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MARS LBNF Beamline Model

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Meeting Title

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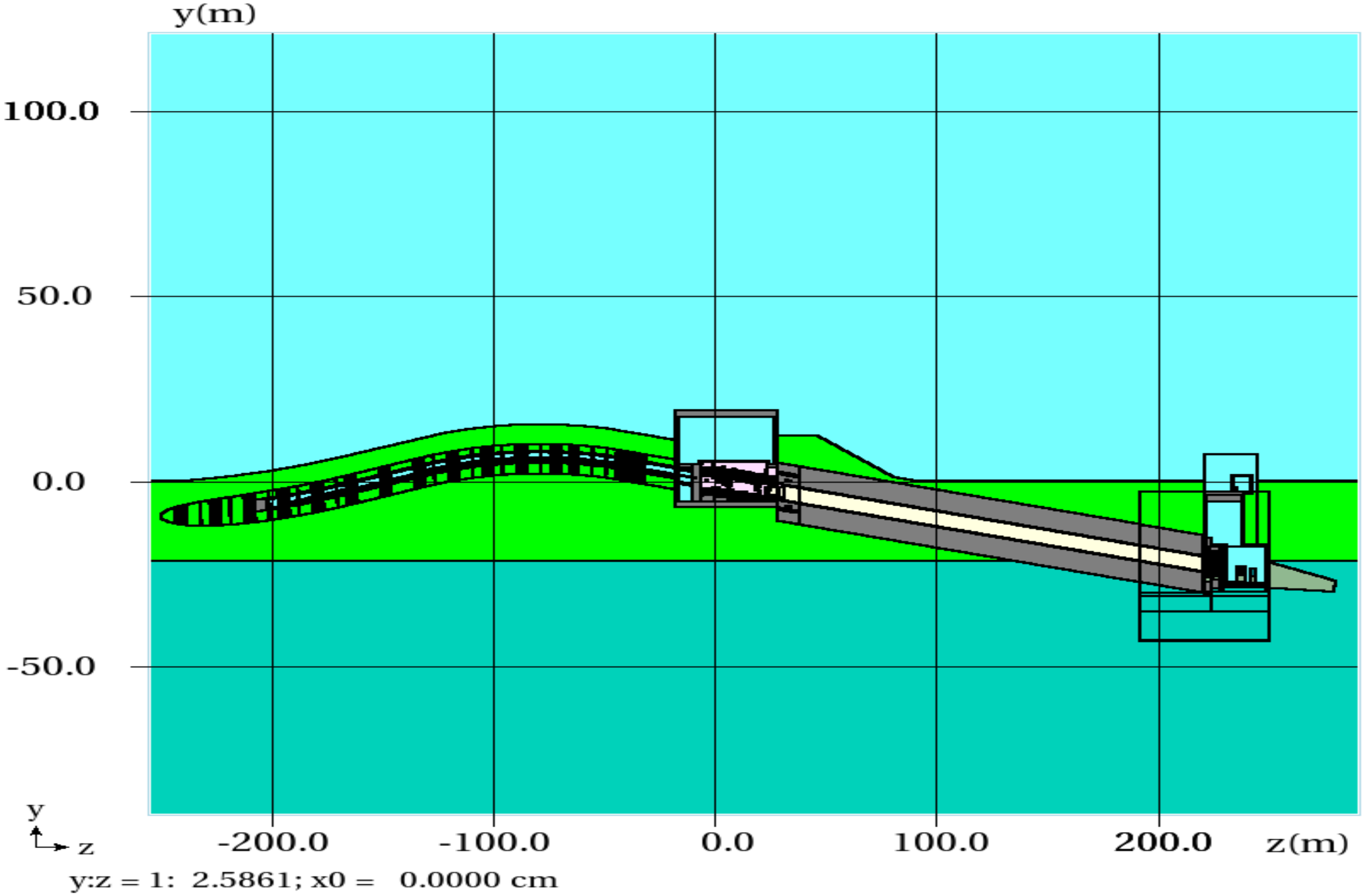
MARS Introduction

- MARS simulation code is primarily used for radiation studies at Fermilab.
  - Tabulates particle fluxes, energy deposition, direct dose, residual dose, inelastic interactions, nuclide production, etc.
  - Default outputs are either 2D histograms or table of average values in a volume.
    - User can define other forms of output.
- Multiple methods for defining geometry.
  - Native, ROOT, Fluka, MCNP, MAD.
    - ROOT geometry allows for import and export between different platforms that also use ROOT geometry.
      - GDML import/export not currently supported.
    - Fluka, MCNP, MAD import only.

MARS LBNF Model

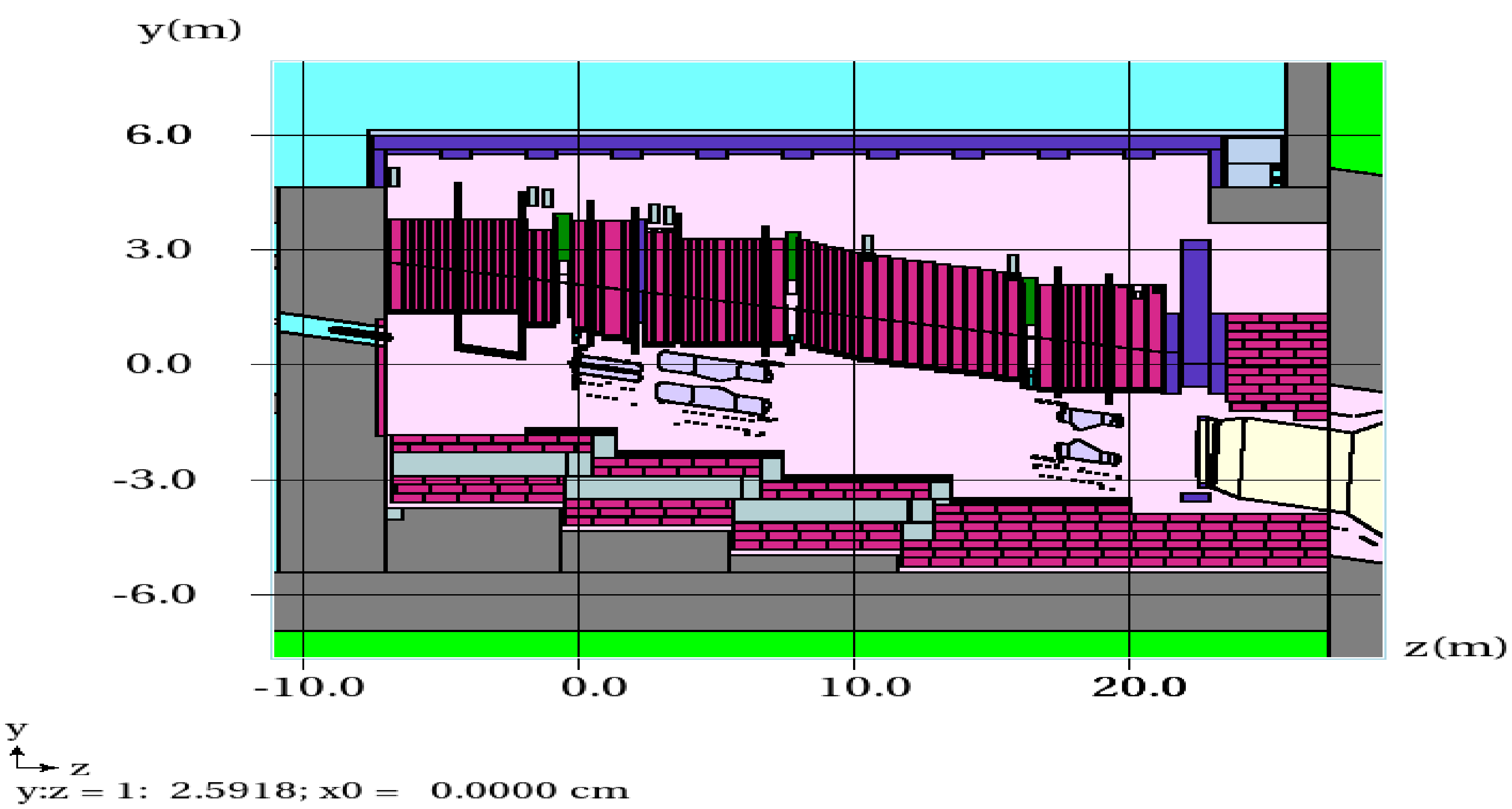
- Model of LBNF beam line geometry described with ROOT.
- Model contains the primary beamline, target station, target hall and support rooms, decay pipe, and absorber hall.
- Target hall, support rooms, primary beamline and absorber complex are all self contained and can be modified independently from each other.
- MADX used to define the primary beamline.
- Details such as shielding, cracks in shielding, water lines, helium lines, and penetrations are included as they are important in radiation calculations.



Combined MARS model of the LBNF beamline

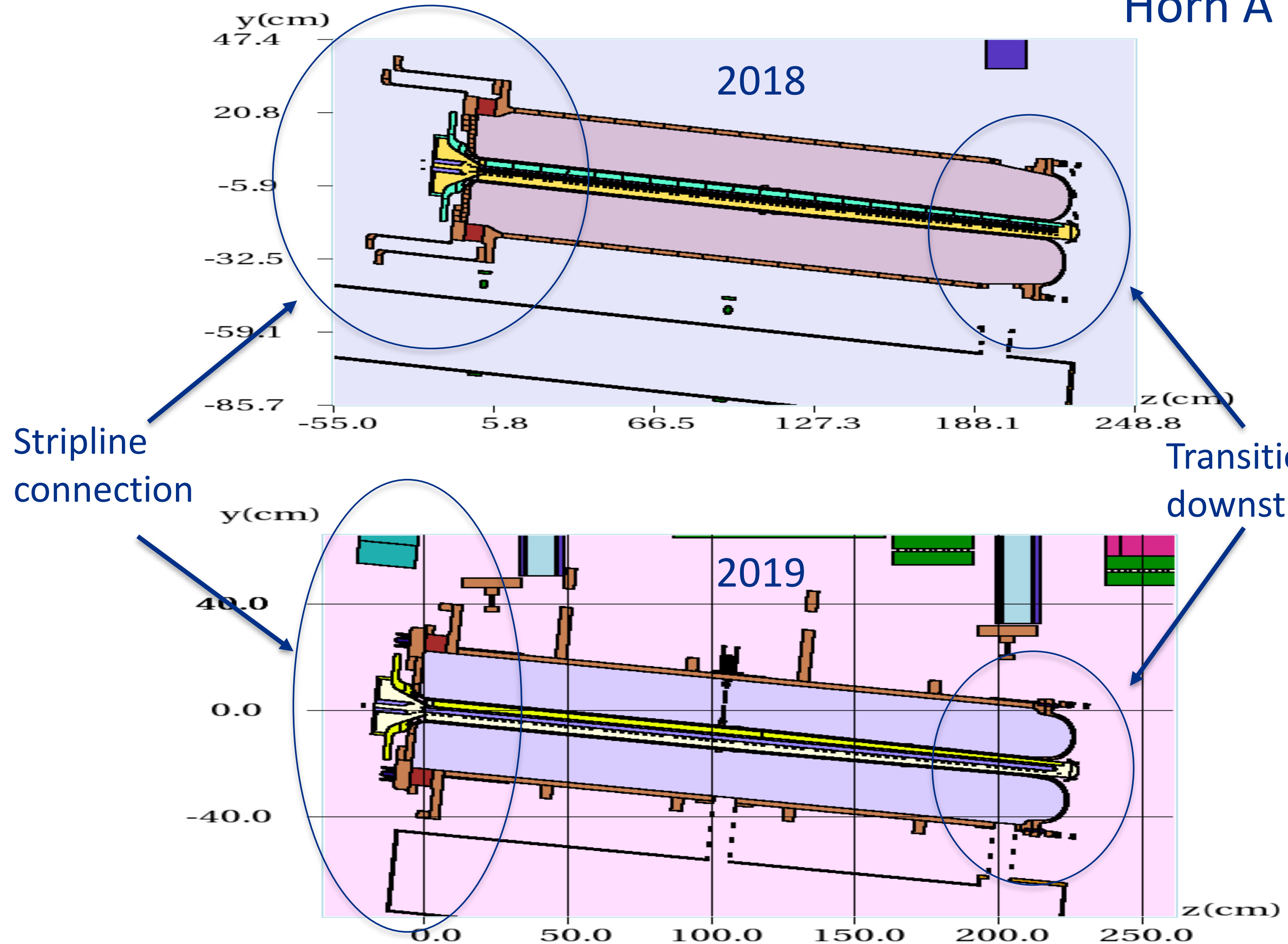
Potential Differences between MARS and GEANT

- Horn A
  - Modifications to outer conductor, stripline.
  - Hanger.
  - New water tank.
- Horn B
  - Shorter equalization section
- Upstream decay pipe window
  - Change in radius of curvature
  - Location of window.
- Absorber
  - Now using uniform absorber

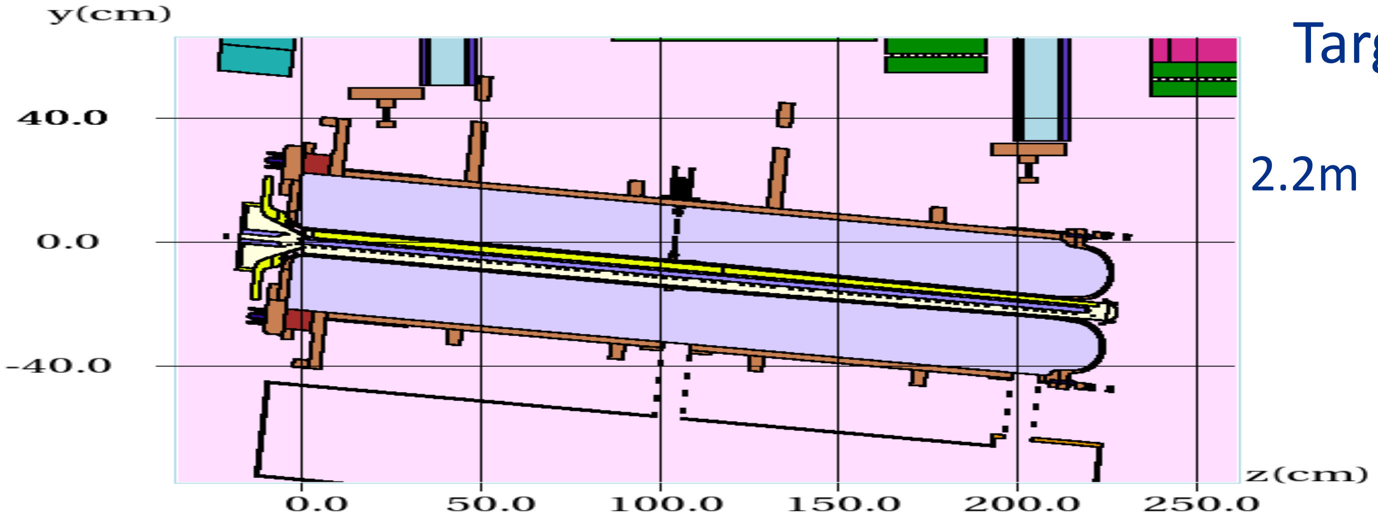


Target station details.

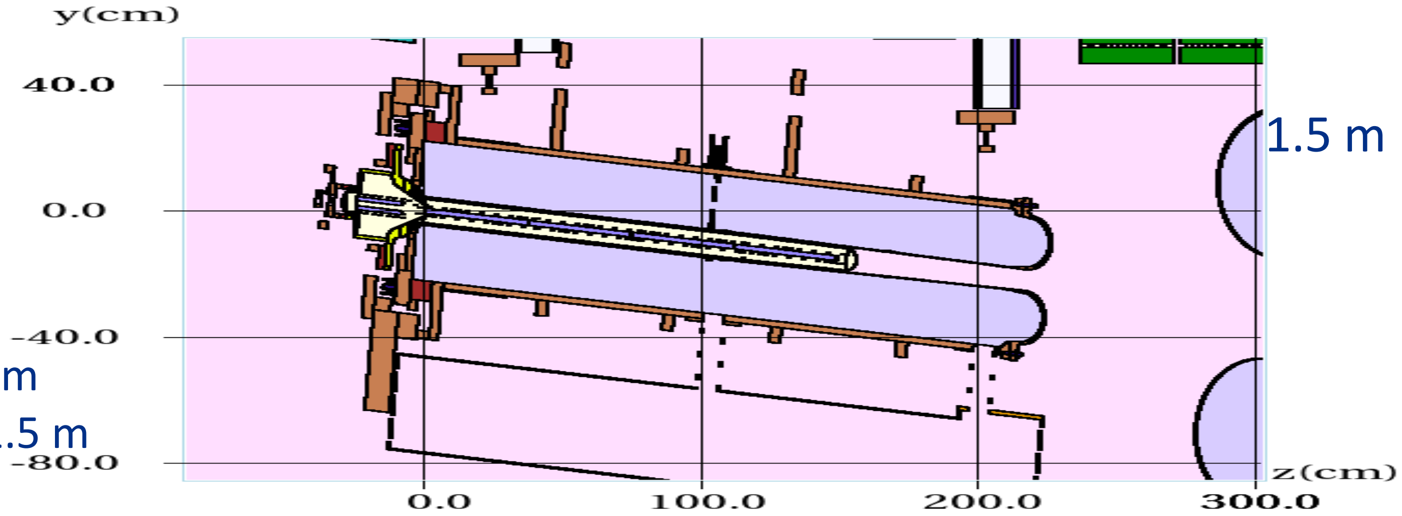
Horn A Evolution



Targets



2.2m



1.5 m

More upstream detail in the 1.5 m target

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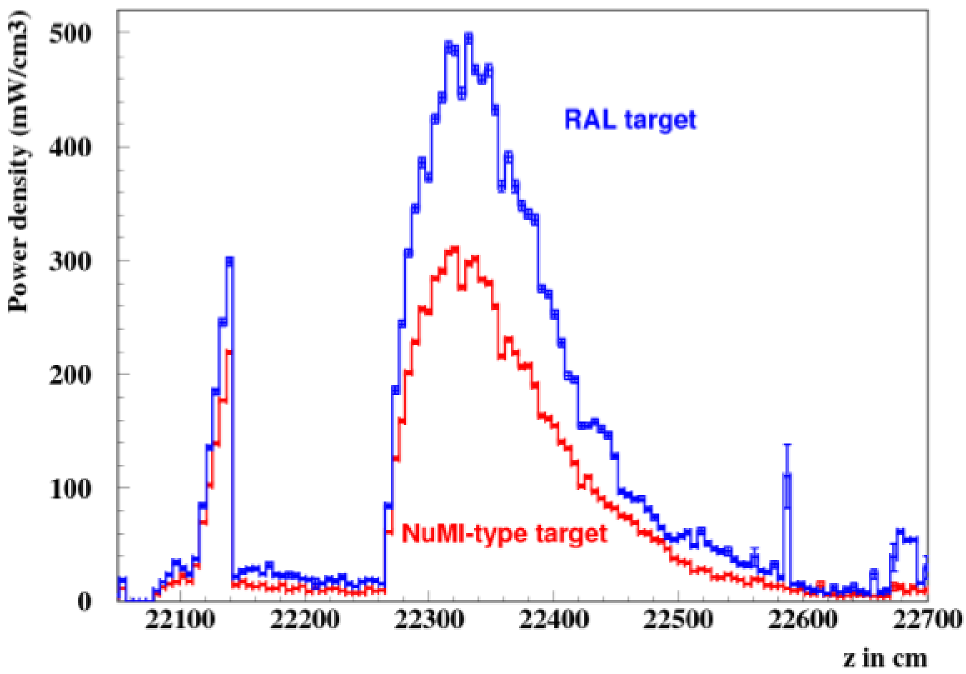
EDEP (mW/cm³) in Uniform Hadron Absorber (UHA)

2-m NuMI-type target vs 2.2-m RAL target



Tolerable temperature in UHA aluminum core < 100 degrees C.

MARS-ANSYS calculation with NuMI-type target predicts that maximal temperature in the core is 35 degrees C for 10-degree water.

Maximal temperature could reach ~60 degrees C for 2.2-m RAL target (still some safety margin).

It was shown that increasing bafflet length from 12 to 18 cm could reduce peak energy deposition to the NuMI-type target level.

Same effect could be achieved by replacement the bafflet and bafflet support by a 18 cm insert into baffle.

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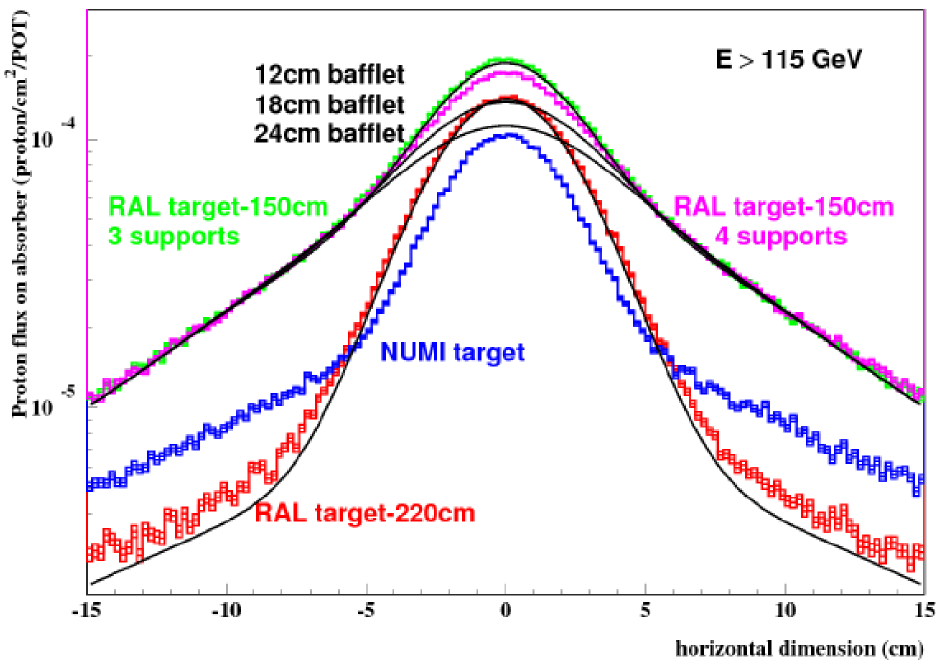
High-Energy Proton Flux in UHA

2-m NuMI-type target vs 1.5-m RAL target

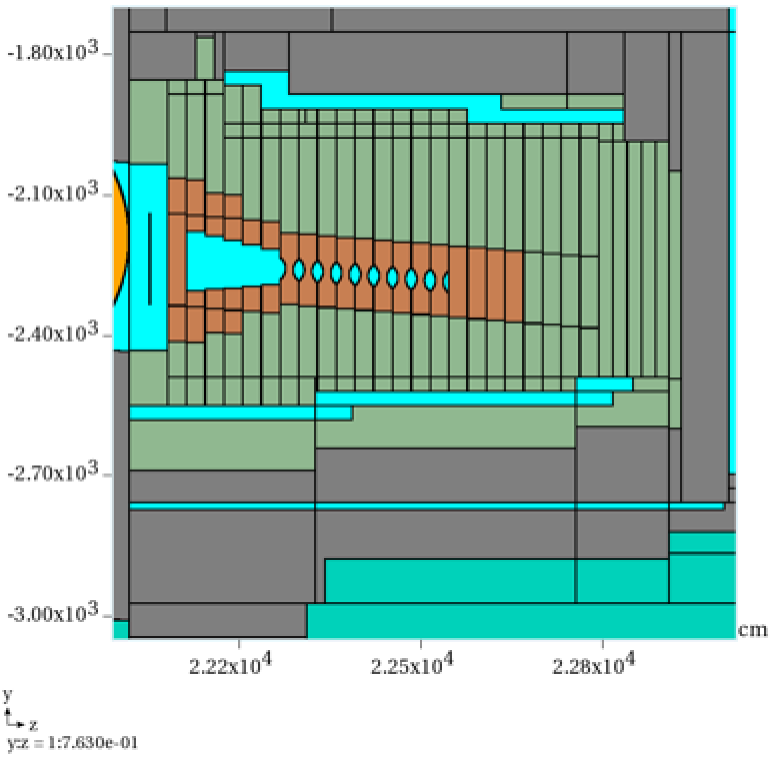


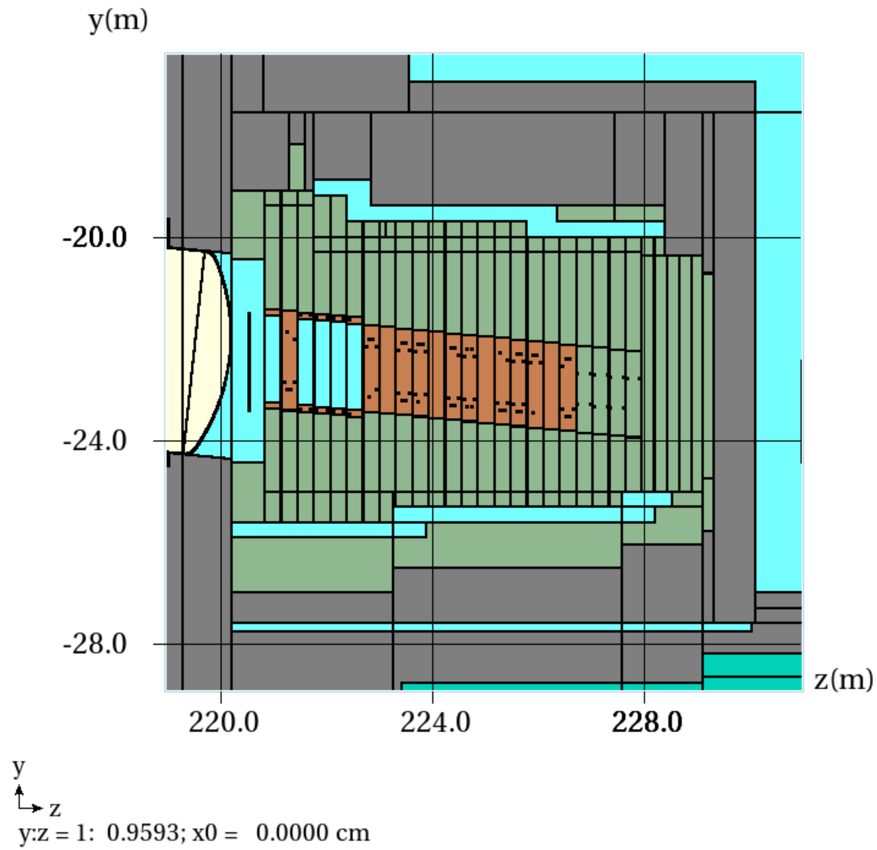
Peak energy deposition in hadron absorber is defined by the coming high-energy proton flux.

Simple Monte Carlo and analytical model calculations of proton flux are in close agreement with full MARSLBNF.

Simple model predicts that peak energy deposition in UHA for 1.5-m RAL target with 18 cm bafflet is the same as for 2.2-m RAL target with a 12 cm bafflet. Increasing bafflet length to 24 cm could reduce peak energy deposition in UHA to the NuMI-type target level.

Note, that 1.5-m target design has some features which were not included yet in the analytical model.





Reference Hadron Absorber. Non-uniform sculpting designed for 1 m target.

Uniform Hadron Aborber. Uniform blocks designed for 2 m target.

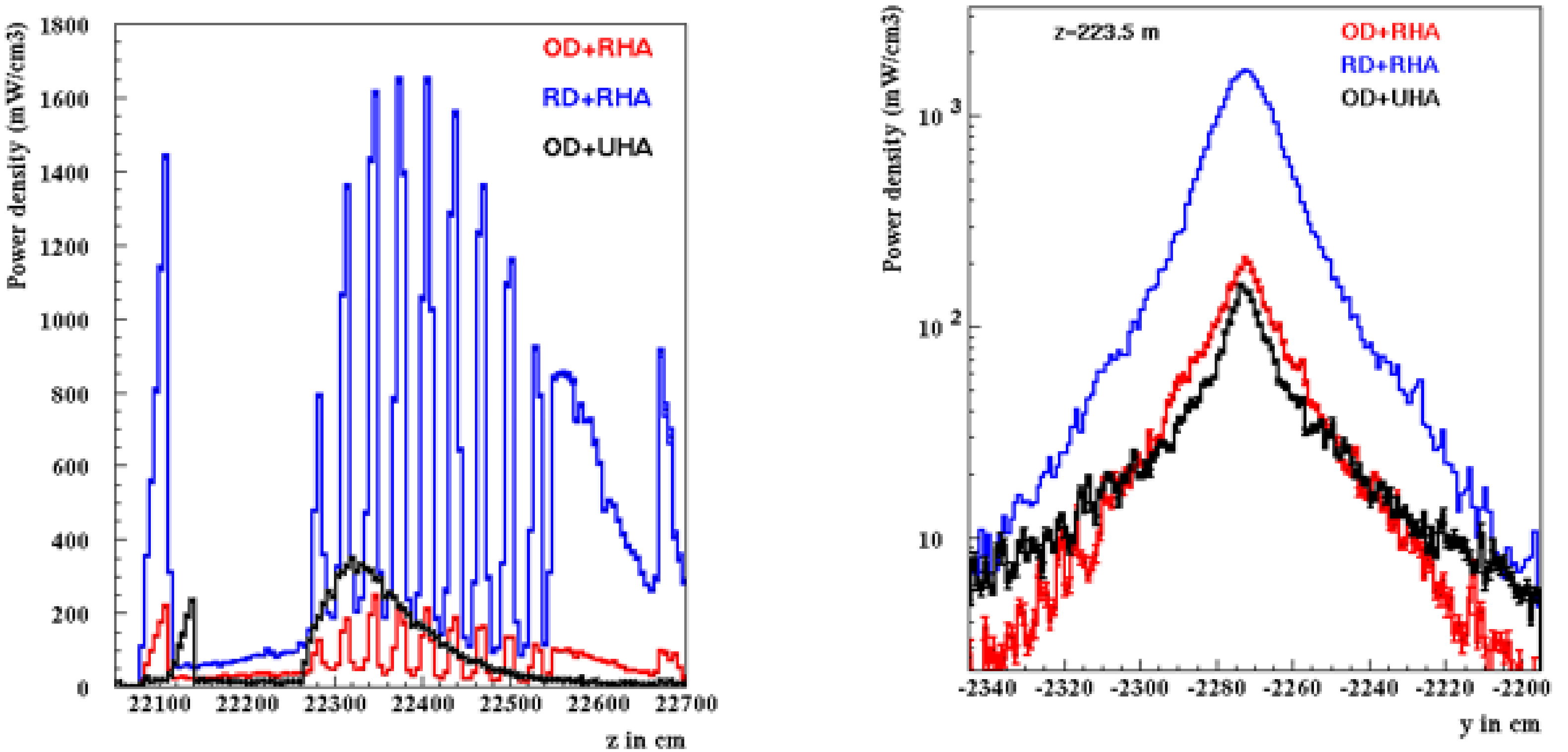


Fig. 2. Energy depositions in reference hadronic absorber (RHA) for reference (RD) and optimized (OD) design and uniform hadronic absorber (UHA) for optimized design. Left: distributions along the beam. Right – distribution in the vertical direction at a cascade maximum.

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Four Water Circuits at 20 to 30 cm from Beam Axis

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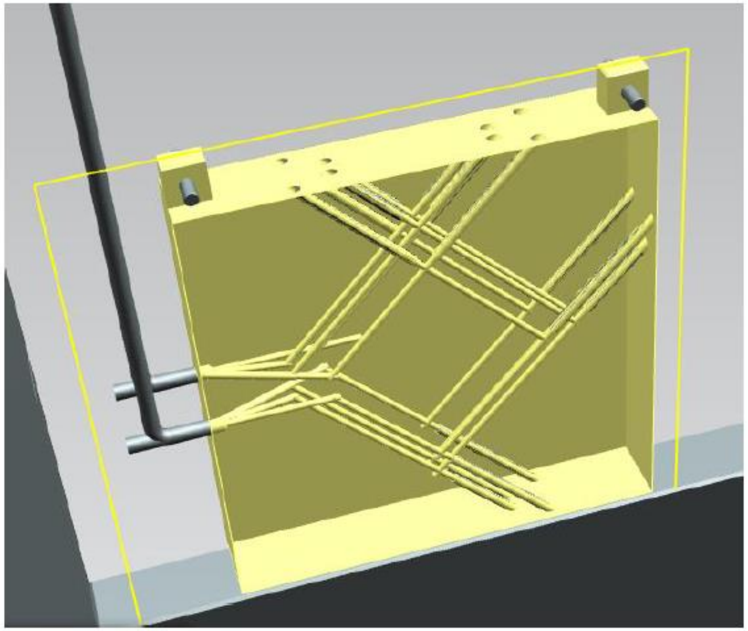

MARS model