Report to the President of the INFN

Il Comitato di Valutazione Internazionale (CVI)

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Introduction and General Comments

The CVI meeting this year was held in Genova from the 6th through the 8th of October. Our charge was to evaluate the accomplishments of the INFN National Scientific Commissions (CSN's), Technology Transfer group, National Laboratories, and Senior Administration; and to advise on priorities for the upcoming year. INFN continues to perform excellent science, and to work on increasing the effectiveness of technology transfer and education/outreach. We continue to be concerned, however, that recent mandates for new appointments and automatic, premature granting of permanent positions are likely to damage the quality and quantity of INFN science. Finally, we should like to express our thanks to the Genova staff for their outstanding hospitality and support for the meeting.

Governance and Strategy

Scientific directions and priorities. This year marks a major transition as President Ferroni and two other members of the executive board completed their second term. We congratulate him and his colleagues for their outstanding successes in strengthening INFN. There is impressive progress across all divisions, with INFN scientists in leading positions in international projects. INFN is well-positioned at CERN, and enjoys vibrant domestic research programs in particle astrophysics, nuclear physics and gravitational wave astronomy. At the time of our meeting, incoming President Zoccoli and his team were still in the review and planning process. The lack of an overall strategic view of INFN made it difficult for the CVI to put the activities of CVIs and Labs in a coherent frame. We look forward to receiving their new strategic plan in the near future!

Staffing. The INFN staff continues to increase, in large part because of mandated hiring which negatively impacts the optimal allocation of resources for research. As we stated last year, further mandated hires are not sustainable, and the restricted boundary conditions, which can change from year to year, present a challenge to achieving an optimal mix of skills among researchers, engineers and technicians, and to long-term planning. Early-retirement plans have not been a significant help because people do not want to leave. However, the recent change in promotion procedures in which tenure decisions must be made after only 2 years is even more serious. Highly damaging and disruptive to research, this issue must be solved for INFN to maintain its excellence.

Budget. President Zoccoli summarised the budget situation. The 2019 base budget has increased over 2018 from 240 M€, to 260-270 M€, allocated as follows: Salaries 140, Research 55, Infrastructure 50, Operations 20. An additional ~10-15% in EU and regional funds are available for "one-shots." Of great importance, INFN submitted a request last year for 300 M€ special funding over ten years for infrastructure, mainly for EuPRAXIA (110 M€) and HPC (240 M€, equally funded by MIUR and the EU)

Central Administration

Central Administration has progressed along the path presented during the 2018 CVI meeting. The reorganization of activities in four processes (in&out management; research services; resource management and systems management) has taken foot. At the same time the major bottleneck that the Administration was facing, i.e. lack of human resources, has been partially addressed. Some results are apparent: despite the high volume of purchases, and the strict and burdensome procedures imposed by the new regulation of public procurement, the Administration was able to run the process rather smoothly, with almost no court cases. As we underlined in our previous report, it is of the utmost importance to demonstrate that the reorganization of Central Administration brings clear results. As for human resource management, we applaud the plan of internal temporary mobility among central and peripheral administrative units. For a decentralized structure like INFN, it is important to look at problems from different perspectives, and to share common values, approaches and languages. The initiative undertaken will be definitely useful for the achievement of a more cohesive administration.

Comments:
The progress in the directions highlighted in previous reports is impressive. Still, open issues clearly emerge from the report of the General Director. We wish to highlight some of them:

- While planning, reporting and accounting closely follow national standards for public accounting, an effort must be done to better reconcile accounting, financial, and economic views, in order to obtain more readable and coherent reports and help decision making. A fundamental improvement would be the adoption of a multi-year scrolling budget in order to gather a full view of the financial impact of strategic choices;
- The survey on the perception of Administrative services has been postponed, for understandable reasons (change of President and INFN boards). It is important to start it in 2020, as a part of a wider plan of quality enhancement and the introduction of a PCDA (Plan, Check, Do, Act) cycle;
- The increase of Administration staff has been obtained mostly using temporary contracts. While this is a reasonable short-term solution, on a longer time perspective it brings the risk of high turnover, less motivated and less trained staff. A rebalance, within the limits imposed by national regulation, must be considered;
- Software for management and productivity tools seem still inadequate to support administrative procedures and the exchange of information between central administration and local units. Investment both on data management and report standardisation should be considered.

Recommendations:
CA-1. Adopt a multi-year (three years) budgetary plan.
CA-2. Start the survey on service satisfaction of Administrative services, and use it in a quality assurance PCDA frame.

CSN1 – Accelerator-based Particle Physics

The First National Scientific Committee (CSN1) coordinates INFN activities in Particle Physics at Accelerators. CSN1 supports experiments with internationally recognized high impact on the field and promotes research and development for high profile future projects. It is a large sector with about 820 affiliated FTEs, slightly growing in the last few years. The budget is 20 M€ with an additional 2 M€ of external funds. CSN1 gives strong and very visible contributions to a broad set of international experiments: ATLAS and CMS (63% of the activities), Flavour Physics including LHCb (25%), Charged Lepton Physics (8%), Proton Structure (3%) and R&D for Future Accelerators (1.5%).
There were various highlights in 2018 marked by the end of LHC Run2 with 150 fb^{-1} of high-quality collected data at 13 TeV. These include ATLAS and CMS measurements of Higgs boson differential cross cross-sections, observation of the ttH process with more than 3σ significance in an individual decay mode (γγ), and a determination of the Higgs width from interference effects. Very rare processes, like tZq production, could also be observed for the first time and many searches for Beyond the Standard Model

physics achieved an unprecedented reach in mass. LHCb further tested lepton universality, made new precise measurements of CP-violation in Bs decays and observed it for the first time in the charm quark sector with 5σ significance. The characterization the penta-quark was improved. The TOTEM and LHCf forward detectors also collected data and produced physics results.
There was also good progress in the experiments at other accelerators. The Belle II detector performed well during the first run at SuperKEKb. First physics results are becoming available. BESIII observed a new decay mode of the X(3872) shedding further light in hadron spectroscopy in the charm quark region. The third physics run of NA62 took place at the SPS in 2018, and 2017 data were analysed. Two very clean $K^+ \rightarrow \pi^+ \nu\nu$ events were observed. The foreseen tracker upgrade should improve background rejection and maintain the quality during the high intensity runs. The KLOE-2 collaboration is now focusing on the physics exploitation of the large ϕ-meson data set collected at DAΦNE until 2017. Many new results have already been presented at conferences. The progress of PADME and SIDDHART2 is reported in the LNF section.
The programme of measurements of charged leptons properties is progressing. After overcoming some technical difficulties, the flavour violation experiment MEG II at PSI is now preparing for data-taking in 2020. The construction of Mu2e at FNAL is well under way. The muon anomalous magnetic moment experiment E989 at FNAL completed the first physics run and a letter of intent for a related μe scattering measurement has been submitted (MuONe at SPS).
The COMPASS experiment dedicated to the study of proton structure is analysing the Drell-Yan data collected in 2018, preparing for an approved run with a polarized target in 2021 and also has submitted a proposal for a future extension of the programme.
We congratulate CSN1 for their rich and successful programme, their critical contributions and leadership role in many experiments and the excellent record of published physics results.

There are also many activities in preparation for the future. The LHC Long Shutdown 2 is ongoing at CERN (2019-2020). Intense Phase I detector upgrade activities are taking place at ATLAS and CMS, as well as at LHCb, with an important INFN participation. These projects are in general progressing satisfactorily, despite some delays. Two ATLAS projects are experiencing difficulties. HV instabilities affect the construction of resistive MicroMegas chambers for the New Small Wheels (forward muon detectors). INFN played a leading role in diagnosing and finding solutions to the problem and provided support to productions sites in other countries. INFN is now on track for completing its production. However, the overall schedule of the New Small Wheels project is uncertain, with at most one of the two wheels to be installed during LS2. A Readiness Review will take place in November 2019 at CERN. This delay affects the schedule of another project under INFN responsibility, the installation of new RPCs in the barrel-endcap transition region. The ATLAS Fast Tracker project (hardware tracking for the trigger) also accumulated serious delays, in spite of INFN's completing most of its part of the project. After the CVI meeting, on 11.10.2019, the ATLAS Collaboration voted to terminate the FTk project.

Longer term projects include the SHIP experiment, a beam dump facility for the search of sterile neutrinos. There is ongoing test beam activity, pending on the European Strategy statement before further pushing the project. Bent silicon crystals have been developed for beam collimation and successfully tested in TOTEM. A collaboration agreement has been signed with CERN to design and build collimators for the HL-LHC. INFN made various contributions to the Circular Colliders Conceptual Design Report submitted to the European Strategy, and participates in many European R&D projects related to future colliders. One relevant project is LEMMA, an innovative concept for a low emittance muon source for a future muon collider, that was well received by the European Strategy. We support exploring further this approach and suggest INFN to try to gather support from CERN and other countries.

Recommendations:
CSN1-1. Closely watch the schedule for the LHC Phase I upgrades. Push for critical reviews and realistic schedules. Try to mitigate the impact of delays on the construction of the upcoming Phase II projects.
CSN1-2. Further develop good indicators to quantify INFN contributions to large international experiments and put them in context of relevant examples.

High-Luminosity Large Hadron Collider (HL-LHC)

The HL-LHC project consists of major improvements to the collider to increase the maximum instantaneous luminosity to approximately 7 x 10^{34} cm^{-2} s^{-1}, and to the detectors to allow them to maintain their current physics capabilities under the demanding conditions of high rates and backgrounds. The detector upgrades are being implemented in two phases:

Phase I**:** All 4 detectors (ATLAS, CMS, LHCb and ALICE) are constructing upgrades in preparation for Run 3, a 3-4 year campaign scheduled to begin in 2021 at somewhat increased luminosities. Progress is largely going well, although as mentioned above the ATLAS "New Small Wheel" muon detector has experienced delays.

Phase II**:** Here we have massive upgrades to most ATLAS and CMS systems, including new silicon trackers. The cost of these upgrades is approximately CHF 270M per experiment in core funding. CERN and the two collaborations have been marshalling core funding with good success, such that the "Money Matrices" were sufficiently-well defined to receive approval from the CERN RRB in 2018, with MOU's with the funding agencies in the process of being signed.

INFN scientists play leading roles in all aspects of this critical program for world High Energy Physics, with strong financial support from INFN and provision of resources from the INFN institutes. In particular INFN groups have huge responsibility for the CMS Silicon Tracker and are heavily involved in ATLAS and CMS muon upgrades. The upgrade program is funded at a level of 56M€ + 8M€ contingency, covering core expenses, extra personnel needed to carry out the program (114 FTE for ATLAS, 123 for CMS), infrastructure and prototyping. Finding good people and ensuring continuity over the many years of the project present serious challenges, but so far so good!

Comments:

The main INFN upgrade projects are highly dependent upon the delivery of unprecedented numbers of silicon sensors, at a time when the load on Hamamatsu is extraordinarily high. As a result the current LHC schedule is impossible to meet. As key players in the LHC science program INFN should protect their programs by participating assertively in the upcoming CERN deliberations on revising the LHC schedule.

Recommendations:

None.

CSN2 – Astroparticle Physics

The 57% increase in CSN2 personnel over the last five years illustrates the attractiveness of the field. Just over the last year, the personnel count has grown from 770 to 862 FTE, with a quarter of people having moved from other CSN's to CSN2 and the rest from outside. This development does not come without reason: as in previous years 2019 was rich and successful in scientific results. New, tight limits have been reported from XENON1T, CRESST and Darkside50 (Dark Matter search), and from GERDA and CUORE (neutrino-less double beta decay). For the first time, CUORE has been able to operate stable over several months. Xenon1T has observed a double electron-capture process with the longest lifetime ever observed for rare processes, demonstrating the enormous capabilities of the technique. Rich astrophysical results have been provided by MAGIC, Fermi, AMS-02 and DAMPE, the latter for the first time precisely measuring the cosmic proton spectrum from space up to an energy of 100 TeV. Virgo has started running with improved sensitivity and detected several new gravitational wave events. The XENON collaboration moves swiftly from XENON1T to XENONnT, with a planned commissioning mid-2020 (see more on the LNGS program below). The transformation of GERDA to LEGEND-200 is in progress. Last but not least, ideas/activities towards new projects in CSN2 have been developed – scientifically a blessing but at the same time a burden from a funding point of view.

We now discuss the central INFN astroparticle projects for the next few years: Darkside20T, KM3NeT and Virgo.

Darkside20k: is a key experiment in searching for dark matter, using argon depleted in the radioactive ^{39}Ar isotope. We observe progress with URANIA (USA), delivering pre-purified argon, and with ARIA (Sardinia), finally purifying the argon via distillation. We are pleased to hear that URANIA funding in the USA is now secured. The global collaboration is substantially growing; for many (but not for all) of the new members it became obvious how strong their commitments, in particular the non-labour costs, are. Going from 50 liters argon to 20 tons, a highly-ambitious factor 400 in searches for rare processes, bears considerable risks. These risks can only be justified by an extremely tough worldwide competition situation. While in the very long term the liquid argon technology is perhaps the only way to go to the 100-ton scale and beyond, the competition with next generation xenon detectors requires speed. DarkSide20k plans to start data taking in 2024, which on the one hand is a significant delay compared to the original plans, but on the other hand, seen from today, appears still to be a very demanding schedule. We learned at our meeting that the DarkSide community is considering operating a 1-ton prototype at CERN. The scientific goals of this device, and its impact on the cost, schedule and technical personnel were not at all clear to us from the presentations and discussion, and should be defined in detail as soon as possible. Darkside20k is an approved LNGS proposal, and hence INFN/LNGS should require a full-blown technical design report (TDR). INFN/LNGS should then conduct a scientific/technical review of the Darkside20k TDR, followed by a full-fledged cost and schedule review à la those performed by the DOE or the CERN Upgrade Cost Group.

KM3NeT: Results with 4 (1) Detection Units for ORCA (ARCA) demonstrate a *potentially excellent performance* for the full configuration. The past technical problems, which have been extremely concerning and delaying, have been analyzed with resulting substantial changes. The in-depth analysis of reasons for failures and the new technical solutions both seem appropriate (as far as one can judge from outside). As in our 2018 report, we note that KM3NeT is not yet "out of the woods," and 2020 will be the year-of-truth for ARCA's reliability and long-term operation feasibility. Progress towards full deployment of Phase-1 should be carefully and continuously monitored. The current plan envisages ARCA Phase-1 (with 24 DUs) to be installed until middle of 2021, and the first full ARCA block of ~100 strings to be completed in mid/end 2023. We note that Baikal GVD has already now the same installed photocathode area as ARCA-Phase 1, so ARCA will have to convince by quality rather than only by size. The scientific case for KM3NeT remains extremely high: with 100 strings, ARCA would reach nearly the size of one full cluster and could do excellent physics comparable to IceCube.

Virgo/ET: Virgo successfully started the O3 run period on April 1 and has recorded a number of gravitational wave events. At least until 2021, when KAGRA in Japan will start operation, Virgo will keep its position as the third of worldwide three top interferometers and will provide unique information for pinpointing the direction of GW events. Upgrade work towards the O4 run are ongoing. The work on the Einstein Telescope ET is now budgetarily separate from Virgo, preventing possible conflicts. Italy is proposing a site for ET in Sardinia, in competition with a site in the Netherlands-Belgium-Germany triangle. While the site parameters in Sardinia seem to be superior to the Dutch site, the potential funding situation from three "host-countries" creates an uphill-battle situation for Italy, increasing the importance of making the Sos Enattos candidature appealing and promoting Sardinia as a potential site. (See more on ET in a separate section below)

Recommendations:
CSN2.1. INFN/LNGS should require a full-blown technical design report (TDR) for DarkSide20 and conduct a scientific/technical review of the TDR. This review should be followed by a full-fledged cost and schedule review.
CSN2.2. INFN should start an organized process of down-selecting the new initiatives in CSN2.

CSN3 – Nuclear Physics

CSN3 has a well-balanced, internationally acknowledged, diverse research program with a healthy amount of external funding. In addition to fundamental research in the four CSN3 sectors, application-oriented research has been pursued in radiobiology and in interdisciplinary research, e.g., antimatter properties. The ongoing facility upgrades at LNL (SPES) and at LNS (SC-Cyclotron, FRAISE) are crucial for extending the research capabilities of this group in the next decade. We are, however, concerned that the expected increase in experiments will put the existing staff under a lot of pressure. More details are given in the LNS and LNL discussions.

<u>Highlights from the 4 research lines:</u>

- Quarks and Hadron Physics:
  - The R&D activities in support of the US Electron-Ion Collider (EIC) could lead to strong involvement in future construction of this facility. A clear INFN strategy should be formulated towards this project.
  - Considering the excellent INFN expertise in polarisation technology and spin physics, we endorse the involvement in the JEDI experiment at COSY, Jülich, for measuring the electric dipole moment of the deuteron.
  - The results of the CLAS collaboration at JLAB indicating modification of the quark-gluon structure of a nucleon bound in an atomic nucleus by the surrounding nucleons (EMC effect) are exciting. The collaboration published two Nature papers since 2018 and several Phys. Rev. Letters where the effect can be explained by a universal modification of the structure of nucleons with n-p Short Range Correlation (SRC) pairs.

- Phase Transition in Hadronic Matter:
  - In an interesting development, plans for a new experiment, NA60+, in addition to the ALICE experiment at CERN are being developed, which would complement and further the research with ALICE.
  - The Italian groups are strongly involved in several aspects of the ALICE upgrade. Prior to the LHC shutdown, ALICE produced extensive data, which led to several highlights, in particular regarding the formation of baryons in *pp* and *p*-Pb collisions.

- Nuclear Structure and Reaction Dynamics:
  - About 1/3 of the manpower is concentrated in the GAMMA experiment, which is mainly pursued at LNL but also at other labs worldwide. Nuclear structure studies include the indirect measurement of the neutron skin of light mirror nuclei, measurements of shape coexistence of neutron-rich nuclei to determine the microscopic origin of nuclear deformation and quantum phase transitions.
  - The NUMEN_GR3 experiment at LNS uses the MAGNEX spectrometer to measure cross sections for double-charge-exchange nuclear reactions for the study of nuclear matrix elements that are crucial in the search for the neutrino-less double-β decay ($0\nu\beta\beta$). An important finding was that possible contributions from competing channels from multi-neutron transfer for the three investigated $0\nu\beta\beta$ systems could be excluded on basis of the comparison between the data and theoretical calculations. The NUMEN experiment is now ready for the construction phase and a TDR is in preparation.

- Nuclear Astrophysics and Interdisciplinary Research:
  - This research line is distributed between the four experiments ASFIN at LNS, ERNA at CIRCE, LUNA at LNGS, and the n_TOF experiment at CERN. LUNA's transition into the LNGS and getting LUNA-MV installation started should continue to have high priority. In 2020, the PANDORA experiment at LNS will add a new research branch. The discovery of the increase in the astrophysically-important $^{12}C+^{12}C$ fusion reaction rate (Nature 2018) via the indirect Trojan Horse method has triggered a lot of discussion in the nuclear astrophysics community. ERNA has

also published direct reaction data on the $^{12}C+^{12}C \rightarrow {}^{23}Na + p$ channel, and data analysis is ongoing on the $^{20}Ne + \alpha$ channel.

- CERN n_TOF experiments are presently affected by the 2-year shutdown at CERN but the collaboration continues analysing data. The publication of the $^{7}Be(n,p)^{7}Li$ cross section with a radioactive ^{7}Be target ($t_{1/2}$= 53 d) produced at the ISOLDE facility shows the unique capabilities of the facility in terms of direct neutron-capture cross-section measurements of short-lived isotopes.
- An overview of the contributions of the astrophysics experiments has been published in Rivista Nuovo Cimento Vol. 042 (2019).

Recommendations:
CSN3-1. Support travelling experimental setups to maximize capabilities of Italian National Labs, e.g., give high priority to AGATA@LNL experiments starting in 2021.
CSN3-2. Support the PANDORA project at LNS since it will add a unique research capability, and define a local operating group including experimental nuclear (astro) physicists.

CSN4 – Theory

The theoretical physics programme undertaken by staff and associates of the INFN remains one of the strongest national programmes in Europe. The basis of this success is the quality staff, both those directly employed by the INFN, and the associated staff employed by the Universities. In CSN4 there are 1014 individuals contributing effort made up of associated staff and direct employees of INFN. The direct employees whose salary is paid by INFN are about 115. There are some INFN units (sezioni) which are large, (in particular, TS and TO), and some which have less than 10 staff (LNS, LNF) which may lack the critical mass to function effectively as theory groups.
The scientific work is divided into six research lines
LS1: String and Field Theory
LS2: Particle Physics Phenomenology
LS3: Hadronic and Nuclear Physics
LS4: Mathematical Methods
LS5: Astroparticle Physics and Cosmology
LS6: Statistical and Applied Field Theory

The three aspects of this research program which the INFN can manage are the post-doc program, the hiring of permanent staff, and the "Iniziative specifiche" (IS).
a) Post-doc program
Since 2012 the INFN has funded about 12 new post-doctoral positions each year, so that in any one year there are about 24 in post. The committee is pleased to see that in recent years this number is increasing. The INFN is to be congratulated on the FELLINI project, which leverages INFN funding with co-funding from the EU. Both the INFN-funded post-docs and the Fellini program are extremely positive for training of early career researchers. Statistics over the last 5 years show that about three quarters of INFN post-docs remain in academia, (and about one third of that number progress to faculty positions),and a further 11% go to work in industry. It is to be noted that spread over more than 20 INFN units + National Labs this number is not extremely high. For comparison in the UK, at any moment there are 36 post-doctoral fellow in particle theory in post, compared with 24 in the INFN, and anecdotal evidence suggests that this number may be much higher in Germany.
b) Permanent staff
The recruitment of 15 new staff in 2016-2017 and 10 new staff in 2019 is an extremely positive development. With 115 total INFN staff working in theoretical particle physics, it is expected that (with a flat age distribution) approximately 4 should retire every three years. However, the management of the program and establishment of a sustainable age distribution of the staff would be easier to manage if calls for new staff occurred on a more regular basis.

c) Iniziative specifiche (IS)
These are networks including personnel from different INFN units, which run for three years. It is foreseen that there will be new IS starting in 2020. These initiatives are important also to make decisions on the distribution of budget and of post-doctoral positions.

Comments: The section on CSN4 in CVI report 2019 contains about 12 pages of one-line descriptions of the work undertaken. Whilst this does reflect the broad spectrum of research undertaken, it is hard to evaluate. In 2020, there will be a new program of "Iniziative specifiche". Therefore in 2020 it would be appropriate to evaluate the strengths and weaknesses of the previous round of IS and report on the changes implemented in the new IS.

Recommendations:
CSN4-1. There are currently about 35 IS. The CVI report for 2020 should focus on the changes instituted in the IS programme and the rationale for those changes.
CSN4-2. The INFN should present bibliometric information for the associates and employees separately.

CSN5 – Technological and Interdisciplinary Research

The Fifth National Scientific Committee (CSN5) coordinates advanced technological research for INFN experimental activities and promotes the development of instruments, methods and techniques for fundamental physics and their application in other fields. These transversal activities across committees contribute to strengthening links with universities and national research institutes.
There are three main areas of activity: *i)* development of radiation detectors, electronics and software (47% of budget); *ii)* production and development of particle accelerators and new prototypes (26%); *iii)* interdisciplinary applications (27%). Technologies are widely used also outside physics research and have social and economic impacts (e.g. medical imaging, cancer therapy, protection of cultural and environmental heritage). Both the number of experiments and the number of FTE have been increasing since 2014, although they are still below the 2010 level. External funds for CSN5 experiments amounted to almost 10M€ in 2018 (according to report), which is about a third of the total 29M€ for 2013-18 (according to presentation). Resources are allocated to three types of projects. In 2018 "standard" projects accounted for the largest proportion of resources: 62% of the budget and 77% of FTE. "Calls for proposals", a scheme introduced in 2013 to enhance excellence, synergies and prioritisation of resources, absorbed 28% of the budget and 17% of FTE. "Grants for young researchers", which were also introduced in 2013 to enhance young researchers' scientific autonomy and capacity to manage external applications (6 per year since 2014), accounted for 10% of the budget and 6% of FTE.
Following the CVI 2017 recommendation, the results of "Calls for proposals" are regularly monitored. The CSN5 evaluation of the first 5 projects which terminated their activities (CALOCUBE, CHIPIX65, MAGIX, AXIOMA, COSINUS) was "very positive". Seven other projects are ongoing (SiCILIA, MOVE_IT, TIMESPOT, TERA, NEPTUNE, ARCADIA, FIRE).

Comments:
We appreciate the very important role played by CSN5 both *substantively*, by developing new technologies and methods, and *instrumentally*, by promoting cooperation across committees and laboratories and with non-INFN research. The search for excellence and capability-building clearly informs the new funding schemes introduced in 2013:"Calls for proposals" and "Grants for young researchers."
While motivations and results are well discussed, we judge that the assessment would benefit from more extensive information on two aspects.

- *Resource allocation criteria among three types of projects*. Standard projects still receive by far the largest share of funding. How are funds allocated to these projects? Are they largely determined by previous commitments for major research endeavours? How are new Standard projects selected? Is

there any plan to shift resources towards the two new funding schemes ("Calls;" "Grants for Young Researchers"), or is the current distribution considered to be satisfactory?

- *Evaluation of the two new funding schemes*. What factors brought the CSN5 to reach a "very positive evaluation" of the first 5 Calls projects? Is the assessment based only on the achievement of pre-established aims and scientific output (e.g. number/quality of publications) or does it take into account also possible/actual applications either internally in large scale INFN projects or externally by private/public enterprises? More generally, how do the outcome and impactof research carried out by CSN5 inform the evaluation?

Recommendation:

CSN5.1. Describe the criteria used to allocate resources among the three active CSN5 programs: Standard proposals, Calls for Proposals, and Grants for Young Researchers.

CSN5.2. Review and explain the criteria developed to evaluate the success of the two newer funding schemes: "Calls for Proposals: and "Grants for Young Researchers."

Technology Transfer

The Commission for the Coordination of Third Mission (CC3M) coordinates all activities that imply a transfer of knowledge for non-academic purposes such as Public Engagement (PE), Life-Long Learning (LLL) and Technological Transfer (TT). The composition of CC3M is such to ensure the development of a common strategy for the Communication Office (CO), the National Committee for Technological Transfer (CNTT), the Technology Transfer Service (STT) and the Local Referents (LR) network for TT.
A rich set of activities was put in place by INFN for PE and LLL. As to TT, INFN tried to improve coordination of different entities (CNTT, STT, LR) where LR are the backbone of activities. Following the definition and implementation of new rules, guidelines and information tools in 2016, the LR network now has a more structured approach.
As a result of the reorganisation of TT activities and of training programmes, the INFN reports a significant improvement in the management of Intellectual Property (IP). The number of invention disclosures, confidential agreements, priority applications filed (in Italy), patent applications filed increased considerably since 2011; the end-of-year stock of active patents steadily rose from 5 in 2011 to 92 in 2018. At the same time, there was an increase in the numbers of licenses granted to EU enterprises (from 3 to 11) and in the number of licenses generating revenues (from 0 to 6).
Several TT-linked activities were implemented in 2018: *i)* new rules regulating spinoffs; *ii)* the Research for Innovation (R4I) programme, selecting technologies ready for external applications (3 R4I projects signed licence agreements with commercial partners); *iii)* the Research to Innovation (R2I) programme, aimed at supporting start-up enterprises; *iv)* contacts with Venture Capitalists to support INFN start-up and spinoff enterprises. Some evaluation exercises analysed the impact of INFN TT activities.
Information on TT activities is also separately provided for INFN national laboratories. It includes two new infrastructure projects (LATINO, SABINA) largely funded by Regione Lazio (LNF); five different contracts with (presumably) private businesses (LNS); a significant TT programme (LNL), including the Master in Surface Treatments for Industrial Applications; the AMD–Additive Metamorphosis of Design project (LNGS).

Comments:

We recognise the value of the multiple PE and LLL activities carried out by INFN. They vary widely in scope and format and contribute to reinforce the scientific leadership of INFN in Italy and to render the INFN an authoritative reference for the public debate.
Our assessment for TT activities is somewhat more complex. There was no specific presentation at the Genova meeting and, as seen, information is scattered around the CVI Report 2019. On the basis of this information, it is our view that INFN has taken seriously TT objectives. On the other hand, the INFN achieves world excellence in a country which is lagging behind other advanced countries in terms of innovation and R&D, and hence transfer of knowledge accumulated through INFN research may reveal crucial assets for the Italian economy and society. The aim should be to further step up the INFN TT

activities and their effectiveness, paying attention equally to economic values (potential commercial uses) and social values (benefits for human well-being, e.g., medical applications). No need to say that this aim must be pursued without distorting and compromising the primary scientific objectives of INFN research. A case in point is to optimise the program at BEST between medical isotope production and LNL basic science.
We therefore conclude that a full assessment of TT activities should consider a number of aspects.

- *Overall architecture of TT activities*. It is unclear what different roles CC3M, CNTT and STT play and the relationships of both, CNTT and STT with LR.
- *Summary classification of TT initiatives within a common frame*. An account of all actions at the local and national level would help grasping the extent of INFN engagement in TT aims.
- *Classification of different relationship with external public/private entities in the development of projects*, e.g. partnership from the outset of the project vs. potential uses of the applications afterwards.
- *Rules and procedures for IP protection*: entitlements to possible benefits (e.g. royalties); training of researchers; structure of legal advice.
- *Qualitative monitoring of patents and licenses.* Provide information not only about numbers but also about uses and results (incidentally, what is the revenue from licenses?).
- *Report on activities of R4I and R2I programmes started in 2018*.

Recommendation:
TT.1. INFN should consider launching a medium-term comprehensive review of its Knowledge and Technology Transfer activities that would lead to a final report in 2021. Proper attention should be given to TT for both economic and social purposes.

Cultural heritage

The Cultural Heritage Network (CHNet) is a growing, very active field of activity in INFN. This is a three level network: a first level connects Italian INFN laboratories; a second level links national laboratories with Universities, Restoration centres and associations involved in cultural heritage; and a third level connects with foreign Universities and research centres. This structure depicts a global research infrastructure of high value and potential. The INFN network enjoys good funding perspectives: currently (year 2019-20) founding (4.5M€) is granted by research projects (European, national, regional, 2.95 M€), the selling of services (0.25 M€) and Universities (1.3 M€). Activities are organized around three main missions: research (50%), education (20%) and third mission (30%). Among the results obtained by the CHNet, the development of the RFQ-based MACHINA project is particularly noteworthy. The project, founded by MIUR and involving INFN, CERN, and Opificio delle Pietre Dure, is aimed at the development of a transportable accelerator for in situ diagnostics of artworks with pulsed beams. MACHINA is a highly promising device, featuring low power consumption, low weight, small footprint and low radiation emission.

Comments: We consider CHNet as an exciting and important activity, promising from the point of view as a service to the country, and as an aid in dealing with property rights and technological transfer.
Given the perspectives of this branch of activities and its potential, a clearer strategic vision of its development should be developed. A fundamental issue regards the balancing of different goals (science, public service and the commercialization of services and licences), and the definition of a structure of incentives in accord to the strategic goals. Given the high potential market interest on the development of instrumentation, special attention must be devoted to the management of intellectual property rights. In this respect, it seems that CHNet is disconnected with the Technology Transfer

Recommendation:
CH.1. Explore opportunities for the management of IP of instrumentation, with the Technology Transfer organization in INFN (National committee, Technology Transfer Service, and Local Referents).

Laboratori Nazionali di Frascati (LNF)

The Frascati National Laboratory (LNF), the largest and the oldest among the INFN National Laboratories, is devoted to the development, construction and operation of accelerators, and the design and construction of forefront particle detectors for particle, nuclear and astroparticle experiments. The research infrastructure comprises the DAΦNE collider and the Beam Test Facility complex; SPARC_LAB and the future EuPRAXIA@SPARC_LAB infrastructure; SCF_LAB to characterize lasers; large assembly halls with several clean rooms and various technical services; and a visitor center. LNF had 288 employees with permanent contract, recovering the level of previous years after the hiring-by-law process. There were in addition 29 temporary, 195 associated (including Cosenza University), and 389 external users in 2018. LNF has devised a clear strategy for the future of the laboratory that is being steadily deployed. Here we report on some of recent highlights and progress.

Research Programme: PADME (search for dark photons) at BTF took its first data taking run from November 2018 to February 2019. The detector is working well, and an improved Monte Carlo simulation can reproduce the background from tails in the positron energy distribution and motivate design improvements for the next run. An incident that interrupted the access to the experiment hall last July is now being fixed and PADME is scheduled to resume data taking in 2020 and collect 10^{13} positrons on target in about 120 days. KLOE2 stopped data taking in April 2018 and the large data sample is now being analyzed. One of the interaction points has been refurbished to host SIDDHARTA-2 (study of Kaonic atoms). A subset of the detector has been installed in April 2019 to check beam background conditions. Various hardware problems slowed down somewhat the commissioning process. The plan is to reach good beam conditions by the end of 2019, complete the detector installation and run during 2020 to collect 800 pb^{-1} of luminosity. PADME and SIDDHARTA2 need different bunch lengths, 200 ns and 5 ns, respectively and cannot run simultaneously. The time sharing in 2020 will be adjusted to optimize the use of the various installations. A run is also foreseen for *BeamLine4Schools* in Autumn 2020. The SCF_LAB produced the Laser Retro-Reflector for Insight (LaRRI) that was taken to Mars soil by the NASA Insight lander. Further reflectors will be taken to Mars by new NASA and ESA missions in 2020 to form the first network of measurement points for geophysics and gravitation measurement by orbiting lasers. LNF plays a strong role in the LHC experiments and its upgrade process (reported in the CSN1 section).

EuPRAXIA Project: The EuPRAXIA H2020 Design Study prepares for pilot infrastructures operating a plasma-based e^- accelerator for a Free Electron Laser up to 5 GeV for photon users. The project has two legs, one beam-driven, the other laser-driven. LNF proposes a new on-site infrastructure, EuPRAXIA@SPARC_LAB, to host the beam-driven plasma accelerator (SPARC_LAB is the existing infrastructure at LNF that does R&D for the above projects), There has been significant progress on that front during last year.

A Conceptual Design Report for EuPRAXIA@SPARC_LAB was released in May 2018, with a cost of the order of 100 M€. The project involves in addition to LNF various INFN institutes, three Italian institutes, and CERN. Regarding funding, INFN has already provided 14 M€ and has applied to a governmental program for the development of infrastructure for 116 M€ (a Research Minister decree should make the funds available soon). LNF also participated in a call from Regione Lazio for EU related funds: the SABINA project granted with 6 M€ to exploit and upgrade SPARC_LAB. An international committee of renowned experts made a detailed review of the EuPRAXIA@SPARC_LAB Conceptual Design Report. The feedback delivered in August 2019 is in general very positive and the committee strongly recommends to move to the Technical Design Report. The detailed review identifies strengths and elements to be improved like the need of a more detailed breakdown of all aspects of the project and an urgent R&D program at SPARC_LAB. Since the release of the CDR, 4,000 m^2 of new land have been acquired. The bid for the new building was published in July 2018 and assigned to a company from Aosta on May 2019. The contract is still to be finalized. The hope is to be able to start soon the contact with the enterprise. A Project Office has been set-up to organize and manage the project in a professional way, with the aim of completing the TDR in about 3 years. SPARC_LAB activity, with many tests and

simulations, has been focused on the demonstration of electron bunches acceleration by particle-driven plasma in the context of EuPRAXIA 2020 study and addressing specific issues of EuPRAXIA@SPARC_LAB. Concerning manpower, LNF turn-over can be used to maintain current competences in accelerator technology and in support of technical infrastructures. However, an injection of extra personnel will be necessary in fields currently outside Lab's competences, like plasma simulation, photon beam lines, lasers, etc. This requires a careful evaluation by the Project Office. It is also worth noting that LNF management has asked the review committee to keep reviewing the project on a yearly basis, which should be beneficial for the project.
The EuPRAXIA H2020 collaboration will hold its final event in October 2019 presenting the CDR for both accelerator facilities, beam-driven and laser-driven. This will be the input for the ESFRI application in May 2020. LNF proposes to host the beam-driven facility, while DESY was originally proposing to host the laser-driven facility. However, DESY recently renounced to this proposal, leaving the laser-driven site still to be identified. This gives an opportunity to LNF and INFN to lead the project at European level and work together with five excellence centers from France, Germany, UK, Portugal, the Czech Republic, etc. While EuPRAXIA@SPARC_LAB fits well within the EuPRAXIA scheme, should the ESFRI submission fail, LNF is ready to continue the project and to prepare specific collaboration agreements with major European Labs. The situation will need careful follow-up during the coming months.
Other recent initiatives at LNF include: LEMMA, a low-emittance muon source for future muon collider (see CSN1), DAΦNE_TF a future infrastructure to use DAΦNE as a test facility for new accelerator technologies (no big progress yet, but raising interest like Crab-Waist technology test for FCC-ee), LATINO (Laboratory in Advanced Technologies for INnOvation) to facilitate access to technology and reindustrialize the local area together with help of the Lazio Region, a successful Visitor Center inaugurated last year, and an ambitious project of a large Science Center being defined.

Recommendation:
LNF-1. INFN should give strong support to EuPRAXIA and EuPRAXIA@SPARC_LAB

Laboratori Nazionali del Sud (LNS)

The KM3NeT experiment, a major activity of LNS, is discussed in section CSN2 above, and some of the LNS nuclear physics activities are covered in the CSN3 section.

LNS has been successful in obtaining several projects of great importance for the future of the lab. Researchers are involved in a large number of research collaborations in addition to the scientific programs at home. The local science program is focused on its two operating accelerators: a 15 MV Tandem Van de Graaff accelerator and the K800 super-conducting cyclotron (SC). The two accelerators accelerate heavy-ion beams in a very wide range of mass and energy and allow nuclear structure, nuclear reactions, and nuclear astrophysics studies, as well as applications of nuclear physics techniques in particle therapy, cultural heritage and other multidisciplinary activities.

The 19.35 M€ upgrade of the research infrastructure is funded by the *POTLNS (POTenziamento Laboratori Nazionali del Sud)* initiative and driven by the physics case of the NUMEN experiment. It includes the upgrade of the SC cyclotron, the installation of the new in-flight fragment separator FRAISE, as well as the upgrade of the MAGNEX spectrometer for the NUMEN experiment. The goal of the upgrade project is to accelerate and deliver high intensity light ion beams with a power of several kW and intensities up to 10^{14} pps by 2022/23. The POTLNS initiative started in June 2019 and must be concluded within 32 months, with a possibility of a 4 months extension. Several critical calls for tender (e.g. new SC magnet, technical specifications of beamlines and stripper etc.) are ready to be submitted before the end of the year, and civil work and technical service upgrades are planned to start at the beginning of 2020.

Comments*:* The upgrades and possible delays in construction will put the local support groups under pressure and will have negative impact on important research activities like the NUMEN experiment. The required prolonged shutdown (summer 2020 until end of 2022 for internal users, reopening as user facility in summer 2023) should be communicated quickly and transparently by the management, so that the scientific staff and external users can start planning for the "local scientific drought". This gap will have to be bridged not only by completing the analysis of already procured data but also by reaching out for beam time at other radioactive beam facilities, not an easy task since several facilities are presently in shutdown (e.g. ISOLDE, RCNP Osaka), will go into a shutdown-phase soon (NSCL), or have only a reduced amount of beam time available (e.g. GANIL, GSI, RIKEN, TRIUMF).

The upcoming extension of the science program is exciting and will require additional support for outside users. The PANDORA (Plasmas for Astrophysics Nuclear Decays Observation and Radiation for Archaeometry) experiment will add a unique capability to the nuclear physics landscape but the project is technically challenging since no one has done it before. A lot of R&D will be necessary, as well as more involvement of experimental nuclear (astro)physicists. It is very important to plan for staff to operate and maintain the device on a day-to-day basis once it is commissioned.

Recommendations:
LNS-1. Communicate a detailed shutdown-plan as soon as possible to staff and users.
LNS-2. Define a local PANDORA group that operates the device on a day-to-day basis.

Laboratori Nazionali del Gran Sasso (LNGS)

The Darkside 20T experiment is discussed in section CSN2 above.

Observations: LNGS is producing excellent physics in spite of dealing with severe restrictions, imposed mainly by the regional government. Unfortunately, Borexino and LVD will be terminated by end of 2020, while in the meantime negotiations and safety studies will hopefully be finalized to allow short term running. Several new experiments remain delayed or on hold because of slowness in ESH evaluations -- they should only take 60 days, but are taking much longer. As yet another disruption, the removal of LVD and hydraulic engineering interventions interfere with experiments, mainly in Hall A (CUORE, LEGEND). XENONnT now plans to use Gd-doped water for its veto, the design of which must be approved, and a process for extracting the Gd must be developed.
Status of new experiments: CUPID is moving ahead appropriately. LUNA-MV is now approved to be an LNGS facility; SABRE now has one good quality crystal, but progress is slow in commissioning it because the collaboration wants to make measurements that involve polyethylene in excess of 5 t, mandating a full safety approval with resulting delays. This problem could be mitigated by avoiding polyethylene but the collaboration doesn't want to go this route.
LNGS conducted a review of DAMA/LIBRA that required a formal review of a CDR and TDR for phase-3 approval. Response from the collaboration so far has been inadequate.

Comments*:* Excellent physics results continue, and the lab is coping as well as possible with the unfortunate environmental/political situation.

Recommendations:
LNGS-1. We strongly support the LNGS requirement that DAMA/LIBRA sustain a formal review of a CDR and TDR for it to continue.
LNGS-2. (Repeated from 2018) The laboratory should set up a stepwise "gateway" process for approving and supporting proposed new experiments and upgrades, going beyond assessment of the physics potential to make sure the safety issues and impact on LNGS resources are understood and covered.

Laboratori Nazionali di Legnaro (LNL)

The local research at LNL is driven by the accelerator infrastructure, which involves the TANDEM-ALPI-PIAVE complex consisting of a 15 MV Tandem accelerator and two superconducting LINACs (ALPI and PIAVE) which are focussed on nuclear physics and nuclear astrophysics experiments (~75% of the beamtime) as well as interdisciplinary research (~25% of the beamtime). Additionally, two small electrostatic accelerators, CN and AN2000, are used for applications of nuclear physics to environmental, material, and cultural heritage science.
The newest facility at LNL is a dual-exit high-current cyclotron for extraction of proton energies between E_p=35-70 MeV, manufactured in Ottawa Canada by Best Theratronics, Ltd., which will be the driver for rare isotope production at SPES.

The research of the laboratory continues to be driven by a healthy mix of fundamental and applied research. The presently ongoing research program in Nuclear Physics and Astrophysics consists of the investigation of nuclear structure and reaction dynamics in the collision of heavy ions, and the study of nuclear processes relevant for the creation of elements in stars. This research is carried out at the TANDEM-ALPI-PIAVE accelerators. The required one-year shutdown for maintenance of the tandem and upgrade of the LINACs in 2018/19 was mostly successful, and the tandem is slowly approaching its nominal maximum voltage of 15 MV again (13 MV are planned to be reached in Dec 2019, then a gradual increase up to 14.5 MeV is planned in 2020). A second one-year shutdown is planned to accommodate further installations for SPES. The plan was to do commissioning with non-accelerated RI beams in 2020, and then go to reaccelerated RI beams up to 10-11 MeV/u in 2021 for the SPES nuclear reactions program. A very prestigious and high-priority European project is the installation of the AGATA (Advanced GAmma Tracking Array) setup at LNL which will start in the second half of 2021. So far 60 Letters of Intent have been received, and a Program Committee will help to down-select and prioritize these cases. It is planned to run 6 months stable and 6 months radioactive beam in 2022. Up to 60% of the total available beamtime will then go to AGATA experiments.

The Applied Physics research program uses the small electrostatic CN and AN2000 accelerators, both of which have delivered ~1000 h of beam, for interdisciplinary physics research like radiobiology, microdosimetry and microanalysis of materials using the ion microprobe, novel detector development tests, novel methods of surface treatment, and studies of radiation damage.
With the LARAMED program, the focus of the SPES facility will shift towards research on new radioisotopes for medical applications (RILAB) and the medical radioisotope production at RIFAC in collaboration with Best Theratronics, Ltd. The contract with Best Theratronics, Ltd. assigns (up to) 2350 h (~14 weeks) per year of cyclotron beamtime for medical isotope production, starting in 2020. The main focus will be the production of ^{82}Sr ($t_{1/2}$= 25 d) for ^{82}Sr/^{82}Rb radioisotope generators. ^{82}Rb ($t_{1/2}$= 1.27 min) is the most prevalent generator-produced radionuclide used in clinical applications and is used as cardiac PET (positron emission tomography) isotope for myocardial perfusion imaging to show the function of the heart muscle and scan for heart conditions, e.g., coronary artery disease. Revenues from this medical isotope production contract will cover operational costs and additional human resources.

The research in the accelerator division is focussed strongly on the development and construction of accelerators and accelerator components. The three main involvements of the group are the commissioning of the radiofrequency quadrupole (RFQ) for IFMIF (Japan), the construction of a drift tube linac (DTL) for the European Spallation Source ESS in Sweden, and the construction of a high-intensity RFQ for the MUNES project. A new test facility for various accelerator components at LNL, called LATA, is ready to be launched and constructed.
The INFN RFQ at IFMIF was successfully tested at 5 MeV with a 125 mA pulsed deuteron beam in July 2019. In the coming months the gradual increase of the duty cycle up to continuous beam and 9 MeV beam energy is planned. The DTL at ESS will accelerate the beam from 3.5 to 90 MeV and is developed in collaboration with INFN Torino and industry partners. The construction and testing are progressing

with an aggressive schedule that has the goal to assemble the first (out of five) tanks at ESS still within 2019 and to carry out commissioning in early 2020.

Comments:
The installation and commissioning of the cyclotron are completed but work on the local infrastructure at SPES is delayed for various internal and external reasons. These upgrades and delays put local support groups under pressure and will have negative impact on research.

- **Delayed SPES schedule:** It was unfortunate to hear about the delays following the rosy picture given last year about the strict timeline for the SPES project. There seems to be a discrepancy between the Accelerator Division and the Research Division what the highest priority project is. It appears that external international projects have been given higher priority although it was mentioned several times that SPES has presently the highest priority for LNL. In view of the unforeseen shortage in manpower, a better hiring strategy for technical personnel and administrative support should be worked out, and internal priorities be reconsidered. As a short-term solution it should be explored if existing skilled personnel from other INFN projects can be shifted part-time to support the timely completion of the SPES project. An updated SPES schedule was promised for early 2020 and should be included in the midterm report.
- **Ambiguity of beamtime distribution at SPES:** Presently, the two exit ports at the cyclotron will only allow parasitic operation in parallel to the medical radionuclide production if the same energy is used. While the present UC_x target design cannot take more than 40 MeV protons at 200 μA for the nuclear physics program, the production of medical radionuclides, e.g., ^{82}Sr via ^{85}Rb(*p,4n*) will require higher energies. A joint committee consisting of members of INFN and Best Theratronics has been proposed and will address beam scheduling conflicts, but it was made clear that priority will be given to medical isotope production to fulfill the contract with Best. This can lead to conflicts and cancellations of other high-priority beamtimes, e.g. AGATA, in case of unexpected longer shutdowns and repairs. The dual-energy upgrade is not yet included in the funding but is something that should have high priority to allow independent operation of both ports to maximize the research output and run both programs simultaneously even at different energies.
- **Funding and personnel:** The funding level of LNL seems adequate to run the lab under "normal" conditions but without any contingency. The large extension of the science program with SPES will require more funding and personnel, and more scientific support for outside users.

Recommendations:
LNL-1: Include funding for the dual-energy upgrade of the cyclotron in the upcoming budget plans to enable experiments at both ports with different energies and maximize the research output.
LNL-2: Provide an updated SPES schedule in midterm report and develop a plan on how to move technical personnel temporarily to ensure a timely SPES completion and operation of AGATA@LNL starting in Q2/2021.

CNAF Tier-1 Center

CNAF in Bologna has been the main INFN computing center since 2003. It hosts one of 13 LHC Tier-1 centers in the world, with growing needs in recent years for more space, power, resources, and a safer site after the flooding in 2018.
One of the three pre-exascale class computers funded by the European High-Performance Computing Joint Undertaking (EuroHPC) will be hosted in Italy by Cineca at the Bologna Technopole. The Italian supercomputer (LEONARDO) will have a peak power of 270 petaflops and will be one of the 5 most powerful supercomputers in the world. The total cost over 5 years is 250M€, funded equally by the MIUR and the European Commission. The new Technopole site in Bologna is thus ideally suited to facilitate also the new Tier-1 infrastructure and include necessary upgrades for the HL-LHC era. The need for the move is driven by increased space and power requirements and is a very good investment in the future.

However, the anticipated timeline for the move within 2 months before LHC Phase 3 starts in February 2021 is very tight, if not impossible. Alternative plans were shown to move whenever the site is ready and without service interruptions.

Recommendations:
None.

Einstein Telescope

The Einstein Telescope (ET) is a proposed third generation (3G) European gravitational wave detector that will increase the sensitivity to gravitational waves by an order of magnitude with respect to Advanced Virgo, and extend the frequency coverage in the range below 10Hz. This facility will be part of a network of planned three 3G detectors comprising the Einstein Telescope, the Cosmic Explorer in the USA and a third 3G detector in a location that maximizes the sky localization ability of the network. This network of 3G detectors will survey the Universe with unprecedented reach into deep space. The Gravitational Wave International Committee (GWIC) has been set up to coordinate planning for the worldwide network.
The ET is the most advanced of the 3G gravitational wave detector projects, having produced a conceptual design report in 2011. The next step for the project is a submission in April 2020 for inclusion in the European Strategy Forum on Research Infrastructures (ESFRI) 2021 roadmap, with a site decision potentially in 2022. The Italian government, INFN, Sassari University, and Regione Sardegna support the candidature of a site close to Sos Enattos (Sardinia) for the Einstein Telescope infrastructure. The ET collaboration will submit the proposal to ESFRI with the site in Sardinia and the South Limburg (NL) site on the border with Belgium and Germany. The site in Sardinia has been qualified in a preliminary way and found to have high quality geological, seismic, and environmental characteristics. While the site parameters in Sardinia seem to be superior to those in the Netherlands, the Dutch site presents considerable competition to Italy because three host countries can consider it their own. This emphasizes the importance of working hard to promote the Sardinian site. Construction and exploitation of the ET infrastructure shares many features with high-energy physics (vacuum and cryogenics, civil infrastructure, computing and data analysis, and project management). These topics lie within the traditional expertise of INFN (and CERN). Full qualification of the Sardinian site is now a high priority for the ESFRI submission.
We note that the funds are available to qualify the Sardinian site, but there is a shortage of technical personnel for both civil engineering and vacuum studies. If these personnel cannot be found inside INFN, the ET team needs administrative support from INFN to help in working with external partners.

Recommendations:
ET 1. We encourage the INFN to facilitate the full qualification of the Sardinian site for the Einstein Telescope.

Appendix I. Agenda

Monday, 7 October

08:45 → 09:15 **A. Zoccoli/S.Smith: brief introduction and charge to CVI** 30m
Speakers: Antonio Zoccoli (BO), Prof. Arthur John Stewart Smith (Princeton University)

09:15 → 10:15 **Report from CSN1** 1h
Speaker: Roberto Tenchini (PI)
CVI-7oct-CSN1-com...

10:15 → 10:45 **coffee break** 30m

10:45 → 11:45 **Report from CSN2** 1h
Speaker: Marco Pallavicini (GE)
Report-CVI-Oct2019_

11:45 → 12:45 **Report from CSN3** 1h
Speaker: Rosario Nania (BO)

12:45 → 13:45 **Lunch Break - CVI in closed session** 1h
CVI in closed session

13:45 → 14:45 **Report from CSN4** 1h
Speaker: Fulvio Piccinini (PV)
piccinini_CSN4.pdf

14:45 → 15:45 **The KM3NET project** 1h
Speaker: Mauro Gino Taiuti (GE)
KM3NeT_Seminar_... KM3NeT_Seminar_... wWnS964slk.mp4

15:45 → 16:15 **coffe break-short** 30m

16:15 → 16:45 **Report from LNL** 30m
Speaker: Diego Bettoni (FE)
Bettoni-LNL-2019.pdf Bettoni-LNL-2019.p...

16:45 → 17:15 **Report from LNGS** 30m
Speaker: Stefano Ragazzi (MIB)
LNGS_CVI_2019.pdf LNGS_CVI_2019.pptx

17:15 → 17:45 **Report from LNS** 30m
Speaker: Santo Gammino (LNS)
Report_from_LNS-C...

Tuesday, 8 October

08:00 → 08:30 **INFN Budget report** 30m
Speaker: Antonio Zoccoli (BO)
Zoccoli.pptx

08:30 → 09:00 **Report from AC** 30m
Speaker: Bruno Albino Alain Quarta (AC)
CVI 2019-10-07 v2_...

09:00 → 10:00 **Report from CSN5** 1h
Speaker: Valter Bonvicini (TS)
CSN5_CVI2019.pdf | CSN5_CVI2019.pptx | Report on CSN5 Cal...

10:00 → 10:25 **Coffee Break** 25m

10:25 → 10:55 **INFN and Cultural Heritage** 30m
Speaker: Francesco Taccetti (FI)
Taccetti_CVI_2019... | Taccetti_CVI_2019...

10:55 → 11:45 **The INFN Tier1@Technopole Project** 50m
Speaker: Gaetano Maron (LNL)

11:45 → 12:35 **High Luminosity LHC** 50m
Speaker: Nadia Pastrone (TO)
CVI_NPastrone_HL-...

12:35 → 13:50 **Lunch Break - CVI in closed session** 1h 15m

Closed Session of CVI (lunch continues in room)

13:50 → 14:40 **The Eupraxia Project** 50m
Speaker: Pierluigi Campana (LNF)
Campana_20191100...

14:40 → 15:30 **The Einstein Telescope Project** 50m
Speaker: Michele Punturo (PG)
ET-CVI.pdf

15:30 → 17:00 **CVI in executive session** 1h 30m

17:00 → 17:15 Closeout with INFN: management, heads of the CSN's, etc.

Appendix II. Recommendations

CA-1. Adopt a multi-year (three years) budgetary plan.
CA-2. Start the survey on service satisfaction of Administrative services, and use it in a quality assurance PCDA frame.
CSN1-1. Closely watch the schedule of LHC Phase I upgrade projects. Push for critical reviews and realistic schedules. Try to mitigate the impact of delays on the construction of the coming Phase II projects.
CSN1-2. Further develop good indicators to quantify INFN contributions to large international experiments and put them in context of relevant examples.
CSN2.1 INFN/LNGS should require a full-blown technical design report (TDR) for DarkSide20 and conduct a scientific/technical review of the TDR. This review should be followed by a full-fledged cost and schedule review.
CSN2.2 INFN should start an organized process of down-selecting the new initiatives in CSN2.
CSN3-1: Support travelling experimental setups to maximize capabilities of Italian National Labs, e.g., give high priority to AGATA@LNL experiments starting in 2021.
CSN3-2: Support the PANDORA project at LNS since it will add a unique research capability, and define a local operating group including experimental nuclear (astro) physicists.
CSN4-1. There are currently about 35 IS. The CVI report for 2020 should focus on the changes instituted in the IS programme and the rationale for those changes.
CSN4-2. The INFN should present bibliometric information for the associates and employees separately.
CSN5.1. Describe the criteria used to allocate resources among the three active CSN5 programs: Standard proposals, Calls for Proposals, and Grants for Young Researchers.
CSN5.2. Review and explain the criteria developed to evaluate the success of the two newer funding schemes: "Calls for Proposals: and "Grants for Young Researchers."
TT.1. INFN should consider launching a medium-term comprehensive review of its Knowledge and Technology Transfer activities that would lead to a final report in 2021. Proper attention should be given to TT for both economic and social purposes.
CH.1. Explore opportunities for the management of IP of instrumentation, with the Technology Transfer organization in INFN (National committee, Technology Transfer Service, and Local Referents).
LNF-1. INFN should give strong support to EuPRAXIA and EuPRAXIA@SPARC_LAB
LNS-1: Communicate a detailed shutdown-plan as soon as possible to staff and users.
LNS-2: Define a local PANDORA group that operates the device on a day-to-day basis.
LNGS-1. We strongly support the LNGS requirement that DAMA/LIBRA sustain a formal review of a CDR and TDR for it to continue.
LNGS-2. (Repeated from 2018) The laboratory should set up a stepwise "gateway" process for approving and supporting proposed new experiments and upgrades, going beyond assessment of the physics potential to make sure the safety issues and impact on LNGS resources are understood and covered.
LNL-1: Include funding for the dual-energy upgrade of the cyclotron in the upcoming budget plans to enable experiments at both ports with different energies and maximize the research output.
LNL-2: Provide an updated SPES schedule in midterm report and develop a plan how to move technical personnel temporarily to ensure a timely SPES completion and operation of AGATA at LNL starting in Q2/2021.
ET 1. We encourage the INFN to facilitate the full qualification of the Sardinian site for the Einstein Telescope.

Appendix III: Requests and suggestions for next year's report and for the CVI meeting.

1. As in past years we would appreciate receiving a mid-year report, including documentation of INFN's response to our recommendations, along with significant highlights (and lowlights).
2. INFN should be sure to deliver the 2020 GLV report a month or more before the meeting, i.e. on or before Sept 15, 2020. Only then it can be ensured that all committee members have enough time for detailed reading and feedback. The sections of the report should be more streamlined to ensure that they contain a similar amount of information.
3. To make the meeting more efficient, we would like to have a round of Q&A before the meeting, so that it is unnecessary for speakers to spend valuable time in their presentations to address questions.
4. Committee members lamented the lack of a high-level "Governance and Strategy" section in this year's report, and the absence of an "Overview" presentation at the CVI meeting. We assume these items will be included next year, covering main mission and vision, financials, personnel, main projects, major problems arose in the last year, charge to the committee, etc.
5. We plan to circulate next year's draft agenda to CVI members for comments and suggestions for changes, and therefore ask INFN to please send it to the CVI chair by the first week in September.
6. Presentations should be available and posted two days before the meeting, to allow CVI members to download and study them before boarding their planes.
    a. The presentations should be more streamlined and focus on main achievements, funding, personnel, significant issues, mission, future plans, rather than repeating in detail what is in the GLV report.
    b. *More analysis, less detail.*
7. The total time allocated to presentations needs to be shortened to free up time for committee discussion and closeout. To simplify planning, we propose that all presentations be finished by 13:00 of the second day.
8. Proposed afternoon program for second day:
    a. 13:00 – 15:30 committee lunch and executive session;
    b. 15:30-17:30 closeout. Lengthening the closeout will allow substantive discussion, fact-checking, etc.
9. Finally, it would be great to have name tags for participants and committee members with their affiliations and functions. (e.g. Lab director, Deputy lab director, CSN Group Leader, Giunta Esecutiva member).