WITS Image Differencing & Extraction pipeline (WIDE)

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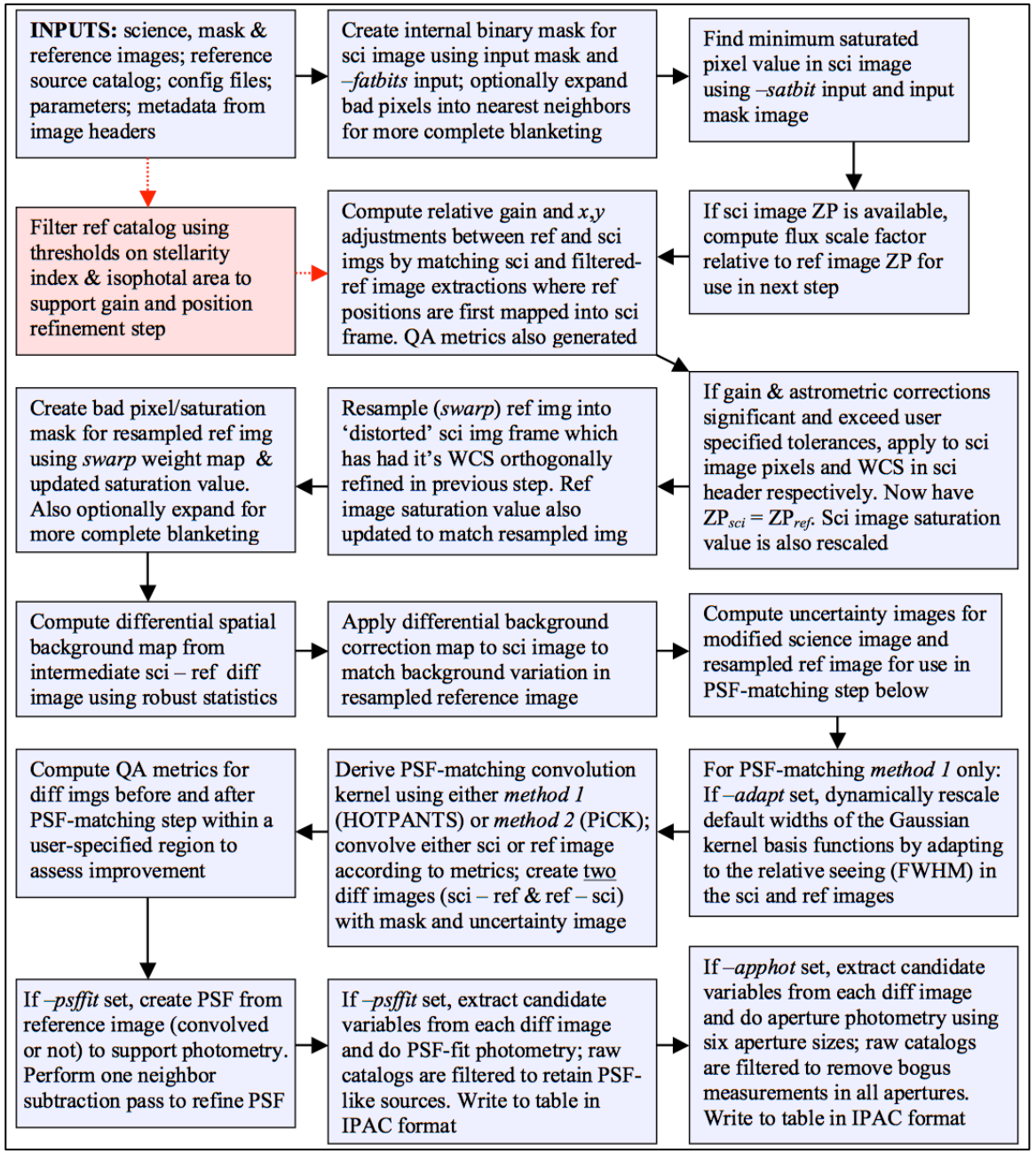
IPAC/Caltech

Summary

- WIDE was recently ported from the Palomar Transient Factory's Image Differencing and Extraction pipeline (designed for PTF-I and PTF-2). Written by Masci (2012) – description document available upon request.
- The PTF version is currently undergoing beta-testing by Caltech post-docs.
- Extracts candidate transients and variables from "*science minus reference*" and "*reference minus science*" difference images with photometry and diagnostics.
- Emphasis is to maximize reliability to low flux levels using a number of pre-calibration steps, e.g.,
  - Photometric-gain matching between science and reference image
  - Relative astrometric refinement
  - Relative spatial Background matching
  - Spatially-dependent PSF-matching designed for optimal detection in regions with high source density and/or complex emission (e.g., nearby galaxies)
  - Candidates are extracted using a match filter and photometered using PSF-fit photometry; aperture photometry also available to assist with quality assurance
- Goal is to ease the vetting and dissemination process downstream.
- A number of metrics from the PSF-fitting are used to filter unreliable candidates (e.g., instrumental glitches; residuals from bad PSF-matching, bad relative registration etc…).

The "WIDE" pipeline [from Masci, 2012]

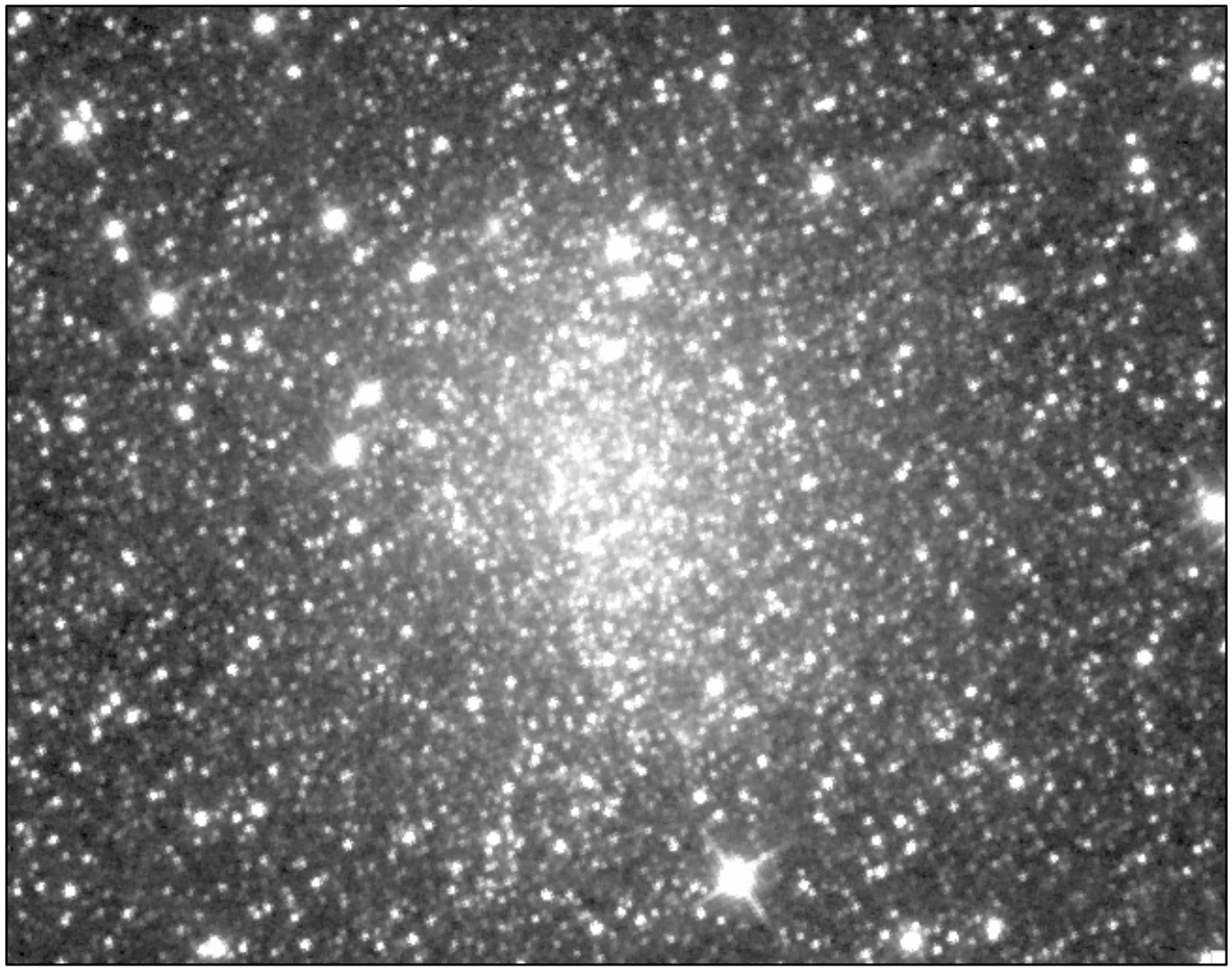


Recommendations for WITS

- Need to optimize co-add generation for the reference images. The All-Sky Image Atlas is not appropriate due to its ~ √2 lower resolution used to support matched filtering for optimal source detection in the WISE pipeline.
  - For WITS, I've been experimenting with a linear area-weighted (drizzle) interpolation method.
  - Desirable to build the reference images on a grid aligned with the ecliptic coordinate system, i.e., close to the orientation of the WISE scans. This minimizes the propagation of diffraction-spike artifacts after reprojecting pixels for registration, PSF-matching, etc.
- Also desirable to make reference image (co-adds) windowed in time throughout the survey (e.g., the WCON or ~ 18 day span, and perhaps longer off the ecliptic?)
  - Primarily for better PSF-matching and depth.
  - These can be used for differencing with single-exposures (with the known bias against longer-period variables on the ecliptic using one epoch); other co-aligned WCON co-adds at higher ecliptic latitudes (as allowed by the depth-of-coverage); or with other co-adds across epochs.
- Need vetting of candidates using spatial and temporal metrics (e.g., frames close-in-time for glitch mitigation, bright-source artifacts, asteroid detection).
  - two bands are also a bonus, but important to note that sensitivities in each band differ.
- WISE has its own idiosyncrasies compared to ground-based data (e.g., transient hot pixels, bright-source induced artifacts, latents, soft-edged CRs from SAA, abnormal PSF-profiles in saturated/non-linear regime, highly non-isoplanatic PSFs…)
  - WISE team expertise will be needed to assist in building candidate vetting infrastructure.

NGC 6822 W1 co-add (reference image)

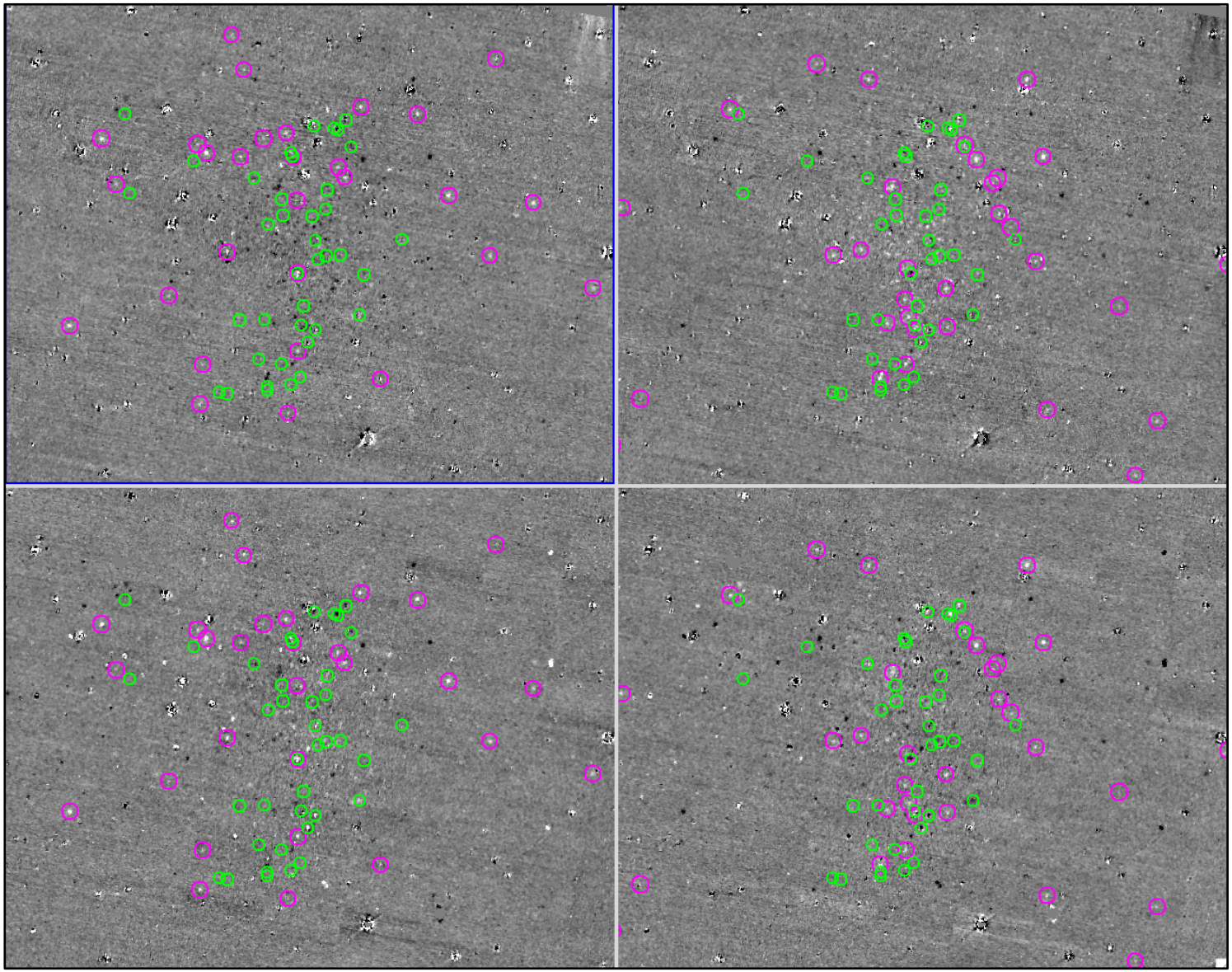
- field ~ 19 x 23 arcmin^2 field
- co-add created from epoch-1 (cryo) frames
- same footprint used for image-differences on next slide



NGC 6822 W1 difference images

single exposure #1 – reference

reference – single exposure #1



single exposure #2 [+ 3.2 hrs] – reference

reference – single exposure #2 [+ 3.2 hrs]

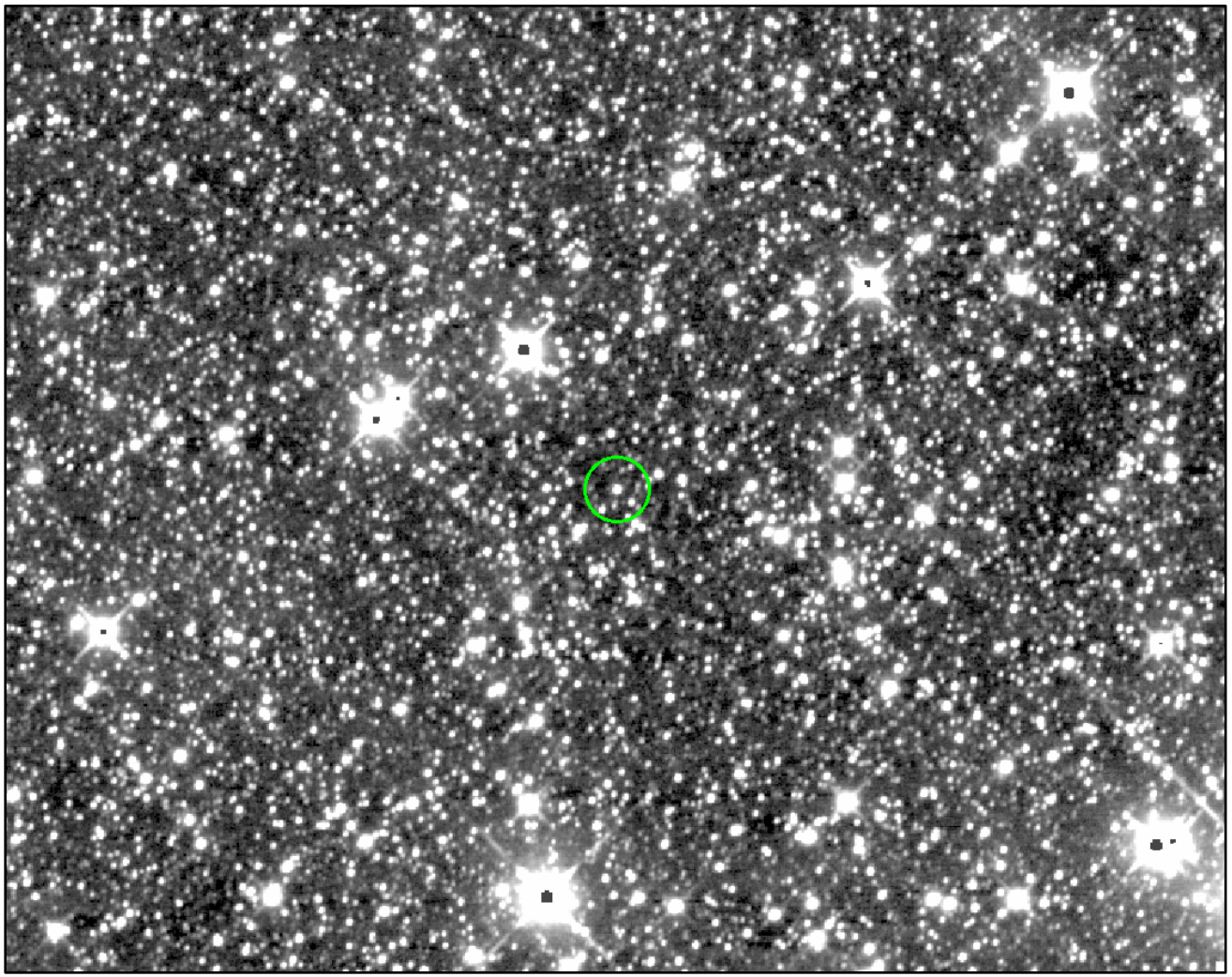
- magenta = candidates from WIDE

- green = known Cepheids from optical surveys. 3 of the 6 detected in W1 were extracted by WIDE.

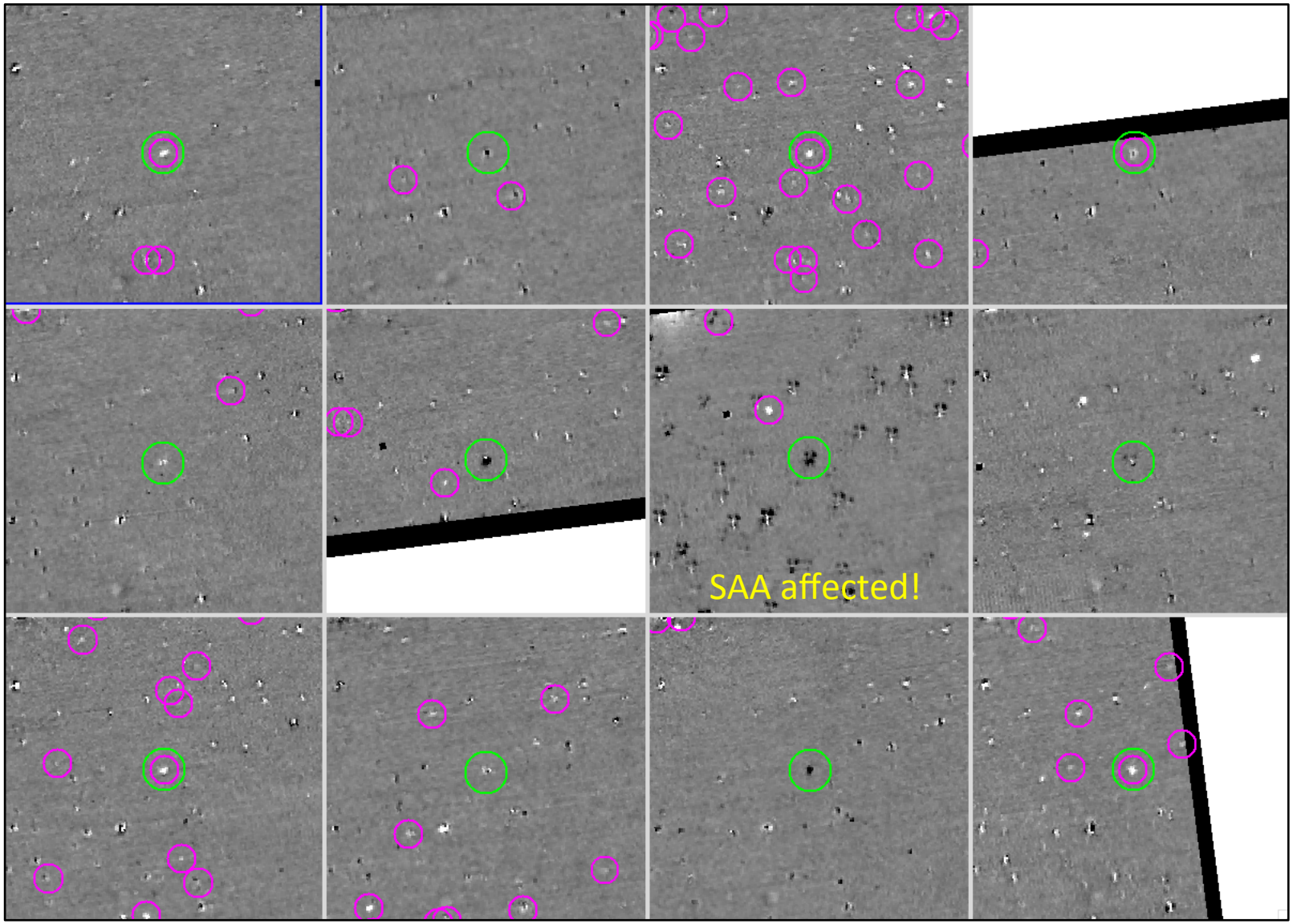
- **N.B:** only <u>common</u> extractions between this frame pair were retained, for both difference images

W1 co-add (reference image) on galactic plane

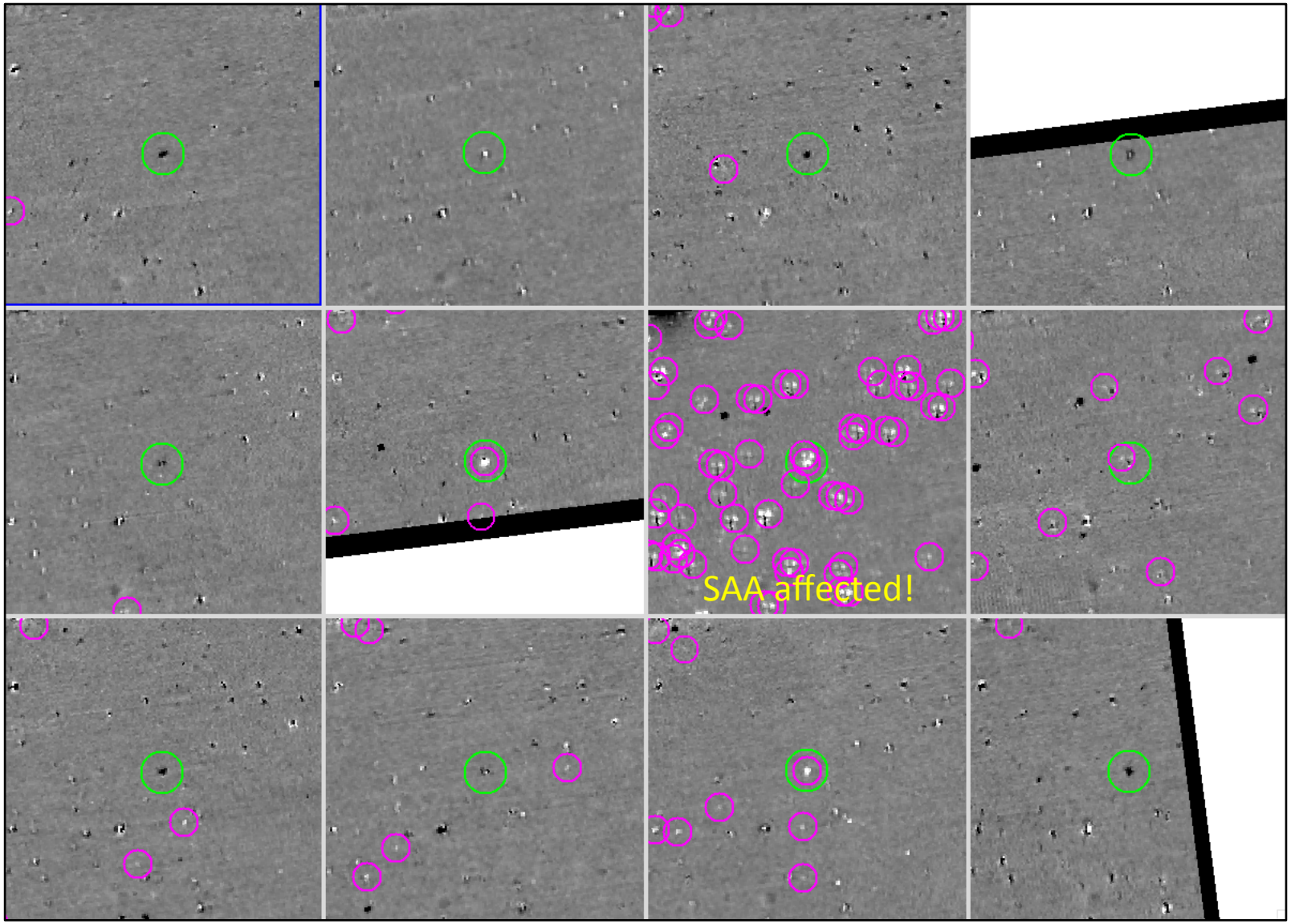
- field ~ 20 x 28 arcmin^2 field
- galactic latitude ~ 0.74 deg.
- field contains a known RR-Lyra: EZ Mon (green circle)
- co-add created from epoch-1 (cryo) frames



W1 "*science – reference*" differences on galactic plane (EZ Mon RR Lyr = green)

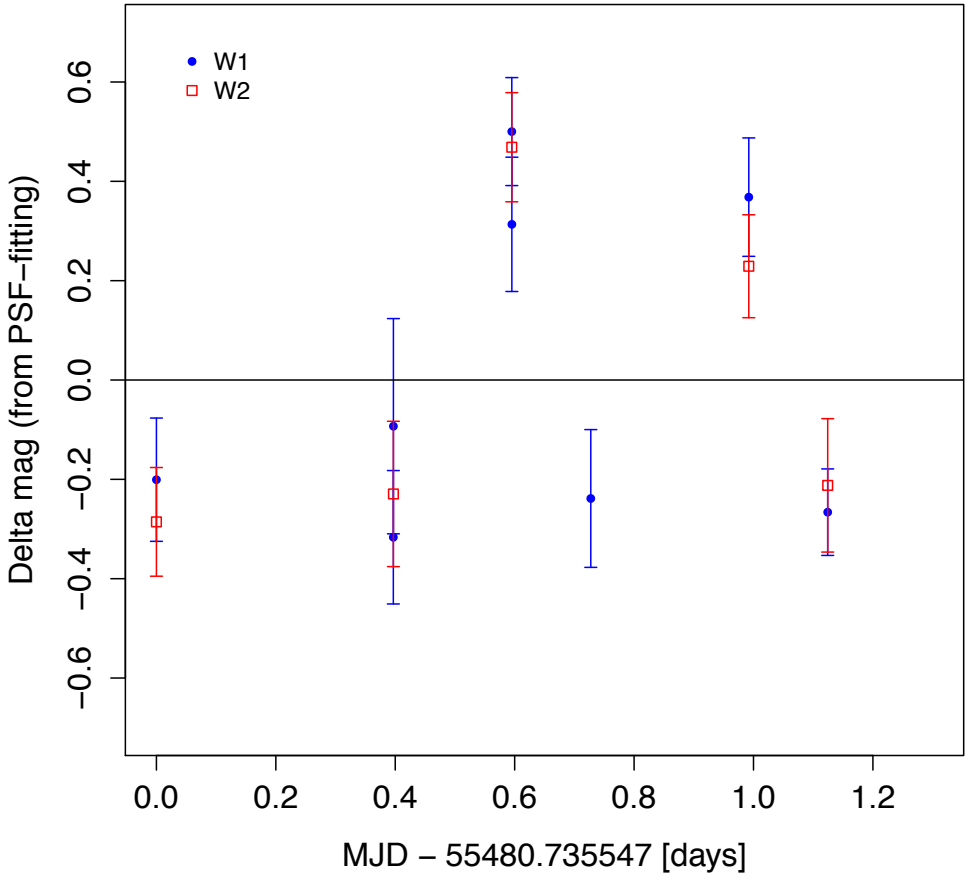


W1 "*reference – science*" differences on galactic plane (EZ Mon RR Lyr = green)



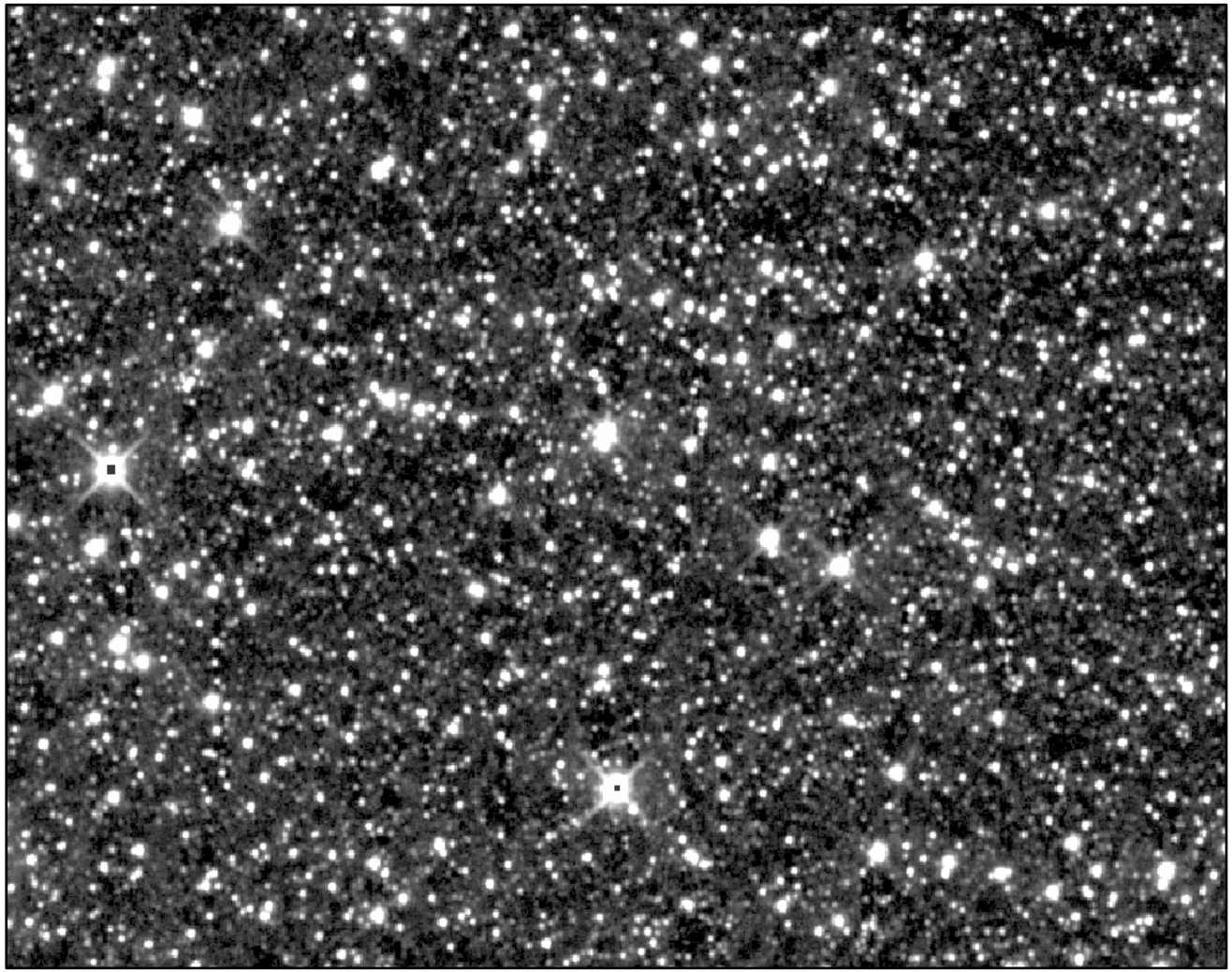
Differential light curves for RR Lyra: EZ Mon

- Uses calibrated PSF-fit photometry directly from the WIDE pipeline.
- Reminder: extracted from difference of post-cryo frames with co-adds created from cryo-mission frames.
- Photometry is only shown for > 3σ difference-image detections.
- **N.B:** photometry and uncertainties from WIDE not yet formally validated.



W2 co-add (reference image) on ecliptic

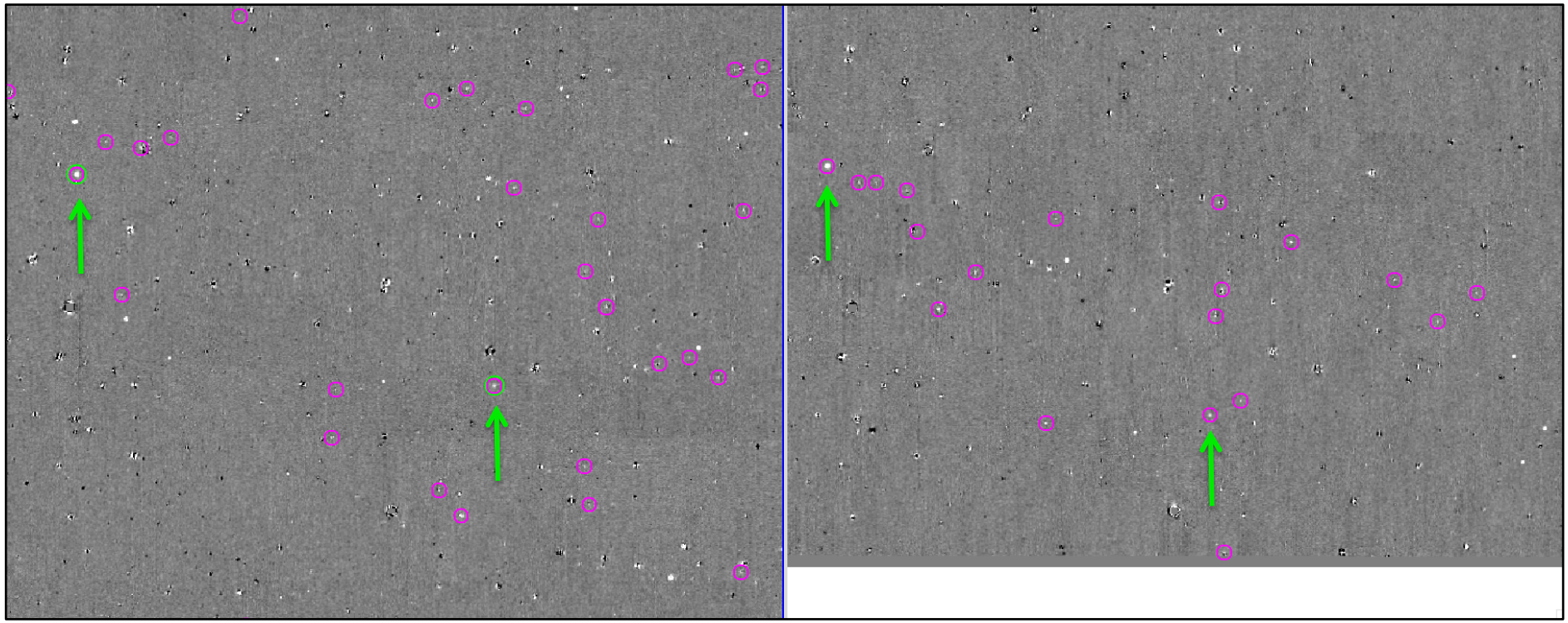
- field ~ 26 x 32 arcmin^2 field
- galactic latitude ~ 10 deg.
- co-add created from epoch-2 (post-cryo) frames
- field contains **two known asteroids**; see difference images on next slide



W2 difference images containing asteroids

single exposure #1 – reference

single exposure #2 [+ 3.2 hrs from #1] – reference



magenta = transient/variable candidates from WIDE
green = known asteroids, which moved appreciably between the above exposures