Beam-beam simulations for SuperKEKB Phase-3

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Acknowledgements:

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SuperKEKB mini-optics meeting

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Outline

- Introduction
- Simulation using BBWS and BBSS
- Summary

1. Introduction

➤ Phase-3 machine parameters (Early stage)

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

	1		1(op1)		1(op2)		2019.03.30		2019.04.02	
	HER	LER	HER	LER	HER	LER	HER	LER	HER	LER
I_b (A)	1.0	1.2	1.0	1.2	1.0	1.2	0.21	0.26	0.17	0.22
# bunch	1576		1576		1576		789		789	
ε_x (nm)	4.6	2.0	4.6	2.0	4.6	2.0	4.728	1.731	4.537	1.641
ε_y (pm)	368	160	160	160	160	160	122.5	40	53.33	13.33
β_x (mm)	100	100	100	230	80	80	200	200	100	200
β_y (mm)	3	3	3	3	3	3	4	4	3	3
σ_z (mm)	6	6	6	6	6	6	6	6	6	6
ν_x	45.57	44.57	45.57	44.57	45.57	44.57	45.564	44.571	45.5439	44.5568
ν_y	43.61	46.61	43.61	46.61	43.61	46.61	43.603	46.610	43.6082	46.618
ν_s	0.0258	0.0225	0.0258	0.0225	0.0258	0.0225	0.0256	0.0219	0.02576	0.02205
ξ_y(Geom.)	0.0272	0.0262								
$\mathcal{L}$(Geom.)	1.06E+34		1.36E+34		1.37E+34		1.50E+33		1.85E+33	
$\mathcal{L}$(BBSS)	1.00E+34		9.30E+33		1.34E+34					

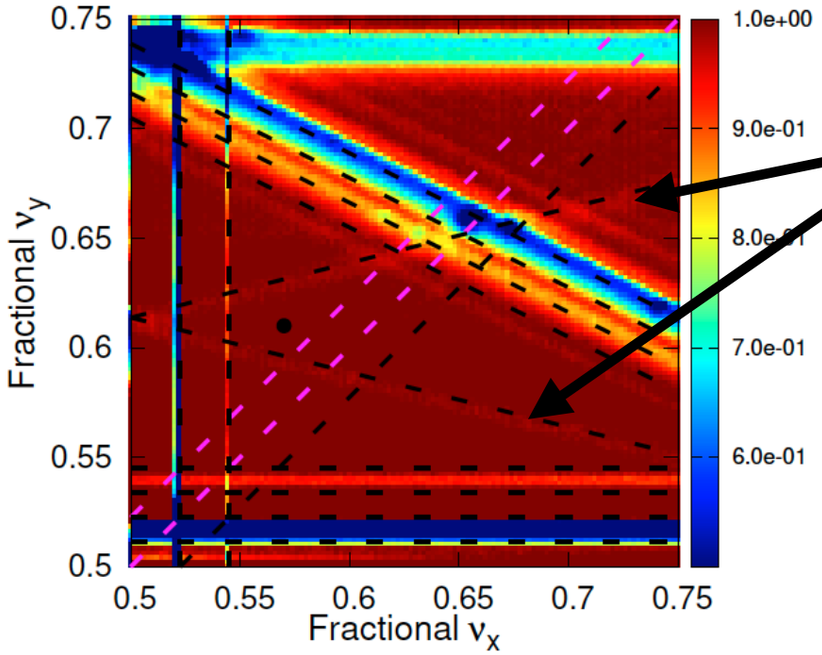
2. BBWS simulation: Tune scan

Talk on Dec.13, 2018

➤ Parameter set (1)

e+(W)e-(S)

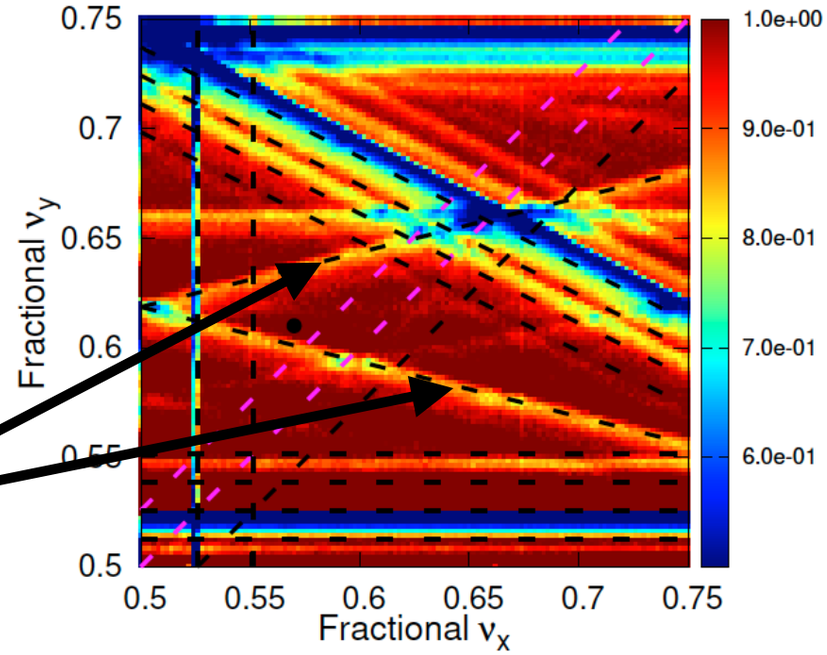
Lum. (L/L_0)



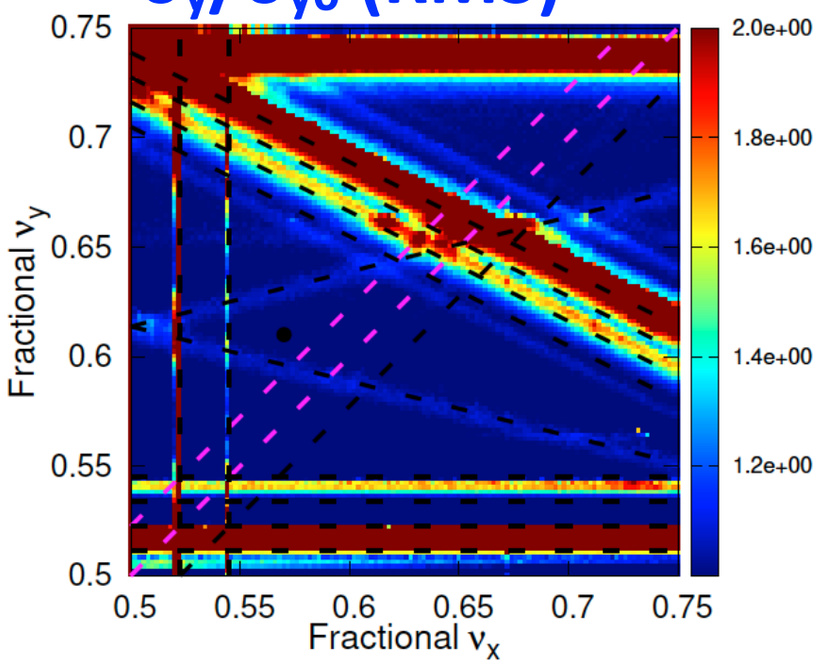
$\pm\nu_x+4\nu_y+2\nu_s=N$

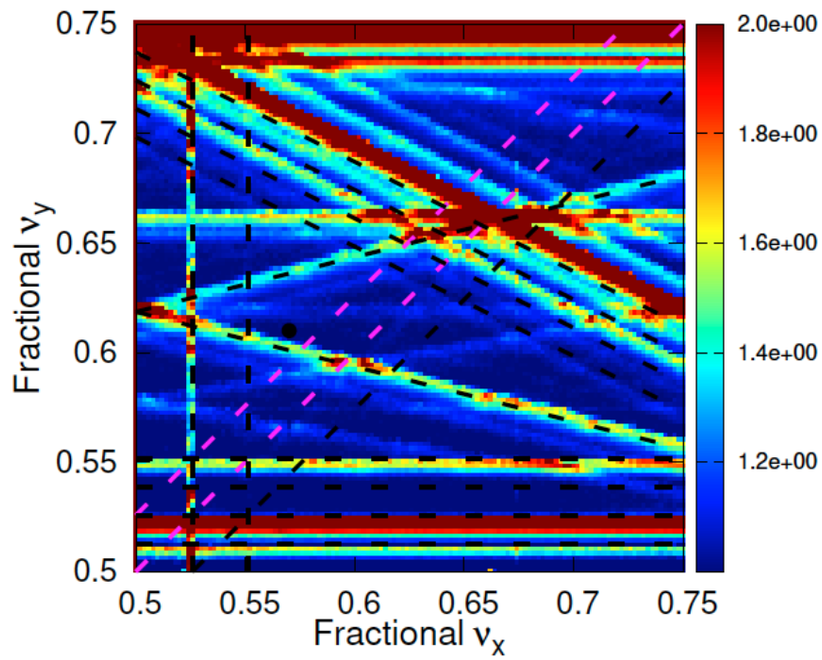
$\pm\nu_x+4\nu_y+\nu_s=N$

e+(S)e-(W)



σ_y/σ_{y0} (RMS)





2. BBWS simulation: Tune scan

➤ Parameter set (1(op1))

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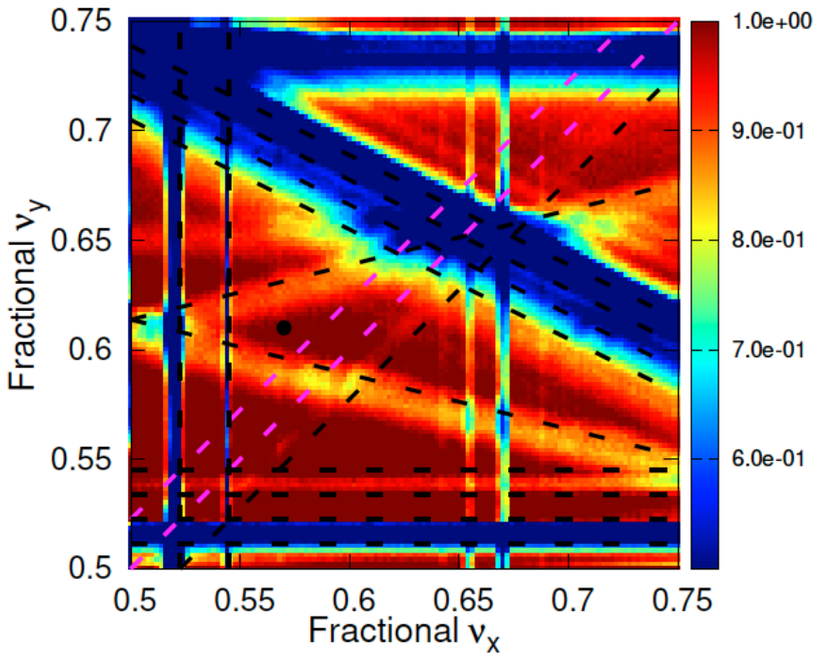
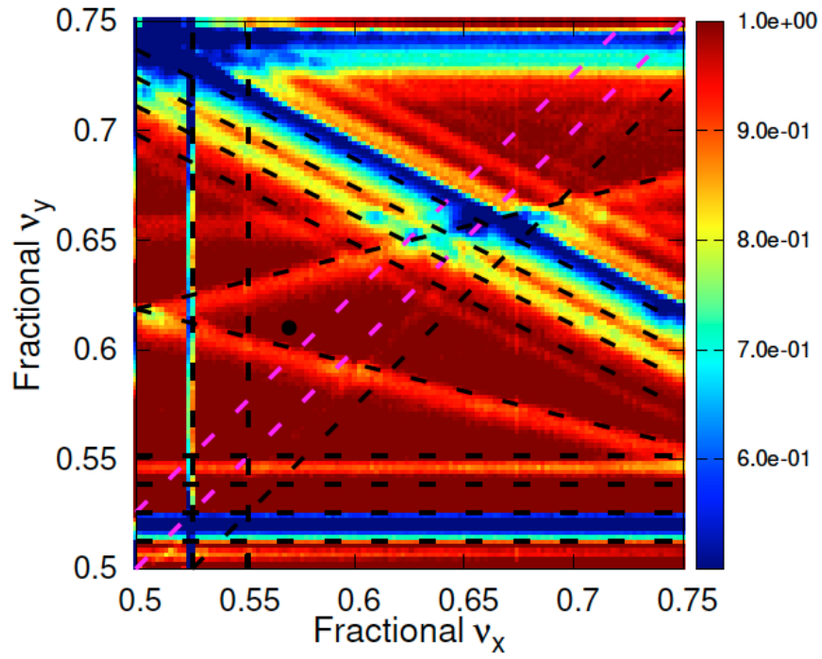
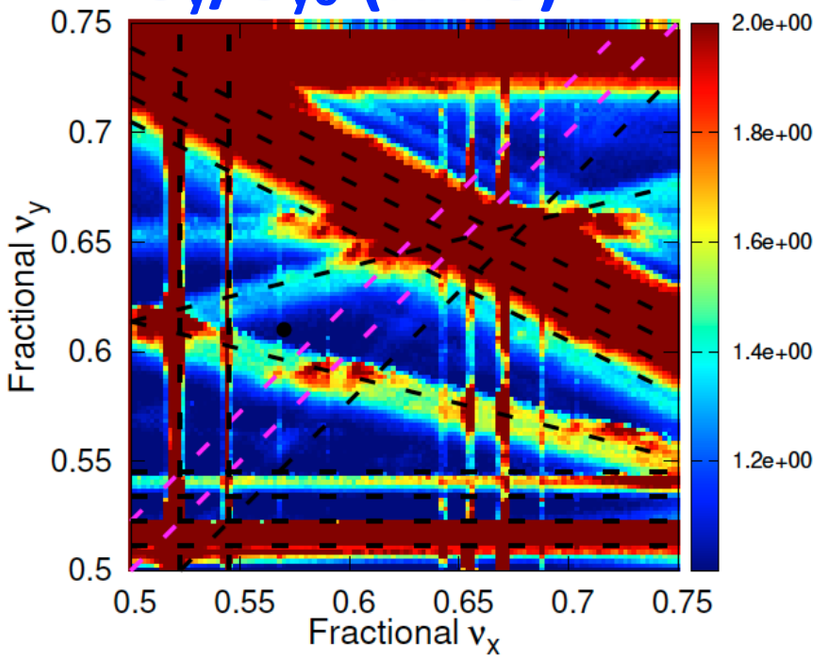
Lum. (L/L_0)

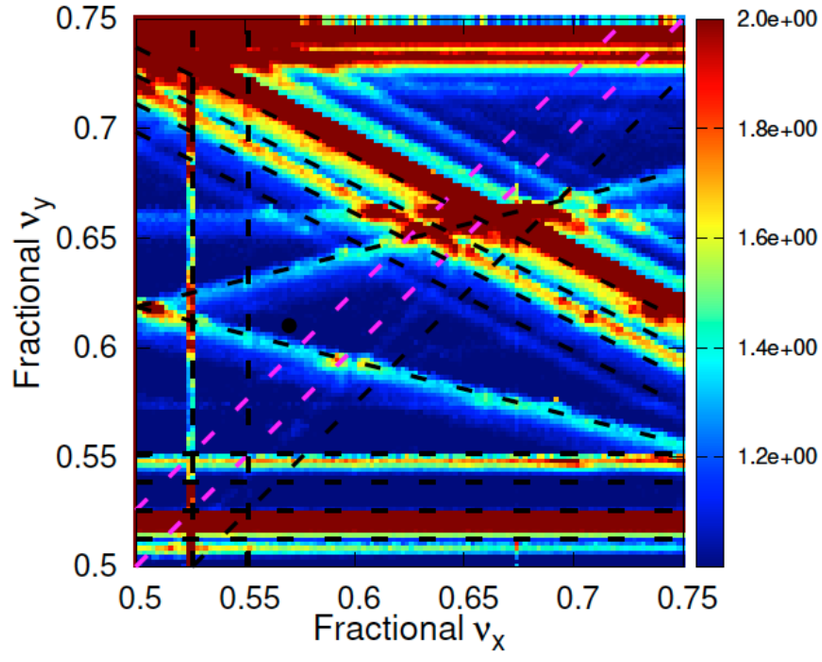


e+(S)e-(W)



σ_y/σ_{y0} (RMS)



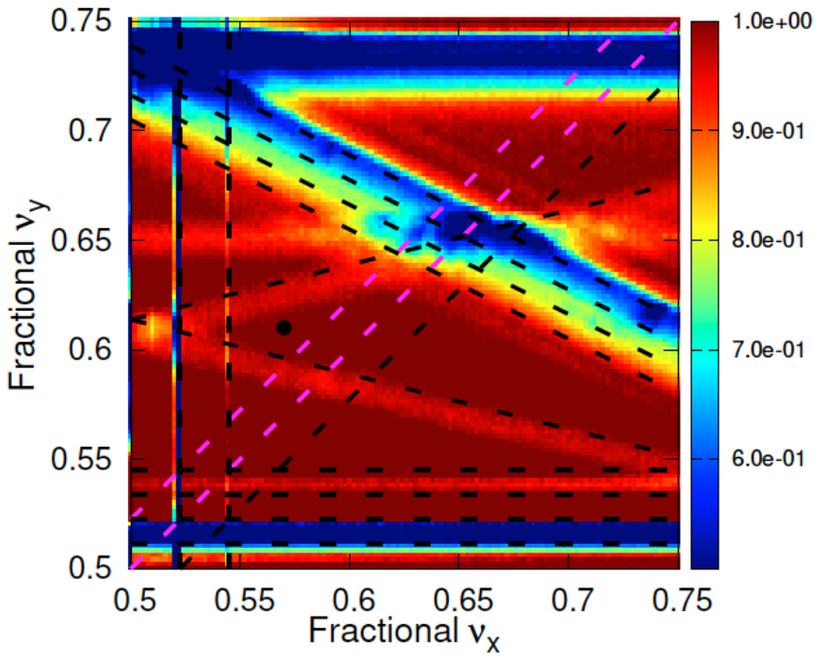


2. BBWS simulation: Tune scan

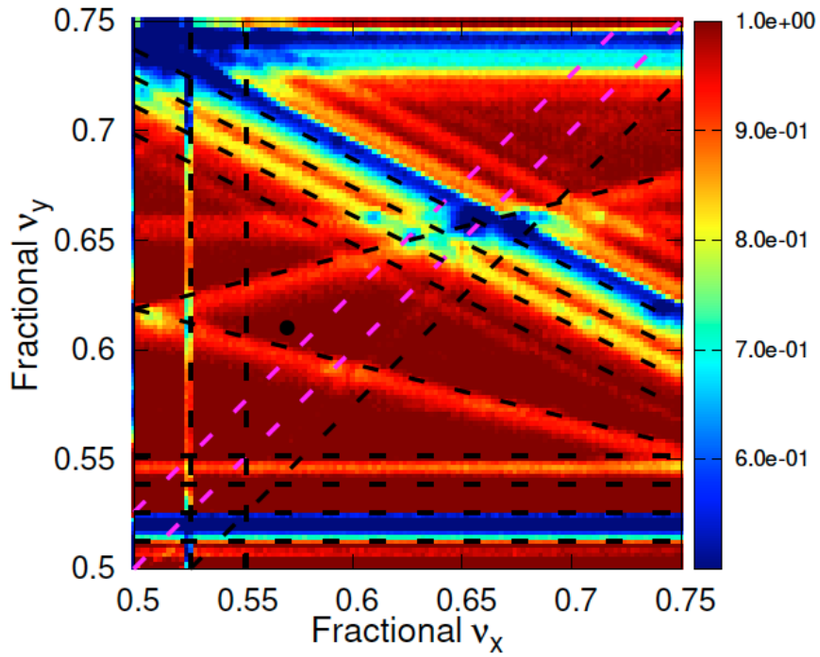
➤ Parameter set (1(op2))

e+(W)e-(S)

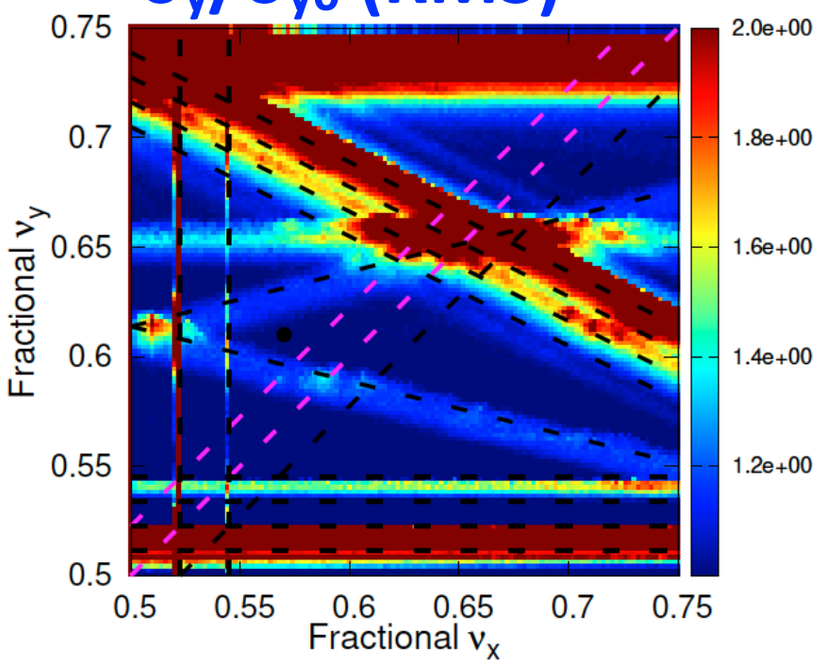
Lum. (L/L_0)

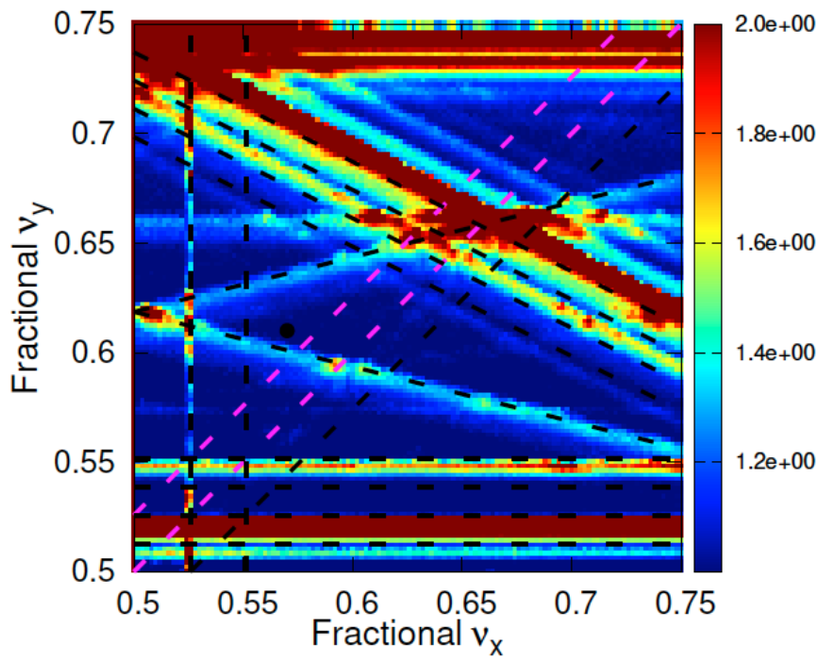


e+(S)e-(W)



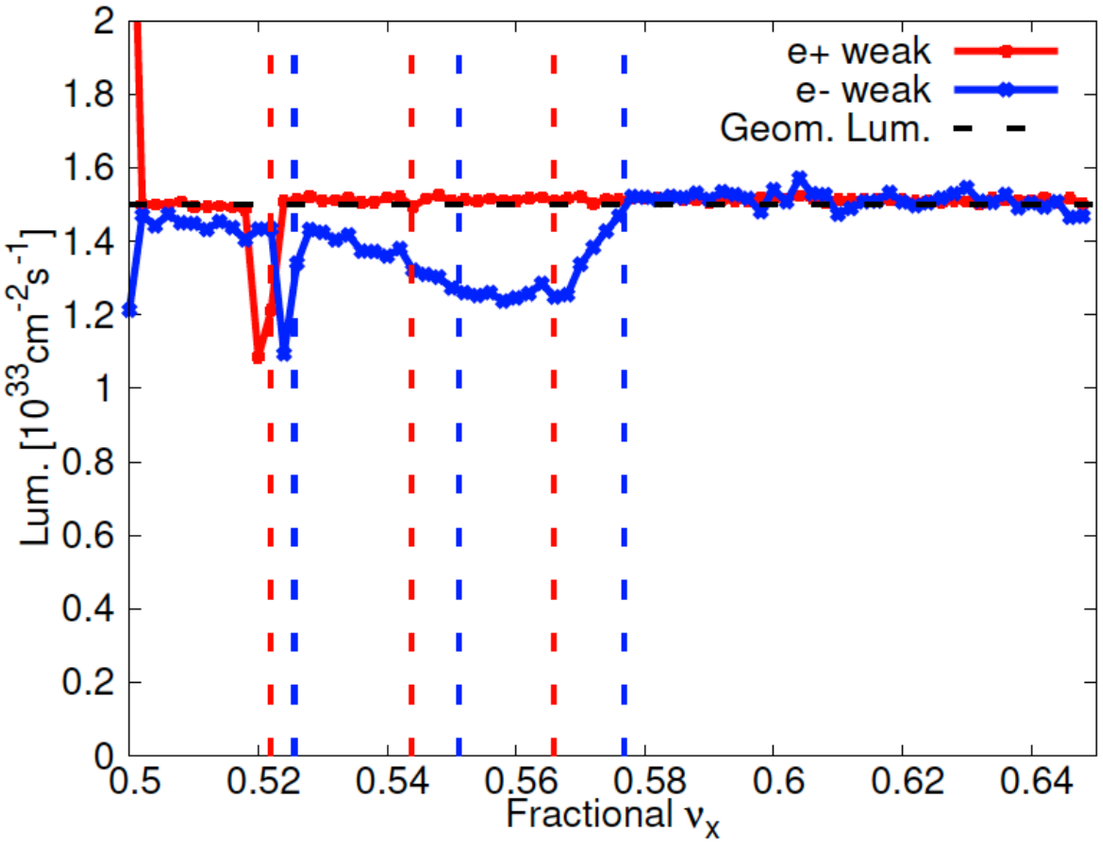
σ_y/σ_{y0} (RMS)

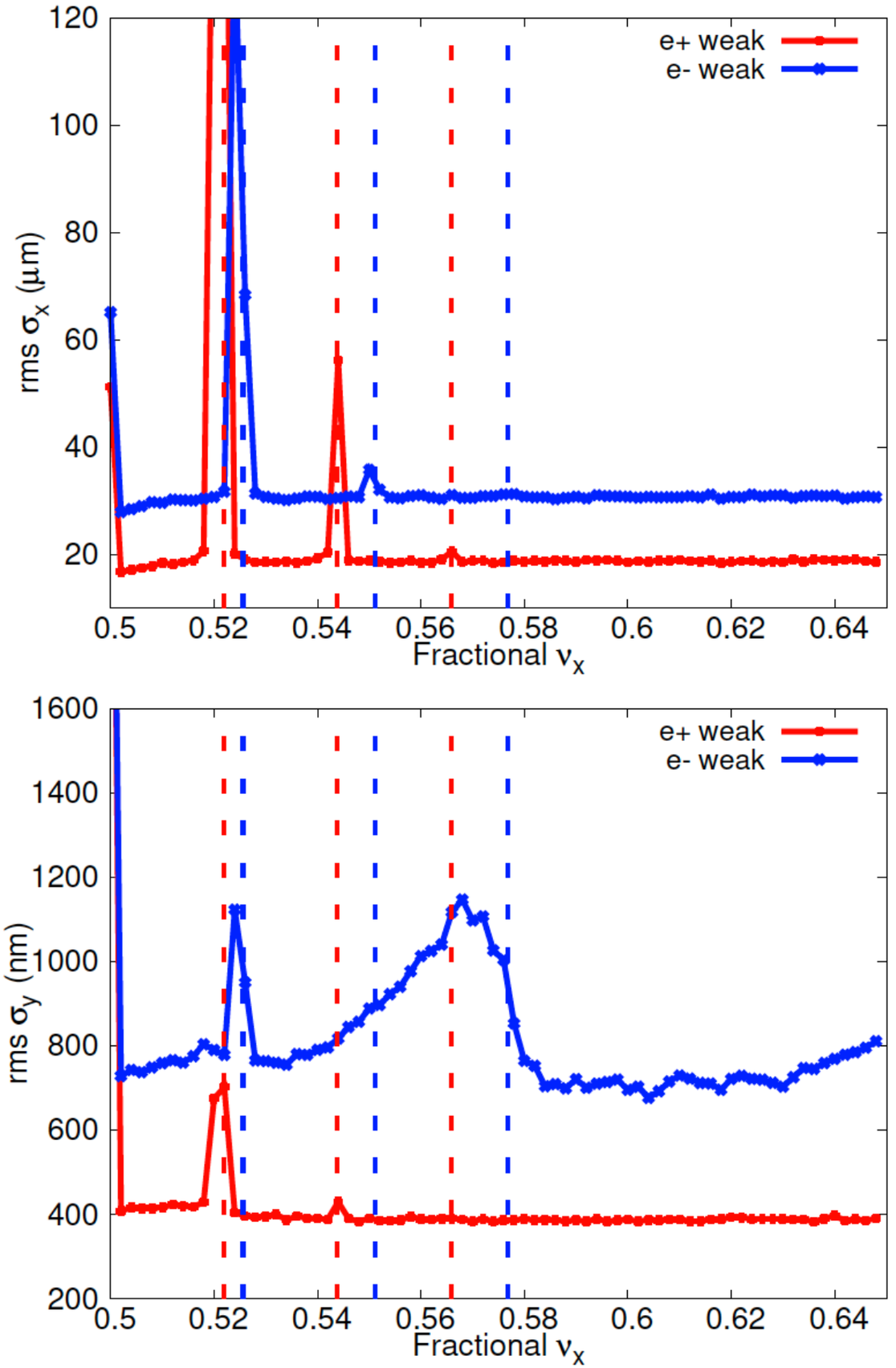




2. BBWS simulation: Tune scan

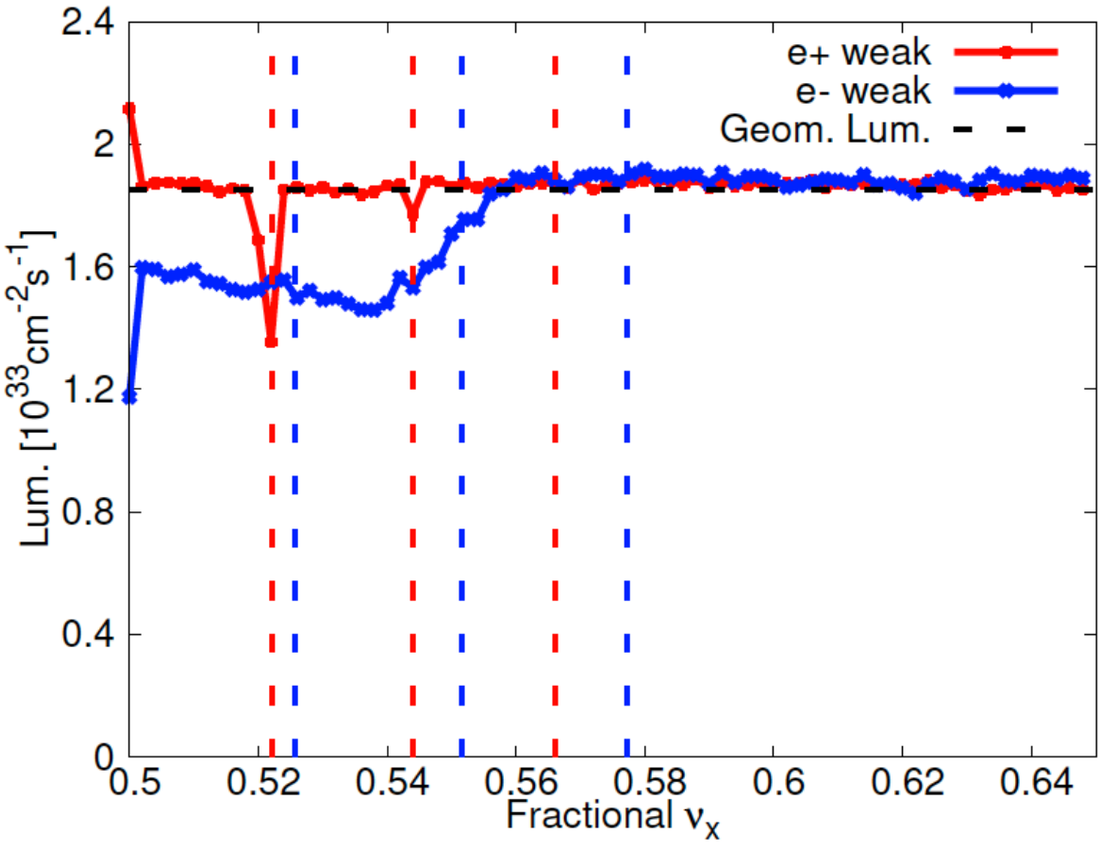
➤ **Parameter set (2019.03.30)**

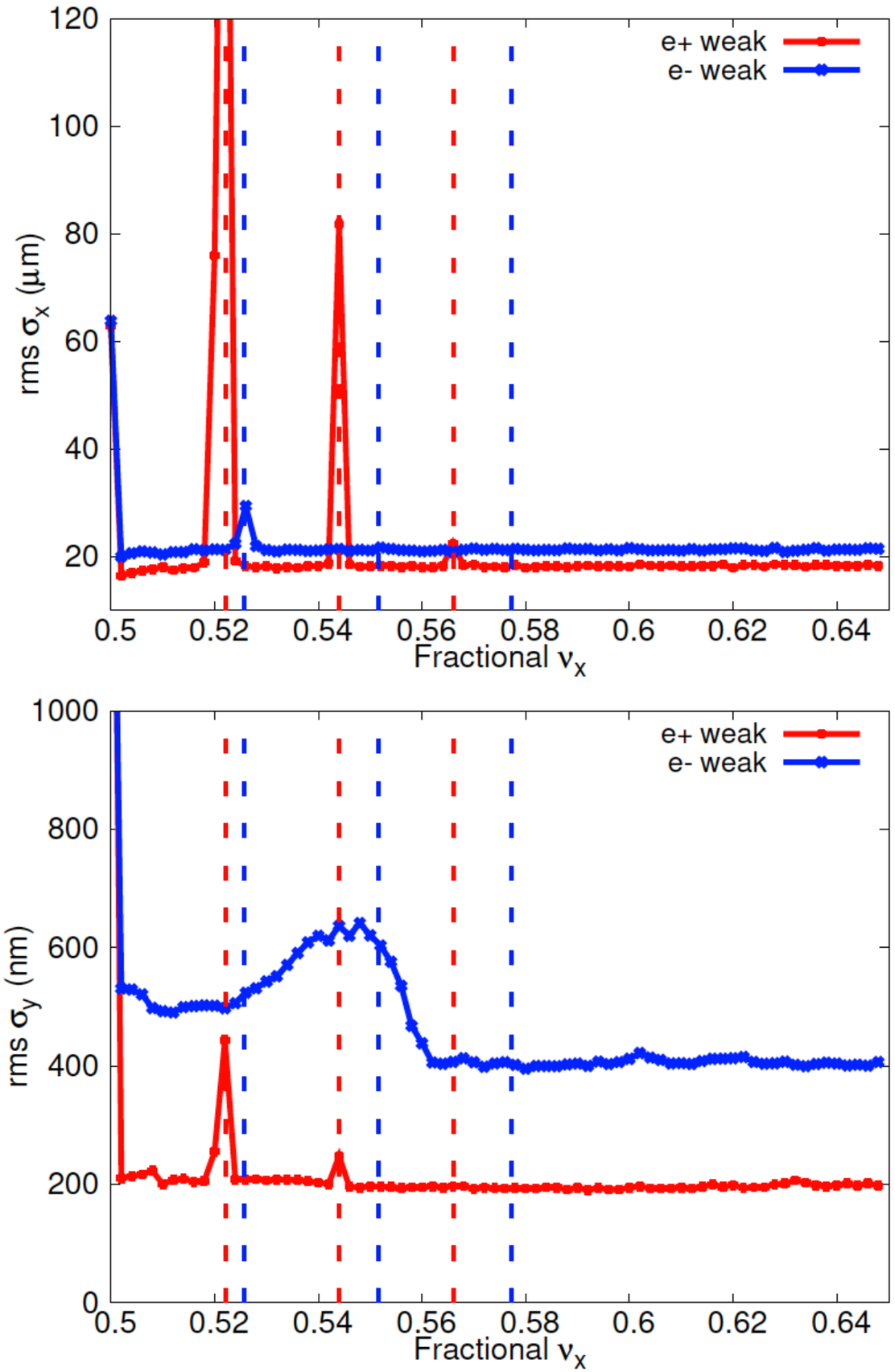




2. BBWS simulation: Tune scan

➤ **Parameter set (2019.04.02)**

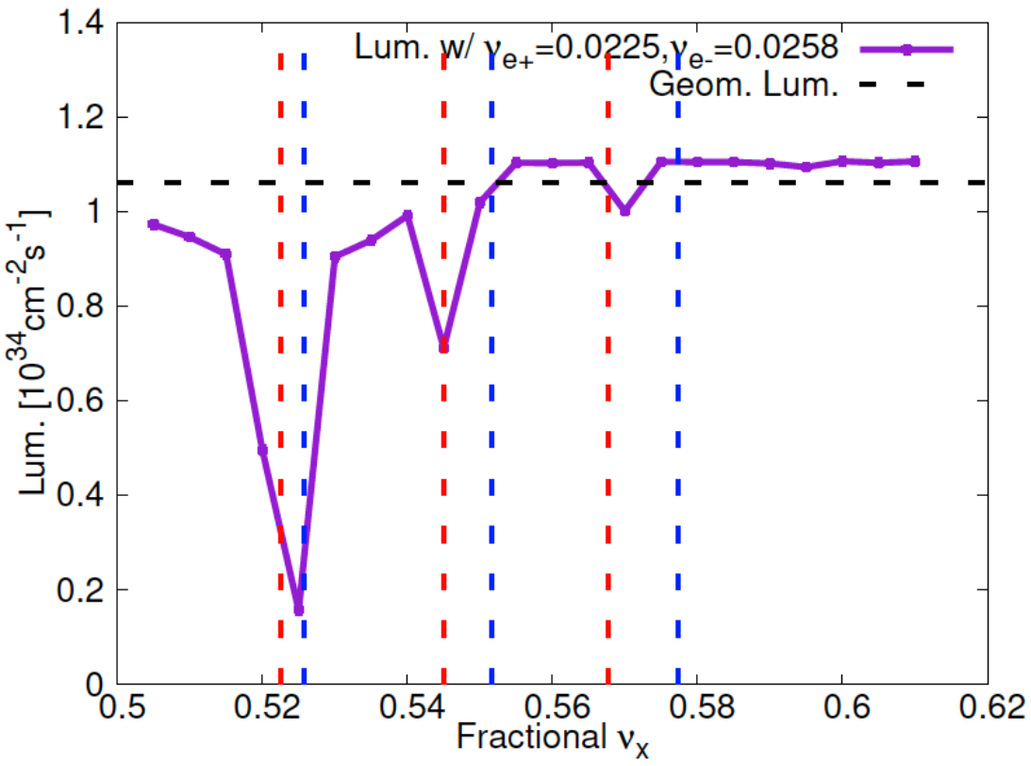


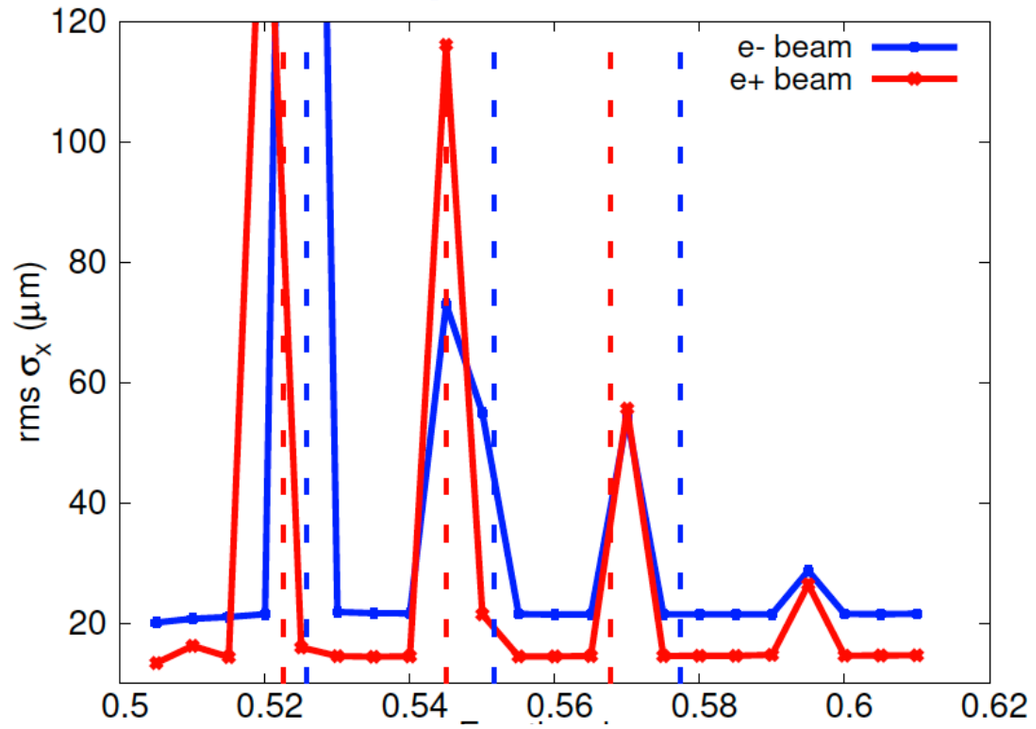


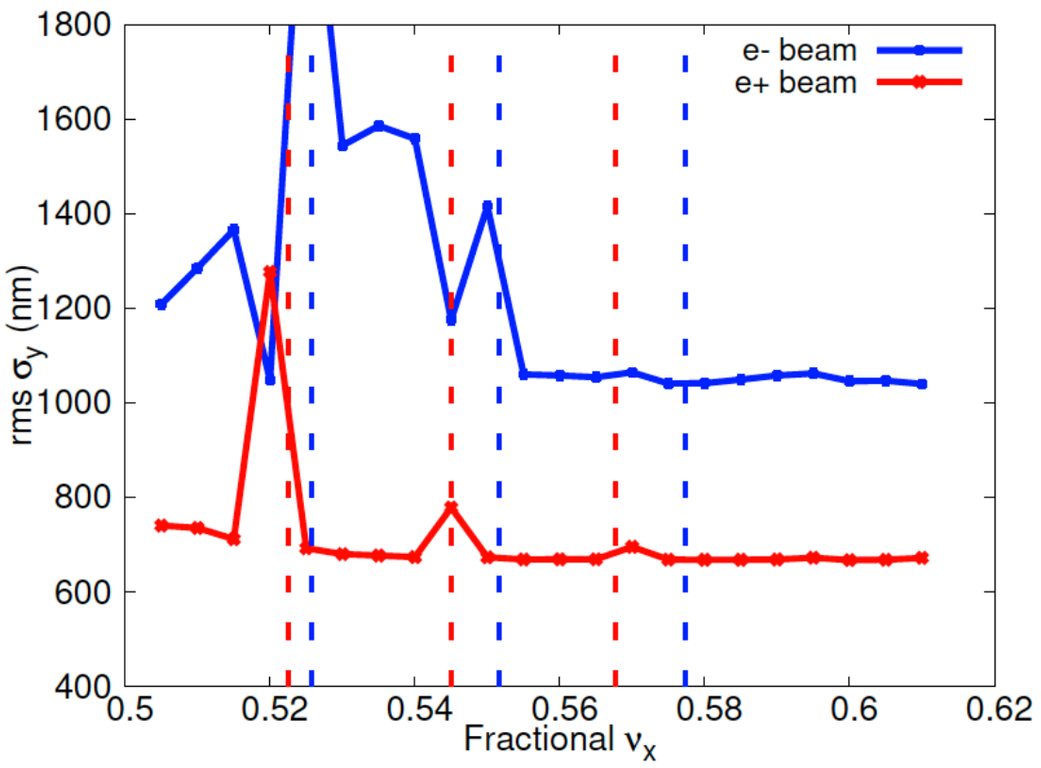
3. BBSS simulation

➤ All parameter set (1): ν_y=*.61

- **Scan of ν_x (same fractional part for LER and HER)**





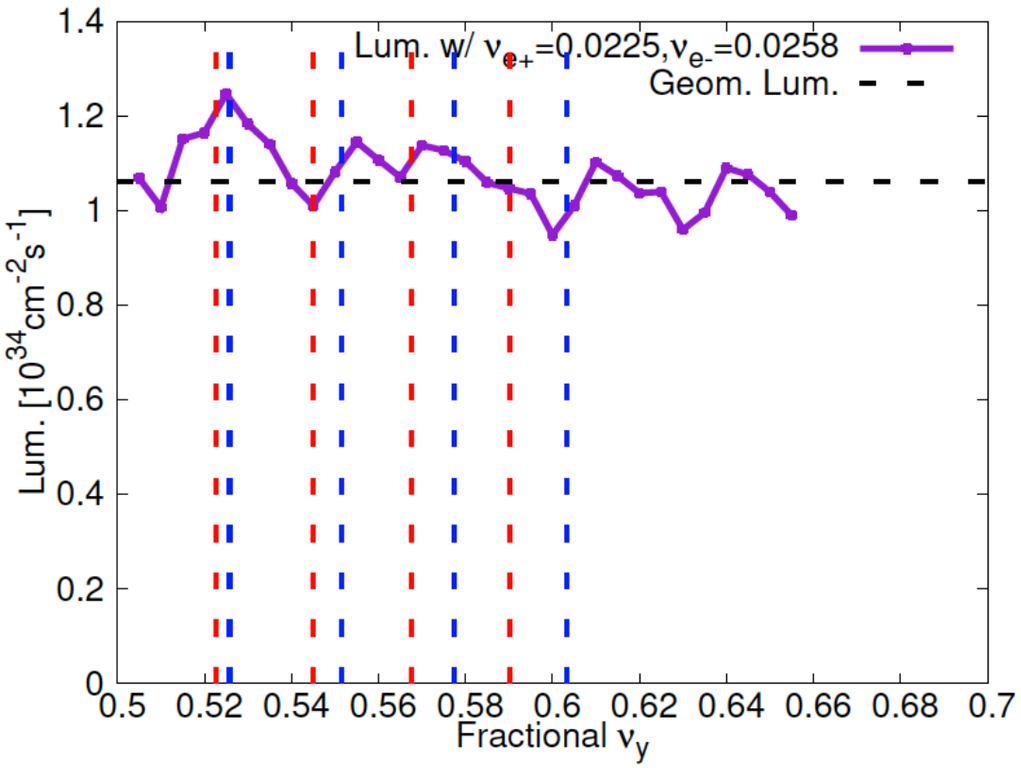


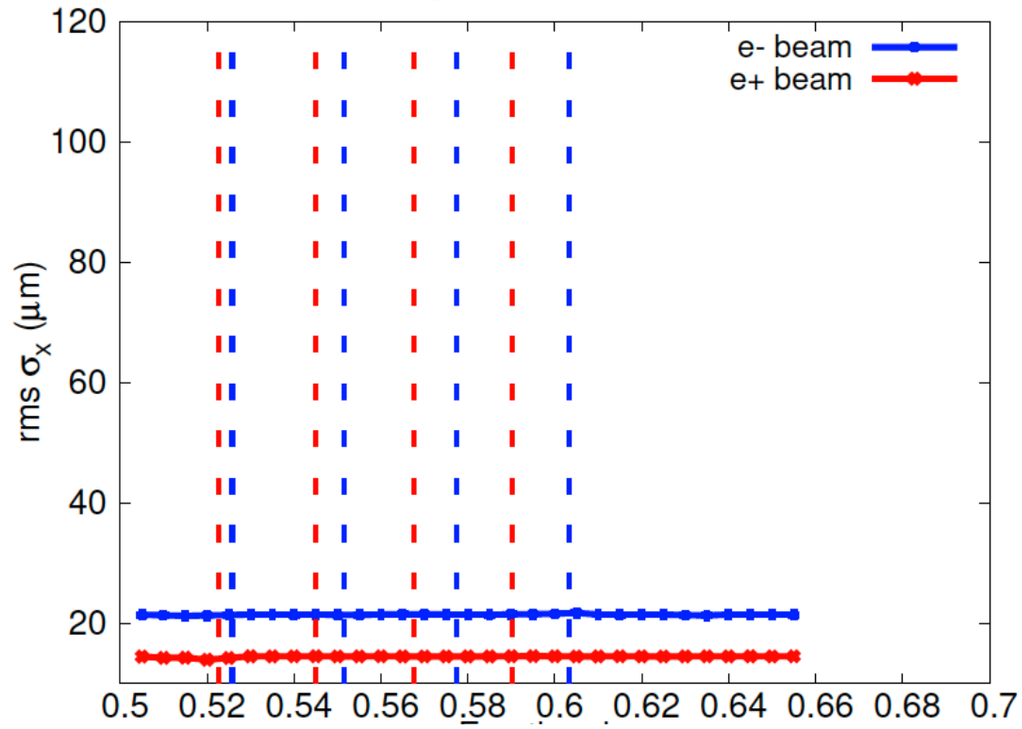
Beam sizes for ν_{s+}=.0225, ν_{s-}=.0258

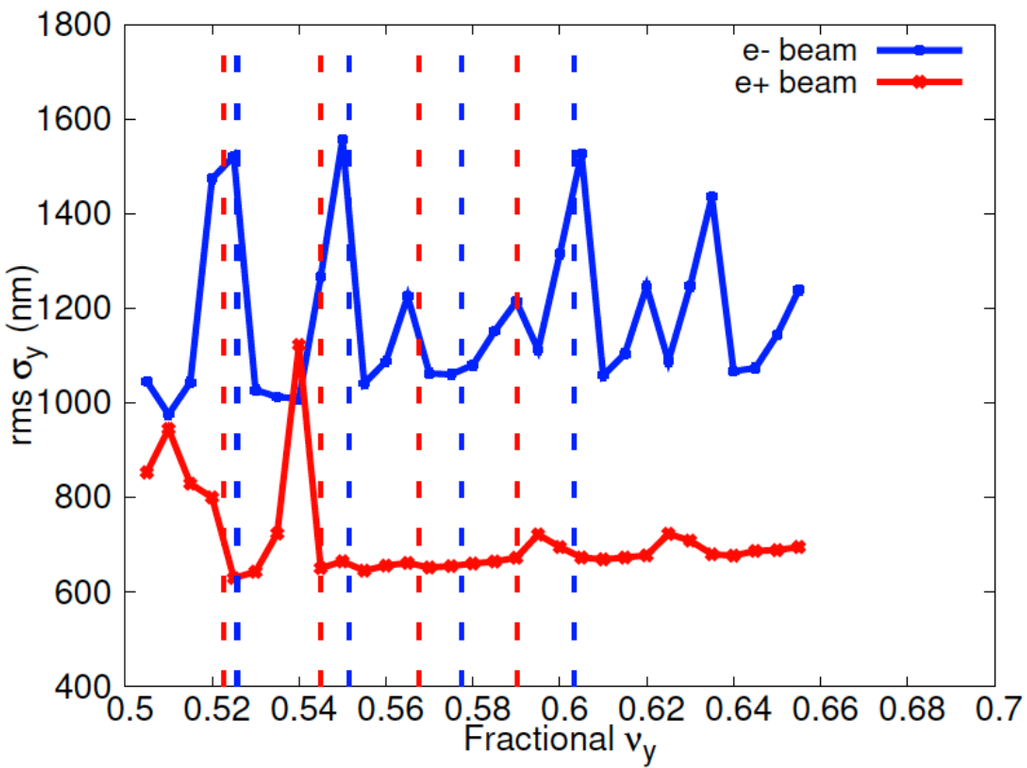
3. BBSS simulation

➤ All parameter set (1): ν_x=*.56

- Scan of ν_y (same fractional part for LER and HER)
- Beam very unstable for ν_y<*.53







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➤ **All parameter set (1): ν_x=*.56**

- **Scan of ν_y (same fractional part for LER and HER)**
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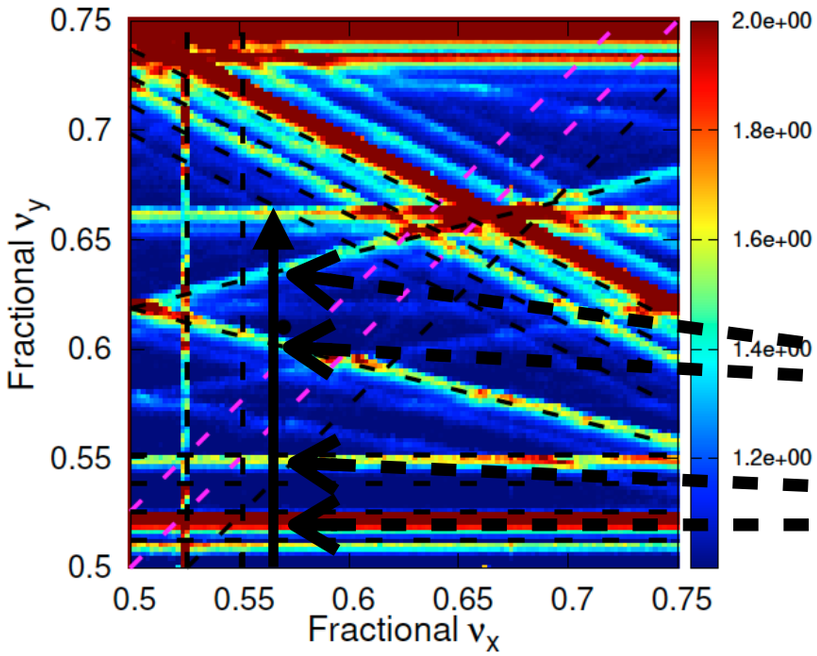
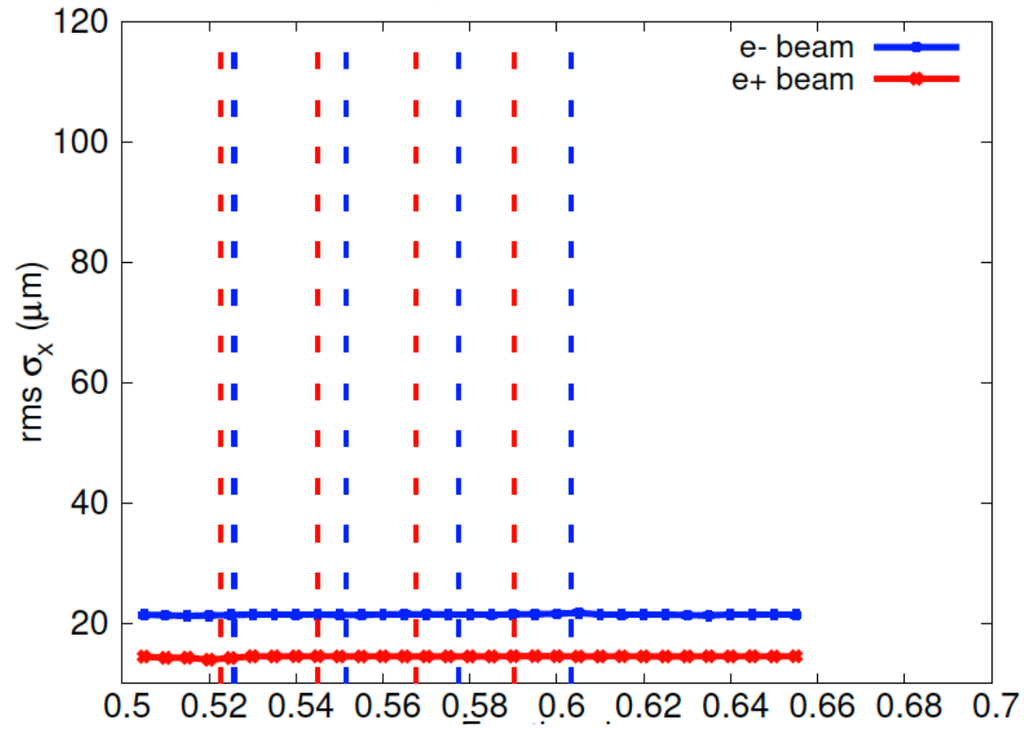
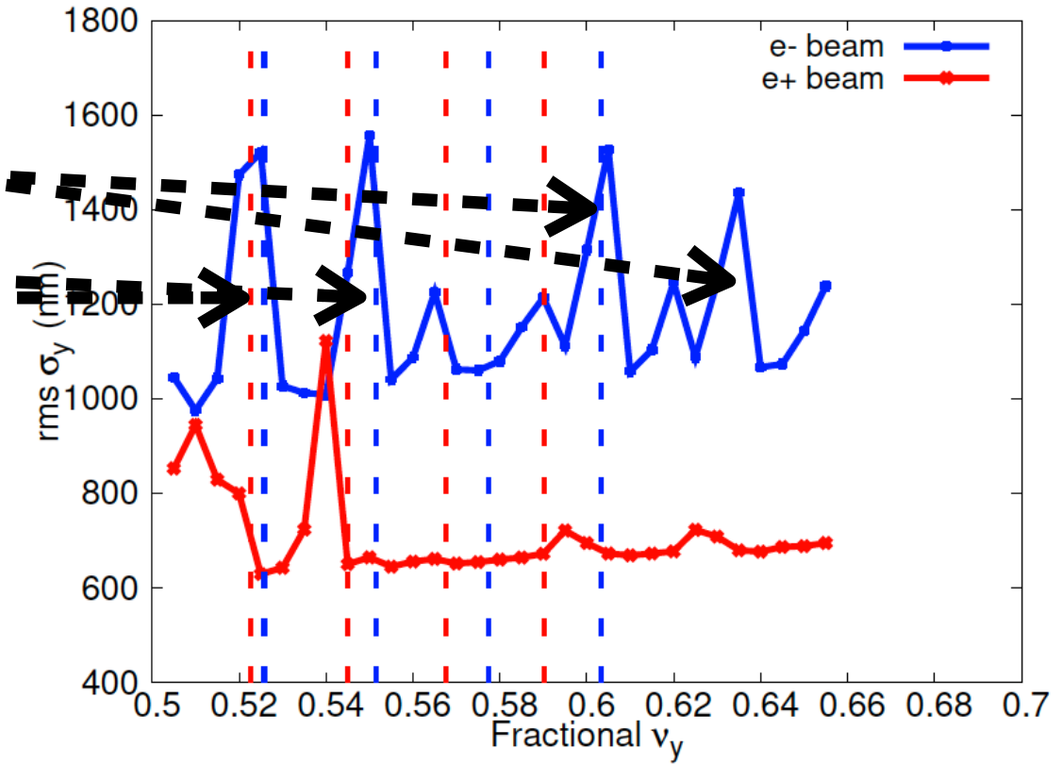
e+(S)e-(W)

σ_y/σ_{y0} (RMS)







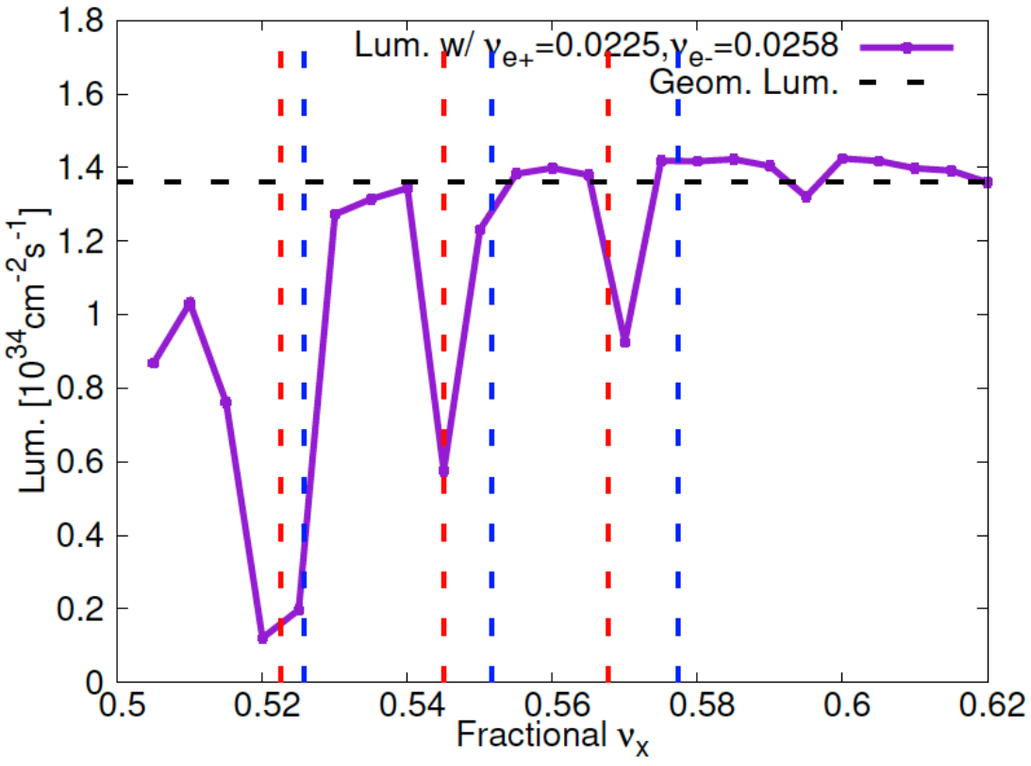
Beam sizes for ν_{s+}=.0225, ν_{s-}=.0258

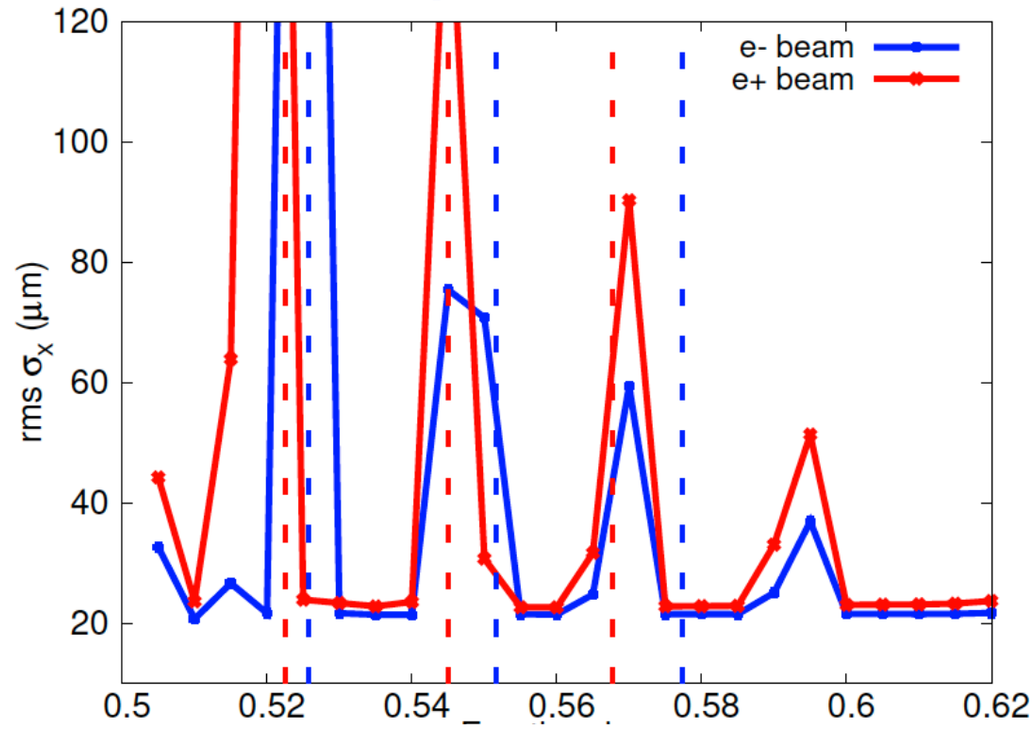
3. BBSS simulation

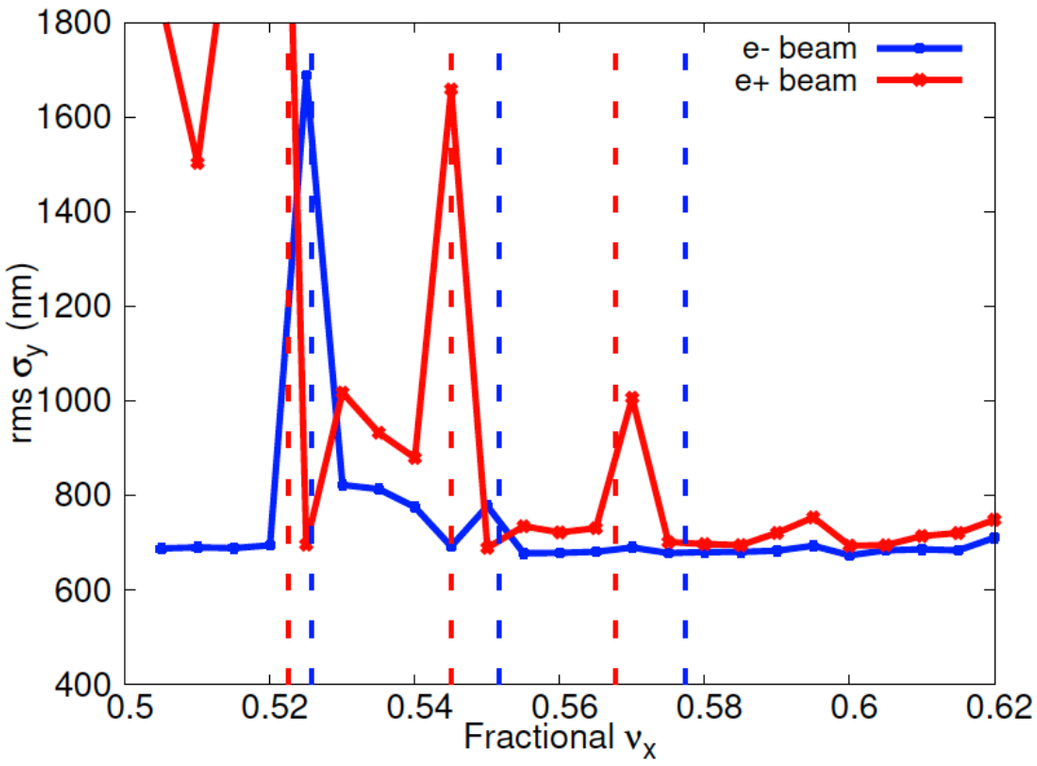
➤ All parameter set (1(op1)): ν_y=*.61

- **Scan of ν_x (same fractional part for LER and HER)**

Change parameters(1 -> 1(op1)):
β^*_{x+}=0.1 m -> 0.23 m (equalize σ^*_x)
ε_{y-}=0.368 nm -> 0.16 m (equalize σ^*_y)







Beam sizes for ν_{s+}=.0225, ν_{s-}=.0258

3. BBSS simulation

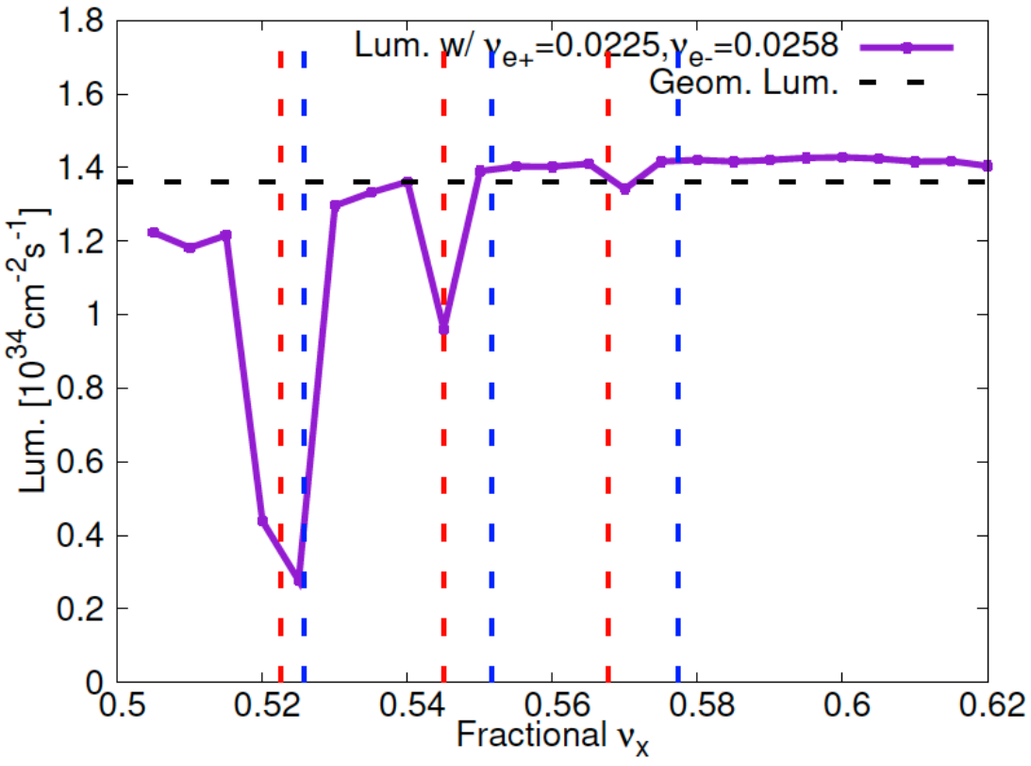
➤ All parameter set (1(op2)): ν_y=*.61

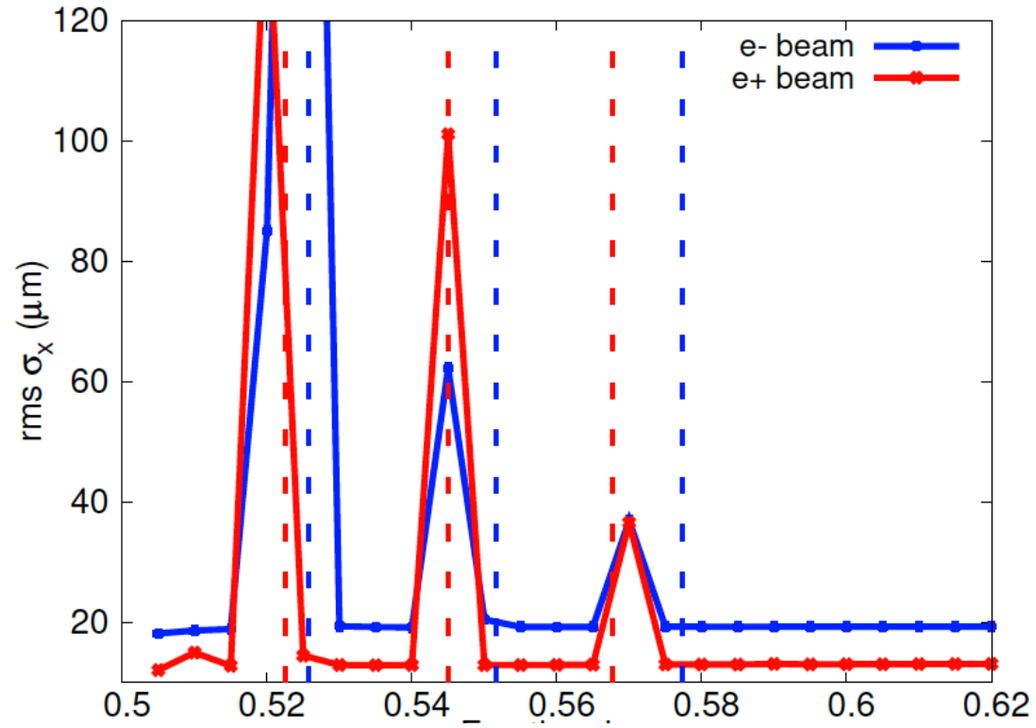
- **Scan of ν_x (same fractional part for LER and HER)**

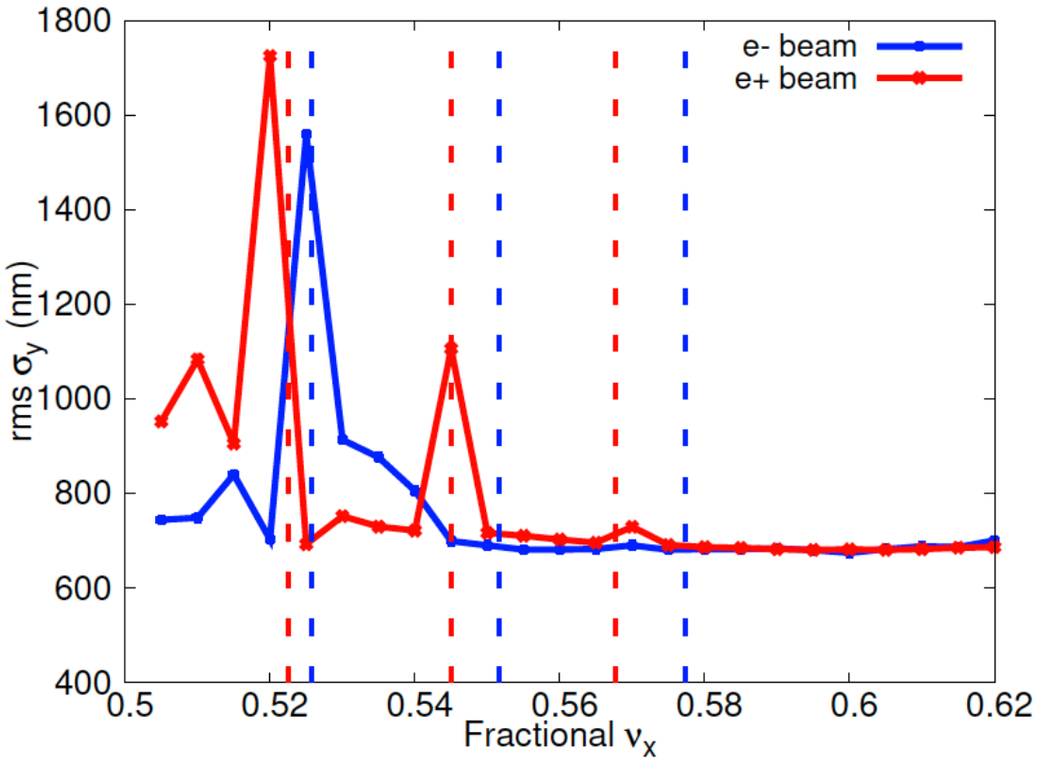
Change parameters(1 -> 1(op2)):

$\beta^*_{x-}=\beta^*_{x+}$=0.1 m -> 0.08 m (squeeze σ^*_x)

ε_{y-}=0.368 nm -> 0.16 m (equalize σ^*_x)







Beam sizes for ν_{s+}=.0225, ν_{s-}=.0258

4. Summary

➤ Personal comments

- Squeezing βx* is essential in suppressing beam-beam resonances:
  * ν_x-{1,2,3,4}ν_s=N/2
  * ν_x{+-}4ν_y+α=N
- General agreements found between BBSS and BBWS
- Coherent beam-beam instability or emittance growth needs strong-strong simulations (BBSS)