FLUKA simulations of accidental beam impact on TOTEM Roman Pots

A. Lechner, V. Boccone and F. Cerutti (on behalf of the FLUKA team)
with valuable input by D. Wollmann

Machine Protection Panel

June 1st, 2012

Introduction

TOTEM Roman Pots – accident scenarios originally discussed with MPP:

- Asynchronous dump with 3σ impact parameter (see Daniel's presentation)
- Grazing incidence

In this presentation, the first scenario is considered

- Second case can be presented at a later stage

FLUKA simulations were performed from matching section and DS to arc cells 12L5 and 13L5

- Energy density in magnets evaluated
- All results are presented per nominal bunch

Asynchronous beam dump on XRPH.A6L5.B2

Accident scenario:

- Roman pot alignment at 4 TeV
- Kick in all MKDs
- Beam dump on XRPH.B6L5.B2 jaw with 3σ impact parameter (jaw at 4σ)

(see Daniel's presentation for details)

Beam parameters at XRPH.B6L5

σ_x	σ_y
88 μm	384 μm

offset (x)	angle (x')
0.620 mm	1.323 μrad

XRPH.B6L5 located -219.551 m from IP5

FLUKA geometry model:

- Accurate FLUKA model of Roman pots (by V. Boccone), see figures on right
- Accelerator line from XRPH.B6L5 to arc cell 13L5

XRPH.B6L5 jaw: beam traverses in total

- 10×0.3 mm=3 mm of Si and
- 2×0.5 mm=1 mm of steel

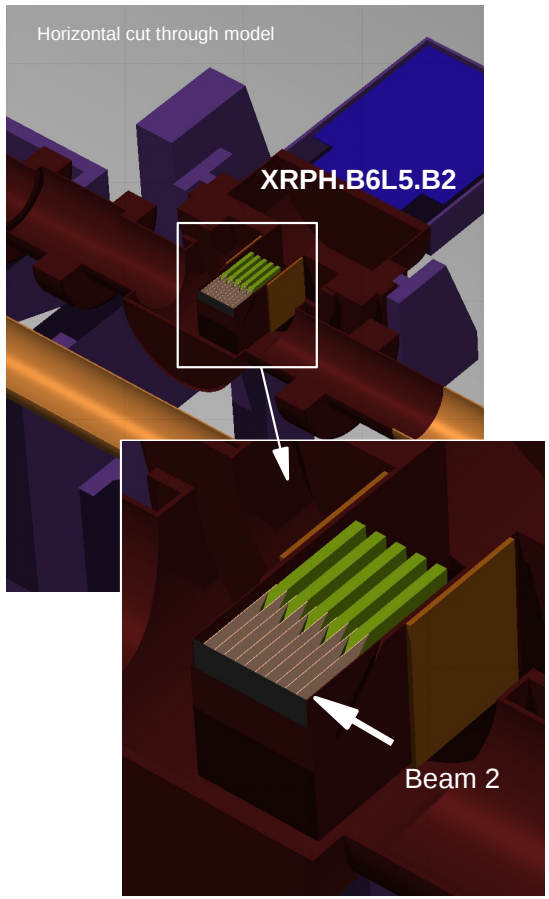


Figure left: FLUKA model of Roman Pot Unit for TOTEM in IR5

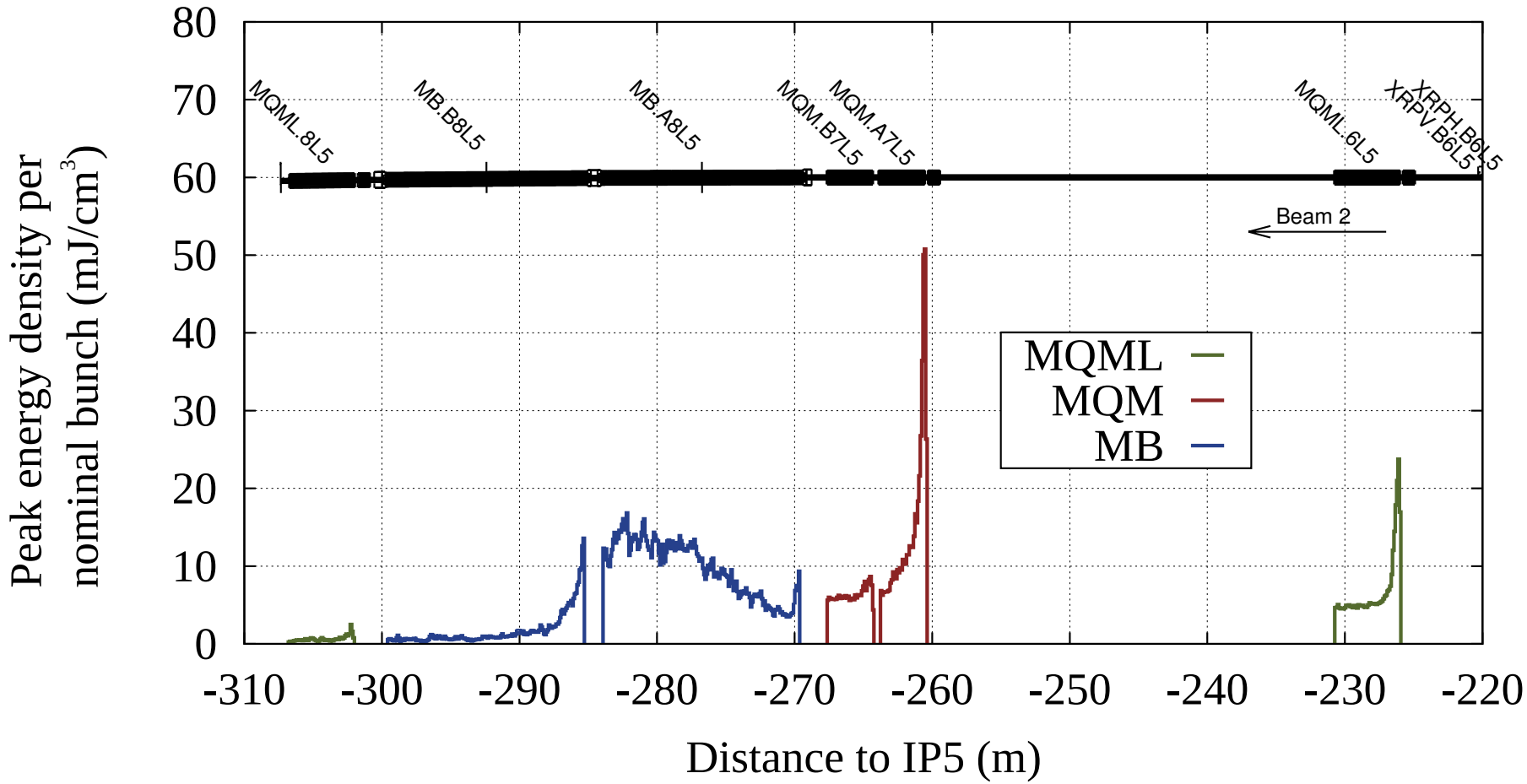
Figures right: horizontal cut through XRPH.B6L5 and focus on jaw

Energy deposition in magnets up to MQML.8L5

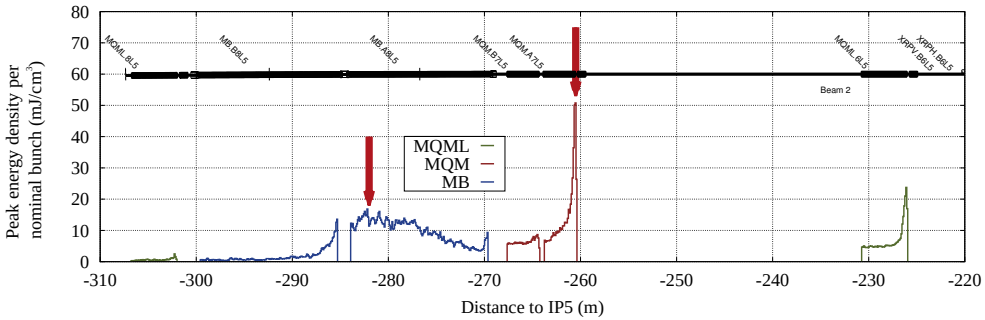
Figure:

- Peak energy density per nominal bunch (1.15×10^{11} p) in magnet coils (matching section and first DS cell)
- Mesh for energy density calculation in coils: $\Delta r \approx 2$ mm, $\Delta\phi = 2^{\circ}$, $\Delta z \approx 10$ cm

- Up to MBs in cell 8L5: energy density in coils dominated by collision debris of inelastic interactions in RP jaw
- Highest value in MQM.A7L5: $\sim 51 \pm 4$ mJ/cm^3

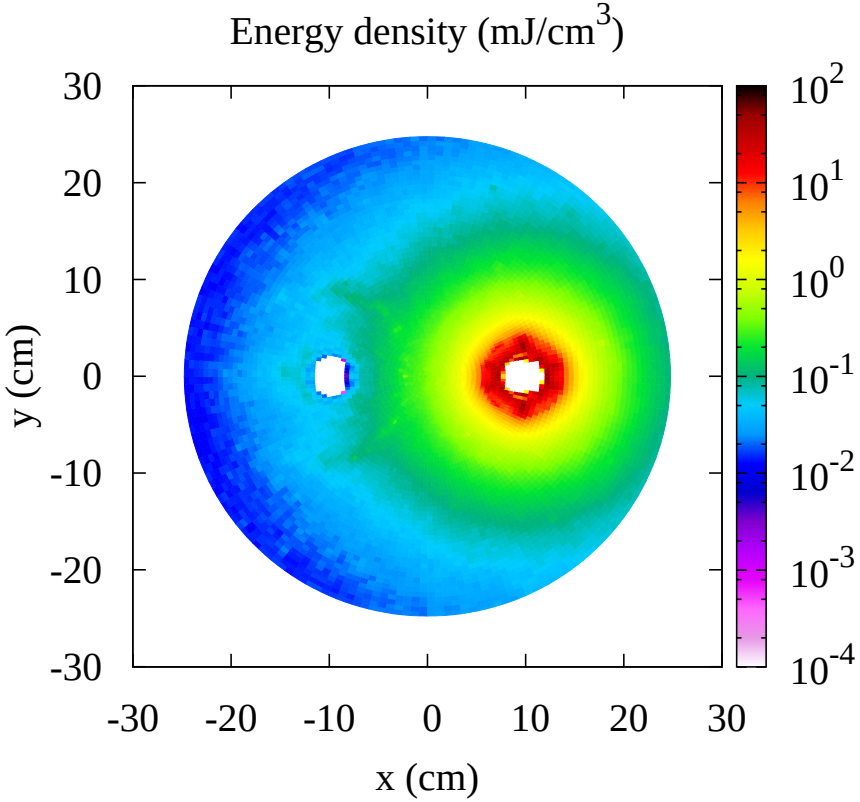


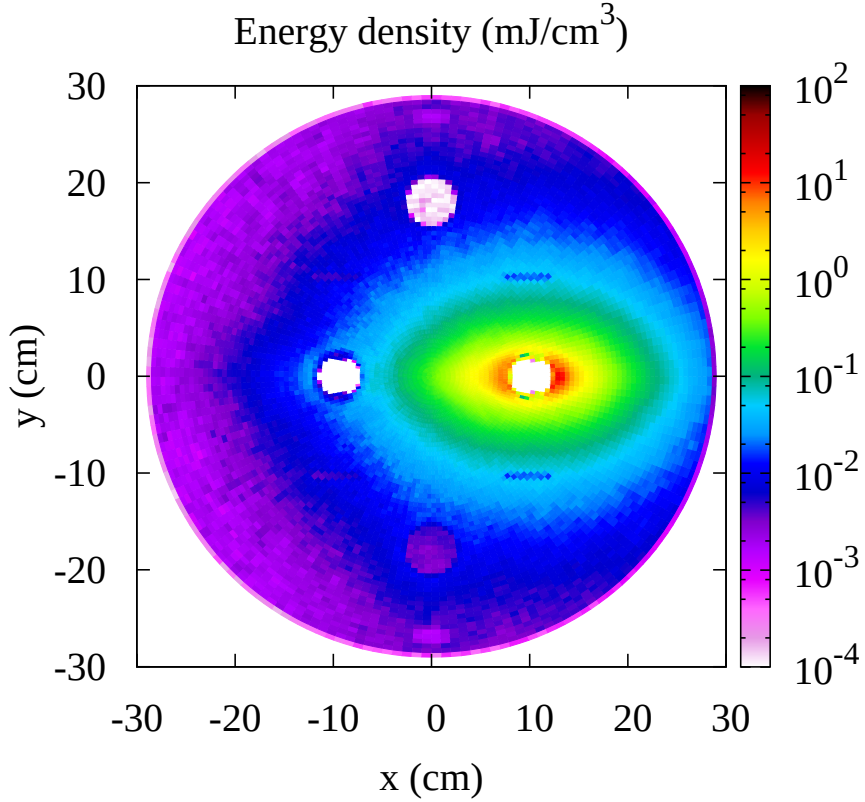
Lateral energy density profiles in MQM.A7L5 & MB.A8L5



Figures below:

- Lateral energy density profiles in MQM.A7L5 (bottom left figure) and MB.A8L5 (bottom right figure) at longitudinal positions where the largest peak energy density can be observed in the respective magnets (see red arrows in plot on the left)
- Energy density is again per nominal bunch impacting the Roman Pot





Long. energy density profiles in MB.A8L5 & MB.B8L5

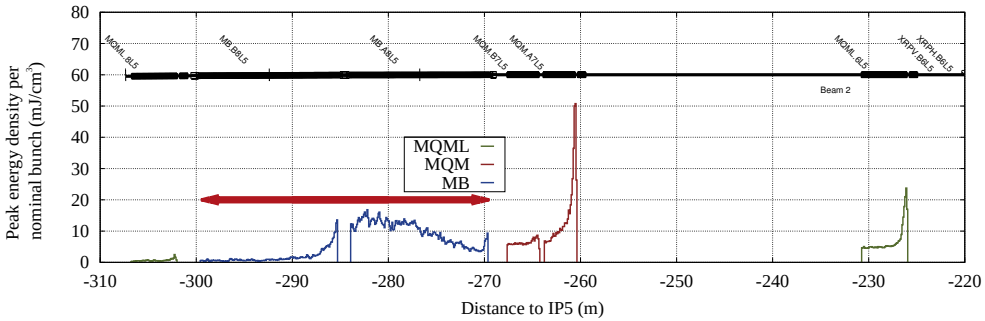
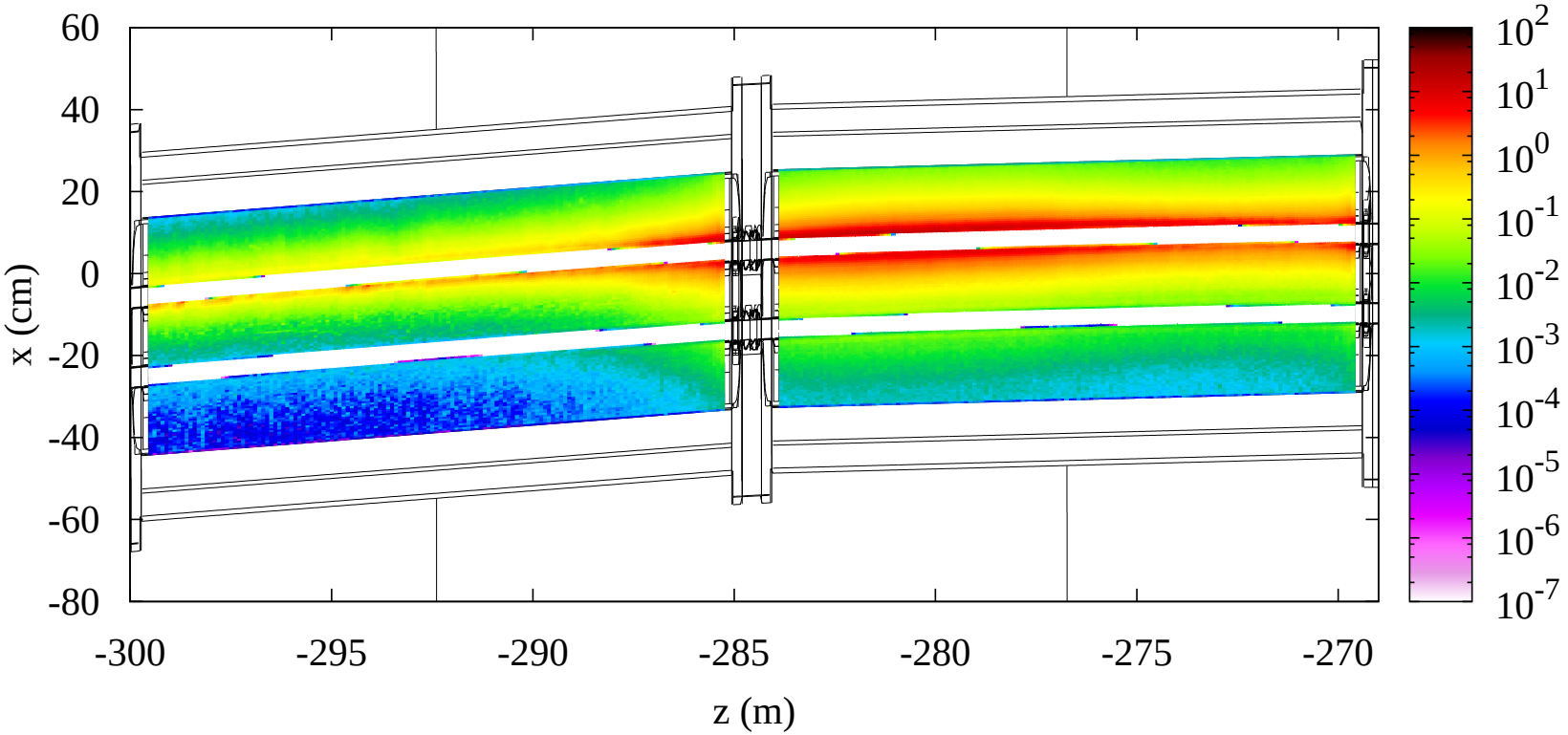


Figure below:

- Energy density profiles in the horizontal plane of MB.A8L5 and MB.B8L5 magnets (see red arrow in plot on the left)
- Energy density is again per nominal bunch impacting the Roman Pot

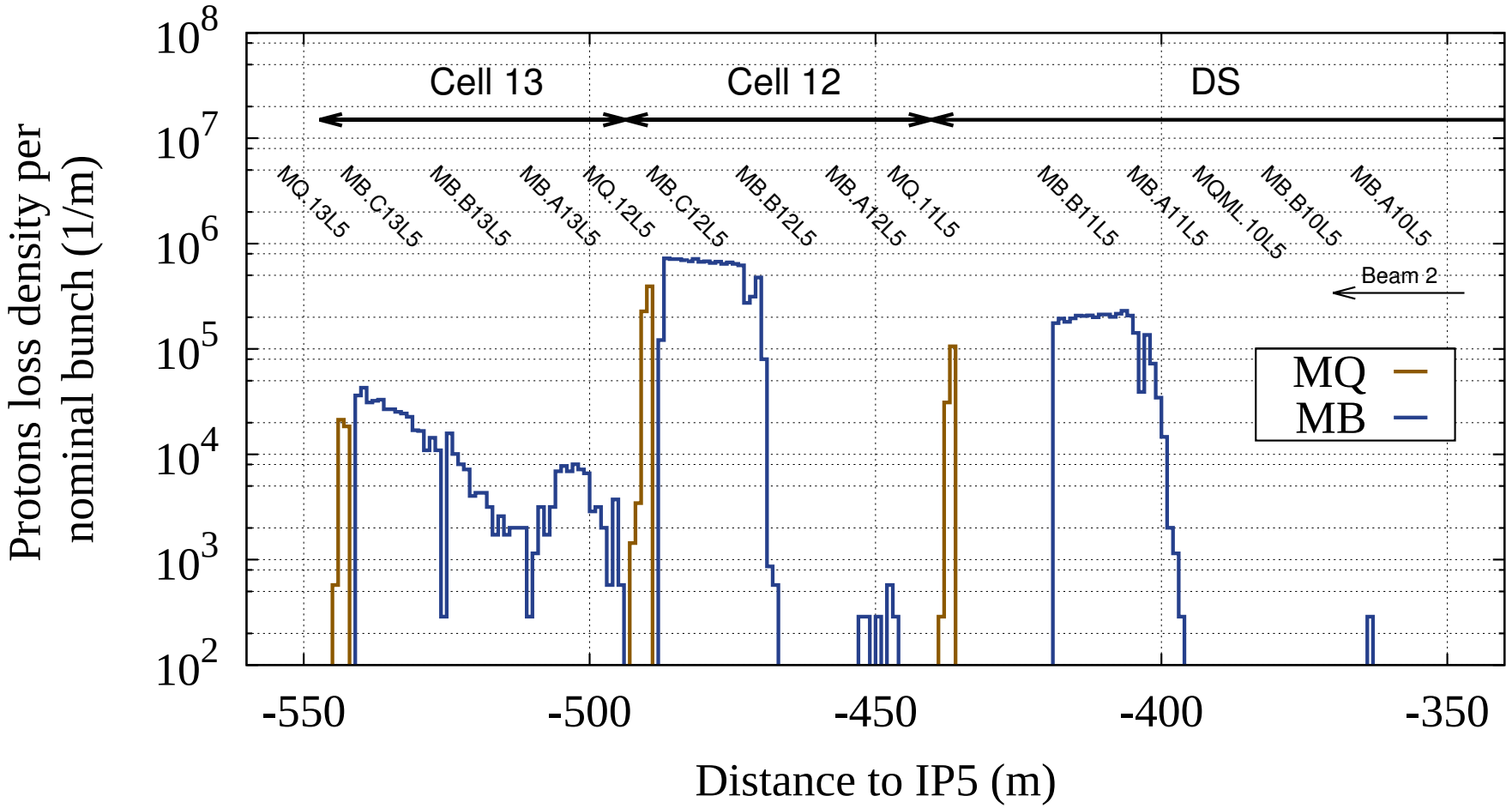


Proton losses in cells 10L5 to 13L5

Figure:

- Proton loss density per nominal bunch in MB and MQ magnets of the last two DS cells as well as in cell 12 and 13
- Note: losses outside of MB and MQ 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)



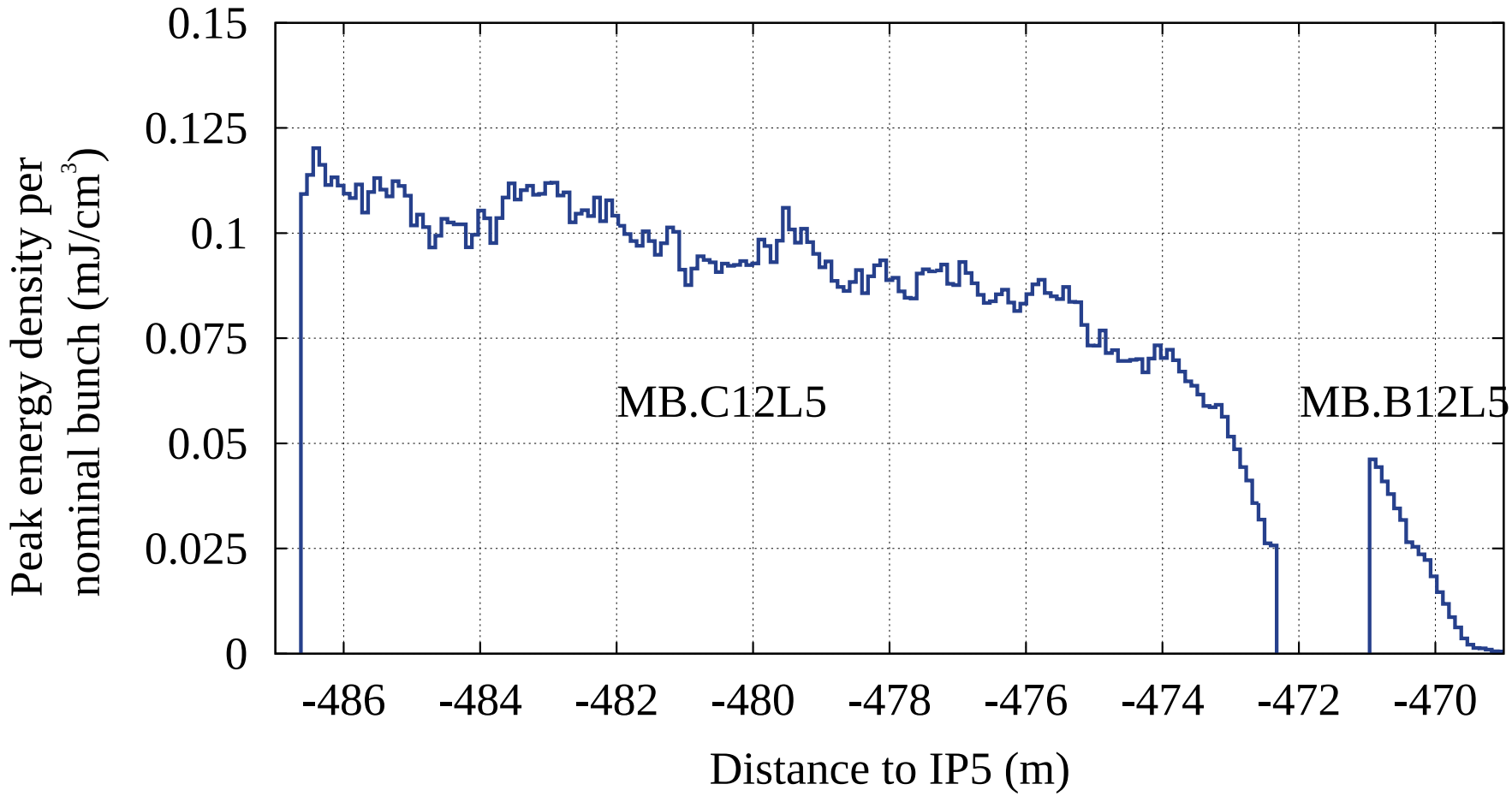
Peak energy density in MB.B12L5 and MB.C12L5 coils

Simulation strategy:

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

Figure:

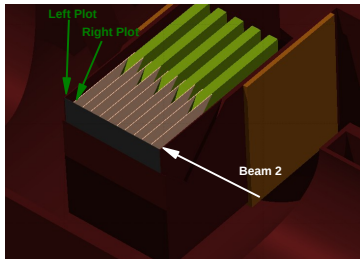
- Peak energy density per nominal bunch in MB.B12L5 and MB.C12L5 coils
- Again, mesh for energy density calculation was: $\Delta r \approx 2$ mm, $\Delta\phi = 2^{\circ}$, $\Delta z \approx 10$ cm

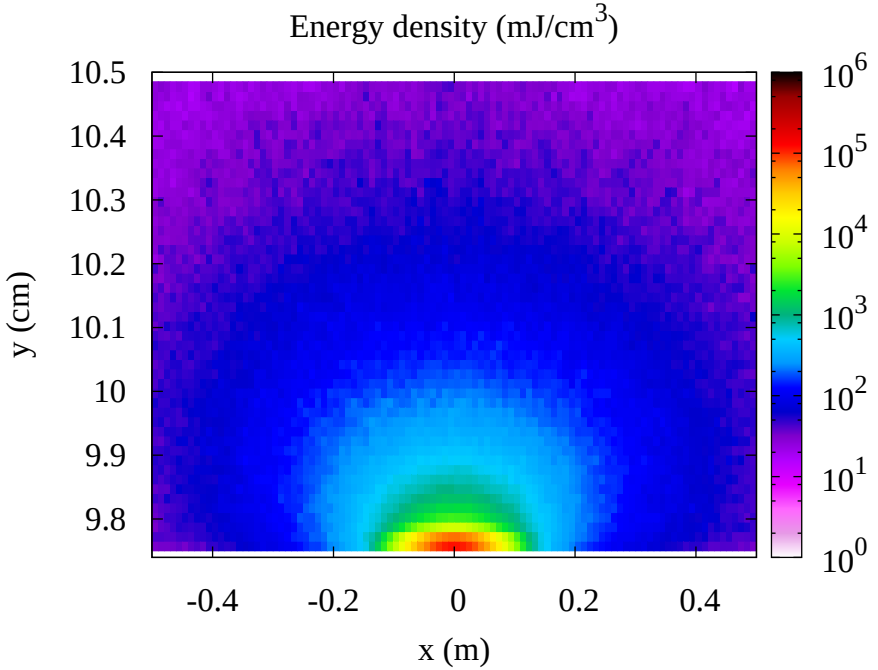


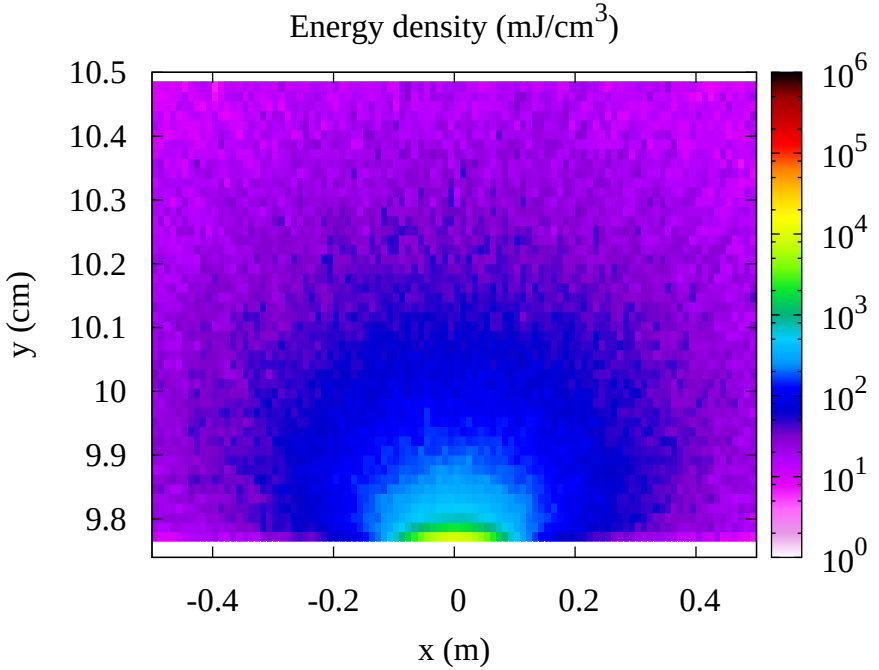
Energy density in Roman Pot

Figures below:

- Lateral energy density profiles in downstream steel window (bottom left figure) and last Si layer (bottom right figure) of the Roman Pot
- Energy density is again per nominal bunch impacting the Roman Pot







Summary and conclusions

- Asynchronous dump was studied: beam impact on XRPH.B6L5.B2 with 3σ impact parameter
- Highest energy density is observed in the matching section: for one nominal bunch the simulation predicts
  - $\sim 24 \pm 2$ mJ/cm^3 in MQML.6L5 coils and
  - $\sim 51 \pm 4$ mJ/cm^3 in MQM.A7L5 coils
- Peak values reach up to $\sim 15 \pm 2$ 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:
  - corresponding loss pattern would require further tracking studies
  - FLUKA coupling with Sixtrack would be available