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Update on the Suspended Injection bench requirements - MC Automatic Alignment noise projection

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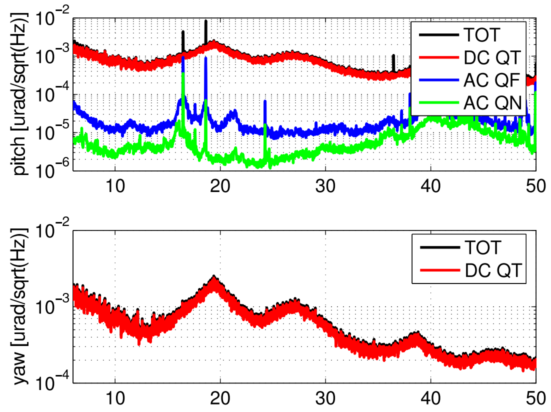

Figure 1: MC error signals for the pitch and yaw directions, top and bottom plots respectively. Both signals are dominated by the QT DC diffuse light noise.

1 Introduction

The MC Automatic Alignment control noise has been estimated, in low power and radiation pressure regimes, in the previous Virgo note "Suspended Injection bench requirements - MC Automatic Alignment noise projection" [1]. The control noise was evaluated starting from the present performances of the SIB accuracy and high frequency noise (few μrad for the SIB accuracy and 10^{-13} rad/$\sqrt{Hz}$ at 10 Hz) and it has been demonstrated to be compliant with the Advanced Virgo sensitivity requirements.
In this note the SIB angular requirements will be evaluated to take into account a possible modification of its suspension system.
Since the actual performances of the SIB are not easily achievable in the Advanced Virgo configuration, in this note the requirements for the SIB control are set trying to make them most relaxed as possible to leave to the SAT and PAY subsystems a large margin of feasibility.
The easiest way to relax the requirements, without changing radically the MC control strategy, it is to improve the MC Automatic Alignment sensing noise, as was pointed out in the previous note [1].

2 Sensing noise improvement

The MC Automatic Alignment control uses a mix of signals in reflection and in transmission from the MC mirror, the sensing matrix is:

QT DCh	QT DCv	QF ACh	QF ACv	QN ACh	QN ACv	
0	2.6	0	9.5	0	0.8	pitch
2.7	0	0	0	0	0	yaw

Table 1: MC Automatic Alignment sensing matrix.

Where QT DCh/v are the horizontal and vertical asymmetries of the quadrant DC output placed in transmission of the MC End mirror, QF ACh/v and QN ACh/v are the demodulated signals of the quadrants placed in reflection of the IMC installed on the External Injection Bench at the Far and Near Field positions respectively.

Looking at the signal spectra, shown in Figure 1, it is possible to evaluate the contribution to the MC AA error signal noise from each single quadrant signal used to reconstruct it. The most noisy ones are the DC signals

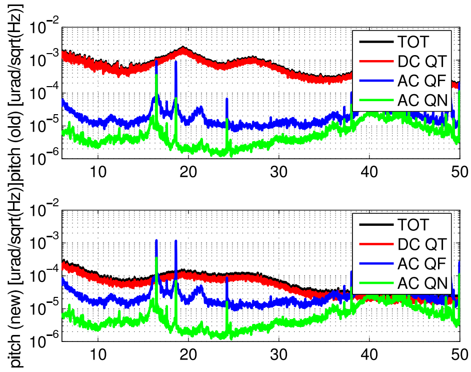

Figure 2: Improvement of the MC AA error signal in the pitch direction before and after the stray light cleaning campaign.

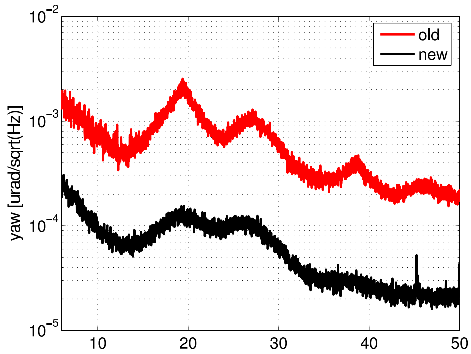

Figure 3: Improvement of the MC AA error signal in the yaw direction before and after the stray light cleaning campaign.

coming from the quadrant place in transmission to MC mirror which dominates both the pitch and yaw error signals.
The noise of these DC signals are dominated by diffused light coming from stray light.
Some interventions have been done on its detection bench, on the 19^{th} of November 2010 [2], to reduce the noise coming from diffuse light.
The error signals have been improved by a factor almost 10 in both directions, as it is shown in Figures 2 and 3.

3 SIB requirements

In order to set the requirements for the SIB angular performances, both in the the low power and in the radiation pressure regimes, the MC Automatic Alignment control noise projection in the sensitivity has been computed by scanning the SIB accuracy (the RMS) and the high frequency level (the control noise starting from 10 Hz) to have the MC angular control noise below the Advanced virgo sensitivity of a factor of 10 plus a factor of $\sqrt{2}$, to taken into account both directions, which will be called sensitivity safety curve.
The MC Automatic Alignment noise is compliant with the Advanced Virgo requirements if its projection is below the sensitivity safety curve.
Since the AA control noise depends on the SIB angular performances [1], i.e. the RMS and the noise in the detection band, the distance between the control noise projection and the sensitivity curve can be computed as a functions of these two parameters.

In order to simplify the computations the slope of the SIB angular noise starting from 10 Hz has been considered as the actual one and only the 10 Hz level has been scanned [1].
Moreover it has to be noticed that the control filter for controlling the pitch direction has been modified, with respect to the one used in the previous note, to suppress the two frequency lines (16 - 18 Hz) due to seismic motion of the bench.

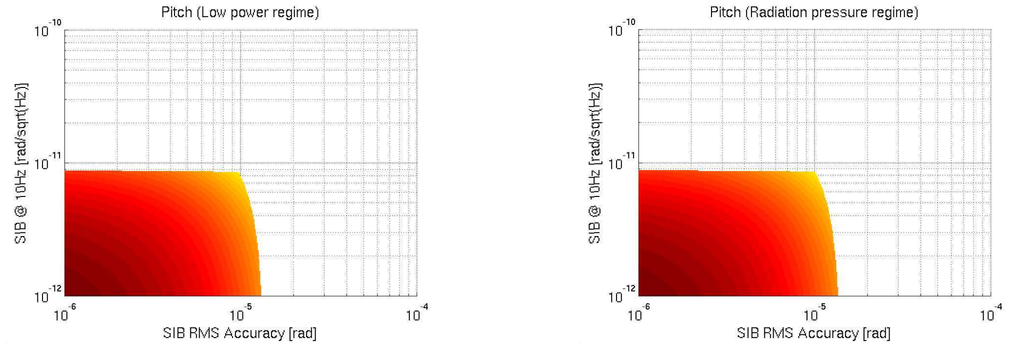

Figure 4: Distance between the MC AA control noise projection as a function of the SIB accuracy and the high frequency performance in the pitch direction for low power regime, left plot, and radiation pressure regime, right plot. The MC AA control noise is compliant with the sensitivity requirements in the red region.

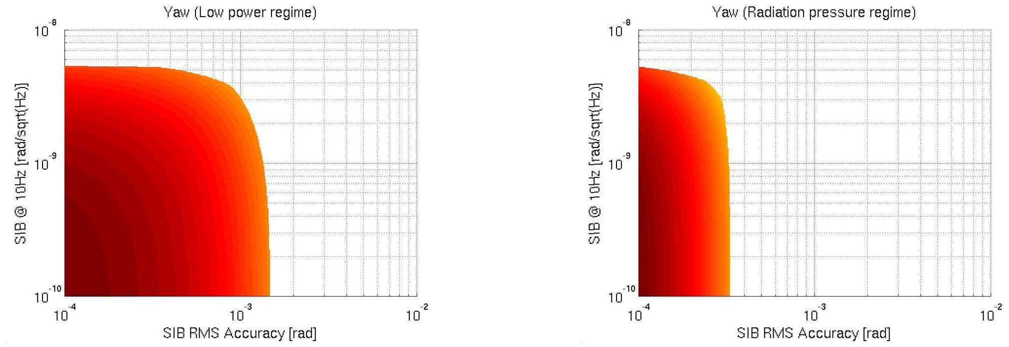

Figure 5: Distance between the MC AA control noise as a function of the SIB accuracy and the high frequency performance in the pitch direction for low power regime, left plot, and radiation pressure regime, right plot. The MC AA control noise is compliant with the sensitivity requirements in the red region.

The Figures 4 and 5 show the computed distance between the MC Automatic Alignment control noise projection and the sensitivity safety curve. In these plots only the values for which the MC control noise fulfills the requirements are shown (red points). The requirements for the SIB are then:

direction	regime	10 Hz [rad/$\sqrt{Hz}$]	RMS [rad]
pitch	low power	$8 \cdot 10^{-12}$	10^{-5}
pitch	rad. press.	$8 \cdot 10^{-12}$	10^{-5}
yaw	low power	$2 \cdot 10^{-9}$	10^{-3}
yaw	rad. press.	$2 \cdot 10^{-9}$	$2 \cdot 10^{-4}$

Table 2: Angular requirements for the Suspended Injection Bench.

[1]Since the slope of the SIB high frequency noise has been left as the actual one if the high frequency behavior will change the computation has to be redone

4 Conclusions

In this note the requirements for the SIB alignment performances, both the accuracy and both the noise in the detection band, are set.
As it is shown in the Table 3 the most stringent requirement is for the pitch direction which requires an high frequency angular displacement for the SIB of about $8 \cdot 10^{-12}$ [rad/$\sqrt{Hz}$].
Since the slope of the SIB control noise starting from 10 Hz has been left as the actual one if this will change the requirements have to be re-computed.
Moreover it is important to notice that for the MC angular control noise, if the control strategy will be left as it is, it is not mandatory to suspend and place under vacuum the quadrant diodes used to reconstruct the alignment error signals.

5 Acknowledgements

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References

[1] M. Mantovani " Suspended Injection bench requirements - MC Automatic Alignment noise projection " - VIR-0598A-10 2, 3

[2] Virgo Logbook entry 28352 3