

Beam dynamics issues in SuperKEKB: beam-beam, lattice nonlinearities , and space charge

- Updated results

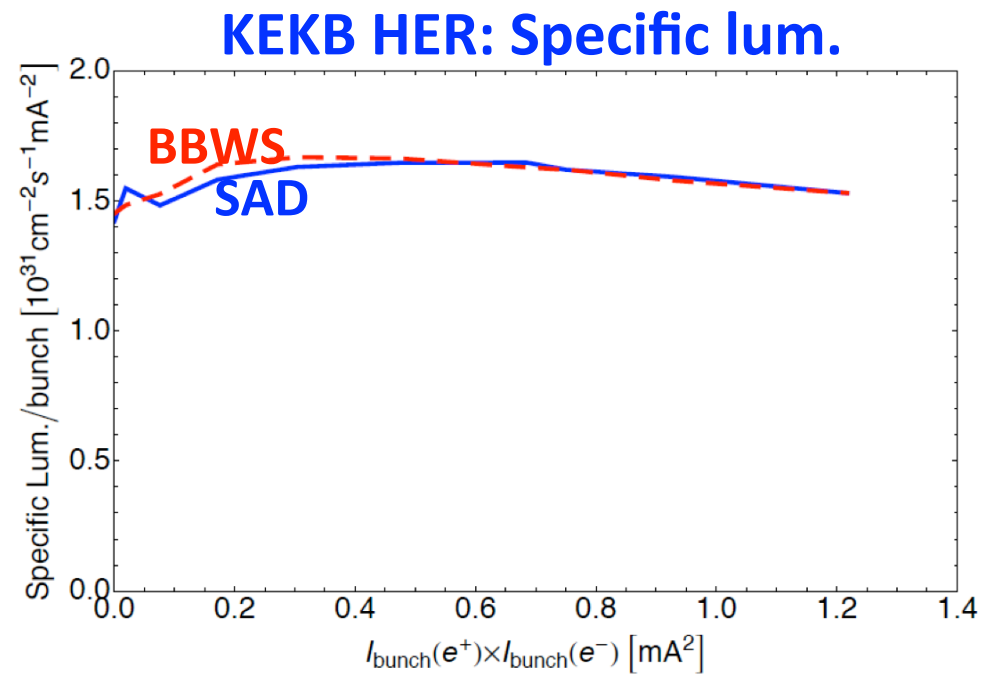
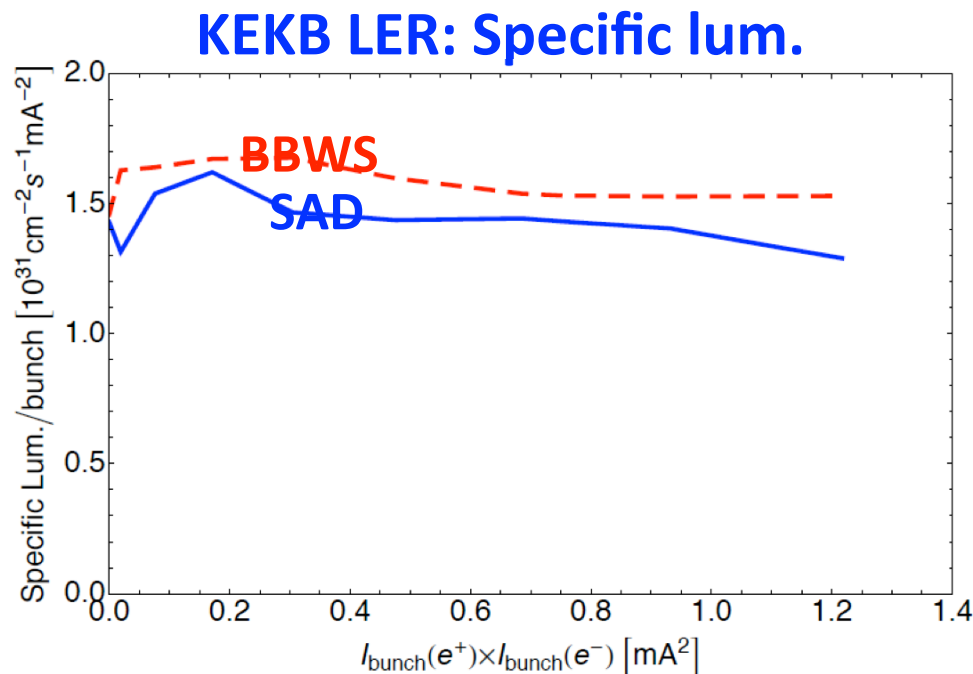
D. Zhou, K. Ohmi, Y. Ohnishi, K. Oide

SuperKEKB optics meeting

Apr. 16, 2013

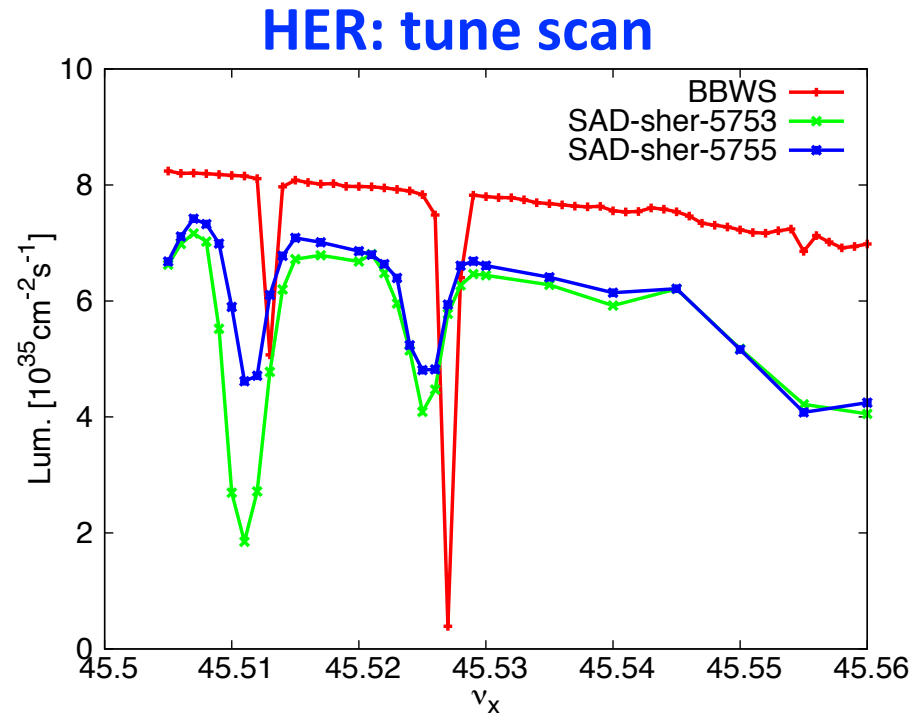
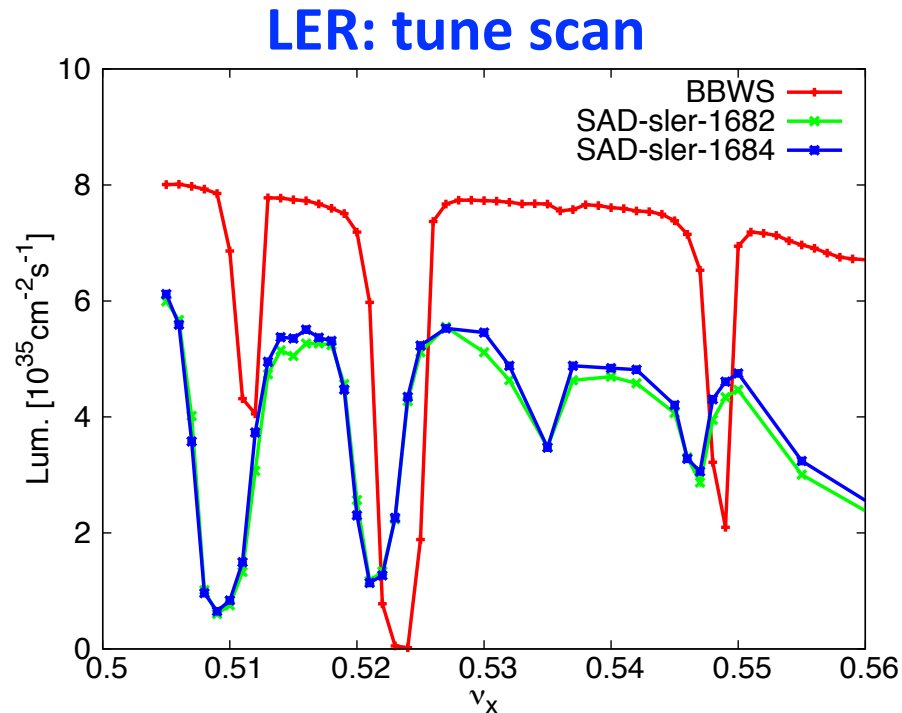
1. BB + LN: KEKB

- Low emit. => Strong lattice nonlinearities
- LN crosstalk with beam-beam and space charge
- BB sim. (w/o crab cavity) => Not important in KEKB



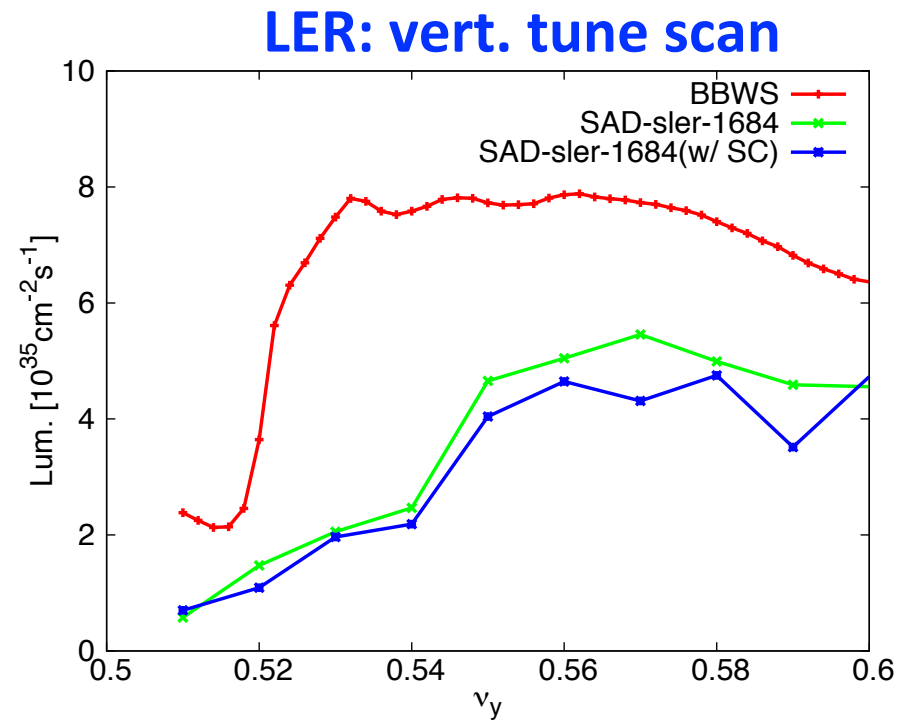
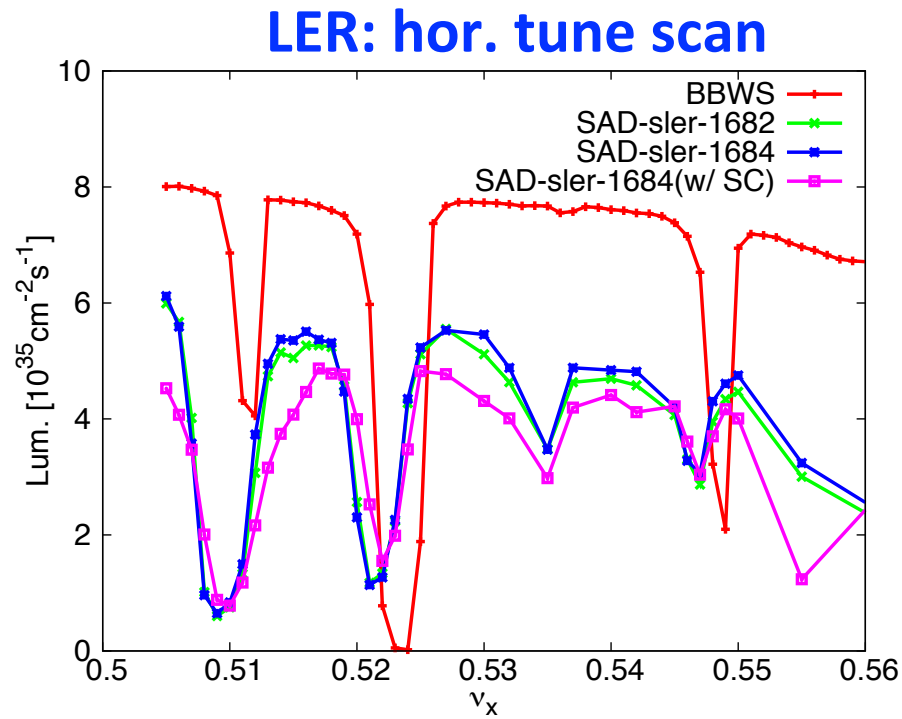
1. BB + LN: Tune scan

- Simulation: BBWS(NP=10000), SAD(NP=1000)
- Significant lum. loss **independent on hor. tune**
- LN enhance synchro-betatron resonances (BB: x^2z^2)
- **Depend on optics**



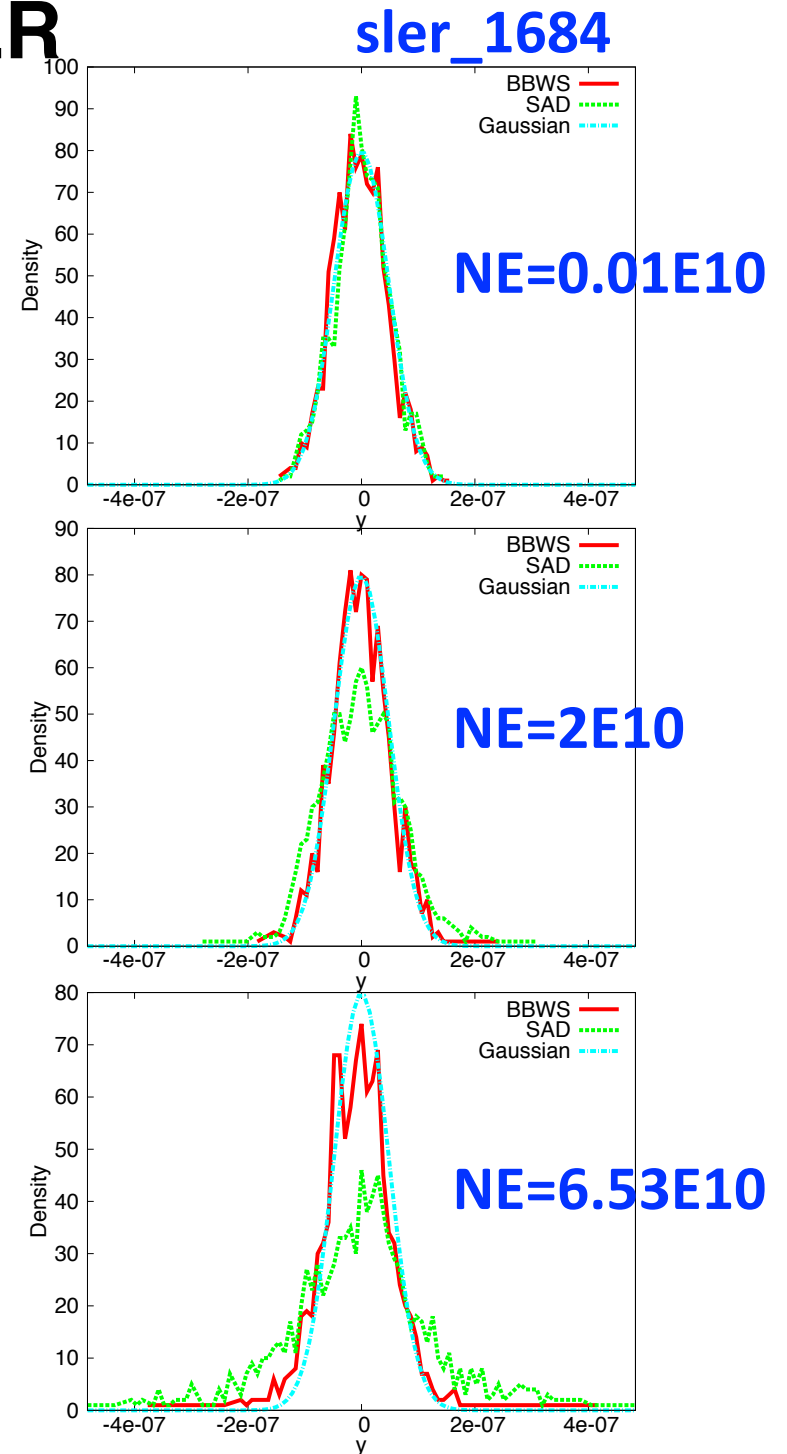
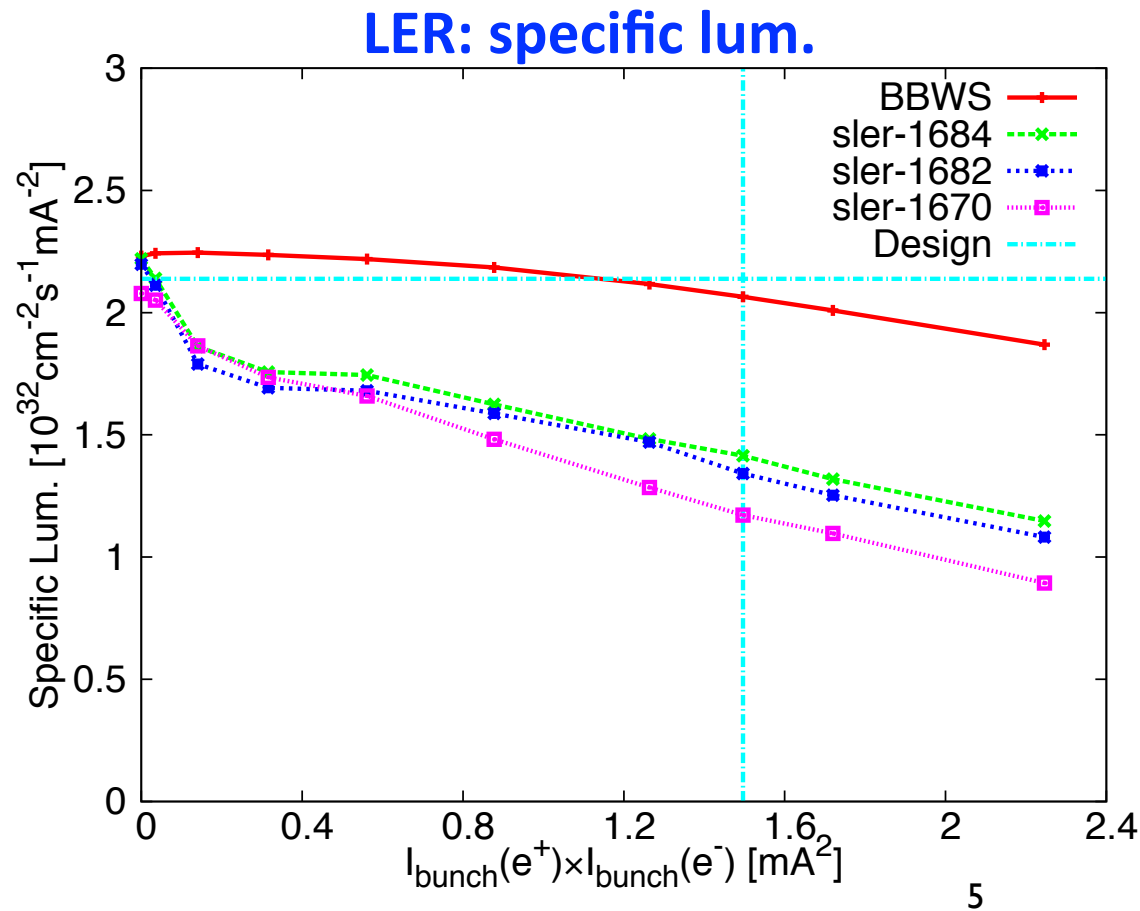
1. BB + LN + SC: SLER

➤ SC causes lum. degradation



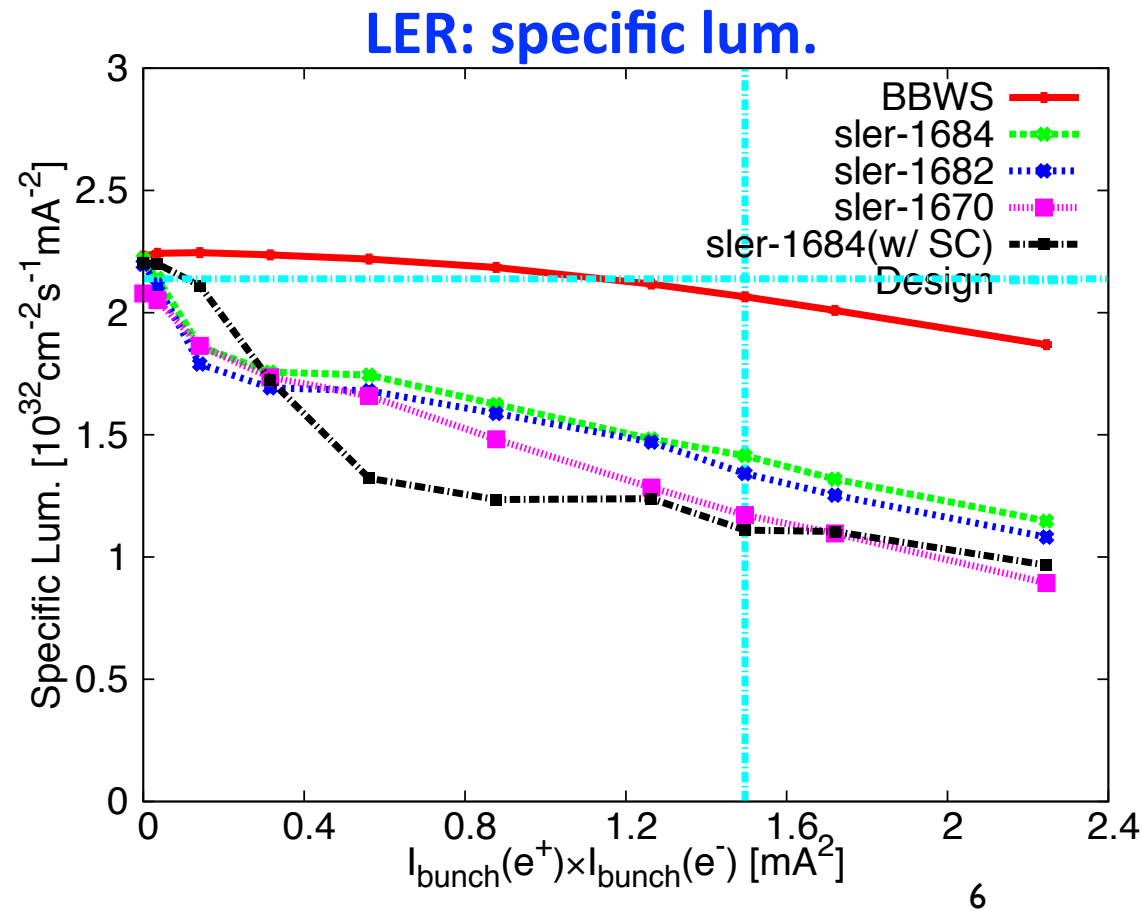
1. BB + LN: Specific lum.: SLER

- BB: weak-strong
- Direct vert. emit. growth
- Current dependent
- Mechanism to be understood

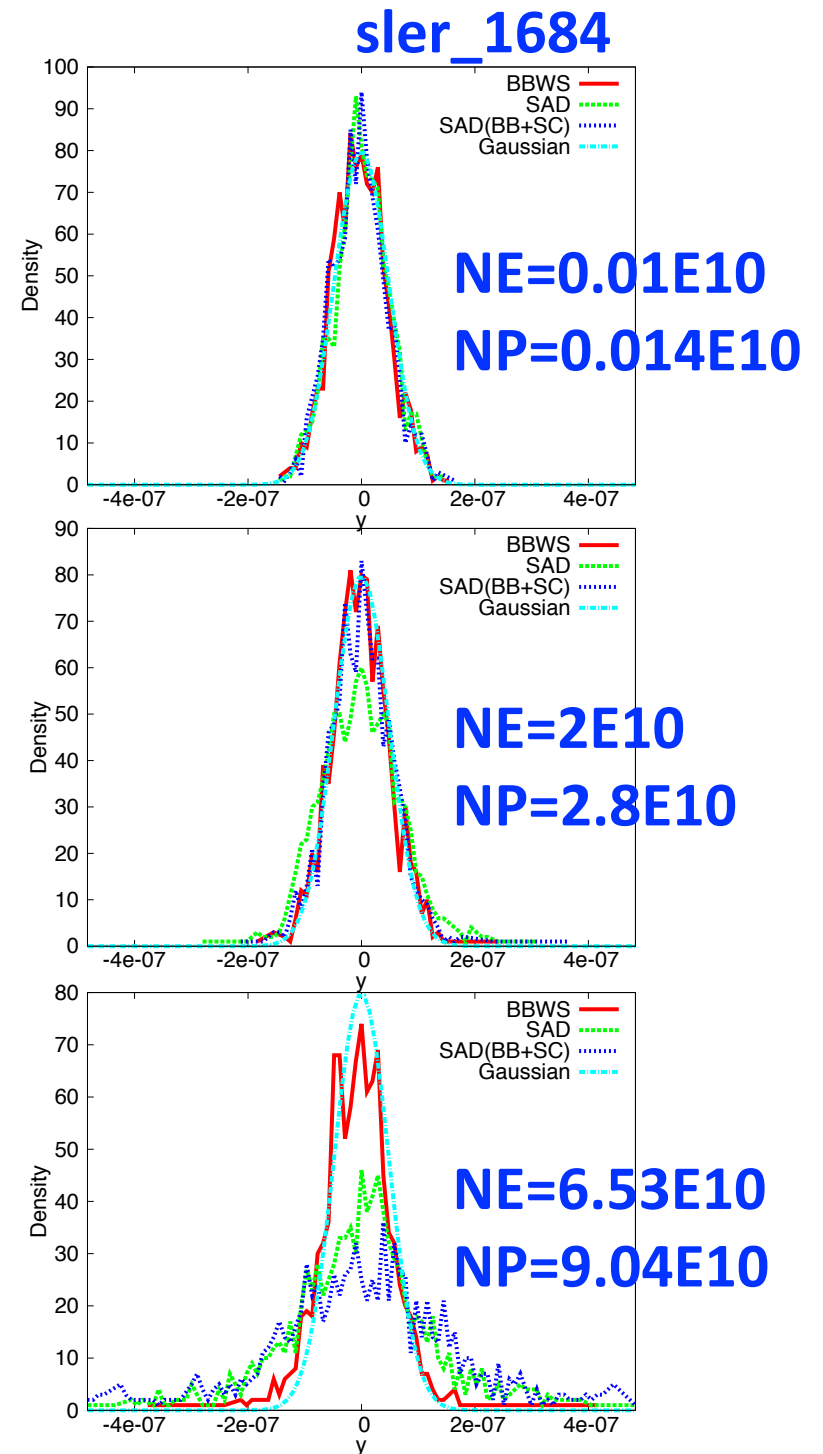


1. BB + LN + SC: SLER

- SC causes lum. degradation
- BB + SC: compensate at low current?



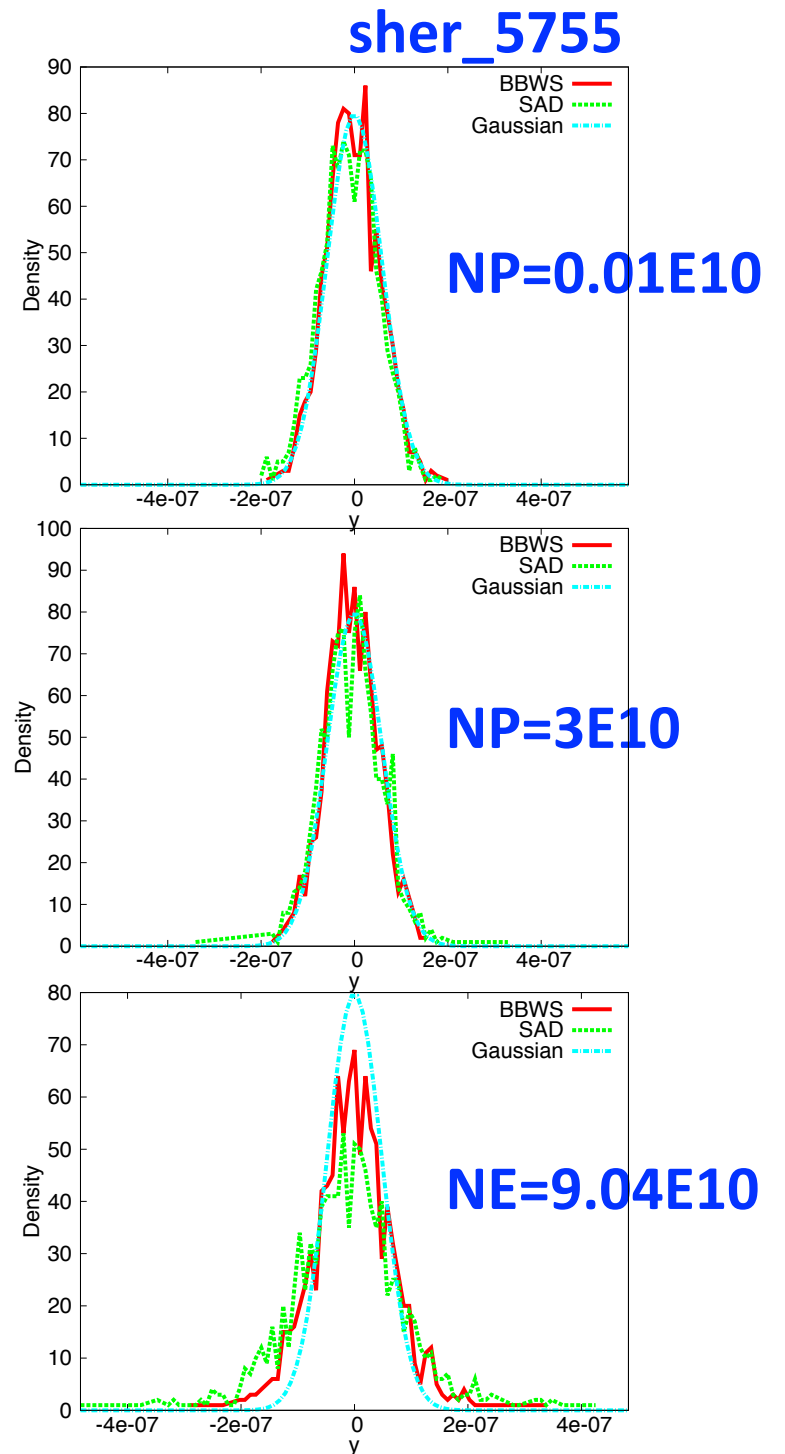
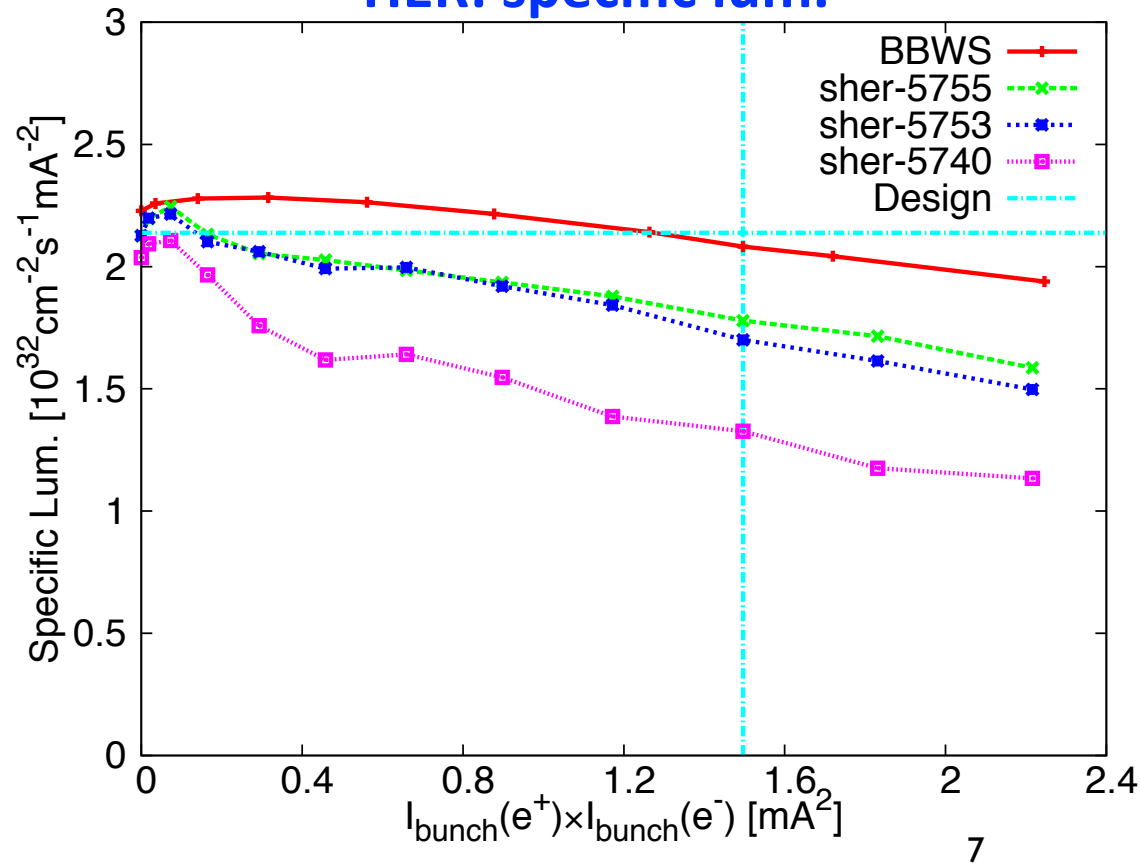
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1. BB + LN: SHER

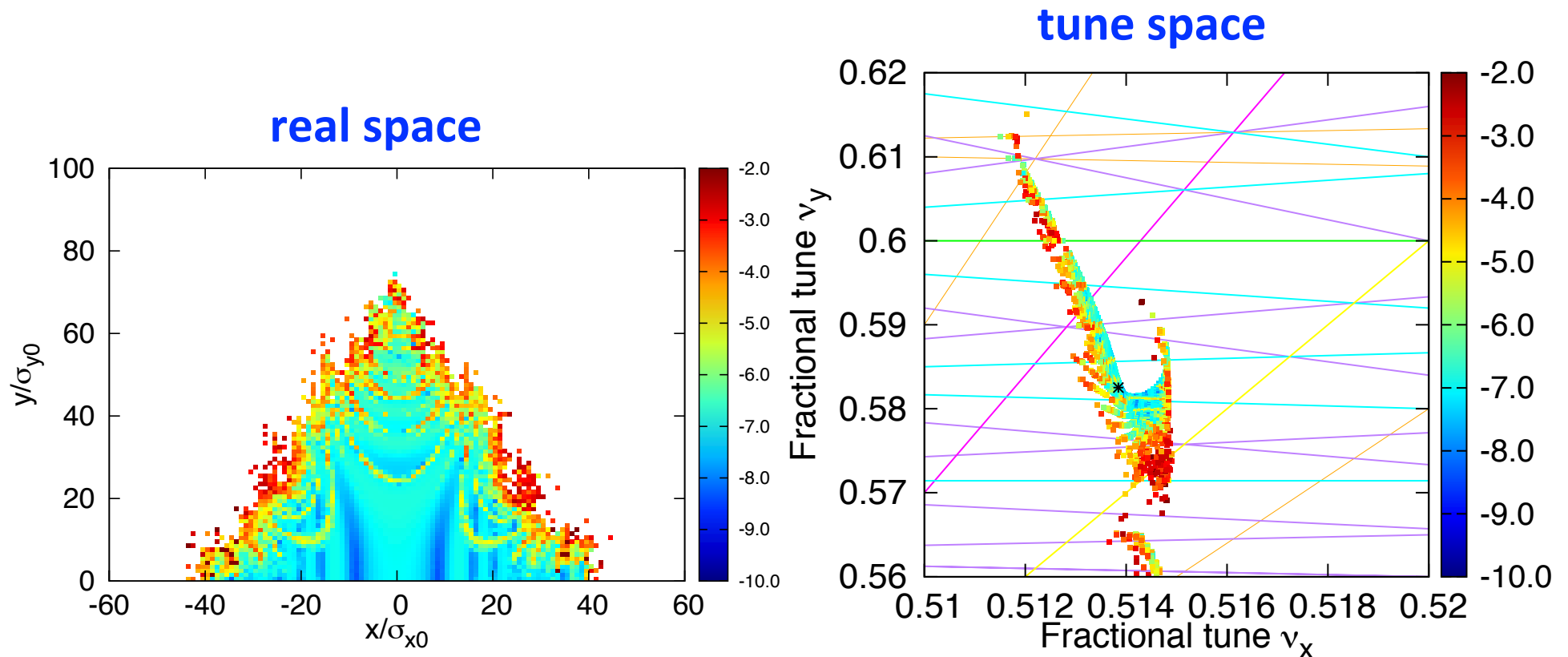
- BB: weak-strong
- Direct vert. emit. growth
- Current dependent
- Mechanism to be understood

HER: specific lum.



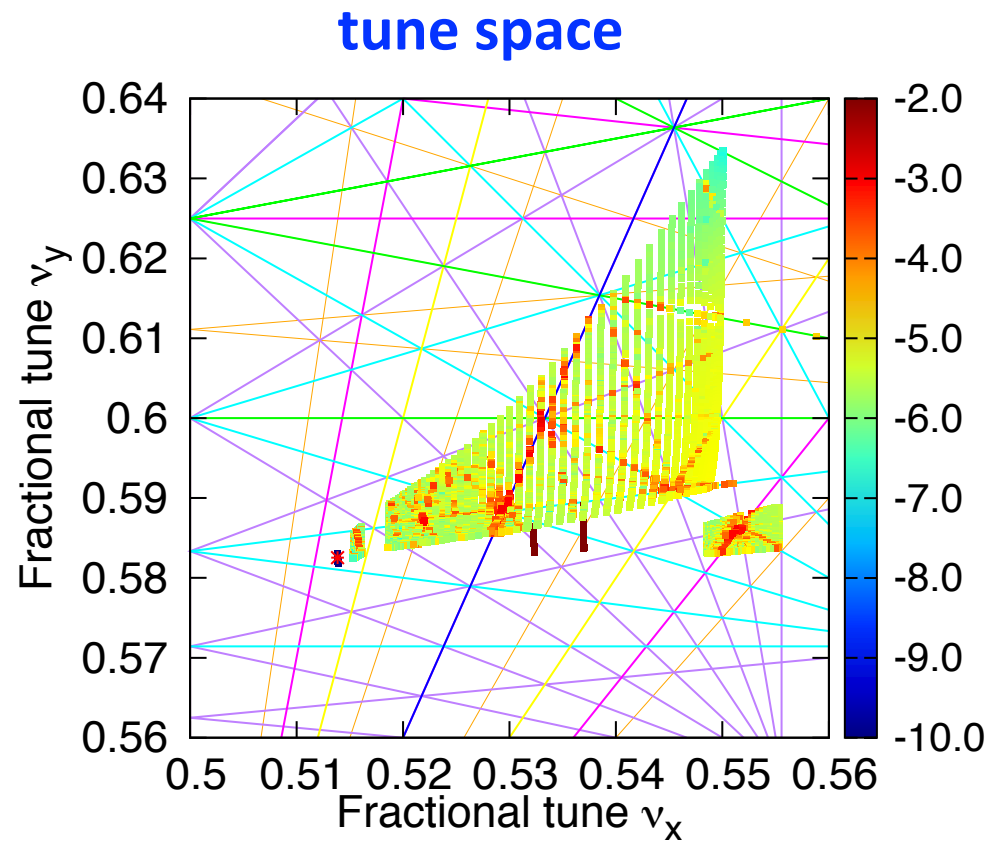
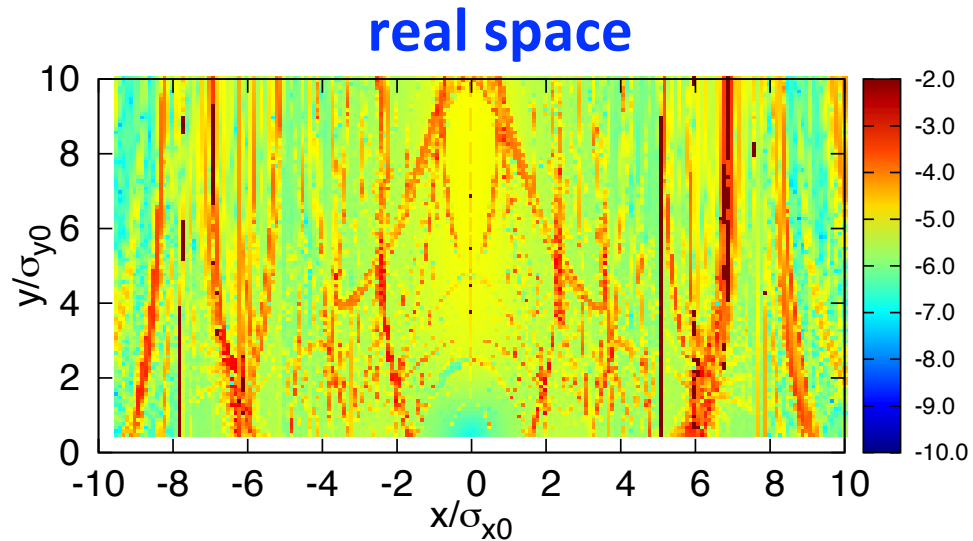
2. FMA: KEKB HER: Bare lattice

- Track on-momentum particle
- Vary amplitude, No BB
- Resonance lines: up to 10th order



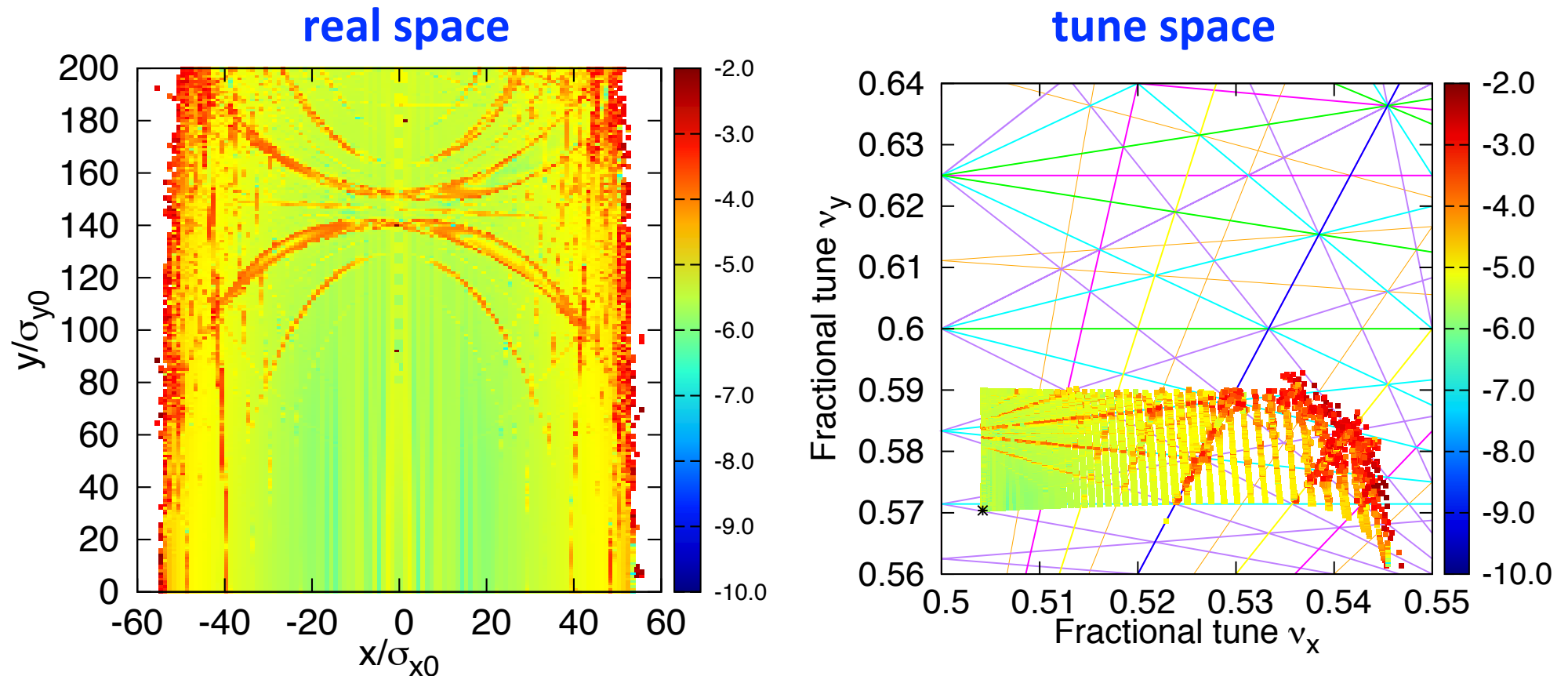
2. FMA: KEKB HER: BB + LN

- BB w/o crab cavity
- Beam distribution: $10\sigma_x \times 10\sigma_y$
- Resonance lines: up to 10th order



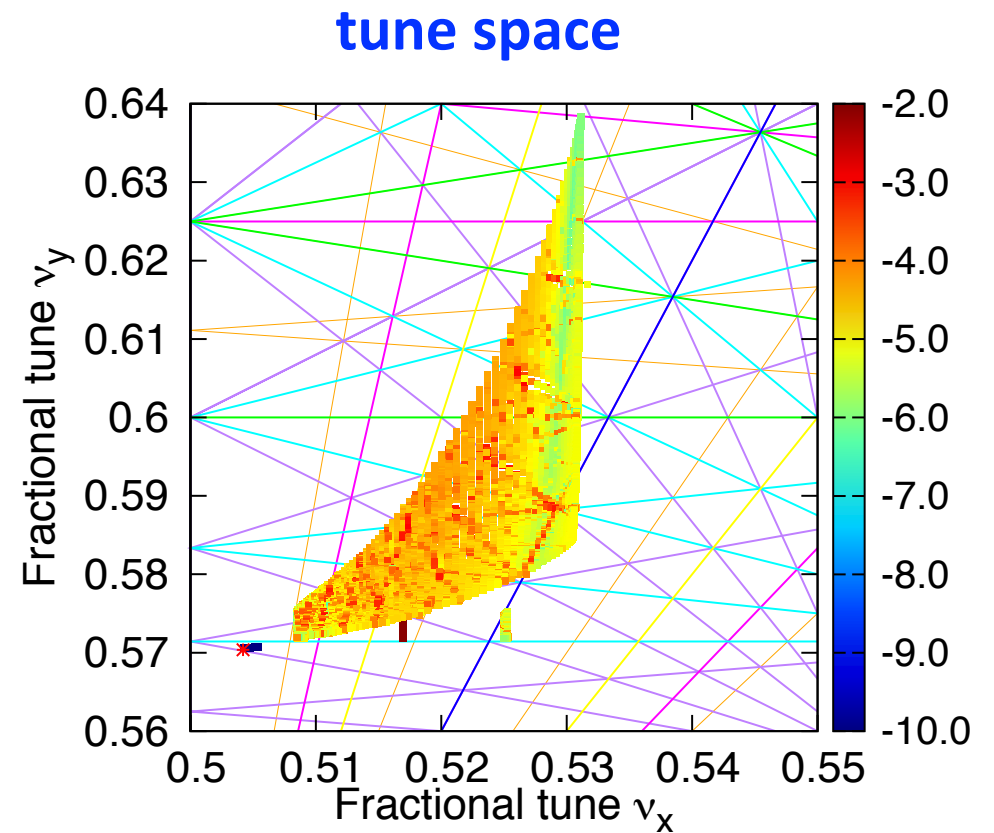
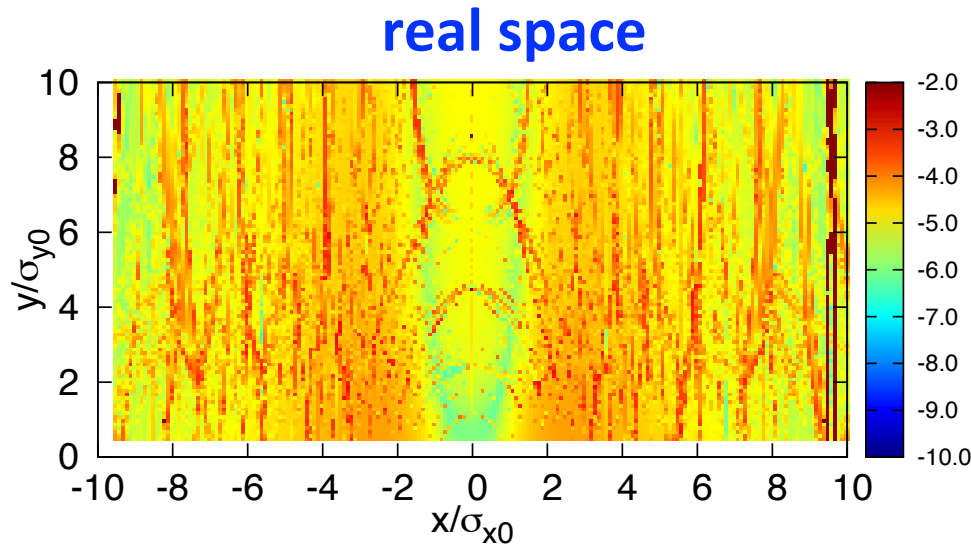
2. FMA: KEKB LER: Bare lattice

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2. FMA: KEKB LER: BB + LN

- BB w/o crab cavity
- Beam distribution: $10\sigma_x \times 10\sigma_y$
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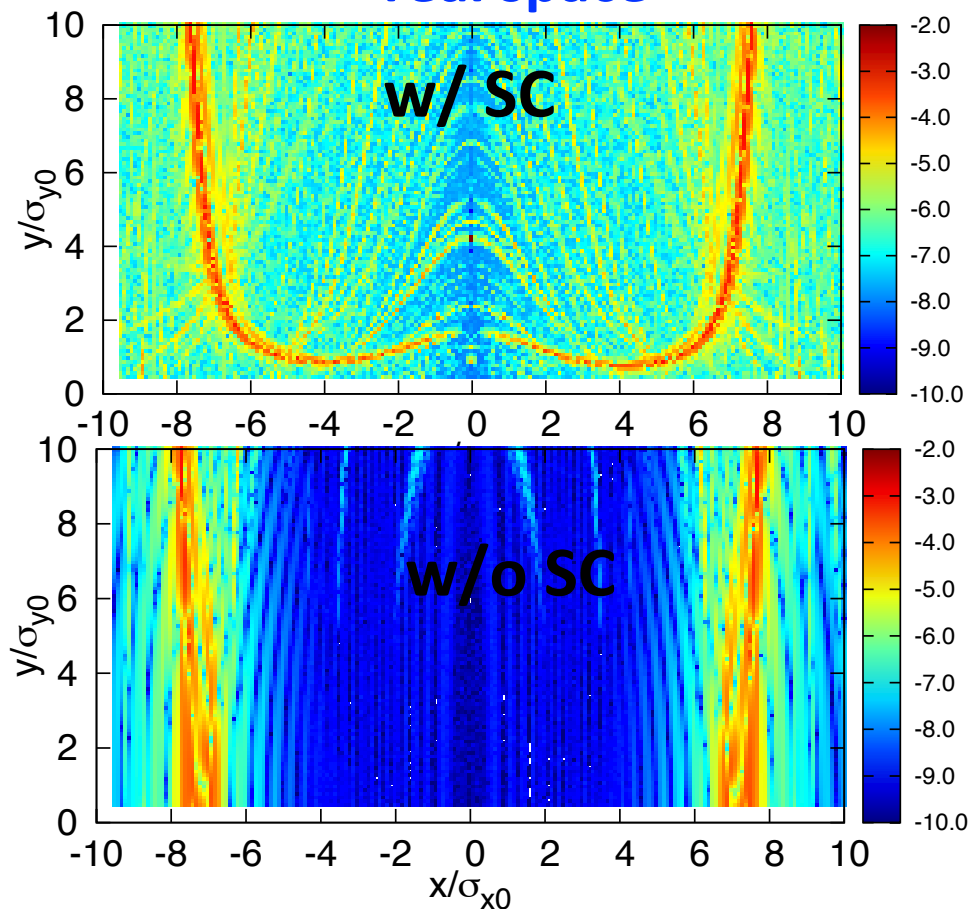


2. FMA: SKEKB HER: SC + LN

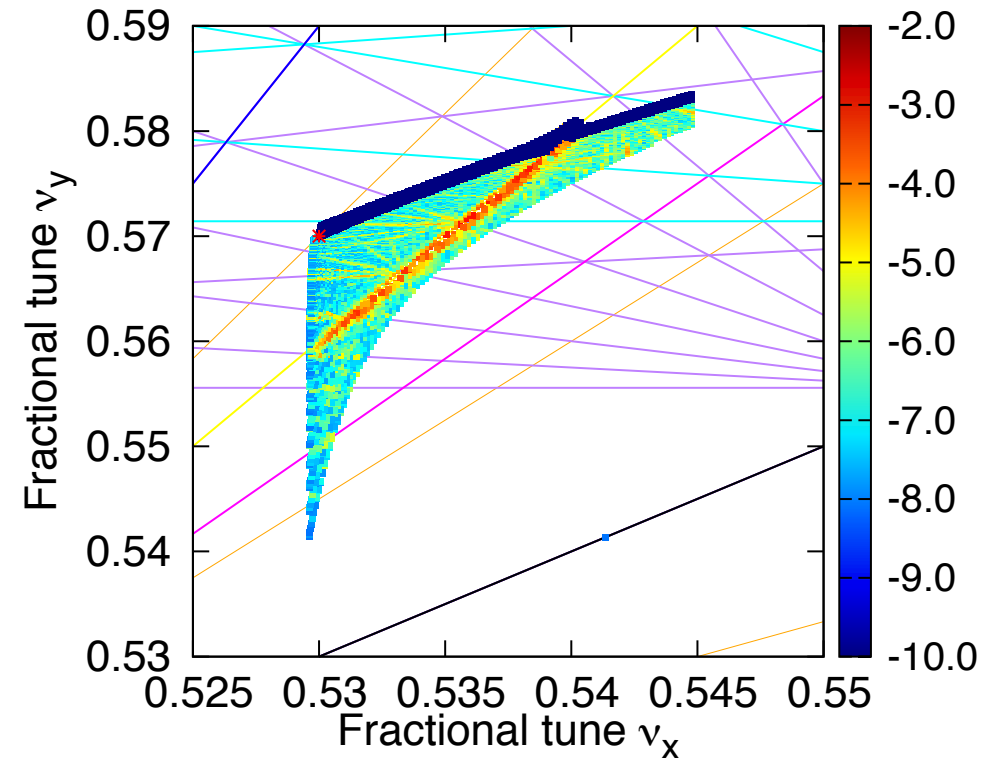
sher_5755

- SC: weak-strong
- Beam distribution: $10\sigma_x \times 10\sigma_y$
- Resonance lines: up to 10th order
- SC tune shift: $\Delta\nu_y \approx -0.03$

real space



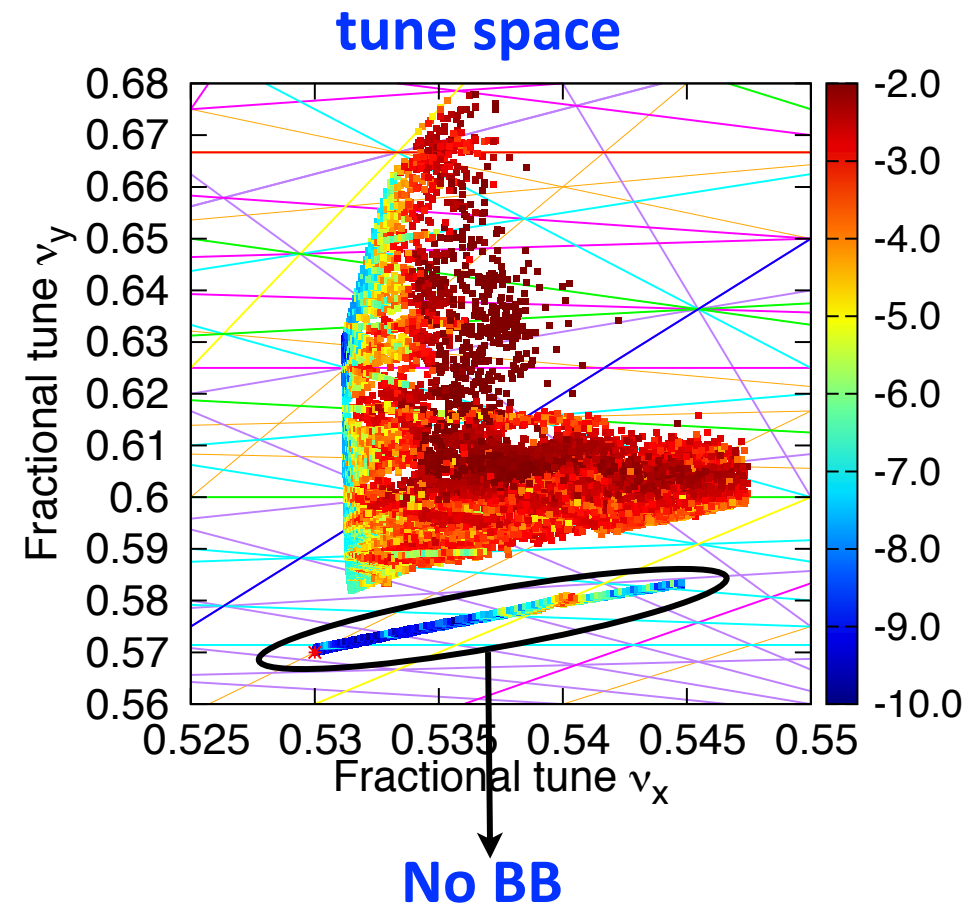
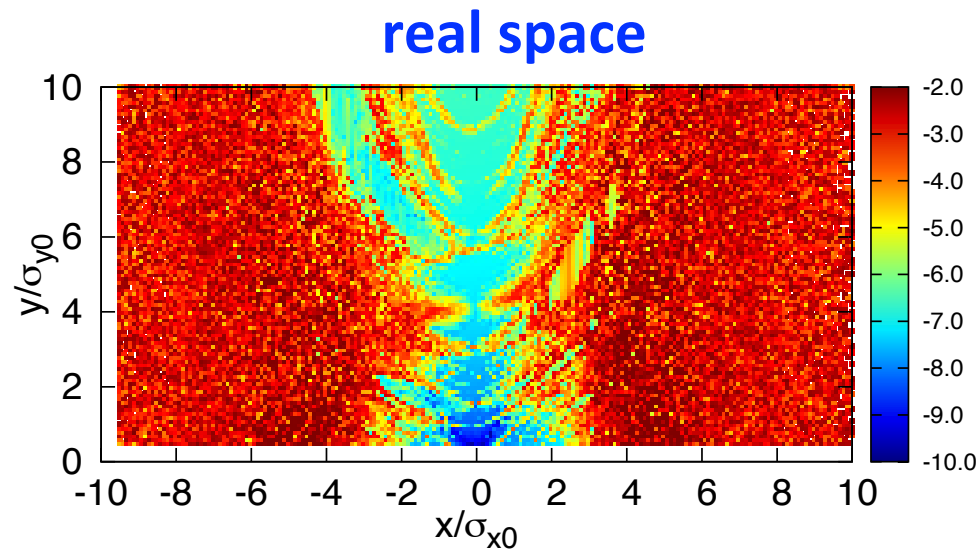
tune space



2. FMA: SKEKB HER: BB + LN

sher_5755

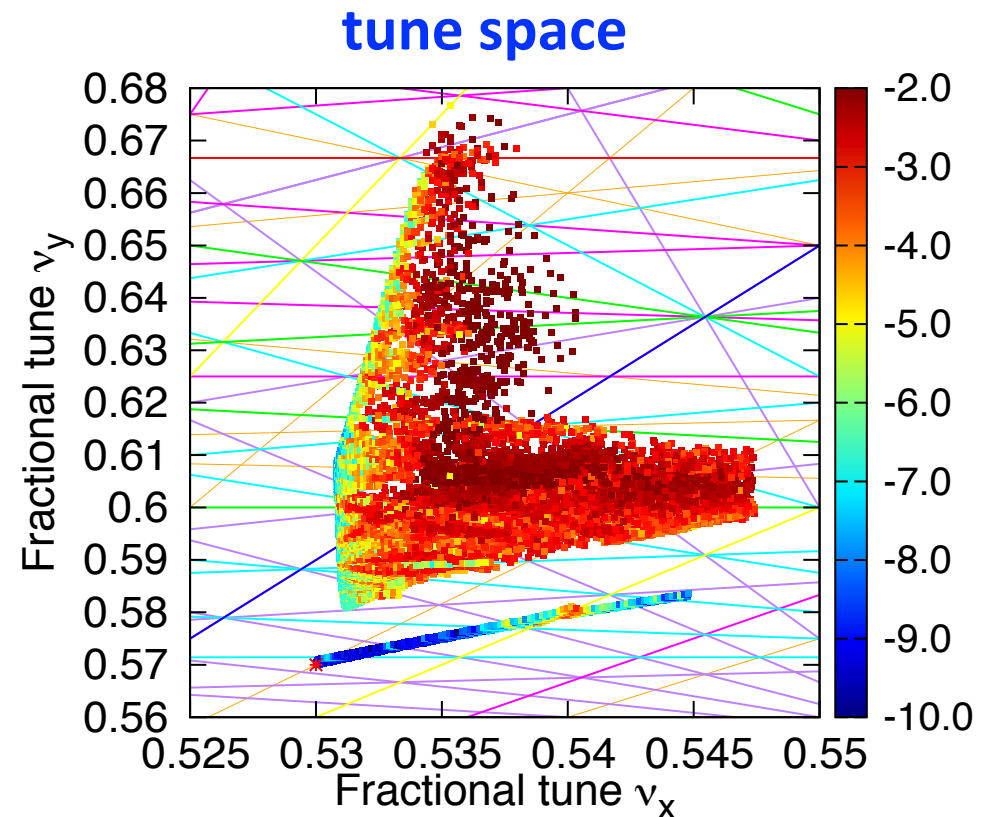
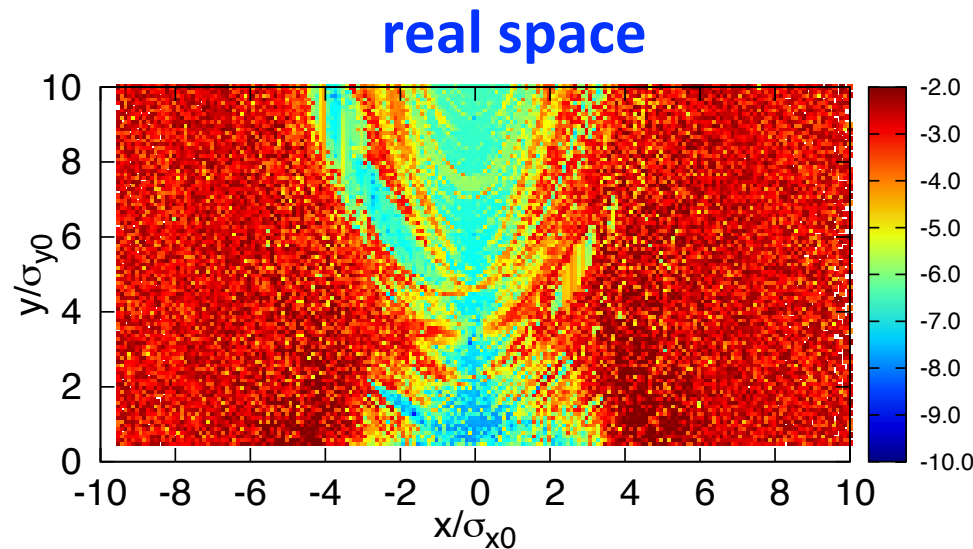
- BB: weak-strong
- Beam distribution: $10\sigma_x \times 10\sigma_y$
- Resonance lines: up to 10^{th} order



2. FMA: SKEKB HER: BB + SC + LN

sher_5755

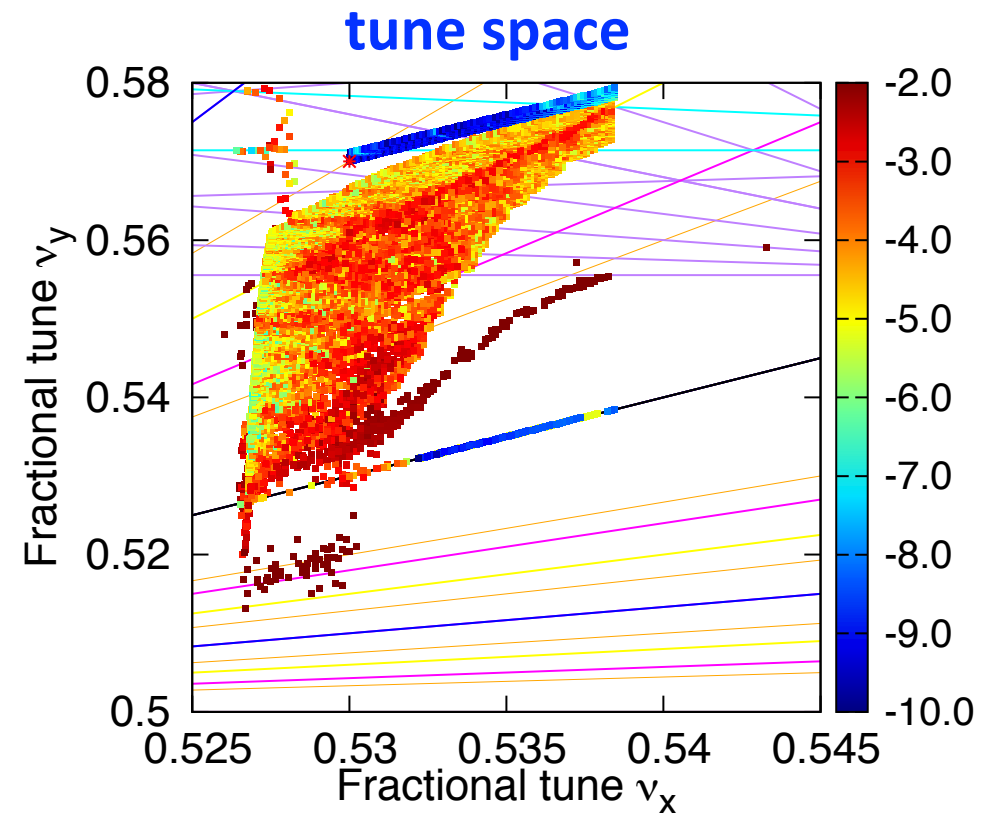
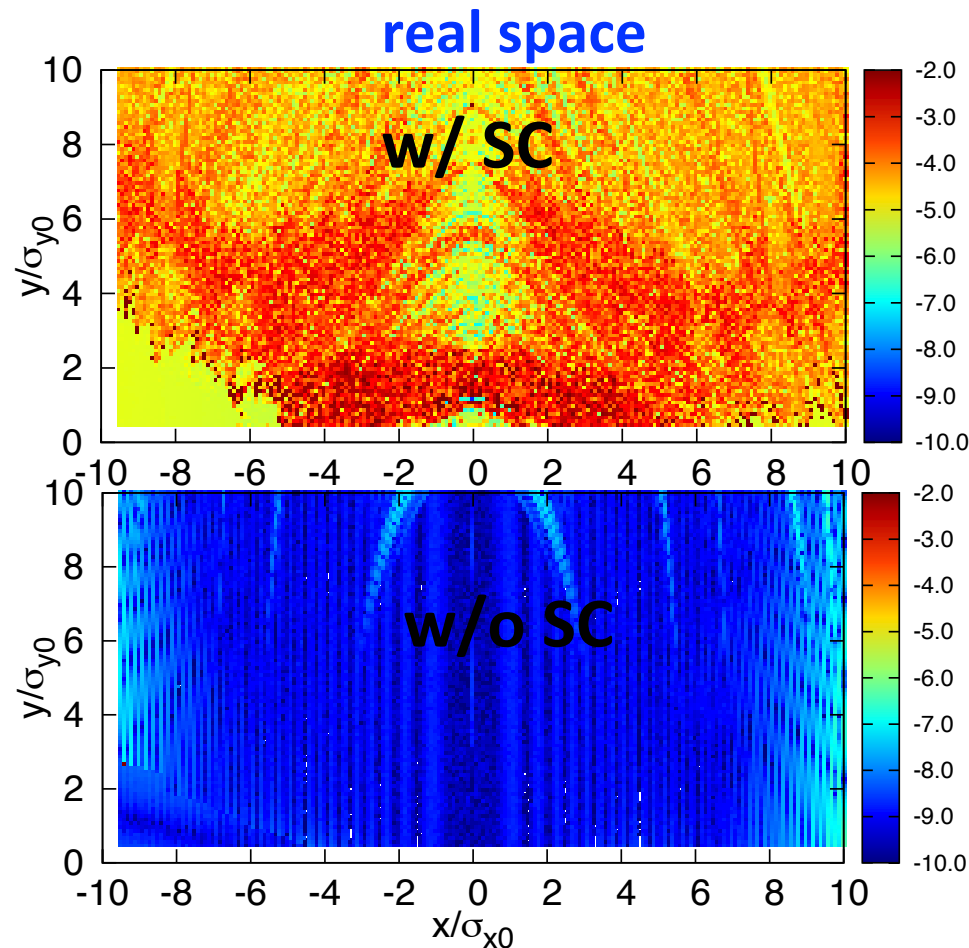
- BB and SC: weak-strong
- Beam distribution: $10\sigma_x \times 10\sigma_y$
- Resonance lines: up to 10^{th} order



2. FMA: SKEKB LER: SC + LN

sler_1684

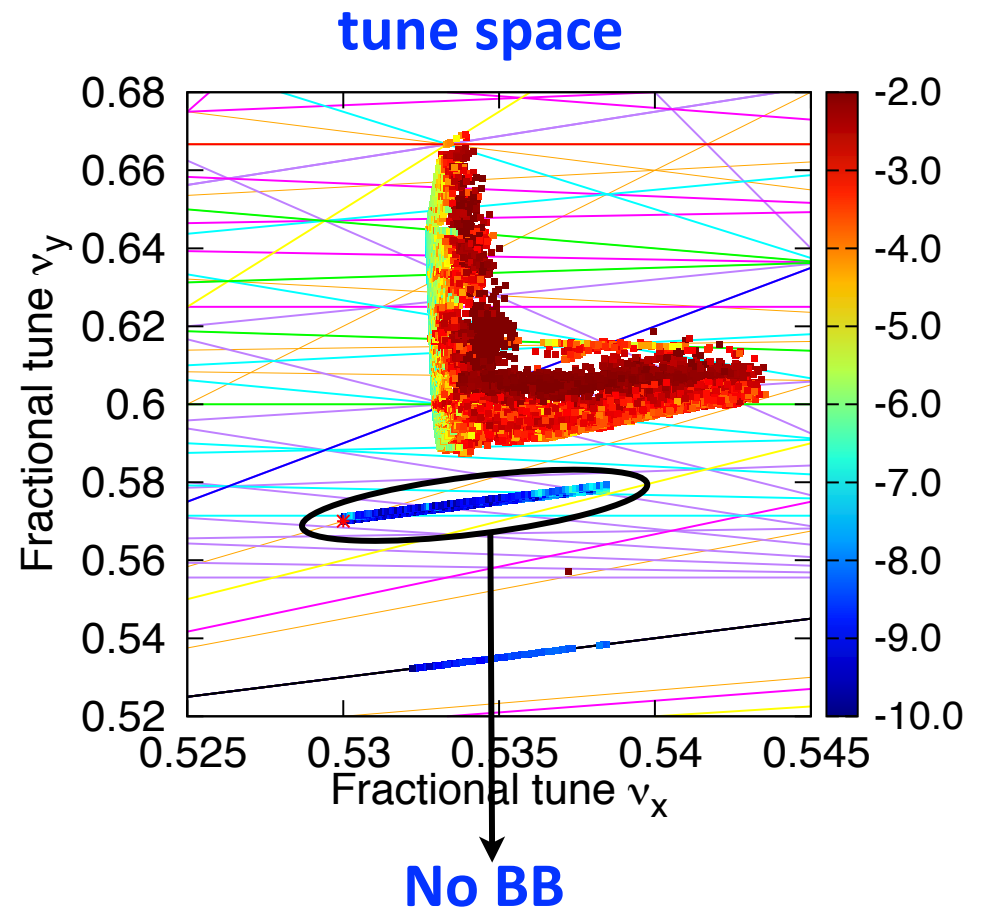
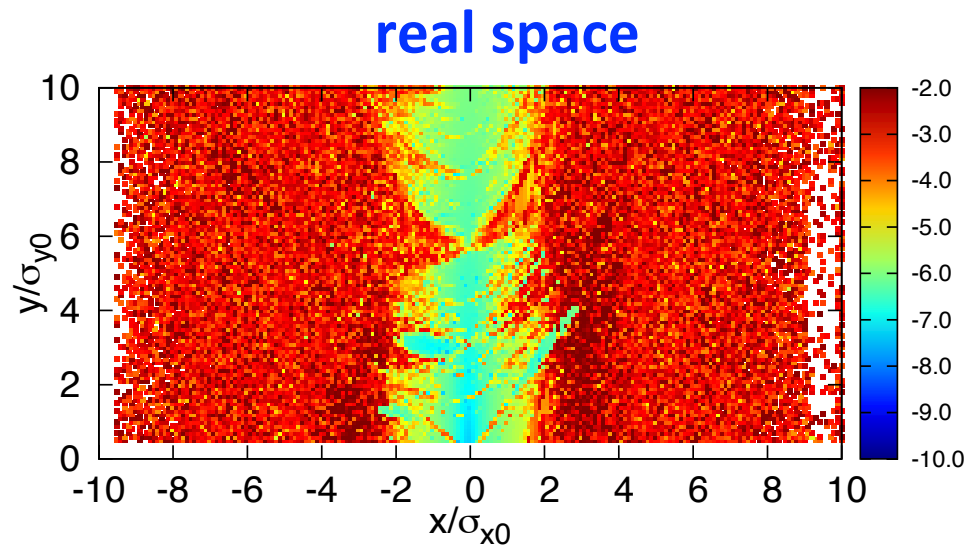
- SC: weak-strong
- SC tune shift: $\Delta\nu_y \approx -0.14(?)$, $\Delta\nu_x \approx -0.003(?)$
- Beam unstable if $\nu_y = 46.57$ w/o BB? Affect injection or Phase 1 beam commissioning?



2. FMA: SKEKB LER: BB + LN

sler_1684

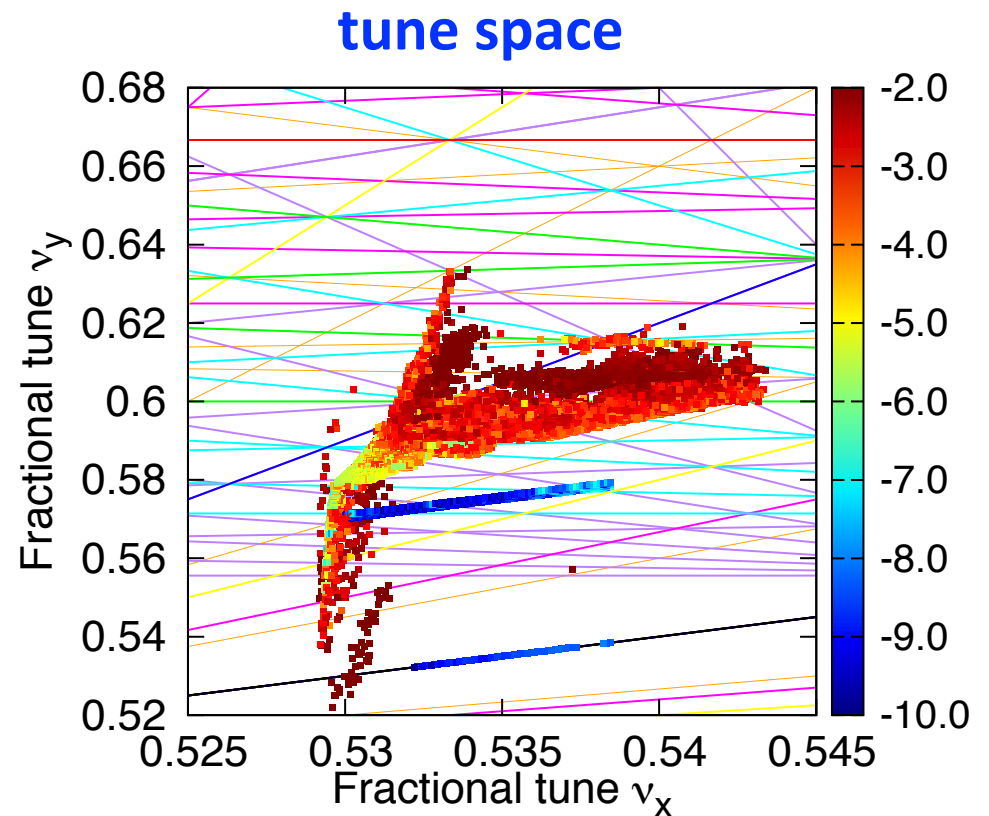
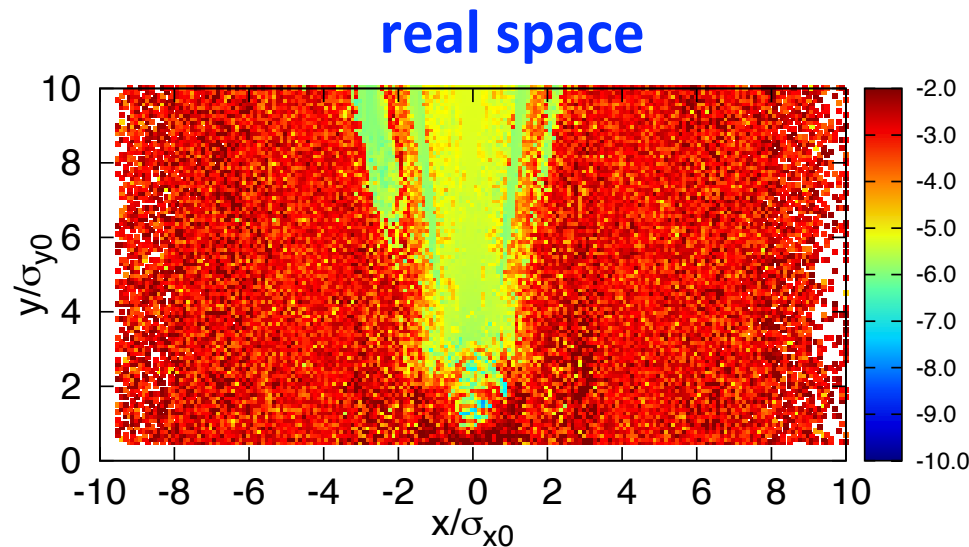
- BB: weak-strong
- Beam distribution: $10\sigma_x \times 10\sigma_y$
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2. FMA: SKEKB LER: BB + SC + LN

sler_1684

- BB and SC: weak-strong
- Beam distribution: $10\sigma_x \times 10\sigma_y$
- Resonance lines: up to 10^{th} order



3. BB and SC: Linear tune shift

➤ SuperKEKB LER

- Tune shifts for SC and BB have opposite signs
- But never compensate with each other

	SuperKEKB ¹⁾		KEKB ⁴⁾	
	LER ²⁾	HER ³⁾	LER	HER
ϵ_x (nm)	3.2	4.6	18	24
ϵ_y (pm)	8.64	11.5	180	240
ξ_x	0.0028	0.0012	0.127	0.102
ξ_y	0.0881	0.0807	0.129	0.09
$\Delta\nu_x$	-0.0027	-0.0004	-0.0005	-3.00E-05
$\Delta\nu_y$	-0.0943	-0.0121	-0.0072	-0.0004

¹⁾Main parameters from Y. Ohnishi et al., Prog. Theor. Exp. Phys. 2012;

²⁾slr_1682;

³⁾sher_5753;

⁴⁾Lattice used on Jun.17, 2009.

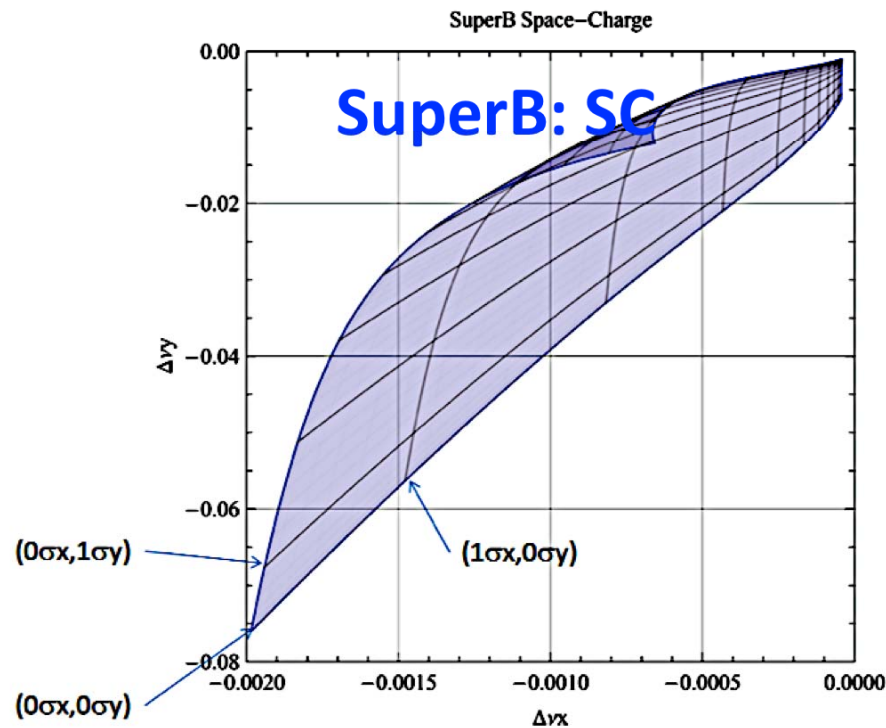
3. BB and SC: Tune shift

➤ SuperB

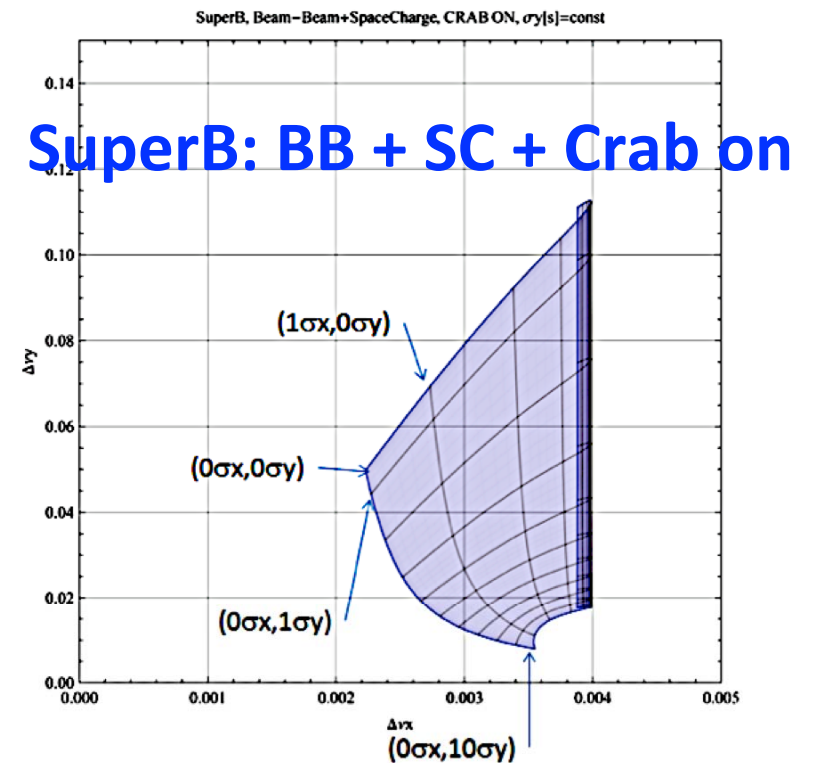
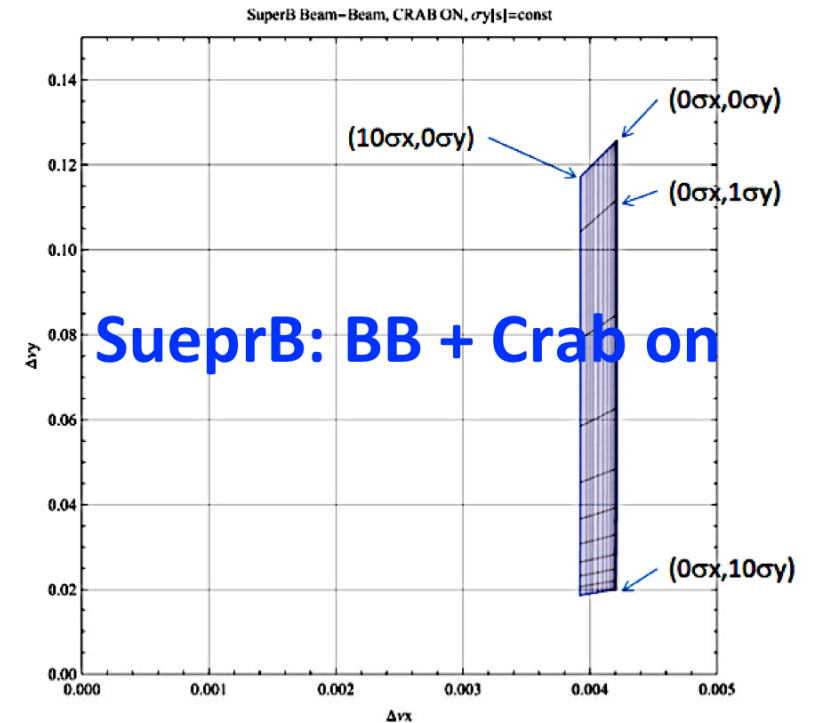
- Linear SC tune shift $\Delta\nu_y \approx -0.08$
- Linear BB shift $\Delta\nu_y \approx 0.12$

➤ SuperKEKB

- More complicated w/ LN



Courtesy of E. Levichev



4. Summary

- LN causes tune-independent lum. loss => To be understood
- SC effects might be significant in LER:
 - Emit. growth and Lum. loss
 - Affect tune choice, injection, and phase 1 beam commissioning?
- BB+SC+LN: complicated, need heavy investigations
- To-Do list:
 - BB: very different from KEKB, need better understanding
 - Sources of emittance growth: IBS, BB, Errors, SC, ...
 - LN: dominant momentum- and amplitude-dependent terms