Laser Projection System for TNG

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ABSTRACT

In the framework of the Adaptive Optics for TNG the mechanical, optical and engineering aspects of the Laser Projection system for the TNG are briefly shown. The laser beam is projected through the elevation axis on the Nasmith foci usually devoted for spectroscopic purposes and otherwise unused during imaging scientific activities. The optical design of the projector is also outlined. It is foreseen that in the very first phase a Rayleigh laser will be operated at TNG, later replaced by a mesospheric Sodium LGS generator.

Keywords: telescope, laser, laser guide star.

1. INTRODUCTION

The TNG telescope is being equipped with an adaptive optics module able to provide a partial adaptive optics correction up to an 8×8 sampling of the entrance pupil. This translates into full adaptive optic correction for a Fried parameter $r_0 \approx 0.45$m. Such a figure is unrealistic at visible wavelength, with perhaps the exception of (rarely) extremely good seeing that can occasionally occour at the TNG site. By the way it is a figure that can be easily occour at the infrared wavelengths. While the adaptive optic system (namely AdOpt@TNG) has been fully approved and funded, there is no any definitive statement about the implementation of a Laser Guide Star (LGS) projection system or a further sampling of the input pupil.

We think that an LGS projection system is a prioritary choice with respect to the adoption of, say, a 16×16 adaptive optics system. The latter, in fact, will require a very bright source (that is a very powerful laser) in order to have some interesting (from the scientific point of view) sky coverage; the implementation of an LGS projection system for the 8×8 system, on the other hand, is a feasible goal reachable with the existing technology. In this framework the TNG telescope is built with a full predisposition for the implementation of such a facility.

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The details are described in this paper. Moreover we are proceeding to perform an in–deep study of the LGS tilt indetermination problem[1...6].

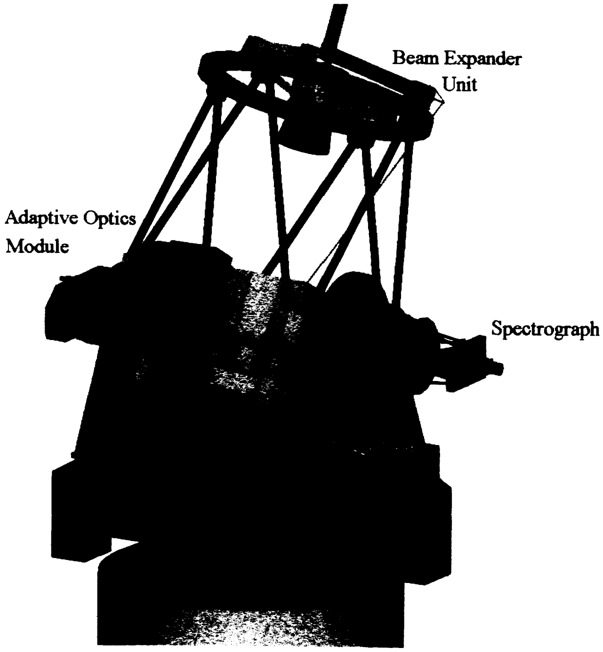

Figure 1: Overall layout of the laser projection system.

2. THE BEAM EXPANDER

A two mirror, all reflective, afocal beam expander, using two parabolic mirror has been designed and a tolerance analysis has been performed in order to verify for the feasibility of such a component. It is to be pointed out that the output beam will exhibit a central obstruction, not present in the input beam. In this way a $\approx 8\%$ loss of light is obtained. As an alternative one could have an holed primary mirror (the convex and smaller parabolic one).

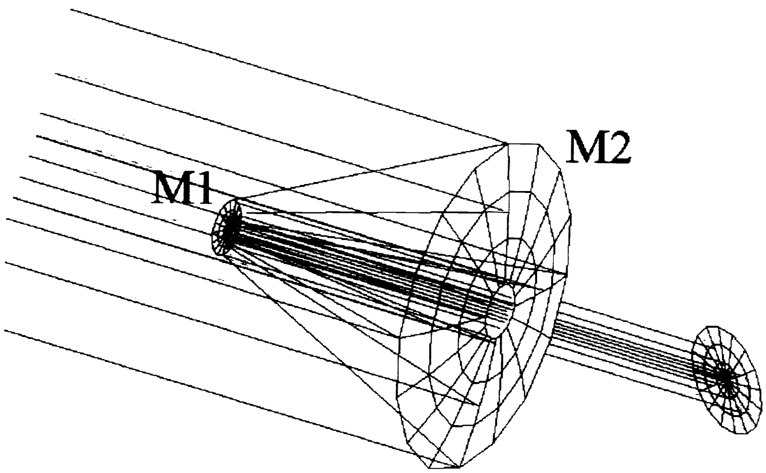

Figure 2: Optical layout of the beam expander.

This last solution, however, will introduce a smaller pencil beam in the projected one and, due to diffraction reason, a larger spot will be obtained at the mesospheric sodium layer height. By the way it can be useful to reinforce Rayleigh scattering at intermediate height. It is well known both from the theoretical[7] and the experimental[8] point of view that a Rayleigh beacon can provide poorer performances but on a wider *isoplanatic* patch than the Sodium beacon. The adoption of both Rayleigh and Sodium beacon, using the same laser beam projector, is currently under investigation.

3. THE OPTICAL TRAIN

The laser beam is fed from the power laser unit through a number of small, properly coated, flat mirrors. Because of heat dissipation of the power laser unit it is strictly required that this one is placed in one of the two Nasmith rooms of the TNG rotating building. Moreover, the laser beam is to be aligned with the elevation axis in order to be fed to the rear side of the secondary mirror's cage without any *active* repositioning of the flat mirrors. This is accomplished by mounting one flat relay mirror in the Rotator/Adapter devoted to spectroscopic purposes and a second one on the back of the tertiary mirror unit of the telescope. In this way the exit pupil of the power laser system will be seen as rotating by the projector system mounted on the top–ring of the telescope. This can translate into an additional rotation of the LGS spot on the sky, if the purity of the generated wavefront is not warranteed at all. As a minor remark one should also note that misalignment or defects of the beam expander optics will add to the described effect, leading to a more complex pattern evolution that is not studied here.

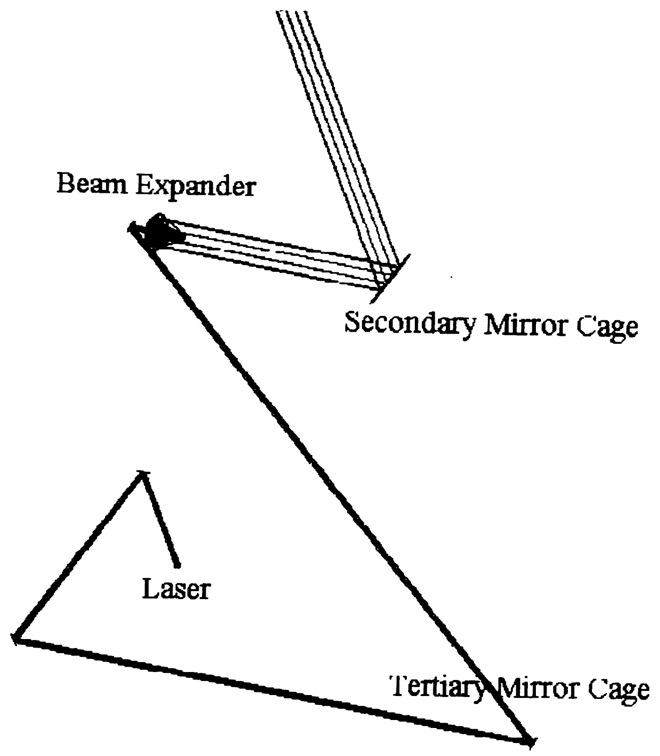

Figure 3: The optical train of the laser projecting system.

The beam expander is mounted horizontally on the top–ring unit and the enlarged beam is folded along the main TNG optical axis by a larger flat folding mirror. This choice is due to mechanical reasons imposed by the crane operations in the case of removing the secondary mirror unit. Care has to be given to the fact that from the Nasmith foci where the imaging (and the adaptive optics correction) is performed, there is no any direct observation of any of the flat mirrors. In this way any dust deposition on this mirror will produce a poorer quality LGS spot, but this will not translates into a brighter background.

It can be easily seen that small misalignment of the optical train can be corrected (at least within a given range) by re–alignment of the folding mirror and of the optics of the beam expander. In this way one can think to produce an *active* beam compressor unit, using as a feedback directly the image of the LGS as seen on the sky. All the other mirrors will be left unactive during nominal operations of the telescope.

4. CONCLUSIONS

After commissioning of the AdOpt@TNG module a decision will be taken in order to implement an LGS facility at the TNG site. At that time it will be easy to incorporate such an option in the telescope structure and, hopefully, a firm solution to the LGS tilt indetermination problem will be available with, we think, some our significant contribution. Full sky coverage, even with partial compensation, could becomes available to our astronomical community.

5. REFERENCES

[1] Foy R., Migus A., Biraben F., Grynberg G., McCullough P.R., Tallon M. (1995) "The polychromatic artificial sodium star: a new concept for correcting the atmospheric tilt" A&ASS **111**, 569

[2] Ragazzoni R. (1996) "Absolute tip–tilt indetermination with laser beacons" A&A **305**, L13

[3] Ragazzoni R., Esposito S., Marchetti E. (1995) "Auxiliary telescopes for the absolute tip–tilt determination of a laser guide star" MNRAS **276**, L76

[4] Ragazzoni R. (1996) "Propagation delay of a laser beacon as a tool to retrieve absolute tilt measurements" ApJ Letter, to appear on the 1^{st} July issue

[5] Belenkii M.S. (1995) "Full aperture tilt measurement with a laser guide star" SPIE proc.**2471**, 289

[6] Ragazzoni R., Marchetti E. (1996) "Further techniques for LGS tilt recovery" SPIE proc. **2871** (this conference)

[7] Ragazzoni R., Marchetti E. (1995) "Rayleigh vs. Sodium beacon for a large Field of View partial correction" Atmospheric and Ocean Optics **8**, 174 (Original in Russian: **8**, 342)

[8] Christou J.C., Ellerbroek B., Fugate R.Q., Bonaccini D., Stanga R. (1995) "Rayleigh beacon adaptive optics imaging of ADS 9731: measurements of the isoplanatic Field of View" ApJ **450**, 369