

Hubble Source Catalog



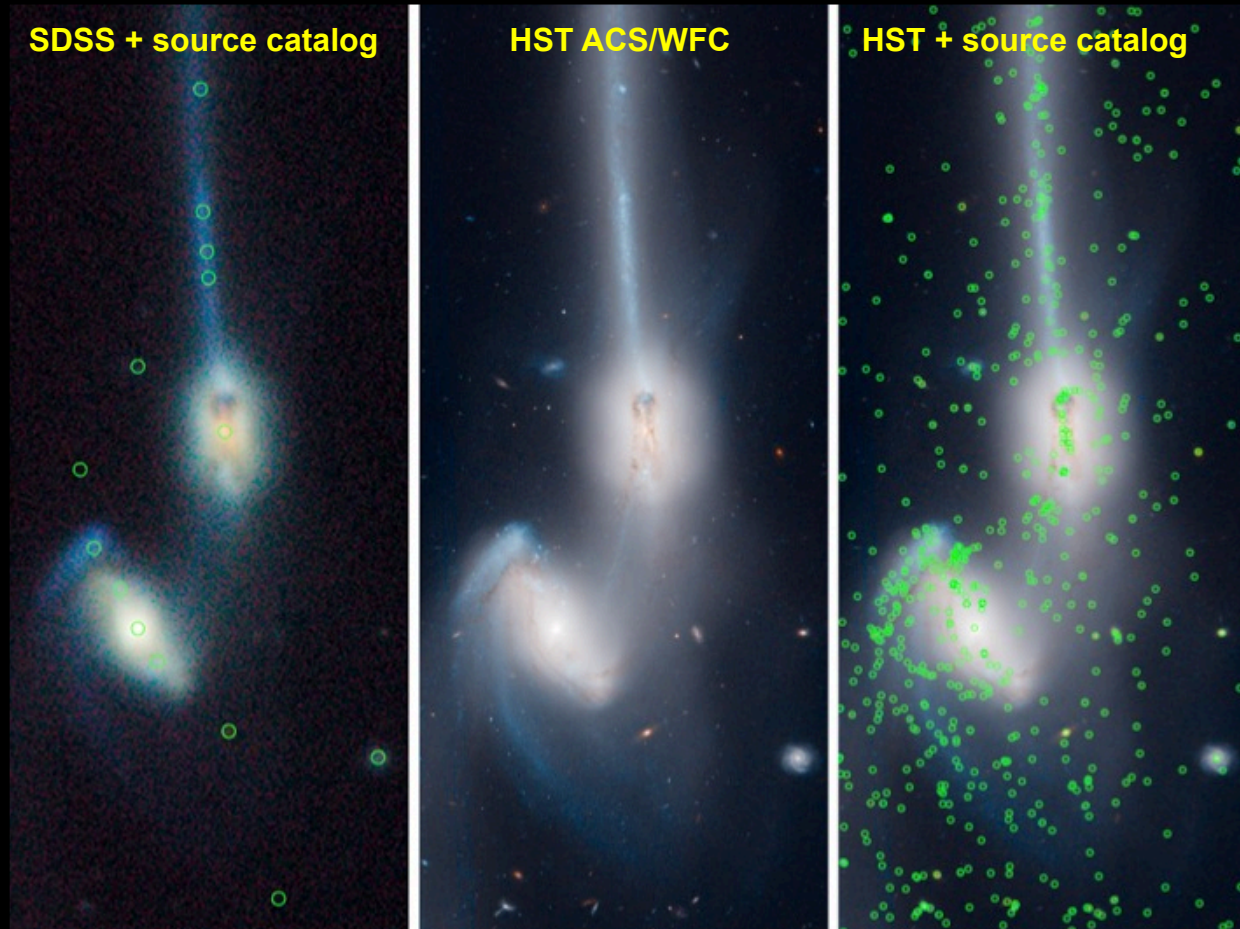
Brad Whitmore

(with Stefano Casertano, Anton Koekemoer,
Steve Lubow, Rick White)

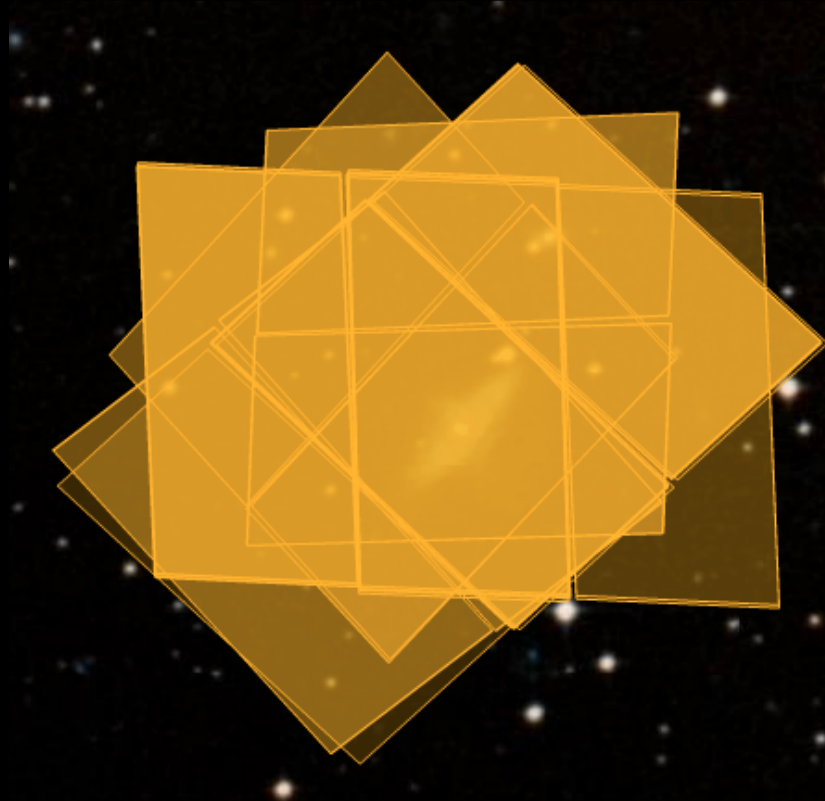
STUC Meeting, April 13, 2012

HST Source Catalog

- Easily accessible catalogs of objects are a mainstay of astronomy.
- Example: The SDSS source catalog is a primary catalyst for SDSS science productivity.
- HST Source Catalog
 - Increases the scientific return of the archive for decades to come
 - Fundamental reference for JWST science
 - Complements upcoming surveys (PanSTARRS, LSST)



Multi-Visit Mosaics Make Archival Data Analysis More Efficient



- This combined multi-visit image is several magnitudes deeper than a single-visit image.
- 80% of archival imaging data would benefit from such mosaics.

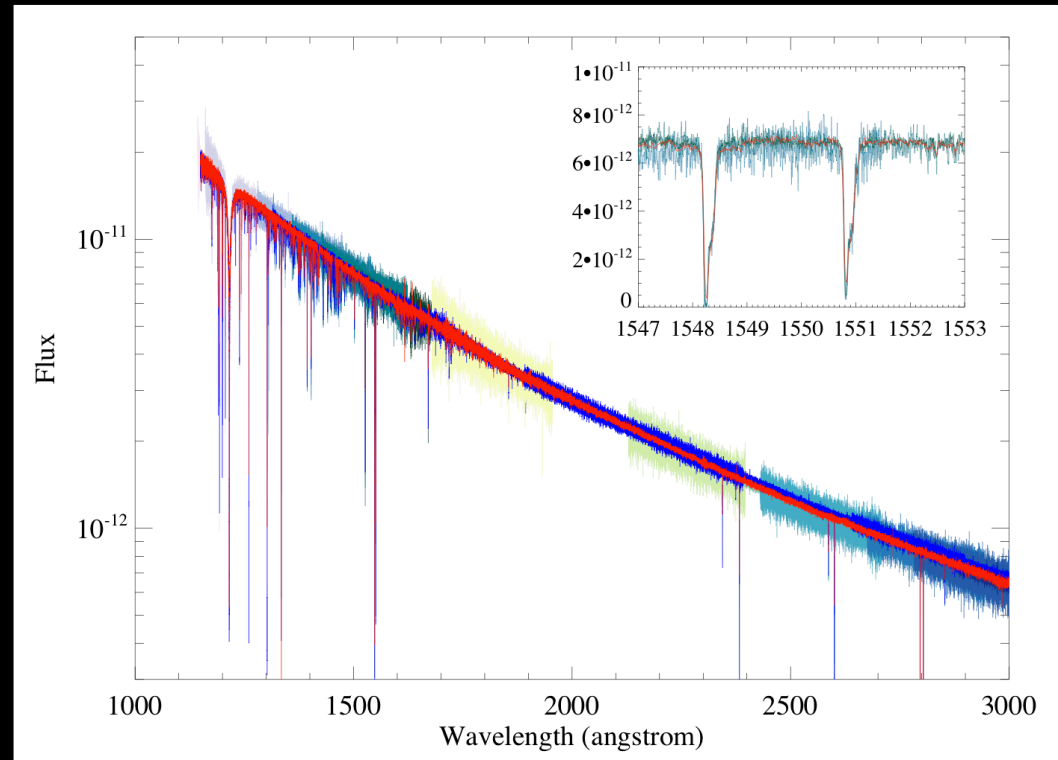
- This mosaic (124 images, 29 separate visits) would not be made by PI team since looking for micro lensing events.
- Making such a mosaic requires expertise and would have to be done by each archive researcher unless it exists as a High Level Science Product (HLSP).



Enhanced Spectral Products

Open New Possibilities

- Archive contains a limited number of high level spectral products
 - Barrier to spectral science productivity
 - Researchers must co-add and stitch together individual spectra
- **Slit spectra and multi-object grism observations**
- **Higher S/N than individual spectra**
- **Use of overlap regions to ensure a consistent flux scale**



Example: 30 individual spectra at 15 different settings

Goals and Requirements

The overarching goal of the Hubble Source Catalog (HSC) project is to **optimize science from HST by developing a single catalog** containing the majority of all sources ever observed by Hubble.

The **baseline goals** are to:

B1) - Provide a general, easily accessible, time-resolved catalog of "all" 10 sigma sources observed by HST, using the ACS, WFC3 and WFPC2.

B2) – Cross-reference with a basic list of existing catalogs (e.g., SDSS, 2MASS, Spitzer, GALAX, Chandra, existing Hubble HLSP, ...) as well as HST spectroscopic datasets that may be relevant.

B3) - Develop tools for easy access and quick-look analysis. These would include a relational database search capability, and a quick-look, time-resolved phenomena tool.

Goals and Requirements – cont.

The **stretch goals** are to:

S1) - Extend the catalog to other instruments (e.g., NICMOS, STIS, ...) and develop more focused, "value added" catalogs addressing specific science topics.

S2) – Cross-reference with a more extensive list of catalogs. Develop a spectroscopic pipeline (similar to the imaging pipeline used in the HLA) and cross match the relevant spectroscopic information with the HSC.

B3) - Develop more advanced tools including a three-plane visualization tool (i.e., tracking the same data points in image - plots - catalog space).

These basic goals will guide the development of a set of formal requirements for the program.

Backup - 1

Caveat:

It is important to note that the HSC will not eliminate the need for astronomers to make more detailed catalogs optimized to **address their own specific science goals in many cases.**

The HSC is designed to be a **general-use catalog** sufficient for many, but not all users.

We explore the potential of making **value-added catalogs** as part of the stretch goals.

Backup - 2

How will people use the HSC ?

1. What HST data exists in my area of interest? (100 %)
2. Do a sanity check on my own catalog (80 % ?)
3. Find cross matches with other catalogs (HST HLSP, SDSS, Chandra, Spitzer, ... (50 % ?)
4. Use it to do my science (10 – 50 % ?)

Basic Approach

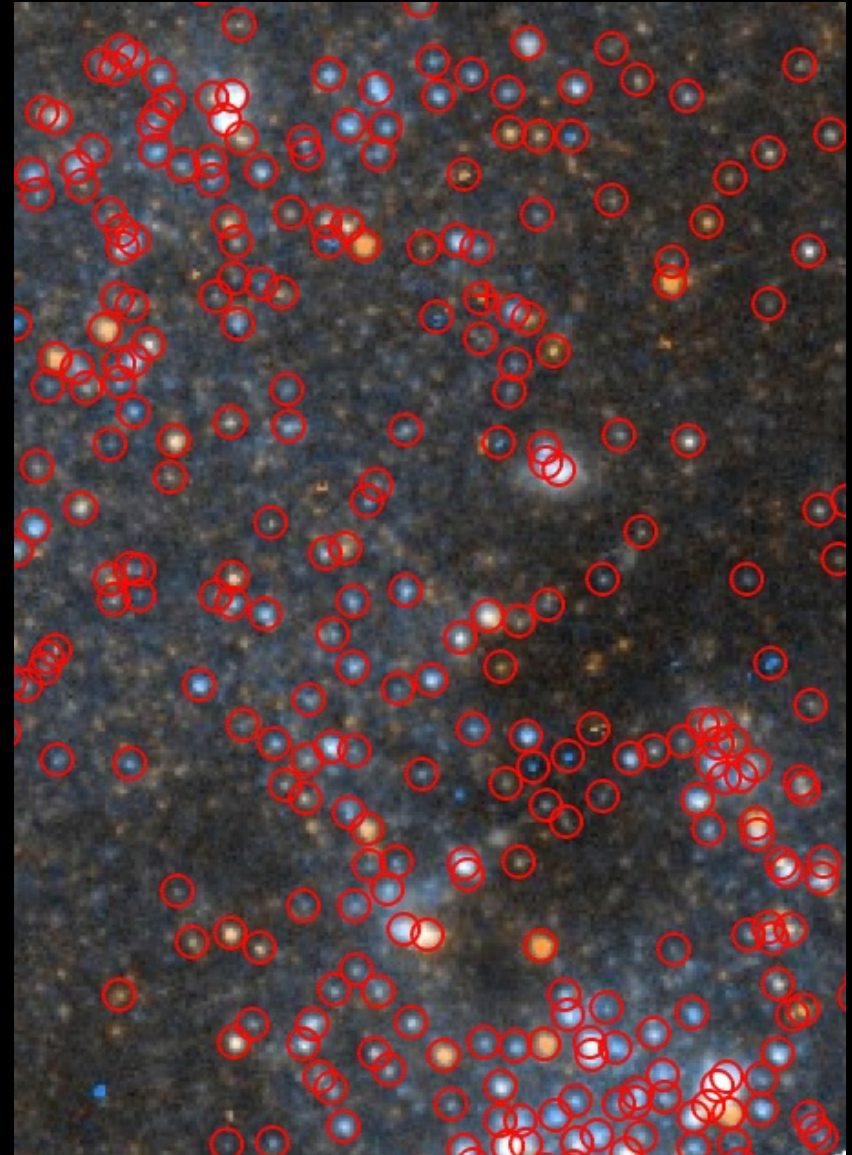
General-use source lists are already generated in the HLA for *single-visit* imaging observations.

- DAOPHOT (point and point-like objects)
- SExtractor (extended, point, and point-like objects)

Improvements to the existing HLA images will be made before regenerating new source lists.

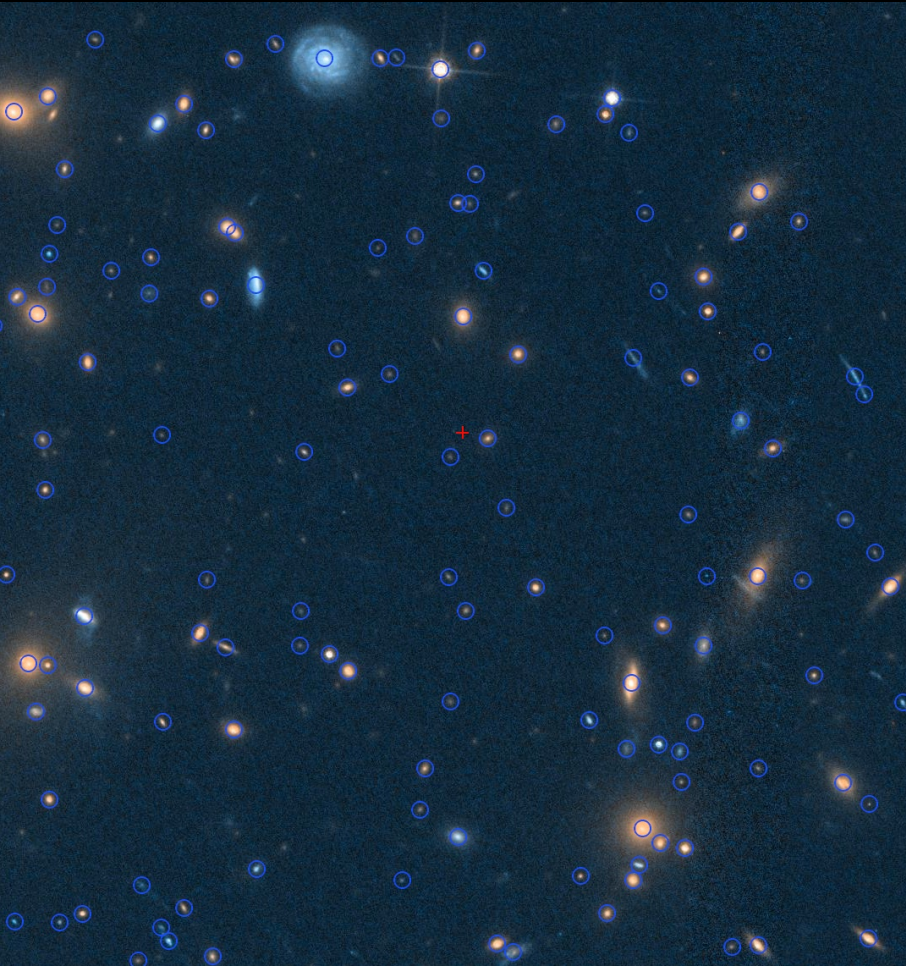
These **single-visit source lists** will then be combined, keeping track of the time domain.

In addition, it will be necessary to develop a system that automatically updates the HSC regularly as new data enter the archive.



DAOPHOT source list for part of
10918_22_ACS/WFC F814W/F555W_M101-F2 image

Some Challenges



SExtractor source list for part of
9722_05_ACS_WFC_F814W_F555W_MACSJ0717+3745
image

Uniformity – Requires reliable uncertainty estimates. Our approach will be to use empirically determined “true” errors (e.g., from repeat measurements of the same objects) to bootstrap our error estimates.

Completeness - One of the keys is to stay well above the completeness level, hence our goal of using 10 sigma as our detection criteria.

Different spatial resolution - This is especially important when cross matching with external catalogs (i.e., 0.1” for Hubble – 2” for Spitzer), but is also an issue when comparing WFC2 (0.10”), ACS (0.05”), WFC3 (0.04” and 0.13”).

Community Involvement

Five generic use cases will help guide the development of the HSC:

Point source photometry (e.g., color-magnitude diagrams in globular clusters and in the field) [Potential members: Tom Brown, Jay Anderson, Jason Kalirai, Peter Stetson, Abi Saha, Julianne Dalcanton, ...]

Nearly point source photometry (e.g., compact clusters in external galaxies) [Brad Whitmore, Nate Bastian, Soeren Larsen, ...]

Extended object photometry and morphology (e.g., faint galaxies in survey fields, photometric redshifts) [Harry Ferguson, Anton Koekemoer, Mark Dickinson, ...]

Multi wavelength (and spectroscopic) cross matches (e.g., ULIRGs, gamma-ray bursts, x-ray counterparts) [Lee Armus, Bob Hanisch, Knox Long, ...]

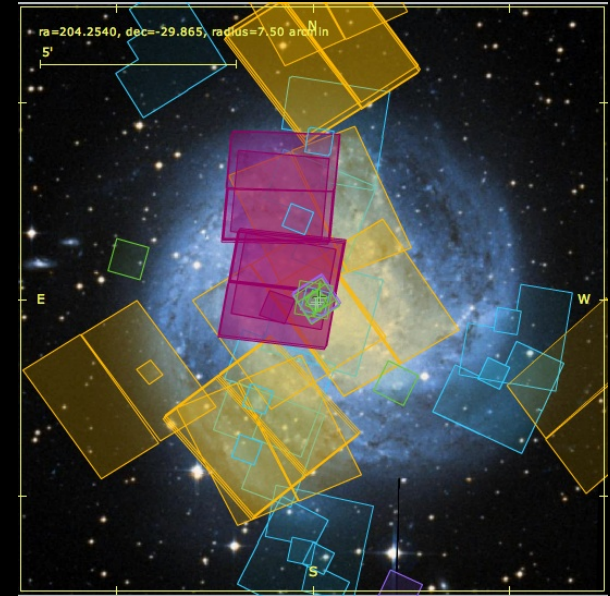
Time-resolved phenomena (e.g., Cepheids, supernova, variable stars, ...) [Stefano Casertano, Adam Riess, Nathan Smith, ...]

We will also **proactively seek advice** from other catalog projects (e.g., SDSS, Chandra, Spitzer, ...).

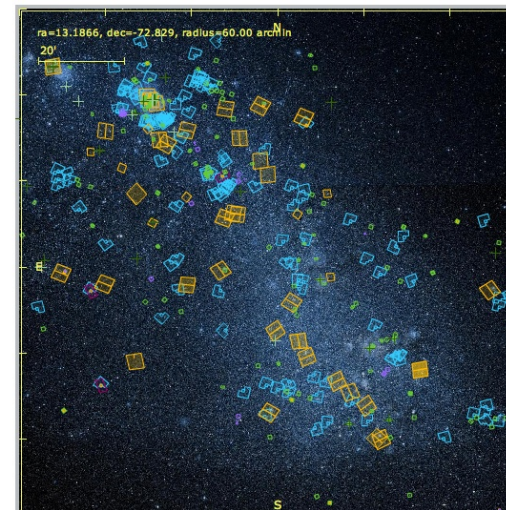
Backup - 3

Examples of potential HSC Users:

1. JWST user in 2025 cross matching with their sources in M83. (combine catalogs from 269 images – not an HST user so don't no differences between WFPC2/ACS/WFC3/NICMOS).
2. Someone making CMD of stars in SMC (> 3000 observations- combine WFPC2 and ACS catalogs or not ?)
3. Brad Whitmore – “A catalog of young star clusters in 500 galaxies” – 30 are done after 2 years. (cross- matching WFPC2/ ACS – footprint nightmares)
4. Someone looking at variable stars (but not Cepheids) in galaxies with lots of repeated observations.



Instruments	#Footprints
✓ALL	3720
✓ACS	376
✓ACSGrim	0
✓WFPC2	916
✓WFPC2-PC	813
✓NICMOS	126
✓NICGrim	0
✓WFC3	6
✓COS	452
✓STIS	844
✓FOS	143
✓GHRS	44

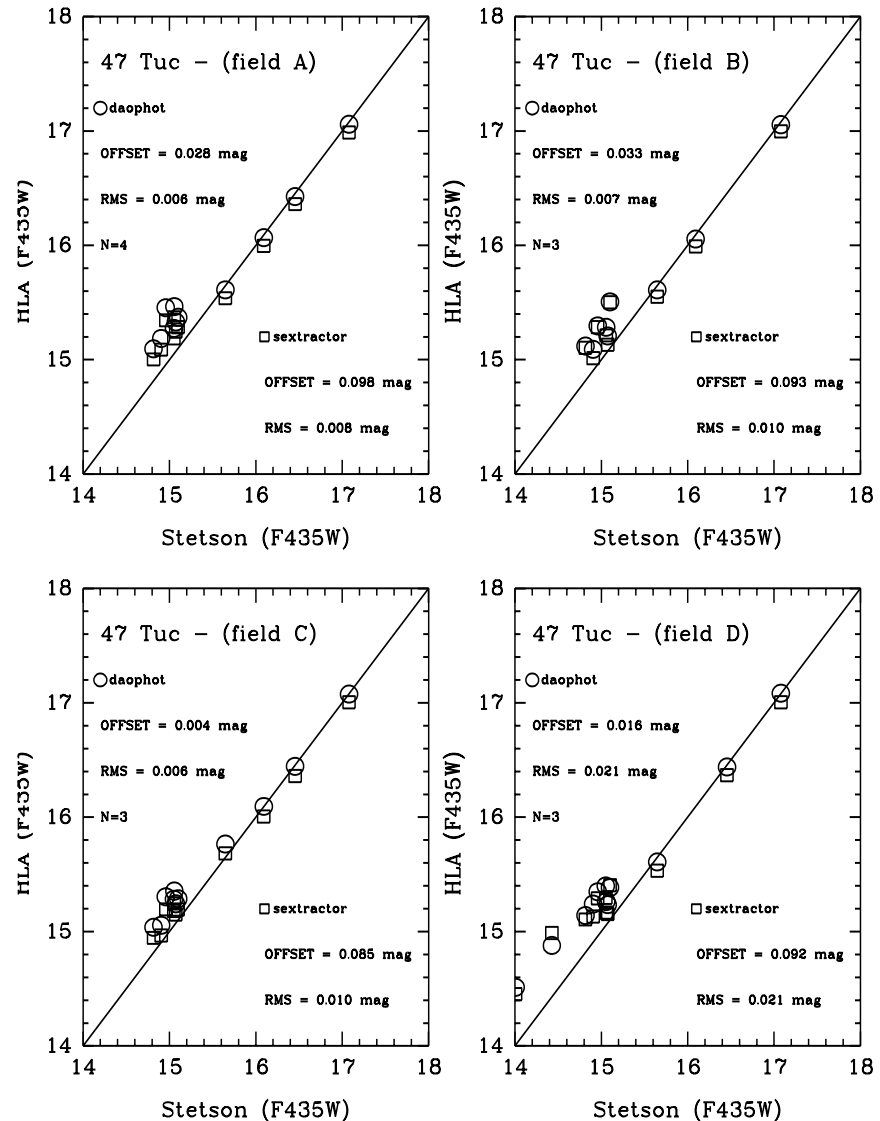


Getting the Word out

Science cannot be enhanced if no one knows about the HSC.

Besides advertising in the normal ways (i.e., MAST, HLA, HST websites, STScI newsletter, AAS meetings, ...) we will also:

- have **bi-annual workshops** at STScI (tentatively the Fall of 2013 and 2015) titled "Doing Science with the Hubble Source Catalog",
- write a **PASP paper** that provides the primary reference for the HSC. (e.g., comparison with other photometry).



Tools

The **utility of a catalog** can be greatly enhanced if it is:

- easy to access,
- possible to "tune" for a user-specific purpose,
- possible to do quick-look analysis.

The development of tools will therefore be a priority. These may include:

1. Developing a **relational database** search capability
2. Building user-defined, subset catalogs
3. **Cross matching** with existing user-provided catalogs
4. Plotting and quick-look analysis of **time-resolved phenomena**
5. A **three-plane visualization** tool
6. Ability to make new user-specified catalogs for certain datasets (e.g., to go deeper).

A Jump Start

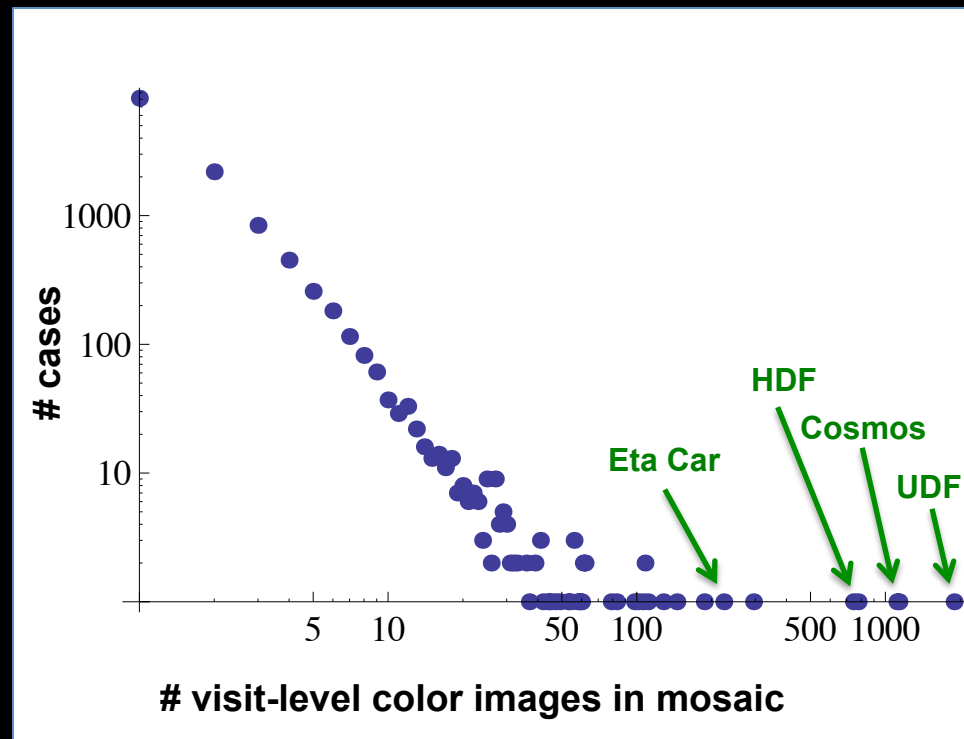
HST Cross-Matching Catalog Project

Lubow (STScI) & Budavari (JHU)

- Goals:
 - Cross-match HLA source lists of 30 million source detections into searchable HST object catalog
 - Improve astrometry
- NASA AISRP grant started over 2 years ago, expires in June 2012
- Have **recently completed** an initial catalog system (tables + software) that covers **ACS/WFC and WFPC2**.

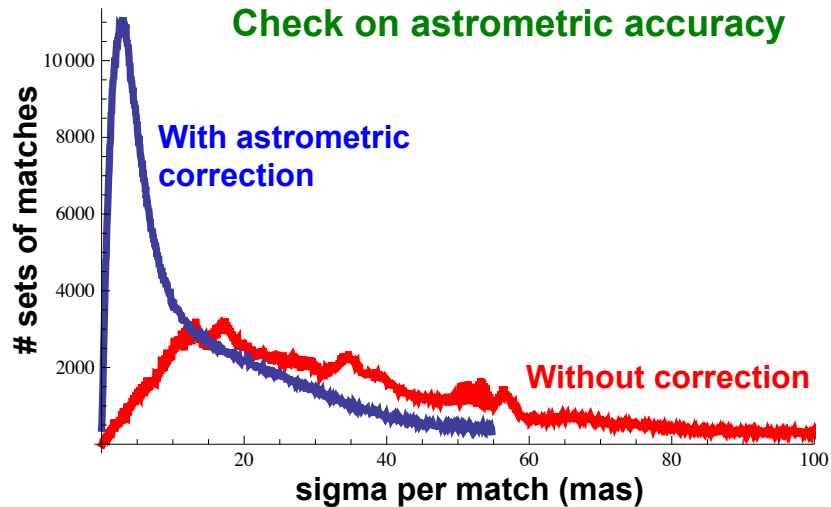
Approach

- Based on single-visit WFPC2 and ACS/WFC color images.
- Organize data into mosaics of overlapping exposures for cross-matching.
- Query interface provides source detections and non-detections (dropouts).

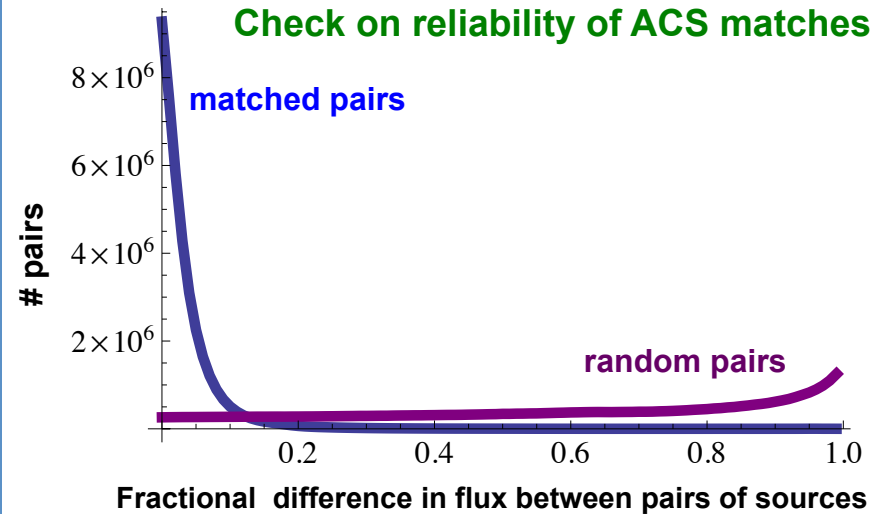


Results

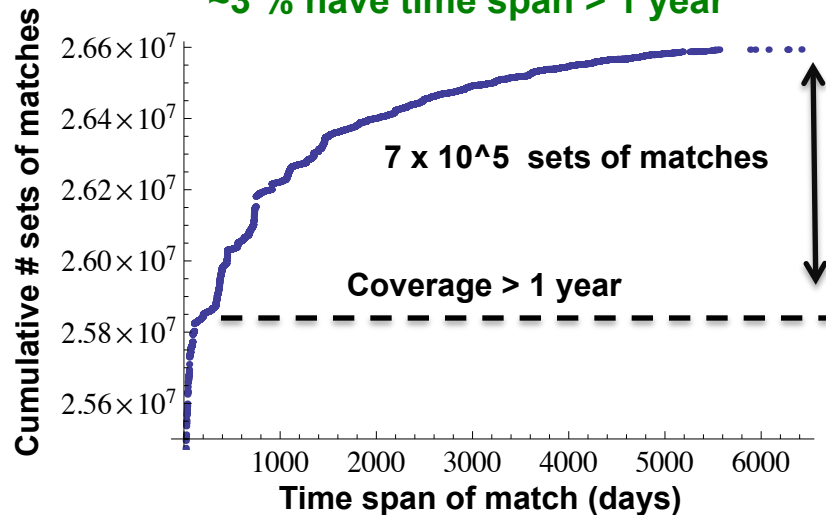
Check on astrometric accuracy



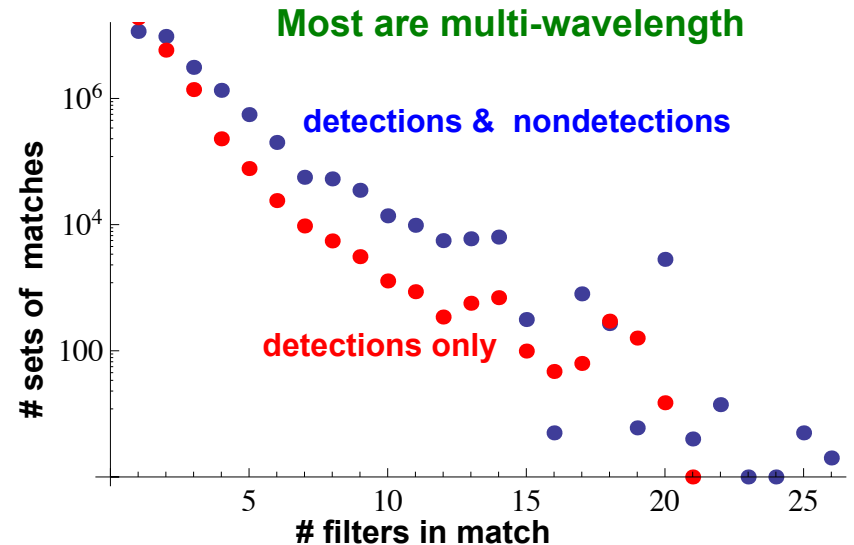
Check on reliability of ACS matches



~3 % have time span > 1 year



Most are multi-wavelength



Summary

An HST Source Catalog will add a valuable **new dimension** to the information available to both present and future users of the Hubble Space Telescope for decades to come.

It will enable efficient studies of time-variable phenomena.

It will provide a **bridge to future missions** both in space (e.g., JWST), and on the ground (e.g., LSST).

