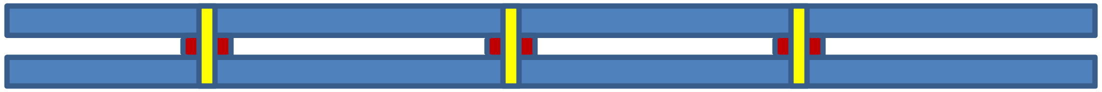
Detector and Component Stress & Deformation Analysis

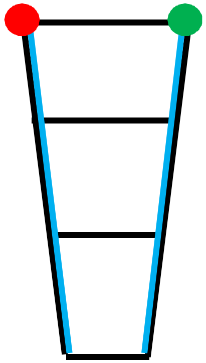
Ronan McGovern & Diego Perini

Summary

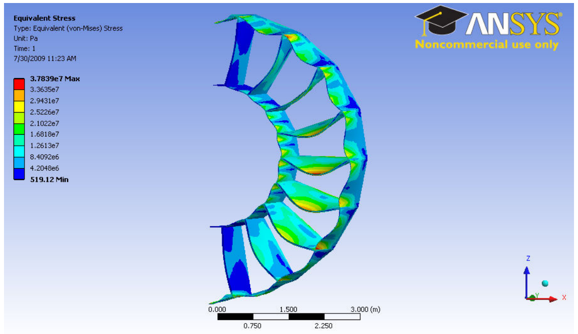
- Layer & Bolting Analysis



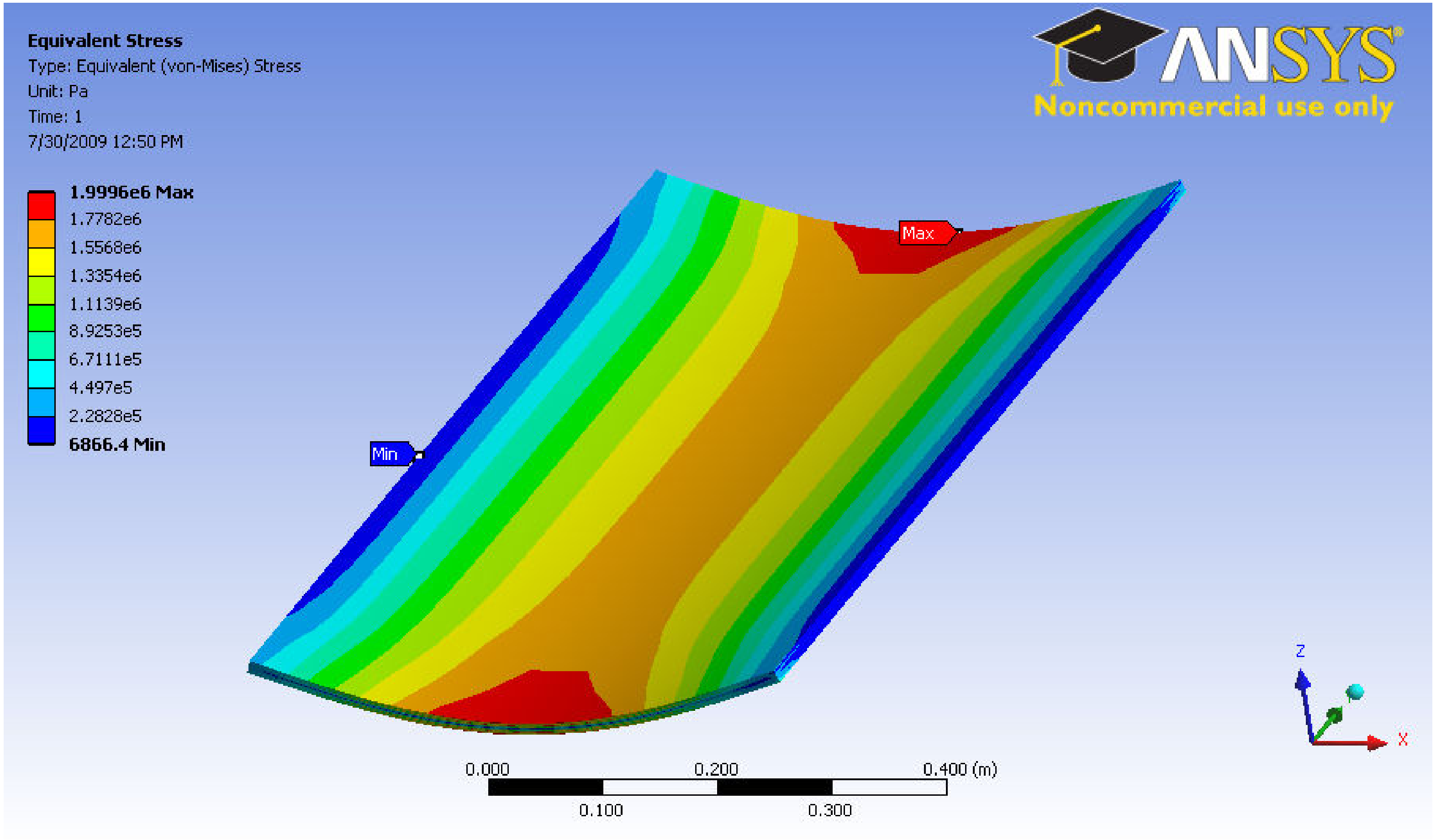
- Detector Section 2D analysis



- 3D detector analysis

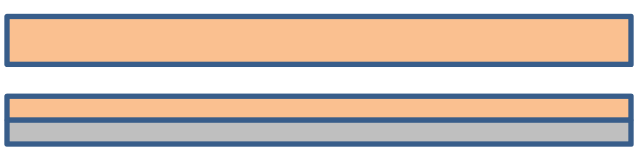


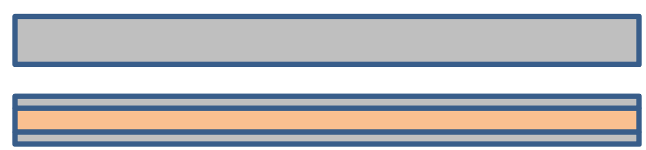
Layer Analysis – Layer Options



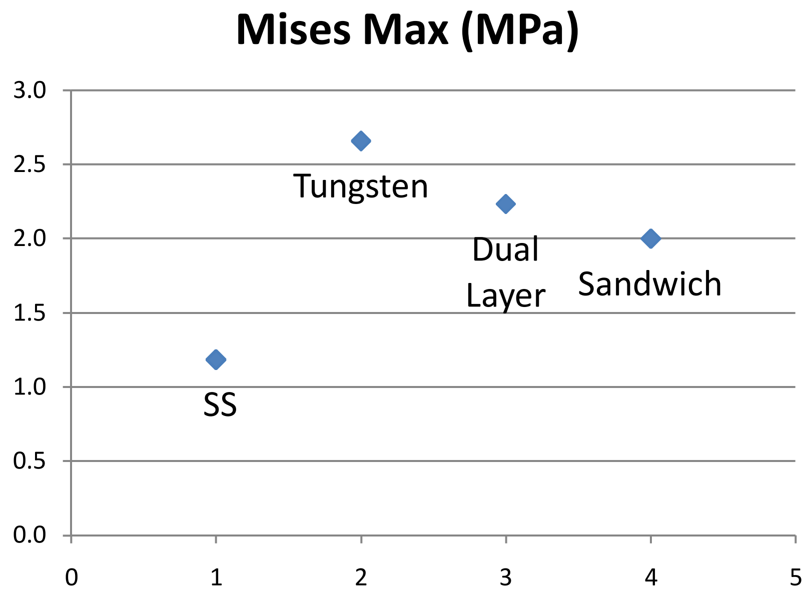
Layer Analysis – Layer Options

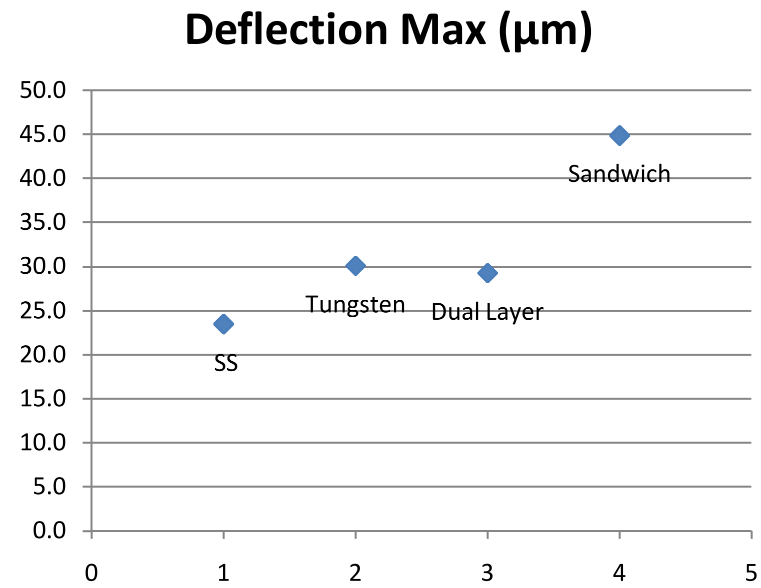
Tungsten Layer Design										
Densities						Sandwich				
Tungsten	17600	kg/m^3				Material	Thickness			
SS	7800	kg/m^3			1	SS	3.25			
Detectors	2300	kg/m^3			2	W	6.5			
Gap	0	kg/m^3			3	SS	3.25			
							13	mm		
Detectors						Dual Layer				
1	Silicon	7				Material				
(Gap) 2	Vaccuum	1			1	SS	6.5			
Total		8	mm		2	W	6.5			
		2012.5	kg/m^3				13	mm		
Total Layer Density/ Compartment Density										
Sandwich				8628.571	kg/m^3	Dual Layer			8628.571	kg/m^3



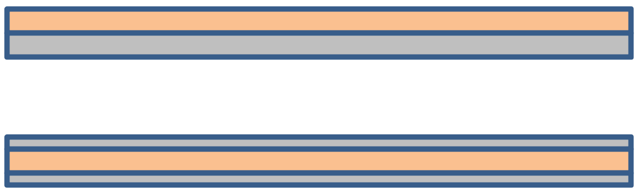


Layer Analysis – Layer Options



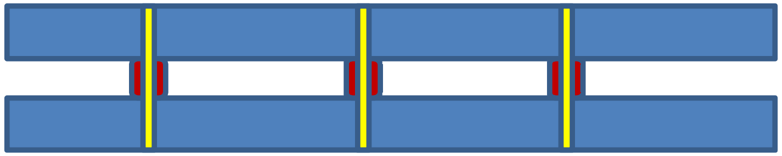


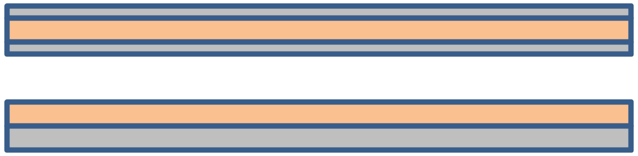
- Layer subjected to it's own weight



Layer Analysis – Layer Options

- Advantages of SS-W layer over W layer
  - Reduced costs
  - Allow a reduction of concentrated forces applied to W.
- Sandwich versus Dual layer
  - Sandwich protects Tungsten from washer forces
  - Thickness of SS in sandwich is thin - difficult to bolt

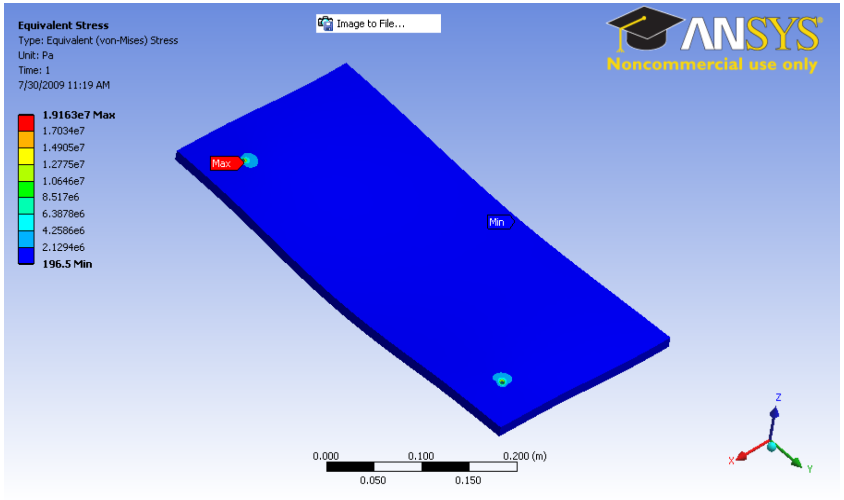


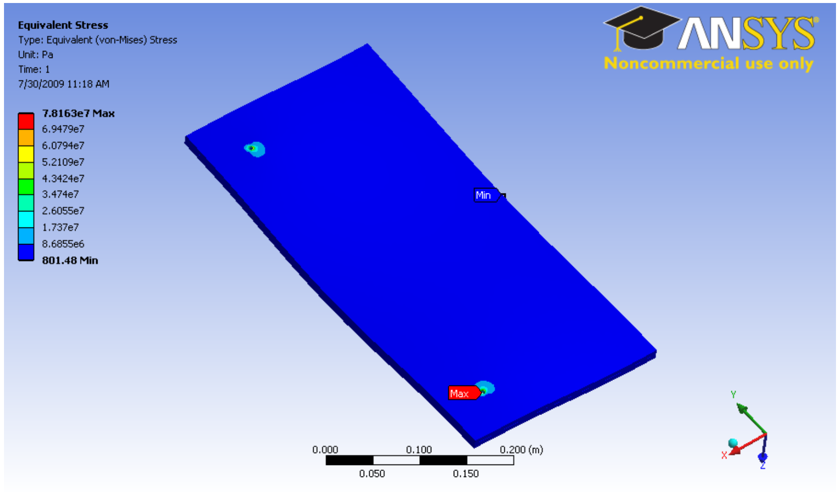


Layer Analysis – Bolting Analysis

- Normal Weight – 1 Plate
- Force - 1275.652 N/m
- Max Mises – 19 MPa

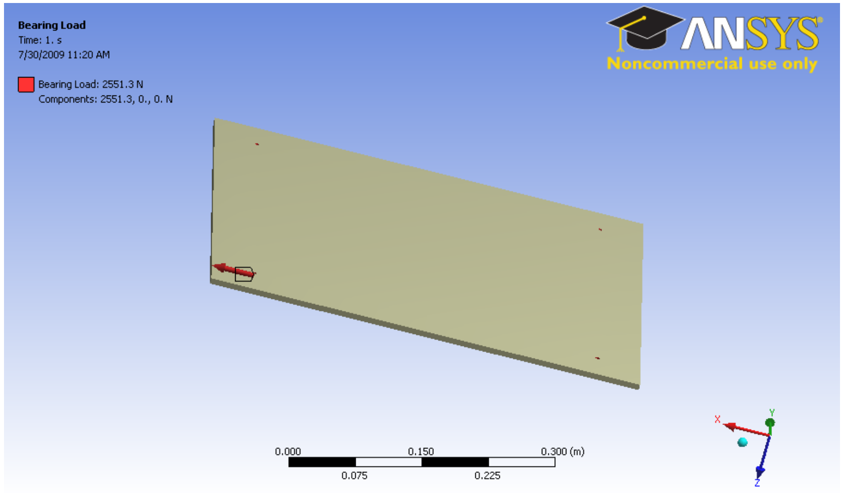
- Normal Weight – 4 plates
- Force - 5102.606 N/m
- Max Mises – 78 MPa

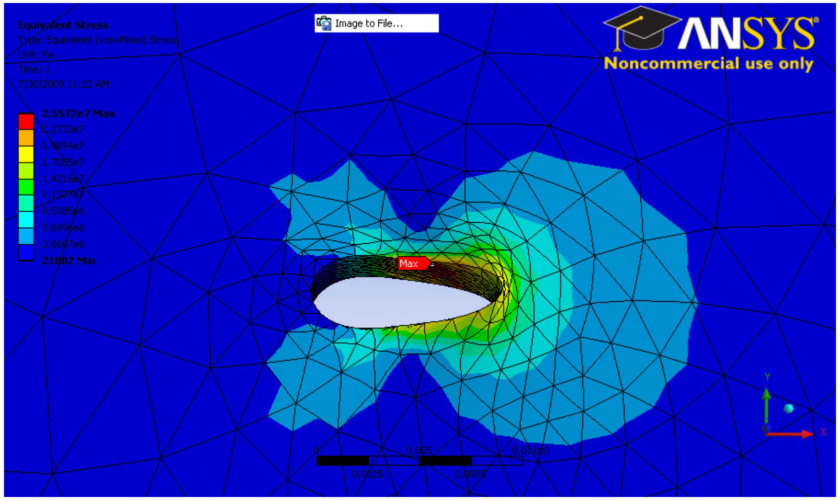




Layer Analysis – Bolting Analysis

- Shear Weight – 4 plates
- Force - 5102.606 N/m – distributed over 4 bolts
- Max Mises – 256 MPa

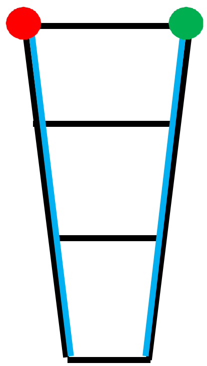




Layer Analysis – Bolting Analysis

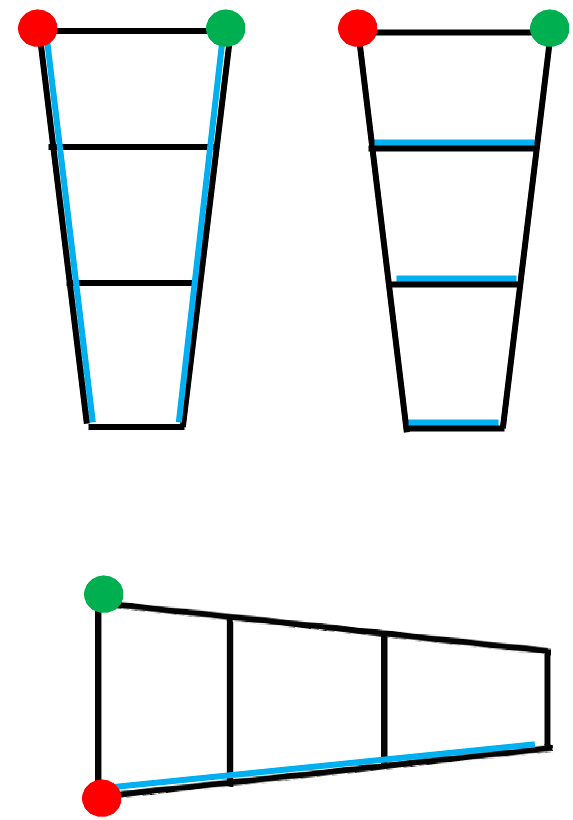
- Conclusions
  - From initial calculations bolting remains feasible
- However, difficulties lie within calculation of
  - Bolt thread stress
    - Note: Threads were previously used in INERMET in other detectors
  - Forces exerted upon plates by SS lattice and washers

Detector Section 2D analysis



Detector Section 2D analysis

Section Parameters		
Number of compartments	18	radial
Supports per compartment	2	
Exterior Arc Length	1.01	m
Interior Arc Length	0.49	m
Diagonal Length	1.50	m
Compartment Height	1.41	m
2D Area	1.05	m^2
Compartment Depth	1.00	m
Compartment Volume	1.05	m^3
Compartment Mass	9102.51	kg
Weight of Layers	89295.61	N/m

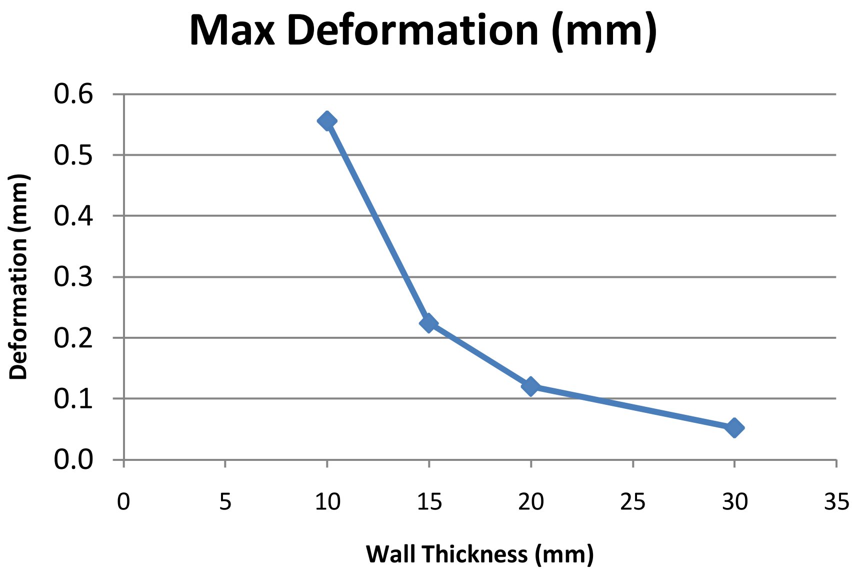


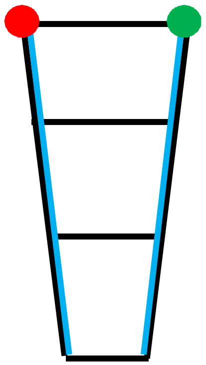
❖Simulation does not take into account the rigidity of the layers.

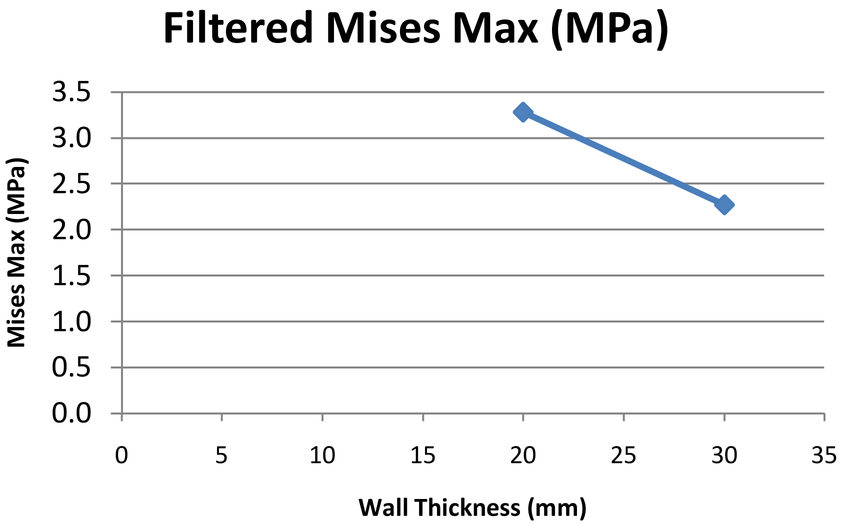
Section 2D analysis – Layer Density

Tungsten Layer Design										
Densities						Sandwich				
Tungsten	17600	kg/m^3				Material	Thickness			
SS	7800	kg/m^3			1	SS	3.25			
Detectors	2300	kg/m^3			2	W	6.5			
Gap	0	kg/m^3			3	SS	3.25			
							13	mm		
Detectors						Dual Layer				
1	Silicon	7				Material				
(Gap) 2	Vaccuum	1			1	SS	6.5			
Total		8	mm		2	W	6.5			
		2012.5	kg/m^3				13	mm		
Total Layer Density/ Compartment Density										
Sandwich				8628.571	kg/m^3	Dual Layer			8628.571	kg/m^3

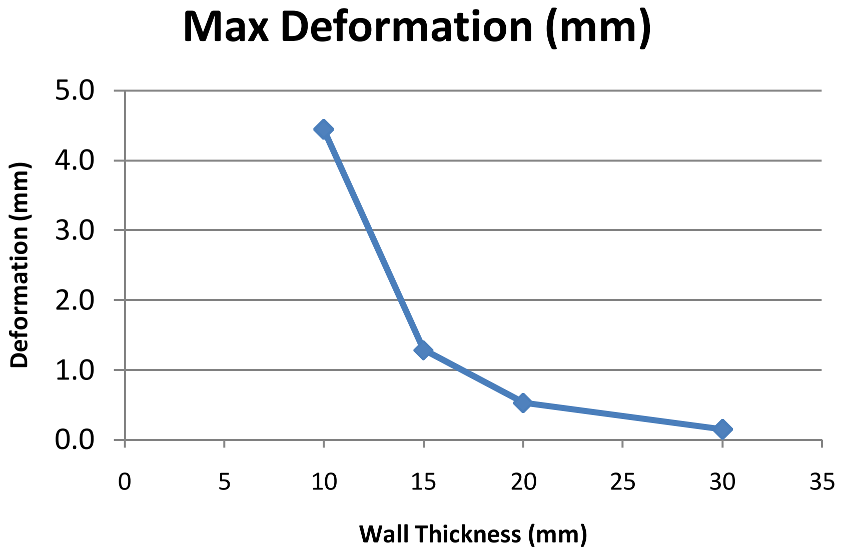
Detector Section 2D analysis

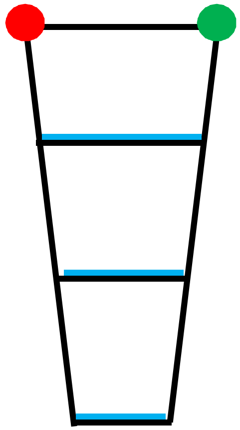


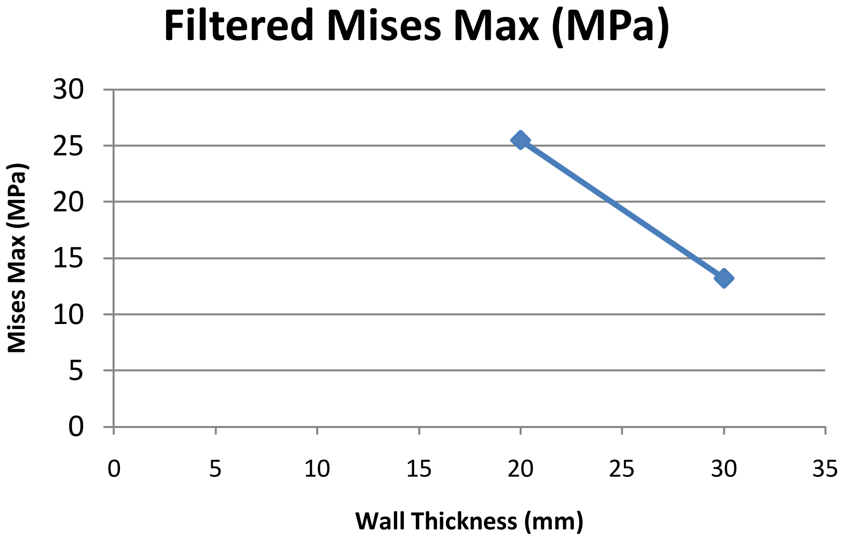




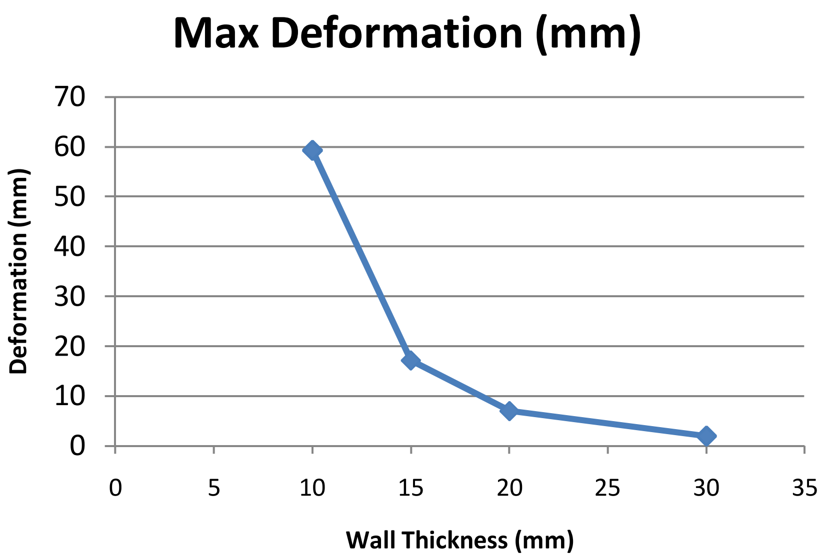
Detector Section 2D analysis

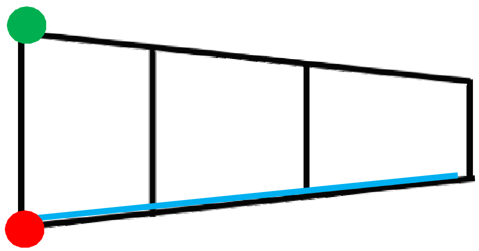


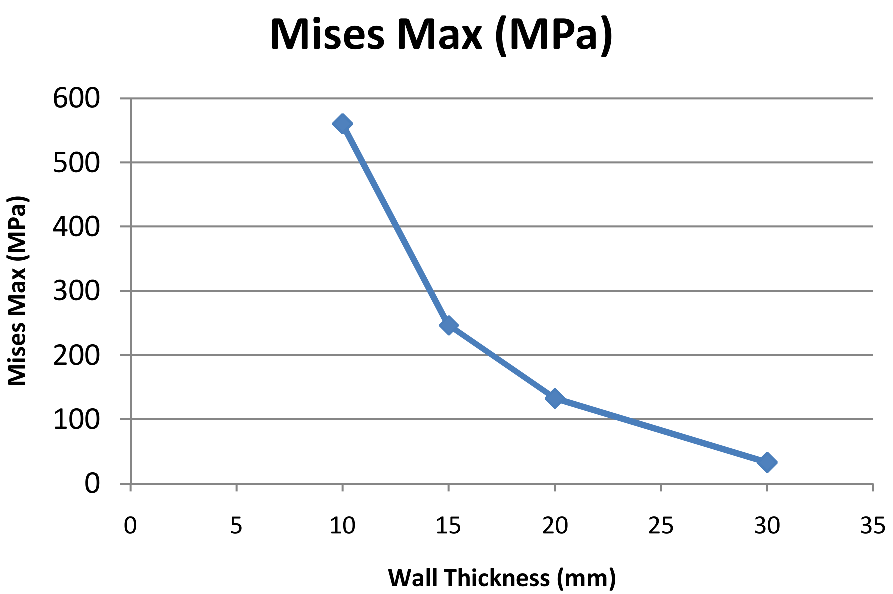




Detector Section 2D analysis



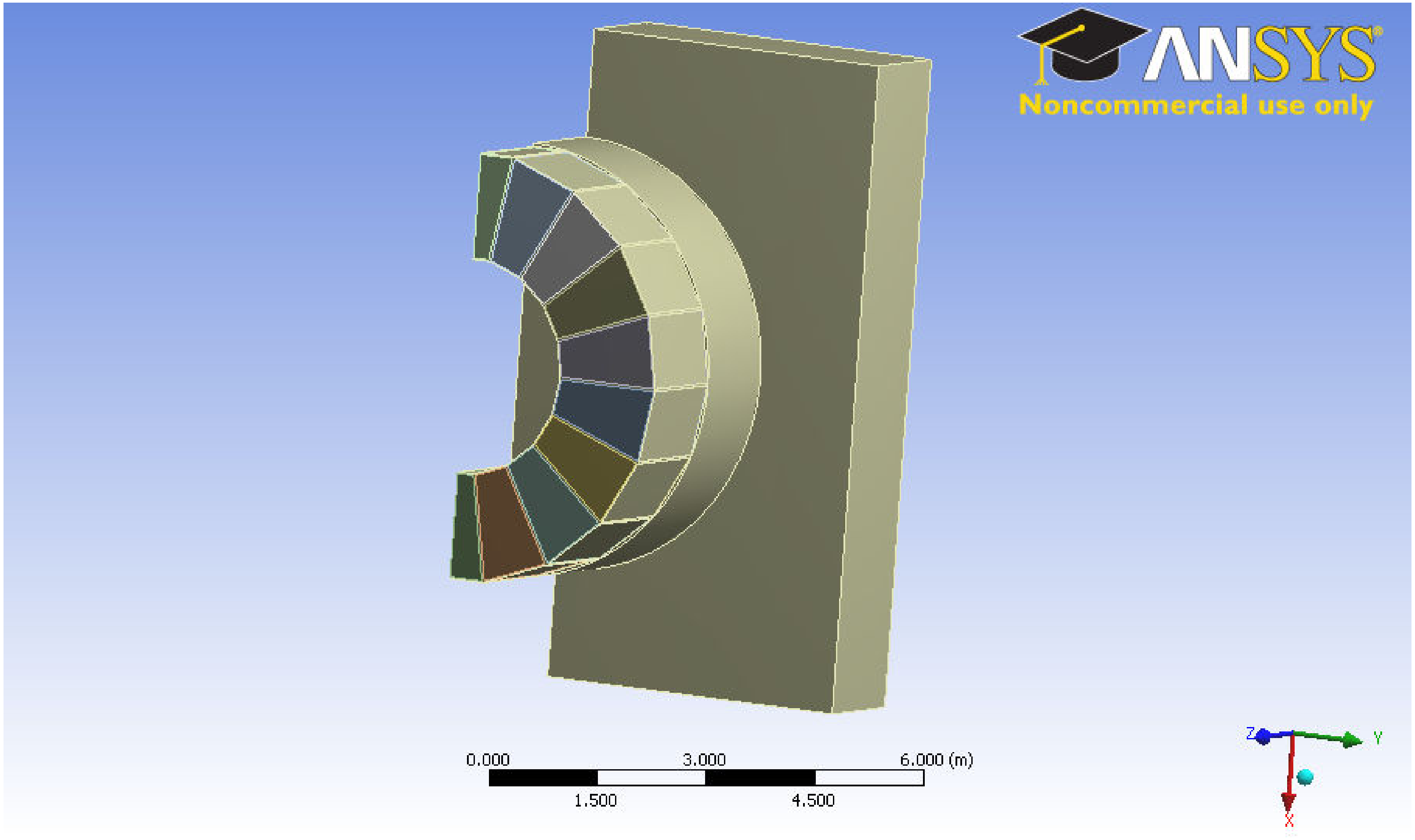




Detector Section 2D analysis

- Conclusions
  - Initial wall thickness approximation = 20 mm
  - Stresses in horizontal sections need to be estimated allowing for the rigidity of internal layers

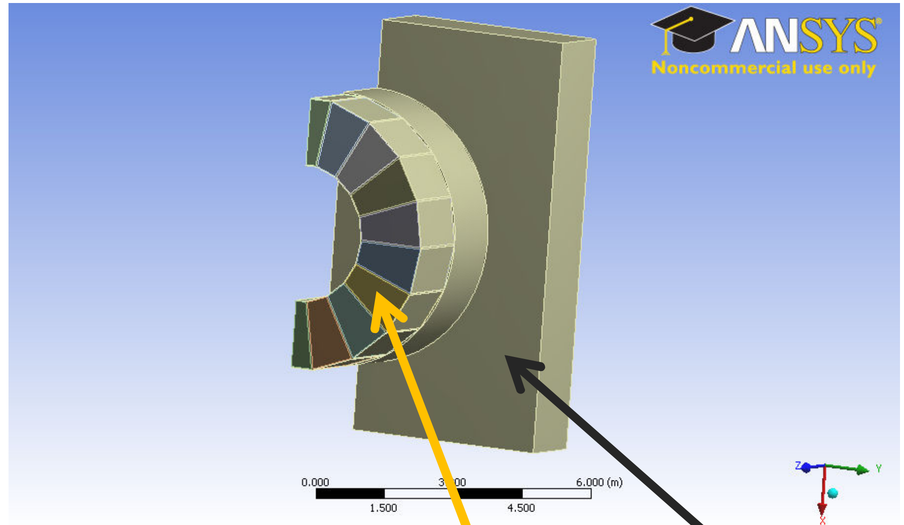
3D detector analysis



3D detector analysis – Overall Model

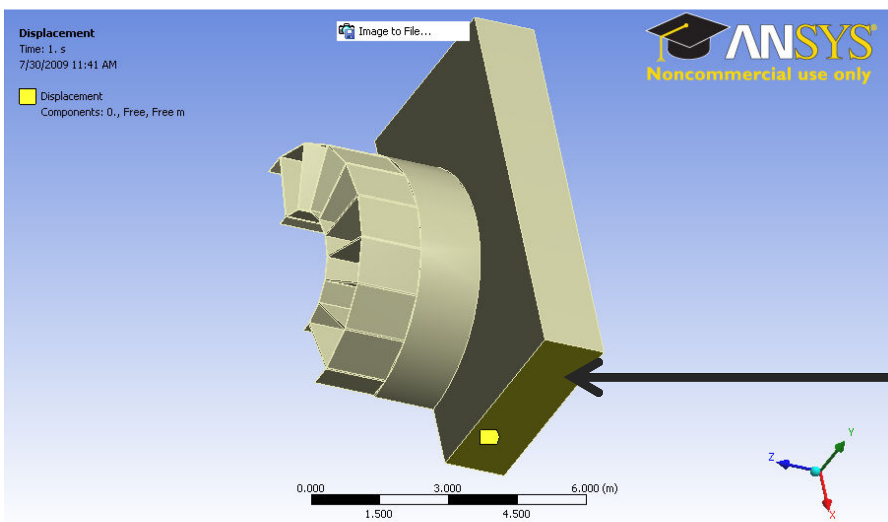
We seek to calculate the maximum deflection

❖Simulation does not take into account the rigidity of the layers.



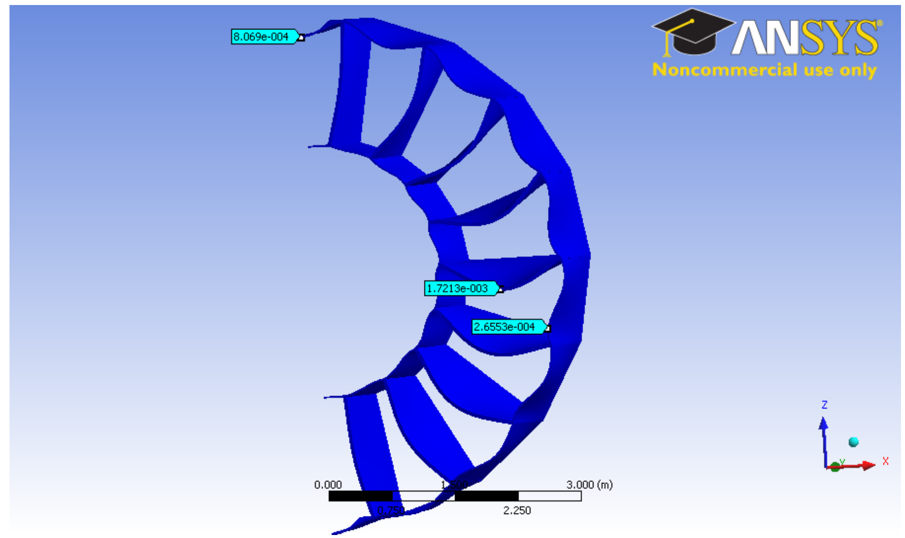
Layers (Dual Layer Composition)

Iron

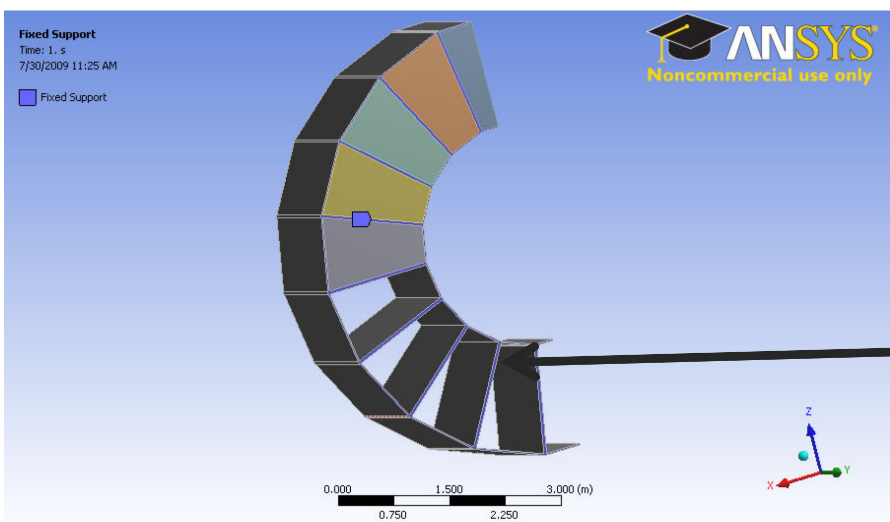


Imposed zero displacement condition

3D detector analysis – <u>Detector Lattice</u>

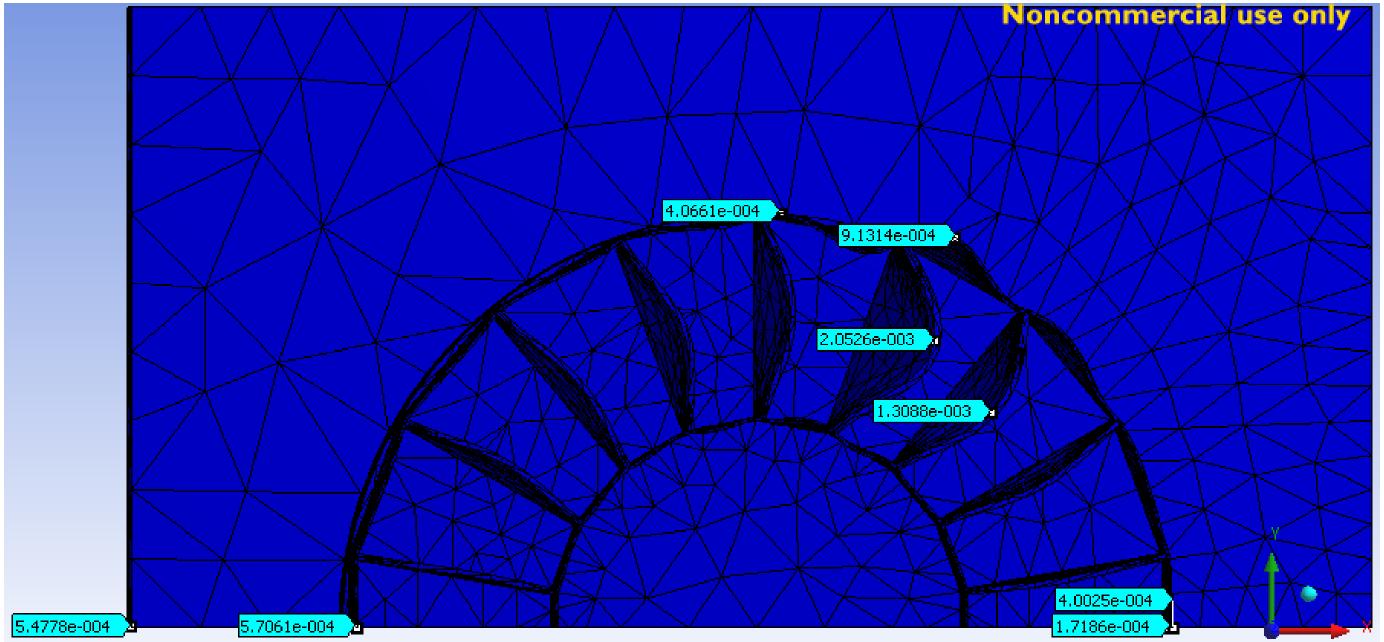


We seek to calculate the maximum deflection and stress



❖Simulation does not take into account the rigidity of the layers.

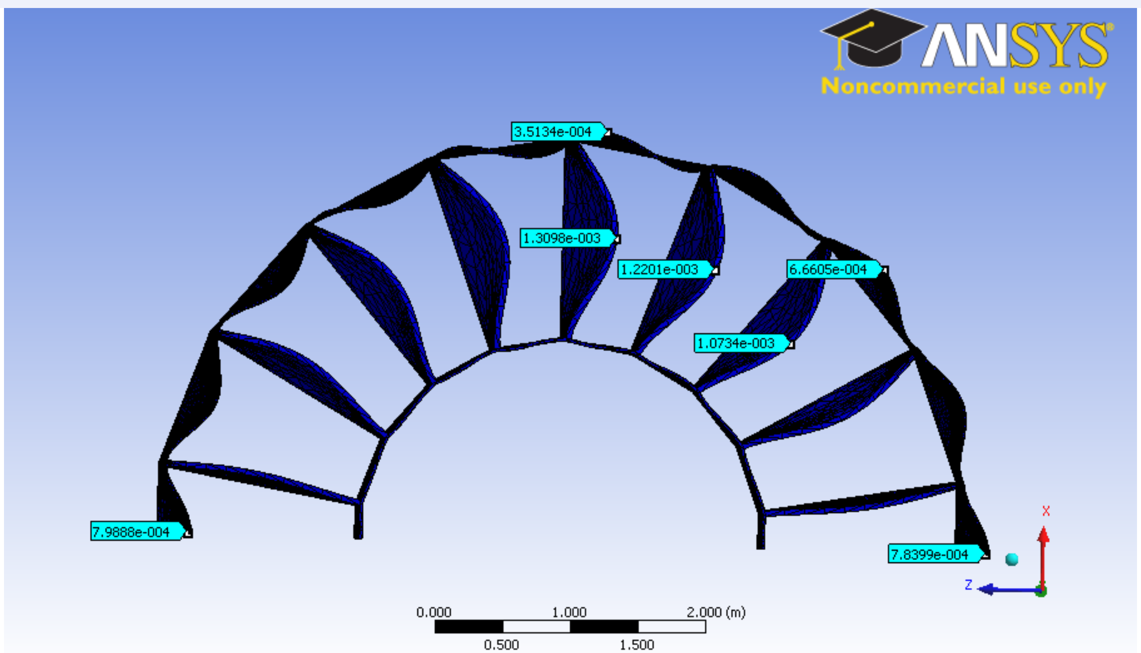
Zero displacement imposed on SS lattice face.



<u>Overall model</u>

Max Total Deformation

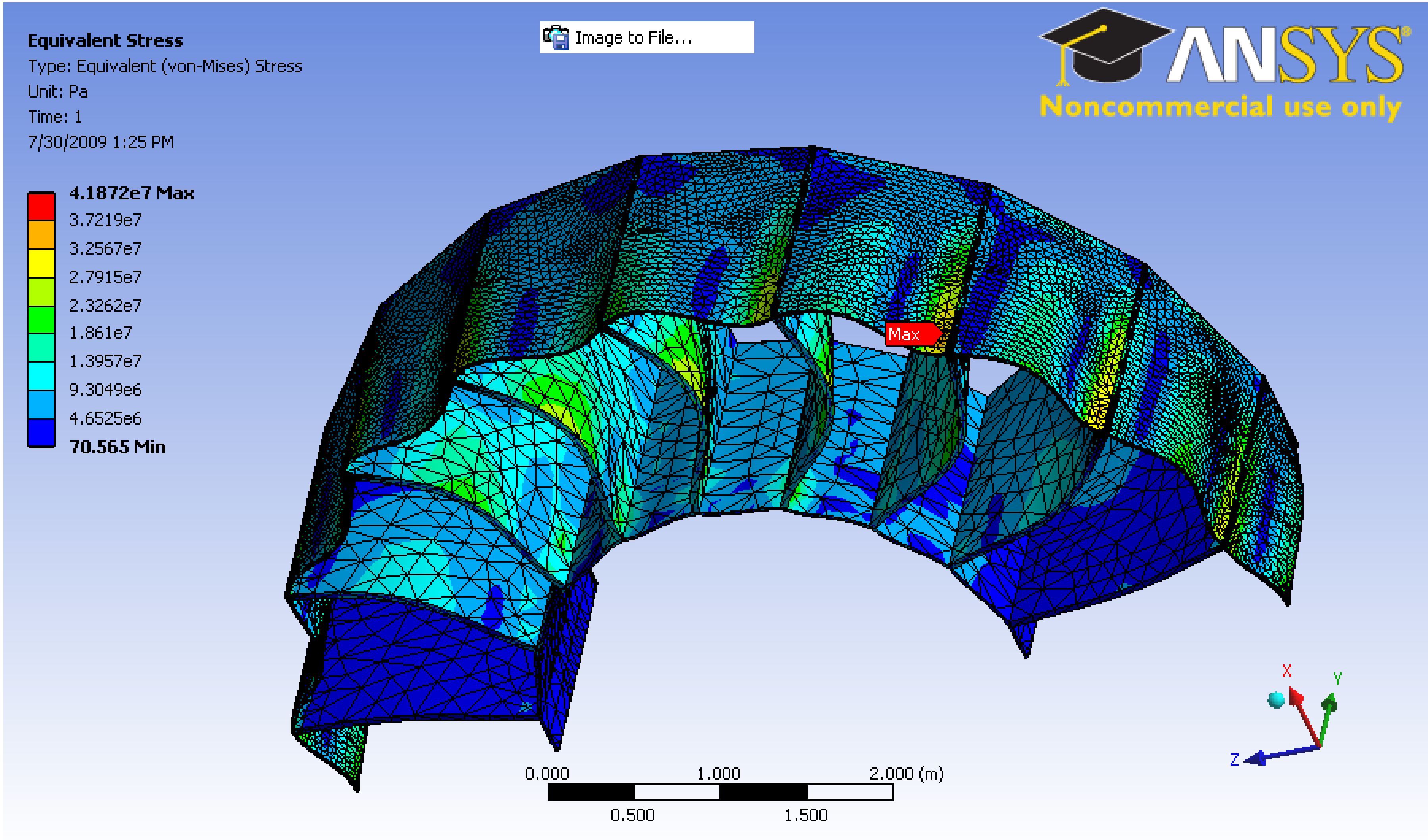
= 2.05 mm



<u>Detector Lattice</u>

Max Total Deformation

= 1.31 mm



Max Stress = 42 MPa

3D detector analysis – Detector Lattice

- Conclusions
  - Welding or bolting the detector lattice to such a mass is very advantageous in reducing deformation and stress compared to supporting the detector at radial points.
    - “Closed section” greatly reduces stress and deformation.
    - Weight of each section is mainly supported by the iron mass rather than other sections.
    - The feasibility of having an iron mass at either end of the detector should be carefully considered.
  - Stresses fall within a reasonable range
    - Especially considering that the rigidity of the layers has been neglected
  - Deflection goes beyond 1 mm but in reality the rigidity of the layers should reduce this.
  - Boundary condition issues regarding distribution of the weight of layers on SS lattice

Further work

- Transfer of 3D detector model from Philippe Lenoir to Ansys Workbench. (Week of 3rd Aug. 09)
- Analysis of stress and deformation distributions for various support configurations of the detector lattice, including radial. (Completed by Tuesday 4th Aug. 09)