

# HL-LHC beam parameters at injection

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# Beam and machine parameters: SPS

- Q20 optics ( $\gamma_t = 18$ )
- Assumed longitudinal particle distribution (reconstructed without intensity effects from the best fit to measured bunch profiles at 450 GeV):

$$F(J) = (1 - J/J_0)^{3/2}$$

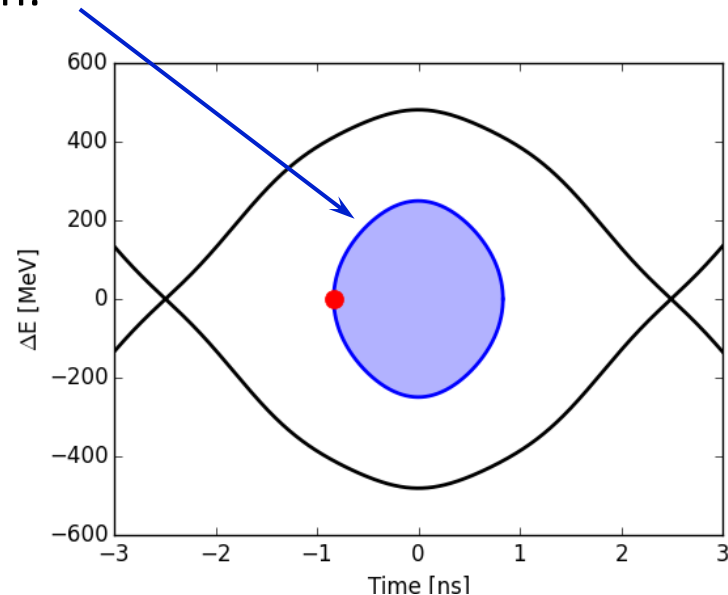
- Impedance used in simulations:  $\text{Im}Z/n = 3.5 \text{ Ohm}$
- Two cases considered:
  1. Target bunch length  $\tau = 1.67 \text{ ns}$  ( $4\sigma$  Gaussian fit as used now in measurements)  
→ Max  $N_b = 2.0 \times 10^{11}$ , with  $V_{200} = 11.5 \text{ MV}$  (estimated value taking into account beam loading for 25 ns beam) and  $V_{800} = 1.15 \text{ MV}$ . Bunch length of 1.67 ns is obtained for beam induced voltage with  $\text{Im}Z/n = 3.5 \text{ Ohm}$ .
  2. Target intensity  $N_b = 2.3 \times 10^{11}$   
→ Min bunch length = 1.83 ns, with  $V_{200} = 10 \text{ MV}$ ,  $V_{800} = 1.0 \text{ MV}$

# Beam and machine parameters: HL-LHC

- 450 GeV/c
- $\gamma_t = 53.789$
- $V_{400} = 8$  MV
- Longitudinal impedance:  $\text{Im}Z/n = 0.11 \Omega$
- Two cases considered at injection (1<sup>st</sup> turn):
  - $N = 2.0 \times 10^{11}$ ,  $\tau = 1.67$  ns
  - $N = 2.3 \times 10^{11}$ ,  $\tau = 1.83$  ns

# Beam parameters: definitions

- Full bunch length  $\rightarrow$  3 methods used:
  - Gaussian fit ( $4\sigma_t$ ),
  - 4 x rms,
  - $\frac{2}{\sqrt{2 \ln 2}}$  FWHM.
- From the trajectory of a particle with a synchrotron oscillation amplitude corresponding to the full bunch length:
  - $\rightarrow$  Energy spread  $\Delta E$  (maximum)
  - $\rightarrow$  Emittance (area)



# Beam parameters at SPS/LHC transfer

		SPS at extraction LHC 1 <sup>st</sup> turn			LHC after capture (after ~100ms)		
$N_b$		Gaussian fit	rms	FWHM	Gaussian fit	rms	FWHM
$2.0 \times 10^{11}$	Bunch length [ns]	1.670	1.582	1.712	1.316	1.281	1.332
	Energy spread [ $10^{-3}$ ]	0.536	0.514	0.547	0.705	0.691	0.712
	Emittance [eVs]	0.610	0.555	0.637	0.636	0.607	0.649
$2.3 \times 10^{11}$	Bunch length [ns]	1.830	1.737	1.877	1.391	1.386	1.411
	Energy spread [ $10^{-3}$ ]	0.535	0.513	0.543	0.735	0.733	0.743
	Emittance [eVs]	0.665	0.606	0.689	0.698	0.693	0.714