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Cryogenic Target Pylon Stability Working Group Preliminary Report

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By

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Introduction

This preliminary report presents the findings of the Cryogenic Target Pylon Stability Working Group that was assembled to investigate the potential mounting schemes of the Cryogenic Target Pylon and develop a recommended baseline design to mount the pylon. To accomplish this objective the working group agreed that the following five tasks needed to be undertaken.

A) The first task was to construct a finite element model of the Cryogenic Target Pylon and Ignition Target Insertion Cryostat (I-TIC) to be incorporated into the NIF global finite element model. Figure 1 illustrates an overview of the information provided to the LLNL Structural Mechanic Group to incorporate into their NIF global model.

B) The second task was to incorporate the five different proposed mounting schemes into the NIF global model. These different mounting schemes would then be analyzed to determine the deflection at the pylon tip when subjected to a random vibration spectrum applied at the base of the global model. The results of these five different pylon-mounting schemes would then be compared against each other to determine which design had the best stability characteristics. The following describes the five different mounting schemes.

    1) The first mounting scheme consists of mounting the pylon directly off the flange of Port D62. Figure 2 illustrates this mounting scheme as it is modeled in the NIF global model.

    2) The second mounting scheme has the pylon mounted to a frame that is supported by the lower diving board. There is compliance in the axial direction at the frame location and the pylon is also attached to Port D62. Figure 3 illustrates this mounting scheme as it is modeled in the NIF global model.

    3) The third mounting scheme is the same as the second except that the pylon support frame is attached to both the lower and upper diving boards. Figure 4 illustrates this mounting scheme.

    4) The fourth mounting scheme has the pylon mounted to a support frame that is supported by the lower diving board. The pylon is not attached to Port D62 and the support frame is modeled as an ideally stiff panel in all six degrees of freedom. Figure 5 illustrates this mounting scheme.

5) The fifth mounting scheme is the same as the fourth except the ideally stiff panel is supported by both the upper and lower diving boards. Figure 6 illustrates this mounting scheme as it is modeled in the NIF global modeled.

C) The third task is not directly associated with the pylon mounting schemes. It involved measuring the force time history at the cryo-cooler mount location and applying this force time history to a stand-alone finite element model that depicts the best estimate of the cryogenic target pylon and I-TIC.

D) The fourth task was to directly measure deflections at certain locations in the NIF facility and compare these deflections against deflections predicted by the NIF global model.

E) The fifth task of the working group was to investigate the use of a surrogate aluminum pylon to measure actual pylon deflections. The measured deflections would then be compared against the analytical results predicted by the NIF global model that incorporated a similar aluminum pylon. The aluminum surrogate pylon should have similar dimensions, weight and dynamic characteristics as that of the cryogenic target pylon with the I-TIC attached. This test would not only verify the global model results, but also provide confidence that the measured deflections would be similar to those of the actual cryogenic target pylon and I-TIC. Measured deflection of the surrogate pylon can also provide data needed to calculate translation and rotation stiffness at the target chamber support flange Port D62. This information will be incorporated into future finite element models.

Summary of the results

Table 1 presents the comparison of the pylon tip deflections for the five mounting schemes. Mounting schemes 1 and 5 have predicted deflections that are less than the other 3 schemes. Although schemes 1 and 5 have essentially identical values, scheme 5 mount was analyzed as being ideally stiff which tends to over estimate the stiffness of the final mount design. It is believed that scheme 5 will experience greater deflections than predicted. For this reason, mounting scheme 1 was judged to be the most stable of the five mounting schemes and was chosen as the baseline mount design. All five mounting schemes have predicted deflections that are less than the stability requirements of 6 μm translation and 1mrad rotation. This is positive but it must be emphasized that the results were only viewed from a relative deflection point of view and not as being actual measurable deflections.

Table 2 contains the comparison of the measured deflections at three locations in NIF compared against the values predicted by the global model. The global model predicted deflection on the average of 6.5 times higher than the measured deflections. There is a consistent trend for the global model to over-predict deflections. The analysts are currently upgrading the soil interaction model to try and reduce these conservative predictions.

The force time history measured at the cryo-cooler support base has been completed but the analysis has not been completed and therefore no preliminary results are available.

Using the baseline mounting design, two finite element beam models were constructed. The first beam model used dimensions and weights (non-uniform weight distribution across the length) shown in Figure 1. The second beam model constructed was that of an aluminum tube that used essentially the same cross sectional dimensions as the first model. After minor adjustment of the second model it was determined that a 142-inch long, uniform cross section aluminum pylon matched the first seven modes of vibration of the first beam model that depicted the cryogenic target pylon with the I-TIC attached. In addition, the aluminum pylon would weigh approximately the same as the cryogenic target pylon weight with the I-TIC (est. 300 lbs) attached. In order to judge the dynamic similarities of the two beam models, a force time history was applied to both models. The results suggested that for this specific force time history, the aluminum beam model predicted deflections approximately 50% greater than the cryogenic target pylon beam model. This suggests that measured deflections of the aluminum surrogate pylon should be conservative. It was agreed that the surrogate pylon, using the baseline mounting design should be constructed and installed in NIF during the shut down projected to be October - March 2004.

Conclusion

Future work will include applying cryo-cooler and shroud retraction force time histories to stand alone finite element models of both the cryogenic target pylon and the I-TIC.

Contributors

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All tables and finite element figures presented in this report came from information generated by the LLNL Structural Analysis Group Members:

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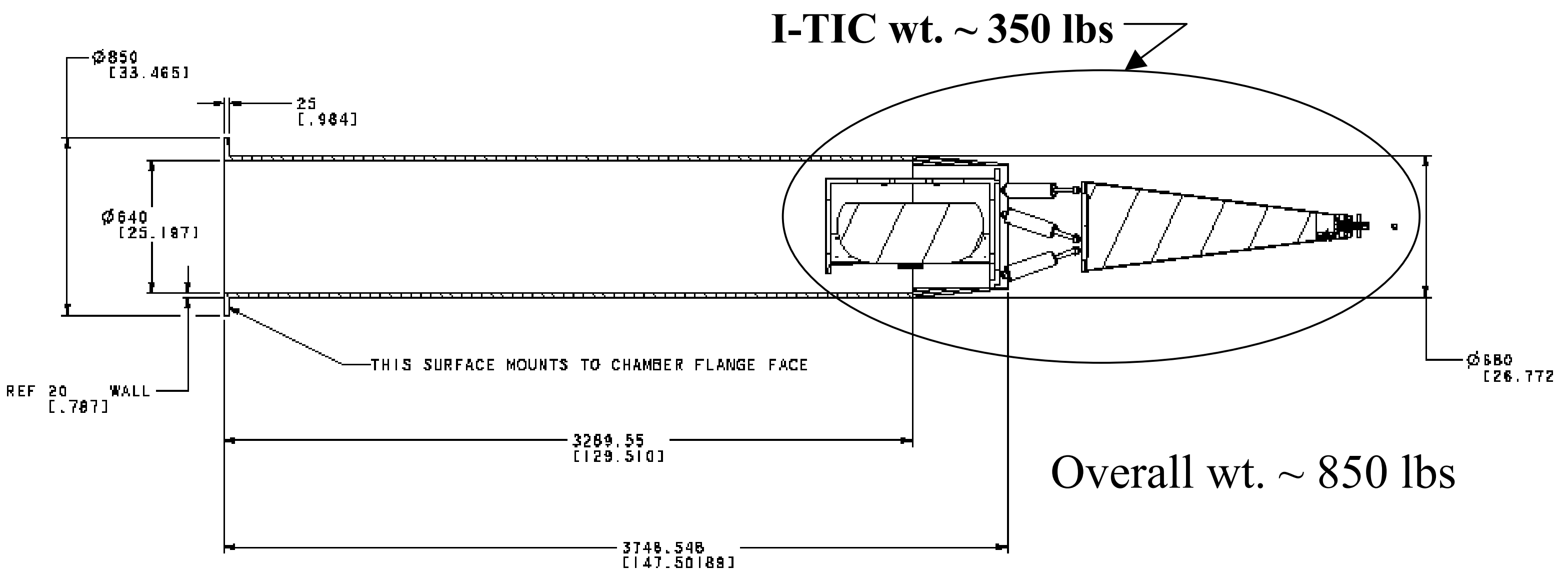

Figure 1
Cryogenic Target Pylon With I-TIC

CASE	MOUNTING SCHEME	Coupling to Port D62	Structure at Diving Board(s)	Cryogenic Target Pylon Tip Stability	
				Translation, microns (μm)	Rotation, micro radians (μrad)
1	Port D62 Spool	Directly Coupled to Spool	None	1.045	0.117
2	Port D62 Spool + Diagnostic Floor Diving Board	Directly Coupled to Spool	Compliant in axial direction of CTARPOS	1.921	0.285
3	Port D62 Spool + Diagnostic Floor Diving Board + Upper Mirror Room Diving Board	Directly Coupled to Spool	Compliant in axial direction of CTARPOS	1.881	0.278
4	Diagnostic Floor Diving Board	Not Coupled	Ideally stiff panel	2.374	0.368
5	Diagnostic Floor Diving Board + Upper Mirror Room Diving Board	Not Coupled	Ideally stiff panel	1.042	0.132

Displacements & rotations are calculated from stability analysis conducted using Title II input. Each displacement & rotation is a SRSS resultant of the three RMS components.

Table 1
Cryogenic Target Pylon Stability Analysis Results
Comparison of Mounting Schemes

Location	Displacement, microns (μm)	
	Target Bay Global Model Stability Analysis[1]	Ambient Vibration Measurement[2]
Target Chamber Port D62 Flange	0.861	0.141
Diving Board, 17' 6" Level, at tip	0.731	0.166
Diving Board, 29' 6" Level, at tip	0.824	0.094

1. Displacements are calculated from stability analysis conducted using Title II input. Each displacement is a SRSS resultant of the three RMS displacements.
2. Vibration measurements on 3/9/04. Each displacement shown is a SRSS resultant of the three RMS displacements calculated from accelerometer measurements.

Table 2
NIF Target Chamber Port D62 Flange & adjacent Diving Boards
Comparison of Calculated Versus Measured Displacements

Mounting Scheme 1

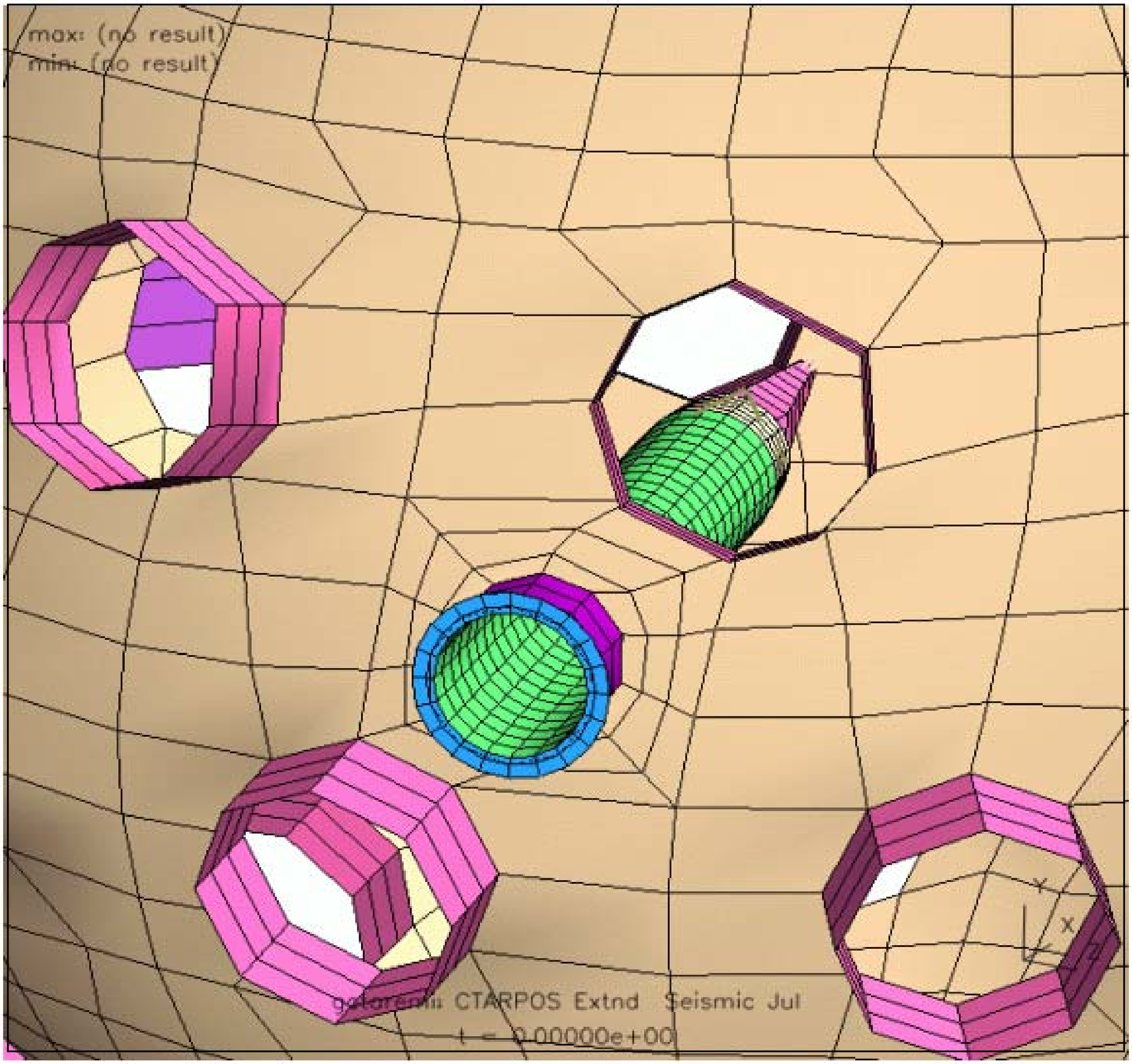

Figure 2

Cryogenic Target Pylon Mounted Directly To Port D62 Spool

Mounting Scheme 2

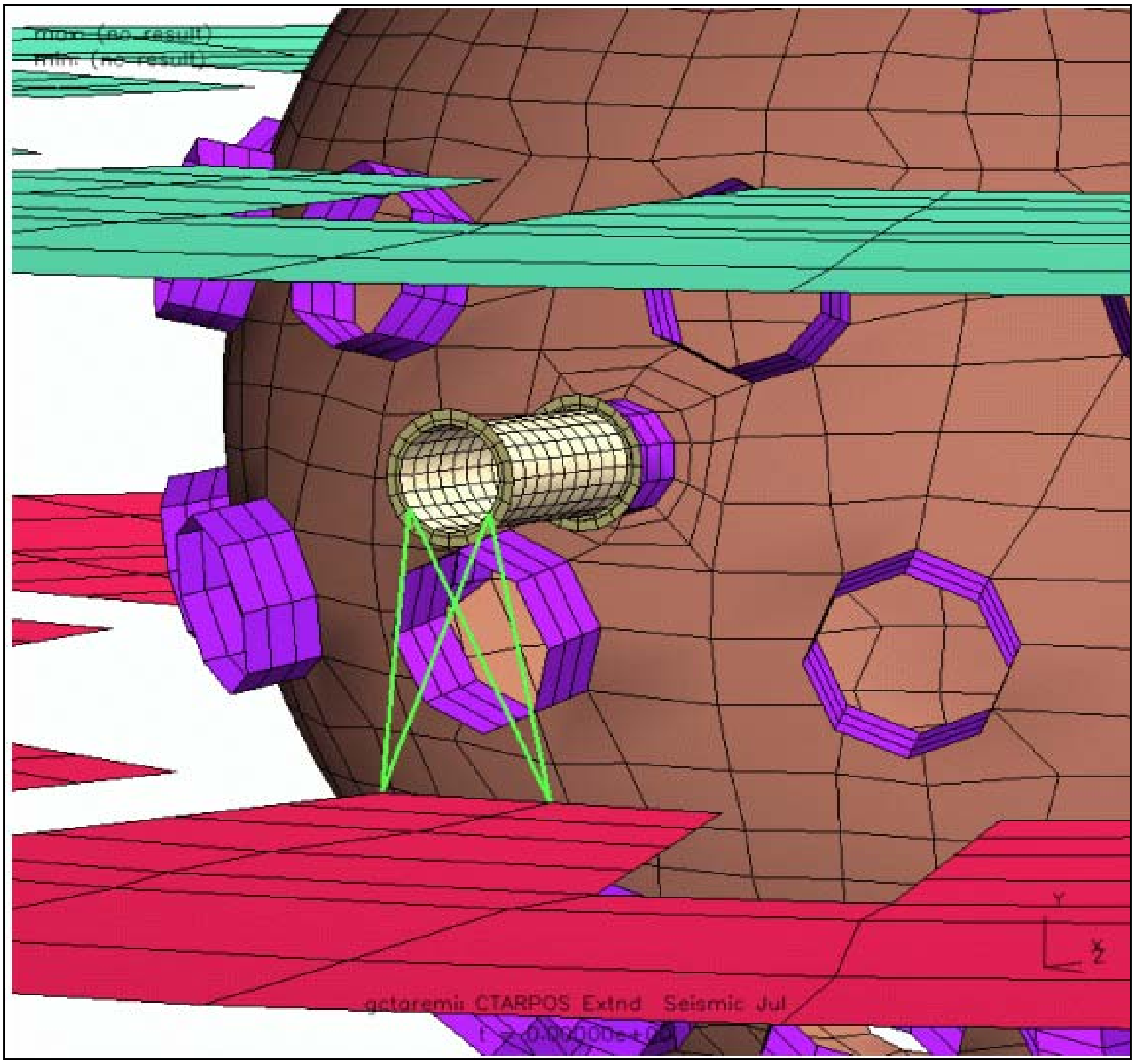

Figure 3

Cryogenic Target Pylon Mounted Directly To Port D62
Spool + Diagnostic Floor Diving Board

Mounting Scheme 3

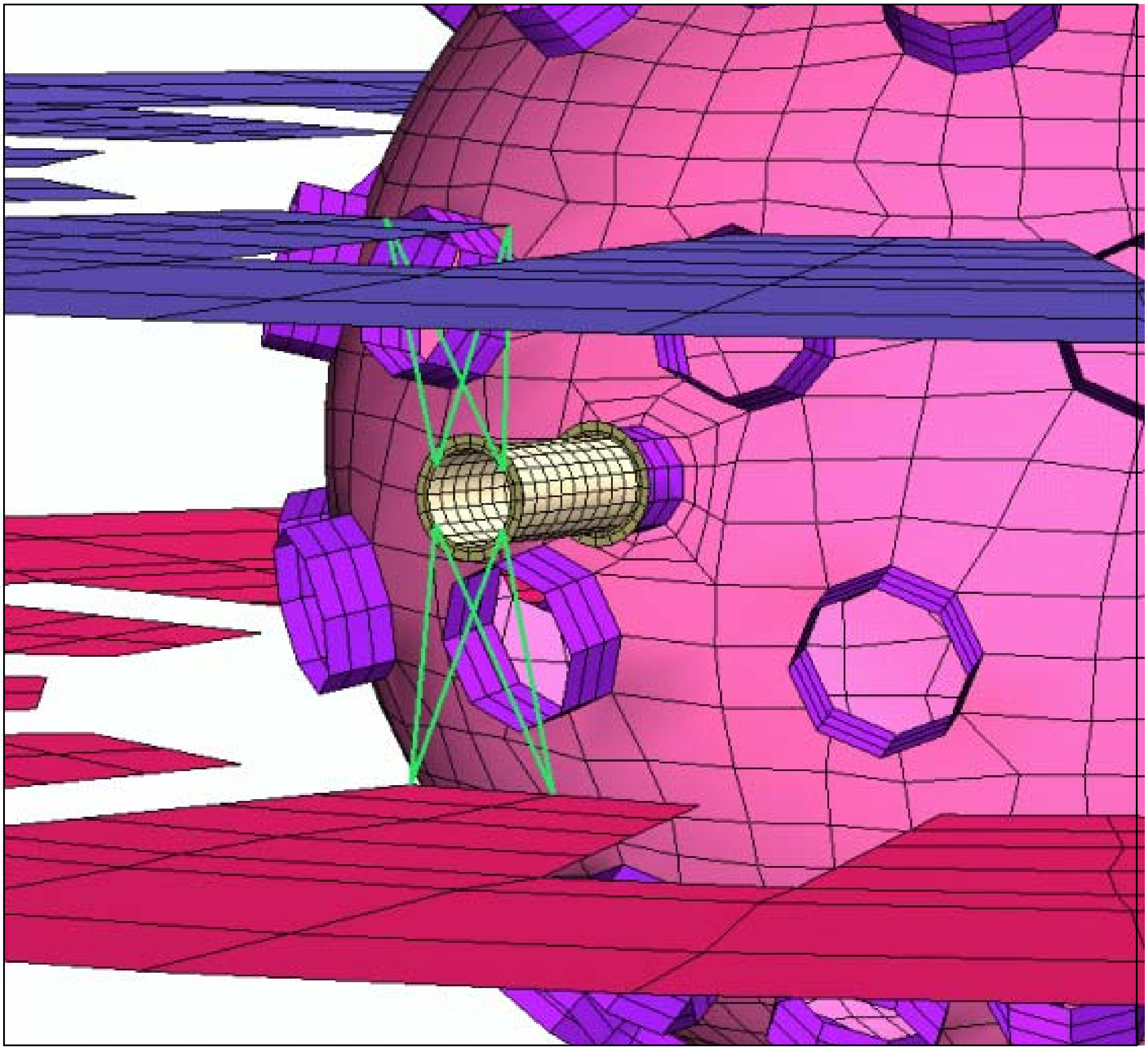

Figure 4

Cryogenic Target Pylon Mounted Directly To Port D62 Spool + Diagnostic Floor Diving Board + Upper Mirror Room Diving Board

Mounting Scheme 4

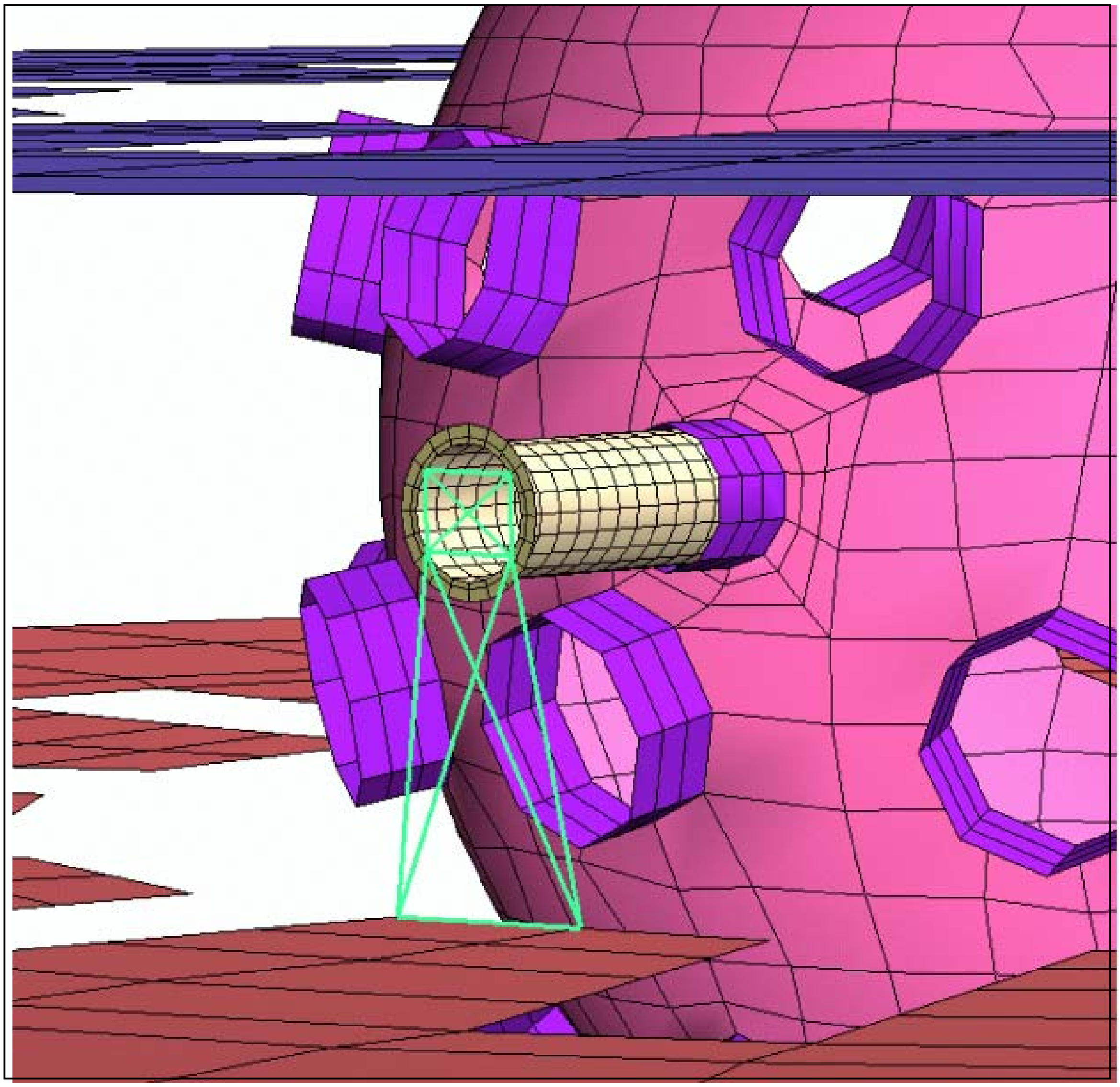

Figure 5

Cryogenic Target Pylon Is Mounted To An Ideally Stiff Panel That is Attached To The Diagnostic Floor Diving Board (Cryogenic Target Pylon Is Decoupled From Port D62)

Mounting Scheme 5

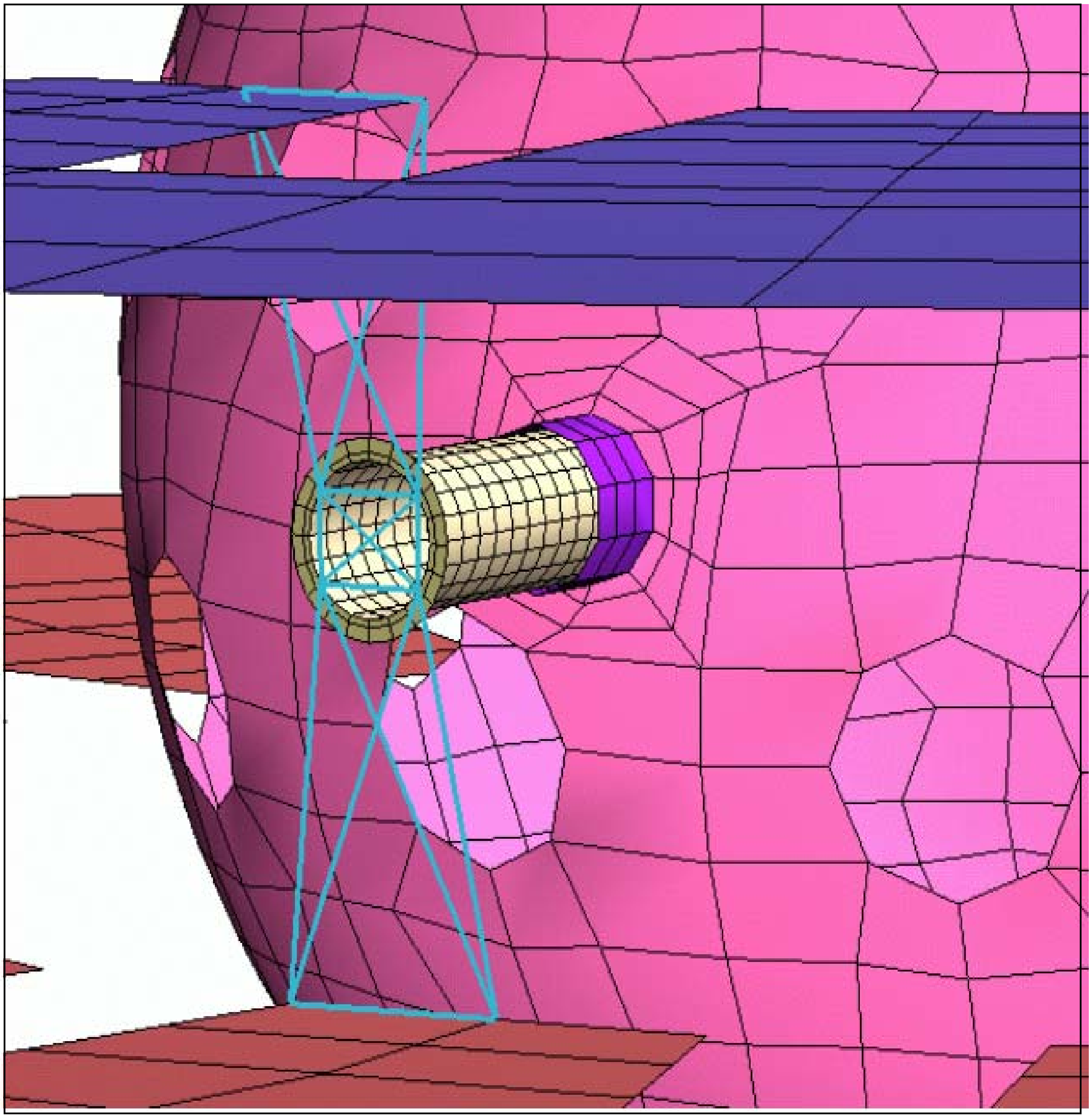

Figure 6

Cryogenic Target Pylon is Mounted To An Ideally Stiff Panel That Is Supported By Both The Upper & Lower Diving Boards (Cryogenic Target Pylon IS Decoupled From Port D62)