EYESAFE LADAR for Autonomous Special Vehicles and for Robotic

ARIEL Photonics Assembly, Ltd.

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Summary

Roadmap of ARIEL includes development, manufacturing, demonstration and sell of a high end LADAR for autonomous vehicles for demanding applications.

- We have developed and demonstrated operational key components:
  - Fiber Laser,
  - Laser Receiver,
  - Transceiver Optical module, and
  - Ranging
- We have solid design for manufacturing of pilot unit
- We need ~ 1.5 years to complete full scale development (with all DRs), including manufacturing of few pilot units, integration with platform, field tests.

Market

LADAR's market is not limited by civil cars only.

There are special demanding applications for high end LADARS

- Large expensive autonomous cars for Defense and for Home Land Security
- Transportation in dangerous / hostile environment
- Transportation of dangerous / expensive materials and equipment
- Borders control, Police, Convoys
- Heavy tracks, Mining, Forest control / management, Forest road navigation
- Large vehicles for transportation, Large buses
- Support for ships navigation (by rivers / channels)

Market Continued

Those applications require more that the existing LADARs can provide

- Better Accuracy
- Higher Speed
- Longer Range
- Safety
- Agility
- Special functions
- Harsh environment
- Durability

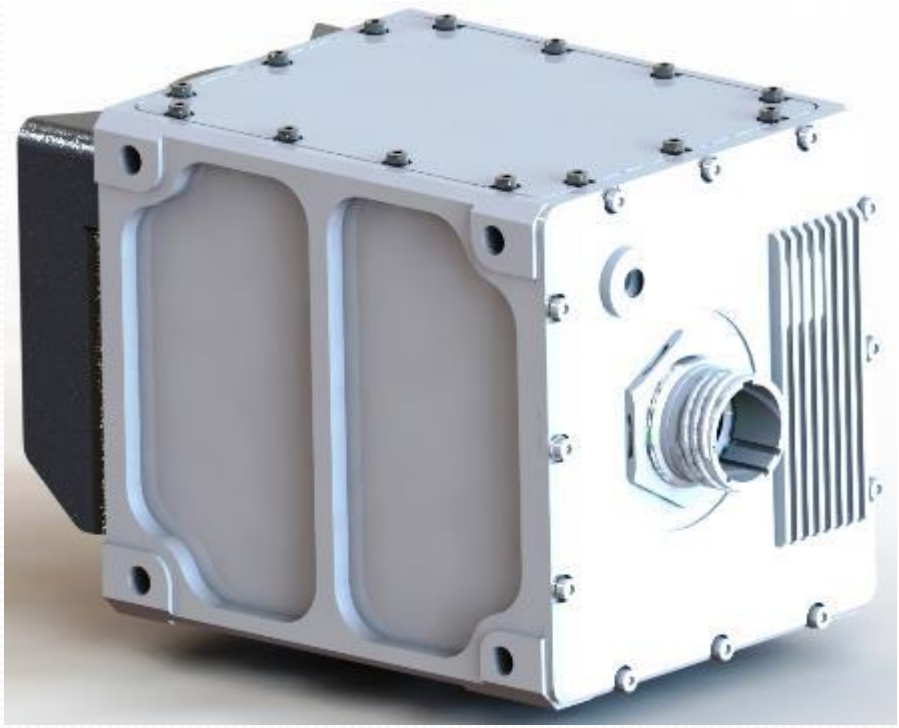
Approach

We are developing a ladar that is capable to allocate its data collection and processing capabilities to the region of interest, and to provide situation awareness by allocating a fraction of capabilities (via time sharing) to collect and process data from around the vehicles.

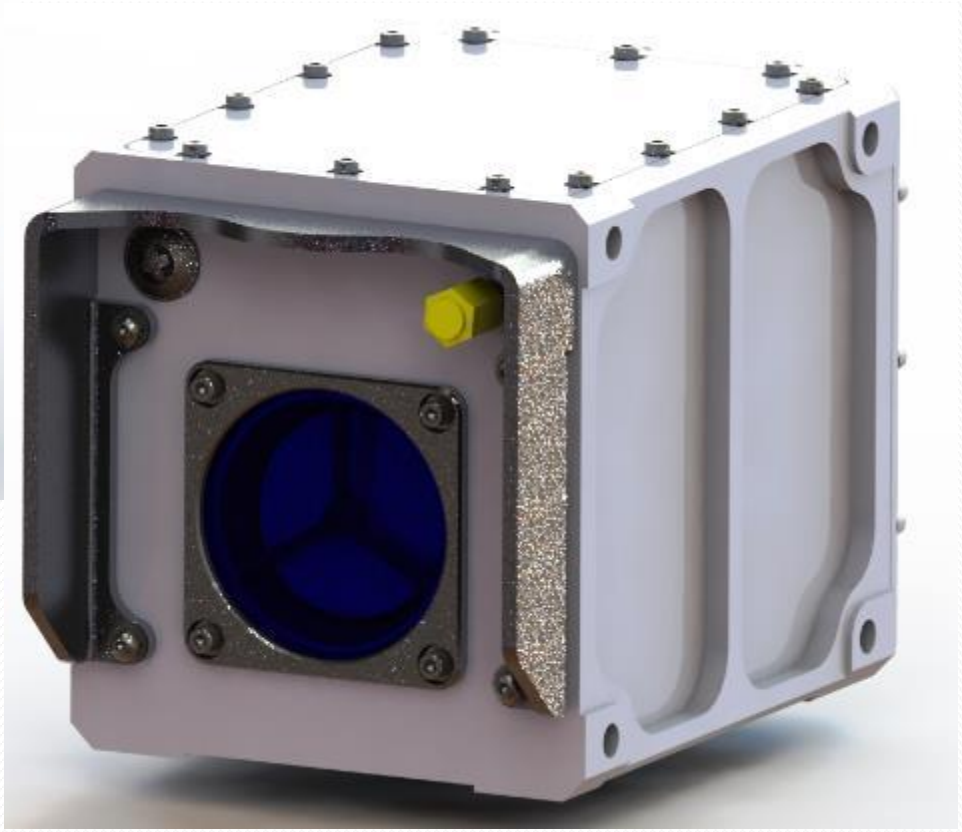
This is insured by continuous adjusting of Field of regard (FOR), Field of View (FOV) and Line of sight (LOS) of LADAR in accordance with current situation, and in accordance with current task.

The LADAR is a small robust unit (Volume of 1 Litter), having dimensions of a car head lamp or of a night vision camera.

LADAR Design, External view



BACK



FRONT

Main Features

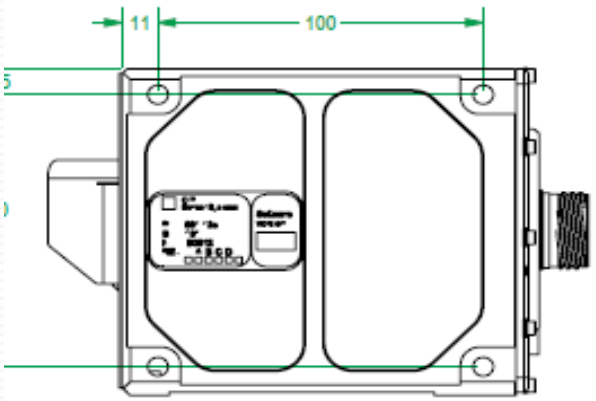
* Eyesafe SWIR Laser LADAR
* Long Range 200m (1km optional)
* High resolution, High scan density
* Ranging Rate 500 KHz (up to 2MHz optional)
* Manufactured for outdoor use
* Ultra Compact

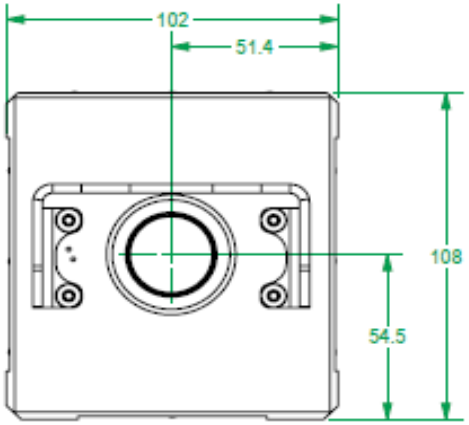
APPLICATIONS

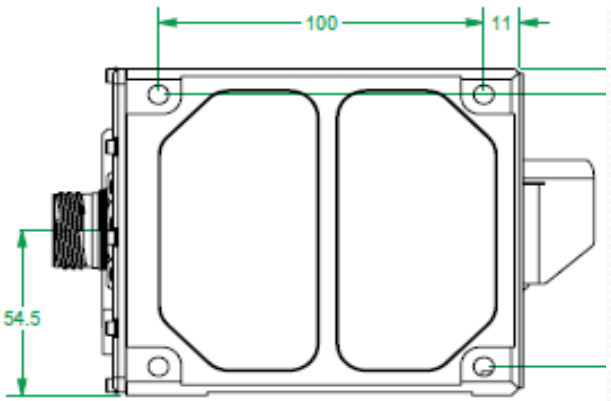
* Autonomous vehicle Navigation
* Traffic Safety
* Robotic
* 3D objects detection and recognition
* 3D Mapping
* 3D Infrared imaging
* 3D live video
* Helicopters / UAV landing at zero visibility

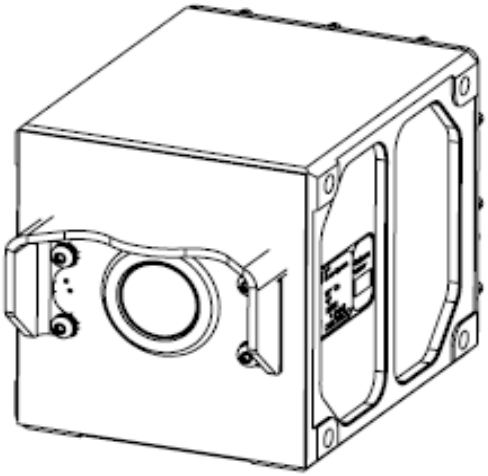
EYESAFE LADAR MAIN PARAMETERS, MODEL: ARLR-SWIR-HR	
Amount of Channels	1
Wavelength, nm	1560
Field of regard (FOR), deg	45
Scan pitch, mrad	1.66@2fps, 2.6@5fps, 3.7@10fps
Scan Resolution, mrad	1
Beam Divergence, mrad	1
Repetition rate, pps	450,000 Programmable
Frame rate, fps (Hz)	10 (2 - 20)
Amount of pixels in a frame	44,500 (222500 - 22250)
Fill factor	0.072
Scan density, 1/mrad^2	0.072
Range, m	200
Range accuracy, m	0.02
Optics Clear Aperture Diameter, mm	40
Peak output power, W	100
Boresight to mechanical interface, mrad	1
Clear Aperture diameter of laser output beam, mm	10
Eye safety class (EN-60825, IEC60825-1)	1M, Eye safe at all ranges for the unaided eye
Operation Voltage MIL 1275, EMI 461F	DC 24 Volts
Power consumption, W	<50
Communication, Controls, Interfaces, Protocols	RS422, Discretes, Lase Enable, System BIT, 100 Mbps Ethernet Laser echo waveform – optional
Operating Temperature Range, °C	-12 to +55
Storage Temperature Range, °C	-40 to +71
Lifetime, Operational, hours	>10000
Calculated MTBF laser, hours	10000 operational, 40000 standby
Environmental sealing for	IP67
Cooling Interface	Passive Cooling
Weight, kg	~ 2
Dimensions, mm NTE (see Figure 1.)	L166 x H108 x W102

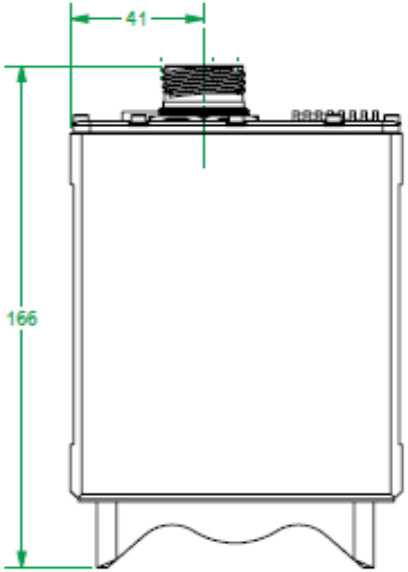
Technical Drawing



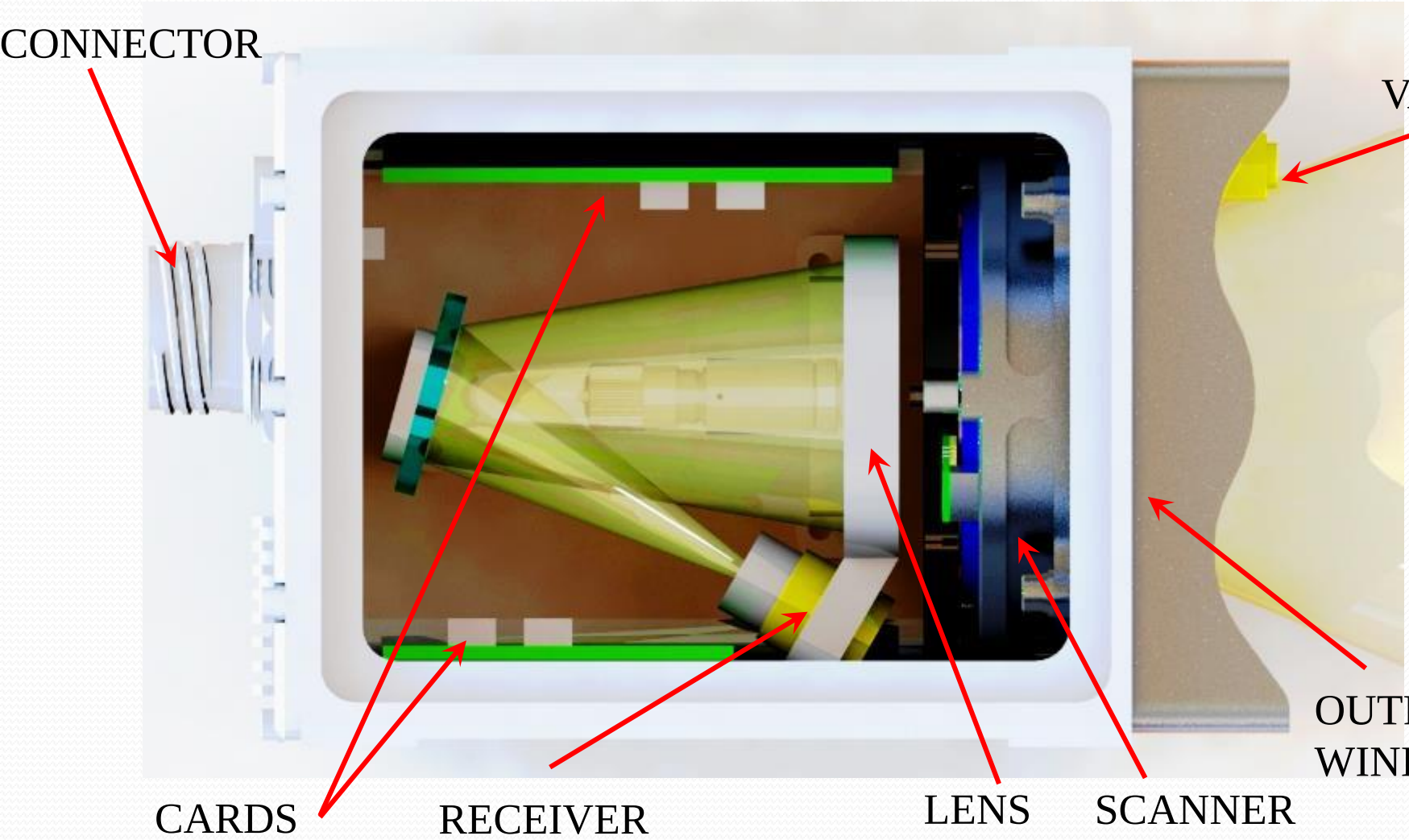




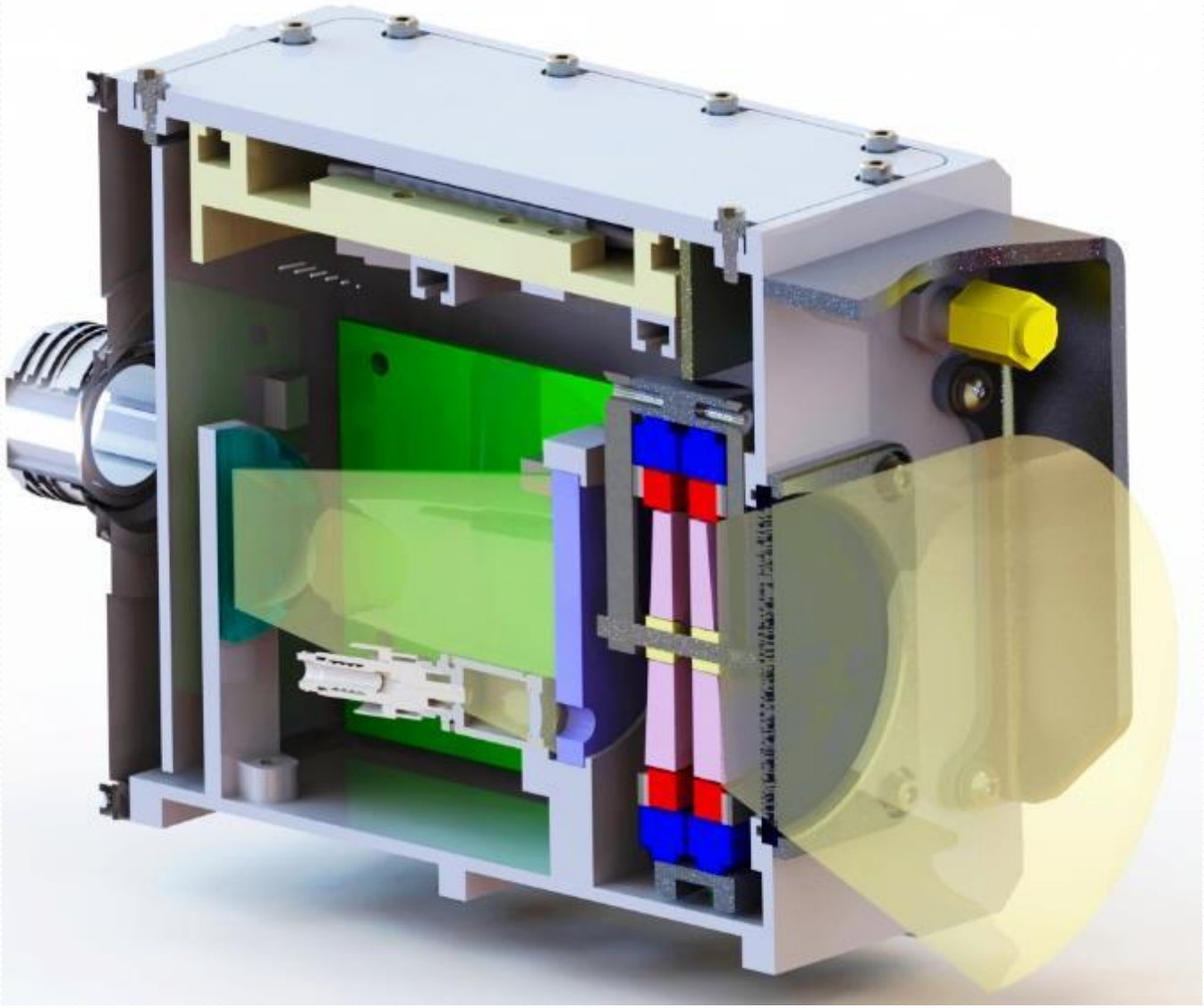




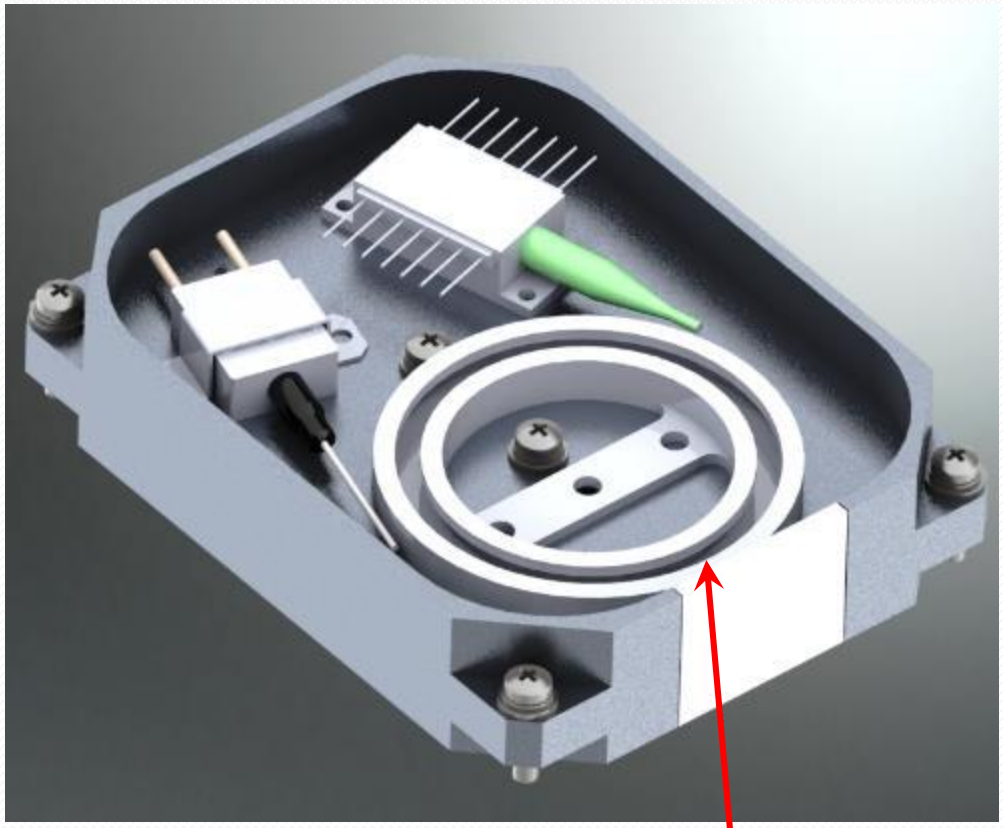
Ladar Design, Cover is open, Top view

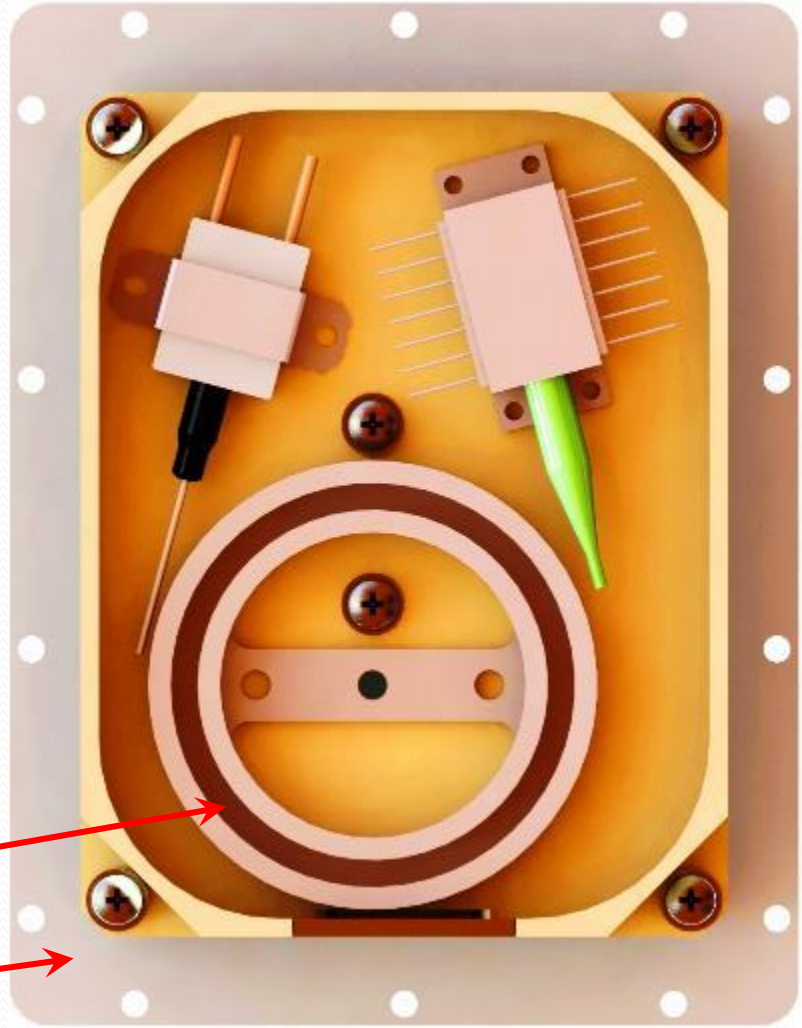


LADAR Design, cross section



Fiber LASER design: E/O SIDE





ACTIVE FIBER COIL

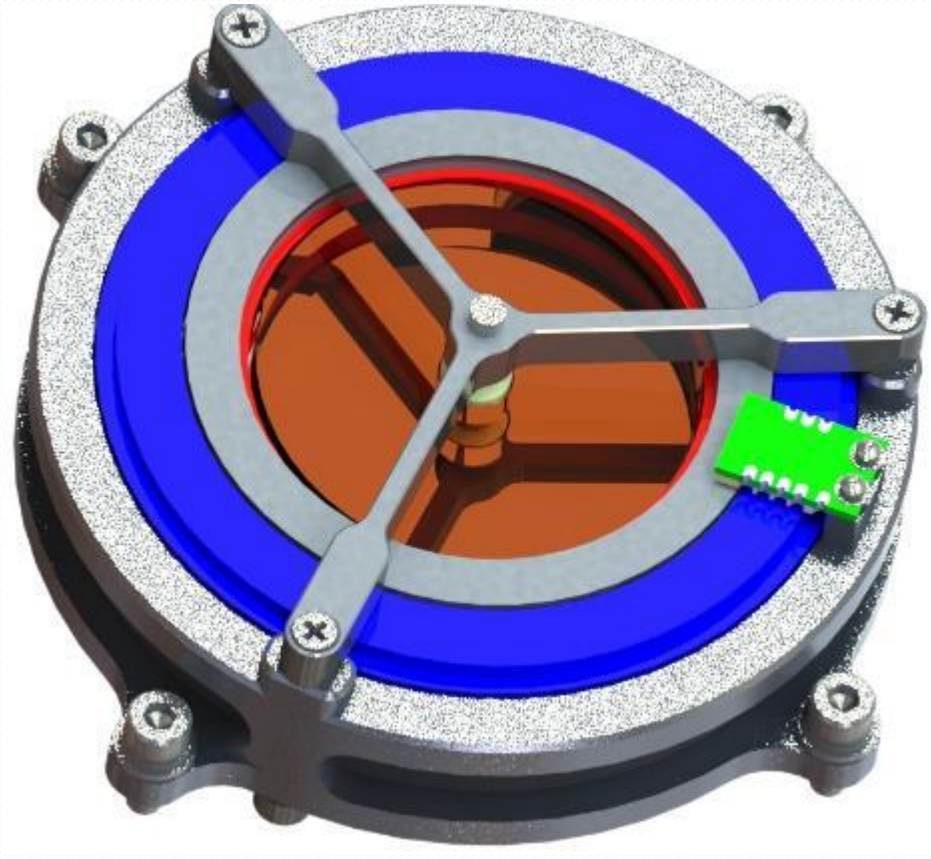
COVER

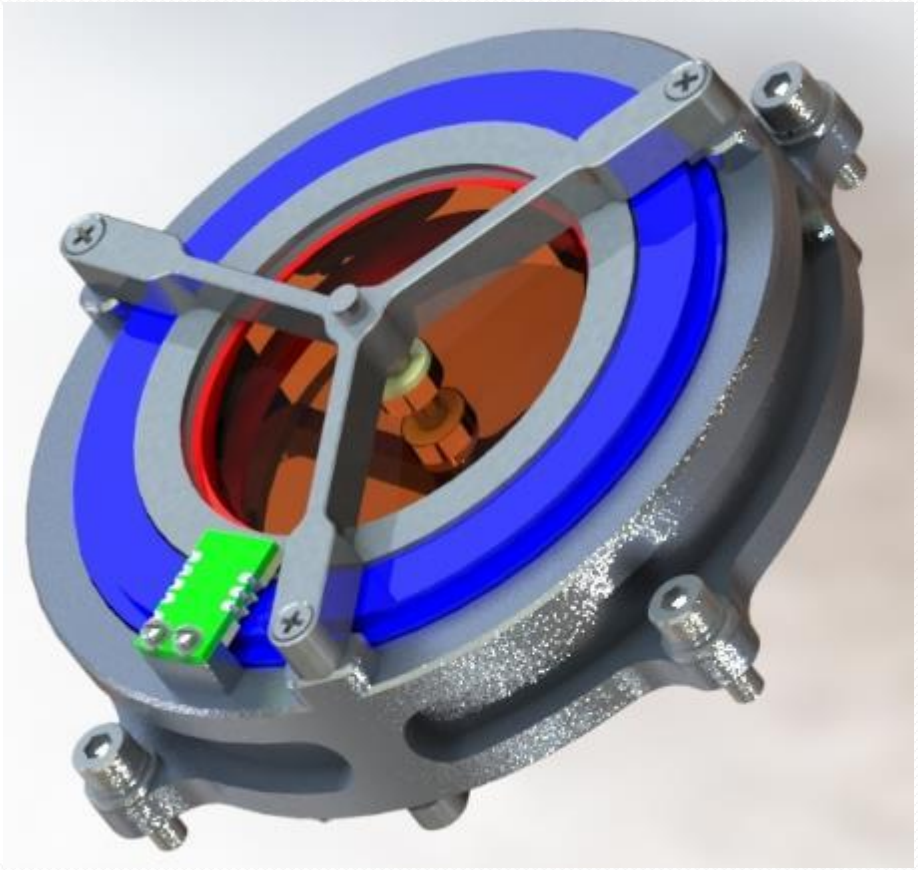
FIBER LASER: COMPONENTS SIDE

The fiber laser dimensions are 80mm x 50mm x 20mm

Scanner

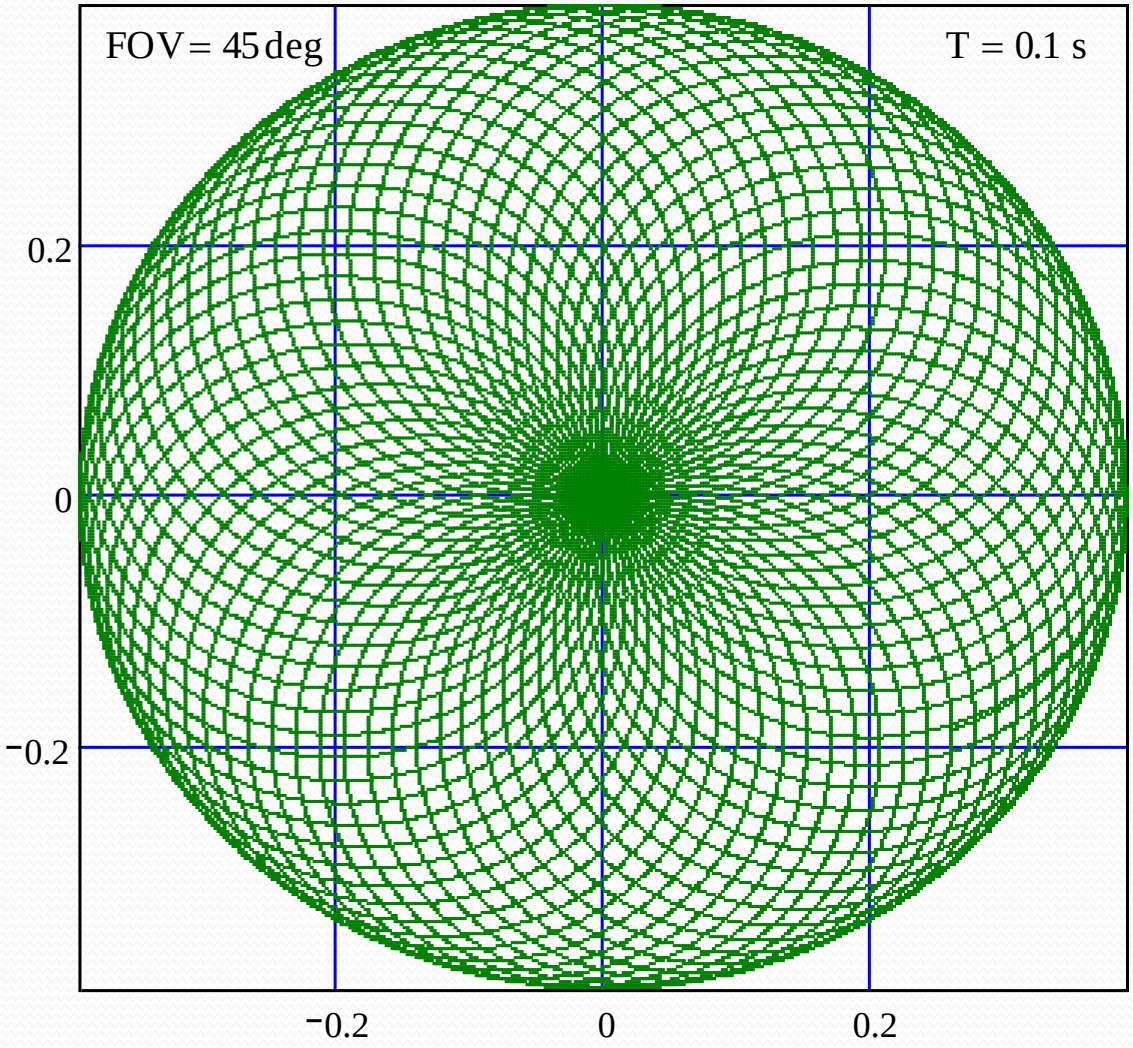
The scanner is based on 2 rotating optical wedges and direct drive motors



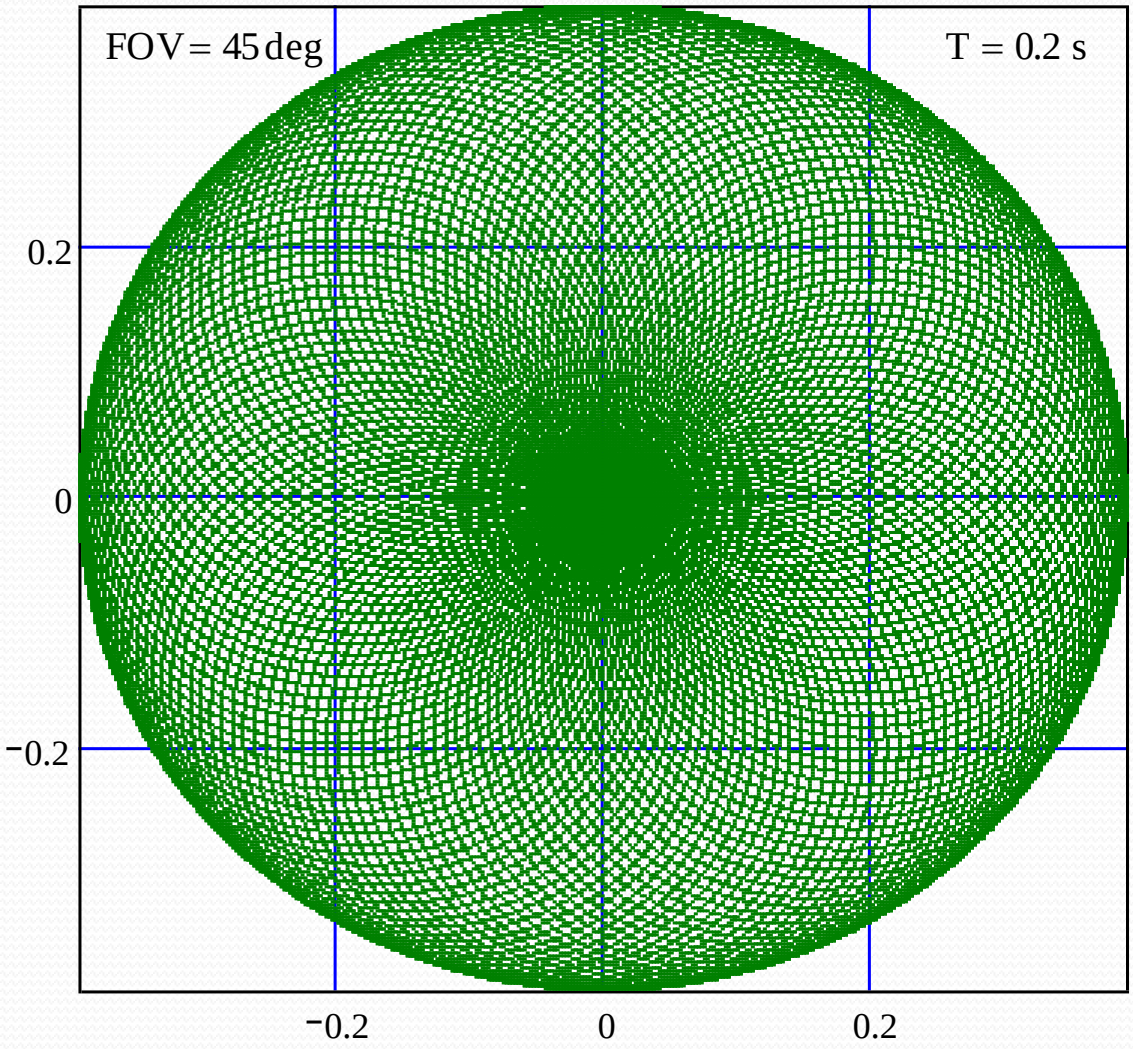


LADAR Exterior and Components

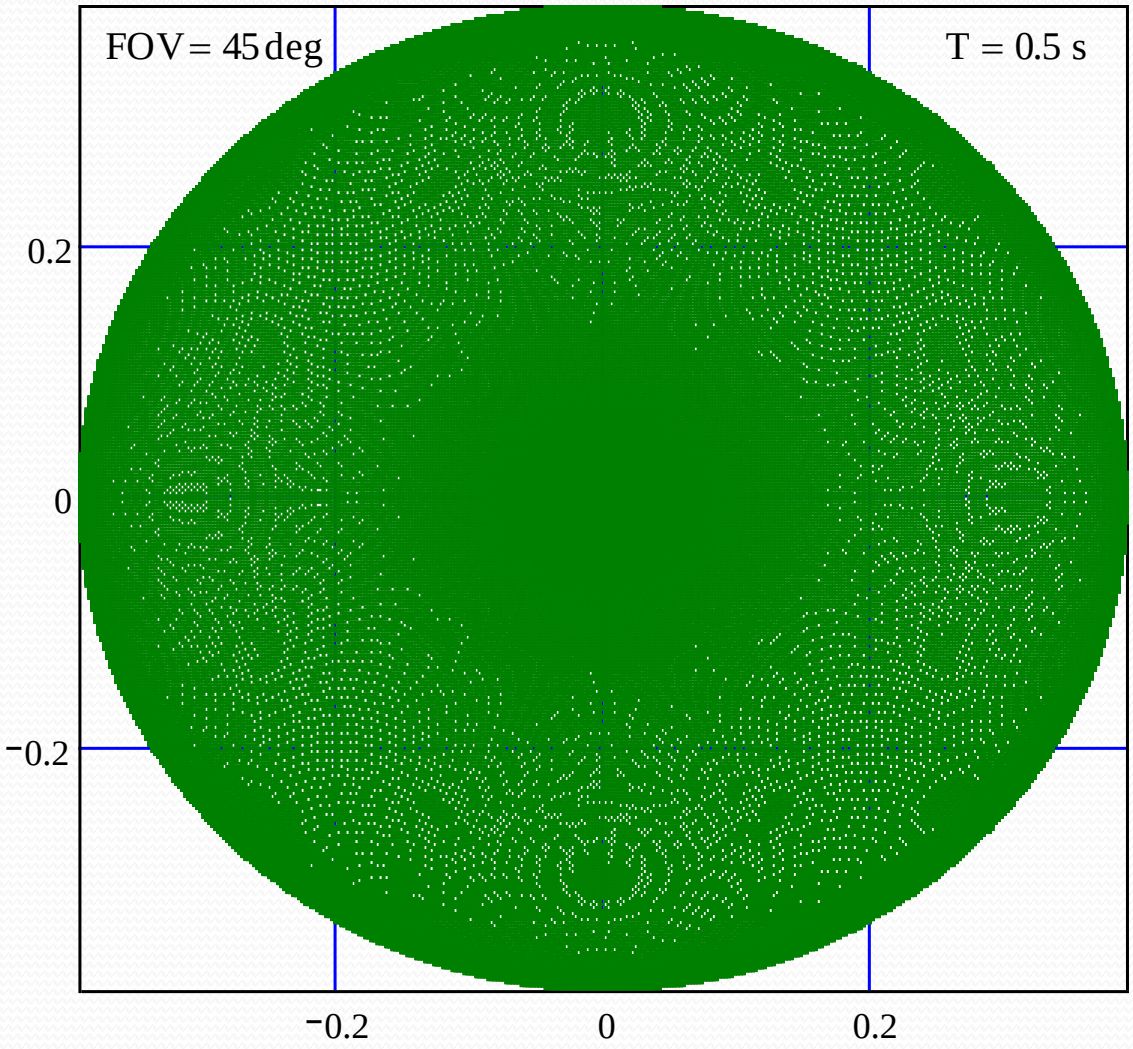
Scan pattern, single frame for 10fps



Scan pattern, single frame for 5fps



Scan pattern, single frame for 2fps



Data Processing

The LADAR provides a 3 dimensional stream of points, similar to a video camera, with addition of Range/Distance to every pixel. Each frame is a 3D cloud of points. This output data will be processed together with inputs from other sensors (GPS, INS, Sonar, Radar, Digital Map etc.) of navigation system, for data fusion, objects recognition and classification, for prediction and autonomous decisions making. Processing of output data will be done by a navigation system integrator, outside of the LADAR, to reduce cost of LADAR, and to increase versatility.

This approach is similar to conventional video systems, where hardware (camera) manufacturing is separated from image / video processing software development.

Alternatively, for some applications of the LADAR, software development and output data processing can be done by ARIEL, as we do for our other products.

Already performed Demonstrations

Demonstration of Fast Eyesafe Fiber Laser, designed for the LADAR

- Master Oscillator – Power Fiber Amplifier design

- Repetition rate =0.5MHz–4MHz, wavelength 1550nm, Pulse width 10 ns, to be shortened to 1-2ns

The fiber laser is assembled using mechanics of an ARIEL's industrial fiber laser TORREN -20

Solid Mechanical design of the compact laser is completed and demonstrated.

Demonstration of Fast Ranging at distance of 50-200 meters

- Ranging rate 500kHz. Includes building of Transceiver Optical module.

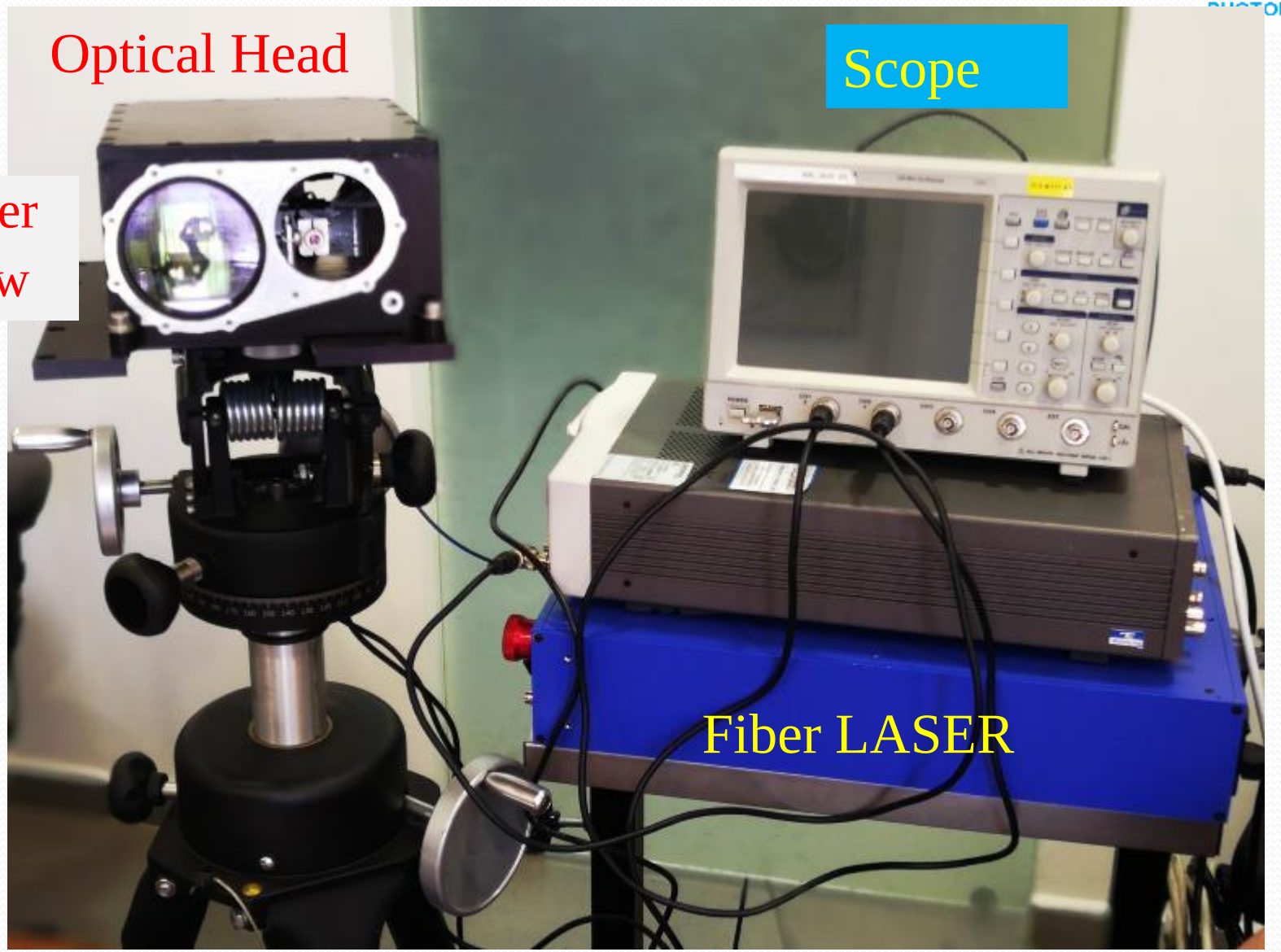
- Receiver is based on a fast photodiode.

- Digital oscilloscope is used for presentation of laser pulse echo (return laser pulse) and for recording of digital data.

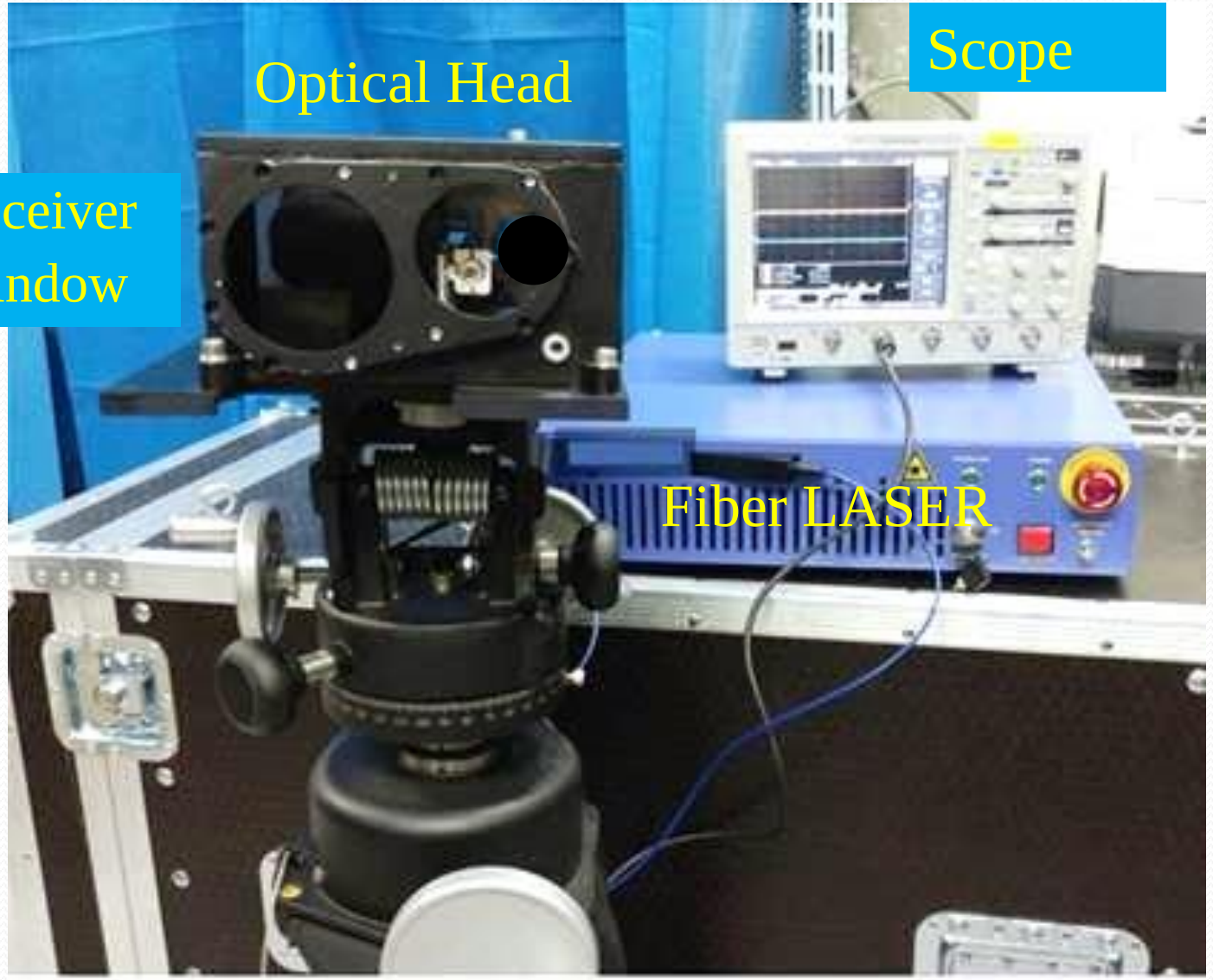
- Accurate measurement of time of flight and range definition is done via laser return data processing. The calculations are done in real time (using in the oscilloscope processing) and off line using a computer.

The Optical Head is assembled using mechanics of an ARIEL's product OWG-P

Demonstration Setup

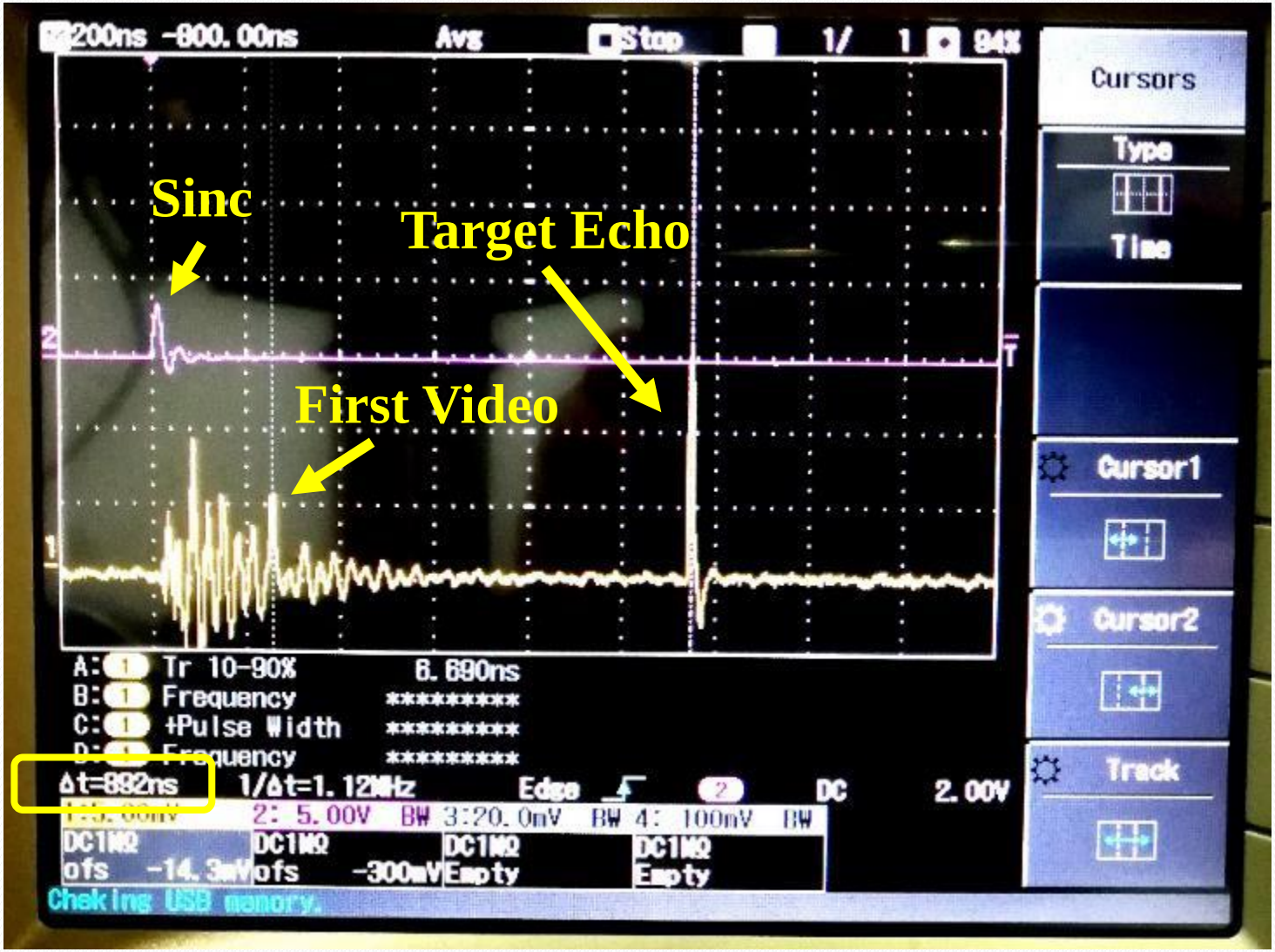


Setup of Demonstration



Field Targets

Record of Laser Echo – receiver output



Results of Range Measurements

Line	Target	Delay, ns	Range, meters	LRF, meters
1	Wall 1	256	38.4	40
2	Wall 2	524	78.6	80
3	Trees	760	114	112
4	Lamp	892	134	136

Comparison of our results (Range) and of a commercial Laser Range Finder LRF

Results of Fiber Laser Measurements

Line	Parameter	Value
1	Wavelength	1545nm
2	Output Aperture Diameter	5 mm
3	Divergence, FW, e-2	1 mrad
4	Repetition rate	500 kHz
5	Output power	1.4W
6	Pulse width	10ns
7	Pulse energy	2.8uJ
8	Peak Power	280W