Appendix B

Coordinate Systems

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In this appendix we summarize the relations between various coordinate systems of interest; these include:

- Tower: HRMA Alignment Test System Tower at EKC (HATS measurements)
- DPSAOsac: Double-pass raytraces to simulate HATS measurements
- SAOsac: standard raytraces (e.g., XRCF conditions)
- XRCF: coordinate system at the XRCF test facility
- HRMA: HRMA-based coordinate system aligned with the standard AXAF coordinate directions

Figure B.1 illustrates the different coordinate systems. Note that the XRCF coordinates differ from the standard HRMA/AXAF coordinate system by a flip of 180° about the $X_{HRMA}$ axis, while the DPSAOsac coordinates differ from the standard SAOsac coordinates by a flip of 180° about the $X_{SAOsac}$ axis (the $Y_{HRMA}$ axis). Note also that we are primarily concerned here with the directions of the coordinate axes rather than the location of the coordinate origin.

The SAO/MST raytrace system, SAOsac, specifies rigid-body positioning in terms of the location and orientation of the body-center of the optic. The body-center “tilt” coordinates are `azmis` and `elmis`, where

- `azmis`: positive rotation about an axis parallel to the SAOsac $Y$ axis; positive rotation is right-hand-rule rotation with angle increasing from the $+Z$ axis towards the $+X$ axis. ($X'$ axis is the new $X$ axis after `azmis` rotation; $Z'$ axis is the new $Z$ axis after `azmis` rotation).
- `elmis`: negative rotation about an axis parallel to SAOsac $X'$ axis; positive rotation is right-hand-rule with angle increasing from the $+Y$ axis towards the $+Z'$ axis. Positive `elmis` rotation takes $+Z'$ axis towards the $+Y$ axis.

For completeness, the corresponding conventions for mirror element rotations in the HRMA and XRCF coordinates are
The raytrace simulations are always performed in the appropriate SAOsac coordinate system; the orientation of the HRMA relative to the source is given by bundle_el and bundle_az, the direction from the source towards HRMA. The relation between pitch, yaw, bundle_el, and bundle_az are summarized in Table B.1.

Table B.1: Relations between coordinate systems

<table>
<thead>
<tr>
<th>Relation</th>
<th>SAOsac</th>
<th>DPSAOsac</th>
</tr>
</thead>
<tbody>
<tr>
<td>$+\theta_{Z}$</td>
<td>$-\theta_{HRMA}$</td>
<td>$-X_{SAOsac}$</td>
</tr>
<tr>
<td>$+\theta_{Y}$</td>
<td>$-\theta_{HRMA}$</td>
<td>$+Y_{SAOsac}$</td>
</tr>
<tr>
<td>$+\theta_{Z}$</td>
<td>$+X_{HRMA}$</td>
<td>$-Z_{SAOsac}$</td>
</tr>
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<td>$-\theta_{Y}$</td>
<td>$+\theta_{Y}$</td>
</tr>
<tr>
<td>$+\theta_{Z}$</td>
<td>$-\theta_{Z}$</td>
<td>$+\theta_{Z}$</td>
</tr>
</tbody>
</table>

Table B.2: Relations between coordinate systems

The relations between coordinate directions are summarized in Table B.2.