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SPHERE-IFS: The spectro differential imager of the VLT for exoplanet search

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Abstract. The SPHERE is an exo-solar planet imager, which goal is to detect giant exo-solar planets in the vicinity of bright stars and to characterize them through spectroscopic and polarimetric observations. It is an complete system with a core made of an extreme-Adaptive Optics (AO) turbulence correction, pupil tracker and interferential coronagraphs. At its back end, a differential dual imaging camera and an integral field spectrograph (IFS) work in the Near Infrared (NIR) Y, J, H and Ks bands (0.95 - 2.32microns) and a high resolution polarization camera covers the visible (0.6 - 0.9microns).
The IFS is a low resolution spectrograph (R 50) which works in the near IR (0.95 - 1.6microns), an ideal wavelength range for the detection of planetary features. In our baseline design the IFU is a new philosophy micro-lens array of about 145x145 elements designed to reduce as low as possible the contrast. The IFU will cover a field of view of about 1.7 x 1.7 square arcsecs reaching a contrast of 10-7, giving an high contrast and high spatial resolution "imager" able to search for planet well inside the star PSF. Currently in the first phase of integration IFS will see the first light at ESO Paranal, as VLT II generations instruments, in the Q3 2011.

1. Introduction

This paper describes the procurement activities done and performance tests of the IFS Subsystem at INAF leading to the subsystem acceptance before the General Integration at LAOG. The tests and verifications included in this paper should allow to demonstrate that IFS meets its subsystem specifications and to get a complete knowledge of the behavior of IFS under working conditions.

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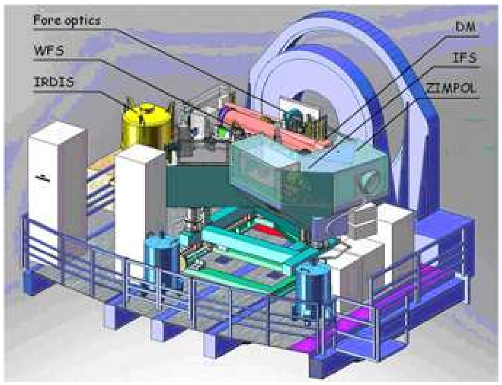

Fig. 1. Sphere Instrument - overall view.

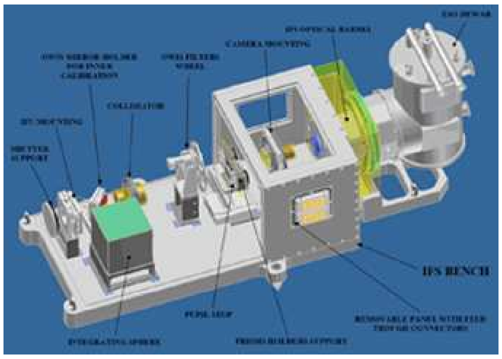

Fig. 2. Mechanical layout of IFS arm - overall view.

2. Instrument overview

The basic characteristic of an IFS is to image the array of Slits generated by an Integral Field Unit and chromatically separated by a suitable dispersing device on the final image plane. Once chromatically dispersed, the final Exit Slits form then the array of spectra of an Integral Field Spectrograph. The mechanical components and assemblies included in IFS arm are: optical bench, entrance shutter, optical mountings, motorized functions, optical barrel and dewar cryostat. All the external surfaces of the optical elements will be covered with a protection stopper, in order to prevent a dust during alignment phases and for the handling/shipping operations. Standard commercial components, where possible, have been selected. The main support structure of the IFS arm, referred as the optical bench, is a box shape (made of Al Mg4,5 Mn0,7) show in Fig. 2 . The planarity of optical layout suggests to consider a bench like mechanical element, parallel to the plane defined by the chief-ray, as reference element for all the mountings; at the same time, the external dimension of the bench (1380x600mm) demands a rather thick bench to achieve the needed stiffness. The copresence of some wall structures, adding rigidity to the system and they allow the assemblage of the dewar cryostat.

3. Procurement of mechanical parts

In the last September 2009 we have started the procurement of the bench and the supports for the optical barrels. The bench, show in Fig. 3, was manufactured by an external vendor. All the supports for the optical barrels, were manufactured by the INAF-IASF workshop. In order to minimize the impact of spurious reflection in the spectral region of interest (0.95-2.5microns), all mechanical machined components of IFS arm will be painted with black spray NEXTEL Velvet Coating 811-21, after having received a process of organic black oxidation. This paint is a black one-component spray coating material. It is readily cleanable also by brushing with aqueous detergents. They are typical used to minimize the stray light reflections in instruments interiors and for infrared absorbing. This paint allows very low diffuse reflection assuring the compliance with the requirement on cleanliness for the instrument.

4. Procurement of optics

BIGRE device has been produced in five elements by AMUS and is it ready to be assembled in the instrument. The characteristics of the realized elements are all well inside goal specifications. Collimator, camera and Amici prisms are being manufactured by SILO; they will be ready and tested for assembly in July 2010. Both camera and collimator are composed by one doublet and a singlet. The glasses

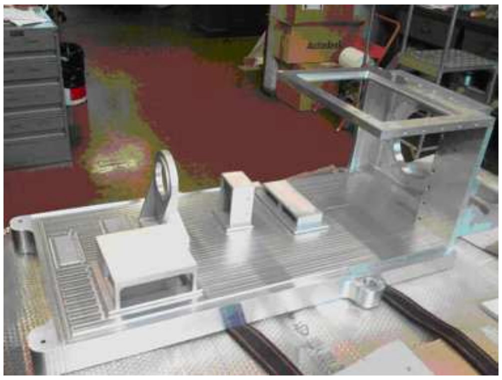

Fig. 3. Mechanical bench of IFS arm and some optical supports.

Fig. 4. Setup used for flexure measurements of the IFS bench - 1.

used are BAF2 and STH11; this pair requires particular attention when gluing the doublets. Dichroic filters were released at half of May; they resulted within specifications. Final delivery of the optical components is foreseen for July 2010.

5. Characterization measurement

5.1. Mechanical measured performances

To assure the image quality required by design, IFS optical bench flexures must not exceed 144 arcsec at the focal plane with the detector cryostat mounted on it. To verify that the bench is compliant with this specification an experimental setup with the dummy bench has been prepared and different loads in the detector position simulate the working situation of IFS. Using a MAT for angular measurements (results shown in Fig. 7) and a comparator for linear one (results shown in Fig. 6), flexures as functions of loads have been qualified.

The dummy optical bench of IFS was tested against the flexure due to the mounting of the E.S.O. full tank (49kg). The Tank has been simulated by a variable weight mounted on a flask in the same position of the dewar (Fig. 4). The measurements have been performed with two different setups.

In the first setup the flexure of the bench has been measured with a comparator mounted in the inner part of the dewar castle. Further

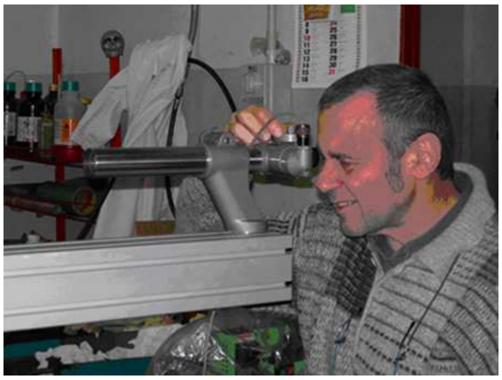

Fig. 5. Setup used for flexure measurements of the IFS bench - 2.

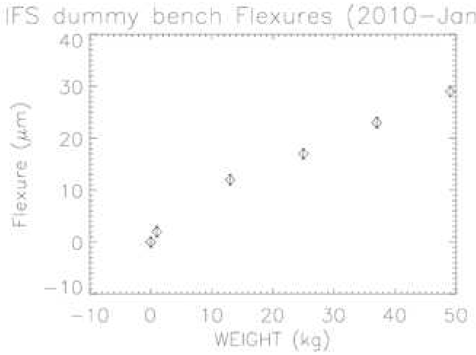

Fig. 6. Measurements of flexure of the optical bench with variation of the cryostat weight, expected due to LN2 consumption. Measures with a comparator.

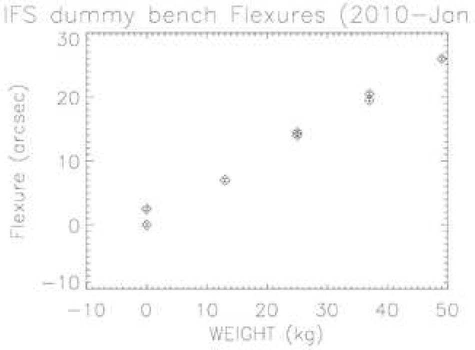

Fig. 7. Measurements of flexure of the optical bench with variation of the cryostat weight, expected due to LN2 consumption. Measures with MAT in auto-collimation mode.

several burdens of 12kg were added in the back where the dewar will be tied.

The second setup repeats the same flexure measurements but exploiting a MAT working in autocollimation (Fig. 5) posed on a rail away from a circular mirror fasten at the center of the position of the dewar. The obtained results are shown in the two next Figures. For both measurement sets the results indicate that the flexure of the bench is linear with the weights.

6. Acknowledgements

In this paper we have presented the status of integration of IFS Spectrograph for 2nd Generation VLT instruments, a result of a collaborative effort of a Consortium formed between ESO and different partner institutes in Italy, France, Swiss and German. It is thanks to their qualified contributions and commitment that the project is fully carrying out with the first phase of integration; it will be delivered a well tested instrument for observations to the ESO-VLT community by 2011.

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