

**MEMORANDUM**

Date: December 13, 2002  
 From: Nancy R. Adams-Wolk  
 To: ACIS Operations Team, MIT ACIS Team  
 Subject: ObsId 7501- Cygnus X-1 failure simulations  
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**Abstract**

A cycle 8 observation of the Cygnus X-1 shocked shell is simulated to estimate damage to the detector. The actual observation puts the x-ray source off of the detector, however I simulated the worst case scenarios to determine if we need to have a real time contact during the observation to confirm that the observation is run as expected.

**1 Introduction**

ObsId 7501 is an ACIS-I observation of the Cygnus X-1 shocked shell. Cyg X-1 is placed just off of the I array as shown in Figures 1 and 2. The source is currently in a low flux state (0.188 crab). As planned, the observation should not damage the detector.

In the case of a pointing or dither error, it is possible, albeit not probable, that Cyg X-1 could fall on-axis. In this case, a significant percent of the mission dose could impinge the detector. I have simulated 8 cases to estimate the damage that could happen if there are any issues with the spacecraft that would put the source on axis or if the spacecraft failed to dither.

Model Component	Parameter	Value	Unit
phabs	nH	1.40000	10e22
highcut	cutoffE	27.4000	keV
highcut	foldE	237.000	keV
bknpower	PhoIndx1	1.72800	
bknpower	BreakE	9.22000	keV
bknpower	PhoIndx2	1.53600	
bknpower	norm	1.03000	
gaussian	LineE	6.35000	keV
gaussian	Sigma	0.370000	keV
gaussian	norm	3.10E-03	

Table 1: Cyg X-1 Low flux state model: Using a phabs\*highcut(bknpower+gaussian)

**2 The Simulations**

I used two different models as provided by M. Nowak(Tables 1 and 2): the first model describes the low flux/hard spectrum, hereby referred to as “low” and the second describes the high flux/soft spectrum, hereby referred to as “high”. I created the models in xspec and then converted the models for MARX use via *xspec2marx*. I used *MARX v3.0* for the simulations. The high model was scaled

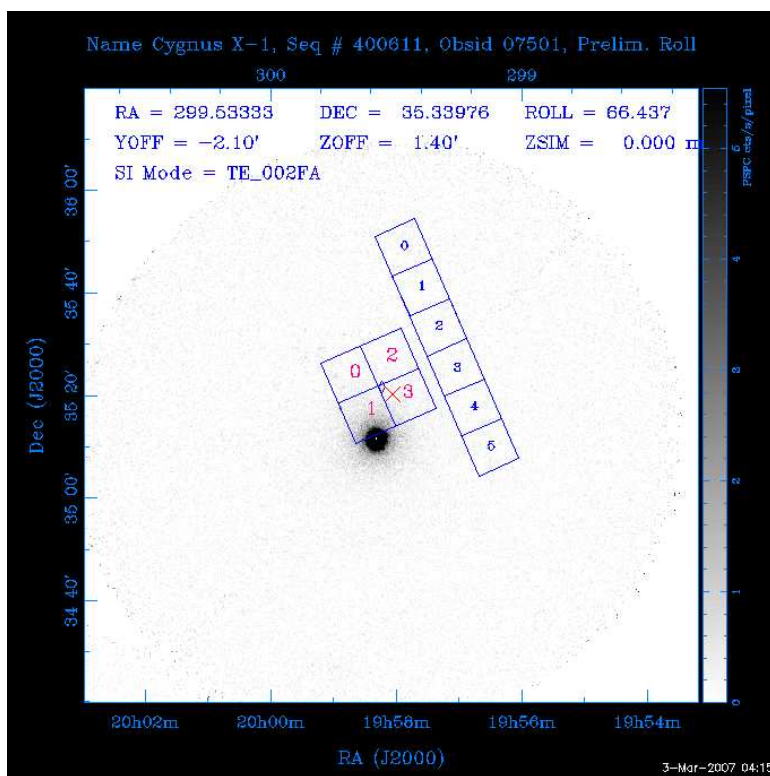


Figure 1: ObsId 7501-Over the ROSAT PSPC image. The offsets and nominal pointing place the Cyg X-1 source just off the I array. The pointing parameters and offsets are labeled on the plot.

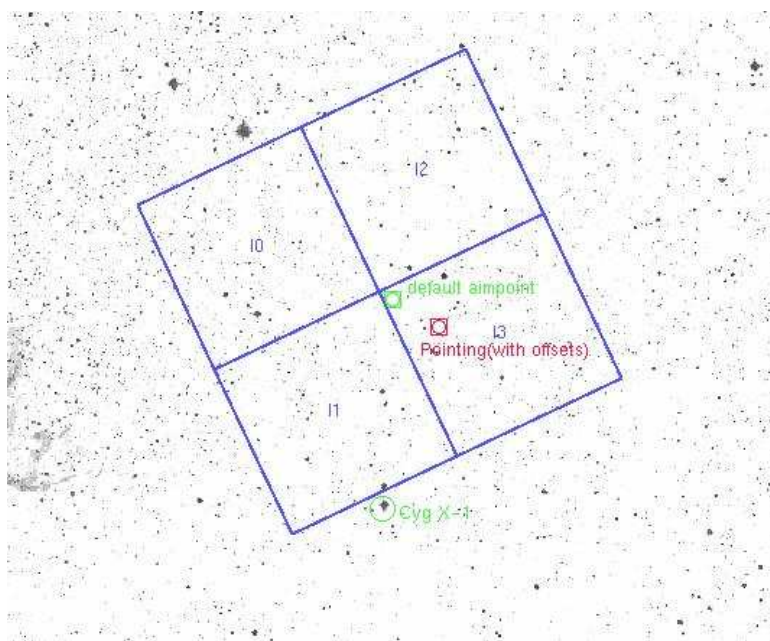


Figure 2: ObsId 7501-Over the DSS image. The offsets and nominal pointing place the Cyg X-1 source just off the I array.

Model Component	Parameter	Value	Unit
phabs	nH	0.300000	10e22
highcut	cutoffE	21.1000	keV
highcut	foldE	146.000	keV
bknpower	PhoIndx1	2.74000	
bknpower	BreakE	10.1600	keV
bknpower	PhoIndx2	1.94000	
bknpower	norm	19.8000	
gaussian	LineE	6.52000	keV
gaussian	Sigma	0.420000	keV
gaussian	norm	2.30E-02	

Table 2: Cyg X-1 High flux state model: Using a phabs\*highcut(bknpower+gaussian)

by 1000 to help the simulations run faster and to limit the file size of the resultant fits file. The results were scaled up by 1000 for the high model cases. In the first 4 simulations, the source is on axis for the low and high models and dither is on and then turned off. The last 4 simulations are for the actual parameters with the low and high models with the dither on and off.

### 3 Maximum Dose

Once the simulations were completed, I used *marx2fits* to create a fits image from the MARX data. The FITS files were copied to only include the aim point ccd (*dmcopy*), then converted to an image from the event list (*dmcopy*) and finally a statistical summary of the image was performed to find the maximum counts in a pixel (*dmstat*).

All of the maximum pixels were scaled to an exposure time of 50 kseconds and in the case of the high model, the proper flux. To determine the damage to ACIS, I used the total budgeted dose of radiation for the mission, the Mission Dose (MD). This is described in Butt's memo as 25 krad as the MD for FI CCDS with a 135:1 cts/pix:rad/pix ratio.

Simulation	Source Flux	OnAxis	Dither (x,y)	Pixel (Peak pixel)	Max Counts	Dose krad	%MD
1	Low	YES	ON	71157	(944,936)	0.527	2.11%
2	Low	YES	OFF	5628327	(960,952)	41.69	166.77%
3	High	YES	ON	2364000	(944,936)	17.51	70.04%
4	High	YES	OFF	195102000	(960,952)	1445.2	5780.8%
5	Low	NO	ON	15	(204,7)	1.1e-4	4.44e-4%
6	Low	NO	OFF	5	(461,7)	3.70e-5	1.48e-4%
7	High	NO	ON	1000	(462,4)	7.4e-3	2.96e-2%
8	High	NO	OFF	1000	(462,4)	7.4e-3	2.96e-2%

Table 3: ObsId 7501 Simulation Results for the maximum counts in a pixel for the 50ks observation.

### 4 Summary

The observation 7501 is safe as planned. If Cyg X-1 goes into the high flux state, and the source falls on-axis, the ACIS detector will receive an extraordinarily high dose of radiation.

If Cyg X-1 stays in the current low flux state, it is not a large hit on the mission dose if dither stays active and the source falls on-axis.

As planned, the observation poses no danger to the ACIS instrument regardless of the flux state.

## 5 References

1. S. Virani, "MARX Simulations of the AO4 Crab Nebula/Saturn-Titan Conjunction Proposals", CXC Memo, 27, June 2002
2. Y. Butt, "Operational Limits for X-ray Photon Dose On ACIS", CXC Memo, 3 May 2002