Some ideas for/from the SPS

LIU-SPS team

Scrubbing (only) for ecloud in SPS?

- aC coating remains baseline.....
  - but scrubbing has many potential advantages compared to aC coating, in terms of work, risk, radiation, vacuum, ...
  - and we have to make scrubbing work for LHC
- Some “exotic” ideas for scrubbing (JMJ, GA, BG, KC, ES) – some maybe also interesting for LHC
  - Filling SPS, with 8 batches of 25 ns beam, at 26 GeV/c
  - 5 ns spacing for scrubbing with high (nominal?) bunch intensity
  - “Slip-scrubbing”, using longitudinal displacement as proposed for bunch merging to sample all bunch spacings (but maybe poor duty cycle), or recapture to give 5+20 or 10+15 ns spacing
  - Deliberate deregulation of PS splitting to increase odd-even bunch intensity modulation, and enhance ecloud
  - Deliberate presence of 5-10% of uncaptured beam, seen in past to enhance ecloud effect
- Many potential issues for the different ideas...
- Filter, then simulations and MD of most promising ideas
- Deadlines for aC coating decision...

longitudinal transfer SPS -> LHC?

- Longer bunches at transfer?
  - Need to blow up longitudinal emittance in SPS to overcome longitudinal coupled bunch instabilities
  - Also expect longer bunches at transfer for low gamma T optics
- Increases capture losses in LHC - what are allowable limits?
  - Determined by injection losses and beam loss on collimators at start of ramp
- Should consider all mitigation measures
  - Abort gap/injection cleaning
  - Injection BLM sunglasses
  - BLM thresholds and shielding
- May be possible to significantly increase present limits, (although anyway with 25 ns some degradation is expected)
- Other routes?
  - 400 MHz in SPS or buncher cavities in TLs do not seem feasible.
  - 200 MHz in LHC?
  - Bunch by bunch longitudinal damper in SPS/LHC?
  - Identification and removal of impedance sources?

Other ideas?

- **Bunch merging in SPS/LHC**: if limited by single bunch intensity at 26 GeV/c or injectors for 50 ns (Elena)

- **Different working points;** mitigate resonance crossing from space charge/eCloud – being studied in context of Q20 optics, plus Q26 (Hannes/Yannis/Benoit)

- **Low gamma T (as a universal panacea)**: increase instability thresholds...still many issues to address (multibunch, RF volts, longitudinal transfer to LHC, ...) (Hannes/Yannis)

- **Alternative filling patterns for LHC if limited by total SPS current**: e.g. 3 batches with 4/3 bunch intensity gives ~60% better luminosity in LHC, assuming 2592b can be injected c.f. 2808

reserve

Known SPS limitations

- RF power (beam loading). **Total SPS intensity** to between 2.2 and 2.9 A (1.7 – 2.3 e11 for 25ns, 3.0 - 4.0 e11 for 50 ns). This performance available after 2018 LS2
- eCloud: badly affects **25 ns beam** With mitigation hope to remove effect for "much higher" 25 ns bunch intensities (value?). For 50 ns beam should be possible to scrub with 25 ns and not be limited (signal x10 lower for same bunch intensity). HBW FB to combat eCloud instability, but not incoherent emittance growth (is this well understoof in simulation?)
- **TMCI**: 1.6e11 for Q26 and 3e11 for Q20 (~zero Q'). Other mitigation includes HBW FB and higher chromaticity (plus ongoing impedance effort)
- **Emittance/intensity**. 2010 Q26 assumed to be ε [um] $\approx 2\times$N[e11] – 1. 2011 measured only with Q20 optics: find ε [um] $\approx 0.8\times$N[e11]. Would imply 1.6 um for 2e11 per bunch, or 2.7 um for 3.5 e11
- **Heating of MKE kickers**: should be "cured" after LS1. Other mitigation includes running with lower duty cycle LHC beam except for LHC filling
- **Longitudinal coupled bunch instability** (onset 2e10 p+/b) requires 800 MHz system for Landau damping, plus controlled emittance blowup through cycle. Very delicate – not obvious that larger emittance can improve. May improve with Q20 but needs more voltage. Could be important limitation – 200 MHz in LHC, or HBW long damper in LHC.

2011 news from MD

- **Nominal 25 ns** beam 4 batches accelerated to 450 GeV with low losses and about **1.15e11, 2.5 – 2.8 um.** Latest MD results without strong indications of eCloud – WS results checked since and confirmed.
- **DB 50 ns** accelerated to 450 GeV, **1.6e11 p+/b and 2 um**, 4 batches, low capture losses (3%) - eCloud seen (<25 ns).
- **SB 50 ns** single batch for comparison, 450 GeV, **1.45e11 p+/b, 3 um**, low capture losses (3%).
- Some limitations from (un-serigraphed) MKE heating for 25 ns beam 50% duty cycle. No major issues with ZS.
- **Q20 single bunch** accelerated to 450 GeV, for **3e11 p+, 2 um** (limited by PSB), losses <10 % and longitudinal instability above 2.5e11.
- **Emittance/intensity limit** with Q20, in range 1-3e11 of ε **[um] ≈ 0.8×N[e11]** (not including effect of bunch lengthening). SPS contribution?
- **eCloud**: suppression with **clearing electrode** demonstrated (as for aC), but increased eCloud seen with 50 ns double batch (ultimate current)