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Editorial: Applied Nuclear Physics at Accelerators

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Editorial on the Research Topic

Applied Nuclear Physics at Accelerators

Nuclear physics has seen continuous application in many fields of science [1]. The fields span from energy to the environment, geophysics, materials research, astrophysics, and, of course, biology and medicine. Nuclear Physics plays a prominent role both in the diagnostics and therapy of different diseases [2].

Particle accelerators are fundamental tools in nuclear physics, and many applications are based on their technology. There are of course many kinds of accelerators that span a very wide range of energy and accelerate different types of particles. The number of particle accelerators in the world has increased rapidly in the past years, reaching a total number of about 40,000 excluding X-ray tubes and electron microscopes [3] (**Figure 1**). In spite of that, as shown in **Figure 1**, the number of large, high-energy accelerators in science has remained approximately constant in the twenty-first century. A possible motivation for this trend is the cost of such accelerators, which requires large national investments. It is not surprising that these large and expensive machines include intense applied physics programs [4] in order to provide direct benefits to society.

The largest nuclear physics accelerator under construction is the Facility for Antiprotons and Ion Research (FAIR) built by the GSI Helmholtz Center in Darmstadt (Germany) [5]. However, many other accelerators are under construction or in operation in Europe, Asia, South Africa, and America. Those new facilities are also either planning or upgrading the applied physics programs, mainly focused on biology and medicine.

The aim of the effective coordination of these efforts has led to the creation of the International Biophysics Collaboration, which goes beyond FAIR to involve many other accelerator facilities described in this special issue (Patera et al.). The biomedical applications depend on the intensity and energy available at accelerators. While many applications are possible with current machines, even more can become available at higher energies and intensities, such as those now achieved in the new machines.

The special issue had over 60 submissions, and with 56 accepted manuscripts it is one of the biggest in the *Frontiers in Physics* journal. This clearly shows the interest and relevance of the topic. Over half of the manuscripts are related to topics that can be already studied by means of the present accelerators, such as dosimetry (Bourgouin et al.; Kokurewicz et al.), imaging (Fiorina et al.; Magalhaes Martins et al.), radioisotope production (Niculae et al.), radiobiology (Fisher et al.; Schielke et al.), measurements of nuclear interaction cross-sections (Battistoni et al.; Norbury et al.), beam delivery (Bottura et al.; Dauvergne et al.), treatment planning (Gajewski Schiavi, et al.; Gajewski Garbacz, et al.), and modeling (Bellinzona et al.; Muraro et al.).

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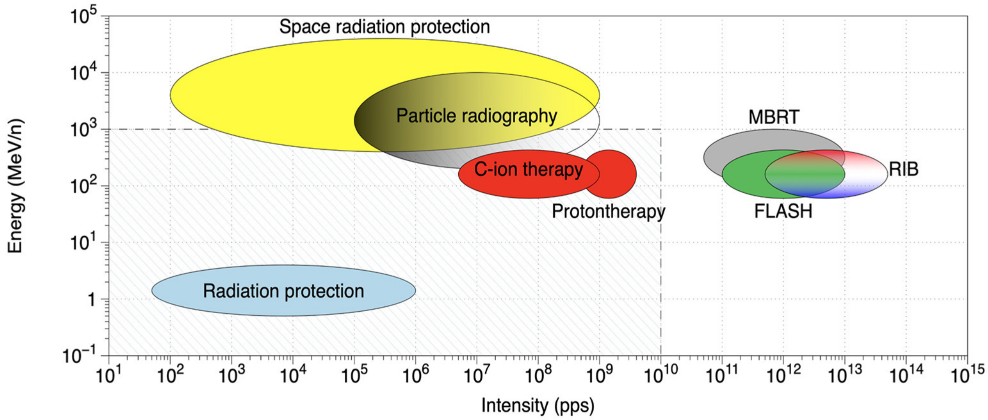

FIGURE 1 | Evolution of the number of accelerators worldwide in the past 50 years. The plot is based on data reported in [3] and is reproduced from [4] under Creative Commons license (CC BY-NC 3.0).

These papers give an overview of the activities ongoing at a particle accelerator in cancer therapy, basic radiation damage studies, and radiation protection. The remaining manuscripts deal with new topics that can be studied at new accelerators. A total of 10 papers focus on experiments that benefit from the higher intensity or from innovative delivery modalities of new accelerators, such as minibeam irradiation (Dal Bello et al.; Guardiola and Prezado), radioactive ion beams in therapy (Durante and Parodi), and ultra-high dose rate (FLASH) radiotherapy (Di Martino et al.; Vignati et al.). A sizeable part of the issue covers Research Topics that will benefit from the higher energy that can be achieved in new accelerators for space radiation research (Höeffgen et al.; Schuy et al.) or particle radiography (Alme et al.). This special issue has the goal to report the present landscape and the outlook of accelerator facilities, within and outside Europe, where the research into nuclear physics and biophysics applied to medicine and space is likely to have an important development in the next 10 years. With this in mind, seven papers now describe new facilities under construction (Amaldi et al.; Aymar et al.; Cirrone et al.; Patera et al.) and new concepts and ideas for accelerator experiments (Kim et al.). Last, but not least, this issue embeds also a paper related to the use of ionizing radiation in the quest for the COVID-19 vaccine (Durante et al.).

The variety of the topics in the issue and the great success of the initiative are very promising for the future application of accelerators to biology, medicine, and other sciences. The benefits of accelerators in society are already solid and evident, and they are likely to expand further in the near future.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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