INFN CVI Report 2010

Conclusions of the CVI Meeting on 11-13 October 2010

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Members of the CVI Panel:

P. Drell, SLAC, USA
E. Fernandez, IFAE, Spain
B. Ferrario, SAES Getters S.p.A., Italy
A. Frey, University of Göttingen, Germany
F. Iachello, Yale University, USA
J. Iliopoulos, LPTENS, Paris, France (Chair)

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1 Excutive Summary

This year the CVI had its annual meeting in the *Laboratori Nazionali del Sud* (LNS), in Catania. Although, as usual, the main purpose of the meeting was the evaluation of the entire spectrum of INFN performances, scientific, technical and educational, including their socio-economical impact, the visit to Catania allowed us to obtain first hand information on the activities of LNS.

Before the meeting we had received a complete report on the *INFN Scientific Productivity and its Socio-Economic and Inter-Disciplinary Impact* which offered a valuable picture of the entire profile of the Institute. We had a detailed presentation on the scientific program of the LNS followed by a visit of the facilities. The INFN President presented a report on the scientific and technical activities, as well as the questions related to the resources (financial and personnel). We heard comprehensive presentations covering each one of the five sections and a specialised one on the socio-economical impact.

This year is marked by the long awaited first results from LHC. The accelerator is working according to schedule and the detectors perform beautifully. We have been through a series of lean years and we rejoice to the idea that exciting new physics lie ahead.

Based on all this material, as well as the personal expertise of the panel members which covers most of INFN activities, we came to the conclusion that as an institution **INFN 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 leading position is exemplified by the fact that this year the spokespersons of all four major experiments at the LHC come from Italy. In spite of the difficult situation of the institute as regards its financial and human resources, the scientific program is rich and diverse with many important experiments presenting their final results, running or being prepared. The role of the Institute in the Italian educational system remains very strong with an excellent training program for young scientists, complemented by a truly remarkable activity in the domain of dissemination of scientific culture among the general public.

The effort for technology transfer, as well as for scientific and technical collaborations with other institutions and industries, has been pursued, with notable success in several applied fields such as medicine, computing, or cultural heritage. This social impact is further strengthened by INFN's role in the creation of hi-tech industries in the most advanced technological domains. The CVI fully approves the recent policy of the Institute to support the presence of INFN scientists in these industries. All CVI panel members unanimously expressed their appreciation for the scientific and technical achievements of the Institute.

The uncertainty we noticed last year over the financing of some very large, or large, projects whose cost exceeds the INFN regular budget, remains unsolved. The main very large project is the design, construction and operation of a collider dedicated to the study of the B-$\bar{B}$ system. Among the large projects, one which is particularly important for LNS, is the future of the underwater neutrino observatory. These projects are technically very challenging and scientifically very exciting. The CVI encourages the President to continue seeking National and Regional funds. Obtaining these funds will provide a strong incentive to attract other international partners.

The President presented the difficult situation of the Institute related to financial and human resources. **The CVI believes that the situation has reached a critical level**, in spite of the efforts by the management to optimise their use. It puts severe strain on existing and future programs and may jeopardise Italy's position in the field internationally. Indeed, in some other countries research budgets have been increased. **In particular, the absence of promising career opportunities in the Italian University and Research systems, has resulted during the last years in a severe brain drain with many among the brightest young scientists leaving the country.** Unless significant new resources become soon available, the INFN Direction may loose the capabilities of launching new initiatives. **The CVI strongly supports the President in his efforts to recover the budget the Institute lost over recent years.**

The CVI welcomes the decision of the Ministry to conduct an in-depth five-year evaluation of all research Institutions (V.Q.R.) and believes that INFN will rank among the very best Institutions of the country. However, we want to point out that the rules which are supposed to govern this evaluation are ill-adapted to an Institute with such a broad spectrum of activities, often taking place inside large international collaborations, and we wish to strongly urge the authorities to adopt a more flexible approach. Concerning the new rules of governance issued by the Ministry, the CVI considers as very positive the fact that the procedure for the designation of the President, which has

always been based on scientific grounds, is now explicitly recognised and guaranteed. Furthermore it believes that the changes concerning the governance of the Institute could lead to a more efficient day-to-day administration while, simultaneously, allowing for a better definition of long term strategic policy. The CVI urges the Direction to use these new rules to improve performance in both aspects.

In conclusion, the CVI expresses its appreciation to the President and the Members of the Executive Board for their leadership during the recent years which allowed the Institute to maintain its outstanding contribution to science under difficult conditions. They deserve the gratitude of the international scientific community.

2 INFN ACHIEVEMENTS AND PERSPECTIVES

The broad picture of the present status of INFN and its future perspectives were presented to the CVI panel both in the GLV comprehensive report, which was available prior to the meeting, and the presentation by the President. The activities of the five scientific sections as well as the overall socio-economic impact of the Institute were the subjects of specialised talks and will be reviewed below.

The general picture is one of prolific activity combined with scientific excellence. All sections remain at the frontier of modern research. Italy's international position is very strong inside the large collaborations. Italian teams have played a leading role in the preparation of the LHC experiments and this can be testified by the fact that, at this moment, all four major LHC collaborations are led by Italian physicists. At the end of the first year's run the quality of the data and the excellent performance of the detectors give us confidence that important discoveries lie ahead. The INFN teams appear to be ready to participate in this exciting adventure. The same is true for their contribution in running experiments at Fermilab as well as experiments in neutrino, astroparticle, or nuclear physics. A highlight of the neutrino run in Gran Sasso is the first candidate of a tau production, thus confirming the existence of a ν_μ–ν_τ oscillation. The INFN supported research in theoretical physics is at an equally high level. Future projects are challenging and cover an impressive range of topics, from particle accelerators to underwater neutrino observatories and space based gravitational wave antennas.

The Institute's very large project remains the construction of a high intensity electron-positron collider dedicated to the study of the B-$\bar{B}$ system, the Super-B facility. The scientific interest of the project was reviewed in our last year's report. The new elements are the progress towards a complete technical design report as well as the establishment of a first international collaboration around the project. A Memorandum of Understanding has been signed with the United States, France, Russia and Canada. On the other hand, a firm decision on its finance is still pending. The CVI re-iterates the encouragement we expressed last year to the President in his efforts to secure outside funds, since the cost of the project far exceeds the Institute's regular budget.

A large project, whose outcome will influence the future orientation of LNS, is

the underwater neutrino detector, known as KM3. Several Mediterranean sites are in competition for the eventual construction, among which a prominent one is in Sicily. During our visit we were impressed by the progress made by the experimental teams in developing robot systems for deep sea installations. If realised here, the operation of the detector will be ensured by LNS and the INFN Sezione di Catania. A decision on the technology which will be adopted is expected to be made next year, but already, based on the lessons learnt by the operation of a competitor project Amanda and Ice Cube, we know that a volume as large as possible is essential. This, together with the fact that a large part of the finance will probably be regional, implies that a multi-site choice should not be *a priori* excluded.

The President informed the CVI that the elaboration of the INFN long-term strategic policy, which is under way, will incorporate all possible decisions for the funding of these large projects.

In our report last year we included a figure showing the evolution of the Institute budget over the past years. We had already pointed out that the financial situation was critical. We present here a similar graph showing the loss of budget in real terms, *i.e.* at constant 2009 prices. No improvement is in sight.

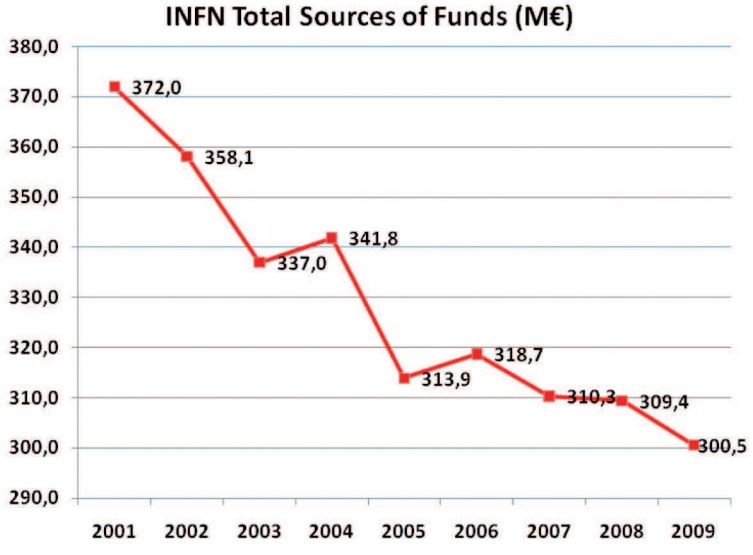

Figure 1: The nine-year trend of total sources of funds managed by INFN adjusted to 2009 constant prices applying the Italian official rate of inflation. It reflects an actual budget decrease of 19.2%.

The consequences of this policy are already visible. In the section regarding theoretical physics we shall comment on the decision not to invest on a state of the art computational tool for performing lattice simulations of quantum chromodynamics. INFN was among the pioneers in this field and for many years Italian teams were playing a leading role. This leadership is now declining and it will soon be lost. Without any drastic steps to reverse the present trend of diminishing budget this decline will soon be felt in the experimental programs. Scientifically important projects will have to be abandoned, or substantially reduced. This will be tragic for Italian physics but also for science in general. It comes in a particularly critical moment when long term investments in technology and infrastructure are starting to produce exciting results. The Italian teams will suffer a serious handicap in the international competition to harvest and exploit these results. The situation in the human resources front is equally worrisome. The lack of positions resulting from the Government policy to reduce the public sector has given rise to a severe brain drain with a significant number of very talented and well trained young Italian physicists leaving the country to find permanent positions abroad. Although this is highly beneficial to foreign Universities and Research Centres, it will become detrimental to the Italian institutions for which the renewal of generations will be only partially fulfilled. No efforts should be spared to convince the Government to ease the application of these hiring restrictions to both the research and the University sectors. During the last years the CVI has repeatedly warned against all these severe budget and personnel restrictions in INFN, but this time we believe we are facing a red alert.

Two years ago we initiated a series of visits to the National Laboratories with the purpose of getting a first hand evidence of the work done there, but also of the specific problems each one is facing. This year our meeting took place at the Laboratori Nazionali del Sud which has a rich and diversified research program ranging from fundamental nuclear physics to applications in radiotherapy. Particularly impressive was the R & D performed in preparation of the underwater neutrino detector. A decision concerning the future of this project will directly impact on the medium and long term development of the laboratory.

A new element in this year's meeting resulted from the government decision to switch from a three year to a five year evaluation plan. All research institutions are required to supply the elements which will allow an in depth evaluation of their activities for the last five years. The CVI approves this plan which is closer to the system applied to other countries. We were presented with a summary of the elements INFN intends

to supply and we are confident that the Institute will rank among the best in the country, given its outstanding international record. We notice however that the rules issued by the Ministry are more applicable to institutions in which research is thematically well defined and performed by small, or even individual, teams. For them indicators such as the number of publications divided by the number of authors may provide meaningful information. They loose all significance for INFN which has a very large spectrum of activities and whose teams are often engaged in large international collaborations including hundreds, and even thousands, of researchers. The CVI strongly urges a more flexible approach, more in line with international practice, in which each discipline is evaluated with criteria adapted to its own activity.

We had noticed already last year that the INFN Direction had initiated a series of measures aiming at a more efficient governing structure. Several new elements appeared this year. The most important concerns the regulations which determine the relations with the Ministry. If the Institute has been so successful in the international scientific scene over many decades, this is due, in particular, to the fact that its successive Presidents were chosen on the basis of their scientific merits and, together with the governing board, they were free to determine the scientific policy of the Institute. Strange as it may sound, this independence was only an established tradition. The CVI notices with satisfaction that, with the new regulations, this sound practice is explicitly recognised and guaranteed. At the same time these new regulations bring some changes in the administration which could lead to an increased efficiency. All research institutions are facing new and difficult challenges, both because of scientific and technical evolutions, but also because they operate in an increasingly complex international environment and have to relay more and more on a diversified profile of financial support. These conditions will make future strategic decisions even more complex. The CVI urges the INFN Direction to use these new rules in order to be better prepared for the difficult strategic decisions it will soon have to make.

As with previous years, the GLV report contained an important section on the socio-economic impact of the Institute as well as its educational role. The CVI judges the performance of the Institute in both these areas excellent. The initiatives aiming at a strengthening of the INFN-Industry relations should be pursued, although they drain manpower at a moment when the resources are limited. Another example of the negative impact of the budget and personnel restrictions on the ability of the Institute to launch novel and ambitious projects. The CVI had several times the occasion to congratulate INFN on its very successful educational policy. We have noticed that the

Italian School of high energy and nuclear physics, both theoretical and experimental, is one of the best in the world. This time we cannot help thinking that, due again to the scarcity of new positions, this considerable effort profits more and more foreign Universities.

3 CSN1: EXPERIMENTAL PARTICLE PHYSICS WITH ACCELERATORS

The major event of the past year for CSN1 was clearly the successful restart of the LHC at CERN. CSN1 holds the largest budget of the INFN research lines (about 40 %), and within CSN1 the majority of researchers (ca. 65%) and budget (ca. 70%) are devoted to experimentation at the LHC, comprising ATLAS, CMS, LHCb as well as the dedicated forward experimentation with Totem and LHCf. The collaborations have made the best possible use of the unfortunate delay using cosmic rays to reach a truly impressive detector understanding and excellent detector efficiencies. Given this performance it is seriously envisaged to continue running during 2012 at an energy as high as 4.5 TeV per beam and delay for a year the shutdown which will allow to reach the design value of 7 TeV. A decision on this issue is expected to be made early next year. First results have already been presented, with of course much more to come in the next years.

The Grid centres (Tier-1 and Tier-2) are ready to handle the enormous amount of data collected at the LHC. The Italian Tier-1 centre at CNAF is second only to CERN in reliability with an impressive 98%, a major achievement. INFN physicists hold many leadership positions in all four big LHC experiments. This is strongly underlined by the fact that three spokespersons are from INFN and the fourth is of Italian education. In addition, a significant number of physics group convenors and subdetector responsibles are associated to INFN, clearly showing the high skills of the researchers and also the appreciation by the collaborations of the outstanding Italian contribution to the detector hardware and commissioning. This is reflected also by the many plenary talks at important international conferences awarded to INFN physicists.

The Tevatron at Fermilab is still collecting data. With foreseen potential run extension a discovery or exclusion of a light Higgs as predicted from electroweak fits is within reach (and difficult for the LHC). The continued strong engagement of INFN in CDF ensures participation in any possible discovery. In addition, the expertise in the newest analysis techniques in hadron collisions gained at the Tevatron will certainly help the analyses at LHC and strengthen Italy's contribution to new physics results.

BaBar and ZEUS, albeit no longer taking data, are still publishing final analyses,

an effort that will and should continue for a few more years in order to fully exploit the valuable data.

Flavour physics is traditionally strongly supported by the Italian physics community with significant participation in BaBar, CDF and LHCb for B-physics as well as NA62 and KLOE at the DAPHNE accelerator at LNF for Kaon physics.

The flagship future project at the high intensity frontier is the Super-B facility. The ingenious techniques developed at Frascati for an accelerator delivering 100 times the luminosity of the first generation B-factories are truly outstanding. The superb skills of the INFN accelerator researchers have yet again been proven by the successful upgrade of the DAPHNE facility, strengthening further the case of Super-B at Frascati. A project as large as Super-B requires obviously strong international participation. The CVI applauds the INFN management for setting up the framework of such a collaboration with MoUs already signed with the US, France, Russia and Canada. Technical Design Reports for the machine and detector have been published recently. The project is very rightly at the top of the Italian government's scientific roadmap and the CVI hopes the government will take a timely decision, as its outcome will greatly influence all future planning, not only within CSN1, but also in the entire Institute. INFN's participation in the MEG experiment at PSI and the Compass experiment at CERN continued. MEG has already shown intriguing first results. The Compass collaboration presented a proposal for a second run (Compass II) which is currently under evaluation. Specific expertise of a few researchers allowed new participation to BESIII at Bejing, P-Mu2e at Fermilab and the R&D project UA9, which complete the attractive CSN1 program.

Possible new discoveries at the LHC and/or Tevatron may well change the physics landscape in the next few years and it is essential to prepare for various scenarios in terms of instrumentation. INFN has a well deserved excellent reputation in this area. The CVI welcomes the activities being started on R&D for the planned LHC upgrade in the tracking and trigger area as well as the more generic R&D on radiation hard devices (e.g. power supplies) and new silicon detectors that not only have potential applications at a future linear collider and Super-B, but are also relevant for technology transfer (e.g. medical or space applications).

In conclusion, CSN1 has a strong and attractive experimental program. The main focus is now on the physics at LHC where after many years of preparation finally the harvest can begin. INFN physicists have a major impact in the collaborations.

There are two significant issues that CSN1 needs to face in the coming period.

First, to maintain the very strong position that the programs currently have, it is of paramount importance that attractive career positions be available to the outstanding young researchers in this field in Italy. Without clear career paths, they will either choose to leave the country (brain drain) or the field will no longer continue to attract the best young research talent. The very stringent current hiring atmosphere has the potential to do significant damage to this research area where INFN has traditionally been a world leader. Additional damage is being done by the recently reduced travel budgets in 2010, now that the LHC is in full swing and presence at CERN is very important.

The second issue that CSN1 must prepare to face is that, while for the near future, INFN is well positioned with its participation in the LHC upgrade, KLOE at the improved DAPHNE and the construction of NA62 under way, the longer term plans depend critically on the decision about the Super-B project. In the next year the Super-B situation is expected to be clarified and CSN1 should initiate a strategic planning study to address the plans and needs for the coming decade in order to maintain a strong and vital program through a period of significant change.

4

CSN2 : ASTROPARTICLE PHYSICS

The activities in CSN2 are grouped into the six sectors described below. The budget is the second largest of the five INFN Research Lines, after that of Sub-nuclear Physics. The INFN has the worldwide leadership in some of the fields in this area owing in part to the existence of the Gran Sasso National Laboratory (LNGS), the largest in the world for non-accelerator particle and nuclear physics. For this same reason, some of the experiments taking place in Italy have a significant international participation.

As noted in the 2009 report, most of the experiments in this area are in the phase of full exploitation, producing very significant results, and they deserve full support. The next steps for many of these areas of science will require large multinational projects and planning for the future should take place in the international context. INFN is well positioned to play a leadership role in future large scale experiments. It would be appropriate to begin exploring the possibilities and discussing which areas are the best targets for investment scientifically and technically. In what follows we comment on some specific aspects of the many experiments included in the six sectors, and make some final remarks.

1. Neutrino Physics: neutrino physics (21.2% of the CSN2 budget) includes the accelerator-based CNGS (CERN to Gran Sasso) experiments OPERA and ICARUS-T600 and participation in the long baseline experiment T2K in Japan. During the last year OPERA has seen the first tau-neutrino event in the analysis of a fraction of the collected data. ICARUS-T600 and T2K have both started taking data also within the last year. The BOREX (formerly BOREXINO) experiment has been running since 2007 and has recently published results on the detection of a clear geo-neutrino signal, consistent with the hypothesis that the intrinsic heat production from the Earth is of radiogenic origin. The last year has indeed been very successful in this sector.

2. Search for Rare Processes: Three main areas of research are being pursued in this sector (19.2% of the budget):

(a) Neutrinoless Double Beta Decay.

This area includes the CUORE (consisting of about 100 cryogenic Tellurium oxide bolometers) and GERDA (enriched Germanium crystals inside a Liquid Argon bath) experiments both at the LNGS. These are leading experiments in the field and have a large international participation. The US participation in CUORE was approved last year and the GERDA cryostat has been cooled at the end of 2009. GERDA is now being commissioned. Both will be able to probe the region of the claimed signal from the Heidelberg-Moscow collaboration and lower the limit on the Majorana neutrino mass if the above result does not hold.

(b) Direct Dark Matter Searches. These experiments try to observe nuclear recoils induced by the interaction of dark matter particles with the target material.

The DAMA/LIBRA experiment (using ultra-low background NaI scintillators), led by INFN scientists, has continued running and the results confirm the positive effect of an annual modulation. New photomultipliers will be installed at the end of this year, with the goal of improving the sensitivity below the present energy threshold.

The commissioning of the WARP-100 (100 litres, double phase, liquid and gas, Argon TPC) has been delayed. The Xenon-100, which uses liquid Xe instead of liquid Ar, has been commissioned and had presented measurements of a short run, showing great promise, as it has obtained the lowest background of all the direct dark matter search experiments. Plans for a Xenon-1ton exist and the Gran Sasso laboratory will be willing to host that experiment, with INFN participation.

(c) Search for Supernova Neutrinos. The LVD detector at LNGS has been in stable operation for years integrated into the Supernova alert system.

3. Cosmic Rays (ground and underwater): This sector (21.6% of the budget) comprises the study of cosmic neutrinos with underwater telescopes and the study of gamma and charged cosmic rays with ground detectors.

INFN participates in AUGER, completed at the end of 2008 and taking data since then. The experiment has confirmed the GZK cut-off but the significance of extreme high energy sources has somewhat weakened since early indications. The ARGO-YBJ experiment in Tibet (INFN-Chinese Academy of Science collaboration) is also taking data and has observed anisotropies in the charged cosmic ray flux at intermediate (median 10 TeV) and low (median 2 TeV) energies.

MAGIC (at La Palma, Canary Islands) is now operating two Air Cherenkov Telescopes (17m diameter each) in stereo mode and is producing many results.

INFN participates in the ANTARES underwater neutrino telescope, which has

been taking data with 12 strings off the French cost near Toulon, and has detected atmospheric neutrinos. R&D on KM3 has also continued at LNS. A mechanical model of a tower has been deployed near Capo Passero, and equipment at 4000m near Catania is being monitored. This work is done in coordination with the KM3NET collaboration funded by the EU.

4. Cosmic Rays in Space:

This sector (14.9% of the budget) includes the Fermi, PAMELA and AMS-2 projects.

The Fermi satellite has now been operating very successfully for two years. The collaboration has more than 100 publications including many source discoveries. The spectrum of electrons plus positrons has been measured from 20 GeV to 1 TeV. These data are compatible with the PAMELA result (see below) but they are not with the claimed excess of positrons around 600 GeV seen by ATIC.

The PAMELA satellite has found that the ratio of positrons to electrons increases with energy from about 10 GeV to 90 GeV (the maximum energy with significant statistics), which is unexpected. The experiment has operated for 3 years and has been extended for an additional two years.

The AMS-2 is a magnetic spectrometer planned for the Space Station, to search for antimatter and dark matter and for CR studies. After tests at the ESA-ESTEC laboratory a decision was taken to run with the conventional magnet used in AMS-1. The experiment has left CERN for the Kennedy Space Centre this summer and will be launched with the last Space Shuttle flight planned for next January.

5. Gravitational Waves:

In this sector (12% of the budget), Italy hosts the VIRGO interferometer located near Pisa, operated by a French-Italian collaboration. VIRGO has reached the design sensitivity with the VIRGO+ upgrade. The Advanced Virgo upgrade has been approved with the goal of improving the sensitivity by another factor of 10. The upgrade will take from the summer of 2011 to 2014, during which the INFN will operate two of the three cryogenic bars, named Auriga and Nautilus, that were operated in the past.

The INFN is also involved in the LISA-Pathfinder (launch planned for 2011), with the aim of testing the feasibility of the future LISA project.

6. General physics:

This sector (1.9% of the budget) includes a number of small experiments, focusing

on fundamental physics. PVLAS eliminated the spurious signal that mimicked an axion-like effect, and is now building a more sensitive detector. MAGIA and MICRA aim at measuring the gravitational constant while MIR will try to measure the dynamic Casimir effect.

In conclusion, the INFN has maintained a very competitive program in the field of astroparticle physics, gravitational waves and neutrinos. Several major first generation experiments are now producing results, obtaining the scientific return of a long-term investment in the field.

Some of the experiments have a natural continuation in second-generation detectors. Major possible future projects that can be envisioned are KM3 or a large Liquid Argon detector at the LNGS but it is too early to decide on a major future program at present.

5

CSN3: EXPERIMENTAL NUCLEAR PHYSICS

During the period covered by this evaluation, July 2009-September 2010, several major events have occurred and milestones reached in the experimental nuclear physics program (CSN3) of INFN.

In line 2, Phase transitions in nuclear matter, the ALICE Collaboration, took data for p-p collisions from 900 GeV to 7 TeV, producing with the 900 GeV data the first LHC physics paper, November 28, 2009, a major milestone for LHC. The data taken were sufficient to measure the charged multiplicities as a function of rapidity, and they were published in an article in the Euro-physics Journal in January 2010. This paper and few others in print also in Physical Review Letters are landmarks for future experiments with heavy-ions, in particular, Pb-Pb collisions planned for November 2010. Also Tier-1 of the ALICE GRID in Italy is fully operative and Tier-2 is proceeding. The INFN sites provide 20% of the total computing and data analysis of ALICE.

In line 3, Nuclear structure and reaction mechanisms, the AGATA Demonstrator Detector, a smaller version of the full AGATA detector, was completed at LNL, inaugurated May 9, 2010, and a measurement campaign with Tandem-ALPI accelerator complex was started at LNL. The AGATA demonstrator is part of a European project and will remain at LNL until the end of 2011, will be at FRS at GSI in Germany for a period of 18-24 months, and eventually after that will move to SPIRAL2 at GANIL in France. The excellent energy resolution and high counting rate capability of this detector will allow a deeper study of nuclear properties. Also, plans for the construction of the SPES ISOL facility at LNL have proceeded. Several companies bid for the construction of the cyclotron and the competition was won by a Canadian company with connections with TRIUMF. The cyclotron is expected to be delivered in 2013/14 and will form the first component of the SPES facility. Bids for the construction of the building that will host the cyclotron are expected to be requested within the end of 2010.

In line 1, Quarks and hadron dynamics, the upgrade of JLAB in the USA to 12GeV was approved and detector development started. INFN is contributing to the upgrade of the CLAS spectrometer including new parts such as the forward tracker based on a scintillation barrel.

In addition to these major events, the research program in all areas has continued. Some highlights are:

Line 1. Quarks and hadron dynamics.

The HERMES experiment at DESY is now definitely concluded and data analysed. The experiment of untangling the various contributions to the spin of the nucleon is being continued at JLAB12, with the result that the orbital contribution appears to be large. The new data taken at JLAB in three months have a statistics ten times higher than the data taken at HERMES in six years. The MAMBO experiment in Germany is studying baryonic and mesonic resonances. Hypernuclei and kaonic atoms have been studied in the SIDDHARTA and FINUDA experiments at LNF. R&D for PANDA and PAX at FAIR at GSI has proceeded. These detectors will take advantage of the unprecedented quality of the antiproton beam at the HESR ring of FAIR to study a variety of problems, among which the time-like form factor of the proton.

Line 2. Phase transitions in nuclear matter.

As mentioned above the highlights here are the delivery of a 3.5 TeV proton beam at CERN-LHC and related measurements. Noteworthy is the measurement of the invariant $\mu^+\mu^-$ mass spectrum in the region of the J/Ψ. The invariant mass resolution appears to be close to the design value.

Line 3. Nuclear structure and dynamics.

This line of research has been pursued both at LNL (GAMMA-PRISMA-EXOTIC-NUCLEX) where heavy ion beams with energies in the range 5-10 MeV/u have been delivered, and at LNS (MAGNEX-LNS-STREAM-FRIBS-EXOCHIM) with beams in the range of 50 MeV/u. The research has concentrated on the study of nuclear structure, with measurements of life-times of nuclear states with PRISMA-CLARA at LNL, and of nuclear reactions, with measurements of the isospin dependence of the nuclear equation of state with EXOCHIM-CHIMERA at LNS. Also, INFN has participated in experiments at GSI with the array RISING to study gamma and beta decays in heavy nuclei in connection with the r-process of nucleosynthesis.

Line 4. Nuclear astrophysics and interdisciplinary research.

The program of this line has two areas of research, the study of nuclear reactions for astrophysical applications and the study of the neutron capture process for applications to energy generation. In the first area, highlights are the study of the $^{15}N(p,\gamma)^{16}O$ reaction (LUNA at LNGS), and the study of the $^{18}O(p,\alpha)^{15}N$ reaction (ASFIN at LNS) at energies around the Gamow peak. In the second area, the highlights are the measurements of neutron capture cross sections (n_TOF at CERN), in particular

^{240}Pu(n,γ) and ^{237}Np(n,F). These are important both for astrophysical applications and for emerging nuclear technologies. Line 4 has also plans for an upgrade to a 4 MeV accelerator, LUNA-2, and would benefit considerably from a decision on the location of this accelerator, LNGS or other.

In conclusion, the INFN program for CNS3 has received a major boost in 2009-2010 with the first data taken at CERN-ALICE (line 2) and the completion of the AGATA demonstrator at LNL (line 3). The program is very much in line with the NuPECC Long Range Plan 2010 and with its recommendations. The quality of the research is excellent and often leading in Europe.

Progress toward developing a second generation mid-size radioactive beam facility at LNL (SPES project) has been made, but this progress should be accelerated if the facility would have to find a niche of research in the European context, before the large scale facilities SPIRAL2 at GANIL and FAIR at GSI will become fully operative.

The goal of developing a program for two of the other laboratories, LNS (line 3) and LNF (line 1), is still on hold, waiting for a decision on the projects NEMO at LNS (CSN2) and Super-B at LNF (CSN1). Once the situation with these two projects becomes clear, INFN will be in a position to address the question of the future of the two laboratories. Their development is necessary to maintain the role that Italy has in experimental nuclear physics in Europe.

6

CSN4 : THEORETICAL PHYSICS PHYSICS WITH ACCELERATORS

In our last year's report we emphasised the particular role played by INFN for Theoretical Physics in Italy. It covers areas such as Theoretical Particle Physics, Theoretical Nuclear Physics, Mathematical Physics and Statistical Physics. In these areas essentially all groups with a significant scientific activity are financed by INFN.

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.

The large majority of Theoretical Physics groups supported by INFN belong to the Universities and the senior researchers are often University Professors. INFN support covers running expenses, computing facilities, travel money, organisation of Schools, Workshops and Conferences, as well as student and postdoctoral fellowships and some junior positions. Particularly noteworthy is the Galileo Galilei Institute for Theoretical Physics in Florence. It functions as a centre for thematic meetings and workshops which bring together experts from all over the world in a given subject for periods from a few weeks to a few months. The programs run so far were of very high scientific level and the Institute stands very well the competition of similar institutions in Europe and the United States (Newton Institute, Henri Poincaré Institute, Santa Barbara Institute, ...). The CVI wishes to congratulate the members of its Scientific Committee.

The record of CSN4 in training young scientists has always been impressive. It counts for half of the PhDs awarded in INFN related subjects. The CVI notices with satisfaction that a considerable effort has been deployed by CSN4 in collaboration with CSN1 in preparing young theorists for the analysis of the LHC results.

However, this bright picture hides a much more gloomy reality. The first worrisome point concerns the travel funds. A recent regulation results, effectively, in a severe reduction. Given their modest amount compared to public expenses and their importance in maintaining the flow of exchange of ideas, so crucial for scientific research, the CVI

wishes to urge the authorities to reconsider the regulation for the research sector. A second point is due to the large implementation of the Italian Theoretical Physics community in the Universities. It makes it vulnerable to the recent budget cuts and, most importantly, the freezing of positions. In our reports over the last two years we emphasised strongly the danger of this policy. Now 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. The third point concerns the computing and simulation program in theoretical physics. The CVI notices with regret that the critical financial situation of the Institute did not allow for a timely decision to acquire the necessary computing power which would be a match to similar infrastructures we find in the US, other European countries, or Japan. In fact, this amounts to a decision to abandon the project. It is the first concrete victim of the budget cuts. Let us remember that in the past years the APE project had allowed Italy to play a leading role in this field. The physicists involved have developed novel techniques in every aspect of it, starting from the hardware of the computer itself and going to new fast algorithms as well as more theoretical problems, such as that of chiral fermions on the lattice, or the reformulation of the renormalisation program. In all these problems the Italian physicists took often the leading role in international collaborations. A rich harvest of results was obtained which includes the standard questions on the spectrum of light hadrons, but also the computation of the hadronic matrix elements appearing in weak decays, as well as problems outside high energy physics, such as the numerical study of various disordered systems, or the application of statistical mechanical methods to problems of complexity. Although the study of some of these problems can continue using less performing installations, the more demanding ones will have to be abandoned. With the lack of the appropriate facility the expertise of the Italian Theoretical Physics community in this field will soon be lost.

7 CSN5 : TECHNOLOGICAL AND INTER-DISCIPLINARY RESEARCH

CSN5 covers an important role in developing technologies, designing and realising 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 Accelerators, Detectors and Computing , Interdisciplinary research.

The CSN5 Budget, in line also with the other CSNs, shows a decrease as already seen last year, along all the three sectors of activities with Interdisciplinary Research accounting for its biggest portion (about 50%). The scientific production in terms of ISI publications, however, remains strong, showing the great interest of the researchers for new developments, particularly due to multi and interdisciplinary activities. It is interesting to notice a steady increase of their average impact factor (from 1,46 in '04-'06 period to 1,96 in 2009). Also the number of talks at international Conferences remains high (even if slightly decreasing compared to the previous year); this can be considered an important sign of the CSN5 commitment in the dissemination of scientific results and the internationally acknowledged quality of its scientific competences. However travel budget cuts may negatively affect this commitment.

Considering the scientific and technological achievements and the projects actually in progress, we want to mention the following.

Related to the area of activities concerning Detectors:

XDXL (project aimed at the development of large size silicon detectors for X and gamma rays in satellite radio-astronomy and radiation for radiation protection), DASIPM1 (based on electric and spectroscopic characterisation of SiPM, also performed for the construction of a small animal PET prototype), SOIPD (experiment aimed at developing pixel detectors based on innovative techniques of Si deposition on insulators in CMOS technology, with potential for the development of new particle detectors; it is important here to keep collaborations with semiconductor companies having similar projects to optimise research efforts).

Related to the Accelerator sector:

HELIOS (in collaboration with GSI in Germany and JYFL in Finland, to improve

the performance of Electron Cyclotron Resonance source and produce ion beams in high charge state, applied , for example, at CNAO Pavia with the result of doubling the transmission beams of carbon in the Linac), SALAF (experiment in collaboration with SLAC, concerning high power tests on 11,424 GHz accelerating cavities with results applied successfully to CLIC cavities, then convincing CERN to follow the solution worked out), and NUVOLA (to analyse and possibly find out how to check and control e-cloud effects in high intensity beam accelerators, resulting in the identification, for the first time, of the chemical secondary electron yield).

Various projects and experiments refer to imaging for medical/biological and environmental together with cultural heritage application where INFN has long reached an excellent scientific quality and maintains a leading position by developing original nuclear techniques measurements. This is a very interdisciplinary areas (involving also disciplines different from physics) which has proved to be very successful with projects such as CATANA and CNAO (inaugurated this year). To be mentioned:

PRIMA (aimed at implementing an image system with protons in proton computed tomography useful in testing and treatment in hadron therapy, allowing to evaluate the distribution of stopping power of proton within tissues and reveal details not visible with standard Xray images), BEATS (experiment based on international collaborations with BNL and UCLA, to take measurements at the inverse Compton Scattering source at ATF-BNL applying the Inline phase contrast imaging; it shows great application potential in the Imaging field), ERMES (experiment aimed at the characterisation of neutron background with HPGe gamma spectroscopy and scintillation liquids, which, for example, showed unprecedented anomalous variation of activity concentration of uranium in water associated with the geodynamic processes in the L'Aquila earthquake), ETRUSCO (addressed to a "tracking laser" providing a direct measurement of the absolute position of satellites with respect of the centre of mass of the Earth; it is co-financed by ASI, INFN and Italian industries to optimise and qualify the retro-reflectors of Galileo-the European constellation of satellite navigation)

It clearly appears that the CSN5 areas of activities are not only important for the fundamental research, which is the primary unrivalled objective of INFN activities in Italy; they entail also an important potential and real socio-economical impact and relevant industrial applications in certain high tech niches.

INFN has shown the right sensitivity to this issue by working out a more accurate Technology Transfer (TT) policy. Since mid 2009 a specific Committee made up of 15 people with different experiences has 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 has been finalised and interesting practical examples of their applications are: collaboration with FBK foundation in Trento in the field of Si sensors; a spinoff company started for production and commercialisation of SIPM from which INFN receives royalties; two products concerning beam monitoring and software developments have been licensed to the Belgian company IBA. The overall funding from TT turns out to be still limited but its existence and its increase potential is a good and promising sign.

Moreover, in order to stress the message that fundamental research can be an important engine for innovation, INFN has established the so called strategic projects. In this frame, especially the competences applicable in the medical field are considered particularly important. CSN5, together with CSN3, has therefore become the reference scientific committee for the strategic INFN-MED project started to promote and coordinate the INFN competences considered ripe for developing innovative products related to imaging, diagnostic, accelerators and related software for medical applications, in collaboration with other institutions and particularly with industries .

In general the CSN5 technological competences appear to be well in line and very synergistic with other INFN strategic projects as foreseen in the 2010-2012 triennial Plan, such as NTA (New Technologies for Accelerators) and INFN-E (applications in the Energy field) besides special projects such as Super-B, SPARC/X and SPES. In consideration of the numerous projects to meet and the available resources, it might be necessary to continue giving accurate attention to planning priorities.

It is recommended to keep further sensitising Italian industries and their Associations (even if sometimes it may turn out to be a challenging task) to exploit the fall out of the technologies and methods stemming from CSN5 (and others CSNs) research and keep soliciting supports also from regions especially as far as health, cultural heritage and environmental applications are concerned, in the light of the interest that at least some of them seem to show.

In summary, CSN5 confirms the high level of competences achieved, often in clearly leading position in the worldwide complex scientific context, and also their relevant socio-economical impact. It is felt therefore important that CSN5, as the other CSNs, receives adequate resources, as foreseen in the 2010-2012 INFN triennial Plan, to keep pace with the INFN scientific challenges ahead and to elaborate sound plans for a longer timescale.

8 EDUCATION AND OUTREACH ACTIVITIES

The record of INFN in both these fields has always been outstanding. 50% of all Physics PhDs awarded in Italy, are in INFN related subjects. This percentage is the highest in the world. The scientific level in all stages of higher education is excellent and this is particularly true for the PhD level. In addition to this institutional training a large number of specialised Schools are organised every year to initiate young graduate students and post-docs to the latest scientific and technological developments. During the last year a particular emphasis was put into LHC related subjects. This considerable effort results in a strong attractivity of these research fields among Italian students, in contradistinction with what we see often in other countries in which the brightest students seem to turn away from Physics. The CVI is pleased to acknowledge this fact and wishes to bring it to the attention of the Government authorities in order to plead for the creation of promising career opportunities for these talented young physicists. The present situation leads to a considerable waste of national talent.

The outreach activities are rich and diversified. We find a most impressive list covering all INFN related topics and using a large variety of communication tools: public lectures, exhibitions, radio and TV programs, press releases, multimedia tools, educational material, etc. They aim at all audiences, from school kids to university students, journalists as well as the general public. The public exhibitions organised last year attracted large crowds of visitors. Thanks to these efforts the Italian public has a higher degree of awareness for the latest scientific issues than, probably, in any other country in the world. The CVI was particularly impressed by the very stimulating program addressed to school students in which they are led to participate in a collective effort of real scientific measurements. It expresses its congratulations to the Communication Office of the Institute and to all those who help in this program.

In the presentation made during our meeting we learnt about the relations of INFN with European organisations such as the European Science Foundation and the European Union. A particular section in this year's GLV report is devoted to this subject. The CVI encourages the development of these relations which will enrich the European Research Area to the great benefit of all countries involved.

9 GENERAL CONCLUSIONS AND ACKNOWLEDGEMENTS

All CVI panel members unanimously declare that our last visit to Catania 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 would like to ask the President to transmit to all the personnel our appreciation for the work done. We would also like to thank him together with the members of the Executive Board, the chairpersons of the scientific sections and the Direction of LNS for organising such a successful meeting as well as for the warm hospitality extended to us.

10 POSTSCRIPTUM

The INFN community has suffered this year the loss of Nicola Cabibbo, former President of INFN and one of the leading figures in the international scene of High Energy Physics. The CVI shares with all the members of the Institute the sadness of this loss and wishes to express to his family and his friends its most sincere condolences.

Progetto Grafico: Ufficio Comunicazione Infn - Francesca Cuicchio