BNL-105099-2014-TECH

Booster Technical Note No. 52;BNL-105099-2014-IR

Heavy ion acceleration RF program for the Booster

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July 1986

Collider Accelerator Department

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U.S. Department of Energy

USDOE Office of Science (SC)

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HEAVY ION ACCELERATION RF PROGRAM FOR THE BOOSTER

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In this note we propose a senario for the RF program for heavy ion acceleration at the Booster. A third harmonic system(h=3) is assumed for the acceleration system, also the frequency range is covered by the three different cavities each covering a certain frequency range.

i) CAPTURE

Since the heavy ions from the Tandem Van de Graaff have virtually no energy spread, and so called addiabatic capture takes too long (>100 m-sec), We propose to capture the heavy ions with RF voltage which gives reasonable synchrotron period of 2.5 milli-seconds. The corresponding bunch size is 0.05 eV/amu/bucket at 0 degree phase angle. The RF voltage should be on this level about a 1/4 of the synchrotron periods(.7 m-sec). At this point the RF level should be increased twice of the capture volatage which gives the size of the bucket 1.4 times of the bunch size. The table gives the bunching voltage and corresponding momentum spreads for the represetative ion speces.

ii) ACCELERATION

The energy gain per turn for the ions in the synchrotron is given by

$$\Delta E/Q/\text{turn} = Cm\ (dB\rho/dt) = eV \sin\phi_s$$

where Q ; Charge state of the ion

Cm; Circumference of the machine

ρ ; Bending radius of the machine

V ; Peak RF voltage

ϕ_s ; Stable phase angle

After the ions are bunched and established the bucket, the power supply for the magnets are adjusted to give a linear rise of dB/dt to (parabolic rise of the magnetic field) the final value of the dB/dt. At the same time RF voltage rises linearly to its final value listed in the table.

The final dB/dt required is about 2.55 Tesla/sec which is equivalent to dP/dt of 10.5 GeV/c/sec. We propose the time required for this change should be about 20 milli-secons which is about 10 synchrotron periods. The radial and phase loop should keep the appropriate stable phase angle and frequencies. Since the RF voltage required for the given bucket size depends on mass and the charge of the ions, final required RF voltage for each speces of the ions are diferent. The table gives the relevant information about representative ions. The figure shows the dB/dt and B in function of time.

TABLE

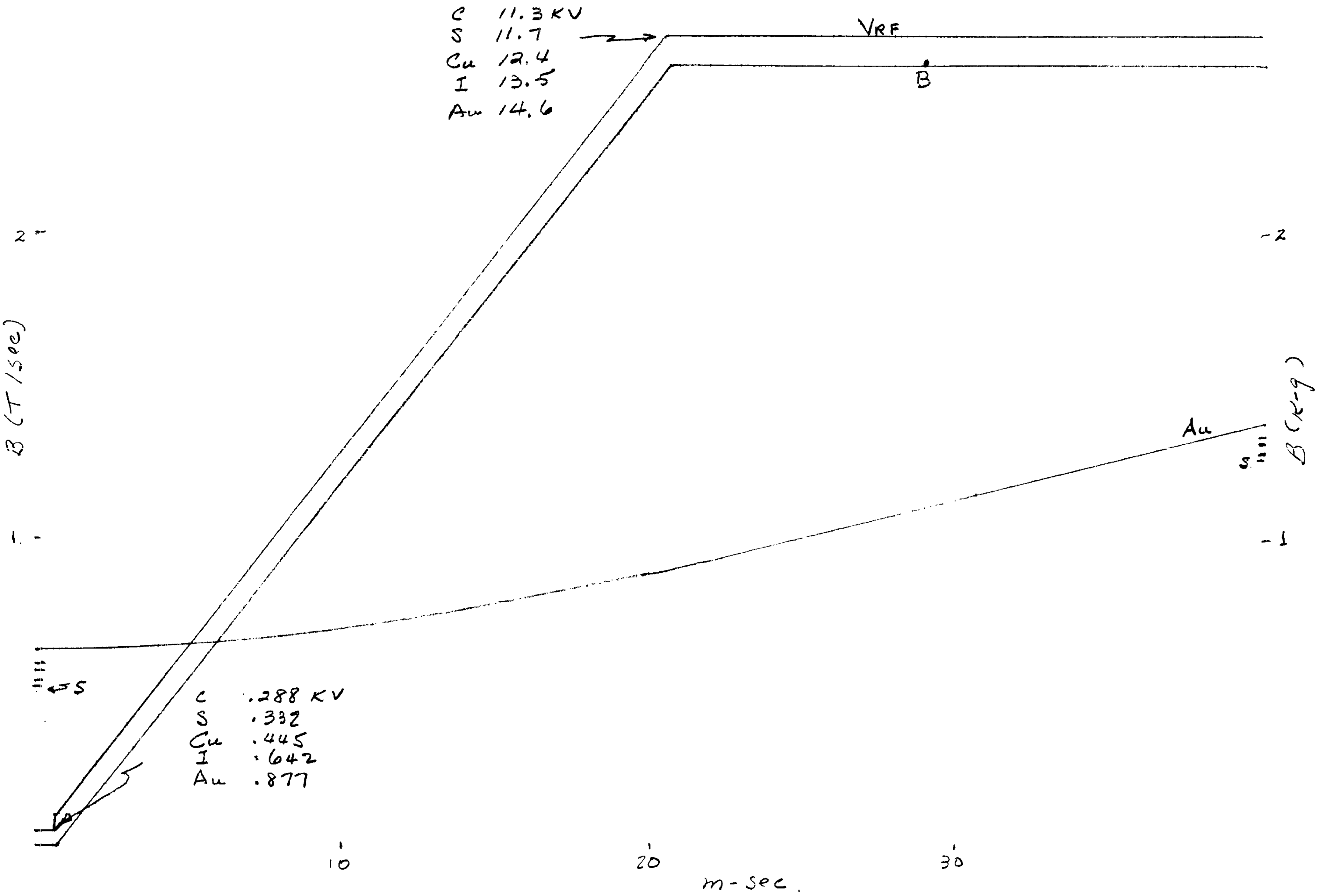
Ion	E_{inJ} MeV/amu	Q	B_{inJ} K-g	f_{inJ} MHz	V_{bunch} KV	$\Delta P/P$ %	V_{acc}* KV
Carbon	7.5	6	.576	.562	.288	.15	11.3
Sulfer	4.7	14	.519	.448	.332	.19	11.7
Copper	2.9	21	.531	.349	.445	.24	12.4
Iodine	1.65	29	.590	.265	.642	.31	13.5
Gold	1.	33	.645	.213	.877	.40	14.6

* From 20 m-sec to the end of the cycle

A_{bunch} ; .05 eV-sec/amu/bunch

A_{bucket}; .o71 eV-sec/amu/bucket

dB/dt ; 2.55 Tesla/sec


C 11.3 KV
S 11.7
Cu 12.4
I 13.5
Au 14.6
VRF
B
2
1.
-2
-1
B (T/sec)
B (K-g)
Au
S
S
C .288 KV
S .332
Cu .445
I .642
Au .877
10
20
30
m-sec.