Science with GMACS

The ability to obtain moderate resolution spectra of astronomical targets at optical wavelengths has been a fundamental scientific capability for more than a century. The GMACS spectrograph on GMT will be able to observe targets that can only be imaged with broadband filters today; the scope of future science opportunities with this instrument and telescope is vast. We expect that GMACS will form one of the most basic scientific capabilities of the GMT.

The GMACS Conceptual Design Report outlines several specific science cases (see http://instrumentation.tamu.edu/gmacs.html) for which GMACS will be particularly powerful. However, it is worthwhile pointing out explicitly that these specific cases are merely representative of the science that GMACS can and will produce.

- Evolution of the distribution of cold gas around galaxies from z=2 to z=4
- Measuring evolution of Lyα emission from composite systems
- Census of local group dark matter mass function and the dark matter profiles of dwarf galaxies
- Constraining the galactic halo and galactic center through spectroscopy of galaxy halo and hypervelocity stars
- The end of the stellar mass function: identifying brown dwarfs and cool subdwarf stars
- Measuring the faint end slope of the Lyα luminosity function at z = 6
- White dwarfs as a probe of stellar evolution
- Surface composition of Kepler Belt Objects
- A measurement of the galaxy power spectrum at z > 2.5

In the CoDR we also describe in detail specific synergies with LSST that will make GMACS+GMT a powerful instrument in the southern hemisphere. Below we outline two specific science cases that GMACS+GMT will be able to complete particularly well:

The evolution of the distribution of cold gas around galaxies from z=2 to z=4

The intervening absorption systems in background galaxy spectra provide our best constraints on the extent of cold gas in the circumgalactic medium around distant galaxies. Rest-frame UV spectra of distant galaxies are the detailed study of galaxy-scale outflows of cold gas via strong interstellar absorption lines and Lyman-alpha emission. GMACS observations could provide the first direct detection of these cold-gas components at these redshifts.

The conceptual mechanical design of GMACS has two basic sub-systems: a focal plane unit and labeled sub-assemblies.

The technical objectives drawn from the GMACS science case include:

- Sensitivity: High throughput: >50% at peak and no worse than 30% at any wavelength
- Sensitivity: Detectors with low readout noise (5% addition to background noise)
- Excellent image quality: <0.2 arcsec r.m.s over the entire detector plane
- Accurate and precise sky subtraction: use direct slits
- Multi-object capability: focal plane masks
- Wide field: 100 arcmin
- Broad wavelength coverage: at least 400-950 nm
- Moderate redshifts: 3000-5000
- Swinging limited operation: 0.7 arcsec slit (could make use of GACD in the red)
- Spectral accuracy over long exposures of <0.1 resolution element; flexure compensation

The GMACS conceptual design presented here meets or exceeds all of these requirements.

Optical design

The GMACS optics provide complete, simultaneous spectral coverage over the wavelength range from 380 nm to 10 µm for hundreds of objects in an 18-arcmin field of view. The resolution with a 0.7 arcsec slit is 1400 in the blue and 2700 in the red. GMACS incorporates a multi-slit mask to provide the best possible sky subtraction and instrumental throughput. To create the maximum possible field, the optical design divides the focal plane into four quadrants and makes use of multiple collimators and cameras with fields of 4.5 x 9 arcmin each, providing a 9 x 18-arcmin overall field of view. The total available slit length is 36 arcmin.

The conceptual mechanical design of GMACS has two basic sub-systems: a focal plane unit that translates into the active space in the GIR and is lifted to the telescope focal plane via an elevator mechanism and a pair of optics modules that contain the individual arms and channels. The focal plane unit is stored in the lower half of one GIR bay; the optics modules are permanently fixed to the "ceiling" of the GIR and occupy the top half of two bays.

Accomplishments

The GMACS focal plane is divided into four arms, two per optics module. The light is split in each arm into a red and blue channel. Each arm contains a collimator, dichroic, four VPH gratings (low and high resolution for each bandpass), and a red and a blue camera. Each pair of cameras (red and blue on each side) articulate as a pair to achieve different spectroscopic modes.