

## Booster parameter list with 90 Kv RF voltage

Z. Parsa

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Collider Accelerator Department  
**Brookhaven National Laboratory**

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BOOSTER PARAMETER LIST WITH 90 Kv RF VOLTAGE

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Z. PARSA

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ACCELERATOR DEVELOPMENT DEPARTMENT  
*Brookhaven National Laboratory*  
Upton, N.Y. 11973

## 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  $\text{Au}^{+33}$  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., normalized 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 are taken 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	$q_x = 4.82, q_y = 4.83$
$\beta_x$ max/min	13.865/3.5754
$\beta_y$ max/min	13.644/3.7033
$x_p$ max	2.9515 m
transition $\gamma$	4.8812

Energy (MeV)	At Injection	At Ejection
protons	200 MeV ( $B\rho = 21.4962$ kG-m)	1.5 GeV ( $B\rho = 75.069$ kG-m)
heavy ions	$\geq 1$ MeV/amu ( $B\rho = 1.4403$ A/q kG-m)*	$p = 5.252$ q/A GeV/amu-c ( $B\rho = 175.194$ 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  $\uparrow$  protons)  
 2 for heavy ions  
 (where  $\uparrow \equiv$  polarized)

harmonic number  
 3 for protons (including  $\uparrow$  protons)  
 3 for heavy ions (1 for RHIC)

frequency range (MHz)	
for protons (including $\uparrow$ 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 $\uparrow$ protons)	90
for heavy ions	17
acceleration time (ms)	
for protons (including $\uparrow$ protons)	62
for heavy ions	500
repetition rate	
for protons	7.5 Hz (4 pulses/AGS pulse)
for $\uparrow$ 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 ( $<10^{-4}$ )	$16 \times 6.6$ cm
injection field (kG)	
for protons (including $\uparrow$ protons)	1.5633
for heavy ions (1 MeV/amu)	0.1047 A/q
ejection field (kG)	
for protons (including $\uparrow$ 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  $G_f = +11.999$  (kG/m)  
 $G_d = -12.369$  (kG/m)

injection pole tip field (kG)  
 for protons (including  $\uparrow$  protons)  
 $B_f = 0.9899$ ,  $B_d = 1.0204$   
 for heavy ions (at 1 MeV/amu)  
 $B_f = 0.06635$  A/q,  $B_d = 0.0683$  A/q

ejection pole tip field (kG)  
 for protons (including  $\uparrow$  protons)  
 $B_f = 3.457$ ,  $B_d = 3.5635$   
 for heavy ions  
 $B_f = 8.0706$   $B_d = 8.3078$

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  $\uparrow$  protons) 0.45761  
 for heavy ions (at 1 MeV/amu) 0.03065 A/q



ejection pole tip field (kG)  
 for protons (including  $\uparrow$  protons)  
 for heavy ions

### 1.7. Other Parameters

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

max. intensity (particles per pulse)

for protons  $1 - 3 \times 10^{13}$

for  $\uparrow$  protons  $10^{12}$

for heavy  $\sim 10^{11}$  A/q<sup>2</sup> (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 MHz	p GeV/c	E <sub>inj</sub>		B <sub>inj</sub> kG
				MeV	MeV/amu	
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 MHz	p GeV/c	E <sub>ejec</sub>		B <sub>ejec</sub> kG
				GeV	GeV/amu	
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).

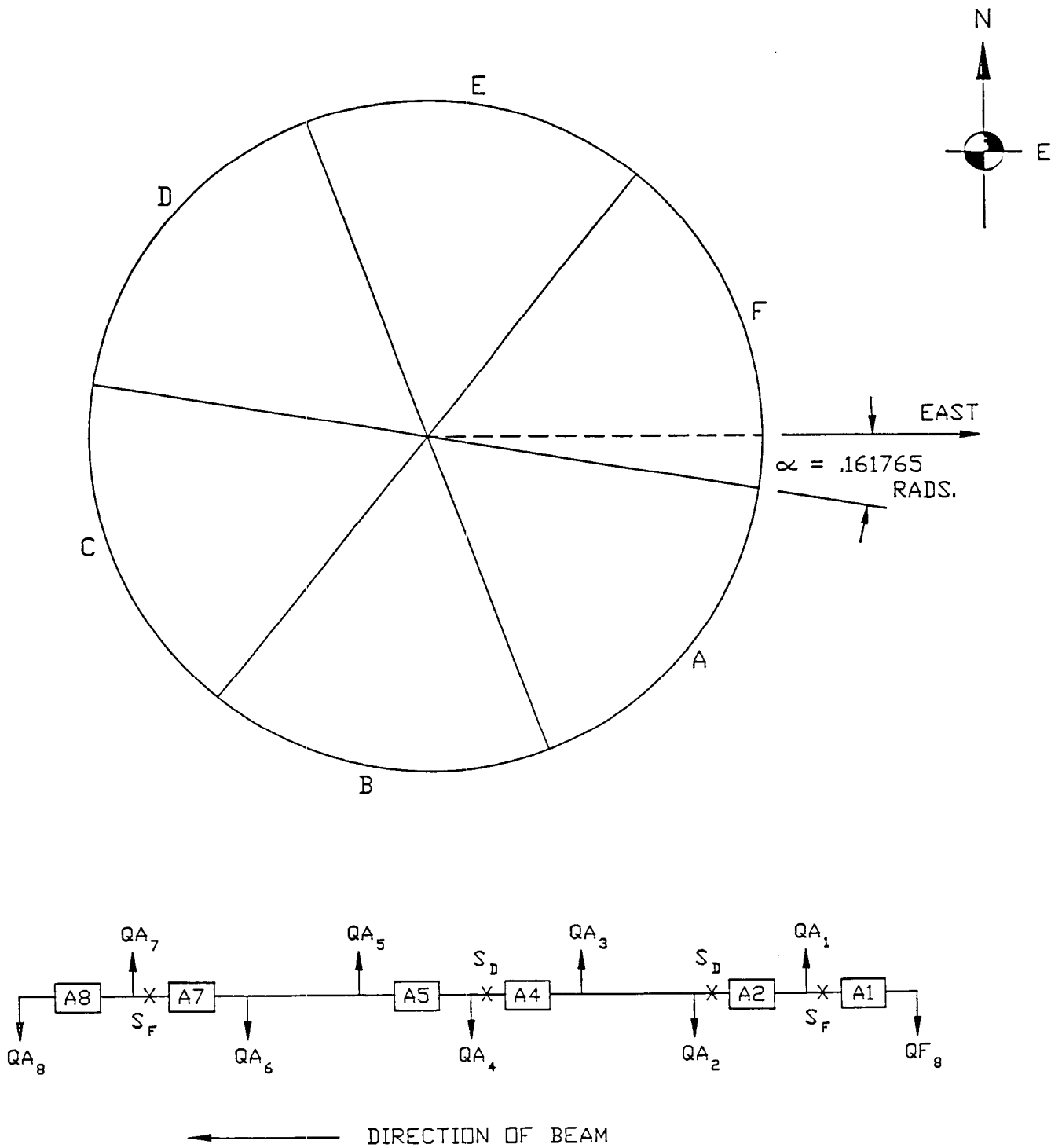


Fig. 1 a Standard AGS - Booster

- ↑ = FOCUSING QUADRUPOLE
- ↓ = DEFOCUSING QUADRUPOLE
- = BENDING MAGNET (DIPOLE)
- X = SEXTUPOLE

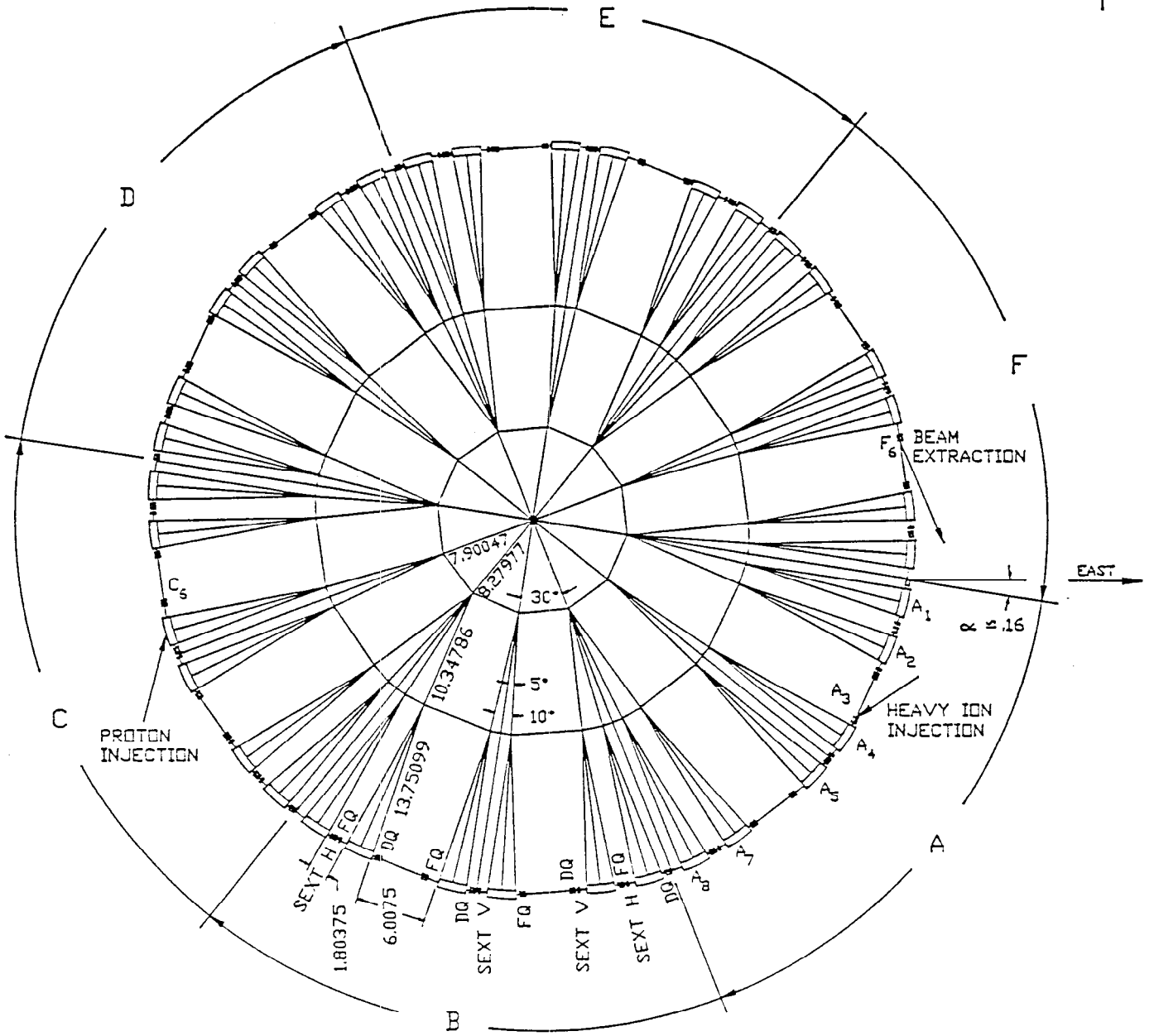
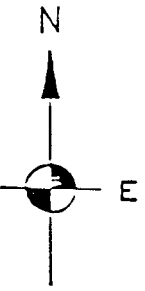


Fig. 1 b The Standard AGS - Booster Lattice

0 5  
  
 METERS

NOTE: ALL DIMENSIONS ARE IN METERS