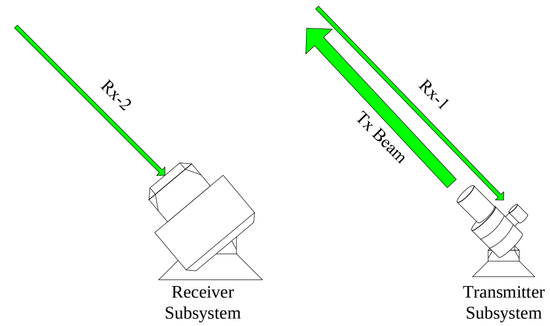
LLR System Design with Separate Transmit and Receive Telescopes



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Outlines

Our Goal

Similar Double-Head LR Systems

The Design of Major Subsystems

Calibration Methods

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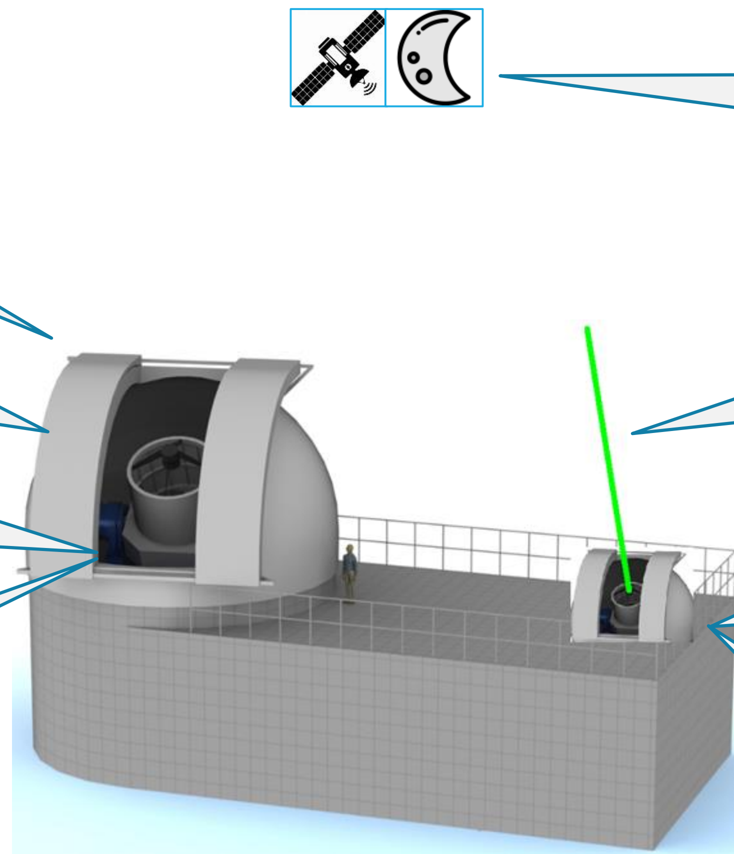
Summary

Our Goal is this



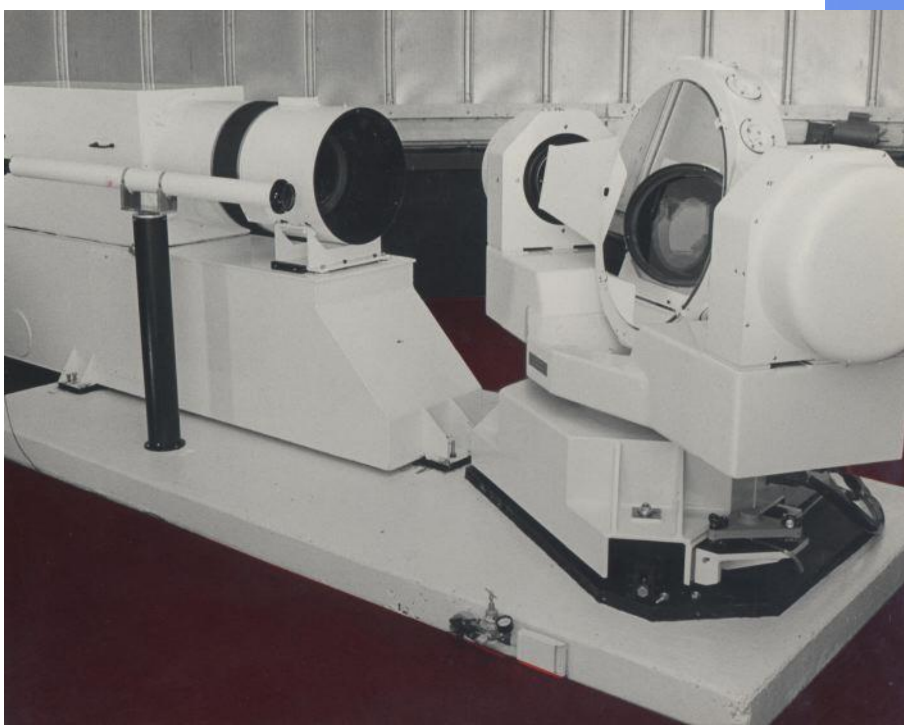
Similar Double-Head LR Systems

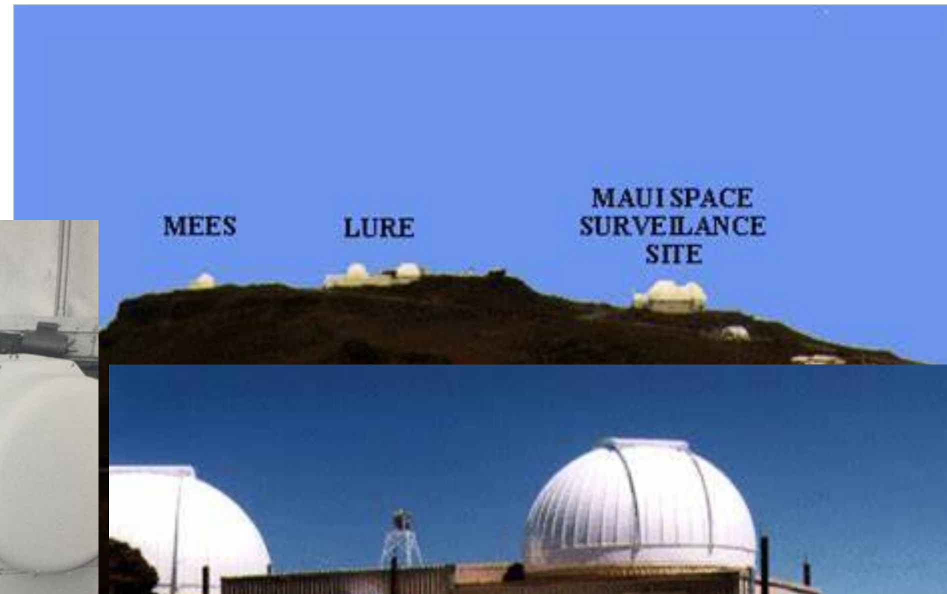
The DiGOS system:

https://digos.eu/satellite-laser-ranging/

Similar Double-Head LR Systems

The Hawaii LURE system:



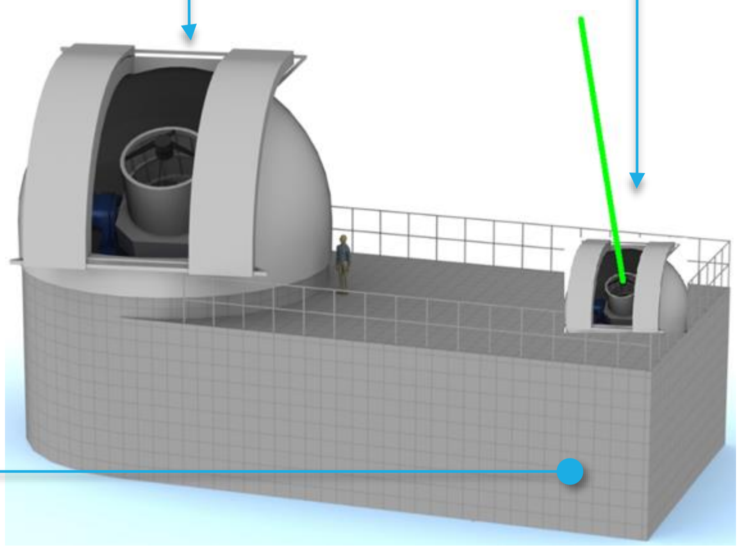


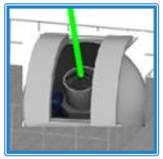
http://kopiko.ifa.hawaii.edu/Lure/

Design of Major Subsystems

Our system design can be divided to three major subsystems:

- Transmitter
- Receiver
- Laser





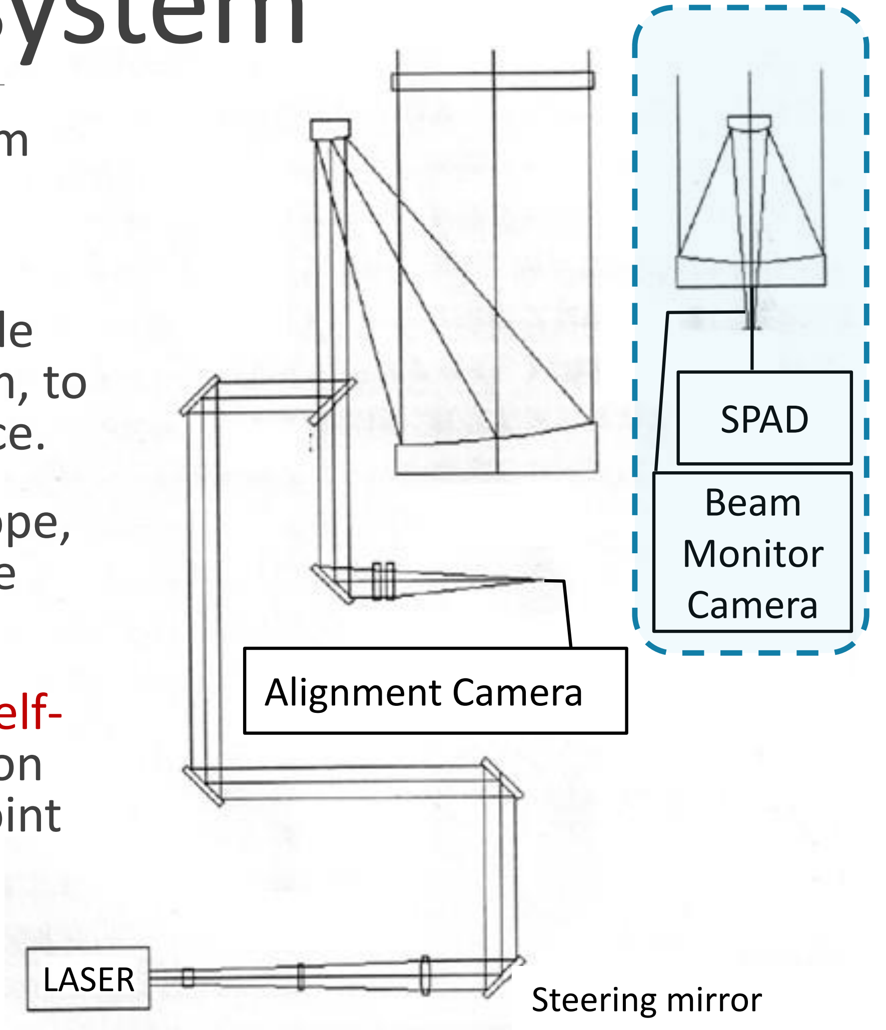
Transmitter Subsystem

The transmitter is designed to be ~60cm off-axis reflective beam expander, with Coudé path to connect to laser room.

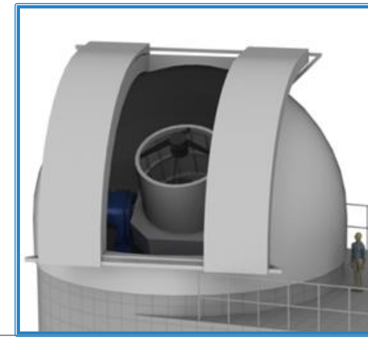
The off-axis design can keep laser profile near diffraction limit, or Gaussian beam, to reduce the speckle size on moon surface.

The piggy-back ~30cm reflector telescope, to carry single photon detector package and beam monitor camera.

The transmitter subsystem should be self-sufficient in tracking LAGEOS. Its rotation fixed point represents the reference point of the whole station.



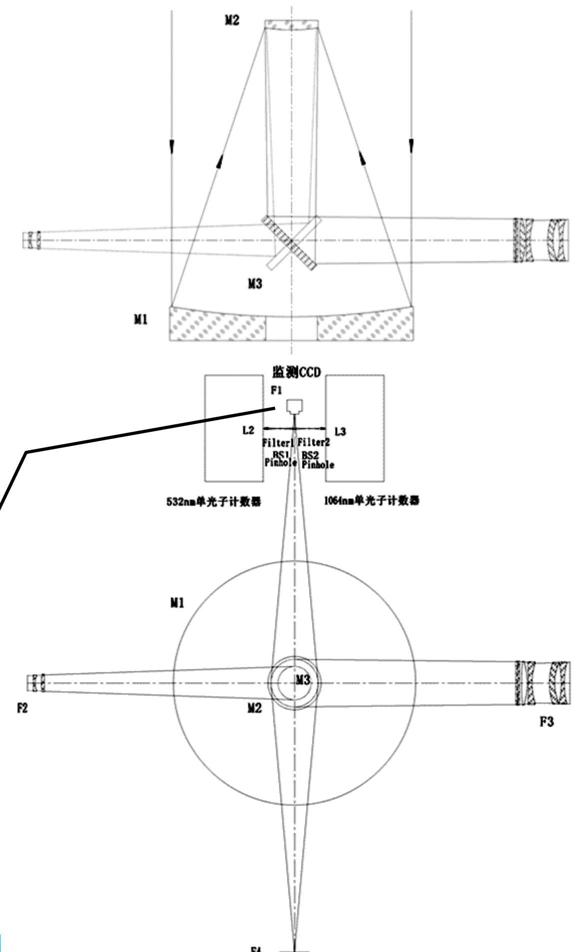
Receiver Subsystem



The receiver subsystem should be a general-purpose R-C reflector telescope, with multiple Nasmyth foci, selected by rotable tertiary mirror M3.

The ranging terminal will contain 1064 and 532 detector packages and alignment camera. They are connected by beam-splitters.

In moonless nights, the receiver subsystem should perform astronomy tasks on its own.



Laser Subsystem

The laser subsystem should contain an Nd:YAG laser.

We hope the laser should work in both 532nm and 1064nm wavelengths. The laser should output 20mJ pulses in 1kHz repetition rate. Pulse duration should not exceed 100ps.

Wave length	532nm / 1064nm
Repetition	～1 KHz
Max. average laser power	20W
Pulse energy	20mJ
Pulse duration	100ps
Beam quality M^2	< 1.2

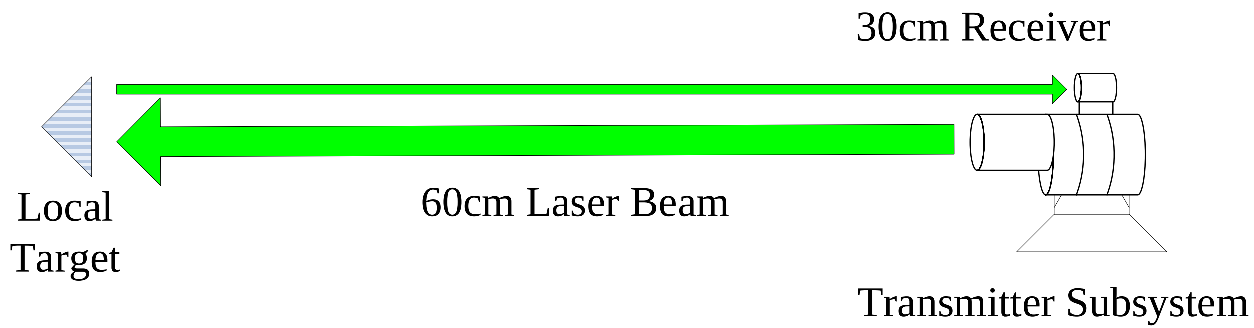
*Model of the laser is not decided yet.

Calibration Methods (I)

We planned several calibration methods.

The first and most important is to calibrate the transmitter subsystem.

It is done by ranging to local target, like normal SLR calibration.

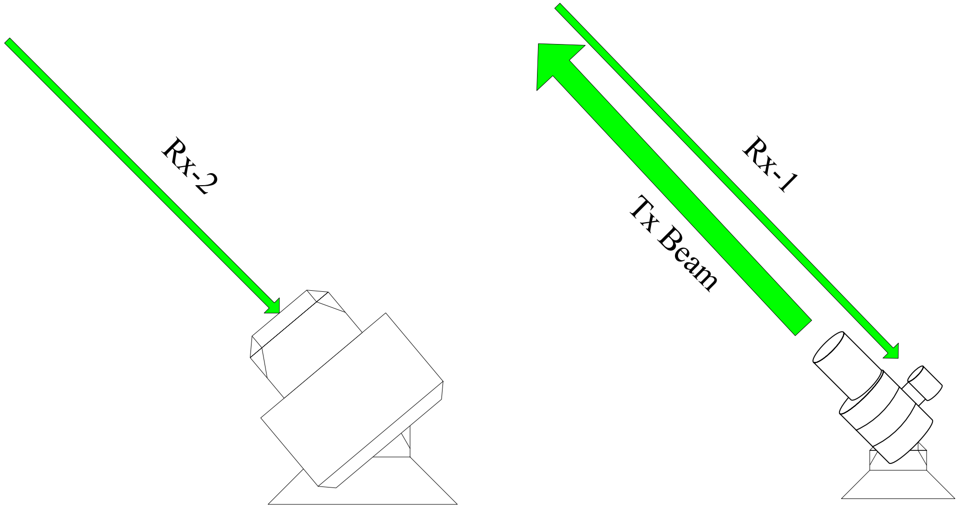


Remote Target

Calibration Methods (II)

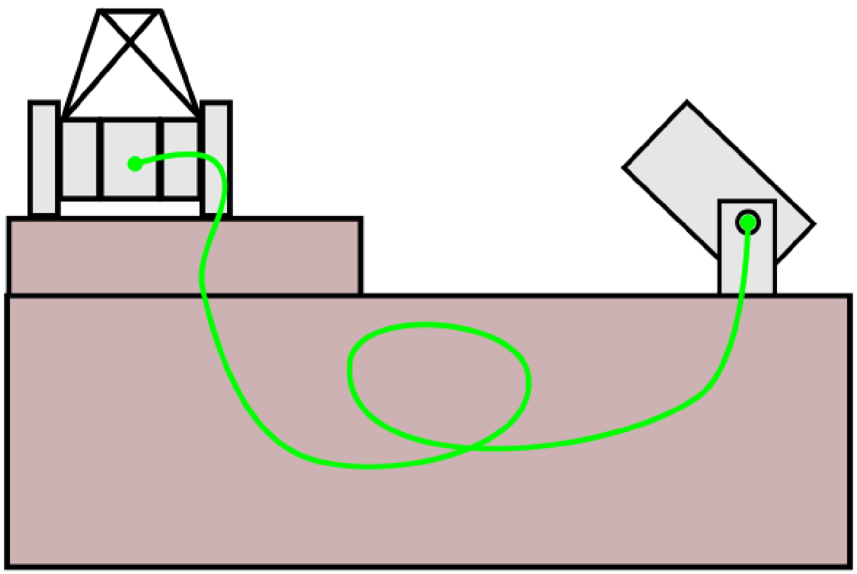
The second way of calibration is ranging to a remote target, preferably the LAGEOS'.

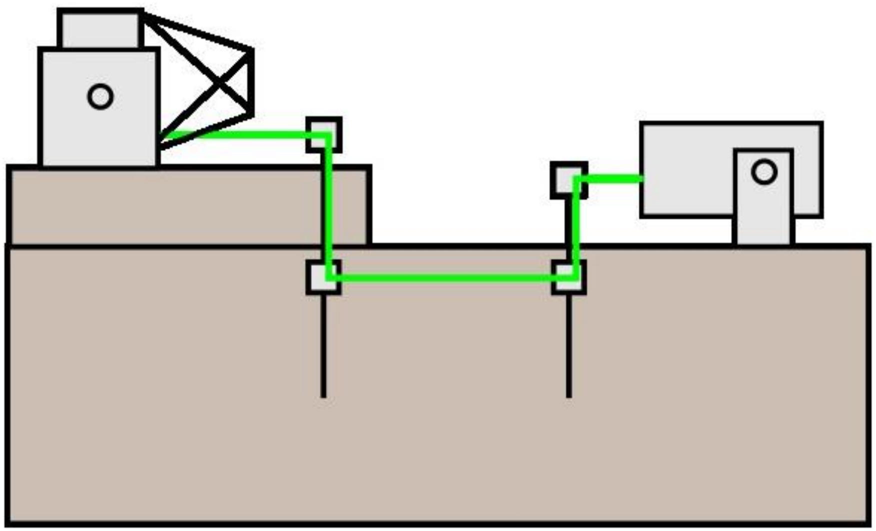
By compensating range difference between T/R subsystems, the T-R system delay can be determined.



Calibration Methods (III)

We also designed alternative local calibration methods. It can be done by optical fiber links, or a series of diagonal mirrors. However, these methods are affected by building deformation and environment temperature.

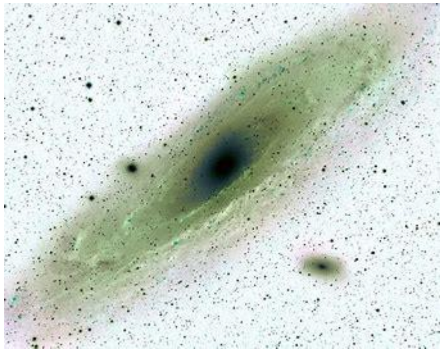


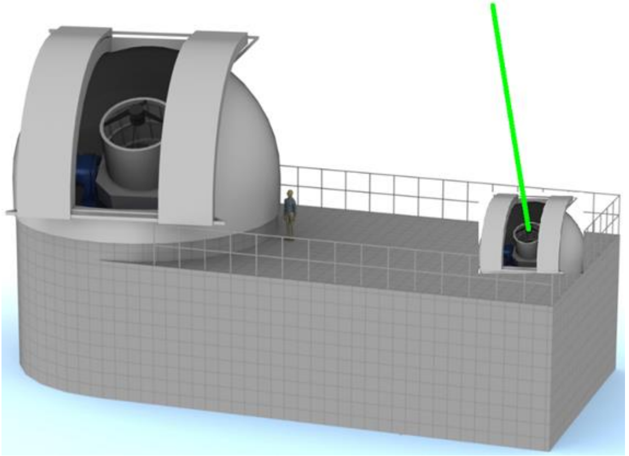


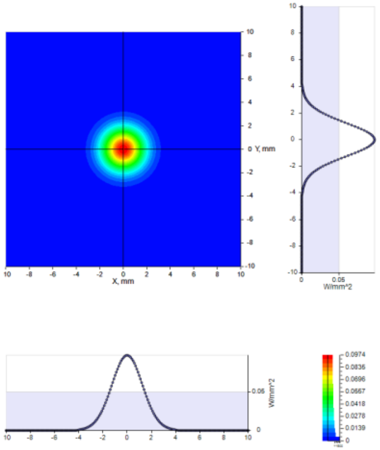
Pros and Cons: Pros

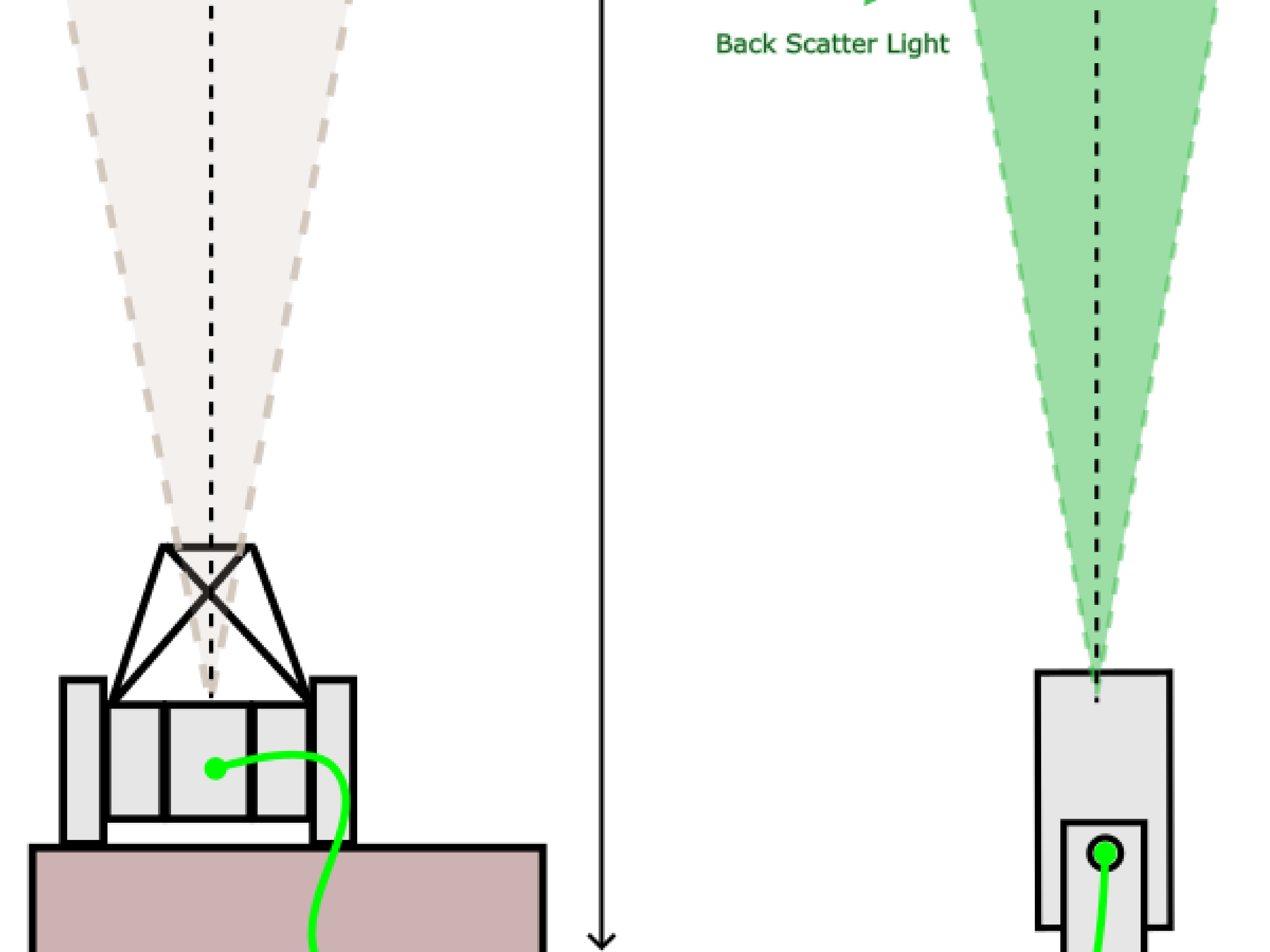
The separate T/R design has advantages:

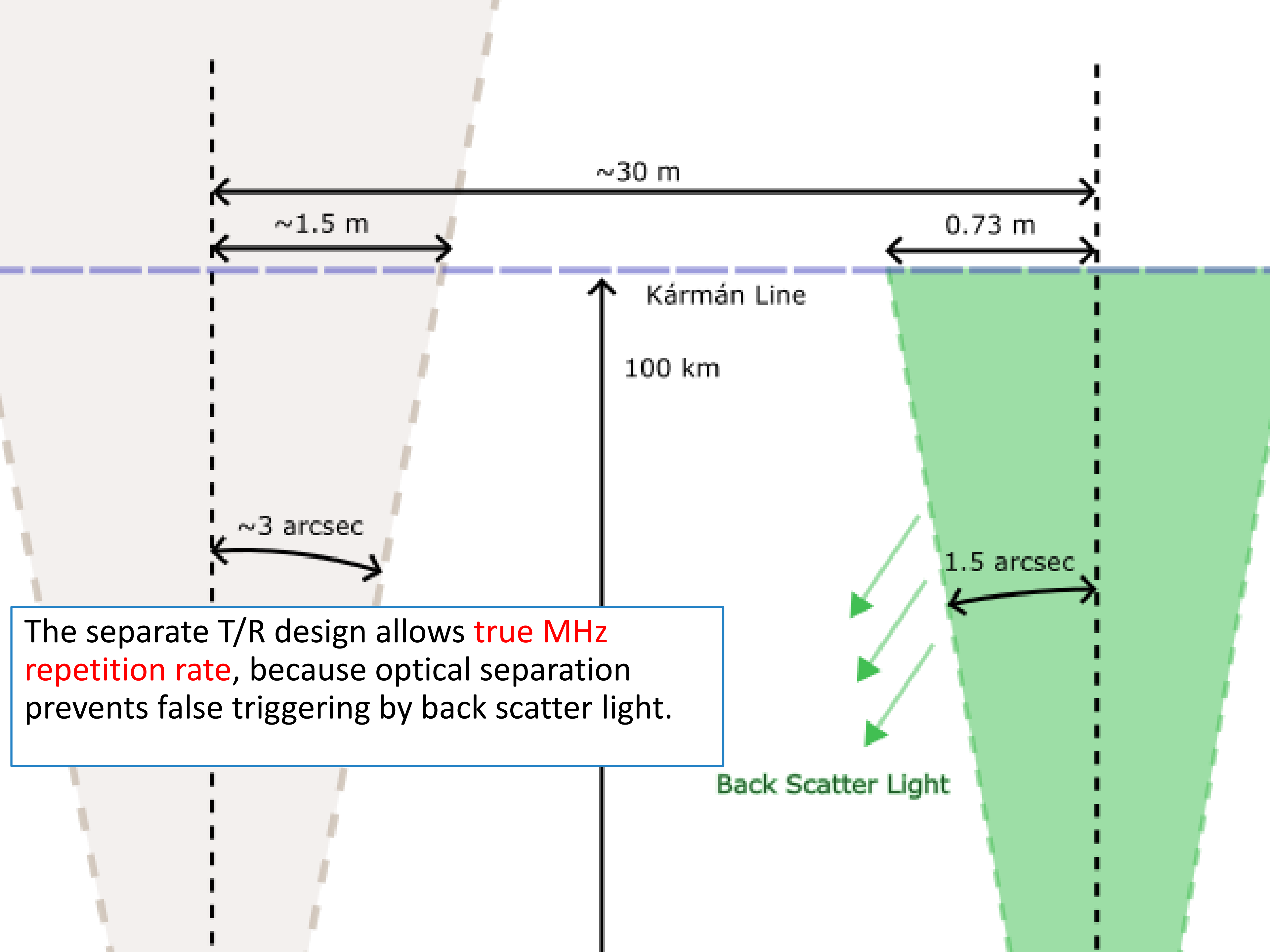
- Off-axis transmit optics keeps integrity of laser profile. Gaussian beam diverges slower.
- Supports arbitrary high repetition rate.
- The bigger telescope can do astronomy tasks in moonless nights.
- The transmit telescope can do SLR on its own, to maintain site coordinates.








Back Scatter Light



The separate T/R design allows true MHz repetition rate, because optical separation prevents false triggering by back scatter light.

Pros and Cons: Pros

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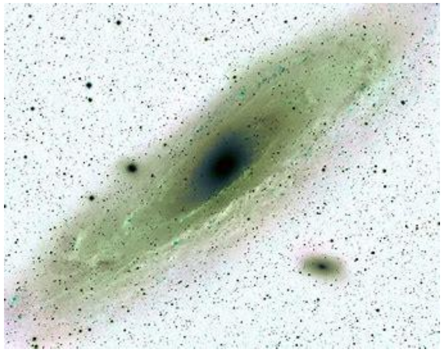
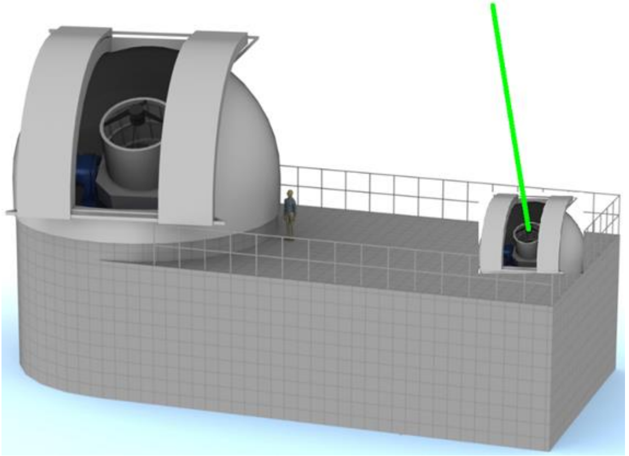
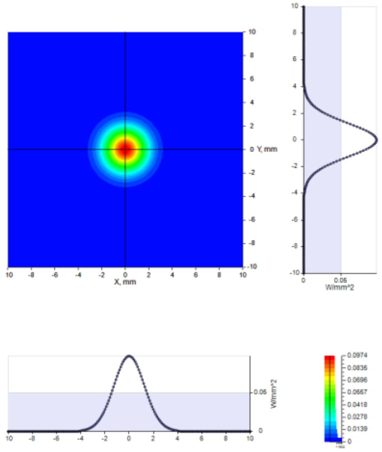


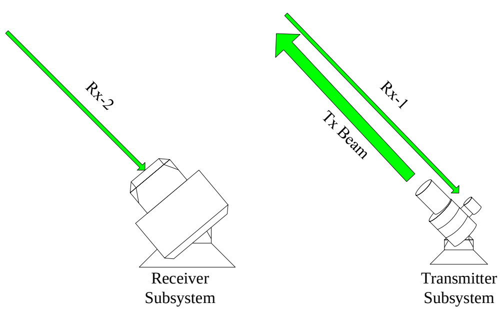


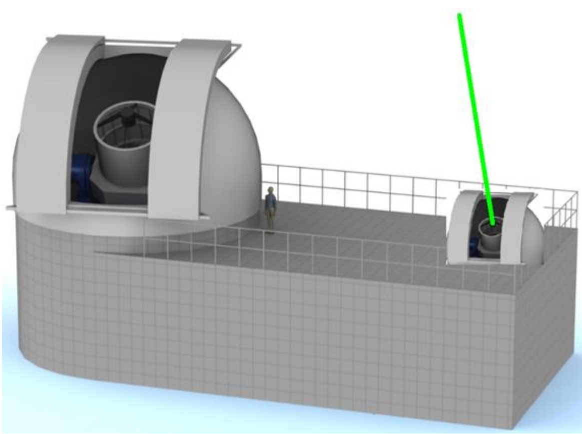


Pros and Cons: Cons

The disadvantages of separate T/R design:

- Transmit and receive alignment is not rigid, but dynamically kept by both mounts. As Comparison, the alignment is rigid in mainstream design.
- There is no equivalent rotation fixed point. Time-of-fly calculation takes extra correction terms, which is related to current point angle.
- Extra mount and longer cables needs more maintenance work.
- …welcome more comments about disadvantages!





Summary

In this talk, we talked about

- A design of an LLR system with dedicated transmitter telescope and a general purpose receiver telescope.
- Introduced design of critical subsystems.
- Introduced several ways of calibration.
- Listed pros and cons.
- Described the possibility to perform true MHz ranging.

Thank you

Gracias

Paldies

Merci

谢谢关注

Danke

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