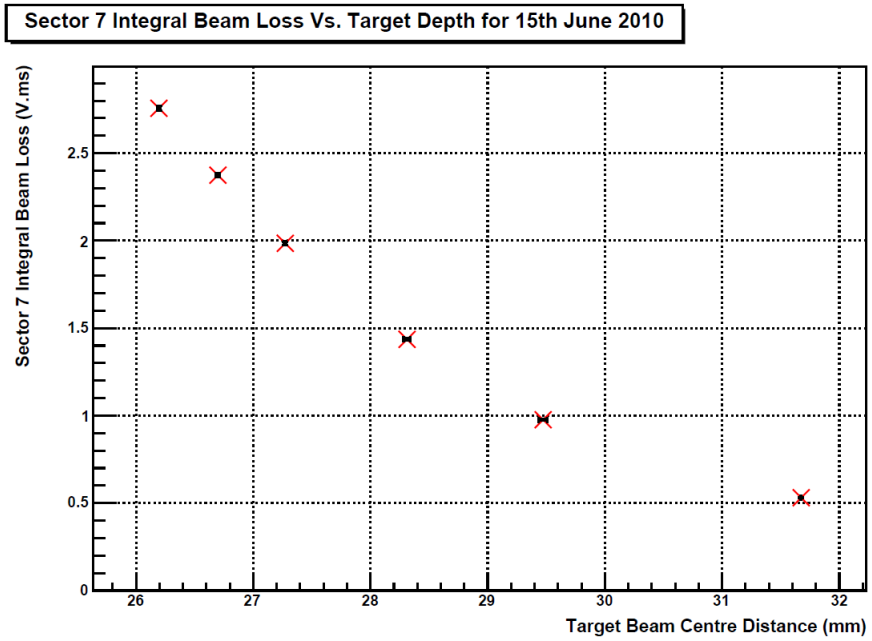


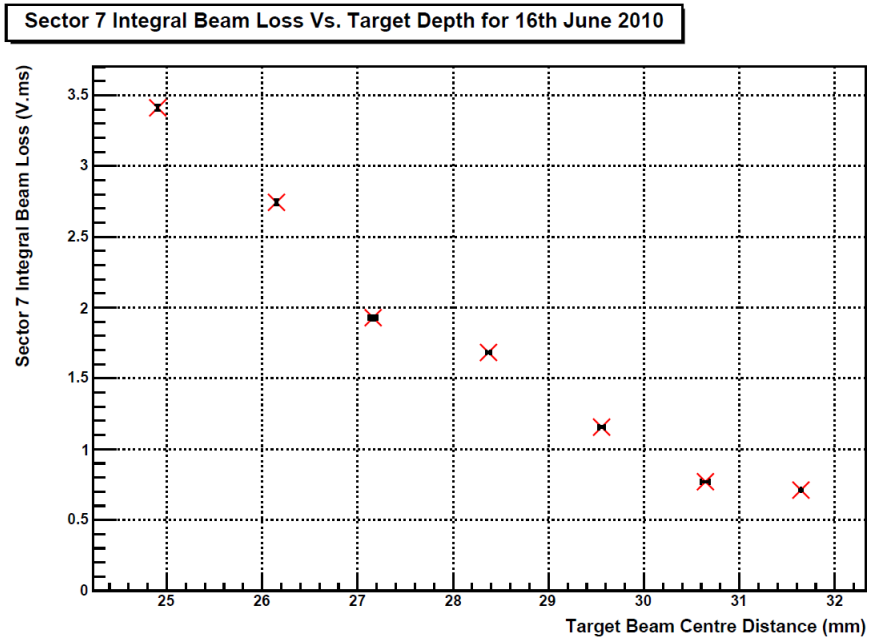
All detectors show roughly linear increase of rate with beam loss



Saturation observed in reconstructed track rate when move above ~ 2.5V.ms

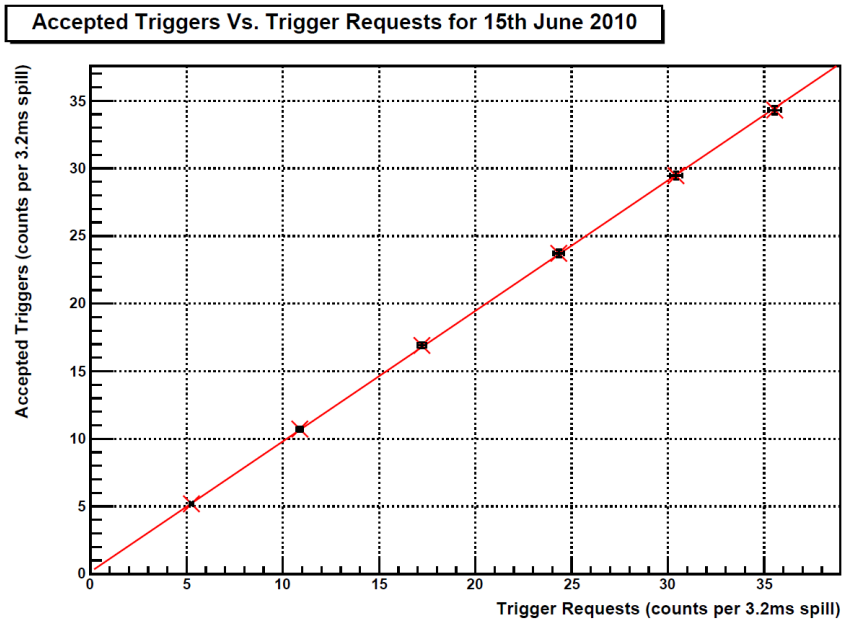
June 10: Target Depth Vs. Beam Loss

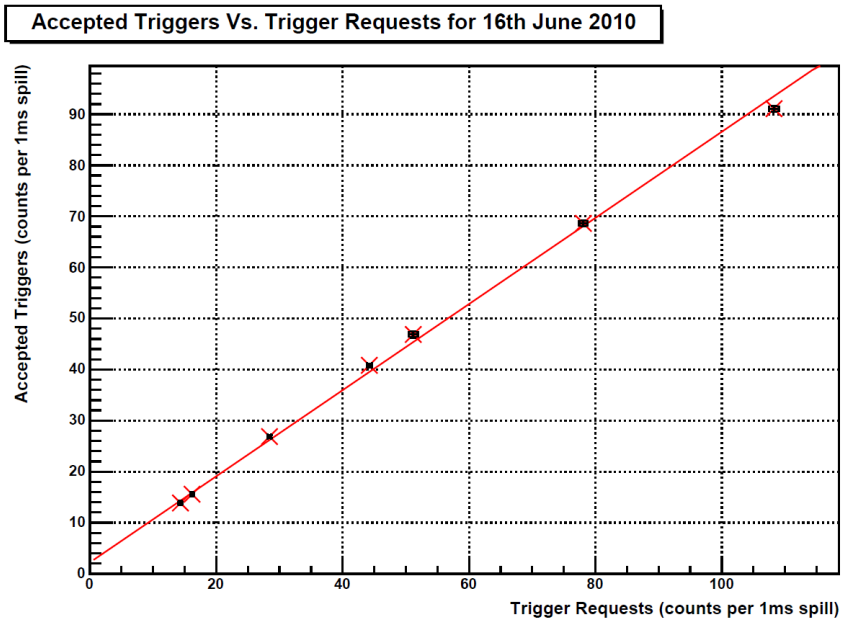




Exponential? Or linear once through the beam halo?

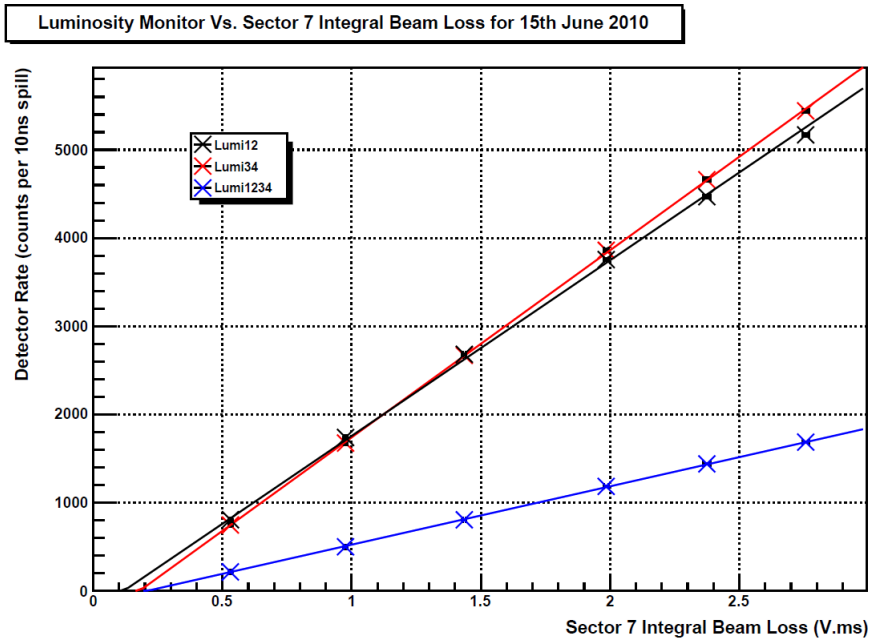
June 10: Deadtime

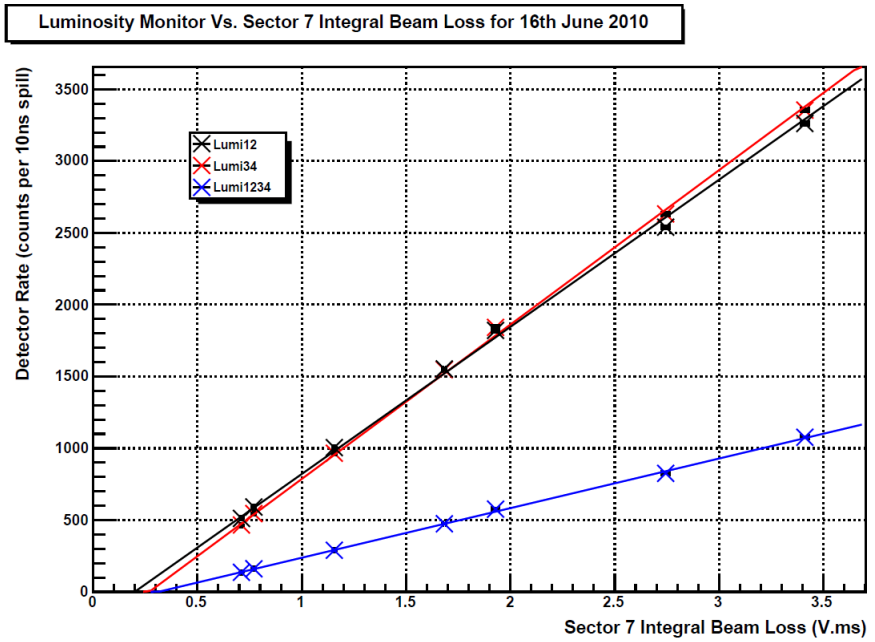




Negligible deadtime for 15th, ~ 15% of trigger requests lost for 16th

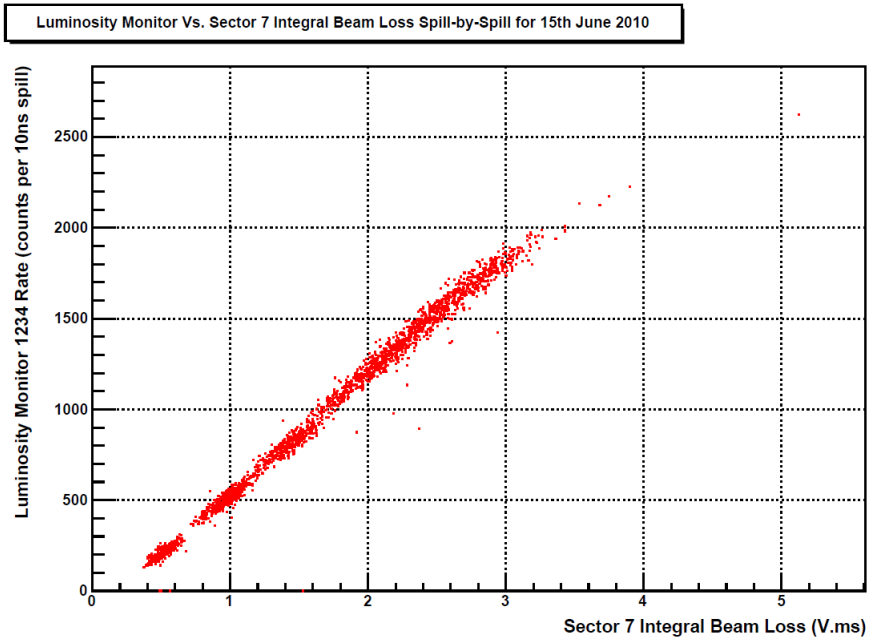
June 10: Luminosity Vs. Beam Loss

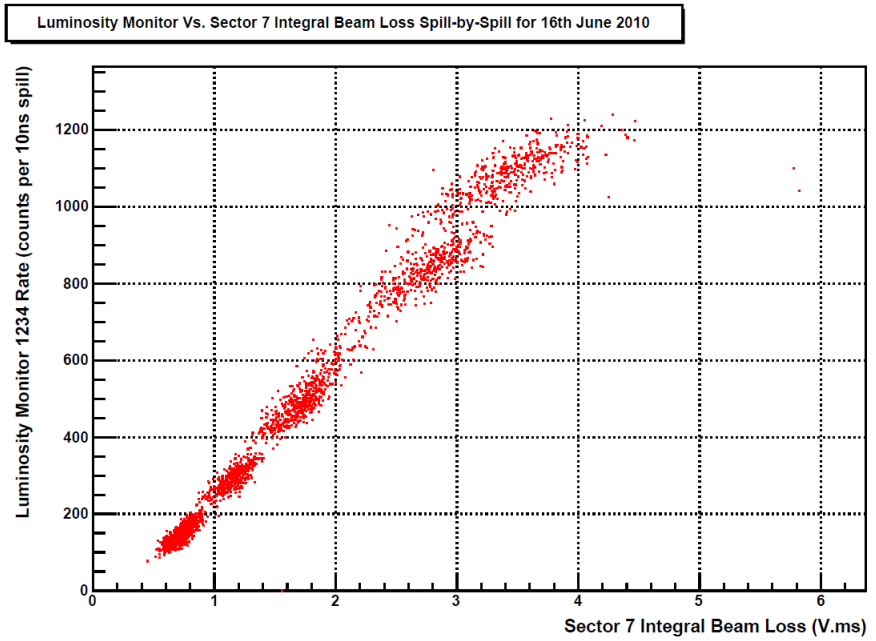




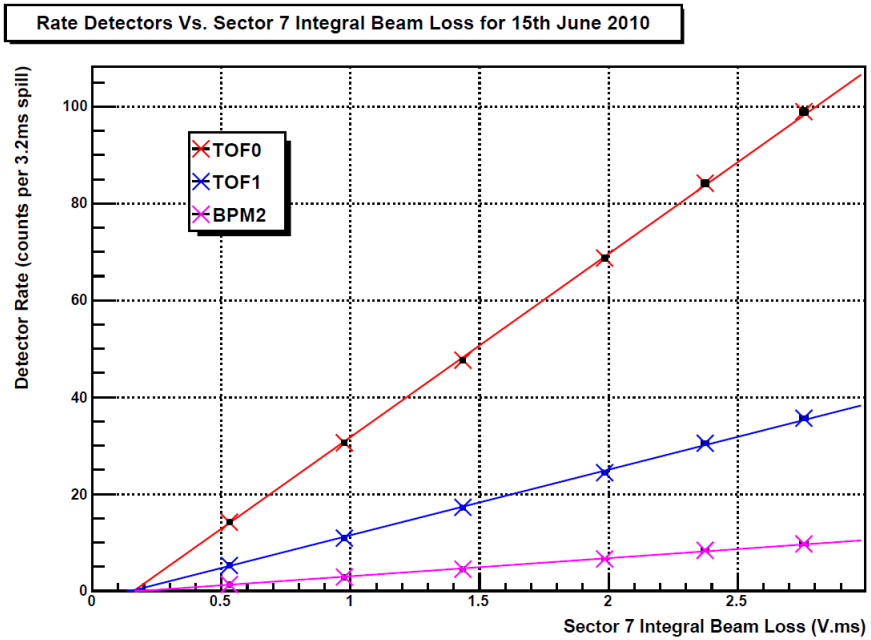
Nice and linear in all cases.

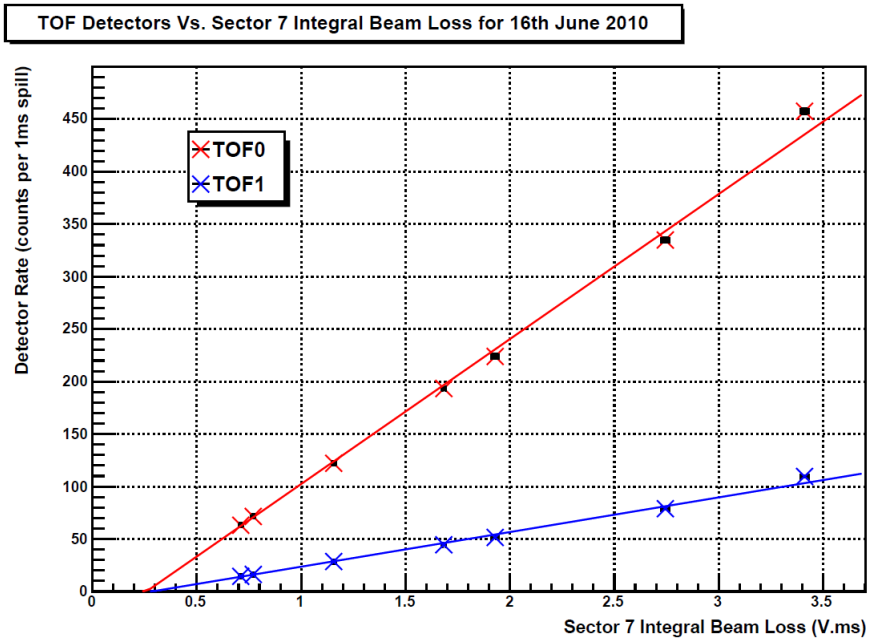
June 10: Luminosity Vs. Beam Loss Spill-by-Spill





June10: Rate Detectors





15th study: 15 TOF1 hits per 3.2ms spill at 1.3V.ms
25 TOF1 hits per 3.2ms spill at 2V.ms

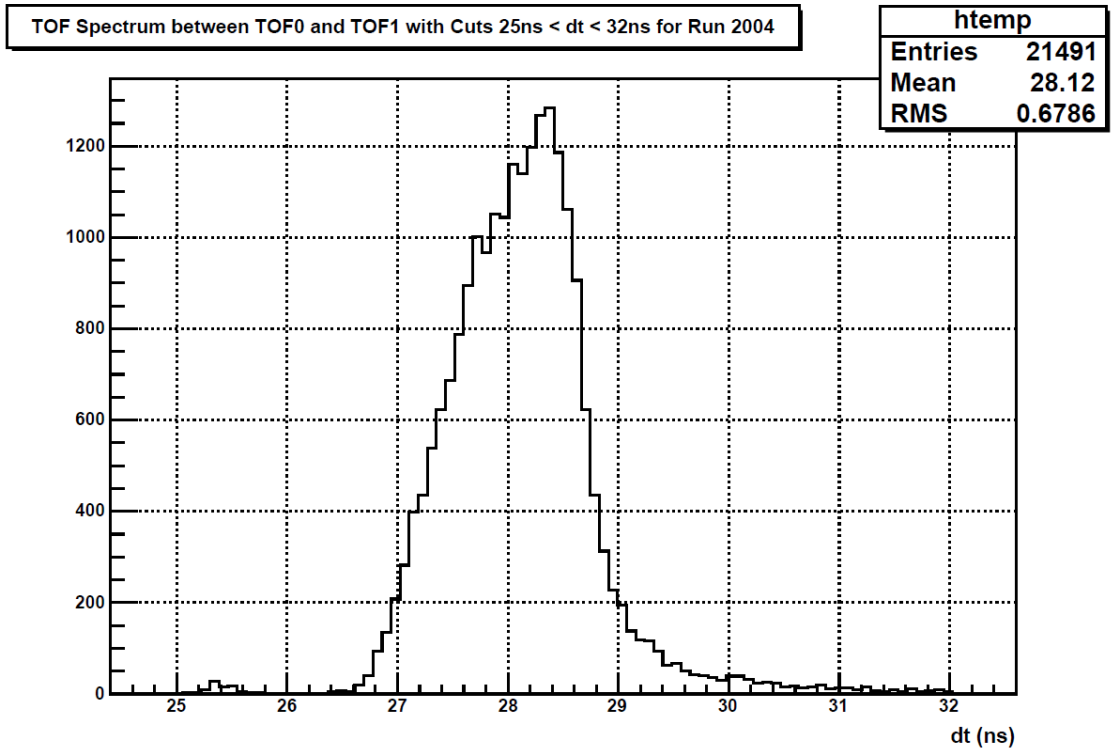
Assuming linearity of rate across the spill:

5 TOF1 hits per 1 ms spill at 1.3V.ms
8 TOF1 hits per 1ms spill at 2V.ms.

16th study: 30 TOF1 hits per 1ms spill at 1.3V.ms
60 TOF1 hits per 1ms spill at 2V.ms.

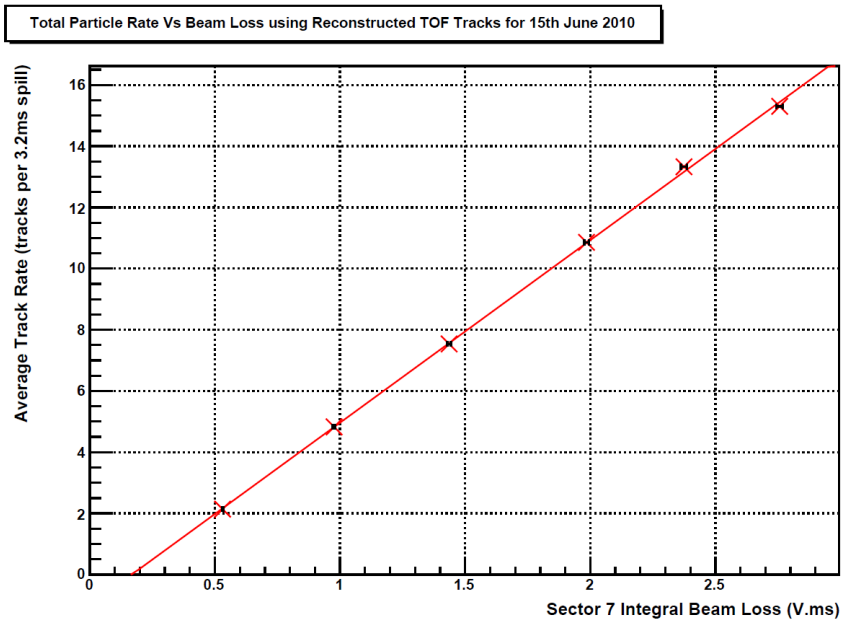
NB: 1.3V.ms ~ 2V peak in R8BLM1

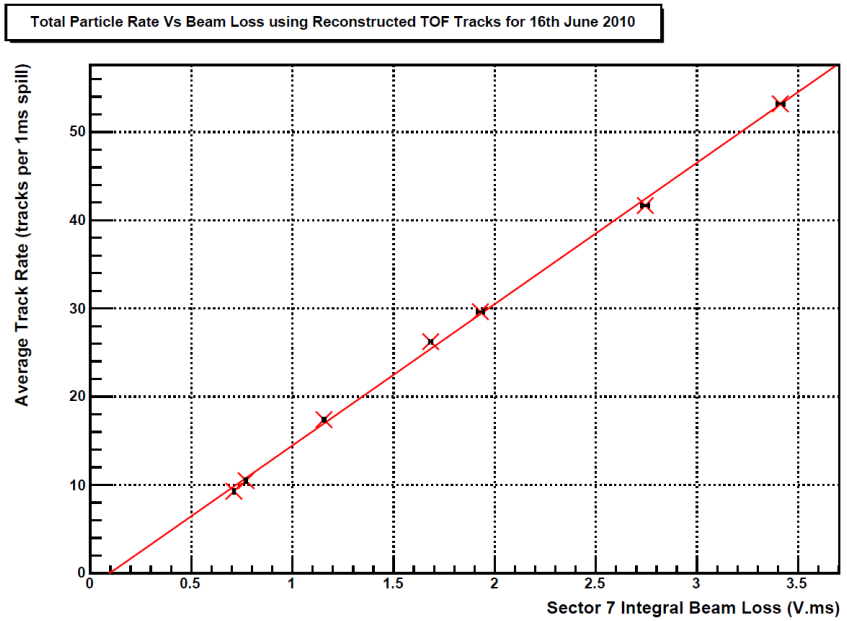
16th June: TOF PID for Run 2004



- Large peak is mainly muons with perhaps some pion contamination in tail
- Small peak to the left is positrons

Reconstructed TOF Tracks Vs. Beam Loss





15th study: 7 tracks per 3.2ms spill at 1.3V.ms
11 tracks per 3.2ms spill at 2V.ms

Assuming linearity of rate across the spill:

2 tracks per 1 ms spill at 1.3V.ms
3.5 tracks per 1ms spill at 2V.ms.

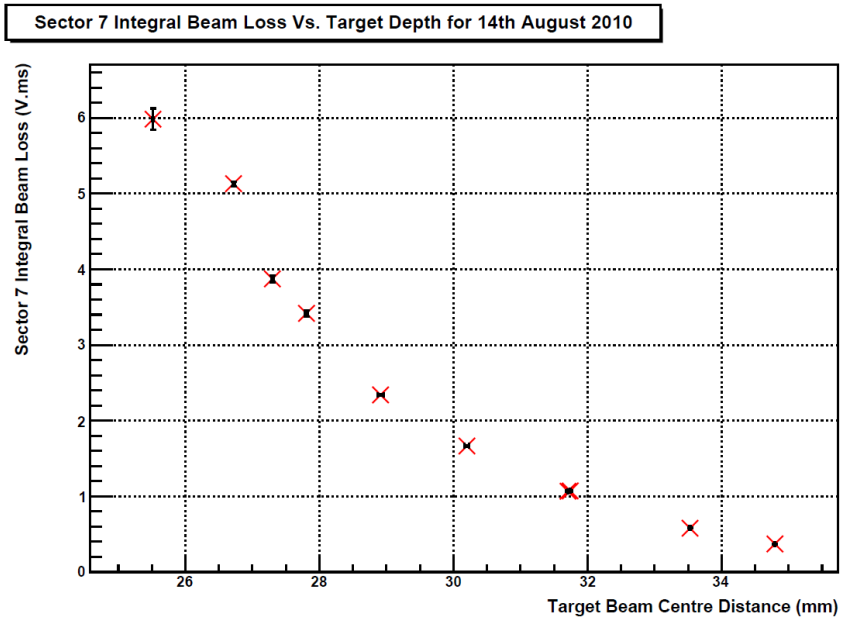
16th study: 19 tracks per 1ms spill at 1.3V.ms
30.5 tracks per 1ms spill at 2V.ms

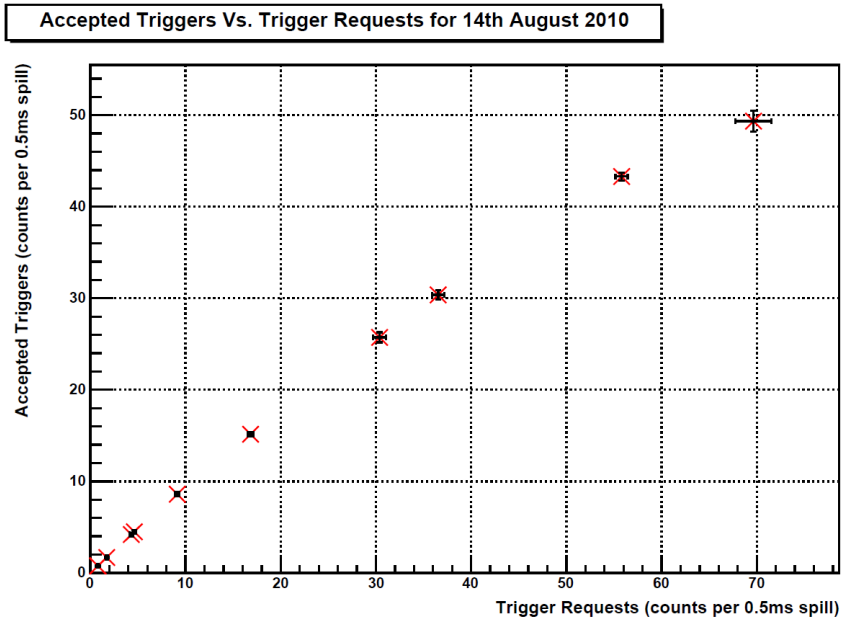
→ Reduction of ~ 60% for 15th, ~ 40% for 16th
Possible causes include neutral particles, tracks resulting from TDC hits requiring coincidence (~ 1.28μs) with trigger c.f. Scalers which record all particles within spill gate, and DAQ deadtime.

Losses between Scalers and TOF Tracks

- TDC hits and Scalers: TOF Tracks are formed from TDC hits which must be in coincidence (within ~ 1.28μs) of a trigger. Scaler channels record *all* hits within the spill gate (0.5, 1 or 3.2ms). Leads to:
- **Deadtime:** a trigger request is rejected if it occurs in coincidence with a previous trigger. Effect estimated by looking at accepted triggers as a function of trigger requests.
- **Neutrals**: a neutral particle can only cause a hit in a TOF station if it interacts, meaning it cannot then be detected again in another station. → Neutrals cannot contribute to TOF tracks but can to Scaler hits.
- Additionally **Software Reconstruction Efficiency** decreases with increased rates, as tracks become harder to distinguish.

Aug 10: Target Depth and Deadtime

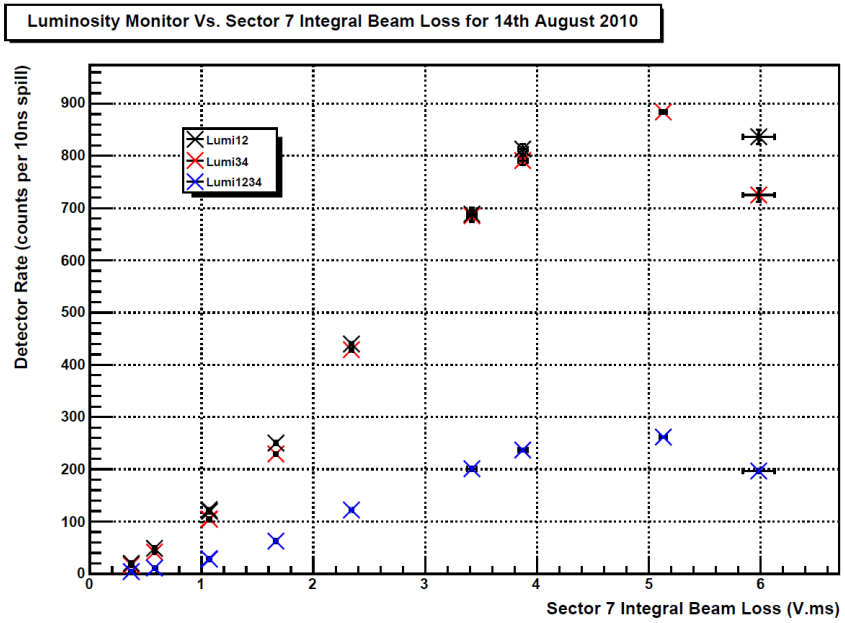


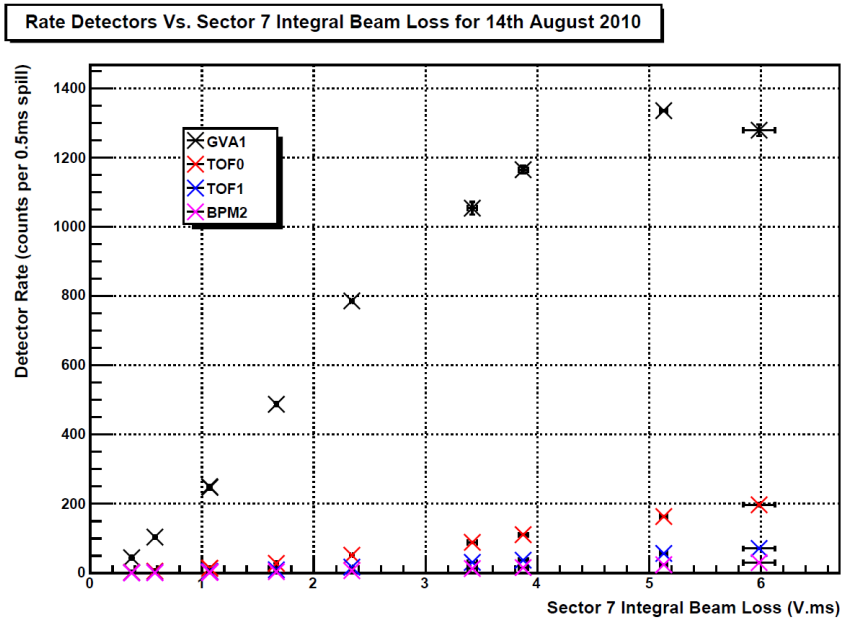


Exponential? Or linear once through the beam halo?

Significant deadtime effect ~ 30% of trigger requests lost at highest beam losses

Aug 10: Saturation of GVA1 and LM

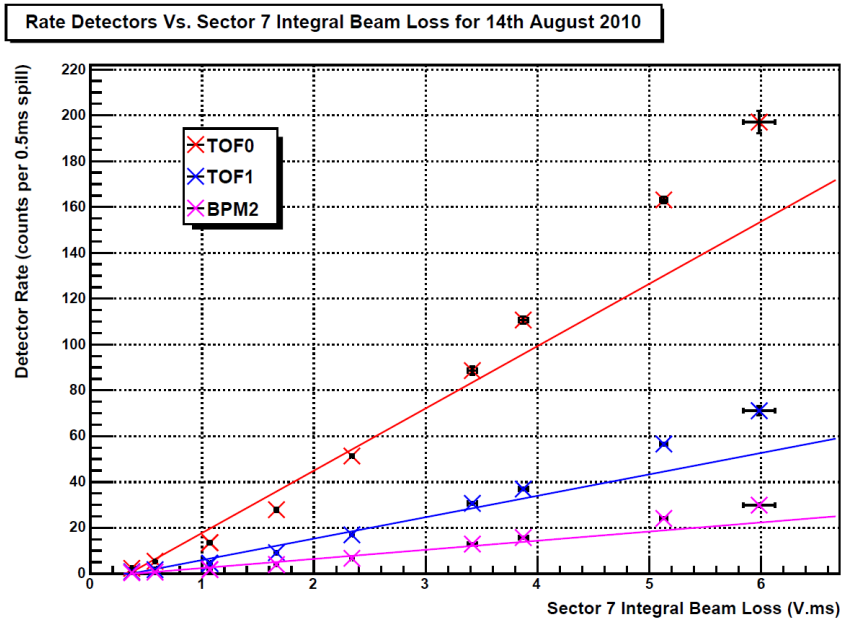


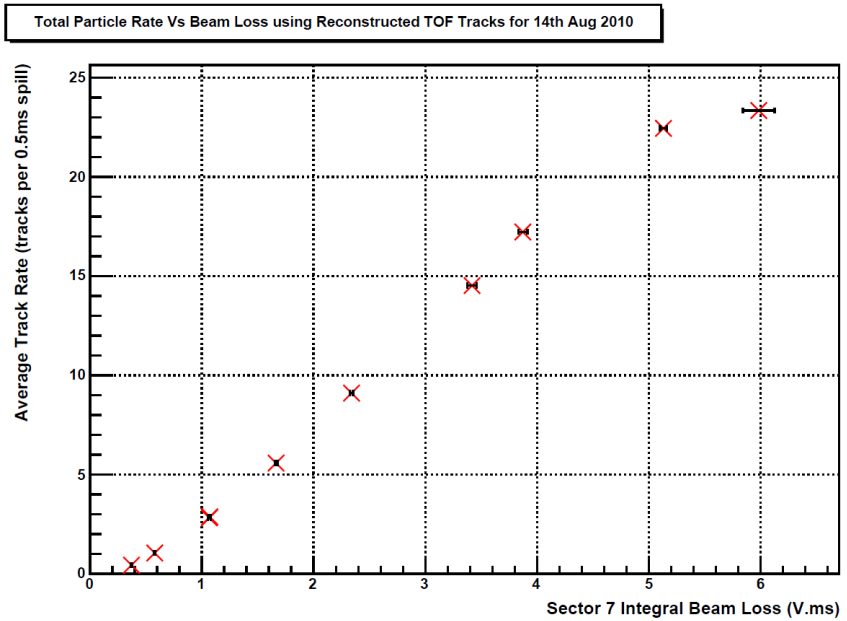


LM saturating at ~ 4V.ms (see David Forrest's talk).

GVA1 also saturating at ~ 4V.ms.

Aug 10: Rate Vs. Beam Loss





DATE DAQ Gate short and late wrt to spill → target parabola swinging later in spill as depth increases could cause observed non – linear rate increase with beam loss.

Tail off at the end of TOF Tracks plot probably caused by DAQ deadtime or software reconstruction inefficiency (although number of particles in whole spill gate is not high, very large beam losses do lead to very large instantaneous rates).

3. Conclusion

Summary

Future Plans

Summary

- Particle Rate in the MICE Beamline scales approximately linearly with increasing Beam Loss up to 5V.ms in (Sector 7 Integral)
- At 2V beam loss for $\pi \rightarrow \mu$ optics observed:
  - 8 TOF1 hits per 1ms spill for –ve
  - 60 TOF1 hits per 1ms spill for +ve

NB Remember doublet optics, and losses due to reconstruction, triggering and DAQ deadtime when interpreting this.

Future Plans

- No more high beam loss data runs planned in nearer future
- More study on neutrals – what fraction of Scaler hits is caused by them?
- Model beam line with G4BeamLine / G4MICE simulations to determine species content and what fraction of observed particles will translate into "good" muons
- Use ORBIT to understand loss patterns around ISIS, optimise target, etc

Spares

Preliminary TOF Analysis