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Physics and Society

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Strategic importance of dialogue between science and society

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Science and basic research are drivers of technologies and innovations, which are key to find solutions for global societal challenges, like climate change, energy, health etc. The United Nations has summarized these challenges as 17 Sustainable Development Goals (SDGs)[1], providing the global Agenda 2030 agreed upon by most of the countries worldwide. Today, innovation and SDGs are buzzwords gradually gaining public popularity. Educating kids on how to “save the world” through engaging for SDGs and innovating became fashionable and politically correct. Many schools and universities launch programs on SDGs, big number of organizations, initiatives and projects focus on them. However, it is striking how little, if any connection with (natural) sciences they include. Strategic role of natural sciences, fundamental research and STEM (Science, technology, Engineering and Mathematics) education for resolving the challenges, is not sufficiently emphasized and understood, while SDGs are considered as a topic for specialists on economics, law, social sciences, finance and international relations [2]. And thus, the vast majority of the students exposed to programs on SDGs do not even realize that the world needs a new generation of not only innovative thinkers but also of technically skilled specialists who will develop the required technologies. Furthermore, as found by a UNESCO study in 2017 [3], the interest of the young generation in STEM studies is falling, despite jobs in these areas are growing at rate three times faster than in any other sector. Projection given current trend is 7 million of new STEM jobs in Europe in 2025 and not enough skilled people to fill them.

Many young people are fascinated by physics thanks to its mind-boggling findings and intriguing open questions, but find it also too complicated and nerdy, and therefore are not attracted at all. Our subject, however, appeals much more when individuals find out about its direct societal impact and usefulness out-of academia. Apart from general interest in physics, I have chosen my PhD thesis work back in 2004 in thermonuclear fusion because of its potential contribution to linger or solve the world energy crisis. Winners of a recent campaign and competition “Girls, do physics! [4]”, organized by the International Particle Physics Outreach Group (IPPOG) [5], which aimed at showing the growing and di-

verse career opportunities studies of physics do offer, and exemplify the need for equal contribution of both genders to societal challenges, are also very clear about the topic: *“We understood that physics plays a relevant role in today’s technologies and it will do so even more in the future. Its applications, such as hadron therapy among many others, fascinated and encouraged us to study physics and to continue our college education up to completing a Ph.D. We think that the future of science and a good job in this field is waiting for us.”*

To the detriment of all of us, there is a big difference in the perception of the importance of natural sciences, especially physics, between scientists and the rest of the population, whose knowledge is limited to information received through mainstream channels and formal education. The non-scientists find physics too abstract and too mathematical, and also ignore its omnipresence in their daily lives.

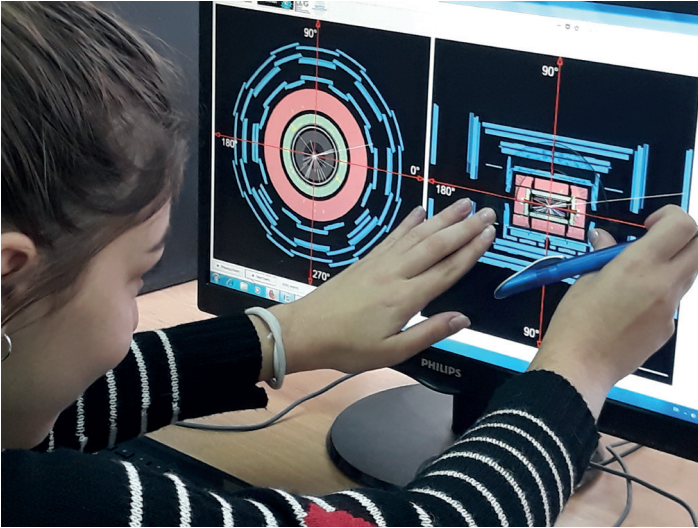
Let’s take an example of CERN, hosted in Switzerland. Try to ask your neighbor, kids, family members or mayor of your city, whether they know about the medical or other applications that are spin-offs from (particle or high energy) physics or the stream of highly qualified people CERN continuously produces after their limited-term contracts have ended, which is the fate of most who land a fellow or staff position with CERN at an early stage in their career, in over 80% of cases bringing excellent technical skills and international experience to business and industry.

Working with a wide spectrum of stakeholder’s groups in the last decades, I have witnessed, that the “unconverted” audiences never look at our subject with the same eyes once they’ve learned about its applications and science-for-peace initiatives. This was confirmed also by a recent survey Creating Ambassadors for Science in Society (CASS) [6], co-organized under the umbrella of IPPOG. *“Many people are not aware that behind all innovations, there is science. I wasn’t aware of most of the inventions coming from CERN, which are currently essential for our everyday lives”*, claims a 16-year old participant.

And to which extent is the scientific community itself aware? Taking an example of CERN again: Do most “Cernois” even know about the 26 start-up companies that are based on CERN technologies, or the hundreds of technology disclosures from CERN, of which 31 have been disclosed only in 2019? Or about the numerous success stories contained within the CERN impact brochure [7] and/or many resources of CERN Knowledge Transfer group [8]. Even though “impact” is gaining visibility and attention, anecdotally, when I presented these facts to my research colleagues only few years ago, they were not fully aware. Yet who else do we expect to be our ambassadors, if not us?

Some in the scientific community are resistant to communicate physics spin-offs because this is not our primary purpose. Yet, millions of people who have lost their income or

The **International Particle Physics Outreach Group (IPPOG)** is a network of scientists, science educators and communication specialists working across the globe with the aim to maximize the impact of education and outreach efforts related to particle physics. It contributes to global efforts in strengthening the cultural awareness in the understanding and support of particle physics and related sciences, in raising scientific literacy in society, educating the public on the values of basic research and in developing and training the next generation of researchers, scientists and engineers. IPPOG collaboration comprises 37 members (30 countries, 6 experiments and CERN as an international laboratory) and 2 associate members.



High school students in Serres, Greece analysing ATLAS collisions during World Wide Data Day 2019 organised under the umbrella of IPPOG. Credits: Mairi Polykapoulou, 3rd Senior High School, Serres, Greece

jobs as a result of COVID-19 are rather more concerned about where their next rent and food payments are coming from, than they are about the couplings of the Higgs boson to Standard Model particles. And yet, these couplings and other in public's eyes seemingly "useless" knowledge [9] are part of the representation of the world that science has built little by little and which is central to our whole culture [10]. In its input to the European Particle Physics Strategy Update (EPPSU [11]), IPPOG clearly states: *"The future projects will require a long-term, world-wide commitment of significant monetary resources and human expertise. It is for this reason that current, well-focused concerted and global outreach and communication efforts to engage the public are already today of vital strategic importance."* [12]

In these current challenging times, when all public finances are being directed to uphold the economy, we will never get the next big experiments "sold" to the public and policy-makers based on the physics case alone, but only when we make clear the whole impact large-scale scientific projects have on society and economy, as is also stated in "The Economics of Big Science" [13], co-edited by the SPS president. Reaching out to non-physicists is more important than ever, especially to those with an indifferent or even negative attitude to science.

When addressing non-scientifically educated people, the strategic information should be proactively communicated to all stakeholders of society (be it students, the general public or politicians), especially the young, who will be future leaders, decision- and opinion-makers. It is crucial that they become scientifically aware citizens and ambassadors of science in society, rather than ill-informed policy makers. While emphasising the crucial role of freedom of creative thinking, which allows for unexpected discoveries from basic research, the information must be provided in a way that non-physicists can relate to, for example eye-opening, surprising and emotionally charged stories about practical applications of curiosity-driven discoveries.

There is no shortage of examples, particle physics and CERN being only one of the rich sources of these, by far not limited to the invention and development of the world wide web more than 30 years ago. Take also touchscreen technology developed first at CERN about 40 years ago;

humanitarian satellite mapping for disaster risk reduction, water security and more, being done almost for 20 years by UNOSAT hosted at CERN and using its computing infrastructure. Millions of patients are being diagnosed daily thanks to medical imaging tools like PET and MRI, without even thinking about where the technology comes from. More recent medical developments include innovative radioisotopes from MEDICIS for precision medicine and theranostic or first 3D colour X-ray images of the human body and its organs. Superconductivity potentially usable for long distance electricity transport, is also enabling to reduce the size of cancer therapy machines in compact synchrotrons and novel gantries. Environmental impact is also in the spotlight: CERN spin-off Planetwatch develops a global network of air quality sensors (which are already deployed in Italy), of fiber optics sensors FOSS4I to help improving water and pesticide management, or the cosmic rays studies with the CLOUD experiment and giving crucial input to climate models, where solar activity and the impact solar wind has on cloud formation needs to be included. CERN open-source software INVENIO is used for digital preservation of libraries, for example in the UN. CERN computing resources have been heavily deployed in many useful ways, including the fight against the current pandemic. e.g. CERN Openlab BioDynamo software for simulating the spread of COVID-19, ZENODO for data-sharing, ROOT for research of vaccine production etc. Sensor technology TERABEE used in drones to explore places with difficult access or high-risk proved to be also helpful in context of the current and therefore also of any possible future pandemic.

All these and also the examples of CERN science diplomacy, like cold-war agreements and peace-building in turbulent parts of the world, e.g. Middle East (SESAME [14]) or Balkan (SEEIIST [15]), through scientific collaboration for the benefit of society (like hadron therapy for cancer), can be powerful, but only to the extent of how known they are in all societies. IPPOG has been making efforts in this direction since few years having two working groups dedicated to creating the tool for scientific community and outreach materials not only to explain particle physics to lay audience but also to justify the basic research, including recommended reactions for potential provocations from media and general public engaging stories about applications.

Considerable effort is needed to firstly collect and write these stories, and secondly to communicate them proactively and efficiently. Through the knowledge transfer and R&D involved in applications development, industry represents direct link from science to society. The potential of captains of industry as outreach partners and ambassadors for physics research and education is not to be underestimated. Even though this avenue of innovative outreach – as described by European Committee for Future Accelerators (ECFA) [16] – could considerably increase the societal impact of already successful and fruitful academia-industry collaboration, it has not been much exploited yet.

"In a confusing world of endangered reasoning we have to strengthen the trust in science and its method of evidence-based decision making to offer future generations a meaningful base that generates supportive structure in their life", advocates IPPOG [12]. Science is the key for fact-based and thus sustainable decision making to preserve our planet and humanity. As the CERN DG rightly states *"Soci-*

ety as a whole can learn from the way science works.” [17]

Credibility and trust in science, needed for establishing deep appreciation of fundamental research, can only be built by scientists themselves, while working hand in hand with professional communicators, but not relying only on them. Extracurricular activities, like those offered by IP-POG, CERN, other institutions and individual initiatives, are of crucial importance to foster the deep societal values, scientific research has, often misperceived among the public at large. This is especially relevant as school physics curricula, where modern physics is hardly taught, often fail to teach the scientific method or to create the fascination that is coming from understanding the laws of nature; however, changing of curricula is a long-term process [18]. A participant at one of the IPPOG events [6] puts it this way: “*I always found it dry and detached from the real world, but I learned that physics can be extremely fascinating and relevant, and I now realized that I actually enjoy physics, just not what is taught in our school curriculum.*”

Building bridges between science and society, strengthening the dialogue between scientists and politicians, bringing forward the fact-based and multidisciplinary decision making process and open global collaboration are clearly recognized as crucial elements for ensuring the promising future for humanity. There are numerous international and national bodies and projects, promoting Science Diplomacy, including the European Commission [19,20], UNITAR [21] and Inter-Parliamentarian Union (IPU), while the Swiss government is also strongly supporting these topics [22,23]. During the 2019 General Assembly of the IPU [24] in Geneva the importance of inspiring the young generation, especially girls, to study STEM subjects, was also highlighted at the common workshop with CERN.

The fact that these subjects are gaining momentum is very positive, because in societies with lack of sustainable leadership (i.e. with long-term well-being of society and planet in mind) [25,26], Science Diplomacy is needed more than ever. Scientists should develop proactive strategic ap-

proach and even consider becoming active in policy making following the shining example of those who made large impact like science ministers (e.g. in project SEEIIST [15]), chief science advisors and even public scientific personalities, like Einstein. One of the most alarming examples why is this so important is greenhouse gases - induced climate change, whose catastrophic impact was understood since over half a century, based on early works of many, going back to French physicist Joseph Fourier around 200 years ago [27]. Scientists need to participate in decision making.

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