Comparison of the Design and Measured (Jan 27, 2004) Optics

(A. Valishev, Runs finished 03/25/2004)

Model parameters:

- Number of particles: 5000
- Hard aperture limit: 20 σ (x,y,z)
- Beam-beam parameter per interaction point: 0.0075
- Betatron tunes: 0.57, 0.56 (x,y)
- Betatron tune chromaticity: +20
- Noise matrix: 1.0e-12, 8.1e-16, 1.0e-12, 8.1e-16, 0, 1.5e-15 (x,px,y,py,z,dp/p)
- Tracking time: 4,000,000 turns

Optics modifications:

1. "Design optics": Tevatron design with equal horizontal and vertical beta-functions (35cm), zero coupling and dispersion at the IPs.
2. "Measured optics": Tevatron model from differential orbit measurements by V.Lebedev. Its main differences from the design are:
   - Changed helix
   - Non-negligible crossing angle at both main IPs
   - Different horizontal and vertical betas, with minima shifted from the reference IP.
   - Non-zero coupling
3. "Corrected main IPs": the "Measured optics" with optics of the B0 and D0 IPs equal to that of the "Design optics"
4. "Excluded parasitic IPs": the "Measured optics" without parasitic collision points. The betatron tunes were adjusted to compensate the effect of the parasitics.
5. "Design without parasitics": the "Design optics" without parasitic collision points + adjusted tunes.

These modifications were aimed at revealing the main source of problems seen in the initial comparison of the design and measured optics: higher losses and faster luminosity decay in the latter.

The figures below present main characteristics of the beam-beam system. Figs. 1,2 show evolution of the transverse beam emittances with time. In Fig. 3 the longitudinal beam size is plotted. Number of lost particles and rate of losses are given in Figs. 4,5. Since the instantaneous rate of losses comes to a constant after approximately 2e6 turns an attempt was made to evaluate the established value for different modifications of optics. The results are shown in Fig. 6. In Fig. 7 the specific luminosity is presented:

$$L_{spec} = \frac{L}{L_0} \cdot \frac{I}{I_0},$$

where L and I are values of the luminosity and the beam intensity, and "0" index marks initial values.

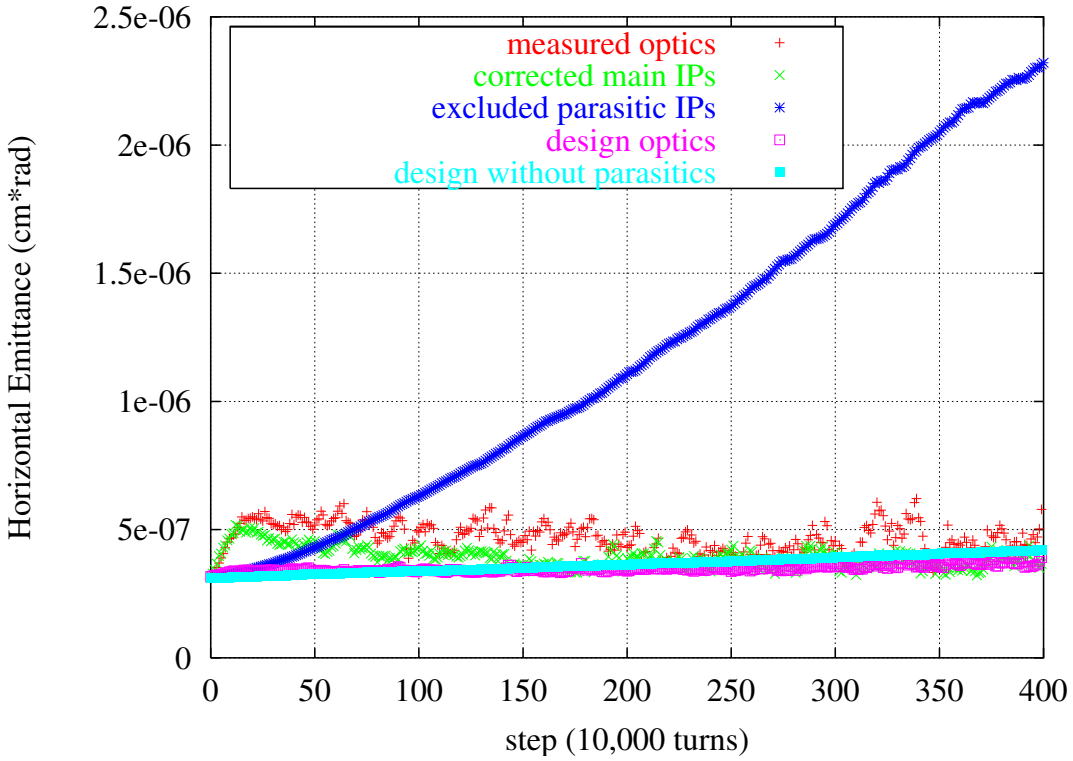

Figure 1. Evolution of the horizontal emittance.

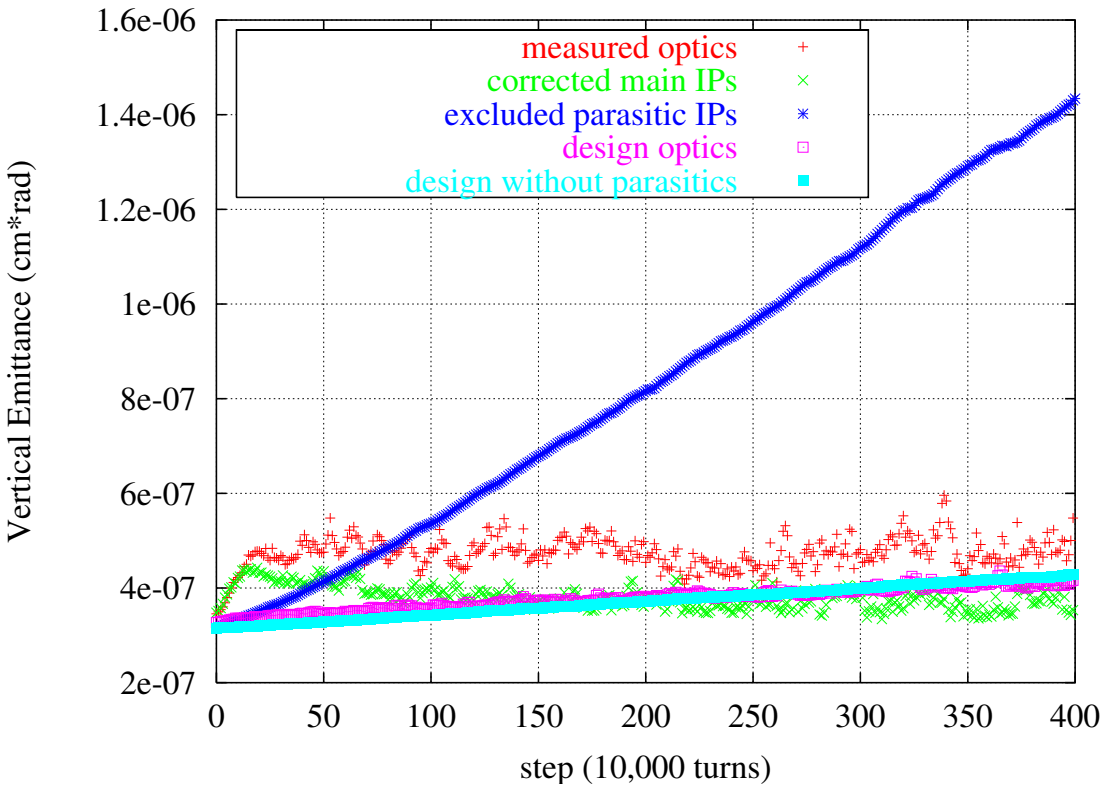

Figure 2. Evolution of the vertical emittance.

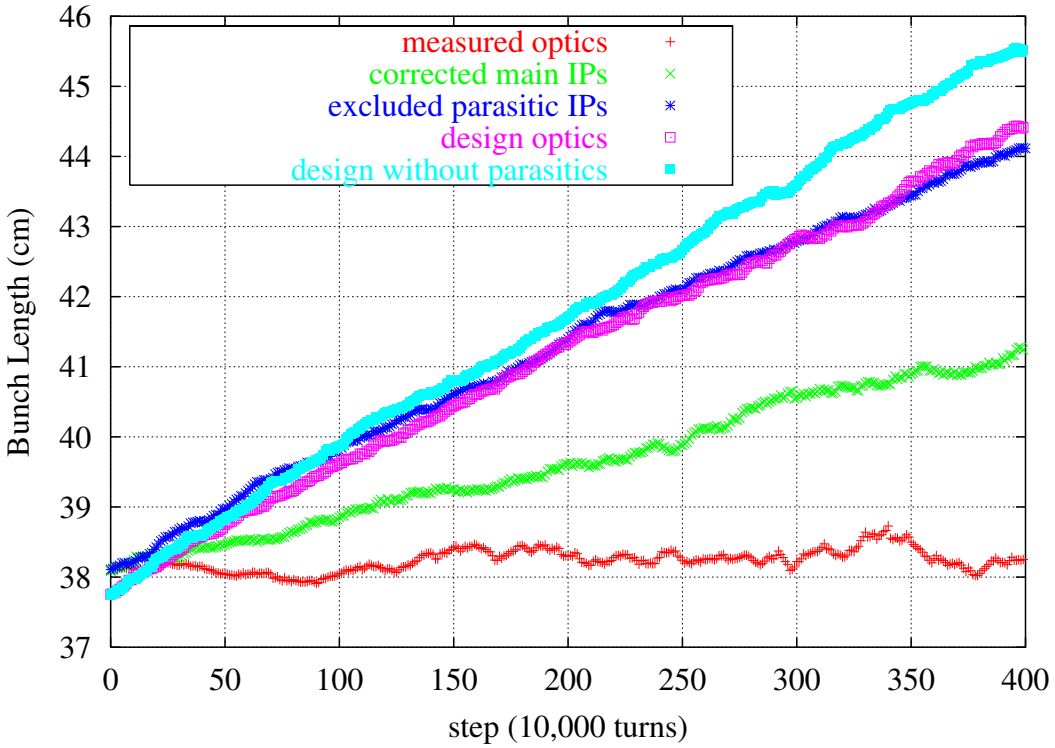

Figure 3. Evolution of the longitudinal beam size.

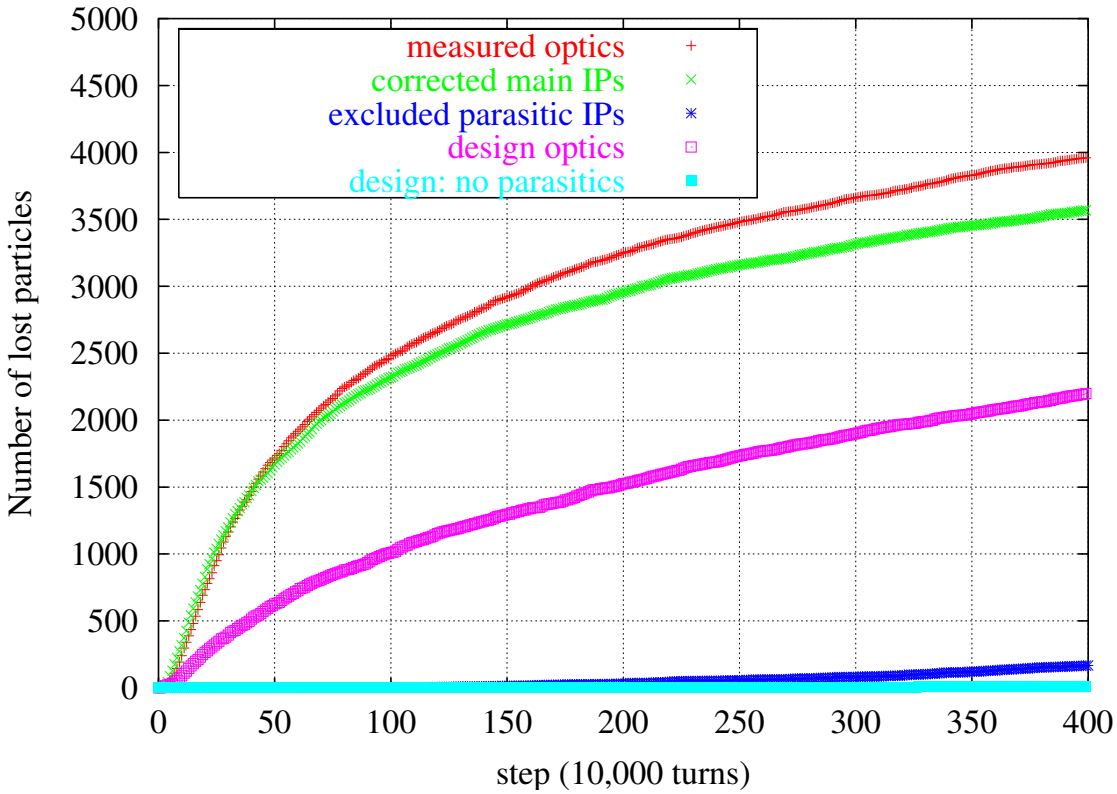

Figure 4. Total number of lost particles vs. turn number.

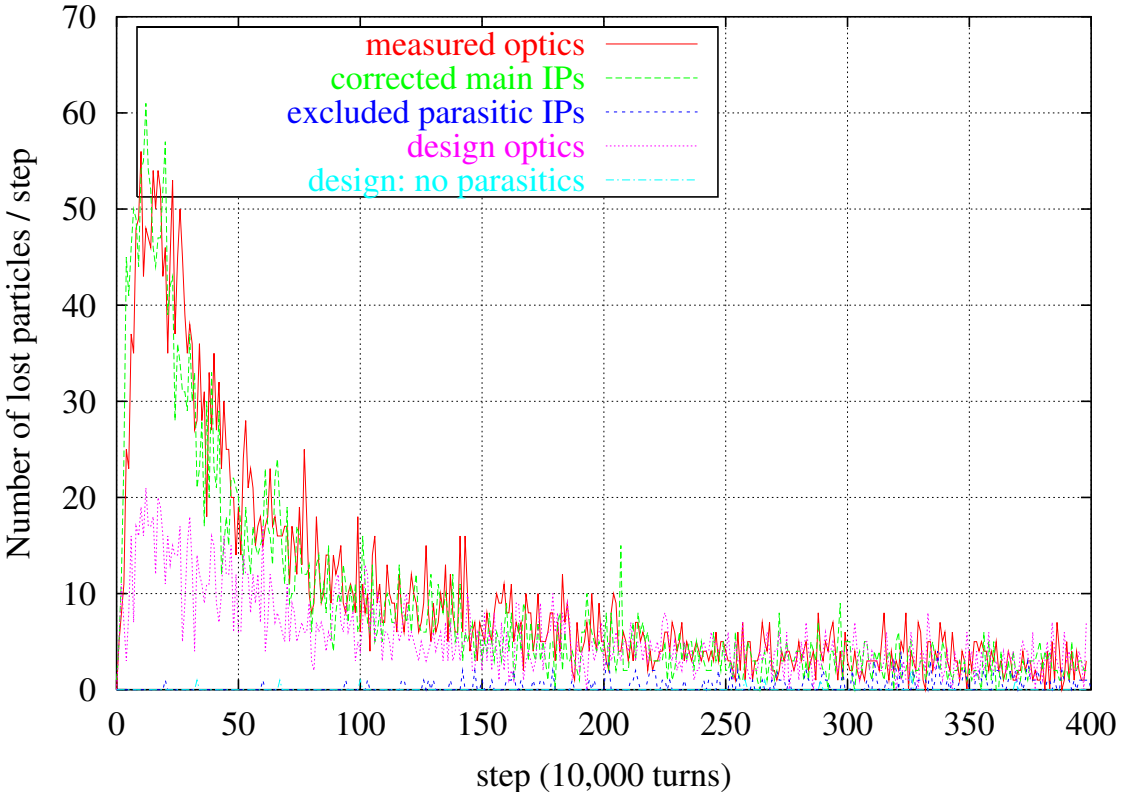

Figure 5. Instantaneous rate of losses vs. turn.

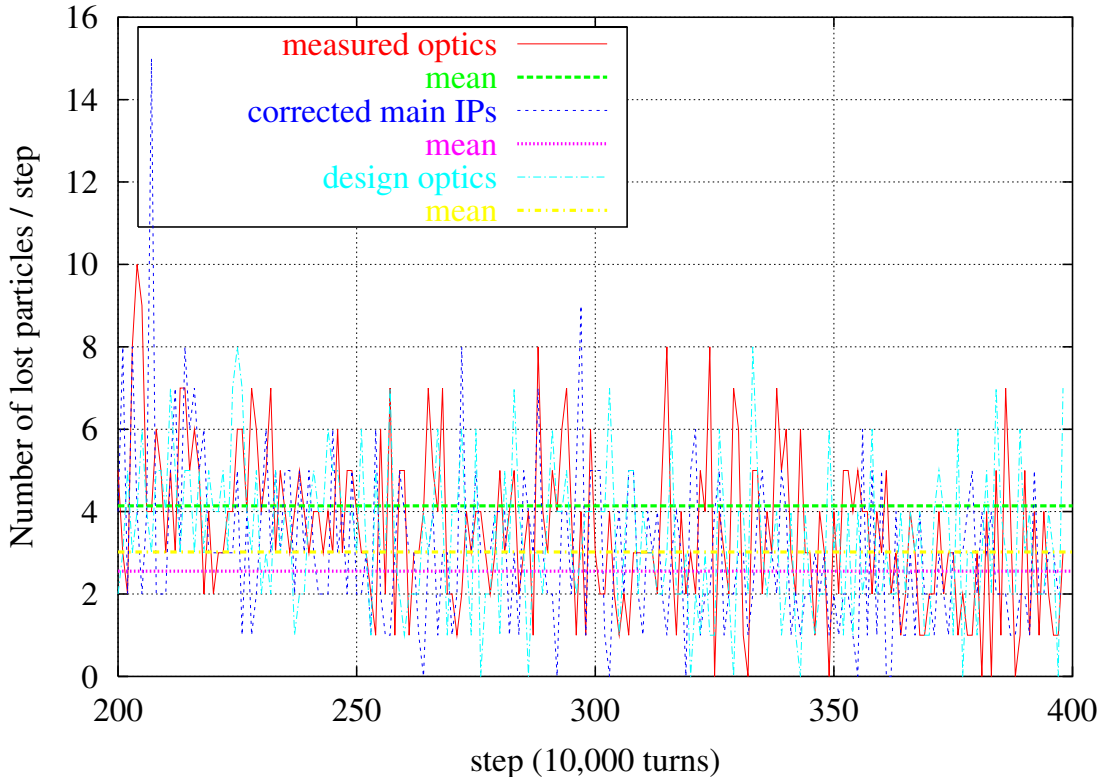

Figure 6. Mean values of the instantaneous loss rate at equilibrium.

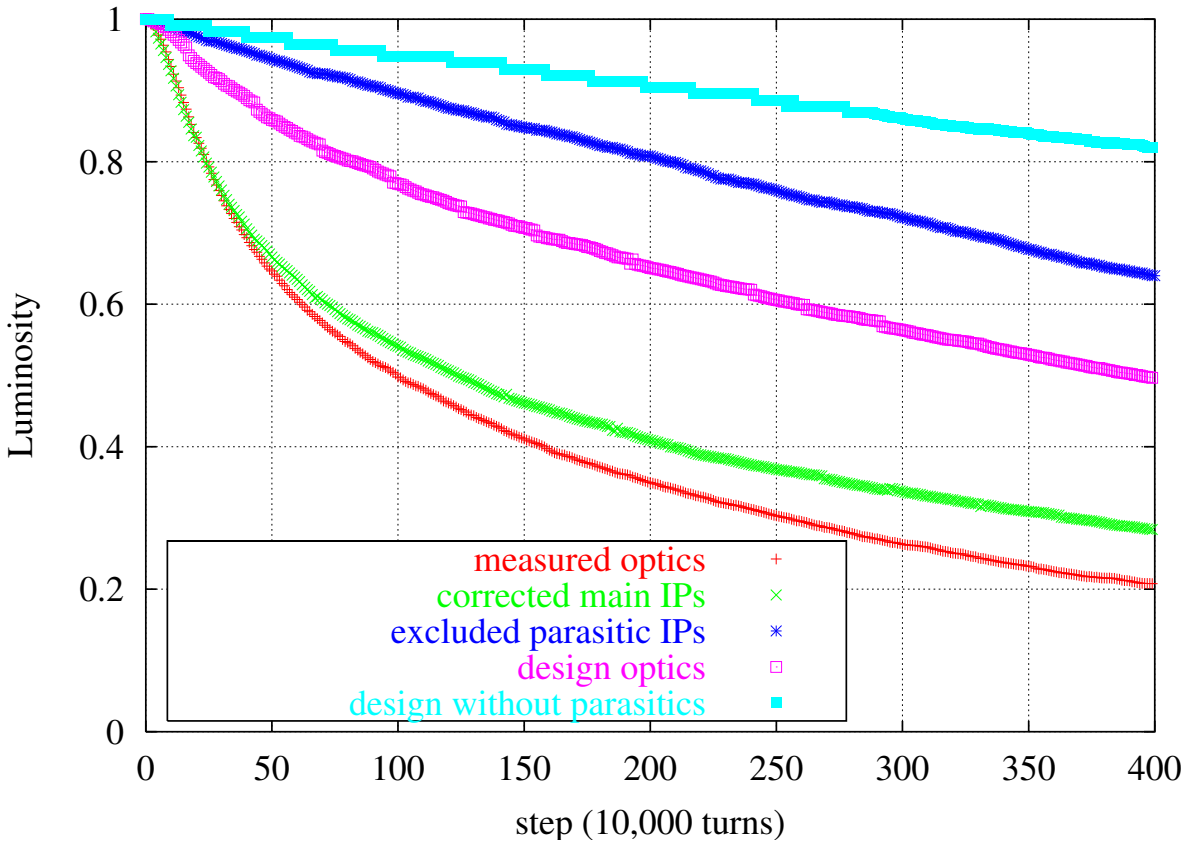

Figure 7. Specific luminosity vs. turn number.