



ChaRT Issues and Caveats

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Introduction

With the combination of ChaRT and MARX, users may now easily perform detailed simulations of the Chandra PSF. Both of these pieces of software have limitations of which users should be aware; those limitations are described here.

A list of known problems with ChaRT is available from the [bugs page](#). Also, the [Chandra Instruments and Calibration page](#) contains the most recent status information.

Run ChaRT Interface

There is a suggested limit on the maximum ray density of 10 rays/mm². However, this is only an approximate to our runtime-limited maximum of 1 hour per request. Running multiple energies in a single job can bump into the runtime limit. If your job returns the message:

"A problem was encountered while our servers were processing your request."
Then please re-submit the job with fewer energies or a lower ray density.

SAOsac

The raytraces performed by SAOsac are designed to precisely model the optics and their support structures, and are based upon mirror metrology, as-built and as-designed drawings of the support structure, and pre-flight tests of the HRMA. The raytraces are deterministic, rather than statistical, in that they follow individual photons through the optical system (see the [Chandra optics overview](#) for a description).

The model is calibrated by comparing it to actual observations. Such calibration is ongoing; see [HRMA calibration pages](#) and [Chandra Calibration Workshop proceedings](#) for current analyses.

The [HRMA User's Guide](#) contains a more detailed discussion of HRMA PSF characteristics, including some SAOsac issues.

- *On-axis PSF:*

The low-energy (< 2keV) PSF core and inner wing region (out to 10 arcseconds) match well with observations (see [ARLac memo, Jerius 2002](#)).

We believe that the high energy core should be well modeled.

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High energy (greater than 2keV) comparisons of the PSF with in flight data are not yet sufficiently mature enough to draw quantitative conclusions (see the [PSF wings presentation](#)), but the models seem to underpredict the flux in the wings (both close to the core and further out) at these energies.

- ***Off-axis PSF:***

The off-axis PSF is a complicated function of energy and source off-axis and azimuthal position. The gross (and not so gross) structure of the PSF is well modeled. There are differences in the details of the structures in the cores of the PSF, but unless one is doing incredibly detailed off-axis structural analysis (which it is not recommended to do at this point), this is not an important consideration.

- ***HRMA Vignetting***

The model seems to replicate the observed HRMA vignetting well (to better than 10%). This has been calibrated (in rather large 1keV bins) against observations, see [HRMA calibration pages](#) for details.

- ***Aspect***

The SAOsac model currently *does not model the dither motion of the telescope*, and does not include residual blur from aspect reconstruction errors. This is important only for (extremely) detailed spatial analyses of on-axis sources. The current residual blur is less than known detector event position uncertainties or pixel sizes, so this is in general is not an issue.

- ***Errors***

It is difficult to quantify errors in individual representations of the PSF, so the generated rays do not include error information. The user is directed to the calibration analyses to estimate their errors.

- ***Monte-Carlo errors***

A single raytrace of the PSF samples only a portion of the possible optical paths in the HRMA, especially when run with the number of photons typical of most Chandra observations. Several realizations (or one with a larger number of photons) may be necessary in order to make a detailed comparison with observations.

MARX

- ***Detector chips***

Currently the user can either select ACIS-S or ACIS-I chips but not a combination ACIS-S and ACIS-I chips. For example, MARX cannot project the rays generated with ChaRT if the observed source is located on an ACIS-I chip, but the aimpoint is on ACIS-S.

- ***Aspect reconstruction uncertainties***

By default, MARX simulations should be run with the DitherModel parameter set to a value of "INTERNAL" to ensure sub-pixel event location information is preserved in the final Sky X and Y values stored in the event file. This value is the default. For real Chandra data, the [aspect reconstruction](#) process introduces small (~0.35 arcsec for ACIS and 0.18 arcsec for HRC) positional errors in the derived sky positions for events. MARX includes the effects of these errors using the DitherBlur parameter.

The DitherBlur parameter is a statistical term which combines aspect reconstruction accuracy, pixelization by the detector, and pixel randomization ("anti-aliasing"). The default value for this parameter derives from comparison to flight data. For exact projection of a priori known photon positions to the sky without this blurring, the value can be set to zero. See the [MARX manual](#) or the [Using MARX to Create an Event File thread](#) for further details.

• *ACIS pileup simulation*

If users choose, they may simulate the effects of photon pileup in the ACIS detectors by using the PILEUP tool included as part of the MARX package. This option is not run by default. This tool implements the pileup algorithm developed by John Davis (MIT). This same algorithm has been implemented into the ISIS, Sherpa, and XSPEC spectral fitting packages.

While this implementation of the pileup algorithm emulates most of the qualitative effects of ACIS photon pileup, users should keep in mind that we are still calibrating the procedure. The ACIS pileup model is statistical and is not an a priori photon–silicon interaction model which generates charge clouds and then PHAs per event "island." The model is valid on–axis for point sources for low to moderate pileup. While valid for *qualitative* predictions of the effects of pileup on the PSF, it has not been verified for image reconstruction. Detailed studies of the effects of pileup on the HRMA PSF including comparisons to actual on–orbit data are still underway. The model is very good for spectral modeling of light to moderately piled point sources. Users should interpret all ChaRT and MARX results including the effects of pileup cautiously.

Further reading about ACIS pileup modeling:

- ◆ [MARX manual](#)
- ◆ [HEAD 2002 Pileup Talk](#) (J. Davis)
- ◆ [Pileup Correction in ISIS, Sherpa, and XSPEC: A Comparison for Low Pileup Fractions](#) (M. Nowak)

• *HRC Micro–Channel Plate (MCP) event position uncertainties*

For simulations utilizing the HRC–I or HRC–S, event locations are not calculated from simulated tap voltages, but assume low–level instrumental signatures have been removed (i.e., degapped) and converted to linear detector coordinates. In MARX, the positional uncertainty produced by the HRC detection process is modeled using a simple Gaussian blurring factor. There may be differences in detail from the observed PSF due to uncalibrated non–linearities in the detector.

Detectors

• *HRC*

When comparing simulations with data, users should be cautious in interpreting any extension of HRC sources as astrophysical. There is a blur term in the HRC observations *in addition* to the errors due to

- ◆ the HRMA PSF,
- ◆ an intrinsic detector PSF, and
- ◆ [aspect reconstruction](#)

Note that the first term is modeled by ChaRT and the second and third are modeled by MARX.

The additional blur, which *is not* modeled by either ChaRT or MARX, is caused by dithering over residual errors in the HRC event detector position reconstruction. Its size depends on how the dither pattern samples detector space but is typically 3–4 HRC pixels (0.4–0.5 arcsec). For more information see the [Blur from Residual Errors in HRC Event Position Reconstruction memo](#).

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