Updates on beam-beam simulations for SuperKEKB

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Acknowledgements

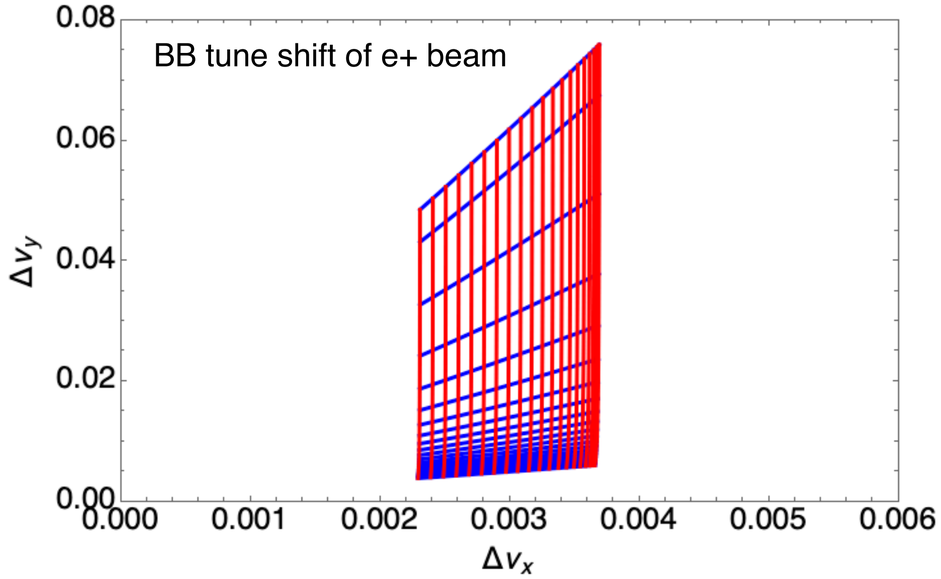
K. Ohmi, D. Shatilov,
and SuperKEKB commissioning group

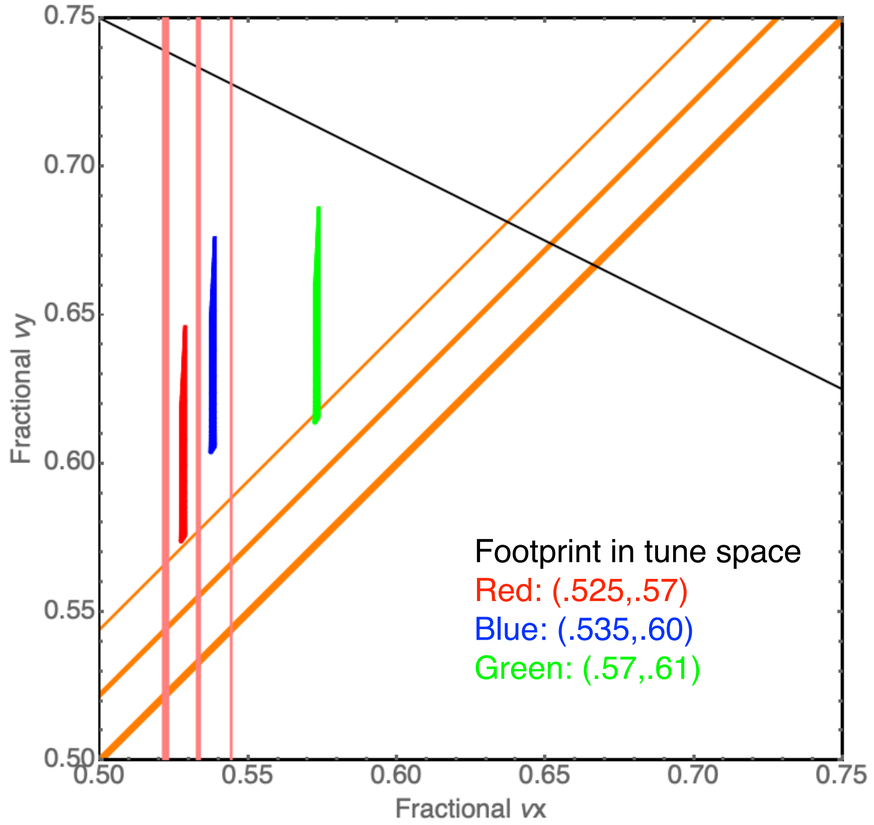
3rd meeting of beam-beam workgroup, Oct. 28, 2021, KEK

Updates on beam-beam simulations

- Tune scan with longitudinal pseudo-Green function wakes
  - Beam parameters similar to observations on 2021.07.01.

	2021.07.01		Comments
	HER	LER	
I_{bunch} (mA)	0.80	1.0	
# bunch	1174		Assumed value
ε_x (nm)	4.6	4.0	w/ IBS
ε_y (pm)	23	23	Estimated from XRM data
β_x (mm)	60	80	Calculated from lattice
β_y (mm)	1	1	Calculated from lattice
σ_{z0} (mm)	5.05	4.84	Natural bunch length (w/o MWI)
ν_x	45.532	44.525	Measured tune of pilot bunch
ν_y	43.582	46.593	Measured tune of pilot bunch
ν_s	0.0272	0.0221	Calculated from lattice
Crab waist	40%	80%	Lattice design

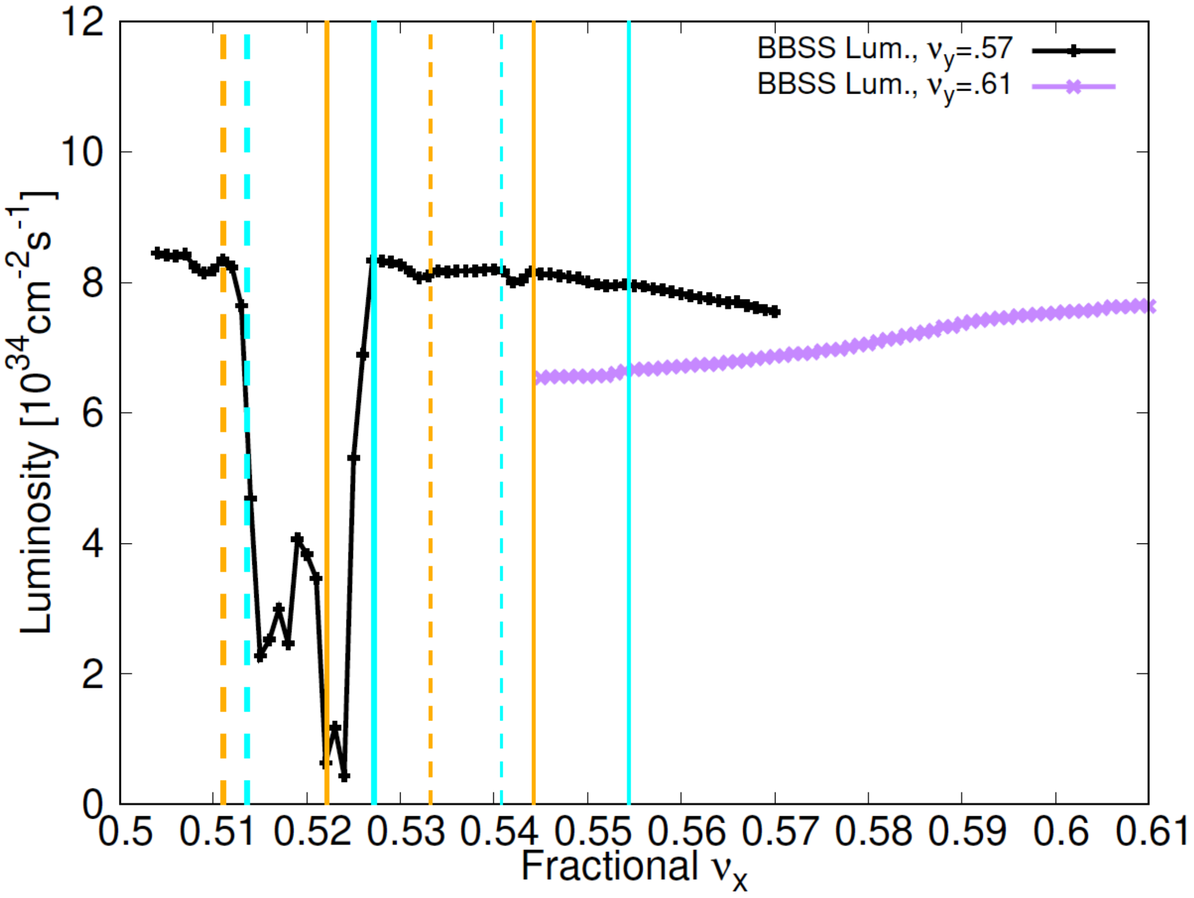




Updates on beam-beam simulations

- Tune scan with longitudinal pseudo-Green function wakes
  - Assume equal ν_x for HER and LER. Fractional vertical tune set as $\nu_y = .57/.61$, scan ν_x. Track 2e6 macro particles to 12000 turns.
  - Plots: Luminosity and beam sizes (the data at the last turn) as a function of ν_x.
  - Data for $0.513 < \nu_x < 0.526$ do not arrive at equilibrium.
  - For $\nu_y = .61$, luminosity decreases when horizontal tune moves from $\nu_x = 0.61$ to $\nu_x = 0.54$. This is caused by vertical blowup of HER beam, and should be related to beam-beam resonance of $\nu_x + 4\nu_y + \alpha = N$ with insufficient HER crab waist strength (40%).

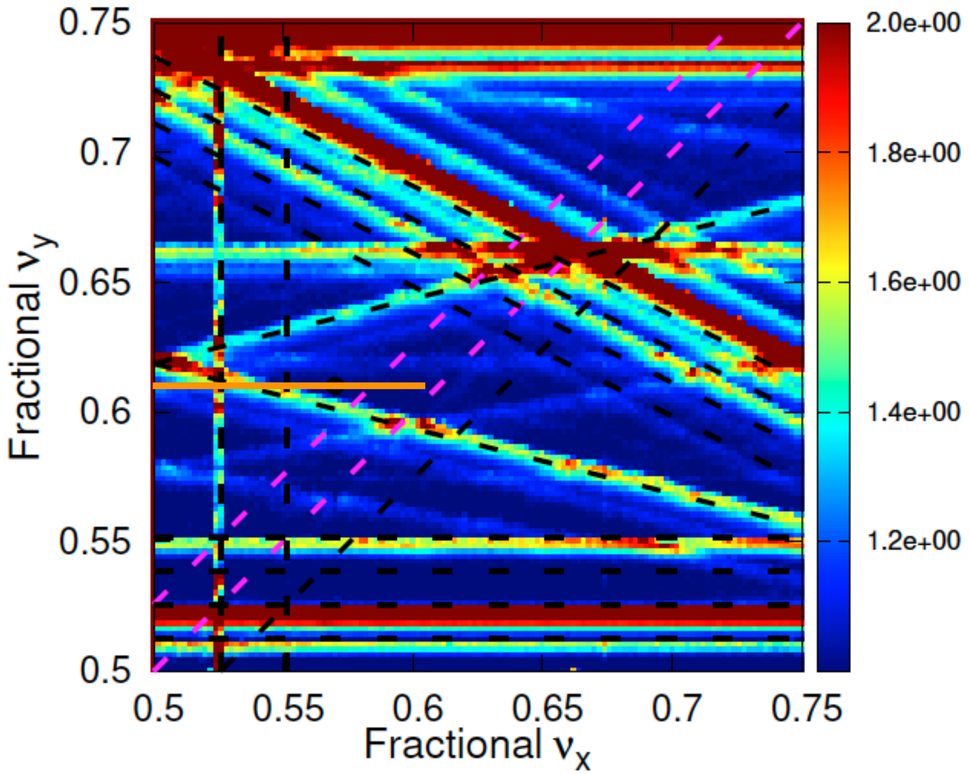
Synchro-betatron resonances: $\nu_x - k\nu_s/2 = N/2$
Odd k: Dashed lines; Even k: Solid lines
Orange lines: LER; Cyan lines: HER

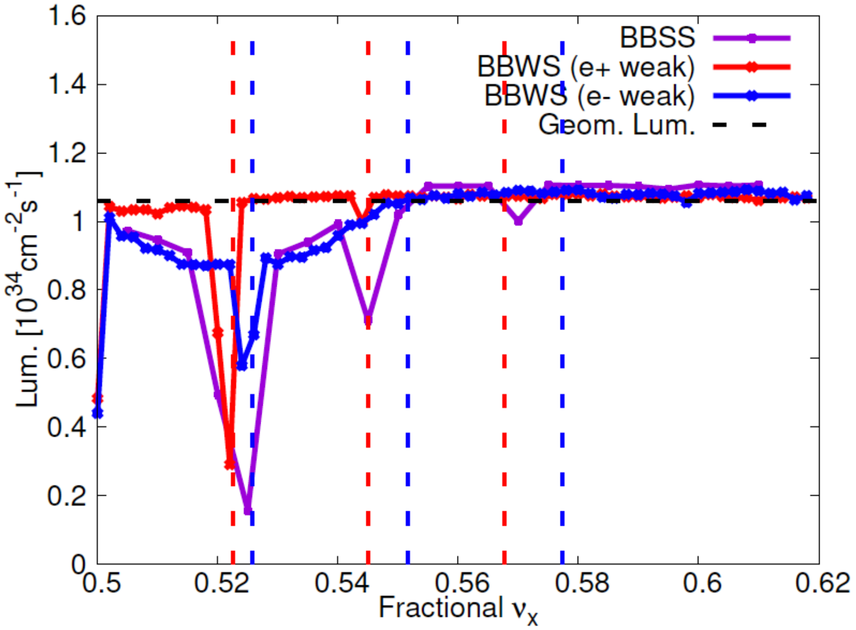


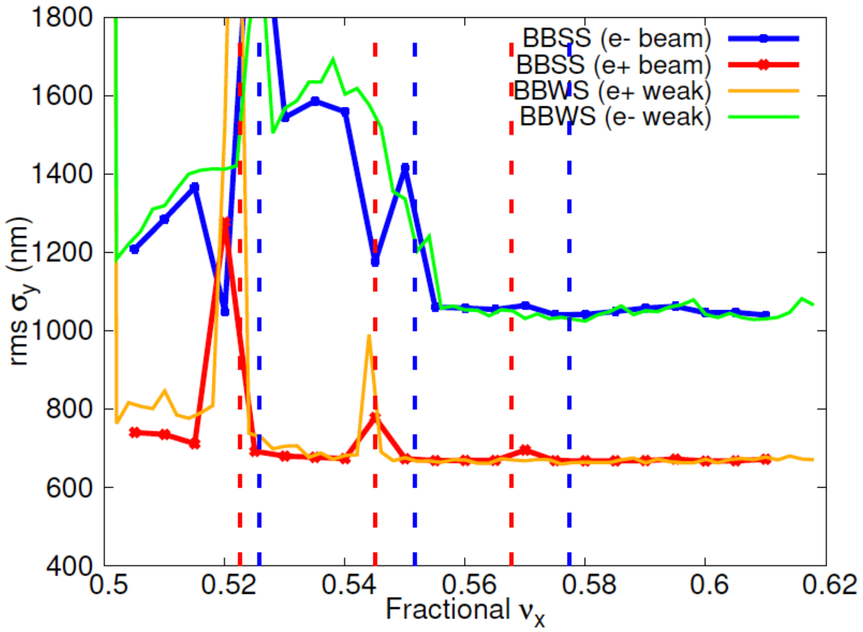
Updates on beam-beam simulations

- Old studies of ν_x scan
  - Old beam-beam simulations (ν_x scan with $\nu_y = 0.61$) showed effects of $\nu_x + 4\nu_y + \alpha = N$ without crab waist [1].

	1	
	HER	LER
I_b (A)	1.0	1.2
# bunch	1576	
ε_x (nm)	4.6	2.0
ε_y (pm)	368	160
β_x (mm)	100	100
β_y (mm)	3	3
σ_z (mm)	6	6
σ_y (nm)	1051	693
ν_x	45.57	44.57
ν_y	43.61	46.61
ν_s	0.0258	0.0225
ξ_y(Geom.)	0.0272	0.0262
$\mathcal{L}$(Geom.)	1.06E+34	
$\mathcal{L}$(BBSS)	1.00E+34	





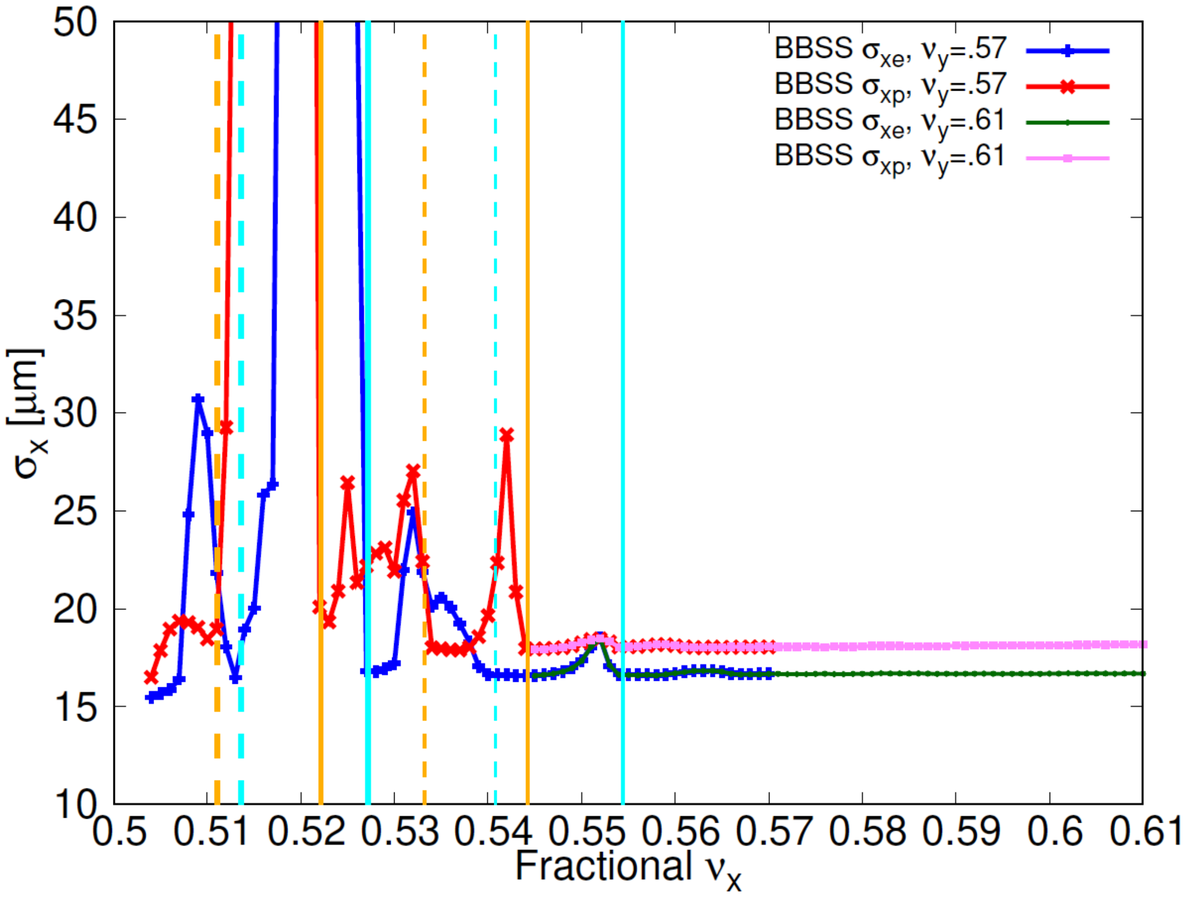


[1] D. Zhou, Talk presented at the 1st SuperKEKB Beam Dynamics Mini-Workshop, KEK, Jul. 17, 2019 (https://kds.kek.jp/event/31793/).

Updates on beam-beam simulations

- Tune scan with longitudinal pseudo-Green function wakes (cont'd)
  - Tune scan with $\nu_y = 0.61$ ongoing. It should reproduce the resonances seen in the tune scan with $\nu_y = 0.57$ on the left of $\nu_x - 2\nu_s = N/2$.

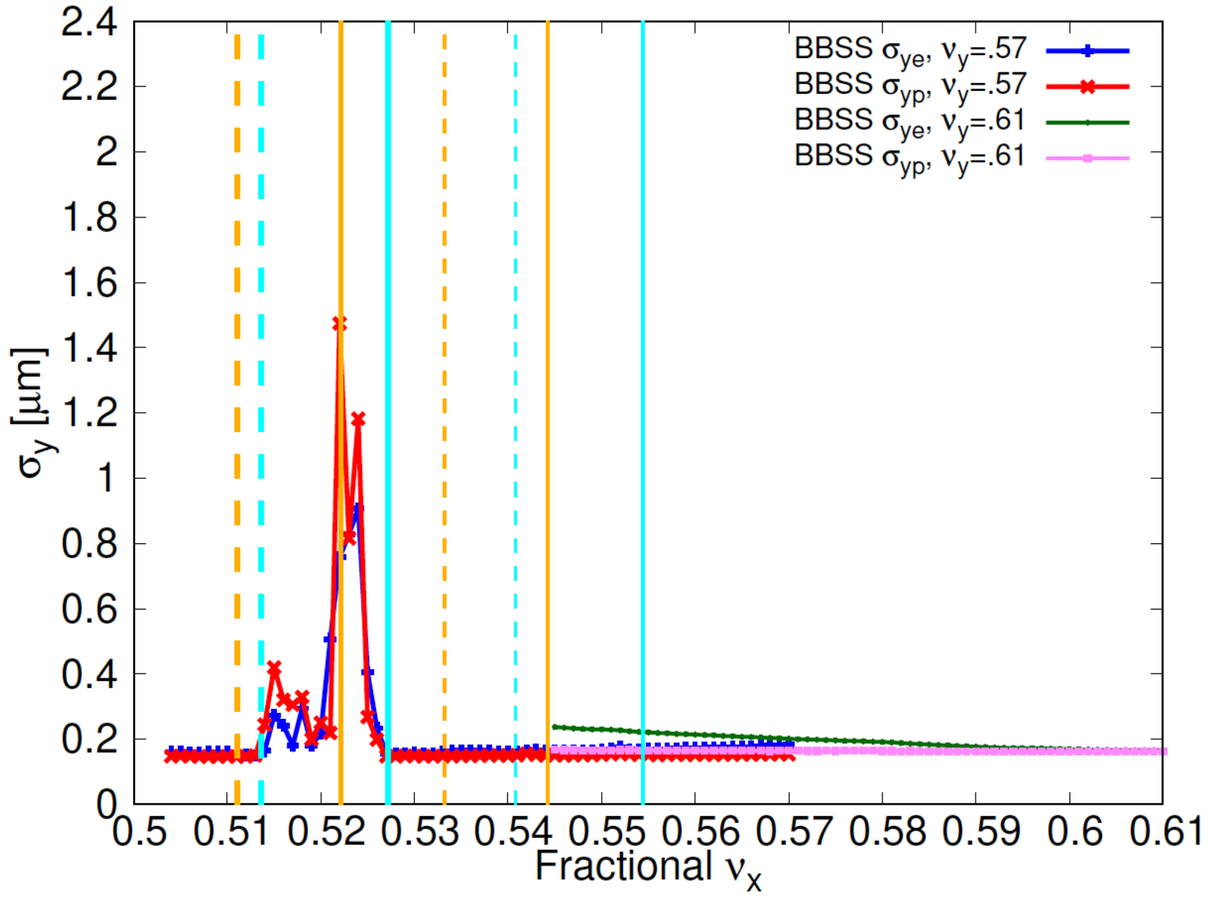
Synchro-betatron resonances: $\nu_x - k\nu_s/2 = N/2$
Odd k: Dashed lines; Even k: Solid lines
Orange lines: LER; Cyan lines: HER



New results

- Tune scan with longitudinal pseudo-Green function wakes (cont'd)
  - Vertical blowup of HER beam with $\nu_y = 0.61$ should be related to $\nu_x + 4\nu_y + \alpha = N$ with insufficient HER crab waist strength (40%).
  - "In collision schemes with ϕ >> 1, an increase in εx itself does not have a noticeable impact on luminosity. However, this leads to a proportional increase in εy due to the betatron coupling, so eventually the luminosity will decrease several times." [2]

Synchro-betatron resonances: $\nu_x - k\nu_s/2 = N/2$
Odd k: Dashed lines; Even k: Solid lines
Orange lines: LER; Cyan lines: HER



[2] D. Shatilov, "FCC-ee Parameter Optimization", ICFA Beam Dynamics Newslett. 72 (2017) 30-41.