OVERVIEW OF THE FERMILAB ANTIPROTON SOURCE

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Fermilab is beginning the construction of an antiproton source for the proton-antiproton collider. The goal of this project is to achieve proton-antiproton collisions at 2 TeV in the center of mass with luminosities exceeding $10^{30}cm^{-2}sec^{-1}$. The Tevatron, reported on elsewhere in this conference, will be the storage ring. The collisions will take place at two experimental halls, located at BØ and DØ straight sections.

A plan view of the antiproton source is shown in Figure 1. The project includes an antiproton production target, beam transport lines, and two new rings, the Debuncher Ring and the Accumulator Ring, to collect and store antiprotons.

Basic parameters of the Antiproton Source are outlined in Table I. Every two seconds a single booster batch of protons (about 80 RF buckets at 53 MHz), containing a total of $2x10^{12}$ protons, is accelerated by the Main Ring, extracted, and focused onto the antiproton production target. Prior to extraction, RF manipulations reduce the proton bunch widths to less than 1 nsec. Antiprotons are focused by a pulsed lithium lens into the antiproton transport system. The expected yield is about $8x10^{7}$ antiprotons at 8.9 GeV/c with transverse emittances of 20π mm-mrad and momentum spread of $\Delta p/p = 3\%$. These 80 buckets of antiprotons (a 1.5 μsec pulse) are injected into the Debuncher Ring (revolution period = 1.69 μsec), where RF manipulations reduce the momentum spread to $\Delta p/p = 0.2\%$. The debunched beam is then cooled from 20π to less than 7π mm-mrad transverse emittance in less than 2 seconds by the Debuncher betatron stochastic cooling systems.

Table I Basic Parameters of the Fermilab Antiproton Project

Main Ring Energy	120 GeV
# protons on target/2 sec cycle	$2x10^{12}$
pulse length	1.5 μsec
$\bar{p}$ production momentum	8.9 GeV/c
# $\bar{p}$'s per cycle	$8x10^{7}$
transverse emittances ϵ_x, ϵ_y	20π mm-mrad
momentum spread $\Delta p/p$	3%
Debuncher Ring	
transverse acceptance	20π mm-mrad
momentum acceptance $\Delta p/p$	4%
$\bar{p}$ $\Delta p/p$ after bunch rotation	0.2%
$\bar{p}$ transverse emittance after 2 sec	< 7π mm-mrad
Accumulator Ring	
transverse acceptance	10π mm-mrad
$\bar{p}$ density at injection	7 per eV
in core	> 10^{5} per eV
stacking time	5 hours
# $\bar{p}$'s in stack core	$5x10^{11}$
$\Delta p/p$ of stack core	0.1%
transverse emittance of core	2π mm-mrad

The beam is then transferred to the Accumulator ring (revolution period = 1.59 μsec) where antiprotons are stochastically cooled and stacked for periods of many hours. There are 6 stochastic cooling systems, 3 working on the newly injected antiprotons in the stack tail, and 3 working on the stack core. During this stacking process the transverse emittances are further reduced to about 2π mm-mrad, and the density in momentum space is increased from about 7 per eV at injection to over 10^{5} per eV in the stack core. The total number of antiprotons in the stack core is expected to reach $5x10^{11}$ after 5 hours stacking. At regular intervals, of the order of $1x10^{11}$ antiprotons are removed from the core, transported backwards down the beam transfer line where they are injected into the Main Ring, accelerated, rebunched into a single 53 MHz RF bucket, and transferred into the Tevatron.

A plan view of the Debuncher and Accumulator rings, indicating the position of the stochastic cooling systems, is shown in Figure 2. Basic parameters of the stochastic cooling systems are outlined in Table II. All systems are microwave, operating in either the 1-2 GHz or 2-4 Ghz band. All pickups and kickers are loop (quarter wave) couplers, which have a natural octave bandwidth.

Low noise GaAsFet amplifiers are used throughout, and are cooled to liquid nitrogen temperatures (as are the back termination resistors) to reduce thermal noise. In all cases, traveling wave tube amplifers (TWT's) are used as the source of output power in the microwave bands.

Table II Stochastic Cooling Systems in the Fermilab Antiproton Source

System	Frequency	Gain	Power	# TWT's	loop coupler pairs pickups	kickers
Debuncher H betatron	2-4 GHz	135 db	500 W	8	128	128
Debuncher V betatron	2-4	135	500	8	128	128
Accumulator stack tail momentum	1-2	150	1600	40	172	160
Accumulator stack tail H betatron	1-2	125	210	2	32	32
Accumulator stack tail V betatron	1-2	125	20	1	32	32
Accumulator stack core momentum	2-4	110	30	1	64	32
Accumulator stack core H betatron	2-4	105	10	1	8	8
Accumulator stack core V betatron	2-4	105	10	1	8	8

*Operated by Universities Research Inc., under contract with the U.S. Department of Energy.

The largest system (Accumulator stack tail momentum) uses 40 TWT's, for a total RF power output of 1600 watts. This system is the most complex, and is reported on in a following paper. Two other papers report on the status of R&D efforts related to this system; the development of superconducting notch filters, and the development and evaluation of loop coupler pickup arrays. The paper on page 581 reports on the design of the Debuncher betatron cooling system.

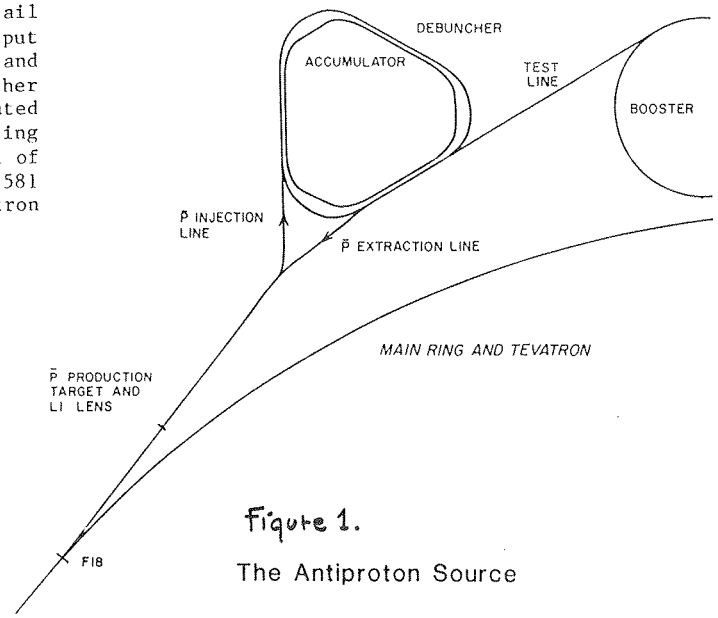

Figure 1.

The Antiproton Source

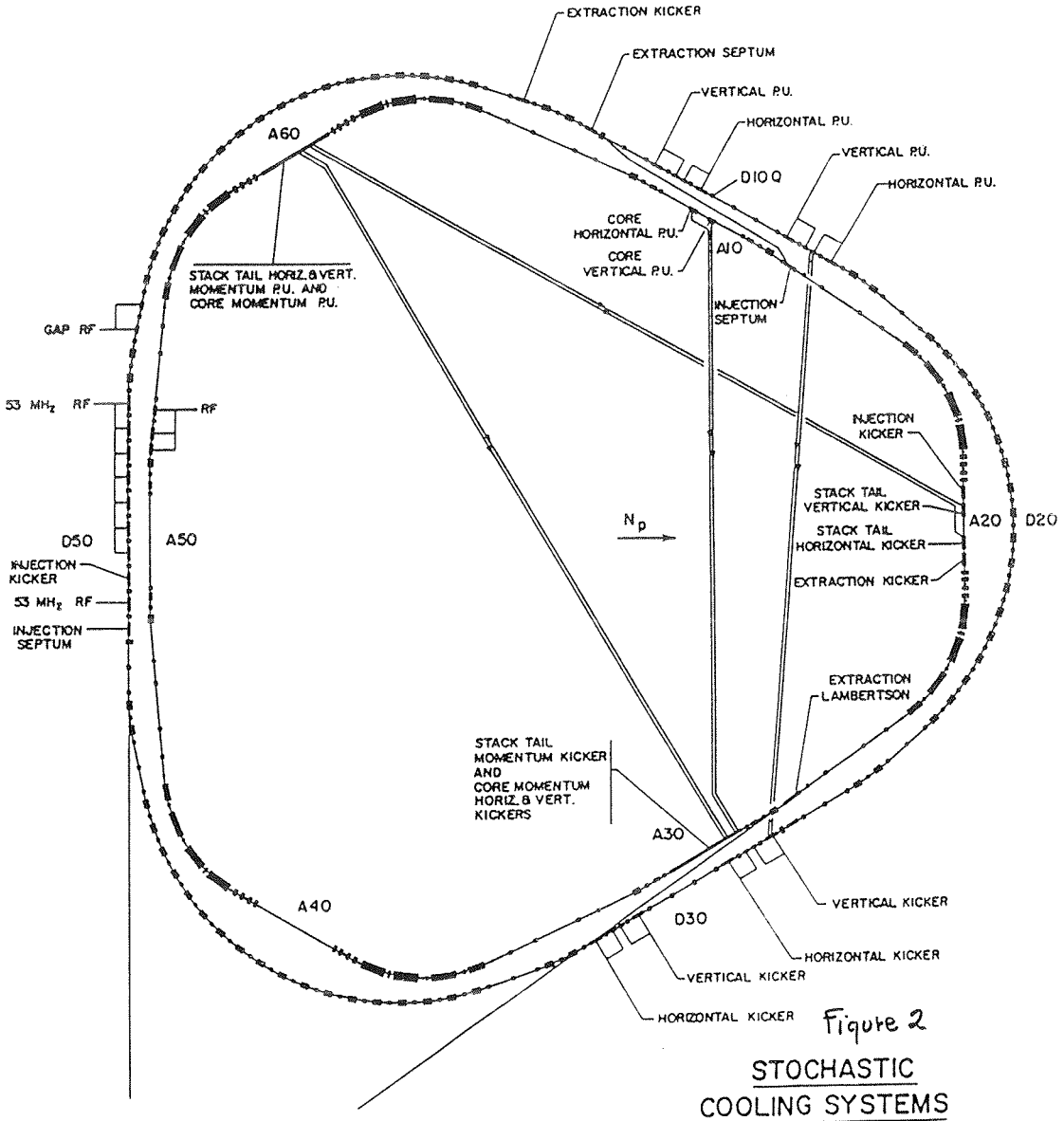

Figure 2

STOCHASTIC COOLING SYSTEMS

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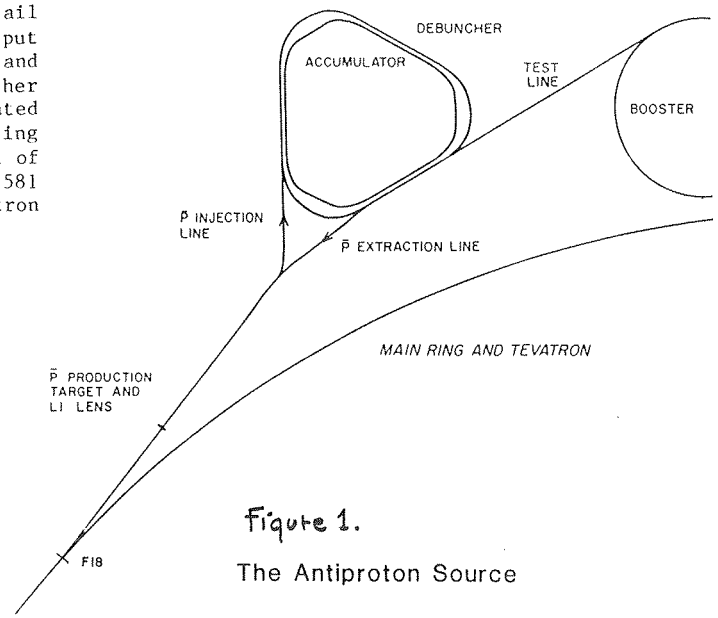

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The Antiproton Source

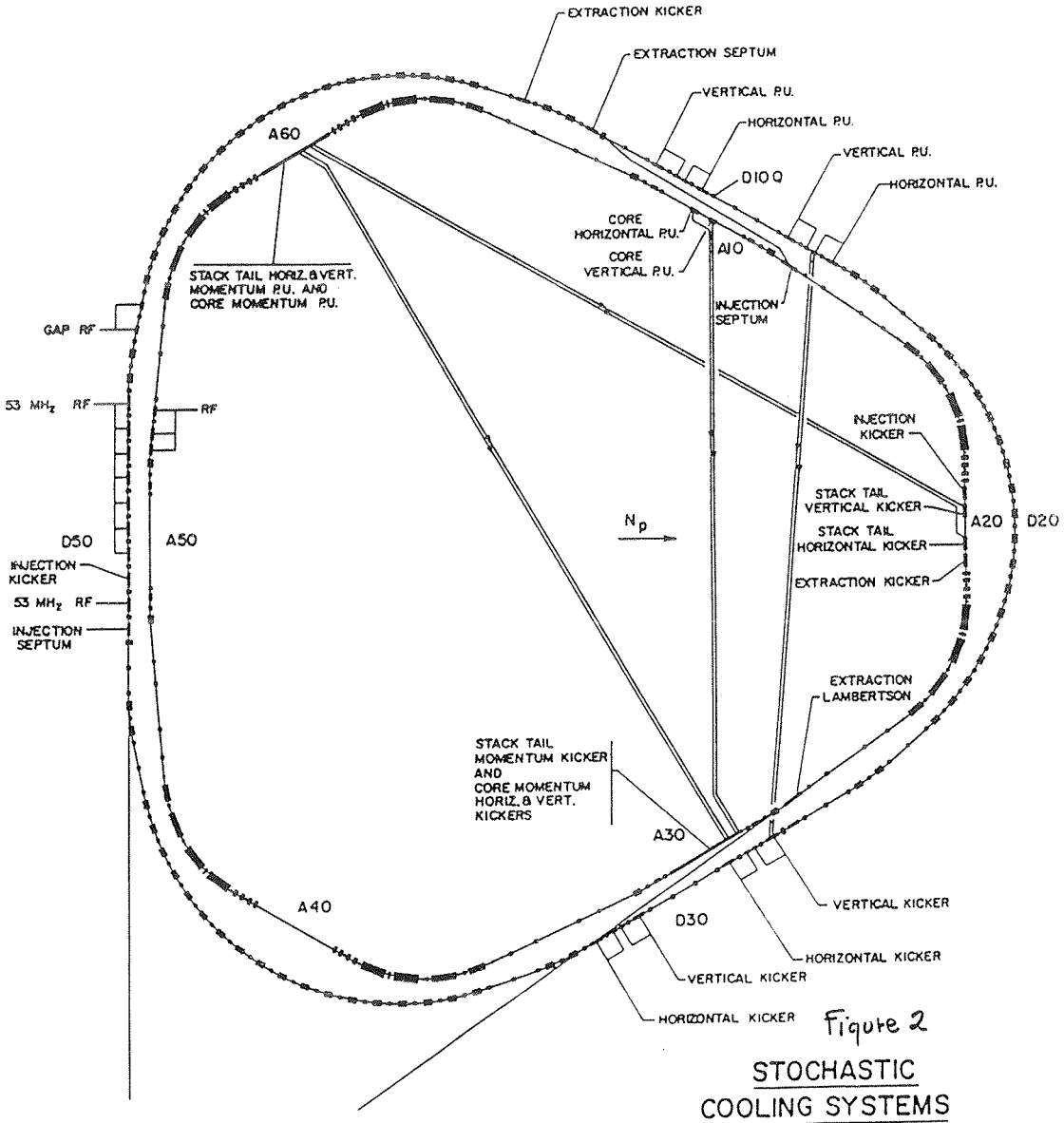

Figure 2

STOCHASTIC COOLING SYSTEMS