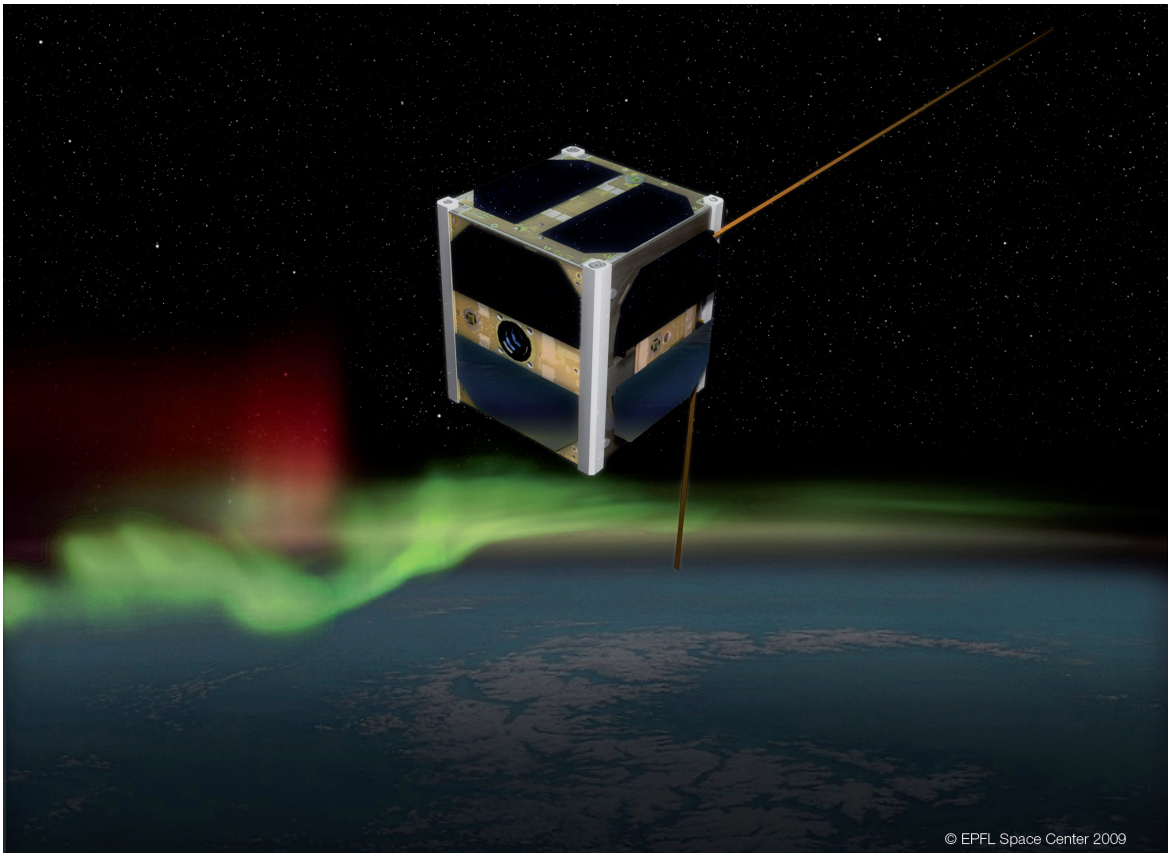
Space Research

2009 – 2010
in Switzerland



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Swiss Academy of Sciences
Akademie der Naturwissenschaften
Accademia di scienze naturali
Académie des sciences naturelles

Space Research 2009 – 2010 in Switzerland
Report to the 38th COSPAR meeting, Bremen, Gemany, July 2010

Editors: Stephanie Ebert and Werner Schmutz
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Contents

1 Foreword

The Committee on Space Research (COSPAR) was established in 1958 by the International Council for Science to promote international scientific research in space. COSPAR is an interdisciplinary scientific organization focused on the exchange of information concerning progress in all kinds of space research. Its main activity is the organization of biennial Scientific Assemblies. The Swiss national Committee on Space Research is a working group of the Swiss Academy of Sciences and its contribution to COSPAR is an overview of space-related national activities.

By tradition, this report is compiled biennially in coordination with the COSPAR Assemblies. The last Swiss COSPAR report was published in 2006, i.e. the report, due in 2008, was omitted, because in that year the Swiss astronomical community published an extensive overview of its activities with the publication Roadmap for astronomy in Switzerland 2007-2016. However, as the roadmap focused on astronomical themes, science research related to Earth observations from space was not included. Therefore, the present report not only covers the nominal period 2008-2010 but also to some extent the period 2006-2008.

As earlier COSPAR reports testify, Switzerland has traditionally been a strong and active participant in the field of space applications in both, hardware development as well as in utilizing space-related observations for scientific advancement. The growing length of the reports is an indication that space-related observations are ubiquitous in everyday science. One missing element has been a satellite system, entirely manufactured in Switzerland. This shortcoming has now been resolved with the first launch of a Swiss satellite, the Swiss Cube, which was a highlight of last year. In the name of the Swiss commission on space research I would like to express my hopes that this was the forerunner of a larger Swiss science satellite project in the near future.

Werner Schmutz
President of CSR

Weblinks:
COSPAR: http://cosparhq.cnes.fr
Swiss Committee on Space Research: http://spaceresearch.scnatweb.ch
Swiss Academy of Sciences: http://www.scnat.ch

2 International Institutes

2.1 International Space Science Institute (ISSI)

Directors: Roger-Maurice Bonnet (Executive Director)
André Balogh
Lennart Bengtsson
Rudolf von Steiger
Johannes Geiss (Honorary Director)

Staff: 9 scientific, 7 administrative

Board of Trustees: Simon Aegerter (President)

Science Committee: Johann Bleeker (Chairman), SRON Netherlands Institute for Space Research, Utrecht, the Netherlands

Fields of research

The programme of ISSI covers a widespread spectrum of disciplines from the physics of the solar system and planetary sciences to astrophysics and cosmology, and from Earth sciences to astrobiology.

Introduction

The International Space Science Institute (ISSI) is an Institute of Advanced Studies at which scientists from all over the world are invited to work together to analyze, compare and interpret their data. Space scientists, theorists, modelers, ground-based observers and laboratory researchers meet at ISSI to formulate interdisciplinary interpretations of experimental data and observations. Therefore, the scientists are encouraged to pool their data and results. The conclusions of these activities –published in several journals or books– are expected to help identifying the scientific requirements of future space science projects. ISSI's study projects on specific scientific themes are selected in consultation with the Science Committee members and other advisers.

ISSI's operation mode is fivefold: International Teams, multi- and interdisciplinary Workshops, Working Groups, Visiting Scientists and Forums are the working tools of ISSI.

In all the activities the Young Scientists scheme is designed to bring PhD students and young post docs in contact with the science community at work. These young scientists are invited by ISSI to complement the membership of Workshop, Working Groups, International Teams and Forum.

More than 220 young scientists have participated in the ISSI activities since its implementation in 2007.

The European Space Agency (ESA), the Swiss Confederation, the Swiss National Science Foundation (SNF) provide the financial resources for the ISSI's operation. The University of Bern contributes through a grant to the Director and in-kind facilities. Since 2010 the Russian Academy of Sciences is supporting ISSI with an annual financial contribution.

Realizations in 2009 and 2010

In 2007 ISSI entered into a contractual relation with the Earth Observation Programmes Directorate of ESA, and set up a programme, funded by ESRIN (ESA center for Earth Observation) and managed within ISSI, focused on the IPY (International Polar Year) and related Living Planet topics. This international and interdisciplinary programme, encompassed the 2008-2010 period. It is structured in two phases, of 16 and 20 months respectively. The components of this programme are IPY projects, International Living Planet Teams, Workshops and Forum.

Since 2009 ISSI is a full partner in the Europlanet network. The "Europlanet Research Infrastructure" (Europlanet RI) is a project funded by EU within FP7. Its objective among others is to promote planetary science in Europe. A part of its activity is to organize annual workshops at ISSI on subjects approved by Europlanet and ISSI.

In total, ISSI welcomes by now about 800 visitors annually.

All scientific activities result in some form of publication, e.g. in ISSI's hardcover book series Space Sciences Series of ISSI (SSSI), published by Springer (reprinted from Space Science Reviews), in ISSI Scientific Report Series (SR), published by ESA's Communications Production, or individual papers in peer-reviewed international scientific journals. As of the end of 2010, 34 volumes of SSSI, and 9 volumes of SR have been published. Information about the complete collection can be found on ISSI's website http://www.issibern.ch, in the section "Publications ".

In 2009 and 2010, the following volumes appeared:

SSSI Volume 31: *From the Outer Heliosphere to the Local Bubble*
J. Linsky, E. Möbius, V.V. Izmodenov, and R. von Steiger (eds.), ISSI Workshop held in October 2007, published in May 2009. Reprinted from Space Science Reviews, Vol. 143, No. 1-4, 2009. ISBN 978-1-4419-0246-7.

SSSI Volume 32: *The Origin and Dynamics of Solar Magnetism*
M.J. Thompson, A. Balogh, J.L. Culhane, A. Nordlund, S.K. Solanki, and J.-P. Zahn (eds.), ISSI Workshop held in January 2008, published in May 2009. Reprinted from

Space Science Reviews, Vol. 144, No. 1-4, 2009. ISBN 978-1-4419-0238-2.

SSSI Volume 33: *Planetary Magnetism*
U. Christensen, A. Balogh, D. Breuer, and K.-H. Glassmeier (eds.), ISSI Workshop held in September 2008, published in October 2010. Reprinted from Space Science Reviews, Vol. 152, No.1-4, 2010. ISBN 978-1-4419-5900-3.

SSSI Volume 34: *The Nature of Gravity – Confronting Theory and Experiment in Space*
C.W.F. Everitt, M.C.E. Huber, R. Kallenbach, G. Schäfer, B.F. Schutz, and R.A. Treumann (eds.), ISSI Workshop held in October 2008, published in June 2010. Reprinted from Space Science Reviews, Vol. 148, No. 1-4, 2009. ISBN 978-1-4419-1361-6.

SR Volume 9: *Observing Photons in Space*
M.C.E. Huber, A. Pauluhn, J.L. Culhane, J.G. Timothy, K. Wilhelm, and A. Zehnder (eds.), Results of an ISSI-Working Group, published in September 2010. ISBN 978-92-9221-938-3.

There are a number of upcoming publications, which result from ISSI activities in 2009 and 2010:

SSSI Volume 35: *Satellites of the Outer Solar System: Exchange Processes Involving the Interiors*
O. Grasset, M. Blanc, A. Coustenis, W. Durham, H. Hussmann, R. Pappalardo, and D. Turrini (eds.), ISSI-Europlanet Workshop held in November 2009, to be published in January 2011.

SSSI Volume 36: *Terrestrial Magnetism*
M. Mandea, A. Balogh, U. Christensen, C. Constable, G. Hulot, and N. Olsen (eds.), ISSI Workshop held in March 2009, to be published in 2011.

SSSI Volume 37: *Comparison of Plasma Environments of Mars, Venus, and Titan*
K. Szegö, A.M. Harri, and N. Krupp (eds.), ISSI-Europlanet Workshop held in November 2009, to be published in 2011.

SSSI Volume 38: *Multiscale Physics in Coronal Heating and Solar Wind Acceleration*
D. Burgess, E. Marsch, J. Drake, M. Velli, T.H. Zurbuchen, and R. von Steiger (eds.), ISSI Workshop held in January 2010, to be published in December 2011.

SR Volume 10: *The Physics of Shock Waves in Collisionless Plasma*
A. Balogh, K.-L. Klein, R.A. Treumann et al. (eds.), Results of an ISSI-Working Group.

SR Volume 11: *Space Instrumentation for Space Physics*
A. Balogh, et al. (eds.), Results of an ISSI-Working Group.

SR Volume 12: *Ground-based Remote Sensing and In-situ Methods for Monitoring Water Vapour*
N. Kämpfer et al. (eds.), Results of an ISSI International Team.

SR Volume 13: *Towards Understanding the Climate of Venus*
L. Bengtsson et al. (eds.), Results of an ISSI-Working Group.

SR Volume 14: *30 Years of Interplanetary Background Observations*
E. Quémerais et al. (eds.), Results of an ISSI-Working Group.

Furthermore results and published papers of international Teams in scientific journals can be found in ISSI's Annual Reports 14 (2008–2009) and 15 (2009–2010), which are available online (http://www.issibern.ch/publications/ar.html).

Outlook

23 new International Teams – approved in 2010 by the Science Committee - start their activities in the sixteenth business year (2010/11). Furthermore, four Workshops will take place:
- Coupling between the Earth's Atmosphere and its Plasma Environment
- Observing and Modeling Earth's Energy Flows
- Quantifying the Martian geochemical reservoirs (in collaboration with Europlanet)
- Particle Acceleration in Cosmic Plasmas

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2.2 The Integral Science Data Centre for Astrophysics (ISDC)

Academic staff: Marc Audard
Thierry Courvoisier
Laurent Eyer
Andrii Neronov
Stephane Paltani
Roland Walter

Staff: 50 people

Fields of research

High-energy astrophysics, the core science of the ISDC, is the study of the most energetic phenomena of the Universe, namely accretion and particle acceleration, in compact (black holes and neutron stars) and extended (supernova remnants, pulsar winds and clusters of galaxies) objects as well as phenomena that take place in their vicinity, and by the history of these phenomena along the Universe evolution. Based on an approach merging high-energy astrophysics with particle physics, the recent, related field of astroparticle is developing rapidly at ISDC. High-energy astrophysics research at ISDC has benefited enormously from the dynamics offered by the participation in the INTEGRAL mission. A large fraction of the research activities in this area revolves around the topics to which INTEGRAL makes a significant contribution, from the nearby X-ray binaries up to the cosmological scales, with the study of active galactic nuclei and clusters of galaxies.

Other high-energy observatories, in particular XMM-Newton and Chandra, are part of the daily tools at ISDC, whether for the follow-up of INTEGRAL sources or for specific research projects. A SNF professor with strong expertise in X-ray spectroscopy has also joined the ISDC; his group focuses on the multi-wavelength studies of star forming regions (millimeter, infrared, optical, and X-rays), in line with the historical stronghold of the ISDC, namely multi-wavelength studies of high-energy phenomena. Astroparticle is a rapidly developing research field connecting high-energy astrophysics with particle physics. Its central topics are the nature of dark matter and dark energy, the origin of cosmic rays and astro- physical particle accelerators. Research in this field involves the data from X-ray and gamma-ray telescopes like XMM-Newton, INTEGRAL and Fermi, as well as those from space and ground-based gamma-ray telescopes operating at still higher energies, like Fermi, MAGIC, HESS or the future Cherenkov Telescope array. The scientific staff at the ISDC has increased from one full professor to three permanent researchers and two SNF professors, with a large number of Ph.D. students and postdocs funded by the SNF. The present size and level of science production of the ISDC makes it an increasingly significant player on the high-energy astrophysics and astroparticle international scene.

Project activities

Founded 15 years ago in the framework of ESA's INTEGRAL mission, the ISDC Data Centre for Astrophysics has considerably developed its activities and its manpower, so that it has become one of the important players in the field of high-energy astrophysics. Currently active in three major ESA missions, INTEGRAL, Planck and Gaia, the ISDC has joined international collaborations on several future projects. The strategy of the ISDC is based on four development pillars, to which it aims at providing significant contributions, and even assuming leadership: (i) scientific research in high-energy astrophysics and astroparticle; (ii) data center activities and science operations; (iii) hardware development for high-energy astrophysics missions; (iv) service to the scientific community and to the public in general. The data center activities at ISDC serve an important role for the Swiss space science community by increasing the contribution of Switzerland in major space projects in collaboration with other Swiss institutes. The ISDC participation in Gaia with another group of the Geneva Observatory is a prime example of a very successful synergy. The ISDC also occupies a prominent place in the objectives of the University of Geneva, by building strong synergies with the Section de physique. The ISDC is now in an excellent position to play a major role in the international space-science landscape by contributing to a number of future projects centered on the ISDC core science (ASTRO-H, IXO, SPICA, CTA, JEM-EUSO, POLAR) or performed in collaboration with other swiss groups (Euclid, SPICA). In addition to the participation to the data processing and exploitation, significant hardware contributions are provided to approved (Astro-H) or planned (Polar, IXO, JEM-EUSO) missions. The ISDC is also providing services to the scientific community and the public by providing data and analysis services (in particular in the frame of the INTEGRAL), shaping the European high-energy astrophysics community (in particular leading the HEAVENS & AHEAD FP7 proposals) and outreach and education.

Realisations

Research status, results and publications are listed in the project specific sections of this report.

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3 Swiss Space Missions

3.1 SwissCube

Institute: Space Center EPFL

In cooperation with: UniNE
UniBe
HES-SO
FHNW
RUAG
Oerlikon
CSEM

Principal Investigator: Maurice Borgeaud and Muriel Noca

Method: Measurement

Development and construction of satellite: SwissCube is the first entirely-built Swiss student satellite

Development of software: Substantial new developments of software took place during the development of SwissCube

Purpose of research: The SwissCube project was initiated in 2005 by the Space Center EPFL and the EPFL LMTS (Microsystems for Space Technologies Laboratory). Its primary goal is educational, in the sense that students learn how to build a complex engineering system from A to Z. Though the satellite is rather small in size, a cube with sides of 10cm for a weight of 1 Kg, it contains all the critical sub-systems and functions present in larger satellites.

SwissCube has also a scientific goal to image the night-glow luminescence created by the recombination of atoms of oxygen at 100 Km of altitude and a technological aim to study a new generation of Earth-sensors for satellites. Building a satellite from scratch involves competences in all the main domains of engineering taught at EPFL, from electronics to electrical power, from mechanical to thermal engineering, from communications to antennas, from material to soldering techniques, from computer science to coding theory, and from control theory to propulsion, hence many of them hosted or closely linked to the Electrical Engineering Institute.

In addition, all the equipment has to be light, robust, support heavy doses of radiation, and resist extreme temperature variations. With this project, the Space Center EPFL was able to federate and attract students not only at EPFL but in several other Swiss

academic institutions (e.g. HES-SO, University of Neuchâtel, FHNW) since the design, construction, and tests of such a complex system require expertise available from both EPF and HES engineers. SwissCube has been successfully launched from India on Sept. 23 2009 at 8h21. Plans are made for the next generation of EPFL satellites, slightly bigger and even more powerful than SwissCube.

Status: SwissCube was successfully launched on 23 Sept 2009 with an Indian launcher (PSLV). Communications with the satellite are taking place on a daily basis and plenty of telemetry data has been acquired. The satellite was designed with a 4-month life time but it is still working 16 months after its launch. Unfortunately, due to a high tumbling rate, it has not yet been possible to acquire images of the nightglow.

Time-Line	From	To
Planning	2006	2008
Construction	2008	2009
Measurement phase	2009	2010
Data evaluation	2010	

Publications:

1. M. Borgeaud, N. Scheidegger, M. Noca, G Roethlisberger, F. Jordan, T. Choueiri, and N Steiner, “SwissCube : The first entirely-built Swiss student satellite with an Earth observation payload”, Small satellite missions for Earth observation: new developments and trends, edited by R. Sandau, H.-P. Röser, A. Valenzuela, pp. 207-213, Springer Verlag, Berlin, 2010
2. M. Noca, F. Jordan, N. Steiner, T. Choueiri, F. George, N. Scheidegger, H. Peter-Contesse, M. Borgeaud, R. Krpoun, and H. R. Shea, “Lessons Learned from the First Swiss Pico-Satellite: SwissCube”, 23rd Annual AIAA/USU Conference on Small Satellites, Logan, USA, 11-14 August 2009

Final design of SwissCube

4 Astrophysics

4.1 Very high energy astrophysics

Institute: ISDC

Principal Investigator: R. Walter

Co-investigators: F. Pauss (ETHZ/CERN)
M. Pohl (UniGE)
M. Ribordy (EPFL)
U. Straumann (UniZH)

Method: Simulation
Theory
Measurement

Based on existing instrumentation: Fermi, INTEGRAL, XMM, Hershel, Planck, archival data from all wavebands

Purpose of research: Very high energy phenomena span a wide field of galactic and extragalactic astrophysics, of plasma physics, particle physics, astro-particle physics, and fundamental physics of space-time. They encode information on the birth and death of stars, on the matter circulation in the Galaxy, and on the history of the Universe.

We are following several lines of research on particle acceleration in pulsars, pulsars winds, stellar clusters and winds, SNR, X-ray binaries, active galaxies, galactic clusters and the annihilation of dark matter.

The group started in 2010.

Publications:

1. Balbo et al., A&A in press, Twelve hours pikes from the Crab Pevatron
2. Farnier et al., A&A, in press, Eta Carinae: a very large hadron collider
3. Lenain et al., A&A in press, Seyfert 2 galaxies in the GeV band: jets and starburst
4. Balbo et al., A&A in press, HESS J1632-478, an Energetic Relic

4.2 INTEGRAL

Institute: ISDC

Principal Investigator: R. Walter

Co-investigators:

UCD (IE)	Univ. Southampton (UK)
Ondrejov Obs. (CZ)	INAF (I)
CEA (F)	IAAT (D)
MPE (D)	Univ. Liege (B)
DNSC (DK)	GSFC (USA)
CAMK (PL)	

Method: Simulation
Theory
Measurement

Development and construction of software: INTEGRAL Science Data Centre

Purpose of research: INTEGRAL, the gamma-ray observatory of the European Space Agency, continuously observes the sky in the X-ray and gamma-ray band, reaching the inner parts of our the Milky Way, and also much farther away source. The science spans all types of compact objects and particle accelerators in our Galaxy, active galactic nuclei, gamma-ray bursts, nucleosynthesis and diffuse annihilation emission.

On the mandate of ESA, the ISDC staff process the full INTEGRAL telemetry in real-time, monitor and calibrate the science instruments in collaboration with the instrument teams, detect one gamma-ray burst per day (almost 13000 triggers studied since launch), scrutinize the hard X-ray sky which generates 1 Astronomical Telegram per week on average (688 since launch), archive and distribute the data to the world-wide science community.

About 20 visitors are using the ISDC archive services every day, downloading 3TB of data per month.

INTEGRAL science at the ISDC is centered on the understanding of accreting sources and accelerators in and outside of the Galaxy. The aim is to understand the physical mechanisms at play in deep gravitational wells, extreme magnetic fields or jets, and their geometry and environment. Paper are written on isolated pulsars, magnetars, X-ray binaries, AGN populations, processed and absorption in individual Seyfert galaxies, accretion flows, clusters of galaxies, gamma-ray bursts and soft gamma-ray repeaters.

Publications: The INTEGRAL data distributed by the ISDC are generating about 8 referred papers per month, 1420 publications since launch.

ISDC scientists are involved in about 50 INTEGRAL related papers per year.

Status: INTEGRAL is in operation. The mission is extended at least up to 2014.

Time-Line	From	To
Construction	1995	2001
Measurement phase	2002	-
Data evaluation	2002	-

4.3 Processing and Analysis of variable celestial objects from the Gaia Spacecraft (Coordination Unit 7, Data Processing Centre Geneva)

Institute: Geneva Observatory/ISDC, University of Geneva

In cooperation with: ESA
15 institutes across Europe including the EPFL and the SixSq company

Principal Investigator: Laurent Eyer

Co-investigators:
Mathias Beck
Pierre Dubath
Leanne Guy
Asif Jan
Isabelle Lecoeur-Taibi
Nami Mowlavi
Krzysztof Nienartowicz
Lorenzo Rimoldini
Maria Süveges

Method: Measurement

Development of software:

A) Software system for the data processing of photometrically variable objects including software for the characterisation, statistical analysis and classification of these objects;

B) The building up and the operation of a processing center with the relevant hardware required to support the data analyses;

C) The integration and the maintenance, until the mission completion, of the data processing pipeline for the variability analysis.

Purpose of research: Gaia, ESA's cornerstone mission to be launched in 2012, will repeatedly scan the entire sky. Over the 5-year nominal lifetime, the instruments onboard the Gaia satellite will measure positions, distances, brightnesses, colours and the motions of approximately one billion celestial objects. A detailed map of our Galaxy will be obtained, providing a new understanding of its formation and evolution mechanisms. Outstanding contributions are foreseen to many other fields such as studies of asteroids, stellar evolution and variability, binary stars, exoplanets, general relativity and cosmology.

In order to face the major challenge represented by the processing of the huge data stream received from the spacecraft, the European community has organized itself into 8 Coordination Units (CUs), dividing the task into different thematics. Following a formal ESA selection process in 2007, the Coordination Unit 7 (CU7) is formed as an international consortium led by a team based at Geneva Observatory. This group is also in charge of hosting one of the five Gaia Data Processing Centres responsible for the operational aspects. This activity directly builds upon the expertise gathered through the important participation of the Geneva Observatory/ISDC in two other ESA missions, Hipparcos and INTEGRAL.

The CU7/DPCG group is in charge of all aspects of the analysis of the variability of the celestial objects. The first task is to characterise this variability, deriving a number of statistical parameters, searching for periods and fitting models to the Gaia photometric light-curves and radial velocity time series. The goal is then to use these information to classify the objects into a number of different types which directly reflect the physical processes responsible for the variations. In several cases, these processes can be further described through additional parameters derived from a detailed analysis of objects from a specific variability type. The CU7/DPCG work results in a catalog-type information that will make part of the Gaia data archive.

The Geneva team is also pursuing an active research program on stellar variability. The main research topics are the study of stellar oscillation (Asteroseismology), the variation due to the slow evolution of stars driven by nuclear fusion, and of the census and properties of variable star populations in different environments. This work is currently based on available survey data and on dedicated observation programs. The Geneva team will be in a privileged position to exploit the Gaia catalog data when they become available.

Geneva also contributes to the work of other Coordination Units: to that of CU6 in the multiple transits analysis work package and to CU2 with models of variable objects implemented in the Universe Model.

The Geneva group consists of 18 people, contributing at different levels (scientists, software engineers, post-docs, PhD students, system administration).

The ESA project related Gaia activities in Geneva are supported by the University of Geneva, funding provided by the Swiss Prodex Programme and the Swiss Federal Mesure d'Accompagnement. The preparation of the scientific exploitation of Gaia data is supported by FNRS and RTN-FP6/ITN-FP7 EU grants.

Status: The software is under development and extensive tests are carried out using existing data from other surveys and simulated Gaia data. The hardware requirements for the data processing are being established. A test setup is in place and is currently used to analyze the chosen solutions in terms of performance, robustness and maintainability.

Time-Line	From	To
Planning	2002	2022

The development process is an iterative waterfall model common to all the 8 coordination units of the Gaia Data Processing and Analysis Consortium. Every 6 months requirements are revised, new or improved software is implemented and tests are carried out.

Abbreviations:

CU2	Gaia Coordination Unit 2: Simulation
CU6	Gaia Coordination Unit 6: Spectroscopic Processing
CU7	Gaia Coordination Unit 7: Variability Processing
DPAC	Data Processing and Analysis Consortium
RTN	Research Training Network
ITN	Initial Training Network

4.4 Cryogenic Receivers for the Herschel/HIFI Spectrometer

Institute: Institute of Astronomy, ETH Zurich

In cooperation with: ESA

Principal Investigator: A. O. Benz (ETH)

Co-investigators: S. Bruderer (ETH)
C. Dedes (ETH)
S. Wampfler (ETH)

Method: Measurement

Development and construction of instruments: Demonstration models and flight models of the Common Optics Assembly and Mixer Subassemblies. Asssembly of mirrors and other items. Low-noise and low-power amplifiers (InP HEMTs) and assembly box for intermediate frequency amplification.

Development of software: Ground software for data calibration and evaluation, data pipeline

Purpose of research: The Herschel Space Observatory has reached successfully its location far away from Earth (Lagrangian point 2). It is ideal to search for water in star forming regions, protostellar envelopes and the rest of the universe. As a wide spectrum is completly covered at high spectral resolution for the first time Herschel has already discoved new molecules in a region of the spectrum that is inaccessible from the ground (from 0.5 to 1.9 THz or 150 to 800 microns). At ETH Zurich we have for instance discovered ionized water (H2O+) for the first time in star-forming regions. The HIFI spectrometer is the largest of three instruments on board.

The Swiss hardware contribution for the HIFI instrument grantees observing time on HERSCHEL (forth cornerstone of ESA). ETH Zurich has lead the production of some hardware and is now contributing to develop software in collaboration with FHNW Windisch.

The prime focus in Switzerland is on water and other hydrides in the envelopes of very young stellar objects of both high and low mass (ETH Zurich). The main goal is to study the effects on water and other molecules produced by the irradiation of far UV and X-rays. These reactions can destroy or form water, depending on irradiation, temperature and density. These molecules are also tracers for the physical conditions and processes in star-forming regions. In particular, we study the irradiation by protostellar far UV and X-ray emission.

A second project is the investigation of water in the atmosphere of Mars, using the high spectral resolution of HIFI to derive the water distribution from the line profile (University of Bern).

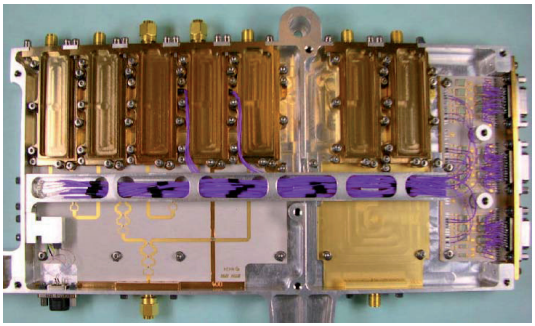
Status: The Herschel Space Observatory was launched sucessfully on May 14, 2009. The HIFI instrument works according to specifications after some delays in the start-up periode. The hardware components we have contributed work perfectly. The software including the pipeline are used by the whole community to prepare the data for scientific analysis. The first results papers will be published by Astronomy and Astrophxsics in a dedicated issue in late 2010. The Institute of Astronomy at ETH has contributed 4 first authored publications (see below).

Time-Line	From	To
Planning	1999	2000
Construction	2000	2008
Measurement phase	2009	2013
Data evaluation	2010	2013

Publications:

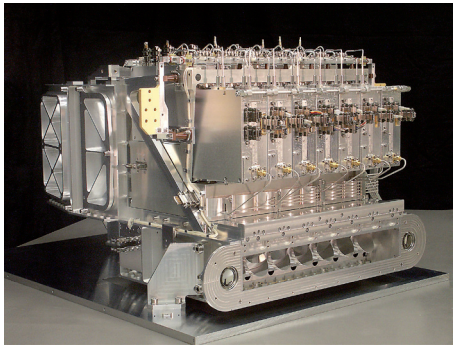
1. A.O. Benz, S. Bruderer, E.F. van Dishoeck, et al.: „Hydrides in Young Stellar Objects: Radiation tracers in a protostar-disk-outflow system“, Astronomy and Astrophysics Letters, in press (2010)
2. S. Bruderer, A.O. Benz, E.F. van Dishoeck, et al.: „Herschel-HIFI detections of hydrides towards AFGL 2591: Envelope emission versus tenuous cloud absorption“, Astronomy and Astrophysics Letters, in press (2010)
3. S. Wampfler, G.J. Heczeg, S. Bruderer, et al.: „Herschel observations of the hydroxyl radical (OH) in young stellar objects“, Astronomy and Astrophysics Letters, in press (2010)

The frequency amplification unit, including low-noise and low-power amplifiers (InP HEMTs), for the HIFI instrument on the Herschel Space Observatory. The unit was designed and constructed by the Laboratory for Electromagnetic Fields and Microwave at ETH Zurich. The figure shows the qualification model. The flight model was produced by RUAG Aerospace and Baumer Electronics, Frauenfeld.



Abbreviations:

HIFI	Heterodyne Instrument for the Far Infrared
HEMT	High Electron Mobility Transistor
SRON	Space Research Organization of the Netherlands



Common Opotics Assembly of HIFI on the Herschel Space Observatory, an ESA space craft operating at the Lagrangian Point L2, 1.5 million km from Earth. The mechanical structure and components were produced by RUAG Wallisellen.

4.5 Software development for ESA‘s Planck mission

Institute: ISDC Data Centre for Astrophysics

In cooperation with: LFI DPC in Trieste, Italy

Principal Investigator: Marc Türler

Co-investigators: Reiner Rohlfs
Nicolas Morisset
Mohamed Meharga
Pavel Binko

Method: Measurement

Development of software: Planck/LFI level 1 data processing software

Purpose of research: ESA‘s Planck mission was successfully launched on 14 May 2009 together with Herschel. Planck is scanning the sky to produce full-sky images in the radio to sub-millimeter range. The main scientific goal is the study of the cosmic

microwave background radiation emitted about 380‘000 years after the Big Bang and which is the key to derive the cosmological parameters describing the history and fate of the Universe. The other scientific goals of the mission are foreground objects, in particular galaxy clusters, active galactic nuclei (AGN) and our own galaxy, the Milky Way.

The Planck payload is composed of two instruments: the low-frequency instrument (LFI) and the high-frequency instrument (HFI). The LFI data processing centre (DPC) is located in Trieste, Italy and the HFI DPC in Paris, France.

The ISDC Data Centre for Astrophysics attached to the Observatory of the University of Geneva was responsible for developing the software for the first steps of the LFI data processing. This Level 1 software has been defined as mission critical by ESA and is running smoothly since launch at the LFI DPC in Trieste. It consists in retrieving daily from the Mission Operation Centre (MOC) in Darmstadt the available scientific and housekeeping (HK) data of the LFI instrument and HK data of the sorption and the 4K coolers; to sort them by time and by type (detector observing mode, etc.); to extract the spacecraft attitude information from auxiliary files; to flag the data according to several criteria; and to archive the resulting Time Ordered Information (TOI). The output of the Level 1 software is then used to produce maps of the sky in different spectral bands. The ISDC also provided tools to graphically display the incoming data both at the MOC and the DPC.

Scientific exploitation of the Planck data at the ISDC are mainly focussing on the study of AGN, with a prime interest on the observation and analysis of the flaring activity of the most extremely variable sources, the so-called blazars.

Status: The scientific exploitation of the Planck data started in fall 2010. A series of papers on first Planck results are getting published in January 2011. The associated catalogue of early released Planck compact sources will be made available by the ISDC through the HEAVENS interface in the first months of 2011.

In winter 2009-2010 and spring 2010, we developed six additional display tools that were identified as very useful for routine operations by the LFI DPC. The scientific exploitation of the Planck data started in fall 2010.

Time-Line	From	To
Planning	Nov 2001	Sep 2005
Construction	June 2002	May 2010
Measurement phase	June 2009	on-going
Data evaluation	Sep 2010	2013?

Publications:

1. Critical design decisions of the Planck LFI Level 1 software, In: Proceedings of ADASS XIX in Sapporo, Japan (4-8 October 2009) Morisset N., Rohlfs R., Türler M., Meharga M., Binko P., et al. 2010, ASP Conf. Series, in press
2. Level 1 on-ground telemetry handling in Planck-LFI, Zacchei A., Frailis M., Maris M., Morisset N., Rohlfs R., et al. 2009, Journal of Instrumentation, Vol. 4, p. 2019
3. A systematic approach to the Planck LFI end-to-end test and its application to the DPC Level 1 pipeline, Frailis M., Maris M., Zacchei A., Morisset N., Rohlfs R., et al. 2009, Journal of Instrumentation, Vol. 4, p. 2021

Abbreviations:

ADASS	Astronomical Data Analysis Software and Systems
AGN	Active Galactic Nuclei
DPC	Data Processing Centre
ESA	European Space Agency
HFI	High Frequency Instrument
HK	Housekeeping
LFI	Low Frequency Instrument
MOC	Mission Operation Centre
TOI	Time Ordered Information

4.6 POLAR. Measuring for the first time polarization in Gamma Ray Bursts

Institute: ISDC, DPNC, PSI

In cooperation with: LAPP Annecy France
IPJ Warsaw Poland

Principal Investigator: Nicolas Produit

Co-investigators: M. Pohl
W. Hajdas
T. Courvoisier

Method: Measurement

Development and construction of instruments: Polarimeter, front end electronic, central trigger, scintillating target, overall mechanical cover

Development of software: Firmware of front end electronic; Firmware of central trigger; On board software; Ground segment software, analysis software

Purpose of research: POLAR is a compact detector to be flown on-board of the Chinese space station.

It is dedicated to measure polarization of Gamma Ray Bursts (GRB) in hard X-ray energies. Gamma Ray Bursts belong to the most important subjects of the contemporary astrophysics. GRB are linked with explosive births of black holes. GRB are from cosmological origin. Polarization of GRB is one of the most important parameter to understand the GRB phenomenon. This parameter has not yet been measured convincingly and POLAR should be the first experiment that will perform this important measurement with controlled systematics.

POLAR is a wide field of view Compton polarimeter using light scintillation material. It cover an energy range from few tens up to several hundred Kev. The polarization detection capability are 10 GRB per year with a polarization precision better then 10 percent. After 3 years in space POLAR will be able to discriminate between the different GRB theories.

Status: Monte-Carlo prediction of the instrument has been realized and compared to measurements in the laboratory. The split of responsibility document as been signed with the Chinese partners. One module has been calibrated and theoretical performance verified in a polarized photon beam (ESRF) end of 2009. Construction of a 4X4 module prototype with national fund financing. Spatialisation of the electronic take place from June 2010 to June 2011.

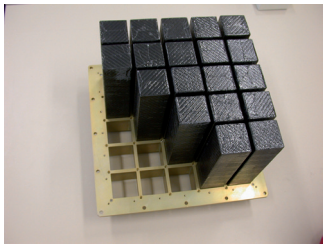
Time-Line	From	To
Planning		June 2011
Construction	Depend on Chinese space station Schedule., Baseline is 2012	
Measurement phase	Baseline is 2014	
Data evaluation	Baseline is 2014-2017	

Publications:

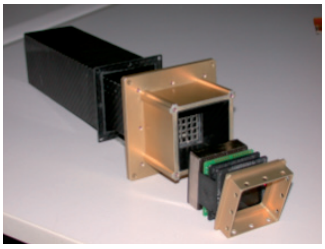
1. N. Produit et al. NUCL.INSTRUM.METH.A 550 616 (2005)
2. Estella Suarez Doctorate thesis 2010. University Geneva library.
3. Localization of gamma-ray bursts using POLAR. PROCEEDINGS OF THE 31st ICRC, ŁODZ 2009

Abbreviations:

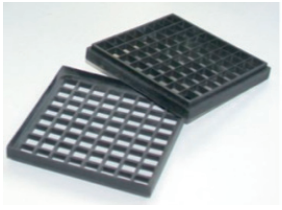
GRB	Gamma Ray Bursts
DPNC	Département de physique nucléaire et corpusculaire
ISDC	Data Centre for Astrophysics
PSI	Paul Scherrer Institute
LAPP	Laboratoire d'Annecy pour la physique des particules
IPJ	The Andrzej Soltan Institute for Nuclear Studies
ESRF	European Synchrotron Radiation Facility

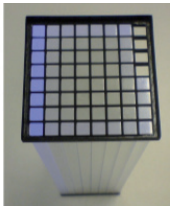


Mechanical enclosure of the 5X5 partially populated POLAR detector



One module of POLAR. Enclosure, grid, multichannel photomultiplier and electronic





Support grid and scintillating bars mounted in one module target

4.7 ASTRO-H SXS Filter Wheel

Institute: ISDC, Observatory of the University of Geneva

In cooperation with: DPNC, University of Geneva

Principal Investigator: Stéphane Paltani

Co-investigators: Martin Pohl (DPNC)

Method: N/A (Hardware development)

Development and construction of instruments: Filter wheel for the SXS instrument on board the Japanese ASTRO-H mission

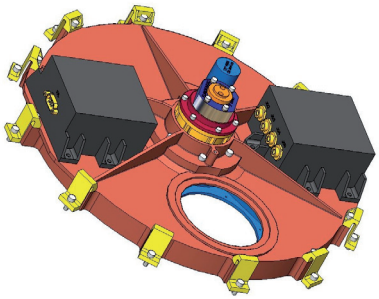
Purpose of research: ASTRO-H is a mission of the Japan Aerospace Exploration Agency (JAXA) with a planned launch date in February 2014. It is part of a very successful scientific program dedicated to high-energy astrophysics, the latest mission being Suzaku (2005), which is still in operation. ASTRO-H can also be viewed as a precursor to the International X-ray Observatory (IXO), a mission proposed in the framework of ESA's Cosmic Vision program. The ISDC and Geneva Observatory have been invited to collaborate, together with the Dutch space agency SRON, to the project by developing a filter wheel for the Soft X-ray Spectrometer (SXS). The SXS is a cryogenics silicon detector working at 50 mK, aiming at providing excellent energy resolution (about 4 eV) in the 0.3-10 keV energy range, while preserving some imaging capabilities and high throughput. This instrument will be first operational cryogenics detector on an X-ray satellite. The purpose of the filter wheel is to select different optical elements, either to reduce X-ray count rate or optical load on the detector, as well as to protect the detector from micro-meteorites. It also supports and commands active calibration sources, which are provided by SRON. The participation to the ASTRO-H mission ensures a participation in the scientific exploitation of the mission.

Status: The preliminary design of the filter wheel and its associated command electronics has started early 2009. The Preliminary Design review has been passed successfully in April 2010. Resolution of all RIDs and consolidation of the Interface Control Documents is on-going, and very close to completion. The project will enter Phase C/D in July 2010. Industrial contracts will be passed by ESA with Swiss industries through the Prodex program over the Summer, with a kick-off expected at the beginning of Fall 2010.

Time-Line	From	To
Phase B	2009	2010
Phase C/D	2010	2012
Measurement phase	2014	-
Data evaluation	2014	-

Abbreviations:

SXS Soft X-ray Spectrometer



Filter wheel of the SXS instrument on board the ASTRO-H mission. Two high-voltage sources (in black) are fixed to the filter wheel housing to drive the active calibration sources, which are mounted on a ring around the filter wheel housing's hole (not shown).

4.8 IXO XMS Filter Wheel

Institute: ISDC, Observatory of the University of Geneva

Principal Investigator: Stéphane Paltani

Method: N/A (Hardware development)

Development and construction of instruments: Filter wheel for the XMS instrument on board the ESA/NASA/JAXA IXO mission

Purpose of research: The International X-ray Observatory (IXO) mission is Europe's next major X-ray astronomy mission, after ESA's cornerstone mission XMM-Newton. IXO will surpass XMM on all counts, in particular the collecting area (more than a factor 20) and state-of-the-art detectors. The main IXO instrument will be a cryogenic imaging spectrometer (X-ray Micro-calorimeter Spectrometer, XMS), which will allow imaging with a few electron-volt resolution, i.e. an improvement by a factor about 50 over current imaging instruments. It has to operate at cryogenic (50 mK) temperatures. This will be achieved by a complex, multi-stage mechanical cooling chain. Integral part of this instrument will be a filter wheel which is directly mounted onto the cryostat. The filter wheel will provide the following functionalities:

- the capability to insert different optical and X-ray attenuating blocking filters to reduce optical light from bright objects (O, B stars) and to reduce the X-ray count rate for very bright objects in order to prevent detector saturation.

- the capability to insert a polarization sensitive filter in the beam. These filters are currently under development and would allow polarization measurements in the X-rays, which has never really been done in astronomy. This filter requires the use of a

micro-calorimeter. Such filter would need to be placed at different orientations when placed in the beam to create a modulated signal.

- the capability to include a bended micro-channel plate (MCP) in one filter position. The purpose of this MCP is to divert the beam in case of a strong point source in order to reduce the count rate per detector element.

- the capability to generate mono-energetic X-ray photons. This is done through the use of active X-ray sources which can illuminate the full detector upon request.

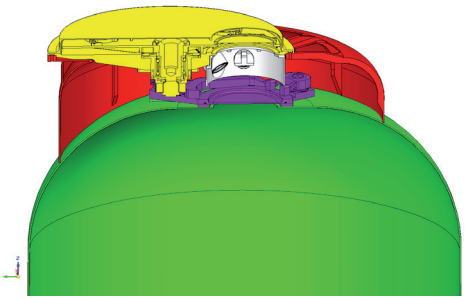
- integration of the filter wheel and the dewar door mechanism. The cryogenic instrument will be launched under vacuum and needs therefore to be closed by a vacuum tight door. This door, which must be opened only once when final orbit has been reached, is part of the subsystem discussed here.

Status: The XMS filter wheel has started assessment phase in September 2009. The XMS team passed the mid-term review in April 2010, and is currently preparing the Instrument Technology Readiness Review (July 2010). The filter wheel itself and the calibration sources are directly adapted from our work on the ASTRO-H filter wheel. The dewar door mechanism is however a new subsystem. A bread-board model of the filter wheel, in particular the door mechanism, will be built at the end of this year.

Time-Line	From	To
Assessment phase	2009	2010
Definition and implementation phase	2011	2018
Measurement phase	2021	2031
Data evaluation	2021	2040

Abbreviations:

IXO	International X-ray Observatory
XMS	X-ray Microcalorimeter Spectrometer



Current design of the XMS filter wheel subsytem. The filter wheel itself is in yellow. The calibration source ring is in grey. The dewar door mechanism is in violet. The dewar (640 mm in diameter) is in green.

4.9 IXO HTRS Filter Wheel

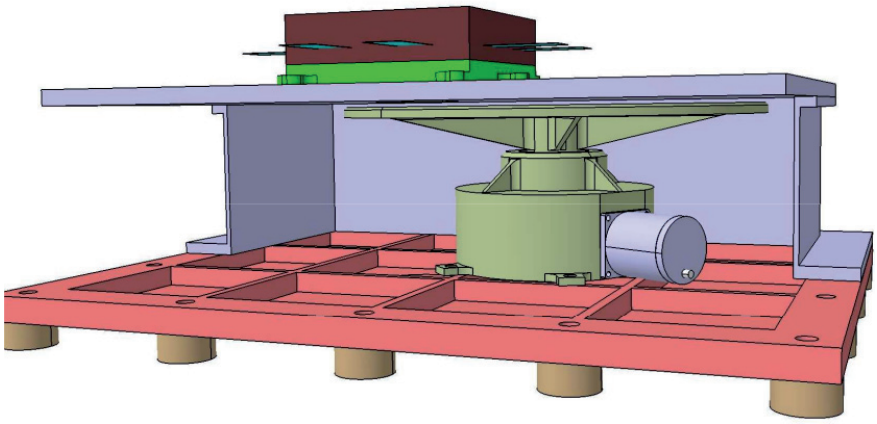
Institute: ISDC, Observatory of the University of Geneva

Principal Investigator: Stéphane Paltani

Method: N/A (Hardware development)

Development and construction of instruments: Filter wheel for the HTRS instrument on board the ESA/NASA/JAXA IXO mission

Purpose of research: The International X-ray Observatory (IXO) mission is Europe‘s next major X-ray astronomy mission, after ESA‘s cornerstone mission XMM-Newton. IXO will surpass XMM on all counts, in particular the collecting area (more than a factor 20) and state-of-the-art instruments. One of these instruments, the High Time Resolution Spectrometer (HTRS), is relatively simple, based on silicon-drift detectors. It is designed to be able to sustain very high count rates up to 20 Crabs with acceptable dead-time. The ISDC/Geneva Observatory participates to the project by developing a filter wheel. The filter wheel m ust be very lightweight and compact. The purpose of the filter wheel is to select different optical elementsto reduce optical load on the detector, as well as to protect the detector from micro-meteorites and other potentially damaging events (solar flares, etc.). It also includes a radioactive source for the energy calibration.



Current design of the HTRS filter wheel integrated in the HTRS focal-plane assembly. All active mechanical parts (motor and gears) are hidden under the housing in order to prevent contamination from reaching the detector.

Status: The HTRS filter wheel has started assessment phase in September 2009. The HTRS team passed the mid-term review end of Winter 2010, and is currently preparing the Instrument Technology Readiness Review (July 2010). A bread-board model of the filter wheel will be built at the end of this year.

Time-Line	From	To
Assessment phase	2009	2010
Definition and implementation phase	2011	2018
Measurement phase	2021	2031
Data evaluation	2021	2040

Publications:

1. D. Barret, et al., 2010, ‚The High Time Resolution Spectrometer (HTRS) aboard the International X-ray Observatory (IXO)‘, proceedings of the SPIE 2010

Abbreviations:

HTRS	High Time Resolution Spectrometer
IXO	International X-ray Observatory

4.10 High-energy processes in young star forming regions

Institute: ISDC & Geneva Observatory

In cooperation with: ETH Zurich, Switzerland
University of Vienna, Austria
University of Colorado, USA
Observatoire de Grenoble, France
Penn State University, USA
several other institutes in Europe and in the USA

Principal Investigator: Marc Audard (Univ of Geneva)

Co-investigators: Carla Baldovin-Saavedra (Univ of Geneva)
Manuel Guedel (ETHZ and Univ of Vienna)
Stephen Skinner (Univ of Colorado)
Thierry Montmerle (Observatoire de Grenoble)
Leisa Townsley (Penn State University; PI of Chandra Carina Survey)
several other co-investigators throughout Europe and the USA

Method: Measurement

Based on existing instrumentation: Chandra, XMM-Newton, Suzaku, Swift

Purpose of research: High-energy processes in young star forming regions are commonly producing plenty of X-ray photons that can be detected via X-ray satellites. Such high-temperature plasmas are the ideal laboratory to study the physical processes occurring in coronal plasma in low-mass young stars or wind shocks in more massive young stars.

The origin of the X-rays in low-mass young stars has long been thought to be mainly originating from coronal processes such as in the Sun‘s corona, albeit at much higher X-ray luminosities and plasma temperatures. Recent X-ray grating and CCD observations have shown the importance of shocks in jets and of accretion in the production of X-rays in accreting young stars.

We are involved in several projects to study the high-energy processes in young stars. For example, jet-driving protostars were observed in X-rays and show X-ray detections of the jets, an evidence of the fast velocity of jets (DG Tau, PI Guedel; RY Tau, PI Skinner). A multi-wavelength campaign was initiated to understand better the jet mechanism in DG Tau (lead Guedel). Another project involves the observations with Chandra and Spitzer of the infrared cluster NGC 2071 (PI: Skinner). Of particular interest was the detection of an infrared source showing strong 6.4 keV fluorescent emission, probably due to irradiation by hard X-rays of col material near the protostar. We are also participating in a very large program with Chandra to studythe Carina massive star forming regions (PI: Townsley). The phase-resolved study of the accreting binary T Tau star V4046 Sgr by XMM-Newton is also currently ongoing (PI: Montmerle). The influence of accretion on the X-ray emission will be studied as a function of the orbiting phase.

We have also published a paper presenting Chandra HETGS spectrum of a weak-lined T Tau binary together with Keck imaging. The goal of this paper by Baldovin-Saavedra et al. was to study the coronal properties of the binary and to understand the effect of the clearing of the interstellar medium by a previous supernova on the X-ray properties of the star.

Status: Several projects ongoing

Publications:

1. Skinner, S.L., Sokal, K.R., Megeath, S.T., Guedel, M., Audard, M., Flaherty, K.M., Meyer, M.R., & Daminelli, A. 2009, ApJ, 701, 710: „Chandra and Spitzer Imaging of the Infrared Cluser in NGC 2071“

2. Baldovin Saavedra, C., Audard, M., Duchene, G., Guedel, M., Skinner, S.L., Paerels, F.B.S., Ghez, A., McCabe, C. 2009, ApJ, 697, 493: „HDE 245059: A Weak-lined T Tauri Binary Revealed by Chandra and Keck“

Abbreviations:

HETGS High-Energy Transmission Grating Spectrometer

4.11 Spitzer Survey of the Taurus Molecular Cloud

Institute: ISDC & Geneva Observatory

In cooperation with: Several institutes in the USA and Europe

Principal Investigator: Deborah Padgett (Caltech)

Co-investigators: Marc Audard (University of Geneva)
Carla Baldovin-Saavedra (Univ of Geneva)
Spitzer Taurus survey team

Method: Measurement

Based on existing instrumentation: Spitzer

Purpose of research: Spitzer has mapped the Taurus Molecular Cloud (TMC) in the infrared at wavelengths from 3.6 to 70 microns. The survey has helped to detect many new young star candidates, new Herbig-Haro knots tracing shocks from jets and outflows from young stars, and it provided superb photometry for young stars with transition disks, optically thick disks, edge-on disks, or with enveloppes. The Taurus Spitzer Legacy survey is complementary to other Taurus surveys recently done in X-rays (XEST) and optical (SDSS and CFHT).

Our team has further obtained follow-up data with Spitzer‘s IRS spectrometer for newly identified Taurus candidate members with the goal to study their spectral features (silicates, ices, gas lines). The goal will be to determine if their properties differ from previously known Taurus members.

Status: The project is ongoing with several publications already published. Terebey et al. (2009) has studied the far-infrared properties of a very low luminosity embedded source in Taurus, while Rebull et al. (2010) has published a large catalogue of new candidate Taurus members. The overview paper presenting the data is in preparation (Padgett et al. 2010), together with two other publications on transition disks (Mc-

Cabe et al) and Herbig-Haro objects (Stapelfeldt et al.). Baldovin-Saavedra will also present the IRS spectra of Taurus candidates newly identified by the Spitzer Taurus survey. Such spectra show evidence of silicate emission from the protoplanetary disk atmosphere, but also absorption features such as carbon dioxide ice, water ice, etc.

Publications:

1. Rebull, L.M., Padgett, D.L., McCabe, C.-E., Hillenbrand, L.A., Stapelfeldt, K., Noriega-Crespo, A., Carey, S., Brooke, T., Huard, T., Terebey, S., Audard, M., Monin, J.-L., Fukagawa, M., Guedel, M., Knapp, G.R., Menard, F., Allen, L.E., Angione, J.R., Baldovin-Saavedra, C., Bouvier, J., Briggs, K., Dougados, C., Evans, N.J., Flagey, N., Guieu, S., Grosso, N., Glauser, A.M., Harvey, P., Hines, D., Latter, W.B., Skinner, S.L., Strom, S., Tromp, J., Wolf, S. 2010, ApJS, 186, 259: „The Taurus Spitzer Survey: New Candidate Taurus Members Selected Using Sensitive Mid-Infrared Photometry“
2. Terebey, S., Fich, M., Noriega-Crespo, A., Padgett, D~L., Fukagawa, M., Audard, M., Brooke, T., Carey, S., Evans II, N.J., Guedel, M., Hines, D., Huard, T., Knapp, G.R., McCabe, C., Menard, F., Monin, J.-L., Rebull, L. 2009, ApJ, 696, 1918: „Far-Infrared Observations of the Very Low Luminosity Embedded Source L1521F-IRS in the Taurus Star-Forming Region“
3. Padgett, D., et al. 2010, in preparation: „The Taurus Spitzer Legacy Survey: Spitzer data“

Abbreviations:

TMC	Taurus Molecular Cloud
IRS	Infrared Spectrometer

4.12 Searching for gas lines in protoplanetary disks of the Taurus star forming region with Spitzer

Institute: ISDC & Geneva Observatory

In cooperation with: University of Vienna, Austria
Caltech, USA
UK Astronomy Technology Centre, UK
University of Colorado, USA

Principal Investigator: Marc Audard (Univ of Geneva)

Co-investigators: Carla Baldovin-Saavedra (Univ of Geneva)
Andres Carmona (Univ of Geneva)
Manuel Guedel (Univ of Vienna)
Deborah Padgett (Caltech)
Luisa Rebull (Caltech)
Sergio Fajard-Acosta (Caltech)
Adrian Glauser (UK Astronomy Technology Centre)
Stephen Skinner (Univ of Colorado)
Caer McCabe (Caltech)

Method: Measurement

Based on existing instrumentation: Spitzer, XMM-Newton

Purpose of research: To understand the mechanism leading to the disk dispersal and planet formation we need to constrain the processes involved. Our knowledge of protoplanetary disks is based mainly on the study of dust while gas is the main component of the disk mass. Thanks to the Spitzer Telescope we have searched for gas lines in the IRS spectra of 61 pre-main sequence stars in the Taurus Molecular Cloud. We have detected molecular hydrogen, Ne II, and Fe II lines in a number of targets. We have performed several statistical tests looking for correlations between the line luminosities and stellar parameters (mass, accretion rate, etc). The results indicate that shocks play an important role in the formation of gas lines detected with Spitzer. X-ray irradiation does not seem to be the major mechanism for producing atomic lines such as [Ne II]. Due to the low spatial and spectral resolutions of Spitzer, higher resolution observations from the ground (e.g., ESO VLT) or with future space instruments (e.g., JWST) are needed to provide kinematical and spatial information to

determine the origin of the gas emission.

Status: The manuscript is being finalized and will be submitted in July 2010. Follow-up ground observations with ESO‘s VLT were otained to confirm the Ne II detections and provide information on the kinematics of the line. A publication on the VLT VISIR data will be soon written.

Publications:

1. Baldovin-Saavedra, C., Audard, M., et al. 2010, A&A, to be submitted: „Searching for gas lines in protoplanetary disks of the Taurus star forming region with Spitzer“

Abbreviations:

IRS Infrared Spectrometer

4.13 A multi-wavelength study of the young star V1118 Orionis in outburst

Institute: ISDC & Geneva Observatory

In cooperation with: University of Colorado, USA
ETH Zurich, Switzerland
Stony Brook University, USA
Villanova University, USA
New Mexico State University, USA

Principal Investigator: Marc Audard (Univ of Geneva)

Co-investigators: G. S. Stringfellow (Univ of Colorado)
M. Guedel (ETHZ)
S. L. Skinner (Univ of Colorado)
F. M. Walter (Stony Brook University)
E. F. Guinan (Villanova University)
R. T. Hamilton (Villanova University and Villanova University)
K. R. Briggs (ETHZ)
C. Baldovin-Saavedra (Univ of Geneva)

Method: Measurement

Based on existing instrumentation: XMM-Newton, Chandra, Spitzer, SMARTS CTIO Observatory, Villanova Observatory

Purpose of research: The accretion history of low-mass young stars is not smooth but shows spikes of accretion that can last from months and years to decades and centuries. Observations of young stars in outbursts can help us understand the temporal evolution of accreting stars and the interplay between the accretion disk and the stellar magnetosphere. The young late-type star V1118 Orionis was in outburst from 2005 to 2006. We followed the outburst with optical and near-infrared photometry. The X-ray emission was further probed with observations taken with XMM-Newton and Chandra during and after the outburst.

In addition, we obtained mid-infrared photometry and spectroscopy with Spitzer at the peak of the outburst and in the post-outburst phase. The spectral energy distribution of V1118 Ori varied significantly over the course of the outburst. The optical flux showed the largest variations, most likely caused by enhanced emission by a hot spot. The hot spot dominated the optical and near-infrared emission at the peak of the outburst, while the disk emission dominated in the mid-infrared. The emission silicate feature in V1118 Ori is flat and does not vary in shape, but was slightly brighter at the peak of the outburst compared to the post-outburst spectrum. The X-ray flux

correlated with the optical and infrared fluxes, indicating that accretion affected the magnetically active corona and the stellar magnetosphere. The thermal structure of the corona was variable with some indication of a cooling of the coronal temperature in the early phase of the outburst with a gradual return to normal values. Color--color diagrams in the optical and infrared showed variations during the outburst, with no obvious signature of reddening caused by circumstellar matter. Using Monte-Carlo realizations of star+disk+hotspot models to fit the spectral energy distributions in ¨quiescence“ and at the peak of the outburst, we determined that the mass accretion rate varied from about 2.5E-7 Msun/yr to 1.0E-6 Msun/yr; in addition, the fractional area of the hotspot increased significantly. The multi-wavelength study of the V1118 Ori outburst helped us to understand the variations in spectral energy distributions and demonstrated the interplay between the disk and the stellar magnetosphere in a young, strongly accreting star.

Status: The multi-wavelength study was published in two papers, the first one presenting the initial results, the second one the full data set. A follow-up ground observation with the ESO/VLT has recently been awarded to confirm the Ne II detection and to study its spatial extent. The observations should take place in early 2011.

Publications:

1. Audard, M., Stringfellow, G.S., Guedel, M., Skinner, S.L., Walter, F.M., Guinan, E.F., Hamilton, R.T., Briggs, K.R., Baldovin-Saavedra, C. 2010, A&A, 511, 63: „A multi-wavelength study of the young star V1118 Orionis in outburst“
2. Audard, M., Guedel, M., Skinner, S.L., Briggs, K.R., Walter, F.M., Stringfellow, G.S., Hamilton, R.T., Guinan, E.F. 2005, ApJ, 635, L81: „X-Ray spectral variability during an outburst in V1118 Ori“

Abbreviations:

Msun	Solar mass

4.14 Black Holes: Supermassive black holes

Institute: International Space Science Institute (ISSI), Bern

In cooperation with: Department of Physics & Steward Observatory, The University of Arizona, Tucson, USA
CEA, IRFU, Service d'Astrophysique, Centre de Saclay, France
AstroParticule et Cosmologie (APC), Paris, France

Principal Investigator: M. Falanga

Co-investigators: F. Melia (Univ. Arizona)
A. Goldwurm (CEA, APC)

Method: Simulation
Theory
Measurement

Purpose of research: One of the most exciting recent development in Astrophysics has been the use of current instruments to probe the space-time within only a few Schwarzschild radii of the supermassive black hole at the Galactic center. Interesting X-ray and IR flares from this supermassive black hole (Sag A*) seem to display a modulation in the light curve, consistent with orbiting matter about 3 Schwarzschild radii above the event horizon. With my collaborators we are studying these flares theoretically. We have carried out highly detailed theoretical modeling of this phenomenon, beginning with a full magnetohydrodynamic simulation, and culminating with the most recent general relativistic ray-tracing calculation of the time-dependent emissivity from this object during such a flare. The combination of this unusual and important observation by XMM-Newton, the subsequent analysis by our group, and the ensuing theoretical modeling, have produced a noteworthy advance in our understanding of the supermassive black hole at the Galactic center.

I am carrying out deeper theoretical modeling to understand these flares, now focusing strictly on the alternative possibility that the modulation is associated with a disturbance rotating at the local Keplerian velocity. This assumption is always made when one attempts to infer the radius of the marginally stable orbit in order to extract a value for the black hole's spin. We hope through our efforts we will be able to answer the question, "Where exactly is the inner edge of the accretion disk in Sagittarius A*?" In order to achieve this goal, we will examine the nature of the observed quasi-period and focus on its implications for the flow of matter through the innermost stable circular orbit. A principal result of this study is a ray-tracing simulation of the general-relativistically modulated lightcurve produced as the disrupted plasma spirals inwards towards the disk's "stress edge". We will simulate the lightcurve using my ray-tracing code to determine the general-relativistically modulated X-ray luminosity

expected from plasma coupled magnetically to the rest of the disk as it spirals inwards below the innermost stable circular orbit towards the „stress edge“ in the case of a Schwarzschild metric. The resulting lightcurve modulation will then be compared with that observed during a recent X-ray flare from Sgr A*.

Publications:

1. Polarized Multi-Wavelength Imaging of Sag A*, Falanga M., Melia F., & Goldwurm A., 2010 ApJ to be submitted
2. Falanga M., Melia F., Tagger M., Goldwurm A., Bélanger G.,: General Relativistic Flux Modulations from Disk Instabilities in Sagittarius A*, 2008, ApJ Letter, 622, 15
3. Falanga M., Melia F., Pretscher M., Bélanger G., Goldwurm A. 2008: Modulated X-Ray Emissivity near the Stress Edge in Sagittarius A*, ApJ Letter, 679, 93

5 Solar Physics

5.1 Solar wind noble gases measured in collectors from the Genesis mission

Institute: ETH Zurich, Earth Sciences

In cooperation with: NASA, UCLA, Los Alamos Natl. Lab., JPL, CRPG-Nancy

Principal Investigator: Rainer Wieler

Co-investigators: Nadia Vogel
Veronika Heber (UCLA)
Donald Burnett (JPL)
B. Marty (Nancy)

Method: Measurement

Based on existing instrumentation: Noble gas mass spectrometry

Purpose of research: The isotopic composition of the solar wind serves as proxy for the composition of matter in the solar accretion disk, from where sun and planets formed. For ultravolatile elements like noble gases, oxygen and nitrogen, the solar wind is the only source to obtain such information crucial to understand the formation of meteorite parent bodies, which are proxies for planetary building blocks. The elemental composition in the solar wind is furthermore of interest to study acceleration processes in the solar wind.

We measure the isotopic and elemental composition of noble gases captured in various target material exposed to the solar wind for about 2 years onboard NASA‘s Genesis space mission. The analyses are done by mass spectrometry and are of unprecendented accuracy, e g., compared to previous meausurements on lunar samples or aluminum foils exposed on the lunar surface during the Apollo missions. Noble gas analyses in one special target also serve to correct for instrumental isotopic fractionation of oxygen and nitrogen isotopes measured by other groups at UCLA
and the CRPG, Nancy France. The latter two elements are the highest priority goals of Genesis.

Status: Most analyses completed. Publications underway.

Time-Line	From	To
Planning	1996	2004
Construction	2000	2005
Measurement phase	2004	2010
Data evaluation	2004	2010

Publications:

1. Grimberg, A., et al. 2006, Science, 314, 1133
2. Heber, V. S., Wieler, R., Baur, H., Olinger, C., Friedmann, T. A., & Burnett, D. S. 2009, Geochim. Cosmochim. Acta, 73, 7414
3. Marty, B., et al. 2010, Geochim. Cosmochim. Acta, 74, 340

Abbreviations:

UCLA	Univ. California, Los Angeles
CRPG	Centre de Recherches Petrographique et Geochimiques (Nancy)

5.2 Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI)

Institute: Institute of Astronomy, ETH Zurich

In cooperation with: University of California, Berkeley, USA
NASA, Goddard Space Filght Center, Greenbelt, USA
Paul Scherrer-Institut, Villigen, CH

Principal Investigator: R. P. Lin, UCB

Co-investigators: B.R. Dennis (Goddard SFC)
A. Zehnder (PSI)
A. O. Benz (ETHZ)

Method: Theory

Development of software: Data analysis software, Data archive, Quick-look images

Purpose of research: The RHESSI mission is devoted primarily to the study of solar flares in X-rays and gamma-rays. It also has observed cosmic gamma-ray bursts, high-energy radiations of the supernova nebulae, X-rays produced by terrestrial

lightening. The energy release of flares is a nonthermal process that accelerates electrons and ions to relativistic velocities. In large flares up to 10^27 MWh are released. The primary products are energetic particles that can best be studied by emissions in hard X-rays, gamma-ray lines and radio waves. RHESSI is a Small Explorer class satellite of NASA with a strong Swiss envolvement.

The HESSI Experimental Data Center (HEDC) has been developed as a collaboration between three ETH institutes (Astronomy, Computer Systems and Information Systems) to cope with the flow of RHESSI data and distribute them in Europe. Images and light curves are reconstructed at HEDC from single photon energy and time data. The data products demand considerable computing time. They are stored and can be browsed through the Internet. This greatly facilitates the overview on existing data and the selection for further analysis.The user also can have more products computed on-line and store them in the archive that is automatically growing in information on interesting events. The data center is being moved to Fachhochschule der Nordwestschweiz in Windisch.

Status: RHESSI was launched on February 5, 2002. The data are transmitted to the ground station in Berkeley every 12 hours and distributed through Internet to be stored in HEDC. First data products are being produced for quick look browsing, data evaluation and selection every night. The satellite is in excellent conditions and delivers high quality data. The observations in 2005 show solar activity in the declining phase of the solar 11 year cyle, and include the observation of an extremely powerful gamma-ray burst.

RHESSI data are complemented by radio observations by the ETH spectrometer PHOENIX-2 in Bleien (Switzerland). Software development is continuing and focusses mostly on imageing spectroscopy.

The data analysis at ETH has focussed on the spectral properties of the acceleration process. We have quantitatively measured the relation between X-ray flux and hardness for the first time. The motion of the X-ray sources on the disk has shown surprising results, contradicting the existing scenario of steady reconnection.The future analysis will focus on spectroscopy in picture elements (imaging spectroscopy), on relating the coronal source (representing the acceleration process) with the footpoints, and derive the energetics in a new scenario.

Time-Line	From	To
Planning	1998	1999
Construction	2000	2003
Measurement phase	2002	-
Data evaluation	2002	-

Publications:

1. M. Battaglia, A.O. Benz: „ Observational evidence for return currents in solar flare loops“, Astronomy and Astrophysics, 487, 337 -- 344 (2008)
2. M. Battaglia, L. Fletcher, A.O. Benz: „Observations of conduction driven evaporation in the early rise phase of solar flares“, Astronomy and Astrophysics, 498, 891 -- 900 (2009)
3. B. Dabrowski, A.O. Benz: „Correlation of decimetric radio emission and hard X-rays in solar flares“, Astronomy and Astrophysics, 504, 565 -- 573 (2009)

Abbreviations:

RHESSI	Reuven Ramaty High Energy Solar, Spectroscopic Imager
PHOENIX	Radio spectrometer of ETH Zurich in Bleien, near Graenichen, AG
HEDC	HESSI European Data Center

5.3 VIRGO/SOHO

Institute: PMOD/WRC

In cooperation with: ESA/NASA

Principal Investigator: Claus Fröhlich (PMOD/WRC)

Co-investigators: Wolfgang Finsterle (PMOD/WRC)
Werner Schmutz (PMOD/WRC)
Christoph Wehrli (PMOD/WRC)

Method: Measurement

Development and construction of instruments: VIRGO package and sensors

Purpose of research: VIRGO provides continuous high-precision measurements of the total and spectral solar irradiance (TSI and SSI). The data are used for research in two areas: 1) Evaluation of the direct and indirect solar influence on the terrestrial climate; 2) MHD-investigations of the variable amplitude of solar acoustic eigenmodes (as measured by the three spectral channels on VIRGO).

Status: After 15 years VIRGO on SOHO is still operational. The SOHO mission is presently extended until 2014.

Time-Line	From	To
Planning	n/a	-
Construction	n/a	-
Measurement phase	1996	ongoing
Data evaluation	1996	ongoing

Publications:

1. Fröhlich C. (2009), A&A 501, L27-L30, „Evidence of a long-term trend in total solar irradiance“
2. Simoniello, R.; Finsterle, W.; García, R. A.; Salabert, D.; Jiménez, A.; Elsworth, Y.; Schunker, H. (2010), A&A 516, A30, „Acoustic power absorption and enhancement generated by slow and fast MHD waves - Evidence of solar cycle velocity/intensity amplitude changes consistent with the mode conversion theory“
3. Steinhilber, F.; Beer, J.; Fröhlich, C. (2009), GRL 36, L19704, „Total solar irradiance during the Holocene“

Abbreviations:

MHD	Magnetohydrodynamik
SSI	Spectral Solar Irradiance
SOHO	Solar and Heliospheric Observatory, Space Mission of ESA and NASA, launched December 1995
TSI	Total Solar Irradiance
VIRGO	Variability of Solar Irradiance and Gravity Oscillations, PMOD/WRC Experiment on SOHO

5.4 SOVIM/ISS

Institute: PMOD/WRC

In cooperation with: ESA
NASA

Principal Investigator: Claus Fröhlich (PMOD/WRC)

Co-investigators: Wolfgang Finsterle (PMOD/WRC)
Werner Schmutz (PMOD/WRC)
Christoph Wehrli (PMOD/WRC)

Method: Measurement

Development and construction of instruments: SOVIM was a re-flight experiment, which was built around original components from the SOVA instruments that flew on the EURECA platform in 1992. The start of the project was in 1998, launch occurred 10 years later on February 7, 2008. SOVIM has a mass of 21 kg and a nominal power consumption of 30 W. First switch-on of SOVIM occurred in the night of February 15 to 16, 2008 and it was operational until October 28, 2008. SOVIM contains two pairs of absolute radiometers, one pair of type PMO6 radiometers developed and built by PMOD/WRC and one pair of DIARAD radiometers from IRMB, Belgium. There are two 3-channel sun-photometers, and a two axis Sun sensor. The latter two instruments are also built by PMOD/WRC.

Purpose of research: SOVIM is an experiment within the ESA payload SOLAR on the International Space Station, which was realized by PMOD/WRC and IRMB. SOVIM was an under-flight experiment to verify the instrumental degradation of the SOHO/VIRGO absolute radiometers and filter photometers, which have been flying in space for more than a decade. The SOVIM measurements confirmed the validity of assessing instrumental degradation by operating two identical sensors in parallel but with largely different duty cycles of the exposures.

Status: SOVIM failed after being in orbit for about eight months. A failure of the power supply (DC/DC convertor) is the probable cause.

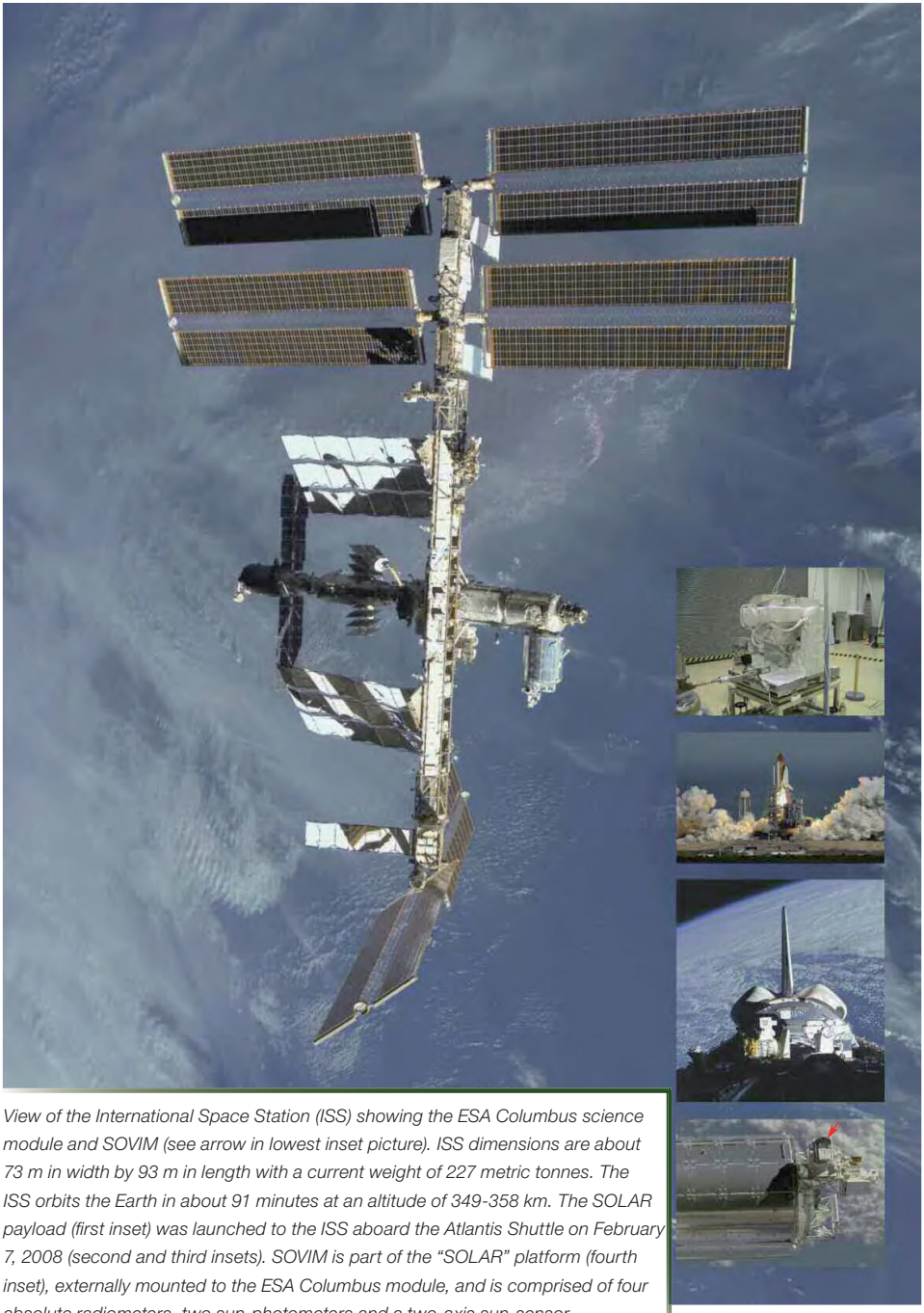
Time-Line	From	To
Planning	n/a	
Construction	1998	2007, funded by Swiss PRODEX
Measurement phase	15/02/2008	28/10/2008
Data evaluation	2008/2009	

Publications:

1. Finsterle et al. (2009), “The TSI measurements of PMOD/WRC“, MOCA-09
2. Fröhlich C., Finsterle W., and The SOVIM team (2009), “Results from the SOVIM Experiment on the International Space Station: Comparison of the Radiometers with those of VIRGO”, Annual report 2008, PMOD/WRC Davos, p. 31
3. Koller S., Pfiffner D. (2009), “Space experiment SOVIM”, Annual report 2008, PMOD/WRC Davos, p. 16

Abbreviations:

ISS	International Space Station
SOVIM	Solar Variability and Irradiance Monitoring, PMOD/WRC experiment on the International Space Station Alpha, launched and operational 2008



View of the International Space Station (ISS) showing the ESA Columbus science module and SOVIM (see arrow in lowest inset picture). ISS dimensions are about 73 m in width by 93 m in length with a current weight of 227 metric tonnes. The ISS orbits the Earth in about 91 minutes at an altitude of 349-358 km. The SOLAR payload (first inset) was launched to the ISS aboard the Atlantis Shuttle on February 7, 2008 (second and third insets). SOVIM is part of the "SOLAR" platform (fourth inset), externally mounted to the ESA Columbus module, and is comprised of four absolute radiometers, two sun-photometers and a two-axis sun-sensor.

5.5 LYRA/PROBA2

Institute: PMOD/WRC

In cooperation with: Royal Observatory of Belgium (ROB)
ESA

Principal Investigator: Marie Dominique, ROB, B
Until 2010: Jean-François Hochedez, ROB, B

Co-investigators: Wolfgang Finsterle (PMOD/WRC)
Werner Schmutz (PMOD/WRC)
Christoph Wehrli (PMOD/WRC)

Method: Measurement

Development and construction of instruments: The Lyman-Alpha Radiometer (LYRA) is a payload on ESA's technology mission PROBA2. Hardware and electronics were designed and manufactured in-house at PMOD/WRC. The novel diamond detectors were contributed by IOMEC, Belgian. The project began in 2002 and the flight unit was delivered to Verhaert Space, Belgium in 2007. The launch of PROBA 2 was in November 2, 2009 from Plesezk, Russia. LYRA has a mass of 3.5 kg, a nominal power consumption of 3 W, and measures 315 mm x 92.5 mm x 222 mm. First light of occurred on January 6, 2010 and the instrumentation successfully passed the commissioning phase. LYRA continues to be healthy and fully operational.

Purpose of research: LYRA is a solar EUV and FUV filter photometer, designed and manufactured by a Belgian–Swiss consortium. It monitors the solar irradiance in four passbands relevant to Solar Physics, Space Weather and Aeronomy:

- 115-125 nm Lyman-αlpha channel,
- 200-220 nm Herzberg continuum channel,
- Aluminium filter channel (17-50 nm) including the strong He II at 30.4 nm, and
- Zirconium filter channel (1-20 nm), rejecting He II.

LYRA is a payload on ESA's technology mission PROBA2. The technological innovation of LYRA is that it tests wide bandgap detectors based on diamond: LYRA is the first space assessment of the so call BOLD detectors (Blind to Optical Light Detectors). Diamond makes the sensors radiation-hard and solar-blind: its large bandgap energy makes them insensitive to visible light. LYRA contains three UV filter radiometer instruments, each equipped with four channels. Two instruments are equipped with BOLD detectors one instrument uses silicon detectors for assessment of the novel diamond detectors.

Status: LYRA is operational and provides near-real-time monitoring of the solar FUV and UV irradiance. Archived data and a graphic representation of the latest 3 days of that solar FUV irradiance are accessible through the PROBA 2 website: http://proba2.oma.be/index.html.

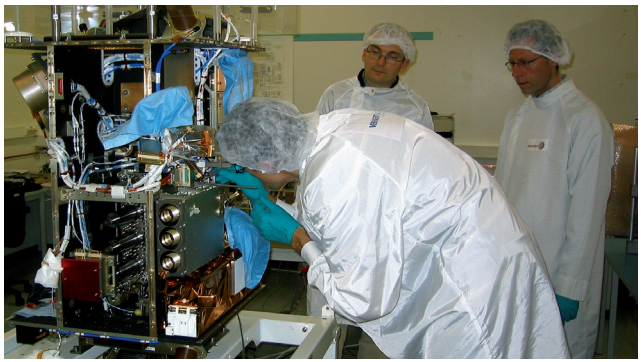
Time-Line	From	To
Planning	n/a	
Construction	2002	2007, funded by Swiss PRODEX
Measurement phase	Jan 6, 2010	still operational
Data evaluation	2010	ongoing

Publications:

1. Hochedez J.-F., Schmutz W., Stockman Y., et al. (2006), "LYRA, a solar UV radiometer on Proba 2", Adv. Space Res. 37, 303-312
2. Egorova T., Rozanov E., Hochedez J.-F., Schmutz W. (2008), "Reconstruction of the solar spectral UV irradiance for nowcasting of the middle atmosphere state on the basis of LYRA measurements", Atmos. Chem. Phys., 8, 2965-2973
3. Benmoussa A., Dammasch I.E., Hochedez J.-F., et al. (2009), "Pre-flight calibration of LYRA, the solar VUV radiometer on board PROBA2", A&A 508, 1085-1094

Abbreviations:

EUV	Extreme Ultraviolet
FUV	Far Ultraviolet
LYRA	Lyman-Alpha Radiometer, PMOD/WRC experiment on PROBA2



Integration of LYRA on the spacecraft PROBA 2 on March 5, 2007 at the Belgian firm Verhaert Space. The person to the right is Silvio Koller, LYRA instrument engineer at PMOD/WRC, responsible for all manufacturing aspects of the hardware and electronics.

5.6 PREMOS/PICARD

Institute: PMOD/WRC

In cooperation with: LATMOS, F
CNES, F

Principal Investigator: Werner Schmutz (PMOD/WRC)

Co-investigators: A. Fehlmann (PMOD/WRC)
W. Finsterle (PMOD/WRC)
G. Hülsen (PMOD/WRC)
E. Rozanov (PMOD/WRC)
M. Suter (PMOD/WRC)
Ch. Wehrli (PMOD/WRC)

Method: Measurement

Development and construction of instruments: PREMOS was designed, developed, and built in house at PMOD/WRC. The project was funded by Swiss PRODEX. The PREMOS experiment has a mass of 10 kg and its power consumption in regular operation is 10 W.

Purpose of research: PICARD is a French space mission, which was launched June 15, 2010. PICARD is monitoring the solar activity with three experiments. PREMOS (PREcision MOnitoring of the Solar irradiance) is a Swiss PI experiment, developed, and built by the Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center (PMOD/WRC). PREMOS had first light on July 27, 2010 and is working as expected, monitoring the solar irradiance with a time resolution of one minute. The PREMOS experiment comprises six filter radiometers, measuring at 212, 215, 268, 535, 607 and 782 nm, and an absolute radiometer for measurement of the total solar irradiance. PREMOS is the first space experiment with a calibration of the absolute radiometer which is fully end-to-end traceable to SI. The observations of PREMOS have now resolved a dispute on the absolute value of the Total Solar Irradiance: There was a disagreement of more than 4 W/m^2 between all previously flown experiments to TIM on SORCE which was launched in 2003. The traceable PREMOS measurements now yield a Total Solar Irradiance in August 2010 of 1361.7 W/m^2 with an uncertainty of 0.7 W/m^2. The PREMOS value is 0.6 W/m^2 higher than that of TIM/SORCE and thus, agrees within the uncertainty, but is 3.4 W/m^2 below that of, e.g., VIRGO/SOHO. Therefore PREMOS falsifies the higher value of all other experiments.

Status: The satellite PICARD was launched June 15, 2010 with a VEGA rocket from Baikonour, Kasachstan. PREMOS had first light on July 27, 2010 and is since then operational as expected.

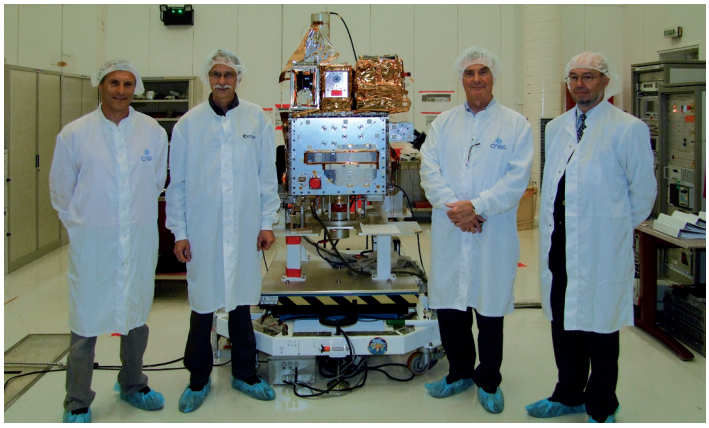
Time-Line	From	To
Planning	n/a	
Construction	2000	2009
Measurement phase	27/07/2010	ongoing
Data evaluation	2010/2011 commissioning phase	

Publications:

1. Schmutz W., Fehlmann A., Hülsen G., Meindl P., Winkler R., Thuillier G., Blattner P., Buisson F., Egorova T., Finsterle W., Fox N., Gröbner J., Hochedez J.-F., Koller S., Meftah M., Meisonnier M., Nyeki S., Pfiffner D., Roth H., Rozanov E., Spescha M., Wehrli C., Werner L., Wyss J.U. 2009, The PREMOS/PICARD instrument calibration, Metrologia 46, S202–S206, doi: 10.1088/0026-1394/46/4/S13
2. Thuillier G., Dewitte S., Schmutz W., The Picard Team, 2006, Simultaneous measurement of the total solar irradiance and solar diameter by the PI- CARD mission, Adv. Space Res. 38, 1792–1806, doi: 10.1016/j.asr.2006.04.034

Abbreviations:

PREMOS	Precision Monitoring of Solar Variability, PMOD/WRC experiment on PICARD
TSI	Total Solar Irradiance



Visit to the CNES laboratories at Toulouse during the PICARD Science Committee meeting on October 22, 2009. The satellite PICARD is finally fully-assembled with the science experiments PREMOS, SOVAP, BOS, and SODISM (from left to right). Persons from left to right are: the PICARD project manager, François Buisson, CNES France; PREMOS PI Werner Schmutz, PMOD/WRC Switzerland: PICARD PI and SODISM PI Gérard Thuillier, LATMOS France; BOS PI Michel van Ruymbeke, ROB Belgium.

6 Earth Observation, Remote Sensing

6.1 Swiss scientific National Point of Contact for Satellite Images (NPOC)

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: Swiss Federal Office of Topography (swisstopo)

Principal Investigator: Prof. Dr. Michael E. Schaepman

Co-investigators: Felix Seidel

Purpose of research:

- Scientific advice to Swiss stakeholders (i.e. federal offices, research institutions, industry) in the procurement, processing and use of remote sensing data and satellite images, as well as in relation to the International Charter on Space and Major Disasters.
- Promote the scientific use of Earth observation data and inform Swiss stakeholders on ESA and Third Party Missions, European initiative Global Monitoring for Environment and Security (GMES), archives, data sharing programs, Announcements of Opportunity, conferences and workshops, etc.
- Scientific support for Swiss federal offices in the research and development of new Earth observation products and services.
- Support for the Swiss Space Office and its delegates in the field of Earth observation, including the preparation and implementation of information meetings and conferences, promotion of ESA Earth observation activities in Switzerland and the participation in the development of Swiss positions in international bodies (incl. PB-EO, DOSTAG, GAC, FP7/Space).

Status: Project is operational since 2004 with slightly adjusted objectives since 2008.

Publications:

1. Teichler D., Seidel F., and Schaepman M.: Study on the needs for Geoinformation for the Swiss Federal Department of Foreign Affairs, 2010 (orig. in German)

2. Seidel F. and Teichler D.: Evaluation of the Swiss requirements regarding a future user strategy for GMES, 2010 (orig. in German)
3. Seidel F. and Kellenberger T.: The use of remote sensing for rapid mapping, 2006 (orig. in German)

Abbreviations:

NPOC	National Point Of Contact
RSL	Remote Sensing Laboratories
GMES	Global Monitoring for Environment and Security

6.2 Radiometric Terrain Correction for Spaceborne SAR

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: European Space Agency
Canadian Space Agency

Principal Investigator: Dr. David Small

Co-investigators: Dr. Erich Meier

Method: Measurement

Based on existing instrumentation: ENVISAT ASAR, ALOS PALSAR, TerraSAR-X, RADARSAT-1/2, ERS-1/2

Purpose of research: In this project, the University of Zurich Remote Sensing Laboratories (UZH-RSL) works directly with ESA and other partners to develop a new kind of spaceborne SAR image product whereby many of the effects of topography on radar image brightness are modelled and corrected before estimating the backscatter coefficient at every point.

The new type of product would offer several benefits. Comparisons of backscatter from image acquisitions made from differing orbital tracks become possible. Flattening the terrain-effects on radar brightness enables significantly more frequent revisits to a given point on the Earth, particularly given the availability of a wide swath mode

such as ASAR WS, RADARSAT-1 & 2 SCN & SCW, and ALOS PALSAR WB (wide beam).

This development enables a great improvement in „temporal resolution“, a parameter of critical importance in land cover monitoring, lowering the probability of missing the cusp of an event. Deep time series can be built up for a chosen area much more quickly from a single sensor given a wider variety of tracks (even combinations of ascending and descending passes). There is an added benefit: it becomes much easier to integrate backscatter measurements from a diversity of sensors. Each sensor is typically characterised by the single orbital repeat period chosen at launch and the set of beam modes on offer. Different sensors therefore almost always implies differing tracks, modes, and nominal incidence angles that without terrain-flattening triggers incompatability with a meaningful comparison. Only terrain-flattened backscatter, a product we call terrain-flattened gamma nought, offers the possibility of combining data from multiple SAR sensors acquired over terrain.

Future sensors such as the ESA Sentinel-1a and Sentinel-1b satellites, the first of which is currently set for launch in 2012, offer the promise of possible daily images of Switzerland. Given the severe topography in the country, construction of backscatter time-series requires rigorous radiometric calibration that accounts for track-dependent effects of terrain. If a standard terrain-flattened backscatter product could be offered by ESA, that would simplify interpretation not only in Switzerland, but throughout the world.

Status: The terrain-flattened gamma methodology has been developed and tested on the major spaceborne SAR sensors. Tests have been performed and published using data from ENVISAT ASAR, ALOS PALSAR, RADARSAT-2, and TerraSAR-X. In the case of ASAR WS data covering Switzerland, over 400 images from the time period between 2002 and 2010 have been processed, and seasonal trends have been established. The springtime melting in the Swiss Alps generates a strong signal: terrain-flattened backscatter makes monitoring the snow melt every three days theoretically possible using the ASAR WS mode.

Wet snow measurements have been evaluated qualitatively and will be tested against state-of-the-art operational methdologies in the coming months. Stacks of nearly one hundred WS images have also been analysed over four further areas outside of Switzerland: similar wet-snow trends were observed. Dual polarisation L-band ALOS PALSAR fine-beam dual (FBD) data is being used to evaluate the potential for forest biomass measurement and monitoring in Switzerland.

Time-Line	From	To
Planning	ongoing	
Construction	-	
Measurement phase	ongoing	
Data evaluation	ongoing	

Publications:

1. Small D., Miranda N., Zuberbühler L., Schubert A., and Meier E.: Terrain-corrected Gamma: Improved Thematic Land-cover Retrieval for SAR with Robust Radiometric Terrain Correction, Proc. of ESA, Living Planet Symposium, Bergen, Norway, 28 June - 2 July 2010, 8p
2. Small D., Miranda N., and Meier E.: A revised radiometric normalisation standard for SAR, Proc. of IEEE International Geoscience & Remote Sensing Symposium 2009, Cape Town, South Africa, pp. 566-569
3. Small D., Jehle M., Schubert A., and Meier E.: Accurate geometric correction for normalisation of PALSAR radiometry, Proc. of ALOS PI, Symposium 2008, 3-7 Nov. 2008, Rhodes, Greece.

Abbreviations:

ALOS	Advanced Land Observation Satellite
ASAR	Advanced Synthetic Aperture Radar
ESA	European Space Agency
JAXA	Japanese Space Agency
PALSAR	Phased Array L-band Synthetic Aperture Radar
RSL	Remote Sensing Laboratories
SAR	Synthetic Aperture Radar
SCN	RADARSAT ScanSAR Narrow
SCW	RADARSAT ScanSAR Wide
UZH	University of Zurich
WB	ALOS PALSAR Wide Beam
WS	ENVISAT ASAR Wide Swath

6.3 SAR Geometry

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: European Space Agency (ESA)
German Aerospace Center (DLR)

Principal Investigator: Dr. David Small

Co-investigators: Dr. Adrian Schubert
Dr. Michael Jehle
Dr. Erich Meier

Method: Measurement

Purpose of research: The European Space Agency (ESA), Germany's Aerospace Center (DLR) and Japan's Aerospace Exploration Agency (JAXA) all provide space-based synthetic aperture radar (SAR) remote sensing images of the Earth to scientific and commercial users. Their SAR products inherently contain precise information describing the satellite orbit and instrument characteristics, permitting the data to be projected into a map geometry either by the agencies themselves, or the users. The quality of the map projection determines how well the location of a given image sample (pixel) can be said to be known. In other words, a SAR product's geolocation accuracy determines how well the image can be made to fit on top of a reference map. The higher its geolocation accuracy, the better this data can be merged, combined, or overlaid with additional remote sensing images or geographic information system (GIS) layers from other data sources - ultimately increasing end-user confidence in the data and their ability to use it as an interpretative aid.

The SARLab, a research group integrated within the Remote Sensing Laboratories (RSL) at the University of Zurich, estimated the geolocation accuracy of SAR sensors from ESA, DLR, and JAXA using different methods, providing feedback and offering possible solutions when problems were discovered.

In collaboration with ESA, DLR and JAXA, SARLab made measurements of the absolute geolocation accuracy of their standard SAR products using trihedral corner reflectors deployed at Swiss test sites. The reflector positions were measured to centimeter accuracy using differential GPS. Because they appear as strong localized bright peaks in the SAR images, they served as accurate ground control points for the image geometry. In parallel with these corner reflector measurements, different

product types were tested for geometric consistency relative to each other. To this end, all images were projected into a given reference map geometry, and pair-wise image matching revealed relative shifts between the images. These effects were often restricted to the sub-pixel level, testifying to the extremely high accuracy and stability of these sensors. In November 2010, these methods were applied to validate the SAR products delivered by the ASAR instrument on the ENVISAT satellite, the orbit of which had recently been modified to extend its mission.

In the case of DLR's TerraSAR-X SAR sensor, providing sub-metre resolution to the scientific community, SARLab was able to detect and quantify the effect of atmospheric refraction for the first time. This not only confirmed the high geometric quality of the system as a whole, but made it possible to recommend ways to correct for atmospheric distortions.

As a further testimony to TerraSAR-X's abilities, SARLab was able to show that its highest-resolution acquisition mode can be used to detect glacier flow, given a time-series of images acquired with a single viewing geometry over the same area.

To help meet the increasing demand for standardized methods for geometric quality control among SAR products, and in collaboration with ESA, SARLab developed several quality indicators that can be applied to products from any SAR sensor. It is hoped that these indicators will help standardize the determination of geolocation accuracy in future SAR sensors.

Status: In November 2010, SARLab applied geometric quality control methods to validate the SAR products delivered by the ASAR instrument on ESA's ENVISAT satellite, whose orbit had been recently been modified to extend its mission lifetime.

To help meet the increasing demand for standardized methods for geometric quality control among SAR products, and in collaboration with ESA, SARLab developed several quality indicators in 2010 that can be applied to SAR products from any sensor. It is hoped that these indicators will help standardize the determination of geolocation accuracy in future SAR sensors.

Time-Line	From	To
Planning	ongoing	
Construction	-	
Measurement phase	ongoing	
Data evaluation	ongoing	

Publications:

1. Schubert A., Jehle M., Small D., and Meier E.: Influence of Atmospheric Path Delay on the Absolute Geolocation Accuracy of TerraSAR-X High-Resolution

Products, IEEE Transactions on Geosciences and Remote Sensing, Vol. 48(2), Feb. 2010, pp. 751-758

2. Jehle M., Perler D., Small D., Schubert A., and Meier E.: Estimation of Atmospheric Path Delays in TerraSAR-X Data using Models vs. Measurements, Sensors, December 2008
3. Schubert A., Small D., and Miranda N.: Geometric Quality Indicators for SAR Products, Proc. of CEOS SAR Cal/Val Workshop 2010, University of Zurich, Switzerland

Abbreviations:

ESA	European Space Agency
DLR	German Aerospace Center
GIS	Geographic Information System
JAXA	Japan Aerospace Exploration Agency
RSL	Remote Sensing Laboratories
SARLab	Synthetic Aperture Radar Laboratory
SAR	Synthetic Aperture Radar

6.4 Airborne Ultra-Wideband Low-Frequency SAR

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: armasuisse
Swedish Defence Research Agency

Principal Investigator: Dr. E. Meier

Co-investigators: D. Henke
A. Barmettler

Method: Measurement

Based on existing instrumentation: airborne-sensor CARABAS (FOI, Sweden)

Purpose of research: We are investigating the potential of low-frequency ultra-wideband (UWB) SAR for mapping glacier beds. To realize this research objective we make use of data from the Swedish FOI airborne SAR sensor CARABAS operating in the

20-90 MHz bands and developed a three dimensional SAR processing method to generate height profiles from these CARABAS data. Therefore, a 3D reconstruction grid is spanned based on a digital terrain model and the backscattering response for each grid point is calculated by a time-domain backprojection algorithm. Subsequently, the single flight tracks are merged by a point-wise incoherent multiplication due to the low number of available flight tracks.

The 3D SAR application of the CARABAS sensor is especially interesting for estimating glacier height profiles since the low-frequency radar waves penetrate into ice and thus approximate the profile of the glacier bed up to a certain depth. The reason why the algorithm is based on incoherent multiplication is to allow a meaningful estimations of glacier profiles out of only few, arbitrary flight tracks.

To further improve results a refractivity model was incorporated into the algorithm and results were compared with other studies of glacier volume estimation methods which are based on glacier flow dynamics.

Status: Promising first results for data from a 2003 campaign over the Aletsch glacier region could be obtained. Up to a certain depth significant backscattering response can be measured and a clear line is visible which indicates probably the slope of the glacier bed. For the future, an objective validation of the results is necessary which includes ground truth measurements (e.g. with ground penetrating radar).

Time-Line	From	To
Planning	-	
Construction	-	
Measurement phase	2003	2006
Data evaluation	2004	ongoing

Publications:

1. Henke, D. and Meier, E.: Preliminary results of a low-frequency 3D-SAR approach for glacier volume mapping, Proc. of IEEE International Geoscience & Remote Sensing Symposium, Honolulu, USA, 2010
2. Henke, D., Barmettler, A. and Meier, E.: Bistatic experiment with the UWB-CARABAS sensor — First results and prospects of future applications, Proc. of the IEEE International Geoscience & Remote Sensing Symposium, Cape Town, South Africa, 2009
3. Barmettler, A. et al.: Swiss airborne monostatic and bistatic dual-pol SAR experiment at the VHF-Band, Proc. of EUSAR 2008, V. D. E. Informationstechnische Gesellschaft, VDE Verlag, 2008, pp. 139-142

Abbreviations:

RSL	Remote Sensing Laboratories
SAR	Synthetic Aperture Radar
FOI	Swedish Defence Research Agency
CARABAS	Coherent All RAdio BAnd Sensing

6.5 APEX - Airborne Prism Experiment

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich-Irchel
Winterthurerstrasse 190
8057 Zurich

In cooperation with: European Space Agency / PRODEX
European Space Agency / EOEP
VITO (Belgium)

Principal Investigator: Prof. Dr. Michael E. Schaepman

Co-investigators: Koen Meuleman (VITO)
Dr. Michael Jehle (RSL)

Method: Measurement

Development and construction of instruments: APEX

Development and construction of software:
Processing and Archiving Facility (PAF)

Purpose of research: Based on the present demand for airborne and spaceborne imaging spectroscopy data in remote sensing, the European Space Agency (ESA) has initiated a project to build a new generation airborne hyperspectral imager named APEX. APEX is a pushbroom imager with 300-500 spectral bands, operational in the spectral region from 380 to 2500 nm, and with 1000 pixels across track. It will be flown in an aircraft at operating altitudes between 2 and 14 km having a spatial resolution of 1-7 meters.

The mission objectives of APEX are mainly being a simulator, calibrator, and validator for spaceborne multispectral and hyperspectral instrument (such as ENMAP). APEX shall also foster the application development for hyperspectral imaging in Europe and

APEX Thermal Control Unit in Dornier DO-228 aircraft including Leica stabilizing platform

Support grid and scintillating bars mounted in one module target

worldwide. The project shall be an European answer to the scientific success of American hyperspectral instruments. Its specifications are state-of-the-art in resolution and overall radiometric performance.

Status: RSL is responsible for the scientific management of the project, for industrial consulting concerning the specialities of maging spectrometer instrument, and for the construction of the Processing and Archiving Facility (PAF). The latter will be an universal, database driven system supporting the processing and distribution of all APEX data acquisitions. Sophisticated information technology tools are used for a versatile processing system, which will be persistent throughout the operational phase of the instrument.

ESA EOEP has taken the lead within APEX by providing the SWIR detector technology, the calibration home base, and the technical management.

The project is currently at the end of Phase C/D, first flights have been successfully accomplished. Instrument acceptance is expected by the end of December 2010.

Time-Line	From	To
Planning	1997	2000
Construction	2002	2010
Measurement phase	2011	2015
Data evaluation	2011	2015

Publications:

1. D'Odorico, P., Alberti, E. and Schaepman, M.E.: In-flight spectral performance monitoring of the Airborne Prism Experiment, Appl. Opt., vol. 49, pp. 3082-3091, 2010

2. Itten, K.I., Dell'Endice, F., Hueni, A., Kneubuehler, M., Schlaepfer, D., Odermatt, D., Seidel, F., Huber, S., Schopfer, J., Kellenberger, T., Buehler, Y., D'Odorico, P., Nieke, J., Alberti, E. and Meuleman, K.: APEX - the hyperspectral ESA Airborne Prism Experiment, Sensors, vol. 8, nr. 10, p. 6235-6259, 2008

3. Schlaepfer D., Kaiser J.W., Brazile J., Schaepman M.E. and Itten K.I.: Calibration concept for potential optical aberrations of the APEX pushbroom imaging spectrometer, International Symposium on Remote Sensing. In: Sensors, Systems, and Next Generation Satellites VII. SPIE, Barcelona, Vol. 5234, pp. 221-231, 2003

Website: TV Coverage (SF TV, Einstein)
http://www.youtube.com/watch?v=yJ1ZDMAw9hc

Abbreviations:

APEX	Airborne Prism Experiment
EOEP	Earth Observation Envelope Programme
PRODEX	PROgramme de Developement d`EXperiences Scientifiques
RSL	Remote Sensing Laboratories
ENMAP	ENvironmental Mapping and Analysis Program
VITO	Vlaamse Instelling voor Technologisch Onderzoek

APEX in final integration in Dornier DO-228 aircraft and ready for take-off

6.6 GLADA - Global Assessment of Land Degradation and Improvement

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstr. 190
8057 Zurich

In cooperation with: Laboratory of Geo-Information Science and Remote Sensing (GIRS), The Netherlands
ISRIC - World Soil Information, The Netherlands

Principal Investigator: Dr. D. L. Dent (ISRIC)

Co-investigators: Prof. Dr. Michael E. Schaepman (RSL)
Rogier de Jong (WUR)

Method: Measurement

Based on existing instrumentation: Development of new analysis methods for time-series of satellite imagery, applied to NOAA AVHRR global NDVI dataset.

NDVI has a strong relationship with the fraction of photosynthetically active radiation (fPAR) absorbed by the plant; it is strongly correlated with vegetation cover and above-ground net primary productivity (NPP). Biomass is an integrated measure of biological productivity. Its deviance from the local norm may be taken as a measure of land degradation or improvement.

Purpose of research: Ever-increasing demands on the land from economic development, burgeoning cities and growing rural populations are driving unprecedented land use change. In turn, land use change is driving land degradation: soil erosion, nutrient depletion, salinity, water scarcity, pollution, disruption of biological cycles, and loss of biodiversity. This is a global issue, yet there is no authoritative measure of land degradation or its counterpoint of land improvement. The only harmonized assessment, the Global Assessment of Human-induced Soil Degradation is a map of perceptions on the type and degree of degradation. Dating from 1991, it is now out-of-date.

There was pressing need for an up-to-date, quantitative and reproducible assessment to support policy development. In response, within the GEF-UNEP-FAO program Land Degradation Assessment in Drylands (LADA), the Global Assessment of Land Degradation and Improvement (GLADA) identifies hotspots suffering extreme constraints or at severe risk and, also, areas where degradation has been arrested or reversed.

Status: The final report has been accepted by FAO. Methodological research will be caried on for one more year, resulting in a PhD dissertation early 2012.

Time-Line	From	To
Planning	Jan. 2005	Dec. 2005
Pilot phase	Jan. 2006	Dec. 2006
Analysis phase	2007	2009
Data evaluation	2008	2010

Publications:

1. Bai, Z.G., Dent, D.L., Olsson, L., and Schaepman, M.E.: Proxy global assessment of land degradation. Soil Use and Management, 24, 223-234, 2008
2. White, M.A., de Beurs, K.M., Didan, K., Inouye, D.W., Richardson, A.D., Jensen, O.P., Magnuson, J., OÕKeefe, J., Zhang, G., Nemani, R.R., van Leeuwen, W.J.D., Brown, J.F., de Wit, A., Schaepman, M.E., Lin, X., Dettinger, M., Bailey, A., Kimball, J., Schwartz, M.D., Baldocchi, D.D., Lee, J.T., & Lauenroth, W.K. (2009). Intercomparison, interpretation, and assessment of spring phenology in North America estimated from remote sensing for 1982 to 2006. Global Change Biology, 15, 2335 - 2359
3. de Jong, R., de Bruin, S., de Wit, A., Schaepman, M.E., and Dent, D.L.: Analysis of monotonic greening and browning trends from global NDVI time-series. Remote Sensing of Environment, 2010 (in press)

Abbreviations:

AVHRR	Advanced Very High Resolution Radiometer (spaceborne)
FAO	Food and Agricultural Organization of the United Nations
fPAR	Fraction of Photosynthetically Active Radiation
GLADA	Global Assessment of Land Degradation and Improvement
LADA	Land Degradation Assessment in Drylands
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NPP	Net Primary Productivity

6.7 HyperSwissNet

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: Space Center EPFL, Lausanne, Switzerland
Laboratory for Air Pollution and Environmental Technology, EMPA Duebendorf
Institute for Meteorology, Climatology and Remote Sensing, University of Basel, Basel
Remote Sensing Group, University of Bern, Bern
Land Use Dynamics Unit, Swiss Federal Research Institute WSL, Birmersdorf

Principal Investigator: Prof. Dr. M.E. Schaepman

Co-investigators: Dr. Alexander Damm

Method: Measurement

Based on existing instrumentation: APEX

Purpose of research: The Swiss University Conference (SUK) and ETH-board funded HyperSwissNet project aims at developing and supporting the scientific expertise and infrastructure in Switzerland for the exploitation of imaging spectroscopy (IS) for different Earth observation (EO) applications. The development of imaging spectrometers, the availability of Earth observations in high spectral resolution from air- and spaceborne platforms and the facility of their processing have remarkably evolved over the last decade. This trend leads to a level of maturity, which makes imaging spectroscopy accessible and useful for a larger research and user community. Against this background HyperSwissNet will develop a range of prototype application products drawing from the diverse expertise present in the project consortium and the respective user community.

The development and implementation of the different products will be based on dedicated flight experiments with the airborne ESA (European Space Agency) imaging spectrometer APEX (Airborne Prism Experiment) and will directly build on and link into the operational capabilities of the APEX processing and archiving facility (PAF). The scientific expertise gathered during the project will be further disseminated within the Swiss research community by integrating the developed capabilities into specific teaching modules.

Status: The HyperSwissNet project entered in 2010 into its third year. The project work was focused on the consolidation of the scientific design, the development of a teaching course and the development of dedicated algorithms for parameter retrieval form APEX imaging spectroscopy data. During an extensive field campaign in June 2010, APEX IS-data were acquired over seven different test sites in Switzerland. Field investigations were carried out in parallel and consist of data for calibrating and validating APEX data and algorithms.

Time-Line	From	To
Design phase	2008	2008
Preparation phase	2009	2009
Development phase	2010	2011
Evaluation phase	2011	2012

Publications:

1. Koetz, B., Itten, K.I., Borgeaud, M., Brunner, D., Buchmann, B., Feigenwinter, C., HŸsler, F., Kneubuehler, M., Parlow, E., Psomas, A., Wunderle, S. and Zimmermann, N.: HYPER-SWISS-NET: Fostering the Swiss Research Community in the Field of Imaging Spectroscopy, in Proc EARSeL Imaging Spectrometry Workshop. Tel Aviv, Israel, 2009
2. Damm, A., Kneubuehler, M., van der Linden, S. and Schaepman, M.E.: The APEX vegetation processor - an operational implementation of a physical approach for characterizing agricultural crops, Hyperspectral Workshop 2010, 17-19 March 2010, ESA-ESRIN, Frascati (Rome), CD-ROM, 2010
3. Damm, A., Erler, A., Meroni, M., Verhoef, W., Schaepman, M.E., Hillen, W. and Rascher, U.: Modelling the impact of sensor configurations on the FLD retrieval accuracy of sun-induced chlorophyll fluorescence, in Remote Sensing of Environment (submitted)

Abbreviations:

APEX	Airborne Prism Experiment

6.8 Ecochange - Biodiversity and Ecosystem Changes in Europe

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: 23 European Institutions

Principal Investigator: Prof. Dr. Michael Schaepman (RSL)

Co-investigators: Dr. Zbynek Malenovsky (RSL)

Method: Measurement

Based on existing instrumentation: MODIS LAI/FPAR product, airborne imaging spectroscopy data and products

Purpose of research: A range of advanced modelling approaches has been used so far to assess the impact of global change on biodiversity and ecosystems.

The project follows four main limitations that remain associated with these approaches:

- Knowledge and data of past species distribution is still limited, yet necessary for testing them in the past before projecting them to the future.
- We miss sound estimates of species and long distance migration rates in order to assess whether species will be able to keep pace with rapid global change.
- Some key assumptions of models, such as niche stability over time and/or space, are not well tested.
- We need more reliable estimates of uncertainties in model predictions.

Ecochange follows 5 approaches:

- Improve the current data structure with respect to biodiversity, climate, land use, land structural and socio-economic information.
- Improve current models and test critical model assumptions to cope with the required forecasting.
- Integrate prediction uncertainties into forecasting.
- Test a series of assumptions relevant for predicting the effects of global change upon biodiversity, ecosystems and relevant goods and services.

- Develop a series of future projections of biodiversity, ecosystem functions and the goods and services they provide based on coupled climate and land use and socio-economic change scenarios both at EU and case study scales.

The final goal of the project is to provide data, scenarios and associated confidence limits so that policy markers and land managers can use them for anticipating societal problems and for designing sustainable conservation strategies by accounting the most likely global change effects on biodiversity and ecosystems.

Status: The project is entering its final phase (year) for data dissemination and result publication.

Time-Line	From	To
Planning	-	2006
Measurement phase	2007	2008
Data evaluation	2009	2011

Publications:

1. Schaepman, M.E., Malenovsky, Z., Mücher, C.E., Kooistra, L., and Thullier, W.: Bridging Scaling Gaps for the Assessment of Biodiversity from Space. In The Full Picture (ed.) GEO Secretariat (Geneva, Switzerland), Tudor Rose, ISBN 978-92-990047-0-8, pp. 258-261, 2007
2. Malenovsky, Z., Mishra, K.B., Zeme,k F., Rascher, U. and Nedbal, L.: Scientific and technical challenges in remote sensing of plant canopy reflectance and fluorescence. Journal of Experimental Botany, 60(11), 2987-3004, 2009
3. Verrelst, J., Schaepman, M.E., Malenovsky, Z. and Clevers, J.G.P.W.: Effects of woody elements on simulated canopy reflectance: Implications for forest chlorophyll content retrieval, Remote Sensing of Environment, 114, 647-656, 2009

Abbreviations:

MODIS	Moderate Resolution Imaging Spectroradiometer
LAI	Leaf Area Index
FPAR	Fraction of Absorbed Photosynthetically Active Radiation

7 Earth Resources

7.1 Quality Layers for Hyperspectral Imaging Products (HYQUAPRO)

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: VITO (Belgium)
WUR (The Netherlands)
DLR (Germany)
TAU (Israel)
INTA (Spain)
PML (UK)
ISBE (Czech Republic)
GFZ (Germany)
FUB (Germany)

Principal Investigator: Dr. Ils Reusen (VITO)

Co-investigators: Prof. Dr. Michael E. Schaepman (RSL)
Dr. Mathias Kneubuehler (RSL)
Andreas Hueni (RSL)

Method: Simulation

Based on existing instrumentation: APEX

Purpose of research: HYQUAPRO, a Joint Research Activity (JRA) within FP-7 EUFAR, aims at the development of harmonized quality layers for Level 1 and Level 2 hyperspectral imaging data and higher performing water and soil products including quality measures. HYQUAPRO consists of 11 research partner institutions. The impact of this activity will be on increased transparency on the processing and quality of hyperspectral imaging data and products. RSL (in collaboration with VITO) is dealing with the definition of quality issues for the airborne APEX Processing and Archiving Facility (PAF).

EUFAR (www.eufar.net) is an Integrating Activity funded by the 7th Framework Programme of the European Commission. The FP7 EUFAR project (33 partners) runs

from 2008-2012 and aims at providing and improving the access to airborne facilities (i.e. aircraft, airborne instruments, data processing centers) for researchers in environmental and geo-sciences through Networking Activities (NA), Trans-national Access (TA) Activities and Joint Research Activities (JRA). The long term objectives of EUFAR are to lay the groundwork of a European distributed infrastructure for airborne research in environmental and geo-sciences for each European scientist to get access at „equal terms“ to the airborne facility the most suited to his scientific objectives.

Status: A concept for Uncertainty Propagation Analysis (UPA) of hyperspectral data processing was developed and applied. First, the input parameters of a number of imaging spectroscopy data processing chains were identified and a selection of uncertain input parameters was made. Then, a core set of quality indicators (QI) was established for pre-processed hyperspectral data sets and adapted to the participating PAF‘s in the project. Currently, selected robust and higher performing algorithms for application to airborne imaging spectroscopy data are developed and implemented. This research focuses on the areas of algorithms for Case 2 water quality and for soils, where hyperspectral remote sensing has shown to make significant improvements over conventional multispectral remote sensing techniques.

Time-Line	From	To
Planning	2008	2009
Construction	-	
Measurement phase	2009	2010
Data evaluation	2010	2011

Publications:

1. Itten K.I., DellEndice F., Hueni A., Kneubühler M., Schläpfer, D., Odermatt D., Seidel F., Huber S., Schopfer J., Kellenberger, T., Bühler Y., D‘Odorico P., Nieke J., Alberti E., Meuleman K.: APEX - the Hyperspectral ESA Airborne Prism Experiment, Sensors, Vol. 8, pp. 6235-6259, 2008
2. Reusen, I., Bachman, M., Beekhuizen, J., Ben-Dor, E., Biesemans, J., Brenguier, J.L., Brown, P., Chabrillat, S., Eisele, A., Gomez-Sanchez, J.A., Grant, M., Groom, S., Hanus, J., Heuvelink, G.B.M., Holzwarth, S., Hueni, A., Kaufmann, H., Knaeps, E., Kneubühler, M., Malthus, T., Meuleman, K., de Miguel Llanes, E., Mueller, A., Pimstein, A., Prado Ortega, E., Purcell, P., Ruhtz, T., Schaale, M., Schaepman, M. and Wendisch, M.: EUFAR goes Hyperspectral in FP-7, Workshop on Hyperspectral Image and Signal Processing- Evolution In Remote Sensing (WHISPERS’09), Grenoble (F), 26-28 August 2009, CD-ROM
3. Jehle, M., Hueni, A., Damm, A., D’Odorico, P., Kneubühler, M., Schläpfer, D., Schaepman, M. E. and Meuleman, K,: APEX – Current Status, Performance and Product Generation”, Proc. IEEE Sensors 2010 Conference, 01-04 November 2010, Waikoloa (HI), USA, CD-ROM

Abbreviations:

APEX	Airborne Prism Experiment
HYQUAPRO	FP-7 Joint Research Activity on „Quality Layers for Hyperspectral Imaging Products“
EUFAR	FP-7 Integrating Activity „European Framework for Airborne Research“

7.2 e-SOTER

Institute: Laboratory of Geo-Information Science and Remote Sensing
GIRS
Wageningen University
Droevendaalsesteeg 3
6708PB Wageningen
The Netherlands

In cooperation with: ISRIC, The Netherlands
University of Miskolc, Hungary
BGR, Germany
JRC, Italy
Cranfield University, England
Alterra, The Netherlands
Szent Istvan University, Hungary
SciLands, Germany
INRA, France
UNOTT, England
Czech University, Czech Republic
ISSCAS, China
ENA, Morocco
Wageningen University, The Netherlands

Principal Investigator: Dr. Vincent van Engelen (ISRIC)

Co-investigators: Dr. Sytze de Bruin (WUR)
Prof. Dr. Michael E. Schaepman (RSL)
Titia Mulder (WUR)

Method: Theory
Measurement

Based on existing instrumentation: ASTER imagery, SRTM, Fieldspec PRO FR

Purpose of research: There still exist gaps in the knowledge of how to apply advances in remote sensing to soil and terrain mapping. This study aims to contribute to filling these gaps by developing an integrated approach for using proximal and remote sensing for (1) identifying any of the factors of soil formation to stratify the landscape, i.e. into large relatively homogeneous soil-landscape units which can be used as covariate for Digital Soil Mapping or whose soil composition can be determined by classical sampling, (2) allowing measurement or prediction of soil properties by means of physically-based and empirical methods, and (3) supporting spatial interpolation of sparsely sampled soil property data as a primary or secondary data source in Digital Soil Mapping. This approach is especially useful for soil and terrain mapping on a regional scale, in areas where soil legacy data is sparse or unavailable.

Status: The research proposal has been approved in the beginning of 2009. All the necessary data has been collected and the fieldwork has been performed. Also, the first paper is submitted. The second paper will focus on an integrated approach for soil mineral mapping on a regional scale using proximal and remote soil sensing. This work is still in progress.

Time-Line	From	To
Planning	2008	
Fieldwork and Measurements	2010	
Research	2009	2012

Publications:

1. Mulder, V.L., de Bruin, S., Schaepman, M.E., & Mayr, T. (2010 (in print)). The use of remote sensing in soil and terrain mapping, a review. Geoderma

7.3 Multi-sensor image simulation and validation for deriving biophysical and -chemical variables of the Earth‘s surface

Institute: Laboratory for Geo-Information Science and Remote Sensing
Wageningen University
P.O. Box 47
6700 AA Wageningen
The Netherlands

In cooperation with: Remote Sensing Laboratories (RSL), University of Zurich
Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands

Principal Investigator: Valérie Laurent (WUR)

Co-investigators: Prof. Dr. Michael E. Schaepman (RSL)
Prof. Dr. Ing. Wout Verhoef (ITC)
Dr. Ir. Jan Clevers (WUR)

Method: Simulation

Development and construction of software: Radiative Transfer Code

Purpose of research: Physically-based approaches allow estimating vegetation parameters independently of space and time location by using radiative transfer (RT) models. Classically, the first step is to invert an atmospheric RT model to provide the top-of-canopy (TOC) reflectance data, which is then used as a reference for inverting a canopy RT model, thus providing estimates of the vegetation variables.

The pre-processing of the remote sensing data to TOC reflectances involves atmospheric correction and eventually also corrections for adjacency, topography and directional effects. These corrections are applied individually and sequentially. In reality, however, all these effects are inter-related, and the correction of each effect is complex and requires assumptions about the other effects, which entails a number of limitations in the TOC approach.

Alternatively, it is possible to couple the canopy and atmosphere RT models and to simulate the top-of-atmosphere (TOA) radiance. Adjacency, topography, and surface directional effects can then be included in the forward canopy-atmosphere model, yielding more accurate simulations. The model output is directly comparable to the radiance measured by the satellite, facilitating the parameter estimation process, as the preprocessing is reduced to a minimum. The TOA approach will benefit data assimilation and multi-sensor studies.

The purpose of this research is to investigate the TOA potential of the TOA approach for estimating canopy parameters. First, a proof of concept is provided by a simple case study using nadir data to estimate forest parameters. Then, more complex cases such as multi-angular data and image simulation will be investigated.

Status: A simple case study for estimating forest parameters in Czech Republic using CHRIS nadir data has been conducted. The results showed that TOC and TOA approaches had comparable performance for estimating the parameters. This provides a proof of concept for the TOA approach. The estimation of the forest parameters at the same site using the full set of CHRIS angular observation almost complete. The results show a good performance of the TOA estimation process.

Further research will include TOA image simulation for estimating vegetation parameters as well as a multi-temporal or multi-sensor study.

Time-Line	From	To
Project Duration	2008	2012

Publications:

1. Laurent, V., Verhoef, W., Clevers, J. and Schaepman M.E.: Estimating forest variables from top-of-atmosphere radiance satellite measurements using coupled radiative transfer models, Remote Sensing of Environment (in review)
2. Laurent, V., Verhoef, W., Clevers, J. and Schaepman M.E.: Estimating forest parameters from top of atmosphere multi-angular radiance data using coupled radiative transfer models, Symposium on Recent Advances in Quantitative Remote Sensing, Valencia, September 2010, CD-ROM
3. Laurent, V., Verhoef, W., Clevers, J. and Schaepman M.: Estimating forest parameters from top-of-atmosphere radiance measurements using coupled radiative transfer models, Hyperspectral Workshop, Frascati, March 2010, CD-ROM

Abbreviations:

RT	Radiative Transfer
TOC	Top Of Canopy
TOA	Top Of Atmosphere

8 Planets

8.1 FAMARS (First AFM on MARS)

Institute: Institute of Microengineering (IMT) from EPFL (Former institution of the University of Neuchâtel)

In cooperation with: Nanosurf AG, Liestal
University of Basel, Dpt of Physics

Principal Investigator: Urs Staufer (now at TU Delft)

Co-investigators:

Sebastian Gautsch	Teru Akiyama
Daniel Parrat	Nico de Rooij
Dominik Braendlin	Lukas Howald
Hans-Rudolph Hidber	Andreas Tonin
Micheal Hecht	William T. Pike

Method: Measurement

Development and construction of instruments: FAMARS instrument
Others: High resolution microscope

Purpose of research: The Phoenix Lander Mission investigated the geology, the climate, and the history of water in the northern arctic region of Mars from May 25 till November 2, 2008. For the first time, also an atomic Force Microscope experiment was included in such a robotic planetary science mission in order to investigate the soil particle size, size distribution, shape and texture.

Light scattering experiments conducted by the Viking and MER missions indicated that airborne dust, which eventually settles and becomes part of the top surface layer, has a particle diameter of one to a few micrometers. Scanning force microscopy or AFM (Atomic Force Microscopy) is a high resolution three-dimensional imaging method, having a resolution comparable to electron microscopy. It works on conductive and non-conductive samples. It was therefore decided to take besides an optical microscope (OM) also an AFM on board of Phoenix.

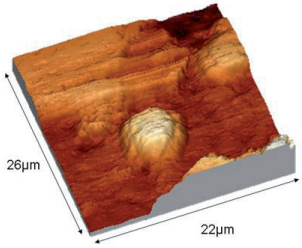
The low atmospheric pressure (~ 10mbar) and large temperature variations (~ 60 deg C) required special design solutions for the scanner of the instrument. In order to avoid electrical discharges, a low voltage Lorenz actuator was employed rather than the usual piezo-electric scanner. The damping was achieved by means of internal friction of the spring suspension. The instrument was successfully operated on Mars and produced the first high resolution images of Martian soil particles.

Concept of the Experiment
The dust samples were acquired by means of the robot arm and delivered to a substrate wheel, which was mounted on a rotation and translation stage. It was then pulled back into the box and rotated in front of the microscopes. A set of optical microscope images were acquired, sent to Earth and analyzed. Based on that, areas of interest for AFM imaging could be selected. The translation and rotation stage was then used to fine position the sample and perform the approach of the substrate to the AFM cantilever. For full details about the Phoenix AFM experimental procedure, the reader is referred to a paper by M. Hecht et al(Jour. of Geophysical Research - Planets 113, E00A22 (2008))

Instrument Design
In a first assessment, bulkiness, high sensitivity and required interaction between the instrument and an operator render atomic force microscopy unsuitable for planetary missions. However, microfabrication technologies combined with innovative design ideas allowed to build an error tolerant system with functionality for addressing the challenges generated by a 9-month space travel and the Martian surface conditions (S. Gautsch, Development of an Atomic Force Microscope and Measurement Concepts for Characterizing Martian Dust and Soil Particles, PhD thesis Univ. of Neuchatel, 2002; UFO Dissertation Band 423, ISBN 3-935511-24-8).

For redundancy, the microfabricated silicon sensor chip featured eight, about 6µm thick cantilevers each with a KOH-etched 7 to 8 µm high silicon tip. Cantilevers were mounted on support beams, which were also cleaved away. These beams were fabricated using DRIE to etch through the handle layer of the SOI. The cantilever deflection was measured using implanted, p-type piezo-resistors. Thermal drifts were compensated by a reference piezo-resistor (T. Akiyama, et al, Sensors and Actuators

Assembled AFM scanner with mounted silicon sensor chip



Martian soil particles as observed by the Phoenix AFM showing 4 particles. The spheroidal particle in the center is 8 µm in diameter, above it a plate-like particle is seen, the other two cross the image boundary.
(Image taken from [P. Smith et al, Science 325, 58 (2009). DOI: 10.1126/science.1172339], online supporting material, reprinted with permission of Science).

A 91, p. 321 - 325 (2001)). The silicon chip was glued on a triangular platform, which was suspended from the rigid body of the scanner by means of symmetrically arranged polyimide springs. The later also contained the electrical contacts to the chip. Three magnets were attached in the corners of the platform. An electrical coil mounted underneath each magnet allowed deflecting them. The whole scanner measured 12mm×18mm×24mm and weighed 15g.

Conclusion

The FAMARS AFM instrument has executed 85 experiments of which 26 were needed for calibration and for initially defining operational parameters. Of the remaining experiments about half (28) returned images where at least a signature of particles could be discerned. On sol 98, we successfully cleaved the first tip and cantilever, which was contaminated by that time, and continued operation with the second probe. We observed spheroidal and platy particles. The size distribution derived from these images was used in combination with the results from the optical microscope of the MECA platform to assess the whole range from 100nm to 200µm.

Acknowledgements

This work was supported by financial grants from the Wolfermann-Nägeli Foundation (CH), the Swiss priority program MINAST, the Space Center at EPFL (CH), the Republic and Canton of Neuchatel (CH) (CH), STFC (UK), and the NASA through the Phoenix Mission (USA). We would like to acknowledge P. Smith and the Phoenix Science and Engineering Teams for many helpful discussions.

Status: AFM images of Martian soil are still under investigation by the scientific community.

Time-Line	From	To
Planning	1998	1999
Construction	1999	2006 (2 generations)
Measurement phase	May 2008	September 2008
Data evaluation	July 2008	Ongoing

Publications:

1. M. Hecht et al, Jour. of Geophysical Research - Planets 113, E00A22 (2008)
2. T. Akiyama, et al, Sensors and Actuators A 91, p. 321 - 325 (2001)
3. P. Smith et al, Science 325, 58 (2009). DOI: 10.1126/science.1172339

Abbreviations:

AFM	Atomic Force Microscopy
MECA	Microscopy, Electrochemistry, and Conductivity Analyzer

8.2 BELA - BepiColombo Laser Altimeter

Institute: Physikalisches Institut of the University of Bern

In cooperation with: Deutsches Zentrum für Luft- und Raumfahrt - Institut für Planetenforschung (DLR-PF), Berlin, Germany
Instituto de Astrofisica de Andalucia (IAA), Granada, Spain
Max-Planck-Institut für Sonnensystemforschung (MPS), Katlenburg-Lindau, Germany

Principal Investigator: Nicolas Thomas (Uni Bern, Co-PI Hardware)
Tilman Spohn (DLR-PF, Co-PI Science and Operations)

Co-investigators:

J. P. Barriot (F)	W. Benz (CH)
G. Beutler (CH)	U. Christensen (D)
V. Dehant (B)	C. Fallnich (D)
D. Giardini (CH)	O. Groussin (F)
K. Gunderson (CH)	E. Hauber (D)
M. Hilchenbach (D)	L. Iess (I)
L. Jorda (F)	P. Lamy (F)
L.-M. Lara (E)	P. Lognonné (F)
J.J. Lopez-Moreno (E)	H. Michaelis (D)
J. Oberst (D)	D. Resendes (P)
R. Rodrigo (E)	S. Sasaki (J)
U. Schreiber (D)	

Method: Measurement

Laser altimetry is a powerful remote sensing technique although the measurement concept is simple. The time-of-flight of a pulse of light from a laser to a reflecting surface and back is measured. This travel time, combined with ancillary information such as laser location and pointing at the time of each laser shot, enables the laser footprint to be geolocated in a global reference frame. BELA uses a Nd:YAG laser at 1064 nm which pulses at 10 Hz. The energy per pulse is around 50 mJ and a 5 ns broad pulse is generated. The return pulse is detected by a 20 cm beryllium telescope with an avalanche photo-diode in the focal plane. The system is expected to have an accuracy of better 2 m in most operational cases for ranges from 400 to 1055 km.

Development and construction of instruments: Bepi-Colombo Laser Altimeter (BELA) for the European Space Agency's BepiColombo mission to Mercury for launch in 2014

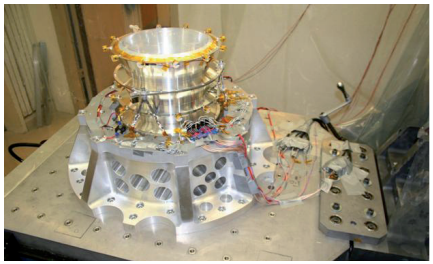
Purpose of research: The BepiColombo laser altimeter (BELA) is a joint Swiss-German project with a smaller involvement from Spain. Some additional hardware studies

are carried out in France. The scientific objectives of the experiment are to measure the

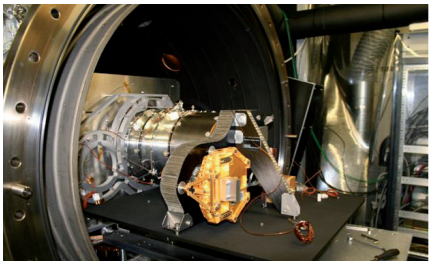
- figure parameters of Mercury to establish accurate reference surfaces
- topographic variations relative to the reference figures and a geodetic network based on accurately measured positions of prominent topographic features
- tidal deformations of the surface
- surface roughness, local slopes and albedo variations, also in permanently shaded craters near the poles.

BELA will form an integral part of a larger geodesy and geophysics package, incorporating radio science and stereo imaging. Although stand-alone instruments in their right, only the synergy between these will make full use of present-day technology and scientific capability. The synergy will cover the problems of planetary figure and gravity field determination, interior structure exploration, surface morphology and geology, and extend into the measurements of tidal deformations. The reference surfaces and the geodetic network will provide the coordinate system for any detailed exploration of the surface, geological, physical, and chemical. The topography is needed to develop digital terrain models that allow quantitative explorations of the geology, the tectonics, and the age of the planet surface. The topography is further needed for a reduction of the gravity field data because topographical contributions to gravity must first be removed before using gravity anomalies for the investigation of sub-surface structures. The use of topography together with gravity data will constrain, by an admittance analysis between the two and with the help of a flexure model for the lithosphere, lithosphere and crust properties. Examples here would include the lithosphere elastic thickness (essential for the reconstruction of the thermal history of Mercury) and the crustal density (essential for the construction of a Hermean internal model). In addition

The receiver baffle for the BELA instrument mounted on an adaptor prior to undergoing vibration testing at the University of Bern.



The BELA baseplate unit (BPU) inside the thermal vacuum chamber in Bern being readied for test. The gold coloured object in the foreground is the laser head. The telescope is on the far side of the optical bench. The reflective baffle is mounted.



to the moments of inertia which will be provided by the radio science experiment, the tidal deformations measured by BELA and the radio science instrument will place further constraints of global models of the interior structure. BELA will contribute by providing the deformation of the surface while the radio science package will measure the mass relocations. Under favourable conditions, it will even be possible to constrain the rheology of the interior of the planet by measuring the time lag between the motion of the tidal bulge and the disturbing potential.

Status: The Structural and Thermal Model (STM) of the instrument has been completed (end 2010) and is about to be shipped to ESA (see image below). The Electrical Model (EM) is nearing completion and should be shipped for integration with the EM spacecraft in February 2011. The first mirrors for the receiver telescope are in manufacture. This involves several critical elements because the mirrors are being built in beryllium in Swiss industry – a first for European interplanetary missions.

Many other technical developments have also been made. A digital rangefinder bread-board has been produced, a solar simulator (for simulating the flux from the Sun at Mercury's orbit) has been developed and manufactured, and a highly reflective baffling system for the receiver telescope has been produced.

Time-Line	From	To
Planning	May 2004	June 2008
Construction	July 2008	June 2013
Launch	2014	
Measurement phase	Mid-2020	2022
Data evaluation	Mid-2020	End 2024

Publications:

1. Gunderson, K. and Thomas, N., (2010) BELA receiver performance modeling over the BepiColombo mission lifetime, Planetary and Space Science, 58, 309-318
2. Seiferlin, K., Chakraborty, S., Gunderson, K., Fischer, J., Luethi, B.S., Piazza, D., Rieder, M., Sigrist, M., Thomas, N., Weigel, T. (2007) Design and manufacture of a lightweight reflective baffle for the BepiColombo Laser Altimeter, Optical Engineering, 46(4), 043003-1
3. Thomas, N., T.Spohn, J.-P.Barriot, W.Benz, G.Beutler, U.Christensen, V.Dehant, C.Fallnich, D.Giardini, O.Groussin, K.Gunderson, E.Hauber, M.Hilchenbach, L.Iess, P.Lamy, L.-M.Lara, P.Lognonne, J.J.Lopez-Moreno, H.Michaelis, J.Oberst, D.Resendes, J.-L.Reynaud, R.Rodrigo, S.Sasaki, K.Seiferlin, M.Wieczorek, and J.Whitby, (2007) The BepiColombo Laser Altimeter (BELA): Concept and baseline design, Planetary and Space Science, 55, 1398-1413

8.3 ROSINA / Rosetta

Institute: Physics institute, department of space research and planetology, University of Bern

In cooperation with: MPS, Lindau, Germany
TU, Braunschweig, Germany
IPSL, St. Maur, Paris, France
CESR, Toulouse, France
BIRA, Brussels, Belgium
University of Michigan, Ann Arbor, USA
Lockheed Martin, Palo Alto, USA
SwRI, San Antonio, USA

Principal Investigator: Kathrin Altwegg

Co-investigators (Bern): Hans Balsiger
Peter Wurz
Ernest Kopp
Peter Bochsler
Peter Eberhardt
Annette Jäckel

Method: Measurement

Development and construction of instruments: ROSINA package (DFMS, RTOF, COPS and DPU)

Purpose of research: ROSINA will investigate the volatile material of comet 67P/ Churyumov-Gerasimenko. It will determine the elemental, isotopic and molecular composition of the neutral gas as well as of the ionized plasma in the coma and analyze the gas dynamics arpound the comet from close to aphelion through perihelion. Its two mass spectrometer and the pressure sensor have an unprecedented sensitivity and mass resolution.

Status: Rosetta has passed the second asteroid Lutetia and is currently at a solar distance of 3.8 AU about to begin the hibernation period which will last from late spring 2011 till January 2014. It will arrive in the vicinity of the comet in summer 2014 and then follow this comet in close vicinity for at least 1 ½ years through its perihelion. During the last six years ROSINA has gathered very valuable data on spacecraft outgassing which help to understand phenomena observed with other space missions, e.g. degradation of optical instruments or unexpected behavior of spacecraft during manoeuvres. These measurements will also be crucial in the early phase of the comet mission when the coma of the comet will be very tenuous.

Time-Line	From	To
Planning	1994	1996
Construction	1996	2001
Measurement phase	2014	2015
Data evaluation	ongoing	

Publications:

1. Schläppi B., K. Altwegg, H. Balsiger, M. Hässig, A. Jäckel, P. Wurz, B. Fiethe, M. Rubin, S. A. Fuselier, J. J. Berthelier, J. De Keyser, H. Rème and U.Mall, "The influence of spacecraft outgassing on the exploration of tenuous atmospheres by in situ mass spectrometry", submitted to Journal of Geophysical Research
2. S. Graf, K. Altwegg, H. Balsiger, and P. Bochsler B. Fiethe E. Montagnon, (2007), Thruster plumes –a source for high pressure and contamination at the payload location , J. Spacecraft and Rockets, Vol. 45, No. 1, January–February 2008, pp. 57-64S
3. H. Balsiger, K. Altwegg, P. Bochsler, P. Eberhardt, J. Fischer, S. Graf, A. Jäckel, E. Kopp, U. Langer, M. Mildner, J. Müller, T. Riesen, M. Rubin, S. Scherer, P. Wurz, S. Wüthrich, E. Arijs, S. Delanoye, J. De Keyser, E. Neefs, D. Nevejans, H. Rème, C. Aoustin, C. Mazelle, J.-L. Médale, J. A. Sauvaud, J.-J. Berthelier, J.-L. Bertaux, L. Duvet, J.-M. Illiano, S. A. Fuselier, A. G. Ghielmetti, T. Magoncelli, E. G. Shelley, A. Korth, K. Heerlein, H. Lauche, S. Livi, A. Loose, U. Mall, B. Wilken, F. Gliem, B. Fiethe, T. I. Gombosi, B. Block, G. R. Carignan, L. A. Fisk, J. H. Waite, D. T. Young and H. Wollnik, (2007), ROSINA – ROSETTA ORBITER SPECTROMETER FOR ION AND NEUTRAL ANALYSIS,, Space Sci Rev, 128/1, 745-801

Abbreviations:

DFMS	Double focusing mass spectrometer
COPS	Comet pressure sensor
ROSINA	Rosetta Orbiter Spectrometer for Iob and Neutral Analysis
RTOF	Refelctron time of flight mass spectrometer

9 Life Science

9.1 Electrophysiological study investigating cellular effects of weightlessness induced muscle atrophy

Institute: ETH Zurich, Space Biology Group

In cooperation with: Institute for Biomedical Engineering, ETH Zurich
Laboratory of Organic Chemistry, ETH Zurich
Institute of Physiology, University of Zurich

Principal Investigator: Dr. Marcel Egli

Co-investigators: Dr. A. Franco-Obregón (ETH Zurich)
Prof. P.S. Dittrich (ETH Zurich)
Dr I. Forster (University of Zurich)

Method: Measurement

Development and construction of instruments: "OoClamp" unit (electrophysiological device for the investigation of living cells)

Development and construction of own software: "OoClamp" software (to run and control the electrophysiological device)

Rocket (foreseen)
ESA parabolic flights (2008, 2009, and 2010)

Purpose of research: Among the many physiological consequences of manned space flight, muscle atrophy is certainly the most obvious and one of the most detrimental to the human condition. The currently applied countermeasures, however, can only partially alleviate the muscle wasting associated with the mechanical unloading because of reduced gravitational force. Muscle atrophy studies have shown that the resting intracellular calcium concentrations as well as the calcium entry across the membrane are decreased in response to mechanical unloading. During early muscle development calcium enters muscle cells through membrane pores (ion channels) that open in response to membrane stretch, stretch-activated calcium channels. An increase in intracellular calcium levels (as a result of the opening of the stretch-activated channels) activates the reading of muscle-specific genes. We have strong preliminary evidence generated from pharmacological studies that mechano-sensitive channel activity is adversely influenced by reduced gravity, short-circuiting the biochemical cascade leading to muscle regeneration. We have designed and developed

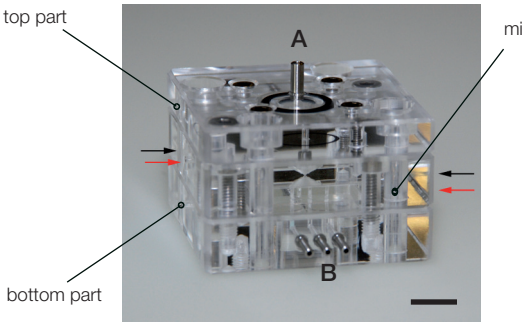
an experimental system that allows electrophysiological recording of mechanically-gated calcium influxes in living cells during periods of microgravity and hypergravity generated by parabolic flights. Ultimate goal of our experiments is to unequivocally demonstrating the influence of gravitational forces over stretch-activated calcium channel gating.

Status: We are currently in the preparation phase of a new ESA parabolic flight campaign, start fall 2010.

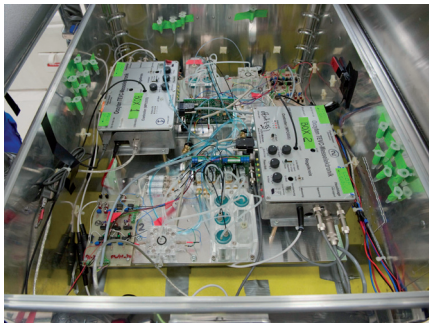
Time-Line	From	To
Planning	2006	2010
Construction	2006	2010
Measurement phase	2008	2010
Data evaluation	2008	2010 (after each experiment)

Publications:

In preparation



Prototype of the recording chamber in which cells are electrically investigated: A = cell inlet, B = culture media and test liquid plugs (inlet), black arrows = current and voltage electrode insertion sites, red arrows = reference electrode insertion sites.
Measuring bar = 10 mm



"OoClamp" hardware configuration on flight day

9.2 PADIAC: Pathway different activators - T-lymphocytes in microgravity: A genetic analysis of the CD28-mediated pathway using different activation ways

Institute: Space Biology Group ETHZ

In cooperation with: Veterans Affairs Medical Center / University of California, San Francisco (USA)
University of Sassari, Sassari (I)

Principal Investigators: Isabelle Walther
Marcel Egli

Co-investigators: M. Hughes-Fulford
P. Pippia

Method: Measurement

Development and construction of instruments: PADIAC instrument

Development and construction of software: Software for the automation of the hardware

Purpose of research:
Aim:
To test the hypothesis that the inhibition of IL-2 receptor expression on T-cells in microgravity is due to a sensitivity of the CD28 co-stimulatory pathway to microgravity
Specific goals:
Determine how microgravity affects the expression of genes mediated by CD28 activation
Assess whether the IL-1 receptor (CD121a) is involved in the inhibition of T-cell activation in microgravity
Compare the gene expression between the different activation pathways
Clearly distinguish the effect of microgravity from other spaceflight factors by use of a 1.g on-board centrifuge
Verify finding from baseline ground studies performed using the random positioning machine (RPM)
Parameters measured:
Gene expression by gene array and realtime PCR, with specific focus on key cytokines (post-flight analysis)

Status: The manufacture of the last FM unit is completed, the other elements of the hardware are ready to use. Biological tests have been performed in our laboratory.

The hardware has been tested in an Experiment sequence test in ESTEC, Noordwijk in March 2010. The instrument and the software are ready, the flight was postponed from June to October due to a defect incubator on board ISS which is needed for the experiment.

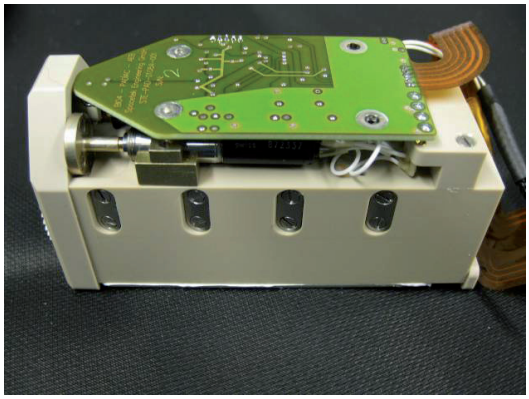
Time-Line	From	To
Planning	Nov 2007	2008
Construction	2008	Jan 2010 (the hardware had to be modified 3x from manual to automatic)
Measurement phase	10/10/2010	12/10/2010 (launch on 24S)
Data evaluation	post flight (down with 23S end 26th November 2010)	

Publications:

1. FEBS Letters 436 (1998) 115-118. Simulated microgravity inhibits the genetic expression of interleukin-2 and its receptor in mitogen-activated T lymphocytes; Isabelle Walther, Proto Pippia, Maria Antonia Meloni, Franco Turrini, Franca Mannu, Augusto Cogoli
2. submitted: T Cell Early Signaling Events are Gravity Dependent and Inhibited During Spaceflight; Tammy T. Chang, Isabelle Walther, Chai-Fei Li, Jim Boonyaratanakornkit, Grazia Galleri, Maria Antonia Meloni, Proto Pippia, Augusto Cogoli, Millie Hughes-Fulford

Abbreviations:

FM	Flight unit
EST	Experiment Sequence TestUntertitel



PADIAC automatic hardware: 4 cell culture chambers under the small metallic plates on the front side, electronic board and motor to move the inner plunger and activate/fix the cell after defined times. Hardware designed by Dr. Dany Lightweight (DDL GmbH), electronic and software by Spacetek GmbH. Overall responsibility with ESA by RUAG Aerospace, Nyon.

9.3 SEN4SCI - Sentinels for Science

Institute: Remote Sensing Laboratories (RSL)
Dept. of Geography
University of Zurich
Winterthurerstrasse 190
8057 Zurich

In cooperation with: ZEMKON Inc.
Environmental Earth Observation IT GmbH (ENVEO)
European Space Agency (ESA)

Principal Investigator: Dr. Zbynek Malenovsky

Co-investigators: Prof. Dr. Michael E. Schaepman

Method: Theory

Based on existing instrumentation: Sentinel space missions

Purpose of research: In order to enable ESA to facilitate a more complete exploitation of the scientific potential of Sentinel observations, the objective of SEN4SCI is to define an approach to identify and consolidate, through a structured consultation process that involves representatives of the scientific community:

- Research issues and questions to which the Sentinel data could most usefully contribute;
- Required data products, with a view to identifying products that may not be planned for the baseline Sentinel 1-3 or other ESA missions, but could enhance the scientific yield from the missions;
- Inputs from the broader scientific community with respect to these requirements;
- Characteristics of the missing products and recommendations for further implementation and validation activities leading to Algorithm Theoretical Basis Documents (ATBD).

Status: The project is in a first phase dealing with identification of the scientific requirements for the potential Sentinel products. An expert workshop will be conducted in 2011 in order to collect the opinions of a broad scientific community. The final phase will consist of gap analysis on potential new Sentinel products, their algorithms and calibration/validation approaches.

Time-Line	From	To
Planning	-	2010
Data evaluation	2011	2011

Publications:

No publications yet.

Abbreviations:

SEN4SCI	Sentinels for Science
LAI	Leaf Area Index
ENVEO	Environmental Earth Observation IT GmbH
ATBD	Algorithm Theoretical Basis Documents

10 Cosmology and Fundamental Physics

10.1 Non-Gaussianity in Planck

Institute: Martin Kunz, Theoretical Physics, University of Geneva

In cooperation with: N. Aghanim (IAS Paris)

Principal Investigator: J.L. Puget (IAS Paris, Planck HFI mission PI)

Method: Simulation
Theory
Measurement

Based on existing instrumentation: Planck satellite

Purpose of research: Planck is an ESA satellite launched in 2009 and measuring the anisotropies in the CMB. Among many other things, it will allow to study the statistics of those fluctuations to very high precision, and to quantify departures from a Gaussian random field (or from statistical isotropy). Non-Gaussianities can be due to different sources, which can be broadly classified into primordial, astrophysical and instrumental contributions. Non-Gaussianity at the instrumental level is mostly used as a test for possible systematic errors, but it also needs to be controlled in order to have access to the other two sources of non-Gaussianity. Astrophysical contributions are due to e.g. the presence of galaxy clusters which affect the CMB signal in various ways at late times. This is a known source of deviations from a Gaussian probability distribution, and studying it will help to put constraints on, for example, unresolved point sources. The existence of primordial non-Gaussianity is uncertain, but its discovery would have a major impact on our understanding of the early universe, as it could be generated during inflation or by phase-transition remnants (topological defects, e.g. cosmic strings) at the end of inflation.

Publications:

1. G. Efstathiou, C. Lawrence, J. Tauber et al., The Planck Bluebook, http://www.rssd.esa.int/SA/PLANCK/docs/Bluebook-ESA-SCI(2005)1_V2.pdf (2005)
2. N. Aghanim, M. Kunz, P.G. Castro and O. Forni, Non-Gaussianity: Comparing wavelet and Fourier based methods, Astron. Astrophys. 406, 797 (2003)
3. M. Kunz, N. Aghanim, L. Cayon, O. Forni, A. Riazuelo and J.P. Uzan, Constraining topology in harmonic space, Phys. Rev. D 73, 023511 (2006)

Abbreviations:

ESA	European Space Agency
CMB	cosmic microwave background

10.2 Constraining Dark Energy and Modified Gravity with Euclid

Institute: Martin Kunz, Theoretical Physics, University of Geneva

In cooperation with: L. Amendola (U. Heidelberg)
D. Sapone (U. Madrid)
R. Durrer (U. Geneva)

Principal Investigator: A. Refregier (CEA Saclay, Euclid mission PI)

Method: Theory

Purpose of research: The nature of the dark energy is one of the most important questions facing cosmology and fundamental physics. So far no convincing explanations have been found. Large future surveys, like the ESA cosmic vision satellite project Euclid will be able to probe not only the expansion history of the universe, but also directly the evolution of the perturbations in the metric (‚wrinkles' of the space-time). In this project we are working on computing expectations from theoretical physics on how these metric perturbations look like for existing models, and on forecasting how well Euclid will be able to constrain them.

Publications:

1. L. Amendola, M. Kunz and D. Sapone, Measuring the dark side (with weak lensing), JCAP 0804, 013 (2008)
2. A. Refregier et al., Euclid Imaging Consortium Science Book, arXiv:1001.0061 (2010)
3. R. Laureijs, et al., Euclid Assessment Study Report for the ESA Cosmic Visions (Yellowbook), arXiv:0912.0914 (2009)

Abbreviations:

ESA	European Space Agency