# Improvements to the SLS Booster Synchrotron Performance Towards SLS 2.0

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# Introduction

- 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.

# Vertical beam size minimization

- 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.

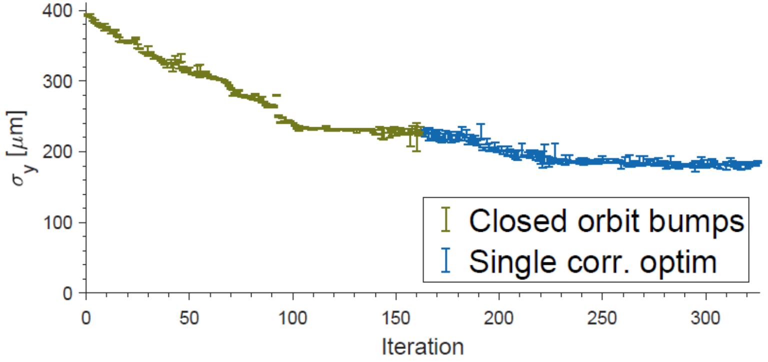
- Orbit correction is only done at injection energy and without ramping the corrector pattern
  - Cannot be corrected at maximum beam energy due to insufficient number of BPMs available

➔ 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: $\sigma_y = \left(\beta_y \epsilon_y + \sigma_\delta^2 \eta_y^2\right)^{1/2}$

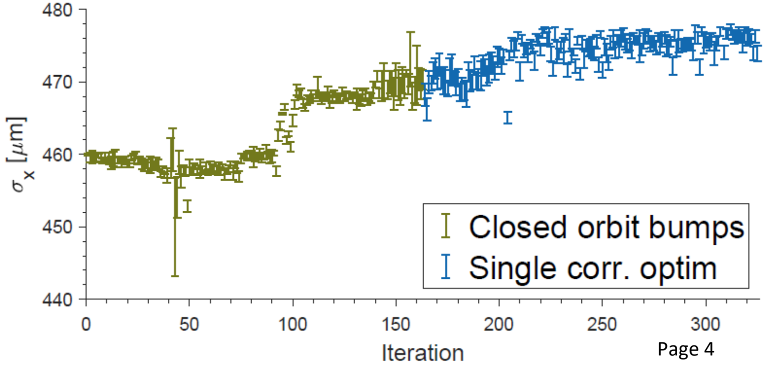
a) Use iterative vertical closed-orbit bumps
b) Use single-corrector adjustments




(a)

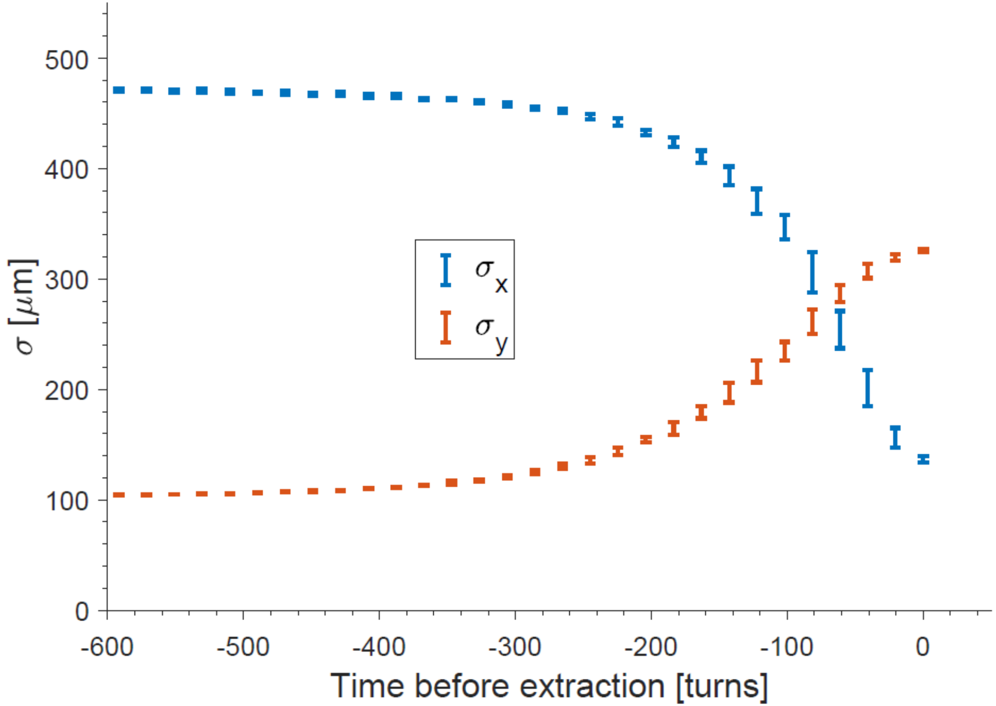
After minimization:

- Vertical beam size decreased by factor 2
- $|C| \approx 0.002$ ← factor 10 decrease
  – $|C|$ control by scaling corrector pattern



# Vertical beam size minimization

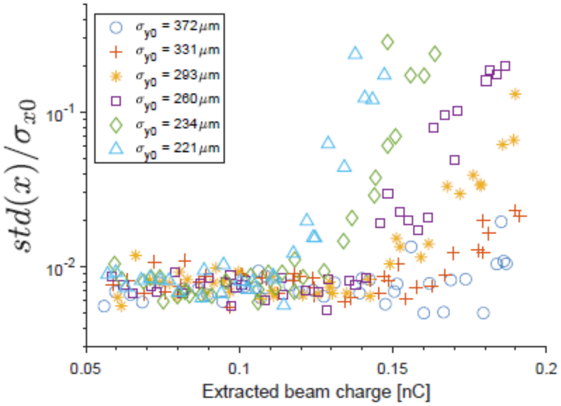
- Emittance exchange by coupling resonance crossing improved after minimization
- $\epsilon_x \approx 1$ [nm rad] after exchange



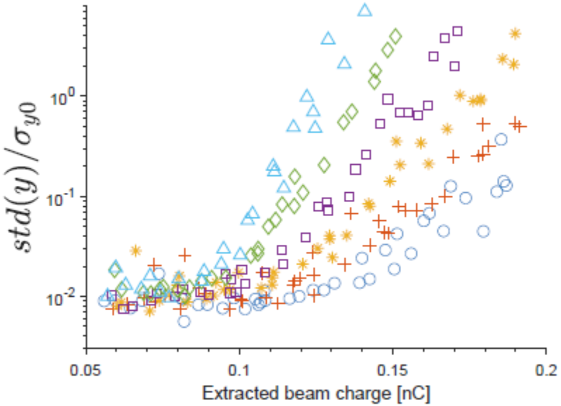
# Instability encounter and cure

- 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)



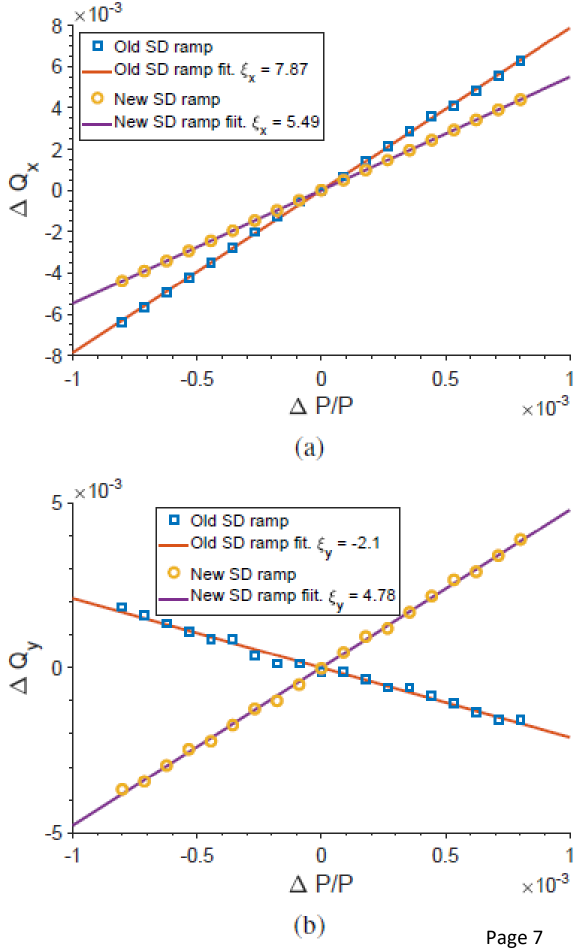
(b)

# Instability encounter and cure

- 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 $\delta Q = -\frac{\xi}{\alpha_c}\frac{\Delta f}{f_{rf}}$

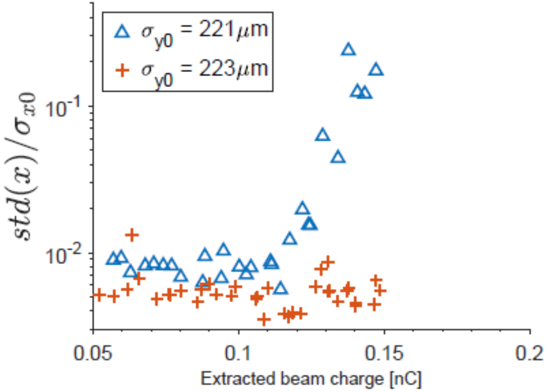
- We found to be $\left[\xi_x, \xi_y\right] = (+7.9, \mathbf{-2.1})$



# 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



(a)