Progress Report May 2014

MCAO SIMULATIONS AND TESTS 2/2

Deformable Mirrors order

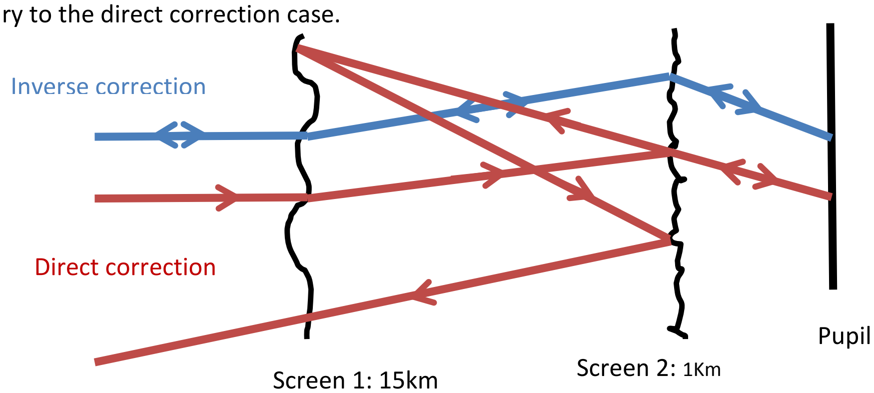
Objective

Modern telescopes include deformable mirrors (DMs) in their optical train to compensate for the aberrations induced by the terrestrial atmosphere in the incoming wavefront. To that aim, the distortion is evaluated and the necessary shape of the DMs is calculated to minimize the residual aberration. With multi-conjugate adaptive optics (MCAO), several DMs are conjugated at different heights to correct the effect produced by the stratification of turbulence.

There are two options to place deformable mirrors (DMs) in the optical train of a MCAO system: (a) correcting the layers in the same order as they are optically conjugated ("direct correction") and (b) correcting the layers in the inverse order to conjugation ("inverse correction"). A total cancellation of phase and amplitude is only achieved in the latter case. Direct correction is commonly adopted for MCAO systems in night Astronomy. However, it has been claimed in the literature (Flicker 2001) that direct correction is not effective for visible wavelengths and low elevation angles, and that the degradation is due to amplitude fluctuations originated by the wavefront propagation. Aimed to verify this idea we used the ZEMAX tool to compare the performance of a MCAO system for a 4m telescope (like EST) as a function of the sequence of the phase correction.

Examples of Simulations and Analysis

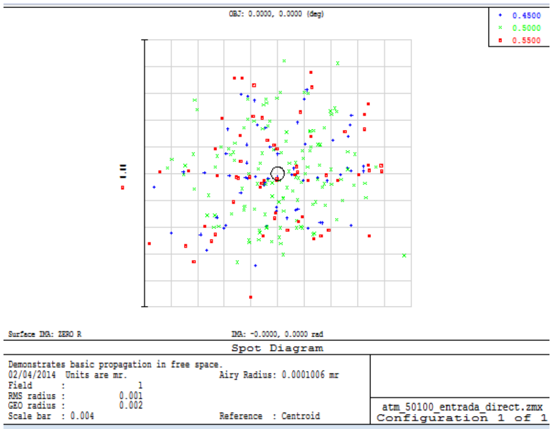
One simple propagation system with two turbulent layers situated at altitudes of 1km and 15km is simulated. The correction is performed by using the same phase screens but with opposite signs. Blue lines represent the inverse correction (screen1-screen2-pupil-screen2-screen1). Red lines represent the direct correction (screen1-screen2-pupil-screen1-screen2). In the inverse correction case the optical path difference is zero, contrary to the direct correction case.

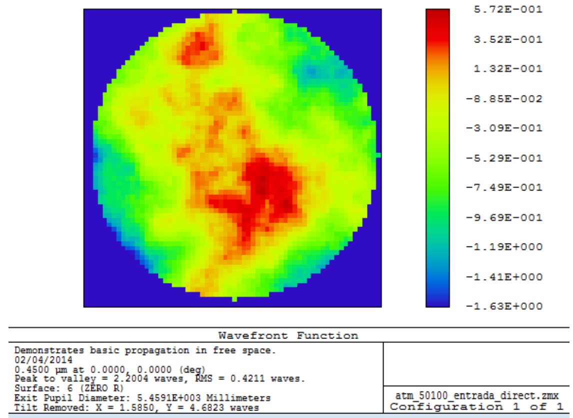


Ray tracing for two turbulent layers MCAO system, direct correction (red) and inverse correction (blue)

As expected, the correction in the inverse case is perfect and the residual wavefront error is zero, while in the direct case the correction is not perfect.

WITHOUT CORRECTION

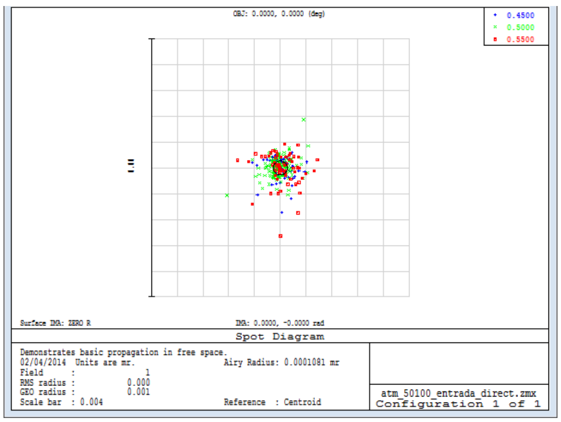


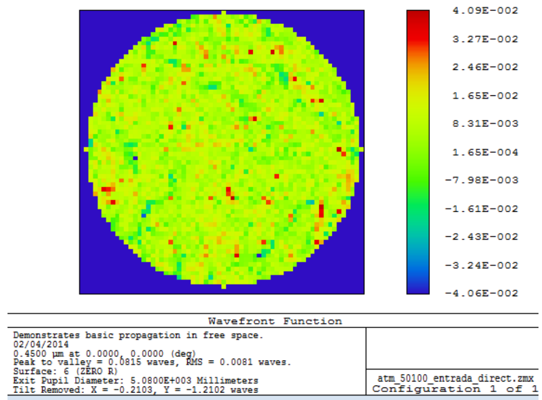


Spot Diagram

Residual wavefront error

DIRECT CORRECTION

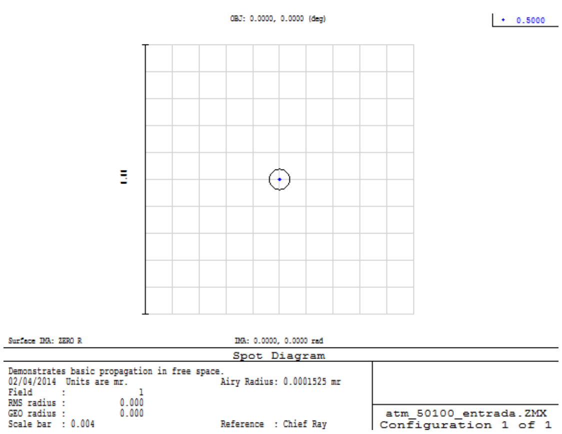


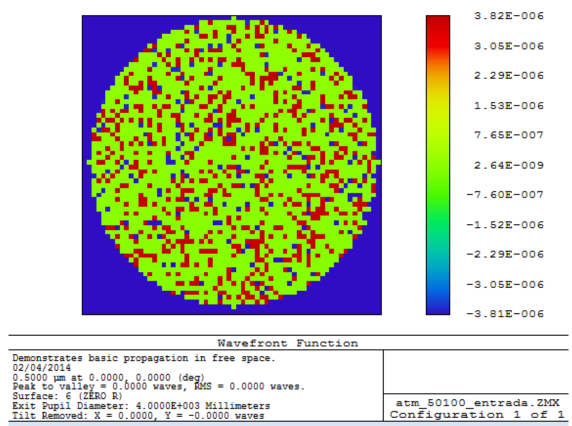


Spot Diagram

Residual wavefront error

INVERSE CORRECTION





Spot Diagram

Residual wavefront error

Next step

Our simulations based on the ZEMAX tool do not allow verifying the effect of scintillation on wavefront propagation. Therefore, wavefront propagation will be implemented in future simulations to quantify the effects of sequence of phase correction.