NEWSLetter
Excellence Cluster Universe

Issue 2 / 2012

Dear Readers

On June 15, shortly before the DFG press conference at 3.30 p.m., we received the eagerly awaited email of the Deutsche Forschungsgemeinschaft: The Universe Cluster will be funded for a second phase! We were ecstatic.

During the last six years the Universe Cluster became well established and has attracted international attention. The funding for Universe will now run until 2017. The modern research infrastructure set up during the first phase will be further enhanced, thus allowing the scientists to work at the highest standard in future.

We would like to take this opportunity and thank all Universe scientists and employees who made this success possible. We are looking forward to five more years of innovation and successful cooperation!

Prof. Dr. Stephan Paul
Cluster Coordinator

Prof. Dr. Andreas Burkert
Vice Cluster Coordinator

PICTURE OF THE MONTH

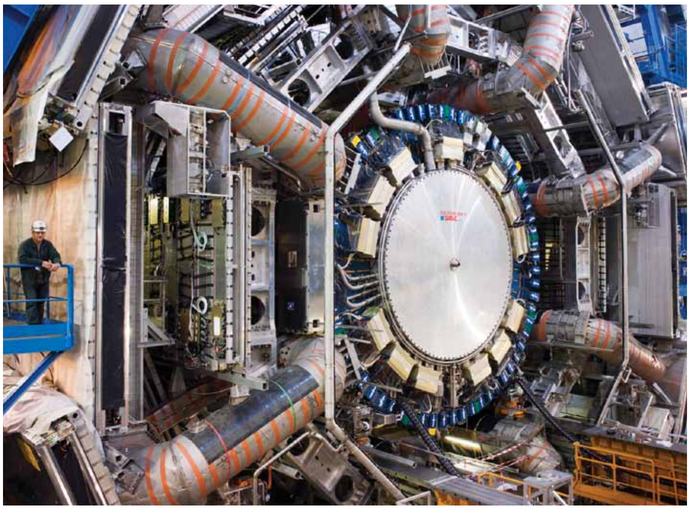
Extreme requirements must be met for the measurement of the electric dipole moment of the neutron at the research neutron source Heinz Maier-Leibnitz (FRM II). To reduce magnetic contaminations at the new beam position, more than 100 m^3 of concrete were removed on a floor space of 10 x 7m and replaced by a non-magnetically reinforced concrete structure that is independent of the surrounding building. The planned completion of this work before the end of the summer will allow already prepared components to be installed within the year.

CLUSTER RESEARCH

Universe Cluster makes it to the second round

The Excellence Cluster Universe has made it to the second round of funding! On June 15, the Federal Minister for Education and Research, Annette Schavan, announced at a press conference held by the German Research Foundation (DFG) which new and existing Clusters of Excellence had been approved for the next five years.

The Universe Cluster brings together the physics faculties of the two Munich universities, the Max Planck Institutes for Physics, Astrophysics, Extraterrestrial Physics and Plasma Physics, and the European Southern Observatory (ESO). Since 2006 around 250 theoretical and experimental astrophysicists, nuclear and particle physicists have been working on deciphering the structure of the universe.



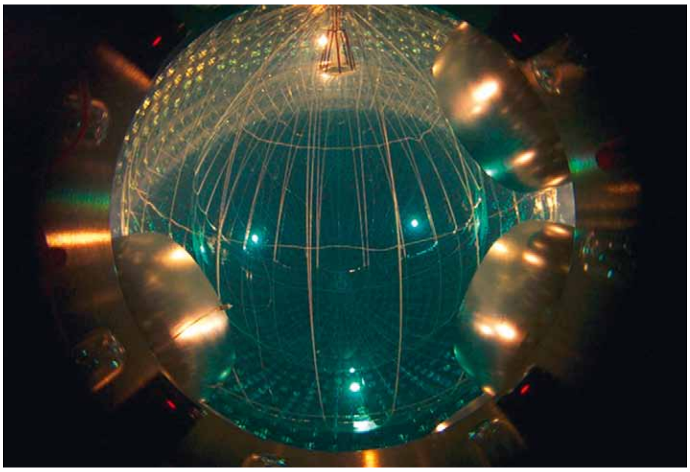
CERN – Atlas Experiment showing the detectors

Research over the next few years

Until 2017, the Universe Cluster scientists can now build on the outstanding work and achievements of the last six years. The expansion and focus of the research fields, along with further networking of the various disciplines, will receive special emphasis. The possibility for interdisciplinary utilization of data from particle physics and astrophysics and the use and completion of the newly-created research infrastructure form an exceptional springboard for the Cluster scientists. In the second round of funding, major new findings are expected:

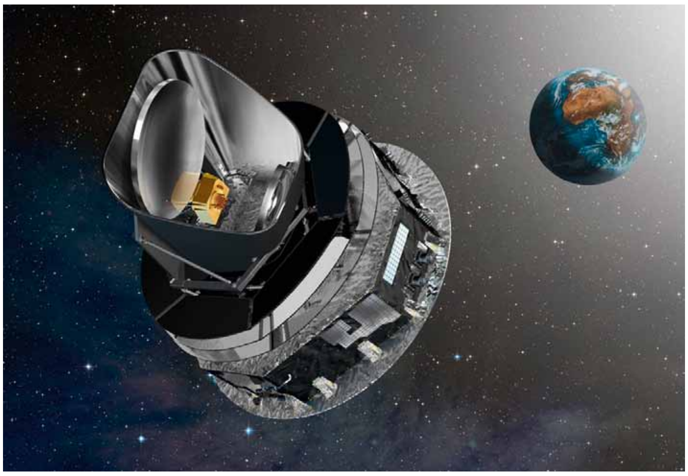
Special particles, consisting of bottom quarks, have been promising the discovery of new frontiers within particle physics. A bottom quark is one of the six quarks which are, according to the standard model of particle physics, elementary components. Within so-called B-Physics these unstable particles have been examined in large international collaborations at the Japanese research institute KEK. Three Junior Research Groups of the Universe Cluster and other Cluster scientists are engaged in this research field.

The researchers hope for new findings in their search for the Higgs particle before the end of the year. The Universe Cluster is contributing to this research field, which is on the verge of a breakthrough, through the participation of Cluster scientists from the Max Planck Institute for Physics and LMU who are working on the ATLAS experiment.



Liquid sphere with light detectors

With the aim of researching the properties of neutrinos, Universe Cluster scientists, primarily in leading roles, are participating in the large-scale experiments Borexino, Gerda, EXO and IceCube. In the physics of stellar explosions, neutrinos play a prominent role, as they drive the explosion in the collapsing stellar core. Universe scientists are investigating this basic physics and, to this effect, simulate stellar explosions on supercomputers. This represents a close link with nuclear astrophysics, as the heaviest chemical elements above the iron group are created in stellar explosions.



ESA satellit PLANCK

New findings on the nature of dark matter and dark energy, as well as the formation of the chemical elements and galaxies, are also expected. Universe astronomers are conducting their research as part of large-scale, international observation campaigns with the intention of investigating the cosmological evolution of a large number of galaxies. In the field of astroparticle physics, one of the Universe Cluster's research groups is participating in the CRESST experiment in the Gran-Sasso underground laboratory in Italy in order to detect dark matter particles directly in the subterranean laboratory. These measurements are already underway and will provide further results in the next few years. To study dark energy, the Cluster scientists make use of the international major projects EUCLID, the Dark Energy Survey (DES), and ESA's PLANCK mission.

New facilities for the Cluster

New core elements of the Universe Cluster will be two interdisciplinary facilities.

In cooperation with the Leibniz Supercomputing Center (LRZ), **C^{2}PAP**, a computer-aided center for particle physics and astrophysics, is being established. At this worldwide-unique facility, scientists from the Universe Cluster can jointly process data from different satellite missions and experiments in particle physics and astrophysics, and combine it with data from computer simulations over wide frequency and energy ranges.

The Munich-based Institute for Astrophysics and Particle Physics, **^{M}IAPP**, will in future hold six workshops a year with selected international experts. ^{M}IAPP is a central, interdisciplinary center for international scientific exchange which, firmly anchored in the outstanding scientific environment in Munich, represents a superb platform for the development of new visions.

The junior research groups appointed during the first funding period are continuing their work as normal research groups and have been integrated into the work of the universities. As the work is continued, five to seven new junior research groups will now be set up and will focus on research areas pertinent to the Cluster.

Public outreach and schools program

The Cluster places great importance on communicating the latest scientific findings. Its Public Outreach work will focus particularly on increased collaboration with schools and expanding its teacher training and advanced training program.

Established series of events, such as "Wissenschaft für Jedermann (Science for Everyone)", which is organized jointly with the Deutsches Museum, or "Café und Kosmos (Café and Cosmos)" will continue to inform the public about the Cluster's research work. The monthly "Café und Kosmos" events have been a great success in Munich for years. Through short talks, the scientists introduce their research in the fields of physics and

Exhibition at the Deutsche Museum, München cosmology, followed by a spontaneous and entertaining discussion with the audience.

The "Evolution of the Universe" exhibition, which was es-ta-blished within the framework of the International Year of Astronomy in the Deutsches Museum, became a crowd-puller and has meanwhile become a permanent feature in the museum's astronomy department. Scientist's from the Universe Cluster and the participating partner institutes regularly give guided tours of the exhibition to groups of visitors, mainly school classes.

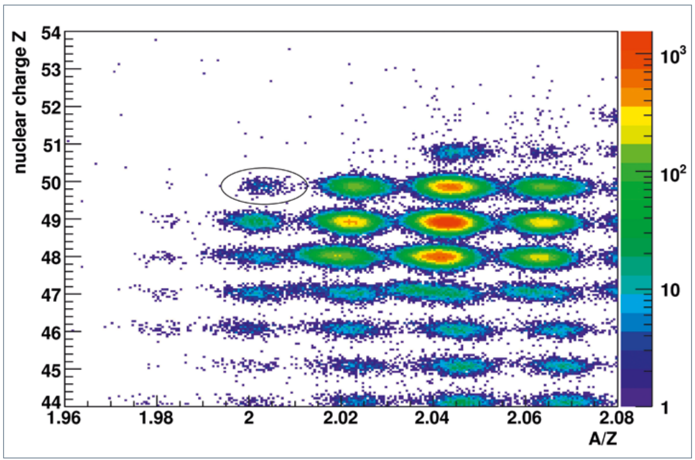
Since 2008, training courses for teachers on cosmology and astrophysics have been a permanent part of the Universe Cluster's public relations work. In future it intends to increase its commitment to teacher training in collaboration with the TUM School of Education and the Chair for Physics Teaching at LMU. The Universe Cluster has compiled a visitors' program for school classes for the Garching Campus. In addition, Cluster scientists regularly give talks in schools, provide internships for pupils, and assist teachers in propaedeutic science seminars and other school events. Visual material and sample calculations for physics lessons are also available on the Universe website. Moreover, the Universe website has a special search engine that schools can use to search for speakers on specific topics in the fields of astrophysics, particle physics and cosmology throughout the whole of Germany.

The next five years will therefore be an interesting time for science, as well as for the interested public – a time during which a large number of new findings can be expected.

Unstable tin-100 for the first time investigated in detail

Shortly after the big bang the universe was still largely devoid of chemical elements, which formed in the cosmos only bit by bit. Hydrogen and helium were present a few minutes after the big bang around 13.7 billion years ago. But it took several hundred million years before heavier elements appeared on the cosmic stage. First, hot stars capable of breeding elements up to iron by nuclear fusion had to form from the distributed matter via gravitation. The heavier elements, e.g. platinum, gold or lead are then created primarily in stellar explosions.

The cosmic mix of elements ultimately found its way into our solar system 4.5 billion years ago. That is why we can breathe oxygen and exhale carbon dioxide today, and why iron flows in our veins.



The nuclear physicists arrange the various confirmed atomic nuclei into a grid to differentiate between them. Atomic nuclei have an atomic number Z that represents the number of protons. They also have a mass number A, defined as the number of protons plus the number of neutrons. The doubly magic nucleus of tin-100 has 50 protons and 50 neutrons, and thus Z=50 and A=100. In the diagram with A entered over A/Z, tin-100 is located at the position Z=50 and A/Z=2. The color indicates the intensity and clearly confirms the result.

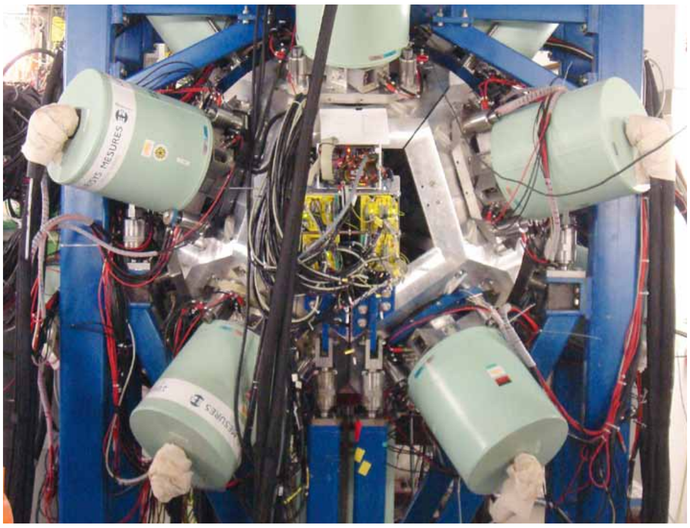
To better understand how the elements in the universe formed and to shed light on the myriad details of the processes, nuclear physicists and astronomers at the Excellence Cluster Universe collaborate closely. In their work, they also look at isotopes that decay after short periods of time. Isotopes are atomic nuclei of the same element that differ merely in their atomic weight. The difficulty to synthesize tin-100 is an example of such an isotope. Artificially producing this special nucleus and determining its properties was regarded as the "holy grail" of nuclear physics. Researchers from the Excellence Cluster Universe, in collaboration with the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt have now succeeded in doing just that. They now present the results of their work in the renowned scientific journal Nature ("Superallowed Gamow-Teller Decay of the Doubly Magic Nucleus Sn-100" by Hinke et al., Nature 486, 2012).

Tin-100 is different in that it has fewer neutrons, electrically neutral particles in atomic nuclei. Normal tin has at least 112 particles in its nucleus: 50 protons, positively charged particles, and 62 neutrons. The neutrons act as a kind of buffer between the electrically repelling protons, thereby preventing normal tin from decaying. Tin-100 has fewer neutrons: 50 to be exact. The buffer is thus weaker and tin-100 decays quickly as a result.

What makes tin-100 so special is the fact that it has exactly the same number of protons as neutrons, i.e. 50:50. And 50 is a magic number when it comes to atomic nuclei. Further neutrons are relatively weakly bound and additional protons remain unbound. Nuclear physicists refer to this property as "doubly magic."

Since the atomic nucleus tin-100 is so unstable, it is very difficult to produce and verify. In an experiment, xenon-124 ions were shot onto a plate of beryllium at nearly the speed of light, thereby shattering into a variety of fragments that continue on their trajectories and can thus be identified. Scientists at the TU München developed novel particle detectors for the experiment, in addition to the standard technology at the GSI. Even though the first tin-100 nuclei were created and verified as early as the mid 1990s at the GSI and a facility in France, the real breakthrough did not come until now.

In the experiment at the GSI that lasted for three weeks the nuclear physicists have produced 259 tin-100 nuclei and investigated their decay. The protons in tin-100 are prone to beta decay, i.e. they transform into a neutron, a positron and a neutrino. This changes the number of protons in the nucleus (corresponding to the atomic number), resulting in an isotope of the element indium, which is located to the left of tin in the periodic table. The researchers were able to measure the half-life and the decay energy, thereby confirming something that had long since been postulated: tin-100 has the fastest beta decay transition of all atomic nuclei. The scientists also determined the energy of the gamma rays that are released when the excited residual nucleus settles down. This pioneering work was first presented in the scientific journal Nature on June 21, 2012. The lead author, Dr. Christoph Hinke, was honored with the PhD Award 2011 of the Excellence Cluster Universe for his work.



A view of the experiment at the GSI from a perspective against the beam direction. The fragments are stopped at the center of a "hedgehog" of 105 liquid nitrogen-cooled gamma ray detectors, where the precise time of the beta decay and the released decay energy are measured using 25 large particle detectors.

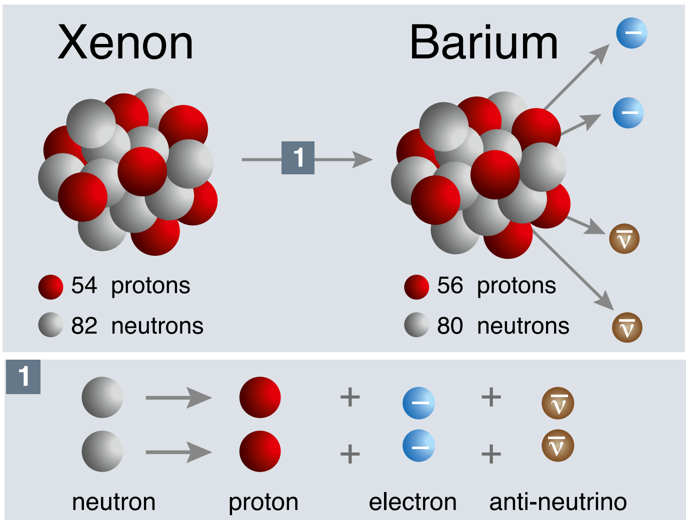
Understanding the properties of tin-100 is of great interest to particle and astrophysicists . During explosions at the surface of compact stars, increasingly heavier elements are formed by the successive capture of protons (in so-called rp processes). This is how nature creates the nucleus tin-100. Understanding the properties of tin-100 helps physicists understand what precisely is happening in the cosmos when heavy nuclei are synthesized in this way. In fact, the physicists may even be able to deduce the mass of neutrinos from a profound understanding of this decay. A further improvement of the experiment is scheduled for the next spring at the RIKEN research center in Japan. The beam intensity at RIKEN is higher in the mean time, allowing even more precise measurements.

How much do neutrinos weigh?

Are neutrinos their own anti-particles? And, what is their mass? An international group of particle physicists from the Stanford-University-based EXO-200 (Enriched Xenon Observatory) experiment, including Universe Cluster scientists Professor Peter Fierlinger, Dr. Michael Marino and Wolfhart Feldmeier are searching for the answers to these questions.

Neutrinos are ghostly particles, being both extremely light and electrically neutral. They interact very weakly, meaning that they pass mostly unaffected through normal material. An important natural source of neutrinos is the sun: fusion processes deep within the sun‘s core produce not only radiation and heat, but also a myriad of neutrinos. Every second roughly 60 billion of these solar neutrinos stream through every thumbnail-sized patch of area on the earth‘s surface. Despite the large number of neutrinos, the earth and its inhabitants are almost completely unaffected due to the weakly interacting nature of the neutrino.

These elementary particles are generated in nuclear reactions. In one such reaction, called ‚beta decay‘, a neutron in the atomic nucleus decays into a proton, releasing an electron and a neutrino - more particularly an anti-neutrino - in the process. In some nuclei it is also possible that two neutrons decay at the same time, a so-called ‚double-beta decay‘. If the neutrino and anti-neutrino are actually equivalent, it is possible for the two emitted neutrinos to ‚cancel‘ each other out so that only two final electrons are produced. This particular reaction, called neutrinoless double-beta decay, is what particle physicists have been searching for for de-



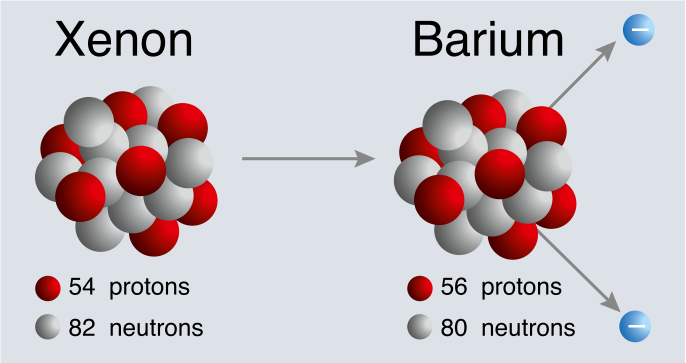
The Xenon nucleus has 54 protons and 82 neutrons. During a double-beta decay, two of the neutrons become protons creating a barium nucleus. To satisfy Standard-Model conservation laws, two electrons and two anti-neutrinos are also produced. This process in Xenon-136 was observed previously for the first time by the EXO experiment.

cades. Observation of this decay would indicate that the neutrino is its own anti-particle: a so-called ‚Majorana' particle.

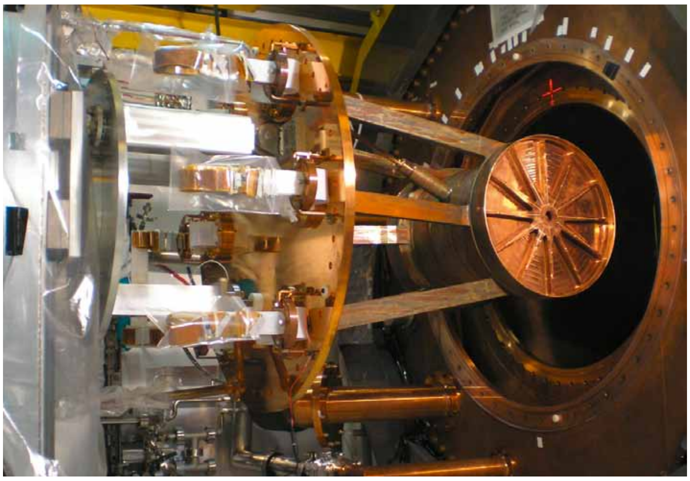
For roughly half a year, experimenters in the EXO experiment lab have been taking data, ‚watching' to determine whether the isotope Xenon-136 decays in such a way. Xenon-136, a particular isotope of the noble gas, has 54 protons and 82 neutrons. In neutrinoless double-beta decay, two of the neutrons in the nucleus would become protons, resulting in a final nucleus with 56 protons and 80 neutrons: a barium nucleus.

To reduce background from radioactive sources and cosmic radiation, the EXO detector is located 655 meters below the surface in a salt mine in New Mexico, USA. 160 kilograms of the isotope Xenon-136 are contained in liquid form at -100 °C within the detector cryostat. This amount of Xenon-136 represents more than the yearly worldwide production of this isotope. The picture below shows the inside of the detector before the completion of final construction. The copper cylinder seen in the middle of the picture holds the liquid Xenon, which serves as both detector and source. This inner piece of the detector is surrounded by layers of shielding material, and the entire assembly resides in an underground cleanroom.

The result of the measurement is the definition of a lower limit on the lifetime of the neutrinoless double-beta decay of Xenon-136: it must be longer than 1.6 x 10^{25} years, more than a million billion times the age of the universe. With this number the EXO scientists established the so far strongest constraints on the calculation of the mass of the neutrino, which results in an upper limit between 140 and 380 milli-electronvolts. To achieve this degree of accuracy, an extremely elaborate strategy was applied to avoid even the smallest amount of radioactive contamination. For example, the whole detector was constructed and assembled underground to avoid cosmic radiation. The result is a milestone for this area of physics and one of the most precise measurements ever accomplished. With this experiment EXO physicists plan to further improve the results during the next few years of ongoing data taking, thus getting closer to finding an answer to the question of whether neutrinos are their own anti-particles.

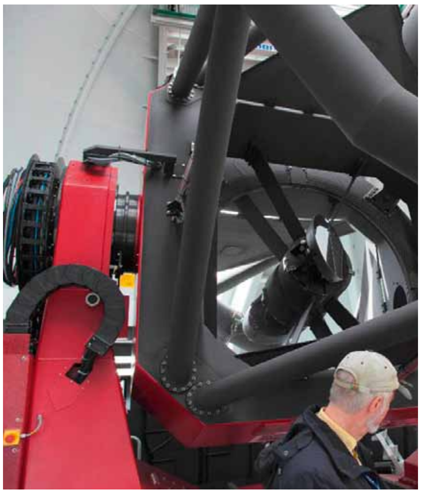


Is the neutrino its own anti-particle? If yes, Barium can also be created without the emission of the two neutrinos. There has been so far no definitive experimental evidence for this process.



A view of the 'heart' of the EXO-200 experiment.

New 2-meter telescope on Mount Wendelstein



Left: Opening Ceremony at the Wendelstein. Right: View of the Telescope

On 21 Mai, the University Observatory München (USM) – a partner institution of the Excellence Cluster Universe – introduced their new telescope at the Wendelstein Observatory in the Bavarian Alps. The telescope's mirror has a diameter of two meters, and is thus more than twice as big as its predecessor. The heart of the new telescope consists of infrared cameras, which provide images from the depth of the Universe. The cameras were developed by the USM scientists Ralf Bender and Ulrich Hopp in collaboration with colleagues from the University of Hawaii. The Excellence Cluster Universe provided funding.

The planning and construction phase took about four years. More than 700 Helicopter flight were necessary to transport the telescope, its dome, and the construction material to the Observatory, which is located on top of the 1838 meter high mount Wendelstein. The effort was well worth it, since the Bavarian Alps provide a very dark and clear sky.

With the new telescope, the Astronomers will be able to look up to ten billion light years into the outer space. This will allow the exploration of distant galaxies and clusters of galaxies. Furthermore, the scientists plan to gain new information about the mysterious dark matter and dark energy as well as super massive black holes in the centers of galaxies. The telescope will also help to take advantage of synergies with international large telescopes.

First observations regarding the examination of dark energy are planned for this year in collaboration with the Hobby-Ebberly-Telescope (HET) in Texas. The 10-meter-telescope of HET will scan different areas of the sky and the Wendelstein Observatory will provide the images required for comparison.

In the future, USM Scientist will explore remote galaxies and clusters of galaxies together with Astronomers from the University of Hawaii. The Hawaiian telescopes will scan large sections of the sky for those star systems. The Wendelstein telescope will perform follow-up studies: It will focus on the discovered galaxy clusters to determine their distance and structure. Thereby, the astronomers will gain knowledge about the origin and the evolution of the Universe.

EVENTS

Annual PhD Meeting at Mount Wendelstein

PhD students of the Universe Cluster during their visit at the Wendelstein Observatory

Once a year the Excellence Cluster Universe organizes a meeting for all its PhD students in the Bavarian country side. This year's event took place in Flintsbach, a village near Mount Wendelstein, from May 23rd to May 25th. The purpose of these encounters is to bring together all PhD students and to improve the communication among the different Cluster communities. The meeting started with all 22 participants introducing some highlights of their research in short talks. These talks took into account the diverse backgrounds of the audience and were tuned to be understandable and interesting for astrophysicists, mathematical physicists, particle physicists and nuclear physicists alike. Thus, the talks provided an opportunity for vivid discussions.

A field trip to the newly reopened Wendelstein Observatory was a highlight of the event. Despite the bad weather forecast, Dr. Arno Riffeser, scientist at the Wendelstein Observatory, was able to show the participants some nice sun spots with the historic Coronograph and to introduce the newly installed 2 meter telescope.

Xth Quark Confinement and the Hadron Spectrum

From 8 – 10 October 2012, the TUM Physics Department with support from the Excellence Cluster Universe will host the tenth conference on “Quark Confinement and the Hadron Spectrum”.

This conference will cover all aspects of strong interactions and Quantum Chromodynamics (vacuum structure and confinement, light quarks, heavy quarks, deconfinement, QCD and New Physics, nuclear and astroparticle physics, strongly coupled theories) bringing together about 250 international participants working in these fields.

Being number ten in the series of conferences, it will be of particular importance. On the one hand, it will provide a retrospective view of what happened during the past conferences. On the

other hand, it will take place at a very important time for particle physics, since the LHC has been operating and closing in on the search for the last building block of the standard model and for new physics sectors. "Quark Confinement and the Hadron Spectrum" will support a forum to discuss perspectives and the future of strongly coupled theories.

The conference will feature four round tables with panel experts and lively discussions on "Strongly coupled scenarios", "What can compact stars really tell us about dense QCD matter", "Low energy precision experiments to limit extensions of the standard model", and "Deconfinement at heavy ions experiments".

More information at: **http://www.confx.de**

Conference on Supernovae in Garching

From 10 – 14 September 2012, the Max Planck Institutes for Astrophysics and extraterrestrial Physics, the European Southern Observatory (ESO) as well as the Excellence Cluster Universe will host the conference "Supernovae Illuminating the Universe: From Individuals to Populations". Venue will be the TUM Physics Department at the Campus Garching.

The conference will cover all aspects of supernova research and in particular the advances of the past decade. Major topics will be Searches, Rates, Stellar Evolution, Progenitors, Explosion Modeling, Remnants and Surroundings, as well as Special Objects.

More information at: **http://www.mpa-garching.mpg.de/sn2012**

PEOPLE

"Exciting opportunity" – Markus Kissler-Patig becomes new Gemini Director

On August 1st, Dr. Markus Kissler-Patig will become new Director of the Gemini Observatory in Hawaii. The Astronomer is a founding member of the Excellence Cluster Universe and since 2008 Project Scientist for the European Extremely Large Telescope (E-ELT) at ESO. Markus was born in 1970 in Geneva and grew up in France. He obtained his PhD in 1997 from the University of Bonn. After a postdoctoral position at the University of California Santa Cruz, he came to ESO in late 1998. Together with his wife and his four children he will move to Hawaii at the end of July. We talked to Markus about his prospective task and his expectations regarding his new "home".

The decision to move with your family to Hawaii was certainly not an easy one. What made you decide to take over the position as new Gemini Director?
It was of course a very difficult decision to leave the stimulating environment of the Garching Campus. However, the exciting prospect to head one of the world's leading observatories was too good of an offer to deny. The opportunity of living in Hawaii also got the family very excited.

What does your new task precisely entail?
In my new position as director, I will be leading on behalf of the international partnership, the Gemini observatory and its approximately 200 staff members. Gemini is running two 8m-class telescopes, one in Hawaii and one in Chile, and is offering state-of-the-art ground-based observing capabilities to the bulk of the world's astronomical community.

What will be the main focus of your new position?
The Gemini observatory is in a transition phase, preparing for the next decade of research with 8m-class telescopes. The goal for the next few years is to install several new, high-tech instruments, as well as to move the plant's operation to a more

versatile and flexible scheme. Overall, Gemini will deliver even more powerful scientific findings. There will be two highlights: The unique, ground-based multi-conjugated adaptive optics system which allows obtaining diffraction limited images over a wide field of view, thus competing with the Hubble Space Telescope in sharpness. And, the Gemini Planet Imager, capable of directly imaging giant exoplanets around nearby stars, mapping the planetary systems around us for the first time.

You are connected to ESO since your doctorate. In 2008 you became Project Scientist for the E-ELT. Who will lead this project in the future?
I have spent a total of 14 years at ESO, the last 12 years continuously. It has been a fantastic time, seeing the Garching Campus evolve, especially during the last few years with the establishment of the excellence clusters. At ESO, the E-ELT project is entering a transition phase as it moves into a 10-year construction phase. It is a natural time for changes.

I can leave with a clear conscience, knowing that the science office, now led by Jason Spyromilio, as well as the newly formed E-ELT project science team, assembling multi-disciplinary scientists from our community, will provide a strong scientific leadership for the project. And remember, the "first light" of the E-ELT will be seen in a decade: at that time I might be back in Garching...

Since 2010 you are adjunct professor (Privatdozent) at the Ludwig-Maximilians-Universität München, teaching Astrobiology. In addition to your task at the Gemini Observatory, do you plan to teach at the University of Hawaii as well?
I have been lecturing for eight years at the LMU, for a few years formally as Privatdozent. The close contact with students has always been very motivating. Teaching, in particular astrobiology, was great fun. I have already contacted another "Munich Export" to Hawaii, Günther Hasinger, now director of the Institute for Astronomy at the University of Hawaii and made sure that I could get involved in teaching and the supervision of students - as time permits in my new position.

Nighttime image of the Gemini North Observatory. The laser beam produces an artificial star in the atmosphere of the Earth which is used as a reference star for the adaptive optics systems.

Markus-Kissler-Patig

With your departure from Garching, the Excellence Cluster Universe will lose an important member. Do you plan common projects in the future?
The Universe Cluster is a great success. This is testified by the fact that it attracted international attention and served as stepping stone for some of its founding members to accept prestigious positions at institutions around the world, thus creating a solid scientific network and providing for collaborations with foreign institutions. I am determined to stay in close contact with the researchers in Garching – new opportunities for new projects!

Apart from the assumption that there is no beer in Hawaii (according to a German song), what will you most likely miss there?
Munich and its surrounding areas are very attractive. We will be missing many things, not least the Biergartens. But rumor has it that life in Hawaii has its sunny sides too. The beaches and the snorkeling are probably better on the Big Island than along the Isar… and by the way: the Big Island has some very interesting micro-breweries which I am happy to report.

The most exciting aspect is certainly the complete change of lifestyle. Not only all the new professional challenges ahead, but also the new family life are expected to be thrilling. My family and I are looking forward to a great experience!

IMPRINT

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