

# HERA LIDAR INSTRUMENT DEVELOPEMENT

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The AIDA (Asteroid Impact & Deflection Assessment) is a collaboration between NASA DART mission and ESA Hera mission. The aim is to study asteroid deflection through a kinetic collision. For this mission two spacecrafts will be developed DART provided by NASA and HERA provided by ESA. DART spacecraft will collide with Didymoon, while the orbit change is monitored by ground stations. HERA spacecraft will study the post impact scenario. The HERA spacecraft is composed by the main spacecraft and two small CubeSats. HERA will study the asteroid with imaging, Radar, Satellite-to-Satellite Doppler tracking, Lidar, Seismometry and Gravimetry. We report a first iteration on the LIDAR instrument that we called HELENA (HERA LIDAR ENGINEERING MODEL ALTIMETER). HELENA is a TOF altimeter that provides time tagged distances and velocity measurements. The instrument can be used to support near asteroid navigation and provides scientific information (e.g. asteroid 3D topography, fall down velocity).The development of this instrument is done in the frame of an ESA activity. The LIDAR design comprises a microchip laser and a low noise sensor. The synergies between these two technologies enable the development of a compact instrument for range measurements of up to 20 km. We report the LIDAR design, namely, optics, opto-mechanics and electronics.

## Hera mission and LIDAR requirements

HELENA is an TOF altimeter instrument that will measure the distances from HERA spacecraft to asteroid, providing information for a 3D topographic mapping of the asteroid. The key design requirements for HELENA are provided in Table. Most's measure operations will be performed at 14 km to 10 km distances by the end of mission more risky operations will be performed, such as Fly byes or landing operations.

LIDAR specification	Value	LIDAR specification	Value
Range	500m to 14 km (goal=20 km)	Total mass	<2 kg
Accuracy	0.5m (goal 0.1 m)	Power consumption	< 14 W
Repetition rate	10Hz	Receiver FOV	1.5 mrad
Laser Wavelength	1535 nm	Emitter FOV	1 mrad
Op. Temperatures	-40 °C to +60 °C		

## HELENA architecture

The digital interface will be made via USL link over an RS422 physical layer. HELENA main sub-systems are:

- 1- Power Supply Board (PSU): responsible to generate the secondary voltages from the S/C power interface (unregulated 28 V), and also for the Discrete interfaces (HPC, Status and TRP output);
- 2- Backend Electronics (BE): responsible for the instrument control, data acquisition and processing and for the serial interface with the S/C;
- 3- Frontend Electronics (FE): responsible for the Laser power supply and triggering, also for the Laser pulses digitalization;
- 4- Time of Flight (ToF): responsible to timestamp the pulses detected by FE;
- 5- Optical System (OS): the opto-mechanical concept of the unit, made by the Laser Telescope and APD telescope;
- 6- Mechanical Box (MB): the mechanical Box and structure responsible to hold the other sub-units.

The operation modes of the Altimeter are:

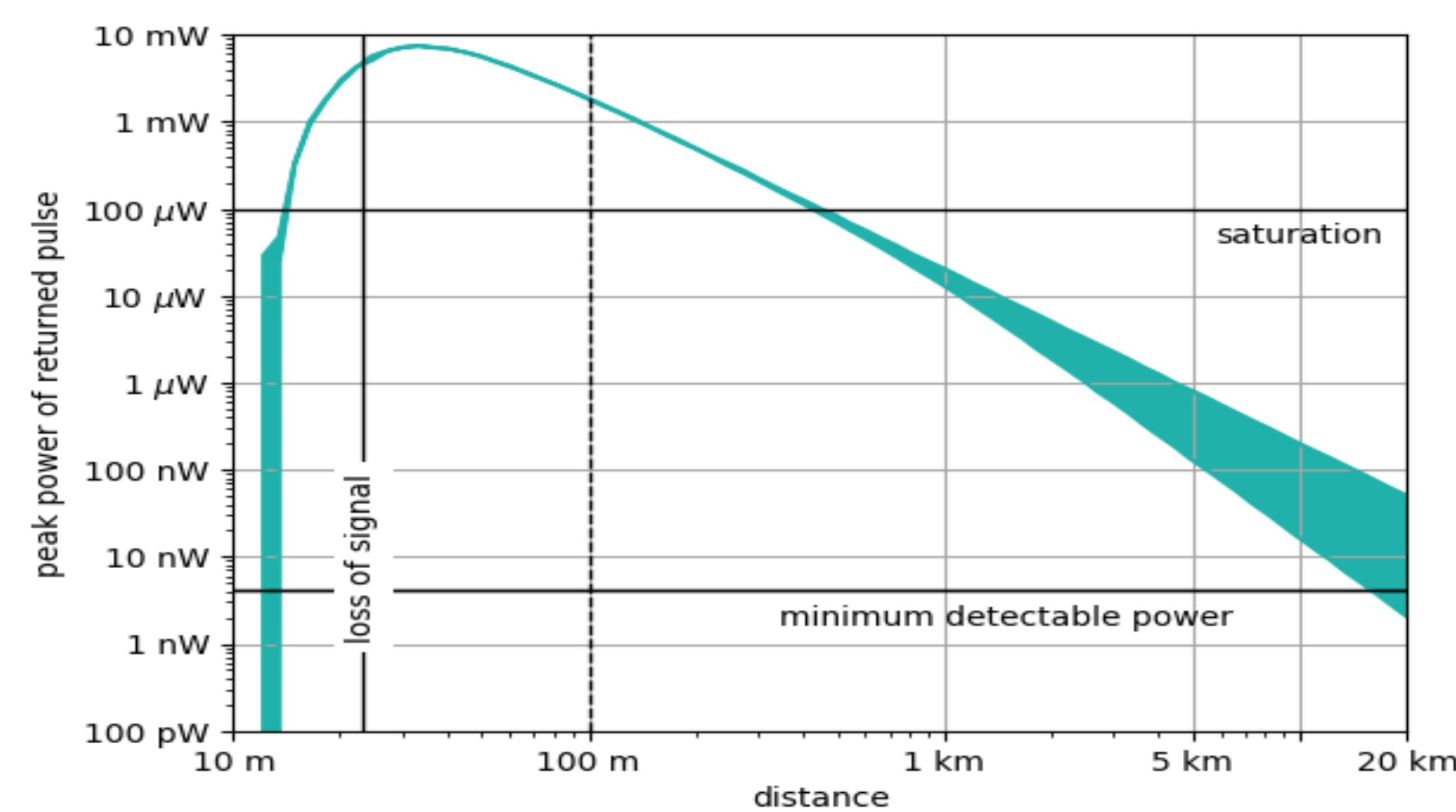
- 1) Start-up – responsible for the initialization of LIDRA controller and circuitry.
- 2) Idle Mode – Only communications and HK functions are running.
- 3) Acquisition Mode – LIDAR is enabled, and lidar is in full operating mode. Acquisitions can be made in BURST or SINGLE Mode; in BURST mode the instrument will output a measurement at a configurable periodicity (maximum 10Hz) In both working modes HELENA, will also periodically send a housekeeping packet with the equipment health information.

## Radiometric calculations

The returned energy is given by:

$$E_r \approx E \times (\text{emitter transmittance}) \times (\text{asteroid reflectance}) \times \frac{\text{telescope area}}{\pi \text{ distance}^2} \times (\text{receiver transmittance}) \times (\text{overlap})$$

ER – Receiver energy; E – Emitted energy; Overlap is a complex geometric formula that takes in account the LASER emitter angle and receiver telescope FOV.

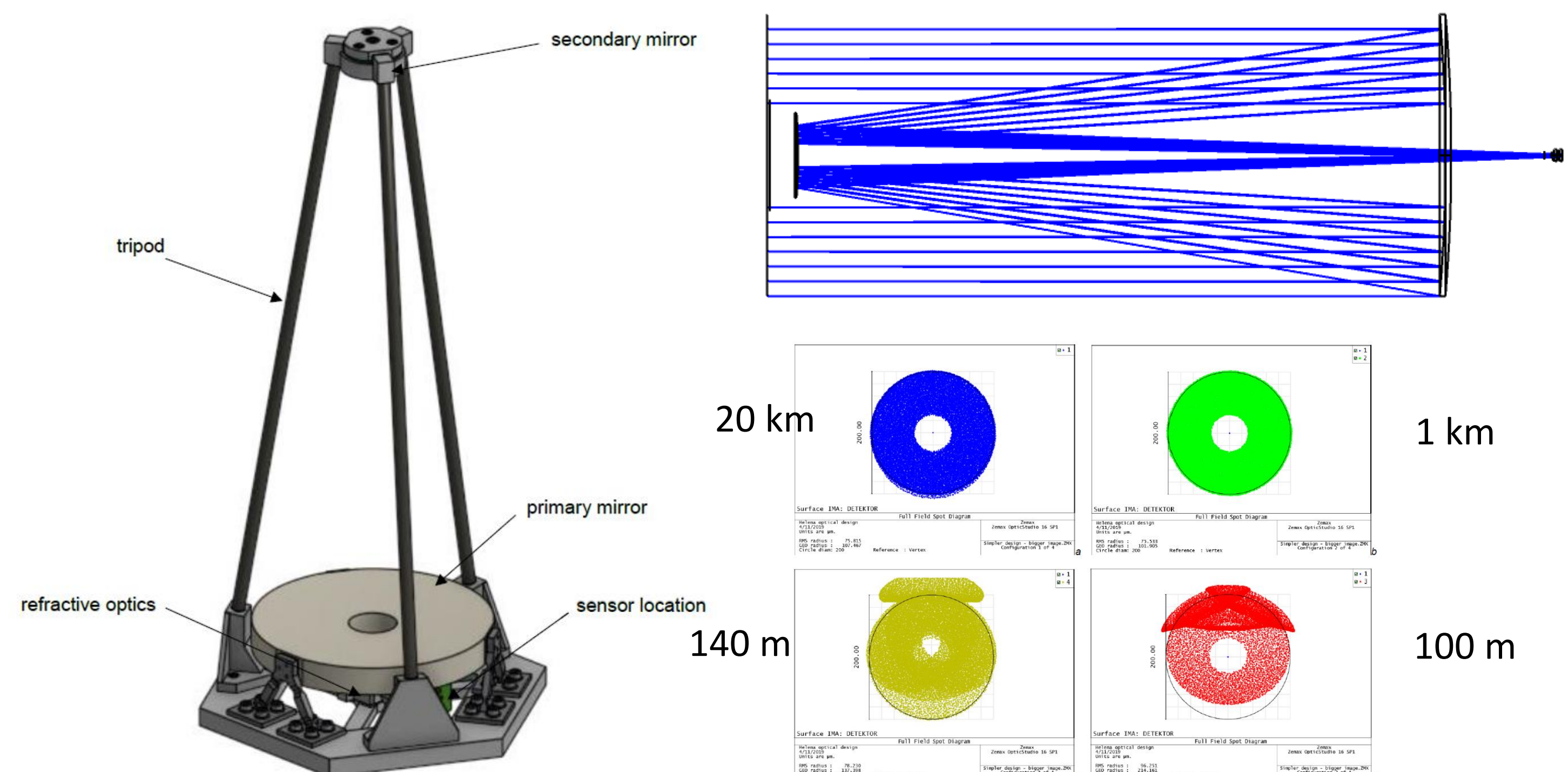


Inputs for the simulations:

Receiver diameter = 100 mm  
Receiver obscuration ( $\phi$ ) = 30 mm  
Sensor @M=20, 1550nm":230\*kV/W  
Transmittance = 0.91  
Laser pulse = 100  $\mu$ s  
Emitter optics transmittance = 0.94  
Asteroid albedo = 0.1  
Filter centre wavelength = 1500 nm  
Filter bandpass = 745 nm

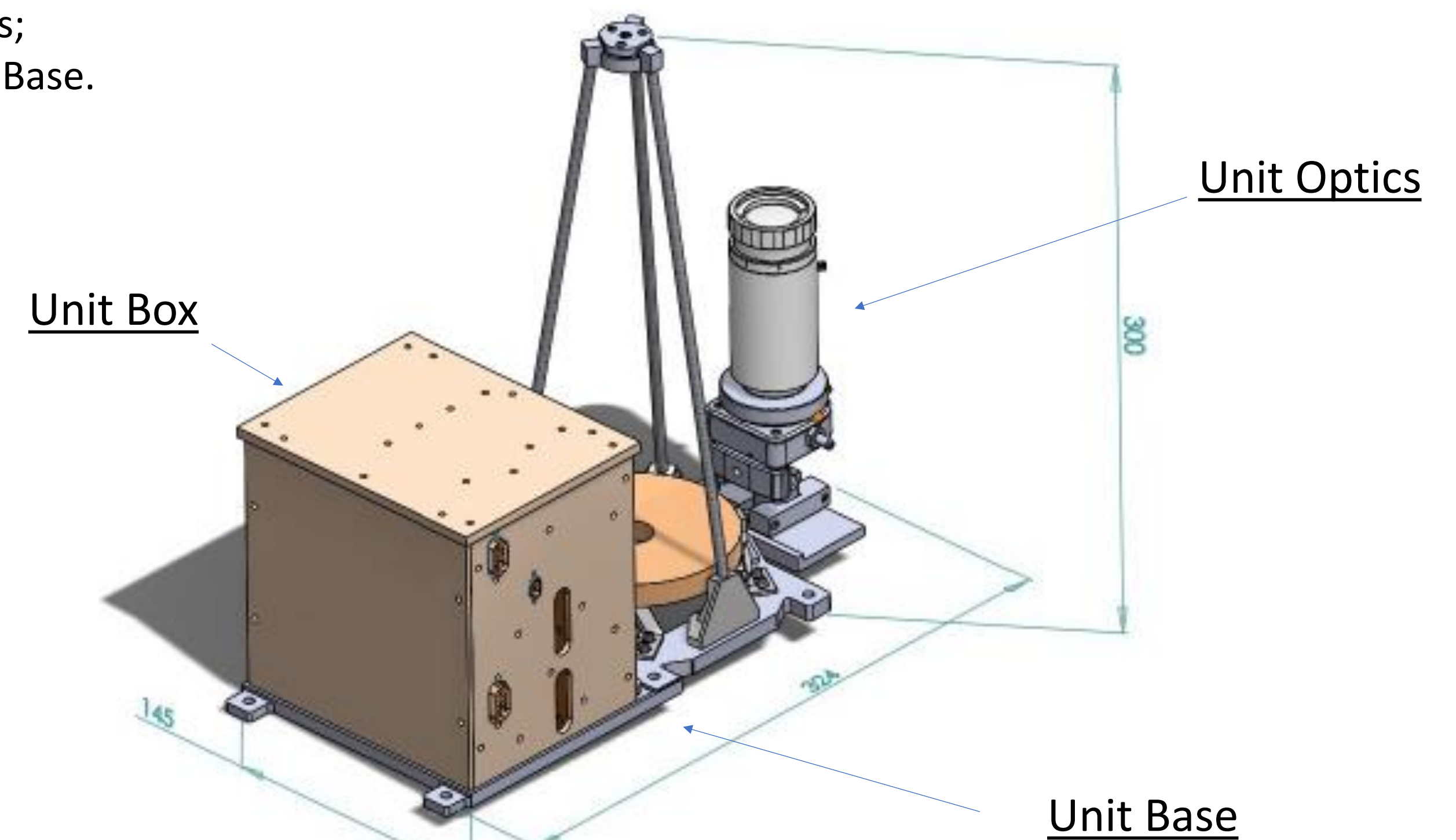
## Optics and mechanics

The most critical component of the optics front end is the receiver telescope. The receiver telescope has an Cassegrain design. The primary mirror is made of zerodur and has 100 mm diameter. The secondary mirror is assembled on a carbon fiber tripod structure. On the left the telescope ray tracing (zemax design) is presented. The footprint (on the sensor) for different operating distances is also presented.



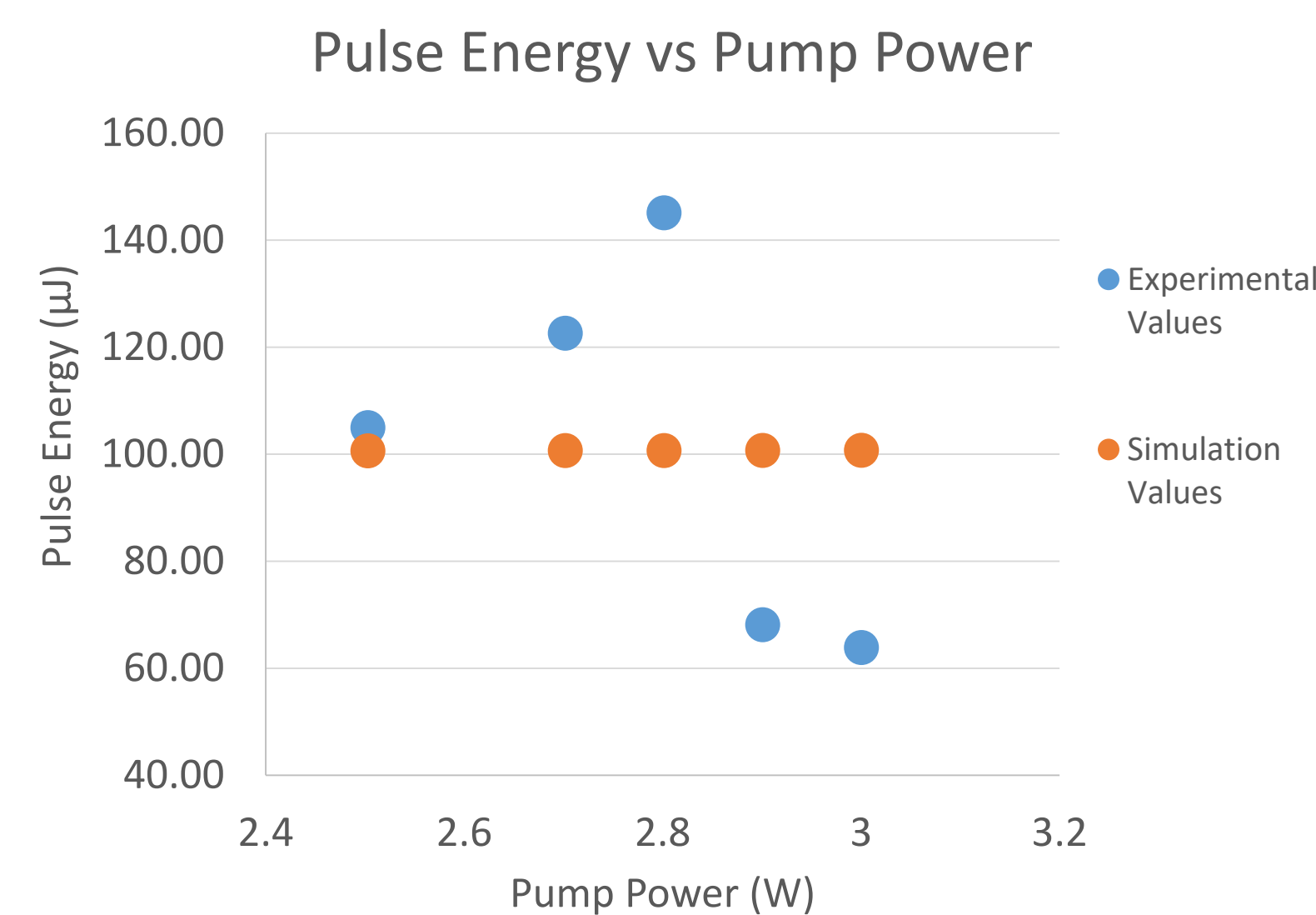
HELENA's full mechanical structure has two main components and a complementary one:

- Unit Box, which houses circuitry, instrument PCBs and the interface between these;
- Unit Optics, composed of an emission source and receiving telescope, composed by a set of mirrors;
- Unit Base.



## Laser unit

The preferred LASER source for HELENA is currently being developed at Faculdade de Ciências da Universidade de Lisboa (FCUL). The laser used as source is a diode pumped, passively Q-switched Yb-Er Microchip Laser targeting a 100  $\mu$ J pulse with a full-width half-maximum (FWHM) of 2 ns. A first prototype with lower pulse energy has been integrated, and is now under test.



Pulsed microchip laser results (during breadboarding).

First prototype.