Progress Report

Ian Evans
On behalf of the Chandra Source Catalog Project Team

Chandra Users' Committee Meeting
October 25, 2010

Summary

- Catalog version 1.1 was released on 2010 Aug 10
  - Includes public HRC-I imaging observations and "catch-up" public ACIS imaging observations, as well as several minor updates to release 1.0 data, but otherwise retains the same general characteristics as release 1.0
- Catalog interface updates
  - Updated version of CSCview with several new and enhanced capabilities was released with version 1.1 of the catalog
  - Updates to the CSC Sky in Google Earth catalog visualizer, the CSC 1.1–SDSS DR7 cross-match database, and the CSC 1.1 limiting sensitivity service will be released in the next few weeks, along with a version of CSCview that includes a catalog cross-matching capability
- Statistical characterization of release 1.1 is largely complete
- Prototyping of critical path release 2.0 enhancements is underway, and roadmaps for the remaining effort are being developed

Science Highlights Since Last CUC Meeting

- Provided science support for release 1.1 production
- Continued working on statistical characterization of HRC processing
- Updated public web site with latest user documentation and threads
  - **http://cxc.cfa.harvard.edu/csc/**
- Documents released
  - Default Spectral Fit Parameters for the CSC, rev. 3/31/10 (McCollough, M. L.)
  - Chandra Source Catalog Requirements, Ver. 1.1, 5/10/10 (Evans, I. N.)
- Publications
  - Catalog description paper: published
    - *Evans, I. N., et al. 2010, ApJS, 189, 37*
  - CSC absolute astrometric error paper: submitted
    - *Rots, A. H. & Budavári, T. 2010, ApJS, submitted*
  - Catalog statistical characterization paper: being revised after internal review
    - *Primini, F. A., et al. 2010, in preparation*
  - Aperture photometry algorithm paper
    - *Kashyap, V. & Primini, F. A. 2010, in preparation*

Software Highlights Since Last CUC Meeting

- Software team completed production operations of catalog release 1.1, data migrations, and catalog release
- Released archive and user interface updates to support release 1.1
- Working on remaining interface updates for release 1.1 (to be released shortly)

Catalog Releases

CSC	1.1	10 Aug	HRC-I and ACIS imaging catch-up

Catalog Production System Releases

CAT	3.2.4.1	16 Jun	Detect QA GUI physical coordinates bug fix
CAT	3.2.4.2	24 Jun	Detect QA GUI manually modified region bug fix
CAT	3.2.5	28 Jul	Archive updates for release 1.1, includes updates to CSCview 1.1, CSCcli, SCS, SIAP user interfaces

Upcoming Releases

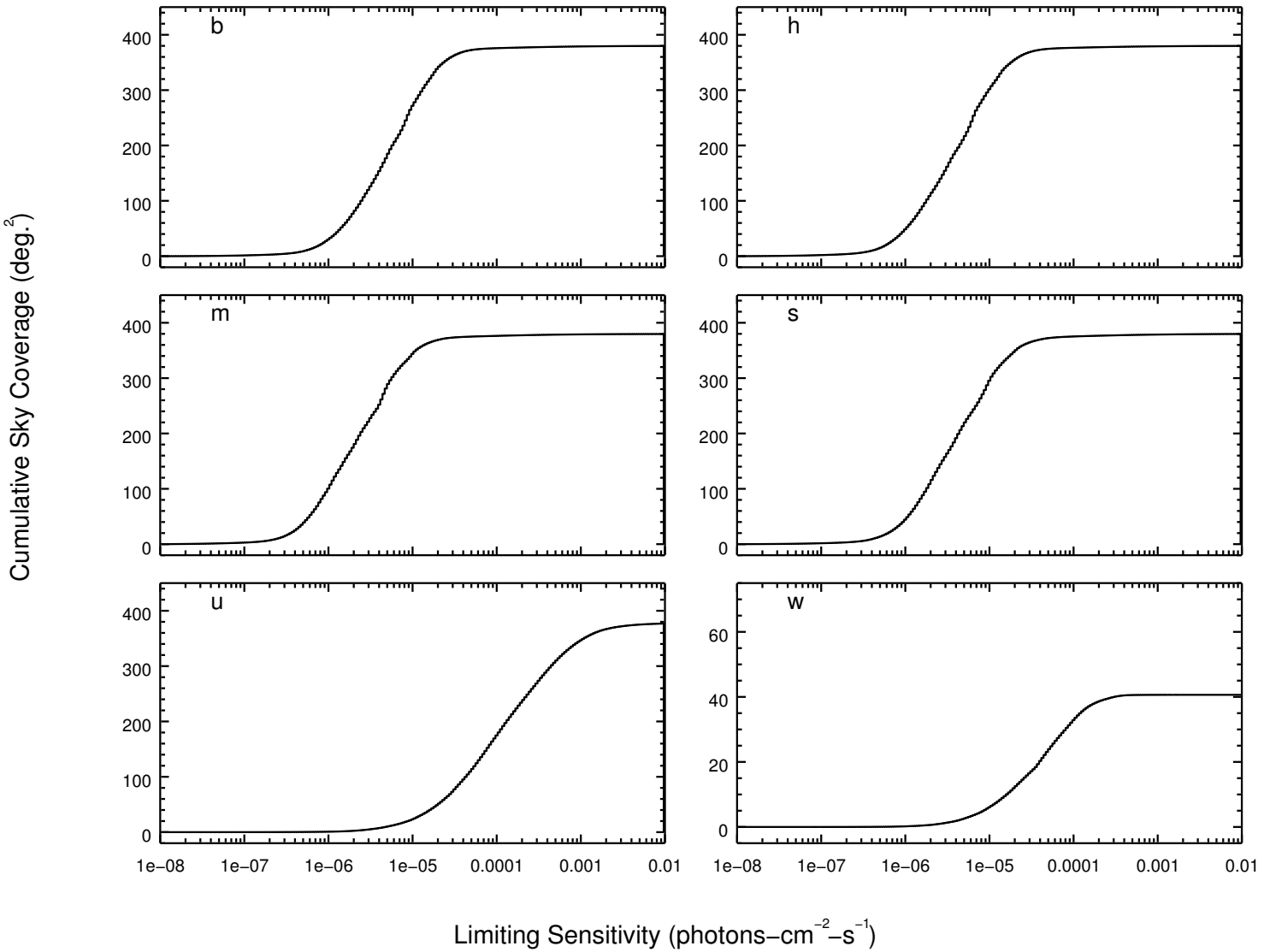
CAT	3.2.6	Oct/Nov	CSCview 1.1.1: adds simple cross-matching capability
CSC Sky	1.2	Oct/Nov	Add catalog images, FoVs, source balloons for rel. 1.1
LimSens	1.1	Oct/Nov	Update limiting sensitivity service for rel. 1.1
Xmatch	1.1	Oct/Nov	Update CSC-SDSS cross-match catalog for rel. 1.1

CSC Release 1.1

CSC release 1.1 was made available on 2010 Aug 10

- Extends the release 1.0 point and compact source catalog by adding public HRC-I imaging observations since the start of the mission, and ACIS imaging observations that became public after release 1.0
  - In addition, ~250 observations included in release 1.0 were reprocessed, and some properties were updated for all sources, to address release 1.0 deficiencies
- Source Statistics
  - 106,586 master sources [cf. 94,676 in release 1.0]
    - Includes 104,628 ACIS-only, 1,034 HRC-only, 924 both ACIS and HRC
  - 158,071 source detections [135,914]
    - Includes 152,296 ACIS, 5,775 HRC
  - 5,110 observations [3,912] with at least one detected source
- Release was delayed by ~3 months compared to the schedule reported at the last CUC meeting, for two reasons
  - Manual quality assurance review noted errors for some very piled-up sources
    - After investigation, two production system bug-fixes were applied and ~70 observations were reprocessed to resolve the issue
  - Manual QA review required significantly more time to complete than expected due to resource competition

Release 1.1 Cumulative Sky Coverage



Release 1.1 Cumulative sky coverage (note different scale for HRC wide band)

CSC Usage Statistics 2010 Apr–Sep

Interfaces intended primarily for professional use

- 2,759 queries* via CSCview (~72% non-CfA)
- 69,823** queries via VO cone search (~82%)
- 114,696 queries via scripting interface (~5%)
- 8,767 data file downloads (~59%)

*Note that the numbers of queries cannot be compared directly between different interfaces

**Excludes 303,566 queries associated with testing TOPCAT "Multicone" search capability

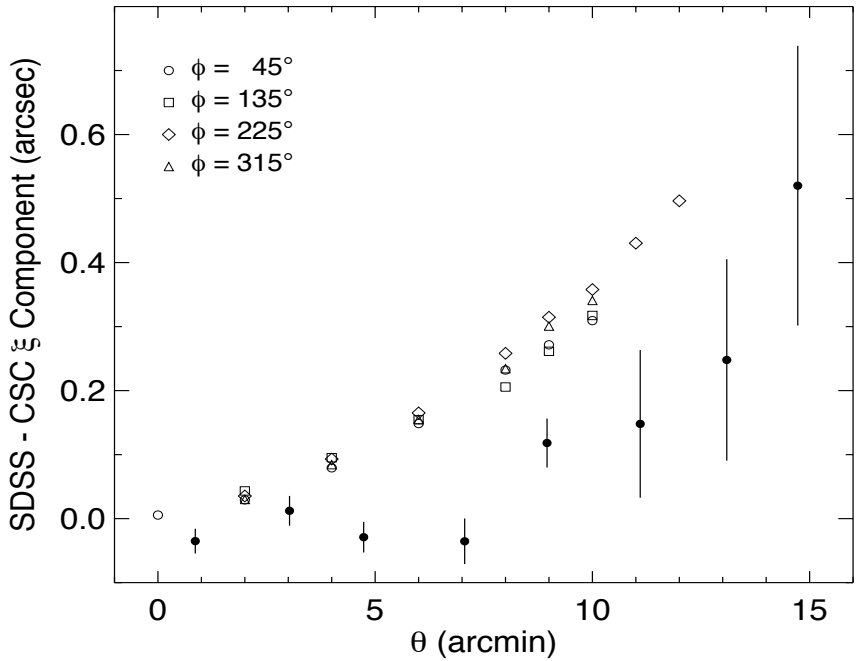
CSC Sky in Google Earth Statistics

- Mix of professional and non-professional users
- ~107K page hits/month
- ~1500 user sites/month
- ~10GB/month data volume

Catalog Statistical Characterization

- Statistical properties of release 1 are available on the catalog web site
  - **http://cxc.cfa.harvard.edu/csc/char.html**
- Draft of the paper describing the statistical properties of release 1.0 (Primini, F. A. et al.) was circulated for internal review
  - Currently incorporating revisions and expect to submit to ApJS soon
- Characterization simulations for release 1.1 are completed
  - Includes HRC blank fields and fields with simulated point sources injected

Release 1.0 Characterization



Statistical accuracy of `wavdetect`-derived source positions in CSC 1.0

- Comparison of measured SDSS DR7 source positions and CSC 1.0 `wavdetect`-derived positions for bright sources ($\geq$ 500 net counts) shows good agreement for $\theta \lesssim 8$ arcmin *without* applying any correction for PSF asymmetry (solid circles above)
  - The expected correction for PSF asymmetry along the vector ξ from the wavdetect-derived centroid position to the nominal PSF position is shown by the open symbols above
  - For $\theta \gtrsim 8$ arcmin, some position adjustment may be appropriate, but is clearly less than the magnitude of the correction expected based on PSF asymmetry alone
  - Uncertainties in the relative positions and tilts of ACIS-I and ACIS-S could also reproduce the observed behavior
- Additional study is warranted and will be pursued as part of the CSC release 2.0 effort

HRC Observation False Source Rate

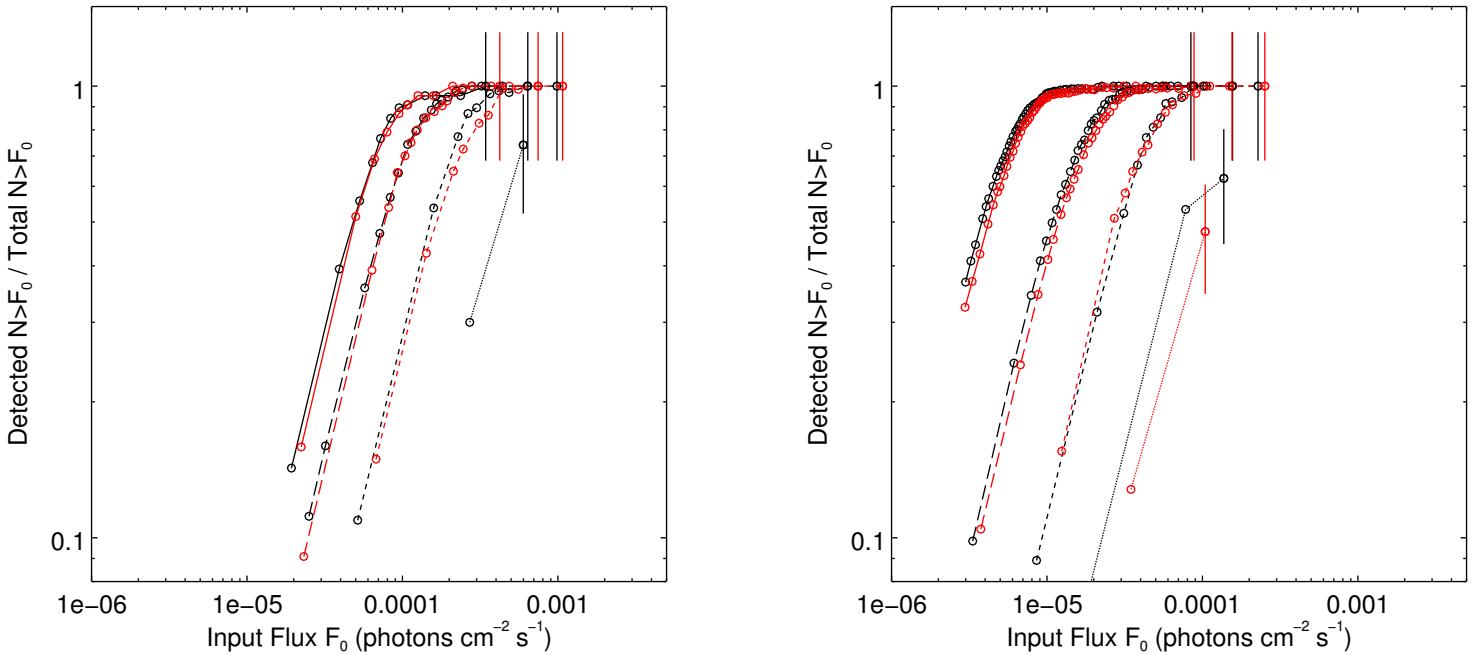
- Blank fields for 5 seed ObsIds were simulated to compute false source rates for HRC observations
  - For each ObsId, 50 runs were executed
  - These were then processed through the CSC source detection pipeline
- Computed false source rate is negligible for observations $\lesssim$ 50 ks
  - Results comparable to ACIS observation false source rate

ObsId	Exposure (ks)	#Detected/#Runs	Rate
7275	1.1	0/50	0
9033	5.1	1/50	0.02
720	10	0/50	0
4849	20	1/50	0.02
1912	50	7/50	0.14

HRC observation false source rate as a function of exposure time computed from simulations

HRC Observation Detection Efficiencies

- For each blank field, sources were simulated for standard power-law and black-body spectra and injected into the event lists
  - These were then processed through the detect and source properties pipelines
  - ~12,000 sources for each spectrum were detected and met catalog inclusion criteria



HRC cumulative source detection efficiencies for 1.1 ks (*left*) and 20 ks (*right*) exposures

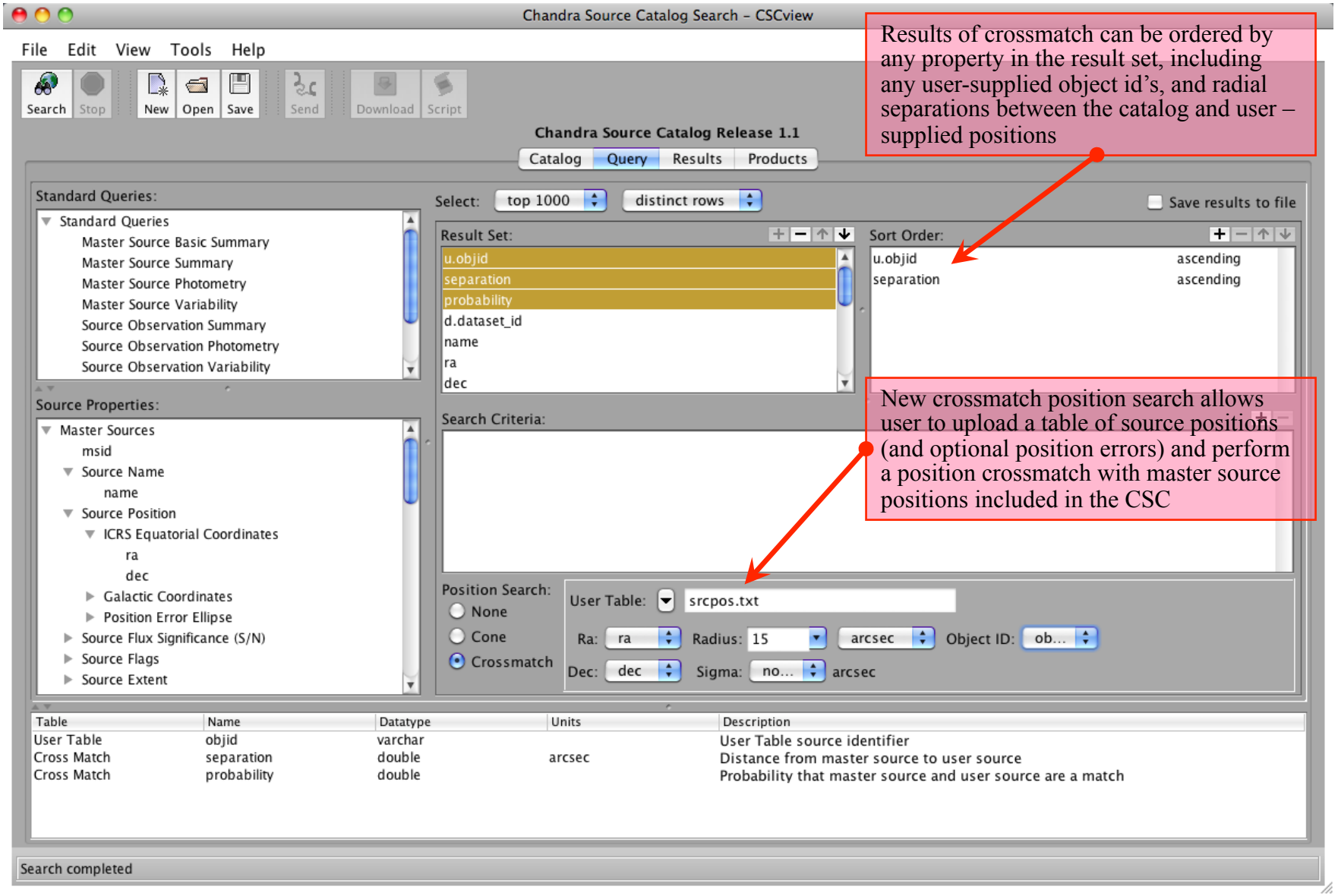
Black: power-law spectra, *Red:* black-body spectra; the four sets of curves are for (left to right) $0 \le \theta < 5$, $5 \le \theta < 10$, $10 \le \theta < 15$, and $15 \le \theta < 20$ arcmin

Catalog User Interfaces: CSCview

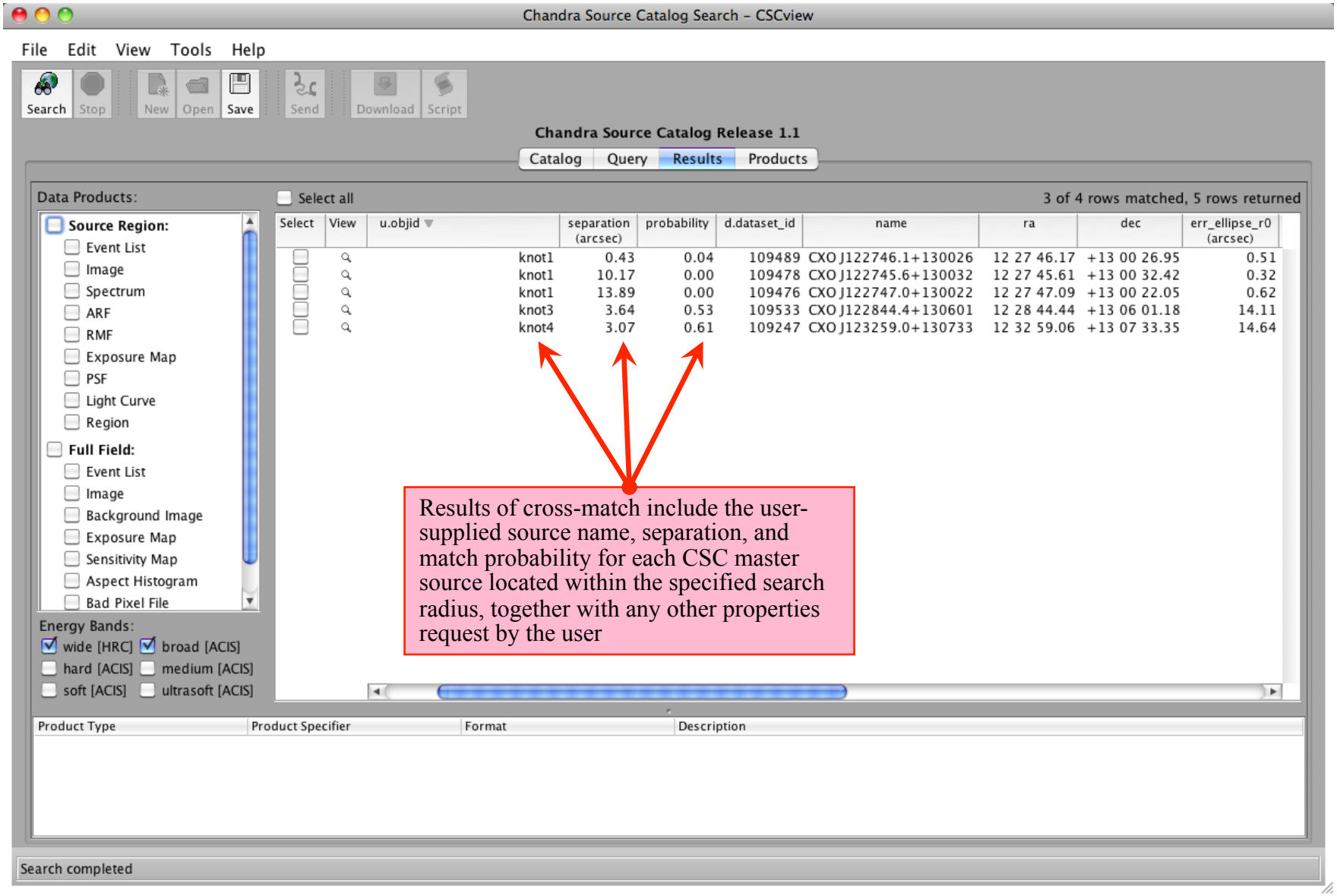
CSCview

- CSCview 1.1 was released with CSC 1.1, and includes numerous enhancements
  - Updated standard queries include HRC observations
  - Metadata display window on Query and Results pages provides brief descriptions of source properties (including units) and file-based data products
  - Improved user interface simplifies changes to queries, and simplifies data product selection and retrieval
  - Query results display is now a single page, and the results can be resorted by clicking on column name headers
  - Source preview allows user to display "quick-look" JPEG images of selected source region and associated local PSF images, as well as full-field images
  - Cone searches now display the separation of the source from the user-specified search position
  - Save to file supports output in tab-separated-value (TSV) and VOTable formats
  - IVOA Simple Application Messaging Protocol (SAMP) interface allows CSCview to communicate with other SAMP-aware applications (such as ds9, TOPCAT, Aladin, …)
- CSCview 1.1.1 adds a source position cross-match interface, and will be release shortly (Nov.)

CSCview GUI Enhancements (Nov. Release)

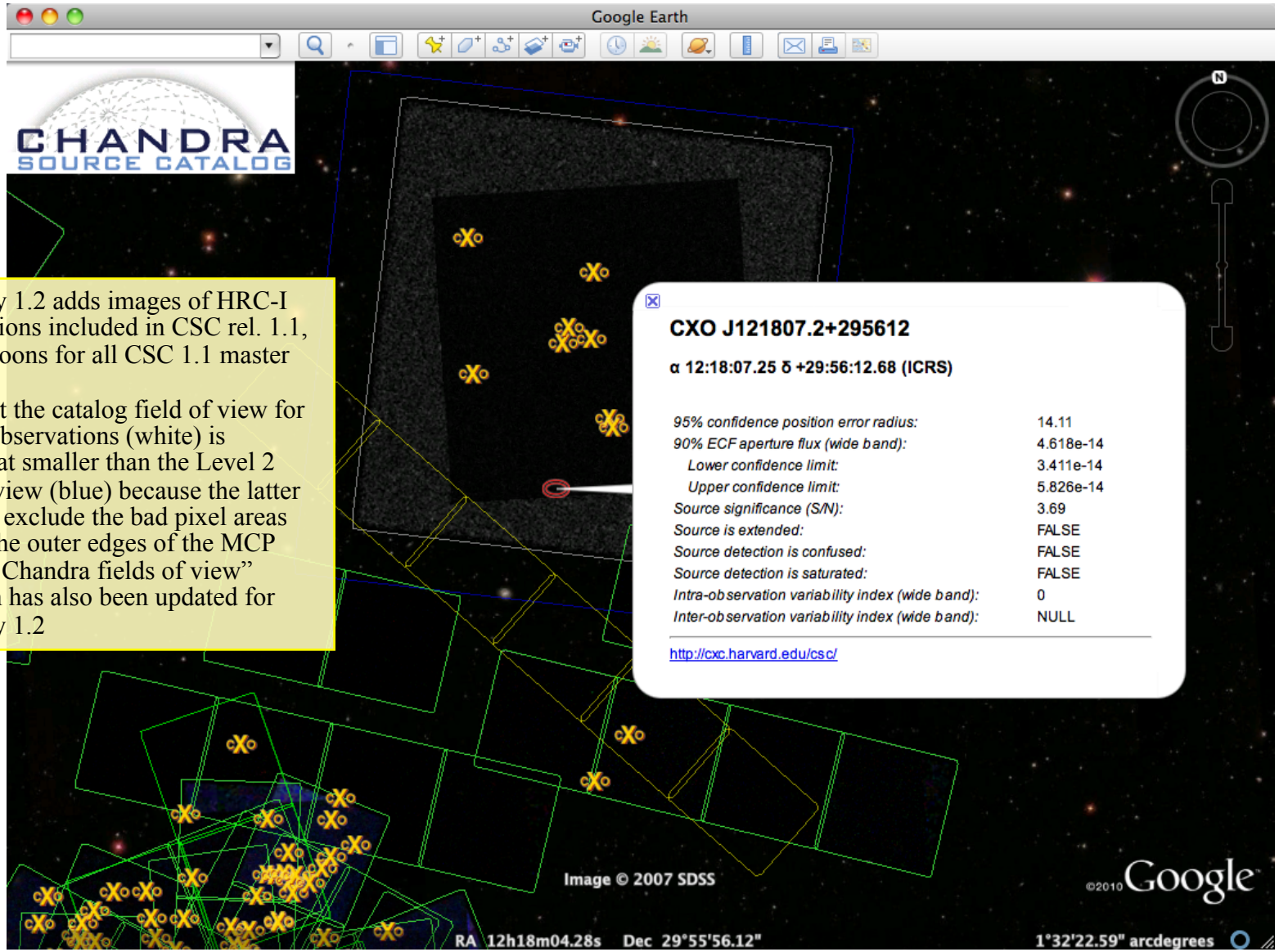


CSCview GUI Enhancements (Nov. Release)



CSC Sky 1.2 Updates (Nov. Release)

- CSC Sky 1.2 adds images of HRC-I observations included in CSC rel. 1.1, plus balloons for all CSC 1.1 master sources
- Note that the catalog field of view for HRC-I observations (white) is somewhat smaller than the Level 2 field of view (blue) because the latter does not exclude the bad pixel areas around the outer edges of the MCP
- The "all Chandra fields of view" selection has also been updated for CSC Sky 1.2



Release 2.0 Research and Development

- Draft processing "roadmap" document describing overall processing algorithm plan is currently being reviewed, and will be posted shortly
- Draft infrastructure roadmap document is being developed
- Several scientific enhancements have already been identified
  - Improve observation calibrations
    - Match planned Repro IV updates
    - Investigate improved high-background rejection algorithms
  - Stack observations prior to source detection
    - Prototype in development (part of MLE investigation)
    - Existing tools for applying astrometric corrections need some updates
  - Improve source detection backgrounds
    - Open, but have some improvements over rel. 1 identified
    - May not be as critical as rel. 1 because of MLE grading
    - Investigate use of local background models in areas with localized extended emission on ~60 arcsec scale (*e.g.*, galaxy cores)
  - Improve source detection
    - Revise `wavdetect` parameters
    - Investigate better algorithm for combining detections from multiple `wavdetect` runs (combining blocking factors and energy bands)

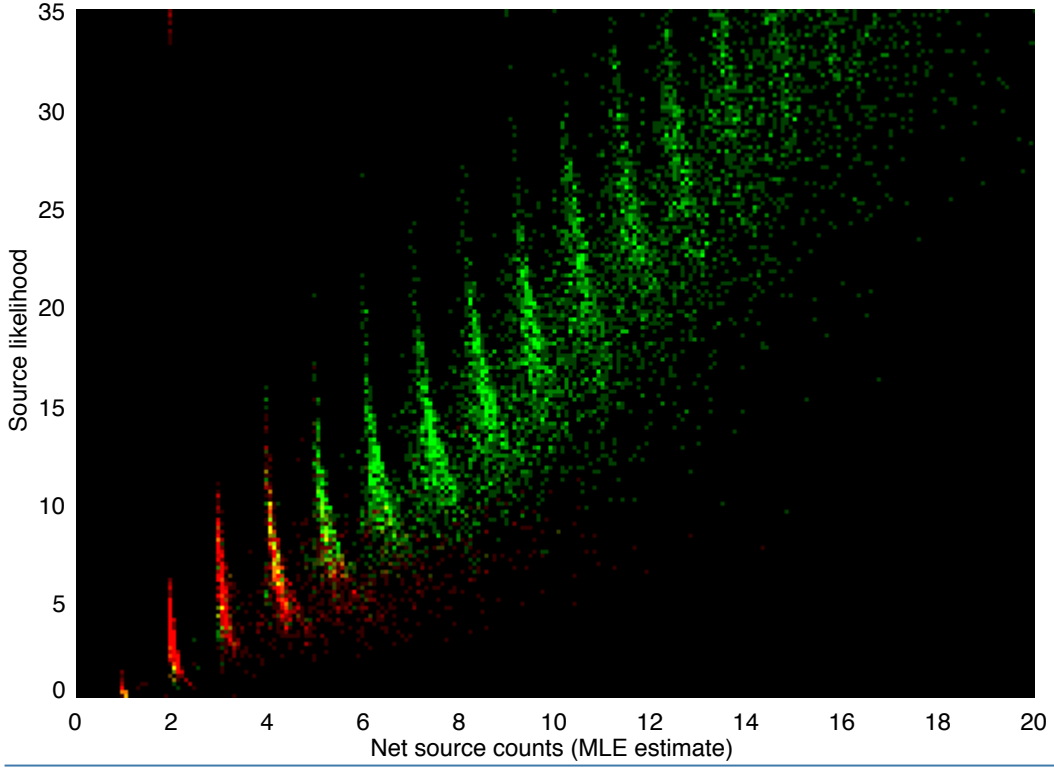
Release 2.0 Research and Development (cont.)

- Scientific enhancements (cont.)
  - Improve extended source handling
    - Investigate whether localized extended emission can be detected separately using `wavdetect` with large scales/blocks or `vtpdetect`
  - Use MLE to evaluate source detections
    - Prototype in development, results look promising
  - Revise limiting sensitivity algorithm for consistency with rel. 2 approach
  - Revise aperture photometry analysis
    - Use spectrally weighted ARF and apply energy-dependent ECF corrections
    - Simultaneously determine intensities of overlapping sources
    - Improve method for merging multiple intensity values for a single source
  - Add upper limits to temporal variability analyses
- Infrastructure enhancements
  - Processing pipelines must be redesigned to support observation stacks
  - AP infrastructure must be updated to run a split observation stack/master processing configuration on Linux
    - Aim to run bulk observation stack processing on Herndon SI cluster, and run master processing locally (since latter is tightly coupled to archive)
  - Archive, database, and UI updates required to addition of observation stacks

Prototype MLE Performance

Work in progress

- Prototype Maximum Likelihood Estimator performance
  - Evaluated using simulations of blank field "postage stamps" and isolated point sources at various off-axis
  - With "permissive" parameters, `wavdetect` detected false sources in ~1/3 of simulated blank field postage stamps with $\theta \lesssim 5$ arcmin
  - The MLE prototype is quite effective at differentiating true and false sources down to a few source net counts (on-axis)



- Figure is a 2-D histogram of source likelihood versus net source counts estimated by MLE, for an isolated on-axis source
- The source simulations include the nominal background equivalent to a ~35 ks ACIS observation, and span a range of input source counts range of 1—20 counts
- Detections in green are valid sources
- Detections in red are false sources
- A very small number of false sources have low counts and high likelihood
  - They occur because of the narrowness of the PSF on-axis (these are not seen at 5 arcmin off-axis) but are easily separable in this diagram

Short Term Plans (from last CUC meeting)

- Catalog Releases
  - Release 1.1 COMPLETED
- Public Interfaces
  - CSCview GUI
    - Release 1.1 updates previously discussed COMPLETED
    - Support for cross-matching with user supplied catalogs IN TEST/NOV RELEASE
  - CSC Sky in Google Earth
    - Next release will include display of HRC observations and be updated for release 1.1
      IN TEST/NOV RELEASE
  - Catalog limiting sensitivity service
    - Next release will include HRC observations and be updated for release 1.1
      IN TEST/NOV RELEASE
  - CSC-SDSS cross-match
    - Update for release 1.1 IN TEST/NOV RELEASE
  - Enhanced command-line interface
    - Simplified access to catalog file-based data products via URL NOT COMPLETED
  - External Interfaces
    - Access to a subset of catalog master source properties through Vizier
      REQUIRES FURTHER DISCUSSIONS WITH CDS (NOV)
    - Access to a subset of catalog master source properties through NED
      DATA PROVIDED TO IPAC, EXPECT RELEASE BY NED IN ~1 MONTH
      - » Expect to complete both after release 1.1

Future Directions

Short Term Plans

- Release 2 development
  - Work release 2 development items according to the roadmap documents, with critical path and research items taking priority
    - Expect to report on this effort in more detail at the next CUC meeting
- Public Interfaces
  - External Interfaces
    - Continue discussions with outside agencies (CDS, HEASARC) aimed at providing access to a subset of catalog master source properties through those interfaces

Longer Term Plans

- Catalog releases
  - Future releases
    - Simultaneous source detection across overlapping observations with different detectors and pointings (and thus very different local PSFs)
    - Detection and classification of very extended sources