

ESA Experiment Programme Overview

The experiments that are carried out by the European Space Agency (ESA) on the International Space Station are part of the European Programme for Life and Physical Sciences (ELIPS). This programme is financed by 13 of the 17 member states of ESA: Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, and Switzerland, with the addition of Canada who has a cooperation agreement with ESA.

ELIPS covers a large range of scientific disciplines, which encompass physics, chemistry, biology, physiology, psychology and related research fields.

The uniqueness of the programme is that its orientations are based on the inputs from the scientific and industrial user community in Europe in a process which is supervised by the European Science Foundation (ESF). The ELIPS scientific and industrial user community is of highest international quality and has doubled in the past five years. ELIPS exploits all possible research platforms, like ground-based facilities, drop towers, parabolic aircraft flights, sounding rockets, unmanned capsules and the International Space Station (ISS). The main characteristics of these facilities is their very specific operational and

physical environment, especially weightlessness. Weightlessness provides a unique environment for scientific research, giving an unusual opportunity to answer questions that would be impossible to tackle on Earth. Much more processes in physics, chemistry, biology or physiology that are relevant for biological, physical or industrial processes on Earth are effected by gravity than was expected in the early days of spaceflight. Research in weightlessness is unique and leads to high-level discoveries or changes of commonly accepted scientific understandings. Even Nobel prize-winning hypotheses, like eye movement reflexes, have been found partly erroneous thanks to experiments made by astronauts during spaceflight missions.

In terms of research topics for experiments on the ISS, addressed by ELIPS, the programme is organised along so-called research cornerstones.

The ELIPS cornerstones in Life Sciences include biological research, focussing on the effects of gravity on fundamental processes in plant and animal cells. From this research a better understanding evolves on how cells adapt to their environment, which in turn can be exploited in medical and biotechnological applications, such as studies on the immune system, food production, etc.

Human Physiology studies aim at research on, often age-related, health problems such as osteoporosis, cardiovascular and respiratory diseases and equilibrium disorders, which are induced or accelerated in weightlessness. The results do not consist only of new diagnostics and treatments that can be used in Earth medical practice, but are also clearly very relevant for the preparation of long-duration human space missions regarding effective countermeasures to retain the fitness of the astronauts.

In Fundamental Physics, novel states of matter such as complex plasma's and solid/liquid dust particles, cold atoms and Bose-Einstein condensates are examined within the ELIPS programme. Careful study of these systems requires weightlessness, since on Earth they are too much influenced by gravitational effects. These studies are very fundamental in nature and will lead to new theories on physical processes. However, practical examples such as very stable atomic clocks that can be used in future navigation systems are also envisaged.



Launch of Texas 42 sounding rocket on 1 December 2005 from the Esrange launch site near Kiruna in northern Sweden. (Image: SSC)



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European Experiment Programme and Additional Activities

In Material Sciences, the space environment is used to measure thermo-physical properties of metals and alloys with unprecedented accuracy. These properties are being used by industry in numerical models to optimise their production processes and even develop new materials with advanced properties. With European Union funding, a large 5-year research project is carried out within the ELIPS programme for the development of more efficient aircraft engines and hydrogen fuel cells.



Research within the ELIPS programme could make significant developments in turbine blade production for use in, for example, the aerospace industry. (Image: AP Photo/Mark Duncan)

Also in fluid physics, the weightless environment on the ISS helps in studying the physics of fluids and interfaces in an undisturbed way. Apart from the theoretical importance, this can be used for example to optimise chemical industrial processes or to optimise combustion process in power plants or car engines. The close link between material and fluids research leads to substantial gains in physical understanding and process advancements.

Finally, the field of exobiology concerns the very fundamental question of the origin, evolution and distribution of life in the Solar system and beyond. It focuses in particular on defining if, where, and how traces of fossil or even existing life could be found during planned robotic and human missions to Mars.

The set of European-built experiment facilities and instruments which are available on the International Space Station are also very important as precursors for the multi-user facilities of the European Columbus laboratory. Some of them are already in use today; others will be prepared for use in the near future. This includes ESA's so-called Early Utilisation Facilities for the American

Destiny laboratory, like the EMCS (European Modular Cultivation System), MELFI (Minus Eighty Degrees Laboratory Freezer for the ISS), PEMS (Percutaneous Electrical Muscle Stimulator),



Expedition 14 commander Michael Lopez-Alegria working with MELFI in the ISS Destiny laboratory on 3 October 2006 (Image: NASA)

PFS (Pulmonary Function System) and the MSG (Microgravity Science Glovebox). These facilities are very essential for the execution of ESA's ISS utilisation programme. Some of them will even be transferred from Destiny to the Columbus laboratory once it is deployed on orbit.



Pedro Duque during experiment operations in the MSG during the Cervantes mission. 20 October 2003. (Image: NASA)

European Experiment Programme and Additional Activities

The majority of Christer Fuglesang's time at the Station will be taken up with ISS assembly tasks. However, he will still be undertaking a number of experiments and additional activities during the Celsius mission. One experiment (Chromosome-2), one activity monitoring radiation dosimetry (EuCPD), and two education activities (ALTEA Filmed Lesson, Frisbee Competition) are supported by ESA. A further experiment: ALTEA is supported by ASI, the Italian Space Agency.

ALTEA (Human Physiology/Radiation Dosimetry)



ALTEA Flight Hardware. (Image: NASA)

The ALTEA project investigates the effects of cosmic radiation on brain function. The focus of the programme will be on abnormal visual perceptions (often reported as "light flashes" by astronauts) and the impact that particle radiation has on the retina and visual structures of the brain under weightless conditions. ALTEA will also provide more information on the radiation environment in the ISS.

The ALTEA facility is a helmet-shaped device, which covers most of the astronaut's head. It consists of six particle detectors and will permit a 3-D reconstruction of cosmic radiation passing through the brain: measuring particle trajectory, energy and particle type. At the same time a 32-channel EEG will measure the astronaut's brain activity and a visual stimulator and a pushbutton will be used to determine visual performance and occurrence of light flashes. When not in use by an

astronaut, the ALTEA device will be used to collect continuous measurements of the cosmic radiation in the US Destiny laboratory on the ISS.

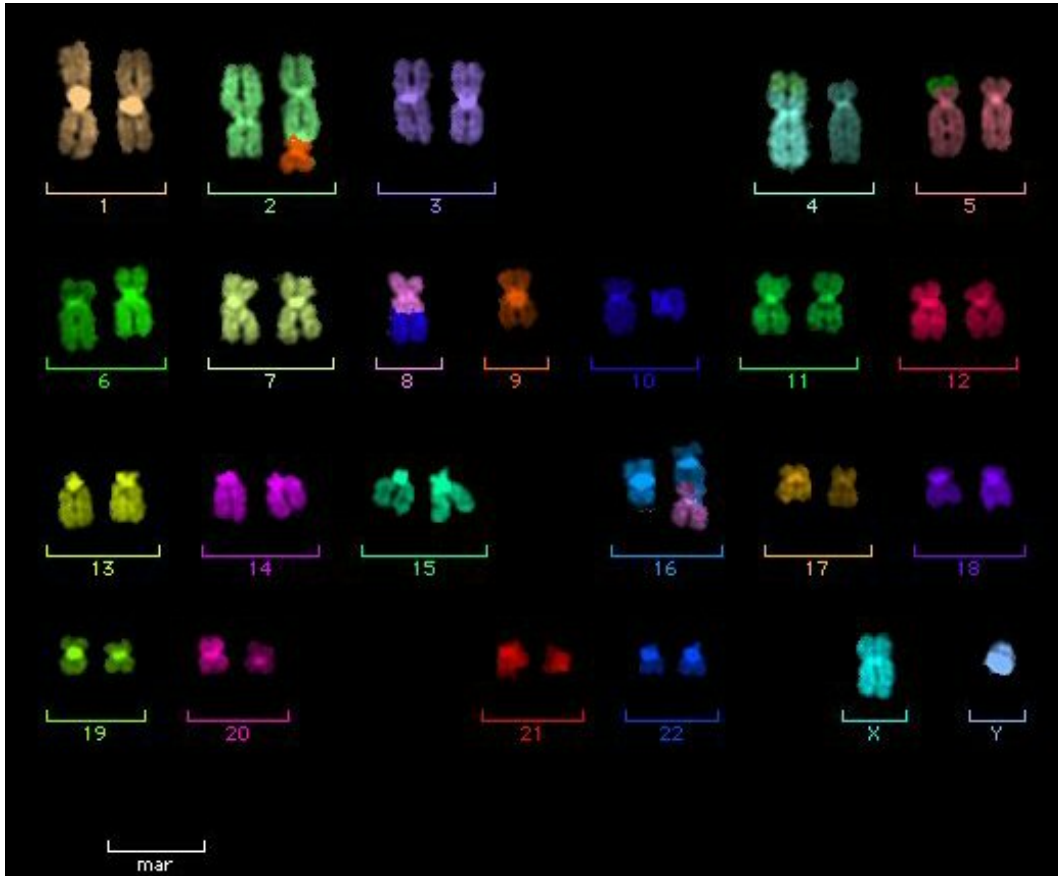
The ALTEA experiment follows on from the precursor Alteino experiment that took place during the European Marco Polo and Eneide missions (2002 and 2005), now continuing with the European ALTCRISS project.

The ALTEA experiment is particularly important with the increasing length of human operation on board the International Space Station (ISS), and in the perspective of longer-term journeys to Mars. Results may also hold benefits on Earth in neuroscience in, for example, the use of ion therapies to treat brain tumours.

Science Team

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Chromosome-2 (Human Physiology)



Multi-fluorescent chromosome map of a cell exposed to cosmic radiation. (Image: M. Durante)

During space flights crew members are exposed to different types of ionising radiation. To assess the impact of these radiations at a genetic level, an analysis will be made of abnormalities in chromosome number and structure in lymphocytes (white blood cells) of ISS crew members.

Venous blood samples will be taken a few days prior to launch and directly on return from the long-duration and short-duration missions. From these blood samples, whole blood cultures will be set up with a substance (phytohemagglutinin), which stimulates the lymphocytes to enter the cell cycle, i.e. to go through the cell division process.

48 hours after the start of the incubation period, the samples will be prepared for analysis. This consists of adding two substances to the samples. One (calyculin A) will cause the DNA strands to become tightly packed in the chromosomes, a process that occurs in cells at the beginning of the cell cycle. The other (colchicine) will prevent the

chromosomes dividing into two for cells at a later stage in the cell cycle.

Hereafter the preparations will be analysed by one of two methods to determine the full spectrum of abnormalities in the chromosomes. This will either be by the fluorescence in vitro hybridization (FISH) method or classical Giemsa staining.

A small portion of the blood samples will be irradiated with X-rays. The frequency of abnormalities induced by this irradiation will provide information about the radiosensitivity of individual crew members and probable changes in sensitivity caused by spaceflight.

The Chromosome-2 experiment is planned to be carried out using eight subjects: four subjects from short-duration flights and four Expedition crew members.

Science Team:

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European Crew Personal Dosimeters (EuCPD) (Radiation dosimetry)



ESA astronaut Thomas Reiter wearing European Crew Personal Dosimeter during sample processing on the ISS. (Image: NASA)

ESA astronaut Christer Fuglesang from Sweden will be equipped with passive personal radiation dosimeters to measure the radiation exposure during his flight. ESA astronaut Thomas Reiter has been using similar dosimeters since arriving at the ISS in July 2006.

The personal dosimeters have to be worn around the left-hand side of the waist and the left ankle for astronauts inside the Station and at the same locations above the liquid cooling garment inside the space suit for astronauts undertaking spacewalks.

Each dosimeter is only 8 mm thick and consists of a stack of five different passive radiation sensors, i.e. sensors that provide a measure of the overall radiation dose rather than a measure of radiation with relation to time. The different sensors will measure different radioactive particles such as a range of neutrons (thermal, epithermal and fast), and heavy ions as well as measuring particle impact angles and energy transfer from particles.

The different sensors to be used will include a layer of thermo-luminescence dosimeters that are also used in the European Matroshka radiation dosimetry experiment that has been located at the ISS following its launch on 29 January 2004.

Two European Crew Personal Dosimeters will be worn by Fuglesang during launch. The others will be transported to the ISS as Shuttle cargo.

Post flight analysis of the different radiation sensors will be carried out in a laboratory environment according to standardised methods developed by the science team.

Project Team

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ALTEA: Filmed Lesson on Radiation (Education)



NASA astronaut Jeff Williams next to the ALTEA hardware in the U.S. Laboratory of the ISS during Expedition 13. (Image: NASA)

This activity involves the filming of a mini documentary about the ALTEA experiment to form part of a lesson on radiation for 16-18 year olds. While ESA astronaut Christer Fuglesang is undertaking the ALTEA experiment on the ISS as part of the Celsius mission, ESA astronaut Thomas Reiter, currently on the ISS as an Expedition 14 flight engineer will film the experiment.

The footage will be recorded on video tape and returned to Earth. This footage will be combined with additional footage that was filmed during Christer Fuglesang's training with ALTEA hardware at the Johnson Space Center in Houston prior to launch and accompanied with commentary from a member of the ALTEA

science team and by Fuglesang himself. Fuglesang has been previously involved as a member of the scientific team for a similar experiment: SiEye, which investigated light flashes in astronauts eyes on the Mir Space Station between 1995 and 1999.

The ISS Education Office will coordinate the development and content of the lesson together with the ALTEA science team. Once the production is complete, ESA will distribute the lesson to European secondary school teachers and their students.

Project Team

ESA ISS Utilisation Strategy and Education Office

Frisbee Competition (Education)



The frisbee that Fuglesang will be taking into space. (Image: ESA)

A little known fact about Christer Fuglesang is that he was once a Swedish national frisbee champion, holding the national title in '*maximum time aloft*' in 1978 i.e. the longest time a frisbee can stay in the air. Hereafter he competed in the Frisbee World Championship in 1981.

This activity is a competition for children up to 15 years of age that will stimulate the interest of children in space and culminate in a live link up with the competition winner on ground and Christer Fuglesang on the ISS. During this in-flight call Fuglesang will 'try' to break the current world record for maximum time aloft, which stands at 16.72 seconds. This should not prove to be too difficult a prospect as Fuglesang has the advantage of weightlessness on his side.

The competition will be organised in Sweden by the national newspaper 'Aftonbladet' and will be based on questions including the topics of space, space activities and frisbee games. The competition winner will be announced during the in-flight call and they will present Fuglesang with the licence, necessary to be able to compete in professional competition. Once this has occurred, Fuglesang will begin his world record attempt.

The frisbee that Fuglesang will take to the ISS with him is one of his personal frisbees, which marks an Atlantic crossing he made.

Project Team

ESA Education Dept./ESA Communication Dept.