

MEGARA Multi-Object Spectroscopy robotic positioners

Multi Espectrógrafo en GTC de Alta Resolución para Astronomía

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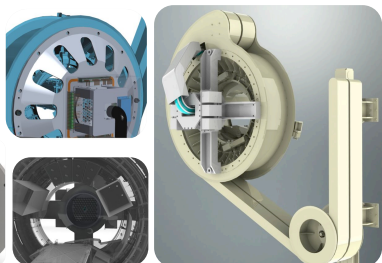
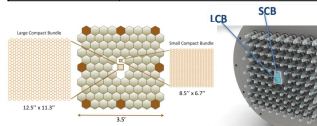
Abstract

MEGARA is the future optical Integral Field Unit (IFU) and Multi-Object Spectrograph (MOS) for the 10.4-m Gran Telescopio CANARIAS (GTC). This poster summarizes the design of the MEGARA Fiber MOS and the positioner robot prototypes built and tested. The fiber positioner of the MOS are considered a critical part of the instrument due to the high positioning accuracy required and its micro mechanics. Therefore, a fiber positioner prototype has been manufactured for the PDR stage of the project. Its reliability and performance have been tested and manufacturing process optimized for the mass production of the positioner.

Fibers arrangement at the Folded Cassegrain Focal Station

MEGARA shall provide three different modes, which 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).

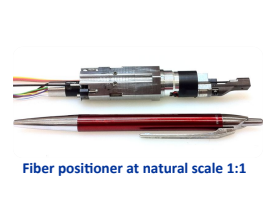
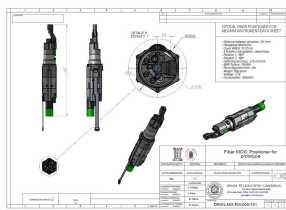
IFU bundles	12.5x11.3 arcsec ² (LCB), 8.5x6.7 arcsec ² (SCB)
MOS	100 objects in 3.5x3.5 arcmin ²
Spaxel (fiber) size	0.62 arcsec (LCB & MOS), 0.42 (SCB)
Wavelength range	3650-10000 Å
Spectral resolution	LCB/MOS: R=6000-18700 SCB: R=7000-21500
# of spectrographs	1 (IFU or MOS) (650 simultaneous spectra)
GTC station	Folded-Cass [spectrograph @ Nasmyth]



MEGARA fiber MOS positioner prototype

The positioner system consists of 100 identical positioners distributed on the focal station. 3.5 x 3.5 arcmin² (on sky) area around the two IFU bundles. The technological challenge associated to the development of the positioner system lies on the reduced size and precision required for positioning the fibers with the fiber positioners.

The Fiber MOS positioner prototype includes a complete Fiber MOS positioner and the 7-fiber minibundle attached to the positioner.



Positioner prototype datasheet

Positioner performance tests

Geometrical tests have been carried out to determine the behavior of both rotations (R1 and R2) concluding that the positioner prototype achieves the requirements and provides high repeatability and high positioning accuracy. The tests carried out at AVS include Probe force tests, Geometrical tests, Zero Protocol tests, Step uniformity and resolution, Backlash, Target repeatability and Lifetime test.

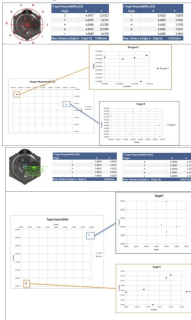
To perform all mentioned tests, a specific set up has been developed. Such set up consists of a focal plate used as a jig in which the positioner is fixed as it would be in the final focal plate, a CMM (Coordinate Measuring Machine) to get the positioning of the reference button of the positioner and a basic electronics card with specific software to easily govern the positioner movements from a PC.

A reference button has been manufactured and placed in the positioner arm in order to have a part with reference surfaces to take reliable measurements. The used reference button dimensions are 63mm ± 2.5µm.

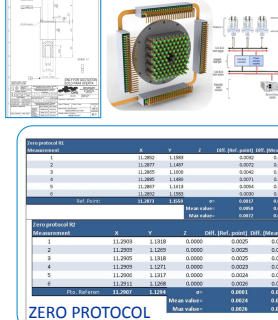
MEASURING CONCEPT: The probe takes the position of the reference button by measuring 6 points equally distributed around its diameter. These 6 measurements allow positioning the center of the button in the space. Another measurement is made with the probe on the top surface of the button in order to measure its height. These 7 points are translated into geometrical points for its further data comparison.



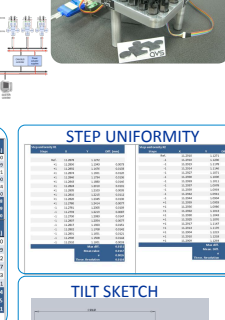
TARGET REPEATABILITY



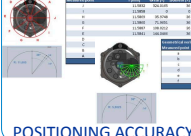
ELECTRONICS



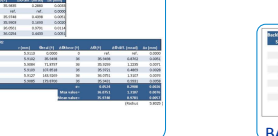
STEP UNIFORMITY



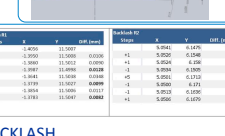
POSITIONING ACCURACY



ZERO PROTOCOL



TILT SKETCH



CONCLUSIONS / TESTS SUMMARY

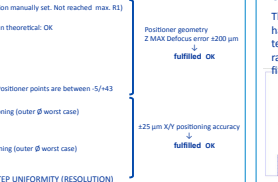
GEOMETRICAL TESTS
 R1 RADUS value: 21.136mm (23.21mm nominal) → OK (Position manually set. Not reached max. R1)
 Flanets R1: 3 µm → OK
 R2 RADUS value: 5.810mm (5.8025mm nominal) → Larger than theoretical OK
 Flanets R2: 4 µm
 Parallelism R1/R2 plane: 36µm → OK
 Parallelism R1/R2 reference surface: 29 µm → OK
 Parallelism R2 reference surface: 22 µm → OK
 Eccentricity R1/R2 center: 9 µm → OK
 MAX POSITIONER TILT required 3mm (0.19°) → OK Positioner points are between 5°/43°

POSITIONING ACCURACY
 R1 Positioning accuracy: 6µm with respect to the absolute positioning (outer Ø worst case)
 Max value: 11.4 µm
 Mean value: 5.4 µm
 (standard deviation) 4 µm
 R2 Positioning accuracy: 6µm with respect to the absolute positioning (outer Ø worst case)
 Max value: 7.6 µm
 Mean value: 5.7 µm
 (standard deviation) 3.6 µm

STEP UNIFORMITY (RESOLUTION)
 R1 Difference with respect to the theoretical step (Δs = 11.4 µm):
 Max value: 3.5 µm
 Mean value: 1.7 µm
 (standard deviation) 1.1 µm
 R2 Difference with respect to the theoretical step (Δs = 3.6 µm):
 Max value: 1.5 µm
 Mean value: 0.6 µm
 (standard deviation) 0.3 µm

BACKLASH
 R1 Max difference with 1° measurement: 16.2 µm
 R2 Max difference with 1° measurement: 2.7 µm
LIFETIME TEST 20 DAYS of continuous movements
 Measured difference: 22 µm
 No significant mechanics wear detected

BACKLASH



COATING TESTS

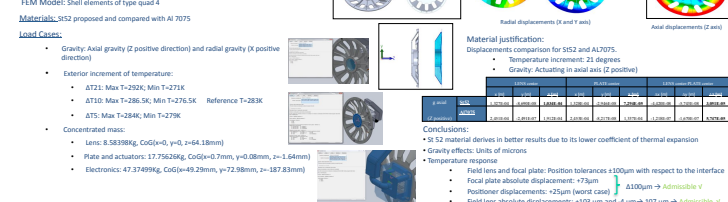
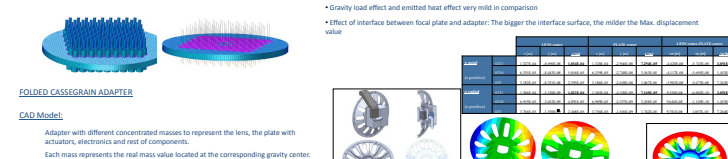
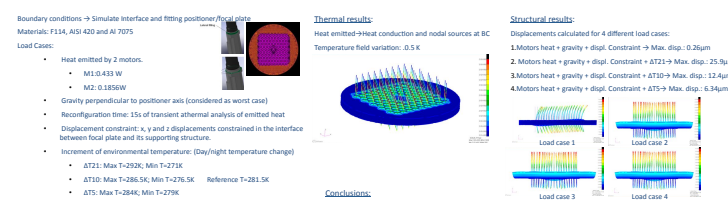
The mechanical behavior and the coating length have also been validated during the prototype testing stage. The cable length (300mm) and torsion range were initially discussed and validated by the fiber manufacturer.

Summary

The results summarized show that the positioner requirements are fulfilled. The manufactured prototype has been a good mock up in order to identify aspects to be taken into account for series manufacturing verification phase.
 High repeatability with high resolution offers high positioning accuracy

MEGARA fiber MOS FEM & Thermal analysis

FEM and thermal analysis of the different subsystems at the focal plane have been performed to assess the design and selected materials.



THESE RESULTS VALIDATE THE PRELIMINARY DESIGN OF THE FOCAL PLATE / ADAPTER

MEGARA fiber MOS positioner for mass production

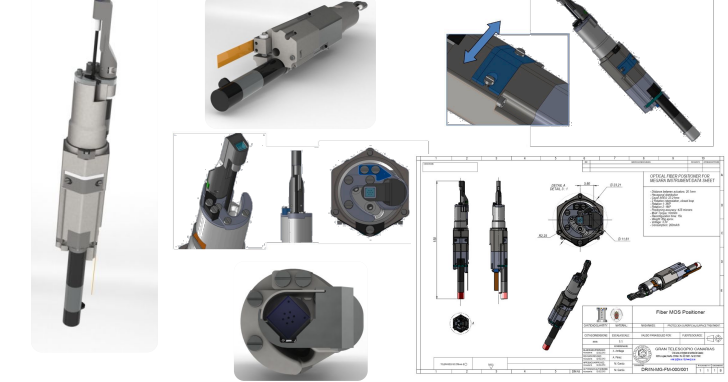
The design changes performed to the Fiber MOS positioner prototype presented at the PDR are related to the adaption of the design to solve maintenance issues and the addition of improvements taking into account the handling, manufacturing and adjustment of the mass production series of the final positioners.

The main changes are listed below:

Increase of the central fiber path from Ø1.3mm to Ø3.65mm: This larger central path allows an easy fiber system handling for the assembly and disassembly phase improving the maintenance of the positioner. The fiber unit will be assembled from the rear part of the positioner.

Adjustable hard stops for R1 and R2: The mechanical hard stops limiting R1 and R2 have been updated and the new design allows adjusting both hard stops at each positioner. With these adjustable hard stops, the zeros of both rotations can be adjusted identically for each positioner. All positioners are interchangeable.

R1 preloading system simplicity: Which allows using lower torque motors due to the efficiency enhancement of the positioner.



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