CALIBRATION/INSTRUMENTAL EFFECTS: HRMA PSF

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Cal/Inst effects: HRMA PSF

- **Chandra produces the sharpest images than any X-ray telescope to date**

➡ **Provides opportunity for unprecedented high spatial resolution studies**

- **Key to this capability is the knowledge of the PSF characteristics**

➡ **Blurring is introduced by:**

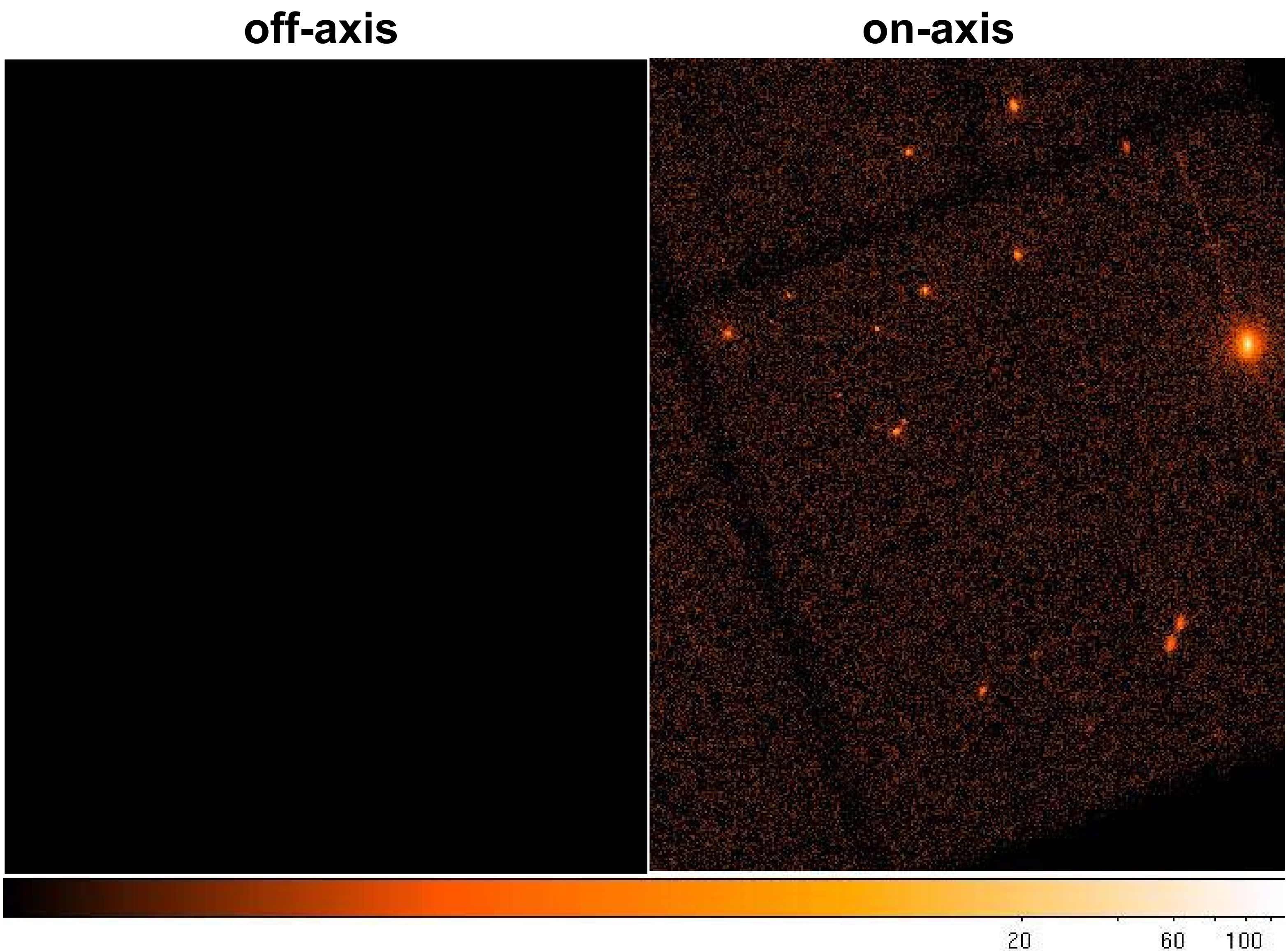
HRMA PSF + Aspect + size of Detector pixels + Detector effects

Cal/Inst effects: HRMA PSF

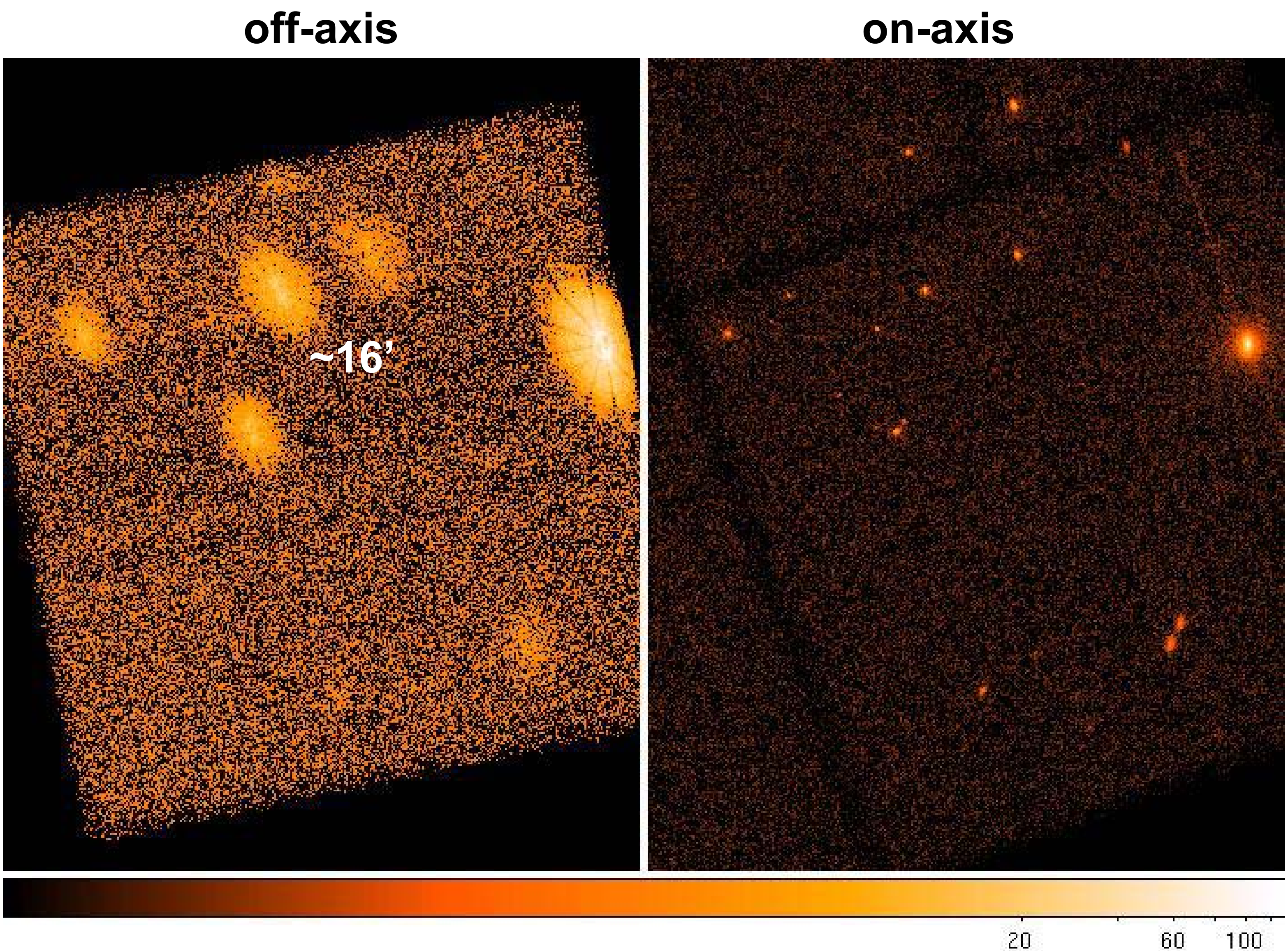
- **The shape and size of HRMA PSF varies as a function of off-axis angle and energy (i.e. depends on location and spectral distribution of the observed source)**

  - Image quality is the best in a small area centered around the optical axis (subarcsecond size at 0.3 keV)

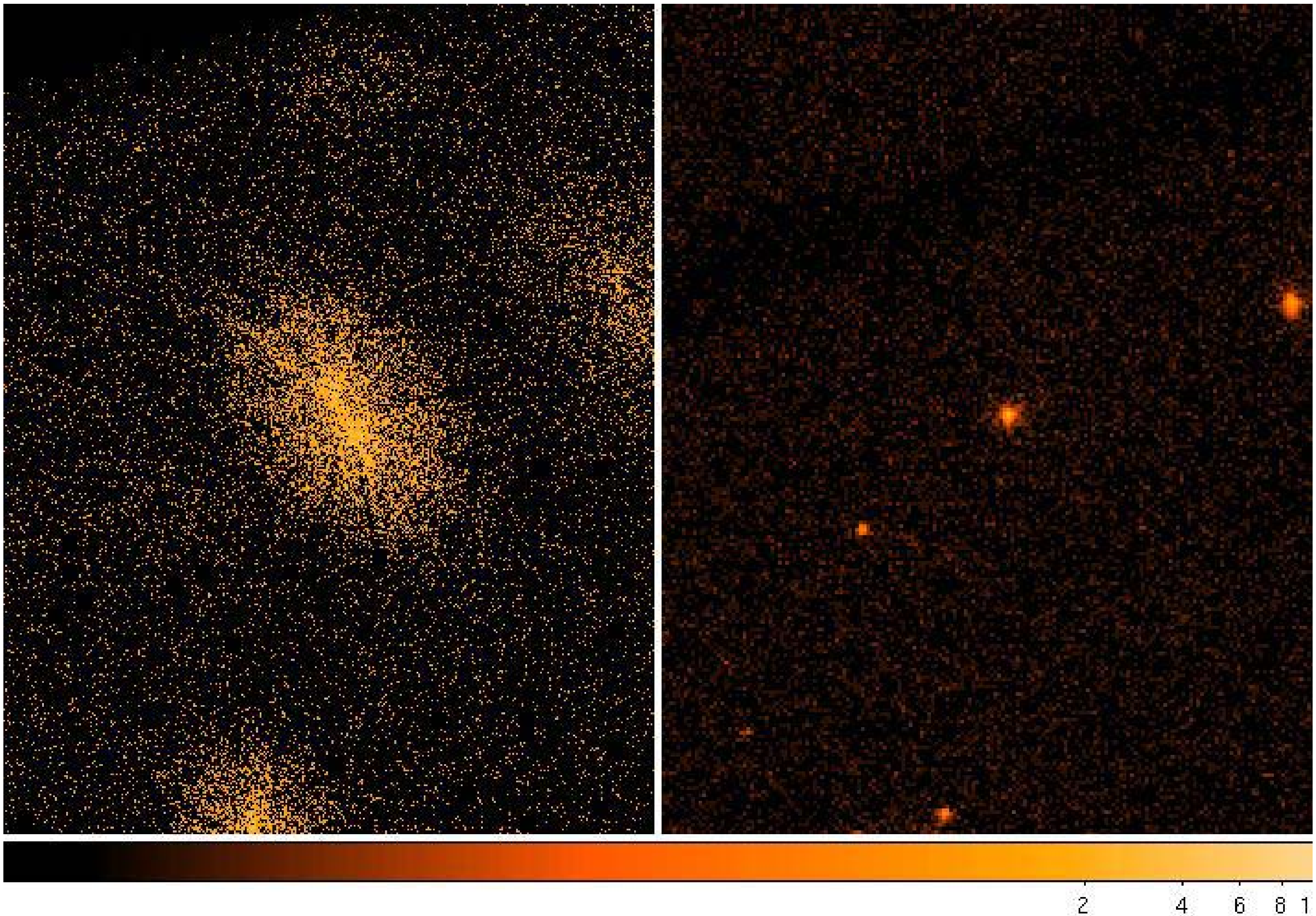
Cal/Inst effects: HRMA PSF

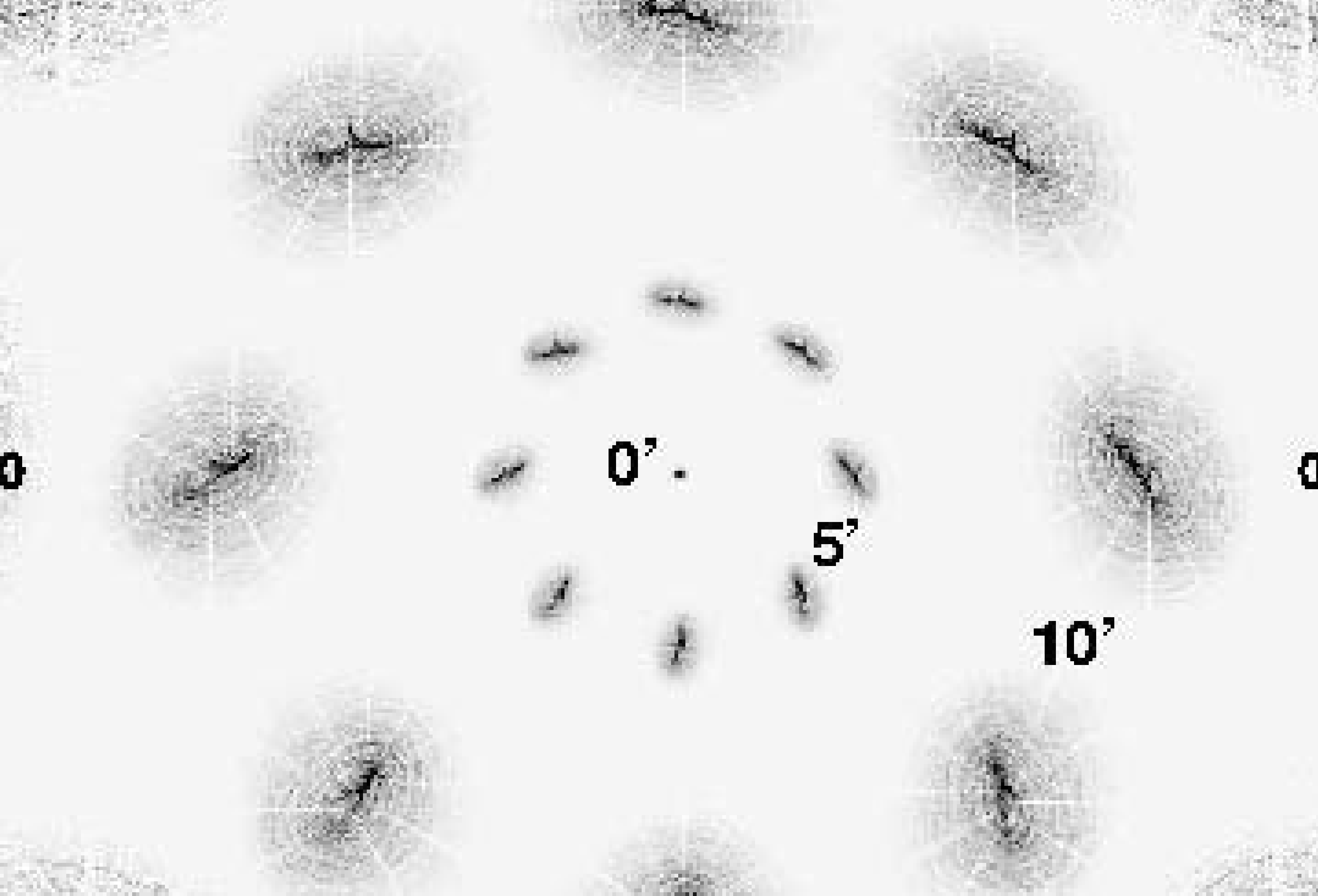


Cal/Inst effects: HRMA PSF



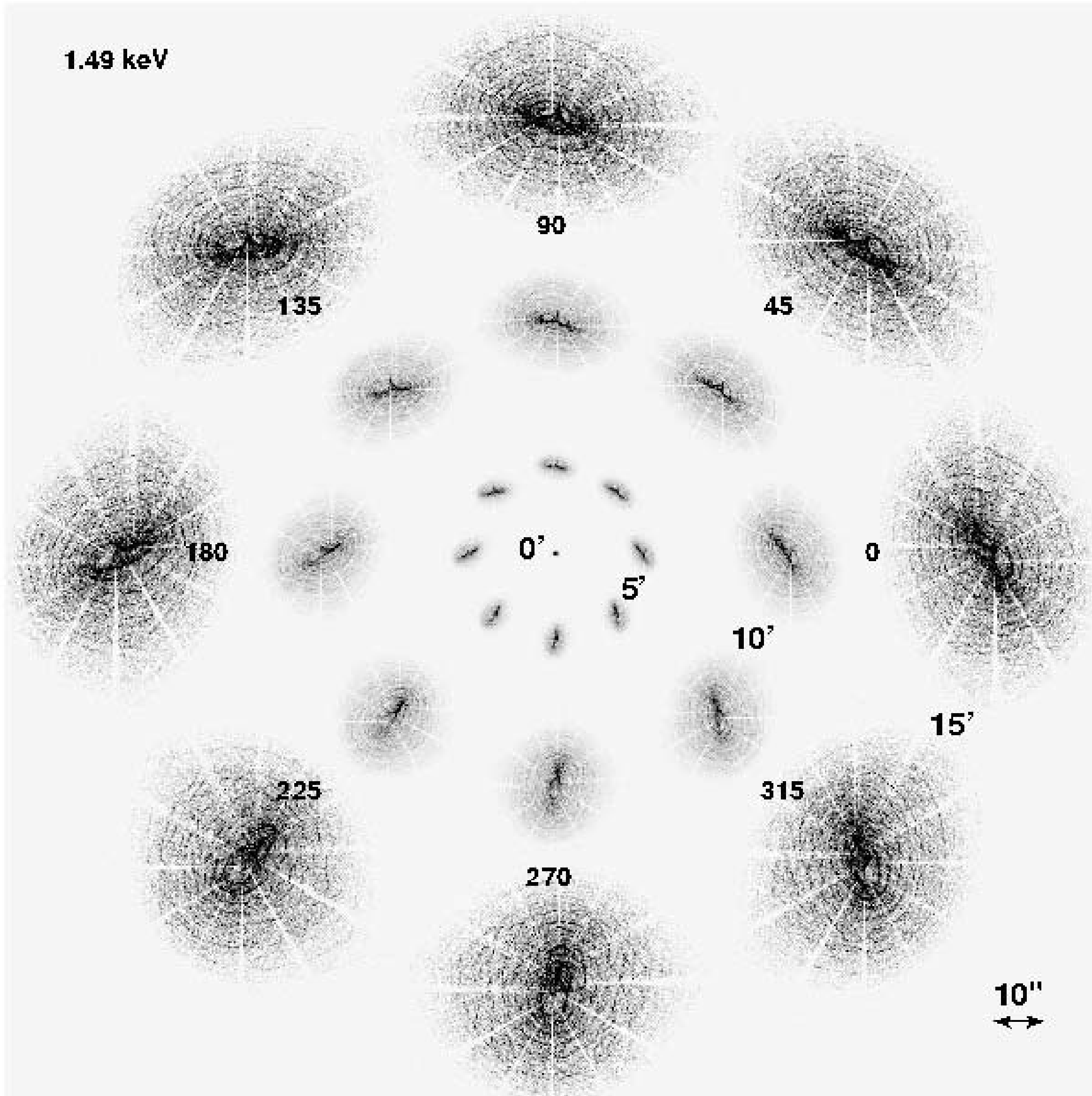
Cal/Inst effects: HRMA PSF





0'
5'
10'

Cal/Inst effects: HRMA PSF



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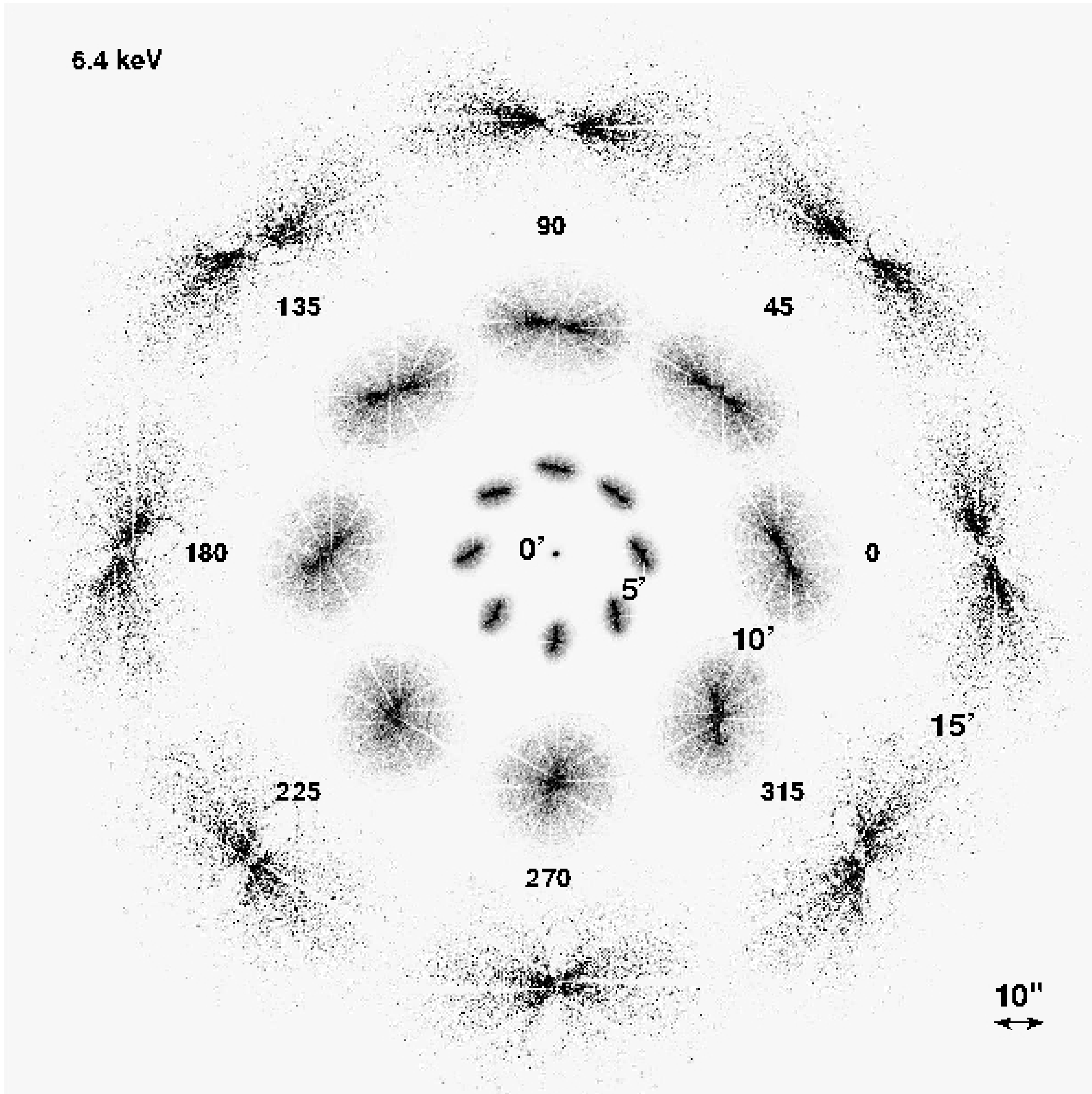

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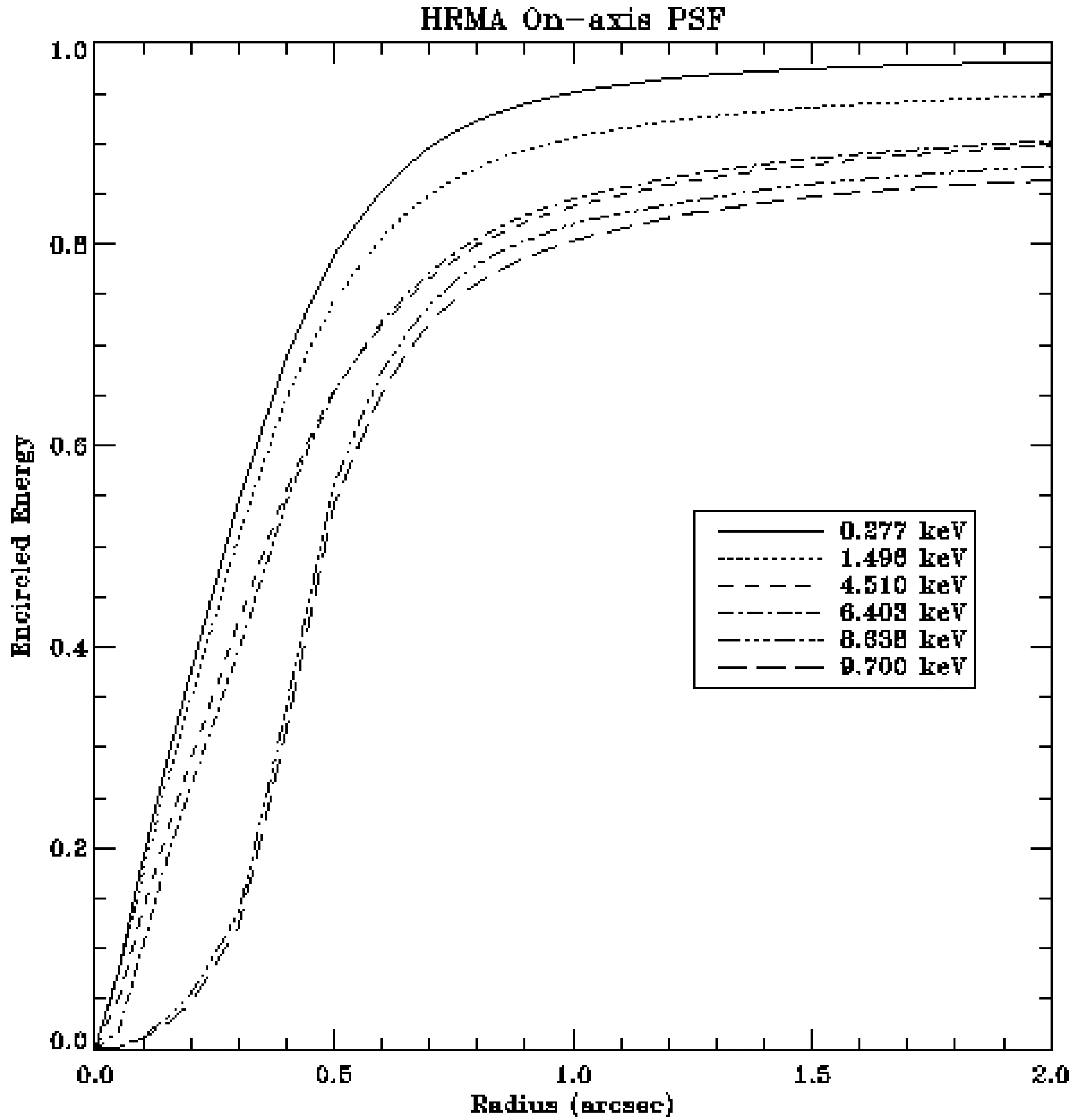

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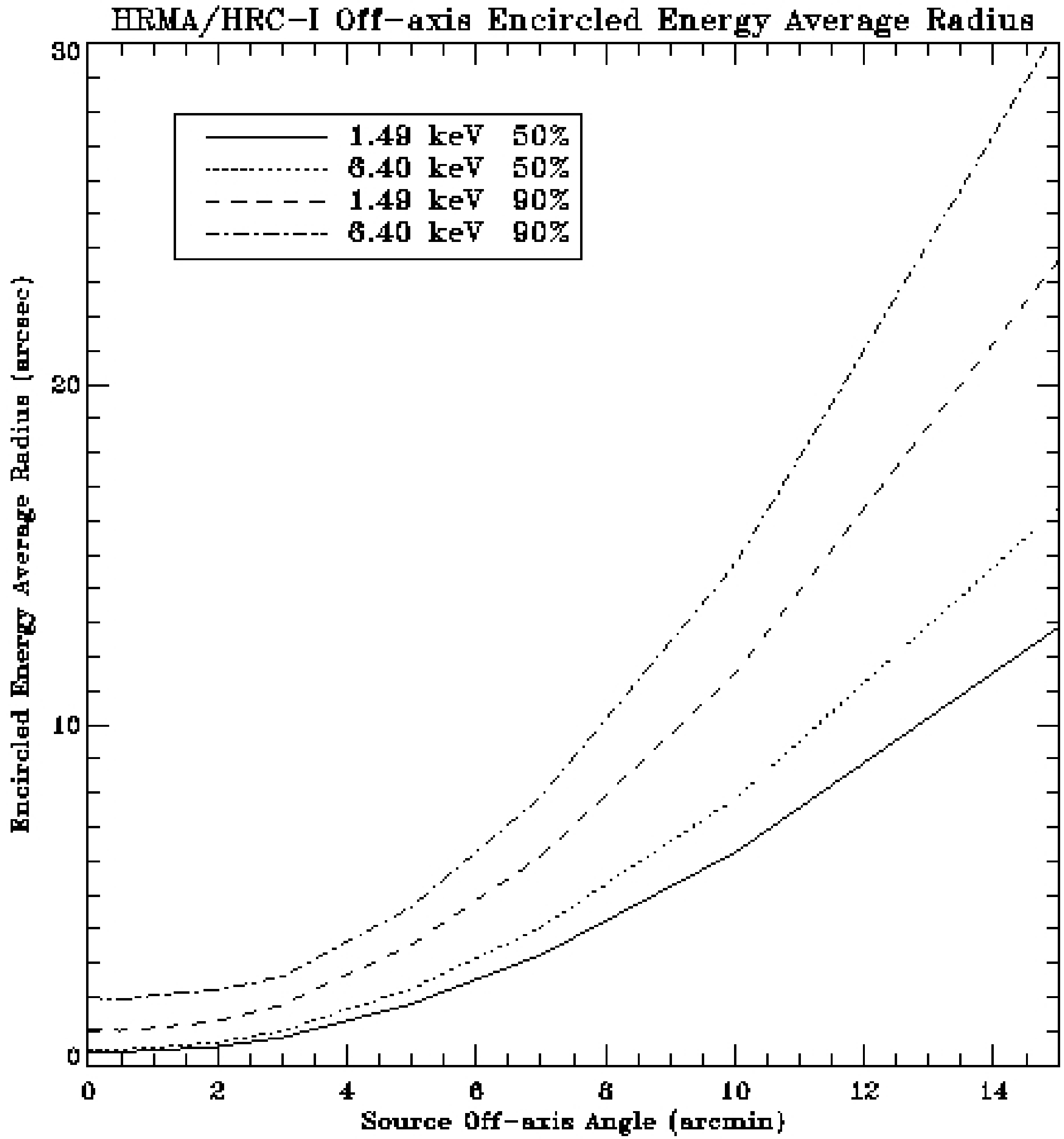

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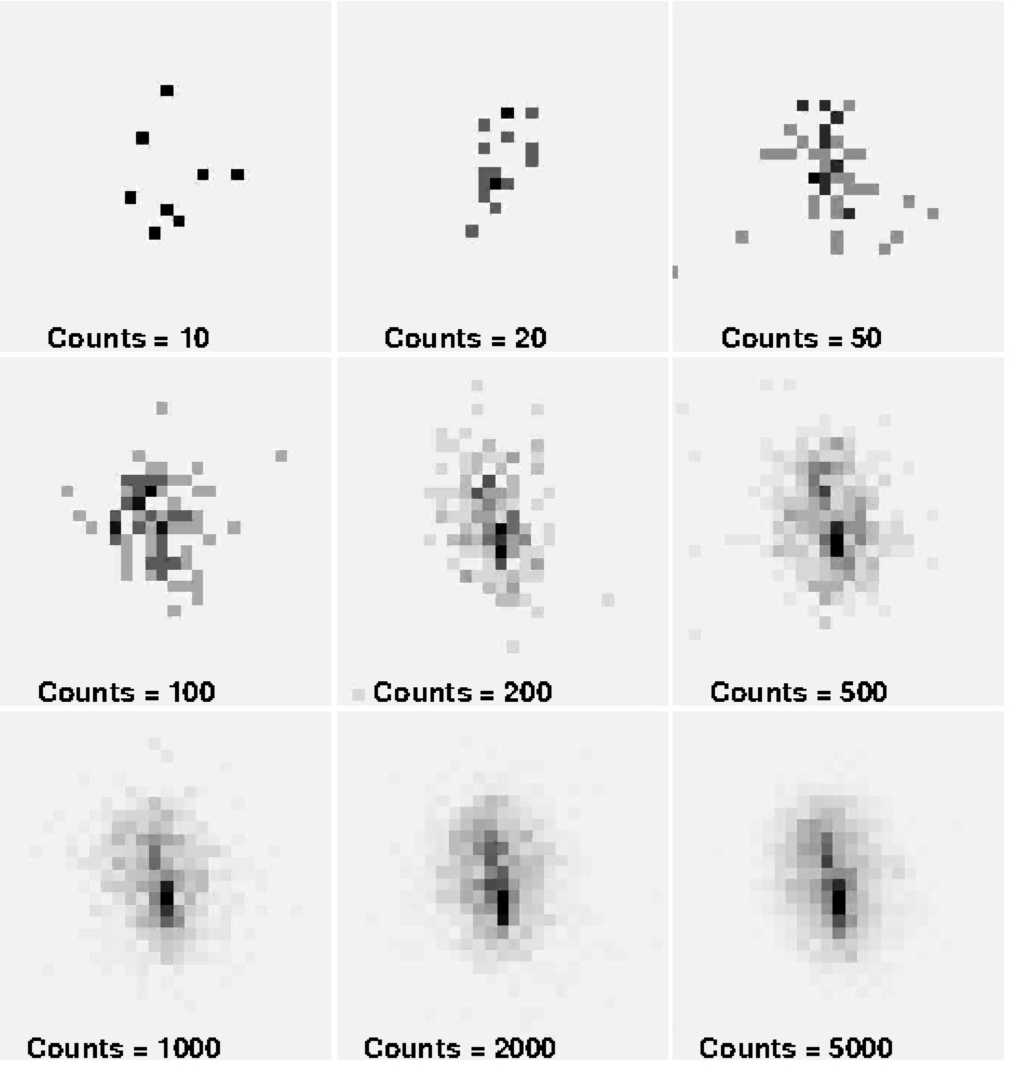

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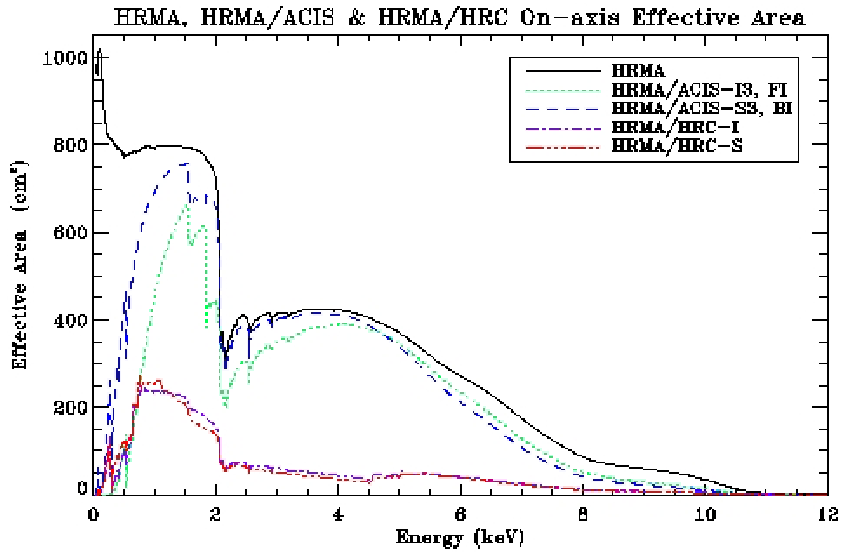

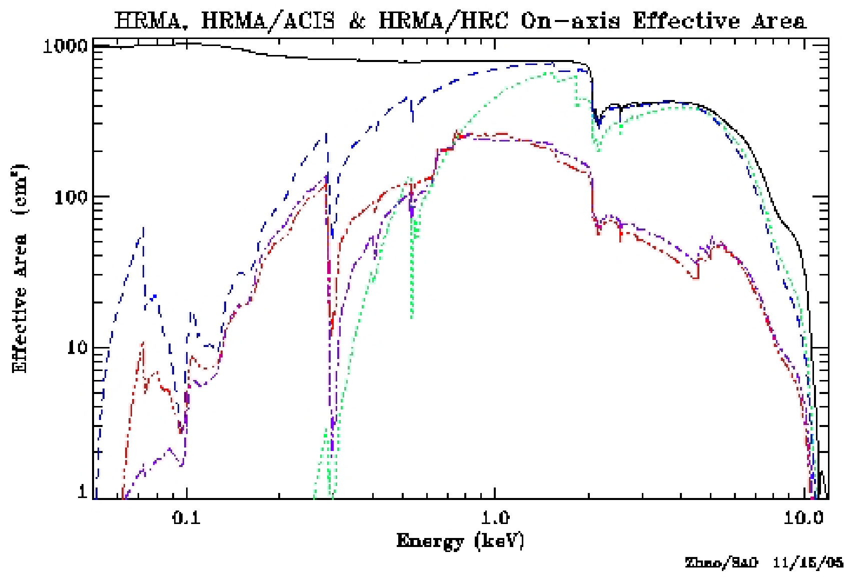

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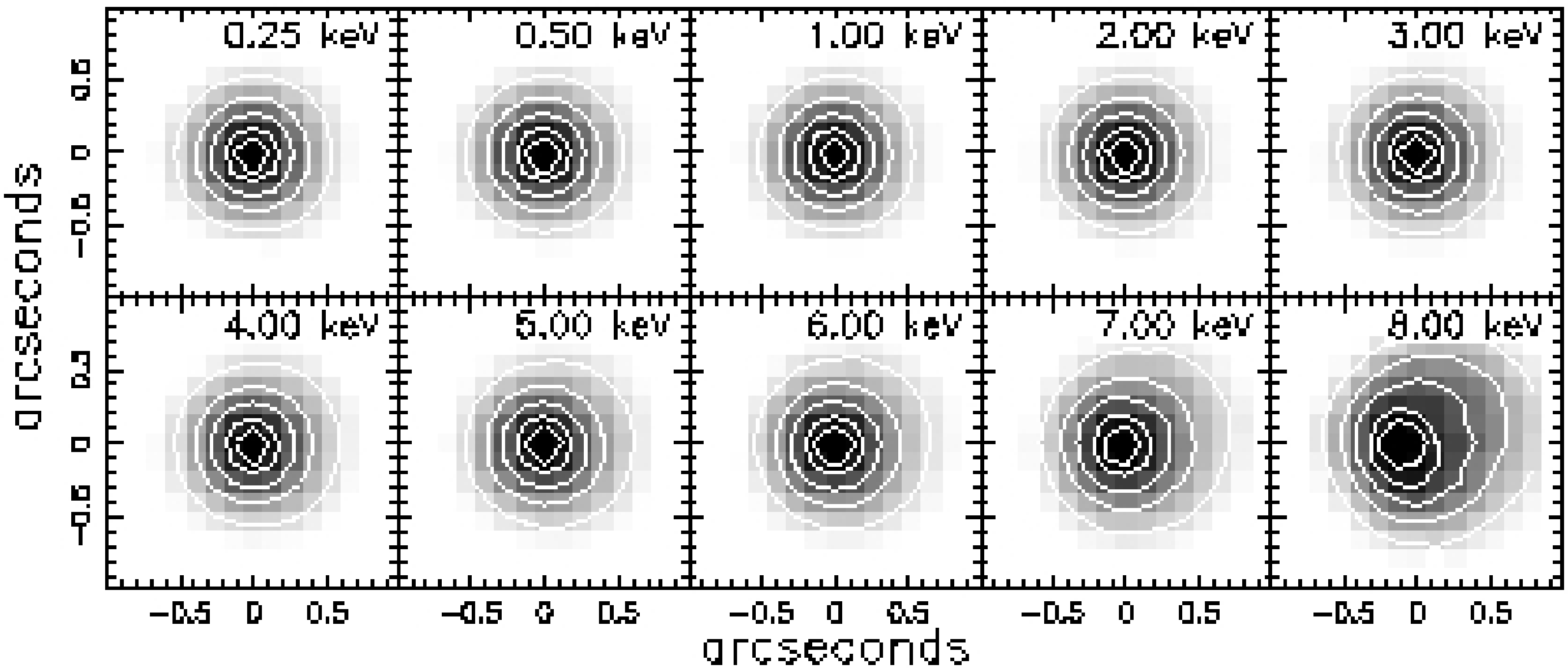

- **Simulating the HRMA PSF with ChaRT/SAOsac is the first step in obtaining a good model of a PSF**

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HRMA PSF simulator

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.

http://cxc.harvard.edu/cal/hrma/psf

Cal/Inst effects: HRMA PSF

Chandra X-ray Center

http://cxc.harvard.edu/chart

Chandra Ray Tracer (ChaRT)

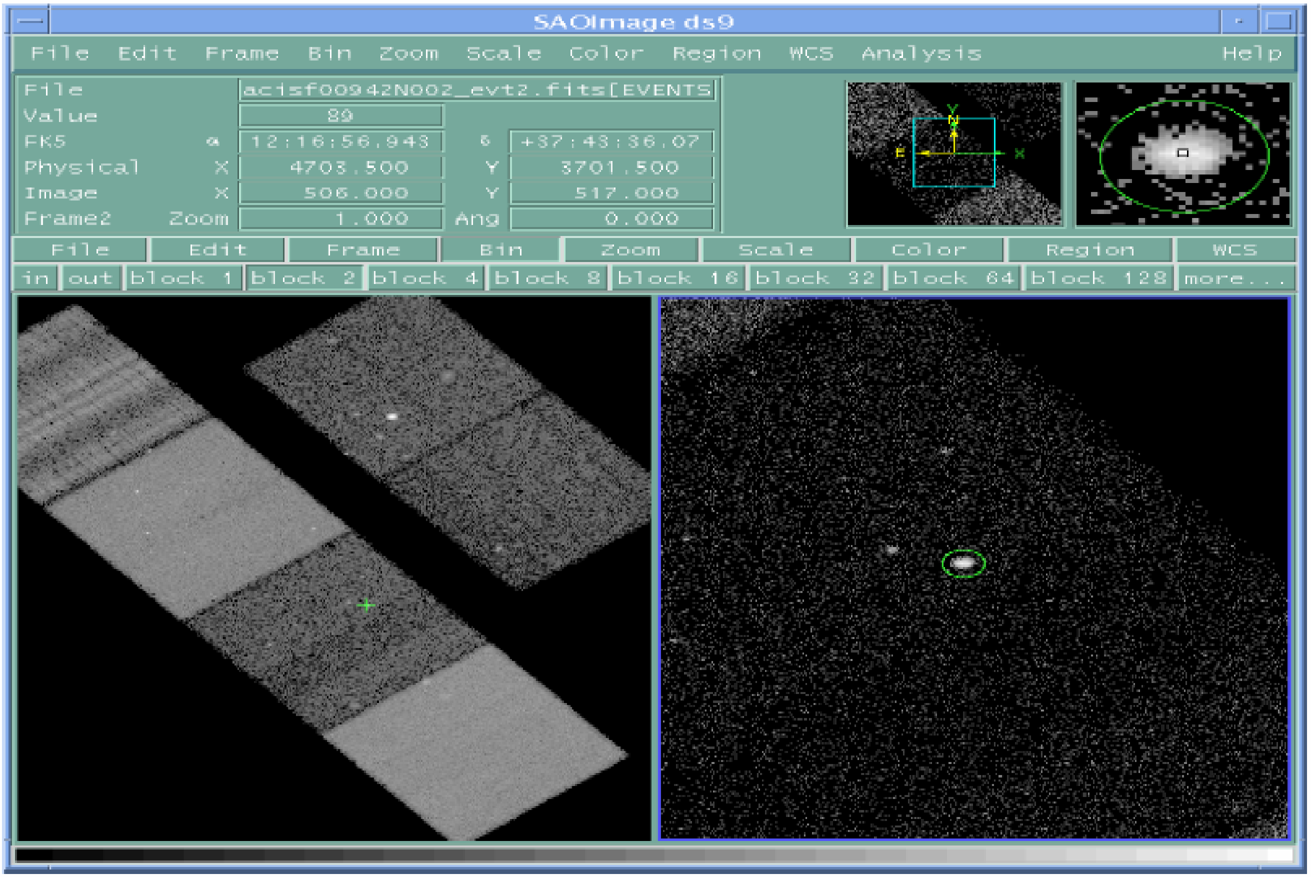
The Chandra Ray Tracer (ChaRT) - the Chandra PSF simulator - is a web interface to the SAOsac raytrace code which was developed by the CXC for calibration purposes. ChaRT traces rays through the Chandra X-ray optics to produce a collection of rays. The rays are then projected onto the detector (via MARX), taking into account any detector effects. The result is an event file from which an image of the point spread function may be created.

Since Chart runs the same code that is used internally at the CXC for calibration, it gives the best available HRMA PSF for a point source at any off-axis angle and for any energy or spectrum. Technical details are available from the ChaRT description page.

Determine the Off-axis Angle

It is necessary to find the location of the source (or position) for which you would like to generate a PSF. To find the coordinates of a source - that is, the offsets from the optical axis - display the event file in ds9:

```
unix% ds9 acisf00942N003_evt2.fits
```



ChaRT

There are known problems inputting monochromatic energies when using Safari or Mozilla Firefox; please refer to the ChaRT bug page for more info.

Step 1 (of 3): Enter information about request

Name: user's name — *Your name.*

Email Address: user@location.edu — *Your email address.*

Multiple Request Help:
When preparing source lists, please keep in mind that you're only allowed to submit one request at a time. If you're waiting for a recent request to finish simulation, you may still prepare and verify another list of sources, but you must wait to submit it until you recieve confirmation (via email) that your previous job has completed.

Random Seed: 115014930 [New Seed] — *A random integer. You may use the one has been generated for you, or you may supply your own. It must be between 1 and* ***2147483561***

Src #	Location	Energies or Spectrum File	
	Coordinates:	Spectral and Limit Specification:	Monochromatic Energies [keV] or Spectrum:
1	Theta [arcmin]: 2.96 Phi [deg]: 237	(●) Energies with Density ( ) Spectrum with Exposure Time	1.5 [Browse...] Density [ray/mm^2] or Exposure Time [ksec]: 0.1
	Coordinates:	Spectral and Limit Specification:	Monochromatic Energies [keV] or Spectrum:
2	Theta [arcmin]: 15.27 Phi [deg]: 168	(●) Energies with Density ( ) Spectrum with Exposure Time	6.5 [Browse...] Density [ray/mm^2] or Exposure Time [ksec]: 1

[More Sources] [Reset] [Submit]

ChaRT

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Step 2 (of 3): Verify request

You've submitted the following request:

Name: user's name
Email Address: user@location.edu
Random Seed: 115014930

Source 1 :

- **Theta:** 2.96
- **Phi:** 237
- **Energies:** 1.5
- **Density of rays to generate:** 0.1

Source 2 :

- **Theta:** 15.27
- **Phi:** 168
- **Energies:** 6.5
- **Density of rays to generate:** 1

Please review this information and, when you're certain that it's correct, click the `Proceed' button. If you'd like to make any changes, just click the `Go Back' button.

Go Back | Proceed

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Step 3 (of 3): Submit request

```
job submitted: 44242.young
job submitted: 44243.young
job submitted: 44244.young
job submitted: 44245.young
job submitted: 44246.young
job submitted: 44247.young
job submitted: 44248.young
job submitted: 44249.young
job submitted: 44250.young
```

Your request has been submitted and will promptly begin processing. You will recieve an email (at the address user@location.edu) when your job has completed.

Home | Go Back | Resubmit

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- **Next step: HRMA PSF rays are projected to detector planes**

  - The ChaRT ray-event file can be used as input to MARX and detector effects are simulated

http://cxc.harvard.edu/chart/threads

ChaRT Threads

Other threads: CIAO | Sherpa | Proposal

ChaRT is easily run with a few input parameters, producing output data files that contain the simulated HRMA PSF. The following threads illustrate collecting the necessary input for ChaRT, unpacking and identifying the output files and the final step of projecting the HRMA PSF onto the detector plane.

- Preparing to Run ChaRT
- Introduction to ChaRT Data Files

After running ChaRT, the simulated PSF must be projected onto onto the detector plane. This is done with MARX, which includes the detector response.

- Using MARX to Create an Event File
- Creating an Image of the PSF

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- **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 needed in order to make a detailed comparison with observations.

Very Important!

ChaRT Issues and Caveats

http://cxc.harvard.edu/chart/caveats

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/mm^2. 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.

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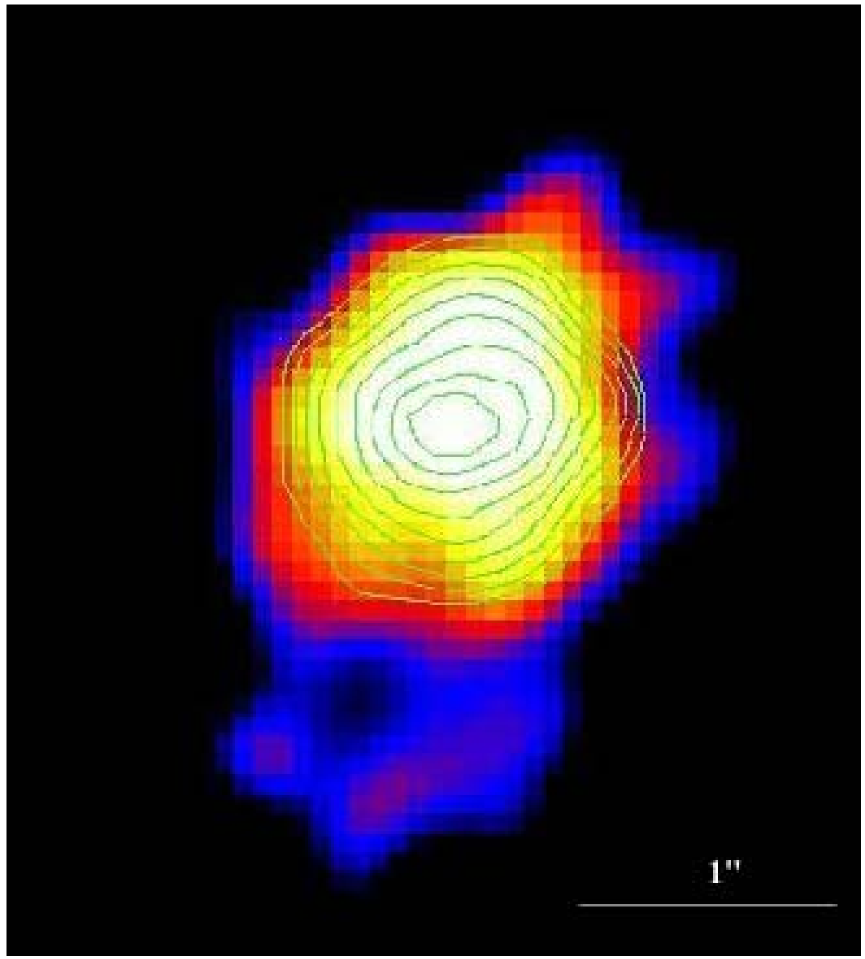

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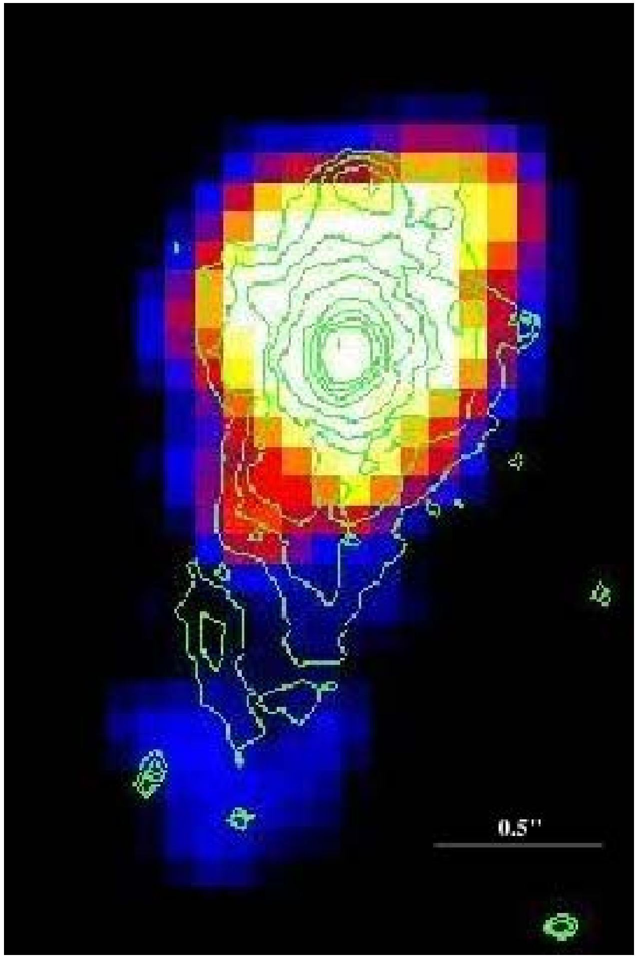

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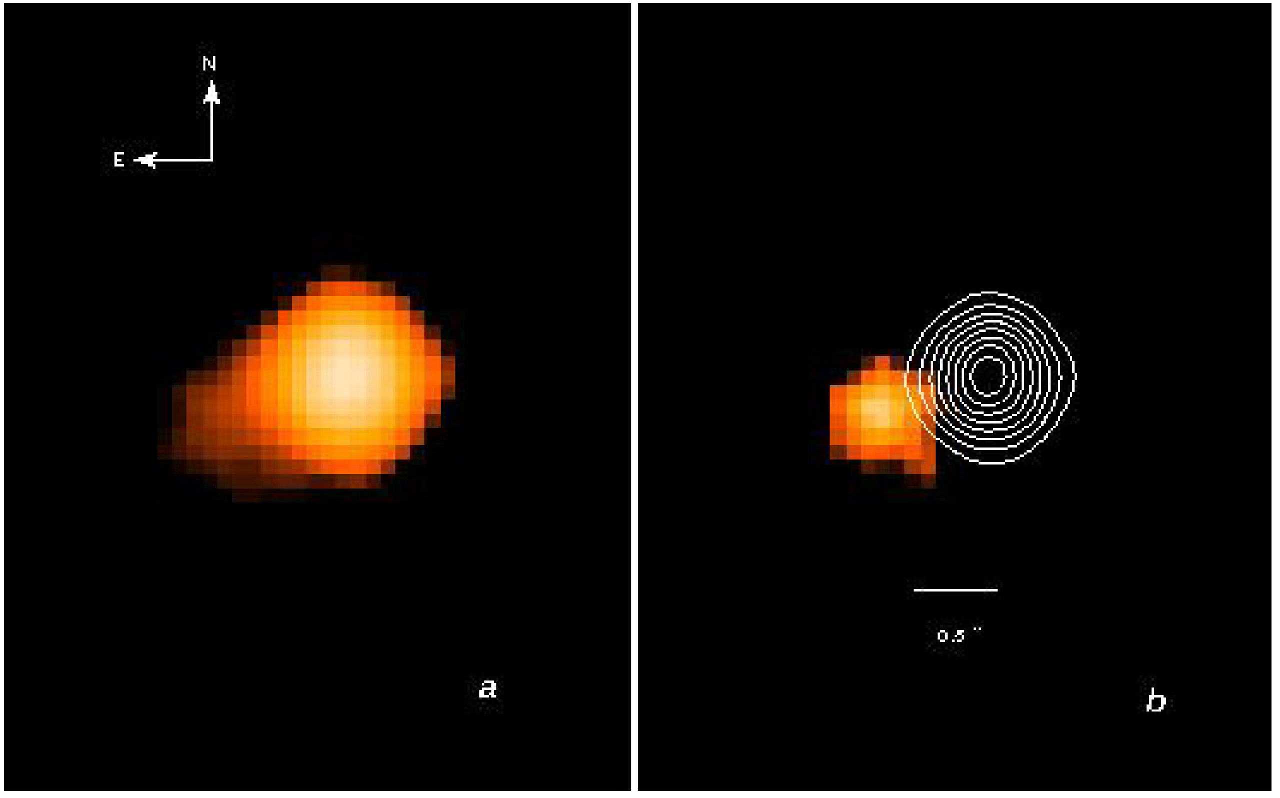

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