Report to the President of the INFN

Il Comitato di Valutazione Internazionale (CVI)

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Introduction and General Comments

The 2015 meeting of the CVI took place the 19th through the 21st of October, at the Trento Institute for Fundamental Physics and Applications (TIFPA). In preparation for the meeting, INFN management provided us with the annual report of the Gruppi di Lavoro per la Valutazione (GLV), which nicely summarised the accomplishments of and issues facing the several INFN research programmes and served as reference for our discussions with the directors of the National Scientific Commissions (CSN's). Highlights of the meeting included a ceremony inaugurating TIFPA, a tour of its impressive facilities, and a visit to the adjacent Center for Materials and Microsystems of the Bruno Kessler Foundation (FBK). We wish to express our thanks to TIFPA Director Marco Durante and his staff for their efforts on our behalf that made the meeting very efficient and productive. The meeting agenda, a list of our recommendations, and a set of requests and suggestions for next year's GLV report are attached as appendices.

It is our consensus opinion that INFN continues to select and support outstanding activities, and that the President has established a strong strategic plan for success. As has been standard practice for the CVI, we reviewed the five CSN mes along with Technology Transfer, and Education and Outreach. In addition, we focused this year on an assessment of TIFPA, on the new director's plans and strategy for Frascati National Laboratory (LNF), and on the quality and emphasis of the R&D carried out in the various INFN institutes. We also look forward in the near future to the results of ongoing reviews of the "What Next?" initiative, the LNS programme, and the GSSC in L'Aquila. We shall comment when they are available.

Our meeting began with a discussion with INFN President Fernando Ferroni. We congratulate him on his well-deserved re-election, which should result in continuation of policies we have endorsed previously. He reported that the INFN budget had lost 9M€ this year, and that the Competitive Project funding has been delayed more than a year. On a positive note INFN expects to receive 14M€ in funds redirected from the SuperB project. The budget situation and recent constraints placed on hiring have resulted in a ~10% loss of staff, that they are not allowed to replace. For researchers, the rules restrict INFN to choosing from unsuccessful applicants from a competition that is now five years old, and foreclose the hiring of technicians, who are classified as administrators, where positions are frozen. <u>The CVI views this as a devastating problem; without relief in the near future, INFN will simply not be able to accomplish its programme.</u>

The "What Next?" initiative is now well underway, inspiring exciting new directions that merit strong support. Early ideas include CMB polarization, Dark Energy, and searches for dark photons at the Frascati BTF. We were especially pleased to learn of new programmes for students and young scientists, in which 90 applicants competed for grants in support of experimental projects. Nine grants were awarded for the highest quality projects. GSSI in L'Aquila has generated wide interest and recruited strong initial classes. Funding is provided by the region, MIUR and INFN in a ratio of 6:2:1. GSSI is currently midway through an initial term as a pilot project, with a decision upcoming on its long-term future.

Under the President's leadership INFN has initiated several innovative activities to couple science to industry and regional economies. As an example, a ~100M€ facility has been proposed for large-scale separation of gaseous isotopes. Located in a Sardinian mine, a 350 m high column would produce >20 tons/yr of depleted argon for dark matter experiments, and also refine large quantities of ^{18}O, ^{13}C, and ^{15}N. The income from this investment would be repaid in 5 years – a big boost for the region. In Trento TIFPA is focusing on compact accelerators for medical applications, and a highly promising collaboration among FBK, Lfoundry and INFN (TIFPA) is developing badly needed silicon photomultipliers for various applications. We also were informed of a new initiative into neuroscience.

A broader goal is to integrate INFN R&D with non-INFN academic and industrial research centres to form a Single Digital Market. EU involvement is essential here. As a related comment, we remark that INFN should contribute where possible on European projects and will benefit by doing so. In this regard the above-mentioned R&D competition will prepare young investigators for ERC competitions, for both starting and consolidator grants.

Stagnant budgets will require even more selectivity to preserve the quality of INFN's excellent repertoire. For example the entry into neuroscience should be monitored to verify that it is making significant intellectual impact and is well integrated with medical scientists and biologists. We are especially concerned that recent hiring freezes, especially for technicians, are seriously impeding INFN's capability to carry out its committed programme and are stifling new initiatives. Without relief, this national jewel could be irreversibly damaged.

Recommendation

Intro 1. INFN should consider working together with other public research institutions and propose a request and rationale to the government for a new law to lift the hiring freezes on technicians/administrators, and to authorise new searches for researchers. It may be advantageous to establish startups to fill gaps on the administrative side.

CSN1 – Accelerator-based Particle Physics

The CSN1 programme continues to thrive and produce important results with the highest scientific impact. After the two-year-long shutdown, the Large Hadron Collider at CERN successfully restarted this year and is delivering data to the experiments at unprecedented energies. With LHC clearly being the largest activity not only within the section, but also INFN as a whole, CSN1 pursues in addition a diverse and healthy research programme with

experiments in all stages of upgrades and preparation. This is of paramount importance to sustain the expertise in technological development as well as for the education of young scientists.

The ATLAS and CMS collaborations are now probing the uncharted energy regime at 13 to 14 TeV searching for new physics beyond the Standard Model and probing electroweak symmetry breaking by detailed measurement of the Higgs boson's properties, all the while producing exciting new results on top physics, B physics, QCD and also forward physics with the dedicated TOTEM and LHCf experiments. Italian scientists continue to play an extraordinarily visible role in all LHC experiments and hold many leadership positions at all levels. Italian Fabiola Gianotti will become the first female Director-General of CERN. Moreover, Italian collaborators receive more than their share of presentations at international conferences. This reflects the appreciation by the international community of the high quality of the Italian physics education and the talent of the scientists. Every effort should be taken by the country to offer these highly skilled young physicists attractive career perspectives in Italy.

Preparations are progressing well, with significant contributions from INFN, for the Phase-I upgrades of ATLAS, CMS and LHCb, that will be installed during the long shutdown 2019-2020. Also this year, a decisive milestone in the planning of the Phase-II upgrades for ATLAS and CMS, Step 1 approval by CERN, was completed successfully in October. To deal with the largely increased luminosity, the detectors will have to undergo major upgrades around 2025. Funding plans outlining the cost and responsibility sharing have recently been presented by the two collaborations and the Technical Design Reports will be due in about two years. At this meeting, we have been presented a solid and reasonable financial plan to contribute to this large global effort. This commitment will ensure that INFN will remain a major player in the HL-LHC programme. We look forward to hearing about progress towards the TDRs at future meetings and comment that necessary investments into computing infrastructure will also be vital to optimally exploit the unparalleled science opportunities offered at the (HL-)LHC.

Flavour physics is a traditionally strong research line within CSN1. The LHCb experiment is clearly dominating the field now, but many other experiments also profit from the strong impact of the INFN scientists, e.g. the Belle-II experiment under construction, BES-III and NA62 that successfully started data taking this year.

The performance of DAFNE and the progress of the KLOE experiment situated at LNF have been a concern during the last few years. We are pleased to see the accelerator finally performing in an efficient and reliable fashion, and a well-defined revised physics programme with clear milestones for the final two-year run. We deem it crucial that enough manpower is available to exploit the final KLOE run data fully and strongly support the idea of ensuring the open availability of the data after the end of running. The participation in the smaller lepton flavor-violation experiments MEG, Mu2E and G-2, which are currently upgrading or under development has been strengthened, in particular by the highly skilled former SuperB physicists.

"What Next?" initiative, outlining scenarios and possible priorities for the next 10 to 20 years in accelerator-based particle physics. As an example, new experiments at beam dumps are proposed, SHiP at the SPS at CERN and PADME at LNF-BTF. LNF will certainly profit from such a future scientific experiment on site.

The committee highly commends the strategic process of the "What Next?" exercise and looks forward to hear about the evolving strategies. We see an upcoming stress on the resources of the institutes - in terms of budget and manpower - as the construction of the LHC Phase-II upgrades approaches, and it will be challenging but most important to balance this effort with a diverse program at other accelerators. Care should be taken to ensure coherence while keeping a rich program.

Recommendation

CSN1 1. In considering future experimental proposals and directions, CSN1 should work with INFN and LNF to maintain a rich, coherent programme and avoid excessive fragmentation.

Laboratori Nationali di Frascati (LNF)

As the largest entity in the INFN programme, a successful LNF is essential. The laboratory faces a fundamental decision point on its future as the DAFNE programme draws to a close, so we were reassured to see that in a very short time in office the new director has launched a strategic planning exercise. We strongly support the directions being pursued, and suggest that the enterprise would benefit from a clear and emphatic mission statement. We expect LNF to be a major item for next year's meeting.

For the short term, improved DAFNE performance validates the recent decision to pursue a two-year campaign to complete its physics programme, provided there is a sufficiently strong physics team to acquire and analyse high-quality data. Post-DAFNE, however, it is essential for LNF to recognise that its programmes have become somewhat fragmented in recent years, resulting in several apparently subcritical efforts, and therefore the lab might greatly benefit from focusing the scientific and support staff on high-priority activities, while maintaining and improving infrastructure and facilities as it restructures. Going forward, it will be a major challenge to match expertise and scientific interests with the coherent LNF strategic plan. The director put it well: "We should only be engaged in experiments where LNF matters." Currently the LNF staff is comprised by 270 people with indefinite contracts, and 61 people on short-term externally-funded contracts. The laboratory is losing competencies at an increasing rate because of retirements, and cannot replace people because of hiring freezes and rules. <u>If this trend is not reversed the situation will be catastrophic within a few years.</u>

The LNF mission is to provide Accelerator Science for Particle Physics, manifested in Accelerator R&D, and the expertise and infrastructure to design and build detectors. These core capabilities should be preserved, at a level to influence new machines and to be a technological hub for LHC upgrades. The laboratory also provides societal benefits via outreach, especially to younger generations, and special infrastructure to attract external resources to partner in technology transfer.

LNF has a very active in accelerator physics and R&D: complete the DAFNE programme, jointly construct ELI-NP in Romania, operate and upgrade the SPARC_LAB, and participate in other activities around the world. Much of the R&D programme is completely dependent on external funds– 12M€ in 2015 – presenting a challenge to guarantee enough resources to sustain strategic activities. DAFNE's luminosity has improved via the innovative crab waist scheme invented at LNF to 2×10^{32} cm $^{-2}$ s $^{-1}$ peak, 200pb^{-1}/month. Plans call for a 5 fb^{-1} campaign (~2 years) to complete the physics programme. Design and construction proceeds on ELI-NP, supported by EU structural funds, to provide a competitive source of 20 MeV photons for various uses. ELI building construction has been delayed by 6 months, which may shift the target for completing construction and commissioning to 2019.
With SPARC_LAB, LNF is a world leader in the field of combined-concept laser/plasma acceleration. A crucial test is scheduled for 2016 on a PWFA plasma capillary cell to accelerate electrons. The desired strategic plan has SPARC operating stably in 3 years with an upgrade of the linac and other components in 5 years, and possibly a second bunker, to make it a European user facility in the ~ 200 M€ range.

LNF's preliminary thoughts on the "What Next?" initiative involve programmes at a European level, and engagement of industry. The high-risk, high-value EUPRAXIA study would represent an optimal initiative, but alternatives are clearly needed. A high-quality beam test facility based on the DAFNE linac figures prominently in future plans, operating 200 days/year at an upgraded intensity, including beams of tagged photons and neutrons. The programme would include an experimental search for dark photons, and space qualification tests for industrial users, e.g. a facility to characterise reflectors and a clean room with solar simulators. There would also be a cryostat for detector integration in balloons or small satellites. A further option would be a micropattern detector facility. Currently CERN is the only provider, but LNF could become a hub for phase-II upgrades and other experiments in partnership with CERN and industry.

Recommendations

LNF 1. INFN should strongly support the director in refocusing the laboratory's post-DAFNE programme to have maximum impact on the world scene. LNF should concentrate resources on high-priority activities, and incentivise staff to move to high-priority activities. INFN should assist LNF in competing for external funds.

LNF 2. INFN should work to improve coherence of LNF and the CSN's, particularly 1, 3, and 5.

LNF 3. At our next meeting LNF and INFN should describe how SPARC_LAB and the ELI's will relate to each other over the years, with and without an eventual European Facility.

CSN2 – Astroparticle physics

The CSN2 programme is rich, with a strategic view that builds on the historic role and the strengths of astroparticle physics in Italy in what can naturally be a rather fragmented field. INFN has a historically strong role and belongs to the world leaders in this field (the others being France, Germany, USA, Japan and, rapidly evolving, China). The streamlined programme structure, with its 4 instead of previously 6 research lines, appears more strategic and logical: 1) Neutrino properties, 2) Dark Universe, 3) Cosmic Radiation and 4) Gravitational Wave and Quantum

Phenomena. There are 3 strategic pillars on which the programme rests: The rich programme in LNGS, the space programme and the gravitational wave programme (Virgo, and in the future, LISA). A fourth pillar will hopefully be added soon: neutrino astronomy with KM3NeT. We acknowledge the support for technological innovation projects like CUPID or SABRE in order to be prepared for the future.

The programme has moved successfully in most projects, with only a few exceptions. We note a project reduction at a few places (gravitational-wave bar detectors, ARGO/YBJ, Gamma-400) in accordance with our previous recommendation. The question remains whether this reduction is sufficient and leaves enough room for new/innovative approaches in the spirit of "What Next?". On the other hand, astroparticle physics is diverse by definition. In many of the "small" projects INFN has leadership (e.g. those in LNGS) or unique expertise (e.g. JUNO).

We see a strategic approach in nearly all areas. For example, for the direct search for WIMP dark matter a better understanding of the DAMA/LIBRA signal via their low-threshold runs is envisaged and at the same time a (long-awaited!) independent confirmation is prepared with the SABRE project. Beyond that, a programme is started to reach the ultimate (neutrino-limited) sensitivity with noble liquid detectors. One of the ingredients of this approach is the plan for isotope enrichment with the ARIA project in Sardinia (which in the long-term could lead to a commercial profit). For the search for neutrinoless double-beta-decay, the near future is defined by GERDA and CUORE. At the same time, innovative approaches are prepared within the CUPID project (rather than just increasing the mass). These activities are flanked by the plan for a better determination of the relevant matrix elements with the NUMEN programme in Catania.

For cosmic radiation, INFN plans to extend direct CR measurements far into the TeV region with the DAMPE satellite (up to ~100 TeV). It was hoped to go up to 1 PeV with the Russian Gamma-400 project, but the change of the GAMMA-400 design and priorities led to an exit of INFN, a decision we clearly support. The future of ground-based studies at highest energies will be defined with AugerPrime, and finally full-sky neutrino astronomy after IceCube will be started with KM3NeT (a modified 1st tower plus 1st string are going to be deployed in December). This is a good strategy at the high-energy frontier. We note, however, that INFN's role in CTA was not reported. The gravitational wave programme has a clear short-term goal: to operate Virgo and discover, together with LIGO, gravitational waves – a centennial harvest after a half-a-century path. The lower frequencies will be addressed by LISA; we are happy to hear that the LISA-Pathfinder will be launched this December. Decisions have to be taken in the near future on INFN participation in several experiments (AugerPrime, LHHASO, HERD), and projects to determine oscillation parameters and in particular the neutrino mass hierarchy (NMH) and the CP violation phase [JUNO (NMH) vs. ORCA (NMH) vs. Dune (CP/NMH) vs. Hyper-Kamiokande (CP/NMH)]. We note that a determination of the NMH could have substantial impact on the neutrinoless double-beta-decay (DBD) programme. In case Nature has chosen the direct mass hierarchy, neither the present detectors nor one of the planned next-generation experiments could reach the necessary sensitivity, and a totally new approach would be necessary.

A possible participation in **JUNO** has to be decided rather soon. Measuring NMH with JUNO and ORCA could reduce ambiguities for CPV determination. For JUNO the necessary 3% energy resolution is a very high benchmark, but even the secondary goals alone would provide an excellent benefit/cost ratio for INFN. JUNO provides an excellent application for INFN expertise. We take note of concerns on the extreme Chinese dominance, but JUNO seems more appropriate than participation in Hyper-K, where no particular expertise exists in INFN. Participation in **Dune** has to be seen in a broader European context, with the CERN policy and with the existing INFN expertise from ICARUS; Participation in **ORCA** comes automatically via KM3NeT ..

With respect to **AugerPrime** we note that ultrahigh-energy cosmic ray physics is at a turning point. The high-energy cut-off has been clearly confirmed but its nature remains unclear, and no point sources have been detected. The key to move ahead in both questions is a more precise mass assignment of individual events and the separation of a proton event sample which is minimally polluted by heavier nuclei. A proton component less than, say 5%, would very likely herald the end of the race towards *astronomy* with charged cosmic rays. Vice versa a proton component higher than the presently estimated 10% might open the path towards cosmic ray astronomy. Therefore the ratio between science benefit versus cost could hardly be more advantageous, as AugerPrime could detect first point sources and break through a long-standing wall. We are pleased by the INFN decision to participate in the **DAMPE** project, with high-tech developed in Italy and paid by China, and with very good physics case.

There are some concerns about the **KM3NeT** delay, both for towers and strings. However, the Sea is a challenging medium and provides a much higher threshold to start an experiment than experiments underground or at the surface,and we encourage INFN to keep supporting the project.

We found that some of our requests from last year's CVI report have not been addressed: detailed information on Holmes, and a "more detailed discussion on the options, the strategy to define priorities and milestones for decisions in Italy and by foreign partners". We also requested a clear description of the roles of LNGS and CSN2 management, and hope to get a more explicit response to these points.

Recommendations

CSN2 1. Implement the presented strategy for dark matter, neutrinoless double-beta Decay, and for exploring further possibilities in the Chinese space programme (in particular HERD).

CSN2 2. Make sure that there is a sufficient team to analyze the VIRGO data.

CSN 2 3. Participate in AugerPrime provided enough other countries sign in.

CSN2 4. Continue political support for KM3NeT because of the strong physics case and strategic importance for Italy. We support activities towards KM3NeT Phase-2, in particular after the first few strings and towers have demonstrated the feasibility of the technical concept on a broader basis than at this point.

CSN2 5. Consider INFN participation in Juno because of the strong physics potential, and position INFN to leverage Italian expertise to achieve maximum impact.

CSN2 6. Possible participation in LHAASO should be weighed within the political context of other science connections to China, recognizing that its science case is lower than that of KM3NeT or AugerPrime. We would like more clarification of the role of INFN in CTA at the next review.

CSN3 – Nuclear Physics

We are pleased to congratulate M. Taiuti on his re-election for the coming 4-year period, and for his steady management of CSN3. We were informed that PANDA-RD has been closed, and that no participation in PANDA@FAIR is envisaged in the future. The NUMEN R&D phase foreseen in "What Next?" and the ALICE upgrade have started. CSN3 has for the first time financed a proposal for nuclear physics applications in medicine, an interesting development in view of the fact that INFN within the framework of TIFPA supports medical research for proton therapy.

The budget of CSN3 has been decreasing over the last 5 years, from ~ 11 M€ to 9.2 M€, but seems to have been stabilised over the last two years. An additional budget of 1 M€/year on the average is obtained from external funds. Considering the overall decrease in the INFN budget, the CSN3 budget seems reasonable, if no big technical projects are planned in the coming four years. There is a good distribution of the total budget over the different activities, some of which are committed to maintenance and upgrade of available instrumentation and a compulsory contribution to CERN.

In a similar trend, the INFN CSN3 total staff showed a decrease in the last three years that is almost commensurate with the decrease in the budget. Because the male staff decreased whereas the female staff has increased slightly, the gender balance has improved and continues to be the best among the CSNs. Very worrying, however, is the age distribution of the CSN staff, which peaks both for males and females in the category 51-60 years old. This is exacerbated by the recruitment policy that does not allow replacements when scientific staff retire, a central issue for the last few years. Fortunately, the collaborating university staff are more or less stable in numbers and display a very healthy age distribution. The gender balance of INFN staff fulfilling roles as spokespersons, coordinators or are involved in important international bodies is also quite good.

Scientific production has been very high with many articles published in high-impact international journals, among which seven Nature and two Science articles are equally divided between CSN3 experimental lines. We are impressed by the high publication rate, the steady increase in quantity (from ~200 in 2009 to ~ 350 in 2014) and improvements in quality. Many interesting results have been reported by all four lines of CSN3 research. In particular, the successful campaigns of AGATA at LNL, GSI and GANIL have produced and are still producing exciting results. The ALICE experiment has made the highest-precision direct measurement of the mass differences of d and ^{3}He and their anti-nuclei, obtaining a null result in agreement with CPT invariance. The CSN3 staff should be congratulated on all these successes and we recommend that in all respects CSN3 divisions should stay the course.

Considering that the expectations for NUMEN are very high because of the implications of the measurements on the nuclear matrix elements for neutrinoless double-beta decay, CSN3 should

make sure there is a strong collaboration between nuclear-structure and nuclear-reaction theorists. The data will be obtained at energies where the spin-isospin term of the nucleon-nucleon (NN) interaction is relatively weak compared to the NN isospin term, and where the central NN scalar-isoscalar term is very strong. Therefore, for a good interpretation of the data nuclear reaction theorists will have to disentangle the coherent single-step and multi-step transitions at varying momentum transfers.

Recommendation

CSN 3. 1 INFN should make sure there is strong collaboration among nuclear-structure theorists and nuclear-reaction theorists in the NUMEN programme.

CSN4 – Theory

As in previous years, we have a very positive opinion of the overall functioning of CSN4, and take the opportunity to congratulate Alberto Lerda on his re-election, for the proactive role he has taken, and for the innovations he has introduced.

The data presented shows a rather well-balanced distribution among the six sectors of CSN4: string and field theory, particle phenomenology, hadronic and nuclear physics, mathematical methods, astroparticle physics and cosmology, statistical and applied field theory. The other encouraging feature is that this distribution is dynamical, and that some theorists move from one sector to another one. The GGI is a very successful endeavour of CSN4, as evidenced by a significant donation from the Simons Foundation that recognises GGI as one of the leading centres in the world for hosting long-term workshops.

The number of FTE's remains approximately constant (980). The CVI has already praised the way chosen to modulate the funding with the overall activity through a clever practical application of renormalisation, as well as the consolidation into 39 Iniziative Specifiche (IS). We approve the external evaluation of these IS which has been decided for this year. We note that CSN4 appears to be quite successful with the postdoctoral fellowship programme that it has set up, and would like to have some elements on the subsequent prospects of the postdoctoral fellows hired in recent years.

We also applaud CSN4 for two specific aspects of their actions: the good connection with the other CSNs and the interest in training young researchers. Regarding the former, one may cite many examples where CSN4 actively collaborated with other CSN's: strong participation in the "What Next?" meetings, working group on LHC, successful collaboration with ECT*, and involvement in the NUMEN project.

Finally, we commend CSN4 for its continuous attention to the training of young researchers, as well as for the resources allocated to this task. An example is the Ph.D. schools organised by the Galileo Galilei Institute (GGI), which appear to be quite successful.

Recommendations

None.

CSN5 – Technological and Interdisciplinary Research

The mission statement of CSN5 is simple and clear: "coordinate and promote." CSN5 coordinates the advanced technological research of INFN and promotes its application to other fields. Its range of activities comprises radiation detectors, accelerators, electronics, and interdisciplinary applications. CSN5 has been reorganising to focus on a smaller number of experiments, with a steady annual reduction since 2008, followed by a reduction to 56 experiments in 2014 compared to 65 in 2013. In spite of the simultaneous reduction in the number of FTEs involved, the number of FTEs/experiment increased slightly over the last three years. CSN5 has done very well in other key performance indicators: i) the number of invited talks, including plenary and parallel sessions is large; ii) the number of theses at all levels has increased; iii) the number of publications has seen a ~ 25% increase in 2014 compared to 2013, whereas the number of publications/FTE saw a 50% increase in the same period; iv) INFN CSN5 budget increased from 3.6 M€ in 2011 to 5 M€ in 2013 and 2014; v) CSN5 obtained 18 M€ of external funds in total in the period 2011-2014 (11 M€ of which *premiali* funds); and last but not least vi) a staff member of CSN5 won an Advanced ERC Grant with a budget of 1.9 M€. We congratulate CSN5 on all these successes and in particular the coveted, highly competitive Advanced ERC Grant.

CSN5 followed a track to reposition itself and improve its instruments for funding. It worked on funding a smaller number of projects, which would have a higher potential of success and impact, introduced grants for young researchers with training for ERC applications, and introduced a call for proposals in addition to the standard bottom-up approach. The instruments have been very successful and especially the grants for young researchers attracted a large number of applications. Three grants were awarded in 2013, and this was doubled in 2014 through additional grants from CSN1, CSN2 and CSN3, which indicates a good collaboration spirit between the CSNs. A new funding scheme was introduced in 2013 combining a call for proposals and a normal "bottom-up" procedure. This had a mixed success in the years 2013 and 2014. By contrast the introduction of a "thematic call" in 2015 was a big success with 9 applications for the "thematic call" and five for the "open call". In the end, three projects were approved. Research performed in the framework of CSN5 resulted in 4 patents and a few are still under consideration.

We are impressed with the various recent successes of CSN5. The grants for young researchers instrument is a success, and we would like to hear in the next meeting on how many of the awardees applied for an ERC grant and hopefully got it. We strongly endorse the new method for calls (open and thematic), which seems to be quite attractive to young researchers, and the selection processes for the grants for young researchers. We highly appreciate the involvement of CSN5 in the ELIMED project to design and develop a transport beam line for laser-driven beams that will be installed at the ELI-Beamlines facility in Prague.

Recommendation

CSN5 1. The CVI encourages a stronger involvement of CSN5 in European projects, such as ELI, since this will increase the collaboration of CSN5 with other European groups, attract extra funding and enhance the visibility of CSN5's research.

Trento Institute for Fundamental Physics and Applications (TIFPA)

TIFPA, an exciting new laboratory for innovation and translational research, contributes to 26 INFN experiments and hosts virtual laboratories in space research, medical physics and sensor development. Its world-class facilities are most impressive, including new cleanrooms and ovens for SiC sputtering and rapid thermal processing, and a positron beam for studying open volume defects. TIFPA enjoys a strong, well-aligned collaboration with FBK, which is located as close as possible geographically. Joint TIFPA-FBK efforts in fabrication and characterisation of imagers and sensors, microsystems and integrated systems are of high relevance to INFN and to European particle and nuclear physics. The APSS programme pursues proton therapy with unique capabilities to combine radiation and chemotherapy, and to treat metastatic patients with low damage to neighbouring organs.

With the University of Trento TIFPA operates control rooms for AMS-2 and the soon-to-be-launched LISA Pathfinder, and leads the LISA Pathfinder analysis team. Other space-science activities include the design and testing of inertial sensors, and radiation tests of new materials for missions to Mars and for a moon base.

The laboratory has made excellent progress since last year, and has recruited an excellent new director. The programme is well focused with clear priorities, and has created important synergies among collaborating institutions. The close presence of FBK is an existential advantage that INFN has wisely invested in. The presence of the European Theory Center ECT* is beneficial – the current relationship seems at an appropriate level. On the negative side we are surprised and concerned by the lack of permanent staff (currently only 2 FTE), and would expect TIFPA and INFN to redress this weakness.

Recommendation

TIFPA 1. INFN should continue its strong support for TIFPA, and take steps to remedy the severe shortage of personnel to prevent damage to TIFPA programmes.

Technology Transfer

A structural and functional collaboration with industrial enterprises is a strategic asset for the development of INFN, with the potential to have highly-positive effects on its research activities, its application opportunities, and last but not least, its placement for PhD students and researchers.

In the last two years INFN has taken the CVI's suggestions very seriously, and focused on the definition and starting up of the INFN technology transfer structure. The plan is based on a very articulated organization linking the national level – the CNTT (National Committee for Technology Transfer and External Training), with the local one – the Network of local TT contact persons (TT Representatives).

Great attention was paid to the definition of internal and external rules for technology transfer activities (i.e. contracts, IP management, revenue distribution …,) and to the promotion of a collaborative approach inside the centres. We consider particularly relevant the action taken to

reduce the times taken by the various steps in the process: to patent/contract, to definition of R&D activities and patents, to distribution of revenue, and to mapping TT actions and results within INFN. Similarly, we are impressed by INFN's holistic approach, covering the definition of the structure and rules and their relation to INFN's many different TT activities: external training, collaboration with other research centres and infrastructures, business incubator action, agreements with industry, definition of external research networks. We highlight and emphasise the importance of enlarging the collaboration on business incubator action with other national partners.

Recommendations

TT 1. INFN should continue and reinforce actions to improve connections with enterprises that are growing, but so far have seemed, to the "inner circle" of those that have already worked with INFN in the infrastructures construction, to be too limited. It could be useful to develop the collaboration with industrial networks and regional and national technological clusters, exploring different ways to meet and participating in common R&D projects.

TT 2. INFN should explore the possibility to promote at the national level a more structured approach at national and international R&D infrastructures (in collaboration with other Research centres and with enterprises organisations) in order to fully exploit their potential, starting from the construction phase up to the participation in R&D activities.

Communication, Outreach and "Third mission"

Communication and outreach is a fundamental activity for the future of INFN because, on one side it accomplishes a social duty and the statutory mandate of dissemination of science; and on the other side it helps increase the social acceptance of a public investments in fundamental research, and the understanding of the multiple facets and social impact of the research in nuclear physics and related fundamental science.

In the last few years, INFN has responded promptly to this challenge: a very active team of young professionals has been put in charge of all communication and outreach activities. The team shared with the Direction a clear statement of the method, based on an "Integrated communication" approach. This approach enables engagement with various publics through different products (text, press releases (PR), photos, video, brochures, posters, exhibits), that are composed in a modular way. A shared communication conveys the basic values of INFN research.

With this approach, multiple activities have been quickly put in place, ranging from the re-design of the web page and a new approach to social media, to communication and information to schools, and to organization and participation to exhibits. Imaginative ways to communicate science to a large public have been designed and realised.

We have been impressed by how INFN has enhanced its communication and outreach mission. It is clear that, despite budget and personnel constraints, INFN places strategic importance on the investment in a group of professionals. The Communication Team, on its side, seems to be aware of the multiple dimensions of science communication, and has put in place an impressive variety of activities directed to different publics. We encourage INFN to pursue this valuable activity, and we hope to hear on the progress of actions undertaken in the next CVI meeting.

Recommendations

C&O 1. INFN should explore opportunities for funding coming from the European programmes for science communication and diffusion.

C&O 2. INFN should define more precisely its goals of communication directed to different publics, and devise metrics of goal attainment where possible and reasonable..

C&O 3. INFN should consider giving increased attention to social media, particularly in order to reach young people and students.

Conclusion

As clearly demonstrated by the documentation and presentations at this meeting, INFN continues to produce outstanding science, while increasing its reach in technology transfer, collaborations with industry, and outreach to the public. The "What Next?" initiative is proceeding nicely, and with the President's reelection will continue coherently. LNF and TIFPA are progressing well under their new directors, but are suffering from government-wide hiring freezes and constraints as are INFN activities in general. This serious problem, if not corrected, will damage the excellence of INFN, possibly irreversibly. We encourage INFN to cooperate with other government-supported science and technology agencies to advocate for relief.

It would be of benefit to the committee if INFN could brief us on its action plans for addressing and tracking our recommendations, and otherwise keep us informed of major developments throughout the year.

Finally, we thank again Marco Durante and his staff, the members of the executive board and the chairpersons of the scientific sections for their hard work in preparing all the information they provided us and for their warm hospitality, which together made the meeting efficient, collegial and successful.

Appendix I. Agenda

CVI Meeting at TIFPA – Trento

October 19-21, 2015

In the following timetable, all presentations are 15', followed by 45' discussion
(except F. Ferroni's presentation, which will be followed by 15' discussion).

==========19/10 Monday==========

12.30 at TIFPA CVI meeting with INFN GE
lunch break 13.30-14.30

14.30 F. Ferroni: report and charge to CVI
15.00 N. Pastrone: CSN1
16.00 Coffee break
16:30 M. Pallavicini: CSN2
17.30 P. Campana: Future plans for LNF

18.30: CVI has business dinner w/o other participants
========== 20/10==========
9.00 V. Bonvicini: CSN5
10.00 M. Durante: TIFPA
11.00 Coffee break
11.30 TIPFA inauguration and visit

13.00 lunch break

13.30-15.00: CVI Closed Session (lunch continues in camera).
15.00: S. Falciano: INFN and Technology Transfer
16.00: break
16.30: A. Lerda: CSN4
17.30: E. Cossi: Communication Office: from Institutional Communication to Science Outreach

Dinner CVI+GE+Labs Directors
========== 21/10==========
9.00 M. Taiuti: CSN3
10.00 coffee break
10.30 closed session

Lunch (Closed session CVI)

13:00 Closeout with INFN
End by 2 PM

Appendix II. List of Recommendations

Intro 1. INFN should consider working together with other public research institutions and propose a request and rationale to the government for a new law to lift the hiring freezes on technicians/administrators, and to authorize new searches for researchers. It may be advantageous to establish startups to fill gaps on the administrative side.

CSN1 1. In considering future experimental proposals and directions, CSN1 should work with INFN and LNF to maintain a rich, coherent programme and avoid excessive fragmentation.

LNF 1. INFN should strongly support the director in refocusing the laboratory's post-DAFNE programme to have maximum impact on the world scene. LNF should concentrate resources on high-priority activities, and incentivise staff to move to high-priority activities. INFN should assist LNF in competing for external funds.

2. INFN should work to improve coherence of LNF and the CSN's, particularly 1, 3 and 5.

3. At our next meeting LNF and INFN should describe how SPARC_LAB and the ELI's will relate to each other over the years, with and without an eventual European Facility.

CSN2 1. Implement the presented strategy for dark matter, neutrinoless double-beta decay. Consider INFN participation in Juno because of the strong physics potential, and position INFN to leverage Italian expertise to achieve maximum impact.

2. Make sure that there is a sufficient team to analyze the VIRGO data.

3. Participate in AugerPrime provided enough other countries sign in.

4. Continue political support for KM3NeT because of the strong physics case and strategic importance for Italy. We support activities towards KM3NeT Phase-2, in particular after the first few strings and towers have demonstrated the feasibility of the technical concept on a broader basis than at this point.

5. Possible participation in LHAASO should be weighed within the political context of other science connections to China and further possibilities in the Chinese space programme, e.g. HERD, recognizing that LHAASO's science case is lower than that of KM3NeT or AugerPrime. We would like more clarification of the role of INFN in CTA at the next review.

CSN 3. 1 INFN should make sure there is strong collaboration among nuclear structure theorists and nuclear reaction theorists in the NUMEN programme.

CSN5 1. The CVI encourages a stronger involvement of CSN5 in European projects, such as ELI, since this will increase the collaboration of CSN5 with other European groups, attract extra funding and enhance the visibility of CSN5's research.

TIFPA 1. INFN should continue its strong support for TIFPA, and take steps to remedy the severe shortage of personnel to prevent damage to TIFPA programmes.

TT 1. INFN should continue and reinforce actions to improve connections with enterprises that are growing, but so far have seemed, to the "inner circle" of those that have already worked with INFN in the infrastructures construction, to be too limited. It could be useful to develop collaborations with industrial networks and regional and national technological clusters, exploring different ways to meet and participating in common R&D projects.

2. INFN should explore the possibility to promote at the national level a more structured approach at national and international R&D infrastructures (in collaboration with other Research centres and with enterprises organisations) in order to fully exploit their potential, starting from the construction phase up to the participation to R&D activities.

C&O 1. INFN should explore opportunities for funding coming from the European programmes for science communication and diffusion.

2. INFN should define more precisely its goals of communication directed to different publics, and devise metrics of goal attainment where possible and reasonable..

3. INFN should consider giving increased attention to social media, particularly in order to reach young people and students.

Appendix III. Requests and Suggestions for the 2016 GLV report

At the request of INFN we have put together below a set of suggestions and requests for information to aid the GLV in preparing its 2016 report. These items may also be useful in choosing topics for the 2016 CVI meeting.

1. Please include in the report an expression of INFN's overall strategic view.

2. Please include INFN's response to each of the recommendations in Appendix II; e.g., actions taken, work in progress.

3. We welcome a description of and the results of the decision process in CSN2 for choosing among the large number of options presented this year for new activities.

4. INFN-LNS-CSN3 should give an overview of the cyclotron upgrade, its aims, its technical realisation and its impact on the scientific programmes of LNS and CSN3.

5. INFN-LNL-CSN3 should give an overview of the envisaged scientific programmes at SPES-LNL and discuss the sharing of time between physics programmes and isotope production for medicine and other applications.

6. Please provide data and discussion on the current positions and career paths of past postdocs of the very successful postdoctoral programme of CSN4.

7. Please include a section describing in some detail how INFN is stimulating and reinforcing connections with enterprises.

8. For the National Laboratories, particularly LNF but also LNS and LNL, we would like status reports on their strategic plans, programme priorities, and their integration with the programmes and priorities of the CSN's. Conversely each CSN section report should indicate, where relevant, how its programmes are integrated with LNF and/or other national laboratories.

9. It would help us in our evaluation of the National Laboratories if their reports could follow a more standard format, as is now the case for the CSNs.