



Nuclear physics midterm plan in Italy: introduction to the series

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Abstract In this contribution, the motivations for a Focus Point on the future nuclear physics researches in the Italian laboratories are described. The organization of the preliminary workshops and of the final reports in this series is described.

1 Introduction

In the next years, the upgrade programs of the Italian National Institute of Nuclear Physics (INFN) laboratories will be completed: SPES at the Laboratori Nazionali di Legnaro (LNL: <https://web.infn.it/spes/>), POTLNS at the Laboratori Nazionali del Sud (LNS: <https://potlns.ins.infn.it/en/>), the LUNA-MV accelerator of the Bellotti Ion Beam Facility at the Laboratori Nazionali del Gran Sasso (LNGS: <http://l.infn.it/lngs-accel>). In addition, important decisions must be taken at Laboratori Nazionali di Frascati (LNF) concerning the possibility to still continue Daphne operations for physics researches in the next few years, while the Eupraxia complex will be built with possible involvement in the field of nuclear physics studies.

These new facilities will open up new opportunities to the nuclear physics community. Therefore, it is timely and beneficial to carry out a scientific dialogue on the foreseen prospective physics program till the end of the decade. It will be fundamental to better understand the nuclear structure and the dynamic of the interactions, while nuclear astrophysics will look for high sensitivity measurements of processes of interest for stellar evolution. In any case, higher statistics and searches for more rare decays will be the main challenges from the experimental and theoretical side.

Moreover, the above programs will require a careful R&D on new, more performing detectors that could benefit from the many technological developments presently underway. Studies on new detectors and new readout electronics capable to manage large volume of data are a mandatory to achieve the goals of the future researches. As a consequence, it is important to spread the specific knowledge on a larger community and to have moments for discussions and exchange of ideas.

Next years will also be fundamental to prepare the basis for the nuclear physics experiments beyond 2030. To this purpose, it is necessary to combine all future physics possibilities with the developments of new detectors and propose new experimental facilities for the laboratories. Such a preparatory work is important also within a wider context, considering the programs currently underway and planned at the European and international level.

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To address all these issues, the Nuclear Physics Division (CSN3) of INFN decided to organize a series of workshops in the Italian national laboratories as described in the next section. The present EPJ Focus Points will report on the outcome of these workshops, gathering all related documents in a unique site.

As a reminder, the CSN3 is organized into six main research lines (following the NuPECC research structure) that however have strong interconnections: Quarks and Hadron Dynamics, Phase Transition in Hadronic Matter, Nuclear Structure and Reactions, Nuclear Astrophysics, Symmetries and Fundamental Interactions and Application and Societal Benefits (<https://web.infn.it/csn3/index.php/en/>). A review of the CSN3 activities in Nuclear Astrophysics is available in [1], whereas the large variety of knowledge developed on particle identification within CSN3 was reviewed in [2].

2 Defining the nuclear physics midterm plan in Italy

On the occasion of the celebrations for the 70th anniversary of the INFN, a series of workshops on *The Nuclear Physics MidTerm Plan in Italy* was organized by the CSN3 of INFN with the goal to provide a unique opportunity for the entire experimental and theoretical nuclear physics community to come together to document a scientific vision for its future in Italy. In particular, this exercise challenged the interest and passion of the new generation of nuclear physicists who will be the leading forces in the exploitation of the new facilities.

The workshops involved national and international potential users of the INFN national laboratories, over a broad range of topics spanning from applications to nuclear astrophysics and nuclear structure and dynamics. The contributions and participation were organized in specific working groups coordinated by conveners, with the task of discussing the items in the preceding months and prepare a summary report during the final events in the laboratories. More details are available at the workshop website: <https://web.infn.it/nucphys-plan-italy/>. The task of each working groups was to identify the most important questions in the field of nuclear physics and the tools to address them, underlying possible synergies and complementarities among the nuclear physics laboratories in Italy and the different experimental campaigns, including theoretical developments.

Four workshops were organized during 2022, one per INFN laboratory. At LNS on April 4/5 (for more details please check the event website: <https://agenda.infn.it/event/28717/>), at LNL on April 11/12 (<https://agenda.infn.it/event/28738/>), and at LNGS on October 11 (<https://agenda.infn.it/event/31580/>). The last event took place at the Laboratori Nazionali di Frascati (LNF) on December 1/2 (<https://agenda.infn.it/event/32709/>) discussing the physics program of LNF and setting up a roadmap for future detectors in the field of nuclear physics.

Table 1 reports few information on the attendance, including the participation to the working groups, to the events (carried out on hybrid mode), and the participation of researchers from foreign institutions.

3 From the meetings to the reports

In parallel with the organization of the workshop and under the coordination of the conveners, documents have been prepared to report on the outcome of the discussions and on the new physics ideas from each working group.

The present Focus Point contains four papers (besides this introductory one), one for each national laboratory. A fifth document is focused on the R&D for future detectors. The contributions describe the present status of the facilities, the oncoming developments, and a summary of the research activities carried out by each working group. A tentative timeline for the execution of the physics program is also given in tabular and graphical form, using hyperlinks to connect items to the relevant section of the papers. The proposed physics projects are labeled as Phase A if feasible already at the start of the operations, Phase B in case of small upgrade/additions to the experiments are needed and Phase C when the full machines performances are required as well as important experiments update.

The chapters and the sections of each paper closely follow the structure of the workshops and are the outcome of the discussions chaired by the conveners. An executive summary at the beginning of each report is also present to guide the reader through the discussion.

Table 1 Some statistics of the four events

Event	Number of WG	Number of participants to WG	Number of participants to the final events	From foreign institutions (%)
LNS	4	160	270	29
LNL	4	180	279	27
LNGS	3	75	90	10
LNF	7	170	223	10

Though mostly focused on experimental nuclear physics, a significant involvement of the theory groups has been fostered during the meeting.

It should be underlined that few topics requiring further specific discussions have been identified as a follow-up of these meetings. In the near future, they will be the subject of dedicated workshops, with the same structure, that are here anticipated. As a consequence, more contributions are expected to appear in the present Focus Point.

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References

1. Brogini, C, et al. Experimental nuclear astrophysics in Italy. *Riv. Nuovo Cim.* **42**, 103 (2019). <https://doi.org/10.1393/ncr/i2019-10157-1>. arXiv:1902.05262 [nucl-ex]
2. Badalà, A, et al. Trends in particle and nuclei identification techniques in nuclear physics experiments. *Riv. Nuovo Cim.* **45**, 189–276 (2022). <https://doi.org/10.1007/s40766-021-00028-5>