

## SDN 021.09 Flex Rig

The optical schematic for the telescope simulator used for the GNIRS testing on the flex rig is shown in Fig. 1. The simulator is a straightforward refractive design utilizing an achromatic triplet which provides 1:1 reimaging of the source target onto the instrument image plane. The optical path is 1200 mm long. A pupil stop approximately 300 mm in front of the lens is reimaged to the 16.2 m distance of the Gemini secondary as seen by the instrument.

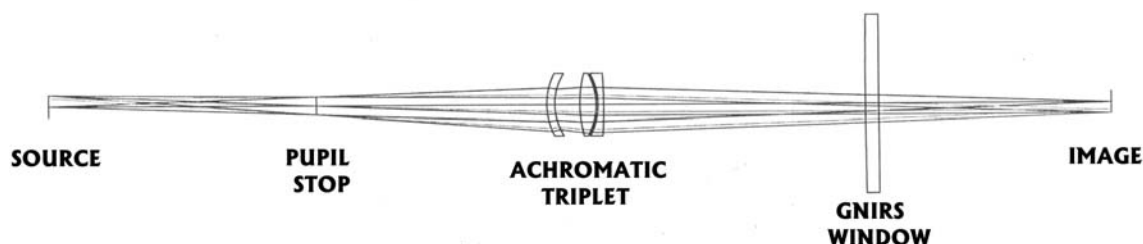


Fig. 1 Optical schematic of Telescope Simulator

### Source

The source (Fig. 2) is an existing in-house integrating sphere mounted on an XY microscope stage providing 25 mm travel in both coordinates. A locking screw prevents any inadvertent motion or creep with changing gravity vector. The stage is in turn mounted on a linear micrometer stage providing 25 mm adjustment in the Z (axial) coordinate for focus. Over this range, the relation between an axial motion of the source and that of the image is close to unity.

The integrating sphere itself has a clear aperture of 22 mm. There is a slide at the exit of the sphere which accepts brass shim target plates. A variety of targets were used in the GNIRS testing. For measuring the spectrograph (slit – detector) flexure and image quality, the full aperture of the source was used to illuminate the pinhole mask at the slit slide. Single and multiple-pinhole targets were used for measurement of the instrument flexure with respect to the ISS and spectrograph-OIWFS differential flexure.

The integrating sphere has a source mount which is a slip fit to a standard Pen-Ray emission line source. For a continuum source, we used an incandescent lamp whose intensity could be remotely adjusted from the flex rig control room.

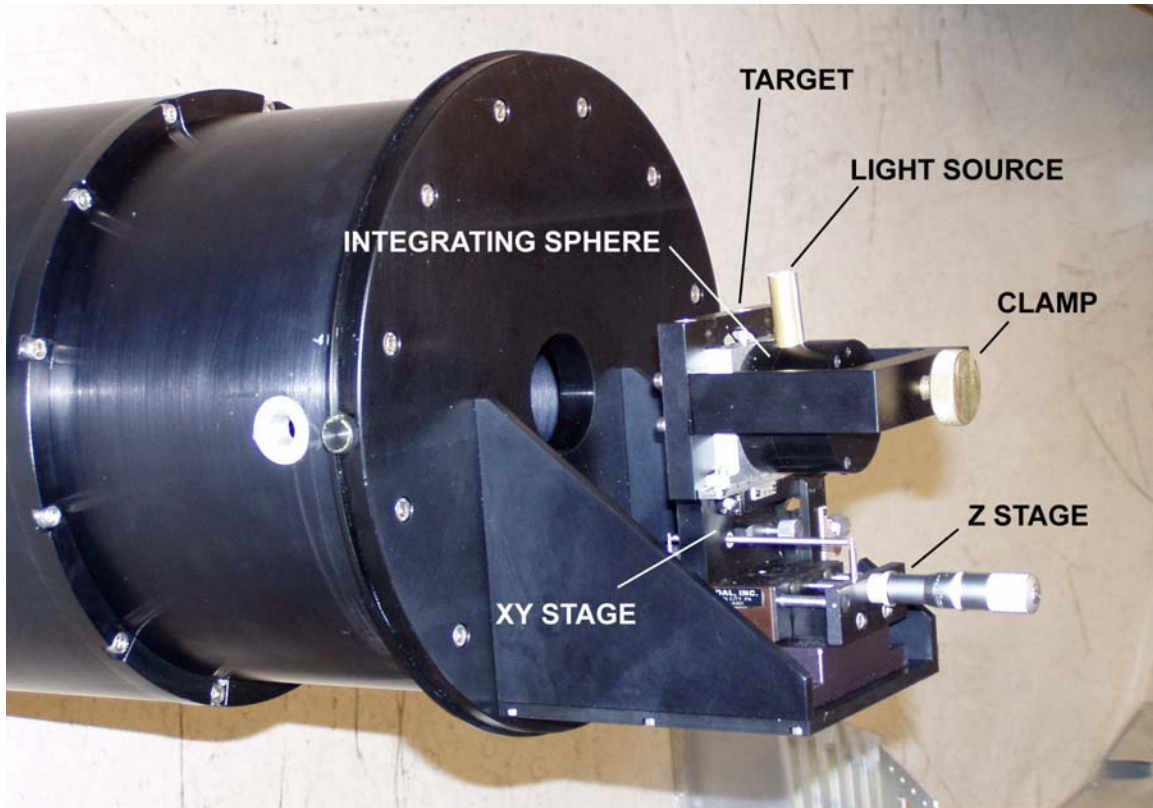


Fig. 2 Telescope Simulator Source Components

### **Pupil Stop**

The pupil stop is a removable plate with an appropriate aperture. For most of the testing, we used a 20 mm diameter aperture to provide an  $f/15$  beam, somewhat faster than the Gemini beam. A wire crosshair centered on the aperture was used as a fiducial during the GNIRS tip-tilt procedure and greatly simplified the task of aligning the simulator and instrument pupils. A smaller pupil stop was used to provide an  $f/33$  beam for investigation of aberrations in the OIWFS optics.

### **Lens**

The telescope simulator lens is a  $\text{ZnSe}/\text{BaF}_2/\text{CaF}_2$  triplet designed to be achromatic over the 1.1 – 4.2 micron range to permit evaluation of both the Red and Blue GNIRS cameras. The lens is not achromatic into the visible, so a combination of measurement and modeling was necessary to ensure that the infrared focus of the simulator is at the required 300 mm back focal distance from the ISS (see below).

Since the lens is not cooled, a simple lens mount with two radial hard stops was employed. The elements were radially preloaded with a spring plate installed opposite the two hard stops. Spacing rings were used for axial alignment, and a spring-loaded end plate provided axial preloading.

## Alignment/Focusing

To ensure that the beam from the telescope simulator was focused at the required 300 mm behind the ISS, we constructed an eyepiece fixture to be installed on the flex rig ISS plate. Prior to installation, the reticle of the eyepiece was set to the proper back focal distance using a digital height gauge in the instrument shop. Focusing was then a matter of installing a small (50 micron) aperture target in the source and adjusting the source axial position so that the aperture was focused on the eyepiece reticle. The micrometer reading was then recorded. This procedure had to be carried out prior to the installation of GNIRS on the flex rig.

With the eyepiece in place, the flex rig was moved throughout its range of travel and the image of the target was noted at each position. The maximum p-p excursion was about 0.1 mm. This was considered negligible for the purpose of the GNIRS testing, so no attempt was made to model the motion.

As noted above, the telescope simulator lens is not achromatic into the visible, but the focusing procedure must be carried out at visible wavelengths. ZEMAX modeling of the lens showed that the focus at 633 nm is 3.2 mm longer than in the 1.1 – 4.2 micron range, so the eyepiece was adjusted to put the reticle 303.2 mm behind the ISS. Because focusing a laser image can be difficult, we used a Ne Pen-Ray lamp after determining empirically that the generally red output of the lamp, combined with the transmission of the ZnSe lens element, gave a focal position indistinguishable from a HeNe laser.

Although there was no formal requirement on centering the GNIRS beam with respect to the ISS, we centered the target image on the eyepiece reticle and noted the X and Y readouts for future reference.

Although the ZEMAX modeling suggested that the image quality in the visible and IR should be excellent, we noted some spherical aberration and astigmatism in the optical images during the actual focus procedure. Some evidence for astigmatism was also seen in the IR using GNIRS in acquisition mode. Although the mounting technique is an obvious suspect, we could not find a clear problem. The as-built lens characteristics (from the vendor) and the as-built (in-house) lens spacers were all within tolerance, and the technique of using two radial hard seats and a leaf spring has been used in other instruments. Because of this residual aberration and the relatively slow f/15 beam, the uncertainty in determining the best focus was about  $\pm 0.75$  mm.

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