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Romaniuk, R S (Warsaw University of Technology Poland)

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Astronomy and Space Technologies Photonics Applications and Web Engineering WILGA May 2012

Ryszard S.Romaniuk
Warsaw University of Technology, Institute of Electronic Systems, Poland

ABSTRACT

This paper is the first part (out of five) of the research survey of WILGA Symposium work, May 2012 Edition, concerned with photonics and electronics applications in astronomy and space technologies. It presents a digest of chosen technical work results shown by young researchers from different technical universities from this country during the Jubilee XXXth SPIE-IEEE Wilga 2012, May Edition, symposium on Photonics and Web Engineering. Topical tracks of the symposium embraced, among others, nanomaterials and nanotechnologies for photonics, sensory and nonlinear optical fibers, object oriented design of hardware, photonic metrology, optoelectronics and photonics applications, photonics-electronics co-design, optoelectronic and electronic systems for astronomy and high energy physics experiments, JET tokamak and pi-of-the sky experiments development. The symposium is an annual summary in the development of numerable Ph.D. theses carried out in this country in the area of advanced electronic and photonic systems. It is also a great occasion for SPIE, IEEE, OSA and PSP students to meet together in a large group spanning the whole country with guests from this part of Europe. A digest of Wilga references is presented [1-275]. Wilga Sessions on HEP experiments were organized under the umbrella of the EU FP7 Project EuCARD – European Coordination for Accelerator Research and Development.

Keywords: nanomaterials, optical fibers, optoelectronics, photonics, measurement systems, astronomy, high energy physics experiments

1. INTRODUCTION

XXXth Jubilee Symposium of young scientists WILGA 2012 on Photonics and Web Engineering has gathered over 250 participants. There were presented over 200 papers – mainly concerning the realized Ph.D. theses and participation in research projects relevant to the topical area of the meeting. There were also presented a few plenary papers introducing the audience into new research areas of photonics and electronics. The symposium is organized under the auspices of the SPIE – The International Society for Optical Engineering, IEEE (Poland Section and Region 8), Photonics Society of Poland, KEiT PAN, PKOpto SEP and WEiTI PW. The symposium is organized annually by young researchers from the PERG/ELHEP Laboratory of ISE PW with cooperation of SPIE and IEEE Student Branches. Media patronage over the symposium is extended by Elektronika monthly technical magazine, Symposium proceedings are published by Elektronika, IJET – Int. Journal of Electronics and Telecommunications KEiT PAN and Proceedings SPIE. Wilga Symposium is topically associated with the cyclic research meetings on optical fibers and their applications organized in Bialowieza (prof.J.Dorosz, Bialystok Uni. Technology) and Krasnobrod, now Naleczow, (UMCS Univ., and Lublin Univ. Technology, prof.W.Wojcik) every 18 months. Below, there are discussed some presentations from the main of the most interesting sessions or topical tracks of WILGA 2012 Symposium, May Edition. This part 1/5 debates the sessions on Photonics Applications in Astronomy and Space Technologies.

Fig. 1 shows the main entrance to the WILGA resort by Warsaw University of Technology (WUT).

2. TOPICAL TRACKS OF THE JUBILEE XXXTH SYMPOSIUM WILGA MAY 2012

The topical session and tracks of WILGA 2012 were as follows: nanotechnologies and nanomaterials for optoelectronics and photonics, optical fibers for sensors and all-photonic devices for sensors, active optical fibers, sensors and sensory networks, object oriented design of optoelectronic and photonic hardware, photonics applications, advanced bioelectronics and bioinformatics, co-design of hybrid photonic – electronic systems, computational intelligence in optoelectronics and robotics, development in the wide-angle astronomic observations of the whole sky – pi-of-the-sky project, processing and imaging of multimedia data streams, machine vision, vehicles – quadrocopter and Mars rover, analog transmission systems in noisy conditions with digital reverse transmission channel, optoelectronic and photonic metrology, reconfigurable measurement systems, high performance – low-jitter low-latency transmission systems – White Rabbit, thermonuclear fusion experiments – JET and ITER tokamaks, research results update from HEP experiments – TOTEM and CMS/LHC in CERN. A number of Wilga sessions concerned applications aspects of photonic and electronic circuits and systems, including in this advanced applications which combine hardware and software. A separate session track was organized by SPIE, IEEE, OSA and PSP - Photonics Society of Poland students for the new students beginning their adventure with the science of photonics and electronics.

3. ASTRONOMY AND SPACE TECHNOLOGIES

During the XXXth Jubilee Symposium WILGA 2012 there were organized two topical sessions on observational astronomy (IR, optical and X-ray), space and satellite technologies, measurements and photonics/electronics equipment for these applications. The sessions were chaired by dr Piotr Orleański from CBK PAN (Space Research Center SRC PAS) Warsaw and prof. Filip A. Żarnecki of Faculty of Physics UW Warsaw in cooperation with prof. L. Mankiewicz of ZFT PAN and CAMK PAN (Mikołaj Kopernik Astronomical Center). The sessions gathered a few tens of young scientists and engineers from several research groups. There were presented over 20 papers concerning the current technical involvement of these labs. These sessions were organized a few days before Poland is going to be accepted as a new full member of the ESA – European Space Agency.

4. ELECTRONIC AND PHOTONIC EQUIPMENT FOR SATELLITES

PICO and NANO SATELLITES

Picosatellites and nanosatellites cheaply invade the space for massive and varied research purposes. They are equipped in specialized miniature instruments optical, photonic, magnetic and electronic. The first part of the word satellite refers to their minute size. A satellite of the volume of 1 liter is usually called a picosatellite, while 10 liters satellite would be called nano. Why do astro researchers sent picosatellites to space? They are low cost. They carry pretty advanced scientific experiments. They create inexpensive platform for technology tests. They are initial platform for making bigger systems. They can form clusters while on the orbit, like proposed TechSat-21 mission. A picosatellite or a cluster of them can easily, and nearly at no cost, be added to larger space missions as the weight is usually lower than a few kg and power consumption less than a few W. CubeSat is one of proposed standards for a universal family of picosatellites. The international CubeSat project started in 1999. The aim was to provide a standard for design of picosatellites to reduce the cost and development time, increase accessibility to space and to sustain frequent launches. The standardized and open access CubeSat Design Specification largely simplifies building satellites. Small satellites frequently use common solutions and components for OBC (on-board computer) systems like ARM processors, TI secondary processors, PPC processors, embedded processors in FPGA fabric, single board computers, reconfigurable computers, standardized solutions for Mission Interface Computers - MIC. Most of these systems have multiple low-power modes of work. Some of them offer in-flight configuration of FPGA fabric. Typical I/O ports include servicing of telemetry, optical, magnetometry, thermal, communication, etc. Some of such systems are offered by: GOM Space, Clyde Space, Andrew Space, Space Micro, and more. The latter vendor designs the ProtonX-Box which is an Avionix Suite for CubeSats. It resides on a single board computer with PPC, DSP and FPGA chips.

The requirements for the OBC design are as follows: low power consumption, choice for multiple low-power modes, high computing power, resistance to radiation present at low Earth orbit, high reliability, low cost, small weight, board size suitable for picosatellite standard (like Cube Sat), usage of common communication links as are often used in picosatellite designs, preparedness for standardized operating scenarios, fast communication links for payload and radio. A new architecture for OBC was chosen with ATmega128 microprocessor realizing tele-commands, telemetry, power control, logs and task queue. Spartan FPGA realizes operation of payload, processing, compressing and storing of payload data, and ADCS algorithms. Power consumption of this system is: active PC (at around 10MHz) uses 100mW, idle PC uses 50mW, sleeping PC uses 100μW. FPGA chip (at 100MHz) uses below 2W. The peripherals of this system are: FLASH, ADC, RTC and RAM. The I/O ports are UART, USB, I2C, CAN, and high speed serial links. Payload, radio, PSU, ADCS units are using I2C. Test port is using USB and UART. Payload and radio are using HS serial links. Estimations for SEL and SEU effects in LEO for both micro-processors, are well beyond (i.e. one order of magnitude greater) the lifetime of the satellite. Reliability in the system is obtained by hardware redundancy.

BRITE

BRITE (Bright Target Explorer) network of six satellites represents a new approach in space research. They are small, cheap and very specialized, and easy to be launched to the polar orbit. The constellation of six BRITE nano satellites will continuously monitor (multi-spectrally in blue and in red) small changes in the brightness of nearby (i.e. very bright) hot stars, in order to study their oscillation behavior. Out of the six two satellites Lem and Heweliusz will be made in Poland at CBK PAN. Such observations of the brightest stars cannot be made by large telescopes. Observation for m the orbit avoids disturbances caused by Earth's atmosphere and adds paralax (simultaneous multiple and distant observation points to improve the imaging). The constellation of satellites assures the continuity of observations of chosen group of stars. The total mass of the nano satellite is 7 kg and it is of a cubical shape with 20 cm in dimension. The satellite consists of an optical telescope, computers (HKC, ACS, IOBC), communications, power system (control boards, PV cells, regulators), ACS magnetometer, star tracker, sun sensor, torquers, reaction wheels, radio receiver (2.2 GHz) and transmitter (437.365MHz). The scientific payload done at CBK PAN is a red telescope, while the technological payload are: power supply unit, solar cells, battery, lock and release mechanism, micro-antenna boom, radiation dosemeter and beacon. The launch schedule of Polish Scientific Satellites is: BRITE-PL1 Lem – end of November 2012, BRITE-PL2 Heweliusz – second half of 2013. Additional payload is considered for Heweliusz. The objectives are tests of COTS photonic/electronic components and systems – candidates for long space missions by SRC. Details include: verification of LEO radiation simulations, RadFET and LED dosimetry, evaluation of fault mitigation techniques, components behavior studies including FLASH, SDRAM, ADC, FPGA. These tests are considered after the basic experiments are finished.

SPHINX

Sphinx X-ray solar spectrometer, constructed by CBK PAN in Wrocław is one of the instruments at the Coronas-Photon satellite. The satellite was launched in January 2009 from Plesetsk. The instrument weight was 4 kg and power consumption 10W. It detected photons in the range 1 – 15 keV, with time resolution 6μs, energy resolution 500eV. It provided telemetry data of 150MB/day. The scientific objectives of the experiment were: investigations of quiet corona heating processes via photon arrival time analysis; studies of short period soft X-ray oscillations; search for transient ionization plasma effects to determine flaring plasma densities, analysis of chemical composition of plasma (Al, Ar, Ca, Fe, Mg, Si, S). determination and time variability of differential emission measure (DEM); creating a reference photometric standard in soft X-rays with absolute accuracy of 10%; verification of a novel, fluorescence based, photometry measurement method; monitoring of solar X-ray flux in the intensity range covering seven orders of magnitude. SphinX is comparable to similar orbiting instruments: Resik, GOES, SOXS, RHESSI. SphinX measures soft X-rays with four silicon PIN diode XR-100CR detectors, with different apertures to measure wide range of fluxes. The entrance windows of the detectors are covered with 13μm beryllium foil. Each detector has temperature sensor, Peltier cooler (operational temperature -20C) and FET preamplifier inside the package. SphinX NG is under design. New types of detectors are used of SDD type (silicon drift detectors). They are characterized by much larger dynamic range than PIN diodes. CdTe detectors are also added. The measurements of photons are done in the range of 4keV to 200keV. All the measurement system is fully digitized with filters, pulse height analyzer and controls implemented in FPGA.

ESA SOLAR ORBITER - STIX

The SRC PAS in Warsaw participates in the ESA Solar Orbiter (SO) mission with the STIX instrument. SO explores the Sun – heliosphere connection in the visible, extreme ultraviolet and X-rays. SO has elliptical orbit around the Sun with perihelion as low as 0,28AU (closer than ever before) and with increasing inclination up to 25^{o} with respect to the solar equator. Life time is predicted for 7 years nominal with launch time in 2017 (from Cape Canaveral), then cruising and reaching Sun orbit in 2021. Six gravity assists are scheduled (two by the Earths and four by Venus) to reach elliptical near Sun orbit – lasting for 168 days. STIX tries to answer the following questions: How and where do the solar wind plasma and magnetic field originate in the corona? How do solar transients drive heliospheric variability? How do solar eruptions produce energetic particle radiation that fills the heliosphere? How does the solar dynamo work and drive connections between the Sun and the heliosphere? The SO will try to determine in-situ the properties and dynamics of plasma, magnetic fields and particles in the near-Sun heliosphere, to survey the detail of the Sun's magnetized atmosphere, to identify the links between activity of the Sun's surface and the resulting evolution of the corona and inner heliosphere, to observe and characterize the Sun's polar regions and equatorial corona from high latitudes. The So has the following in-situ instruments: energetic particle detector, magnetometer, radio and plasma waves measurement, solar wind plasma analyzer, extreme UV imager, multispectral coronograh, polarimetric and helioseismic imager, heliospheric imager, spectral imaging of the coronal environment, and StiX – X-ray spectrometer / telescope. The data of StiX are: mass 5 kg, power 5W, dimensions 22x22x80cm, energy range 4-150keV (pixelized CdTe detectors), energy resolution 1-15keV, field of view 2^{o}, finest angular resolution 7 arc seconds, spatial resolution up to 1400 kn on the Sun surface, time resolution >100ms. STIX subsystems contain: X-ray window, imager, aspect system, attenuator, detectors and ASICs, instrument data processing unit, power supply, and full system simulator.

URSA OBC – an onboard computer for satellites

Further developments of a versatile self-reconfigurable digital processing platform for aerospace applications were summarized. Current trends for cheap satellite equipment are: increasing demand for computing power, fast communication channel internal and external including RF and optical, utilization for COTS components in LEO satellites, change of system functionality during the flight, needed re-configurability, usage of radiation immune components like ASICS and SRAM FPGAs, wide usage of popular interfaces to decrease the design effort and costs. Yet, the COTS components are radiation verified. The fundamental requirement of the system is the highest possible availability. Components of this fundamental requirement are: reliability, dependability, radiation endurance, multiple switchable functionalities, availability of own housekeeping and state monitoring, etc. A construction work is going on a universal pre-flight prototype called URSA. URSA uses antifuse FPGA and JTAG reconfiguration. Has an extended diagnostics and self-diagnostics capabilities including tracing of early wrong process and failure syndromes. It reports malfunction, performance and functional state to break down analysis block. In a case of need the decision block acquires new configuration changing or not changing the system functionality. The SRAM and RAM memories are under constant verification. Leon3 processor was used to run user software. It checks the functionalities of the Central Module of the Spacecraft, which is responsible for telemetry. URSA, which is a reconfigurable high speed digital processing platform with standard interfaces, in its pre-flight configuration, undergoes standard space-grade electrical tests, functional tests for all available FPGA configurations, thermal-vacuum chamber tests and vibration tests. The system passed typical acceptance tests for satellite equipment. Now it is subject to system level radiation tests including SEU, SEL and TID. The possible improvements include usage of larger antifuse FPGA and daughter boards.

Reliable AI based Power supplies for satellites

Onboard a satellite there is a need for several voltage levels. Different voltage values are provided by space-grade DC-DC converters, which are electronic circuits which convert a source of DC from one voltage level to another. It belongs to a class of power converters. There are linear and switching converters. The DC source on a satellite are batteries and solar panels. The following voltage levels are needed onboard a satellite: 7V for a heater, 5V for X-ray sensor, 24V for antenna, 3.3V for electronics, 12V for a gyro. Satellite technology uses digital DC/DC converters, which have some advantages over analog ones: more reliable and stable in changing temperatures, less sensitive to aging and components degradation, increased resistance against radiation by using EDAC algorithms, smaller size, reduced mass, potentially smaller power consumption, , possibility to use adaptive algorithms and optimization techniques. Digital DC/DC adaptability can: reduce the problem with phase lag leading to low phase margins, allow switching the controller from DCM to CCM and vice versa, optimize the converter by updating controller parameters depending on operating conditions, increase the system resistance to degradation and damage. Digital DC/DC converter consists of analog part – filters, drivers and switches and digital part – ADCs, compensator, and DPWM. Digital converter is a modular device and was implemented for a constant 50% duty cycle output.. Cross line detector estimates the moment when the current slope crosses the calculated control value for current mode implementation. DCM/CCM crossing detection unit changes PID parameters when converter enters or leaves the DCM or CCM. GUI unit serves as an user interface allowing the user to set the controller parameters, output voltage level and ADC word length. OV unit detects overvoltage condition and switches the converter off. Reset switches on and off and resets other modules.

AI module synchronizes other units by sending requests to them in the right order. ADC unit is an interface for ADC converters. Filter module unit provides a simple digital filtering of the input data. Reference module calculates the error signal that is a difference between requested output voltage and its actual value. STD PID is a digital implementation of a PID controller with added high frequency pole. DWPM unit is a digital implementation of PWM with 5ns resolution. Digital DC/DC converters have two main drawbacks: increased jitter because of ADC noise and phase lag due to time delays between making a measurement of the output voltage and application of control effort in the power control stage. The delay results in the open loop frequency response of the converter as a rapid phase decrease for higher frequencies (phase roll-off). The converter bandwidth has to be limited by decreasing the crossover frequency, in order to keep phase margin at a desired margin. The limited bandwidth of the converter results in its larger transit response. Digital DC/DC converters suffer some problems while CCM/DCM border crossing. DCM converters have lower gain than CCM ones. DCMs exhibit lower efficiency under higher loads. The phase margin is increased by flexible voltage sampling. Implementation of DCM/CCM border crossing detection and automatic change of controller parameters (increase in the bandwidth) results in a possibility to change the frequency response of the device after it enters into different work mode. The device is equipped in the following features: detection of degradation or failure of the output power stage, automatic switching from the current to the voltage work modes, overvoltage protection by applying additional crowbar circuitry for fast dumping the energy gathered in the power stage.

Reconfigurability of the onboard satellite equipment

One of the key factors in space applications of photonic and electronic circuits is the ability of dynamic partial FPGA reconfiguration. During such configuration it is to define reconfigurable partition boundary, fit-check all modules and generate. Proxy logic is done automatically while decoupling logic is done by the user. The outcome of this process is a set of bit streams: static, modules, full and black boxes. Process is started by the need for new functionality and freeing some resources to cover partial reconfiguration. Process is also started by detecting a malfunction, and isolation of the faulty module – fault mitigation. The function is moved to a new place in the matrix. A very good area for testing of partial reconfiguration are vendor DevBoards. The reconfigurability test setup consists of test monitor, input and output ports located on a PCB and source, sink and at least two areas in FPGA serving as reconfigurable partitions. The functionality can be switched back and forth. The question remain open if one can efficiently mitigate faults (radiation induced) in FPGA fabric by fast (blind or smart) scrubbing.

Image sensor tester for satellite telescopes

An universal image sensor tester was build as a platform for laboratory purposes for CCD matrices characterization. The purpose is to enable setting of proper operating points for matrix pixels, searching for bad pixels, lines, characterize distribution of sensitivities. Such a low cost tester is an invaluable tool for compensation of CCD characteristics, when the CCD matrix is used for measurement purposes like making spectral characteristics of unknown sources, also for astronomical applications. The key components of the CCD tester are: a wide range of efficient linear regulators, high speed CMOS drivers for charging/discharging the CCD capacitances, four-state high-voltage digital switches of three voltage levels and high impedance, digital I/O compatible with 5V and 3.3V CMOS work voltage levels, SPI and I2C buses, precision thermal controller made of Peltier modules with temperature stabilization, fast CDS and S&H video ADCs, LVDS interfaces, camera link, fast and efficient data converter implemented in FPGA, dedicated GUI at a PC.

5. PI OF THE SKY ASTRONOMICAL TELESCOPE NETWORK

Pi of the Sky is a network of robotic optical telescopes. The webpage of the project is: http://grb.fuw.edu.pl. The telescopes and the project is run by a collaboration consisting of FUW, Warsaw University Astronomical Observatory, NCBJ, CAMK and WUT. All telescopes operate fully autonomously , without human intervention. Currently there are two telescopes. Working prototype apparatus is in San Pedro de Atacama SPDA in Chile. It was moved from ESO LCO (European South Observatory, Las Campanas Observatory) in Chile where it worked for several years. The first telescope of the final system is located in INTA El Arenosillo test centre in Mazagon near Huelva Spain. Towards the end of 2012 there will be mounted three new units in the INTA location. The third observation site will be located near Malaga. Pi of the Sky research program embraces the following observations, measurements and cataloguing of: changing stars, transient astronomical processes, gamma ray bursts GRBs, gravitational waves detection, optical counterparts to other astronomical phenomena, cosmic rubbish, spectral analysis of bursting sources, photometric analyses of measured astronomical data, using parallax for measurements.

Photometric analysis of Pi of the Sky data

Pi of the Sky has gathered a lot of measurement data from optical observations at two locations in Chile LCO and SPDA and two locations in Spain INTA and Malaga. The stream of astronomical data acquired by Pi of the Sky telescopes is too big to be fully processed. It has to be reduced on-line and off-line, prior storing them for further analysis. On-line data reduction includes: flash recognition in real time analysis frame by frame; dark frame subtraction; fast photometry including numerical filter; comparison with reference image taken from series of previous images. Off-line data reduction includes: algorithms optimized for data reduction; adding 20 subsequent frames; dark frame subtraction; multiple aperture photometry (ASAS), astrometry, normalization to V magnitudes from TYCHO catalog; cataloguing of raw data to the database. Additional analysis is done by multilevel selection system to reject strong background like – fluctuations, hot pixels, cosmic ray hits, satellites. Photometry accuracy is significantly improved after removing bad quality data. Color correction and calibration algorithm is added to image improvement procedures. The assumptions are: no filters were used in cameras, detector response is correlated with the star spectral type B-V or J.K, catalog stars measurements are corrected for spectral type (R.Opiela, CFT PAS). To improve the data quality, a dedicated system of filters was build to mark bad measurements or frames. The data quality improvement procedure is applied to new data together with cataloguing procedure. Additionally the data quality is improved by applying approximate color calibration algorithm based on the spectral type of catalog stars. Statistical method was developed, taking into account all stars in the frame, allowing to reject bad quality exposures. The accuracy of photometry is increased to the level of 0,01-0,03, by applying the new frame selection algorithm. A dedicated analysis of selected objects leads to further improvements of the measurement results. Quality of the data is good enough for research purposes.

Parallax in the Pi of the Sky project

Primary aim of the Pi of the Sky is to search for transient flashes in the sky of unknown origin and to determine the parameters of such events, like position, time, duration, distance, etc. Usage of the parallax effect is the most direct method to determine a distance from the observer to the object. There are no special assumptions to measure the distance. What is needed for measurements: directions of the lines of sight from two places, angle between them and distance between these places – called the base. The bigger the base the deeper one sees into space. Parallax method has a lot of main limitations. The parallax angle gets smaller with the distance very quickly. Parallax can be used only for relatively close objects. To improve parallax based observations, more powerful telescopes or larger base, or both are needed. Pi of the Sky North Observatory in Southern Spain in INTA location is in use since October 2012 (A.Majcher, NCBJ, Swierk). The new design of equatorial mount is carrying four cameras, designed by SRC, PAS. Two observational modes are used Wide and Deep. Pi of the Sky South observatory in Northern Chile at SPdA location (located 740km North from LCO) is in use since March 2011. Since March 2011 Pi of the Sky is able to observe a parallax of objects close o Earth. It allows these two observatories to reject false triggers, mostly originating from artificial satellites, rockets and space debris elements.

The base is huge, almost 8500 km along the Earth's chord. It is possible to observe parallax from 25" to over 14^{o}. Combination with camera diagonal results in an observable parallax angle for objects more than 20600 km from Earth centre. For closer objects, the parallax angle exceeds the image size. Combination with diagonal of the pixel results in an observable angle for objects over 38 million km from the Earth centre. For farther objects the parallax angle is smaller then the pixel size. Between these two limiting distances the system allows for observations of: geostationary and GPS satellites, space debris, the Moon, near Earth comets, planetoids, etc. The third Pi of the Sky observatory will be located in Southern Spain near Malaga, a distance around 249 km from INTA. Two Spanish Pi of the Sky observatories allow for observations of objects between 6800 and 870000 km from the Earth centre. LEO (low Earth orbit) objects, like ISS, HST and other, will be available for these observations using parallax. If observations were performed at the same time, i.e. fully synchronized, it is possible to determine a straight line connecting the observations with the object, which are simply parameterized. Then the position of the center of the vector connecting positions of their smallest distance can be determined by simple geometrical measurements. Due to huge parallax the Pi of the Sky system observes precisely the parallax of geostationary satellites. Observations are done once or twice a night. Each observation lasts 90 minutes. Measurements are synchronized. The algorithm searches for flashes with maximal angular distance. Every flash candidate is verified in TLE NORAD satellites database. A list of candidates is published on the Pi of the Sky website. On the average, during 90 minutes of observations, Pi of the Sky telescopes record almost 3000 different satellites. It is possible to determine the distribution of difference between the satellite distances known from the TLE database and the distance R determined by the Pi of the Sky algorithm.

Pi of the Sky as a gravitational wave telescope

Pi-of the sky project of wide angle sky observations in the optical spectrum is used now for gravitational waves searches (A.Zadrozny, CAMK, PAN). Gravitational waves are still undetected. Some of detectable gravitational wave sources are expected to have EM counterpart. The pi-of-the-sky observations base on this assumption. Gravitational waves are assumed to come from binary coalescence and supernova explosions. Detection of gravitational waves base on large optical interferometers like LIGO. The method bases on locating and observing optical counterparts to un-modeled pulses. The involved experiments in the Looc-Up Project, for runs spanning from 2009 till now, are: TAROT North in France and Tarot South in Chile, QUEST - Chile, Swift, Skymapper, Pi of the Sky - Poland, ROTSE, PTF, ZADKO - Autralia, Liverpool, LOFAR and LUMIN. Lumin, for example is a system for very fast locating and positioning of an event on the sky with medium accuracy. The aim is to alert big telescopes for directed observations and for helping the operators to make decision about the observations. Now, Lumin sends up to one alert a day. The succession of work of Lumin is as follows: data generation and transfer, identify triggers, write to database, select triggers and determine positioning, send alerts to telescopes. The total latency is less than 30 minutes. The major contribution to the latency is by manual event validation. The models of the possible sources are: long GRB, long GRB off axis, short GRB, short GRB off-axis, supernovae, kilonovae, and other.

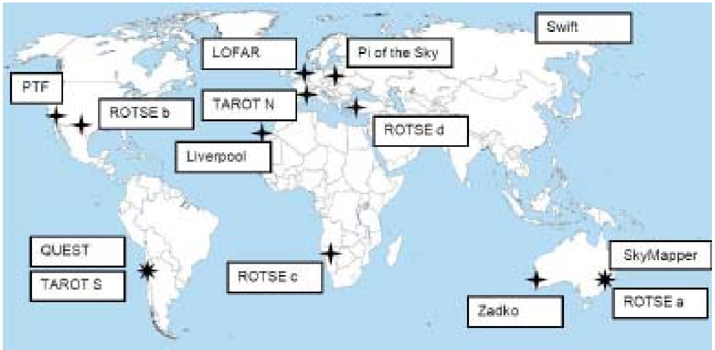

Fig. 2. Telescopes involved in Looc-Up Project

Pi of the Sky has four cameras with the FOV 20x20 deg, exposition time 10s, limiting brightness 12 mag, CCD 2Kx2K, observation site is near Warsaw. Catalog based pipeline is used for analysis. Guide Star Catalog with stars up to 11 mag is used as a seed for star catalog. For each exposition all recognized stars are added to the database with their brightness measurements. Normalization of brightness to V magnitudes is from TYCHO catalog. Transient search concerns: new objects that fulfill quality constraints, objects that suddenly increase their brightness. All transients are inspected manually. Objects that are suspected to be transients are cross-correlated with INTA (Spain) images (4 cameras), taken later than the science runs. Due to wide field view, with pi-of-the-sky system it is possible to image huge part of the sky within less than an hour. On-line transient recognition might be essential in science runs fro effective transient observation and recognition. The main aim of the project is to make externally triggered search connected with optical transients of unknown astronomical origin. Currently the data are available from the Pi-of-the-Sky telescope. These data include: 40 optical transients observed from the Las Campanas Observatory in Chile, 31 transients observed from San Pedro di Atacama (Chile). Most of these transients have duration of less than 10s. The sources are off-axis short GRBs or orphaned after glows from such GRBs, or some unknown astronomical events. Two sites of pi of the sky telescopes located away of 100 km from each other in Spain allow for using the parallax for effective measurements. Pi-of-the Sky project is part of two gravitational wave search projects: Loos-Up and Optical Transient ExtTrig Search. Published results from both projects are expected in 2013. Pi=of-the-Sky is the biggest FOV telescope that is taking part in gravitational waves search.

Pi of the Sky upgrade – Icinga

An advanced monitoring system is under construction for Pi-of-the-Sky experiment (A.Cwiek). The monitoring system will supervise all hardware and software, i.e. any device or service for which one is able to write a plugin that reads the parameters and returns them. What is monitored: each telescope, status of the dome, status of computers that support the telescopes, mount status, camera status like chip temperature, frame size, number of stars, astrometry. The slow control parameters are too many to be controlled manually for each telescope. The control requirements are met by Icinga. Icinga is a fork of Nagios and is backward compatible. It is an enterprise grade open source monitoring for network and network resources.. It notifies the user of errors and recoveries, generates performance data for reporting. It is scalable and extensible, can monitor complex, large environments across dispersed locations. It stores data in text files, MySQL, PostgreSQL, and Oracle. Icinga architecture consists of three components: Core, API, Web and common database IDOIDB (Icinga data out database). Icinga core manages monitoring tasks, receives check results from various plugins, communicates these results to the database. Icinga API fetches information from the core to the database and supports various interfaces from database PHP PDO output to pipe and SSH input. Icinga web is an online portal to view Icinga monitoring results and send commands to the core. Thanks to the loose bundling of Icinga core, web, API and database, these components can be distributed and connected by a switcg or any other intermediary. Such systems ensure that monitoring system itself is fail safe, so should one component fail out, it can be replaced without disturbing the system as a whole. The applied Icinga system allows to continuously monitor vital parameters of detectors and computers which control them in Pi of the Sky experiment. Icinga facilitates fast response to anomalies or failures in experiment performance. Automatic recording of parameters of all components of the Pi of the Sky experiment allows an efficient identification of possible causes of failures.

Global Robotic Telescopes Array - GLORIA AND LUIZA

Gloria is an FP7 project Global Robotic Telescopes Intelligent Array for e-Science [Gloria-project.eu]. Luiza is data processing system for Gloria. The coordinator of Polish participants is prof. F.A.Zarnecki of UW, Faculty of Physics. It gathers 13 partners and 17 robotic telescopes in Europe, Africa, South America and New Zealand. The project goals are: create free and open-access network of robotic telescopes for citizen science, to develop Web2 environment for easy access to telescopes and other network resources, design tools for doing on-line experiments – observations, and off-line analysis, develop full framework for doing research with robotic telescopes allowing also for easy integration with Gloria network, outreach in science and astronomy. The approach is based on earlier Cyclope project, located at Montegancendo Astronomical Observatory, UPM, Madrid. Data processing concept in the system is based on HEP experiments, like LHC or ILC, which gather enormous amounts of data. Marlin framework is developed for efficient data reconstruction, reduction and analysis. The aim is only relevant event building out of huge amount of data. Merlin is based on the following approach: data reconstruction and analysis should be divided into small, well defined steps, implemented as so called processes; each step has to have well defined input and output data structure; by defining universal data structures one makes sure that different processors can be connected in a single chain analysis allowing for data exchange and analysis results; processors configuration and their parameters can be set by user at run time in a simple steering file. The same concept is used in Luiza framework dedicated for Gloria. Efficient and flexible analysis framework for Gloria was developed based on HEP concept. Basic structure of tools were implemented, ready to work on Gloria experiments. First public version is available. First off-line experiments with Luiza are scheduled for September 2012.

Spectral characteristics of X-ray bursters

Spectral analysis allows astronomers to determine the mass and radius of a neutron star. In consequence, physics of super dense matter is revealed, as well as more precise models of neutron stars and binary stars can be created. The masses of neutron stars show strong concentration around 1.4 solar masses, at least for pulsars. Theoretically, the mass of a neutron star can be in the range of 0,1 – 3,0 solar masses. X ray busters were discovered in 1976 by Grindlay et al and Belian et al. These sources are neutron stars in interacting binaries. The companion star has low mass. The neutron star has a weak magnetic field. During decay of the burst the spectrum becomes softer, what is classified as type I of the burst. X-ray bursts are recurrent events but not strictly periodic. Time interval between the bursts are typically 10^4 – 10^5 s. Energy released per burst is around 10^{39} erg. The source of the X-ray burst is a thermonuclear flash. The burst spectrum spans in the area of 0 – 20 keV photons, with maximum from 5 to 7 keV. An example is MXB 1728-34 X-ray source discovered in 1976 during Uhuru sky monitoring. The data are: neutron star, atoll type, 4-8 h time between bursts, spin frequency 364 Hz, optical counterpart not observed, distance 4,2 – 5.1 kpc, no superbursts present. The assumptions for spectrum research were as follows (A.Majczyna, J.Madej, M.Nalezyty, NCNR, WUO). Analyzed spectra were integrated over 0,25s at the end of bursts. The model simplifying assumption is that the atmosphere is static with constant temperature. Accretion disk and flow was neglected. Only the neutron star atmosphere is a source of photons. The neutron star is non rotating. Magnetic field does not modify opacity coefficients. Relativistic corrections are not included in model atmosphere. F-f, b-f and b-b processes were included and Compton scattering. Photons are scattered on relativistic electrons with thermal velocity distribution. Large relative energy and momentum exchange between photon and electron is allowed during a single scattering event. Analysis of spectral characteristics with these assumptions allow for the determination of neutron star parameters, which are independent on the distance. The core radius can be determined without the radius of the emitting area. The best fit is obtained for the models with He/H=0,11, Fe/H=10^{-3}. One sigma confidence model gives approximately M= 0,1 – 1,5 M_s, R= 2 – 10 km. These parameters are in agreement with EOS of strange quark matter.

6. PHOTONICS AND ELECTRONICS APPLICATIONS

A number of session concerning the applications of photonic and electronic circuits and systems included work on particular engineering and technical solutions for various fields like: car industry, airborne industry, robotics, management of the road traffic, remote control methods for utility systems via the Internet, audio and video techniques, biomedicine, safety techniques, home appliances. A group of work concerned the development of a mobile platform for a universal robot equipped with advanced devices like cameras, grippers, Other group concerned the development of distributed measurement networks for minimum energy service of the network of self configuring environmental sensors. These sensors are expected to use a lot of energy harvesting.

7. CONCLUSIONS AND WILGA 2013

The WILGA May 2012 meeting was a fruitful event gathering young researchers from the fields of photonics and electronics systems. The 2013 Symposia on Photonics and Internet Engineering will be held on 24-27 January 2013 at WEiTI PW building in Warsaw and on 27.05 – 02.06 2013 in Wilga Resort by PW. The organizers warmly invite young researchers to present their work. The WILGA Symposium web page is under the address: http://wilga.ise.pw.edu.pl .

8. ACKNOWLEDGMENTS

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WILGA Symposium has produced more than 2500 articles, out of which over 1000 were published in Proc.SPIE. Several hundred of them are associated with the research activities of the PERG/ELHEP Research Group at ISE WUT. The Group is an initiator and major organizer of the WILGA Symposia. The paper was prepared using the invited and contributed presentations debated during Wilga 2012 May Edition. Some fragments of the text were quoted from these presentations and from session discussions.

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Wilga session on light sources and POLFEL, 28.05.2012, Chair dr Robert Nietubyć, NCBJ Swierk

Wilga sessions on Image Processing, Multimedia Technologies and Nonlinear Optical Fibres, 29.05.2012, Chairs prof. Władysław Skarbek (multimedia) IRE PW and prof. Mirosław Karpierz (optical fibers) WF PW.

Wilga session on Photonics and Electronics for High Energy Physics Experiments, 29.05.2012, Chair prof Janusz Marzec, IRE PW

Wilga session on Artificial Intelligence, 29.05.2012, Chair prof. Jan Mulawka, ISE PW

Wilga session on High Performance Computing, 30.05.2012, Chair prof. Stanisław Jankowski, ISE PW

Wilga Sessions on Biomedical Applications – Chair prof.Antoni Grzanka ISE PW and on Nanomaterials Technology – Chair prof Małgorzata Jakubowska, Mechatronika PW, 30.05.2012

Wilga Session on Space Applications, 31.05.2012, Chair dr Piotr Orleański, CBK PAN Warsaw, Book Exhibition organized by Oficyna Wydawnicza PW


Wilga Session on Optical Fiber Technology, 31.05.2012, Chair prof. Dominik Dorosz, Białystok University of Technology

Wilga Session on Photonics Applications, 01.06.2012, Chair prof. Ryszard Romaniuk, ISE WUT

A map of WILGA Village. Left down corner in Vistula River. Left middle are large fish ponds. Up is Wilga River flowing through Wilga Town (up from the fish ponds) to Vistula River. Wilga Town is 50 km South of Warsaw, up the Vistula River.