The Chandra Multi-wavelength Project (ChaMP): X-ray Analysis

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Abstract

We present preliminary results of X-ray data analysis as part of the Chandra Multi-wavelength Project. We describe in detail X-ray data analysis techniques, including data correction and data screening in addition to those applied in CXC standard data processing, and source detection and source property determination. We have performed a series of simulations to assess source reliability and positional uncertainty. We have also used Chandra data to complement the simulation studies. Probabilities of finding false detections or missing real sources are found to be as good as expected. The positional error is $< 1''$ for a bright source, regardless of its off-axis angle while it can be as large as $8''$ for a weak source (~20 counts) at off-axis angle $> 500''$. We present preliminary results of a new method to correct the large positional error. 50 out of 160 fields selected in AO1 and AO2 have been processed through the ChaMP X-pipeline. About 3000 sources are detected. Chandra serendipitous sources characteristics are discussed, in terms of LogN-LogS and X-ray colors.

XPIPE

(ChaMP X-ray PIPELINE)

- Remove bad column and pixels
- Remove time interval with background flare
- Remove after-glow
- De-streaking on S4 chip
- Re-apply gain correction and aspect correction
- Detect by **wavdetect** per chip per energyband
- Flag sources (eg., nearby source, extended source etc.)
- Find extendedness and time variability

Detection Probability

(Type I and II error)

- MARX simulations of sources with varying source and background counts
- **wavdetect** run on an 256x256 postage-stamp image per source.
- Type I Error : as good as or better than expected
- Type II Error: 30% detection probability for a source with 7 counts
  80% detection probability for a source with 18 counts

Positional Uncertainty

- Performed SAOSAC simulations for ~6000 sources with varying off-axis angles and count rates
- Complementary study with HDF-N data
- Error could be as much as 6-8” with a faint, off-axis source
- Correction can be made by re-running **celldetect** with varying cellsize.

  cellsize ~ psf at r < 500”

  ~ much smaller than psf at r > 500”

Ł Positional Error < 2”

Log N – Log S

Soft band (0.3-2 keV)

- 400 sources within 5 arcmin from on-axis in 13 ACIS-I obs
- Consistent with ROSAT results (Hasinger et al.)
- Consistent with HDF-N results (Brandt et al.) at $S \sim 10^{-15}$ erg s^{-1} cm^{-2}
- Lower than HDF-N results at $S \sim 10^{-16}$ erg s^{-1} cm^{-2}

Hard band (2-8 keV)

- 350 sources within 5 arcmin from on-axis in 13 ACIS-I obs
- Consistent with HDF-N results (Brandt et al.)
- Lower than HDF-N results at $S > 10^{-15}$ erg s^{-1} cm^{-2}

X-ray Color

Table. Energy bands and Definition of X-ray Colors

Energy band selection:

Broad (B):	0.3 - 8.0 keV
Hard (H):	2.5 - 8.0 keV
Soft1 (S1):	0.3 - 0.9 keV
Soft2 (S2):	0.9 - 2.5 keV

X-ray Color

$$C21 = -\log(S2) + \log(S1)$$

$$C32 = -\log(H) + \log(S2)$$

Energy bands and X-ray colors are selected

1. to maintain similar counts in each band to minimize statistical errors
2. to reduce background particle events (upper limit at 8 keV)
3. to compare with previous X-ray missions (eg., ROSAT)
4. to confine most soft X-ray lines seen in soft sources (eg. stellar sources)
5. to ***isolate*** 2 interesting spectral parameters (eg., intrinsic hardness and absorption)

X-ray colors

- C21 primarily depends on absorption; C32 primarily depends on intrinsic hardness
- X-ray color differ between ACIS-S (S3) and ACIS-I
- Most sources fall at N_H ~ a few $x10^{20}$ cm^{-2} and Photon Index ~ 1.5-2.5
- Found many interesting sources (highly absorbed, very hard, very soft …)
- On average, C21 gets smaller (harder) as the count rate decreases
    - Ł A population with ***absorbed*** X-ray spectra exists