INFN CVI Report 2011

Conclusions of the CVI Meeting on 11-12 October 2011

Members of the CVI Panel:

N. Amodio, Confindustria, Italy (through a teleconference)
P. Drell, SLAC, USA
E. Fernandez, IFAE, Spain
A. Frey, University of Göttingen, Germany
M.N. Harakeh, KVI Groningen, The Netherlands
F. Iachello, Yale University, USA
J. Iliopoulos, LPTENS, Paris, France (Chair)
E. Zaninotto, Università di Trento, Italy

November 5 2011

1 Executive Summary

This year the CVI had its annual meeting in the *National Laboratory of Legnaro* (LNL). With this meeting we concluded our visits to all four National Laboratories and we have a complete picture of the activities of the Institute at both National and International levels. As usual, we reviewed the entire spectrum of INFN performances, scientific, technical and educational, including their socio-economical impact.

- All four Laboratories present a rich research programme, often with important projects designed or under construction. The CVI was pleased to see that in the LNL SPES is progressing according to schedule.

- Before presenting our conclusions we want to emphasise that this was a remarkable year for the activities of the Institute. On the international scene the year is marked by the excellent performance of the LHC, both the collider and the detectors, and the shutdown of the Tevatron. The accumulated luminosity in every experiment at LHC goes beyond all expectations and this is expected to continue next year. At the domestic front we witnessed the important decision by the Italian Government to approve the establishment of the Nicola Cabibbo Laboratory and to finance the construction of the super-B factory. Both present great opportunities, but also enormous challenges, for INFN. The CVI is confident that they will be successfully met and that they will lead to exciting new Physics and fundamental discoveries.

- Based on all available input, supplemented with our own expertise, we came to the conclusion that, again this year, **INFN, as an Institution, remains at a very high level of scientific and technological excellence and compares favourably with similar Institutions world wide.** Italian teams play often a leading role in international collaborations and the Italian School of Particle, Nuclear and Astro-Particle Physics is one of the best in Europe. This excellence has been maintained in spite of the continuing difficult situation of the Institute as regards its financial and human resources. The scientific programme remains at a very high level with many important experiments presenting their final results, running or being prepared. Furthermore, the performances of the Institute in the fields of education, the dissemination of scientific knowledge, as well as its efforts for the transfer of front-line technology to industry, are truly exceptional.

- A milestone for the Institute is marked by the approval of the super-B project. The CVI fully agrees with the Management's decision to establish a Consortium, with a well separated budget, which will be in charge of the project's realisation. This structure should be maintained. It is particularly appropriate to the attraction of new national and international partners which will allow a speedy completion and meet foreign competition.

• The President presented a clear picture of the global situation of the Institute. The CVI was surprised to hear that, due to an incredible administrative blunder, a substantial percentage of the budget, the one which is based on performance, was not given to the Institute for this year. This came in addition to the severe budget cuts accumulated over many years which had already put the Institute under severe stress. It resulted into a nearly catastrophic situation, forcing the Directorate to act in an emergency, engage all the reserves and redirect funds initially marked for new projects. This situation cannot perdure. The CVI hopes that this error will be soon corrected and the lost budget will be fully recovered. This will not solve the financial problems of the Institute, it will merely change them from catastrophic to critical. In the President's report we see that, since 2001, the budget of INFN, independently of this year's error, has decreased effectively by 15.3%. This amounts to a cumulative loss of more than one year's income. To maintain in the long term INFN's competitive position in the international scene, a reversal of the recent tendency of constantly diminishing budget is urgently needed. An equally critical point is that of human resources. The brain drain, which we have signalled in our last year's report, continues due to the absence of promising career opportunities in the Italian Universities and Research Centres. Many among the brightest young Italian physicists, who have received an excellent training following the programmes sponsored by INFN, leave the country.

• The in-depth evaluation of all research Institutions (V.Q.R.), now spanning seven years, from 2004 to 2010, which was announced last year, enters its final phase of application. Although the reservations which we had expressed in our previous report concerning the inadequacy of the rules to an Institute like INFN, with such a broad spectrum of activities and large international collaborations, still remain valid, we are confident that the Institute will rank among the very best in the country. We hope that this will be reflected into a substantial increase in its resources. The CVI has reviewed and approves the material which the Directorate will present to the evaluation committee.

• The new rules of Governance, which will be completed by the appointment of a Director for the Administration, are already in place. The CVI expects that they will contribute to easing the administrative burden from the Board of Directors which will have more time to concentrate on issues of scientific strategy.

- The CVI meeting coincided with the change in the Presidency of the Institute. We wish to express our deepest appreciation to Professor Roberto Petronzio for his inspired and successful leadership during all these years of great economic stress, but also years of new and exciting scientific achievements. We congratulate Professor Fernando Ferroni for his appointment and we wish him great success in his mission. He can count on our support.

2 INFN Achievements and Perspectives

This report is based on several input elements:

(i) A document on the *INFN Scientific Productivity and its Socio-Economic and Inter-Disciplinary Impact* , which we received before the meeting, offering a valuable picture of the profile of the Institute.

(ii) A detailed presentation on the scientific programme of the National Laboratory of Legnaro followed by a visit of the facilities.

(iii) The report presented by the INFN President on the scientific and technical activities, as well as the questions related to the resources (financial and personnel).

(iv) The comprehensive presentations covering each one of the five sections, as well as the super-B project and a specialised one on the socio-economical impact.

(v) Our own expertise which covers essentially the entire spectrum of the INFN activities.

In the following sections we shall review each one of the scientific and technical sections of the Institute and we shall highlight the achievements as well as the difficulties. Here we give a summary of the main conclusions.

As it was the case in previous years, the overall picture is one of prolific activity combined with scientific excellence. All sections remain at the frontier of modern research. In all fields the contribution of the Italian teams is remarkable, both in the domestic laboratories as well as inside the large international collaborations.

During the last year the Physics of Elementary Particles was dominated by the long awaited outstanding performance of the Large Hadron Collider. All experiments collected a wealth of data beyond expectations. We had been through many lean years in Particle Physics and we cannot hide our enthusiasm with the perspective of fundamental discoveries. Since our meeting, the first glimpse of a Higgs signal was announced, adding to the excitement. INFN physicists had played a major role in the preparation of all important experiments and this is recognised by the international community since the spokespersons of all four major LHC experiments are Italians. LHC is scheduled to continue running during 2012 before a long shutdown for technical consolidation in the perspective of reaching the designed energy of 14 TeV and luminosity of 10^{34}.

The Tevatron terminated its operation and left a rich harvest of data which is still being analysed. In addition the results from the flavour physics experiments are in the final phase of publication.

The super-B project was approved this year. The CVI was impressed by this decision of the Italian Government in spite the current difficult financial conditions. For the realisation of this project, new resources have been allocated and a multi-year funding scheme has been established. It will present an enormous challenge for the entire Particle Physics community in Italy, both at the technical as well as the organisational level. Since it is planned to operate as an international facility, the CVI approves the Management's decision to establish a separate Consortium. Although a transfer of resources at the level of technical expertise, from INFN to the new entity, should take place, the CVI strongly advises to keep the two budgets strictly separated. As the project advances, a process of establishing priorities should be initiated and the CVI wishes to receive a report on this issue during its next meeting.

In view of the expected competition with the Japanese project, the time element will be of the utmost importance. The Italian Super-B will be technically superior offering better Physics possibilities, nevertheless its discovery potential will decrease if it arrives too late. The possibility of running as a new state-of-the-art light source is certainly interesting, but it should not result into the transfer of already scarce resources from Particle Physics to other fields.

The field of Astroparticle Physics in INFN presents a very large variety with many experiments covering a wide range of subjects. The underground laboratory at Gran Sasso is a world class facility attracting scientists not only from Italy but from many other countries as well. In addition a great activity is being developed in space based experiments, cosmic ray studies, gravitational wave antennas and R&D towards the construction of an underwater neutrino detector. All these activities are producing, or promise to produce, exciting physics results and the CVI worries whether the diminishing resources will allow INFN to make significant advances to all these fronts.

.

Our visit at LNL gave us the opportunity to have a detailed view of the INFN commitment in Experimental Nuclear Physics. It is the main research activity of the Laboratory which attracts many collaborators from Italian, as well as European, Universities. The star project of LNL is the construction of the SPES facility which is under way and proceeds on schedule. Together with the radioactive beams it will assure a prominent position of LNL in the European Nuclear Physics landscape.

In our previous reports we had often expressed our appreciation for the Italian School of Theoretical Physics. It remains at the highest level and covers a large variety of fields from mathematical physics to phenomenology. In some of these areas, as for example, in the physics of disordered systems, or that of Elementary Particles, it is one of the best in the world. We were pleased to learn this year that a cluster computing facility has been installed in Pisa to allow for large scale numerical simulations. Although it is not a substitute for the state-of-the-art super-computer system whose absence we deplored last year, it will allow some groups to remain competitive.

The Galileo Galilei Institute continues to be a success story with numerous high level research workshops and training schools being organised every year.

In each one of our reports in recent years we have repeatedly presented graphs showing the constant decrease of the INFN budget. In our last year's report we showed the loss of budget in real terms, *i.e.* at constant 2009 prices. No improvement seems to come. In addition this year, as a result of an unfortunate mistake in the application of an administrative rule, the Institute lost a substantial part of its budget, the one which is linked to performance. We emphasise that this loss is not due to an evaluation which found INFN un-performing, but to a mere mechanical change in the rules. We assume that it was not meant to penalise the Institute and we expect this part of the budget to be restored. This restoration should occur very rapidly for the dammage to be repaired.

Independently of this blunder, the constant pauperisation of the Institute cannot continue indefinitely and requires drastic measures in all fronts. First, no effort should be spared to recover, at least partly, the lost budget. The very capacity of the Institute to continue its performance or to launch new initiatives is at stake. Second, the decision making process should be revised. Looking at the budget evolution of the various Sections, we see that the cuts were almost equally distributed among them. This uniform policy cannot be sustained and the CVI encourages the Direction to elaborate a long term strategy and establish priorities, both among the scientific Sections as well as inside each one of them.

An even more critical and recurrent problem is that of human resources. The absence of new recruitments at all levels, both in the INFN personnel, as well as the associated Universities, has already caused irreparable damage to all Italian science. The absence of career opportunities forces the most talented among the young Italian physicists to leave the country. All the enormous effort developed by INFN in the training of young researchers, which has created one of the best Schools of High Energy and Nuclear Physics in the world, profits almost entirely foreign countries. It is incredible how much harm a blind across-the-board cut can cause with so little effect on public finances.

During our meeting we have reviewed the material which the Institute intends to present for the seven-year evaluation (VQR). The CVI approves the choices of the Direction and we are confident that the evaluation will confirm INFN's position as the leading Research Institute in the country.

As with previous years, the GLV report contained an important section on the socio-economic activities of the Institute as well as its educational role. The CVI judges the Institute in both these areas excellent. In contrast, we lack precise quantitative information on the impact and the results of the Technology Transfer policy and, as a result, the CVI expresses its difficulty in judging the efficacy of the INFN Technology Transfer activities in 2010. Some practical recommendations to improve this situation are outlined in a special section below.

3 CSN1: Experimental Particle Physics with Accelerators

3.1 Physics results

During 2011, the majority of manpower and resources in CSN1 was committed to the LHC experiments, ATLAS, CMS, LHCb and the dedicated forward physics experiments LHCf and TOTEM. The LHC accelerator has been run very successfully and more than 5 fb-1 of integrated luminosity have been delivered to the ATLAS and CMS experiments, more than 1 fb-1 to LHCb. A successful heavy ion run completed the data taking. While ATLAS and CMS provided numerous measurements on Standard Model physics as well as setting limits on supersymmetry, LHCb is quickly taking the lead in heavy flavour physics, for instance with the best limit on the $B_s \to \mu\mu$ branching fraction. Since our meeting the wealth of new results has been completed with a most tantalising possible Higgs signal around 125 GeV. Fortunately, the long shutdown of the accelerator has been postponed to 2013, so new exciting results are expected for 2012.

The harvest of results from experiments that are no longer taking data rightfully continues. The Tevatron stopped its successful long running period finally in 2011, with many publications still forthcoming. BaBar and ZEUS are finalising their analyses. In the flavour sector, in addition to LHCb and the Super-B preparation, INFN owns a world-class facility with the soon upgraded DAFNE machine and the KLOE experiment. INFN also plays important roles in the construction of NA62 as well as BES-III. The search for lepton flavour violation continued at MEG, the collaboration presented a new measurement and rules out LFV at a limit of 10^{-12}.

Excellent R&D contributions for future experimentation have always been a strong asset in INFN's outstanding and varied research program. The CVI is impressed by the near future perspectives, namely the upgrade programs of ATLAS, CMS and LHCb, a planned upgrade of the MEG experiment, resulting in an improved sensitivity by two orders of magnitude, the planned Mu2E experiment at Fermilab, an upgrade of COMPASS as well the UA9 R&D effort that is looking into beam bending with crystals. While all these proposals offer excellent scientific prospects, INFN with its limited budget will clearly have to make choices, in particular in light of Super-B. The CVI encourages strongly a long-term strategic planning study, in order to maintain INFNs very strong position in the research covered by CSN1.

As emphasised in last years report, the visibility of INFN physicists in the competitive LHC environment is outstanding (e.g. spokespersons of all four large LHC experiments are Italians), underlining the appreciation by the particle physics community of the excellent contributions to the detector hardware, commissioning and physics analyses.

3.2 The super-B project

A most significant event in the past year, impacting INFN as a whole and CSN1 in particular, was the approval of the flagship project Super-B by the Italian Ministry of Research and Education in April 2011. A financial allocation of 250 Million Euro for the superb flavour factory has been made with 19ME allocated in 2010 and another 40ME expected for 2011. It is a triumph for INFN that the project has been approved. The outgoing INFN President should be commended for his dedicated efforts to secure this project.

The Super-B project builds on the successful operations of the first generation B-factories (the BaBar detector operating at PEP-II in the US and the Belle detector operating at KEK-B in Japan) to develop a versatile flavour physics experiment that can probe new physics observables in a wide range of heavy flavour decays. If the facility performs as claimed within the timeframe outlined, it will deliver world leading capability in this important science area.

The project has been moving quickly since approval, with a site competition resulting in the selection of the Tor Vergata site next to the INFN laboratory at Frascati. The development of a governance structure has started. While INFN was the host to start the project, the Super-B project has now moved outside of INFN and is managed by a consortium made up of University and INFN partners. The Cabibbo Laboratory, which will host the project, has been founded and a director general will be appointed and a directorate formed by the end of the year 2011. The goal is that Cabibbo Lab will be eventually managed as a European Research Infrastructure Consortium (ERIC). The definition of the work packages and responsibilities for the project is underway. Negotiations with foreign partners are starting.

The funding for Super-B, as a flagship project of the Italian government, will not come from the normal Particle Physics budget, but from specific allocations of the Italian Government. Of the roughly 500ME needed to build the project, it is anticipated that 100ME will come from foreign partners and roughly 15ME/year will come in co-financing from INFN. The project is in the process of developing a detailed project cost and schedule that can be reviewed by external experts for validation. We believe this is a very important step to establish the credibility of the project time line and science delivery.

As the time schedule for the planned Super-KEKB upgrade at KEK/Japan is not so different with a start-up in late 2015, the fruitful and healthy competition between the B factories will open a new chapter in this decade. The Super B project has additional advantages in the unique possibilities of beam polarisation and of running at the tau/charm threshold.

4 CSN2: Astroparticle Physics

The Astroparticle Physics area includes several distinct activities, distributed in six sectors, namely i) Neutrino Physics using both accelerator-produced beams and natural neutrino sources, ii) Searches for Rare Processes, such as neutrinoless double-beta decay and direct dark-matter detection, iii) Study of Cosmic Rays in Ground-Based Detectors, including cosmic neutrinos with underwater detectors, iv) Study of Cosmic Rays in Space, v) Search for Gravitational Waves, both in ground- and space-based detectors, and vi) General Physics, mainly gravity and quantum vacuum studies. The number of personnel in CSN-2 has been stable during the last few years, with 650 FTE (about 820 persons) in 2010, only second in size to CSN-1 among the

INFN Commissions. As in other commissions, the budget has decreased with respect to previous years and further decreases are foreseen until 2014. Both the number of publications and their impact factor have been steadily increasing during the last few years.

The Neutrino sector has reached a mature state: all experiments are producing results and two of the major ones, OPERA and ICARUS, both at the Gran Sasso Laboratory (LNGS) using the CNGS beam from CERN, will be completed in the next two to three years. An unexpected result showing that the neutrinos from CERN could possibly travel at a speed larger than the speed of light had been announced by OPERA prior to our meeting. Since then, new investigations by the same collaboration seem to indicate the resolution of the puzzle. BOREXINO, also at the LNGS, has measured precisely the Be-7 solar neutrinos, providing independent evidence for the Large Mixing Angle, matter-effect enhanced, oscillation hypothesis.

In the search for neutrinoless double-beta decay, two of the largest experiments in the world, GERDA and CUORE, are being assembled at LNGS and should be completed within the next three years. On the direct dark-matter searches the LNGS hosts four leading experiments, three of which have strong INFN participation: DAMA/LIBRA, WArP and XENON100. DAMA/LIBRA is running under very stable conditions with an improved detector. XENON100 has shown the potentiality of the technique with much improved results over those obtained previously, and will be extended to XENON1T (one tone of liquid Xenon).

Ground-based cosmic-ray experiments include ARGO (in Tibet) for the study of very high energy charged cosmic rays and gamma rays, the MAGIC Telescopes (La Palma) for very high energy gamma rays and the AUGER Array (in Argentina) for extremely high energy charged cosmic rays. All these experiments are producing many and very interesting results. On the underwater neutrino telescopes the INFN participates in the ANTARES 12-string detector, which is actually running, in the NEMO demonstrator project and in the KM3-NET Collaboration. NEMO is contributing to the KM3-NET, aiming at a full TDR for an underwater Mediterranean detector.

Cosmic rays in space are studied with the Fermi LAT detector, which has now been in orbit for two years running stably, with the AGILE and PAMELA satellites and, since the summer of this year, with the AMS-2 detector. AMS-2 was launched in May on board of the Shuttle to the ISS, and shortly afterwards was able to detect and identified the ions of several nuclei. All these experiments have produced significant results this year. Fermi in particular has discovered more than 1500 new sources and the collaboration has already published more than 100 scientific papers.

In the study of gravitational waves Italy hosts one of the more advanced detectors in the world, the VIRGO interferometer located near Pisa, which is now being upgraded to Advanced Virgo. This improvement will multiply by 1000 the effective volume explored. The AURIGA and Nautilus antennas will also continue operations. The INFN is also involved in the LISA Pathfinder mission, and in the LISA studies.

Overall the INFN contribution to the field of Astroparticle Physics is impressive. In some areas, some of the leading experiments in the world are located in Italy, namely at the LNGS, and this attracts a large international community to collaborate with the Italian groups. The Committee notes that, during the next two to three years some major efforts will be completed which will open opportunities for new initiatives. As in other areas, the experiments in Astroparticle Physics are growing in complexity and the committee encourages the INFN to plan the future within the framework of the international planning effort taking place in Europe and elsewhere.

5 CSN3: Experimental nuclear physics

During the past year the research lines of experimental nuclear physics performed excellently, as evidenced by the large number of papers produced and of invited talks to international conferences and workshops. In addition, these lines fulfilled their objectives by realising almost completely the scientific and technical milestones foreseen for the past year. However, a point of concern is the small number of PhDs granted in CSN3 relative to the total number granted by INFN. A larger effort should be made to attract PhD students at least if the positions are available and also to open new research positions in Nuclear Physics. This, of course, will be more difficult to achieve if the perspective of a steadily decreasing budget is not reversed. Nevertheless, CSN3 should be applauded for keeping vibrant lines of research resulting in many highlights in the last year in spite of the financial difficulties.

In line 1, Quarks and Hadron Dynamics, many experiments have been performed at JLAB (USA), MAMI (Mainz), ELSA (Bonn) and DAFNE (Frascati). Also, research and technical developments have continued for the approved upgrade to 12 GeV of the JLab facility and for the PANDA detector at FAIR/GSI. Interesting results have been obtained on two-photon exchange contribution to elastic lepton-proton scattering through a precise comparison of positron-proton and electron-proton elastic scattering. Probing the strange sea in the nucleon has been made through the measurement of the polarisation in semi-inclusive deep inelastic scattering. The precise measurement of the ratio of the electromagnetic factors of the proton has been extended to $Q^2 \sim 8.5 GeV^2$ allowing better discrimination between theoretical models. Tensor correlations were precisely measured in ^{3}He(e,epp)n for a large momentum-transfer range. In the MAMBO experiment at Bonn and Mainz, which studies baryonic and mesonic resonances between 1.5 GeV - 3 GeV, progress has been made through first measurement of the circular beam asymmetry in the $\gamma p \rightarrow \pi^0 \eta p$ reaction and identifying small contributions from positive-parity resonances via interference terms with the dominant D_{33} amplitude. Hypernuclei and kaonic atoms have been studied in the FINUDA and SIDDHARTA experiments at LNF. In addition to the hypernuclear spectroscopy in p-shell nuclei, a highlight of the measurements at FINUDA is the non-mesonic decays of the Λ hypernuclei with contributions from correlated two-nucleon pairs. SIDDHARTA delivered a precise measurement of the energy of the 1s level for the hydrogen kaonic atom. The opportunities to participate in the large international projects, the 12 GeV upgrade for JLab and PANDA, triggered a large number of technical activities. Among these for JLAB12 are development of a neutron detector for CLAS, simulation and construction of the forward tagger, and the design of a ring-imaging Cherenkov detector for CLAS12, development of a hybrid tracker based on Si and GEM for Hall A. For PANDA, the R&D concentrates on development of the micro-vertex detectors and tracking detectors using straw tubes. There is also strong involvement in experiments at COSY, Jlich to study the mechanism of polarisation build-up, which is of great importance for obtaining polarised antiproton beams at PANDA.

In line 2, Phase Transitions in Nuclear Matter, the ALICE Collaboration profited from the operation of the experiment for the full 2010. Data were obtained for $p-p$ collisions at 7 TeV colliding beams, and for Pb-Pb at 2.76 TeV per nucleon pair colliding beams. Data analyses with full involvement of the INFN groups have progressed fast yielding exciting results on production of resonances, π^0 and γ, charm (D mesons), J/Ψ in the dimuon and dielectron channels and jets, which are important observables for the quark-gluon plasma (QGP). In the measurements, charged particles were identified at low, intermediate, and high transverse momentum. Charged-particle multiplicity measurements and two-pion Bose-Einstein correlations were performed for both $p-p$ and Pb-Pb collisions. The remarkable highlights resulting from these measurements are i) the jet quenching observed as suppression of hadrons at high-p_T in Pb-Pb collisions as compared to p-p collisions and ii) the indication from two-pion correlations that the fireball formed in nuclear collisions at high energies at LHC is hotter, lives longer, and expands to a larger size at freeze-out as compared to lower energies. The development of the Tier2 centres is continuing and ALICE upgrade has been going on, in particular with the installation of the transition radiation detectors (TRDs) and the electromagnetic calorimeter. Several other upgrades of ALICE are planned for the shutdown period and beyond. INFN is strongly involved in one of them, *i.e.*, the inner tracking upgrade in which a 2nd generation vertex detector will be installed with excellent capabilities to study production of heavy flavour baryons.

In line 3, Nuclear Structure and Reaction Mechanisms, research at the INFN national laboratories LNL and LNS and the large European research infrastructures GSI and GANIL addressed mainly two themes: 1) the study of single-particle and collective degrees of freedom in nuclear excitations in order to understand the evolution of shell structure and nuclear properties as function of proton-to-neutron ratio, N/Z, and 2) the study of the nuclear equation of state (EOS) and its isospin dependence (symmetry-energy term) through nuclear reactions with heavy ions. The first theme profited from the presence of the AGATA demonstrator at LNL till the end of 2011. This was used in combination with Si arrays for light-ion detection and the PRISMA spectrometer for heavy-ion detection. The AGATA demonstrator lived up to the expectations and the energy resolution of γ-rays emitted by recoiling nuclei could be strongly improved by its tracking capabilities. Lifetimes of levels could be precisely measured with AGATA coupled to a differential plunger. At GSI, g-factor measurements were performed using the γ-ray array RISING. The second theme was pursued using the CHIMERA set-up at LNS with light radioactive beams to study isospin effects at the Fermi energy. CHIMERA was later used in conjunction with the LAND detector at GSI at high beam energies to study isospin dependence of EOS. This will eventually help in understanding neutron-star formation, the fission process and dynamics of heavy-ion reactions. The groups in this line of research are involved in R&D within international collaborations towards developing novel and state-of-the-art detection systems for high-energy γ-rays and for neutrons. $LaBr_3$ crystals backed by NaI ones will form the units for the PARIS array for detection of high-energy γ-rays and have demonstrated excellent properties of high efficiency and excellent time resolution. The FAZIA collaboration has shown important progress in particular with the beam tests performed at different facilities with prototypes of the detection cells which provided impressive results concerning the performances of the new silicon detectors. Both identification techniques based on standard E-ΔE measurements and pulse-shape analysis with a single detector show outstanding resolutions in charge and mass. Most of the results obtained during the R&D phase have been published. The NEDA neutron wall is an important addition to the γ-ray detection arrays and will be used in the future in experiments with AGATA. The construction of the SPES ISOL facility at LNL is progressing well. The driver cyclotron is expected to be installed in 2013/14 and will deliver 200 μA of proton beam at 40 MeV (8 kW). R&D on the UCx target and radioactive ion beam is performed in the framework of an international collaboration and is well on track although more resources are needed in the near future.

In line 4, Nuclear Astrophysics and Interdisciplinary Research, nuclear reactions at stellar energies are studied in order to have a good understanding of nucleosynthesis at different stellar environments. Direct capture measurements (LUNA at LNGS) require very low beam energies in the region of the Gamow peak, *e.g.*, the study of the $d(\alpha\gamma)^6$Li reaction at around 100 keV needed to resolve the discrepancy between observed ^{6}Li abundance and expected one on basis of Big Bang Nucleosynthesis. Indirect capture measurements (Trojan Horse method) are pursued (ASFIN2 at LNS) and interesting results have been obtained recently in the study of the ^{17}O$(p,\alpha)^{14}$N reaction. The neutron capture studies for astrophysics and reactor applications are pursued at n_TOF at CERN. Recently interesting results on neutron capture on ^{186}Os and ^{187}Os were obtained. These reactions are studied in order to determine the s-process abundance of ^{187}Os at the time of formation of the solar system because of its importance for the cosmic clock. Also, precise data obtained on fission of ^{237}Np induced by neutrons at high energies differed significantly from earlier evaluations. This could have important consequences for accelerator-driven systems.

To conclude, the INFN-CNS3 programme has performed exceedingly well in the last year profiting largely form the full operation of ALICE at CERN and the extensive running campaign with the AGATA demonstrator at LNL. The quality of research in all lines of CSN3 is excellent and INFN scientists are often leading collaborations in Europe. The SPES project at LNL is part of the INFN Road Map for Nuclear Physics, and the CVI is pleased to know of the strong commitment of the INFN presidency to this project, which has been reiterated during the meeting. Progress has been made with the construction of this facility and also on R&D of some of the critical components to produce the radioactive beams. The momentum should be maintained for a timely realisation of this facility with its full potential to have impact on European and even international level when the large radioactive-ion beam facilities are fully operational. In addition, the plans for a few MV accelerator, LUNA-2 at LNGS, in the future have entered the phase of a feasibility study of the site and the installation of the accelerator and its shielding.

6 CSN4: Theoretical Physics

Theoretical Physics continues to be an important component of INFN activities. It covers a very large spectrum from Theoretical High Energy Physics and Theoretical Nuclear Physics to Astro-Particle Physics and Cosmology, Mathematical Physics and Statistical Physics. Although most of the senior researchers in these areas are University Professors, essentially all groups with a significant scientific activity are financed by INFN. In this respect the Italian model of organisation is exemplary. It is one of the rare cases in which both experimentalists and theorists covering essentially all fundamental Physics belong to the same Institution. This is probably one of the factors which made the Italian School in this area one of the best in the world.

Among the groups supported by INFN several are of world class. In Theoretical Particle Physics Italy has a leading role in Europe and many Italian theorists are holding senior positions at CERN as well as many European and American Universities. In Statistical Physics, and especially the Physics of disordered systems, the Italian School is probably the best worldwide.

Last year we had noted with regret the fact that the financial difficulties of the Institute had forced the Direction to abandon the project of acquiring a state of the art super-computing system to perform large scale numerical simulations. The Italian community could no more stand the competition from the US, other European countries, or Japan. This year we were glad to hear that a cluster facility has been installed and is already running in Pisa. Although it is not a substitute for the large system many had hoped for and it will not be used for the most demanding projects, such as large scale lattice QCD simulations, it will certainly help in many other problems. It is already fully booked.

The record of CSN4 in training young scientists has always been impressive. It counts for half of the PhDs awarded in INFN related subjects. In our last year's report we had expressed our satisfaction with the programme developed by CSN4 in collaboration with CSN1 in preparing young theorists for the analysis of the LHC results. We are glad to see that this effort continues and has already brought significant results. Italian teams are among the leaders in the theoretical studies related to LHC Physics, such as background computations, expected signal estimates etc.

The critical situation which resulted from the freezing of positions in the

Italian Universities has severely damaged all INFN activities and even more so those of CSN4 due to its more significant dependence on such positions. Professor Lerda in his annual report notes:

"Unfortunately the number of INFN and University staff is rapidly decreasing and the average age...is steadily increasing."

In our last year's report we stated "...the brain drain is no more a danger but a fact. The question is now how to prevent its effects from becoming irreversible. Indeed, it takes generations to build a world class School of Theoretical Physics, but a few years may be sufficient to destroy it." Taking into account the small number of positions involved compared to the entire public sector, we believe that a more flexible application of the rules would have an enormous beneficial effect to the country's Universities and Research Centres.

We were pleased to see that the CSN4 Committee has established rigorous and meritocratic rules to distribute the Institute's support among the various research teams. This will lead to increased efficiency and should be encouraged. However, as Professor Lerda points out, "....all our efforts may fail if the total CSN4 budget keeps decreasing...". Last year we had pointed out, among other dangerous effects related to the budget decrease, the problem of travel funds, so essential to maintain international collaborations. It is again due to a blind application of some administrative rule and we regret to see that the problem has not yet been solved.

A very successful initiative of INFN and CSN4 is the Galileo Galilei Institute in Florence. Established a few years ago it has reached now the age of maturity. It organises every year several workshops, mini-Conferences or specialised meetings in various "hot" subjects in Theoretical Physics. They bring together in Tuscany the best specialists in these fields for the greatest benefit of the Italian, but also the International, scientific community. The Institute compares favourably with similar Institutions worldwide, such as the Newton Institute in the UK, the Henri Poincaré Institute in France, or the Kavli Institute in Santa Barbara in USA. The CVI wants to reiterate its congratulations to the members of the Scientific Committee.

7 CSN5 : Technological and Inter-Disciplinary research

CSN-5 serves an important role in developing technologies, designing and realizing facilities and tools, as well as experimental methods addressed both to fundamental research and a variety of interdisciplinary applications. Its activities have been carried out according to the usual sectors of i) Accelerator Physics, ii) Detectors, Electronics and Computing, and iii) Interdisciplinary research.

The total CSN5 Budget was roughly flat from 2010 to 2011. However, larger shifts in budgets and numbers of personnel between the sectors are observed, in particular, between sectors (i) and (iii), indicating reasonable flexibility in assignment of human and financial resources. This is essential when having projects of short duration of up to three years as is the case for CSN5.

The scientific production in terms of ISI publications remains strong, showing the great interest of the researchers for new developments, particularly in multi- and inter-disciplinary activities. Excellent examples of forefront research are evident in all three thrust areas of the section. Much of the R&D has direct synergy with future INFN programs. Several outstanding examples are the detector and accelerator R&D for the Super-B project, R&D on new detectors for future astroparticle physics initiatives in CSN-2, and accelerator and detector R&D supporting activities in CSN-3. However, there is also R&D that is focused on technologies that can be applied well outside of the INFN mission such as for applications in medicine, archaeology, cultural heritage, environment and nuclear energy.

CSN5 has an excellent track record of scientific and technological achievements. Some of the relevant and successful projects have been discussed in our earlier reports. In the following, we would like to mention a few examples of recent projects that have the high potential to benefit major INFN scientific programs as well as R&D that benefit society.

Accelerator-related are IMCA (Innovative Materials and Coatings for Accelerators) and HELIOS. HELIOS, a pan-European project to improve beam brightness of next generation ion sources, has made significant progress in the understanding of the fundamental process of plasma heating by RF and the influence of different ion-source parameters. The results are very encouraging as potentially higher currents of multiply charged ions may be produced by Electron Cyclotron Resonance Ion Sources (ECRIS) benefitting many labs worldwide and hadron-therapy facilities that use heavy-ion beams.

Projects to develop detectors, electronic devices and software and hardware facilities have been initiated and/or made progress in the last year (e.g. ORIONE, XDXL, and VIPIX). ORIONE has the aim of synthesizing and characterizing polysiloxane organic scintillators, which are promising for detection of fast and thermal neutrons in harsh environments. They could be widely used in experimental setups as well as for various applications outside the realm of physics. The XDXL project, aiming to improve the performance of large-area silicon drift detectors, achieved surprisingly excellent results that it became at the basis of various proposals and was selected by ESA for further study.

Medical imaging is pursued by different groups within CSN5 using novel technologies and methods such as proton computed tomography in the framework of the PRIMA project and diagnostic radiology with tunable monochromatic X-ray beams. Both are excellent techniques for high-resolution imaging and are very promising for cancer-treatment planning.

With the eye on the future, CSN5 unfolded, together with CSN1, CSN2, CSN3 and INFN-NTA, a strategy to work on different projects benefitting the future scientific programs pursued by these sections. Some of the remarkable items include R&D on accelerator components and detectors for Super-B, and laser plasma acceleration including plasma acceleration of protons for use in medical applications.

The research funds in CSN-5 are awarded on the basis of peer reviewed proposals and typically the awards are for 2-3 years. Given the tight fiscal constraints developing within INFN and the critical importance of this R&D to INFNs future, we have several suggestions in case the section is faced with the need to make increasingly difficult prioritizations in the coming years.

Much of the R&D in section 5 is driven bottom up by the individual investigators with exciting new ideas. This must always be encouraged as fundamentally this will always be the best source for innovation. However, INFN might want to consider some top down strategic direction to focus the R&D efforts, specifically giving more resources in certain areas of R&D most relevant to INFN future directions. The breadth of the CSN5 R&D efforts is quite staggering and it is hard to imagine that significant successful efforts can blossom in so many diverse areas in times of very constrained funding.

We also suggest that it might be valuable to have an internal process developed to define and measure the success (or failure) of the individual R&D investments. One clear measure of success would be the fraction of R&D investments leading to new detectors that then are deployed in new projects by INFN, or that research results find direct applications to societal issues or in industry. However, we believe it should also be considered a success if INFN R&D results in new technologies deployed in non-INFN projects in the international community. Another suggestion is to ensure that in areas of R&D that are outside the direct mission of INFN, such as medical applications, there be some process to ensure that the R&D is focused on solving a problem that the external customer actually needs solved. Finally, we encourage INFN to utilize strategies to develop and exploit the intellectual property associated with the R&D that they are doing. In this respect, a clear policy on patents should also be worked out to define INFNs intellectual rights when cooperating with industries on research projects, and/or when certain INFN inventions find direct commercialization by industry.

While these suggestions may be too specific we encourage INFN management to think along these lines and articulate whatever investment strategy that they feel will best serve their mission. We also encourage them to be bold in taking decisions on high-potential but risky research. The existence of metrics, for example, should not result in a risk adverse R&D investment strategy. It should always be acknowledged up front that the investments in CSN-5 are high risk, high reward in nature!

8 Technology Transfer

The 2011 report on the INFN Scientific Productivity and its Socio-Economic and Inter-disciplinary Impact rightly opens mentioning that ten years after the launch of the Lisbon Strategy, the European Union is facing a global economic crisis requiring the adoption of extraordinary measures. The commitment for Europe to become the most dynamic and competitive knowledge economy in the world implied that EU countries were asked to increase their investment in research up to about 3% of their GDP: unfortunately this has not happened throughout the continent.

In our report last year we had noticed that INFN had shown the right sensitivity by working out a more accurate Technology Transfer (TT) policy. Since mid 2009 a specific Committee made up of 15 people with different experiences had been set up with the aim to prepare rules for collaboration and TT with industries and Institutions (including an appropriate patent strategy) and rules for starting spinoff companies for INFN staff. The set of rules had been finalised and we were presented with some interesting examples of their applications. Therefore, this year we were quite disappointed not to see any detailed follow up in the report. We know that INFN has developed a strategy towards a more efficient TT policy, but we lack any quantitative information on the impact and the results of this policy. As a result, the CVI expresses its difficulty in providing an accurate judgment of the INFN Technology Transfer activities in 2010. The section on the purely scientific production is well documented in terms of publications, citations and impact factors but contains little information on patents and results applicable to industry.

The CVI wishes to have a detailed presentation on this issue in its next meeting. It underlines the necessity to integrate in the report detailed information on the results of applications, patents, partnerships with enterprises and any other technology transfer activities carried out by INFN. Furthermore, it recommends to dedicate more attention to TT activities and to partnerships with Italian and international industries both in the research and education activities. Some simple steps to improve Technology Transfer activities, as well as the information concerning them, could be:

-To draw a map of INFNs infrastructures and competences that could be used as a base to develop partnerships with enterprises.

-To develop partnerships with industrial associations (Confindustria for example) for the purpose of promoting partnerships with enterprises in research and education activities.

-To better organise the TT part of the web site with updated data.

9 Budgetary issues and human resources management

9.1 Budget

In the last nine years, INFN's budget decreased of about 15% in real terms. Given that an important part of the budget is allocated to fixed costs for personnel, the reduction of the share of budget available for research project is even more pronounced, reaching a total of 324 million euros between 2001 and 2009. Moreover, in the last year, the share of budget assigned on performance basis was not transferred by the Ministry to INFN. It is still not clear whether the payment has been postponed to the next year, or this will be a permanent budget cut. In the first case, INFNs budget would stay in the coming two years 2012-2013 on a figure of around 270 M. The CVI expresses its worries in two respects. First, INFN already faced a severe budget cut. Had it to suffer new cuts, this would put the Institute in an emergency situation, so to cut important research programs. The second issue is the uncertainty the Institute is facing, that makes difficult to put up rational programs of adjustment. CVI understands the problems that Italian public finances are currently facing. Were budgetary restrictions unavoidable, it would be important at least to design them rationally and give the Institute the time and a sure budgetary frame under which to act, given the very long time-horizon for research in Nuclear and Particle Physics. On the other side CVI suggests also some measures to improve the planning procedures of INFN. CSNs have to learn how to act strategically in order to guide selective options. Currently this happens only in few cases: in general research plans seem to be driven by the curiosity of research groups that apply for funds. This is a traditional approach, that encourages exploration. But, in front of severe budget cuts, this attitude should be balanced by a more directive approach, aimed at defining and reinforcing the strengths of each Committee. We would like to see the CSNs present, in future, not simply a list, but a strategy of research, based on the competences they have and making use of a clear analysis of strengths and weaknesses. In case of further budgetary cuts, this would guide the reallocation more rationally than just haircutting. The same strategic attitude should be adopted also for budgetary decisions taken by central bodies of INFN. History based budgeting can be highly inefficient, especially when funds are decreasing. Allocations based on performance (scientific results, timing of projects) can provide incentives to the Committees to reach the goals stated by the National bodies of the Institute. We invite the President and the Giunta to make an effort of defining priorities, and designing an incentive based method of budget allocation aimed at aligning the programme of each CSN to the general goals of the Institute. The Direction has already implemented a sophisticated system of performance measurement, so it should not be very difficult to use it for budgetary management, once the goals are clearly stated. A final suggestion is about the necessity to present a multi-year plan for the renewal of laboratories. Plant and machinery renewal has to be carefully planned, and enter year by year in the budget of the Institute. Otherwise, the risk is that, when facing budgetary cuts, renewals are postponed and laboratories become obsolete and no more attractive.

9.2 Human resources

Human resource management faces similar problems. On one side, the CVI has highly appreciated the new regulation for personnel and the introduction of a carrier track policy: this can be highly beneficial for human resource management, as it has proved effective in several research Institutions. On the other side, the CVI is extremely worried about the ageing of researchers and its impact on productivity. From the figures presented, we were informed that in five years, between 2003 and 2008, the modal age of researchers increased by five years, from 40-44, to 45-49. At the same time, the negative relationship between age and research productivity is a well established fact, and is confirmed also in INFN. Ageing researchers should be devoted to management and research organisation tasks, while junior researchers have to breed new ideas.

This has important implications. One is that, given the uneven age distribution of researchers, keeping fixed the number of personnel, just replacing retirements with a nil net turnover, would imply ageing and, by consequence, a slowdown of scientific productivity. A good practice would be to hire new people at a constant rate, targeting a long term equilibrium. The consequence would be a positive turnover in the next 10 years, and a negative one in the future. This is clearly incompatible with budgetary limits imposed by the Italian Government. It must be added that the Government imposed even stricter limits to turnover: at present only 20% of people leaving for retirement can be replaced. This puts the Institute in a very delicate position, that can jeopardise the huge capital of competences and reputation accumulated by INFN. We urge the Ministry to consider carefully the risks of this policy: it would be better to target a lower long term personnel equilibrium and act accordingly with a plan of hiring junior researchers (through the career track programme designed by the new regulation), than simply postpone the replacement of retirements. A last remark is devoted to gender issues. Despite the gender policies activated by the Institute, the ratio of women over the total working force is low, particularly among researchers. Some member of the CVI noted that such low figures are customary among research Institutes in physics, even in countries less gender discriminating than Italy. On the other hand, however, the number of women who obtained their PhD at INFN is higher than that of men. This can be a hint pointing to real career obstacles for women. The CVI, while appreciating gender policies put in action by INFN and the comparatively good figures presented, asks to carefully evaluate the efficacy of those policies. The present system of entry with temporary contracts can lead to discrimination if it does not take into account the average age of maternity. The new personnel regulation, and the career track system, should protect female workers against this risk implicit in the use of temporary contracts.

10 General conclusions and Acknowledgements

All CVI panel members who participated in our meeting last October, unanimously declare that our visit to Legnaro was a most instructive and enjoyable experience. We learnt about new and exciting projects and we had the pleasure to see many scientifically interesting new results. INFN is a research Institution of the highest quality and we can only wish it is given the means to continue its road of success. We acknowledge a fruitful collaboration with Professor Roberto Petronzio during all the years he served as President of

the Institute and we praise his leadership, often through difficult conditions. We welcome Professor Fernando Ferroni as the new President and we wish him a most successful term. We would like to ask them to transmit to all the personnel our appreciation for the work done. We would also like to thank them together with the members of the Executive Board, the chairpersons of the scientific sections and the Direction of LNL for organising such a successful meeting as well as for the warm hospitality extended to us.