Project: FOTONIKA-LV

Unlocking and Boosting Research Potential for Photonics in Latvia - Towards Effective Integration in the European Research Area

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Interim report on upgrading, development or acquisition of research equipment

WP3 - Upgrading, Development or Acquisition of Research Equipment

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Public

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<u>Change History</u>

Version 0.1 – Structure / Table of Content

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Version 1.0 final release

Version.2.0 – Final release

Release Approval

Name	Role	Date
Edgars Smalins	WP Leader	
Sandra Smalina	Quality Manager	
Arnolds Ubelis	Project Manager	

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1. Introduction

This WP3 was designed to answer the needs for upgrade of the existing research infrastructure via replacement of outdated equipment, purchase of new components and modules, and developing new apparatus' replacing the old ones. Such upgraded infrastructure will ensure that the human potential gained via recruitment or repatriation of researchers through WP2 has been placed in the *state-of- the-art* environment enabling them to efficiently perform research. Furthermore, condition of the infrastructure is also an important precondition for the achievement of full mutual benefit from cooperation with partnership organizations and secondments organised in WP1.

2. Upgrading, development or acquisition of research equipment

2.1. Task 3.2. Development of satellite laser ranging systems towards application of Femtosecond lasers and Frequency Combs

Leading scientist	Janis Alnis
Laboratory Upgraded	Institute of Atomic Physics and Spectroscopy Association FOTONIKA-LV, University of Latvia
Equipment Purchased	There are purchased following equipment" 1) Laser stabilization resonator; 2) Frequency comb
Amount spent	1) 29700 Ls = 42260 EUR 2) 209095 EUR
Justification for the purchase of equipment	This equipment was planned to purchase in the project to fulfill the tasks of lead scientists Janis Alnis, recruited in WP2.
Progress toward task implementation	Laser stabilization resonator arrived at the end of July and is set up. Frequency comb will arrived in the middle of August and will be set up in September.
Scientific results	An application is received for a PhD student position. There is planned preparation of poster at Biofotonika 2013 conference in Riga (August 2013).

Femtosecond laser system is used for optical frequency standards, remote sensing and laser ranging. It is emitting a rainbow of colors in the range 500...1000 nm. Frequency comb has applicability in bio-optics research, for example skin fluorescence after illumination with fs pulses, and could be used for cancer diagnostics.

Picture 1. Femtosecond laser system

Temperature-stabilized Fabry-Perot resonator inside a vacuum chamber is used as an optical frequency standard to narrow spectral line width of lasers to ca 1 kHz in the range of 650-1100 nm. It's short term stability is a better compared to frequency comb and is be used for precision measurements of atomic (Rb) or molecular (Iodine) optical transition frequencies.

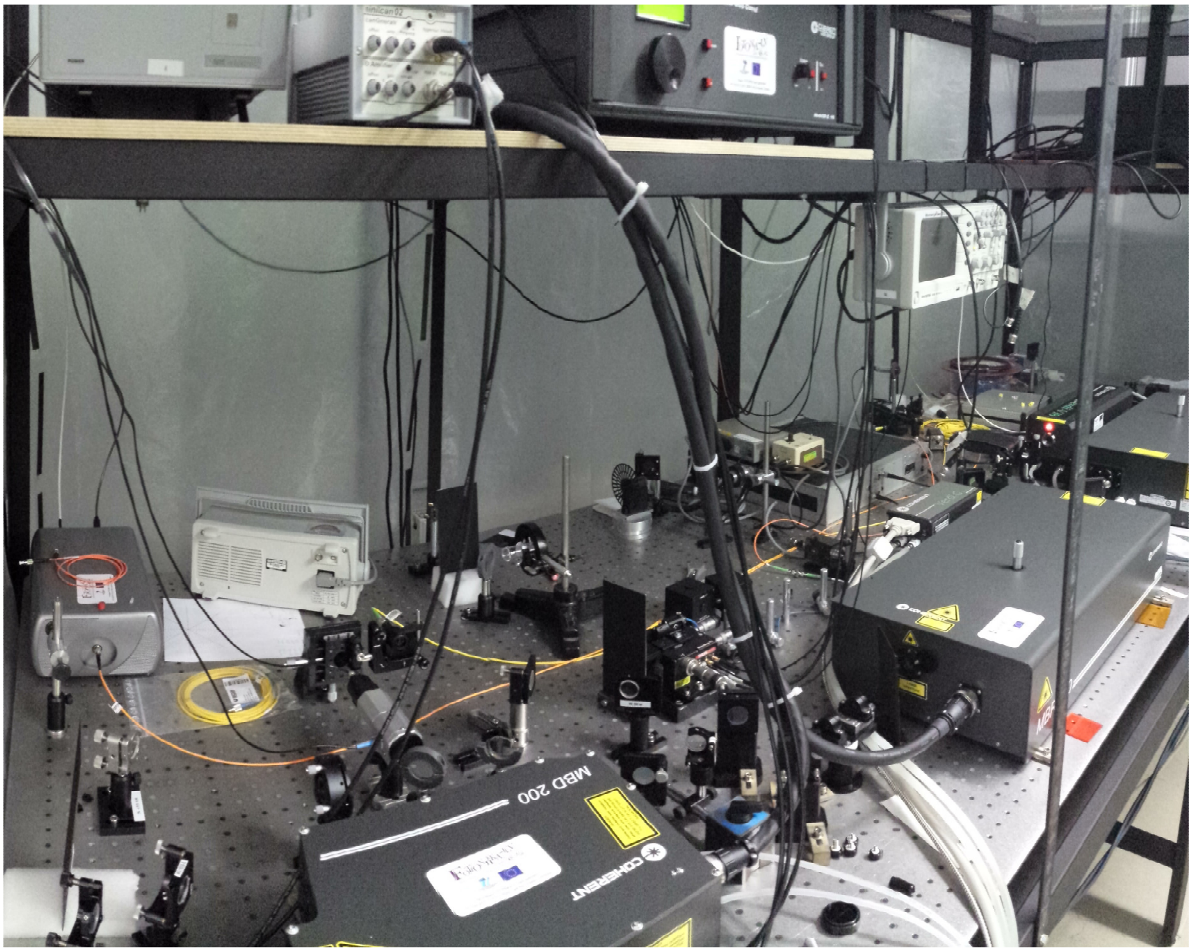
Picture 2. Temperature-stabilized Fabry-Perot resonator inside a vacuum chamber

2.2. Task 3.3 Upgrade of laser equipment of the Molecular Beam Laboratory of the repatriated researcher Dr.A.Ekers

Lead scientist	Dr. Aigars Ekers
Laboratory Upgraded	Molecular Beam Laboratory of the Laser Centre Institute of Atomic Physics and Spectroscopy Association FOTONIKA-LV, University of Latvia
Equipment Purchased	The key components of the purchased tunable single frequency laser system with frequency doubling included **1)** Coherent Verdi - G18 CW, Single-Frequency *(532 nm)* Laser Properties: solid state single frequency cw radiation source at 532 nm with power up to 18 W, low noise level and built-in cooling contour; **2)** Coherent MBR -110 Ring Laser Properties: actively stabilised single frequency laser with monolith ring resonator, tuning range700-1100 nm, experimentally tested single-frequency peak power of 6 W and 18 W pump power; **3)** Coherent MBD - 200 Frequency doubler Properties: frequency doubling of laser radiation compatible with the MBR-110 output, with experimentally tested frequency conversion efficiencies of up to 15%; **4)** Supplementary optics and devices Properties: the supplement included options for laser wavelength measurement, mode structure monitoring, beam shaping and fibre coupling optics and controllers; a full set of optics for MBR -110 laser and optics and crystal sets for MBD-200 frequency doubler covering the entire lasing range of Ti:Sa crystal.
Amount spent	316 930 EUR
Justification for the purchase of equipment	Resolution of laser dressed states in the Autler-Townes spectra upon laser coupling of hyperfine level systems require a high stability of laser frequency and large Rabi frequencies of the respective quantum transitions. The laser system upgrade undertaken within this task included replacement of an outdated system of Ar+ ion laser pumped Coherent CR-699-21 dye laser by a new generation tunable Ti:Sa solid-state pumped laser system with frequency doubling option, which has far superior characteristics in terms of stability and power of output radiation. The upgrade package included also a laser wavemeter allowing a continuous and accurate monitoring of laser wavelength, a Fabri-Perot interferometer for laser mode structure monitoring, and an accurate adjustable single-mode polarization-maintaining fibre coupler system that enables efficient delivery of laser radiation to the experiment. The laser wavelength and mode structure monitoring, as well as accurate laser radiation delivery and polarization control enable a substantially higher accuracy experiments than what was possible with the old system. Of particular importance is the possibility to achieve substantially higher Rabi frequencies. In addition, the new laser system is substantially more energy- and resource-efficient, consuming by more than an order of magnitude less electrical power than the old system, thus complying with environment-friendliness policy of the laboratory.
Progress toward task implementation	The laser system including optical components and fibre couplers have been installed in the laboratory, fundamental Ti:Sa laser radiation of up to 6W in single frequency and second harmonic radiation of op to 500mW are available for experiments. Some minor technical problems related to replacement of not well suited optical diode isolating the Ti:Sa laser from back reflections from

	the frequency doubler optics and from the fibre coupler, as well as incompatibility of the supplied beam collimator with the output beam size are being solved with the supplier. Currently, a new experiment is being set up for observation of dark state formation upon strong coupling of hyperfine levels inthe Na 3p and 3d states of Na at 819 nm.
Scientific results	The first test experiments with strong coupling between the 3 s and 3p states of Na and probing between 3p and 7d states have revealed oscillatory structures in the 7d excitation spectra. The theoretical analysis revealed that, given the available single frequency laser power of several watts at the 819 nm with the new laser system corresponding to coupling of 3p and 3d states, the coupling scheme with probe on 2s-3p and laser-dressing on 3p-3d should enable there solution of laser dressed states formed upon coupling of individual hyperfine sublevels. Such experiment is being set up with the new laser system.

Laser system upgrade provides wider range of laser frequencies and higher laser output power. An essential improvement is that the new laser systems enable the achievement of higher Rabi frequencies in experiments, which in turn ensures the right experimental conditions for the achievement of well-resolved interference fringes.



Picture 3. Laser system upgrade provides wider range of laser frequencies and higher laser output power

The acquired laser sources have been set up on an optical table, and both the fundamental Ti:Sa laser frequency and the doubled frequency are available for experiment. Notable, 6W single mode output power of Ti:Sa laser has achieved at 819 nm at 18 W pump power at 532 nm. The fibre coupling stages have been installed, enabling a transmission of 40% of laser power via optical fibres to the experimental setup.

Picture 4. Laser system upgrade provides wider range of laser frequencies and higher laser output power

2.3. Task 3.4. Upgrade of UV and vacuum UV, spectroscopy instrumentation, and linked quartz & glass blowing workshop and technology laboratory and development of far UV laser spectroscopy.

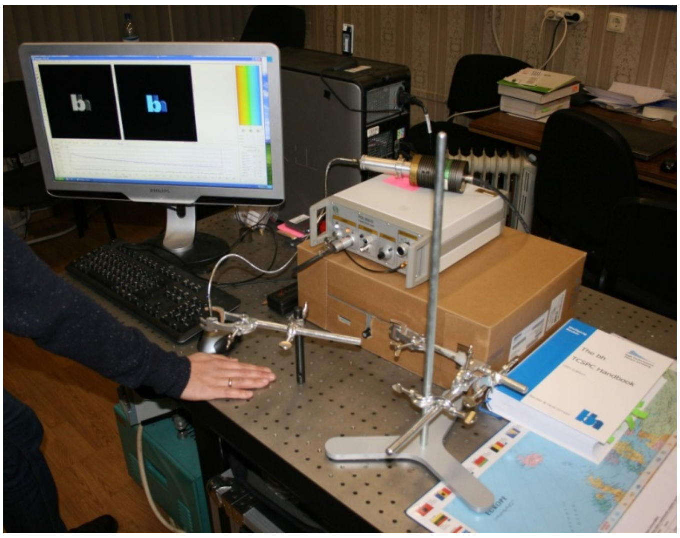
Lead scientist	Dr. A.Ubelis, Uldis Gross
Laboratory Upgraded	Institute of Atomic Physics and Spectroscopy, Latvian University
Equipment Purchased	There are purchased Parts for a vacuum spectrometer Mc Person 234/302 1. 8302-0190-0, Grating Holder 3gab. 2. 355-107853-1, 1200 G/mm concave corrected grating 1 gab. 3. 355-107855-1, 600 G/mm concave corrected grating 1 gab. 4. 355-107856-1, 300 G/mm concave corrected grating 1 gab.
Amount spent	Payment foreseen in next project period.
Justification for the purchase of equipment	Spectrometer can record spectra in the range from 37nm -151nm at the same time, which allows performing complex and effective research of UV sources and respective radio frequency excitement generators.
Progress toward task implementation	Procurement procedure is finished and supply of equipment is expected in September
Scientific results	UV radiation source and radio frequency excitement generator research.

2.4. Task 3.5. Upgrade of biophotonics research facilities.

Lead scientist	Dr. Janis Spigulis; Edgars Kviesis-Kipge
Laboratory Upgraded	Institute of Atomic Physics and Spectroscopy, Biophotonics Laboratory, Association FOTONIKA LV, Latvian University
Equipment Purchased	MSO4054B - Mixed signal oscillograph
Amount spent	9541,09 Ls (13575,748 EUR) [0.702804]
Justification for the purchase of equipment	Mixed signal oscillograph was purchased to facilitate the electronics product development and testing.
Progress toward task implementation	Oscillograph is actively used for the development of electronic devices.
Scientific results	Oscillograph is a measurement device that is used in electronics product development. With oscillograph scientific research have not been performed.

Lead scientist	Dr. J.Spigulis ; Inesa Ferulova
Equipment Purchased	TCSPC (Time-correlated single photon counting) set-up: Photon counting detector, PMC-100-4; Detector's controller DCC-100; Data processing system, SPC-150; Three pico-second lasers: LDH-D-C-405, LDH-D-C-470, LDH-D-C-510; Lasers controller: PDL 800-D.
Amount spent	70866 EUR
Justification for the purchase of equipment	For skin's autofluorescence lifetime measurement. Lasers and lasers controller is one system. With this three wavelengths we worked before, measured autofluorescence photo bleaching. Photon counting detector, Detector's controller, Data processing system, SPC-150 is one system for photon counting and time-correlating; with the minimum requirements for lifetime imaging.
Progress toward task implementation	Participation in two conferences (DOC 2013; BPR-2013) , Proc. paper in SPIE. Investigate the skin autofluorescence lifetimes before and after low power cw laser pre-irradiation.
Scientific results	Participation in conference BPR-2013, Proc. paper in SPIE
Equipment Purchased	TCSPC (Time-correlated single photon counting) set-up: Photon counting detector, PMC-100-4; Detector's controller DCC-100; Data processing system, SPC-150; Three pico-second lasers: LDH-D-C-405, LDH-D-C-470, LDH-D-C-510; Lasers controller: PDL 800-D.

Picture 5. Tektronix Oscilloscope is an important tool in the electronics lab of Prof. Spigulis for develping of microcontroller circuits.



Picture 6. Single photon detection setup consisting of laser emitting picosecond pulses and fast photomultiplier detector with time interval counter card.

Equipment necessary for skin's autofluorescence lifetime measurement. Lasers and lasers controller is one system. With this three wavelengths we worked before, measured autofluorescence photo bleaching Photon counting detector, Detector's controller, Data processing system, SPC-150 is one system for photon counting and time-correlating; with the minimum requirements for lifetime imaging.

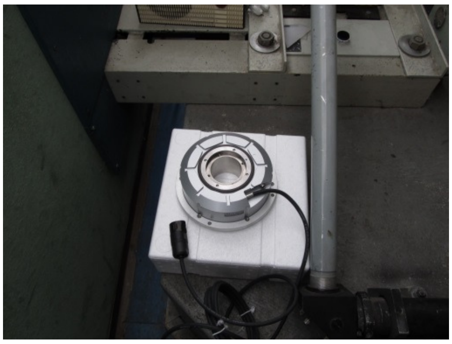
2.5. Task 3.6. Advanced upgrade of research equipment for Fundamental Geodynamical observatory

Lead scientist	Kalvis Salmins
Laboratory Upgraded	Institute of Astronomy, Fundamental Geodynamical observatory
Equipment Purchased	GNSS (GPS+GLONASS+GALILEO) receiver Leica GR25 with calibrated AR25 antenna Calibrated Tektronix DC power supplies PWS2185, PWS2721, PWS4205 Mintron night vision camera and 2.4Ghz transmitter/receiver components Leica distance meter with digital point finder Disto D5 Digital multimeter Tektronix DMM4050 Frequency counter Pendelum CNT-91 with high accuracy time base Picoscope USB oscilloscope and signal generator Jewell Instruments digital tiltmeter D701 25m single mode Thorlabs 460HP fiber with custom adapters to fit in the existing SLR system's calibration optical path
Amount spent	~47650 EUR, incl. 21% VAT
Justification for the purchase of equipment	Leica GR25 with calibrated antenna AR25: to upgrade SLR station's existing receiver antenna with state of the art geodetic receiver with support for all major GNSS satellite systems (GPS/Navstar, Galileo and Glonass), high frequency (up to 50Hz) data recording option, multiple data streaming options. Riga 1884 is the EUREF class "A" station and IGS base station. Upgrade will improve station performance and will fulfill the international GNSS network requirements; will allow to participate in upcoming projects like planned Grace-FO satellite mission in 2017. Measurement equipment: digital multimeters, USB oscilloscope, frequency counter are used for the SLR station equipment performance monitoring and testing, particularly to check the existing time and reference frequency setup involving connections between buildings, PMT and telescope optical path alignment. Distance meter with digital point finder: required to remeasure optical patches within telescope, external target distances and horizon masks for GNSS antenna and SLR system. Optical cable: replaced existing multimode fiber cable with unknown properties. Tiltmeter: to monitor telescope vertical axis orientation changes and mechanical accuracy of internal mechanical components and to directly measure certain mount model parameters independently from the star observations. Night camera with accessories: to give station operator a wide angle viewon TV monitor of tracking path on sky: cloudiness, approaching planesDC power supplies: to replace old units, some of them more than 25 years old, with new calibrated sources e.g. PMT, laser start epoch circuit.
Progress toward task implementation	Updated requirements for the necessary upgrades to improve performanceof the existing system and to participate in upcoming projects like space debris tracking. Next steps: mount model improvement, SLR telescope receiver path performance, time and frequency base upgrade and to develop new telescope control system. Prepared specifications for the newpurchases: optical components - lenses, interference filters and dichroicmirr rs and related mechanical components; step motors and their controllers, microprocessor

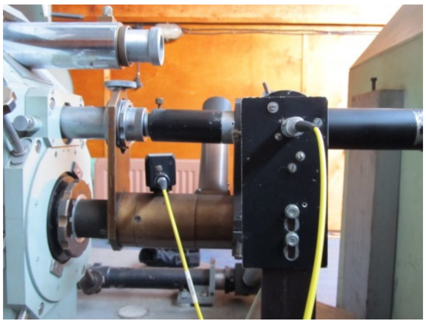
	boards for the telescope control system, additional time and frequency receiver, signal generators, temperature, pressure, humidity sensors, distributed frequency amplifiers and other accessories.
Scientific results	Improved SLR system calibration accuracy, calibration RMS now is about 7ps instead of 14ps, checked existing time and frequency basis, calculated parameters of the optical elements (lenses) for the SLR system upgrade with reduced number of optical surfaces to improve SLR system receiver path performance. Next steps: after test run to install new GNSS receiver, upgrade event timer and data processing software, purchase necessary components to upgrade telescope receiver path, upgrade time and frequency base, make new telescope mount model incorporating measurements with the tiltmeter, prepare to upgrade telescope controls system hardware and software.

Geodynamical observatory

Picture 7. SLR (Satellite Laser Ranging) station test and measurement equipment: Frequency counter and analyzer Pendelum CNT-91



Picture 8. Heidenhain angular encoders for SLR telescope mount control

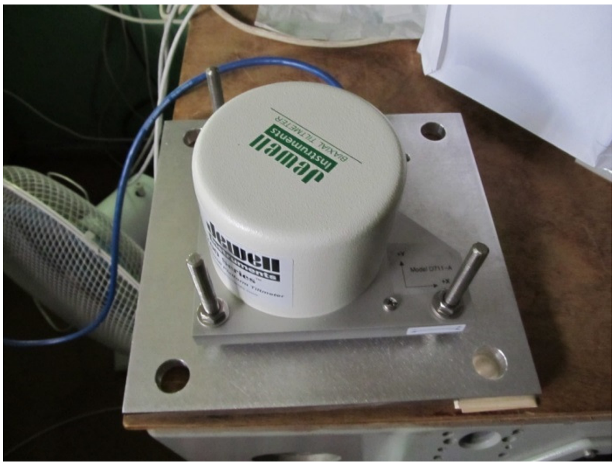


Picture 9. Single mode optical fiber cable for SLR system calibration

Picture 10. High stability Tektronix/Keithley DC power supply for Hammamatsu PMT photon detector installed at SLR system

Picture 11. Calibrated Leica AR25 GNSS receiver antenna about to be installed at IGS/EUREF site Riga

Picture 12. Geodetic GNSS receiver Leica GR25 capable of tracking all major GNSS systems: GPS, Glonass, Galileo, Beidou installed at Geodynamical station Riga



Picture 13. Jewell Instruments tiltmeter D711, mesaurement accuracy 1 microradian, for monitor laser ranging telescope vertical axis orientation and mount stability

2.6. Task 3.7. Advanced upgrade of largest Baltic wide field Schmidt system telescope.

Lead scientist	Dr. Ilgmars Eglitis
Laboratory Upgraded	Institute of Astronomy, upgrade wide field Schmidt system telescope
Equipment Purchased	Flatbed scanner complex: flatbed scanner scan format 300x400 mm, resolution at least 2400 dpi, optical density up to 3.8 D; connectivity USB 2.0; supported environment, WindowsXP; with computer: dual-core processor; CPU over 2 GHz; RAM 2048 MB; CD-ROM, DVD-RW; 4 USB canals; at least 300 GB HDD; 21-inch LCD monitor;
Amount spent	2269EUR, excl. 21% VAT
Justification for the purchase of equipment	Flatbed scanner complex needed to digitalize a wide field Baldone Schmidt telescope astronomical plate archive, which obtained 1966-2005 time period. The uniqueness of plate archive is regular observations almost 40- year long period toward constellation of Swan and anticenter of Galaxy directions. Digitization will give a high volume database which will allow to explore the brightness variability of stars of different spectral types in long time span, to measure the intrinsic speed of stars, to discover new asteroids and comets.
Progress toward task implementation	The digitalization process was begun.
Scientific results	1000 astronomical plates from Schmidt telescope archive are digitalized till the July 2013.

Picture 14. CCD 2184 x 1472 pixels, Size of pixel 6,7 x 6,7 μ

Pictures 15. Scanner for astronomical plates 25x25cm

■ Will be acquired 98% of the unexploited scientific information;
■ be obtained photometric data changes (in B, V, R systems) in selected fields for almost over a period of 40 years of stars in different evolutionary stages;
■ The data will be used in stellar astrophysics, the interstellar medium and small bodies of the solar

system studies;
■ To be included in the international Virtual Observatory Alliance;
■ A large set of several PhD study of star formation process.

Picture. 16. For visitors in Baldone Observatory the projector was used to presenting photonics sector developments

2.7. Task 3.8. Zenith Refractometer

Lead scientist	Dr. M.Cakule , Dr. J.Balodis
Laboratory Upgraded	Laboratory Institute of Geodesy and Geoinformatics
Equipment Purchased	Laptop computer DELL Latitude E5520 15,6" 1366x768/i3- 2310M/2GB/DVD-RW/BT/ 802.11n/ Windows 7 Professional Solid Edge University Perpetual license with technical support (Insight XT/Ms Share Point App) up to 31.08.2015. * CCD matrix: Santa Barbara Instrument Group, model: STT-8300M * GNSS receiver: Hemisphere GPS, model: A325 with interface cable * multifunctional printer HP Photosmart 6510 e-All-in-One;
Amount spent	***19920 EUR***
Justification for the purchase of equipment	According to concept of zenith refractor: 1. Equipment for mobile computerized large volume data flow registration in field conditions is necessary. The purchased laptop computer will be used for this purpose. It will serve also for mechanical component design and associated calculations using Solid Edge software package and for device control and data acquisition software compiling 2. SBIG CCD matrix will be used for star field image acquisition, necessary to calculate accurate instrument orientation, relative to coordinate system, defined by reference stars. 3. Hemisphere GPS A325 will be used to determine an accurate instrument position in geocentric coordinate system and .time of star imaging events. Tripod and a number of mechanical and electronic components will be used for instrument assembly, power supply, data flow support and control functions.
Progress toward task implementation	- Software package for event timing and geocentric coordinate data acquisition using Hemisphere GPS A324 is developed and tested; - Tests of optical system are being performed; - Software packages for reference star catalog download, formatting, data extraction, astrometric apparent position calculations are developed; - Work drawings of mechanical components are being prepared. The progress of design and construction of the instrument is limited by available personnel funding, which, unfortunately is far from adequate.
Scientific results	Instrument is under construction, scientific results are expected when it is at least partly functional.

Picture 17. Laptop computer DELL Latitude E5220.

Laptop will be used with SolidEdge package for mechanical component design purposes and as device control computer.

CAD software package SolidEdge (academic licence) - will be used for learning of mechanical component design and load analysis

Picture 18. GNSS receiver Hemisphere GPS A325

GNSS compact high accuracy GNSS time and coordinate receiver, integrated with antenna. Will be used for site geocentric coordinate and time acquisition and event timing (gps.jpg).

Picture 19. CCD camera SBIG STT-8300M

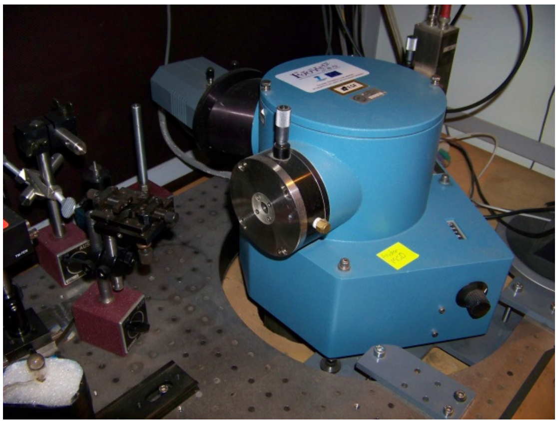
8Mp resolution monochrome CCD camera, will be used for acquisition of star field images needed for determination of instrument orientation relative to geocentric reference frame.

2.8. Task 3.10. Advanced upgrade of electron-beam and resistive evaporation of dielectric, semiconductor and metal multilayer achromatic optical coating installation - VU-2M for interference mirrors and filters etc. (250-1100 nm) with simultaneous photometric layer testing

Lead scientist	Dr. Arnolds Ubelis, Electronic Ing. Janis Blahins
Laboratory Upgraded	Institute of Atomic Physics and Spectroscopy, Labor.of Atomic Phys&Photochem on behalf of new erectable Laboratory of Vacuum Coatings
Equipment Purchased	Bought: 1) Ventilator 4000 m3/h 2) Air conditioners 3 pcs 3) Stainless steel (3 separate cases) 4) Welding electrodes 5) Floor constructive 6) Antidust paints and antidust floor installing Planed at future: 1. Vacuum turbo pump with driver module; 2. Cryopump with few coldheads and helium compressor; 3. Tangentventilators; 4. HEPA filter sections; 5. Dust pollution control measurers
Amount spent	1) 1332,27 LVL (Energostar) 2) 2707,33 EUR (Instarom) 3) 1612,78+1461,07 LVL (Steeltech) 4) 85,40+169,79 LVL (Rumba-V) 5) 493,23 LVL (Baumachinen) 6) 3631,10 EUR (Hagmans)
Justification for the purchase of equipment	1) For general air inlet to cleanroom where the sputtering laboratory will have processing machinery, calculated in accordance to standard for cleanrooms HVAC systems. Seller was chosen cheapest of those having high enough quality and good exploitation costs 2) Bought according to calculated heat flux from instruments to the dust-free cleanroom to maintain minimum working conditions to personnel (under 27 C), taking in consideration heat balance from air ventilators. Modell was choose with known very good lifespan expectancy, with air nanoparticle electrostatic filtering and anti-humidity functions, and bought in the shop abroad where prices was lower than for less advanced models at Riga. 3) Steel was bought for specific cleanroom environment HVAC, filtering box constructing, ventilation piping needs, for needs of most clean part of cleanroom on-wall ventilator channel mounting and for new large sized astronomical mirror aluminization apparatus vacuum chamber constructing. The seller was chosen as cheapest having the needed assortment. 4) To weld vacuum chaber and mentioned above stainless steel constructions. Seller was used geographically nearest to us who has relatively low price. 5) For cover the technical communication channels (electricity, canalisation, cooling water) with strong, cleanable and easily openable plastic covers, allowing 250 kg/m2. The seller was chosen only at region having such covers. 6) For to insulate a most cleanest part of cleanrooms walls and ceiling with specially designed and qualified for that need antidust paint and paint cleanroom floor with industrial quality antidust qualified plastic covering, and paint all floors for other clean zone laboratory space with less expensive

	industrial floor permitting to save them well clean. The seller was chosen only in region having quality warranties and good qualification proofs.
Progress toward task implementation	Bought: 1) Ventilator 4000 m3/h, bought, installed for 90%. 2) Air conditioners 3 pcs, bought, installation in progress. 3) Stainless steel, first stocks are already installed, last stock is in progress. 4) Welding electrodes, used for 80%, will be need for buy more 5) Floor constructive, 95% installed 6) Antidust paints and antidust floor installing stopped due plan changes about cleanroom configuration - there stand up idea to widen clean zone, destroy some inner walls, and therefore until now floor is not made ready for painting. Expecting that will be done in September or latest November. Planed at future: 1) Vacuum turbopump with driver module. Specifications are made, but previous concourse returned empty. This time we shall give a few seller name to concourse administrators. 2) Cryopump with few cold heads and helium compressor. Specifications are about be made with a term at 01.09.2013. 3) Tangent ventilators. All trials to buy them from local producer at Germany ended with policy "we are not selling less than million". As soon as we shall find other concurrent the concourse will be opened. 4) HEPA filter sections. Seller is known but forbidden by University regulations. As soon as local laws will be suspended for our case, them will be bought. Laws forbid e-bay and most of EU producers if they havent undergone long mediator chains, what is unacceptable by viewpoint of price-economy. Dust pollution control measures. Specifications and models are about clear, will be formulated at autumn concourse end-term 01.09.2013.
Scientific results	Results will be gained at point when all equipment will be laid to work. Today we had tiny test deposition what was used as student (bacalaure) graduation work experimental part results. At future is planed to process few astronomical mirrors as soon is possible and many at future, is planed to have optical equipment small series producing by demand, is planned to install the negative ion research apparatus GRIBAM at hall next to cleanroom, the crystal growing owe with zone cleaning regime, and use the semi-clean zone for ion implantation instrument constructing and adjusting whilst it stays at us. Later implanter place will be occupied with special laser or precision frequency comb instrument. Cleanroom will be permanently occupied with three deposition devices and sample cleaning equipment.

Picture 20. Ventilator for sputtering clean room



Picture 21. Interference Grid for optical coating installation - VU-2M

Picture 22. Air conditioner for sputtering clean room

3. Conclusions

All purchases of Equipment are made according planning made in beginning of project. Purchased equipment allows strengthen capacity of Association Fotonika LV and support scientists are recruited in a project. It will allow making scientific research at a much higher scientific level using upgraded equipment.

Next procurement procedures are foreseen in October, 2013 and May, 2014