CHIPP Roadmap 2020:

Status and Outlook on Particle Physics in Switzerland

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Contents

1 Impact on education and society

[Main Editor: Katharina] [(2-6 pages) – How is your research positively impacting on education and society? What are the benefits of the pursued research? Is your field offering a service to society (e.g. health, meteorology, agriculture, environment, energy, hazard warning, etc.)? Is there a link with the politics, do you provide advice for political decisions? Do you have links with museums and scientific collections? Do you support the promotion of young talents in your field? Do you have outreach activities? Is there something to say in relation with the sustainable developments goals (SDGs) or with possible citizen science?]

1.1 Education

The purpose of this section is to briefly discuss the structure of particle physics education in Switzerland offered at the universities with a focus on students studying physics as a major. The success of particle physics research in Switzerland largely results from the high-qualified and innovative scientific and technical teams within Swiss institutes. To maintain that quality, the best highly motivated students must be attracted to the field. For this to achieve education in particle physics in all undergraduate physics curricula is mandatory.

1.1.1 Bachelor and master

At Swiss universities general courses in nuclear and particle physics are commonly included in the final year of the Bachelor programs. Some counter example exist, however. There are Bachelor programs in physics for which an option with strong emphasis on nanoscience and technology or an option with an extended minor can be chosen. These curricula include nuclear and particle physics only as a elective or core elective modules, allowing the possibility of a student being awarded a Bachelor degree in physics without having followed these courses.

All Swiss universities offer master programs with a strong focus on particle or astroparticle physics. Some of the master programs are clearly structured, targeting towards a specialisation in the chosen topic areas, while others encourage breadth but allow specialisation, if the student so wishes. ETHZ offers a unique and very attractive joint Masters degree in High Energy Physics together with École Polytechnique (Institut Polytechnique de Paris (IP Paris)) preparing excellent students for a future research career in High Energy Physics. The two-year Master program is set up symmetrically between the two universities: students spend one year in Zurich, and one year in Paris.

1.1.2 PhD

CHIPP initiated a specialised education program in particle physics open to PhD students all over Switzerland with the CHIPP Winter School and the Zuoz Summer School organised bi-annually. The purpose of the schools is to learn about recent advances in elementary-particle physics from local and world-leading researchers and our PhD students are expected to participate at least once during der PhD studies. The program includes lectures on accelerator and non-accelerator particle physics from an experimental and phenomenological perspective based on the activities of the swiss institutes involved in particle and astro-particle physics. Further education of the students is guaranteed and supported by the institutes through specialised schools offered by CERN, Fermilab, DESY or other institutions.

1.2 Outreach activities in Switzerland

Any new large-scale project to be proposed in particle physics will need concerted, global education, outreach, and communication efforts, with a strong and committed dialogue with the public and stakeholders, and adequately educating pupils and students at all ages. Scientific outreach fulfils important and necessary obligations to society. The activities involve direct participation of scientists active in current research of particle and astro-particle physics to improve public understanding of our field, appreciation of the benefits of fundamental research, to rise interest and enthusiasm among young people, and to strengthen the integration of science in society.

Current efforts in particle physics outreach in Switzerland raise awareness, appreciation and understanding of the field and its current state of research. The different outreach activities address diverse audiences and different venues ranging from traditional ones such as schools, science festivals or museums to YouTube videos, science slams, bars or music festivals. Audiences include primary and secondary school pupils, teachers, journalists and communicators, key stakeholders and policy makers, as well as the general public. Outreach activities of all institutes and universities are thus developing broad, long-term impact, making use of current research to raise and maintain the interest of the audience, but taking also the time to address the underlying nature of the scientific process, the strength of fundamental research and its key role in society.

Outreach activities within CHIPP are intended to inform the political platform and the general public but also to target specifically potential young physicist and high-school students in general. In the view of the Swiss particle physics community, the primary aim is to convey to young secondary school students by conveying the importance, excitement and fantasy of basic physics and in particular recent particle physics and related cosmology developments. In this process the importance of a sound mathematical background is transferred as physics is by definition a mathematical description of fundamental phenomena. By convincing the audience of the importance of fundamental research in general and particle physics in particular these outreach activities serve to the benefit of all STEM related subjects and fundamental research in general.

In the following we outline a few of the key activities for the general public and high-school students of the past years

- Visits to CERN: CERN as the centre of high energy research is extremely attractive for visits which are organised regularly by CHIPP members. In recent years about 50 visits a year were organised for university students in physics and other disciplines, high-school students, alumni, politicians, members of societies, media, and the general public at large.
- Talks to the general public, the industry and high schools: many CHIPP members, involving all CHIPP institutes are actively participating giving talks to the general public in addition to the regular public talks organised by the institutes.
- Teacher education: we collaborate with secondary-school teachers in the development of innovative and interesting physics demonstrations, sometimes using particle physics data. Education of secondary-school teachers is done by providing teaching material, via the CERN Teacher program (https://teacher-programmes.web.cern.ch/) and specific topological workshops as well as open days for teacher at our institutes.
- YouTube video 'How particle-physics works: hope and worries on the B-physics anomalies': This short movie illustrates how experimental and theoretical physicists at UZH that work together to understand recent puzzling results in B-physics reported by the LHCb experiment (https://www.youtube.com/watch?v=9dLyTS0Xscw).
- Exhibits: A multidisciplinary Art& Science exhibition at the Espace Ballon in Château-d'Oex presenting on the discovery

of cosmic rays, protagonating the Swiss physicist Albert Gockel from Fribourg who established first hints in his balloon flights over a century ago. Experiments carried out at high altitudes, in balloons, airplanes and in high mountain stations, such as the Jungfraujoch and Gornergrat research stations, allowed researchers to detect radioactivity in the atmosphere and to conclude on the existence of cosmic radiation (https://www.chateau-doex.ch/de/P395/ballonraum-espace-ballon).

- Scientifica – the Zurich Science Days: this bi-annual event attracts typically more than 25'000 visitors. Particle and astro-particle physicists of ETHZ and University of Zurich contribute regularly with topical talks and booths. In 2019 for example the general topic of the Scientifica 'Science fiction - Science facts' was perfectly suited to discuss antimatter and Dark Matter with the general public. In 2017 the discovery of the Higgs boson was discussed in the overall context of 'What data reveals' (https://www.scientifica.ch).

- Dark Matter Day: Since a few years, the world celebrates end of October the hunt for the unseensomething that scientists refer to as dark matter. Swiss institutes regularly contribute with local events and highlight the experiments that could deepen our understanding of the mystery of dark Matter.

Specialised school labs as well as lectures and workshops for school classes play a key role in attracting young students to study STEM related subjects. There are several dedicated laboratories at our institutes that offer special courses in cosmology as well as particle, astroparticle and neutrino physics for school classes targeting different ages of young students. With hands-on experiments, visits to the labs and by meeting bachelor and master students they get in contact with state of the art research and passionate researchers (https://www.psi.ch/ilab/, http://www.sciencelab.uzh.ch,https://dqmp.unige.ch/physics-for-all/physiscope/).

1.2.1 International outreach network

The International Particle Physics Outreach Group (IPPOG) (http://ippog.org/) has the mission to maximise the impact of education and outreach efforts related to particle physics and is an excellent example how outreach is done in a collaborative effort. Since 2016 IPPOG is an international scientific collaboration of scientists with experience in research, education & outreach from 26 countries, six experiments and two international laboratories. IPPOG provides a network of scientists, science educators and communication specialists working across the globe sharing knowledge and providing tools for outreach in particle physics and related topics such as astro-particle, neutrino physics, radiation treatment and gravitational waves. Hans Peter Beck (University of Berne and Fribourg) served as IPPOG co-chair from 2016 – 2019.

The European Particle Physics Communication Network (EPPCN) (https://espace.cern.ch/EPPCN-site) is a network established by the CERN Council in 2005 following the approval of the European strategy for particle physics. It is a network of professional communication officers, with Angela Benelli for Switzerland, from each member and associate states with the mandate to support and strengthen communication between CERN and the member states.

1.3 Support of young talents

Particle physics is a field that equally fascinates and attracts high-school and university students; the research field is therefore very well suited to attract interested, talented high-school students to study physics and later to motivate excellent students to follow a career as a researcher. Several activities for different ages are already in place others will be developed in the next years.

In the following the different activities to attract young talents to our field of research are summarised:

- International Particle Physics Masterclass program for high-school students (https://physicsmasterclasses.org/): This international one-day program is targeting high school students that are very interested in physics and particle physics in particular. After an introduction in the concepts of the Standard Model and the measurement techniques the students learn through hands-on experiments and interaction with physicists at CERN how to perform a simple analysis. In Switzerland the various masterclass events typically attract about 200 students each year;
- High-school internship at CERN (https://hssip.web.cern.ch/): Two weeks internship at CERN for 24 high-school students from Switzerland which is offered in 2021 for the first time. More than 60 excellent applications of extremely motivated students were received which made the selection of the candidates a challenging task;
- Individual coaching for high-school students, eg. an internship or support with the matura thesis;
- Internship for students in physics or related fields in our research groups;
- CERN summer student program for students pursuing bachelors or masters degrees in physics, computing, engineering or mathematics (https://home.cern/summer-student-programme). Students attend lectures and perform their own research projects at CERN during eight to thirteen weeks. As this is an international project with more than 3000 applications for the 340 places, competition is high and only well prepared applications of extremely motivated students succeed;
- Mentoring of PhD students and Early Postdocs in the LHC collaborations ALICE, ATLAS, CMS and LHCb. All LHC collaborations have installed early career offices that organise trainings for newcomers and provide help and advice in the early career of young scientists. Senior scientists from the Swiss universities are actively supporting these early career efforts.

Our efforts will be further enhanced in the coming years to strongly motivate and support young talents in order to strengthen the next generation of young scientists that choose to engage in the particle physics community.

1.4 Service to society

Traditionally, particle physics has been a driving force for new technical developments in medicine, such as positron-emission tomography or cancer therapy with proton or heavy ion beams. In addition detectors, that have been developed for measurements of charged particles in high-energy experiments are nowadays used for precise position in medical imaging. Many tools and software applications are in fact very similar in particle physics and medical applications. With the need of even preciser and faster detectors, radiation harder detector material and readout electronics, R&D is continuously ongoing, our understanding deepens and it can thus be expected that further developments in the detector material and types, electronics and analysis algorithm will have a significant impact in other fields such as medicine, material sciences or space sciences.

1.5 Summary

As the number of scientists engaged in outreach increases, so do the variety and ingenuity of their efforts reflected in the wide selection of activities, ranging from Open Days to Public Lectures, from lab tours to special workshops for high-schools. Travelling and standing exhibitions attract broad audiences and various events are organised at schools, universities, museums, and science

cafes to raise interest and engage the audience. Many institutes offer projects primarily aimed toward high school students and teachers. Often, as a result of these efforts, young students might become more inclined to choose a STEM-related subjects for their studies. They might even go on to join the next generation of particle physicists. What is most important, however, is the fact that they will be more educated and appreciative of the importance of research, and thus more suited to make informed decisions about science and scientific questions in their future.