

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

N. P. Abreu

August 2007

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

C-A/AP/#284
August 2007

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**

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

N.P. Abreu and W. Fischer

August 17, 2007

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 0.5σ [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}	0.86σ horizontal offset at PHENIX and STAR and 0.87σ horizontal offset at BRAHMS and PHOBOS for about 15 min
2	4625	Au-Au	0.8×10^9	6×10^{-4}	0.79σ vertical offset at PHENIX and STAR and 0.75σ vertical offset at BRAHMS and PHOBOS for about 15 min
3	5259	p-p	1.4×10^{11}	3×10^{-3}	1.12σ 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 measurement. A double exponential function,

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

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:

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

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	$\Delta\Sigma$ before offset	$\Delta\Sigma$ 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 1.12σ , and offset times of 15 min we have not detected any additional transverse emittance growth.

4 Acknowledgments

We are thankful for discussions with W. Herr, J. Qiang, and F. Zimmermann.

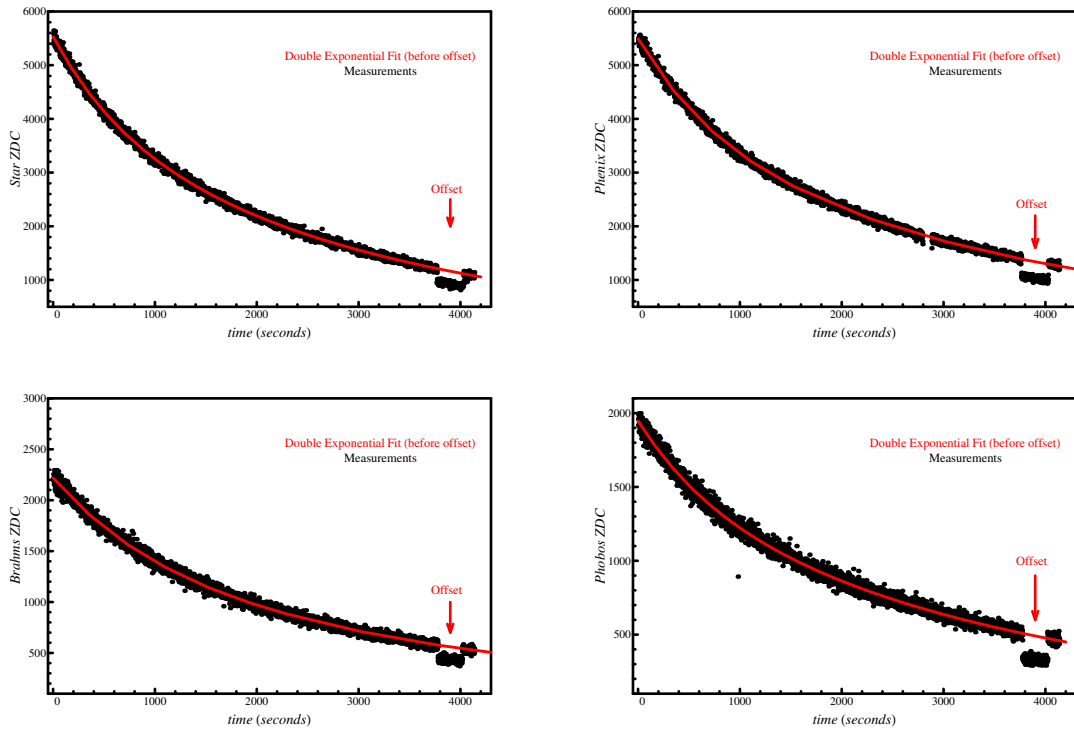


Figure 1: *Luminosity measured at STAR, PHENIX, BRAHMS and PHOBOS (ZDC measurements) and the double exponential fit for experiment # 1.*

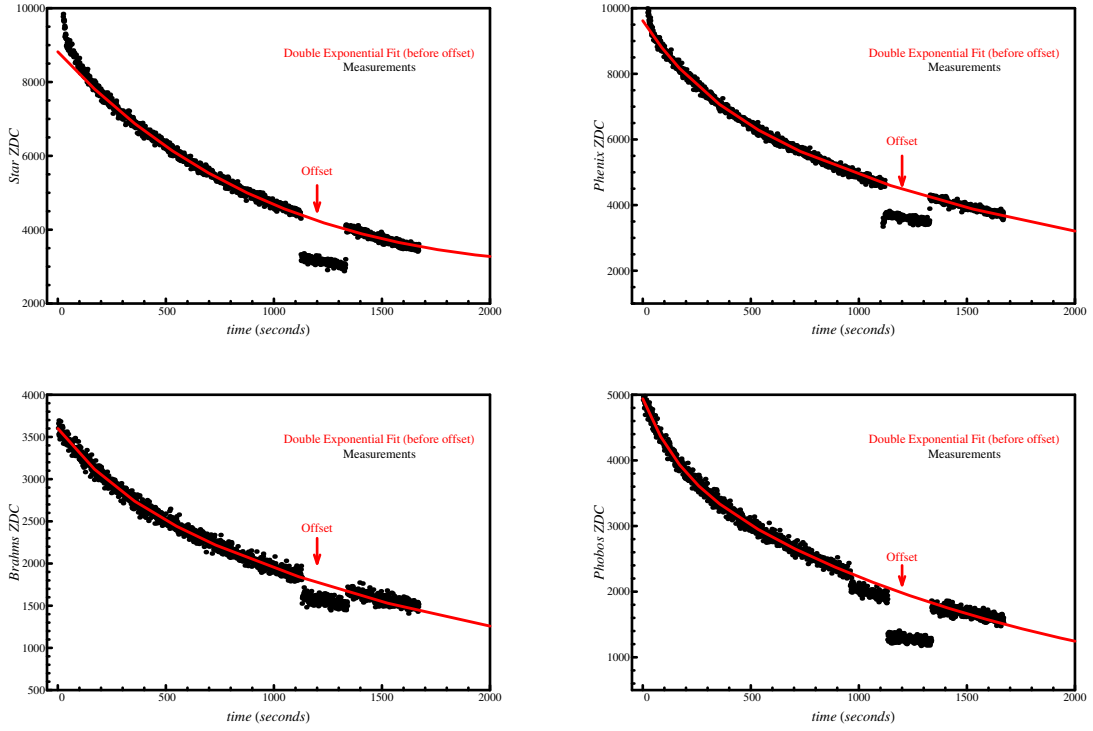


Figure 2: *Luminosity measured at STAR, PHENIX, BRAHMS and PHOBOS (ZDC measurements) and the double exponential fit for experiment # 2.*

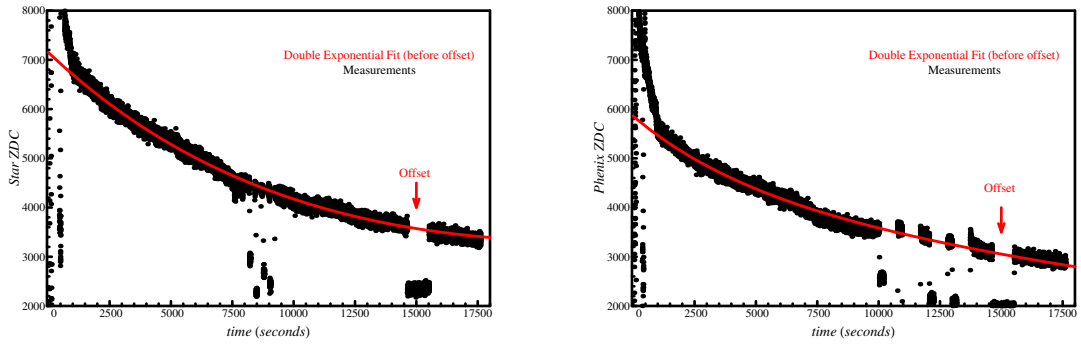


Figure 3: *Luminosity measured at STAR and PHENIX (ZDC measurements) and the double exponential fit for experiment # 3.*

References

- [1] O.S. Brüning, P. Collier, P. Lebrun, S. Myers, R. Ostojic, J. Poole, P. Proudlock (editors), “LHC Design Report v.1: the LHC Main Ring”, Vol. I, CERN-2004-003-V-1 (2004).
- [2] W. Herr, “Effects of PACMAN bunches in the LHC”, CERN LHC Project Report 39 (1996).
- [3] B. Muratori, “Study of offset collisions and beam adjustment in the LHC using a strong-strong simulation model”, CERN LHC Project Report 593 (2002).
- [4] C. Montag, R. Bonati, J.M. Brennan, J. Butler, P. Cameron, G. Ganetis, P. He, W. Hirzel, L.X. Jia, P. Koello, W. Luie, G. McIntyre, A. Nicoletti, J. Rank, T. Roser, T. Satogata, J. Schmalzle, A. Sidi-Yekhlef, J. Sondericker, and T. Tollerico, “Observation of helium flow induced beam orbit oscillations at RHIC”, NIM A **564**, pp. 26-31 (2006).
- [5] J. Qiang, M. Furman, R.D. Ryne, W. Fischer, T. Sen, and M. Xiao, “Parallel strong-strong/weak-strong simulations of beam-beam interactions in hadron accelerators”, in “Beam halo dynamics, diagnostics, and collimation”, proceedings of HALO’03 and Beam-Beam’03, Montauk, New York, AIP Conference Proceedings 693 (2003).