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

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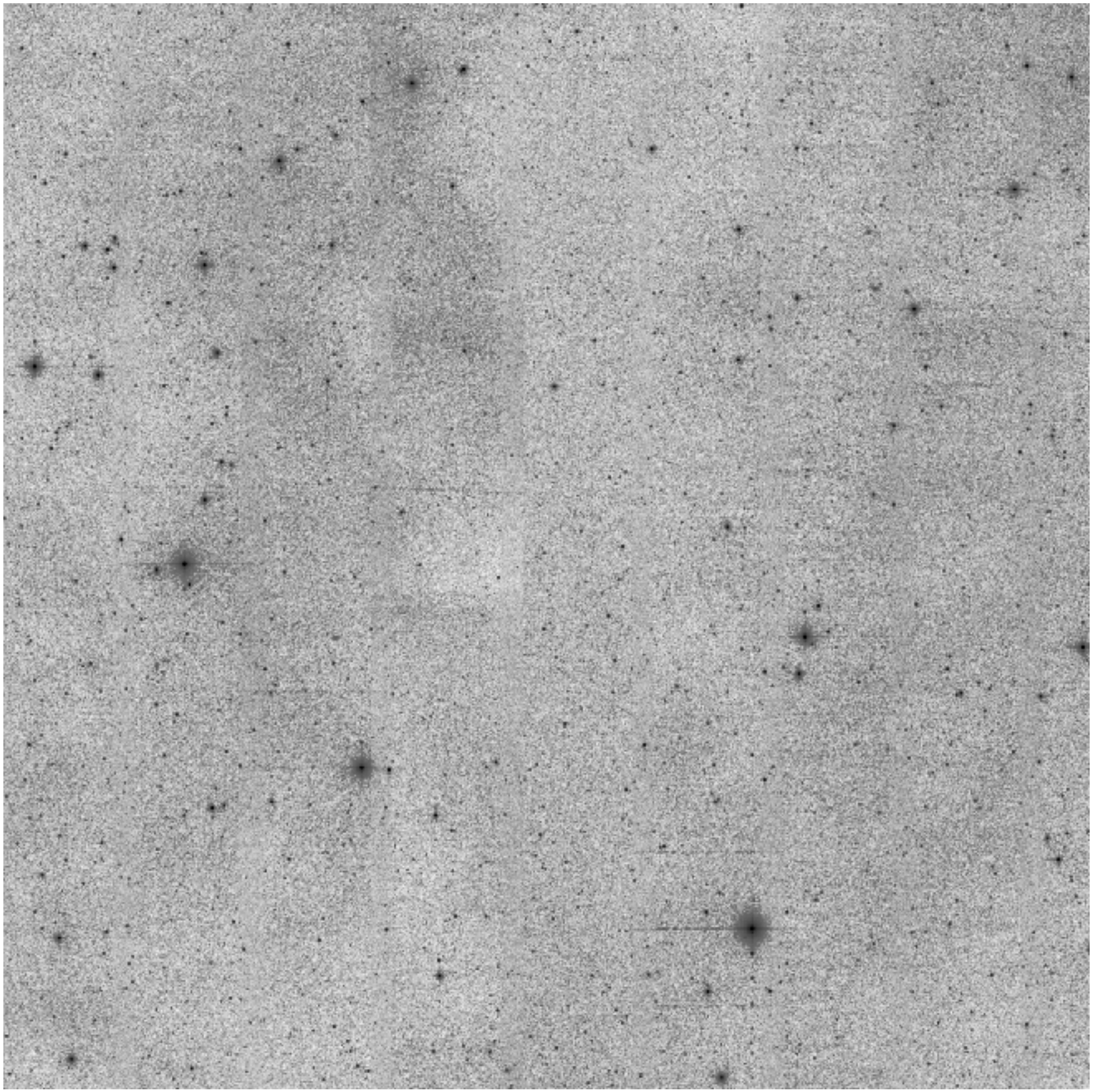
Cardiff, 19/9/17

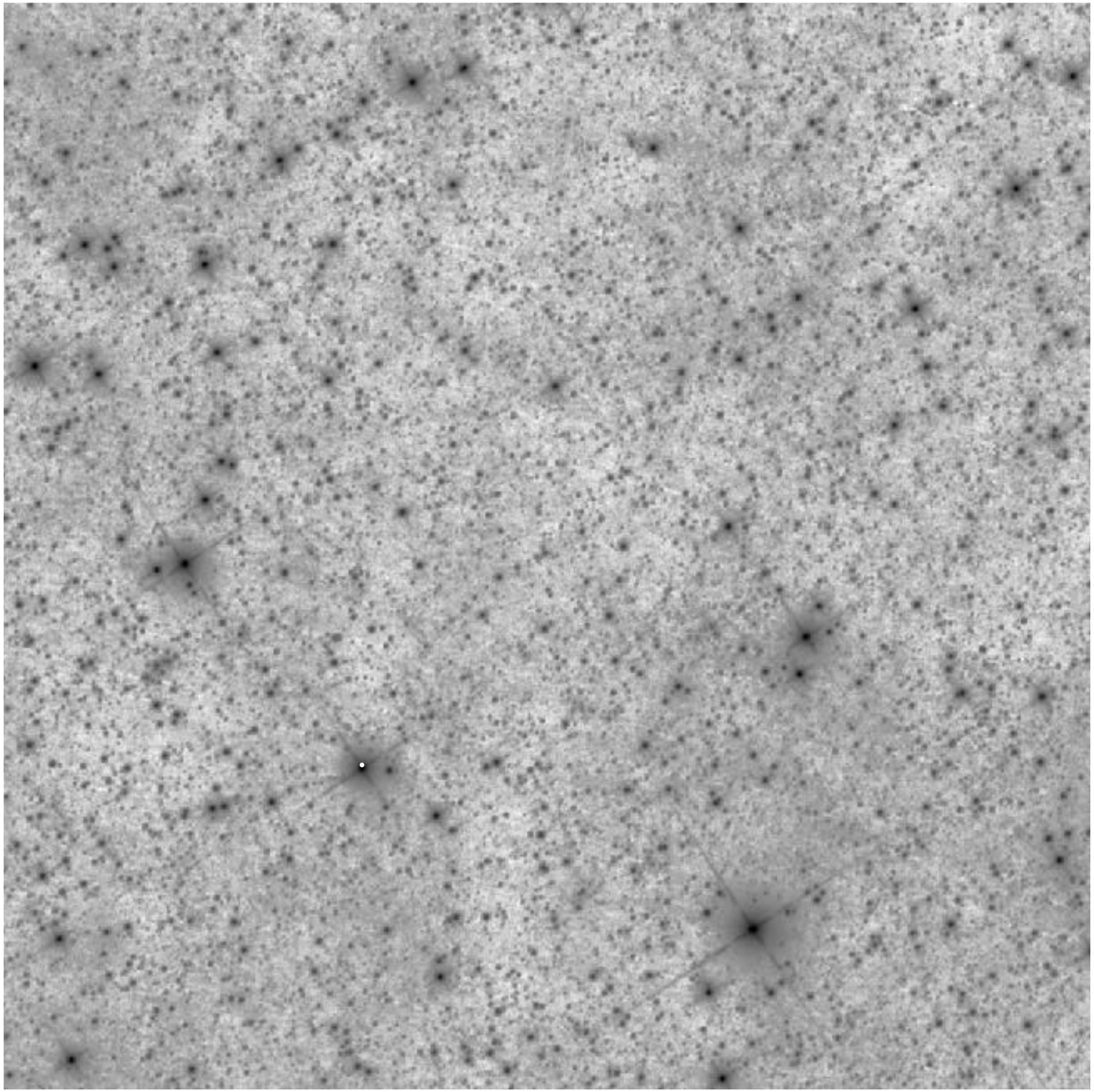
Photometric Observations of Star Formation



2MASS J

2MASS - Skrutskie et al., 2006, AJ, 131, 1163

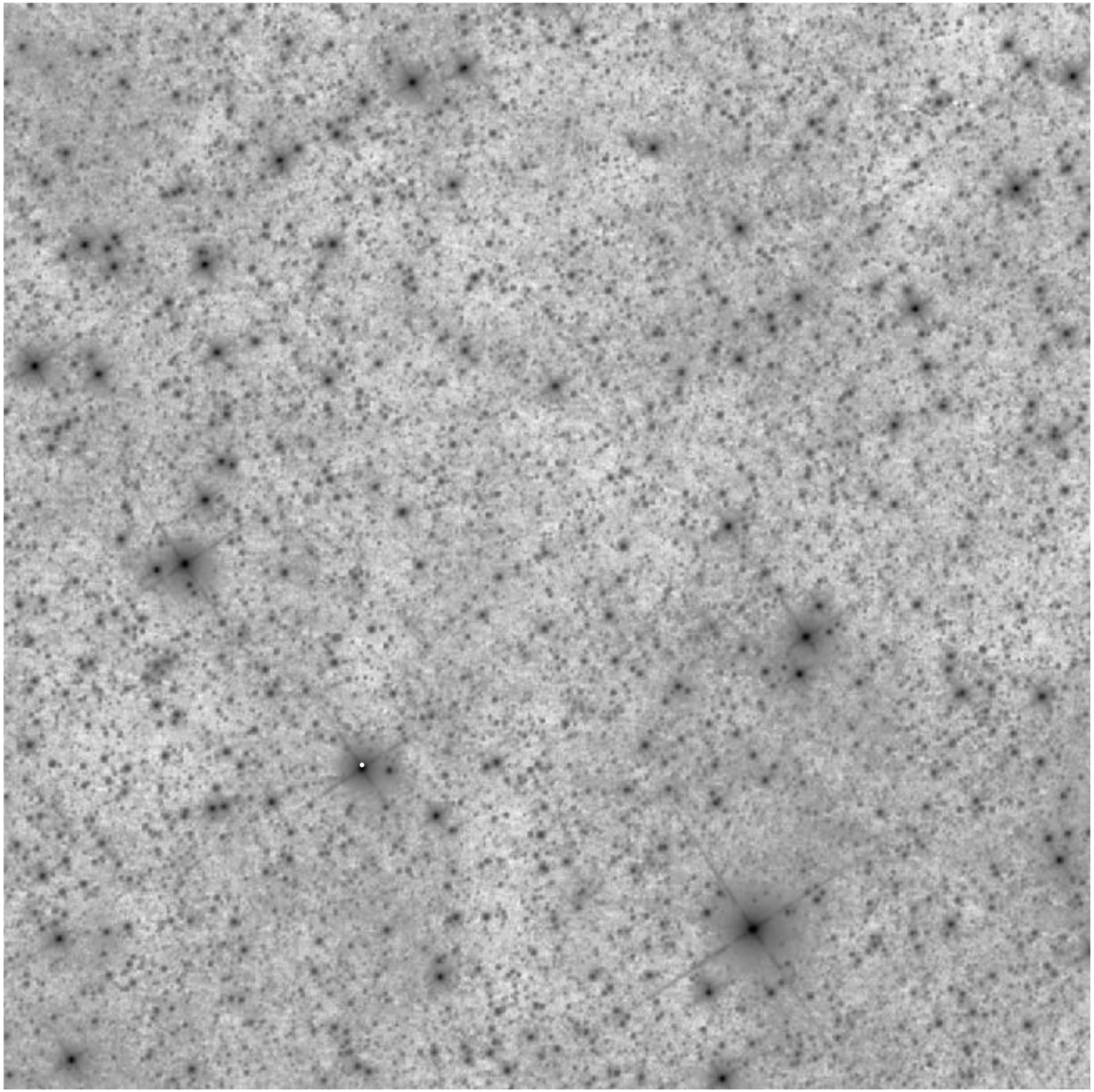
Photometric Observations of Star Formation



WISE W1

2MASS - Skrutskie et al., 2006, AJ, 131, 1163 WISE - Wright et al., 2010, AJ, 140, 1868

Photometric Observations of Star Formation



WISE W1

2MASS - Skrutskie et al., 2006, AJ, 131, 1163 WISE - Wright et al., 2010, AJ, 140, 1868

The Astronomy Error Function

"Suppose the rifle replaced by a telescope duly mounted; the wafer by a star on the concave surface of the heavens, always observed for a succession of days at the same sidereal time; the marks on the wall by the degrees, minutes, and seconds, read off on divided circles; and the marksman by an observer; and we have the case of all direct astronomical observation where the place of a heavenly body is the thing to be determined… And hence it further follows, that the probability… must be expressed by the same **exponential function of the sum of their squares…**" - J. F. W. Herschel, "Quetelet on Probabilities", 1850, emphasis mine

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

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The Astrometric *Uncertainty* Function

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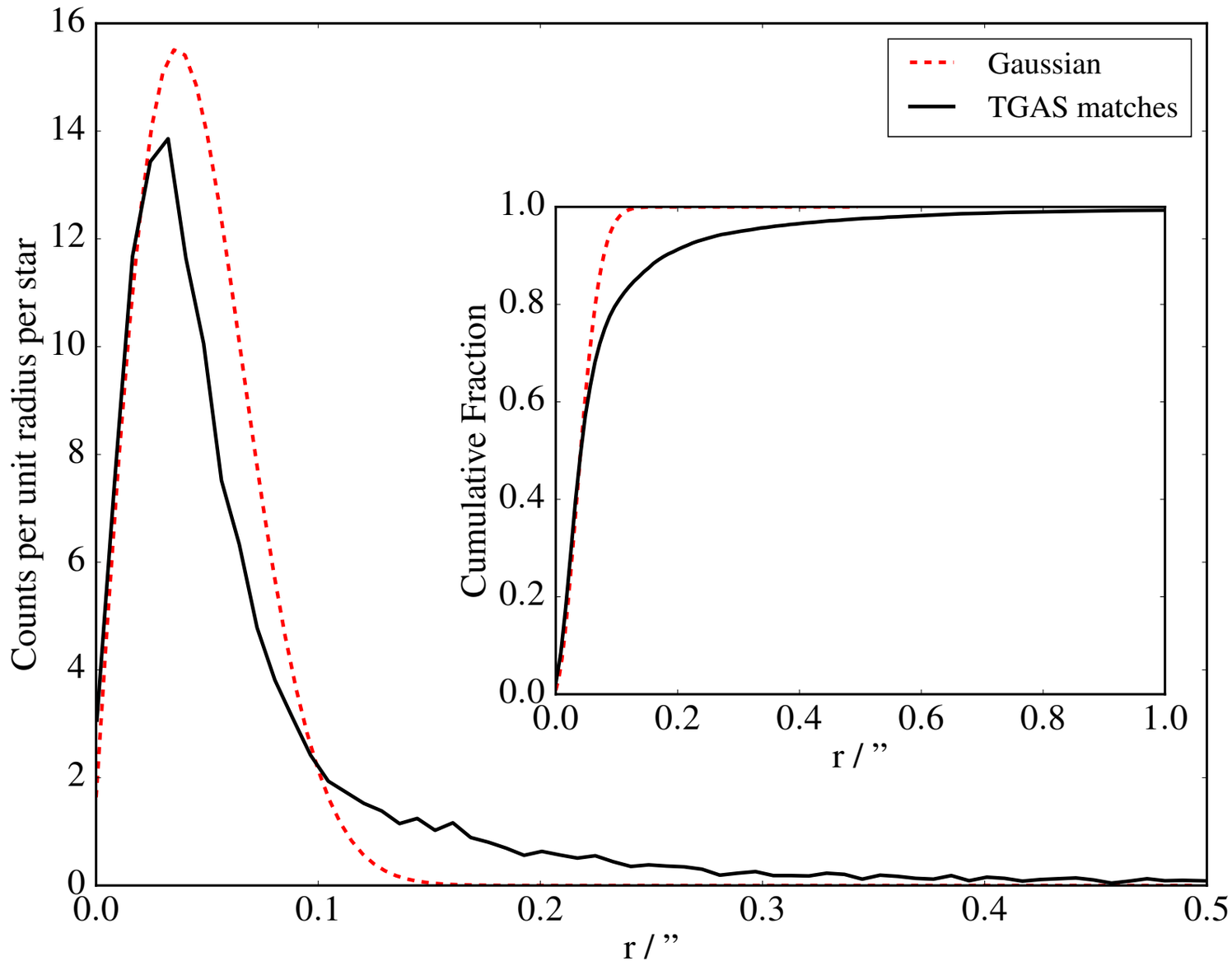
The Astrometric Uncertainty Function

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

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



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Wilson T., Naylor T., 2017, MNRAS, 468, 2517
WISE - Wright et al., 2010, AJ, 140, 1868
TGAS - Michalik D., Lindegren L., Hobbs D., 2015, A&A, 574, 115
Gaia - Gaia Collaboration, Brown A. G. A., et al. 2016, A&A, 595, 2

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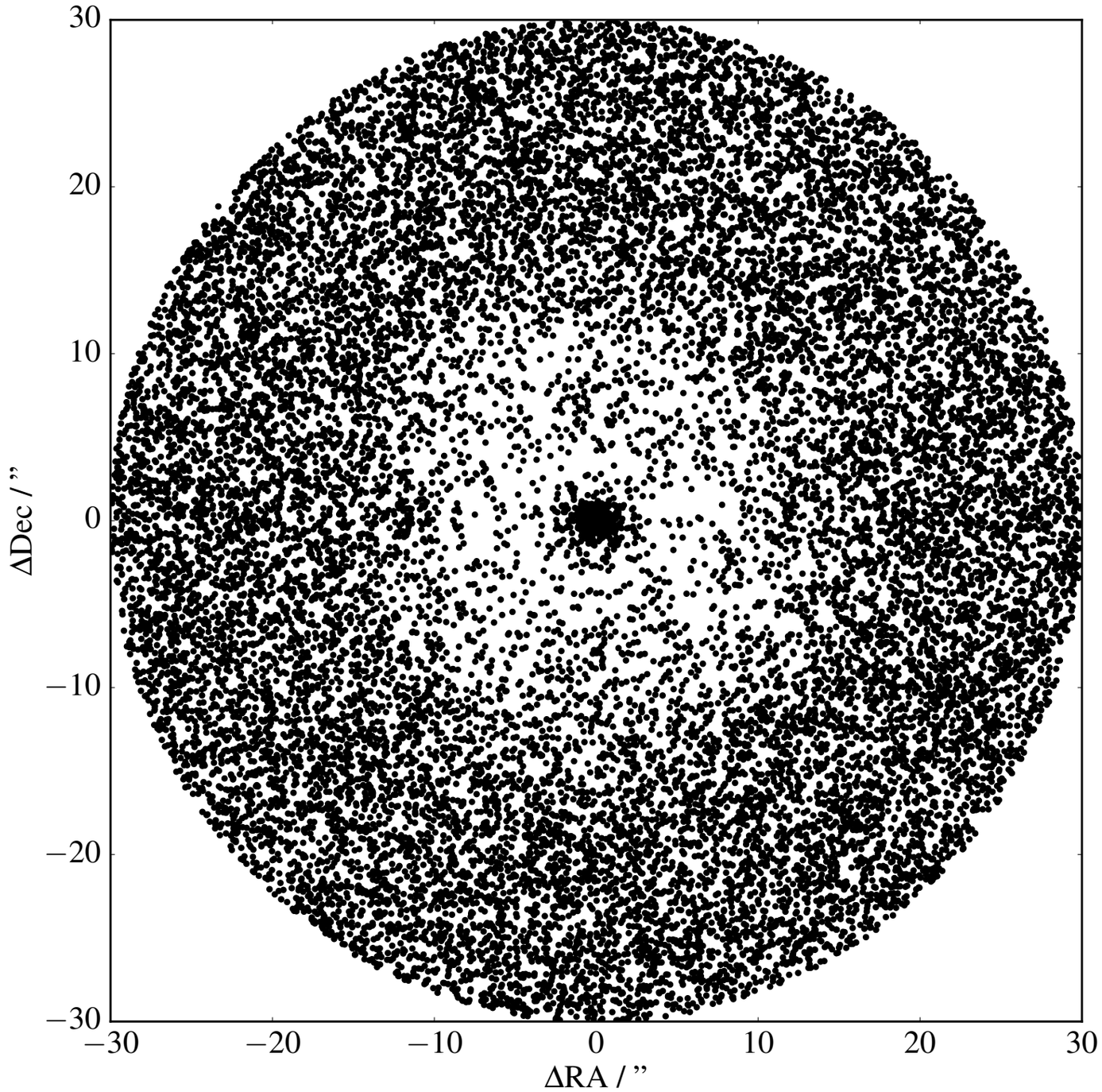
The Astrometric Uncertainty Function: Crowding



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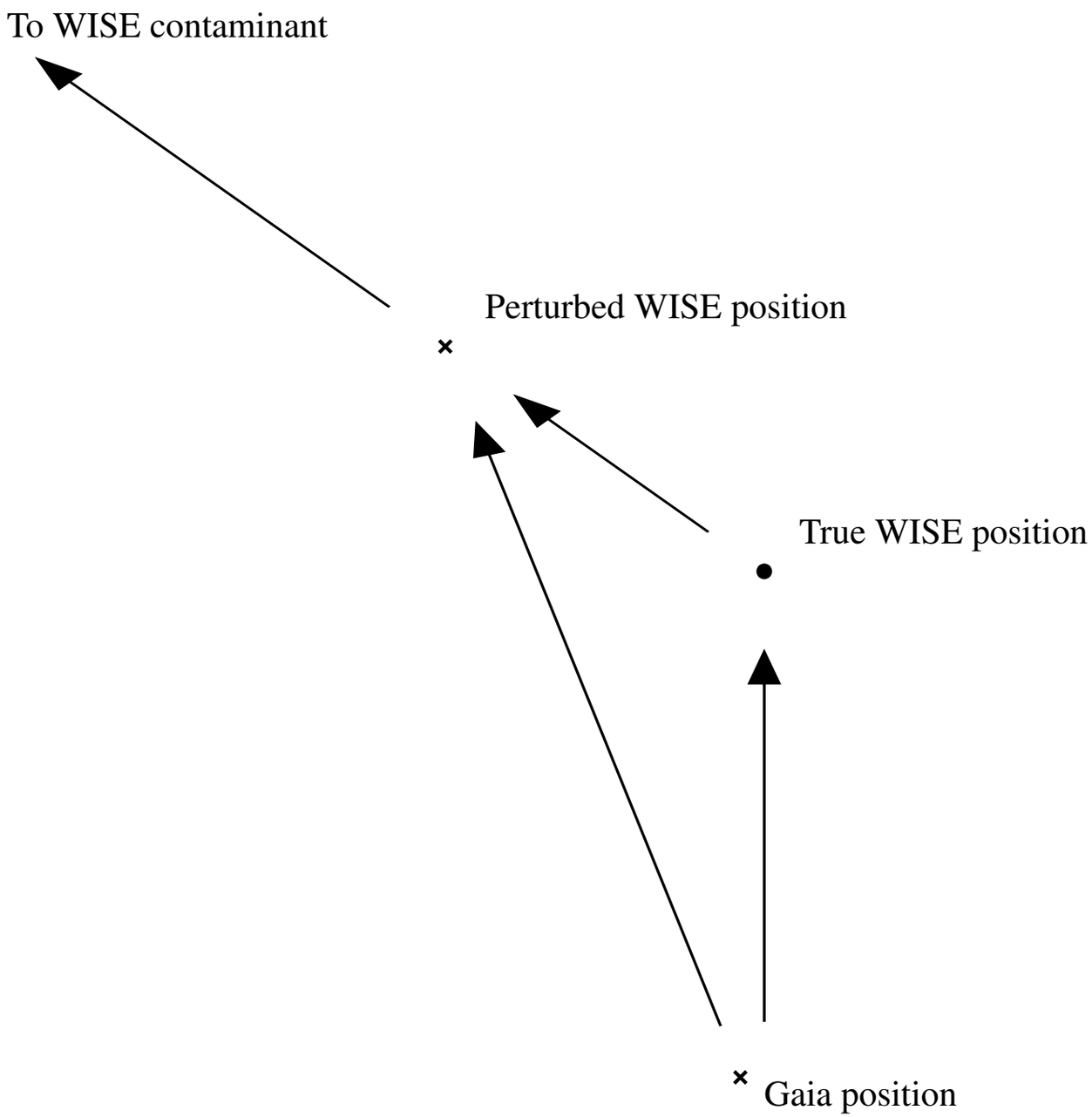
The Astrometric Uncertainty Function: Perturbation



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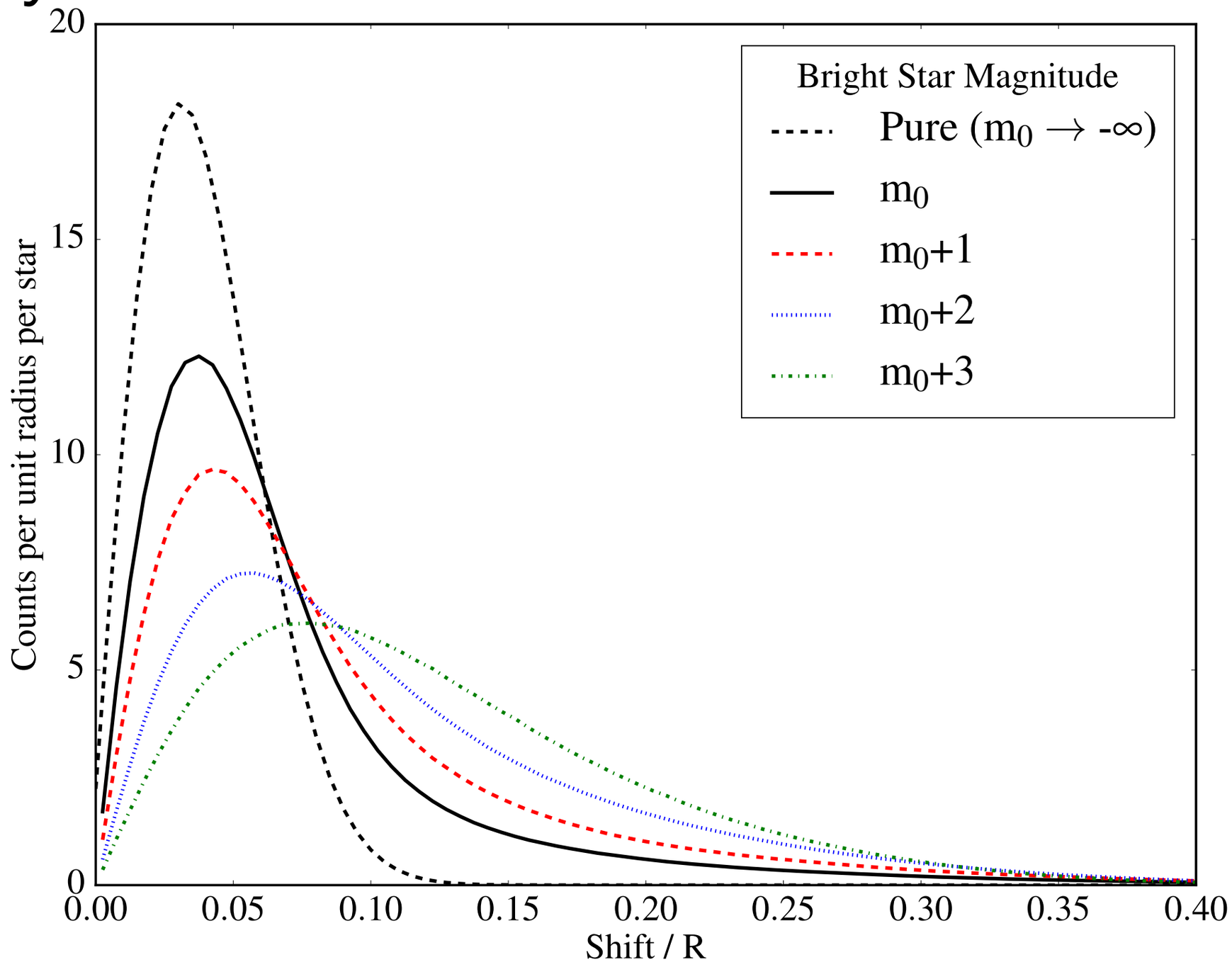
The Astrometric Uncertainty Function: Synthetic Non-Gaussian Tails



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Probability-Based Catalogue Matching

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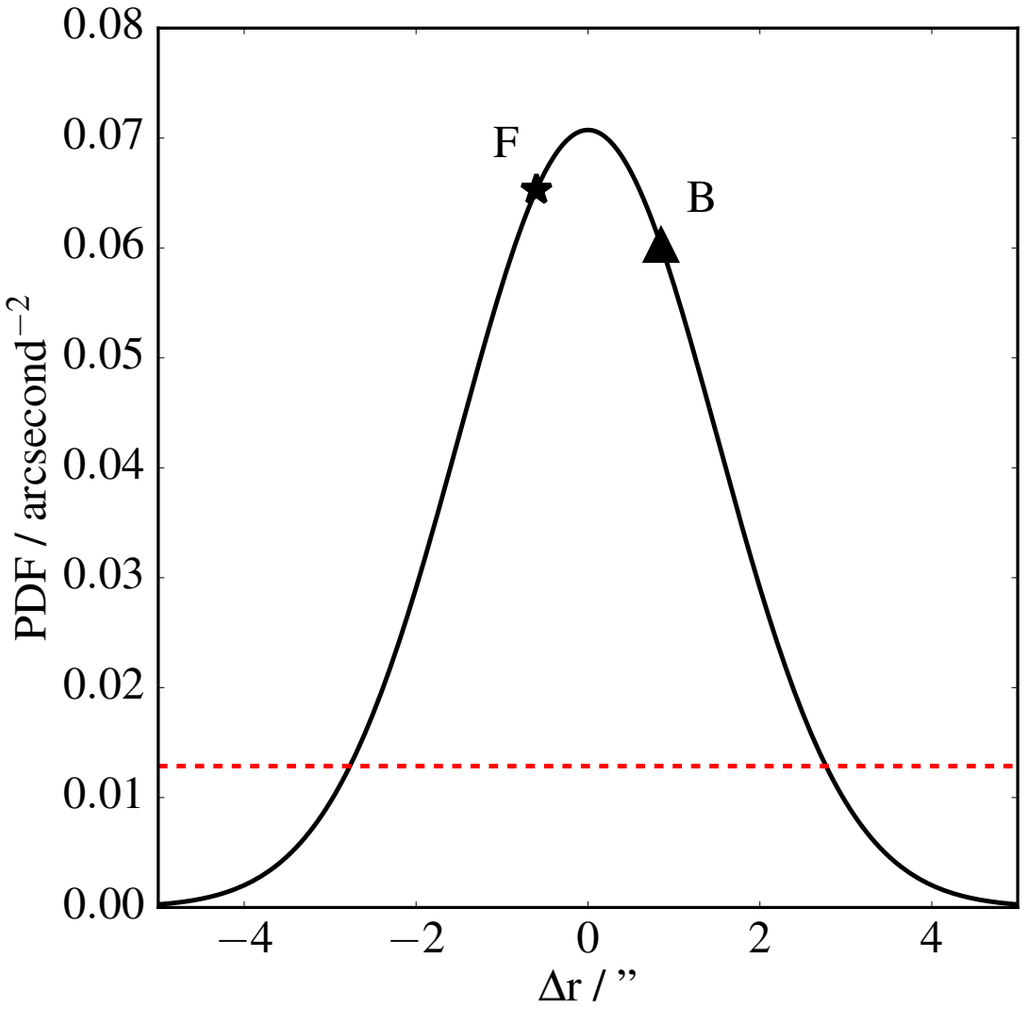
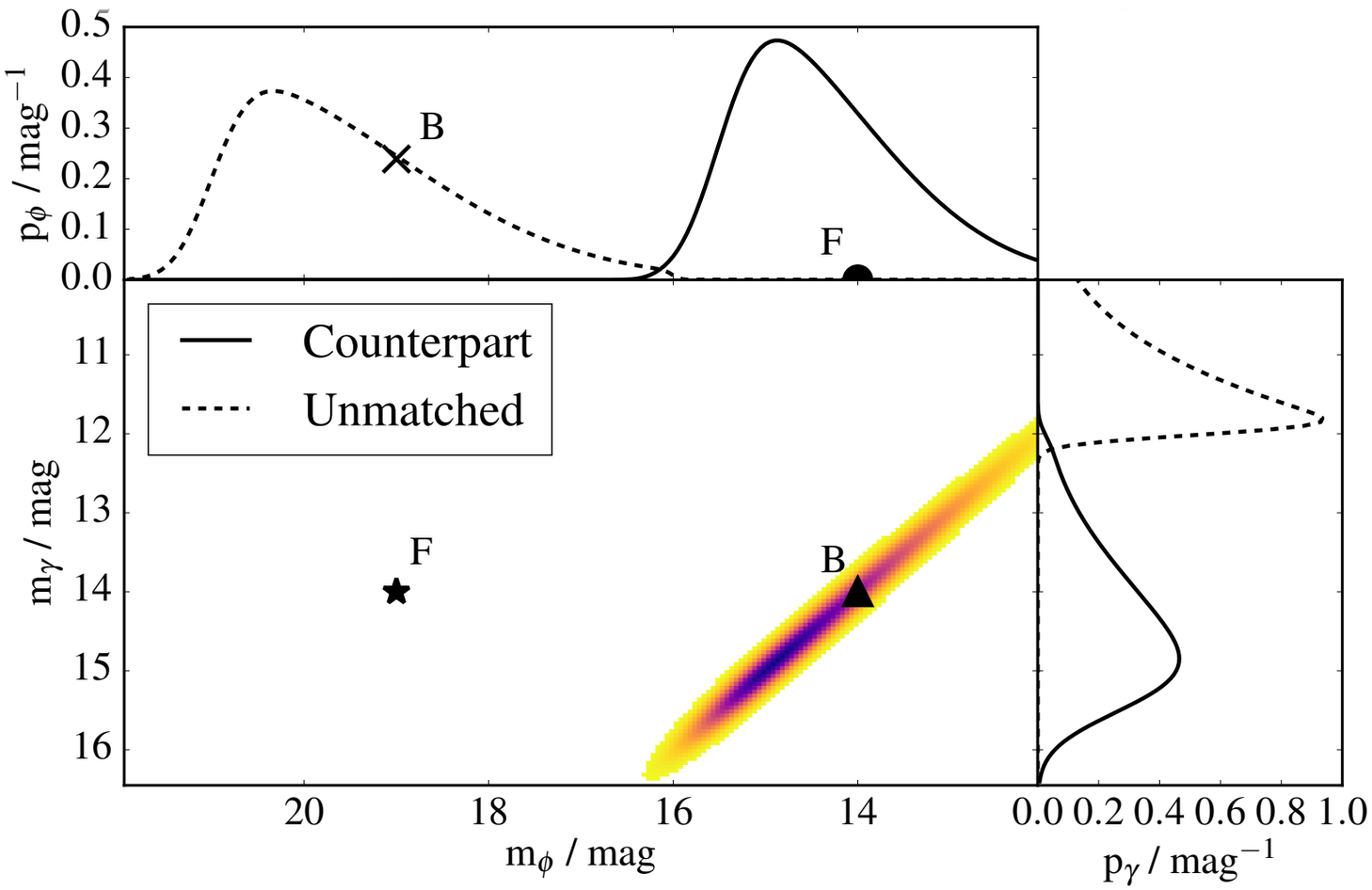
Probability-based Catalogue Matching

$$P(\sigma, \lambda, k|\gamma, \phi) = K \times \prod_{\delta \notin \sigma \cap \delta \in \gamma} N_\gamma f_\gamma^\delta \prod_{\omega \notin \lambda \cap \omega \in \phi} N_\phi f_\phi^\omega \prod_{i=1}^{k} N_c G^{\sigma_i \lambda_i} c^{\sigma_i \lambda_i}$$





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

$$= N_c \times (h_\gamma * h_\phi)(\Delta x_{kl}, \Delta y_{kl}).$$

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The Photometric Effects of Contaminant Stars

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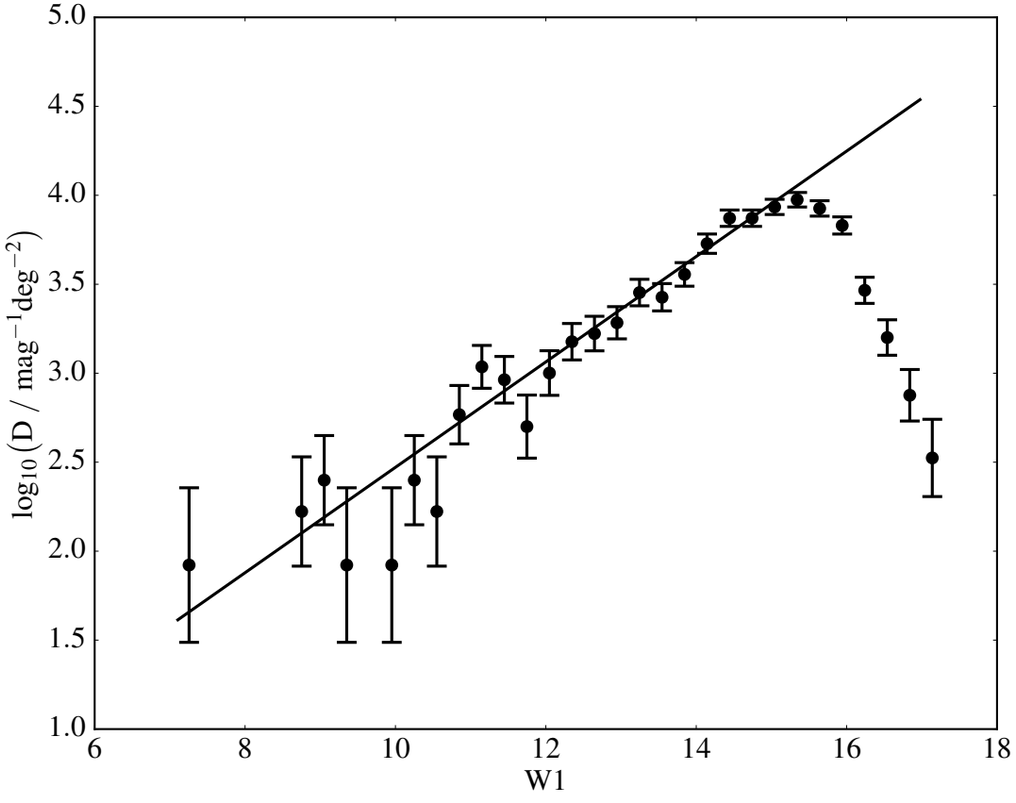
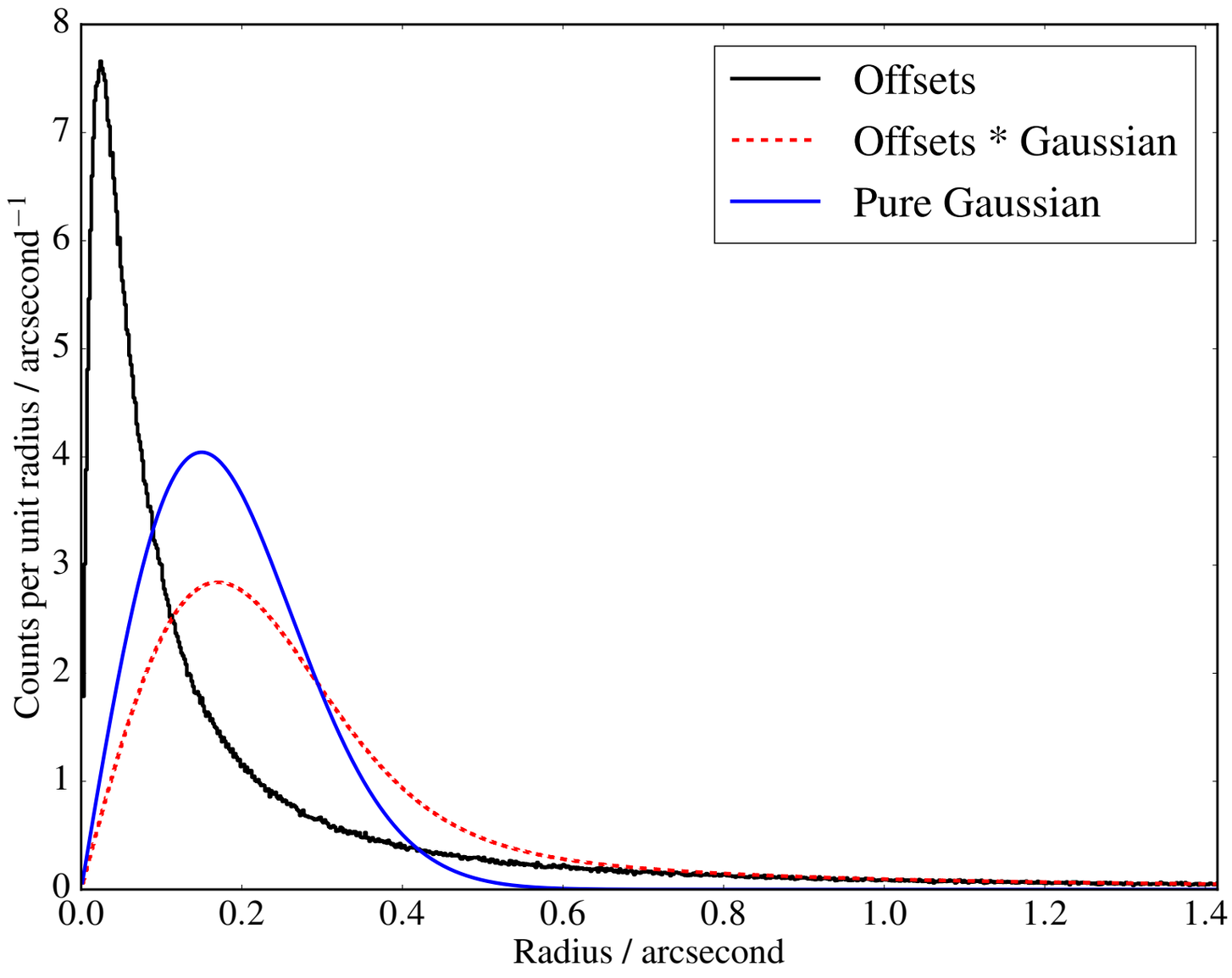
Photometric Contamination: Building Empirical AUFs

$$P_B = \int_{m+\Delta m}^{m+\Delta m+\mathrm{d}m} N z^{m'} \pi R^2 \, \mathrm{d}m'$$





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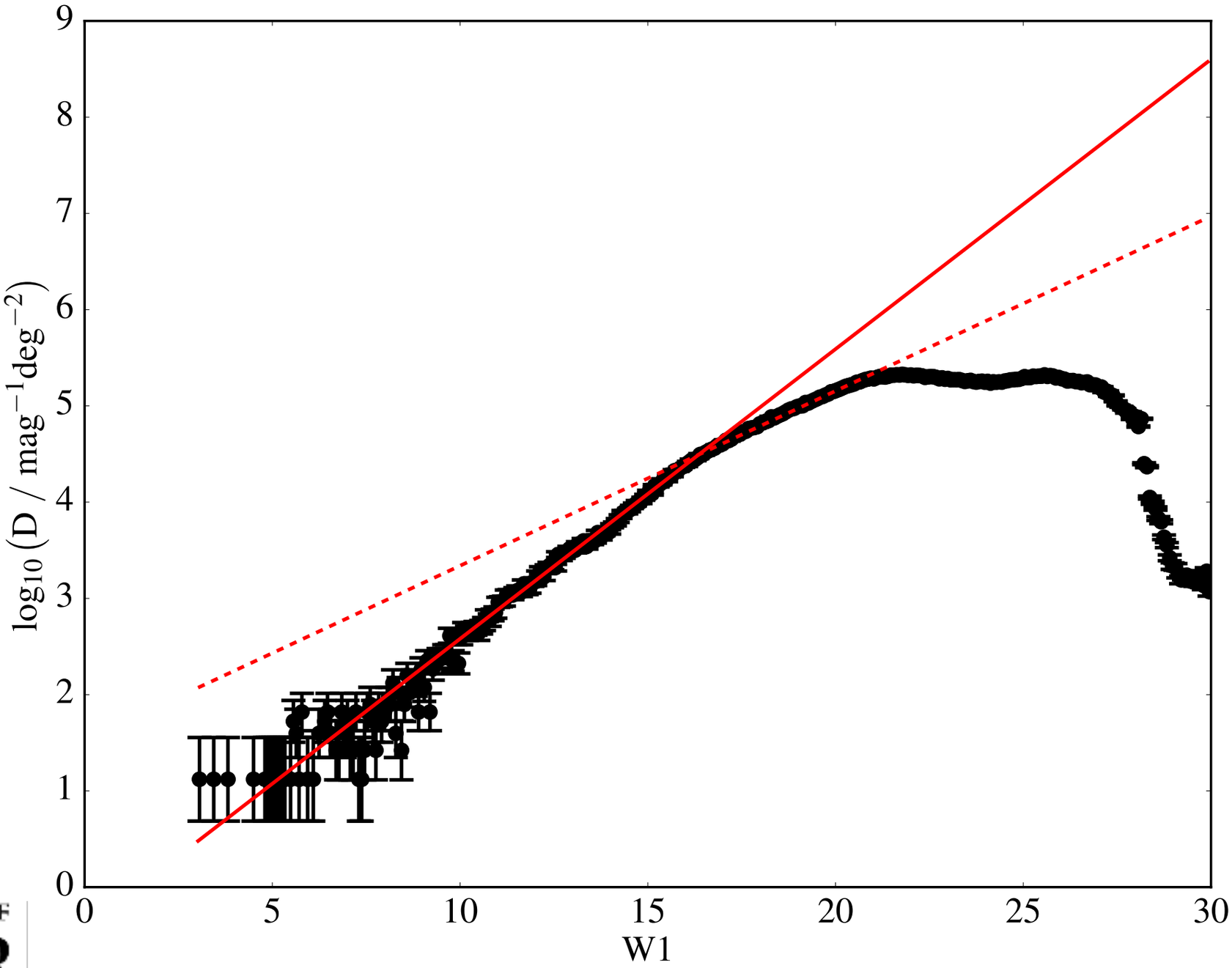
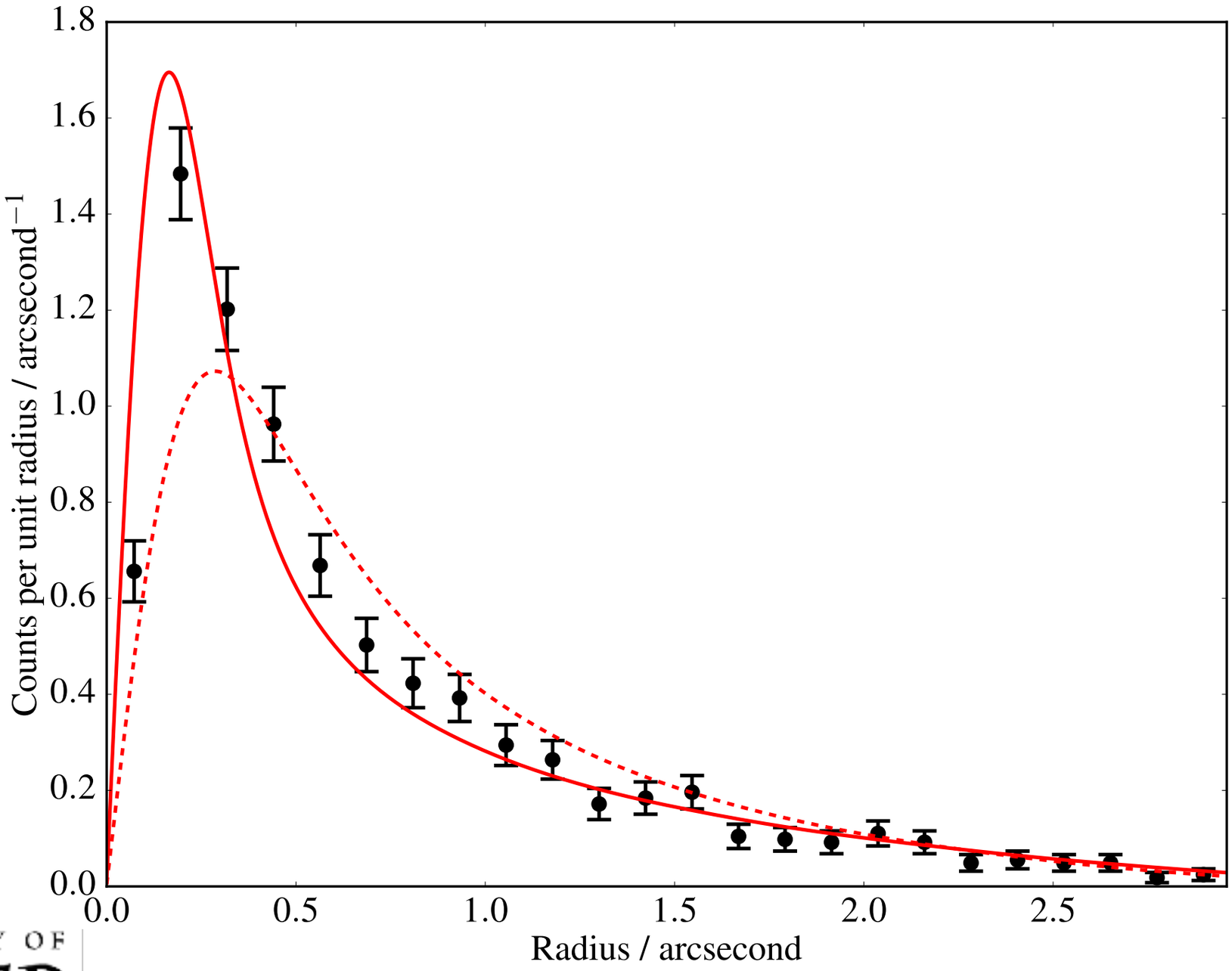
Photometric Contamination: Effects Below Sensitivity Limit



TRILEGAL - Giradi et al, 2005, A&A, 436, 895

Photometric Contamination: Effects Below Sensitivity Limit



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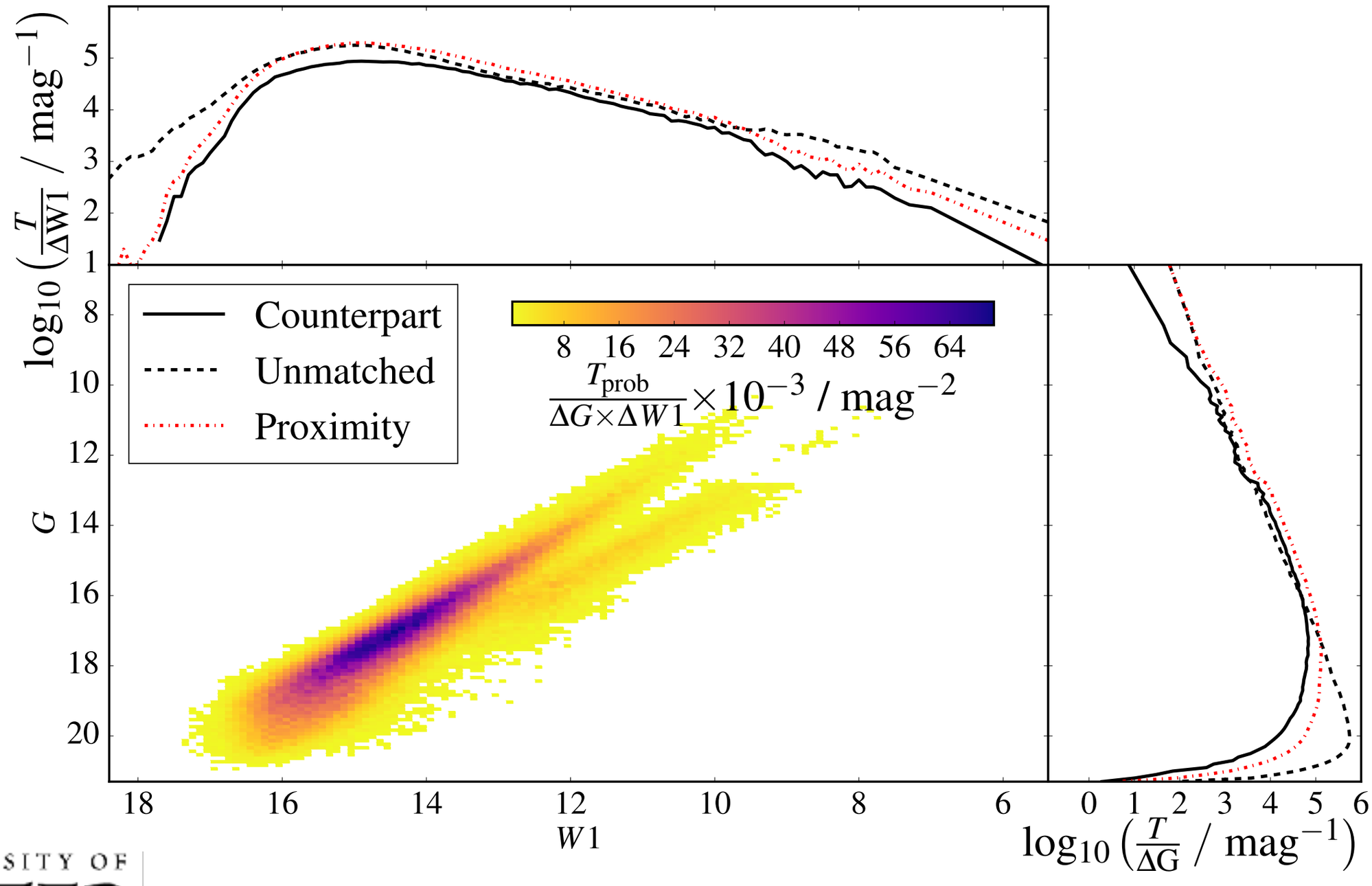
Photometric Contamination: WISE-Gaia Gaussian Matches



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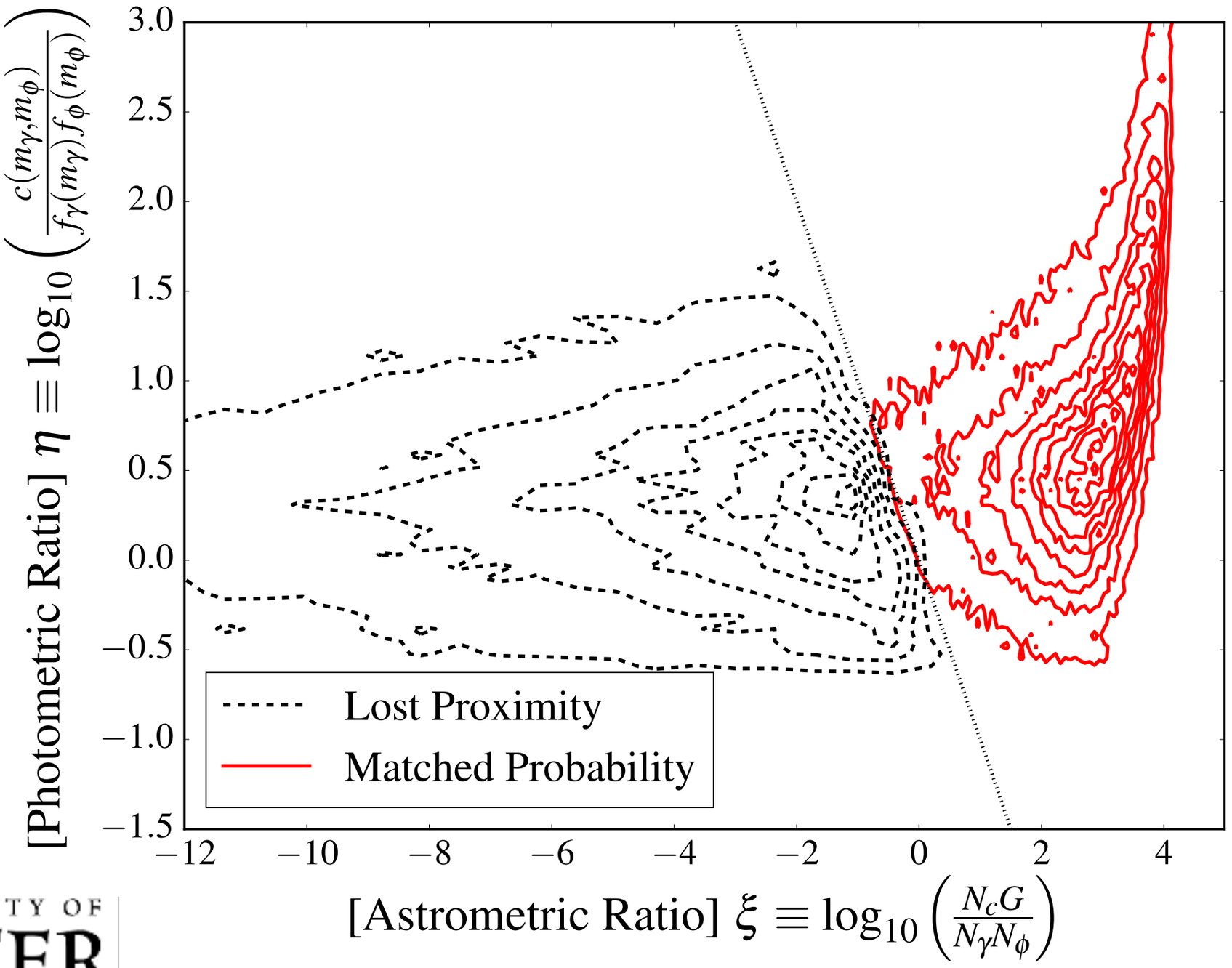
Photometric Contamination: Lost Proximity Matches



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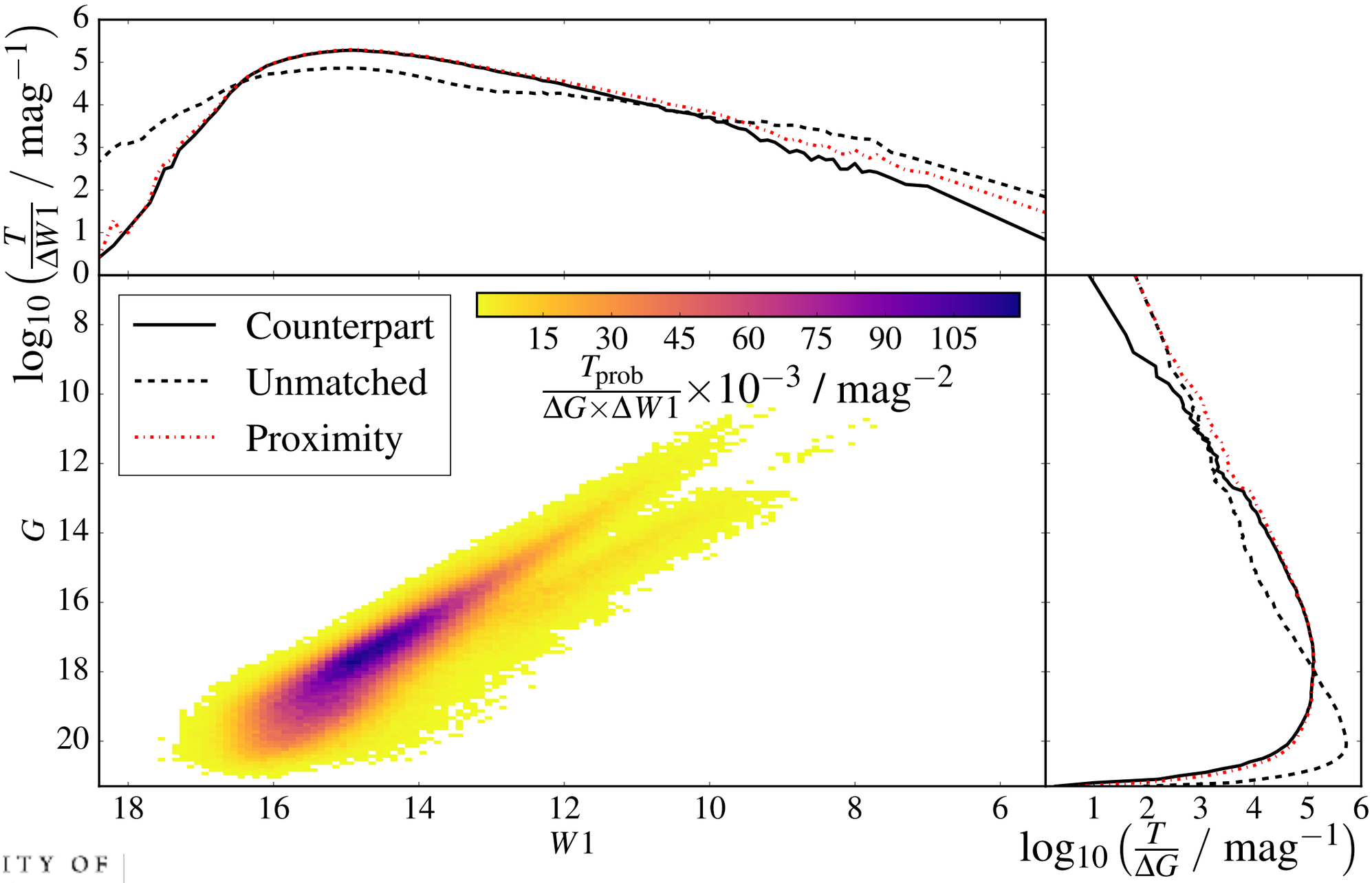
Photometric Contamination: WISE-Gaia Empirical Matches



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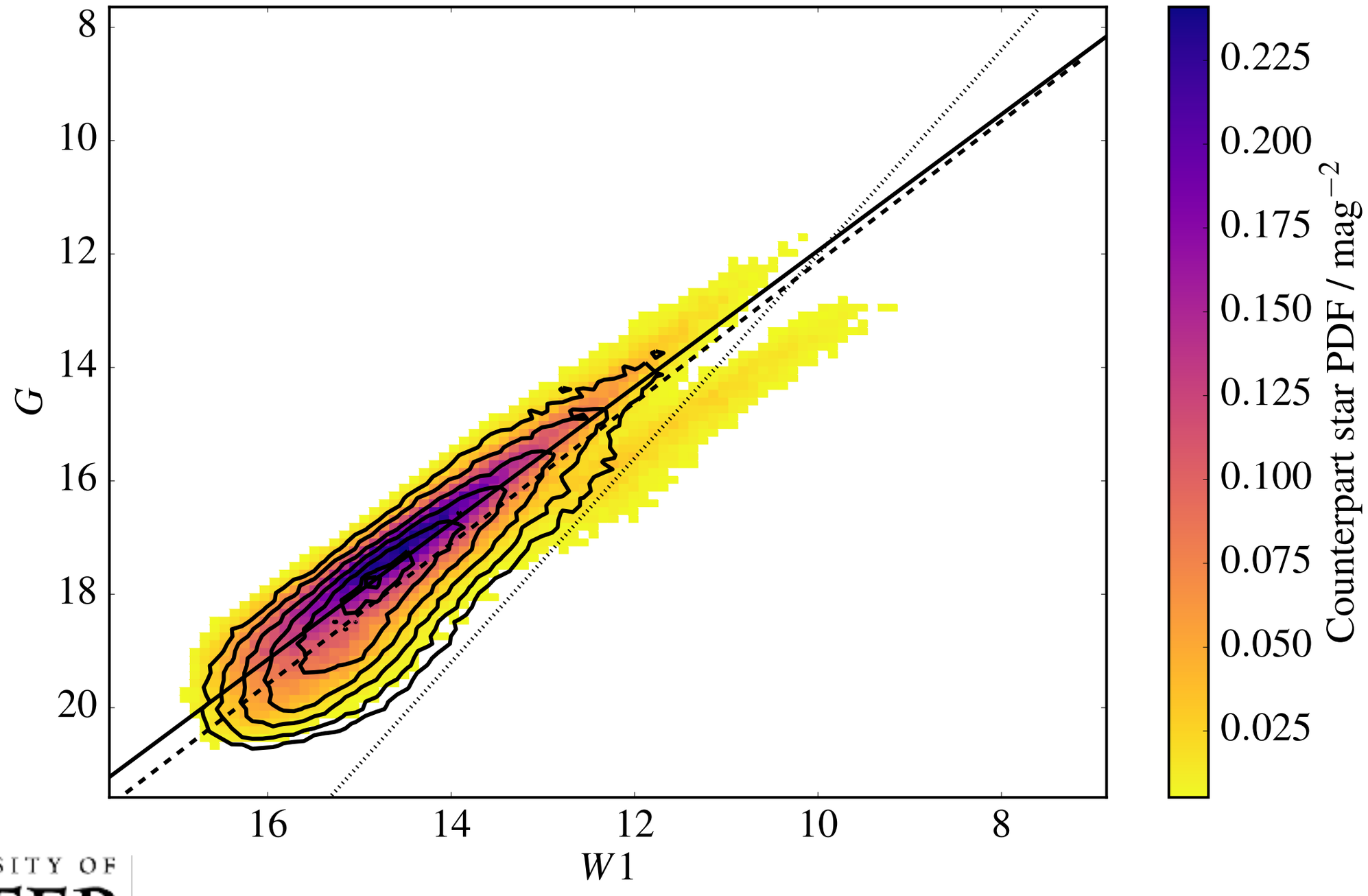
Photometric Contamination: Astrometry Perturbation Correlation



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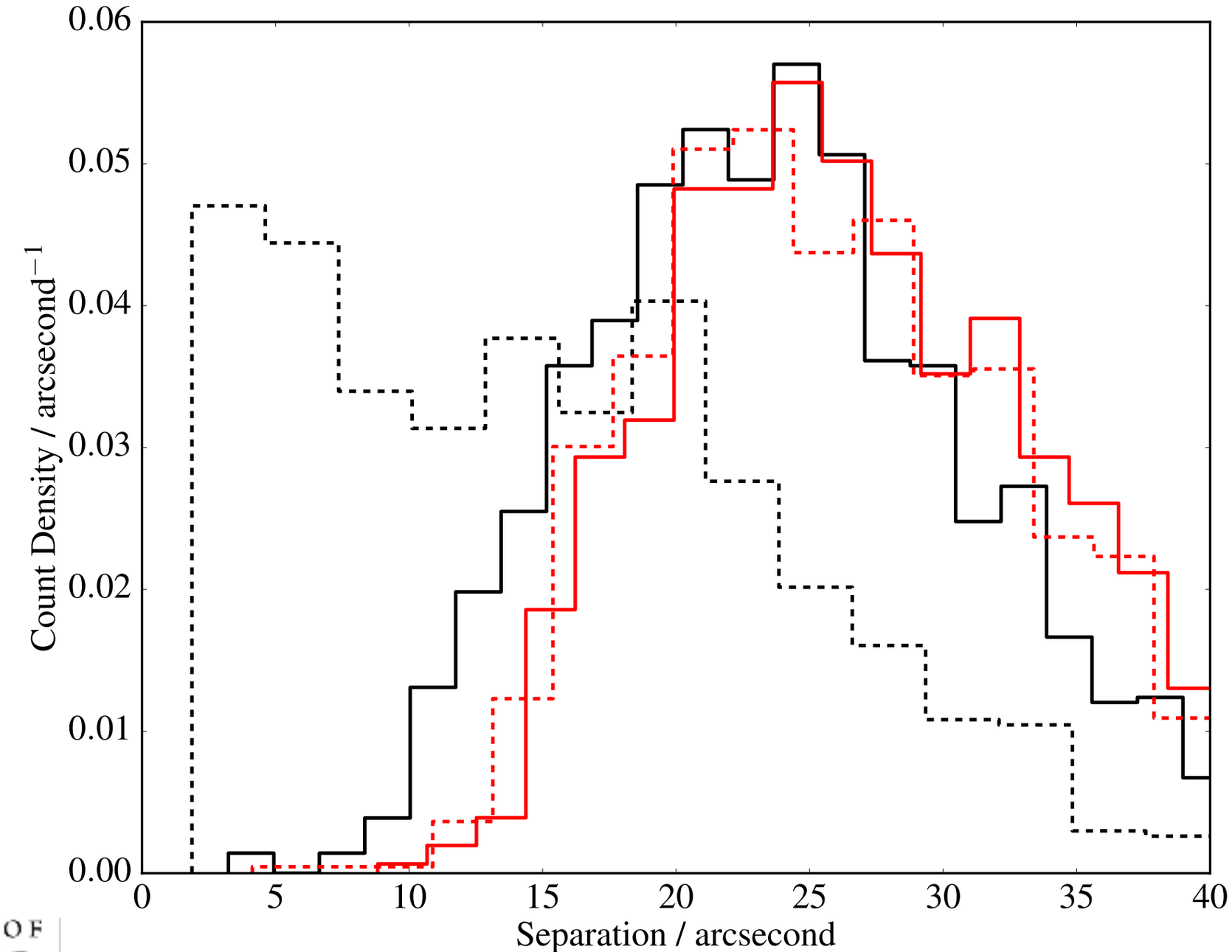
Photometric Contamination: Resolving Contaminants



Spitzer - Werner et al., 2004 ,ApJS, 154, 1
IRAC - Fazio et al., 2004, ApJS, 154, 10
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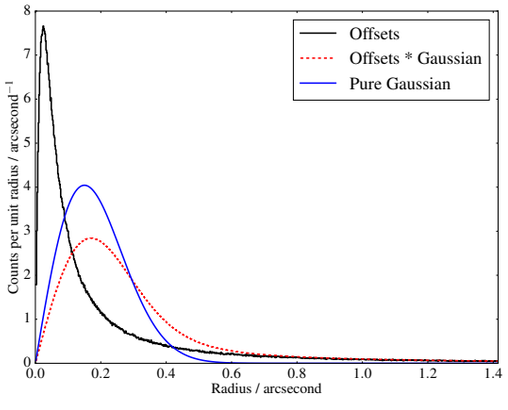
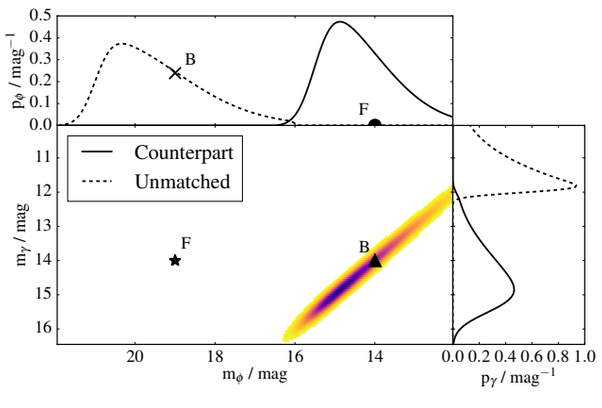
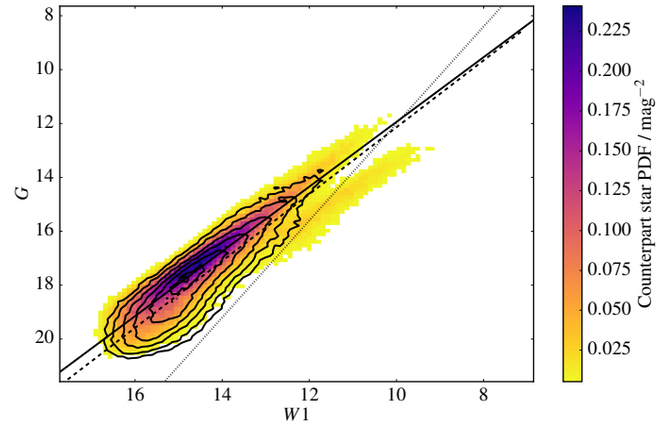
The Effects of Unresolved Contaminant Stars on the Cross-Matching of Photometric Catalogues: Conclusions

- Astrometric Uncertainty Function is not necessarily astronomy error function; contaminants cause non-Gaussian wings
- Matching possible using probability-based matching process
- WISE objects astrometrically perturbed above a certain level are 20% flux contaminated compared to those not perturbed







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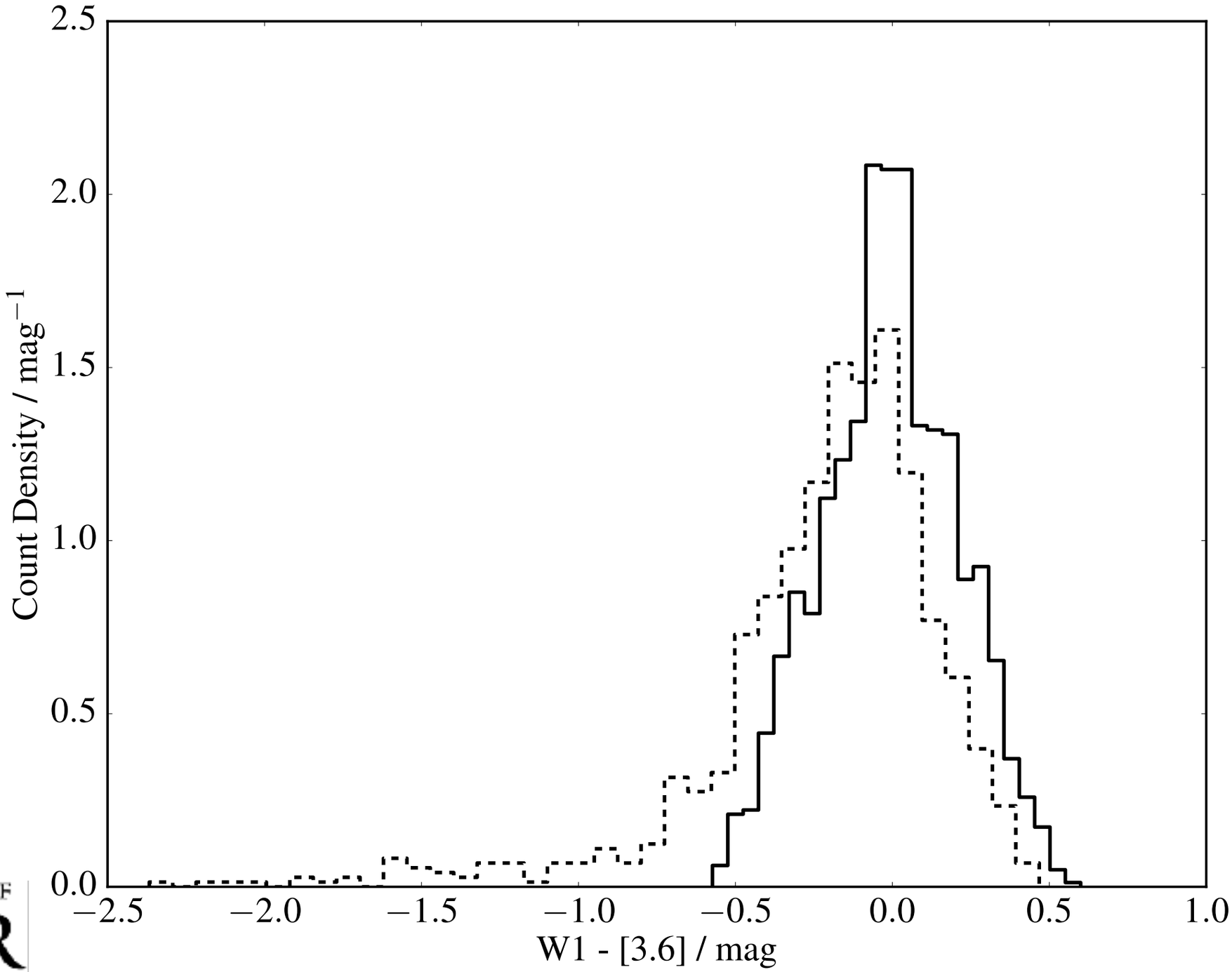
Photometric Contamination: Resolving Contaminants



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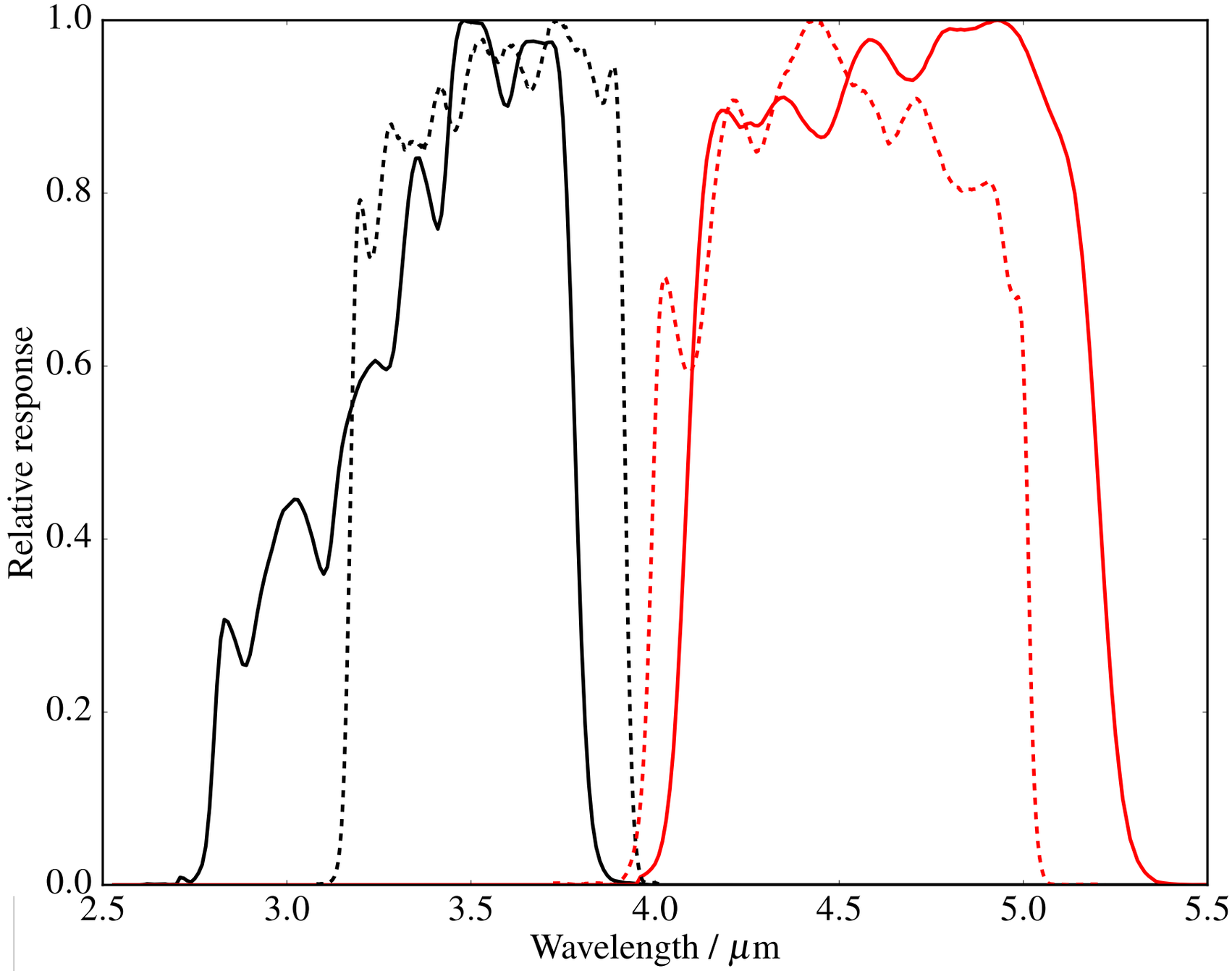
Photometric Contamination: Wavelength Coverage



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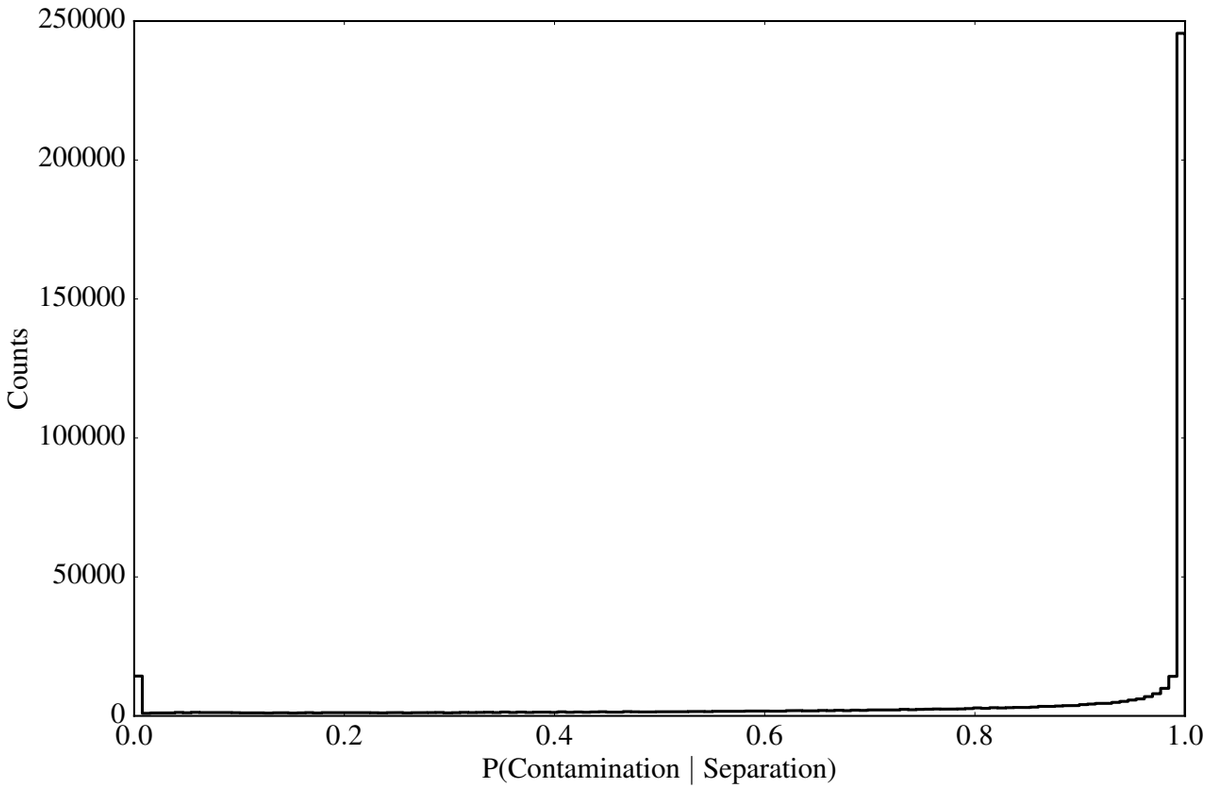
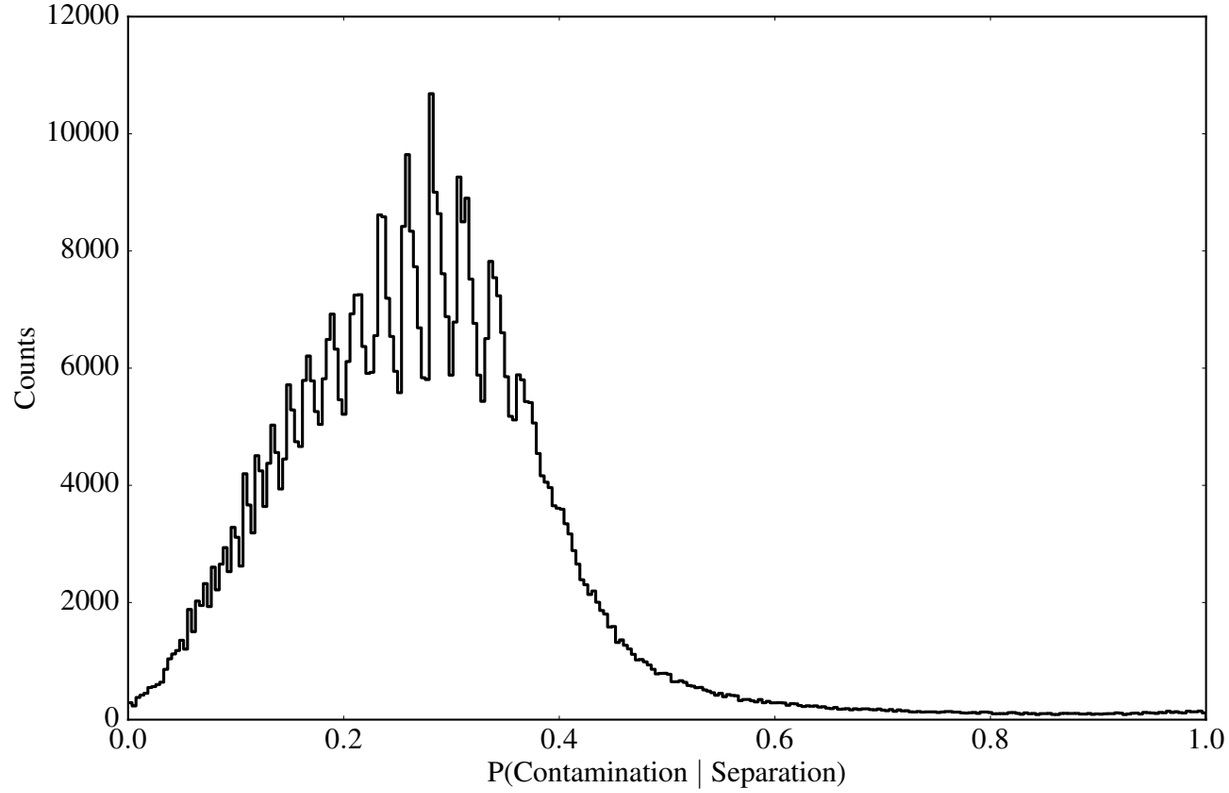
Photometric Contamination: WISE/Spitzer Contamination %





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