FLUKA simulations of accidental beam impact on TOTEM Roman Pots: new results (and corrigendum to previous results)

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Introduction

TOTEM Roman Pots & asynchronous beam dump

Beam kicked by MKDs:

- With the current optics the horizontal Roman Pots cannot be hit by beam, neither B1 nor B2 (*D. Wollmann*)
- Nevertheless, FLUKA simulation results are presented as a reference (MPP request)

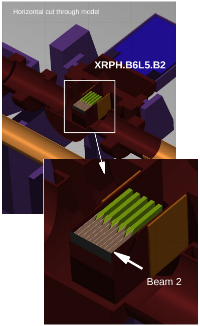


Figure left: FLUKA model of Roman Pot Unit for TOTEM in IR5
Figures right: horizontal cut through XRPH.B6L5 and focus on jaw

Beam at XRPH.B6L5 (-219.551 m from IP5):

σ_x	σ_y
88 μm	384 μm

Two cases are considered (both in single-passage):

- **CASE 1:** x-offset of beam 2 at XRPH.B6L5 $= 7\ \sigma$ (i.e. 3 σ impact parameter)

  Beam traverses different parts of Roman Pot (housing (steel), Si layers); a small fraction of the beam also impacts steel foil at the bottom of the Pot.

  Results were presented at last MPP (01/06/2012). Due to an unfortunate error, the presented results were a factor 2 too low; corrected values are presented in the current slides.

- **CASE 2:** x-offset of beam 2 at XRPH.B6L5 $= \sim 4.85\ \sigma$ (i.e. $\sim$0.85 σ impact parameter)

  Beam impacts directly on steel foil (foil thickness in x $=$ 150 μm, foil length in beam direction $=$ 5 cm); considering the beam size in x, about 60% of particles hit the foil; can be considered the worsed case.

$\longrightarrow$ from a simple calculation of inelastic interaction lengths, one can expect the second case to be 5–6 times worse than the first one

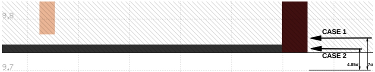


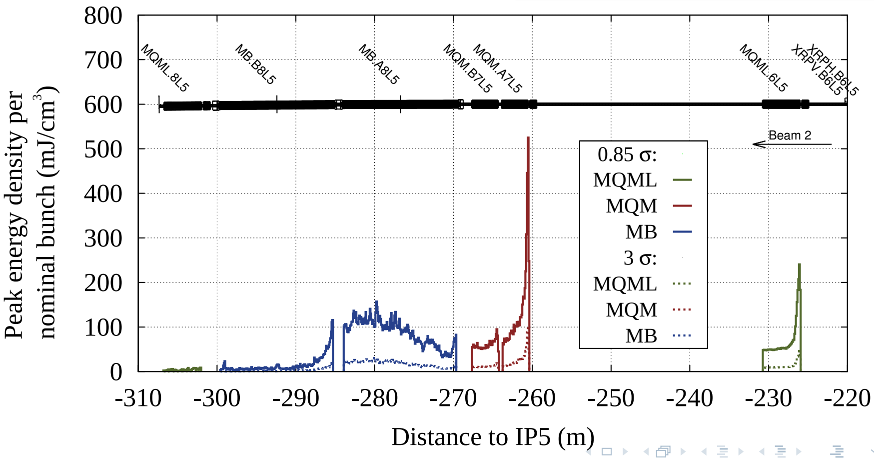
Figure: Illustration of the two impact cases (figure shows the entrance window on the right, the stainless steel foil at the bottom and the first Si layer on the left)

Energy deposition in magnets up to MQML.8L5

Figure:

- Peak energy density per nominal bunch (1.15×10^{11} p) in magnet coils (matching section and first DS cell)
- Dashed lines: **CASE 1** (Corrigendum to MPP 01/06/2012), solid lines: **CASE 2**
- Mesh for energy density calculation in coils: $\Delta r\approx2$ mm, $\Delta\phi=2^{\circ}$, $\Delta z\approx10$ cm

- Up to MBs in cell 8L5: energy density in coils dominated by collision debris of inelastic interactions in RP jaw
- **CASE 1**: highest value in MQM.A7L5: $\sim101\pm7$ mJ/cm^3, **CASE 2**: highest value in MQM.A7L5: $\sim547\pm43$ mJ/cm^3

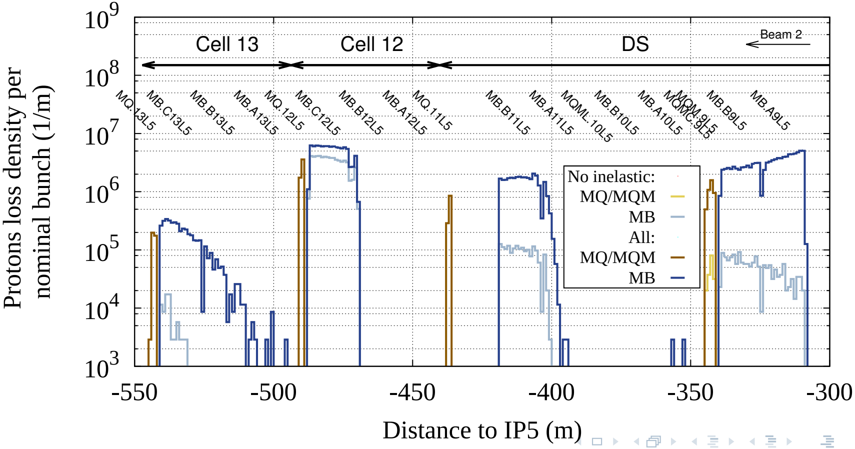


Proton losses in cells 9L5 to 13L5 (CASE 2 only)

Figure:

- Proton loss density per nominal bunch in MB, MQ and MQM magnets of the last three DS cells as well as in cell 12 and 13
- Lighter colours: particles undergoing only elastic interactions in Roman Pot, darker colours: particles undergoing any type of interaction in Roman Pot
- Note: losses outside of MB, MQ, MQM magnets are not shown (i.e. in connection cryostat)

- Loss map calculated with FLUKA using high-energy cut (1 TeV)
- Largest losses occur in MB.C12L5 (primary protons which received a vertical kick in XRPH.A6L5 jaw)



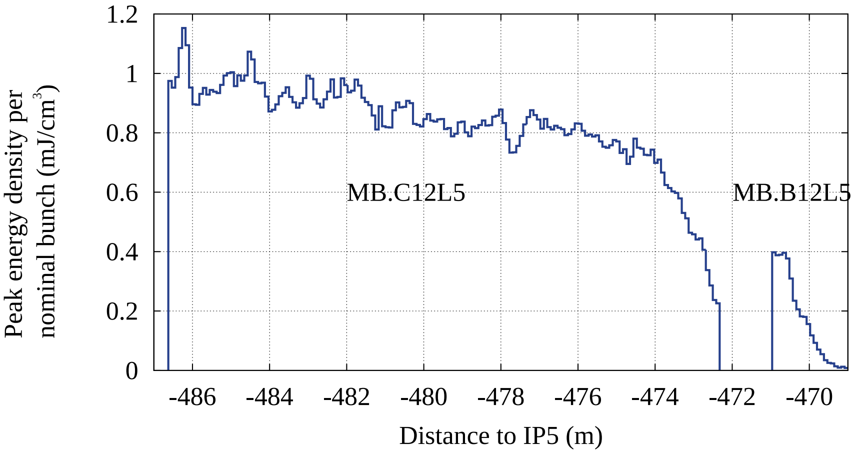
Peak energy density in MB.B(C)12L5 coils (CASE 2 only)

Simulation strategy:

- Local snippet of loss map in MB.B12L5 and MB.C12L5 loaded and corresponding shower calculations performed

Figure:

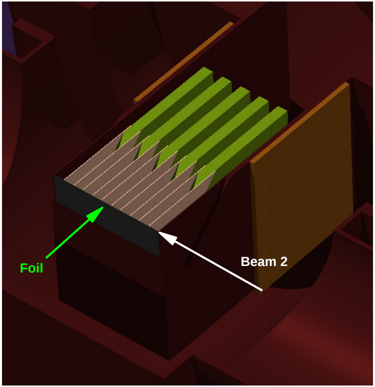
- Peak energy density per nominal bunch in MB.B12L5 and MB.C12L5 coils
- Again, mesh for energy density calculation was: $\Delta r \approx 2$ mm, $\Delta\phi = 2^{\circ}$, $\Delta z \approx 10$ cm

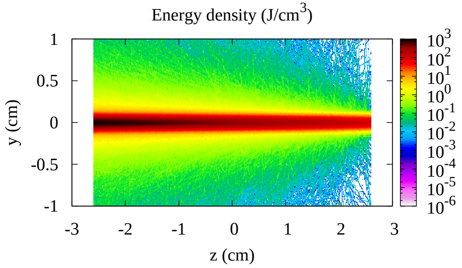


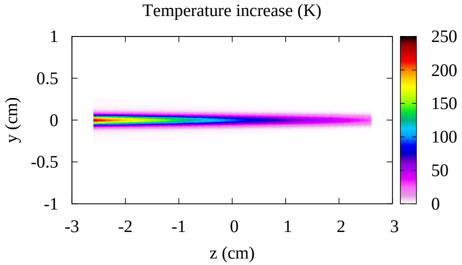
Energy density and temperature increase in Roman Pot

Figures on the right:

- Energy density (top figure) and temperture increase (bottom figure) in Roman Pot stainless steel foil
- Values are per nominal bunch impacting the Roman Pot (impact **CASE 2**)
- Assumptions for temperature calculation: adiabatic, heat capacity of 0.5 J/g







Summary and conclusions

- Beam impact on XRPH.B6L5.B2 with 0.85/3σ impact parameter was studied
  - Both cases give similar energy deposition pattern
  - Absolute values depend on the effective material traversed by the beam in each individual case
- For either case, the highest energy density is observed in the matching section
- Considering 0.85σ, the simulation predicts for one nominal bunch:
  - $\sim$241$\pm$11 mJ/cm^3 in MQML.6L5 coils and
  - $\sim$547$\pm$43 mJ/cm^3 in MQM.A7L5 coils
- Peak values reach up to $\sim$157$\pm$33 mJ/cm^3 in the MB.A8L5 of the first DS cell
- Energy density in coils at least an order of magnitude smaller in cells further downstream
- Nuclear elastic and Coulomb interactions as well as single-diffractive scattering in RP can lead to proton losses beyond cell 13L5 or to multi-turn losses