TM-87
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BOOSTER REFERENCE DESIGN, PART I

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Introduction

The purpose of this note is to summarize the booster reference design and present corresponding parameters. To avoid further delay in disseminating this information, the design will be described in general terms in this note and in more detail in later notes.

General Description

The reference design of the booster has developed from the concept of modular construction of the synchrotron ring as utilized at the Cornell 10 GeV machine. As presently envisioned, the machine module will consist of a magnet pair (F and D) supported by a box beam. This contains the resonant energy storage components for the magnets, a vacuum pump, and a multiplex monitoring station. The module design is being refined with a view to minimizing the number of connections which must be made to it.

The magnet itself has been progressively reduced in overall size and stored energy without decreasing the acceptance. This was achieved: 1) by curving the magnet to eliminate the sagitta; 2) by dividing each magnet into two regions having apertures commensurate with the beam profile; 3) by allowing the good field width to reduce with the increasing field; and 4) by removing the vacuum chamber from between the poles. As presently conceived, the magnet and its coil will be enclosed in a stainless steel vacuum box.

The reduction in the magnetic stored energy facilitated the installation of the resonant energy storage components inside the box beam which serves as the support for the magnet pair. This, in turn, removed the necessity for an equipment gallery running around adjacent to the whole ring. Consequently, the gallery has been reduced to 90° sectors adjoining the injection and ejection locations. This will allow for up to 8 rf locations which correspond to the amount of rf which would be required with normal 15 Hz magnet excitation. However, a study of adding second harmonic excitation to the magnet cycle has indicated the possibility of reducing the number of rf cavities required from 16 to 14 (7 rf locations).

The flexibility inherent in the 48 cell resonant network for the magnet excitation, permits reconnection of the components for cycling rates of 7.5 Hz, 15 Hz, or 30 Hz. It is now intended to start up the booster at 7.5 Hz with only 8 rf cavities. This is referred to as Phase I. At this repetition rate the filling time of the Main Ring would be 1.6 seconds; thus, the design intensity for the Main Ring could be achieved with 25% more charge per cycle from the booster than that required at 15 Hz.

During the first few months of operation, efforts will be made to assess the required repetition rate by measurements on both the linac and booster beams. For purposes of allocating straight action space, possible future operation at 15 Hz or 30 Hz will be referred to as Phase II and Phase III, respectively.

GENERAL PARAMETERS

Output energy	10 BeV
Input energy	0.2 BeV
Harmonic number	84
γ (transition)	5.373
Beam intensity	3.5×10^{12} protons/pulse
Main ring intensity	1.5×10^{13} protons/sec.
Average orbit radius	75.4717 m
Circumference factor	1.709
Focussing period	FoFDooD
No. of focussing periods	24
Cycling rate	15 Hz*
Average guide field at 200 MeV	487 Gauss
Average guide field at 10 GeV	8.234 kG
Betatron oscillation wave numbers	$\nu_x = 6.7$ $\nu_x = 6.8$
Synchrotron oscillation wave number	$(\nu_x)_{max} = 0.08$
Injector accelerator	Alvarez Linac
Lowest calculated space charge limit (i.e. incoherent transverse defocusing)**	8.7×10^{12} protons/pulse
Linac beam intensity, nominal	75 mA
Typical injection operational mode	4 turns, 67.5 mA; horizontal stacking
Charge injected into main ring (13 cycles)	4.5×10^{13} protons
Revolution period τ (inj)	2.77 μsec
Revolution period τ (ej)	1.57 μsec

* Can be reconnected for 7.5 Hz or 30 Hz.

** $\Delta\nu = 0.25$, "good field" acceptance limit.

Injector transverse emittance area	9π μrad-m, at 67.5 mA
Transverse emittance area, after stacking	$18\pi \times 54\pi$ (μrad-m)^2
"Good field" ($\Delta\nu < 0.1$)* acceptance	$40\pi \times 90\pi$ (μrad-m)^2
Transverse emittance, at ejection, nominal	$1.1\pi \times 3.3\pi$ (μrad-m)^2
Linac momentum spread, ($\Delta p/p$), after debuncher	$\pm 0.8 \times 10^{-3}$
Momentum spread for bunched beam, at injection	$\pm 1.8 \times 10^{-3}$
Bunching factor	0.44
Longitudinal phase space area at injection	1.6 eV-sec. (10^{-2} radians)
Bucket area, at injection	3.0 eV-sec.
Momentum spread, at ejection**	$\pm 0.6 \times 10^{-3}$
Booster bunching factor, at ejection	0.14
Longitudinal phase space, at ejection**	3.2 eV-sec.

MAGNET SYSTEM

Excitation

$$I\ (\text{amps}) = 634 - 526 \cos(2\pi\, 15t) + \frac{526}{8} \cos(2\pi\, 30t + 1)$$

<u>Gradient Magnets (H Type)</u>

	F Magnet	D Magnet
Number of gradient magnets	48	48
Effective (magnetic) length	2.8896 m	2.8896 m
Physical length	113.764"	113.764"
Cross section, V x H	12" x 16"	12" x 16"
Lamination thickness	0.025" (Gauge 24)	
Steel type	Electrical steel, Grade M22	
Magnet core weight per magnet	4420 lbs.	3980 lbs.

* $\delta p/p$ taken to be zero

** dilution factor of 2

	F. Magnet	D Magnet
Total weight, magnet settl	195 tons	
Magnet support	F, D magnet single modular unit	
Modular unit weight	6 tons	
Beam orbit height	4 ft.	
Number of coils per magnet	4	4
Number of turns per coil	12	14
Conductor cross section	0.45" square with 0.25" diameter hole	

EONG STRAIGHT SECTION ALLOCATIONS

1L	Injection septum
2L	Injection monitoring
5L	Beam scraper
10L	Ejection kickers
11L	Ejection septum
12L	RF (Phase I)
13L	RF (Phase I)
14L	RF (Phase I)
15L	RF (Phase I)
16L	Radial and phase pickup electrodes
17L	Wide band beam detector
18L	Radial and phase pickup electrodes
19L	RF (Phase II)
20L	RF (Phase II)
21L	RF (Phase II)
22L	RF (Phase II)

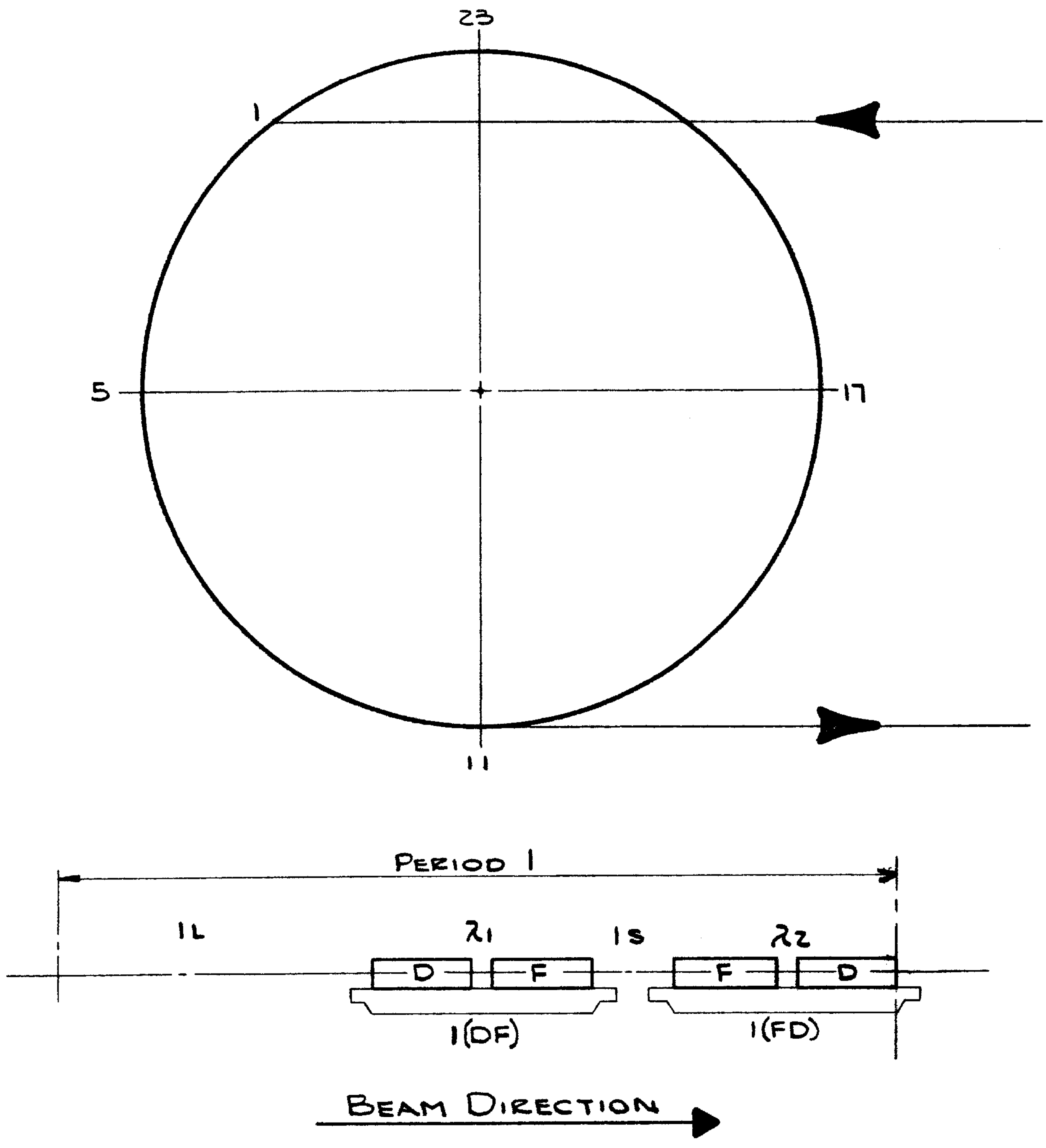

FIGURE 1

PERIOD NOMENCLATURE

Figure 2 LATTICE PARAMETERS

D_1		L		D_1		D_2		λ		F_1		F_2		S
Orbit Lengths (m)		6.000		1.481		1.4086		0.5		1.6156		1.274		1.2
Betatron Functions (m)	β_H	6.12	7.59		10.55		17.31		20.89		30.94		33.68	33.67
	β_V	19.99	20.44		18.44		12.99		10.82		6.44		5.35	5.28
Momentum Compaction Function α_p (m)		1.874	1.874		2.016		2.43		2.63		3.11		3.22	3.22
Minimum Semi-Apertures (mms)	H	24	26		31		40		44		53		55	55
	V	29	29		28		23		21		16		15	14
Magnet Gaps (inches)				2.25		2.14				1.64		1.27		
Total Excitation Turns					28						24			
Bending Angles (mrads)				28.524		28.524				36.591		37.261		
Peak Central Field (kG) (10 BeV)				7.001		7.361				8.233		10.632		
Profile Parameter (m^{-1})				-3.00		-2.85				2.39		1.85		
Peak Ampere-turns					31840						27290			