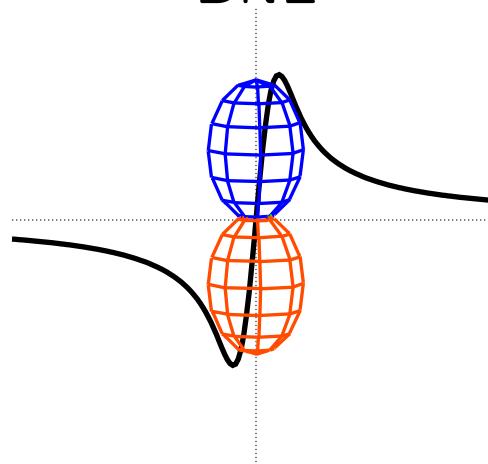


pp Luminosity Development

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BNL



November 2, 2004

- 50% emittance growth in 2 hours at $I=1.7 \times 10^{11}$ protons.
Open lines of investigation:
 - Triplet oscillations at ≈ 10 Hz → Orbit feedback (C. Montag)
 - Understanding the early stages of collision with simulations (N. Malitsky).
 - Optimization of lattice parameters.

Contents:

- Recent experience, quest for a new working point:
 - Gold experience & simulations at store
 - The Proton run
- Project: Optimize phase advance between two IPs.

Candidates for a new working point

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Hadron collider tunes (accommodated for pp collisions):

<i>Ring</i>	<i>Qx</i>	<i>Qy</i>	<i>Resonances</i>	<i>Spin?</i>
RHIC design	0.19	0.18	5,6,11	OK
RHIC oper.	0.235	0.225	4,9	OK
HERA-p	0.292	0.298	7,10	No
LHC	0.31	0.32	3,10	OK
Tevatron	0.578	0.59	2,7,10,11	No
ISR	0.955	0.93	10,11	No
SPS	0.685	0.68	3,10	OK
RHICpp_04	0.735	0.73	4,7,11	OK

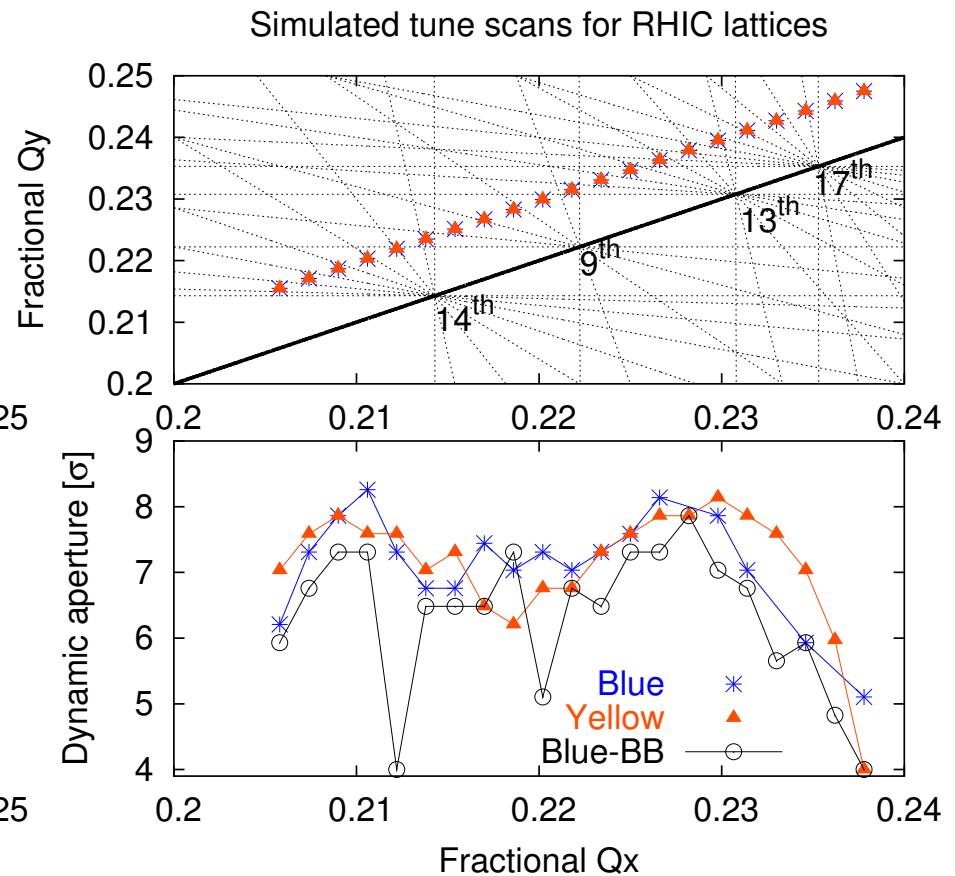
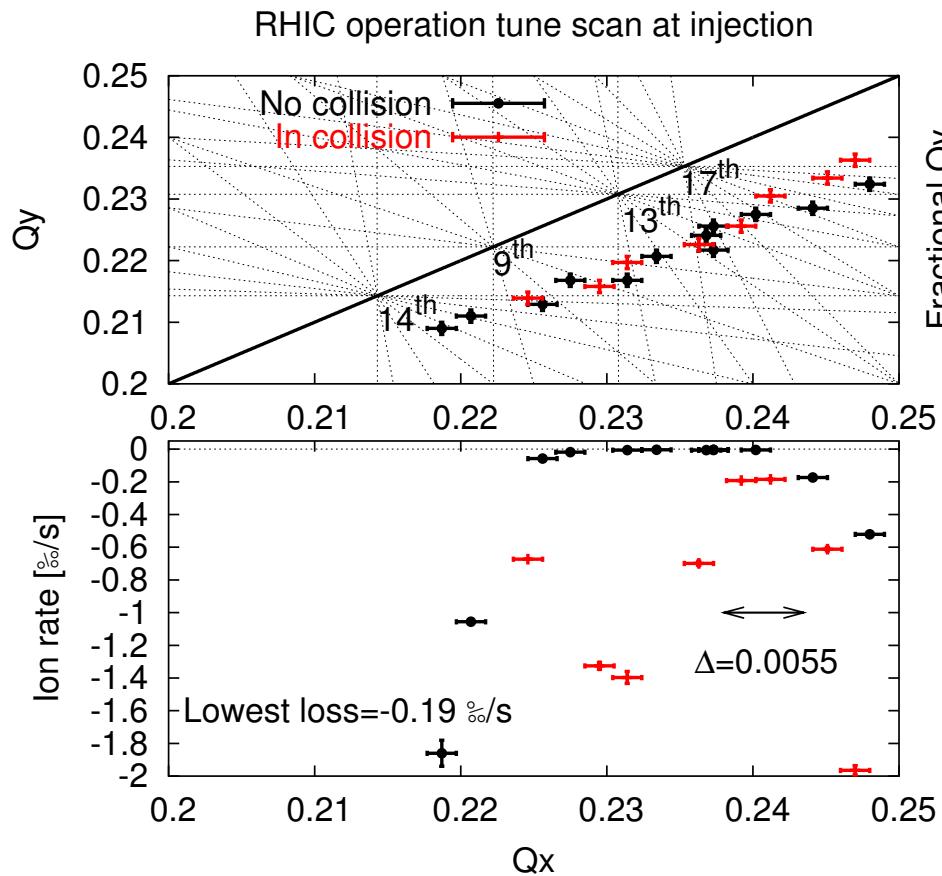
- Measurement of beam lifetime vs tune (hint: beam-beam does not depend on the energy, therefore we can easily experiment at injection energy!)

$$\xi_{x,y} = \frac{Nr_0}{4\pi\epsilon_N}$$

- Simulations: computation of the Dynamic Aperture using the weak-strong approximation (at top energy there are strong non-linearities)

Gold experience & Simulation: RHIC operation

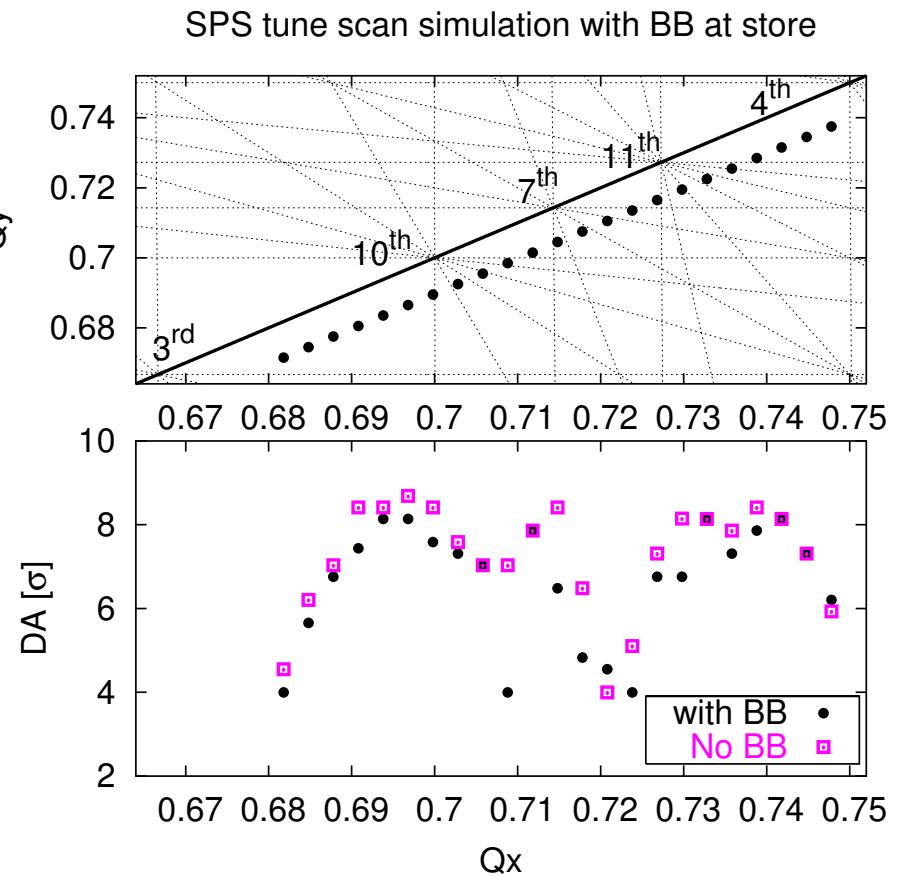
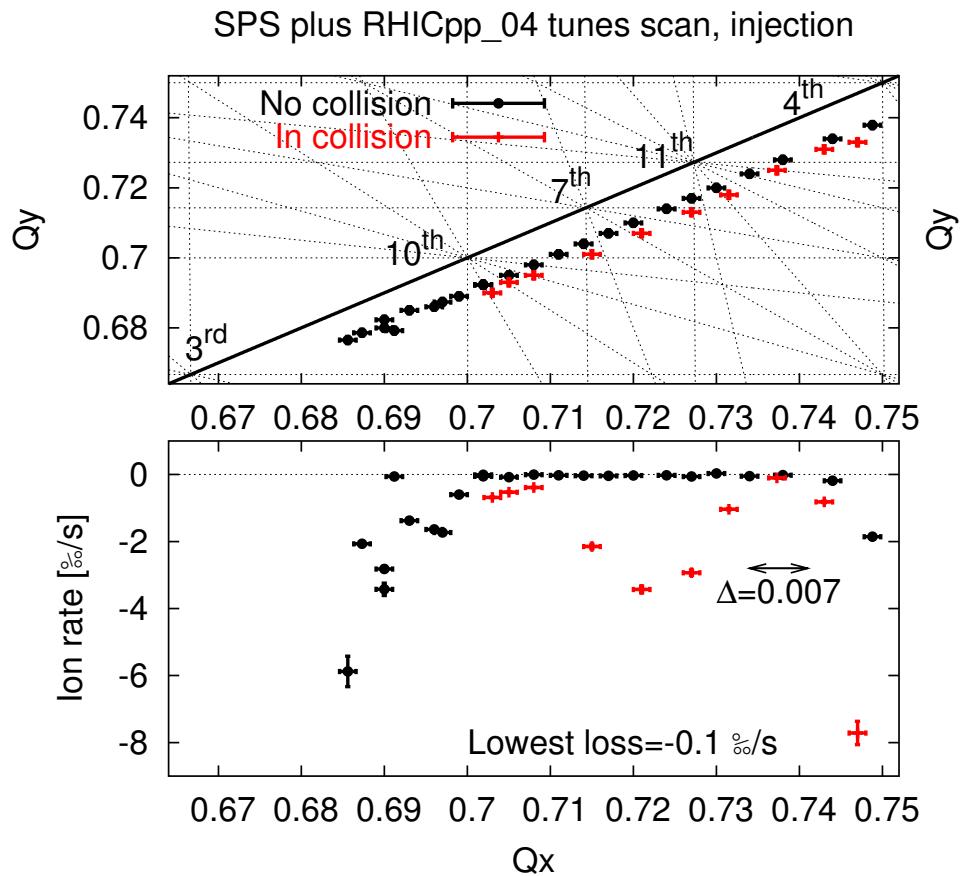
5



- Very good at injection but sensitive to beam-beam. DA at store with BB smaller than 8σ .

Gold experience & Simulation: SPS & RHICpp

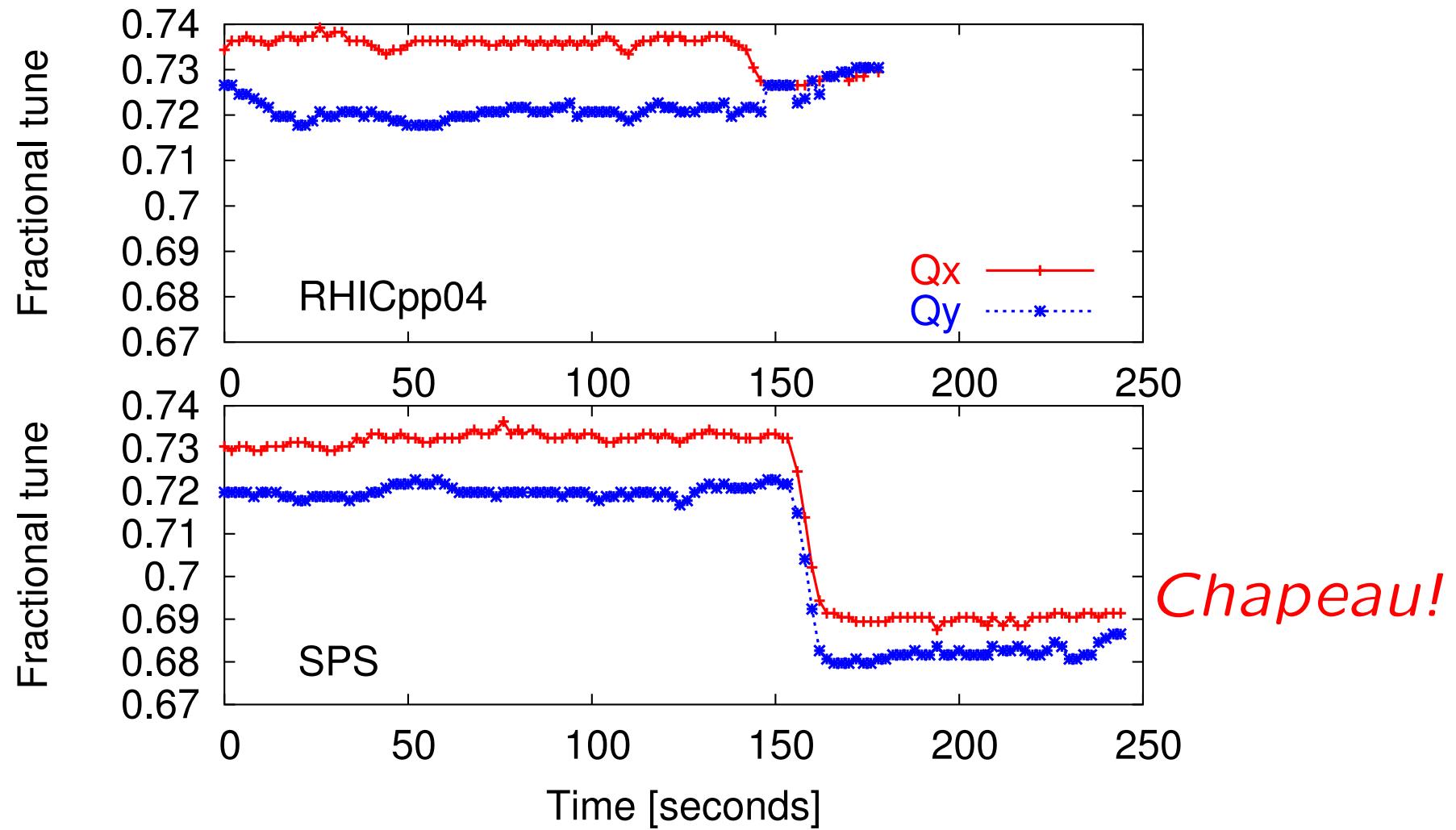
6



- SPS: Impossible injection but DA at store larger than 8σ .
- RHICpp: Good at injection, at store $DA > 8\sigma$

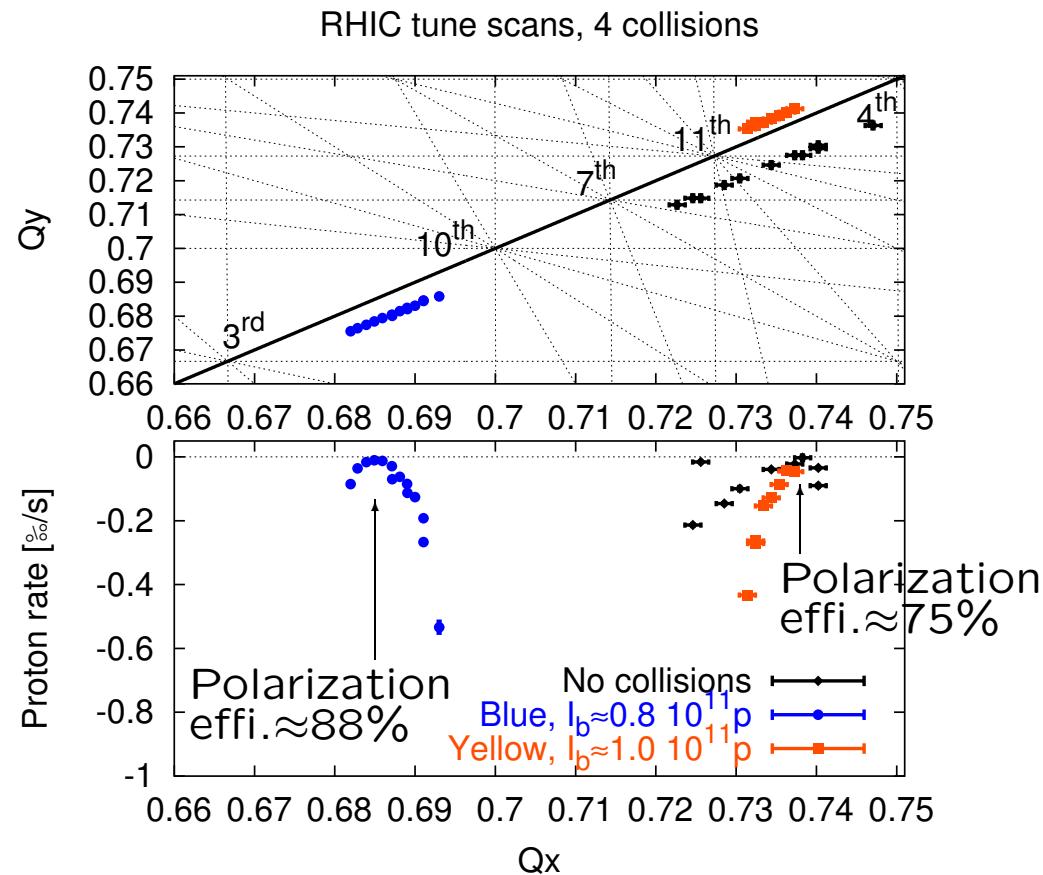
The PP run

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The PP tune scans

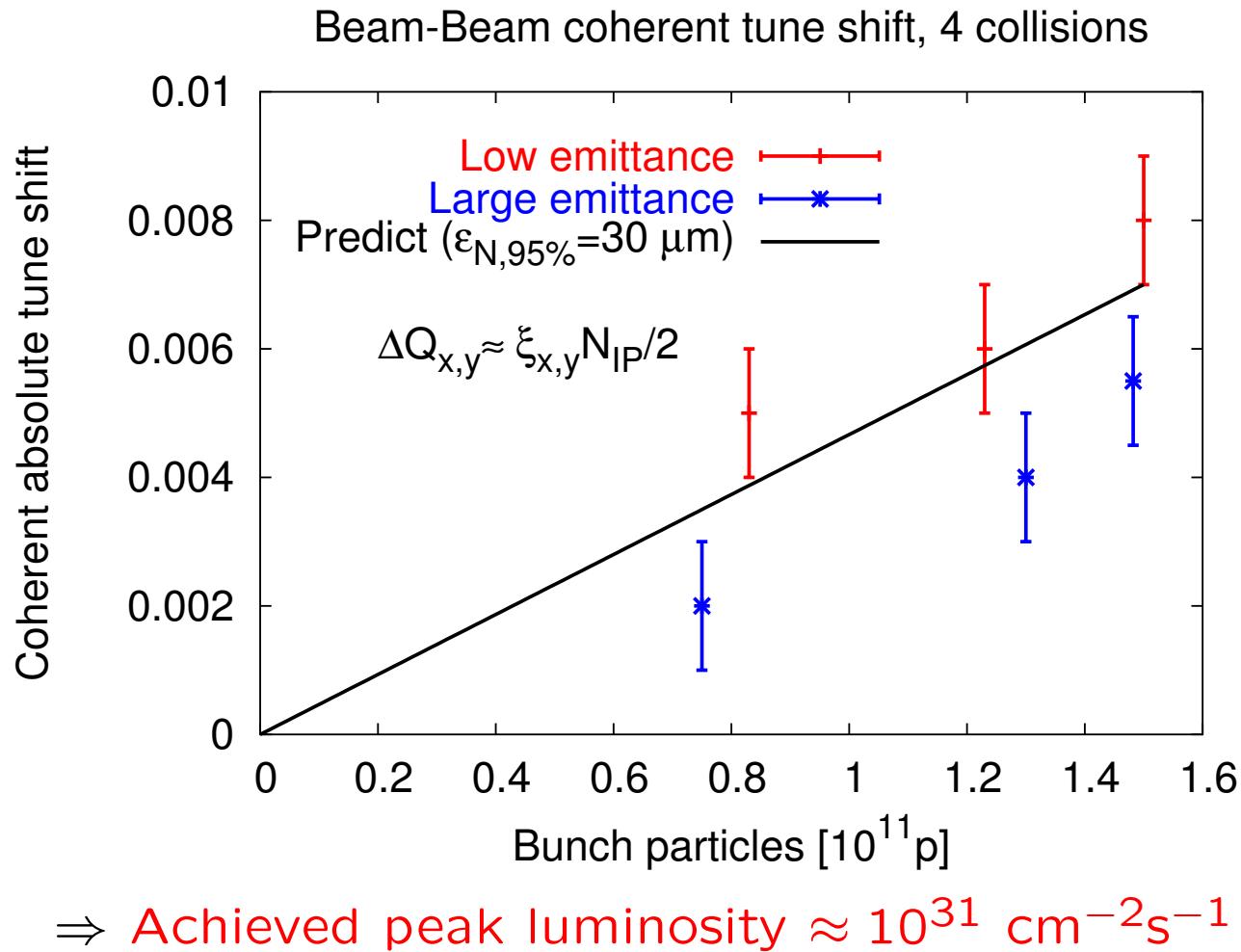
8



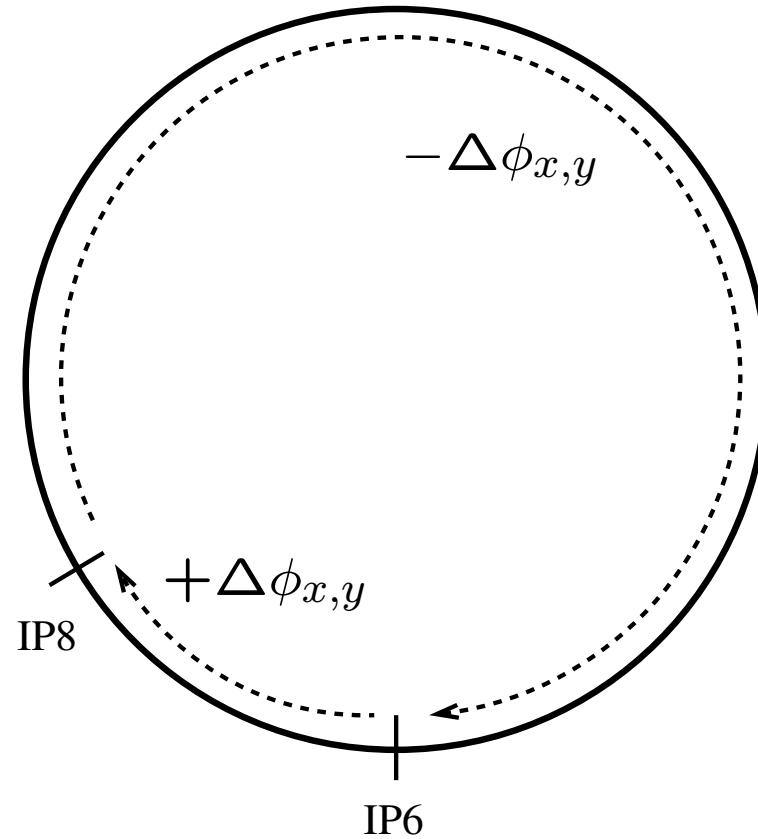
- SPS tunes have slightly better lifetime than RHICpp.
- Polarization also prefers SPS tunes.

The PP luminosity

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- Which are the best $\Delta\phi_{x,y}$ for given tunes?



With two identical interaction points the resonance strength:

$$f_{(j,k)} \propto \frac{1 + e^{i2\pi(j\Delta\phi_x + k\Delta\phi_y)}}{1 - e^{i2\pi(jQ_x + kQ_y)}} \quad (1)$$

For given tunes:

- The strength is maximum if

$$j\Delta\phi_x + k\Delta\phi_y = N, \quad N \text{ any integer} \quad (2)$$

- The strength is zero if

$$j\Delta\phi_x + k\Delta\phi_y = N/2, \quad N \text{ odd integer} \quad (3)$$

→ Similar diagrams to those of the working point

Do not need new hardware:

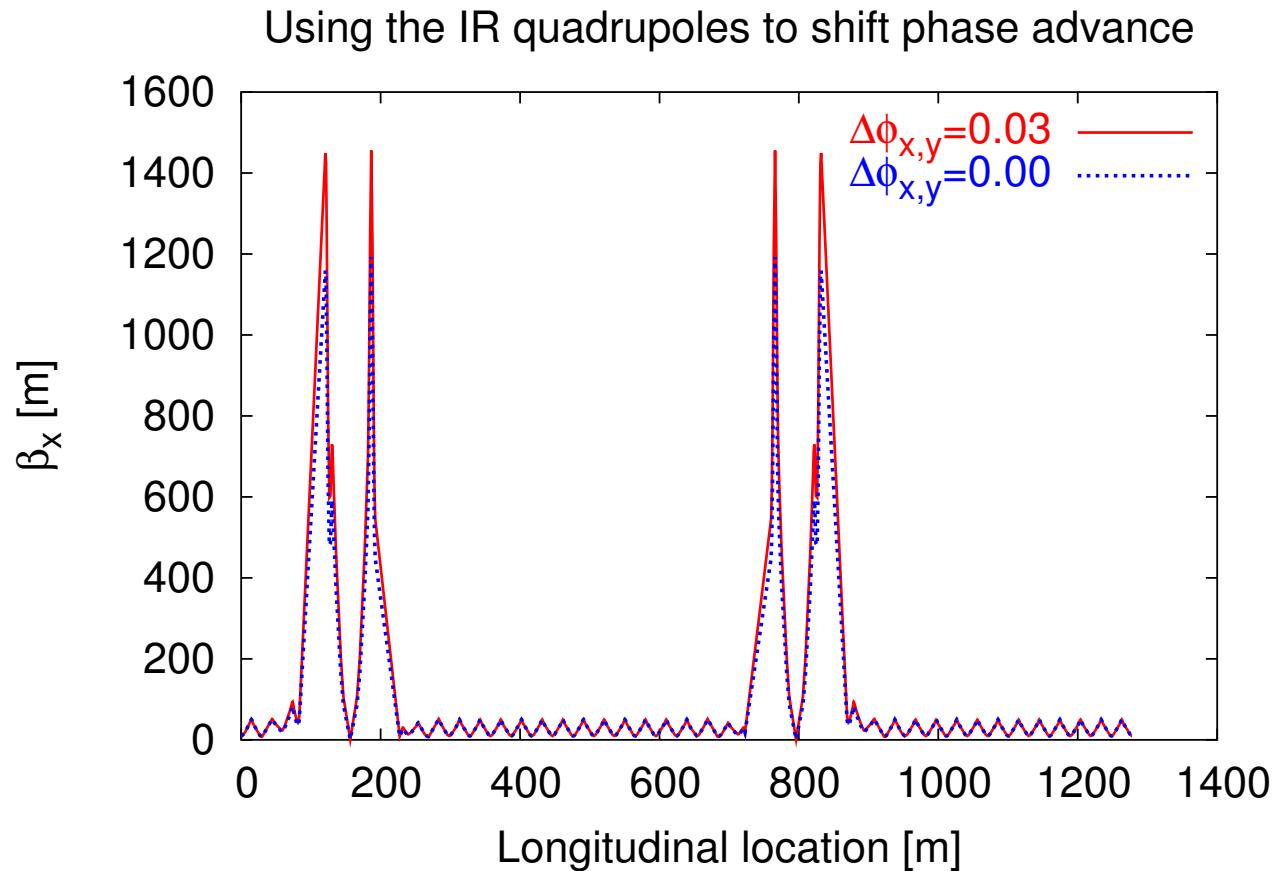
- Use of IR quadrupoles → Does not work
- Use of γ_T quadrupoles → Does not work

Need new hardware:

- Use of all arc quadrupoles → Works with limitations
- Use of 8 arc quadrupoles → Works

Use of the IR quadrupoles

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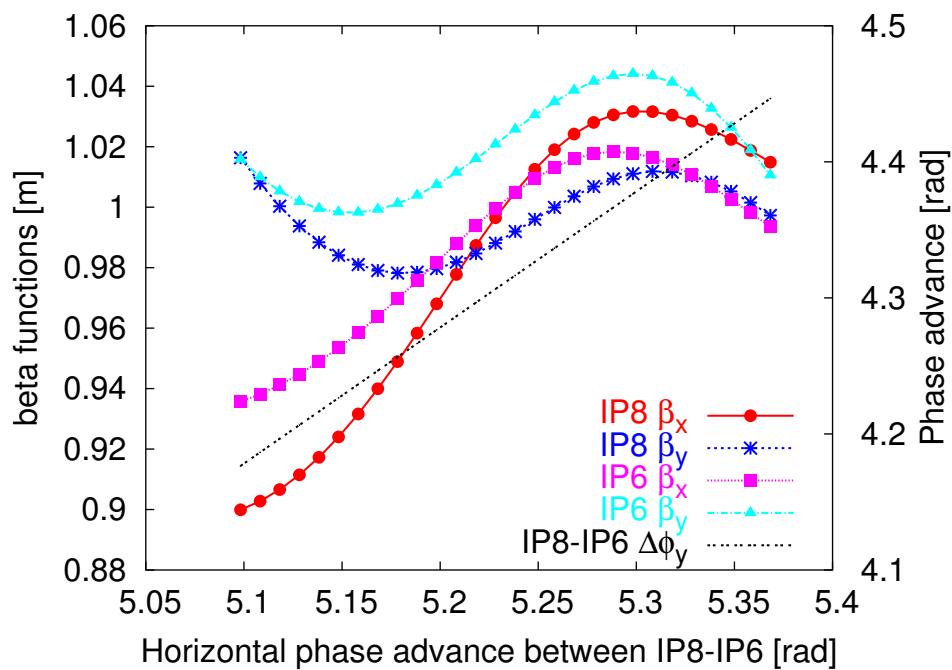


- $|\Delta\phi_{x,y}| \leq 0.03$ is not enough

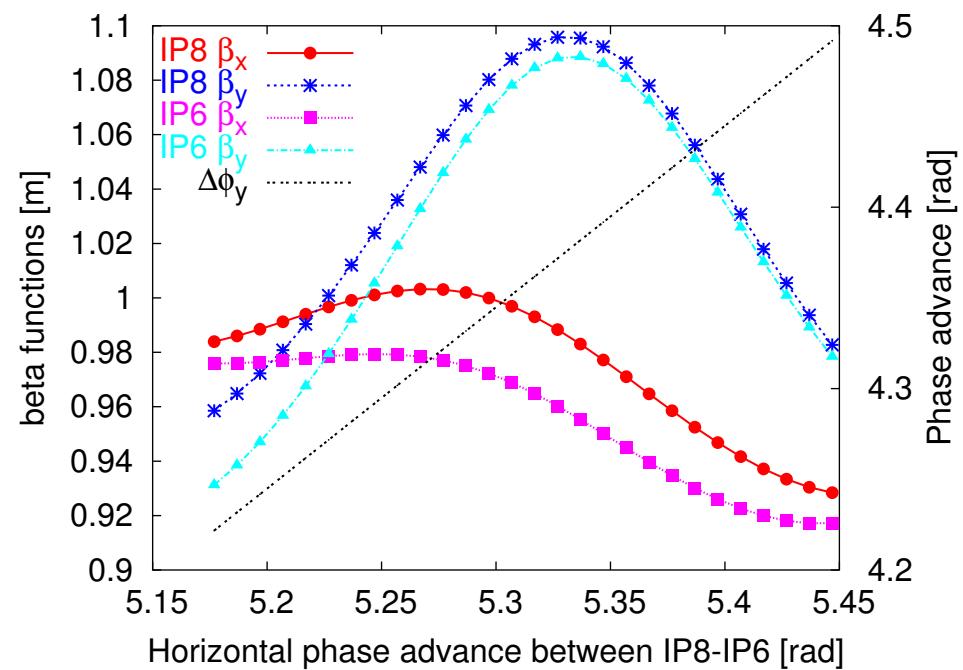
Use of all arc quadrupoles

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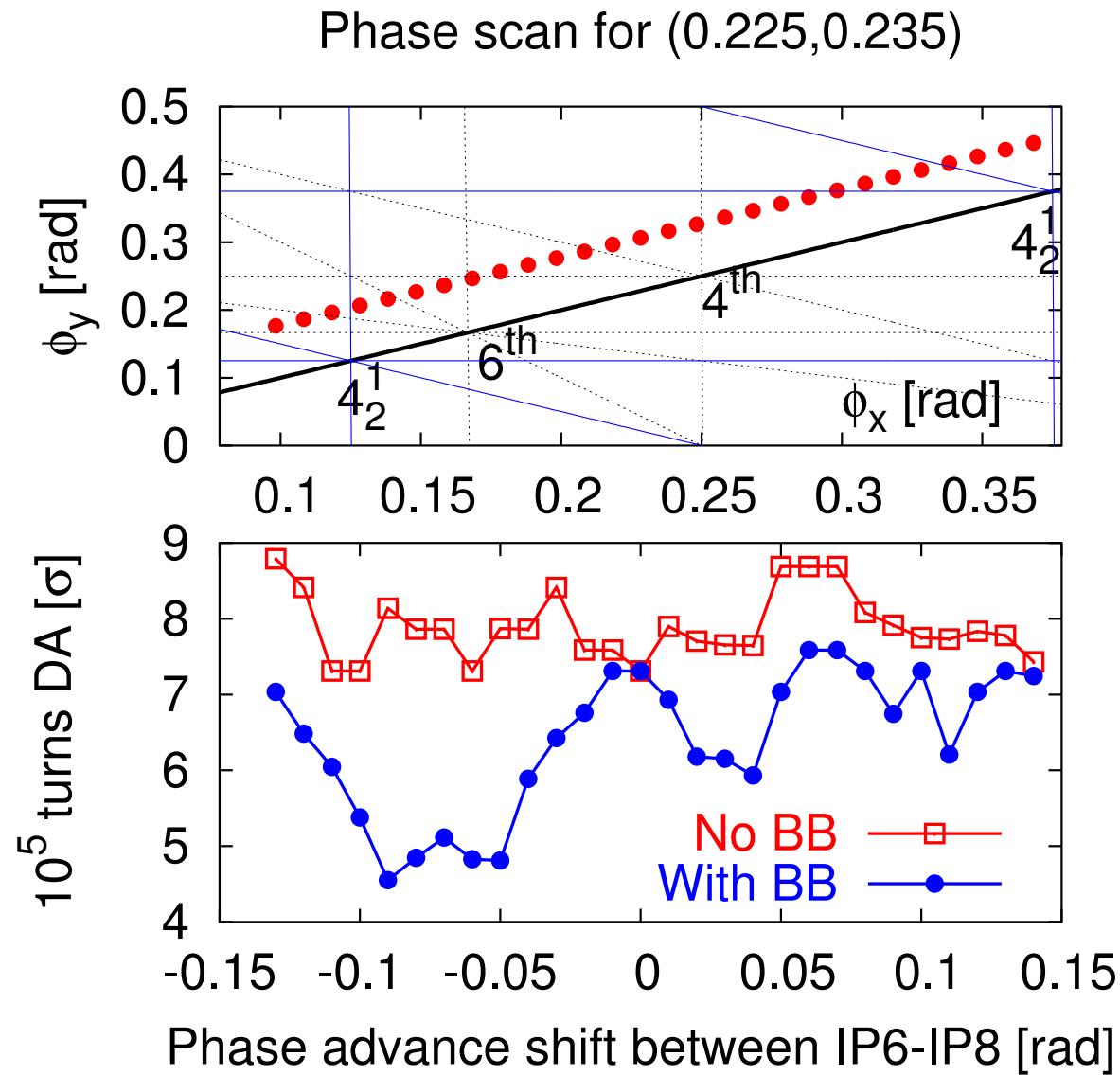
RHIC operation (0.225, 0.235)

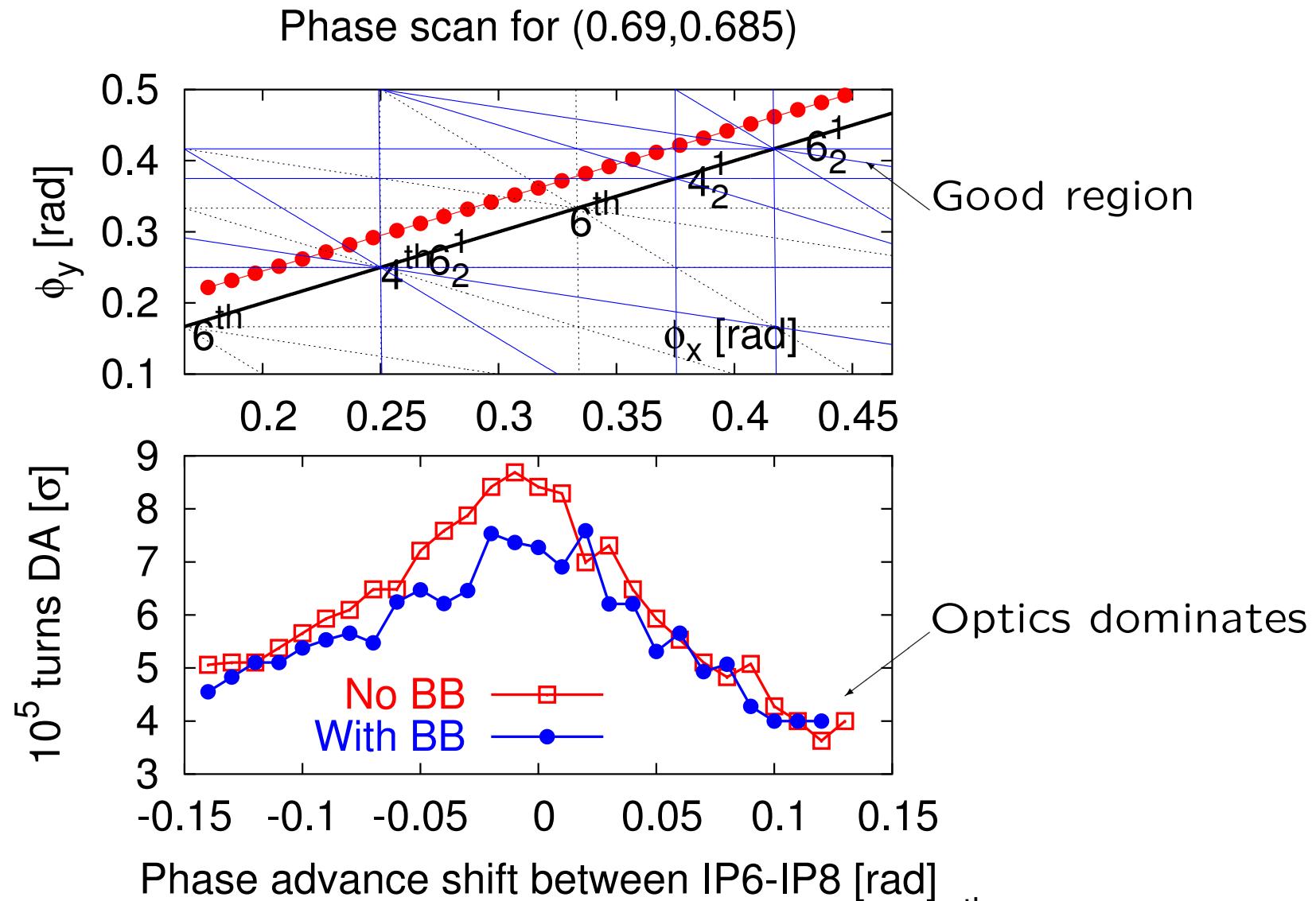


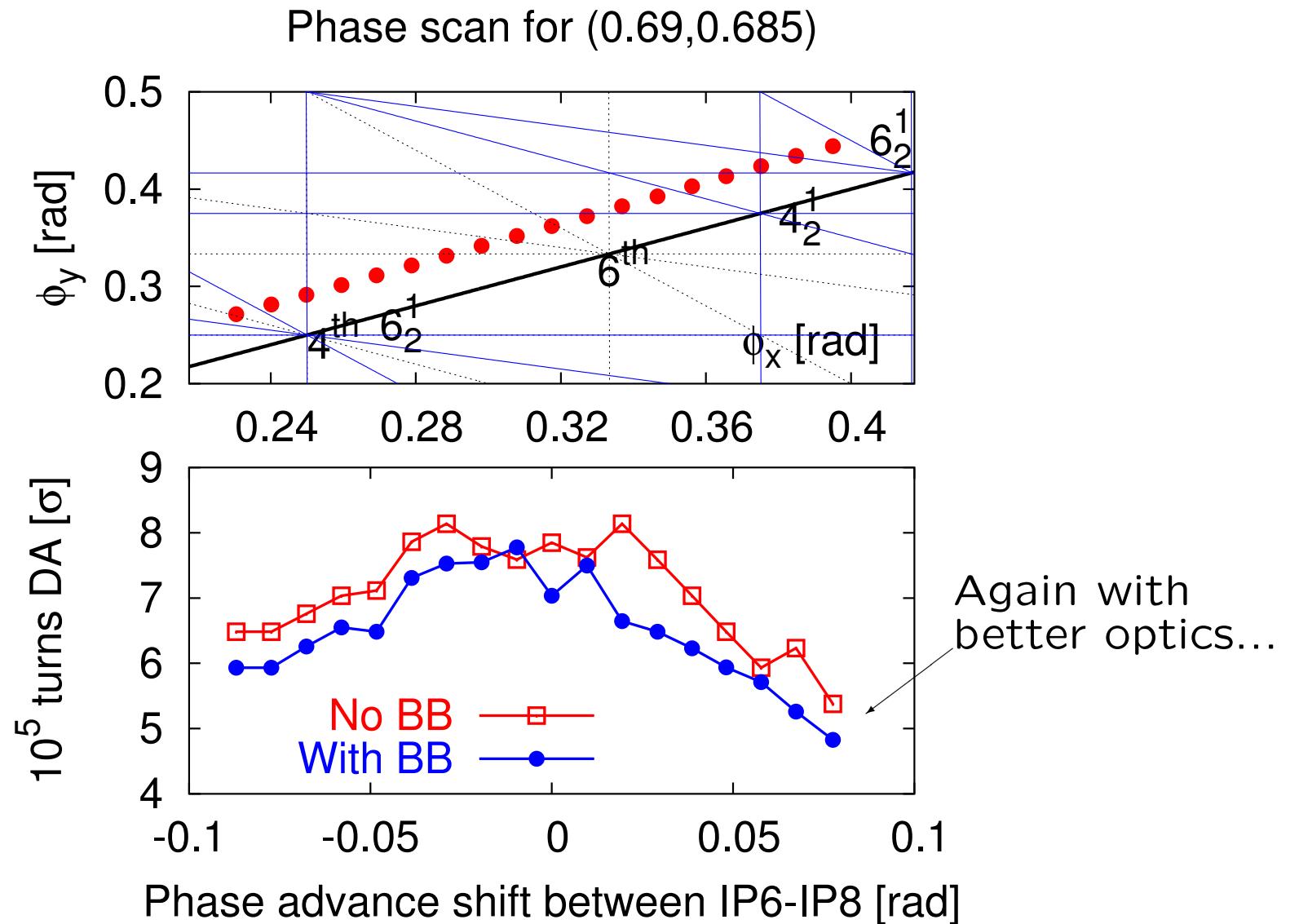
SPS (0.69, 0.685)

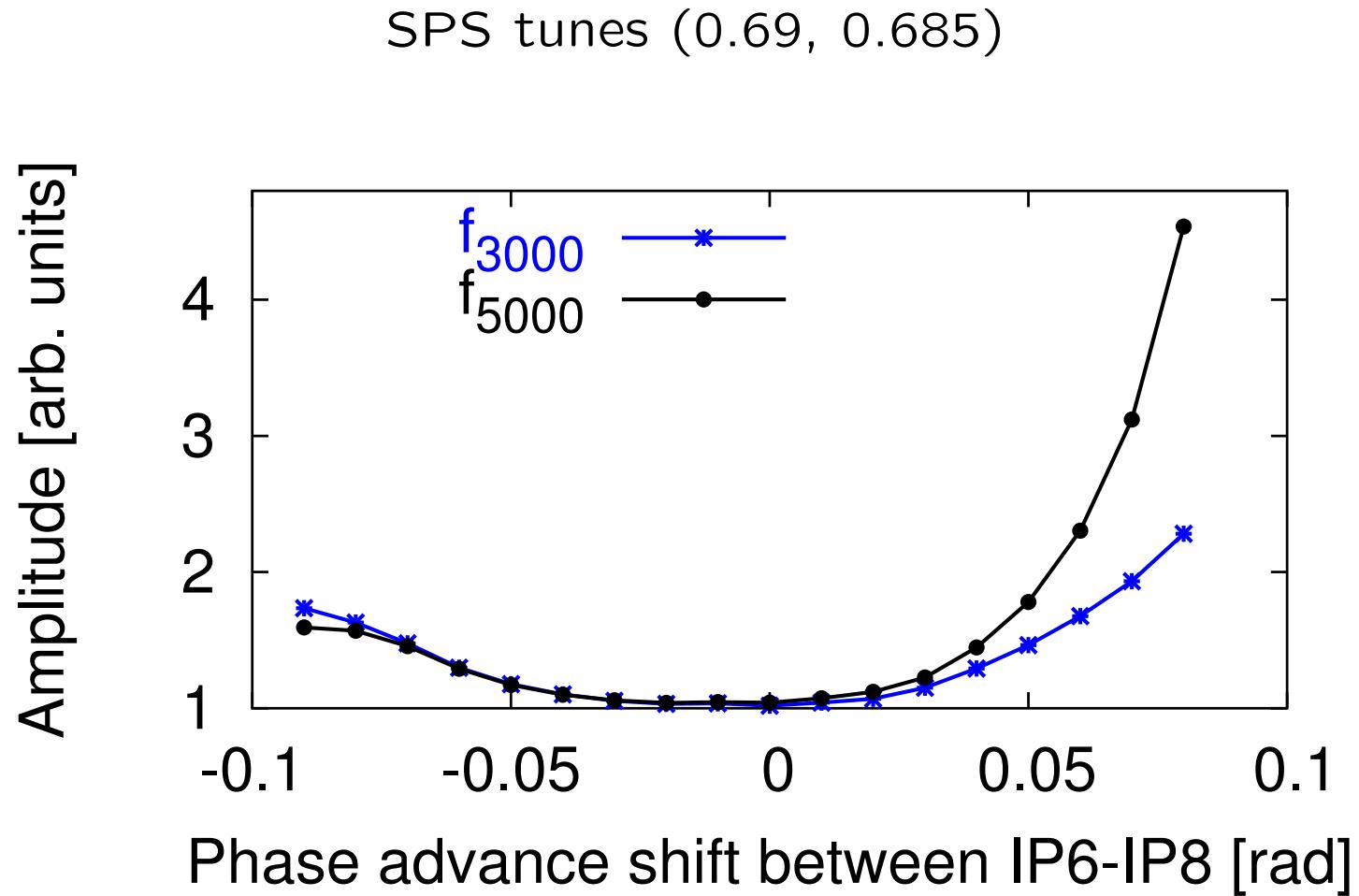


→ Optics are more sensitive for the SPS tunes









→ The phase shift enhances resonances at (0.69, 0.685)!!

Conclusions

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- SPS tunes (0.69, 0.685) had the best performance in presence of beam-beam
- Experimental phase scans need new hardware
- Phase shifts at SPS tunes enhance dangerous resonances
- Phase scans could improve luminosity for other working points like (0.225, 0.235)