



NEWSLETTER 22

Italian National Institute for Nuclear Physics

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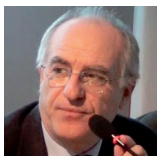
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INSTITUTIONS

THE ITALIAN PREMIER MATTEO RENZI VISITS FERMILAB

During his latest visit to the USA, the Italian Prime Minister, Matteo Renzi, visited the Fermi National Accelerator Laboratory (Fermilab), one of the most important particle physics centres in the US, with

which Italy, through the INFN and important Italian companies, leaders in frontier technologies, has signed numerous research and collaboration agreements. During the visit, the Prime Minister was accompanied by a delegation of Italian physicists, including Nobel laureate Carlo Rubbia, Panofsky prize winner Luciano Ristori and the Italian physicists Antonio Masiero (INFN Vice President), Giorgio Bellettini, Sergio Bertolucci and Carlo Pagani.

Since the 80s, many Italian researchers, more than 130 in 2015, have been working at Fermilab with important roles. They are engaged in experiments studying neutrinos, with NOvA, LBNF/DUNE and ICARUS - conceived by Carlo Rubbia and in operation, before being included in the Fermilab programmes, at the INFN Gran Sasso Laboratories as part of the CERN Neutrinos to Gran Sasso project - and experiments studying muons, as Muon g-2 and Mu2e. As part of the muon research programme, a major order for the accelerator magnets has been placed with Italian industry. Another important joint research front is the study of dark matter with the Dark Side experiment at the Gran Sasso National Laboratories, based on argon purification, made possible thanks to the know-how of Fermilab and the technologies of Italian industry. Theoretical physicists, on the other hand, are engaged in studies on the QCD lattice and simulations. Every year, moreover, the Italians at Fermilab Association, through the INFN, funds 20-30 summer scholarships for physicists and engineers who follow a study programme at the American laboratory. ■



INTERNATIONAL COLLABORATIONS

FIRST ITALIAN-CHINESE JOINT FELLOWSHIP BETWEEN IHEP AND INFN

The first joint Fellowship between the Institute of High Energy Physics (IHEP) of the Chinese Academy of Sciences (CAS) and the INFN got underway. The fellowship was awarded to researcher Lia

Lavezzi, associated with the INFN Division of Turin and since approximately one year member of the Beijing Spectrometer III (BESIII) International Collaboration.

Lia Lavezzi will play an important liaison role, supporting the two-way technology transfer between INFN and IHEP in the construction of the Cylindrical Gas Electron Multiplier Inner Tracker (CGEM-IT) detector for the BESIII Collaboration spectrometer. She will be also involved in strengthening the impact of innovative technologies on the collaboration between IHEP and the Italian group of INFN researchers in BESIII. In particular, Lavezzi, in collaboration with the IHEP colleagues, will be involved in modifying the tracking algorithms and reconstruction of the BESIII experiment, in order to best exploit the potential of the CGEM-IT detector. A highly innovative detector, the latter, funded firstly by the Ministry of Foreign Affairs and International Cooperation (MAECI) within the scope of the Italy-China Executive Programme, and also by the European Union within the scope of Horizon 2020. Its construction, using entirely Italian technology, and its funding process were mentioned during the recent visit of the Minister of Education, University and Research, Stefania Giannini, to IHEP in November 2015, as a virtuous example and as the start of a new phase in Italian-Chinese scientific cooperation. ■



ADVANCED EDUCATION

GRAN SASSO SCIENCE INSTITUTE STABILISED

With the signing, which took place on 8 April 2016, by the Minister of Education, University and Research, Stefania Giannini, of the decree law on the functionality of the education and research system, the

Gran Sasso Science Institute GSSI was stabilised and established via a spin-off from the INFN.

The GSSI, an international PhD and advanced education school, activated by the INFN at L'Aquila in 2012 as its National Centre for advanced studies, has been awarded a grant of 3 million euros as from 2016. This represents an important step for the future of an innovative institute which, just a few years after its establishment, has managed to stand out as a centre of excellence at the international level, being able to attract prestigious professors and dozens of students from abroad every year. Its international character is also demonstrated by the fact that 50% of students come from abroad. ■

» INTERVIEW



LHC: COST-BENEFIT ECONOMIC ANALYSIS TO 2025 AND BEYOND

Interview with the economist Massimo Florio, professor at the University of Milan

In April, CERN of Geneva and INFN organised the FCC Week, an international conference which brought together around the table in Rome 450 scientists from around the world to discuss the Future Circular Collider (FCC) concept. The conference was attended by the economist Massimo Florio, Professor at the University of Milan, who worked on the first study on the impact of a scientific research infrastructure. The Cost-benefit analysis of the Large Hadron Collider to 2025 and beyond was concluded in July 2015, with the benefits outweighing the costs.

Professor Florio, what is the context underpinning your study on the impact of a major research infrastructure such as the LHC?

Three years ago, a call was issued by the European Investment Bank, which has its own grant programme dedicated to Universities on issues of interest to the EIB. So we formed a team of experts, twenty or so people, from the departments of economics and physics of the University of Milan, and from the Centre for Industrial Studies (CSIL), including economists, statisticians, physicists and professionals with analysis experience of traditional infrastructures, such as bridges, motorways or railways, who had collaborated on the implementation of the guidelines of the European Commission on the subject, since 1994, the year of their first edition. The European guidelines, however, did not previously include specific chapters dedicated to methodologies on the cost-benefit analysis of research infrastructures. So the analysis work carried out on the LHC was the first study on this type of major infrastructures.

In our study we decided to propose two case studies: we examined two similar machines, i.e. two hadron accelerators, one used for basic research, the Large Hadron Collider at CERN, and one used for applications, in particular in the medical field, the National Oncology Hadrontherapy Centre (CNAO) in Pavia, where the accelerator is used to treat patients suffering from tumours which cannot be

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treated with conventional radiotherapy. We therefore tried to apply a methodological approach for two different cases but which envisage the use of the same type of machine, even if of course on a different scale and with different objectives. As already mentioned, we were aware that since the existing guidelines did not include a specific chapter on these infrastructures, we would have had to develop a new methodology. So, we started from a conceptual model that we developed during the first year of our work, while the next two years were dedicated to analysing these two case studies in detail. The EIB was interested in our study because in recent years it has started receiving numerous requests for funding for the construction of research infrastructures, hence the need for tools enabling it to make its own impact analyses, as it does for other large infrastructure projects.

What considerations did you make to identify the methodologies to be used for the impact assessment?

What we did in our study was to apply to research infrastructures a number of methodologies already known but which had never been combined together in this specific way. In particular, we analysed the costs, or more precisely the aggregation of costs incurred by the different entities. In the case of the LHC, the system is extremely complex: it is necessary to consider, for example, the accelerator construction costs, those for the experiments and supplies in kind. The cost study was, therefore, very challenging, despite the significant collaboration of CERN in putting all the necessary information at our disposal.

Subsequently, we assessed the benefits. Here we distinguished between user benefits and non-user benefits, i.e. between the benefits of the direct users of the machine and the benefits to civil society.

We therefore considered the main system of measurement of scientific output, i.e. publications in specialised journals, the long-term benefits for students and post-docs, i.e. for young researchers, and the benefits deriving from what we call "scientific tourism", i.e. visitors to CERN, approx. 100,000 per year, considering the infrastructure as a cultural centre, a museum or an archaeological site, or rather a 'science city'. For each of these components we used economic analysis methodologies.

What first of all is the impact of the benefits on the direct users of the infrastructure?

As regards publications and scientific output, the impact is relatively small compared to other benefits because, although involving large international collaborations, when compared with other research areas, the number of users is nevertheless limited.

The major benefit, on the other hand, regards the careers of young researchers. We needed a time horizon, so we took 2025 as the reference date, when the High Luminosity LHC project (see interview with Lucio Rossi in Newsletter14, August 2015, ed.) will be launched. In this perspective, if we consider the plethora of PhD students and post-docs, we arrive at approx. 36,000 young researchers. Since we can assume that the effects will last for approx. 35 years, then the fact

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of being able to include this experience in one's CV produces a considerable overall impact. We conducted interviews with 400 people, including current and former students, asking them on a given scale in which range they positioned the "LHC effect" on their careers; a significant positive effect emerged which was convergent for both current and former students.

As for companies, on the other hand, we calculated the incremental profits from potential incremental sales of technologies developed for LHC, i.e. the impact of being included in the supply chain of advanced technologies. In this case, we also had previous surveys conducted by CERN at our disposal, based on which we were able to conclude that for every euro of high-tech supplies to CERN there were 3 euros of additional sales to other customers. We considered the years from 1991 to 2013, considering more than one thousand companies. For a total of 333 CERN suppliers, we were able to examine the history of the financial statements before and after the supply event. Here we found a discrepancy between hi-tech and traditional companies, as expected: in the case of hi-tech companies, we measured a statistically significant and positive effect on profits. Among other things, we also considered the significant social impact on computing, thanks to the availability of advanced software for free to thousands of users, also in industry and in hospitals.

Finally, as regards the effects that we could call "cultural", we used a method that is used in the US for natural parks: the so-called travel cost method, which we could summarise by reflecting on the fact that, when a visitor goes to visit a cultural site, such as a museum, its impact is not given so much by the cost of the ticket to enter the site, but by everything the visitor does before, during and after his visit. In the analysis we also considered the wide-ranging effects, for example, itinerant exhibitions implemented by CERN, visits to web sites and the media impact.

The impact of the benefits on civil society is also part of your assessment.

The benefits for those not directly using the infrastructure, the non-user benefits, are conceptually of two types. The first concerns the potential for scientific discovery: i.e. what it brings in terms of future uses. But asking ourselves today what we could do tomorrow with the Higgs boson creates confusion and rhetoric. It is the scientists themselves who tell us that this factor can not be evaluated, it is not possible to make its cost-benefit analysis. So we decided to assign it the value 0, which means that we consider its impact unpredictable for the time being, but certainly not negative.

The second concerns the willingness to pay, even by those who have no interest in using the infrastructure. Let me make a familiar example: the panda. There are people willing to pay to see it but there are also those who are willing to pay just to know that it exists, to preserve it from extinction: this is called *non-user willingness-to-pay, existence value*. In this case we made an experiment with one thousand students (including non-scientific courses) of four European universities, two in large cities (Milan and Paris) and two in smaller cities (Exeter and A Coruna in Spain), on their willingness to pay for the existence, in this case, of a major research project, the LHC to be precise.

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In conclusion, overall in our study we extracted the average and distribution of the discounted difference of costs and benefits (net present value), using for the calculation of the probability distribution the Monte Carlo methods, also known in the physics world, and we obtained a 90% probability of the benefits outweighing the costs.

Did you identify any weaknesses in major research infrastructure projects?

For large infrastructures, from transport to energy and the environment, governments adopt coded social cost-benefit analysis procedures. For research infrastructures, the decision-making process is fragmented, based on intrinsic ad hoc criteria, such as the scientific reasons, so it is difficult to carry out a systematic analysis. But, since civil society pays the bill through taxes, a commitment to make the decision-making process more transparent and to conduct a social impact assessment is also necessary. A criterion complementary to the scientific criterion, but necessary, also because there is competition between different projects.

Do you think that the approach used in this study can also be applied to other cases?

Yes, we believe that this methodology can also be used for new infrastructures, so much so that the ESFRI (European Strategy Forum on Research Infrastructures) in its latest report (Strategy Report 2016) mentions us, underlining that in the area in question there is progress and it is open to the study of these cost-benefit analysis methodologies. In addition, the 2014 edition of the Guide to Cost-Benefit Analysis of the European Commission now has a chapter that we wrote on this subject.

You will be appointed by CERN to make a similar assessment for the FCC project.

We are thinking about this appointment. Our idea is to apply what we have learned in conducting the LHC study, although in this new case, of course, specific criteria and expedients will need to be adopted since it is a totally ex-ante assessment, with a variety of possible scenarios, given that the scientific community is still in the discussion stage of the project concept. Also this time we will work with a team of economists and physicists, with a coordination group comprising representatives of CERN, the University of Milan and CSIL, within the broader framework of the FCC Study, also considering the prospects of the High Luminosity LHC. The interdisciplinary approach is very stimulating and fruitful. ■

» FOCUS ON



THE ITALIAN ACCELERATOR FOR THE INTERNATIONAL FUSION MATERIAL IRRADIATION FACILITY (IFMIF/EVEDA), IN JAPAN

The commitment of the international community in the design and testing of nuclear fusion reactors for energy production has been constant since the second half of the last century. Nevertheless, there are several critical aspects in the realisation of power plants of this type; among these, are the degradation effects on the materials implied in the construction, which are due to the large amount of high energy neutrons produced in the fusion reactions. In order to permit the proper design and validation of such plants, an intensive study phase of the mechanical properties of the reactor materials when bombarded by intense flows of high-energy neutrons, is therefore compulsory. For this purpose, in the frame of the ITER (International Thermonuclear Experimental Reactor) project, the International Fusion Material Irradiation Facility (IFMIF) will be built by an international collaboration with major contracts won by the domestic industry. Main objective of IFMIF will be the production of an intense source of neutrons with energy and flux equivalent to those that will characterise future nuclear fusion plants.

The preliminary phase of IFMIF (which is named IFMIF EVEDA - Engineering Validation and Engineering Design Activities) is the result of a collaboration between Europe - with Italy, France and Spain responsible for the accelerator and high-tech instrumentation - and Japan, which provides the infrastructure and site for experimentation in the coming years, in Rokkasho. Here, in April, a ceremony was held for the delivery of the RFQ (Radio Frequency Quadrupole), built at the INFN National Laboratories of Legnaro as the Italian contribution to the very high intensity LIPAc (Linear IFMIF Prototype Accelerator) accelerator, prototype of the IFMIF.

Designed and built by a team of physicists and engineers from LNL and from the INFN divisions of Padua, Turin and Bologna, thanks to a special allocation of 25 million euros to INFN by the Minister of Education, University and Research (MIUR), the radio frequency quadrupole (RFQ) of the IFMIF prototype accelerator is a very advanced system, capable of producing the maximum intensities of

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the accelerated particle beam. It has as its ultimate goal the production of very intense neutron fluxes to bombard the materials that will be implied in the construction of critical parts of future nuclear fusion power plants. The RFQ consists of a ultra-pure copper structure, approximately 10 metres long, constructed with high mechanical precision criteria, capable of accelerating a continuous and very intense beam of deuterons (deuterium nuclei) up to 5 MeV.

The INFN is one of the few research institutes in the world capable of providing the technologies and skills necessary for the construction of accelerators of this type. After the design and production of the prototypes and of the most complex parts, implemented within the INFN, the construction was awarded, under the supervision of INFN, to specialised companies via international tenders, in which Italian companies obtained particularly encouraging results, demonstrating the validity of Made in Italy also in areas such as very high-precision mechanics and electronics for power radiofrequency. ■

ITALIAN NATIONAL INSTITUTE FOR NUCLEAR PHYSICS

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