Hubble Legacy Archive and Hubble Source Catalog

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Current teams:

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MAST Users Group Meeting

Jan 14, 2016

Hubble Legacy Archive (HLA)

http://hla.stsci.edu

- Goals:
  - Process HST data to produce higher-level, science-ready data products: combined images, mosaics, source catalogs
    - Based on software developed for data analysis (e.g., Multidrizzle) and research projects (e.g., Anton's pipelines for GOODS, COSMOS, etc.)
  - Develop advanced web interfaces to the archive using next-generation browser technology
- Primary recent & future focus is on data product generation as MAST portal becomes the user interface
  - HLA user interface concepts (and some technology) adopted by portal and used for many other MAST services already
- History: DR1 (2008 Feb 08) through DR9 (2015 Dec 11)

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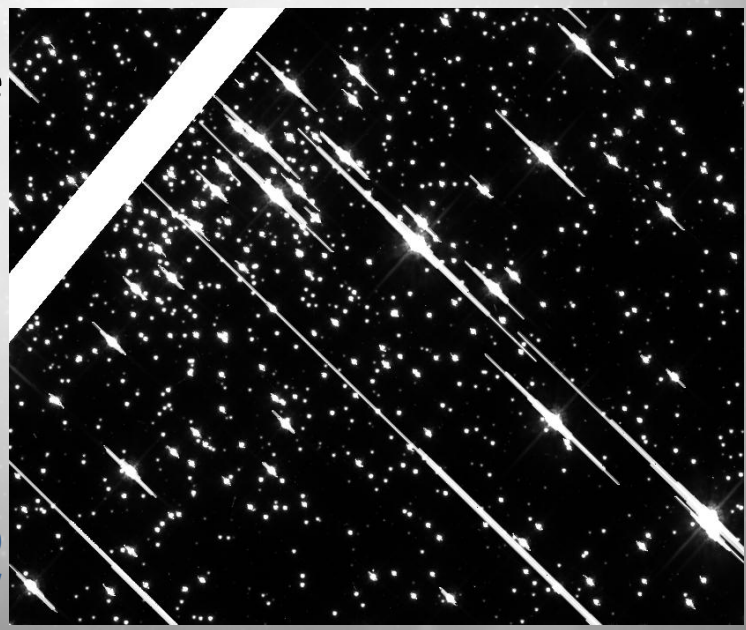
Hubble Source Catalog (HSC)

http://archive.stsci.edu/hst/hsc

- Goal: Create master catalog of objects from HST images to enable database-driven research
- Challenges:
  - Highly inhomogeneous sky coverage, hundreds of filters
  - Unreliable astrometry makes cross-matching hard
- History:
  - Beta 0.1 (2012 June): ACS/WFPC2 HLA SExtractor source lists (Budavári & Lubow 2012 paper)
  - Beta 0.2 (2013 May): Improved source matching (using automated pre-offsets from 2MASS), improved tools (HLA source overlays, summary form, …)
  - Beta 0.3 (2014 March): Includes WFC3/UVIS and WFC3/IR HLA source lists, better source matching (fewer spurious sources)
  - Version 1 (2015 February 25): Deep WFC3 source lists, improved astrometry, access through CasJobs and MAST portal

HLA highlights for 2015

- DR8.1 (2015 February 25)
  - Interface enhancements to support release of HSC version 1
- DR9 (2015 December 11)
  - New & reprocessed ACS data with astrodrizzle-based pipeline
    - Higher quality products in same format as WFC3 products
    - 40% more processed data
  - Much improved ACS source lists
    - Deeper and cover more visits
    - Will be used for HSC version 2



Comparison of ACS DR8 & DR9
ACS/WFC 10257_01 F625W

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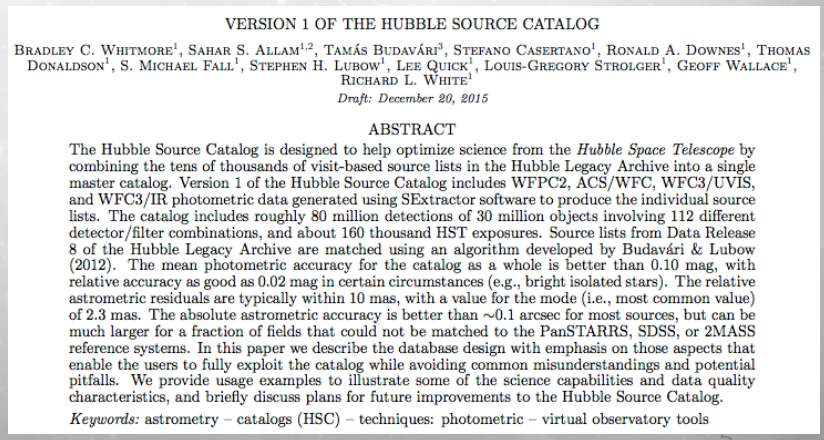
HSC Highlights for 2015

- HSC version 1 release (2015 Feb 24)
  - Science-quality catalog with tools for simple and advanced projects
- Hubble Catalog of Variables project begins
  - 3-year ESA-funded project at National Observatory of Athens, Greece, to build a catalog of variable objects starting from the HSC
  - Leading the way toward higher quality HSC photometry
- AJ paper describing HSC completed
  - Expect acceptance for publication soon
- Talks at IAU, ADASS, AAS



VERSION 1 OF THE HUBBLE SOURCE CATALOG

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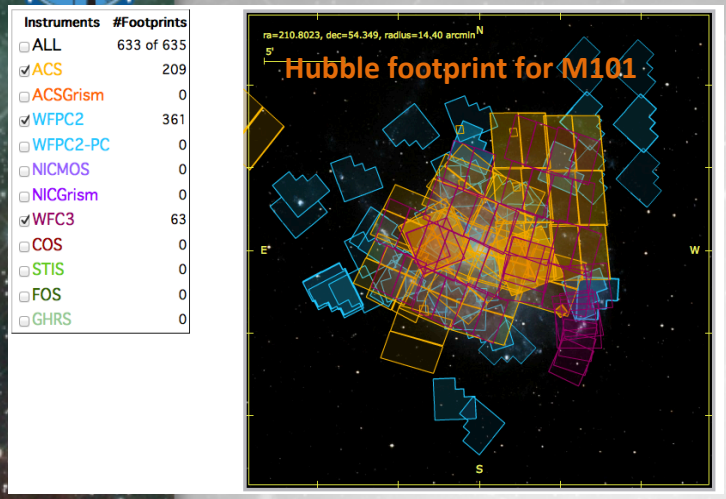
Draft: December 20, 2015

ABSTRACT

The Hubble Source Catalog is designed to help optimize science from the *Hubble Space Telescope* by combining the tens of thousands of visit-based source lists in the Hubble Legacy Archive into a single master catalog. Version 1 of the Hubble Source Catalog includes WFPC2, ACS/WFC, WFC3/UVIS, and WFC3/IR photometric data generated using SExtractor software to produce the individual source lists. The catalog includes roughly 80 million detections of 30 million objects involving 112 different detector/filter combinations, and about 160 thousand HST exposures. Source lists from Data Release 8 of the Hubble Legacy Archive are matched using an algorithm developed by Budavári & Lubow (2012). The mean photometric accuracy for the catalog as a whole is better than 0.10 mag, with relative accuracy as good as 0.02 mag in certain circumstances (e.g., bright isolated stars). The relative astrometric residuals are typically within 10 mas, with a value for the mode (i.e., most common value) of 2.3 mas. The absolute astrometric accuracy is better than ∼0.1 arcsec for most sources, but can be much larger for a fraction of fields that could not be matched to the PanSTARRS, SDSS, or 2MASS reference systems. In this paper we describe the database design with emphasis on those aspects that enable the users to fully exploit the catalog while avoiding common misunderstandings and potential pitfalls. We provide usage examples to illustrate some of the science capabilities and data quality characteristics, and briefly discuss plans for future improvements to the Hubble Source Catalog.

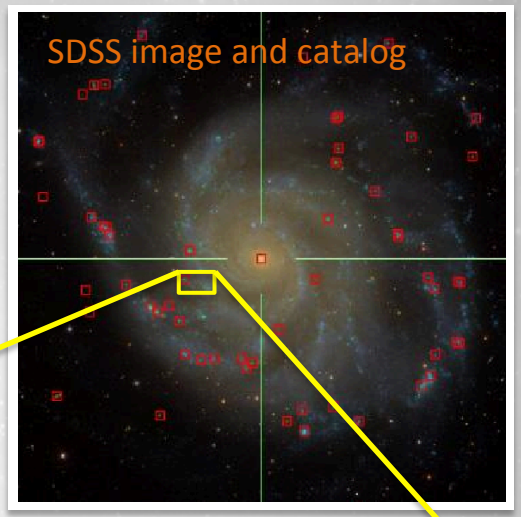
Keywords: astrometry – catalogs (HSC) – techniques: photometric – virtual observatory tools

The volume and diversity of Hubble data provides a challenge



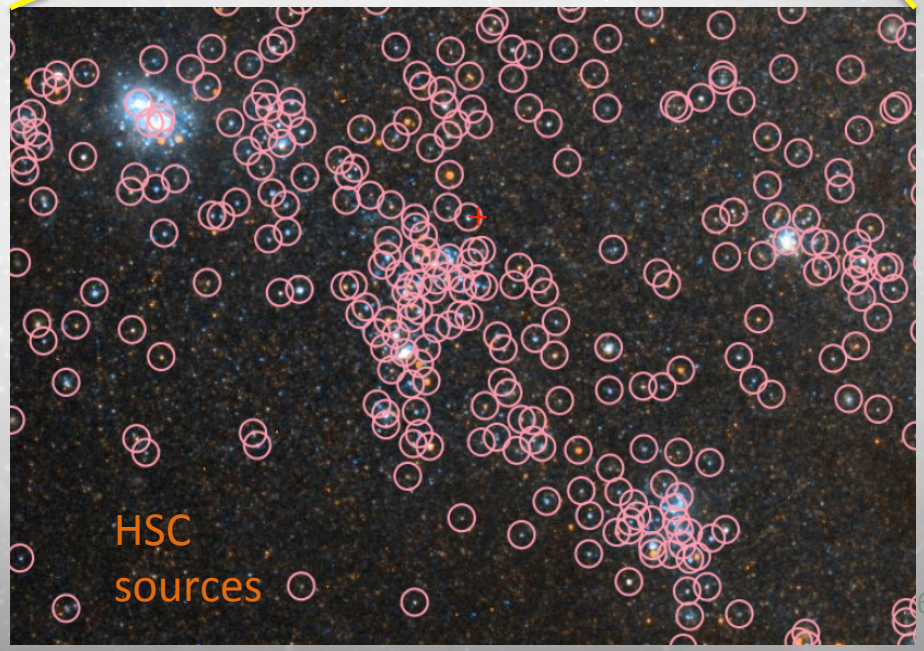
The HSC is NOT your standard, uniform, all-sky catalog.

It uses deep pencil beam observations and a variety of instruments and filters.



The Hubble Source Catalog:

- Combines tens of thousands of HLA visit-based source lists into a master catalog.
- Will be a fundamental reference for JWST users, and upcoming surveys (e.g., PanSTARRS, LSST).



Three reasons to build the HSC

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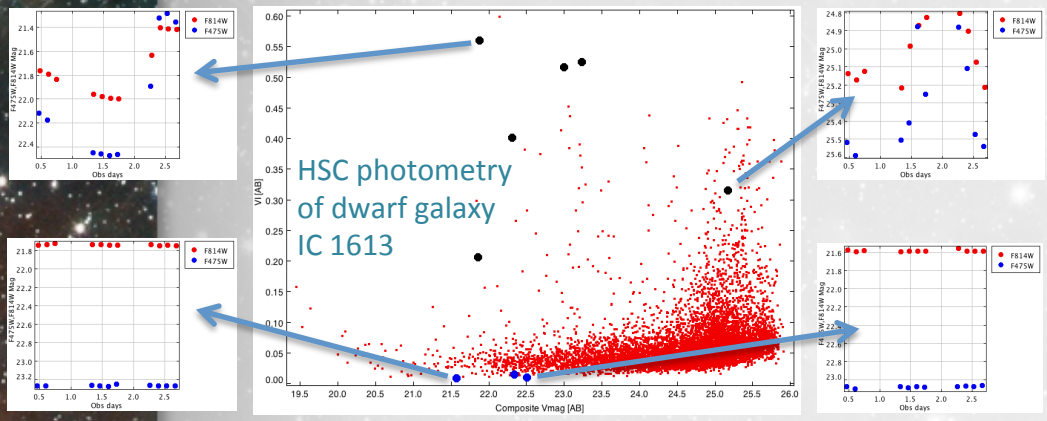
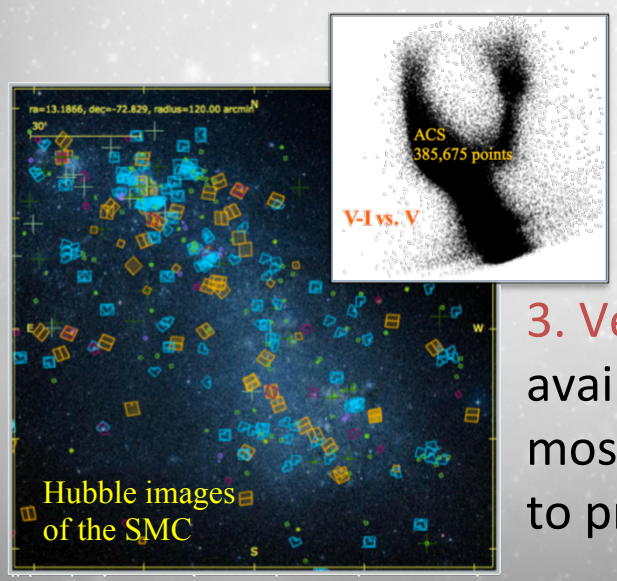
1. Time-variable phenomena – The HSC supports time-variable studies over >20 year baseline.



2. Mosaics – Accurate spatial offsets between observations are needed to build the HSC. These can then be used to make mosaics.

Instruments	#Footprints
ALL	7289
ACS	1366
ACSGrism	0
WFPC2	1539
WFPC2-PC	1232
NICMOS	217
NICGrism	17
WFC3	347
COS	912
STIS	1390
FOS	185
GHRS	84



3. Very large datasets – Replicating what is available in the HSC in seconds would take most researchers weeks, months, or years to produce.

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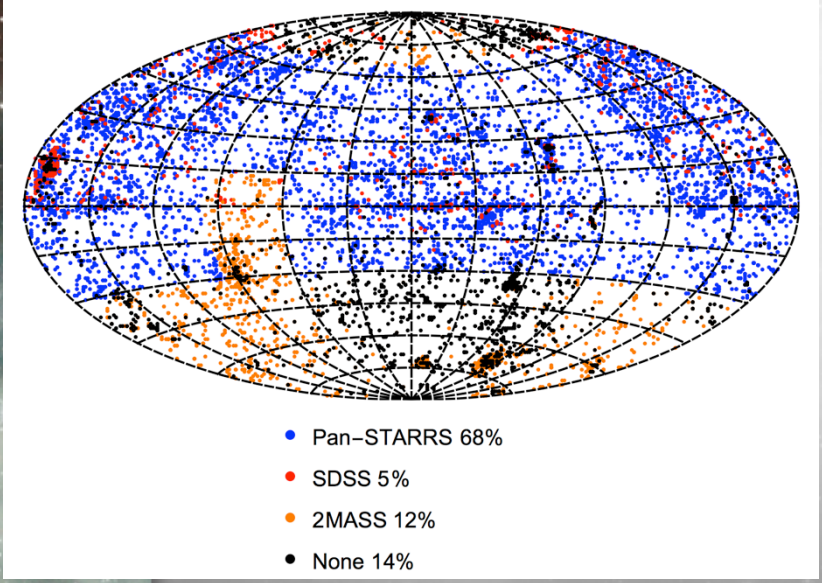
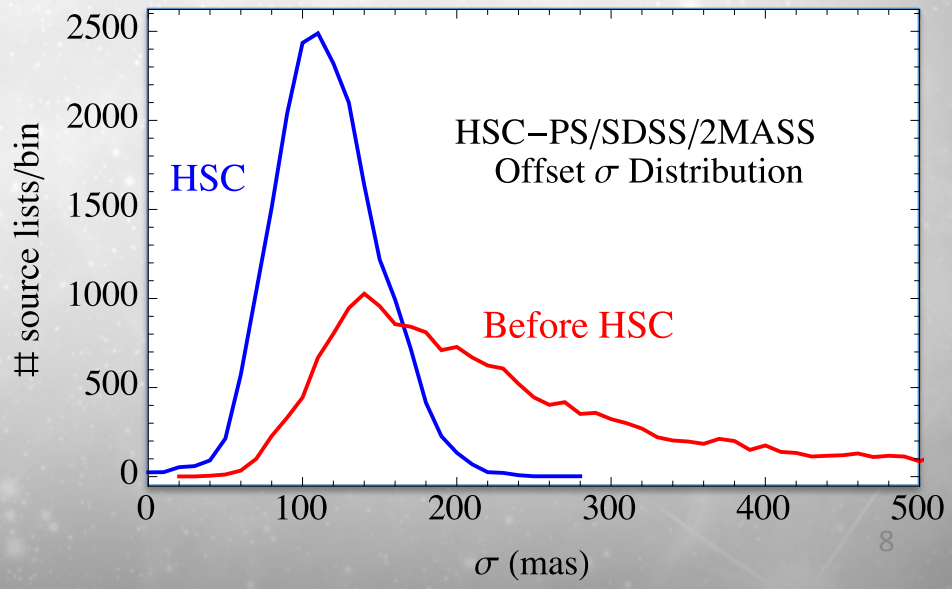
HSC Basics

1. Combines tens of thousands of SourceExtractor HLA source lists into a single **master catalog**. Uses matching algorithm from **Budavari & Lubow 2012**.
2. Includes **WFPC2, ACS/WFC** (before 2011), and **WFC3**.
3. **Absolute astrometry** is good to **~0.1 arcsec** (relative to PanSTARRS and 2MASS). This can eventually be improved to ~0.01 arcsec using GAIA observations.





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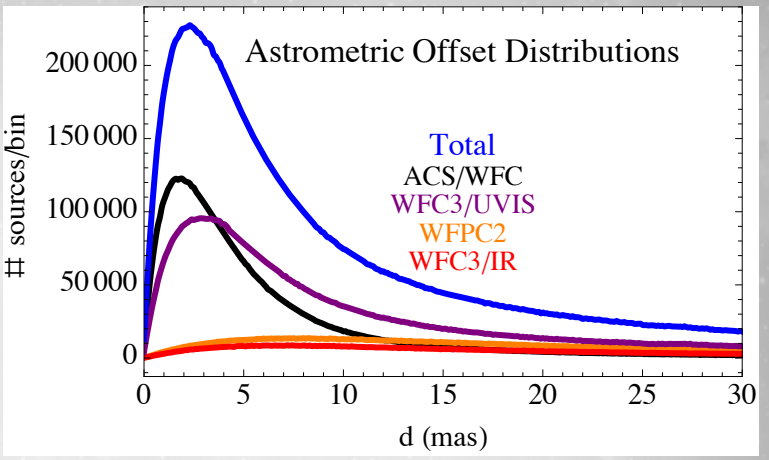
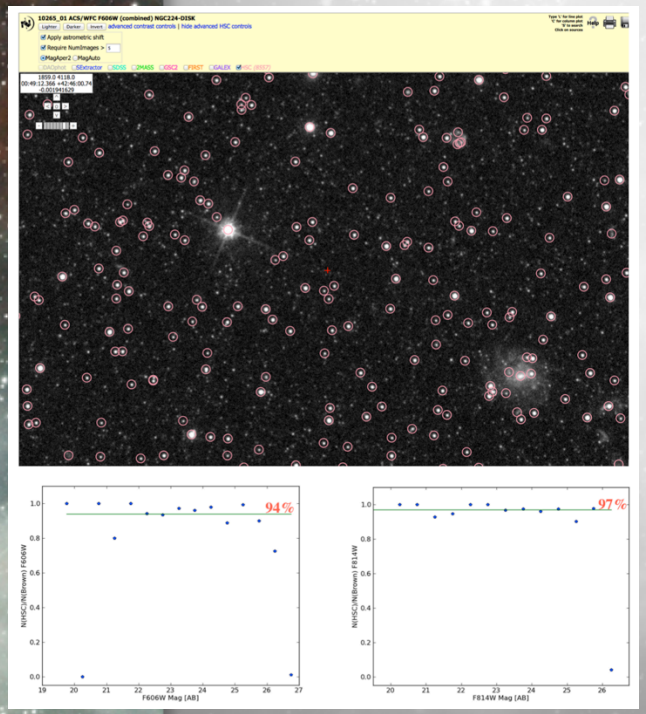
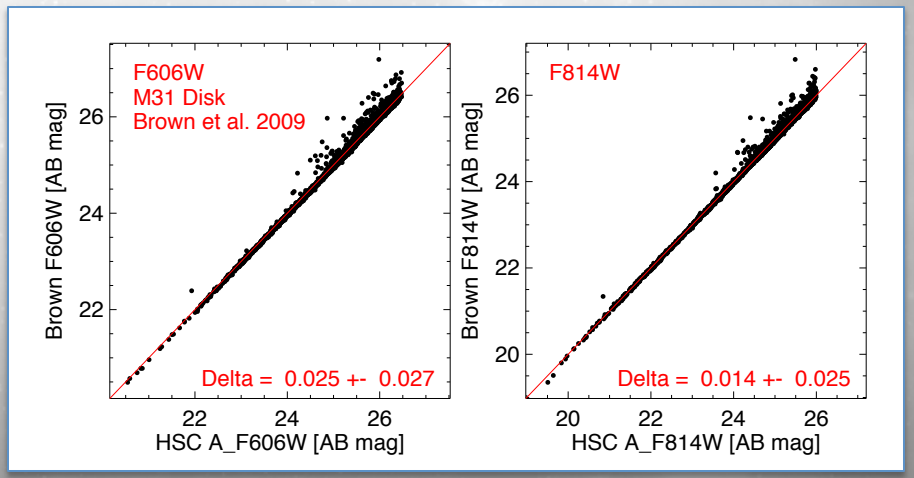
HSC Basics

4. **Relative astrometry** good to better than ~0.01 arcsec (i.e., **10 mas, and ~2 mas** in many cases.)





5. **Photometry (aperture)** typically good to **0.10 mag**, and **0.02 mag** when S/N is sufficient.



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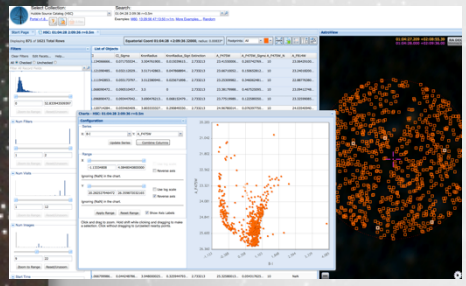
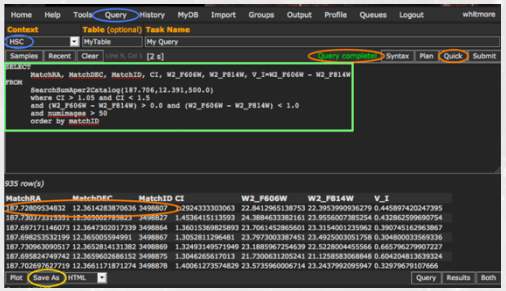
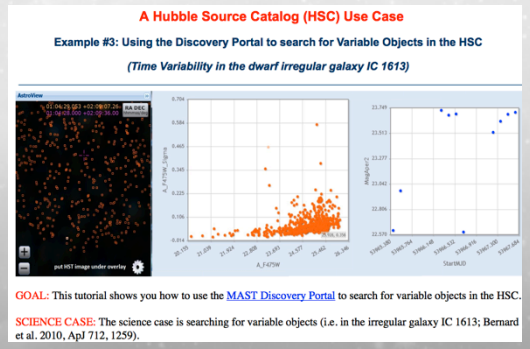
HSC Basics

6. **The MAST Discovery Portal** is our primary interface, but we also have a **CasJobs** (similar to SDSS) interface for larger and more complex queries, and the **HSC Home Page** for special cases.



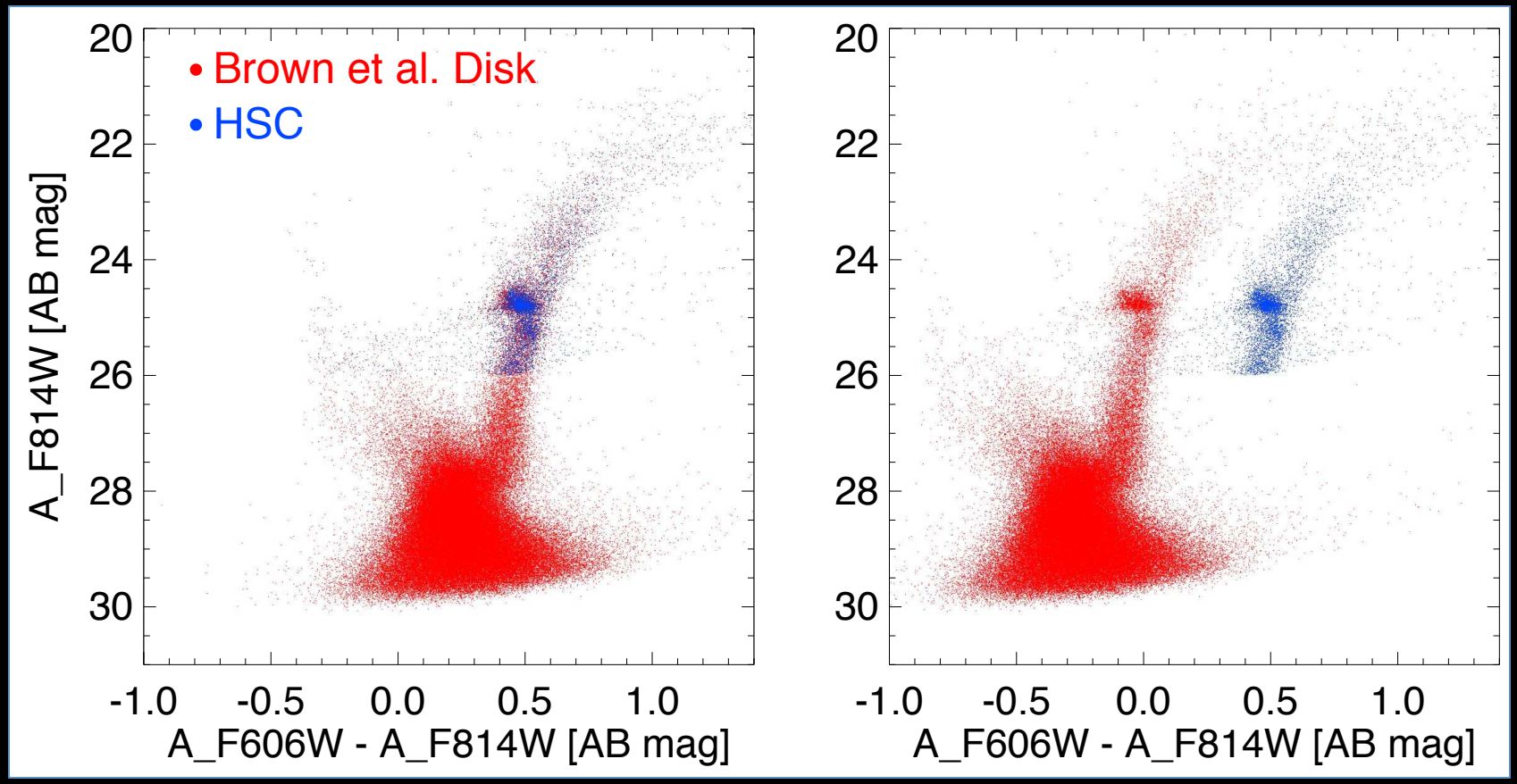


7. A range of **help documents** and learning aids are available (e.g., FAQ, use cases, videos, draft article)



How well does the HSC re-create various science results?

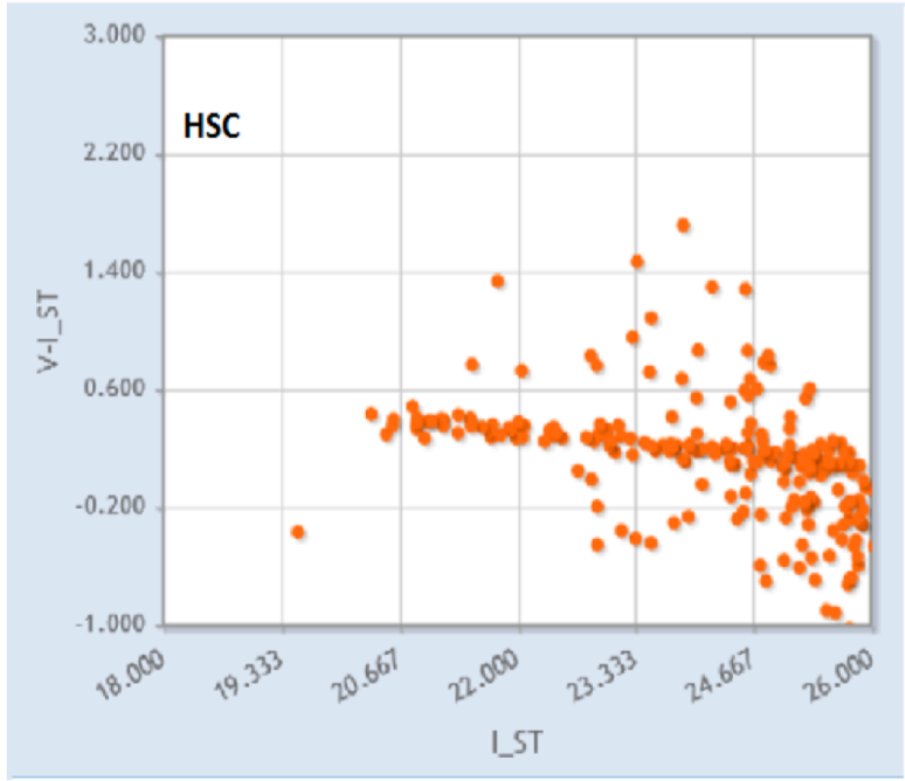
HSC Use Case # 1 – M31 Photometry – Brown et al. 2008

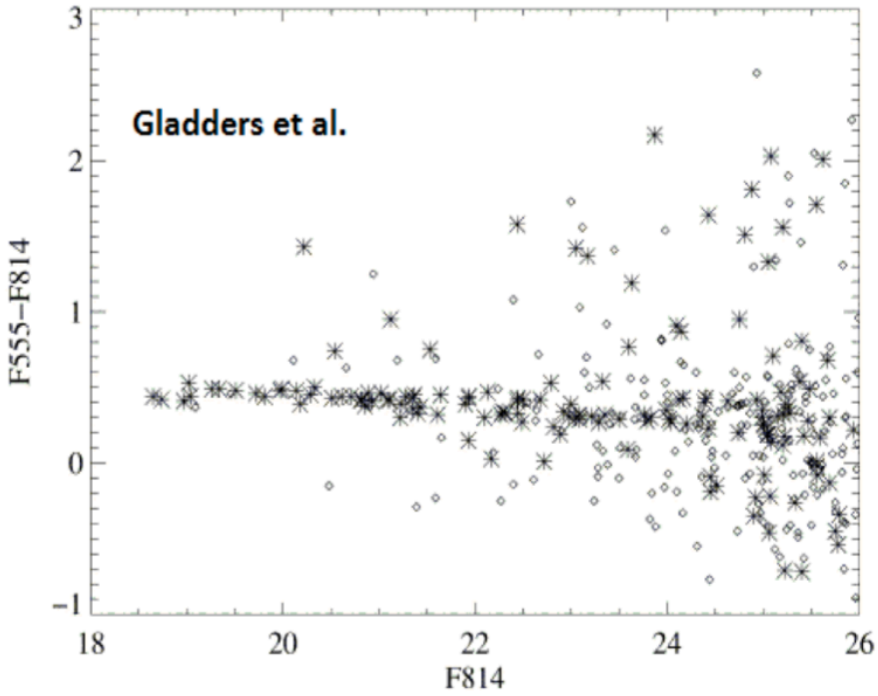


While the agreement in the region of overlap is very good, the HSC is much shallower, since it uses visit-based HLA source lists rather than a deep mosaic adding all 30 visits together.

How well does the HSC recreate various science results?

HSC Use Case # 6 – Red sequence for galaxies





Re-creation of red sequence for elliptical galaxies in Abell 2390 by Gladders et al. (1998). The agreement with the resulting slope is quite good, i.e., m = -0.042 +/- 0.007 using the HSC and m = -0.037 +/- 0.004 from Gladders et al. 1998.

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HLA & HSC Future Plans

Hubble Legacy Archive

- DR9.1 (Summer 2016): Astrometry from HSC incorporated into HLA images & catalogs
- DR10 (Fall 2016): New WFPC2 images processed using AstroDrizzle and improved WFPC2 source lists
- Future:
  - NICMOS and STIS astrodrizzled images with source lists
  - Wide and deep mosaics with source lists using HSC astrometry
  - Incorporate HLA pipeline products into standard HST data processing

Hubble Source Catalog

- Version 2 (May 2016)
  - New ACS catalogs from HLA DR9
  - Spectral cross-matches with Hubble spectrographs (COS, GHRS, FOS, ACS grism)
  - Discovery Portal Integration Phase 2 (advanced search capabilities and other additions)
- Version 3 (Early 2017)
  - New WFPC2 catalogs from HLA DR10
  - Inclusion of ACS/HRC source lists
  - More spectral cross-matches including STIS spectra
- Future
  - NICMOS and STIS imaging source lists included
  - Mosaic image source lists included
  - Hubble Catalog of Variables data products and algorithmic improvements (e.g., improved photometry)
  - Forced photometry and photometry-on-demand
  - Photometric redshifts, SEDs, and other higher-level products

Detecting the Unexpected: Workshop at STScI 2017 Feb 27 – Mar 2
(with HSC participation)