

INFN INTERNAL REVIEW COMMITTEE (CVI) REPORT: May 2002

Rome May 16-18, 2002

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Executive Summary

The Istituto Nazionale di Fisica Nucleare is the institute for research in particle, astroparticle, and nuclear physics in Italy.

The Comitato di Valutazione Interna (CVI) was appointed (Appendix A) by the Board of Directors of INFN and charged with performing reviews of the activities of the institute on a regular basis. The activities of the CVI are part of a more global response to the Italian governmental requirements for assessment, using criteria of certified validity and the highest possible objectivity, through the auspices of the Comitato di Indirizzo per la Valutazione della Ricerca (CIVR). The assessment criteria and their relative weights, have been approved by CIVR.

The 2002 review is the fifth in the series. It follows the submission of material in summer of 2001, which included the May 2001 CVI Report to the CIVR and the subsequent receipt by INFN of the response and further requests from the CIVR. For this review, INFN provided the committee with the following written reports:

1. Report on the INFN Activity in the last year: 2001.
2. The Socio-Economic and Interdisciplinary Impact of the Scientific Activity
3. Financial Resources
4. Large Equipments: Costs, scientific and social outputs.

The CVI met May 16-18, 2002 in Rome. It heard verbal reports from principals in the INFN management (Appendix B) and extensive time was available for questions and discussion. Before adjourning, the committee provided the President of INFN with a verbal report.

The scientific content of the overall program continues to be exciting and excellent. The particle physics and theory contributions have a strong impact on a global level. The initiatives in astroparticle physics have placed INFN in the forefront of European efforts. The spectrum of nuclear physics, both in Italy and at external laboratories, is on a high level and touches all the primary fields of interest. The experimental physics programs are well supported by a strong program of technological development, which also has significant socio-economic impact.

Over the course of the next year, the international particle physics arena will be colored by the emphasis, which must be given to the management of the construction of the accelerator and of the experiments of the Large Hadron Collider at CERN. Each of the scientific lines of INFN will be affected and INFN must participate strongly in discussions of the directions to be followed, as a result of possible delays to the accelerator completion.

In response to the request of the CIVR, we comment more extensively on the socio-economic and interdisciplinary impact of the scientific activity; this is organized by national scientific committee. The indicators of socio-economic and interdisciplinary impact are very positive. A large fraction of the funds used by INFN to purchase equipment is disbursed to Italian industry and in many cases the interaction also involves improvement of the industrial capability. The indicators with respect to the impact on training of students appropriate for a highly technological society, are also excellent.

The resource management process is judged to be good. The general financial situation is balanced, even if the introduction of cash limits, since 1998, has significantly affected the research activity. Medium term plans, covering 4-5 years appear to be very reasonable.

With this review, we have completed a cycle through the National Laboratories. The Large Equipment installations, the national laboratories of Frascati, Gran Sasso, Legnaro

and Sud, as well as the European Gravitational Observatory, provide an impressive array of scientific installations. In all cases, the fraction of the resources, human and fiscal, which is devoted to the science, is high and the availability of the facilities for operation is high.

With respect to the social impact, the larger fraction of the purchases, made by the laboratories, is from Italian industry. The laboratory facilities are made available on a broad basis, from material science to medical science, through collaboration with other Italian and international institutes. Direct treatment of cancer by new variants of radiotherapy is a prominent feature. The laboratories have outreach programs, some very active, which visibly promote the science. This is important in our modern society and should be strongly encouraged.

The following perspective applies to this report.

- a) The view taken by the CVI is “International”; the implication is that the standards being used are those of physics on a worldwide scale.
- b) The cycle of self-assessment and review followed by changes, never ends, but the utility of the process depends on the organization under study. The CVI notes with pleasure, the continued substantial efforts on the part of INFN to be responsive to our main recommendations.

1. Introduction

The CVI (Appendix A) met May 16-18 (Appendix B). This was the fourth meeting of the CVI. The initial meeting of October 1999 had a primary goal of establishing a methodology. The second review, in December 2000, was the first of the regular reviews but it lacked input data concerning institutes in other countries. Given the short time between the December, 2000 and May, 2001 reviews, it was agreed that the May 2001 report be based substantially on that of December, 2000, with incremental changes to reflect the new information and perceptions.

The present review follows the submission of material in summer of 2001, which included the May 2001 CVI Report to the CIVR and the subsequent receipt by INFN of the response and further requests from the CIVR.

In 2002, INFN provided the committee with the following reports:

1. Report on the INFN Activity in the last year: 2001.
2. The Socio-Economic and Interdisciplinary Impact of the Scientific Activity
3. Financial Resources
4. Large Equipments: Costs, scientific and social outputs

The committee was very impressed with the presentations of the activities of the institute. Many exciting opportunities continue to be offered to Italian physicists working within INFN to initiate, to lead, and to participate in, international programs of nuclear, particle and astroparticle physics at the forefront of attempts to reach a fundamental understanding of our world and its origins.

The structure of this report is as follows. In Section 2, we comment primarily on the changes over the past year in the main scientific features. In response to the request of the CIVR, we comment more extensively on the socio-economic and interdisciplinary impact of the scientific activity; this is organized by national scientific committee. With this meeting, we have completed a cycle through the National Laboratories; a report on the scientific programs of the Laboratori Nazionali di Legnaro and the Laboratori Nazionali del Sud are included in Section 3, which is devoted to National Laboratories and Sections. In Section 4 we discuss the Resource and financial management of INFN. Section 5 contains a consolidated discussion of the management and impact of Large Equipment. For this report the Large Equipment have been defined as the four national laboratories and the European Gravitational Observatory at Cascina. Finally in Section 6, we attempt a synthesis of the report into a series of findings and commentaries on the individual aspects of INFN.

2. The National Committees: Science, Socio-economic and Interdisciplinary Impact

The construction of the Large Hadron Collider accelerator at CERN in a new project schedule shows a delay of approximately one year, to 2007. This impacts broadly the scientific program of INFN and affects experiments being constructed within each committees CSN I, II and III. Given this impact INFN must participate strongly in the planning of the reaction of the European physics community to these realities.

Approximately one third of Laureate degrees in physics are associated with INFN and work with experimental groups as undergraduates. In addition, approximately half of that number work with the theorists in the INFN program but do not become associates themselves. The flow of these associated students through the system has a rather understandable pattern. In a given year (1997) there were 400 associated students. After

one year, 40% had graduated and found employment outside of INFN. After a further year, another 26% had left, and most of those remaining were pursuing a doctorate. After 4 years, all those remaining, slightly more than 25%, were pursuing a doctorate. The data on the ultimate destination of these physicists are not complete. Of 270 graduates who ceased their affiliation with INFN, there are data for 187. Of those, 41% went to industry. These people are an important contribution to the technologically educated leadership potential demanded by modern society.

A major interdisciplinary function provided by INFN is their management of, and execution of, the GARR-B project, which provides high bandwidth, high quality, communications and network bandwidth to Italian academics and researchers in Universities. This service is available to all, independently of discipline.

2.1 Physics with accelerators: CSN I

In the past year, there have been two significant changes to the scientific landscape of subnuclear physics.

- The LEP experiments have now essentially completed their analyses so will no longer figure strongly in the program of CSN I.
- There has been a significant delay, of about one year in the start of the LHC accelerator operations.

The LHC experiments, ATLAS and CMS, are in the phase of the experiment which is dominated by production of the sub-detectors and the start of the assembly of the large components. Although slightly less well advanced, this phase is also starting for the LHC-B and Totem experiments.

The LHC accelerator delay, if limited to a single year, will have the primary effect of making the initially installed detectors for ATLAS, CMS and LHC-B, more complete. Should the delay be significantly longer than one year, we can anticipate a loss of focus in the experiment collaborations.

The CSN I experiments operating at CERN in 2002-3 will be the successful neutral kaon experiment, NA48, which is now concentrating on K_S^0 decays, and the recently assembled COMPASS experiment.

This relative hiatus in the CERN program puts a premium on the productivity of the other operating experiments.

The BaBar experiment at Stanford Linear Accelerator Center is fully productive with an unprecedented integrated luminosity and an impressive flood of new results.

After a slow start, the operation of the Tevatron Collider at Fermilab is quickening and the CDF experiment has started to show results from this new run. At HERA, the ZEUS experiment awaits the completion of commissioning of the accelerator upgrades to HERA. Meanwhile the DAΦNE accelerator has shown an impressive increase in instantaneous and delivered luminosity. The kaon experiment, KLOE is presenting results on, relatively rare, kaon decays and radiative decays of the ϕ meson. Research and development work continues on the possible experiments BTeV (FNAL), MUG (PSI), and KOPIO (BNL).

The social impact of the work of CSN I is impressively broad, ranging from education to stimulation of the economy. The material presented by INFN does a good job of quantifying this, especially the return, to Italian industry, of these investments.

A large fraction of the funding for research in CSN I, is spent on the construction of large experiments. Of the funding assigned to the Atlas and CMS experiments at the LHC at CERN, between 56% and 80% is disbursed in contracts with Italian industry. In comparison with other CERN member states the "return coefficient" with respect to the direct Italian contribution to the CERN budget exceeds that of all countries except the two "host" states, France and Switzerland. Further this coefficient is high across a broad spectrum of industries. Many of the contracts with Italian industry involve development work by the company involved. Often, work with the physicists establishes a new product or improves the quality of an existing product.

Interdisciplinary impact is clearly demonstrated in the steady migration of new detector techniques, through large scale utilization in the experiments of CSN I to novel, innovative, and successful use in a broader context. One of several recent examples of spin-off is the use of silicon pixel detectors designed for the LHC experiments, in the field of medical X-ray imaging. The data handling for the present generation of collider experiments at the B factories and the Tevatron are enormous. For the LHC experiments they will be greater still. This has led to particle physics experiments being drivers of the handling of data through the burgeoning GRID network computing initiatives.

Perhaps the most dramatic potential for impact on other fields since the introduction of synchrotron radiation techniques, which had such an important impact on materials science and biology thirty years ago, is now in the offing. The research and development work for a new high energy linear electron-positron collider, in which INFN collaborated with DESY, Hamburg and other international institutions, has led to the demonstration of the possibility of Free Electron Laser beams of amazing brightness. A proposal is in preparation with other Italian institutions, CNR, ENEA, and the Rome 'Tor Vergata' University, to construct a device dedicated to broad, FEL-based, science.

2.2 Astroparticle and Neutrino Physics: CSN II

The field of fundamental research, Astroparticle and Neutrino Physics, is currently in a rapid expansion world-wide. Due to an early start and farsighted decisions, the INFN enjoys a leading role in this area. Most of the leadership stems from the availability of the Gran Sasso underground laboratory (LNGS). About half of the resources of CSN II are currently devoted to the LNGS and to the newly formed gravitational wave observatory EGO.

Arguably the most enigmatic and challenging objects in particle physics are neutrinos (ν). Significant progress in their understanding has been made in recent times with fundamental contributions coming from experiments carried out by INFN or by experiments with strong INFN participation. Recently, the preparation for ν oscillation experiments, i. e., the search for ν_τ appearance, in the LNGS has been started. The approved experiment OPERA will be installed in Hall C and the ICARUS prototype in Hall B. As a highlight of detector development the successful operation of the prototype ICARUS T300 liquid-Argon drift chamber module should be mentioned. ICARUS works like a massive time projection chamber with unprecedented performance. When enlarged to the full size of 3000 tons, it is well suited for various ν studies (ν 's from the CERN-Gran Sasso ν beam, solar and atmospheric ν 's) as well as for proton decay searches. The financing of a large fraction of both experiments (both experiments have a significant but not sufficient international contribution) will put a severe burden on the INFN budget; this needs attention. Another large detector in the LNGS, the Borexino experiment for the detailed study of solar neutrinos, is fairly advanced in construction but its start-up is delayed to spring 2003 due to some technical problems with the containment of the inner scintillator. Nevertheless the experiment is still timely due to its low energy threshold, and due to its ability to detect solar ν 's from the ^7Be reaction. If there would be further delays, the competitiveness of the experiment might diminish.

Numerous smaller experiments for dark matter and double β decay searches and solar neutrino studies are profiting from the extreme low background conditions and excellent infrastructure of the LNGS (for details see the 2001 report).

The set-up of the gravitational wave detector VIRGO has been basically completed and given a full laboratory status: EGO (European Gravitational wave Observatory) operation within the next year is eagerly anticipated. AURIGA, a resonant bar gravitational detector is now working successfully inside the worldwide detector network. The newly built cryogenic resonant bar, NAUTILUS at LNF, has been cooled to record low temperature of 0.1 K and thus might be even able to observe possible gravitational waves from SN 1987A.

In the sector of cosmic ray experiments, the participation of INFN groups in new international experiments has been approved, e.g., in two satellite-borne detectors (AMS2 for the search of antimatter and GLAST, an MeV, GeV γ -ray observatory), three ground-based experiments (ARGO and MAGIC, for γ -ray astronomy, and AUGER, for the study of the highest energy cosmic rays) as well as in the deep sea ν detector experiment, ANTARES. In all these cases the INFN collaborators are already fairly advanced in the construction of their detector contributions.

A longer term activity is in the initial phase of discussions: the NEMO high energy cosmic ν observatory in the Mediterranean 70 km off Catania. The general conditions of this deep-sea site are excellent. They might allow expansion for a futuristic detector of, say, 10 km³ volume because of the depth, the flat seabed, low water currents, minimal sedimentation and bioluminescence, as well as the good light transmission quality of the water. The technological impact of deep-sea technology, optoelectronics and other instruments developed for such a laboratory would go far beyond the scientific goals.

The socio-economic impact of the field is high.

- The research field attracts many students (mostly in physics but also in engineering) and the rate of laureas and PhD theses is amongst the highest in comparable fields. The selection criteria for accepting students are very high. The excellent training conditions for students, both in the IT and technology sectors, offers good prospects for positions in industry or other science areas.
- The public interest is also remarkably high, reflected, for example, by the numbers of visitors to the LNGS; this number is about half of that of the much larger and longer established European laboratory, CERN.
- The publication rate (productivity per author of 0.18, productivity coefficient of 102.8) and the impact factor of 0.49 per author, are significantly higher than France and Germany, the other two leading European countries.
- The high quality and the excellent working conditions in the INFN labs and experiments is reflected also by the strong international interest in participation as well as the desire to carry out experiments in the INFN laboratories.
- There is also a healthy trend of increased participation of INFN physicists in large international collaborations outside of Italy, thereby enhancing cross-fertilisation of ideas.
- The innovation and development of instruments for the experiments is mostly on the forefront of technology. These, in turn, are the seeds for new instruments in day-to-day life. As an example we recall the impact on new medical diagnostic instruments and procedures.
- The needs of new instrument developments have triggered the formation of small companies (for example three have been formed in connection with the LNGS) or have initiated developments in Italian companies that could, in turn, increase their market presence in Europe in the "high-tech" sector.

- The financial return from past orders placed at Italian companies (the majority of the investment budget) is such, taking a multiplication factor of 2 into account, that it nearly balances the operation and investment budget of the CSN II group.

2.3 Nuclear Physics: CSN III

As compared with the previous year there have been few major changes in the research activities. Overall, the research efforts have been better coordinated and interrelated and, as a consequence, the number of distinct experiments has been reduced. In the field of quark and hadron dynamics the DISTO and OBELIX have been terminated after having produced a wealth of important results and publications. Also CLAMKAON was terminated. The Italian HERMES and NUCSPIN collaborations have been amalgamated.

At DAΦNE two transitions from kaonic nitrogen were observed for the first time in a feasibility experiment with DEAR. The assembly of FINUDA has been completed, and the setup is waiting to be moved into the beam after the first run with KLOE has been completed. In physics with ultra-relativistic heavy ions, the enormous effort continues on the construction of the ALICE detector. Very noteworthy is the achieved timing resolution of better than 100 ps in the prototype of the high-granularity TOF detectors. After considerable problems with the beam extraction the cyclotron in Catania was able to deliver a large number of different beams on target in 2001 for the experiments on the dynamics of intermediate energy heavy ion reactions.

Nuclear physics traditionally has had a major impact on other sciences such as surface and solid state physics, environmental physics, dating, geology and nuclear medicine. At Legnaro 4500 hours of beam from the single ended Van de Graaff accelerators are delivered annually for interdisciplinary research and applications such as ion implantation, the characterization of physical properties of materials via ion beam analysis, and cell irradiation. A large number of these experiments are conducted by groups of other Research Institutions such as INFN, ENEA and ISS. At Legnaro, a detection system for land mines based on nuclear methods is being developed. At Catania irradiation with high energy heavy ions is used for radiobiology studies and to modify the properties of High T_c superconductors through flux pinning. Most importantly the CATANA proton therapy facility for the treatment of ocular diseases has reached the stage where patients can be treated on a regular basis. Notable is also the portable system LANDIS developed in Catania for the non-destructive analysis of paintings and other items of cultural heritage.

The relatively small size of typical nuclear physics experiments and collaborations, in many cases, allows students to obtain hands-on experience in every aspect of the experiments, which makes them very attractive to undergraduate and PhD students. There is thus a large number of young researchers attracted by the nuclear physics experiments. Of the undergraduate students (90 in 2001) the largest fraction goes into industry after graduation, while most of the graduate students (68) stay in research. Lowering the age for obtaining the PhD may lead to a beneficial increase in demand for PhD physicists in industry that traditionally prefers to hire laureates.

A large effort is made by the national laboratories to disseminate nuclear physics scientific culture to the public, and in particular to secondary school students, by hosting school classes during the Weeks of Scientific and Technological Culture, Physics Olympic Games, and Summer Stages. In 2001 almost 6000 high school students profited from these programs.

Italian nuclear physics is very international. This is by definition the case for the experiments at foreign accelerator laboratories. In the opposite direction the national laboratories in Legnaro and Catania attract many foreign users, almost 300 at Legnaro in 2001 and more than 100 in Catania.

The productivity of nuclear physics in terms of scientific publications is good and compares well with those of the equivalent organisation IN2P3, for which numbers exist for 2000. Italian nuclear physicists are also strongly represented in leadership positions in the collaborations in which they participate.

From the budget for experiments, typically more than 60% are spent on apparatus, and of these 26% on catalogue items, 22% on non-standard products, and 16% on R&D on high-tech products beyond the know-how of the industrial firms. Especially the latter are of great importance for enhancing industrial standards and know-how.

2.4 Theoretical physics: CSN IV

- *Update on scientific activities*

Very high quality research has continued in the traditionally strong areas of CSN IV: field and string theory on the one hand, and phenomenology in accelerator-based experiments on the other. The group has also shown clear signs of evolution along the lines recently recommended by the CVI. In particular:

- Growing emphasis was given to the physics of relativistic heavy-ion collisions: a new study group (Giselda), with about 40 participating theorists, is exploring a number of possible new research projects in this field;
- There has been a noticeable increase of activity in astro-particle theory and phenomenology: two new projects have started in this area with a remarkable increase in scientific production.

The special APemille project has produced interesting new results particularly in K-meson physics. The use of parallel computing has also been extended to the study of numerical general relativity through the new Albert100 lattice server in Parma. The corresponding project on gravitational waves has become competitive on an international scale.

Milestones have been set towards the realisation of the new APEnext project, and a referee panel has been formed. A 400 Gigafllops prototype is planned for June 2003 with a decision to construct the full APEnext system hopefully following shortly thereafter. Most physics programs used by APemille can be recompiled and executed on APEnext in order to check the correctness of the design and to evaluate performances.

- *Socio-economic impact*

The dissemination of scientific culture is a particularly appropriate task for CSN IV, the general public being especially receptive of the conceptual issues of theoretical physics. It is not easy to quantify the involvement of CNS IV in this respect, e.g. through public lectures, and high-school presentations. Such initiatives should be certainly encouraged.

There is a close connection between INFN and Italian Universities. This favours considerable mobility from CSN IV towards the fields of higher education. Mobility to other scientific research organisations, such as INFN, is also present though modest.

Methods and techniques originating from the theory of fundamental interactions have found application to subjects of technological and economic interest, for instance in

superconductivity, in the study of chaotic systems, of spin glasses, and of neural networks.

APE had also a non-negligible socio-economic impact: IPITEC, NEGRAL, and DIVIDE, were founded by (or have received crucial know-how from) APE, which is also closely collaborating with AMERICAN ATMEL and NEURICAM.

Many other fields of pure and applied research, such as turbulence, biotechnology, finance, and even the film industry, can greatly profit from the development of parallel computing.

2.5 Technological and interdisciplinary research: CSN V

The experimental challenges implied by the primary mission of INFN provide an excellent environment for the development of new instrumentation, including electronics, of new materials and processes. Interdisciplinarity, training and technology transfer are therefore relevant characterizations of the activities in the framework of CSN V. The use of particle accelerators for medical and other applications is actively and successfully pursued.

The mechanisms in place within CSN V, for selecting and monitoring the projects, are adequate.

A few of the highlights of recent research include: development of pixel scintillators for X-ray detection; development of an RF streak camera with a resolution better than 500 (potentially 100) fs; development of large (10") HPD's; two dimensional X-ray imaging using Si drift detectors (applications: structural biology, time-resolved crystallography, etc.). A compact linear accelerator for proton therapy was successfully built and tested.

Furthermore, cross-disciplinary projects in the area of research of CSN V include studies of dosimetry, and effects of ionising radiation on biological systems. Of particular relevance is the use of accelerators and neutron sources for treating tumors. Two recent successes are the treatment of eye-tumors and Boron Neutron Capture Therapy (a 'world first' successful treatment of liver cancer was reported).

Further developments and progress in (X-ray) imaging, with (integrated) image processing will lead to very sensitive devices with high spatial, temporal and energy resolutions with, potentially, a wide range of applications from medical imaging to astronomy.

All projects referred to above and many other projects in CSN V are of high scientific, technological or practical interest and are unique; most of them would have not have happened if it were not for the environment offered by the INFN scientific programme and related infrastructures.

The researchers who are involved in CSN V projects are usually also (and naturally) involved in the activities directly related to the primary scientific mission of INFN; on average the sharing is 50-50. The productivity in terms of achieved milestones (74%) is very good, certainly if one takes into account the inherently risky, because innovative, nature of the research. The output measured by publications (0.7/FTE/year) also indicates an excellent productivity; the total number of papers, 255, represents a 20% increase as compared to the previous year.

The relatively small scale projects within CSN V offer an excellent environment for training students and young researchers. 65 academic degrees are awarded each year; 63

PhD's are active within CSN V; 47 fellows and 33 'assegni di ricerca'. About 30% of the researchers find employment in industry (or related) after obtaining their degree.

As for all challenging research, the (international) competitiveness is high; the results achieved cover the spectrum up to the highest qualification: 'breakthrough'. Roughly 75% of the projects have a potential spin-off outside high energy physics such as in biomedical and industrial applications. New instruments produced include opto-electronic components, accelerator sources, and sensors.

Successful collaborations with industry exist in many areas (e.g. the development of compact linacs; instrumentation for dosimetry; imaging devices.)

In conclusion, CSN V offers a unique and excellent environment for conducting innovative research in the field of radiation detection, materials and accelerators with a proven large potential for a wide variety of applications, among others for biomedical research and therapy.

3. The National Laboratories and Sections

There are four national laboratories, L.N. Frascati, L.N. Gran Sasso, L.N. Legnaro, L.N. Sud (Catania). Three of the laboratories Frascati, Legnaro, Sud are historically accelerator based while the Gran Sasso laboratory is based on the underground experimentation. There are also nineteen sections. Over the course of the past three meetings we have heard reports from the Directors of all four laboratories. Although there is a risk that the first two are slightly outdated, we include our commentary on all four for completeness.

At the December 2000 meeting the CVI heard a report from the then Director of L.N. Frascati, Paolo Laurelli.

The L.N. Frascati has a staff of 323 of which 98 are research physicists. Approximately half of the physicists work on experiments in other laboratories. There are approximately 300 external researchers, including 70 foreign physicists, who work at the laboratory. The laboratory has two external advisory committees, one addresses the physics program and the other concentrates on the accelerator program. Both contain renown international experts.

The primary physics facility is the DAΦNE electron-positron storage ring which operates at the mass of the ϕ meson. The associated experiment (KLOE) executes a program of research with the goal of measuring the CP violating parameter in kaons. The luminosity of the machine and the associated backgrounds are key to the success of the program. These had been a major source of concern but over time significant improvements have been made. The experiment can now imagine making a significant contribution to the primary physics issue within the next year.

There are other experiments concerning exotic atoms and hypernuclei (DEAR and FINUDA) as well as X-ray or infrared synchrotron light facilities on the machine. Also the laboratory has developed the large Nautilus cylindrical bar detector for gravitational waves.

The involvement of the accelerator physicists in a number of advanced projects including linear electron positron collider physics points to a future involving the exploitation of phenomena such as the Free Electron Laser as a future source of short wavelength light, which has enormous cross disciplinary interest.

At the May, 2001 meeting, the CVI heard a report about the L.N. Gran Sasso by its Director, Sandro Bettini. Besides its physics program the report covered many additional aspects such as the historical developments, the infrastructure, the resources,

both human and financial, the economical and social impact, the outreach activities and plans for the future expansion. In addition, safety aspects were covered.

The laboratory was originally constructed to support a proton decay experiment, but already the layout took a possible beam from CERN into account. The LNGS is unique worldwide and has developed into a key laboratory in the field of neutrino physics and particle astrophysics. It provides attractive low-background facilities, deep underground but with relatively easy tunnel access. The quality of management and infrastructure matches that of CERN and DESY. The laboratory, and its results, among the highlights of Italian research, contribute very much to the INFN visibility worldwide. The physics program is very rich and covers a wide variety of experiments, most of them addressing very important fundamental questions. The recently approved CERN to Gran Sasso neutrino beam project adds another important role to the laboratory and ensures its near-term high profile in the field.

The experiments are carried out by a total of more than 700 scientists, nearly half of them non-Italian, but only a fraction is continuously present at the lab. There are in total 32 physicist employed by the LNGS (9+1 staff position, 6 non-permanent positions and 17 fellowship positions, 9 of them for students). In addition there are short-term fellowships available (FAI), corresponding to 59 month/year.

The discussions of the future expansion by the addition of two halls and an extra access tunnel are ongoing. The CVI considers such an expansion as very important.

The early and far-sighted decision by Italy to build such a laboratory can be seen in the context of the present plans of the US (20 years later) to build a similar laboratory in the Homestake mine, and a similar less advanced plan of Spain to build an underground laboratory in Tenerife.

The Laboratories of Legnaro and Sud are the domestic cornerstones of nuclear structure and interaction physics. At the meeting in May 2002 the directors of these laboratories, G. Fortuna and E. Migneco, gave an overview of their respective facilities, their infrastructure and mission, as well as of the ongoing research.

The Laboratory at Legnaro (LNL) has a staff of 122 of which 24 are research physicists, and 22 technologist. There are about 100 associated scientific staff supported by various external institutions. In 2001 there have been more than 500 Italian and foreign users from thirteen different countries. The program advisory committee consists of internationally renowned nuclear physicists.

The Laboratory at Legnaro is very much a multi-disciplinary, user oriented laboratory with nuclear physics research and its applications as core activities. Its main facility is an XTU Tandem with the superconducting linac, ALPI, as a post-accelerator. ALPI is undergoing a major upgrade to improve its performance and reliability. The total time of beam on target amounted to more than 5000 hours in 2001. With the PIAVE injector presently under construction it will be possible to accelerate all ions up to uranium to energies well above the Coulomb barrier. The tandem linac-laboratory is excellently equipped with detectors such as PRISMA, GASP and the fragment separator. It is the only facility of its kind in Europe, and as such there will remain a need for it in European nuclear physics for years to come. This is reflected in the recognition of Legnaro as a European large-scale-nuclear facility.

In addition to the tandem-linac-accelerator complex, Legnaro houses two single stage Van de Graff generators fully devoted to Applied Nuclear and Interdisciplinary Physics. A large fraction of these experiments is conducted by groups from other National Research Institutions such as INFN, ENEA and ISS. The nuclear and interdisciplinary physics activities are complemented by fundamental physics studies on gravitational waves with the AURIGA detector, an experiment, PVLAS, exploring the quantum

vacuum as a birefringent medium, and a Magneto-Optical Trap for the study of parity violation in atoms. A large experimental hall serves as a staging area for particle physics experiments and for large, stand alone experimental setups such as PVLAS. The excellent infra-structure of Legnaro makes the laboratory well suited for the concept and prototype development of the low-energy part of a very high intensity linac for waste incineration of the INFN-ENEA TRASCO project. The idea of using the low-energy part of TRASCO as a mid-sized ISOL-type radioactive beam facility SPES is an interesting concept that will need further consideration in a national and European context.

The Laboratory Sud in Catania (LNS) is, in the range of its activities, a more focused laboratory. It has a total staff of 99, of whom 24 are researchers and technologists. The number of users is 212, with 106 coming from outside Italy. As with LNL there it has an international program advisory committee.

The main accelerators at LNS are a tandem Van de Graaff and a cyclotron with superconducting coils. In the energy range of heavy ions the Catania facility is largely complementary to Legnaro. Similarly to Legnaro the accelerator laboratory is excellently equipped with very advanced and elaborate detectors such as CHIMERA and MEDEA-SOLE-MACISTE. The ECR source with superconducting coils, developed in collaboration with Grenoble, is among the best in the world. Stable operation of the cyclotron with some 2600 hours with beam on target has commenced in 2001. A facility, for the production and acceleration of radioactive beams, EXCYT, involving both the cyclotron and the tandem, is under construction. The CVI welcomes the decision of Catania to give the highest priority to the completion of EXCYT and CHIMERA, while at the same time maintaining a vigorous research program, on at least the 2001 level by increasing efficiency of the cyclotron use. Aside of the fundamental work in nuclear and astro physics the facility is extensively used for interdisciplinary and applied research. Most notable is the successful start of patient treatment on a regular basis with the CATANA proton-therapy facility for the treatment of ocular diseases, making use of beams of the cyclotron. In the INFN-ENEA TRASCO project LNS has taken the responsibility for the high-intensity source.

Since 1999 LNS is also actively involved in the R&D phase of the NEMO project of a Neutrino Mediterranean Observatory which offers a very interesting long term perspective for the laboratory. A multidisciplinary laboratory has been set up on the coast which is connected with an underwater station for long term tests of electronics, mechanical structures, and optical and acoustic detectors.

Following the recommendations of the CVI a joint scientific policy committee has been set up in 2001 for LNS and LNL to advise on a coordination of the research efforts of both laboratories and the planning for their mid- and long-term futures in the context also of European nuclear physics.

The CVI feels strongly that in addition to the increasing prominence of applications and of interdisciplinary research, the pursuit of excellence in the science should continue to enjoy the highest priority.

4. Resource and financial Management

The quality of resource management is judged to be very good given the constraints faced by INFN. We confirm our opinion that the administrative structure is appropriate: it blends centralisation and decentralisation in a reasonable way. The use of available resources could nevertheless be improved by an increased mobility of researchers within the institute: despite some improvement, the data indicate that the internal mobility is still very low.

As we already observed last year, it must be stressed that, in the long run, the attainment of the objectives of the INFN will fundamentally depend on its capacity to offer competitive wages nationally and internationally (to attract the best researchers in the international scientific community).

On the budgetary side, in the last two years the commitments amounted to around 580glit, with cash limits of 500 glit. These figures show that a certain fraction of commitments either has not been honoured or has not yet reached maturity. We think however that the excess of commitments, actual and potential, implicit in these figures is reasonable: we recall that some commitments concern multiyear research projects and, as already said, will come to maturity in the future. INFN has successfully operated under the cash flow limitation for four years and has used flexibility to mitigate this negative impact. In the future it could also be that the Treasury makes available the funds currently frozen.

Two further points should be mentioned. Since 1998, the introduction of cash limits has significantly reduced the availability of financial resources of INFN. If we add the yearly difference between the apportionments of the state budget and cash limits set for each year, we can see that this mechanism has limited the financial resources, actually committable, by around 150 glit. As a consequence, the research activity has been negatively affected.

Positive judgment of the financial situation and management of INFN finds further support in the multiyear budget plan (which was duly compiled, following our request of the last year). The data produced show a reasonable degree of financial flexibility, given the planned research activity and in the hypothesis of constant state financing.

In the definition of the future plans of activity of INFN it is, in any case, prudent to assume that in the future state funding will not increase. Given this perspective, it is important to look for alternative sources of financing. Two positive points can be mentioned in this respect. In 2002 a new service has been established within INFN to follow the initiatives of the European Union. Secondly, INFN is an active member of the bodies where the research is planned and realized, in particular CERN, but also APPEC and NUPECC). It is in any case desirable the strengthening of the cooperation with the industrial community.

5. Management and Impact of Large Equipment

In response to the specific request of the CIVR, we provide a coherent treatment of the impact of the items of Large Equipment operated by INFN. For this purpose INFN has defined these items to be its four national laboratories plus the almost-complete gravitational wave detector, which is operated by the recently created European Gravitational Observatory, in collaboration with the French CNRS institute.

The five establishments are characterised by a few relevant parameters collected in the following table.

	Cost 2001 M€	Staff 2001	External Users 2001	Beam on Target	Publications 2001
LNF	42.5	323	323	5400	180
LNGS	40	59	729	N/A	92
LNL	17.2	122	550	10000	68
LNS	11	99	214	4400	70
EGO	7.5	18 → 35	N/A	N/A	--

All the laboratory make their facilities are available on a broad basis, from material science to medical science, through collaboration with other Italian and international institutes. Direct treatment of cancer by new variants of radiotherapy is a prominent feature. The laboratories also have outreach programs, characteristic of the particular laboratory. some very active, which visibly promote the science. All the laboratories have outreach programs characteristic of the particular laboratory. For example, LNGS exploits its attractive site in the mountains to play an active and very successful role in interactions with the general public, and with physics teachers. These are an important activities.

Laboratori Nazionali Frascati

The Frascati National Laboratories are the largest of the INFN laboratories. The personnel total 323 of whom 98 are researchers. The budget for operations is 13 M€, excluding personnel, for Research the budget is 13.5 M€ and the total personnel cost is 16 M€. The biggest installation at the laboratories is the DAPHNE accelerator which is home to three experiments, KLOE from CSN I and DEAR and FINUDA from CSN III. These experiments attract large numbers of visitors. The laboratory participates in a large number of international collaborations. These collaborations include experiments under the auspices of the national committees at a number of laboratories across Europe and the United States. In addition the accelerator expertise, especially in electron acceleration, has led to a strong participation in major international initiatives such as the research and development towards a future linear collider. This work is primarily in collaboration with the DESY laboratory in Hamburg, Germany. Approximately 50% of the laboratory resources are devoted to work in Frascati, approximately 50% to work abroad.

A primary measure the performance of the laboratory is provided by the number of hours of operation of the large accelerator facility, DAPHNE. This provided beam for physics during about 5400 hours in 2001 and the luminosity in 2002 is already showing a very significant improvement with respect to previous years of operation.

A major cross disciplinary effort at Frascati is being mounted to make a proposal to construct a very advanced Free Electron Laser light source which would have a major impact on both biology and material science.

Laboratori Nazionali del Gran Sasso

The Gran Sasso National Laboratory continues to be one of the world's leading laboratories in the field of astroparticle physics, in addition providing infrastructures for performing experiments in a low background environment. Furthermore the laboratory will receive a neutrino beam from CERN in order to do neutrino oscillation studies, in particular through the observation of tau-neutrino appearance (unique on a global scale).

LNGS is run with an annual budget of 10 M€ (operations, research and personnel). The total staff amounts to 59 (of whom 8 researchers, 9 engineers and 30 technicians); the laboratory receives a remarkable number of 11200 visitors in 2001. The user community (729) is roughly equally divided between 'Italian' and 'foreign'. 30 undergraduates are trained at the lab each year and 20 Ph.D. thesis written.

A survey performed on 56 regional firms has shown a considerable beneficial effect from the contacts with LNGS with respect to investments, training and the development of new products. LNGS also offers its facilities and infrastructures for research in other fields such as geology, biology etc.

Laboratori Nazionali di Legnaro

The laboratory at Legnaro (LNL) is one of the two nuclear physics laboratories of INFN. Aside of its core activity of basic research in nuclear physics, centered on its Tandem-Linac accelerator complex, the laboratory is host to a number of large scale experiments such as the gravitational antenna AURIGA (see also sect. 3), and it has a strong program on applied and interdisciplinary work. Two single ended Van de Graaff accelerators are used for the latter work,

LNL has a staff of 122 of which 24 are research physicists, and 22 technologists. 11 of the research physicists are directly involved with the program at the tandem-linac accelerator complex. There are about 100 associated scientific staff supported by various external institutions. Of the human resources 50% are involved in accelerator research and support services, 16% in research programs, 18% in R&D projects, and 16% in management support. The total budget of M€ 17.2 contains M€ 5.4 for personnel costs, which represents a very favourable ratio between personnel and research and operation costs.

In 2001 there were 5500 hours of beam on target from the tandem and the tandem-linac for nuclear physics research, and 4500 hours of beam from the single ended Van der Graaff generators for applications and interdisciplinary work. The achieved hours of beam time represent a very good exploitation of the accelerator facilities. There have been more than 500 users of the Legnaro facilities in 2001, of which half were non-Italian from 12 different countries, thus attesting to the attractiveness of the facilities at Legnaro.

Laboratori Nazionale del Sud

The Laboratory Sud in Catania (LNS) is the second nuclear physics facility of INFN. Its main accelerators are a tandem Van der Graaff and a large cyclotron with superconducting coils. In addition a facility for the production and acceleration of radioactive nuclear beams, EXCYT, is under construction. Of great socio-economic importance is the dedicated irradiation facility with the CATANA protontherapy facility for the treatment of ocular diseases, that very recently treated its first patients, and that will put a continuing demand on beam time.

LNS has a total staff of 99, of which 24 are researchers and technologists. The technical and administrative staff amounts to 63 and 12 persons, respectively. The number of associated researchers is 82. The total budget in 2001 was M€ 11 of which 3.5 M€ are personnel costs. Beam on target amounted to a total of 4400 hours from the cyclotron and the tandem. This relatively low number is accounted for by the need in 2001 of producing many new cyclotron beams. The total number of users was 212, of which 106 came from outside Italy.

In addition to the nuclear physics activities and the application of nuclear beams and methods LNS is also actively involved in the R&D phase of the NEMO project of a Neutrino Mediterranean Observatory. A multidisciplinary laboratory has been set up at the coast that is connected with an underwater station for long term tests of electronics, mechanical structures and optical and acoustic detectors.

The French-Italian Consortium EGO, Cascina

The European Gravitational (wave) Observatory EGO was recently established at Cascina to operate the large gravitational wave interferometer VIRGO. This laboratory differs from all the other INFN laboratories in that responsibility for its operation is international. The VIRGO detector has been constructed by a French-Italian collaboration and EGO will be operated by a French-Italian staff. The CVI endorses

fully the formation of this new laboratory and its function as a nucleus for broader activities in this field of fundamental research becoming now intensified world-wide.

6. Conclusions, Remarks, Recommendations

We summarise the report with a series of remarks pertaining to each of the aspects of INFN, which have been discussed. Given the nature of the committee the perspective is predominantly that of the international physics community. However, our deliberations are guided by the objective criteria agreed between INFN and CIVR. Where appropriate, our remarks take the form of recommendations.

i. Scientific Activities

In general, the scientific activities of INFN have remained at a high level. The scientific stands are high in all the five main scientific areas and the productivity, at an international level, continues to be high.

The construction schedule for the Large Hadron Collider at CERN has been delayed by approximately one year and there is a significant increase in the cost. This potential hiatus in the science puts a premium on the performance over the next 5 years of the currently operating experiments at CERN but most importantly at other laboratories around the world. The management of the concomitant impact on the program (CNGS) for neutrino beams to the Gran Sasso laboratory must be handled carefully. The details of the CERN response to the situation are still under discussion.

The multiple impacts on the Italian science demand that INFN participate strongly in the development of a coherent strategy.

ii. Socio-Economic and Interdisciplinary Impact:

The indicators of socio-economic and interdisciplinary impact are very positive. The positive role of the 'national committee for external training and technological transfer' is acknowledged, both in fostering contacts with industry and in organising training *stages*. A large fraction of the funds by INFN to purchase equipment is disbursed to Italian industry and in many cases the interaction also involves improvement of the industrial capability. The indicators with respect to the impact on training of students appropriate for a highly technological society, are also excellent. Assessment of the situation would be facilitated if the data were systematically available over a long period. This would permit monitoring by INFN management and permit the detection of trends, both positive and negative.

INFN should work towards a more systematic collection and presentation of data concerning the social impact of the work.

iii. The National Laboratories and Sections:

The national laboratories, Laboratori Nazionali di Legnaro and Laboratori Nazionali del Sud have been developed as prominent nuclear physics laboratories and indeed have very active nuclear physics programs. Nevertheless the characters of both laboratories have evolved in multidisciplinary directions with some emphasis on the use of nuclear techniques for a broad range of science on the one hand, and for nuclear medicine on the other. Innovative new methods of treatment have been developed in close collaboration with the medical establishment. In response to recommendations, the two laboratories have established a single scientific policy committee in which the strategy for the two laboratories, also within the context of nuclear physics within the European Union, is developed.

Emphasis on the excellence of the scientific programs of the national laboratories should continue.

iv. Resource and financial management:

Despite the constraints imposed by the funding policy, the management of resources within INFN is in a healthy state. In addition to projections for the immediate needs, INFN has now developed a rational view of the future over a period of approximately 4-5 years. This projection takes into account possible evolution of the different scientific directions.

v. Large Equipment:

The Large Equipments, the national laboratories of Frascati, Gran Sasso, Legnaro and Sud, as well as the European Gravitational Observatory provide an impressive array of scientific installations. In all cases, the fraction of the resources, human and fiscal, which is devoted to the science, is high and the availability of the facilities for operation is high.

With respect to the social impact, the larger fraction of the purchases, made by the laboratories, is from Italian industry. The laboratory facilities are made available on a broad basis, from material science to medical science, through collaboration with other Italian and international institutes. Direct treatment of cancer by new variants of radiotherapy is a prominent feature. The laboratories have outreach programs, some very active, which visibly promote the science. This is an important activity within our modern society and should be strongly encouraged.

Again, we note with pleasure, the substantial efforts on the part of INFN to be responsive to our main recommendations made in earlier reports.

Appendix A – Membership of the committee

- Prof. R. Artoni, Bocconi University, Milan, Italy
- Prof. C. Castellano, ESAOTE SpA, Genova, Italy
- Prof. J. Engelen, NIKHEF, The Netherlands
- Dr. H.E.Montgomery (Chairman), Fermi National Accelerator Laboratory, U.S.A
- Prof. R.H.Siemssen, K.V.I., The Netherlands
- Prof. G. Veneziano, CERN., Geneva, Switzerland

Observer: Dr. E.Lorenz, Max Planck Institute, Munich, Germany

Prof. L. Mandelli (Scientific Liaison), University of Milan, Italy

Agenda of the INFN CVI Meeting

Rome, May 16-18 2002

Thursday, May 16

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|-------|--|--------------|
| 09:00 | Welcome and Introduction from the President of INFN
Discussion and approval of the Agenda
<i>Closed session</i> | E. Iarocci |
| 09:30 | Report on the INFN activity and introduction to the evaluation
exercise on the socio-economical impact
<i>Discussion</i> | E. Iarocci |
| | <i>Break</i> | |
| 11:10 | Evaluation exercise for the experimental subnuclear physics
with accelerators
<i>Discussion</i> | U. Dosselli |
| 12:20 | Evaluation exercise for the experimental subnuclear physics
without accelerators, astroparticle and neutrino physics
<i>Discussion</i> | E. Coccia |
| 13:30 | <i>Lunch</i> | |
| 14:30 | Evaluation exercise for the experimental nuclear physics
<i>Discussion</i> | E. Chiavassa |
| 15:40 | Evaluation exercise for theoretical physics
<i>Discussion</i> | C.M. Becchi |
| | <i>Break</i> | |
| 17:10 | Evaluation exercise for technological and interdisciplinary
research
<i>Discussion</i> | A. Vacchi |
| 18:20 | Closed Session | |
| 19:15 | Queries and questions to the INFN Executive Board and to the Scientific Committee
Chairmen | |
| 20:30 | <i>Social Dinner</i> | |

Friday, May 17

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|-------|--|------------|
| 09:00 | Report on the activities of the Legnaro Laboratory
<i>Discussion</i> | G. Fortuna |
| 10:10 | Report on the activities of the LNS Laboratory
<i>Discussion</i> | E. Migneco |
| | <i>Break</i> | |
| 11:40 | Responses to queries and questions posed to the INFN Executive Board
and to the Scientific Committee Chairmen | |

12:30 Closed session

13:00 *Lunch*

14:00 Report on resource management
Report on cost and impact of large equipments
Discussion

A. Scribano
G. Puglierin

15:30 Closing discussion with the Executive Board

17:00 Closed session (report drafting)

Saturday, May 18

9:00 Closed session (report drafting and preparation of closeout presentation)

Break

11.30 Closed session (report drafting and preparation of closeout presentation)

13:00 *Lunch*

14:00 Closeout: Comments and remarks by the CVI members
Discussion
Closure of the official part of the meeting

15:00 Closed session (draft of the final report)

Sunday, May 19 and Monday, May 20

Finalization of the report by H.E. Montgomery. Committee members may contribute.

Final remarks

- INFN Executive Members will be present to the presentations and discussions. All other invited participants will be present at the presentations and at the pertinent discussions.
- The time reserved for the presentations of the scientific programs are expected to be equally shared between presentation and discussion.