DARK ENERGY
SURVEY

DECam Pipeline and Products

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DARK ENERGY SURVEY

Outline

- Current DESDM Processing Model
- Single Epoch Processing Pipeline
- Nightly Quality Assessment (by exposure)
  - “is that really all the data”
- Coaddition
- Y2

Current Dataflow and Pipelines

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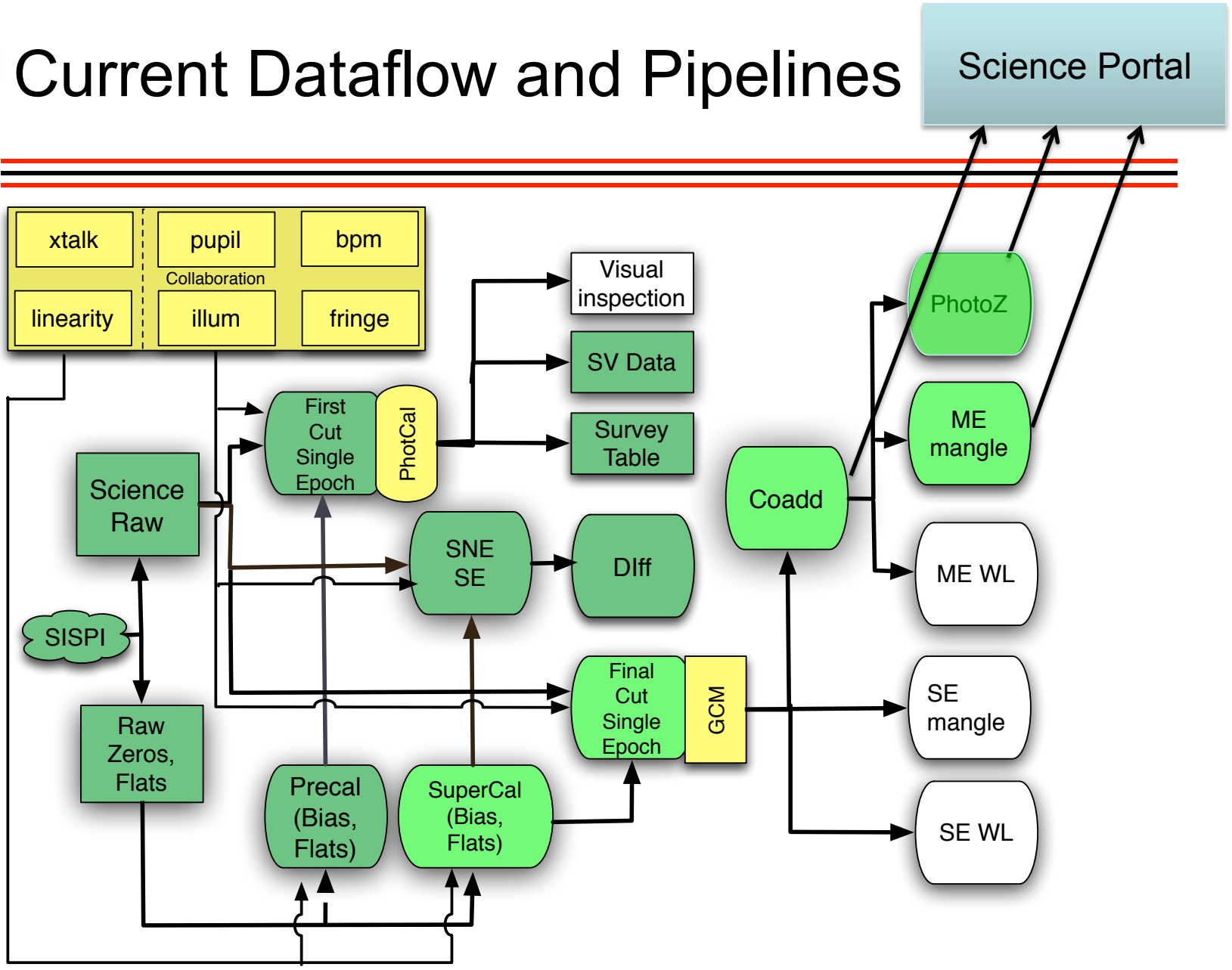

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Year 1: Single-Epoch Pipeline Overview

FINALCUT (Y1A1):

- DECam_crosstalk: overscan, crosstalk, header-update
- Imcorrect: bias, linearity, flat, BPM, pupil, illumination, fringe
- Astrorefine: SExtractor + SCAMP
- Mkbleedmask: mask/interpolate bleed trails, bright stars, super-saturated crosstalk, edge-bleed)
- Maskcosmics:
- Streak-finder: Hough transform search for satellite trails
- create_catalog_modelfit: Sextractor w/ PSF model fitting
- Compress_files
- Photometric Standards Module
- QA assessment

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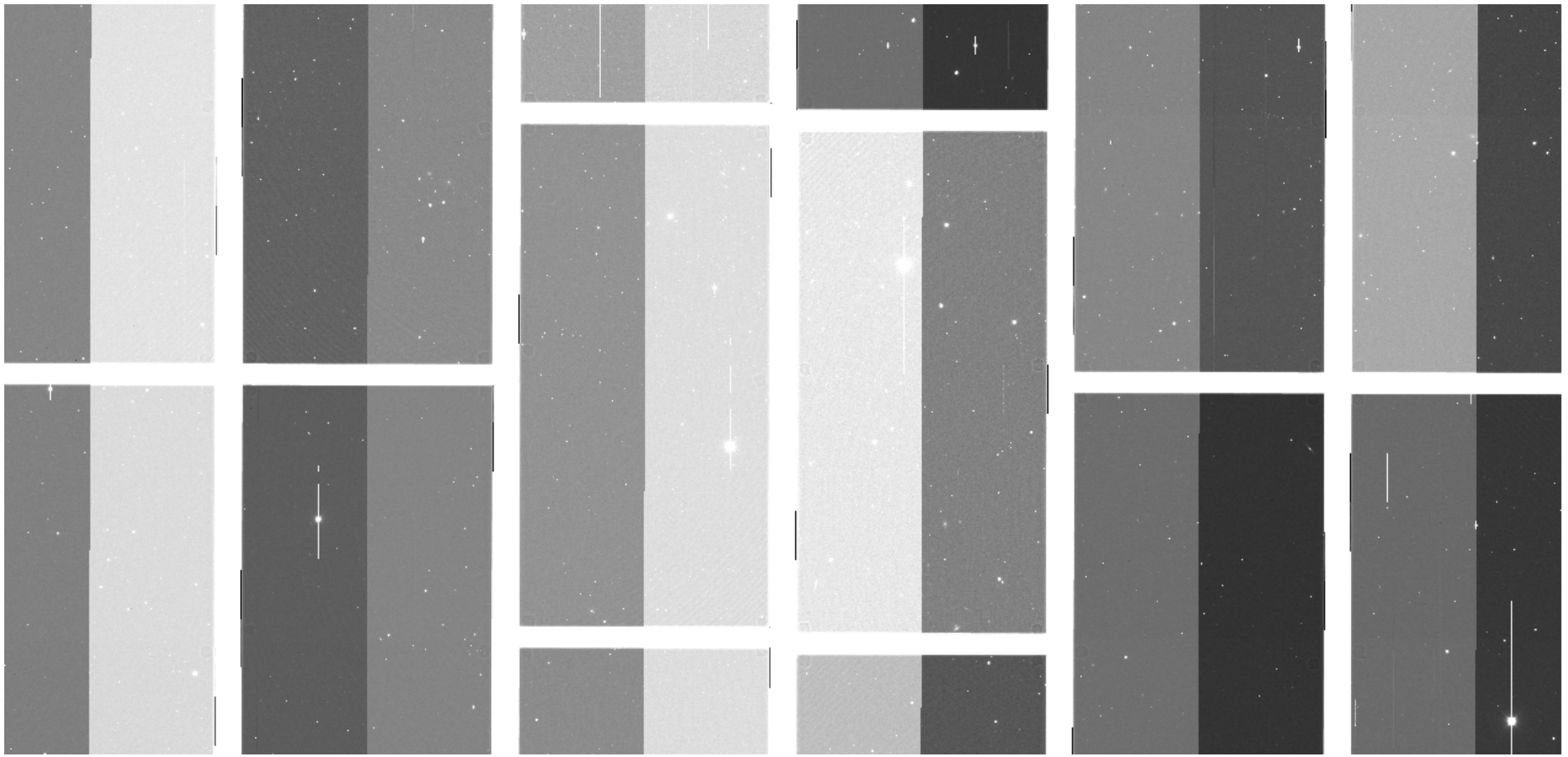
DECam (raw from the telescope)



March 12, 2015 (π - 2)

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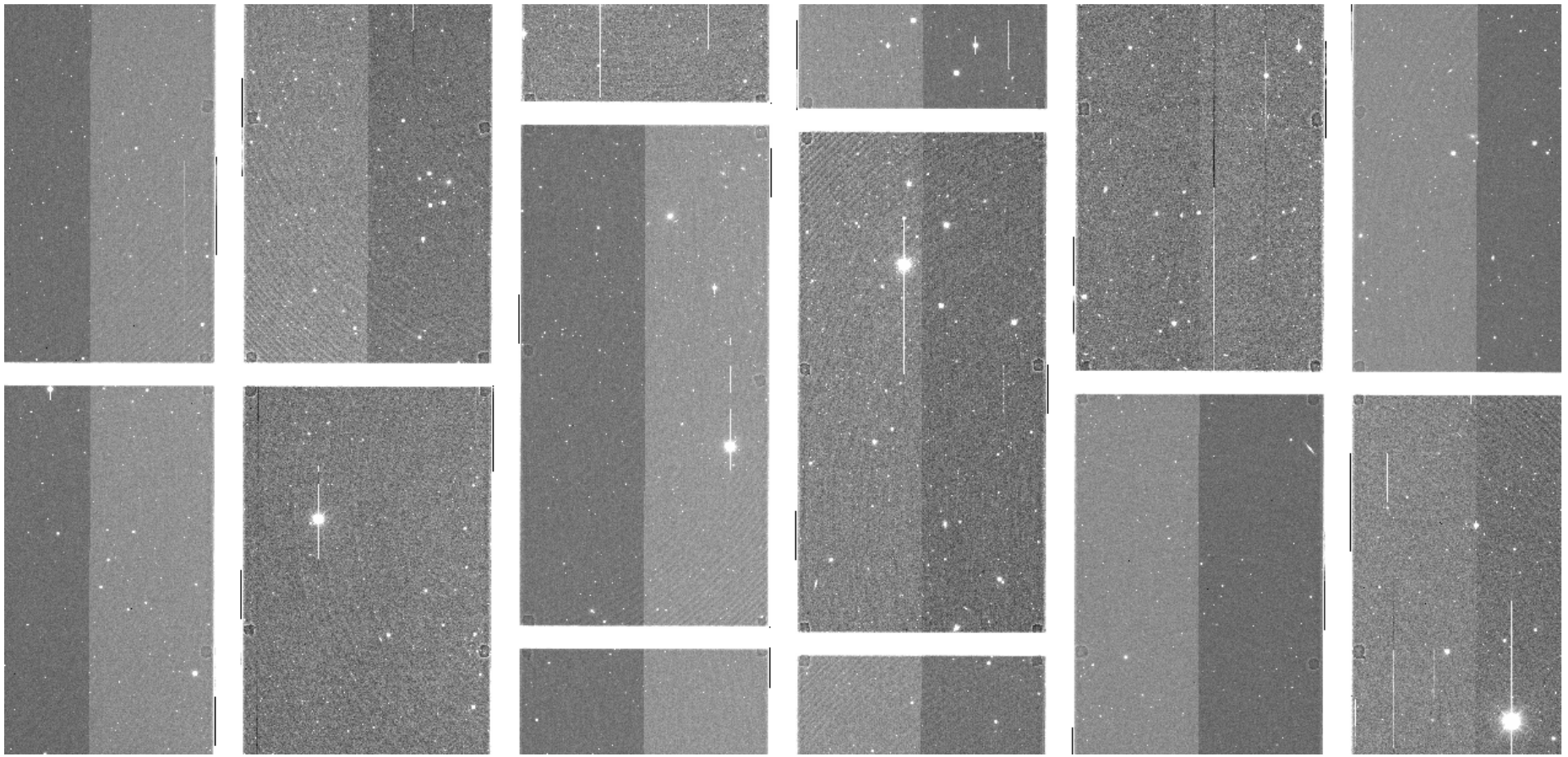
Overscan and Cross-talk correction



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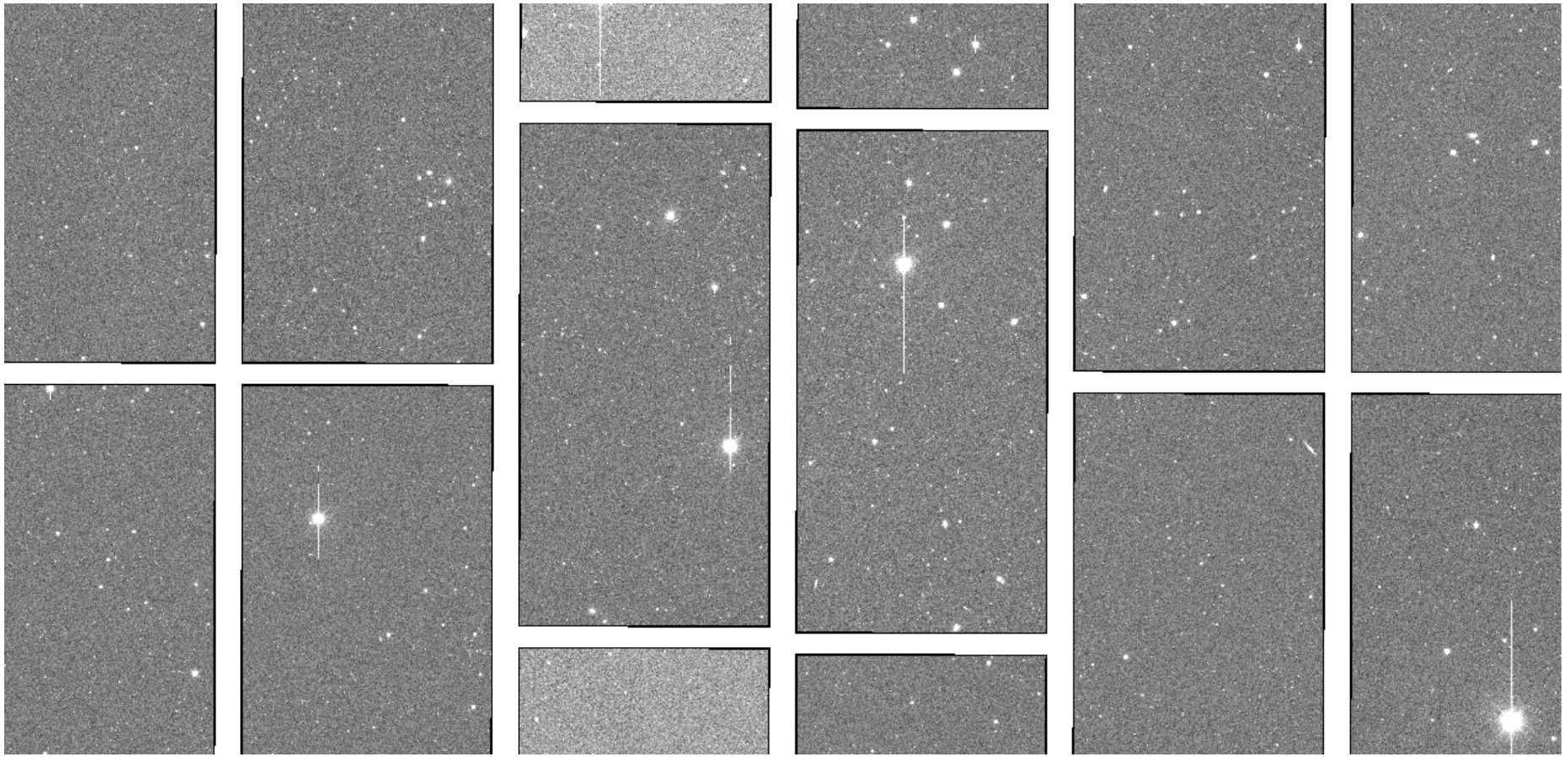
Detrend



Detrend

- Bias (either nightly or super-bias)
- Linearity Correction
- Flat (also either nightly or super-flat)
  - not normalized across focal plane
- Pupil/Illumcor derived from starflats
- Fringe (zY-bands only)
  - currently scaled by sky brightness
    not a fit to fringe amplitude

Astrometric Solution (Sextractor + SCAMP + UCAC4)

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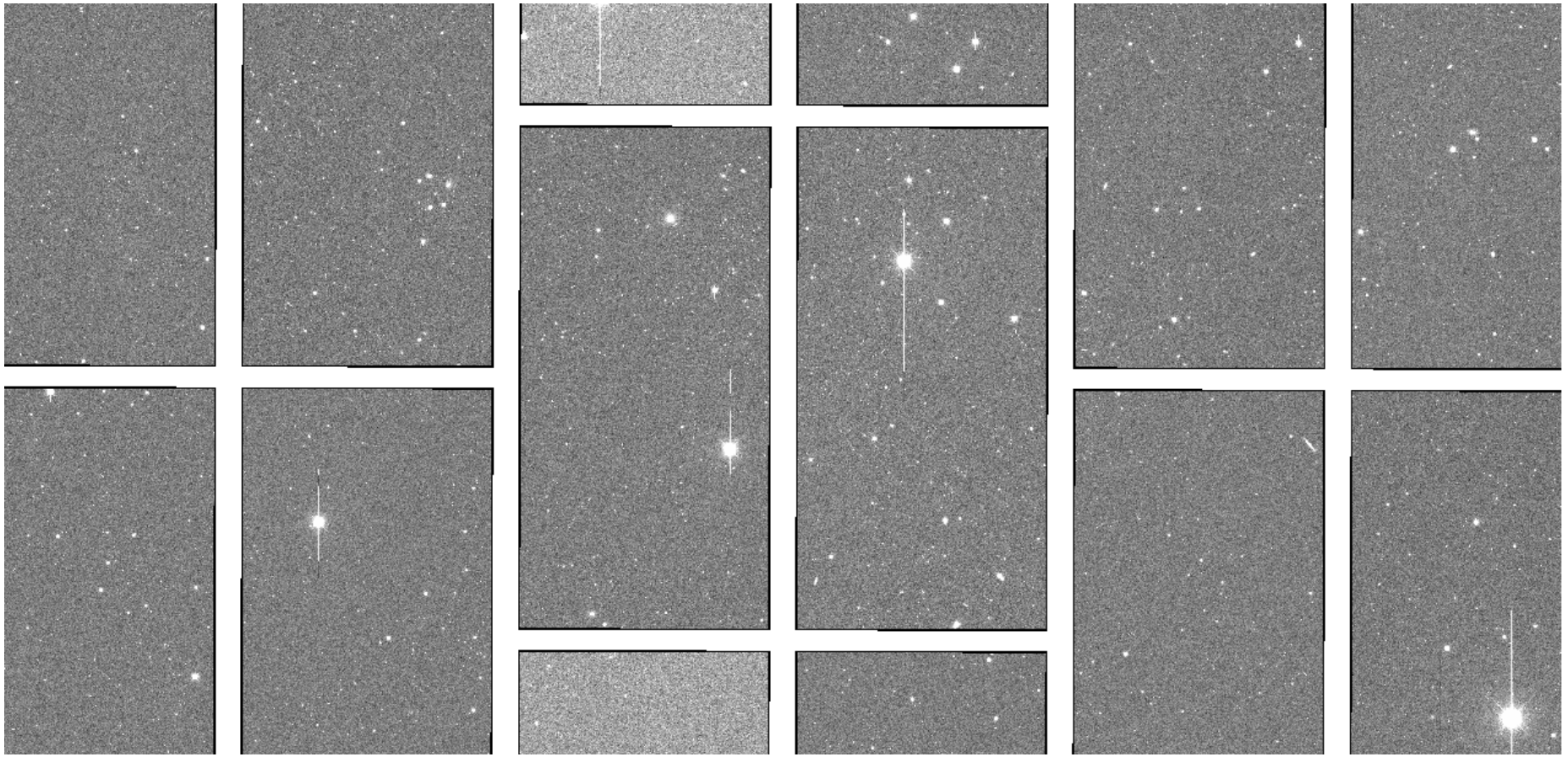
Typically σ=200-250 mas (external)



Bleed & Edge-Bleed Saturated Stars (Y1 included interpolation)

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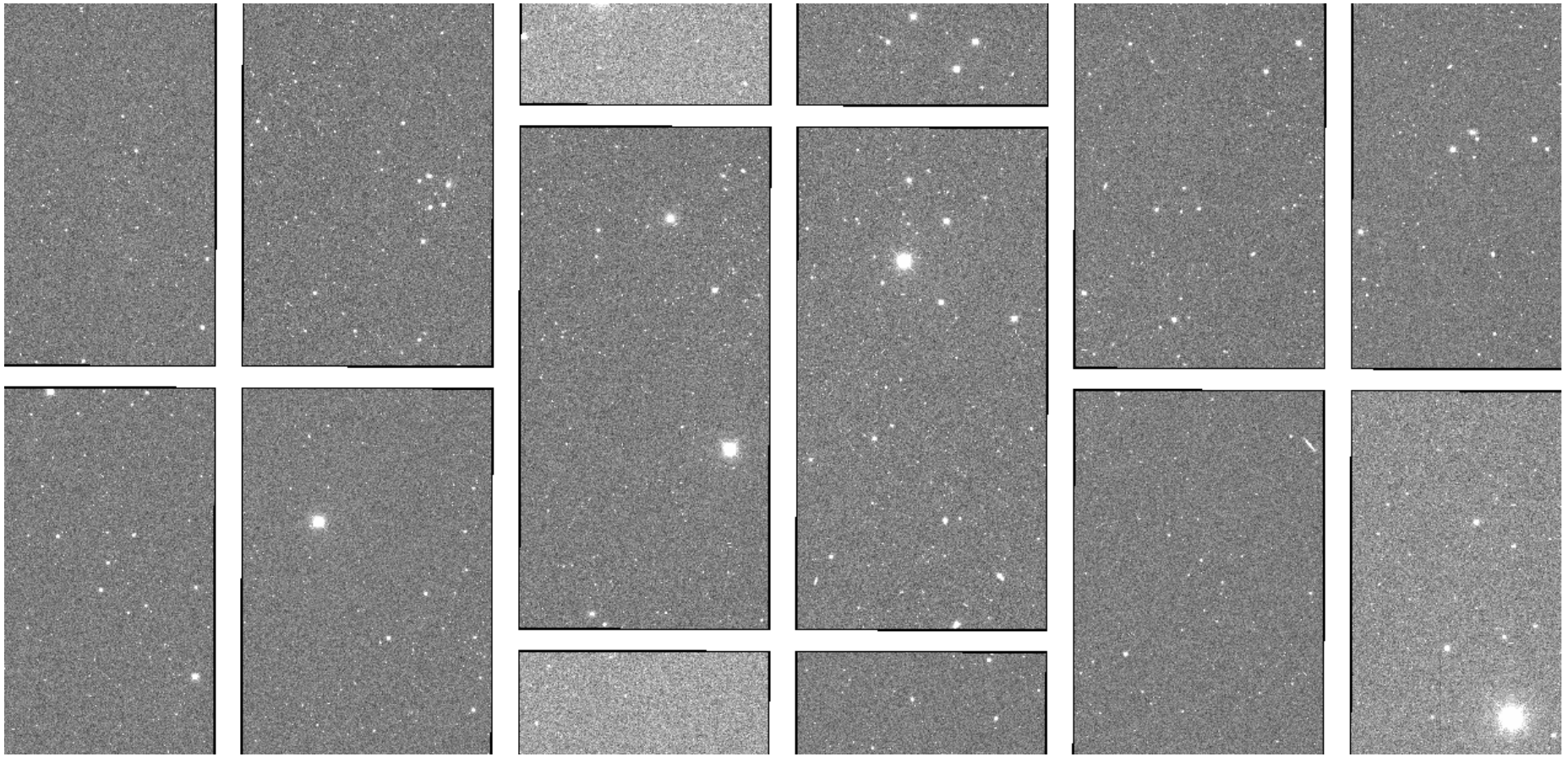

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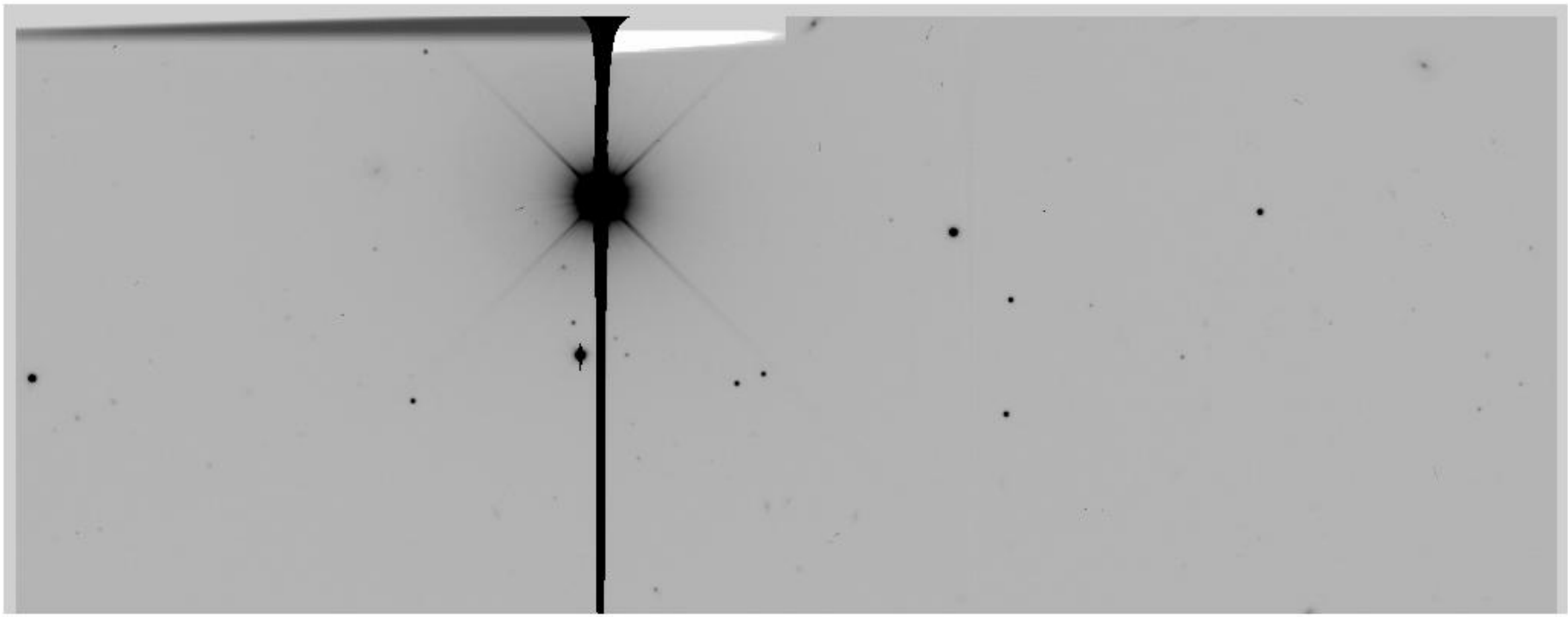
Edge-Bleed



Edge-Bleed

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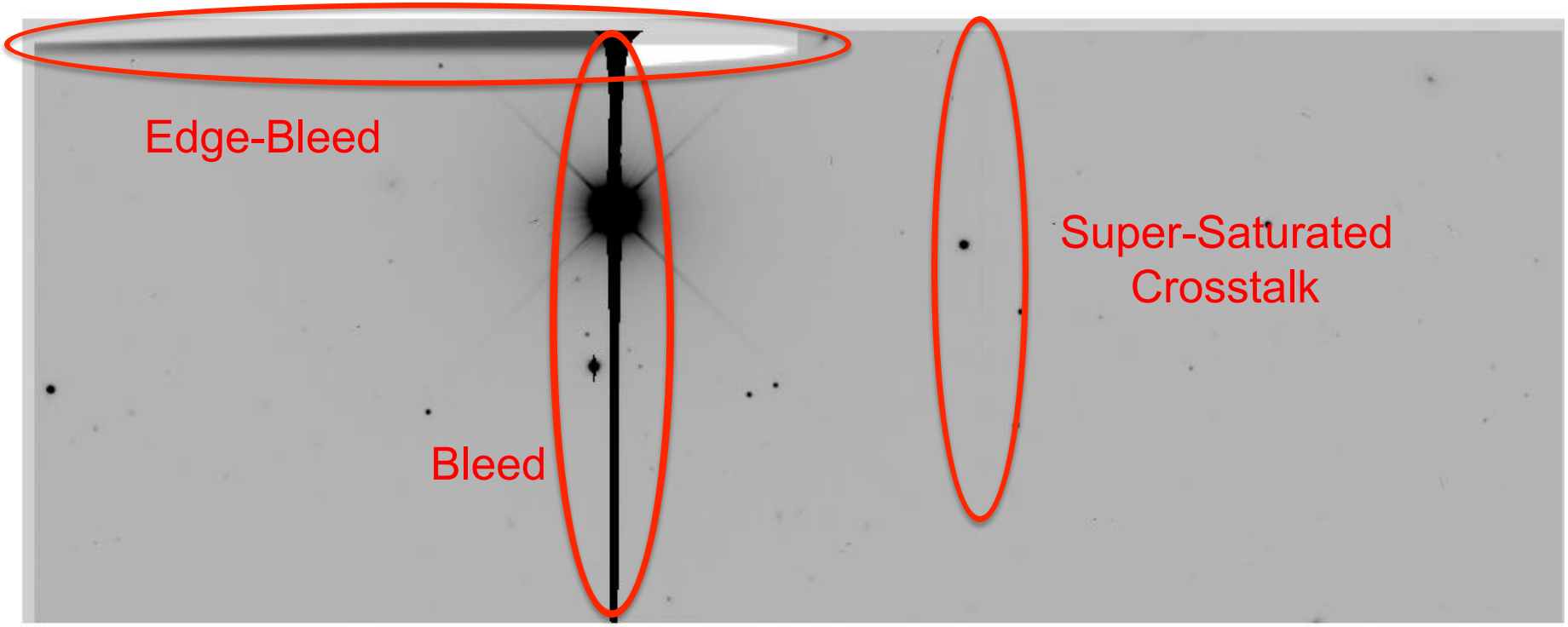

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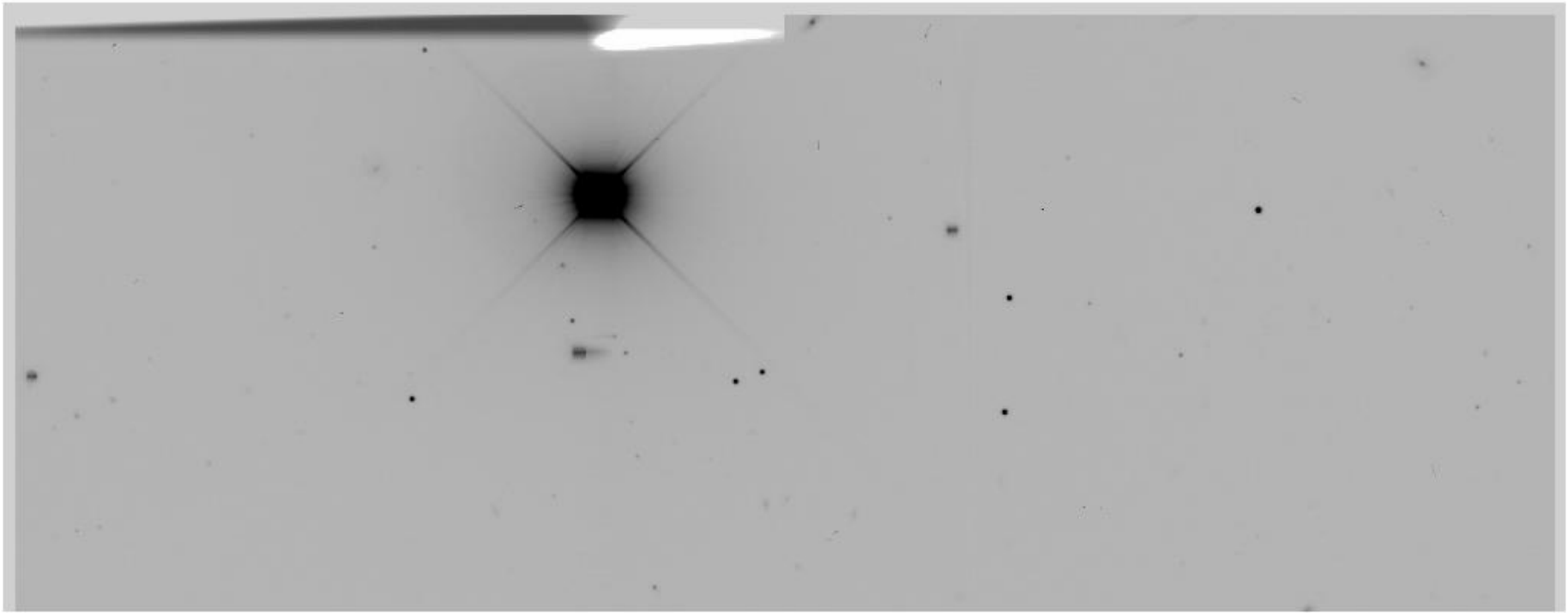
Edge-Bleed (Y1 included interpolation)



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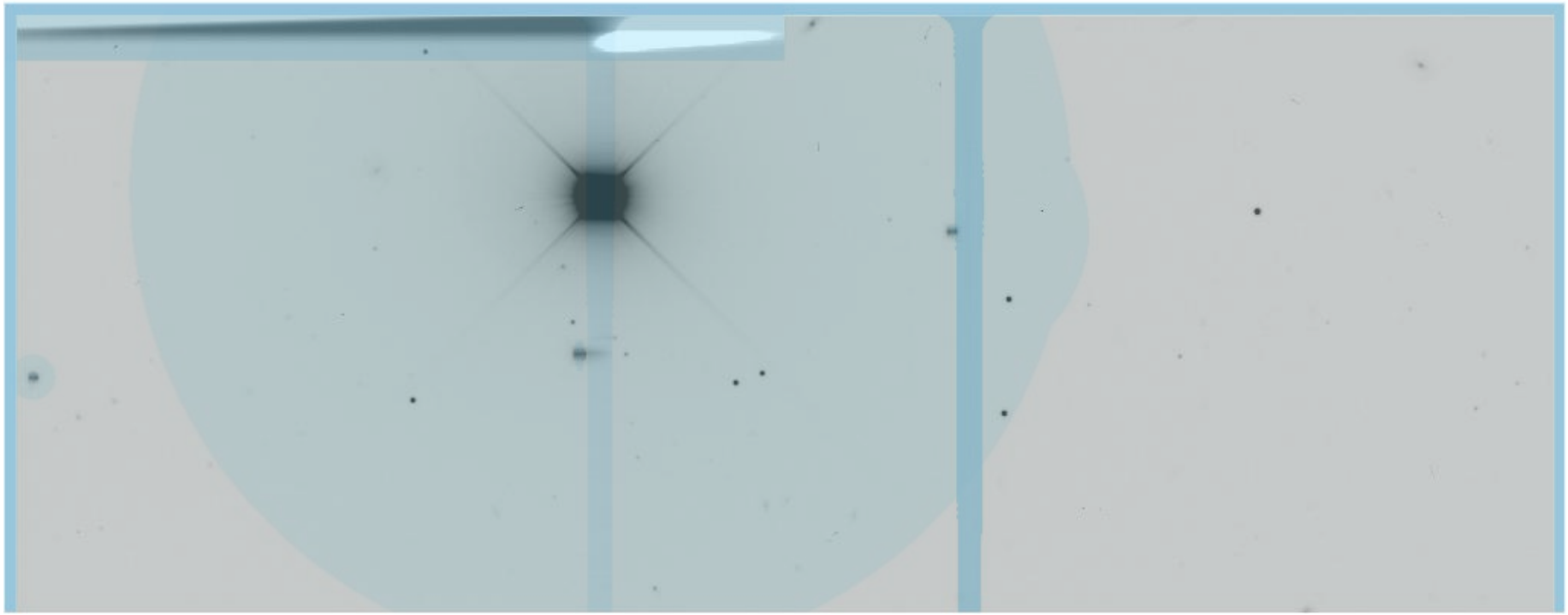
Bleed & Edge-Bleed Saturated Stars (Y1 included detailed mask)



Bleed & Edge-Bleed Saturated Stars (interpolation has its drawbacks)

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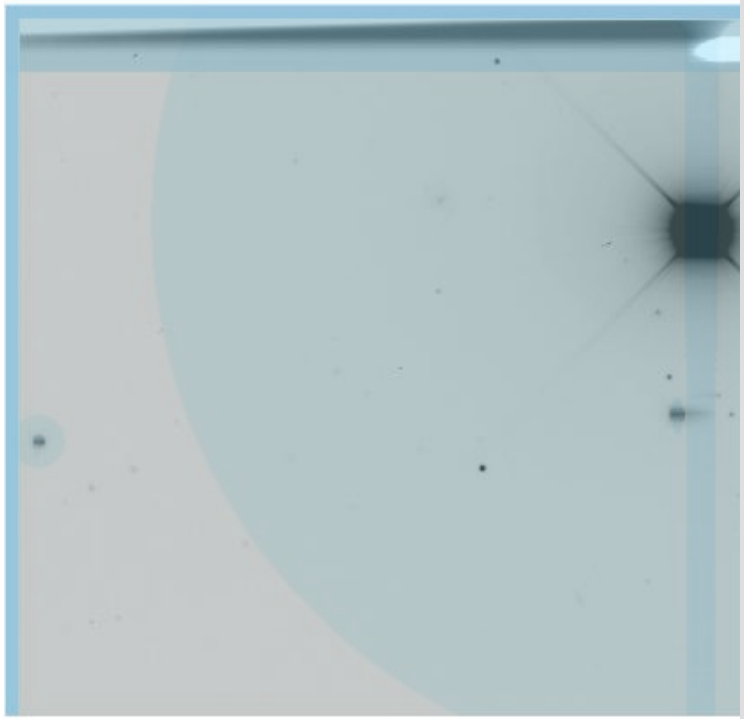

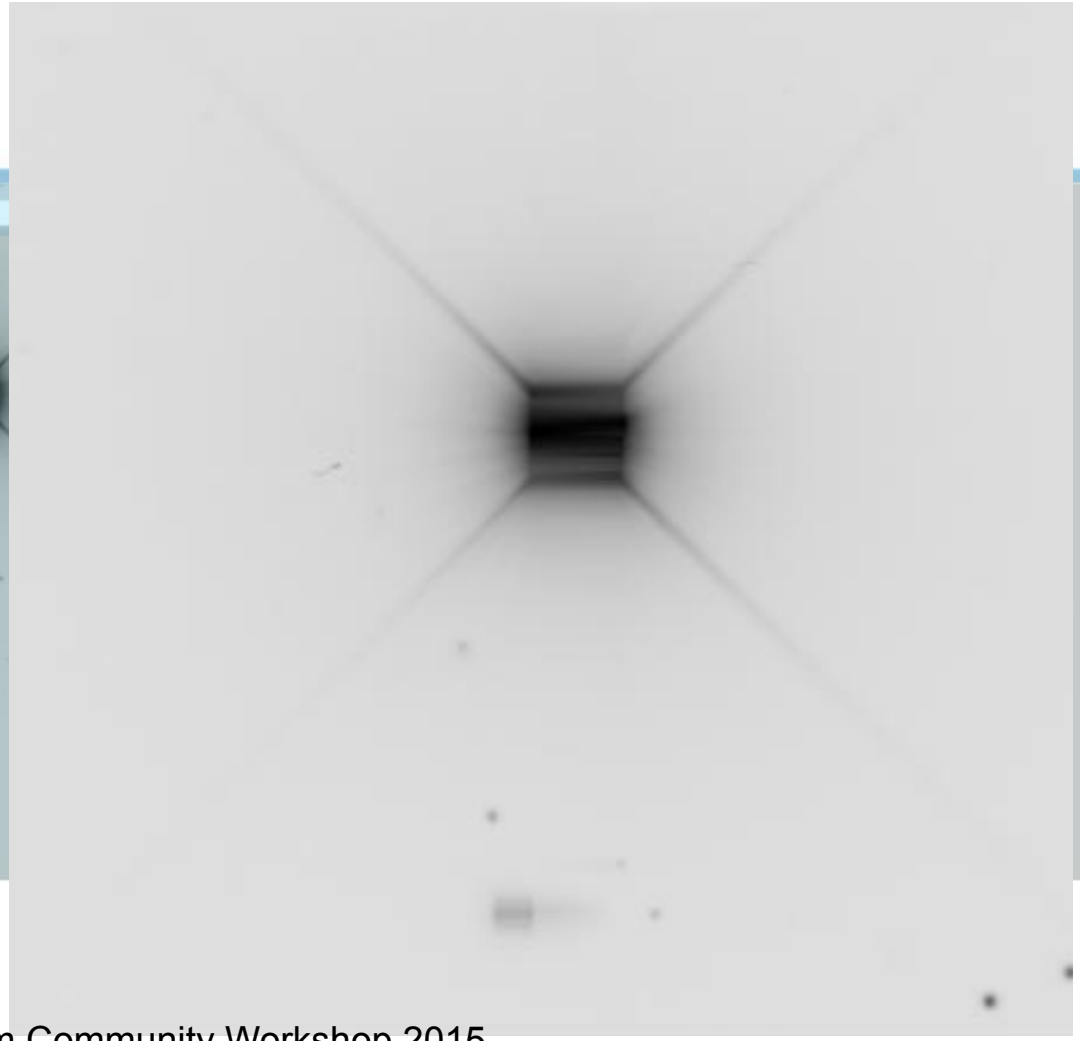

Bleed & Edge-Bleed Saturated Stars (Y2?)

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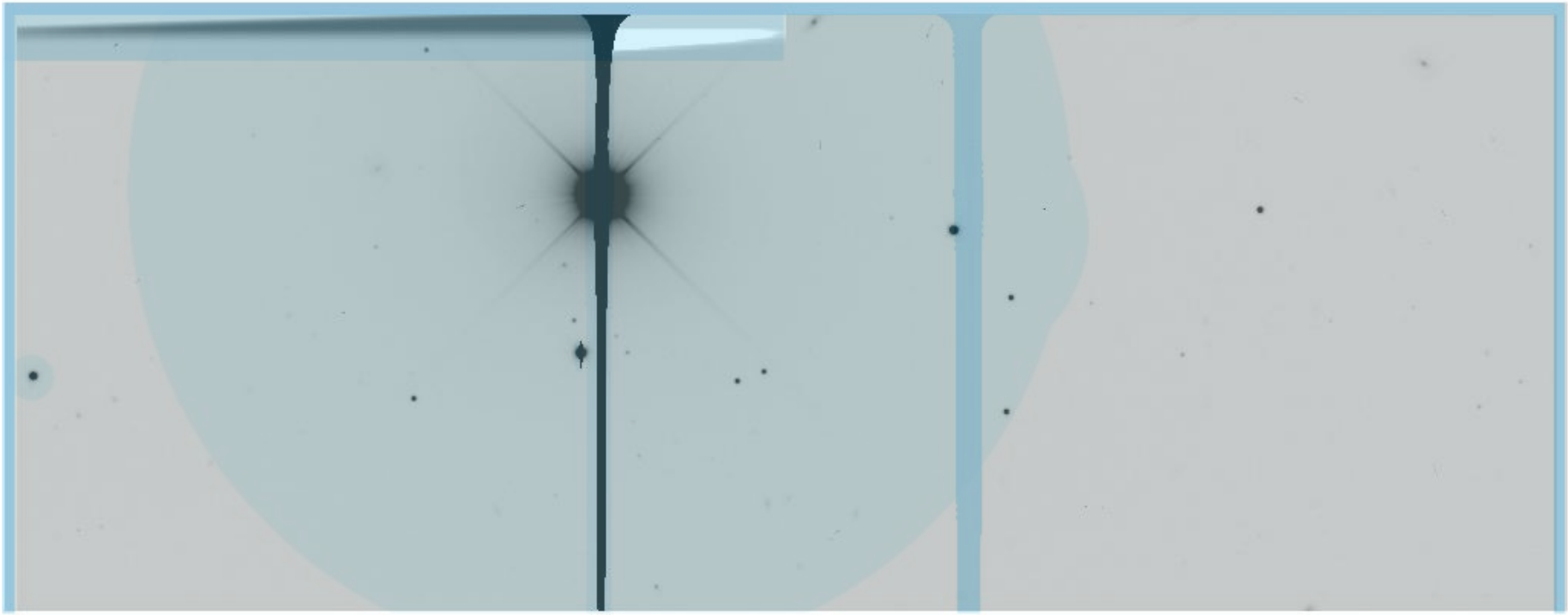
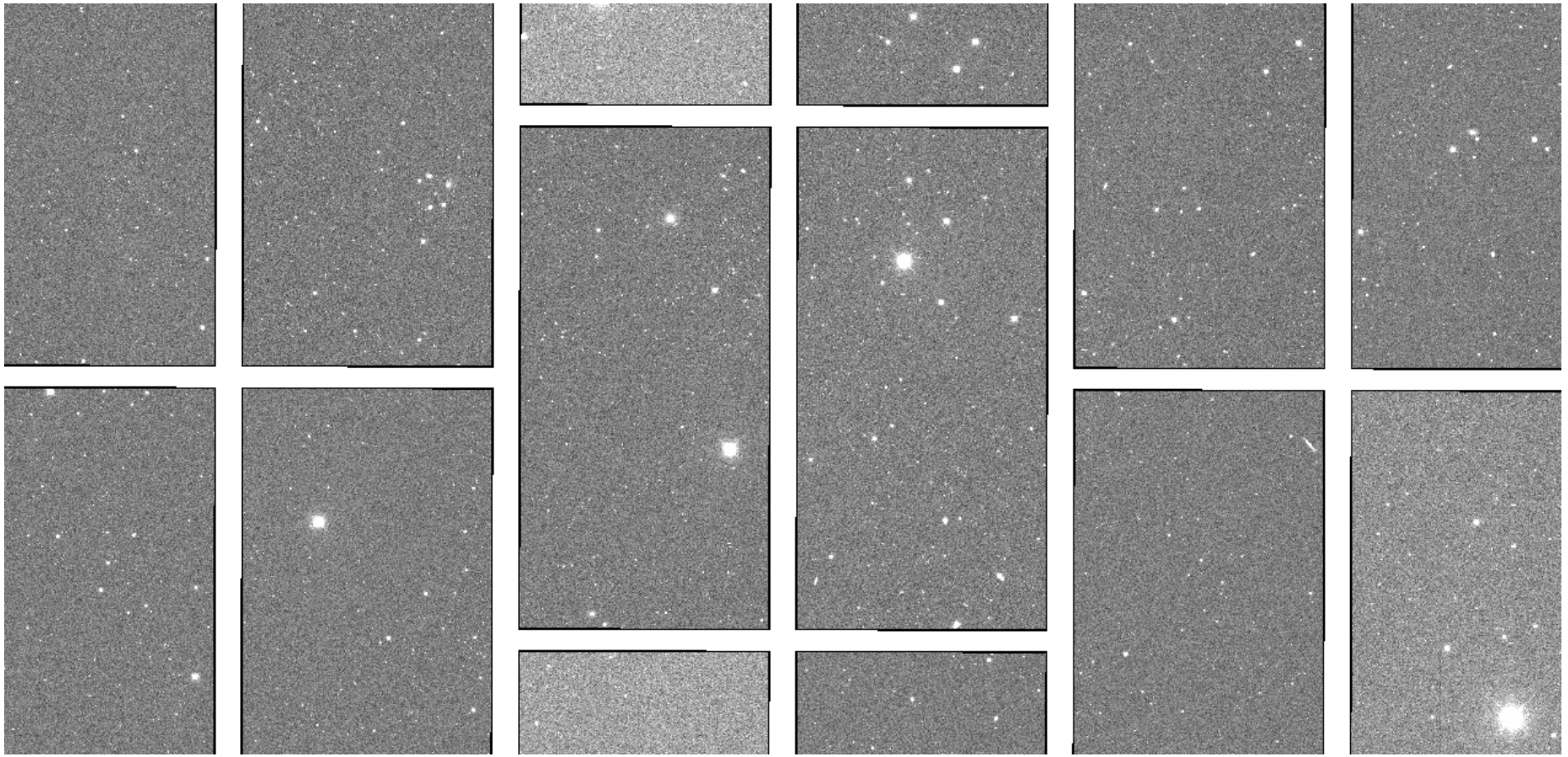


CR and Streak Masking



CR-reject & streak finder

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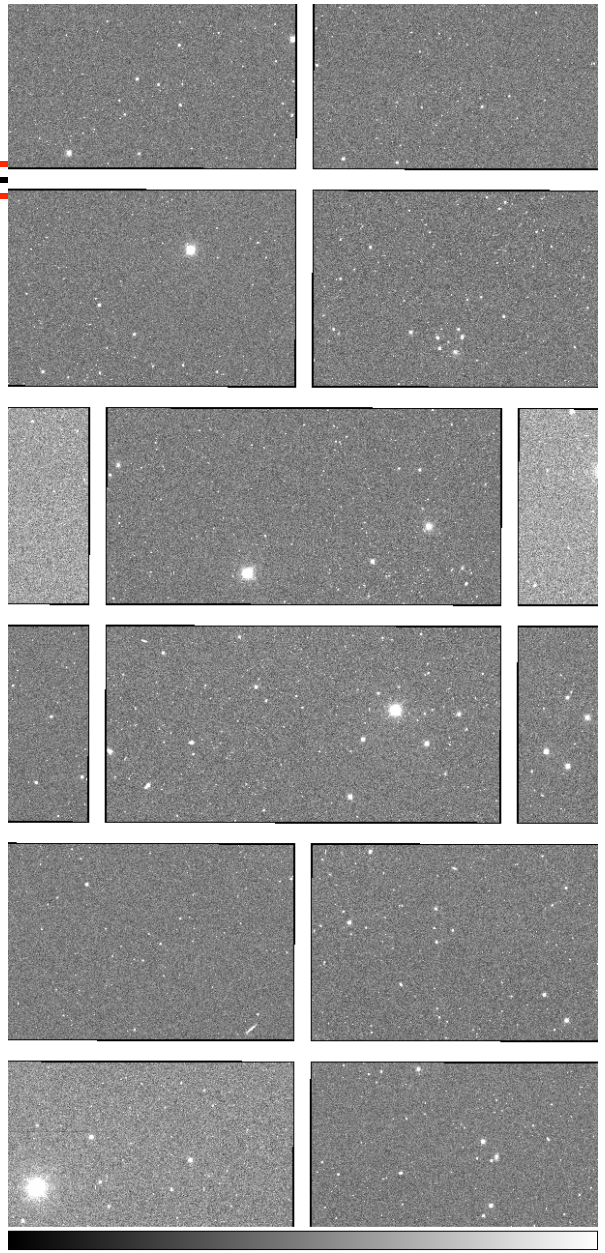
- Early CR-rejection was by neural net identification (only partially effective).
- SV: Single-Image CR-rejection was via gradient (better)
- **Y1: Implemented LSST-stack CR-rejection algorithm within DESDM pipelines.**
- Streak finder deployed in Y1 uses identification via Hough transform



Streaks/Satellite Trails

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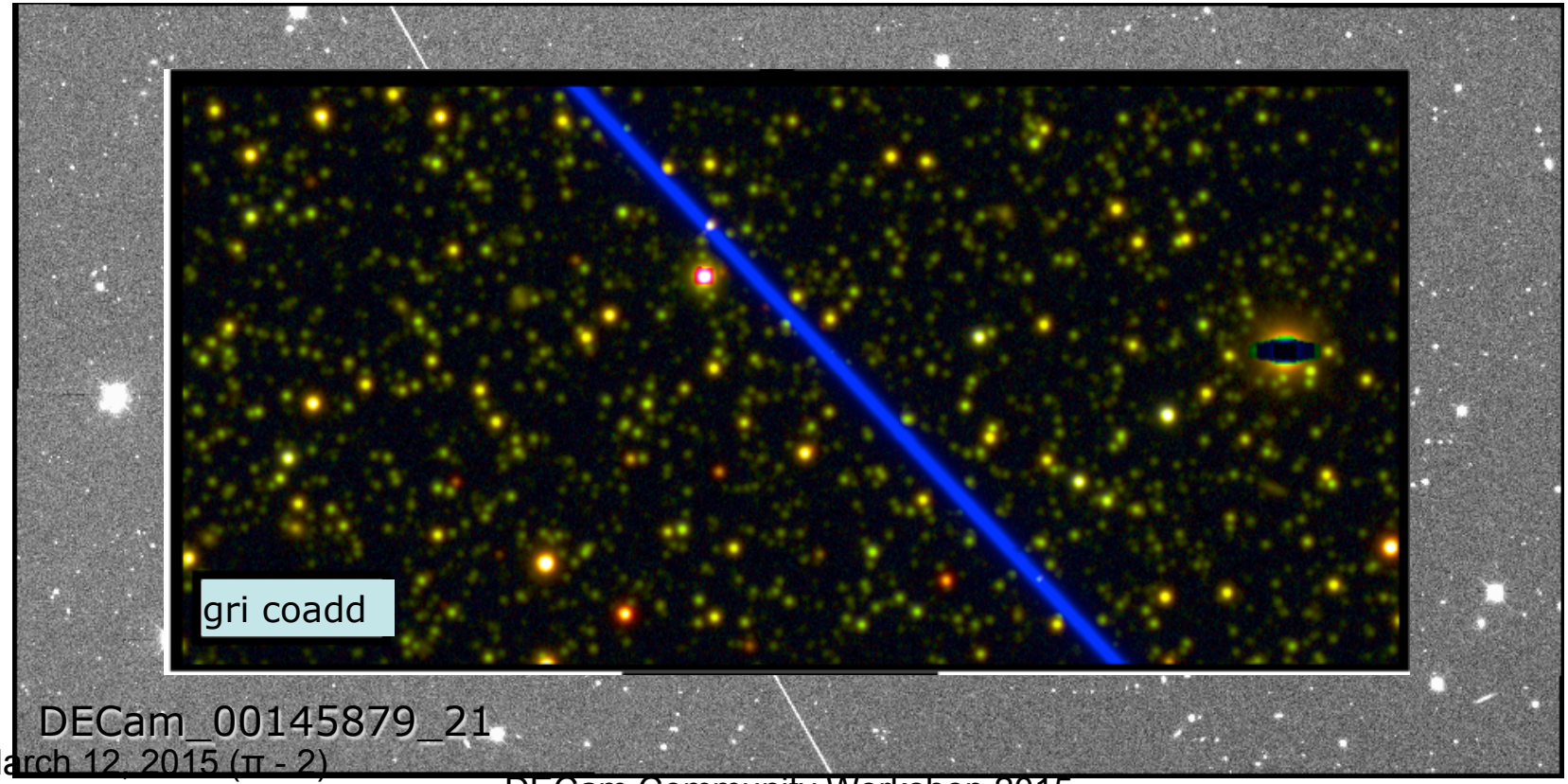
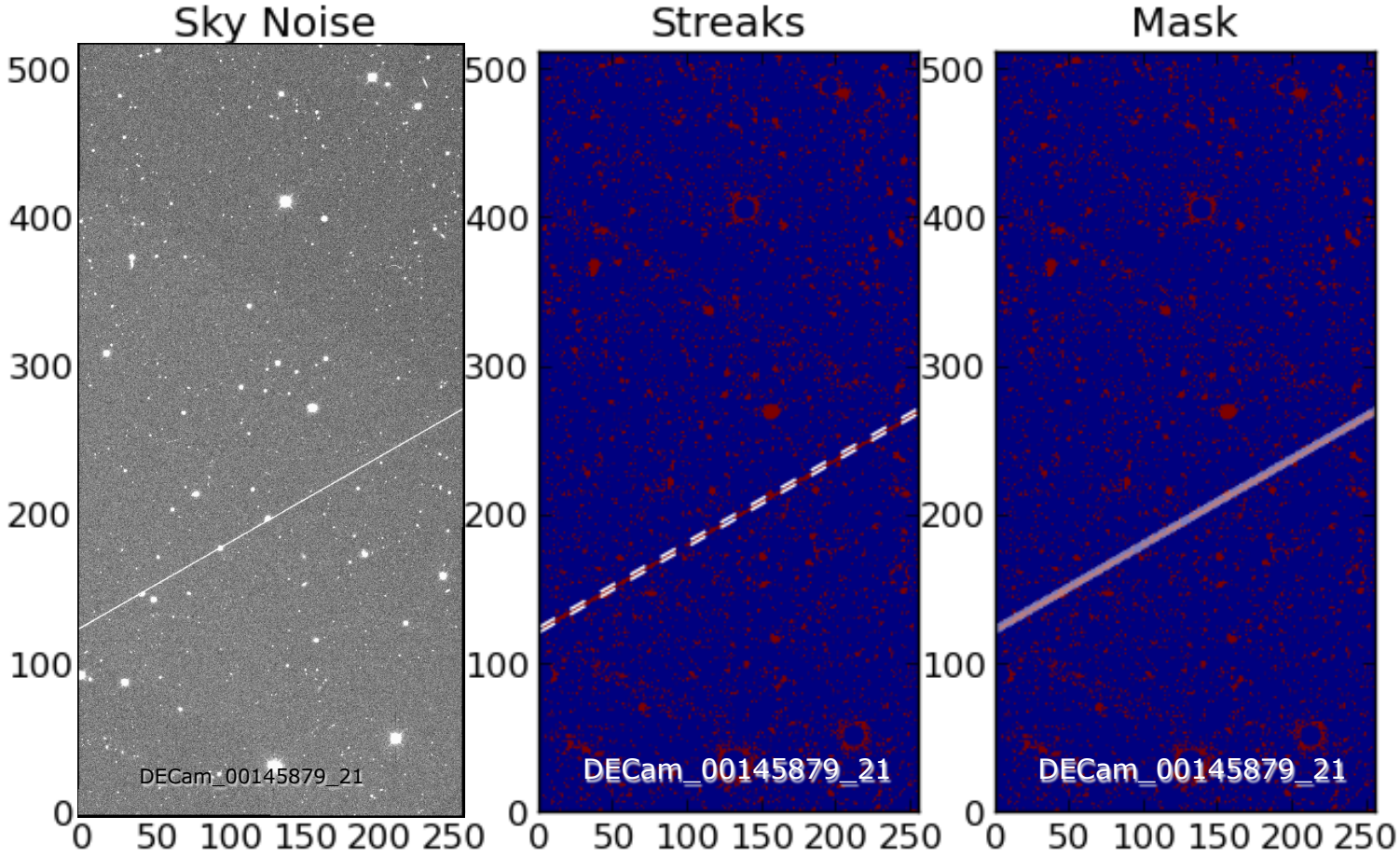
- Occasionally (~6% of CCDs in single epoch exposures) have bright objects streaking across them (satellites, meteors, etc.)
- Streaks can impact photometry in both single epoch and co-added images.



Detection and Masking of Streaks



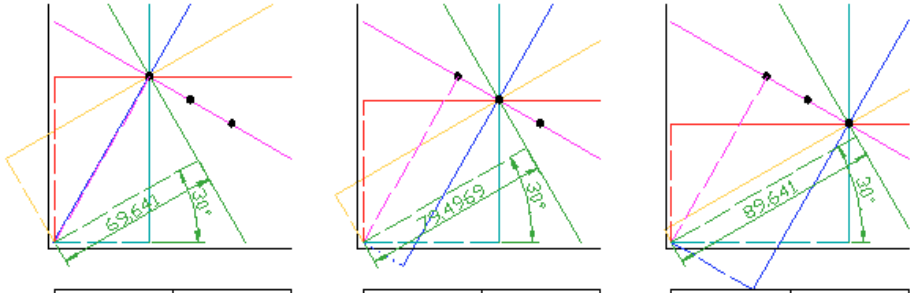
Performance:

~7 sec on 2.4 Ghz Core i7 MacBook Pro (includes I/O time)

Hough Transform

(Eli Rykoff's pyhough http://github.com/erykoff/pyhough)

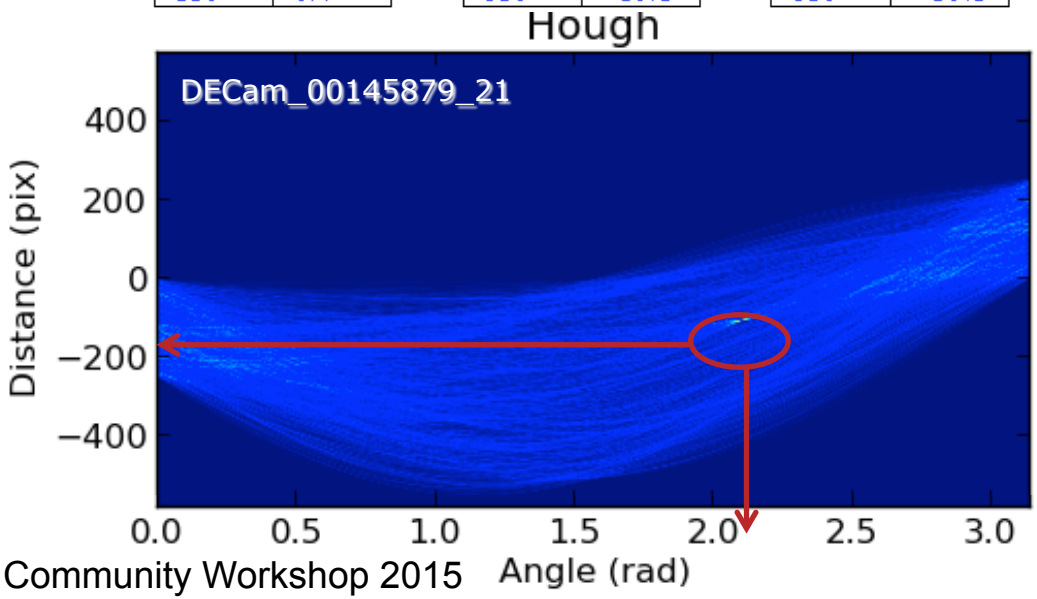
- Iterate through each pixel of the thresholded image and count how many pixels lie at each possible angle
- Create a 2D histogram in "Hough-space" where lines accumulate as localized over-densities



Angle	Dist.
0	40
30	69.6
60	81.2
90	70
120	40.6
150	0.4

Angle	Dist.
0	57.1
30	79.5
60	80.5
90	60
120	23.4
150	−19.5

Angle	Dist.
0	74.6
30	89.6
60	80.6
90	50
120	6.0
150	−39.6



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Single Epoch Cataloging

- PSF modeling through AstrOmatic PSFex (has small issues with brighter-fatter effect in fully depleted CCDs
- Single Epoch model fitting using SExtractor provides single-epoch catalogs
- Currently, detailed analysis/monitoring of PSF (e.g. shape/whisker analysis) is not included
- **After Global Calibration Module ~25 mmag rms**

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Exposure Based Assessment

Current assessment script evaluates each exposure based on single-epoch products. The goal is to determine whether each observations meets basic survey requirements.

Assessment is rendered based on calculation of the effective exposure time:

$$T_{eff} = (0.9\ k / FWHM)^2\ (Bkgd_{dark} / Bkgd)\ (10^{-2\ cloud\ /\ 2.5})$$

$$= F_{eff}\ B_{eff}\ C_{eff}$$

Current cutoffs used are $T_{eff} > 0.2$ (gY-band)
$T_{eff} > 0.3$ (riz-bands)

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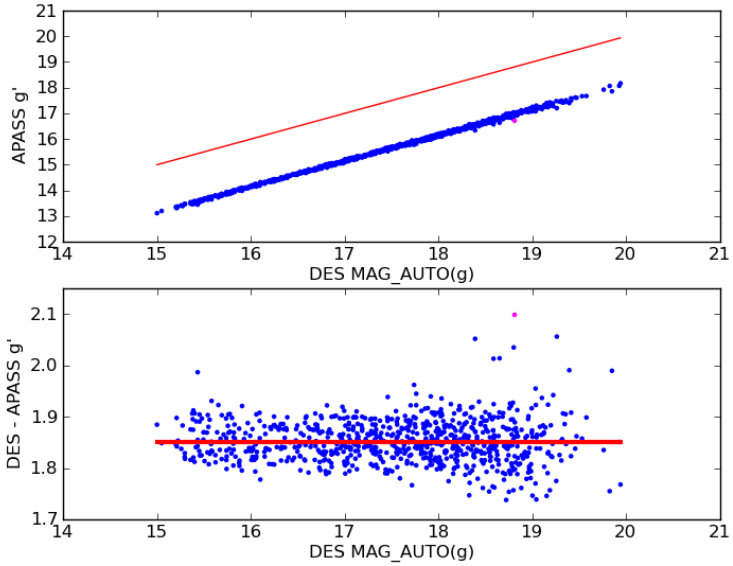
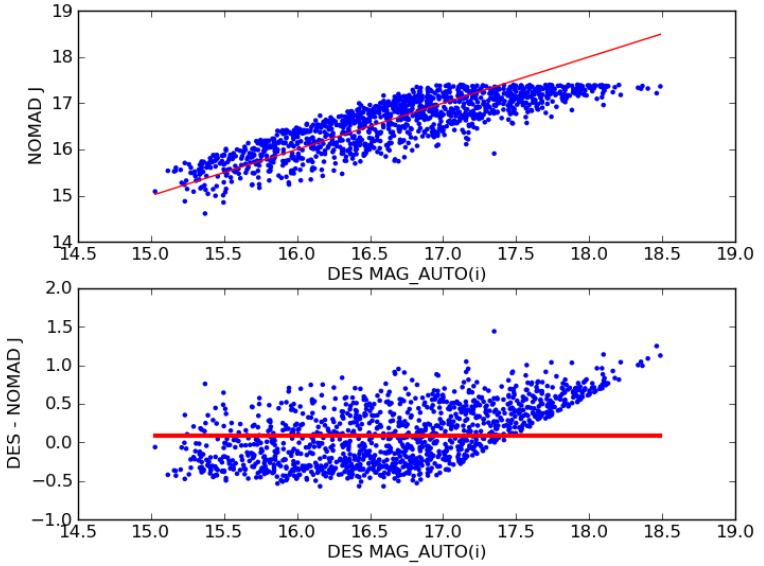
Cloud (C_{eff}) Determination

Cloud/extinction measurement is made by comparison of Single Epoch Catalog with respect to APASS (gr-bands) and NOMAD (grizY-bands).





Current comparison with NOMAD is crude (but probably sufficient).

Year 1 (vs. SVA1): Breakdown T_{eff}

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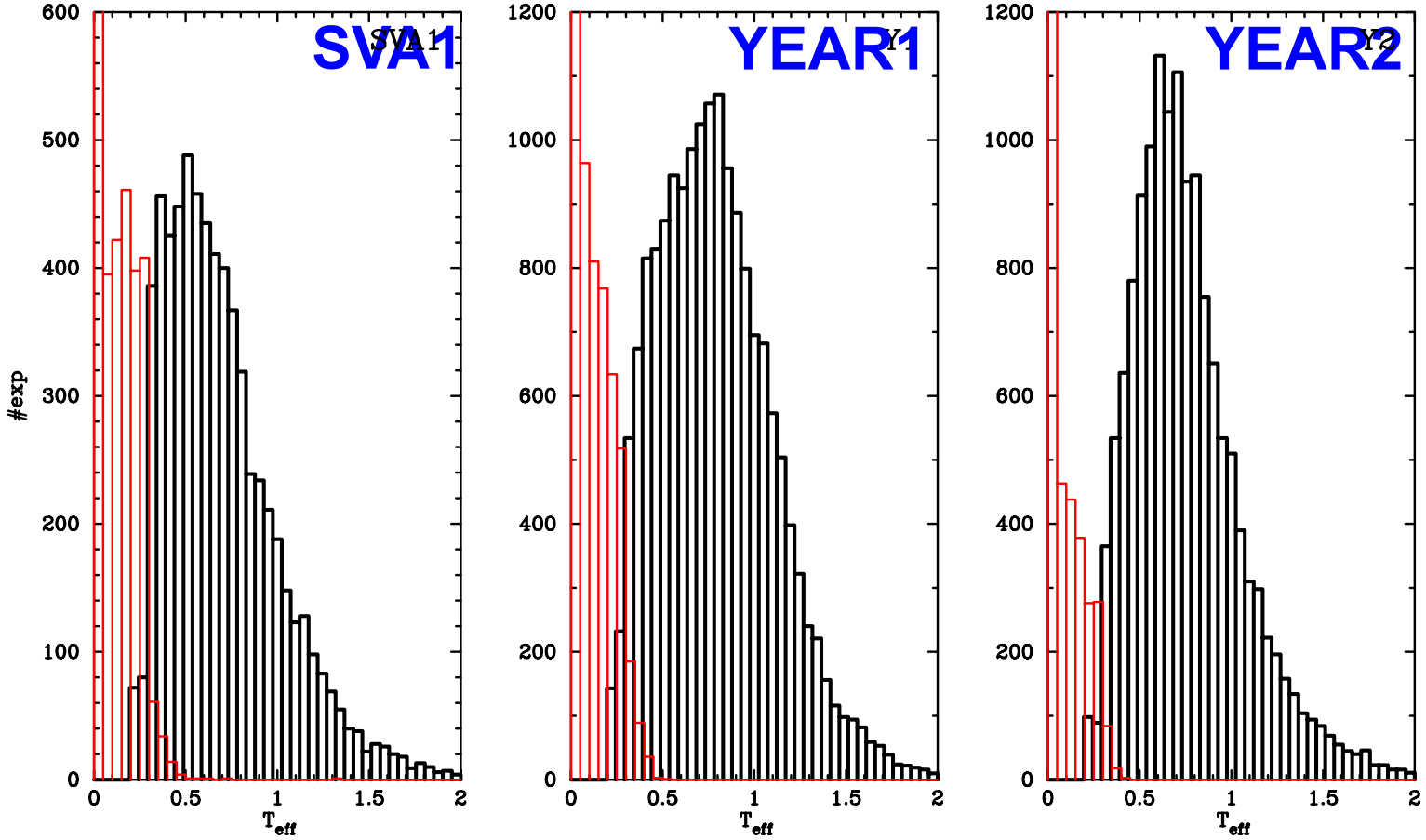

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Year 1 (vs. SVA1): Breakdown

	SVA1		YEAR1	
Time period	11/01/12 − 02/15/13		08/31/13 − 02/15/14	
	# exposures	% accepted	# exposures	% accepted
All bands	10929*	60%	17605*	82%
g	1998	58%	4203	73%
r	2086	53%	2782	90%
i	2281	57%	2916	93%
z	2375	65%	2965	96%
Y	1608	88%	4738	70%

Y1 Observations Footprint

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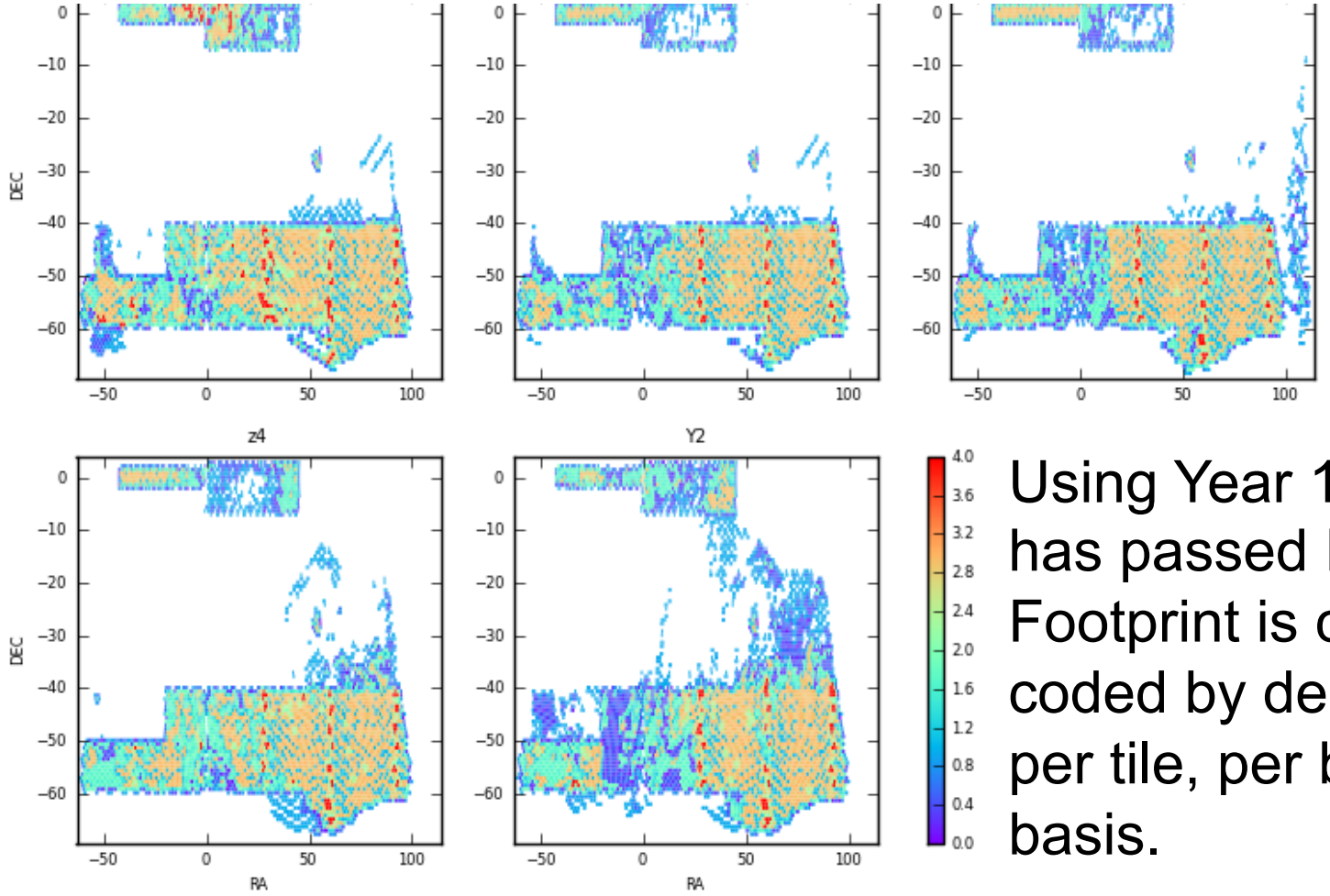

Using Year 1 data that has passed FirstCut, Footprint is color coded by depth on a per tile, per band basis.

Y1A1 Footprint(s)

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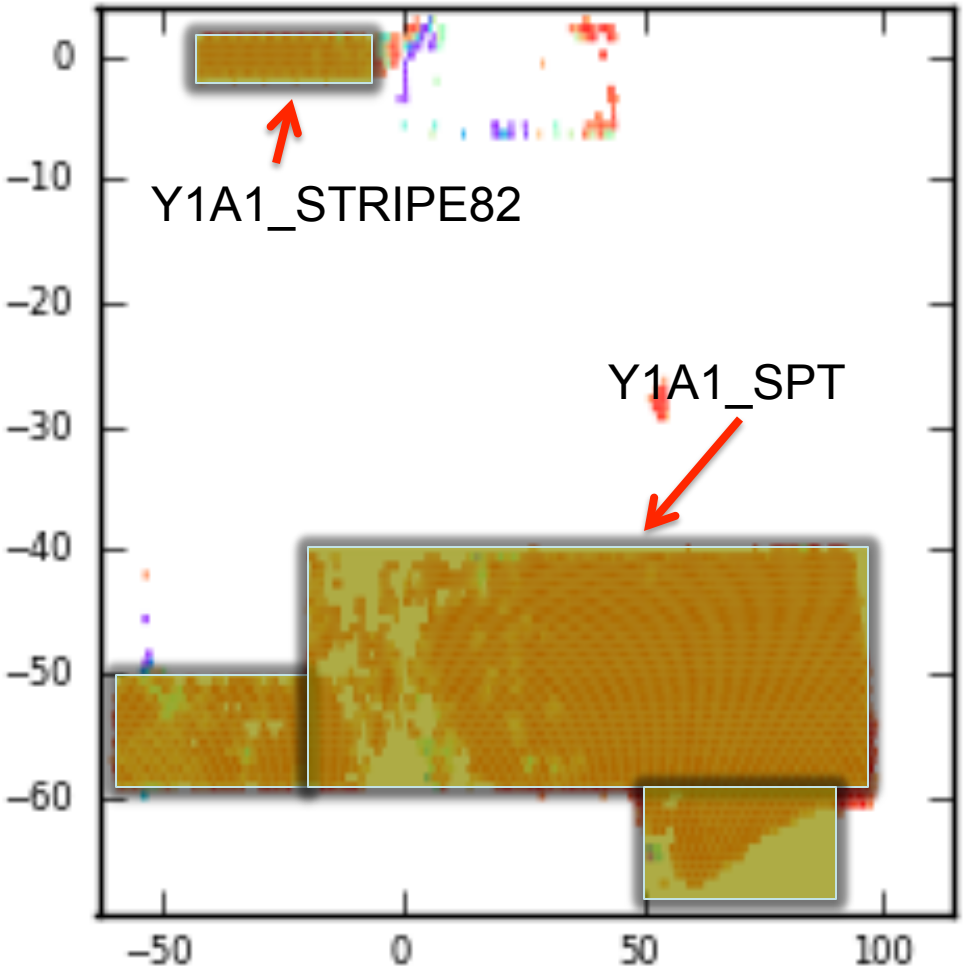

Y1A1 footprint:

- STRIPE82, SPT
- SPT: Depth 2 (or greater):
  - ~3000 tiles
  - ~1500 sq degrees
- Depth 3 (or greater):
  - ~50% of area

COADD

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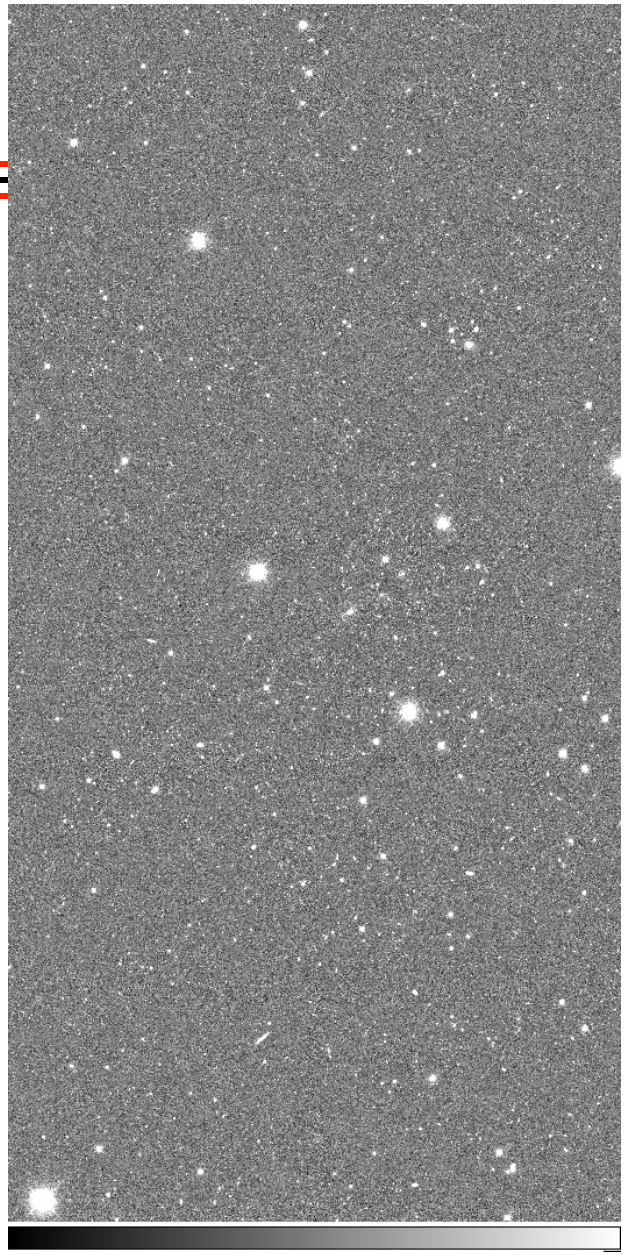
COADDITION of single-epoch images requires a global calibration based on single epoch photometry (~25 mmag).

In Y1A1 an astrometric refinement step was added. Reduces the relative (i.e. internal) astrometric residuals:

- (internal) < 50 mas rms (all bands),
- (external) ~150-200 mas rms (2MASS)

Cataloging is based on a detection image (currently a linear combination of *r*, *i*, and *z*-bands).



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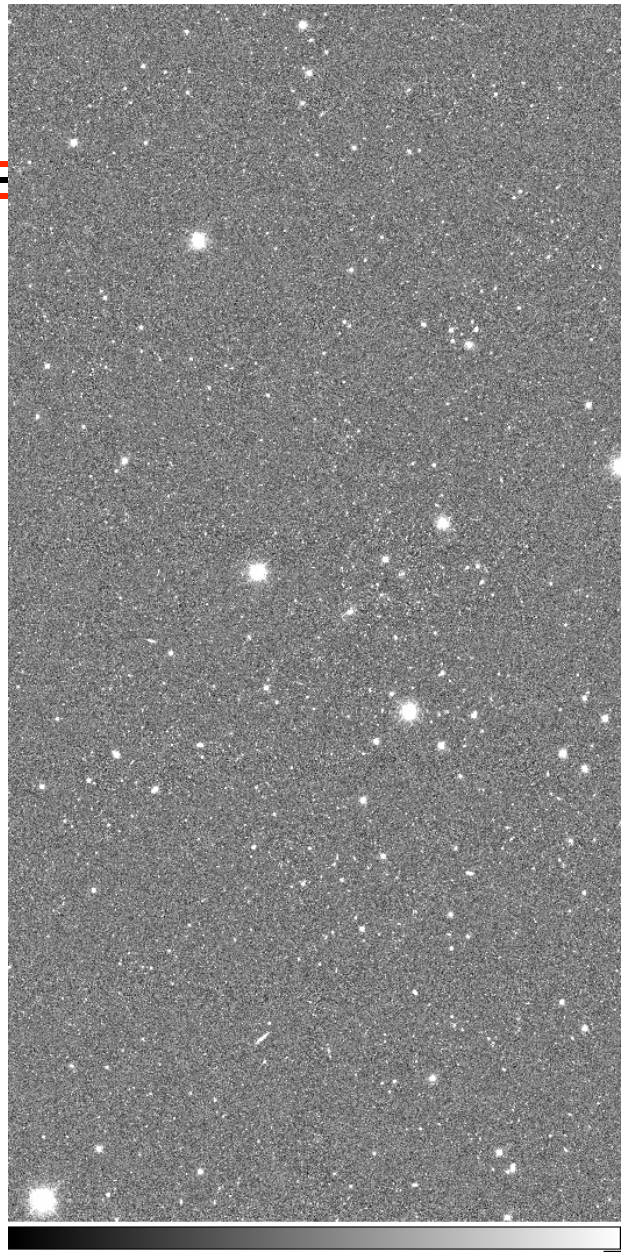
COADD

Y1 (and Y2) depth is nominally 4 exposures per survey pointing.

Due to variations in PSF there are known systematic problems with PSF magnitudes. MAG_AUTO and MAG_APER are likely better choices for science in the near-term.

Detailed QA of COADDs has been implement within the Brazil Portal (see talk by Luiz de Costa).



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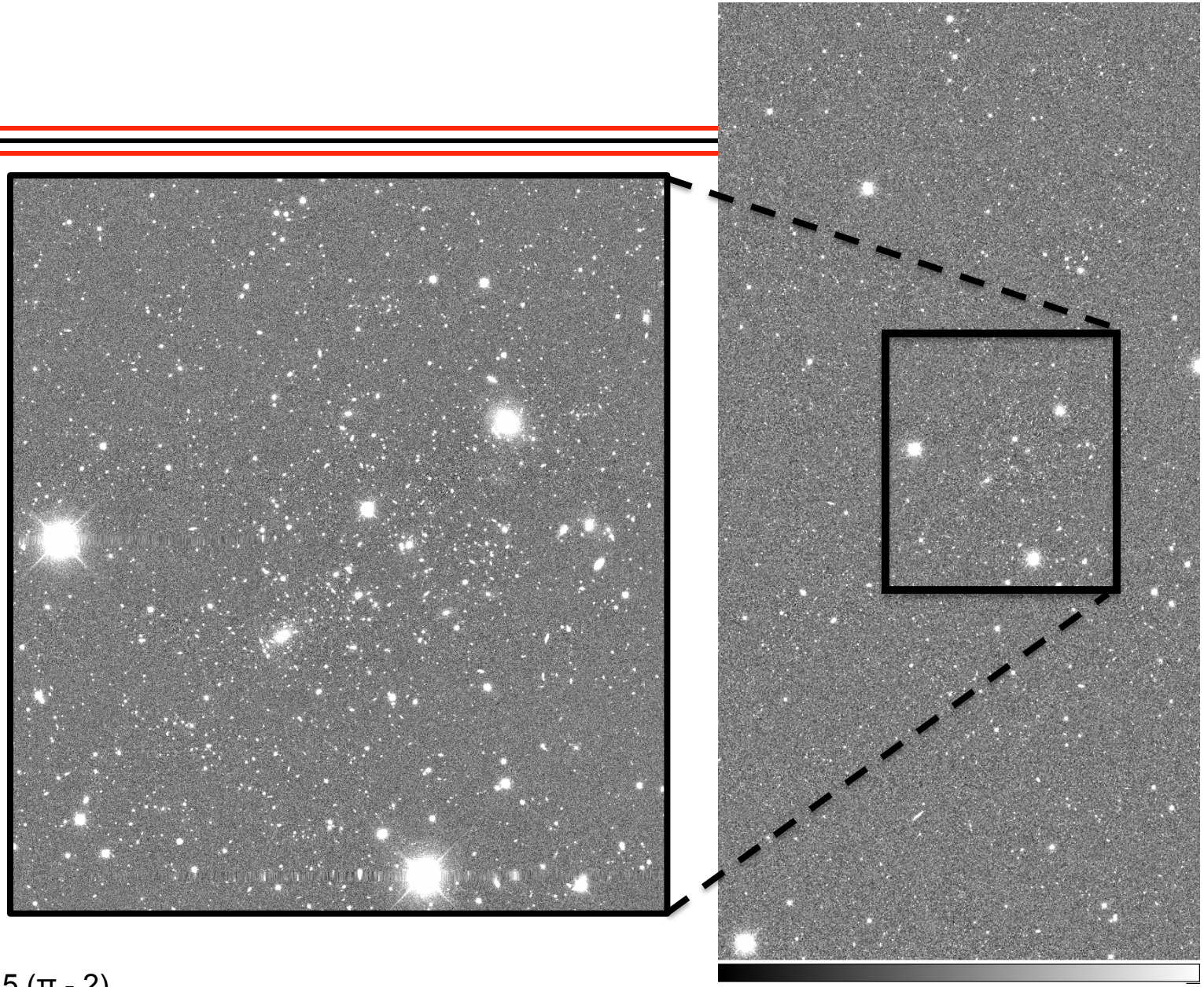
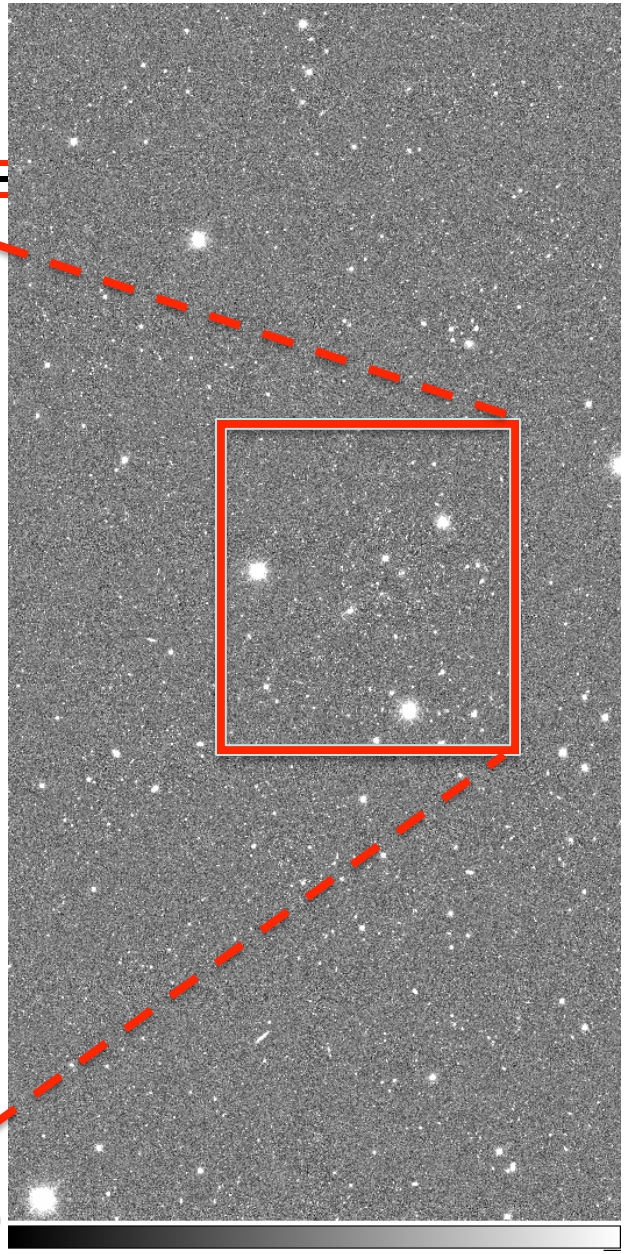


COADD merge



(F. Menantaeu)

Y1(Y2?) COADD

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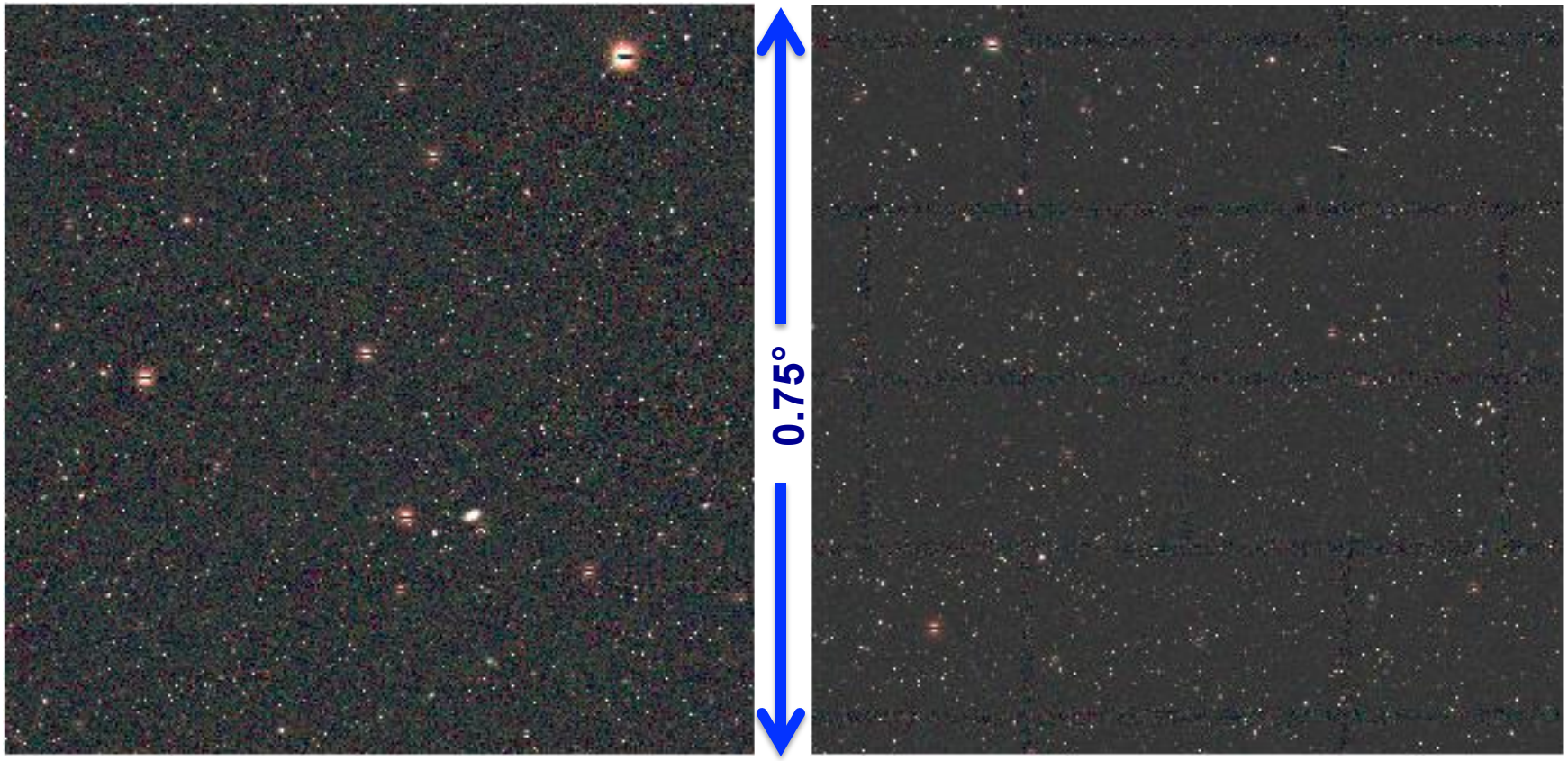
Typical survey Field

SN Deep Field



riz-band

Y1(Y2?) COADD

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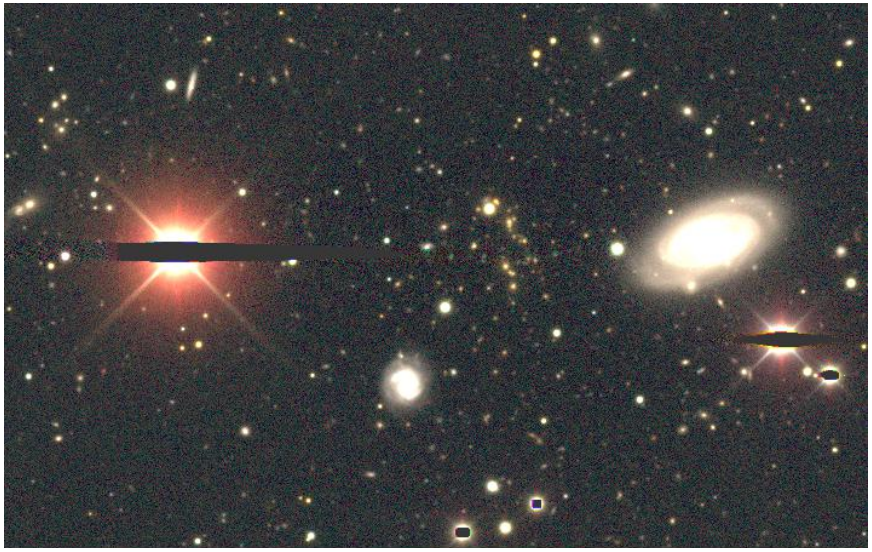
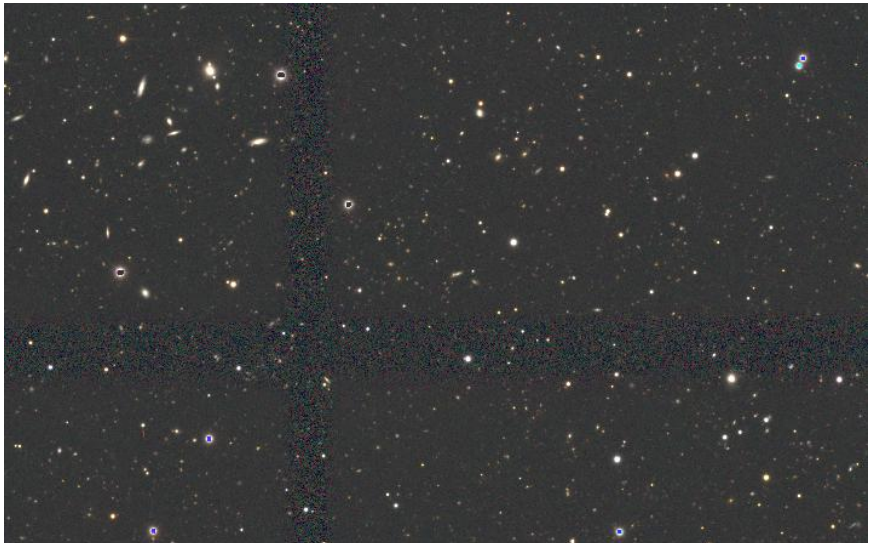
Typical survey Field



SN Deep Field



Y1(Y2?) COADD

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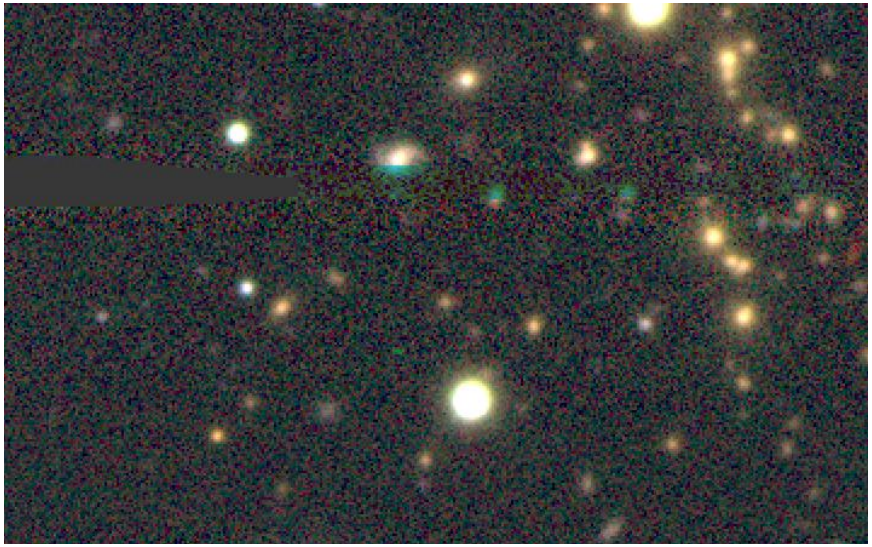
Typical survey Field



SN Deep Field

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Current Y2 pipeline upgrades

1. Add Brighter/Fatter
2. Reorganize detrending to accommodate PCA template sky fitting.
   - Likely change from ADUs to electrons
3. Revamped handling of weights
   - carry ALL weights forward and adjust based on mask prior to steps that make measurements
4. More detailed masks that reflect artifacts that may be tolerated for some measurements…

- Framework/orchestration enhancement to improve throughput on OSG type compute resources
- Detailed provenance tracking
- Direct incorporation of afterburner production (extinction, Mangle, etc…) into COADD pipelines.

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Unspoken Thoughts