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Emittance growth with offset beam-beam collisions And small beam-beam parameters

N.P. Abreu and W. Fischer

Collider-Accelerator Department
Brookhaven National Laboratory
Upton, NY 11973

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Abstract

We investigate experimentally the possible enhanced emittance growth from offset beam-beam collisions. For this we displace beams at the end of a store for 15min, and, after removing the offset again, compare the expected luminosity with the measured one.

1 Experiment goals and setup

Offsets between beams under collision can cause emittance growth of both beams. This is a concern for all colliders but in particular for the LHC, where due to PACMAN effects some bunches will collide with an offset of up to 0.5 σ [1, 2, 3]. In RHIC beams have static offsets due to uncorrected orbit errors, and modulated offsets due to mechanical triplet vibrations [4]. In simulations, these offsets lead to an increased emittance growth [5].

The experiments were performed at the end of a store when the luminosity decay can be well fitted and therefore extrapolated. The beams are then offset at the collision points for 15 min, and then restored the "zero offset" situation. By comparing the extrapolated luminosity from the fit before the offset was introduced, with the actual luminosity after the offset was removed again, the emittance growth can be deduced. The experiments were performed during the 2004 Au-Au run and the 2004 polarized proton run.

Table 1: Summary of the offset experiments.

Exp#	fillno	species	N_{bunch}	ξ	Characteristics
1	4381	Au-Au	0.4×10^9	3×10^{-4}	0.86 σ horizontal offset at PHENIX and STAR and 0.87 σ horizontal offset at BRAHMS and PHOBOS for about 15 min
2	4625	Au-Au	0.8×10^9	6×10^{-4}	0.79 σ vertical offset at PHENIX and STAR and 0.75 σ vertical offset at BRAHMS and PHOBOS for about 15 min
3	5259	p-p	1.4×10^{11}	3×10^{-3}	1.12 σ horizontal in STAR and PHENIX and no bump in any other IP for 15 min

2 Data sets and analysis

Tab. 1 summarizes the characteristics of each measurment. A double exponential function,

$$f(t) = Ae^{-t/\tau_A} + Be^{-t/\tau_B} \tag{1}$$

was fitted to the data points before the offset and then extrapolated to the data points after the offset was removed. To compare the fits before and after the offset the spread of the data points around the fitted function was calculated, using the expression:

$$\Delta\Sigma = \sqrt{\frac{\sum (y_i - f(t_i))^2}{N-1}} \tag{2}$$

and the result for each fit is shown in Tab. 2.

Table 2: Rms spread of the data points around the fitting function

Exp#	IP	ΔΣ before offset	ΔΣ after offset
1	STAR	53	35
	PHENIX	53	40
	BRAHMS	34	23
	PHOBOS	33	27
2	STAR	81	72
	PHENIX	76	70
	BRAHMS	50	56
	PHOBOS	64	64
3	STAR	77	86
	PHENIX	74	70

In all experiments we could not measure any difference due to the offset (Figs. 1, 2 and 3).

3 Summary

We have investigated the emittance growth from transverse offset beam-beam collisions experimentally with d-Au, Au-Au and p-p beams. For beam-beam parameters up to $\xi = 3 \times 10^{-3}$ and 2 collisions, offsets up to 1.12 σ, and offset times of 15 min we have not detected any additional transverse emittance growth.

4 Acknowledgments

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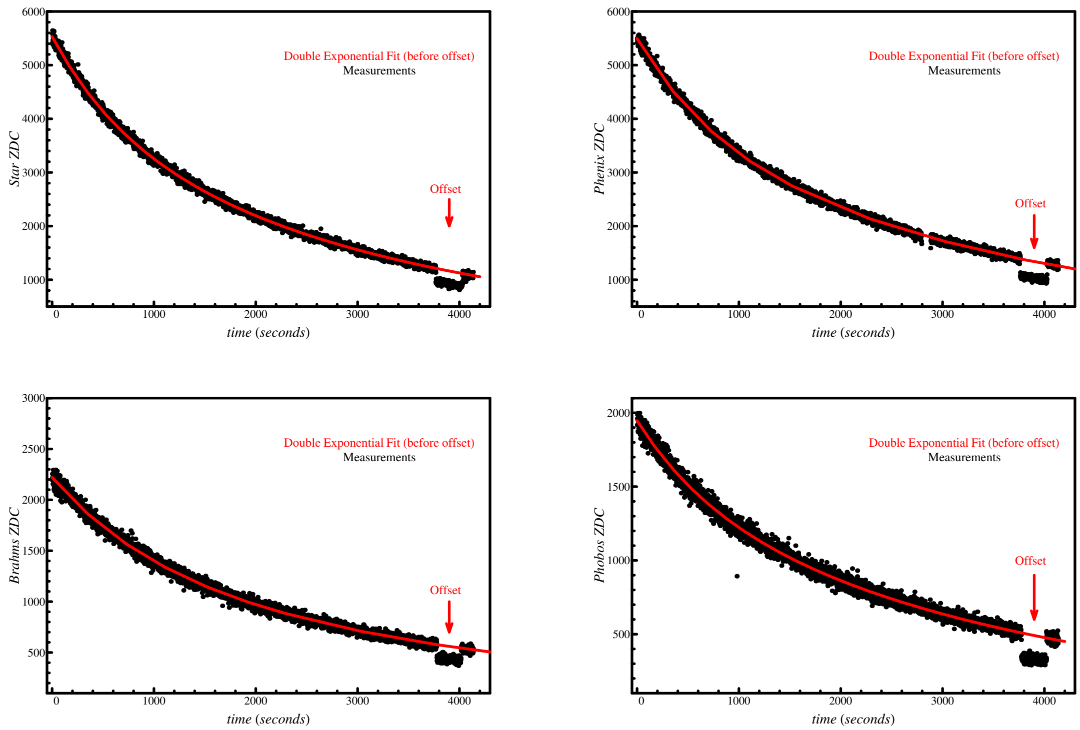

Figure 1: *Luminosity measured at STAR, PHENIX, BRAHMS and PHOBOS (ZDC measurements) and the double exponential fit for experiment # 1.*

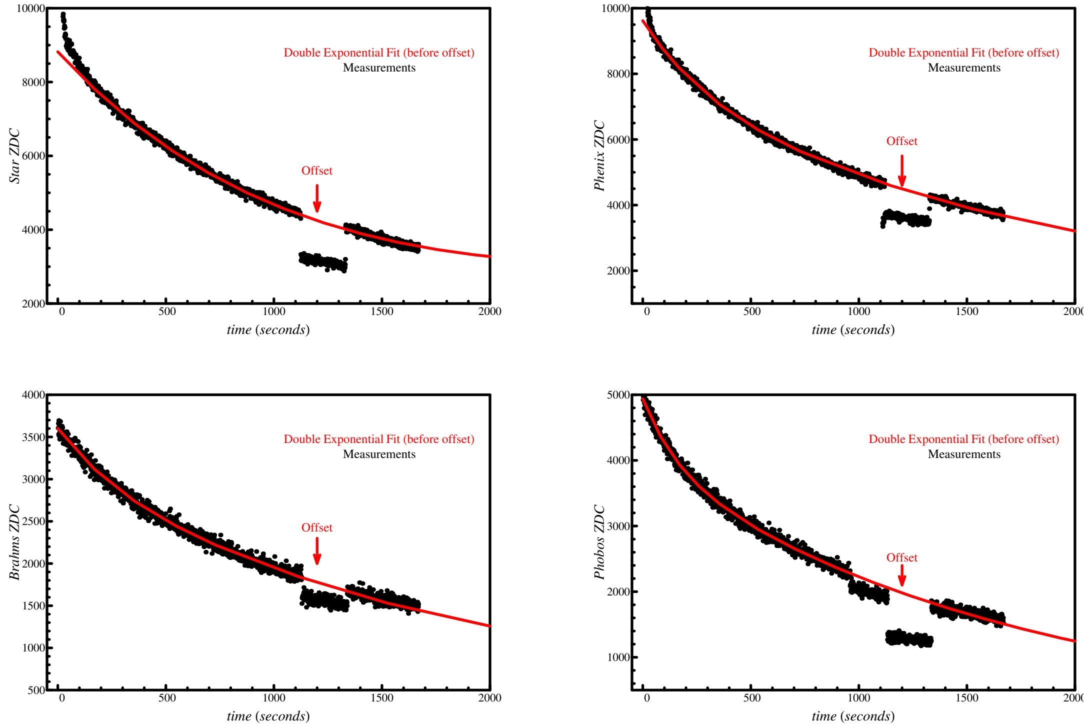

Figure 2: *Luminosity measured at STAR, PHENIX, BRAHMS and PHOBOS (ZDC measurements) and the double exponential fit for experiment # 2.*

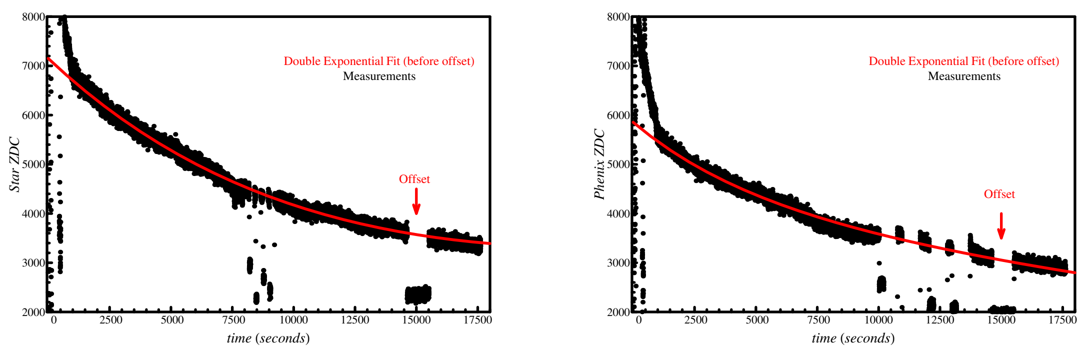

Figure 3: *Luminosity measured at STAR and PHENIX (ZDC measurements) and the double exponential fit for experiment # 3.*

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