Services based on optical radiometry - applications for aquatic environment (ORAQUA)

Presentation of ESA PECS project in Tartu Observatory
MVT Frascati March 23th 2012

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Estonian PECS projects – first 12

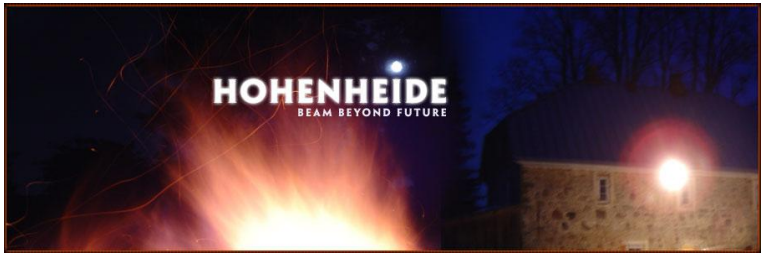
- *Tartu Observatory:* ***GAIA – Emission Line Star Classification in the GAIA Catalogue. Phase I***
- *Tartu Observatory:* ***Services based on optical radiometry applications for aquatic environment***
- **Tallinn University of Technology:** ***Environmental monitoring of harbour dredging***
- **Tallinn University of Technology:** ***Study of the role of individual plant myosins in gravitropism***
- *Regio AS:* ***Improving the quality of greenhouse gas inventory in Estonia***
- **Tensiotrace OÜ:** ***Heart rate and blood circulation Holter device for continuous monitoring of cardiovascular parameter on Earth and in the space***
- **MYOTON AS:** ***Development of a Myoton device for medical measurements of superficial skeletal muscle tone and biomechanical properties***
- **Modesat Communications AS:** ***Enhanced synchronization for DVB-S2/RCS on SDR platform***
- **Vertex E stonia AS:** ***High Accuracy Reflector Panel***
- **Estrotech OÜ:** ***Radiation and Temperature Induced Damage of Ionic Electroactive Polymer Materials for MEMS Devices in Space (EAP4SPACE)***
- **Skeleton Technologies OÜ**: ***Electric Double Layer Capacitors for Space Applications***
- **Tartu University**: **Student satellite EstCube1**
- **ESA IAP Feasibility study "Coastal floof warning system for the Baltic Sea „**

Goals of ORAQUA

- Establishing reference testing center for optical parameters of aquatic environment relevant for remote sensing applications.

- Services include support to whole chain of ground measurements starting with instrument development, ensuring quality control and validation satellite products.

Tartu Observatory and partners



expertise in instrumentation design based on photodetectors and characterization by using laser radiation and scanning technique;

INTERSPECTRUM®

developer and producer of optical (mainly FTIR) spectroscopy instruments.

Workpackage for image analyses - validations and improving local algorithms

Validation of ESA sensor MERIS/Envisat products and algorithms – test sites: large shallow lakes Peipsi, Võrtsjärv , Estonian coastal waters of the Baltic Sea

Development measurement protocols for validation satellite products specifically for optically complex waters: radiometers- TriOS ramses set, transect measurements, hand held instruments (WISP) .

Established good connections with national end users VeeOBS

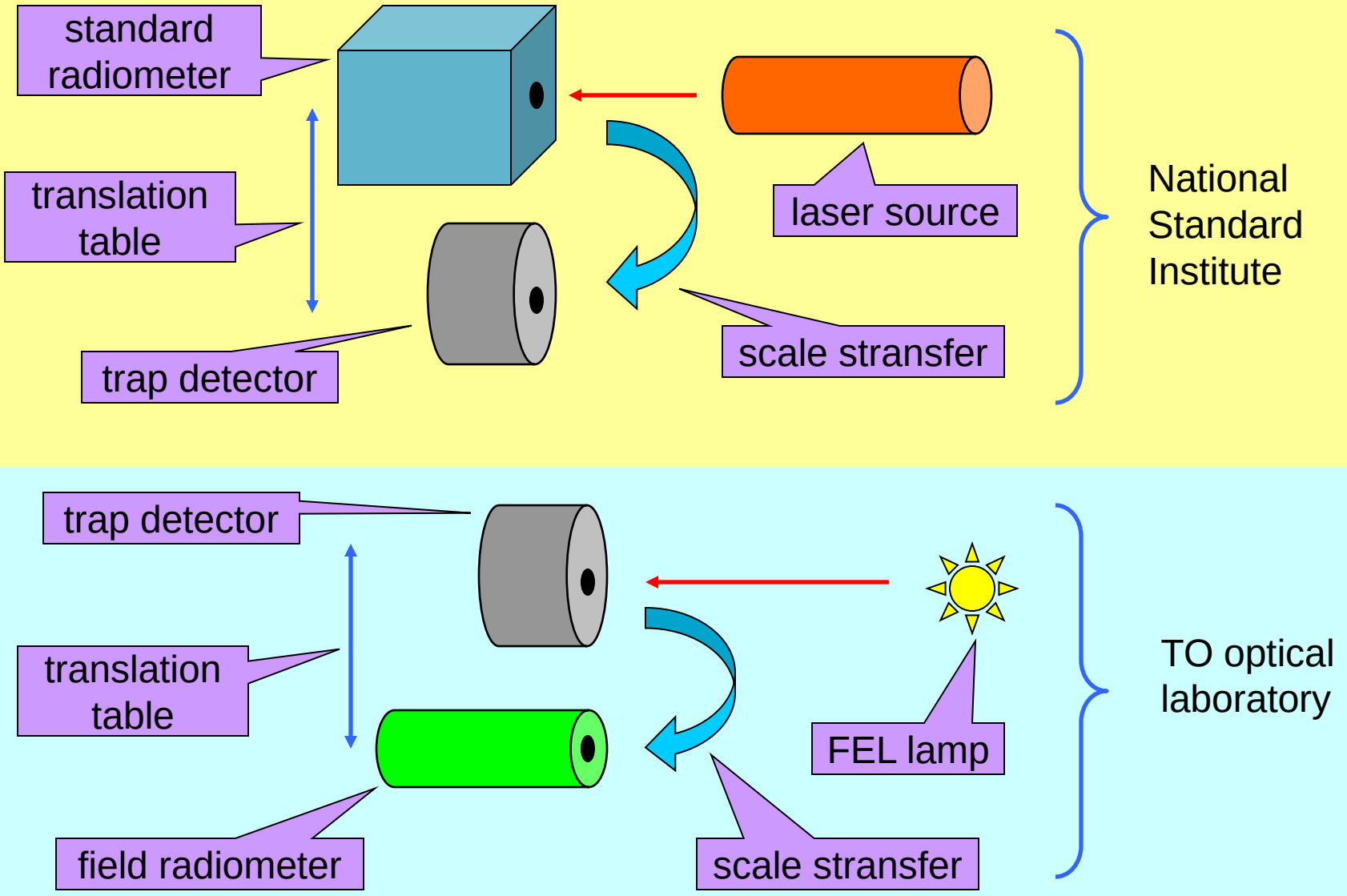
Facilitating baseline optical laboratory for calibration and characterization spectroradiometers for validation satellite products

- Establishment and enhancement of a spectral irradiance scale for spectroradiometers: the wavelength range 350-1500 nm (the goal is to reach a 1 % uncertainty); develop multipurpose extended wavelength range trap detector and a miniature multi element photodetector.
- Development of characterization capabilities for spectroradiometers - methods and systems
- Ensuring environmental and ambient conditions calibration procedures. Development of the methods and systems and to ensure reliable services.

Improvement of the radiometric scale: the trap detector

- The goal: migrating from the source-based scale to the detector-based scale
- Result: shorter measurement chain, reduced uncertainty
- Temperature stabilized 10 nm bandpass filters (400, 500, 600, 700, 800, 900, 950 nm)
- Calibrated and characterized by MRI (Finland) and Hohenheide
- Resulting calibration uncertainty for field radiometers: <=1%
- Operating in September 2012 (requires clean-room)

Transfer of radiometric scale

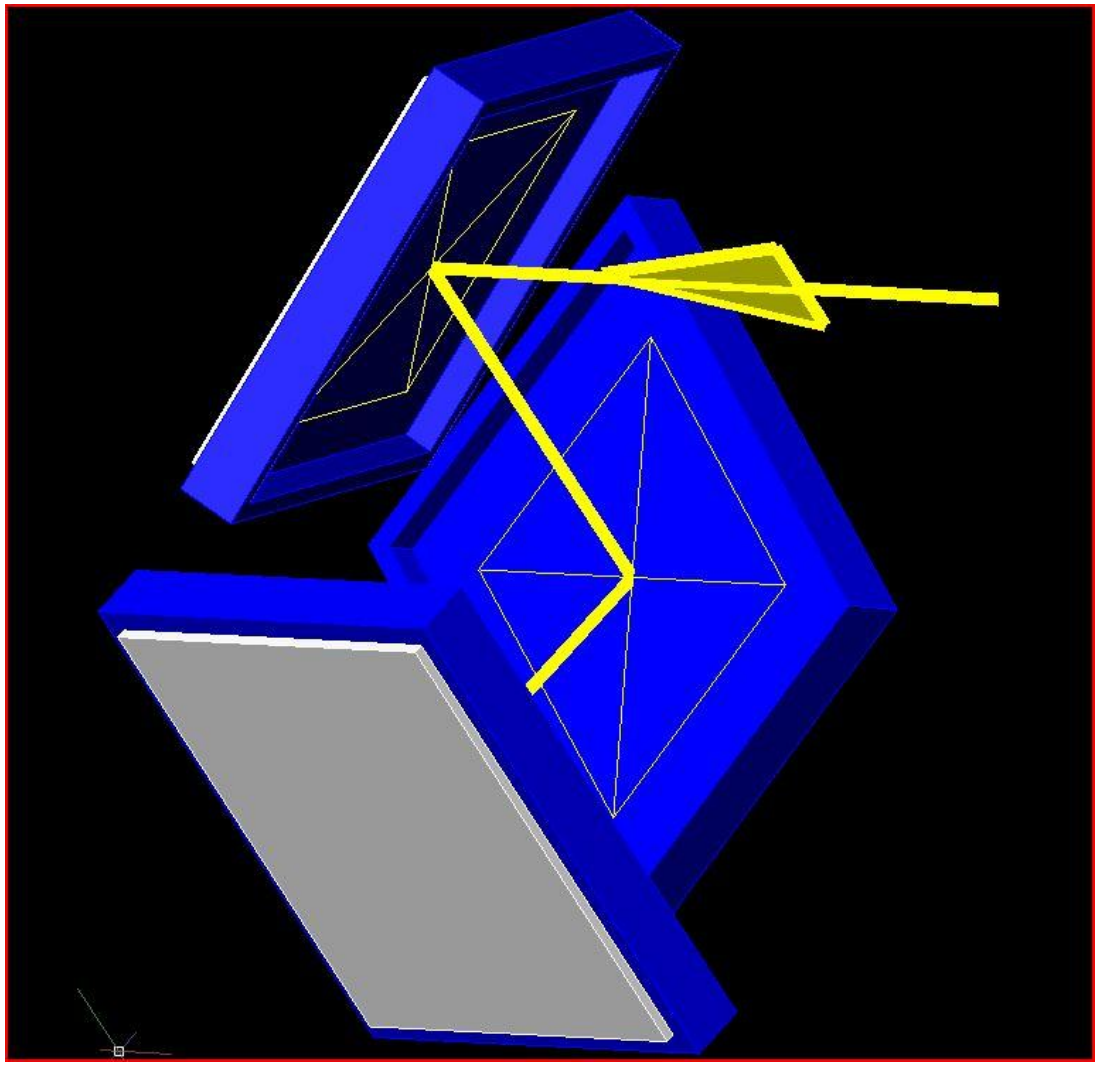


Schematic lay-out of the designed filter radiometer for wavelength range 440 900 nm.

Figure 1

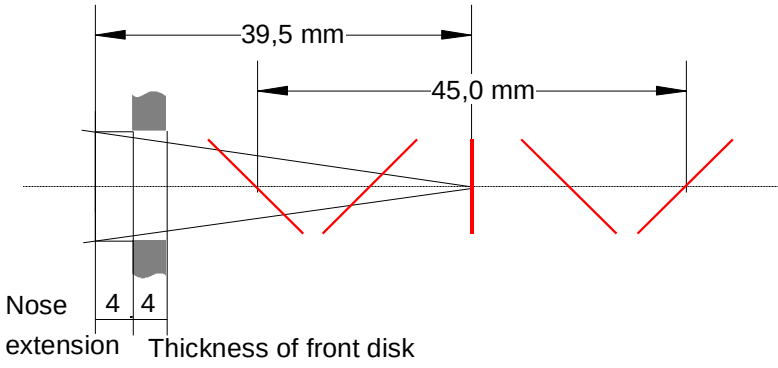
1 brass mounting ring,
2 aperture holder with precision aperture,
3 metallic enclosure with filter,
4 metallic heater/cooler incl copper heater, plastic isolator and Peltier' thermocooler,
5 plastic centering ring,
6 trap detector,
7 electrical connector.

Original design – the Trap detector

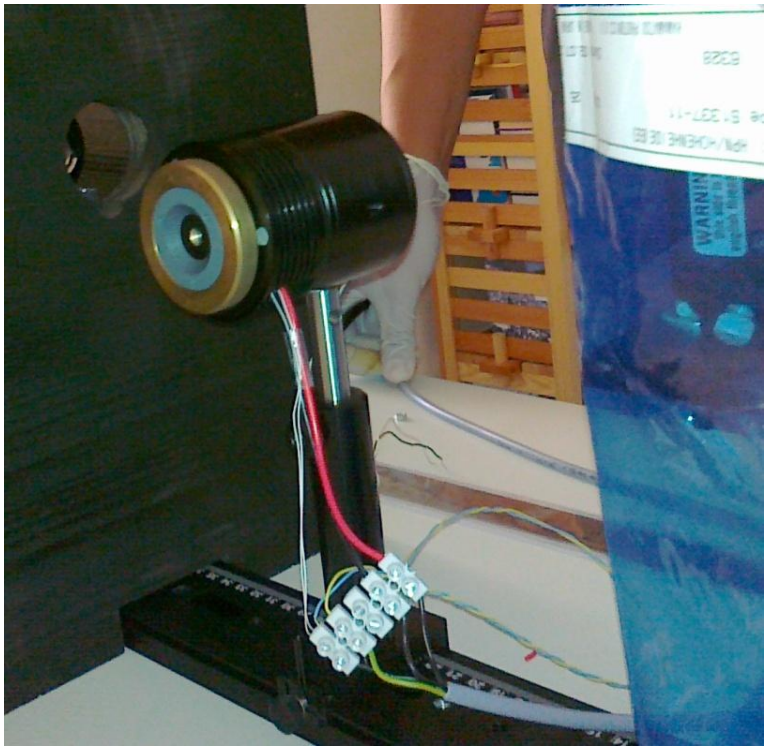


The trap detector consists of three photodiodes arranged in such a way that light can emerge from the detector only after multiple reflections.

Optical path length, apertures and focal point in the photodetector based on three silicon photodiodes type Hamamatsu 1337-1010 BR.



Quality control- temperature stabilization, comparisons



Wavelenght, nm	Measured value, mW m^{-2} nm^{-1}		Difference
	Our	Aalto Univ.	
442,5	35,971	33,551	7,2%
503,0	65,134	63,783	2,1%
570,5	103,17	103,10	0,1%
598,0	118,95	119,04	-0,1%
704,5	170,99	171,06	0,0%
801,5	198,59	199,71	-0,6%
900,0	209,07	210,00	-0,4%
944,4	211,74	-	-

The measured spectral irradiance values were compared to the calibration values supplied by Aalto University for lamp No 7-1637

Multi-spectral Volume Scattering Meter

- Analyses of the availability of existing experience, schemas and competences. Specify characteristics for design the instrument.
- Development of optics, electronics and software for MVSM.
- Producing one prototype of MVSM
- Comparison with modeling results
- Tests and field validations of the MVSM

Work done so far

Analyses of the existing instruments:

- optical scheme uses a special periscope prism that allows the direct determination of the MSVSF over a wide range of angles (0.5° to 177.6°) with a high angular resolution (0.3°).
- autonomous measuring device with remote control capability. - data visualization and starting measurement has to be done over Ethernet connection with computer or dedicated remote control device
- use two separate microcontrollers for MVSM:: one for using photomultiplier tube (PMT) for measuring and the other for controlling the measurement and communication process.
- Light source will be built using power LED-s with different wavelengths and for changing LED-s special step motor will be used, controlled by separate microcontroller. The same microcontroller stabilizes light intensity and equalizes it for different LED-s.

Ready- draft schemes both for electronics and optics , specified design of the instrument, schemes, drawings, Complemented the list of details, analyses of prizes, elements purchased

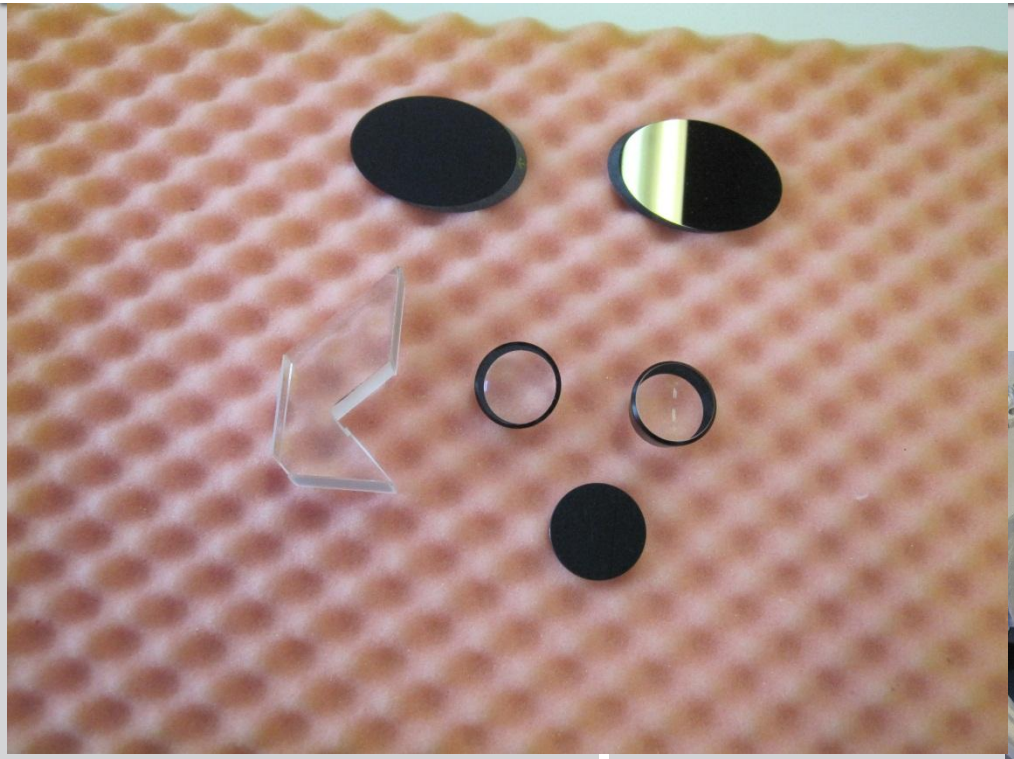
Elements of the „hard“ part of the instruments are ready

Enginer of Opto-electronics Aivo Reinart

Software enginer Henri Kuuste

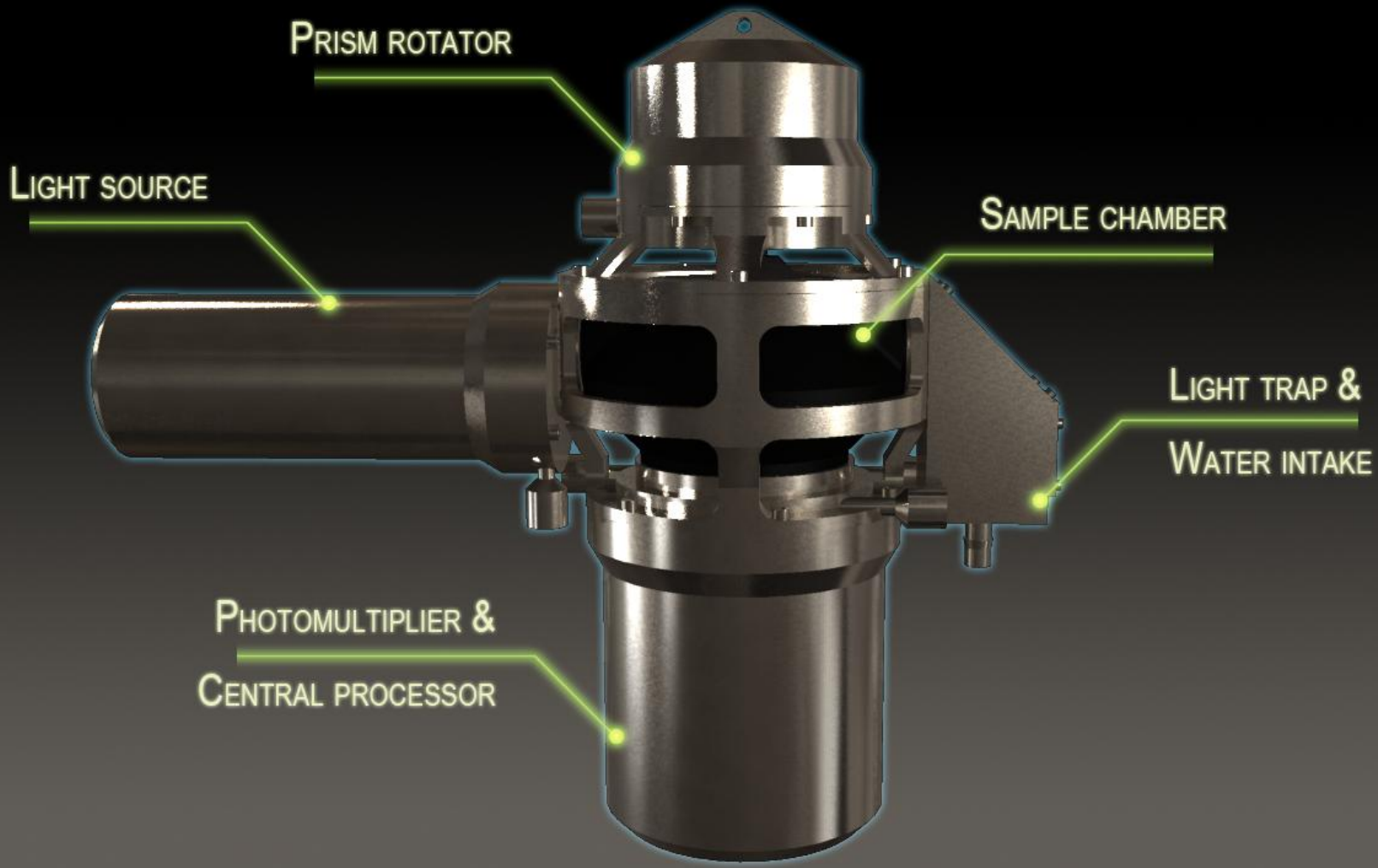
in ***Interspectrum*** laboratory

Optical elements



Waters sample chamber

Schematic view of the Multi-spectral Volume Scattering Meter



Schematic view of the Multi-spectral

Further plans

2012 December-
building of the first prototype,
test, theoretical modelling and comparisons,
improvements in hardware and software,

2013 April - laboratory working prototype is ready, field tests start-
need for international collaboration network (NordBaltRems, WaterS, Glass, Sevastopol Marine)

New position in WaterS

expert (PhD, 4-10 years of research experience) in atmospheric physics

Time: June 1st 2012 – 30 May 2014 (24 months).

To work on atmospheric correction over turbid waters; combining atmospheric radiative transfer models and local bio-optical models with measured data about aerosol and lakes.
Extensive use of local AERONET stations data. Possibility for Co-supervising at least 2 TO PhD students.