# The Green ring reference survey

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Electron-Ion Collider

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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 $\theta$ [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 $\theta_0$ 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 $\theta$ |
|---------|---------------|---------------|--------------|----------------|
| 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 [$\mu$m] |
|-----------|----------|
| 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 $\theta$ |
|---|---|---|---|---|
| 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.