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Mercury Beam Dump Simulations

Tristan Davenne Ottone Caretta
STFC Rutherford Appleton Laboratory, UK

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Mercury beam dump design from NUFACT Feasibility Study

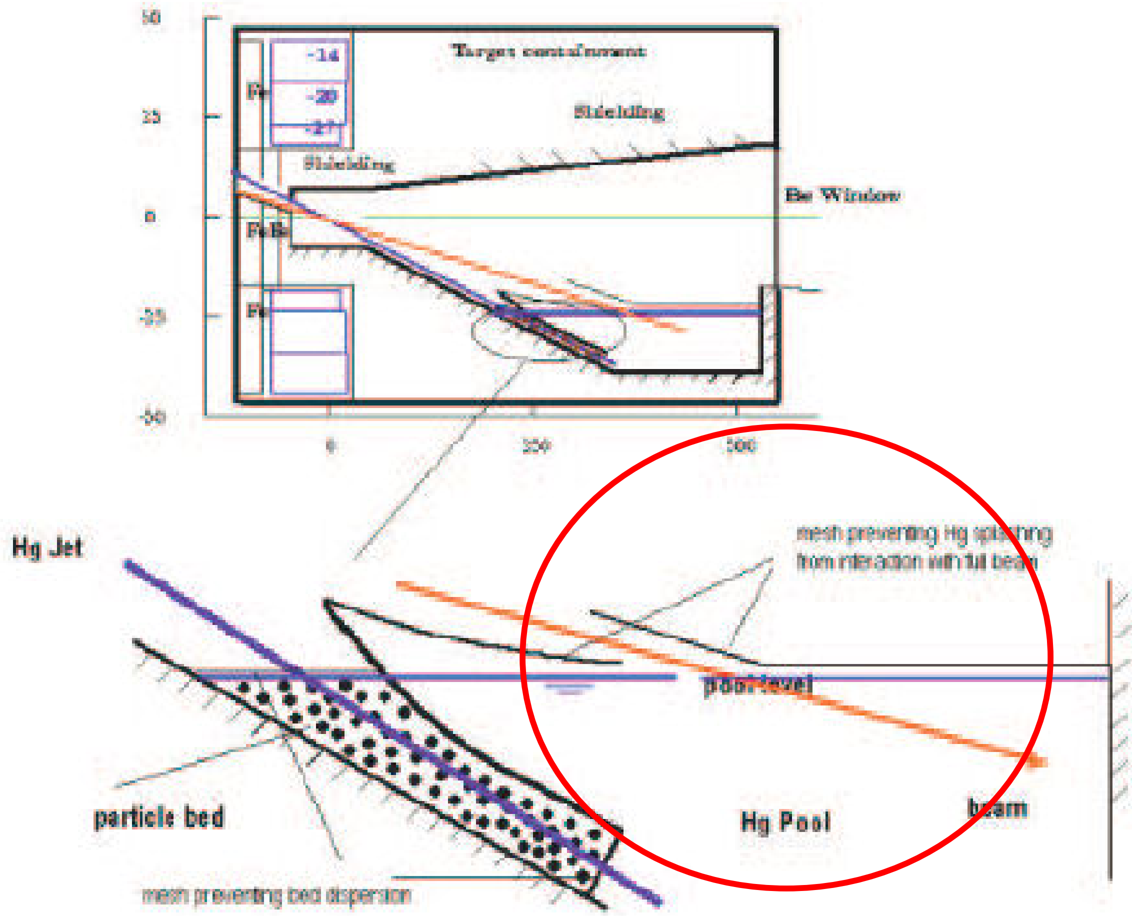

Figure 3.36: Schematic of the mercury pool that serves as the proton beam absorber.

Mercury beam dump design from NUFACT Feasibility Study

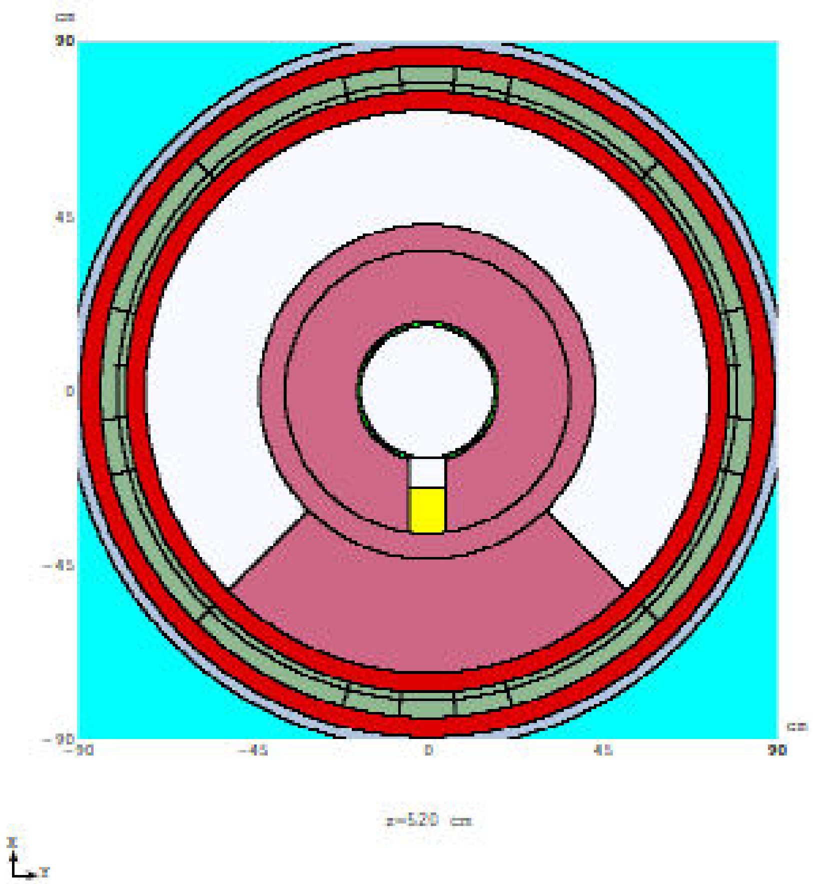

Figure 3.13: Transverse section of the target system at $z = 5.2$ m, showing the mercury pool that serves as the proton beam absorber.

Thermal shocks and magnetohydrodynamics in high power mercury jet targets

J Lettry, A Fabich, S Gilardoni, M Benedikt, M Farhat and E Robert

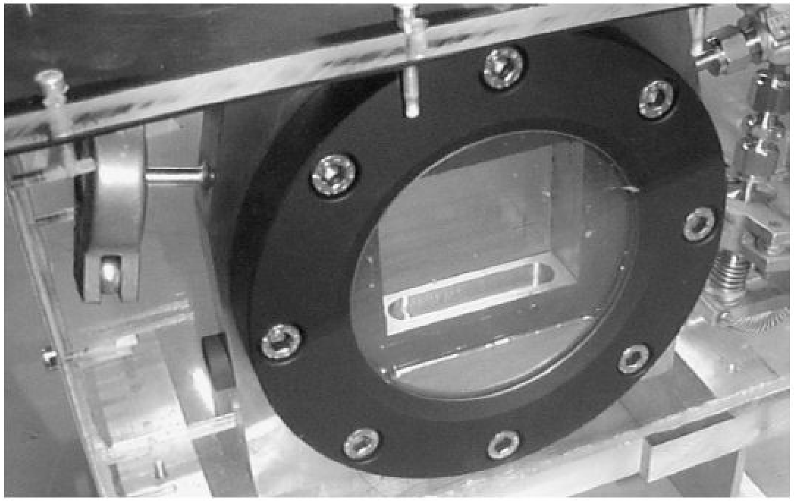

Figure 1. *Trough target. The trough is excavated in a steel frame, with the viewing windows on both sides. The steel frame is placed in a second confinement.*

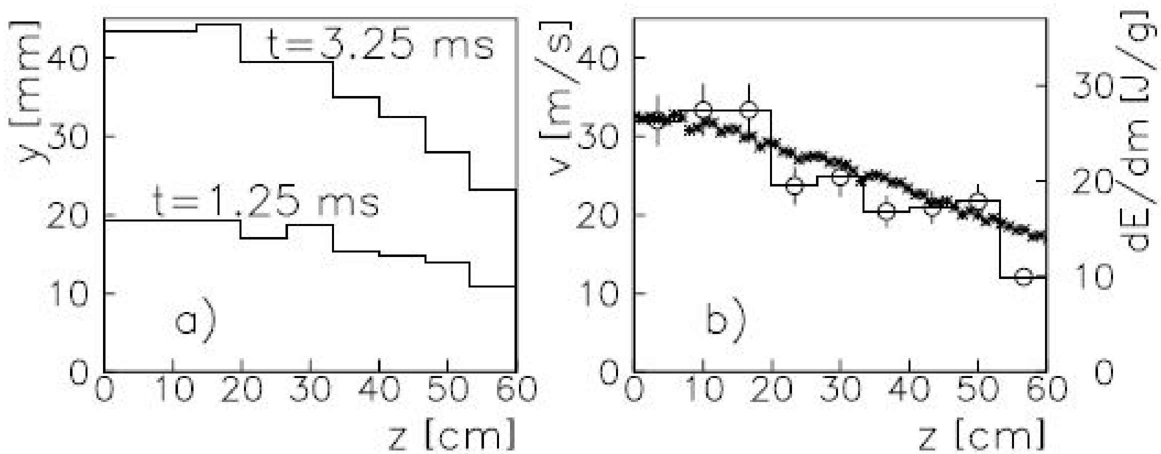

Figure 2. Reaction of $\approx 7\,\mathrm{cm}^3$ mercury contained in a 60 mm long stainless steel trough irradiated with a proton pulse of $20\mathrm{x}10^{12}$ 1 GeV protons. a) The height of the Hg-droplets obtained by image processing is averaged over ≈ 7 mm sections, 1.25 and 3.25 ms after proton impact. b) The computed [8, 9] energy deposition (asterisk) on beam axis of the proton pulse is compared to the initial velocities of the Hg-droplets (open circles). The predicted proportionality of the initial velocity to the temperature elevation is confirmed within the precision of the measurement.

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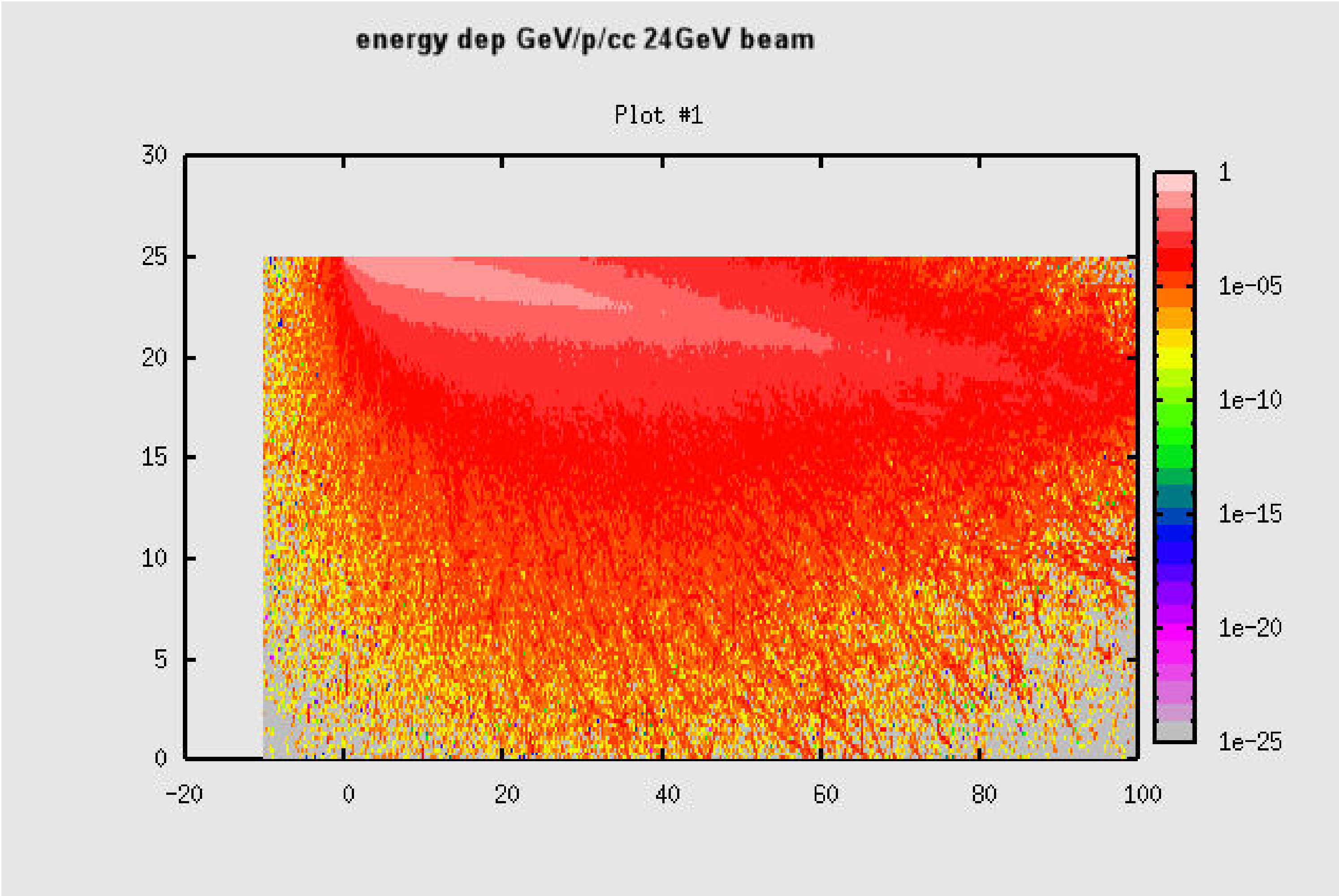
Fluka Simulation - Energy deposition in mercury pool with 24GeV beam

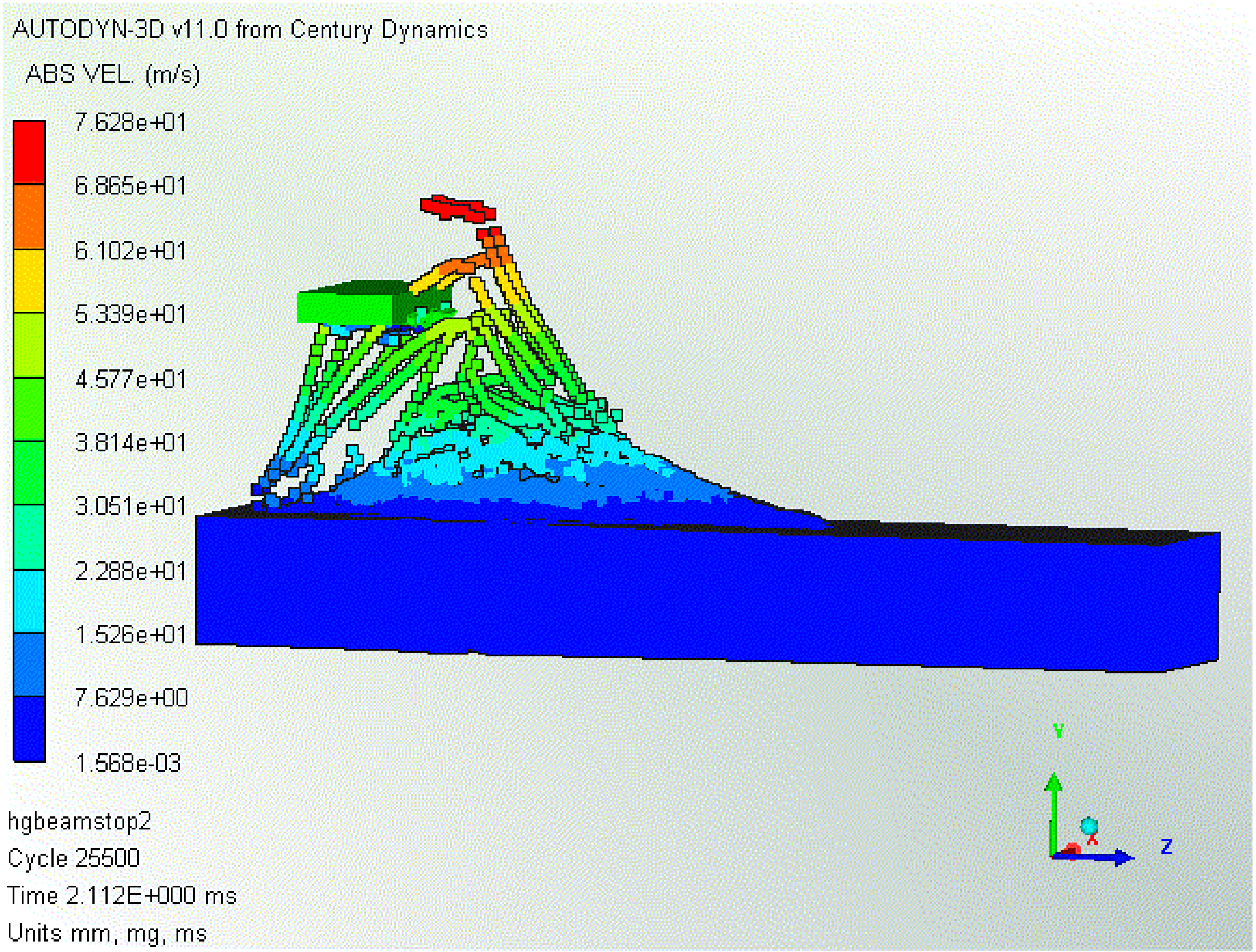


How much of the beam energy is absorbed in the beam dump?

Agitation 'eruption' of mercury pool surface due to 24GeV proton beam

Autodyne simulation

Splash following pulse of 20Terra protons



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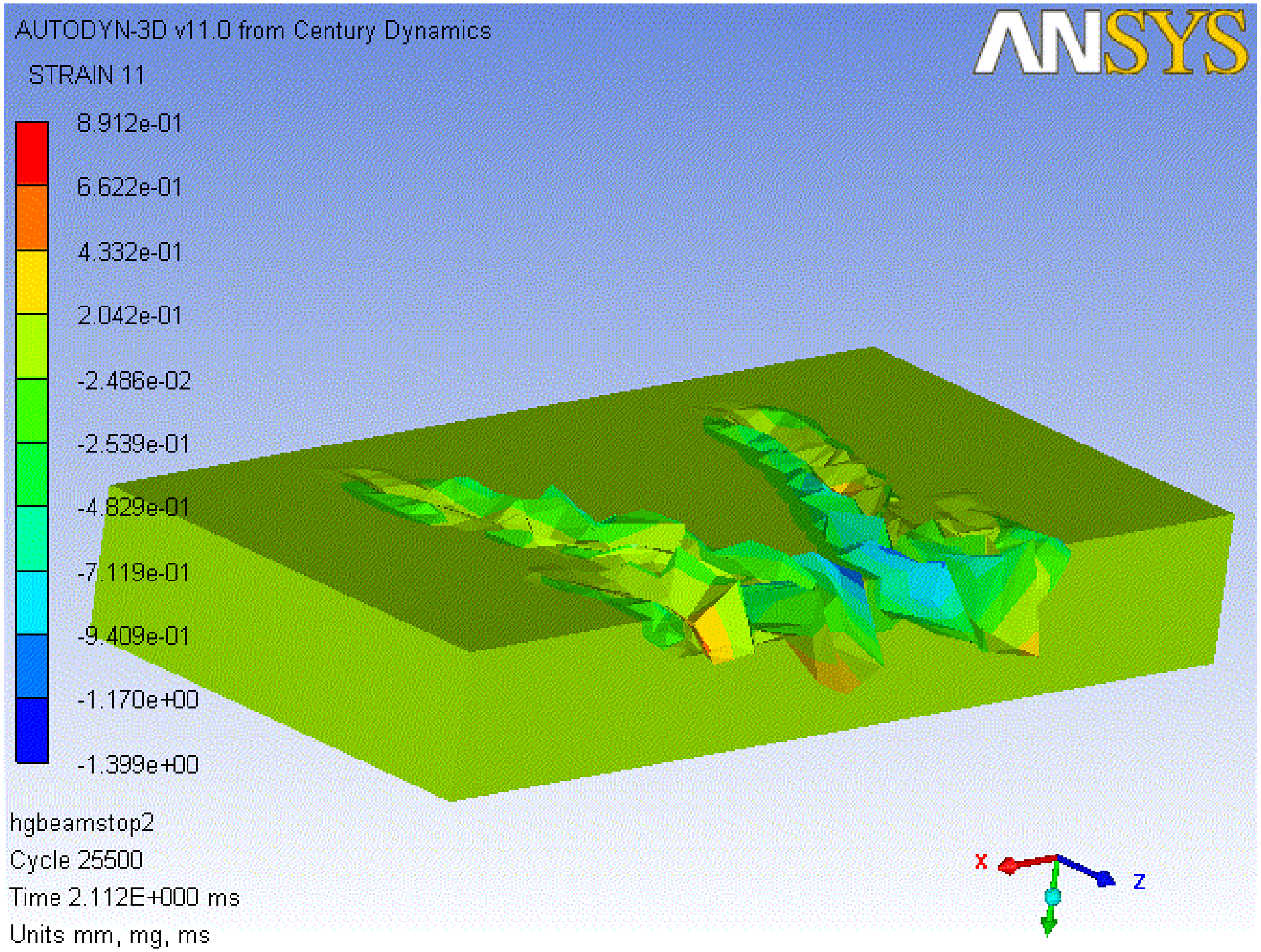
Damage to underside of stainless steel plate

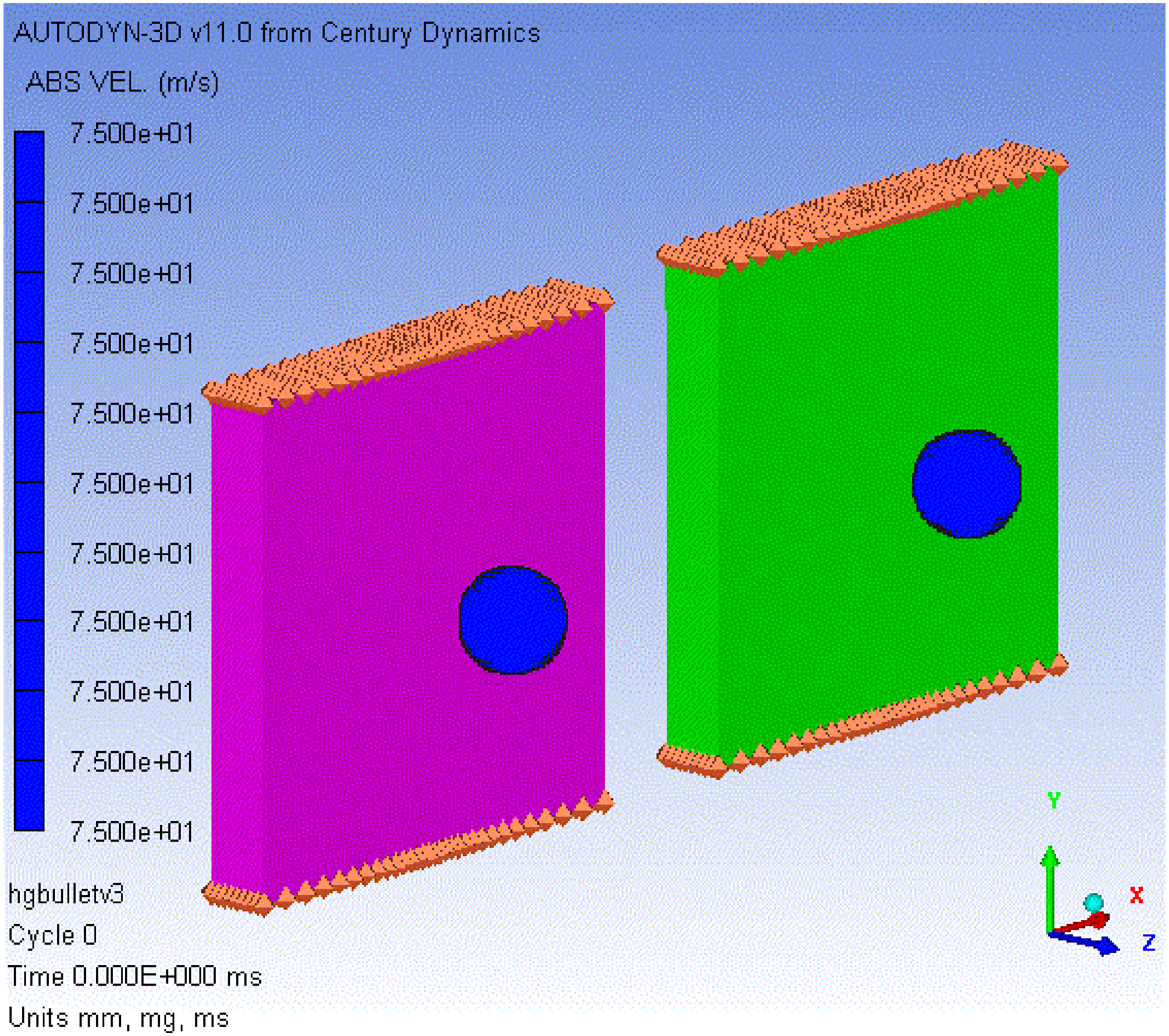
fluid - structure interaction



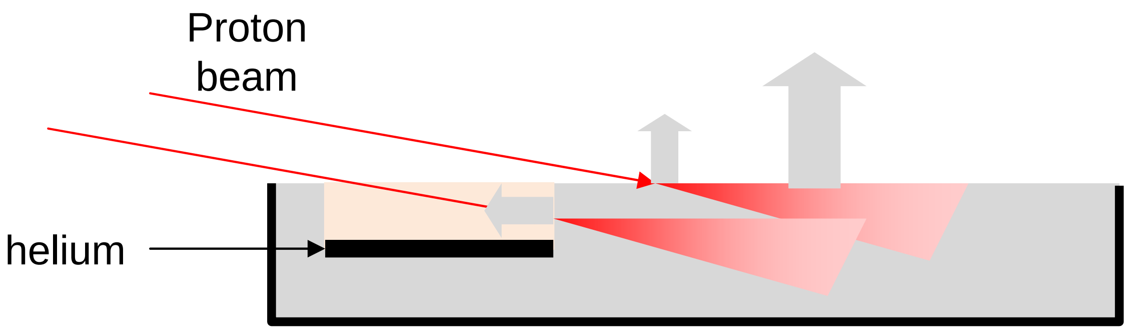
maybe sprung baffles would be help reduce damage

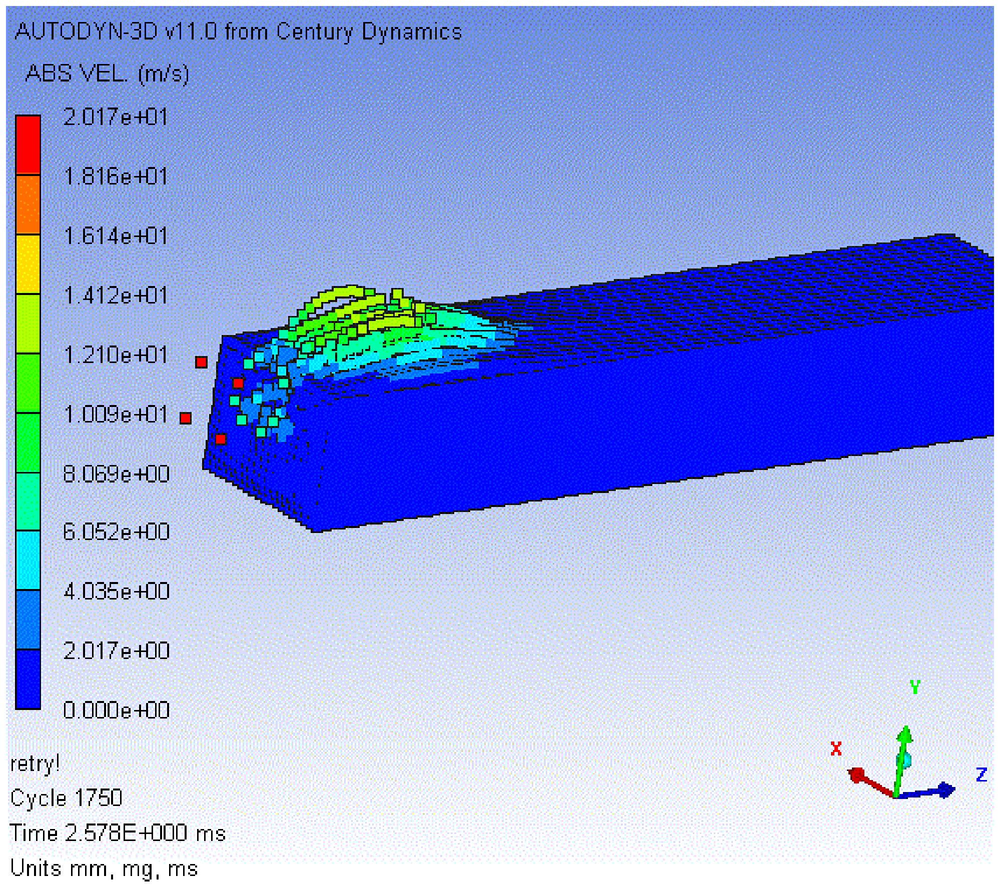
Damage as a result of high speed impact of a mercury droplet

Stainless Steel vs. Ti-6Al-4V



Consider helium bubbles in beam dump reduce splash velocity





Mercury beam dump design from NUFACT Feasibility Study

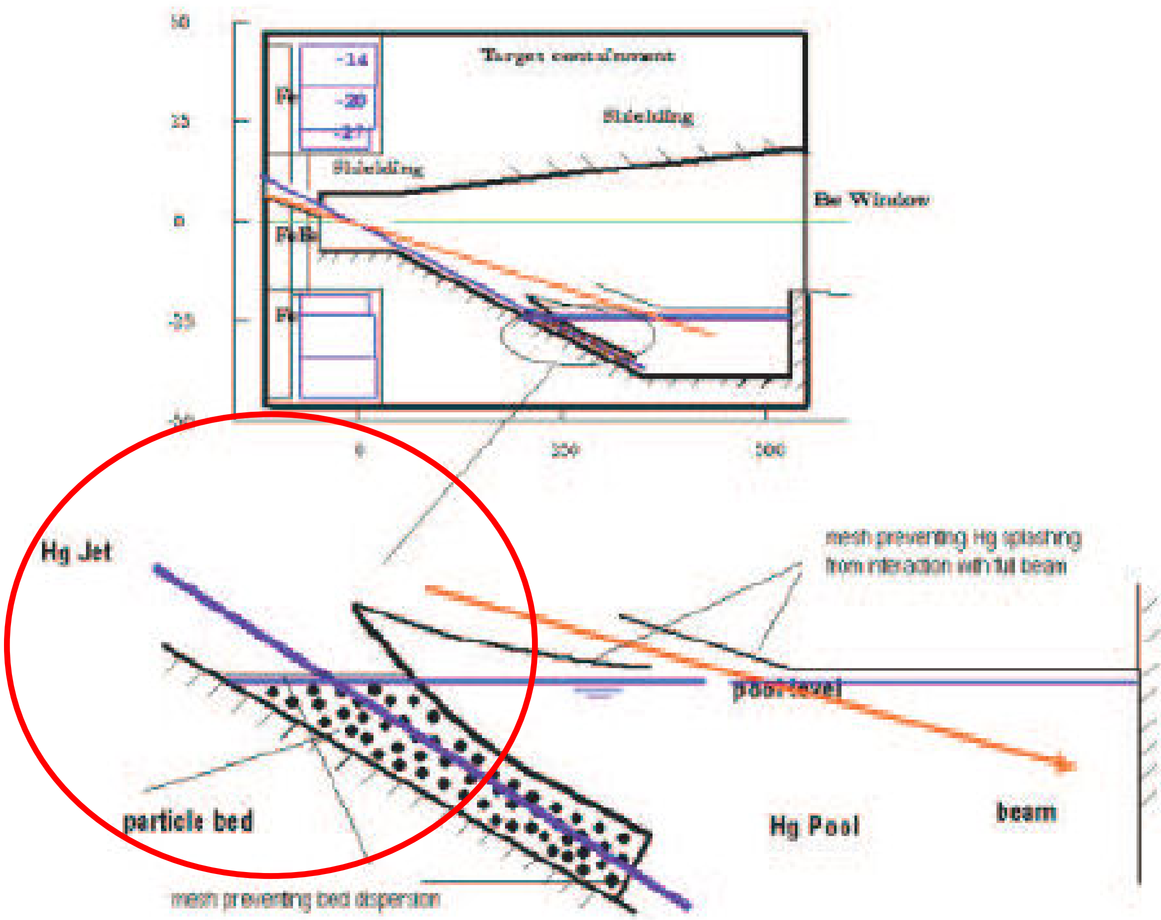
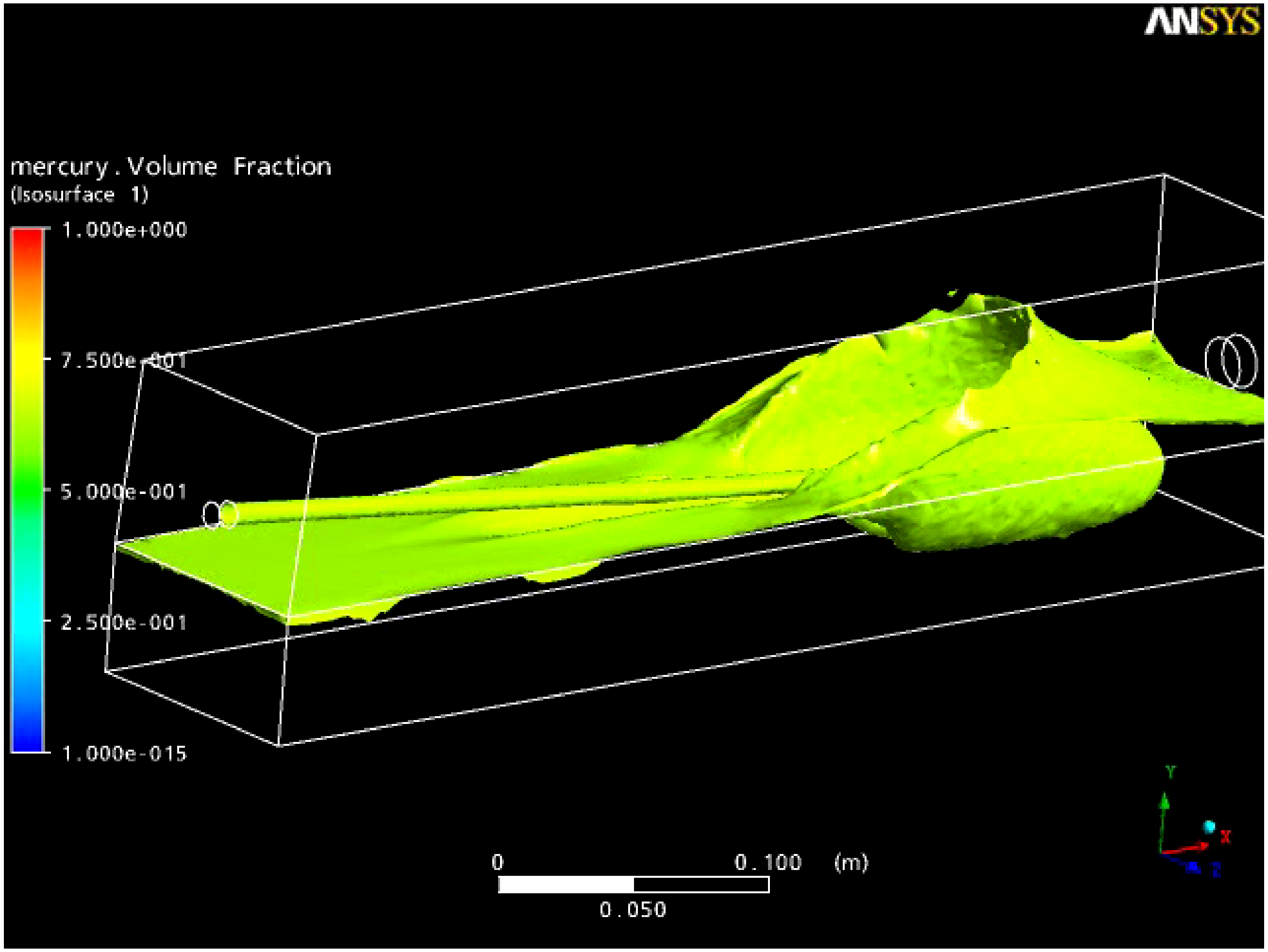


Figure 3.36: Schematic of the mercury pool that serves as the proton beam absorber.

Agitation of mercury pool surface due to impinging mercury jet

2 phase CFX model
mercury jet velocity = 20m/s
Angle of attack = 5.7°
mercury pool surface area = $0.05m^2$



Summary

Conclusions

Simulations indicate that mercury splashes with a maximum velocity of 75m/s will result when a pulse from the undisrupted 24GeV beam is absorbed by the mercury beam dump.

A 3mm diameter mercury droplet impacting a stainless steel plate at 75m/s is predicted to cause significant damage. Ti-6Al-4V is predicted to be more resistant to damage due to higher ultimate strength and shear strength.

Significant agitation of the mercury surface also results from the entry of the mercury jet.

Addendum: 12 Nov 08

- Autodyne simulation of the momentum in an Hg drop that hits a steel plate at t = 1.3 ms.
- Momentum drops linearly with time during the splash
- Area of contact is very small at beginning of splash, so high initial impact pressure.

AUTODYN-3D v11.0 from Century Dynamics