Beam-beam simulations for SuperKEKB Phase-3

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Acknowledgements:

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Outline

- **Introduction**
- **Tune scan using BBWS**
- **Simulation using BBSS**
- **Summary**

1. Introduction

➤ Phase-3 machine parameters (Road map)

- Ref. A. Morita, Talk at SuperKEKB commissioning meeting, Oct. 12, 2018

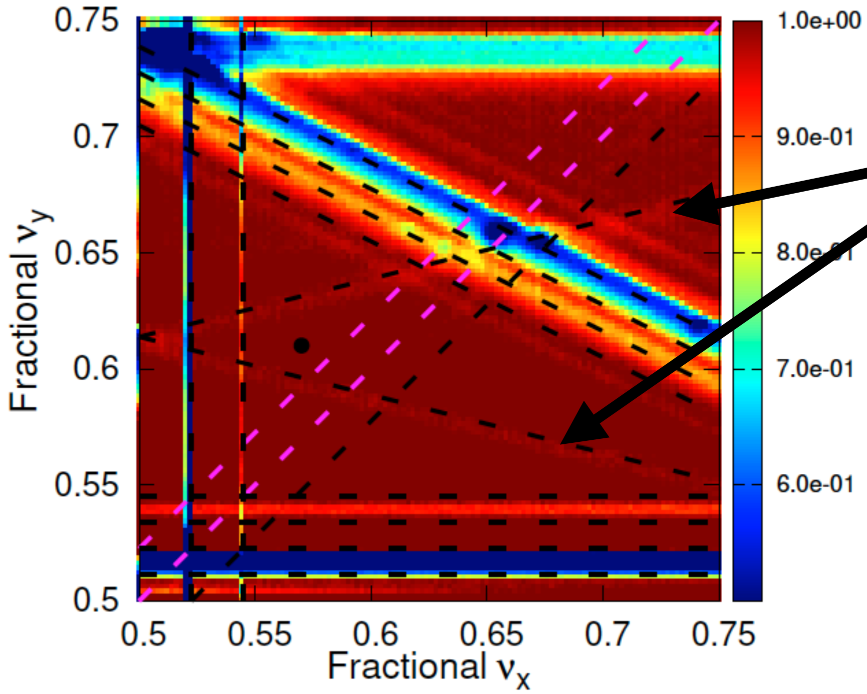
	1		1ex		2		2ex		3		3’		3ex	
	HER	LER	HER	LER	HER	LER	HER	LER	HER	LER	HER	LER	HER	LER
I_b (A)	1.0	1.2	1.0	1.4	1.0	1.4	1.2	1.7	1.3	1.8	1.15	1.6	1.4	2.0
# bunch	1576		1576		1576		1576		1576		1576		1576	
ε_x (nm)	4.6	2.0	4.6	2.0	4.6	2.0	4.6	2.0	4.6	2.0	4.6	2.0	4.6	2.0
ε_y (pm)	368	160	230	150	138	140	128.8	130	138	140	101.2	100	101.2	100
β_x (mm)	100	100	100	100	100	100	100	100	100	100	100	100	100	100
β_y (mm)	3	3	3	3	2	2	2	2	1.4	1.4	1.25	1.25	1.2	1.2
σ_z (mm)	6	6	6	6	6	6	6	6	6	6	6	6	6	6
ν_x	45.57	44.57	45.57	44.57	45.57	44.57	45.57	44.57	45.57	44.57	45.57	44.57	45.57	44.57
ν_y	43.61	46.61	43.61	46.61	43.61	46.61	43.61	46.61	43.61	46.61	43.61	46.61	43.61	46.61
ν_s	0.0258	0.0225	0.0258	0.0225	0.0258	0.0225	0.0258	0.0225	0.0258	0.0225	0.0258	0.0225	0.0258	0.0225
ξ_y(Geom.)	0.0272	0.0262	0.0328	0.0331	0.0278	0.0351	0.0351	0.0436	0.0302	0.0387	0.0301	0.0397	0.0369	0.0453
$\mathcal{L}$(Geom.)	1.06E+34		1.46E+34		2.08E+34		3.14E+34		4.11E+34		4.00E+34		6.20E+34	
$\mathcal{L}$(BBSS)	1.00E+34		1.30E+34		1.74E+34		2.16E+34		2.52E+34		2.55E+34		3.21E+34	

2. BBWS simulation: Tune scan

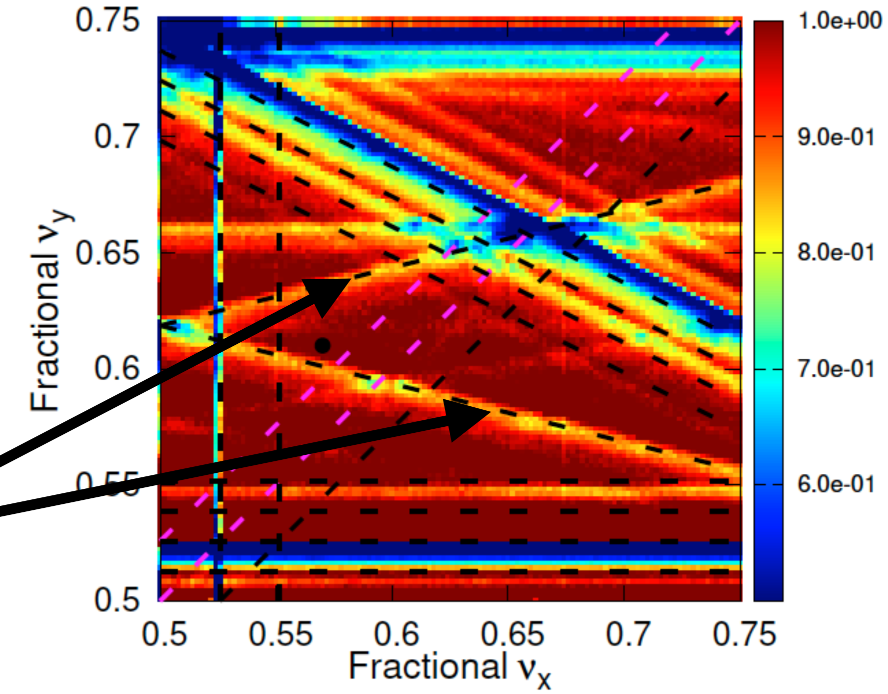
➤ Parameter set (1)

e+(W)e-(S)

Lum. (L/L_0)



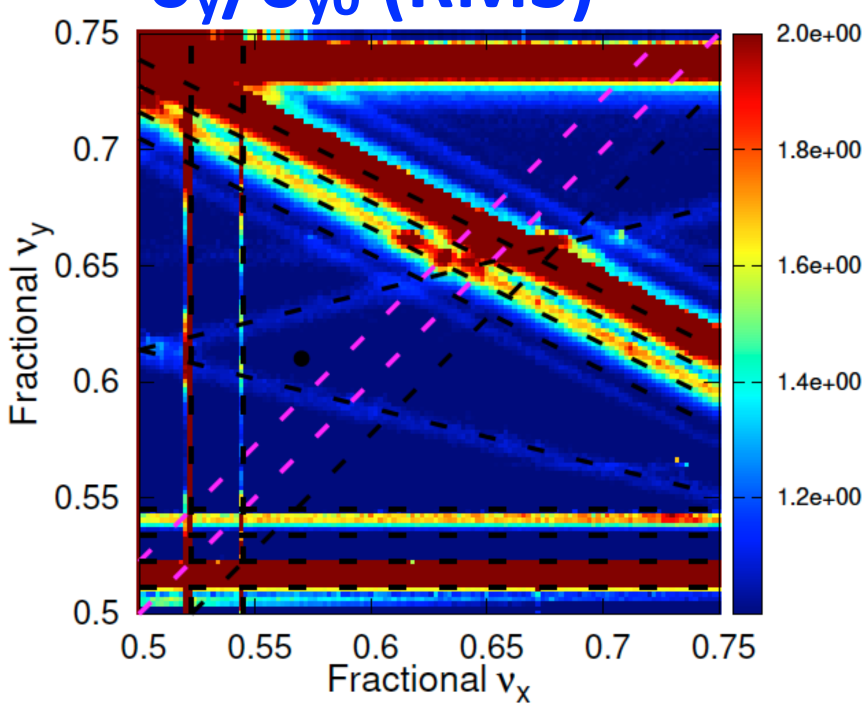
e+(S)e-(W)

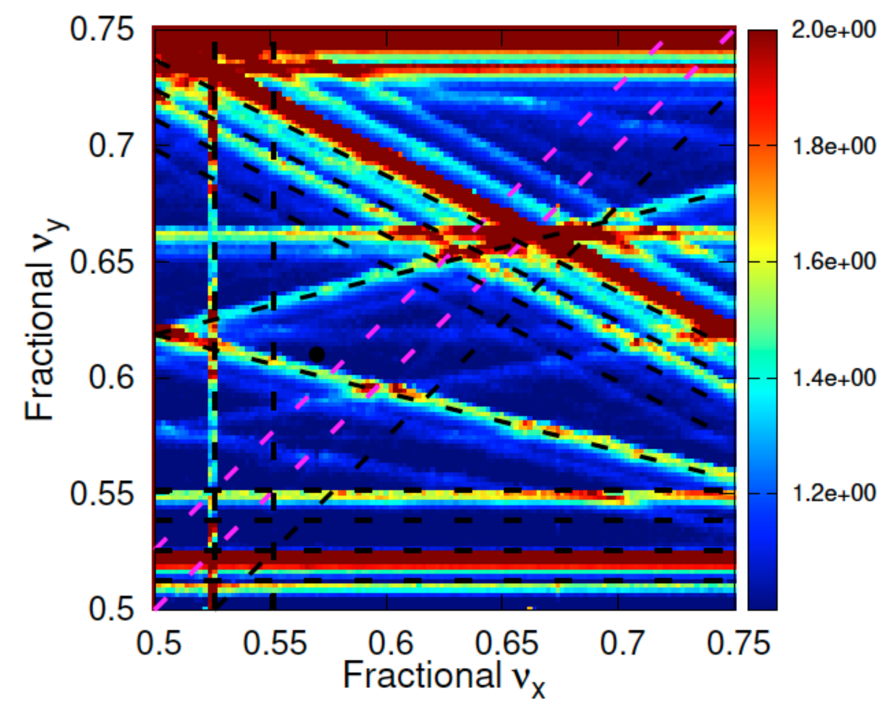


$\pm\nu_x+4\nu_y+2\nu_s=N$

$\pm\nu_x+4\nu_y+\nu_s=N$

σ_y/σ_{y0} (RMS)



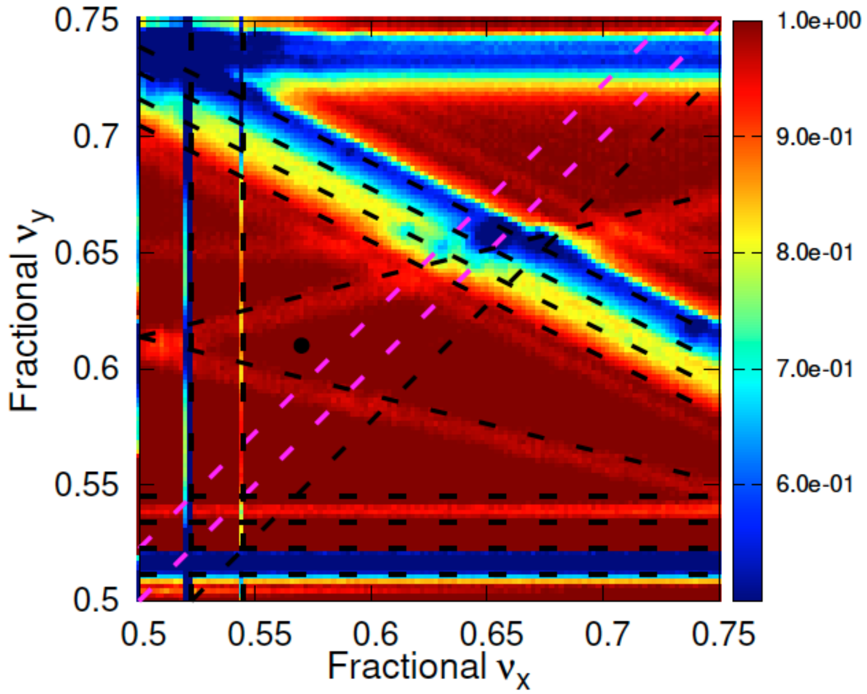


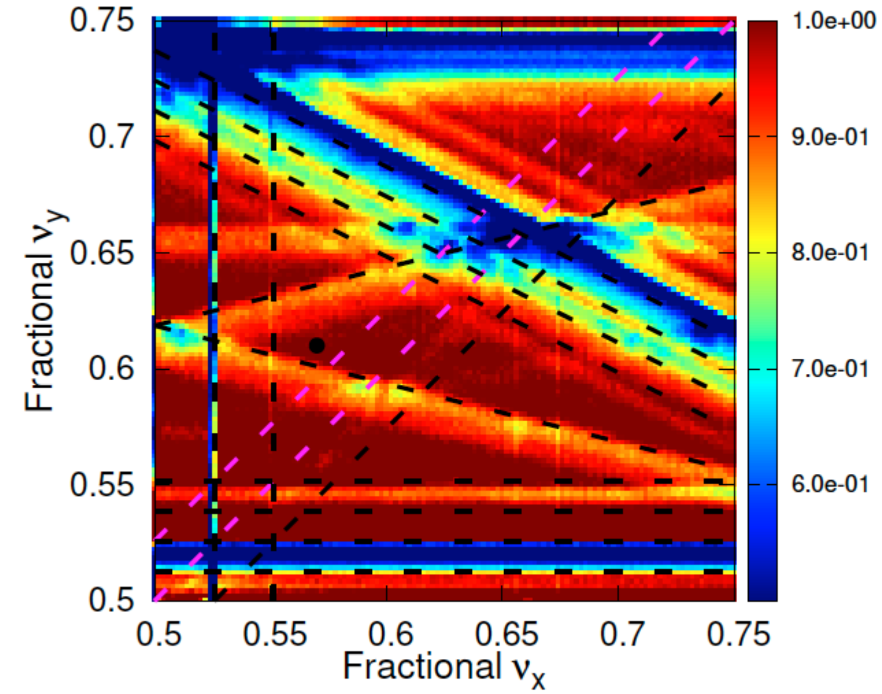
2. BBWS simulation: Tune scan

➤ Parameter set (1ex)

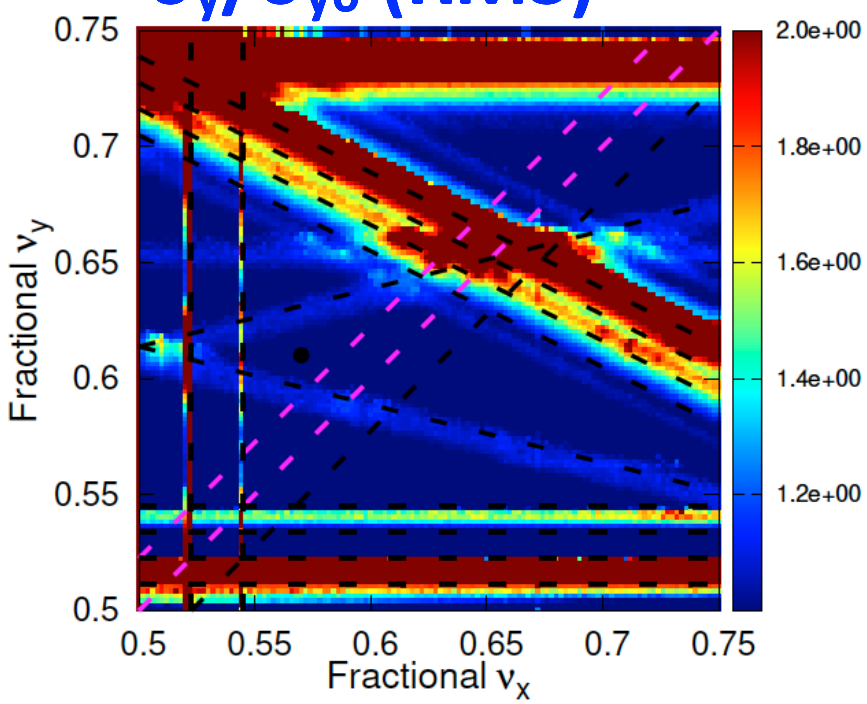
e+(W)e-(S) **e+(S)e-(W)**

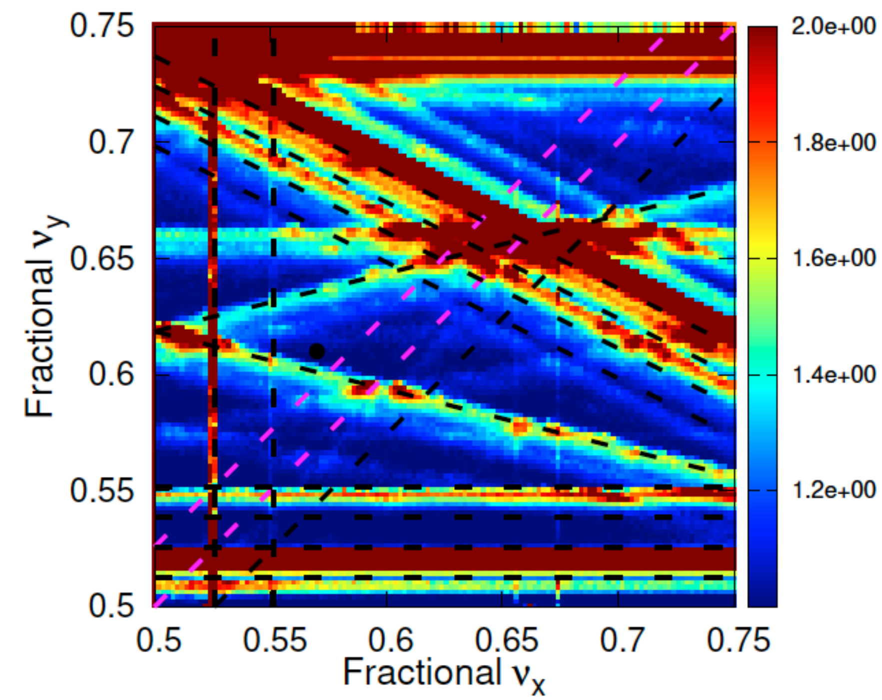
Lum. (L/L_0)





σ_y/σ_{y0} (RMS)



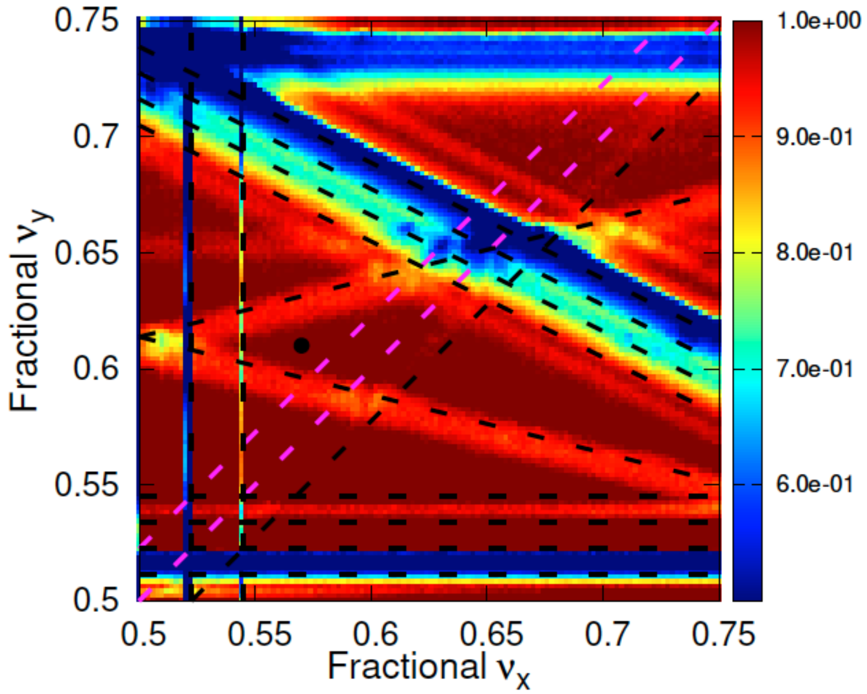


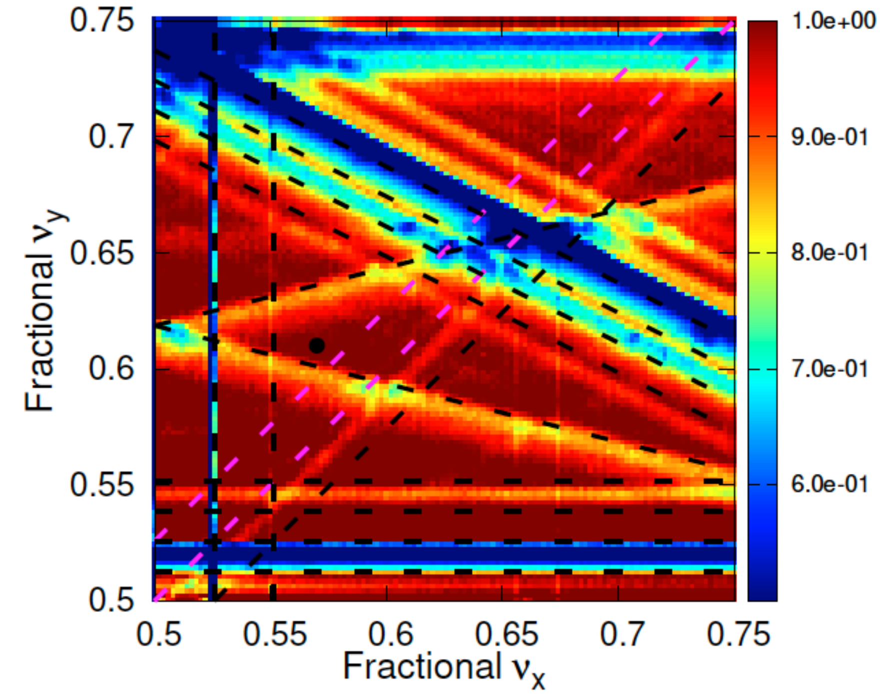
2. BBWS simulation: Tune scan

➤ Parameter set (2)

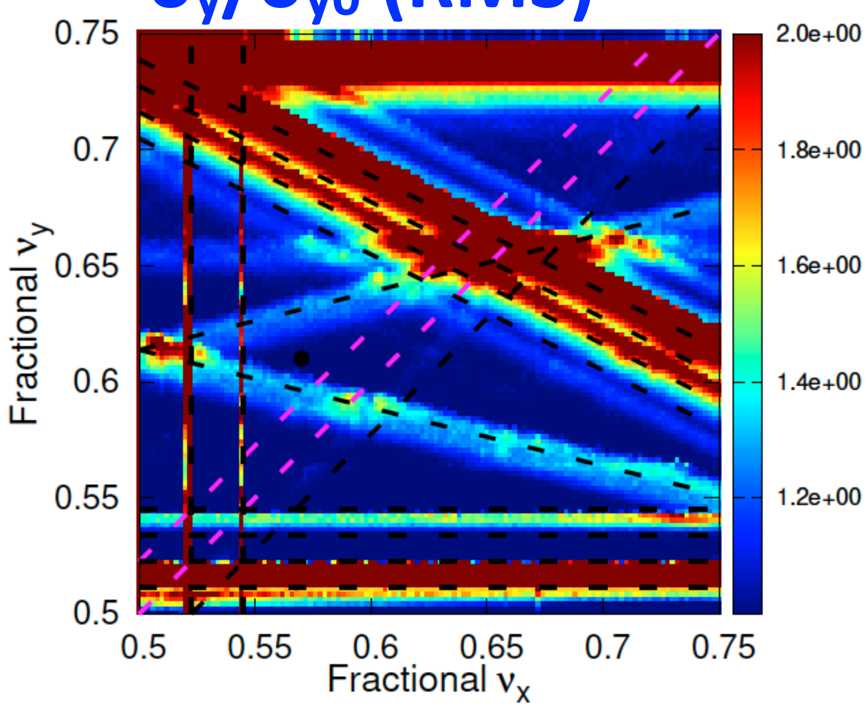
e+(W)e-(S) | **e+(S)e-(W)**

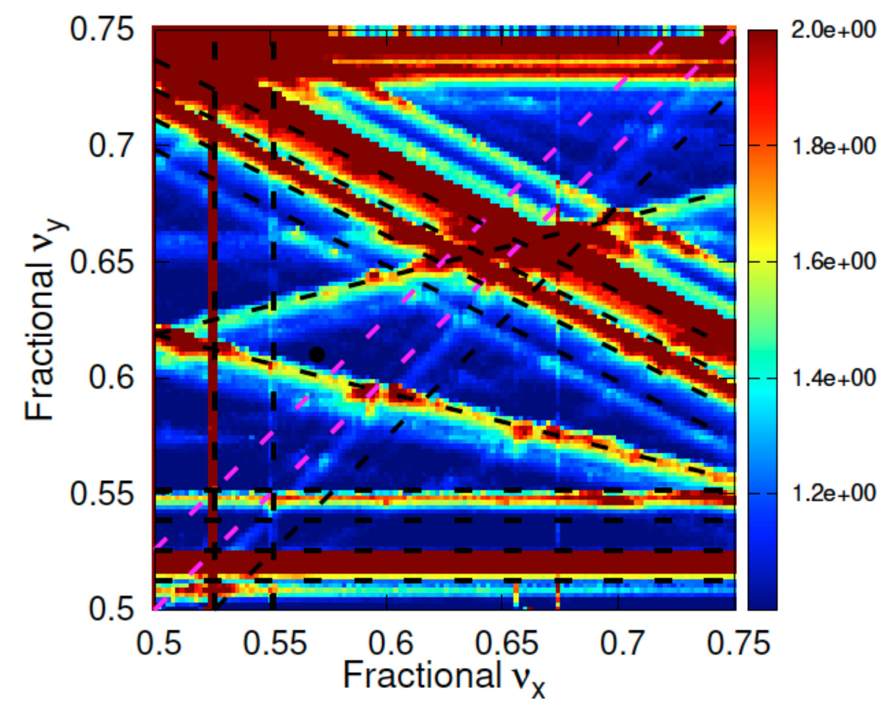
Lum. (L/L_0)





σ_y/σ_{y0} (RMS)



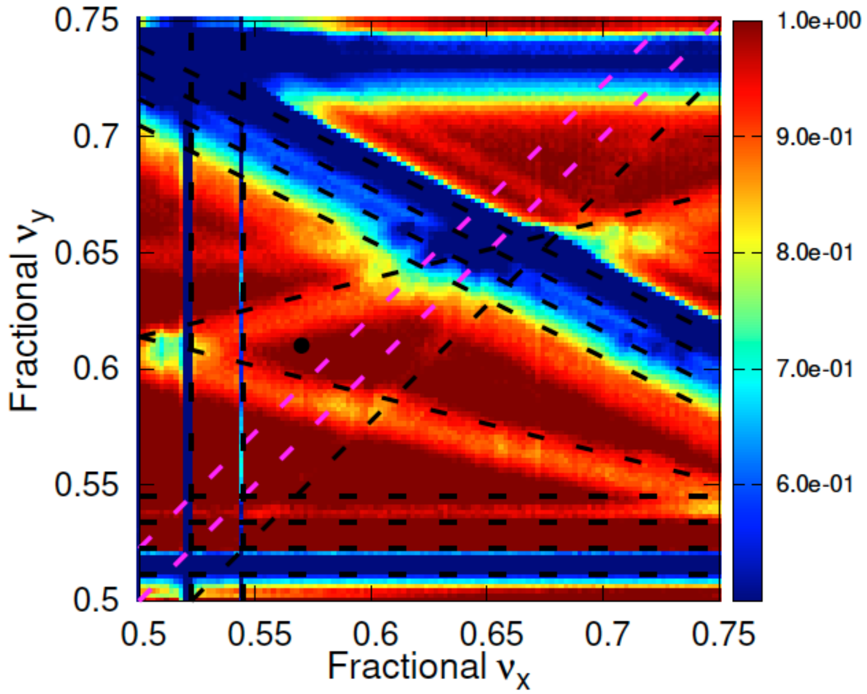


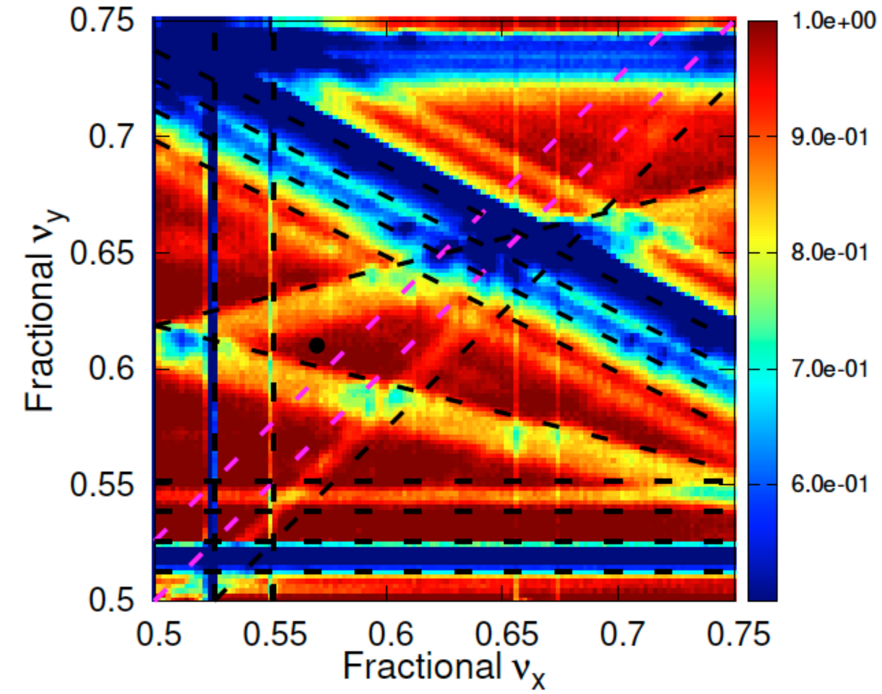
2. BBWS simulation: Tune scan

➤ Parameter set (2ex)

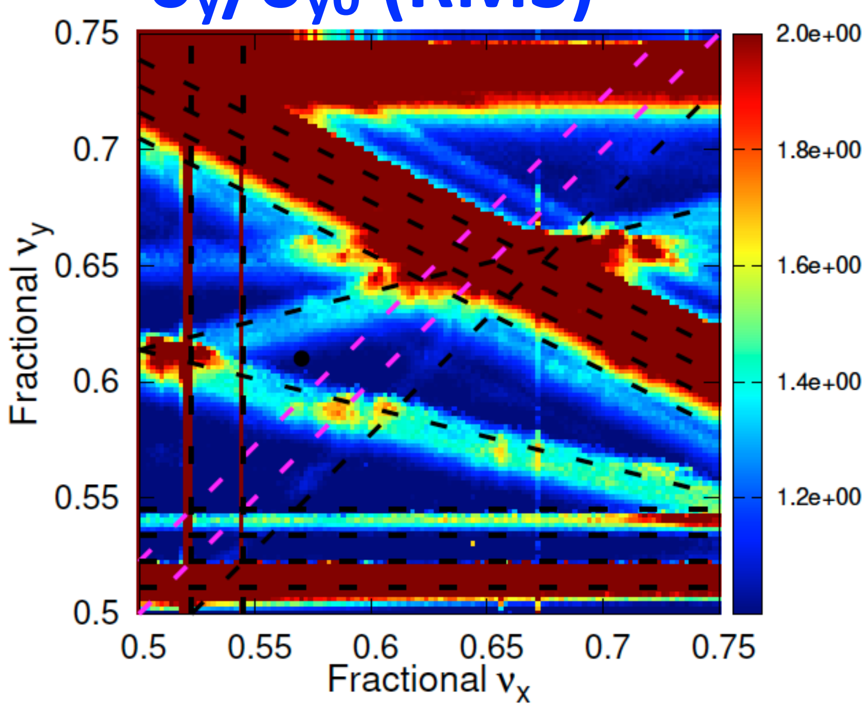
e+(W)e-(S) | **e+(S)e-(W)**

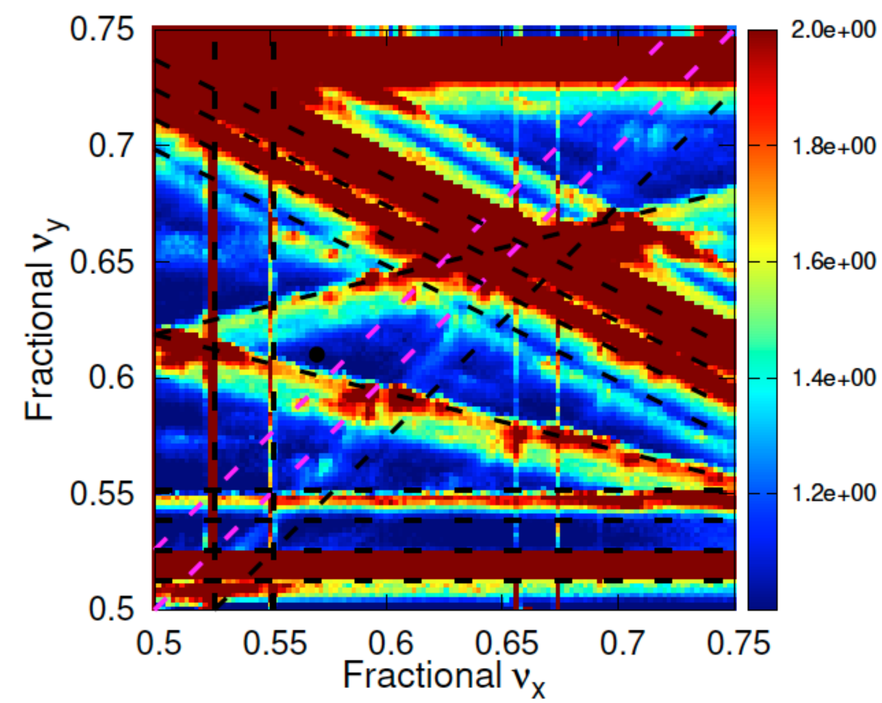
Lum. (L/L_0)





σ_y/σ_{y0} (RMS)



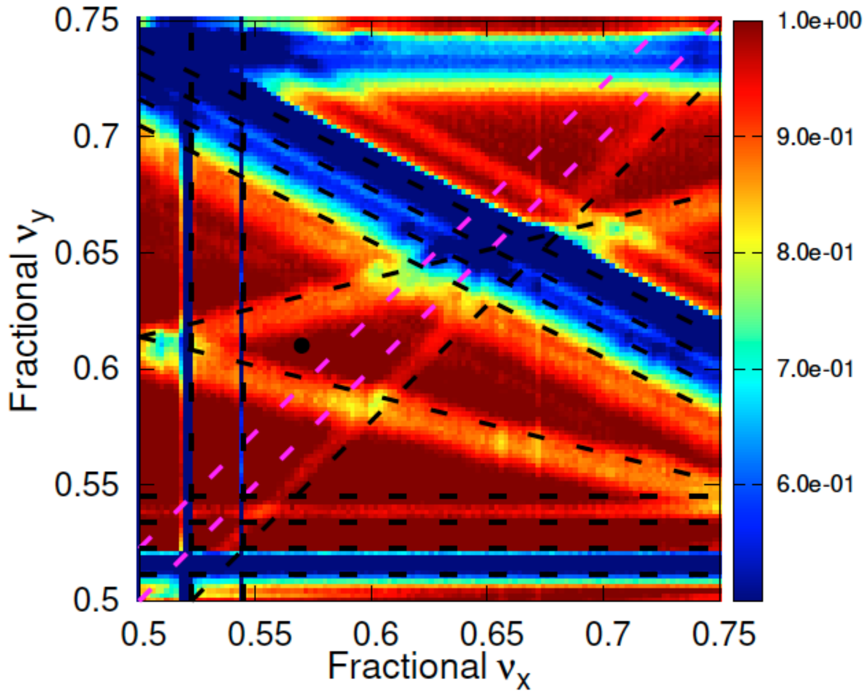


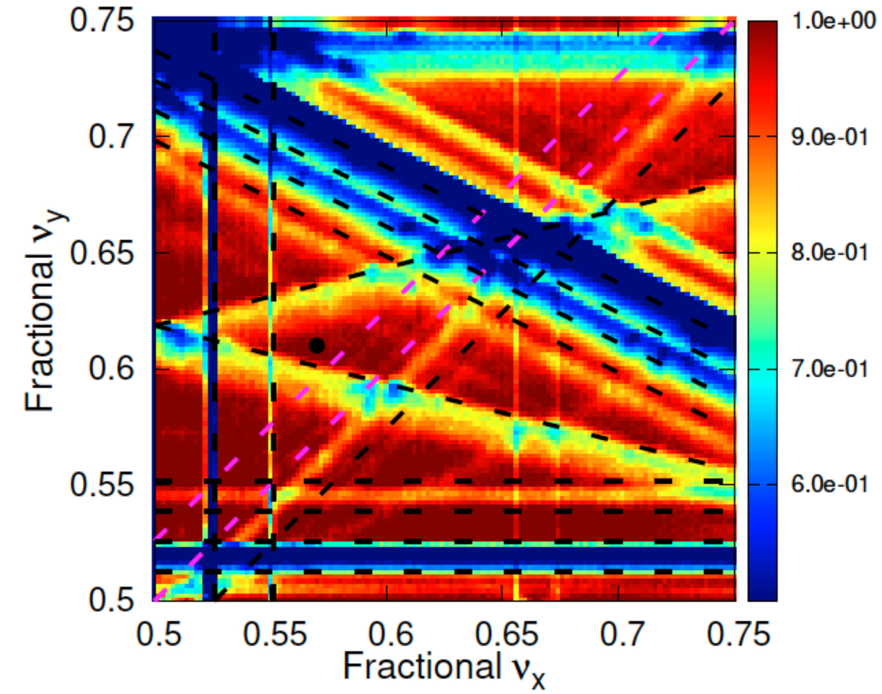
2. BBWS simulation: Tune scan

➤ **Parameter set (3)**

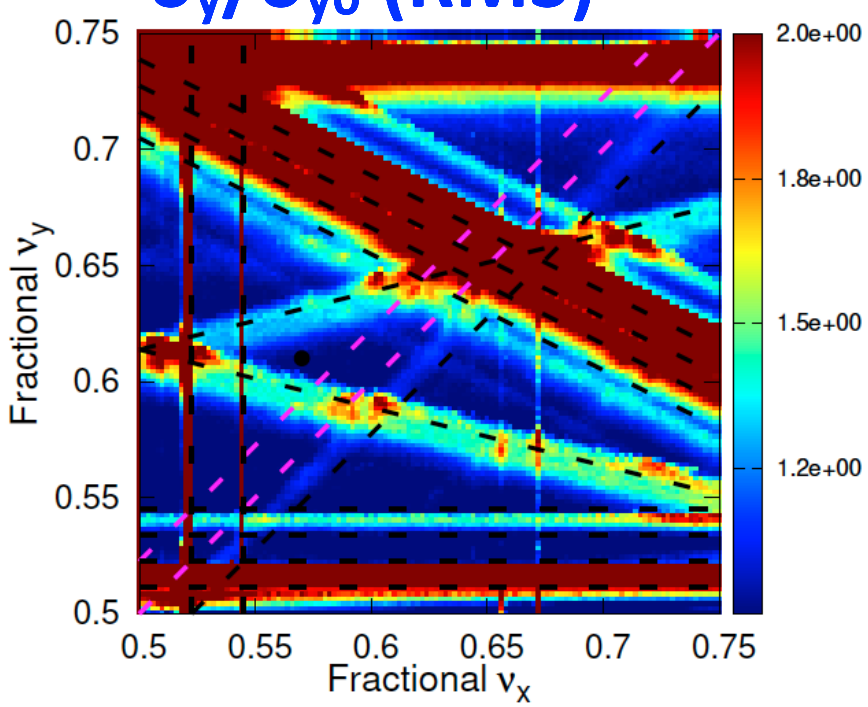
e+(W)e-(S) | **e+(S)e-(W)**

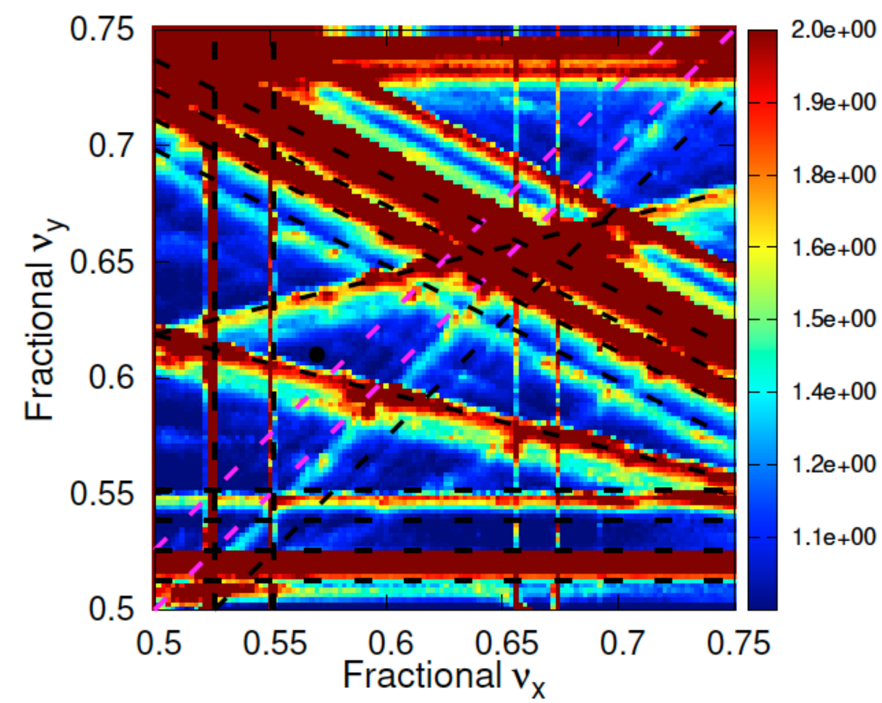
Lum. (L/L_0)





σ_y/σ_{y0} (RMS)



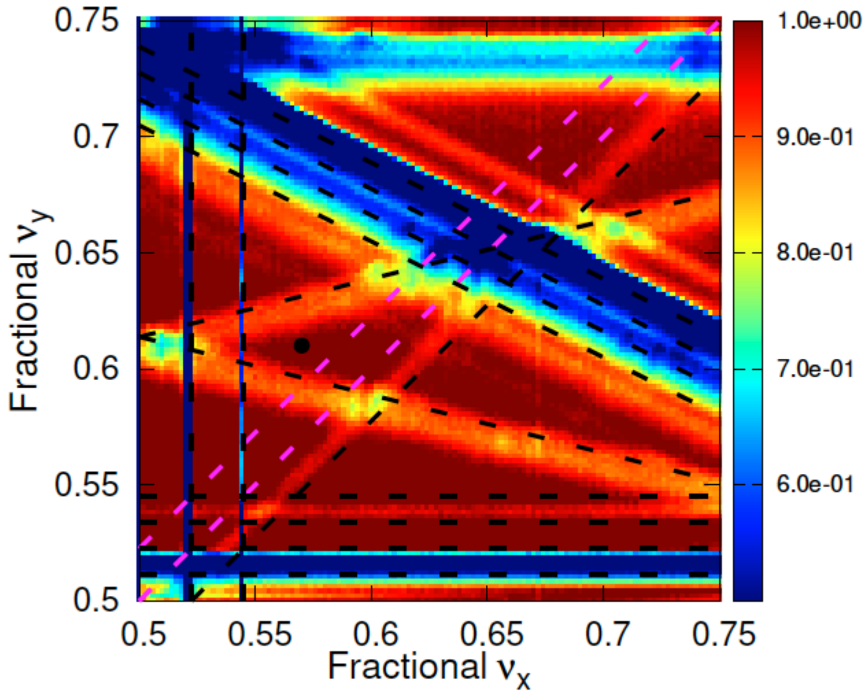


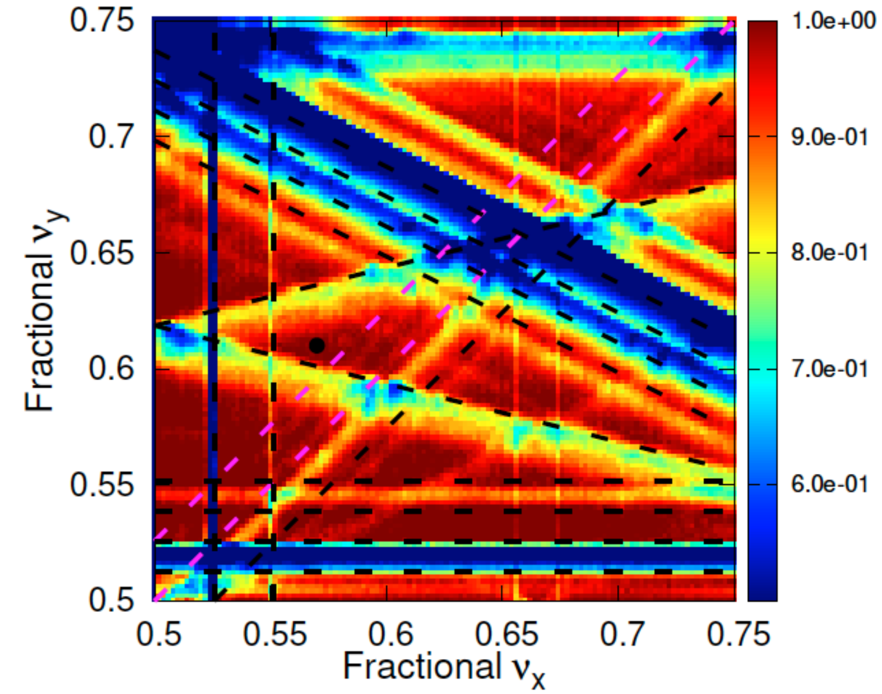
2. BBWS simulation: Tune scan

➤ Parameter set (3’)

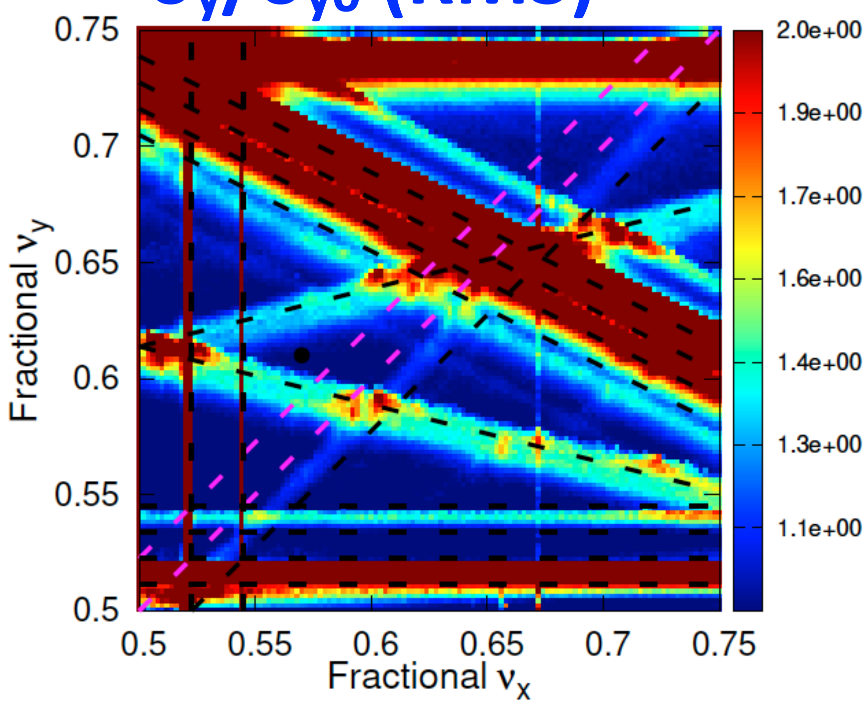
e+(W)e-(S) | **e+(S)e-(W)**

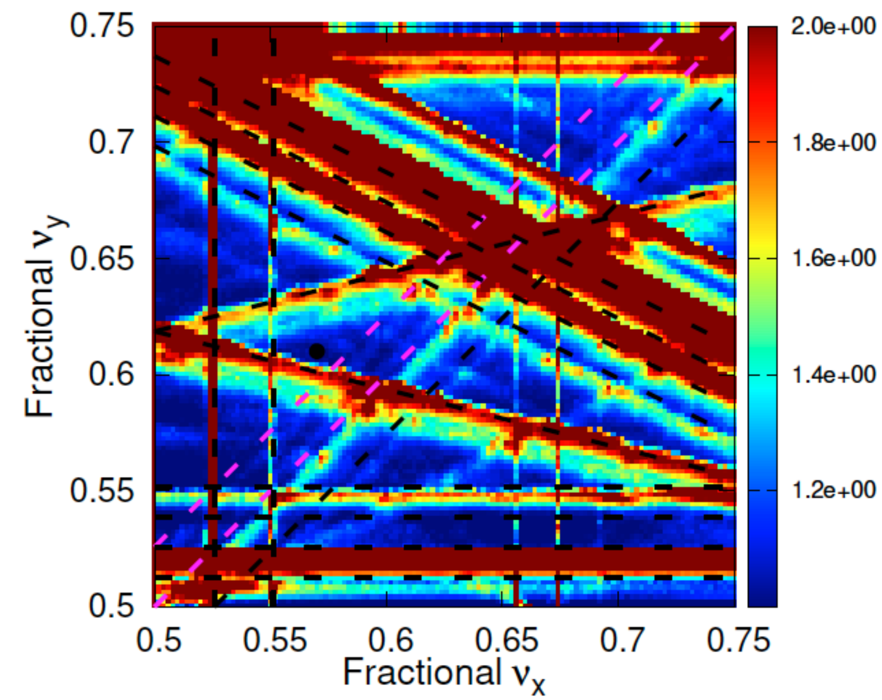
Lum. (L/L_0)





σ_y/σ_{y0} (RMS)





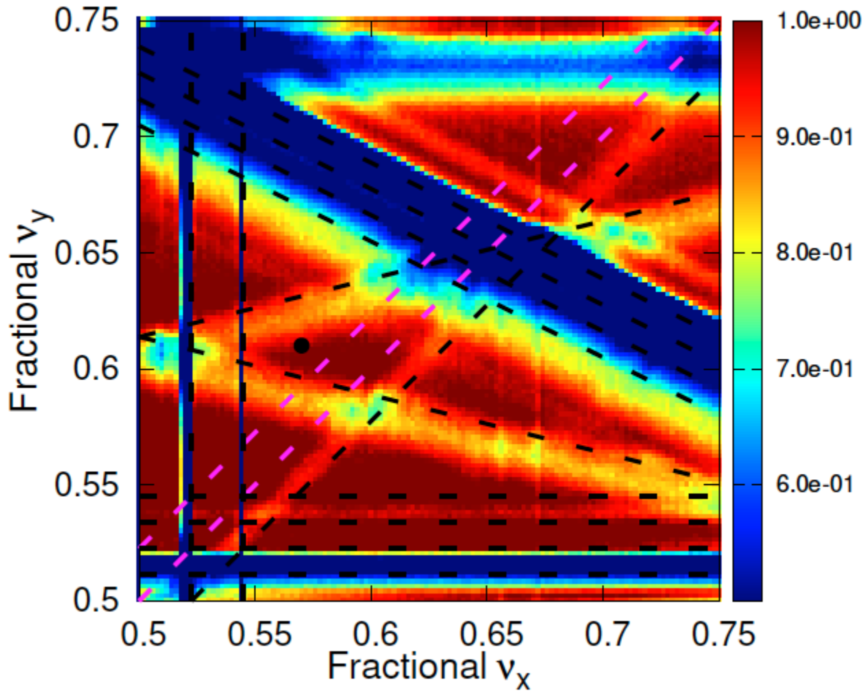
2. BBWS simulation: Tune scan

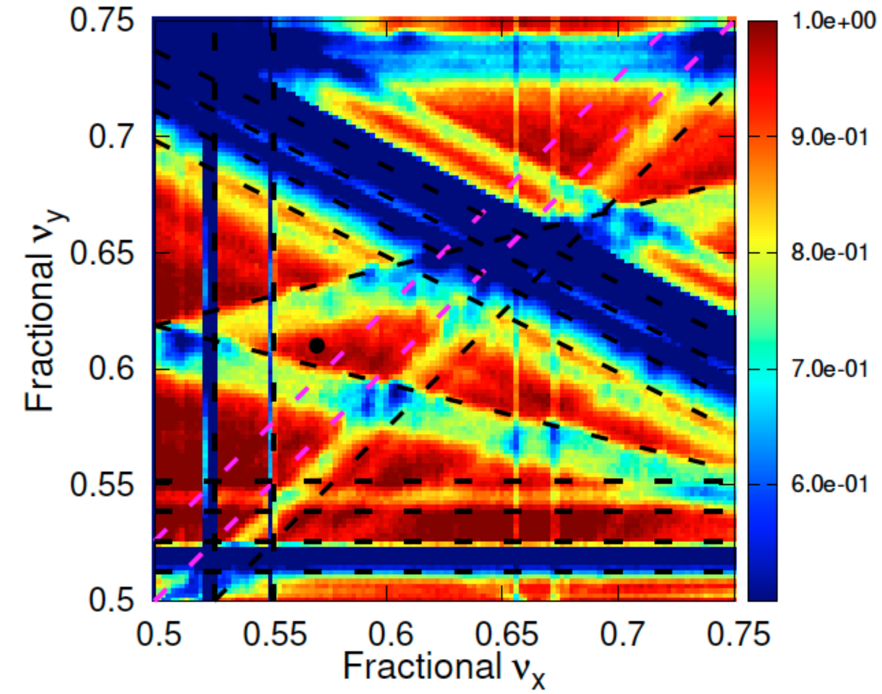
➤ Parameter set (3ex)

e+(W)e-(S)

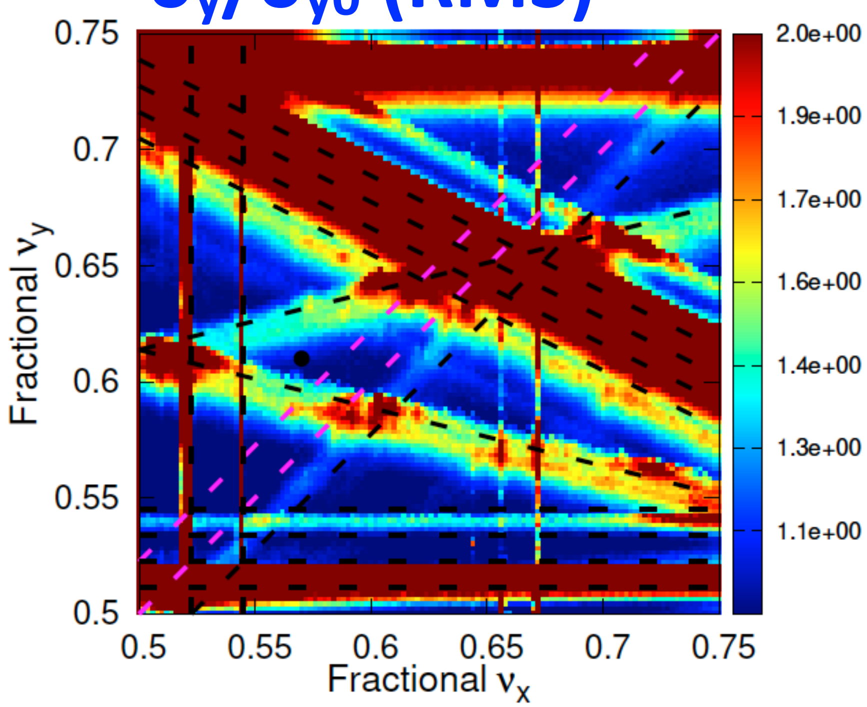
e+(S)e-(W)

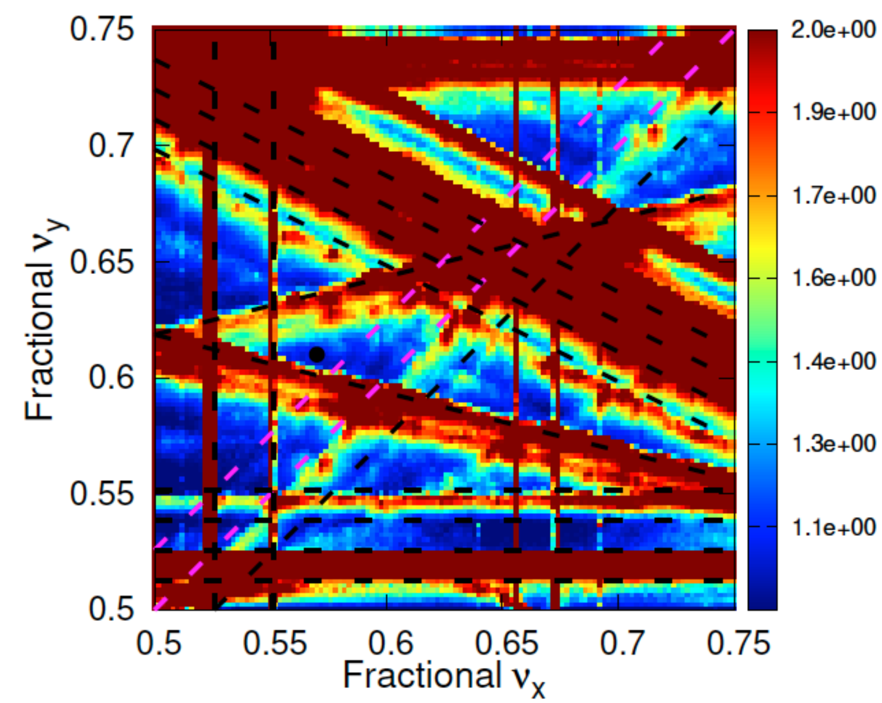
Lum. (L/L_0)





σ_y/σ_{y0} (RMS)



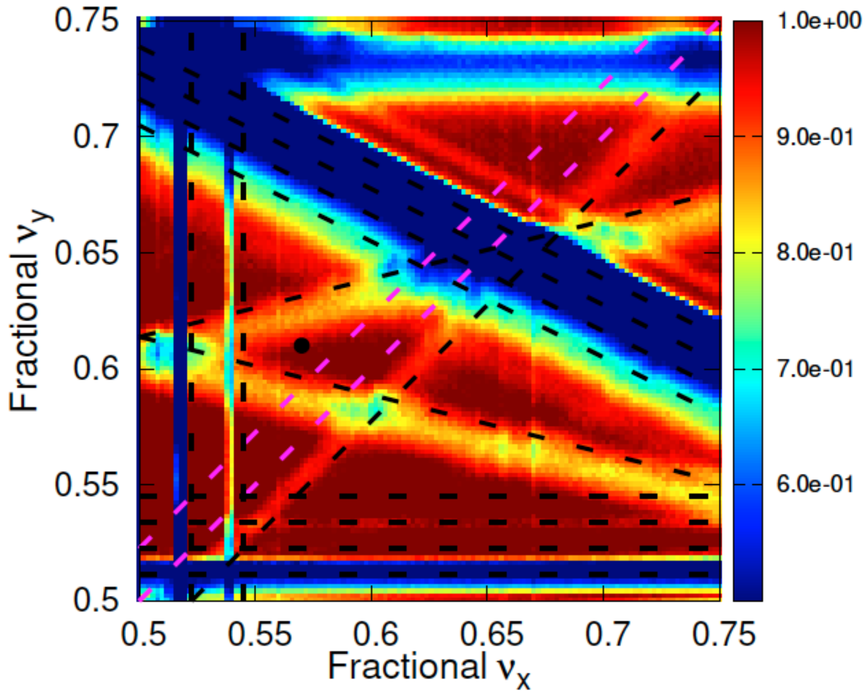


2. BBWS simulation: Tune scan

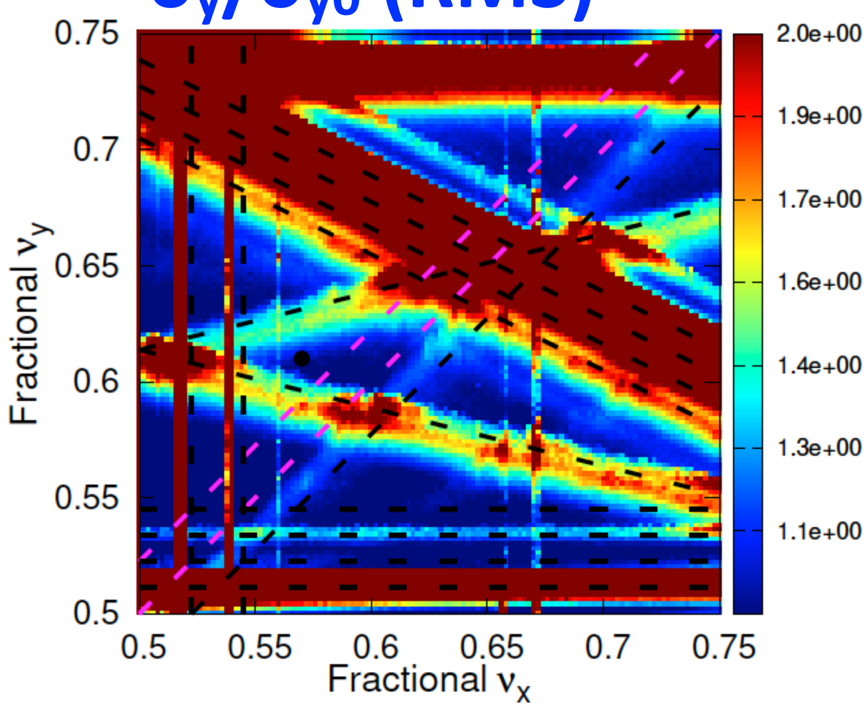
➤ **Parameter set (3ex)**

e+(W)e-(S)

Lum. (L/L_0)



σ_y/σ_{y0} (RMS)

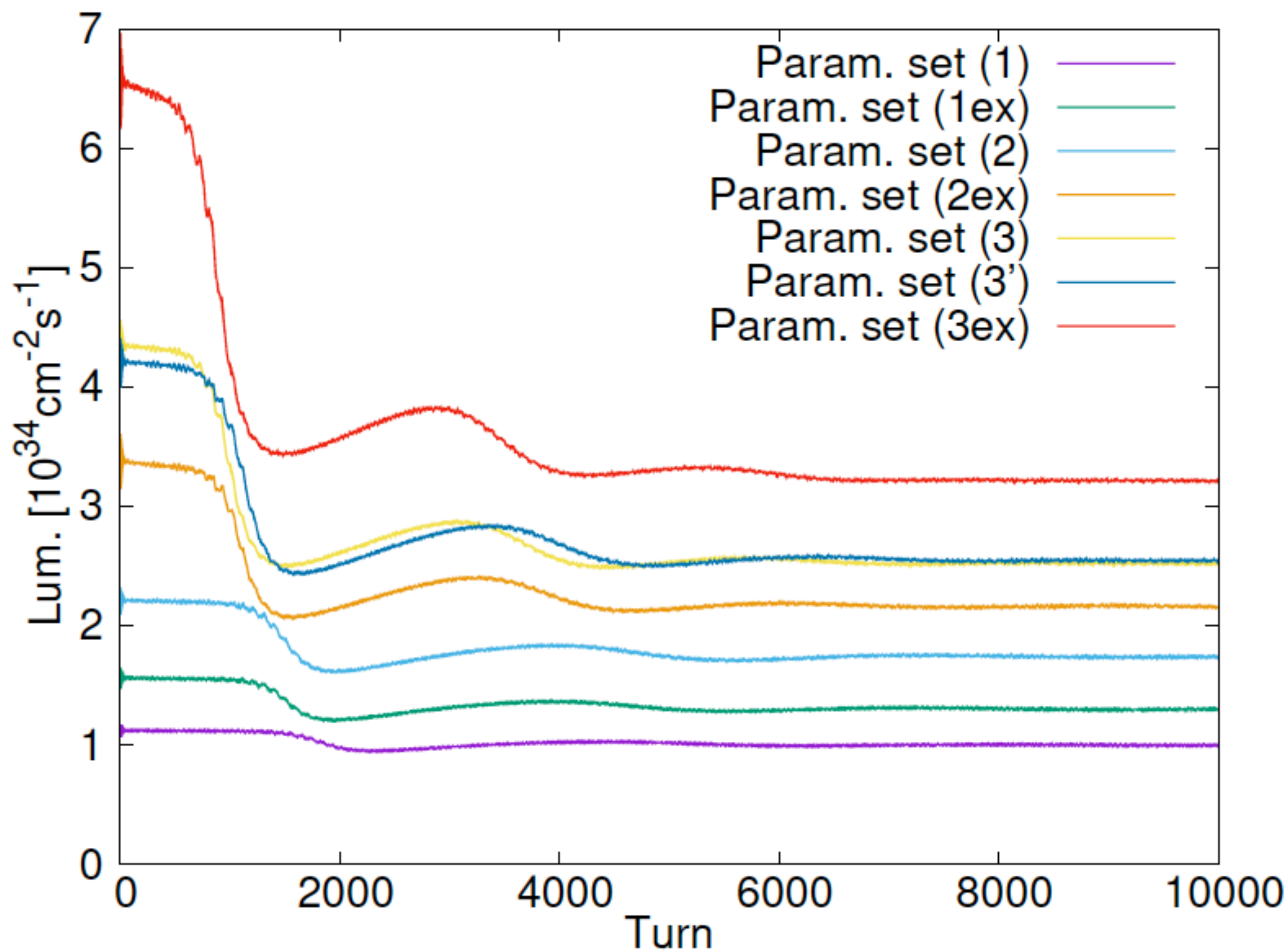


$\nu_x+k*\nu_s=N$ shifted as expected when changing ν_s.
BUT resonance lines of $\pm\nu_x+4\nu_y+C=N$ NOT shifted?

3. BBSS simulation

➤ **All parameter sets: Luminosity**

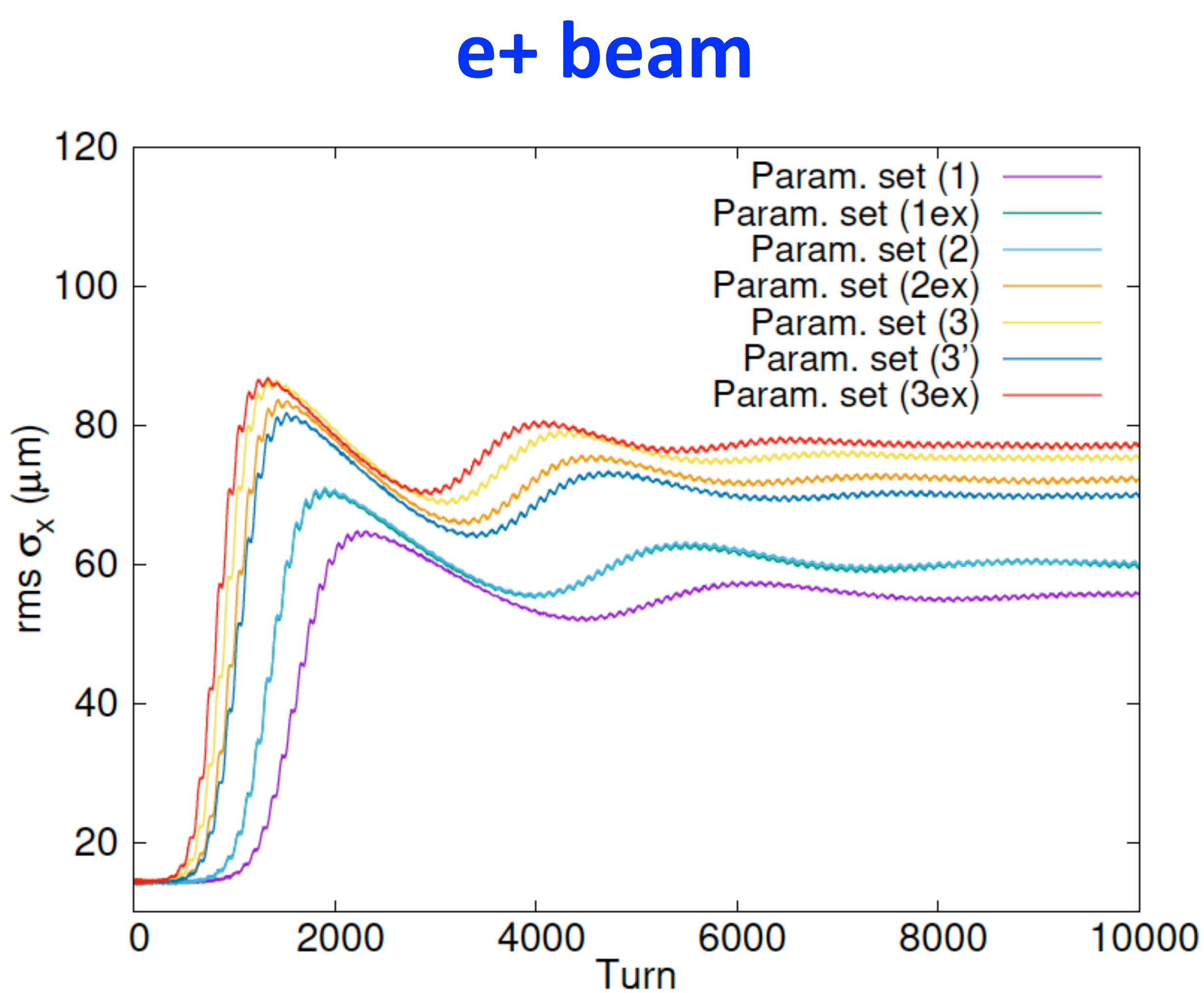
- **Working point: LER (44.57, 46.61), HER (45.57, 43.61)**

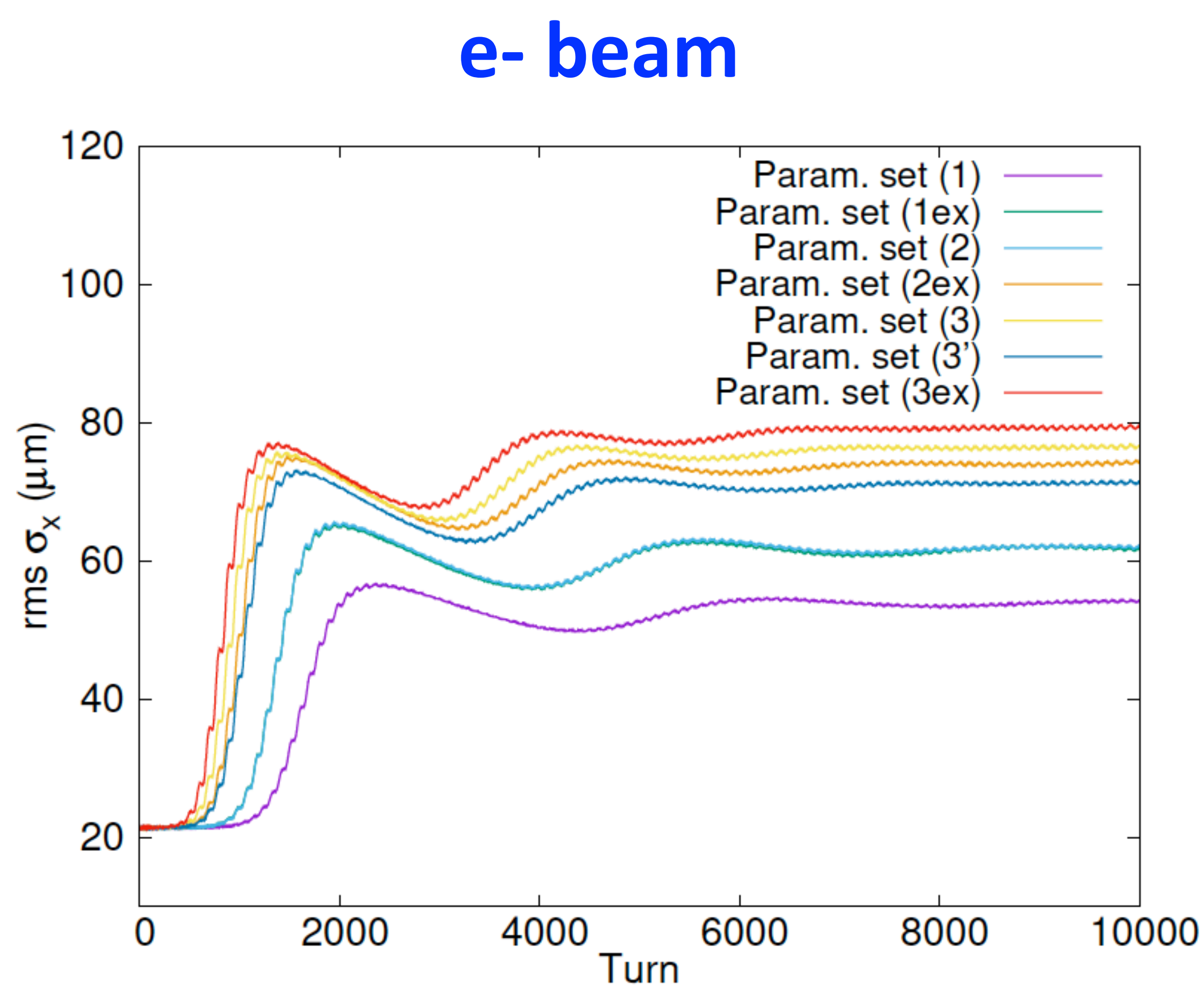


3. BBSS simulation

➤ **All parameter sets: Hor. beam size**

- **Working point: LER (44.57, 46.61), HER (45.57, 43.61)**
- **Typical x-z instability studied by K. Ohmi et al.**



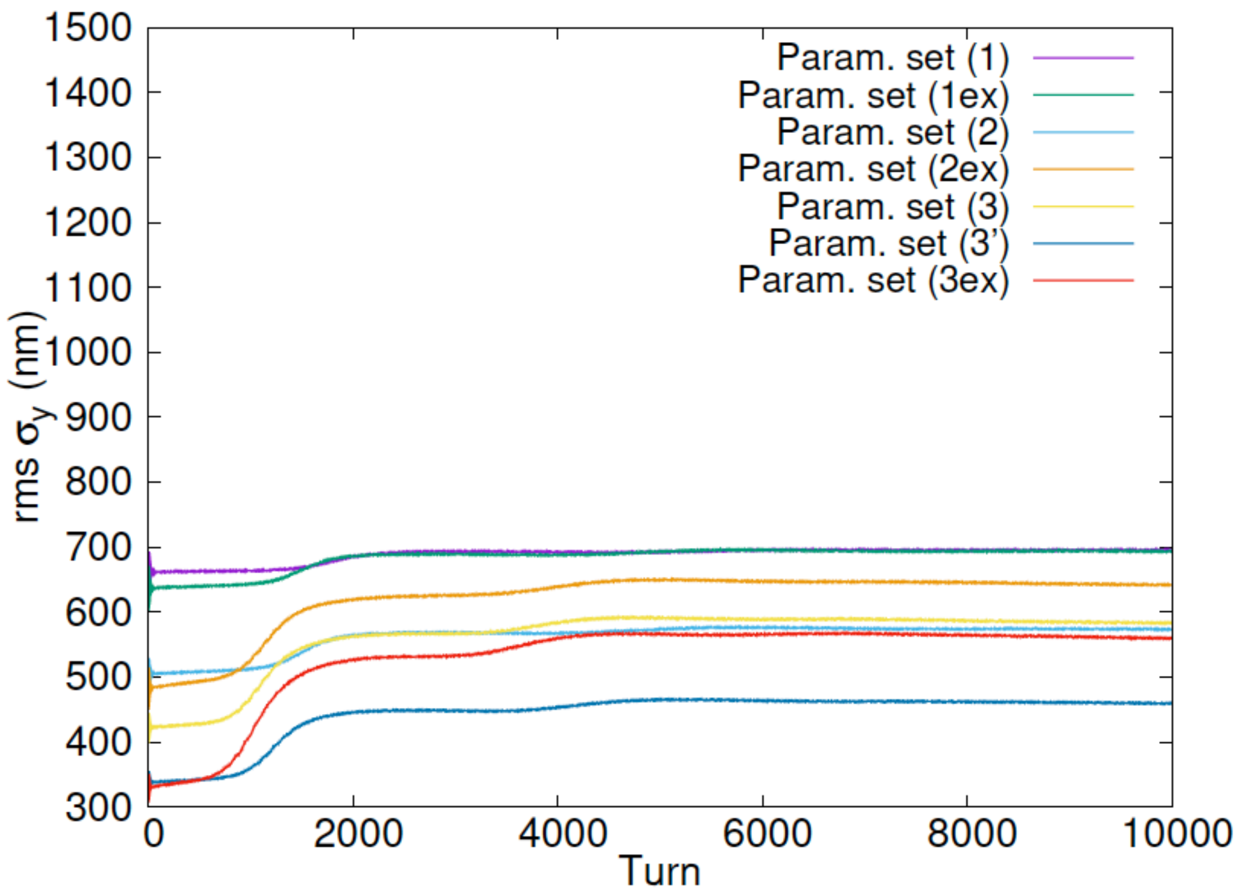


3. BBSS simulation

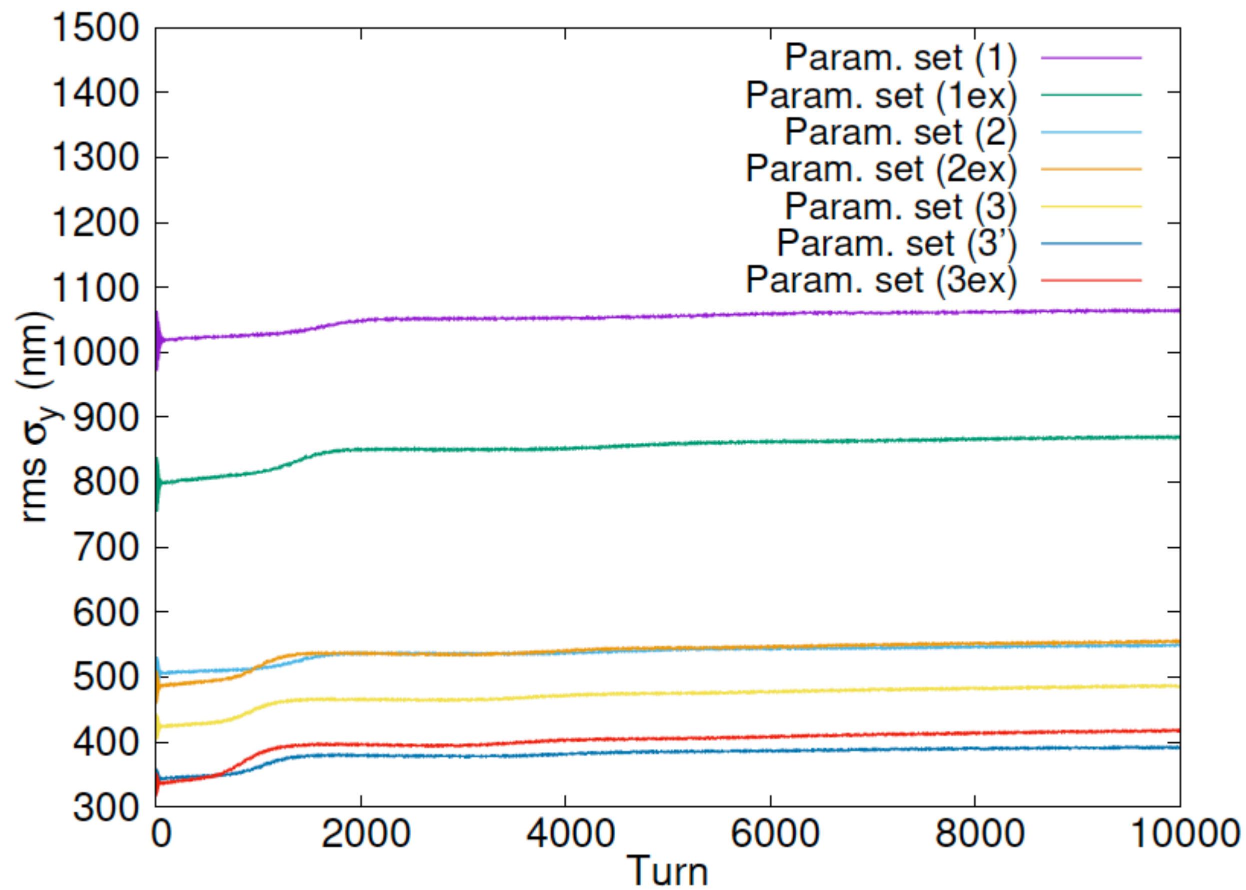
➤ All parameter sets: Ver. beam size

- **Working point: LER (44.57, 46.61), HER (45.57, 43.61)**

e+ beam



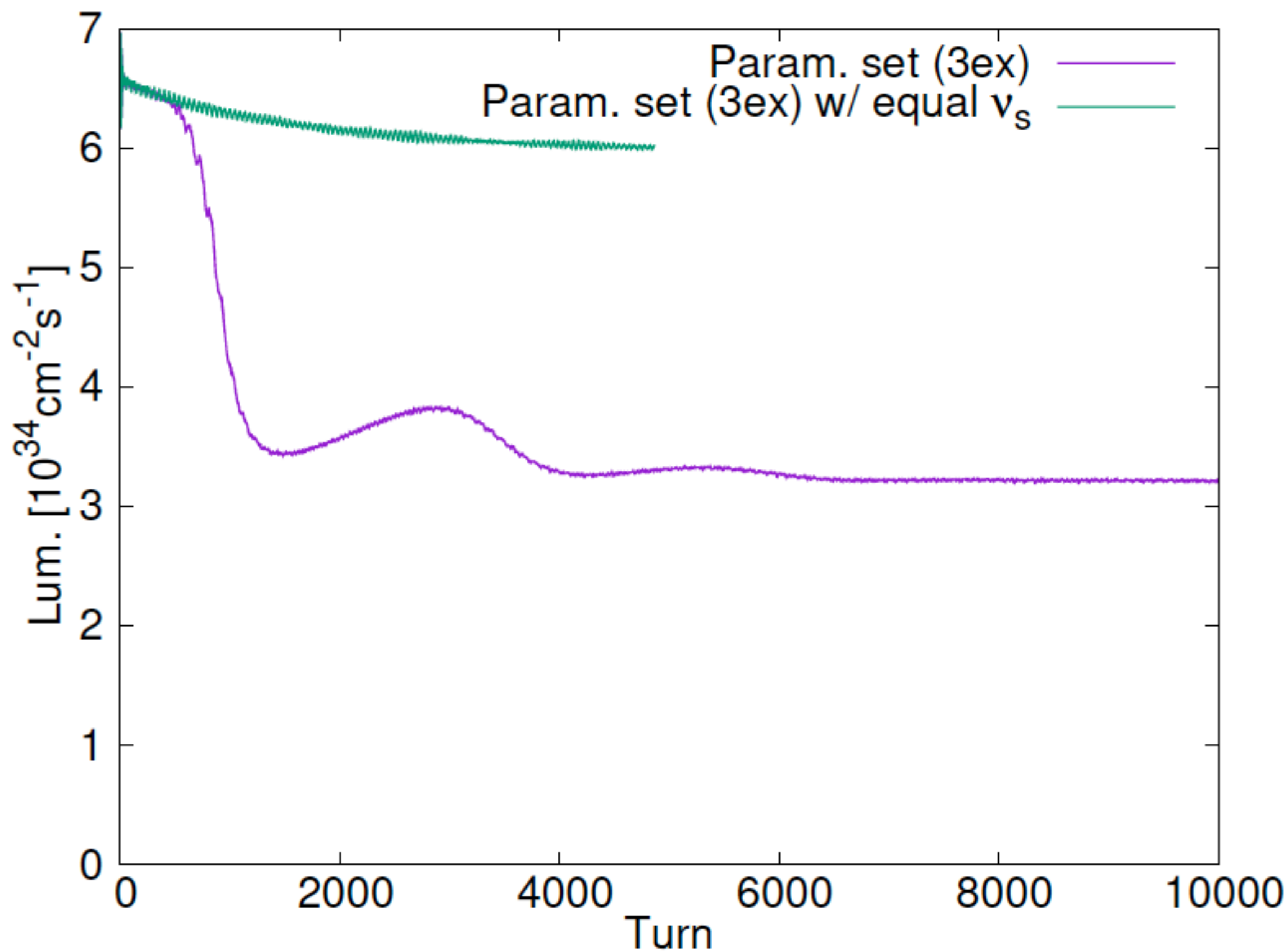
e- beam



3. BBSS simulation

➤ **Parameter set (3ex): Equal ν_s for e+ and e- beams**

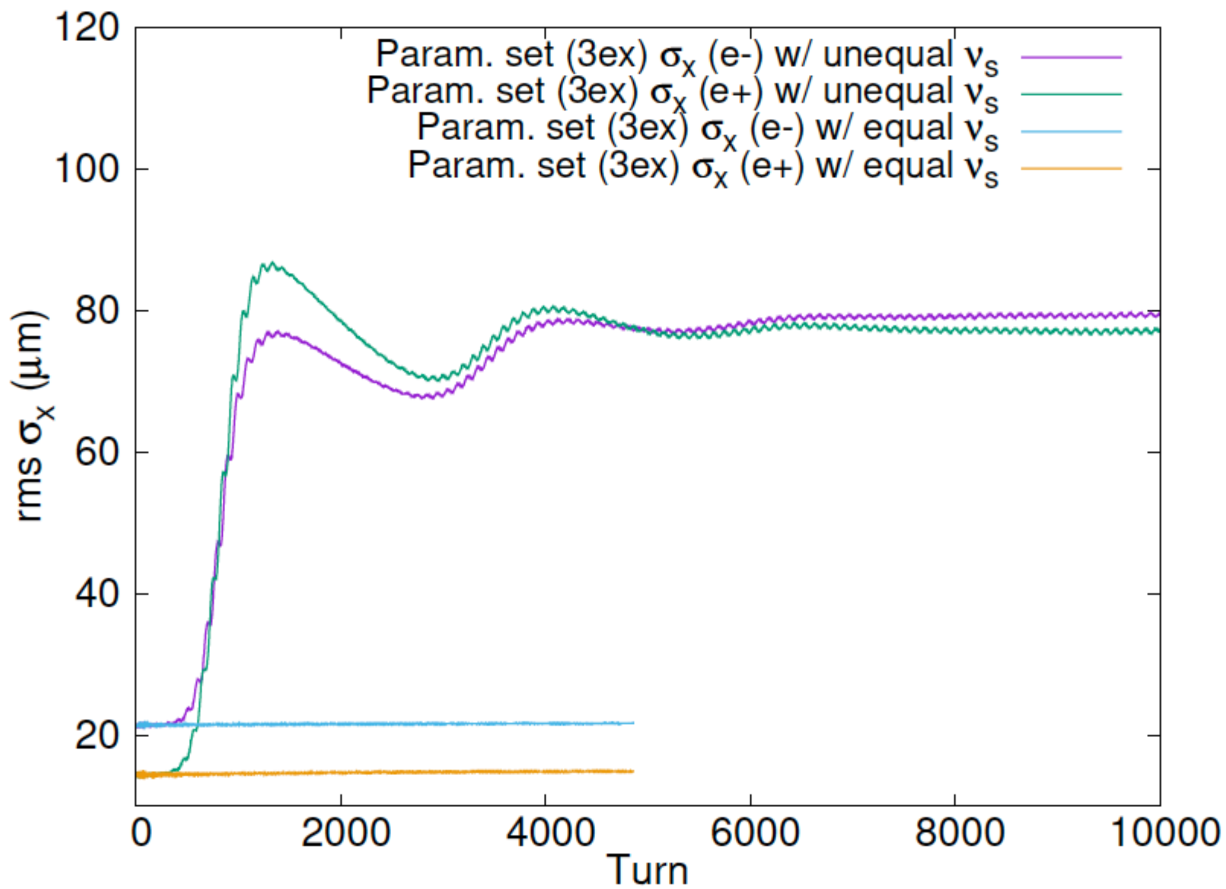
- **Working point: LER (44.57, 46.61), HER (45.57, 43.61)**
- **$\nu_s(e+) = \nu_s(e-) = 0.0225$**



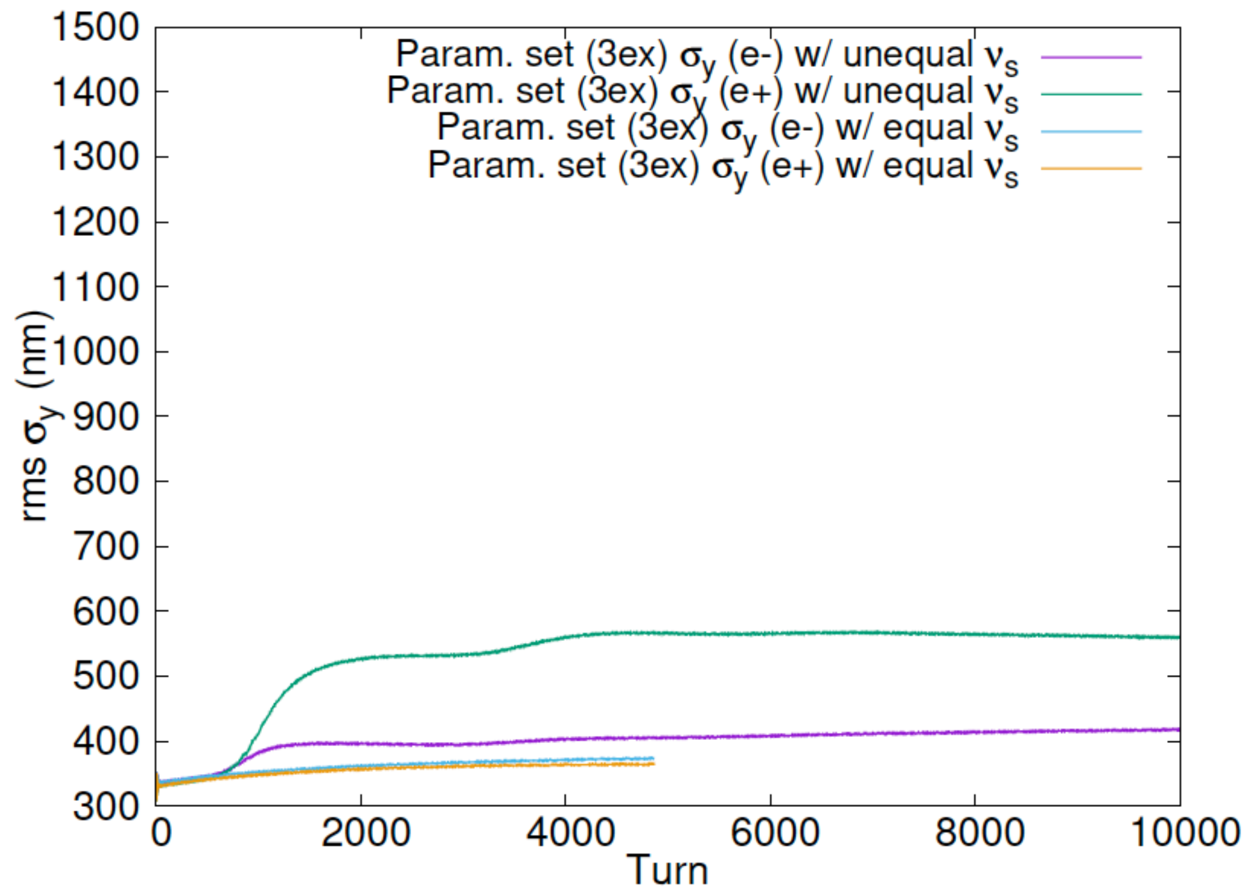
3. BBSS simulation

- **Parameter set (3ex): Equal ν_s for e+ and e- beams**
  - **Working point: LER (44.57, 46.61), HER (45.57, 43.61)**
  - **ν_s(e+) = ν_s(e-) = 0.0225**

rms σ_x



rms σ_x



4. Summary

➤ **Tune scan using BBWS**

- **Good lum. region around (.57, .61) as Phase-2**
- **The "sweat" area get smaller from Param. set 1 to 3ex**
- **Near the (.57,.61) working point, the beam-beam resonance $\nu_x+4\nu_y+C=N$ is strong. BUT, what is C? NOT correlated to ν_s! Correlated to beam-beam tune shift?**

➤ **Simulations using BBSS**

- **x-z beam-beam instability are not seen in BBWS simulations, but seen in BBSS simulations at (.57, .61)**
- **Cure #1: Squeezing β_x^* as suggested by K. Ohmi**
- **Cure #2: Equalizing ν_s of e+ and e- beams? Possible? How necessary?**
- **Cure #3: Shifting ν_s. $\nu_x+3\nu_s=N$ is important? To be checked.**

➤ **Future work**

- **Optimizations of key parameters: (I_{bunch}, $\beta_{x,y}^*$, ν_x, ν_y) for HER and LER => More beam-beam simulations**

2. BBWS simulation: Tune scan

➤ **Parameter set (3ex): rms σ_x**