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Polarized Proton Parameters for the PP-on-Aluminum Setup in RHIC

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Proton mass-energy equivalent $m_p c^2 = 938.272046(21)$ MeV [1]

Proton g factor $g_p = 5.585694713(46)$ [1]

Proton $G = (g_p - 2)/2 = 1.79284735650$

Booster Injection Kinetic Energy = 200 MeV

Booster Extraction $G\gamma = 4.5$

Nominal Booster radius-of-curvature $\rho = 13.8656$ m

Nominal AGS radius-of-curvature $\rho = 85.378351$ m

Ags Injection $G\gamma = 4.5$

Ags Extraction $G\gamma = 45.5$

Nominal RHIC Circumference: $C_r = 3833.845181$ m

RHIC Store $G\gamma = 198.5$

Circumference Shifts

The RHIC circumference shift due to snakes [2, 3] is

$$\delta L = 26.1928376473988/(B\rho)^2 \quad (1)$$

where the units of δL and $B\rho$ are m and Tm respectively.

Shift at $G\gamma = 45.5$ due to snakes: $\delta L = 4.1582$ mm

Shift at $E = 100$ GeV due to snakes: $\delta L = 0.2354$ mm

Shift at $G\gamma = 191.5$ due to snakes: $\delta L = 0.2344$ mm

Shift at $G\gamma = 198.5$ due to snakes: $\delta L = 0.218156$ mm

Shift at $E = 250$ GeV due to snakes: $\delta L = 0.0377$ mm

There are also circumference shifts δD due to unequal ion rigidities in the DX magnets.

The total RHIC circumference shift is $\delta C = \delta L + \delta D$.

Ags Circumference at Extraction = $4(C_r + \delta C)/19$.

The DX magnets give shift $\delta D = 10.367846$ mm at blue injection [4].

The DX magnets give shift $\delta D = 8.995322$ mm at blue store [4].

References

- [1] P.J. Mohr and B.N. Taylor, "Values of Fundamental Physical Constants", Physical Constants, Physical Reference Data, www.nist.gov.
- [2] W. MacKay, "Path Length through Helical Snakes and Rotators", C-A/AP/Note 140, March 2004.
- [3] Formula (1) follows from those derived in [2]. It is used by Al Marusic to obtain path lengths in the RHIC snakes.
- [4] As calculated by Al Maursic.

Table 1: Polarized Protons in Booster

Parameter	Injection	Extraction	Unit
$G\gamma$	2.17500674495	4.5	
W	200.000	1416.76626314	MeV
cp	644.444581326	2160.05810228	MeV
E	1.13827204600	2.35503830914	GeV
$B\rho$	2.14963573675	7.20517826462	Tm
β	0.566160421483	0.917207203761	
γ	1.21315779454	2.50997386012	
η	-0.6362	-0.1159	
h	1	1	
hf	841.166737926	1362.77884657	kHz
R	$201.780/(2\pi)$	$128.4526/4$	m

Table 2: Polarized Protons in Booster

Parameter	$G\gamma = 3$	$G\gamma = 4$	Unit
$G\gamma$	3.0	4.0	
W	631.753493427	1155.09533990	MeV
cp	1.25881919359	1.87131840691	GeV
E	1.57002553943	2.09336738590	GeV
$B\rho$	4.19896885328	6.24204631230	Tm
$(B\rho)/\rho$	0.302833548731	0.450182199999	T
β	0.801782621988	0.893927372480	
γ	1.67331590675	2.23108787566	
η	-0.3143	-0.1581	
h	1	1	
hf	1.19123988020	1.32814294910	MHz
R	$201.780/(2\pi)$	$201.780/(2\pi)$	m

Table 3: Polarized Protons in AGS for PP-on-Aluminum Stores

Parameter	Injection	Transition	Extraction	Unit
$G\gamma$	4.5	15.2392025302	45.5	
W	1.41676626314	7.03703998500	22.8737819686	GeV
cp	2.16005810228	7.91992760710	23.7935613552	GeV
E	2.35503830914	7.97531239100	23.8120540146	GeV
$B\rho$	7.20517826462	26.4180348630	79.3667776499	Tm
β	0.917207203761	0.993055471537	0.999223390833	
γ	2.50997386012	8.5000	25.3786245857	
η	-0.1449	0.0	0.01229	
h	12	12	12	
hf	4.08833653972	4.42642071890	4.45370998977	MHz
R	128.4526	128.4526	128.458468103	m

Table 4: Polarized Protons in RHIC for PP-on-Aluminum Stores

Parameter	Injection	$G\gamma = 191.5$	$G\gamma = 198.5$	Unit
$G\gamma$	45.5	191.5	198.5	
W	22.8737819686	99.2816915541	102.945084479	GeV
cp	23.7935613552	100.215571393	103.879119213	GeV
E	23.8120540146	100.219963600	103.883356525	GeV
$B\rho$	79.3667776499	334.283163964	346.503444104	Tm
β	0.999223390833	0.999956174327	0.999959210867	
γ	25.3786245857	106.813332047	110.717735830	
η	3.560×10^{-4}	1.8209×10^{-3}	1.8270×10^{-3}	
f	78.1352629784		78.1929095053	kHz
h	360		360	
hf	28.1286946722		28.1494474219	MHz
δC	14.5260		9.2135	mm

Table 5: Polarized Protons in RHIC for 250 GeV PP Stores

Parameter	Injection	$G\gamma = 477.5$	$E = 250$ GeV	Unit
$G\gamma$	45.5	477.5	477.699235564	
W	22.8737819686	248.957459646	249.061727954	GeV
cp	23.7935613552	249.893970242	249.998239285	GeV
E	23.8120540146	249.895731692	250	GeV
$B\rho$	79.3667776499	833.556560794	833.904364882	Tm
β	0.999223390833	0.999992951261	0.999992957140	
γ	25.3786245857	266.336115157	266.447243170	
η	3.560×10^{-4}	1.8945×10^{-3}	1.8945×10^{-3}	
h	360	360	360	
hf	28.1287707269	28.1504646061	28.1504647716	MHz
δC	4.160	0.038	0.038	mm

Table 6: Polarized Protons in RHIC for 255 GeV PP Stores

Parameter	Injection	$G\gamma = 487.0$	$E = 255$ GeV	Unit
$G\gamma$	45.5	487.0	487.253220275	
W	22.8737819686	253.929207188	254.061727954	GeV
cp	23.7935613552	254.865752145	254.998273809	GeV
E	23.8120540146	254.867479234	255	GeV
$B\rho$	79.3667776499	850.140640113	850.582684802	Tm
β	0.999223390833	0.999993223582	0.999993230624	
γ	25.3786245857	271.634948862	271.776188033	
η	3.560×10^{-4}	1.8950×10^{-3}	1.8950×10^{-3}	
h	360	360	360	
hf	28.1287707269	28.1504722721	28.1504724704	MHz
δC	4.160	0.038	0.038	mm