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Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral

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ESO - LA SILLA

LA SILLA OBSERVATORY

LED / Optics

3m60 Main Mirror

Status

Technical Report

LSO-TRE-ESO-75331-006

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1 Purpose.

This document will present a status of the 3m60 Main mirror. Included in a maintenance program several tests illustrated the weaknesses of the actual control system of the main mirror lateral pad.

2 Related Documents

[1] - All 3p60 Image quality reports - LSO-TRE-ESO-75331-001 to 005

3 The present Mirror Status.

3.1 Image Quality

Since the modification of the lateral pad control system and after the last improvements performed on the telescope the image quality of the telescope has been very good with slightly high astigmatism residual to be expected for old generation telescope.

- Coma is now below 0.2 arcsec within a 60deg ZD cone. Top ring exchange degrades it if no re collimation is done. Seeing also contributes on coma variability especially on low values.
- Astigmatism shows increase at larger ZD North and East (up to 0.4 arcsec).
- Triangular term is related to astigmatism, a clear correspondence with the mirror bending modes.
- Aberration total is within 0.4 arcsec on a 60 deg ZD cone.
- Dominant residual is clearly astigmatism with some Triangular term effect.

The next figure [1] illustrate the actual telescope Image Quality on a testing special sequence..

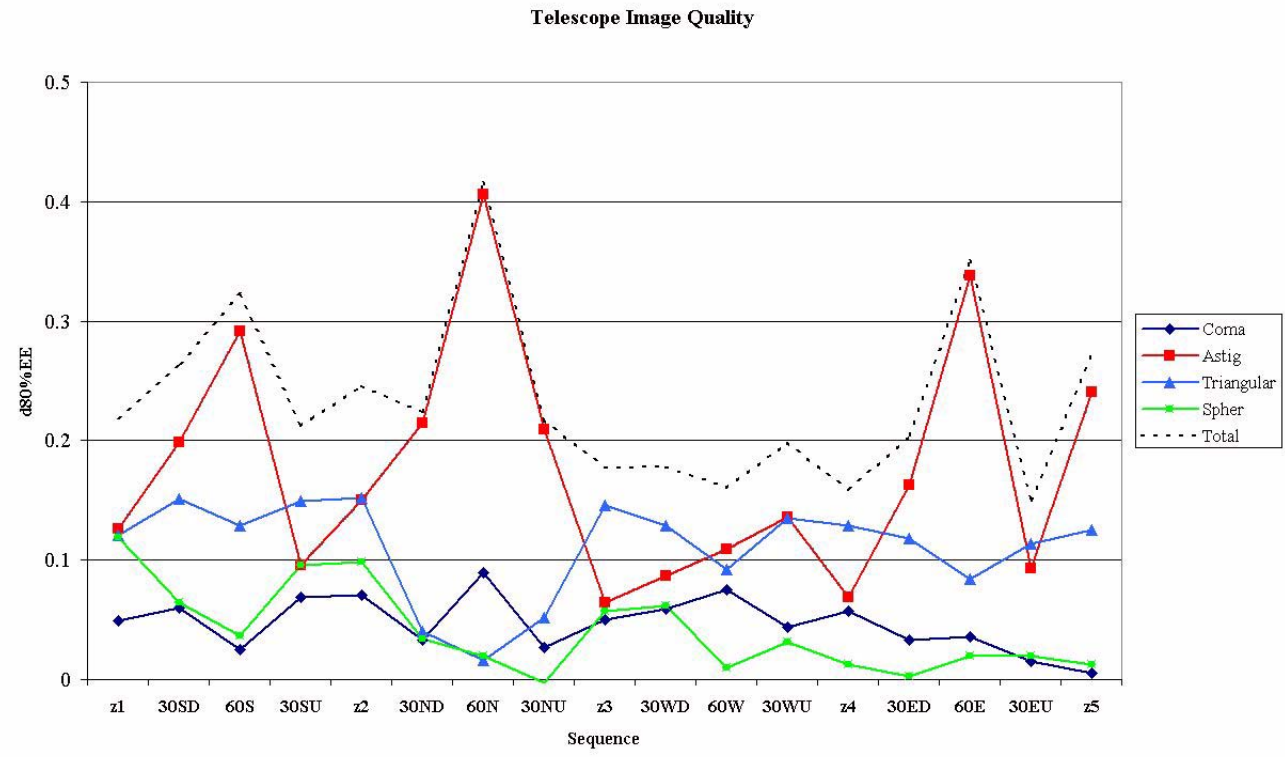

Figure 1.: Telescope Image Quality

This sequence is also used on a systematic maintenance check of the M1 pads behaviour.
The sequence described on the [1] documents resumes as:

- Pre-init sequence to set the telescope moves history: Z, 4hWest, Z, +29degN, Z
- Sequence: Z, 30Sdown, 60S, 30Sup, Z, 30Ndown, 60N, 30Nup, Z,... and on West and East

Since the installation of the balls system on the axial fixed pads a reset in position of the axial pads has been less required to restore the image Quality as illustrated above. The reset description will be detailed in a next chapter.

The most critical residual error was coma before the M2 top ring modification and the following upgrades. Afterwards the coma contribution stays below 0.2arcsec. The figure [2] shows the coma variation with the M2 reference position (x:4.5 y:5.4mm) close to the nominal ones (x & y at 5.0mm)

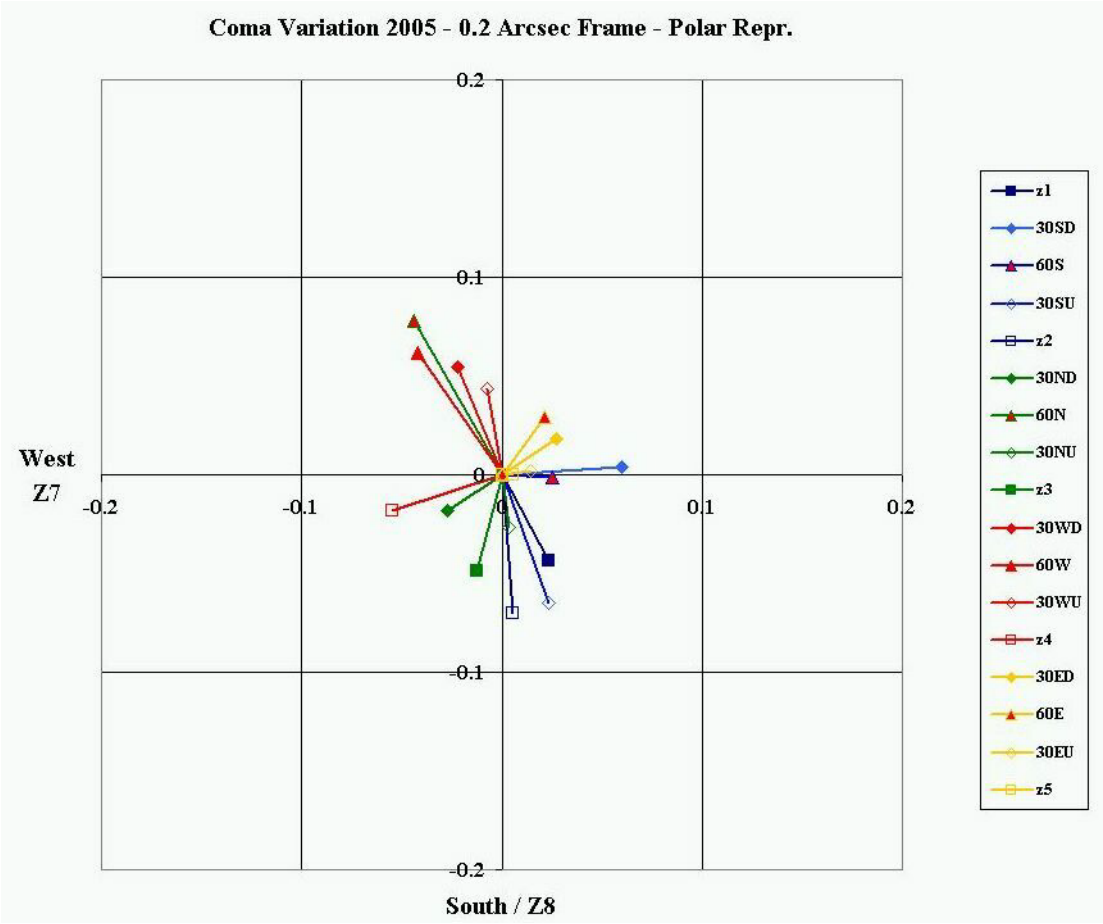

Figure 2.: Coma vector variation

Observers have been satisfied of the telescope Image quality status and very good imaging has been obtained with EFOSC (<0.5arcsec fwhm) as well as higher efficiency on HARPS (+20%)
The quality was accepted as good and then no further improvements have been requested.

3.2 Mechanical M1 mirror behaviour

3.2.1 Mirror control status

After the final telescope quality acceptance the possibility on closing the control loop of the lateral force application was postponed as not of first importance to obtain a good image quality. Coma correction was mandatory justifying efforts for improvements.
As the telescope image quality improved largely thereafter no further improvements was considered.
The lateral pad system remained with open loop control.
The actual system based on old generation PC computer (now obsolete) is performing as:

- reading of two inclinometers to obtain equivalent delta and alpha telescope position
- according the static model of lateral theoretical forces to be applied a calculation of the pad pressure is performed.
- pressure is applied on each pad
- force applied check by loadcell installed on each lateral pads.
- Independently M1 three position sensors are read as well as axial load cell

The same process is repeated every 4 or 5 sec.

Some remarks :

- During preset the pressure applied on 4 or 5 sec delay is not as fast as needed. Mirror moves by gravity effect when presetting at higher ZD and is pushed up during preset to smaller ZD.
- Spread of residual force error is large and will be reduced by closing the force loop control

3.2.2 Regular maintenance check

Since 2 years a regular maintenance check has been done on the axial and lateral pads behaviour.
The above described sequence is used and at each position a save of the force log file is done , latter analysed using excel macros.
The maintenance planning was established first monthly (2002-2005) modified since 2006 on trimestral period as no significant changes were detected. A trimestral period seems enough.

3.2.2.1 Axial Pads.

Axial pads are located on three rings: outer as A (12 pads + 3 fixed), middle as B (12 pads) and Inner C (6 pads)
Axial pads behaviour including counterweight horizontally (telescope at zenith) is analysed. No major variation are detected, the horizontal error of the pad counterweight position is well below 1deg.
Errors between theoretical and measured forces are within +-5 kg only.
On few occasions larger error on axial C pads have been detected but with not systematic effect.

3.2.2.2 Lateral pads.

18 lateral pads with pneumatic control are located by group of 6 around three fixed points.
Lateral pads difference between theoretical and applied force is analysed. Because of a non closed loop control of the applied force the spread of the error is large and illustrated on the next figures.
Pad L1 and L6 shown a large error on North and East part of the sequence.

Both pads doesn't suffer leakage, the electrovalves seems delivering not enough air pressure if the loadcell calibration is still valid.
Figure 3 illustrates the 2005 June test and the figure 4 the 2006 June one.

All tests present almost the same pattern (justifying the trimestral periodicity of the monitoring).

It is interesting to relate the test with the aberration measures. October 2005 test done during the night is presented above in term of image quality (figure [1]).
The south and east 60 deg ZD shown L1 error as well as higher astigmatism. Cause effect relation may be existing here but hard to confirm directly.
It is one of the driver to finally close the control loop of the lateral pad force. Minimizing the lateral force error distribution we expect to reduce mirror bending associated with telescope astigmatism.

Unfortunately the present lateral pad design is not optimum in term of astaticity. When the telescope is inclined the upper lateral pads should pull the mirror instead of pushing it even with no pressure applied (own pad weight). In consequence the expected mirror deformation concerns the first bending mode associated with astigmatism. Fortunately the mirror thickness will ensure a limited flexibility.
The fine tuning of the mirror lateral pads certainly requires to minimize the lateral force errors.

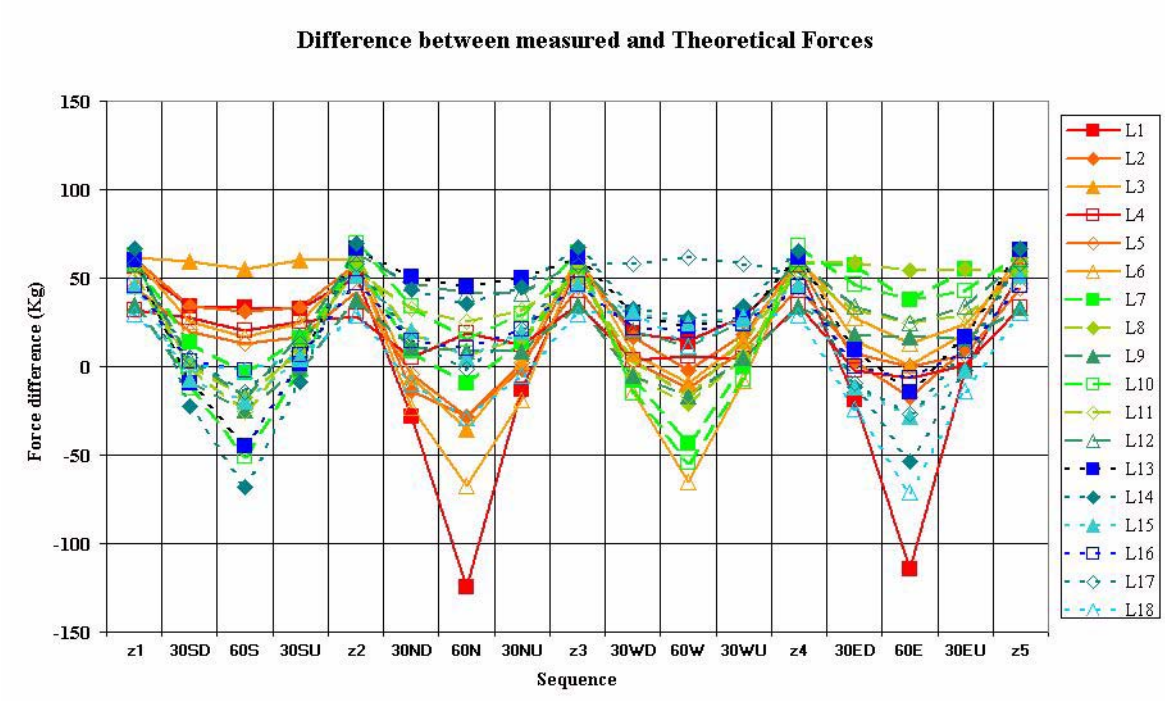

Figure 3.: June 2005 test

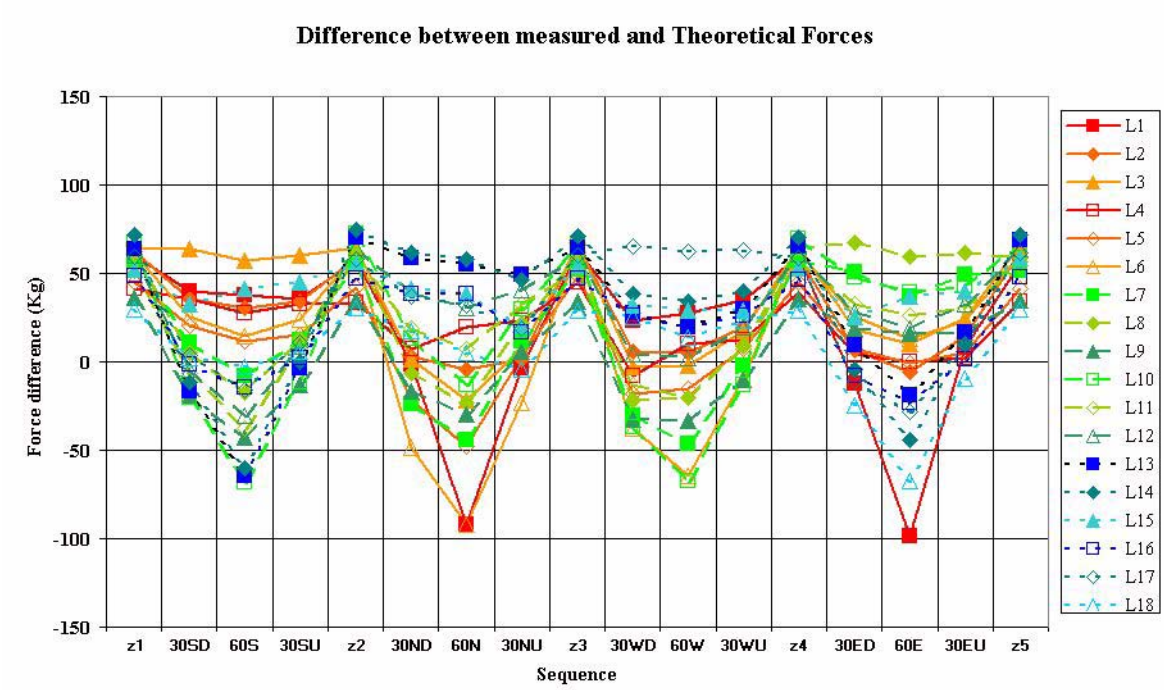

Figure 4.: June 2006 test

3.2.2.3 Mirror lateral position.

On passive mode the position of the mirror within its cell is monitored by three linear gauges installed on the central Cassegrain hole. The sensors are located south, north-west and north east at 120 deg separation.
Due to the configuration the real movements of M1 are opposite.
The mirror translation in x , y direction is then calculated from the three sensor values.
On the following figure 5 several sequence are presented. The north South direction is around 45.deg while West-East -45 deg. Sign is not corrected here !.
Some sequence present a very reproducible pattern. Other one with displacement errors. The source of these errors is not totally understood. The delay on the pressure application during the preset could be one possibility.
The total range of movement on this ZD cone angle of 60deg amount +/- 0.25 mm with low impact on coma formation (<0.1 arcsec). M1 mirror translation has negligible effect on astigmatism adding a field component.

A better tightening of the three lateral fixed points could minimize the mirror translation. But it is again a compromise with the raising of the triangular aberration contribution over-stressing the mirror on three lateral points.

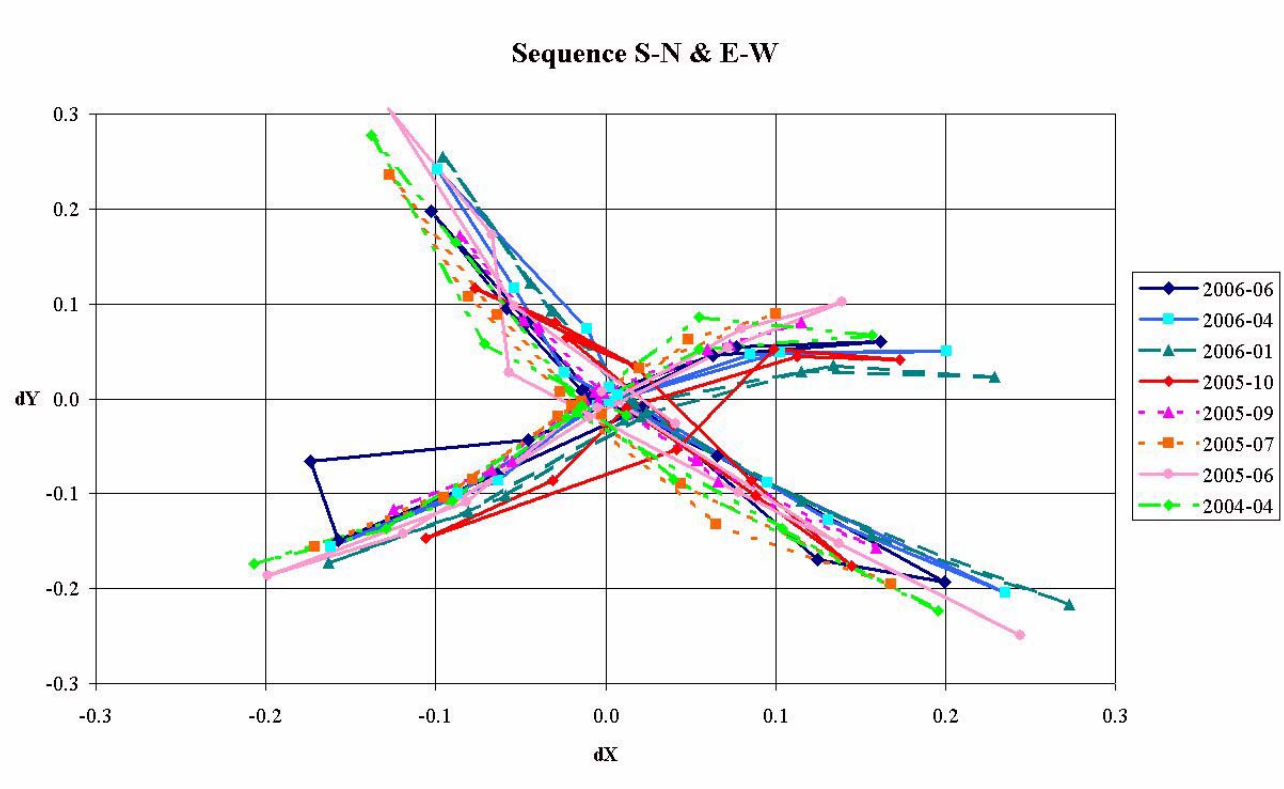

Figure 5.: Mirror moves (mm).

3.2.3 Un-regular maintenance check

At least every 6 months the mirror axial position is checked. Three apertures close to the axial fixed points allows the mirror axial tilt check.

On South fixed point:72.43 mm (aluminization: 72.45)
North-West: 72.88 mm (aluminization: 72.86)
North-East: 70.19 mm (aluminization: 70.18)

The values are very stable. (Expected in fact with the mirror weight)

3.2.4 Mirror reset.

On few occasion a mirror reset has been required to improve the image quality. Immediate effect was noticed with real improvement after the reset without large seeing change. Higher deformation modes degraded the telescope image quality, the reset released them.
This reset consisted on relaxing the pad from the mirror back surface by moving the pad counterweight.
We assumed that lateral stresses accumulated on each axial pads due to a small mirror movement within the cell during the telescope preset. The occurrence decreased after the modification of the axial fixed points. Ball contact replaced the fixed one. A separation of the lateral effect on axial pad is guaranteed.

4 Conclusion

Almost all previous reports [1] mentioned the need on replacing the old control system. A re-calibration of all loadcells on lateral pads is compulsory (axial ones performed during last aluminization w/o identified errors). The load cell manufacturer recommended yearly check. The installed lateral load cells have been never verified, time was not granted to perform this verification during the past aluminizations.
Astigmatism is the most difficult aberration to track and solve.
Many sources can produce it as:

- Any mirror deformations. either M1 or M2
- Thermal activities with asymmetrical contribution on the wavefront
- telescope mis-alignment with field astigmatism contribution (never check on 3m60)

The mirror lateral motion is not critical in term of coma contribution but at the condition that deformations are minimum. No lateral effects are added on the axial pads. Axial effects exist on the lateral pads unfortunately as designed.

We expect a better image quality variation minimizing the force errors with a close loop (lower residual error up to 10 kg) and faster system response (faster than 4 or 5 sec).
In fact the possible contribution of the M1 deformations will be minimized.
Unfortunately we cannot guaranty a complete reduction of the total astigmatism with this requested upgrade.

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