

---

# TIPTOP: cone effect for single laser adaptive optics systems

Guido Agapito\*<sup>1</sup>, Cedric Plantet , Fabio Rossi , Arseniy Kuznetsov , Simon Conseil ,  
and Benoit Neichel

<sup>1</sup>INAF – Italy

## Abstract

TIPTOP is a python library that is able to quickly compute Point Spread Functions (PSF) of any kind of Adaptive Optics systems. The goals of this library are several: support the exposure time calculators of future VLT and ELT instruments, support adaptive optics systems design activities, be part of PSF reconstruction pipelines, support the selection of the best asterism of natural guide stars for observation preparation. Here we report one of the last improvements of TIPTOP: the introduction of the error given by a single conjugated laser, the so-called cone effect. Cone effect was not introduced before because it is challenging due to the non-stationarity of the phase. We chose a different approach considering spatial frequency by spatial frequency that the correction corresponds to a measurement done on turbulence above the ground level is associated with a lower spatial frequency. In fact there is a magnification of the beam footprint on the turbulence layer due to the finite distance of the source. Therefore, we estimate the residual power by computing the difference between two sinusoids with different periods: replicating this for each spatial frequency we obtain the power spectrum associated with the cone effect. We compare this estimation with the one given by end-to-end simulation and we present how we plan to validate this with on-sky data.

**Keywords:** simulation, single conjugate adaptive optics, laser, cone effect

---

\*Speaker