GMACS: a wide-field, moderate-resolution spectrograph for the Giant Magellan Telescope

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ABSTRACT

We discuss the latest developments of a spectrograph for the Giant Magellan Telescope. The instrument is designed to provide high throughput, moderate resolution, optical spectra for the telescope and be capable of flexible and rapid reconfiguration. The focal plane can be populated with custom slit masks or multiple fibers, allowing for observations of multiple objects simultaneously.

Keywords: Extremely Large Telescopes, spectrographs

1 INTRODUCTION

The Giant Magellan Telescope Multi-object Astronomical and Cosmological Spectrograph (GMACS) is a first light instrument for the Giant Magellan Telescope (GMT) that will provide wide field, multi-object, moderate resolution, optical spectroscopy of faint targets. The primary objective of the instrument is to provide spectroscopic observations of objects identified by current or future imaging surveys. The instrument has a long history[1] and was one of the first instruments envisioned for the GMT. There have been multiple conceptual design and trade studies done for the instrument; the latest is focused on assessing cost and risk for various instrument parameters (wavelength coverage, field-of-view, etc.). The final conceptual design process started in 2017 and is currently on-going.

The instrument is best described as a general-purpose spectrograph for the GMT. The overall goals are to create an instrument with high throughput and wide-wavelength coverage that works in the natural seeing limit (0.7 arcsec slit width is assumed). Multi-object modes using slit masks and, eventually, fiber input are also crucial objectives. Further, the instrument will need to make very precise radial velocity measurements, so control of flexure, wavelength calibration, etc. is critical. We will include the capability of reconfiguring the instrument to accommodate a range of observational capabilities during a given night, so resolutions, wavelength ranges, slit masks, and other instrument parameters will be straightforward to change quickly.

The instrument coupled to the GMT will have a vast range of science applications; including exoplanet atmospheres, star formation and chemical evolution studies, galaxy assembly histories, and intergalactic medium tomography. The performance will be optimized for faint targets and will effectively exploit the GMT's large collecting area and wide field. A particular goal will be to enable spectroscopic follow-up of DES and LSST objects; the instrument should be capable of obtaining spectra of any LSST alert, for example, within roughly one hour. The instrument will also be coupled to the MANIFEST fiber positioner MANIFEST[2,3] (see also Lawrence et al 10702-372 in these proceedings), which will significantly enhance the range and flexibility of the instrument. The project overall is integrated with the general GMT systems engineering effort and coordinates work plans/schedules with the project office (see Faes et al. 10702-46 in these proceedings).

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2 OBJECTIVES AND GENERAL DESIGN

A list of objectives for the instrument are given in Table 1; these have been derived from many input sources but are mainly based on the results of multiple consortium-wide workshops and internal science advisory committee recommendations. These have evolved somewhat over many years but represent an important and heavily used set of capabilities desired by the astronomical community. The objectives also make good use of the special characteristics of the GMT relative to other Extremely Large Telescopes, which includes wide field-of-view and reasonable plate scale.

We have made a number of design choices for the instrument based on these objectives. These include largely refractive optics and an approach that include no folds of convenience. The instrument will also have two simultaneous channels (blue and red) and use separate VPH gratings as dispersers. We believe these choices will lead to the highest possible throughput and allow the instrument to meet all objectives. These choices do lead to additional mechanical complexity, multiple detector planes, etc. We have developed concepts for the mechanisms, control systems, and other parts of the instrument and built and tested some prototypes to ensure specifications can be met (see Cook et al 10702-365 in these proceedings; other details of the mechanism controls and software are also given in this paper).

Table 1 GMACS Principal Functional Parameters

Parameter	**Objective**
Field of View	50 arcmin sq.
Wavelength Coverage	320-1000nm
Spectral Resolution (0.7 arcsec slit width)	Blue: <1000-6000, Red <1000-6000
Throughput	>40% at all wavelenghts
Image Quality	80% EE at 0.15 arcsec
Spectral Stability	0.1 spectral resolution elements/hour
Number of Gratings	>2
Slit Mask Exchange	>12

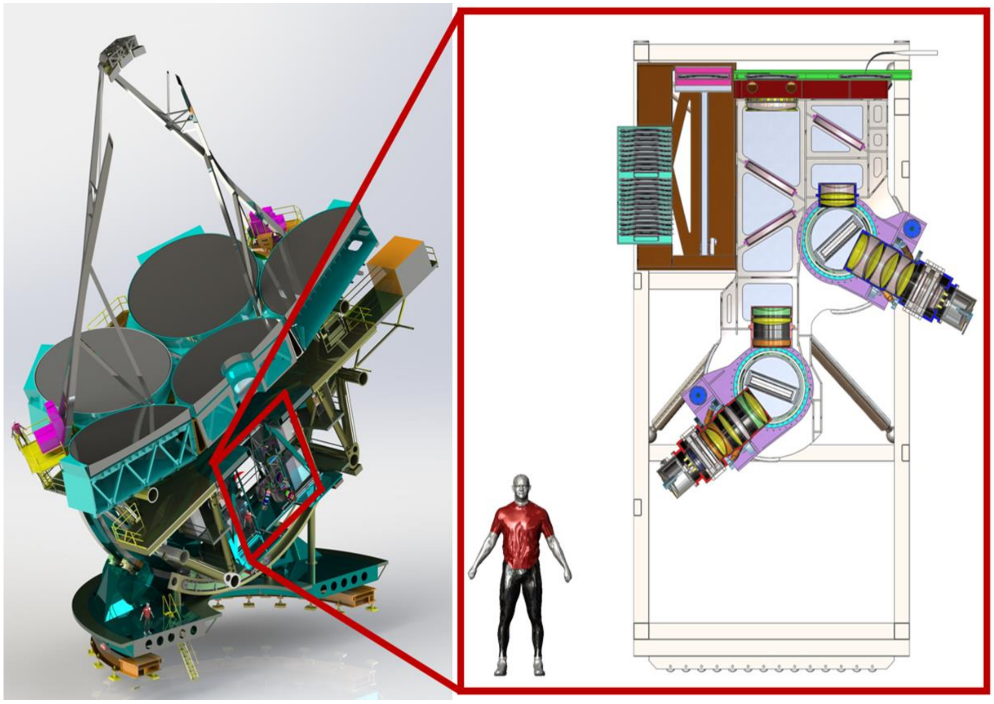
3 OPTICAL DESIGN

The basic optical design of the instrument is a classic collimator-camera configuration. A dichroic will be used to separate the science light into two channels (roughly 320-580nm and 520-1000nm) each of which will have an independent focal plane. The beam is roughly 270mm in diameter and the dichroic will separate at roughly 550nm. More details of the optical design, particularly lens material choice, initial performance estimates, and possible alternate designs, are given in Ribeiro et al (10702-340 in these proceedings) and Schmidt et al[4].

4 OPTOMECHANICAL DESIGN

The optomechanical design of the instrument is well advanced and is based on many previous studies and instruments. The structural elements will interface to the GMT, support all optical components, and hold all mechanisms. A rendering of a current concept is shown in Figure 2. The lens barrels and cells, for example, are based on designs of numerous ~300mm class lens elements, which employ flexures, thermal compensation, etc. to provide adequate support. Mechanisms will include slit mask interchange racks, camera/collimator angle adjustment, and flexure compensation. Many more details of these concepts are given in Prochaska et al.[5] and Prochaska et al (10702-365 in these proceedings).

Figure 2: Rendering of the current concept for GMACS.



5 USE WITH MANIFEST

The MANIFEST fiber positioner will increase the observational capabilities of GMACS significantly. The MANIFEST fibers will be "re-mapped" into a slit for GMACS and mounted on the instrument in a special cartridge that can accommodate a wide range of configurations (see Prochaska et al. 20702-364 in these proceedings). MANIFEST will allow two important additions to GMACS: the ability to observe objects over the entire 20 arcminute GMT field (in multiple modes, including single objects, multiple integral field units, etc.) and the ability to effectively "re-map" the fibers to a narrow input slit, which can increase the instrumental resolution by a factor of ~5. Both these modes will be heavily used for a wide variety of science projects.

6 FUTURE WORK

There is substantial work to be done on the instrument, but we expect that by mid-2018 the full concept will be determined and all major design choices will have been made. We are actively working on the finalizing these choices. The plan is to coordinate with the GMT commissioning schedule for deployment of the instrument. We currently expect science operations in roughly 2025.

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