Crosstalk between beam-beam interaction and lattice nonlinearities in the SuperKEKB

- Preliminary results

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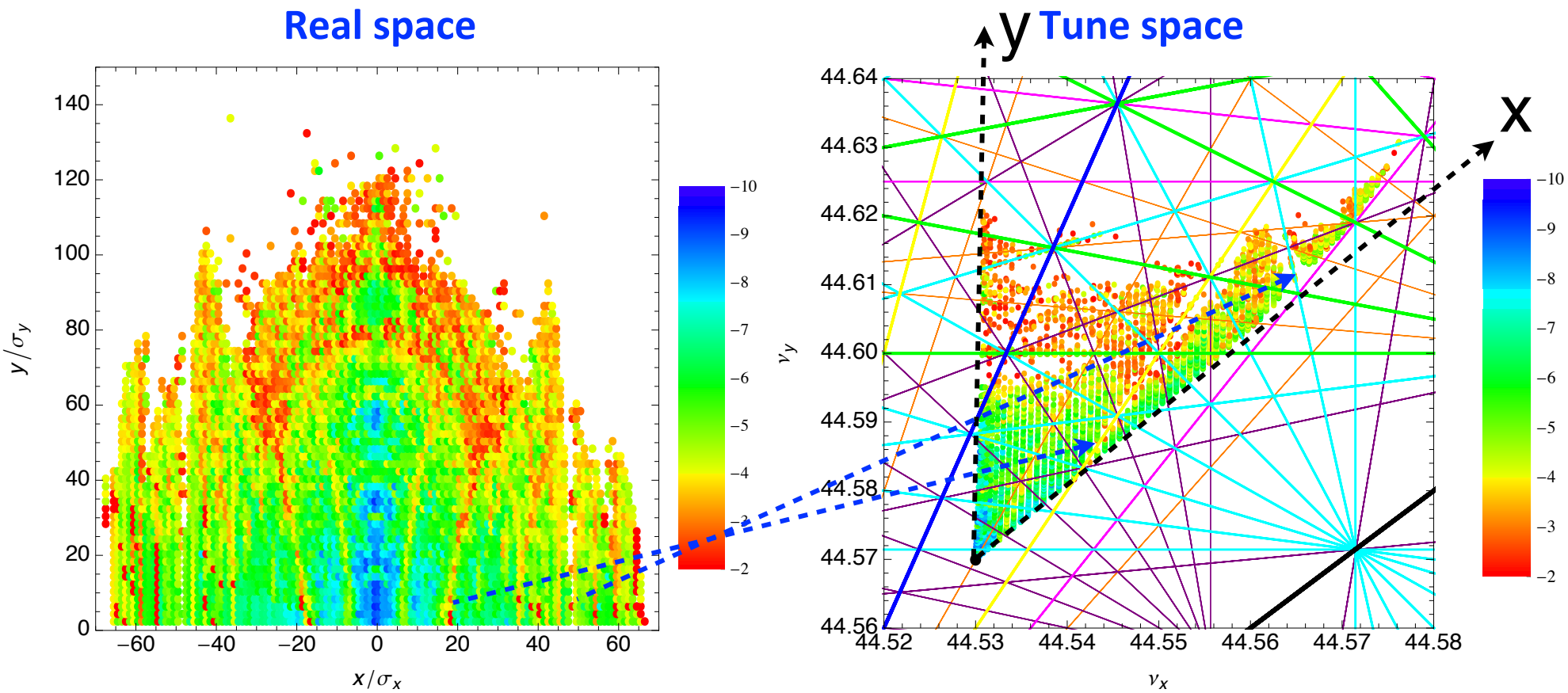
SuperKEKB optics meeting

Dec. 21, 2012

1. Motivation

sler_1670: Dynamic aperture (w/o beam-beam)



Frequency map analysis

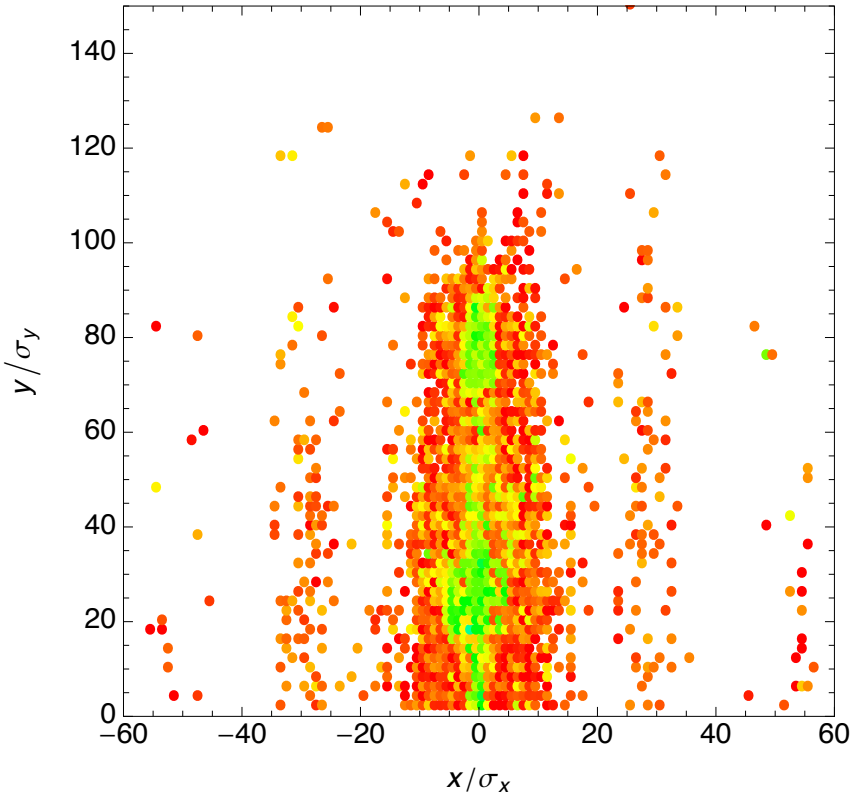
Resonance lines:
Blue: 4th order
Green: 5th order
Yellow: 6th order
Cyan: 7th order

D. Zhou et al., SuperKEKB optics meeting, Jul.17, 2012

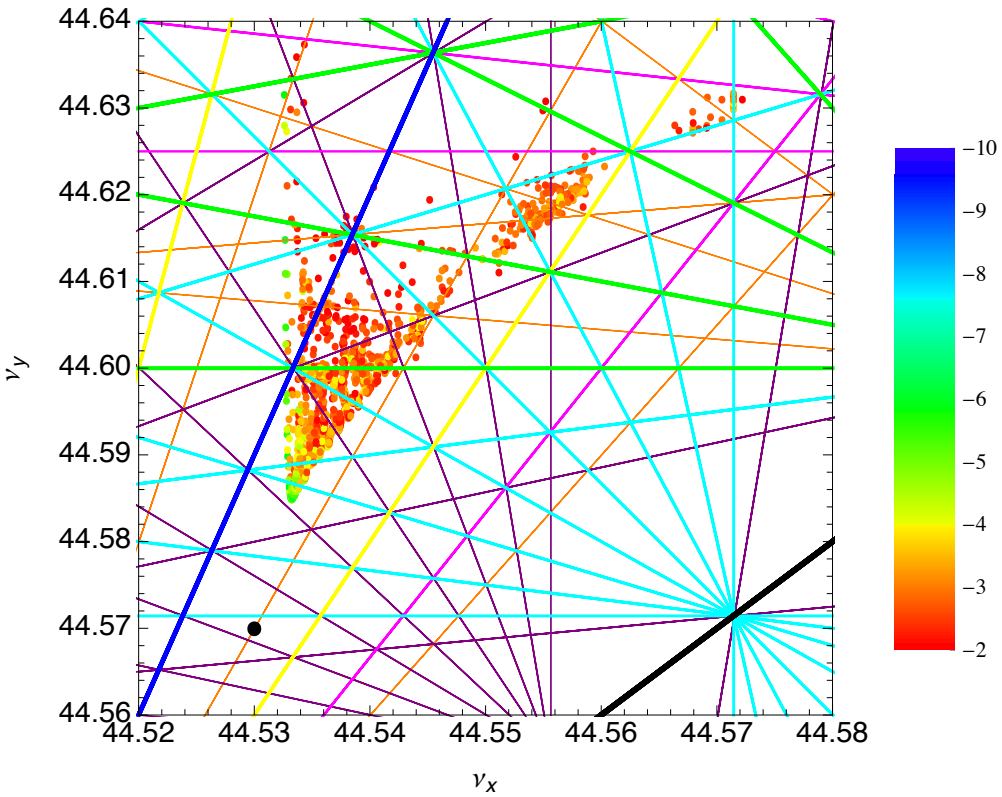
1. Motivation

sler_1670: Dynamic aperture (w/ beam-beam):

Real space



Tune space



Frequency map analysis

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1. Motivation

Question:
How lattice nonlinearities affect the luminosity performance of SuperKEKB?

Proposals for simulations:
1) Beam-beam simulation based on SAD: all lattice nonlinearities included
2) BBWS code: pure beam-beam with simple one-turn linear map
3) Simulate all the knob-scans in the control room and compare with the results of BBWS

2. Simulation based on SAD

TABLE 1 Machine parameters. * indicates values at IP.

	LER	HER	Unit
E	4.000	7.007	GeV
I	3.6	2.6	A
N_b	2500		
C	3016.315		m
ε_x	3.2	4.6	nm
ε_y	8.64	11.5	pm
β_x^*	32	25	mm
β_y^*	270	300	μm
$2\phi_x$	83		mrad
α_p	3.25×10^{-4}	4.55×10^{-4}	
σ_δ	8.08×10^{-4}	6.37×10^{-4}	
V_c	9.4	15.0	MV
σ_z	6	5	mm
ν_s	-0.0247	-0.0280	
ν_x	44.53	45.53	
ν_y	44.57	43.57	
U_0	1.87	2.43	MeV
τ_x/τ_s	43.1/21.6	58.0/29.0	msec
ξ_x	0.0028	0.0012	
ξ_y	0.0881	0.0807	
L	8×10^{35}		$\mathrm{cm}^{-2}\mathrm{s}^{-1}$

Beam-beam simulation with SAD:

1) Intra-beam scattering (IBS) affect the emittance but hard to model in tracking ⇝ IBS neglected.

2) Close the radiation damping and quantum excitation in SAD ⇝ Add damping and excitation manually and set the emittance (zero beam current) to design values.

Y. Ohnishi et al., Prog. Theor. Exp. Phys. 2012 (to be published)

2. Simulation based on SAD

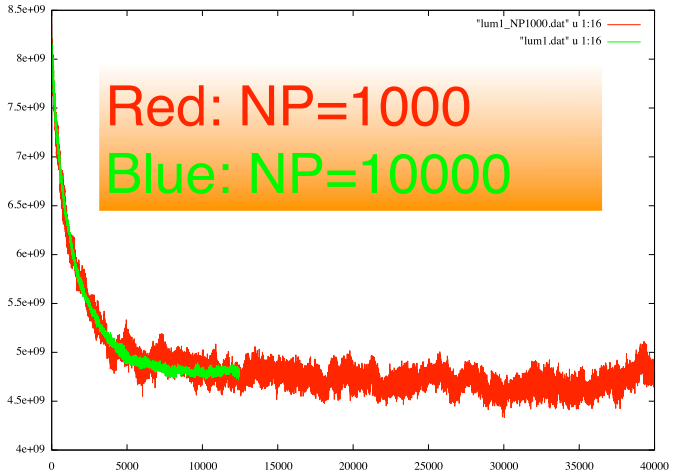
Other simulation conditions:

➤ **SAD: NP=1000 (limited by CPU time, 2 days for one simulation), nturn=40000,Design lattice (No magnet errors)**

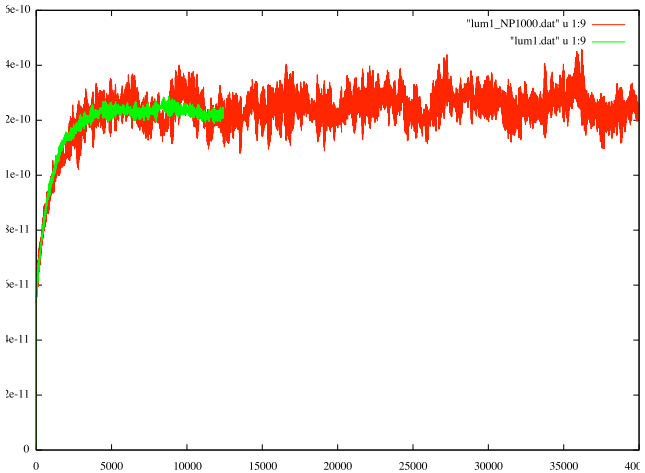
➤ **BBWS: NP=10000 (2.5 hours for one simulation), nturn=40000, Simple one turn map**

SAD simulation example

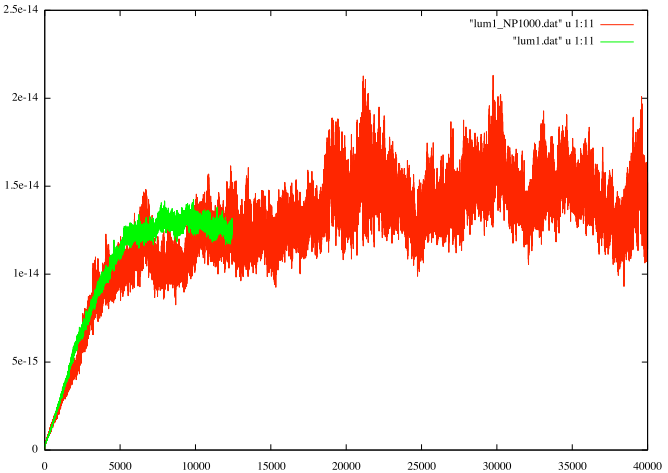
Luminosity



$\langle x^2 \rangle$



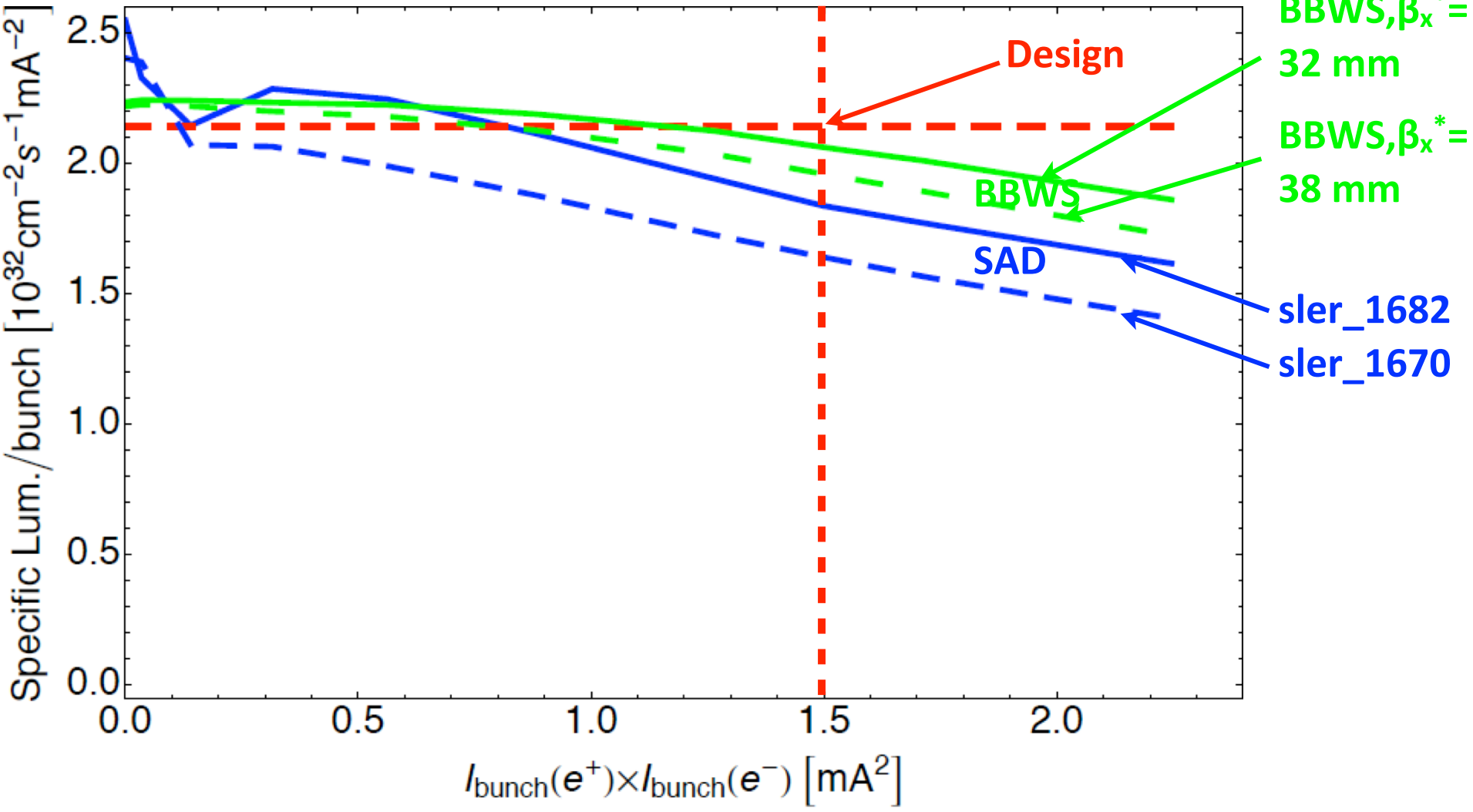
$\langle y^2 \rangle$



3. Simulation results

Specific luminosity:

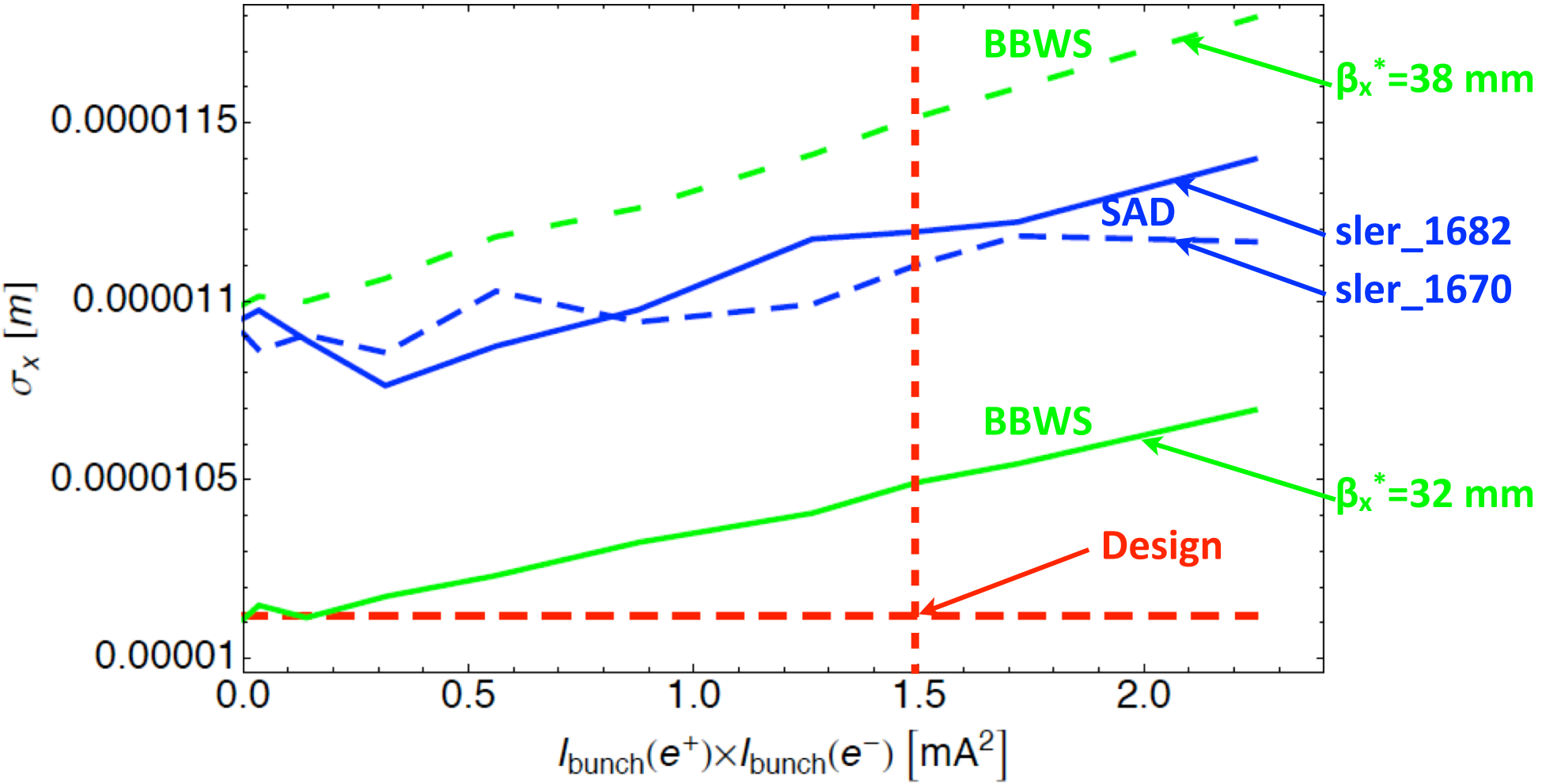
Number of particles:
SAD: NP=1000
BBWS: NP=10000



3. Simulation results

Number of particles:
SAD: NP=1000
BBWS: NP=10000

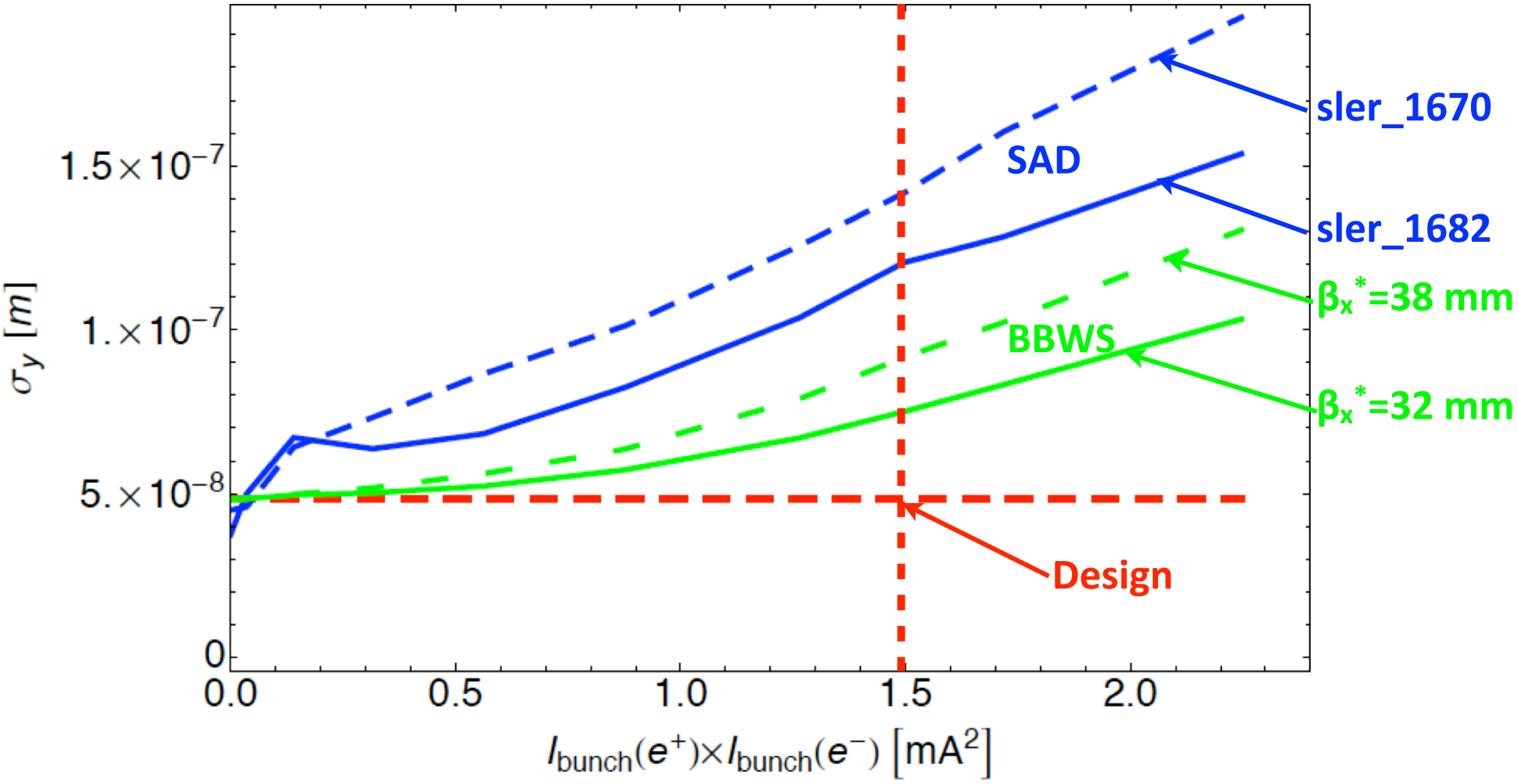
Horizontal beam size:



3. Simulation results

Number of particles:
SAD: NP=1000
BBWS: NP=10000

Vertical beam size:



4. Tentative conclusions and Future work

Tentative conclusions:

- **Lattice nonlinearities may affect luminosity performance (~10%?)**
- **The effect depends on lattice design**

Future work:

- **Understand the anomalous beam size blow-up**
- **Repeat the study for HER**
- **Simulate all the knob-scans in the control room and compare with the results of BBWS**
- **Consider effects of errors**
- **Investigate lattice nonlinearities**