Impact of a 120-GeV on-target and off-target Beams on the LBNF Hadron Absorber

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BSM meeting

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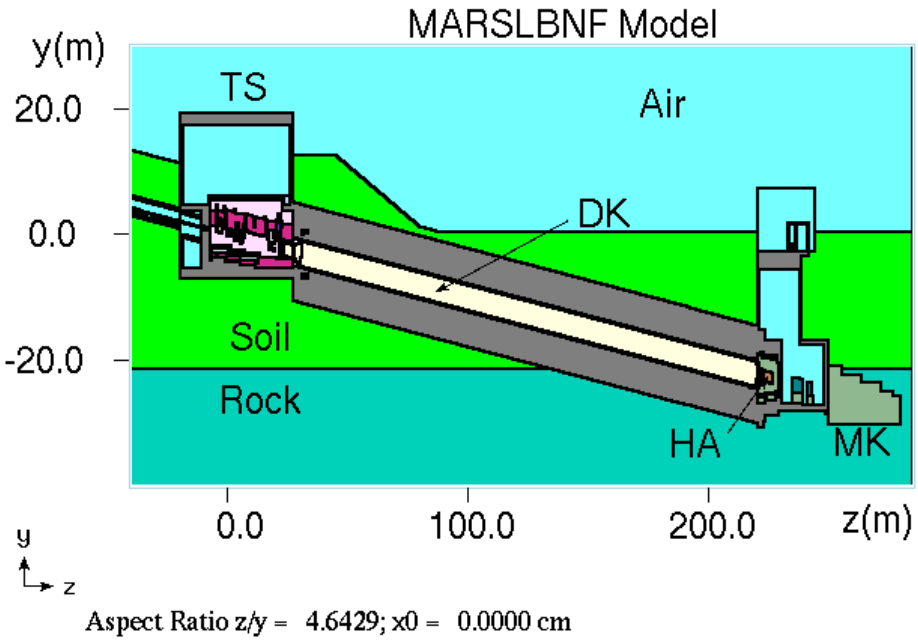
Outline

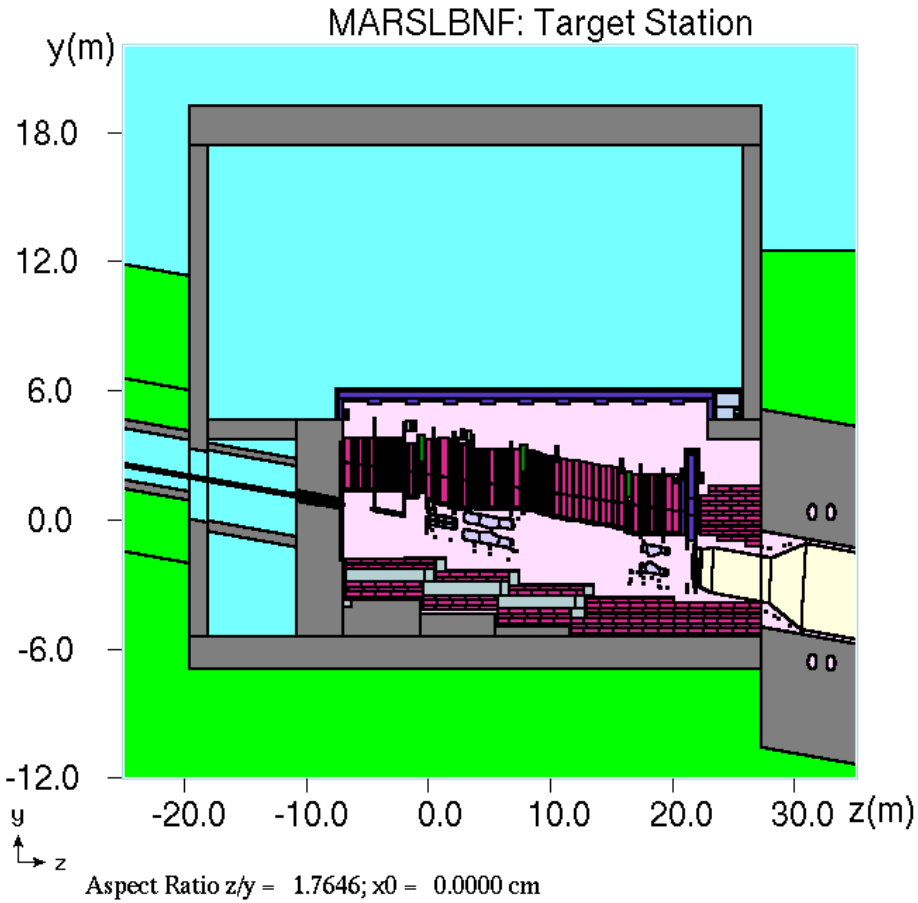
- MARSLBNF Model
- Nominal Operation
- Off-target Beam on Hadron Absorber

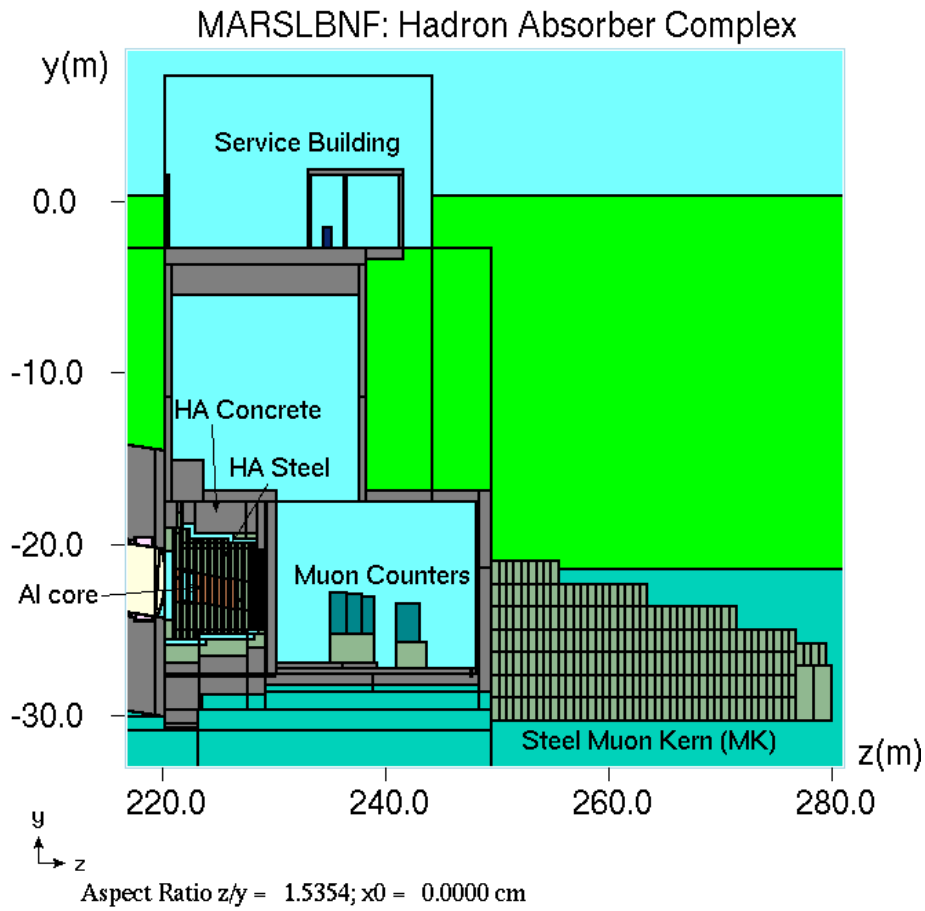
MARSLBNF Model with MARS15-2019 Code

- Beamline from Main Injector, Target Station (TS), Decay Channel (DK), Hadron Absorber (HA) Complex, Muon Kern (MK) and Near Detector (ND)
- **Nominal operation**: 120 GeV proton beam @ 2.4 MW on target
- **Off-target beam:** 120 GeV protons @ 2.88 MJ (=1.5e14ppp) hitting the US and DS windows, hadron monitor, spoiler and the HA core with 1.2 s between pulses



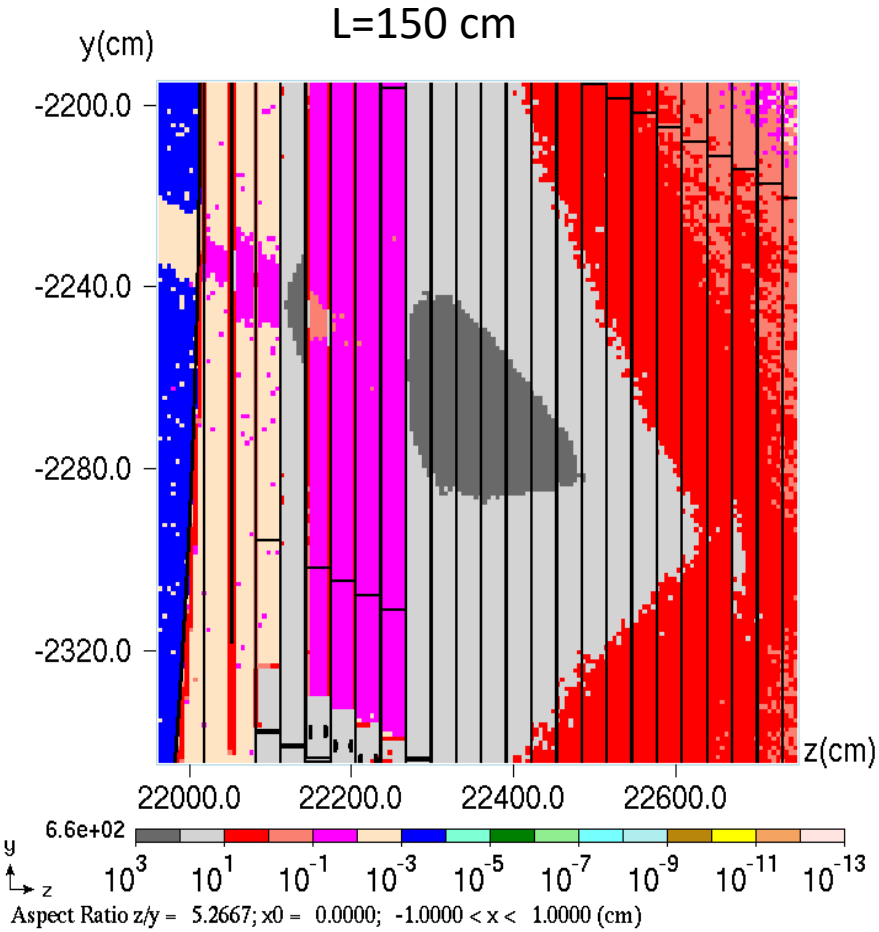
MARSLBNF: Target Station and Hadron Absorber Complex

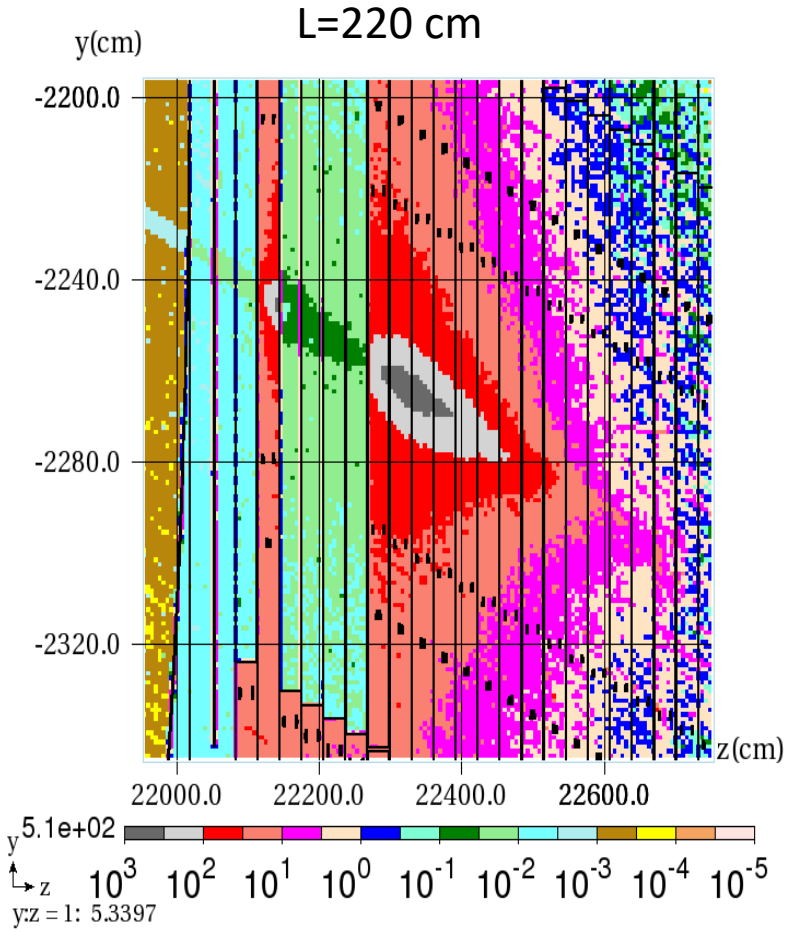




Nominal operation

EDEP Density (mW/cm³) in Hadron Absorber *vs* RAL Target Length

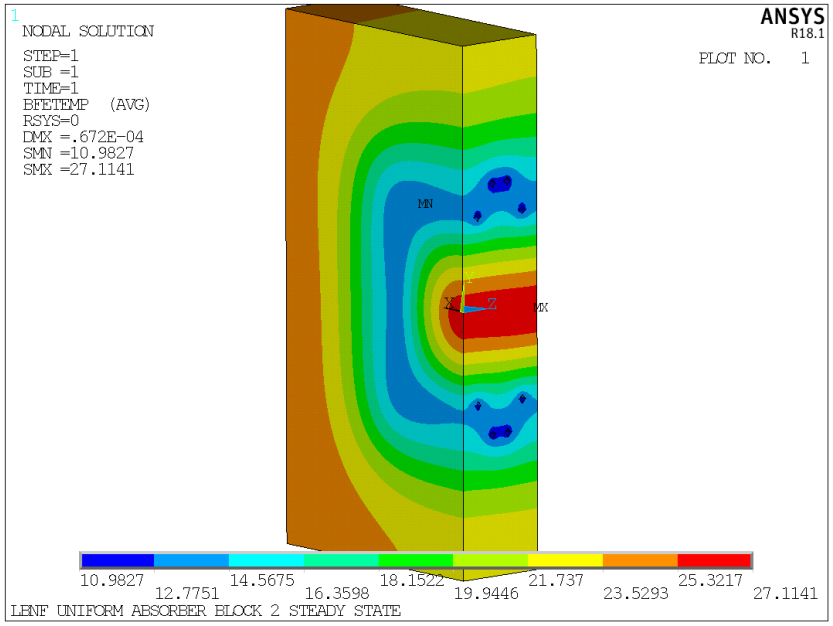




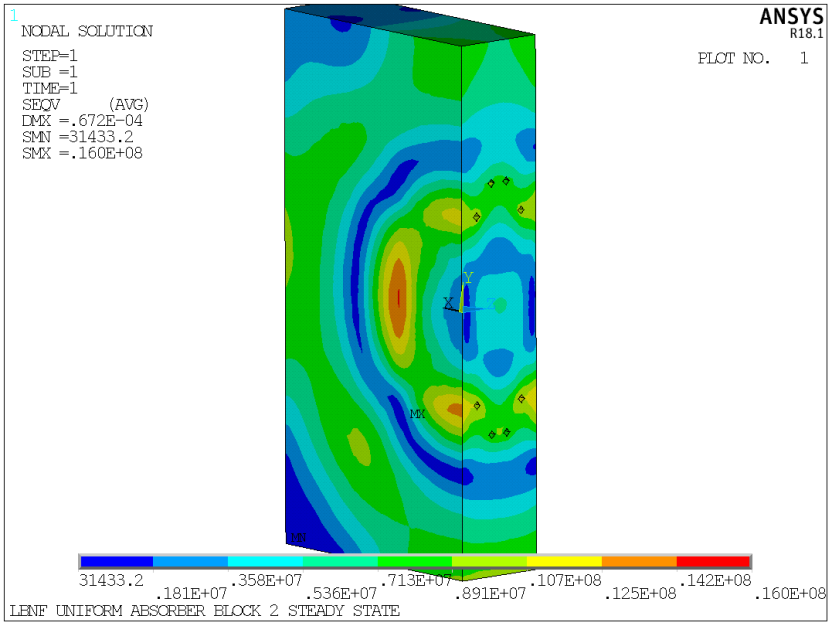
Nominal operation

Temperature and Stress in HA 2nd Al Core Block

Temperature – 27 C Max



Stress – 16 MPa Max



+ Radiation Damage

Nominal operation

LBNF Power Dissipation and Balance

System	kW
Target Station	1132*
Decay Channel	553**
Hadron Absorber Complex	524
Neutrino power generated	45
Others	146
Total	**2400**

*) Target itself: 54 kW

**) Double-walled steel decay pipe: 341 kW

Nominal operation

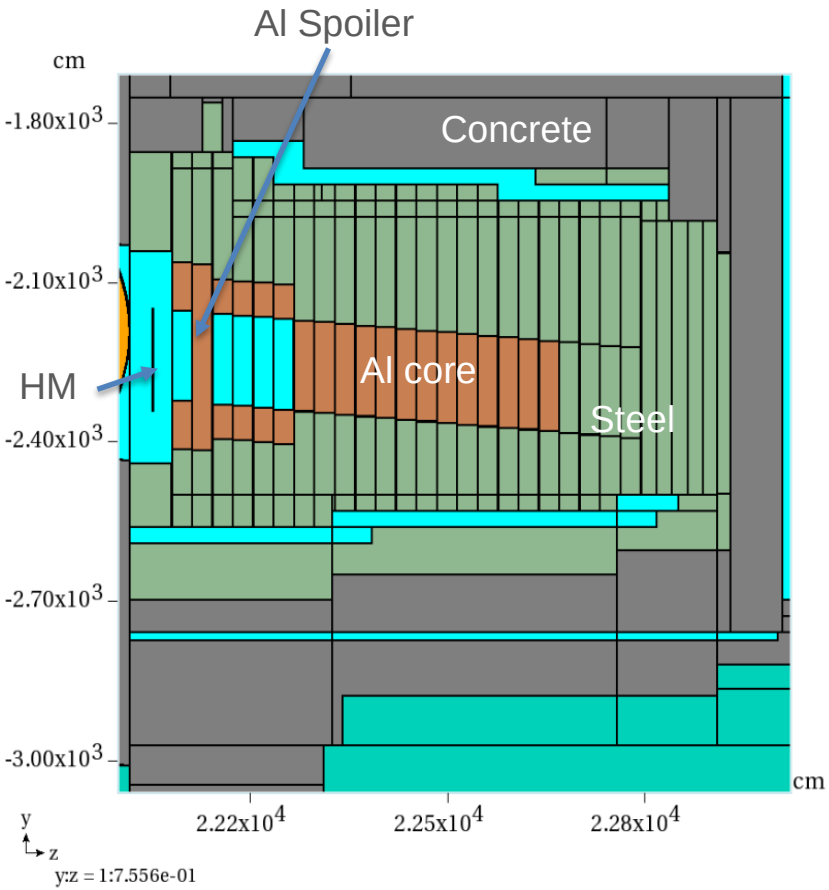
Power Dissipation in Hadron Absorber Complex

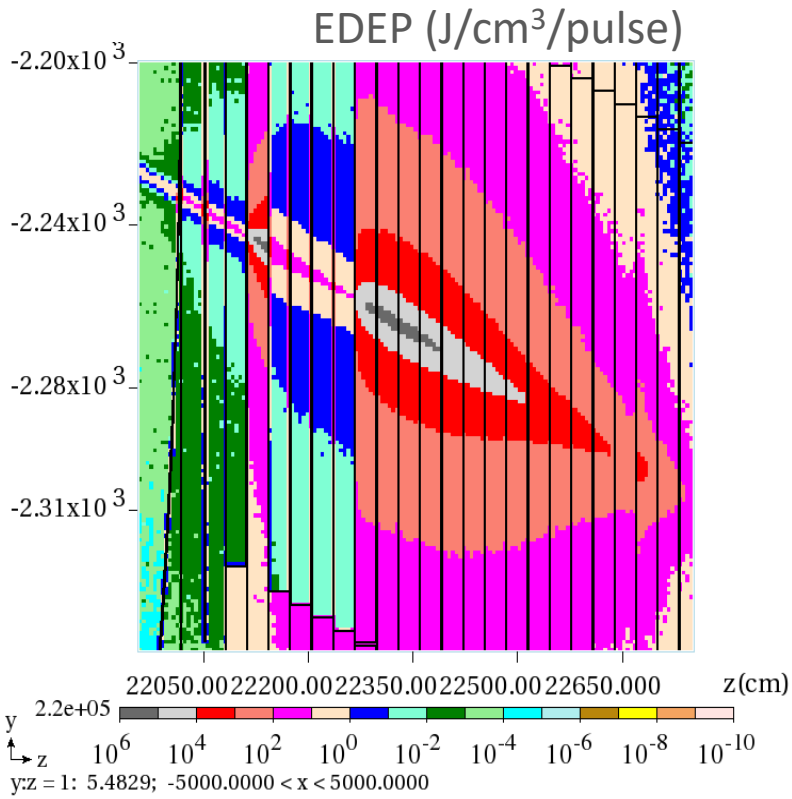
Component	kW
Stainless-steel DS window and frame	2.5
Aluminum spoiler and core	228.7
Absorber steel	244
Concrete	3
HA hall	41
Muon kern	1.14
Miscellaneous*	3.66
Total	**524**

*) Air, infrastructure, rock, soil, nucleon binding energy, sub-threshold particles

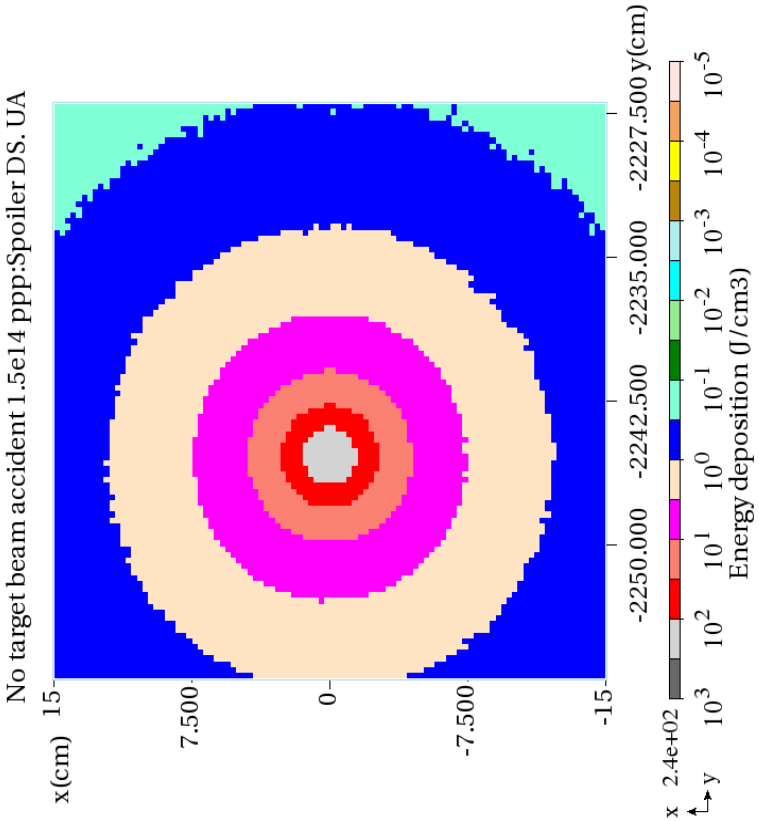
Off-target Beam on Hadron Absorber

For the 20 π mm-mrad emittance, the off-target proton beam has the minimal spot size at the hadron absorber for σ = 2.4 mm at MCZERO compared to the default operational σ = 1.7 mm.





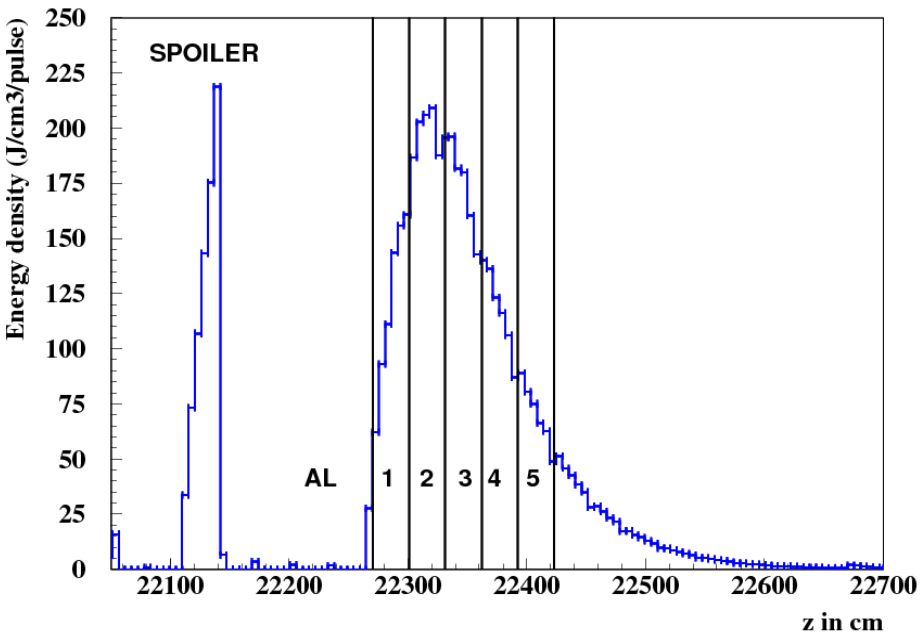
EDEP(J/cm^3/pulse) in Hadron Absorber at the Downstream End of Spoiler

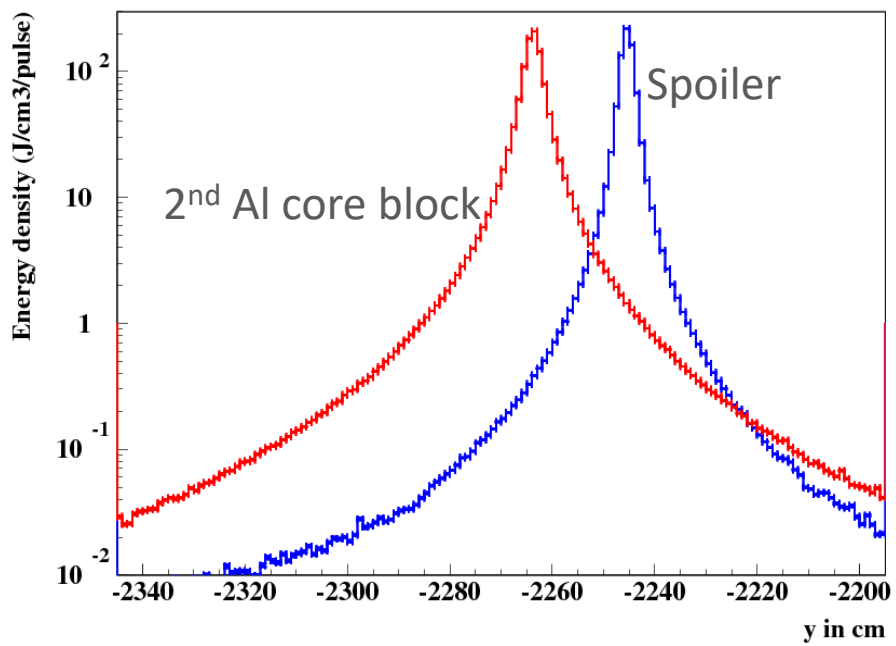


1. Peak EDEP ~ Nppp and roughly ~1/σ^2
2. HA is designed to withstand up to two consecutive 2.88-MJ beam pulses

EDEP Density (J/cm^3/pulse) for Off-target Beam on Hadron Absorber

Longitudinal EDEP density (J/cm^3/pulse) in HA along the beam axis (left) and in the vertical plane (right) for the spoiler downstream end and second Aluminum core block.



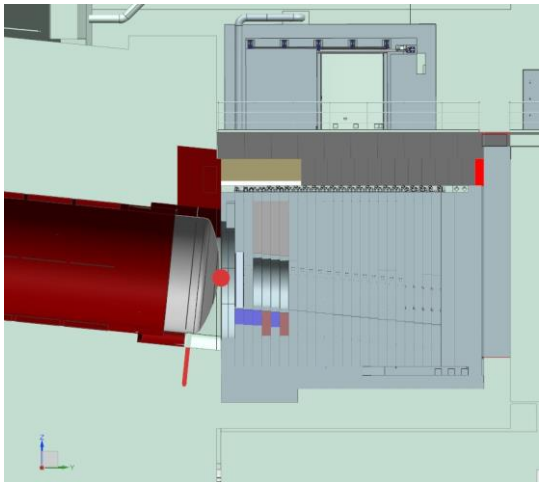


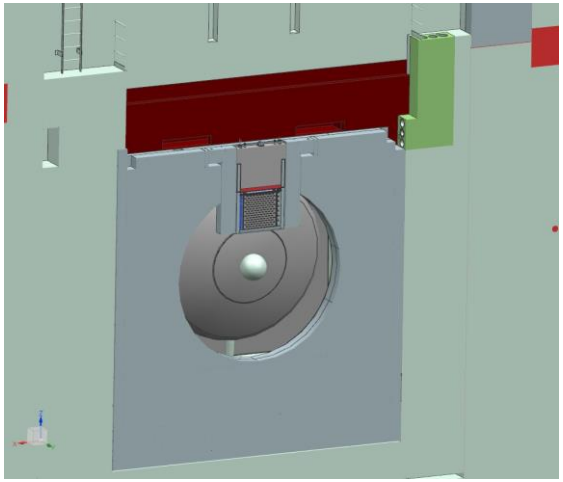
EDEP in HA for 2.88-MJ off-target Beam

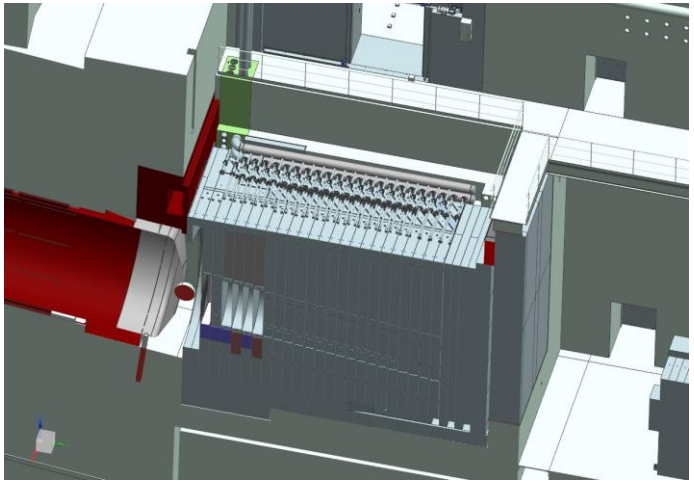
HA Component	EDEP (MJ/pulse)
Al central	2.366
Steel core	0.022
Steel others	0.075
Concrete	0.007
Minor components	0.009
Total	2.479

1. 86% of beam power captured by the HA complex components
2. 10% of beam protons are lost in nuclear interactions with helium in DK, nitrogen in the target hall, US and DS windows, and hadronic monitor
3. 2% of beam energy go to neutrino production
4. 2% miscellaneous

Details of the current CAD Model being Implemented to the MARS Geometry Model







Courtesy Matt Sawtell