NEWSLetter
Excellence Cluster Universe
Issue 1 / 2012

Dear Readers

Following a longer break we are happy to present our first Newsletter 2012. For the last four years, our newsletter was edited by the Cluster's PR Manager Barbara Wankerl. At the beginning of this year, Barbara accepted a new challenge within the Technische Universität München. Andreas Müller and Alexandra Wolfelsperger were in charge of the current newsletter while Ulrike Ollinger, our media designer, provided the familiar layout.

We hope to provide fascinating research news from the Universe Cluster also in the years to come. The decision about a second funding period is due on 15 June, when the Deutsche Forschungsgemeinschaft will announce which projects of the excellence initiative will be funded until 2017. Please keep your fingers crossed!

Dr. Birgit Schaffhauser
General Manager

PICTURE OF THE MONTH

Super moon

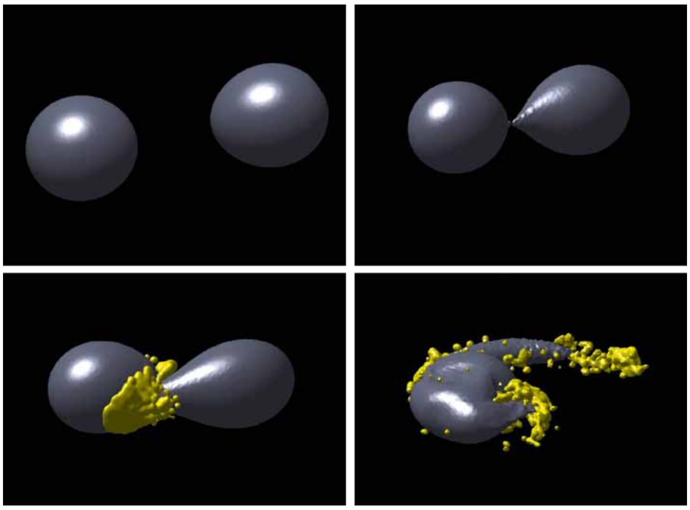
The full moon on 6th May 2012 at 5:35 am MEST coincided with the closest approach of moon's elliptical orbit to the earth with a distance of only 356.000 km. Hence, the moon appeared 15% bigger in size and 30% brighter. Such an event only happens once per year approximately. This picture shows the super moon in front of Fort Collins, Colorado (USA).

CLUSTER RESEARCH

Research Area G Science Day

Once a year the scientists of one of the seven Research Areas (RAs A-G) of the Universe Cluster get together for a Science Day. The current developments and findings of the respective RAs are presented in scientific talks and discussed. The Science Days provide a forum for close interaction and exchange of information within the RAs, networking among scientists and getting ideas for stimulating new projects.

The RA G Science Day took place at the Max Planck Institute for Astrophysics (MPA) in Garching on 19 April 2012. Organizers were the Cluster scientists Prof. Wolfgang Hillebrandt (MPA), Dr. Bruno Leibundgut (ESO) and Prof. Barbara Ercolano (LMU), who provided for a varied program, which was the center of interest for students, junior and senior scientists alike.



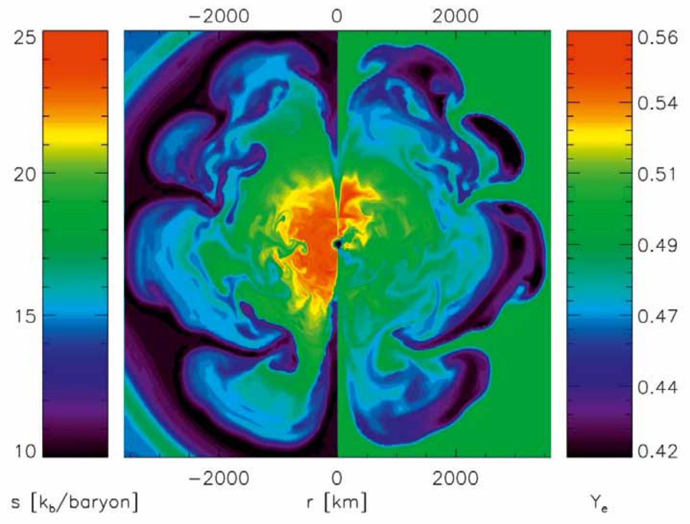
Simulation of a neutron star merger

The program dealt with research topics like star formation, supernovae Type Ia, neutrino interaction and its effect on Type II supernovae, or the search for the ejected matter of supernovae on the earth and moon. Other topics were the r-process in nuclear astrophysics, nuclear fission, as well as the possible connection between the chemical composition of stars and their planets.

The most outstanding information came from Dr. Andreas Bauswein (MPA) and from MPA's director Prof. Wolfgang Hillebrandt.

Andreas Bauswein discussed one of the exciting questions of nuclear astrophysics namely the origin of heavy elements beyond iron. In the so-called r-process, atomic nuclei capture neutrons, which decay through beta decay in protons, electrons and anti-neutrinos. Whereas the last two species leave the atomic nucleus, protons are enriched in the atomic nucleus. This increases the atomic number, so that new and heavier elements are formed.

Previously, the core-collapse supernovae (SN Type II), which are massive stars that die in a stellar explosion and thus provide for the neutron-rich environment, were favored sites in



Simulation of a supernova explosion

the cosmos, where the r-process was meant to occur. New research findings at the MPA and the Universe Cluster are now challenging this theory.

Predicted new sites for the occurrence of r-process and its production of heaviest elements are fusions of compact binary stars (two neutron stars or a neutron star with a black hole). In addition, configurations are possible where a black hole ingests surrounding matter from a type of matter hose. During this process strong particle winds are generated, in which very heavy atomic nuclei could be produced.

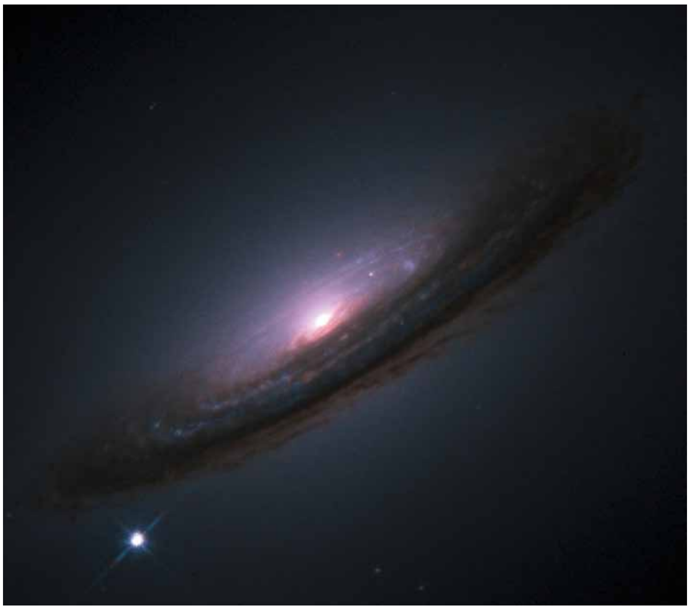
One of the products of this merging of compact binary stars is the element europium (atomic number 63). Its abundance in the Milky Way can be used to estimate the merger rate of these binery stars in the Galaxy. Accordingly, a merging of two compact stars in the Milky Way occurs once every 100,000 years.

The amazing result: the greater part of the r-process elements in the Milky Way apparently originates from such merging events. These findings were made by Dr. Andreas Bauswein, group of Dr. Thomas Janka (MPA), in collaboration with Dr. Shinya Wanajo, a Universe long term guest from the University of Tokyo. (ApJ 746, 180, 2012).

Prof. Wolfgang Hillebrandt talked about the thermonuclear supernovae (SN Ia) which still mystifies astrophysicists in many ways. Until recently the idea was that the explosions are triggered exclusively when a single white dwarf accumulates matter from the surrounding area, exceeds its maximum mass and explodes. In the meantime, a competing scenario has emerged, namely that of a binary star made up of two merging white dwarfs.

Nevertheless, the observed Type Ia supernovae in their entirety do indeed show a very inhomogeneous class of astronomical events. At least 30% of the Type Ia supernovae are extremely unusual. To the regret of theorists and modelers of these explosions, several very different explosion scenarios explain the observation data comparatively well. So, what exactly is going on? The MPA is investigating the secrets of Type Ia supernovae with international colleagues and especially in cooperation with the University of Würzburg. What significance this set of problems has for cosmology with Type Ia supernovae is still unclear.

The Research Area G Science Day can be found in the event calendar of the Cluster intranet. The presentations can be downloaded as PDF files.



The galaxy NGC 4526 showing the supernova 1994D (bottom left). Do astronomers sufficiently understand these supernovae to use them in cosmology?

GENERAL RESEARCH

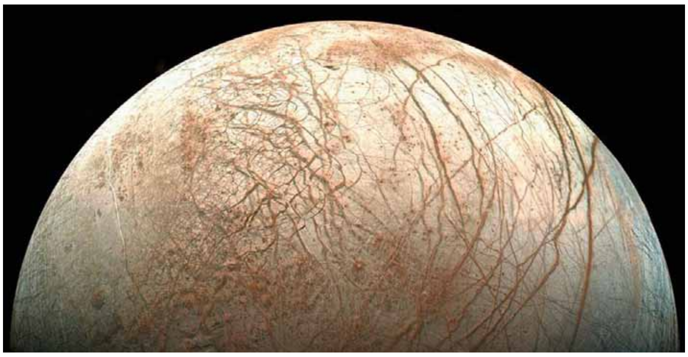
Next Large ESA Mission to research planets

The European Space Agency ESA made the decision on 2 May 2012: The future of the European Space Research is to be dedicated to the study of the solar system and the search for life for the next two decades.

In 2007 ESA appealed to research groups worldwide to propose a mission of the so-called L-class in the context of the “Cosmic Vision 2015-2025” program. L stands for “Large” and refers to a space project that is so large that only the biggest European satellite-launching rocket, Ariane 5, can transport the space probe into space. The project requires one billion euros in research funding.

In the end there were three large missions in the running, and as is not uncommon fundamental physics, astronomy and planetology were in competition with one another. Three themes,

Mission concept of the spacecraft JUICE , shown here in front of its destination, Jupiter, the biggest planet in the solar system.



Jupiter's moon Europa. Does its icy surface hide life?

three missions: Fundamental physics entered the NGO instrument for the detection of gravitational waves in the race. Astronomy proposed the X-ray telescope ATHENA and for planetology and the study of the solar system, JUICE should determine the years to come. The ESA directorate decided in favor of planetary research.

The JUICE mission stands for "JUpiter ICy moon Explorer" and is scheduled to be launched in 2022. The mission involves the study of the Jupiter moons. Jupiter is the largest planet in the solar system, a gas planet, which orbits the sun between the paths of Mars and Saturn in twelve earth years. Jupiter has at least 67 moons, several of which represent highly interesting research projects.

The mission targets three of the four Galilean moons, which the universal genius and founder of modern astronomy Galileo Galilei already observed more than four hundred years ago. These include Jupiter's largest moon Ganymede, as well as Callisto and Europa. The moons are covered in ice but the NASA Galileo Mission found evidence that the simplest forms of life could develop under their ice. Many kilometers beneath the ice conditions similar to those existing in the earthly deep sea might prevail.

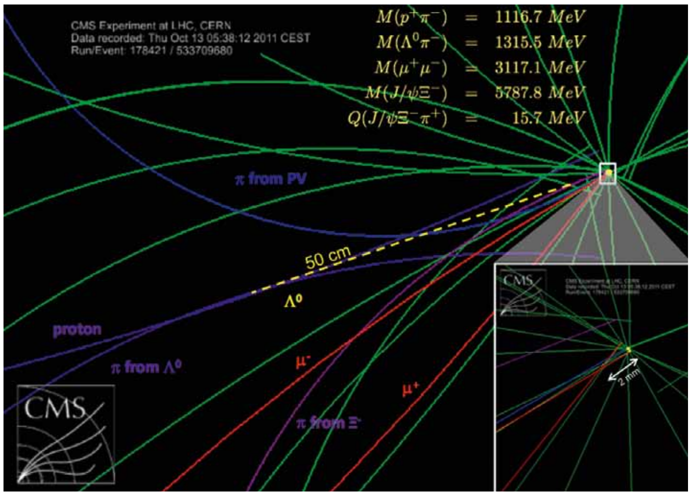
Eight years after the start, that is in 2030, JUICE is anticipated to reach Jupiter and its moons in order to begin the investigation. Jupiter's atmosphere and its complex magnetic field are to be studied also. A three-year research mission is planned.

New Particle Discovered at CERN

The CMS collaboration presented a surprising discovery at CERN. Not the Higgs boson or supersymmetric particles but a new particle has been discovered, which is made up of three quarks.

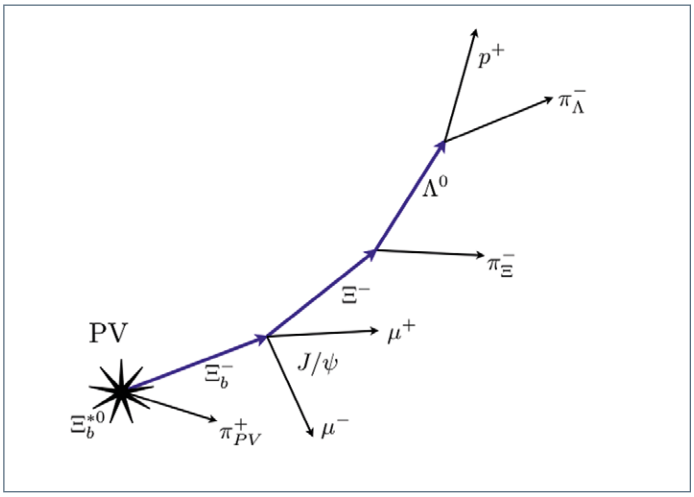
According to the Standard Model of particle physics quarks and leptons are the building blocks of matter. There are six quarks and their anti-particles. Particles composed of two or three quarks, like a building set, are found in nature. The former are called mesons and the latter baryons.

The newly discovered particle answers to the name of $\Xi^{*}{}_{b}{}^{0}$. One could call it the "USB particle" because it is composed of the three quarks: up, strange and bottom (or beauty). The quarks have third integer electric charge measured in units of the elementary charge *e*. Altogether it adds up to the charge of up (+2/3*e*), strange (-1/3*e*) and bottom (-1/3*e*) to an electrically neutral particle; this explains the superscript zero. Its mass was determined to be 5945.0 MeV, that is, almost six times heavier than a proton or almost as heavy as a lithium atom. It has a spin of 3/2, and is thus a fermion.



This figure shows how such an event looks in the volume detector, however, only the basic decay products are shown here.

The * indicates that the particle is excited. The subscript *b* stands for the contained b-quark. Ξ_b-baryons in their ground-state were already observed in the past. In ad-



This figure illustrates the complex decay chain: The neutral $\Xi^*{}_b{}^0$ decays to the negative $\Xi^*{}_b{}^-$ and a positively charged pion π. From this the J/Ψ meson and other Ξ–baryons emerge. Finally muons μ and Λ baryons are formed. The very end of the cascade leads to two muons, three pions and one proton.

dition to the neutral $\Xi^*{}_b{}^0$, which is composed of the *usb* quarks, there is a particle comprising the *dbs* quarks. As the down-quark *d* has the charge -1/3*e* compared to the up-Quark *u*, the charge adds up to -*e*. This particle is called $\Xi_b{}^-$. "PV" stands for primary vertex and indicates the place of origin of the new particle in the two diagrams.

It was difficult to produce this very unstable baryon and to provide evidence on the basis of its decay products. The strange und bottom quarks are very heavy, which means that the particles they contain decay very quickly.

This success was achieved at CERN by the particle physicists of the CMS collaboration who are in charge of the large-scale experiment CMS, the Compact Muon Solenoid. It is one of four large-scale experiments, which is built into the particle accelerator LHC (Large Hadron Collider).

Literature and web links
News on CMS website:
http://cms.web.cern.ch/news/observation-new-xib0-beauty-particle
Scientific publication:
arXiv: http://de.arxiv.org/abs/1204.5955 (to be published in the Physical Review Letters)

EVENTS

Cluster Symposium "Symmetries and Phases in the Universe 2012"
Researchers introduce new scientific findings

The symposium's participants in front of Kloster Irsee

For the second time, the Excellence Cluster Universe hosted the Symposium "Symmetries and Phases in the Universe". For that purpose, the Cluster invited internationally renowned scientists to Kloster Irsee, located in the Bavarian countryside, from 27 February to 1 March.

During this interdisciplinary conference the roughly one hundred participants focused on many questions regarding the formation and evolution of the Universe. Star formation and stellar evolution, galaxy evolution and cosmic nucleosynthesis, high-energy astrophysics, dark matter and dark energy, particle physics, gravitation, inflation and string theory as well as CERN's Large Hadron Collider were the symposium's main topics.

Highlights of this event were, among others, the talk by Bruno Leibundgut (ESO) about the Nobel Prize awarded topic on supernova cosmology. Jeremiah Ostriker from Princeton University introduced the latest results from the Universe-Princeton cooperation on galaxy physics.

A vivid discussion between Georgi Dvali (LMU, MPP) and Cliff Burgess (Perimeter Institute) turned out to be quite entertaining for the audience. Armed with crayons, they fought a battle about gravitation theory on the black board.

The last day of the symposium mainly concentrated on the world's most powerful particle collider, the Large Hadron Collider at CERN. CERN's general director Rolf-Dieter Heuer and CERN's long time leader of its theory division John Ellis talked about the current status of the LHC and were quite positive regarding the discovery of the Higgs boson.

At the end of the symposium, the Cluster coordinators Stephan Paul (TUM) and Andreas Burkert (LMU) were highly satisfied with its outcome: "It is great to meet every three years at Irsee and to take stock of the latest scientific findings. Our symposium makes a big contribution in connecting particle- and nuclear physicists with astrophysicists and cosmologists."

The Universe arrives in School

Teacher training at the Deutsche Museum München

Shortly after the founding of the Excellence Cluster Universe, a physics teacher of a Munich Gymnasium (secondary school) approached the Vice Coordinator of the Cluster, Astrophysics Professor Andreas Burkert. The teacher's wish: to acquire insights into aspects of modern cosmology. This theme is included in the Bavarian curriculum for the 10th class of Gymnasium and stipulates as content the Big Bang, particles and forces, as well as galaxies, black holes and cosmology.

Together with the astrophysicist and Scientific Manager of the Cluster Dr. Andreas Müller and the particle physicist Dr. Frank Simon, Andreas Burkert developed a one-day teacher training which introduced the most important topics of the curriculum. 40 Bavarian secondary school teachers participated in the event. The participants' response was so positive that the teacher's training has since taken place every year at the end of July at the Deutsche Museum. In addition to two lectures and rounds of discussions, a tour through the exhibition "Evolution of the Universe", which was planned and devised by the Excellence Cluster Universe, is also part of the agenda.

"Our goal is to bring the findings from the study of the Universe directly to the center of society – also and especially to young people. The Bavarian curriculum provides guidelines to bring not only astronomy and cosmology, but also nuclear and particle physics to schools", Andreas Müller explains the motivation behind the Cluster's engagement in school activities.

Since the introduction of the eight-year Gymnasium, the Bavarian curriculum also provides for a so-called alternative curriculum, astrophysics, in the 12th class. Pupils that have chosen physics as a subject in the 12th class may select the astrophysics course as an alternative to different subject areas. Prerequisite for this course is a trained teacher who is familiar with the astronomical content.

At the start of July 2011 the Excellence Cluster Universe thus held a teacher training course on the alternative curriculum astrophysics for the first time. As the course included the five main topics sky orientation, solar system, sun, stars and large-scale structure of the Universe, the course spanned three days. There was thus sufficient time for the mediation and discussion of the varied content, as well as astronomical observations with the Cluster's own mirror telescope. The event was held at the youth hostel in Dachau.

"We were skeptical to begin with, whether enough participants would register for the three-day course during the school year. But within a very short time we actually had twice as many applications as available places", Andreas Müller is pleased to explain. The event was a great success in the end. Not only the exciting content contributed towards the success of the course, but also the outstanding trainers: Professor Harald Lesch (LMU), Professor Simon White (MPA), PD Dr. Ewald Müller (MPA), Dr. Hans-Ulrich Käufl (ESO) and Dr. Andreas Müller (Universe Cluster).

"We would like to attract teachers to these topics with our training courses, so that the pupils will ultimately experience astrophysics and cosmology as active and living science", so Müller.

In addition to the planning and performing of the teacher training, regular school visits are also on Andreas Müller's agenda. He travels all over Germany in order to spark children's and young people's interest in astronomy and natural science with exciting topics from the solar system to black holes. Andreas Müller was awarded the Johannes-Kepler Prize 2012 for his dedication. This prize is awarded every two years by the German association for the advancement of education in mathematics and natural science (MNU) and the Cornelsen Verlag for special merit in the advancement of instruction in astronomy. The tribute was made in the context of the opening event of this year's MNU national congress on 2 April in Freiburg.

Award ceremony in Freiburg: Ariane Aring from Cornelsen Verlag, Andreas Müller and Gerwald Heckmann, MNU Executive Committee for Physics

This year the teacher training on the "Alternative Curriculum Astrophysics" will take place from 4-6 July at the Dachau youth hostel. "Aspects of Modern Cosmology" will be presented on 26 July at the Deutsche Museum. The number of participants for both courses is limited to 20 people.

For further information please see:
http://www.universe-cluster.de/lehrerfortbildungastrophysik2012

Strings 2012

From July 23rd to July 28th the conference "Strings 2012" will take place at the Ludwig-Maximilians-Universität (LMU) in Munich. The event is jointly organized by the LMU, the Max Planck Institute for Physics (MPP) and the Arnold Sommerfeld Center for Theoretical Physics (ASC) with support from the Excellence Cluster Universe.

This annual event hosts about 400 researchers in string theory from around the world. Since the 1980s, it has grown to be the largest and most important conference in this field. International experts are invited to review the most recent achievements in string theory and discussions between the participants lead to new developments and insights.

In the course of this event, there will be two public lectures on Saturday, 28 July, at the Große Aula at LMU, Geschwister-Scholl-Platz 1: At 10.30 am, Professor Rolf-Dieter Heuer, General Director of CERN, will talk about the "world machine", the Large Hadron Collider at CERN (in German language).

At 12.00 Professor Edward Witten from the Institute for Advanced Study at Princeton University will give insight into "The String Theory and the Universe" (in English language).

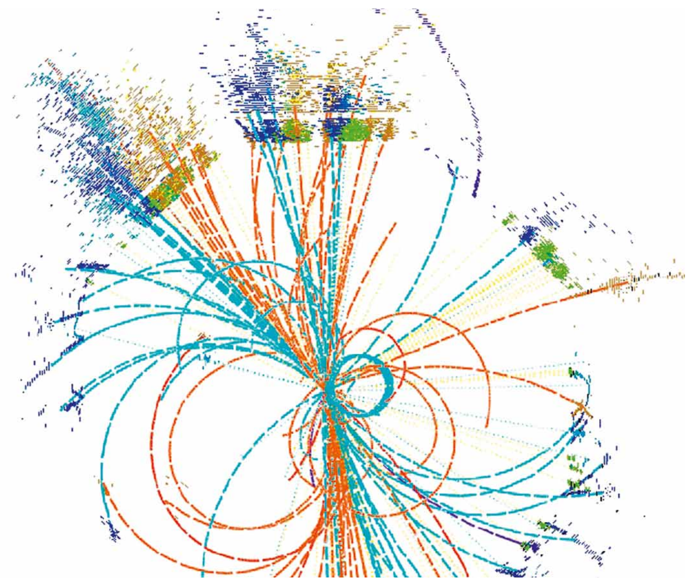
More information at: strings2012.mpp.mpg.de

PORTRAIT

In Search of New Physics
The Cluster Research Group "Detector Development in Particle Physics"

Particle physics is currently in a very exciting phase: The European Organization for Nuclear Research CERN reported the first indications of the mysterious Higgs boson and precision measurements in the area of B physics are increasingly restricting the parameters for physics beyond the Standard Model of particle physics. Furthermore, at the beginning of next year the European strategy for particle physics will set the course for the long-range future of particle physics in Europe.

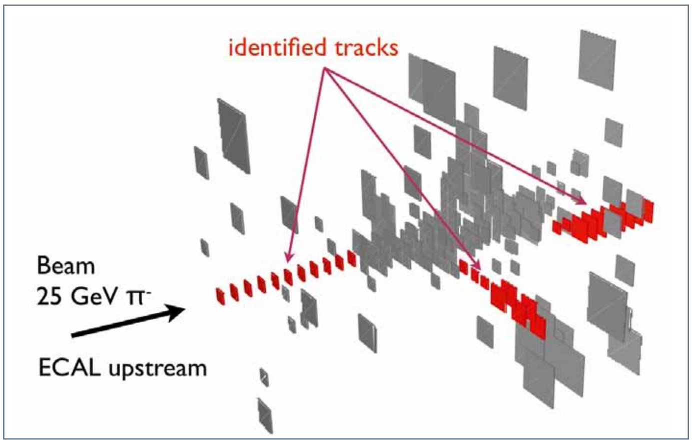
Members of the Excellence Clusters Universe are participating in numerous international large projects of particle physics. The main focus of the Cluster Junior Research Group "Detector Development in Particle Physics" lies on the physics and development of detectors for future, high-energy electron-positron accelerators. The research group is located at the Max Planck Institute for Physics and led by Dr. Frank Simon. After two-and-a-half years as a postdoctoral researcher at the Massachusetts Institute of Technology (MIT) in Boston, the experimental particle physicist came to the Excellence Cluster Universe as the first junior research group leader in October 2007. Two international projects are the main focus of Frank Simon's research group: The International Linear Collider (ILC) and the Compact Linear Collider (CLIC). Both of these prospective particle accelerator concepts will compliment the currently most powerful particle accelerator, the Large Hadron Collider (LHC) at CERN.



Event simulation at the Compact Linear Collider CLIC at 3 TeV center of mass energy

Based on the anticipated results from the LHC, the scientists are hoping to obtain answers to several open questions in particle physics with the help of these accelerators. In comparison with the LHC these future accelerators have the advantage that real elementary particles collide with one another, thus well defining their initial states. The theoretical description and the experimental conditions will become considerably easier as there is much less background and the collision energy is better known. For this reason, a very high level of precision can be achieved by means of the electron-positron accelerators. Or, to put it more simply, the LHC is considered to be a "discovery machine", whereas an electron-positron accelerator is viewed as a "precision machine", from which discoveries beyond the capabilities of the LHC are expected also. With such a collider, for example the Higgs could be studied with greater accuracy than at the LHC. In addition, these linear colliders enable more exact measurements of top quarks, as well as a precise investigation of new physics beyond the Standard Model.

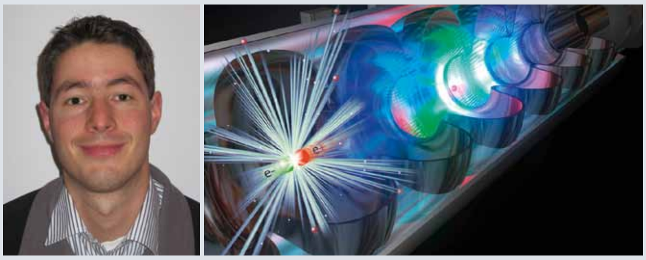
Both colliders, the ILC and the CLIC, must be built as linear accelerators due to the high energy loss of high-energy electrons. The ILC is based on superconducting accelerating structures with an energy of 500 GeV and possible upgrades of up to 1 TeV – this is significantly less than at the LHC. Through the collision of elementary particles, however, other than in the case of the LHC, the full energy is available for the production of new particles. In combination with less background, there is discovery potential complementary to that of the LHC despite the actual lower energy. Considerably higher energies of up to 3 TeV can be reached with CLIC. For this purpose, an innovative two-beam acceleration concept is being used, which is still in the development phase. Such an accelerator requires the most modern detectors, in order to achieve the required measuring precision. The calorimeters play a significant role in these experiments, that is, the detectors that measure the energy of the particles. For ILC and CLIC, these are highly granular detectors which also supply an exact 3D image of the particle showers in addition to the energy measurements. This improves the event reconstruction and allows the exact measurement of every single particle in the events. Large numbers of silicon photomultipliers were used for the first time in the development of prototypes of such a detector. Since then this technology has been implemented in many other experiments and has also been further developed for medical imaging. “With this project, we are contributing to the field of scintillator readout with silicon photomultipliers, and we are one of the leading groups in the data analysis of the extensive test beam program carried out with our calorimeters”, Simon explains.



High-resolution image of a hadronic shower at the CALICE calorimeter with unprecedented precision including identified tracks of secondary particles. These data contribute significantly to a better understanding of the physics of hadronic showers and help to improve simulations of detector physics.

In addition to the development of detector technologies, it is also crucial to study the actual performance for physics measurements in simulations in order to see what the detectors can achieve and what is necessary to reach the desired precision. For this purpose, the research group of Frank Simon is studying the physics processes, especially in the framework of CLIC. The investigation of the top quarks and supersymmetric particles are the focus here. At the beginning of 2012 the CLIC collaboration presented a “Conceptual Design Report”. “For this document, we’ve performed two of altogether six so-called benchmark studies. With these studies, we have shown that a 500 GeV collider based on CLIC technology allows very precise measurements of the top quark mass. We’ve also shown that it is possible to study strongly interacting supersymmetric particles with high precision at the full energy of 3 TeV”, Simon explains.

Junior Research Group: Detector Development in Particle Physics



Dr. Frank Simon has been leading the Junior Research Group (JRG) “Detector Development in Particle Physics” since October 2007. The experimental particle physicist received his PhD from the Technische Universität München and the Max-Planck-Institut für Physik. Between May 2005 and October 2007, Frank held a postdoctoral position at the Massachusetts Institute of Technology (MIT). There, he played a leading role in the data analysis within the spin physics program of the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory.

Research Group

In the field of detector development, Frank Simon works with the PhD students Katja Seidel, Christian Soldner, Michal Tesar and Lars Weuste, and the master students Simon Pfau and Marco Szalay. Frank’s research work with Belle/Belle II has been supported by the postdoc Jeremy Dalseno and the PhD students Andreas Moll and Kolja Prothmann.

Research Interests

Frank’s research focuses on the physics and detector development for future high-energy electron-positron accelerators. In addition, he investigates the CP violation with the help of the Belle/Belle II experiment.

Collaborations

At the Excellence Cluster Universe, Frank Simon works with the Junior Research Group “Heavy Quarks” of Professor Jochen Schieck (LMU) as part of Belle II. An exchange between theory and experiment as regards B-Physics takes place between Frank’s group and the JRG “New Physics beyond the Standard Model”, led by Dr. Martin Gorbahn (TUM). Outside the Cluster, Frank’s research partners are mainly located at the Deutsche Elektronen-Synchrotron (DESY), at CERN, KEK, and the Argonne National Laboratory.

The “Detector Development” group has also developed reconstruction algorithms for highly granular calorimeters, which improve the resolution of the detector by 20%. Furthermore, the group performed a study of the 3D sub-structure of hadronic showers and with it provided evidence that the simulation of hadronic showers have reached a high degree of precision by now. “This is crucial for putting trust in our physics simulations”, according to Simon.

In addition to the detector development, an important point for Frank Simon‘s group is the investigation of CP violation with the Belle experiment which is located at the Japanese Research Center for Particle Physics (KEK). The aim of this investigation is to understand the origin of the asymmetry of matter and antimatter in the Universe. Under the term CP (C for charge and P for parity) particle physics understands the combination of charge exchange and the mirroring of all spatial coordinates. Simon’s group is investigating the CP violation in the decay of B mesons using the large data set of the Belle experiment. For the experiment Belle II, which is anticipated to go into operation at the end of 2015, Simon's group has made large contributions to the software development. It is also studying the influence of the background on the pixel detector which is planned for Belle II and is being built under the leadership of the Munich Max Planck Institute for Physics.

PEOPLE

Cluster member Elisa Resconi receives Heisenberg Professorship

Elisa Resconi

The Cluster scientist Prof. Elisa Resconi receives a Heisenberg Professorship from the Deutsche Forschungsgemeinschaft (DFG) at the Technische Universität München. This professorship will focus on neutrino astronomy, a relatively new branch of astronomy which observes neutrinos as well as higher energetic sources like active galactic nuclei (AGN) and gamma-ray bursts (GRBs). Elisa Resconi is only the second female physicist in Germany to receive a Heisenberg Professorship.

Scientists can apply for a Heisenberg Professorship after a successful appointment procedure at a German University. The admitting University must create a new position and demonstrate to the DFG that a new research focus will be established through this Heisenberg Professorship. Elisa Resconi's research focus has been for several years the IceCube experiment, a neutrino telescope at the South Pole, which aims to detect the sources of cosmic rays and the unknown dark matter.

Elisa Resconi received her PhD in 2001 in the field of astro-particle physics at the University of Genova, where she participated in the international solar neutrino experiment Borexino. Between 2005 and 2010 she led an Emmy-Noether Research Group of the DFG at the Max-Planck Institute for Nuclear Physics in Heidelberg, exploring high-energy neutrinos with the help of the IceCube Experiment. Since 2011 Elisa has been continuing her research within the Excellence Cluster Universe. "The Heisenberg Professorship offers a great opportunity to continue my work within the IceCube Collaboration in an independent way at TUM and to combine my scientific work with my family", Elisa says. For the next five years the professorship will be financed by the DFG.

Cluster welcomes new Research Fellow

Oton Vázquez Doce

Oton Vázquez Doce is a new Research Fellow at the Excellence Cluster Universe. The experimental particle physicist is part of the Cluster's research area "D", which studies the phase transitions in the early Universe.

Vázquez Doce received his PhD from the University of Santiago de Compostela in Spain. Before moving to Garching he spent five years at the "Istituto Nazionale di Fisica Nucleare" (INFN) in Frascati, close to Rome, participating in the Siddhartha and Amadeus collaborations.

The Siddhartha (**Si**licon **d**rift **d**etectors for **h**adronic **a**tom **r**esearch by **t**iming **a**pplication) project has measured with unprecedented accuracy the shifts and the widths due to the strong interaction in the emitted X-ray spectrum of kaonic hydrogen, and aims to measure kaonic deuterium and other light kaonic atoms in a second phase of the experiment.

Amadeus (**A**ntikaonic **m**atter **a**t **D**AΦNE: an **e**xperiment with **u**nraveling **s**pectroscopy) will perform a systematic and complete spectroscopic study of kaon-nucleon interaction at low energy in the nuclear environment. Such a study has important impact on the understanding of low-energy quantum chromodynamics (QCD). QCD is a theory of the standard model of particle physics which describes the strong interaction between quarks and gluons making up hadrons, which is responsible for the nuclear forces that bind protons and neutrons in nuclei.

At the Excellence Cluster Universe, Oton Vázquez Doce will continue his experimental research on low-energy quantum chromodynamics investigating the kaon-nucleon potential studying the possible formation of kaonic clusters. These clusters are very dense states of matter in which kaons are attached inside light nuclei. The patterns of collective flow of kaons in heavy ion collisions will provide valuable information on the nuclear equation of state at high densities.

IMPRINT

Realisation: Ulrike Ollinger (Layout), Alexandra Wolfelsperger (Concept & Text)

Authors: Alexandra Wolfelsperger, Dr. Andreas Müller

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Print: flyeralarm GmbH, Alfred-Nobel-Str. 18, 97080 Würzburg

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The Excellence Cluster Universe is supported by the German Excellence Initiative