Transitioning the Hubble Legacy Archive (HLA) to Normal Pipeline Operations

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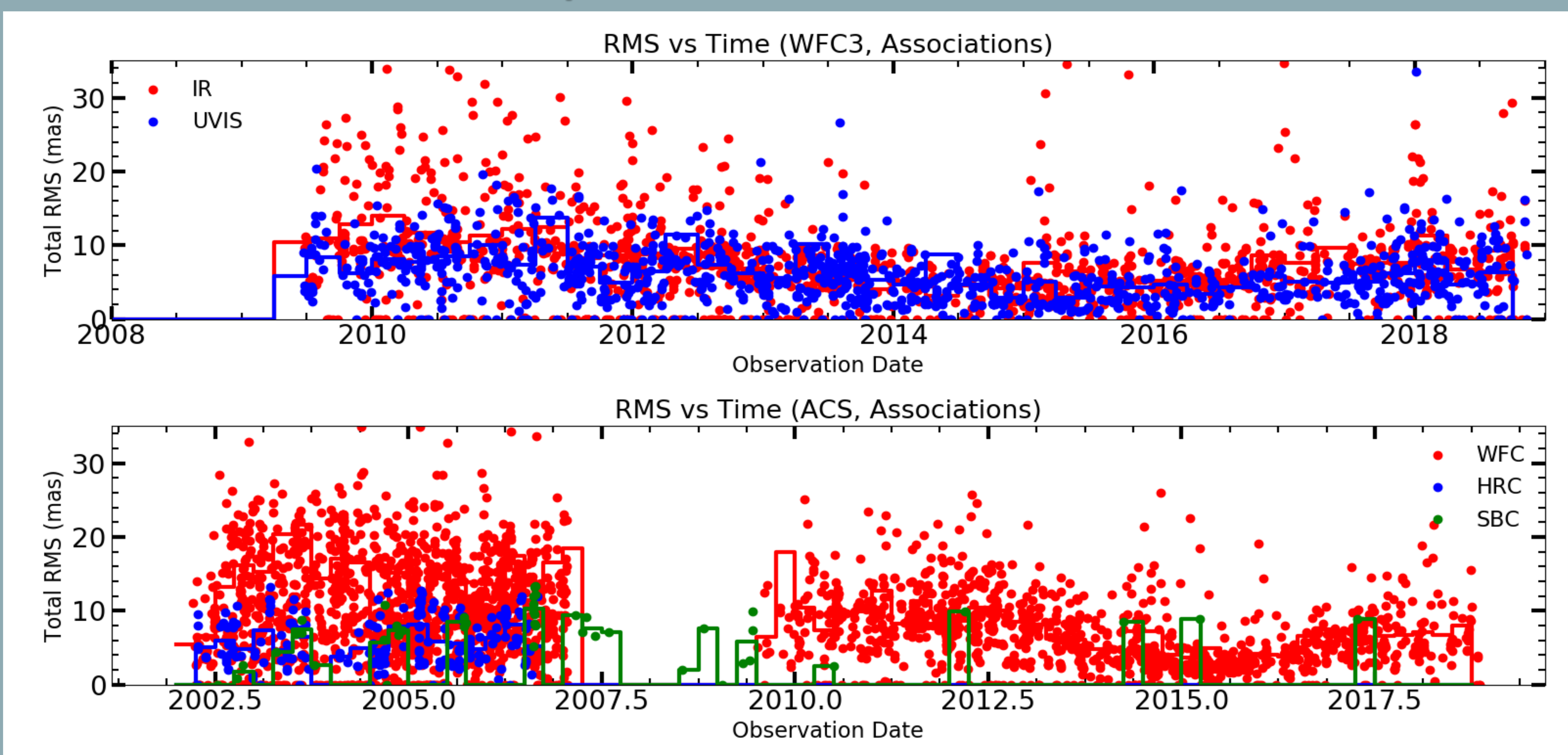
Summary

- The Hubble Legacy Archive (HLA) has been producing high-level drizzled science products with data obtained by several instruments from the Hubble Space Telescope (HST), including coadded, mosaiced images and source catalogs from single-visit, as well as multi-visit, cross proposal exposures.
- The generation of these products often requires highly interactive and intensive manual intervention that makes it difficult for routine generation of these products in an automatic pipeline.
- Improvements in astrometric corrections achieved by matching to the Gaia catalog is allowing us to transition the HLA into part of the standard HST data processing pipelines for two instruments, the Advanced Camera for Surveys (ACS) and the Wide Field Camera 3 (WFC3).
- The new high-level fully automated pipelined Hubble Advanced Products (HAP) will replace the HLA for these instruments.

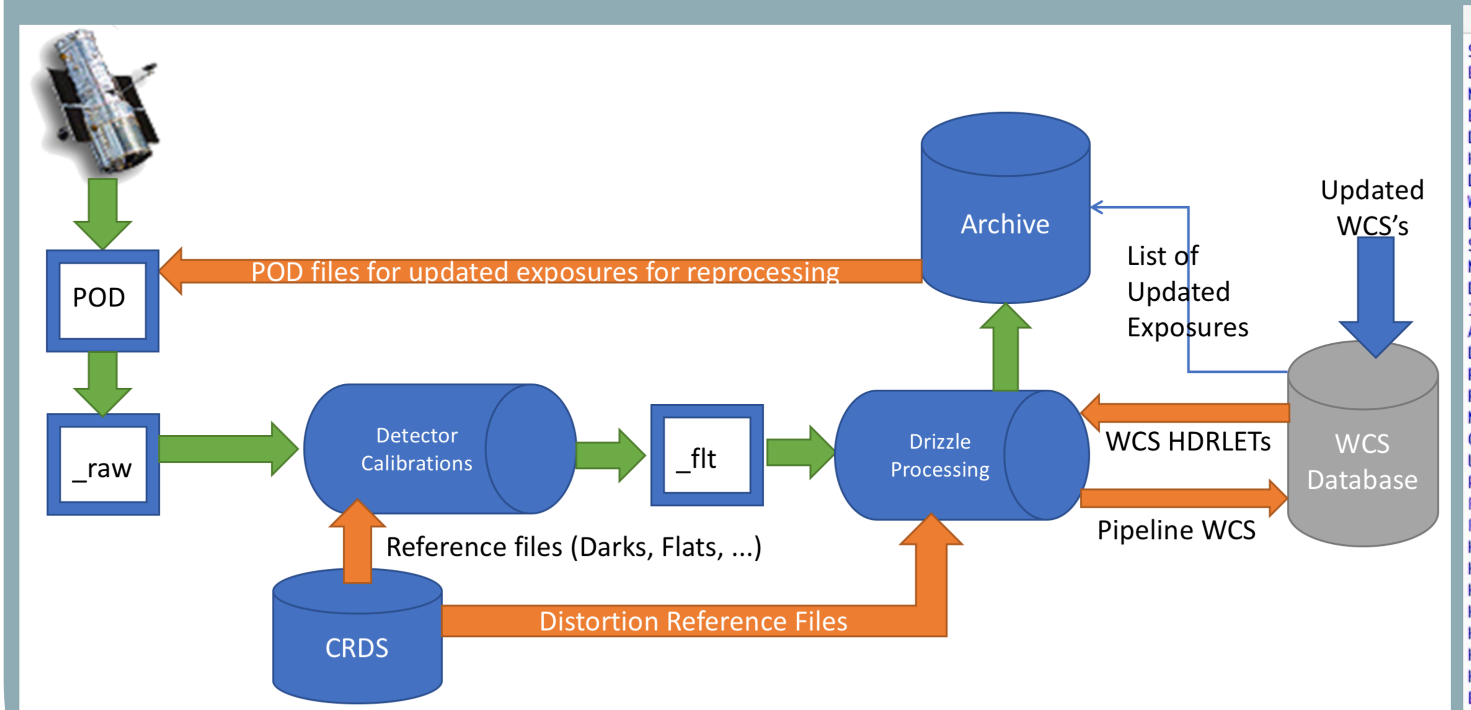
Improved Astrometry in the Calibration Pipeline

- New WCS information for ACS and WFC3
- ***a priori*** astrometry: Updates to the guide star catalog based on Gaia catalog
- ***a posteriori*** astrometry: Matching sources in images to the Gaia catalog
- All available WCS solutions are saved in the *headerlets (*FITS extensions containing WCS transformation)
- The updates are expected to go into operations soon
- ACS and WFC3 data are reprocessed to populate new WCS information
- Documentation: https://drizzlepac.readthedocs.io/en/latest/astrometry.html
- Success rate in matching to Gaia: 72% (requirement: 70-80% of data to precision of 10 mas or better)

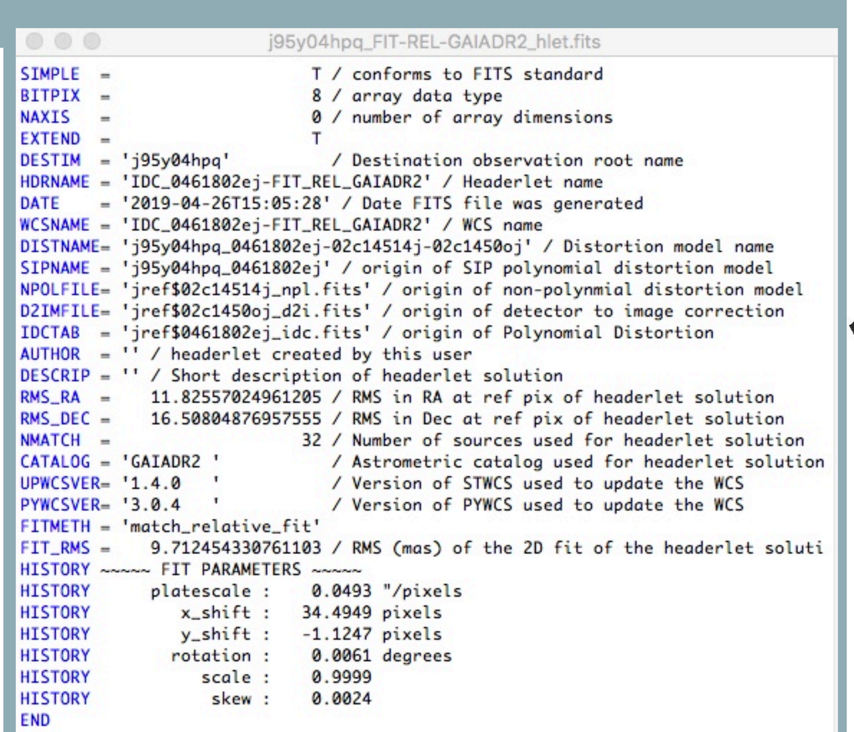
A posteriori Results



Instrument	Detector	n	n rms<5	n rms<10	n rms<20	% rms<5	% rms<10	% rms<20
WFC3	IR	1299	468	1003	1214	36%	77%	93%
WFC3	UVIS	1060	465	926	1049	44%	87%	99%
ACS	WFC	2526	822	1602	2279	33%	63%	90%
ACS	HRC	197	95	171	197	48%	87%	100%
ACS	SBC	44	11	38	44	25%	86%	100%
ALL	**ALL**	**5126**	**1861**	**3740**	**4783**	**36%**	**73%**	**93%**



Workflow for updating HST astrometry



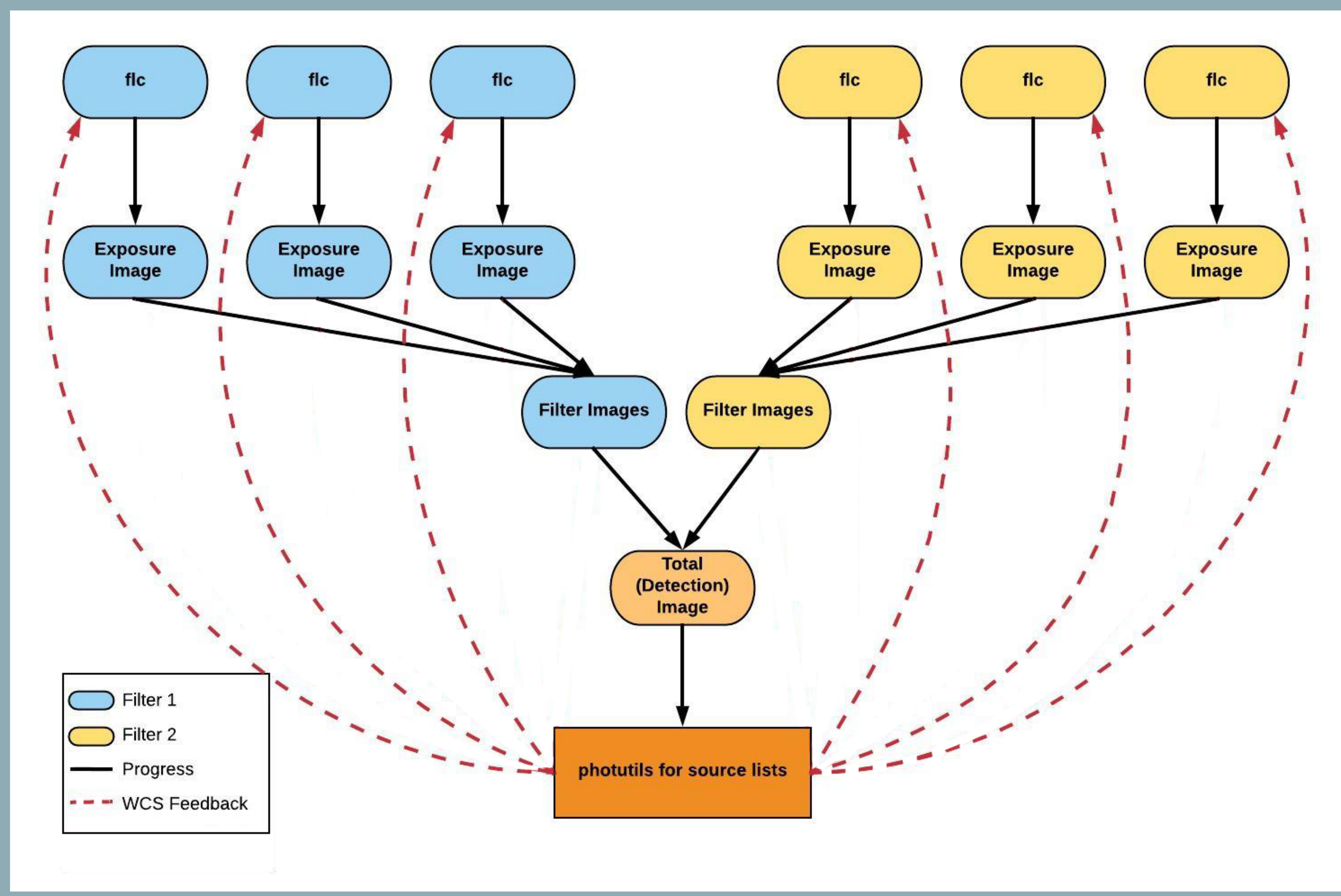
```
j95y04hpq_FIT-REL-GAIADR2_hlet.fits
SIMPLE  =                    T / conforms to FITS standard
BITPIX  =                    8 / array data type
NAXIS   =                    0 / number of array dimensions
EXTEND  =                    T
DESTIM  = 'j95y04hpq'          / Destination observation root name
HDRNAME = 'IDC_0461802ej-FIT_REL_GAIADR2' / Headerlet name
DATE    = '2019-04-26T15:05:28' / Date FITS file was generated
WCSNAME = 'IDC_0461802ej-FIT_REL_GAIADR2' / WCS name
DISTNAME= 'j95y04hpq_0461802ej-02c14514j-02c1450oj' / Distortion model name
SIPNAME = 'j95y04hpq_0461802ej' / origin of SIP polynomial distortion model
NPOLFILE= 'jref$02c14514j_npl.fits' / origin of non-polynmial distortion model
D2IMFILE= 'jref$02c1450oj_d2i.fits' / origin of detector to image correction
IDCTAB  = 'jref$0461802ej_idc.fits' / origin of Polynomial Distortion
AUTHOR  = '' / headerlet created by this user
DESCRIP = '' / Short description of headerlet solution
RMS_RA  =    11.82557024961205 / RMS in RA at ref pix of headerlet solution
RMS_DEC =    16.50804876957555 / RMS in Dec at ref pix of headerlet solution
NMATCH  =                   32 / Number of sources used for headerlet solution
CATALOG = 'GAIADR2 '           / Astrometric catalog used for headerlet solution
UPWCSVER= '1.4.0   '           / Version of STWCS used to update the WCS
PYWCSVER= '3.0.4   '           / Version of PYWCS used to update the WCS
FITMETH = 'match_relative_fit'
FIT_RMS =    9.712454330761103 / RMS (mas) of the 2D fit of the headerlet soluti
HISTORY ~~~~~ FIT PARAMETERS ~~~~~
HISTORY      platescale :    0.0493 "/pixels
HISTORY         x_shift :   34.4949 pixels
HISTORY         y_shift :   -1.1247 pixels
HISTORY        rotation :    0.0061 degrees
HISTORY           scale :    0.9999
HISTORY            skew :    0.0024
END
```

A posteriori solution information from a sample headerlet

Creating Mosaics

Single-Visit Mosaic (SVM)

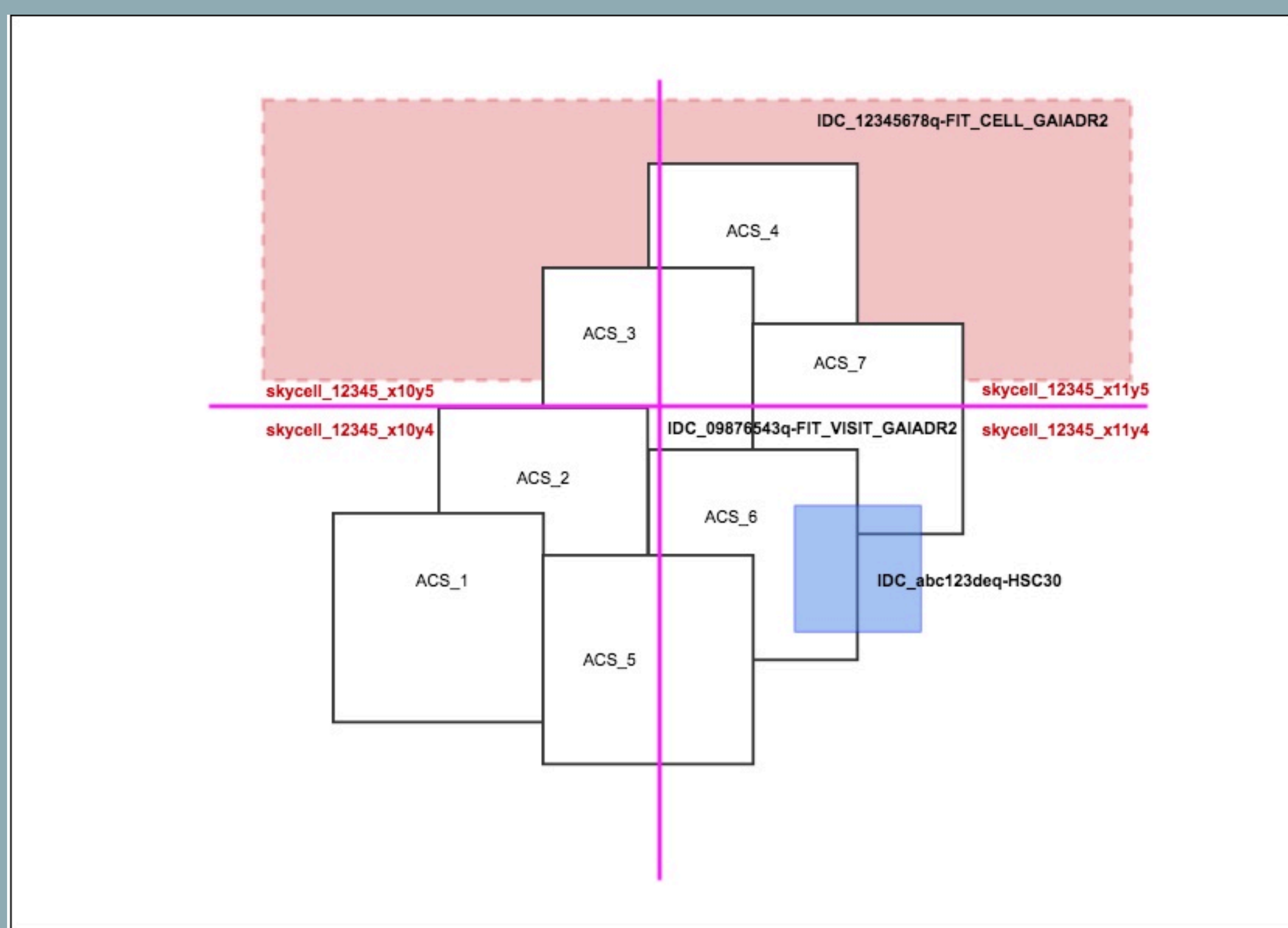
- New drizzle products (HAP) generated as part of normal pipeline operations
- Public and proprietary data
- Exposures spanning a single *obset* (IPPPSS) drizzled on same pixel grid
- Combined exposures for each filter, distortion corrected and rotated N up



New HAP pipeline workflow for SVM

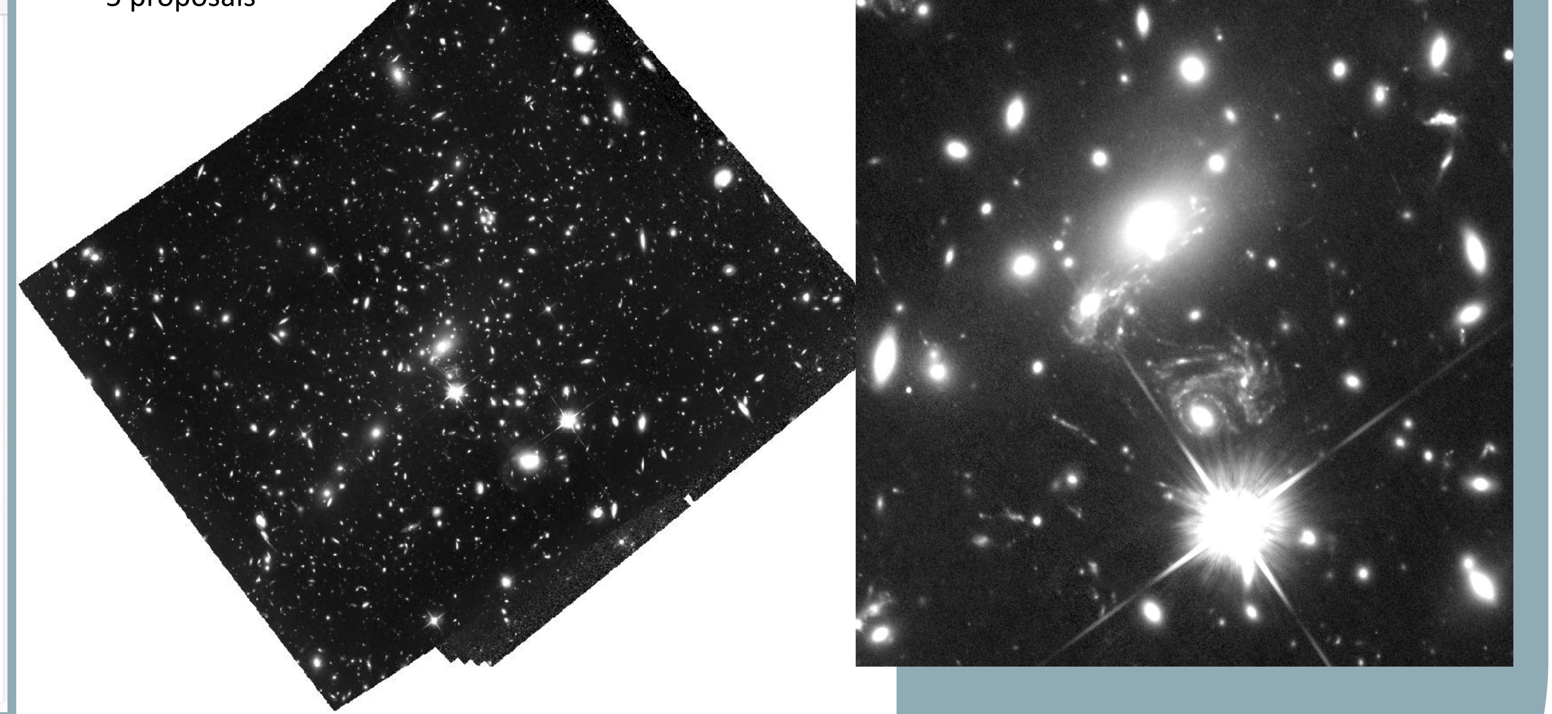
Multi-Visit Mosaic (MVM)

- Public data only
- Combined exposures, including non-overlaps, across visits and programs
- Layers for different filters, instruments/detectors or epochs on same pixel grid
- Use Pan-STAARS sky tessellation method to drizzle exposures onto equally divided, pre-defined *sky cells*, which are sub-divided from 4° x 4° square tangent planes called *projection tiles*
- Each sky cell is .2° x .2° with pixel scale of 0.04"/pix (optical) and 0.12"/pix (IR)



MVM sample use case

- 200 exposures
- 28 visits
- 5 proposals



Example of MVM for MACSJ1149.5+2223 ACS/F814W from the HLA