IMPROVED CONCEPT OF HE-LHC BEAM DUMP

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Outline

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- Distorted Beam Dumps
- Mosaic Beam Dumps
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Motivation

The design of beam dumps becomes difficult challenges with the increasing of the energy and intensity of the particles beams.

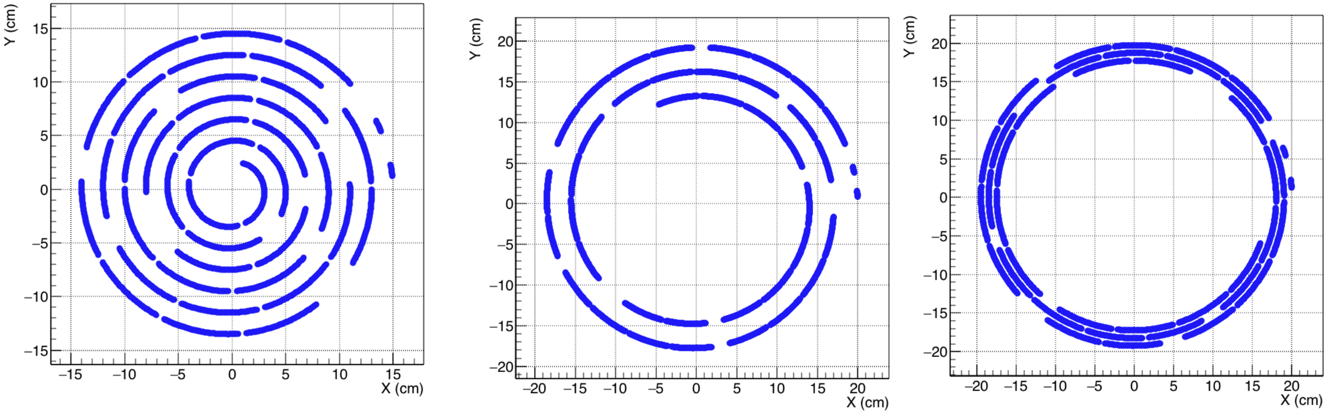
The proposed HE-LHC beam dump system must have the capability to absorb an energy 1.3 GJ per beam.

Construction of such beam dumps demands innovation for escaping the damage of the beam dump.

HE-LHC Beam Parameters used in Simulation

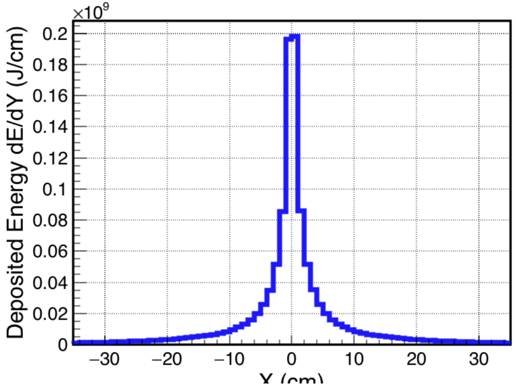
A. Lechner

HE-LHC	Units	
E_{beam}	TeV	13.5
N_p/bunch	10^{11}	2.2
N_b/beam		2760
σ_x	mm	0.94
$\sigma_{x'}$	μrad	1.10
σ_y	mm	0.85
$\sigma_{y'}$	μrad	1.21
σ_p	%	0.1

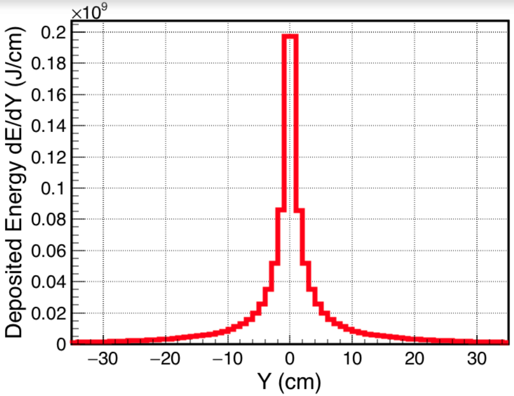


The pattern are constructed such that the temperature in the dump remains acceptable (below 2000 ^{o}C).

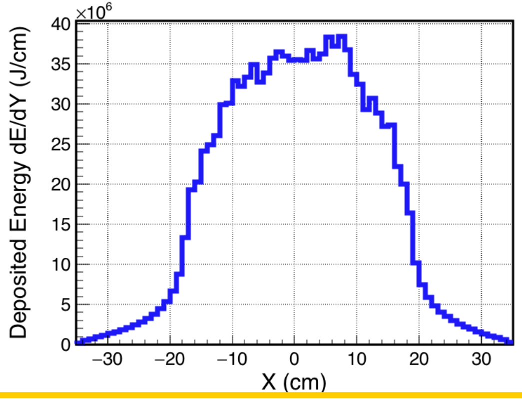
Deposited Energy X and Y Profile in the Graphite Absorber



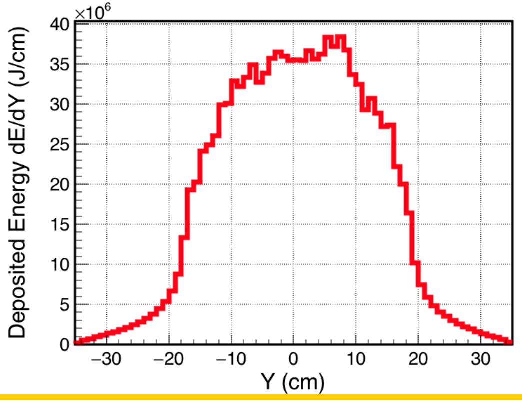
$\sigma_x = 1.7cm$



$\sigma_y = 1.7cm$

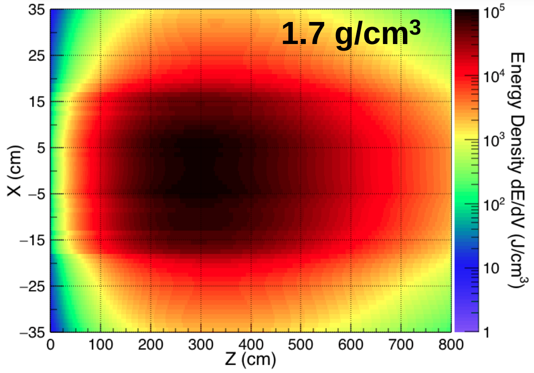


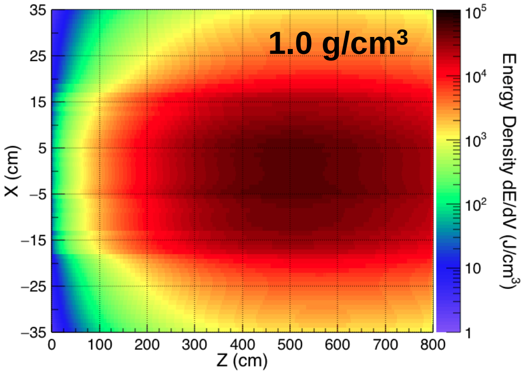
$\sigma_x = 15cm$

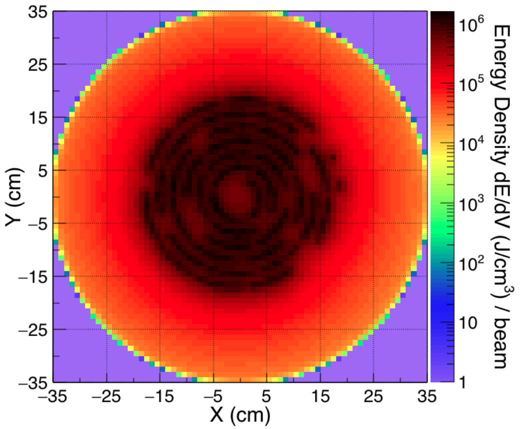


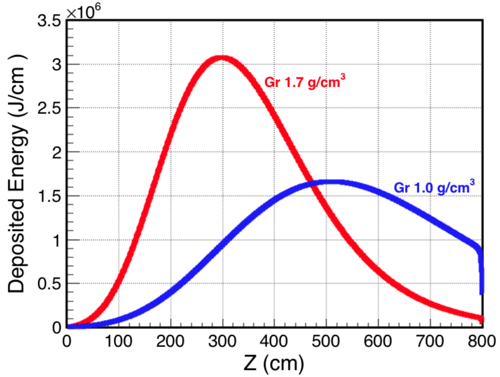
$\sigma_y = 15cm$

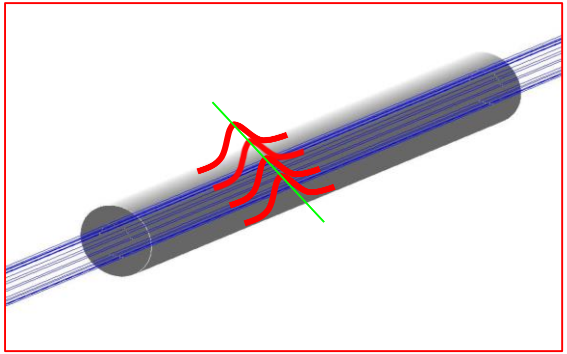
Energy Deposition in Graphite with different densities: 1.7 g/cm³ and 1.0 g/cm³









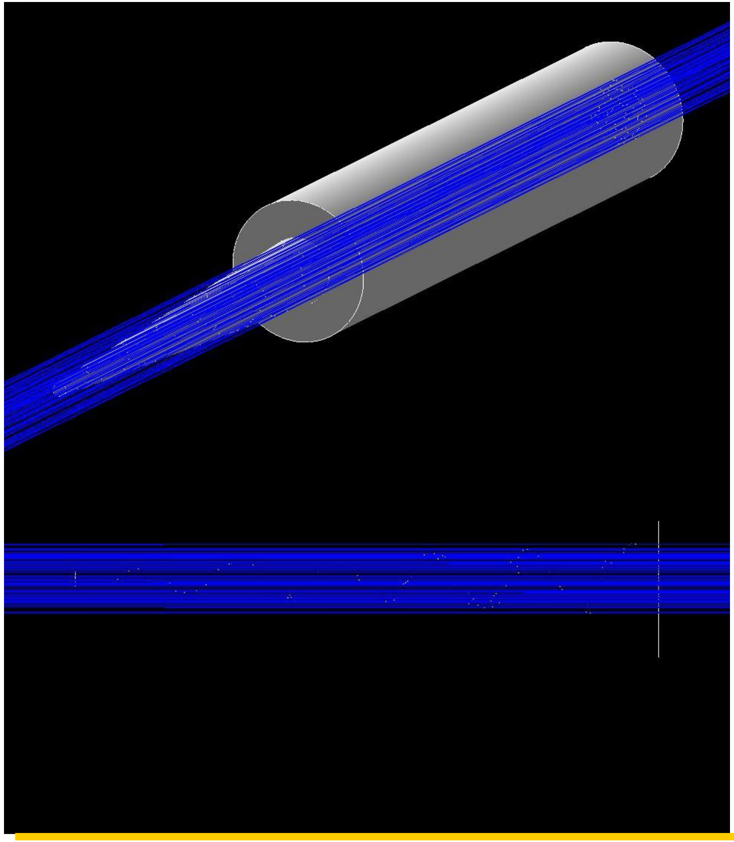


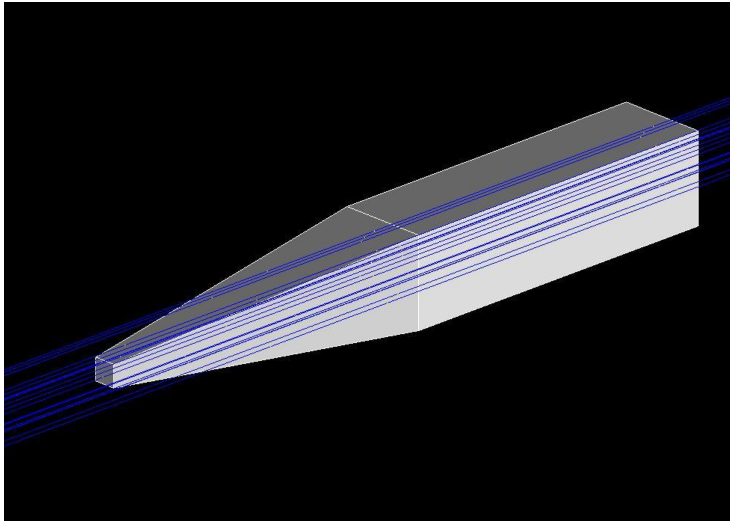
The spiral distribution of the proton bunches on the surface of the absorber solves the problem. The energy deposition in the longitudinal direction is concentrated at a distance of ~300cm or 500cm from the beam dump front surface.

1. Geometrically Distorted Absorbers

- **The main idea for an improved beam dump design is to smear the energy deposition "evenly" over the whole volume of the absorber.**
- **This would allow to better distribute the deposited energy over the whole volume and, thereby to decrease the temperature gradient inside the absorber.**
- **One of the possible solutions is to use distorted geometrical shapes instead of the regular cylinders or blocks of materials.**

Possible Improvement

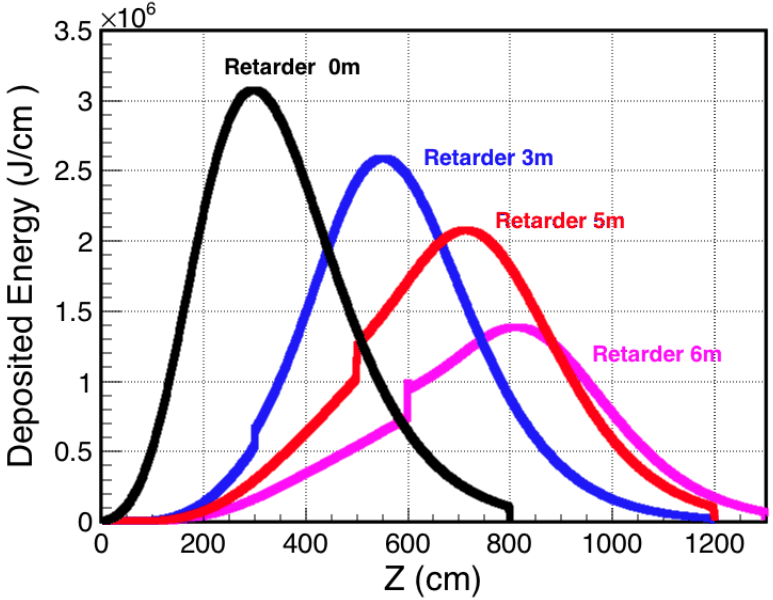




The change in the geometrical shapes should break the symmetry in the distribution of the beam particles inside the absorber. It will redistribute protons spatially wider inside the absorber in Z direction as well.

Energy Deposition in Longitudinal Direction

Comparison of the longitudinal distributions of the deposited energy for the regular and distorted beam dumps.



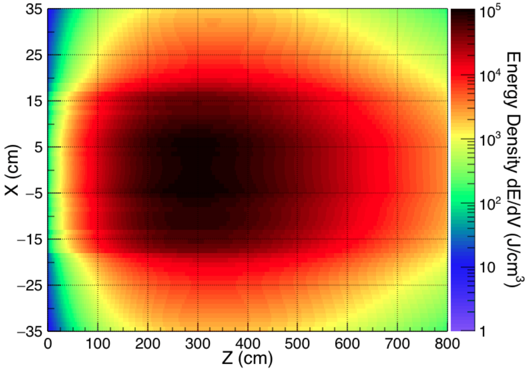
Gaussian fits of the longitudinal extents of the energy deposition yield the standard deviations:

- σ_z = 124 cm
- σ_z = 156 cm
- σ_z = 194 cm
- σ_z = 217 cm

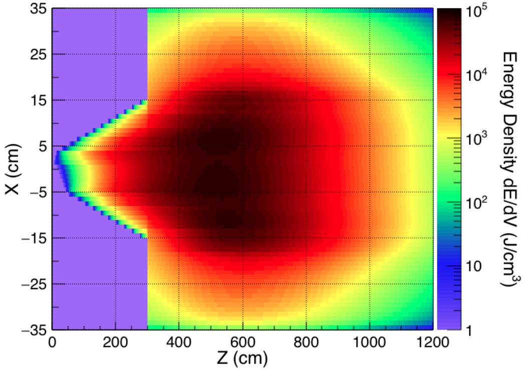
The longitudinal energy deposition is ~1.5 times wider in case of the distorted beam dump. This will decrease the temperature gradient inside the absorber.

Energy Deposition in the Absorber

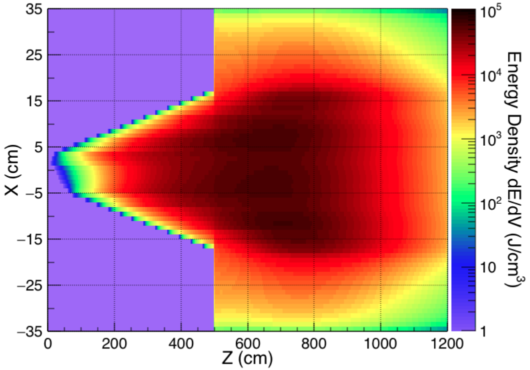
0m



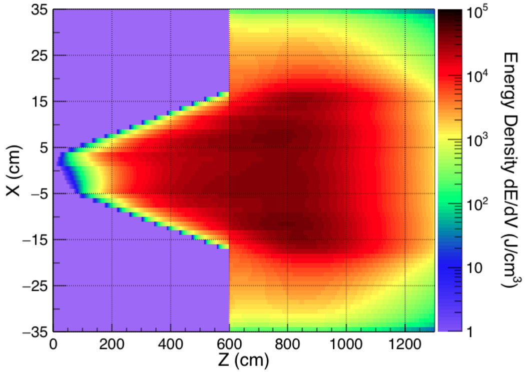
3m



5m



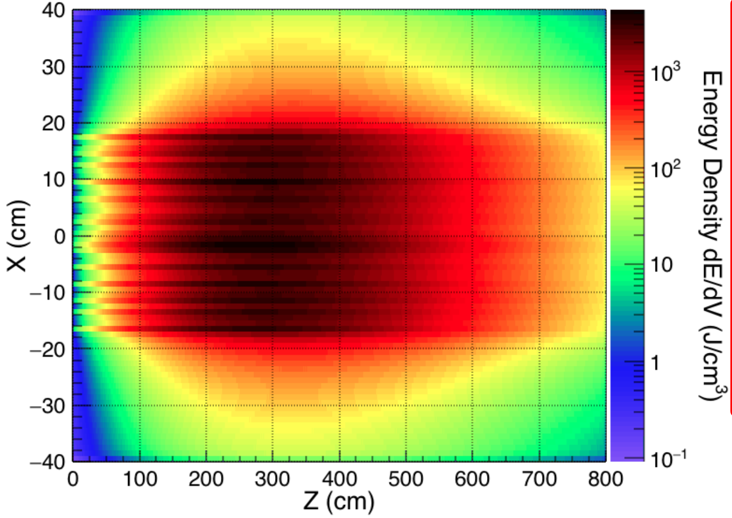
6m



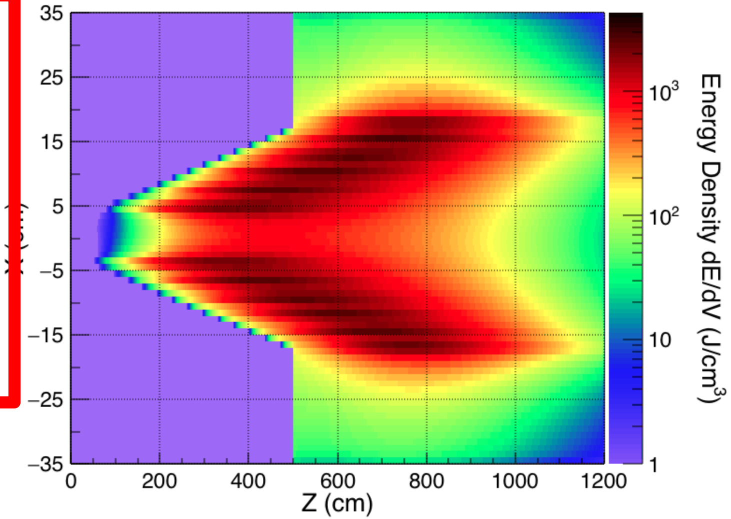
For the distorted absorbers the energy deposition is more deeply distributed.

This is the purpose of the added conical front part.

Maximum Energy Deposition in the Absorber



The maximum energy deposition density in the graphite is found to be:



~4.3 kJ/cm^3, which is equivalent to 2.6 kJ/g. The associated peak temperature rise in the unit volume is ΔT = 3400 ºC.

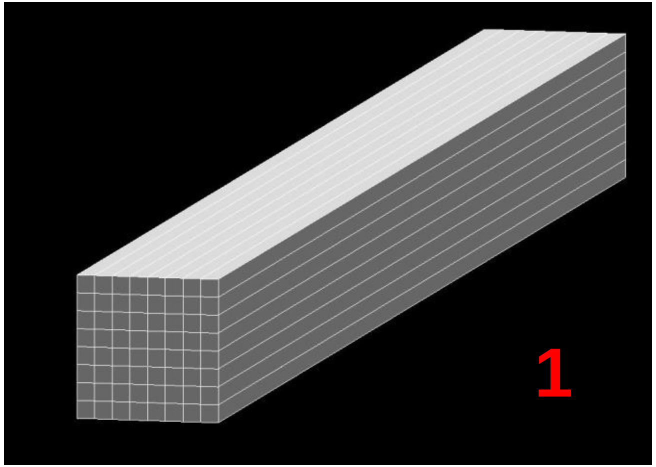
~3.01 kJ/cm^3 equivalent to 1.8 kJ/g. The associated peak temperature rise in the unit volume is ΔT = 2500 ºC.

Mosaic Beam Dump

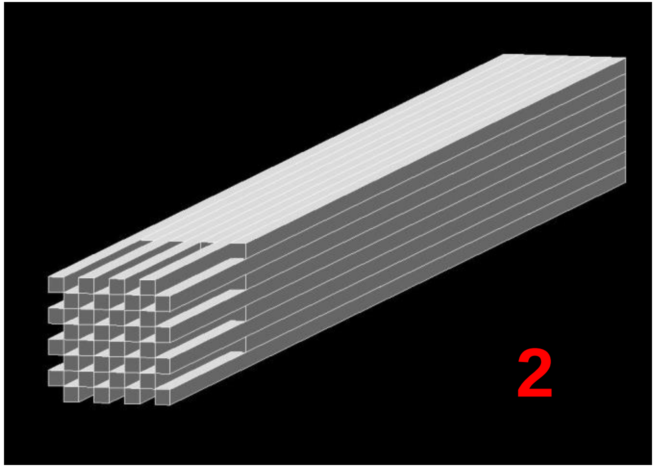
- **As another mitigation method, we considered mosaic beam dumps, e.g. composite dump blocks made from by sets of different materials.**
- **Such a mosaic beam dump can redistribute the deposited energy since the penetration depth of the energy deposition varies for different materials.**

We used blocks made by graphite with different densities, 1.7 g/cm^3 and 1.0 g/cm^3. The dimensions of blocks are 10x10x1000 cm, transversely in alternation, instead of a larger monolithic block from a single material.

Mosaic Beam Dump



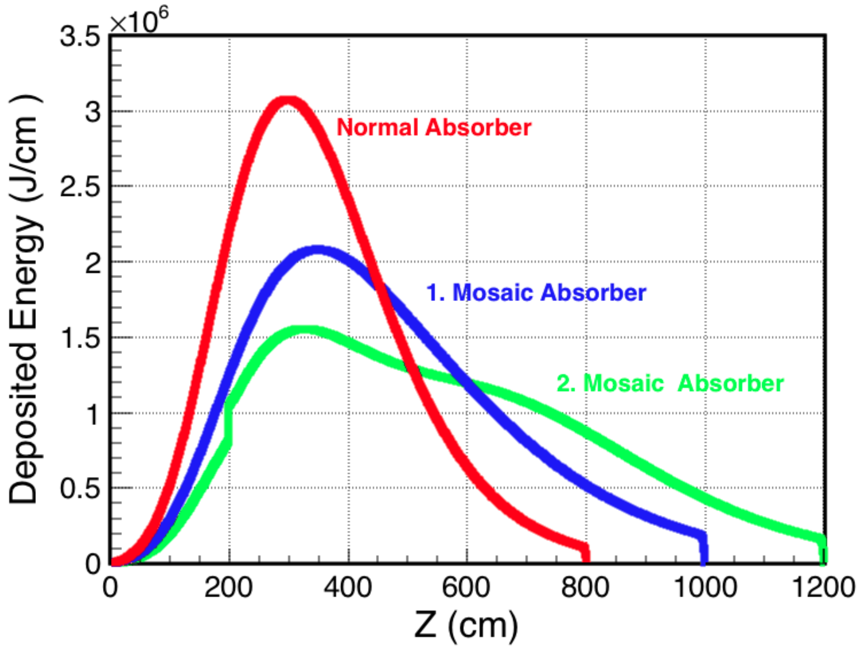
-35.0 1.0 35.0	-25.0 1.7 35.0	-15.0 1.0 35.0	-5.0 1.7 35.0	5.0 1.0 35.0	15.0 1.7 35.0	25.0 1.0 35.0	35.0 1.7 35.0
-35.0 1.7 25.0	-25.0 1.0 25.0	-15.0 1.7 25.0	-5.0 1.0 25.0	5.0 1.7 25.0	15.0 1.0 25.0	25.0 1.7 25.0	35.0 1.0 25.0
-35.0 1.0 15.0	-25.0 1.7 15.0	-15.0 1.0 15.0	-5.0 1.7 15.0	5.0 1.0 15.0	15.0 1.7 15.0	25.0 1.0 15.0	35.0 1.7 15.0
-35.0 1.7 5.0	-25.0 1.0 5.0	-15.0 1.7 5.0	-5.0 1.0 5.0	5.0 1.7 5.0	15.0 1.0 5.0	25.0 1.7 5.0	35.0 1.0 5.0
-35.0 1.0 -5.0	-25.0 1.7 -5.0	-15.0 1.0 -5.0	-5.0 1.7 -5.0	5.0 1.0 -5.0	15.0 1.7 -5.0	25.0 1.0 -5.0	35.0 1.7 -5.0
-35.0 1.7 -15.0	-25.0 1.0 -15.0	-15.0 1.7 -15.0	-5.0 1.0 -15.0	5.0 1.7 -15.0	15.0 1.0 -15.0	25.0 1.7 -15.0	35.0 1.0 -15.0
-35.0 1.0 -25.0	-25.0 1.7 -25.0	-15.0 1.0 -25.0	-5.0 1.7 -25.0	5.0 1.0 -25.0	15.0 1.7 -25.0	25.0 1.0 -25.0	35.0 1.7 -25.0
-35.0 1.7 -35.0	-25.0 1.0 -35.0	-15.0 1.7 -35.0	-5.0 1.0 -35.0	5.0 1.7 -35.0	15.0 1.0 -35.0	25.0 1.7 -35.0	35.0 1.0 -35.0



Front surface of the absorber consists of 64 cells made by Graphite with different densities.

1. **10x10x1000cm for 1.7g/cm^3 and 1.0g/cm^3**
2. **10x10x1200cm for 1.7g/cm^3 and 10x10x1000cm for 1.0g/cm^3**

Longitudinal Distribution of Energy Deposition in Mosaic Beam Dump

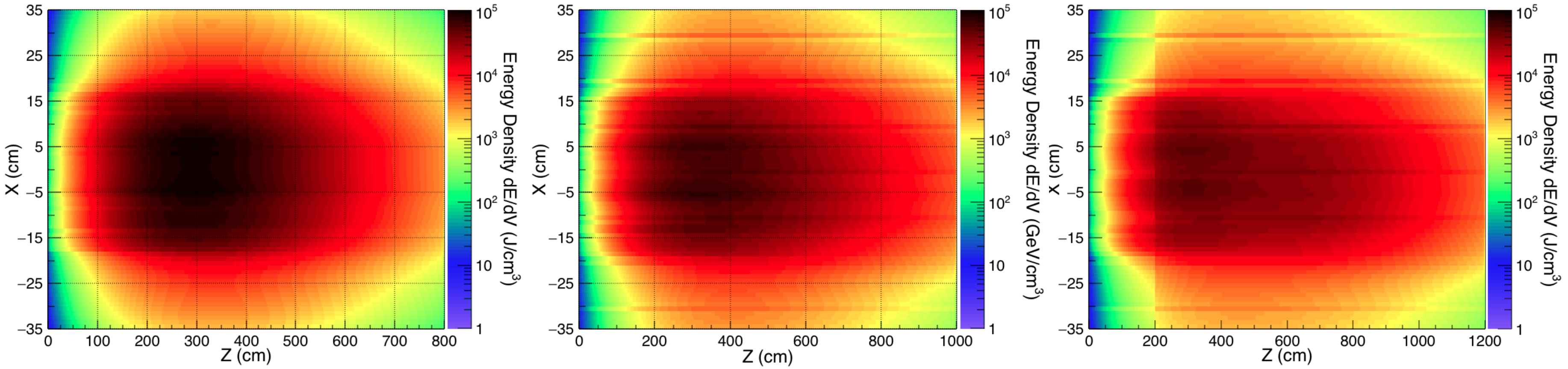


Area under plots

- 1.05551e+09
- 1.01318e+09
- 1.00058e+09

Compared with normal absorber, the energy deposition peak is shifted towards a larger distance from the surface (blue) or has two peaks (green).

Energy Deposition in the Mosaic Absorber



Compared with normal shape absorber, the energy deposition peak is shifted towards a larger distance from the surface, since the interleaved low density subblocks have large penetration depth.

Summary

This was an attempt to reduce dilution kickers requirements: kick strength, frequency …

Two types of dilution system:

- **Active dilution – using dilution kickers to spread bunches in transverse direction**
- **Passive dilution – using distorted or/and mosaic absorber to spread bunches in longitudinal direction**

Summary

- **MC simulations illustrate that both distorted and multi-material mosaic absorbers are promising devices for the future high energy and intensity colliders.**
- **Effective would be a combination of the two concepts, namely a distorted mosaic beam dump.**

Future studies:

- **Study the mechanical design and the feasibility of such types of absorbers**
- **Feasibility of the concepts in case of dilution failure.**
- **Feasibility of the concept in case of beams transverse offset.**

Summary

Thank you for your attention