3.1 Scientific Services

The server room in the basement of the Bothe laboratory.

Central IT Services

The IT group manages the central computer infrastructure of the MPIK, which provides central computing power and storage space for researchers. For this purpose several computer clusters and storage systems have been acquired during the last years. Most of this hardware is located in the computer room, which was finished in the year 2010. In addition the central IT operates services like mail and web and administrates the institute network. Supporting users with the acquisition of desktop hardware and desktop software installations has become a growing activity over the last years.

Fig. 1: Four water-cooled racks containing the 272 servers of the two clusters. The new cluster is located in the two leftmost racks.

Because of increasing computing power needs from various MPIK research groups, a new Linux computer cluster has been installed in 2016 (Fig 1). The cluster consists out of 112 dual processor nodes with a total of 3136 processor cores and 28 terabyte of system memory. Each cluster node is attached with a 10 gigabit ethernet (10 GbE) connection to the network. By using special high performance computing (HPC) optimised server systems, where four servers share a common two rack-units high case with a redundant power supply, the whole cluster allocates only two 19 inch racks in the computer room. Very good energy efficiency is an additional advantage of the new systems. Together with the 160-node cluster installed three years ago, 5696 CPU cores are available for scientific computing.

All servers run Scientific Linux 7 as operating system. The Son of Grid Engine, a community project to continue Sun's old grid engine previously used on the cluster, is used for allocating computing resources to users and running batch jobs on the cluster. Parallel computing jobs are supported through the Message Passing Interface library OpenMPI. Two new cluster head nodes are used for interactive work like program development and submitting jobs to the cluster batch queues. Three additional servers acquired over the last two years are used for memory intensive programmes. Each server provides 72 respectively 88 CPU cores and 1.5 respectively 3 TB of system memory.

The installation of two new Lustre file systems in 2015 and 2016 with 10 GbE storage servers increased the capacity of the parallel file systems from 4 petabyte to 8.5 petabyte. To fully utilise the network speed of the new servers and file systems, the networking in the central server room has been upgraded by a central 40 GbE switch.

An automatic tape library is used for the backup of the central servers and desktop computers and for archiving data from experiments. The library is equipped with four LTO tape drives and controlled by a backup server running IBM Tivoli Storage Manager. In late 2015, the library has been expanded from 1000 to 1200 storage slots and tape drives have been upgraded from LTO5 to LTO6. Moving all data from LTO5 to LTO6 cassettes during the first half of 2016 has completed the upgrade and leaves slots to be filled with LTO6 media. In the current library configuration up to 3 petabyte can be stored. As backup needs increase, the library capacity can be expanded by installing additional storage modules.

Frank Köck

Scientific Information Services

The library is specialised offering services primarily to scientists working at the institute. Scientists from outside are welcome, and usage is possible on appointment.

The collection of books increases continuously. By the end of 2016 our catalogue listed 25 300 monographs and conference reports. About 5700 bound journal volumes are available. Since 2009, the library is e-only for journal content. Access to electronic journals is predominantly covered by the Max Planck Society that ensures a permanent right to full-text access for more than 32 000 journal titles. Access to e-books is also primarily guaranteed via the Max Planck Society.

We manage the documentation of the publication output of the institute via our institutional publication repository PuRe (http://pubman.mpdl.mpg.de/), which presently contains about 6750 datasets. 1250 datasets have been added in the years 2014-2016, of which 523 contain the full text and 445 provide a link to the full text of the publication. Our workflow allows researchers, secretaries, and the librarian to enter publication data and upload full texts. The librarian performs a final quality check. The intention of this electronic document server is among other purposes to increase the visibility of the intellectual output of the MPIK and to contribute to the world-wide virtual repository of high-quality scientific information.

We also actively support various activities – catalogue enrichment, e-books, virtual library, open access, document ordering, electronic resource management – of the MPDL (Max Planck Digital Library).

Yet another task of particular importance is to find, analyse, and present bibliographic and citation information of scientists or institutions by using bibliographic data bases like SCOPUS or the Science Citation Index (SCI).

Gernot Vogt

Public Relations

The MPIK provides a variety of programmes for the general public. The institute is attractive for groups of visitors, for which the public relations team offers guided tours. Usually, a short introductory talk is followed by a tour to several labs, where sometimes explanations are given by specialists, and occasionally talks by members of the theory groups – depending on the interests and background of the visitors. In 2014-2016 we had 41 groups from schools, universities, other institutions or private with altogether about 780 persons.

The most prominent public event in the reporting period was the open day in July 2014. About 1500 visitors were enthusiastic about what they saw and heard at the 63 stations: demonstrations, interactive experiments, exhibitions, posters and talks, see Figs. 2 and 3. All scientific divisions, independent research groups and the technical units including the

Fig. 2: The high-energy gamma-ray astronomy exhibition at the open day in July 2014.

building services and the radiation protection group presented their work. In 2015, the public relations team together with members of the H.E.S.S. group participated in the open day at the MPI for Astronomy/Haus der Astronomie (HdA) presenting the H.E.S.S. model – now comprising all 5 telescopes – and original mirror facets.

In 2015 and 2016, the MPIK again engaged in the "Girls' Day", a Germany-wide initiative to motivate girls for technical professions; every April, companies and institutions offer an action day for girls. Under the motto "light and particles", the girls (in groups according to their school level) got insight into the professions of a physicist, an electronic technician, a precision mechanic or a design engineer. Supervised by mostly female staff, they performed experiments, got explanations and saw original instruments.

Fig. 3: Very attractive: experiments with liquid nitrogen, including the production of ice cream (open day in July 2014).

The "Saturday Morning Physics" courses, addressing high-school students at the advanced level and their teachers, typically attract about 100 persons and provide an insight into the research at the institute or related topics by lectures, discussions and guided lab tours. Two of the overall nine events took place at external sites. The events in 2015 were dedicated to the international year of light.

Every year, the MPIK contributed to the International Summer Science School, where high-school students from Heidelberg's partner cities and partner organisations participate, offering a one-day workshop for all students and a three-week internship for 2-3 students.

In total, 46 press releases about outstanding scientific results have been published in the reporting period. They were all announced online via the MPIK website and in part via the central MPG website as well as via idw (Informationsdienst Wissenschaft, idw-online.de), and also sent to selected journalists. The appointment of two new directors at MPIK as well as the numerous prizes awarded to MPIK members and appointments of MPIK scientists to other institutes were also announced on the MPIK web pages (40 releases).

The institute booklet and flyer (in German and English) were updated following the appointment of two new directors; revised editions of a number of topical flyers were prepared for the open day and in addition flyers – with revised layout – about new projects were created. The series of "MPIK-NEWS" has been continued, also in a slightly revised form. All of the printed matter can also be downloaded as PDF files from the MPIK web pages, which are continuously maintained to keep them up to date. The home screen of MPIK's web pages now presents more information: direct access to the research pages via clickable thumbnail pictures at the top, the latest science news as teaser, and an automatic research image cycle, see Fig. 4.

For the inauguration ceremony of the CSR in May 2016, a special booklet has been designed and produced together with the CSR team. The high-energy gamma-ray astronomy showcase in the first floor of the Bothe laboratory has been newly arranged, now providing an overview from HEGRA to CTA, and models of the H.E.S.S.-II telescope (scale 1:100) have been installed both at the MPIK and at the HdA – both in time for the open days. Six poster-sized pictures representing the research of the divisions have been selected to decorate the central seminar room together with an overview poster.

Last but not least, scientists of the MPIK gave overall 24 public lectures at various external institutions, among them 2 talks at the Haus der Astronomie.

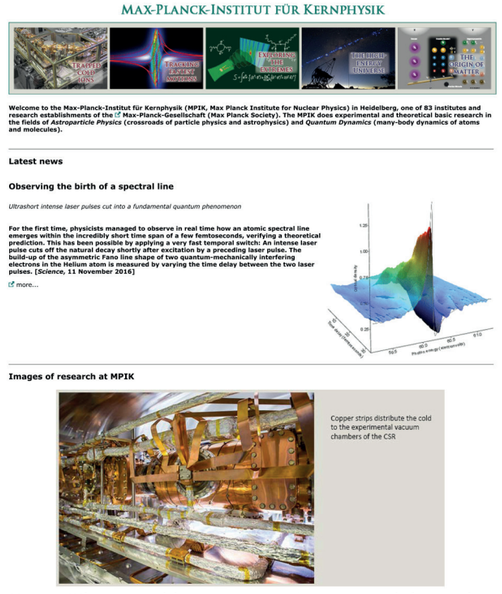
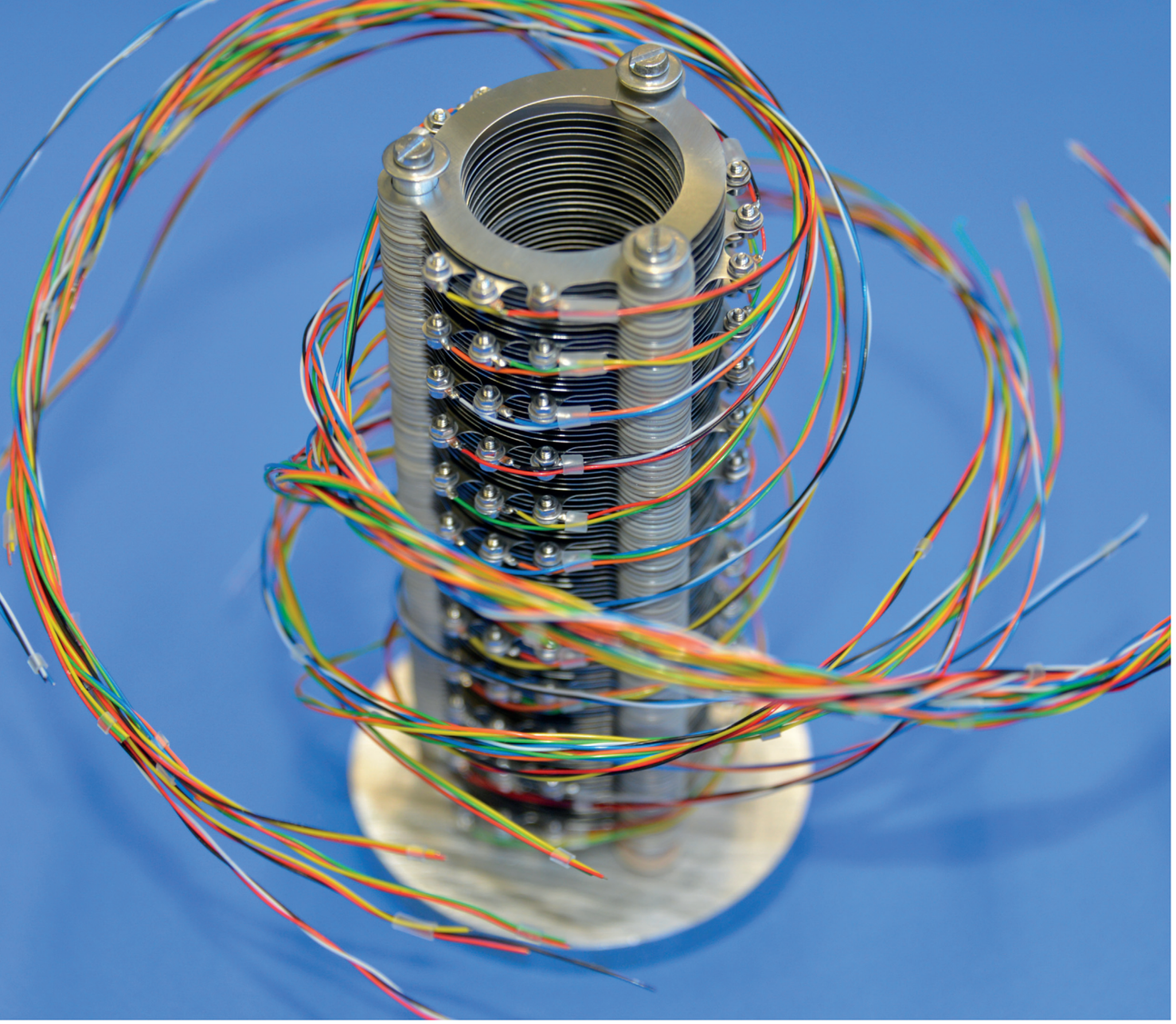


Fig. 4: The revised home screen of www.mpi-hd.mpg.de.

Bernold Feuerstein, Gertrud Hönes



3.2 Technical Units

The novel RF ion funnel for airborne high-sensitivity ion-trap mass spectrometer measurements of atmospheric trace gases and ions. A first successful technical test took place in August 2016 in close collaboration with DLR on the high-altitude research aircraft Geophysica at 23 km altitude. Numerous flights are planned for the Geophysica measurement campaign STRATOCLIM (Stratospheric Climate) in July 2017.

Precision Mechanics

Central Workshop. During the period from 2014 to 2016, more than 45 000 working hours were dedicated to producing components and instrumentation for the institute's research divisions. The 15 professionals of the central precision mechanics workshop are occupied with manufacturing highly precise components tailored to the needs of the experiments by using CNC-controlled machines and in part by laborious handicraft. The machinists are thoroughly trained, highly skilled and very knowledgeable. Periodically, they receive continuous training through specific and intensive upgrade courses. New staff are usually recruited among the apprentices of the institute's precision mechanics workshop following their graduation. Right from the start of their vocational training, the apprentices are required to become acquainted with the regular tasks of the central precision mechanics workshop.

Because of the complexity of the components required for science, in 2016 an additional CNC machine was purchased, namely a precision turning lathe (Fig. 1) for the purposes of producing highly precise turned workpieces such as electrodes for Penning traps. Now, the central workshop is equipped with overall eight, and the apprenticeship workshop with three CNC machines.

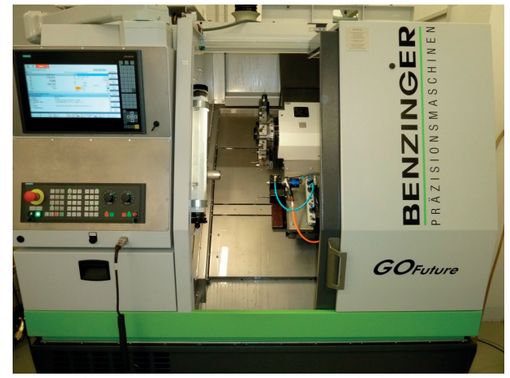


Fig 1: The new CNC precision turning lathe.

Apprenticeship Workshop. During the years 2014 to 2016, eight apprentices have successfully completed their vocational and practical training. The excellent achievement of one apprentice during her training period was honoured by the apprentice award of the Max-Planck-Gesellschaft. Two apprentices – in 2015 and 2016 respectively – came first at a competition hosted by the district chamber of crafts; they received their prizes in ceremonies at the Handwerkskammer Mannheim Rhein-Neckar-Odenwald.

The work on the Foucault pendulum at the Helmholtz Gymnasium was completed in 2015 (Fig. 2). The final step was the installation of a rotatable time disk in the centre of the pendulum. This allows the approximate time to be read with the aid of the pendulum. The official inauguration took place on Feb. 2, 2015 in the presence of the mayor of Heidelberg.

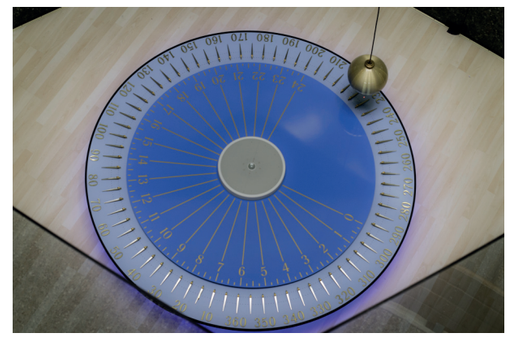


Fig 2: The finally assembled Foucault pendulum at the Helmholtz Gymnasium.

Engineering Design Office. The main task of the team, which consists of engineers, technicians and design draughtsmen, is to develop and design mechanical components for various experimental setups. In close cooperation with the scientific groups and the precision mechanics workshop, the team has been involved in numerous projects during 2014 to 2016, including PENTATRAP, ALPHATRAP, Astrolab, GERDA, HeXe, various reaction microscopes, H.E.S.S. II and X-MUSIC.

A major challenge has been the completion of the CSR with its more than 11 000 different workpieces. The electron cooler for the CSR turned out to be a particular demanding con-

struction task. The frequently encountered extreme requirements of the experiments such as high vacuum, cryogenic temperatures, extreme material requisition and high precision micrometers (as needed for Penning traps) posed particular challenges.

With the product data management software PDM professional, introduced in 2015, the project structure, documentation, and CAD data management have been further optimised.

Joint projects. A primary example joint project is the design and manufacturing of the Penning trap ALPHATRAP (see Chapter 2.2, p. 62). This project is characterised by the very challenging precision required of the trap electrodes of only 0.005 mm (Figs. 3, 4). The complete setup consisting of vacuum chamber, nitrogen and helium cryostats and many further components was designed and manufactured mostly in-house. The individual electrodes were produced with the newly purchased precision turning lathe. Finally, the electrodes were plated with gold.

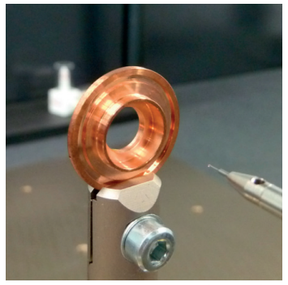


Fig 3: A Penning trap electrode.

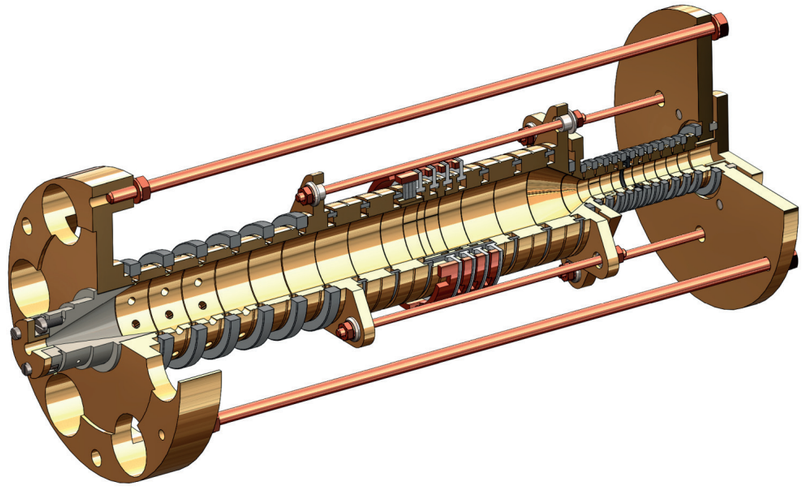


Fig 4: Cross-sectional view of the ALPHATRAP Penning traps.

Another example is the water-cooled front plate for the CHEC camera (Fig. 5) for the small-size telescopes of CTA (see Chapter 1.1, p. 12); it has been produced from aluminium alloy in the precision mechanics workshop. Therefore, the existing CAD models were revised in the engineering design office, to make their production compatible with our 5-axis milling machine. Further support is provided for the development of the camera case (Fig. 6), which must be able to reliably protect the sensitive electronics against dust and water during its later deployment.

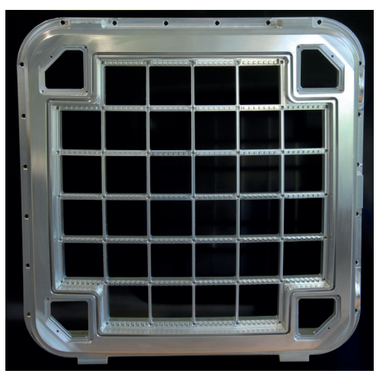


Fig 5: Front plate for CHEC.

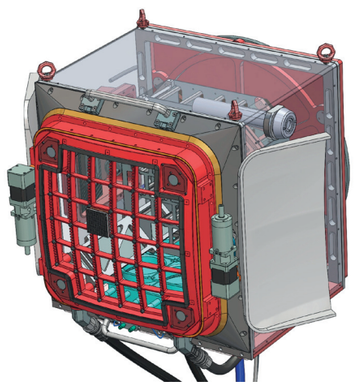


Fig 6: CHEC Camera case.

Thorsten Spranz, Stephan Flicker, Frank Müller

Electronics

Central Workshop. Throughout the years 2014 to 2016 many development projects have been carried out in the central electronics workshop. Only a brief overview will be given on the wealth of projects to illustrate the variety of fields of work.

The Cherenkov Telescope Array (CTA) will utilise a great number of telescopes to accurately reconstruct the energy and direction of high-energy cosmic gamma rays (see chapter 1.1, p. 9). In a novel fully digital camera („FlashCam"), the electrical pulses of the photomultiplier tubes (PMTs) are continuously digitised at 4 ns intervals. The key component of the FlashCam camera concept is the so-called motherboard featuring a low-cost field programmable gate array (Xilinx Spartan6™), Gbit LAN connectivity and two high pin-count connector slots for attaching specific daughter cards.

For the FlashCam readout system various high-speed multilayer boards (a 12-channel ADC daughter board, a fast DAC card, a trigger card, a backplane and a clock-trigger distribution master board) have been designed and manufactured within the central electronics workshop. A full set of boards is currently being used to perform system tests of a full-size FlashCam prototype camera, see Fig. 7. Tests include optimisation, power distribution, safety and cabling as well as 24/7 operation, as preparation for the deployment of two pre-series cameras at the CTA experimental site in Chile in 2018.

Due to its versatility, the FlashCam motherboard/daughter card system can be quite easily adapted to other applications. One such application is the High Altitude Water Cherenkov Gamma-Ray Observatory HAWC (see Chapter 1.1, p. 12) where 5 crates of each 3 ADC modules will be employed for the readout of the sparse outrigger array of small water Cherenkov detectors. The beam position monitor of the cryogenic storage ring (CSR) and the silicon-PMT laboratory tests employ one motherboard with 12 ADC channels each.

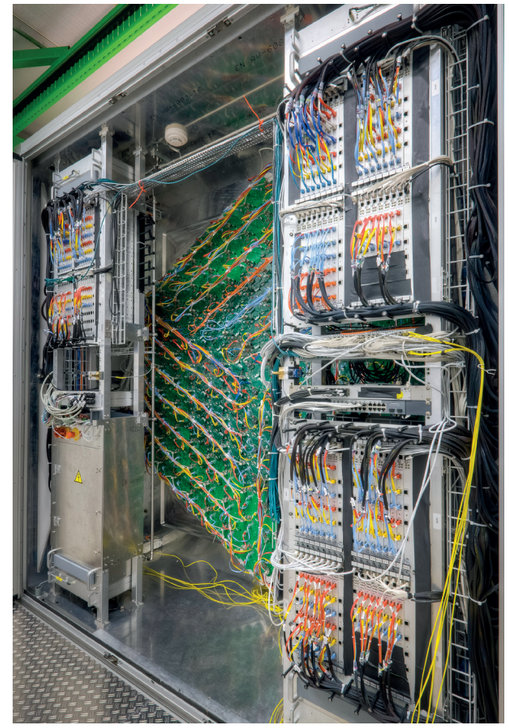


Fig 7: View onto the readout crates of the FlashCam prototype camera (size ~3 × 3 m²) featuring 1764 PMTs.

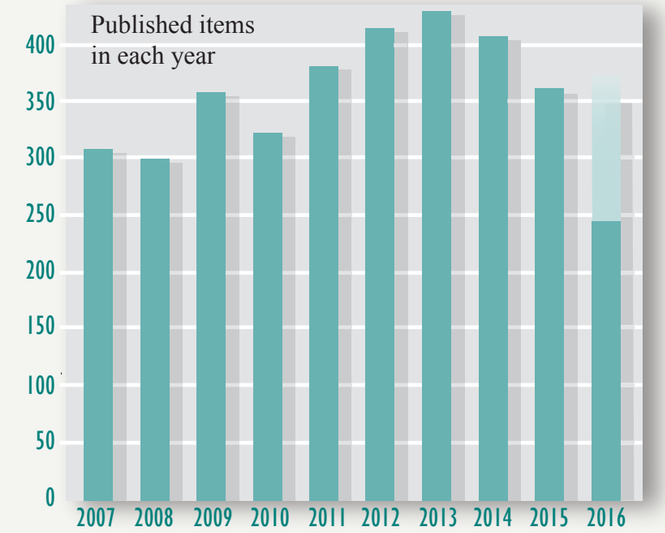
Another large-scale project (STAREP) is the development of a computer-controlled modular voltage source system (Fig. 8) with up to 25 channels for ion traps like PENTATRAP or ALPHATRAP (see Chapter 2.2, p. 62). In order to capture, store and manipulate single ions in such traps, the potentials inside the traps are to be set very precisely and kept extremely stable because voltage variations will dilute all energy level measurements. A first set of 40-channel modules including controller and voltage references have been manufactured externally in 2016.

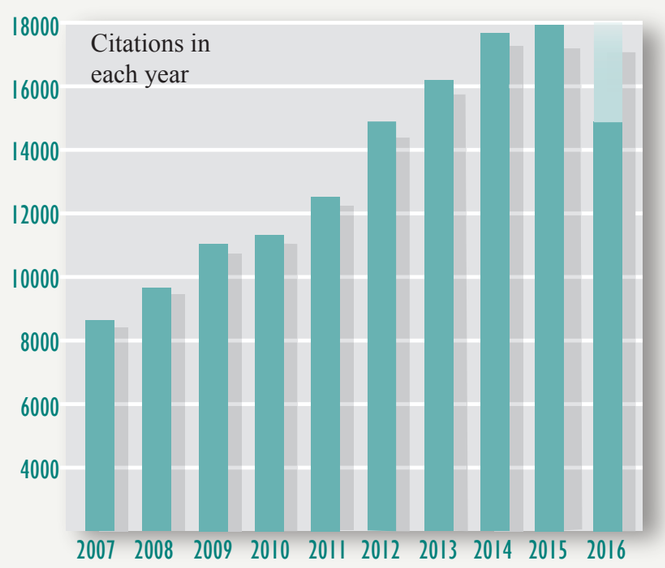
Apprenticeship Workshop. All projects of the central electronics workshop benefit from the close collaboration with the electronics apprenticeship workshop by involving the apprentices in various aspects of the production process such as printed circuit board assembly or cable assembly. The high quality of education in the apprenticeship workshop is reflected by the fact that two former apprentices have been given a permanent contract at the MPIK during the last three years.

Christian Bauer, Jochen Stephan

Fig 8: Rack setup featuring ten STAREP channels with controller and reference.

MPIK citation report
for the last decade*





estimated figures

*Source ISI Web of Science, November 2016.

3.4 Statistics

Yearly numbers of published items and citations of papers by MPIK authors; from Web of Science. Information for 2016 is incomplete.

Publications

In 2014-2016, the overall number of citations of publications by MPIK scientists has reached a higher level compared to previous years, although the number of publications did not increase. The following table lists the journals, in which the highest numbers of papers were published, in the order of journal impact factor:

Journal	Number of papers*
Nature, Nature Physics, Nature Communications, Nature Photonics	29
Science	8
Physical Review Letters	87
Journal of High Energy Physics	89
Astrophysical Journal	32
Astronomy & Astrophysics	30
Monthy Notices of the Royal Astronomical Society	39
European Physical Journal C	20
Physical Review D	70
Physics Letters B	44
Physical Review C	28
Physical Review A	77
Journal of Physics B	28
Journal of Instrumentation	16
Journal of Physics Conference Series	67
XXIX International Conference on Photonic Electronic and Atomic Collisions	40

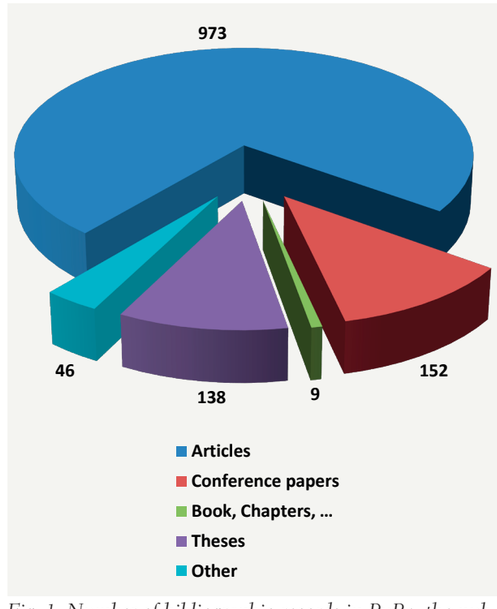


Fig. 1: Number of bibliographic records in PuRe, the publication repository of the Max Planck Society, for the years 2014-2016, as of November 2016.

Theses

	2014	2015	2016*
Bachelor theses	11	17	9
Master theses	14	12	10
Dissertations	24	19	16
Habilitations	5	0	2

*) preliminary – as of November 2016

International Max Planck Research Schools

The MPIK is involved in three International Max Planck Research Schools (IMPRS). Two of them are coordinated by the institute, while the third one is coordinated by the MPI for Astronomy (MPIA). The IMPRS are part of the Heidelberg Graduate School of Fundamental Physics (HGSFP) at the University of Heidelberg.

IMPRS-QD: Quantum Dynamics in Physics, Chemistry and Biology
Spokesperson: Christoph H. Keitel
Coordinator: Antonino Di Piazza (until 12/2015), Jörg Evers (since 12/2015)
Institutions: MPIK, Heidelberg University, German Cancer Research Center, MPI for Medical Research, GSI Helmholtzzentrum für Schwerionenforschung (Darmstadt)

	2014	2015	2016
PhD students	36	39	45
female	4	5	7
from foreign countries	19	20	25
funded by IMPRS-QD	11	18	13
graduations	14	11	9

IMPRS-PTFS: Precision Tests of Fundamental Symmetries
Spokespersons: Manfred Lindner and Klaus Blaum
Coordinator: Werner Rodejohann
Institutions: MPIK, Heidelberg University

	2014	2015	2016
PhD students	20	20	21
female	4	4	6
from foreign countries	8	7	8
funded by IMPRS-PTFS	13	15	20
graduations	8	5	6

IMPRS-HD: Astronomy and Cosmic Physics @ MPIA
During the reporting period, 11 PhD students (5 female, 7 from foreign countries) were working at the MPIK.

Institutional Collaborations

MPIK researchers participate in a large number of institutional collaborations, in part in a leading role – throughout the reporting period overall 84 projects. By far the largest collaboration is CTA with presently 237 institutes from all over the world and led by Werner Hofmann. The second largest consortium is SPARC (108 institutes), followed by LHCb (69 institutes), FLAIR, NUSTAR (both 46 institutes), and H.E.S.S. (39 institutes). On the other hand, there are 43 collaborations with only one or two partner institutes.

Electronic Annex

Complete lists of publications, invited talks, lectures and courses at universities, jointly organised conferences and workshops, habilitations, dissertations and theses, as well as institutional collaborations can be found online: www.mpi-hd.mpg.de/mpi/en/research/