FINDINGS AND RECOMMENDATIONS

1 THE INTERNAL EXPERIMENTAL PROGRAM

As of this meeting, the Scientific Committee began reviewing the LNF particle physics projects that use external facilities, such as LHC-related work. In view of the fact that the majority of the Research Division personnel works on the external experimental program, such reviews should produce useful recommendations on the resources to be dedicated to the external and internal programs and on their synergy.

Certain general aspects such as the number of permanent researchers, of postdocs and of thesis students are addressed in the final section of this document.

This first review addressed some of the large experiments at CERN and at LNGS. Future reviews will address other LNF external programs.

1.1 ATLAS

The ATLAS group has given major contributions to the construction of the precision drift chambers of the muon spectrometer system. In particular, this group has fabricated about 10% of the total precision chamber area (≈600 m^2), and is strongly involved in the commissioning of the muon system.
Besides being involved in the TDAQ software, the group has been working on the performance of the spectrometer, in particular on the determination of the muon energy scale, and on new

physics channels involving muons, such as heavy Z-boson and LFV in the $\tau \rightarrow 3\mu$ decay channel.
The group is to be congratulated for its very important contributions to the ATLAS muon system, made possible by its numerical strength (10.5 permanent and 4 temporary FTEs) and by the experience of its members..
The effort in the preparation of the analysis is already important and should be pursued further, in order to appropriately profit from the large investment made, For this purpose it would be useful to increase the strength of the younger component of the group.

1.2 LHCb

The LNF LHCb group is one of the leading groups in the collaboration. They are responsible for the LHCb muon system consisting of five layers (M1 to M5) of GEM+MWPC detectors. This involved construction, testing, repair & commissioning of the detectors; design of support structures and services as well as the design of front-end and data-acquisition electronics. The work on layers M1 to M4 is largely finished with excellent results. The last layer, M1, will be completed on schedule for first LHC collisions. The group should be congratulated for these results.

In preparation of physics data analysis the group is currently working on muon identification algorithms in view of rare decay channels involving muons, and CP violation studies using B-decay channels with muons in the final state. With these preparations underway, the committee considers the group well positioned to maintain its present strong position in the LHCb collaboration.

The size of the group (5.5 permanent and 4 temporary FTEs) is adequate.

1.3 CMS

This group has a long track record in flavour physics; it joined CMS after the cancellation of BTeV in 2005. Despite this short time scale the physicists have been able to give an important hardware contribution with the RPC group.
It is not yet clear whether this somewhat smaller group, consisting of 5.5 permanent and 2 temporary FTEs, will be able to give as significant a contribution to physics analyses. The committee encourages them to rapidly prepare for this stage, and not only in the *b*-physics sector. Close collaboration with other Italian institutes is strongly encouraged in order to avoid dispersion of efforts.

1.4 OPERA

The LNF OPERA group has given very large and crucial contributions to the detector, even though this was not stated very explicitly in the open session presentation. Among them, the very impressive Brick Assembly Machine (BAM), the magnets and the RPCs. The success of all these efforts was clearly demonstrated in the 2006 CNGS run when OPERA observed muon tracks induced by neutrinos originating from CERN. The group should be congratulated for these achievements.

The crucial outstanding task of the collaboration is to increase the target mass to the planned 150,000 bricks from the 4,000 bricks inserted at the time of 33rd SC. The collaboration expects to complete the target mass in May 2008. For the CNGS (re-)commissioning run (September 2007) and subsequent data run (October-November 2007) OPERA expects to have inserted 60,000 to 90,000 bricks and to accumulate about 10^{19} protons-on-target. This should yield 465 neutrino interactions in the bricks, corresponding to about 20 charmed hadron decays.

To match the emulsion scanning capacity to the expected rate from 2008 onwards, the LNF group intends to also install at LNF a scanning facility. The committee takes a favourable view of this initiative.

The size of the group (5.3 permanent and 5 temporary FTEs) is adequate. The group is encouraged to prepare for future data analysis.

2 THE INTERNAL PROGRAM: STATUS

2.1 DAΦNE OPERATIONS

The DAΦNE team is to be congratulated on the excellent daily integrated luminosity being delivered to FINUDA. With patient and systematic work by the operations crew and accelerator physicists, this quantity has increased more than threefold since November 2006, a time when the machine was still being tuned-up in its new configuration. The reservations expressed then have been dissipated, mainly by the increase in stored positron current at the beginning of January. This, in turn, allowed the electron current to be increased. One of the measures that helped increase the positron current was the rapid commissioning of two new, very flexible, bunch-by-bunch feedback systems. This is a key way in which DAΦNE is preparing the ground for future electron-positron factories with even higher luminosity.

Although it has been successfully dealt with, the nature of the fast horizontal instability limiting the positron current is still not fully understood. In any case, it seems that further increase of the stored currents would be limited by beam-beam effects since the beta-functions at the FINUDA IP are larger than they were at KLOE. If time and appropriate diagnostics were available, it would be worthwhile to clarify its relation to electron cloud effects and possible cures.

Further improvements to specific luminosity came from a number of measures, particularly several concerned with minimising parasitic beam-beam effects and finding a better working point. Increasingly faithful beam-beam simulations are a very valuable tool here. The net result is a daily integrated luminosity very similar to that obtained at the other interaction point in the last KLOE run.

It is notable that this performance has been achieved with a reduced magnetic field in the wigglers, resulting in a substantial saving (about 40%) in operating power and cost. Together with the availability of a third cooling tower, this has permitted better operating conditions for the cooling system, reducing the risk from the omission of maintenance because of the reduced divisional budget. Sustaining the present performance and high operational efficiency (up-time), DAΦNE should come very close to the goal of $1fb^{-1}$ by the end of the present run.

Finally, the Committee appreciates the documentation of the effects of removal of the ion clearing electrodes at the recent Electron Cloud Clearing (ECL2) workshop (EUROTEV-Report-2007-016).

Overall, as we have previously remarked, the luminosity potential of the present configuration of DAΦNE appears very close to being fully realised. Occasions when the daily integrated luminosity falls below about 6 pb^{-1} are attributable either to operation for the X-ray beam line or to faults and maintenance activities. The time is ripe to implement a luminosity upgrade.

2.2 KLOE

There is progress across the board in KLOE data analysis. The extensive simulations necessary to analyze the 2 fb^{-1} data set are practically complete. Many results using the 2001-02 data sample ($0.4fb^{-1}$) have been obtained and published, in particular in 2006 there were ten journal publications. Several analyses using the remainder of the data are on their way; at the May 2007 conferences, KAON07 and ETA07, many new results were in line to be presented.

Among these one may highlight:

- new results on $K_L \to \pi^- e \nu \gamma$, and on the scalar form factor in $K_L \to \pi^- \mu \nu$

- the absolute branching ratios in $K^+ \to \pi^0 l \nu$, $K^+ \to \pi^+ \pi^0$, and the K^+ lifetime

- the work on rare decays, using the full $2fb^{-1}$ sample: the final result on $K_S \to \gamma\gamma$, which disagrees with NA48; also, a new upper limit on $K_S \to e^+ e^-$; these preliminary results are

relevant as chiral tests and as auxiliary channels for more rare decays like $K_L \rightarrow \pi^0\gamma\gamma$ and $K_L \rightarrow \pi^0 e^+ e^-$.

Much work is ongoing on hadronic physics:

- $\eta \rightarrow 3\pi$ Dalitz analyses, very interesting and close to publication

- the $\eta \rightarrow \pi^+\pi^- e^+ e^-$ analysis, with CP tests.

- the recently published η' gluonium content in the study of ϕ decays.

Preliminary results from 2002 data on the $e^+e^- \rightarrow \phi \rightarrow \pi^+\pi^-\gamma$ cross section with photon emission at small angle are eagerly awaited, because these results should help clarifying the hadronic contribution to g-2.

In addition, the collaboration has prepared comprehensive reviews of the determination of V_{us} from K decays, and on quantum interference phenomena and CPT violation.

The critical issue of staffing, which was viewed with concern at the previous SC meeting, is addressed in the section on KLOE upgrade.

2.3 FINUDA

The Committee acknowledges receipt of a useful and timely report by the collaboration, as requested at the last meeting. The report was useful in allaying the concerns about the running conditions that were expressed then. With beams, only a very small degradation of the momentum resolution of the muon tracks is seen on the bottom of the detector volume, where more He-bag air contamination is present.

The FINUDA collaboration is to be congratulated for the continuing good use of the luminosity being delivered by DAΦNE. An integrated luminosity of $1 fb^{-1}$ is expected by mid June, thereby completing the current FINUDA data-taking program.
Calibrations, preliminary to full data analysis, are being energetically pursued; results on alignment with cosmics without magnetic field and on calibration are very good. However more calibration work remains to be done.

The analysis on hypernuclei is in progress. The background from two-nucleon absorption seems important at this time, but will be reduced when the vertex algorithm will be refined. In general the preliminary results are already encouraging.
The Committee would like to have a detailed presentation of the analysis status at its next meeting, that should again be preceded by a short written report by the end of October 2007.

2.4 SIDDHARTA

The Committee was favorably impressed by the technical progress on all components of the apparatus. Construction and testing of the vacuum chamber proceeds according to plan and should be finished by the end of June, while the cryogenic target cell is foreseen to be completed by mid August 2007. The setup of the SDD detector involves testing of the chips and implementation of LV+HV supply and DAQ systems. Intermediate problems that occurred with the front-end electronics were solved. Along the line the kaon trigger will be tested and installed. The full SDD detector assembly and its installation at DAFNE is expected to be completed by the end of October 2007 so that first beam tests can be conducted in November/December. The committee congratulates the SIDDHARTA group for their very professional performance and looks forward to timely completion of this phase.

The upcoming beam time requirements include 100 pb^{-1} for tuning, 400 pb^{-1} for the K^-p runs and 600 pb^{-1} for the K^-d measurements. Under these conditions the expected precision to be reached for the kaonic hydrogen 1s energy shift and width is ±2.0eV and ±4.5 eV, respectively,

an order-of-magnitude improvement over the previous DEAR results. For kaonic deuterium the estimated accuracy for the 1s shift and width is ±15 and ±40 eV. This will be the first determination of the complex K^-d scattering length.

Under discussion is the possibility of launching a kaonic ^{3}He programme with SIDDHARTA, in view of promising results from KEK which appear to be at variance with earlier data, thereby removing a longstanding discrepancy between theory and experiment.

2.5 KLOE for nuclear kaon reactions

A nice surprise of this meeting was a new analysis of past data collected with the He drift chamber of KLOE. This is a joint venture of subgroups formed by SIDDHARTA and KLOE members conducting a preparatory study of the physics case for AMADEUS. The successful cooperation and synergy between these groups was well recognized. The feasibility of this analysis was well demonstrated by the very accurate mass identification of Λ's based on only a fraction of the available data sets. Further studies plan to include (Λd) invariant mass spectra in search for possible signals of bound antikaon-nuclear clusters. A report on these survey investigations is expected at the next meeting.

3 THE INTERNAL PROGRAM: FUTURE

3.1 DAΦNE LUMINOSITY UPGRADE

The comprehensive report highlighted deeper understanding and significant technical progress with the luminosity upgrade since SC 33, going beyond the information in DAΦNE Technical Note G-68, which was available at the previous meeting. The extreme interest of testing the scheme of large crossing angle and crab-waist sextupoles is evident, not only for the DAΦNE physics program but also as a potential path to a new generation of high luminosity e^+e^- factories. The results of the test are eagerly awaited but, like all luminosity upgrade schemes, it is unlikely to yield results immediately. The DAΦNE team knows the value of a systematic approach, taking the time to make careful measurements and to understand and solve the problems that arise. The Committee recommends due patience.

The details of the new layout were clearly presented and construction and installation of the new hardware (quadrupoles, chambers, injection kickers, luminosity monitors, etc.) is well managed and progressing on schedule. There is some risk that the pulsers for the injection kickers may arrive late but a backup solution is available.

Notable progress in evaluation of dynamic aperture was presented (see also DAΦNE Technical Note G-69). This is an obvious concern because of the strong crab-waist sextupoles. The algorithm for maximising dynamic aperture while correcting the chromaticity in steps with the other sextupoles seems direct and effective. Showing that there are working points in the tune diagram simultaneously providing good luminosity and dynamic aperture (evaluated separately) is an important step. Nevertheless the upgraded DAΦNE may start up with the crab sextupoles switched off, gaining luminosity initially only by the geometrical effects of the large crossing angle. The sextupoles can then be turned on gradually to an optimum crab-waist setting.

Careful evaluations of beam losses and the contributions of particles lost by the Touschek effect to experimental backgrounds have shown that these effects remain acceptable.

Some relevant studies have already been done on the present DAΦNE: not only the feedback systems (see above) but also an initial verification that adaptation of the injection frequency to the change in circumference of DAΦNE does not adversely affect the injection efficiency.

The large-angle crossing with crab-waist is being implemented for SIDDHARTA, a detector with no magnet. It is expected that the scheme will work for a detector with solenoid, such as KLOE, because the coupling compensation scheme block-diagonalizes the 4 by 4 transfer matrix between the crab sextupoles and the IPs; therefore the crab rotation and the coupling

compensation are essentially independent and should be compatible. The necessary adaptation of the KLOE IR hardware would also be straightforward.

A pre-requisite for a luminosity upgrade, that should extend the life of the present collider, is that the basic hardware and infrastructure remain in reliable condition. Discussions with AD members confirmed that this is generally the case: there is no significant ageing of important components, faults remain at a normal level and adequate stocks of spare magnet coils are at hand. The technical capabilities of the Division's staff ensure that repairs (e.g., the recent water leak in an injection septum) can be carried out rapidly and efficiently. A long-standing problem with control of the quadrupole power supplies is not understood but can be lived with.

Nevertheless, the fact that the luminosity upgrade is being implemented within a significantly reduced budget has made short-term compromises necessary. Maintenance of power supplies and cooling systems has been skipped, for now, where the risks seem acceptable. Only two of the new feedback systems have been installed although it may be preferable to install more to control both planes of transverse oscillation of both beams with similar systems. Challenging times are ahead for DAΦNE and appropriate resources will be needed.

3.2 KLOE2

The DAΦNE luminosity upgrade plans have placed the KLOE upgrade on a faster course. However the collaboration appears to be reacting well to the additional pressure implied by the machine plans, which might call for installation of KLOE2 in early 2009. One important and very positive development is the addition to the collaboration of a group from Bari, with a strong background in electronics. This group is expected to play a strong role in the GEM detector readout.

On staffing, the situation exposed at the past meeting, namely the possible loss of five temporary positions, has been temporarily avoided, by replacing one person and extending the contracts of the others. However the problem will present itself again for 2008.

Planning and actual work on the hardware for the upgrade is proceeding along several parallel lines. The indispensable and urgent work on front-end electronics, slow control and HV system is proceeding. The item requiring most R&D is the Inner Tracker, for which a cylindrical triple GEM configuration has been chosen and several promising almost full-scale prototypes have been built and will be tested in the next few months. This new detector will provide more accurate vertexing, allowing greater precision in kaon interferometry studies and increasing the acceptance for several kaon decays. Two other upgrade projects are being worked on: a $\gamma\gamma$ tagger (which will run parasitically with SIDDHARTA) and an upgrade of the e.m. calorimeter readout, where two orthogonal solutions, involving MAPMTs (hence higher granularity) or PMTs with higher quantum efficiency are under study.

In general, it should be clarified which channels will benefit simply from higher luminosity, and which require the detector upgrades to be carried out. The collaboration will meet in July 2007 to further specify its upgrade plans.

Overall, the Committee is pleased with the progress of the KLOE2 upgrade but remains watchful of possible staffing problems.

3.4 Planning for the next experiments at DAΦNE

The SIDDHARTA experiment at IP 2 will provide the first test of the luminosity upgrade. The use of IP 1 for KLOE2 and other groups needs careful planning; the LoIs reviewed in the past by the Committee will have to be followed up by Technical Proposals, with detailed consideration of the planned technical and human resources.

The Committee expects to clarify the desired timing of these proposals in its 36th meeting, in November 2007.

4 ACCELERATOR DIVISION MATTERS

Although no presentations of activities other than DAΦNE were made at this meeting, the Committee took note that:

- SPARC is now almost completely assembled with the first undulator section about to arrive. Construction to accommodate the FLAME laser is under way.
- The CTF3 combiner ring installation at CERN is complete and beam has made a first turn.
- Installation of CNAO has started in Pavia with the ion sources already installed although there are some delays with buildings and ancillary systems.
- The BTF facility continues to run satisfactorily for numerous users.
- Important steps are being taken towards the SPARCX project and the Accelerator Division is considering its organization for the technical design.

Rejuvenation of the AD staff to support its diverse range of world-class activities remains a major concern. The Committee recommends finding ways to encourage more Ph.D. research in accelerator physics in the lab, possibly following the model of collaboration with universities used at CERN.

5 CONCLUSIONS

Reviewing both the external and the internal activities of the laboratories in one meeting allowed the Committee to focus on issues common to both. The Committee devoted attention to the following issues:

5.1 PERSONNEL

The availability of positions at the senior (permanent) level, at the temporary level and at the doctoral student level is severely limited. In particular:

- the freeze on permanent INFN positions in recent years severely limits the career opportunities of young scientists as well as threatening the normal activities of long-term projects. Recent news appear to promise a reversal of this trend.

- the laboratory should be endowed with more than two or three postdoctoral position a year

- the small number of PhD students in all experiments, but especially in the LHC groups is an obvious mismatch to the opportunities that will soon open up.

While these issues are mostly outside the reach of LNF management, the Committee thinks that imaginative actions should be taken to remedy these problems, particularly concerning students and postdocs. The laboratory can attract the best physicists by ensuring the presence and livelihood of centres of excellence, based for instance on a strong in-house experimental program, or on analysis opportunities and in general on a research environment that would make it attractive to younger people to work at the lab. In addition, agreements with local University groups should be pursued.
The Committee expects to revisit these issues in future meetings.

5.2 COMPUTING

The advent of the LHC experiments and the higher DAΦNE data rates call for acquiring the computing resources and the associated manpower that will be needed on one hand for the LHC groups to give visible contributions to the analysis, and on the other for the timely exploitation of the KLOE2 physics. Adequate resources in this sector are necessary to ensure the privileged conditions advocated here.