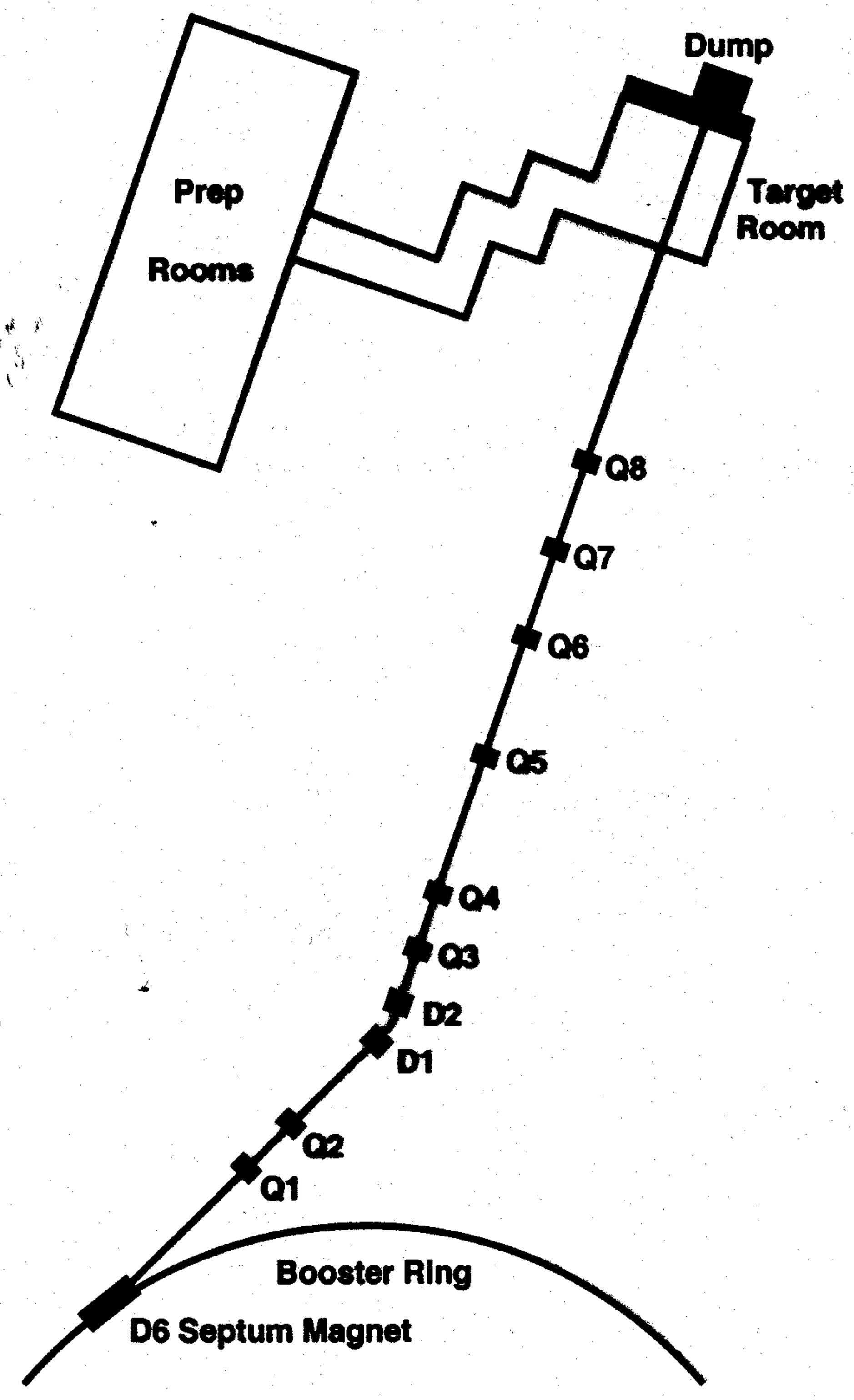

Figure 3: BAF Transport Line

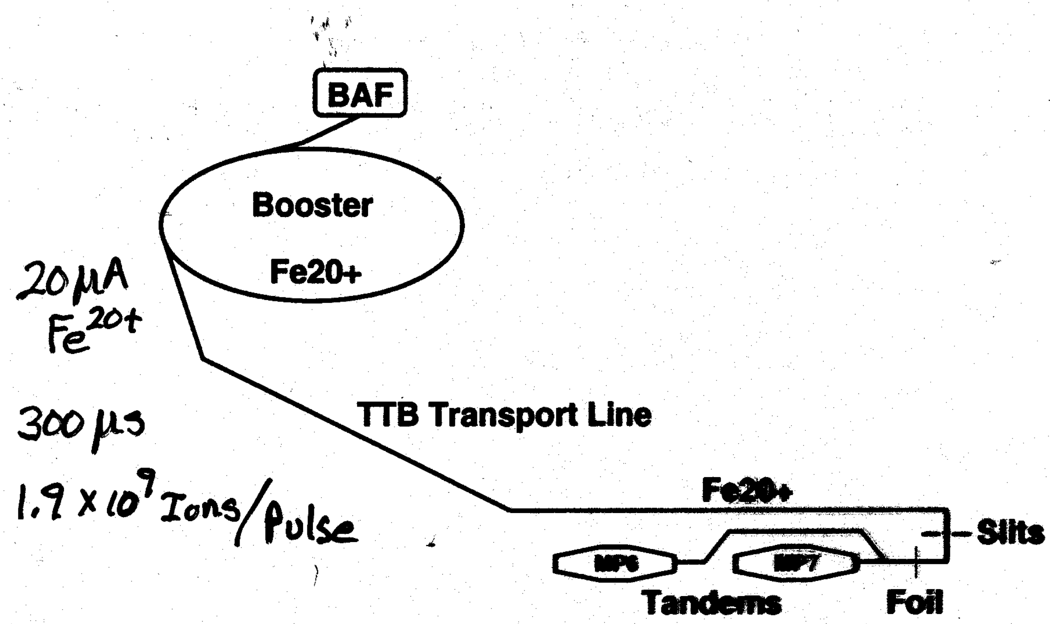

Figure 1: Layout of Accelerators for BAF

Table 8: Parameters for Fe^{21+} at Top Energy

$B\rho$ (Tm)	W (MeV/n)	cp (MeV/n)	β	hf (kHz)
14.84404	980.3296	1668.7992	0.87346544	5.190934
14.94404	990.1570	1680.0414	0.87484967	5.199160
15.04404	1000.0000	1691.2836	0.87621280	5.207261
15.14404	1009.8581	1702.5259	0.87755521	5.215239
15.24404	1019.7312	1713.7681	0.87887730	5.223096

milliradians) respectively throughout the acceleration cycle. For Au^{32+} ions, the combined capture and acceleration efficiency is about 80%. The efficiencies for Fe^{20+} and Fe^{21+} ions are not yet determined.

6 The Magnetic Cycle

6.1 Field and Current at Injection and Top Energy

The magnetic field produced by the 16-turn main winding on the Booster dipole is given by [11]

$$B = KI \tag{22}$$

where $K = 2.43$ Gauss/A and I is the current in the winding. Using (20) and the magnetic rigidities listed in Tables 4, 5, 7 and 8 one obtains the fields and currents listed in Table 9 for gold and iron ions at injection and at top energy. Here we see that for the acceleration of Fe^{20+}, the field goes

Table 9: Booster Dipole Fields and Currents

Ion	W (MeV/n)	$B\rho$ (Tm)	B (Gauss)	I (Amps)
Au^{32+}	182.13/197	0.852334	615	253
	101.1721	9.152950	6601	2717
Fe^{20+}	150.97/56	0.661932	477	196
	1000	15.796292	11392	4688
Fe^{21+}	164.965/56	0.659024	475	196
	1000	15.04404	10850	4465

from 477 Gauss at injection to 11392 Gauss at top energy. The

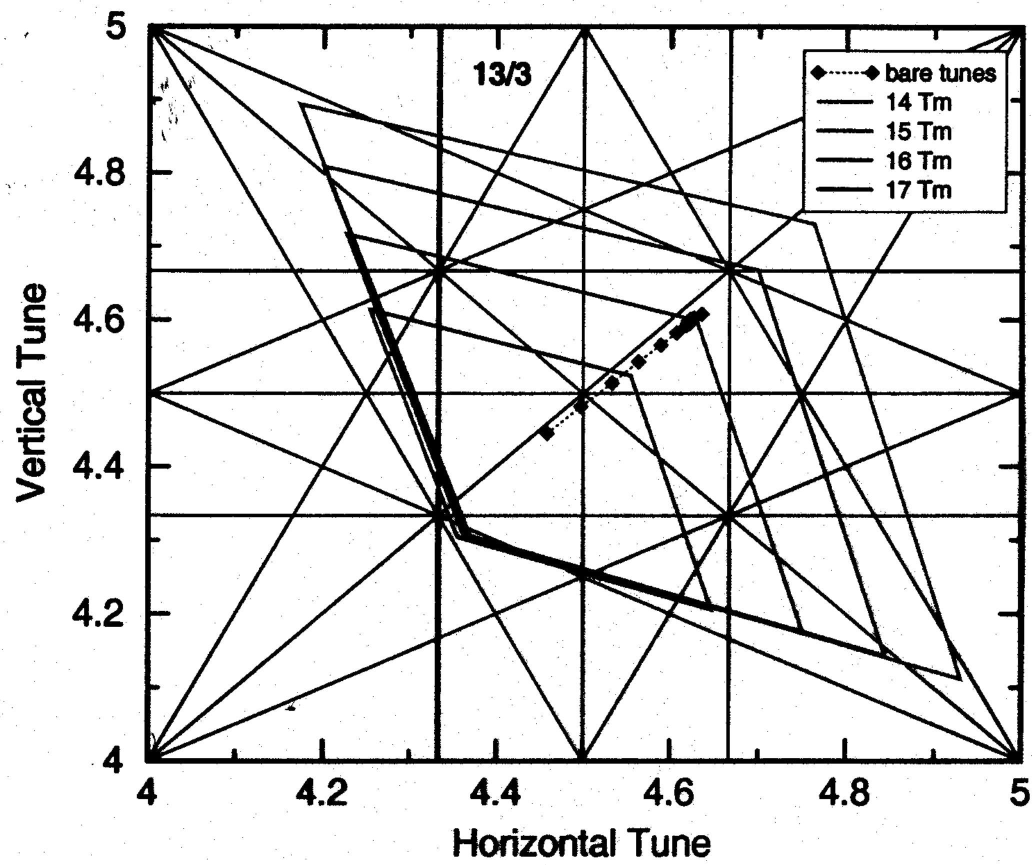

Figure 2: Booster Tune Control at High Field

$hf = 5.21$ MHz at top energy. Here the frequencies at injection are certainly within the range of the cavities, but the frequency at top energy may be too high. At harmonic $h = 3$ one has $hf = 339$ and 354 kHz at injection, and $hf = 3.91$ MHz at top energy. Here the frequencies at injection may be too low. The various frequencies are summarized in Table 6.

Table 6: Harmonic Number and Cavity Frequencies

Ion	h	hf Injection	hf Extraction	W Extraction
Au^{32+}	6	397 kHz	3.85 MHz	101 MeV/n
Fe^{20+}	6	677 kHz	7.81 MHz	1000 MeV/n
	4	451 kHz	5.21 MHz	
	3	339 kHz	3.91 MHz	
Fe^{21+}	6	708 kHz	7.81 MHz	1000 MeV/n
	4	472 kHz	5.21 MHz	
	3	354 kHz	3.91 MHz	

If the cavities can be made to operate in the range of 450 kHz to 5.2 MHz, or in the range of 340 kHz to 3.9 MHz, then the entire acceleration to 1000 MeV per nucleon could be carried out at one harmonic. Otherwise, one possible scenario would be to capture at harmonic $h = 6$, accelerate a bit, merge the six bunches into three, and then continue acceleration to full energy at harmonic $h = 3$.

5.2 Adiabatic Capture and Electron Capture Losses

During injection and capture, the Booster magnetic field is held constant and beam is captured into stationary RF buckets with the net RF voltage raised adiabatically from zero. (The two cavities are initially counterphased so that the net voltage seen by the beam is zero. By gradually decreasing the amount of counterphasing, the net voltage can be raised slowly). For the capture of Au^{32+} ions we have found [7, 8] that extending the time allowed for adiabatic capture on the Booster injection porch from the 1–3 ms used in the past to approximately 6 ms improves beam survival. This is contrary to the expectation that spending more time at low energy produces more beam loss. Here the cross sections for electron capture interactions between gold and residual gas or ions in the vacuum chamber are relatively large [9]. Clearly, if too much time is spent

h is the RF harmonic. The inflector voltage V_I is given by.

$$eV_I = \frac{G}{R_I} c^2 p^2 / (Q_b E) \tag{19}$$

where $G = 0.017$ m is the gap between the cathode and septum, and $R_I = 8.74123$ m is the radius-of-curvature along the nominal trajectory through the inflector. The values of hf are calculated assuming RF

Table 4: Booster Injection Parameters for Fe^{20+}

W (MeV)	V_I (kV)	cp (MeV/n)	$B\rho$ (Tm)	hf (kHz)
148.97	28.930	70.40049	0.657526	448.482
149.97	29.124	70.63672	0.659732	449.978
150.97	29.318	70.87217	0.661932	451.470
151.97	29.512	71.10685	0.664123	452.956
152.97	29.706	71.34076	0.666308	454.437

339 kHz

Au^{32+} 192.13 41.506 0.8523 396.923

Table 5: Booster Injection Parameters for Fe^{21+}

W (MeV)	V_I (kV)	cp (MeV/n)	$B\rho$ (Tm)	hf (kHz)
162.965	30.137	73.63774	0.655011	468.984
163.965	30.322	73.86368	0.657021	470.414
164.965	30.507	74.08893	0.659024	471.839
165.965	30.691	74.31351	0.661022	473.261
166.965	30.876	74.53741	0.663013	474.677

354 kHz

harmonic $h = 4$. The nominal injection parameters for Fe^{20+} and Fe^{21+} are those corresponding to kinetic energies $W = 150.97$ and 164.965 MeV respectively.

4.2 Dipole Magnetic Field at Injection

The magnetic field required in the bending dipoles of Booster at injection is given by

$$B = (B\rho)/\rho \tag{20}$$

where $\rho = 13.8656$ meters is the nominal radius of curvature in the dipoles and $B\rho$ has the values listed in Tables 4 and 5. (There are 36 bending

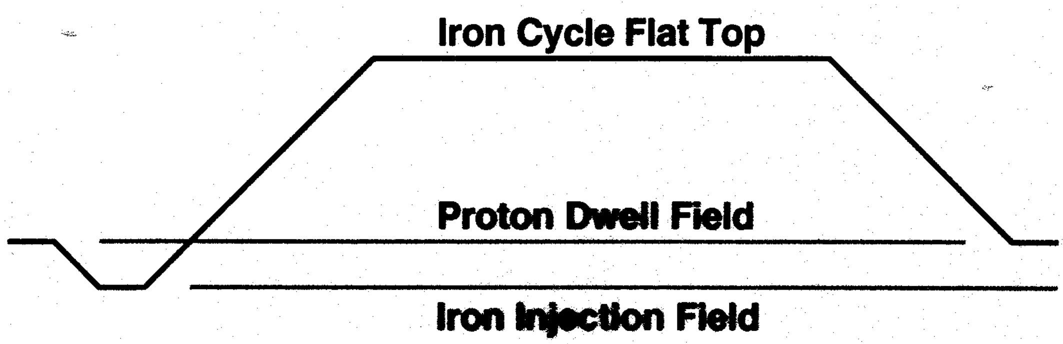

Figure 4: Iron Magnetic Cycle