Summary notes from the 2013 BI-LIU activity review

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Introduction
The 2013 BI LIU took place on the 3rd of October 2013 at CERN.

https://indico.cern.ch/conferenceDisplay.py?confId=268078

The following questions should be addressed:
1. Are the specifications clear and can they be met by the proposed systems?
2. What are BE-BI’s installation/commissioning planning of the various instruments?
3. Are there resource conflicts between machines/systems/projects, and if this is the case how can they be resolved?
4. Does LIU need to provide priorities?

General Remarks

Specifications

- **Intensity and Position.** Functional specifications covering the whole injector complex have well advanced and can be released for approval.
- **Beam Loss.** Functional specifications can be released for engineering check.
- **Beam Size.** Original document produced in 2006: (https://edms.cern.ch/document/772786/1) needs update to take into account LIU parameters
- **General Machine Parameters.** It was agreed that a single document containing future beam configurations for all injectors, of which LIU beams are a subset, would be useful to ensure that a coherent parameter set is used for all specifications.

**ACTIONS:**
- BI to proceed with the finalization and release of functional specifications for observables as soon as possible
- BI, LIU and OP to collect together future beam parameters for all injectors in a single document that should be released as soon as possible.

Commissioning in 2014

Several new or modified systems will be coming on-line after LS1 which will require significant commissioning time, with new PSB BPM & BLM in parallel to old systems; BCTs and SEMs renovated throughout the complex; wire-scanners all removed and recalibrated. A priority list per domain and instrument from OP and LIU was requested to target the effort during the injector start-up in 2014.
**ACTION:** LIU and BE-OP to provide BE-BI with a prioritized list of instruments for commissioning in 2014

**PSB including LN4 connection**

**Beam Intensity**

1) LN2 to PSB transfer-lines
   
   A total of 7 existing, old devices on the LT, LTB, LBE and LBS lines need to be replaced by new ones before 2016 using the injector consolidation budget (270kCHF required). Their signal cables and related acquisition electronics will be renovated during LS1 for improved measurement precision.

   Five injection BCTs (BI.BCT10 and BI.BCT20*4) on the BI line require an upgrade to enable them to work with short LN4 pulses. Dose rates were originally estimated very high implying a large collective dose for those intervening but this proved to be wrong so the required changes will be made during LS1.

2) H0/H- intensity measurement at injection dump
   
   A monitor (likely to be based on Faraday-cup technology) will be used to measure the H0/H- beam currents. It will be positioned in front of the injection beam dump to allow an efficient setting-up of the injection process. The specifications have been written (EDMS 1069244) and include the monitor being part of the interlock system. Studies have been performed on the best material to use (high conductivity, acceptable thermal load, low activation, compatible with BS4 magnetic field), with titanium seeming the best option. The mechanical integration inside the BSW4 magnet is ongoing with TE-ABT and the complete system is expected to be ready by 2015.

   **ACTION:** LIU-PSB & BI-PM to decide on whether the measurement of horizontal beam position should be included in the specifications

3) DC BCT
   
   During LS1 new electronics derived from the LHC system will be used to upgrade the 4 systems and improve the resolution. After LS1 additional work will be done to prepare the system for the full range of LN4 beams and allow handling the modified B-field transmission.

4) Fast BCTs for LN4 watchdog
   
   When LN4 is connected to the PSB, a request has been made to prevent subsequent injections in case the difference between a BCT in the BI line and the circulating beam exceeds predefined thresholds. This system will require modifications to the four existing detectors (BRi.TMD.BL1) as well as additional cabling, work that can only start after LS1. The new system should be available by 2016. Spare vacuum chambers with a ceramic gap also need to be manufactured for these devices.

5) Extraction line BCTs
   
   All PSB extraction line BCTs detectors and their signal cables will be renovated during LS1 for improved accuracy and resolution specifically for the low-intensity LHC beams.
Beam Position

1) LN2 to PSB transfer-lines
   The existing detectors along with their cables, electronics and software for the LT, LTB, LBE, LBS and BI BPMs will be upgraded during LS1 with hardware and software similar to that used for LN4.

2) Plates in injection septum
   A recent request to provide analogue signals from plates for the relative beam position inside the PSB injection septum has been made for the LN4 beam. This requires urgent studies on the most suitable material to be used and for their integration in collaboration with TE-ABT.

   ACTION:
   • LIU-PSB to create WU and specifications for this device.
   • To be implemented in the updated LIU baseline early 2014.
   • BI-PM to find suitable material & coordinate integration with TE-ABT

3) Orbit and trajectory system
   The specifications for the new PSB orbit system are near to completion (EDMS 1233008). The system will be based upon the same acquisition electronics used for the newly upgraded PS system and will, amongst other things, provide turn-by-turn capability. However, for a full deployment, additional cabling is required which cannot be provided during LS1. It has nevertheless been decided to install this system in parallel to the existing system during LS1. This will allow single ring turn-by-turn measurements to be performed with this system after LS1, but with reduced performance.

   ACTION:
   • LIU-PSB to determine if hybrid solution is sufficient for LN4 commissioning needs
   • LIU-PSB & BI-PI to clarify earliest possible cable installation date with EN-EL

4) Extraction line BPMs
   The existing capacitive-type BPMs are seriously affected by beam losses and the remaining pickups will be replaced during LS1 with the inductive type. The acquisition chain will be upgraded allowing for fewer gain stages making it much simpler to find suitable operational parameters. The new system will be ready for the start-up in 2014.

5) Wide-band pick-up
   In order to help diagnose instabilities, an additional wide-band pick-up has been requested (EDMS 1259212). An existing design will be used for the new device which should be placed in the BTP line at the end of 2016.

Energy spread
   The energy spread is currently foreseen to be measured by the Feschenko monitor in the LBS line. However, its resolution may not be good enough to optimise longitudinal painting at injection. A recent request has therefore been made to study the possibility of using Schottky signals for such a measurement in the PSB. The feasibility of such a measurement based on using existing
pick-ups is already underway, but would require a longer injection plateau as averaging is required to reach sufficient signal quality. The precise specifications for such a monitor are still missing and no work-unit or budget has so far been added to cover this task.

**ACTION:**
- LIU-PSB to provide specifications for this monitor
- LIU-PSB to decide on go-ahead for funding once the initial feasibility study is complete

**Beam Size**

1) **BTV screens at stripping foils**
   The BTV screen will allow a visual inspection of the stripping foil and also allow the measurement of the injected beam’s transverse position and size. The mechanical integration already well underway in collaboration with TE-ABT, with a prototype expected to be ready for 2014 with the full production of 4 BTVs and 2 spares ready by end of 2015.

   **ACTION:**
   - LIU-PSB & BI-PM to clarify final cost of this system as questions were raised about the 110kCHF currently allocated.
   - To be implemented in the updated LIU baseline early 2014.

2) **Wire-grid for injection matching**
   A wire-grid for each of the two transverse planes has been requested in PSB ring #3 to be used to acquire turn-by-turn beam profiles. The functional specifications for this measurement are incomplete and several questions and comments were raised regarding this request, namely:
   
   1. The insertion of a wire-grid is potentially dangerous and will require an interlock on the LN4 pre-chopper to shorten the beam pulse.
   2. The request to have the device available for standard operation implies being able to have a PPM based system. There was a concern that such cyclic in/out movements of the monitor would quickly lead to destruction of the SEM wires. This requirement therefore needs to be fully justified.
   3. The electronics for this system is challenging as it requires a radiation hard, low noise acquisition system. The experts capable of designing this will not be available before 2015.

   **ACTION:**
   - LIU-PSB and OP-PSB to provide the full specifications for this system with particular justification for requesting a PPM based monitor.
   - LIU-PSB and BI-PM to investigate the consequence of the late start to the electronic development and, if needed, BI-PM to look into intermediate solutions.

3) **Wire-scanners**
   There is a request to improve the positioning accuracy of the existing PSB wire-scanners. The new design, foreseen for prototype installation in the SPS during LS1, will require significant modifications for integration in the PSB. This integration study is foreseen to start in 2014. The proposed BI priority for manufacturing and installation is SPS (4 scanners), PS (5 scanners), PSB (8
scanners). With the resources available this may mean that PSB installation will not be possible until after LS2.

**ACTION:**
- LIU management to confirm priority for wire-scanner installation.
- BI to search for means to validate and install new wire scanners in all machines before or during LS2 at the latest.
- BE-BI, LIU-PSB & PSB-OP to look into consequences of delaying PSB wire-scanner installation until after LS2 if impossible to do it before.

**Beam Loss**

1) **H- Injection monitoring and observation systems**

Two types of BLM detectors are foreseen for the PSB injection region:

1. Standard ionisation chambers for beam loss measurements. These are mainly to be used to monitor any stripping foil degradation and prevent subsequent injection into the PSB in case of foil failure. A final design of the region is required from TE-ABT to allow integration of the BLM supports.
2. A total of 8 fast BLMs capable of monitoring fast losses are request to optimise the stripping efficiency over the injection duration. Diamond detectors are currently being considered for this task. The choice of digital acquisition electronics is still pending.

2) **Ring**

A renovation of the main PSB BLM acquisition system is underway under the umbrella of the consolidation project. In addition LIU-PSB has requested new monitors at several locations, paid by the LIU project.

- 32 LHC type ionisation chambers will be installed during LS1 in the L2 position in addition to the old monitors.
- A further 32 flat ionisation chambers will be added in the L3 position during LS2

Cabling for the 32 LHC type ionisation chambers will be completed during LS1 and will allow the new acquisition system to be tested in parallel to the old BLM system.

3) **Injection and extraction lines**

The supports and cables for the existing PSB injection and extraction lines will not be provided during LS1 and the installation and later commissioning will therefore wait until after LS1.
PS

Beam Intensity

1) Fast BCTs in TT2:
The Fast BCT detectors will be upgraded to a type successfully tested for beam position and bunch length dependency before LS1. New cables will also be installed. An absolute electronics calibration with a precise current source will be performed before the start-up on all devices.

2) DC BCT in the PS ring:
The DC BCT electronics will be prepared during LS1 for the higher LN4 beam intensity, and a more performing front-end acquisition system will be put into operation after LS1. Specifications concerning the new B-field transmission system after LS1 are pending.

ACTIONS:
• OP-PS to confirm the intensity range to be considered (currently 2E9 to 4E13 charges)
• OP-PS and BE-CO to provide specifications regarding the new B-train transmission

3) Longitudinal Intensity Profile:
Two new Wall Current Monitors and their associated cabling will be installed in the PS during LS1. One will be connected to OASIS and used for Bunch Shape measurements and the Tomoscope. The second will use dedicated BI electronics for ghost and satellite detection. A fast digitizer will be used for this system but, due to the absence of Linux drivers, will require significant software development for operational integration. A specific issue related to attenuating or protecting against the high intensity beams sufficiently while still allowing measurements on low intensity beams is common for both systems. Collaboration between BI and CO is therefore needed to design, develop and test this front-end electronics.

ACTION: BE-BI and BE-CO to collaborate on finding a common solution to protect the acquisition systems against the effects of high intensity beams while measuring low intensities.

Beam Position

1) TT2 monitor relocation
A presently unused BPM will be moved to the very beginning of TT2 which is expected to become available after LS1.

2) Wide-band pickup
An additional wide band pickup has been requested for the PS Ring and is expected to be installed in 2016. Clarification required on whether new acquisition system and cables are required.

ACTION:
• LIU-PS to clarify what acquisition system to be used and if new cables are required. The present budget foresees currently only for the pick-up itself (neither cables nor electronics).
• To be implemented in the updated LIU baseline early 2014.
Beam Size

1) Wire-scanners

There is a request to improve the positioning accuracy of the existing PS wire-scanners. The new design, foreseen for prototype installation in the SPS during LS1, will require only minor modifications for integration in the PS. The present plan foresees a gradual replacement of PS wire-scanners from 2015 onwards based on a mechanical design similar to that of the SPS with the replacement complete by the end of LS2.

A request to provide bunch-by-bunch beam size measurements at 40MHz at high energy for an existing wire-scanner is being investigated for installation during LS1 with the help from BE-RF for the synchronisation signals.

2) Ionisation Profile Monitor (BGI)

A feasibility study for the PS has started, funded by LIU, which should lead to a technical design by the middle of 2014. Upon completion and review of the technical design, an agreement to committing further resources is then required from LIU. The implementation the full system is estimated to cost 0.4MCHF. The earliest that this could be installed in the present plan is the 2015/2016 winter technical stop.

**ACTIONS:**
- LIU-PS to determine if the required 0.4MCHF funding could be made available from 2015 onwards.
- To be implemented in the updated LIU baseline early 2014.
- BE-BI to organise a technical review for project approval in mid-2014.

3) Wire-grids

The electronics and software renovation of all wire-grids in the PS will be finalised during LS1. Related to the higher PS injection energy following the PSB upgrade, a wire-grid situated between the new septum 42 and the ring has been requested and a study of its mechanical integration should be started after LS1.

A wire-grid for each of the two transverse planes has been requested in the PS ring to be used to acquire turn-by-turn beam profiles. The functional specifications for this measurement are incomplete and several questions and comments were raised regarding this request, namely:

1. The request to have the device available for standard operation implies being able to have a PPM based system. There was a concern that such cyclic in/out movements of the monitor would quickly lead to destruction of the SEM wires. This requirement therefore needs to be fully justified.
2. The electronics for this system is challenging as it requires a radiation hard, low noise acquisition system. The experts capable of designing this will not be available before 2015.

**ACTIONS:**
- LIU-PS & BE-BI to define the WU and provide the budget for the new SEM grid linked to septum 42.
To be implemented in the updated LIU baseline early 2014.
LIU-PS and OP-PS to provide the full specifications for this system with particular justification for requesting a PPM based monitor.
LIU-PS and BI-PM to investigate the consequence of the late start to the electronic development and, if needed, BI-PM to look into intermediate solutions.

**Beam Loss**

1) **Monitoring (measurement and interlocking)**

The original consolidation plan, elaborated several years ago was to develop a new electronic acquisition system for the existing PS detectors and re-use the existing cabling. In the meantime, the specifications provided by both OP-PS and LIU-PS, and the success of the LHC BLM system, have led to a new proposal to replace the whole of the old PS BLM system – monitors, cables and electronics. This implies a considerable increase in the overall BLM budget request, which has so far not been incorporated in the consolidation or LIU planning. Installation of this system is currently foreseen for LS2.

In addition an upgrade of the TT2 line and FTA/FTN lines has been requested. It is clear that the FTA/FTN upgrade will not be funded under LIU, while it remains to be decided whether the LIU project can fund the TT2 line BLMs.

New front-end electronics and software will be available for the existing BLM system after LS1, eradicating the need to rely on obsolete controls until the final system can be made operational.

**ACTION:**
- LIU, BI and BE management to address the funding issue related to the PS BLM system.
- Part relevant to LIU to be implemented in the updated LIU baseline early 2014.

2) **Observation (high bandwidth measurement with no interlocking)**

The LIU project has committed to cover the procurement and integration of 16 BLMs for observation purposes to be installed in the ring during LS2. The choice of most suited detectors (likely to be either Diamond or Cherenkov monitors) remains to be made by the BI-BL team in collaboration with LIU-PS.

**SPS**

**Beam Intensity**

1) **Fast Ring BCT**

The Fast BCT is mainly used to determine relative bunch intensity variations at 40MHz. Issues with beam position dependency and cross-talk between bunch-slots (limited analogue bandwidth) have affected performance to date. The effect of shorter cables will be studied after LS1 with a new installation in LSS5. Longer-term studies based on different detector technologies (Integrating Current Transformer (ICT), and inductive pick-ups) have started for initial installation in
the LHC. If proven successful, a new monitor based on one of these technologies could also be installed in the SPS. The currently allocated budget is enough for the upgrade of the ring monitor, but an upgrade of the electronics would require an additional 50kCHF of funding from LIU-SPS.

**ACTION:**
- LIU-SPS to decide on allocation of additional budget for a complete refurbishment of the SPS ring fast current transformer.
- To be implemented in the updated LIU baseline early 2014.

**Beam Position**

1) **Orbit and trajectory**

The SPS ring orbit and trajectory system is being upgraded to eradicate obsolete electronics and improve the performance. The system requires an optical fibre infrastructure to be put in place between the 6 surface buildings and the tunnel. The first part of the installation will be provided during LS1 with completion expected during LS2. Prototype tests have taken place early 2013 and showed good overall performance with necessary improvements identified for the next pre-series version of the electronics. Radiation testing is required for the tunnel electronics. This has already started for several components and is expected to continue in 2014. During LS1, BA6 will be equipped with a complete installation of the new electronics in parallel to the old MOPOS system. This will allow complete testing with beam during 2014 to qualify the system for full deployment in subsequent years.

**Beam Loss**

1) **TT10:**

The PS to SPS transfer-line (TT10) is presently not equipped with any BLMs. A request (not yet funded by LIU) has been made to install around 30 such monitors along with cables and electronics. Details concerning resources must be discussed between now and LS2.

**ACTION:**
- LIU-SPS, BE-OP and BE-BI to decide on the funding source for this request and on the timescale for the installation.
- Part relevant to LIU to be implemented in the updated LIU baseline early 2014.

2) **Monitoring (measurement and interlocking):**

An upgrade of the SPS Ring BLM acquisition system is currently foreseen in the LIU-SPS project. The proposal is to base this system on developments currently on-going for HL-LHC, in particular the development of a radiation hard front-end ASIC. This would allow installation in the SPS tunnel and profit from the optical fibres now being installed for the SPS Orbit system. The timescale for this upgrade, currently foreseen for LS2, needs to be reviewed in the light of the delays due to cabling issues to the PSB and PS installations and a new proposal to renovate the LHC BLM system in LS2.

**ACTION:**
• LIU and BI management to agree on a coherent planning for all the injector BLM systems taking into account cabling constraints and available resources.

3) Observation (high bandwidth measurement with no interlocking)
Two Diamond detectors are installed in the extraction areas (LSS4 and LSS6) of the SPS allowing the measurements of loss signals with high bandwidth. The acquisition systems are presently based on Windows-based oscilloscopes and a study has started to identify alternatives with improved performance and reliability and allowing a better operational integration.

**Beam Size**

1) Wire-scanners
The performance of the present SPS wire-scanners is limited by the maximum intensity and resolution at high energy. A prototype of a new mechanics and electronics is being produced in view of performing beam tests with BE-BI expert tools during 2014. A suitable space has been found in LSS5 of the SPS and an ECR for the space reservation is circulating. If successful, production of the final systems would begin in 2015 with the entire replacement of existing SPS wire-scanners completed by the end of LS2.

2) Ionisation Profile Monitor
The existing SPS BGIs were consolidated with LHC-type optics and electronics during 2012 allowing measurements to be made before LS1. The performance for low emittance proton beams is believed to be limited by space-charge with the only full solution involving the installation of stronger guide field and associated corrector magnets with their power supplies. During LS1 work is on-going to upgrade the detectors as well as addressing machine protection issues related to the magnet powering.

**ACTION:**
• BI to continue testing/debugging the SPS BGIs after LS1 in view of operational availability asap.

3) Injection matching system
The injection matching system is based on acquiring the beam size turn-by-turn and analysing the evolution off-line. To protect the screen from damage, this can only be undertaken during dedicated machine development periods in an inject and dump mode. The existing system, installed in LSS5, is based on a thin BTV screen. Some electronics upgrade will be carried out during LS1 to allow testing with expert tools in 2014.

4) Synchrotron light monitor
The existing SPS BSRT system, based on the extraction of synchrotron light from a dipole magnet in LSS5, is being refurbished during LS1. Work is ongoing to align the detector and upgrade the optics and electronics. According to calculations this should provide adequate light for beam size measurements above 300 GeV. The first parasitic measurements since many years with this system are therefore expected during 2014. Providing reliable measurements at lower energy would require an undulator. The design and integration of such a magnet would be complicated due to the period and gap size required.
Gated Tune measurement

Electronics and low-level software similar to that successfully tested on the LHC before LS1 will be used to provide a bunch gated system tune system after LS1. Integration into an operational application will be required following the commissioning of the system.

ACTION:
- BI-SW and BI-QP to ensure that BE-OP receives specifications for integrating this system into the operational SPS tune measurement application.

Head-tail diagnostics

The existing acquisition electronics for SPS head-tail measurements does not cover the requirements in terms of analogue and digital bandwidth nor storage capacity. A market survey identified a suitable product which has been ordered on LIU funds for delivery during LS1. Once the system is available at CERN, a significant software effort will be required to integrate this into the control system. Systematic performance testing of this system is foreseen to be carried out after LS1.