

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

- Updated results

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SuperKEKB optics meeting

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# 1. On previous results

Previous results:

D. Zhou et al., SuperKEKB optics meeting, Dec. 21, 2012

Problems in the previous results:

1) Flags in SAD script not properly set:

“RAD OFF”  $\rightsquigarrow$  “NORAD”

2) Bunch length in LER not correct

$\sigma_z=4.8$  mm  $\rightsquigarrow$   $\sigma_z=6$  mm

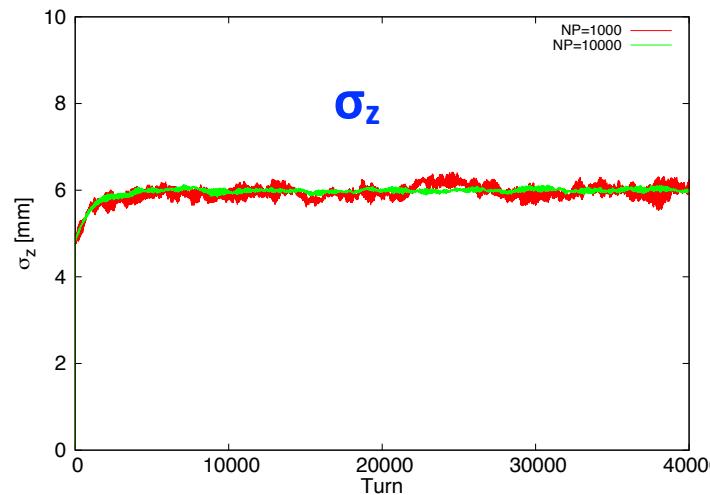
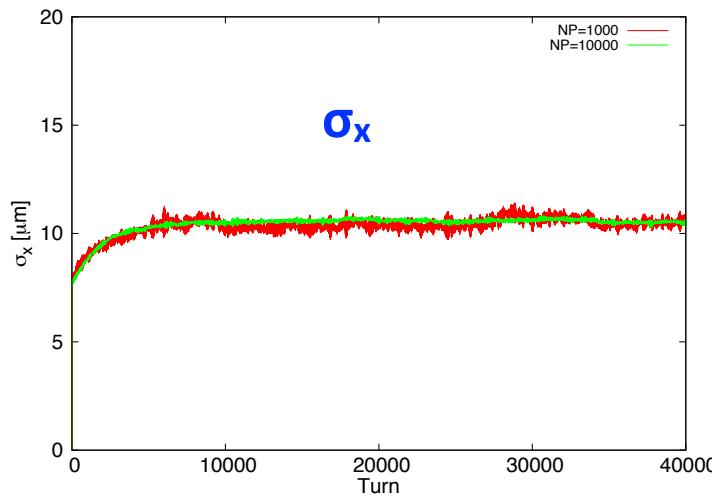
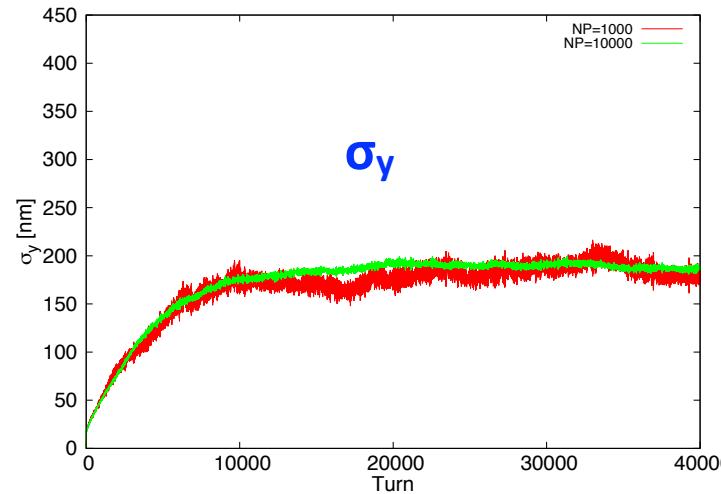
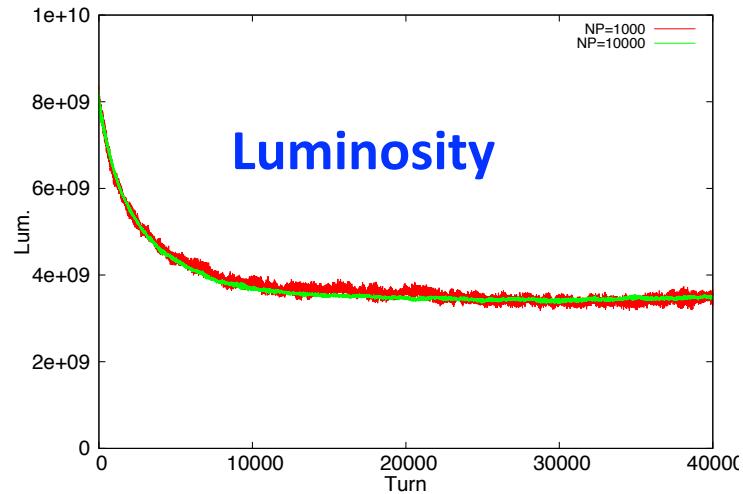
Updated beam-beam simulations using SAD:

1) Add damping and excitation **manually** and set the emittances ( $\epsilon_x/\epsilon_y/\epsilon_z$ ) to design values (see page 4).

**Note:** This is a “qualitative” study at present because of two aspects:  
weak-strong model and unknown emittance coupling (X-Y).

# 1. SuperKEKB: sler\_1682: NP=1000/10000

Turn-by-turn data:



## 2. Machine parameters

	LER <sup>1)</sup>	HER <sup>1)</sup>	Bare lattice		Unit
			LER <sup>2)</sup>	HER <sup>3)</sup>	
$\epsilon_x$	3.2 <sup>4)</sup>	4.6 <sup>4)</sup>	1.858	4.47	nm
$\epsilon_y$	8.64 <sup>5)</sup>	11.5 <sup>5)</sup>	0.758	1.54	pm
$\sigma_z$	6 <sup>6)</sup>	5 <sup>6)</sup>	4.81	4.90	mm
$\sigma_\delta$	8.08	6.37	7.73	6.30	$\times 10^{-4}$

<sup>1)</sup>Design, Y. Ohnishi et al., Prog. Theor. Exp. Phys. 2012 (to be published);

<sup>2)</sup>ler\_1682;

<sup>3)</sup>sher\_5753;

<sup>4)</sup>Intra-beam scattering;

<sup>5)</sup>X-Y coupling, beam-beam, errors, etc.;

<sup>6)</sup> Collective effects.

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Used for simulations

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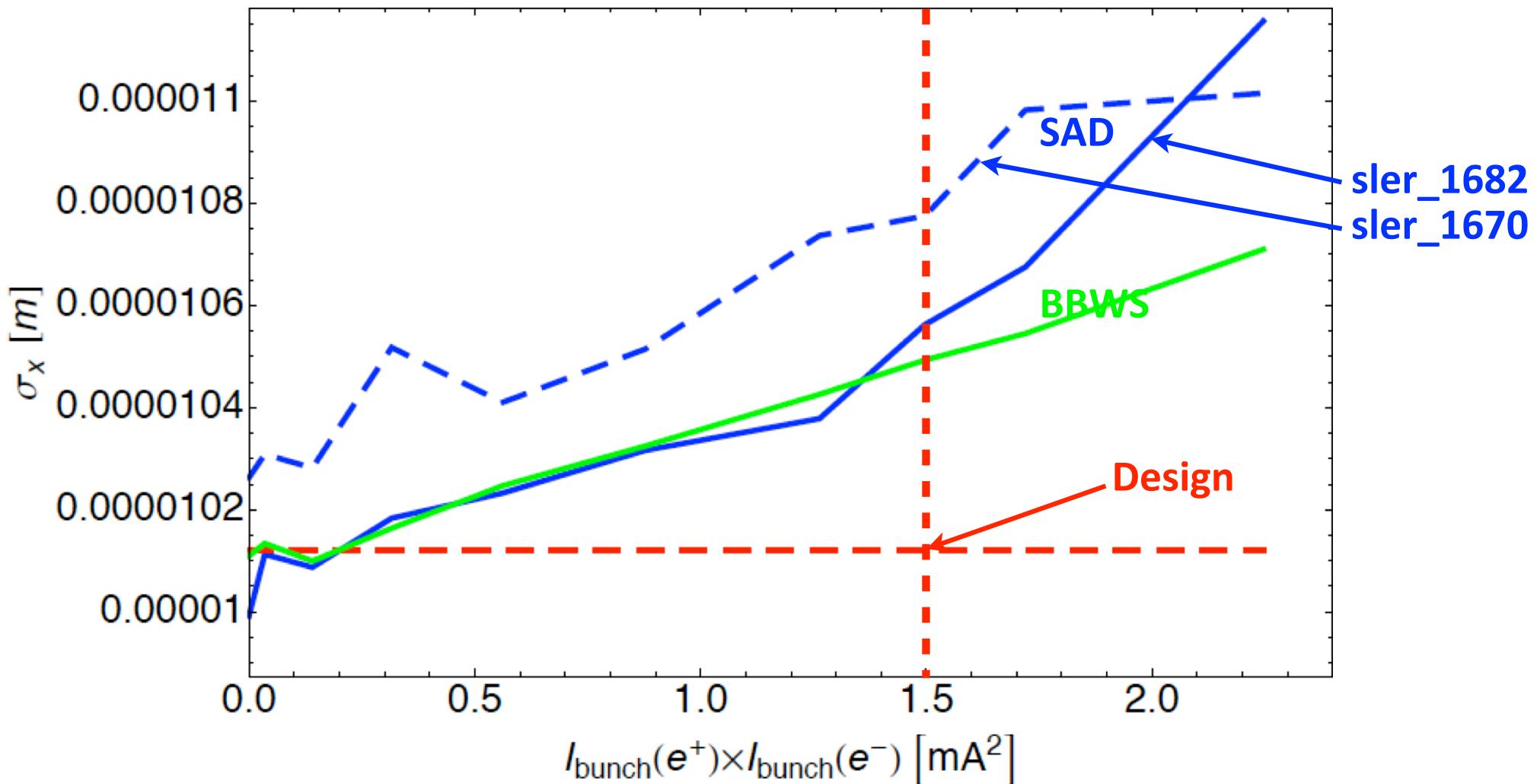
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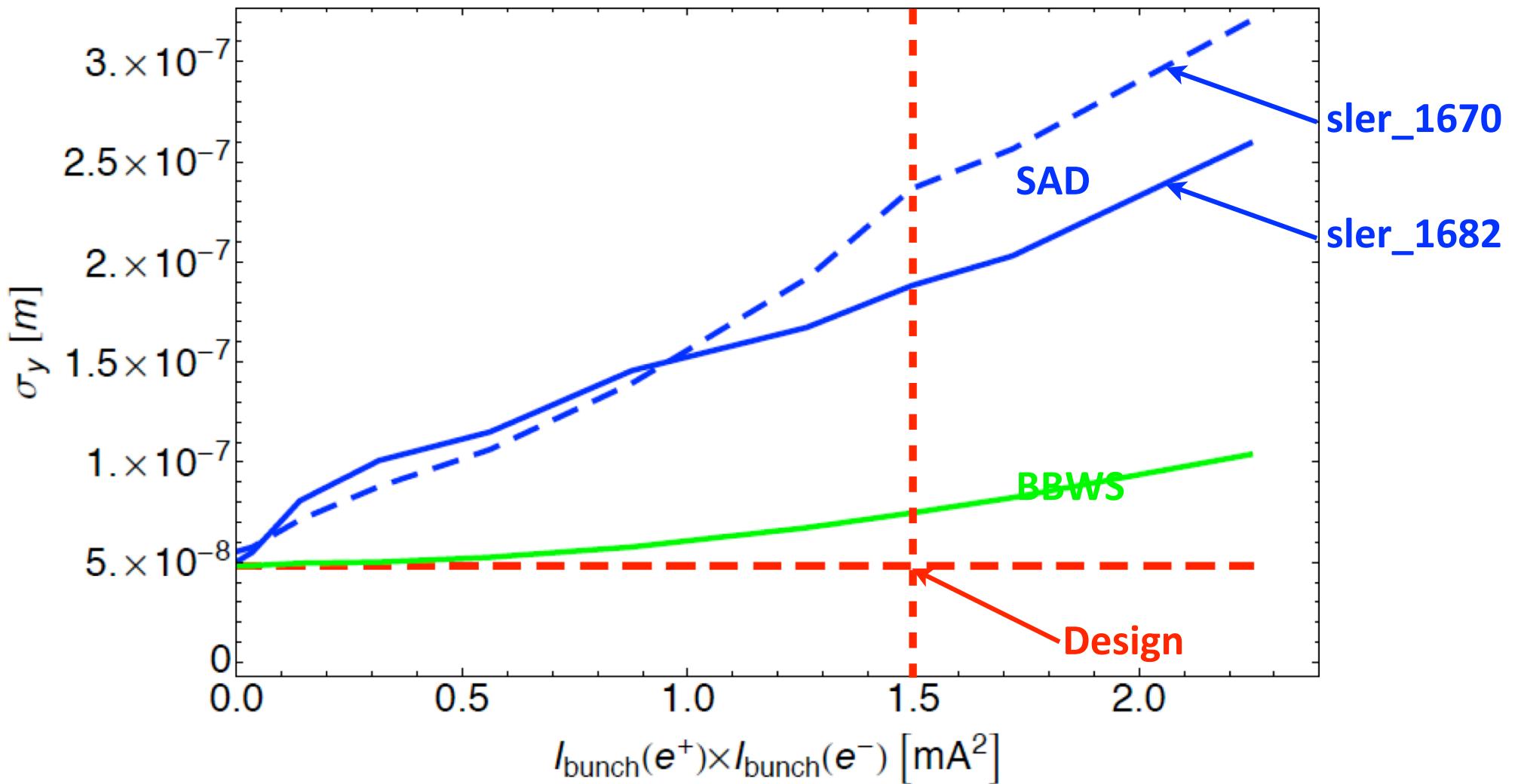
### 3. Simulation results - LER

Horizontal beam size: now the results are fairly reasonable



### 3. Simulation results - LER

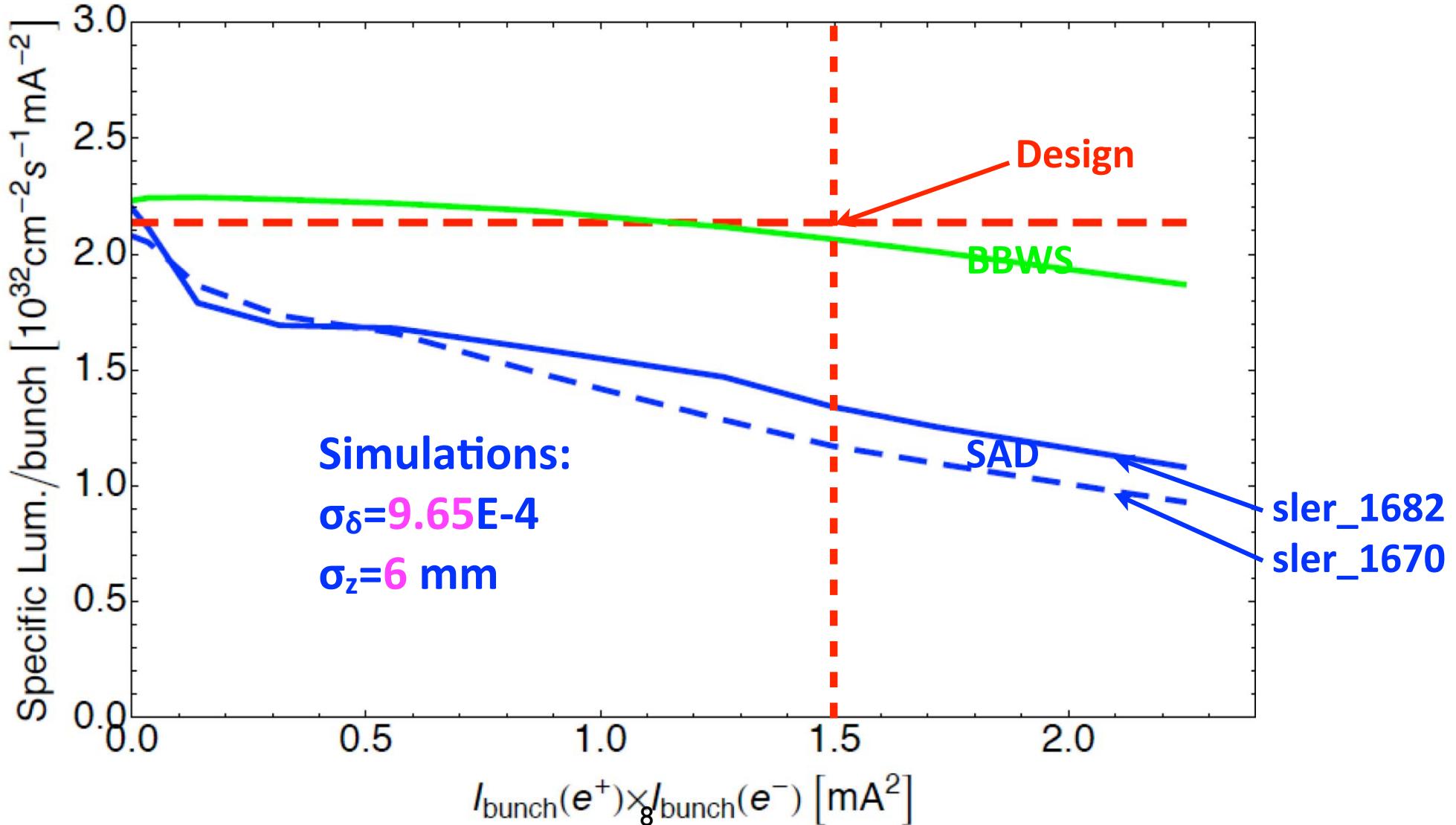
Vertical beam size:



### 3. Simulation results - LER

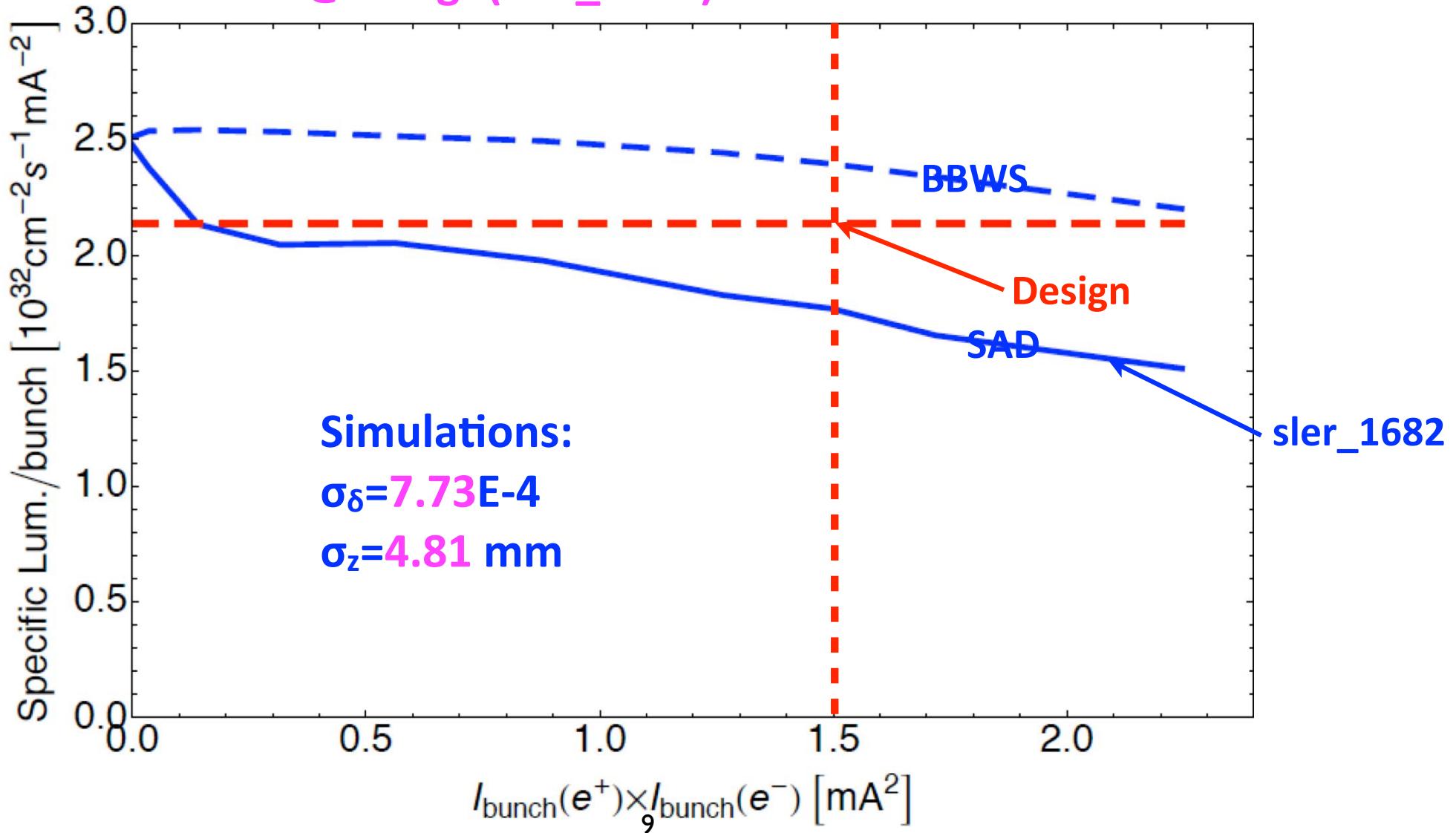
Use wakefields?

Specific luminosity: use  $\sigma_z$  of design ( $\sigma_\delta$  over-estimated ↗  
momentum-dependent nonlinearities overcounted)  
↗ ~35% loss@Design(sler\_1682)



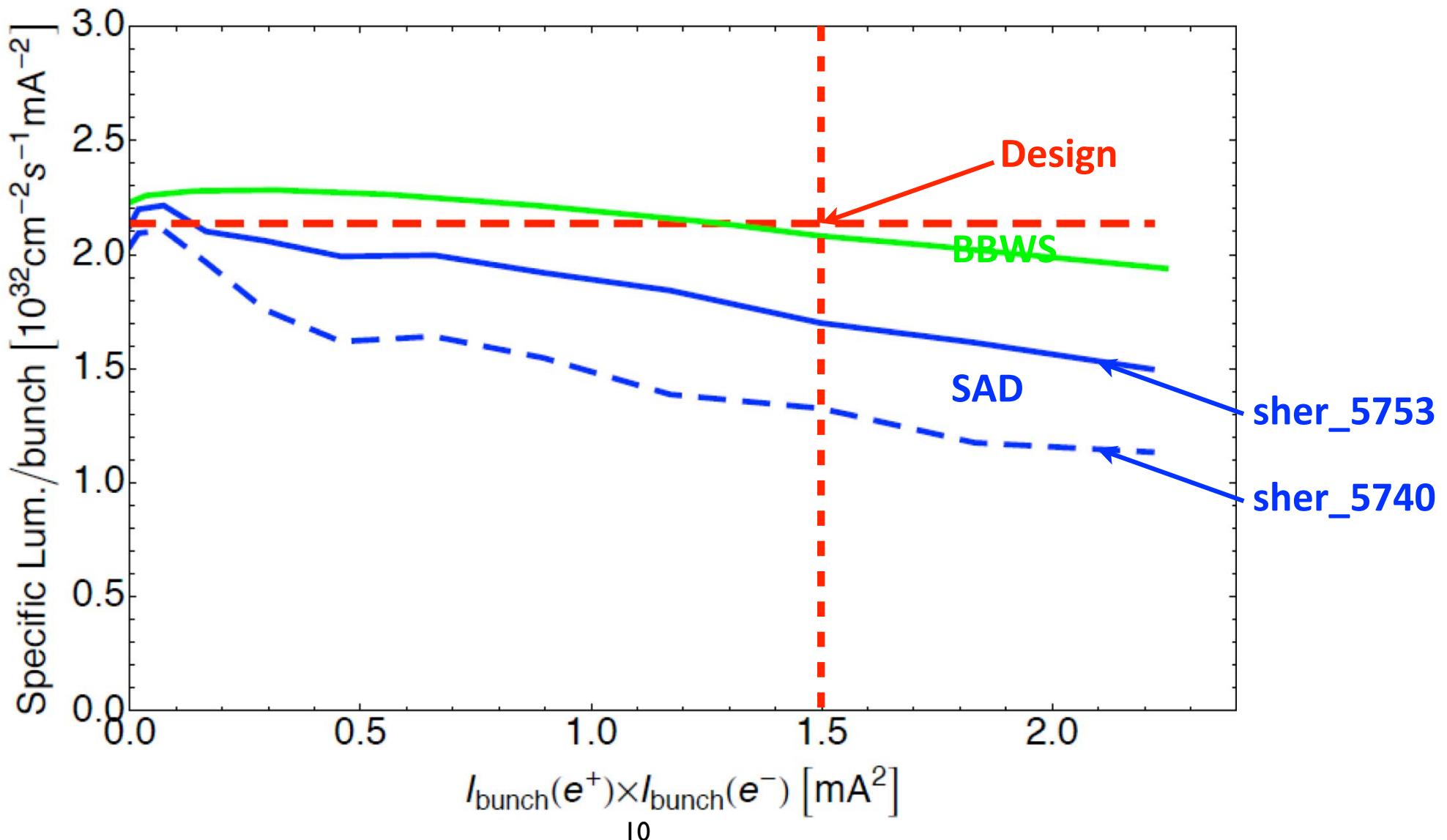
### 3. Simulation results - LER

Specific luminosity: use  $\sigma_z$  of bare lattice ( $\sigma_\delta$  under-estimated ↗  
momentum-dependent nonlinearities undercounted)  
↗ ~25% loss@Design(sler\_1682)



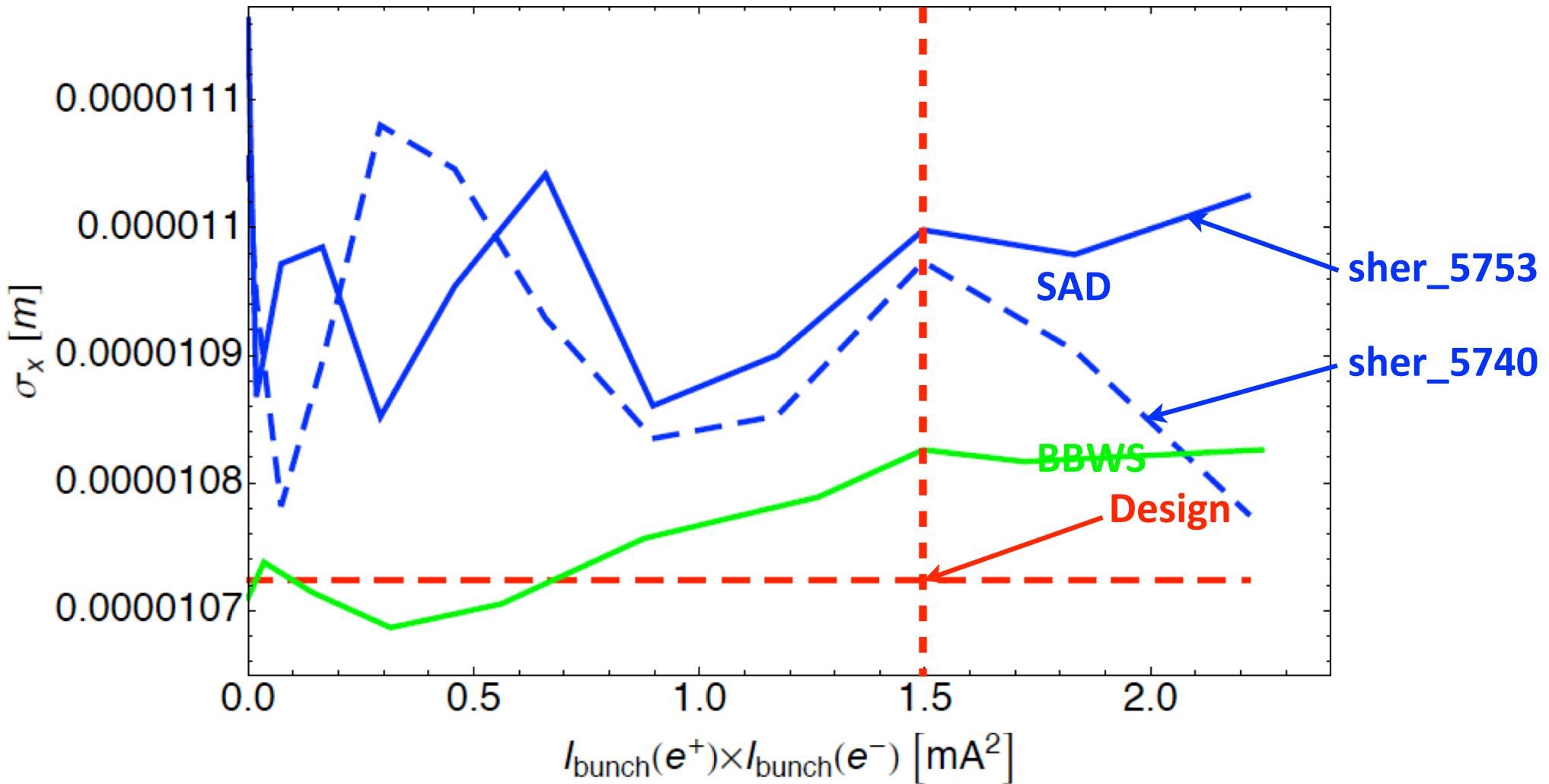
## 4. Simulation results - HER

Specific luminosity: use  $\sigma_z$  of design  $\rightsquigarrow \sim 20\% \text{ loss}@\text{Design(sher\_5753)}$   
luminosity loss is mainly due to blow-up in  $\epsilon_y$



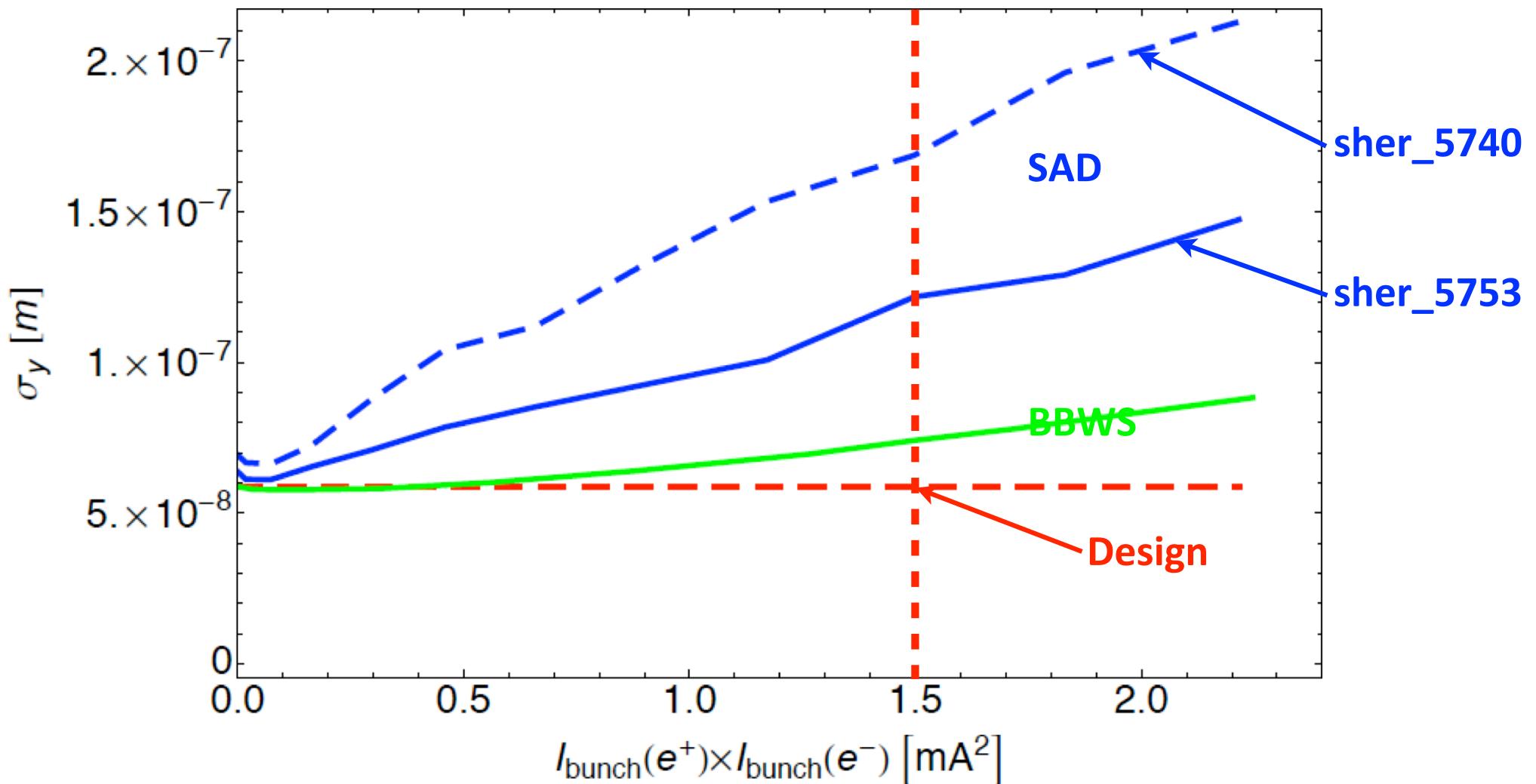
## 4. Simulation results - HER

Horizontal beam size: blow-up in  $\sigma_x$  is weaker than LER



## 4. Simulation results - HER

Vertical beam size:



## 5. KEKB: Machine parameter

	LER <sup>1)</sup>	HER <sup>1)</sup>	Bare lattice		Unit
			LER <sup>2)</sup>	HER <sup>2)</sup>	
$\epsilon_x$	19.25	24.19	19.25	24.19	nm
$\epsilon_y$	192.5	241.9	1.716	8.646	pm
$\sigma_z$	4.68 <sup>3)</sup>	5.20 <sup>3)</sup>	4.68	5.20	mm
$\sigma_\delta$	7.27	6.67	7.27	6.67	$\times 10^{-4}$

<sup>1)</sup>Used for simulations;

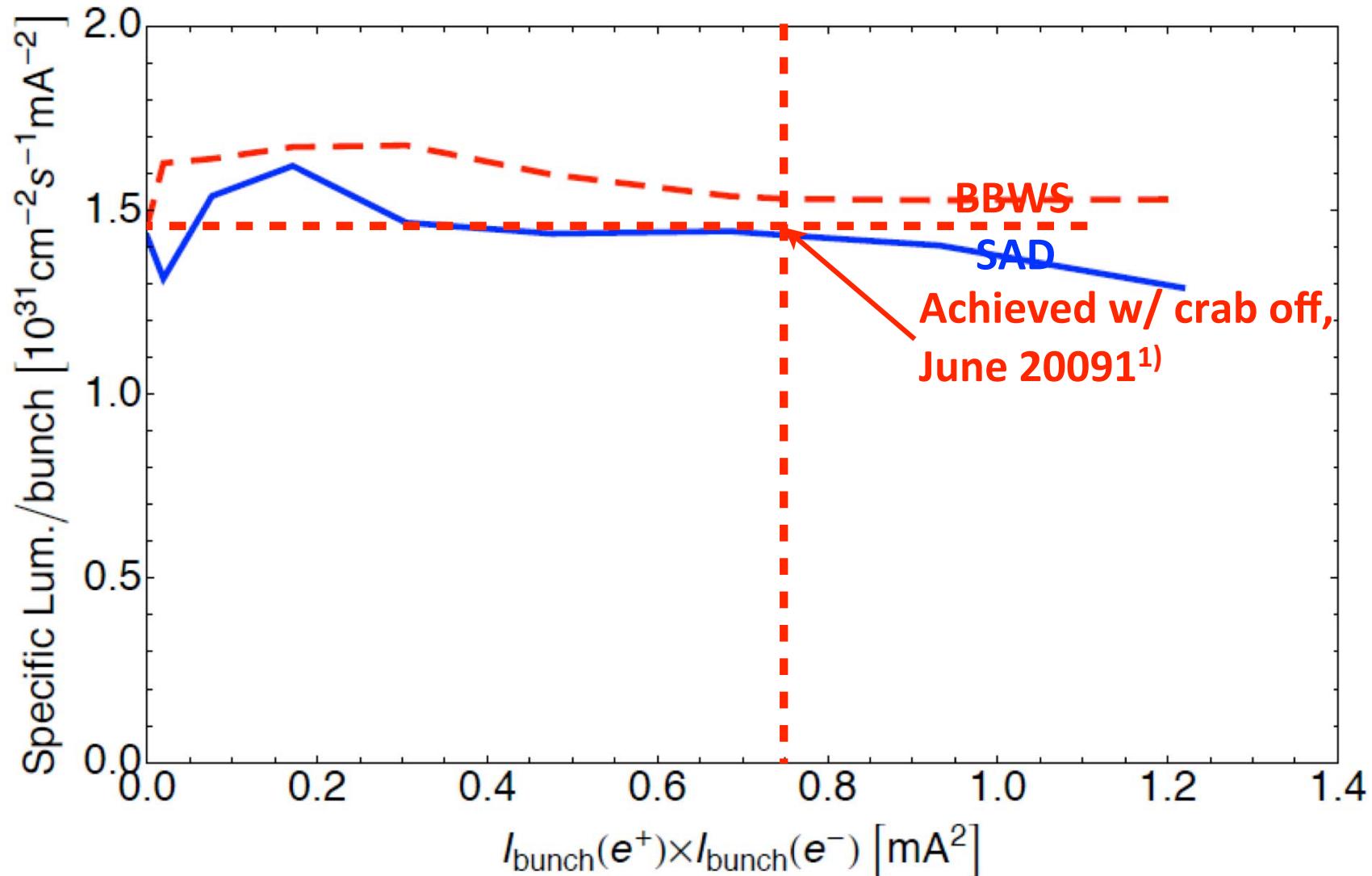
<sup>2)</sup>provided by Y. Ohnishi, lattice used on Jun. 17, 2009;

<sup>3)</sup> No collective effects.

## 5. KEKB: LER: Simulation results w/o crab cavities

Specific luminosity: use  $\sigma_z$  of bare lattice(Jun.17, 2009)

→ ~6% loss@Beam currents on Jun.17, 2009

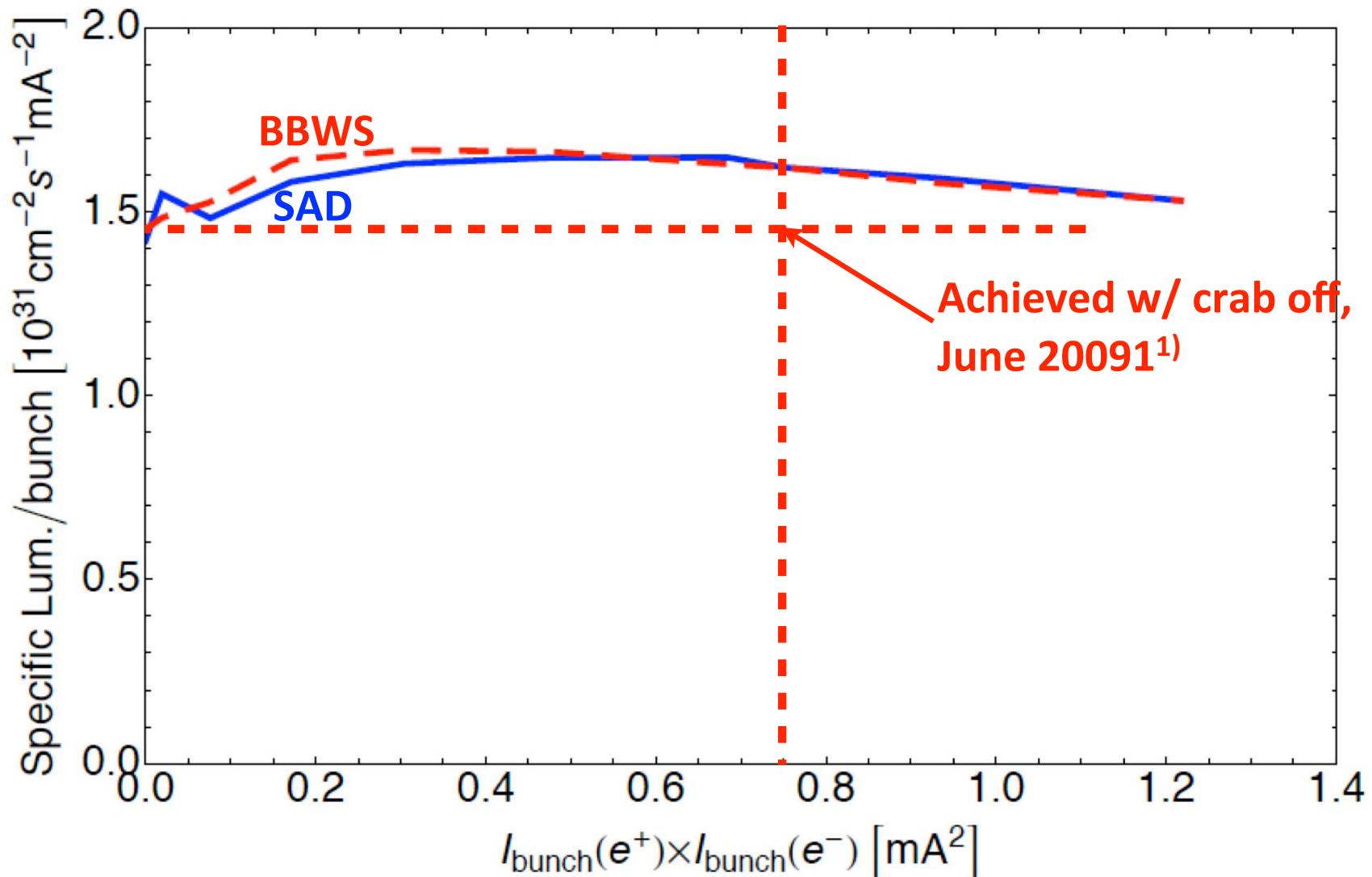


<sup>1)</sup>Y. Funakoshi et al., Prog. Theor. Exp. Phys. 2012, to be published.

## 5. KEKB: HER: Simulation results w/o crab cavities

Specific luminosity: use  $\sigma_z$  of bare lattice(Jun.17, 2009)

~~~ almost no loss@Beam currents on Jun.17, 2009



<sup>1)</sup>Y. Funakoshi et al., Prog. Theor. Exp. Phys. 2012, to be published.

## 6. Summary

Tentative conclusions:

- Lattice nonlinearities may affect luminosity performance significantly(Need to be confirmed)
- Lattice nonlinearities played a role in KEKB(w/ and w/o crab cavities)?(need to be studied in detail)

Existing issues:

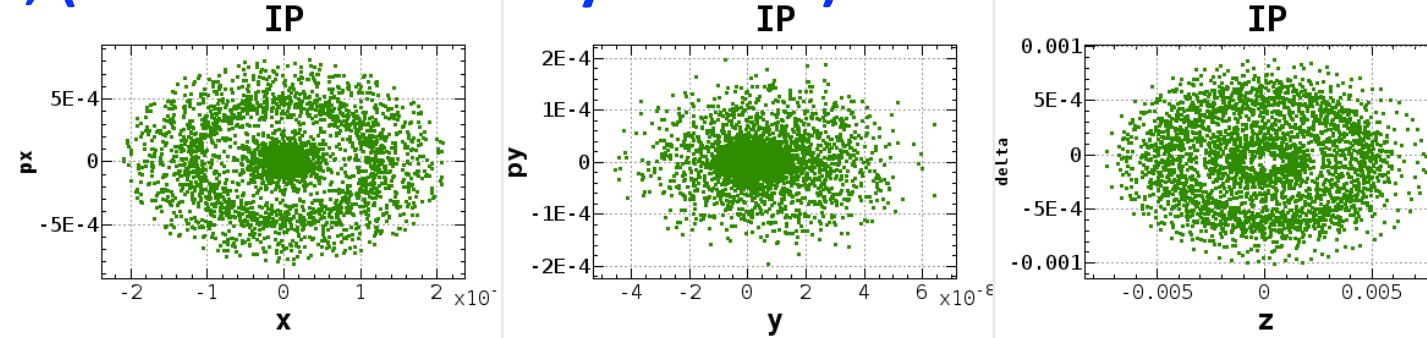
- $\sigma_\delta$  need to be properly set in SAD(add wakefields?)
- Numerical techniques: Increase number of particles (depend on computing power)? Need benchmarking?

To-do list:

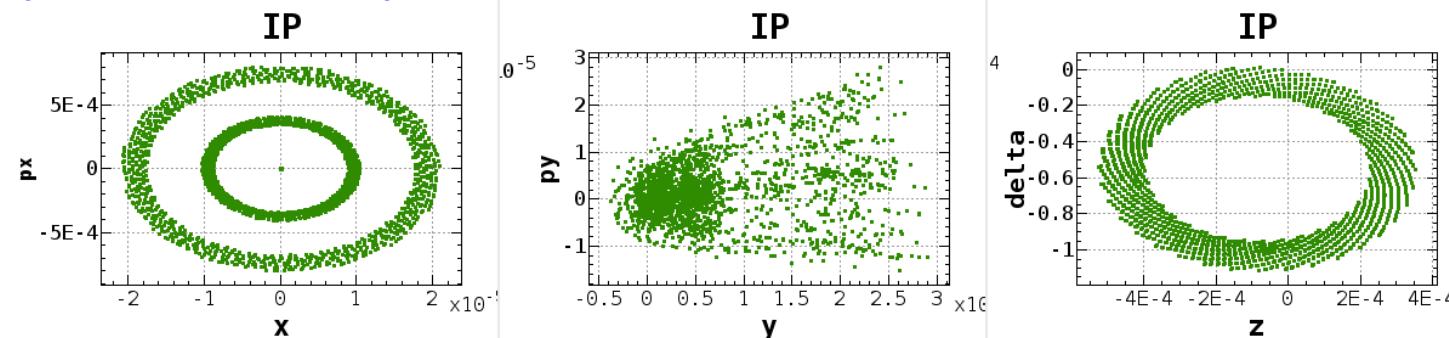
- Estimate emittance growth due to beam-beam (with given X-Y coupling)
- Consider errors

# **Backup**

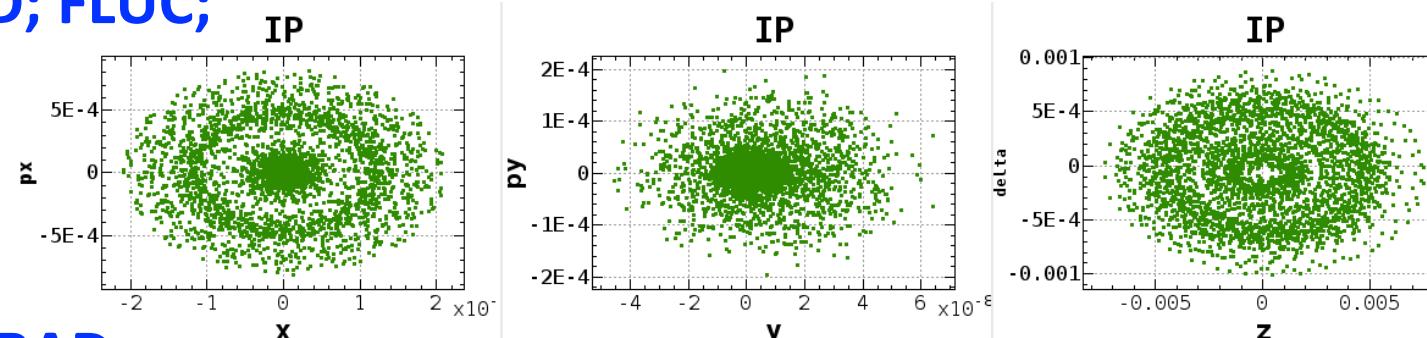
## RAD; (FLUC automatically set on?)



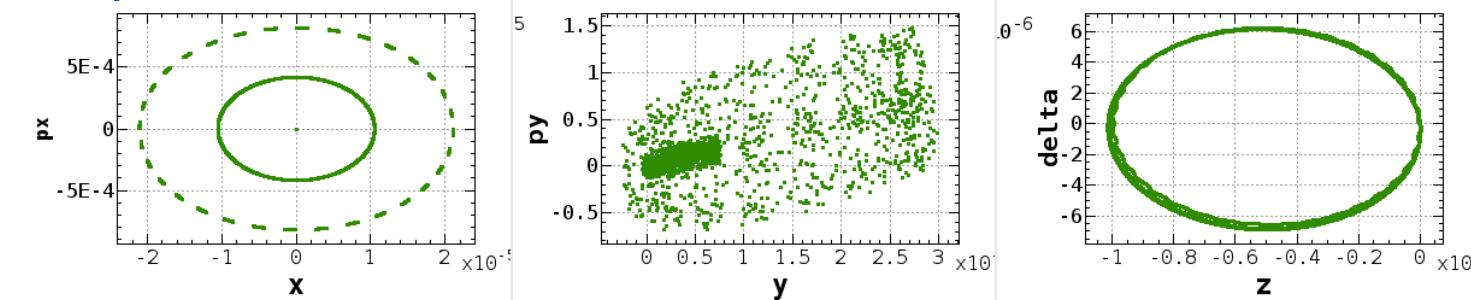
## RAD; DAMPONLY;



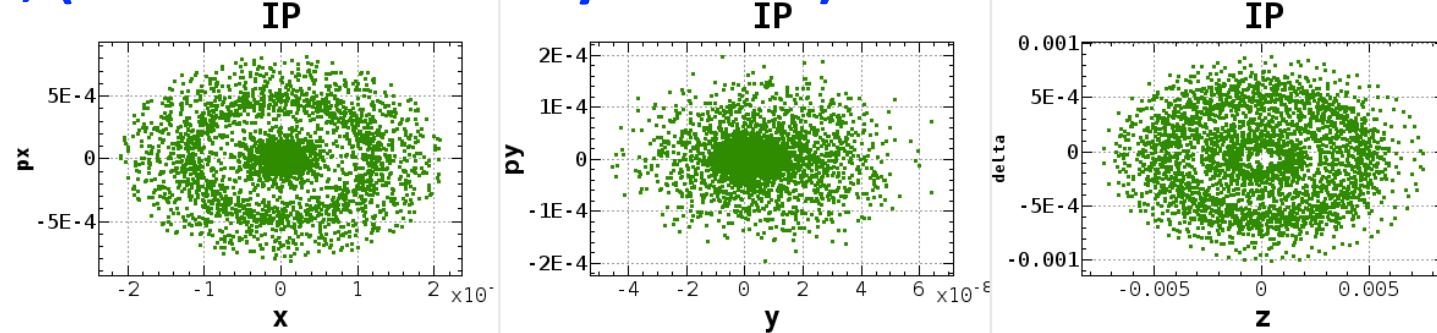
## RAD; FLUC;



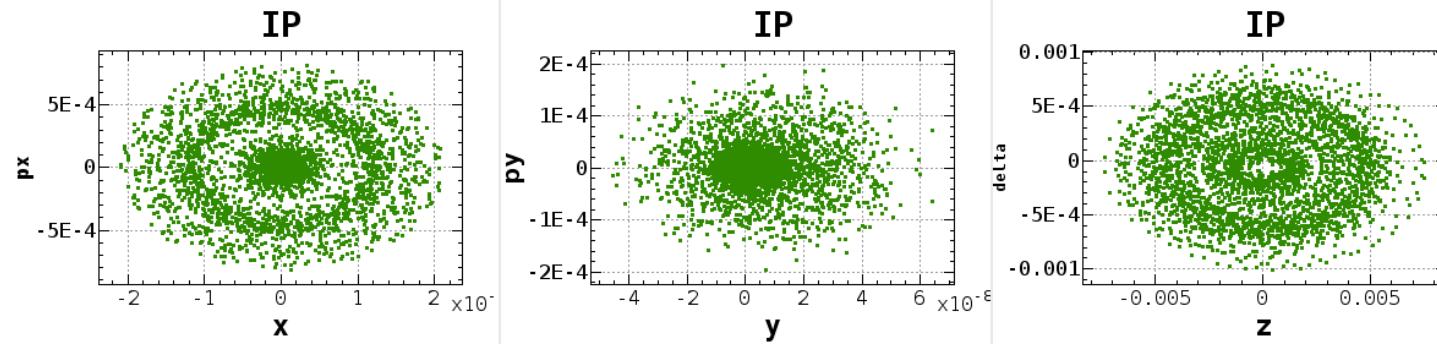
## NORAD;



**RAD; (FLUC automatically set on?)**

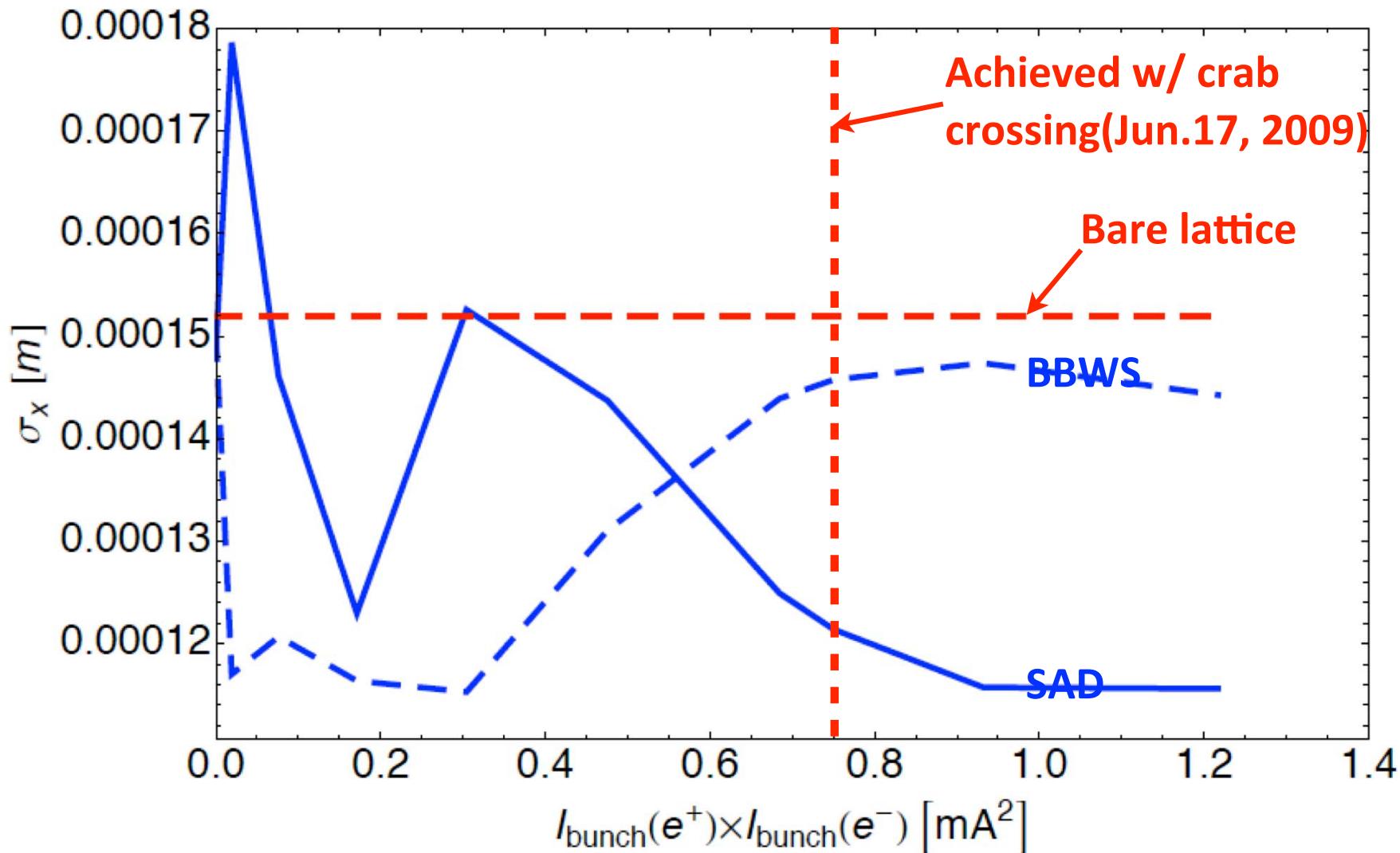


**RAD OFF; (This command does not work!)**



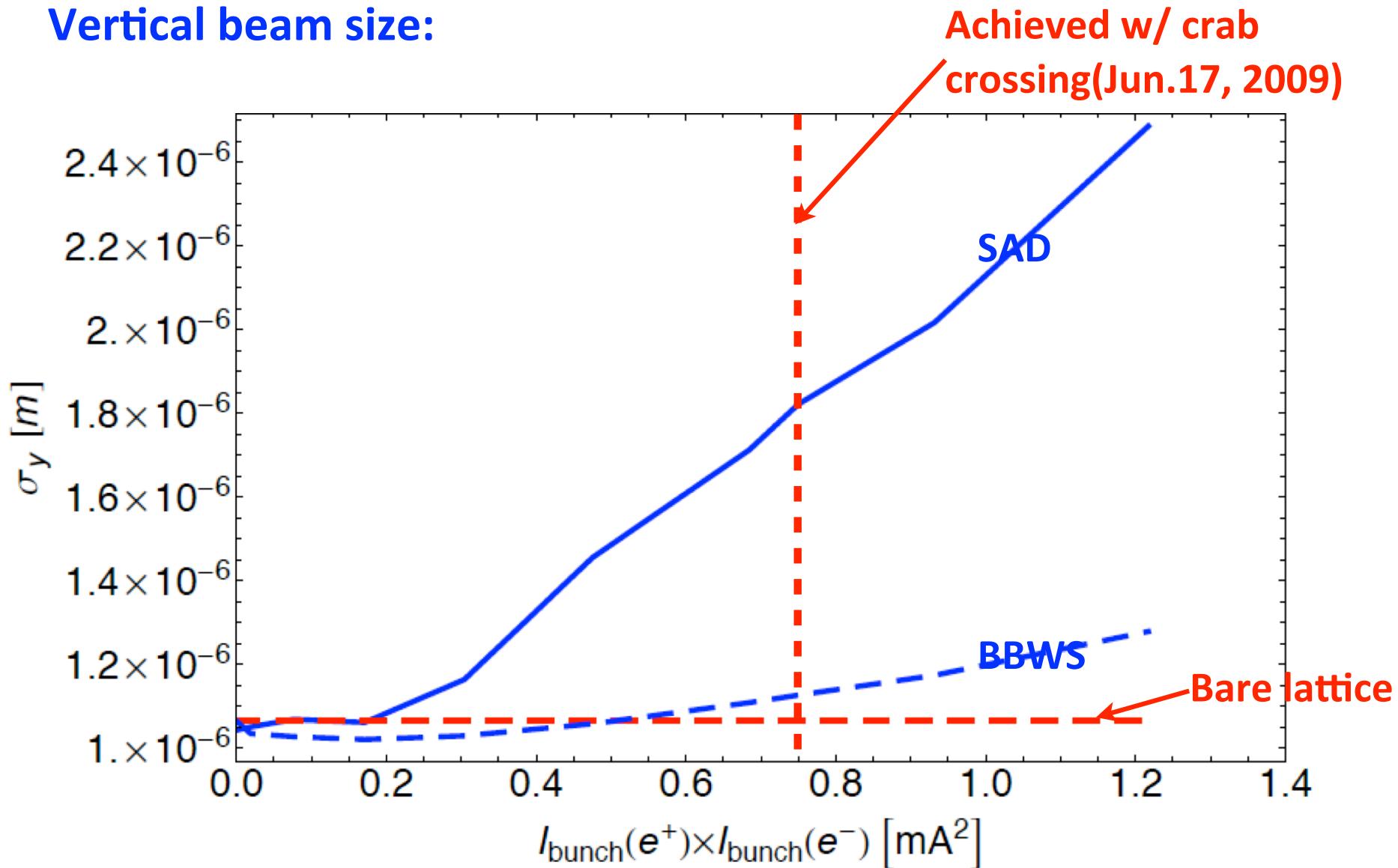
## 5. KEKB: LER: Simulation results w/o crab cavities

Horizontal beam size:



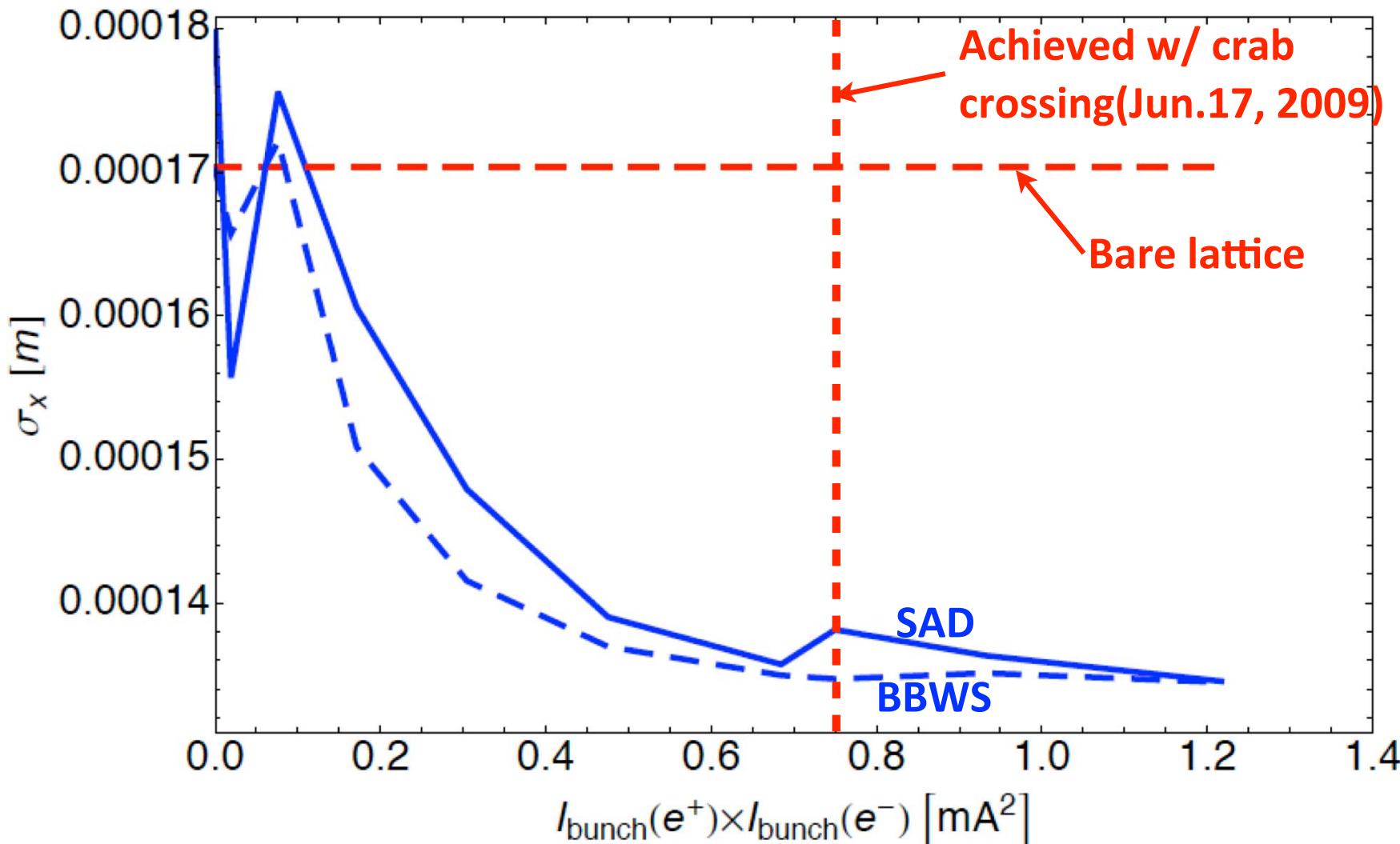
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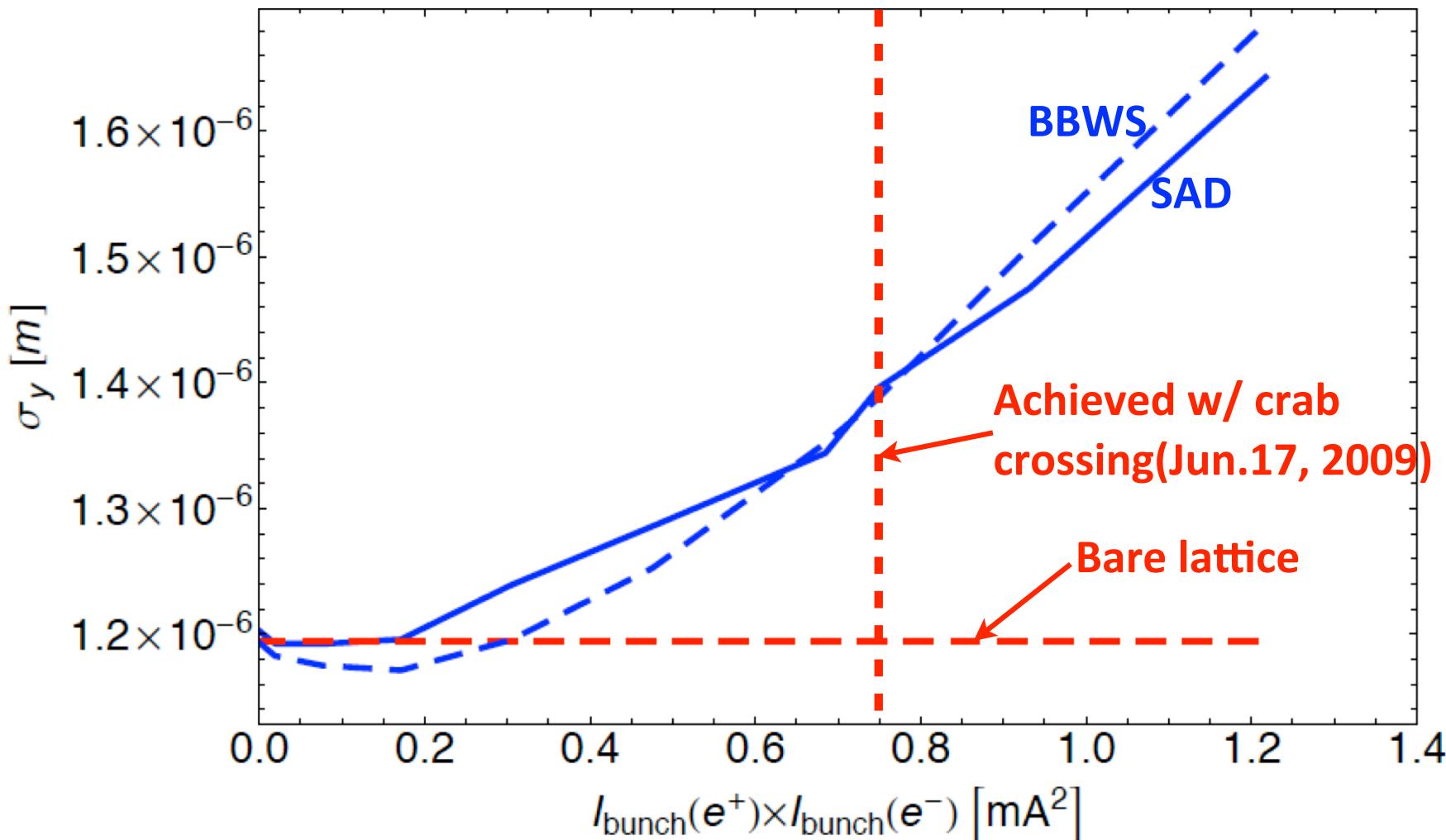
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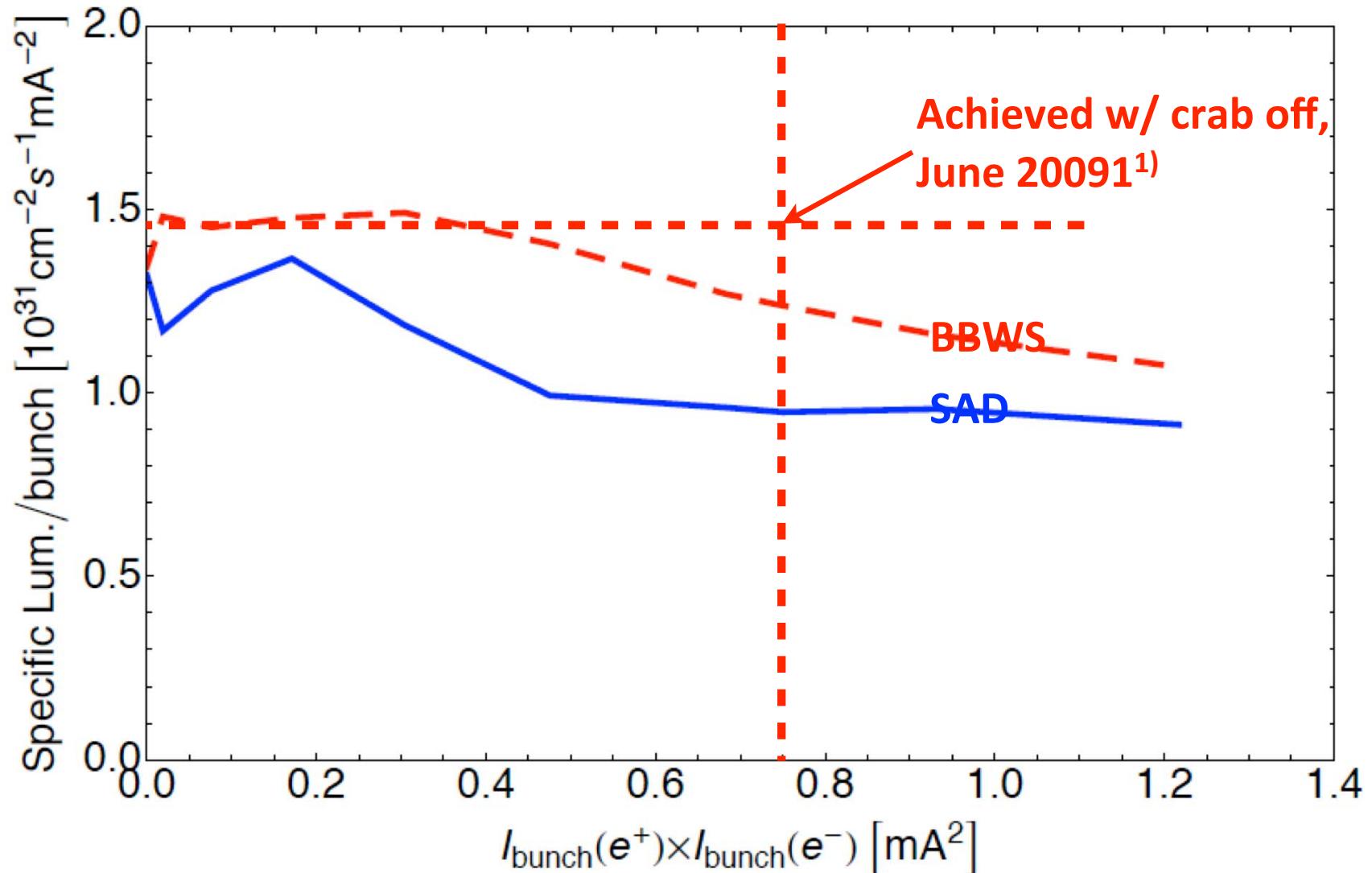
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Vertical beam size:



## 7. KEKB: LER: Simulation results w/o crab cavities

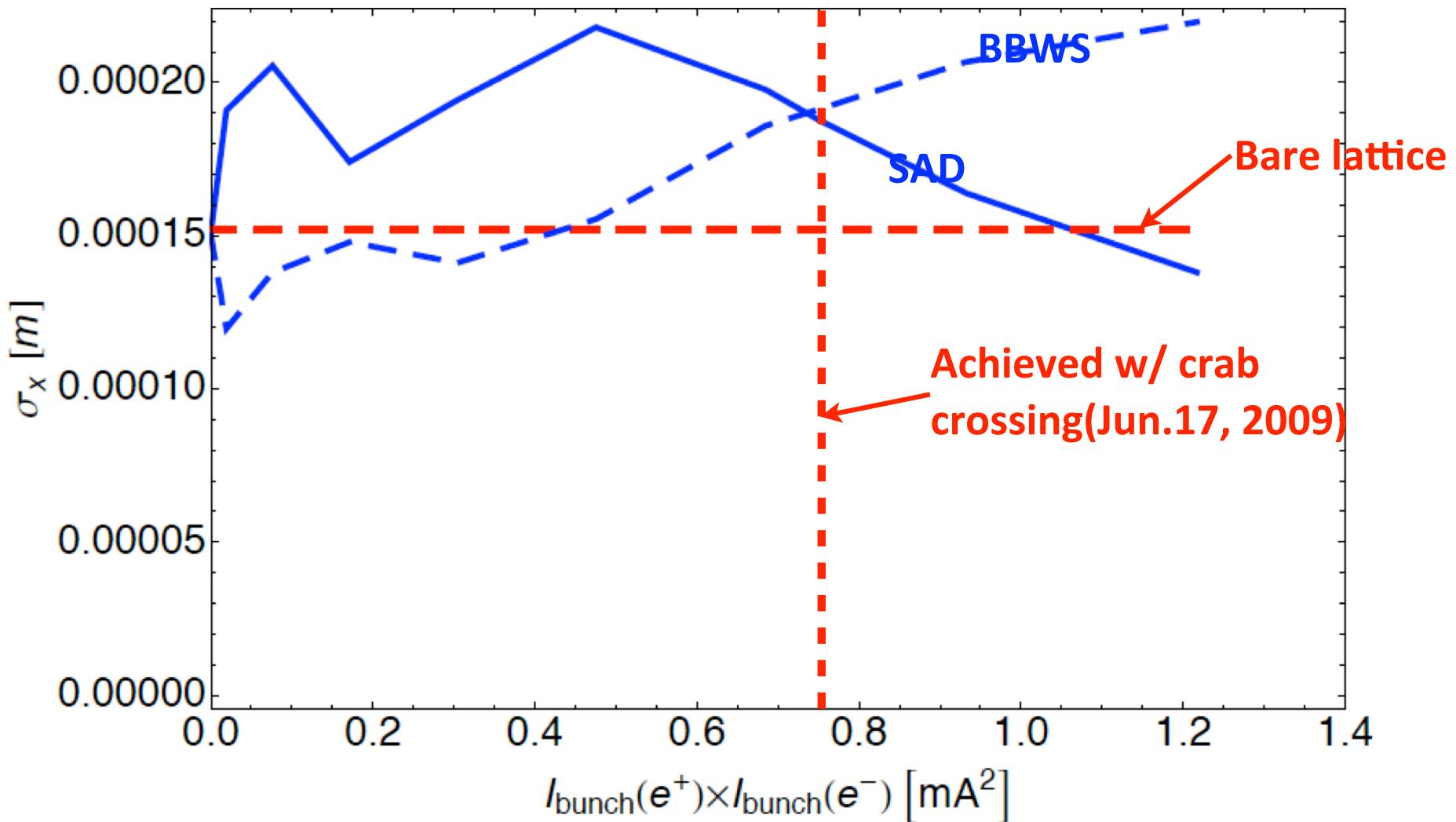
Specific luminosity: use  $\sigma_z$  of measurement(momentum-dependent nonlinearities overcounted)  $\rightsquigarrow \sim 23\%$  loss@Design      Add wakefields?



<sup>1)</sup>Y. Funakoshi et al., Prog. Theor. Exp. Phys. 2012, to be published.

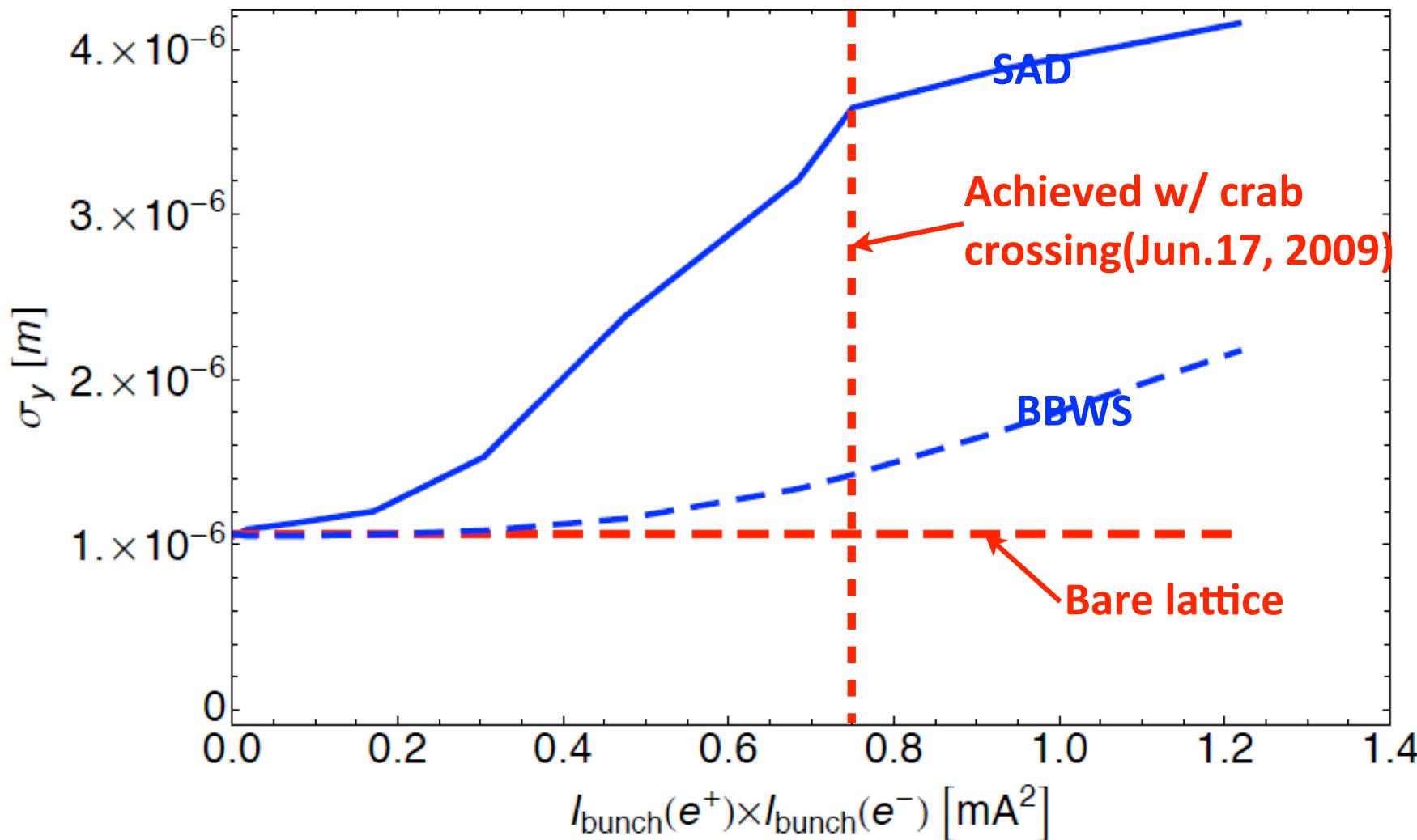
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Horizontal beam size:



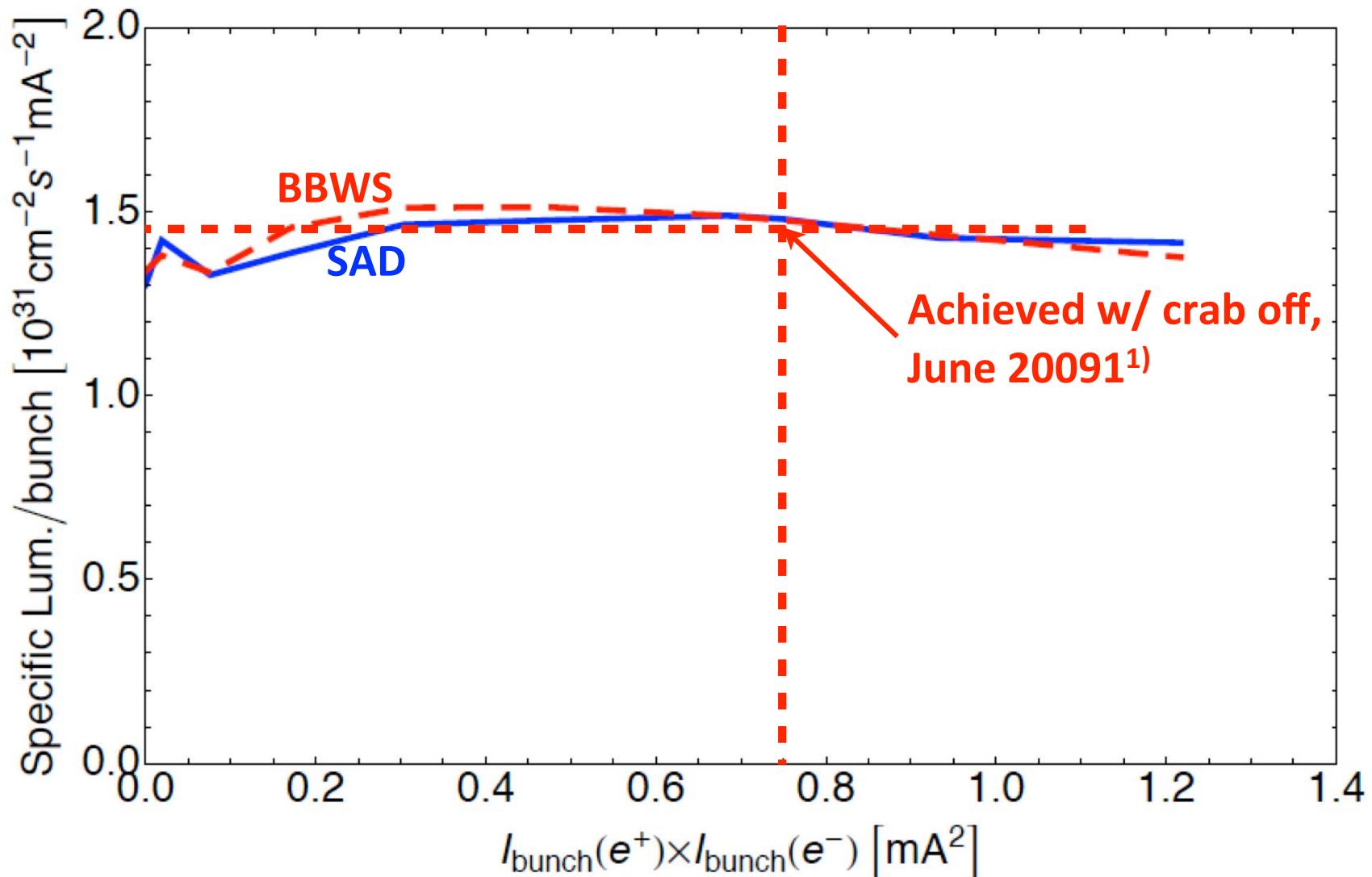
## 7. KEKB: LER: Simulation results w/o crab cavities

Vertical beam size:



## 7. KEKB: HER: Simulation results w/o crab cavities

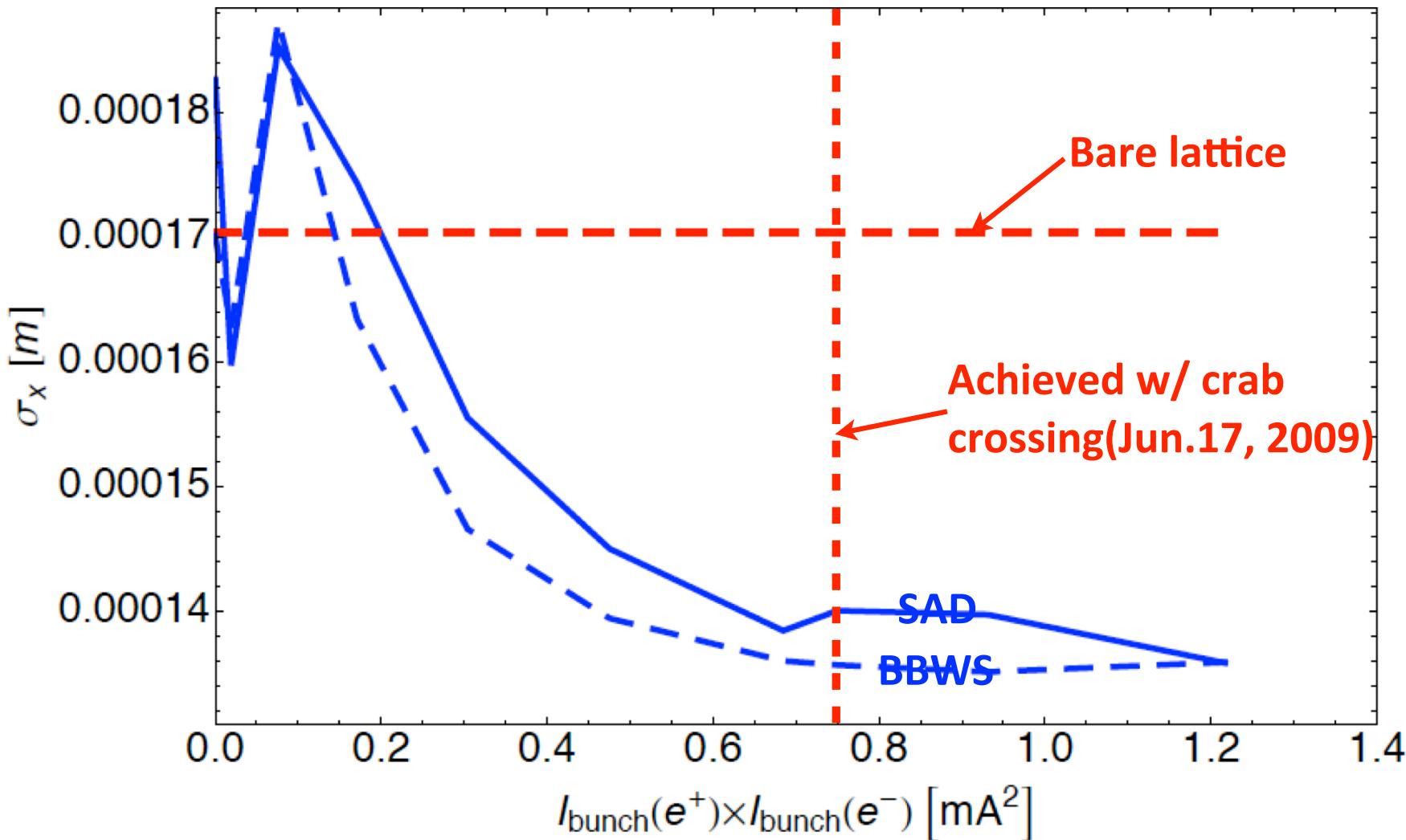
Specific luminosity: use  $\sigma_z$  of measurement(momentum-dependent nonlinearities overcounted)  $\rightsquigarrow$  almost no loss@Design



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Horizontal beam size:



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Vertical beam size:

