Proposed SLR optical bench required to track debris using ~1550 nm lasers.

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Abstract: A previous study has indicated that by using ~1550 nm wavelengths a laser ranging system can track debris objects in an "eye safe" manner, while increasing the expected return rate by a factor of ~2/unit area of the telescope[1]. In this presentation we develop the optical bench required to use ~1550nm lasers, and integration with a 532nm system. We will use the optical bench configuration for NGSLR as the baseline, and indicate a possible injection point for the 1550 nm laser. The presentation will include what elements may need to be changed for transmitting the required power on the ~1550nm wavelength, supporting the alignment of the laser to the telescope, and possible concerns for the telescope optics.

Maximum Eye Safe Power

	532 nm	1064 nm	1550 nm
10 sec exp.	0.0001 J	0.001 J	0.982 J
0.25 sec exp.	0.0001 J	0.001 J	37.767 J

-Based on results using USAF LHAZ6.0 which is calculated using 2014 ANSI standards
-Calculated using 1 ns pulse, 50 Hz rep rate, 25 cm beam diameter
-1550 nm remains eye safe at **orders of magnitude** higher power than 1064 or 532 nm

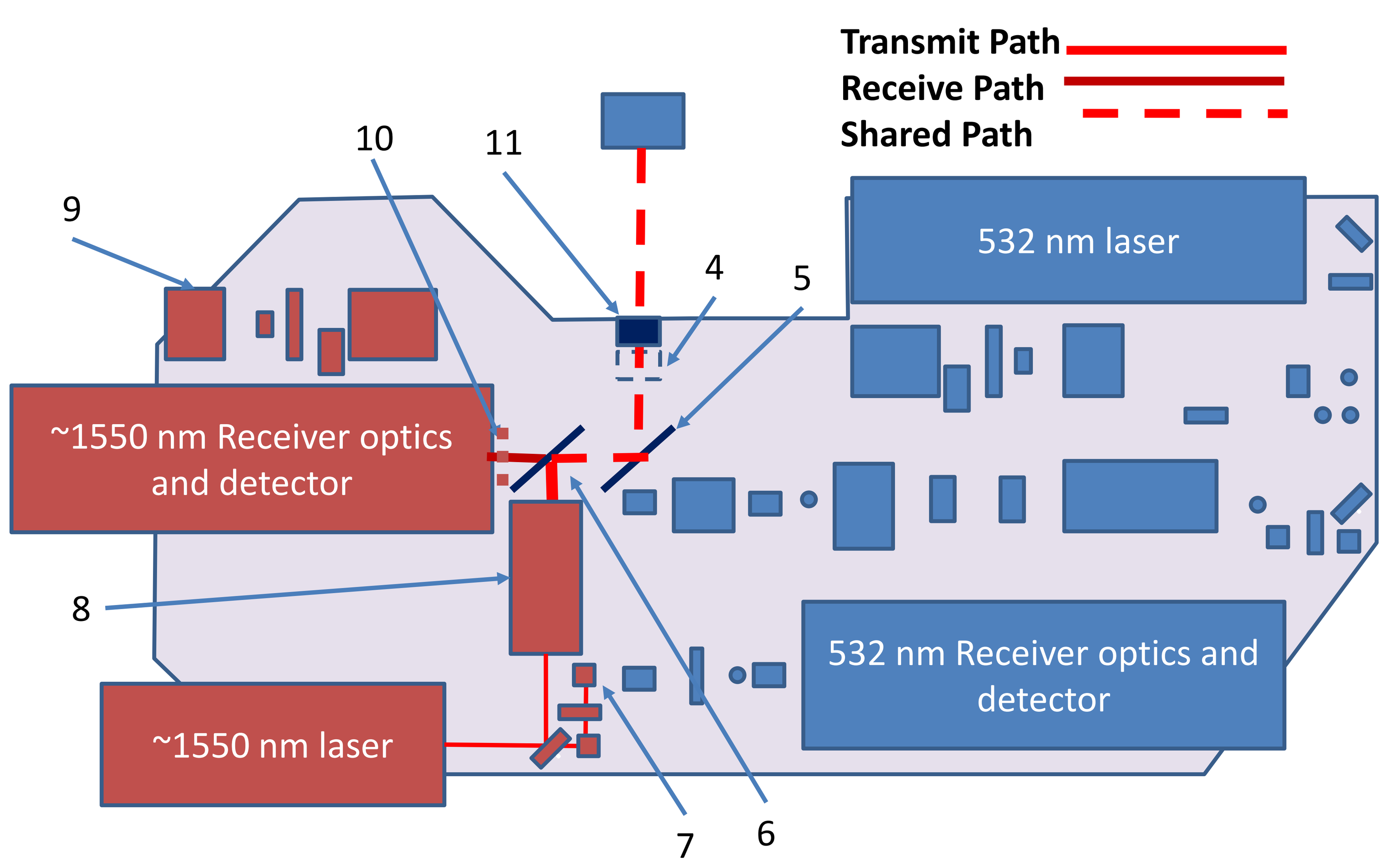

Figure 2: Debris tracking components on NGSLR optical bench. Components in blue 532 nm, red 1550 nm and black are components that need to be added/removed to swap operation from one wavelength to the other.

- 4) The one 532 nm optic that needs to be removed for 1550 nm operation the alignment mirror
- 5) 1550 nm injection mirror
- 6) 1550 nm transmission mirror (see discussion section)
- 7) ~1550 nm diode to monitor outgoing laser power
- 8) 1550 nm Beam Expander (x10 fixed)
- 9) Camera for alignment of laser to telescope
- 10) Beam chopper for stray light suppression
- 11) Removable mirror, installed for alignment of the 1550 nm laser, removed for operation.

References:

[1] **Tracking orbital debris in a busy airspace environment (3115).** M. Shappirio et al., 2014 ILRS conference proceedings

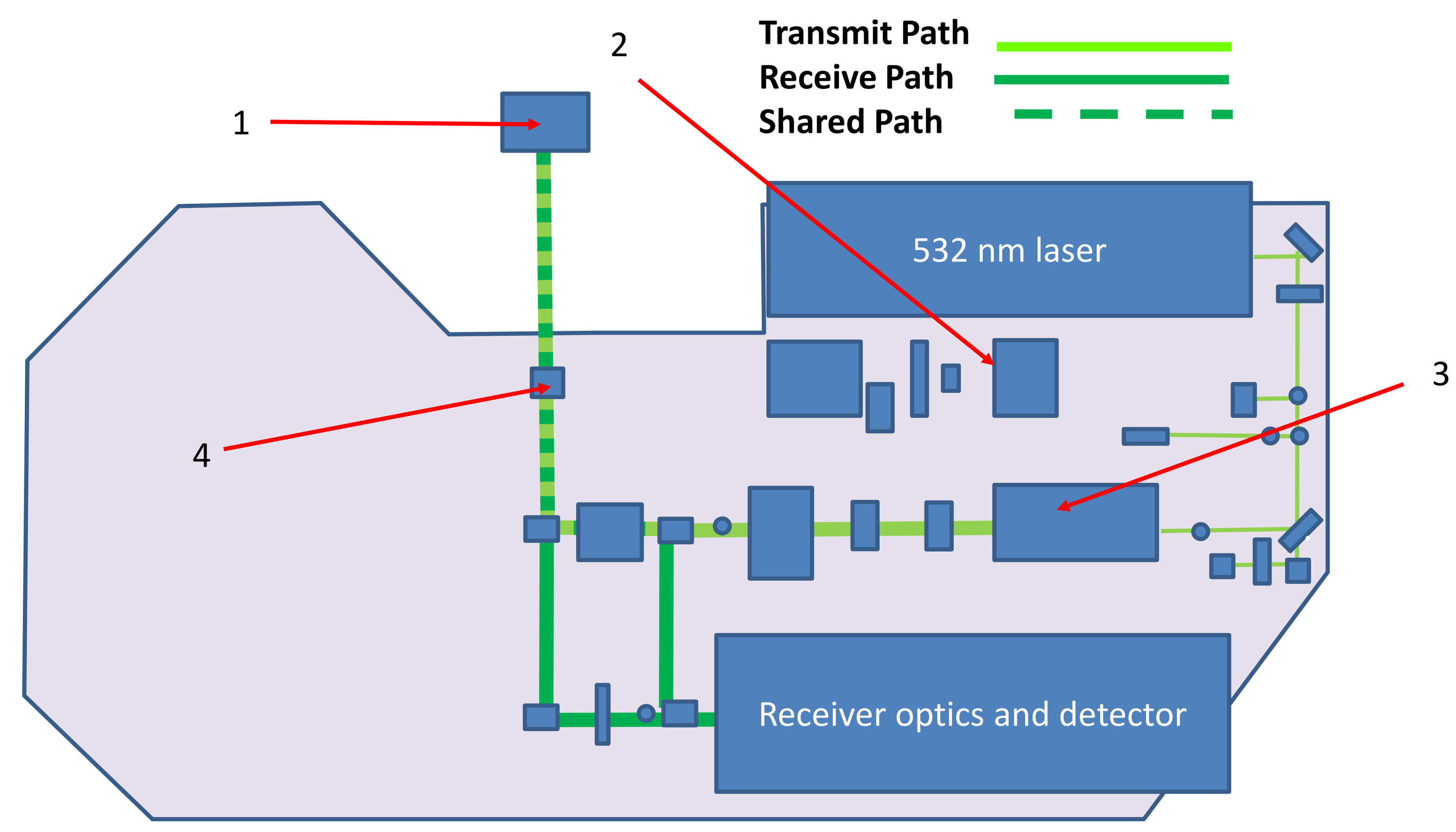

Figure 1: NGSLR optical bench [2]

- 1) Mirror at base of Coude path
- 2) Camera for alignment of laser to telescope
- 3) Removable mirror, installed for alignment, removed for operation
- 4) Variable power Beam Expander

Discussion

- Three optics need to be removable without re-alignment when replaced,
  - the 1550 nm injection mirror,
  - the optic splitting the 532 nm signal for alignment
  - the optic splitting the 1550 nm signal for alignment
- The 1550 nm beam expander might need to have the ability to be adjusted
- The 1550 nm side is an aperture share setup
- The 1550 nm transmission mirror in this design is mostly a transmission optic with a small mirrored section (aperture sharing)
- Due to shared paths for the transmission and receive the detector should be gated to protect from backscatter light from the transmission
- Detector may also require chopper wheel for additional stray light reduction
- The 1550 nm laser might be large enough that placement on the optical bench is impracticable, could use a fiber to couple the laser to the bench
- Parts or all of the 1550 nm optical bench could be placed above the 532 nm optical bench

Additional considerations

-Telescope optics, particularly the Coude path mirrors, need to be able to handle high power laser pulses in the 1550 nm wavelength
-The optical bench should be designed to be as modular as possible to facilitate installation into different systems