# Characterization of an acousto-optic deflector for the correction of asymmetric wavefront distortions through high speed $CO_2$ beam scanning

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**Abstract**

Shot noise is a fundamental limit to the sensitivity of advanced gravitational wave detectors above few hundred Hz. This limit can be reduced by increasing the circulating optical power. However, a larger power circulating in the resonant optical cavities is likely to give rise to thermally induced wavefront distortion in the core optics, due to the non-zero optical absorption in coatings. Thermal aberrations include thermo-optic and thermo-elastic contributions. These effects will lead to a degradation of the performances of the detector and, eventually, they could even prevent its operation.

Advanced Virgo is equipped with a system for the measurement of the aberration budget and its correction with different purpose actuators (Thermal Compensation System [1]). The system is also used for the compensation of cold defects, that are present in the core optics due to tolerances in their production process.

In the TCS scheme, the wavefront distortion through the input optics can be compensated through thermo-optic effect using a high power $CO_2$ laser beam, properly shaped and projected onto auxiliary optics placed just before the cavity input. While the axi-symmetric part of the optimal heating pattern is provided by shaping the beam through suitable optical elements (axicons), the residual non symmetric distortion is compensated using a scanning system [2] in which the laser beam is moved along a raster scan pattern onto the auxiliary optic; to approach the optimal heating distribution as a sum of all the spots, the beam intensity is modulated point by point. The beam is deflected along the scan by a couple of Galvo mirrors, with an optical lever of 3 m and a maximum operation frequency of 3 kHz. The drawback of the scanning system relies in the fact that it could inject noise at frequencies in which the detector has its sensitive bandwidth.

We present a novel solution for the deflection of the $CO_2$ beam in the scanning system scheme. An acousto-optic device can be used to steer the beam throug Bragg diffraction, and, since this method does not involve moving parts, the deflection angle can be changed very rapidly by just changing the frequency of the acoustic wave propagating into the crystal. The same device allows also the intensity of the deflected beam to be modulated. We report the characterization of a commercial IntraAction AOD (acousto-optic deflector) to be used as a deflector for the Advanced Virgo scanning system. The performances of the AOD are shown to be optimal for the described application up to 700 kHz scanning frequency. Such an high scanning speed will allow the noise introduced by the scanning system to be moved well above the sensitivity band of Advanced Virgo.

## References

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