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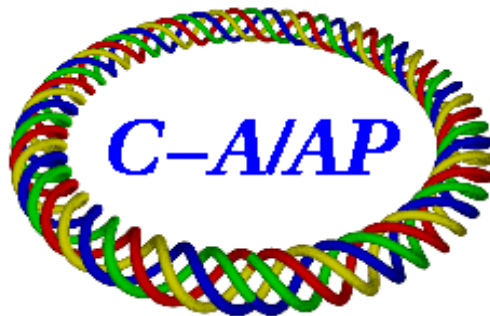
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# Polarized Proton Parameters for the 2015 PP-on-Au Setup in RHIC

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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  $\delta L$  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  $\delta D$  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  $\delta D = 12.807866$  mm at blue injection [4].

The DX magnets give shift  $\delta D = 11.225979$  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](http://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
$\beta$	0.566160421483	0.917207203761	
$\gamma$	1.21315779454	2.50997386012	
$\eta$	-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
$\beta$	0.801782621988	0.893927372480	
$\gamma$	1.67331590675	2.23108787566	
$\eta$	-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-Au 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
$\beta$	0.917207203761	0.993055471537	0.999223390833	
$\gamma$	2.50997386012	8.5000	25.3786245857	
$\eta$	-0.1449	0.0	0.01229	
$h$	12	12	12	
$hf$	4.08833653972	4.42642071890	4.45370715516	MHz
$R$	128.4526	128.4526	128.458549862	m

Table 4: Polarized Protons in RHIC for PP-on-Au 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
$\beta$	0.999223390833	0.999956174327	0.999959210867	
$\gamma$	25.3786245857	106.813332047	110.717735830	
$\eta$	$3.560 \times 10^{-4}$	$1.8209 \times 10^{-3}$	$1.8270 \times 10^{-3}$	
$f$	78.1352132485		78.1928640114	kHz
$h$	360		360	
$hf$	28.1286767694		28.1494310441	MHz
$\delta C$	16.9661		11.4441	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
$\beta$	0.999223390833	0.999992951261	0.999992957140	
$\gamma$	25.3786245857	266.336115157	266.447243170	
$\eta$	$3.560 \times 10^{-4}$	$1.8945 \times 10^{-3}$	$1.8945 \times 10^{-3}$	
$h$	360	360	360	
$hf$	28.1287707269	28.1504646061	28.1504647716	MHz
$\delta C$	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
$\beta$	0.999223390833	0.999993223582	0.999993230624	
$\gamma$	25.3786245857	271.634948862	271.776188033	
$\eta$	$3.560 \times 10^{-4}$	$1.8950 \times 10^{-3}$	$1.8950 \times 10^{-3}$	
$h$	360	360	360	
$hf$	28.1287707269	28.1504722721	28.1504724704	MHz
$\delta C$	4.160	0.038	0.038	mm