Modular Setup of SLR Laser and Detection Packages

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Abstract

An increasing number of facilities capable of doing satellite laser ranging, space debris laser ranging or optical communication pushes the demand to create accurate, cost-efficient, reliable and yet simple components to be integrated. In the framework of the development and upgrade of the new Izaña-1 SLR station located on Tenerife in Spain, IWF Graz created new concepts for modular piggyback laser and detection packages. Optical components are selected based on commercial off the shelf components and simulated with ray-tracing software. We present the key design aspects of these newly developed laser and detection packages.

1. Introduction

The International Laser Ranging Service (IRLS) network supports an ever-growing number of responsive SLR targets. Apart from the existing stations, several future facilities with SLR capability are planned or in construction e.g., Yebes in Spain, Ny Ålesund on Svalbard, La Plata (AGGO) in Argentina, Metsahovi in Finland (IRLS, 2022). There is a clear benefit to be gained from additional accurate and productive SLR stations within the network since filling the network gaps, especially in the southern hemisphere, will contribute towards a uniform global coverage to support all segments of the satellite orbit (Otsubo, 2016). In order to increase the overall number of stations capable of SLR, the technology required for operation needs to be affordable, robust and easily available while still satisfying the high precision requirements (Wilkinson, 2019). The technology presented here aims to contribute towards these efforts.

In 2015, the Graz SLR group successfully demonstrated the direct mounting of a laser onto a telescope at Wettzell laser ranging observatory (Kirchner, 2015). This Single-Photon Detection, Alignment and Reference Tool (SP-DART) is a complete, transportable Mini-SLR-System and can be used for performance tests of the host system. Further efforts based on this groundwork led to the development of modular piggyback laser and detection packages presented here. The packages require a suitable tracking mount and in return provide a facility with SLR capability while eliminating the need for a dedicated laser room and a Coudé path, thereby reducing cost and complexity. Such laser and detection packages are part of the new Izaña-1 (IZN-1) SLR station located on Tenerife in Spain. IZN-1 started with laser ranging to cooperative targets and demonstration of passive-optical debris tracking and will be upgraded in the future with the capability to do laser ranging to non-cooperative targets/debris and space-to-ground laser communication (Kloth, 2019). In the following, we will discuss the methods applied to achieve a compact and modular set-up of the packages. Furthermore, we will present the key design aspects of the specific laser and detection packages in use at IZN-1.

2. Methods

Both package types consist of an optical bench, which acts as the main supporting structure for all optical components. It is housed in an aluminum enclosure. Besides providing a mechanical support structure to avoid micro-deformations of the plate during tracking, this closed environment enables each package to operate a temperature control system through a water-cooling loop. The electronic compartment, which is a major source of heat, is either spatially separated (detection packages) or fully outsourced (laser packages) from the optical compartment to further support temperature stability within the package. To avoid corrosion, materials are anodized whenever possible.

A commercial off the shelf (COTS) cage-rod-system provides the basic framework for all optical components within a package. COTS optical components like cameras, sensors, lenses and mirrors are then integrated through adapter configurations that enable insertion into the cage-rod system. This insertion can be done horizontally or vertically, the flexibility granted by this allows for a more compact design. The cage-rod system favors modularity, which makes future additions and upgrades easier. This is an important aspect in the face of the adaptability required by IZN-1. By identifying reoccurring subunits within the package and standardizing them, existing solutions, like camera adapters or motorized units, can be transferred to future projects without the need for major redesigns. Through this, a library of modular solutions can be obtained over time. The modeling and documentation of the process are done with the 3D-CAD-Software *Autodesk Inventor*.

The compact piggyback-type design of the enclosures allows for direct mounting on the tracking telescope while still granting access for maintenance or upgrade purposes. Figure 1 illustrates how the packages can be mounted to the host system. The packages provide the necessary interfaces to connect to e.g., event timers, power supply or control PC. The reliance on motorized linear and rotary units allows flexible remote divergence variation, FOV control, direction control and power measurements.

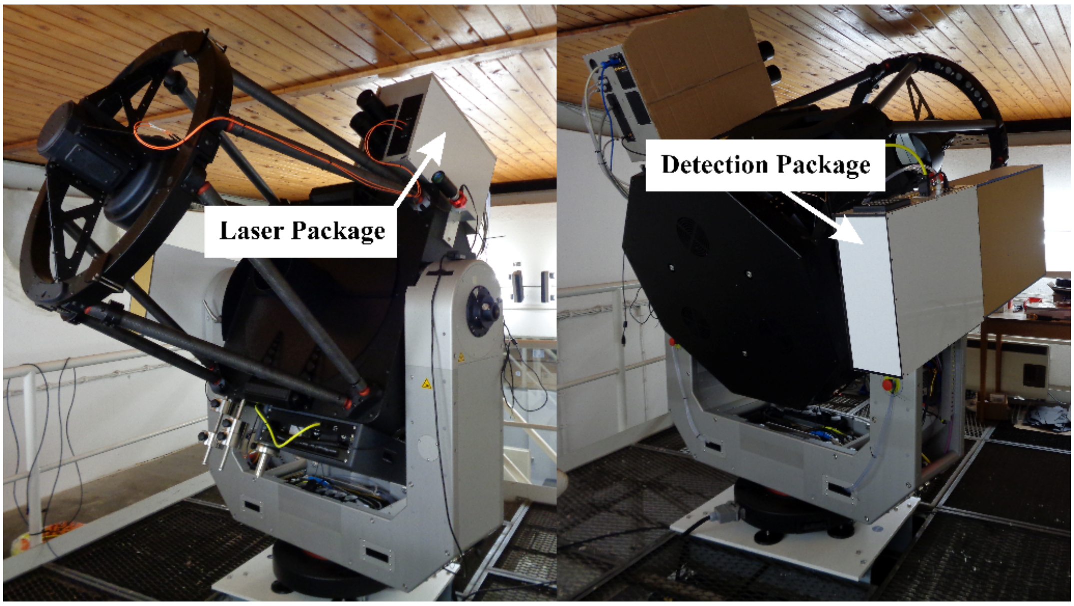

Figure 1: Laser and detection packages mounted on telescope for tests (Potsdam)

3. The Izaña-1 packages

3.1. Laser Package

The laser package takes advantage of recent development towards lighter and smaller picosecond lasers and provides a pulsed laser source of wavelengths 532nm and 1064nm with a repetition rate of 400Hz (Kloth, 2019). It consists of the laser with two separate beam expansion telescopes and a collimated part in between (Figure 2), which can be used for imaging of e.g., the backscatter laser beam or the visualization of stars for alignment purposes. A combination of wave plates held by motorized rotary units and polarizing beam splitters allows for power adjustment and measurement. One of the lenses is mounted on an electronically moveable lens holder which gives the possibility for flexible variation of the beam divergence and a motorized tip-tilt mirror enables direction control of the laser beam. Furthermore, start pulse detection is integrated.

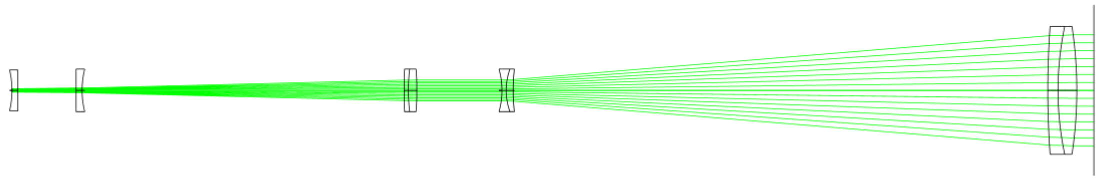

Figure 2: Optical ray-tracing simulation including two beam expansion telescopes and a collimated part in between.

3.2. Detection Package

The detection package has the capability to receive both wavelengths (532nm and 1064nm) and is mounted in one of the Nasmyth foci of the COTS type astronomical telescope, which in case of IZN-1 is a Ritchey-Chrétien telescope with an 80 cm main mirror and two Nasmyth foci through the elevation axis (Kloth, 2019). In the beam path direction, the field of view iris is followed by optics to collimate the entering photons to approximately 1 cm with some flexibility to tune the field of view of the telescope. Dichroic mirrors separate the incoming light with regards to wavelength and distribute it to various sensor modules like single photon avalanche detectors for green (C-SPAD) and infrared (IR-SPAD), optical guiding cameras and beam adjustment cameras. In addition to the existing sensors, the IZN-1 detection package provides a slot in the cage-rod system for the future addition of a light curve detector (Steindorfer, 2015).

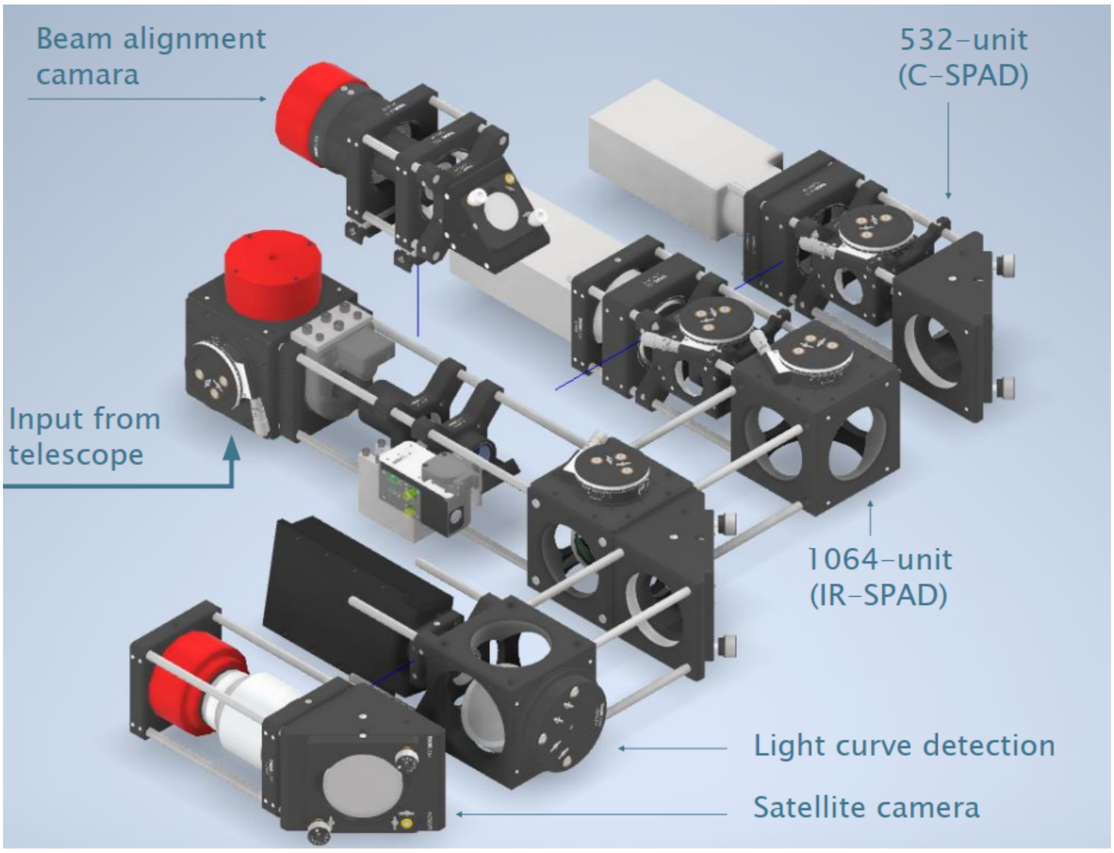

Figure 3: Boomview of the detection package's cage rod system

4. Summary

Modular laser and detection package concepts for the new Izaña-1 station in Spain on Tenerife were created. The compactness of the piggyback packages is achieved by relying mostly on COTS components which are integrated in a cage-rod framework within the packages. The reliance on motorized units within the package allows for remote adjustment of various parameters (e.g., divergence, FOV). Both packages operate a temperature control system, provide several interfaces and can be mounted directly onto the tracking optics, which eliminates the need for a dedicated laser room and a Coudè-path.

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