# MERIT Experiment On-Going Studies

1 - Target Station Beam Windows

2 - Magneto-dynamic Analysis

3 - Beam-Hg Interaction Analysis

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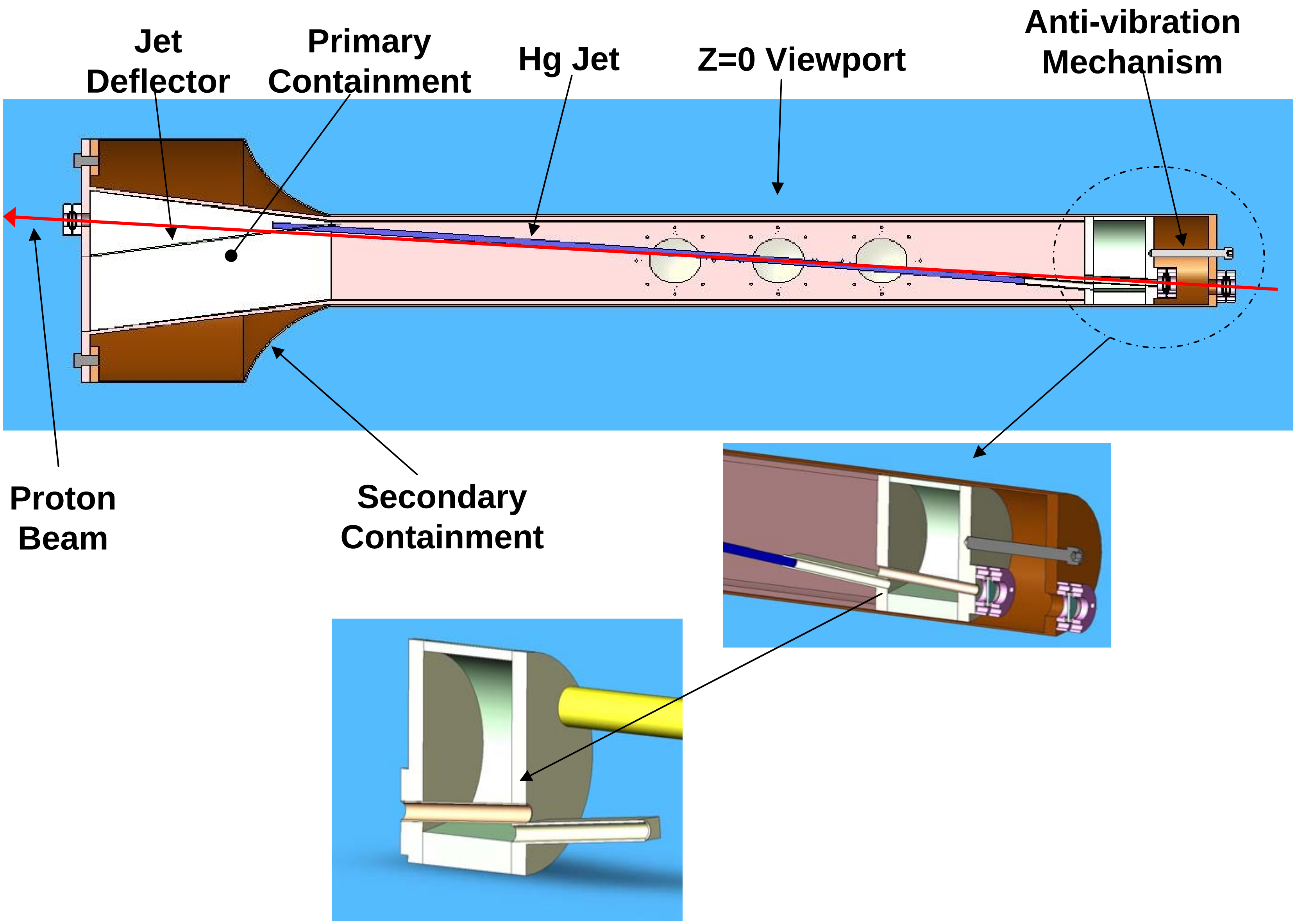
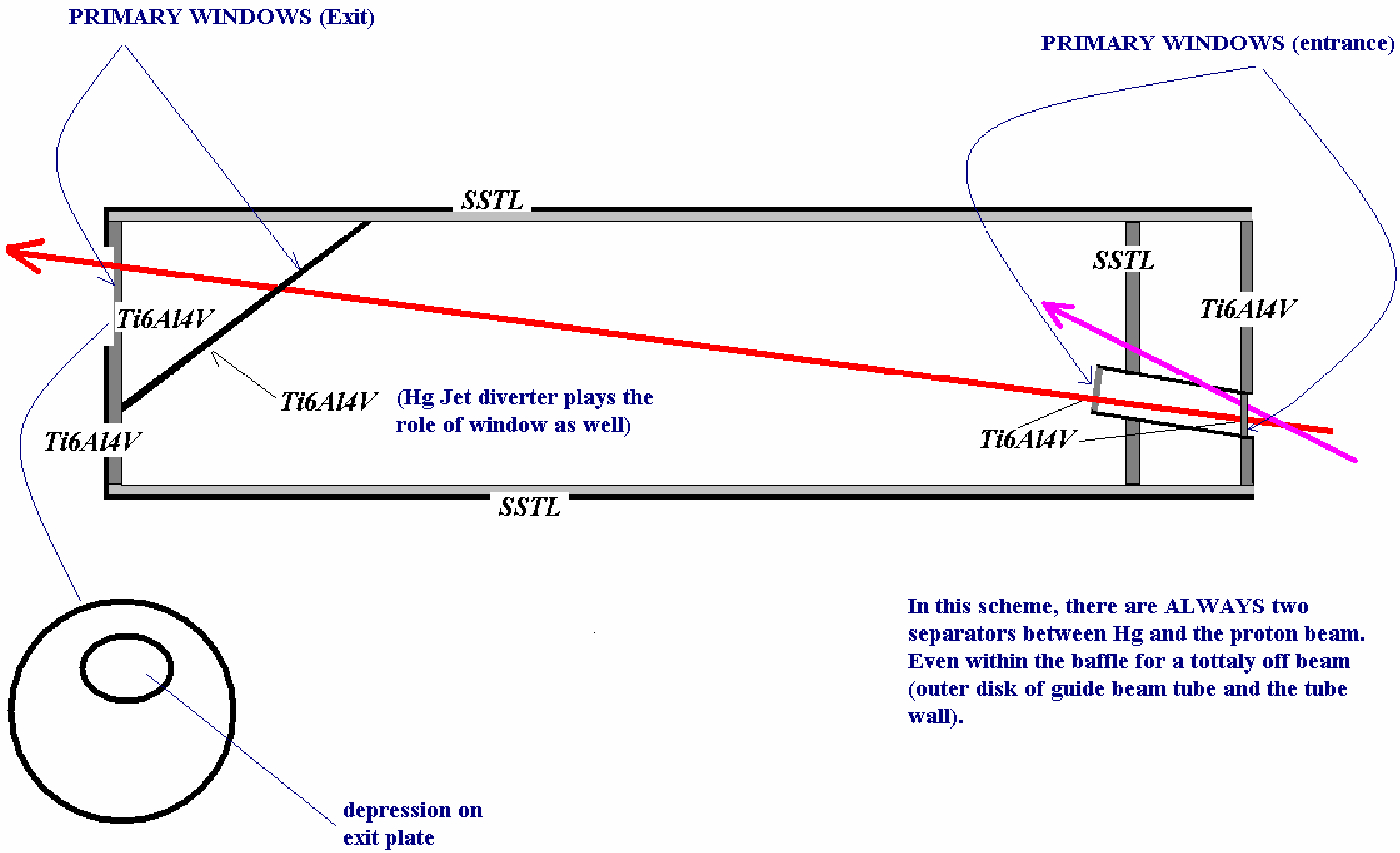
# Baseline Target Assembly Concept

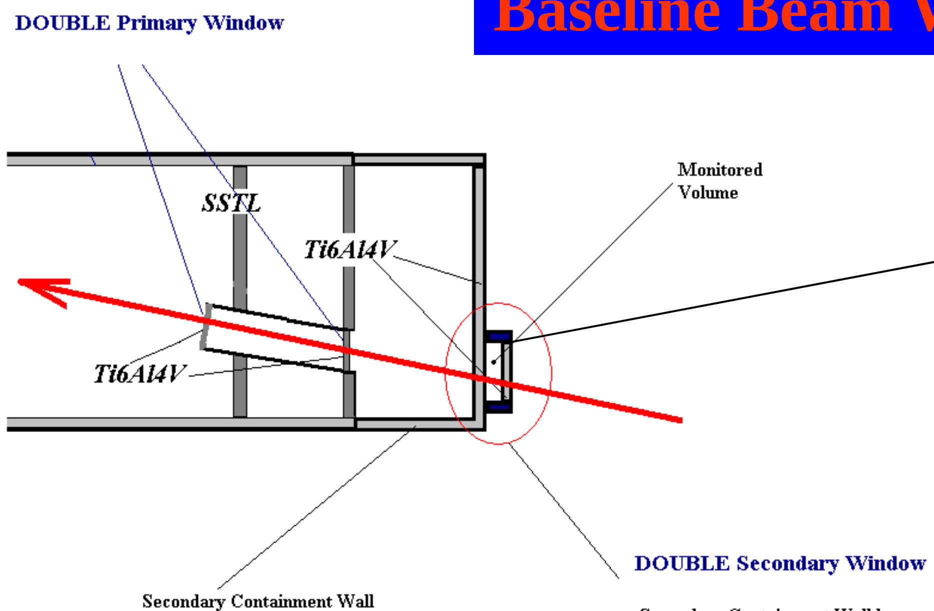


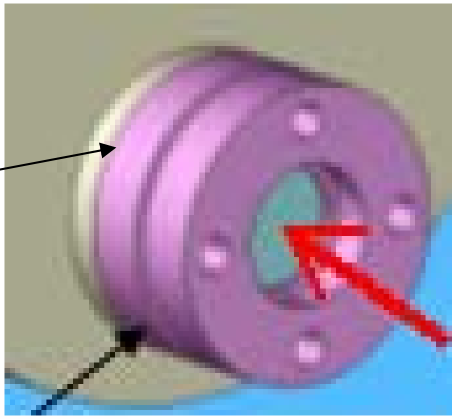
# Baseline Target Assembly Concept



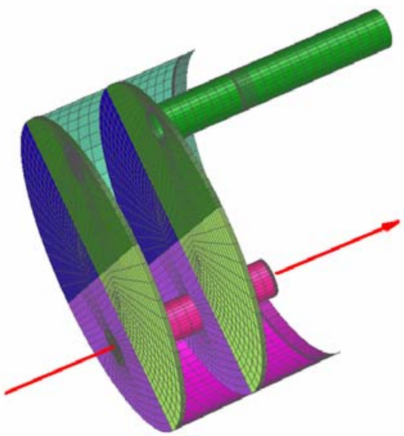

In this scheme, there are ALWAYS two separators between Hg and the proton beam. Even within the baffle for a tottaly off beam (outer disk of guide beam tube and the tube wall).

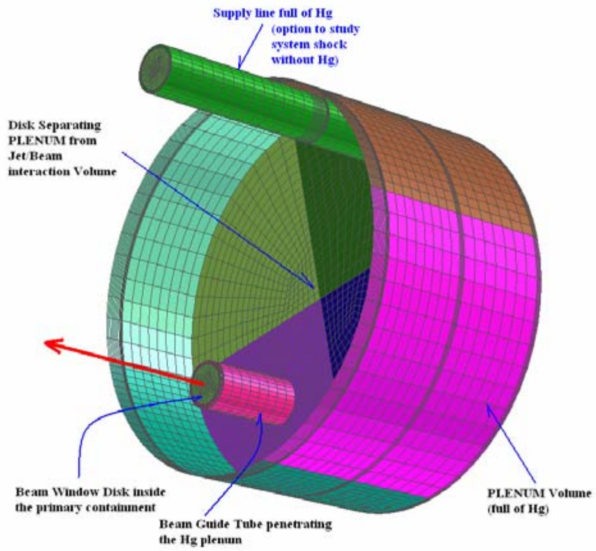
# Baseline Beam Window Concept

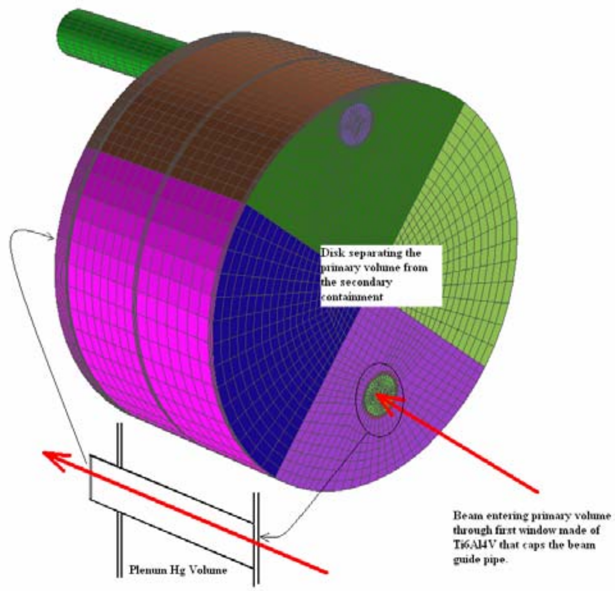


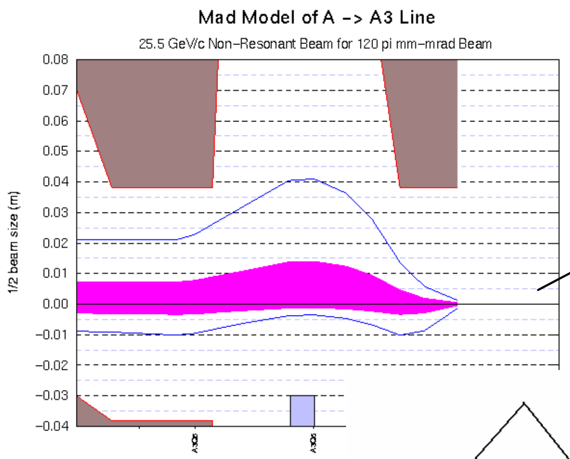
Secondary Containment Wall becomes the inner disk of the double secondary window. Both (secondary wall and outer window disk made of Ti-6Al-4v)

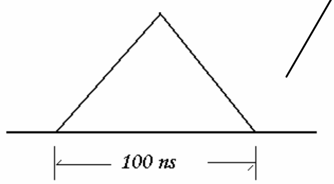




# CONCERNS realized in E951 experiment and applicable to MERIT as well



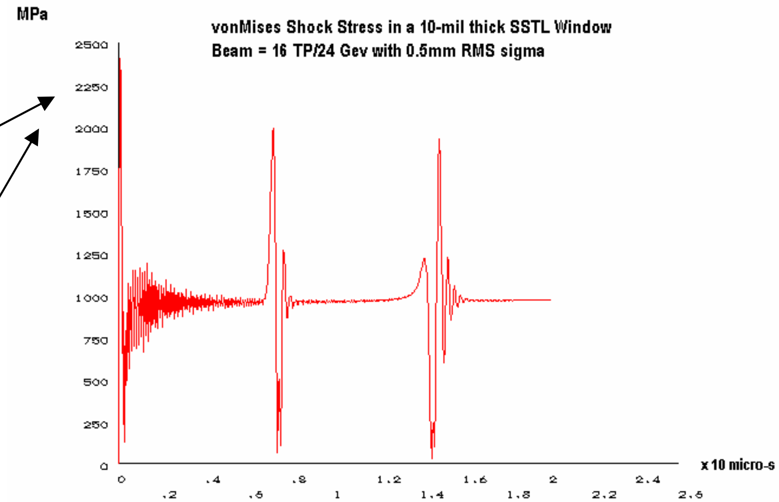
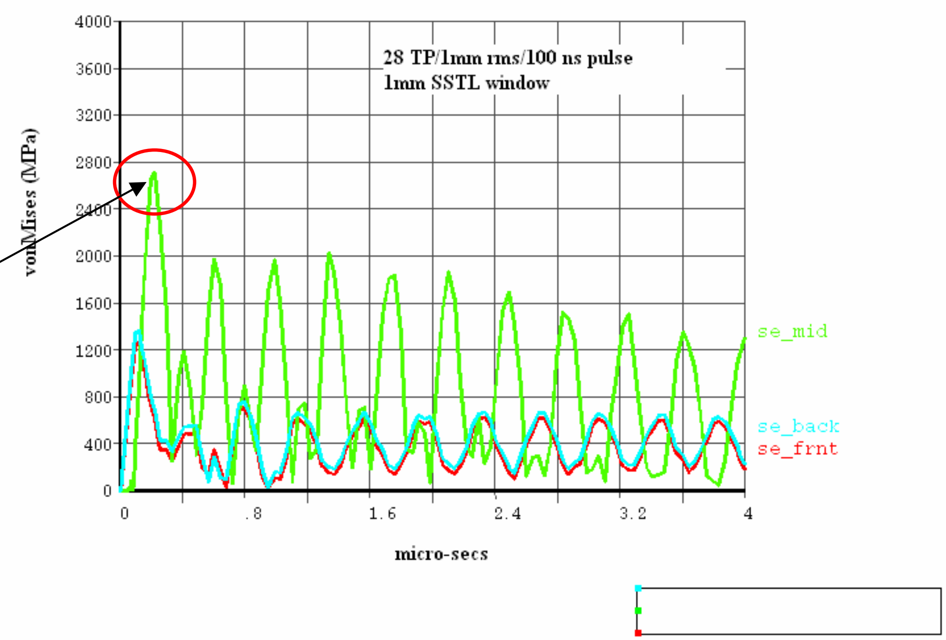




**Figure above depicts the tight beam spot requirement (0.5 x 0.5 mm rms) for target experiment at AGS**

**Induced shock stress in a window structure by 16 TP intensity beam and the spot above will likely fail most materials in a single short pulse ( ~ 2 ns)**




## MERIT Experiment Issues with SSTL Windows

The composition of Ti6Al4V Grade 5

| | Content |
|---|---|
| C | <0.08% |
| Fe | <0.25% |
| $N_2$ | <0.05% |
| $O_2$ | <0.2% |
| Al | 5.5-6.76% |
| V | 3.5-4.5% |
| $H_2$(sheet) | <0.015% |
| $H_2$(bar) | <0.0125% |
| $H_2$(billet) | <0.01% |
| Ti | Balance |

## Fabrication

- Weldability – Fair
- Forging – Rough 982°C (1800°F), finish 968°C (1775°F)
- Annealing - 732°C (1350°F), 4hr, FC to 566°C (1050°F), A.C. F.C. not necessary for bars
- Solution Heat Treating – Forgings
- Ageing – 904-954°C (1660-1750°F), 5 min-2hrs, W.Q. 538°C (1000°F), 4hr, A.C.

**Ti-6Al-6V tested as beam window with the24 GeV AGS Beam (3.5 TP)**

## Physical Properties

Typical physical properties for Ti6Al4V.

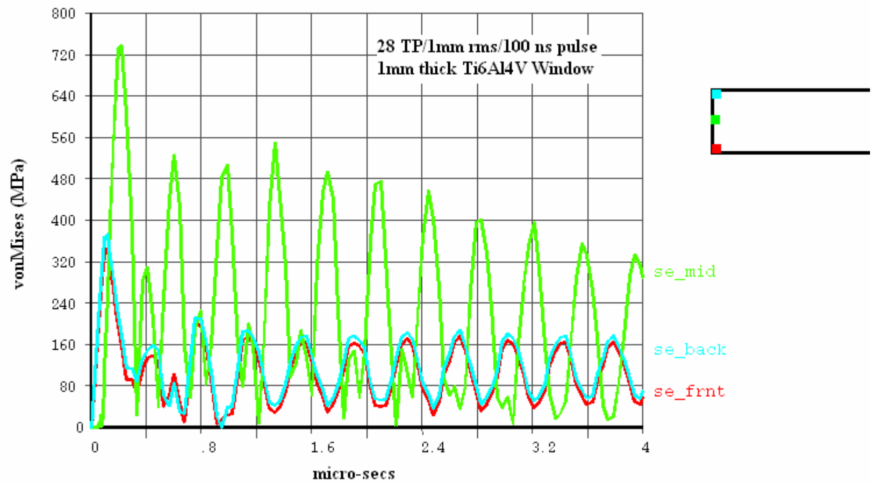
| Property | Typical Value |
|---|---|
| Density g/cm$^3$ (lb/ cu in) | 4.42 (0.159) |
| Melting Range °C±15°C (°F) | 1649 (3000) |
| Specific Heat J/kg.°C (BTU/lb/°F) | 560 (0.134) |
| Volume Electrical Resistivity ohm.cm (ohm.in) | 170 (67) |
| Thermal Conductivity W/m.K (BTU/ft.h.°F) | 7.2 (67) |
| Mean Co-Efficient of Thermal Expansion 0-100°C /°C (0-212°F /°F) | $8.6\times10^{-6}$ (4.8) |
| Mean Co-Efficient of Thermal Expansion 0-300°C /°C (0-572°F /°F) | $9.2\times10^{-6}$ (5.1) |
| Beta Transus °C±15°C (°F) | 999 (1830) |

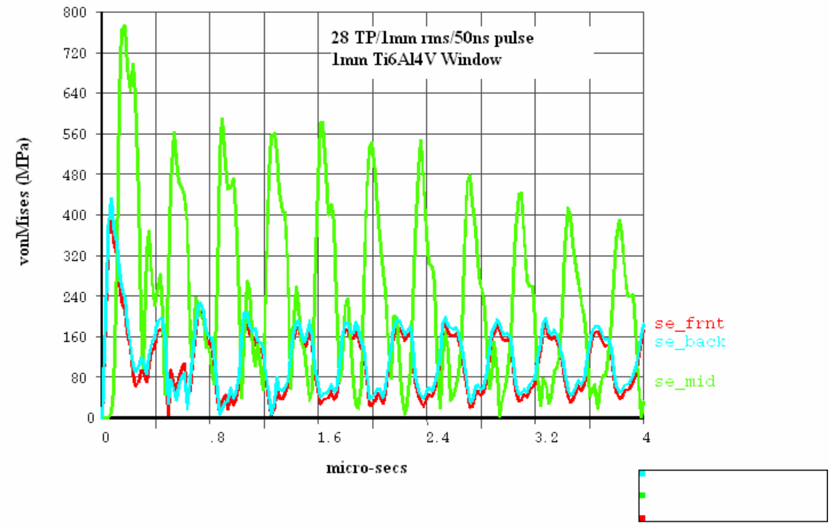
## Mechanical Properties

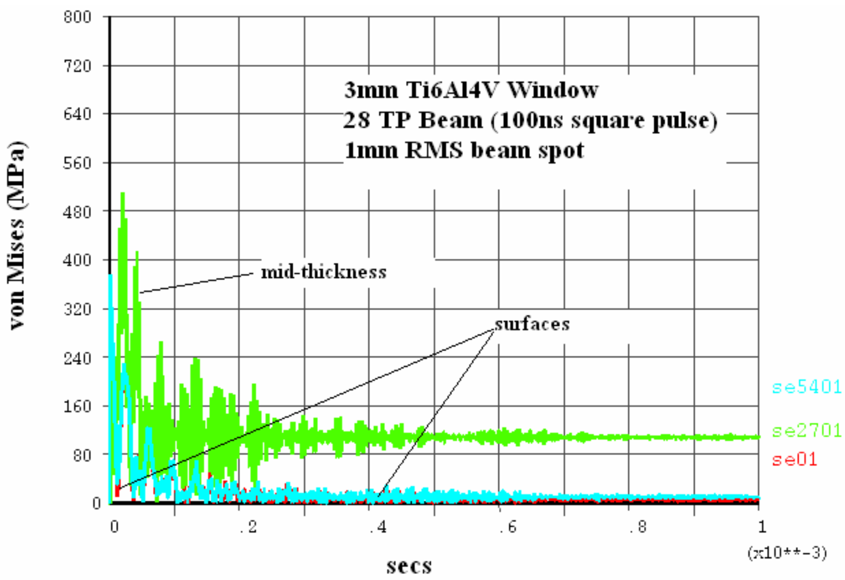
Typical mechanical properties for Ti6Al4V.

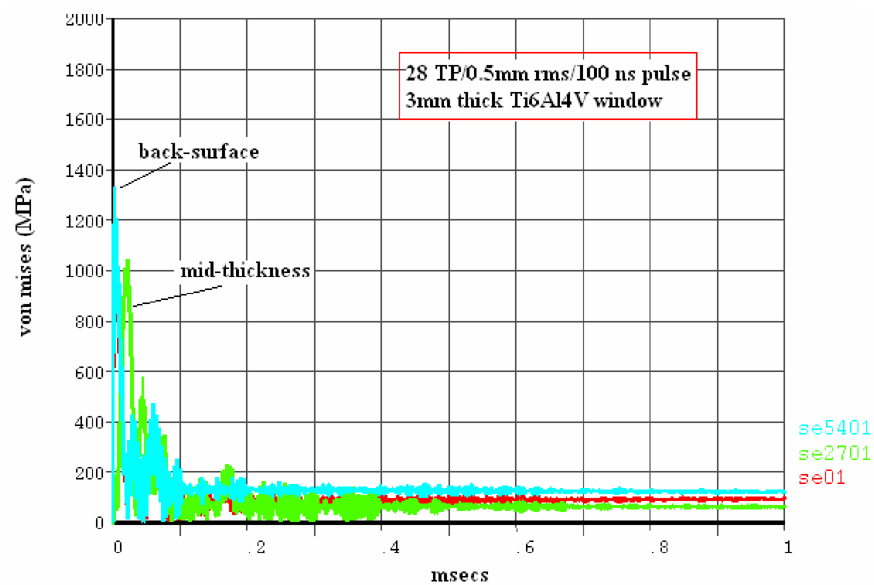
| Property | Minimum | Typical Value |
|---|---|---|
| Tensile Strength MPa (ksi) | 897 (130) | 1000 (145) |
| 0.2% Proof Stress MPa (ksi) | 828 (120) | 910 (132) |
| Elongation Over 2 Inches % | 10 | 18 |
| Reduction in Area % | 20 | |
| Elastic Modulus GPa (Msi) | | 114 (17) |
| Hardness Rockwell C | | 36 |
| Specified Bend Radius <0.070 in x Thickness | | 4.5 |
| Specified Bend Radius >0.070 in x Thickness | | 5.0 |
| Welded Bend Radius x Thickness | 6 | |
| Charpy, V-Notch Impact J (ft.lbf) | | 24 (18) |

# Beam Window Study on T-6Al-4V and Thickness Requirement

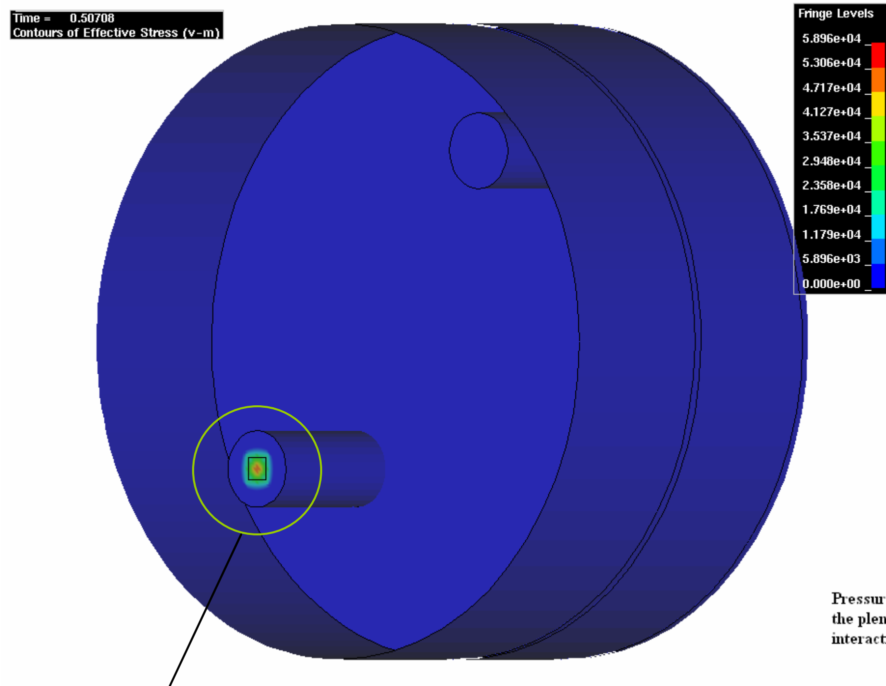


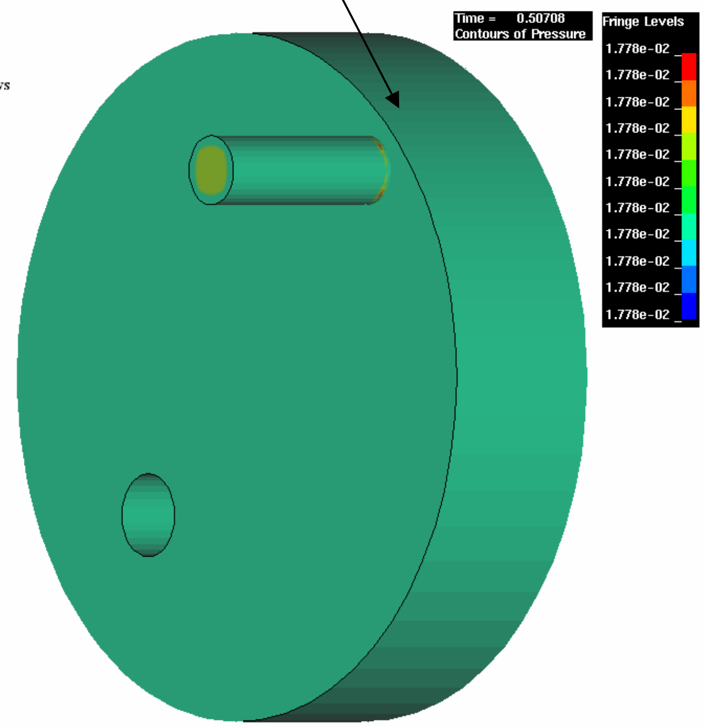
# 3D Beam Window Study that include Hg in the Baffle



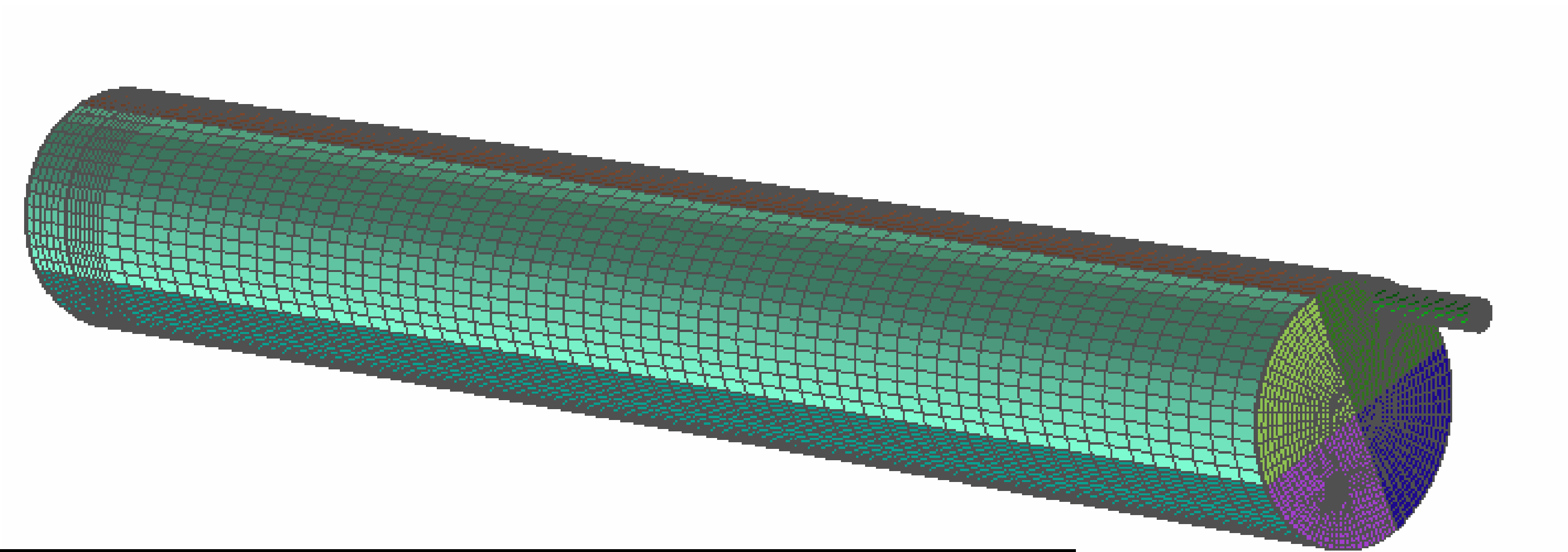

Beam Window inside Hg/beam interaction volume

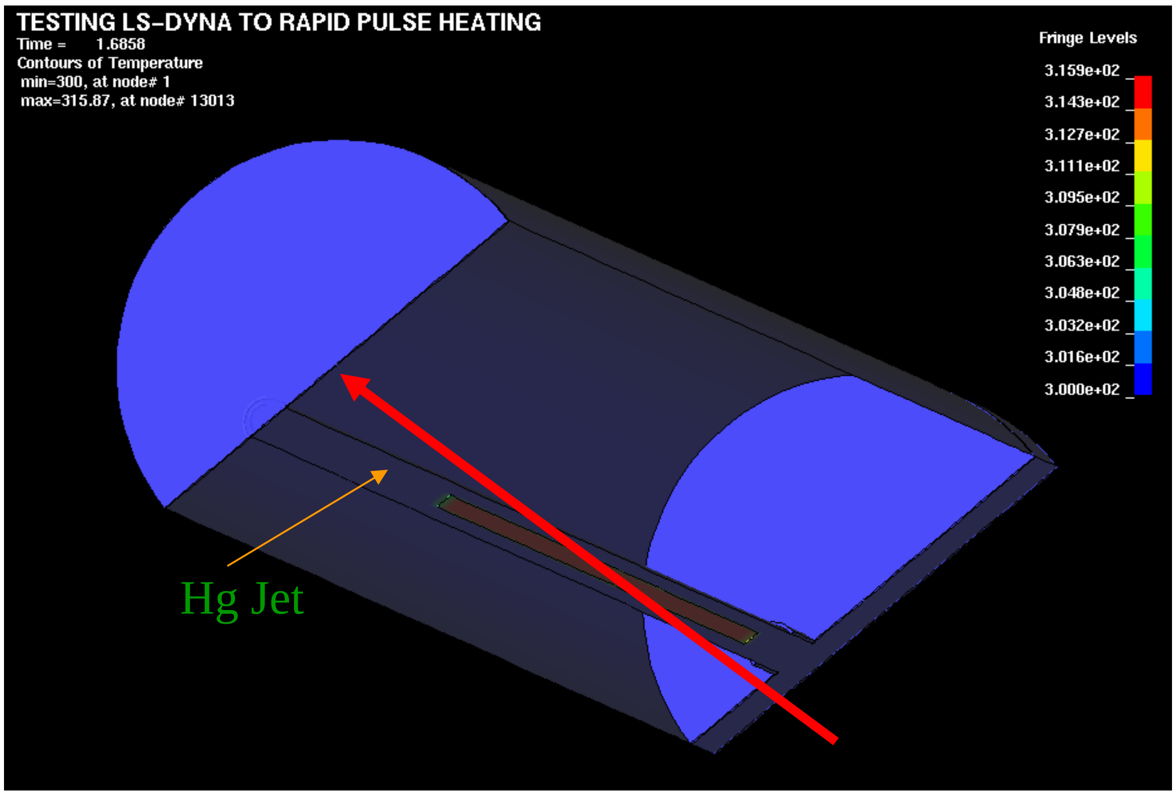
Pressure developed in Hg within the plenum as a result of beam interacting with the beam windows

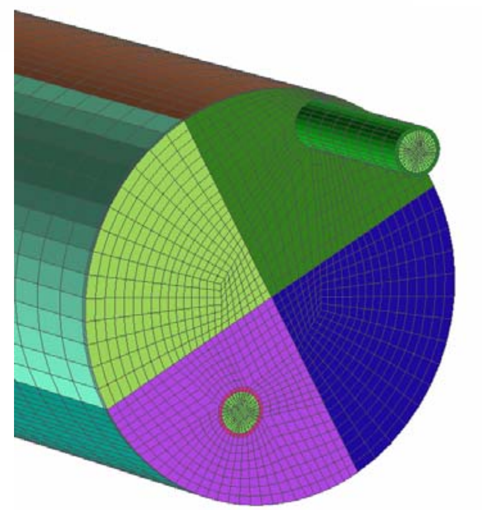
Hg



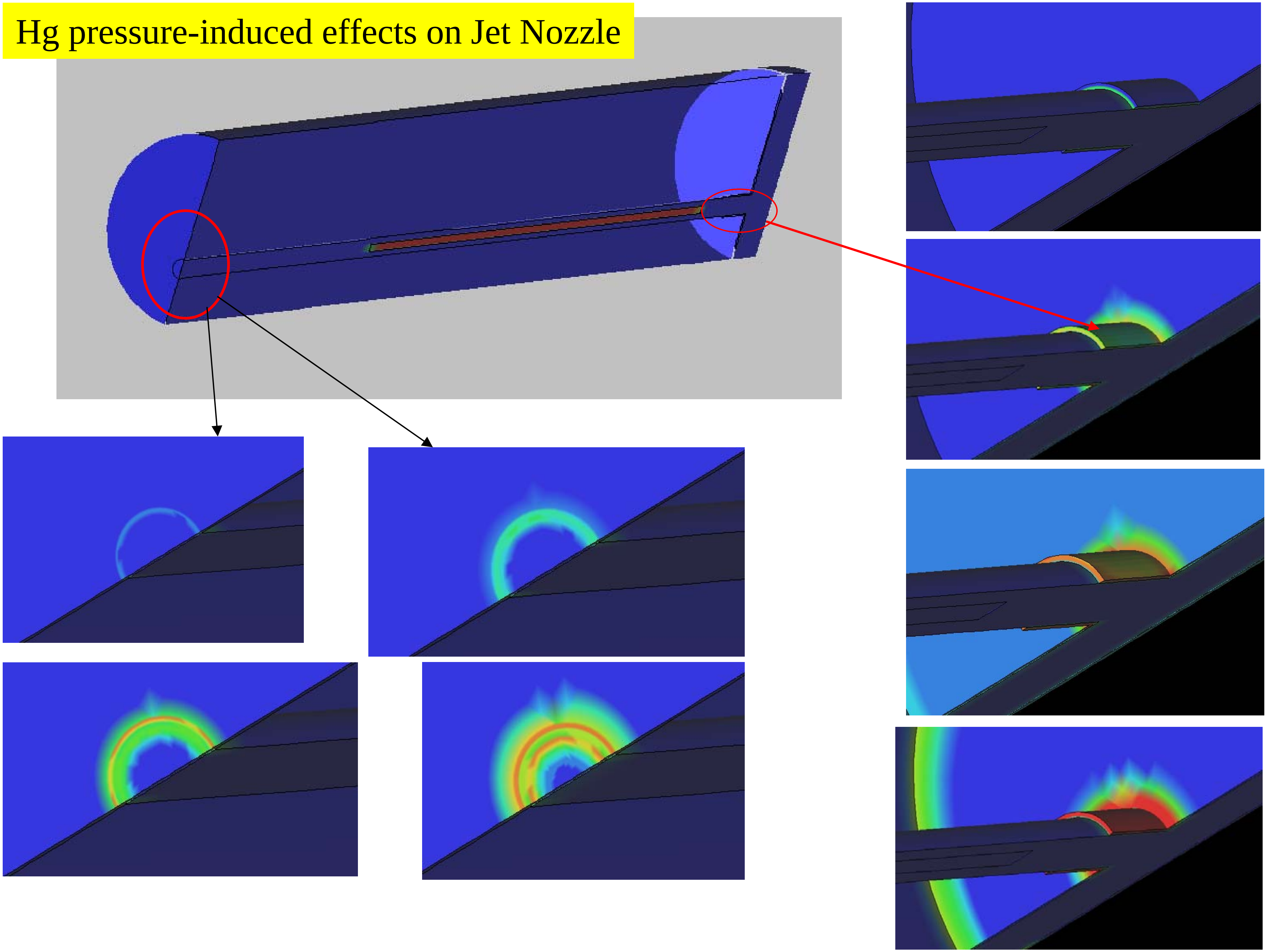

Volume of Hg in baffle experiencing pressure from beam interacting with entrance window




TESTING LS-DYNA TO RAPID PULSE HEATING
Time = 1.6858
Contours of Temperature
min=300, at node# 1
max=315.87, at node# 13013
Fringe Levels
3.159e+02
3.143e+02
3.127e+02
3.111e+02
3.095e+02
3.079e+02
3.063e+02
3.048e+02
3.032e+02
3.016e+02
3.000e+02
Hg Jet



# Hg pressure-induced effects on Jet Nozzle

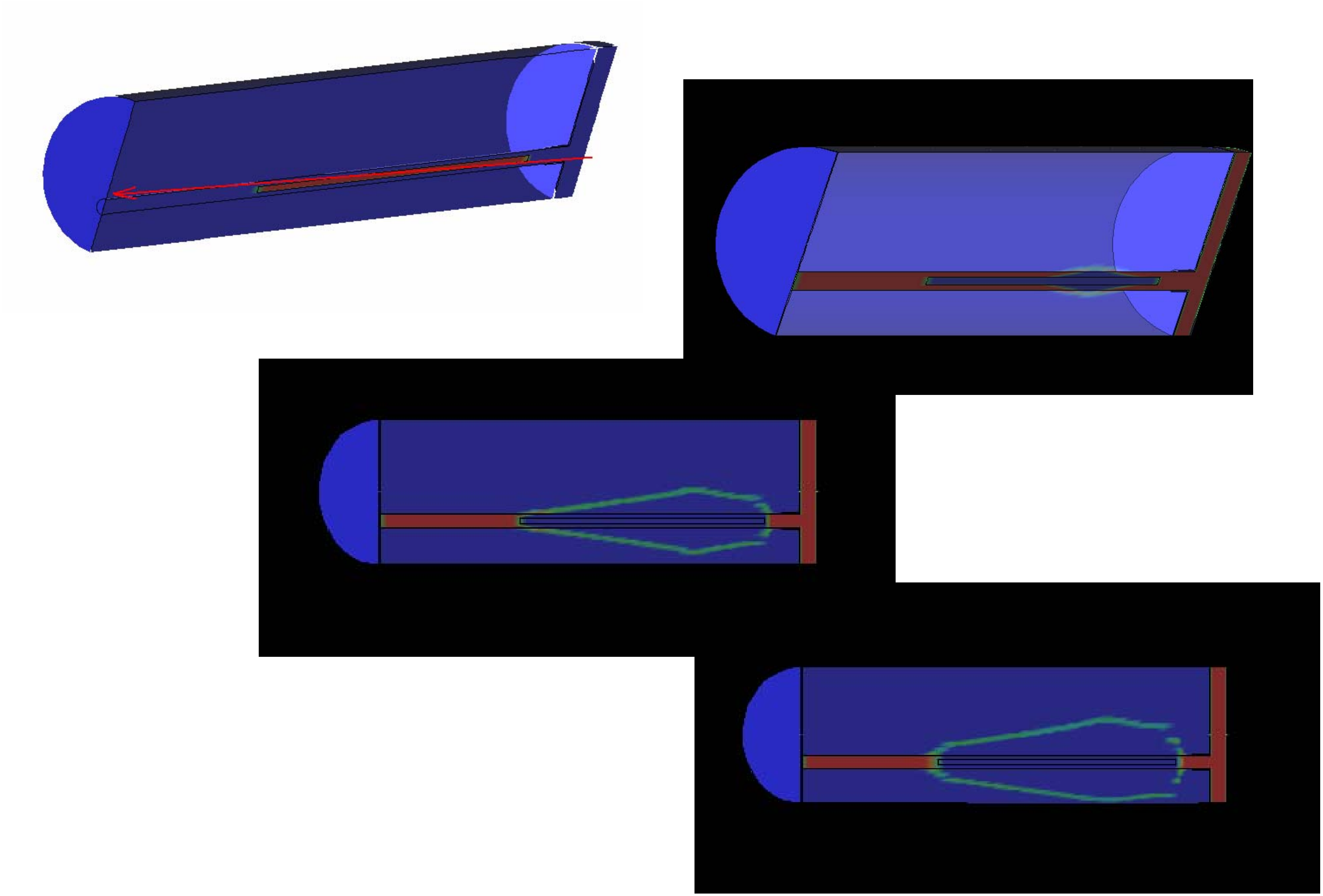


# OTHER ON-GOING Studies:

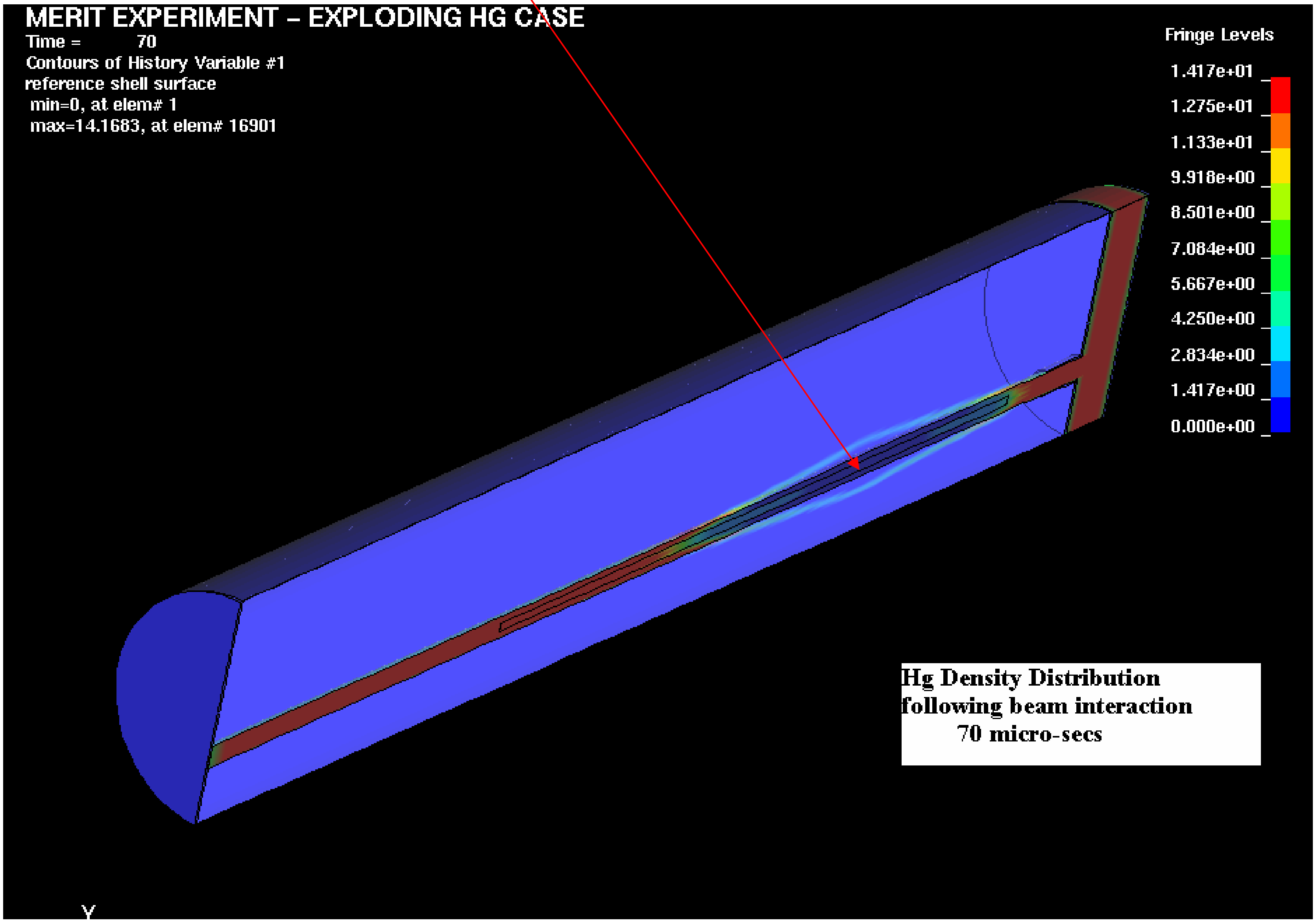
**(a) Beam-induced Hg jet destruction**

LS-DYNA analysis with Eulerian-Lagrancian formulation to account for fluids and solids in the same analysis. Goal is to, hopefully, benchmark a simulation of the event with the test data. The benefit will be a clear understanding of how quickly the jet destructs that will in turn provide information as to how close the pulses in the real muon collider can be stacked

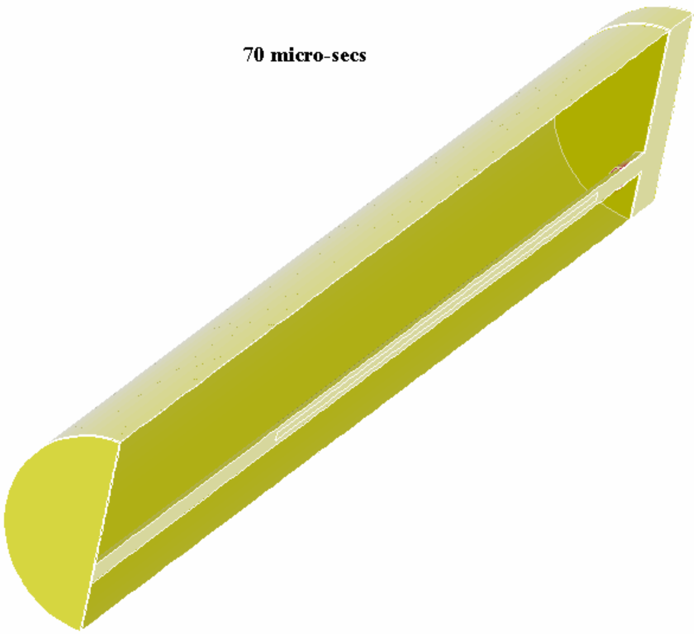
# Preliminary Hg splash analysis induced by beam

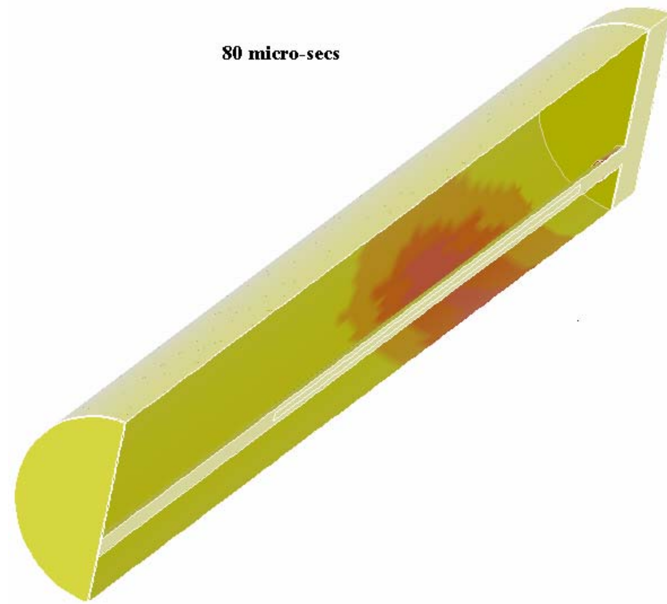


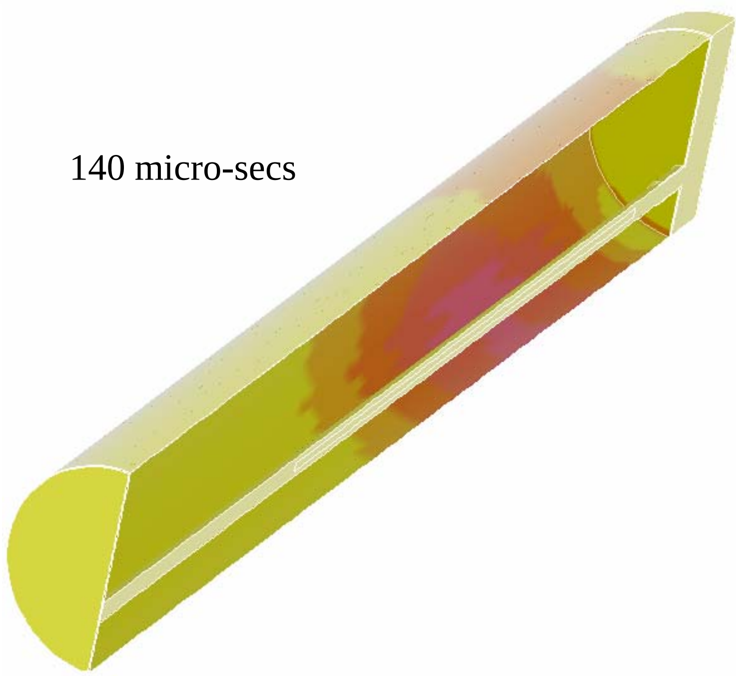
Preliminary Hg/beam interaction analysis – NO Field
Figure shows the zeroing of Hg density within the jet

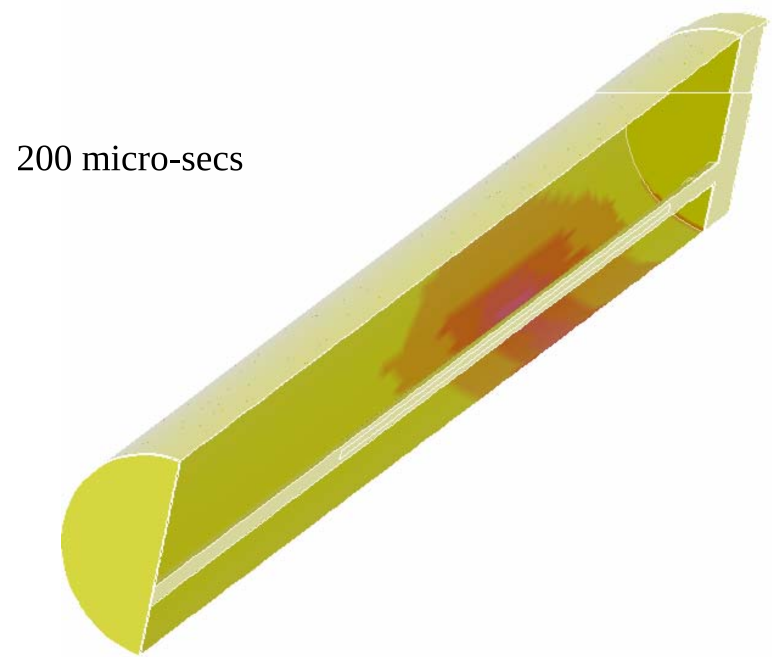


# Snapshots of stresses in the outer vessel generated by splashed Hg



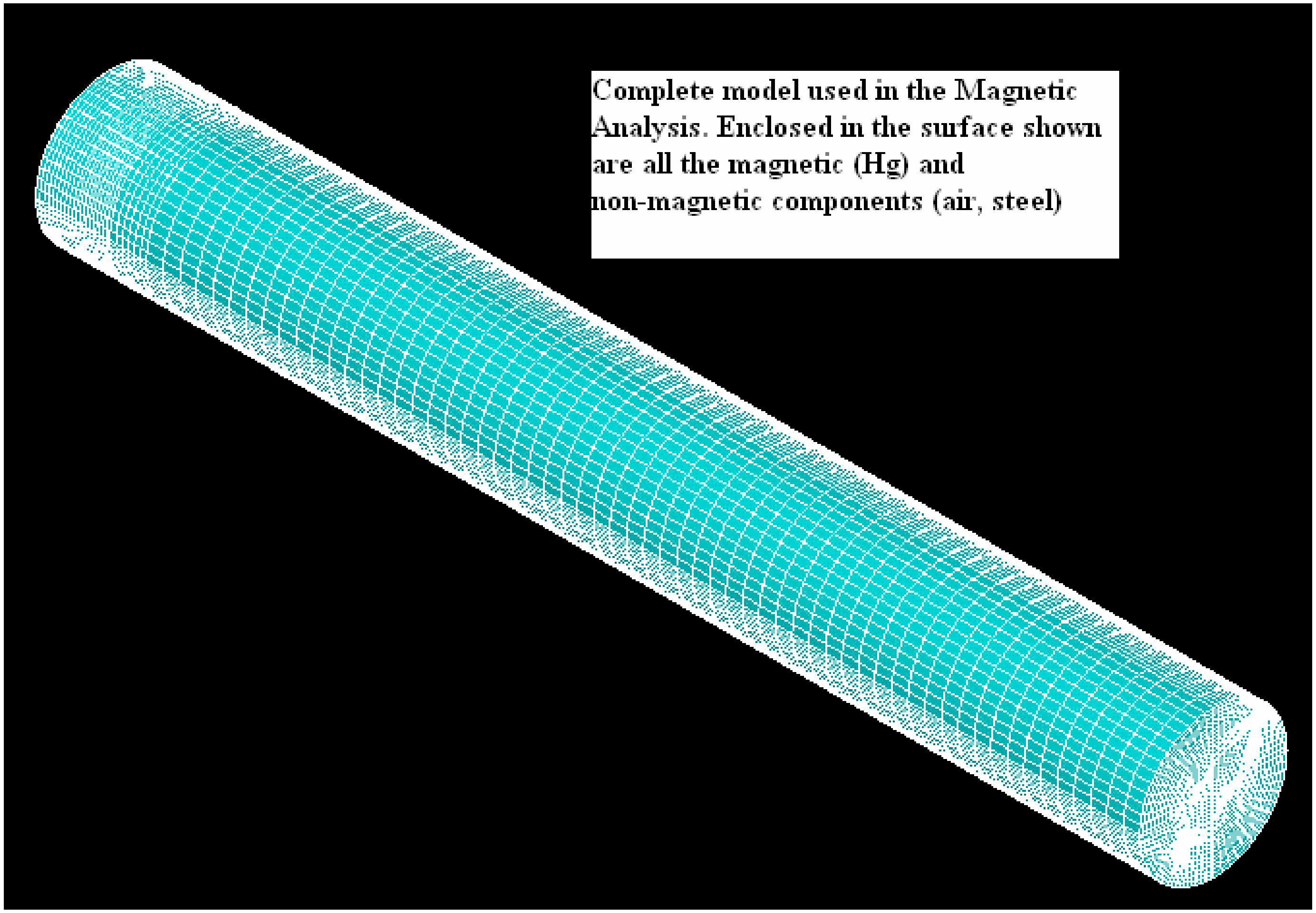



## OTHER ON-GOING Studies:

**Eddy currents and magnetic forces in the Hg volume** just prior to jetting out into the target/beam interaction volume with 15 Tesla field present.
Based on ANSYS magneto-dynamic analysis looking to assess the forces the jet must overcome as it tries to come out of the nozzle



Conducting Volume (Hg) used in analysis. Air, steel and Ti not shown.
Uniform 15 Tesla magnetic field is imposed