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The Green ring reference survey

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The Green ring reference survey

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The fictional "Green ring" described here lies radially between the RHIC Blue and Yellow rings. It is used to generate a convenient reference line against which to compare the surveys of real EIC accelerators. The Green ring is particularly useful for recording radial offsets, including the inner and outer tunnel walls. It is constructed entirely from four segments – long bend, short bend, long straight, and short straight – with the parameters listed in Table 1. These segments can be considered to be dipoles and drifts. Four segments together make half a sextant, with the sequence shown in Table 2. Six identical sextants make the Green ring, with exact hexagonal symmetry. Zero length reference markers are added for convenience at the RHIC interaction points ("IP6" et cetera) and in the middle of each arc ("arc center").

Segment name	**Abbreviation**	**Length L** [m]	**Angle θ** [radians]
Long bend	LB	177.7322059	0.466203623
Short bend	SB	28.69757623	0.057395152598
Long straight	LS	85.0	
Short straight	SS	28.058606063	

Table 1: Parameters of the Green accelerator segments.

Beamline	**Beamline element sequence**
Sextant	LS SB SS LB arc_center LB SS SB LS
Green	IP6 sextant IP8 sextant IP10 sextant IP12 sextant IP2 sextant IP4 sextant IP6

Table 2: Sequence of elements in a sextant, and sextants in the Green ring, including reference markers.

1 Tuning the geometry

The Green ring is guaranteed to close if

$$\theta_{\text{short bend}} = \frac{\pi}{6} - \theta_{\text{long bend}} \tag{1}$$

because of the 12-fold symmetry. Green and Holy Lattice IP6 locations are guaranteed to be identical if the initial co-ordinates are set to be

$$X_0 = 31694.295102 \text{ [m]} \tag{2}$$
$$Z_0 = 30209.627602 \text{ [m]} \tag{3}$$
$$\theta_0 = 3.10668784834 \text{ [radians]} \tag{4}$$

in the RHIC Survey Frame [1]. Green IP12 co-ordinates are tuned to agree with the Holy Lattice IP12 co-ordinates listed in Table 3 by adding more digits of accuracy to θ_0 in Equation 4, and by tuning the length of the short straight to the value listed in Table 1. Table 4 lists the irreducible errors that then remain between Green and Holy Lattice IP locations. These sub-micron residuals are due to the Holy Lattice interaction points not quite having perfect hexagonal symmetry, as in the Green ring. The remaining differences are negligible for almost all practical purposes.

Element	**Azimuth** s [m]	**"North"** X [m]	**"East"** Z [m]	**Angle** θ
IP6	0.000000	31694.295102	30209.627602	3.106687849
IP8	639.445028	32007.254798	29708.785410	2.059490298
IP10	1277.948394	32597.476707	29729.395361	1.012292746
IP12	1917.393423	32874.738921	30250.847505	-0.034904805
IP2	2555.896789	32561.779225	30751.689697	-1.082102356
IP4	3195.341817	31971.557315	30731.079746	-2.129299907

Table 3: Survey anchors at the 6 RHIC IPs, as fundamentally defined and frozen in the Holy Lattice files.

IP number	**Residual** [μm]
6	0.00
8	0.41
10	1.11
12	0.00
2	0.41
4	0.78

Table 4: Residual differences between Green and Holy Lattice IP locations, after setting the Green geometrical parameters to the values listed in Table 1 and Equations 2, 3 and 4.

2 Survey output data

Table 5 illustrates the survey data readily generated from the Green ring lattice, in the RHIC Survey Frame [1]. Longer surveys, with finer s-resolution, are available on request. Software is available to compare two such survey files, in order to generate radial offset versus s.

References

[1] *Accelerator Physics coordinate conventions*, W. Mackay and S. Peggs, RHIC/AP/12, 1993.

Element	**Azimuth** s [m]	**"North"** X [m]	**"East"** Z [m]	**Angle** θ
IP6	0.000000	31694.295102	30209.627602	3.106687848
Arc center	319.488388	31757.977251	29901.220297	2.583089073
IP8	638.976776	32007.254798	29708.785410	2.059490297
Arc center	958.465164	32306.184433	29609.732117	1.535891522
IP10	1277.953552	32597.476707	29729.395361	1.012292746
Arc center	1597.441940	32832.724193	29938.749372	0.488693970
IP12	1916.930329	32874.738920	30250.847504	-0.034904805
Arc center	2236.418717	32811.056771	30559.254809	-0.558503581
IP2	2555.907105	32561.779224	30751.689696	-1.082102356
Arc center	2875.395493	32262.849589	30850.742989	-1.605701132
IP4	3194.883881	31971.557315	30731.079745	-2.129299908
Arc center	3514.372270	31736.309829	30521.725734	-2.652898683
IP6	3833.860658	31694.295102	30209.627602	-3.176497459

Table 5: Key anchor locations in the Green ring survey. More extensive files with a finer s-resolution are easily generated from the Green lattice, for example by MADX.