Magellan 6.5 Meter Telescopes Project
Design and Analysis of the Nasmyth Instrument Guider Housing

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CIW No.:

1. Structural Design:

The guider housing is shown on drawings in Figures 1 & 2 and FEM graphics plots in Figures 3 through 5. It has been designed to support the Echelle spectrograph and future small instruments. The Echelle is partially shown in phantom in Figures 1 & 2 and graphics plots of model ECH28 in Figure 3. This model also includes the guider housing, spacer, and Nasmyth Instrument Rotator (NIR) disk. The latter structures are shown unobscured by the Echelle in Figure 4. Figure 5 is a half-section view of model ECH29 - the same guider housing, spacer, and NIR disk but with a simplified beam element representation of a small instrument.

As shown in Figures 1 & 2, the guider housing weldment consists of two 3/4" thick flat plates connected by a 48 3/4" diameter, 3/8" thick cylindrical wall. The cylindrical wall has two small slots to accommodate extremes of travel of the guider mechanism which resides inside the housing. All other structure clears the mechanism by at least ½" (indicated by the irregular polygon in the large view of Figure 1). The slots will have small non-structural covers. This arrangement for the cylindrical wall minimizes bending of the NIR disk and allows for external access to all housing and spacer assembly screws.

The outer flat plate mimics the three screw hole patterns that exist in the NIR disk. The Echelle and guider housing use the outermost row of twelve ½-13 NC tapped holes. The Echelle will require (10) additional tapped holes located near structural gussets, shown in phantom. The guider will include eight radial gussets welded to the two flat plates and cylindrical wall. These gussets are necessary (only) for instruments that attach at the central hole. The guider housing is approximately 258 mm thick.

The cylindrical spacer has the same diameter and wall thickness as the housing, and is about 115 mm thick. The housing flanges are undercut to assure stiff axial preloading of the cylindrical wall of the housing and the cylindrical spacer. The guider housing and flat and cylindrical spacers are made of mild steel. The guider housing/cylindrical spacer structures weighed 600 lbs as modeled. The actual assembly with more solid inner flat plate, plus flat spacer and guider mechanism, will weigh approximately 1,000 lbs. The Echelle instrument assembly (including counterweight) is estimated to weigh about 1,700 lbs.

2. Finite Element Analysis:

The Echelle portion of model ECH28 used the earlier model ECH19. This was a global model of (only) the outer structure of the Echelle with the material density artificially increased to account for internal mechanisms and optics. In model ECH19 the model was fixed at the (6) intersections of the large circular plate and the structural gussets. Model ECH28 was restrained by fixing translations (not rotations) of all nodes along the ball centerline of the large four-point contact ball bearing behind the NIR disk. For both models in load case 1 gravity was applied in the negative-Z direction ("down" in views of Figure 3). Load case 2 included this loading, plus the effects of the counterweight system, applied using nodal loads. Thus, the structural effects of the mass and compliance of the guider housing and cylindrical spacer could be evaluated both with and without the astatic counterweight system. The results of the finite element analyses were as follows:

Model ECH19 - Echelle fixed at mounting flange		
	Peak deflection	Deflection at slit
Without counterweight	34 microns	1.7 microns
With counterweight	1 micron	2 microns

Model ECH28 - Echelle plus guider, spacer, and NIR disk		
	Peak deflection	Deflection at slit
Without counterweight	57 microns	7.5 microns
With counterweight	6.6 microns	9.1 microns

Model ECH29 - Small instrument plus guider, spacer, and NIR disk (500 lbs at 6" beyond focal plane)		
	Translation at c.g.	Tilt at c.g.
(No counterweight)	5.2 microns	1 arcsecond

3. Results and Conclusions:

Note that no optimizing of the counterweight was done when the guider was added (model ECH28). That is, the same counterweight forces were applied in ECH28 as were used in ECH19. The counterweight could be optimized either to further reduce the peak deflection, or to increase the peak deflection to match the deflection in the area of the slit. In fact, it is likely that the final structural performance in the Echelle configuration will be determined more by local structural effects (camera optics benches, local grating supports, etc.) than by the global deflections summarized above. Due to the adjustable control of global deflections provided by the astatic counterweight system, it is therefore concluded that the guider and spacer structures defined here are adequately stiff for the Echelle spectrograph.

It is noted that, while model ECH29 did not include any stiffening of the guider housing by the small instrument, it also did not include any additional motion due to strains in the instrument itself. Still, it is asserted that a reasonably designed small instrument structure would likely result in motions in the instrument on the order of (less than) 10 microns translation and a few arcseconds of tilt. Such motions will likely be acceptable, indicating that the guider design is also acceptably stiff for small instruments.

It is noted that model ECH28 was first run without the radial gussets. The gussets were then added and the model run again. The effect of the radial gussets was negligible in the Echelle configuration. However, it is apparent that for instruments mounted only at the center hole, the gussets will substantially reduce out-of-plane bending of the 3/4" thick annular mounting plate of the guider. Therefore, the radial gussets should be included in the guider housing design.

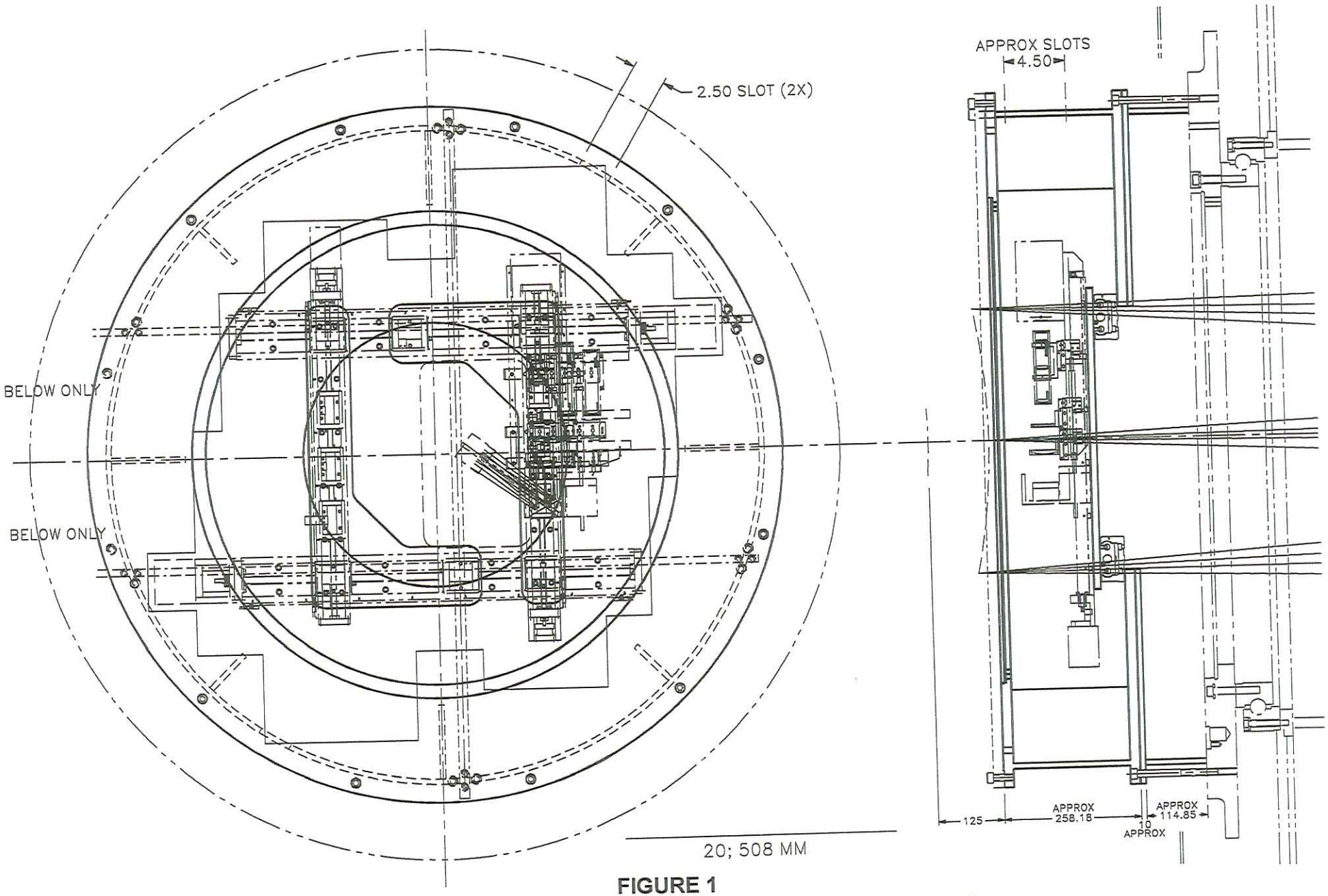


FIGURE 1

Guider housing / Spacer layout (with Echelle Spectrograph in phantom).

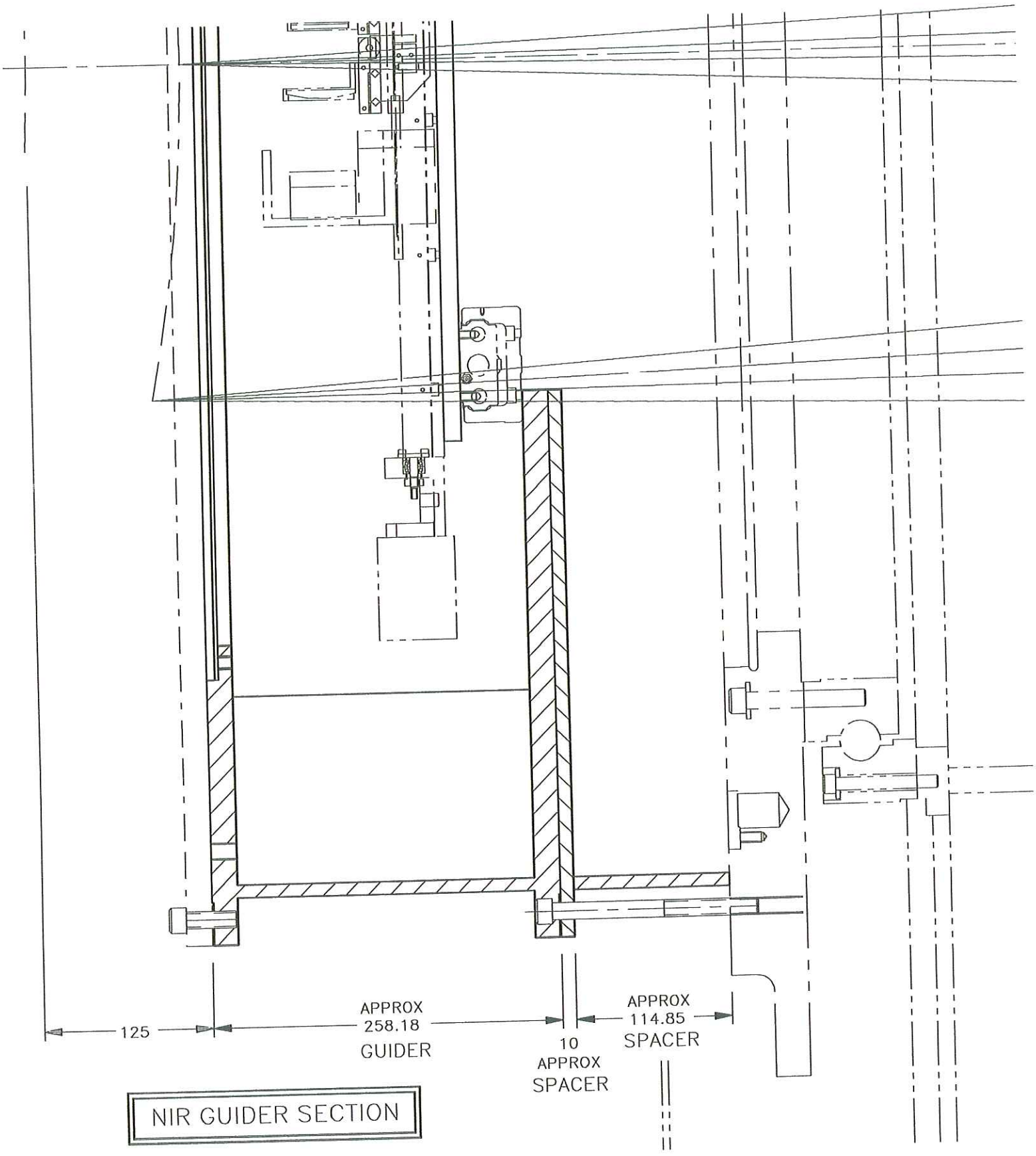

125
APPROX
258.18
GUIDER
10
APPROX
SPACER
APPROX
114.85
SPACER
NIR GUIDER SECTION

FIGURE 2

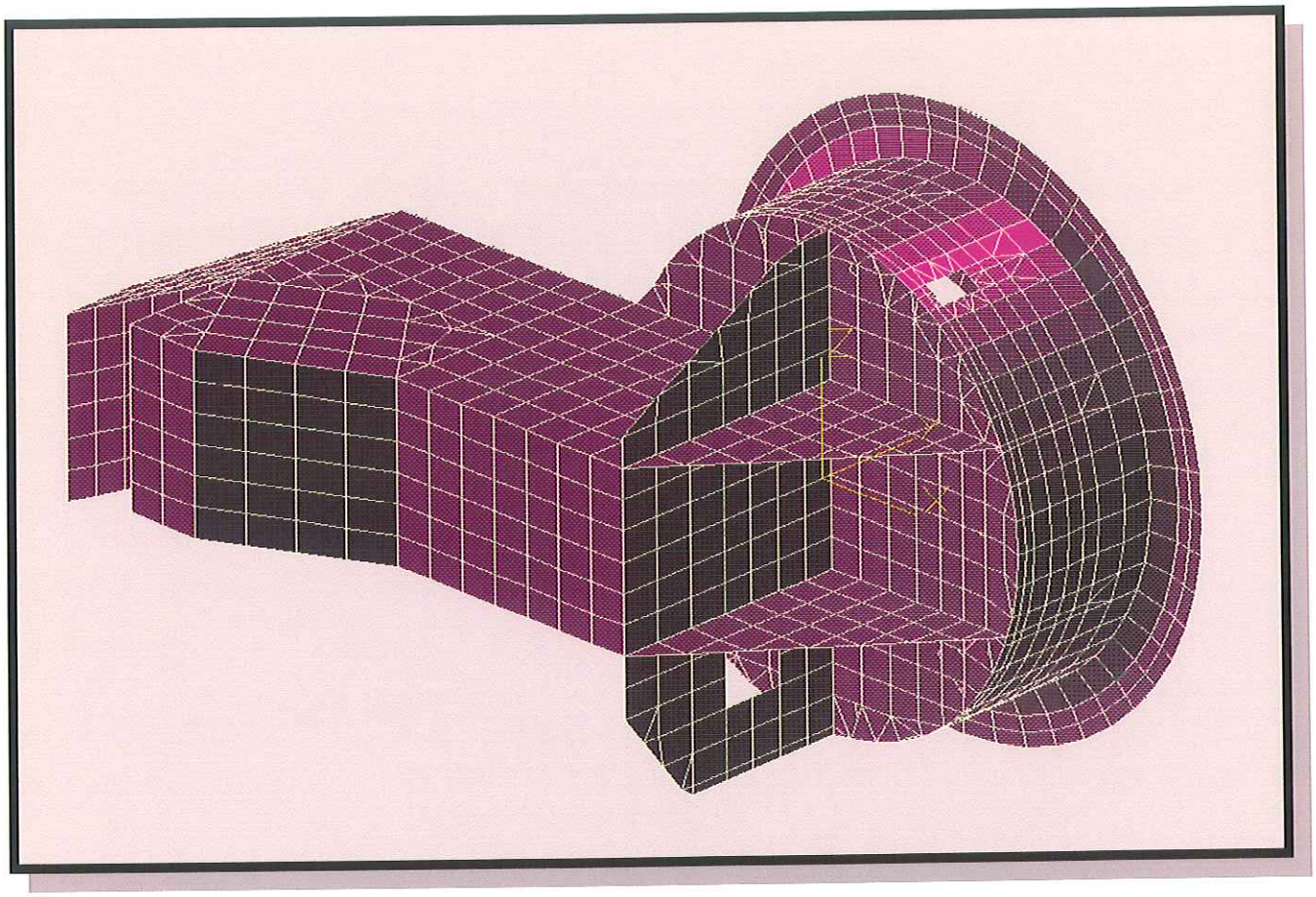
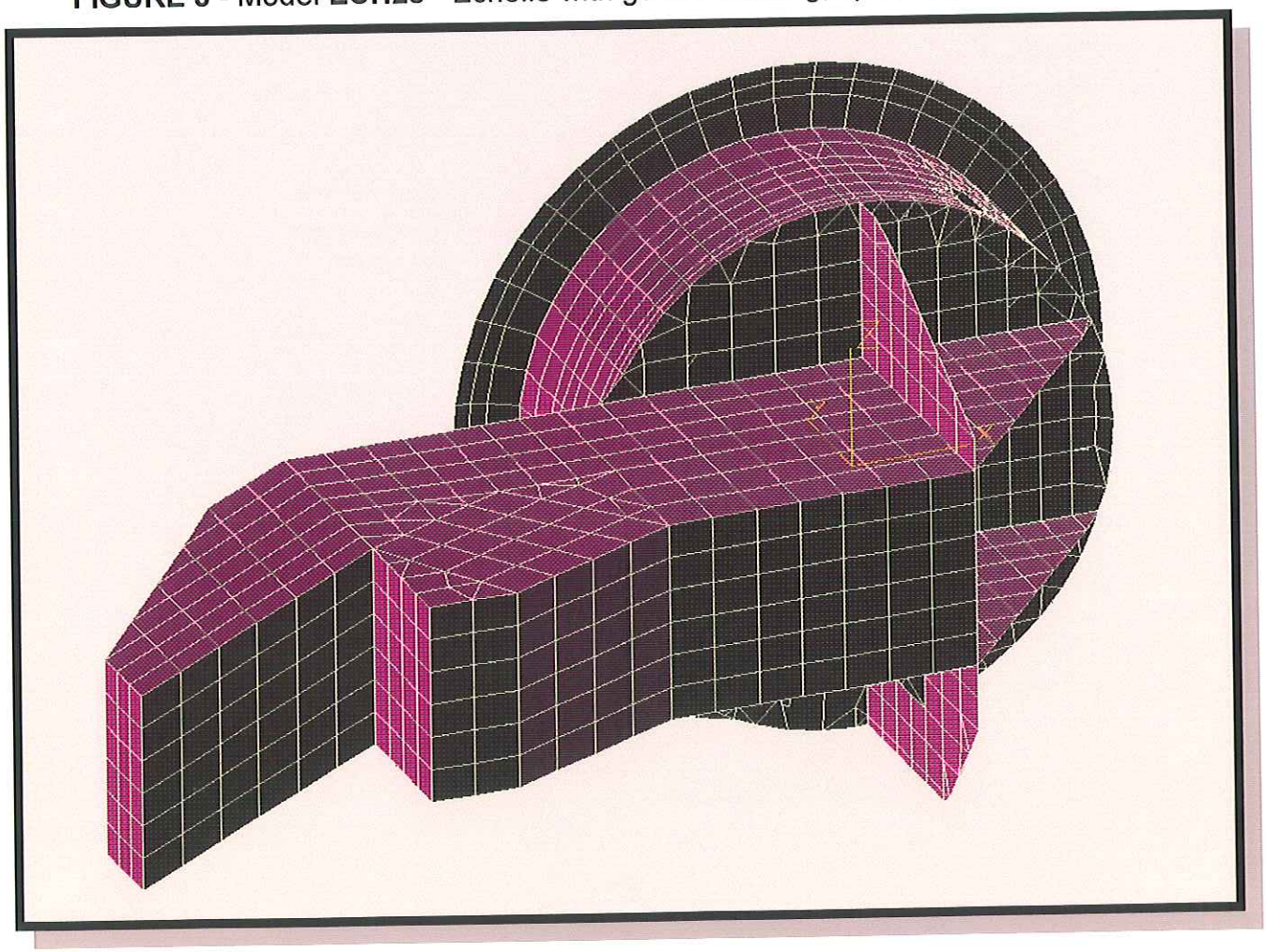


FIGURE 3 - Model **ECH28** - Echelle with guider housing, spacer, and NIR disk.



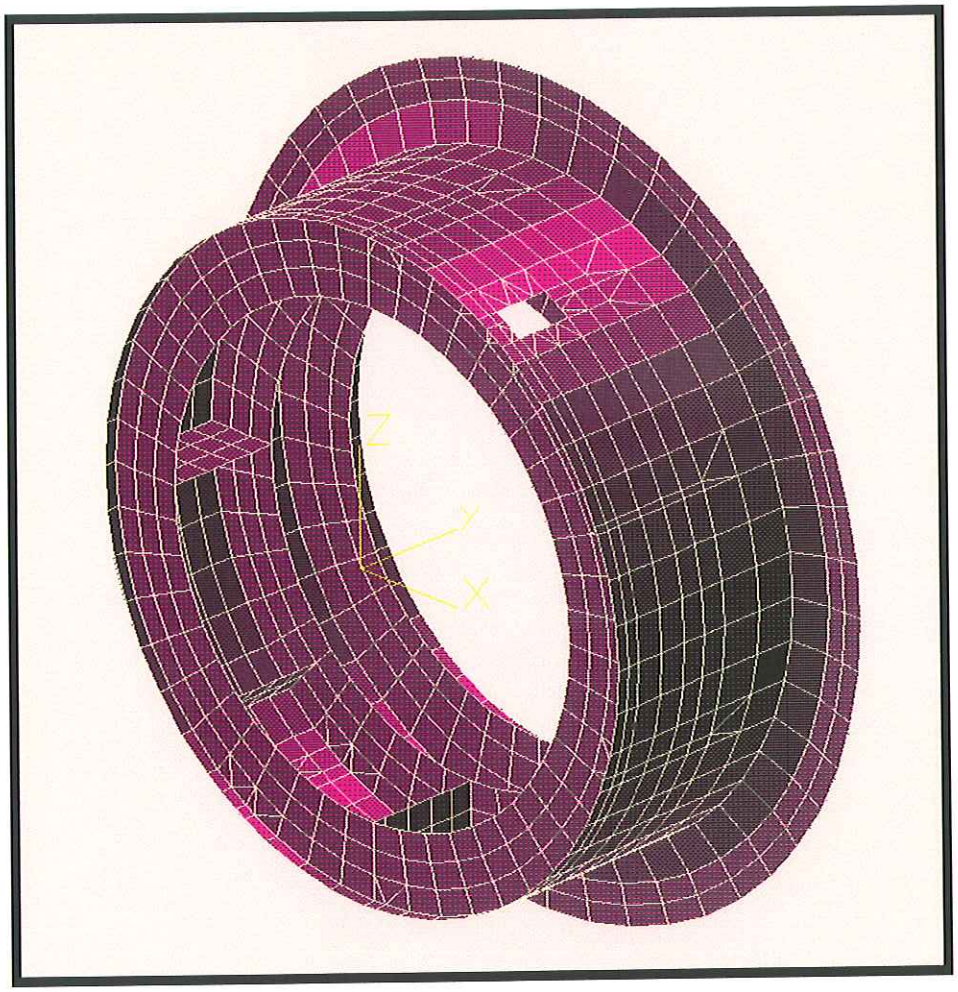


FIGURE 4

Guider housing, spacer, and NIR disk from model ECH28.

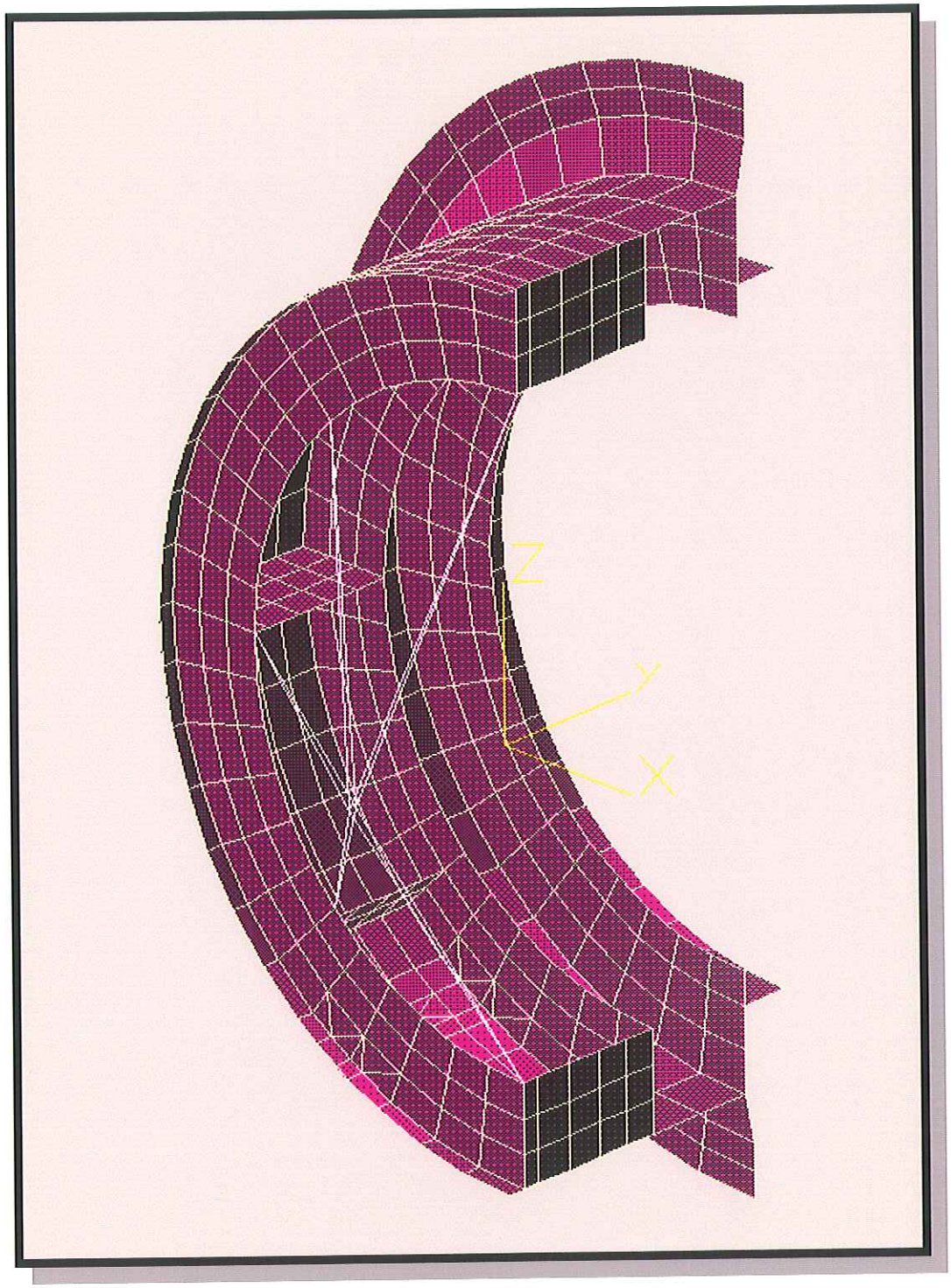


FIGURE 5

Model **ECH29** - Guider housing, spacer, NIR disk, and beam elements representing small instrument. One set of beam elements was used to apply instrument weight loading (500# @ 6" beyond focal plane). The second set of beam elements was used to determine motion of small instrument c.g. Beam elements were modeled in such a way as to not stiffen the guider housing.