# The Hubble Source Catalog: A Progress Report

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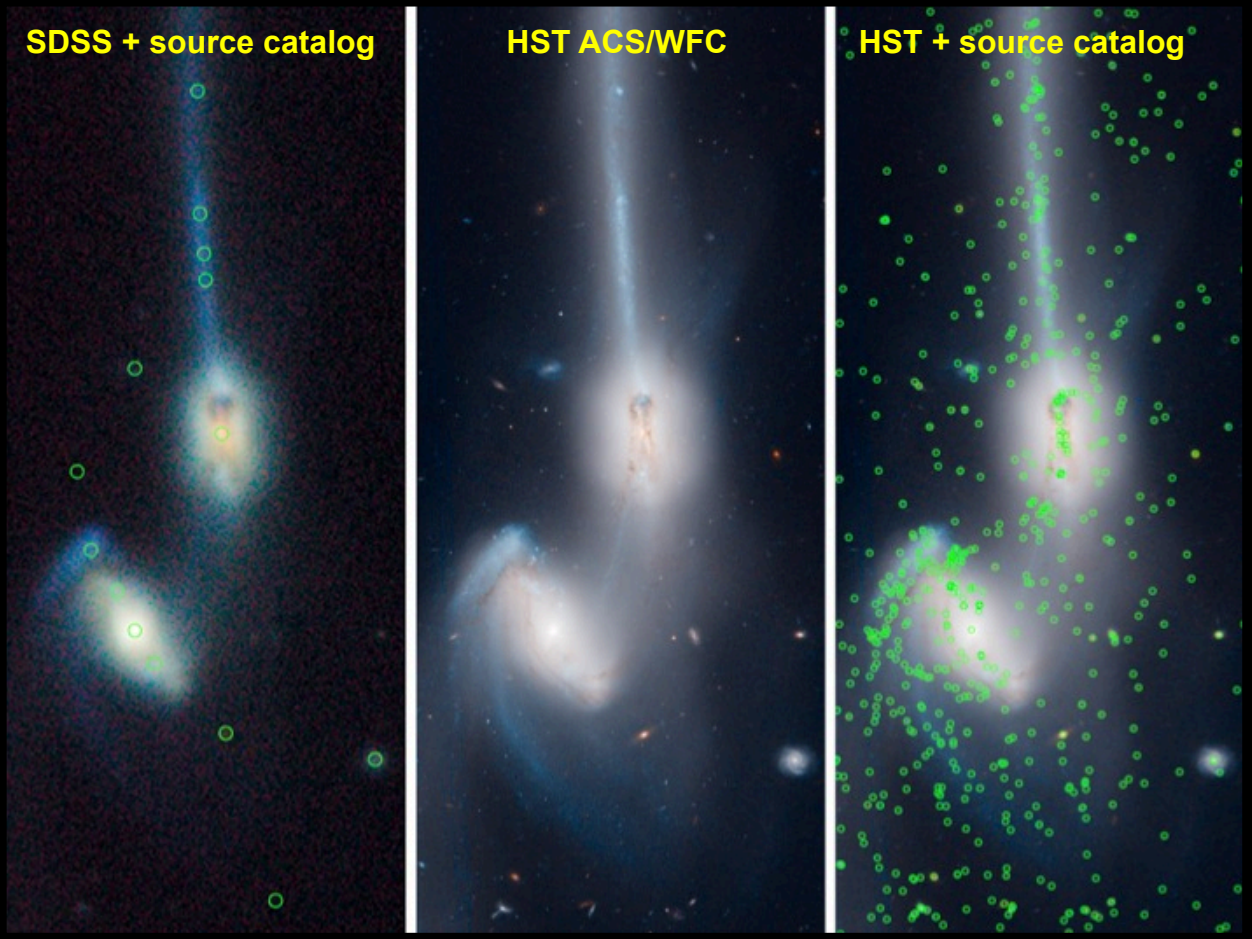
1. Background and Motivation
2. Methodology: Use Cases > Requirements
3. Progress
4. Timeline

# 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)




See April 2012 STUC presentation and white paper for background material.

# High Level Science Requirements

1. Provide online (downloadable) search capability for photometry of a target (or list of targets) using WFPC2, ACS, WFC3 source lists from the HLA (~90 % completness level, e.g., no source lists for ACS SBC).

   [Stretch - Include other HST instruments? e.g., NICMOS]

2. Provide averaged magnitudes, number of repeats, and RMS for each filter and instrument combination. Also provide detailed version of form that shows all data.

3. Include temporal information.

4. Provide cross reference between HSC sources and SDSS, 2MASS, Spitzer, Chandra, GALAX catalogs. Include matches with existing HST spectral extractions (e.g., NICMOS and ACS grisms)

   [Stretch - Include matches with future HST spectral extractions.]

5. Develop tools for easy access and quick-look analysis (e.g., correlations, light curves, …

   [Stretch - Relational search capabilities (e.g., all Sc galaxies from Messier catalog with UBVI observations longer than 500 sec).]

6. Provide uncertainties for all measurements (accurate to ~ 25 %).

# High Level Science Requirements – cont.

7. Involve the community (e.g., small working groups) to insure the final products meet the needs of research scientists.

8. Document/advertise the HSC (e.g, algorithms, comparisons with existing standard datasets, PASP paper, workshops, ...).

9. Develop use cases and detailed requirements (e.g., accuracies, % of artifacts, completeness estimation, ...)

10. Promote the development of value-added catalogs from the HSC (e.g., compact star clusters).

**Some questions under discussion:**

1. DAOPHOT and/or SExtractor catalogs (i.e., the HLA currently has both, but only SExtractor catalogs are currently used by HSC) ?
2. Output options (e.g., include SQL search) ?
3. Versioning (e.g., do we need to save all old versions of software or just products) ?
4. Degree to which mosaics are incorporated.

# How will people use the HSC ?

1. What HST data exist for my particular target ? (100 %)

2. Do a sanity check on my own catalog (80 % ?)

3. Make use of existing cross matches with other catalogs (HST HLSP, SDSS, Chandra, Spitzer, spectral extractions, … (50 % ?)

4. Use  it to do my science (10 – 50 % ?)

## Caveats:

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 are in an early stage (Beta-1) of the project. The HSC has a number of known shortcomings that are being addressed for a Beta-2 release planned for January, and a Version 1 release in May.

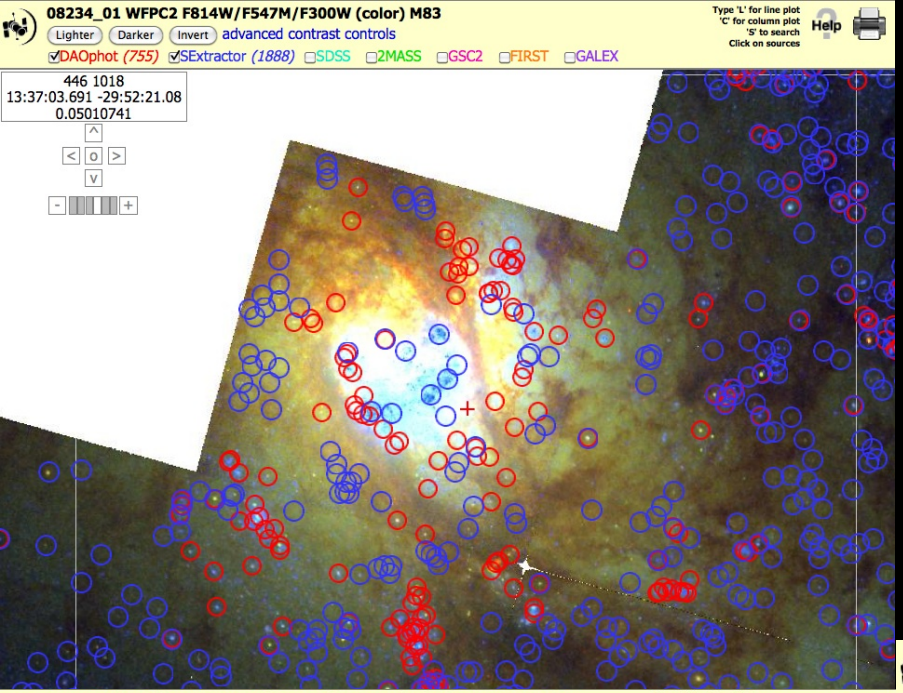
# Feedback Loops and other Improvements

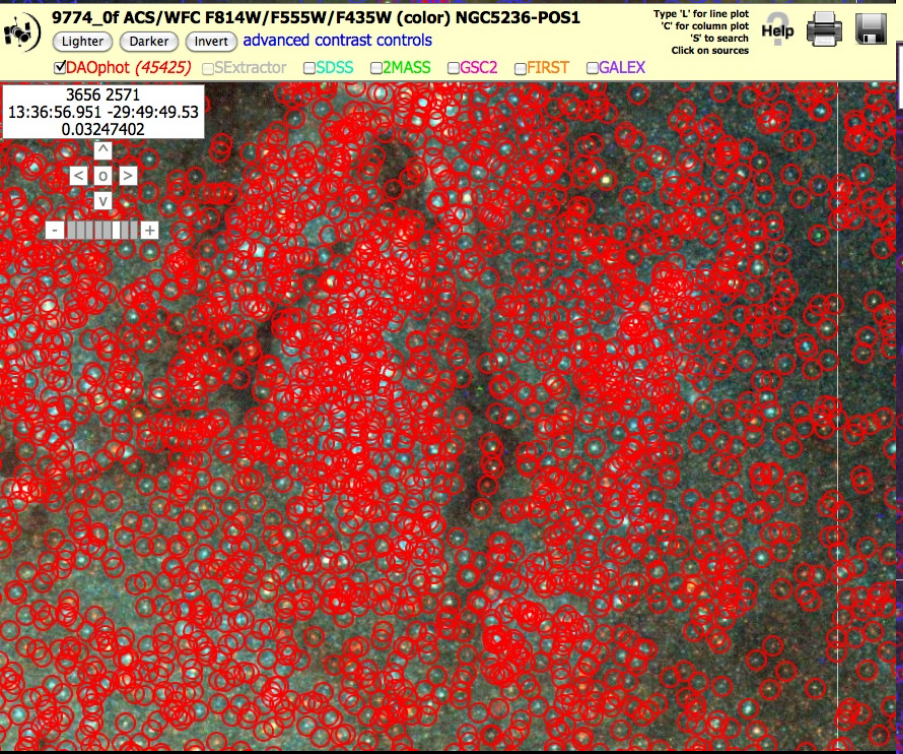
**As we learn how to make better sources lists (e.g., better treatment of WFC3 background), this improves the entire HSC database.**

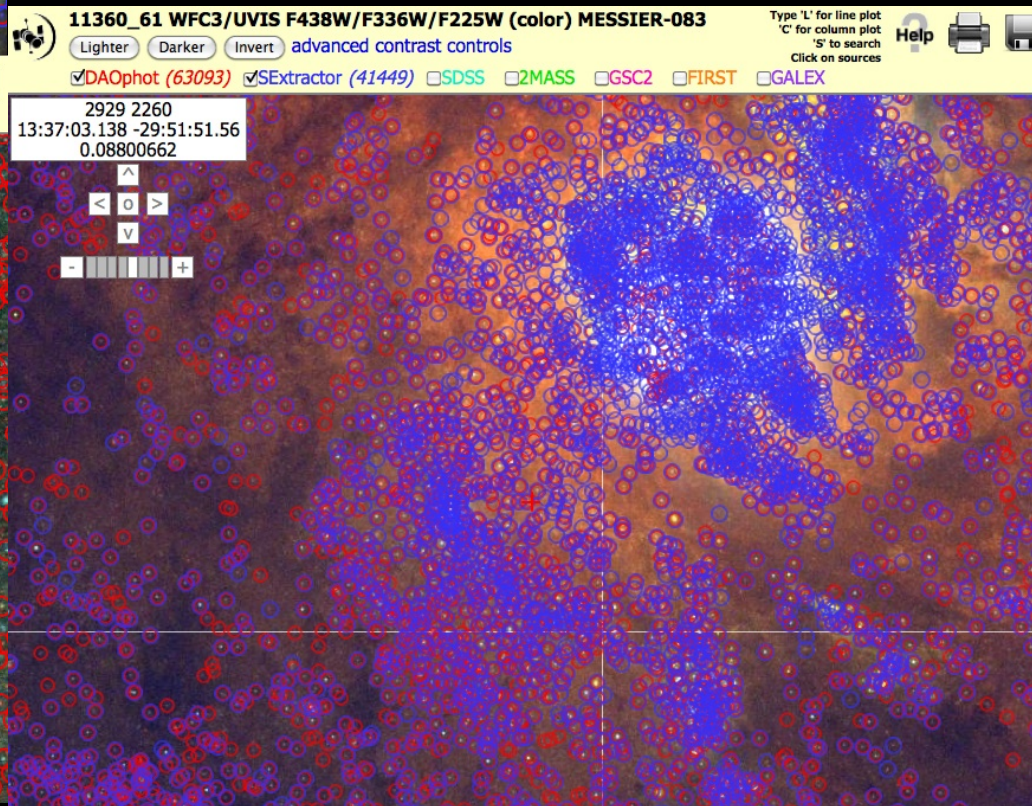
**Other artifacts are more easily caught by using the HSC database (e.g., cosmic ray or zeropoint problems).**

**This allows us to improve the individual source lists, which in turn improves the entire HSC database.**

**Hence there is a circular feedback loop that leads to continual improvement.**



# Use Case Categories

1. **Time variability** (e.g., SN, GRBs, light echos, proper motion, transients)

2. Astrometry (absolute astrometry, identification of "blind" sources such as ULXs)

3. **Photometry** (e.g., CMDs, color-color, photo-Z's, ...)

4. Morphology (of individual objects rather than ensemble - e.g., clumpy galaxies, star vs cluster, …)

5. Structure determination (use ensemble of objects - e.g., Milky Way components, streams, galaxy clusters, …)

6. Very large datasets (e.g., all LMC observations)

7. Cross-matching catalogs (e.g., with user-supplied catalog , multiwavelength catalogs, ...)

8. Spectroscopic cross-matching (e.g., with ACS and NICMOS grism extractions)

NOTE: HLA data release 7, highlighting search and display of contributed spectroscopic products - Nov. 2

also

"Enhancing the Legacy of HST Spectroscopy" meeting – Nov 15 -16

# Example of a detailed version of a use case

## Category 3 – Photometry

## "Finding LBVs in M83 and similar galaxies" - Brad Whitmore

**Reference: Chandar et al. 2010, ApJ, 719, 966**

**Step 1 - Make U-B vs. V-I color-color diagrams for stars (using concentration index [CI] or equivalent to isolate stars from clusters and background galaxies).**

**Step 2 - Allow definition of selection box in the color-color diagram to isolate LBV candidates. Make a working catalog (various formats allowed) based on objects in the selection box.**

**Step 3 - Show where these subsets are by overlaying on image. Are they associated with star formation regions or are they random.**

**Step 4 – Edit working catalog (approve/disapprove each object as go or change a selection criteria and see how it affects which objects get selected).**

**Step 5 - Look for variability in the photometry from repeat measurements. Compare/overplot light curves from various filters if available**

**Step 6 - Identify other Messier galaxies with the needed combination of filters.**

# The Use Cases guide the development of a set of tools and requirements for the project

LBV example - Required tools

- Make plots ½ ✔
- Over plot SED models ---
- 3-plane visualization tool ½ ✔
- Make working catalogs ½ ✔
- Plot "light curves” ---
- Relational search capabilities ---

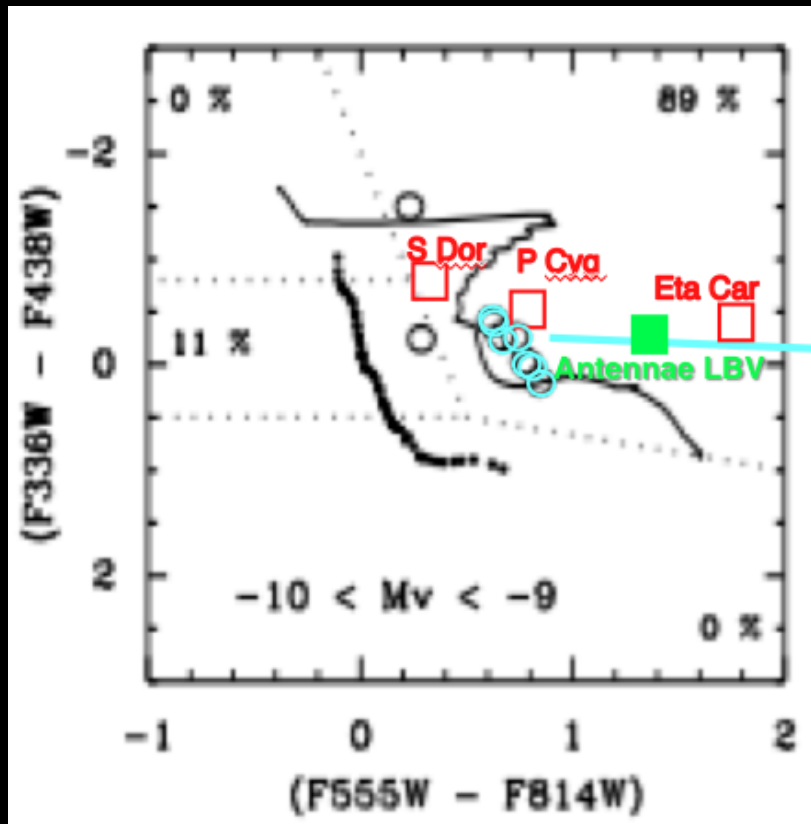
# The Use Cases guide the development of a set of tools and requirements for the project

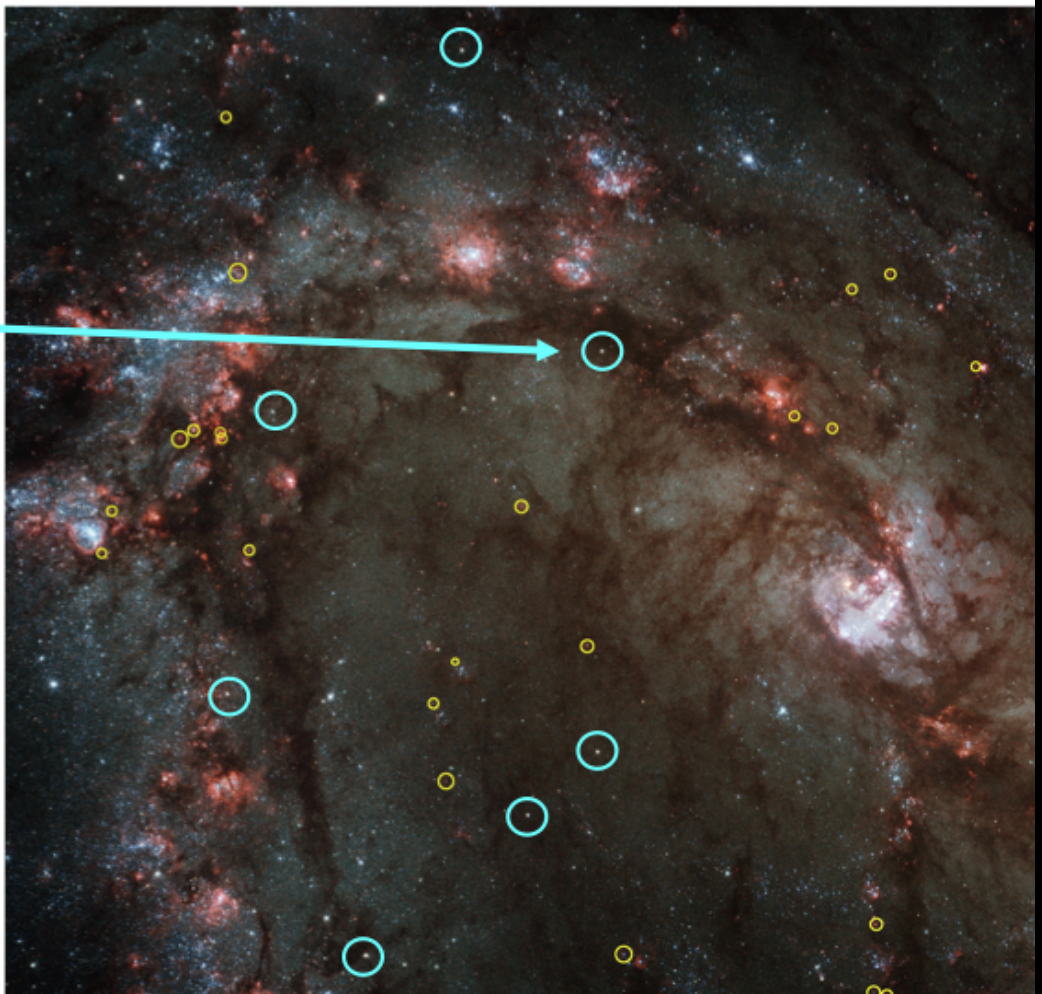
LBV example – Data quality requirements

- Accuracy of photometry better than 0.1 mag in UBVI
- < 5 % artifacts (mismatched objects, false detections, …)
- Measurement of a concentration index (sufficient to separate stars from clusters at m-M = 30 with < 5 % artifacts)
- Include WFPC2, ACS, WFC3
- Estimation of completeness as function of magnitude / filter

# In Chandar et al. 2010, we found that Luminous Blue Variable (LBV) candidates could be identified from a color-color diagram in M83.

- We then used this technique to identify a LBV in the Antennae.
- What makes this a challenging archival task is the cross-matching of several instruments over long periods of time.

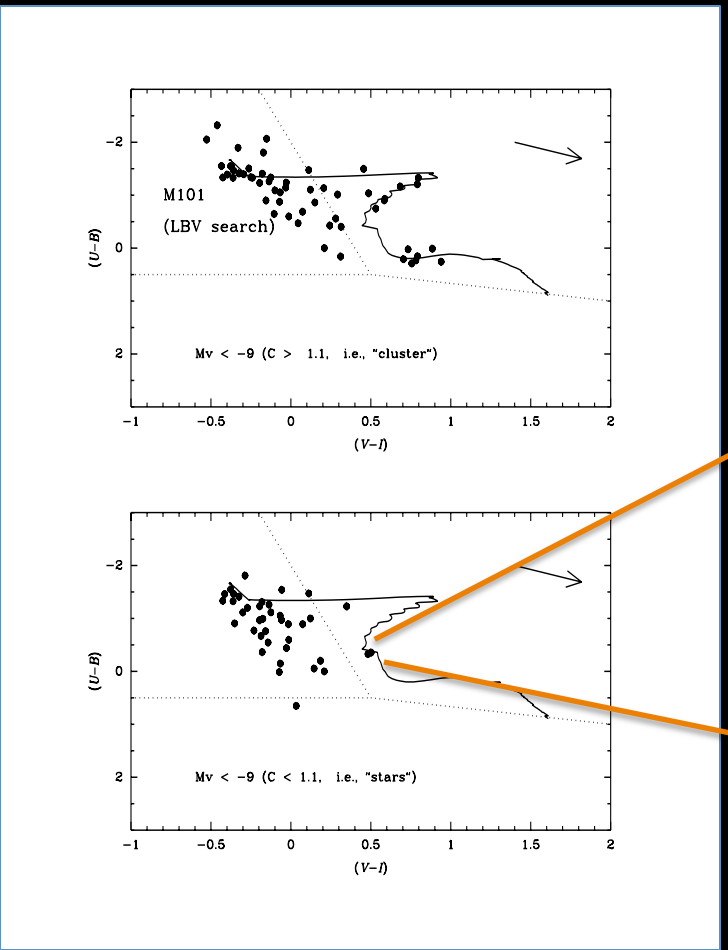


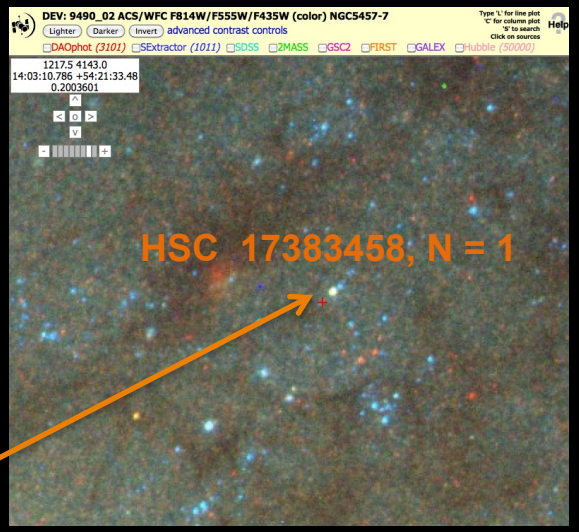



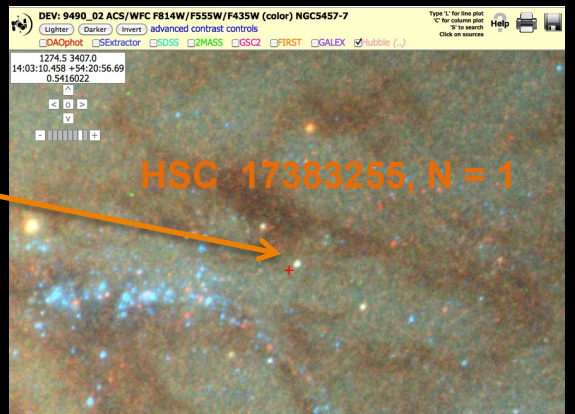
As part of this use case investigation, 2 excellent LBV candidates were found in M101 (using IRAF rather than the HSC since F336W is not currently in the list of included HSC filters).

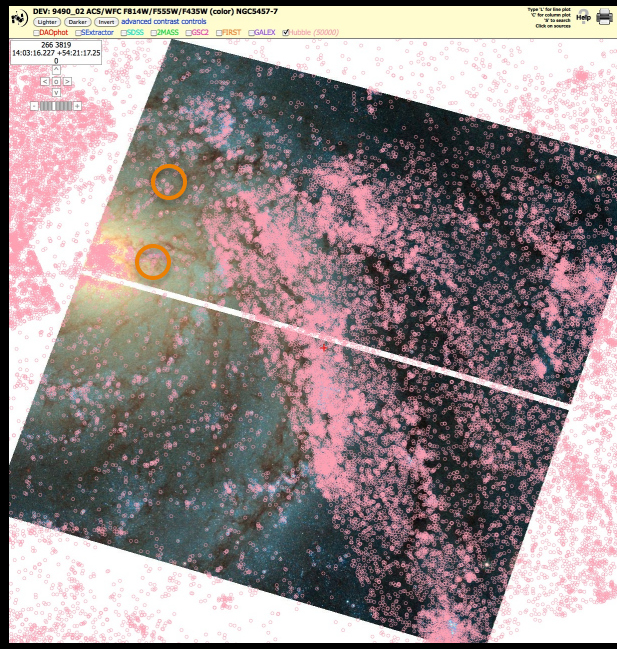
Unfortunately, the two are not in the region with extensive coverage, in both time and filters, hence it is not possible to determine if they are actually variable using the HSC.

Will need to wait for version 1 of the HSC before this is easy to do (e.g, when a better ACS SExtractor catalog becomes available for image 9490_02).



# Community Involvement

**Four working groups will be formed to help guide the development of the HSC and insure that people using a variety of different analysis tools can use the catalog and tools effectively.**

***Point and Nearly-point source photometry*** **(e.g., color-magnitude diagrams in globular clusters and in the field, compact clusters in external galaxies) [Potential members: Tom Brown, Jay Anderson, Peter Stetson, Abi Saha, Julianne Dalcanton, Brad Whitmore, Nate Bastian, Soeren Larsen, ...]**

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

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

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

**Timing ? Start 1 or 2 groups now, others later ?**

# Early MAST Survey Results

**11. We have recently introduced a preliminary beta version of the Hubble Source Catalog (HSC), with the goal of cross-matching the tens of thousands of individual visit-based source lists that are currently in the Hubble Legacy Archive into a single master catalog.**

- **How frequently do you think you would use the HSC for your research? (250 respondents)**

| | |
|---|---|
| **Extensively** | **27** |
| **Moderately** | **121** |
| **Rarely** | **82** |
| **None** | **20** |

- **What modes might you want to use in interacting with this catalog?**

| | |
|---|---|
| **Download full catalog** | **80** |
| **Cone search (including web services callable from programs)** | **163** |
| **Casjobs/SQL** | **69** |
| **Other** | **12** |

- Would you be interested in serving on a HSC Working Group to help guide the development of this new initiative?

  - 31 yes (out of 232 respondents)

- Any other feedback/suggestions on how this catalog might be useful for your research?

*" This is a great first stab at this (and a long time coming). There are a lot of limitations in the catalog at present (e.g., no flags for suspected cosmic rays, only wide-band filters, assessment of variability/light curve) that need to be sorted out and expanded upon to make the catalog more useful to a broader audience/community."*

*" Include cross matching of catalog sources with source catalogs from other missions/surveys, and conditional matching (e.g., 'find me all HSC sources detected in X-ray and mid-IR and that were observed with HST in at least two bands/filters or grism')."*

*" I think the catalog will be more useful with the highest possible precision in the absolute coordinates of sources."*

# 16. How important are the following current or planned features ?

**Cross-correlations with other missions (e.g., SDSS, 2MASS,...) (235 respondents)**

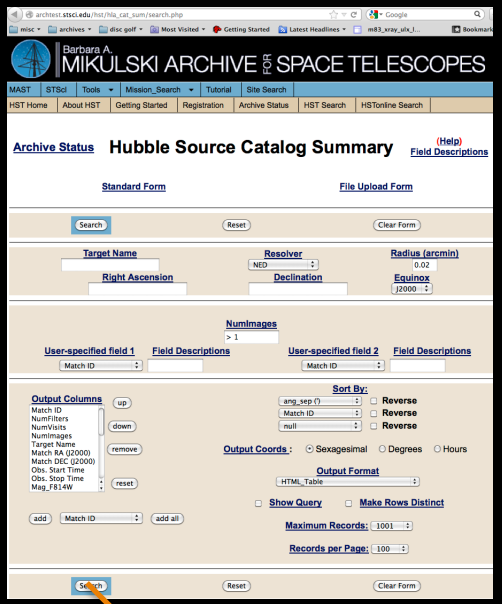
**5 not useful**
**21 unsure**
**209 very useful**

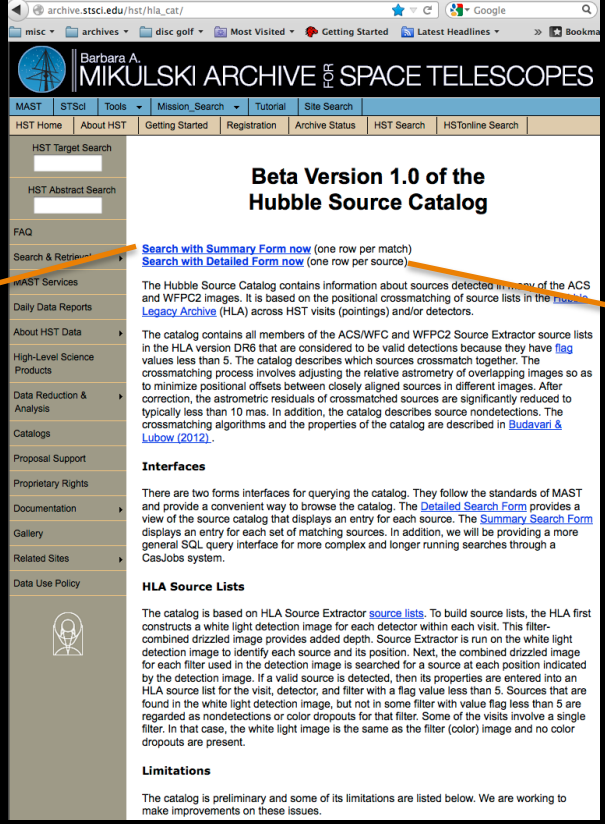
**This was the highest "useful" rating out of 13 options. Others included:**

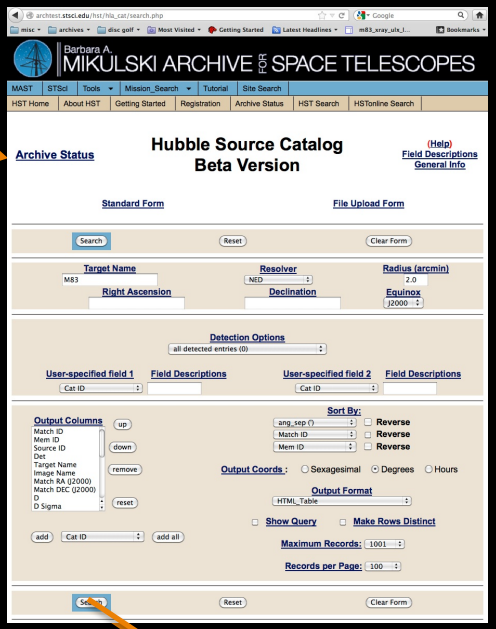
- **footprints from other missions 199**
- **single sign-on user accounts 192**
- **integration with publications 187**

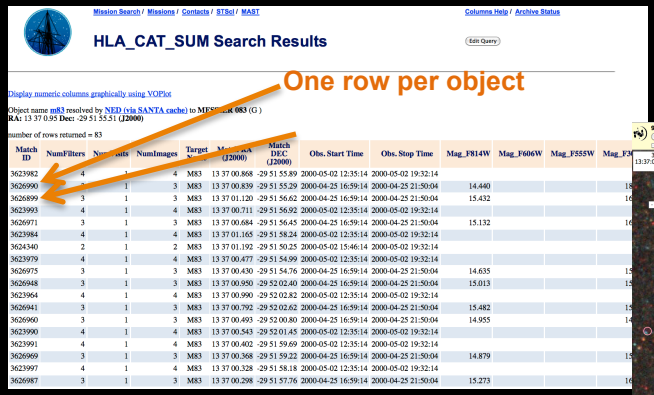
# Current HSC Web Form

http://archtest.stsci.edu/hst/hla_cat/

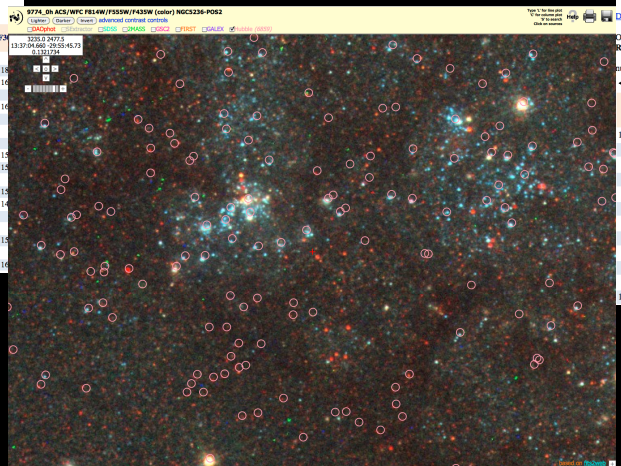


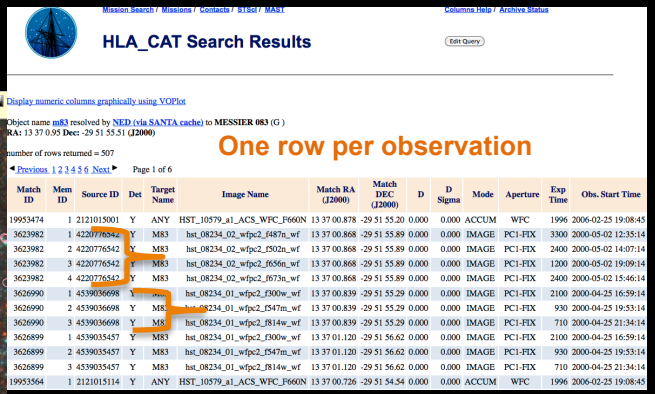




Overlay only available in hla/dev at present





# HSC Timeline

**June 2012 – Beta-1 version released (Lubow + Budavari paper posted)**

- Includes ACS and WFPC2 based on HLA SExtractor source lists
- Only detailed / time-resolved version of form available

**October 2012 – Questionnaire sent. Early results encouraging**

**January 2013 – Beta-2 version of catalog**

- Includes ACS and WFPC2 based on HLA SExtractor source lists
- Include "summary" form (early version made available in version 1.5)
- Improved source filtering and matching

**May 2013 – Version 1 of HSC released**

- Includes ACS, WFPC2, WFC3
- Preliminary cross-matching (e.g., SDSS)
- Improved tools (over plots, correlation plotting, …)

**Future – SQL CASJobs, value-added catalogs, workshops, PASP …**

# Summary

An early Beta version of the HSC has been online since June.

We are using it, in conjunction with several use cases, to test the quality of the HSC and to set detailed requirements.

An aggressive timeline has been established, including strong involvement with the community. How would the STUC like to be involved ?

The HSC will add a valuable new dimension to the information available to Hubble users for decades to come, and providesp a bridge to future missions both in space (e.g., JWST), and on the ground (e.g., LSST).