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MEGARA: THE FUTURE IFU AND MOS OF THE 10.4 M GTC

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RESUMEN

En esta comunicación resumimos las características y estado del proyecto del instrumento MEGARA (Multi-Espectrógrafo en GTC de Alta Resolución para Astronomía), la futura Unidad de Campo Integral (IFU) y Espectrógrafo Multi-Objeto (MOS) ópticos para el telescopio GTC de 10.4 m. MEGARA está siendo construido por un consorcio de instituciones liderado por la Universidad Complutense de Madrid (UCM, España) que también incluye el Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE, México), el Instituto de Astrofísica de Andalucía (IAA-CSIC, España) y la Universidad Politécnica de Madrid (UPM, España). La IFU de MEGARA ofrece dos diferentes haces de fibras ópticas, uno llamado *Large Compact Bundle* (LCB) cubriendo un campo de visión de 14×12 arcsec^2 y un tamaño de *spaxel* de 0.685 arcsec con una resolución espectral de R=6000–19000 y otro denominado *Small Compact Bundle* (SCB) que cubrirá 10×8 arcsec^2 con *spaxels* de 0.48 arcsec y R=8000–25000. La componente MOS permitirá observar hasta un total de 100 objetos en un campo de 3.5×3.5 arcmin^2. En septiembre de 2010 se seleccionó MEGARA como el futuro espectrógrafo óptico de GTC. Su revisión de diseño preliminar (PDR) está prevista para marzo de 2012 y la primera luz para el 2015.

ABSTRACT

In these proceedings we summarize the characteristics and current status of MEGARA, the future optical IFU and MOS for the 10.4 m GTC. MEGARA is being built by a Consortium led by the UCM (Spain) that also includes the INAOE (Mexico), the IAA-CSIC (Spain) and the UPM (Spain). The MEGARA IFU offers two different bundles, one called LCB with a field-of-view of 14×12 arcsec^2 and a spaxel size of 0.685 arcsec yielding spectral resolutions between R=6000–19000 and another one called SCB covering 10×8 arcsec^2 with 0.48 arcsec spaxels and resolutions R=8000–25000. The MOS component allows observing up to 100 targets in 3.5×3.5 arcmin^2. In September 2010 MEGARA was selected as the next optical spectrograph for GTC. Its PDR is scheduled for March 2012 with First Light on 2015.

Key Words: instrumentation: spectrographs — techniques: spectroscopic — telescopes

1. INTRODUCTION

On June 2010, in response to the call for *Letters of Intent for New Instrumentation* issued by GRANTECAN S.A. on September 2009, a consortium led by the Universidad Complutense de Madrid (Spain) the presented the Conceptual Design of MEGARA (*Multi-Espectrógrafo en GTC de Alta*

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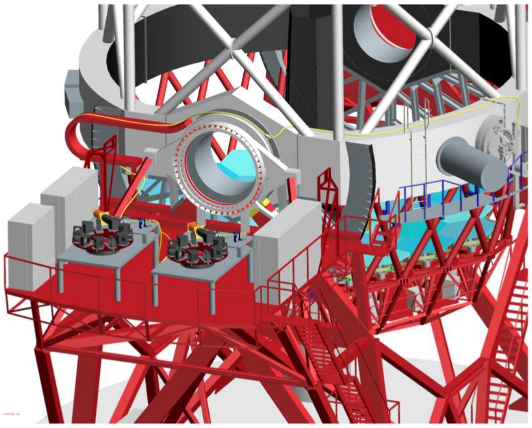

Fig. 1. 3D model of MEGARA at the 10.4 m GTC. All, the Folded-Cass subsystem, the fiber routing and the MEGARA spectrograph at the Nasmyth platform are shown. Note that the expected final destination of the spectrograph according to the long-term instrumentation plans of GRANTECAN is a sub-Nasmyth platform.

Resolución para Astronomía), a mid-to-high spectral resolution spectrograph with both IFU and MOS capabilities. After the selection of MEGARA by the GTC Steering Committee as what should be the next optical spectrograph for GTC on September 2010, the MEGARA Consortium, composed by the UCM, the INAOE, the IAA-CSIC and the UPM, took the responsibility for the design, construction and integration of the instrument.

In these proceedings we summarize the main characteristics of the instrument, both the Folded-Cass focal plane (§ 2) and the MEGARA spectrograph (at the Nasmyth platform; § 3) along with the science the instrument has been designed for (§ 4) and the status of the project (§ 5).

2. MEGARA AT FOLDED-CASS

In Figure 1 we show a 3D model of the whole MEGARA instrument at GTC. In this section we describe the focal-plane subsystem, which is placed at one of the GTC Folded-Cassegrain foci. This subsystem includes the instrument foreoptics.

The first optical element of the instrument is a field lense that allows correcting for telecentricity so the entire MEGARA focal plane sees the same telescope pupil. Right after this field lens we have the two IFU bundles and a system of 100 robotic positioners than constitute the Fiber-MOS instrument mode. In order to minimize the Focal-Ratio Degradation (FRD) at the fibers and to ensure a doable camera that fulfills the MEGARA Science Team requirements in terms of image quality (EED80 in less than four 15 μm pixels for 100 μm-core fibers) and multiplexing ($\sim$600 fibers per pseudo-slit) the input telescope focal ratio ($\sim$f/17) is reduced to f/3 at the input face of the optical fibers. This is achieved by using microlens arrays manufactured by microlithography techniques.

In the case of the Large Compact Bundle (LCB) an array of hexagonally-shaped microlenses with a projected size on the sky of 0.685 arcsec per microlense (i.e., spaxel) yields a total field-of-view (FOV) of 14×12 arcsec^2. These are hexagonally packed so the filling factor is roughly 100%. Each of these microlenses projects the image of the telescope pupil on a 100 μm-core fiber. In the case of the Fiber-MOS each robotic positioner places an array of 7 hexagonally-shaped and packed microlenses, all identical to those used in the LCB IFU, in a patrol area around it. Finally, the Small Compact Bundle (SCB) uses microlenses that yield the same focal reduction but with smaller projected spaxel (0.48 arcsec) and fiber-core sizes (70 μm) than for the LCB and a total FOV of 10×8 arcsec^2. Figure 2 shows the layout of the different instrument modes on the GTC Folded-Cass focal plane.

The fibers coming from each instrument mode (LCB, SCB, MOS) are mounted on a different pseudo-slit. In the current budgetary scenario only one spectrograph is funded which would allow the astronomer to observe with only one of these modes simultaneously. The ultimate goal of both Consortium and MEGARA Science Team is to have two spectrographs installed at GTC to run both the IFU and MOS modes simultaneously.

3. MEGARA SPECTROGRAPH

The optical fibers drive the light from the Folded-Cass to the place where the MEGARA spectrograph is located, in this case the (sub-)Nasmyth platform (see Figure 1). The MEGARA spectrograph is a fixed-angle collimator-camera system that makes use of VPHs as disperser elements and whose design is optimized for the entire optical window. Depending on whether 100 μm- or 70 μm-core fibers are used (LCB/MOS or SCB, respectively) the spectral resolutions range between R=6000–19000 or R=8000–25000, respectively. The lowest resolution (LR VPHs) is achieved using VPHs with flat windows, while the mid- and high-spectral resolutions (MR and HR VPHs, respectively) are achieved using prisms that change the incident angle on the VPH. A novel technique based on the use of sliced-pupil VPHs allows reaching the highest spectral resolutions using a relatively compact pupil element.

Given the high spectral resolutions and relatively good sampling of the lines, the spectral coverage of

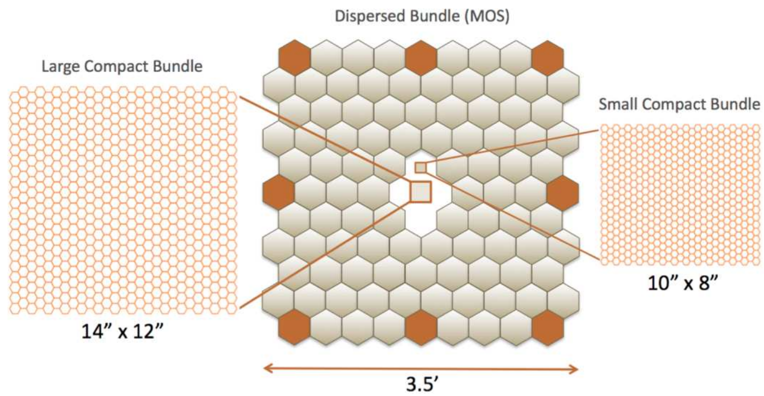

Fig. 2. MEGARA focal plane layout. The two IFU bundles (LCB and SCB) are placed at the center of the focal plane. These are surrounded by a system of 100 robotic positioners whose approximate patrol areas are marked with gray-filled hexagons. The eight color-filled hexagons at the edge of the field are mounted on the same pseudo-slit as the LCB.

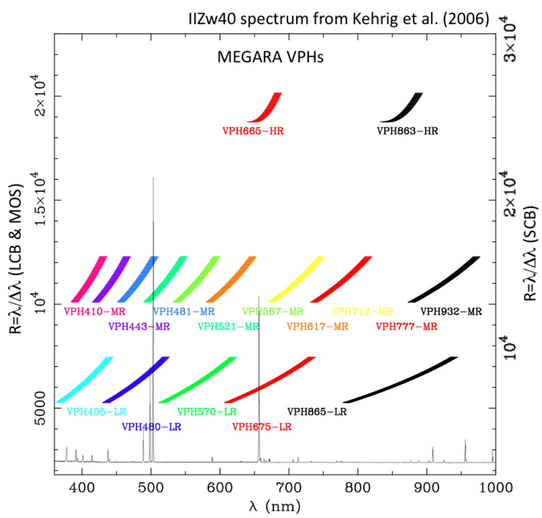

Fig. 3. Wavelength coverage and spectral resolution of all 16 VPHs designed for MEGARA (11 mounted simultaneously). The resolving power is given both for the LCB and MOS (left axis) and the SCB IFU (right axis).

each individual VPH is rather limited and the number of VPHs required to provide full optical coverage is high. Thus, a direct motor has been designed that is responsible for holding all 11 VPHs simultaneously accessible (out of the 16 VPHs designed) and for placing each of them at the pupil position. In Figure 3 we show the spectral coverage of all VPHs designed along with the spectral resolutions achieved both for the LCB and the MOS and for the SCB.

4. MEGARA SCIENCE CASE

The requirements defined by the MEGARA Science Team during the instrument design phases are based of the need of studying two types of astronomical objects. First, the study of nebular objects, both in our Galaxy (PNe or HII regions) and outside (nearby galaxies). With respect to the former both a high spectral resolution, for the study of the post-AGB winds, and a wide wavelength coverage, for the study of different chemical abundance diagnostics, are needed. Regarding the study of nearby galaxies, our main interest is the understanding of the stellar population content and velocity ellipsoid of disks with the objective of determining the relative contribution of in-situ star formation, migration and satellite accretion to the current observational properties of these objects. This again requires of both high spectral resolution at some specific wavelengths and wide wavelength coverage at low resolution.

On the other hand, our team is also interested in the study of point sources with high number densities on the sky, such as Galactic stellar clusters, resolved stellar populations in Local Group galaxies and distant galaxies. Depending on the specific field of research the spectral coverage and resolution needs are different. This drives the necessity of a versatile instrument such as MEGARA, which we believe will also grab the interest of the GTC community.

5. STATUS

The Preliminary Design Review of the instrument is scheduled to take place in Madrid on March 1st-2nd, 2012 with a Critical Design Review in 2013 and First Light at the end of 2015. Significant progress is being made in all fronts and work packages thanks to the contribution of GRANTECAN S.A. (and all GTC partners) through a contract with the UCM for the PDR phase and contributions from the MEGARA Consortium partners plus the support from the AstroMadrid network and the Consolider (CDS00070-2006) project.