Beam-beam simulations for SuperKEKB Phase-3

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Acknowledgements:
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Outline

➤ Introduction
➤ Tune scan using BBWS
➤ Simulation using BBSS
➤ Summary
# 1. Introduction

## Phase-3 machine parameters (Road map)

- Ref. A. Morita, Talk at SuperKEKB commissioning meeting, Oct. 12, 2018

<table>
<thead>
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<th></th>
<th>1</th>
<th>1ex</th>
<th>2</th>
<th>2ex</th>
<th>3</th>
<th>3'</th>
<th>3ex</th>
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<tbody>
<tr>
<td>I₀ (A)</td>
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<td>1.4</td>
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<td>1.4</td>
<td>1.2</td>
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<td># bunch</td>
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<td>εₓ (nm)</td>
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<td>εᵧ (pm)</td>
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<tr>
<td>νₓ</td>
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<td>2.55E+34</td>
<td>2.55E+34</td>
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</table>
2. BBWS simulation: Tune scan

➢ Parameter set (1)

\[ e^+(W)e^-(S) \]

\[ \text{Lum. (L/L}_0) \]

\[ \pm v_x + 4v_y + 2v_s = N \]

\[ \sigma_y / \sigma_{y0} \text{ (RMS)} \]

\[ e^+(S)e^-(W) \]

\[ \pm v_x + 4v_y + v_s = N \]
2. BBWS simulation: Tune scan

Parameter set (1ex)

\[ e^+(W)e^-(S) \]
Lum. \( (L/L_0) \)

\[ \sigma_y/\sigma_{y0} \text{ (RMS)} \]
2. BBWS simulation: Tune scan

➤ Parameter set (2)

\( e^+(W)e^-(S) \)

Lum. \((L/L_0)\)

\( \sigma_y/\sigma_{y_0} \) (RMS)
2. BBWS simulation: Tune scan

Parameter set (2ex)

\[ \frac{e^+(W)e^-(S)}{\text{Lum. (L/L_0)}} \]

\[ \frac{\sigma_y}{\sigma_{y0}} \text{ (RMS)} \]

\[ \frac{e^+(S)e^-(W)}{\text{Lum. (L/L_0)}} \]

\[ \frac{\sigma_y}{\sigma_{y0}} \text{ (RMS)} \]
2. BBWS simulation: Tune scan

Parameter set (3)

\[
\begin{align*}
\sigma_y / \sigma_{y0} \text{ (RMS)} & \\
e^+(W)e^-(S) & \quad \text{Lum. (L/L_0)} & \\
\end{align*}
\]
2. BBWS simulation: Tune scan

➤ Parameter set (3')

\[ e^{+}(W)e^{-}(S) \]

\[ \text{Lum. (L/L}_0) \]

\[ \sigma_y/\sigma_{y0} \text{ (RMS)} \]
2. BBWS simulation: Tune scan

➤ Parameter set (3ex)

\[ \sigma_y / \sigma_{y0} \text{ (RMS)} \]

\[ \text{e}^+ (W) \text{e}^- (S) \]

\[ \text{Lum.} \ (L/L_0) \]

\[ \text{e}^+ (S) \text{e}^- (W) \]
2. BBWS simulation: Tune scan

➤ Parameter set (3ex)

\[ e^+(W)e^-(S) \]

Lum. \( (L/L_0) \)

\[ \sigma_y/\sigma_{y0} \text{ (RMS)} \]

\( \nu_x+k^*\nu_s=N \) shifted as expected when changing \( \nu_s \).

BUT resonance lines of \( \pm \nu_x+4\nu_y+C=N \) NOT shifted?
3. BBSS simulation

- All parameter sets: Luminosity
  - Working point: LER (44.57, 46.61), HER (45.57, 43.61)
3. BBSS simulation

➢ All parameter sets: Hor. beam size
  ● Working point: LER (44.57, 46.61), HER (45.57, 43.61)
  ● Typical x-z instability studied by K. Ohmi et al.
3. BBSS simulation

- All parameter sets: Ver. beam size
  - Working point: LER (44.57, 46.61), HER (45.57, 43.61)
3. BBSS simulation

Parameter set (3ex): Equal $v_s$ for e+ and e- beams

- Working point: LER (44.57, 46.61), HER (45.57, 43.61)
- $v_s(e+) = v_s(e-) = 0.0225$
3. BBSS simulation

- Parameter set (3ex): Equal $v_s$ for $e+$ and $e-$ beams
  - Working point: LER (44.57, 46.61), HER (45.57, 43.61)
  - $v_s(e+) = v_s(e-) = 0.0225$
4. Summary

➤ Tune scan using BBWS
  ● Good lum. region around (.57, .61) as Phase-2
  ● The “sweat” area get smaller from Param. set 1 to 3 ex
  ● Near the (.57,.61) working point, the beam-beam resonance $v_x+4v_y+C=N$ is strong. BUT, what is $C$? NOT correlated to $v_s$! Correlated to beam-beam tune shift?

➤ Simulations using BBSS
  ● x-z beam-beam instability are not seen in BBWS simulations, but seen in BBSS simulations at (.57, .61)
  ● Cure #1: Squeezing $\beta_x$* as suggested by K. Ohmi
  ● Cure #2: Equalizing $v_s$ of e+ and e- beams? Possible? How necessary?
  ● Cure #3: Shifting $v_s$. $v_x+3v_s=N$ is important? To be checked.

➤ Future work
  ● Optimizations of key parameters: $(I_{bunch}, \beta_{x,y}^*, v_x, v_y)$ for HER and LER => More beam-beam simulations
2. BBWS simulation: Tune scan

Parameter set (3ex): rms $\sigma_x$