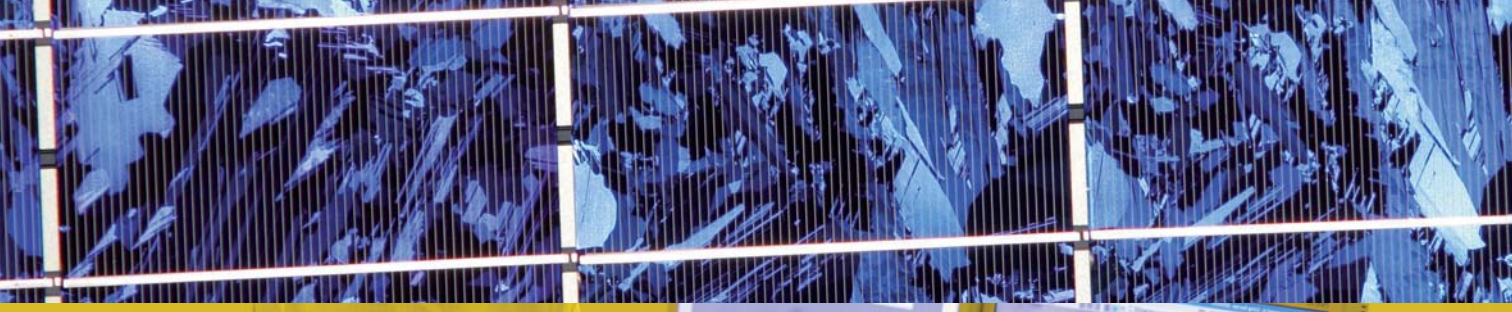


cea

A LOOK BACK AT A YEAR OF RESEARCH

2011

LOW-CARBON ENERGIES

DEFENSE AND SECURITY

HEALTH TECHNOLOGIES

INFORMATION TECHNOLOGIES

VERY LARGE RESEARCH INFRASTRUCTURES

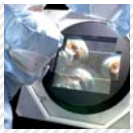
The laboratories, institutes and directorates mentioned in this issue

CEA-List

Laboratoire d'intégration des systèmes et des technologies

CEA-Iramis

Institut rayonnement et matière

CEA-Irfu

Institut de recherche sur les lois fondamentales de l'Univers

CEA-I²BM

Institut d'imagerie biomédicale

CEA-iBiTec-S

Institut de biologie et de technologie de Saclay

CEA-IBS

Institut de biologie structurale

CEA-Leti

Laboratoire d'électronique et des technologies de l'information

CEA-iRTSV

Institut de recherche en technologies et sciences pour le vivant

CEA-Inac

Institut nanosciences et cryogénie

CEA-iBEB

Institut de biologie environnementale et de biotechnologie

LSCE

Laboratoire des sciences du climat et de l'environnement

CEA-iRCM

Institut de radiobiologie cellulaire et moléculaire

CEA-CNG

Centre national de génotypage

CEA-Liten

Institut des innovations pour les technologies des énergies nouvelles et les nanomatériaux

Ines

Institut national de l'énergie solaire

CEA-IRFM

Institut de recherche sur la fusion magnétique

CEA-Dam

Direction des applications militaires

CEA-Den

Direction de l'énergie nucléaire

2011

Contents

A look back at...

A year of mobilisation

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Bernard Bigot,
CEA Chairman

For the international nuclear community, 2011 was marked by the severe accident at Fukushima. Since March 2011, the debate has raged among politicians, think-tanks, industry, safety regulators and the citizens. All aspects of nuclear energy are being called into question: safety standards, extending the lifetime of the facilities, the long-term costs, the place of nuclear power in the energy mix for the 2050 time-frame… These debates can only be seen as a good thing, as nuclear power is not the preserve of the experts but concerns the entire society that uses it. CEA is convinced of the benefits of the long-term combination of renewable and nuclear energies. We are continuing research on biofuels, electric vehicle batteries and photovoltaic cells. We are working on the design of a prototype fast neutron reactor and on intensive computing for reactor core safety and operating design studies. Our day-to-day work consists in developing renewable and nuclear energies that are safer, more efficient and less expensive, that will help reduce imports and consumption of fossil fuels and bring down CO_2 emissions.

© L. Godart/CEA

Catherine Césarsky,
High Commissioner for Atomic Energy

2011 will for a long time be marked by the tsunami of 11th March in Japan. The CEA experts will be extensively involved in providing analyses of the Fukushima accident and in ensuring on-time performance of the complementary safety assessments on the nuclear facilities requested by the Government. This event recalls the interest of top-level research into radiobiology, a field in which CEA has been involved for many years and in which this year it obtained promising results on the signature of radio-induced tumors. Other fields of the life sciences distinguished themselves, such as genomics, with the identification of factors in the predisposition to Alzheimer's disease. Also enjoying the spotlight are the major research infrastructures, from the remarkable achievements of the LHC up to the recent launch of Icos, the European greenhouse gas monitoring network. While maintaining its first-rate fundamental research, CEA this year again consolidated its rank as the leading public organization in Europe in terms of patents filed; highly innovative results were in particular obtained in the field of nuclear and alternative "low-carbon" energies, as well as in energy efficiency technologies. Proof, were it needed, of the dynamic attitude that will no doubt once again be evident in 2012.

cea A LOOK BACK AT A YEAR OF RESEARCH 2011

Published by Commissariat à l'énergie atomique et aux énergies alternatives, R. C. S. Paris B77568019 | **Publication Director** Xavier Clément | **Senior Editor** Claire Abou | **Assistant Editor** Aude Ganier | **Editorial Comittee** Suzana Bahri, Alexandra Bender, Thierry Bosq, Fabienne Lebrun, Élisabeth Lefèvre-Rémy, Sophie Martin, Brigitte Raffray, Emmanuelle Volant | **Artwork** Aude Ganier | **Cover Photos** CEA ; Iztok Boncina/Eso | **Distribution** Lucia Le Clech | **Design and Production** SPÉCIFIQUE – *www.specifique.com* | **N° ISSN** 1163-619X | **This magazine is printed on Galaxi Keramik PEFC paper from sustainably managed forests.**

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INTELLECTUAL PROPERTY

1st PUBLIC RESEARCH ORGANIZATION

With more than 650 priority patents filed in 2011, CEA maintains its position as the leading French research organization.

EUROPEAN FINANCING

4th

CEA stands in 4th place among the European research organizations, in terms of the number of projects (535, including 70 that it coordinates) and financing obtained (nearly €55M) under the European Commission's FP7 framework programme.

BUDGET

30%

CEA's civil programs are 30% funded from external revenues (partner companies, national incentive funds, local authorities and European Union), 49% from the Government and, finally, 21% from two funds dedicated to clean-up of civil and defense facilities.

BUDGET

€151M

Of the €1,391M devoted to low-carbon energies, research into the new energy technologies and nuclear systems of the future each received a budget of €151M in 2011.

EUROPEAN RESEARCH PROGRAMS

8/13

CEA plays a key role in the European Energy Research Alliance, as a founding member, a member of the executive committee and a member of the secretariat. It is France's representative. EERA has launched 13 joint programs, including 6 in 2011. It pools the research efforts of more than 150 institutes and universities, with more than 2,000 staff employed full-time. CEA is present in 8 programs, with 100 full-time staff, in other words 5% of the total partner commitment.

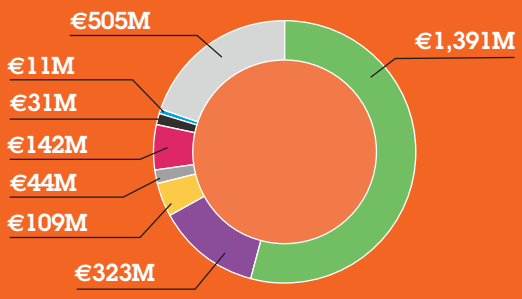
BUDGET

€4.3 billion

CEA budget in 2011, subsidized 64% by the Government, with the rest coming from funds ring-fenced for decommissioning and clean-up (€700M) and from external revenue. €1.7 billion is allocated to the defense sector and €2.6 billion to civil research.

- **€1,391M** Low-carbon Energies
- **€323 M** Information Technologies
- **€109 M** Health Technologies and biotechnologies
- **€44 M** Fundamental Research in Health Technologies

CIVIL RESEARCH



- **€142M** Design and Operation of Major Research Infrastructures
- **€31M** Higher Education and Training
- **€11M** Anti-terrorism (State Subsidy outside Defense Budget)
- **€505M** General Support and Assets

INTERNATIONAL COLLABORATION

Agreements

In 2011, CEA forged new ties with the CCHEN, the Chilean Nuclear Energy Commission. With the NCBJ, the Polish national center for nuclear research, CEA signed a cooperation agreement in the field of scientific and technological research. The ties with VTT, the Finnish technical research center, were expanded and enhanced.

INTERNATIONAL RELATIONS

Representation abroad

CEA is represented by 13 nuclear advisers in the French embassies in Berlin, Budapest, London, Moscow, New Dehli, Beijing, Rome, Seoul, Tokyo, Warsaw and Washington, as well as in France's permanent representation to the IAEA in Vienna and the European Commission in Brussels.

SPIN-OFFS

7

Number of innovative companies created in 2011 from CEA technologies and know-how.

SCIENTIFIC EXCELLENCE

32

Number of grants obtained by CEA researchers from the European Research Council (ERC), since it was set up in 2007 by the European Commission. With 8 "young researcher" winners, 2011 was an excellent year for fundamental research at CEA.

TRAINING

65

Number of nationalities among the 2,277 Master's interns at CEA between 1st June 2010 and 1st June 2011.

NUCLEAR SAFETY

International action plan

The first General Conference of the International Atomic Energy Agency (IAEA) since the Fukushima accident was held from 19th to 23rd September 2011 in Vienna, Austria. It adopted an action plan to strengthen global nuclear safety. France was one of the prime movers in proposing the action plan, adopted by the IAEA and designed to increase the nuclear safety of the facilities in service around the world. Safety and non-proliferation are two pre-requisites for the future of nuclear energy, a position that was put forward by Frédéric Mondoloni, France's IAEA governor and director of CEA's Strategy and external relations center.

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© DR

For this year 2011, marked by the Fukushima accident, the goal is improved safety. This is a key issue being addressed by CEA, while at the same time boosting its R&D on new energy and storage technologies, with particular focus on effective synergy between hydrogen, biofuels, batteries and solar photovoltaic.

ENERGY MIX

BIOFUELS
November 2011

Inauguration of Heliobiotech

Heliobiotech, the 3rd generation biofuels research platform, has been inaugurated at CEA/Cadarache. It will be open to academic and industrial partners and its goal is to boost the production capacity of high energy value molecules by micro-organisms which synthesize them naturally.

SOLAR PHOTOVOLTAIC
October 2011

18%

The single crystal cells of the Photosil project, manufactured on the CEA-Liten Restaure platform at the INES, have achieved an electricity conversion efficiency of 18%. This performance, on a part with that of its competitors, is confirming the researchers in their choice of a process using metallurgical purification of silicon.

Concentrated solar power plant

NUCLEAR

April 2011

Decontamination of the Fukushima site

Specialists from CEA-DEN mobilized to help the Areva teams design and optimize a decontamination process for the water on the Fukushima site. This system, implemented in June 2011 along with a number of others, helped treat nearly 190,000 tons of contaminated water on the site.

ENERGY STORAGE

April 2011

Li-ion storage battery for space missions

Researchers from CEA-Liten are maximizing the mass energy density of Li-ion storage batteries for space applications. These storage batteries have very high mass energy density, from 242 to 278 Wh/kg, offering 10 to 20% longer life than the best commercial technologies.

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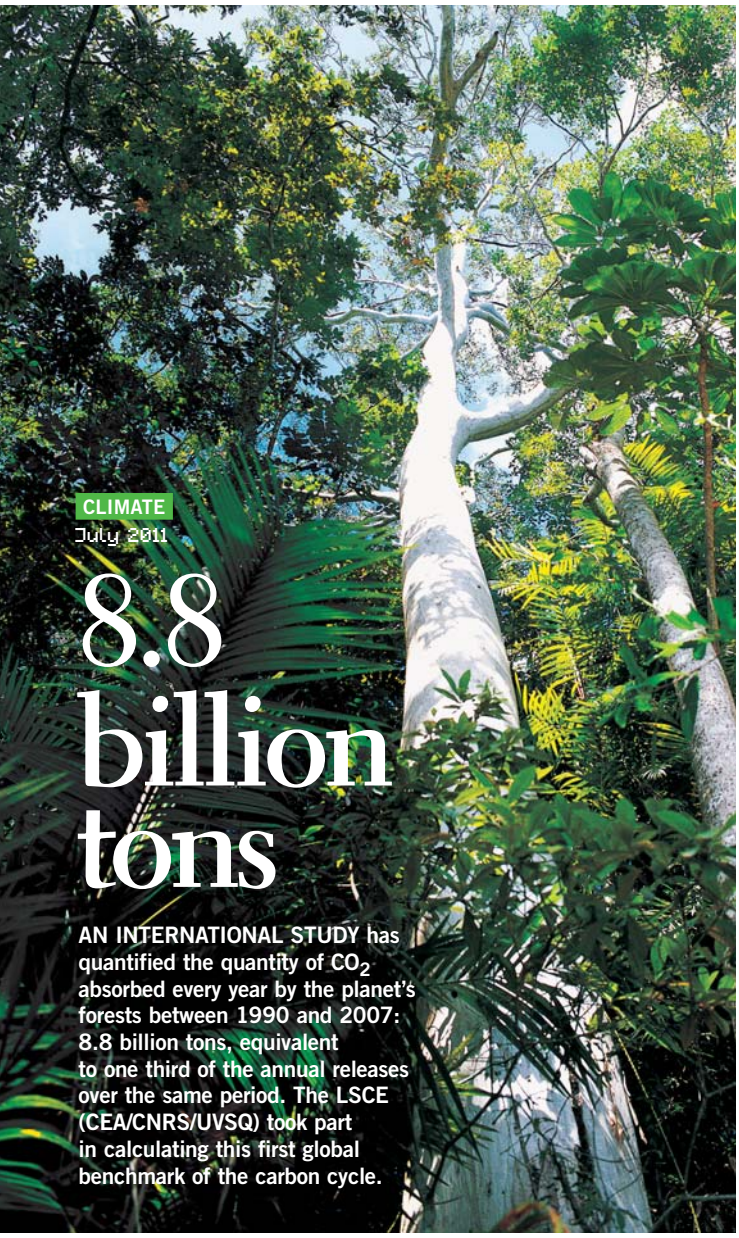


CLIMATE
July 2011

8.8 billion tons

AN INTERNATIONAL STUDY has quantified the quantity of CO_2 absorbed every year by the planet's forests between 1990 and 2007: 8.8 billion tons, equivalent to one third of the annual releases over the same period. The LSCE (CEA/CNRS/UVSQ) took part in calculating this first global benchmark of the carbon cycle.

NUCLEAR
September 2011

DISMANTLING OF CEA/ GRENOBLE

Dismantling of the CEA/Grenoble effluent and waste treatment station buildings is now complete. It will have taken two years and the use of innovative confinement techniques. Clean-up and dismantling of the Grenoble nuclear facilities will end as planned in 2012.

ENERGY EFFICIENCY
September 2011

Optimizing building design and refurbishment

The energy efficiency of buildings is crucial for energy savings and mitigating greenhouse gas emissions. As part of the CLIMB project, CEA-List proposes providing stakeholders in the construction sector with software tools to optimize the building design or refurbishment cycle. In collaboration with CEA-Liten, the CNRS, the CSTB and Armines, it is developing a platform capable of remote and collaborative management of architectural projects. A suite of services and interfaces is also available for optimizing and simulating the energy performance of each of the construction projects.

WASTE PROCESSING
December 2011

Cold crucible vitrification

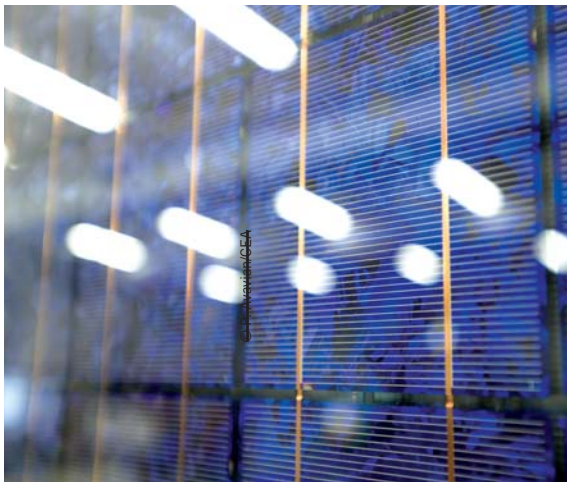
CEA-DEN is sending AREVA the final version of the radioactive waste "Cold crucible vitrification" process book. As the process provider, CEA undertakes to provide this fundamental document which describes the equipment and gives all the specifications and recommendations resulting from the R&D for all the operating phases (nominal, transient or degraded). These data enable the industrial firm to implement them as operational procedures in order to produce a waste confinement glass meeting the expected performance criteria. These data come from the tests being conducted since 2005 on an inactive full-scale test platform at CEA/Marcoule.

View of the vitrification prototype at Marcoule

SOLAR PHOTOVOLTAIC
January 2011

Efficient cell architecture

A team from CEA-Liten has achieved 19% efficiency on an n type silicon substrate by developing a new photovoltaic cell architecture. This silicon has the advantage of offering high electrical quality while not degrading under illumination, unlike the p type. Nonetheless, current cell manufacturing techniques are better suited to the latter type. The architecture developed, which is relatively simple to use, was qualified on a surface area of 148.6 cm² by measuring stability to illumination and temperature. This makes CEA-Liten one of the world leaders in this technology. The next step: achieving 20% efficiency on a larger substrate.



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NUCLEAR
February 2011

Commissioning of a nuclear materials storage facility

The Magenta nuclear facility at CEA/Cadarache is taking its first packages of non-irradiated fissile materials. It was designed to provide storage of non-irradiated solid fissile materials for the next 50 years, to meet the needs of CEA's research programs. Magenta thus takes over from the central fissile materials warehouse which entered service at Cadarache in 1962 and which no longer meets current safety standards. Over and above its storage function, it can also package materials and carry out characterization and inspection work on them.

ELECTRIC VEHICLE
February 2011

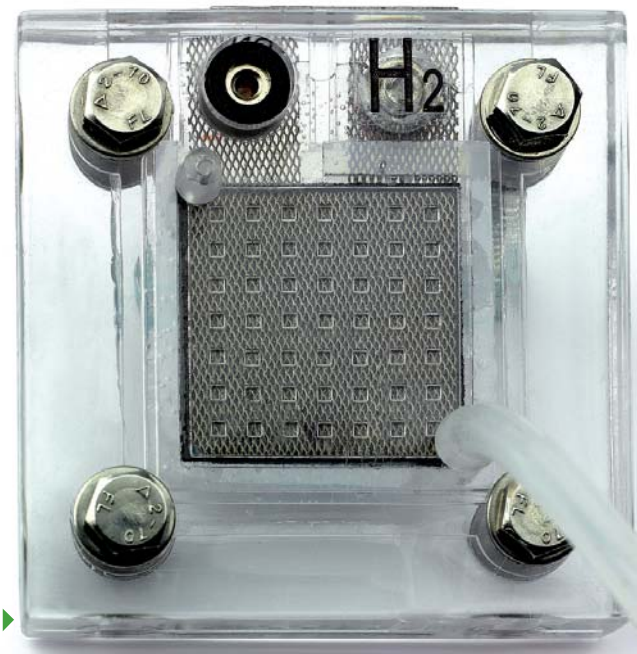
Battery for electric motor

A LiFe battery pack has been delivered to Michelin by CEA-Liten as part of the Forewheel project. This will be integrated into one of Michelin's prototype vehicles on which the electric motor is no longer housed in the engine compartment, but in the wheels. It will be subjected to two series of endurance trials on the test track, covering a total of 20,000 km, to check the mechanical stresses, the electrical performance objectives and the electronic interfaces with the Michelin systems. After each series of trials, the battery pack will be removed from the vehicle for a robustness assessment. The eventual aim of the Forewheel project is to develop a long-range, 5-seater electric vehicle offering real load carrying capacity.

HYDROGEN
February 2011

CATALYZING HYDROGEN WITHOUT PLATINUM

The hydrogen economy is today limited by the very high cost of the platinum used in the catalysts. A team from CEA-iRTSV, jointly with CEA-Iramis, has obtained nanomaterials which no longer need it in order to produce or use hydrogen. The researchers succeeded in immobilizing biomimetic catalysts on carbon nanotubes, derived from micro-organism enzymes functioning with common and inexpensive metals. Their preparation is compatible with printing technologies for deposition of active layers in the electrolyzers or fuel cells with polymer membranes. Furthermore, these nanomaterials are tolerant to the carbon monoxide that poisons platinum-based catalysts.



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Micro-fuel cell membrane with low platinum content

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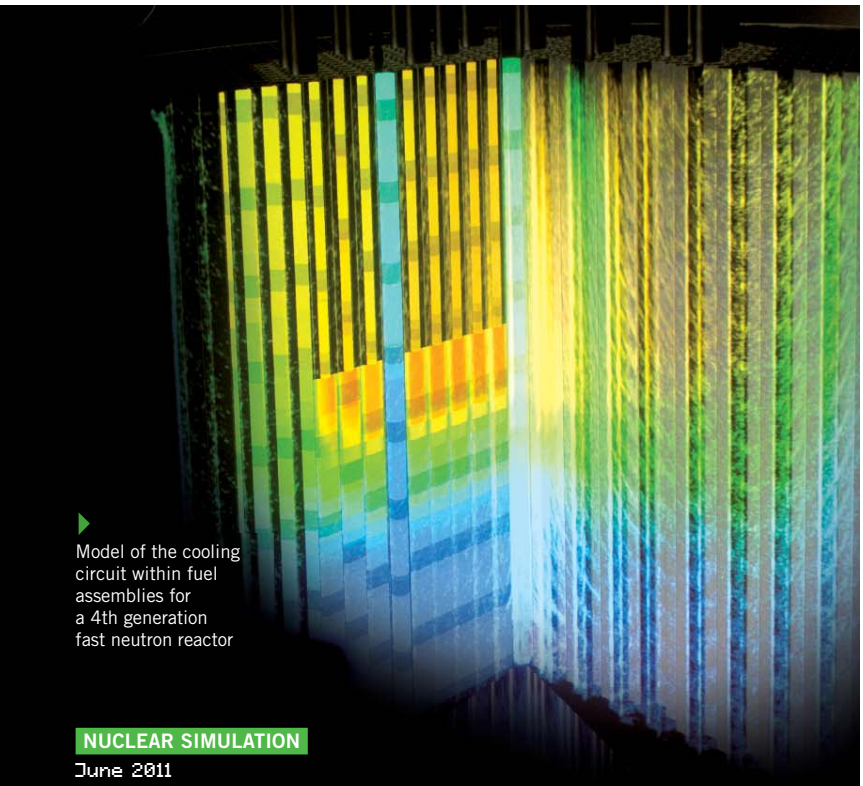


Model of the cooling circuit within fuel assemblies for a 4th generation fast neutron reactor

NUCLEAR SIMULATION
June 2011

DELIVERY OF THE APOLLO 3® CODE

CEA-DEN has provided Areva and EDF with the Apollo3® neutronics simulation code. In accordance with its development plan, it meets the needs of the industrial partners in terms of physics and computing functionalities (solvers, software and data architecture, input/output interfaces, code management) as well as the documentation and industrial protocols. This code will also be used by Areva in its industrial computing chain, in place of the Apollo 2 code, by the end of the decade. Its multi-technology nature will also enable CEA to use it for research and development of naval propulsion reactors, its experimental reactors and the Astrid 4th-generation prototype reactor.

HYDROGEN STORAGE
March 2011

Success of a hydride tank

A prototype metal hydride based tank for storing hydrogen has been successfully tested. It was developed by researchers from CEA-Liten for an agricultural tractor with a fuel cell and has the advantage of high volume capacity at low pressure, unlike pressurized storage tanks. Its internal structure allows good management of the expansion of the hydride powders, a TiFeMn alloy, to absorb the hydrogen. Its absorption kinetics is thus 10 mn for a 50% load. The heat flux leaving the fuel cell is used to release the hydrogen during the operation of the tractor.

NUCLEAR SAFETY
September 2011

Study of release of fission products during severe accidents

The first fission products release test has been performed in the new Verdon facility at CEA/Cadarache. It was carried out on a high burnup fraction uranium oxide fuel heated to 2,600°C. This sample had first of all been re-irradiated in the Osiris reactor at CEA/Saclay to recreate the inventory of short-lived fission products and thus obtain a range of fission products identical to that of a fuel in a reactor. This experiment validated the performance of Verdon. Much has already been learned in terms of fission products release, especially xenon and krypton, and the analyses in progress will continue in 2012.

HYDROGEN PRODUCTION
September 2011

Efficient low-temperature electrolyzer

A team from CEA-Liten has developed an EVHT (high-temperature water vapor electrolyzer) operating at 700°C with a water vapor to hydrogen conversion rate of 77%. This reduced operating temperature means increased durability, with a deterioration of only 2% per 1,000 hours.

High-temperature, low-cost electrolyzer

HYDROGEN PRODUCTION
October 2011

A SUPER-PRODUCING MICROALGAE

© CEA-iBEB

A team from CEA-iBEB has obtained a mutant microalgae producing 3 to 5 times more hydrogen than the original strains. Its study is already providing valuable information for microalgae engineering with a view to the production of biofuels.

Microalgae culture

NUCLEAR OF THE FUTURE
February 2011

Significant breakthroughs for the nuclear energy of the future.

The Astrid 4th-generation fast neutron prototype reactor preparatory design project is under way, with the creation of a dedicated team nearly 500 strong, half of whom are specialists from CEA, but also from Areva, EDF, Alstom and Onett Technologies. Another important step for Astrid is that researchers from CEA are defining a new reactor core architecture based on an even safer concept. This image will act as the benchmark for the safety and design studies for the Astrid fuel assemblies, the design of which is being financed by the investing in the future program, up to the detailed design phase in 2017.

ENERGY EFFICIENCY
October 2011

Non-toxic lighting

Low-consumption light-emitting diodes are often cadmium-based. As part of the Luminosurf project, CEA-Liten is developing semiconductors free of this toxic compound that is prohibited for general public applications, while offering high levels of conversion efficiency. This result was rewarded by the "Silver Photon" award at the Opto 2011 fair.

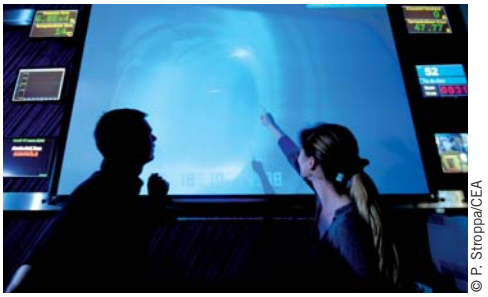
NUCLEAR
December 2011

A new method for uranium extraction

A team from CEA-DEN is developing a new molecule to extract uranium from the phosphate rock used to produce phosphoric acid and fertilizer, thus representing an alternative source of uranium, thereby boosting its resources. The molecule was optimized to extract more uranium, be more selective with respect to impurities – especially iron – and release the uranium extracted. It is already demonstrating rapid extraction, comparable with the benchmark systems. A preliminary process scheme has been defined by simulation and will constitute the basis for continuous small-scale testing in 2012 and 2013.

FUSION
August 2011

Stable, high-density plasma



© P. Stroppa/CEA

Tore Supra control room

For the first time, researchers from CEA-iRFM have obtained a fusion plasma that is durably stable and with a density higher than the Greenwald threshold. Until now, beyond this threshold, the plasma became unstable and suddenly disappeared. The density of the plasma was significantly and uniformly increased by heating it with microwaves, while injecting massive amounts of deuterium gas. This result, obtained in the CEA Tore Supra tokamak at Cadarache, promises potential improvements to plasma performance, while reducing the heating of the tokamak walls. Analyses are under way for possible extrapolation to Iter.

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© H. Raguet/Science&Avenir/CEA

CEA flies the flag in the defense and security field! To help guarantee France's deterrent force and combat nuclear proliferation and terrorism, its staff can call on impressive simulation resources, including Tera 100, ranked the most powerful in Europe for the third time in a row.

HIGH-PERFORMANCE MISSIONS

DEFENSE
May 2011

Science and Defense Award

A team from CEA/Cesta and EADS received the Science and Defense Award for its work on high-performance simulation of wave propagation phenomena. This distinction is in recognition of a very high level of expertise in the field of electromagnetic stealth and the team's contribution to the simulations used to guarantee weapons performance.

SECURITY
May 2011

Toxin detection rewarded

The toxin and pathogenic agents detection tests developed by CEA-DSV, as part of the interministerial NRBC/E program piloted by CEA-DAM, were rewarded by the *Trophées de la Résilience sociétale* (societal resilience awards). They are quick, sensitive and easy to use by response teams (police, fire service) and are being marketed by the NBC-Sys company, under the name KDTB Gold.

Inspection of mirrors for the future LMJ

ENVIRONMENTAL MONITORING

August 2011

CTBTO certified station

A first Spalax gas station, installed on Reunion island, has been certified by the comprehensive nuclear test-ban treaty organization (CTBTO) for its international monitoring network of 321 stations. This station uses a CEA-DAM technology for analyzing the radioactive isotopes of xenon in order to characterize any nuclear tests.

DETECTION

June 2011

New explosives sensors

A new explosives detection demonstrator is being developed by CEA-DAM, in collaboration with CEA-Leti and CEA-List. It is based on a combination of three different sensors and allows the detection of the least volatile explosives traces in the atmosphere.

FOR MORE INFORMATION
www.cea.fr

SECURITY
November 2011

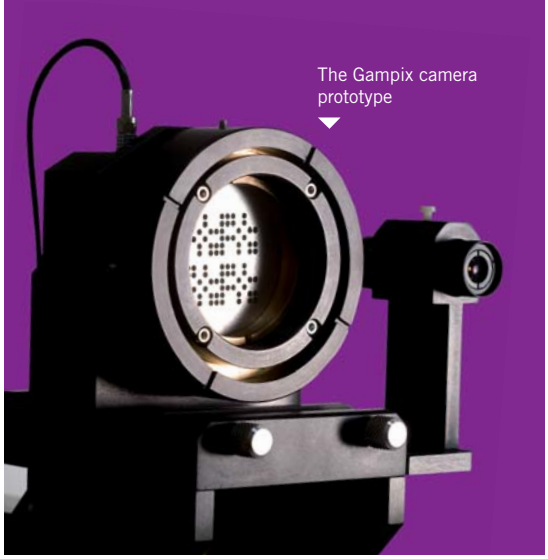
PEDESTRIAN PROTECTION

The Arcure start-up's Blaxtair product incorporates the latest software developments from CEA-List for detecting pedestrians in the proximity of industrial vehicles. This technology differs from existing systems in the shape recognition algorithm which is able to detect individuals standing up or crouching down. Following industrial transfer of this technology, Blaxtair is broadening the scope of its applications to a wide variety of industrial contexts (building sites, quarries, factories, warehouses, etc.)

DETECTION
June 2011

Gamma ray detection

The Gampix project, launched in 2008, presents a camera capable of detecting gamma radiation over a broad energy range, with greater sensitivity than existing models and far improved weight constraints. It was developed by CEA-List teams in collaboration with CEA-DAM and can be used to detect a zone and superpose a gamma image over the real image of the zone in just a few seconds, in order to locate the source of the radiation. It is currently undergoing industrialization at Areva Canberra and is targeting a number of applications such as dismantling of nuclear facilities, security and radiation protection.



The Gampix camera prototype

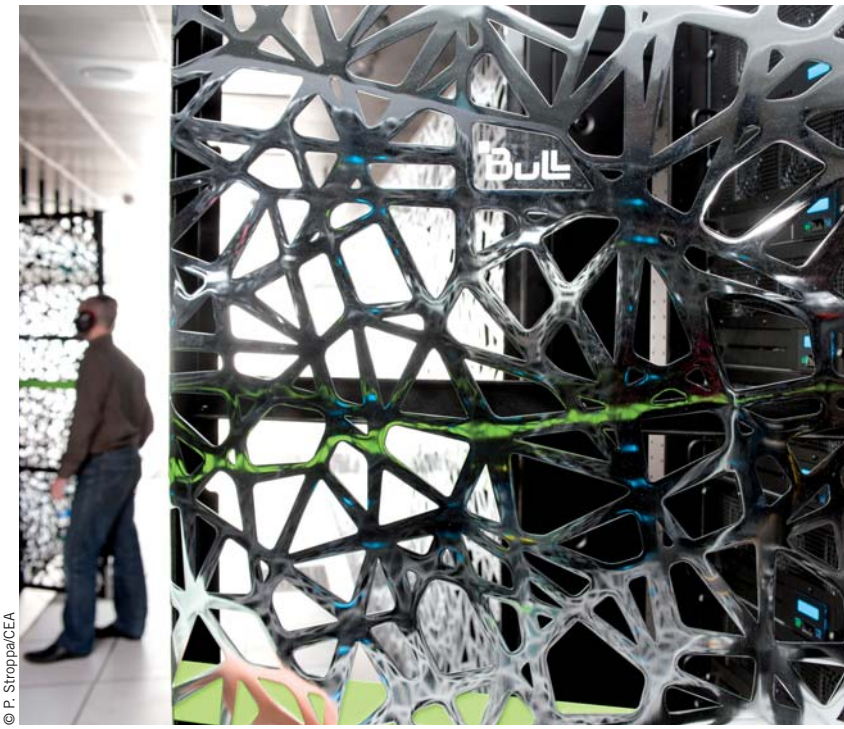
© CEA-DAM

INTENSIVE COMPUTING
June 2011

1.05 petaflops

FOR THE THIRD TIME IN A ROW, the ISC Top 500 ranked Tera 100 as Europe's leading supercomputer. Its power of 1.05 petaflops and its efficiency of 83.7%, demonstrate the quality of CEA-DAM and Bull's design and development for defense applications.

Facade of the Tera 100 computers



© P. Stroppa/CEA

SECURITY
January 2011

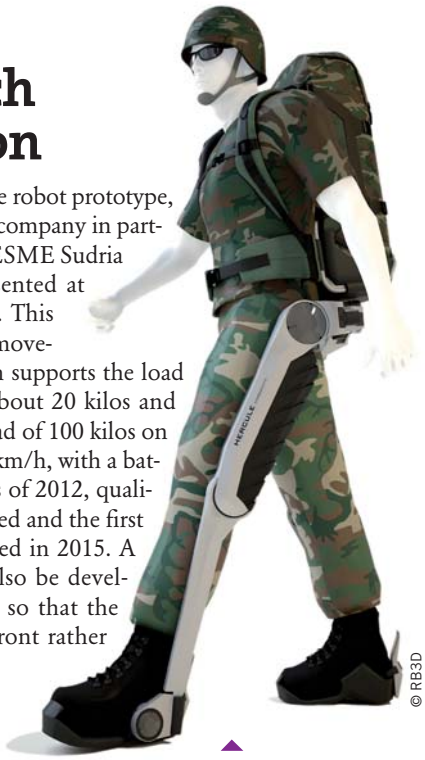
Radio-positioning of firefighters on duty

To ensure the safety of firefighters working in confined spaces, CEA-Leti's Demoloc project proposes real-time positioning and monitoring of their activities. Together with Cassidian (subsidiary of EADS), the 3D+ company and the Departmental Fire and Emergency Service of the Rhone (SDIS 69), it developed an UWB (ultra-wide band) radio-positioning system using a device analyzing the signals output by embedded sensors, to permanently determine the position, stance and activity of the firefighter. Demoloc was successfully tested in a 500m² car park, and in 90% of cases identified the six stances adopted by the firefighters to within a few centimeters (lying down right side, lying down left side, prone, supine, crouching, standing).

DEFENSE
October 2011

First French exoskeleton

The Hercule collaborative robot prototype, developed by the RB3D company in partnership with CEA-List, ESME Sudria and the DGA, was presented at the Milipol fair in Paris. This exoskeleton detects the movements of a user and then supports the load in his place. It weighs about 20 kilos and can be used to carry a load of 100 kilos on the back, at a speed of 4 km/h, with a battery life of five hours. As of 2012, qualification tests will be started and the first devices could be marketed in 2015. A second prototype will also be developed with robotic arms so that the load can be carried in front rather than on the back.



© RB3D

The Hercule prototype exoskeleton developed by CEA-List

SECURITY
February 2011

0.5 µGy

© P. Stroppa/CEA

Maintenance of the Airix accelerator

FOR DOSIMETRY IN THE CEA-DAM FACILITIES (in particular the Airix and Elsa accelerators), the physicists have developed an original, lightweight, compact dosimeter concept. It offers numerous advantages: detection threshold below 0.5 µGy, linear operation over more than 7 decades for ionizing radiation energy levels from a few tens of keV to 20 MeV. Its performance also allows applications in radiotherapy and radiation protection as well as the characterization of gamma sources or environmental monitoring. A patent is pending for this concept.

DECOMMISSIONING
April 2011

DISMANTLING AT PIERRELATTE

Dismantling of the military uranium enrichment plants at Pierrelatte began in 1996 and is now completed. It consisted in the dismantling and processing of all the equipment in the gaseous diffusion plants and the auxiliary premises, packaging of the waste and clean-up of the buildings. This was all done on-time and on-budget, with an extensive worksite comprising 200,000 m² of floors dismantled, 1,200 km of piping processed and 20,000 tons of very low level metal waste generated. This operation constitutes extensive operating experience feedback for current and future decommissioning projects.

Interior of the Pierrelatte uranium enrichment plant after dismantling

© CEA-DAM

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www.cea.fr

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From identification of gene expression mechanisms up to the development of medical imaging data processing algorithms, CEA's expertise covers the full range. It aims to achieve a better understanding of our organism and its exposure to certain types of radiation, while developing new therapeutic protocols and systems.

PREVENTION AND CURE

COGNITION
May 2011

Geometry is universal

All humans could understand basic geometry, without any educational or cultural input. This is the conclusion of a study performed on an isolated group of Amazonian Indians. This study was conducted by CEA-I²BM, CNRS, Collège de France, Inserm, Harvard, Paris Descartes, Paris-Sud 11 and Paris 8 Universities.

BIOLOGY
November 2011

A new weapon in the fight against cancer

Researchers from CEA-I²BM have for the first time demonstrated that tumor cells expressing the HLA-G molecule escape destruction by the immune system. Blocking this molecule by a specific antibody could inhibit the development of the tumor, thus offering an innovative therapeutic tool against cancer.

Observation of living cells with confocal microscopy

GENOMICS

December 2011

Proteins involved in the non-expression of genes

A new range of modifications of the proteins involved in the silence (non-expression) of mammal genes has been identified by researchers from CEA-iBiTec-S and CEA-IG. The potential benefits are a clearer understanding of the gene expression control mechanisms.

IMAGING

May 2011

New radionuclides for nuclear medicine

CEA-List is initiating collaboration with the Arronax cyclotron to study the strontium82/rubidium82 radiopharmaceutical in imaging of the myocardium. This would allow an examination in both "stress" and "rest" modes in less than 30 mn, as compared with the hours today required with thallium201 or technetium99.

FOR MORE INFORMATION
www.cea.fr

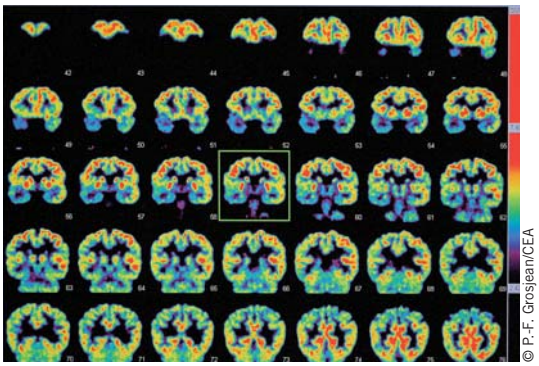
MEDICAL IMAGING
August 2011

MONITORING MULTIPLE SCLEROSIS LESIONS

Researchers from CEA-I²BM, together with a team of neurologists (Tenon Hospital, Paris) and researchers from the *Institut du cerveau et de la moelle* (brain and spine institute Paris), have developed an imaging method to detect damage to the myelin in multiple sclerosis. This damage is only partially reversible and gradually leads to handicapping neurological disorders. The myelin, which surrounds the nerve fibers in the brain and the spinal cord, plays a key role in controlling nervous influx and the communication between neurons. This imaging examination will be able to quantify the damage, monitor its repair and test the treatments currently under development.

© BSIP

Illustration of myelin damage in multiple sclerosis



© P.-F. Grosjean/CEA

Functional images of the brain obtained by PET

IMAGING
November 2011

A PET optimization algorithm

An innovative algorithm for PET imaging data processing is being developed by CEA-List. On the one hand it reduces by a factor of 10 the dose of radionuclides to be injected into the patients and, on the other, enables 3D images to be reconstructed in less than half a day.

TOXICITY
April 2011

Glutathion against cadmium

The first stages of cadmium detoxification using glutathion are described by a CEA-Iramis and CEA-iBiTec-S collaboration. Glutathion is the cell's first defense against cadmium, a highly toxic heavy metal that is often present in industrial waste.

GENETICS
April 2011

New factors in susceptibility to Alzheimer's disease

Five additional factors in the genetic predisposition to Alzheimer's disease have been brought to light by a European consortium of 108 laboratories, including CEA-IG. These factors were identified by analyzing the genomes of 59,176 individuals, including 19,870 affected by the disease, and will help broaden the scope of the research into the causes of this affliction and identify new possibilities for curative treatment. They will also be of use in better identifying the individual predisposition to the disease. These factors will also be pertinent in identifying the subjects at risk, when effective preventive treatment becomes available.

TREATMENT
March 2011

Trapping copper in the organism

A biomimetic molecule capable of selectively encapsulating excess copper in liver cells has been developed by a team from CEA-Inac. Its effectiveness, which has been demonstrated in vitro during a collaborative program with CEA-iRTSV, will be tested in a project currently being qualified and the results of which are already attracting the interest of doctors from a number of hospitals in Lyon and Paris. This molecule could help treat victims of chronic intoxication and individuals suffering from the genetic Wilson's disease, which seriously damages the liver and the nervous system.

BIO-IMAGING
November 2011

NEW FLUORESCENT PROBES

A team from CEA-iRTSV is developing new fluorescent probes. Their faster synthesis requires 1,000 times less reagent and involves a class of molecules of medical interest with a predisposition for interacting with biological targets. These probes could be used in bio-imaging or to identify bio-markers.

New fluorescent molecules for bio-imaging

GENETICS
July 2011

Synthetic bacterial genome

For the first time, an international team of researchers from CEA-IG-CNG, the universities of Berlin and Leuven, and the Heurisko company (United States) are selecting viable bacteria, whose genetic information is carried by chemically modified DNA. To do this, they developed a protocol capable of replacing one of the four bases normally making up the DNA by a synthetic compound. The survival of these bacteria thus depends on this compound, which is not present in nature. They could eventually be used to produce a wide range of molecules of interest, with no risk of them entering into competition nor exchanging genetic material with wild organisms.

THERAPY
January 2011

Innovative vectors against certain cancers

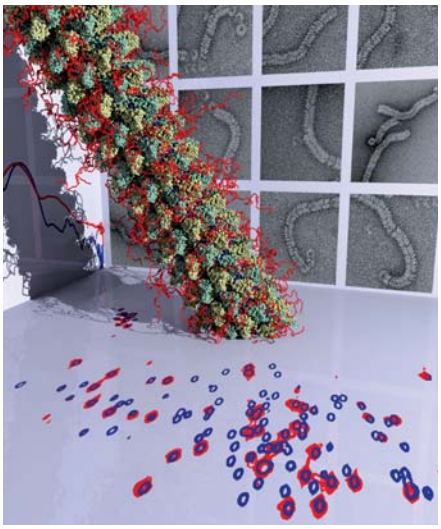
Under the European Target PFT project, a team from CEA-Leti is developing a new technology for carrying photosensitizers used in dynamic phototherapy. This consists in encapsulating them in lipidots, nano-droplets of lipids 50 nm in diameter, carrying small molecules on their surface capable of specifically recognizing the tumor cells to be treated. These are then destroyed by activation of photosensitizers using light energy (laser). This technique is currently undergoing pre-clinical trials for treatment of squamous cell cancers of the head and neck and osteosarcoma.

FOR MORE INFORMATION
www.cea.fr

STRUCTURAL BIOLOGY
June 2011

Measles: a disorderly virus

The structure of a disordered part of a measles protein is observed for the first time in a physiological context. This discovery by CEA-IBS, CNRS and Joseph Fourier University of Grenoble sheds light on how this part works and its potential role in infection by the measles virus.



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Reconstitution of the viral capsid

DIAGNOSTIC
October 2011

A probe for prostate cancer

CEA-Leti is developing and validating the performance of a new imaging probe, combining fluorescence and ultrasounds, to guide biopsies towards the areas of the prostate that are potentially cancerous. The precision of this probe allows a reliable diagnostic in just a single examination, for greater patient comfort.

© C. Dupont/CEA

Cell examination

RADIOBIOLOGY
September 2011

SIGNATURE OF RADIO-INDUCED TUMORS

Researchers from CEA-iRCM have in the laboratory identified a specific signature for thyroid tumors caused either by radiotherapy, or by the nuclear accident at Chernobyl. This enables them to be differentiated from tumors of other origins, referred to as sporadic. These fundamental research results are a key step but much still needs to be done before envisaging the development of a reliable, large-scale test for pertinent screening of tumors and improved patient care.

DIAGNOSIS
April 2011

Sensors for magnetocardiography

The design of ultra-sensitive magnetic sensors at CEA-Iramis means that a clinical magnetocardiography protocol can now be proposed. With these new sensors, it was possible to measure the magnetic component induced by the electrical activity of the heart. Unlike an electrocardiogram which requires the positioning of electrodes, the heart would here be analyzed with no contact, thanks to an array of 25 to 36 magnetic sensors placed around the patient. A dynamic image of the electrical activity of the heart could be produced in a very short period of time, about a minute.

TREATMENT
April 2011

A tool to help fight the recurrence of leukemia

A mouse model reproducing recurrences of certain leukemias has been developed under a collaborative venture between CEA/Inserm/AP-HP/Universities Paris-Sud 11, Diderot- Paris 7 and Pierre et Marie Curie. It is a valuable tool for testing of treatments in these cases of recurrence, observed in 20 to 50% of patients.

GENETICS
September 2011

Enzyme activity under control

A molecular probe capable of precisely controlling the activity of an enzyme within a plant is being developed under a collaborative venture between CEA-iBiTec-S, the CNRS, Inra, the Joseph Fourier University in Grenoble and Montpellier 2 University. Ten years were needed to make the selection from a collection of 24,000 molecules and characterize its operation. By fixing on the enzyme, the probe inhibits its activity, thus reducing the quantity of molecules it is able to synthesize. Over and above controlling the metabolism of a living organism, this approach opens the door to numerous biotechnology applications.

GENETICS
March 2011

A KEY REGULATOR OF GENE EXPRESSION

The cellular player responsible for positioning of the polymerase RNA (key enzyme in gene transcription) on the DNA has been identified by a team from CEA-iBiTec-S. This thus answers one of the fundamental questions concerning the gene expression mechanisms by demonstrating, in vivo, that this is a multiprotein complex called the "transcriptional activation mediator". Its function is to place the polymerase RNA only on the genes to be transcribed along the DNA molecule. A deregulation of its function can lead to a cellular imbalance, which suggests its involvement in certain development pathologies or cancers.

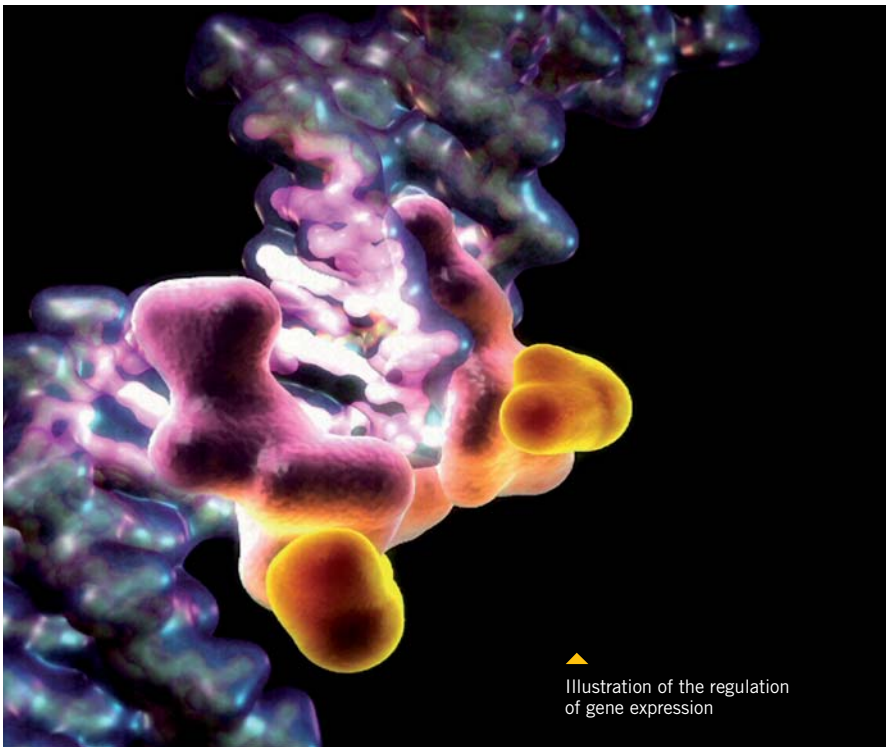

Illustration of the regulation of gene expression

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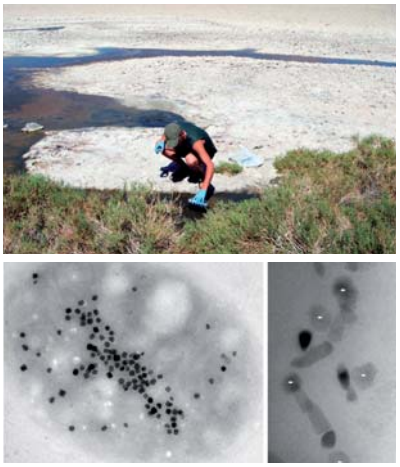

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Sampling and observation of bacteria producing Magnetite and Greigite

MICROBIOLOGY
December 2011

Bacterial nano-magnets

A new group of magnetotactic bacteria producing nano-magnets of Magnetite and Greigite is being characterized by an international consortium involving CEA-iBEB, the CNRS, and American, Brazilian and Hungarian partners. Two groups of genes were identified on this occasion, each involved in the formation of one of the types of nanomagnets. Growth of bacteria producing Greigite nanomagnets is a first and will enable them to be characterized and given biotechnology applications. As for the Magnetite nanomagnets, they are already being studied, particularly for MRI imaging, pollution clean-up and as catalysts.

FOR MORE INFORMATION
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Anticipating the telecommunications of the future, exploring 3D integration techniques to produce ultra-high performance electronic systems, pushing back the boundaries of imaging… Once again this year, CEA is developing and transferring innovative technologies for large, medium and small enterprises.

ANTICIPATION & INNOVATION

INDUSTRIAL TRANSFER
December 2011

CEA and Caltech start-up

The Analytical Pixels Technology (APIX) start-up will be designing, manufacturing and marketing multi-gas analyzers. This is the fruit of the Alliance for Nanosystems VLSI, created in 2007 by CEA-Leti and Caltech (California Institute of Technology) and it is targeting the industrial security, environment and medical diagnostic markets.

OPTICS
November 2011

8

By coupling eight silicon microcavities with the same resonance wavelength, a team from CEA-Inac, with the CNRS and the University of Bourgogne, has obtained an unprecedented optical system capable of adopting eight different spectral states. This offers promising results for sorting or counting of nano-objects.

Work on the upstream technological platform at Minatec

MICROELECTRONICS

April 2011

On-board Krono-Safe systems

CEA-List creates the Krono-safe company to market a real-time embedded systems design platform based on its PharOS technology. The goal is to provide its customers, including Delphi, with a solution to their growing need for on-board computer integration, dependability and performance.

SOFTWARE

October 2011

An industrial modeler for systems architectures

An industrial modeler for systems architectures (for nuclear, aeronautics or automotive applications) is based on the SCADE suite from Esterel Technologies. For the upstream design phases, the company is developing a new suite derived the Papyrus modeler, an industrial version of which has just been delivered by CEA-List.

FOR MORE INFORMATION
www.cea.fr

INNOVATION
July 2011

B2I FOR SMES

CEA/Grenoble has created the B2I (integrative industries building), the first workspace dedicated to the upstream phase of innovation leading to the creation of emerging concepts and prototypes. The B2I is intended for SMEs and proposes a range of tailor-made offerings through a showroom, a technological innovation platform, R&D laboratories and an anechoic chamber.

© CEA

View of the Minatec showroom

AUGMENTED REALITY
January 2011

Sound and vision

iCyclope is a new application available from the Apple Store. CEA-List and the Diotasoft company propose to use it in real time to show a video presentation by the author Bernard Werber actually inside his book. It involves superposing a virtual video model over a real object, the book. The smartphone or tablet camera simply needs to visualize the object for the image processing algorithms to recognize it, thanks to upstream encoding, and the corresponding video can then be launched. For iCyclope, the algorithms were redesigned to adapt to the constraints of use by the general public: variable lighting, blur management and the reflective nature of the book cover.

© CEA

iCyclope application

PHOTONICS
April 2011

0.3 ps

RESEARCHERS FROM CEA-INAC have produced the world's fastest photonic switch. Switching takes 0.3 picoseconds (10^{-12} s), thus achieving terahertz (10^{12} Hz) levels. This is one hundred times less than the best electrical switch! This work opens up major prospects in the field of telecoms.

IMAGING
June 2011

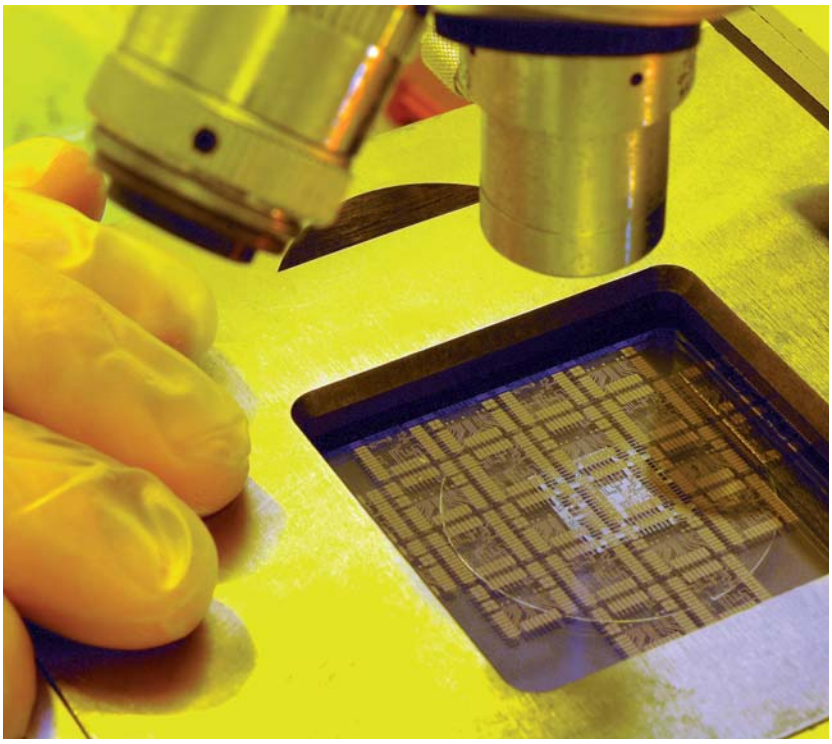
50 pm

THE TITAN PICO ELECTRON MICROSCOPE is now installed on the CEA nano-characterization platform in Grenoble. It was manufactured by the FEI company and its 50 picometer resolution should further push back imaging boundaries for the investigation of matter and its properties. There are only four of these machines in the world.

IMAGING
October 2011

1,500 images/s

AN ULTRA-FAST AND ULTRA-SENSITIVE INFRARED CAMERA prototype has been produced at CEA-Leti. The array is based on HgCdTe photodiodes and it films physical phenomena at a rate of 1,500 images per second. This is a world record for infrared detection, opening up new horizons for astrophysical observations.



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Lithography area of a clean room

MOVEMENT CAPTURE

November 2011

M&NEMS FOR MOVEMENT CAPTURE

The M&NEMS patented concept from CEA-Leti is a technological milestone in the miniaturization of movement sensors, devices that are present everywhere in our daily lives (telephony, sport, re-education, medicine, games, etc.). Movement capture is built around miniature inertial platforms comprising a 3-axis accelerometer, a 3-axis magnetometer and a 3-axis gyro. The M&NEMS concept consists in using piezoresistive nanowires integrated into a micrometric structure for detection purposes. This amplifies the mechanical force to be detected (acceleration, speed, magnetic field). This amplification enables the sensors to be miniaturized, so that the 9 movement axes can be integrated on the same chip.

ELECTRONICS

April 2011

Repair of memory circuits

To improve the efficiency of memory circuits, CEA-List is developing a patented infrastructure to optimize the repair capacity of redundant columns. These are usually employed to hide circuit production defects by replacing the defective columns. The new CEA-List infrastructure, based on an asymmetrical error correction code (ECC), improves this capacity: with three redundant columns, it is now possible to correct seven unique errors instead of three. This solution offers greater efficiency for a surface cost virtually identical to the traditional approach. It is also suitable for memories with or without ECC protection.

NETWORKS

April 2011

The Internet of Things

The "ICT-Micro&Nano Technology" Alliance between the Carnot institutes is publishing a white paper on networks of communicating systems and the Internet of things (extension of the Internet to real world objects). This initiative was put together with industry and is supported by CEA-Leti and Télécom, focusing on technologies and architectures that enable the real world to interface with various sensors interconnected in a network. The document is structured according to the applications scenarios envisaged by the firms and aims to promote an integration effort on platforms in five areas: urban infrastructures, mobile services, large retail, smart homes, transport and aeronautics.

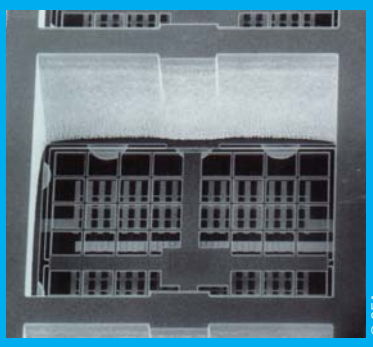
IMAGING

May 2011

Vacuum packaged microbolometers

Microbolometers are used in infrared imagers, especially in astrophysics. They are extremely sensitive heat detectors. The quality of their packaging, which determines the quality of their operation, remains extremely costly. With the Phileas project, CEA-Leti proposes to reduce manufacturing costs by means of pixel level encapsulation. Capsules are built around each microbolometer, using standard silicon technology processes, achieving a level of vacuum of 10^{-3} mbar. They are then sealed by two deposits to guarantee both a hermetic seal and anti-dazzle. A demonstrator is currently under construction, with a view to industrial transfer.

Scanning electron microscope photography of a pixel bolometer



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VIRTUAL REALITY
April 2011

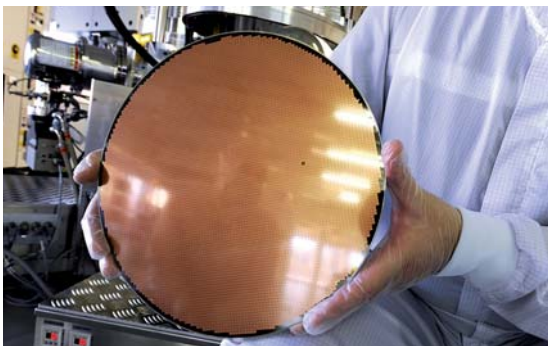
Demonstrators for industrial needs

Through a collaborative project with Renault, CEA-List presents two demonstrators: a virtual prototype and a marketing tool (personalized vehicle configuration in the showroom). A clear illustration of the benefits of combining interactive simulation with low-cost movement capture technologies to meet industrial needs.

MICROELECTRONICS
October 2011

Open 3D

CEA-Leti is launching "Open 3D" on its integrated circuits design technology platforms. The aim is to offer French and European manufacturers innovative 3D technologies for wafer sizes of 200 and 300 mm (including design, testing and packaging) in order to break into new markets.



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Wafer produced with 3D technologies

ELECTRONICS
July 2011

Cutting and folding graphene

Graphene, a two-dimensional carbon crystal, has exceptional properties, owing to its mechanical strength and high electrical and thermal conductivity. For the envisaged applications (ultra-fast electronics, reinforced materials), techniques still have to be found so that it can be shaped without damaging it. At the Ganil in Caen, a team from CEA-Iramis and Duisburg University of Germany are demonstrating that graphene can be cut and folded by grazing incidence irradiation using heavy ions. While irradiation generally leads to the creation of defects, the sheets of graphene obtained in this way have a fine appearance and retain their properties.

© Isorg

Interactive 3D multimedia tablet illustrating the new contactless interfaces based on large-surface optical sensors

DETECTION
October 2011

ORGANIC PHOTODETECTORS

CEA and the Isorg company are continuing their collaboration through a second photo-detection demonstrator. This consists in converting photons into an electrical current and then a signal, through its four 25-pixel arrays, each of which comprises organic photodetectors. This system is based on printing processes, including screen-printing and inkjet printing steps, enabling it to be integrated onto glass or plastic. When thus equipped, these surfaces are then capable of measuring ambient light, colors, optical properties of fluids and gases, and so on. An ideal product for smart buildings, environmental monitoring, lighting and security.

MICROELECTRONICS
April 2011

Thermal accelerometer

Temperature control is a technical and economic challenge for microelectronics, whose components give off considerable amounts of heat. CEA-Liten is developing a thermal accelerometer capable of observing heat fluxes in order to anticipate temperature rises. Its operation is based on thermoelectric phenomena combined with the propagation of heat waves. It consists of two sets of n and p doped thermoelectric elements, connected in the direction of the heat flux. The tests on the first 3D sensors show their good capacity for anticipation. This is a development which is also targeting reduced energy consumption in the home.

ELECTRONICS
August 2011

NEW METHOD FOR WRITING MAGNETIC MEMORIES

A new method for writing data in direct access magnetic memories (MRAM) has been developed by researchers from CEA-Inac, the Catalan Institute of Nanotechnologies and the Autonomous University of Barcelona. By running the current through the magnetic layer, rather than perpendicular to it, the read and write pathways are dissociated: the current no longer passes through the thin layers for writing, thus reducing the risk of damage, and the resistivity of the stack of layers is increased to facilitate reading. It is also possible to envisage devices with three terminals (transistor type), which would represent a significant step forwards for spin electronics.

View of an MRAM wafer

COMMUNICATION
February 2011

Internet connection in transport systems

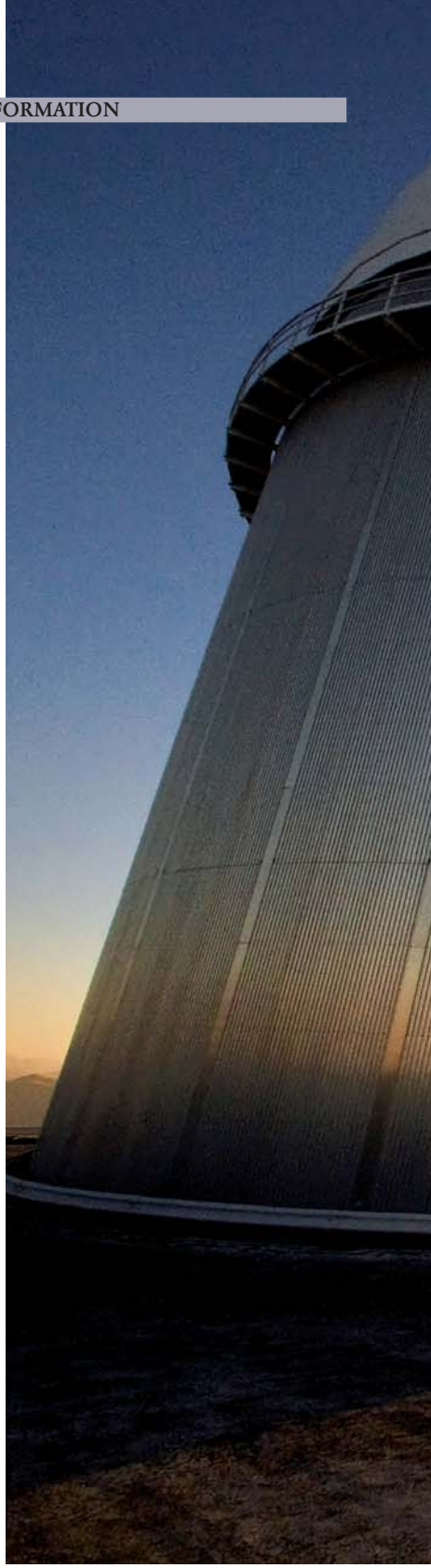
A bus is successfully testing a system providing a stable and reliable web connection from external networks. The device is being developed by researchers from CEA-List and the Institut Télécom, the RATP and Degetel, under the SEAMLESS project. It is based on a mobile router providing WiFi TCP/IP access in the bus and ensuring continuous web access via the various external networks (WiFi, 3G, 3G+, GPRS). Three technological hurdles have been overcome: automatic switching of the connection between heterogeneous access networks (WiFi /3G), interfacing with WiFi Naxos networks along the bus route, offering private non-routable IP addresses, and increased bandwidth between the bus and the wireless system.

NANOSCIENCES
July 2011

Self-organization of molecules

The two-dimensional organization of optically active molecules on a surface is a key challenge for nanophotonics, especially for information processing. However, once deposited on a surface, these molecules lose their functionality. To remedy this, the researchers at CEA-Iramis, with the CNRS and Pierre et Marie Curie University, are using a molecular lego capable of self-assembling basic bricks called “tectons”. One side of the tecton attaches to the surface in a regular paved array and the other side to the molecule, with the dimensions guaranteeing minimal spacing between the molecules and preserving their properties.

FOR MORE INFORMATION
www.cea.fr



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At CEA, 2011 was synonymous with increased use of major infrastructures to help with the development of new technologies and meet today's major scientific challenges. These include experiments being carried out on matter by the LHC and to understand the formation of the first galaxies thanks to the Herschel satellite.

MEETING THE MAJOR SCIENTIFIC CHALLENGES

VLT
March 2011

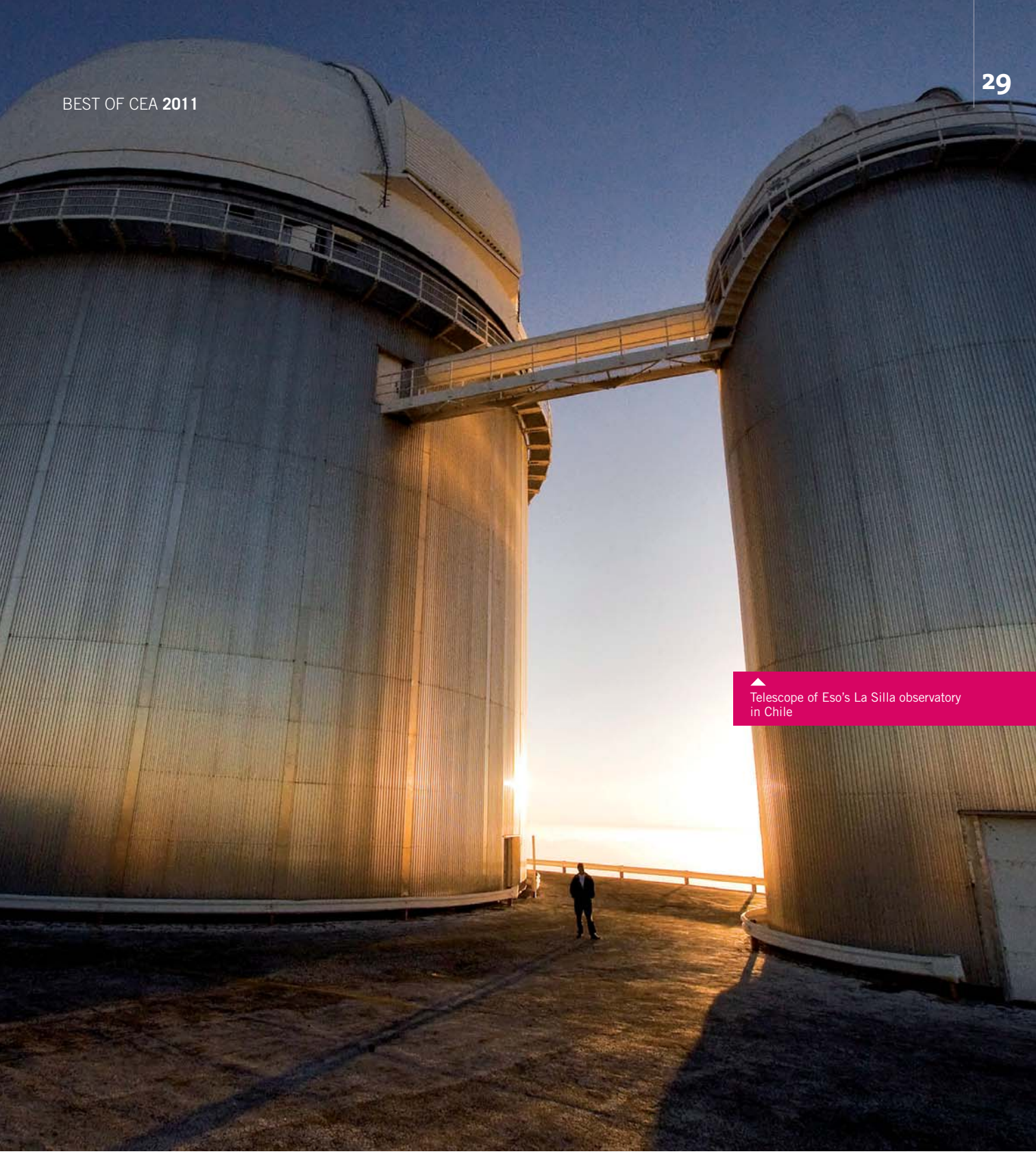
10 billion light years

Researchers from CEA-Irfu have discovered a cluster of galaxies more than ten billion light years away. This is the most distant ever observed, thanks to observations from the VLT very large ground telescopes (Eso) and data from the Hubble Space Telescope (Nasa) and XMM-Newton (Esa) satellites.

GANIL
December 2011

Production of purer ion beams

For the first time, a beam of stable ions has been produced by laser-induced resonant ionization in the Ganil, rather than by electron cyclotron resonance. This technique, which will provide a purer beam of ions, is decisive in the creation of a source of laser ions dedicated to Spiral 2 at the Ganil.



Telescope of Eso's La Silla observatory in Chile

ITER

November 2011

Tore Supra, test lab

The WEST project has been validated by two international panels. It consists in modifying the CEA/Cadarache tokamak, Tore Supra, so that it can test elements of Iter, the future experimental nuclear fusion reactor. This will involve equipping Tore Supra with a tungsten divertor, using Iter technology.

PLANCK

January 2011

First catalogue of sources

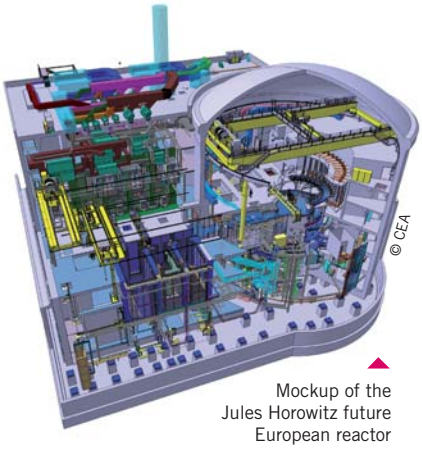
The first edition of the catalogue of sources detected by the Planck satellite has been published, 18 months after its launch. These sources include super-clusters of galaxies located by astrophysicists at CEA-Irfu. The purpose of the catalogue is to map the background radiation of the Universe emitted 380,000 years after the big-bang. The results are expected in 2013.

FOR MORE INFORMATION
www.cea.fr

RJH
July 2011

300 m³

THE FIRST THREE LEVELS of the containment building of the Jules Horowitz reactor (RJH), the future European experimental reactor in CEA/Cadarache, have been concreted. Each one, 2.50 m high and produced under the project management of Areva-TA, required 300 m³ of concrete. The operations were validated by ASN.



© CEA

Mockup of the Jules Horowitz future European reactor

LHC
December 2011

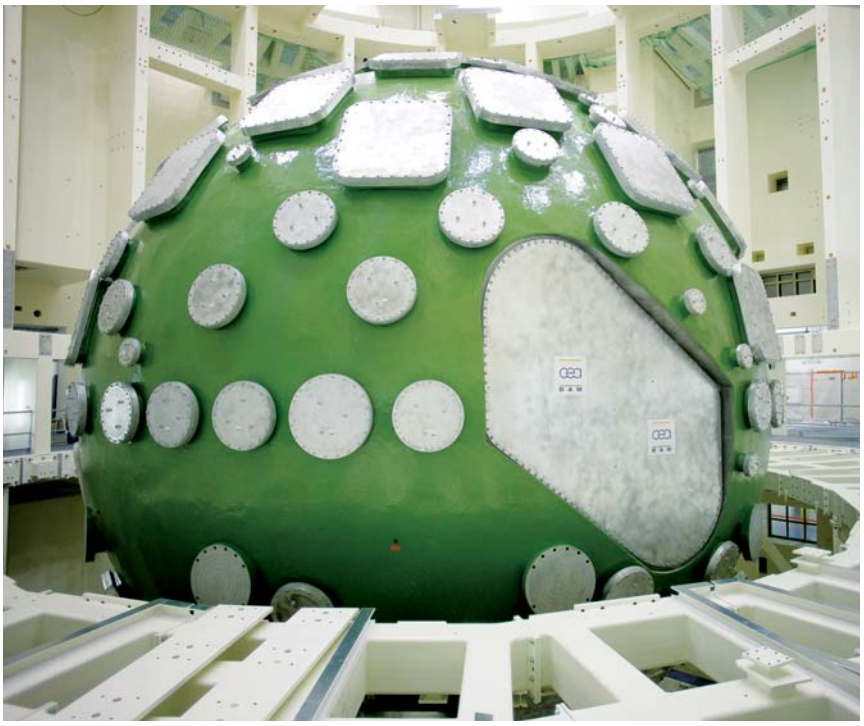
From 115 to 130 Gev

THE SEARCH FOR THE HIGGS BOSON is continuing in the LHC at the Cern, with the involvement of CEA-Irfu. The data acquired in 2010 and 2011 have reduced the mass region in which it could be found to the 115-130 Gev range. However, this advance has not enabled a firm conclusion to be reached on the existence or otherwise of this particle. An answer is expected in 2012.

SOLAR ORBITER & EUCLID
October 2011

2 missions selected

THE NEXT TWO MISSIONS OF THE ESA'S "COSMIC VISION" Universe exploration program have been selected from among 52 candidates. "Solar Orbiter" and "Euclid", dedicated to the study of the Sun and of the dark Universe respectively, will be launched in 2017 and 2019. CEA teams are involved in the scientific objectives and in the construction of the instruments that will be carried by the two future European satellites.



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Experimentation room being prepared at the LMJ

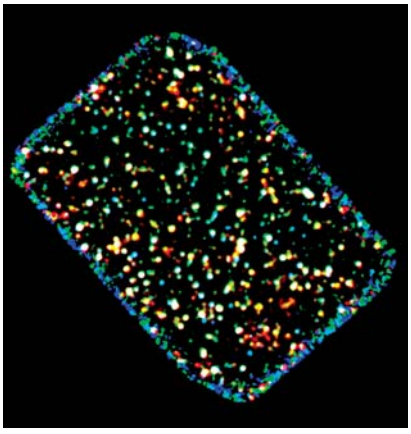
PETAL
September 2011

SUCCESSFUL DEPLOYMENT

The construction of the PETAL laser infrastructures at the Mégajoule Laser (LMJ) installation at CEA/Cesta is nearing completion. This installation is the precursor to a very large civil research infrastructure unique in Europe, for inertial confinement fusion, understanding the Universe and medical research.

HERSCHEL
Septembre 2011

Star formation without collisions



© Esa

Superposition of a field of galaxies using data obtained by Herschel

Collisions between galaxies only play a secondary role in the star formation process, which is more dependent on the quantity of gas contained in a galaxy. This statement, which contradicts the current scenarios, is the result of observations by ESA's Herschel space telescope, under the international GOODS-Herschel program involving researchers from CEA-Irfu. The unprecedented infrared images of 2,000 galaxies located up to 11 billion light years away, have enabled astrophysicists to reach such a conclusion. Collisions between galaxies would in fact only be a factor in the formation of stars when the galaxies do not contain enough gas.

T2K AND DOUBLE CHOOZ

June 2011

Neutrino metamorphosis

The Japanese T2K experiment is for the first time detecting indications of the transformation of muon neutrinos into electron neutrinos. It consists in generating a beam of neutrinos in the JPARK accelerator at Tokaï and sending it 300 km to a detector at Kamiokande. This discovery is supplemented by that of the French Double Chooz experiment which, in November, observed the disappearance of antineutrinos from the nuclear reactor in the Chooz nuclear power plant. The results of these two experiments, in which CEA-Irfu is a participant, offers a significant clue to the oscillation of neutrinos and opens up possible explanations as to why antimatter has disappeared from our Universe.

ICOS

April 2011

Source monitoring and carbon sinks

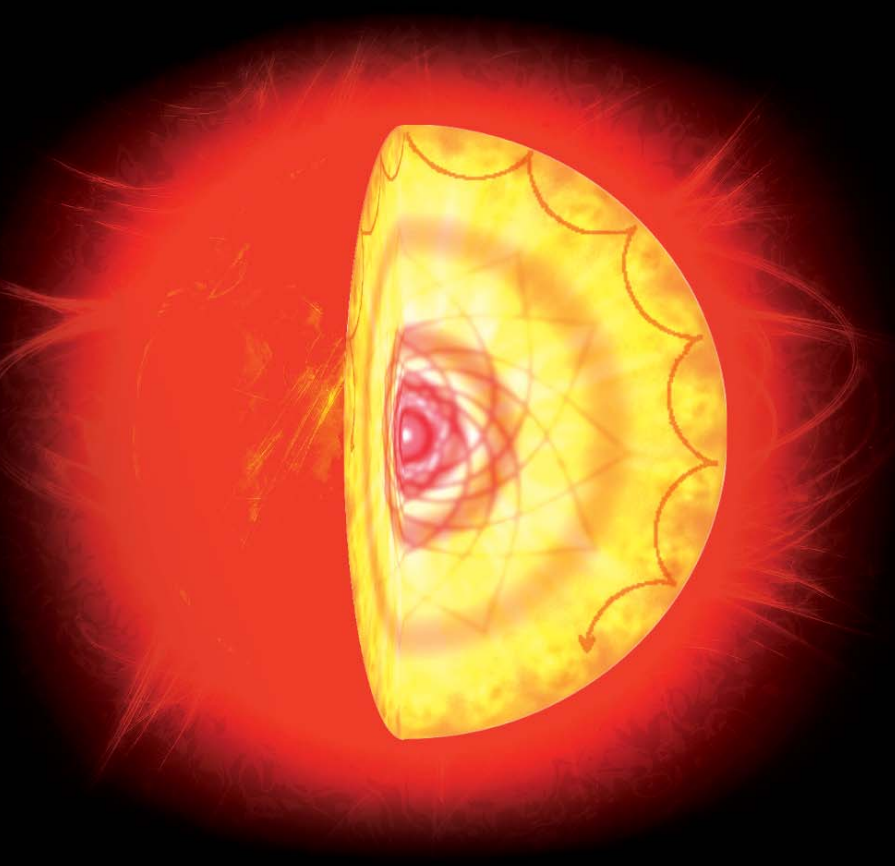
Four atmospheric observatories in Europe have initiated a campaign of measurements to demonstrate the feasibility of the ICOS network for monitoring greenhouse gas sources and sinks. The aim of the experiment is to test the coordination of a small-scale system for long-term, precise monitoring of greenhouse gases. The aim will eventually be to launch the future European ICOS network, dedicated to high-resolution observation of carbon exchanges (carbon dioxide, methane and other greenhouse gases) between the surface of the Earth, the oceans and the atmosphere. This network will be coordinated by LSCE (joint CEA/CNRS/UVSQ unit), and will comprise more than 40 research laboratories from about twenty countries.

KEPLER & COROT

December 2011

THE HEART OF THE RED GIANTS REVEALED

Until recently, the hearts of the red giants could not be seen, but they have now been revealed by the Kepler (Nasa) and Corot (CNES) satellites. For the first time, the phenomenon of core rotation in these end of life stars has been observed. An international team including CEA-Irfu has demonstrated that their core rotates 10 times faster than their envelope. This discovery is the result of data analysis and stellar seismology work, involving the study of the slight variations in the brightness of the stars, in order to deduce their internal structure. The astrophysicists eventually hope to study more than 15,000 red giants in order to better describe this core rotation mechanism, which is also at work in our Sun.

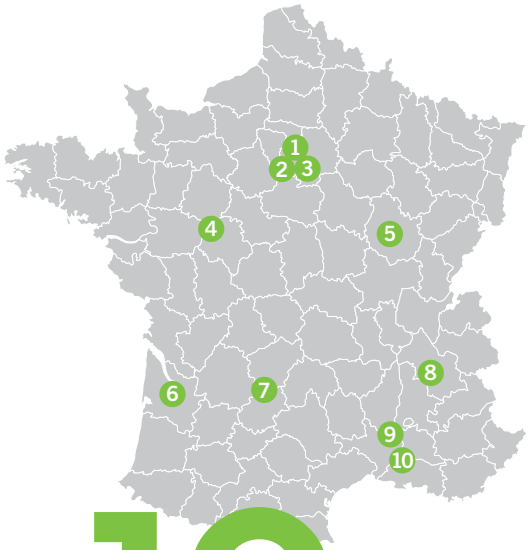


Cross-section of a red giant with acoustic waves around the periphery and gravity waves at the center

cea A LOOK BACK AT A YEAR OF RESEARCH 2011

16,095
The number of staff at CEA in 2011.

"CEA confirms its vision of renewables and nuclear energy working together, **backed by its significant advances** in photovoltaics, biofuels, energy storage, 4th generation systems, etc."

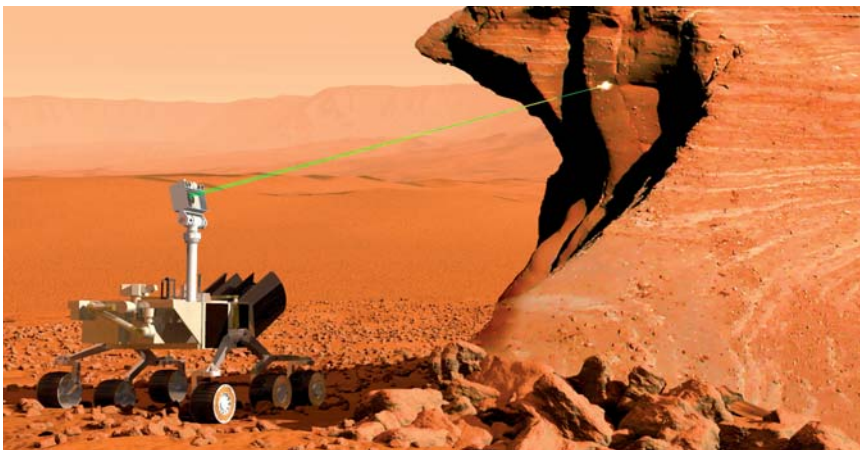


10 centres

1. CEA/FONTENAY-AUX-ROSES
2. CEA/SACLAY
3. CEA/DAM-ÎLE-DE-FRANCE
4. CEA/LE RIPAULT
5. CEA/VALDUC
6. CEA/CESTA
7. CEA/GRAMAT
8. CEA/GRENOBLE
9. CEA/MARCOULE
10. CEA/CADARACHE

World record

With a distance of 1,280 km in 24 hours, an electric car equipped with a CEA **battery pack** has just broken the 1,254 km world record held by a Dutch team.



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First mission to Mars

NASA is launching the American MSL mission to Mars. It will be carrying the Libs system designed by CEA **to study the composition of Martian rock.** It is expected to reach Mars in August 2012.

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