DISCUSSION ABOUT A 3-BATCH INJECTION SCHEME IN THE PS FOR LHC BEAMS

NOMINAL 25 ns IN PS

- **4b + 2b = 6b from PSB on h7 (~ 1.6E12 p/b) within ~ 2.5 µm**

- **Bunch length ~ 180 ns in 327 ns RF bucket (long. emitt. ~ 1.3 eVs)**

- **6b × 3 = 18b on h21 at inj.**

- **Acceleration on h21**

- **18b × 2 × 2 = 72b on h84 at ext.**

- **Cycle lasts 3.6 s and we have to wait ~ 1.2 s at inj.**

- **The nominal 25 ns beam is not yet at the space charge limit**

  - **Where is the space charge limit?**

  - **Could also play with RF voltage and/or longitudinal profile (flattening it) to reduce SC => New limit?**

NEW 25 ns SCHEME?

- **3 × 4b = 12b from PSB on h14 (~ 0.8E12 p/b) within ~ 2.5 / 2 ~ 1.2 µm and ~ ½ nominal long. emitt.?**

- **Bunch length ~ 70 ns? (limited by PSB recombination kickers' rise times of ~ 95 ns) in 327 / 2 = 163.5 ns RF bucket => SC more critical by 180 / 70 = 2.5 at PS injection => Several ways to reduce it (see later)**

- **2-bunch merging to have 6b on h7 and come back to the nominal scheme => Then same thing as usual**

- **Cycle lasts 4.8 s (+ 33%) and we have to wait ~ 2.4 s at inj. => Check in detail the time needed for the 2-bunch merging**

- **Could consider some options to try and reduce the cycle length if needed**

NEW 50 ns SCHEME?

- ◆ **3 × 4b = 12b from PSB on h14 (~ 0.4E12 p/b) within ~ 2.5 / 4 ~ 0.6 μm**

- ◆ **Then, same things as for the 25 ns scheme**

ISSUES? (1/2)

- **Production of required bunch length at PSB extraction (assumed to be ~ 70 ns for PSB recombination kickers' rise times of ~ 95 ns):**

  - **Can we do that? => Does not seem impossible at first sight and is being followed up by AlanF at the moment (will do some tests in the PSB) => Certainly with re-bucketing in h2 (with only 1 bunch)**

- **PS inj. kicker rise-time => Seems to be ~ 95 ns (see below)**

- **SC at PS injection => Could be fought by**

  - **Playing on the longitudinal profile (flattening it in the PSB?)**

  - **Increasing the bunch length in the PS (matched/unmatched?)**

  - **Increasing the PSB extraction energy between 1.4 and 2 GeV (Gain factor ~ 1.6 at max.)**

  - **If not enough, could slightly lower the transverse beam brightness in the PSB (but then we would gain less than a factor 2!)**

frev	437358				
h	frf	Trf [ns]	taub [ns]	deltaT [ns]	
8	3498862	286	190	96	This case was said to be OK in the past => We can assume ~ 95 ns for the PSB recombination kickers
7	3061504	327	232	95	In this case ~ 232 ns could be OK
9	3936220	254	160	94	In this case the bunch length should be reduced to ~ 160 ns
14	6123009	163	70	93	In this case the bunch length should be reduced to ~ 70 ns
What about the PS injection kicker rise-time?					
I found a similar value of ~ 95 ns in the LHC Design Report in Chapter 5.3.3 (to be checked) => Does not put another constraint on the bunch length					

ISSUES? (2/2)

◆ **If we could increase the bunch length at PS injection it would help => What is the maximum we can do?**

◆ **Of course, if the PSB recombination and PS injection kickers rise times can be reduced it would also help…**

CONCLUSION

- **This new scheme uses the current LINAC2/PSB machines**

- **Possible use with LINAC4 being studied by ChristianC**

- **It should be linked to a PSB energy upgrade (between 1.4 and 2 GeV, exact energy to be determined)**

- **Going to 2 GeV bring a factor 1.6 in brightness => Can allow a factor 1.6 increase at PS injection at 1.4 GeV compared to the space charge limit (which still needs to be determined properly)**

- **For intensities larger than nominal the same result should be obtained (considering only space charge) as the beam brightness (intensity to emittance ratio) would be ~ constant => For instance, ~ 2E11 in ~ 2.5 microm for 25 ns and ~ 3E11 in ~ 2 microm for 50 ns**

THANKS

- **AlanF, BettinaM, ChristianC, GabrielM, GianluigiA, GiovanniR, HeikoD, MassimoG, OliverB, RendeS, SimoneG, SteveH**

- **RolandG's talk at the OMCM2011's workshop**