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1 Basic Parameters

A Gold ion with charge eQ has $N = 197$ Nucleons, $Z = 79$ Protons, and $(Z - Q)$ electrons. (Here Q is an integer and e is the charge of a single proton.) The mass is

$$m = au - Qm_e + E_b/c^2 \tag{1}$$

where $a = 196.966552$ is the atomic mass [1, 2] of the neutral Gold atom, $u = 931.494013$ MeV$/c^2$ is the unified atomic mass unit [3], and $m_e c^2 = .510998902$ MeV is the electron mass [3]. E_b is the binding energy of the Q electrons removed from the neutral Gold atom. This amounts to 0.332 MeV for the helium-like gold ion ($Q = 77$) and 0.517 MeV for the fully stripped gold ion. These numbers are given in Ref. [4]. The deuteron mass [3] is 1875.612762(75) MeV$/c^2$.

In a circular accelerator the ion moves along an orbit of circumference $2\pi R$ with revolution frequency f. The radius of the orbit is R. The velocity of the ion is then

$$v = 2\pi R f. \tag{2}$$

This gives momentum, energy, and kinetic energy

$$p = mc\beta\gamma, \quad E = mc^2\gamma = \sqrt{p^2c^2 + m^2c^4}, \quad W = E - mc^2 \tag{3}$$

where

$$\beta = v/c, \quad \gamma = 1/\sqrt{1 - \beta^2}. \tag{4}$$

The magnetic rigidity of the ion in units of Tm is

$$B\rho = kp/Q \tag{5}$$

where $k = 10^9/299792458$ and p is the momentum in units of GeV/c. The angular frequency is

$$\omega = 2\pi f. \tag{6}$$

We also define the phase-slip factor

$$\eta = \frac{1}{\gamma_t^2} - \frac{1}{\gamma^2} \tag{7}$$

where γ_t is the transition gamma.

2 RF Parameters

The stationary bucket area is

$$A_S = 8\,\frac{R_s}{hc}\left\{\frac{2eQV_gE_s}{\pi h|\eta_s|}\right\}^{1/2} \tag{8}$$

where h is the RF harmonic number, V_g is the total RF gap voltage per turn, and the subscript "s" denotes parameter values for the synchronous particle.

The half-height of a bucket is

$$\Delta E = \left(\frac{h\omega_s}{8\sqrt{2}}\right) A_S\,|(\pi - 2\phi_s)\sin\phi_s - 2\cos\phi_s|^{1/2} \tag{9}$$

where ϕ_s is the synchronous phase.

The synchronous phase is given by

$$V_g \sin\phi_s = 2\pi R_s \rho_s \dot{B}/c \tag{10}$$

where ρ_s is the radius of curvature, B is the magnetic field and $\dot{B} = dB/dt$. Employing Gaussian units (R_s and ρ_s in cm, $c = 2.99792458 \times 10^{10}$ cm/s, and $\dot{B}$ in G/s) gives $V_g \sin\phi_s$ in Statvolts. Multiplying by 299.792458 then gives $V_g \sin\phi_s$ in Volts.

The width of a bucket is

$$\Delta t = \frac{|\pi - \phi_s - \phi_e|}{h\omega_s} \tag{11}$$

where the phase ϕ_e satisfies

$$\cos(\pi - \phi_s) - \cos\phi_e = -(\pi - \phi_s - \phi_e)\sin\phi_s. \tag{12}$$

The area of a bucket is

$$A_{\rm bk} = \alpha(\phi_s) A_S \tag{13}$$

where

$$\alpha(\phi_s) = \frac{\sqrt{2}}{8}\int_{\phi_L}^{\phi_R} |(\pi - \phi_s - \phi)\sin\phi_s - \cos\phi_s - \cos\phi|^{1/2}\, d\phi. \tag{14}$$

Below transition we have $\phi_e < \pi - \phi_s$ and the limits of integration are $\phi_L = \phi_e$ and $\phi_R = \pi - \phi_s$. Above transition we have $\pi - \phi_s < \phi_e$ and the limits of integration are $\phi_L = \pi - \phi_s$ and $\phi_R = \phi_e$. The integral $\alpha(\phi_s)$ must be evaluated numerically. An approximate expression is [5]

$$\alpha(\phi_s) \approx \frac{1 - \sin\phi_s}{1 + \sin\phi_s}. \tag{15}$$

The synchrotron frequency for small-amplitude oscillations about ϕ_s is

$$F_s = \frac{c}{2\pi R_s}\left\{\frac{-h\eta_s eQV_g\cos\phi_s}{2\pi E_s}\right\}^{1/2} \tag{16}$$

and the corresponding synchrotron tune is $Q_s = 2\pi F_s/\omega_s$. Note that measurement of F_s gives a value for $V_g\cos\phi_s$, while measurement of dB/dt gives a value for $V_g\sin\phi_s$. These can be used to obtain V_g and ϕ_s.

Let ϕ_l and ϕ_r be the phases at the left and right boundries of a bunch matched to a bucket. We have

$$\phi_l < \phi_s < \phi_r \tag{17}$$

and the width of the bunch is

$$\Delta t = \frac{\Delta\phi}{h\omega_s}, \quad \Delta\phi = \phi_r - \phi_l. \tag{18}$$

In terms of $\Delta\phi$ and ϕ_s we have

$$\phi_r = \frac{\Delta\phi}{2} + \arcsin\left\{\frac{\Delta\phi\sin\phi_s}{2\sin(\Delta\phi/2)}\right\} \tag{19}$$

and

$$\phi_l = -\frac{\Delta\phi}{2} + \arcsin\left\{\frac{\Delta\phi\sin\phi_s}{2\sin(\Delta\phi/2)}\right\}. \tag{20}$$

Note that if $\Delta\phi$ is small we have

$$\sin(\Delta\phi/2) \approx \frac{\Delta\phi}{2}, \quad \frac{\Delta\phi \sin\phi_s}{2\sin(\Delta\phi/2)} \approx \sin\phi_s \tag{21}$$

and

$$\phi_l \approx \phi_s - \frac{\Delta\phi}{2}, \quad \phi_r \approx \phi_s + \frac{\Delta\phi}{2}. \tag{22}$$

The half-height of the bunch is

$$\Delta E = \left(\frac{h\omega_s}{8\sqrt{2}}\right) A_S \left|\cos\phi_r - \cos\phi_s + (\phi_r - \phi_s)\sin\phi_s\right|^{1/2}. \tag{23}$$

The area of the bunch is

$$A_\mathrm{b} = F(\phi_s, \Delta\phi)\, A_S \tag{24}$$

where

$$F(\phi_s, \Delta\phi) = \frac{\sqrt{2}}{8} \int_{\phi_l}^{\phi_r} \left|\cos\phi_l - \cos\phi + (\phi_l - \phi)\sin\phi_s\right|^{1/2} d\phi. \tag{25}$$

The integral $F(\phi_s, \Delta\phi)$ must be evaluated numerically. If $\Delta\phi$ is small we have

$$F(\phi_s, \Delta\phi) \approx \frac{\pi}{64}(\Delta\phi)^2 \left|\cos\phi_s\right|^{1/2}. \tag{26}$$

3 Ring Parameters

Parameter	Booster	AGS	RHIC	Unit
C_I	C_b	C_a	$C_r + \delta C$	m
C_E	$C_a/4$	$4(C_r + \delta C)/19$	$C_r + \delta C$	m
ρ	13.8656	85.378351	242.7806	m
γ_tr	4.806	8.5	22.89	

Here C_I and C_E are the circumferences of the closed orbits in the machines at injection and extraction (or store) respectively. C_b, C_a, and C_r are the circumferences of the "design" orbits in Booster, AGS, and RHIC respectively. These are

$$C_b = 201.780, \quad C_a = 2\pi(128.4526), \quad C_r = 3833.845181 \tag{27}$$

meters. Note that $4(C_r/19) = 2\pi(128.4580)$ m which gives an AGS radius at extraction approximately 5 mm larger than the "design" AGS radius (128.4526 m) reported by Bleser [6, 7]. The radius of curvature ρ in the Booster and AGS main dipoles is given in Refs. [6, 7, 8]. The RHIC ring parameters are taken from Ref. [9] and from MAD runs by Steve Tepikian.

Because the magnetic rigidities of deuterons and gold ions in the DX magnets of the collider are not the same, the orbit circumferences in the blue and yellow rings are not the same. These circumferences have been computed by Steve Tepikian and are given below.

4 Assumptions

The parameters values listed in Sections 5–11 are calculated assuming that:

1. The magnetic rigidity of the Au^{31+} ion and deuteron at Booster injection is $B\rho = 0.8813444$ Tm.
2. The magnetic rigidity of the Au^{31+} ion at Booster extraction is $B\rho = 9.4307359$ Tm; the magnetic rigidity of the deuteron is 7.322360 Tm.
3. The magnetic rigidity of the Au^{77+} ion at AGS injection is $B\rho = 3.7474454$ Tm; the magnetic rigidity of the deuteron is 7.322360 Tm.
4. The magnetic rigidity of the Au^{79+} ion at RHIC injection is 86 Tm. The revolution frequency of the deuterons at RHIC injection is the same as that of the gold ions.
5. The orbit circumference for deuterons in the blue ring **at injection** is 2.245 mm **greater than** C_r. The orbit circumference for gold ions in the yellow ring **at injection** is 2.015 mm **less than** C_r.
6. The energy of the Au^{79+} ion at RHIC Store is 100 GeV per nucleon. The revolution frequency of the deuteron is the same as that of the gold ion. The orbit circumference for deuterons in the blue ring **at store** is 2.113 mm **greater than** C_r. The orbit circumference for gold ions in the yellow ring **at store** is 1.907 mm **less than** C_r.

Please note that more digits are given for some parameters in Sections 5–11 than would be warranted by the precision with which the parameters could be measured; this is done for computational convenience. The notation "$/N$" in the Units column of the tables means "per nucleon".

5 Gold Parameters in Booster

Parameter	Injection	Extraction	Unit
Q	31	31	
m	183.457336	183.457336	GeV/c^2
W	182.75731/197	100.81631	MeV/N
cp	41.577830	444.89933	MeV/N
E	0.93218322	1.0320718	GeV/N
$B\rho$	0.8813444	9.4307359	Tm
β	0.044602637	0.43107400	
$\gamma - 1$	0.99618423/1000	0.10825848	
η	-0.955	-0.771	
ϵ_H (95%)	8.3π	8.3π	mm mrad
ϵ_V (95%)	3.9π	3.9π	mm mrad
h	6	6	
hf	0.39760732	3.8429170	MHz
R	$201.780/(2\pi)$	128.4526/4	m

Here ϵ_H and ϵ_V are the normalized horizontal and vertical transverse emittances. These follow from the assumption that during multi-turn injection the horizontal and vertical acceptances in Booster are completely filled. The horizontal and vertical acceptances are 185π and 87π mm mrad (un-normalized) respectively.

Parameter	Injection	Extraction	Unit
V_g	0.5	30	kV
A_S	2.540	23.04	eV s
dB/dt	0	80.0	G/ms
ϕ_s	0	48.25	degrees
F_s	0.412	2.225	kHz
$A_{\rm bk}$	2.540	3.111	eV s
A_b	0.7263	1.499	eV s
Δt	1008	55.0	ns
ΔE	0.467	17.7	MeV

Parameter	Injection	Extraction	Unit
No. of Bunches	6	6	
Bunch Spacing	2515.044	260.2190	ns
Ions/Bunch	3.47/6	2.98/6	10^9
Bunch Area	0.0221/6	0.0457/6	eV s/N

At Booster injection, the voltage V_I required for particles with momentum p and charge Q to follow the nominal trajectory through the inflector is given by

$$eV_I = \frac{G}{R_I}\left(\frac{c^2p^2}{QE}\right). \tag{28}$$

Here $G = 0.017$ m is the gap between the cathode and septum of the inflector and $R_I = 8.74123$ m is the radius of curvature along the nominal trajectory. Using the tabulated values of cp and E at Booster injection, we obtain $V_I = 22.919$ kV.

The fractional momentum spread $\Delta p/p$ was measured by chopping a short notch out of the unbunched beam in the Tandem-to-Booster (TTB) transfer line, and observing the turn-by-turn spreading of the notch in Booster at injection. This gives $\Delta p/p = \pm 3.9 \times 10^{-4}$. Observation of the notch also gives 15.1 μs for the revolution period at injection. The longitudinal emittance of the unbunched beam after accumulation in Booster is then 0.022 eV-s per nucleon.

Capture of injected beam in Booster occurs on a 6 ms porch at constant field. During this time the gap voltage is increased from 0 to 0.5 kV, capturing the beam into $h = 6$ stationary RF buckets. The tabulated bunch area at extraction was determined from measurements of the bunch width at extraction with $dB/dt = 80$ G/ms and $V_g = 30$ kV. The tabulated intensities (ions per bunch) were obtained during the FY 2007 RHIC run with 5.37×10^9 ions per pulse at the end of the TTB line.

The six bunches are extracted from Booster in a single turn by means of a fast kicker and ejector septum magnet. Measurements of the beam width just downstream of the ejector give 95% horizontal and vertical emittances 4.2π and 2.8π (mm milliradians) respectively. After extraction, the ions pass through a stripper in the Booster to AGS (BTA) transport line where approximately 60% emerge in charge state +77. The stripper used this year consists of a 6.35 mg/cm^2 aluminum foil followed by a 8.48 mg/cm^2 "glassy" carbon foil mounted just downstream. The thicknesses have been optimized to produce the highest yield of Au^{77+}. The high uniformity of the glassy carbon, compared to that of the standard carbon stripper (23.1 mg/cm^2 graphite) used in the past, gives a significant reduction in the increase of longitudinal emittance due variable energy loss as the ions traverse the foil. With the standard carbon foil, this increase was approximately a factor of four; with the glassy carbon, the increase is a factor of 1.8. The measured energy spread of the bunches in Booster at extraction is $\pm$18 MeV while that of the bunches in AGS at injection is $\pm$32 MeV. The measured average energy loss in the foils is 2.5 MeV per nucleon. This is significantly less the the 4 MeV per nucleon observed with the standard carbon stripper.

The Au^{77+} ions are injected into the AGS by means of a septum magnet and a fast kicker. Four batches of six bunches are injected at constant magnetic field to give a total of 24 bunches on the AGS injection porch.

The bunches are injected into stationary buckets at harmonic 24. Because of the reduced energy spread of ions emerging from the BTA stripper used this year, there is more than enough voltage available to match the buckets to the incoming bunches. (This was not possible with the standard carbon foil.) The required voltage was found to be approximately 100 kV per turn. Measurements of bunch width (55 ns) in the matched buckets give a six-bunch longitudinal emittance of 0.082 eV-s per nucleon. This is a factor of 1.8 greater than the emittance measured at Booster extraction. In addition to emittance growth due to variable energy loss as ions traverse the foil there is a phase mismatch caused by the average energy loss. Since the ions emerge from the foil with a smaller average velocity, the distance between bunch centers is reduced. (The time between bunch centers is unchanged.) This means that the 6 bunches of each batch entering the AGS will occupy slightly less than one fourth of the ring. The effect of the mismatch is to cause some dilution of longitudinal emittance during the merging process discussed below.

In the past, shortly after all four batches from Booster were injected, the harmonic 24 voltage was slowly reduced, adiabatically debunching the beam. Once debunched the beam was adiabatically rebunched into 4 bunches (in order to reach the bunch intensity desired for RHIC) and then accelerated to top energy at harmonic 12. Experience with this setup has shown that there can be beam instability and subsequent fast loss due to the small momentum spread of the unbunched beam. To avoid this, a new setup in which the 24 bunches are merged into 4 was developed and implemented this year. The merge is done in two steps. First the 24 bunches are merged into 12 by bringing on harmonic 12 while reducing harmonic 24. Then the 12 bunches are merged into 4 by bringing on harmonics 4 and 8 while reducing harmonic 12. This final merge is done with a single low-frequency. The resulting 4 equally spaced bunches are then accelerated to top energy at harmonic 12.

6 Deuteron Parameters in Booster

Parameter	Injection(a)	Injection(b)	Extraction	Unit
W	8.69245527622	9.25956903701	505.867311144	MeV/N
cp	0.127981400320	0.132110202010	1.09759415138	GeV/N
E	0.946498836276	0.947065950037	1.44367369214	GeV/N
$B\rho$	0.8538	0.8813444	7.322360	Tm
β	0.135215591837	0.139494194681	0.760278556957	
$\gamma - 1$	0.009268923151	0.009873646868	0.539415514111	
η	-0.938	-0.937	-0.379	
ϵ_H (95%)	25π	26π	26π	mm mrad
ϵ_V (95%)	12π	12	12π	mm mrad
h	2	2	1	
hf	0.401790213468	0.414503989495	1.12961556634	MHz
R	$201.780/(2\pi)$	$201.780/(2\pi)$	128.4526/4	m

Here the columns "Injection(a)" and "Injection(b)" give the parameters for deuterons with the same rigidity as Au^{32+} and Au^{31+} ions respectively. The corresponding values of the inflector voltage, V_I, are 67.310 and 71.680 kV respectively. If we use the parameters in the "Injection(b)" column, the deuteron and Au^{31+} ion rigidities at Booster injection will be the same. The parameters in the "Injection(a)" column were used during the last d-Au run (RHIC Run-4) when we were injecting Au^{32+} ions into Booster. If there are problems operating the inflector at 72 kV, we would inject deuterons at the lower Au^{32+} rigidity.

Note that the normalized emittances in the table are significantly larger than those for gold; this is due to $\beta\gamma$ at injection being three times larger for deuterons than it is for gold.

Parameter	Injection	Extraction	Unit
V_g	0.4	24	kV
A_S	0.2174	9.249	eV s
dB/dt	0	0	G/ms
ϕ_s	0	0	degrees
F_s	0.3729	1.052	kHz
A_{bk}	0.2174	9.249	eV s
A_b	0.320/2	0.480	eV s
Δt	1716	146	ns
ΔE	0.0636	2.101	MeV

Parameter	Injection	Extraction	Unit
No. of Bunches	2	1	
Bunch Spacing	2412.522	885.257	ns
Ions/Bunch	10.0/2	8.0	10^{10}
Bunch Area	0.160/2	0.240	eV s/N

Capture of the injected beam occurs on a 12 ms porch at constant field. During this time the gap voltage is increased from 0 to approximately 0.4 kV.

7 Booster Injection Field

The magnetic field at Booster injection is measured with a Hall probe and the Booster Gauss Clock. The Hall probe sits in the reference dipole and gives the value of the field at BT0. The Gauss Clock gives the increment in field between BT0 and the time of injection. The measured field at injection is defined to be the field at BT0 plus the field increment. For the injection of Au^{32+} ions, the measured field should be 611.0 Gauss; for the injection of Au^{31+} it should be 629.5 Gauss.

8 Gold Parameters in AGS

Parameter	Injection	Transition	Extraction	Unit
Q	77	77	77	
m	183.434149	183.434149	183.434149	GeV/c^2
W	0.098348279	6.9835336	9.4497892	GeV/N
cp	0.43911728	7.8597077	10.339083	GeV/N
E	1.0294861	7.9146714	10.380927	GeV/N
$B\rho$	3.7474455	67.075079	88.2341688	Tm
β	0.42654028	0.99305547	0.99596910	
γ	1.1056216	8.5000	11.148647	
η	-0.804	0.0	0.00580	
ϵ_H (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
ϵ_V (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
h	24	12	12	
hf	3.8025000	4.4264207	4.4392242	MHz
R	128.4526	128.4526	128.45791	m

Parameter	Injection	Extraction	Unit
V_g	101.4	179	kV
A_S	32.64	4589	eV s
dB/dt	0	0	G/ms
ϕ_s	0	180	degrees
F_s	4.039	0.1014	kHz
A_{bk}	32.64	4589	eV s
A_b	2.705	6×7.653	eV s
Δt	55.0	16.2	ns
ΔE	31.5	1804	MeV

Parameter	Injection	Extraction	Unit
No. of Bunches	24	4	
Bunch Spacing	262.985	675.794	ns
Ions/Bunch	1.70/6	1.68	10^9
Bunch Area	0.0824/6	0.233	eV s/N

Measurements of bunch width (16 ns) and gap volts per turn (180 kV) just before extraction give a single-bunch longitudinal emittance of 0.23 eV-s per nucleon.

9 Deuteron Parameters in AGS

Parameter	Injection	Transition	Extraction	Unit
W	0.50586731	7.0335479	9.5189290	GeV/N
cp	1.0975942	7.9159969	10.414597	GeV/N
E	1.4436737	7.9713542	10.456735	GeV/N
$B\rho$	7.322360	52.809847	69.478714	Tm
β	0.760278557	0.99305547	0.99597023	
γ	1.5394155	8.5000	11.150207	
η	-0.408	0.0	0.00580	
ϵ_H (95%)	$\leq 26\pi$	$\leq 26\pi$	$\leq 26\pi$	mm mrad
ϵ_V (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
h	8	8	8	
hf	2.2592311	2.9509471	2.9594829	MHz
R	128.4526	128.4526	128.45806	m

Parameter	Injection	Extraction	Unit
V_g	56.20	260	kV
A_S	2.410	117.1	eV s
dB/dt	0	0	G/ms
ϕ_s	0	180	degrees
F_s	1.181	0.113	kHz
A_{bk}	2.410	117.1	eV s
A_b	0.480	1.440	eV s
Δt	146	26.96	ns
ΔE	2.12	34.0	MeV

Parameter	Injection	Extraction	Unit
No. of Bunches	8	4	
Bunch Spacing	442.628	675.794	ns
Ions/Bunch	8.0	16.0	10^{10}
Bunch Area	0.240	0.720	eV s/N

10 Gold Parameters in RHIC

Parameter	Injection	Transition	Store	Unit
Q	79	79	79	
m	183.433312	183.433312	183.433312	GeV/c^2
W	9.4497460	20.382514	99.068866	GeV/N
cp	10.339035	21.293298	99.995665	GeV/N
E	10.380880	21.313647	100.000000	GeV/N
$B\rho$	86.000000	177.117457	831.763013	Tm
β	0.99596910	0.99904526	0.99995665	
γ	11.148647	22.8900	107.395978	
η	-0.00614	0.0	0.00182	
ϵ_H (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
ϵ_V (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
h	360	360	2520	
hf	28.0372056	28.1238015	197.0461986	MHz
δC	-2.015	-2.015	-1.907	mm

Parameter	Injection	Extraction	Unit
V_g	172.6	3000	kV
A_S	128.2	164.4	eV s
dB/dt	0	0	G/ms
ϕ_s	0	180	degrees
F_s	0.120	0.232	kHz
$A_{\rm bk}$	128.2	164.4	eV s
A_b	45.92	137.8	eV s
Δt	16.2	4.0	ns
ΔE	1847	24048	MeV

Parameter	Injection	Extraction	Unit
No. of Bunches	60	60	
Bunch Spacing	214.001	213.148	ns
Ions/Bunch	1.20	1.14	10^9
Bunch Area	0.233	0.70	eV s/N

11 Deuteron Parmeters in RHIC

Parameter	Injection	Transition	Store	Unit
W	9.5189290	20.528582	101.01933	GeV/N
cp	10.414597	21.445893	101.95282	GeV/N
E	10.456735	21.466388	101.95714	GeV/N
$B\rho$	69.4787137	143.071599	680.15602	Tm
β	0.99597023	0.99904526	0.99995770	
γ	11.150207	22.8900	108.718748	
η	-0.00613	0.0	0.00182	
ϵ_H (95%)	$\leq 21\pi$	$\leq 21\pi$	$\leq 21\pi$	mm mrad
ϵ_V (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
h	360	360	2520	
hf	28.0372062	28.123770	197.0461986	MHz
δC	2.245	2.245	2.113	mm

Parameter	Injection	Extraction	Unit
V_g	263.6	3000	kV
A_S	1.803	1.881	eV s
dB/dt	0	0	G/ms
ϕ_s	0	180	degrees
F_s	0.1646	0.2565	kHz
$A_{\rm bk}$	1.803	1.881	eV s
A_b	1.44	1.44	eV s
Δt	27.0	3.72	ns
ΔE	36.8	266	MeV

Parameter	Injection	Extraction	Unit
No. of Bunches	60	60	
Bunch Spacing	214.001	213.148	ns
Ions/Bunch	16	16	10^{10}
Bunch Area	0.72	0.72	eV s/N

12 Low-Energy Gold Parameters at AGS Extraction

Parameter	Energy 1	Energy 2	Energy 3	Unit
Q	77	77	77	
m	183.434149	183.434149	183.434149	GeV/c^2
W	1.56900786	1.66861325	3.66056332	GeV/N
cp	2.32028247	2.42727995	4.49629867	GeV/N
E	2.50014567	2.59975106	4.59170114	GeV/N
$B\rho$	19.8013891	20.7145101	38.3716037	Tm
β	0.928058912	0.933658605	0.979222849	
γ	2.68504365	2.79201535	4.93127986	
η	-0.1249	-0.1144	-0.0273	
ϵ_H (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
ϵ_V (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
h	12	12	12	
hf	4.1365334	4.1614923	4.36458068	MHz
R	128.45798	128.45798	128.45798	m

13 Low-Energy Gold Parameters at RHIC Injection

Parameter	Energy 1	Energy 2	Energy 3	Unit
Q	79	79	79	
m	183.433312	183.433312	183.433312	GeV/c^2
W	1.56900070	1.66860564	3.66054662	GeV/N
cp	2.32027188	2.42726887	4.49627815	GeV/N
E	2.50013426	2.59973920	4.59168019	GeV/N
$B\rho$	19.30	20.19	37.40	Tm
β	0.928058912	0.933658605	0.979222849	
γ	2.68504365	2.79201535	4.93127986	
η	-0.1368	-0.1264	-0.0392	
ϵ_H (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
ϵ_V (95%)	$\leq 10\pi$	$\leq 10\pi$	$\leq 10\pi$	mm mrad
h	387	384	366	
hf	28.0848845	28.0353163	28.0252023	MHz
δC	0	0	0	mm

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