

# Past, present and future

Germany's impressive scientific traditions are a role model for other nations. A recent European committee meeting in Berlin painted a lively and informative picture of the current German scene.



European Committee for Future Accelerators (ECFA) delegates outside the historic Magnus-Haus, situated in the cultural heart of Berlin.

The European Committee for Future Accelerators (ECFA) continued its continual tour of CERN Member States when it met in Berlin in September for an update on the status of particle physics in Germany. (The mission explicitly left out activities directly related to the major DESY laboratory in Hamburg. DESY, a key player on the national and international scene, gets a special treatment – it is visited every second year by ECFA, while each CERN Member State is normally visited only every six years.)

The ECFA meeting took place at the historic Magnus-Haus in the cultural heart of Berlin, across the road from the Pergamon Museum. The building was donated to the Physical Society of the former DDR in 1958 to commemorate the centenary of the birth of Max Planck (1858–1947). It has a distinguished scientific history – among its famous 18th century inhabitants was Joseph Lagrange, one of the founders of analytic mechanics.

## Physics history

Berlin is filled with echoes of physics from the past. It was here, 100 years ago, that the concept of the quantum of action was conceived by Planck, initiating the quantum paradigm, one of the greatest scientific revolutions of the 20th century.

Albert Einstein, the torch bearer of a second revolution, relativity,



Speaking up for German students – Claus Beier (left) of Heidelberg's Kirchhoff Institute with German ECFA delegate Karlheinz Meier of Heidelberg.

spent a considerable part of his life in Berlin. He was the first director of the Kaiser Wilhelm Institute there, and it was in Berlin that he presented his theory of general relativity.

## Quantum century

As the 100th anniversary of quantum theory, the year 2000 was declared in Germany to be the "Year of Physics" (see "www.physik-2000.de" for further information). The Federal Ministry of Education and Research initiated and supported more than 200 physics "events" throughout the country.

Hermann Schunck, representing the Ministry, told ECFA that the "Year of Physics" has been a great success. The grand finale takes place in Berlin in December, with a week of symposia and other events around 14 December, the date when Planck presented his work for the first time.

The Ministry believes in the importance of basic science, Schunck stressed. The Ministry is following closely what happens in particle physics in order to be able to plan for the future. Schunck gave a survey of questions in particle physics to be addressed over the next 20 years – questions related to the Higgs particle, properties of neutrinos and CP violation, among others. He concluded that at the present time, a linear collider, to be commissioned about five

## A German PhD student speaks up

During the ECFA meeting in Berlin, Claus Beier, a graduate student in experimental particle physics from Heidelberg, gave a very personal account of his professional life. He felt that his undergraduate studies had given him a "solid training in a wide variety of physical sciences".

His reasons for going into particle physics were: "it's fun or fascinating"; "the atmosphere is international"; "it gives useful experiences in computing or hardware"; and "it gives good job opportunities". "Research is like a roller-coaster ride," he said.

However, other duties such as teaching, travelling and giving talks can be onerous. The solution is usually long working hours for a modest annual income (DM 25 000–35 000).

Working in a big collaboration (400 scientists), Beier had found the biggest problem to be insufficient flow of information, due to such "trivial things" as lack of documentation. The graduate student inherits vital but incomprehensible "computer code". What a waste of time to have to re-do the job!

What he valued most was academic freedom, the international atmosphere, and the fact that he is constantly learning something new. Beier concluded that the research in particle physics has given him invaluable experiences for "the life after", as he put it. Permanent jobs in research are scarce, so a life in industry is more appealing "because it offers higher income, more free time and permanent employment", he said.

years after CERN's LHC circular machine, looks to be the most obvious major project for the future.

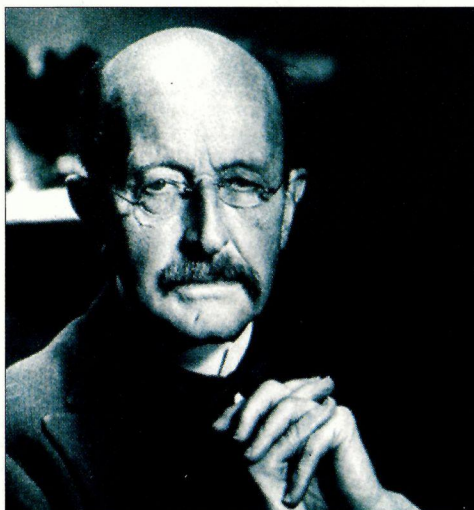
### German organization

The funding of basic science in Germany is more complicated than in most other European countries, due to the country's decentralized federal structure. These intricacies were described by several speakers, including Schunck, Rolf Heuer of DESY and Konrad Kleinknecht of Mainz.

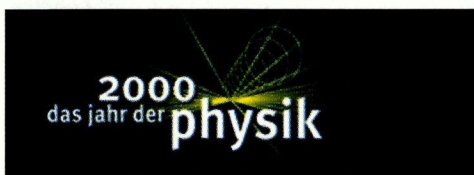
Germany's 16 states (Länder) have considerable autonomy, with each state (Land) having its own local government. In addition, there is of course the Federal Government. Education is the business of the local governments. As in most European countries, in Germany a great deal of basic research is carried out at universities. However, these are governed by local State rules. The researchers at the universities often carry a rather heavy load of other duties such as teaching and administration.

The local funding is in general far from adequate to allow university researchers to take part in research elsewhere. Speaking for the university environment, Kleinknecht noted that for research in particle physics, the federal funding is absolutely necessary.

Science knows no geographic frontiers and a great deal of coordination of research activities at the various universities and research centres is required. In this respect, the role of the Federal Government, especially its Ministry of Education and Research, is vital. The Ministry's annual funding for basic physics is about DM 1.5 billion. This Ministry funds major national research centres and is an indispensable link between Germany and the various international research centres such as CERN. Two of its programmes for funding research by university groups at large research centres are "Structure and Interactions of Fundamental Particles", which has a



*This year is the centenary of the discovery of quantum theory by Max Planck in Berlin.*



*2000 is "The Year of Physics" in Germany.*

budget of DM 75 million for a three year period and "Hadron and Nuclear Physics", the budget of which is DM 66 million, again for three years.

Another important organization is the German Science Council (Deutsche Forschungsgemeinschaft; DFG), a federal research council financed 60% by federal funds and 40% by the Länder. This organization does not directly support projects in particle physics. However, it provides annual funding for particle physics at the level of DM 14 million, supporting PhD students, who for example can work at CERN, and prestigious fellowships.

### German Research Societies

One very special feature of Germany is that it has scientific "Societies" which have a large number of institutes devoted to research in various areas.

The society which is most relevant to particle physics is the prestigious Max Planck Society. This is funded 50% by the Federal Government and 50% by the

Länder. It has some 80 institutes and centres devoted to basic research, and employs about 12 000 people. The Society can restructure itself as it sees fit, for example by creating, merging or dismantling its own institutes. This allows for much more flexibility than would be possible at universities.

The Max Planck Institutes in Heidelberg and Munich focus on particle physics. The major duty of a researcher at a Max Planck Institute is indeed research, so there is a considerable disparity between the responsibilities of these researchers and those at the universities.

### Some facts and figures

Physics is taught at about 60 universities. Enrolment was increasing until the late 1980s. At about that time approximately 1500 PhDs in physics were being awarded per year. Since then there has been a

dramatic drop in the enrolment rate due to several reasons, one of which has been purely demographic.

Nowadays, job opportunities for physicists are good – perhaps too good. There is a great temptation not to continue for a PhD but to work in industry for a much higher salary. Age is also an issue. Germans go to school for 13 years before entering university. Afterwards, in physics, the student does “diploma” work which usually takes five years. Add to that military service or equivalent community service, and four to five additional years for getting the PhD, and the result is that the average age for obtaining a physics PhD is 29 years.

The number of annual diploma exams has fallen from a maximum of 3500 to 2000, and is set to fall further. Since industry needs about 3500 new diploma or PhD physicists per year, and since PhD exams will stay for a few years at 1400, and then decline, there is a shortage of physicists in the university/research sector.

Currently, research in experimental particle physics is carried out at 16 universities, and for theory, 23. There are about 210 staff and 50 PhD students in experimental particle physics at the universities. The corresponding numbers at the Max Planck Society are 90 and 60, respectively. However, these latter numbers include both theorists and experimentalists as well as those working in astroparticle physics.

In addition to those who work at the Max Planck Society, there are about 240 particle theorists at the universities and other research centres, not counting PhD students.

## Projects

German scientists have traditionally made significant contributions to experimental particle physics. For example, the very first neutrino neutral current event from the Gargamelle bubble chamber at CERN was found at Aachen in 1973. Later, German teams played a major role in several neutrino experiments at CERN. The German neutrino tradition is currently being continued by participation in OPERA for the CERN/Gran Sasso project (p7).

The first observation of direct CP violation at CERN is another example of how German researchers have made an essential contribution. Germany is omnipresent in all sectors of physics at CERN, in all four LEP experiments and all four of the large future LHC experiments, as well as in fixed-target experiments such as NA48 and COMPASS. Making antiatoms from antiprotons is another German speciality at CERN.

Outside Europe, other major projects in which German particle physicists participate include the BaBar experiment at SLAC, Stanford, and CDF and D0 at Fermilab as well as heavy-ion experiments at RHIC, Brookhaven. There is also a broad spectrum of non-accelerator particle physics activities such as the historic Gallex solar neutrino experiment, the neutrino mass experiment at Mainz, and double beta-decay studies. Another closely related domain is astroparticle physics, where German physicists are participating in major projects such as AMS, AMANDA and Auger.

As described by Thomas Mannel from Karlsruhe, almost all current topics in theoretical particle physics are being investigated in Germany. Phenomenology, lattice gauge theories and string theory are notable examples.

## National laboratories and R&D

Germany is very special in Europe in that it has several large research centres for particle and nuclear physics – DESY in Hamburg, DESY-Zeuthen (Berlin), GSI (heavy ions) in Darmstadt, KFA in Jülich and FZ in Karlsruhe.

Such a strong home base gives German scientists several advantages. As well as having their own research programmes, these centres also engage in R&D activities. For example, as pointed out by Norbert Wermes of Bonn, a great deal of work is being carried out on detector R&D for high-energy physics, not only at DESY but also at GSI Darmstadt, FZ Karlsruhe and the Max Planck Institutes in Munich and Heidelberg, as well as at 17 universities.

These efforts are funded primarily by the Ministry of Education and Research, and to a lesser extent by the German Research Council, the European Union and the Länder.

There have been interesting spinoffs from these developments. For example, a scintillator/optical fibre development has been shown to be useful for measuring dose distribution in medicine. Another example given by Wermes was a prototype chip which was developed for the ATLAS detector at LHC, but which can also be used for X-ray imaging.

The huge upheavals which occurred due to the German national reunification affected the country's science budget. However, there is now optimism in the air, at least for science. In the latest budget, two domains do rather well – education and traffic infrastructure, Schunck pointed out. □

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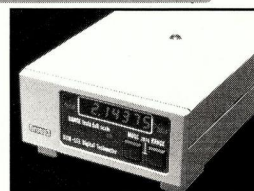
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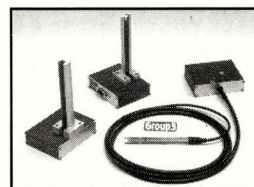
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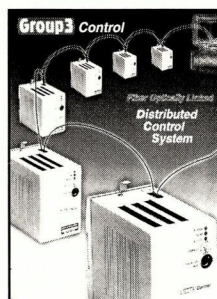


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