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Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral

Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

ESO - LA SILLA

# LA SILLA OBSERVATORY

## LED / Optics

**FEROS on 2p2 Telescope**

**Vibration Study**

**Technical Report**

LSO-TRE-ESO-75441-003

**Issue 1.1**

June 29, 2002

## E.S.O Internal Use Only

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|---|---|---|---|
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| Approved | | | |
| Released | | | |

**Change Record**

| Issue/Rev. | Date | Section/Page affected | Reason/Initiation/Document/Remarks |
|---|---|---|---|
| Issue 1.0<br>Issue 1.1 | May, 2002<br>June, 2002 | Almost all pages | Last tests added |

# 1 Purpose.

The Feros instrument will be moved from the 1m50 to the 2m20 telescope. A suitable place has to be found on the 2m20 telescope to install the Feros bench. Of course this location will require a thermally controlled enclosure having a minimum environmental influences as vibration noise. This report resumes the vibration measurements performed on the 1m50 and the 2m20 as comparison.

# 2 Conditions

## 2.1 Present situation

The Feros spectrograph is a bench instrument using a fiber link from the 1m52 Cassegrain focus. The Feros bench is mounted over a four damping isolators. The bench is a Reliance type from Newport company with no internal damping. The four isolators consist on pneumatic dampers. According the specifications, a damping of a ratio 10 is delivered on the frequency range 10-200Hz.
No vibration measurements have been conducted so far to demonstrate the bench damper role.

## 2.2 General concept

The transfer of the instrument towards the 2m20 should not show evidence of performance degradation either by thermal or vibration contributions.
Vibration measure is not an easy task. In a first approach we decided to compare the level of vibration on the 1m50 with the 2m20 on the possible location for the bench installation.
Measures have been conducted on the 1m50 on two locations, first on the Feros bench itself and then on the side of the Feros room on the same floor tile.
A second set of measurement was performed on the 2m20. The base area of the telescope and the TIO room are the two possible location for the Feros bench. On both places the vibrations was monitored.

## 2.3 Measurement setup.

As early performed on the CES instrument, an APD (Avalanche Photo Diode) has been used to monitor the vibration. The APD is used to monitor a beam position, the frequency response is very high and not reducing the measurement range.
A laser beam is aligned with a four quadrant APD. An electronic signal is obtained when the beam moves out of the center, the intensity is proportional to the offcenter value.
The two directions, either horizontal or vertical, can be selected. The intensity variation of the laser beam is not relevant.
The distance between the laser head and the APD is of course an important parameter related to the beam position offset amount. It is not compulsory to enlarge the distance too much, the laser beam diverges and the spot size enlarge with a lost of precision.
The signal coming from the APD electronic is introduced on a Spectrum Analyser SR760 From Stanford Research System. A FFT analysis is done online and the frequency spectrum is obtained.
The frequency span is 195Hz starting at zero in linear scaling. The intensity is in log scale with 10dbV input range. An average of 1000 measures is done to decrease the instrumental noise, the timing corresponds to 15sec almost.
The same instrumental setup has been used on all measurement.

## 2.4 Procedures.

The measures have been conducted according known perturbations commonly detected during observations.
Dome rotation, telescope pointing and tracking, pumps and compressors (when used) and human activities

could be listed as contribution on possible vibrations.
A comparison between vertical Y and horizontal X measures was done early on the 2m20. The Y mode was found more sensitive and then selected as standard for the full analysis.
The first analysis were performed with a quiet environment and used at each places as a reference. Then sequentially all perturbation were performed to illustrate the vibration effects.
The instrument sign was present on all analysis and the results presented below have been divided by each corresponding reference (quiet environment) to suppress this fix contribution. The reference is an average of 5 measures. Harmonics of 50Hz are present on the instrument sign spectrum at 50, 100 and 150 Hz.
The campaign takes place during a period of low wind conditions.
All data were collected during day time to not disturb the observations.

# 3 Results and Analysis.

## 3.1 1m50 Telescope:

Two set of measures have been done. The first one corresponds to the Feros bench itself with the rigid laser support located at one side of the bench meanwhile the APD was on the opposite side. The distance between both amounted 1m60. The second with the same separation was installed on the side of the Feros room and on the same concrete tile.
As a remark on the Feros room, the isolation of the telescope support tile connected with the Feros one is not properly done with the building. The room walls connect both area. Two of the support feet of Feros are mounted on the Coude spectrograph structure also connected to the main building area.
The results below presented shown the comparison between the two set of measures, on Feros bench and at his side opposite to the corridors. The continuous lines represent the spectrum measured at the Feros bench.

### 3.1.1 Quiet conditions:

The following figure represent each measures (5) divided by the average to figure out the stability of the system and define the threshold level to accept real perturbation. Fluctuations of the low level spectrum has been found but only limited to a final ratio around 2, well below the perturbation.

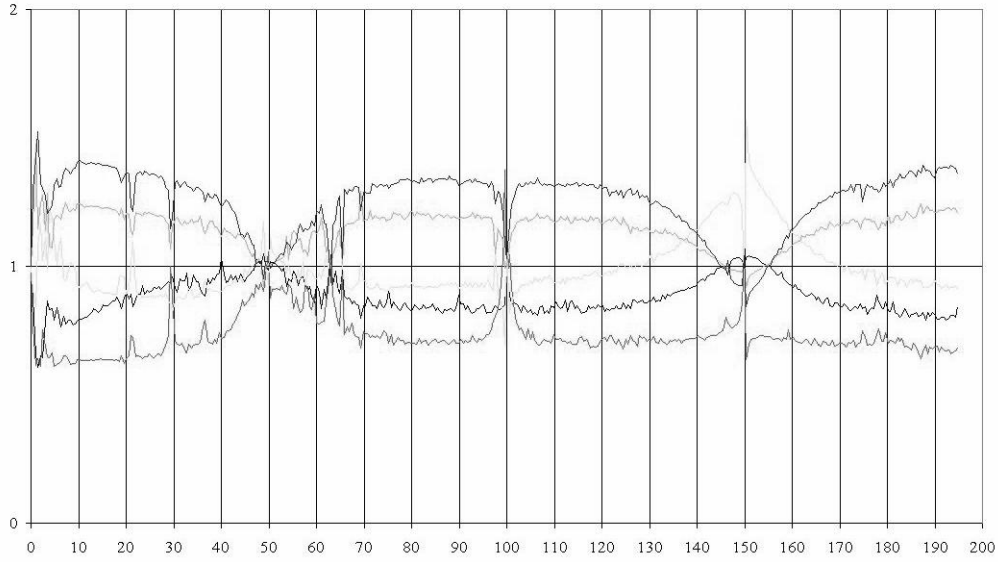



Figure 1.: References stability

The frequencies range from 0 to 195 Hz. The intensity in linear scaling is the ratio of two log scale between two references analysis (quiet environment).

Fluctuations of the low level spectra is present around the three harmonics 50, 100 and 150 Hz. The level is small and lower than 2. All frequencies above this threshold level could be considered as perturbation events.

### 3.1.2 Compressors contribution

During the data reduction process we discovered in fact two different compressor influences: the compressor from the third floor delivering air pressure to the telescope and the compressor from the ground floor delivering air pressure to the building. By location difference the effects of both compressor is very different in intensity despite the same main frequency.

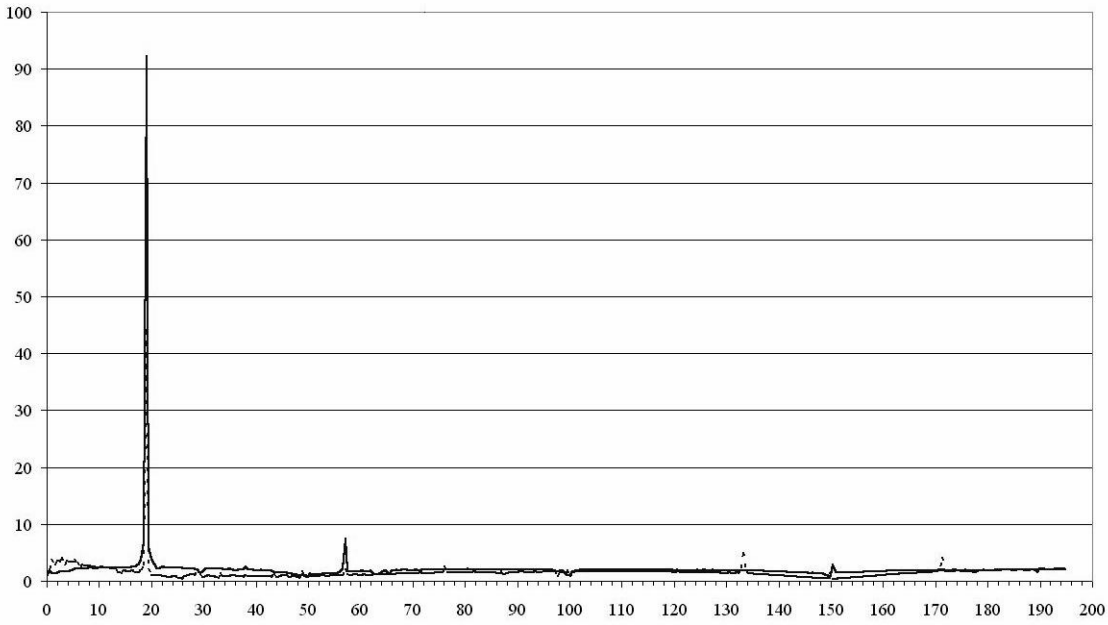



Figure 2.: Compressors contribution

The continuous line corresponds to the Feros bench measurement. It is much stronger than found on the Feros side ! (1/2). In fact on both analysis the compressor was different !
On the Feros bench spectrum the compressor on the ground floor was working meanwhile on the other spectrum the third floor one was active. Two small frequencies at 133 and 171 Hz are produced by the third floor compressor. The main effect concerns the 19 Hz frequence most probably coming from the pistons moves.
The third floor compressor has most probably a damping mounting.

### 3.1.3 Dome rotation contribution

Both rotation directions of the dome have been tested. The following figure shows the spectra found on both locations.
The dome effect is very strong and covers a large frequency range from few to 130 HZ.
The Feros bench isolators reduce the vibration by a factor of at least 3.
Both rotation directions shown a different distribution on the spectrum lines.

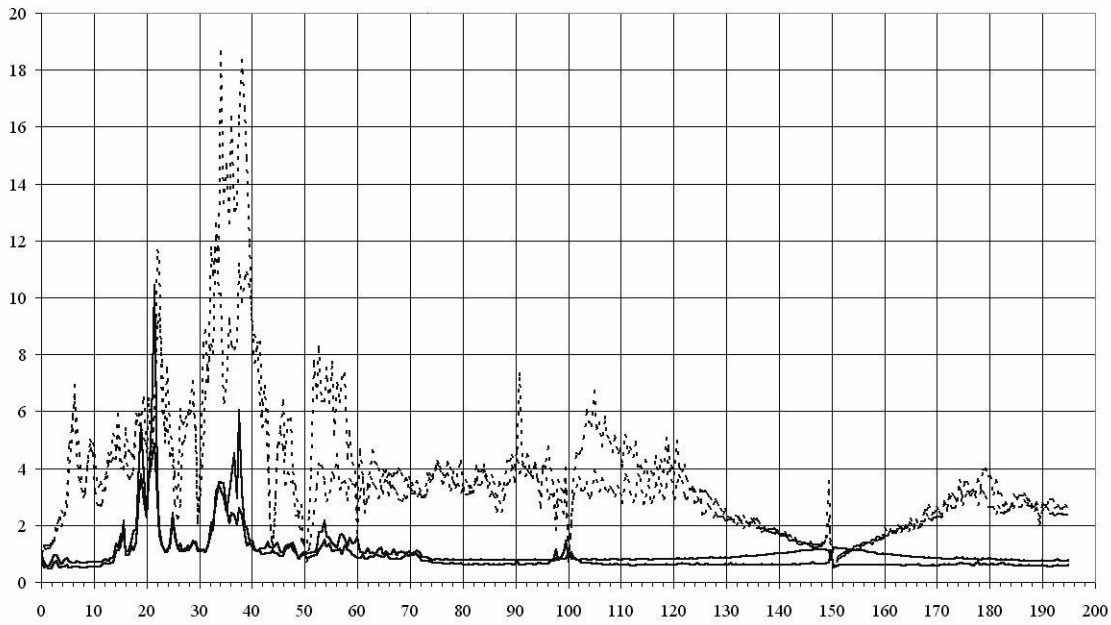



Figure 3.: Dome contribution.

The shaded lines correspond to the spectrum of the dome rotation effects (both directions) measured at the Feros room side and on the same concrete tile.
The continuous lines correspond to the vertical vibrations of the Feros bench.

### 3.1.4 Human activities contribution

On the following figure some of the possible human activities present during observations are analysed.
Door opening, walking on the corridors to go to the dome area from the control room could be classified as normal activities during observations.

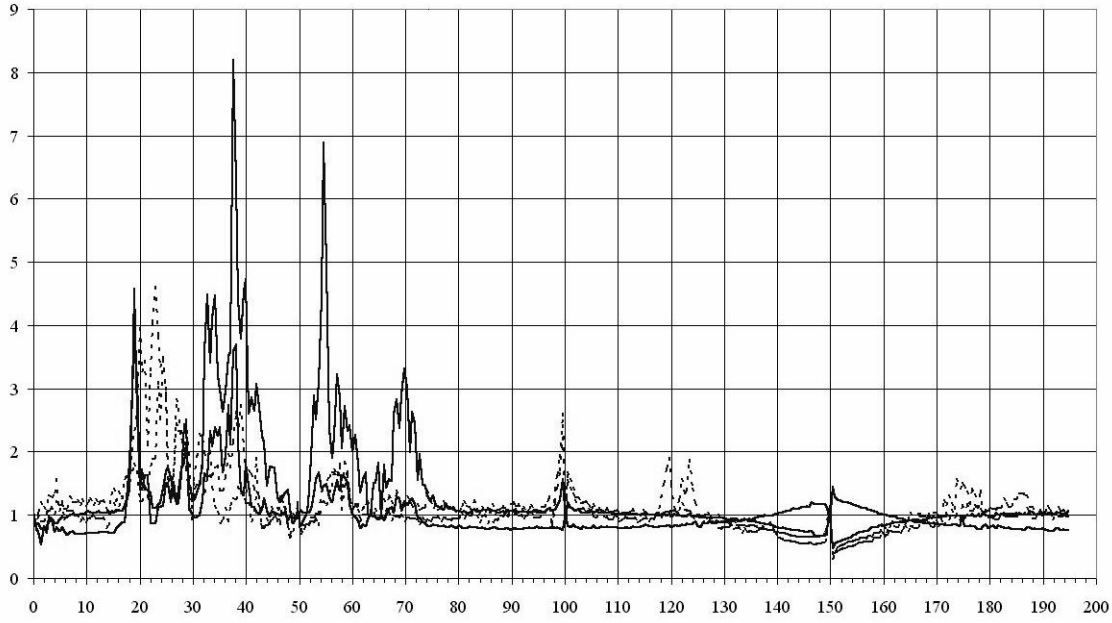



Figure 4.: Human activity contribution

The location of the Feros room close to the corridor and the dome door explains the higher contribution of vibration than measured on the Feros room side opposite to the same passage. From one measure to another on the same location, the spectrum looks quite different. The metallic floor at the side of the 1m50 control room produces a strong noise when walking on it. The effect is much lower on the opposite side of the corridor, even when measured on the same concrete tile.

### 3.1.5 Telescope slewing contribution.

Both delta and alpha axis have been used during the spectrum acquisition.

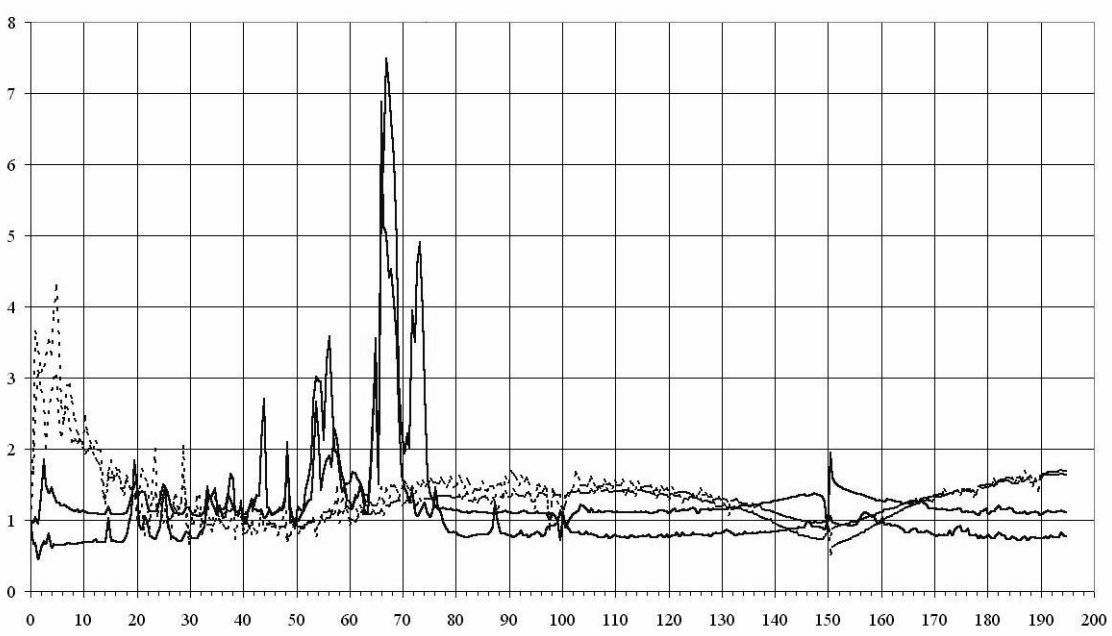



Figure 5.: Telescope slowing Contribution

Again the effects on the Feros bench are not negligible with few frequencies resonance around 44, 55 and 68 Hz. It is not detected on the Feros side room. Lower frequencies below 10 Hz are detected on the Feros room side location, the intensity level is very low.

### 3.1.6 Conclusion

The isolation of the coude tile is not optimum and most probably several short-cut on the Feros room construction remained.
The dome contribution is reduced by the bench isolation system. The compressor from the ground floor as well as people crossing the corridor have some residual vibrations on the instrument.

## 3.2 The 2m20 Telescope

Also two set of measures have been done. The first one corresponds to the telescope base, the second to the TIO office.
On this case the distance between the laser and the APD amounted 3m50 (started early than the 1m50 where space was more limited).
For the first set, the laser was located at the side of the South East pillar meanwhile the APD was on the side of the North East pillar.
On the second, the laser was located on the floor of the bypass room between the telescope base and the TIO

office rooms and the APD at 3m50 on the TIO room. The beam was aligned with the room axis, the APD close to the corridor double door. Because the floor of this room has a carpet, an heavy support has been used to hold the APD.
As presented for the 1m50, the spectra shown the comparison of both locations with different environmental contributions. The figures shown the telescope base spectrum on dashed line.
The intensity axis corresponds to a ratio of the log scale from the perturbation and the reference.

### 3.2.1 References

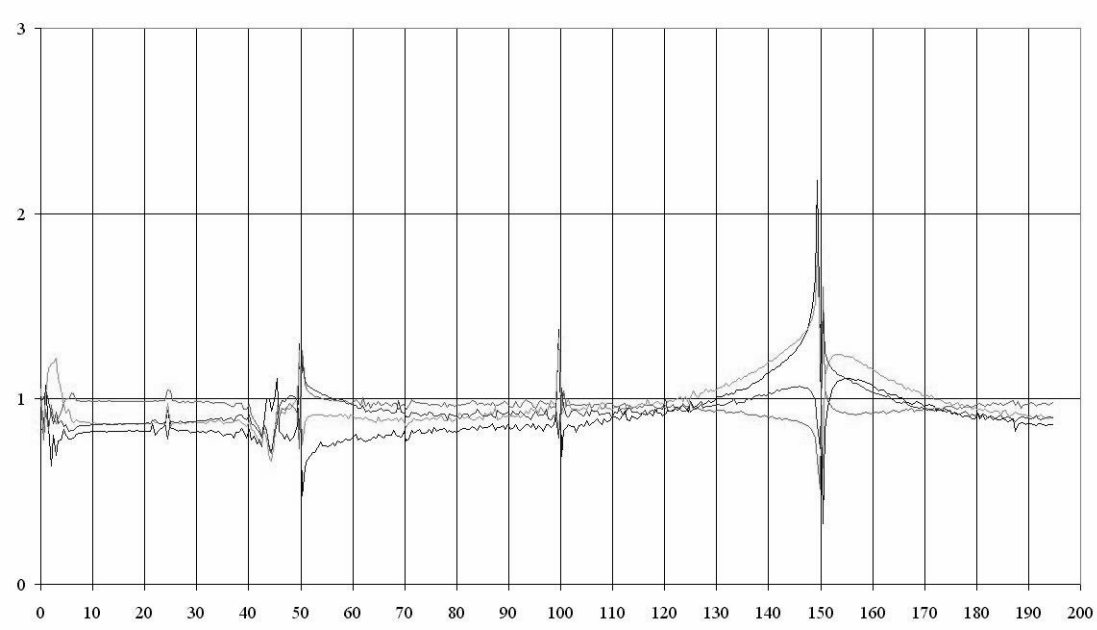



Figure 6.: References

Again the variation detected here is below a factor 2.

### 3.2.2 Oil Pump contribution.

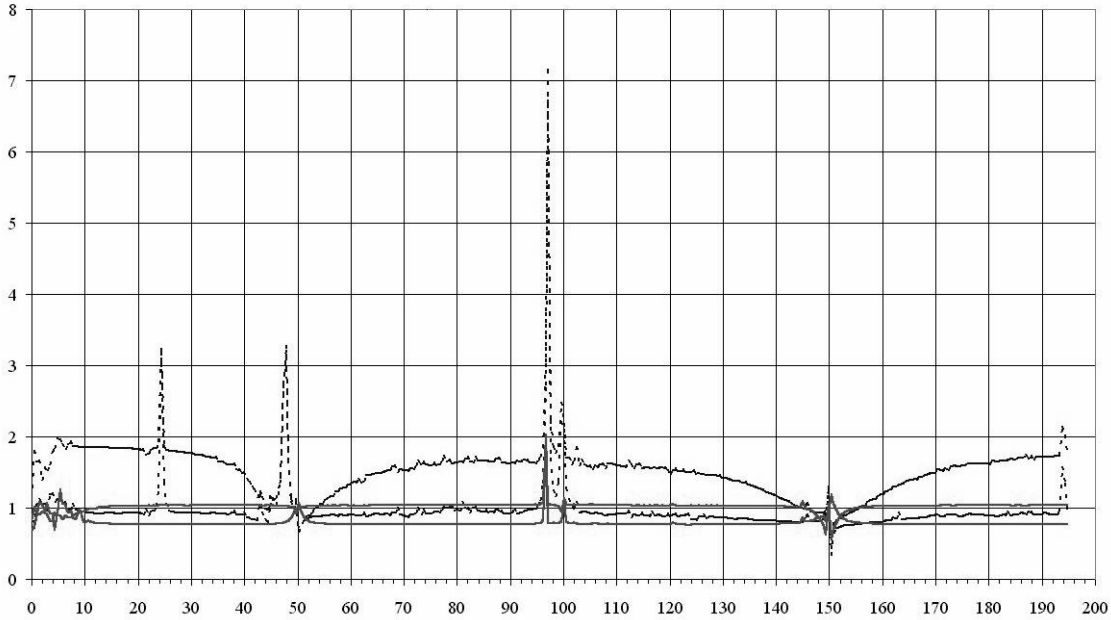



Figure 7.: Oil pump contribution.

The telescope base area shown more perturbation at 25, 48 and 97 Hz. Nothing relevant on the TIO room further away from the telescope base. The tile isolation seems done properly.

### 3.2.3 Dome rotation contribution.

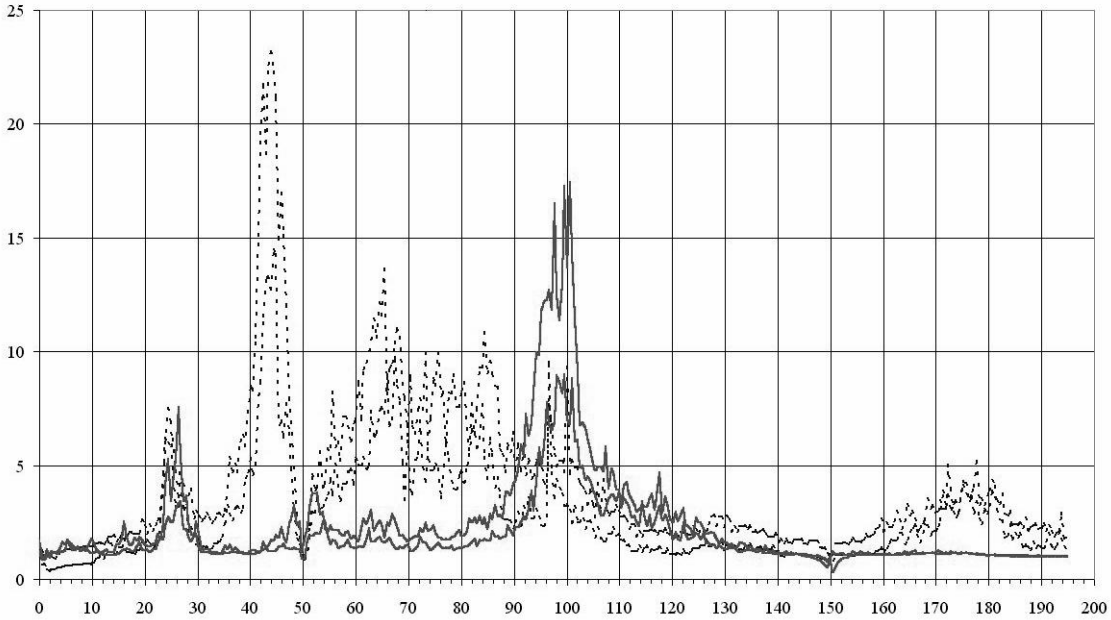



Figure 8.: Dome contribution.

As found on the 1m50, the effect is also strong on the 2m20. The telescope base shown more perturbation than

found at the TIO room. The frequency peak around 100 Hz is not as relevant on the telescope base.
We expected the contrary with the TIO room more sensitive due to the fact of direct building connections. It is difficult to argue on a carpet effect only damping the 35-90 Hz range. The rotation direction shows a different spectrum, the effect is inverse between both measurement set.

### 3.2.4 Human activities contribution.

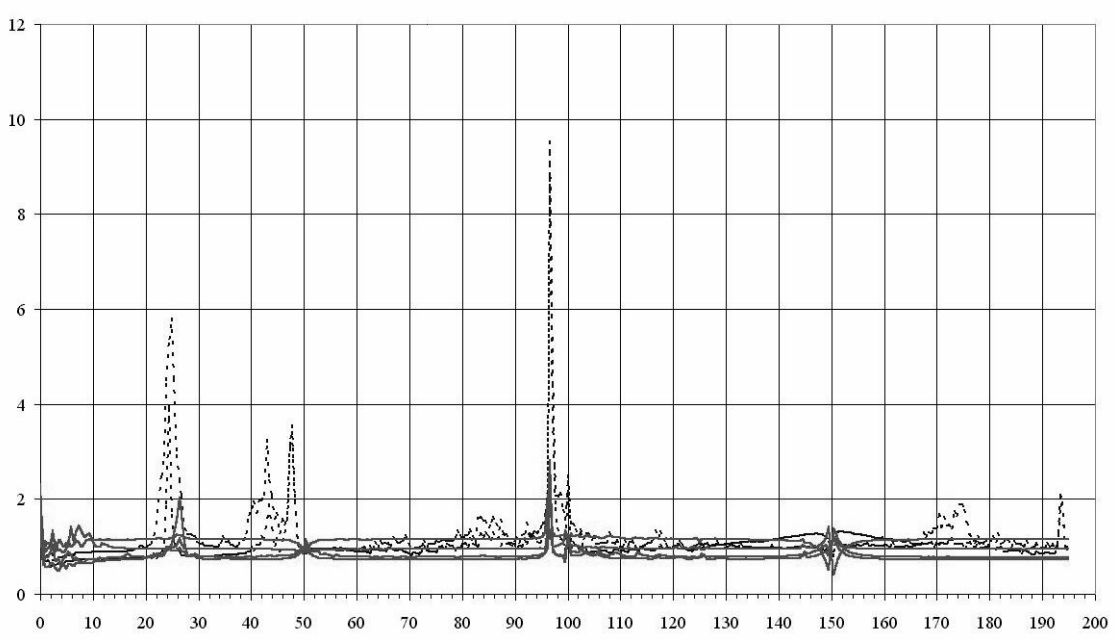



Figure 9.: Human activities contribution

The chair rolling, door closing and people using the stairs have more effects on the telescope base !.
Still a carpet damping ?

### 3.2.5 Telescope slewing contribution.

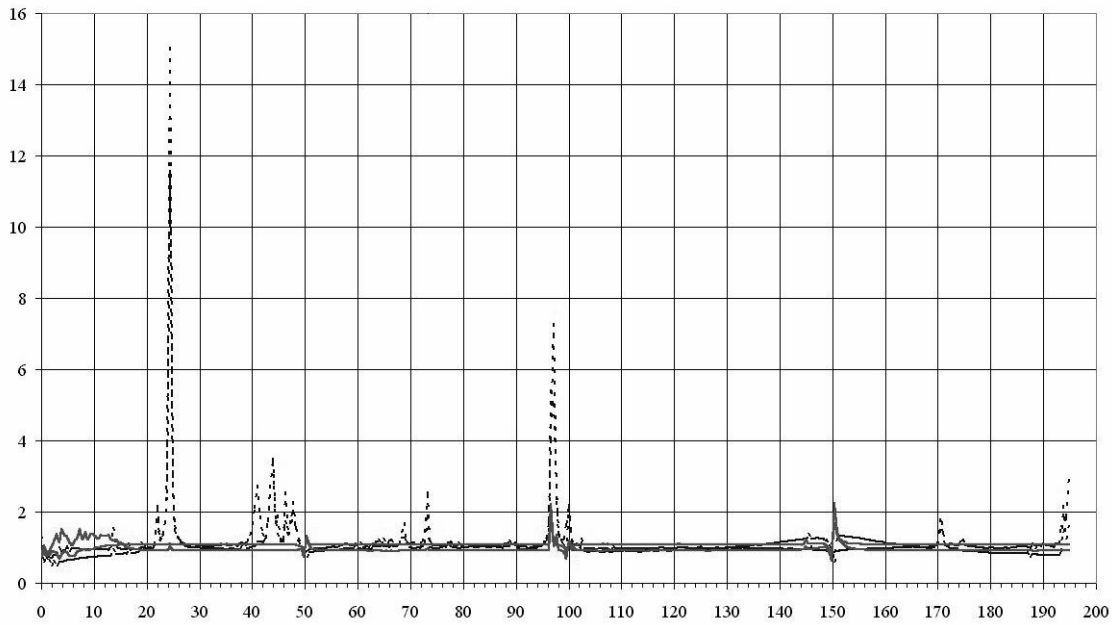



Figure 10.: Telescope slewing contribution

Both telescope axis moves introduced a non negligible effect on the vibration range. Again the TIO room doesn't shown perturbation related to this activity.

### 3.2.6 Telescope Tracking contribution

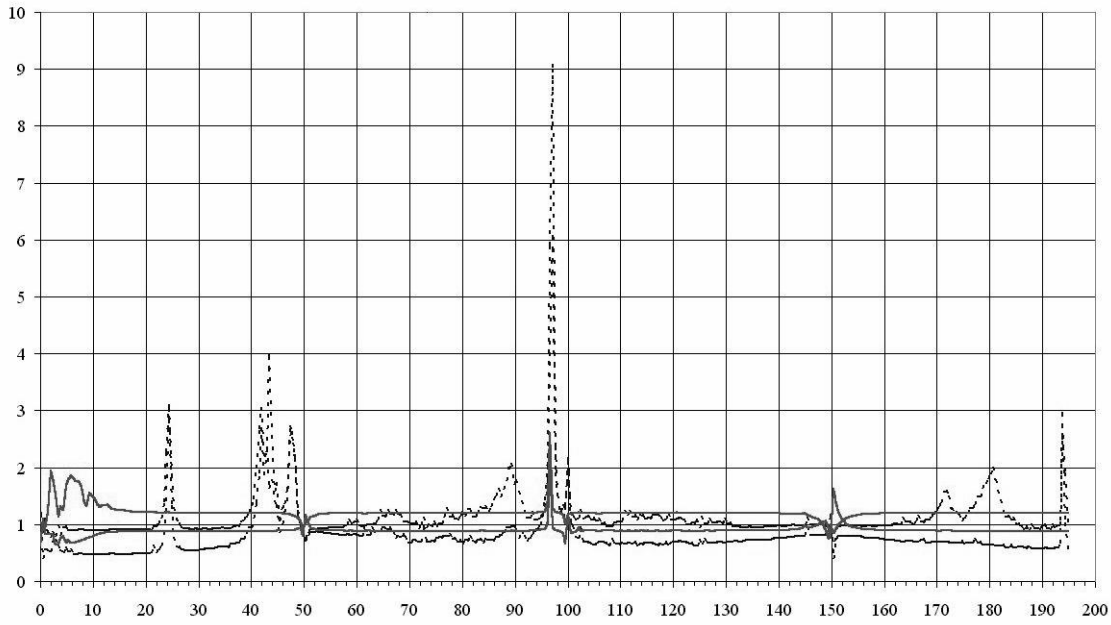



Figure 11.: Telescope tracking contribution.

The slow alpha rotation is also introducing as above a vibration perturbation on the telescope base area.

### 3.2.7 First Test conclusion.

The telescope base area is certainly not the right place to install the Feros bench. All activities introduced vibration perturbation of a non negligible amount.
The TIO room seems to behave in a better way but doubt remained from the carpet eventual damping effect.
The dome rotation is also affecting the TIO room.
Of course the effects above measured are in intensity about twice larger than measured on the 1m50 telescope, the distance between the laser head and the APD was double on the 2m20.

## 3.3 Second Test Period - 2m20 TIO room without Carpet

The same setup was used with the carpet removed.
The test repeated the most higher contribution found early, the dome and human activities.

### 3.3.1 Human Activity Contribution.

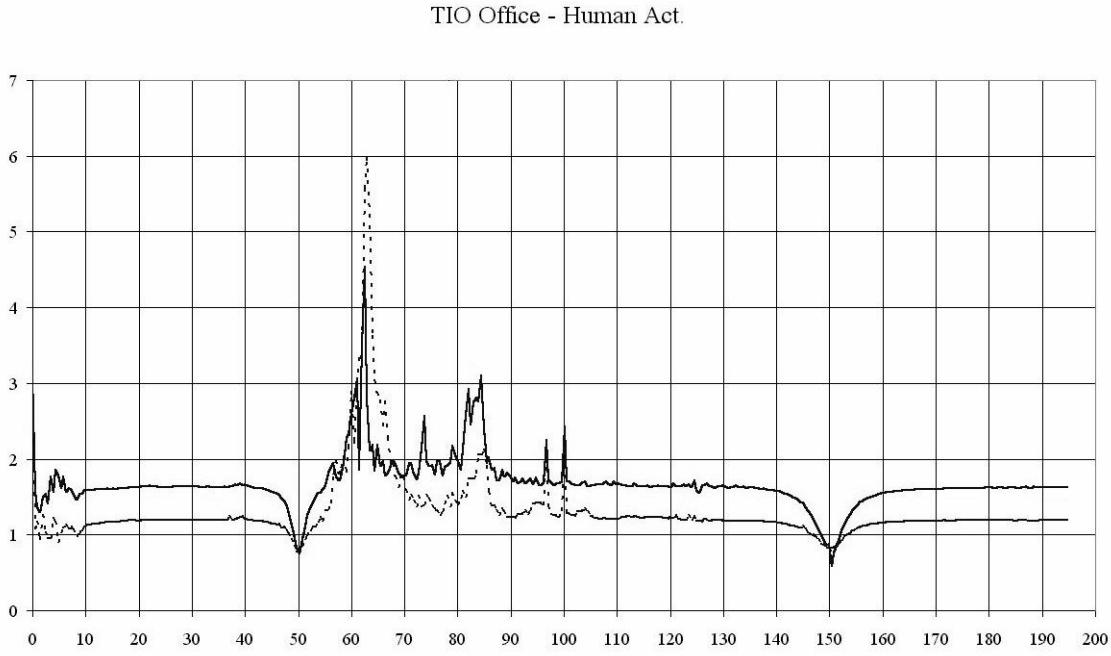



Figure 12: Human Activity

In comparison with the figure 9 the contribution shows here a lover lever.

### 3.3.2 Dome Contribution

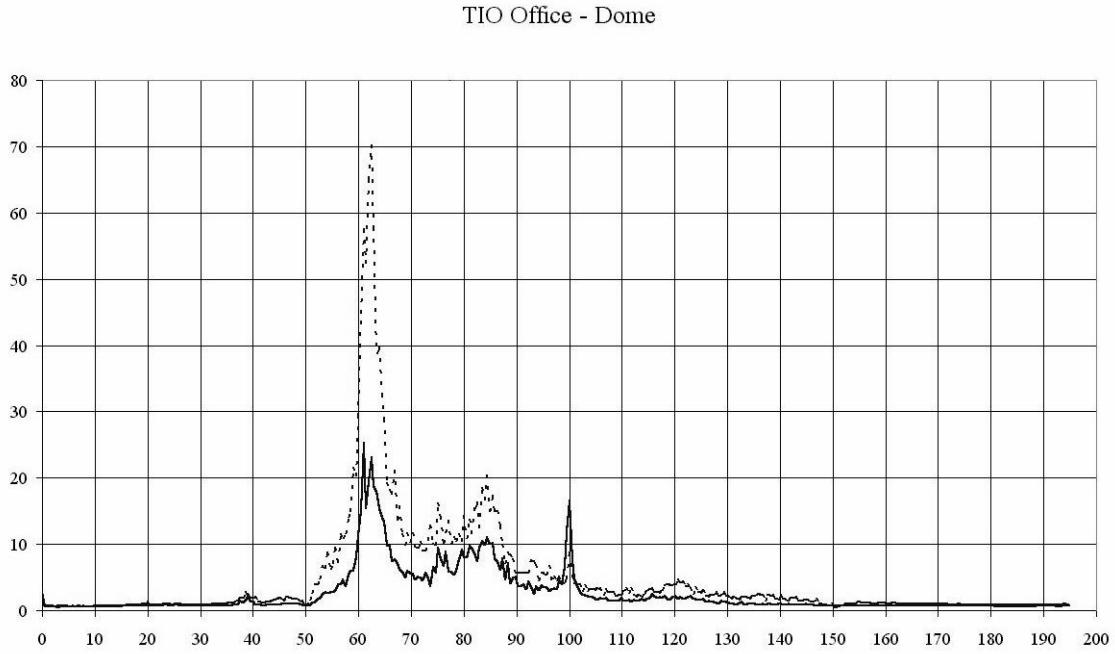



Figure 13: Dome Contribution

In comparison with figure 8, the contribution seems to be of the same order of magnitude. The only difference detected here concerned the strong vibration ( 62Hz) produced at the starting of the rotation also coupled with a noisely sound.

## 3.4 New location on the TIO room

A new possible location of the Feros room on the actual TIO room has been also tested. The area corresponds to the old photographic laboratory at the left corner of the TIO room close to the control room.
The laser head was located then close to the wall separation with the control room meanwhile the APD at 3.5 meters on the main room space area. The laser beam is aligned with the room axis.

### 3.4.1 Human Activity Contribution

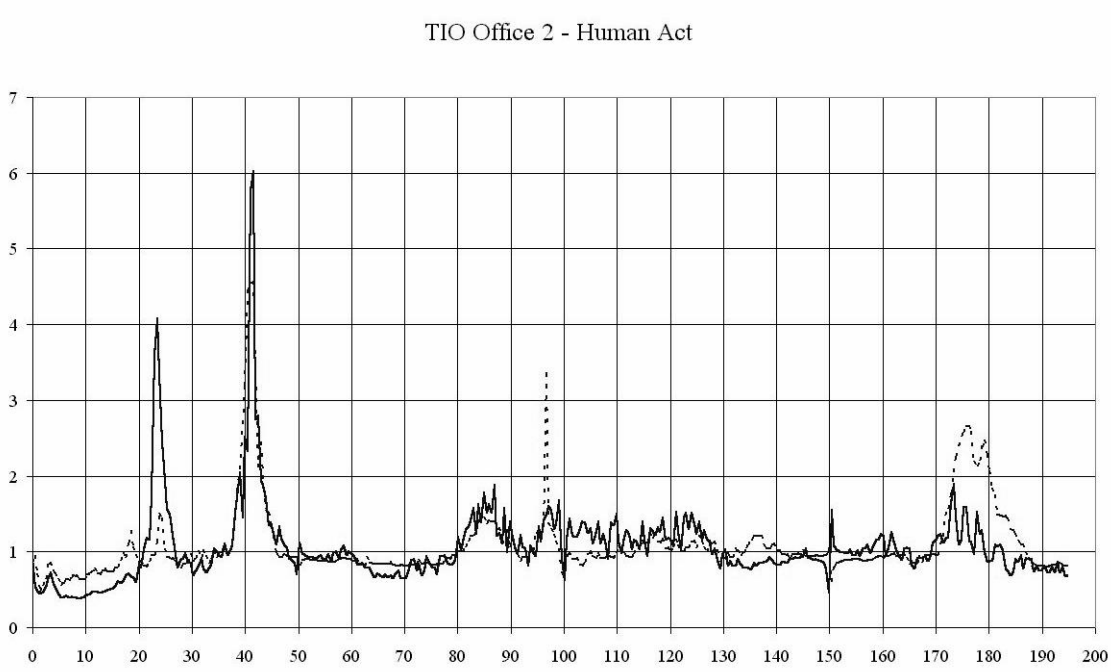



Figure 14: Human Activity

The contribution is small with maxima at 24 and 41 Hz. The comparison with the figure 9 shows also the same frequency distribution. No new events could be noticed.

### 3.4.2 Dome Contribution

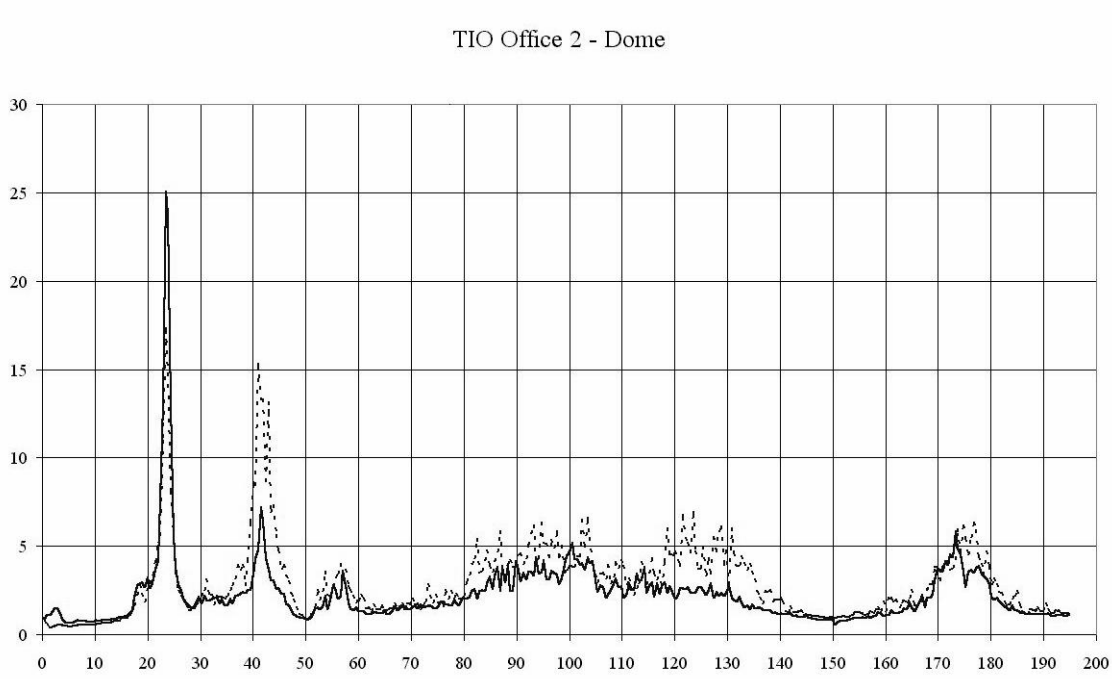



Figure 15: Dome Contribution

The dome spectrum is quite different than found on an other part of the TIO room. The two frequency 24 and 42 Hz are clearly resonance frequency of the floor at this location.
The level is still about the same of the measured one as shown on figure 8.

# 4 Conclusion.

The results can be resumed on the following points:

- The measures correspond to a displacement measurement of a laser beam in a vertical mode only.
- The present installation of Feros is not on a free vibration environment.
- The damping quality of the Feros bench is not the optimum. Of course the present instrument performances are known as good, but the influence of vibrations has been never estimated. If we can improve the instrument stability we should do it.
- The Feros bench is mounted on damping isolation supports. On dome contribution the effectiveness of the damping is detected by at least a factor of 3.
- The 2m20 telescope base shows a high sensitivity on all the perturbation normally existing during observations. It is not a good location for the future installation of the Feros bench.
- The TIO room is a more suitable choice with and without the carpet.
- A possible location on the TIO room closer to the control room has been also tested favourably.
- The dome rotation on the 2m20 is also producing a large range of vibration frequencies. This perturbation should be anyway damped by a factor 3 on the Feros bench.
- All measurement campaign took place during no wind conditions

# 5 Recommendations.

The Feros bench doesn’t require special damping installation on the 2m20.
But the enclosure walls must be separated from the floor to avoid vibration shortcuts.
The best location for the instrument seems to be the new alternative close to the control room decreasing the corridor width.

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