

YASP FOR LEIR TO PS INJECTION

V. Kain, J. Axensalva, H. Bartosik, A. Huschauer, D. Jacquet, D. Nicosia, S. Pasinelli, J. Wenninger

Abstract

The steering program YASP was introduced in the LEIR injection as well as the extraction lines in 2016 to correct the trajectories with well-known model based correction algorithms such as MICADO or SVD. In addition a YASP configuration was prepared to correct the extraction line together with the first turn of the PS. In this way the injection oscillations can be corrected while keeping the trajectory reasonable in the PS injection line.

INTRODUCTION

The steering program YASP [1] provides well-known trajectory and orbit correction algorithms as well as the option to calculate trajectory or orbit bumps for a given shape and amplitude. The optics of the beam line or ring have to be provided such that response matrices can be calculated. The required correction is given in angles for the different bending magnets and steerers.

YASP makes use of the LSA [2] framework, where an optics can be defined and uploaded to a database for a so-called *particle transfer* (which is a combination of one or several accelerator zones). Also, all magnets can be associated with normalized strength parameters (e.g. k for quadrupoles and angle for dipoles) within LSA. The momentum or $B\rho$ is defined as part of an LSA cycle which is associated with a timing user. Together with this information and calibration functions, LSA calculates the required power supply currents with *makerules* and sends the required current value or function to the hardware. In short, a correction in YASP *trims* the parameter angle of one or more dipole magnets and LSA calculates and *drives* the associated current values.

PREPARATION OF LSA FOR THE LEIR TRANSFER LINES

Figure 1 shows the layout of the LEIR synchrotron with its transfer lines. The injection line consists of the lines ITH, ITE, the bi-directional line ETL as well as EI. The extraction line is made up of the lines EE, ETL in the other direction and ETP. One obvious complication for modelling this layout in LSA is the bi-directionality of ETL. Another one is the fact that the lines contain a mixture of PPM as well as non-PPM power supplies, which mostly expect scalar values as settings, but in one case (ETL.BHN10) a function. *Accelerator zones* were created for the different parts of the lines in LSA. In most cases there is a one-to-one match between the physical line and the accelerator zone (e.g. line EE corresponds to accelerator zone EE). The exception is ETL which became three different accelerator zones: ETL_INJ, ETL_EJ and ETL. The hardware actually follows this zoning. In fact the ETL scalar power supplies are equipped with two FESA classes. one to pilot the current for the injected beam and

one for the extracted beam. The function power supply of ETL.BHN10 is contained in the accelerator zone ETL.

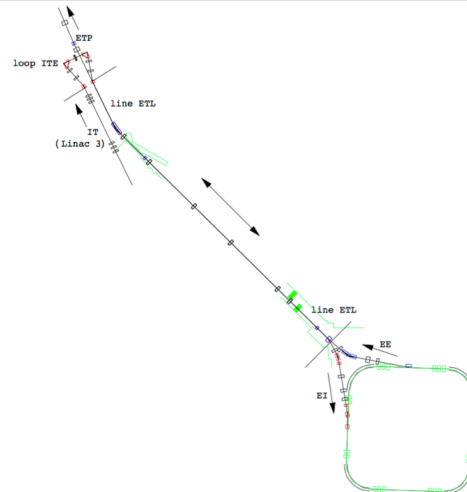


Figure 1: LEIR and its transfer lines

These different accelerator zones were associated with two particle transfers: LEIRInjection and LEIREjection. Different beam processes were then prepared for the particle transfers with the line optics. Discrete beam processes are used for the scalar type power supplies and function beam processes for the function type power supply. At YASP start-up one has to decide whether one wants to work with either the discrete or function beam process. As most of the correctors are scalar type power supplies the usual configuration is to use the discrete beam process.

JMad models have been prepared to upload the optics into LSA.

In order to have all settings required to control the line associated with a particular cycle, virtually ppm current parameters had to be prepared for the non-ppm power supplies in LSA. These virtually ppm current settings are sent to the hardware as if coming from the *non-multiplexed context*. If trims from different cycles occur, the last one wins.

The transfer functions had been collected from Norma and through other sources. Special makerules and linkrules for ETL.BHN10 had to be written. The makerule for the scalar power supplies is `LeirK2CurrMakeRule.java` in the package `lsa-ext-leir`, the makerule for ETL.BHN10 is `K2CurrMakeRule.java` in the same package and the linkrule is `EtlLinkRule.java`. The advantage of this linkrule is that no matter which current is used during the beam passage, $|dI/dt|$ for the ascent and descent is always the same.

LEIR TO PS STEERING

YASP can be configured to acquire the BPMs in the LEIR to PS transfer line at the same time as the injection oscillations in the PS (= first turn minus closed orbit at time 0 ms).

In this mode the horizontal pickups in the PS are multiplied with -1 to take the reference system change into account from LEIR transfer line to PS ring. Thus the first pickup in the PS between the septum and the kickers has a large negative offset, where in reality it has a large offset towards the outside, i.e. positiv offset. As the septum and kickers are also used for the injection oscillation correction in the horizontal plane, their response is also multiplied with -1. Kick

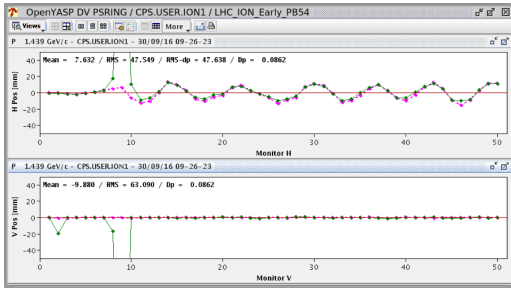


Figure 2: Result of horizontal kick response. The first roughly 10 pickups are in the line, the remainder in the PS.

response measurements were carried out to verify polarities and calibration of the different correctors. Whereas the obtained results were satisfying in the horizontal plane, see Fig. 2, the vertical response for all of the available correctors did not match, see Fig. 3. Optics issues are suspected and will need follow-up during the 2017 run.

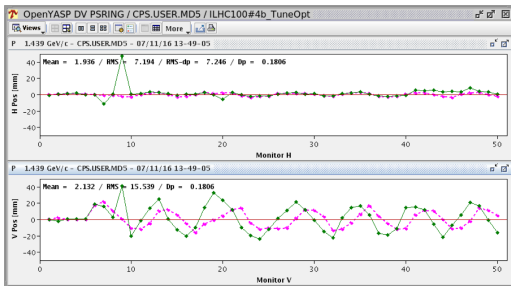


Figure 3: Result of vertical kick response with ETL.BVN10. The first roughly 10 pickups are in the line, the remainder in the PS.

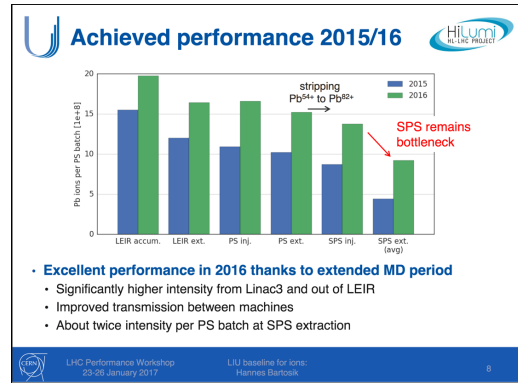


Figure 4: Slide of presentation on LIU baseline for ions by H. Bartosik at LHC performance workshop in Chamonix, January 2017.

This setup was used to steer the ion beam into the PS during the ion run 2016. The transmission from LEIR extraction to PS injection could be increased to essentially 100 % in 2016, see Fig. 4.

OUTLOOK - LEIR TO PS STEERING

The potential optics issue needs to be understood to ensure convergence of corrections under all conditions (currently vertical corrections could only be carried out with low gain). Another improvement could be to remove the offset at the injection region BPM in the YASP configuration LEIR to PS steering to further reduce the complexity of the injection oscillation correction. Reference trajectories will have to be established for the coming ion runs.

REFERENCES

[1] J.Weninger, "YASP: Yet Another Steering Program"
 [2] D. Jacquet et al., "LSA - The High Level Application Software of the LHC and its Performance during the first 3 years of Operation", ICALEPCS, San Francisco, USA, 2013.