# Tevatron Run-II Beam Collimation System

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A purpose of the Tevatron beam cleaning system is to decrease beam loss rates in superconducting magnets and to reduce accelerator related backgrounds in the DØ and CDF detectors. A two-stage beam collimation system is designed for the Tevatron Run II to localize most of losses in the three straight sections D17, EØ and AØ. It consists of horizontal and vertical primary and secondary collimators. Proton impact parameter on a scraper is of the order of $1\mu$m. A thin primary collimator (scattering target), introduced into the lattice as a limited aperture, increases proton amplitude as a result of multiple Coulomb scattering. This results in drastic increase of proton impact parameter on downstream secondary collimators and because of that to in significant increase of a scraping efficiency.

Our studies show that in Tevatron, a 5-mm thick tungsten target placed at $5\sigma$ from the beam axis in both vertical and horizontal planes would function as an optimal primary collimator. At 1 TeV, an optimal length of stainless steel secondary collimator equals 1.5 m. Each of them consists of a L-shape jaw positioned at about $8\sigma$ from the beam axis in horizontal or vertical plane. The collimators are aligned parallel to the envelope of the circulating beam.

Multi-turn particle tracking in the Tevatron lattice is done using the STRUCT code [1] followed by full scale Monte-Carlo hadronic and electromagnetic shower simulations with the MARS code [2]. A RMS normalized emittances in Run-II are assumed to be 3 mm·mrad for proton beam and 2.2 mm·mrad for antiprotons. The luminosity is equal to $8.1\times10^{31}$cm$^{-2}$s$^{-1}$. Based on the numerous optimizational studies and available space in the Tevatron lattice, the following collimation system is proposed for Run-II.

Proton primary collimator is located at the beginning of the D17 straight section inward and down of the closed orbit (Fig. 1). Protons scattered from this collimator are presented by a vertical line in the transverse phase diagram. Particles with negative angle are intercepted by a D17(2) secondary collimator at the end of the D17 straight section. A D17(3) collimator is used to protect superconducting magnets against large amplitude particles emitted from the primary collimator. A EØ(1) and AØ(1) collimator are located outward and down of the circulating beam and intended to intercept the positive angle protons emitted from the primary collimator.

The E0 collimators are used for proton removal and are described elsewhere.

A similar set of collimators located at AØ is used for the antiproton direction (Fig. 1). The D17(3) collimator is used as a secondary antiproton collimator.

$\beta$-functions and phase advances at the collimator locations for proton and antiproton directions are presented in Tables 1 and 2. Collimator locations and $\beta$ functions in the Tevatron lattice are shown Fig 2, 3 and 4.

Beam intensity decreases during the collider run (10 hours) from $9.72\times10^{12}$ to $8.63\times10^{12}$ for protons and from $1.08\times10^{12}$ to $0.65\times10^{12}$ for antiprotons. The total number of $\overline{p}p$ inelastic collisions in the IPs for this period is equal to $1.75\times10^{11}$. For the same time beam halo, formed by elastic collisions in the IPs, by beam-gas interactions and by effects of resonances, ground motion and RF noise, is supposed to be intercepted by the collimators and amounts $9.14\times10^{11}$ for protons and $2.57\times10^{11}$ for antiprotons.

Collimator locations in the Tevatron lattice are shown if Fig. 5. Resulting beam loss distributions in the Tevatron are presented in Fig. 6 and 7.

# References


[1] I.S. Baishev, A.I. Drozhdin, and N.V. Mokhov, "STRUCT Program User's Reference Manual", SSC-MAN-0034 (1994).

[2] N.V. Mokhov, "The MARS Code System User's Guide, Version 13(95)", Fermilab-FN-628 (1995).


| collimator | $\psi_x,^o$ | $\psi_y,^o$ | $\beta_x, m$ | $\beta_y, m$ |
|---|---|---|---|---|
| D17(1) | 0 | 0 | 87 | 34 |
| D17(2,3) | 7 | 12 | 61 | 49 |
| E0(1) | 174 | 194 | 59 | 94 |
| E0(2,3) | 206 | 227 | 100 | 58 |
| A0(1,2) | 301 | 351 | 157 | 62 |
| A0(3) | 331 | 9 | 36 | 226 |

Table 1: $\beta$ -functions and phase advance at the collimator locations. Proton direction.

| collimator | $\psi_x, ^o$ | $\psi_y, ^o$ | $\beta_x, m$ | $\beta_y, m$ |
|---|---|---|---|---|
| A0(3) | 0 | 0 | 34 | 230 |
| A0(1,2) | 30 | 18 | 157 | 62 |
| E0(2,3) | 125 | 142 | 100 | 58 |
| E0(1) | 156 | 174 | 60 | 92 |
| D17(2,3) | 325 | 356 | 61 | 49 |
| D17(1) | 331 | 8 | 85 | 34 |

Table 2: $\beta$ -functions and phase advance at the collimator locations. Antiproton direction.

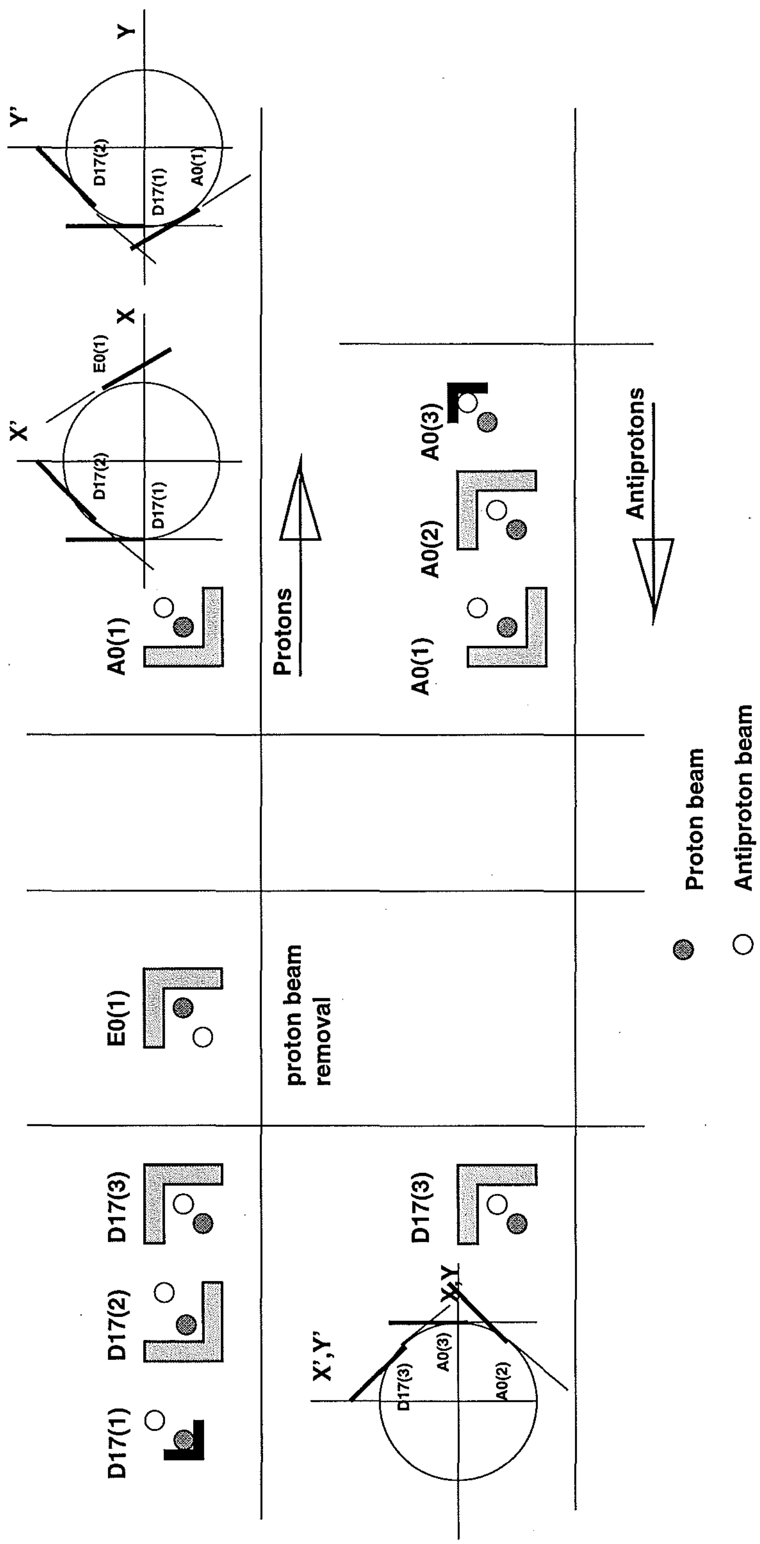


Figure 1: Tevatron Run-II beam collimation system

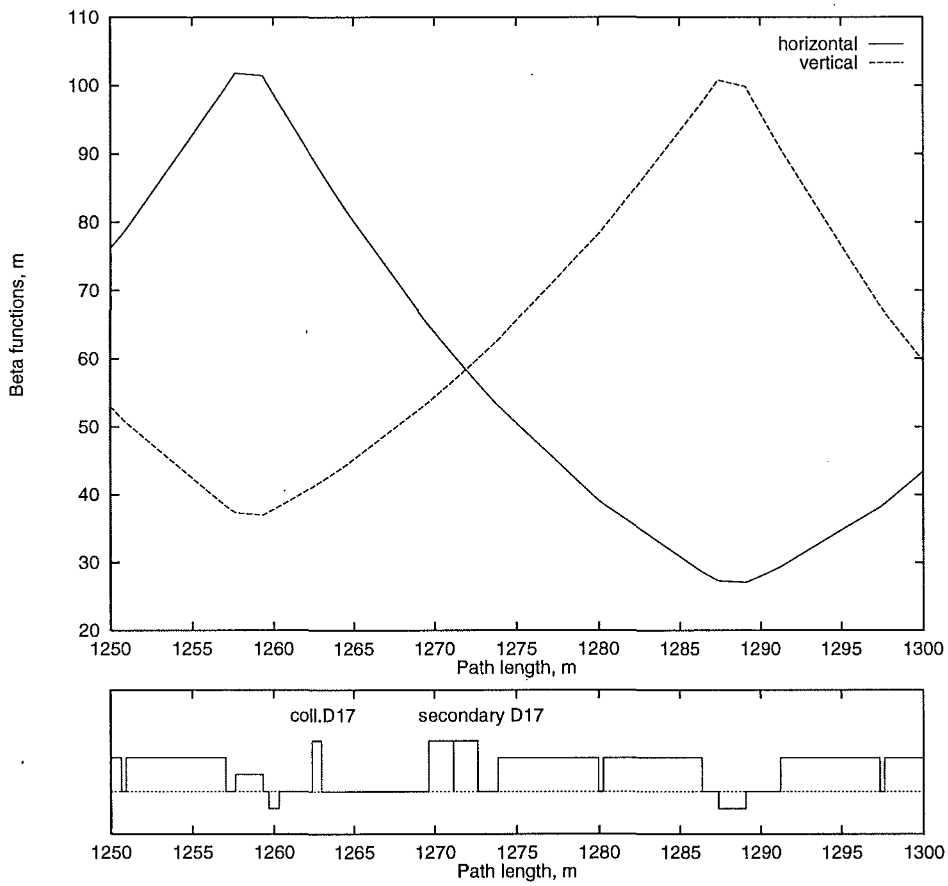


Figure 2: $\beta$ functions in the D17 collimator region

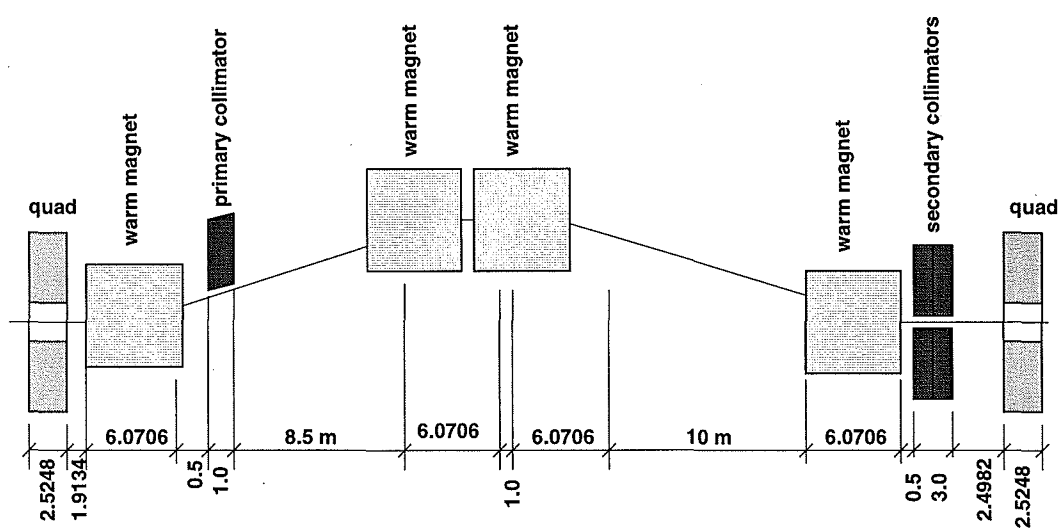


Figure 3: Dog-leg scheme for the proton beam removal at EØ straight section.

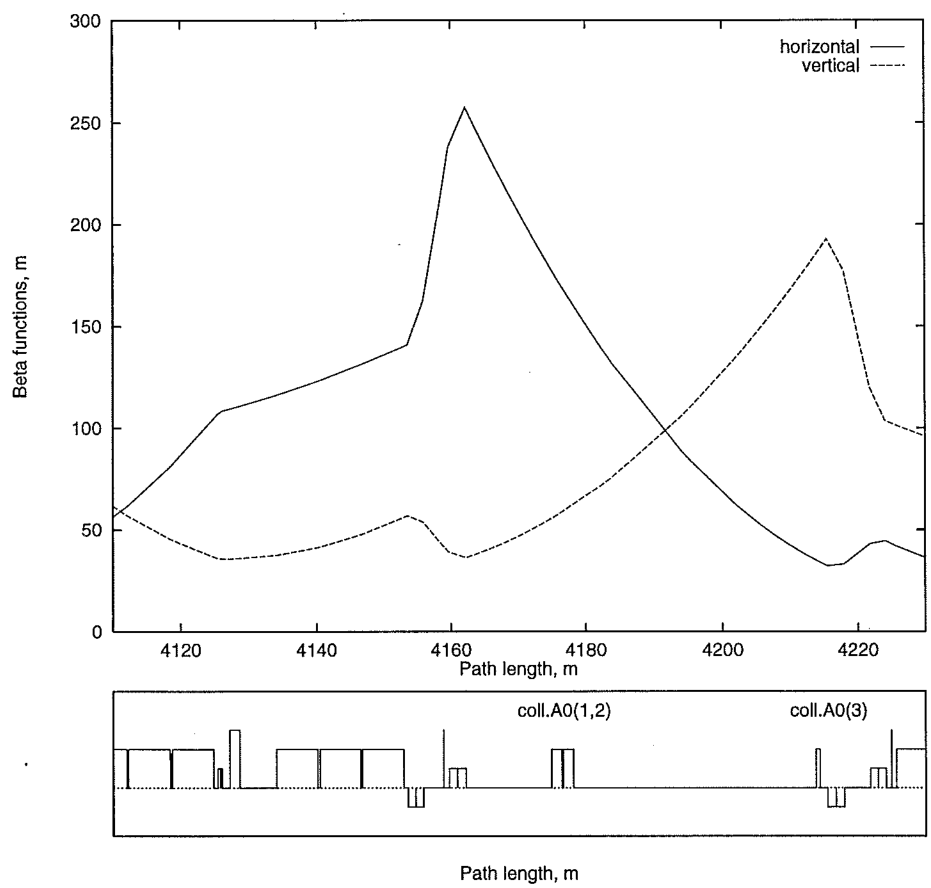


Figure 4: $\beta$ functions in the vicinity of collimators F48 and A0.

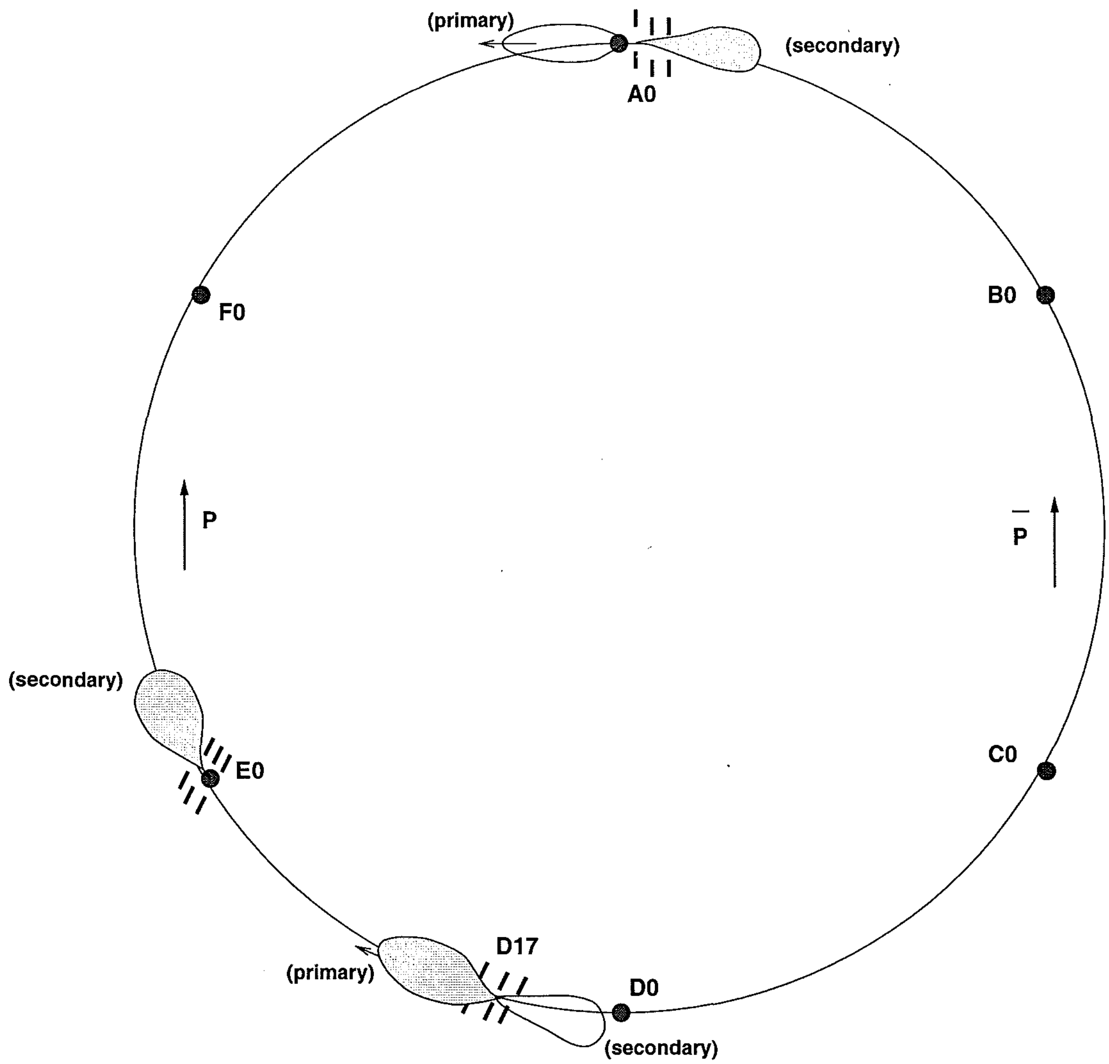


Figure 5: Collimator locations in the Tevatron lattice

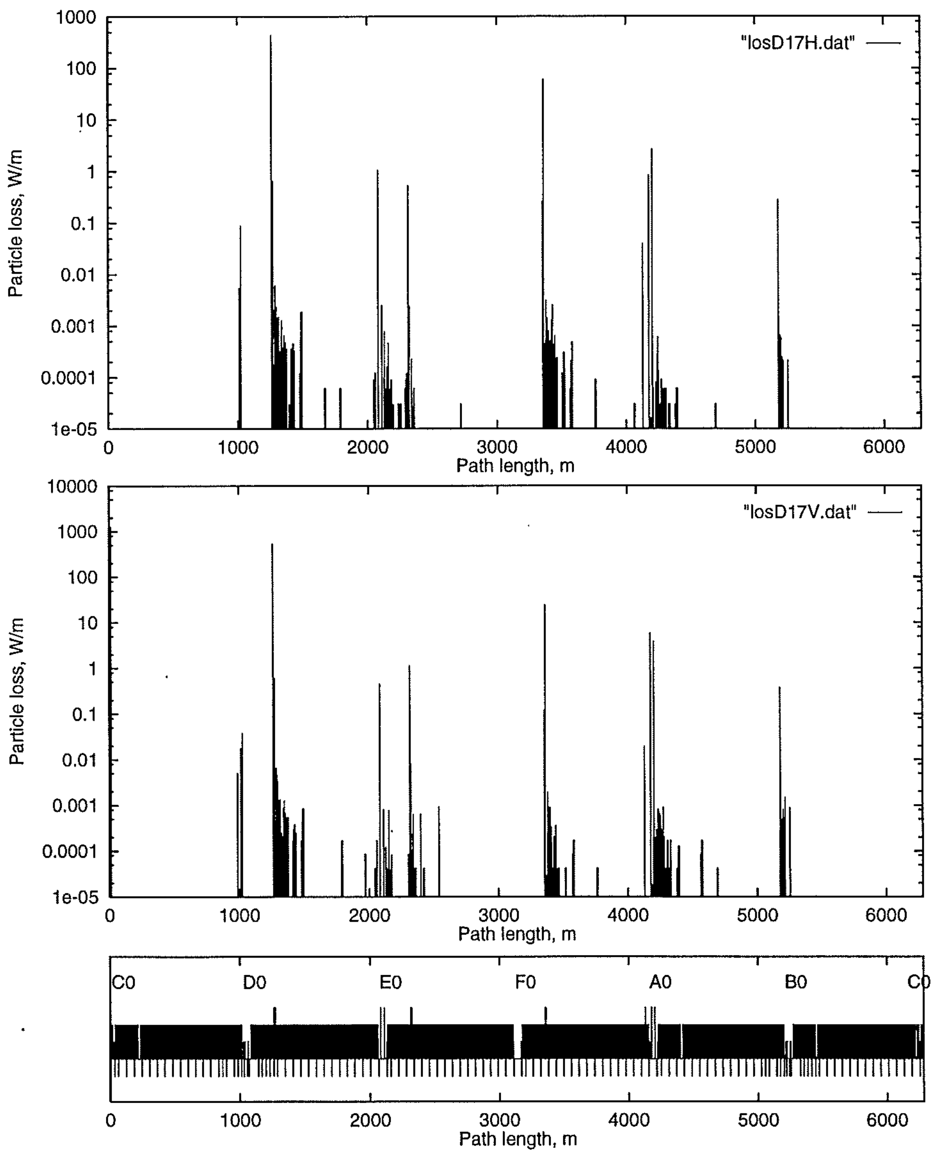


Figure 6: Beam loss in Tevatron at collimation with horizontal and vertical collimators at D17 (proton direction)

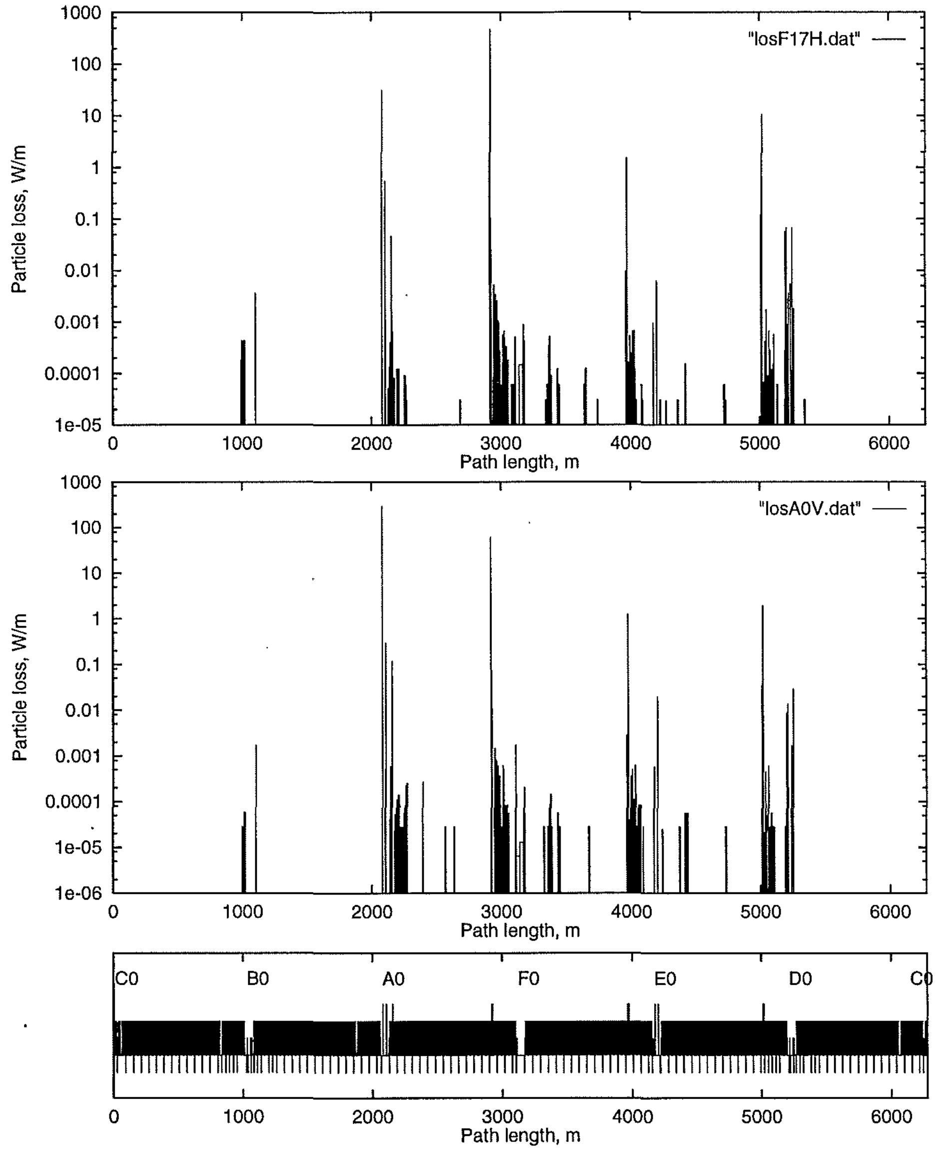


Figure 7: Beam loss in the Tevatron at collimation with horizontal collimator at F17 and vertical collimators at A0 (antiproton direction).