

SPS beam for LHC upgrade (1/4)

Boundary conditions

- **LHC upgrade scenario:** 50 ns spaced, long flat bunches with 5×10^{11} pp/bunch (*F. Zimmermann et al, 2006*)
- **PS:**
 - 72 bunches with 1.3×10^{11} pp/bunch with 0.35 eVs at 25 ns or
 - 2.6×10^{11} pp/bunch with 0.7 eVs at 50 ns distance
- **PS2:**
 - 144 bunches with 2.2×10^{11} (PS2 parameter list, *M. Benedikt, 07/24/2007, <https://paf-ps2.web.cern.ch/paf-ps2/>*)
 - 168 bunches with 3.6×10^{11} at extraction (*Comparison of Options for the Injector of PS2, R. Garoby et al., CERN-AB-2007-014*)

SPS beam for LHC upgrade (2/4)

Large longitudinal emittance in the LHC (4 - 5 eVs) → merging of bunches in the longitudinal plane: (twice longitudinal emittance)

in the PS:

- ⊕ OK at high energy for space charge, manipulations at low energy
- ⊖ Probably extra RF system (20 MHz)
- ⊖ More voltage for extraction to the SPS (4 times) into 200 MHz RF system or new, low frequency, capture RF system in the SPS
- ⊖ More voltage for acceleration in the SPS

in LHC:

- ⊕ done where needed, no extra RF for capture and acceleration
- ⊖ but two extra low frequency RF systems ⊖ beam losses due to manipulations with high intensity beam

→ in the SPS?

SPS beam for LHC upgrade (3/4)

What and when can be done in the SPS

- Bunch merging (in phase)
 - ⊕ no additional emittance blow-up, can be well controlled
 - ⊖ need at least two additional RF systems (20 MHz and 40 MHz) → problems with beam stability (small bunches in large bucket and extra impedance)
- Momentum slip stacking
 - ⊕ Probably can be done with existing 200 MHz RF system → simulations and MDs
 - ⊖ Leads to larger emittance (factor 3?) and probably more losses

SPS beam for LHC upgrade (4/4)

When in the SPS?

- Losses at low energy are less critical
- Large emittance is needed for beam stability $\varepsilon \propto \sqrt{N_b}$
- Manipulation time $\propto \eta$ for fixed $\delta p/p$

→ As soon as possible

- more voltage for acceleration in the SPS but less at capture in the LHC (in comparison with slip stacking on the flat top)

SPS Upgrade - studies and prototyping: Activities (1/2)

Goal of the PAF-SPSU Study Team: to issue in 2010 a Design Report describing the proposed actions and their estimated cost and planning

- **Future intensity increase:**
 - beam control, transverse damper, RF power
 - SPS impedance: studies, MDs, lab measurements
 - SPS vacuum chamber upgrade (as a remedy against e-cloud): studies, MDs, measurements, tests in the lab...
 - upgrade of different equipment: beam dump, instrumentation...
 - beam loss and radiation

SPS Upgrade - studies and prototyping: Activities (2/2)

- Beam production for LHC upgrade scenario:
 - momentum slip stacking
 - new RF systems for bunch merging
- Future injection energy increase (with PS2)
 - injection kicker upgrade
 - transfer line
- Future change of FT/CNGS beam structure (with PS2)
 - MKE rise time reduction
 - RF upgrade
- Future extraction energy increase (new ring...)?

SPS Upgrade: Work in the RF Group (1/2)

LHC Upgrade Scenarios - preliminary estimations of the RF systems

T.Linnecar, E.,S., J. Tuckmantel, AB-Note-2006-042 RF, 2006

- Improvements control of beams

in White Paper, theme 1:

The highest priority is "to fully exploit the physics potential of the LHC", and therefore "to complete the initial programme such that the machine and experiments can operate optimally at their design performance"

- For the consolidation and improvements to enhance the luminosity in the short term

- SPS (and PS) longitudinal feedback (wideband)
- Transverse damping system upgrade (double existing system by adding same)
- Double power of 800 MHz RF system

- Extention of the "limited consolidation programme"

SPS Upgrade: Work in the RF Group (2/2)

- Improved capture systems SPS and LHC
 - in White Paper, theme 3: "advanced accelerator and detector R&D programme to prepare for an LHC upgrade in luminosity"
 - for the increased LHC luminosity, 160/240 MHz RF system in the SPS
 - these RF systems were needed for scenario with 12.5 ns bunch spacing in the LHC
- Power upgrade of the 200 MHz RF system + extra RF system(s) if needed

More information after "enlarged" (DG, Department Leaders and Project Leaders) PAF working group meeting on 12 September 2007 to refine the detailed content of the relevant White Paper activities