Preface

Scientific research at the Physik-Institut covers a broad spectrum of experimental physics, including the physics of biological systems, of nanometer structures, of fundamental properties of materials and of high temperature superconductors as well as surface physics and accelerator and non-accelerator based elementary particle and astroparticle physics. During the reporting period the institute's 104 employees from 21 countries achieved an impressive number of results, as documented by no less than 71 presentations at international scientific conferences and 249 original publications. Nine PhD theses, six master and nineteen bachelor theses have been completed.

This report summarizes the activities of our ten research groups during the past year. The discovery of what meanwhile was confirmed to be the Higgs boson is no-doubt one of the greatest scientific breakthroughs of recent years, linking a very fundamental theoretical prediction from the early 1960's with an enormous experimental effort culminating in its verification half a century later. Four of our research groups contributed to this result.

The scientific and technical portfolio of our institute contains many more topics, in which our results are highly recognized worldwide, as is documented by the seventeen contributions to this report. I'd like to mention three more highlights of the past year:

- Our institute plays a prominent role in the search for the constituents of the mysterious dark matter in the universe, performed in the low-background underground laboratory at Gran Sasso near Roma. XENON100 published the world's most stringent limits on WIMP [a]-nucleon cross sections, both spin-independent and spin-dependent (Sec. 4).
- New imaging techniques with coherent low energy electrons are explored for applications in, for instance, biological systems. Last year a combination of holography and coherent diffraction with low energy electrons has revealed the arrangement of the 660'000 unit cells of a freestanding graphene sheet with 2Å resolution (Sec. 16).
- A long hunt for the decay mode $B_s \to \mu\mu$ has finally come to success with its first observation by the LHCb collaboration (Sec. 11). This decay is very sensitive to hypothetical new physics contributions and a large region of model space can now be excluded. The rare decay $B \to K^*\mu\mu$ was studied in detail the first time ever. Relevant parts of both analyses were done in our LHCb group.

In summer 2012 two new professors joined our institute, both working in the field of experimental particle physics. Prof. Dr. Florencia Canelli joined us in August 2012. She was a member of the ATLAS collaboration at the LHC where her group was mainly involved in the development of the fast track trigger and physics searches including the Higgs boson. Previously her research was based at the D0 and CDF experiments of

[a] *Weakly Interacting Massive Particles*

the Tevatron collider at Fermilab. She left ATLAS in November 2012 and is presently building up her own team within CMS. The CMS experiment is now preparing an upgrade to the silicon pixel tracking detector which is necessary to maintain tracking efficiency and heavy quark identification capability at the future increased interaction rates. Prof. Dr. Florencia Canelli's group is involved in setting up and testing the full readout chain and associated data acquisition software.

The second new group, lead by Prof. Dr. Ben Kilminster, is currently involved in several projects. As a years-long member and former convener of the CDF Higgs group, Ben Kilminster played an important role in the observed evidence for a Higgs boson decaying into b quarks. His work towards improved b-jet and missing energy determinations, multivariate analysis techniques, and b-tagging was instrumental for reaching this result. He joined CMS in time to contribute to the CMS Higgs discovery which is based on the multiple evidence from different final states. The group contributes to technical developments like new cooling systems and prototype supply tube structures. They also plan to integrate the electronics boards, cables and sensor modules of the pixel detector after its upgrade. Kilminster's group is also involved in a development for using CCD detectors in dark matter searches, in order to reach the lowest possible energy thresholds (DAMIC and CONNIE).

Two members of our institute were elected as assistant professors by the Swiss national science foundation (SNF), receiving significant grants to build up their own research groups. Prof. Dr. Hugo Dil, present member of the surface physics group, will join EPFL, while Prof. Dr. Nicola Serra, member of the LHCb group, will start his own group at our institute (both from July 1st, 2013). Based on their longstanding experience the surface physics group (Sec. 15) could join the European *Future & Emerging Technologies* (FET) flagship program on applications of Graphene. In addition they participate in the University Research Priority Program (UFSP) *Light to Chemical Energy Conversion* together with the chemists of our faculty.

By the end of July 2012 Prof. Claude Amsler, a long term member of the institute, retired. Claude started at our institute in 1982 in Peter Truöl's group and was elected Associate Professor in 1987 and Full Professor in 1999. He successfully lead one of the particle physics groups of our institute primarily residing and working at CERN. The group was active in a wide range of experimental research, such as low energy antiproton annihilation, antihydrogen spectroscopy and one of the LHC collaborations. He also served on the board of the Swiss National Science foundation and was a member of the Particle Data Group, where his expertise on meson spectroscopy was highly appreciated. His introductory *Particle and Nuclear Physics* courses were well received by the students and lead to a textbook, which continues to be used by his successors. Claude co-authored more than 500 papers, among them a highly cited article on glueballs. A more detailed presentation of Claude's scientific career follows further below.

Besides pushing back the frontiers of knowledge in our different research projects, communicating our achievements to the public remains a major task which goes beyond the obvious responsibility for the physics education of students at our university. Members of the institute gave talks for the general public and contributed to public events like *Nacht der Forschung* and *Scientifica*. We guided school children through our labs, organized information days for pupils of the *Gymnasium* and visited high schools. We regularly participate in the *European Masterclass for Particle Physics* and have built a model railway, which demonstrates magnetic aspects of superconductivity. There were 25 such outreach events in 2012, corresponding to about 840 working hours in total.

About 800 students have to be taught physics at any point in time. These include students in the medical faculty and those in our own faculty studying biology, chemistry, geography or mathematics. We follow the traditional European concept to unite research and education, so all our 81 physicists are involved in teaching. This includes the 21 Postdocs and 39 PhD students who may teach lab courses or lead problem solving classes. In addition, typically 15 undergraduate physics students and some outside senior physicists support us in teaching.

Members of the institute are active in numerous scientific organisations like the Swiss national research council, and advisory boards and panels of numerous research institutions including CERN and PSI. They also contribute to the academic administration of the university as a whole and are involved in many national and international search committees for new professors.

An important part of the success of our experimental research and our international visibility is based on the excellent technical infrastructure (mechanical and electronics workshop, information technology) and on the highly qualified and strongly motivated technical experts. This allows us to construct state-of-the-art laboratory equipment, and push experimental methods beyond existing technical limits. Our reliable and efficient administrative staff plays a very important role in creating the excellent working climate which is so beneficial for all of us.

Allen Mitarbeitenden möchte ich an dieser Stelle für ihren uneigennützigen Einsatz, ihre Eigeninitiative und die gute Arbeitsstimmung am Institut herzlich danken.

Zürich, June 2013

Prof. Dr. Ueli Straumann

Claude Amsler and co-workers at 46.2019^0 N, 7.1689^0 E, during a recent trip around Ovronnaz

the Scientific Career of Prof. Dr. Claude Amsler

Claude Amsler was born in Solothurn. He studied experimental physics at the ETH-Zürich and obtained his PhD in 1975 with the first particle physics experiment performed at the Paul Scherrer Institute, a measurement of pion scattering on polarized protons. He then joined Queen Mary College (London) as a Research Associate and was delegated to TRIUMF in Vancouver to work on nucleon-nucleon scattering experiments. In 1978 he moved to Brookhaven National Laboratory as a Research Assistant Professor from the University of New Mexico to work on antiproton experiments.

In 1979 he obtained a CERN Fellowship. After a brief leave at the University of Munich he joined in 1982 the Physik-Institut of the University of Zürich, where he submitted his Habilitation in 1987 on nucleon-antinucleon bound states and resonances. He was elected Associate Professor in 1987, then Full Professor in 1999. He has supervised some 40 PhD & Master theses at the Faculty of Sciences.

Claude Amsler contributed to several projects at CERN such as meson spectroscopy in low energy proton-antiproton annihilation - the ASTERIX and CRYSTAL BARREL experiments (which led to the discovery of four mesons), to the first production of cold antihydrogen with ATHENA, and to the first observation of electromagnetically bound kaon-pion pairs (DIRAC experiment). His group joined CMS at the LHC in 1995. He also contributed to the development of liquid argon detectors for dark matter searches (ArDM and ASPERA-DARWIN projects) and to a measurement of the neutrino magnetic moment at the Bugey nuclear power plant (MUNU-experiment).

Claude Amsler is currently involved in the Compact Muon Solenoid (CMS), that has recently discovered a new heavy boson consistent with the Standard Model Higgs particle. His CMS group has also discovered a new particle containing a beauty quark, the Ξ_b^{*0} baryon. Furthermore, he currently participates to the AEgIS-experiment at CERN to measure the gravitational acceleration of antihydrogen.

He is a member of the Particle Data Group, dealing in particular with mesons. Between 1996 and 2003 he led the Forum of High Energy Physicists in Switzerland and coordinated the foundation of CHIPP (Swiss Institute of Particle Physics). He represented Switzerland in the European nuclear physics board NuPECC between 2003 and 2008 and was a member of the ASPERA Evaluation Committees, and is currently advising the Swiss National Research Council, of which he was a full member until 2008.

Since summer 2012 Claude Amsler is Professor Emeritus at the University of Zürich and associated as senior staff member with the Albert Einstein Center for Fundamental Physics of the University of Bern.