Beam-beam Effects at SuperKEKB

D. Zhou, K. Ohmi, Y. Ohnishi

SLAC-KEKB collaboration meeting

Sep. 13, 2013

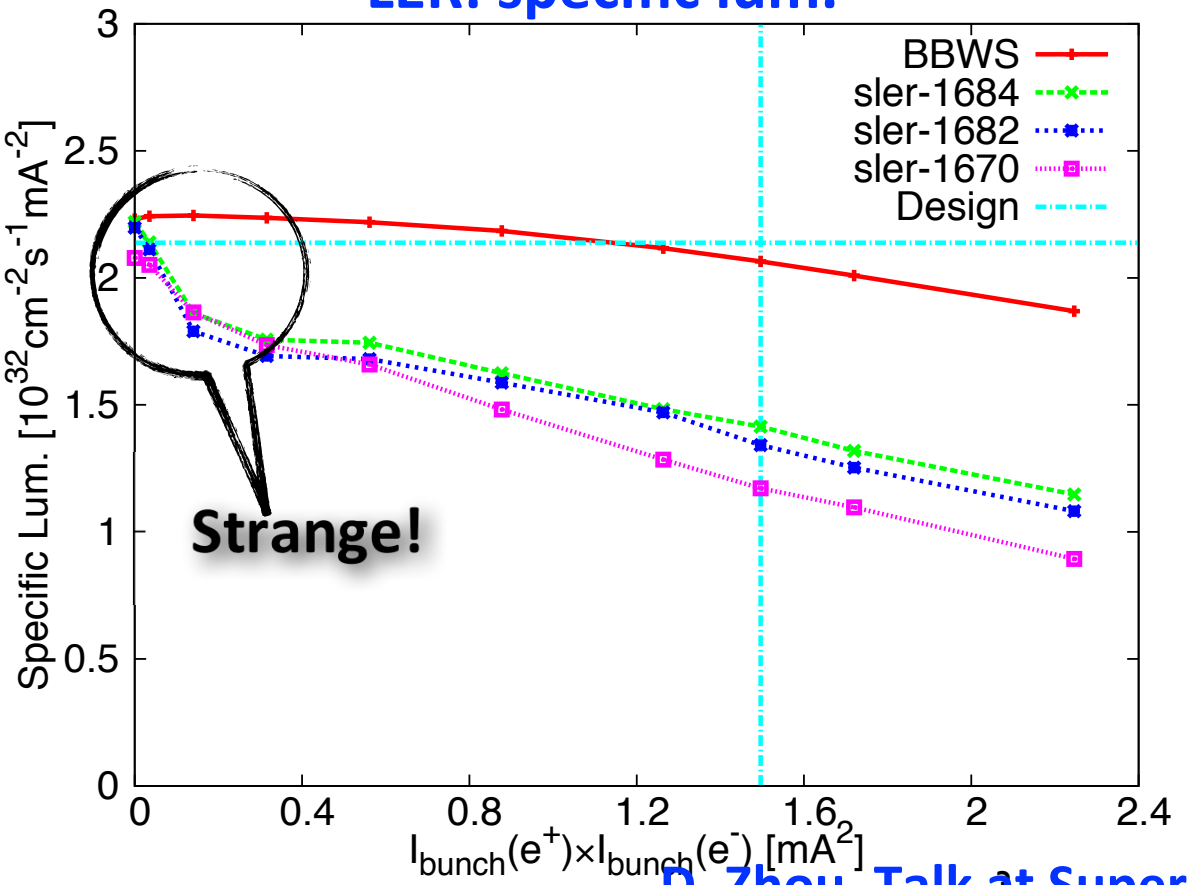
Outline

- **Luminosity calculation**
  - **BBWS: Simple linear one-turn map, weak-strong model**
  - **SAD: nonlinear one-turn map based on design lattice, weak-strong beam-beam and space-charge elements**
  - **Strong-strong: challenges in computing time**
- **Frequency map analysis (FMA)**
  - **SAD: lattice with beam-beam**
  - **FMA: standard method translated to SAD script**
- **Summary**

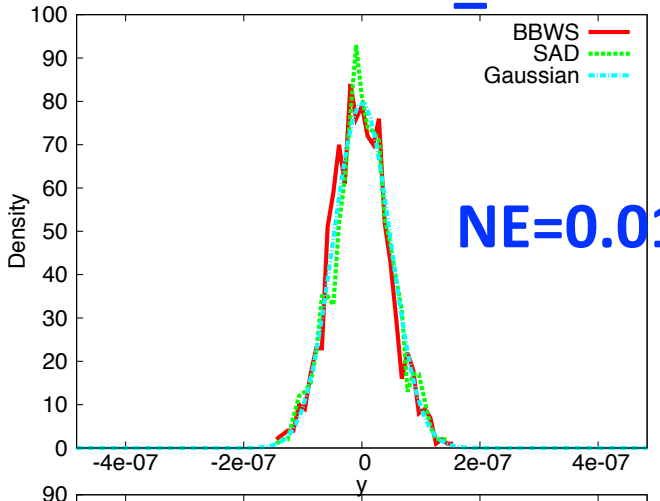
1. Lum.: LER: BB + LN

- BB: weak-strong
- Direct vert. emit. growth
- Current dependent
- Lattice dependent

LER: specific lum.



sler_1684



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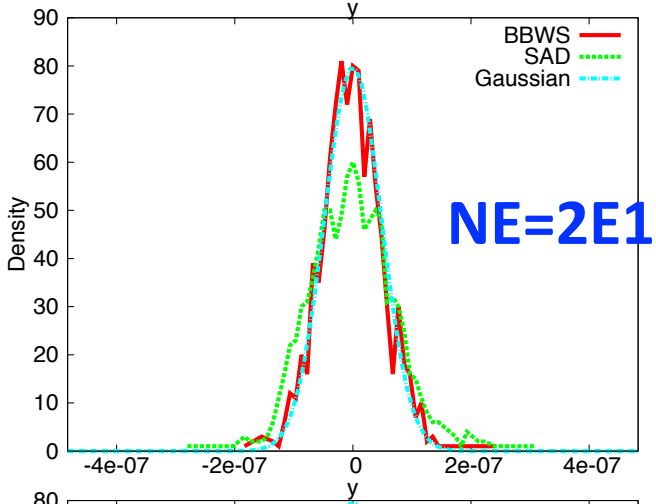

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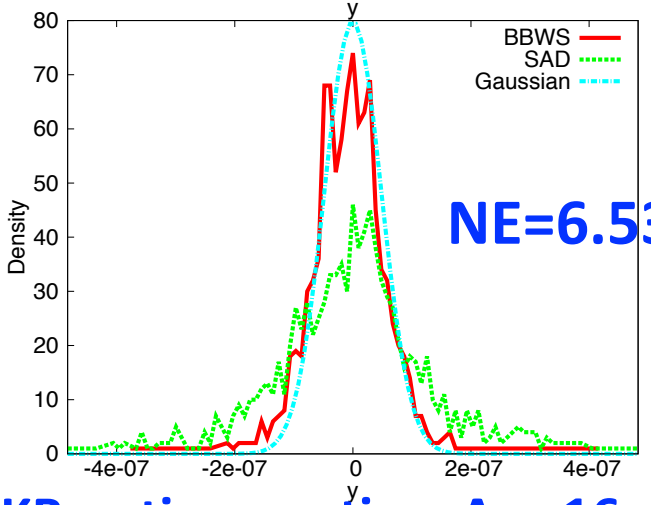

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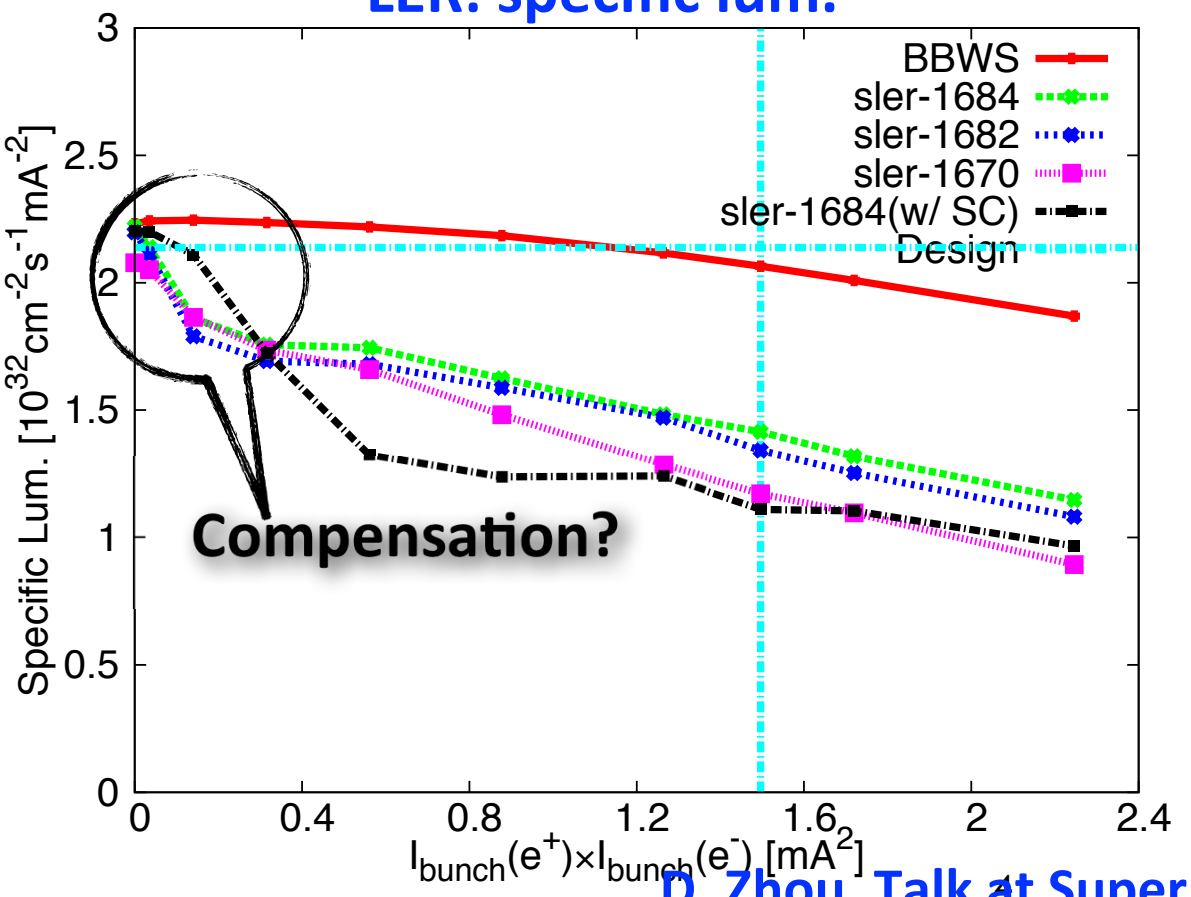
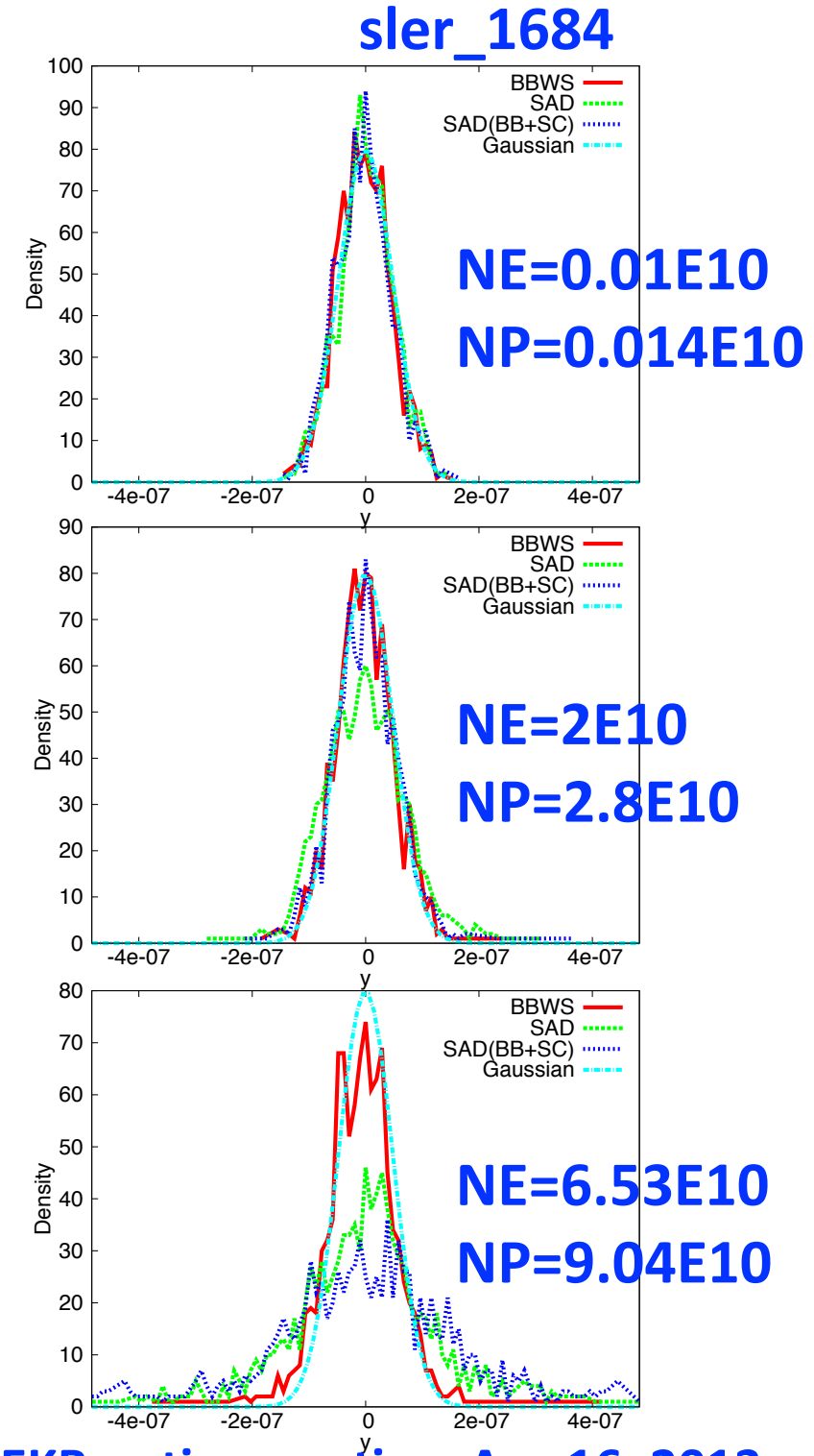
D. Zhou, Talk at SuperKEKB optics meeting, Apr.16, 2013

1. Lum.: LER: BB + LN + SC

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

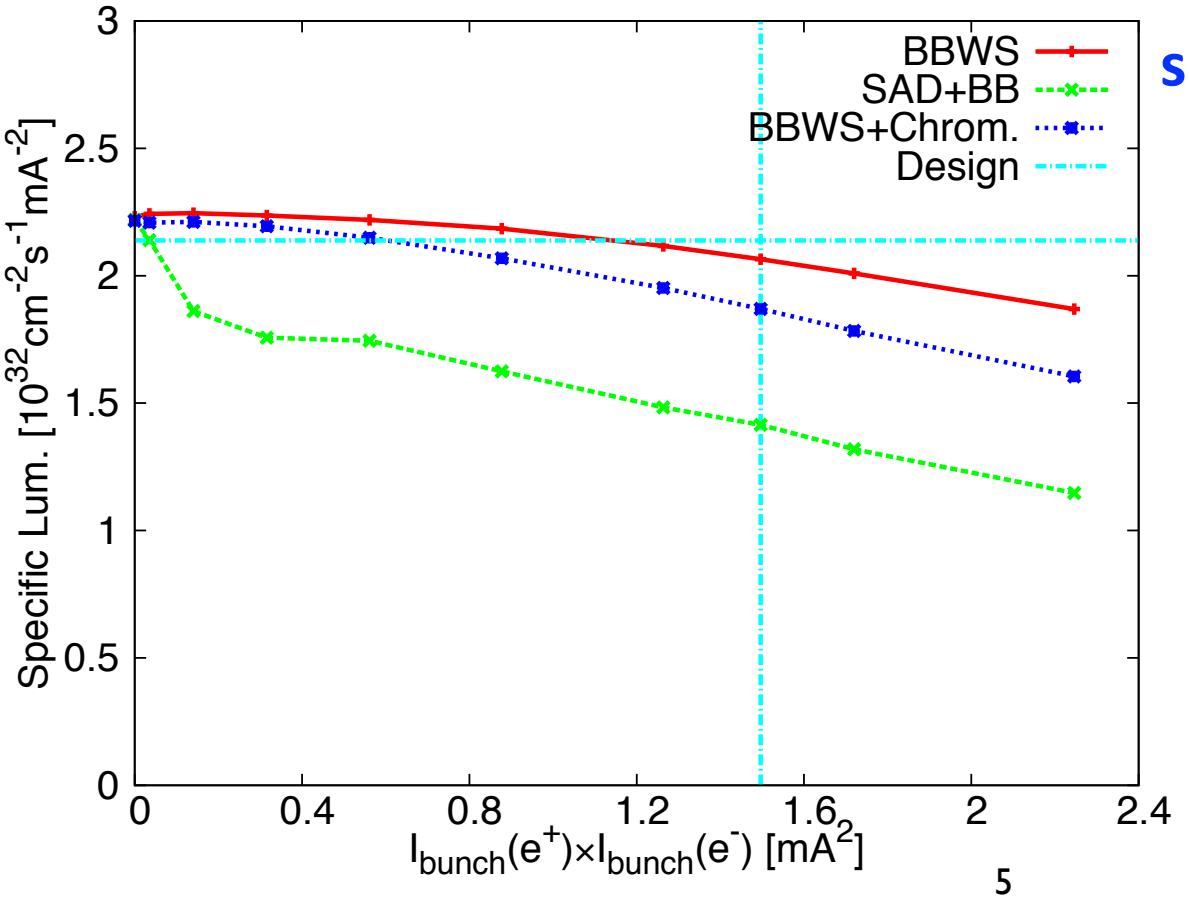




D. Zhou, Talk at SuperKEKB optics meeting, Apr.16, 2013

1. Lum.: LER: BB + Chrom. effect

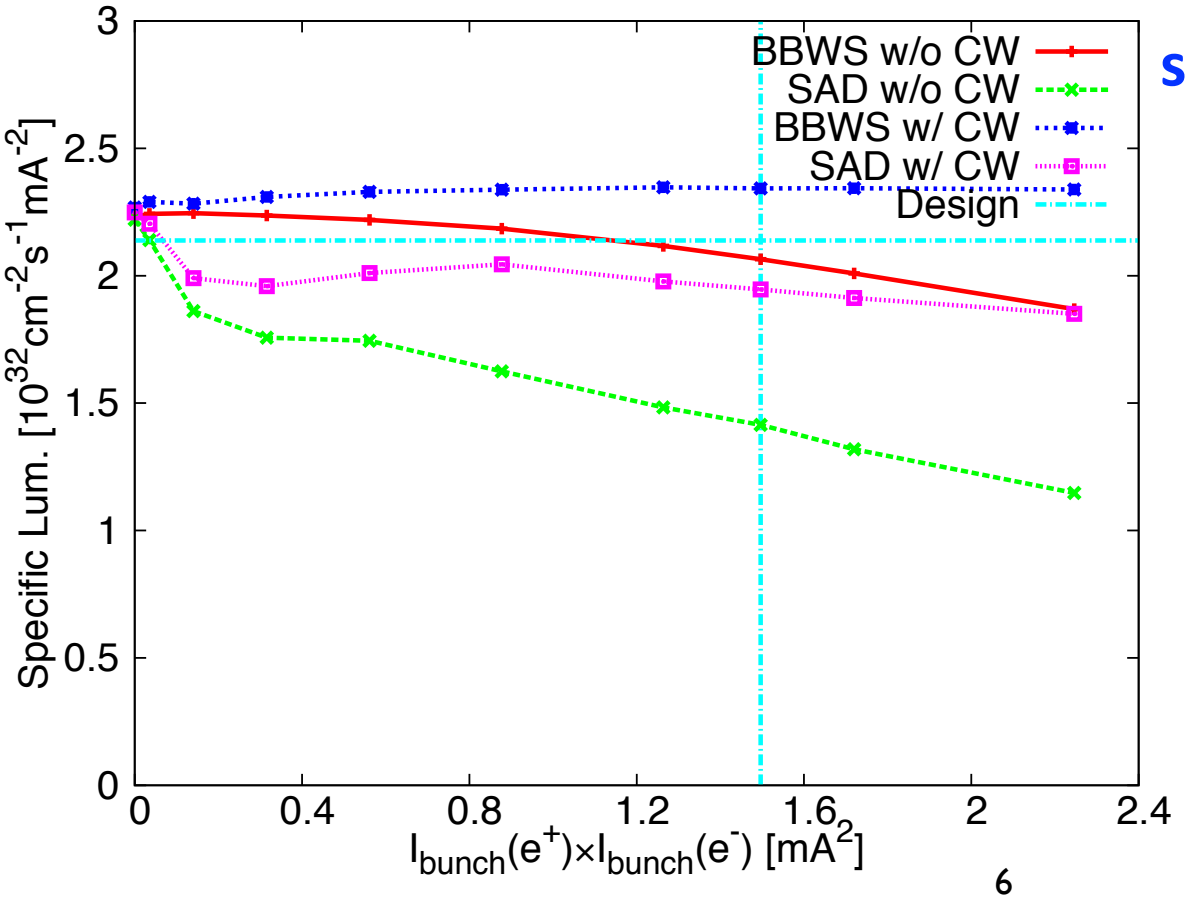
- Chromatic effect: KEKB experiences
- Momentum nonlin. controlled in lattice design
- Chromatic effect can not explain the lum. loss
- Amplitude-dependent nonlin. more important?



sler_1684

1. Lum.: LER: BB + Crab waist

➤ **Crab waist: simple map at IP**

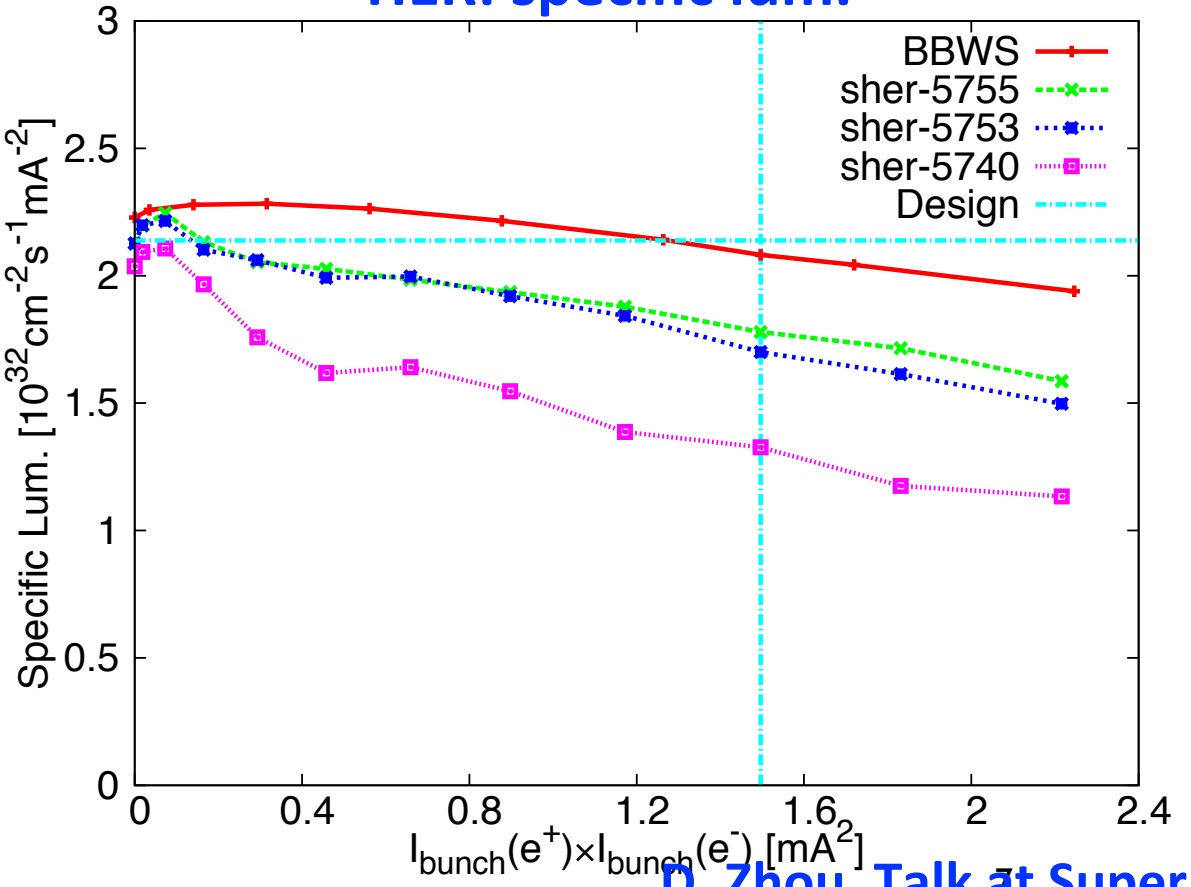


sler_1684

1. Lum.: HER: BB + LN

- BB: weak-strong
- Direct vert. emit. growth
- Current dependent
- Lattice dependent

HER: specific lum.



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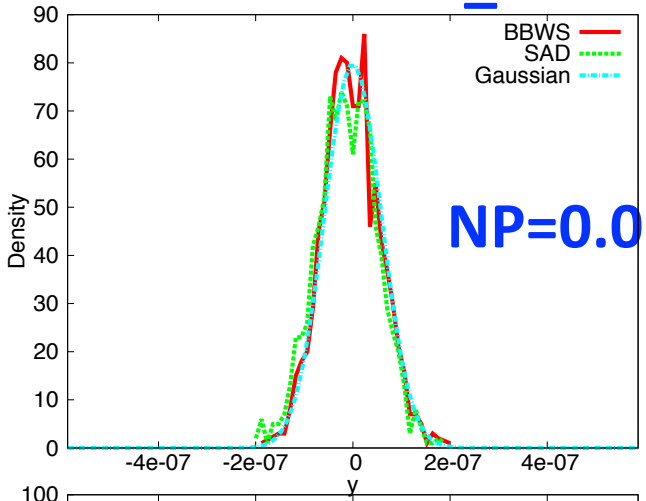

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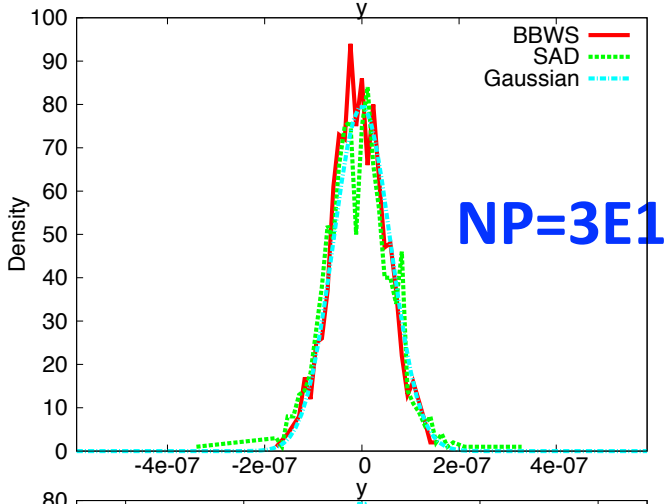

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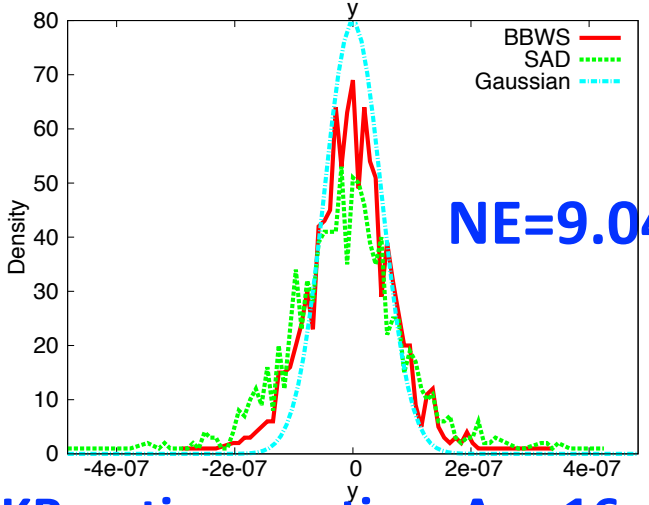

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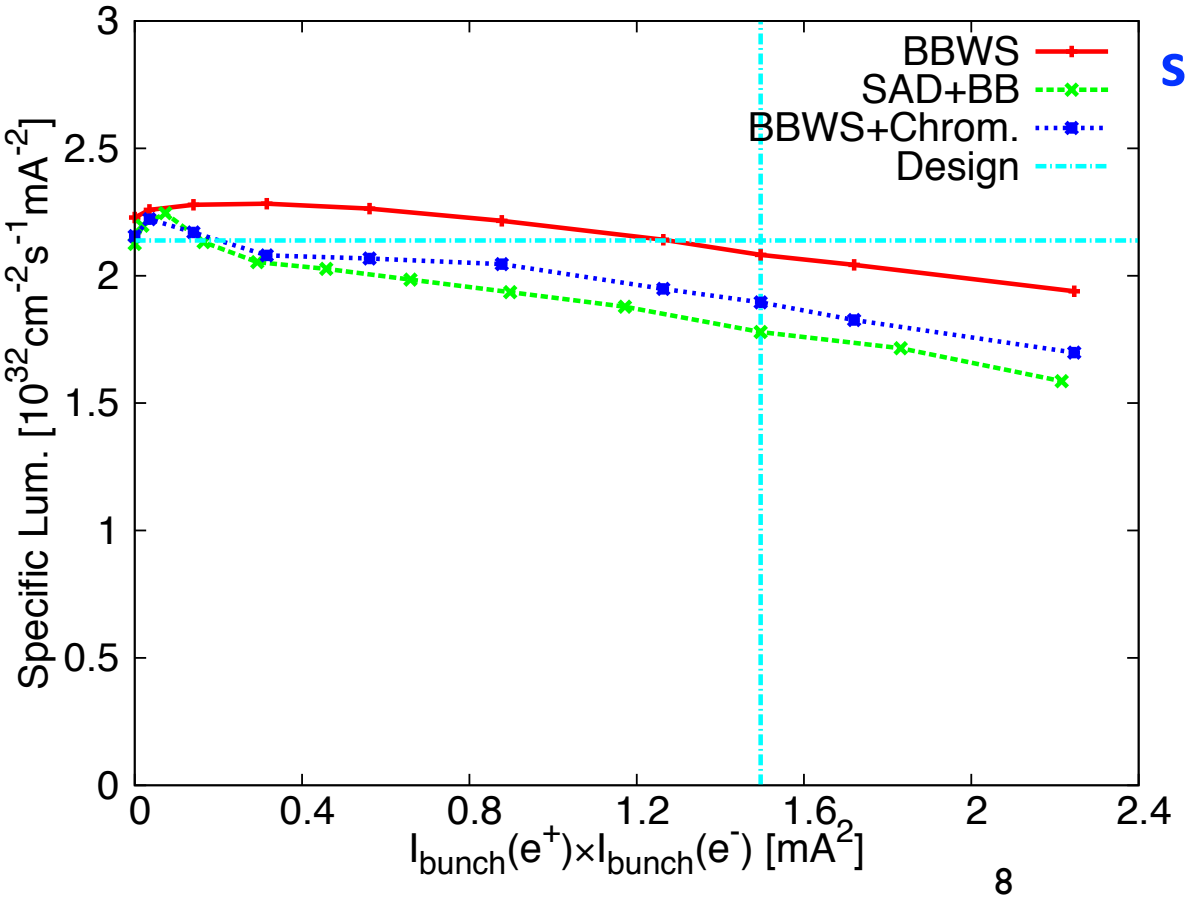
D. Zhou, Talk at SuperKEKB optics meeting, Apr.16, 2013

1. Lum.: HER: BB + Chrom. effect

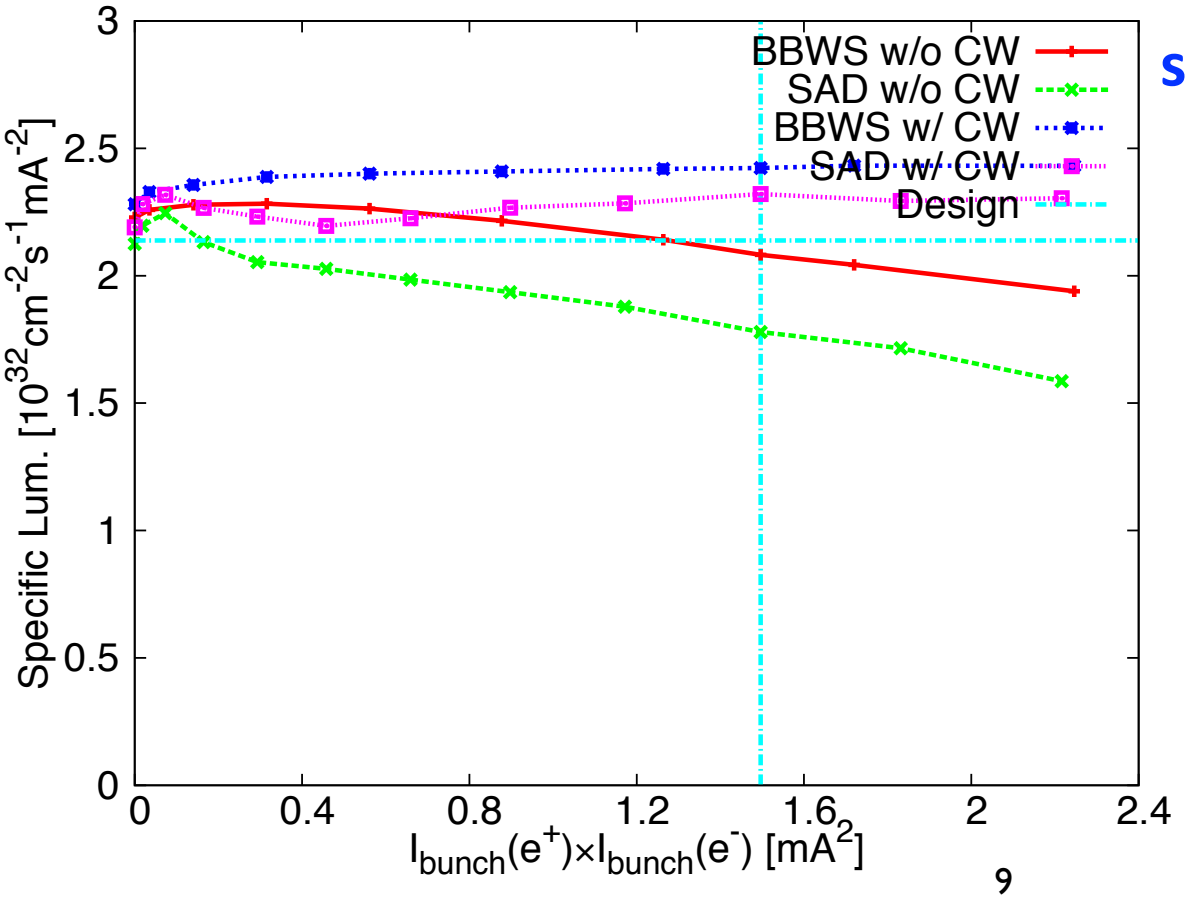
- Chromatic effect: KEKB experiences
- Momentum nonlin. not controlled in lattice design
- The lum. loss is mainly due to chromatic effect



sher_5755

1. Lum.: HER: BB + Crab waist

➤ **Crab waist: simple map at IP**



sher_5755

2. FMA: LER: x-y

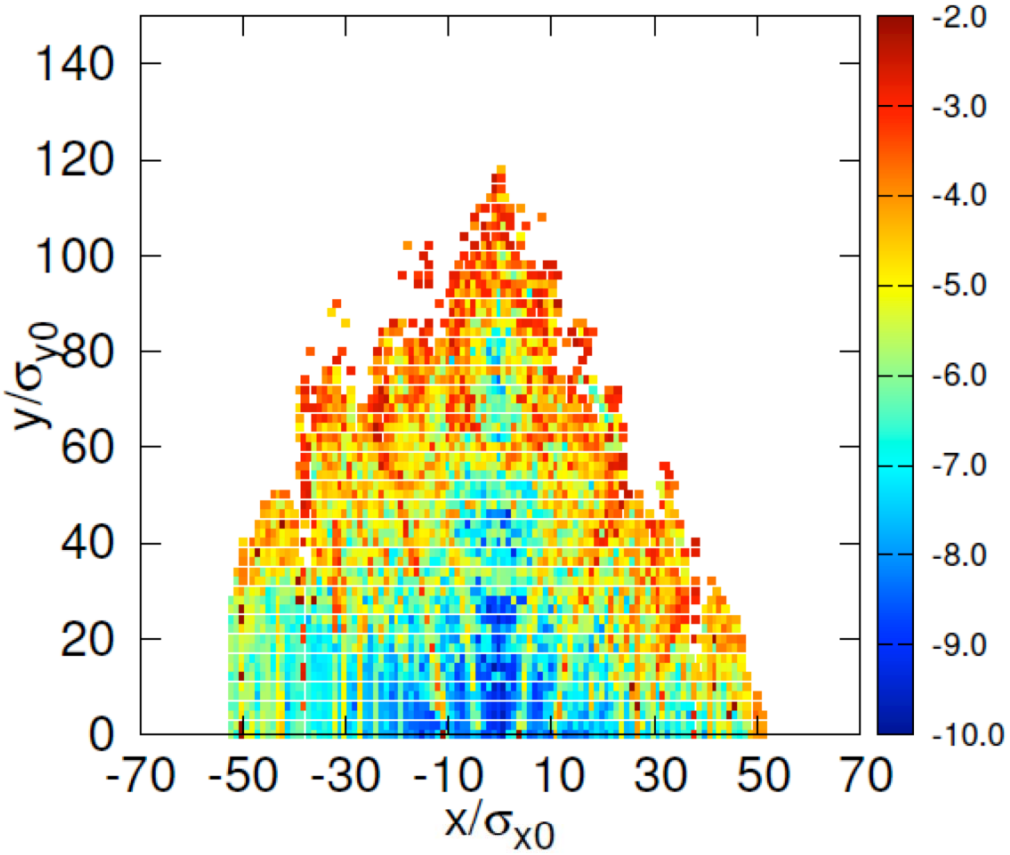
sler_1684

➤ DA w/o beam-beam

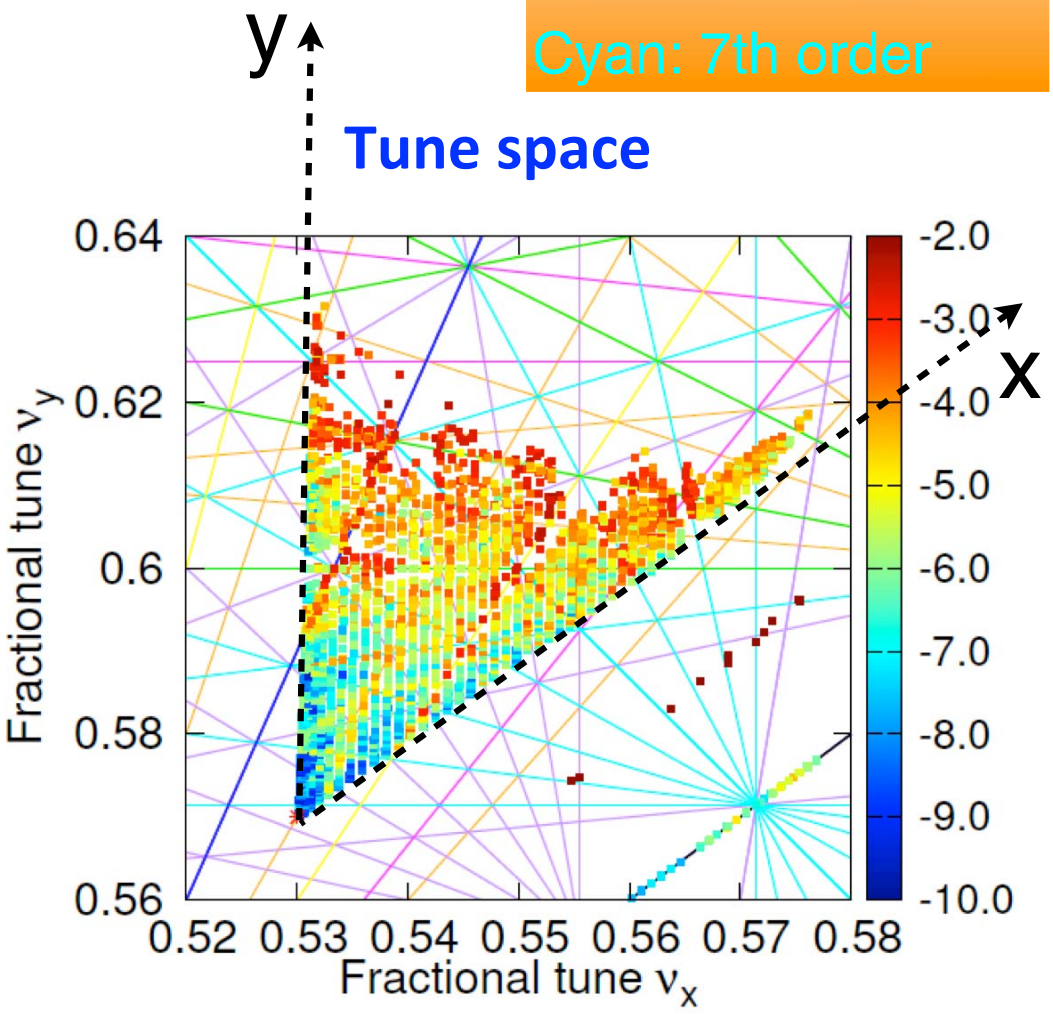
- On-momentum
- Strong coupling in synchrotron and betatron motions => RF on

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

Real space



Tune space



2. FMA: LER: x-y

sler_1684

➤ DA w/ beam-beam

- On-momentum

Resonance lines:
Blue: 4th order
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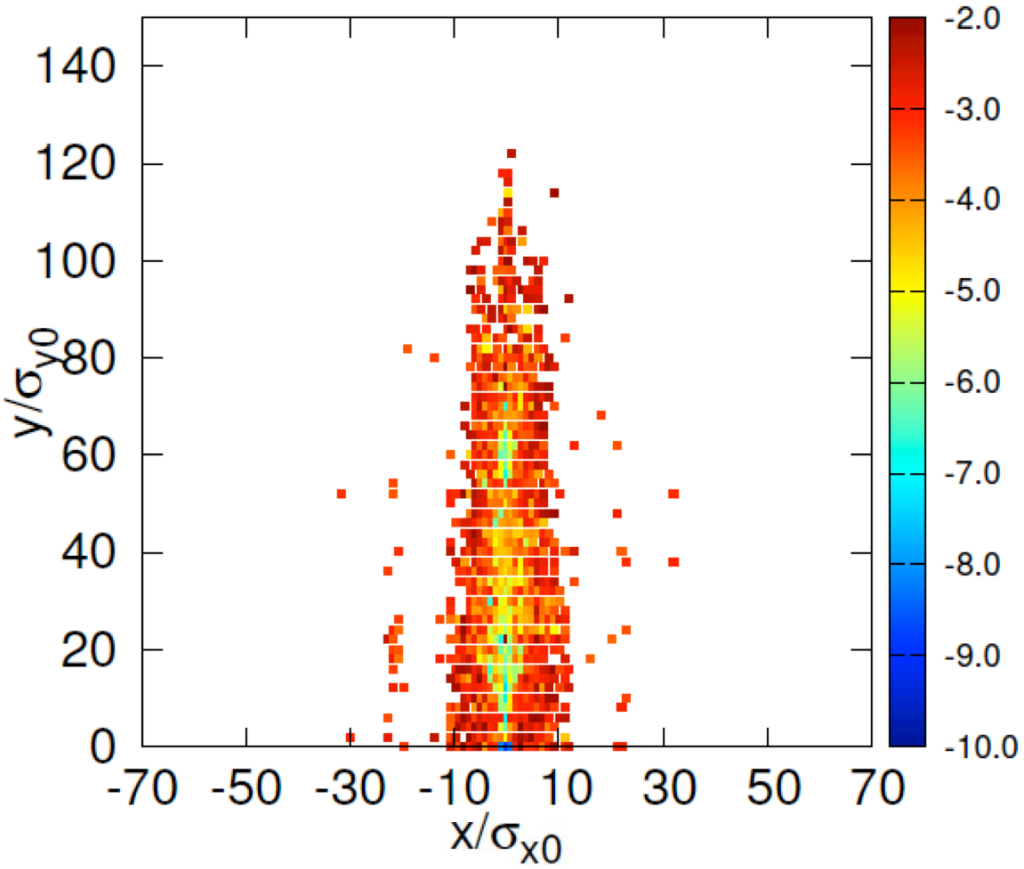
Real space



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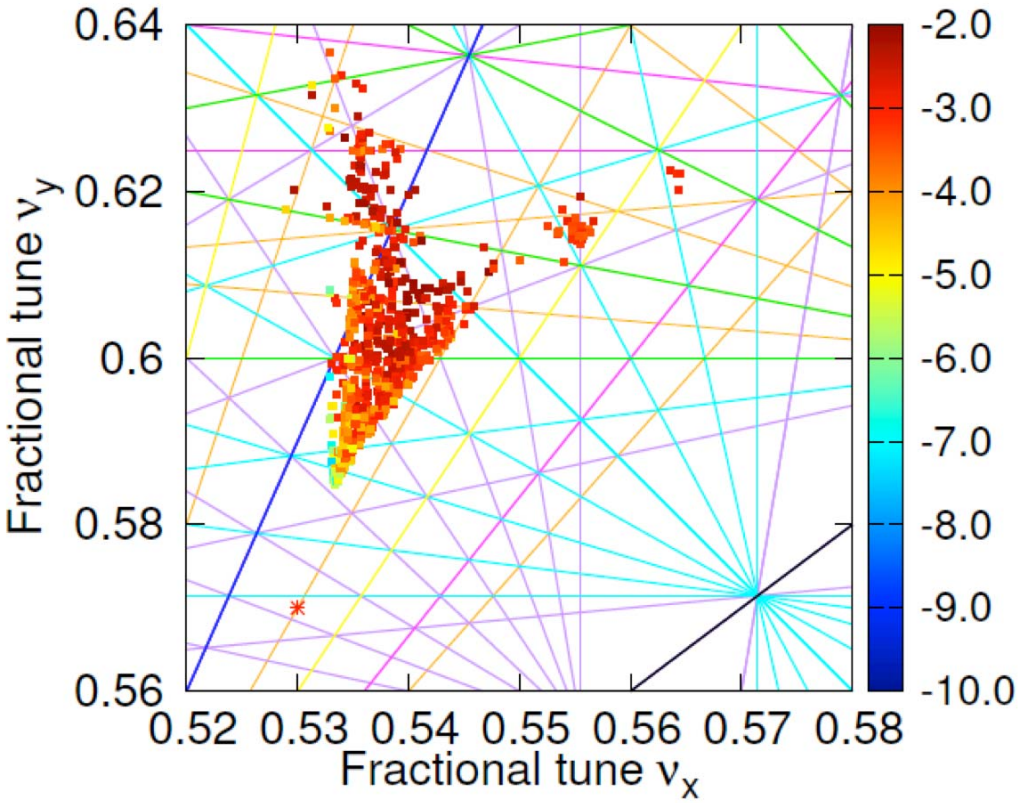


2. FMA: LER: x-y

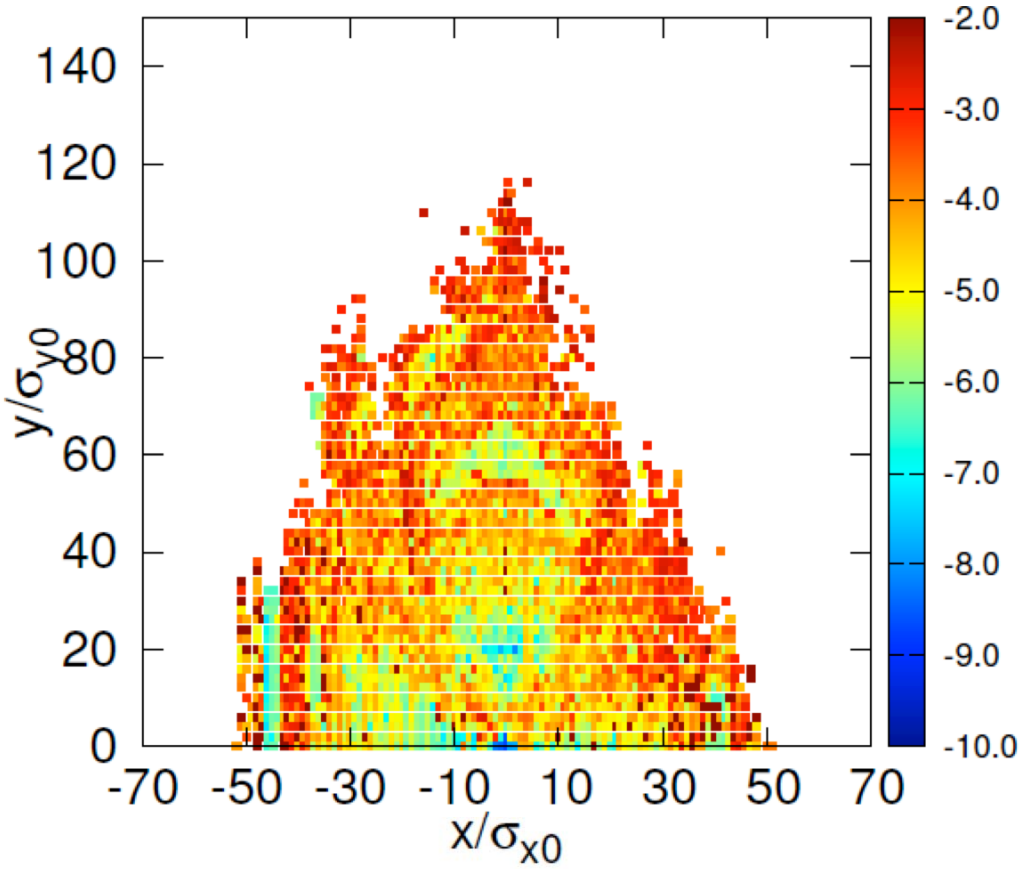
sler_1684

➤ DA w/ beam-beam and Crab waist

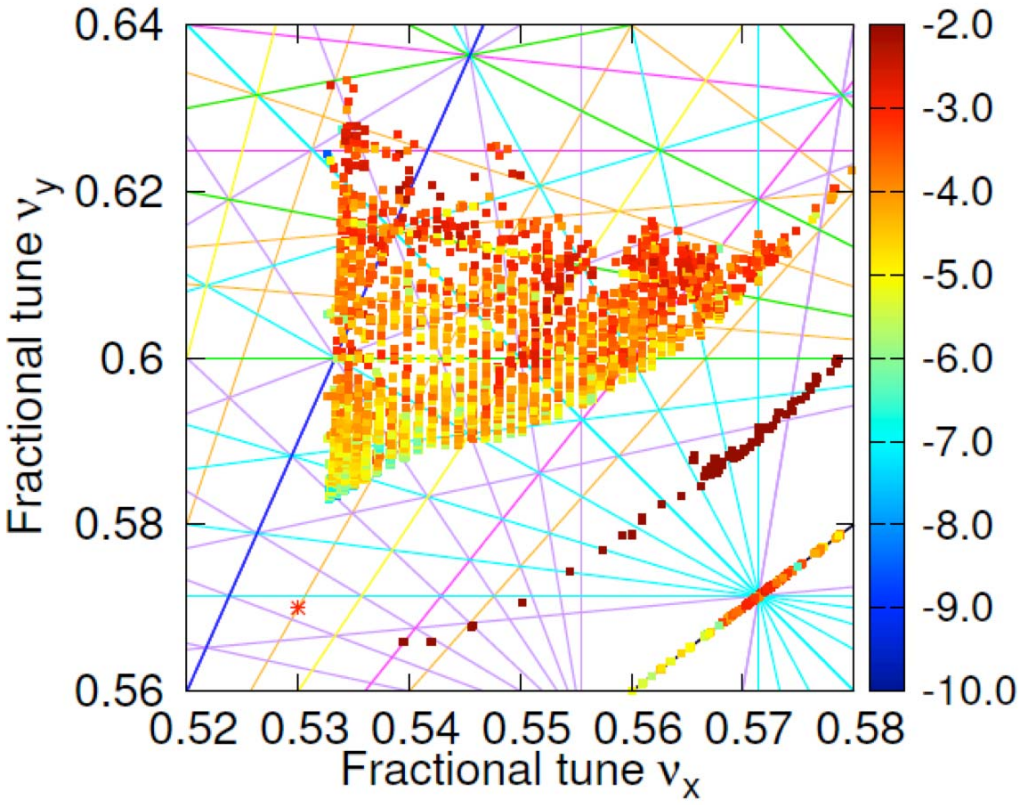
- On-momentum

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

Real space



Tune space



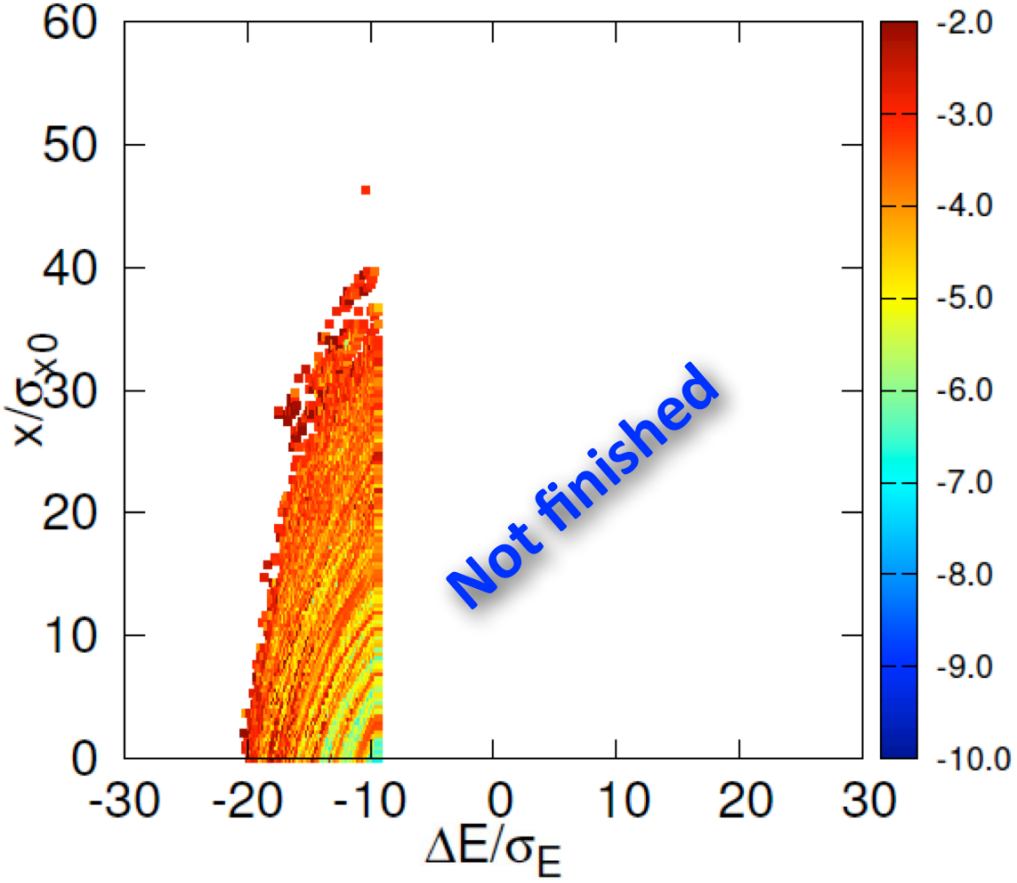
2. FMA: LER: δ-x

➤ DA w/o beam-beam

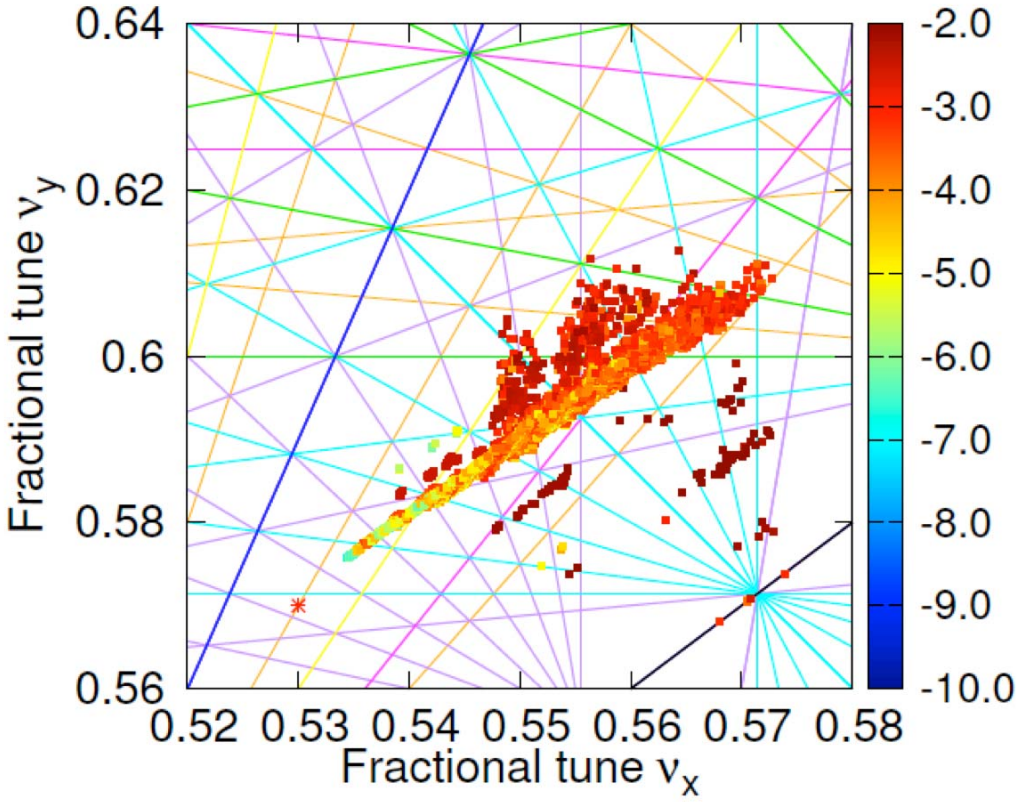
sler_1684

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

δ-x space



Tune space



2. FMA: LER: δ-x

➤ DA w/ beam-beam

sler_1684

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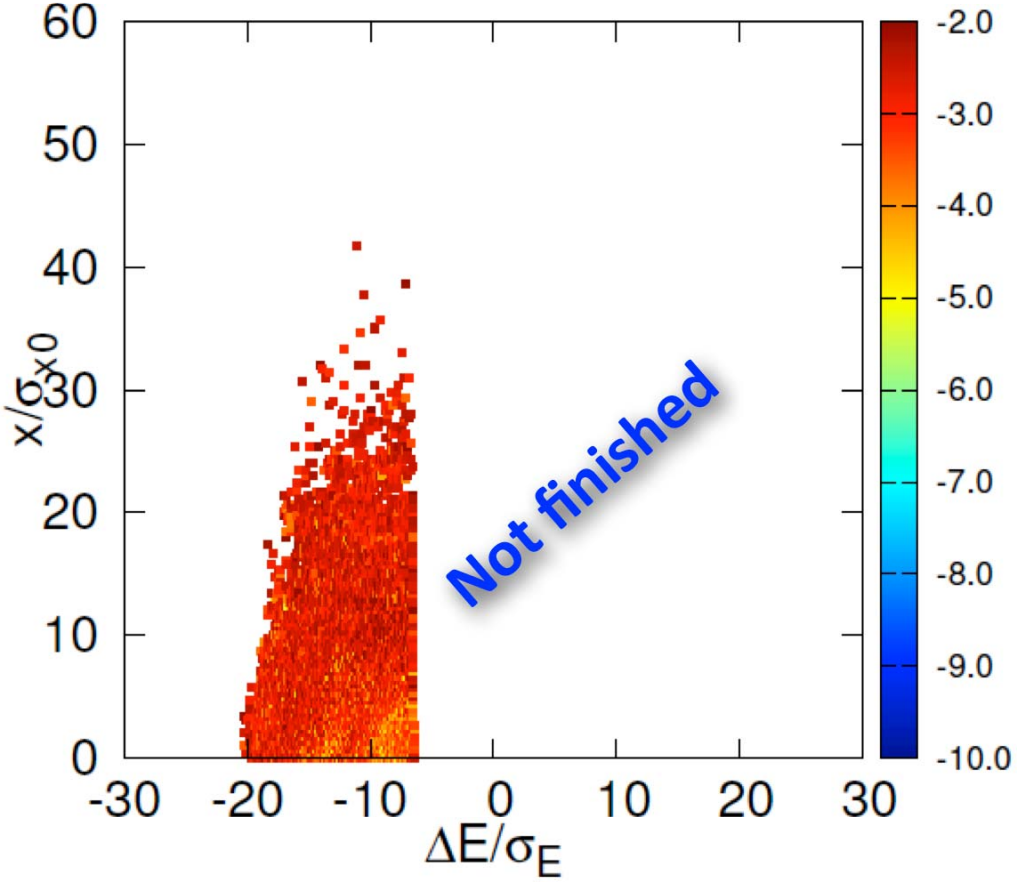
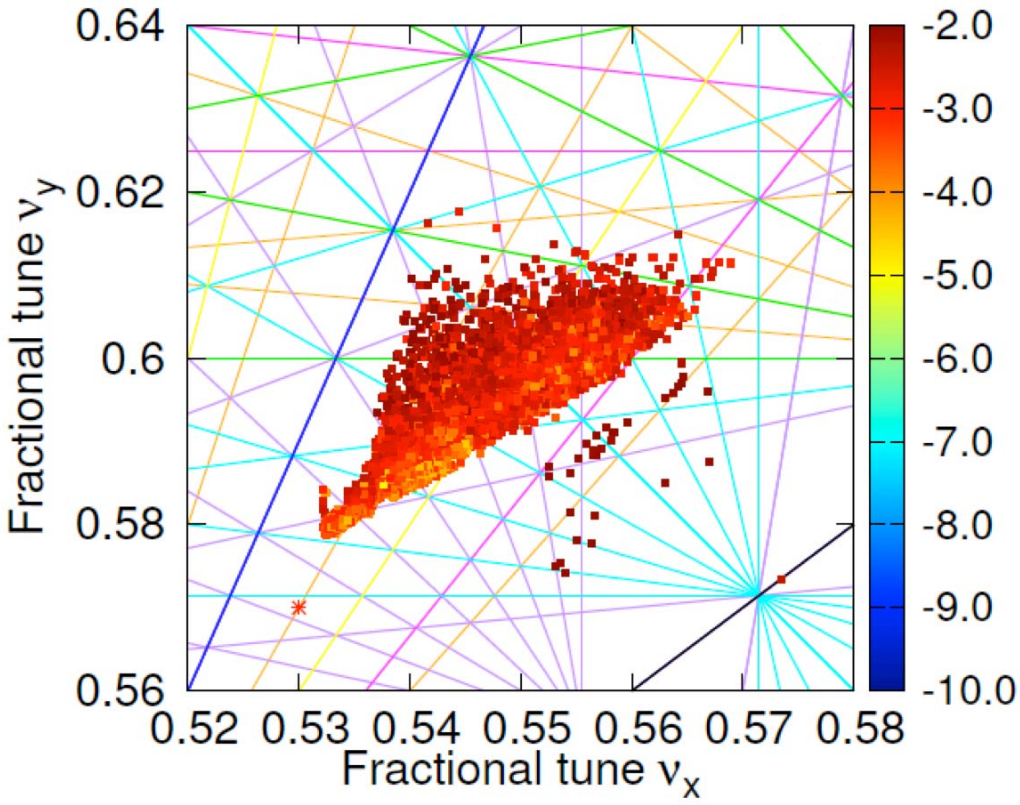
Green: 5th order
Yellow: 6th order
Cyan: 7th order

δ-x space



Tune space



2. FMA: LER: δ-x

sler_1684

➤ DA w/ beam-beam and crab waist

Resonance lines:
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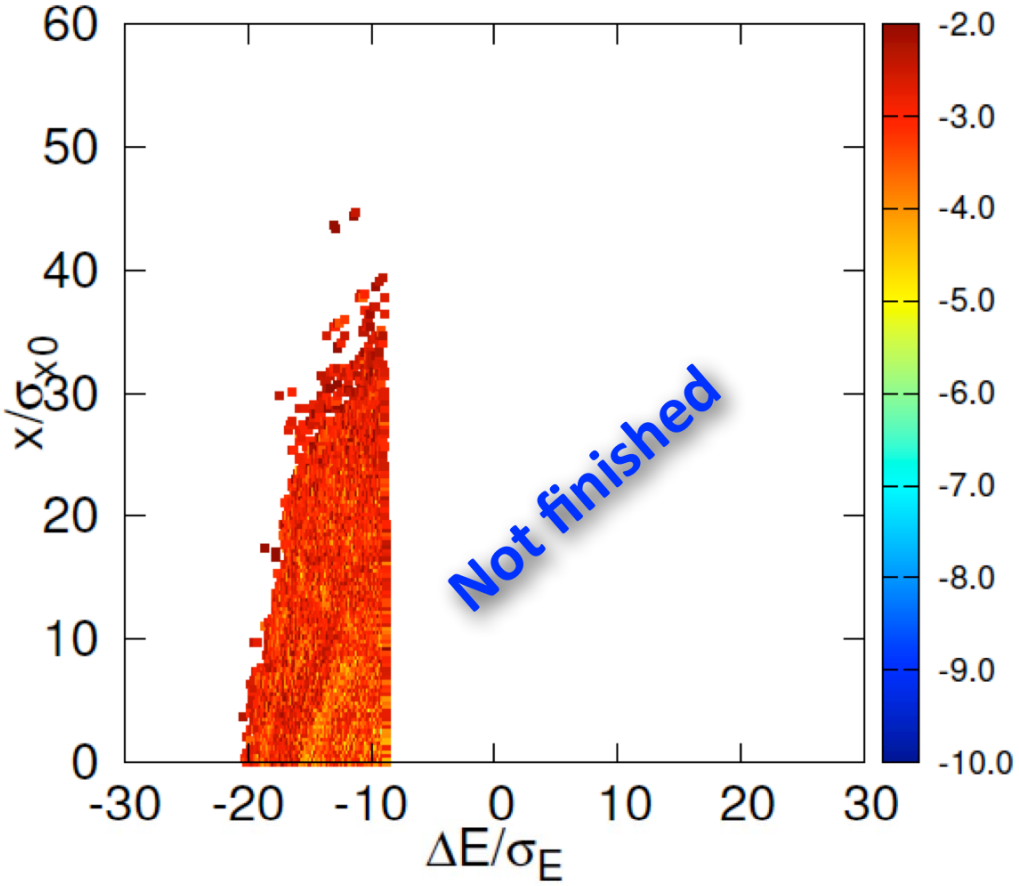
Yellow: 6th order
Cyan: 7th order

δ-x space



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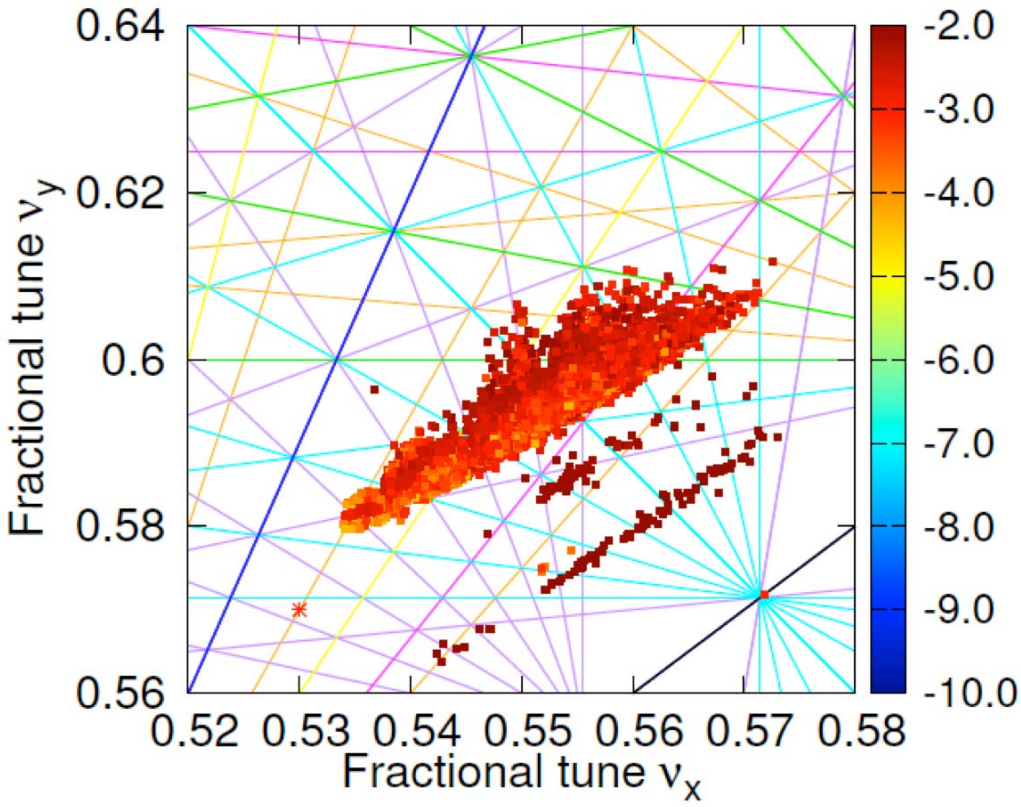
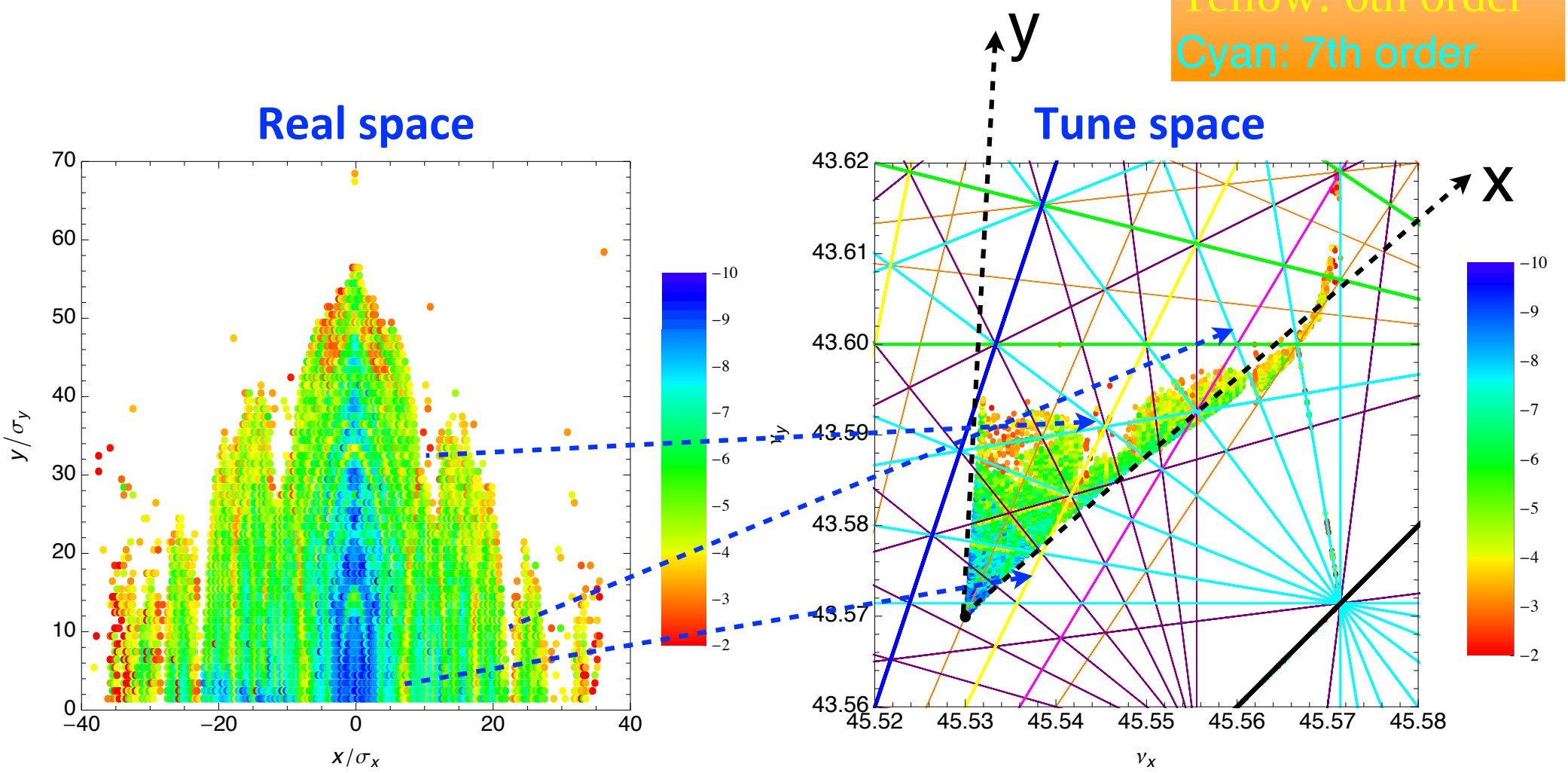


2. FMA: HER: x-y

sher_5740

➤ DA w/o beam-beam

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



D. Zhou, Talk at SuperKEKB optics meeting, Jul.17, 2012

2. FMA: HER: x-y

➤ DA w/ beam-beam

sher_5740

Resonance lines:
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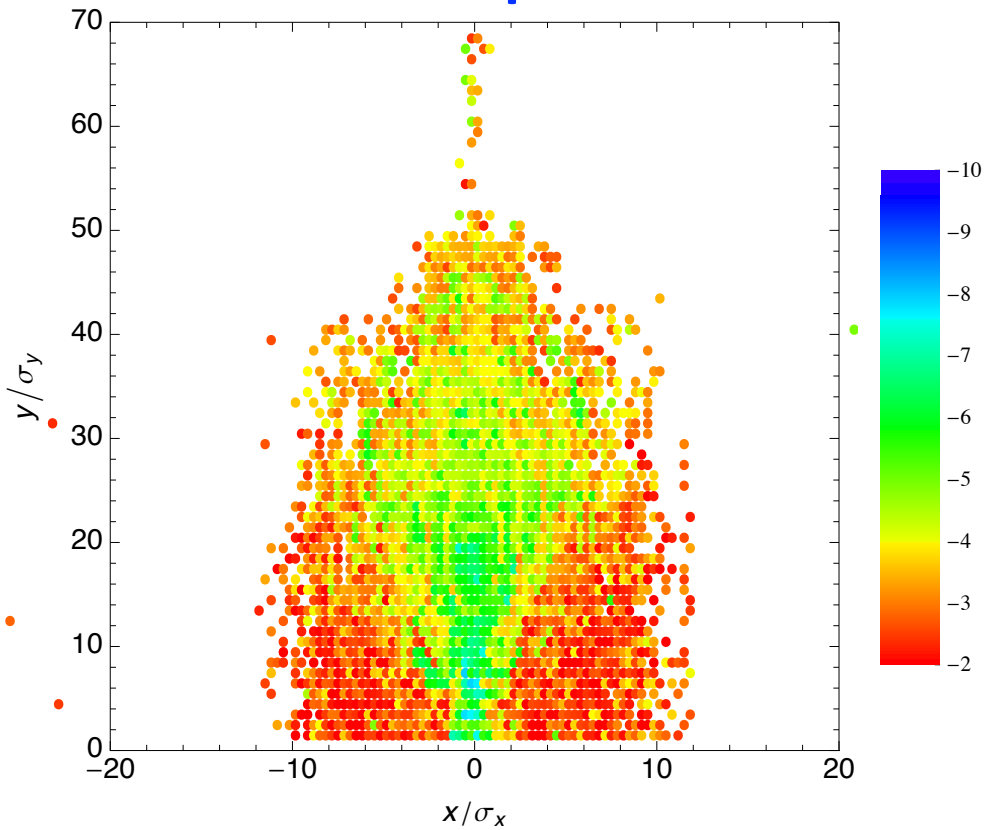
Real space



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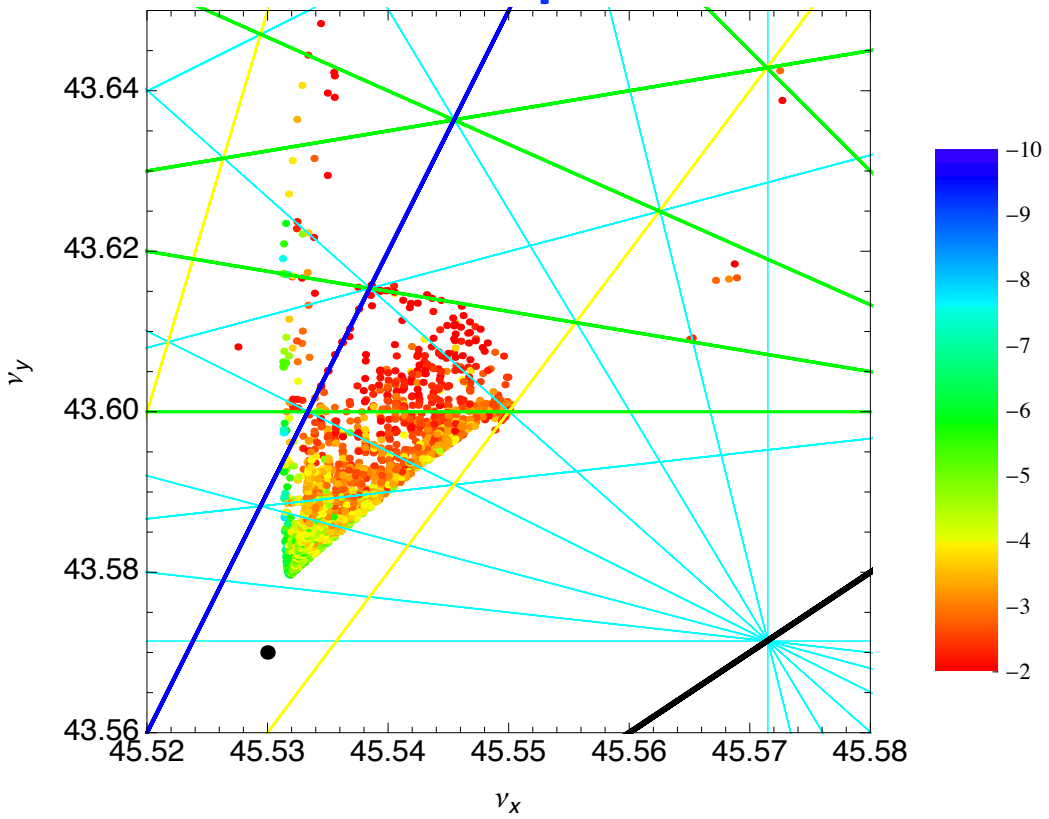

D. Zhou, Talk at SuperKEKB optics meeting, Jul.17, 2012

2. FMA: HER: δ-x

sher_5740

➤ DA w/o beam-beam

Resonance lines:
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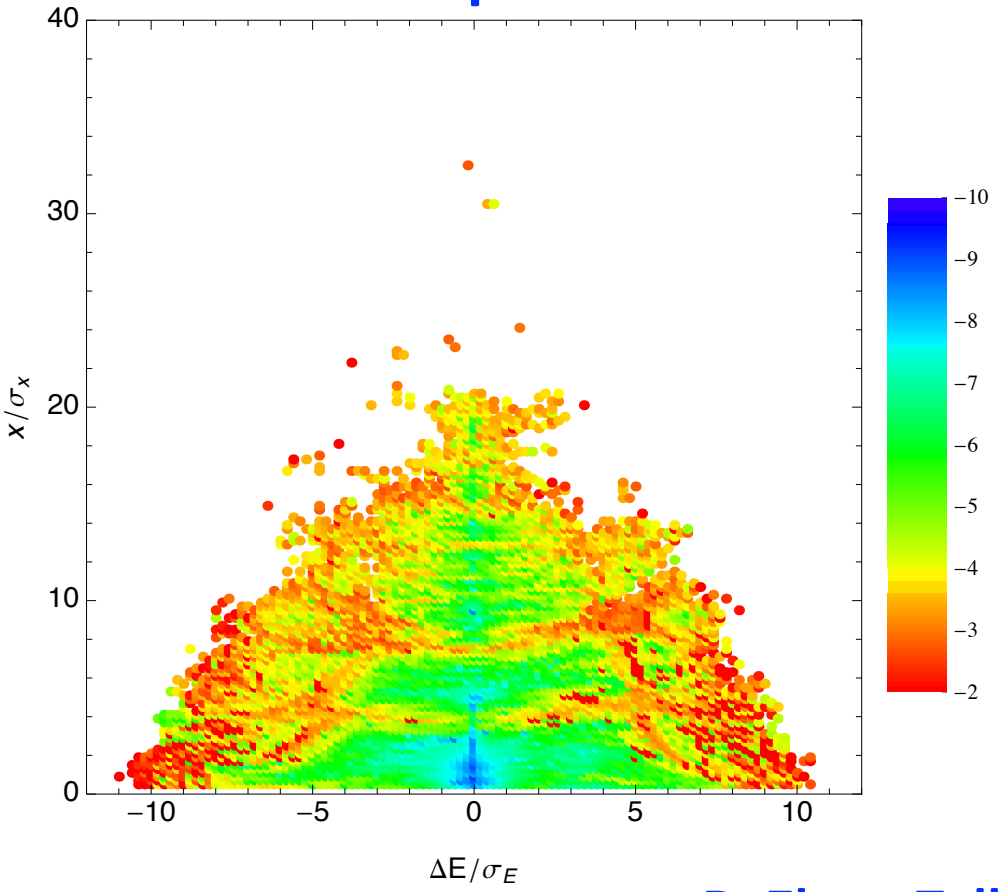
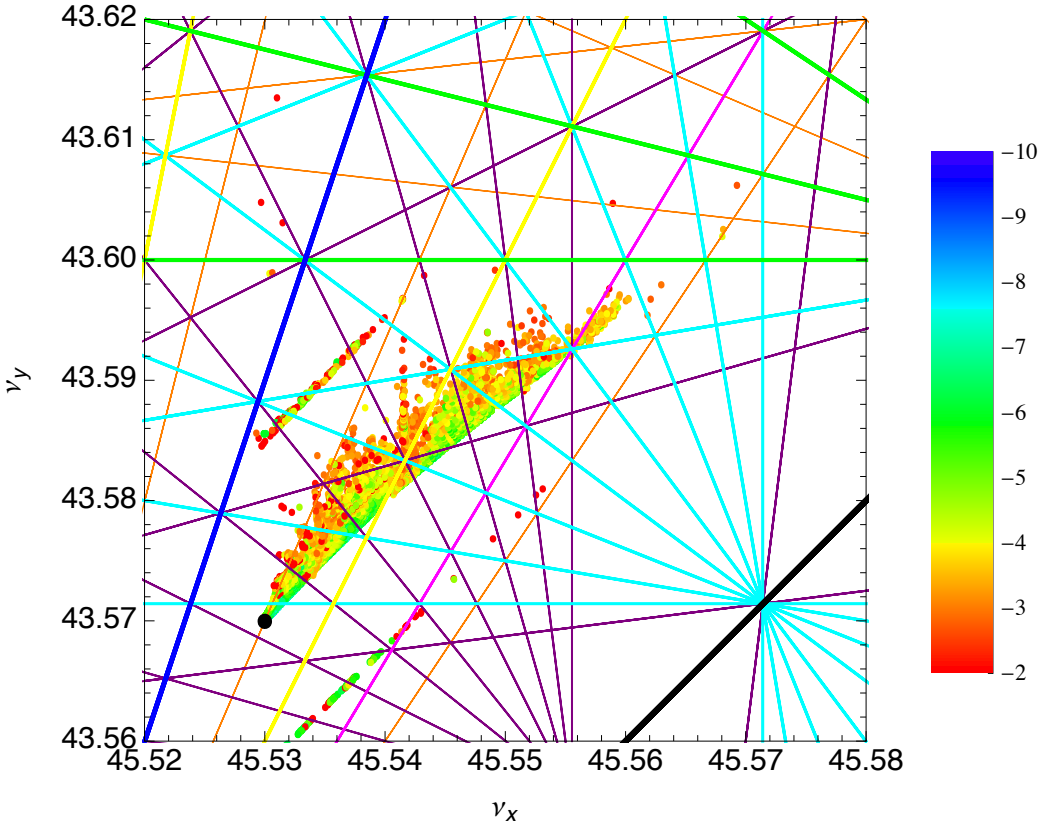
Yellow: 6th order
Cyan: 7th order

δ-x space



Tune space



D. Zhou, Talk at SuperKEKB optics meeting, Jul.17, 2012

2. FMA: HER: δ-x

➤ DA w/ beam-beam

sher_5740

Resonance lines:
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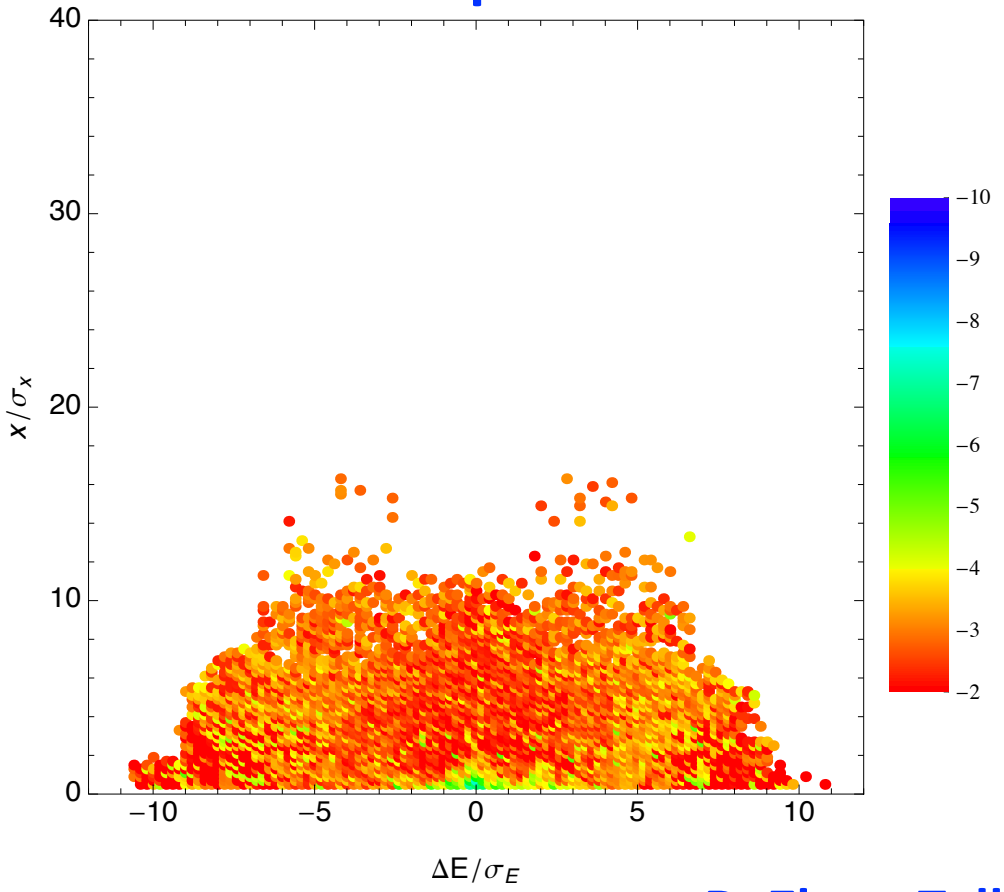
δ-x space



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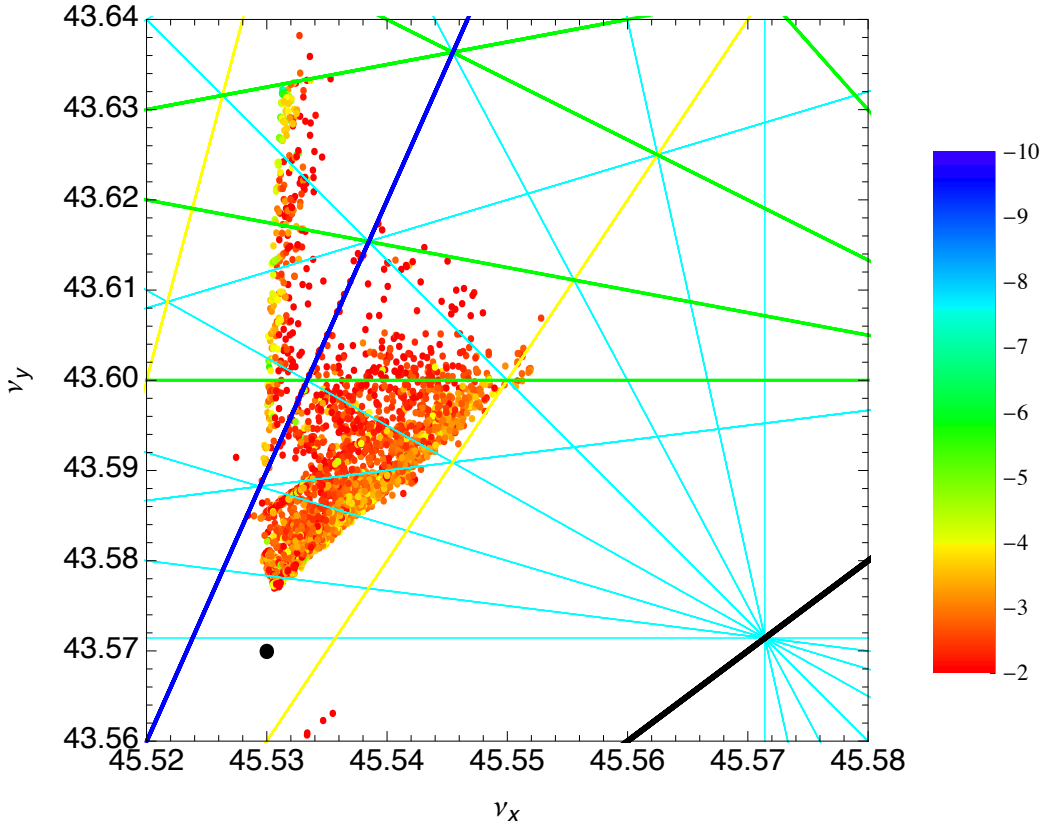

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3. Summary

➤ **LER**

- Lum. loss w/ LN cannot be attributed to chromatic effect, which has been controlled by skew-sextupole knobs
- Amplitude-dependent nonlin. looks to be important
- Crab waist partially mitigates the crosstalk between BB and LN, supposed no mistakes in simulations
- Luminosity decrease quickly at low beam currents, even with crab waist. This is not expected. Mistakes in simulations or new beam physics?

➤ **HER**

- Lum. loss w/ LN can be attributed to chromatic effect, which has not been controlled in lattice design
- Amplitude-dependent nonlin. looks not to be important