Masamitsu Aiba
CERN-Japan Fellow
AB/ABP/LCU

3rd CERN-KEK committee
12th December 2008

Status report

1. Introduction

This report is intended to summarize all the results, not only for 2008 but since October 2006 the beginning of my stay, because my contract will expire a few months before the next CERN-KEK committee. My research activities fall into two major categories, one for the Proton Accelerator for the Future (PAF) WG mainly in the first half of my stay under the supervision of Roland Garoby (AB/BI Group leader and PAF WG convener) and the other for the LHC in the second half under the supervision of Oliver Brüning (AB/ABP Group leader). In Sec. 2, outcomes of these studies are described. In Sec. 3, plans for 2009 are quoted, and a publication/presentation list is attached to this document.

2. Results and status of studies

2-1. For the PAF WG

Proton Synchrotron Booster (PSB)

Study of space charge effect in the PSB is rather important since the performance of the PSB is limited by direct space charge at low energy. A compensation scheme by introducing electron lens has been studied. The idea is that the space charge force in a proton beam could be neutralized by the negative charge of electrons. However, simulation study showed that it is difficult to save the emittance blow-up whereas the tune spread is successfully compensated (Publication/Presentation list [6]).

One of approaches to get over space charge effect is to raise the injection energy. To push up the performance of the injector chain, Linac4, which will accelerates H^- beam up to 160 MeV, has been designed and the construction is started. The design of H^- injection into the PSB is then an urgent task. A lot of studies on stripper foil feasibility, lattice issues and so on have been done [14].

A practical fruit through the study is to activate the usage of ORBIT at CERN [15], which is a modern tracking code for space charge and H^- injection. It was imported from SNS but not used for a while.

Proton driver accumulator and compressor

A proton driver based on the CERN Superconducting Proton Linac (SPL) for the future neutrino factory has been proposed. This is not directly related to the LHC but an interesting future plan. An accumulator and a compressor are necessary to provide very short high intensity bunch onto a production target. The design of two rings, however, was totally open. A detailed lattice design study has showed a feasibility of the complex [10, 12]. The proton driver of neutrino factory is site-dependent and several plans have been proposed by RAL and FNAL for example, but most of them stay a conceptual design stage. Thus the CERN SPL based proton driver is holding an initiative.

2-2. For the LHC

Optics measurement and correction

Due to the enormous stored beam energy and the tight aperture constraints of the LHC, it is essential to measure and to correct its optics properly. Even for the early stage of commissioning, the optics distortion must be corrected down to ~20%, to accept a beam with higher intensity than pilot bunch and/or to accelerate a beam to higher energy than injection energy.

We have prepared a tool for this, a software package for the optics measurement and correction available in the accelerator control room, through many discussions and several tests in the SPS and the RHIC. Fortunately, beam position data from ~500 beam position monitors over 90 turns was acquired for an orbit correction on 12th September whereas our optics measurement and correction was scheduled a bit later. The first optics measurement was successfully performed with the data. A detailed analysis has been carried out and is summarized in an LHC performance note [13].

Lattice study

A study on the LHC lattice has been performed for various purposes, high-beta optics, upgrade optics and nominal optics as well.

The high-beta optics run is scheduled to measure absolute luminosity in ATLAS and CMS (TOTEM) with Roman pot technique. The beta* will be ~2600 m in ATLAS and at maximum ~1300 m in CMS, resulting in a loss of betatron tune about one unit. It is showed that the betatron tune could be kept constant with changing the optics in two or three IRs (2, 4 and 8) [8].

The phase I upgrade requires new optics, which promises a smaller beta* and a feasible collimation scheme for higher beam intensity. Several possible solutions were found partly with my contributions for the optics of IR4 and IR8.

After many updates of the LHC optics, the latest optics V6.503 contains several points to improve, unwanted Beam1-Beam2 phase advance split within IRs, non-zero dispersion in the betatron collimation section IR7 (Beam1), not $\pi/2$ phase advance between IP1 and IP5 and so on. A study to update the optics is underway and getting converged.

3. Plans for 2009

In addition to some ongoing studies/documentations that must be completed early 2009, beam studies in the SPS and possibly in the SOLEIL synchrotron light source and/or in the RHIC are planned so as to extend the ability of our optics measurement and correction tool through off-momentum optics and nonlinear resonance(s), based on turn-by-turn beam position data available in these accelerators as in the LHC. With the consolidated tool, we approach the LHC beam commissioning in 2009.

It is fruitful if the new optics for the nominal operation is approved and adopted to the LHC when it is restarted.

4. Acknowledgements

I would like to thank the CERN-Japan fellowship committee and the CERN-KEK committee for administrations and encouragements, especially to Profs. Takahiko Kondo, Katsunobu Oide and Akira Yamamoto. I am grateful to Drs. Oliver Brüning and Roland Garoby for their kind supervision. I am thankful to many colleagues in AB department, and it is my pleasure to work and to have discussions with them. Last but not least, I thank to Dr. Patrick Fassnacht for helping me at the beginning of my stay at CERN.

Publication/Presentation list

1. M. Aiba, “Memo for scaling-FFAG lattice design”, CERN-AB-Note-2007-015 (2007)
2. M. Aiba, “Accumulator lattice design for SPL beam”, CERN-NEUTRINO-FACTORY-NOTE-151; AB-Note-2007-016
3. M. Aiba, “Compressor lattice design for SPL beam”, CERN-NEUTRINO-FACTORY-NOTE-151; CERN-AB-Note-2007-034 (2007)
4. F. Gerigk, M. Aiba, C. Carli, and M. Martini, “SIMULATION OF THE CERN PS BOOSTER PERFORMANCE WITH 160MeV H^- INJECTION FROM LINAC4”, Proc. of PAC’07, pp.3390-3392 (2007)
5. F. Zimmermmann et. al, “SPACE-CHARGE COMPENSATION OPTIONS FOR THE LHC INJECTOR COMPLEX”, Proc. of PAC’07, pp.1595-1597; CERN-LHC-PROJECT-Report-1020 (2007)
6. M. Aiba, “BENCHMARK OF ACCSIM-ORBIT CODES FOR SPACE CHARGE AND ELECTRON-LENS COMPENSATION”, Presentation at BEAM’07 with proceedings, CERN-2008-005, p104 (2008)
7. M. Aiba, “Accumulator and Compressor for the CERN SPL Proton Beam”, Talk at NuFact07 with proceedings, AIP Conf. Proc. 981, pp. 281-283 (2008)
8. M. Aiba, H. Burkhardt, S. Fartoukh, M. Giovannozi and S. White, “OPTICS FLEXIBILITY IN THE LHC AT TOP ENERGY”, Proc. of EPAC’08, pp.2524-2526; CERN-LHC-PROJECT-Report-1106 (2008)
9. R. Tomás, M.Aiba, R.Calaga, A. Morita and G. Vanbavinckhove, “OPTICS CORRECTION IN THE LHC”, Proc. of EPAC’08 pp.2572-2574; CERN-LHC-PROJECT-Report-1108 (2008)
10. M. Aiba, “SPL accumulator and compressor scenarios for neutrino factory”, Presentation at NuFact’08 with proceedings, http://pos.sissa.it//archive/conferences/074/114/Nufact08_114.pdf (2008)
10. M. Aiba, “Feasibility Study of Accumulator and Compressor for the 6-bunches SPL based Proton Driver”, CERN-AB-2008-060 (2008)
11. M. Lamont et. al, “The LHC Injection Tests”, CERN-LHC-Performance-Note-001 (2008)
12. M. Aiba, **“**A first analysis of 3-bunches and 1-bunch scenario for the SPL based Proton Driver”, CERN-AB-Note-2008-048-BI (2008)
13. R. Tomás, M.Aiba, R.Calaga, A. Franchi, A. Morita and G. Vanbavinckhove and J. Wenninger, “First beta-beating measurement in the LHC”, LHC Performance Note, to be published
14. M. Aiba, Presentations at the PS Booster Beam Dynamics with Lican4 WG http://carli.web.cern.ch/carli/PSBwithLinac4/Welcome.htm
15. M. Aiba, “Summary of ACCSIM and ORBIT benchmarking simulations”, Note under preparation