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Booster parameter list with 90 Kv RF voltage

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U.S. Department of Energy

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BOOSTER PARAMETER LIST WITH 90 Kv RF VOLTAGE

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ABSTRACT

This note describes the parameter list for the AGS-Booster. The following changes were made and should be noted:

The rf voltage was raised to 90 kV, 45 kV per cavity, the number of rf cavities having been increased from one to two.

Please also note the following changes that were made in mid-June upon the recommendation of the Advisory Panel:

Instead of producing 1.0 GeV protons at a 10 Hz rate, the machine will be designed initially to produce 1.5 GeV protons at a rate of 7.5 Hz.

The energy at ejection for Au^{+33} ions will be 350 MeV instead of 320 MeV, and the ejection dipole field for heavy ions will therefore be increased by about 5%. The original field was 12.13 kG.

The large Q5 quadrupoles are dispensed with; i.e., normal-sized main ring quadrupoles are used at the Q5 location.

These changes will be reflected in the Booster Design Manual, Version 1. [1]

BOOSTER PARAMETER LIST

1.1. Introduction

The AGS Booster is designed to be an intermediate synchrotron injector for the AGS, capable of accelerating protons from 200 MeV, the linac operating energy, to 1.5 GeV, (with the possibility of an upgrade to 2.5 GeV), at a repetition rate of 7.5 Hz, and capable of accelerating heavy ions to a magnetic rigidity equal to 17.52 Tesla-meters at a 1 Hz repetition rate.

As presently designed, the Booster will have: A circumference equal to one quarter that of AGS; with six identical superperiods. It will have a FODO lattice with bending magnets missing in some cells in order to accommodate the space needed for RF acceleration, injection, ejection and abort system without otherwise interrupting the periodicity. The dipoles of the proposed lattice have an aperture of 3.25" x 10" and an injection field of about 1.6 kG (0.7 kG for heavy ions).

In total, the Booster will have 36 dipoles, each of 2.4 meter magnetic length, and 48 quadrupoles which have 0.50375 meter magnetic length. We have chosen a "separated function" structure with quadrupoles and zero-gradient dipoles. Furthermore, for maximum tuning versatility the dipoles and the quadrupoles will be independently powered.

This note describes the parameter list of the AGS-Booster. The chromaticity correction sextupole configuration is 1,2,4,7 and the eddy current sextupole strengths aretaken to be 0.12 Tesla per meter square [2]. A schematic layout of the Booster lattice and its superperiods are also included [3-5]. The present values of the Booster parameters are tabulated below. (Note that, the values listed are for theoretical calculations.) This updates the Booster Parameter List given in Ref. 6.

1.2. Lattice

circumference	201.78 m (1/4 AGS)
periodicity	6
number of cells	24 FODO
length	8.4075 m
phase advance/cell	72.3°, 72.45°
tunes	q_x= 4.82, q_y= 4.83
β_x max/min	13.865/3.5754
β_y max/min	13.644/3.7033
x_p max	2.9515 m
transition γ	4.8812

Energy (MeV)	At Injection	At Ejection
protons	200 MeV (Bρ = 21.4962 kG-m)	1.5 GeV (Bρ = 75.069 kG-m)
heavy ions	$\geq$ 1 MeV/amu (Bρ = 1.4403 A/q kG-m)*	p = 5.252 q/A GeV/amu-c (Bρ = 175.194 kG-m)
(q is the charge of the heavy ions, whether fully stripped or not, delivered from the tandem.)		

*At 1 MeV/amu.

1.3. RF System

number of stations (4 in total)
- 2 for protons (including ↑ protons)
- 2 for heavy ions
- (where ↑ ≡ polarized)

harmonic number
- 3 for protons (including ↑ protons)
- 3 for heavy ions (1 for RHIC)

frequency range (MHz)
for protons (including ↑ protons) 2.5 - 4.12
for heavy ions 0.213 - 3.06 (0.071 - 1.02 for RHIC)

peak RF voltage (kV)
for protons (including ↑ protons) 90
for heavy ions 17

acceleration time (ms)
for protons (including ↑ protons) 62
for heavy ions 500

repetition rate
for protons 7.5 Hz (4 pulses/AGS pulse)
for ↑ protons 1 Hz (1 pulse/AGS pulse)
for heavy ions 1 Hz (1 pulse/AGS pulse)

1.4. Dipoles

(dipoles are curved and wedged for 0 entrance angle)

number 36
length (magnetic) 2.4 m
gap 82.55 mm
gap vacuum chamber 66 mm
good field region ($<10^{-4}$) 16×6.6 cm

injection field (kG)
for protons (including ↑ protons) 1.5633
for heavy ions (1 MeV/amu) 0.1047 A/q

ejection field (kG)
for protons (including ↑ protons) 5.459
for heavy ions 12.740

lamination thickness < 1.5 mm
(0.6 mm around ends)

1.5. Quadrupoles

number	48
length (magnetic)	0.50375 m
aperture	16.52 cm

vacuum chamber aperture 15.25 cm (circular)

with Gf = +11.999 (kG/m)
Gd = -12.369 (kG/m)

injection pole tip field (kG)
for protons (including ↑ protons)
Bf =0.9899, Bd =1.0204
for heavy ions (at 1 Mev/amu)
Bf = 0.06635 A/q, Bd = 0.0683 A/q

ejection pole tip field (kG)
for protons (including ↑ protons)
Bf = 3.457, Bd = 3.5635
for heavy ions
Bf = 8.0706 Bd = 8.3078

lamination thickness 0.6 mm

field quality
sextupole harmonic 0
($6\theta/2\theta$ eliminated by shaping pole tip)

all other harmonics $< 10^{-4}$

1.6. Sextupoles

location	1,7 (sf), 2,4 (sd)
number	24 (12 sf + 12 sd)
length	10 cm
aperture	16.52 cm

at 1.5 GeV with integrated strength (T/m):

injection pole tip field (kG)

for protons (including ↑ protons)	0.45761
for heavy ions (at 1 MeV/amu)	0.03065 A/q

ejection pole tip field (kG)
for protons (including ↑ protons)
for heavy ions

1.7. Other Parameters

max. vacuum pressure (N2 eq.) 3×10^{-11} torr

max. intensity (particles per pulse)

for protons	$1 - 3 \times 10^{13}$
for ↑ protons	10^{12}
for heavy	$\sim 10^{11}$ A/q^2 (space charge)

1.8. Illustrative Injection and Ejection Energies

The following tables give the values of injection and ejection energies and dipole field strengths for the charge states shown. (The generalized values are given in the table in section 1.2.)

TABLE I. Injection Energies and Fields

	v/c	f	p	E_{inj}		B_{inj}
		MHz	GeV/c	MeV	MeV/amu	kG
p	0.5662	2.52349	0.64445	200.0	198.5552	1.56326
d	0.1767	0.78778	0.33681	30.0	14.8990	0.81700
C	0.1262	0.56230	1.42112	90.0	7.5021	0.57455
S	0.1000	0.44572	2.99248	150.0	4.6927	0.51850
Cu	0.0782	0.34853	4.59689	180.0	2.8609	0.53099
I	0.0595	0.26534	7.04889	210.0	1.6550	0.58961
Au	0.0478	0.21308	8.78045	210.0	1.0663	0.64543

TABLE II. Ejection Energies and Fields

	v/c	f	p	E_{ejec}		B_{ejec}
		MHz	GeV/c	GeV	GeV/amu	kG
p	0.92299	4.114	2.25052	1.5000	1.48916	5.4592
d	0.94176	4.198	5.25247	3.7017	1.83839	12.7412
C	0.94250	4.201	31.51483	22.2625	1.85572	12.7412
S	0.92690	4.131	73.53459	49.5591	1.55045	12.7412
Cu	0.88308	3.936	110.30189	66.2974	1.05371	12.7412
I	0.79004	3.521	152.32166	74.6045	0.58795	12.7412
Au	0.68676	3.061	173.33155	68.9320	0.35000	12.7412

TABLE III.

	Q	Z	A	Ionic Mass amu
p	+1	1	1	1.00728
d	+1	1	2	2.01355
C	+6	6	12	11.99671
S	+14	16	32	31.96439
Cu	+21	29	63	62.91808
I	+29	53	127	126.88857
Au	+33	79	197	196.94846

References

[1] Z. Parsa and R. Thomas, eds., Booster Design Manual, Version 1, (in progress).

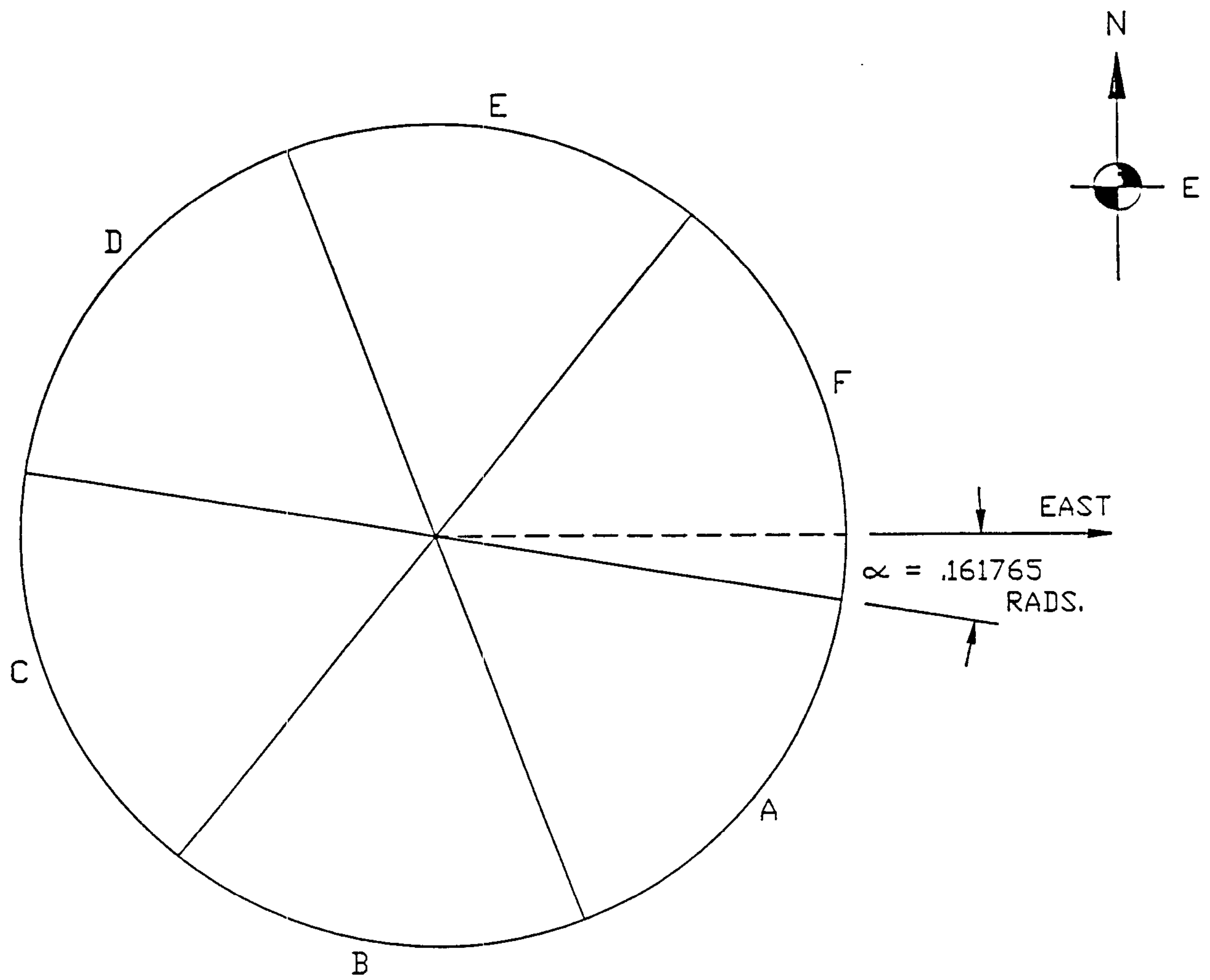
[2] G. Morgan and S. Kahn, Calculation of Eddy Currents, BST/TN 4, (January 1986).

[3] E. Courant and Z. Parsa, Booster Lattice, BST/TN 1, (January 15, 1986).

[4] E. Courant and Z. Parsa, Chromaticity Correction for the AGS-Booster with 1, 2, 4, 7 Sextupole Configuration, BST/TN 17, (March 5, 1986).

[5] Z. Parsa, Booster Coordinates, BST/TN 6, (January 28, 1986).

[6] Z. Parsa, AGS-Booster Parameter List, BST/TN 2, (January 16, 1986); BST/TN 20, (March 10, 1986), BST/TN 25, (April, 1986), BST/TN 43, (April 1986), Z. Parsa and R. Thomas, eds., Booster Design Manual, Preliminary, (May 1986).



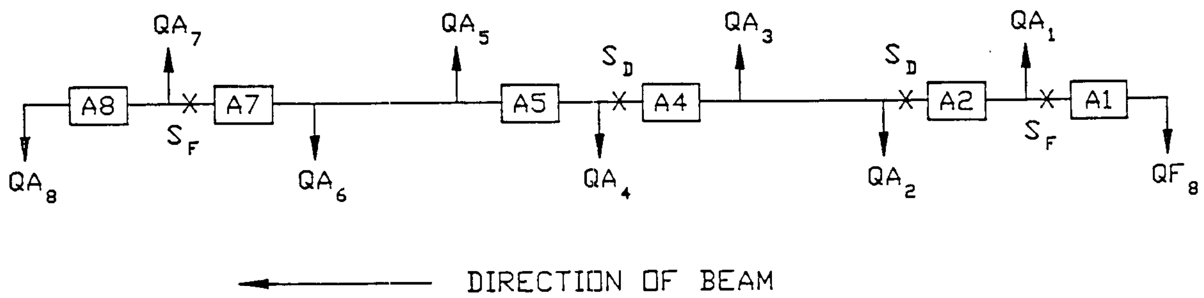


Fig. 1a Standard AGS - Booster

↑ = FOCUSING QUADRUPOLE

↓ = DEFOCUSING QUADRUPOLE

☐ = BENDING MAGNET (DIPOLE)

X = SEXTUPOLE

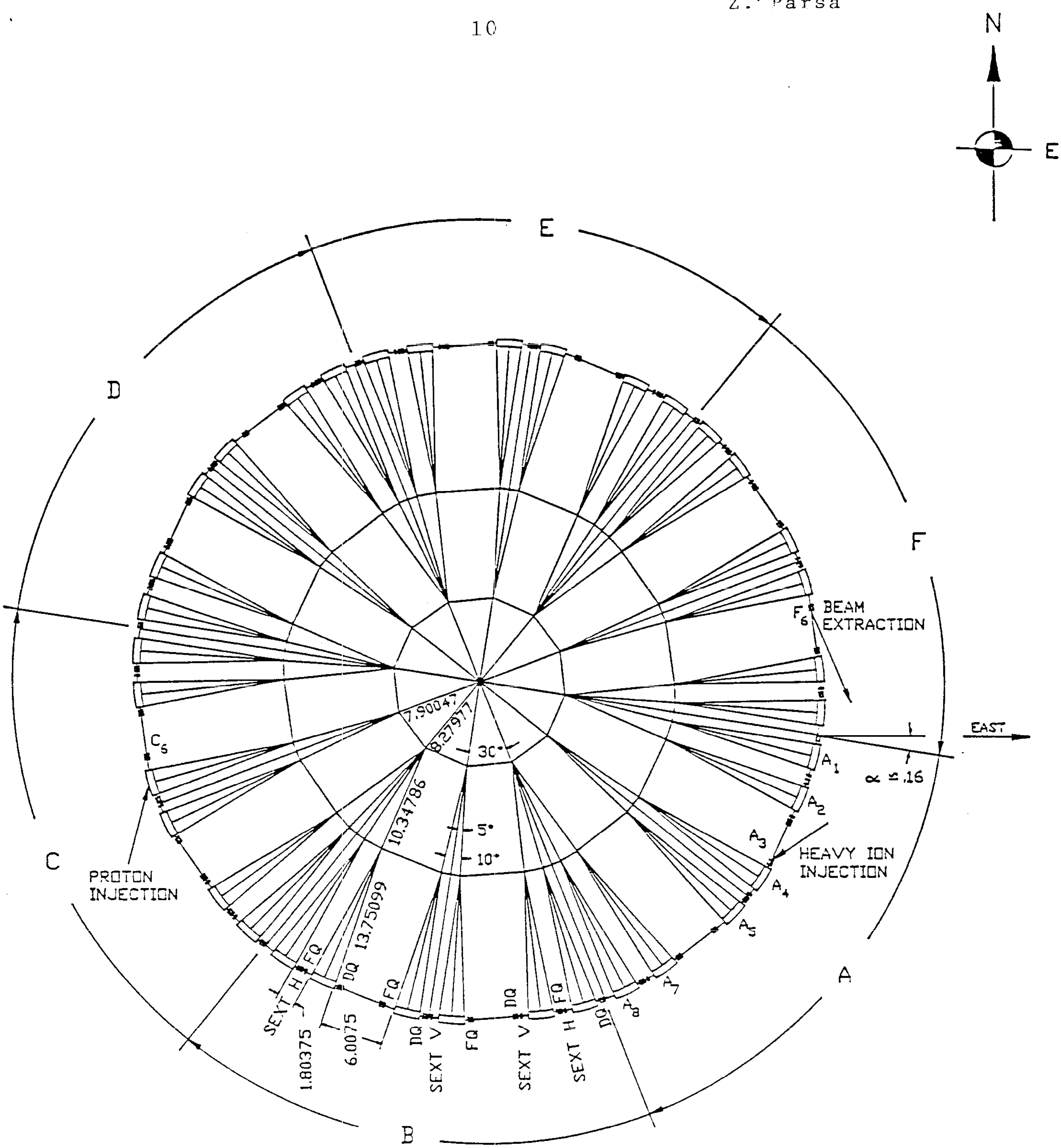


Fig. 1 b   The Standard AGS - Booster Lattice

NOTE: ALL DIMENSIONS ARE IN METERS