Improvements to the SLS Booster Synchrotron Performance Towards SLS 2.0

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• The SLS 2.0 upgrade will reuse the existing booster synchrotron as injector into the new storage ring

• Injections will be performed using two methods:
  a) Off-axis using 4-kicker bump
  b) Single- or few-bunch aperture sharing with short-pulse kicker

• Emittance exchange by coupling resonance crossing in the booster is used to improve injections into the storage ring

• Booster operation has been studied to improve beam quality.
Previously, a substantial transverse coupling coefficient of $|C| \approx 0.02$ was found.

– Decreasing the coupling will help suppress vertical dispersion and emittance sharing.

The SLS booster has sextupole components in all dipole magnets for a rough chromaticity correction + two dedicated sextupole families.

Orbit correction is only done at injection energy and without ramping the corrector pattern.

– Cannot be corrected at maximum beam energy due to insufficient number of BPMs available.

→ The large coupling may stem from vertical beam offsets in sextupoles.
Vertical beam size minimization

- We use the vertical beam size of the extracted beam as indicator for the coupling: 
  \[ \sigma_y = \left( \beta_y \varepsilon_y + \sigma_\delta^2 \eta_y^2 \right)^{1/2} \]

a) Use iterative vertical closed-orbit bumps
b) Use single-corrector adjustments

After minimization:
- Vertical beam size decreased by factor 2
- \(|C| \approx 0.002 \leftarrow\) factor 10 decrease
  - \(|C|\) control by scaling corrector pattern
• Emittance exchange by coupling resonance crossing improved after minimization
• $\epsilon_x \approx 1 \text{ [nm rad]}$ after exchange
• An instability was observed
  – Decreasing $\sigma_y$ leads to increase in centroid jitter
  – Severity increases with bunch change

• At smallest $\sigma_y$ + highest bunch charge the beam could not be extracted
A similar instability was seen during initial commissioning 20 years ago
- Expected due to eddy currents in vacuum chambers
- Fixed by adjusting sextupoles
- But to our knowledge the chromaticities were not checked

Chromaticity was measured by recording the tune changes when shifting the rf frequency \( \delta Q = -\frac{\xi}{\alpha_c f_{rf}} \Delta f \)

We found to be \([\xi_x, \xi_y] = (+7.9, -2.1)\)
Instability encounter and cute

• Sextupole family adjusted to give \([\xi_x, \xi_y] = (+5.5, +4.8)\)
  – Blue triangles: before adjustment
  – Red crosses: after adjustment

• Instability completely gone
  – Injection rate into storage ring increased from 25-30 mA/min to 50 mA/min