Using MARX to Create an Event File

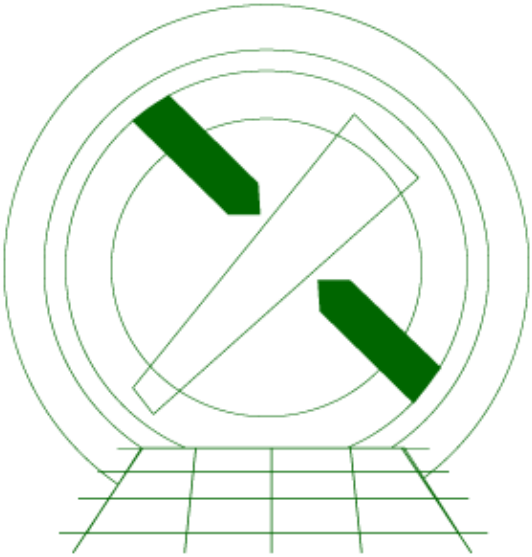

ChaRT Threads

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Overview

Last Update: 18 Feb 2010 - updated to MARX v4.5.0; added Correcting for an Offset section; added mention of the MARX DataDirectory parameter

Synopsis:

The output of ChaRT is a set of rays (a `PSFRAYS` table) which cannot be used directly in your analysis; it must be converted into a suitable format, i.e. a pseudo event file. The MARX software is used to project the rays onto the detector plane.

Using MARX allows us to take into account all changes to the photon distribution emerging from the HRMA due to the detector response. In particular, the detector QE & QEU and the roll are accounted for. In addition to simulating the detector response, MARX uses the ray weights to account for the mirror effects, i.e. different efficiency of different shells at different angles/energies.

Related Links:

- Caveats page: details on what is **not** included when using MARX.
- The MARX Frequently Asked Questions webpage

Get Started

This example uses `HRMA_theta5.949_phi197.7_en1.7_d2.fits`, which was created in the Introduction to ChaRT Data Files thread. Also:

Sample ObsID used: 942 (ACIS-S, NGC 4244)

File types needed: evt2

Setting up MARX

This thread requires the MARX software. If you do not have *at least* MARX v4.0.8 installed, download and install MARX before continuing. MARX v4.5.0 is used in this thread.

Set up your environment to access all the files and directories which MARX needs:

```
unix% setenv MARX_DIR <local_marx_directory>
unix% set path = ($path $MARX_DIR/bin)
unix% setenv MARX_DATA_DIR $MARX_DIR/share/marx/data
```

Alternatively, the MARX DataDirectory parameter can be defined to point to the data files. By default, this parameter is set to the contents of the MARX DATA DIR environment variable. At this point, your system is ready to run simulations

Get Source Coordinates

Before running the simulation, it is necessary to determine the nominal position of the detector during the observation. These values are stored in the header of the level=2 event file:

```
unix% dmlist acisf00942N003_evt2.fits header | grep _NOM
0055 RA_NOM                    184.3430399825           Real8        Nominal RA
0056 DEC_NOM                    37.7808853898           Real8        Nominal Dec
0057 ROLL_NOM                  230.8753656982           Real8        Nominal Roll
```

Additionally, the source coordinates for the PSF are required. These were determined in the Determine the Off-axis Angle section of the Preparing to Run ChaRT thread:

```
unix% punlearn dmcoords
unix% dmcoords acisf00942N003_evt2.fits asol=pcadf075214790N003_asol1.fits
dmcoords>: sky 4704 3700
(RA,Dec):     12:16:57.136    +37:43:35.94
(RA,Dec):      184.23807       37.72665 deg
THETA,PHI          5.949'        197.74 deg
(Logical):        4704.00       3700.00
SKY(X,Y):         4704.00       3700.00
DETX,DETY         3405.57       3875.41
CHIP ACIS-S2       573.49        753.83
TDET              3448.49       2455.83
dmcoords>: q
```

This step could also be done with `dmcoords` in non-interactive mode:

```
unix% dmcoords acisf00942N003_evt2.fits asol=pcadf075214790N003_asol1.fits opt=sky x=4704 y=3700 celfmt
unix% pget dmcoords ra dec
184.2380699128197
37.72665053564964
```

Projecting the Rays

In order to analyze the spatial distribution of the PSF, we need to project the PSF rays in `HRMA_theta5.949_phi197.7_en1.7_d2.fits` onto the detector plane. MARX enables us to do so.

Copy over the parameter file locally:

```
unix% cp $MARX_DIR/share/marx/pfiles/marx.par ./marx.par
```

and set the necessary parameters:

```
unix% pset ./marx SAOSACFile=HRMA_theta5.949_phi197.7_en1.7_d2.fits
unix% pset ./marx OutputDir=HRMA_theta5.949_phi197.7_en1.7_d2.dir
unix% pset ./marx DitherModel=INTERNAL
unix% pset ./marx SourceType=SAOSAC
```

```
unix% pset ./marx RA_Nom=184.34304
unix% pset ./marx Dec_Nom=37.78089
unix% pset ./marx Roll_Nom=230.87537
unix% pset ./marx SourceRA=184.34304
unix% pset ./marx SourceDEC=37.78089

unix% pset ./marx DetectorType=ACIS-S
unix% pset ./marx GratingType=NONE
unix% pset ./marx ExposureTime=0.0
```

There are a few things to note in the `pset` commands:

- Make sure to use the correct detector for the `DetectorType` parameter; valid options are HRC-S, ACIS-S, HRC-I, or ACIS-I.
- The `Exposuretime` is set to `0.0` to ensure that the simulated output has the desired exposure length. The "Simulation Control: Exposure Time" section of the MARX manual (PDF) has more information on setting this parameter.
- In this example, we are simulating an on-axis source, so `SourceRA = RA_NOM` and `SourceDEC = DEC_NOM`. If you are doing an off-axis simulation, they shouldn't be the same.

Now run the tool. Note the syntax (@@) required to use the local parameter file; see Example 9 of ahelp parameter for details.

```
unix% marx @@./marx.par
MARX version 4.5.0, Copyright (C) 2002-2010 Massachusetts Institute of Technology

... screen output omitted...

Initializing source type SAOSAC...
Opening SAOSAC fits file HRMA_theta5.949_phi197.7_en1.7_d2.fits
System initialized.

Starting simulation.  NumRays to collect = 1000000, dNumRays = 100000
Collecting 100000 photons...
        100000 collected.
Reflecting from HRMA
Detecting with ACIS-S

Writing output to directory 'HRMA_theta5.949_phi197.7_en1.7_d2.dir' ...
Total photons: 100000, Total Photons detected: 60805, (efficiency: 0.608050)
  (efficiency this iteration  0.608050)  Total time: 104.231735

Collecting 100000 photons...
        91683 collected.
Reflecting from HRMA
Detecting with ACIS-S

Writing output to directory 'HRMA_theta5.949_phi197.7_en1.7_d2.dir' ...
Total photons: 191683, Total Photons detected: 116315, (efficiency: 0.606809)
  (efficiency this iteration  0.605456)  Total time: 200.602434

unix%
```

Create an Event File

MARX creates a number of ASCII files in the specified directory (`HRMA_theta5.949_phi197.7_en1.7_d2.dir`):

```
unix% ls HRMA_theta5.949_phi197.7_en1.7_d2.dir
b_energy.dat    pha.dat         xpos.dat
```

```
detector.dat    sky_dec.dat     ycos.dat
energy.dat      sky_ra.dat      ypixel.dat
marx.par        time.dat        ypos.dat
mirror.dat      xcos.dat        zcos.dat
obs.par         xpixel.dat      zpos.dat
```

These `.dat` files need to be converted to a FITS event file before they can be used in CIAO. The MARX tool `marx2fits` does this, given the directory name and the output filename:

```
unix% marx2fits HRMA_theta5.949_phi197.7_en1.7_d2.dir marx_HRMA_theta5.949_phi197.7_en1.7_d2.fits
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/time.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/detector.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/energy.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/b_energy.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/xpos.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/ypos.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/zpos.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/xcos.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/ycos.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/zcos.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/xpixel.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/ypixel.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/pha.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/mirror.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/sky_ra.dat
Examining HRMA_theta5.949_phi197.7_en1.7_d2.dir/sky_dec.dat
unix%
```

The file may be viewed in ds9:

```
unix% ds9 marx_HRMA_theta5.949_phi197.7_en1.7_d2.fits &
```

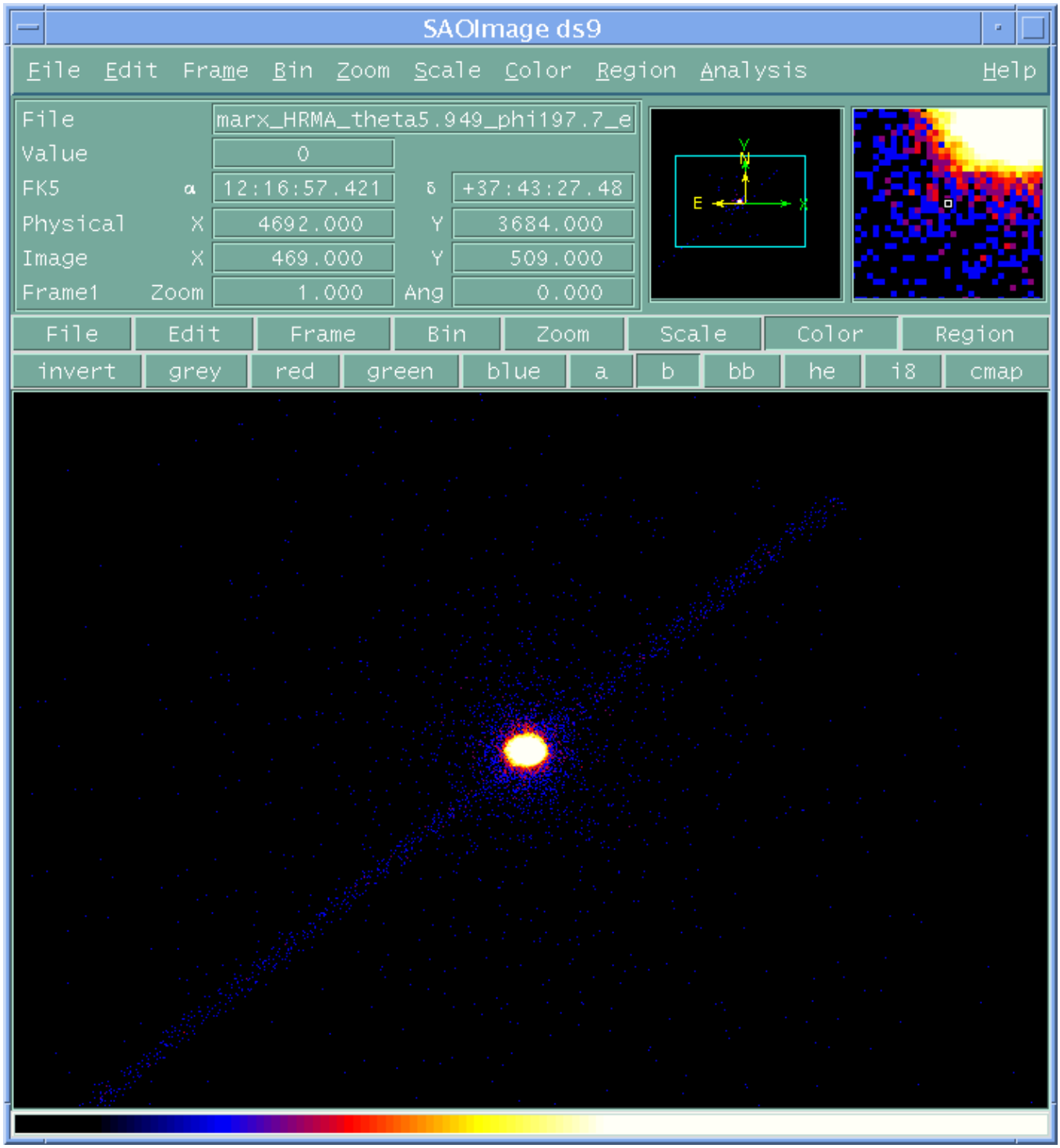

Figure 1: The event file created by MARX

MARX includes a simulation of the ACIS readout streak in the event file.

Correcting for an Offset (Optional)

In some Chandra observations, the science instrument module (SIM) is offset from the nominal location. If this offset is not included in the MARX run, the simulated PSF will be offset from the event file.

The MARX run was done with no offset:

```
unix% plist marx.par | grep DetOffset
    DetOffsetX = 0                Enter Detector X offset from nominal (mm)
    DetOffsetY = 0                Enter Detector Y offset from nominal (mm)
    DetOffsetZ = 0                Enter Detector Z offset from nominal (mm)
```

It is easiest to correct for the observation offset after doing a MARX run with the offsets set to zero. First, compare the SIM values in the original Chandra event file and in the MARX-produced event file:

```
unix% dmlist acisf00942N003_evt2.fits header | grep SIM_
0039 SIM_X                   -0.68282252473119           Real8        SIM focus pos (mm)
0040 SIM_Y                                   0           Real8        SIM orthogonal axis pos (mm)
0041 SIM_Z                     -190.1400660499           Real8        SIM translation stage pos (mm)

unix% dmlist marx_HRMA_theta5.949_phi197.7_en1.7_d2.fits header |grep SIM_
0046 SIM_X                   -0.68426746699586           Real8        SIM offset, mm
0047 SIM_Y                                   0           Real8        SIM offset, mm
0048 SIM_Z                     -190.1325231040           Real8        SIM offset, mm
```

Some observations are done with an offset of several mm. The difference, calculated as `event_file_value - marx_file_value`, is small in this case:

```
SIM_X: -0.68282252473119 - (-0.68426746699586) =  0.00144494

SIM_Z: -190.1400660499   - (-190.1325231040)   = -0.00754295
```

Set these values in marx.par and run the simulation again:

```
unix% pset ./marx DetOffsetX = 0.00144494
unix% pset ./marx DetOffsetZ = -0.00754295

unix% pset ./marx OutputDir=offset_HRMA_theta5.949_phi197.7_en1.7_d2.dir

unix% marx @@./marx.par

unix% marx2fits offset_HRMA_theta5.949_phi197.7_en1.7_d2.dir offset_marx_HRMA_theta5.949_phi197.7_en1.7
```

The resulting MARX file has the new SIM values:

```
unix% dmlist offset_marx_HRMA_theta5.949_phi197.7_en1.7_d2.fits header |grep SIM_
0046 SIM_X                   -0.68282252699586           Real8        SIM offset, mm
0047 SIM_Y                                   0           Real8        SIM offset, mm
0048 SIM_Z                     -190.1400660540           Real8        SIM offset, mm
```

Summary

The output file (`marx_HRMA_theta5.949_phi197.7_en1.7_d2.fits` or `offset_marx_HRMA_theta5.949_phi197.7_en1.7_d2.fits`) is a pseudo event file that can be used, for example, to create an image of the PSF.

History

27 Jun 2003	original version, updated for CIAO 3.0: layout
02 Dec 2004	added note about setting `ExposureTime` parameter
16 Feb 2005	reviewed for CIAO 3.3: no changes
31 Jul 2007	updates for ciao3.4
18 Aug 2008	updated for CIAO 4.0: MARX v4.2.0; minor changes to screen output; image converted to inline
09 Oct 2008	updated to MARX v4.3.0
18 Feb 2009	updated to MARX v4.4.0
19 Mar 2009	updated MARX v4.4.0 syntax to find modified parameter file first
18 Feb 2010	updated to MARX v4.5.0; added Correcting for an Offset section; added mention of the MARX DataDirectory parameter

URL: http://cxc.harvard.edu/chart/threads/marx/ Last modified: 18 Feb 2010