# PS AND SL INTEGRATED MONITORING

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*Abstract*

The performances of the SPS as a fixed-target machine are affected by the quality of the beams delivered by the injectors. In several cases either the observables characterising the beam quality or the hardware acting on these observables are not accessible by the PS or SPS control systems. The stringent requirements on the brilliance of the future fixed-target and LHC beams as well as efficiency considerations demand for sharing the access rights to some of the beam instrumentation and hardware acting on the beam. The point of view of a *user* (not necessarily caring about technicalities) will be given. A list of signals and hardware that are considered essential for the optimisation of the quality of the injected beams are presented, as well as a possible solutions to achieve a PS and SL integrated monitoring within the existing control facilities.

## 1 WHAT? WHY?

By PS-SL integrated monitoring it is meant the availability in both Meyrin (MCR) and Prevessin (PCR) control rooms of information related to beam parameters and machine performance under the form of fixed-displays, video image, logged data. The format of the information should be the same for both control rooms to facilitate the discussion of the data.

The integrated monitoring of the accelerator parameters should help in establishing correlations between machine performances and machine settings and should facilitate an early detection of hardware problems or non-optimum settings. In other terms this should minimise misunderstanding between the operation crews in the two control rooms and loss of time with a corresponding gain in efficiency.

## 2 WHERE INTEGRATED MONITORING WOULD BE ESSENTIAL?

Integrated monitoring is mainly important for all the measurable quantities that might affect or allow monitoring extraction from the PS and/or injection into the SPS. Two broad categories can be distinguished:

- Hardware parameters
- Beam parameters

### 2.1 Hardware parameters

These include:

- PS ring power converter settings at extraction.
- SPS ring power converter settings at injection.
- Magnetic field of the PS main bends. At present no measurement of the main bend and quadrupole magnetic fields is available in the SPS.
- Power converter settings in the transfer lines between PS and SPS.
- PS extraction element settings and their delays with respect to the beam. A typical example is given by the voltage waveform exciting the emittance reduction dipoles in the injection transfer line. Its amplitude and its synchronisation with respect to the beam affect the vertical emittance of the fixed-target proton beam.
- SPS injection kicker settings and delays with respect to the beam.
- Synchronisation signals (SPS injection frequency, SPS revolution frequency, PS extraction pre-pulse, etc.) and position of the beam with respect to them.

### 2.2 Beam parameters

- Bunch longitudinal parameters at PS extraction
- 200 MHz recapture signal at extraction from PS for the fixed-target beam.
- SPS mountain range at injection.
- Beam position in the transfer lines between PS and SPS.
- PS orbit at extraction and SPS first-turn. This might prove very useful for studying the effect of the stray fields at extraction from PS on the initial conditions for the optics in the injection transfer lines.
- Beam profiles (and therefore emittance measurements) in the transfer lines between PS and SPS.
- Beam profiles of the circulating beam in the PS before extraction and in the SPS after injection.
- Intensity measurement in the whole chain of accelerators and in the transfer lines connecting them.
- Beam losses in the injection transfer line and in the PS and SPS ring.
- Basic performance data via the usual video pages.

## 3 WHERE DO WE STAND?

At the present time the data that can be shared or are shareable are:

- Intensity and transmission data for the whole accelerator chain via video pages.
- A 'joker' video channel from PCR to MCR. This can be used to send any video signal available in PCR and it is typically used to transmit the image of

luminescent screens in the transfer lines between PS and SPS.

- Evolution of the vertical position of the fixed-target beam during the continuous transfer (CT) from PS to SPS (5-turn extraction). This is an X-application providing the signal from two split foils in the transfer line TT10 sampled at a frequency of 20 MHz.
- Lepton bunch position and intensity in TT10 and TT70. This information can be displayed in MCR in alphanumeric format.
- SPS-LEP logged data (e.g. intensities in the SPS for the fixed-target proton and lead ion beams, emittance measured in TT10 for the fixed-target beams, etc.). These data can be retrieved and displayed in numerical or graphical format via the application GUILS (Graphical User interface for the Logging System) running under Unix, Windows 95 and Windows NT.
- Intensities measured by the PS-BCT are available under Windows 95 and Windows NT.

One of the main problems encountered in sharing more information between the two control rooms is related to the different platforms on which the control systems for the PS (IBM-AIX) and the SPS (HP-UX) are running. X-displays running in one of the two machines are not readable in the other because the fonts are incompatible. This was the case for the X-application providing the evolution of the vertical beam position for the CT proton beam. The only way to make it available in MCR was to provide an account on a HP/UX SL machine for the MCR operation and to connect to it via an X-terminal emulator running on a PC under Windows 95.

Another obstacle to the extensive sharing of data between the two control rooms is the limited control resources. This limits the number of users who can access a piece of equipment and therefore implies a strict priority handling among the users. At the present time this is often orally handled in each control room. Priority handling and more generally a concept of veto is also required for those measurements that might perturb the beam such us beam profile measurements with SEM grids.

## 4 POSSIBLE (TEMPORARY) SOLUTIONS?

A definitive and neat solution to the demand for an integrated PS-SL monitoring should be found in the frame of the SPS Re-engineering Project (otherwise called SPS 2001 Project [1]) and of the PS-SL Controls Convergence Project. Nevertheless temporary solutions can be obtained using existing software with minor modifications or enhancements.

All the video channels available in any of the two control rooms should be made available to the other and they should be given the same name in both control rooms.

The 'joker' video channel from PCR to MCR proved to be very useful to send heterogeneous information from SPS to PS. It could be interesting to activate the existing channel going in the reverse direction. This kind of tools would prove particularly useful during machine development sessions for their versatility.

Since the beginning of 1998 a project (NSA[1] Project [2] led by B. Desforges, SL/OP) has been launched in the SL division to study the needs and the solutions to perform the digitisation of analogue signals and to facilitate their distribution. As a result of the preliminary study two systems are going to be made available in PCR by 1999. One based on the PS nAos system [3] allowing to display fast signals up to a few MHz on an X-terminal with pre-defined scope settings. The second is the ASOS system developed by SL/CO and SL/OP and based on LabView. It should allow visualising fast signals up to 400 MHz on an X-terminal or on video displays with pre-defined scope settings. Signals observable either via nAos or ASOS should be easily 'exportable' to PS and therefore these two applications are considered as the optimal tool to share fast signals. The concept of priority in the visualisation of a signal exists in the nAos system but not yet in the ASOS system and should be therefore implemented.

The measurement of power converter settings, beam position and beam losses at PS extraction and/or at SPS injection could be accessible by means of the PS 'passerelle' [4]. This has been recently enhanced to access also all the SPS equipment [5] accessible via SL-equip calls [6]. The equipment can be accessed via MS-Excel spreadsheets and therefore pre-defined measurement settings can be saved, shared and retrieved.

The Java-Guils Project [7] (led by R. Billen, SL/OP) was launched at the beginning of 1998 to provide a generic, platform independent tool to visualise and analyse CERN operational data not only for the SL division but also for the LHC, PS and ST divisions. It seems therefore the appropriate tool to share logged data for the PS and SPS accelerators.

Data sharing between the two control rooms requires also an effort in the standardisation of definitions, procedures and, whenever possible, of instrumentation in order to favour the comparison and the correlation of data collected in different accelerators.

Pre-defined measurement settings (e.g., monitor gain, scope settings, etc.) should be available to make easier the access to the data from the 'other' control room without requiring a detailed knowledge of the equipment used for the measurement.

Systematic logging of basic accelerator and beam parameters is essential for off-line analysis of the performances, in that respect this should be developed or

[1] NSA = Numérisation des signaux analogiques.

enhanced in both PS and SPS, once definitions and measurement procedures are agreed.

## 5 …AND MORE

Emittance preservation in the LHC era and minimisation of the losses for the fixed target beam require a fine-tuning of the interface PS-SPS. Often the measurements tools and the hardware to measure and correct certain beam parameters are not accessible from both control rooms. For that reason it would be interesting to have not only an integrated monitoring but also inter-machine 'knobs' acting on the hardware at the PS-SPS interface.

Typical cases are:

- The steering of the injection lines. At present each control room controls half of the two injection lines and the steering at the 'border' is performed by means of a luminescent screen whose image is sent via the 'joker' video channel from PCR to MCR.
- Betatron and dispersion matching at injection in the SPS using all the available degrees of freedom. The injection line for positive particles is split in two sectors: TT2, under PS control, and TT10, under SPS control. Each of the two halves has a matching section at its beginning; 8 independent quadrupole power converters are available in TT10 for dispersion and betatron matching, nevertheless for the fixed-target proton beam an emittance exchange section is active in TT10. This process defines the settings of two of the independent TT10 power converters. The number of degrees of freedom for matching is smaller than the number of constraints imposed by injection matching. Controlling part of the TT2 quadrupoles from PCR could solve this problem.
- In order to allow a bunch-to-bucket capture in the SPS the fixed-target beam is accelerated in the PS up to 14 GeV/c on the harmonic number h=16 and then it is debunched and recaptured on h=420 (about 200 MHz) on the RF frequency generated from the SPS. In order to maximise the capture efficiency the radial position just before debunching is adjusted so that the SPS frequency is an exact multiple of the PS RF frequency. Every change performed in the SPS injection frequency to optimise the capture at acceleration should be accompanied by a corresponding adjustment of the radial position in the PS. This is also even more important when dispersion or chromaticity measurements are performed in the SPS. In that case the SPS injection frequency has to be modified to vary the momentum of the beam. That requires an adjustment of the beam radial position in the PS just before debunching to preserve the beam longitudinal parameters that might affect the measurement of the beam position or tune in the SPS. In this case a tool to vary the radial position in the PS from PCR might be very useful.
- The measurement of the dispersion and dispersion mismatch at injection in the SPS requires the possibility to change the momentum of the beam extracted from the PS. The recapture at the SPS injection frequency is in fact not always possible. In the future this kind of measurement might be done more often and therefore providing automatic routines (based on MS-Excel and the PS 'Passerelle') including pre-defined momentum changes could speed-up the measurement that takes several hours at present.

The implementation of inter-machine 'knobs' will require the achievement of a good integrated monitoring and the definition of a clear 'priority' policy. The systematic logging of the hardware trims (which is presently not foreseen in the PS control software) or, at least, an automatic save of the settings at the start of any session of inter-machine trims should be also foreseen.

At the present time no application exists allowing inter-machine trims. This could be achieved by making visible some of the application programs to the 'other' control room or by specially designing applications for each specific purpose (e.g. an ABS-style steering and matching program).

## 6 CONCLUSIONS

An integrated PS-SL monitoring for the PS-SPS interface and an inter-accelerator control for some critical parameters would significantly enhance the efficiency of operation. This applies for the present operation of the CPS and SPS accelerators to provide hadron beams for fixed-target physics and machine development and lepton beams for LEP. In the LHC era the above two two 'ingredients' will become absolutely necessary because of the tight constraints on the quality of the beam that has to be delivered to the LHC. The SPS 2001 Project and the PS-SL Convergence Project will have to provide the tools for such an integration of the control resources of the PS and SL divisions. Temporary and partial solutions seem to be feasible with software that has been recently (or will be soon) made available in PCR and MCR. The success of such a proposed data sharing will rely on the standardisation of definitions and measurement procedures, on the availability of pre-defined measurement settings and, least but not last, on the collaboration and reciprocal confidence among the potential users.

## REFERENCES


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