

## Netzwerk Teilchenwelt: An outreach network in Germany

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Netzwerk Teilchenwelt is a Germany-wide outreach program comprising 30 universities and research labs. About 150 researchers are involved, bringing cutting edge science into the classroom. 3500 high school students each year take the opportunity to work with original data from HEP experiments in special Masterclasses or to study cosmic particles with detectors. On advanced levels, motivated students continue to engage in research and attend workshops at CERN or conduct their own research projects. Through a Fellow program, highly motivated students are offered early contact with research groups, personal support, and further training. Activities are funded by the German Ministry of Education and Research (BMBF) as an integral part of HEP research. Within the current funding scheme, topics on hadron and nuclear physics are included and links from other projects are created which expand the range of target groups.

*The Eighth Annual Conference on Large Hadron Collider Physics -LHPC2020*  
*25-30 May, 2020*  
*online*

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## 1. Netzwerk Teilchenwelt: A multi-stage program for high school students

Chances for high school students to get in contact with particle physics research are rare. In many countries, particle physics is not part of the curriculum. This is why particle physicists try to provide an insight into their field of research by offering outreach activities such as a visit to CERN or participation in a Masterclass. On these occasions, students can meet physicists and learn about topics of current research and the organization and process of research.

In Germany, Netzwerk Teilchenwelt [1] runs a particle physics outreach program for high school students and the recruitment of young talent which is organized as a multi-stage program. In the basic stage, 3.500 high school students per year take part in a particle physics Masterclass and analyze data from the LHC experiments ALICE [2][3], ATLAS[4][5], CMS [6], or LHCb [7]. A Masterclass is a 1-day workshop, usually held at school, where students become “researcher for a day.” They learn more about particle physics from a mentor before making a measurement based on authentic data. Additional Masterclasses with data from astroparticle physics experiments are also offered. On advanced levels, students can work with special detectors (Cherenkov or scintillation detectors), take their own data and perform different measurement tasks.

On the next stage, highly motivated students are invited to a workshop at CERN, where they can gain in-depth experience with research during a 4-day-stay. Every year, 10-15 particularly committed students work on their own research projects, which they then contribute to their graduation from high school (“Abitur”, university entrance qualification). For this work, the students can spend up to two weeks in a research group at CERN (examples [8] [9]), while preparation and follow-up work take place at a research institute near their home. Every year, several of these research projects are awarded prizes in prestigious national competitions, such as “Jugend forscht”.

### 1.1 PhD and Master students as role models

During all these activities, high school students are supervised by PhD or Master students. About 150 PhD and Master students are engaged in Netzwerk Teilchenwelt. They hold Masterclasses, explain to the students how particle detectors work, and supervise the students’ research projects. At the same time, they act as important role models who can influence the high school students’ career-related aspirations and choices. For their commitment they receive a fee and travel expenses. Netzwerk Teilchenwelt offers soft skill courses for the Master and PhD students with content from science communication, didactics and presentation techniques, which are also beneficial for the further career.

### 1.2 Supporting talents at university

In an evaluation of the program, it was found that a considerable proportion of the high school students who had applied to take part in a CERN workshop subsequently started studying physics at university and were still interested in particle physics. Therefore, a so-called Fellow program has been launched in 2017 in order to support and promote young people during their transition to university and to establish a close connection between these highly motivated students and the research groups. The Fellow program currently has about 190 participants, 50%

females. Via the program, Fellows receive professional and personal training via a) local offers such as internships, excursions, regulars' table, invitation to colloquia and outreach events, and b) central offers, e.g. annual meeting, annual Fellow/Bachelor school in particle physics, invitation to national physics conferences. Through the Fellow program, the participants get early access to the particle physics research groups, whereas the groups benefit from the highly motivated and pre-educated students for support in scientific and outreach activities.

### 1.3 Programs for teachers

Netzwerk Teilchenwelt has also set up activities for teachers. A broad range of context and teaching material was developed, such as a four-volume teaching series on particle physics [10], a card game with particle profiles [11] and a new chapter for the physics teaching platform "LEIFI-Physik" [12], which is very popular among teachers and students in Germany. In addition, two-day teacher training courses are held several times per year as well as a one-week summer school for 20 teachers at CERN [13].

## 2. The structure of Netzwerk Teilchenwelt

Netzwerk Teilchenwelt was launched in 2010. Up to now, 30 universities and research institutes have joined the network. Members of the project team work at TU Dresden, DESY in Zeuthen, and CERN. Since the end of 2019, additional hubs at the universities in Bonn, Mainz, and Münster are funded to provide regional support and to extend the scope of the program with topics from hadron and nuclear physics.

For all participating universities and research labs, the central coordination at TU Dresden provides structures and material, e.g. data base, event calendar, wiki, detector sets, DIY cloud chamber sets to be loan to teachers, educational material, kits for Master and PhD students. Other central tasks are the organization of events, e.g. Fellow physics school, Fellow meeting, soft skill training for Master and PhD students, and the internal and external communication, including website, social media, newsletter, mailings etc.

### 2.1 Activities in the current funding period

The German Ministry of Education and Research (BMBF) funds HEP research in Germany within the current research framework program "Exploration of the Universe and Matter" (ErUM). Currently, Netzwerk Teilchenwelt receives funding from this program through a project called KONTAKT. It can thus be stated that outreach is funded as integral part of research. The KONTAKT project, in which Netzwerk Teilchenwelt cooperates with the German LHC communication agency "Weltmaschine" [14], aims at continuing and consolidating existing programs, at reaching out to new target groups such as journalists and the general public, and at integrating topics from hadron and nuclear physics.

A mobile exhibition module is currently under development. The exhibition is to be set up quick and easy, so that it can travel easily throughout the country. The content is targeting groups that are less likely to access science, thus the tour stops are planned in shopping malls, market places and railway stations. In addition, Netzwerk Teilchenwelt has purchased virtual reality headsets and installed apps from several experiments (LHC, also Belle II and IceCube). The sets are centrally maintained and loan to the universities and research labs for outreach

events. For journalists, a trip to CERN was planned for May 2020, but had to be postponed due to the COVID-19 pandemic.

The existing offers from Netzwerk Teilchenwelt, which mainly cover particle physics and astroparticle physics, are currently enriched with more topics from hadron and nuclear physics, such as a hadron therapy Masterclass [15][16], a Belle II Masterclass [17], a scattering experiment Masterclass [18], and a PANDA Masterclass (under development). Several exhibits are under development as well as a detector school for Fellows/Bachelor students. A 1-week summer course for high school students at the MAMI accelerator (University Mainz) had to be canceled due to the COVID-19 pandemic.

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