VERA C. RUBIN OBSERVATORY

Satellite Streak Masking Challenge

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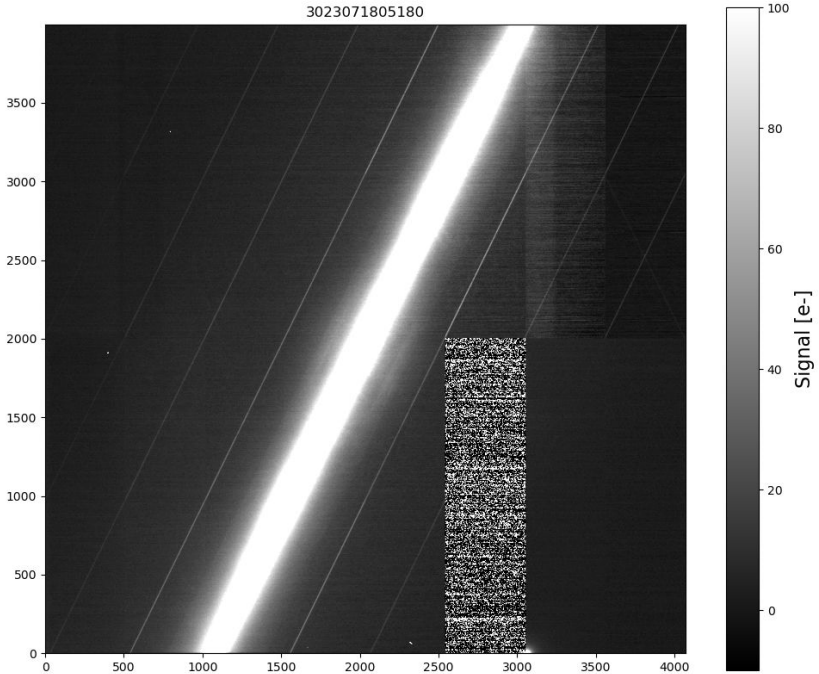
Introduction

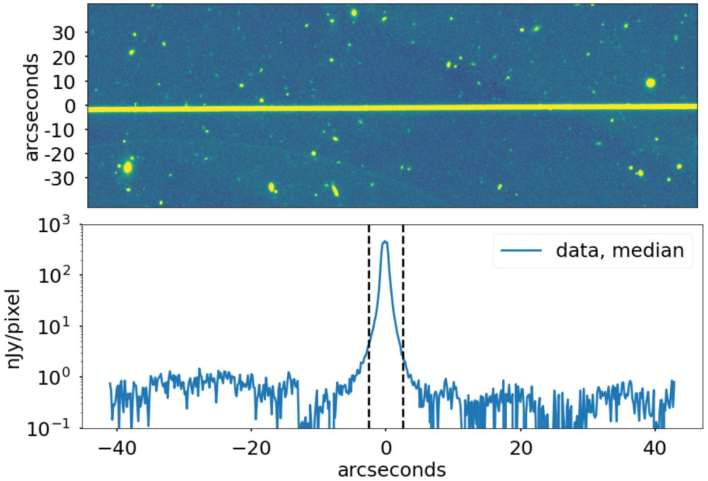


LSST Beam Simulator CCD image of a satellite streak showing crosstalk (see poster by Daniel Polin).

Proliferation of Low Earth Orbit (LEO) satellites will increase the number of satellite streaks in individual exposures.

Calibrating and correcting the crosstalk is only one aspect, it is still necessary to identify and mask the main trail.

Introduction (continued)



Satellite trail in a 300s i-band HSC exposure. Typical faint galaxies in the LSST gold sample have a surface brightness of ~2 nJ/pixel.
Hasan et al (2022)

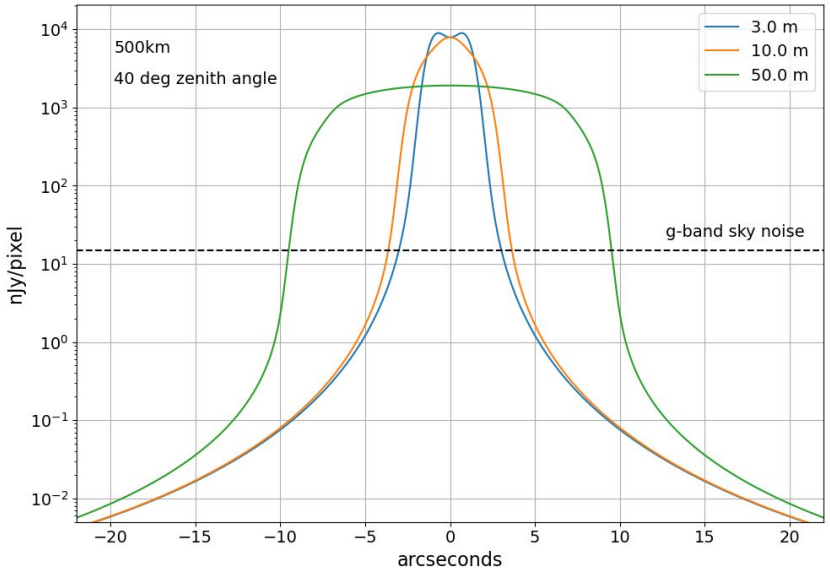
The wings of satellite streaks have surface brightness comparable to the faint galaxies in LSST “gold sample”, that can introduce systematics through:

- Residual spill-over light.
- Lines of “bogus galaxy detections”.

Streak Surface Brightness Profiles

Surface brightness profile depends on:

- Apparent brightness.
- Size of satellite reflective elements.
- Telescope primary mirror size.
- Orbital height.
- Zenith angle.
- Atmospheric seeing.



Simulated satellite trail profiles for 3 differently sized satellites as observed by the Rubin Observatory.
Nourbakhsh et al (in prep)

Simulation tools at:

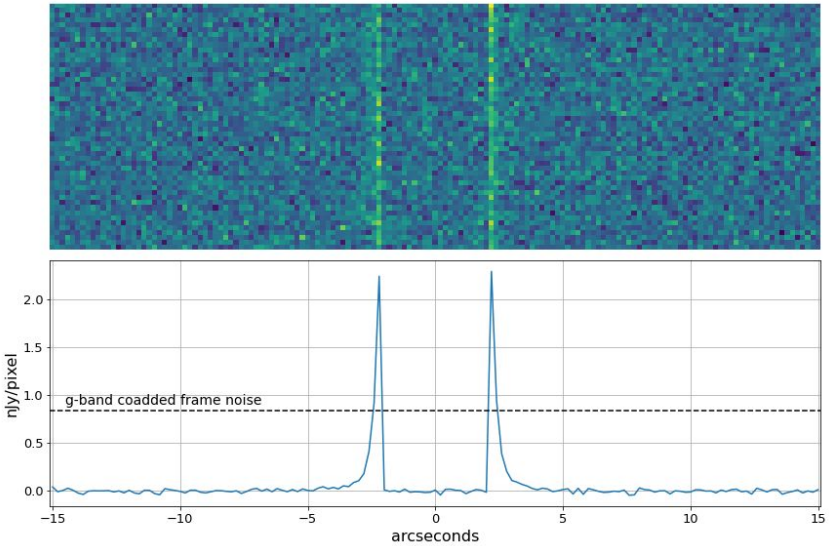
https://github.com/Snyder005/leosim

Bogus Galaxy Detections

It is challenging to prevent the occurence of bogus galaxy detections in all cases, due to:

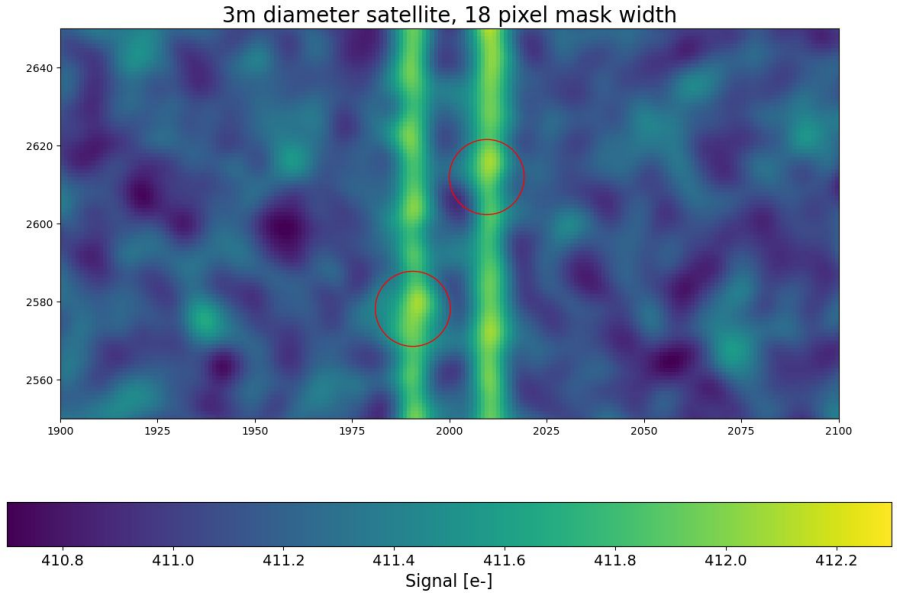
- Variability of streak profiles and mask widths
- Differences in coadd assembly
- Source detection parameters

We can study bogus galaxies using simulated 10-year coadd images.



Example sub-image of a 10-year g-band coadd frame containing an incompletely masked satellite streak. Sky background level has been subtracted.

Bogus Galaxy Occurrence Example #1

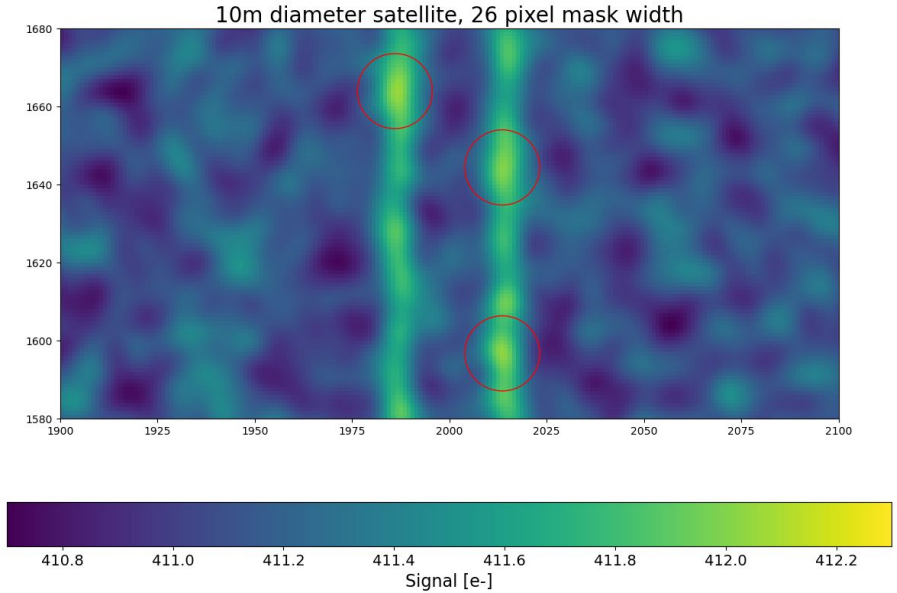


Simulated masked trail in 10-year coadd image (smoothed by the PSF) and example bogus detections.

Example Population:

- 3.0 meter diameter satellite
- 18 pixel wide mask
- 6.0 g-band magnitude
- 5σ detection threshold

Bogus Galaxy Occurrence Example #2

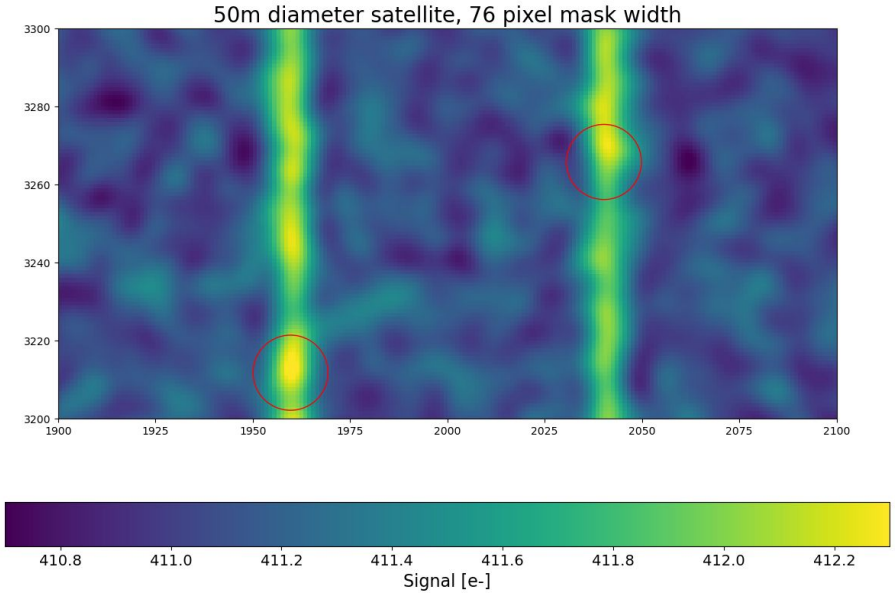


Simulated masked trail in 10-year coadd image (smoothed by the PSF) and example bogus detections.

Example Population:

- 10.0 meter diameter satellite
- 26 pixel wide mask
- 6.0 g-band magnitude
- 5σ detection threshold

Bogus Galaxy Occurrence Example #3

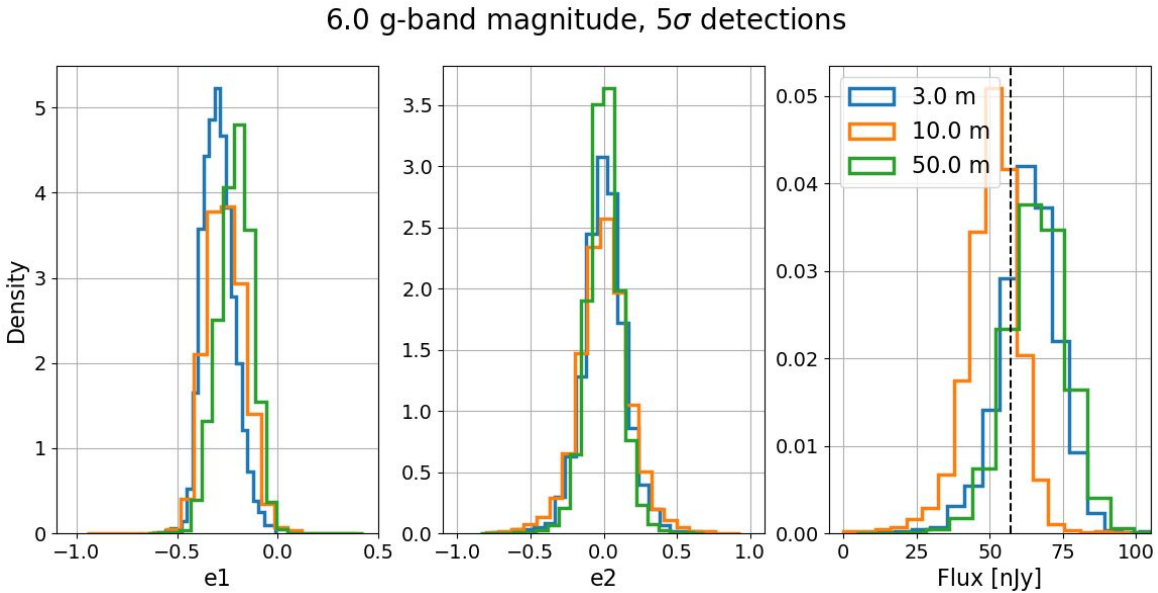


Simulated masked trail in 10-year coadd image (smoothed by the PSF) and example bogus detections.

Example Population:

- 50.0 meter diameter satellite
- 76 pixel wide mask
- 6.0 g-band magnitude
- 5σ detection threshold

Bogus Galaxy Properties

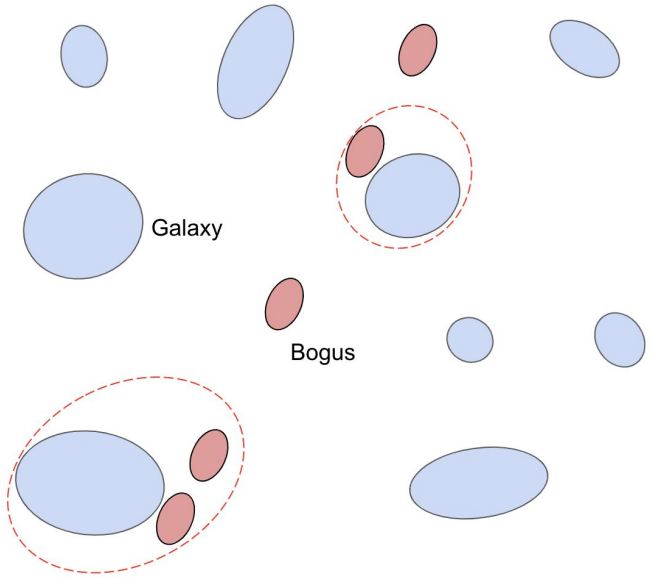


“Populations” of bogus galaxies have similar distributions of ellipticity and flux.

Cosmological Impact

Each residual line of flux at the mask edge (2 per trail) can result in up to 1 detection every 50 arcseconds.

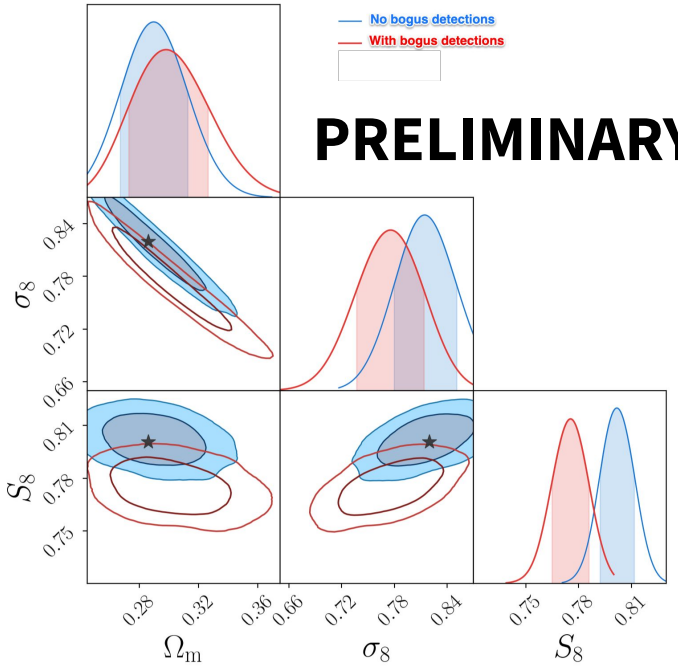
Blending of bogus galaxies and true galaxies introduces spurious shear correlations.



Blending of real (blue) and bogus (red) galaxies.
Nourbakhsh et al (in prep)

Cosmological Simulation

1. Generate an LSST-like catalog of galaxies from an N-body catalog of billions of galaxies.
2. Emulate real+bogus galaxy blending.
   a. Injection of bogus galaxy populations.
   b. Group real and bogus galaxies.
   c. Verify consistency with LSST observations.
   d. Reassign magnitudes and ellipticities.
3. Compare results of cosmological analyses for real and real+bogus catalogs.



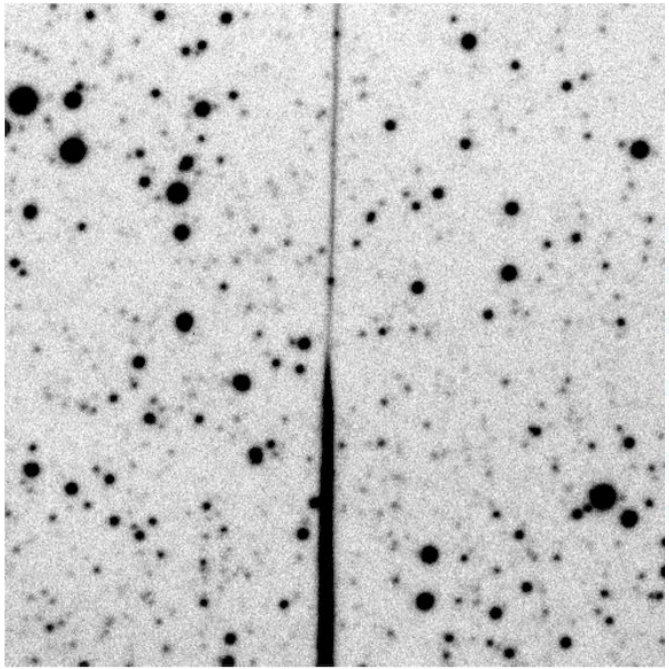
Cosmological inference from only the real galaxies (blue), and including those blended with bogus galaxies (red).
Nourbakhsh et al (in prep)

Streak Masking Challenge Summary

1. Identification of satellites in individual visit exposures.
2. Determination of an appropriate mask width.
3. Prevention of bogus galaxy detections in all cases.

Further complicated by variation of surface brightness profile along the trail.

- Bogus transient events.



A satellite trail whose surface brightness profiles varies along the direction of the trail.
Paillassa et al (2020)

Acknowledgements

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