Beam-beam simulations for SuperKEKB Phase-3

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Acknowledgements:
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Outline

➤ Introduction
➤ Simulation using BBWS and BBSS
➤ Summary
1. Introduction

➤ Phase-3 machine parameters (Road map)

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

<table>
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<tr>
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<th>1</th>
<th>1ex</th>
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<th>3</th>
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<tbody>
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<td>( l_0 ) (A)</td>
<td>1.0</td>
<td>1.2</td>
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<td>1.4</td>
<td>1.0</td>
<td>1.4</td>
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<tr>
<td># bunch</td>
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<tr>
<td>( \varepsilon_x ) (nm)</td>
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<td>4.6</td>
<td>2.0</td>
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<td>( \varepsilon_y ) (pm)</td>
<td>368</td>
<td>160</td>
<td>230</td>
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<td>138</td>
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<td>( \beta_x ) (mm)</td>
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<td>( \beta_y ) (mm)</td>
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<td>( \sigma_z ) (mm)</td>
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<td>6</td>
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<tr>
<td>( \nu_x )</td>
<td>45.57</td>
<td>44.57</td>
<td>45.57</td>
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<tr>
<td>( \nu_y )</td>
<td>43.61</td>
<td>46.61</td>
<td>43.61</td>
<td>46.61</td>
<td>43.61</td>
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<tr>
<td>( \nu_s )</td>
<td>0.0258</td>
<td>0.0225</td>
<td>0.0258</td>
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<tr>
<td>( \xi_y ) (Geom.)</td>
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<td>0.0328</td>
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<td>( \lambda ) (Geom.)</td>
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<td>( \lambda ) (BBSS)</td>
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<td>2.16E+34</td>
<td>2.52E+34</td>
<td>2.55E+34</td>
<td>3.21E+34</td>
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2. BBWS simulation: Tune scan

Parameter set (1)

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

Talk on Dec. 13, 2018
2. BBSS simulation

➤ All parameter set (1): $\nu_y = \ast .61$

- Scan of $\nu_x$ (same fractional part for LER and HER)

Beam sizes for $\nu_s^+ = .0225$, $\nu_s^- = .0258$
2. BBSS simulation

- All parameter set (1): $v_x = * .56$
  - Scan of $v_y$ (same fractional part for LER and HER)
  - Beam very unstable for $v_y < * .53$

Beam sizes for $v_{s+} = .0225$, $v_{s-} = .0258$
2. BBSS simulation

➤ All parameter set (1): $v_x = 0.56$
  - Scan of $v_y$ (same fractional part for LER and HER)
  - Beam very unstable for $v_y < 0.53$

$\sigma_y/\sigma_{y0}$ (RMS)

Beam sizes for $v_{s+} = 0.0225$, $v_{s-} = 0.0258$
2. BBSS simulation

➤ All parameter set (1): $\nu_y = * .61$

- Scan of $\nu_x$ (same fractional part for LER and HER)

Change parameters:
$\beta_{x+}^* = 0.1 \text{ m} \to 0.23 \text{ m} \text{ (equalize } \sigma_y^*)$
$\varepsilon_y = 0.368 \text{ nm} \to 0.16 \text{ m} \text{ (equalize } \sigma_x^*)$

Beam sizes for $\nu_{s+} = .0225$, $\nu_{s-} = .0258$
2. BBWS simulation: Tune scan

- Parameter set (3ex)

**e+(W)e-(S)**

**Lum. (L/L₀)**

**σ_y/σ_y0 (RMS)**

Talk on Dec. 13, 2018
2. BBSS simulation

- All parameter set (3ex): $v_y=*.61$
  - Scan of $v_x$ (same fractional part for LER and HER)

Beam sizes for $v_{s+}=.0225$, $v_{s-}=.0258$
2. BBSS simulation

- All parameter set (3ex): $\nu_y = * .61$
  - Synchro-beta resonances are wider in BBSS simulation than in those in BBWS?
  - The luminosity slope (black arrow) can be explained in BBWS sim.

Beam sizes for $\nu_{s+} = .0225, \nu_{s-} = .0258$
3. Summary

➤ On parameter set (1)
  ● e- beam is weaker than e+ beam
  ● Beam-beam instabilities seen in BBWS simulations are always seen in BBSS simulations (It should be true)
  ● Beam-beam instabilities only seen in BBSS simulations can be questionable (numerical noise or true physics?):
    * \( v_x - 3v_s = N/2, \ v_x - 4v_s = N/2 \)
    * Need to be benchmarked (using another code), or to be checked through beam experiments

➤ On parameter set (3ex)
  ● Agreement found in BBWS and BBSS simulations
  ● Resonances of \( v_x - 3v_s = N/2, \ v_x - 4v_s = N/2 \) to be understood (through benchmark simulation or experiments)