Performance of the First Two Beryllium Secondary Mirrors of the VLT

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During the month of September 1998 REOSC Optique in Paris successfully completed the mechanical mounting and the optical tests of the second VLT M2 mirror in Beryllium. The secondary mirror was accepted by ESO and shipped to Dornier Satellitensysteme for integration in the second Electromechanical Unit, undergoing its final dynamic acceptance testing.

The secondaries of the VLT, with their diameter of 1116 mm, are amongst the largest Beryllium mirrors ever produced. The manufacturing process, set up for the first mirror by REOSC and its subcontractor Brush Wellmann, is optimised to achieve the low mass and inertia demanded by the steering capability of the mirrors, without compromising the optical quality and the long-term optical stability. The manufacturing process, already described in a previous issue of *The Messenger* (No. 86 of December 1996), has been further optimised after the production of the first mirror. The blanks are made out of a Beryllium billet obtained by Hot Isostatic Pressing of structural grade Beryllium powder (I-220H) lightweighted by machining pockets in the back surface. Due to the hardness of the material and the depth of the pockets, there is the risk of vibration of the tool, possibly leading to its rupture. Therefore, the material removal is done at very slow rate.

The total machining time of the back and front faces – the latter up to less than 20 µm tolerance from the final asphere – takes approximately 9 months. After the generation of the asphere by grinding, the blank is Nickel plated on both sides. The polishing is done on the Nickel layer. As the secondary mirror of the VLT is undersized, the optical surface extends up to the mechanical edge. To polish up to the edge, a lip was left at the outer rim of the first mirror, that was later cut by electromachining discharge (EDM). Although the internal stresses in the mirror were very low (estimated around 5 MPa), their release, after cutting off the lip, generated a warping which demanded further polishing.

For the second mirror REOSC has developed a method to polish up to the border without producing a turned down edge. The lip was therefore cut before Nickel plating and the subsequent polishing.

Some of the most relevant physical data of the mirrors are provided in Table 1.

The lower mass of the second mirror is due to a stricter control of the dimensional tolerances during machining and to a slight difference in the values of thickness of the Nickel plating. The variation of the mass and inertia are well within the tuning capability of the control system for the steering mechanism of the secondary unit, so that mechanical adjustment is not needed. The third and fourth mirrors (presently in production) will have characteristics similar to the second one.

The mirrors have been tested after integration in their cells and with the optical face down, therefore under conditions similar to those encountered in the telescope. The mirrors are tested against a Zerodur matrix. The measurements are performed with the mirror mounted in its cell, and with the cell fixed onto a template simulating the eletromechanical unit. The radius of curvature and the conic constant of the matrix were previously measured with a Hartmann test using a null-lens, and then with a second independent null-lens for cross-check.

The specification demanded by ESO contains requirements for the so-called passive and active modes. In the passive mode the full pupil of the mirror is tested and the optical quality is deduced after removal of the effects of mirror curvature (focus error) and conic constant (3rd order spherical aberration). The slope errors are obtained after measurement against the matrix.

The active mode quality is expressed in Central Intensity Ratio (CIR) which compares the performance of the telescope to that of a diffraction-limited telescope in well-defined atmospheric conditions. The CIR is evaluated after removal of the 16 first natural modes of the primary mirror, which are corrected by the active optics of the VLT. The effects of high spatial frequency errors are calculated with a sub-pupil test (mask with sub-apertures on a mirror diameter), and their effect subtracted from the CIR to obtain the final minimum value of the CIR.

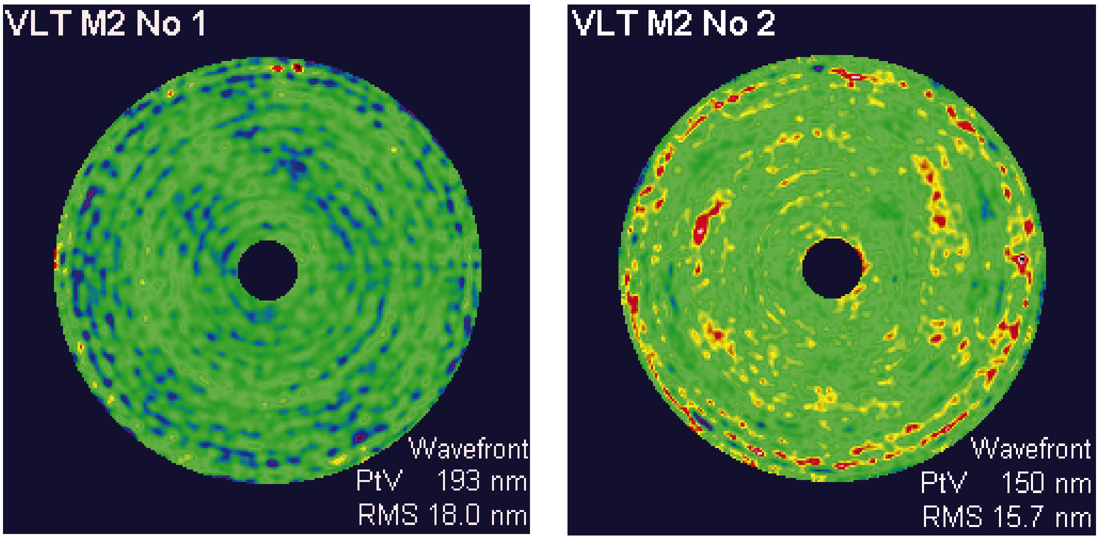
Classical checks such as microroughness, cleanliness and other in-

Table 1. Mechanical characteristics of the first two VLT secondaries

Characteristics	M2 Mirror #1	M2 Mirror #2
External diameter	1116 mm	1116 mm
Diameter of centre hole	46 mm	46 mm
Height at mirror centre	170 mm	170 mm
Dimension of bevel at edge	< 0.2 mm	< 0.2 mm
Mirror mass	43.1 kg	41.8 kg
Total mass (M2 + mounts +cell)	52.5 kg	51.2 kg
Total moment of inertia	4.17 kg m^2	4.07 kg m^2
First eigenfrequency on three rigid points	> 635 Hz	> 635 Hz
First eigenfrequency on the three mounts	> 365 Hz	> 365 Hz

Table 2. Optical performance of the first two VLT secondaries

Performance	M2 Mirror #1	M2 Mirror #2
Radius of curvature	4554.62 mm	4554.91 mm
Conic constant	–1.66980	–1.67046
Optical Quality in Passive mode	0.32 arcsec RMS slope error	0.20 arcsec RMS slope error
Optical Quality in Active mode	18.0 nm RMS (Wavefront)	15.7 nm RMS (Wavefront)
Central Intensity Ratio (min.)	CIR = 97.4%	CIR = 98.1%
Microroughness	1.5 nm RMS	1.8 nm



spections were also performed. The surface quality of both mirrors is excellent and within specification.

Table 2 provides the major optical performance of the first two secondary mirrors. The two mirrors are extremely similar, with only a fraction of the budget of error allocated for the radius of curvature and the conic constant being used. REOSC was also able to improve the optical quality with the polishing of the second mirror.

It is possible to conclude that while the feasibility of the Beryllium technology used had been demonstrated with the delivery of the first secondary mirror and the excellent images already obtained by the first VLT telescope, a further advance in the manufacturing process was achieved by REOSC with the recently delivered second mirror, leading to an improvement of the optical performance and to a shorter production time. The total production of the first mirror demanded more than two years, while the second mirror was produced in around 20 months.

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NEWS FROM THE LA SILLA SITE

The La Silla News Page

The editors of the La Silla News Page would like to welcome readers of the twelfth edition of a page devoted to reporting on technical updates and observational achievements at La Silla. We would like this page to inform the astronomical community of changes made to telescopes, instruments, operations, and of instrumental performances that cannot be reported conveniently elsewhere. Contributions and inquiries to this page from the community are most welcome. (J. Brewer, O. Hainaut, M. Kürster)

News from the NTT

O. R. HAINAUT

During the last three months, the operation of the NTT has been particularly smooth; we did not experience any major problem, and the weather has been fairly cooperative. The technical downtime was of the order of 2%.

On August 12 and 13, the NTT and its team passed a very detailed “Acceptance Review”, during which all the technical and operational aspects of the telescope were presented. This review constituted the formal return of the NTT from the VLT Division to the La Silla Observatory after the Big-Bang. The review board found the technical and operational status of the telescope to be more than satisfactory; the staff, system, operation, and procedures all received excellent reviews.

The dewar of SUSI2 was suffering from vacuum losses since the installation of the instrument (cf. last issue of *The Messenger*). It has been exchanged by a new, improved dewar, which immediately worked perfectly. Also, we identified the source of a mysterious light contamination which occasionally affected the images: the lamps of the rotator and altitude encoders were not perfectly shielded. In some positions of the rotator, a part of the instrument which was not correctly blackened was reflecting the encoder light to the detector. Additional light baffles have been mounted, and the blackening of the instrument completed, resulting in the complete removal of the contamination. SUSI2 is now performing at its expected level.

Over the past couple of months, the Observation Block (OB) database in La