unWISE: unblurred coadds of the WISE images & photometry of 400,000,000 SDSS sources

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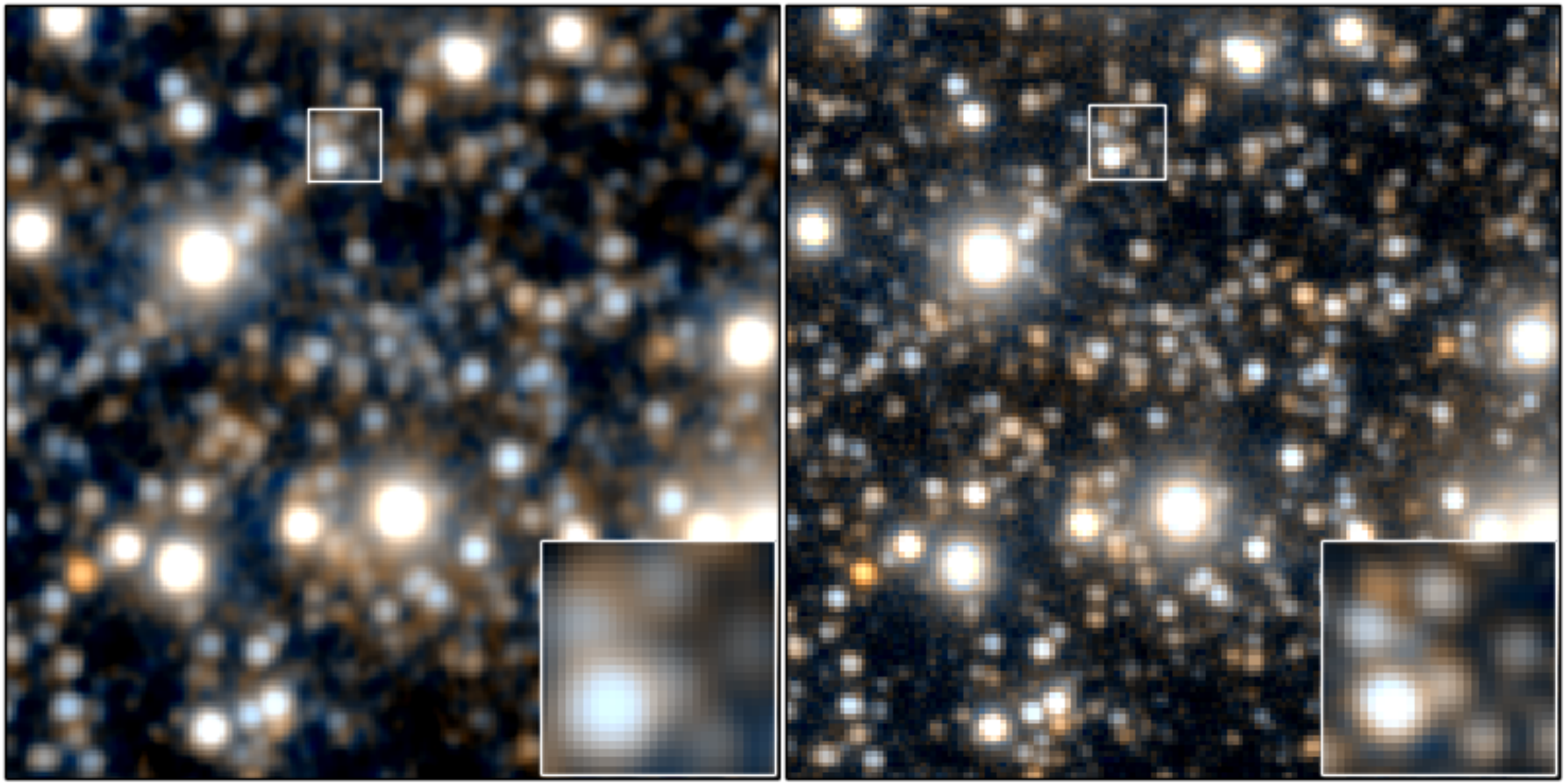
WISE at 5, Pasadena, 2015-02-11

Credits

- This work would not have been possible without the timely and beautifully calibrated data releases from the WISE team
- (In particular the Level 1b calibrated frames — please please please release the Level 1b data products for NEOWISE-R!)
- This is joint work with David Hogg (NYU) and David Schlegel (LBL)
- Compute power provided by NERSC, the DoE's National Energy Research Scientific Computing center
- If the anonymous reviewer is in the audience: Thank you!

unWISE: unblurred coadds

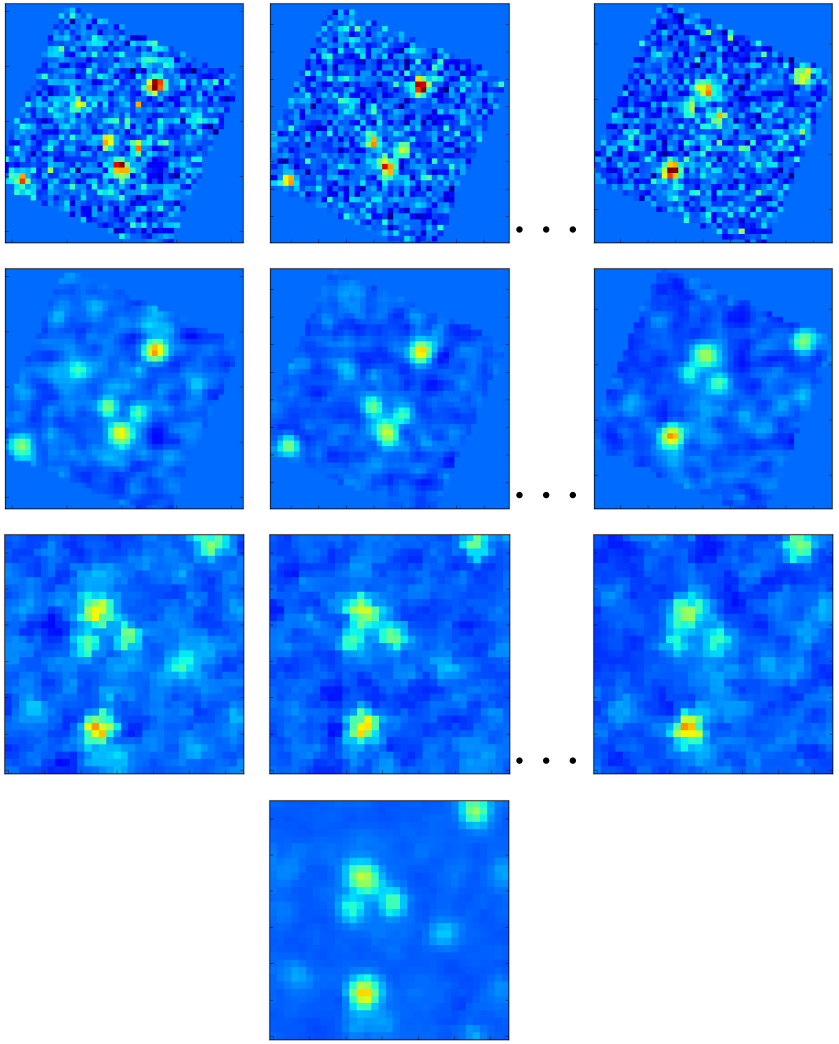


WISE Atlas image unWISE coadd

W1/W2 composite, North ecliptic pole (tile 2709p666), 6 arcmin square

Why the WISE Atlas Images are blurry

- Atlas Images are a by-product of the WISE catalog
- Optimal detection of point sources in image collections:
  - convolve by the PSF — blur
  - resample to a common pixel grid
  - sum (co-add)



Why the unWISE Coadds aren't blurry

Built to retain the resolution of the original WISE images

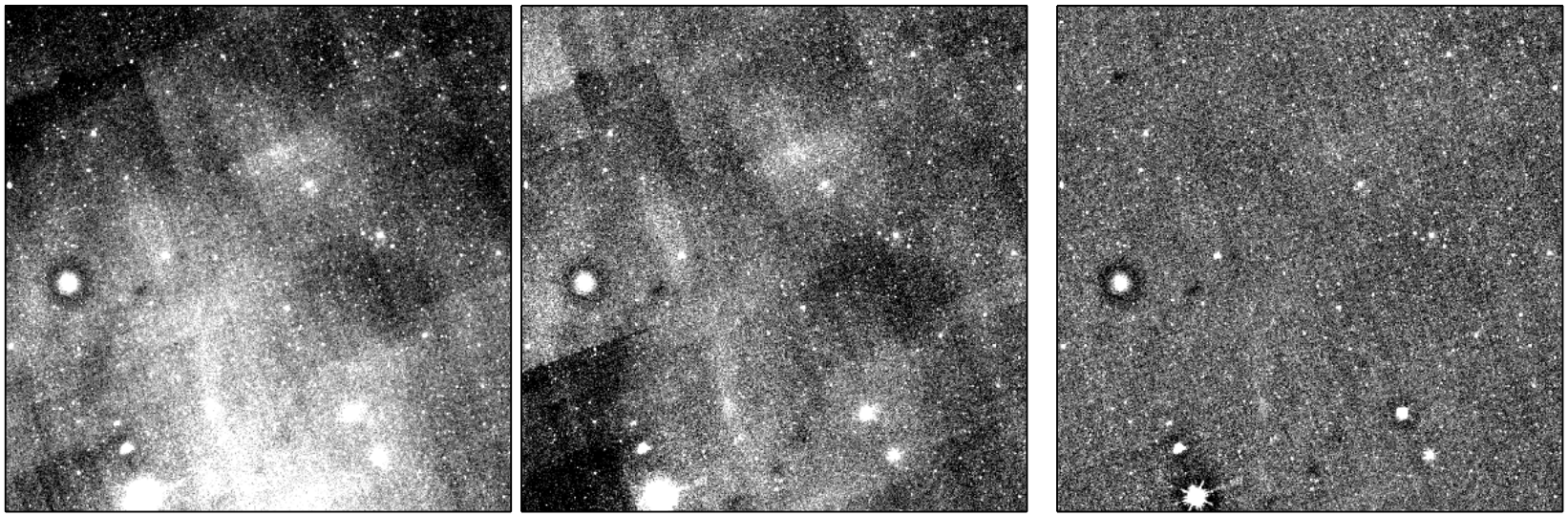
- ~~*convolve* by the PSF~~
- resample to a common pixel grid
- sum (co-add)

Why this works:

- WISE images are well-sampled
  (the pixels capture all the available information)
- $\rightarrow$ Shannon sampling theorem from the 1940s applies
  (can resample to a different pixel grid without loss of information)
- WISE PSF is beautifully stable, so the results are useful

“Should I used them?”

- (Obviously biased opinion:) In general, yes
- (especially if resolution matters!)
- Except: for W3/W4, I subtracted a spatial median filter to reduce the instrumental background — but behaves badly around large, bright objects



WISE no med.filt unWISE (w/ med.filt)

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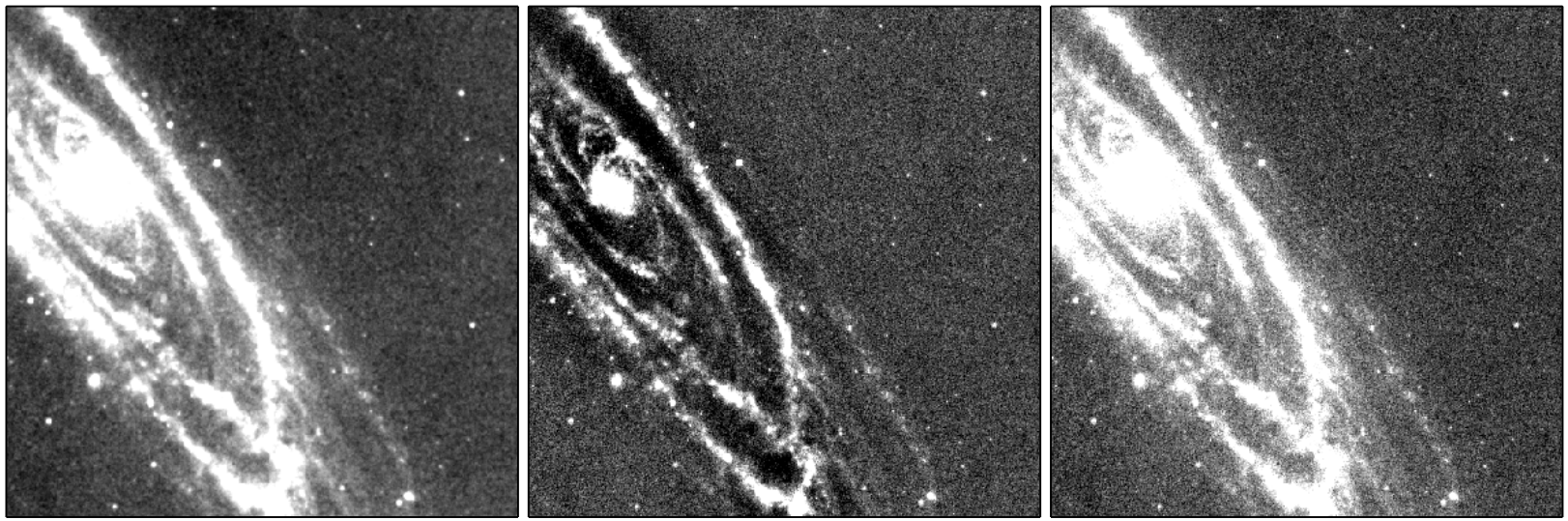


WISE unWISE no med.filt, bg-match

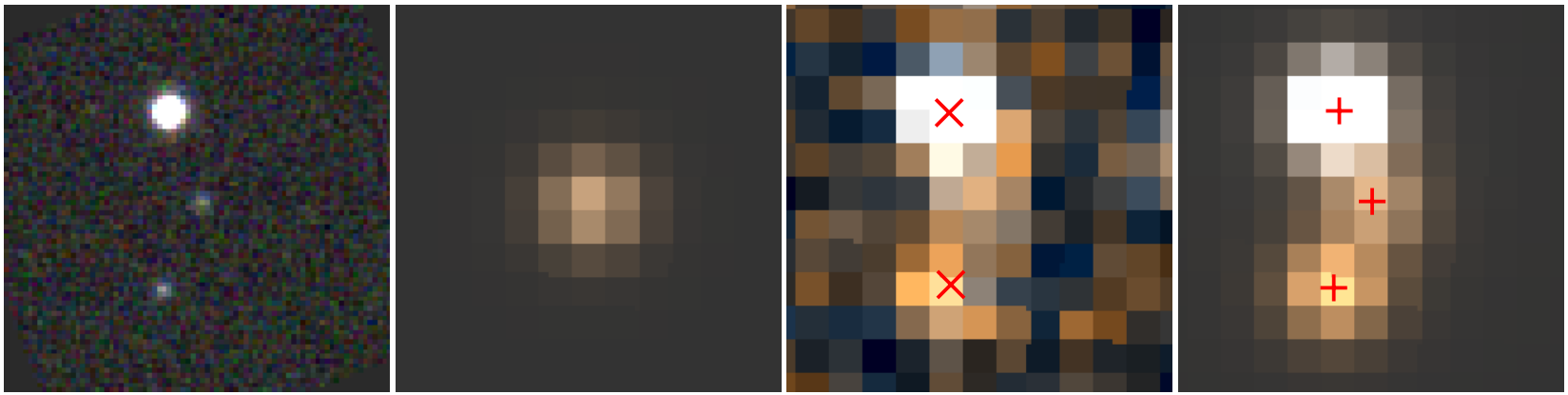
Questions about the unWISE coadds?

Before I move on to what we do with them. . .

WISE photometry of SDSS sources

"Forced photometry"

- take all SDSS object profiles (+ WISE-only sources)
- convolve by WISE PSF
- $\rightarrow$ What would these objects look like in WISE?
- fit a linear combination to best match the observed WISE image
- $\rightarrow$ WISE flux for each SDSS object



SDSS $\rightarrow$ WISE WISE Image Fit model

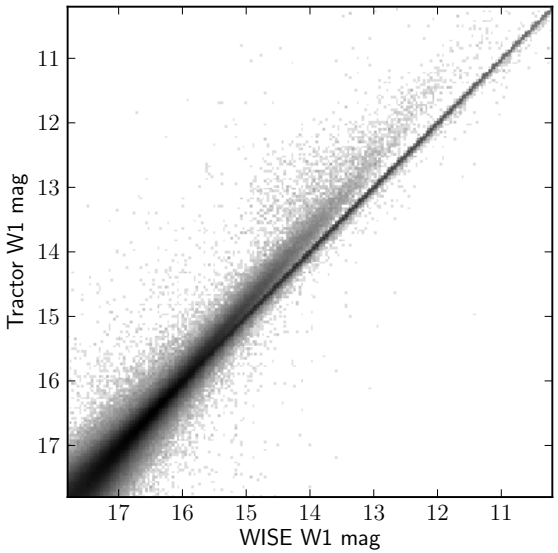
Benefits of forced photometry

- use resolution and depth of SDSS to interpret WISE
- (Note: does not increase signal-to-noise (precision) of the photometry — official WISE catalogs have optimal photometry *of the sources they detect*)
- but we photometer objects that are blended in WISE but resolved in SDSS
- and we produce a lot of few-sigma measurements that can be very useful!

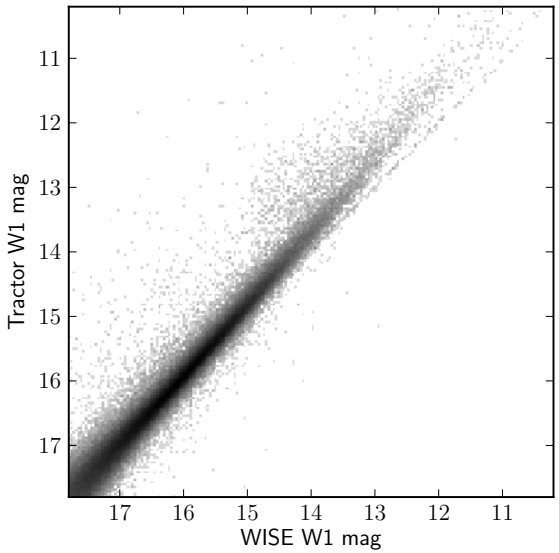
Comparison with AllWISE

W1, unique (one-to-one) matches

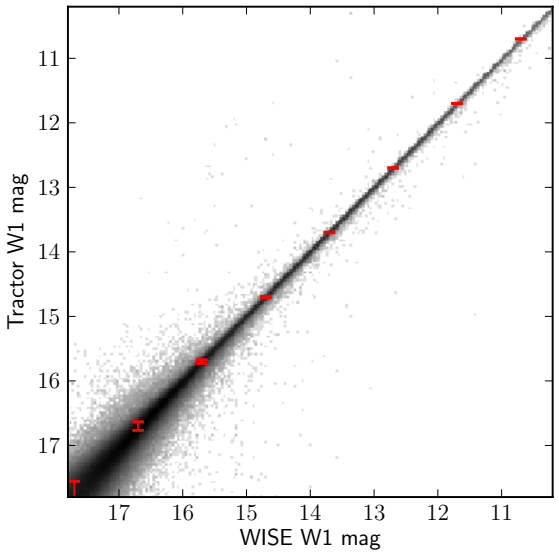
All Matches



Galaxies

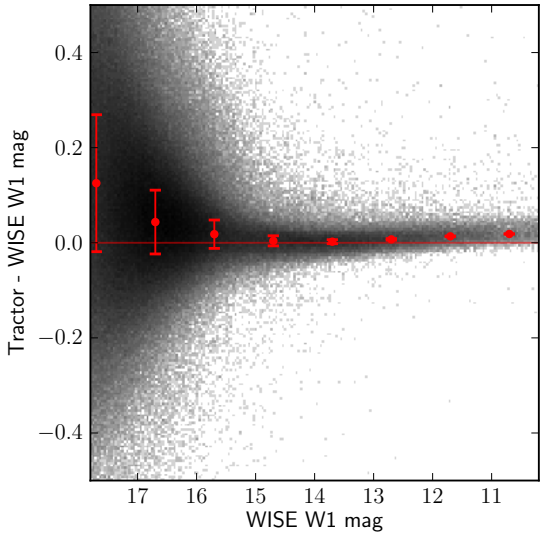


Stars

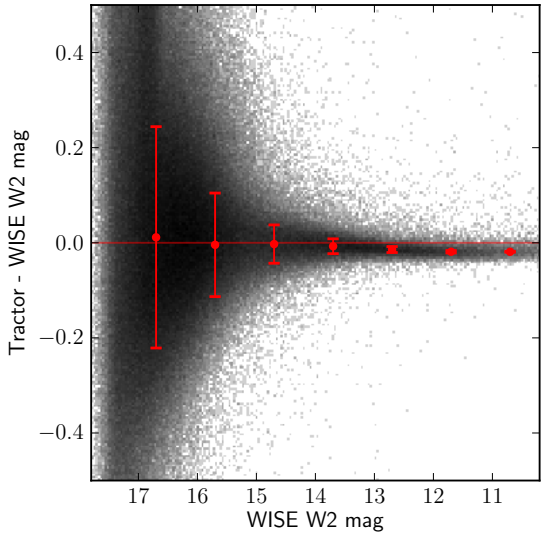


Comparison with AllWISE

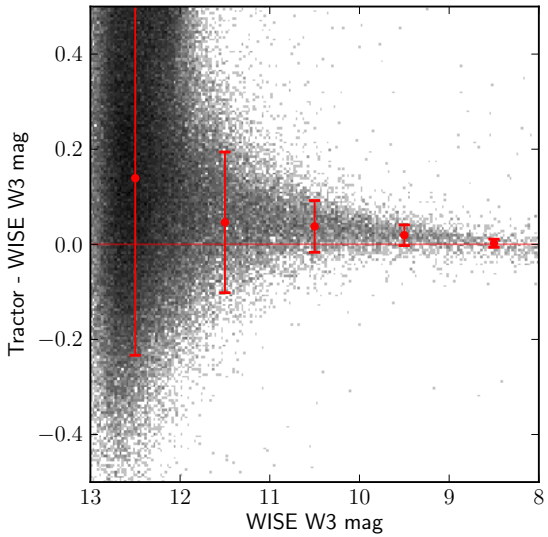
W1



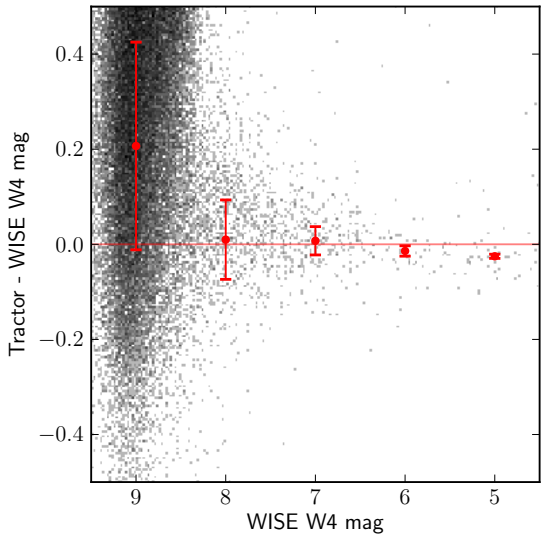
W2



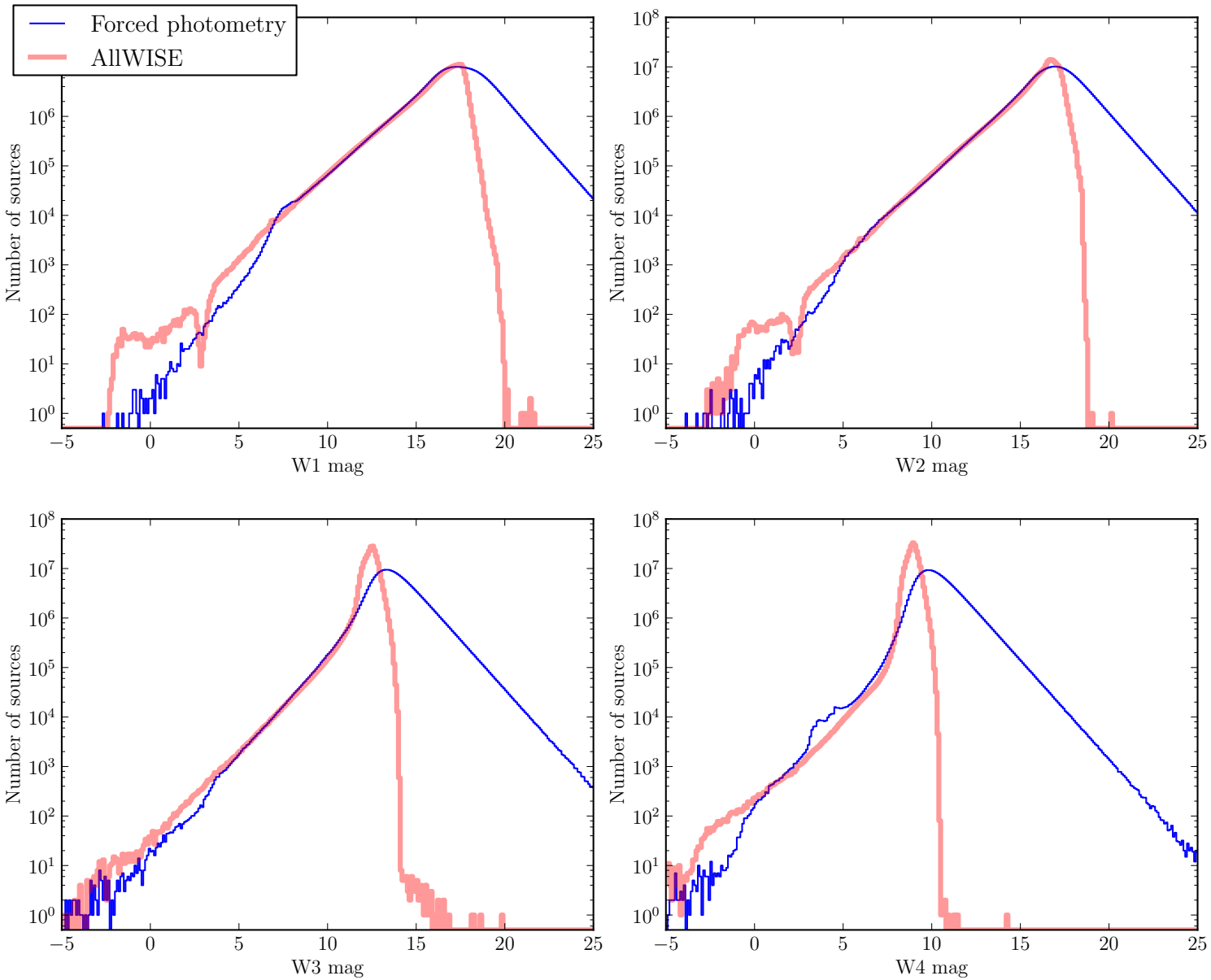
W3



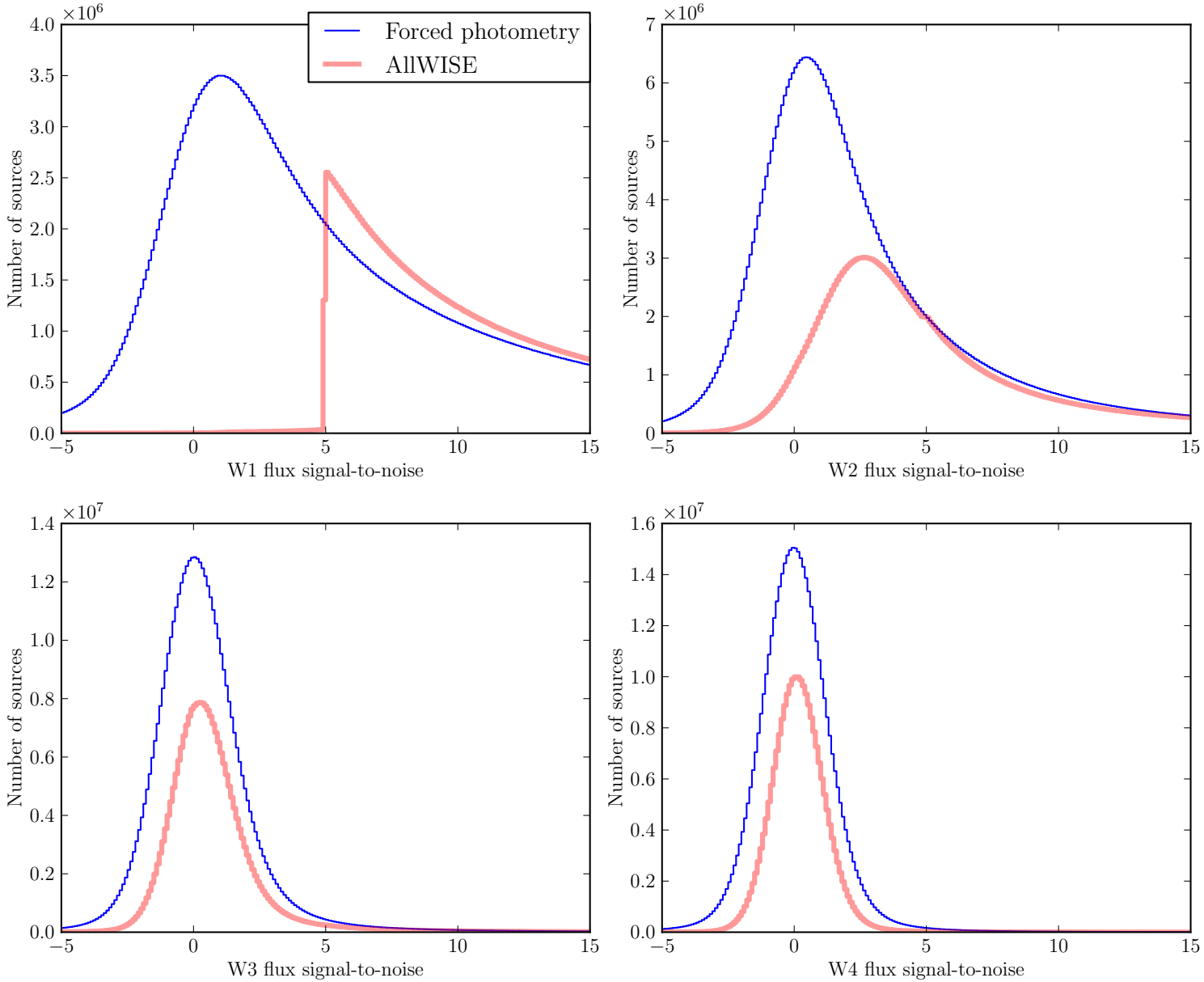
W4



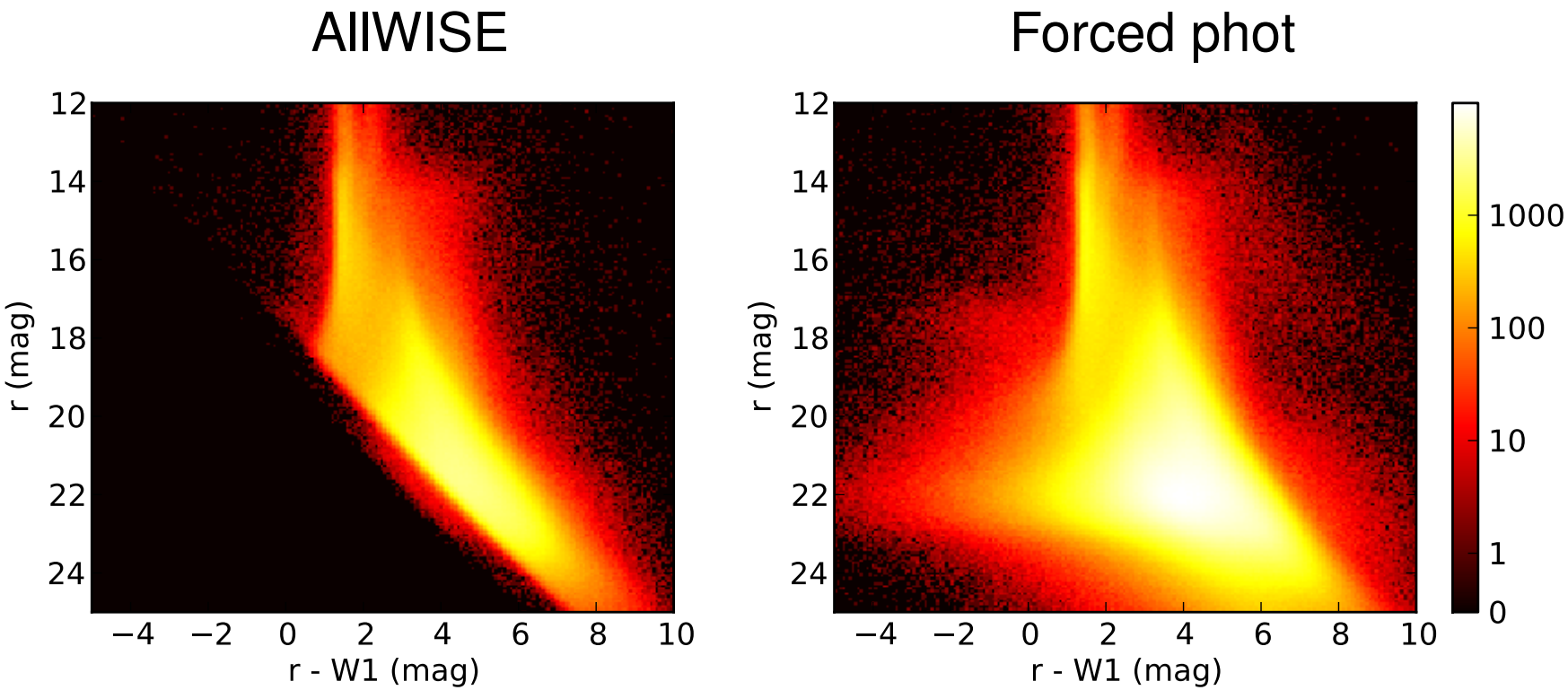
Comparison with AllWISE



Comparison with AllWISE



Comparison with AllWISE

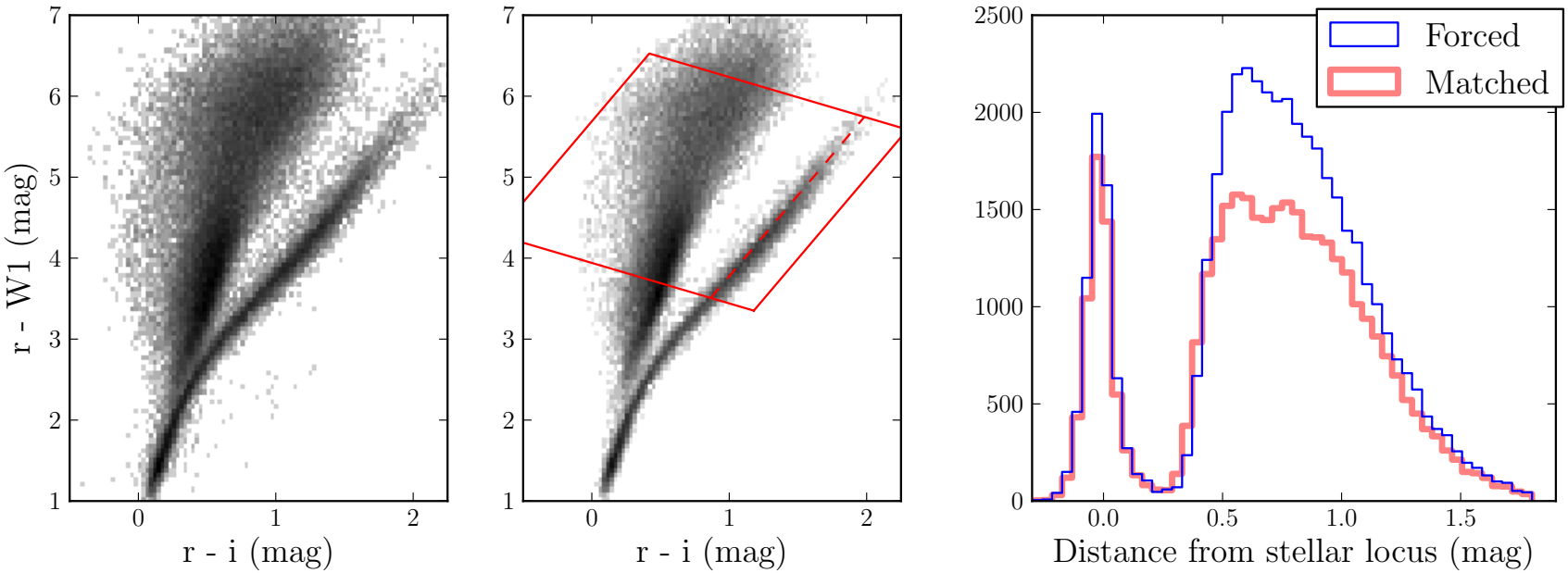


The utility of few-sigma measurements

Selecting Luminous Red Galaxies (LRGs) in SDSS/eBOSS

$$13 < \mathrm{W1} < 17$$

Matching Forced Photometry

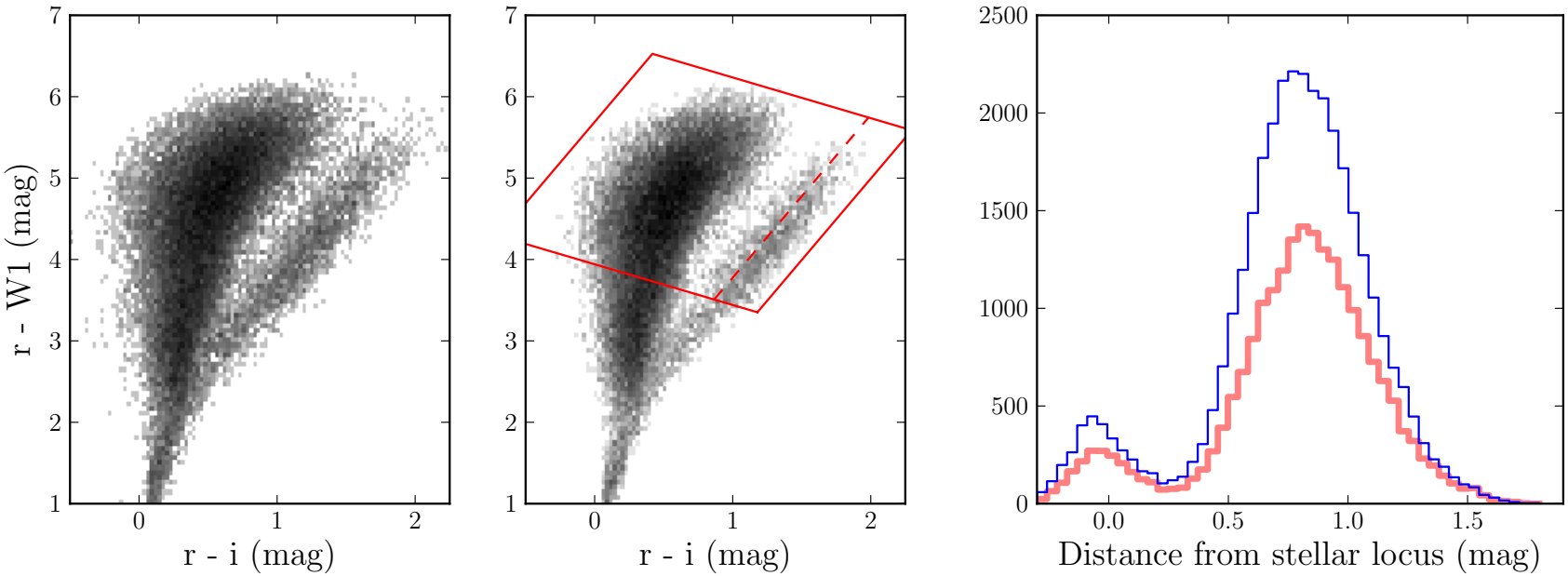


The utility of few-sigma measurements

Selecting Luminous Red Galaxies (LRGs) in SDSS/eBOSS

$$17 < \mathrm{W1} < 18$$

Matching Forced Photometry

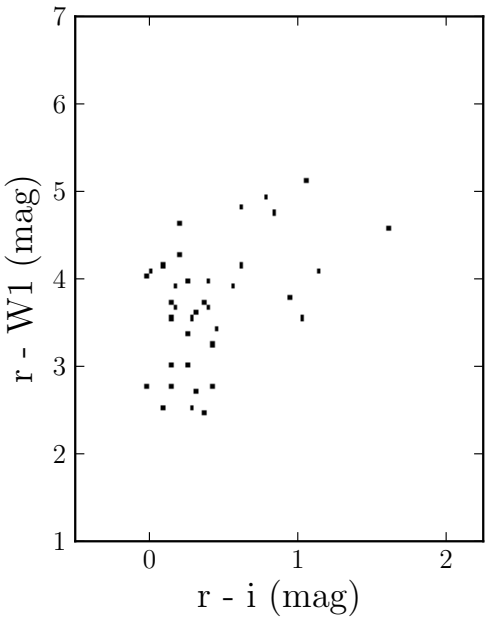


The utility of few-sigma measurements

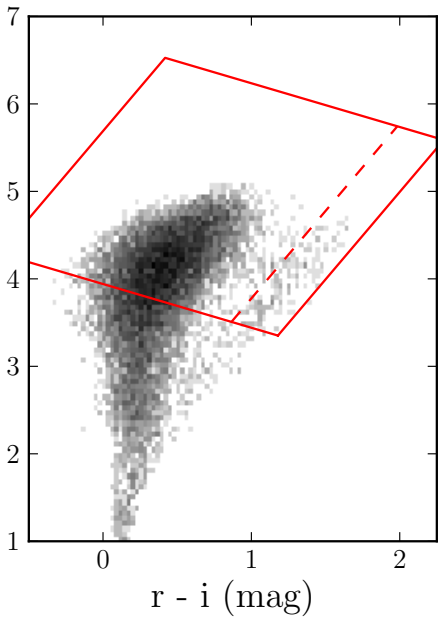
Selecting Luminous Red Galaxies (LRGs) in SDSS/eBOSS

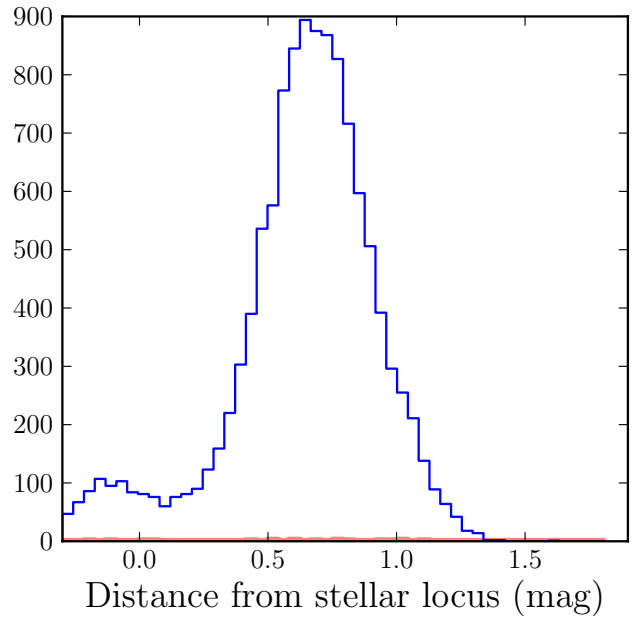
$$18 < \mathrm{W1} < 18.5$$

Matching



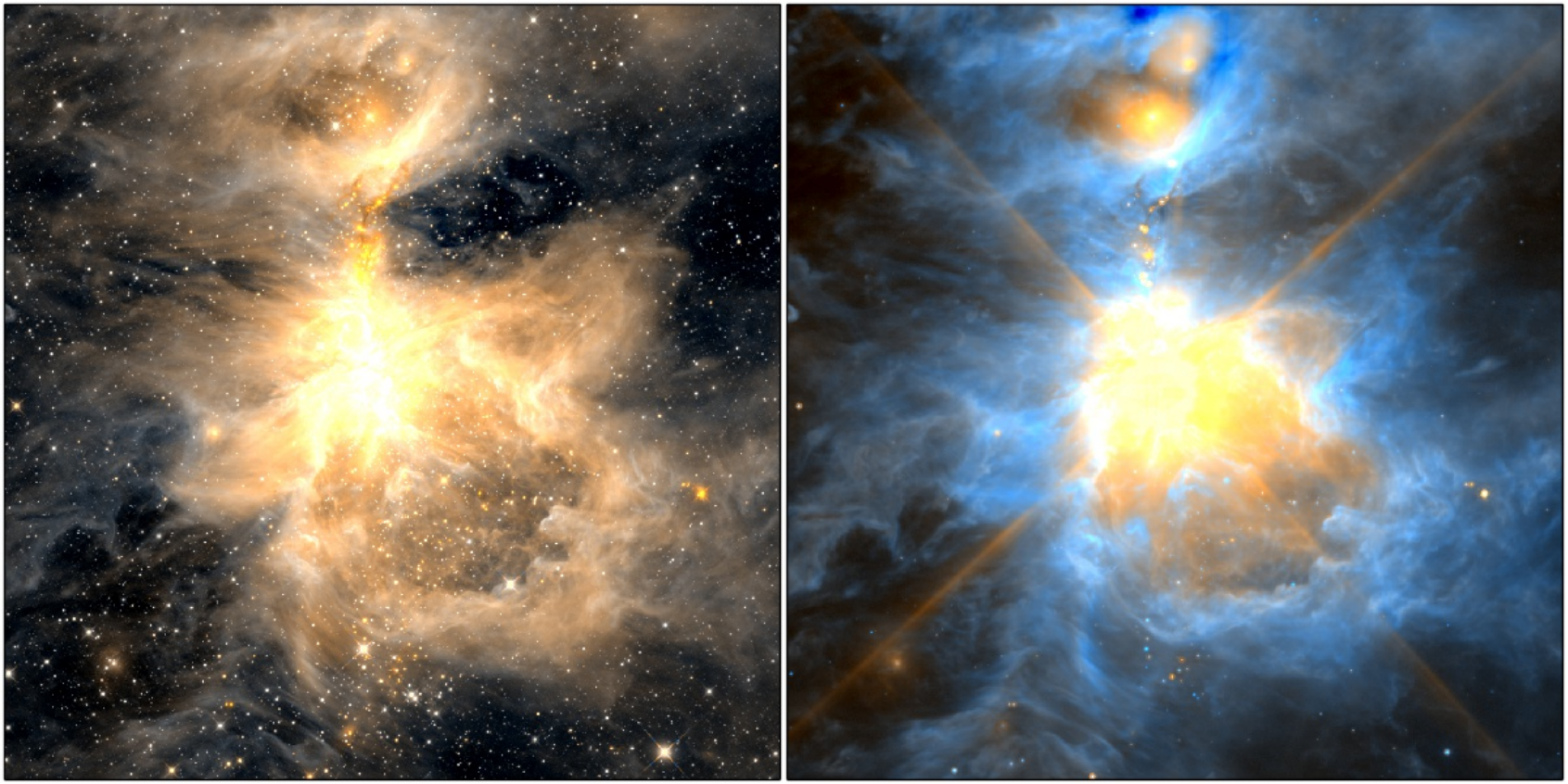
Forced Photometry





Thanks!

unWISE coadds: *arxiv:1405.0308*
SDSS/WISE photometry: *arxiv:1410.7397*
Data for both: *unwise.me*



Orion nebula: W1/W2 (left), W3/W4 (right)