OASys

OPTIMIZE BOTH THE FOCAL SPOT QUALITY AND POSITION

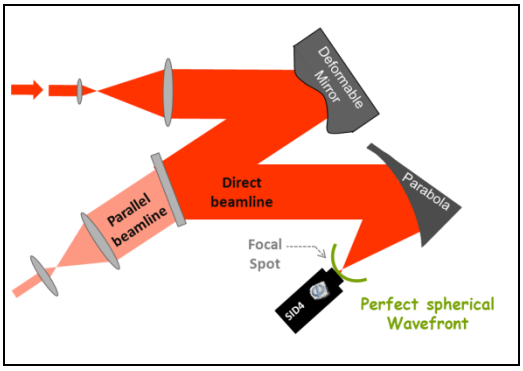
FULL LASER CHAIN CORRECTION

Optimizing laser-matter interactions in high power laser facilities strongly relies on the performance of the adaptive optics loop that is installed. Not only the loop should provide a **high-quality focal spot** that concentrates the light in the tiniest possible volume, but it must accurately control the **focal spot position** so that the interaction with the target can efficiently happen. Moreover, the control of the focal spot quality and position requires **stability and high repeatability** to allow comparing sets of measurements. Finally the loop should be **easy to use** for all users, even non-laser specialists.

Always offering new advanced features, Phasics leads innovation in adaptive optics for high power laser. Along with the **3D pointing module** that directs the focal spot towards the target, Phasics introduced an innovative process that **corrects the full laser chain, including the aberrations due to the last focusing optics** in the interaction chamber. Made possible thanks to Phasics' unique technology, the **quadri-wave lateral shearing interferometry**[1] (SID4), this process provides a **focal spot of the best possible quality**.

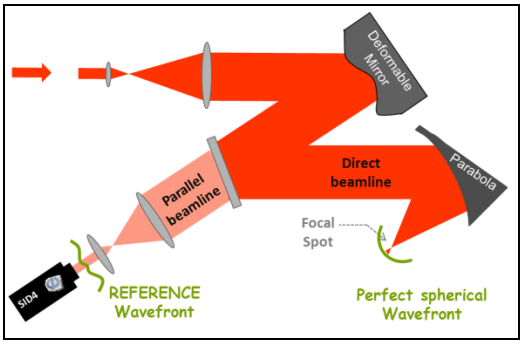
"A NEW PROCESS THAT CORRECTS ALL THE ABERRATIONS, INCLUDING THE LAST FOCUSING OPTICS"

In a classical loop, the best possible focal spot is achieved when getting a flat wavefront on the sensor placed in a parallel beamline before the interaction chamber. It is not yet of optimum quality as the last focusing optics aberrations are not corrected.



1. Step 1: the mirror actuators are moved so as to obtain a perfect spherical wavefront just after the focal spot

Phasics has introduced a simple new process for correcting the aberrations due to the last focusing optics, **that does not reconsider the classical loop**. This new solution consists in a simple **two-step calibration**. First, the Phasics wavefront sensor is directly placed after the focal spot. The focal spot is optimized by adjusting the deformable mirror shape so as to get a perfect spherical wavefront on the sensor. The achieved focal spot is truly the **best possible** one as all the aberrations of the laser chain are taken into account.



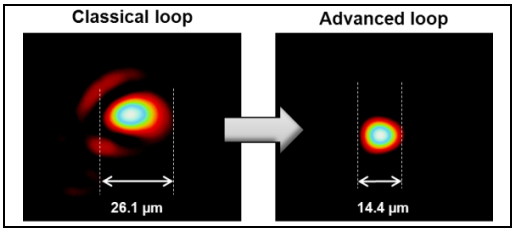
2. Step 2: the wavefront measured in the parallel beamline is saved as a reference

Then the sensor is placed as usual in the parallel beamline. The wavefront is measured with the mirror shape set in the configuration obtained during the first calibration step. **This wavefront creates a perfect spherical wavefront** at the focal spot in the interaction chamber. It will be used as a **reference** that the loop will target instead of the usual flat wavefront. It is interesting to note that this reference also includes misalignment of the telescope in the parallel beamline.

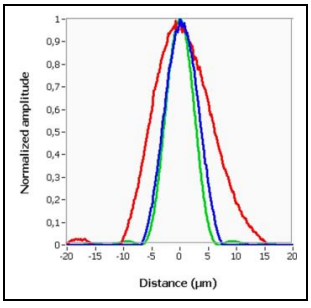
"A DIRECT RELIABLE MEASUREMENT WITH NO RELAY LENS"

Unlike a Shack-Hartmann sensor that only measures collimated beams, the Phasics wavefront sensor can directly measure diverging beams (**up to f/1.5**). Consequently it can be placed just after the focal spot[2] and acquires a phase map **without needing any relay lens**. Thus the calibration process is very **easy to put in place and reliable**: without relay optics, no unwilling aberrations are added and the process stays achromatic for femtosecond lasers. Moreover, the reference can be **immediately used without calculation or additional adjustment** as it is a wavefront map measured by the sensor that itself is used in the loop afterwards, so no error is produced due to the addition of an extra system.

"SIGNIFICANT FOCAL SPOT QUALITY ENHANCEMENT"



3. In this example, the focal spot size of a f/5 beam is improved by 45% with Phasics advanced process



4. With Phasics advanced process, the intensity profile gets close to the Airy pattern

The optimization of the focal spot including a first calibration of the full laser chain shows a **real improvement of the intensity at the focal spot**, as illustrated on the example on the left. The intensity profile comes very **close to the diffraction-limited profile**, with a **Strehl Ratio above 0.95** on the direct beam line at the focal point[3].

REFERENCES

[1] J. Primot et al, ONERA, " Extended Hartmann test based on the pseudoguiding property of a Hartmann mask completed by a phase chessboard", APPLIED OPTICS, Vol. 39, No. 31, November 2000
[2] REN Zhi-Jun et al, SIOM, "Efficient Spherical Wavefront Correction near the Focus for the 0.89 PW/29.0 fs Ti:Sapphire Laser Beam", CHIN. PHYS. LETT. Vol. 28, No. 2, 2011
[3] I. Doudet et al, PHASICS, "Adaptive Optics loop implementation and optimization for petawatt laser facilities", ICUIL 2012