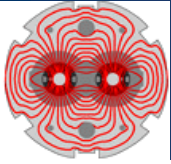
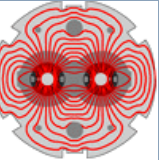


Feedback on SMP from LHC operation

J. Wenninger & M. Solfaroli / BE-OP-LHC

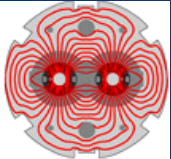


SMP parameters and flags @ LHC

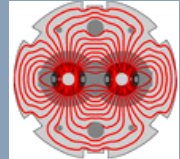


SMP parameters in Run 2:

- ❑ **Safe Beam Energy (SBE).**
 - Energy source: LBDS system.
- ❑ **Setup Beam Flag (SBF) for beam 1 & 2.**
 - Intensity data source: LHC DC BCT.
 - Energy data source: SBE.
 - Threshold equation: SMP.
- ❑ **Beam Presence Flag (BPF) for beam 1 & 2.**
 - Flag source: LHC BI BBQ detector based bunched beam detection (threshold).
- ❑ **Squeezing Factors (SF, correspond to the β^* value) for IP1, 2, 5 and 8.**
 - Data source: LHC SIS.
- ❑ **Safe Stable Beams (SSB) and Movable Devices Allowed (MDA) flags.**
 - Data sources: SBE, SFs and Beam Mode (timing system).



UI view of LHC SMP



- The SMP ran stably for the entire duration of Run 2. I cannot remember a specific problem affecting SMP over that period.

Data Sources

Slow BCT Beam-1 A: 2.0E9 [p]
 Slow BCT Beam-1 B: 0.0E0 [p]
 Slow BCT Beam-2 A: 4.0E8 [p]
 Slow BCT Beam-2 B: 2.0E8 [p]

BETS1 Reference RA: 0.00 GeV
 BETS2 Reference RB: 0.00 GeV
 BETS1 Interlock RA: 0.00 GeV
 BETS2 Interlock RB: 0.00 GeV

Beam Mode: NO_MODE

Squeezing Factor IR1: 0.00 m
 Squeezing Factor IR2: 0.00 m
 Squeezing Factor IR5: 0.00 m
 Squeezing Factor IR8: 0.00 m

BPF (BPM) 1A Horizontal Beam Position: F
 BPF (BPM) 1C Vertical Beam Position: F
 BPF 1E Fast Intensity Measurement: F
 BPF (BPM) 2A Horizontal Beam Position: F
 BPF (BPM) 2C Vertical Beam Position: F
 BPF 2E Fast Intensity Measurement: F

Optics ID Ti2: 0
 Optics ID Ti8: 0

Moveable Devices Allowed In / Stable Beams Generation

Physics Energy Calculation:

Lower limit: 6363.00 GeV ≤ Current: 7864.20 GeV ≤ Upper limit: 6372.96 GeV = **FALSE**

2 out of 4 Select Highest

Beam Squeezed Calculation:

IR	Lower limit	Current	Upper limit	Result
IR1	0.45 m	0.00 m	12.00 m	FALSE
IR2	0.45 m	0.00 m	12.00 m	FALSE
IR5	0.45 m	0.00 m	12.00 m	FALSE
IR8	1.40 m	0.00 m	12.00 m	FALSE

Beam Squeezed: **FALSE**

To Arbiter

Beam-1 Intensity: 6.5535E14 [p]
 Beam-2 Intensity: 6.5535E14 [p]
 Machine Energy: 7864.20 GeV

Moveable Devices Allowed In: **FALSE**
 Stable Beams: **FALSE**

Beta* IR1: 0.00 m
 Beta* IR2: 0.00 m
 Beta* IR5: 0.00 m
 Beta* IR8: 0.00 m

Setup Beam Flag
 Beam-1: **FALSE**
 Beam-2: **FALSE**

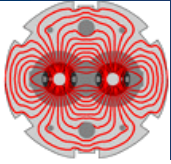
Beam Presence Flag
 Beam-1: **FALSE**
 Beam-2: **FALSE**

OpID_Ti2: 0
 OpID_Ti8: 0

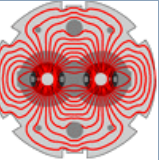
To Extraction BIS

Setup Beam Flag
 Beam-1: **FALSE**
 Beam-2: **FALSE**

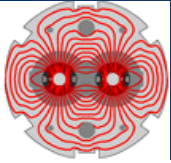
Beam Presence Flag
 Beam-1: **FALSE**
 Beam-2: **FALSE**



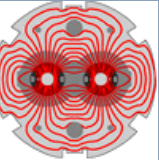
Safe Energy



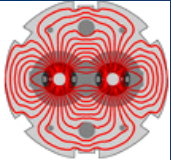
- ❑ The distribution of the **Safe Energy** values through the SMP is consistent with the highly reliable generation of the energy values by the LBDS energy tracking system.
 - With redundancy in the generation (2 sectors) and independent redundancy (2 other sectors) for the internal consistency checking within the LBDS Beam Energy Tracking System (BETS).
- ❑ The energy value is used by many systems across the LHC, some of them being critical for LHC MP.
 - For example the BLM system for the thresholds.
- ❑ Parameter is well adapted to the needs and reliable.



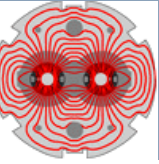
Setup Beam Flag



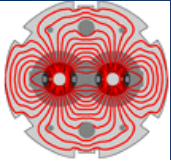
- ❑ The **Setup Beam Flags** (SBF) of the two beams are an essential part of the LHC BIS (and also SIS) since they are used to configure **interlock channel masks**.
- ❑ The energy and intensity dependent threshold equations are stored in the SMP. Eventually the LHC operated effectively with 2 SBF equations:
 - ‘**normal**’ equation which is the default for regular operation,
 - Threshold: $5E11$ charges @ 450 GeV, $\sim 1E10$ charges @ 6.5 TeV.
 - ‘**setup**’ equation which is used for commissioning, MP setup, validation and many MDs.
 - Constant threshold of $3E11$ charges independent of energy.
- ❑ Parameter is well adapted to the needs, the number of equations could be revised.
 - Message: keep the number of equations to the minimum and the configurations simple.



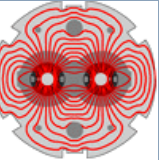
Beam Presence Flag



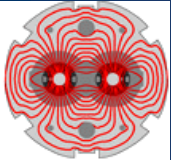
- ❑ The **Beam Presence Flags** (BPF) are used for beam injection in the SPS extraction master BICs in BA4 and BA6.
 - In combination with SBFs of SPS & LHC and the SPS Probe Beam flag.
- ❑ After initial issues with thresholds and reliability of the fast BCT, the BBQ based solution of BI worked remarkably well during Run 2.
- ❑ Parameter is well adapted to the needs and reliable.



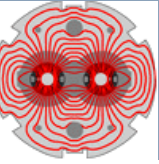
Safe Squeezing Parameters ($= \beta^*$)



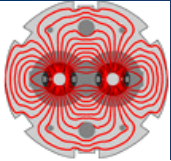
- ❑ The **Squeezing Factors** (SF) were introduced at the start of LHC operation.
 - During MP reviews some persons brought up the risk for operation to declare stable beams with an ‘illegal’ / ‘un validated’ optics → SFs that are fed into the SSB and MDA flags.
 - Quite a crazy concept viewed from operation, given the work required to prepare a configuration.
- ❑ Within the LHC MP, the SFs are used for collimator gap interlocks.
 - Provide independent protection from the standard LVDT interlocks.
- ❑ The SF values are constructed by the LHC SIS (= high level JAVA software).
 - This situation will not change in Run 3/4, the reconstruction becomes in fact more complicated due to the many optics variants that are considered.
 - For Run 3 either LHC SIS or a new LHC state tracker will ‘produce’ the values.
- ❑ With such an important software involvement to define the numerical values, the SMP ‘safety’ function is limited to ensure that values set in the timing are consistent with the SMP state.
 - Are we just ‘safe washing’ those values by passing through SMP?
 - Initially the SFs were directly set in the LHC timing system by SIS without the detour through SMP.
- ❑ Parameters are well adapted to the needs and very reliable given the heavy SW involvement, we could **revise the need to pass through SMP** (which does not harm per se).
 - A **limitation arising from the LHC timing system** is the **maximum value of $\beta^* \sim 650$ m** that can be transmitted for 1 cm granularity – limitation lifted with White Rabbit?



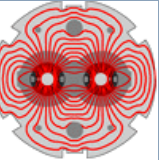
Safe Stable Beam and Movable Devices Allowed Flags



- ❑ The **Safe Stable Beam** (SSB) and **Movable Devices Allowed** (MDA) flags are used only for the LHC experiment protection.
 - SSB flag is used to switch on the full detector including the most sensitive sub-detectors,
 - MDA flag is used for the interlock conditions of Roman Pots and LHCb VELO.
- ❑ Both flags use a combination of:
 - LHC mode,
 - Safe energy,
 - Safe squeezing factors.
- ❑ The only change that is foreseen is the suppression of the ‘Unstable Beams’ mode during Run 3, which is used in the MDA flag.
- ❑ Parameters are well adapted to the needs and reliable.



Max Bunch Intensity Parameter



- ❑ The need of a **Maximum Bunch Intensity** parameter (per beam) has been put forward as a new SMP parameter for interlocking certain operational configurations considered for Run 3.
 - ‘So-called TCDQ luminosity levelling’ → protection of the TCDQ (distance to beam for given peak bunch intensity).
- ❑ But so far **no complete end-to-end interlocking strategy has been worked out** for those scenarios, relying again on software (SIS etc) to implement the interlocks would make a ‘Safe Maximum Bunch Intensity’ parameter potentially an overkill.
- ❑ OP would recommend to wait for a consistent operation and interlocking strategy / need before considering such a new parameter for the SMP.