Source data model: inputs from the *Chandra* Source Catalog 2.0

F. Civano (CfA/CXC)

On behalf of **Ian N. Evans** and the *Chandra* Source Catalog team

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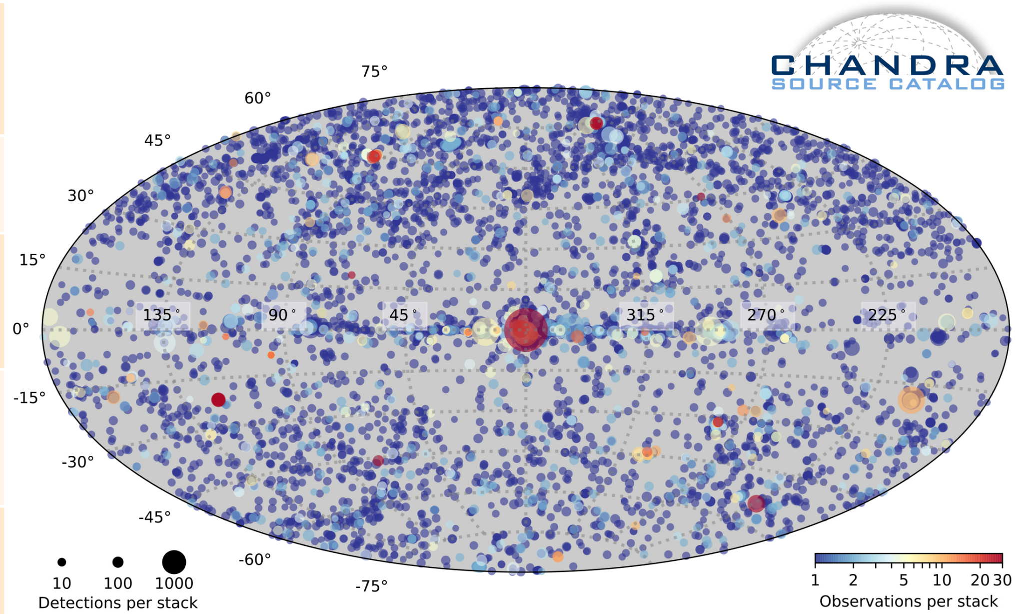
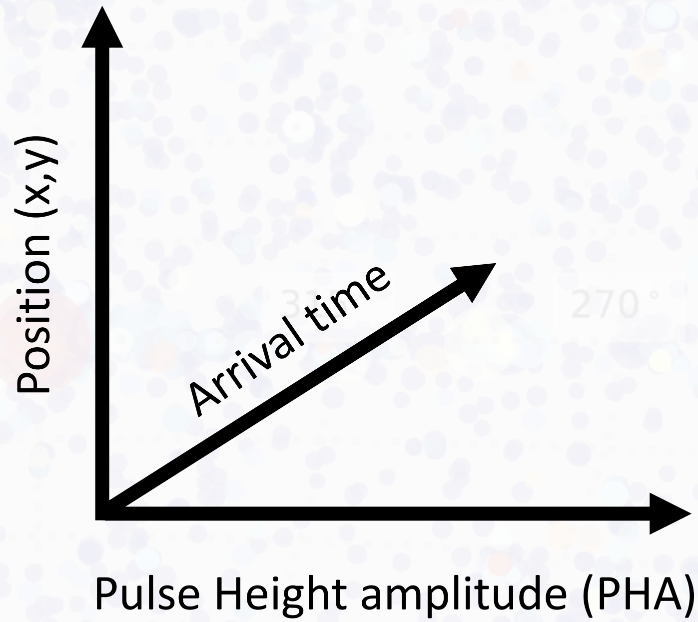
CSC 2.0 in numbers

	CSC 1	CSC 2
Individual obsids	5110	10,382
Obsid years	1999-2009	1999-2014
Total exposure		245.8 Ms
longest exposure	190 ks	5.8 Ms
Counts on-axis	~10	~5
Number of sources	106,586	315,875
Number of detections	158,071	374,349



Chandra detection attributes

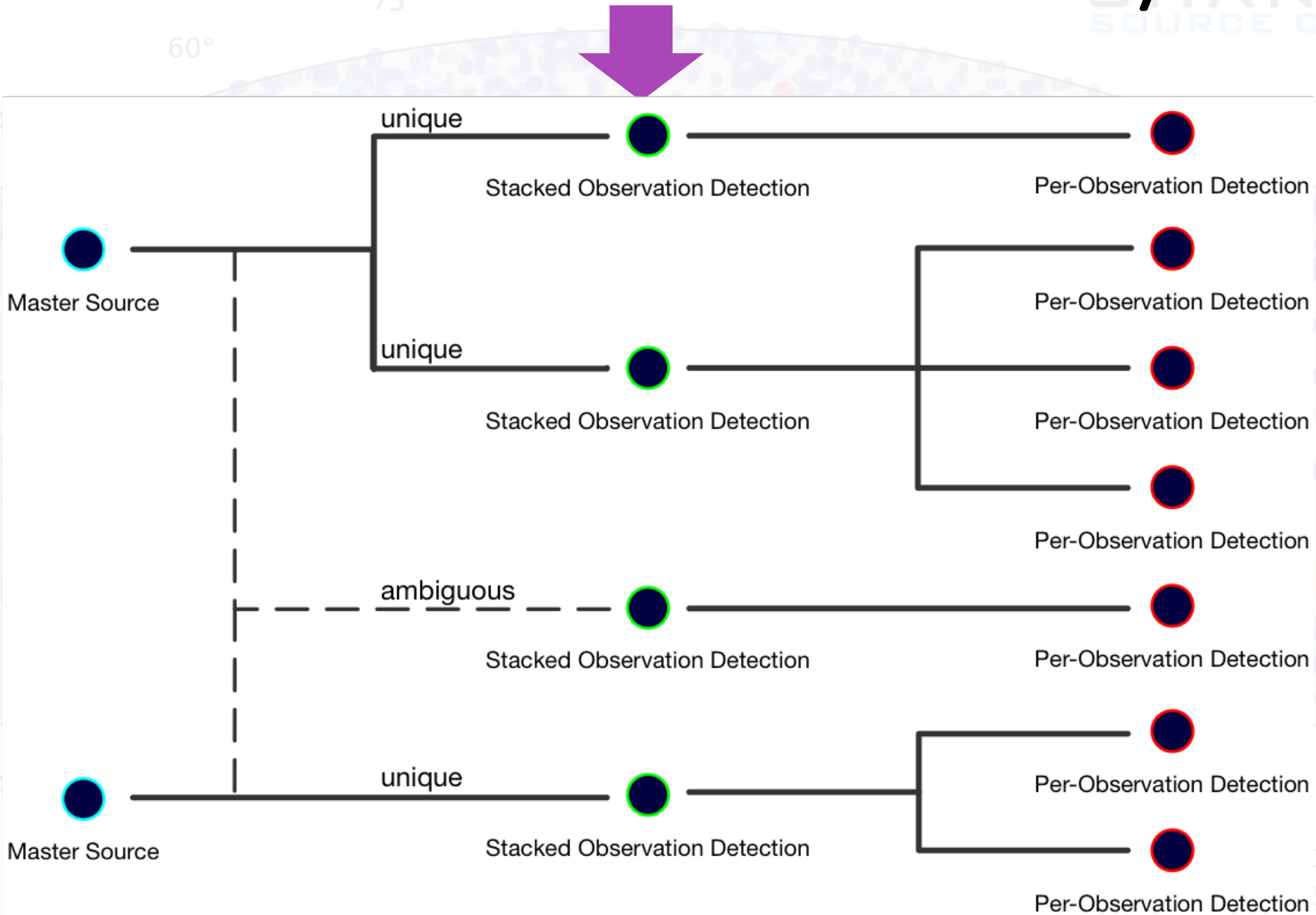
- Name
- Position
- Arrival time/variability
- PHA/intensity
- Source extension



Summary

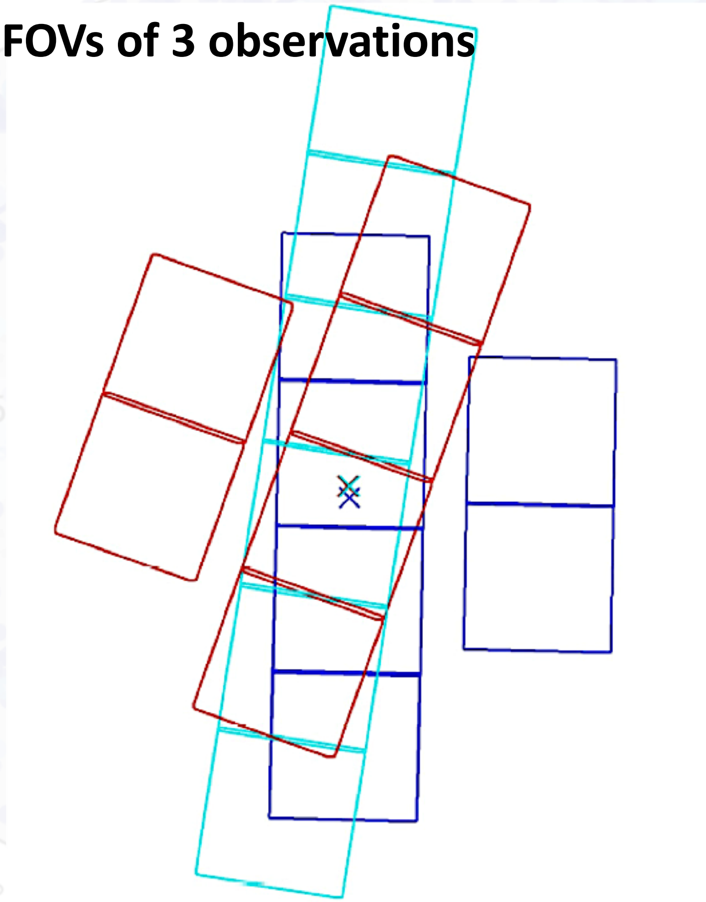
- The differences between sources and detections (each have properties!!)
- Properties aren't just simple numbers with a Gaussian error
- Everything is time variable --> linking together the measurements is important
- Properties depend on calibrations and assumptions (e.g., model spectrum) so they are as much a part of the model as the actual reported values

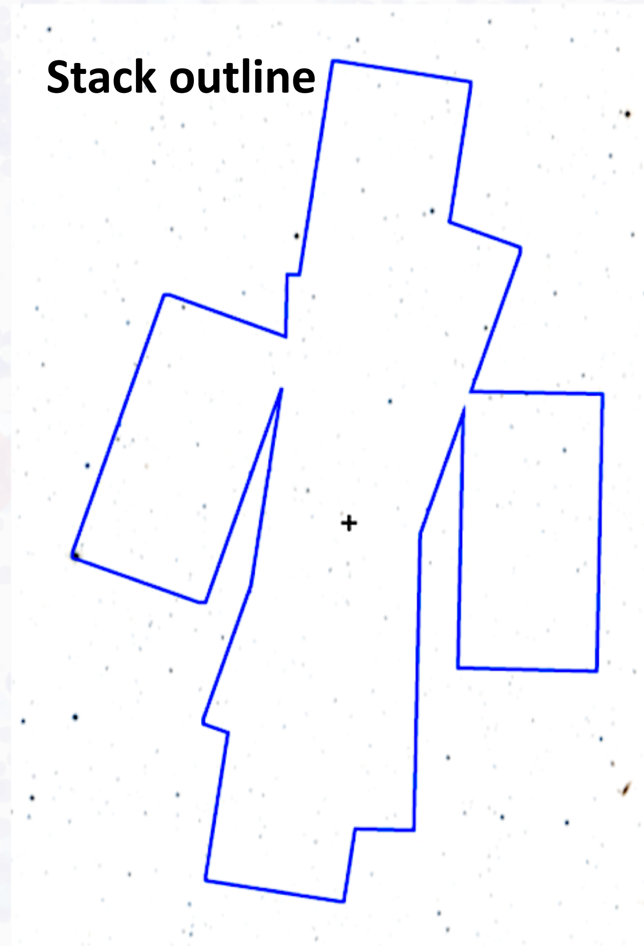
Source detection hierarchy



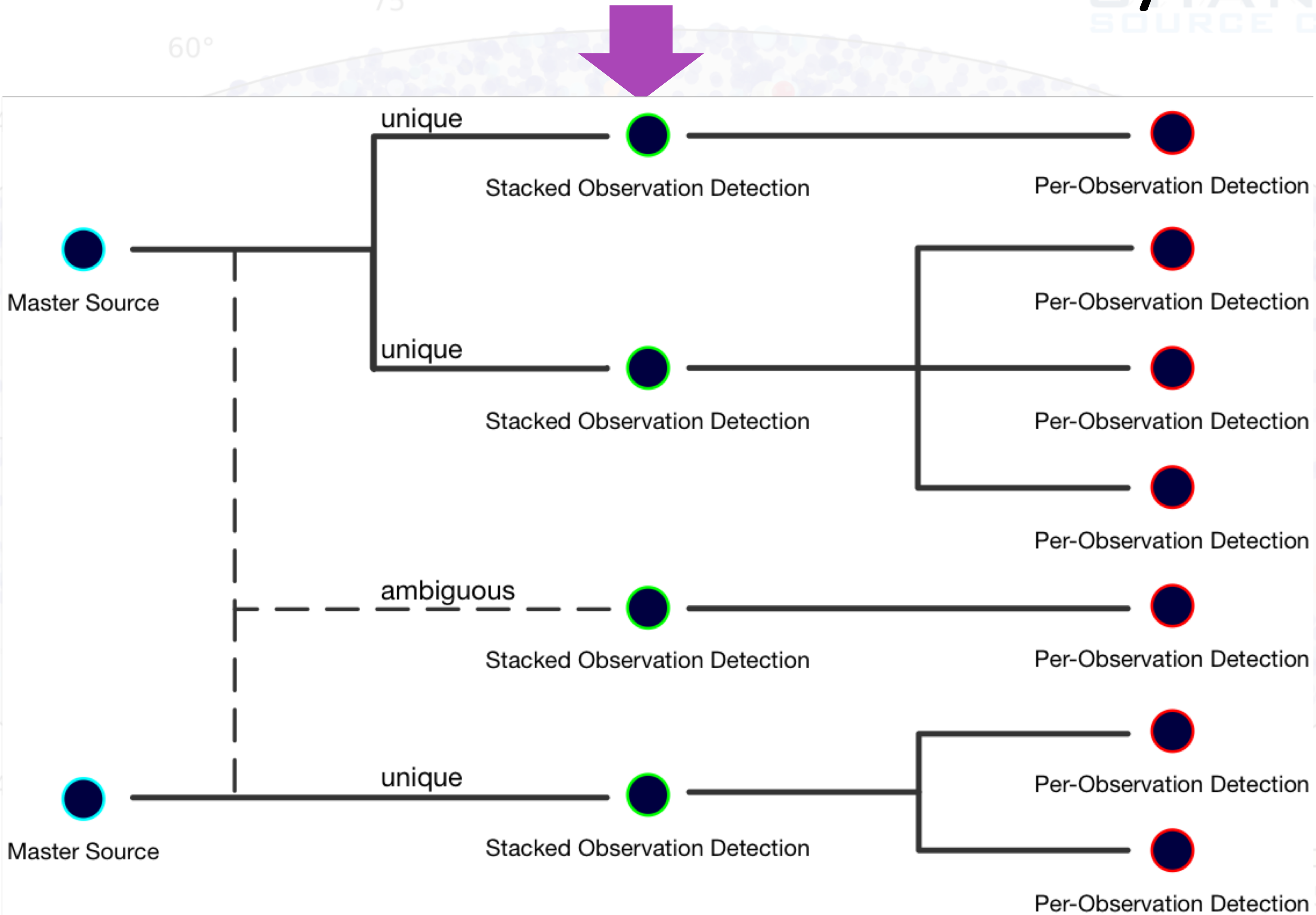
Stacked observations

STACKS: sum of obsids with pointings within 1 arcmin





Source detection hierarchy



Databased properties hierarchy

Master Source Properties

- Source name, position and position errors, significance, source flags, multi-band deconvolved extent, multi-band aperture photometry (photon and energy fluxes, spectral model fluxes [multiple spectral models]), hardness ratios, spectral model fits [multiple spectral models], multi-band intra- and inter-observation temporal variability

Stacked-Observation Detection Properties

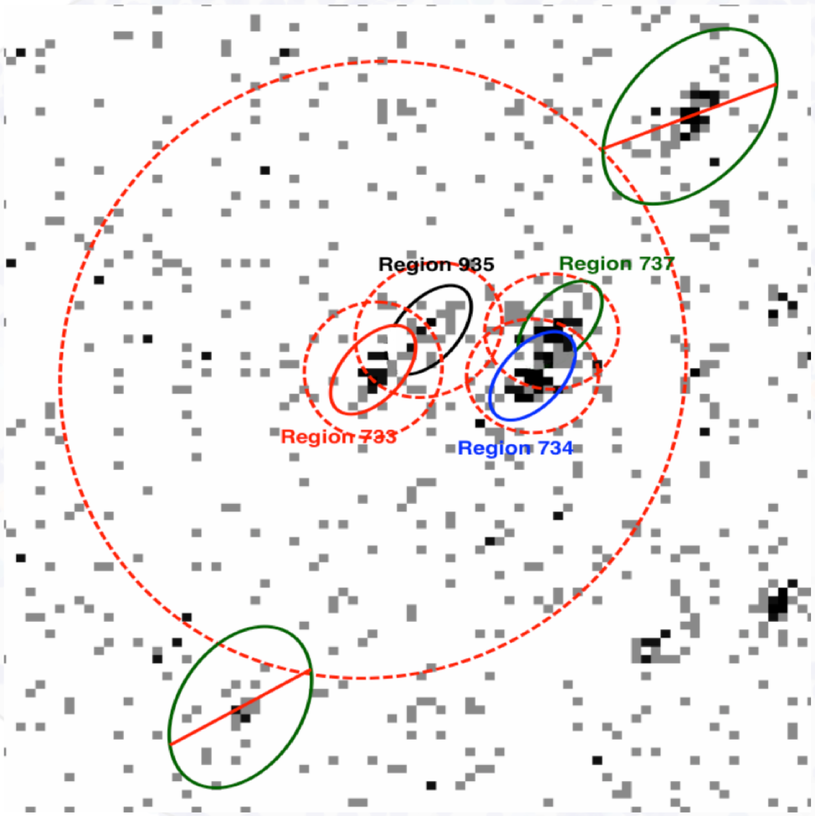
- Position and position errors, multi-band significance, detection flags and codes, multi-band deconvolved extent, multi-band aperture photometry (net counts and count rates, photon and energy fluxes), aperture parameters, hardness ratios, multi-band intra- and inter-observation temporal variability

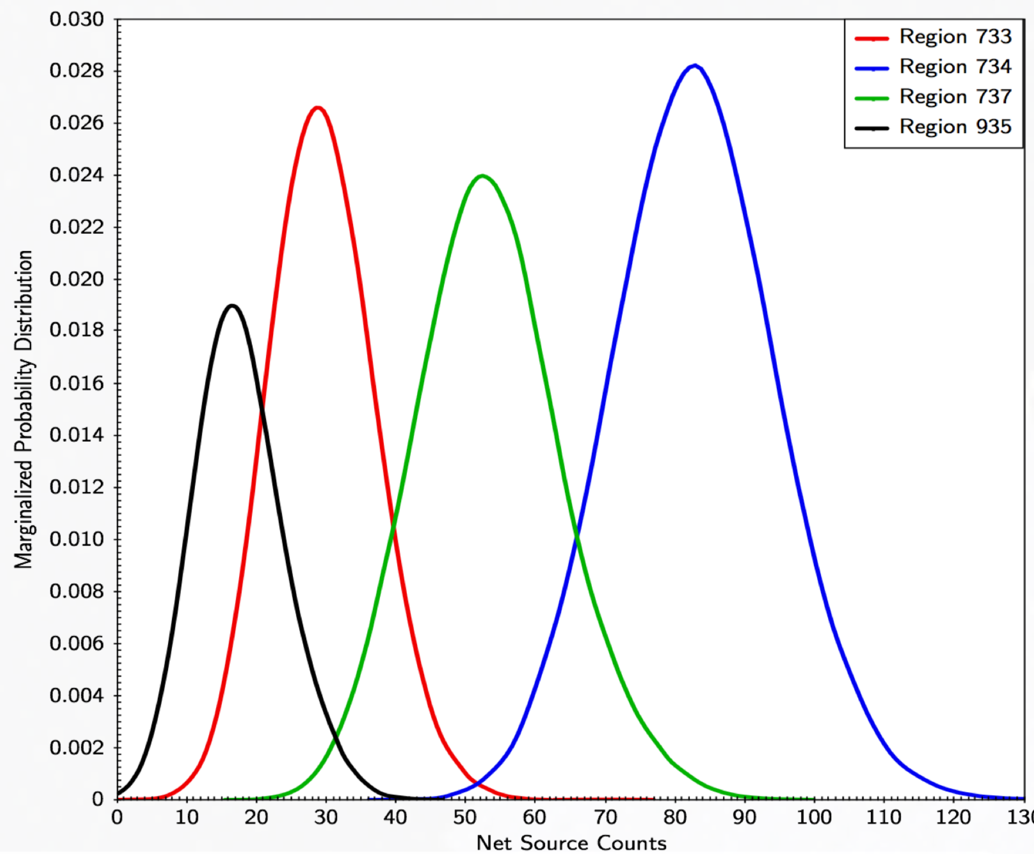
Per-Observation Detection Properties

- Detector position, multi-band significance, detection flags and codes, multi-band raw, PSF, and deconvolved extent, multi-band aperture photometry (total counts, net counts and count rates, photon and energy fluxes, spectral model fluxes [multiple spectral models]), masked aperture parameters, spectral model fits [multiple spectral models], multi-band intra-observation temporal variability

Source Properties: Aperture Photometry

Fluxes are measured in each observation: Bayesian approach for simultaneous aperture photometry estimation in crowded fields *(Primini, F. A. & Kashyap, V. L. 2014)*



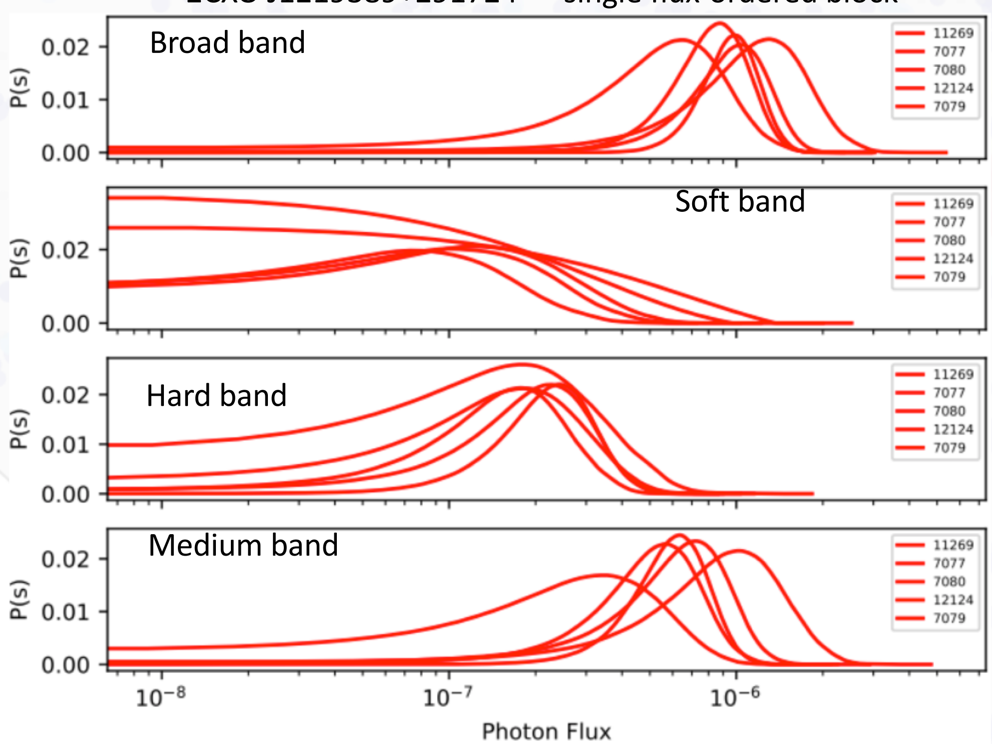


Photometric PDFs are estimated simultaneously for the overlapping detections

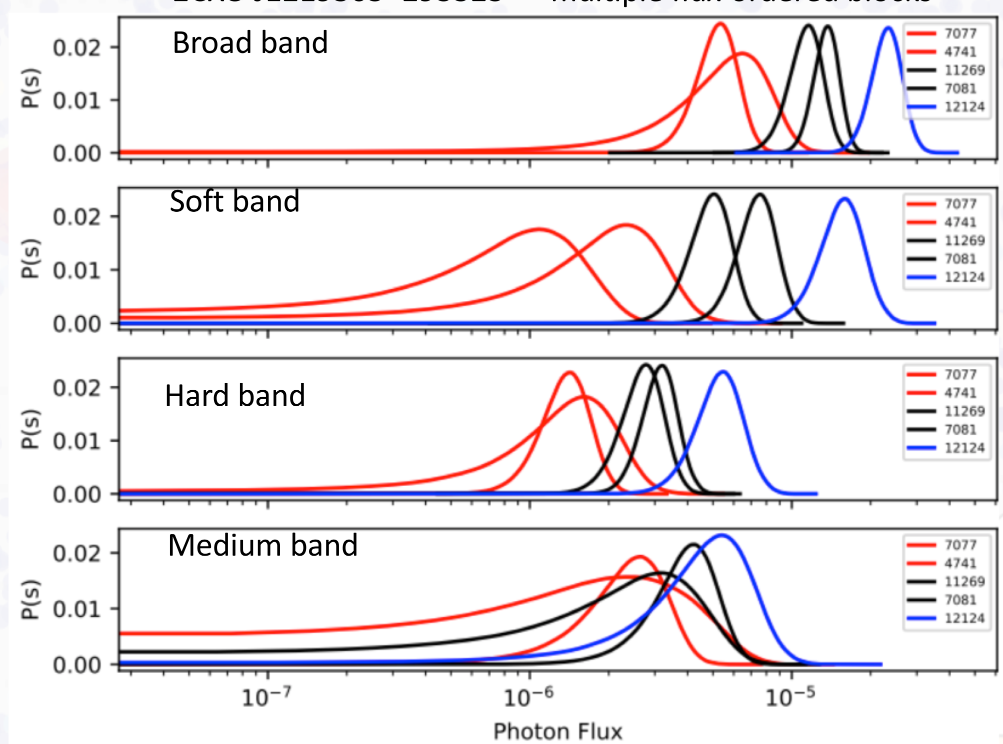
Grouping Observations to Improve S/N

- Multi-band Bayesian Blocks analysis *(Scargle+2013)* on detection fluxes to identify observations that can be analyzed/grouped together
- The combined properties for the longest exposure Bayesian Block are databased, but the properties for *all* blocks are recorded in a FITS data product

2CXO J1219389+291724 — single flux-ordered block



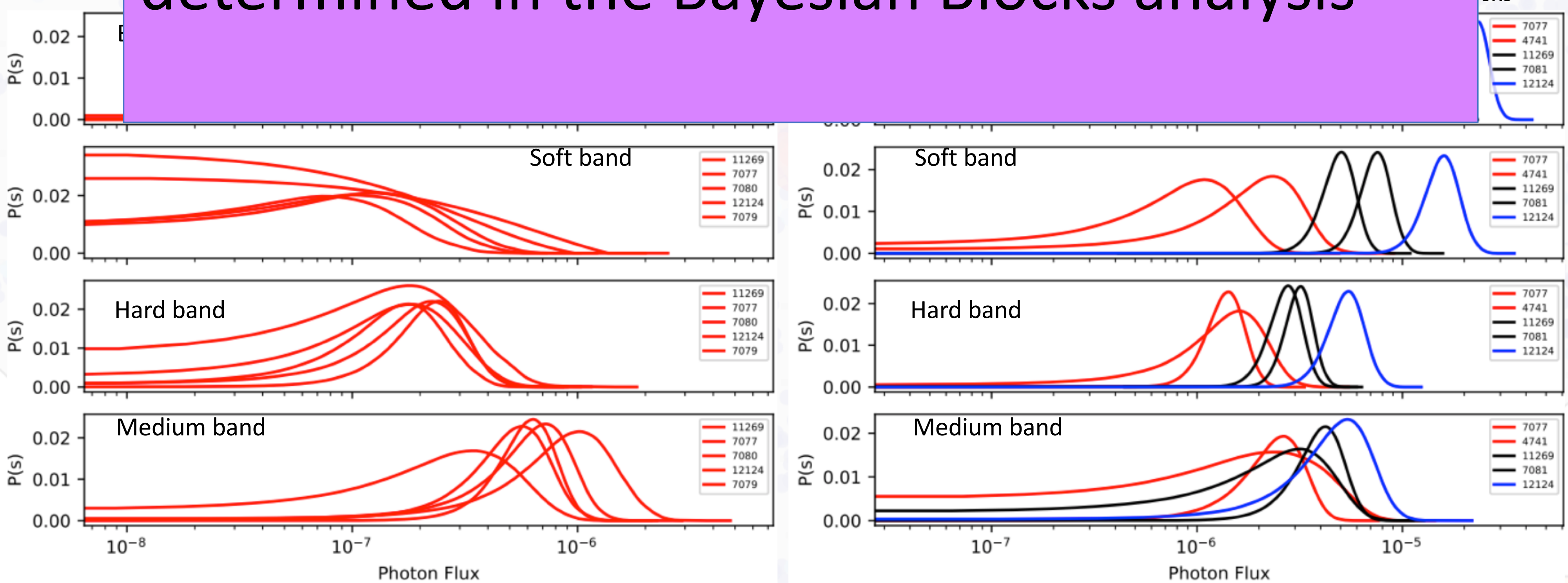
2CXO J1219505+293323 — multiple flux-ordered blocks



Grouping Observations to Improve S/N

- Multi-band Bayesian Blocks analysis *(Scargle+2013)* on detection fluxes to identify observations that can be analyzed/grouped together
- The combined properties for the longest exposure Bayesian Block are databased, but

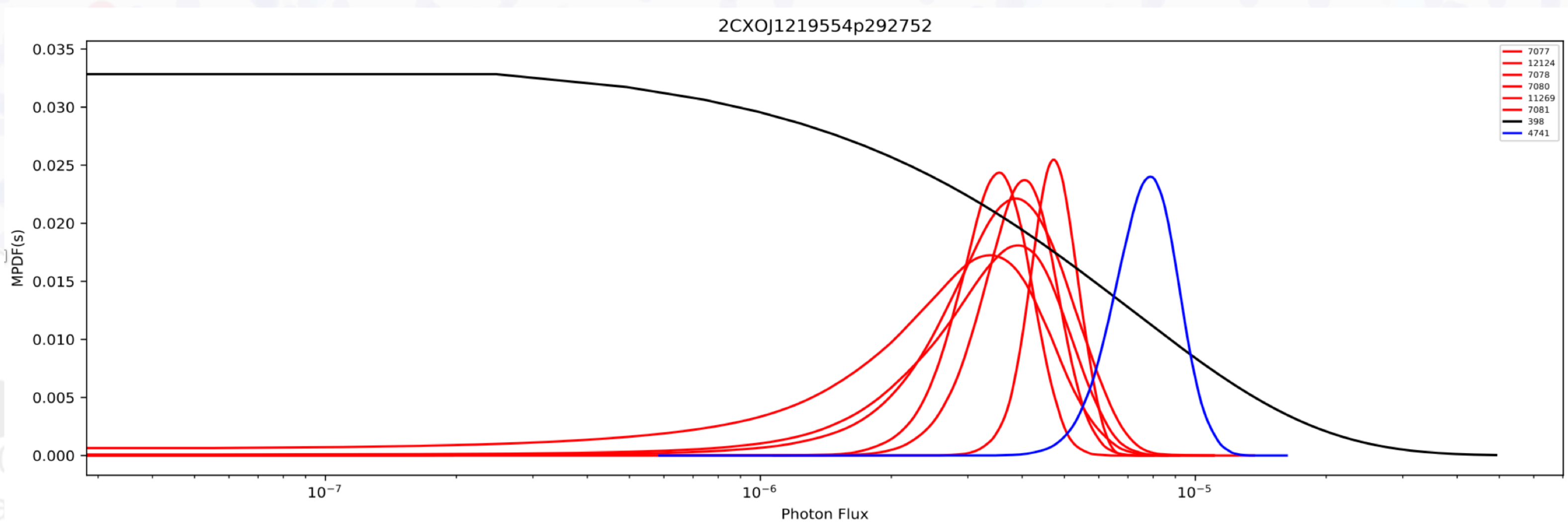
master level fluxes --> the best flux block determined in the Bayesian Blocks analysis



Temporal Variability

- **Single observation:** Gregory-Loredo Test: Hypothesis rejection test (i.e., odds ratio of assuming variability vs not assuming it). The probability that events detected are not arriving at a uniform rate. Used to estimate intra-obs variability (pick max prob among stack obsids).

- **Multiple observations:** Inter-observation variability. Variability test is based on a likelihood ratio between the null hypothesis of no variability, and the assumption of variability, when several observations are considered.



Science-Ready FITS Data Products

Observation Data Products

- Observation event list, aspect solution and histogram, bad pixel map, FoV, pixel mask
- Multi-band images, background images, exposure maps

Stacked-Observation Data Products

- Stack event list, FoV, merged detection list
- Multi-band images, background images, exposure maps, limiting sensitivity

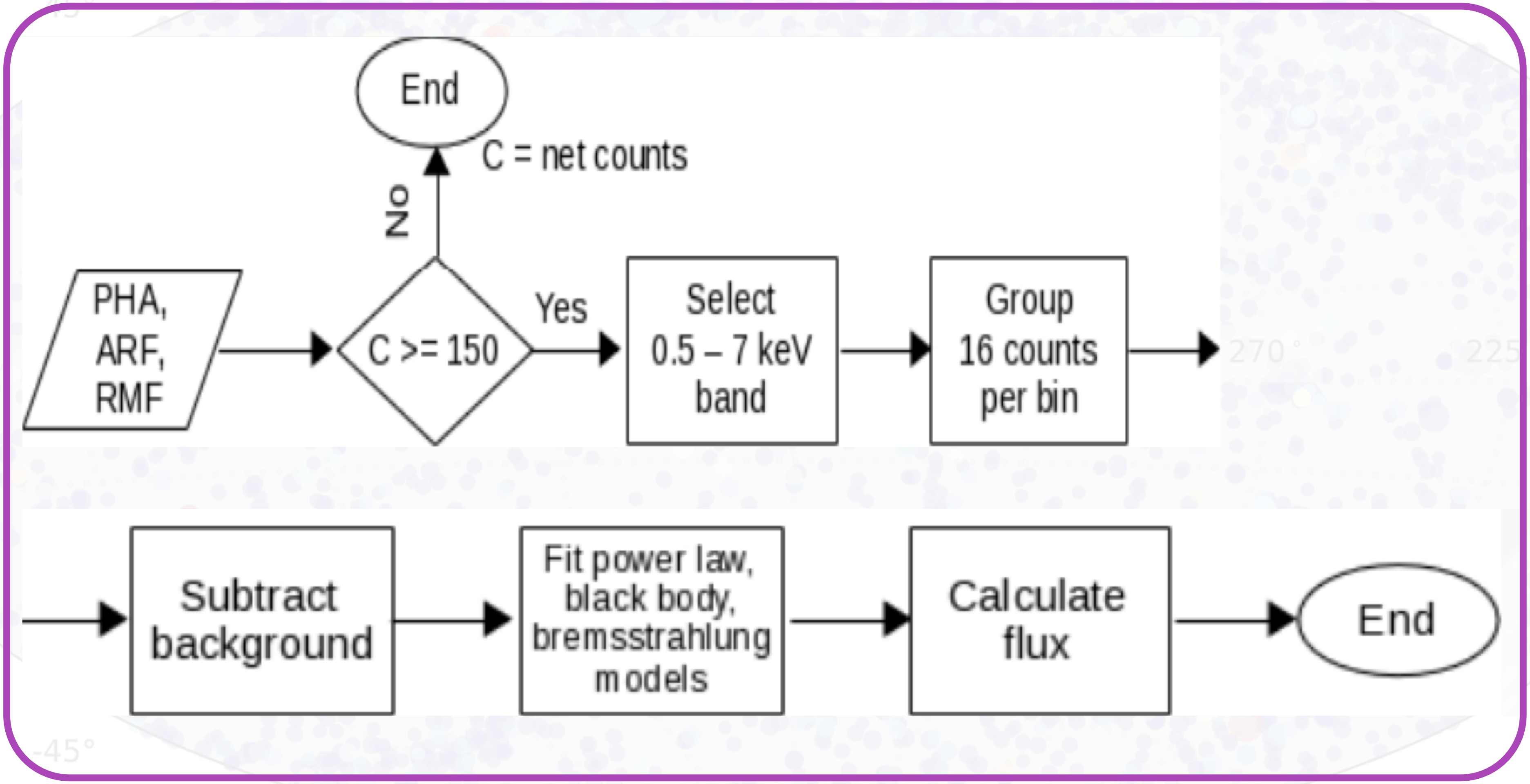
Detection Region Data Products

- Detection region stack and observation region definitions, event lists
- Multi-band per-stack and per-observation images, exposure maps, position error MCMC draws, aperture photometry PDFs
- Multi-band per-observation PSFs, light curves
- Per-observation PHA spectrum, RMF, ARF

Source Level Data Products

- Aperture photometry PDFs, per-Bayesian block properties (aperture photometry fluxes, model energy fluxes, spectral fits, hardness ratios)

Spectral Analysis



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Thoughts on Source Models

Ian N. Evans

Chandra Source Catalog Project Scientist

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Introduction

The *Chandra Source Catalog* (CSC) is the definitive catalog of serendipitous X-ray sources identified in publicly released imaging observations obtained by NASA's *Chandra* X-ray Observatory (CXO). The CSC is developed and published by the *Chandra* X-ray Center (CXC) and is supported by NASA contract NAS 8-3060 to the Smithsonian Astrophysical Observatory for operation of the CXC. Release 2.0 of the CSC, including properties for approximately 316,000 X-ray sources on the sky extracted from about 375,000 detections, will be released in the next few months.

One major aim of the CSC is to make available detailed estimates of the X-ray properties of astronomical sources detected by the CXO in a way that enables them to be immediately useful for scientific investigations by members of the (multi-wavelength) astronomical community who may be less familiar with the details of X-ray data and their reductions and analyses, while simultaneously maintaining the utility of the catalog for X-ray astronomy domain experts. Because of the relative complexity of X-ray data analyses, considerable thought has been