

# PS upgrade: setting the scene

S. Gilardoni  
CERN- BE/ABP

for PS-upgrade study group

LIU Event 01/12/2010



# PS upgrade

## - *Mission of the LIU Project*

“The LHC Injectors Upgrade should plan for **delivering reliably to the LHC the beams required for reaching the goals of the HL-LHC**. This includes LINAC4, the PS booster, the PS, the SPS, as well as the heavy ion chain.”

How this is interpreted for the PS:

- **Evaluate the current performances of the PS for the production of the LHC beams**
  - Determine bottlenecks related to existing hardware
  - Determine beam dynamics bottleneck wrt HL-LHC requests
- **Determine the performances of the PS in the Linac4 era with or without an injection energy upgrade**
  - Determine bottlenecks related to beam dynamics
  - Evaluate the performances with a 2 GeV injection energy
  - Determine the HW changes required with or without the injection energy upgrade
  - Determine if different RF-PS filling scheme can be used

**performances means: transverse emittances, bunch-to-bunch intensity variation, bunch-to-bunch longitudinal characteristics variation...**



# LIU-PS organisation (not all included yet...)

Workpackage	Resp.	Unit
Beam dynamics	G. Rumolo	BE/ABP
Magnets	D. Bodart	TE/MCS
RF systems (LL)	H. Damerau	BE/RF
Power Converters	S. Pittet	TE/EPC
Vacuum	P. Chiggiato	TE/VCS
Commissioning/operation	G. Metral/ R. Steerenberg	BE/OP
Injection	J. Borburgh	TE/ATB
RP and Safety	M. Widorski	DGS/RP
Survey	T. Dobers	BE/ABP
Instrumentation	S. Bart Pedersen	BE/BI
RF systems (HL)	C. Rossi	BE/RF

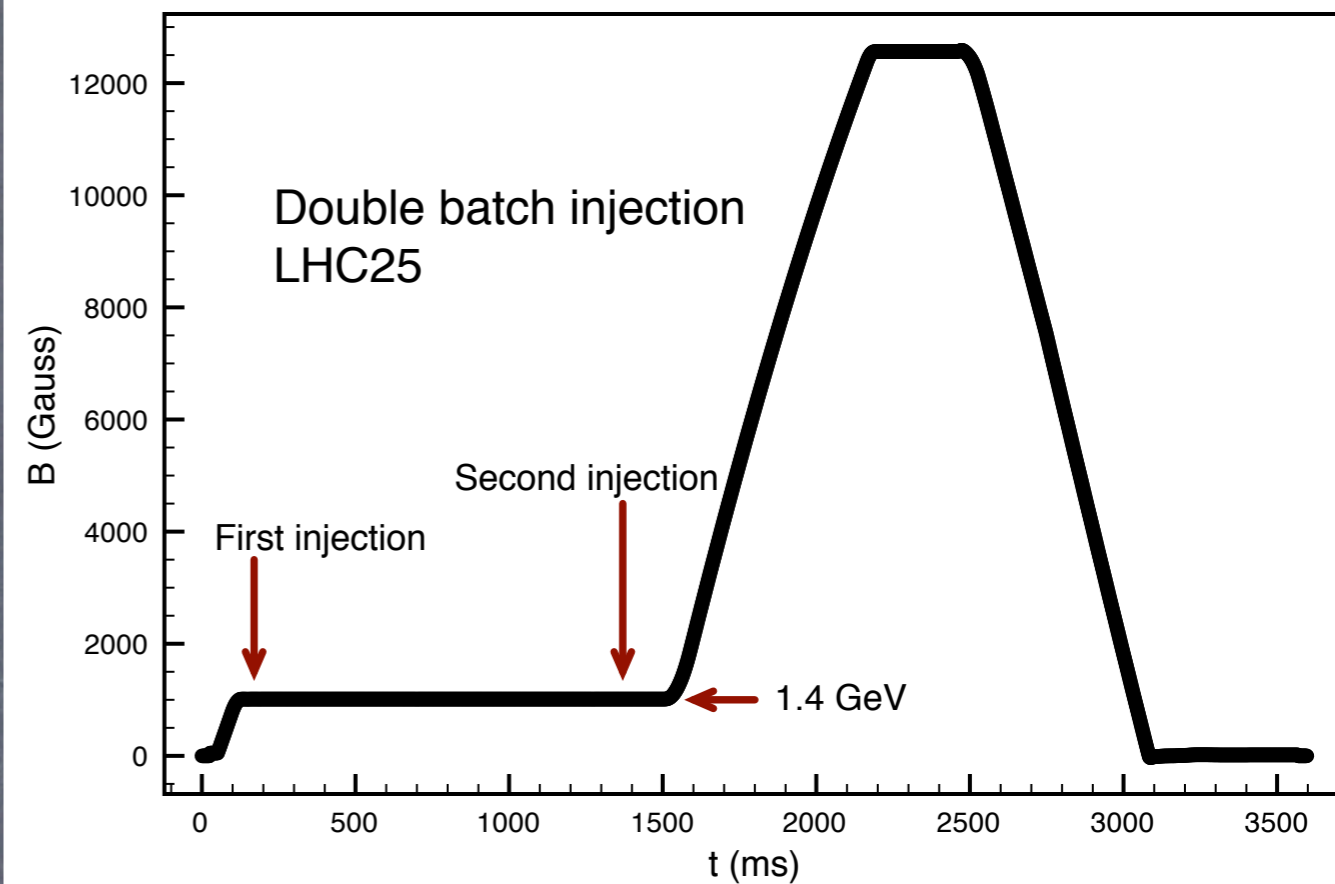
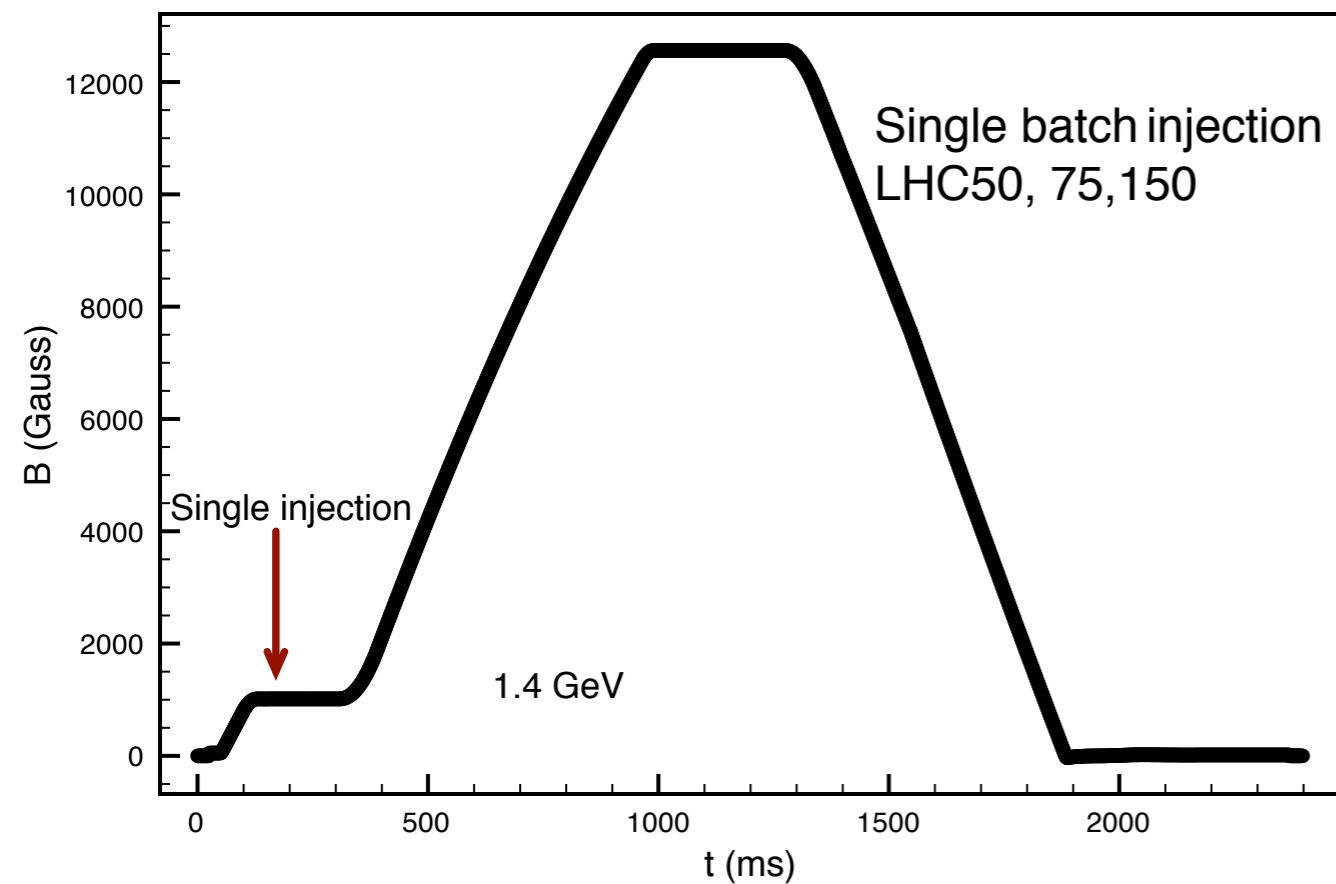


# The role of the PS in the LHC beam production

- **Conserve the transverse emittances produced in the PSB:**
  - Causes of blow-up:
    - Laslett tune shift due to space charge:  $< 0.3$  but recent measurements show that the machine has some margin. **TO BE STUDIED** (see Giovanni slides).
      - Blow-up of first batch waiting for the second batch injection
      - **Can be beaten by increasing the injection energy**  
(Chamonix 2009 proposal from M. Giovannozzi, reason of the previous PSB extraction energy upgrade from 1 to 1.4 GeV)
    - Injection mis-steering/oscillations
    - other effect discussed more in detail later by Giovanni: head-tail instability at injection energy, TMCI at transition crossing, electron cloud at extraction
- **Define the longitudinal structure of the beam**
  - 25-50-75-150 ns bunch spacings are defined by RF gymnastics in the PS (see Heiko slides)
  - longitudinal beam quality can be spoiled by: coupled bunch instability, transient beam loading...



# Excursus on LHC beam production



Depending on the bunch spacing or the intensity per bunch, the LHC beams are produced taking one or two extractions from the PSB.

Today: LHC50, 75, 150 ns produced with single injection  
LHC25 produced with double batch injection (4+2 PSB rings)

The upgrade of the injection energy at 2 GeV would be needed for the beams produced with double batch injection



# What we have to do in 2011

- **Estimate performance with Linac4 as a function of PS injection energy**
- **MDs to evaluate current beam best performances:**
  - to be organised immediately at the start of the run
  - **Understand current machine limitations: in general the LHC beams were provided with better performances wrt to the original design**
  - **Decide if we want to go to 2 GeV or not**
- **MDs to evaluate the existing HW performances at 2 GeV**
  - orbit correctors and low energy quadrupoles
- **Determine the impact on the ring irradiation in case of the energy upgrade**
- **Simulation studies, both for RF as for transverse plane to understand beam performances**
- **Review mandatory consolidation for long term **reliable** operation with respect to possible upgrades**
- **Define the HW changes for the 2 GeV case but also in case of no upgrade to 2 GeV together with **planning and resources****
- **Start to build/test anything?**
  - a part of the upgraded studies might bring in short time to HW modifications that can help already in the production of the existing beams



# Where we are ?

- **First series of MDs already done simulating a large Laslett tune shift**
  - results quite encouraging but more systematic measurements should be taken
- **First analysis of collective effect limitations ongoing (see Giovanni slides)**
- **First analysis of the RF limitations, HL and LL, ongoing (see Heiko slides)**
- **First analysis of the HW changes required for the upgrade to 2 GeV already done also in the framework of the PSB task force**
  - Injection region should be completely rebuilt (septa/bumpers), design progressing, test on the injection kickers done
  - doubts about magnets/power converters used at injection
  - implementation of increase of the shielding on top of the route Goward.  
Analysis of the 2 GeV upgrade on the radiation budget done  
Some actions must be taken already during the next long shutdown
- **Review of the beam instrumentation started**
  - the tendency for the upgrade is to produce small emittances: better precision required in the measurements
  - old definition of the LHC beams was done with zero losses between machine transfer: today we know we are loosing but do not know precisely how much
- **Request for an operational transverse damper**



# What about the other beams?

- The non-LHC type beams could profit from the an eventual injection energy upgrade but:
  - due to the higher injection energy the losses should be reduced by more than the ratio between the energies to reduce the impact of the irradiation on the equipments and, eventually, outside the tunnel
  - there is still no technical solution found to inject high intensity/ large emittance beams at 2 GeV. It might be easier/better to inject at a different energy between 1.4 and 2 GeV
  - some gain should be produced by the reduced physical emittance
- Current approach:
  - the performances of the non-LHC beams should be equal to the current ones after the upgrade



# Outlook

- The PS upgrade related activities just started, profiting from what has been done in the PSB Upgrade task force
- A lot of work has to be done to assess the current and the future performances of the machine, in particular to be able to predict the performances once the Linac4 will be available and once the HL-LHC beam requirements will be better defined
- The planning and resources should be organised to meet the deadline of HL-LHC (2017 start-up)