IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, August 1983

MOMENTUM PRECOOLING IN THE DEBUNCHER RING FOR THE FERMILAB TEVATRON-I PROJECT*

A. G. Ruggiero
Fermi National Accelerator Laboratory, Batavia, IL 60510

J. Simpson
Argonne National Laboratory, Argonne, IL 60439

Introduction

The design of the antiproton source for the Fermilab Tevatron-I project (TeV-I[1]) incorporates two separate rings. The Accumulator Ring uses a stochastic cooling/stacking system to accumulate a sufficient number of antiprotons for use in the Tevatron collider. The Debuncher Ring rotates buckets and debunches antiproton pulses from the production target. This requires, in the Debuncher, a choice of lattice transition energy very near the beam energy, resulting in very narrow spread in the circulation frequency.

If the energy spread could be further reduced in the Debuncher before the beam is transferred to the Accumulator, operational improvements would result in: 1) the reduction of stochastic cooling power in the Accumulator 2) the acceptance of a larger momentum bite of antiprotons in the Debuncher (thus more antiprotons) 3) the reduction of momentum aperture in the Accumulator. On the other hand, the small value of

$\eta = \left|\frac{1}{\gamma^2} - \frac{1}{\gamma_t^2}\right|$, mentioned above, places severe

performance criteria on the depth and frequency of a notch filter used in a stochastic momentum precooling system.

This note describes a quick investigation of the feasibility of precooling within the framework of technically achievable parameters.

Assumptions and Procedure

The precooling was described by the usual Fokker-Plank equation

$$\frac{\delta\psi}{\delta t} = \frac{\delta}{\delta E}\left(-F\psi + (D_1 + D_2\psi)\frac{\delta\psi}{\delta E}\right)$$

where

$\psi = \frac{\delta N}{\delta E}$; the particle density

F = the coefficient of the cooling term

D_1 = the coefficient of the heating term due to thermal noise in the electronic system

D_2 = the coefficient of the heating due to other particles in the distribution

Cooling systems were modeled in an ANL computer code and the evolution of ψ with time calculated for various system parameters. In order to account for observed deficiencies in prototype, superconducting correlator filters (under development at FNAL), random fluctuations in both notch depth and frequency were included in the calculation. Filters of this type are described in a separate report at this conference.[2]

*Work supported by the U.S. Department of Energy

A typical configuration was:

$\eta = \left\|\frac{1}{\gamma^2} - \frac{1}{\gamma_t^2}\right\|$ =	0.006
No. of antiprotons	2×10^8
Pre-amplifier noise figure	3.0 db
System bandwidth	2.0-4.0 GHz
Pickups	192 50 Ω/pair striplines
Kickers	192 70 Ω/pair striplines
Particle energy	8 GeV
Initial momentum spread	0.3% f.w. (parabolic distribution)
Cooling time	2.0 sec.
Pickup-Kicker Separation	0.3 machine circumference
Notch filter	
$\delta \equiv \frac{f_n - nf_o}{nf_o}$	$\pm 10^{-5}$ (uniform distribution)
notch depth	28 ± 5 db (uniform distribution)

f_o = fundamental frequency
n = harmonic number

In the process of calculating the focussing term, 100 equally spaced harmonic numbers within the 2-4 GHz bandwidth were selected at which to calculate representative, randomly fluctuating gains. No harmonic-to-harmonic correlations were assumed.

Results

Figure 1 shows the effective overall gain profile provided by the system described above. Figure 2 shows the resulting particle distribution, ψ, at 0.5 second intervals. A cooling factor of about 2 was achieved in this particular example. We feel that the parameters assumed are realistic.

The total broadband power to the kickers in this example was about 200 watts, most of it due to Schottky noise. This represents, by stochastic cooling systems standards, a relatively modest system.

The implications of this quick investigation are that:

1. precooling in the debuncher would be feasible with existing techniques.
2. there exists another safety margin in the TeV-I design (e.g. a bigger momentum bite).
3. there exists a relatively simple way to provide more antiproton flux to the Accumulator should the stacking system be able to handle it.

References

1. "Design Report-Tevatron I Project", Fermi National Accelerator Laboratory, October, 1982.
2. "Filters for Stochastic Cooling of Longitudinal Beam Emittance", S. L. Kramer et. al., paper K48 this conference.

0018-9499/83/0800-2599$01.00© 1983 IEEE

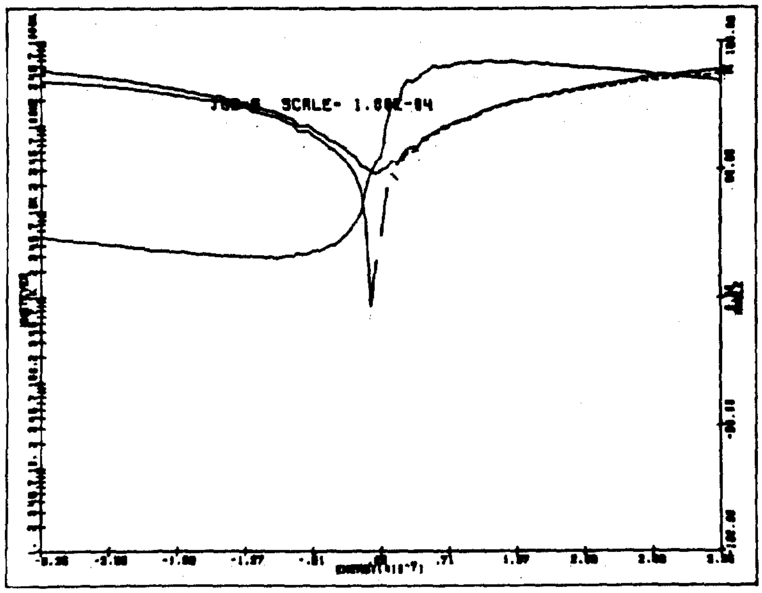

Figure 1. Effective System Gain vs Energy. The phase shift of 180° and the notch at 0 eV are due to the effects of the correlator filter.

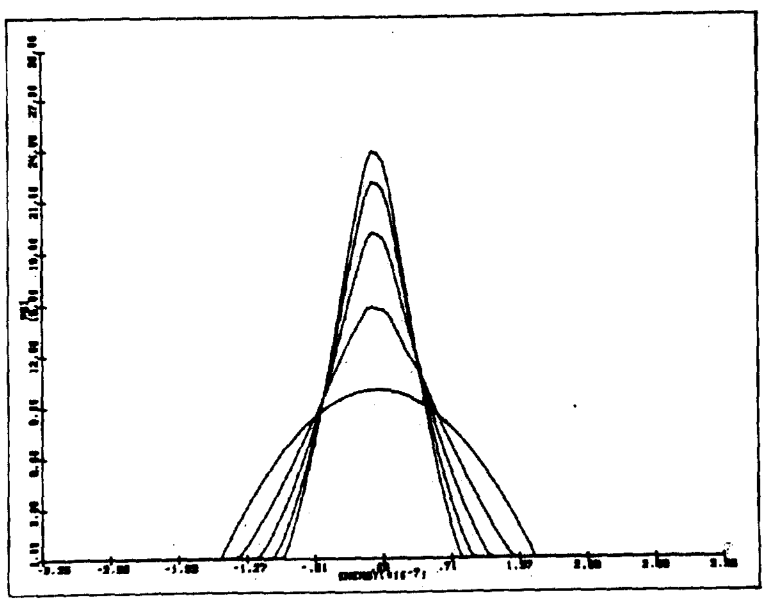

Figure 2. Evolution of Energy Spread while precooling. The initial spread was 0.3%. The distributions are shown at 0.5 second intervals.