

FLUKA Simulations of Q6 Quench Test

—Ultra Fast (Single Turn) Loss—

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Q6 Quench Test

- ▶ Early morning of 15 February, 2013
- ▶ Quench margin of **Q6.L8** at injection for different currents
- ▶ Q6 at 4.5 K (LSS) and horizontally focussing for beam 2
- ▶ TCLIB fully closed and intercepted fully the injected beam

Impact Parameter

- ▶ TCLIB fully closed at 1.04 mm gap (upper jaw at -1.065 mm, lower jaw at -2.105 mm as measured by LVDTs)
- ▶ Beam at nominal orbit $\Rightarrow 3\sigma$ (nominal) impact parameter on the upper jaw (7σ real impact parameter)

Beam 2 Parameters¹ (at Injection Energy: 450 GeV)

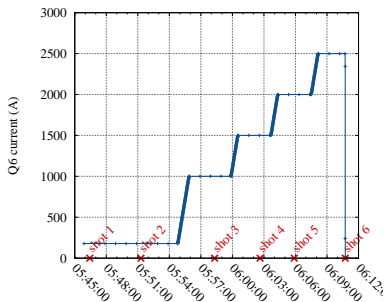
	$\epsilon(\mu m \cdot \mu rad)$	γ_r	$\beta_x(m)$	$\beta_y(m)$	$\sigma_x(\mu m)$	$\sigma_y(\mu m)$
Nominal	3.5	479.6	228.9	21.3	1292	394
Real	0.5^2	479.6	228.9	21.3	488	149

¹optics version 6.503, at the front face of TCLIB

²courtesy: Karel

Attempts to Quench the Magnet

Shot	Time	Q6 Current (A)	Intensity	Quenched?
1	05:46	179	6.2×10^{10}	No
2	05:51	179	6.2×10^{10}	No
3	05:58	1000	6.2×10^{10}	No
4	06:00	1500	6.6×10^{10}	No
5	06:06	2000	6.5×10^{10}	No
6	06:08	2500	6.5×10^{10}	Yes

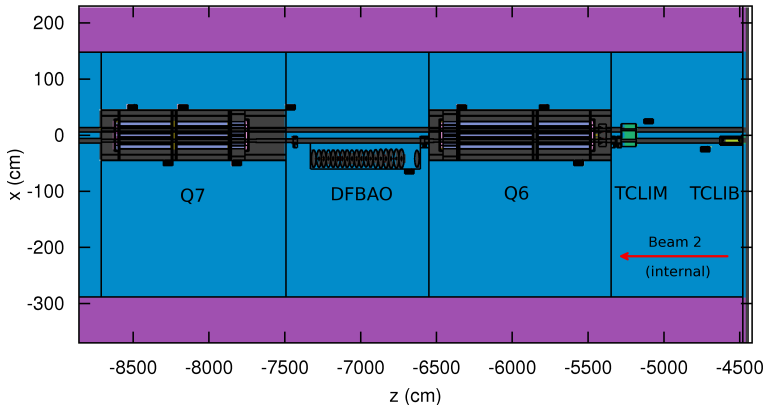


FLUKA Simulation

- ▶ Estimate energy deposition and provide input for quench limit calculation
- ▶ Attempt to reproduce the measured BLM dose
- ▶ Two different simulations:
 - ▶ 2000 A — 4.91 TeV — 74 T/m
 - ▶ 2500 A — 6.13 TeV — 93 T/m

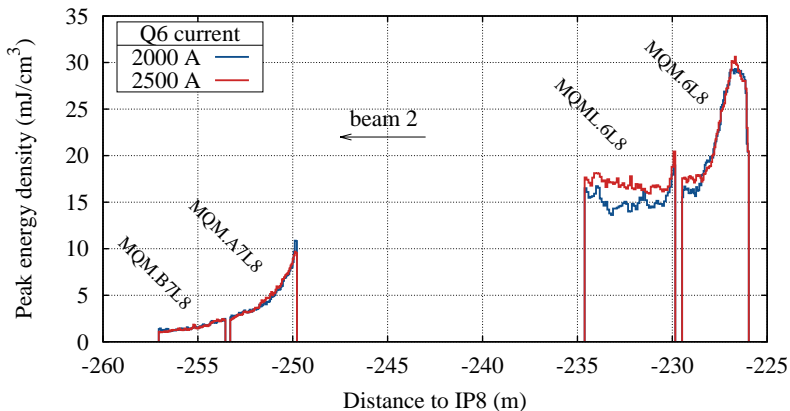
FLUKA Geometry

- ▶ Sensitive dependence on the geometrical details
- ▶ Detailed aperture: beam pipe, beam screen, vacuum modules, cold/warm transitions, BPM



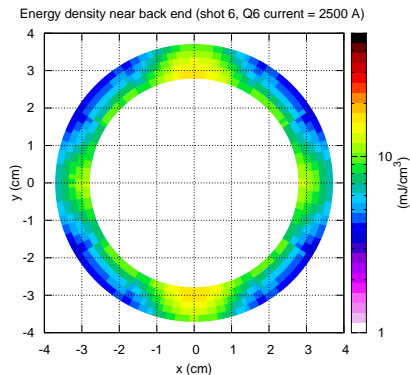
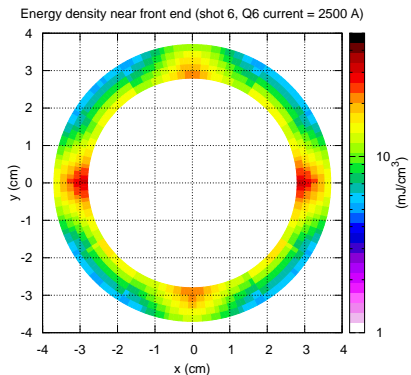
Overview of Energy Deposition in Q6 and Q7 Coils

Q6 Quench Test: peak energy density in magnet coils



- ▶ Max. energy density in Q6 (MQM)
- ▶ $\sim 30 \text{ mJ/cm}^3$ for both 2000 A and 2500 A

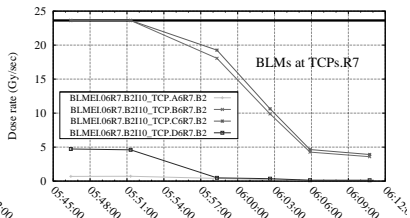
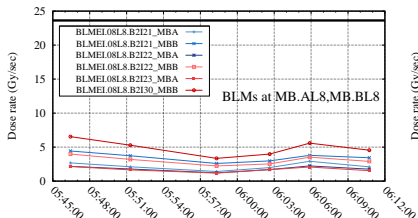
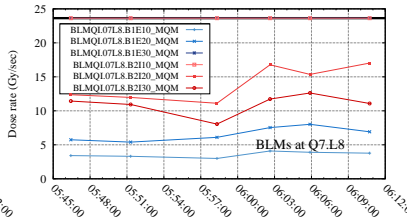
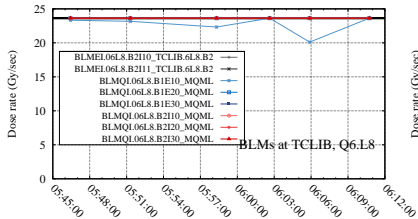
Transverse Profile of ED in Q6 (MQM) Coil



- ▶ Maximum ED in MQM > Inner coil > Horizontal plane
- ▶ ED shifts from horizontal to vertical plane due to focussing

Overview of Measured BLM Dose Rate

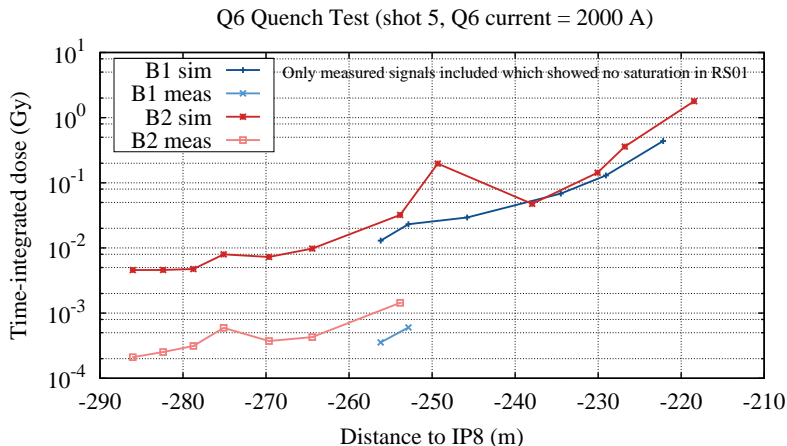
BLM dose rates (RS01) measured during the Q6 Quench Test (15/02/2013)



- ▶ Electronic limit: 23 Gy/s => Many BLMs saturated
- ▶ Protons that do not undergo inelastic collision in TCLIB probably reach the TCPs.R7

Comparison of BLM Dose (Simulation vs. Measurement)

- ▶ Discrepancy is observed between the measured and the simulated values



Possible reasons for discrepancy

- ▶ So far, FLUKA has reliably reproduced BLM dose for fast (ms) and steady state losses.
 - ▶ Losses are ultra fast (single turn) in the present case
- ▶ Simulation results are consistent with previous studies
- ▶ The cause of this observed discrepancy is still being investigated.
- ▶ Possible reasons could be:
 - ▶ Voltage drop due to the saturation of many neighbouring BLMs?
 - ▶ Space charge effects can be excluded (Zwaska, PhD thesis, 2005)
 - ▶ ...

Summary

- ▶ Q6 quench test simulated using FLUKA for two different currents (2000 A and 2500 A)
- ▶ Predicted peak energy density is $\sim 30 \text{ mJ/cm}^3$ for both the cases
- ▶ Quench limit to be determined (data passed on to Arjan)
- ▶ Attempted to reproduce BLM dose, discrepancy observed, and reasons are still being investigated