nTOFF11 Experiment

Beam Window Assessment

Hg Jet Interaction with the 15 Tesla Field
Hydrodynamic Analysis of Hg in Supply/Plenum/Jet
Hg Jet Interaction with Proton Beam

STATUS

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nTOF11 On-going Activities

Beam Windows:

- Conceptualization
- Analysis
- Interfacing/integration
- Design and procurement

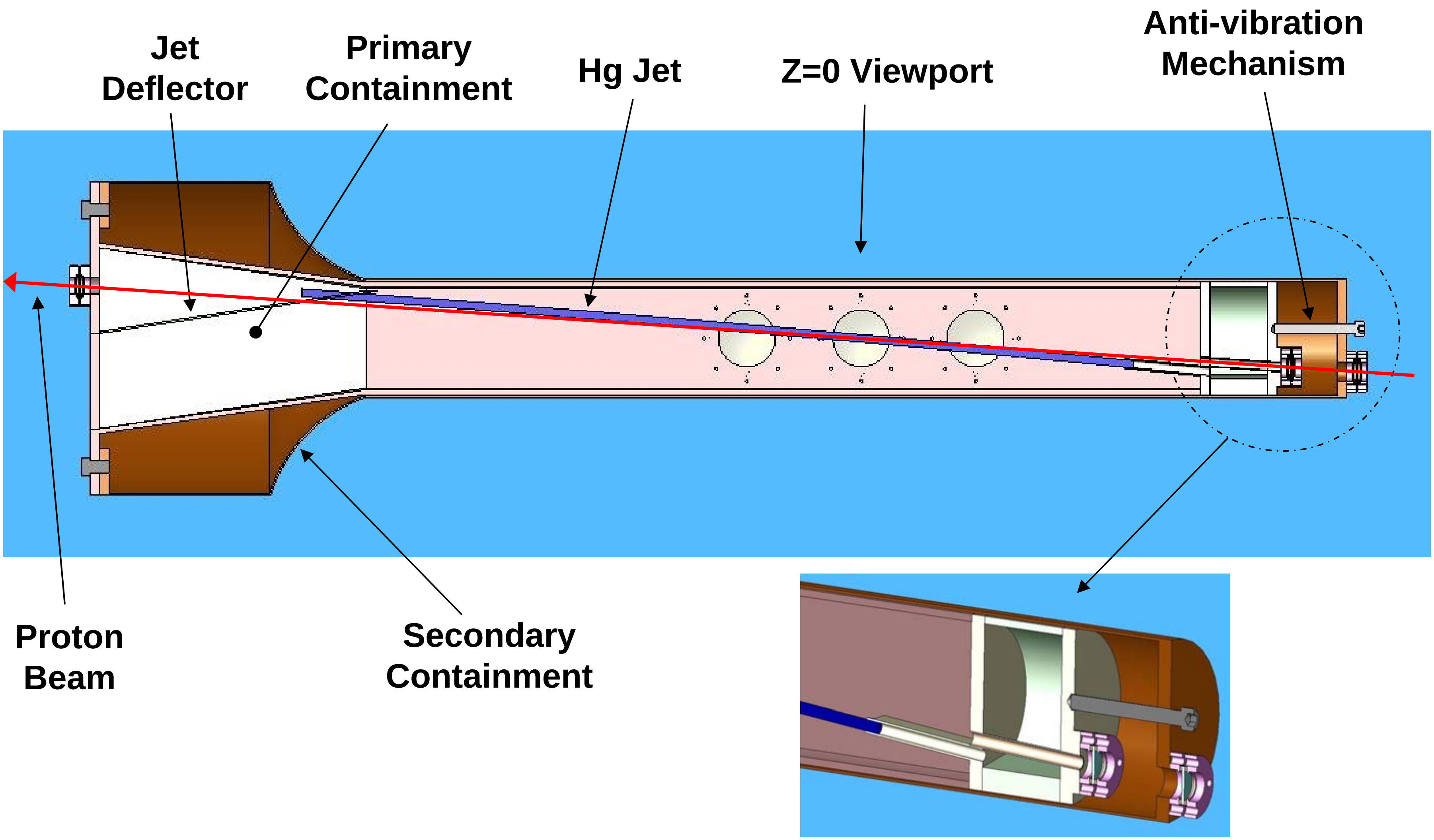
Intense Simulations:

- Interaction of Hg Jet and Target Assembly with the 15 Tesla Field. Estimation of Magnetic Forces (ANSYS 3D Analysis)
- Hydrodynamic Simulation of Hg in Supply Line/plenum/Jet (LS-DYNA)
- Beam/Hg Interaction and Splashing within target cavity (LS-DYNA)

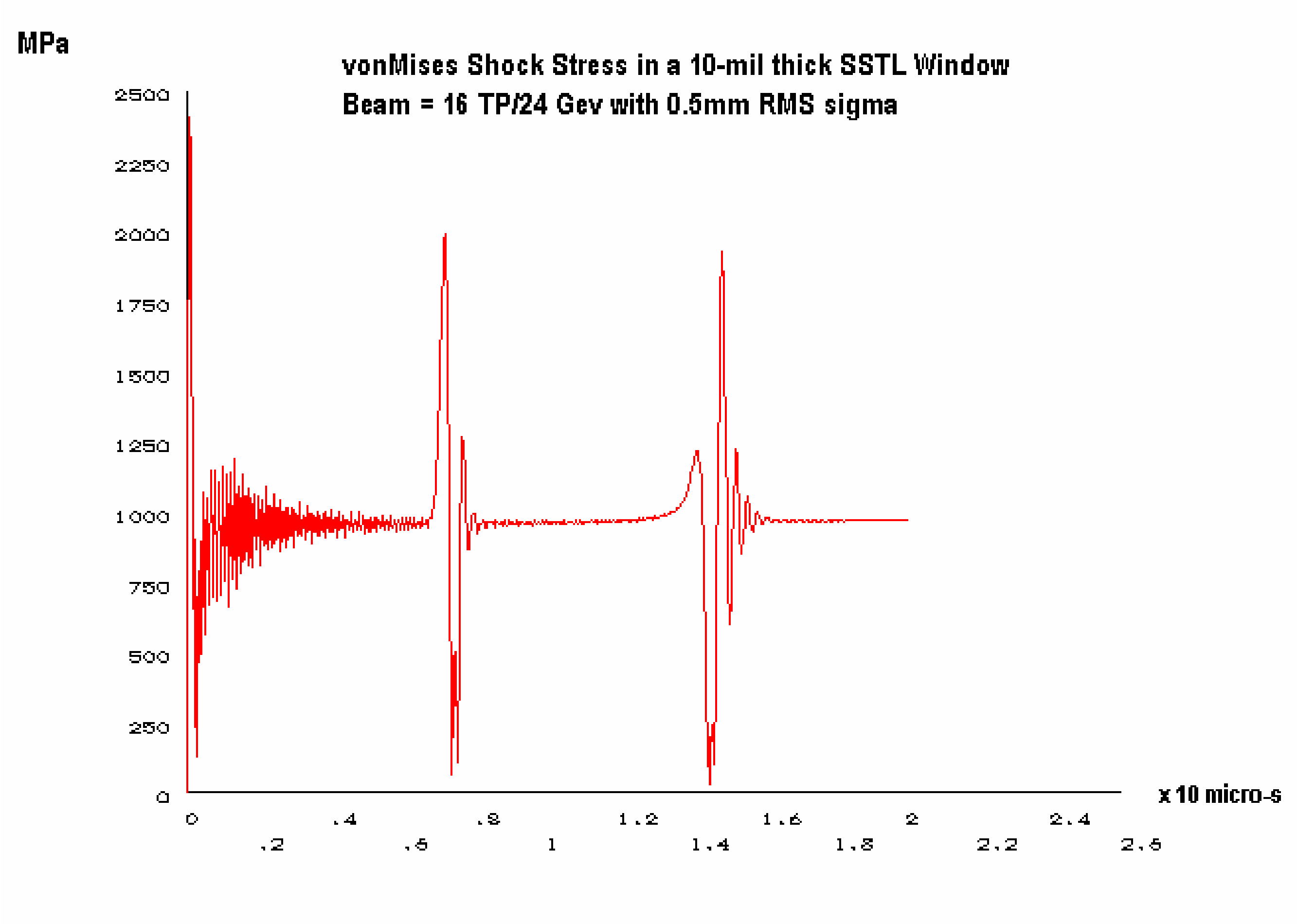
nTOF11 Beam Window Study

- **Find best possible materials/design that can have the best performance as beam windows under nTOFF11 experiment conditions (28 TP/1mm RMS/50-100ns pulse)**
- **ENSURE that multiple defense layers are in place and that they have been studied thoroughly**

CONCEPTUAL DESIGN (fluid)



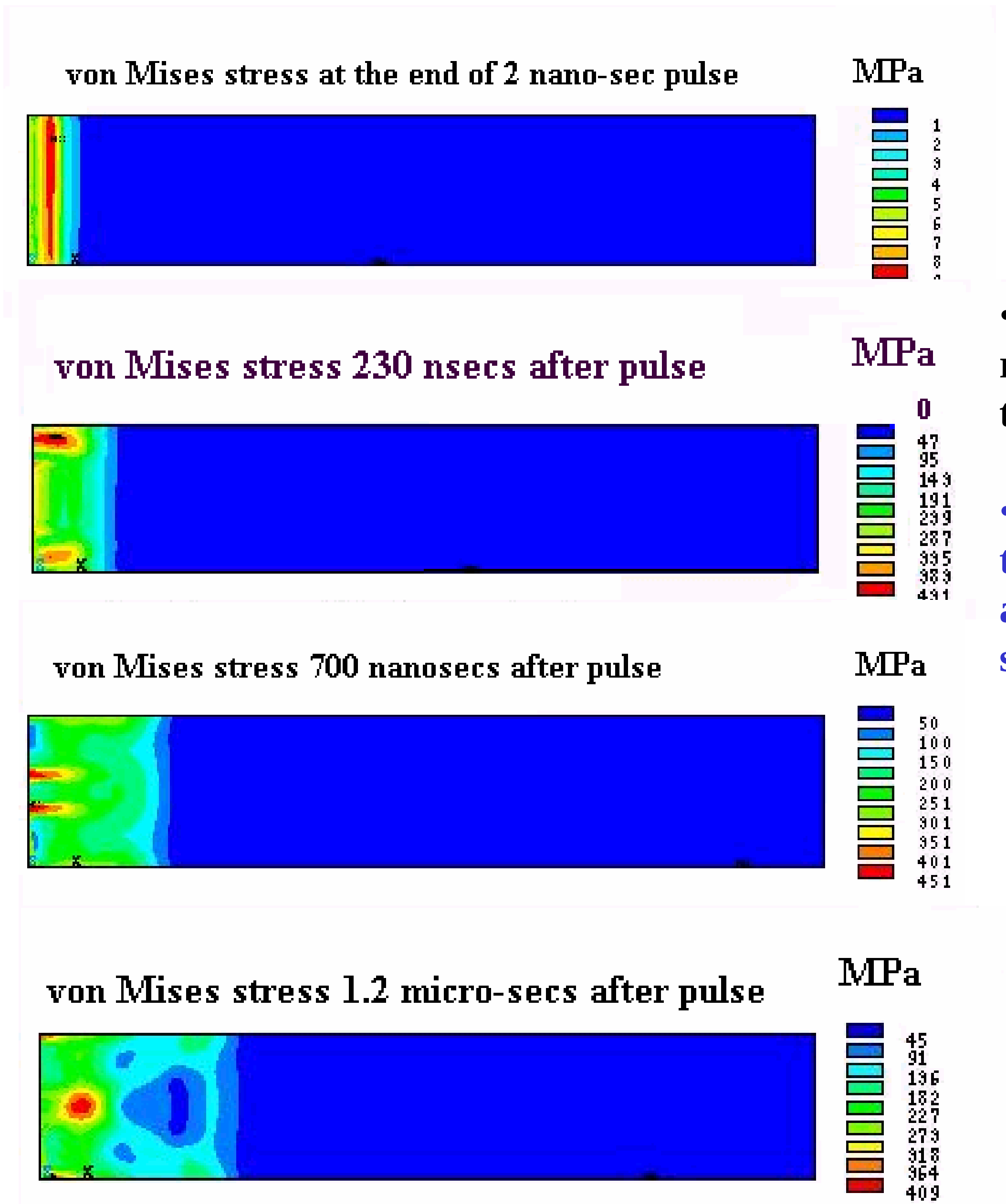
Why do we worry?



Induced shock stress in a window structure by 16 TP intensity beam and a spot of 0.5mm RMS will likely fail most materials in a single short pulse (~ 2 ns)

Figure depicts prediction of von Mises stress in a stainless steel window for the above conditions. Initial shock stress is ~ 3 x yield strength of material !!

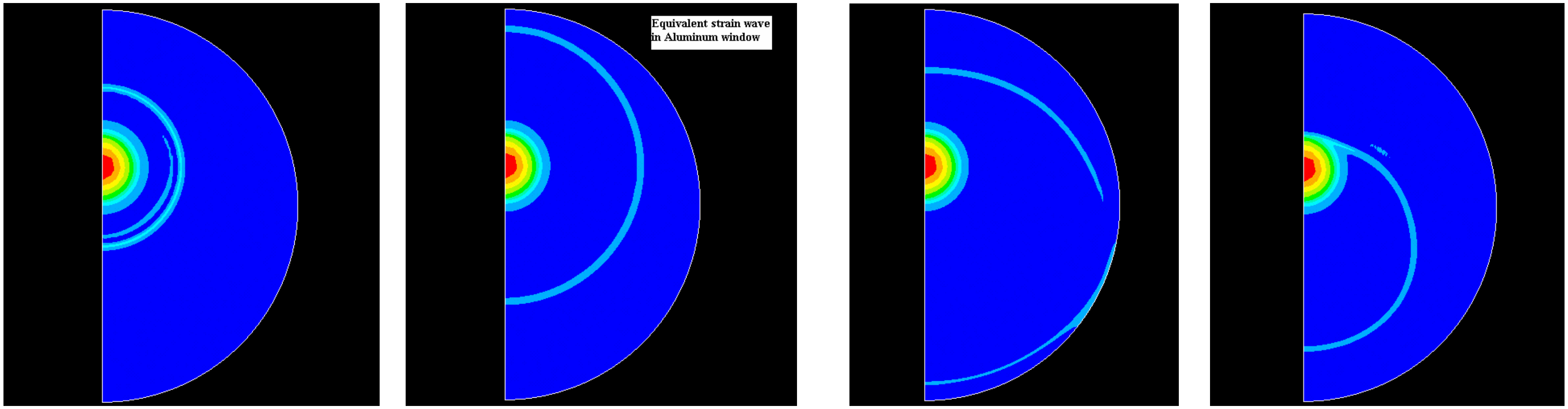
What Did We Learn from Past Studies:
Mechanism of induced shock stress in windows

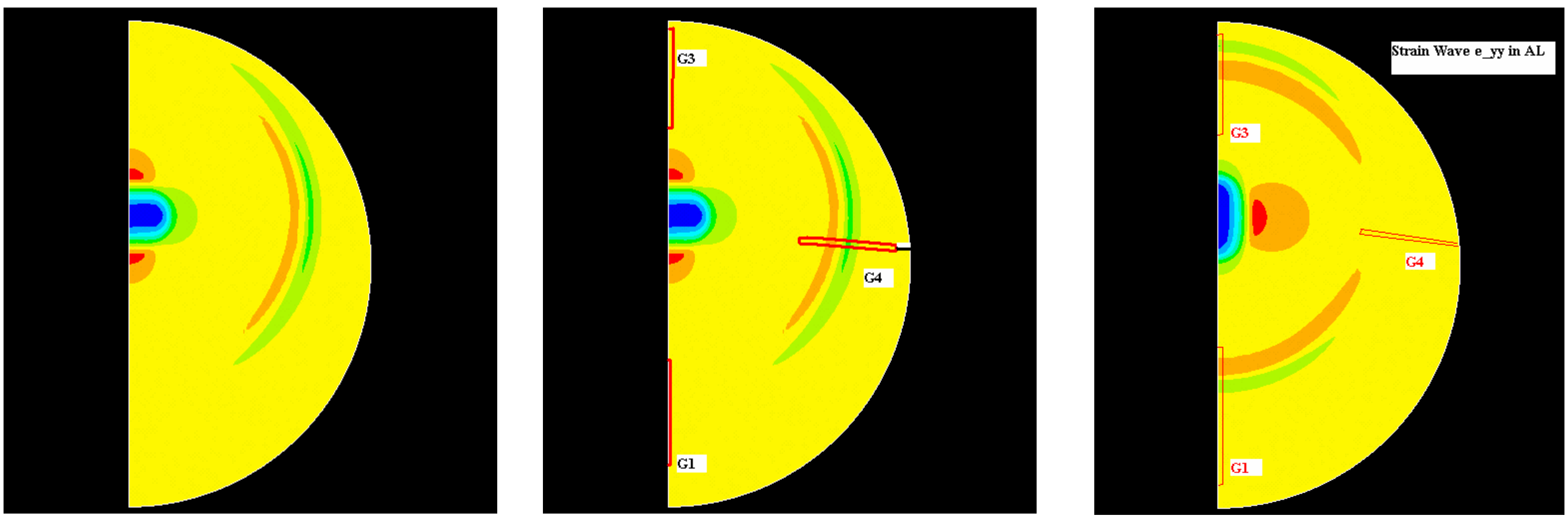


•No matter how thin the window is, the reverberation of stress between surfaces is the key issue

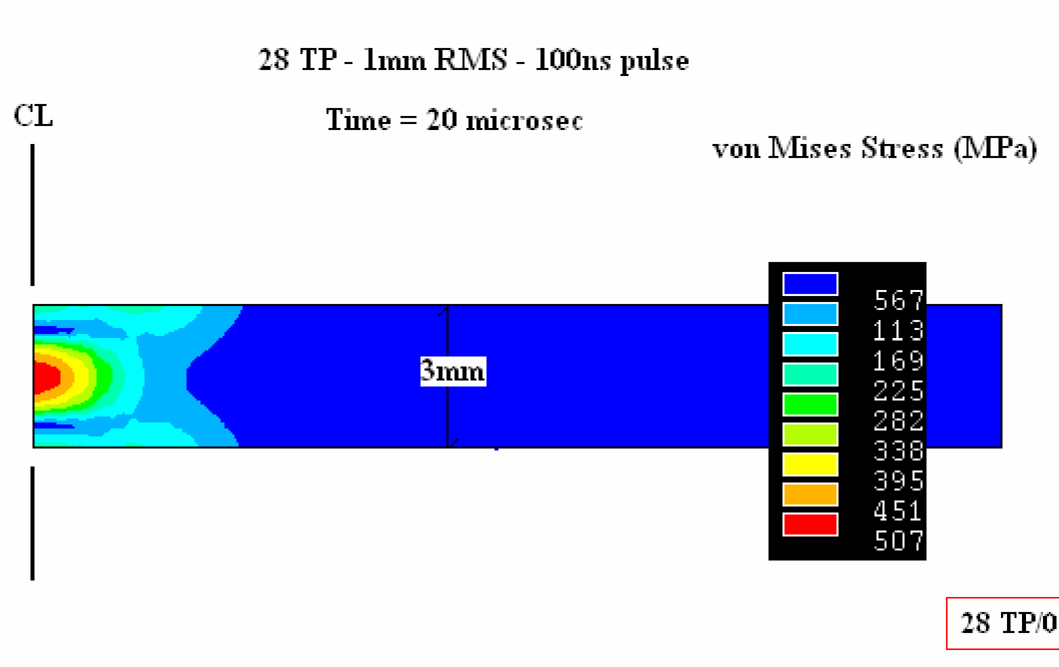
• von Mises stress amplitude depends on the spot size (initial compressive load amplitude), thickness of window, speed of sound and pulse shape

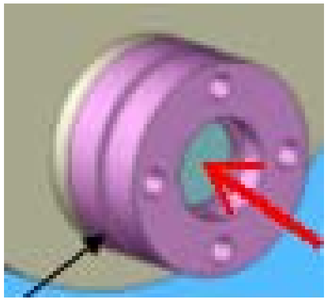
REMEMBER: Beam does not hit where we like it. Things can amplify as we leave the symmetrical world!

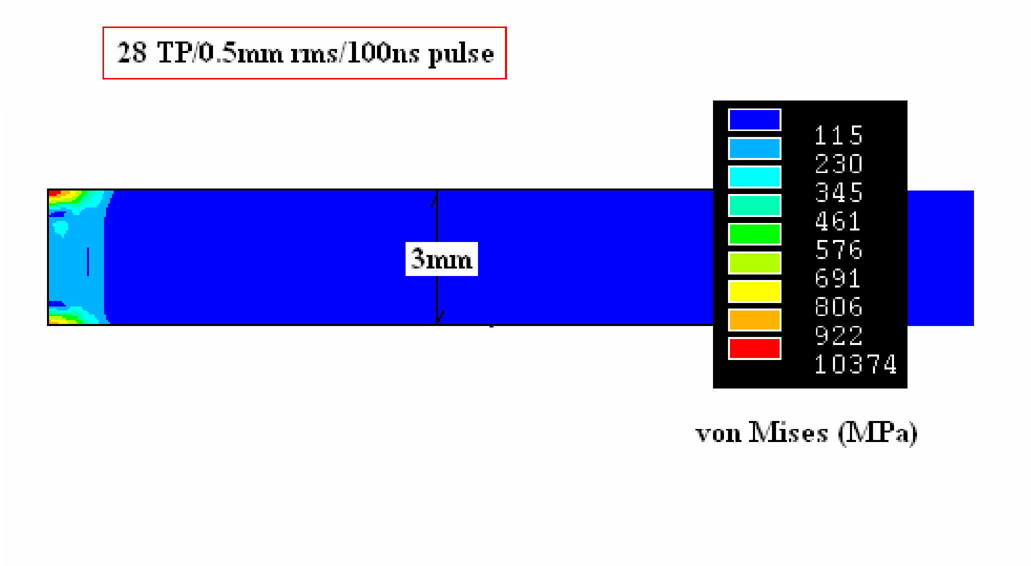




DETAILED BEAM WINDOW ANALYSIS
PHASE I: Windows in a Disk/Flange Arrangement
Window Baseline Material: Ti_6Al_4V

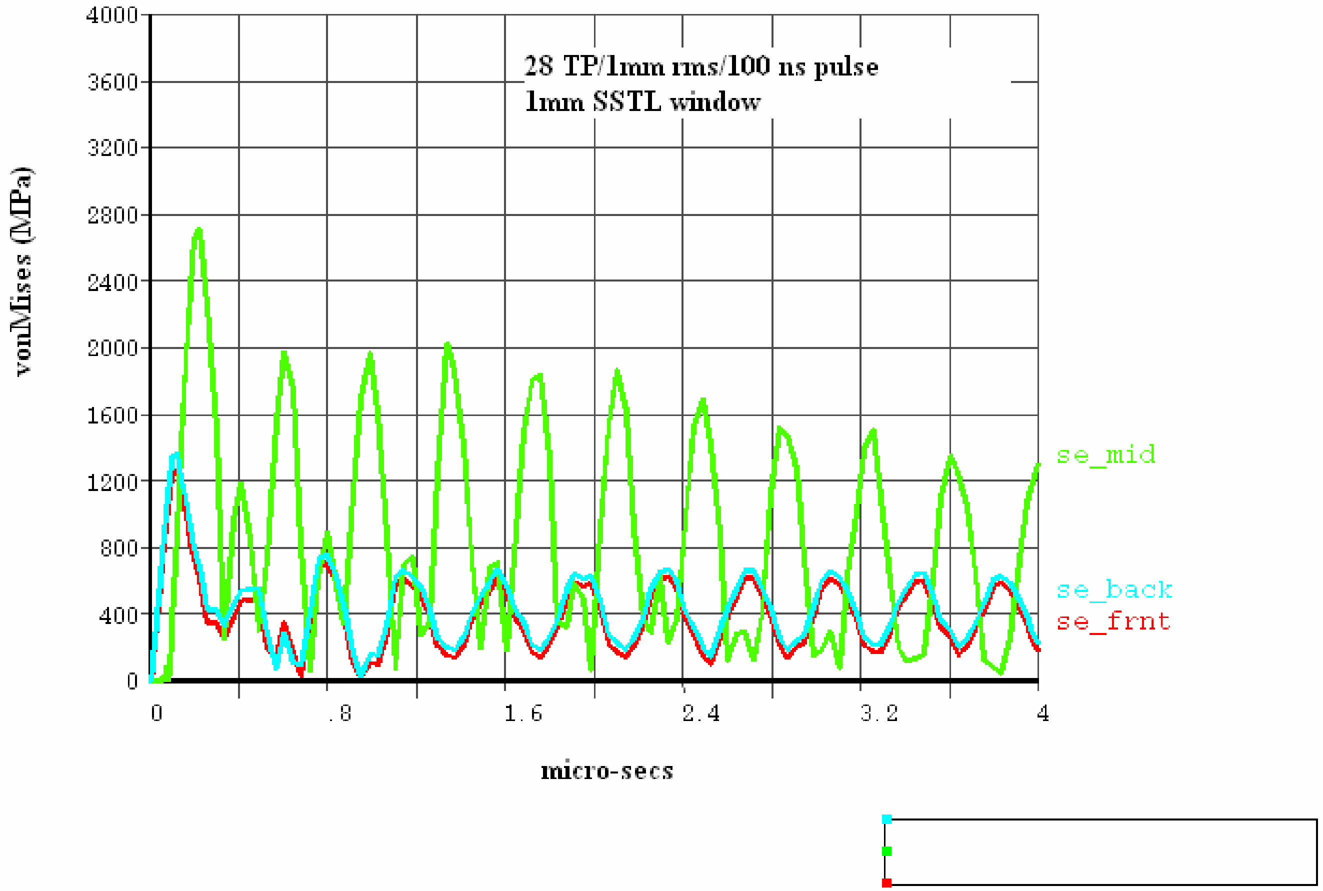






DETAILED BEAM WINDOW ANALYSIS
PHASE I: Windows in a Disk/Flange Arrangement

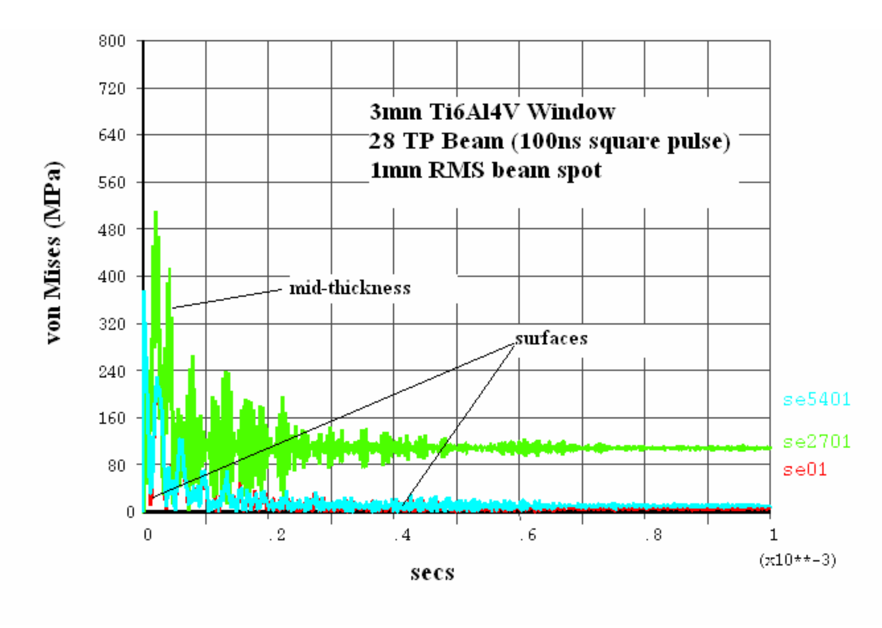
STAINLESS STEEL WINDOW as good as dead

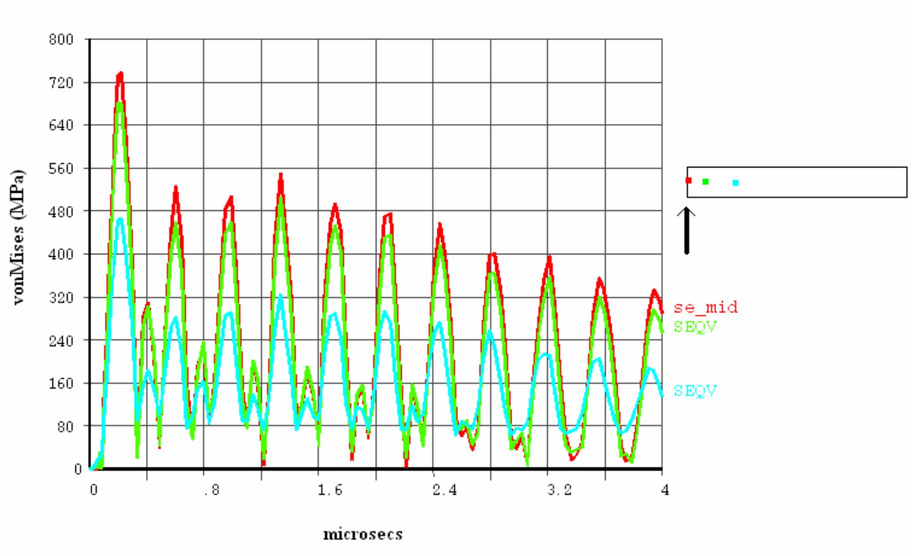


DETAILED BEAM WINDOW ANALYSIS

PHASE I: Windows in a Disk/Flange Arrangement

Scrutinized different window thicknesses/pulse structures





DETAILED BEAM WINDOW ANALYSIS
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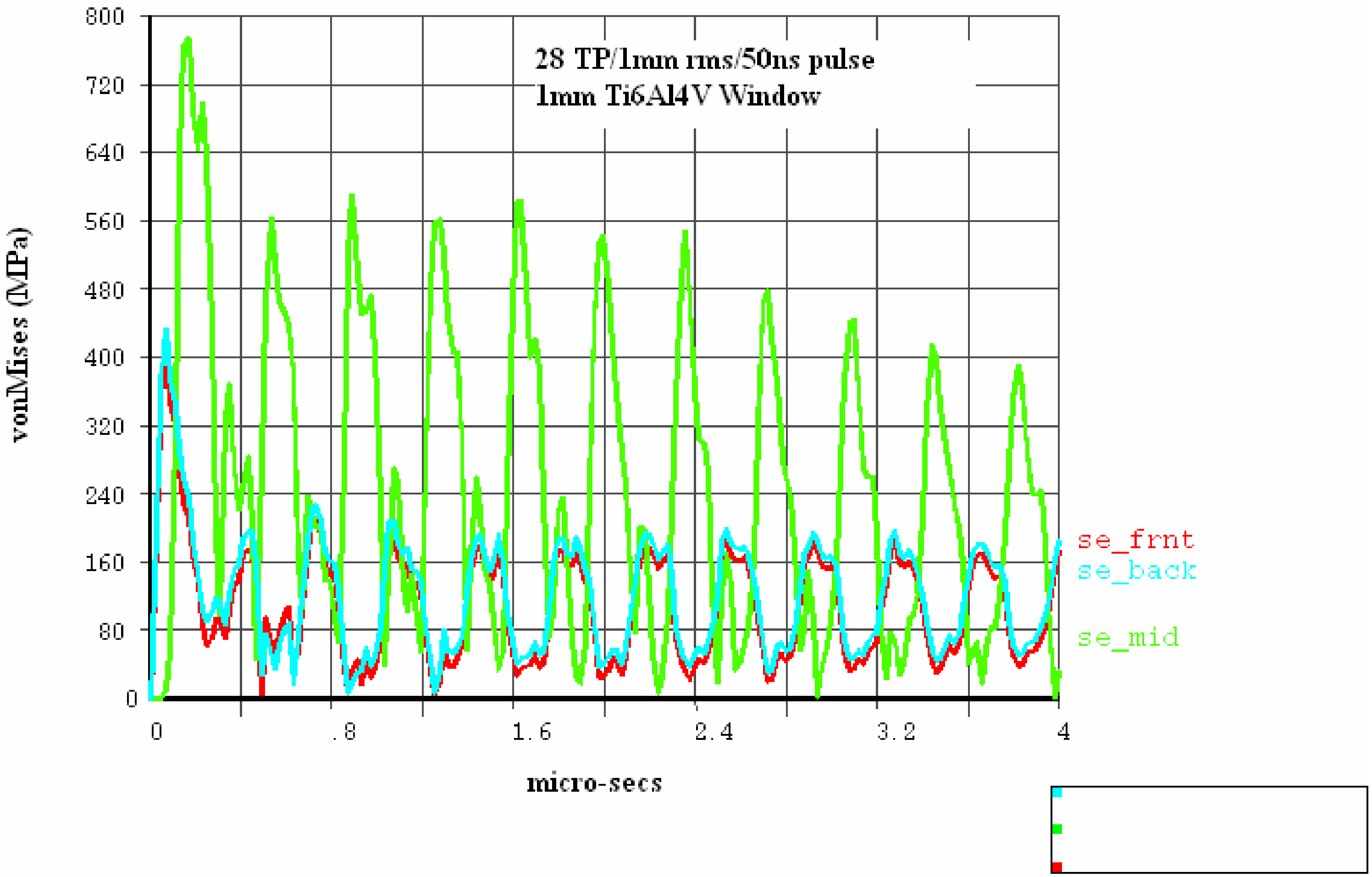

DETAILED BEAM WINDOW ANALYSIS
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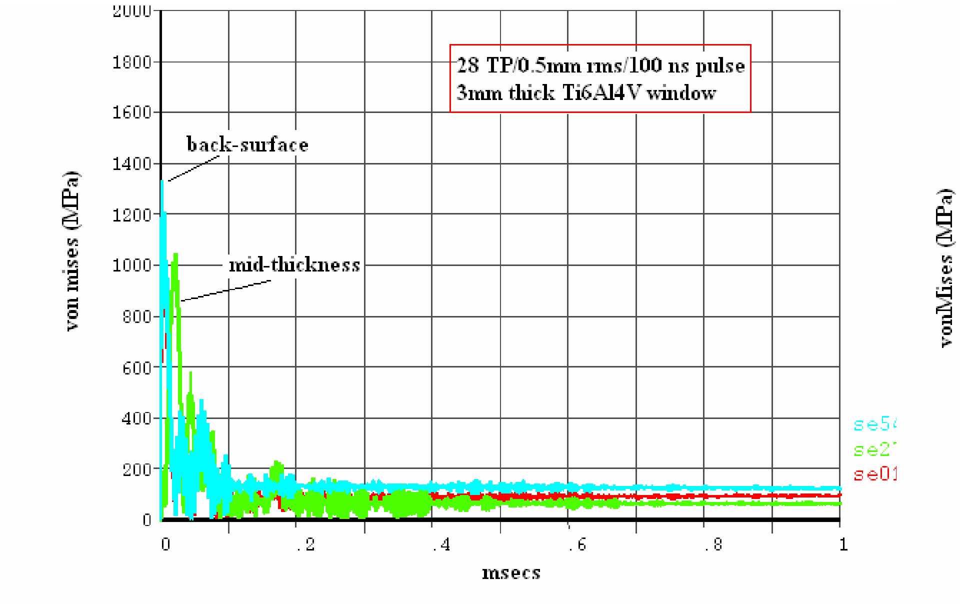
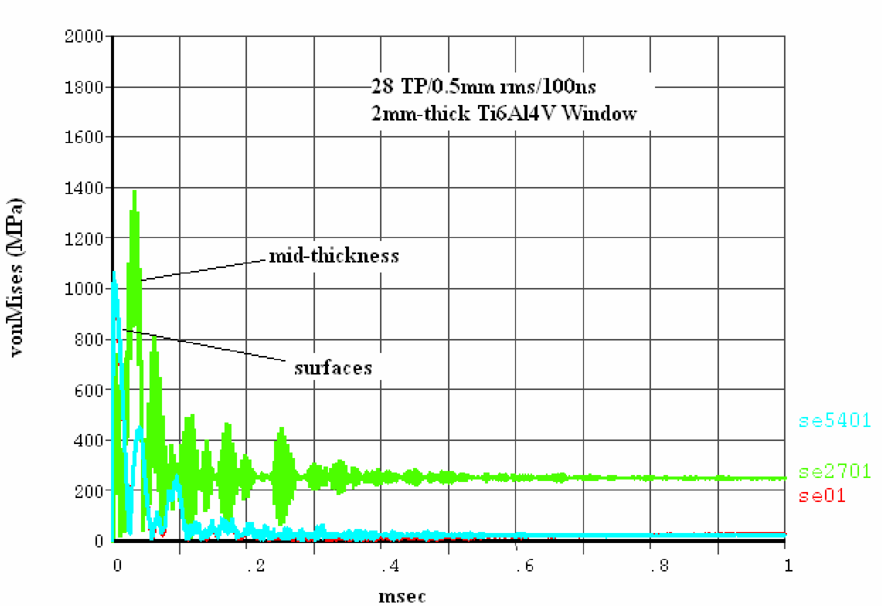
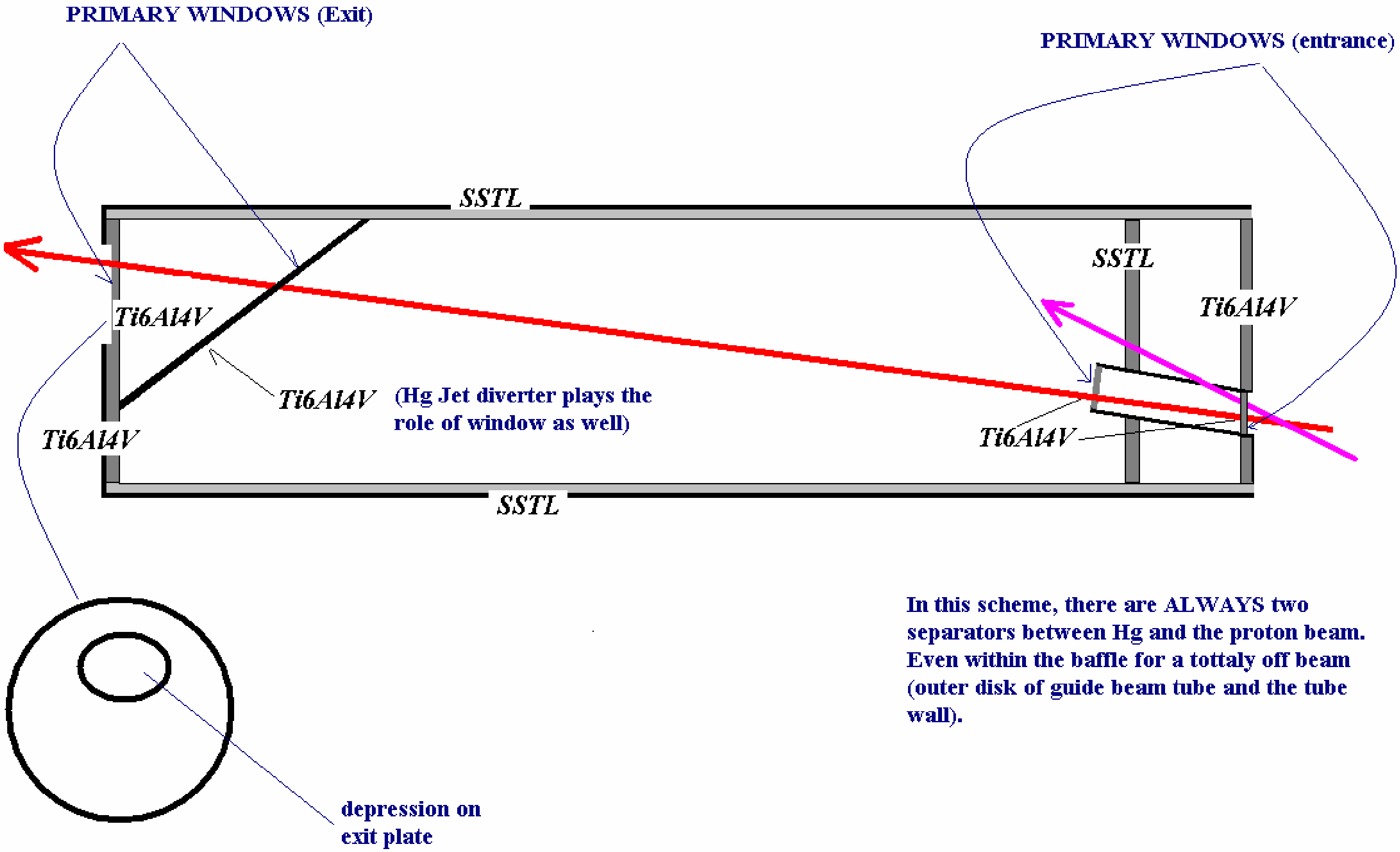




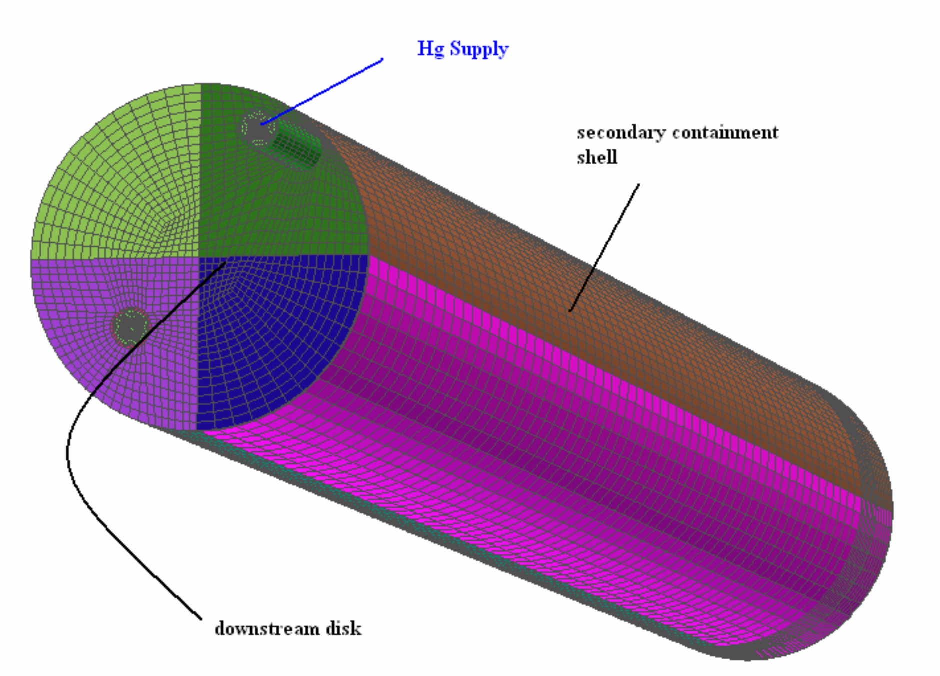
CONCEPTUAL DESIGN of PRIMARY CONTAINMENT/WINDOWS (as introduced at CERN Meeting)

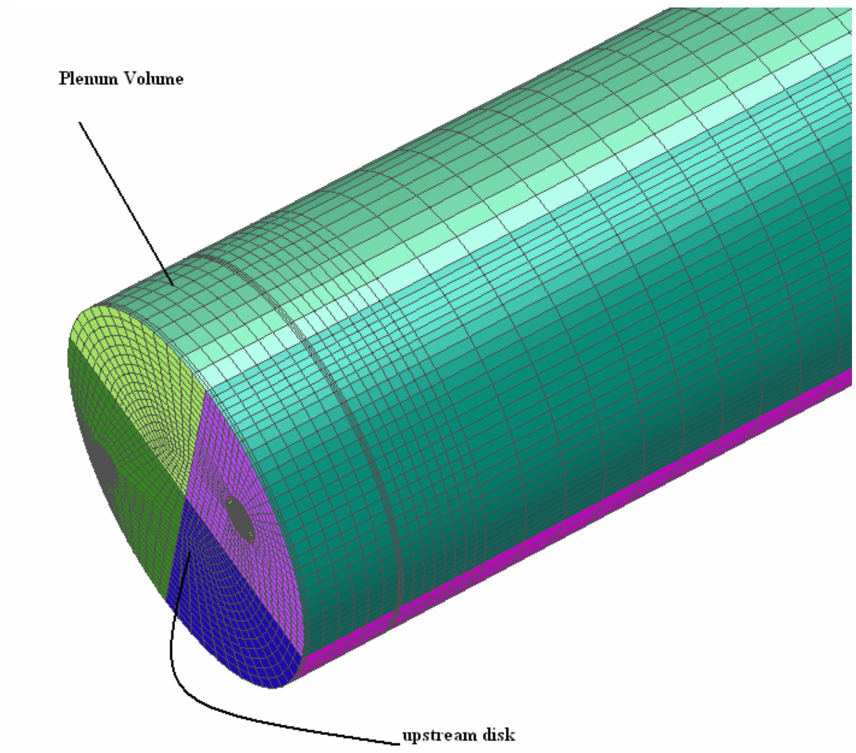


In this scheme, there are ALWAYS two separators between Hg and the proton beam. Even within the baffle for a tottaly off beam (outer disk of guide beam tube and the tube wall).

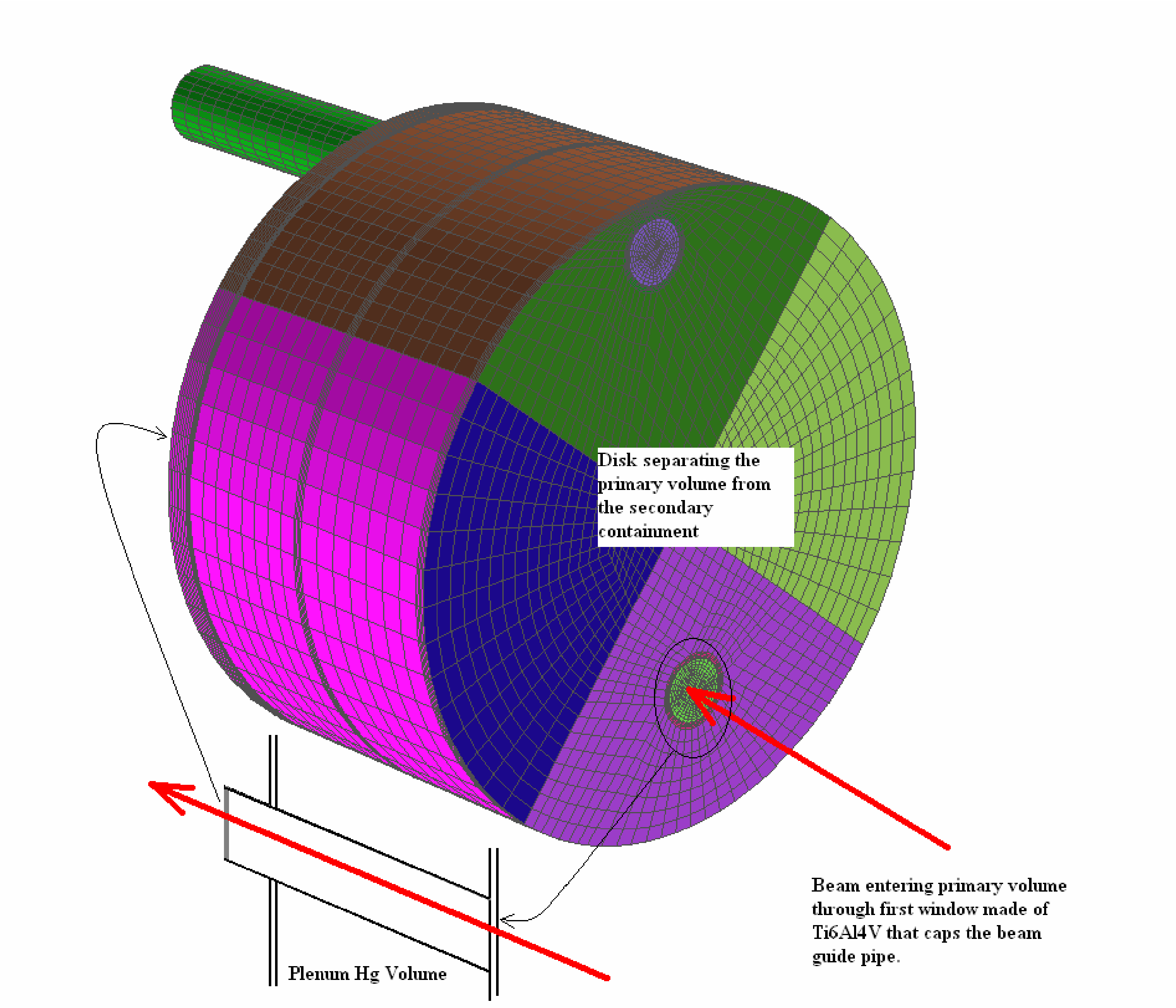
CONCEPTUAL DESIGN of PRIMARY CONTAINMENT/WINDOWS

3-D Analysis with all components in place, including Hg

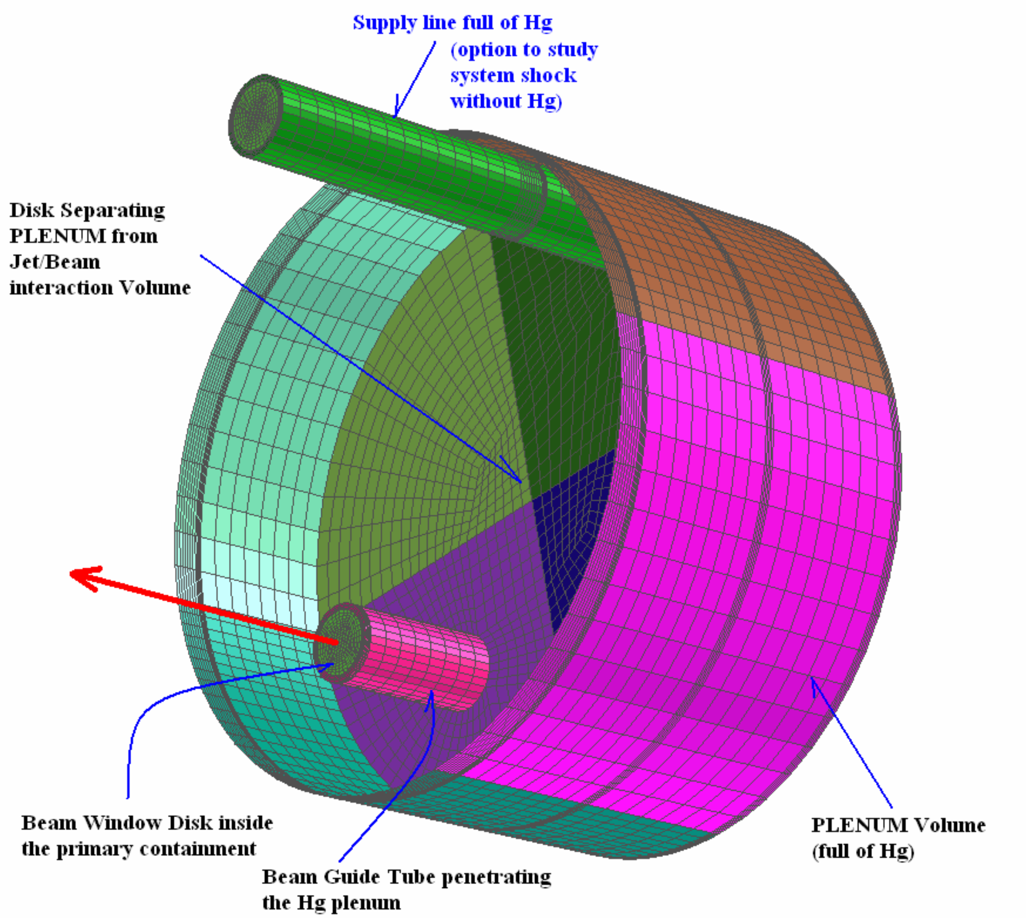


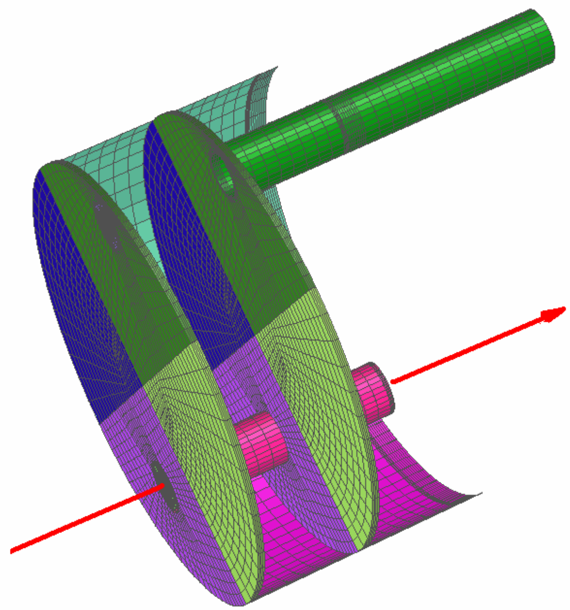


Primary Window DESIGN/ANALYSIS - Detailed Modeling



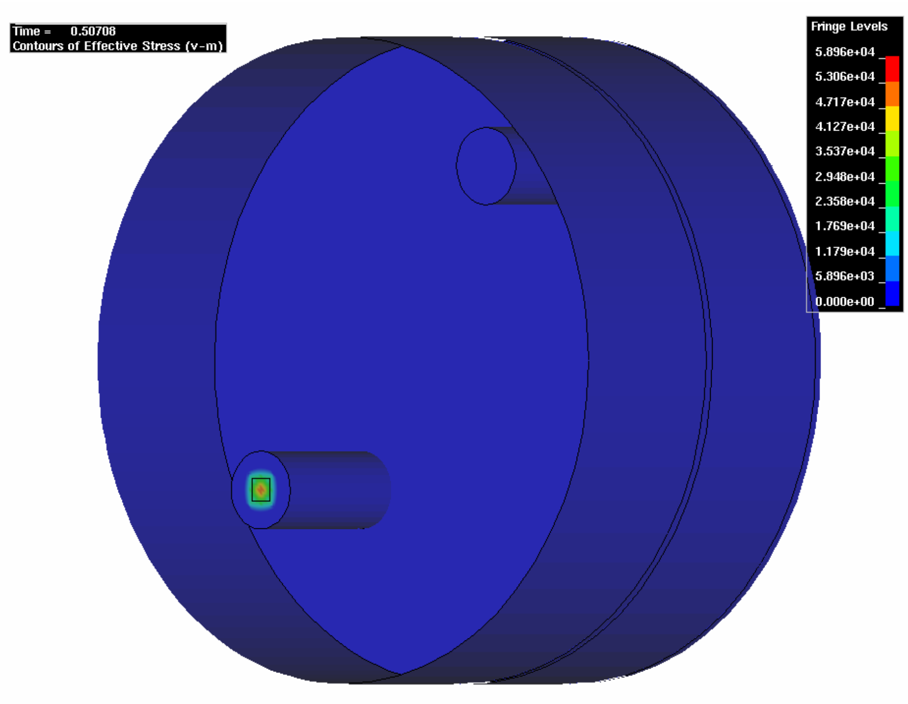
Primary Window Design/Analysis



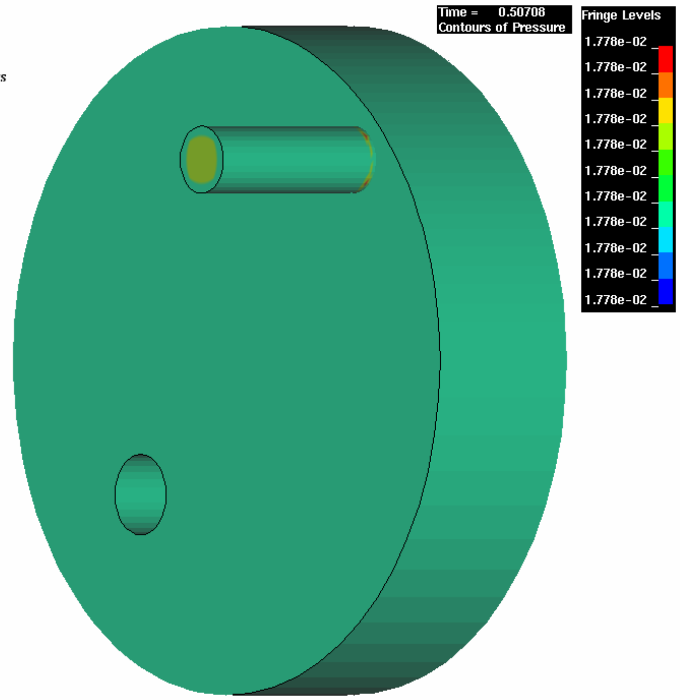


CONCEPTUAL DESIGN

Preliminary Results of Primary Window Stresses and Hg Pressures



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



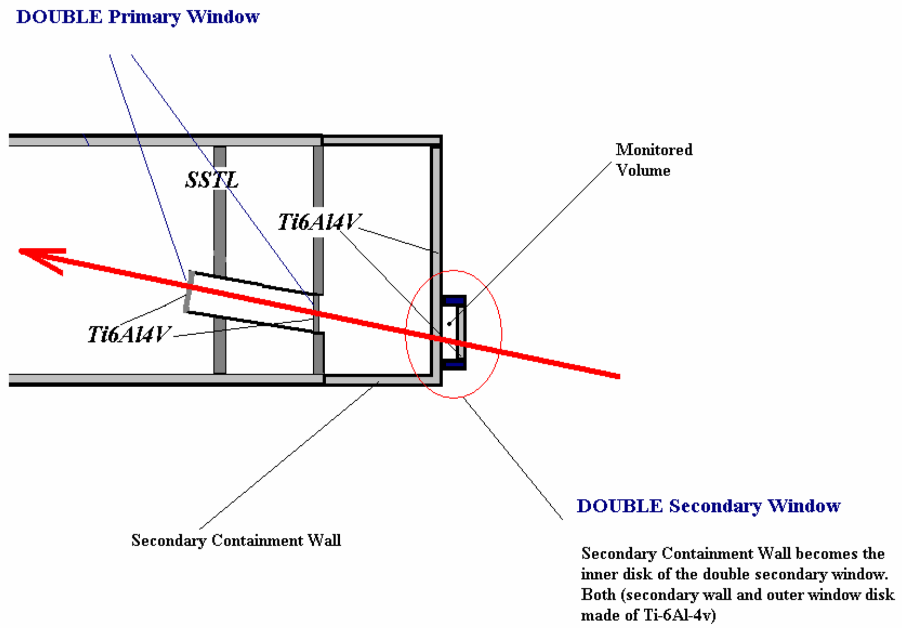
SECONDARY WINDOWS

Use Ti-6Al-4V material for upstream wall of secondary containment and use one window flange arrangement (see Fig. below).

Minimize window infrastructure volume

Create volume for monitoring (as required)

Material chosen able to withstand shock (Ti-6Al-4V)



SUMMARY

- DOUBLE Window Integration both for primary and Secondary can work while minimizing infrastructure
- Material of choice (Ti6Al4V) shown by analysis to do the job even under worst case scenario conditions
- 1mm wall thickness throughout appears appropriate