Update of Vacuum Vessel Analysis

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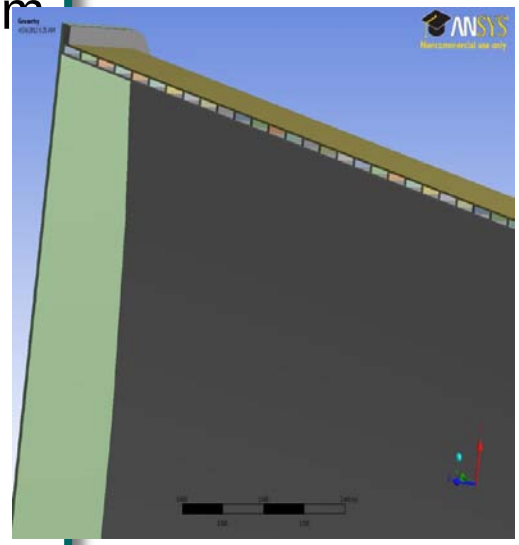
ARIES Meeting
Washington, DC, May 30-June 1, 2012

Revisiting ARIES-AT vacuum vessel

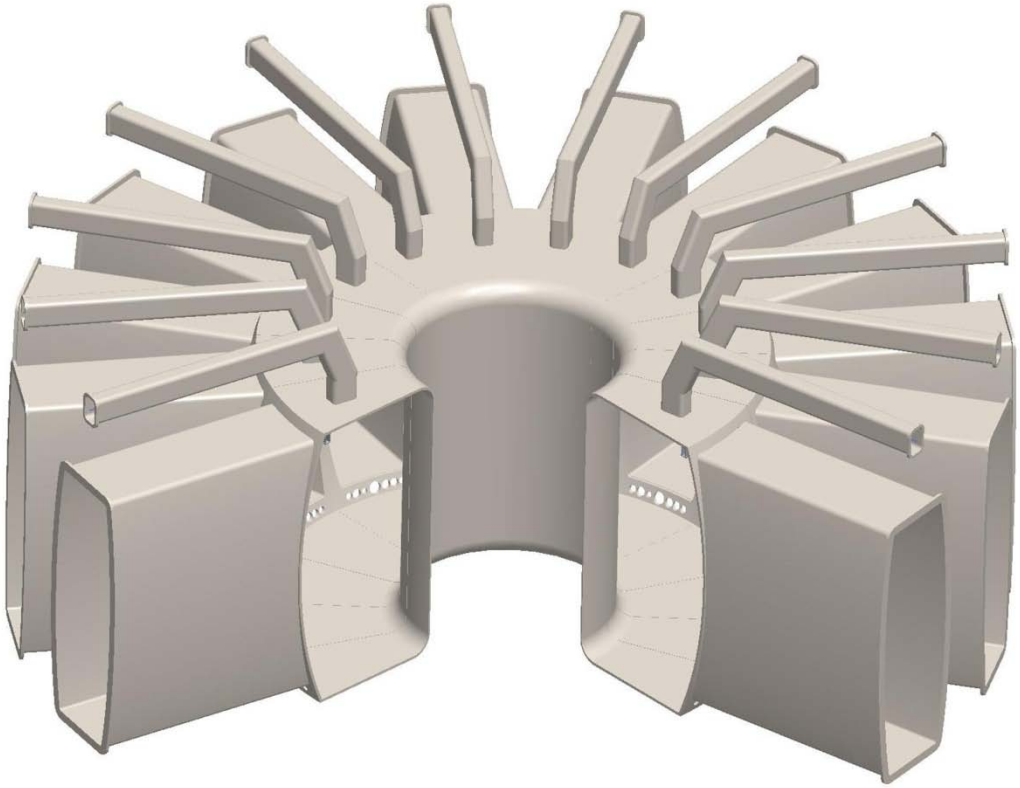
- AREIS-AT had a thick vacuum vessel (40 cm thick) with WC and water to help in shielding. (adoption of ITER vacuum vessel).
  - Expensive and massive vacuum vessel.
  - ITER Components are “hung” from the vacuum vessel. ARIES sectors are self supporting (different loads).
- ARIES-AT vacuum vessel operated at 50^{o}C
  - material?
  - Tritium absorption?
  - Tritium transfer to water?
- Vacuum vessel temperature exceeded 100^{o}C during an accident after a few hours (steam!)

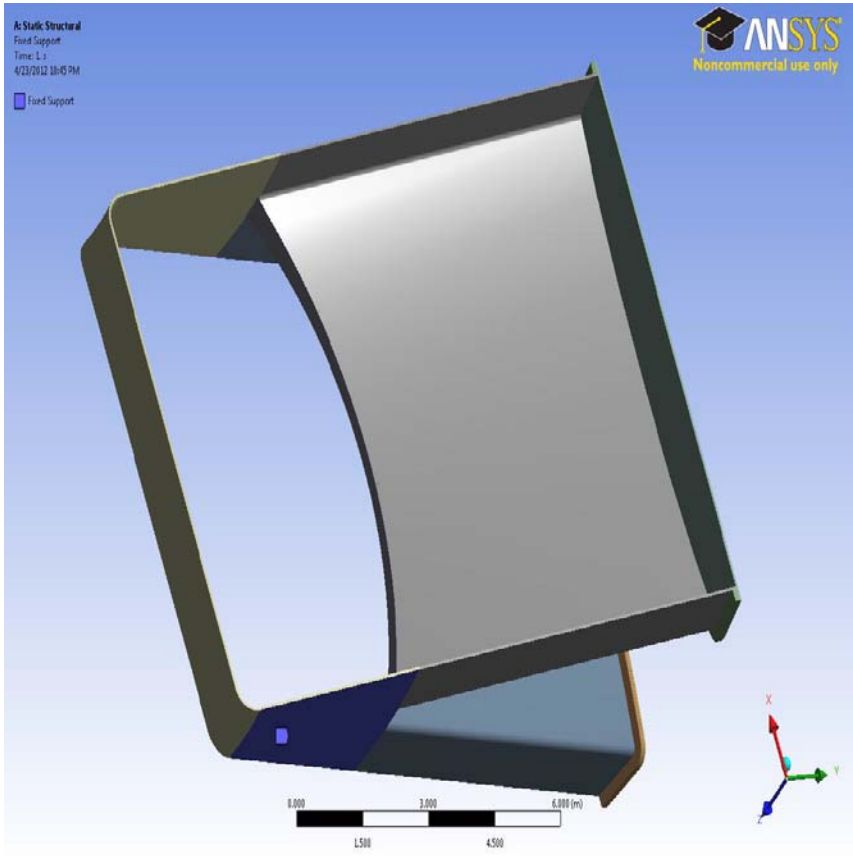
New Vacuum Vessel Design

- Contains no water
  - Can run at high temperature: 300-500^{o}C. (Tritium permeation/inventory can set the temperature).
- Cooled by He flowing between the ribs.
  - Tritium diffused through the inner wall is recovered from He coolant (Tritium diffusion to the cryostat and/or building should be much smaller.
- Smaller (and cheaper?) vacuum vessel



ANSYS Model of the vacuum vessel





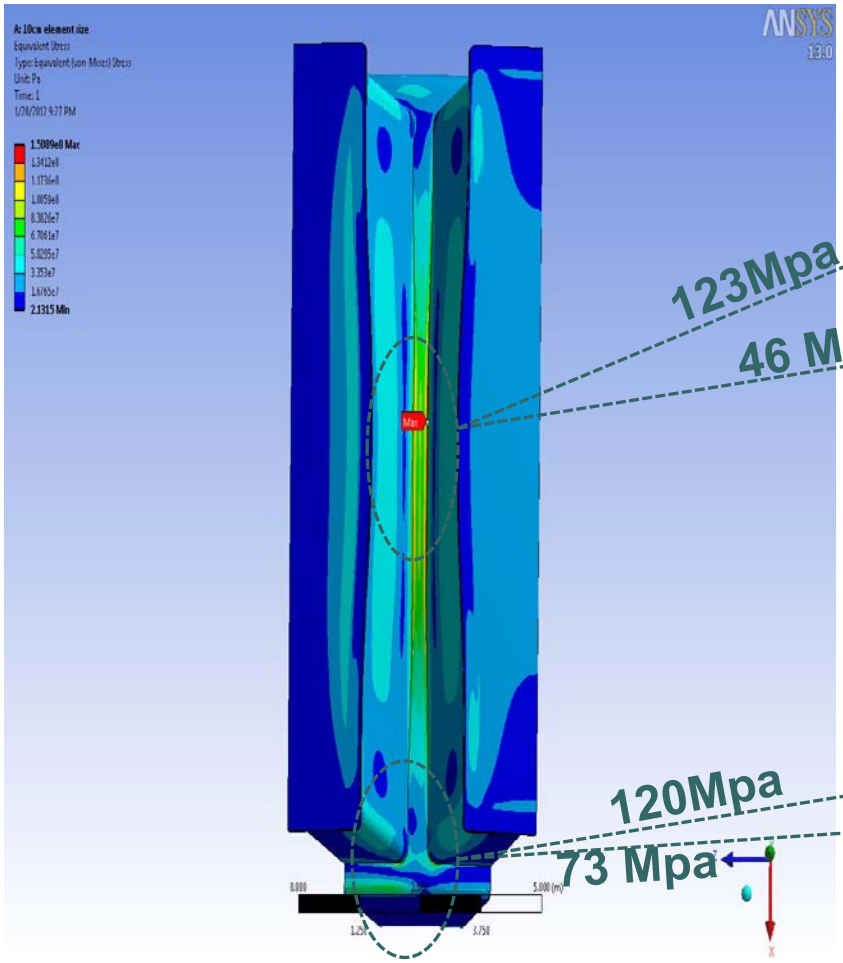
Currently, we are only considering atmospheric and gravity loads.

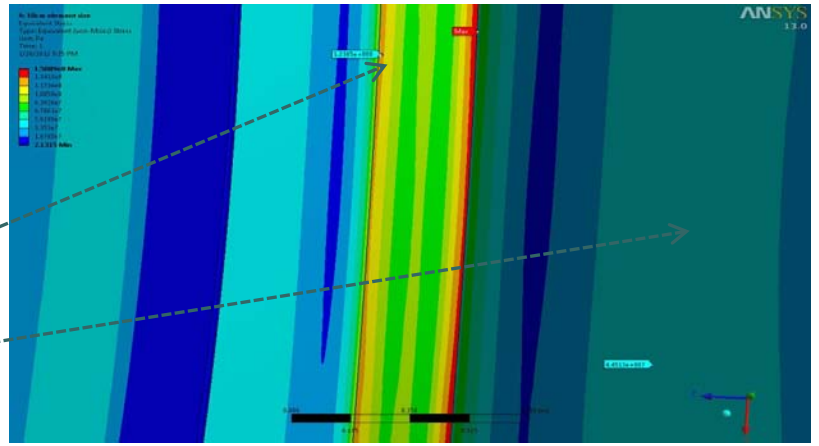
Scoping Studies

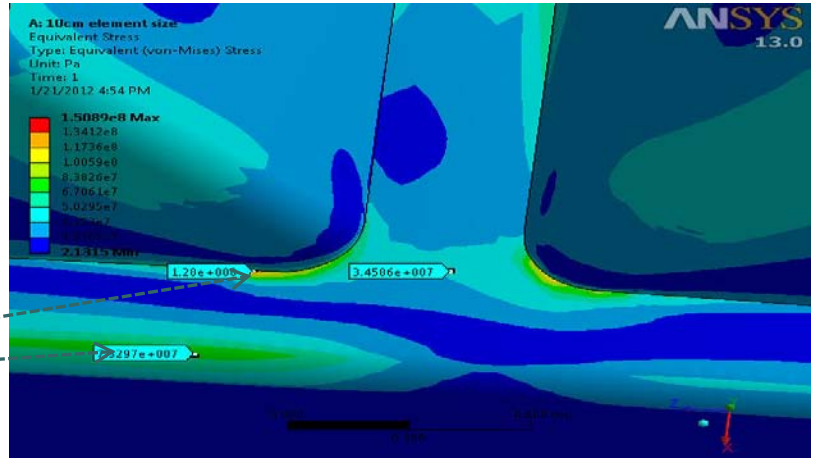
1. Solid, constant thickness vessel for convergence studies and to find the areas of high stress.
   - A 10-cm steel vessel can support the loads. (discussed in the last project meeting).

2. Ribbed structure:
   - Focused on port walls to identify optimum ribbed structure (work is in progress).
   - Complete double-walled vacuum vessel will be analyzed once optimization of the ribbed structure is complete.

10cm Thick “Solid” Vacuum Vessel







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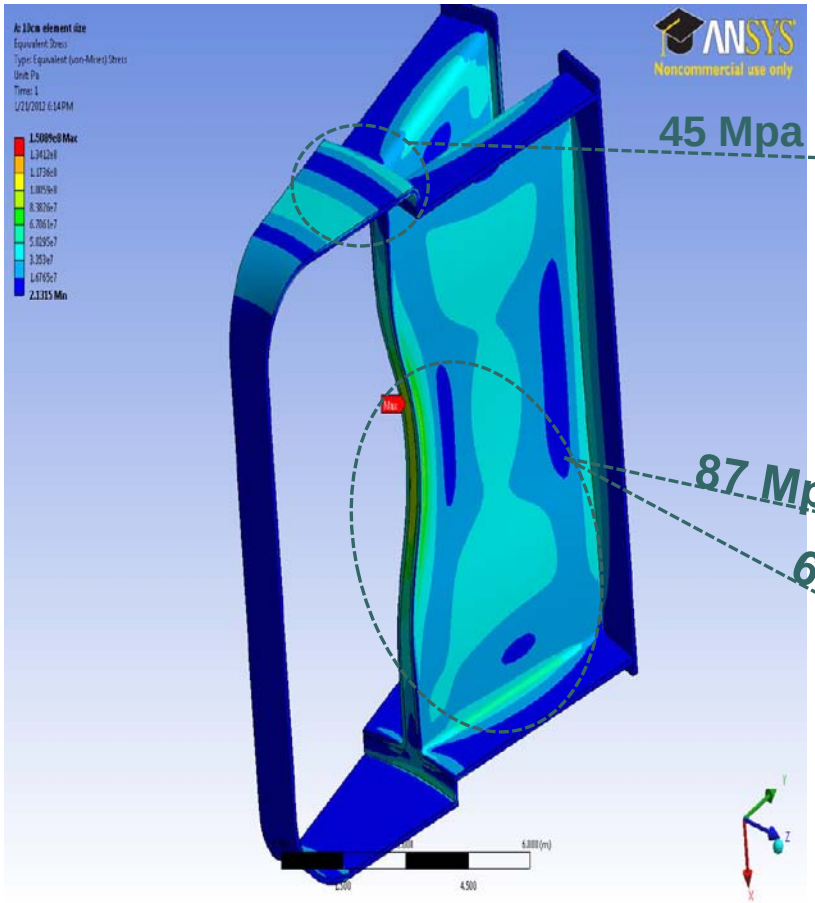

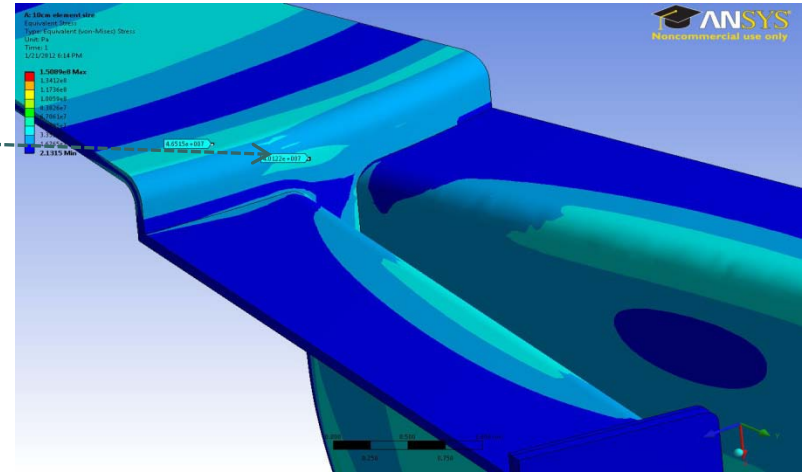

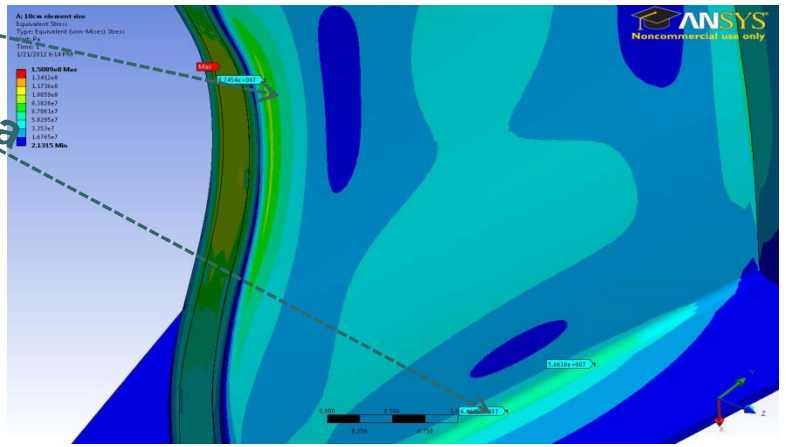

Scoping Studies

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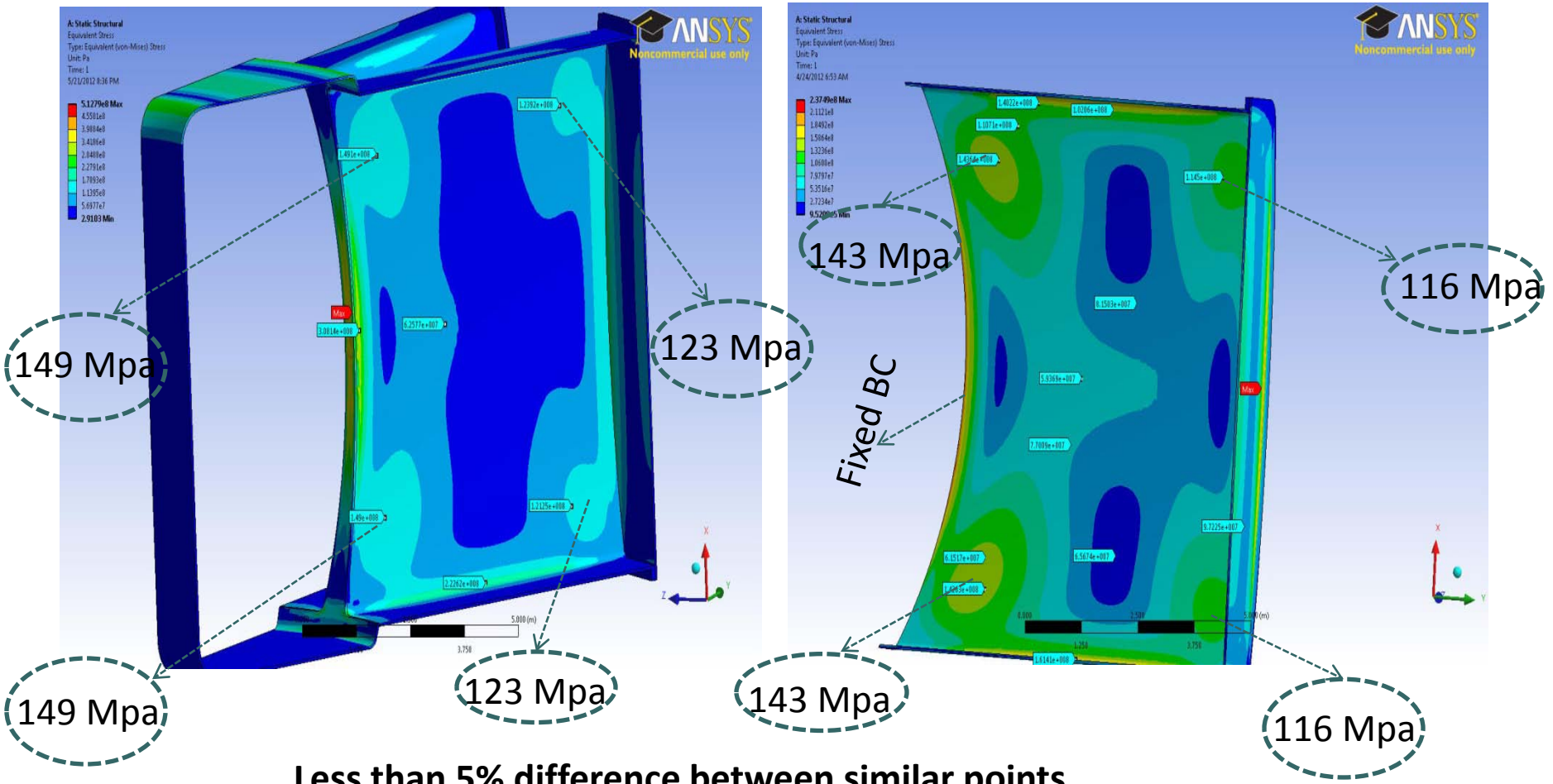
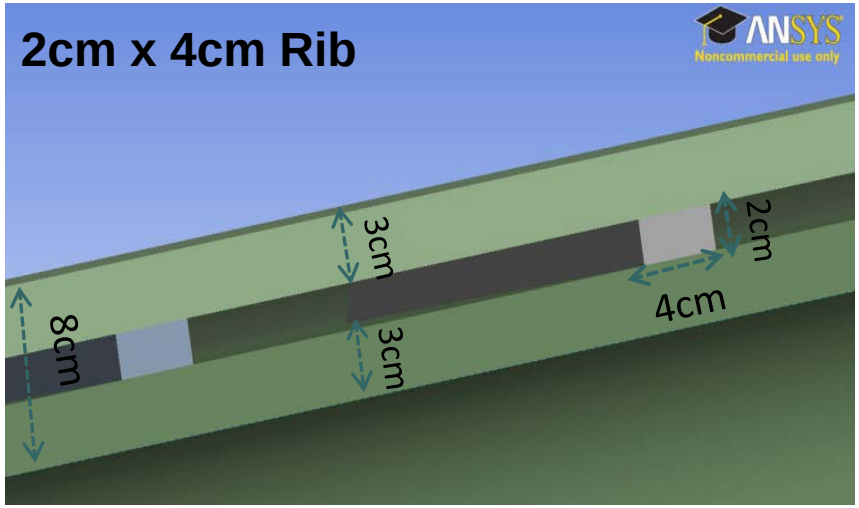
A simplified structure for optimizing ribbed structure:

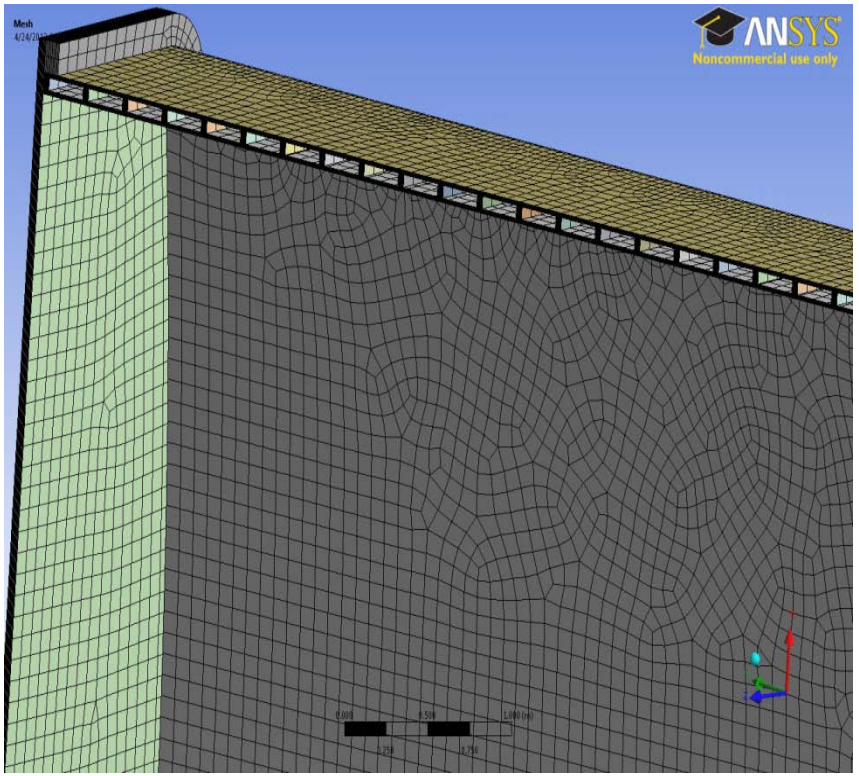
- 5-cm thick Vacuum Vessel
- Fixed BC - 5cm Thick Port

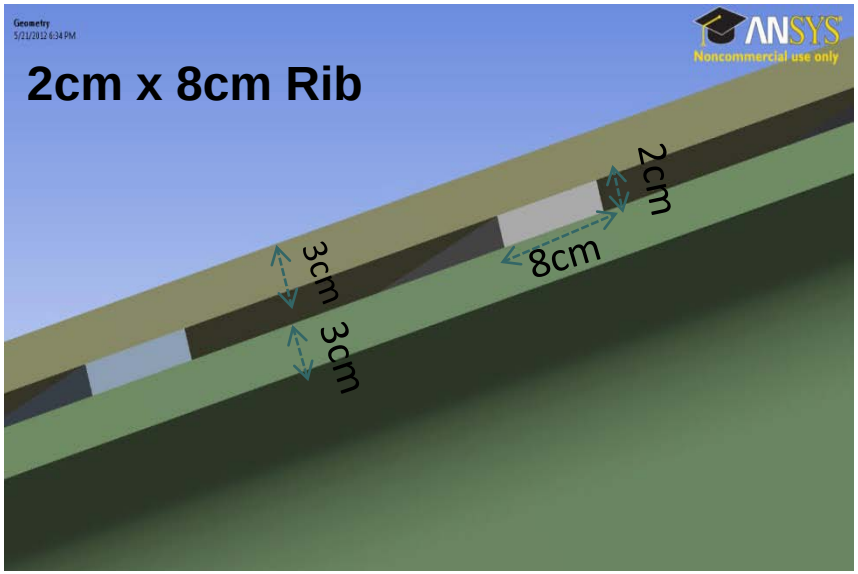


Less than 5% difference between similar points

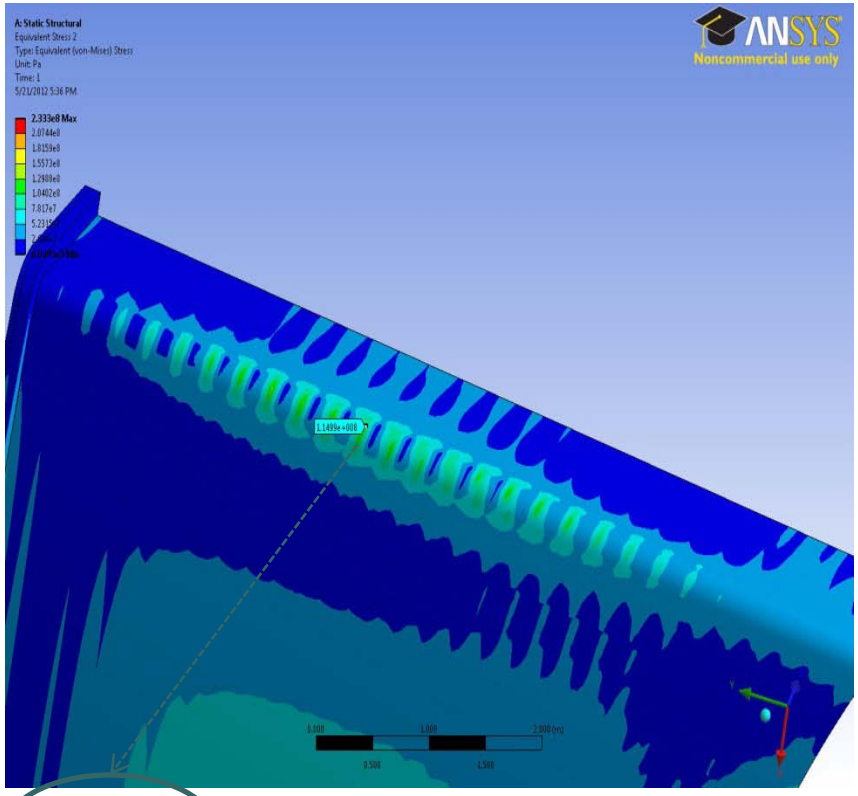
A variety of Rib size/spacing are considered.



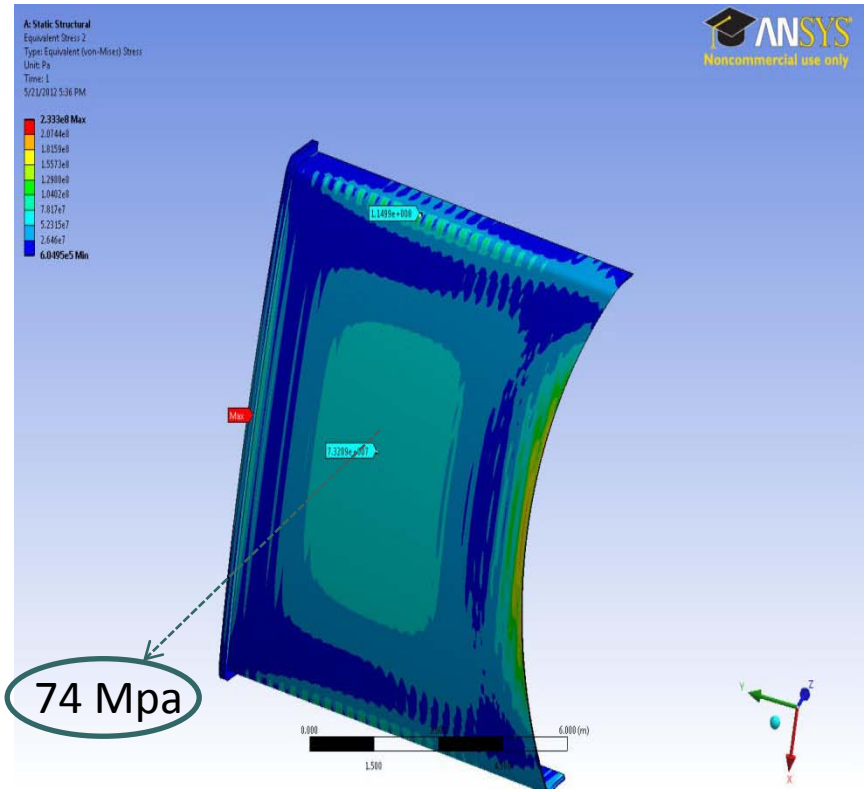




There is a substantial reduction in stress (outer plate)

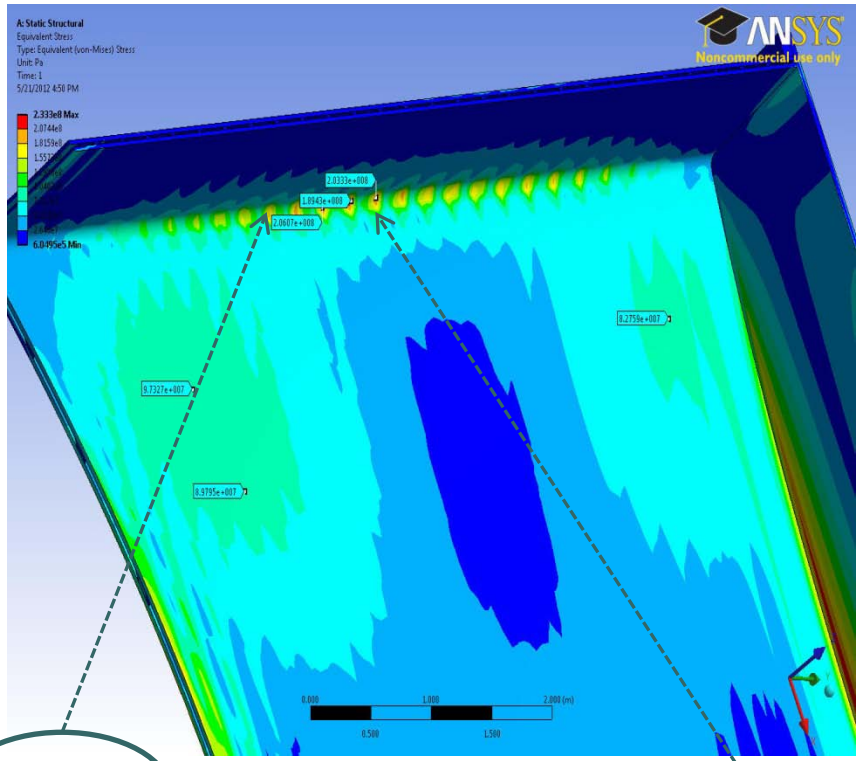


100 Mpa



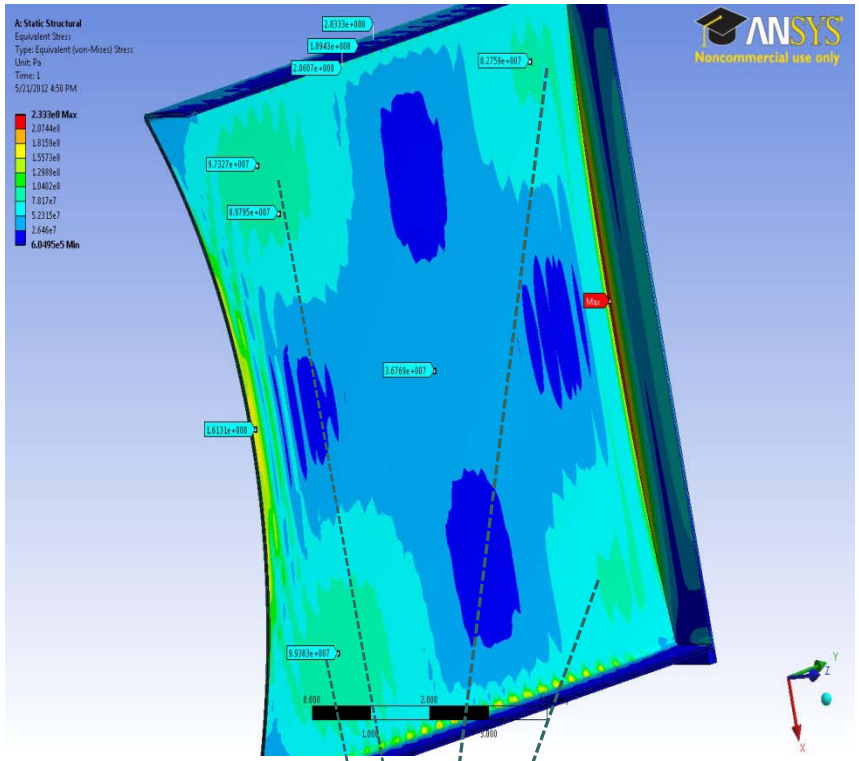
74 Mpa

Stress is higher on the inner plate.



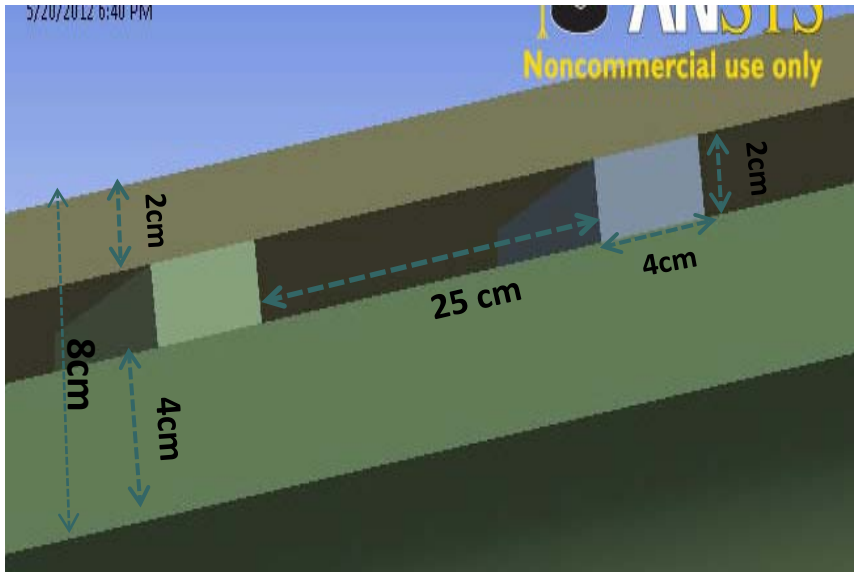
190 Mpa

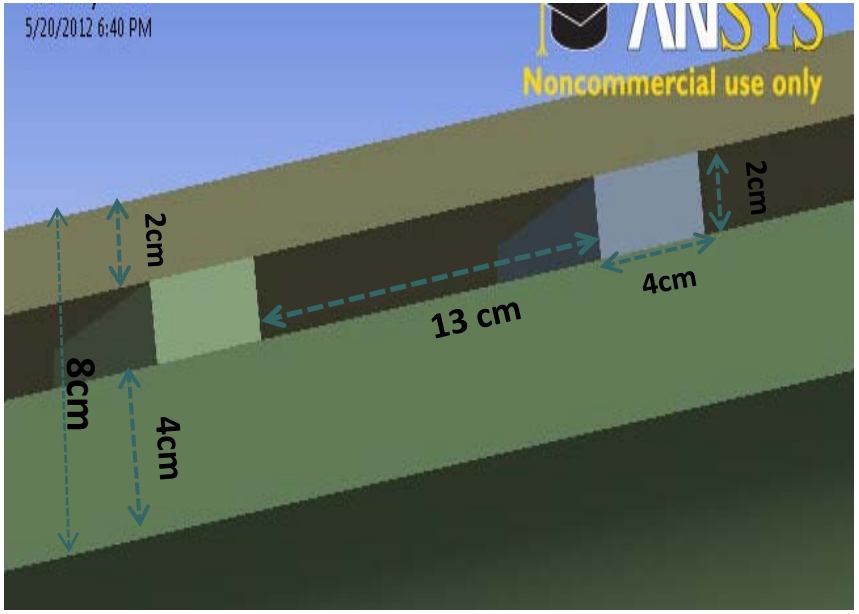
200 Mpa



< 100 Mpa

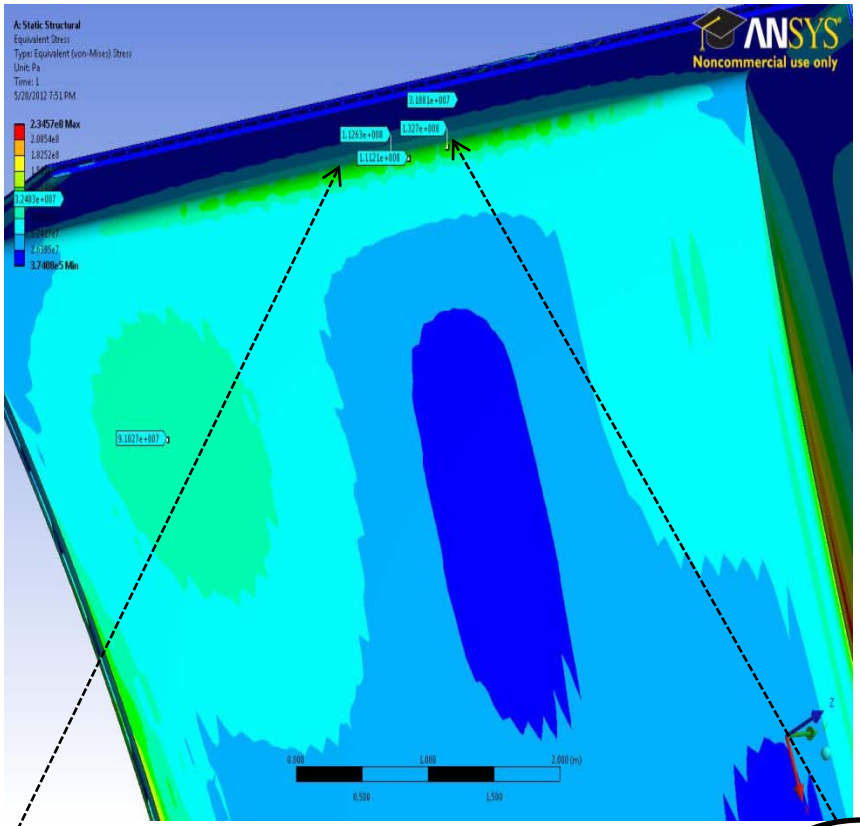
Increasing the thickness of inner plate and reducing distance between ribs helps reduce stresses





Stress Distribution (High Stress Areas)

Inner Sheet (4cm Thick)

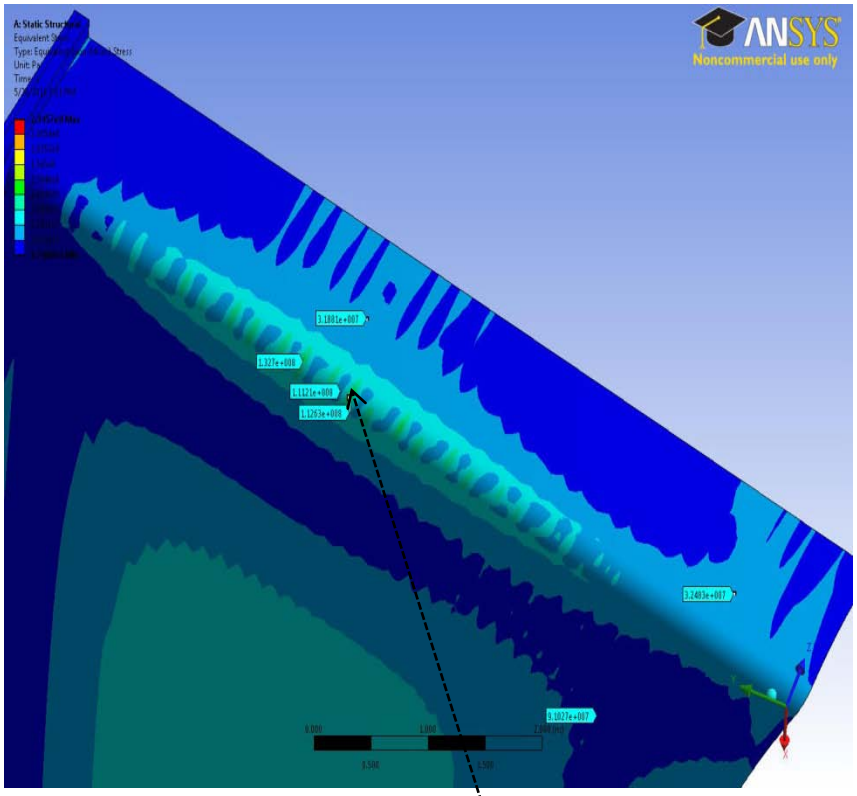


112 Mpa

35% Stress Reduction
Not Over Stressed < 140 Mpa

130 Mpa

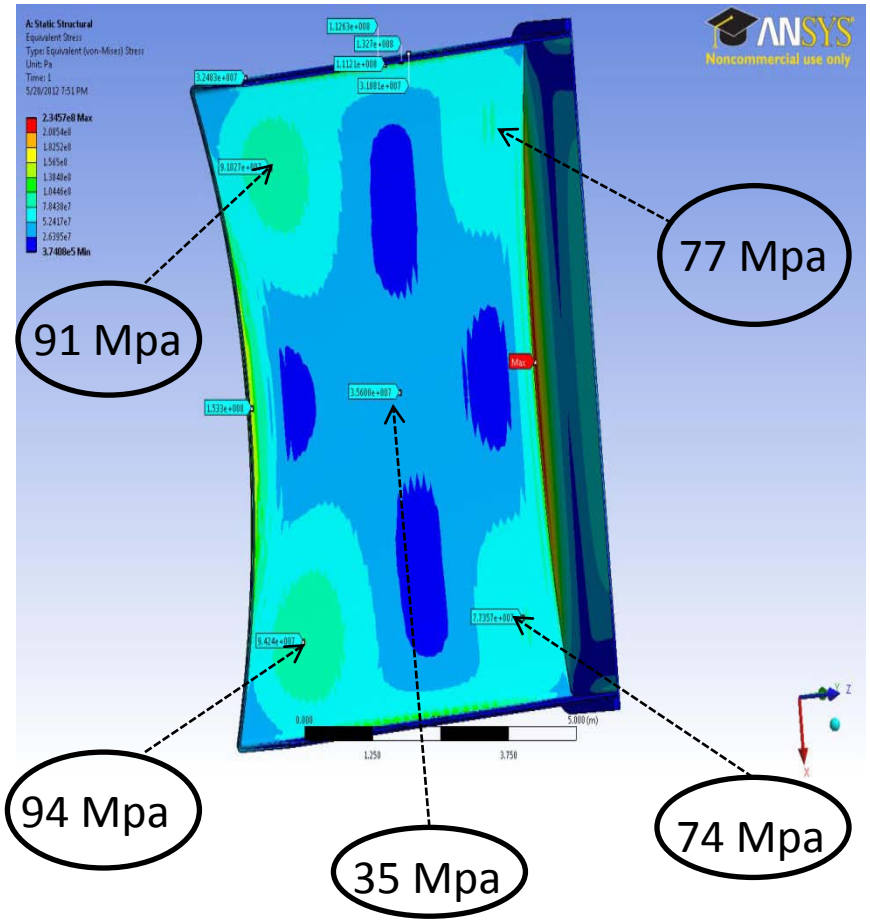
Outer Sheet (2cm Thick)



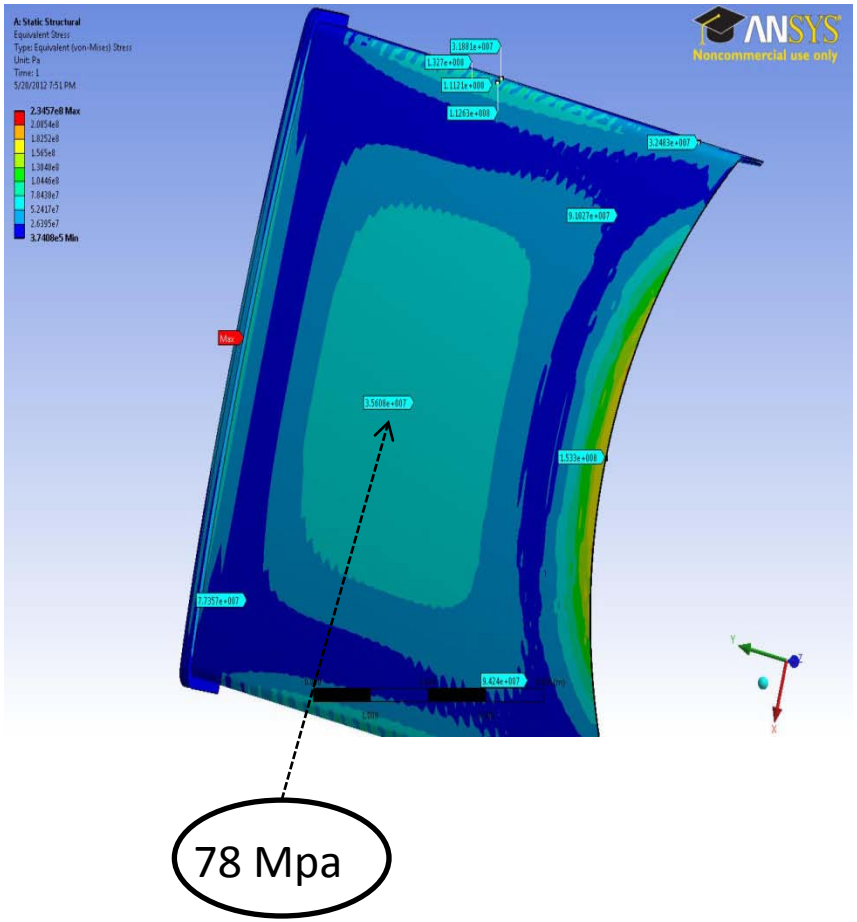
110 Mpa

Stress Distribution

Inner Sheet (4cm Thick)



Outer Sheet (2cm Thick)



Comparison Table

Type of Vacuum Vessel	High Stress Region on the Port
5 cm Single Wall	190 _ 230 Mpa
10 cm Single Wall	80 _ 100 Mpa
8 cm Double Wall (Ribbed Structure)	110 _ 130 Mpa

- We are continuing to optimize ribbed structure (plate thickness, rib spacing, plates spacing, and rib direction).