NEWSLetter
Excellence Cluster Universe

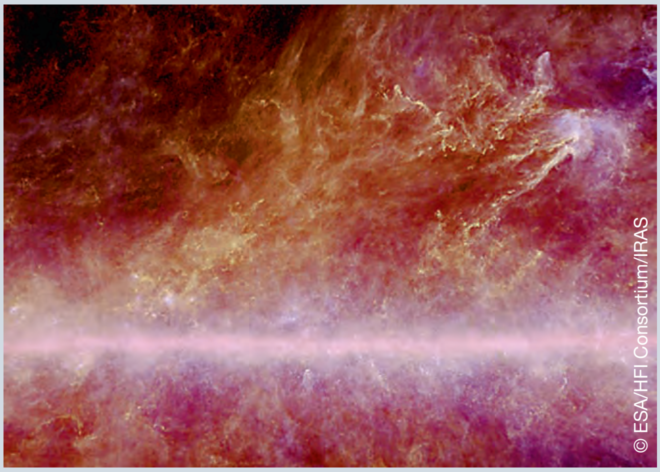
Issue 1 / 2010

Dear Readers,

spring season comes with the first edition of our newsletter in 2010. The year so far was quite busy for the Universe Cluster: We are happy to announce Dr. Claudio Grillo as a new research fellow with the Cluster (page 6). Another important staff news is the arrival of Professor Jochen Schieck, who will lead the Cluster's Junior Research Group on "Heavy Quarks Physics". A portrait of his team and work will follow in one of the next issues. In today's newsletter we would like to introduce a Junior Resarch Group with a "strange" topic - physics on "Dense and Strange Hadronic Matter" led by Professor Laura Fabbietti (page 4). And soon, the Universe Cluster will be on air - on 11 April Germany's international broadcaster "Deutsche Welle" will show portraits of the Cluster and our vice coordinator Professor Andreas Burkert - the films will also be published at http://www.dw-world.de. Have fun watching it!

Barbara Wankerl, PR Manager

PICTURE OF THE MONTH



Clouds in the Milky Way as seen by the Planck Satellite

Giant filaments of cold dust stretching through our Galaxy are shown in this image from ESA's Planck satellite with software for data processing developed by MPA. Analysing these structures not only helps scientists to understand our own galaxy, but also to reveal details of the background radiation reaching us from the far-away Universe.

HIGHLIGHTS

Higher Star Formation Rate in Young Galaxies

Stars form from giant gas clouds in galaxies – the star formation rate however has changed over cosmic timescales. In the young Universe many more stars were born. Scientists from the Max Planck Institute for extraterrestrial Physics (MPE), together with an international team of astronomers including the Universe Cluster have found a plausible explanation: a few billion years after the Big Bang, normal star forming galaxies contained five to ten times more cold gas than today, providing more "food" to fuel the star formation process. (Nature, 11 February 2010).

"We have been able, for the first time, to detect and image the cold molecular gas in normal star forming galaxies, which are representative of the typical massive galaxy populations shortly after the Big Bang" said Linda Tacconi from (MPE), who is the lead author of this Nature paper.

The Plateau de Bure interferometer

The challenging observations yield the first glimpse how galaxies, or more precisely the cold gas in these galaxies, looked a mere 3 to 5 billion years after the Big Bang (equivalent to a cosmological redshift z~2 to z~1). At this epoch, galaxies seem to have formed stars more or less continuously with at least ten times the rate seen in similar mass systems in the local Universe.

The fundamental question is whether these large star formation rates were caused by larger reservoirs of cold molecular gas (which represents the 'food' for newly formed stars), or whether star formation in the young Universe was much more efficient than it is today. Over the past decade astronomers have established a global framework of how galaxies formed and evolved when the Universe was only a few billion years old. Gas cooled and collected in concentrations of the mysterious 'dark' matter (so called dark matter halos). Over cosmological timescales, gas accreting from these halos onto the proto-galaxies, and collisions and mergers of galaxies subsequently led to the hierarchical build-up of galaxy mass.

Detailed observations of the cold gas and its distribution and dynamics hold a key role in disentangling the complex mechanisms responsible for turning the first proto-galaxies into modern galaxies, such as the Milky Way. A major study of distant, luminous star forming galaxies at the Plateau de Bure millime-

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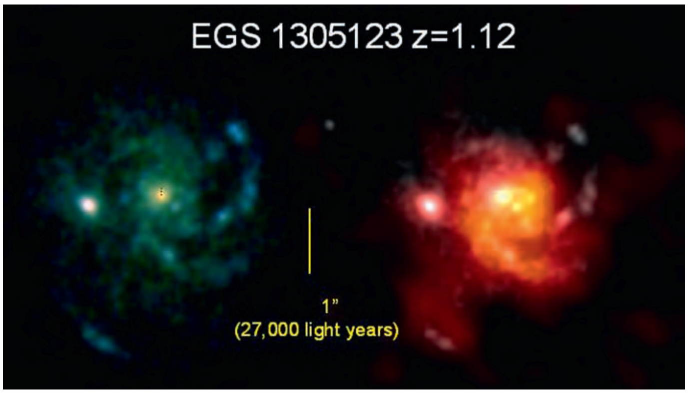


Spatially resolved optical (left) and millimetre images (right) of a typical massive galaxy at redshift z=1.1 (5.5 billion years after the Big Bang).

tre interferometer has now resulted in a break-through by having a direct look at the star formation "food". Previous observations were largely restricted to rare, very luminous objects, including galaxy mergers and quasars. The new study instead traces massive star forming galaxies representative of the 'normal', average galaxy population in this mass and redshift range.

"When we started the programme about a year ago", says Dr. Tacconi, "we could not be sure that we would even detect anything. But the observations were successful beyond our most optimistic hopes. We have been able to demonstrate that massive normal galaxies at z~1.2 and z~2.3 had five to ten times more gas than what we see in the local Universe. Given that these galaxies were forming gas at a high rate over long periods of time, this means that gas must have been continuously replenished by accretion from the dark matter halos, in excellent agreement with recent theoretical work."

"These fascinating findings provide us with important clues and constraints for next-generation theoretical models that we will use to study the early phases of galaxy development in more detail," says Andreas Burkert, specialist for star formation and the evolution of galaxies at the Excellence Cluster Universe. „Eventually these results will help to understand the origin and the development of our Milky Way."

Original Publication:

L.J. Tacconi et al; High molecular gas fractions in normal massive star forming galaxies in the young Universe, Nature, 11. February 2010

Neutron Research in Garching Further Consolidated

The DFG Deutsche Forschungsgemeinschaft (German Research Foundation) is intensifying its commitment to neutron research, which is well represented in Garching: Within the framework of the priority program „Precision Experiments in Particle and Astrophysics with Cold and Ultracold Neutrons", scientists of the Excellence Cluster Universe recently procured funding in the amount of 3.72 million euros. The DFG program was founded in 2009 and is based in Munich and Vienna. The scientific experiments are to be performed at the research neutron sources in Munich (FRM II), Switzerland (PSI) and Grenoble (ILL).

One focus of the priority program is on experiments aimed at providing evidence of an electric dipole moment (EDM) of a neutron. This is a key experiment to the understanding of fundamental symmetries (CP symmetry) and matter/anti-matter asymmetry in the Universe. In addition to the TUM chair E18 of Professor Stephan Paul, the junior research group of Professor Peter Fierlinger of the Universe Cluster is also participating in the experiment. This group is currently working on the construction of a high-precision magnetic shielded room. Inside the plant, magnetic fields in the femto-Tesla range are stabilised. The experiment should thus be capable of measuring tiny deviations in the movement of a neutron in the magnetic field, just as they would be caused by a possible electric dipole moment.

A precursor experiment for the measurement of the dipole moment is currently being realized within the framework of an international collaboration at PSI (Switzerland). The new experiment is intended to be located in Garching: At the neutron source Heinz Maier-Leibnitz (FRM II) a new high-performance source for ultracold neutrons is currently being developed. It is to produce about 10,000 of these particles per cubic centimetre and second as of 2011. Thus it would be the most powerful neutron source of its kind in the world also exceeding the planned source at the PSI. By comparison: Current sources produce approx. 50 neutrons per cubic centimetre and second.

View of the eastern experimental hall near the FRMII - the designated location of the new experiment on the electrical dipole moment of the neutron.

The second main focus is the precise examination of the neutron decay. These experiments are to provide new insights into the structure of the weak interaction and its effects in cosmology. For the measurement of asymmetries in the neutron decay, the development of an innovative large apparatus is planned in an alliance with other scientists. It is to be implemented at ILL or at the planned new particle beam for cold neutrons at FRM II. As in the case of the new EDM experiment, here as well and during the measurement of the lifetime of neutrons, the scientists want to increase the measuring accuracy that has been attained so far by a factor of 10 to 100. Another experiment is to examine a hitherto unobserved decay mode of the neutron.

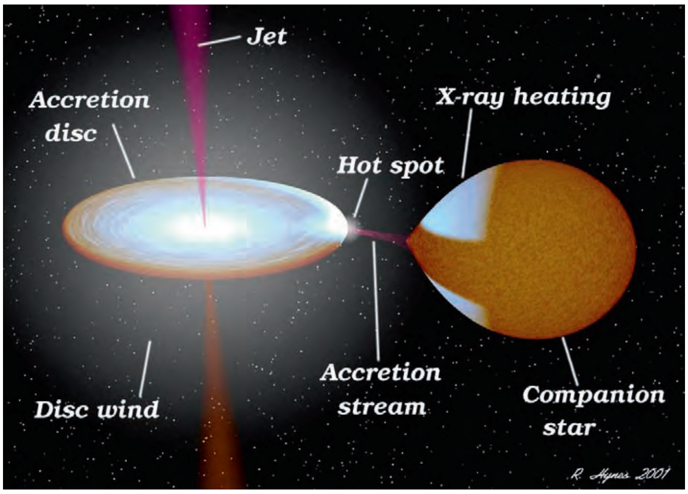
Stephan Paul, coordinator of the Excellence Cluster Universe, is pleased with the success in the current application round: „In 2008 and 2009 neutron research in Garching already received DFG funding in the amount of 2.7 million euros, which means that this area is well established at our re- ⇨ next page

search centre. Along with the new funds, the research region Munich/Garching is very well equipped to tackle important questions in particle and astrophysics complementary to the studies at LHC in Geneva. At the same time the financial aid for our partners in the priority program also plays an important role, as the measurements planned can only be realised in a strong consortium."

It's the Jet, not the Disk: X-rays from the Area Surrounding Black Holes

X-ray binary star systems have been the focus of astronomers for a long time. The unique characteristic of such binary systems, comprising an ordinary star and a black hole (or a neutron star), is that this combination usually leads to a gas flow between both objects. The heated gas gathers as an accretion disk surrounding the black hole; strong magnetic fields then ensure that parts of the gas can be fired into outer space in the form of a highly-energetic and densely bundled stream of matter – a „jet". These phenomena emit characteristic X-ray pattern, on the basis of which astronomers can identify such systems.

Astronomers have for the first time succeeded in separating out the radiation from the accretion disk and the jet. When it came to an outburst in the X-ray binary XTE J1550-564 in the year 2000, data in the infra-red, optical and X-ray wavebands were recorded with the help of the Rossi X-Ray Timing Explorer. The system is 17,000 light years away from Earth and is located in the constellation of Taurus. During their investigation researchers discovered something very surprising: practically all the X-ray radiation from

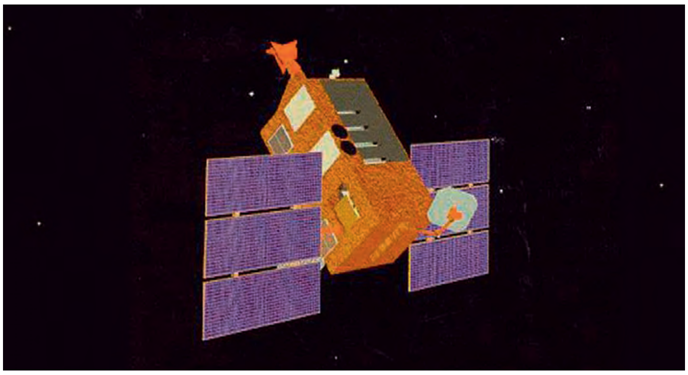


A binary star system with a star in orbit around a black hole. As gaseous matter is pulled from the star, it forms a disk around the black hole and is heated to temperatures of millions of degrees. Strong magnetic fields then ensure that parts of the gas are ejectede as high-energetic a stream of matter – a „jet".

this system is generated in its jet and not in the accretion disk. This result contradicts findings that were obtained from earlier theoretical models. Robert Dunn, a scientist at the Munich Excellence Cluster Universe, contributed an analysis of the X-ray data of the Rossi X-Ray Timing Explorer to the above work.

David Russell from the University of Amsterdam and his colleagues observed the development of the source over time. Since the discovery of the first X-ray binary, a lively discussion has been going on among experts as to the precise origin of the emitted X-ray radiation. The researchers point out that, according to their results, the energy emission of the jet is much greater than previously assumed. The work is an important step in the study of X-ray binaries. In the next step, the goal is to examine through which mechanism and where exactly the radiation is generated.

„These findings on the emission processes of jets will play an important role in future studies of black holes", Robert Dunn explains. „With the new data, scientists can improve on previous theoretical models. We will thus be able to understand more clearly how jets of very large black holes behave and influence the development of galaxies."


Artist's impression of the Rossi X-Ray Timing Explorer satellite

Link to original publication: http://arxiv.org/abs/1002.3729

EVENTS

Strings and Black Holes: Universe Cluster Co-organized the Lüscher Seminar 2010

Astrophysics and particle physics are usually subjects teachers do not focus on within their lessons. To stimulate more interest in those topics, they became theme of this year's "Lüscher Seminar", which was co-organized by the Excellence Cluster Universe. This event is an annual teacher training, intended for secondary school teachers of natural sciences. It took place from 19 – 21 March 2010 in Zwiesel, Lower Bavaria, and attracted about 100 participants. In a total of eight lectures, Cluster scientists gave insight into current research on the composition and development of the Universe. The renowned "Lüscher Seminar" looks back on a long tradition: The TUM professor for nuclear and solid-state physics Edgar Lüscher and a physics teacher held a teacher training together in Zwiesel for the first time in 1976. It was so successful that ever since a seminar covering a different area of physics has been held annually at the Gymnasium Zwiesel. After the death of Prof. Lüscher in 1990, Prof. Walter Schirmacher of the TUM Chair for Experimental Physics (E13) became the scientific leader of this series of seminars, which since then has been named the "Lüscher Seminar".

Workshops

In the weeks to come, there will be two workshops organised by Junior research Groups in the Universe Cluster.

From 12-16 April 2010, Prof. Ilka Brunner (Extra Dimensions in Particle Physics and Cosmology) and her team invite interested scientists to join the workshop „**Fundaments of Gravity**“, taking place at the Arnold-Sommerfeld-Zentrum at the Ludwig-Maximilians-Universität. This workshop focuses on the role of gravity in string theory and within the effective field theory framework. The goal is to bring together leading scientists in these fields and create a stimulating atmosphere with much room for discussions. There is no registration fee, everybody is welcome to attend the workshop.

More information and registration at http://www.universe-cluster.de/fog

The second workshop is a **FOPI Collaborations Meeting**, organised by Prof. Laura Fabbietti (Dense and Strange Hadronic Matter). This event will be held on 17-18 May 2010 at the Seminar Room at MPA and is dedicated to the study of strangeness and heavy ions (also see the report on Laura Fabbietti's group below).

Austrian Teachers Visit Cluster

On 24 February 2010 the Universe Cluster welcomed 27 teachers from Upper Austria for a training on astro- and particle physics. The teachers had joined a three-days journey starting with a visit at the Cluster. Further travel stops included the Paul-Scherrer-Institute and the CERN in Switzerland. Dr. Katja Ketterle, General Manager at the Universe Cluster greeted the guests, introducing them to the general goals of the German Excellence Initiative and the Excellence Clusters, in particular.

Before starting the scientifc program, Dr. Andreas Müller gave an overview on research and scientific experiments at the Cluster. Professor Peter Fierlinger, having Austrian roots himself, then covered the section „particle physics, presenting the research on neutrons of his group (Fundamental Physics with Neutrons). The end of the training was marked by Professor Jochen Weller's introduction into the force commonly known as dark energy, causing the accelerated expansion of the Universe. He presented several concepts to explain the nature of this energy – that although rather complex – triggered quite some discussions between teachers and lecturer.

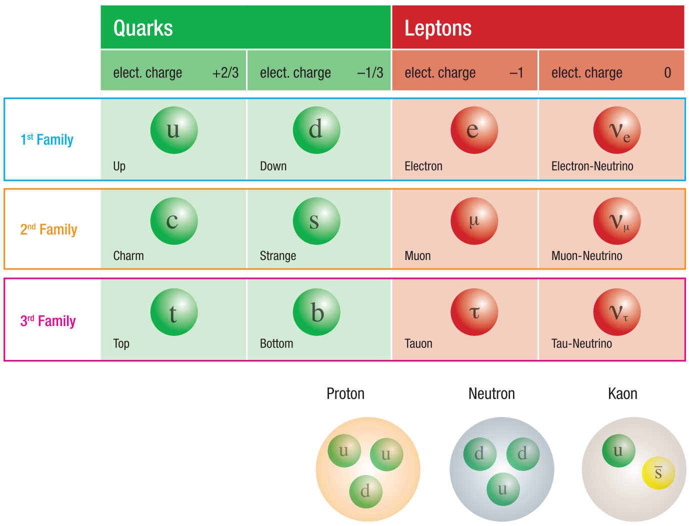
PORTRAIT OF THE MONTH

Think Big, Start Small

When it comes to the investigation of stars, we usually think of large telescopes and satellites, which circle in outer space and gather observation data from all directions in the Universe. This is certainly correct – but the large and visible Universe can often only be understood when we dedicate our time to small and invisible things. This is what the junior research group of Professor Laura Fabbietti does, which concentrates on „Strange Physics“. This does not mean „odd“ physics, but rather an exotic species of elementary particle: the strange quarks.

Stars are celestial bodies whose life cycles are determined by their respective masses. Whereas low-mass stars inflate unspectacularly to red giants and then deflate to cold, white dwarfs, stars with 8 solar masses or more take a completely different route. In their active time they fuse from hydrogen and helium to heavy elements right up to iron. However this is where the cascade of nuclear fusion ends. Heavier elements can only be produced with the help of supernova explosions.

This is the reason why a stable iron core develops in the course of several million years. As a consequence the gravitational pressure within the star increases: The star becomes the victim of gravitation and collapses. During this process gravitation compresses the core more and more, until even the structures of the iron atoms are destroyed: The electrons fuse with the protons, so that a neutron star evolves. Finally the star explodes as a supernova. A compact neutron star with a diameter of approx. 20 kilometres is what remains.



The standard model of physics: up and down quarks unite to form protons and neutrons. Kaons are mesons with a quark and an anti-strange quark.

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In order to better understand these processes, nuclear physicists are studying the states in the interior of neutron stars. In order to do so, they break the neutron star down into different shells depending on their densities and ‚physics'. „We distinguish between the approximately 1-kilometre thick crust and a core with extremely densely packed matter", Laura Fabbietti explains. „However, we don't know what state the matter in the core is in – scientists assume that part of the matter disintegrates and decays to its basic building blocks". As a result, the core could be made up of a precipitate of kaons or quark-gluon plasma, in which the quarks swim about in a kind of hot soup. In addition to this, it is also plausible that some kind of kaon condensate or a mixture of baryons (3 quarks) and mesons (2 quarks) of different quark constellations are formed.

In her experiments, Laura Fabbietti investigates under which conditions kaons are produced in the dense nuclear matter - even though the densities obtained in a laboratory are much smaller than in a neutron star. Kaons (or K-mesons) are composed of one quark and one anti-quark. When a strange quark and an anti up-quark bond, one refers to a negatively charged kaon K-. By the way, quarks are also the elementary building blocks of matter as we know them here on Earth: Nucleons (protons and neutrons) consist of constellations of three up and down quarks.

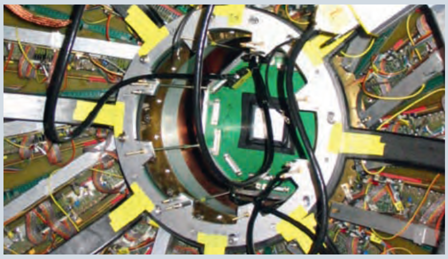
„As we can't look into the interior of a neutron star, we have to simulate the proportions artificially in particle accelerators," Fabbietti explains. "We succeed with the help of collisions of heavy ions, for example calcium, lead, and gold". From these experiments, it is possible to deduct whether the production of kaons at high density would be energetically favourable. If it turns out that when the experiment is performed at high density, mainly kaons are produced, it may be possible to come to conclusions about the precipitate in neutron stars.

A second aspect of the experiments is the generation of ppK-, which consists of two protons and one kaon. Laura Fabbietti: „This product might be formed when protons are allowed to collide with one another. When such a bonded system exists and we're able measure the bond strength between kaons and nucleons, we can obtain information on the interaction of kaons and nucleons". The interaction also provides evidence as to whether a kaon precipitate may exist.

These collision experiments are taking place at the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt. „We evaluate the traces of collision reactions and hope to find our ppK- and other particles", Fabbietti explains. The group uses the FOPI detector for this purpose, which they have equipped with an additional highly sensitive detector called „SILVIO (more precisely: SIΛVIO – Λ represents the Greek character 'Lambda')".

Laura Fabbietti describes what role both SILVIO modules play in kaon research: „In the collision of two protons in the energy range of 3 GeV, a complex reaction cascade occurs, during which a so-called Lambda particle is formed in an intermediary step. It is possible to prove the weak decay of the Lambda with SILVIO during the data acquisition and filter these events". At the same time, additional experiments, for example on the HADES spectrometer, are intended to study further individual aspects of kaon physics. „In the meantime we have already performed a complete measurement with proton collisions. In order to correctly interpret the results, the complex detector systems still have to be calibrated. Only then will we be able to measure the respective speeds and emission angles of the different kinds of particles exactly. With the calibration we reach the next stage in the search for new states of matter."

Junior Research Group: Dense and Strange Hadronic Matter



The group has started in January 2008 and is led by Prof. Dr. Laura Fabbietti (35). Before joining the Universe Cluster, Laura Fabbietti was a post-doc at TUM. In 2007, Fabbietti became the leader of a "Helmholtz Young Investigator Group" at TUM. At the Excellence Cluster Universe, she sets her main focus on the study of the kaonic cluster production. In this position Fabbietti is an important link between the existing experimental and theoretical expertise in nuclear-, hadron-, and astrophysics in the Munich area.

Her group is financed by the GSI Helmholtzzentrum and includes the post-docs Francesco Cusanno and Kirill Lapidus, the PhD students Martin Berger, Eliane Epple, Rafal Lalik, Robert Münzer as well as two diploma students and 3 technical students.

Research interests:

Experimental signature of the in-medium modification of strange mesons in heavy ion collisions, search of deeply bound states of kaon and nucleons (ppK-), test of theoretical model based on chiral perturbation and other phenomenological approaches, strangeness production in pion-induced reactions

Current Research Activities:

- Building of a silicon-based online trigger for the decay of Lambda hyperons
- Study of the spectral shape of the Lambda(1405) resonance produced in p+p reactions
- Study of kaons and phi production in heavy ion and proton-induced collisions
- Particle llow in heavy ion collisions
- Search of kaon nucleons bound state (ppK-) in p+p reactions
- Building of GEM-TPC detector as a high rate vertex tracker
- Development of diamond and silicon devices fort he on-line tracking of pion beams.

Collaborations:

- Physikdepartment (E18), TU München: GEM-TPC Detector experimental hardware
- Stefan Meyer Institute Vienna (SMI): Search of the ppK- bound state with the FOPI spectrometer
- GSI Helmholtzzentrum für Schwerionenforschung: FOPI Collaboration,
- HADES Collaboration
- AMADEUS Collaboration: Experiment at the DaphNe Facility in Frascati
- Physikdepartment (E12), TU München and JPARC, Japan: kaonic bound states and rare strange resonances

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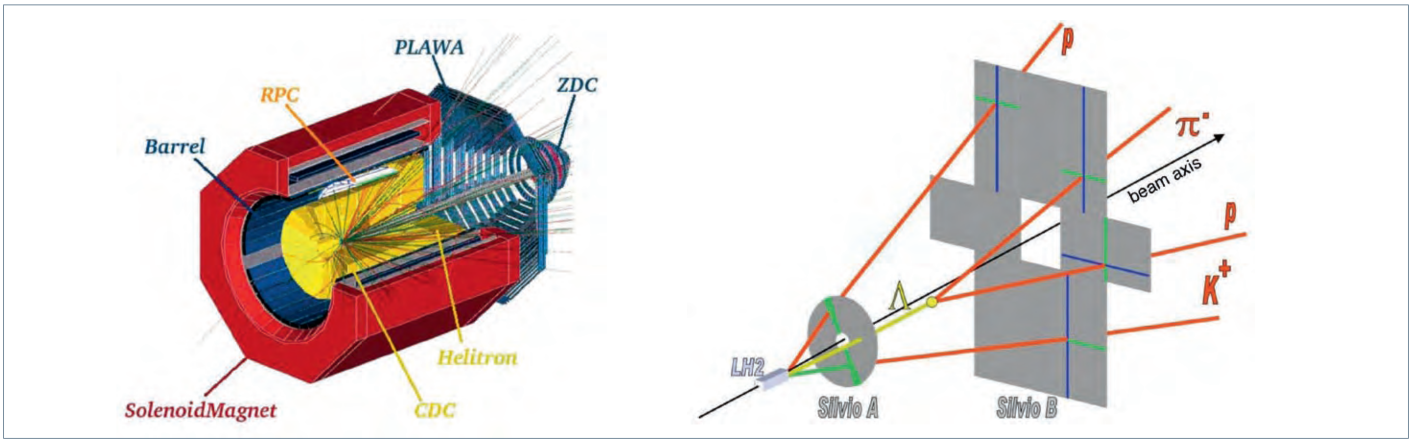

The image shows the FOPI detector (left). The SILVIO detector, designed and developed by L. Fabbietti's group is located inside FOPI.

PEOPLE

Andrzej Buras is New Member of the BAdW

The Excellence Cluster Universe is happy to announce that Professor Andrzej J. Buras is one of the 12 new members of the Bayerische Akademie der Wissenschaften (BAdW). Andrzej Buras belongs to the world's leading researchers in the field of applied quantum field theory, dedicating himself to Flavour Physics in particular. As a founding member of the Universe Cluster, Andrzej Buras heads the Research Area C "Origin of Matter". In 2007, he was honoured with a Carl von Linde Senior Fellowship of the TUM Institute for Advanced Study (IAS), where he leads the group "Fundamental Physics". Since 1988, he has had a full professorship in Theoretical Physics of Elementary Particles at the TUM physics department.

The BAdW has recently elected six members for the philosophical-historical and the natural sciences branch, respectively. Besides Andrzej Buras, also TUM Professor Johannes Buchner of the chemistry department was invited to join the academy. New members are chosen due to their scientific achievements and cannot apply themselves. Founded in 1759, the BAdW today manages a budget of 32 million Euros and is the largest of 8 science academies in Germany. Including the newly elected members, the BaDW now has 172 full members and 156 associated members, 32 of them being TUM professors.

Welcome to the Cluster!

Junior Research Group Leader: Prof. Dr. Jochen Schieck (1 April 2010)

Postdocs: Krühler Thomas (1 April 2010) ++ Dr. Michael Lerchster (1 March 2010)

Guests: Dr. Masayuki Tanaka (IPMU, 8 March 20010 - 12 March 2010) ++ Dr. Jiayu Tang (IPMU, 21 March 20010 - 21 April 2010) ++ Prof. Douglas H. Beck (University of Illinois, 11 March - 13 March) ++ Dr. Tommaso Giannantonio (Universität Bonn, 11 - 14 April) ++ Prof. Helmut Rauch (Technische Universität Wien, 26 April - 31 July) ++ Dr. Diederik Roest (Universität Groningen, 1 May - 31 July) ++ Prof. Paul Shellard (Centre for Mathematical Sciences, 1 May - 31 July) ++ Prof. Rabindra N. Mohapatra (University of Maryland, 1 June - 30 June)

Fellows: Dr. Claudio Grillo (1 March 2010)

Dr. Claudio Grillo Becomes New Research Fellow at the Cluster

Claudio Grillo

On 1 March 2010 the astrophysicist Dr. Claudio Grillo joined the Excellence Cluster Universe as a Research Fellow. He will be part of Research Area E, which studies the dark components of the Universe.

For the last one and a half years, Claudio Grillo was part of the Optical and Interpretative Astronomy Group at the Max-Planck-Institut für extraterrestrische Physik (MPE). His research focuses on strong gravitational lensing and observational cosmology in galaxies and clusters of galaxies.

He is particularly interested in exploring the dark matter distribution in these astronomical objects, as well as the cosmological applications of gravitational lensing. This work is essentially done in the optical regime, with extensive use of the images from the Hubble Space Telescope and measurements from some ground based telescopes, among them the ESO telescopes.

To become part of the Excellence Cluster Universe was an easy decision for Claudio Grillo: "The Cluster's Fellowship program offers to young scientists an almost unique opportunity to work independently, but in close contact with institutes where people make a great effort to try to understand our Universe a little bit better".

Realisation: Ulrike Ollinger (Layout) · Barbara Wankerl (Conception & Text)

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