Plenary Talk PV I Mon 11:40 Audimax

Making uncertainty certain?: Proton therapy, range and in-vivo verification. — •Tony Lomax — WPTA/140 Forschungsstrasse 111 5232 Villigen PSI Schweiz

Proton therapy (RT) is an increasingly important weapon against cancer. By controlling proton energy, and thus proton range, the dose can be concentrated in tumour more effectively than with conventional radiotherapy with photons. However, although proton ranges in water can be determined with sub-millimeter precision, the story in the patient can be quite different due to uncertainties in CT data of the patient, positioning inaccuracies and anatomical changes of the patient during the treatment course. As such, in vivo range uncertainty is one of the major challenges for proton therapy. Consequently, methods such as proton CT/probes, PET activation and prompt gamma imaging are being proposed and developed for direct and in vivo imaging of proton range. This presentation will review and compare each of these, both from their technical practicality and potential clinical impact.

Plenary Talk PV II Tue 9:00 Audimax

The LHC legacy and prospects — •Markus Klute — KIT

The Large Hadron Collider (LHC) at CERN has had two successful and highly productive runs (2009-2013 and 2015-2018), colliding protons and heavy ions with center-of-mass energies of up to 13 TeV and collecting an unprecedented amount of data. Its highlight, the Higgs Boson discovery in 2012, completed the Standard Model of fundamental particle interactions. While the impact of the collected data has been tremendous, many open questions in the world of elementary particle physics remain. At the dawn of the LHC Run 3 (2022-2025), the experiments have an extensive program exploring the uncharted territory at the energy frontier. I will review the main conclusions from the LHC to date and present the prospects of the LHC program in Run 3 and beyond.

Plenary Talk PV III Tue 9:45 Audimax

Particle theory in a data-driven era — •Michael Krämer — RWTH Aachen University

Theory has played a crucial role in developing the Standard Model (SM) and in formulating the questions that point to physics beyond the SM, such as the origin of electroweak symmetry breaking or the particle nature of dark matter. In the first phase of the LHC many searches for physics beyond the SM have been driven by specific new physics models that would address some of the shortcomings of the SM. However, since no conclusive evidence for new physics has been established so far, more model-independent approaches such as effective field theories, or the search for anomalies by machine learning methods, are being pursued. I will try to clarify the role of theory for the discovery of physics beyond the SM in this data-driven era of LHC physics, and highlight the challenges and opportunities for the next decade.

Plenary Talk PV IV Wed 9:00 Audimax

Teaching with Objects and Teaching with Video: The Challenges of Informal Education in Physics — •Allison Marsh — University of South Carolina

Books and lectures are popular ways to impart information, but what about objects and videos? In this talk I will focus on these two approaches to teaching.

The first will focus on material culture – the objects and artifacts that reflect human progress. I will draw on my experience over the last four years writing a monthly column for the magazine Spectrum, the flagship publication of the IEEE. Each article focus on a museum object from the history of computer science or electrical engineering, broadly defined.

The second part of the talk will draw from my experience as the consultant for Crash Course History of Science, an extremely popular series of 46 short (10-12 minute), fast paced videos with goofy animation. I will talk about the collaborative process of deciding what information makes the cut and how that affects the overall content.

I will end with a reflection on audience and how these formats can draw in new people to the subjects, but also the drawbacks of the formats.

Plenary Talk PV V Wed 9:45 Audimax

Quantum gravity, chaos, statistical physics and wormholes — •Jan de Boer — University of Amsterdam

The information paradox for black holes has been an important source of inspiration for research in quantum gravity, as the paradox implies that low-energy effective field theories that include gravity must break down in an interesting and unexpected way. Recent work has managed to clarify the physics behind the paradox considerably and uncovered fascinating relations between gravity and wormholes on the one hand and chaos, quantum information and statistical physics on the other hand. One lesson seems to be that low-energy observers in gravitational theories do in fact have some access to high-energy information, but only to statistical and not to microscopic information. In this picture wormhole solutions are a direct manifestation of this statistical high-energy information.

In this talk I will try to give an informal summary of some of these developments, trying to emphasize the general lessons rather than the technical details.

Evening Talk PV VI Wed 20:00 PEL

Kleine Teilchen – große Chancen: Mit Quantenkorrekturen auf der Suche nach neuen Physikphänomen — •Stephanie Hansmann-Menzemer — Universität Heidelberg

Die Frage was die Welt im Innersten zusammenhält treibt Teilchenphysiker*innen weltweit an. Was sind die kleinsten Bausteine des Universums? Wie wechselwirken sie miteinander? Woraus besteht dunkle Materie und warum gibt es in unserem Universum mehr Materie als Antimaterie?

Am Large Hadronen Collider an der internationalen Forschungseinrichtung CERN in der Nähe von Genf werden Protonen bei höchsten Energien 40.000.000 mal pro Sekunde aufeinandergeschossen. Die Zerfallsprodukte der Kollisionen werden in riesigen Teilchendetektoren vermessen, die größer sind als ein Mehrfamilienhaus. Wie Detektive analysieren die Wissenschaftler*innen die Zerfallsprodukte um so zu rekonstruieren was genau bei dem Zusammenstoß der Protonen passierte. Im Rahmen der Heisenbergschen Unschärferelation kann für eine kurze Zeit die Energieerhaltung in Quantenkorrekturen verletzt werden und so können auch sehr schwere Teilchen kurzfristig produziert werden. Deshalb ist die Studie von Quantenkorrekturen induzierten Prozessen ein vielversprechendes Werkzeug für die Suche nach neuen Teilchen und neuen Physikphänomenen.

Der Vortrag führt in die Teilchenphysik am Large Hadron Collider ein und stellt ausgewählte aktuelle Ergebnisse zur Suche nach neuen Physikphänomenen in Quantenkorrekturen vor.

Plenary Talk PV VII Thu 9:00 Audimax

New perspectives onto the Universe in the era of multi-messenger astrophysics — •Samaya Nissanke — GRAPPA, University of Amsterdam, The Netherlands — Nikhef, The Netherlands

Since the revolutionary discovery of gravitational wave (GW) emission from a binary black hole merger in 2015, the exquisite GW detectors LIGO, Virgo and KAGRA have detected more than 90 compact object mergers. Most notably, one of these mergers corresponds to the first binary neutron star merger, dubbed GW170817. This event has been transformative because it was observed in both gravitational and electromagnetic radiation, thus opening up a new era in multimessenger astrophysics. The multi-messenger characterisation of such an event has enabled major advances into diverse fields of modern physics from gravity, high-energy and extragalactic astrophysics, nuclear physics, to cosmology. In this talk, I will discuss work in strong-field gravity astrophysics and how combining observations, theory and experiment is key to make progress in this field. I will present the opportunities and challenges that have emerged in multi-messenger astrophysics, and what the future holds in this new era.

Plenary Talk PV VIII Thu 9:45 Audimax

The Sun as a source of high-energy particles — •Rami Vainio — Department of Physics and Astronomy, University of Turku, Turku, Finland

Particle acceleration at the Sun occurs in Solar Energetic Particle (SEP) events related to solar eruptions: solar flares and coronal mass ejections. Composition, timing and duration as well as other observational properties of SEP events can be used to assess the mechanisms of particle acceleration at play in these events. However, one particular complication in these analyses has been the relatively large distance of our observers to the source, both in radial and angular distance from the core of the solar eruption. Transport effects can distort the observed particle event substantially and signatures of the acceleration process may be washed out. In the last years, however, the heliospheric research community has obtained new tools to assess a large number of problems with the launch of three new space missions to the in-

ner heliosphere in orbits around the Sun: NASA's Parker Solar Probe and ESA's Solar Orbiter and BepiColombo. In combination with older probes at Earth's distance from the Sun, they offer an unprecedented possibility to disentangle transport effects from the imprints of particle acceleration in the data.

I will provide an overview of observations and models of SEP events and discuss what has been learnt of particle acceleration at the Sun based on the comparison of models and observations. I will conclude with some of the open questions that we expect to solve over the next solar maximum with the new heliospheric fleet.

Plenary Talk PV IX Fri 9:00 Audimax

Shedding light on the axion: one particle solving two problems — •Friederike Januschek — Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

Very lightweight and feebly interacting new bosons like the axion, originally introduced to solve the strong CP problem of QCD, or axion-like particles (ALPs) predicted by theories beyond the standard model, have been found to also be viable cold dark matter candidates. Thus, the existence of axions and axion-like particles has a particular appeal theoretically –and is additionally supported by experimental hints.

Worldwide, experiments have been and continue to employ creative methods to look for these –previously considered invisible– particles and promise to shed further light onto them. At DESY in Hamburg, the ALPS II experiment, a light-shining-through-walls experiment in the laboratory, is close to data-taking. The planned (Baby)IAXO and MADMAX experiments are complementary experiments that will search for axions and ALPs from the sun and dark matter halo, respectively.

In this talk, I will give an introduction to axions and discuss strategies for detecting them, focusing on activities at DESY.

Plenary Talk PV X Fri 9:45 Audimax

Quantum Computing: a future path for High Energy Physics — •Karl Jansen — DESY, Platanenallee 6, 15738 Zeuthen

Quantum computers offer the fascinating possibility to outperform classical computers or to even solve problems that cannot be addressed by classical computations. We will describe particular examples of quantum computing approaches such as the hybrid quantum/classical variational quantum eigensolver and quantum machine learning, including graph neural networks and quantum generative adversarial neural networks. We demonstrate successful applications of these methods at selected problems in theoretical and experimental high energy physics. In addition, we show, how by developing new methods for error mitigation and for analyzing the expressivity of quantum circuits the quantum noise of existing hardware platforms can be mildened.