FLUKA Simulation of the ADT Quench Test

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(on behalf of the FLUKA team)

and with contributions from
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Quench-Test Analysis Working Group Meeting
August 23, 2013

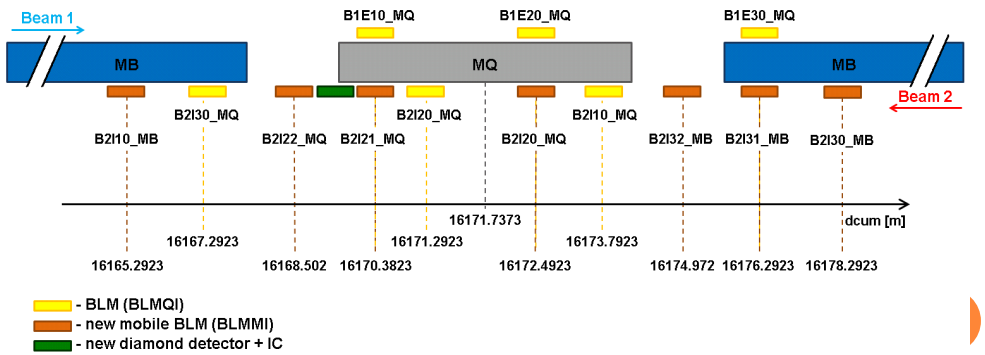
The ADT Quench Test (W. Hofle, A. Priebe, T. Baer, M. Sapinski, D. Valuch)

PREPARATION FOR THE QUENCH TESTS

Cell: 12L6
Location: Versonnex

Additional monitors:

- 7 mobile BLMs
- 1 diamond detector + ionization chamber



QTAWG Agnieszka Priebe 9th April 2013

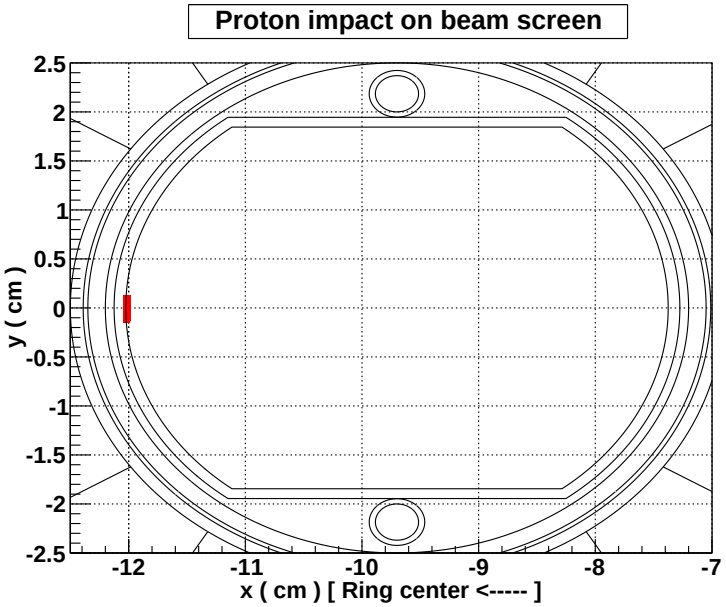
15 February, 2013

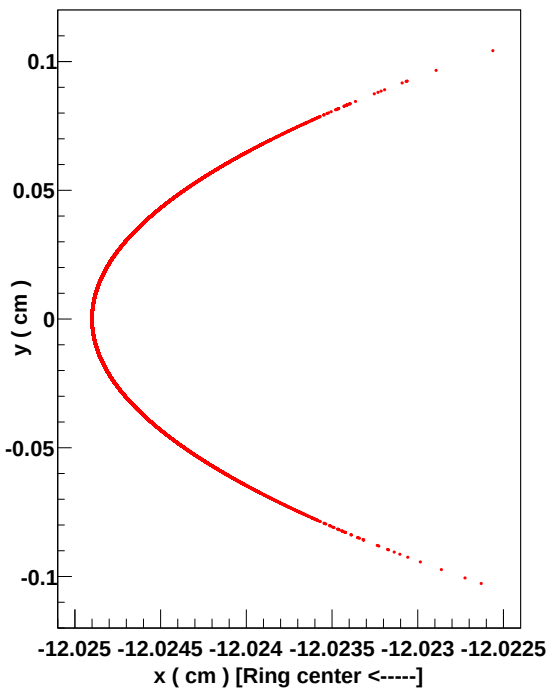
Quench **MQ.12L6** with a single bunch of beam-2 (internal) at 4 TeV

Fast losses induced on the magnet using ADT

	ADT gain	Intensity	Loss duration	Quench
Shot1	200 %	4×10^8 p	~6 - 7 ms	No
Shot2	200 %	8.2×10^8 p (entire loss)	~10 ms	Yes
	~5×10^8 p (?) (until quench)	~5 ms $\pm$ 2.5 ms		

Simulation Procedure





MADX (V. Chetvertkova)

Impact distribution of protons on beam screen

Input to FLUKA

Assumption: Because the loss distribution for all turns is within the same length ($\sim$1.2 m), the partial distribution of the turn where maximum protons are lost is representative of the entire loss distribution. (no time structure dependence)

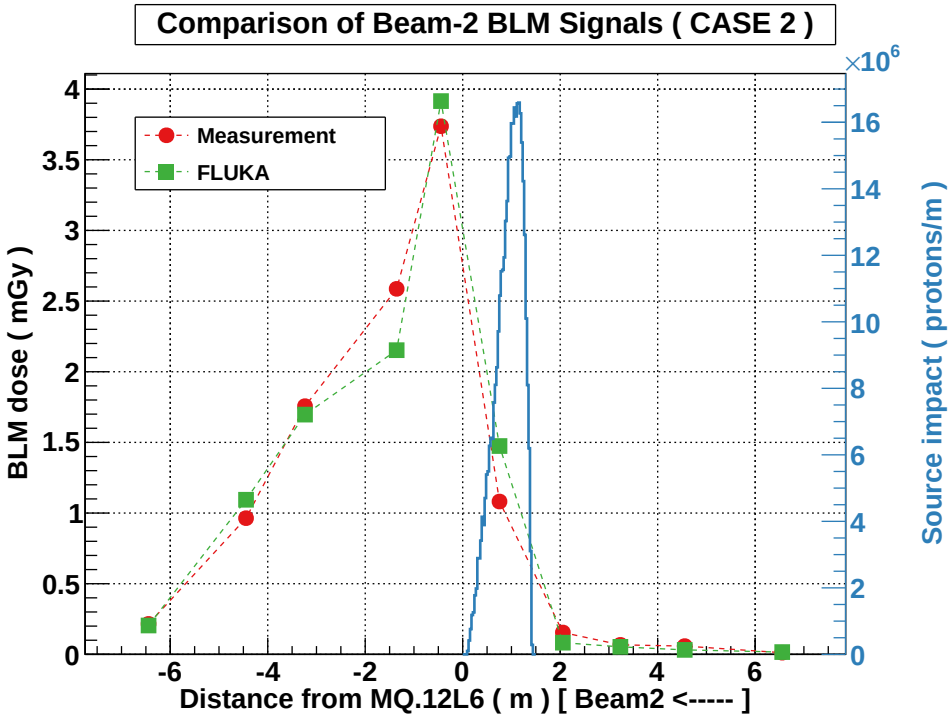
FLUKA

Reproduce absolute BLM signal

Energy deposition in magnet coil (MQ.12L6)

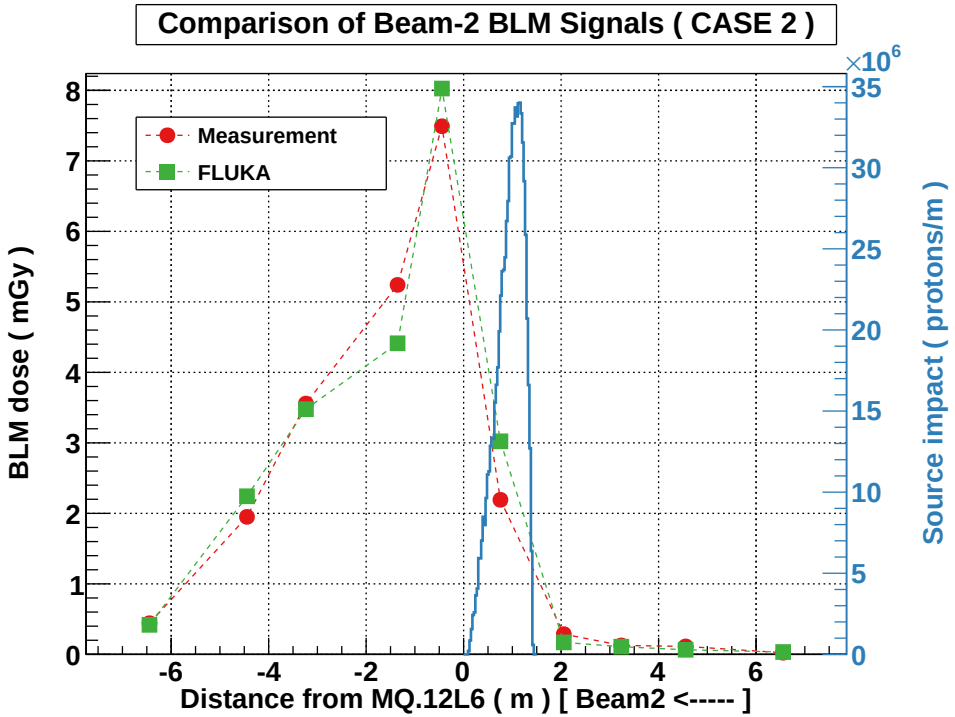
Absolute BLM Dose Comparison (measurement vs simulation)

Shot without quench



FLUKA results normalized per $\mathbf{4} \times \mathbf{10}^{8}$ protons

Shot with quench



FLUKA results normalized per $\mathbf{8.2} \times \mathbf{10}^{8}$ protons

RS07 (81.92 ms) from TIMBER used for comparison

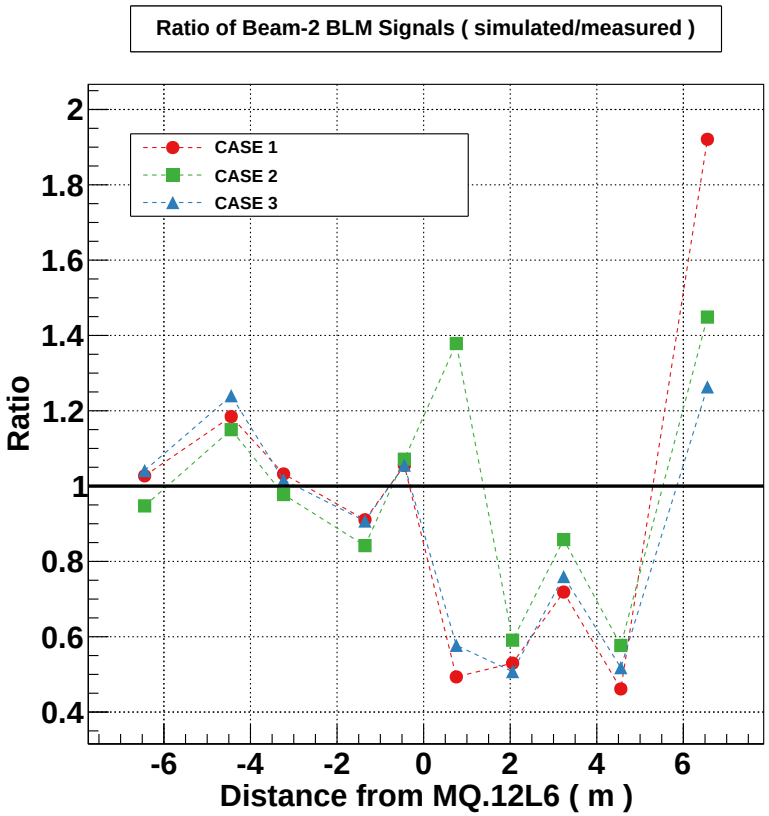
Dose can be scaled for the two measurements

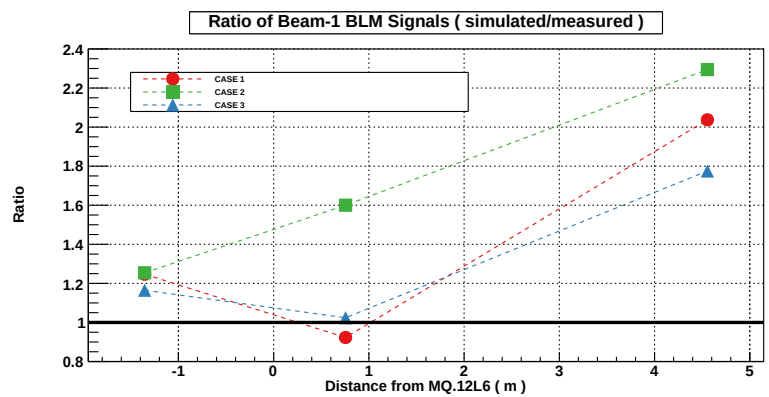
Demonstrating the stability of results vs impact distribution: BLM Simulation Cases

Three simulations with slightly differing impact distributions:

- **CASE 1 -** Loss distribution based on MAD-X simulations with nominal beam screen dimensions and including tolerances (inner beam screen radius 2.2 cm); distribution radially shifted in FLUKA simulations to match nominal beam screen dimension (2.325 cm).
- **CASE 2 -** Loss distribution based on MAD-X simulations with nominal beam screen dimensions and excluding tolerances (inner beam screen radius 2.325 cm); distribution used in FLUKA as generated.
- **CASE 3 -** As in case 2), but no tune correction included.

Conclusions on the Absolute BLM Dose Comparison





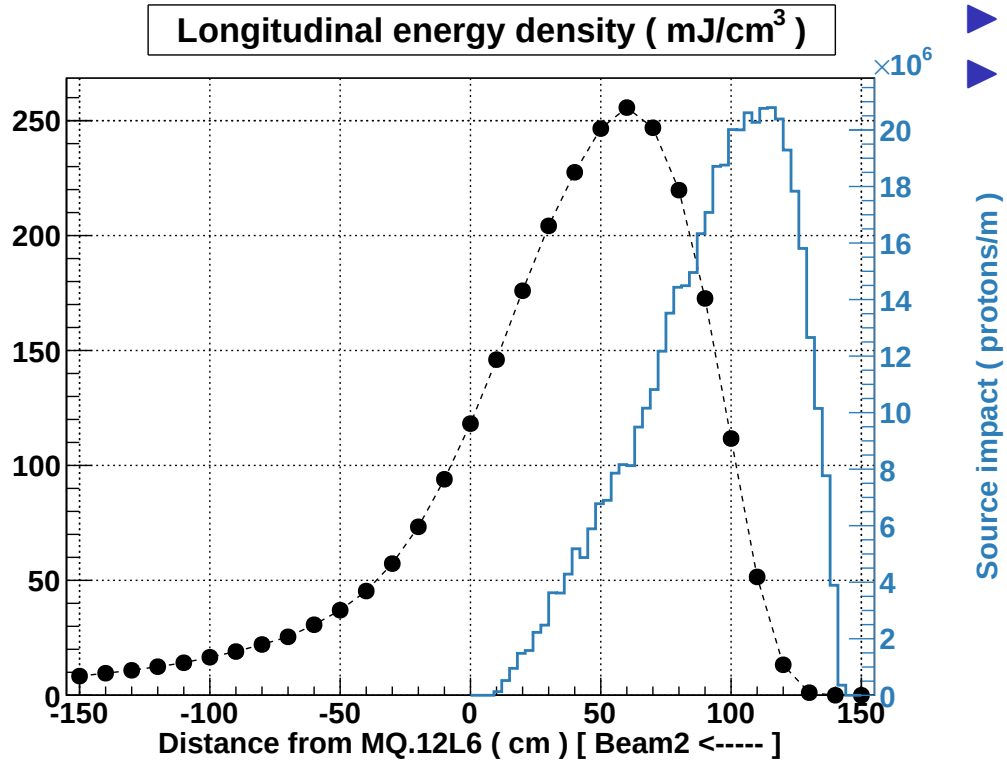
Simulation and measurement agrees within a factor of 2 for all the cases (for beam-1 BLMs as well)

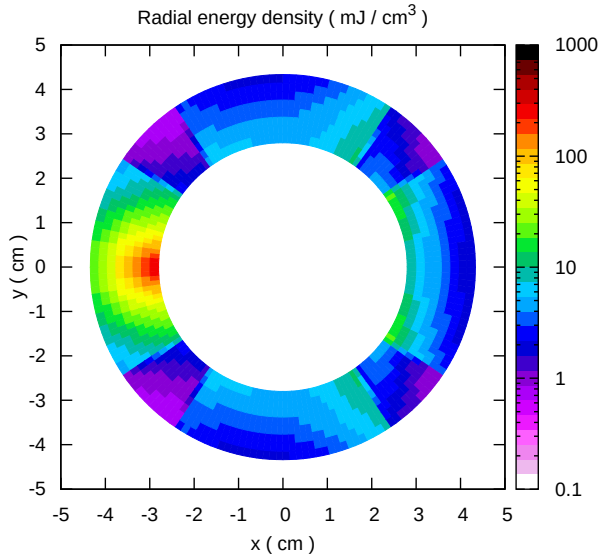
Dose is not so sensitive to the tolerances in beam screen dimension and also to the slight tune changes during the excitation

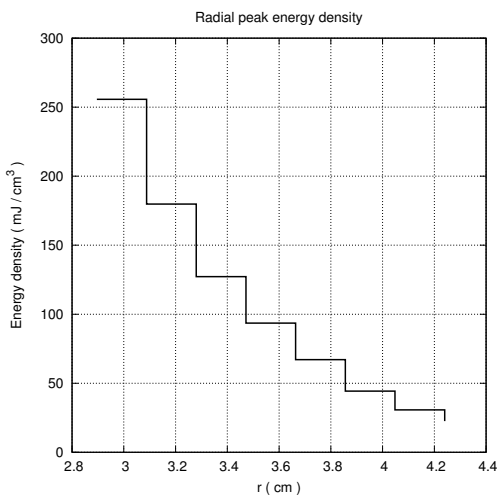
This method (assumption) of simulating fast losses is reliable (that turn in which maximum protons are lost is used for impact distribution, no time structure dependence)

Energy Deposition in MQ.12L6

- <—-Energy deposition follows impact distribution
- All plots normalized per 5×10^8 protons
- FLUKA quench test simulation results' repository- https://alechner.web.cern.ch/alechner/data.html





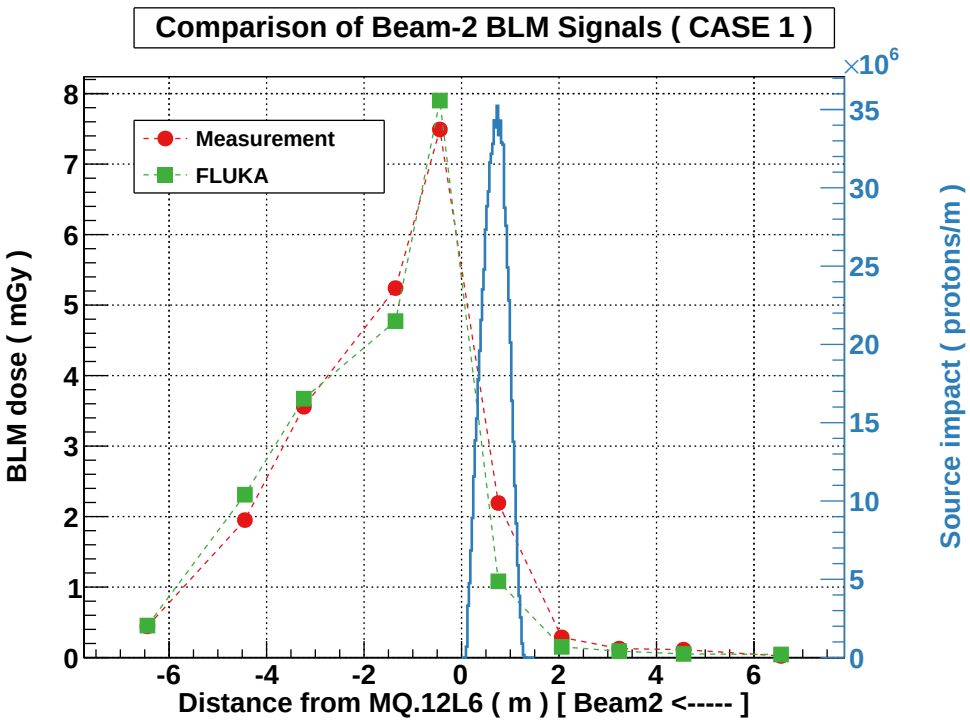


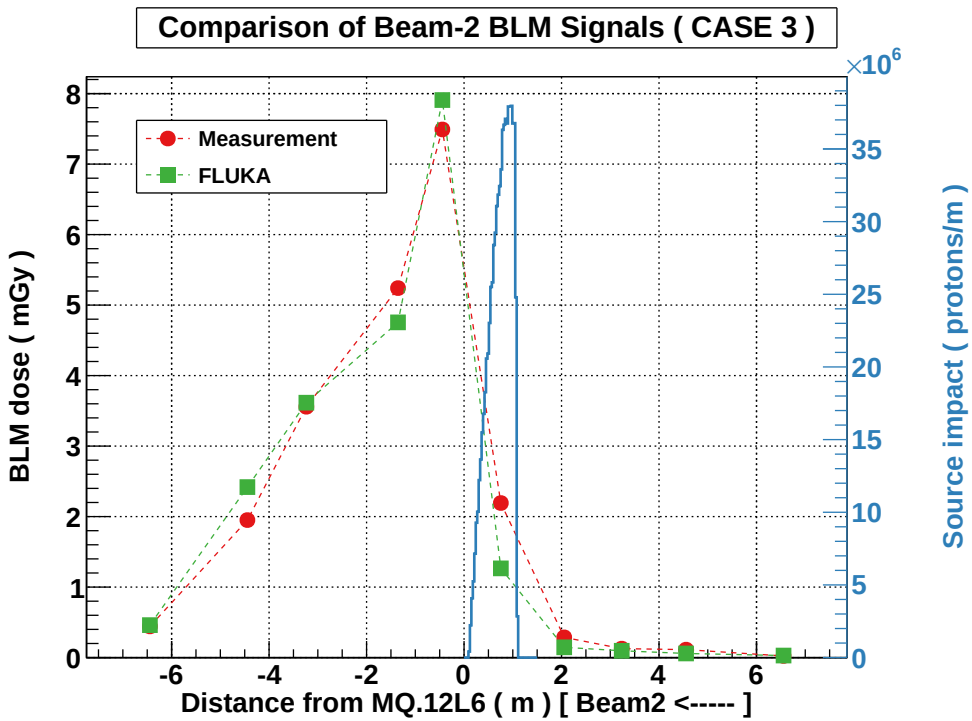
Intensity	Loss duration	Quench	Max. ED
4×10^8	$\sim$6 - 7 ms	No	200 mJ/cm^3
8.2×10^8 (entire loss)	$\sim$10 ms	Yes	420 mJ/cm^3
$\sim 5 \times 10^8$ (?) (until quench)	$\sim$5 ms $\pm$ 2.5 ms		250 mJ/cm^3

Summary & Conclusion

- FLUKA + MADX allows to reproduce the absolute BLM dose accurately (within a factor 2 or better)
- Results do not depend significantly on beam screen tolerances and also on slight tune changes during the excitation
- The good agreement between the measured and simulated BLM dose gives us confidence that we can accurately estimate energy density in coils
- For the shot without quench ($\sim$6-7 ms, 4×10^8), max. energy density is predicted to be $\sim$200 mJ/cm^3
- For the shot with quench ($\sim$10 ms, 8.2×10^8), max. energy density is predicted to be $\sim$420 mJ/cm^3 (but magnet quenched earlier and duration until quench not easy to estimate)

Backup


Comparison of Beam-2 BLM Signals (CASE 1)
Measurement
FLUKA
BLM dose (mGy)
Source impact (protons/m)
×10^6
Distance from MQ.12L6 (m) [Beam2 <-----]


Comparison of Beam-2 BLM Signals (CASE 3)
Measurement
FLUKA
BLM dose (mGy)
Source impact (protons/m)
×10^6
Distance from MQ.12L6 (m) [Beam2 <-----]