

# The Effect of Unresolved Contaminant Stars on the Cross- Matching of Photometric Catalogues

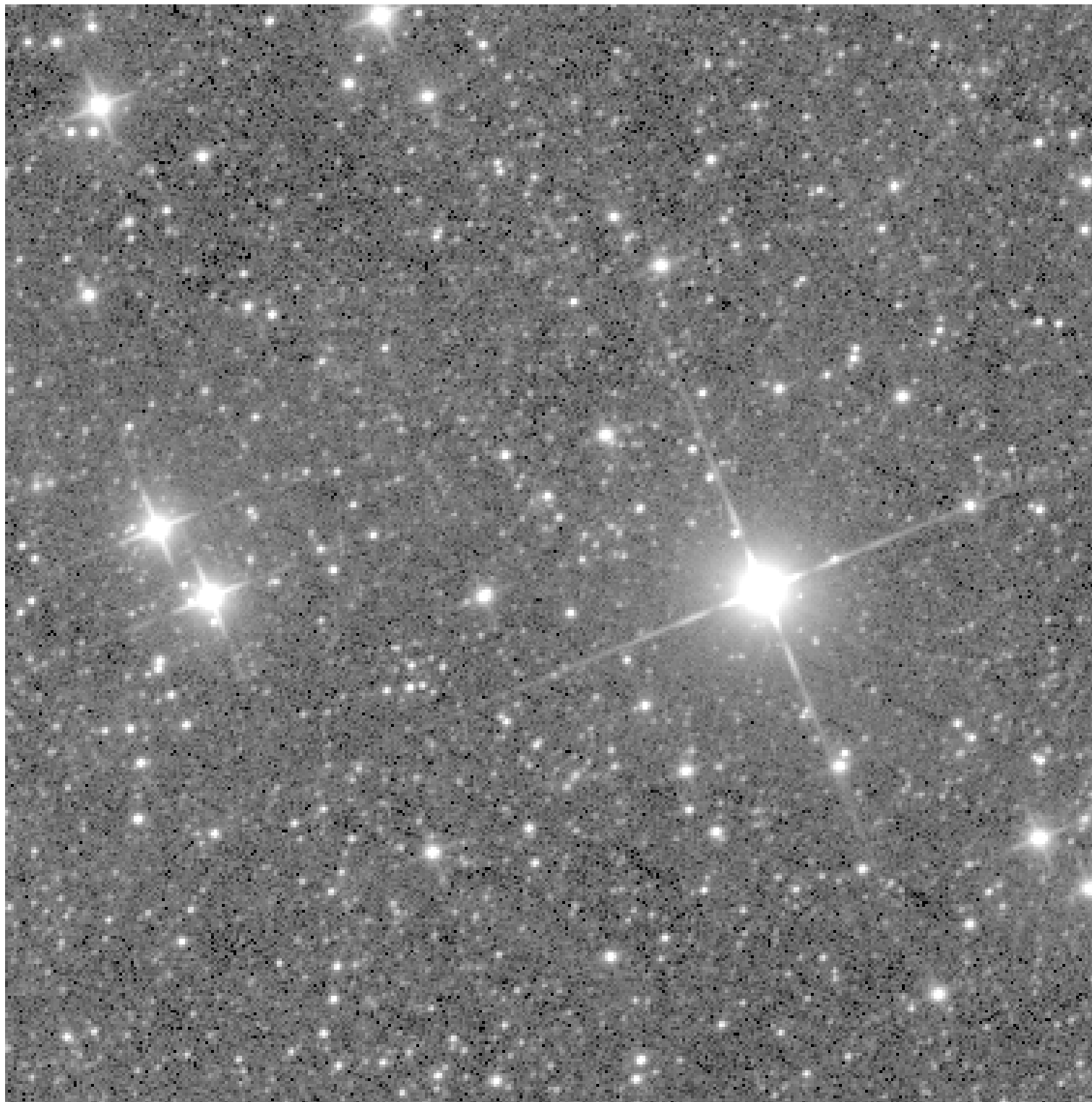
**Tom Wilson**, STScI

Tim Naylor, University of Exeter  
towilson@stsci.edu

HotSci, 6/26/19

Tom Wilson @onoastrmer

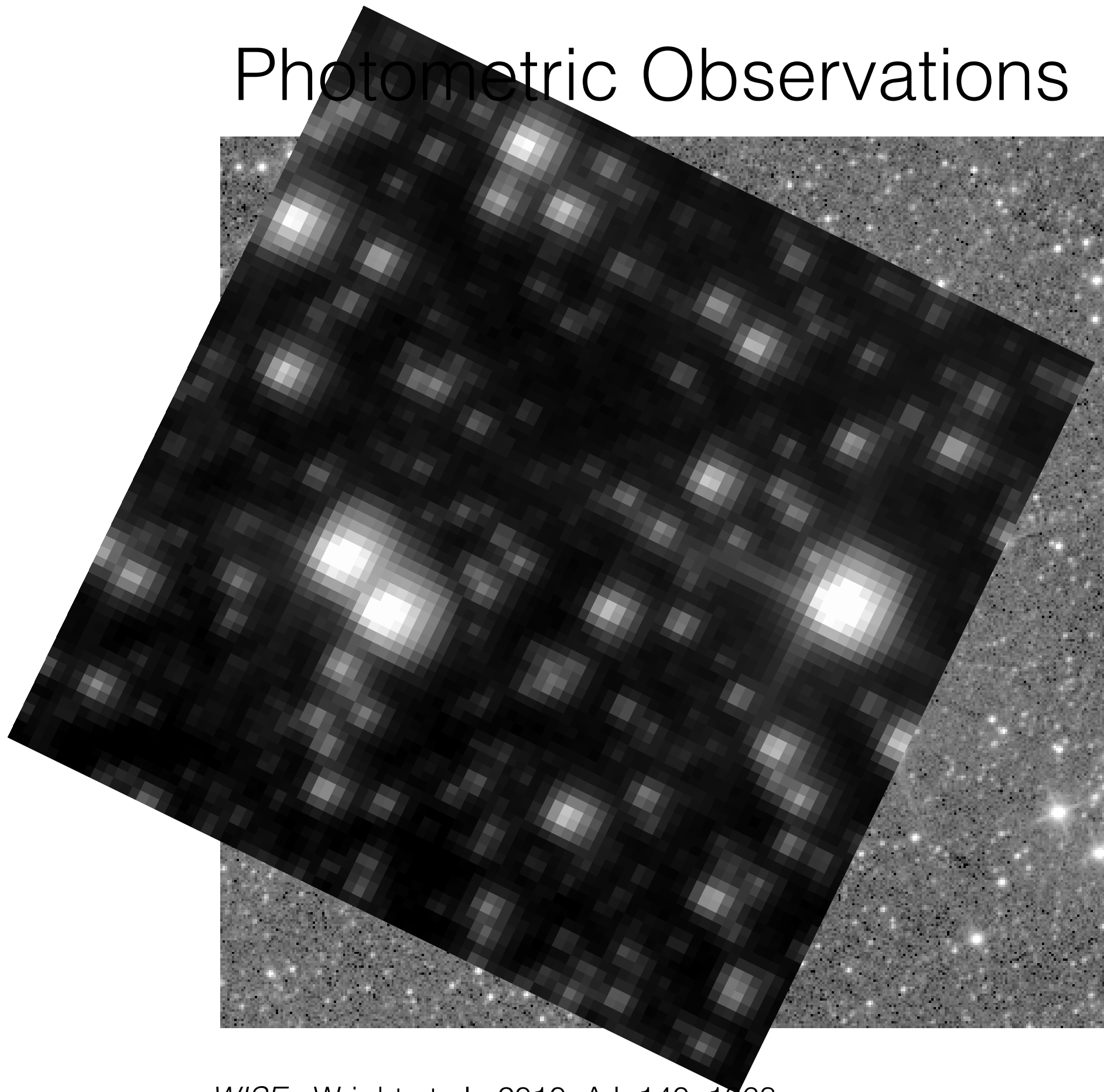
# Photometric Observations



*WISE* - Wright et al., 2010, *AJ*, 140, 1868

*WISE* W1  
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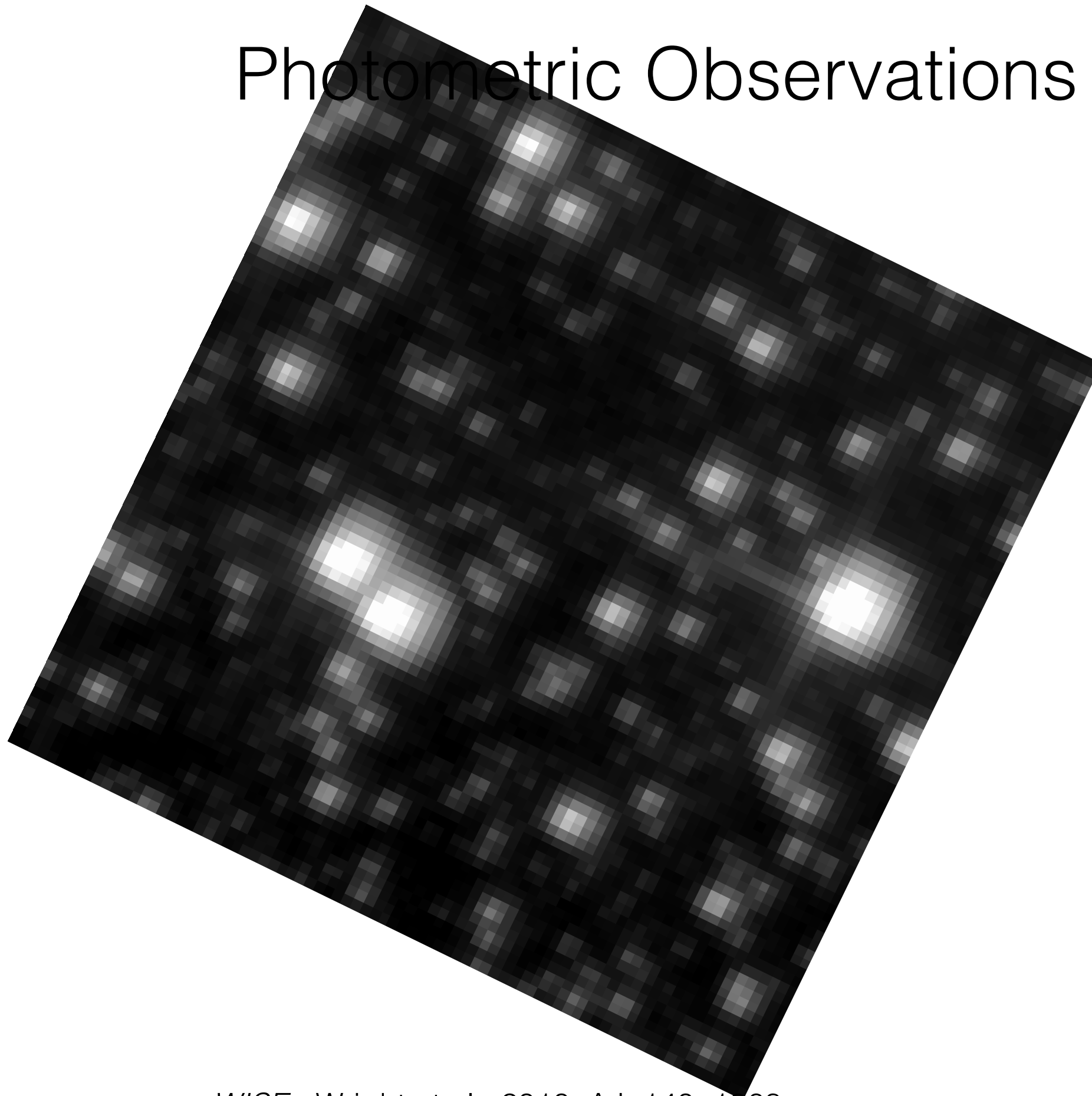
# Photometric Observations



*WISE* - Wright et al., 2010, AJ, 140, 1868  
*TESS* - Ricker et al., 2015, JATIS, 1, 14003

*TESS* T  
Tom Wilson @onoastrmer

# Photometric Observations



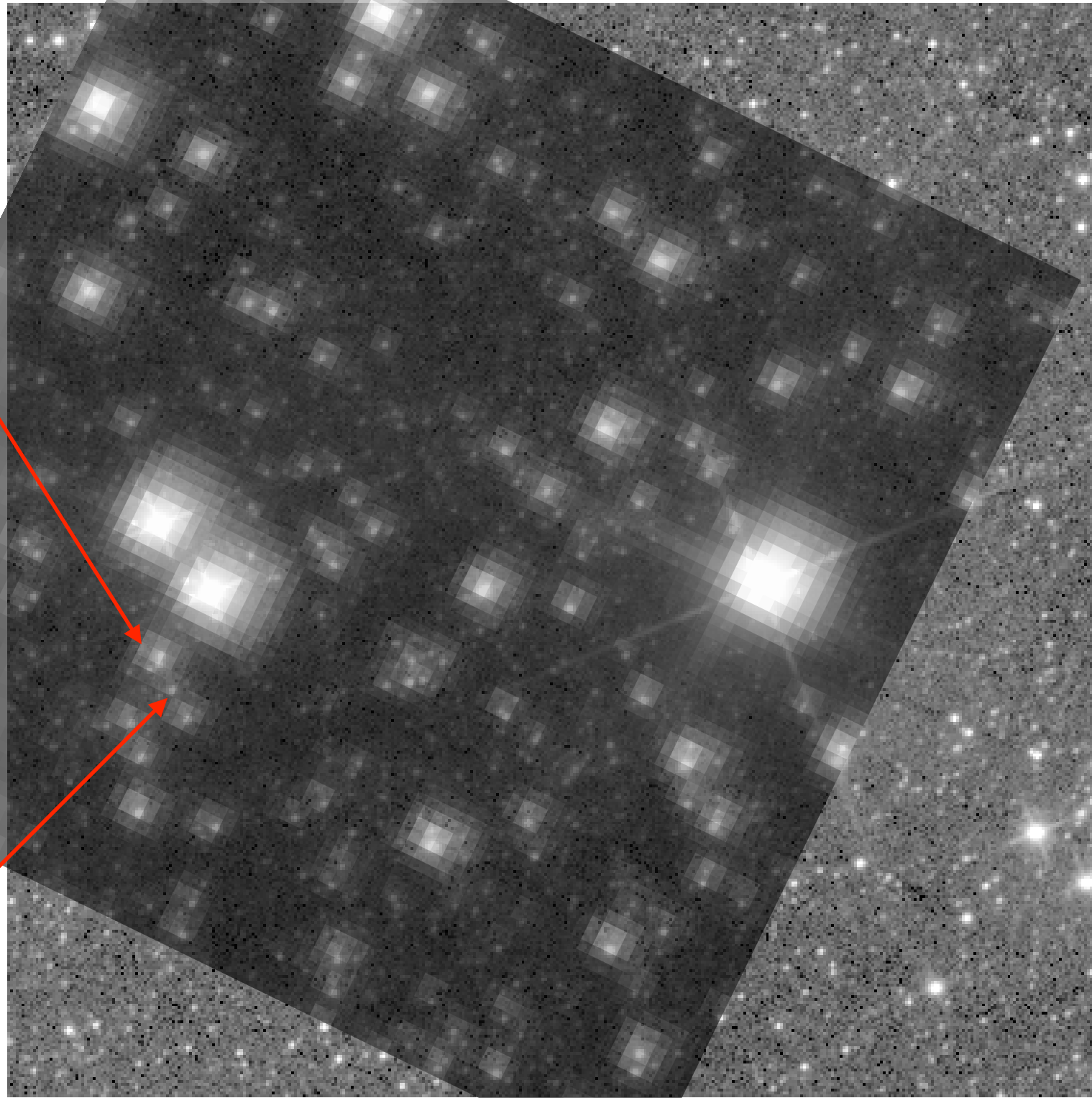
*WISE* - Wright et al., 2010, *AJ*, 140, 1868  
*TESS* - Ricker et al., 2015, *JATIS*, 1, 14003

*TESS* T  
Tom Wilson @onoastrmer

# Photometric Observations

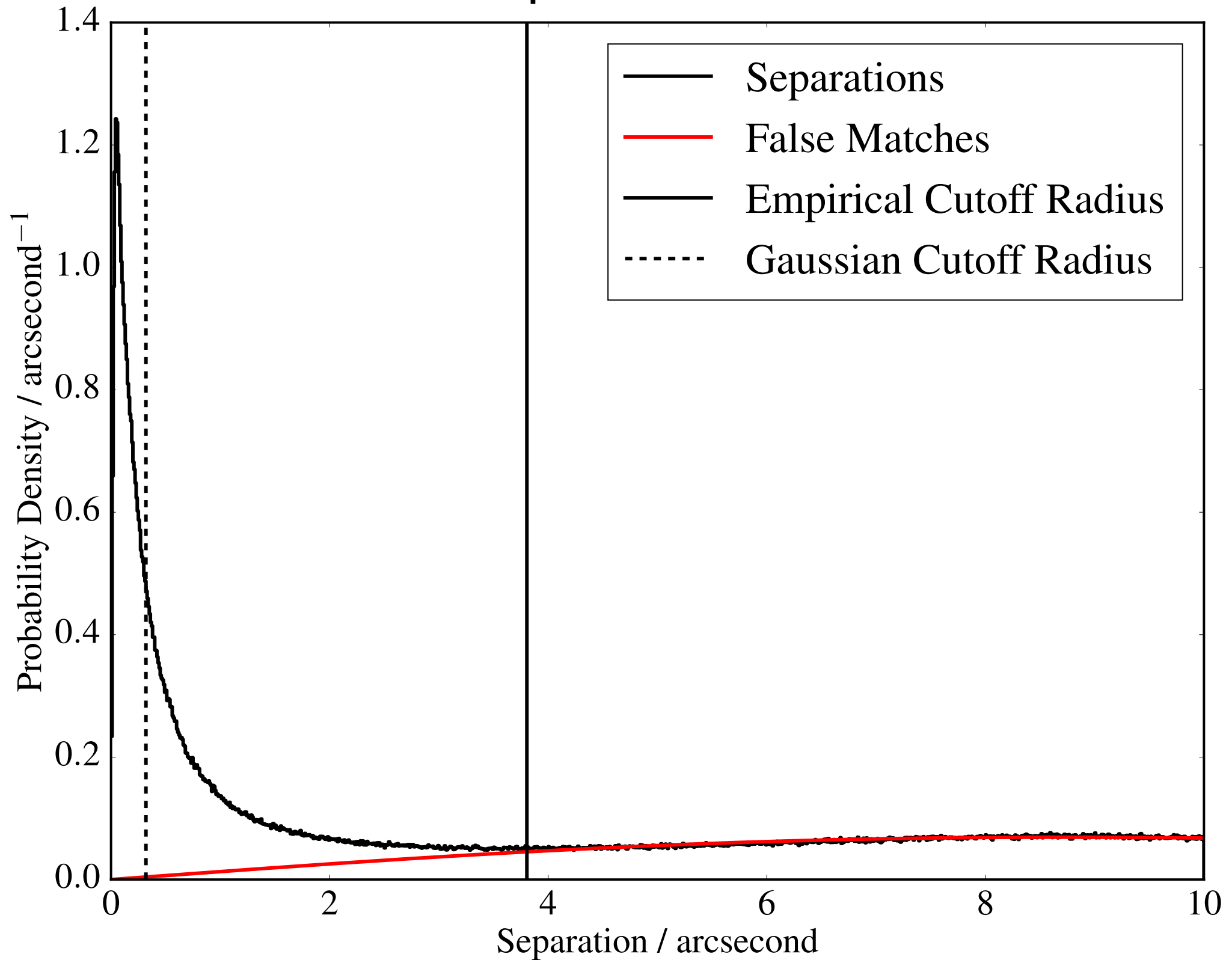
Unresolved  
double star  
“pair”!

Completely  
unresolved  
source!



*WISE* - Wright et al., 2010, *AJ*, 140, 1868  
*TESS* - Ricker et al., 2015, *JATIS*, 1, 14003

# Cross-match Separation Distributions

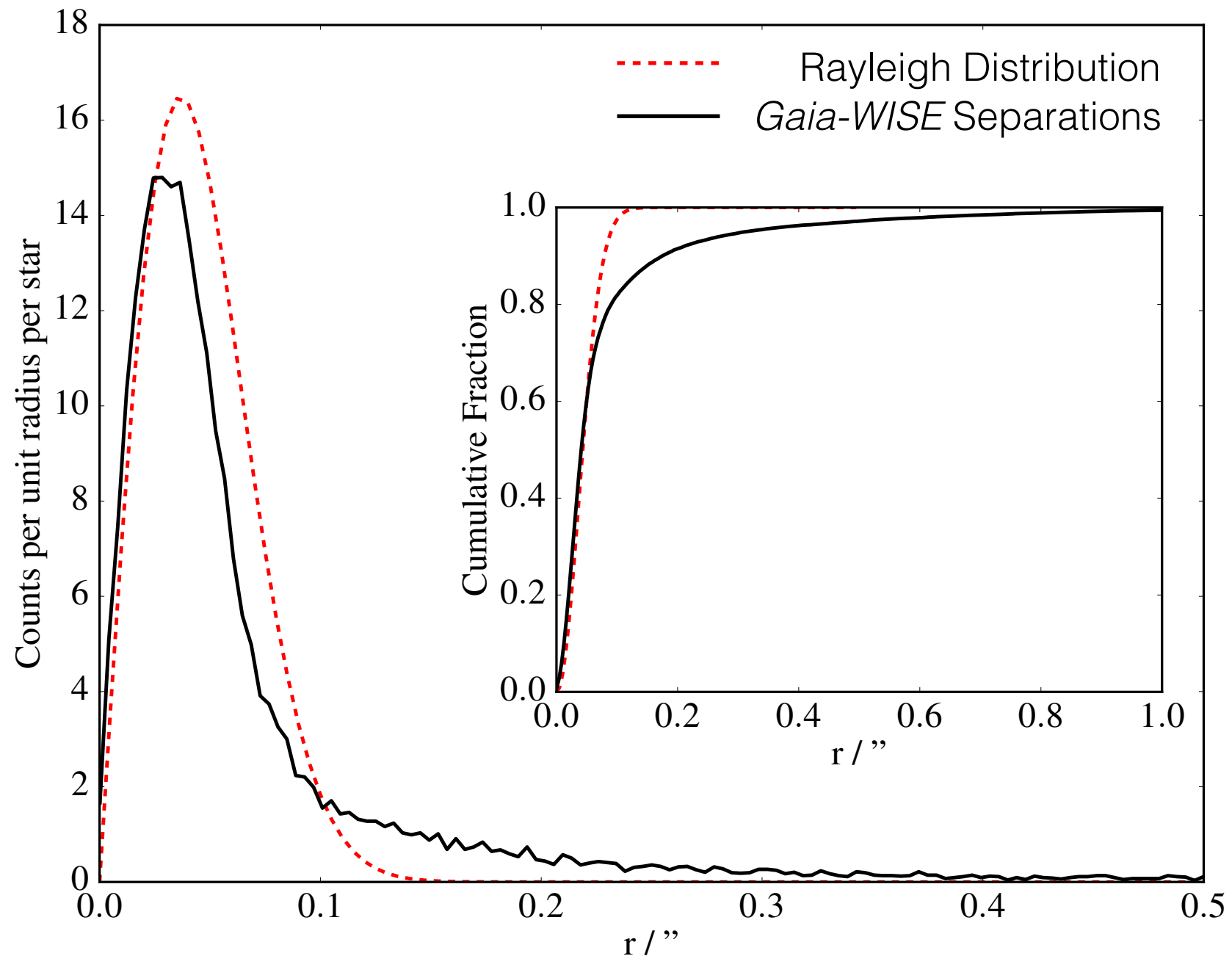
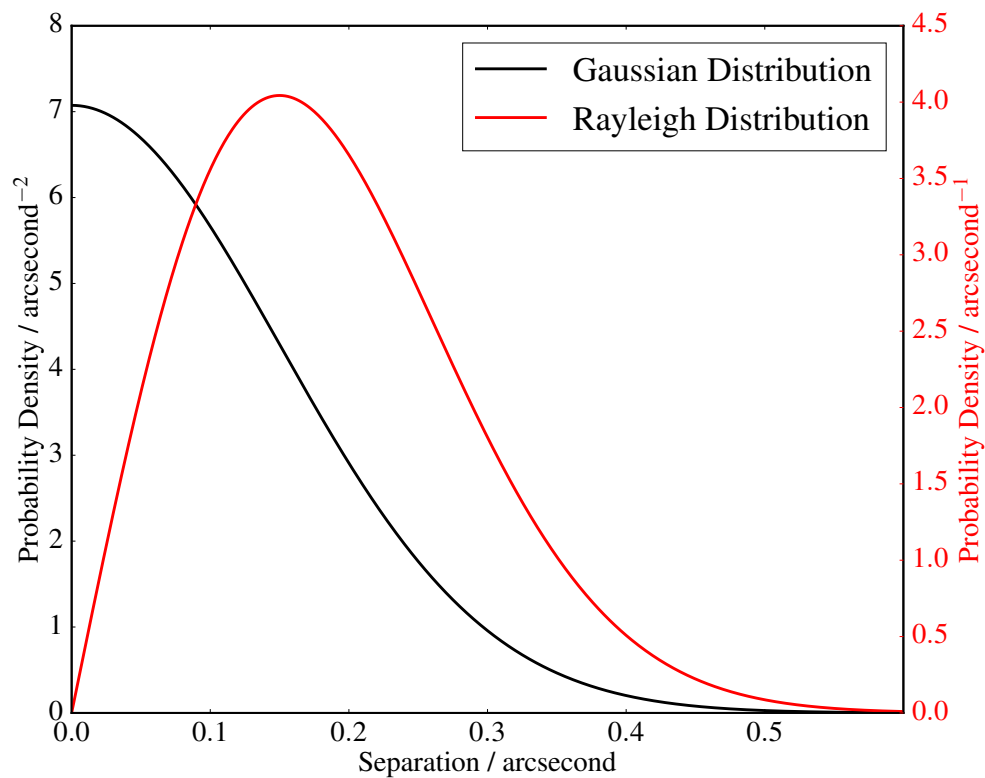


# The Astrometric Uncertainty Function

$$g(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

↓

$$g(r, \sigma) = \frac{r}{\sigma^2} e^{-\frac{r^2}{2\sigma^2}}$$



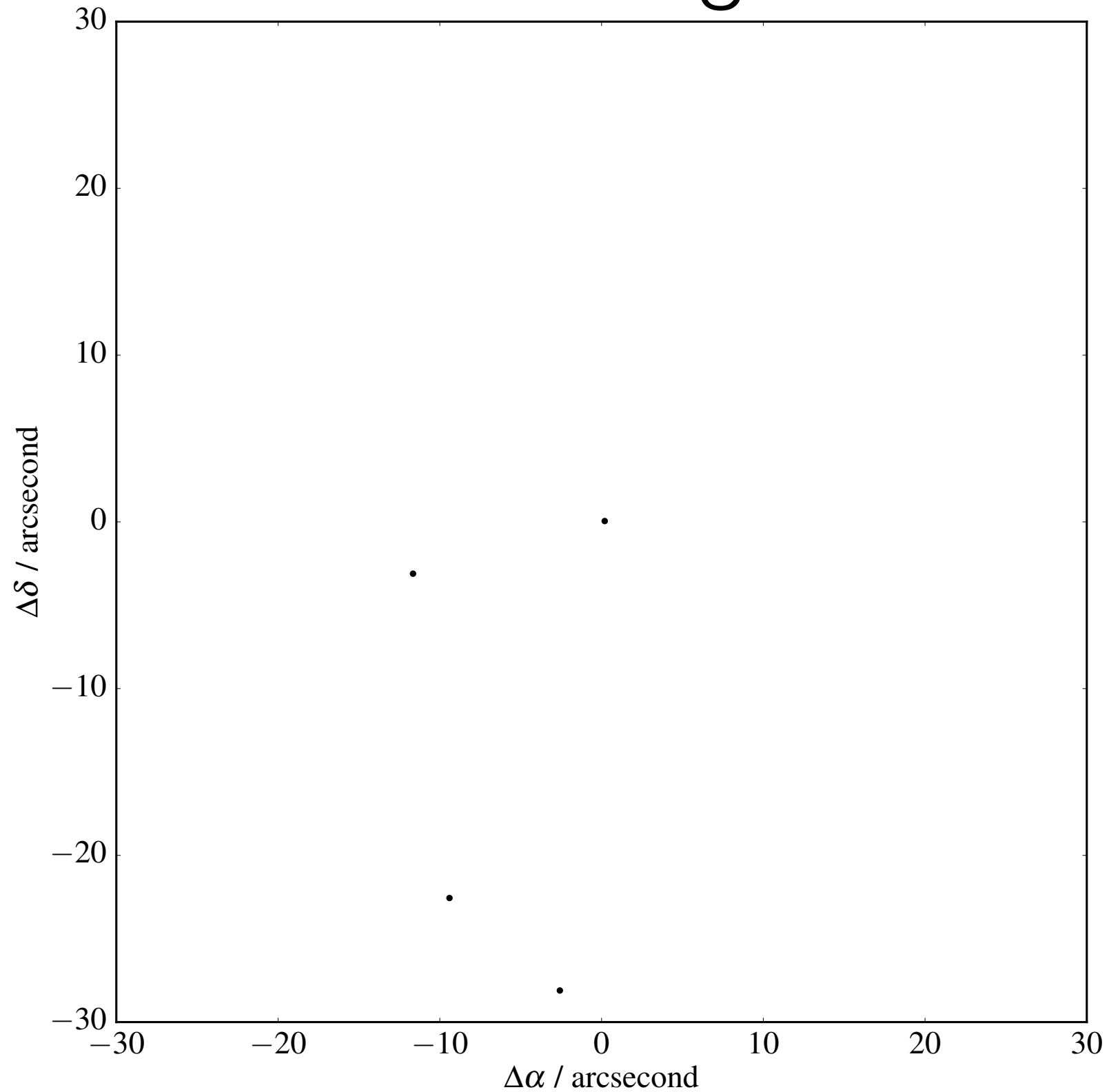
*Gaia* DR2 - Gaia Collaboration, Brown A. G. A., et al. 2018, A&A, 616, 1

*WISE* - Wright et al., 2010, AJ, 140, 1868

Wilson & Naylor, 2017, MNRAS, 468, 2517

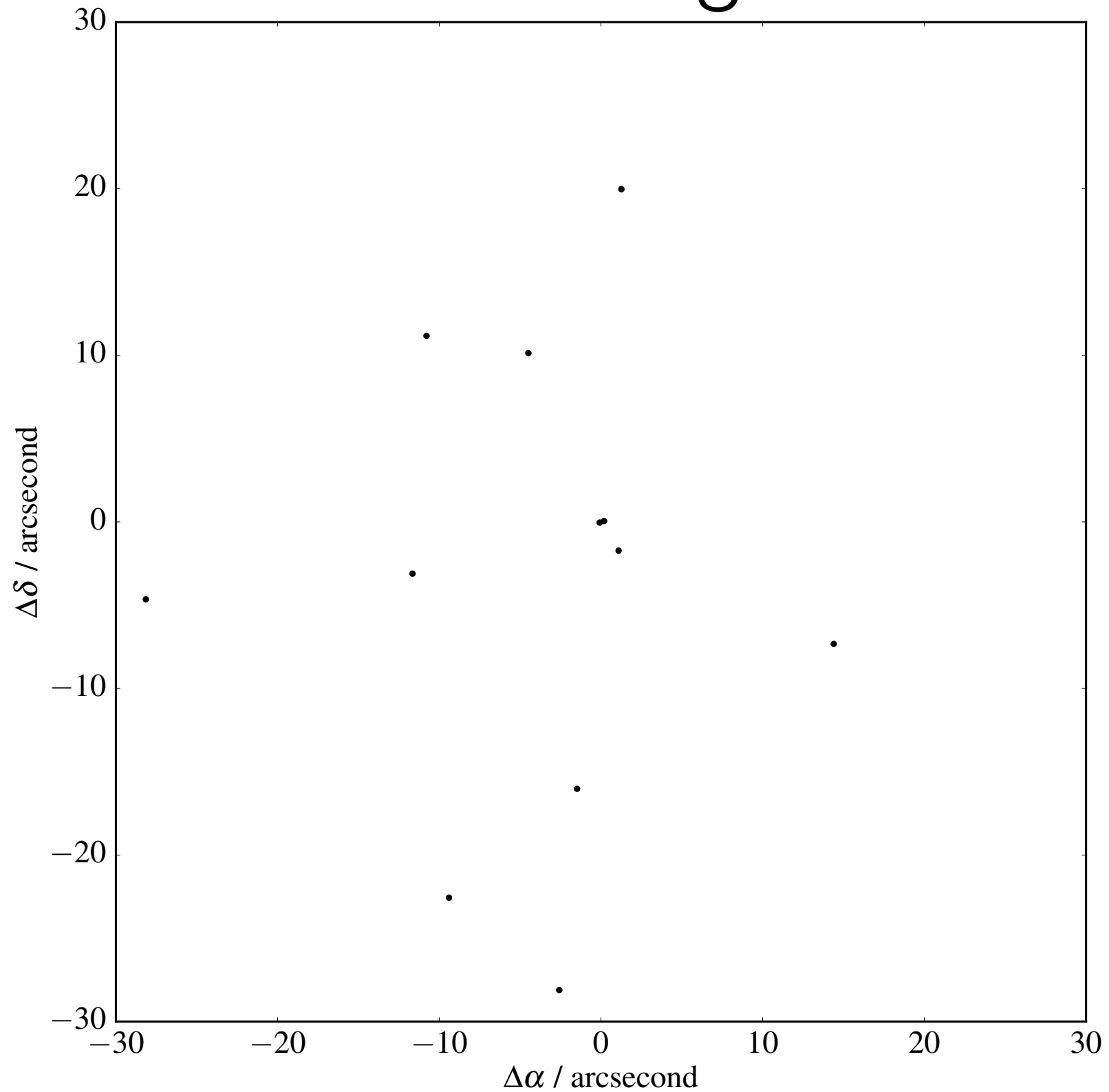
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# The Astrometric Uncertainty Function: Crowding

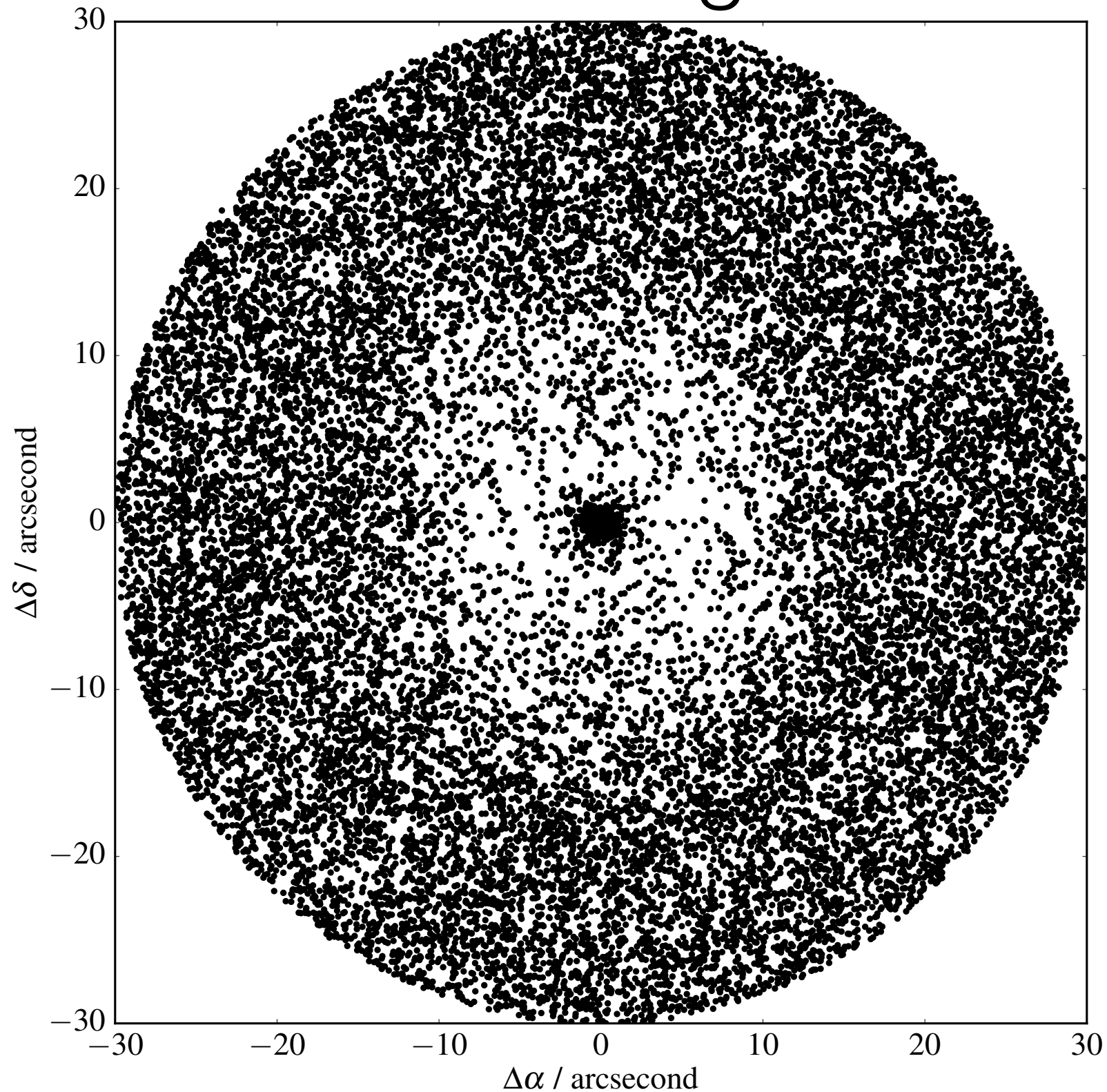




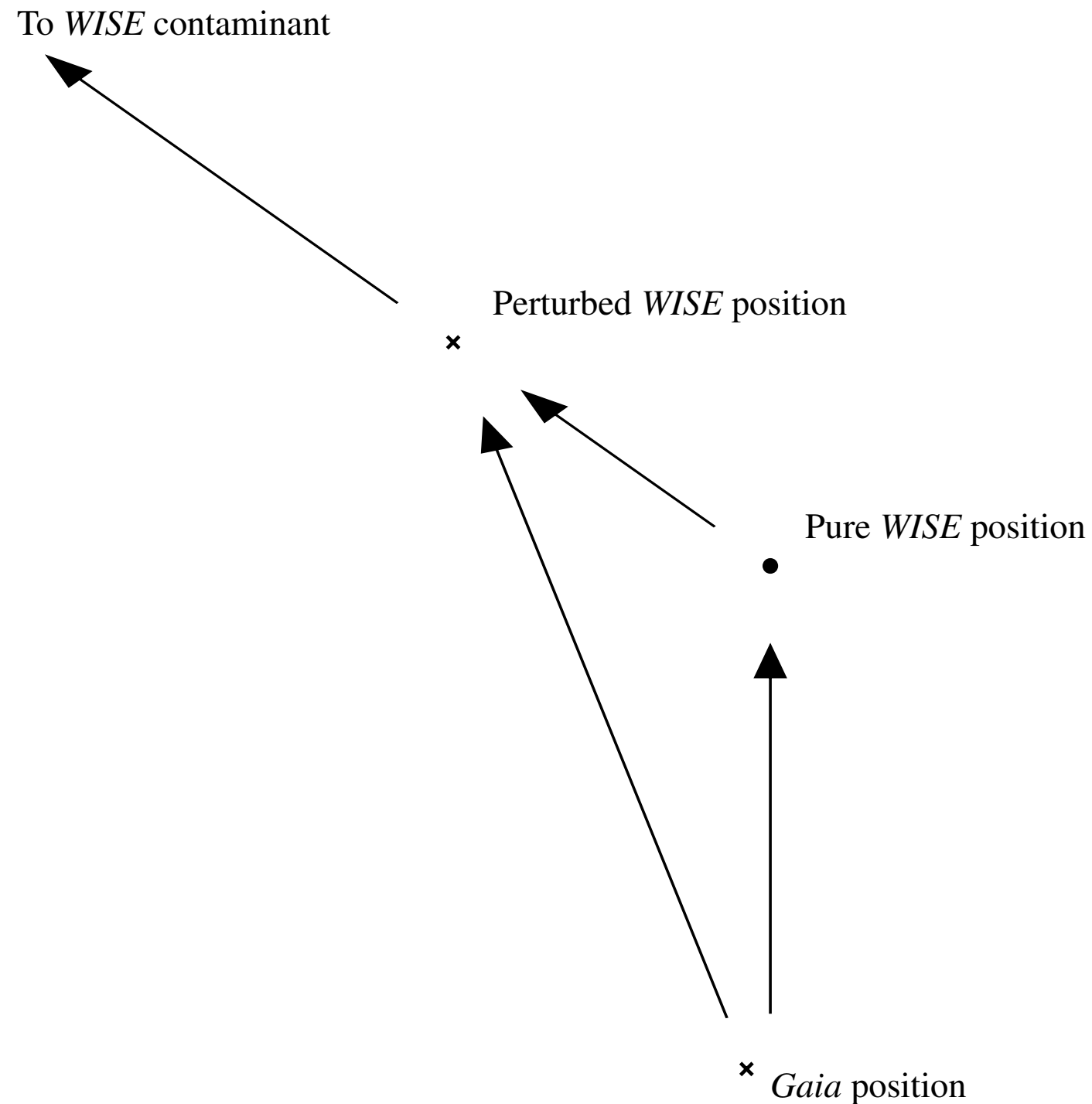
# The Astrometric Uncertainty Function: Crowding



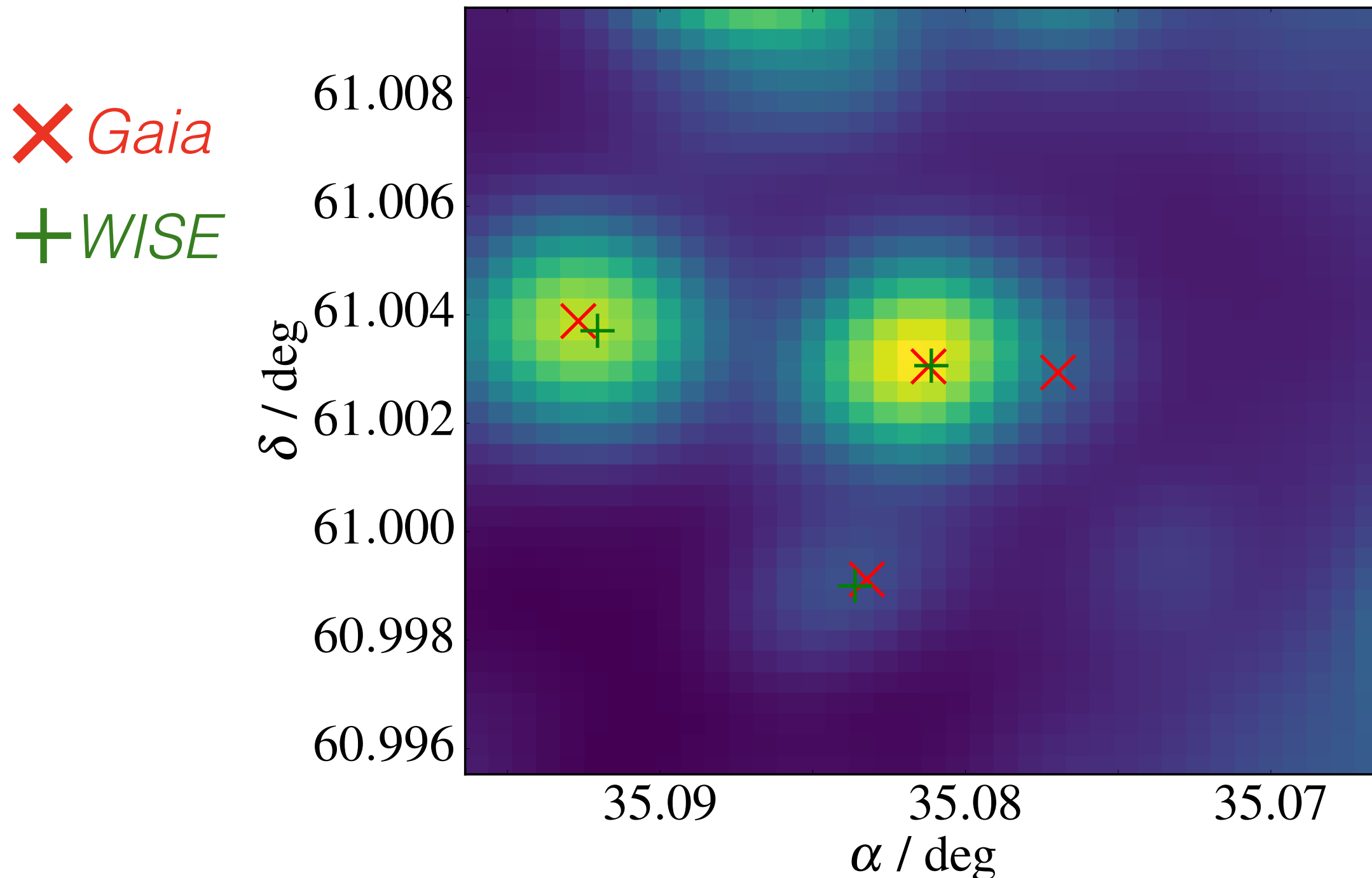
# The Astrometric Uncertainty Function: Crowding



# The Astrometric Uncertainty Function: Perturbation



# The Astrometric Uncertainty Function: *Gaia-WISE* Resolved Blend



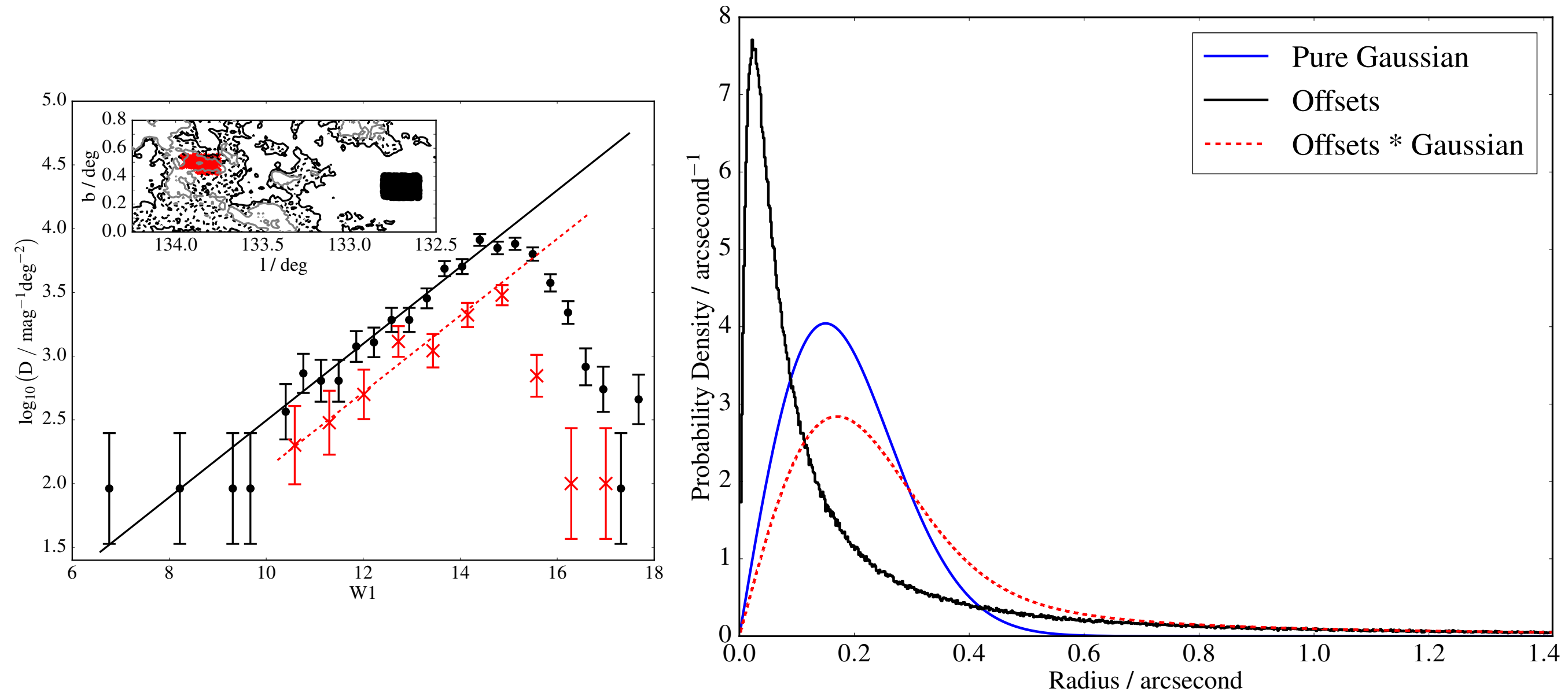
*Gaia* DR2 - Gaia Collaboration, Brown A. G. A., et al. 2018, A&A, 616, 1

*WISE* - Wright et al., 2010, AJ, 140, 1868

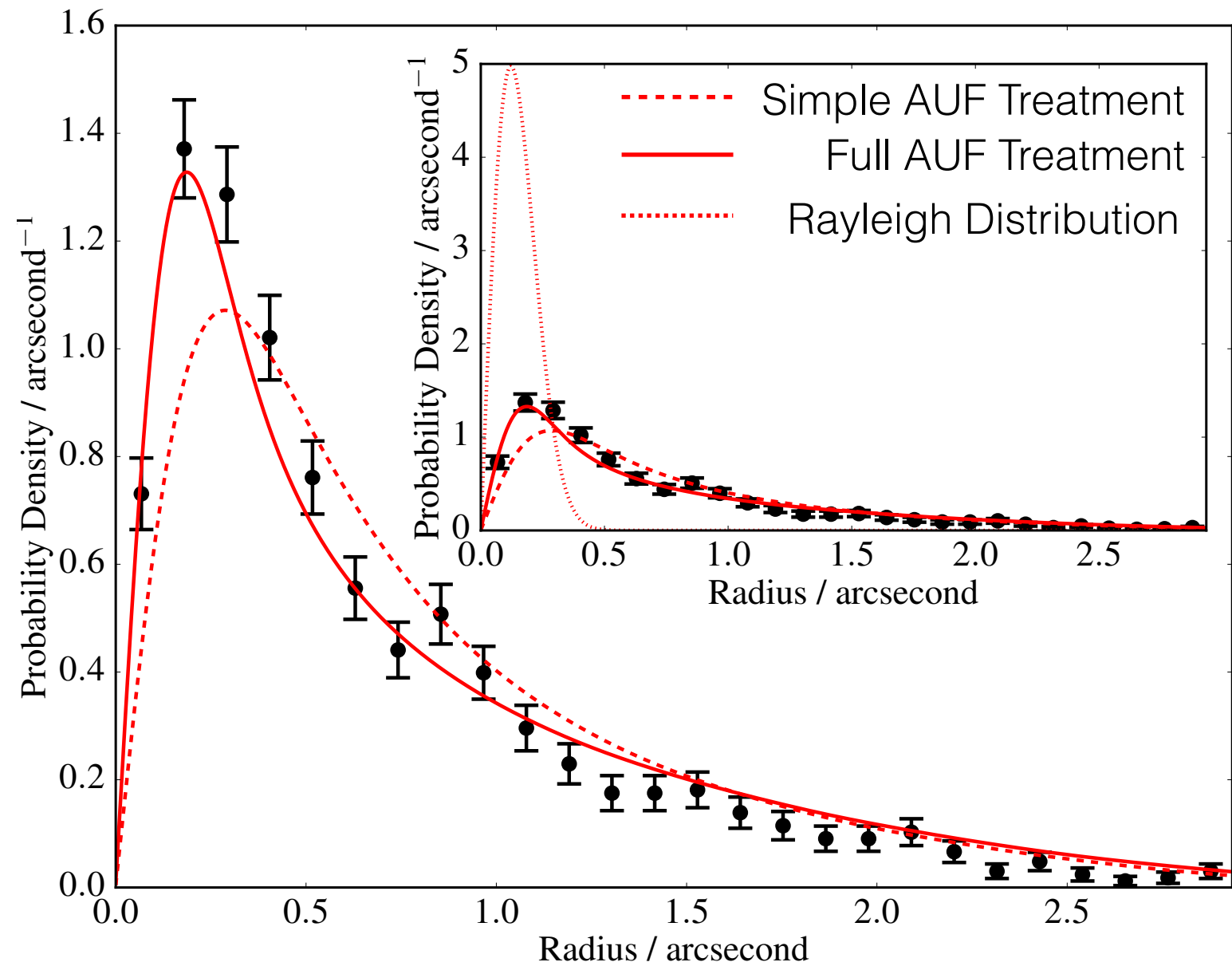
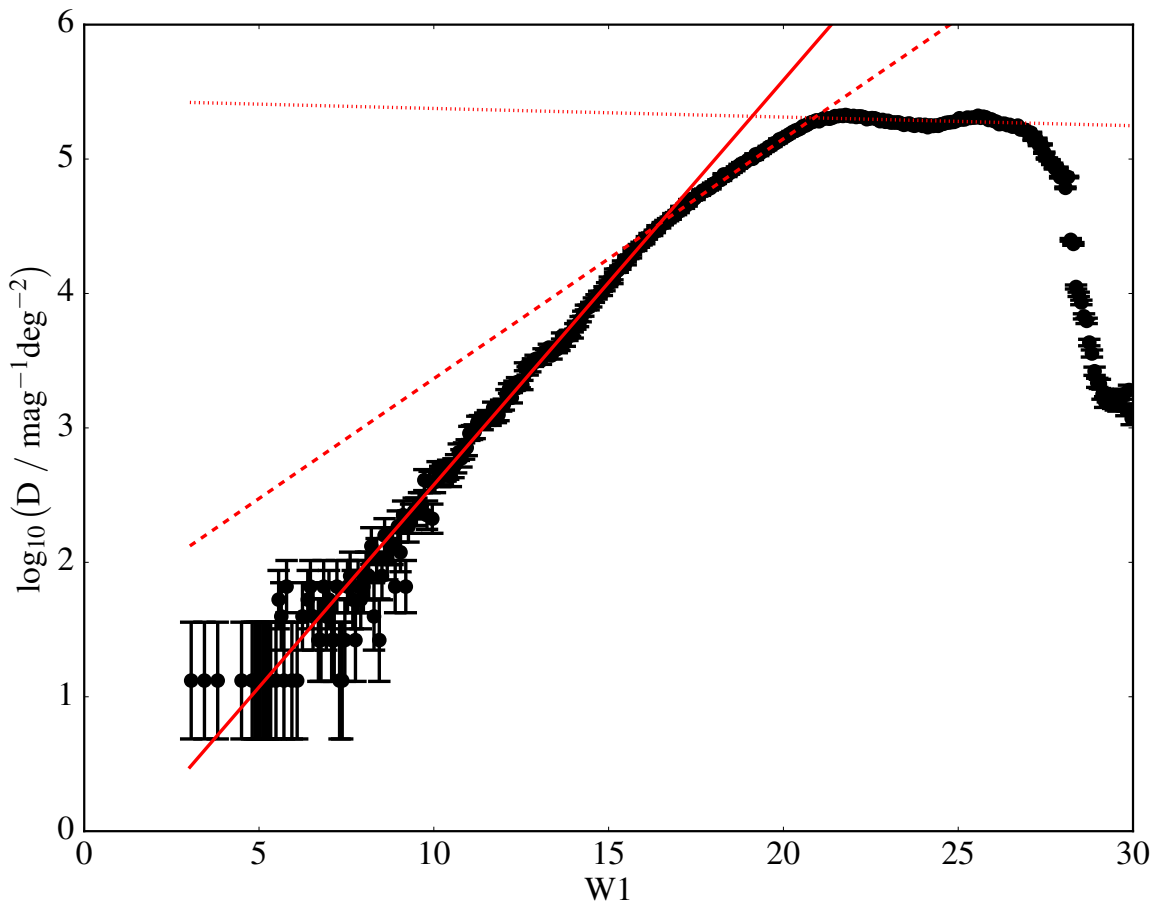
Wilson & Naylor, MNRAS, 2018b, 481, 2148

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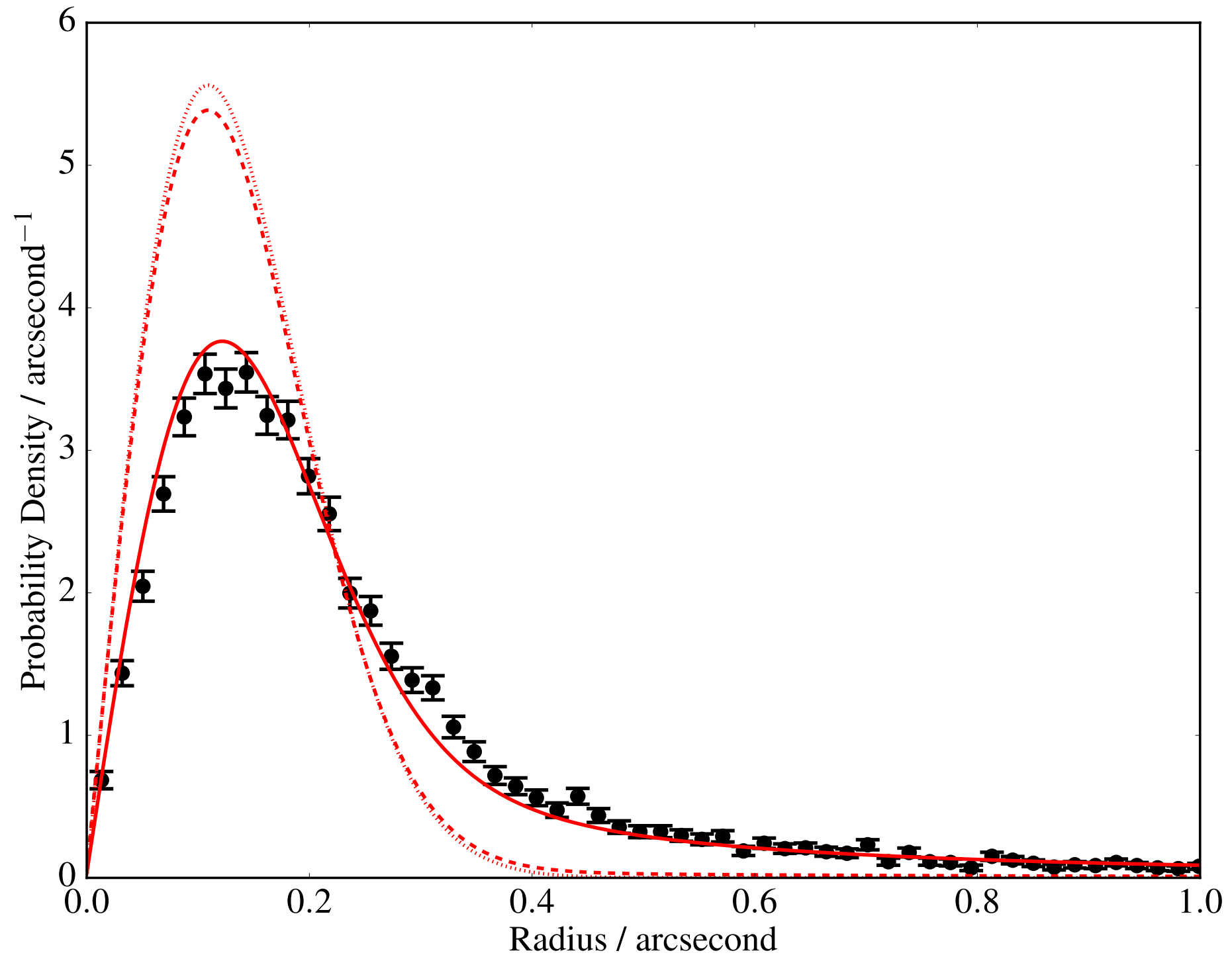
# The Astrometric Uncertainty Function: Building Empirical AUFs



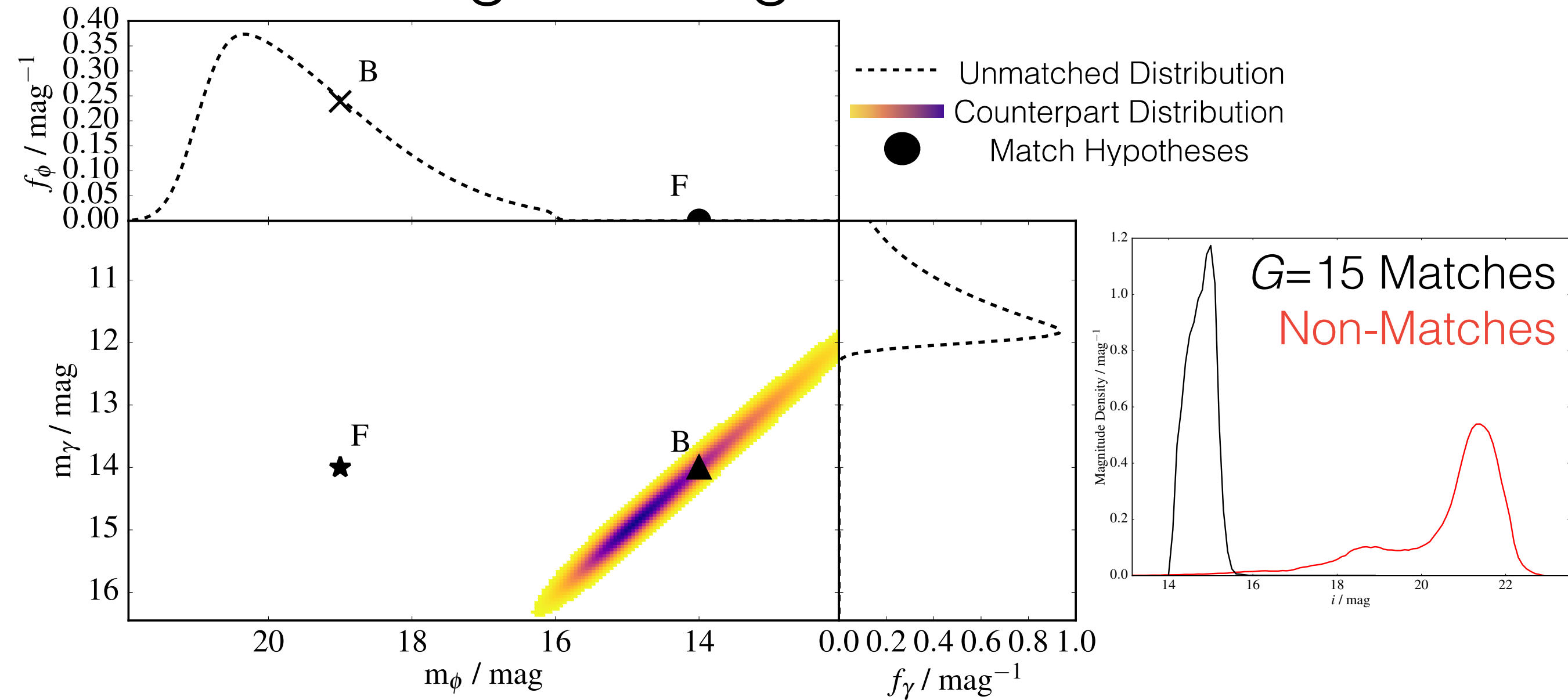
# Contamination Effects: Effects Below Sensitivity Limit



# Contamination Effects: Galaxy Contamination



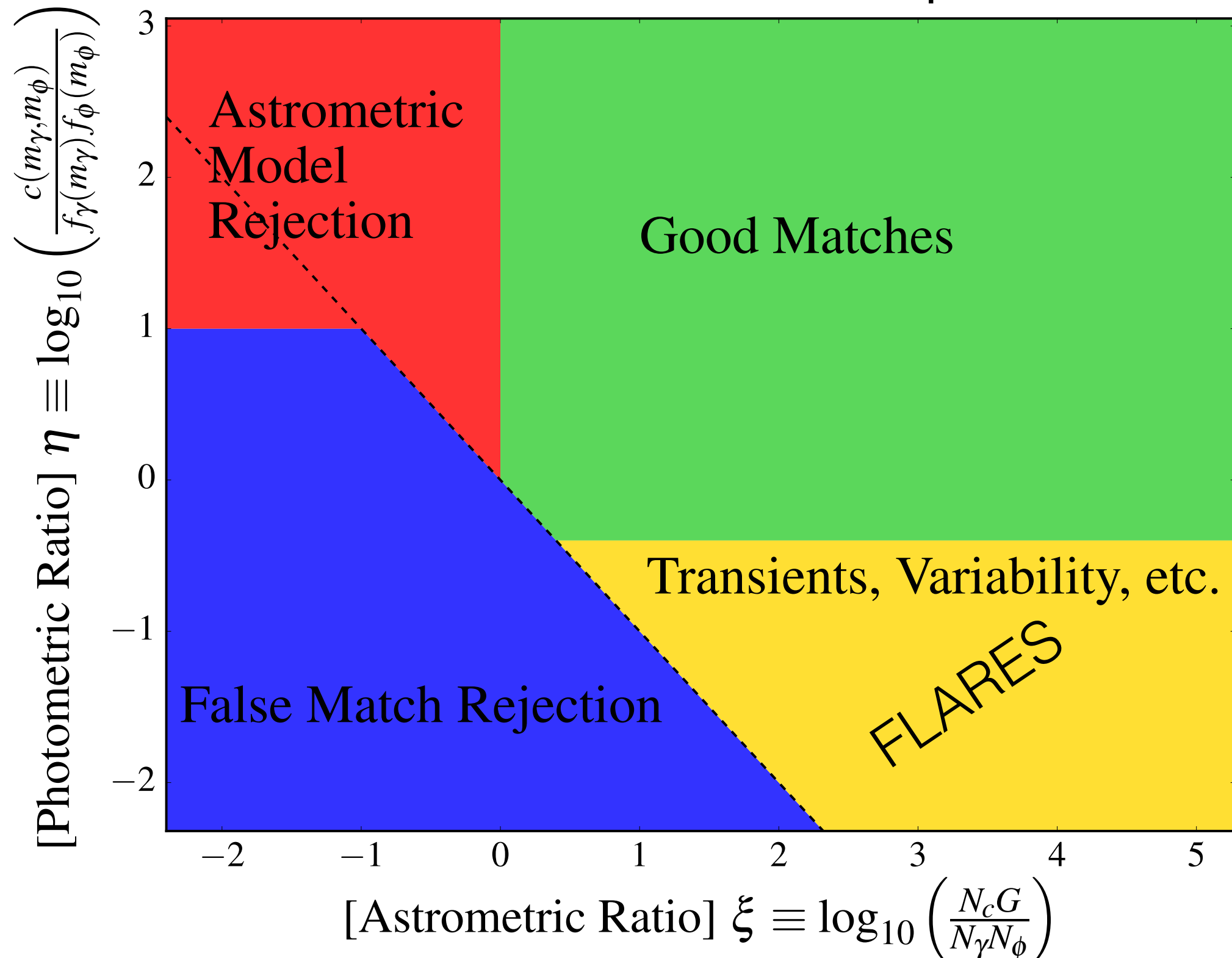
# Probability-based Catalogue Matching: Including the Magnitude Information



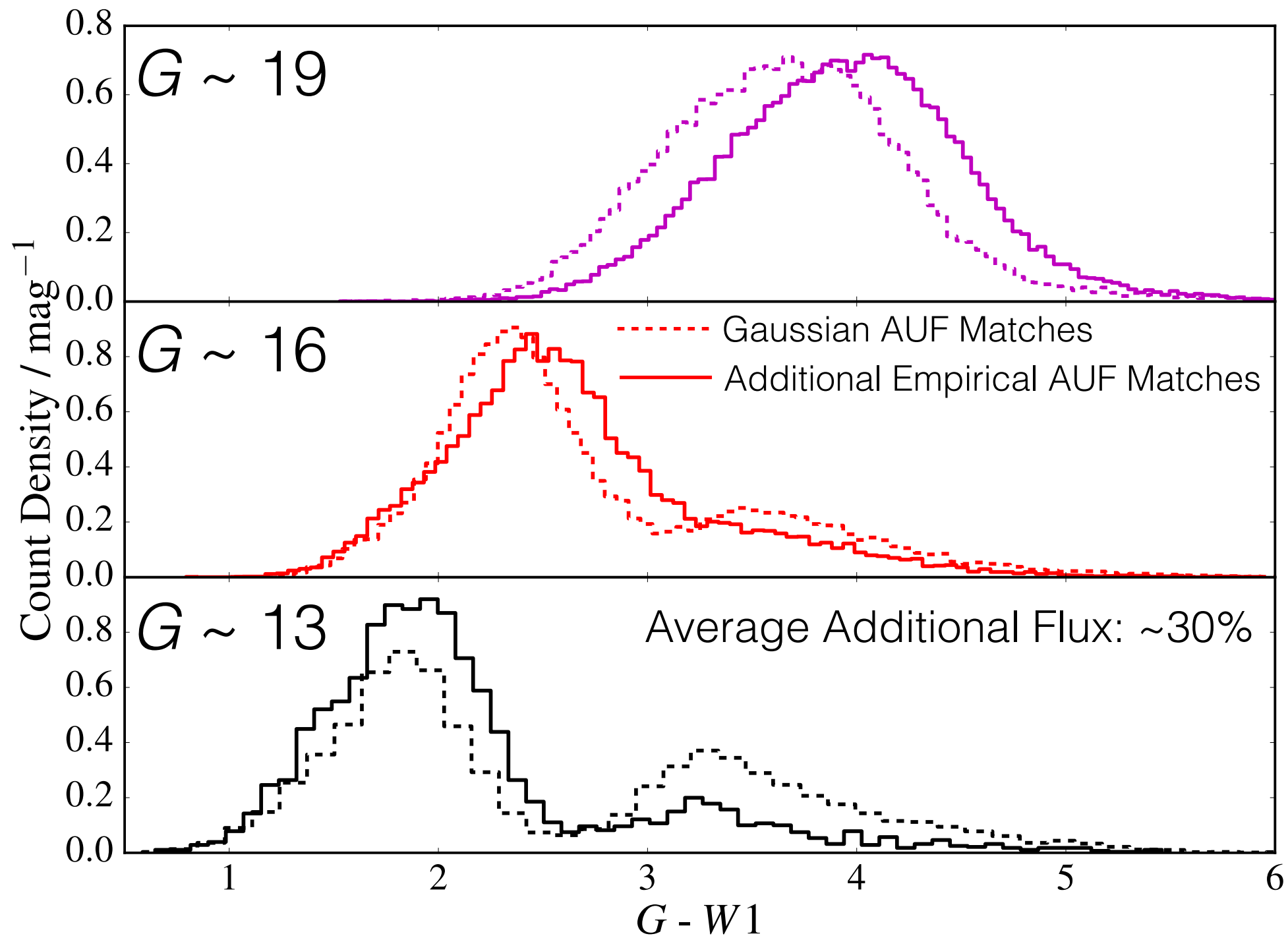
$$\begin{aligned}
 g(x_k, y_k, x_l, y_l) &= N_c \iint_{-\infty}^{+\infty} h_\gamma(\Delta x_{kl} - x, \Delta y_{kl} - y) h_\phi(x, y) dx dy \\
 &= N_c \times (h_\gamma * h_\phi)(\Delta x_{kl}, \Delta y_{kl}).
 \end{aligned}$$



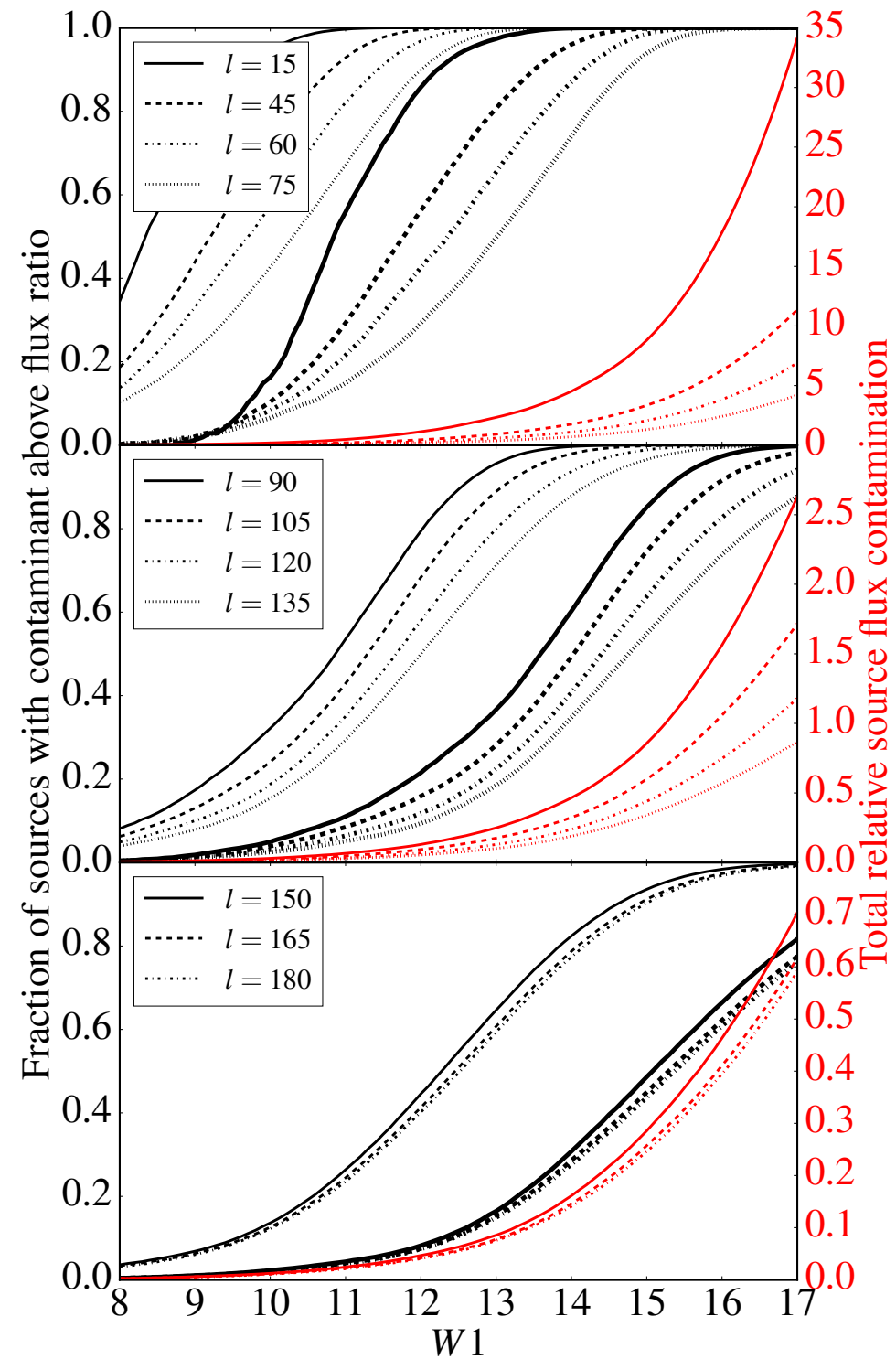
# Probability-based Catalogue Matching: The Likelihood Ratio Space



# Contamination Effects: Perturbation-Colour Correlation

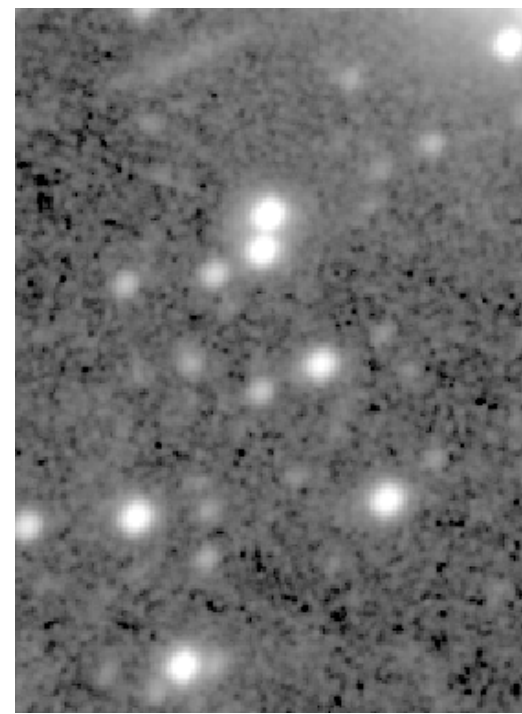
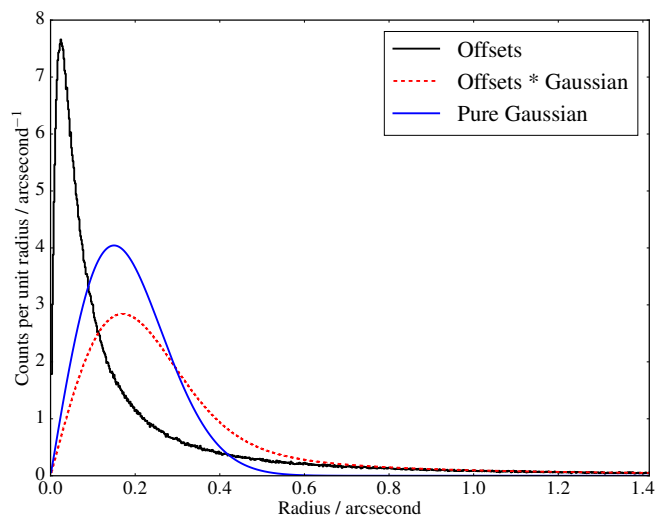


# Contamination Effects: Contamination Rates & Amounts

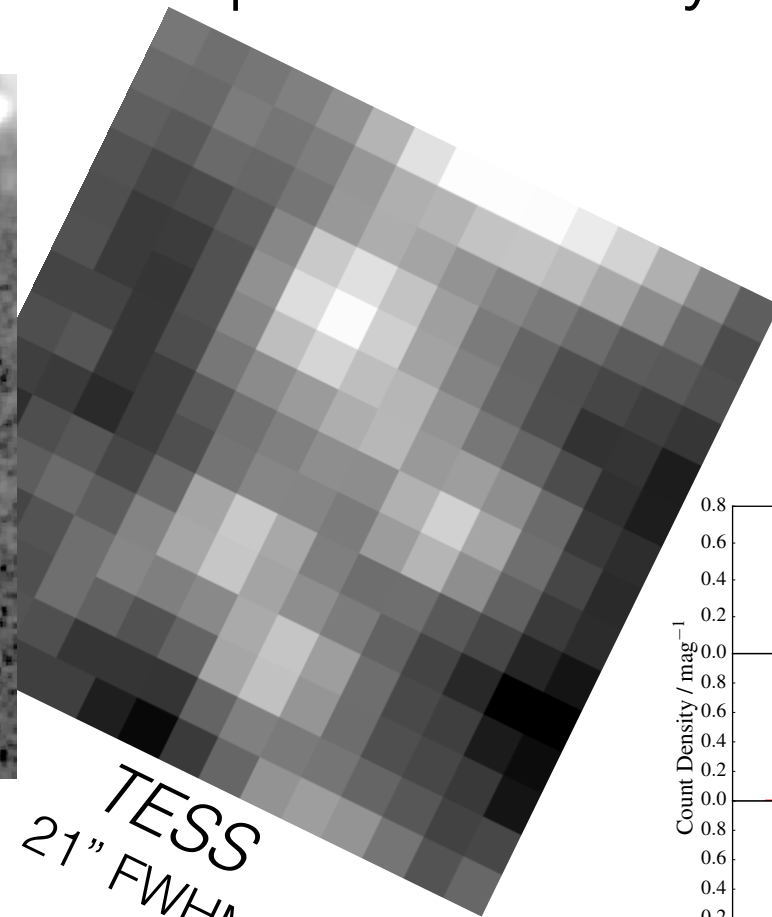


# The Effects of Unresolved Contaminant Stars on the Cross-Matching of Photometric Catalogues: Conclusions

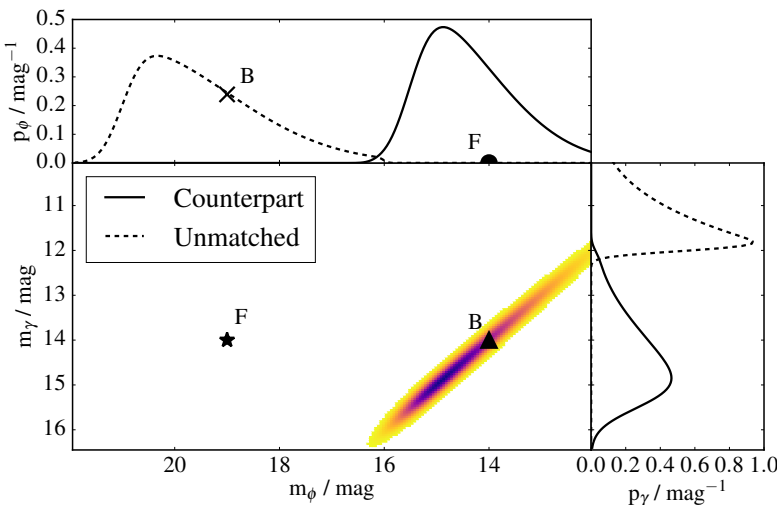
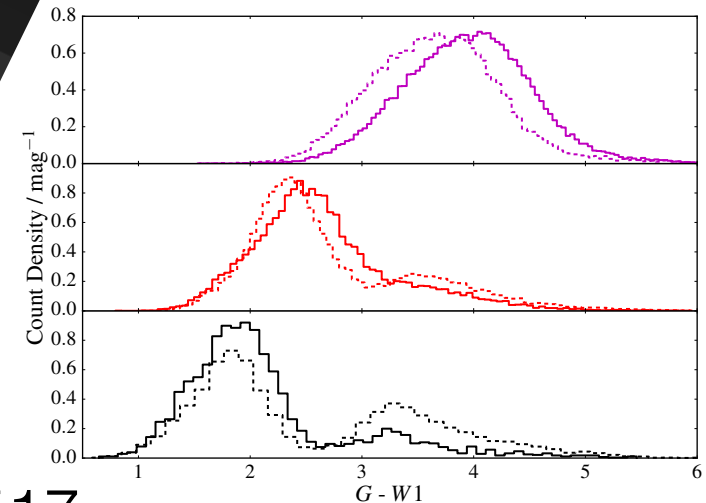
- Blended star contamination causes positional shifts
- *WISE* objects are up to 30% flux contaminated, with *WFIRST* and *LSST* suffering similar blending in the future
- Disentangle this information with proper treatment in the cross-match to a higher angular resolution dataset — important work yet to be done!



*WISE*  
6'' FWHM



*TESS*  
21'' FWHM

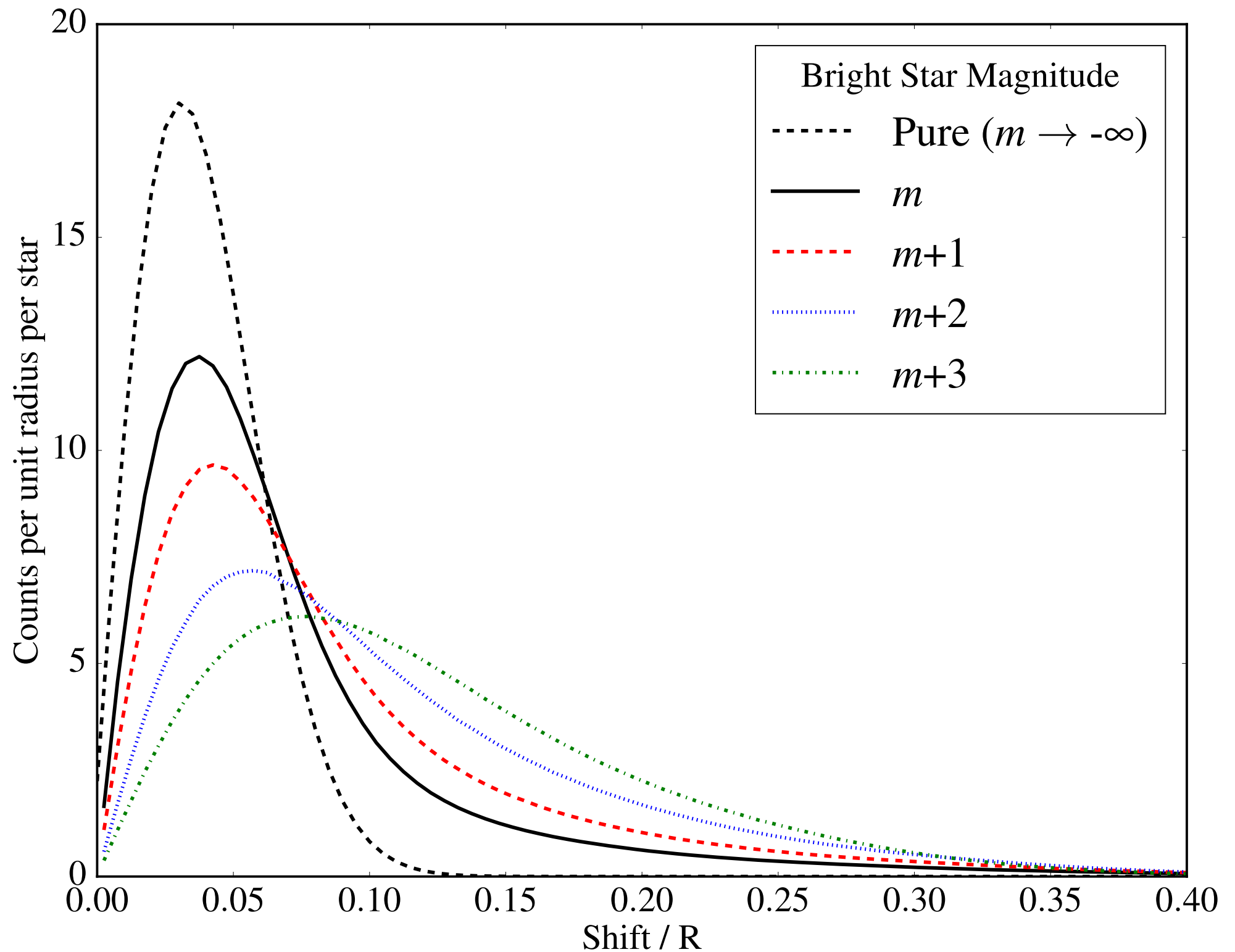


Wilson & Naylor, 2017, MNRAS, 468, 2517

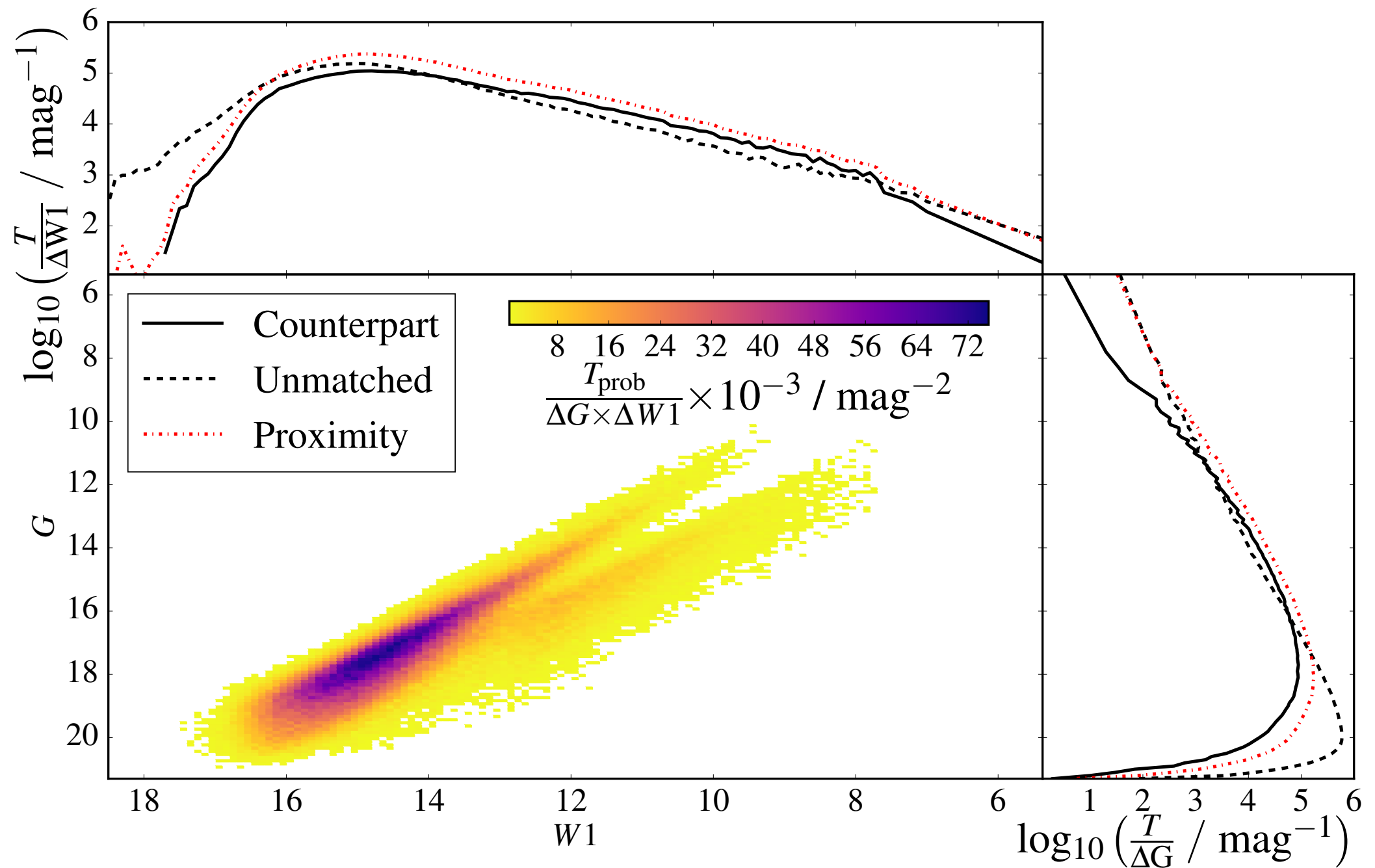
Wilson & Naylor, 2018a, MNRAS, 473, 5570

Wilson & Naylor, 2018b, MNRAS, 481, 2148

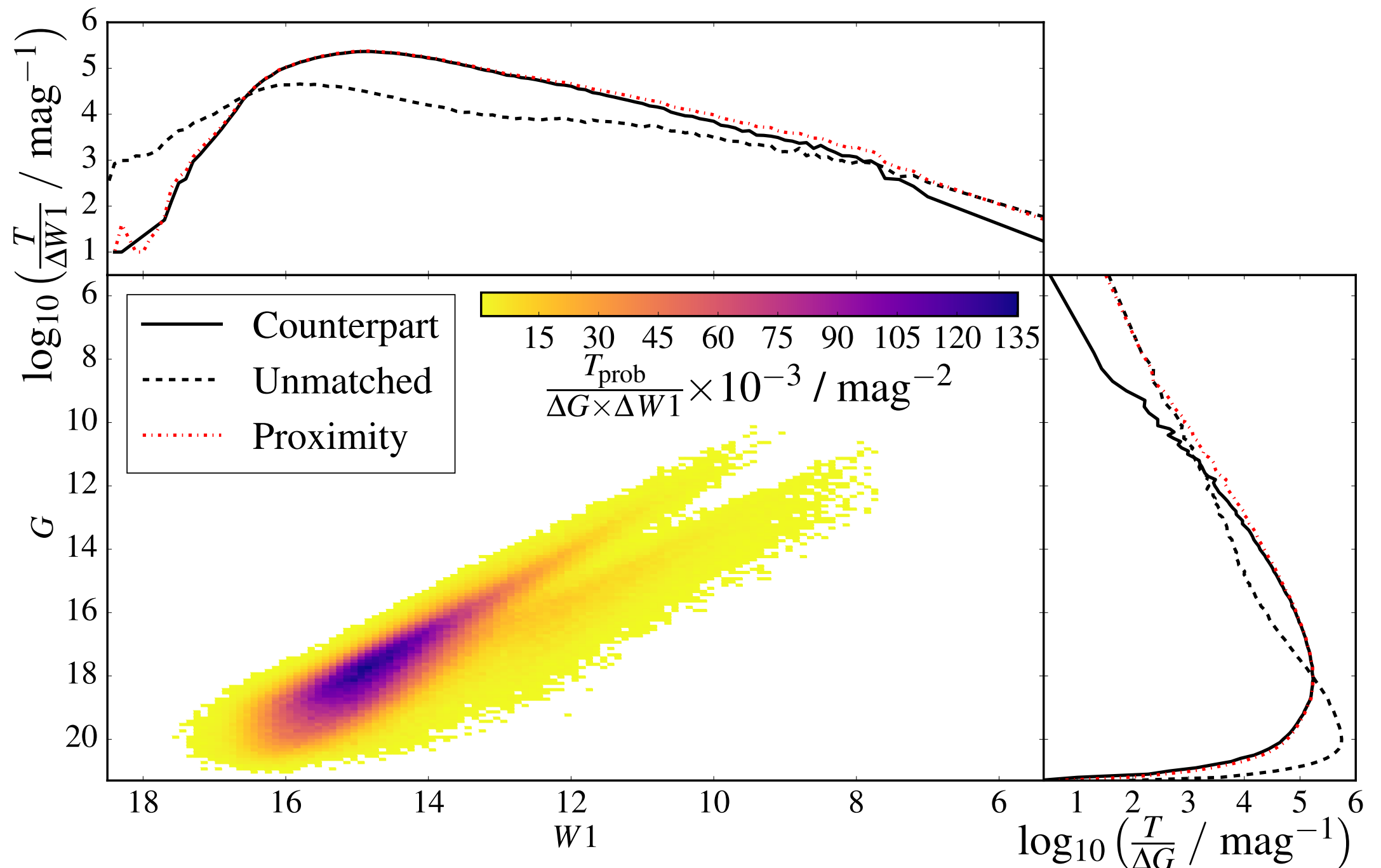
# The Astrometric Uncertainty Function: Synthetic Non-Gaussian Tails



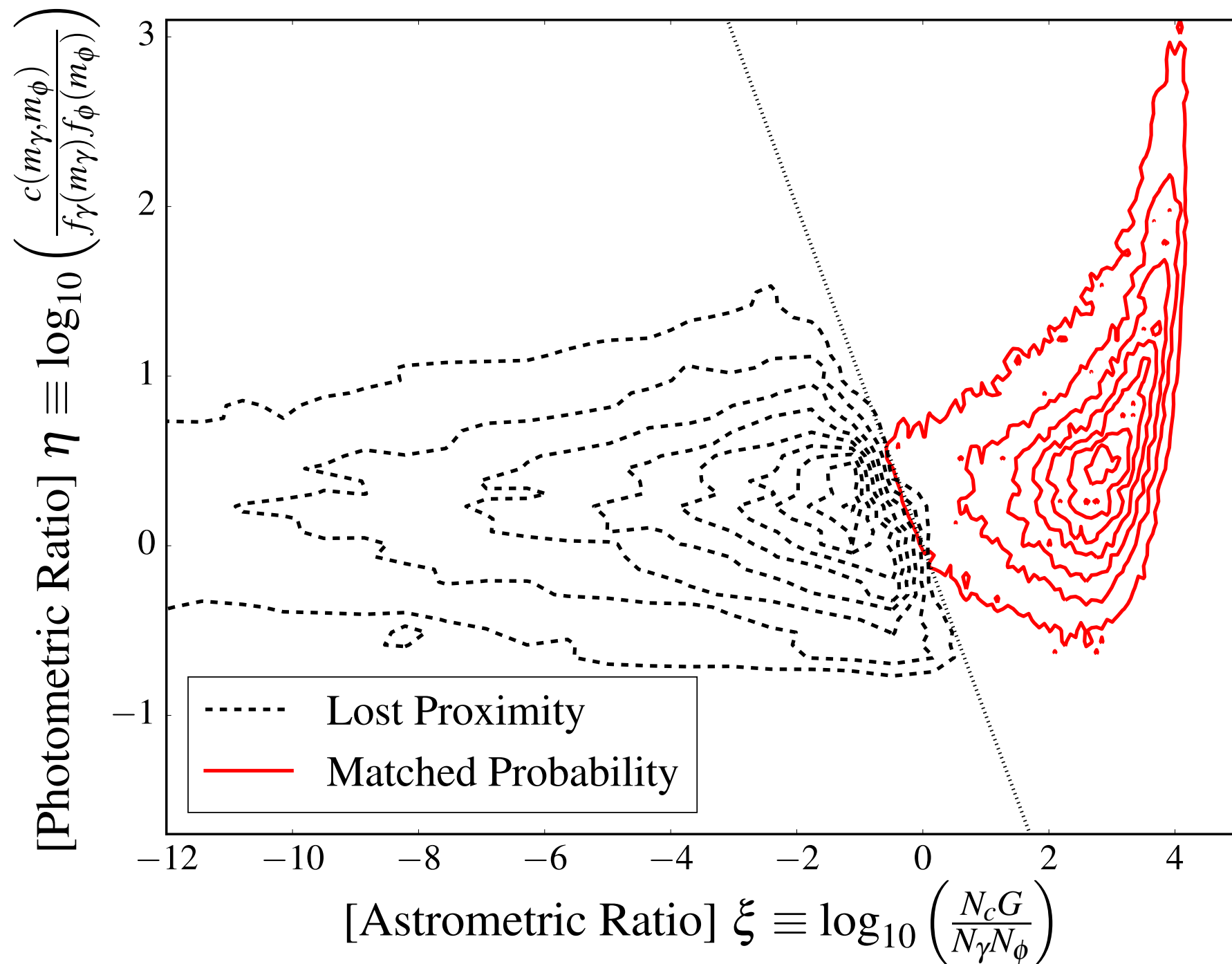
# Contamination Effects: *Gaia-WISE* Gaussian Matches



# Contamination Effects: *Gaia-WISE* Empirical Matches

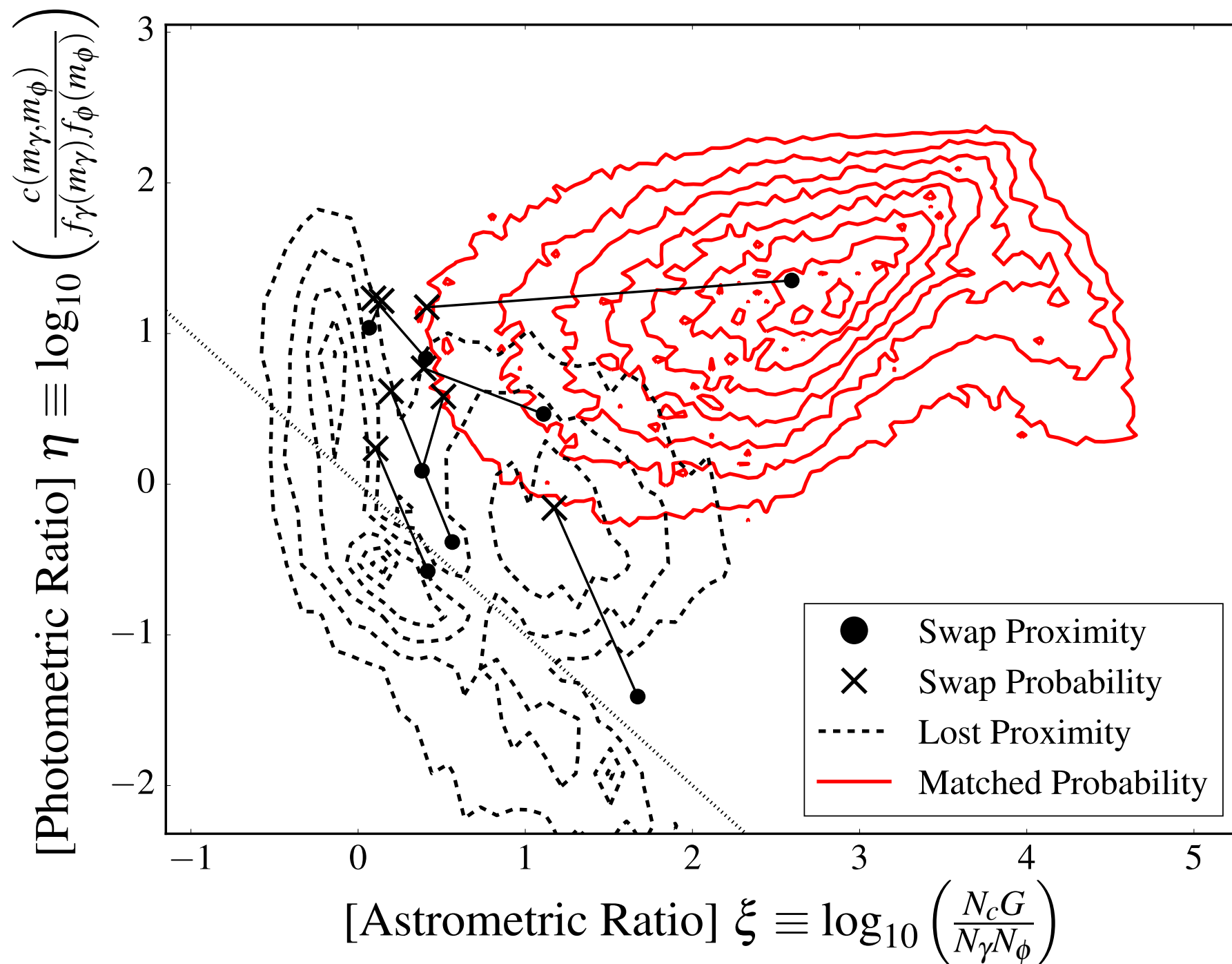


# Contamination Effects: Lost Proximity Matches

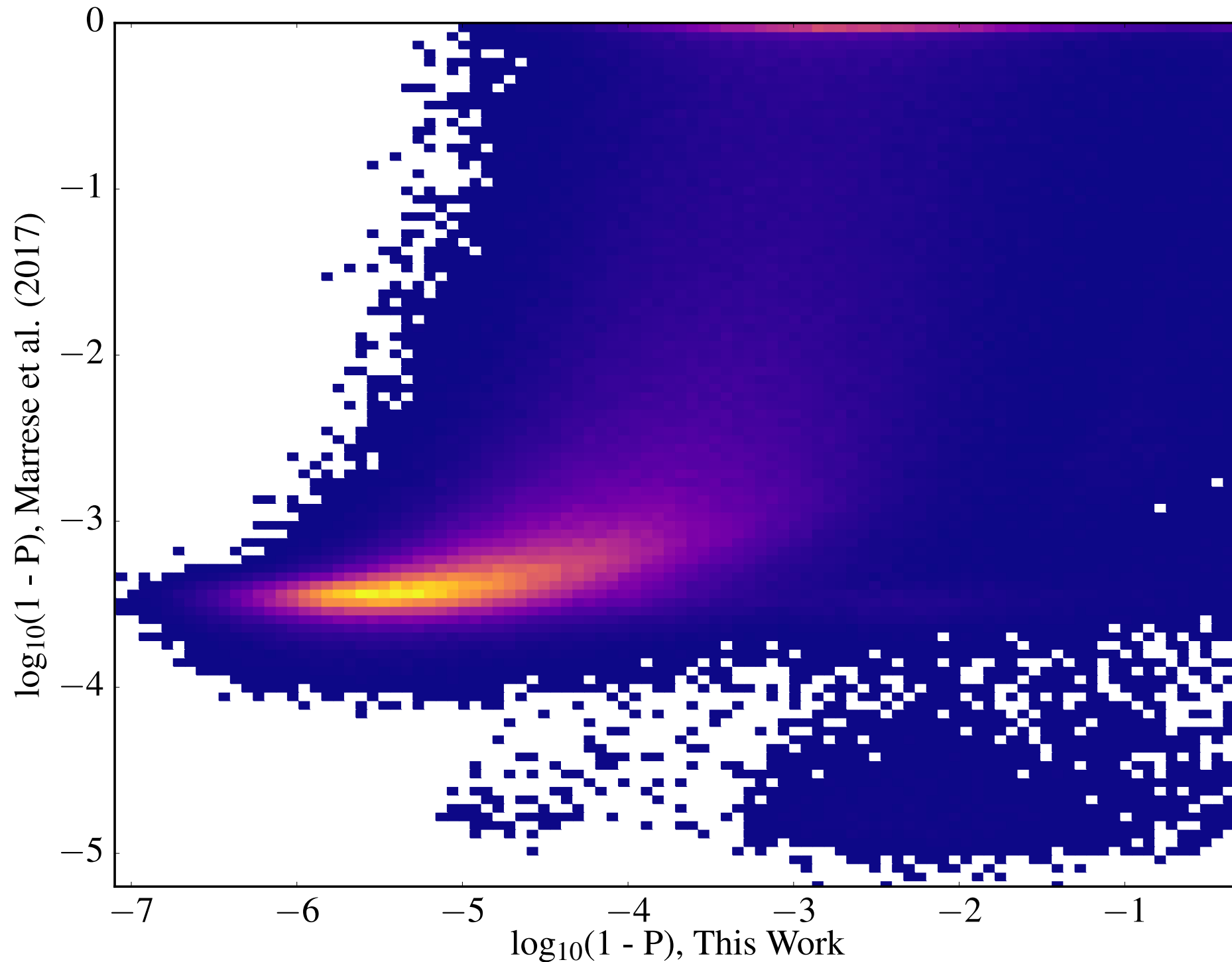




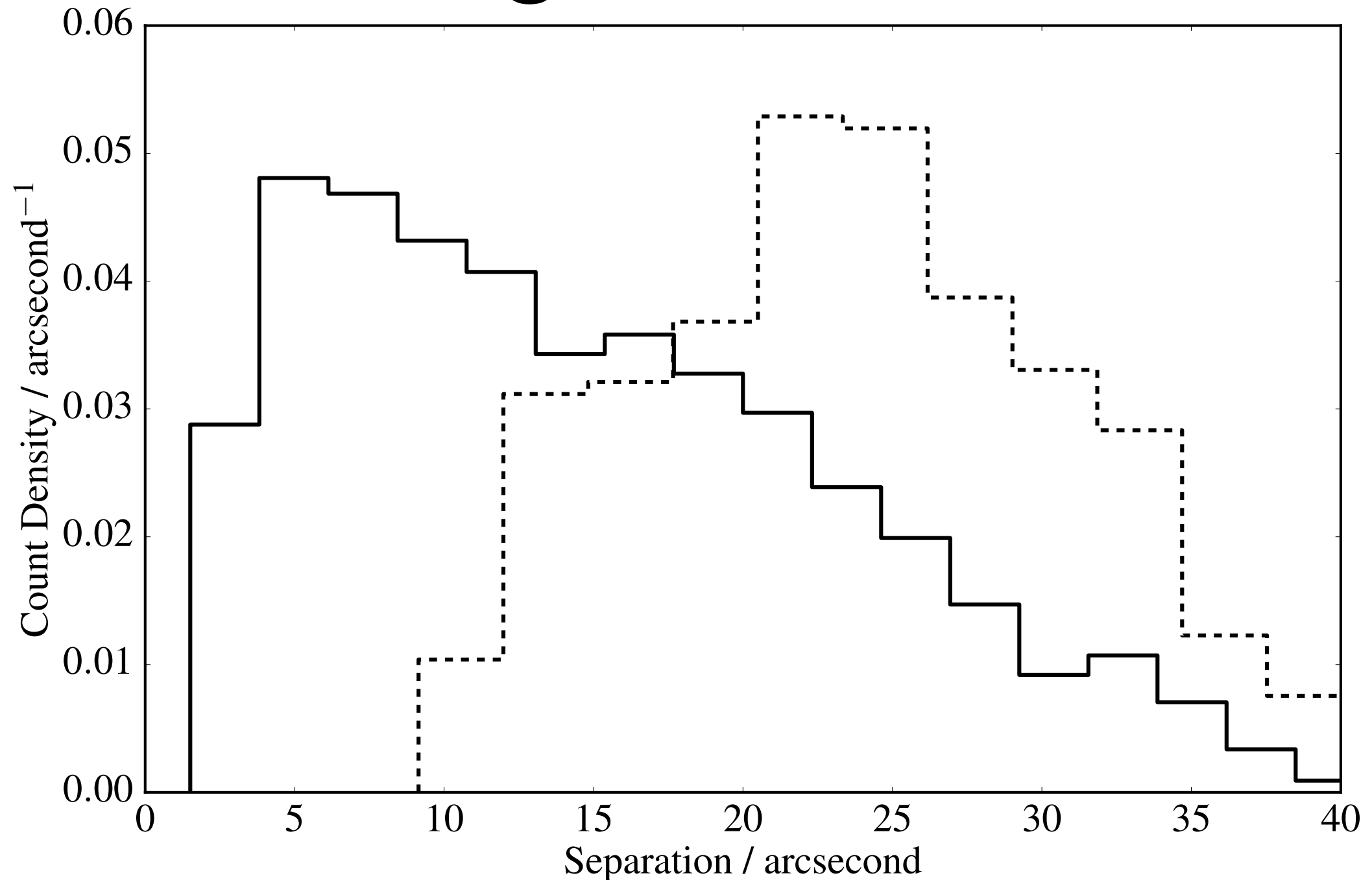
# Contamination Effects: Lost Proximity Matches



# Contamination Effects: *Gaia* Lost Matches

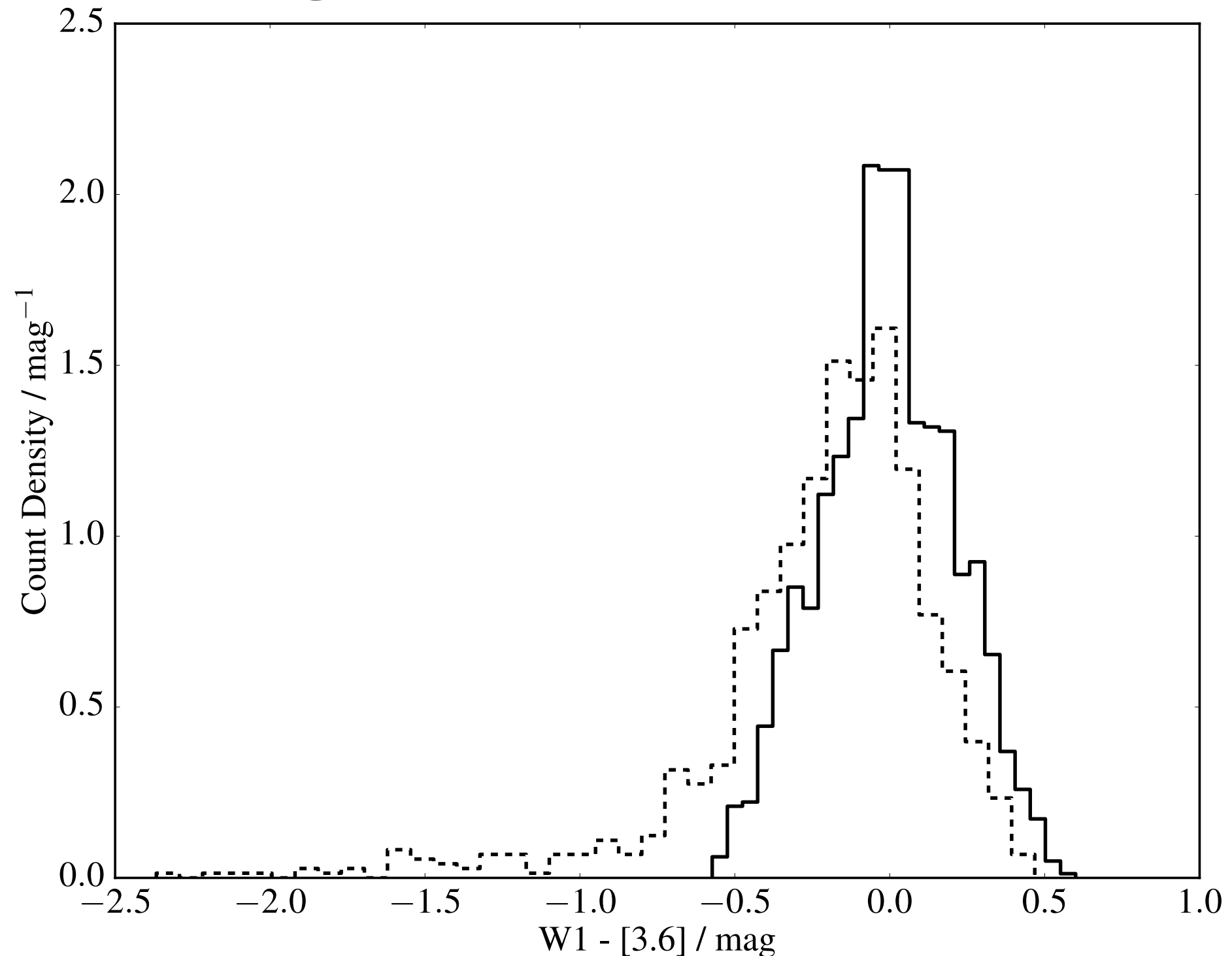


# Contamination Effects: Resolving Contaminants

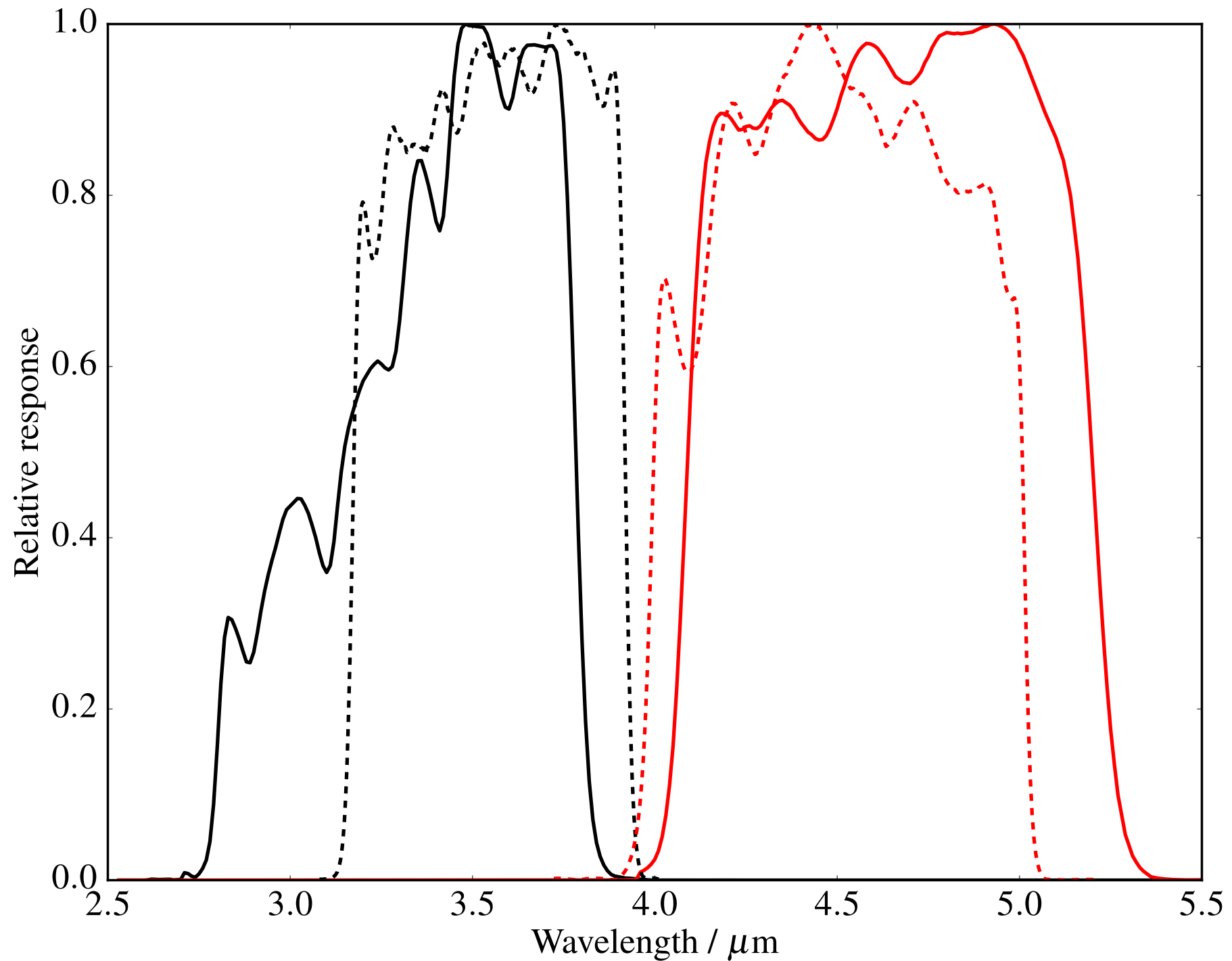


Spitzer - Werner et al., 2004 ,ApJS, 154, 1  
IRAC - Fazio et al., 2004, ApJS, 154, 10  
Wilson & Naylor, MNRAS, 2018b, 481, 2148

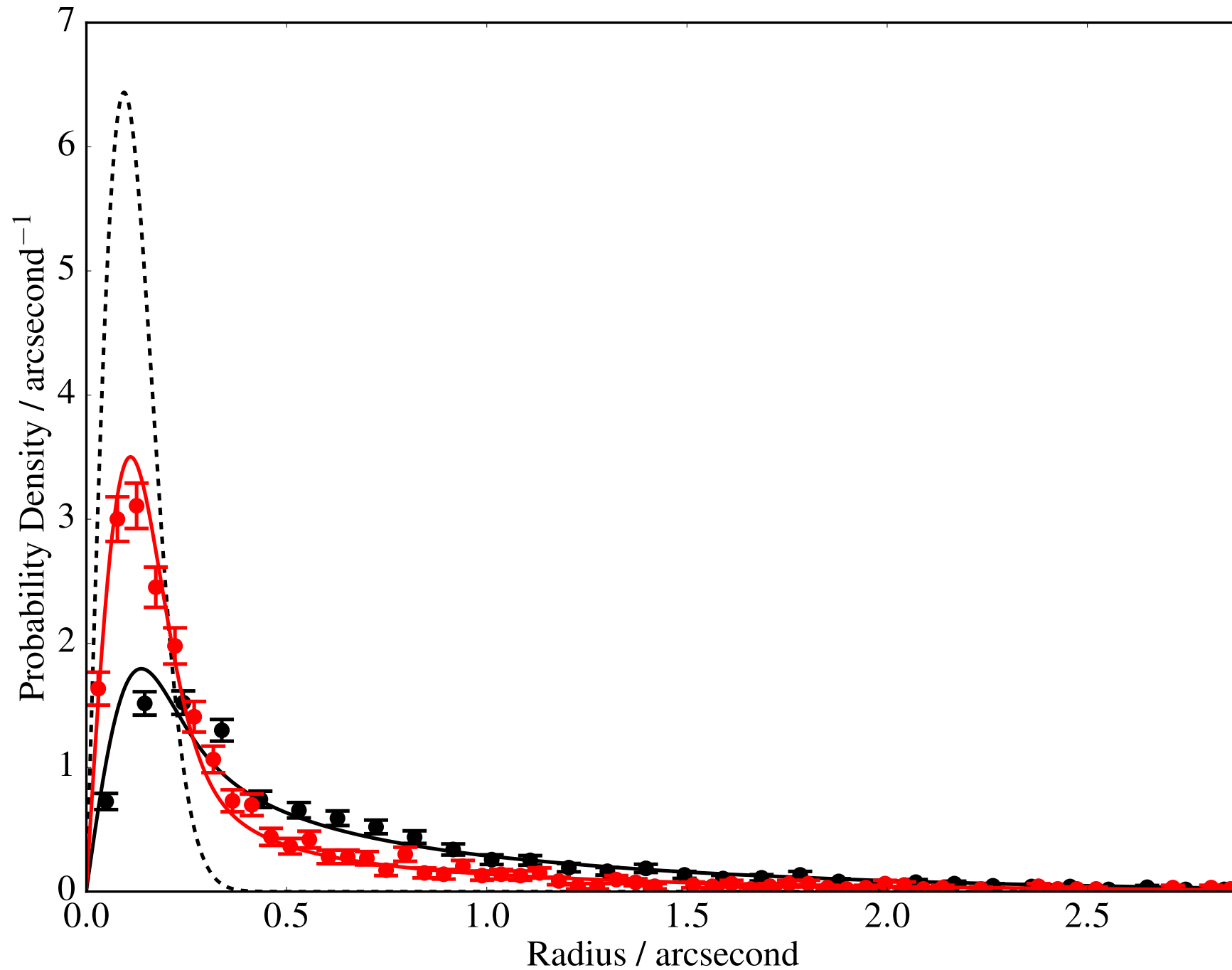
# Contamination Effects: Resolving Contaminant Flux



# Contamination Effects: Wavelength Coverage



# Contamination Effects: Crowding Normalisation



# The Astrometric Uncertainty Function: Analytical perturbations

