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WHEN RESEARCH FINDS APPLICATIONS

Interview with Valter Bonvicini, INFN researcher and chair of the INFN Scientific National Commission 5, dedicated to the coordination of applied research activities

The achievements of the research carried out at INFN are increasingly exploited in areas other than fundamental physics. This is due to the ambitious research objectives of frontier physics experiments. The need to push technologies beyond the limits of existing possibilities often leads to the development of solutions whose high performance can easily be applied inmany sectors. INFN, in particular, is a solid reference at the national and international level for applications related to the development of prototypes and to the creation of today's particle accelerators. Those technologies find application in other research fields and in areas with several and econiomic impact, such as medicine, sensors, electronics, information technology and materials analysis. The INFN National Scientific Commission 5 was established to coordinate technological research and the development of applications of the methods and technologies developed at INFN.
We asked Valter Bonvicini, chair of the Commission, to describe the main lines of research and development in which INFN is investing currently and in the foreseeable future.

Which are the main interdisciplinary applications of the techniques and technologies developed at INFN in recent years?
They are many. Developments in the fields of radiation detectors, electronics, accelerators and calculation techniques are in fact extremely important applications in very different scientific fields: in medicine, for example, both from the point of view of diagnostic imaging as well as treatment, in radiobiology, in the cultural heritage sector, in environmental physics, in geology and volcanology and in the space sector.

How do you define an investment strategy in a sector that depends so strongly on other INFN research activities? What did CSN 5 choose to invest most in and based on which criteria?
In my opinion, it is necessary to act on two levels. The starting point is always frontier R&D for the "core"

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activities of the institute. This involves pushing technologies beyond the existing limit, exploring new solutions and new approaches that, in turn, will open new paths for interdisciplinary applications. One of the many possible examples: the new charged particle plasma acceleration techniques could help in the future to implement a technology for building particle accelerators with high accelerating fields and small dimensions compared to conventional accelerators. In perspective, this is of course extremely interesting for high energy physics, due to the possibility of building compact accelerators, but this technology can also open the road to a whole range of applications in other sectors, such as hadron therapy using ion beams accelerated through laser-plasma interaction.
The other level consists of rationalising and directing the efforts of the scientific community on cutting-edge and high-impact projects, instead of dispersing the resources available in a large number of limited impact experiments. In this sense, to better fulfil its coordination and steering role, the CSN 5 has also adopted new funding mechanisms ("Calls for proposals") that are effective scientific policy instruments.
To answer the last part of the question, among the strategic and growing scientific sectors in recent years, I would mention accelerator technologies and the developments related to oncological hadron therapy (radiobiology, dosimetry, calculation, treatment plan simulation and modelling and detectors).

Is it possible to make a rough assessment of the socio-economic impact of a new technology when it is developed?
Scientific and technological advances have always had an impact not only on society but also on economy. Often, the potential socio-economic impact of a new technology is clear (or at least perceivable) from the outset, while sometimes it becomes evident only as the development progresses. For example, since the last decades of the last century, Artificial Intelligence has undergone an impressive development which is already revolutionising society and economy and which will have even more marked effects in the near future. The computing power available increases exponentially every year and, thanks to this, machine learning techniques are now possible: computers "learn by themselves" to improve the performance of an algorithm, using statistical methods on a huge amount of data.
Another very active field of research, whose overall socio-economic repercussions are however more difficult to estimate at the moment, are quantum technologies; however, considering only their possible application to particle physics, I'd say that the most promising aspects concern quantum sensors and certain aspects related to quantum computation, such as the development of algorithms that can be used in future quantum machines.

How does the idea of applying a technology developed to study particles to a completely different

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area come about? Is it necessary to constantly dialogue with other scientific and industrial realities?
In interdisciplinary applications, the relationship and continuous discussion with the scientific community to which the application is addressed is fundamental. One always starts from the idea of the researcher, but this must be subjected to a proof of principle and then gradually tested and validated with the methodologies of the scientific community to which it is addressed. For example, in the development of a new diagnostic imaging system, interactions with the medical community must begin immediately to understand, first of all, if there is an effective interest in the proposed development in relation to the state of the art in the industry. Then, the prototype must be tested and validated with preliminary, pre-clinical, clinical, and other studies. All this presupposes a complete collaboration with the community of reference (doctors, in this case).
Also for what concerns any industrial applications, communication and collaboration with companies are essential right from the outset. Here our scientific community can count on the functions responsible for coordinating INFN Technological Transfer activities, in order to protect intellectual property, file patents arising from the research activities and for everything related to exploiting innovative skills. It is certainly not surprising that the majority of patents in the institute's portfolio derive from research activities conducted in CSN 5. Ultimately, the close collaboration between CSN 5 and Technology Transfer is natural on the one hand, and fundamental on the other.

Your activity as an experimental physicist concerned and above all concerns the development of detectors for particle physics and astroparticle physics experiments, with the search for antimatter in cosmic radiation. What led you to coordinate the commission that promotes technological application of the skills acquired in research work?
Basically, the belief that CSN 5 is a great resource for our institute. In fact, our Commission plays some fundamental and quite peculiar roles within INFN: it is above all the "forge of ideas", where frontier technologies are proposed and developed for the future experimental activities of INFN; it is the place where scientifically and socially important activities are supported, such as those linked to the interdisciplinary field; and finally, it is the natural incubator where certain activities grow and develop, which then have potential for application and exploitation in the industrial field.
These unique and distinctive characteristics must, in my opinion, be safeguarded and further developed, within a general context that, on the one hand, sees a continuous contraction of the "ordinary" resources of the institute and, on the other, the consequent increasing importance of enhancing the competitiveness of INFN in the acquisition of external funding through participation in competitive tenders. In this way, also the introduction by CSN 5 of grants for young researchers is part of a strategy that aims to foster

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the scientific autonomy of our young people and allow them to gain experience in the preparation, management and scientific execution of projects on key topics for the technological research of the institute.