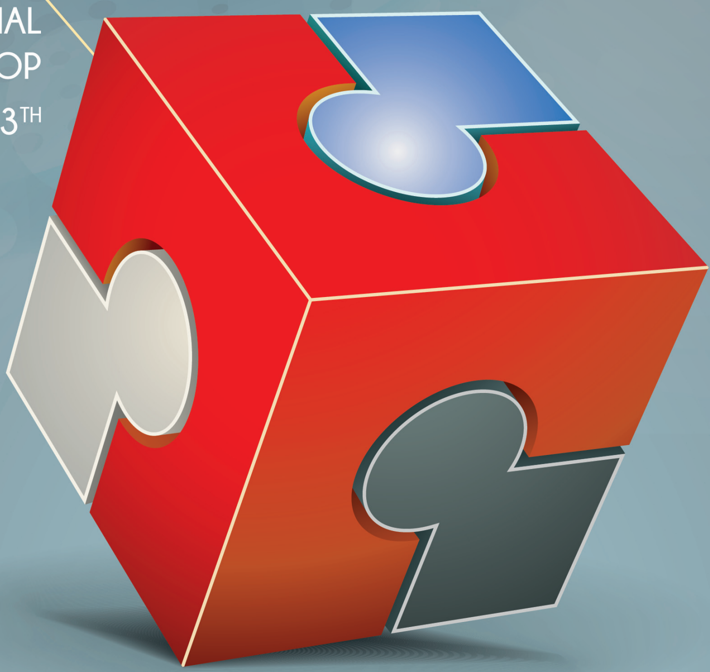
CENTRE SPATIAL UNIVERSITAIRE DE GRENOBLE

THE NANOSATELLITE WEEK

DU 21 AU 25 MARS
À GRENOBLE

THE FUTURE OF NANOSATELLITES

AN INTERNATIONAL WORKSHOP
MARCH 22ND AND 23TH



BOOK OF ABSTRACTS

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Grenoble INP

The Nanosatellite week : International Workshop on
The Future of Nanosatellites

Tuesday, 22nd

Time	SESSIONS	SPEAKERS
9:00	STATE-OF-THE-ART Chair : M. Bathelemy	Opening: F. Dufour / P. Levy
9:15		Opening: G. Fioraso
9:30		NASA JPL: John D Baker
10:00		CNES: Jean-Louis Monin
10:30		CNES: André Laurens
10:45		discussion
11:00	COFFEE BREAK	
11:30	SCIENCE OBJECTIVES Chair : E. Kerstel	Royal Obs Belgium: Ozgur Karatekin
12:00		IQOQ Vienna: Rupert Ursin
12:30		IPAG: Etienne Le Coarer
12:45		discussion
13:00	LUNCH	
14:00	EDUCATION Chair : J. Tantet & E. Kerstel	SSC-EPFL: Volker Gass
14:30		IRAP: Antoine Ressouche
15:00		ISAE-Supaero: Benedicte Escudier
15:30		LAM: Bernard Repetti & discussion
15:45	COFFEE BREAK	
16:15	SOCIETAL RELEVANCE Chair : M. Barthelemy	S-3.ch: Ntorina Antoni
16:45		EPFL: Muriel Richard-Noca (Cleaning)
17:00		UPMF: Thierry Ménissier
17:30		discussion
18:00	END	

Wednesday, 23th

Time	SESSIONS	SPEAKERS
9:00	EMERGING TECHNOLOGIES Chair : A. Gardelein	ESA Noordwijk: Fabrice Cipriani
9:15		G-INP: Florence Maraninchi
9:45		Hyperion: Steven Engelen
10:15		E2V: James Endicott
10:30		ONERA: Nicolas Guerineau
10:45	COFFEE BREAK	
11:15	EMERGING TECHNOLOGIES Chair : F. Maraninchi	PMOD: Wolfgang Finsterle
11:30		Air Liquide: Aurelien Moureau
11:45		SOItec: Eric Guiot
12:00		EPFL: Muriel Richard-Noca (QB50)
12:15		CSUG: Mathieu Barthelemy
12:30		discussion
12:45		UGA: Lise Dumasy
13:00	LUNCH	
14:00	BUSINESS MODELS Chair : TBA	GEM: Sylvie Blanco
14:30		ISISpace: Jeroen Rotteveel
15:00		discussion
15:15	COFFEE BREAK	
15:45	SCIENCE OBJECTIVES Chair : M. Barthelemy	MSU: Vladimir Kalegaev
16:00		MSU: Vladislav Osedlo
16:15		Obs Paris Meudon LESIA: Carine Briand
16:45		IPAG: Evelyne Alecian
17:00		Workshop synthesis
17:15	Jacqueline Tantet & Nathalie Martino: Feedback on Workshop Organisation and Contents	
18:00	END	

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A visible échelle spectrometer for the monitoring of stars in space

Evelyne Alecian * [1,2]

[1] Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) – OSUG, INSU, CNRS : UMR5274, Université Grenoble Alpes – 414, Rue de la Piscine BP 53 38041 Grenoble Cedex 9, France
[2] Laboratoire d'études spatiales et d'instrumentation en astrophysique (LESIA) – Université Pierre et Marie Curie [UPMC] - Paris VI, Observatoire de Paris, INSU, CNRS : UMR8109, Université Paris VII - Paris Diderot, Université Pierre et Marie Curie (UPMC) - Paris VI – 5, place Jules Janssen 92190 MEUDON, France

The dynamic of the close environment of young stars, how they accret mass from their protoplanetary disk, how they interact with their disk and forming planets are still a mistery. To make progress we need to perform dense monitorings of these objects. While recent spatial missions, like COROT or Kepler, performed such monitorings in photometry, and allowed a better understanding of these objects, we need to go further by doing dense monitorings of high-resolution spectra. Such monitoring can only be made from space. I will present the technical challenges to send in space a visible échelle spectrograph fitting in a cubesat, as well as the significant scientific progress such a mission can promise.

*Speaker

Legal Aspects of Nanosatellites

Ntorina Antoni *† [1,2]

[1] Attorney at Law, Athens Bar Association – Greece
[2] In-house Counsel, Swiss Space Systems Holding SA – Switzerland

The major concerns that arise from nanosatellite missions derive from the risks related to space debris creation and in-orbit collision. At the altitude of 650 and above natural orbital decay decreases, and, as a result nanosatellites remain in orbit longer than the life expectancy they are designed for. Their inability to manoeuver and their very small size could pose an imminent risk not only to the mission itself but also to other space objects that cannot exercise debris avoidance manoeuvres without having exact information of the location. The aforementioned risks might be multiplied and, thus, intensify the problem in case nanosatellites are launched in constellations. In order to mitigate these risks, it is imperative that the private industry collaborates with the governmental authorities in order to ensure that the missions are in compliance with the United Nations Space Treaties and Space Debris Mitigation Guidelines. Adeherence to the body of space law provides for a sustainable development of space activities with a responsible behavior of private and public actors, in the interest and benefit of the international space community.

*Speaker
†Corresponding author: ntorina.antoni@s-3.ch

A Future for Planetary SmallSats/CubeSats - JPL

John Baker * [1]

[1] Jet Propulsion Laboratory (JPL) – 4800 Oak Grove Dr, Pasadena, CA 91109, United States

The presentation is about the cubesats and smallsats JPL is developing and creating for the future that allow for high priority science to be performed for NASA. The presentation will also discuss what capabilities we are developing and what we are learning and future directions.

*Speaker

Reshaping business models to create techno-based opportunities

Sylvie Blanco * [1]

[1] Grenoble Ecole de Management (GEM) – Grenoble École de Management (GEM) – 12 Rue Pierre Sémard 38000 Grenoble, France

Looking at innovation failures and successes shows the importance of reshaping business models beyond technology, products and services. Relying on a simplified conceptual framework, we present a short series of examples from vehicles to health and smart cities with the aim to better understand the emergence of new business model archetypes and the power of recombining existing patterns. As conclusion, the potential value and the challenges associated to new business models are introduced.

*Speaker

Nano-sat and space weather : from scientific to operational

Carine Briand * [1]

[1] Laboratoire d'études spatiales et d'instrumentation en astrophysique (LESIA) – Université Pierre et Marie Curie [UPMC] - Paris VI, Observatoire de Paris, INSU, CNRS : UMR8109, Université Paris VII - Paris Diderot, Université Pierre et Marie Curie (UPMC) - Paris VI – 5, place Jules Janssen 92190 MEUDON, France

Space weather can be understood as " The physical and phenomenological state of the natural space environment, including the Sun and the interplanetary and planetary environments", or " The discipline which aims at observing, understanding and predicting the state of the Sun, of the interplanetary and planetary environments, their disturbances, and the potential impacts of these disturbances on biological and technological systems", following the WMO definition.
The physical processes taking place in the space environnement of the Earth are fundamentally 3D, plus time. Building reliable forecast models thus requires a good knowledge of this multi-dimensional space. The nano-sats plateforms are thought to provide a good opportunity to obtain the measurements, in the scientific and operational fame.
Several nano-sat based missions have been launched in the last years to study the space environnement of the Earth. During this presentation, a summary of these missions will be presented. This will highlight the scientific fields not or maginally covered by the missions. Also some aspects of operationnal services based on nano-sat missions will be discussed.

*Speaker

Space Situational Awareness and nanosatellites at ESA

Fabrice Cipriani * [1]

[1] Fabrice Cipriani (ESTEC/TEC-EES) – Keplerlaan 1, 2200AG, Noordwijk, Netherlands

to be updated

*Speaker

CleanSpace One: Using nanosatellites to clean space debris

Simon Dandavino * [1], Muriel Richard† [1]

[1] EPFL Space Engineering Center (eSpace) – Swiss Federal Institute of Technology EPFL ENT ESC PPH 334, Station 13 CH - 1015 Lausanne, Switzerland

With several thousand pieces of debris in Low Earth Orbit, and already multiple debris-generating collisions, the problem of space debris can no longer be ignored. Whether we have already reached the Kessler syndrom, in which cascading collisions render entire orbits inaccessible, can be debated.
The CleanSpace One (CSO) project, led by EPFL, aims to demonstrate the technologies required to actively remove debris from Low Earth Orbit.. The microsatellite (_~80kg) will integrate the latest in miniaturised sensors, on board guidance, navigation and control, and micropropulsion. The project is complentary to ESA's Cleanspace initiative due to its disruptive usage of small satellite components and philosophy. Following the CubeSat mentality, CSO will use off-the shelf components, a streamlined integration and test methodology, and rely more heavily on automated actions and decisions.
In this talk, the most recent developments on CSO will be presented, with particular focus on the physical capture mechanism.

*Speaker
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Beta Pictoris transit with PicSat

Lester David * [1], Sylvestre Lacour [1], Lapeyrere Vincent [1], Jonathan Tanrin [1], Mathias Nowak [1], Alain Lecavelier Des Etangs [2], Guillermo Martin [3]

[1] Laboratoire d'études spatiales et d'instrumentation en astrophysique (LESIA) – Université Pierre et Marie Curie (UPMC) - Paris VI, Observatoire de Paris, CNRS : UMR8109, Université Paris VII - Paris Diderot – 5, place Jules Janssen 92190 MEUDON, France

[2] Institut d'Astrophysique de Paris (IAP) – Université Paris VI - Pierre et Marie Curie, INSU, CNRS : UMR7095 – 98bis, bd Arago - 75014 Paris France, France

[3] IPAG – OSUG, CNRS : UMR5274, Université Grenoble Alpes – 414, Rue de la Piscine, 38400 St-Martin d'Hères, France

The PicSat mission is based on a 3U Cubesat architecture, with a payload specifically designed for high precision photometry. The satellite is planned to be launched in mid-2017, on a 650 km Sun synchronous orbit. The main objective of the mission is the constant monitoring of the brightness of Beta Pictoris.
This star is an A6V star of V magnitude 3.86 which, due to its proximity (63 ly from Earth) and young age (20 Myr), has always been a most promising target for the study of circumstellar environment and planetary systems. In 2003, β Pictoris b, a young Jupiter like giant exoplanet, was directly imaged around this star. Its orbit was latter characterized using multiple astrometric position measurements acquired from 2009 to 2015, and it is now strongly suspected that this is a transiting exoplanet, with a next transit event expected for late 2017 or early 2018. This represents a unique window of opportunity to finely characterize a young giant exoplanet and its close environment (Hill sphere) in front of a bright star.

The payload is designed with a 35mm effective aperture and a single pixel avalanche photodiode. A single-mode fiber is used to guide the stellar light from the focal plane to the photodiode. To guarantee photometric precision and CubeSat stabilization, the three-axis Attitude Determination and Control System is complemented with a two-axis piezoelectric actuation system. Driven by a tailor-made feedback loop control algorithm, the piezo stage is used to lock the fiber on the center of the star in the focal plane. The piezo stage follows the maximum intensity of the signal in the focal plane to compensate the jitter of the pointing system.

*Speaker

Current and future e2v image sensors used in nanosatellites

James Endicott * [1]

[1] E2V Semiconductors SAS [Saint-Egrève] (E2V) – e2v – Avenue de Rochepleine BP 123 38521 Saint-Egrève Cedex, France

Nanosatellite applications have moved from the experimental to the commercial domain. Whilst many still use the platform for development and education, there are a number of companies refining the key systems of standard satellites, but on a significantly reduced scale for commercial, scientific or even military exploitation. e2v's industrial image sensors have been adopted for nanosatellite and microsatellite systems. This talk aims to give an overview of that technology, highlighting the new developments in both the industrial and Space imaging sectors that could match the features required for nanosatellites.

*Speaker

Advanced attitude control for nanosatellites

Steven Engelen *† 1

1 Hyperion Technologies (Hyperion) – Motorenweg 5L 2623 CR Delft, Netherlands

Advanved nano-satellite missions depend either on the level of sophistication of their hardware, or on the revolutionary way of using existing or simple payloads. This presentation takes a look at what current high-end hardware, with a focus on attitude determination and control, can do for advanced nano-satellite missions in the near future. Some technical and physical limits hindering further improvements will be discussed, identifying room for improvement before those limitations put a stop to miniaturisation.

*Speaker

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CLARA - A compact and light-weight absolute TSI radiometer

Wolfgang Finsterle * [1]

[1] PMOD/WRC – Dorfstr. 33, 7260 Davos Dorf, Switzerland

The Compact and Lightweight Absolute Radiometer CLARA will be launched in April 2016 on the Norwegian NORSAT-1 mission. CLARA is an electrical substitution radiometer for TSI measurements. It is based on a new design with three cavities to offer built-in redundancy and degradation tracking capability while minimizing size and weight. NORSAT-1will be the first space mission to carry a CLARA-type radiometer. The CLARA radiometer has been characterized and calibrated against the World Radiometric Reference (WRR) in Davos, Switzerland and the TSI Radiometer Facility (TRF) at LASP in Boulder, CO. We will presrent the new design features and the results of the characterization and calibration experiments.

*Speaker

Nanosatellites as Educational Tools?

Volker Gass * [1]

[1] Ecole Polytechnique Federale Lausanne (EPFL) – EPFL, PPH 339, Station 13 CH-1015 Lausanne, Switzerland

After a short introduction about the Swiss Space Center, the presentation will address ESA' status regarding CubeSats and then focus on the educational aspects related to the development of such a satellite using the experience of SwissCube as example. SwissCube, the first Swiss satellite, was designed, built, launched and operated by a team from the Swiss Federal Institute of Technology (EPFL) with a participation of over 200 students. Launched in 2009, it is today still operating.

*Speaker

Compact and high-performance infrared sensors compatible with nanosatellites : designs and laboratory prototypes.

Nicolas Guerineau * [1], Etienne Le Coarer† [2], Sébastien Verdet [3]

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[2] Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) – OSUG, Université Joseph Fourier - Grenoble I, INSU, CNRS : UMR5274 – 414, Rue de la Piscine BP 53 38041 Grenoble Cedex 9, France
[3] SOFRADIR – SOFRADIR – 364, route de Valence - Actipole - CS 10021 F-38113 Veurey-Voroize, France

There is an emerging demand for compact and high-performance infrared imagers for remote sensing applications from small platforms like UAVs or nanosatellites. "Compact" means SWaP sensors (Size, Weight and Power) with a scope of (1 liter, 1 kg and 1W). "High-performance" stands for infrared imagers based ideally on cooled detectors and cryogenic optics. For a system engineer, designing a compact (or "micro") infrared and cryogenic system is challenging. To reach this goal, technological barriers have already been overcome, leading to the development of infrared focal plane arrays (IRFPA's) of high performances, with large (megapixel) formats and packaged in compact dewar configurations (called Infrared Detector Dewar Cooler Assembly, IDDCA). Ultimately, it would be ideal if the entire infrared system could be reduced to the size of the IDDCA. For several years, the immediate neighborhood of the IRFPA was inaccessible for the optical engineer. Adding optical elements in the dewar could have disturbed the fine IDDCA architecture, fruit of much research work, result of several design improvements. This risk can be overcome if we can integrate simple optical designs, highly compatible with the existing IDDCA. Our approach is based on our skills developed during the last decade in the field of cooled infrared instrumentation for military applications. In particular, our lab is referenced by the French MoD as expert in the field of IRFPA's electro-optical characterizations. Beyond these experimental works, new solutions of infrared micro-systems have been invented. We will review the different optical designs of compact infrared imagers we have proposed, from single axis cameras to multiple channels concepts dedicated to infrared mono-, multi- of hyper-spectral imagery. Different demonstrators of infrared micro-cameras have already been made and tested. We will present and discuss the performances of these prototypes of cryogenic infrared micro-cameras.

*Speaker
†Corresponding author: Etienne.le-Coarer@obs.ujf-grenoble.fr

Operational control of the radiation conditions in the near-Earth's space on the base of multi-satellite measurements

Vladimir Kalegaev * [1], Vladislav Osedlo [1], Mikhail Panasyuk [1], Mikhail Podzolko [1]

[1] Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University (SINP MSU) – 119991, Moscow, GSP-1, Leninskiye Gory 1(2), Russia

The practical human activity in space and on the Earth surface (particularly in the polar and auroral regions) is exposed to space weather risks associated with solar and geomagnetic activity. Radiation conditions are among the most dangerous factors of space weather. Cosmic rays, solar energetic protons and radiation belt particles poses a major hazard to satellites. Trapped relativistic electrons can penetrate spacecraft shielding leaving their energy and charge embedded inside spacecraft devices. Ionizing dose and internal discharges are the main results of such interaction. Energetic protons and heavy ions cause dose and damage like electrons, but also cause single event effects through direct ionization, or through cascades, they create in spacecraft material. Operational control of radiation conditions in space by multi-satellite measurements and real-time data acquisition is very important for space operations. Space Monitoring Data Centre (SMDC) of Moscow State University provides mission support for Russian satellites and give operational analysis of radiation conditions in space. SMDC Web-resources (http://smdc.sinp.msu.ru/ and http://swx.sinp.msu.ru/) and operational services describe the geomagnetic and radiation state of Earth's magnetosphere in near-real time. Quality of such information depends on the data flows that coming from spacecraft. Micro- and nanosatellites give opportunity to expand significantly the total data amount allowing the more exact description of space radiation environment. This research was supported by Russian Science Foundation (Project No 16-17-00098)

*Speaker

Nanosatellites: the current state of thinking in CNES

André Laurens * [1]

[1] Centre National d'Etudes Spatiales (CNES) – CNES – 18, avenue Edouard Belin 31401 TOULOUSE Cedex 9, France

Considering the popularity gathered by nanosatellites during the 10 last years, and the fact they have conquered "professional" domains of space activity due to their low cost and ability to set up a mission in a very short time, CNES has conducted a pre-positioning study to shed light on the actual missions that could benefit from this new kind of spacecraft, on potentially new (or original) mission or space system concepts they could help to create, on organizations and project management practices adapted to nanosatellite projects.
This talk proposes to share the conclusions of this study: nanosatellites for what to do? Cubesats or not cubesats? What can/cannot they do? Is there a nanosatellite development spirit? How much does it cost really? Which are the accessible or relevant uses? Which are their limits and outstanding issues?

It will focus on promising concepts which nanosatellites seem to make affordable – swarms, constellations, mothership/daughterships – and the questions they raise on exchanging individual performance (resp. reliability) for system-level capabilities (resp. resilience), on evolution of operation concepts towards autonomy and in-space networking, on overall (including launch) cost "balance sheet".
The talk will conclude on CNES perspective on nanosatellite usage and ongoing studies.

*Speaker

Science objectives opened by new detectors developed by Grenoble labex FOCUS

Etienne Le Coarer *† 1

1 Institut de Planetologie et d'Astrophysique de Grenoble (IPAG) – Université Grenoble Alpes, CNRS : UMR5274 – Universite Grenoble Alpes/CNRS-INSU 414 rue de la piscine, Batiment D de physique BP 53 38041 Grenoble cedex 9, France

Over the pas several decades Grenoble has become an important developper of visible, infrared, and millemetre wavelength light detectors. The latest evolution in this field permits us to imagine new compact instruments. In the visible domain, the first CSUG satellite mission (ATISE) will use a sub-electron CMOS with very low power consumption. In the milimetre wavelength range, the PACS sussessors and new KIDS detectors should benefit from miniaturised cryostats. In the infrared, the most challenging developpement adresses the detection of entangled photons in the mid-infrared with spectacular MCT avalanche photo diodes. With an excellent quantum efficiency and low amplification noise these detectors greatly improve multiphoton detection.

*Speaker

†Corresponding author: Etienne.Le-Coarer@univ-grenoble-alpes.fr

Resource-constrained Real-Time Embedded Software and Systems

Florence Maraninchi * [1]

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Embedded software and systems are already everywhere (in nuclear power plants, smart grids, pacemakers, cars, trains and subways, planes, rockets and satellites, etc.). Most of these contexts are said to be safety-critical: a failure can cause human injuries or death, or severe environment damage. Others might be "only" business-critical: a failure costs a lot of money. To guarantee a very low probability of failure, the most critical systems are based on costly hardware redundancy, dedicated software development methods, and costly validation methods.

Nanosatellites are not safety-critical, and probably not as business-critical as big commercial satellites. Moreover, they are highly resource-constrained (energy consumption, memory, computing power). These observations could lead to choose cheap solutions. However, given the development time and the cost of the launch procedure, failures should be avoided.

We advocate the idea that the development of embedded software and systems for nanosatellites should try and benefit from the accumulated experience on the development of more critical systems; a key problem is to understand which constraints can be relaxed, and which level of quality can be obtained at a reasonable cost.

*Speaker

New components for electric propulsion

Aurélien Moureaux *† [1]

[1] Air Liquide Advanced Technologies (AL-aT) – L'AIR LIQUIDE – France

Electric Propulsion is a major breakthrough in platform architecture, reducing dimensions and mass, modifying daily operation program and orbit raising program. Electric propulsion is now used for all range of satellites, from scientific missions to telecom bus, from nano-satellites to 6 tons platforms, from one time project to constellations. Propulsion subsystems are very conservative in their way of handling propellant and delivering it to thrusters. Components developed for SatComs are heavy and costly, not adapted to nanosatellites. A completely new approach should be studied to develop components for nanosatellites. Air Liquide Advanced Technologies has developed two breakthrough components for propulsion subsytems.

*Speaker

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Development of multispacecraft system for radiation monitoring

Mikhail Panasyuk [1], Ivan Yashin [1], Mikhail Podzolko *† [1], Alexandr Kovtyukh [1], Ivan Brilkov [1], Vladimir Kalegaev [1], Vladislav Osedlo [1], Vladimir Tulupov [1], Natalia Vlasova [1], Oleg Grafodatskiy [2], Sergey Ishin [2], Sergey Lemeshevskiy [2], Sergey Teselkin [2]

[1] Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University (SINP MSU) – 119991, Moscow, GSP-1, Leninskiye Gory 1(2), Russia

[2] Lavochkina Research and Production Association (NPO Lavochkin) – 141400, Khimki, Moscow Region, Leningradskaya st. 24, Russia

The fluxes of energetic particles near the Earth pose a significant radiation threat to spacecraft electronic. At the same time the fluxes of particles in Earth's radiation belts even during geomagnetically quiet conditions experience mid- and long-term variations within several orders of magnitude. Therefore using the existing static empirical models of Earth's radiation belts to estimate radiation conditions in spacecraft orbits is not always appropriate.
For that reason Skobeltsyn Institute of Nuclear Physics of Moscow State University (SINP MSU) is developing a system of small spacecraft for operative (close to "real time") monitoring of radiation conditions in the near-Earth's space.

Several small spacecraft with a mass of < 50–100 kg should be launched to different circular orbits or a specifically selected elliptical orbit, crossing the wide range of magnetic drift shells at different altitudes; measure fluxes of energetic electrons and protons by multidirectional detectors; and promptly transmit the data of measurements to the ground using satellite retranslation systems. In the ground data-center on the basis of these data the distribution of particle fluxes in the whole Earth's radiation belts (up to GEO) will be computed. Finally the end-user will be able to access the data center by the web and find out current radiation conditions in the near-Earth's space or in a particular orbit.

Other applications of received experimental data will be: developing the new (possibly dynamical) Earth's radiation belt models, and studying the problems of Earth's magnetosphere physics.

For placing satellites into orbit it is planned to take advantage of accompanied launch by "Soyuz" rocket with "Frigate" upper stage developed by NPO Lavochkin, for example during launch of main payload into "Molniya"-type orbit. Alternatives are using the light-class space rocket or rising from LEO by using compact electric rocket engine.
Currently the first research stage of this project is being carried out under the contract with Ministry of Education and Science of Russia, during which the optimal spacecraft orbits and detector construction and placement are being determined.

*Speaker

†Corresponding author: spacerad@mail.ru

Aix-Marseille University NanoSat

Bernard Repetti * [1]

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Presentation of CASAA-Sat, Aix-Marseille University and LAM 2U Nanosat

*Speaker

Quantum communication on a mini-satellite platform

Rupert Ursin * [1], Matthias Fink

[1] IQOQI-Vienna, Austrian Academy of Sciences – Austria

Quantum communication offers possibilities for long-distance quantum key distribution (QKD) and experimental tests of quantum entanglement. The recent small-scale satellite developments are a promising avenue by which a cost effective implementation of LEO-based quantum communication platform becomes realizable. Here, we outline a feasibility study performed for the Austria Research Fund, to perform ground-to-orbit transmission of entanglement and QKD using a mini-satellite platform. This ambitious mission exploits modern advances in attitude control systems and tracking sensors, polarization optics and singe-photon detectors at a small form factor and low power consumption.

*Speaker

InP based engineered substrate enabling record efficiency and radiation hard space solar cells

Guiot Eric * [1]

[1] SOITEC – Soitec – Parc Technologique des Fontaines, 38190 Bernin, France

Multiple-junction solar cells made from III-V compound semiconductors are delivering the highest solar-electric conversion efficiencies. Increasing the number of junctions offers the potential to reach higher efficiencies. Direct wafer bonding offers a unique opportunity to combine lattice mismatched materials through a permanent, electrically conductive and optically transparent interface. In addition, the use of Smart Cut TM technology, associated with its material recycling capabilities allows from a cost perspective the use of expensive bulk material such as InP. Combination of both technologies opens new opportunities to deliver cost effective high efficiency solar cells. In this respect, we have been able to demonstrate a record efficiency of 46,0% with a wafer bonded 4-junction GaInP/GaAs//GaInAsP/GaInAs concentrator solar cell. This same solar cell has a potential of 35% under AM0. In addition to this record efficiency, access to In and P reach junctions open the route to radation hard solar cells. In parallel the developed engineered substrate give access to ultra thin solar cells.

*Speaker

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- Motte Frédérique
- Moureaux Aurélien
- Niot Jean-Michel
- Novakov Emil
- Nowak Mathias
- Osedlo Vladislav
- Pancher Fabrice
- Parmar Mitesh
- Parra Jean-Marc
- Podzolko Mikhail
- Portolan Michele
- Possamai Bastos Rodrigo
- Rafalskyi Dmytro
- Renault Cécile
- Repetti Bernard
- Ressouche Antoine
- Ribas Frédéric
- Richard Muriel
- Rufer Libor
- Segret Boris
- Segura Kevin
- Silva Sousa Lima Isaac
- Silvano Fineschi
- Sirmain Christian
- Tantet Jacqueline
- Thissen Roland
- Tiphene Didier
- Ursin Rupert

- Vaillant Joel
- Vaillant Jérôme
- Velayudhan Vipin
- Velazco Raoul
- Verdet Sebastien
- Vialatte Anne
- Weihnert Sylvia
- Yonnet Jean-Paul