

DESIGN REPORT TEVATRON 1 PROJECT

SEPTEMBER 1984

**FERMI NATIONAL ACCELERATOR LABORATORY
BATAVIA, ILLINOIS**

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

TABLE OF CONTENTS

1.	Introduction and Overview	1-1
2.	Proton Acceleration and Extraction for Antiproton Production	2-1
	2.1 Proton Acceleration	2-1
	2.2 Extraction at F17.....	2-3
3.	Antiproton Production	3-1
	3.1 Antiproton Yields and Targeting	3-1
	3.1.1 Antiproton Production Cross Sections	3-1
	3.1.2 Proton Energy	3-1
	3.1.3 Antiproton Momentum	3-1
	3.1.4 Antiproton Longitudinal Acceptance	3-2
	3.1.5 Antiproton Transverse Acceptance	3-2
	3.1.6 Targeting Limitations	3-2
	3.2 Antiproton Target System Components	3-3
	3.2.1 Antiproton Production Target	3-4
	3.2.2 Antiproton Collection; the Lithium Lens	3-5
	3.2.3 Antiproton Selection	3-6
	3.3 Target Hall	3-6
4.	Debuncher Ring	4-1
	4.1 Purpose of the Debuncher	4-1
	4.2 Requirements of the Design	4-1
	4.3 Choice of Transition Energy	4-2
	4.4 Lattice	4-3
	4.5 Magnets	4-3
	4.6 Tuning	4-4
	4.7 Sextupoles	4-5
	4.8 Magnet Power Supplies	4-6
	4.9 Bunch Rotation and Other RF Manipulation	4-7
	4.10 RF Systems for Bunch Rotation and Debunching	4-9
	4.11 Gap-Preserving RF	4-11
	4.12 Beam Injection and Extraction	4-11
	4.12.1 Injection from the Target Station	4-11
	4.12.2 Debuncher to Accumulator Transfer	4-12
	4.12.3 Injection from the Booster	4-12
	4.13 Betatron Cooling	4-12
	4.13.1 Design Goal	4-12
	4.13.2 Design Considerations	4-13
	4.13.3 Hardware	4-13
	4.13.4 Computer Simulation	4-15
5.	Accumulator Ring	5-1
	5.1 Accumulator-Functional Summary	5-1
	5.2 Design Requirements	5-2
	5.3 Accumulator Lattice	5-3
	5.4 Tuning	5-7
	5.5 Chromaticity Corrections	5-7
	5.6 RF Stacking System	5-8
	5.7 Accumulator Magnets	5-9
	5.8 Accumulator Vacuum System	5-10
	5.8.1 Vacuum Requirements	5-10
	5.8.2 Vacuum System Layout and Characteristics	5-11

5.9	Momentum Cooling	5-12
5.9.1	Introduction to Stochastic Stacking	5-12
5.9.2	Summary of Design Considerations	5-15
5.9.3	Building the Exponential Gain Profile	5-16
5.9.4	Signal Suppression and Stability	5-18
5.9.5	Core Cooling	5-20
5.9.6	Numerical Calculations of Momentum Cooling	5-21
5.10	Betatron Cooling	5-21
5.10.1	Introduction	5-21
5.10.2	Betatron Cooling in the Core	5-23
5.10.3	Stack-Tail Betatron Cooling	5-23
5.10.4	Operation of Betatron Cooling Systems	5-24
5.11	Stochastic-Cooling Hardware	5-24
5.11.1	Pickup Electrodes	5-24
5.11.2	Preamplifiers	5-27
5.11.3	Notch Filters	5-28
5.11.4	Traveling Wave Tubes (TWT's)	5-29
5.11.5	Kicker Electrode Assemblies	5-31
5.11.6	Other Considerations	5-31
5.11.7	Accumulator Stochastic Cooling System Layout	5-32
6.	Extraction of Antiprotons from the Accumulator to the Main Ring	6-1
6.1	Accumulator Beam Manipulation and Extraction	6-1
6.2	Main Ring Acceleration and Bunch Recombination.....	6-4
6.2.1	Introduction	6-4
6.2.2	Injection and Acceleration.....	6-4
6.2.3	Bunch Recombination at 150-GeV	6-4
7.	The Main Ring in Tevatron I	7-1
7.1	Functions of the Main Ring in Tevatron I	7-1
7.2	Antiproton Injection	7-2
7.3	Main Ring Acceleration and Rebunching Hardware	7-3
7.4	Main Ring Overpass	7-3
7.5	Main Ring Diagnostics	7-6
7.6	DO Overpass	7-6
8.	The Energy Saver in Tevatron I	8-1
8.1	Functions of the Energy Saver in Tevatron I	8-1
8.2	Energy Saver Lattice	8-1
8.2.1	Ring Location and Normal Lattice	8-1
8.2.2	Normal and High - Beta Long Straight Section	8-2
8.2.3	Lattice Elements	8-3
8.2.4	Low Beta Long Straight Section	8-3
8.3	Correction Systems	8-4
8.3.1	Types of Correction Elements	8-4
8.3.2	Correction Magnet Circuits	8-5
8.3.3	Coil Strength Requirements	8-6
8.3.4	Excitation	8-9
8.3.5	Power Supplies	8-10
8.4	Main Ring Extraction and Energy Saver Injection and Abort	8-11
8.5	Acceleration of Protons and Antiprotons	8-14
8.5.1	Energy Saver RF Requirements for Colliding Beams	8-14
8.5.2	Failure modes	8-15

8.6	Energy Saver Diagnostics	8-16
8.6.1	Energy Saver Position Detectors	8-16
8.6.2	Beam-Loss Monitors	8-17
8.6.3	Diagnostics for the Energy Saver Collider Operation	8-17
9.	Interaction Regions and Experimental Facilities	9-1
9.1	Experimental Areas	9-1
9.1.1	B0 Experimental Areas	9-1
9.1.2	D0 Experimental Areas	9-2
9.2	B0 Low-Beta Design	9-2
9.2.1	Lattice Design	9-2
9.2.2	Transition to Low Beta	9-2
9.3	Hardware Modifications	9-3
9.3.1	Magnets	9-3
9.3.2	Power Supplies and Bus	9-4
9.3.3	Refrigeration	9-4
9.3.4	Vacuum	9-4
9.4	D0 Low-Beta Design	9-4
10.	Performance and Luminosity	10-1
10.1	Beam Geometry	10-1
10.2	Beam Cross Section at the Collision Point	10-1
10.3	Luminosity	10-2
10.4	Beam - Beam Tune Shift	10-3
10.5	Single - Beam and Luminosity Lifetime	10-3
10.5.1	Effects of Residual Gas	10-4
10.5.2	Intrabeam Scattering	10-4
10.5.3	Beam - Beam Effects	10-6
10.5.4	Total Cross Section	10-7
10.5.5	Luminosity Lifetime	10-7
10.6	Collider Filling Strategy	10-8
11.	Beam-Transport Lines	11-1
11.1	120-GeV Proton Transport from F17 to Target (Line AP-1)	11-1
11.2	8-GeV Antiproton Transport to Debuncher (Line AP-2)	11-3
11.3	Debuncher to Accumulator Transfer (Line D To A)	11-5
11.4	Accumulator to Main Ring Transport (Line AP-3)	11-6
11.5	Booster Test Beam Line (Line AP-4)	11-7
11.6	Beam-Line Vacuum Systems	11-9
12.	Magnets and Magnet Power Supplies	12-1
12.1	Magnets	12-1
12.2	Magnet Power Supplies	12-1
12.2.1	Debuncher	12-1
12.2.2	Accumulator	12-2
12.2.3	Beam Lines	12-3
13.	Controls	13-1
13.1	General Requirements and Architecture	13-1
13.2	Computer Configuration	13-1
13.3	Software	13-2
13.4	Communications	13-2
13.5	Magnet Controls	13-3
13.6	Transfer Marker Timing System (XMR)	13-3
13.7	Vacuum Controls	13-5

13.8	RF Control System	13-5
13.9	Stochastic Cooling Controls and Monitoring	13-6
13.10	Tev I Beam Diagnostics Interface to the Controls System	13-9
	13.10.1 Beam Position Monitors	13-9
	13.10.2 Beam Loss Monitors	13-13
	13.10.3 Beam Current Monitors	13-13
	13.10.4 Beam Profile Measurements	13-13
13.11	Utility Monitoring for the Antiproton Source	13-14
14.	Conventional Construction	14-1
14.1	Antiproton Source Construction	14-1
	14.1.1 F18 Extraction Hall	14-2
	14.1.2 Pretarget Enclosure	14-3
	14.1.3 Antiproton Target Hall and 120-GeV Transport System ..	14-3
	14.1.4 Antiproton Transport Enclosure	14-5
	14.1.5 Debuncher-Accumulator Ring Enclosure	14-6
	14.1.6 Antiproton Service Buildings	14-7
	14.1.7 Booster Beam Enclosure and 8-GeV Target Station	14-8
	14.1.8 Radiation Shielding	14-9
	14.1.9 Survey and Alignment Control	14-11
	14.1.10 Roads, Hardstands, and Parking	14-12
	14.1.11 Underground Utilities	14-13
	14.1.12 Primary Power, Switchgear, and Substations	14-14
	14.1.13 Secondary Power and Distribution	14-15
	14.1.14 Process-Water Systems	14-15
	14.1.15 Finished Site Drainage	14-16
	14.1.16 Landscaping	14-17
14.2	BO Colliding Beam Area	14-17
	14.2.1 BO Colliding Beam Experimental Area	14-18
	14.2.2 200-GeV Vertical Beam Bypass	14-21
	14.2.3 Experimental-Equipment Foundations	14-21
	14.2.4 Radiation Shielding	14-22
15.	Options for Future Improvements	15-1
	15.1 Momentum Cooling	15-1
	15.2 Target Development	15-2
	15.3 Improvements in Stochastic Cooling	15-3
	15.4 Electron Cooling of the Core	15-3

Appendices

- A. Beam Line, Accumulator and Debuncher Notation
- B. Parameters
- C. Site Coordinates
- D. Debuncher SYNCH
- E. Accumulator SYNCH