Minutes of the 6th PAF working group meeting

15. September 2005

******* DRAFT VERSION 2 *******

Participants:

A. Ceccucci, E. Shaposhnikova, R. Garoby (convener), M. Lindroos, M. Mangano, R. Ostojic, F. Ruggiero, W. Scandale, J. Wenninger, J. Ellis.

1) Conclusions of the Villars Meeting

M. Mangano presented the outcome of the SPC Villars meeting held in September 2004. The presentation consists of a mixture of personal considerations and official conclusions.

On the short term (< 2010) a major issue of the SPS is the lack of p.o.t. to complete the COMPASS and CNGS programmes. Until OPERA is fully operational priority must be given to COMPASS. For the PS, DIRAC should be completed by 2008. Support for AD should continue beyond 2005.

There is a consensus in the HEP community that the LHC has the highest priority. Priorities for the SPS physics programme should be assigned based on:

- Potential of experiment to supplement LHC discoveries.
- Compatibility with the LHC upgrades.
- Guarantee a programme alternative to the LHC.

The SPS energy range is ideal to address a number of goals of the heavy ion (HI) physics programme. But the field is in a state of rapid evolution, and there is a need to reassess the SPS potential and need for beam in 2009. The discovery of the critical point is one of the fundamental issues for HI physics, but there is no 100% certainty that it can be observed at the SPS, experimental success is therefore not guaranteed. The connection between physical observables and the critical point is still poorly supported by theoretical considerations. There is no need to anticipate a HI run before 2009. CERN must however maintain the ability to perform a HI program (besides the LHC HI programme). New opportunities from an upgrade of the LHC injector chain should be explored.

There is a case for further QCD studies at the SPS beyond the present COMPASS programme. A solid control over QCD is required to make best use of LHC data, and the LHC itself will add large amounts of data on QCD. Future experiments must not just aim at improvements of existing measurements. Grading of experiments will clearly reflect a personal viewpoint.

Concerning kaon physics, there is a clear physics case for experiments that look for very rare decays (branching ratios of 10^{-10} to 10^{-11}). Since Villars the experimental landscape changed significantly because 3 US lab experiments (BNL & FNAL) have been cancelled.

For neutrino physics, SuperBeams and β-beams fall in the timeframe of 2015-2025, after the presently approved/planned long baseline experiments. The neutrino factory is the ultimate facility. For the CERN neutrino programme, there is the question whether the physics motivation of the SuperBeam and β-beam suffice to undertake the SPL, or if this is only justified in the context of a neutrino factory upgrade. This issue must be understood before the SPL road is taken. In fact an upgrade to a neutrino factory seems unavoidable, since this is the most powerful tool. From the SPC conclusions:

- The SuperBeam alone is not the most attractive option.
- The possibility of an experiment with β-beam must be evaluated.
- CERN should support hadron production experiments with neutrino beams.
- CERN should support a neutrino factory scoping study.

M. Mangano concluded that:

- Neutrino physics is the main driver for future accelerator complex upgrades.
- R. Garoby's table of upgrade options must be analysed in more detail to explore the value of each upgrade for neutrino physics.
- Flavour physics provides the most compelling case for a diversified exploitation of the CERN complex.
- The future of HE flavour physics has only been studied in the context of a neutrino factory. This should be reviewed following criteria such as:
  - The impact of upgrades on LHC operation.
  - The minimal requirements for top scientific value.

Discussion:

- M. Lindroos pointed out that some β-beam options are comparable with a neutrino factory in terms of power.

- J. Ellis said that POFPA needs to have an internal discussion on the various neutrino physics options to define priorities and wish-lists.

2a) Conclusions of the CARE-HHH-APD workshop – injector chain

W. Scandale presented some conclusions on the HHH workshop related to the injector chain.

This second phase of the luminosity upgrade aims at reaching top LHC performance with:

- A super-SPS of 1 TeV (SC ring and transfer lines). This is considered to be the first step towards an energy upgrade of the LHC. A higher injection energy will reduce dynamic effects and provide large acceptance at injection.
- New dipoles reaching 15 T → beam energy of 12.5 TeV.

The basic assumptions for an upgrade is to evenly spread the energy range of 25 GeV (assumed injection energy from PS) to 1 TeV over two rings: the first should reach 150 GeV, the second 1000 GeV. For existing SPS may be reused for the lower energy

ring. The main luminosity gain arises from higher bunch intensities and shorter turn-around time.

With the present magnet packing in the SPS ring, a field of 4.5 T is required. The energy swing should not exceed 10 to reduce the dynamic effects of persistent currents. The repetition time should be around 10 seconds. The coil aperture must be in the range of 70-100 mm.

A major issue for the magnets and cables are the power losses. R&D on low loss cables is very critical to obtain acceptable cryogenic power losses (and size of cryogenic system).

There is a long list of open items, among which installation of such a new machine in the tunnel. R&D is required on:

- Optics, beam control & machine protection.
- High gradient & high aperture SC quadrupoles & RF.
- Fast ramping SC magnets.

The potential luminosity gain with higher injection energy is ~ 3. By doubling in addition the number of bunches, which also requires upgrades to the injectors, a total increase by a factor 6 may be achieved.

Finally, given the problems of the present PS magnets, the possibility of a Super-PS with SC magnets up to 60 GeV has been also discussed. Construction of a Super-PS should start in 2012 (to be completed ~ 2015). Issues that must be addressed include a low loss cable, magnets, RF and lattice.

2b) Conclusions of the CARE-HHH-APD workshop – beam parameters and luminosity upgrade options

F. Ruggiero continued with a presentation of conclusions related (mostly) to the LHC itself.

Several IR upgrade options were discussed, including Crab cavities, quadrupole-first and dipole-first variants, local chromaticity schemes, flat beams.

The peak luminosity can be increased by a factor ~ 5 by increasing the beam intensity to ultimate and reducing β^* to 0.25 m. Another factor ~ 6 is obtained through an upgrade of the injectors (see presentation by W. Scandale).

F. Ruggiero pointed out that the turnaround time of the machine is very critical if β^* is reduced in order to profit from the higher luminosity. This is related to the reduced beam lifetime. On paper the effective luminosity depends only on the ratio of turnaround time and β^*.

Beam-beam compensation schemes based on wires are required for the increased intensities. An important number of open issues must be clarified on this topic.

Various RF issues, limitations and upgrade possibilities were presented.

In his concluding remarks, F. Ruggiero noted:

- What is the gain form a new Super-PS?
- Since long range beam-beam effects will limit the LHC performance, beam-beam compensation wires and large bore quadrupoles are required.
- The SPS is currently the bottleneck of the injectors.
- A SC PS may turn out to be the best choice for CERN, which is an opportunity to develop fast pulsing SC magnets.

Discussion:

- R. Garoby said that the PSB is a known bottleneck in the present injector chain which has until now made impossible to test the SPS up to the ultimate beam parameters. LINAC4 is one of the solutions to remove this bottleneck. It must however be noted that the nominal vertical emittance has not yet been reached in the SPS due to e-cloud.

- R. Garoby suggested that Super-PS could be installed in a new tunnel to be excavated some 10's of meters below the present PS tunnel without disturbing too much machine operation, while for Super-SPS a shutdown installation strategy may be used to minimize the impact on operation.

- The strategy and priority for Super-PS and Super-SPS were debated. W. Scandale pointed out that the critical item is the magnet R&D, which is essentially identical for both machine and is focussed on a low loss cable. There seemed to be a consensus that R&D on magnet cable must be encouraged by PAF. This could be one of the recommendations for the end of the year.

- J. Ellis wondered whether the scope of PAF/POFPA was supposed to include only modest upgrades or also projects like Super-PS & Super-SPS that would eat most of CERN's resources in the coming years. He also recalled that the European Strategy Group on HEP should define the main lines of European particle physics, both accelerator and non-accelerator based. This group is supposed to coordinate and define priorities, and define timescales. J. Ellis said that this group may expect input from PAF & POFPA, even tough CERN is not very present in this group. He also wondered if both groups should consider the expectations of that group.

- W. Scandale indicated that new triplet magnets are a modest improvement that must be prepared now. CERN is presently not doing anything in this area, all the activity takes place in US labs.

- A lively discussion questioned the gain from higher injection energy into the SPS, and into the PS. F. Ruggiero and W. Scandale questioned the issue of booster replacement and improvements. M. Lindroos replied that the optimum for practically all boosters world-wide is a linac energy of 100-200 MeV (see LINAC4). The best option is however the replacement with the SPL. The possibility of replacing the booster with FFAGs (potentially more than one) was mentioned. For FFAG the beam quality may be an issue for LHC beams. R. Garoby proposed to ask for help from F. Meot.

For the SPS, E. Shaposhnikova accepted to make a preliminary analayis of the benefit for the SPS of a higher injection energy (40-60 GeV) for the 17th of October.

3) Miscellaneous:

- The dates of the meetings in October and November have been fixed, with preliminary agendas.
  - 4th October : LHC upgrade (L. Rolandi) and discussion with the DG.
  - 17th October : High power targets (Schmelzbach / GSI).
  - 24th October : β-beams (M. Benedict – to be confirmed).
  - 14th November : Status & re-use of the ISR tunnel (H.G. Menzel).
  - 28th November : Draft report.

F. Ruggiero questions if by the end of November there will be sufficient input for a recommendation, since subjects like RCS, FFAGs … have not been discussed and are not on the agenda (so far). W. Scandale pointed out that we must elaborate on the technology for LHC IR upgrades, since this subject becomes urgent due to the long development delays.

Minutes by J. Wenninger, 19.09.2005