INFN CVI Report 2006

Conclusions of the CVI Meeting on 17-18 July 2006

CVI Panel:

U. Bassler, LNPHE, France;
E. Fernandez, IFAE, Spain;
B. Ferrario, SAES Getters S.p.A., Italy;
F. Iachello, Yale U., USA;
J. Iliopoulos, EPTENS, France;
H. E. Montgomery, FNAL, USA;
R. Paladini, University Roma La Sapienza, Italy;
G. Veneziano, CERN, Switzerland;
A. Wagner, DESY, Germany (Chair)

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Executive Summary

The CVI met on 17-18 July 2006 in order to evaluate the INFN activities in 2005, both scientific and technical. It heard presentations covering the full range of activities of INFN including the results of the studies about the future road map, and the situation with respect to resources. A special emphasis was put on the socio-economical impact. Before the meeting a comprehensive report on this aspect was distributed to the committee.

The CVI came to the conclusion that in terms of international visibility and impact the scientific programme of INFN is outstanding on a world scale and in terms of internal organisation INFN has achieved a very good balance between resources for research, operation and personnel. On the other hand CVI is severely concerned about the budget situation, especially in the personnel sector, and the problems related with providing young researchers an employment perspective.

A major new element of the review was the road map of INFN which was prepared in an INFN-wide process to survey the current scientific

program, to evaluate future projects with respect to their international relevance, to balance activities at the national laboratories with those outside Italy, and to assess the INFN perspective for European road maps. The CVI was very pleased by the process by which the road map had been established and by its present status.

Concerning the different research areas the CVI concluded:

Sub-nuclear Physics with Accelerators (CSN 1): The present program is extremely strong and very productive. INFN is engaged in three programs across the world, BaBar at the B-Factory at SLAC, CDF at the Tevatron at Fermilab and ZEUS at HERA, DESY, which are coming to an end soon. The core for the future programs, with ATLAS, CMS and LHC-B at LHC, CERN, is assured. Therefore CSN 1 is entering a period of transformation and INFN management will need to remain attentive to this evolution and the longer term perspectives.

Astroparticle and Neutrino Physics (CSN 2): This program is one of the largest inside INFN, which has traditionally maintained a strong presence in this area, in particular with the existence of the Gran Sasso National Laboratory (LNGS). This has allowed Italy to lead the field worldwide in several subjects. CSN 2 is carrying out an extensive program of high scientific value, with some experiments leading the field world-wide. The program is sound and should be vigorously pursued. There is some room for consolidation by concentrating the activities in a smaller number of experiments.

Nuclear Physics (CSN 3): The program covers a variety of subjects, ranging from the study of the structure of hadrons to matter at high density (ALICE at LHC, CERN). Its overall assessment ranges from very good to excellent. The program compares well with similar programs in other European countries (most notably, France and Germany), in the USA and Japan. Its embedding within the European framework is good. Its future appears to be well delineated. Its goals, as expressed in the 2006 roadmap, are appropriate and reachable.

Theoretical Physics (CSN 4): The program covers all the main lines of interest in today's theoretical particle and nuclear physics with an additional important expansion into specific areas of statistical physics. There is a good balance in the number of INFN researchers in these different areas and interactions across them are satisfactory. The program maintains a high profile, both within INFN activities and internationally, producing a research output at the highest level. The CVI took special notice of the successful opening of the INFN-sponsored *Galileo Galilei Institute for Theoretical Physics* (GGI), located in Arcetri (Florence), which will attract leading scientist from around the world to Italy to work on topical theoretical issues.

Technological and Interdisciplinary Research (CSN 5): The program has an important social and economical impact by pursuing not only highly scientific activities but also by implementing socially beneficial projects, by stimulating high tech competences at companies supplying products for the technically demanding INFN facilities and by developing projects and know-how which companies can try and exploit to develop new products for the market.

The CVI received an in-depth study on the socio-economic and interdisciplinary impact of the 2005 INFN activities in the areas of cultural effects (training and dissemination), highlights of interdisciplinary infrastructure and technology development, the interaction with industry and its impact (using a macro-economic model), and a national and international comparison of INFN scientific productivity. CVI was impressed by the strong position of INFN in all these areas. The CVI would like to point out, however, that the monitoring of scientific productivity through bibliometric analysis can only partially reflect the true scientific impact and should mainly be used to complement peer reviews.

The severe budget reduction in the research sector as the result of an effective budget increase in the personnel sector creates a very difficult situation for INFN, for the following reason: The increase in the spending on personnel at the expense of research funding jeopardizes the scientific exploitation of the investments made in the past and would endanger the preparation of future scientific involvements. This is the area of greatest concern for INFN.

The CVI would therefore like to encourage the INFN President to take all possible steps to ease the present critical situation by finding ways to recover in full its research budget. The CVI was informed that for universities in Italy a solution has been found for the same problem. Due to its very close collaboration with many Italian universities and its own substantial engagement in graduate education INFN should, in the view of the CVI, be treated in a similar way as universities. The CVI recommends that INFN should not reduce the personnel budget by stopping new recruitment. On the contrary, it should be able to hire young people who are essential for the future of the organization.

The CVI expresses its appreciation of the excellent leadership of the President and the directorate.

The CVI would like to encourage the INFN Executive Board and the Scientific Committees:

- To further sharpen the road maps for INFN as a whole, the National Laboratories and the Scientific programmes,
- To analyse the long-term role of national labs,

- To develop a better understanding of the relative balance between national and international projects,
- To develop a strategy on how to deal with the present budget constraints,
- To develop criteria to help the Scientific Committees in assigning appropriate priorities to projects.

The CVI recognises that these considerations have to take into account the present uncertainty in the future budgets.

Status and achievements of the INFN

The 2006 INFN Plan and Road Map

In his presentation the President focused less on a "running" three years plan, which focuses mainly on the next year, but on the road map of INFN to survey the current scientific program, to evaluate future projects with respect to their international relevance, to balance activities at national labs with those outside Italy, and to assess the INFN perspective for European road maps. As such a road map can only be discussed with a clear understanding of the available resources, the President presented the status of the resources, both in personnel and in budget.

The President outlined the elements of the road map while deferring the details to the presentations from the individual scientific committees. The road map process was guided by the chairs of the Scientific Committees, the directors of the National Laboratories and CNAF.

In short, the road maps of the different committees contain the following key elements:

- Particle Physics (CSN1): LHC and reservation of an adequate diversity (e+ e- collider at LNF (after-DAΦNE), SuperB project and innovative ideas for high luminosity colliders, fixed target: PS++ (kaon physics, superbeams), ILC,
- Astroparticle- and Neutrino Physics (CSN2): A new generation of experiments (Borexino, Opera, T600, Virgo-single experiment, Gerda,Warp, Auger, Argo, Pamela, AMS), and a new generation of investments (Multi-ton liquid argon, Nemo, Cuore, One-Ton dark matter, Virgo+),
- Nuclear Physics (CSN3): Consolidation of the Italian role in Alice , radioactive ions as a probe for new unstable nuclear matter(LNS and LNL), detector developments (Agata), physics at GSI, and keep the excellence in nuclear astrophysics,
- Theoretical Physics (CSN4): Improve communications in the community making use of the Galileo Galilei Institute, keep the role of theoretical simulations in developing dedicated supercomputers such as ApeNEXT, increase the attention to phenomenological studies with direct connection to experimental INFN programs,
- Interdisciplinary Research (CSN5): Picture Archiving and Communication System with grid tools, hadron-therapy, dosimetry, and cultural heritage.

Concerning the role of the National Laboratories the elements of the road map are:

- All Italian initiatives with an international impact rely on the national laboratories of INFN.
- Major activities foreseen at the four laboratories are: Nemo (LNS), Spes (LNL), Cryogenic detectors (LNGS), e+e- (LNF),
- Develop a truly international character for the laboratories.

Another element of the road map is a major new tool for science, Grid, a high power computing network, which has been developed in many countries, triggered by the needs of the LHC experiments. This initiative is supported by INFN through a Tier 1 centre in Bologna and by establishing links to other fields of science.

The INFN road map has been developed with input from other road maps for astroparticle physics (ApPEC), nuclear physics (NUPECC), particle physics (ECFA and Cern Council).

INFN has started a new strategic project: "New Techniques of Acceleration". This project includes activities such as R&D for the International Linear Collider and the CLIC Test Facility 3, the development of high brilliance particle beams with high power laser beams, of pulsed dipoles at large duty cycle, of high intensity proton accelerators, and LHC halo cleaning with Crystal Channeling.

CVI considers the strengthening of accelerator R&D as a very high priority and an essential element of the mission of INFN. The available resources however are considered not adequate for future developments.

In the past year INFN has established or completed some new infrastructure measures: Milano Bicocca, the Galileo Galilei Institute in Florence, and the supercomputing laboratory in Rome. The Tier 1 centre in Bologna became operational and progress has been made in establishing a digital administration.

The CIVR review has resulted in a very good rating for INFN. However, CVI would like to point out that numerical evaluations as the one performed in the review have their know limitations and can only complement the established peer review. Also, evaluation after three years may miss the appropriate relevance of individual publications.

Finally, INFN was very active and successful in its dissemination and outreach activities, as can be seen from the review submitted by INFN working group GVI to this meeting.

Experimental sub-nuclear physics with accelerators-CSN 1

INFN is engaged in three strong ongoing experimental programs across the world. The BaBar experiment is mounted at the PEPII B-Factory at SLAC; CDF is one of two experiments at the Tevatron at Fermilab and ZEUS is one of the experiments at HERA, DESY. These programs have all enjoyed very successful years with all the accelerators reaching record luminosities. The experiments have also been very productive. ZEUS will end in 2007 and the continuation of BaBar and CDF through at least the end of 2008 is assured. At the end of 2008, it is likely that the BaBar experiment will complete its data taking and, in 2007, the Tevatron program will be reviewed to determine its future beyond 2008.

The CSN 1 leadership classifies the determinations of the mixing angles of the CKM matrix as being one of the three most important pieces of work by members of the committee. Overall, the results from BaBar are numerous and of very high quality. In general, they have maintained a competitive edge with respect to the Belle experiment at KEK-B in Japan. BaBar is operating well and the analysis strength of the experiment continues to be strong.

Another "top three" result is adjudged by CSN 1 to be the determination of the mixing parameter in the B_S system by CDF. This experiment has enjoyed high luminosity from good Tevatron running during the past year and is now set for high luminosity exploration of the energy frontier. Among the numerous papers, we also find progress in the search for the Higgs particle and the determination of the top mass, one of the key parameters in the electroweak breaking sector. Again, the work is top class and the contributions of the Italian groups are crucial in many areas. The progress on the b physics measurements depends directly on the displaced vertex trigger developed by INFN.

CSN 1 awarded a clean sweep to its flavor program by citing the determination of V_{US}, one of the elements of the CKM matrix as its top result of the year. This comes from the KLOE experiment at the DAΦNE collider at LNF. KLOE completed its data taking this year. Apart from the cited result KLOE made several important contributions to the understanding of flavor physics. This sector also benefited from the continuing production of results from the NA48 experiment at CERN, which completed data taking some time ago.

The major experiments, ATLAS and CMS, under preparation for the

LHC at CERN have made major advances during the past year. There is also a participation in LHC-B. At this stage the construction schedules of the experiments and the machine are all tight but some collisions during 2007 still seem possible. The Italian responsibilities appear to be in relatively good shape. It is also our understanding that preparations for analysis and physics are advancing. The development of the Tier 1 center in Bologna is well advanced and will undergo an infrastructure improvement next year. Progress is now being made in awarding Tier 2 sites. Further, several Italian physicists are prominent in the computing and software leadership of the experiments.

Currently, CSN 1 sponsors relatively few medium to small enterprises. The COMPASS experiment at CERN has now started to produce results although many are preliminary. COMPASS is expected to run with hadron beams in the future. The MEG experiment at PSI, Switzerland will come online soon and will run until about 2010. The future of the P326 continuation of the CERN (charged) kaon program is not yet assured.

There is work in preparation for the anticipated International Linear Collider and the LHC luminosity upgrade. However, INFN is also examining the potential and feasibility of new flavor physics initiatives. One possibility is a renovation of DAΦNE to produce dramatic increases in luminosity; a second is the participation in an international effort to produce a Super-B factory. Again the key is luminosity.

The present CSN 1 program is extremely strong and very productive. The core for the future, with ATLAS, CMS and LHC-B is assured. However the experiments ZEUS, BaBAR, and CDF, which are currently planned to end in 2007, 2008, and 2009 respectively, together represent 25% of the program. It is clear that we are entering a period of transformation and INFN management will need to remain attentive to this evolution.

Experimental Astroparticle and Neutrino Physics-CSN 2

The area of Neutrino and Astroparticle Physics is one of the largest inside INFN, with 915 participants (658 FTE), of which 233 are INFN staff. It is an area that has grown appreciably during the last few years and one in which the INFN has traditionally maintained a strong presence, in particular with the existence of the Gran Sasso National Laboratory (LNGS). This has allowed Italy to lead the field in several subjects. The activities are classified in six main lines:

Neutrino Physics: The main focus in neutrino physics worldwide is the precise measurement of the neutrino oscillation parameters. Early

INFN-led experiments done at LNGS, MACRO and GALEX (followed by GNO), contributed significantly to this subject, in atmospheric and solar neutrinos respectively. The recent confirmation of atmospheric oscillations with the accelerator neutrino experiment, K2K had also INFN participants. The largest effort of CSN2 at present is the CNGS (CERN to Gran Sasso) neutrino project, aiming at the explicit detection of the oscillation of muon to tau neutrinos in a neutrino beam produced at CERN and studied at the OPERA and ICARUS detectors located at the Gran Sasso. This program will start this year (2006) and should continue for at least five more years. ICARUS is pioneering the use of the Liquid Argon TPC technique which could be the basis of future large experiments. In solar neutrinos, the BOREXINO experiment at the Gran Sasso is aiming at the study of the particularly interesting Berilium-7 neutrinos. The next generation of experiments will be devoted to the measurement of the mixing parameter θ_{13}, for which only an upper limit is known at present. There are INFN researches interested in the two major projects at accelerators being prepared: the already approved T2K project in Japan and the proposed Nova experiment in the US. A decision to participate in these experiments has not yet been taken. The LVD detector, also at the Gran Sasso, is aimed at detecting Supernova neutrinos and has been operational for several years.

Rare Processes: Under this label there are three main areas:
(a) Neutrinoless Double Beta Decay. One of the major future experiments in neutrinoless double-beta decay is CUORE at the LNGS lead by INFN physicists, which will have the largest instrumented mass in the world, with 741 kg of TeO_2 crystals. Its predecessor, COURICINO, is presently taking data. Another major future experiment, GERDA, is also proposed for the LNGS and has been approved for phase-1. It will check the claimed positive detection in the Heidelberg-Moscow experiment, since it uses the same Germanium-76 isotope. A second phase of this experiment is also being proposed. These experiments can also search for dark matter (see below).

(b) Direct Dark Matter Searches. These experiments try to observe nuclear recoils induced by the interaction with the target material of putative dark matter particles. An experiment at the LNGS, DAMA, led by INFN scientists, has claimed a positive observation. The experiment detects an annual modulation of the signal, which is a distinctive feature of interactions with dark matter particles present in the galactic halo as the Earth rotates around the Sun. The DAMA result is certainly intriguing, and given its importance should be independently confirmed by another experiment. A new experiment, LIBRA, has started running in 2003. An innovative technique for searching for dark matter, based in Liquid Argon, is that of the WARP experiment, also led by INFN scientists. A small prototype of WARP has already produced competitive preliminary results.

(c) Measurement of the neutrino mass in ordinary beta decay. Two experiments at LNGS, MANU2 and Mi-Beta, use a bolometric technique to measure the neutrino mass. The two groups have prepared a joint proposal for a new experiment named MARE, aiming at a neutrino mass sensitivity of the order of 1 eV/c^2.

Cosmic Rays on Earth and *Cosmic Rays in Space:* There are many experiments in this area, addressing a number of issues. ARGO (ground array in Tibet) and CREAM (balloon experiment in collaboration with NASA) study the chemical composition. AMS (planned for the Space Station) and PAMELA (recently launched satellite) look for antimatter in space. AUGER (ground array in Argentina) studies the highest energy cosmic rays. MAGIC (Cherenkov telescope in the Canary Islands), AGILE (small satellite), GLAST (major satellite in collaboration with NASA) study, together with ARGO, the non thermal cosmic gamma rays. ANTARES and NEMO (underwater experiments) study the highest energy cosmic neutrinos.

Gravitational Waves: Italy hosts one of the major experiments in the world in this area, the VIRGO interferometer located near Pisa. There are also several resonant antennas, namely AURIGA and ROG, taking data, and DUAL, aiming for a demonstrator in 2008. There is also involvement in the LISA Pathfinder mission of ESA, a demonstrator for LISA, a giant interferometer in space, and R&D on the thermo-acoustic detection of cosmic rays in a superconducting bar, motivated by some anomalous signals seen in the Nautilus detector.

General physics: This category includes a number of experiments on fundamental physics such as the test of the equivalent principle (Galileo Galilei on the Ground, running), the measurement of G and of Newton's law at short distances (MAGIA, running) the dynamical Casimir effect (MIR, in R&D phase) and the study of QED vacuum polarization (PVLAS). This last experiment, PVLAS, aims at measuring the change in polarization when linearly polarized light from a laser passes through a magnetic field. A positive signal has been reported that can be interpreted as induced by the presence of an axion. The report is very recent and the experiment is trying to observe other possible confirmation signals.

The program of CSN2 is clearly very extensive and of high scientific value, with some experiments which are at the forefront of the field in the world. Some consolidation may be necessary in some areas. In this respect the INFN should look at the road maps being elaborated at present in various regions of the world, with a view towards a concentration of the efforts on a smaller number of experiments.

Experimental nuclear physics-CSN 3

The INFN research program in experimental nuclear physics covers a variety of subjects that can be classified into four areas: (i) Structure and dynamics of hadrons; (ii) Structure and dynamics of nuclei; (iii) Matter at high density and temperature; (iv) Nuclear astrophysics.

Structure and dynamics of hadrons. This program includes experiments both at external facilities and at LNF and is of high quality. Among the important results obtained in 2005 particularly noteworthy are: the null contribution of strange quarks to the spin of the nucleon (HERMES at HERA) and the observation of a resonance with mass 2255±9 MeV, presumably a weakly bound state of a K meson and two protons (FINUDA at LNF). The medium term and long term programs appear to be well thought out: for medium term, the measurement of the time-like nucleon form factors at LNF is of particular importance (DANTE at LNF-DANAE); for long term, the study of gluonic excitation in hadrons and high-resolution spectroscopy of charmonium are two important aspects of hadronic structure that need to be elucidated (PANDA at GSI-FAIR). The medium term program strongly relies on the development of an upgraded facility at LNF, with higher luminosity and energy. The development of this facility is also of importance for maintaining a good balance between outside and local activities.

Structure and dynamics of nuclei. This part of the program is concentrated at the National Laboratories LNL and LNS. It is also of high quality. Among the particularly noteworthy results of 2005 are the measurement of thermal fluctuations in nuclei as observed from the width of dipole vibrations (NUCLEX at LNL) and the study of the isospin dependence of the equation of state of nuclear matter (ISOSPIN at LNS). The programs of both LNL and LNS are at the forefront of research in their respective fields of nuclear structure and nuclear dynamics. Other highlights of 2005-2006 are the completion of the PIAVE project at LNL and the successful extraction of a ^{8}Li beam from the cyclotron-tandem complex at LNS (EXCYT project). The medium and long-term programs require further developments of the facilities at LNL and LNS. The SPES project appears to be a very good development plan for LNL. Maintaining strength in this area at LNS would require an upgrade of EXCYT. In view of the successful extraction of a radioactive beam at LNS, the upgrade appears feasible. Integration of this area of research into the European framework is already in place (GANIL-LNL collaboration), and it could be further enhanced with collaborative programs with GSI.

Matter at high density and temperature. This program addresses a problem of current interest: whether or not phase transitions to different forms of matter occur at high density and/or temperature, in particular a transition to a de-confined phase of quarks and gluons. A result of great importance was reported on the anomalous suppression of J/ψ, pointing to incipient de-confinement at SPS energy (IPER at CERN). This result was obtained from an analysis of experiment NA60 at CERN. The main trust of the program is, however, the construction of a detector (ALICE at CERN). The discovery potential of this program is very high. A scientific evaluation of this program will be possible only after the first run of the experiment, expected for 2008. Future developments in this area need to wait until data taking.

Nuclear astrophysics. This is a small program carried out at LNGS and LNS. It is of excellent quality. Results of interest in 2005-2006 were those obtained at LNS on reactions of astrophysical interest, most notably $^{9}Be(p,\alpha)^{6}Li$. The results were obtained with an indirect method, potentially of great importance (AFIN2 at LNS). Future plans for development of this area at LNGS are very good (new accelerator for LUNA). Developments at LNS require a second generation of radioactive beam facility (EXCYT-2).

The overall assessment of this program ranges from very good to excellent. The program compares well with similar programs in other European countries (most notably, France and Germany), in the USA and Japan. Its congruence within the European framework is good. Its future appears to be well delineated. Its goals, as expressed in the 2006 roadmap: (i) consolidate the Italian role in ALICE at CERN, (ii) develop radioactive beam facilities as a probe of unstable nuclear matter, (iii) establish an Italian role in FAIR at GSI, (iv) keep the excellence in nuclear astrophysics, are both appropriate and reachable.

Theoretical physics-CSN 4

The activities of CSN IV basically cover all the main lines of interest in today's theoretical particle and nuclear physics with an additional important ramification into specific areas of statistical physics. There is a good balance in the number of INFN researchers in these different areas and interactions across them appear to be satisfactory, in spite of the inevitable specialization of each subfield. Some comments on each one of the six "Iniziative Specifiche (IS)" of CSN-IV follow:

Quantum Field Theory and Strings maintains its high profile within INFN activities. While considered of little interest to phenomenology and experiments until a few years ago, string theory has lately inspired new ideas of direct relevance for both accelerator and astro/cosmo particle physics, like modifications of gravity at short distance, signatures from the possible existence of extra dimensions, varying fundamental constants, and new cosmological models. String theory has also brought new tools (e.g. via the AdS/CFT correspondence) for studying non-perturbatively a large class of supersymmetric gauge theories while efforts are being made to extend these tools to theories of more direct physical interest, such as QCD. If successful such a line of research would complement nicely the lattice approach that remains, so far, the most powerful way to study non-perturbative phenomena, such as confinement, chiral symmetry breaking, and phase transitions at high temperature/density. Lattice calculations are, in general, an important and successful line of research in CSN 4, a line that cuts across other branches of physics and is tightly connected to the special project APE (see below).

Particle Phenomenology is the other traditionally strong area of Italian theoretical physics, and has also continued to produce a stable research output at the highest international level. On one hand there is much activity on standard model predictions, both in QCD and in the electroweak sector. This work is essential in order to unravel from the standard model background any possible signature of new physics in the data that will soon come out of the LHC. In parallel, much effort goes into working out possible signatures of new physics in those same experiments. Areas of activity range from perturbative QCD to neutrino physics, to supersymmetric extensions of the standard model, to alternative symmetry-breaking scenarios. There is also considerable high-quality work in extracting the basic parameters of the standard model (such as the CKM matrix) from lattice calculations (weak matrix elements, heavy-flavour parameters, signatures for the quark-gluon plasma). This group works in close contact with CSN I and plays an important role in the planning of future LHC experiments.

The *Nuclei and Nuclear matter* group, has continued successfully its traditional lines of research in Nuclear structure, Nuclear reactions, and Nuclear Astrophysics. This activity is tightly related to the experimental program in CSN 2. This subgroup of CSN 4 has further developed, with the new initiative RM31 lead by L. Maiani, its component addressing the physics of relativistic heavy-ion collisions and the search for the quark-gluon plasma in conjunction with the ALICE experimental program.

The share occupied by *Mathematical Methods* has been slowly shrinking, probably as a result of some migration towards the *String*

Theory and the *Statistical Physics* components of CSN 4. Interesting topics belonging to this area of research include: non-commutative geometry and quantum groups, non-linear dynamics and integrable models, constrained systems, quantum information, foundations and interpretations of quantum mechanics.

The *Astro-particle and Cosmology* subgroup, after an initial fast growth, appears to have reached a steady state above a critical mass and to be progressing well. It covers a large spectrum of subjects, from more traditional astrophysical ones, like neutron stars and radiation sources, to conventional and unconventional models of inflation, to dark matter and dark energy. It also covers neutrino astrophysics, as well as gravitational-wave sources.

Statistical physics and field theory has grown recently through migration from the *String and Field Theory*, and the *Mathematical Methods* subgroups. It provides important bridges to other fields of theoretical physics, like those of complex systems, turbulence, biological systems, non-equilibrium statistical mechanics, and stochastic processes.

Besides the above IS, two more items related to CSN 4 are worth mentioning:

ApeNEXT, a special project of CSN 4, has completed its installation of 13 towers in Rome making 10 Tflops available at various locations within INFN but also in France and Germany. This order of magnitude increase in computing power should allow important progress on the particle physics questions mentioned before, as well as in other areas, such as turbulence, the physics of complex systems, and computational biophysics. It is making *ApeNEXT* the most powerful European-made dedicated Supercomputer, as well as an excellent example of technological transfer.

The INFN-sponsored *Galileo Galilei Institute for Theoretical Physics* (GGI), located in Arcetri (Florence) in a building provided by the University of Florence, held its Inaugural Conference in September 2005. The first workshop, "New directions beyond the standard model in field and string theory", took place from 2 May till 30 June 2006, with a very good national and international participation. An interesting programme, with four more workshops extending till the end of 2007, is already scheduled. While the main aim of the workshops remains making progress on hot theoretical issues, participation of doctoral students and post-docs should be further encouraged. The GGI should also play an important role in bringing different communities of theorists together and could provide some impact on society by organizing, in conjunction with some workshops, public conferences and/or seminars for high school teachers and students.

In conclusion, as shown by various numerical indicators, CSN 4 appears to follow a very promising course. The main problem on the horizon is the scarcity of openings for young Ph.D.s and post-docs. This problem is not INFN-specific: actually, for theorists, it is even more acute at the University level, traditionally a strong "absorber" of young Ph.D. theorists. If this problem would extend for too long, it could lead to a (partly already noticeable) dangerous brain drain of the excellent theorists that Italy is able to produce.

Technological and interdisciplinary research-CSN 5

The specificity of CSN 5, in charge of the development of technologies for experimental particles, astroparticles and nuclear physics and of their application in other disciplines or in industry, lies in the variety of the projects managed. More than 100 projects of research and development are currently ongoing, which reflect the liveliness of this sector. These projects are rather short, generally with a lifespan of 2-3 years, involve about 5 FTE and have an average budget of 50k€ per project, even though variations on these numbers can be quite important depending on the nature of the R&D. The projects are divided in 3 categories: research and development for accelerators, detectors and interdisciplinary applications, with a roughly compatible budget between the three categories, respectively 25%, 40% and 35%. The projects undertaken are aimed at finding applications either within the proper research activities of INFN, for interdisciplinary use in academia or with institutional or industrial partners. The policy established by INFN to undertake interdisciplinary R&D only in collaboration with partners outside INFN clearly identified and well defined boundaries is the right way to prevent developments without responding to any demand.

INFN is pursuing its longstanding tradition of accelerator R&D, in particular at LNF. Even though like in many other countries, a special effort is made in this domain, the budget share has slightly decreased and among the three fields, accelerator R&D has currently the lowest share – yet accelerator R&D at INFN is also part of European initiatives and some parts are also funded through the 6^{th} PCRD. The projects in accelerator physics are well established parts of the international R&D efforts for ILC and CLIC in association with the development of FEL facilities (SPARC). These projects include activities with interesting technological impacts such as those related to the superconducting RF cavities with the deposition of superconducting Nb film by UHV arc techniques (in the frame of ARCO project). The INFN projects are essential and well recognized contributions within these programs. A particularly original development is the study of electron clouds around beams, which has lead to a modification of the LHCb interaction region.

Another important area of very interesting and successful activities with high scientific and technological impact are related to the study and development of detectors of various types, in particular Si-based detectors among which, for example, a linear silicon detector with controlled drift as a novel concept of scatter detectors (COMPTON) or the development of fabrication techniques for 3D silicon wafers (TREDI).

One of the most visible areas of the CSN 5 activities outside INFN lies in the medical sector. INFN contributes with the development of detectors, computing support for image analysis and simulation (as, for example, in the case of MAGIC-5 project) and with accelerator developments. An industrial partnership for the SCENT super conducting cyclotron technology for medical applications has been concluded with IBA group in Belgium, which is an important step in the successful finalization of this project, in particular as the collaboration with ACCEL could not be pursued. It should also be underlined that the new patient treatment room outside LNS within the CATANA proton therapy center is now successfully operating. A very original development within CSN-V is HAPTIC, which tries to provide tactile stimuli from visual information for the blind. Close contact with related institution is crucial to provide the necessary feedback for this type of innovative project.

Other fields associated with a high social visibility are applications in the cultural heritage and the environmental sector. The recent development for the analysis of particulate material (PM) from existing (PIXE, PIGE) and new techniques (PESA) may have potentially a high economic impact and could allow to establish links with the automotive industry or other sectors concerned by particulate emissions. In the various fields of interdisciplinary applications, in particular in the medical, environmental and cultural heritage sector, possible financial support from the Italian regions could be further investigated.

In general, CSN 5 is therefore confirmed to be a section with an important social and economical impact by pursuing not only highly scientific activities but also by implementing socially beneficial projects, by stimulating high tech competences at companies supplying products for the technically demanding INFN facilities and by developing projects and know-how which companies can try and exploit to develop new products for the market. In this view, all activities to further increase and strengthen contacts with industry either by technology transfer or insemination of young physicists from the field to work within industry are to be encouraged. Progress has been made to clarify questions of intellectual property, yet it is important to remain attentive in this area.

The overall budget of CSN 5 is rather small, compared to the other sections of INFN and the particular role of the national laboratories as incubators and supportive structures for the development of new and original ideas has to be stressed. It remains important to coordinate and prioritize different projects and to evaluate closely their perspectives, in particular if budget restrictions have to be applied in order to keep in CSN 5 a healthy balance of highly targeted projects and a playground to test new and original ideas.

Socio-Economic Impact

A special emphasis was put on the socio-economical and interdisciplinary impact of the 2005 INFN scientific activities. Before the meeting a comprehensive report on this aspect was distributed to the CVI, prepared by dedicated INFN Working Group (GLV). The report analysed in a first part the impact of INFN research in training, dissemination of scientific culture, the development of frontier technologies and their interdisciplinary implications, including a quantitative analysis of the impact of INFN research on the national economy. In a second part a novel attempt was made to evaluate basic research in a quantitative way, by looking for and applying quantitative measures.

Based on the finings for the report CVI came to the conclusion that INFN is performing very well on an international scale in all the areas mentioned above: INFN plays a key role in Italy in physics education at all levels, is very successful in its programmes to bring science to the public, dedicates significant resources to developing frontier technologies and making them available for interdisciplinary research. The yield of INFN research on the national economy was analysed in four categories and showed the impressive effect of training of industrial companies by providing them with INFN expertise in high technology products. This study was complemented and quantified by a macro-economic model of INFN industrial impact. The report included a national and international comparison of the INFN scientific productivity.

CVI was impressed by the strong position of INFN in all these areas. The CVI would like to point out, however, that the monitoring of scientific productivity through bibliometric analysis can only partially reflect the true scientific impact and should mainly be used to complement peer reviews.

Resource and Financial Management

Since 1997 INFN, like all the other Institutes of the Public Sector, is constrained by various limits, beginning with cash limits in 1997 and ending with staff limits; the main aspects of the legislation which apply to the over all research field are:

- the budget authorisation of the Institute is constrained by a cash limit so that a forced saving is imposed; the cash limits apply bimonthly (with possible derogations);
- operational expenses and temporary staff are limited and procurements are centralised by a public corporation;
- an increase in permanent staff is forbidden.

As was noted in previous reports (2003, 2004), past cash-flow limits imposed on the budget authorisation led to an increasing forced saving, which reached a peak of 130 millions of euro in 2002. Since that year the budget assignment is almost flat. A Ministry decree established a rate of increase of 2005 expenses of 4.5% with respect to 2003 and in October 2005 10% of the operational expenses (6.6 M€), and in July 2006 again 10% (6.2M€) have been frozen. Financial resources will remain fixed or decrease slightly for the next three years apart from resources available from special projects, which represent a percentage of around 5% of total resources. In 2006 the cushion of the forced saving, which has been used to finance some large projects producing payment on a multi-annual basis, will disappear, so that the budget assignment will be binding.

The change in total expenditures from 2003 to expected 2007 is described in the following table

	Operation	Personnel	Research
2004	24,9%	41,7%	33,4%
2005	24,8%	44,8%	30,4%
2006	24%	46,7%	29,3%
2007	22,2%	51,9%	25,9%

There is a clear trend: Personnel expenses have increased by ten percentage points, due to contractual renewals, operation expenses have decreased slightly, but research expenses have decreased strongly.

The CVI report of last year has pointed out that "INFN is conscious, and the committee is concerned, that in the long run, the scientific activity will be seriously endangered, if the financial laws continue to impose these restrictions". We have now to point out that the flat (or even decreasing) trend of total financial resources in nominal terms, leads to nearly total cut for new projects, since they imply new and more expensive machinery. This jeopardises the ability of INFN of maintaining the high standard which rightly INFN has obtained so far. The chance for many Ph.D. and young post-docs to start a research work (for which they have been trained) will decrease. There is a real danger of wasting human capital which resulted of a long tradition in Italian teaching in physics.

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