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DOCUMENT FOR THE 2020 UPDATE OF THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS

Report by Working Group 5 on
Public Engagement, Education and Communication

Report by Working Group 5 of the European Strategy for Particle Physics Update 2020 Public Engagement, Education and Communication

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1. Introduction

Particle physics, as a subject, expresses the basic human impulse to understand the universe around us, and as such has the potential to inspire and excite people well beyond its practitioners. Additionally, as an almost entirely publicly-funded enterprise, it comes with both the obligation and the incentive to share its results and insights with the stakeholders supporting the research. These include the general public, funding agencies and policy-makers. Historically, reaching out beyond the particle physics community has shaped the way our field has been perceived by the general public and the stakeholders much to our advantage. Particle physics speaks to people's imagination and has often been perceived as deserving esteem and support. With other fields of science now engaging more and more with the public and stakeholders alike, our field should at least maintain its efforts in this direction and, where possible, be more effective.

The topics of **public engagement, education and communication** can be distinguished depending on the target audience, and they all have in common the general idea of sharing knowledge, but differ in form and message. In **public engagement**, one tries to entice as many people as possible to engage with particle physics adventures. **Education** is more formal and targets specific groups with intellectually more challenging information. Within this topic, the education of the next generation of particle physicists merits special attention. The **communication** by professionals to the press is identified as a separate strand of information sharing. Among other things, professional **communication** also serves to safeguard the reputation of the research field, the laboratories and researchers. Aspects of all three areas will be discussed in the next sections of this report in a broad-brush way and without the pretence to be complete.

The first European Strategy for Particle Physics led to establishing the European Particle Physics Communications Network (EPPCN)[1]. In the 2013 update of the European Strategy for Particle Physics, the importance of outreach[2], education and communication was emphasised in a rather general way[3]. As will be discussed below, these three areas have further developed nicely over the past decade. While it is essential to maintain the current high standards and even further improve public engagement, education and communication in general, the Working Group identified two strategic objectives that should receive specific attention in the coming 6-8 years: *better engaging with scientists from other disciplines* and *establishing the basics of the Standard Model as an intrinsic component of human culture*.

A recent development is the establishment of the Science Gateway, which will bring public engagement, education and communication together in an emblematic new building at CERN. New content and programmes for public engagement and education will be developed for the Science Gateway, which will act as a hub for similar activities developed elsewhere, thereby serving the entire population in the Member States and beyond. The Science Gateway will also become a portal for

[1] The European Strategy for Particle Physics, Lisbon, 2006, statement 15.

[2] The term "outreach" is being replaced hereinafter with "public engagement" to emphasise a more symmetric notion of communication.

[3] The European Strategy for Particle Physics. Update 2013, Brussels.

promoting the connection between the Arts and Science in the field of particle physics in the broad sense (also including astroparticle, nuclear physics and cosmology). With its high visibility, the Science Gateway will likely offer new opportunity for fundraising for public outreach and education projects.

The Working Group had three half-day face-to-face meetings and one video conference call[4]. It conducted interviews with ten stakeholder groups[5] in the executive domain in order to make an inventory of the fields of public engagement, education and communication, and it reviewed all the material of the submissions to the ESG in December 2018[6] and one submission it received directly[7]. This report takes into account all of the above.

2. Public engagement

Particle physics asks deep questions about the physical universe and uses an array of advanced techniques in the search for answers. At the frontier of scientific knowledge, it can play an inspirational and exemplary role in wider society. Moreover, the vast majority of particle physics research is publicly funded and thus requires public consent at least, and ideally public enthusiasm. These factors make it imperative that the field engages openly with wider society. Last but not least, it is not impossible to envisage that ground-breaking discoveries in the field may culturally influence society in the same way as e.g. quantum mechanics has done. Such discoveries require appropriate explanations of the findings and their consequences. Scientists often only fully realise the societal reach of their discoveries through public engagement.

The key audiences are policy-makers (including politicians and funding agencies), our fellow physicists and people working in other sciences and in academia, and the general public of all ages, including the parents and guardians of students who are addressed as part of educational efforts and via schools. The media play a key role in helping us reach these audiences, and are discussed in the "communications" section. However, the community can also engage directly with the audiences via events such as the masterclasses coordinated by the International Particle Physics Outreach Group (IPPOG)[8], through social media and presence at cultural events such as festivals and exhibitions, where collaboration between artists and scientists can be influential[9]. As mentioned in the introduction, the Science Gateway presents a major opportunity to enhance this direct engagement, especially through exhibition space dedicated to CERN.

Many of these activities are "bottom up" in that they tap successfully into local opportunities and enthusiasms and are highly tailored to specific audiences and needs. A key role of IPPOG, CERN and national agencies and institutions is to provide high-quality resources (images, text, equipment, virtual-reality tours) that can be efficiently used to enhance such activities.

We have not been fully effective in communicating the importance and urgency of the open questions in particle physics to fellow researchers in other science domains. The associated risk is that in selection committees for grants and academic positions, research in our field might be less appreciated than research in other fields of science, and this poses a real threat to the funding of our field at all levels.

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4 Face-to-face meetings on 5 May, 17 June and 23 September 2019, video meeting on 30 October 2019.

5 EPPCN (Perrine Royole-Degieux and Arnaud Marsollier), IPPOG (Steven Goldfarb and Hans Peter Beck), Science Gateway (Charlotte Lindberg Warakaulle, Ana Godinho and Patrick Geeraert), Interactions (Arnaud Marsollier), Symmetry (Kurt Riesselmann and Kathryn Jepsen), CERN Courier (Matthew Chalmers), CERN Education Dept. (Jeff Wiener and Julia Woithe), Arts@CERN (Monica Bello), African School of Physics (Ketevi Adikle Assamagan) and New Scientist (Val Jamieson).

6 22, EPPCN, P. Royole-Degieux & A. Marsollier; 24, Biennial African School of fundamental physics, K.A. Assamagan & M.V. Diwan; 65, JUAS & ESIPAP graduate schools, E. Metral, H.F. Hoffman, J. Collot, P. Lebrun & R.L. Holland; 104, IPPOG, H.P. Beck & S. Goldfarb.

7 A proposal for a CERN Education Hub, I. Bearden & S.M. Schmeling.

8 IPPOG web-site: http://ippog.org.

9 See e.g. https://home.cern/news/news/knowledge-sharing/summer-festivals-cern for examples.

Engagement with colleagues in neighbouring disciplines is strongly encouraged, and academic and professional societies can be an excellent route for such engagement (see also the Communication section).

For general audiences, the distinctions between subfields of our discipline are unclear and of little interest. This means that a degree of coordination and resources-sharing with bodies in other fields is mandatory. In this context, the existing coordination with APPEC, NuPECC and the astronomy community is highly beneficial, and it is good to see that IPPOG and APPEC will coordinate their public engagement activities.

3. Education

The viability of particle physics in the long term relies heavily on the proper education and training of the next generation of particle physicists and engineers, who are expected to draw up the subsequent strategic plans, construct and operate accelerator facilities and conduct the corresponding particle physics experiments.

Therefore, the current generation of particle physicists and engineers has a duty to promote and disseminate our knowledge and skills to the next generation. The main mechanism for this is through the establishment and continuation of strong PhD programmes offering advanced thematic schools in particle and accelerator physics, detectors and instrumentation, high-performance computing and data acquisition. To attract students to these high-level education programmes, it is necessary to expose them to particle physics research and the associated technology before they specialise, for example at undergraduate university level or in vocational programmes. This requires a good presence of particle physicists and engineers in these educational programmes, as well as exciting internships and short training programmes. More attention should be paid to undergraduate students acquiring experimentation skills and developing the intuition they require to follow a series of different methodologies.

The basic knowledge of the Standard Model constitutes an essential part of the intellectual achievement of humanity and thus belongs to the global human heritage. It should now become common knowledge for all people. The new European Strategy for Particle Physics should strongly urge the relevant authorities to incorporate the basic features of the Standard Model into primary and secondary school curricula.

Bringing the Standard Model into mainstream education and thereby also modernising basic physics education will help transform young people’s perception of science in general and physics in particular and hopefully motivate them to pursue a higher education in STEM subjects. The earlier schoolchildren are introduced to concepts such as the Standard Model, the greater the chances of sparking an interest in physics in all children, including girls who remain under-represented among particle physicists.

We must maintain strong efforts on secondary education and the training of secondary school teachers. Through the Science Gateway, CERN has an opportunity to become an important education research hub, hopefully attracting funds from non-particle physics sources for the education of the next generation of physicists.

At bachelor and master level the CERN summer students programme is already extremely well organised and should cater for more students from underdeveloped countries, e.g. by allowing online video connections to the lectures.

The particle physics community should make every effort to exploit conventional and state-of the-art distance-learning technologies to facilitate the best possible transmission of knowledge across people,

respecting the rights of all people to education, the values of humanity and the principles of diversity and geographical inclusiveness. These efforts need to be promoted both globally and locally.

4. Communications

The main vehicles of communication within the particle physics community are the CERN Courier and Symmetry magazine online, both with a world-wide reach. The CERN Courier offers a wide range of news and background stories in glossy print format. Recently, the CERN Courier has started to experiment with online media. Symmetry magazine has already gone online, covering hot news as it emerges and providing the necessary background information, along with profiles of scientists and information relevant to potential future scientists. It reaches an audience far wider than the particle physics community and also attracts contributions from scientists from neighbouring disciplines, funding agencies and policy-makers. The CERN Courier and Symmetry magazine cooperate well and thus offer good complementarity and a joint coverage of particle physics stakeholders.

The European Particle Physics Communication Network (EPPCN) was established as a result of the first European Strategy for Particle Physics in 2006. Since then the network has established formal connections with all Member States and has thus become a truly distributed effort rather than an essentially CERN-based activity. The network's effectiveness would be further enhanced if all the present vacancies for professional communicators in the Member States could be filled.

There is a sizable overlap between the national communications officers in particle physics and astroparticle physics. In addition, APPEC has a seat on the EPPCN, which reinforces communication to the officers of large experiments in astroparticle physics. As an example of such synergy, the EPPCN and the CERN communications office were instrumental in coordinating the worldwide announcement of the first detection of gravitational waves from a black hole merger. APPEC currently lacks the resources to staff a professional communications network. With a very modest additional load on its communications officers, the EPPCN could take on that role for APPEC and this would help European particle physics and astroparticle physics alike and constitute a tangible element of closer cooperation between European particle physics and APPEC.

As already mentioned in the section on public engagement, we have not always been successful in communicating the importance of our research questions to people outside our field. On the one hand, communication efforts aimed at the general public have hitherto tended to stress the satisfactory answers we found to questions we had, sometimes leaving the impression that our understanding is complete. On the other hand, our detailed publications in peer-reviewed specialised journals and reports in conferences and workshops do not reach our fellow researchers from other science topics and domains. Due to the conflicting interests of open science and the private publications business, our field hardly ever produces publications in journals that are read by a wide audience of scientists, such as Nature or Science, a factor that works against our field, especially with respect to colleague physicists from other research domains. In addition to engagement through academic and professional societies, we may better communicate our challenges by inviting speakers and lecturers from other fields to our conferences, workshops and topical schools, as well as targeting audiences from other domains. It is also particularly important to engage our scientific colleagues in the challenges we are addressing in the update of the European Strategy for Particle Physics.

5. Conclusion, recommendations and strategy proposals

The particle physics community is highly active in public engagement and the general public's overall enthusiasm for our field testifies to the effectiveness of our actions. This high level of public engagement should be sustained, in both its bottom-up and top-down forms.

Many of our public engagement activities rely on the efforts of individuals, and it is therefore important that such activities are seen as an integral part of being a scientist and are properly valued in terms of career advancement.

Public engagement effectiveness could be further improved by making available even more high-quality visual material and offering training courses on presentations to the general public. IPPOG has been established as a structural collaboration between countries to streamline particle physics education at the high-school level and its role could be further augmented to that of providing public engagement material. There are excellent opportunities for synergy between IPPOG and the public engagement and educational activities of APPEC. *We recommend to the European funding agencies that the funding of all science research is systematically and explicitly accompanied by resources for public engagement activities.*

Another important strand of public engagement is the communication of particle physics results and activities to the news media and social media. The EPPCN has proven to be an effective network for the professional communication of particle physics, and the network's effectiveness would be even further improved if the vacancies for EPPCN representatives for a number of Member States could be filled. *We recommend continued cooperation between EPPCN and the communication arm of APPEC* to strengthen both particle physics and astroparticle physics.

The thriving teacher and student programmes at CERN, in many cases well connected to national programmes, also provide a fertile ground for studying education research. While this is not part of CERN's primary mission, *we recommend that a hub to coordinate and facilitate education research is created at CERN* and that links should be established to similar research hubs in the Member States and elsewhere. Funding for such a hub should be sought in a combination of national and European education research funding channels.

Education and training of the next generation of particle physicists and engineers are crucial to sustaining the field in the long term. Good particle physics university education is guaranteed by the many CERN users in academic positions. *We recommend that vocational education in the fields relevant for CERN should also be supported.* While this is already addressed through internship programmes at CERN and elsewhere, thought should also be given to providing educational material and teacher programmes for middle- and higher-level vocational schools. Especially for globally organised research, it is important to be inclusive and *we recommend support for initiatives to address under-represented groups, e.g. through topical (particle) physics schools in Africa, South- and Middle-America, and parts of Asia*.

The establishment of the Science Gateway at CERN offers an immense opportunity to reinforce particle physics public engagement and education. This opportunity should not be confined to the Geneva region, but should be seized across the whole of Europe. *We recommend that a solid plan is established to engage all the Member States and other interested countries in the Science Gateway developments.*

In addition to **sustaining and extending the existing efforts**, as mentioned above, the Working Group sees two strategic opportunities for the coming 6- to 8-year period:

Proposed strategy statements:

1. *Particle physics can derive more benefit from advances in other areas of science. Support for particle physics often depends on the opinions of fellow scientists.*

> **The European particle physics community must engage more with physicists in neighbouring fields as well as with scientists from other disciplines in order to enhance the understanding of the importance and urgency of particle physics research and to pool and derive mutual benefit from each other's knowledge.**

To achieve this strategic goal, we must engage better in professional societies, funding agency committees and in general be more visible to other scientists. Also, more collaboration with other fields in topical schools (computing, accelerator, …), both in the selection of teachers and in the admission of students, will increase the mutual understanding and may promote increased mobility of talent.

2. *The Standard Model is by now a well-established theory for elementary particles and it should become a structural component of human culture as the next level after the periodic table of elements and the nucleus.*

> **Basic knowledge of the Standard Model should be adopted in the regular school curriculum.**

Changing school curricula across Europe is a mammoth task and the mechanisms for getting this done will vary from country to country. Action will thus be required at multiple levels. At the ministerial level, the onus is on the CERN Council delegations. At the level of proposal and implementation committees and organisations of education professionals, the network of the CERN teachers' programmes can play a role, and the national particle physics communities should also be active.