There are two sets of clear apertures to maintain above the Binospec focal surface. One set is to maintain during normal observations, and this is set by the outermost points at the focal surface to be used for guiding and for wave front sensing as illustrated in Figure 1. Here, one slit mask half is shown, plus the wave front sensor patrol region.

We have three clear apertures to maintain: the upper and lower surfaces of the entrance window, and the entrance aperture in the “attic” calibration system. These clear apertures are shown in Figure 2, Figure 3, and Figure 4.
Figure 2. Beam footprint at the lower edge of the entrance window, 54.15 inches (1375.41 mm) from the primary vertex. This point is 16.516 inches (419.506 mm) above the vertex of the focal surface.

Figure 3. Beam footprint at the upper edge of the entrance window, 53.65 inches (1362.71 mm) from the primary vertex. This point is 17.016 inches (432.206 mm) above the vertex of the focal surface.
Figure 4. Beam footprint 35.23 inches (894.842 mm) behind the primary vertex. This point is 35.436 inches (900.074 mm) above the vertex of the focal surface.

For the calibration system, we do not need to illuminate the wave front sensor patrol region. The region at the focal surface that we need to illuminate is shown in Figure 5.

Figure 5. Region of focal surface that must be illuminated by the calibration system. Both channels of Binospec are indicated.

The beam footprints at the lower and upper ends of the 45º beamsplitter are shown in Figure 6 and Figure 7.
Figure 6. Beam footprint at the lower end of the beam splitter, 51.75 inches (1314.45 mm) from the primary mirror vertex. This point is 18.916 inches (480.466 mm) from the focal surface vertex.

Figure 7. Beam footprint at the upper end of the beam splitter, 38.134 inches (968.603 mm) from the primary mirror vertex. This point is 32.532 inches (826.313 mm) from the focal surface vertex.

The final clear aperture to check is the required size of calibration screen. The beam footprint on the calibration screen is shown in Figure 8.
Figure 8. Beam footprint at the position of the calibration screen 37.71 inches (957.834 mm) behind the primary mirror vertex. This point is 32.956 inches (837.082 mm) above the focal surface vertex.

In all cases, the Y axis runs along the long direction of the individual slit masks, and the X axis along the short direction of the slit masks. The wave front sensor is off-axis in the X direction.

Table 1. Clear apertures to illuminate slit masks and wave front sensor.

<table>
<thead>
<tr>
<th>Position</th>
<th>Distance from Primary Vertex</th>
<th>X direction (mm)</th>
<th>Y direction (mm)</th>
<th>Circular Aperture Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal Surface</td>
<td>70.666</td>
<td>±175 mm</td>
<td>±106 mm</td>
<td>408 mm</td>
</tr>
<tr>
<td>Window (lower edge)</td>
<td>54.15</td>
<td>±203 mm</td>
<td>±138 mm</td>
<td>460 mm</td>
</tr>
<tr>
<td>Window (upper edge)</td>
<td>53.65</td>
<td>±203 mm</td>
<td>±139 mm</td>
<td>461 mm</td>
</tr>
<tr>
<td>Attic opening*</td>
<td>35.23</td>
<td>-169 mm, +235 mm</td>
<td>±176 mm</td>
<td>519 mm</td>
</tr>
</tbody>
</table>

*The other X clear apertures are also asymmetric, but only this case was explicitly checked due to limited space. The wider opening is needed over the wave front sensor patrol region.
### Table 2. Beam footprints for calibration system

<table>
<thead>
<tr>
<th>Position</th>
<th>Distance from Primary Vertex</th>
<th>X direction (mm)</th>
<th>Y direction (mm)</th>
<th>Circular Aperture Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal Surface</td>
<td>70.666</td>
<td>±97 mm</td>
<td>±105 mm</td>
<td>408 mm</td>
</tr>
<tr>
<td>Beam Splitter (lower edge)</td>
<td>51.75</td>
<td>±135 mm</td>
<td>±143 mm</td>
<td>355 mm</td>
</tr>
<tr>
<td>Beam Splitter (upper edge)</td>
<td>38.134</td>
<td>±163 mm</td>
<td>±170 mm</td>
<td>405 mm</td>
</tr>
<tr>
<td>Calibration Screen</td>
<td>37.71</td>
<td>±164 mm</td>
<td>±171 mm</td>
<td>407 mm</td>
</tr>
</tbody>
</table>