MEGARA Focal Plane Subsystems

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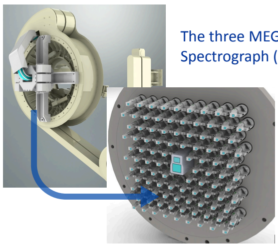
Abstract

MEGARA (Multi-Espectrógrafo en GTC de Alta Resolución para Astronomía) is the future optical Integral-Field Unit (IFU) and Multi-Object Spectrograph (MOS) for GTC. The Fiber Units are placed at one Folded Cassegrain focus and feed the spectrograph located on a Nasmyth-type platform. This paper summarizes the status of the design of the MEGARA Folded Cassegrain Subsystems after the PDR (held on March 2012), as well as the prototyping that has been carried out during this phase. The MEGARA Fiber Unit has two IFUs: a Large Compact Bundle covering 12.5'' x 11.3'' on sky (100 microns fiber-core), and a Small Compact Bundle, of 8.5'' x 6.7'' (70 microns fiber-core), plus a Fiber MOS positioner, able to place up to 100 mini-bundles 7 fibers each (100 microns fiber-core) in MOS configuration within a 3.5' x 3.5' FOV. A field lens provides a telecentric focal plane where the fibers are located. Microlens arrays couple the telescope beam to the collimator focal ratio at the entrance of the fibers (providing the f/17 to f/3 focal ratio reduction to enter into the fibers). Finally, the fibers, organized in bundles, end in the pseudo-slit plate, which will be placed at the entrance focal plane of the MEGARA spectrographs.

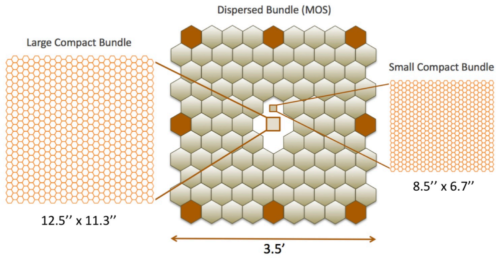
MEGARA modes: Fibers arrangement at the Folded Cassegrain Focal Station



The three MEGARA modes corresponds with the three fiber bundles available: the Large Compact Bundle IFU (**LCB**), the Small Compact Bundle IFU (**SCB**) and the Multi-Object Spectrograph (**MOS**) mode (also called the Dispersed mode).

The **LCB** is composed by 567 fibers of 100 µm core displayed on a square area of about 12.5 arcsec x 11.3 arcsec near the optical axis of the instrument plus 8 positioner robots (orange hexagons in the figure) located in the outer edge of the instrument FOV used for measuring the sky background simultaneously with the observations with the LCB.

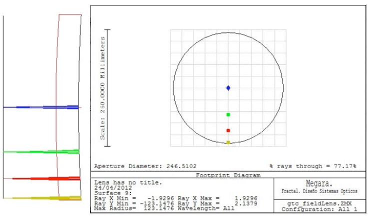
The **SCB** is composed by 500 fibers of 70 µm core distributed in a square image area of 8.5 arcsec x 6.7 arcsec, whose center is offset approximately 19 arcsec from the center of the LCB.

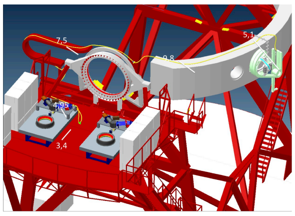


The fibers belonging to **MOS** mode are 100 µm in core and can be positioned anywhere in the central 3.5 arcmin x 3.5 arcmin around the two IFU bundles thanks to the positioner robots, which support a minibundle of 7 fibers each.

Field lens

The lack of telecentricity of the GTC focal station is corrected using a field lens. The opto-mechanical axes of all the fiber bundles will be parallel among them. The field curvature is below 0.1 arcsec in the whole FOV.





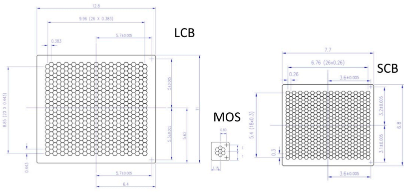
Fibers cables

The selected fibers are FBP 100/140/170 and FBP 70/140/170 from Polimicro. Both are wide broadband fiber, provide a good FRD and have a numerical aperture of 0.2 ± 0.02

Currently, the total fiber link is estimated in 32 meters. The figure (on the right) shows the way to be covered by the fibers from the Folded Cassegrain focal plane to the spectrograph entrance.

Microlens array

The 2D refractive microlens array shall couple the science light at the telescope focal plane into the fibers, defining the FOV to be introduced in the fiber and adapting F# from f/17 to f/3 to minimize FRD. The microlens designs have been done looking for a compromise to optimize (a) the flux recovered from point sources with each MEGARA MOS mini-bundle, (b) the fraction of light lost when reimaging the pupil on the fiber core, (c) the need of fully imaging the fiber core in order to preserve the quality of the relative-flux calibration from fibre-to-fibre and (d)



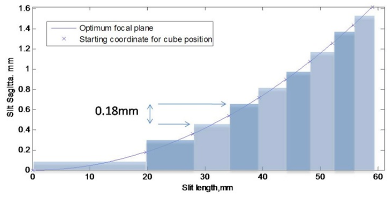
As conclusion, the spaxel size is fixed to 0.62 arcsec for 100 µm and 0.42 for 70 µm.

The microlens will be arranged in different arrays for each mode (LCB, SCB and MOS) that shall follow a hexagonal geometry to maximize the area to be cover. The figure shows the microlens array design for the three diferent bundles.

Pseudo slit

The fibers are placed in front of each spectrograph at the pseudo-slit position, where the focal plane is smoothly curved with a ROC of 1075mm and a size of 119mm.

As the polishing of the fiber mounted in a curved surface is not advisable, the pseudo-slit frame shall be split in several flat frames, called boxes, arranged to follow the curvature of the pseudo-slit (as shown in the figure below).

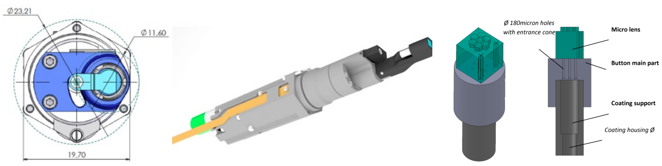


In LCB case, the 623 fibers tube should have an octopus distribution and must be divided in dedicated tube benches to arrive to each box in the LCB pseudo-slit. A similar solution is proposed for the SCB. In MOS case, the fiber minibundles shall be organized in multiples of 7.

The requested gap between fibers (2 pixels separation at the dtector) is reached buffering them side by side.

Fiber MOS

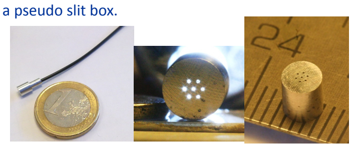
The Fiber MOS allows placing all 100 seven-fiber minibundles (8 of them for LCB sky subtraction) anywhere in the 3.5 x 3.5 arcmin^2 FOV. Each fiber minibundle patrols a circular area of diameter Ø23.21 mm thanks to the two rotations provided by the positioner robot.

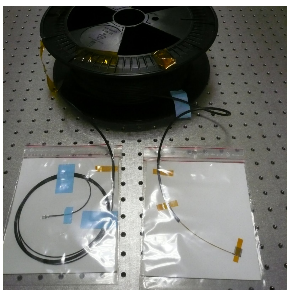


Fiber MOS and Fiber bundles prototypes

Two prototypes have been manufactured during the preliminary design: the Fiber bundle prototype and the Fiber MOS positioner prototype. In both prototypes the fiber link is 40 m to simulate the most pessimistic estimated length at GTC (between Folded Cassegrain focus and the Spectrograph location).

The Fiber Bundle prototype includes a minibundle of 7 fibers. This prototype ends on one side (the Folded Cassegrain Focal Station end) by a standalone positioner button (without the positioner) over which the microlens array shall be mounted and, on the other side (the spectrograph position), by a replica of a pseudo slit box.

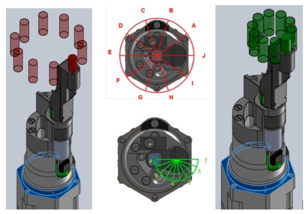


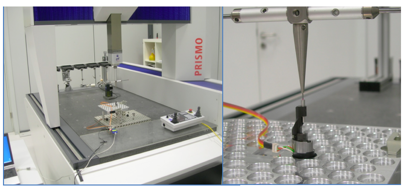


This prototype will be used to carry out several optical tests, as FDR measurements, in order to check the real optical behaviour of the entier fiber system (fibers and microlenses). These tests will be performed at LICA laboratory at the Complutense University (LICA-UCM). We have also proposed to integrate this prototype at GTC in order to repeat these measurements on the GTC when F/C rotator will be installed.

The Fiber MOS positioner prototype includes a complete Fiber MOS Positioner and the 7-fiber minibundle attached to the positioner.. The positioner was designed and manufactured at AVS and then was sent to SEDI, where the fiber minibundle was integrated.

Geometrical tests have been carried out to determine the behavior of both rotations (R1 and R2).





All requirements (radius, flatness, parallelism, eccentricity, tilt and positioning accuracy) have been fulfilled. Therefore, we can conclude that the positioner prototype achieves the requirements providing high repeatability and high positioning accuracy.

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