

GISMO Concept:

GISMO (the Gladders Image-Slicing Multislit Option) is a macroscopic image slicing module designed to work in conjunction with the IMACS spectrograph. *GISMO's function is to optically re-format the central field of view of IMACS (a region of approximately 3.5x3.2 arc minutes) in order to allow for an up-to 8-fold increase in the spatial density of slits in this region.* This is achieved by re-imaging 'slices' (each about 24" high) so that the spectra of objects from adjacent slices do not overlap. Figure 1 below illustrates this image-slicing conceptually.

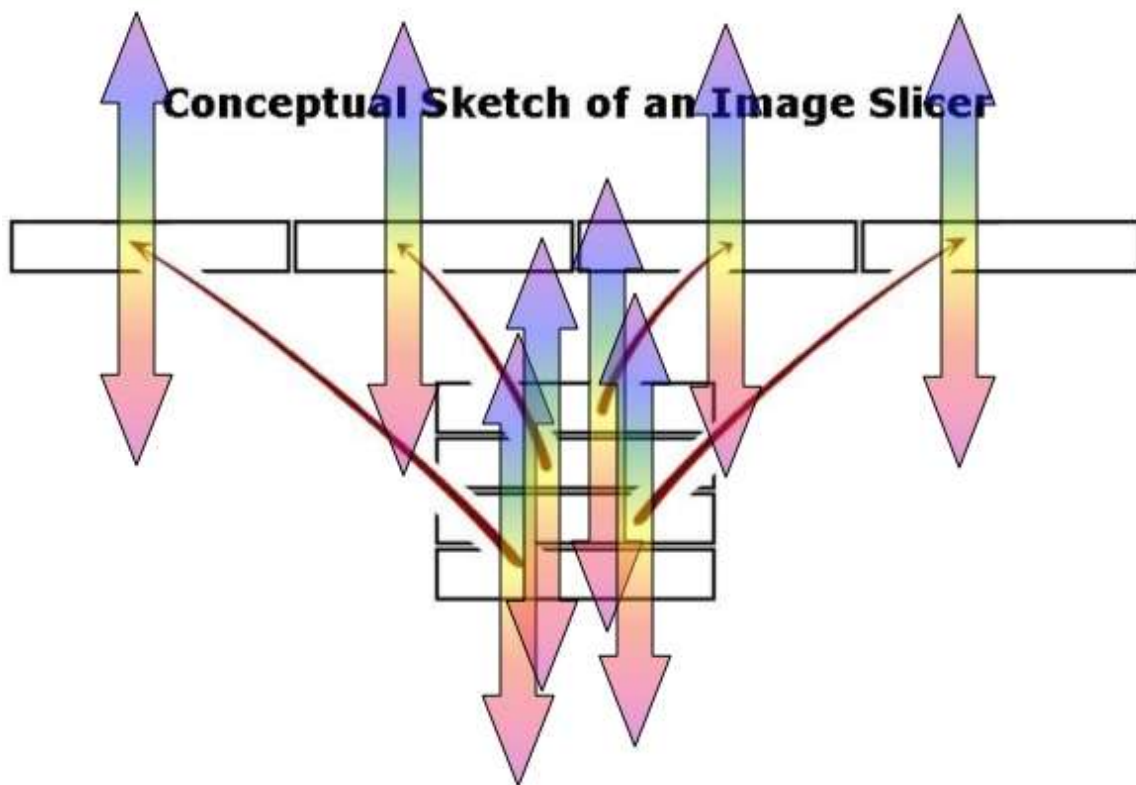


Figure 1: A conceptual sketch of an image slicer. The slices are initially stacked along the dispersion axis, and optically reformatted to be stacked end-to-end along the spatial axis. Hence spectra which might initially collide without reformatting now appear far apart.

The type of image slicer sketched above has been used in Integral Field Unit (IFU) applications in other instruments – for example NIFS on Gemini-North. However in such applications each slice is microscopic and corresponds effectively to a slit or single spatial resolution element across the short axis; GISMO is by contrast a macroscopic image slicer (in that each slice is much larger than a typical slit or spatial resolution

element.) Spectra of individual objects (or regions) are acquired with GISMO by placing a laser-cut slitmask between GISMO and IMACS. It is this combination of an image slicer (with its ability to allow simultaneous spectroscopy of adjacent regions) and a normal MOS (with the typical multiplex advantages thus offered) which makes GISMO unique.

Note that to IMACS the output of GISMO ‘looks’ like the sky. From a perspective of mask design or data reduction the principle effect GISMO has is to change, in a piece-wise fashion, the mapping of RA and Dec onto x and y in the IMACS input focal plane. This means that any of the disperser modes available within IMACS (including MOE) may be used in conjunction with GISMO. Note also that GISMO has been principally designed to work with the f/4 side of IMACS, in that the re-mapped field of view of GISMO just fills the f/4 field of view. However, there is no reason in principle why GISMO cannot be used with f/2; users should contact Mike Gladders (gladders@oddjob.uchicago.edu) if considering such a use.

Detailed Description:

Optical Design and Mounting:

GISMO has a total of 8 fundamental slices (and so in principle allows for a factor of 8 increase in the spatial packing of slits). These slices are split across the spatial axis in order to provide a simple quadrant symmetry to the optical design (and to keep the size of the re-imaging optics small) and so in practice GISMO consists of 16 independent optical paths. Each optical path has a slicing mirror (a rectangular section of a spherical surface, coated to operate as a first surface mirror) followed by a bonded transmissive doublet, then a second so-called ‘fold’ mirror (also a spherical surface) followed by a second bonded doublet. The slicing mirrors are assembled into a separate single unit, which sits at the input focal plane.

The footprint (designed) of GISMO projected onto the f/4 detector plane is shown below. The naming convention for the slices is simply ‘slice 1’ to ‘slice 4’, with slice 1 being the largest innermost slice in the input (i.e., before reformatting), and slice 4 the smallest outermost slice. The figure below also shows the nominal designed location of the outputs for GISMO (this is what actually appears in the detector plane, of course). Note that the mapping of the slices is not totally trivial, in that the positions of slice 2 and slice 1 are reversed in the output. This was done for several reasons, principally to accommodate the physical packing of the optics and optical paths.

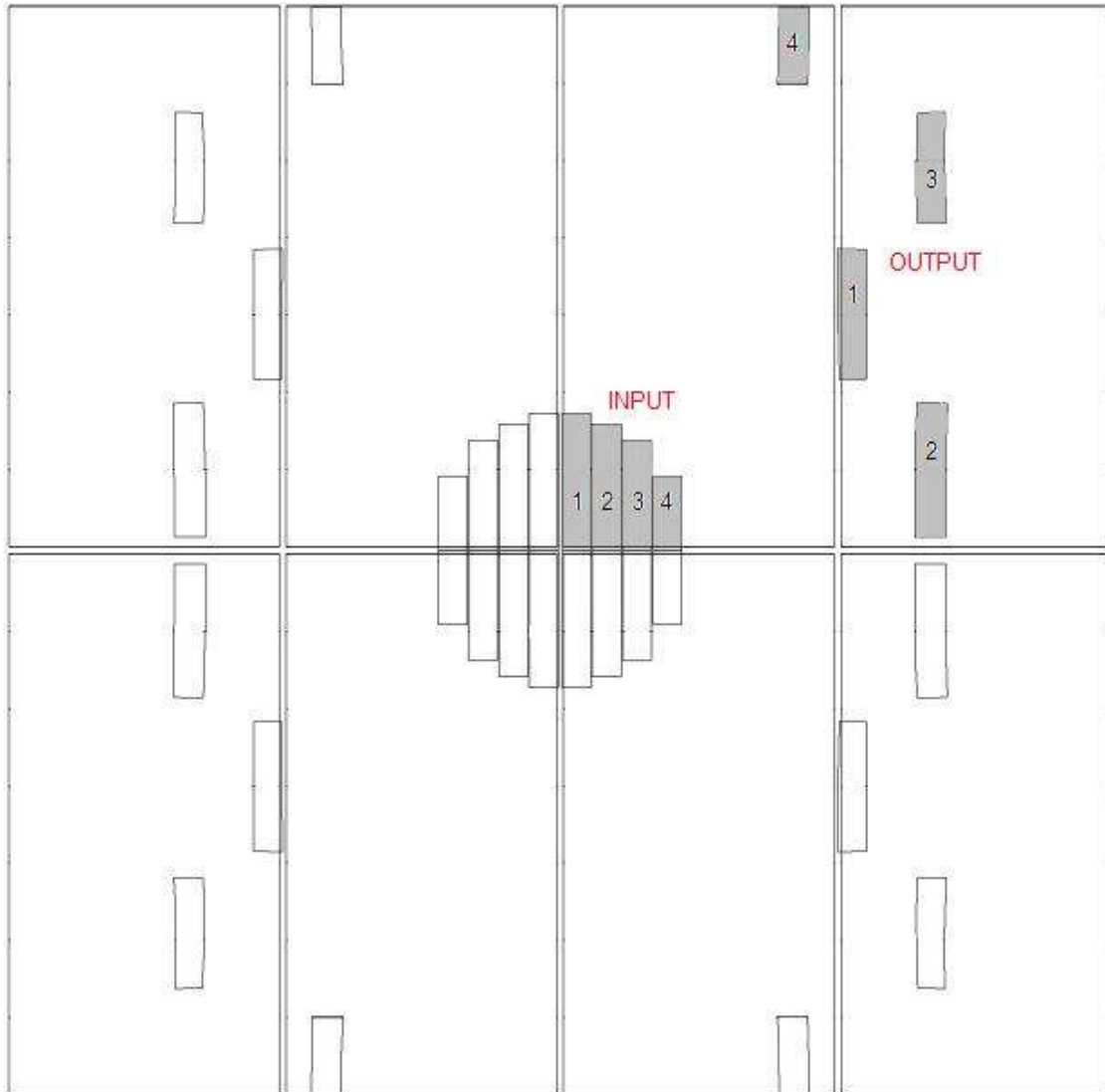


Figure 2: The GISMO footprint (both input and output) projected onto the $f/4$ detector plane. Dispersion runs left-right.

Longslit:

The design of GISMO incorporates a longslit (running vertically in Figure 2 along the central axis) which may be uncovered if desired. The slit is roughly 4 arcmin long, and $0''.6$ wide. This exists principally to facilitate principal-axis spectroscopy on nearby galaxies when using GISMO as sparse-sampled wide-field IFU, and may not be relevant for most users.

Masks:

Masks mount to the back of GISMO. The masks are non-standard, and are milled from flats sheets of stainless steel (of the same thickness as normal IMACS masks) which are

held in a cylindrical form. The intersection of this cylinder and the nominal focal surface of IMACS traces, to a good approximation, the locations of the GISMO outputs slices. GISMO accommodates only a single mask blank; however, this single blank can contain 4 masks designs (in addition to a 'through-hole' pattern, which is used for imaging through GISMO when aligning a mask on the sky.) The different mask designs (a.k.a 'set-ups') can be selected using the IMACS GUI; the mask slide on the back of GISMO is the only moving part of this instrument.

Observing Modes

Filters, Dispersers, Etc.:

As noted above, GISMO looks like the sky to IMACS. As a result any normally allowed combination of dispersers, filters, etc. can in principle be used with GISMO (including MOE). However, GISMO's mapping onto the detector is such that for particular combinations of filter bandpass, grating, and grating angle, the spectra from opposing slices (i.e., on the left and right halves of Figure 2) will not significantly overlap. Some filters and a new grating have been purchased specifically for this mode and are detailed below. (as well as one existing filter which is particularly relevant).

<i>Filter</i>	$\lambda_1(\text{\AA})$	$\lambda_2(\text{\AA})$	$\Delta\lambda(\text{\AA})$	<i>Notes</i>
GISMO-1	4791	6397	1606	new for GISMO, use with 300 ln/mm
GISMO-2	6296	8053	1757	new for GISMO, use with 300 ln/mm
GISMO-3	4507	5454	947	new for GISMO, use with 600 ln/mm
GISMO-4	6226	7171	945	new for GISMO, use with 600 ln/mm
GISMO-5	5694	9819	4125	new for GISMO, use with 150 ln/mm
WB3600-5700	3600	5700	2100	existing, use with 300 ln/mm blue; in conjunction with GISMO-5+150 ln/mm gives full coverage
Others	?	?	?	other existing filter/grating combos possible

Note that one may of course opt for longer spectra (such as when using MOE) which may then be interleaved slice to slice. Slit collisions etc. in the mask design will be handled normally in the mask design tool; there will however be some loss of spectral coverage in this mode. If you are considering using GISMO+MOE, please contact Mike Gladders (gladders@oddjob.uchicago.edu) for some further details on how to simulate MOE in the

mask design software. The two basic approaches to spectra/slit placement in GISMO are shown in Figures 3 and 4 below. Given all the available options, the best way to determine how GISMO may fit into your science program is to load up your favorite catalog in the mask design tool, and start twiddling knobs!

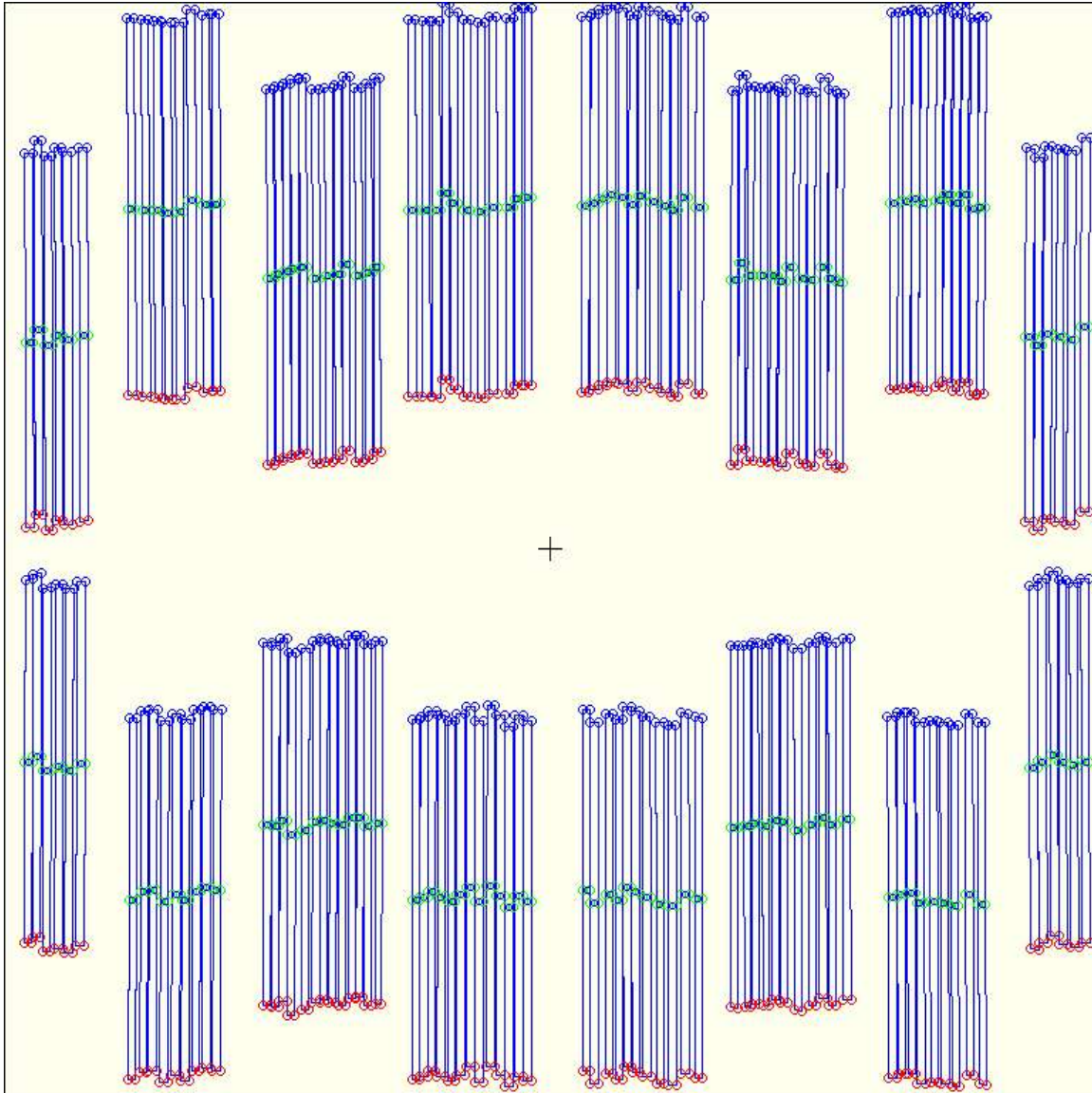


Figure 3: Mask design using a well-filled random catalog, using the 150 ln/mm grating, the wavelength limits listed for filter GISMO-5 above, centered in the middle of the filter. Note that the two ranks of spectra do not overlap, and fill the available detector quite well. Note this images is rotated 90 degrees in comparison to Figure 2

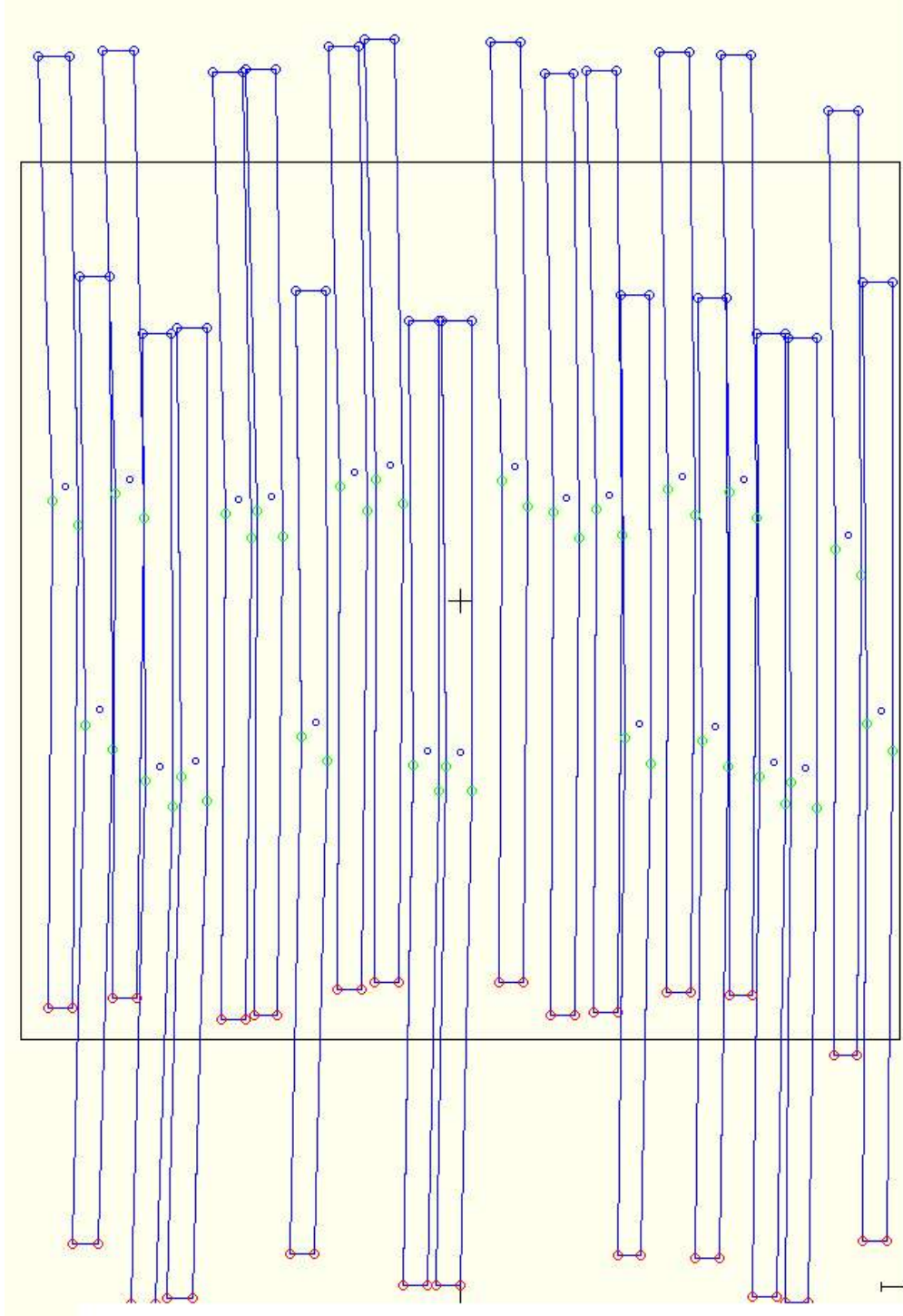


Figure 4: Mask design using the same catalog as Figure 3 above but using MOE as the disperser, and wavelength limits of 4800-7800 Angstroms. Note that spectra interleave across the two ranks, and that some spectral coverage is lost when using GISMO in this manner. Note this images is rotated 90 degrees in comparison to Figure 2

Standard MOS Slits and Nod-Shuffle:

Standard MOS observations (i.e., with slits about 6"-8" long and around 1" wide) are the typical expected GISMO observing mode. For example, the mask in Figure 3 was designed using 6"x1" slits, and contains 155 objects (though with no alignment stars). GISMO should accommodate normal micro-shuffle nod-shuffle observations as well.

Ultrplex Nod-Shuffle:

GISMO allows for an ultra-plex spectroscopy mode in which the central half of slices 1-3 can be used for densely packed spectroscopy. In this mode one places holes (typically 1"x1") on sources, rather than slits, and then nods on- and off-source. Spectra from these active regions map to 3 stripes in the detector, each of which is 1/7th of a detector wide. This mode has not yet been incorporated into the mask design tool; however the active region is mapped in the GISMO region file (see below).

Adding the Longslit:

The longslit will typically be covered. It may be brought into play simply by removing a cover on the back side of GISMO; if you are planning masks which incorporate the central longslit you should think carefully about spectral overlaps; this has not yet been included in the mask design tool. Some of the filters in Table 1 above have been designed to work with the longslit.

GISMO Region File:

A region file suitable for overlaying IMACS f/4 images in ds9 can be retrieved anonymously from [ftp.ociw.edu](ftp://ociw.edu) in /pub/gladders/GISMO/april08/. The file is in pixel coordinates (at the f/4 plate scale); savvy ds9 users may be able to transform this into a more generally usable region file in WCS coordinates (and if this is you, please deposit your modified file at the ftp site so others may use it too!)

Designing Masks

Masks can be designed using the normal IMACS mask design software. The latest version includes GISMO as a selectable option. The current information for GISMO within the mask design tool does not represent the final optical configuration of GISMO (this will be updated after an engineering run in April) but is sufficient to explore the multiplexing advantage of GISMO as changes will be at the sub-arcsecond level. The type of uses envisioned with GISMO suggest that GISMO mask designs (more so than other typical IMACS masks) may benefit from optimization with respect to central position and rotator angle; an IDL wrapper to the masks software which searches for optimal mask placement and rotation exists (it repeatedly calls *maskgen* using modified .obs files derived from an initial mask design) – again contact Mike Gladders (gladders@odjob.uchicago.edu) if you would like to explore this tool. Also note the

missing pieces in the mask design tool (ultraplex nod-shuffle, and longslit) as described in the relevant sections above.

As with a normal IMACS masks, alignments stars are needed to place the mask on-sky. 5-6 are recommended.

Data Reduction

Data reduction of GISMO data is as per normal IMACS data using the COSMOS tool. During the first GISMO shared-risk science run in January 2008, spectra were successfully reduced using COSMOS in near-real time.

Some GISMO Images

For those who are interested, here are a few images of GISMO. Figure 5 shows a side view illustrating the main components. Figure 6 shows the 'telescope' view of the instrument showing the slicing mirror assembly. Figure 7 shows the 'IMACS' view of the instrument with the mask plane and mask control system.

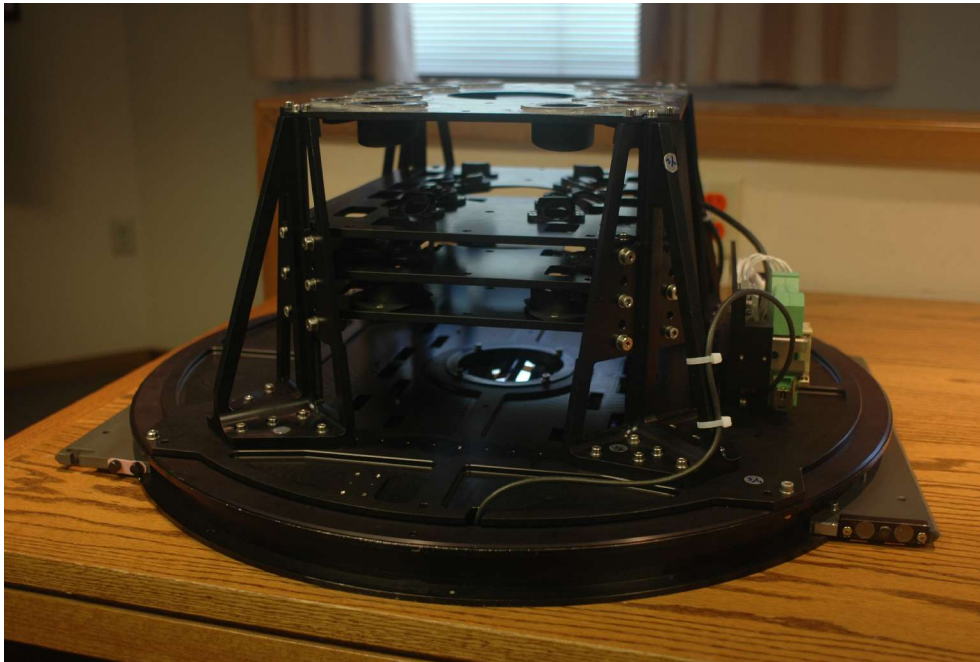


Figure 5. GISMO, complete, as of October 2007. The bottom surface faces the telescope (note the slides – left and right – by which GISMO mounts in the mask server box). A few of the slicing mirrors can be seen on the base plate. The top deck supports the folding mirrors and the three middle decks support the re-imaging lenses, which occur both before and after the folding mirrors. The electronics package for controlling the slit mask is mounted on the side right.

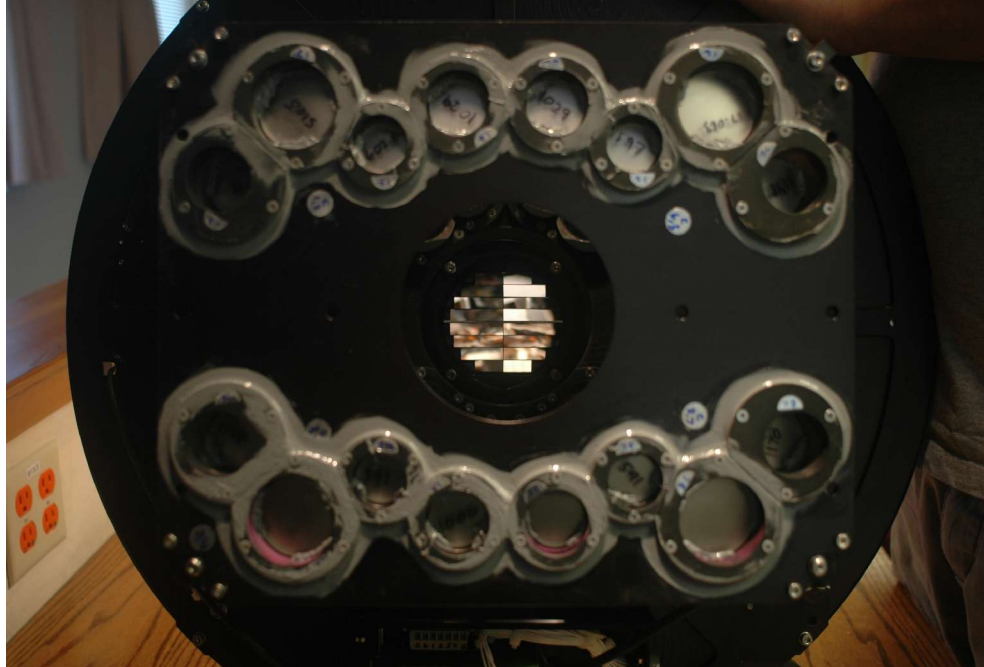


Figure 6. GISMO from the top (toward the telescope), showing the 16 slicing mirrors in the center, and the two rows of 8 folding mirrors (backside) in their cells.

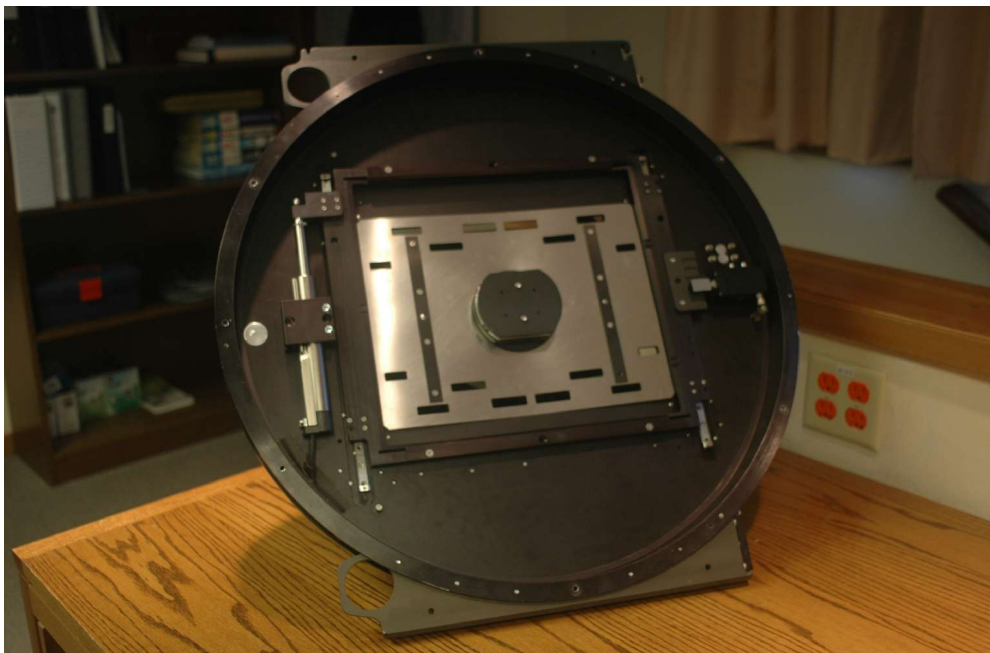


Figure 7. GISMO from the bottom, showing the back of the slicing mirror mount and the decker (silver plate) that blocks the sky from all but the 16 re-imaged slices. A linear motor (left) drives a stage that holds the cylindrically-curved slit mask. The brake and indexer is on the right.