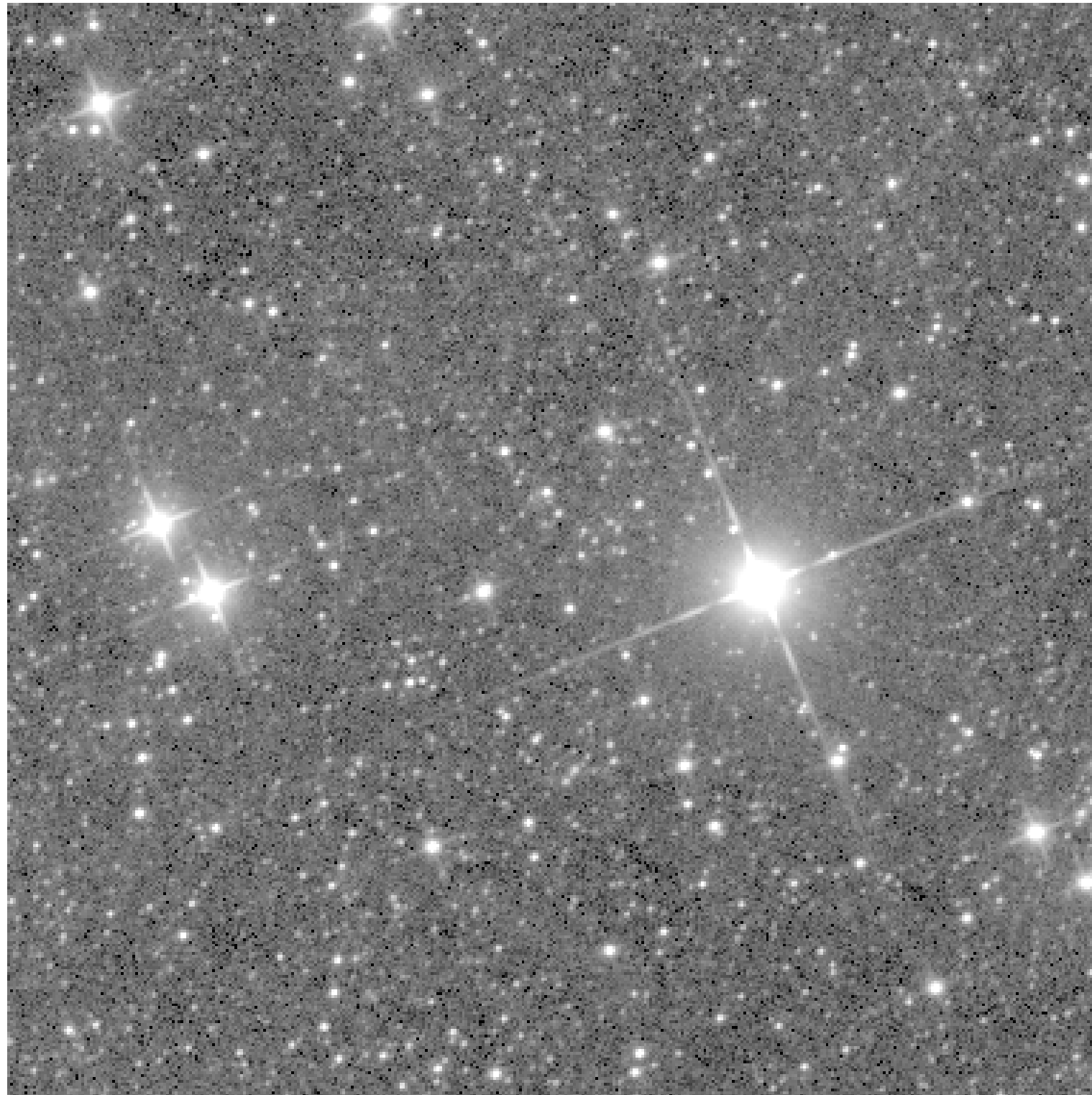


The Effect of Unresolved Contaminant Stars on the Cross- Matching of Photometric Catalogues

Tom J Wilson, University of Exeter
Tim Naylor, also University of Exeter
t.j.wilson@exeter.ac.uk

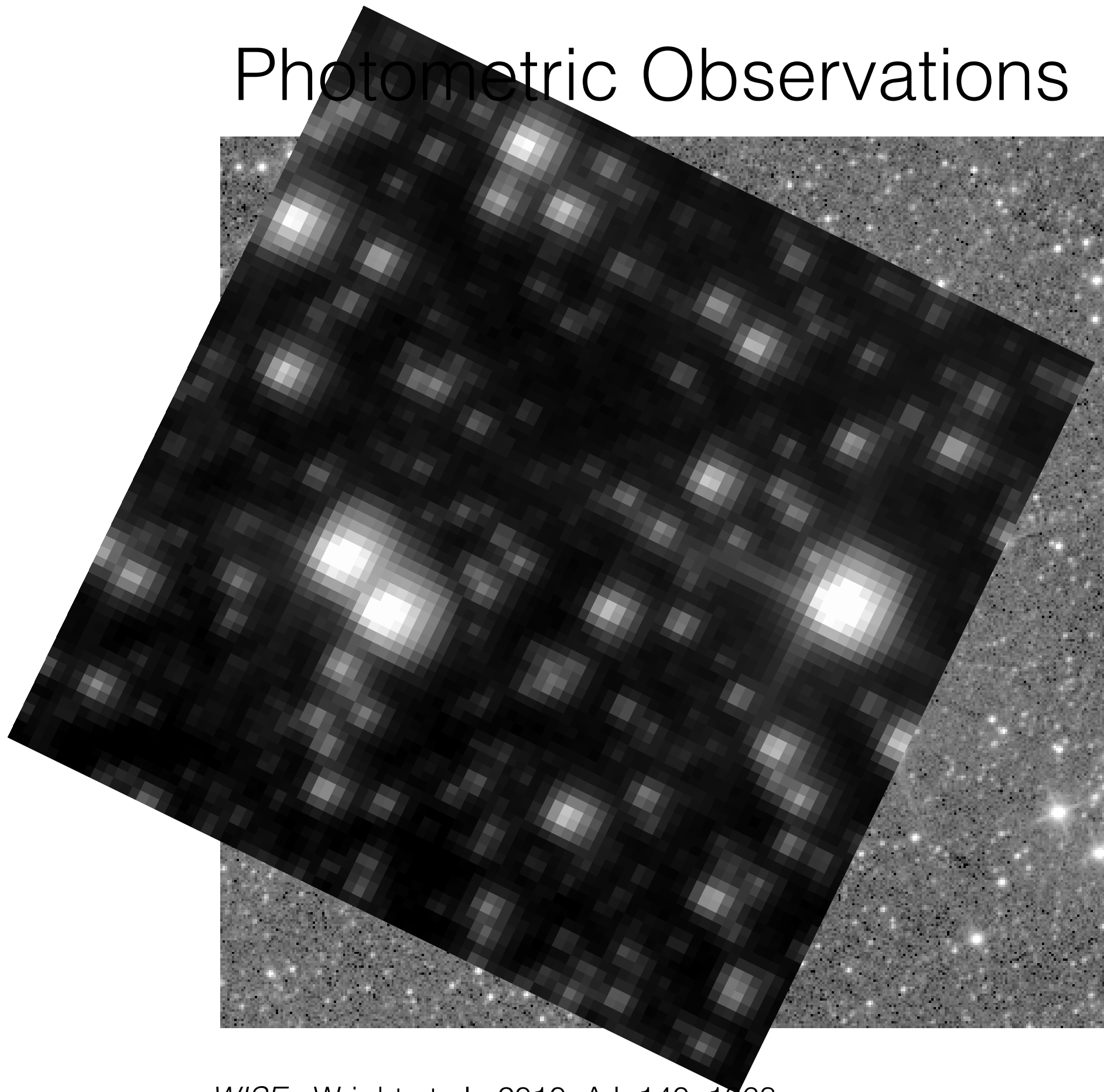
Photometric Observations



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

WISE W1
Tom J Wilson @onoddil

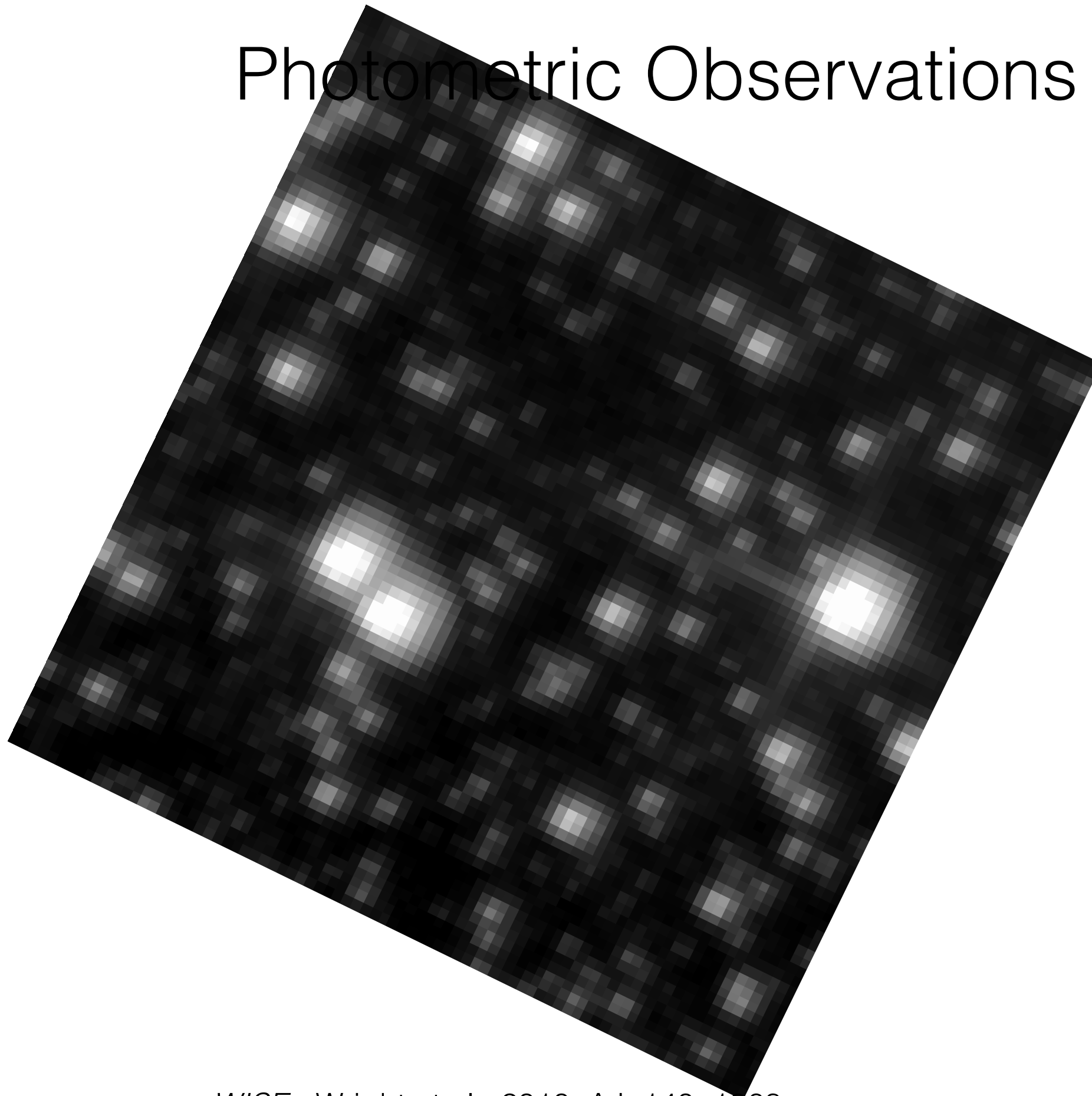
Photometric Observations



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

TESS T
Tom J Wilson @onoddil

Photometric Observations



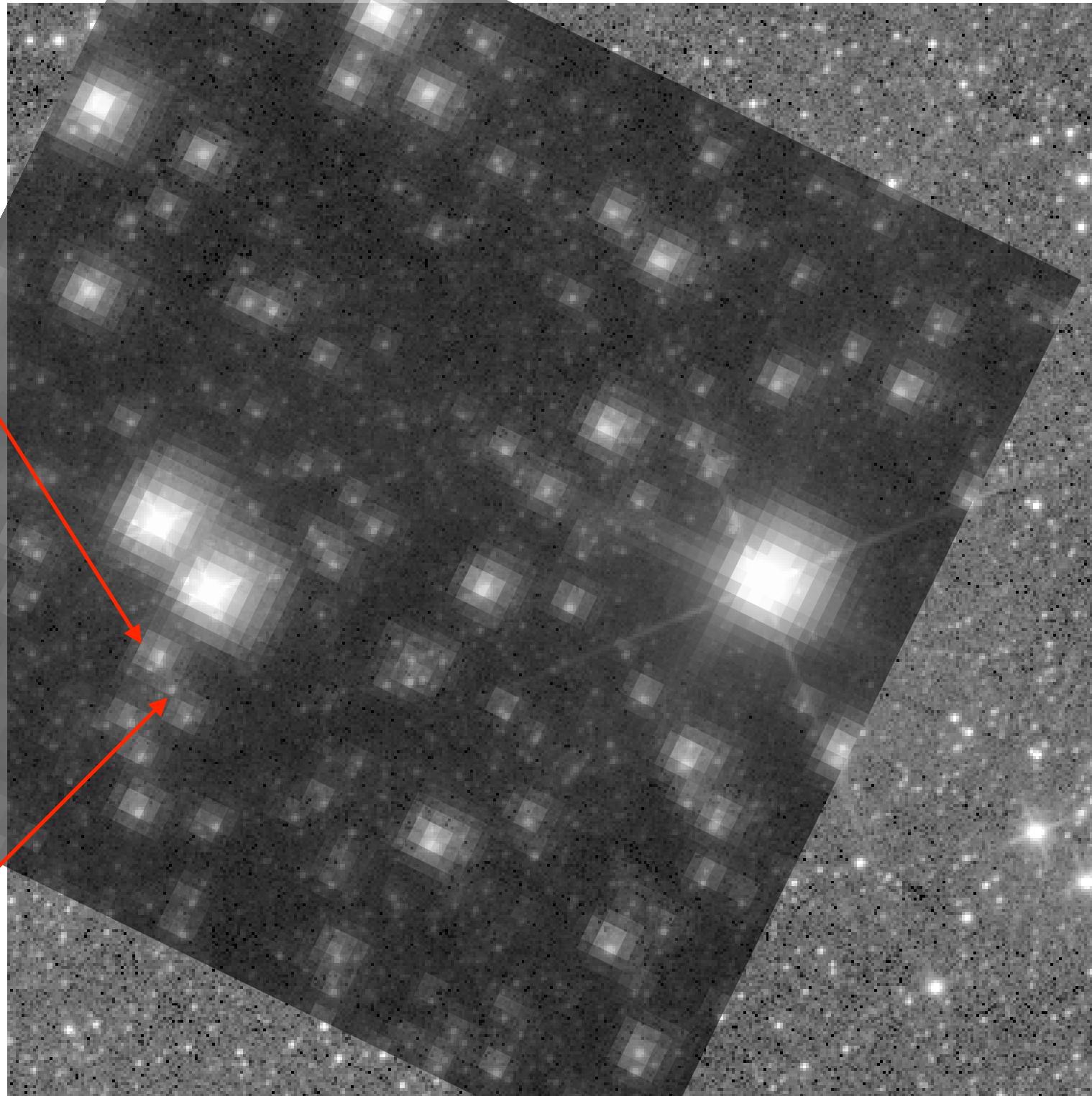
WISE - Wright et al., 2010, *AJ*, 140, 1868
TESS - Ricker et al., 2015, *JATIS*, 1, 14003

TESS T
Tom J Wilson @onoddil

Photometric Observations

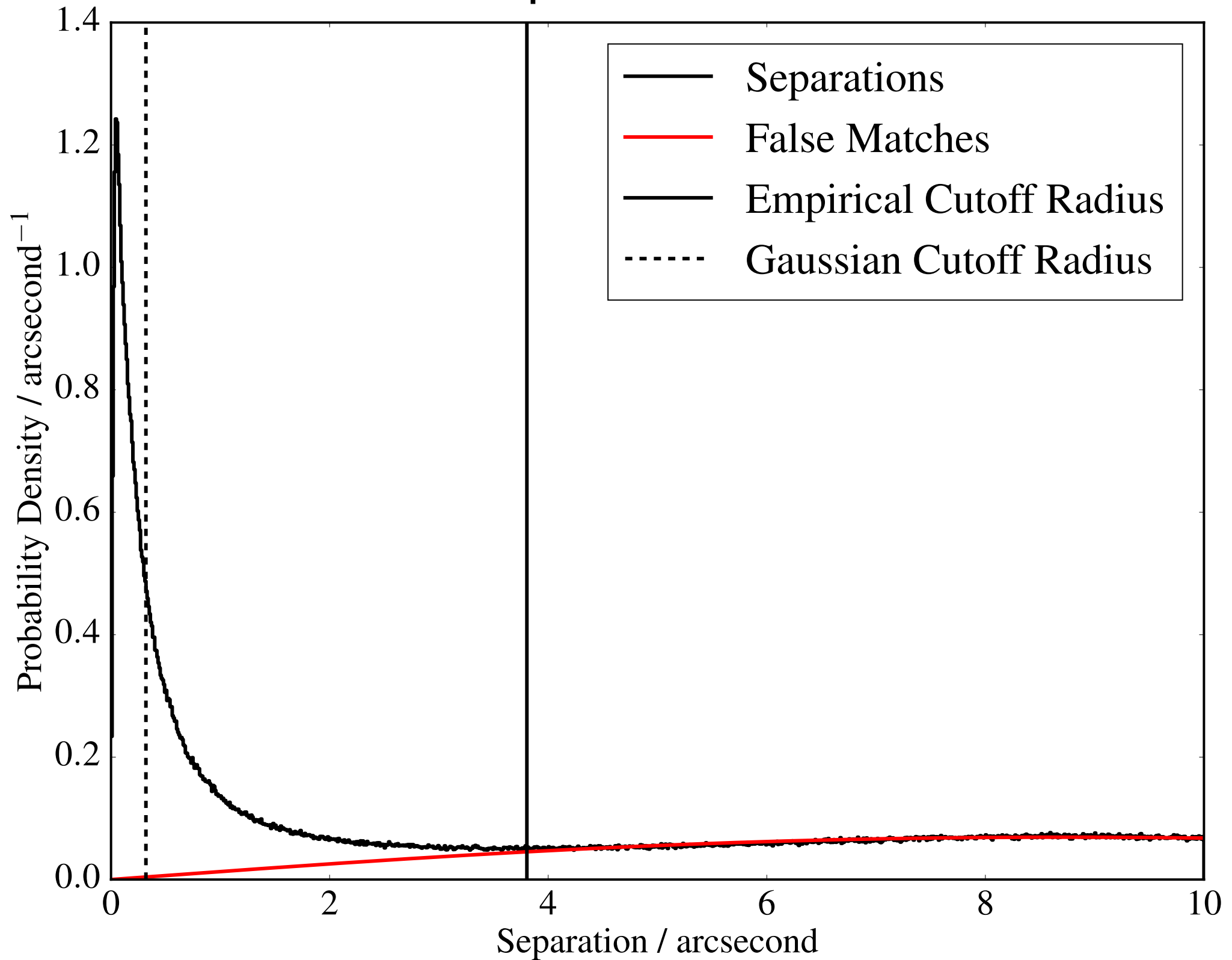
Unresolved
double star
“pair”!

Completely
unresolved
source!



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

Cross-match Separation Distributions



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

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

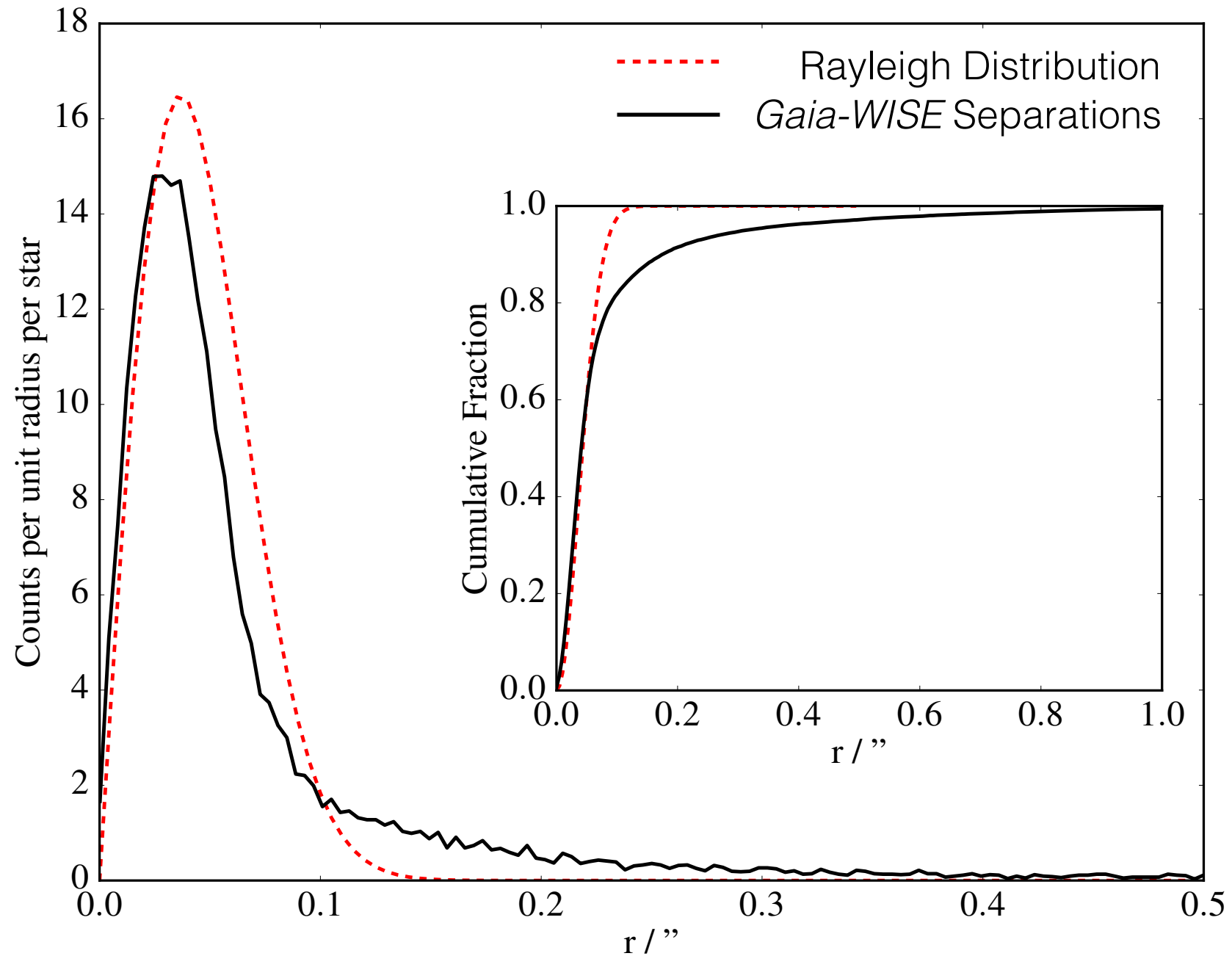
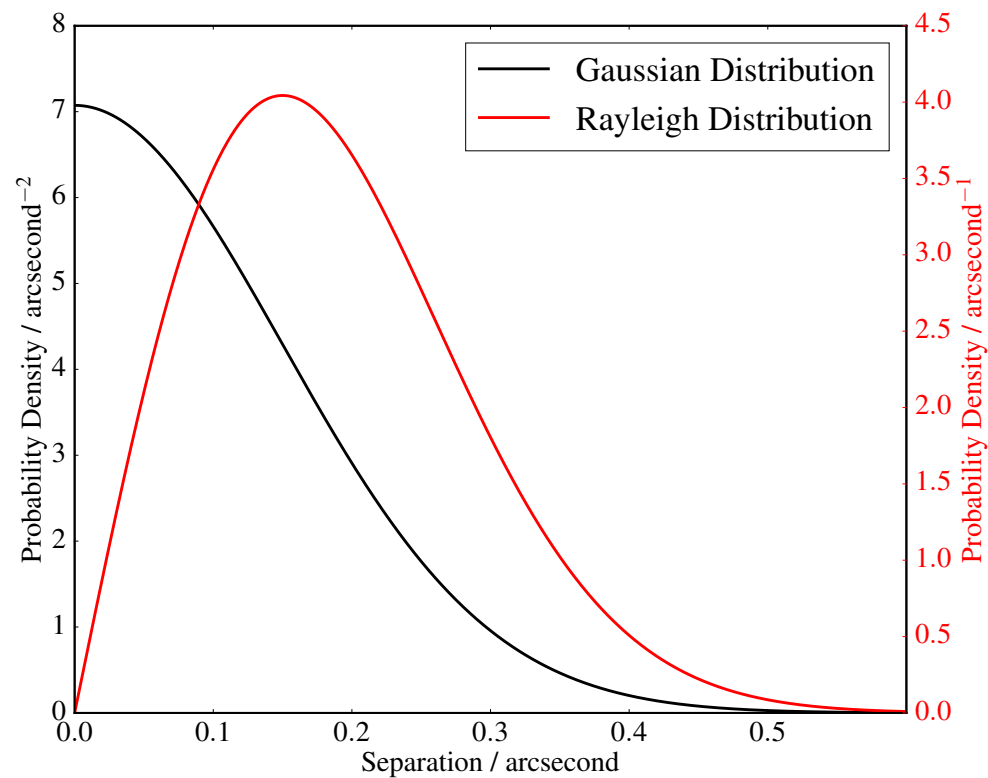
Tom J Wilson @onoddil

The Astrometric Uncertainty Function

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

↓

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



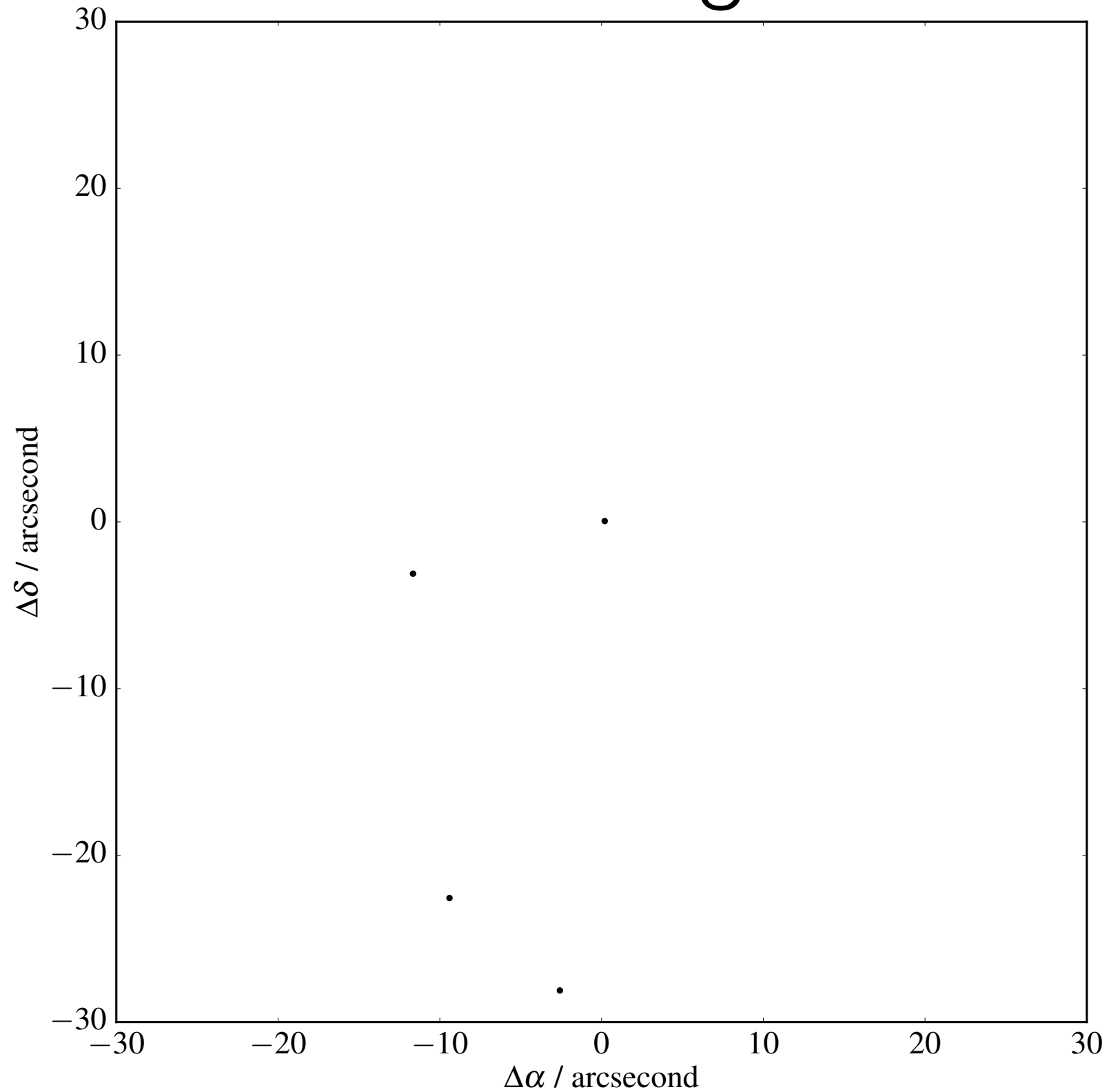
Gaia DR2 - Gaia Collaboration, Brown A. G. A., et al. 2018, A&A, 616, 1

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

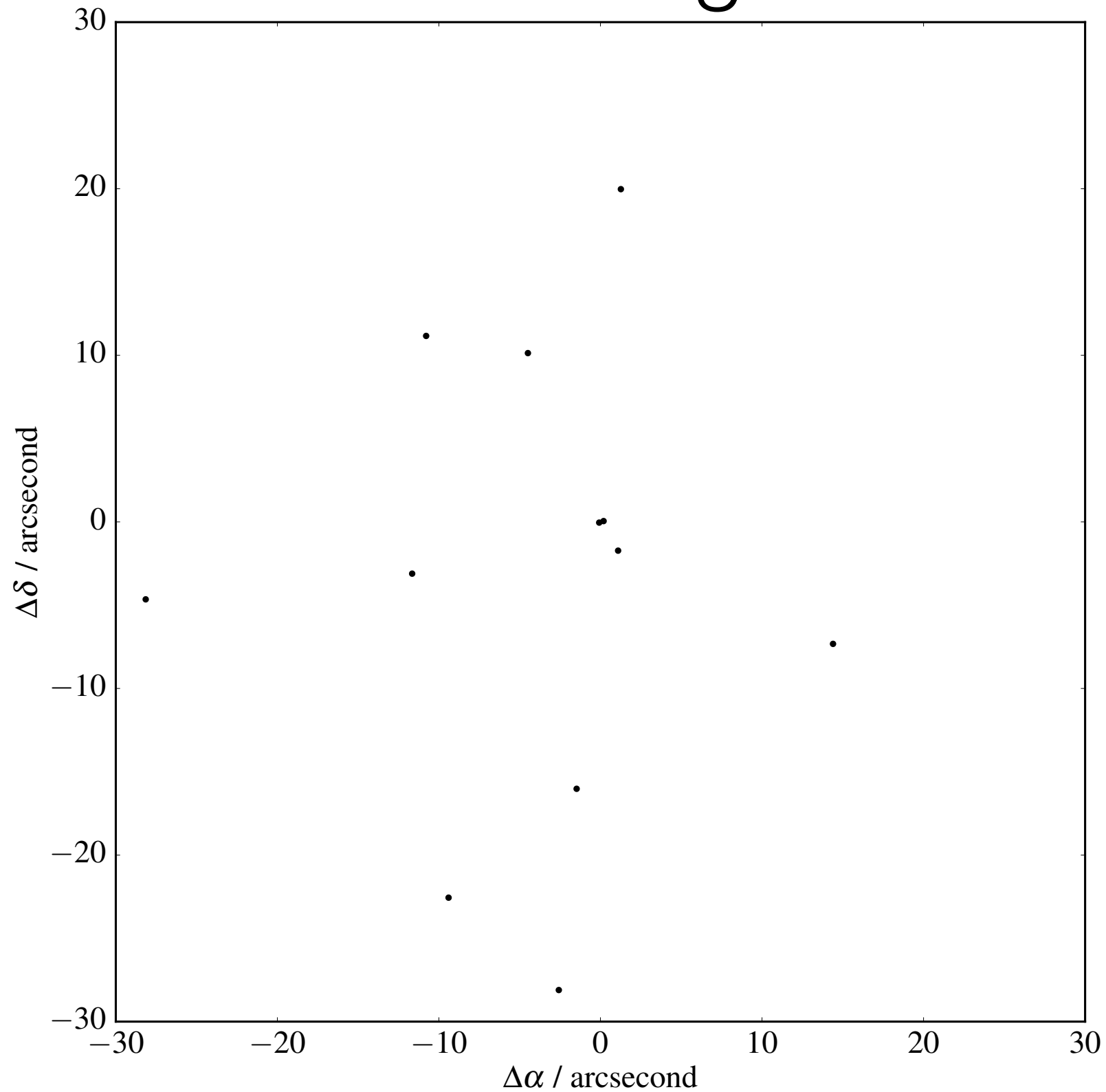
Wilson & Naylor, 2017, MNRAS, 468, 2517

Tom J Wilson @onoddil

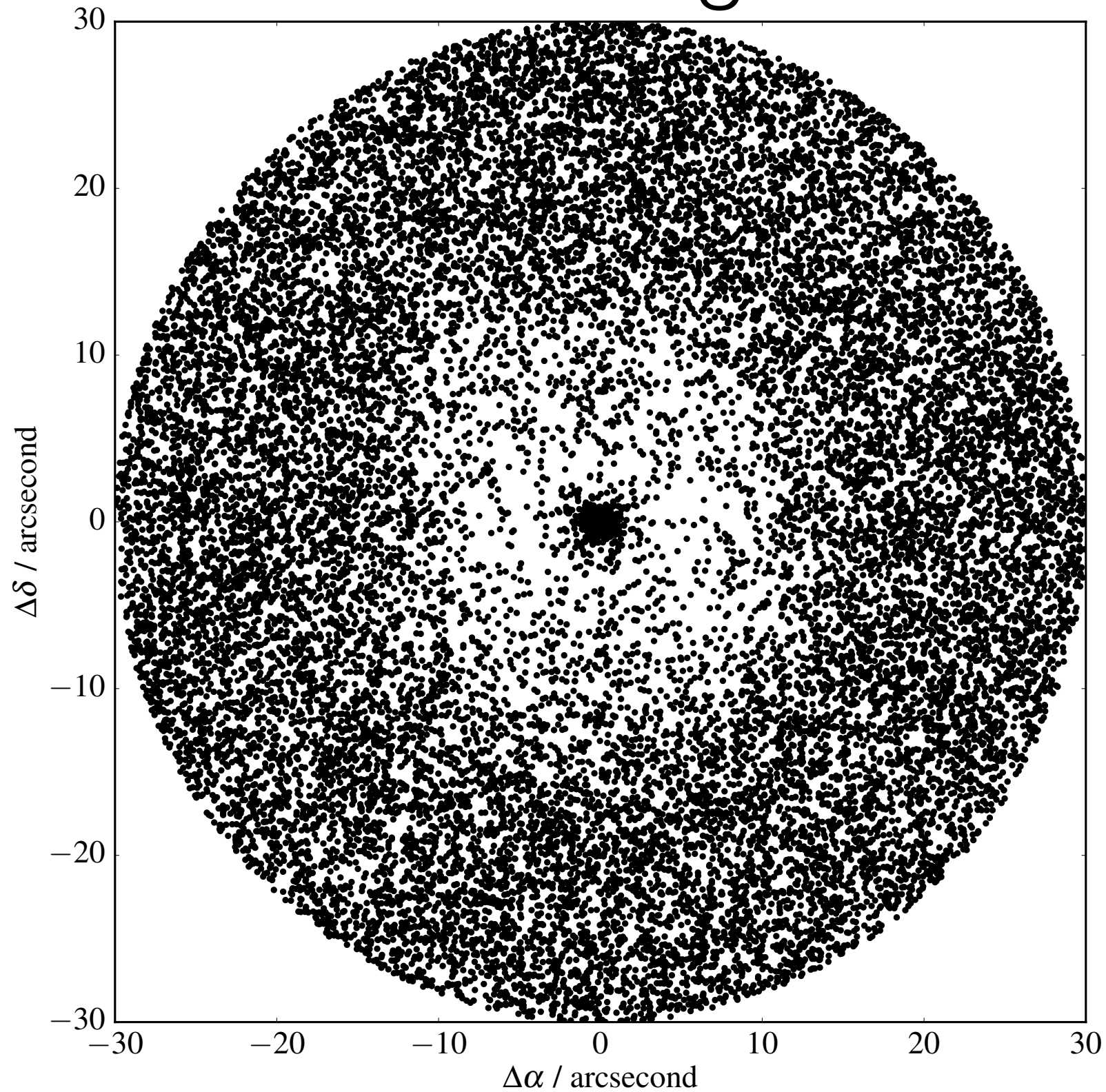
The Astrometric Uncertainty Function: Crowding



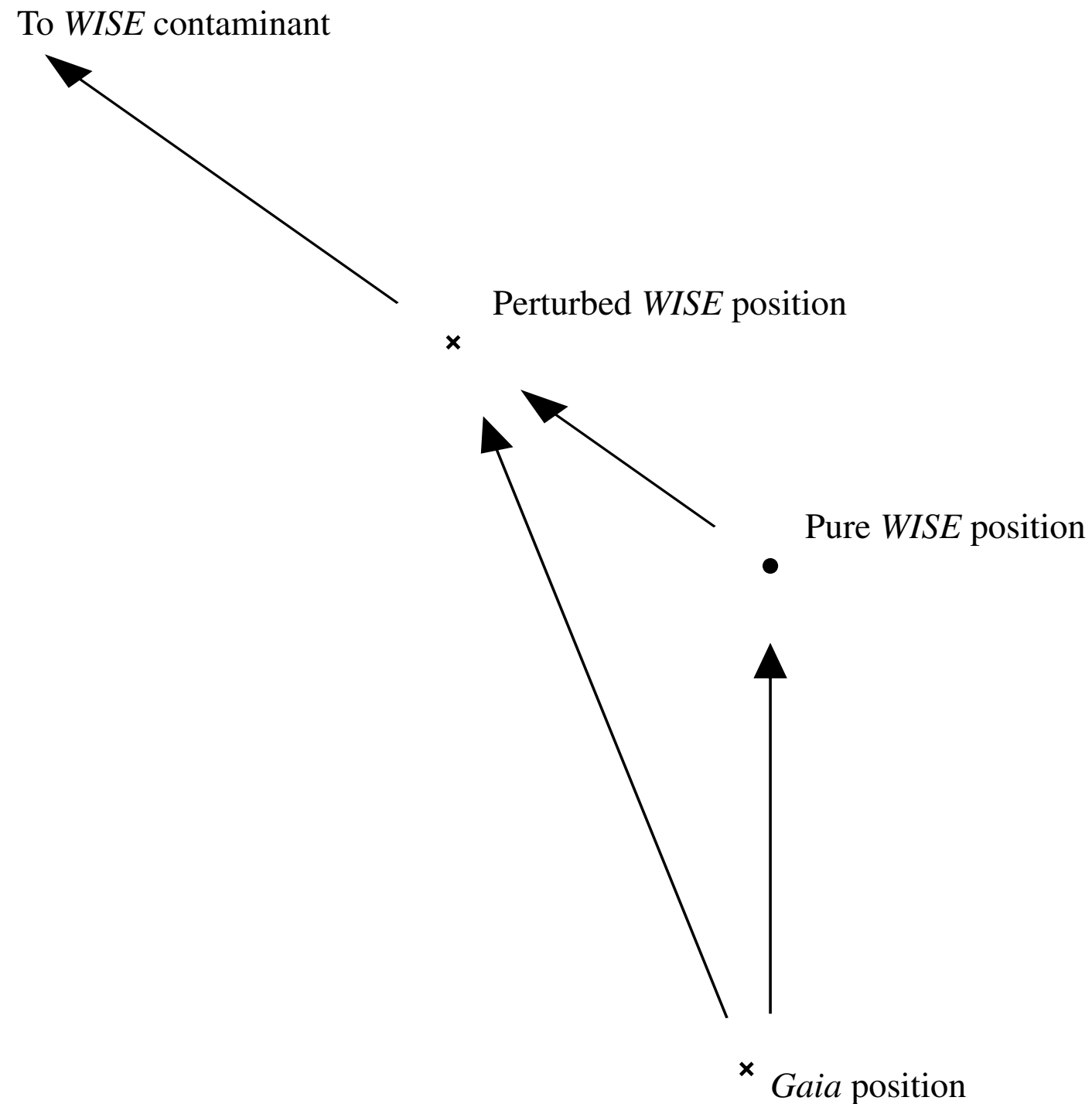
The Astrometric Uncertainty Function: Crowding



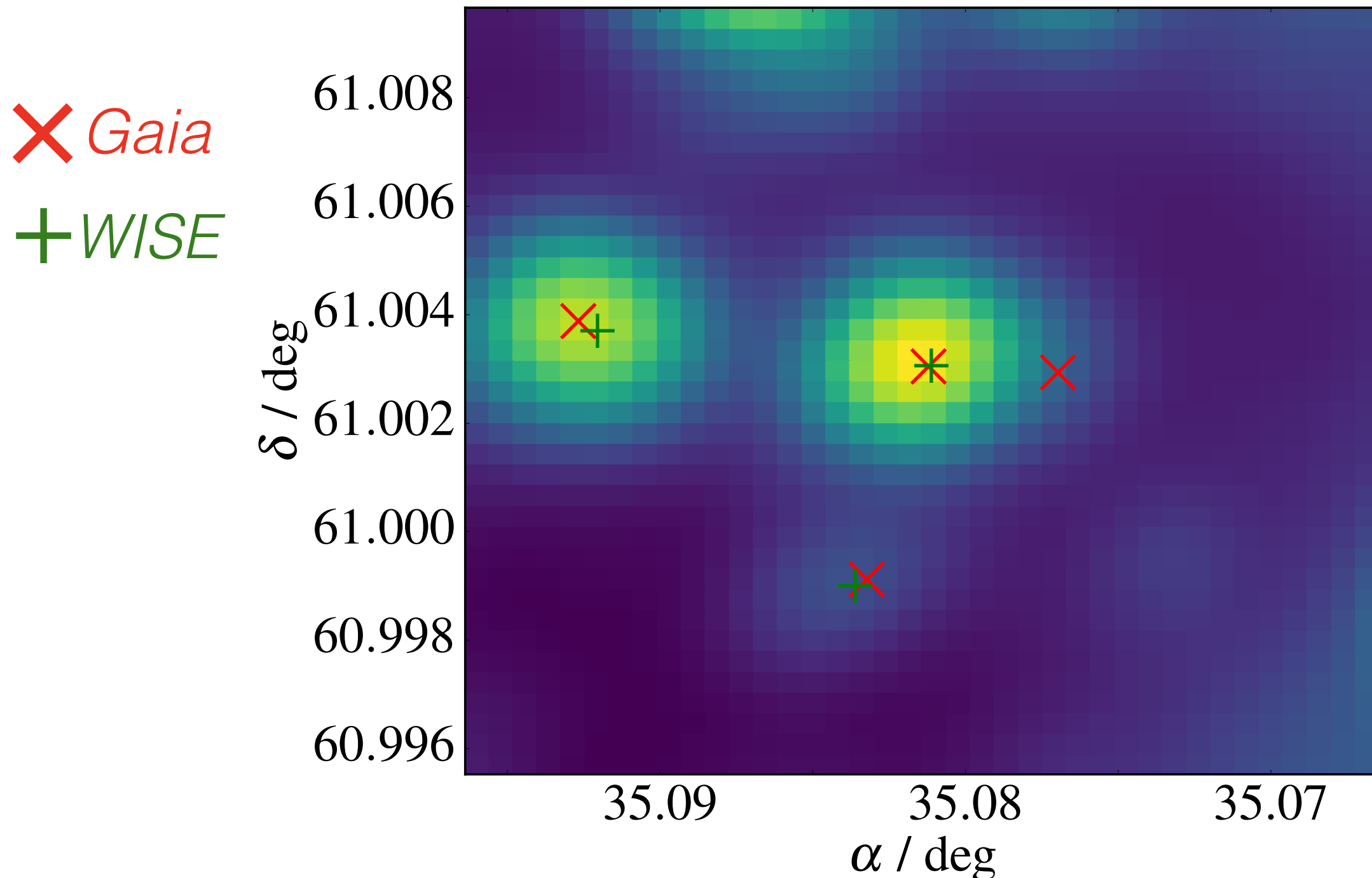
The Astrometric Uncertainty Function: Crowding



The Astrometric Uncertainty Function: Perturbation



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



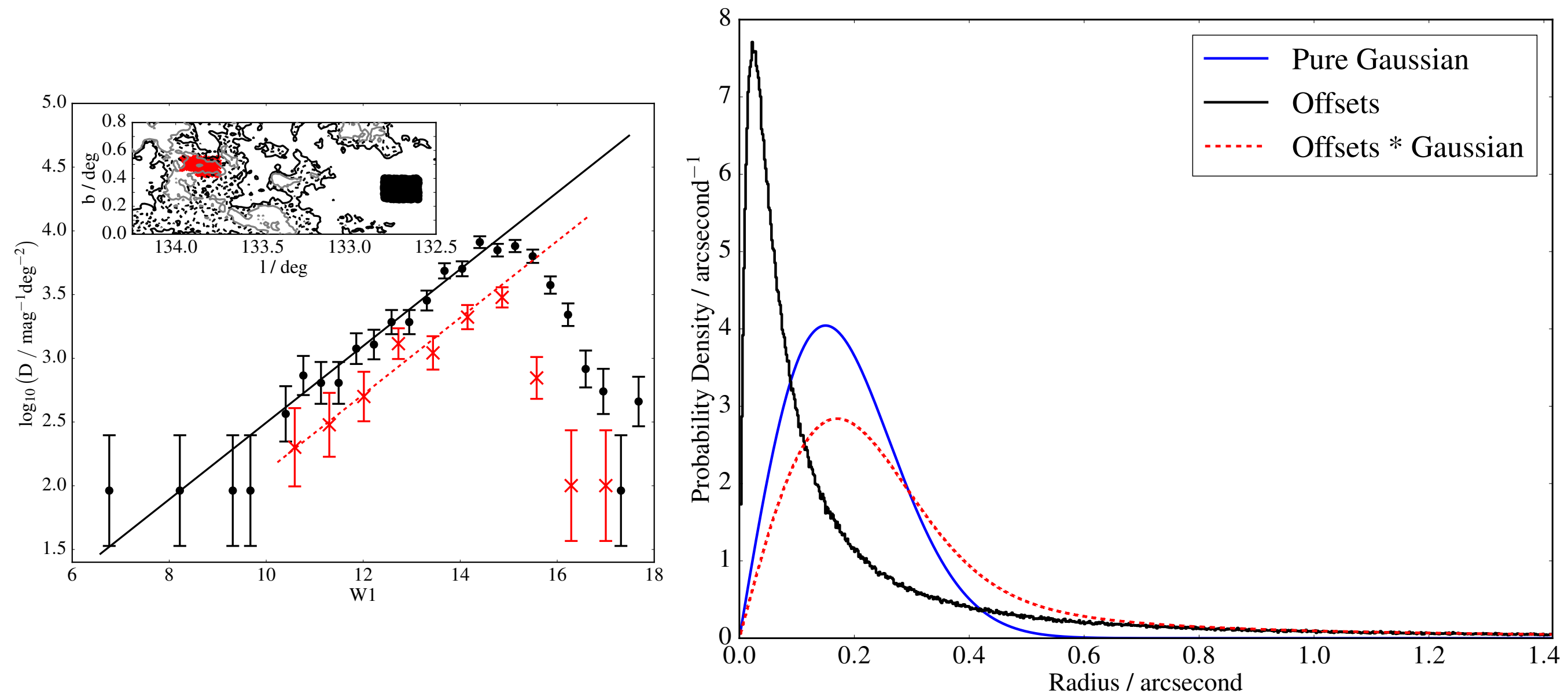
Gaia DR2 - Gaia Collaboration, Brown A. G. A., et al. 2018, A&A, 616, 1

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

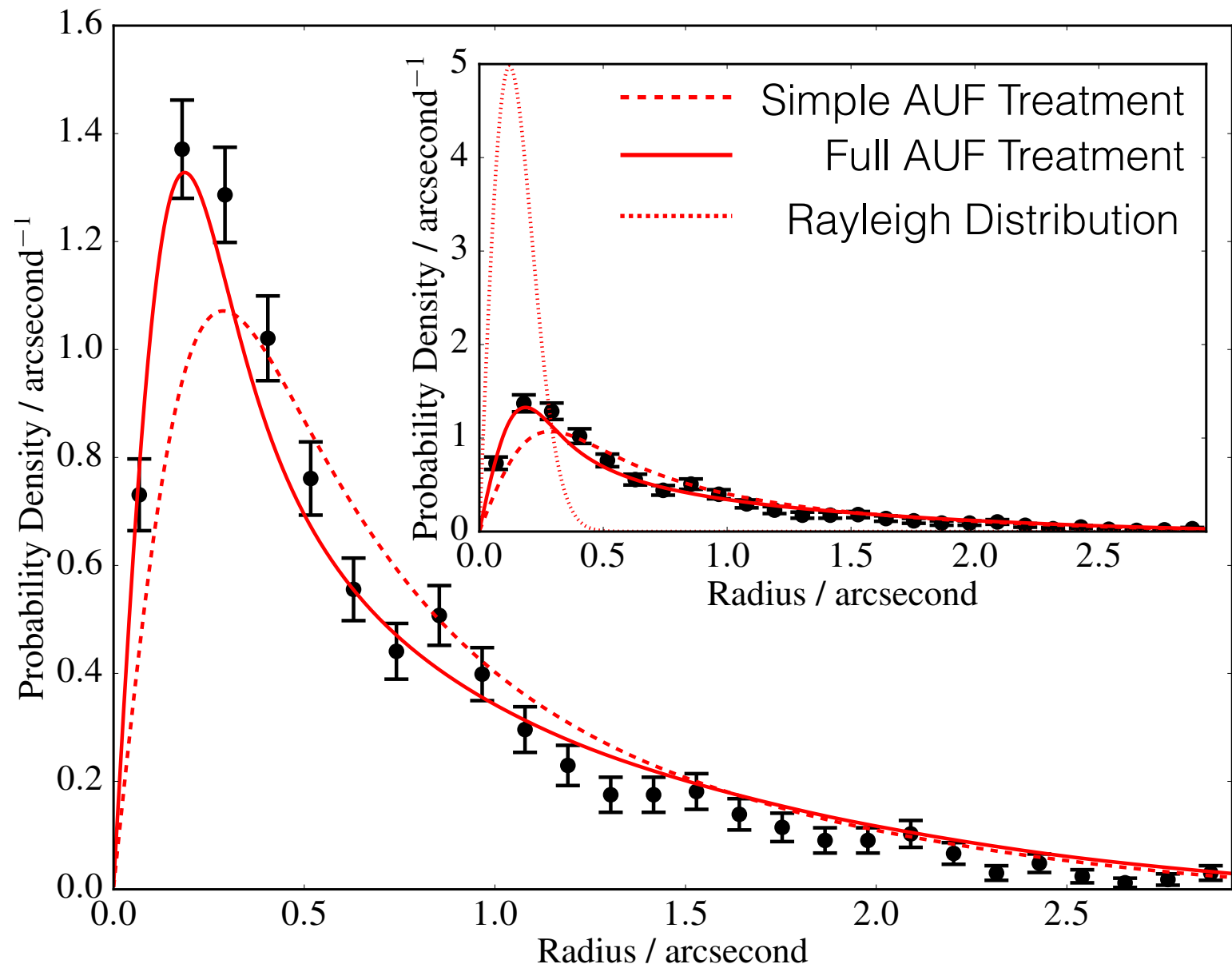
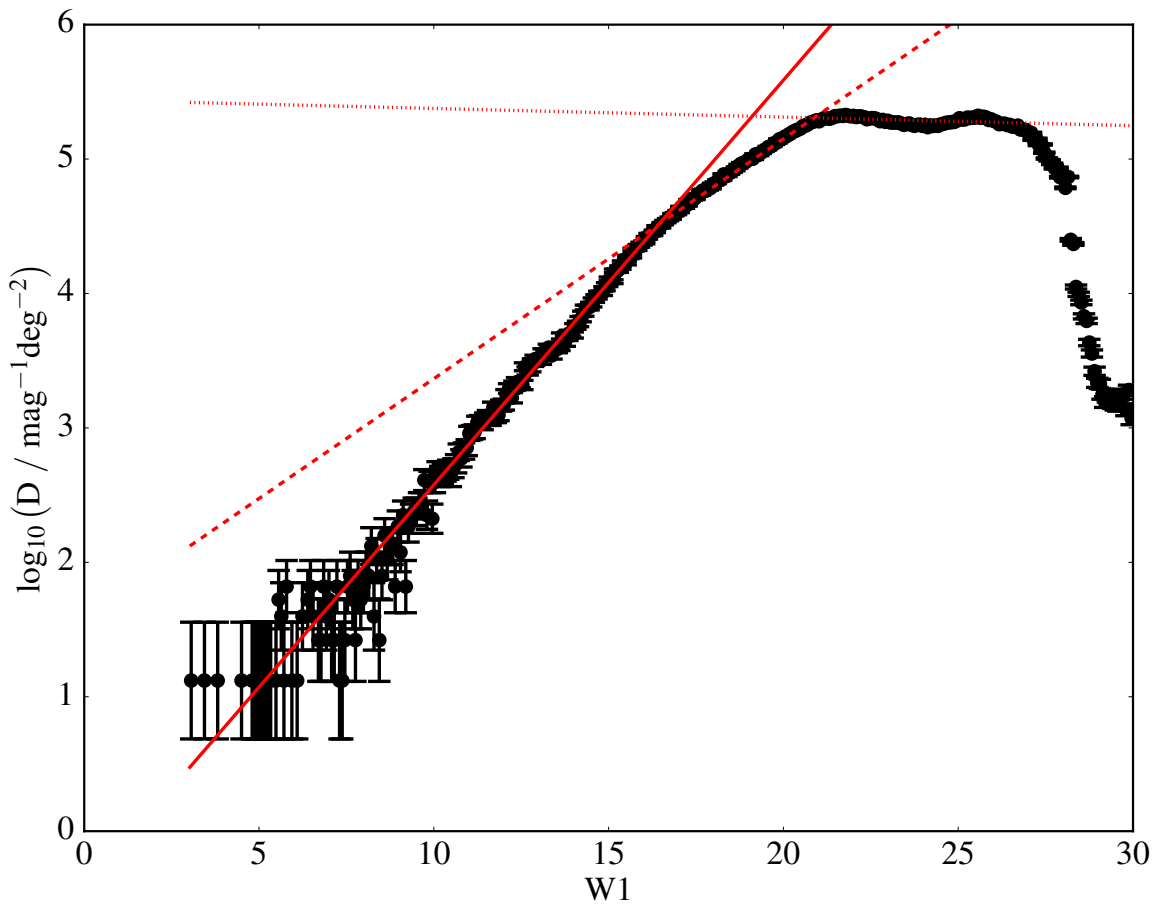
Wilson & Naylor, MNRAS, 2018b, 481, 2148

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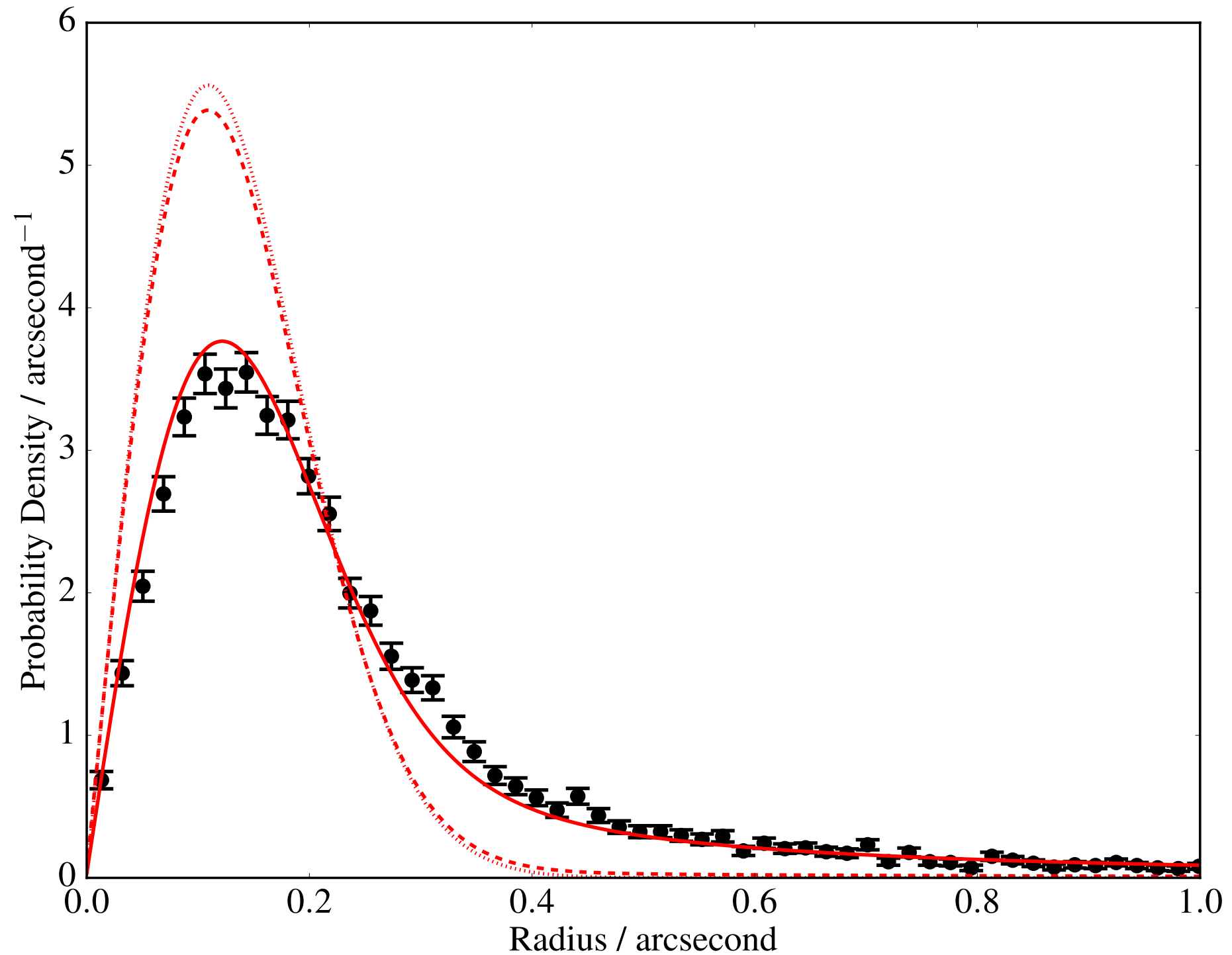
The Astrometric Uncertainty Function: Building Empirical AUFs



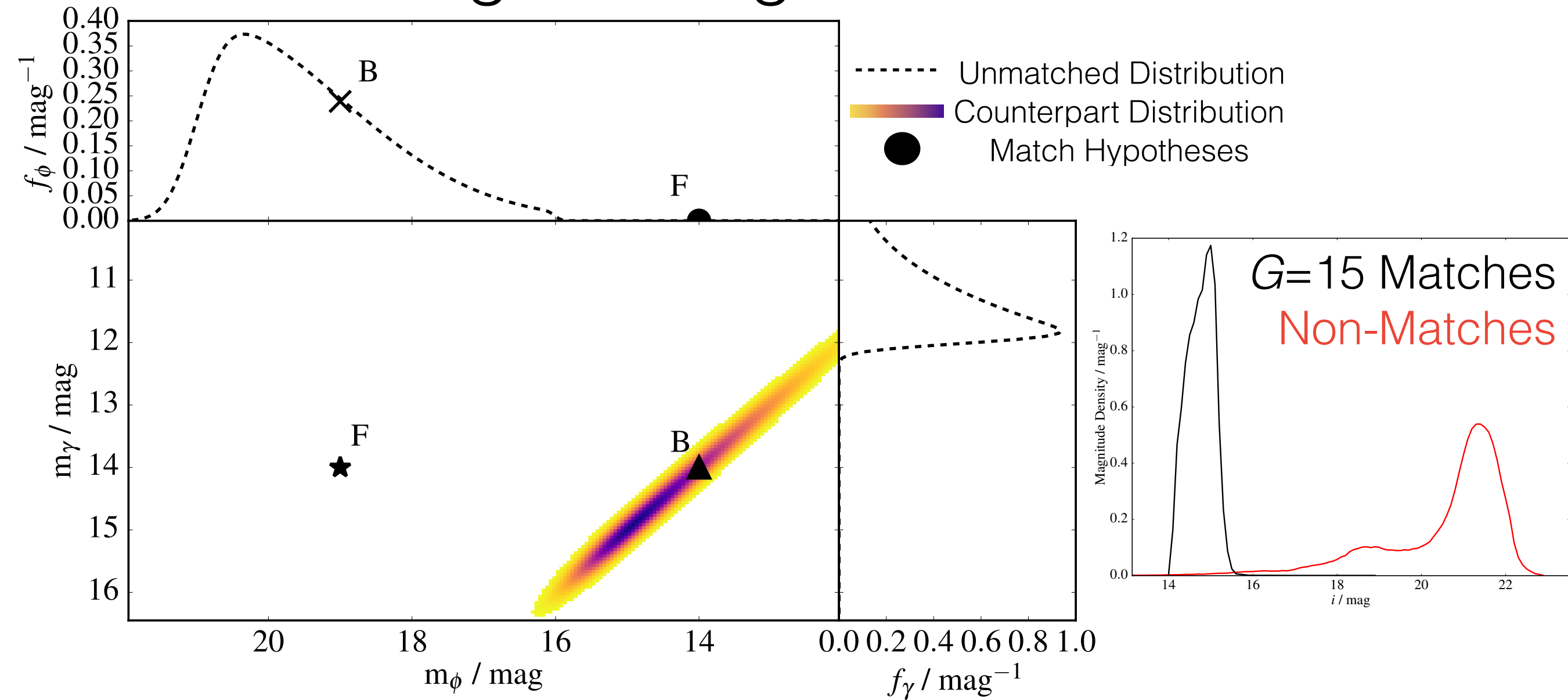
Contamination Effects: Effects Below Sensitivity Limit



Contamination Effects: Galaxy Contamination

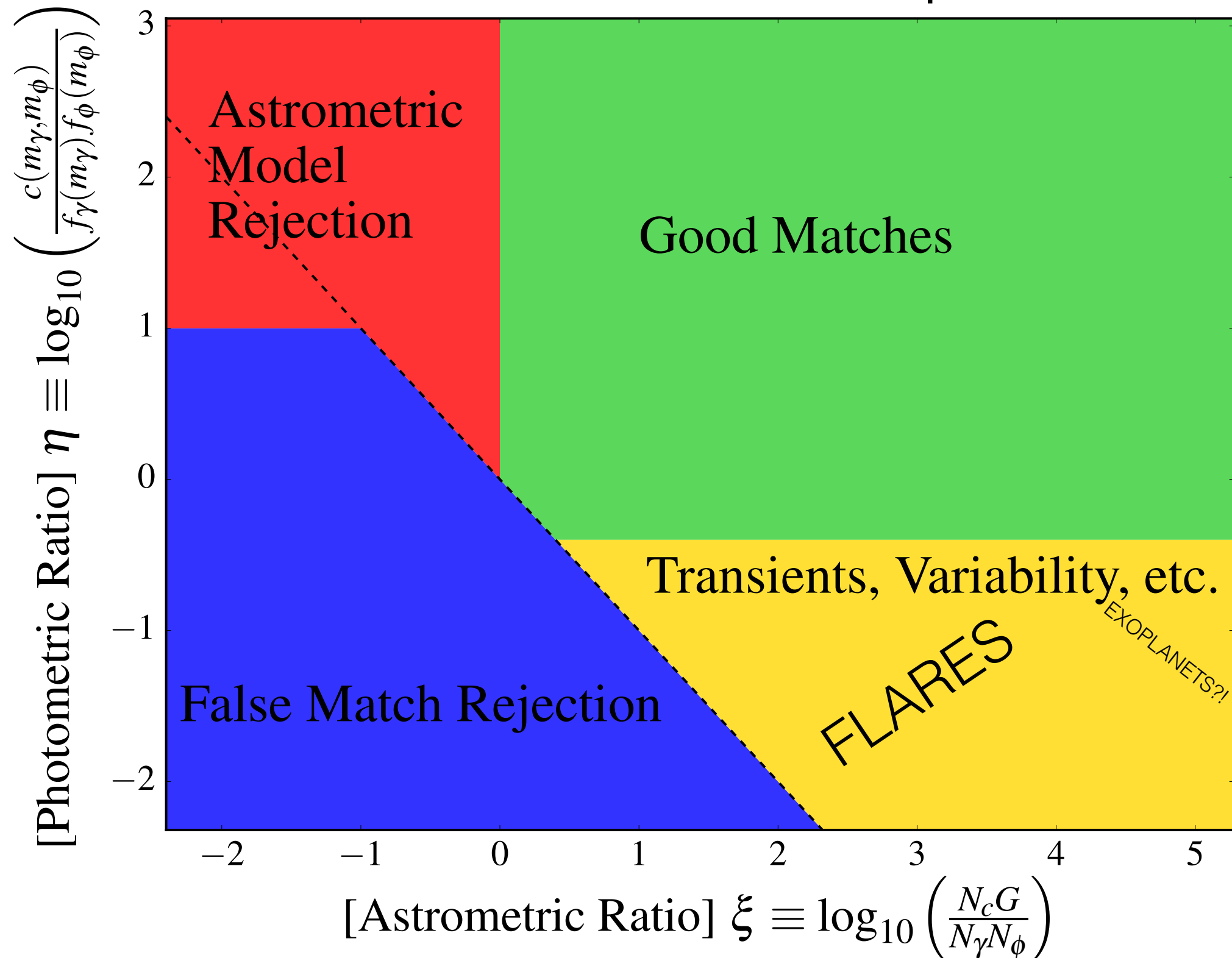


Probability-based Catalogue Matching: Including the Magnitude Information

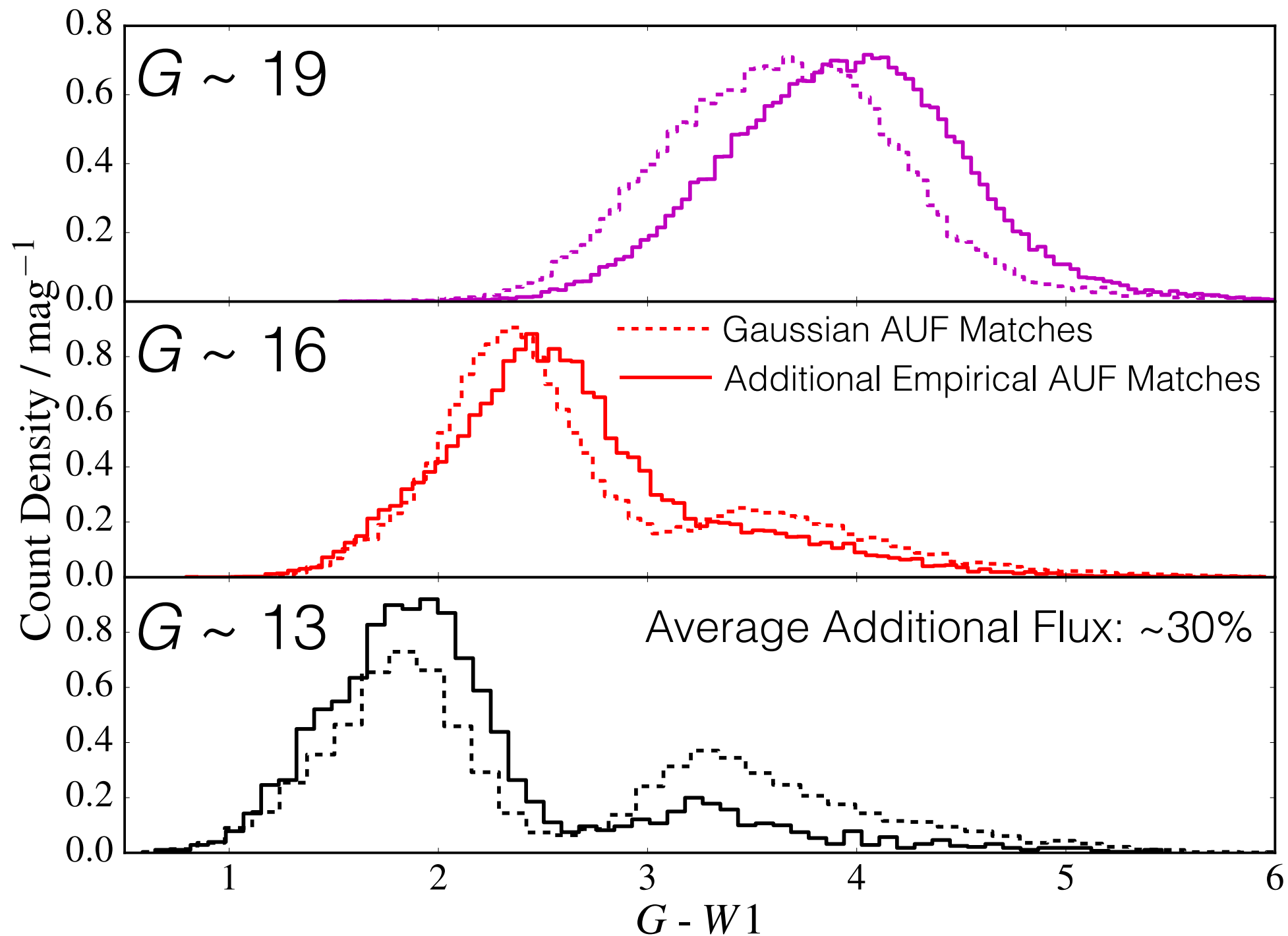


$$\begin{aligned}
 g(x_k, y_k, x_l, y_l) &= N_c \iint_{-\infty}^{+\infty} h_\gamma(\Delta x_{kl} - x, \Delta y_{kl} - y) h_\phi(x, y) dx dy \\
 &= N_c \times (h_\gamma * h_\phi)(\Delta x_{kl}, \Delta y_{kl}).
 \end{aligned}$$

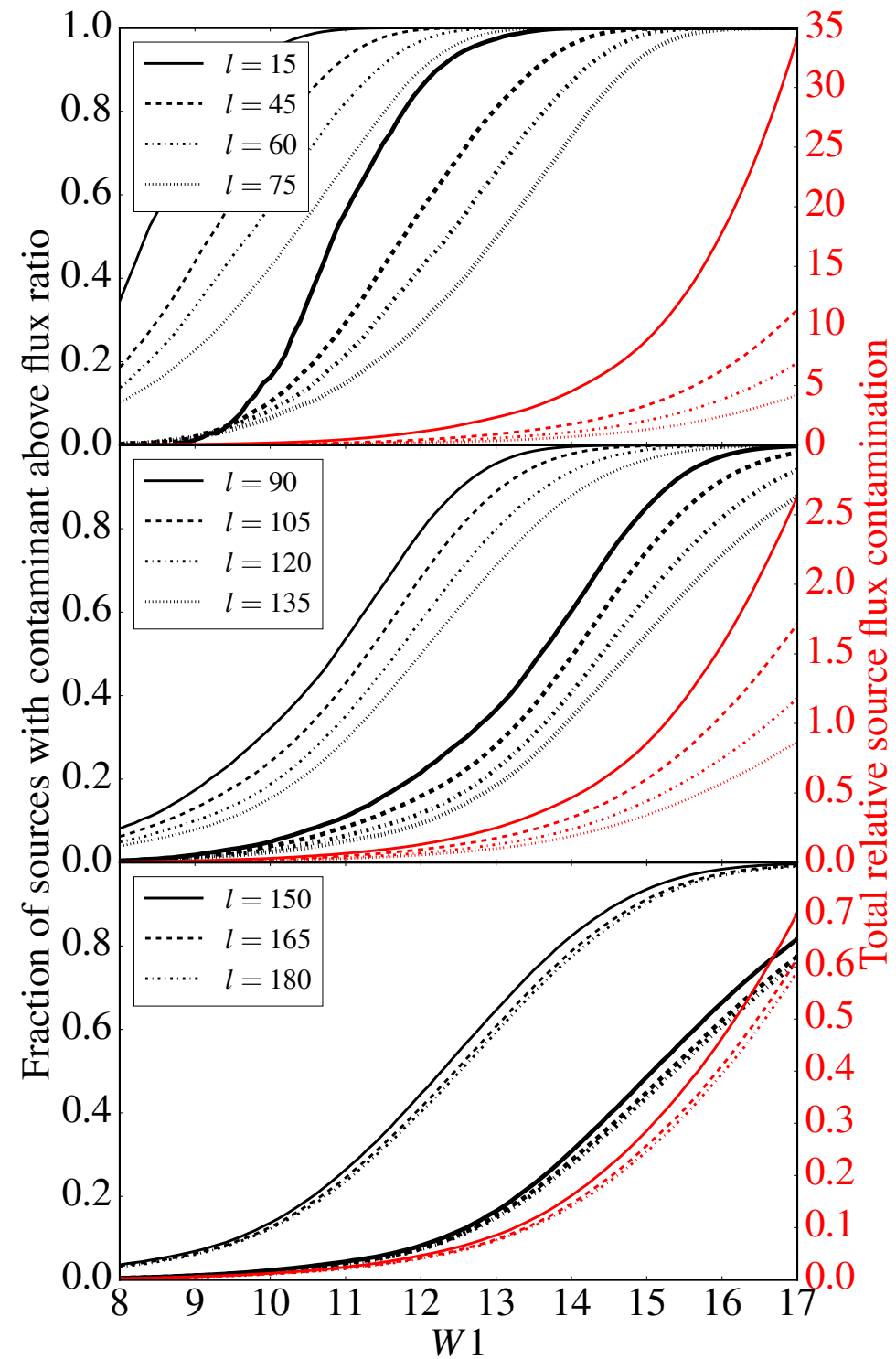
Probability-based Catalogue Matching: The Likelihood Ratio Space



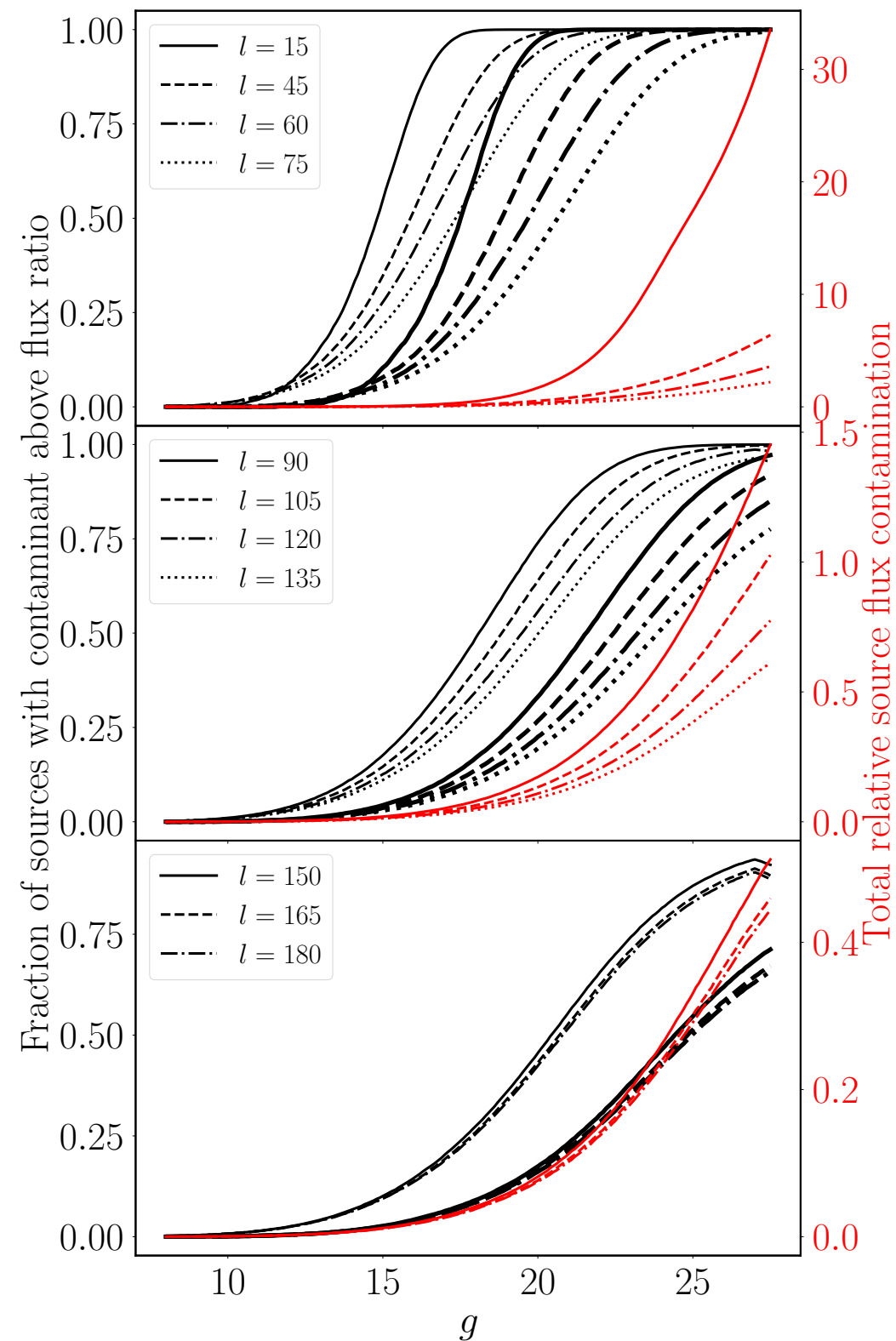
Contamination Effects: Perturbation-Colour Correlation



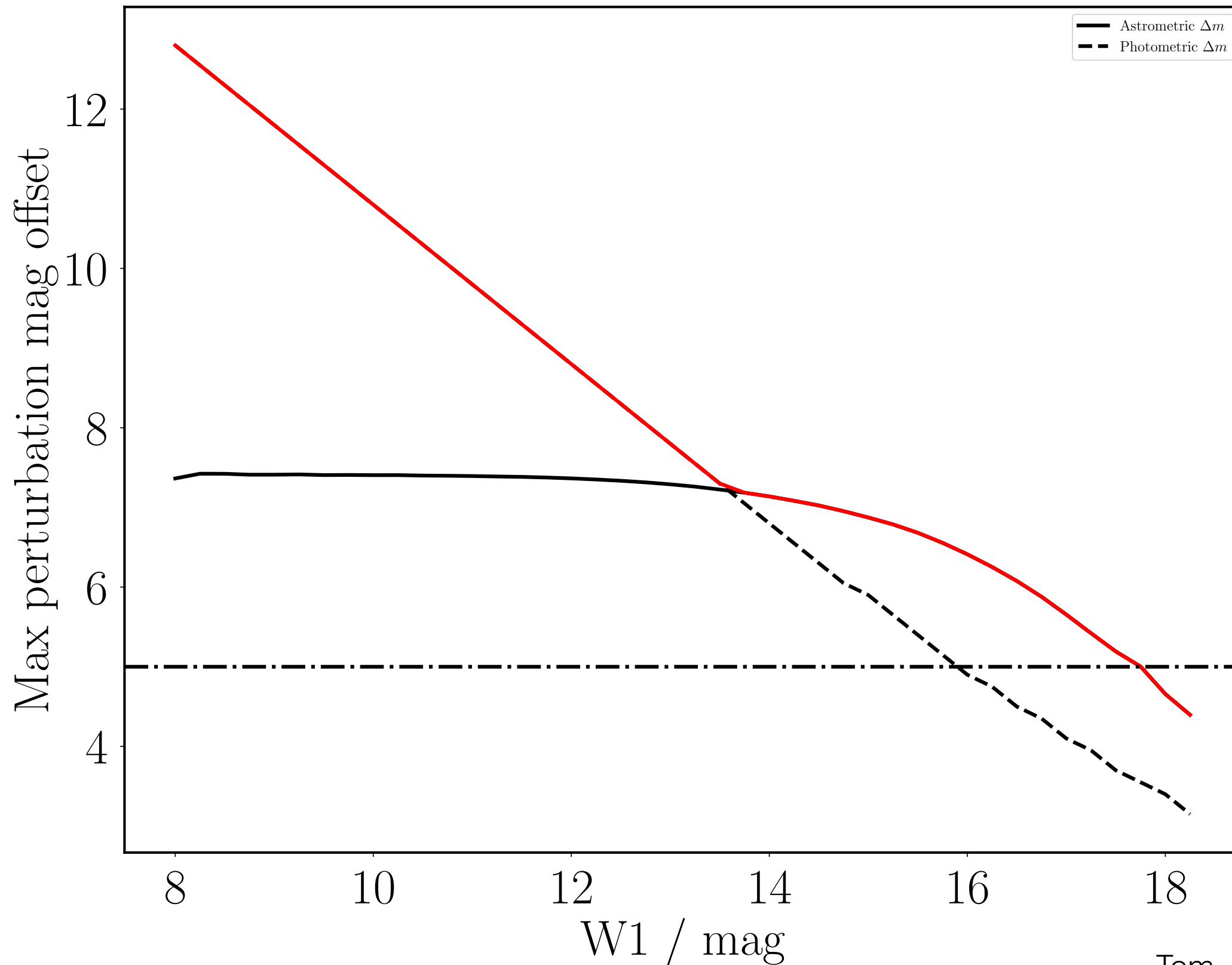
Contamination Effects: Contamination Rates & Amounts



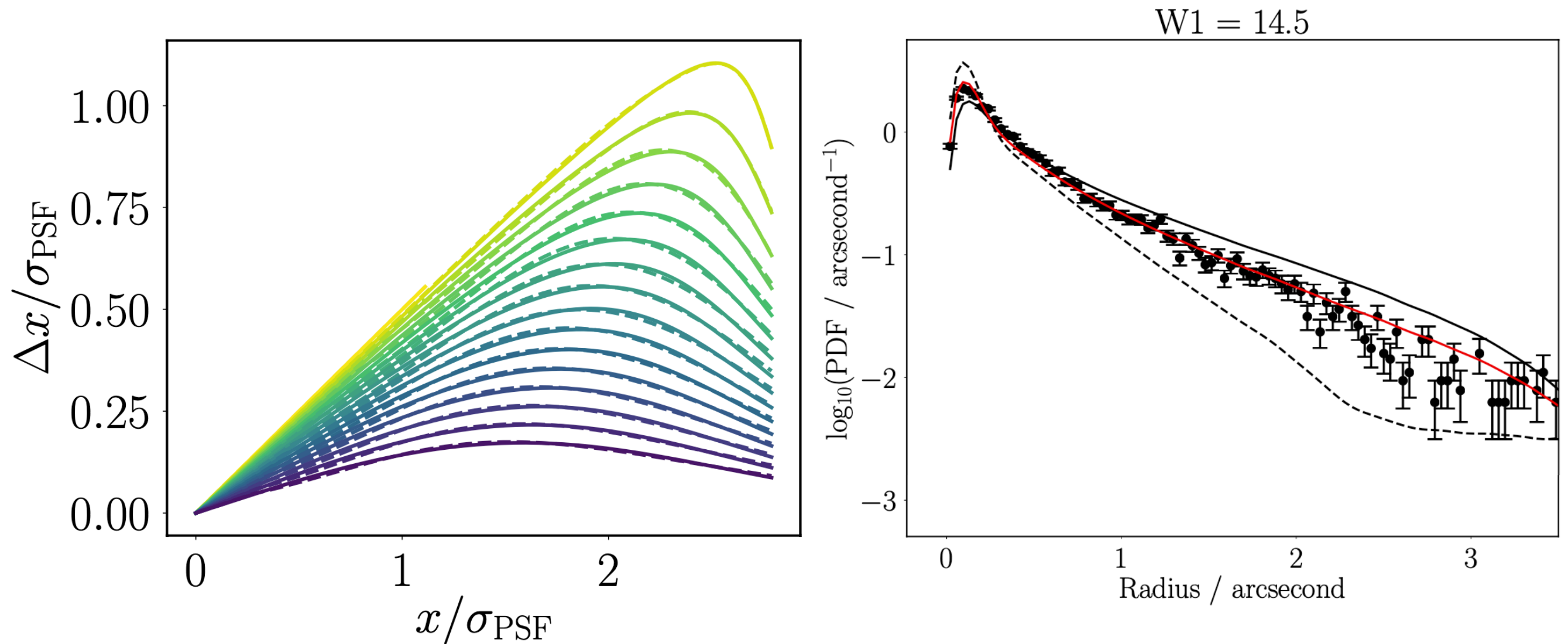
The Astrometric Uncertainty Function: Considering Vera C. Rubin Observatory's LSST



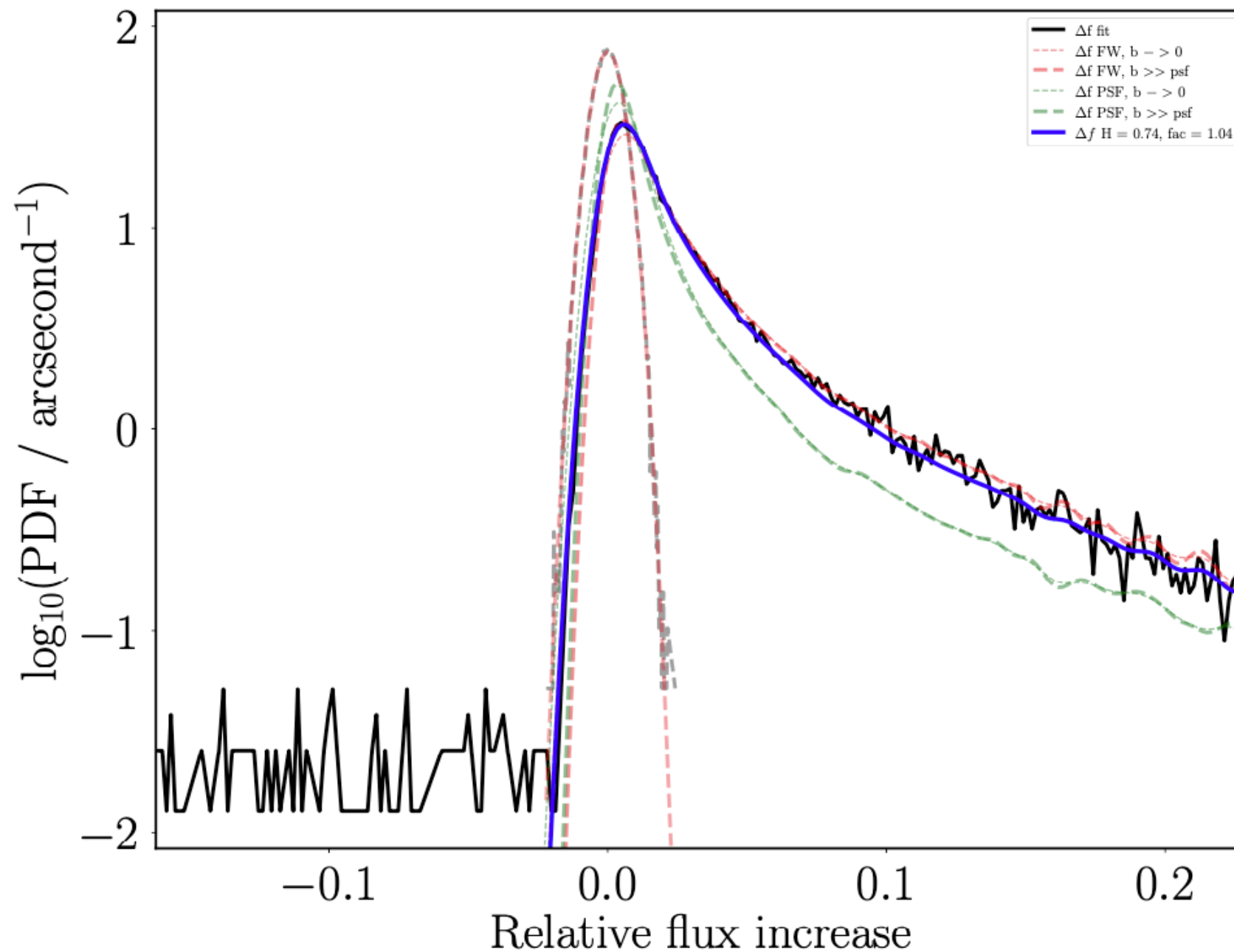
The Astrometric Uncertainty Function and LSST: A Crisis of Completeness Limit



The Astrometric Uncertainty Function and LSST: Probing the Faintest Sources



The Astrometric Uncertainty Function and LSST: Improving the “Photometric Contamination Function”



The Astrometric Uncertainty Function and LSST: Extensions to Cross-Match Algorithm

where

$$P(H_{kl}|D) = \frac{P(H_{kl})P(S_{\gamma\phi}^{kl}) \prod_{i,j|v_{kl}} P(U_{\gamma\phi}^{ij})}{P(H_0) \prod_{i,j} P(U_{\gamma\phi}^{ij}) + \sum_s \sum_t P(H_{st})P(S_{\gamma\phi}^{st}) \prod_{i,j|v_{st}} P(U_{\gamma\phi}^{ij})}$$

$$P(H_{kl}) = \frac{\prod_{j \in D_{\gamma k}} X_{\gamma kj} \prod_{j \in D_{\phi l}} X_{\phi lj} \prod_{i \neq k} \prod_{j \in D_{\gamma i}} 1 - X_{\gamma ij} \prod_{i \neq l} \prod_{j \in D_{\phi i}} 1 - X_{\phi ij}}{1}$$

$$P(H_0) = \prod_i \prod_{j \in D_{\gamma i}} 1 - X_{\gamma ij} \prod_i \prod_{j \in D_{\phi i}} 1 - X_{\phi ij}$$

The Astrometric Uncertainty Function and LSST: Open Source Code Development

Macauff.

The screenshot shows the GitHub interface for the repository 'Onoddil / macauff'. At the top, there are navigation tabs for Code, Issues (5), Pull requests, Actions, Projects, Wiki, Security, Insights, and Settings. Below the repository name, there are buttons for 'Go to file', 'Add file', and 'Code'. A status bar indicates 'This branch is 13 commits ahead of master.' with links for 'Pull request' and 'Compare'. The commit history table shows a recent commit by 'Onoddil' with the message 'Added region parameters for photometric likelihoods c and f, and exte...' and 16 commits. The file list includes folders like '.github/workflows', 'docs', and 'macauff', and files like '.gitignore', 'LICENSE', 'MANIFEST.in', 'README.md', 'pyproject.toml', 'setup.cfg', 'setup.py', and 'tox.ini'. The right sidebar contains sections for 'About' (describing the package), 'Releases' (no releases published), 'Packages' (no packages published), and 'Languages' (Python 100.0%). The README content is visible at the bottom, showing the project name 'macauff' and its description.

Onoddil / macauff Unwatch

<> Code Issues 5 Pull requests Actions Projects Wiki Security Insights Settings

class_structure 2 branches 0 tags Go to file Add file Code

This branch is 13 commits ahead of master. Pull request Compare

Onoddil Added region parameters for photometric likelihoods c and f, and exte... 8818637 12 days ago 16 commits

File	Description	Time
.github/workflows	Added github actions workflow	24 days ago
docs	Initial set up of documentation, folder structure, unit tests etc.	24 days ago
macauff	Added region parameters for photometric likelihoods c and f, and exte...	12 days ago
.gitignore	Initial set up of documentation, folder structure, unit tests etc.	24 days ago
LICENSE	Initial commit	28 days ago
MANIFEST.in	Updated name of project	14 days ago
README.md	Initial commit	28 days ago
pyproject.toml	Initial set up of documentation, folder structure, unit tests etc.	24 days ago
setup.cfg	Initial set up of documentation, folder structure, unit tests etc.	24 days ago
setup.py	Updated name of project	14 days ago
tox.ini	Initial set up of documentation, folder structure, unit tests etc.	24 days ago

README.md

macauff

The python package for Matching Across Catalogues using the Astrometric Uncertainty Function and Flux

About Settings

The python package for Matching Across Catalogues using the Astrometric Uncertainty Function and Flux

Readme

BSD-3-Clause License

Releases

No releases published [Create a new release](#)

Packages

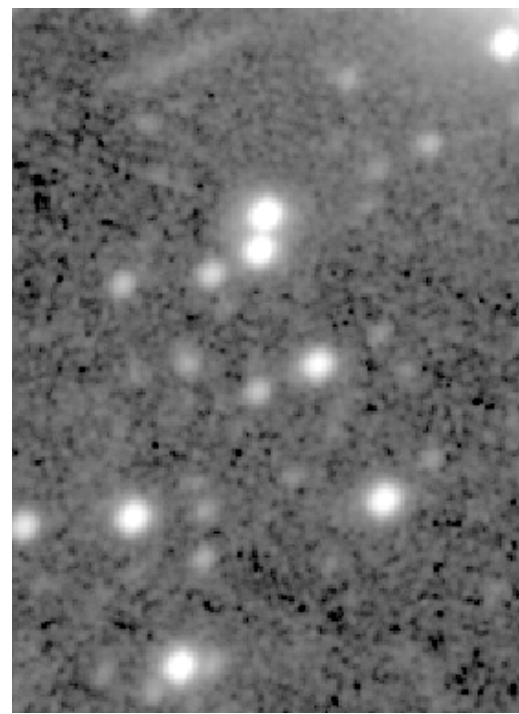
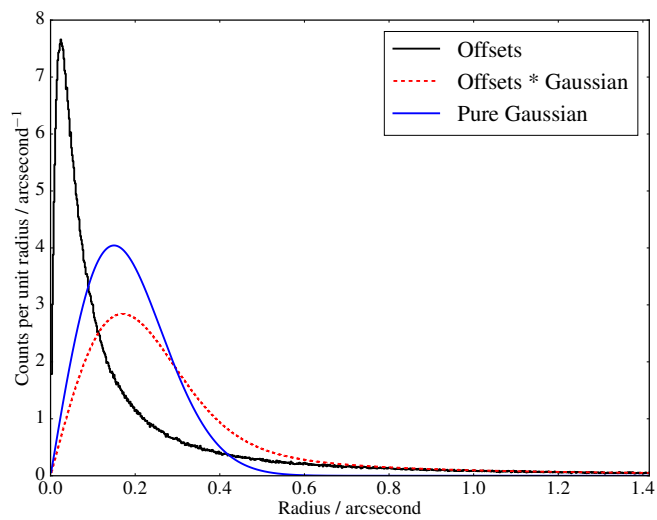
No packages published [Publish your first package](#)

Languages

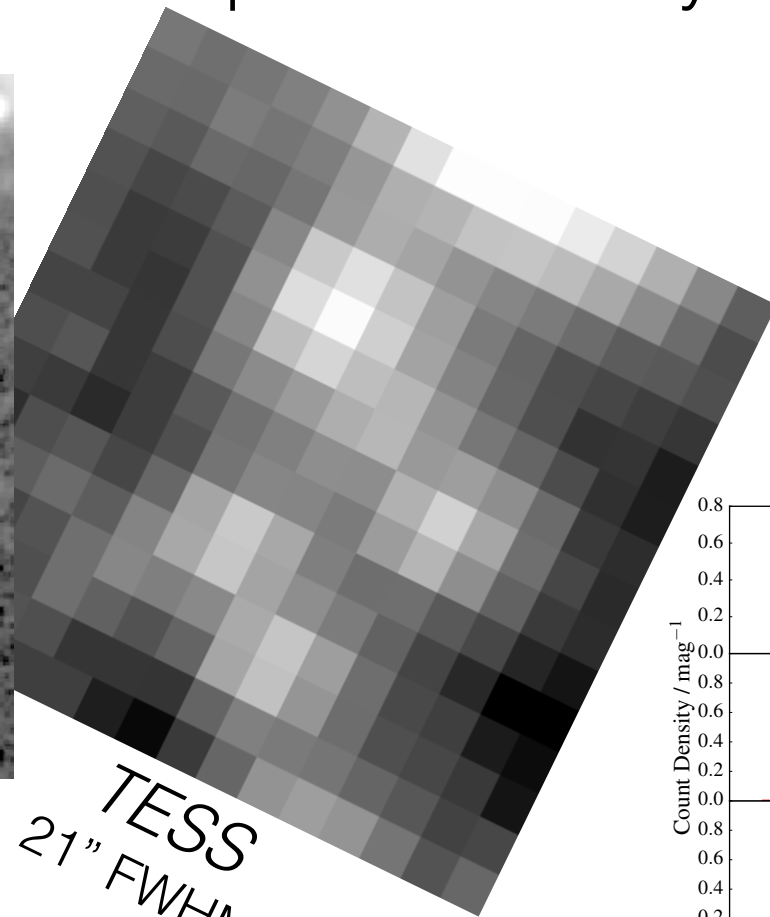
- Python 100.0%

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

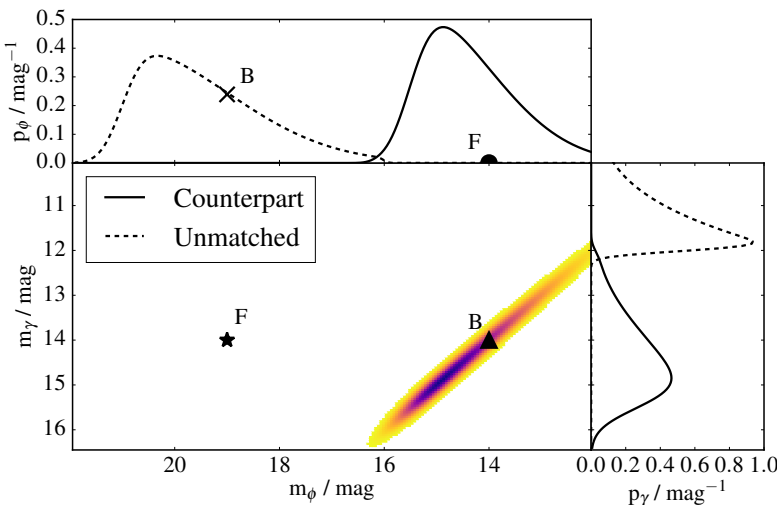
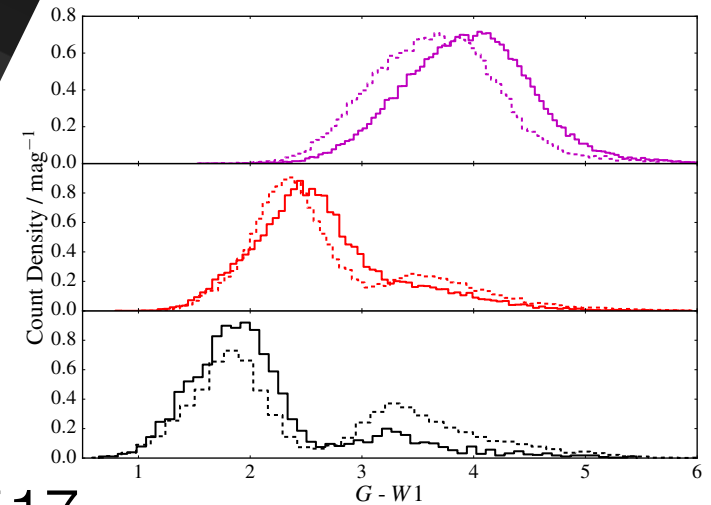
- Blended star contamination causes positional shifts
- *WISE* objects are up to 30% flux contaminated, with *WFIRST* and *LSST* suffering similar blending in the future
- Disentangle this information with proper treatment in the cross-match to a higher angular resolution dataset — important work yet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



WISE
6" FWHM



TESS
21" FWHM



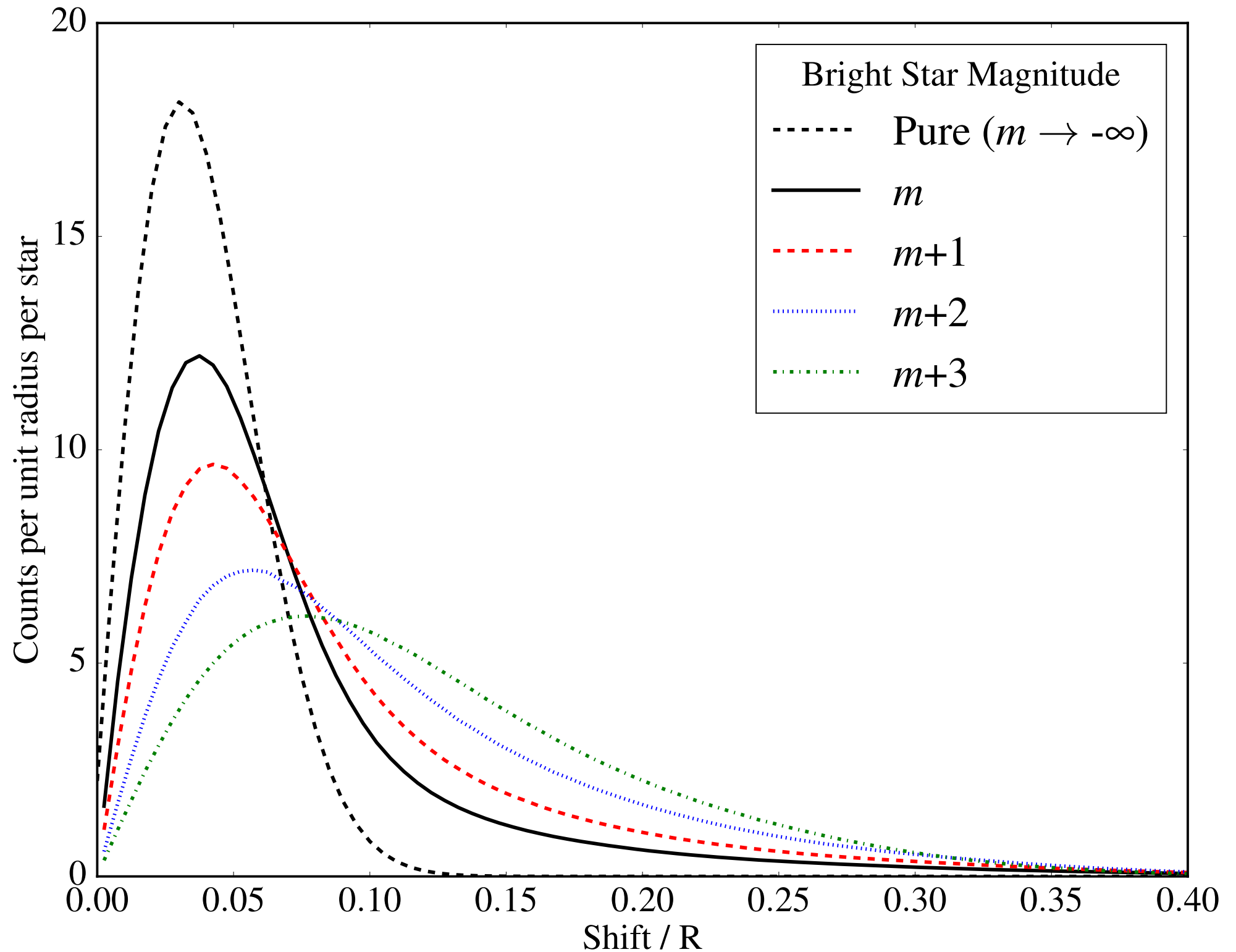
Wilson & Naylor, 2017, MNRAS, 468, 2517

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

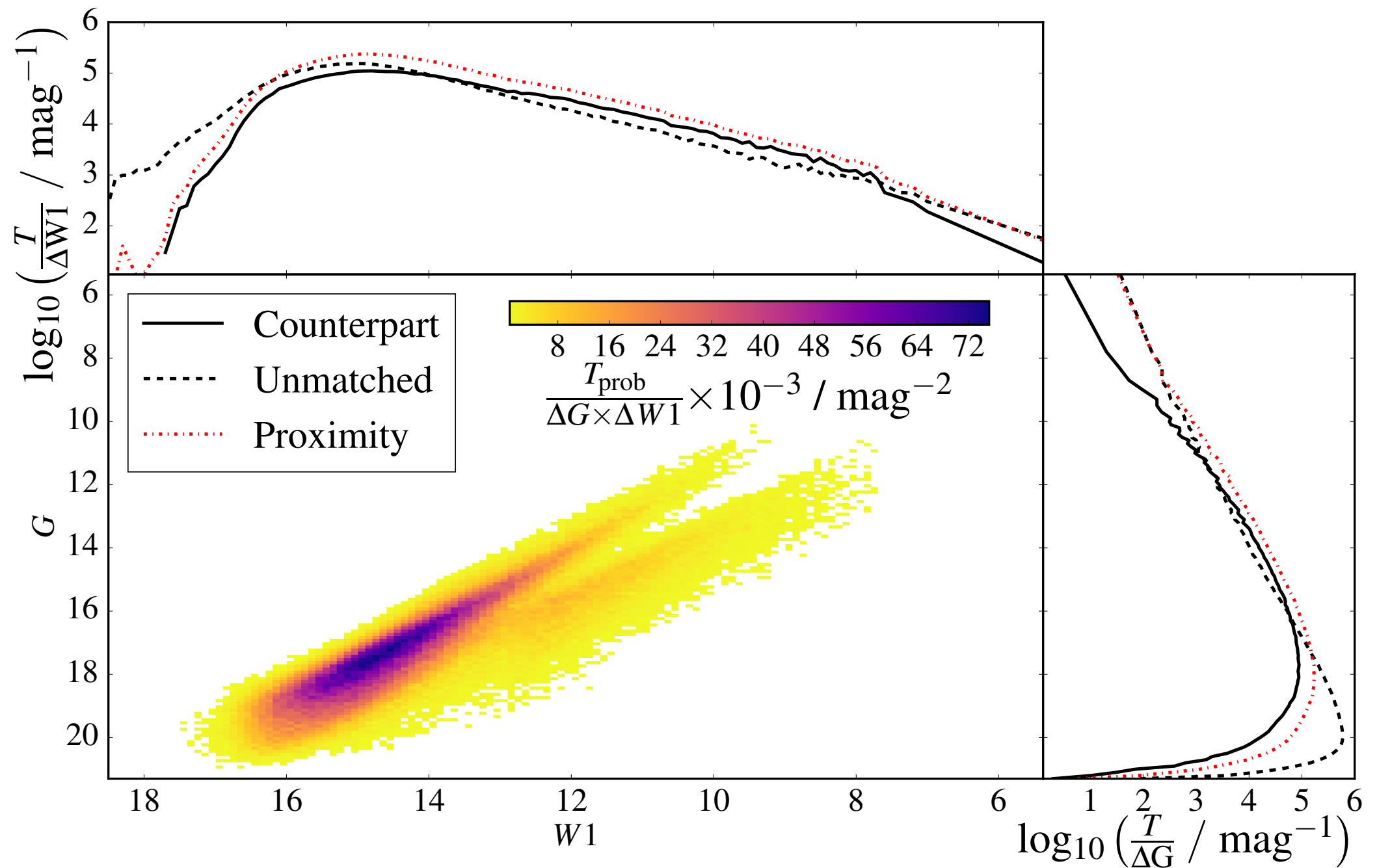
Wilson & Naylor, 2018b, MNRAS, 481, 2148

Tom J Wilson @onoddil

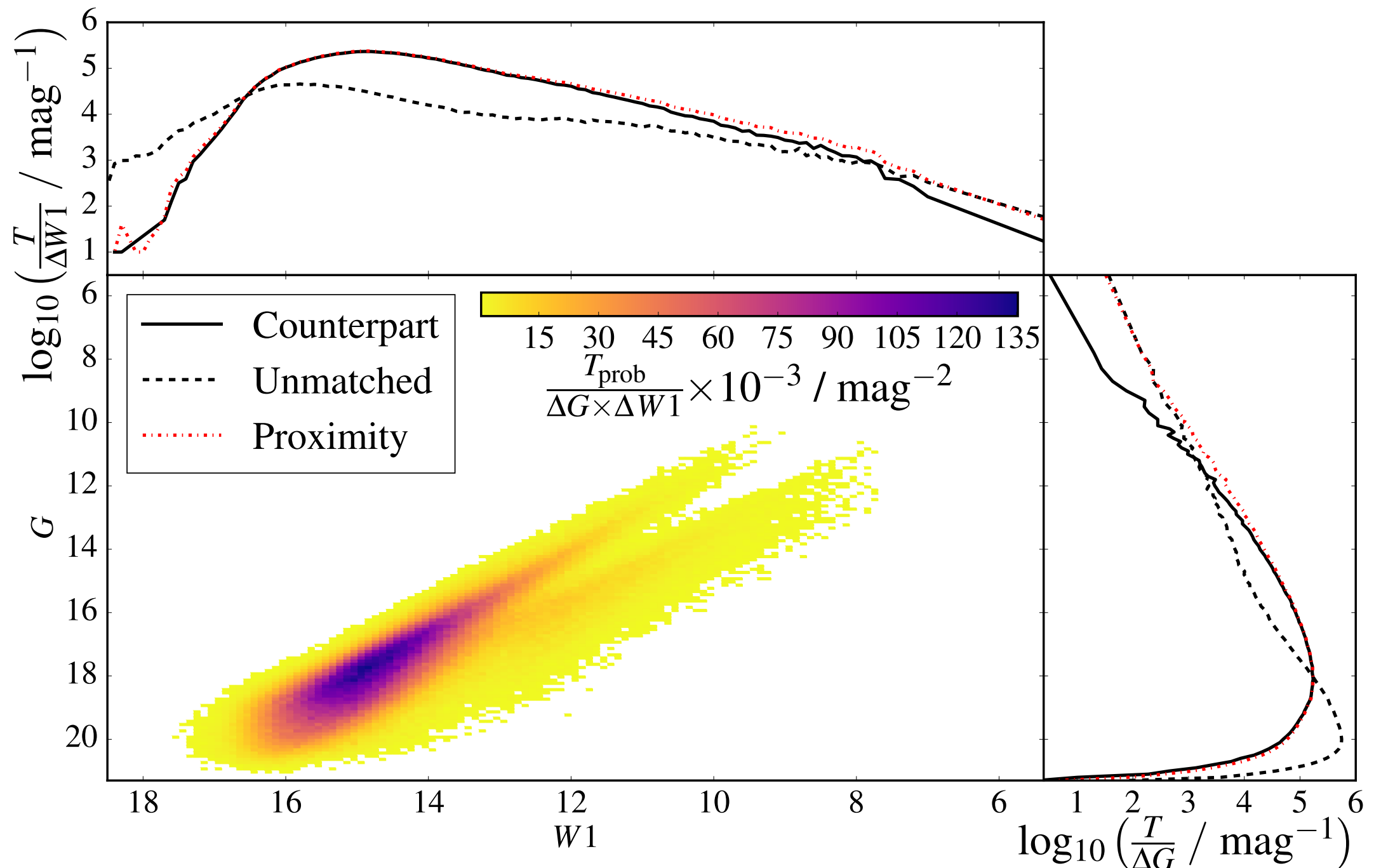
The Astrometric Uncertainty Function: Synthetic Non-Gaussian Tails



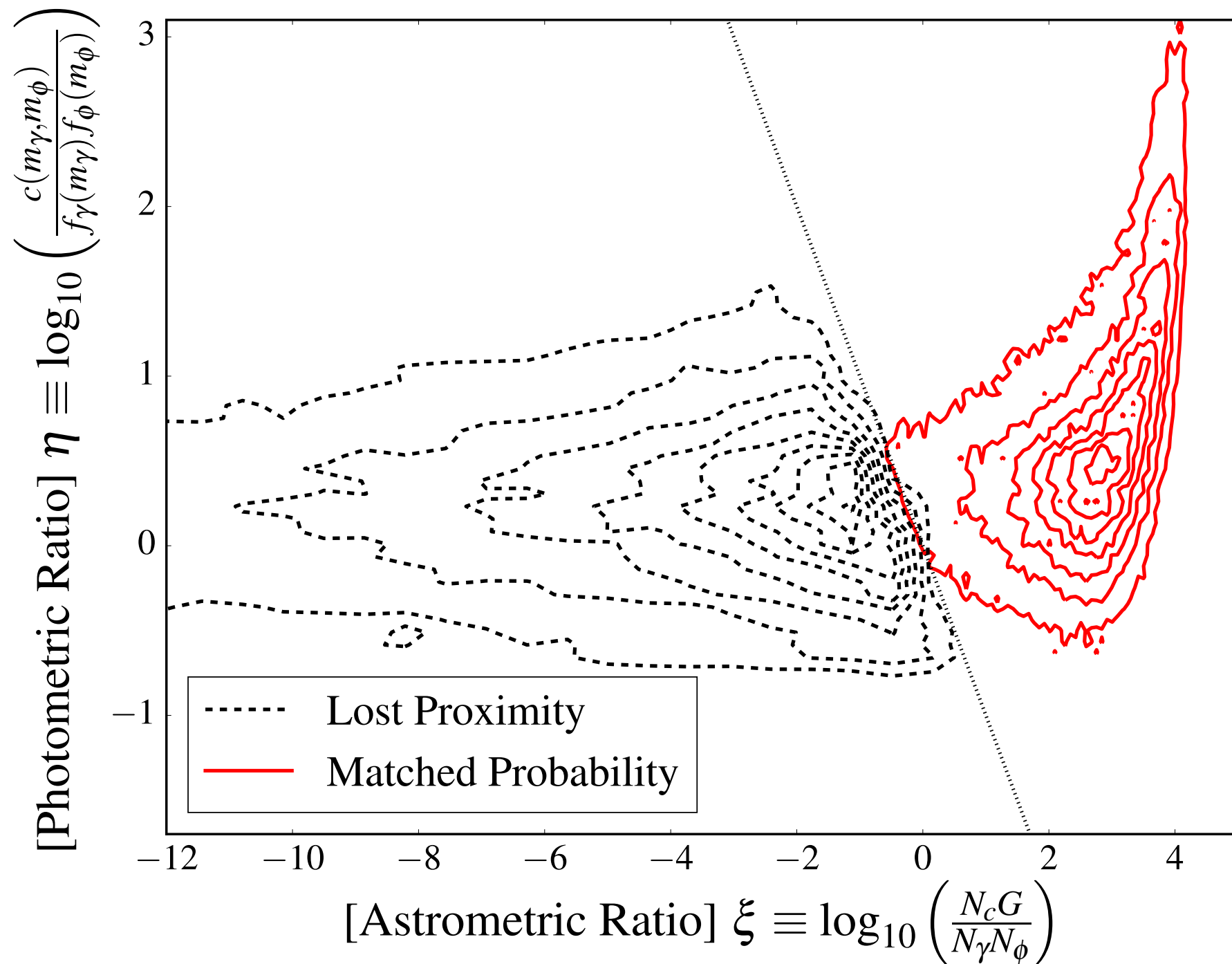
Contamination Effects: *Gaia-WISE* Gaussian Matches



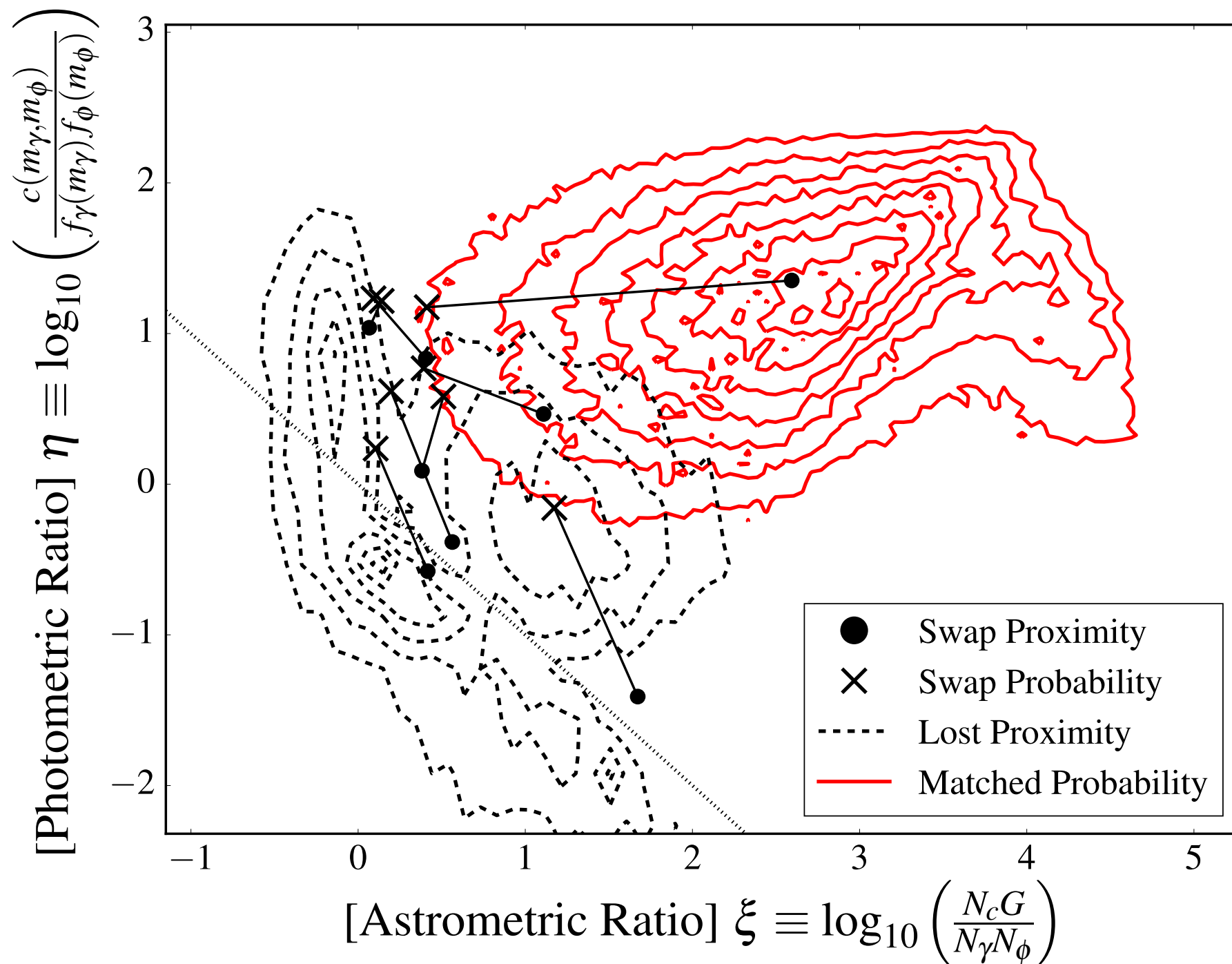
Contamination Effects: *Gaia-WISE* Empirical Matches



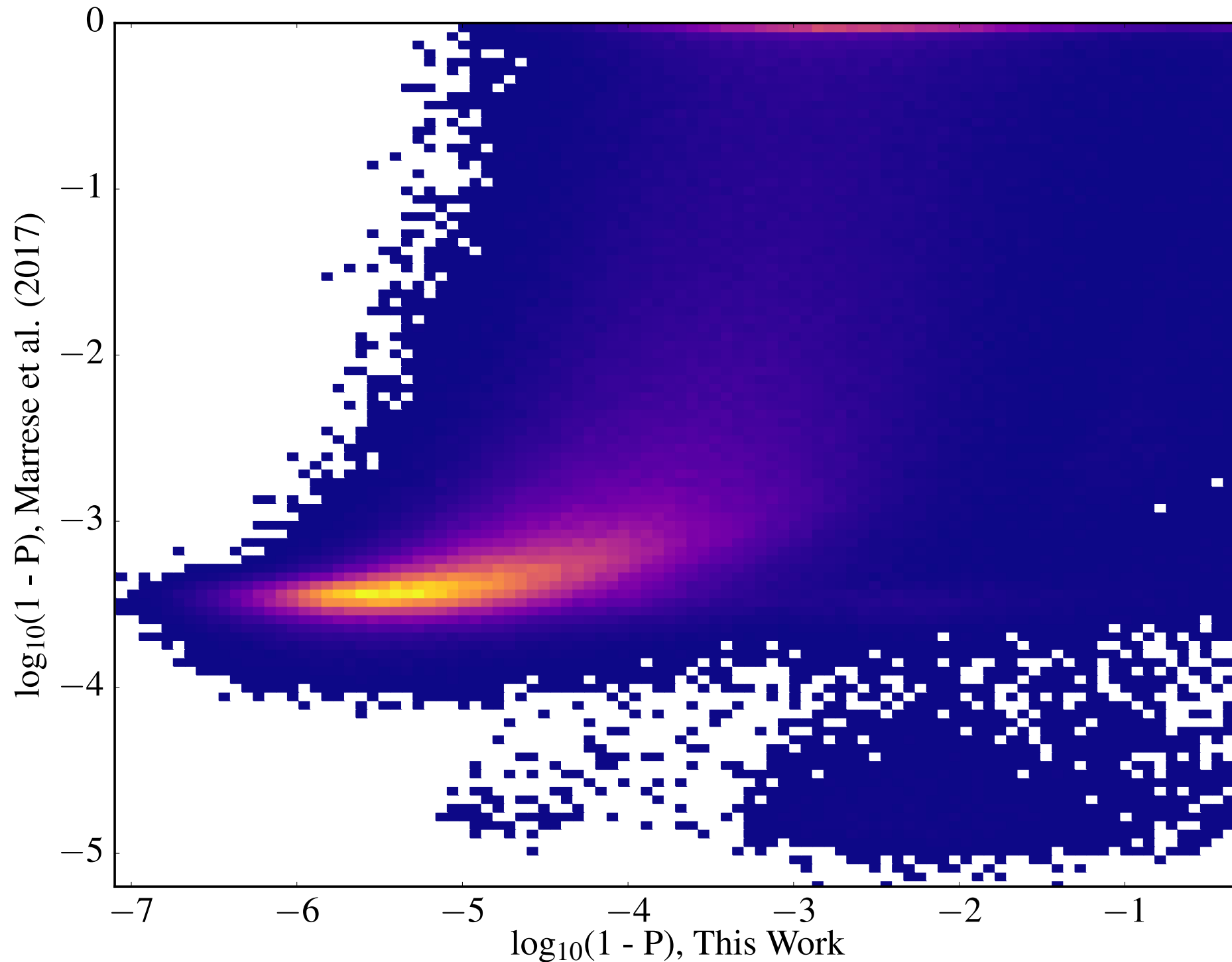
Contamination Effects: Lost Proximity Matches



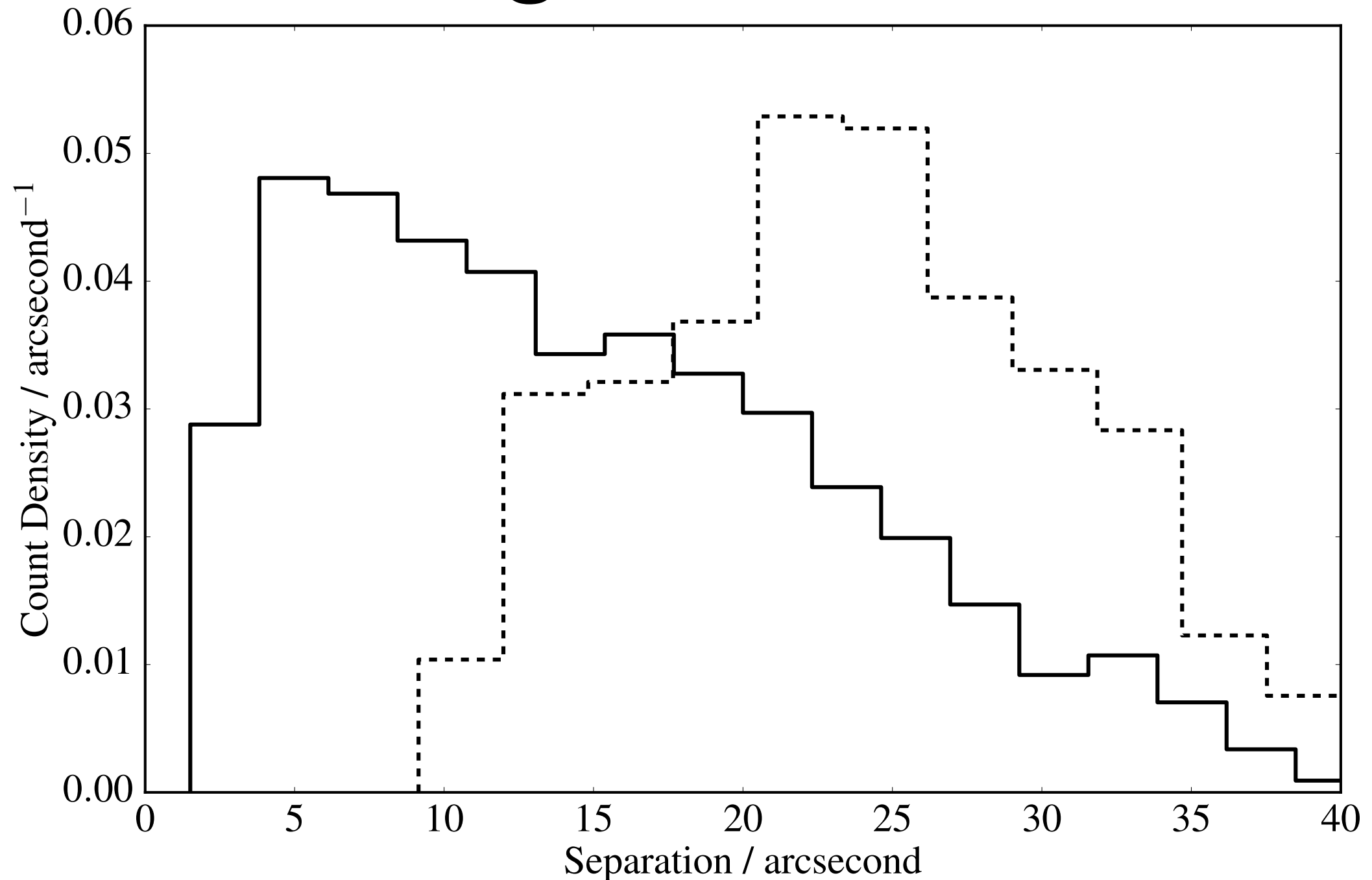
Contamination Effects: Lost Proximity Matches



Contamination Effects: *Gaia* Lost Matches

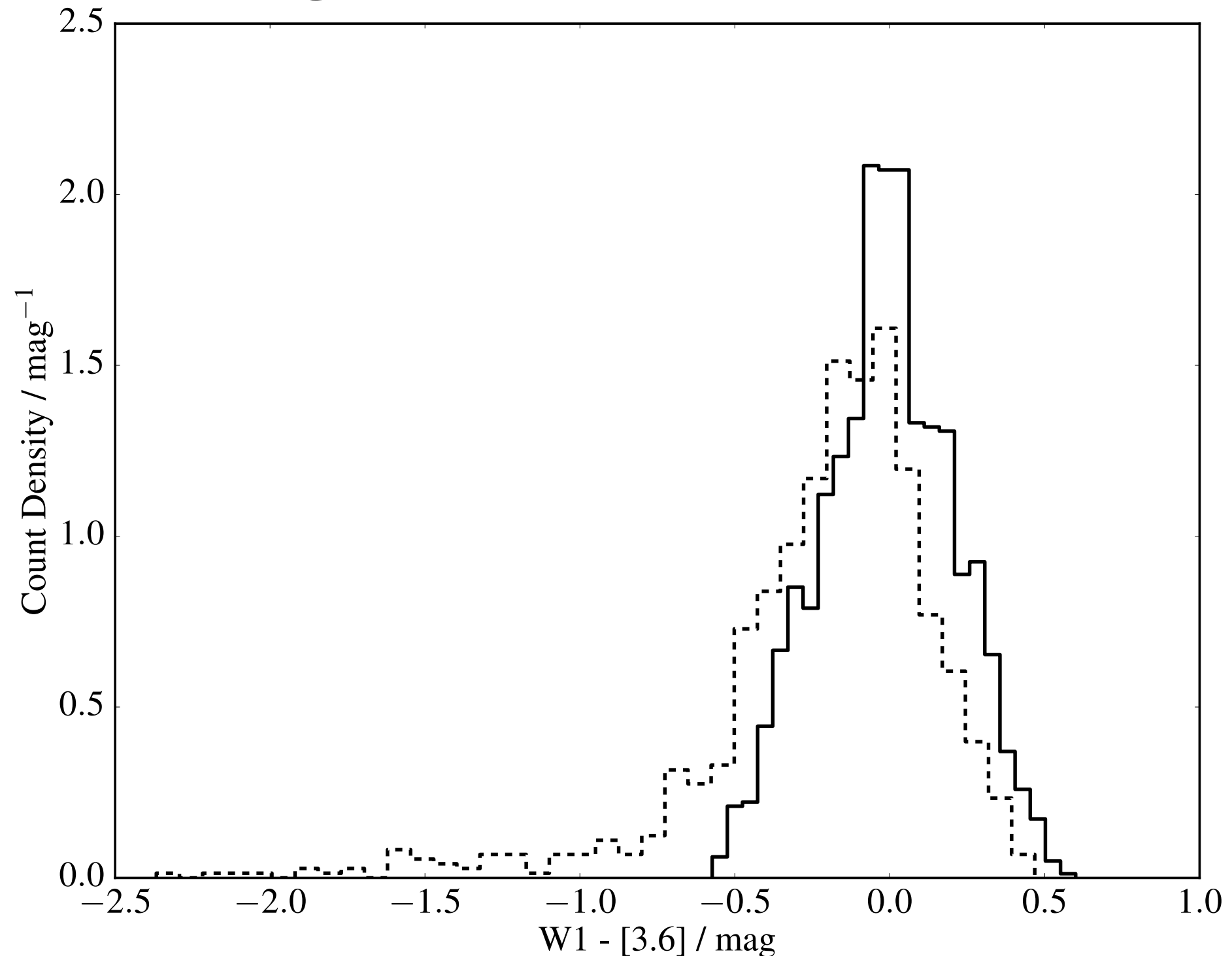


Contamination Effects: Resolving Contaminants

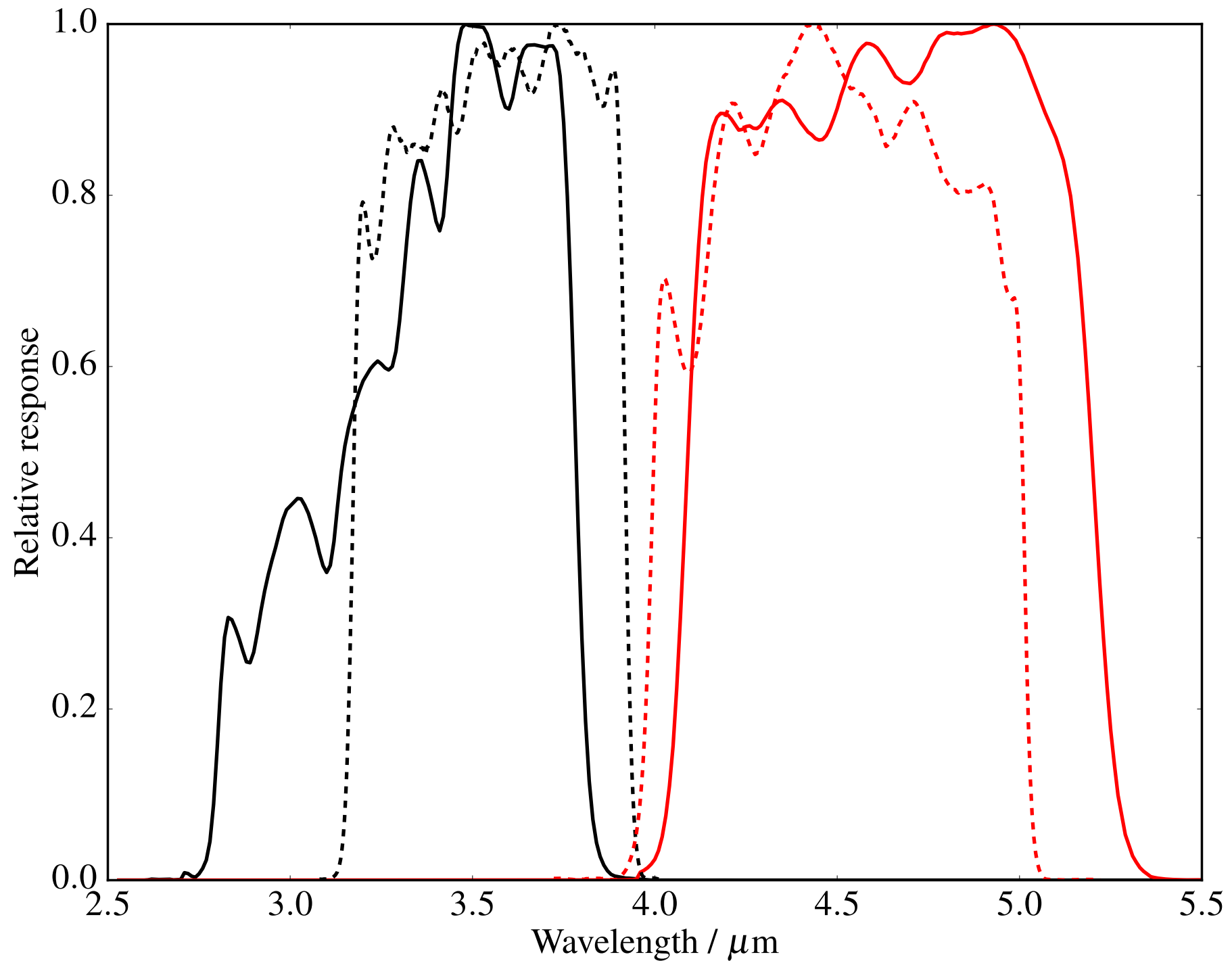


Spitzer - Werner et al., 2004 ,ApJS, 154, 1
IRAC - Fazio et al., 2004, ApJS, 154, 10
Wilson & Naylor, MNRAS, 2018b, 481, 2148

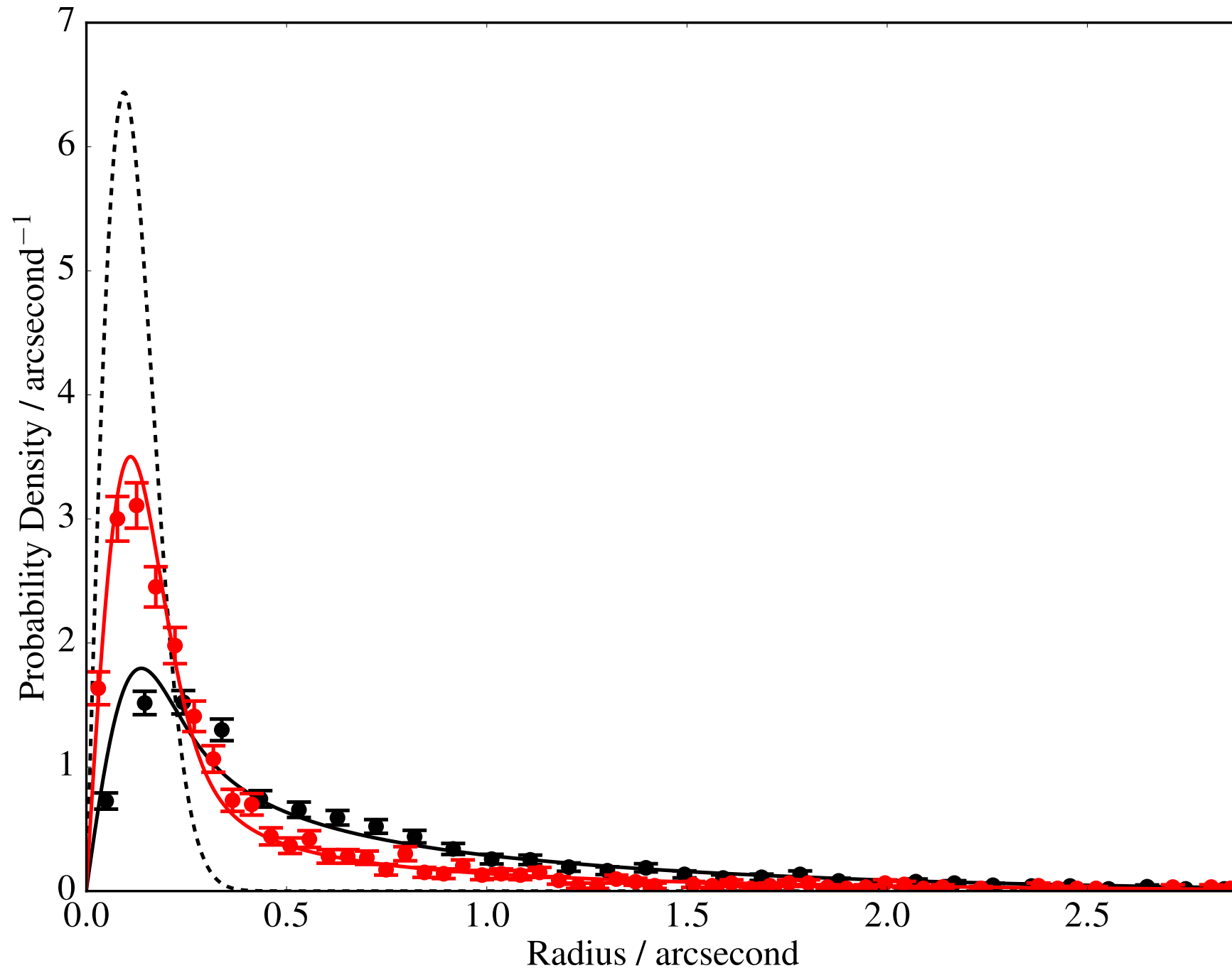
Contamination Effects: Resolving Contaminant Flux



Contamination Effects: Wavelength Coverage



Contamination Effects: Crowding Normalisation



The Astrometric Uncertainty Function: Analytical perturbations

