1.0_Brown_Reformatting

March 8, 2018

1 HELP - Bootes Master List Creation

This notebook presents the creation of the HELP master list on the Bootes field. This field was originally ingested into HeDAM based on a masterlist produced by Eduardo Gonzales-Solares. Ken Duncan subsequently retrieved Michael Brown's precompiled masterlist for the Bootes field and therefore this notebook only contains some simple naming changes and astrometry correction. The original catalogue is described in DMU_0.

```
This notebook was run with herschelhelp_internal version:
33f5ec7 (Wed Dec 6 16:56:17 2017 +0000)
```

1.1 I - Column selection

```
Out[6]: <IPython.core.display.HTML object>

Out[8]: <IPython.core.display.HTML object>
```

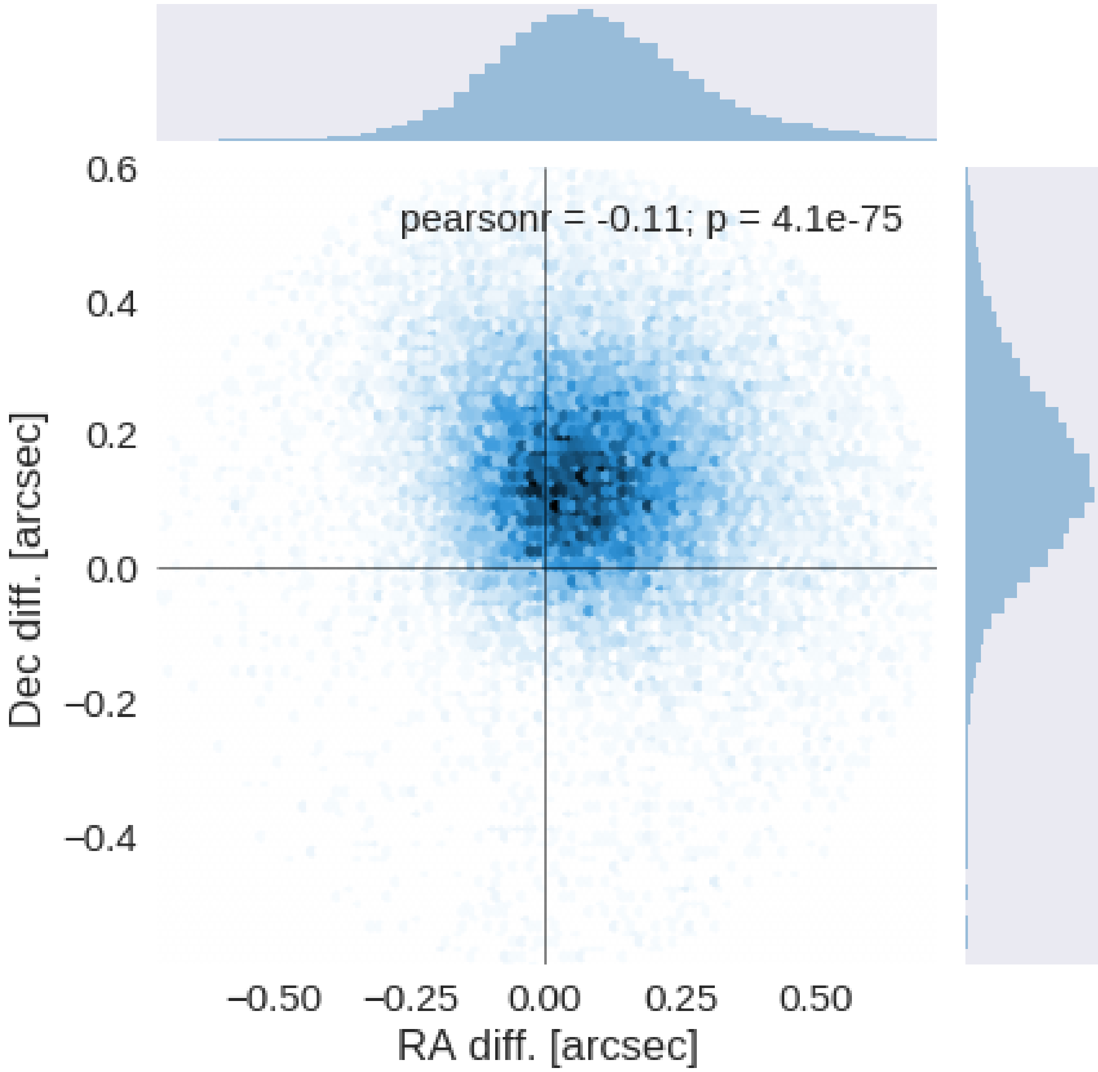
1.2 II - Removal of duplicated sources

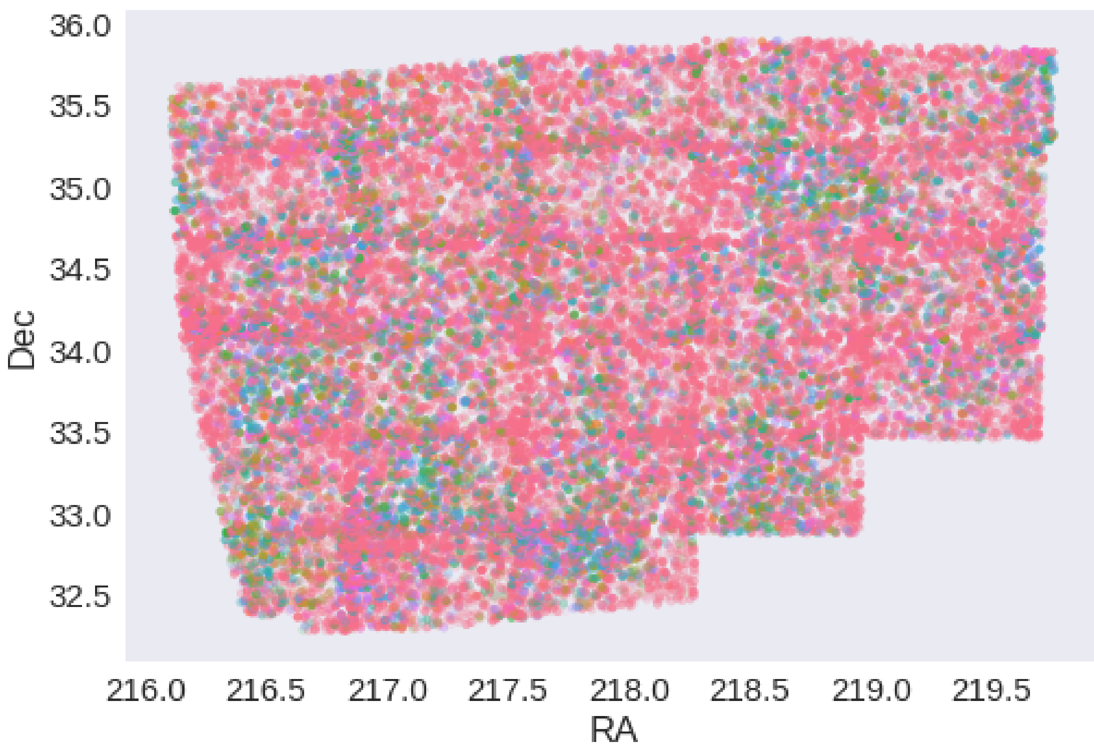
We remove duplicated objects from the input catalogues.

```
Out[9]: 'SORT_COLS = [\'merr_ap_gpc1_r\', \'merr_ap_gpc1_g\', \'merr_ap_gpc1_i\', \'merr_ap_gpc1
```

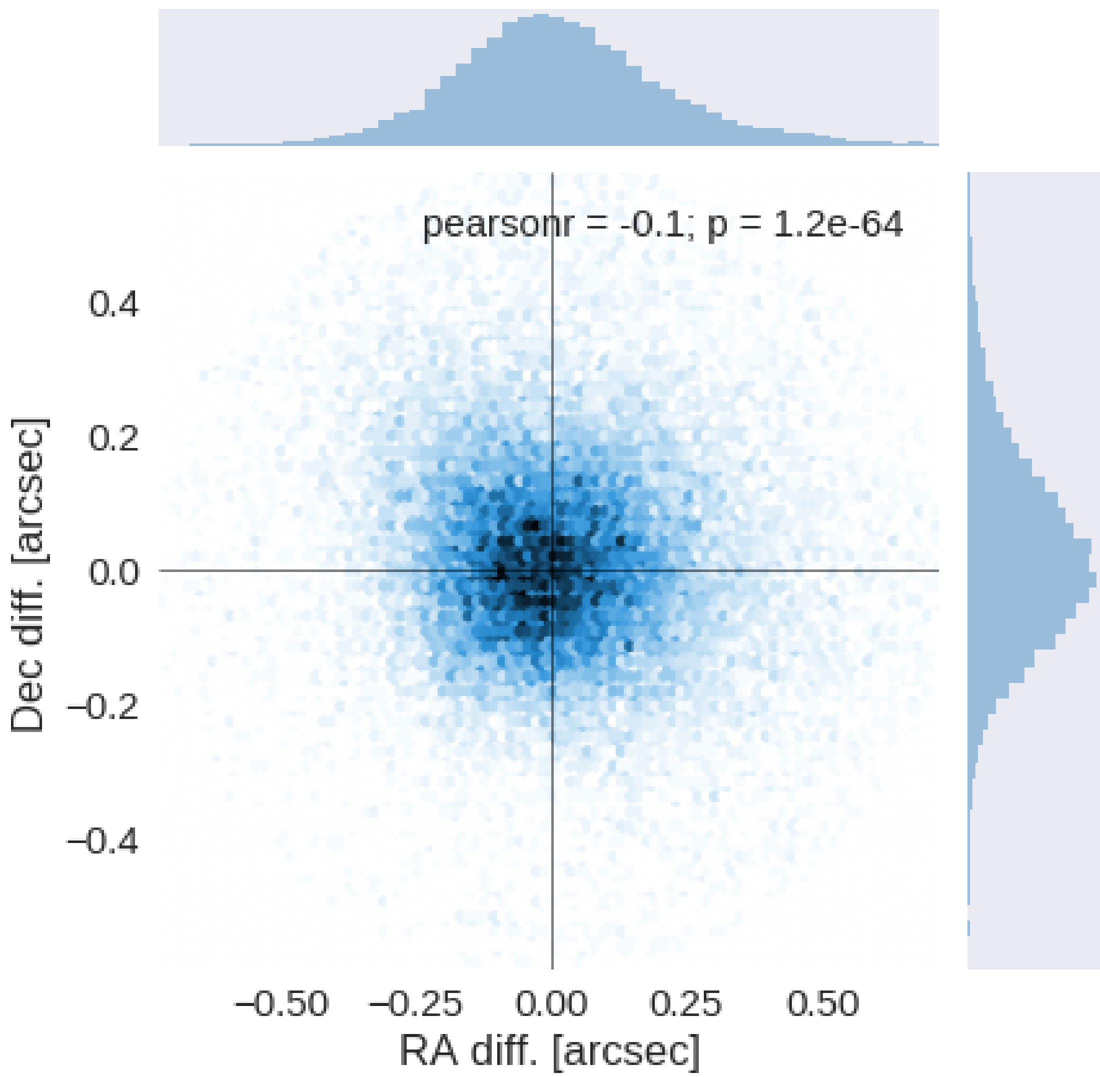
1.3 III - Astrometry correction

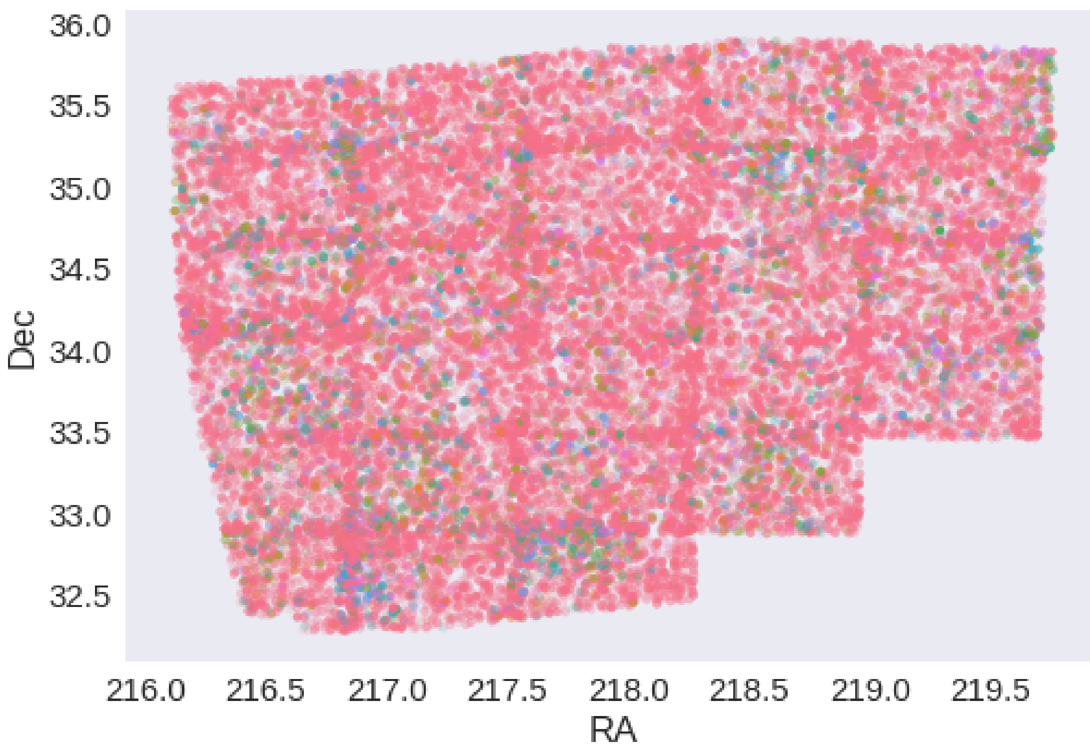
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.


pearsonr = -0.11; p = 4.1e-75
0.6
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]

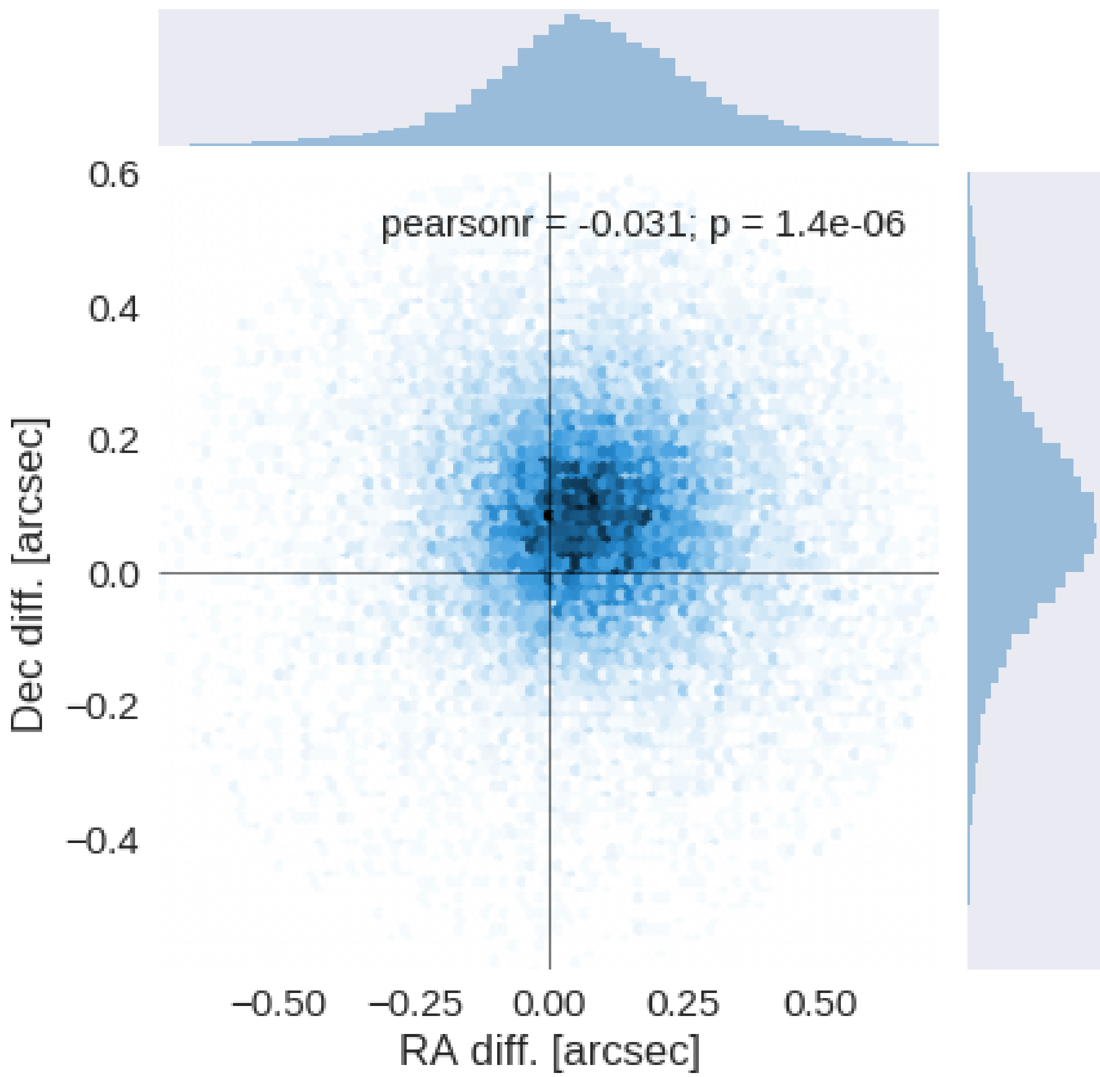


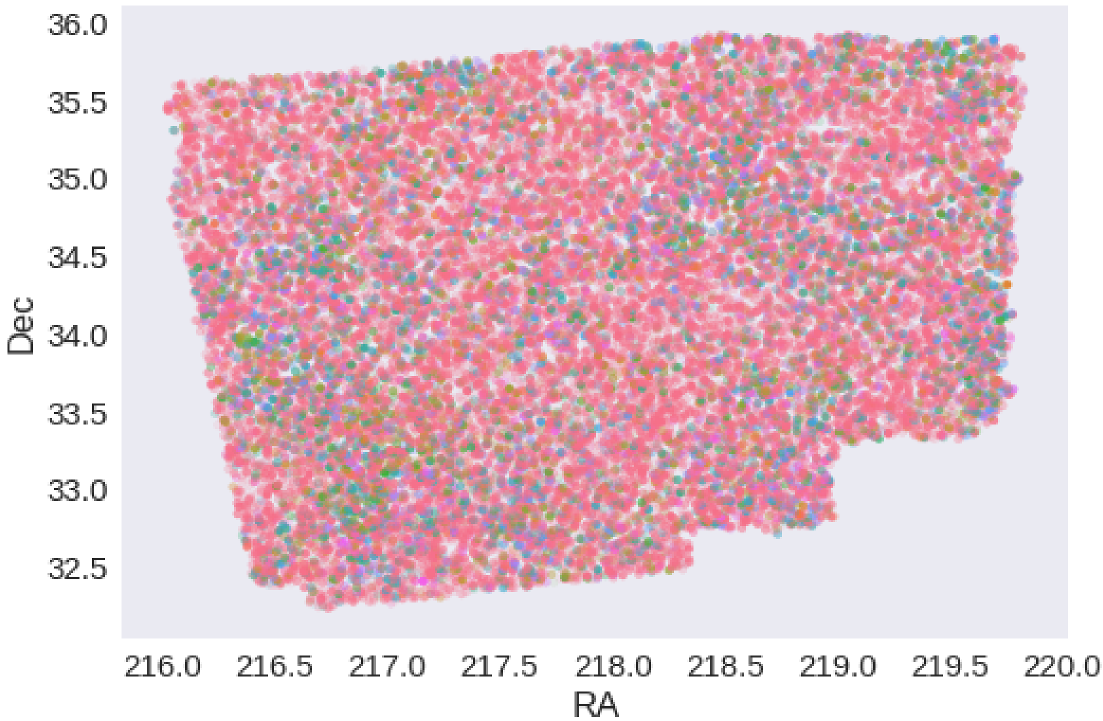

```
RA correction: -0.0735978168904694 arcsec
Dec correction: -0.12698051759514328 arcsec
```


pearsonr = -0.1; p = 1.2e-64
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]

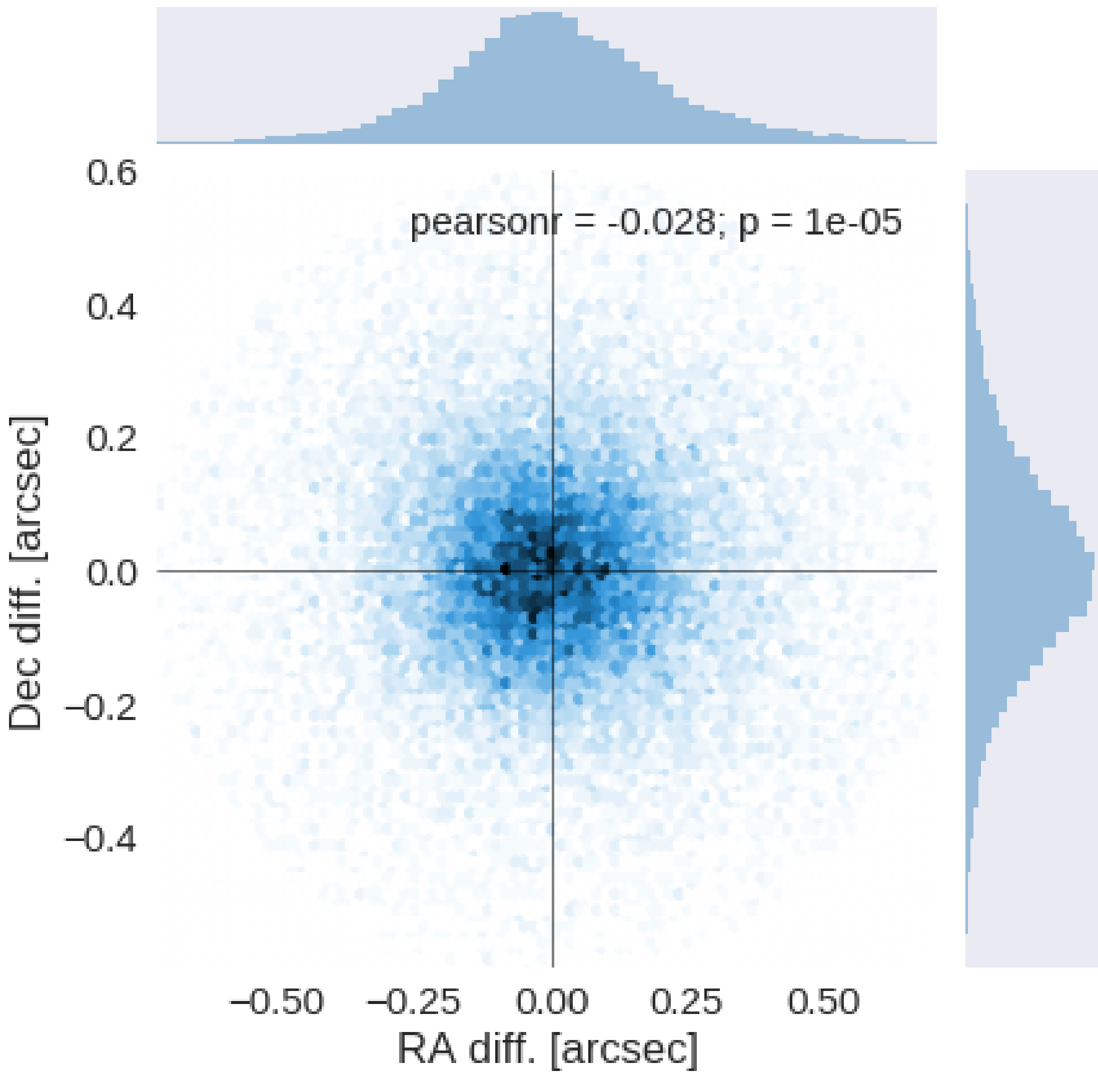


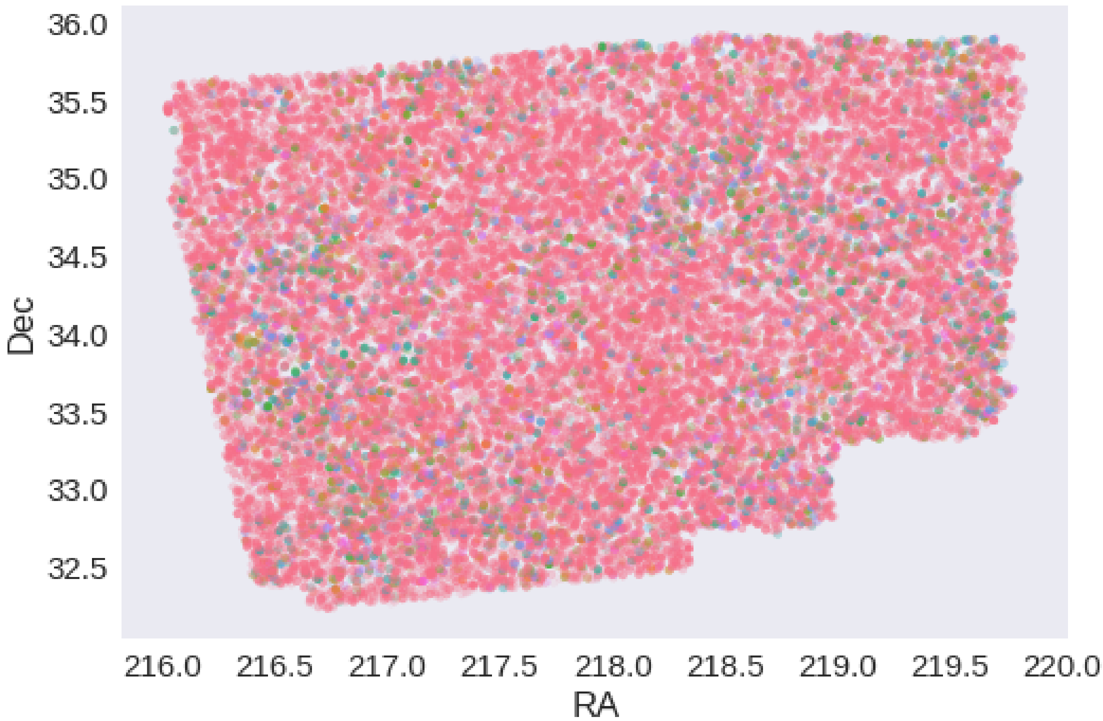
We then correct the other catalogue


pearsonr = -0.031; p = 1.4e-06
0.6
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]

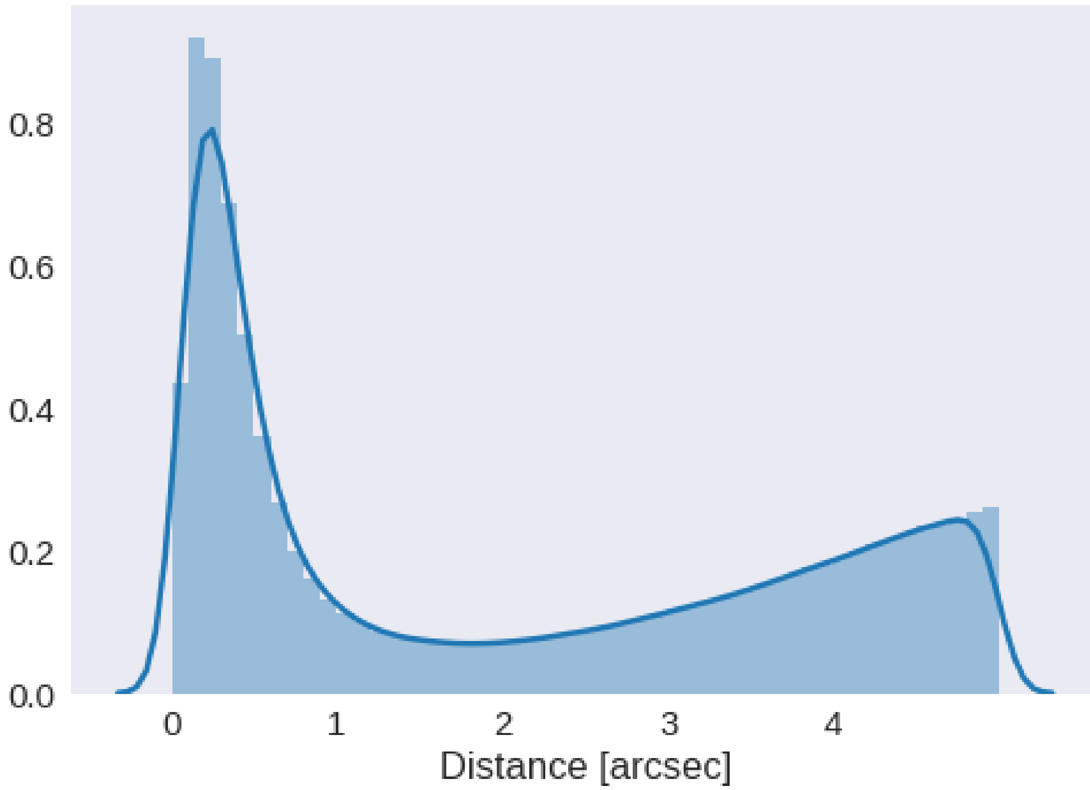



```
RA correction: -0.07916888162640134 arcsec
Dec correction: -0.08063874360573209 arcsec
```


pearsonr = -0.028; p = 1e-05
0.6
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]


36.0
35.5
35.0
34.5
34.0
33.5
33.0
32.5
Dec
216.0
216.5
217.0
217.5
218.0
218.5
219.0
219.5
220.0
RA

2 Merging




```
There are 1580405 sources only in the first catalogue
There are 185203 sources only in the second catalogue
There are 486485 sources in both catalogues
```

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:5: R
```

```
Out[23]: <IPython.core.display.HTML object>
```

2.1 IV - Flagging Gaia objects

```
38129 sources flagged.
```

3 V - Adding HELP unique identifiers and field columns

```
The HELP IDs are not unique!!!
```

4 VI - Saving to disk

1.1_DECaLS

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of DECam Legacy Survey data

This catalogue comes from `dmu0_DECaLS`.

In the catalogue, we keep:

- The `object_id` as unique object identifier;
- The position;
- The u, g, r, i, z, Y aperture magnitude (2");
- The u, g, r, i, z, Y kron fluxes and magnitudes.

We check for all ugrizY then only take bands for which there are measurements

```
This notebook was run with herschelhelp_internal version:
33f5ec7 (Wed Dec 6 16:56:17 2017 +0000)
```

```
WARNING: UnitsWarning: '1/deg^2' did not parse as fits unit: Numeric factor not supported by FIT
WARNING: UnitsWarning: 'nanomaggy' did not parse as fits unit: At col 0, Unit 'nanomaggy' not su
WARNING: UnitsWarning: '1/nanomaggy^2' did not parse as fits unit: Numeric factor not supported
WARNING: UnitsWarning: '1/arcsec^2' did not parse as fits unit: Numeric factor not supported by
```

1.2 I - Aperture correction

To compute aperture correction we need to dertermine two parametres: the target aperture and the range of magnitudes for the stars that will be used to compute the correction.

Target aperture: To determine the target aperture, we simulate a curve of growth using the provided apertures and draw two figures:

- The evolution of the magnitudes of the objects by plotting on the same plot aperture number vs the mean magnitude.
- The mean gain (loss when negative) of magnitude is each aperture compared to the previous (except for the first of course).

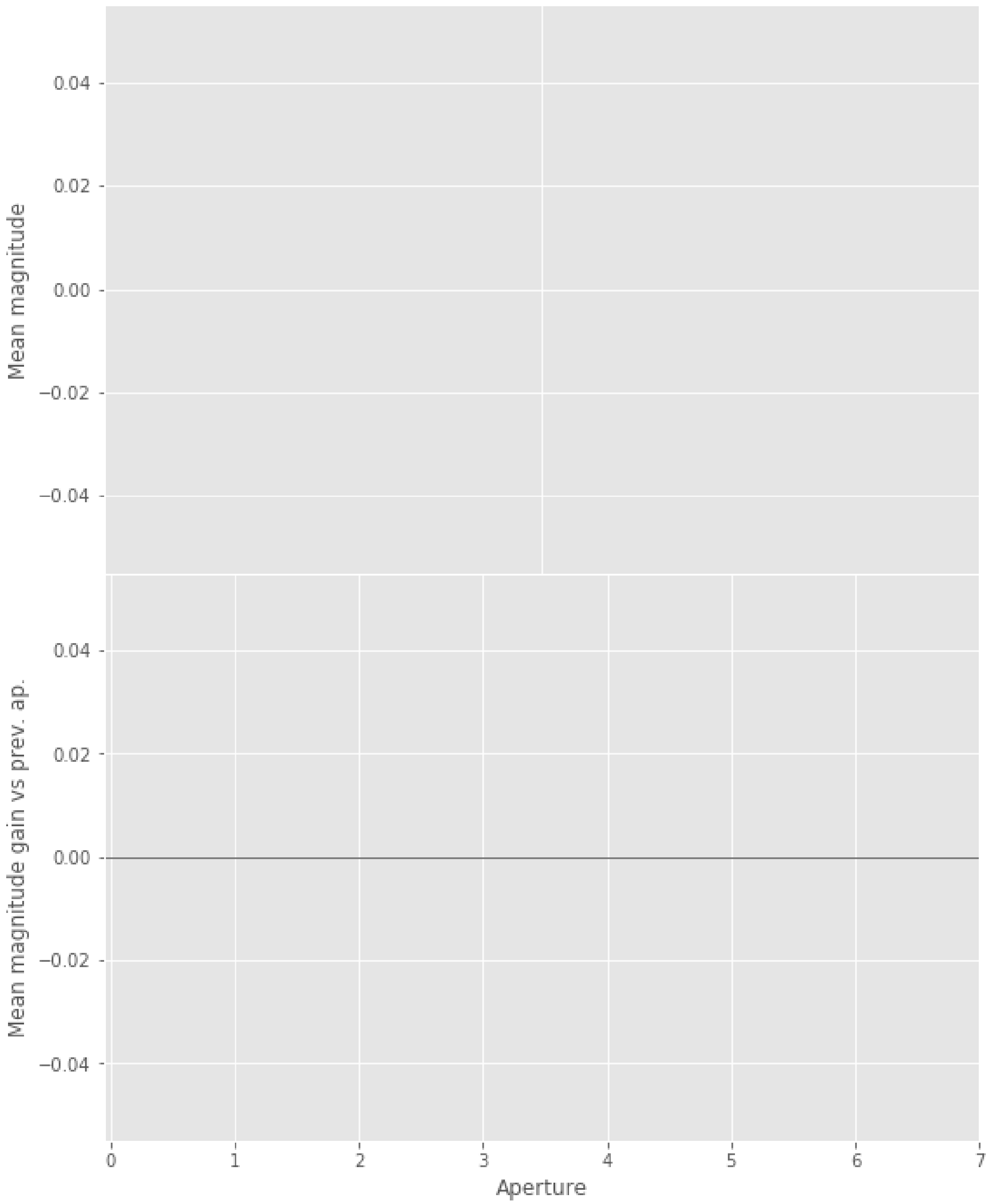
As target aperture, we should use the smallest (i.e. less noisy) aperture for which most of the flux is captures.

Magnitude range: To know what limits in aperture to use when doing the aperture correction, we plot for each magnitude bin the correction that is computed and its RMS. We should then use the wide limits (to use more stars) where the correction is stable and with few dispersion.

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: divide by zero enc
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:80: RuntimeWarning: invalid value enco
  errors = 2.5 / np.log(10) * errors_on_fluxes / fluxes
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: invalid value enco
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
```

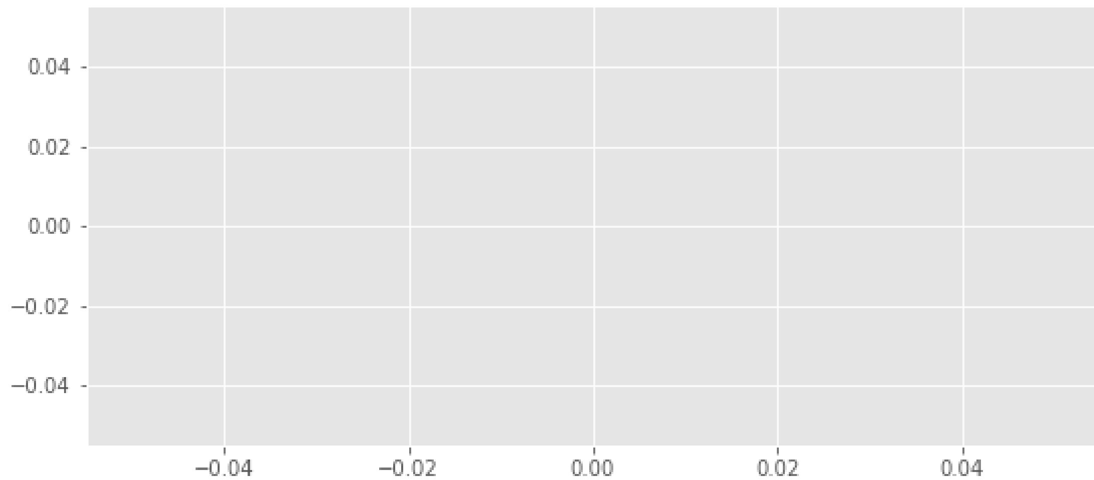
1.2.1 1.a u band

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("Mean of empty slice", RuntimeWarning)
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("Mean of empty slice", RuntimeWarning)
```

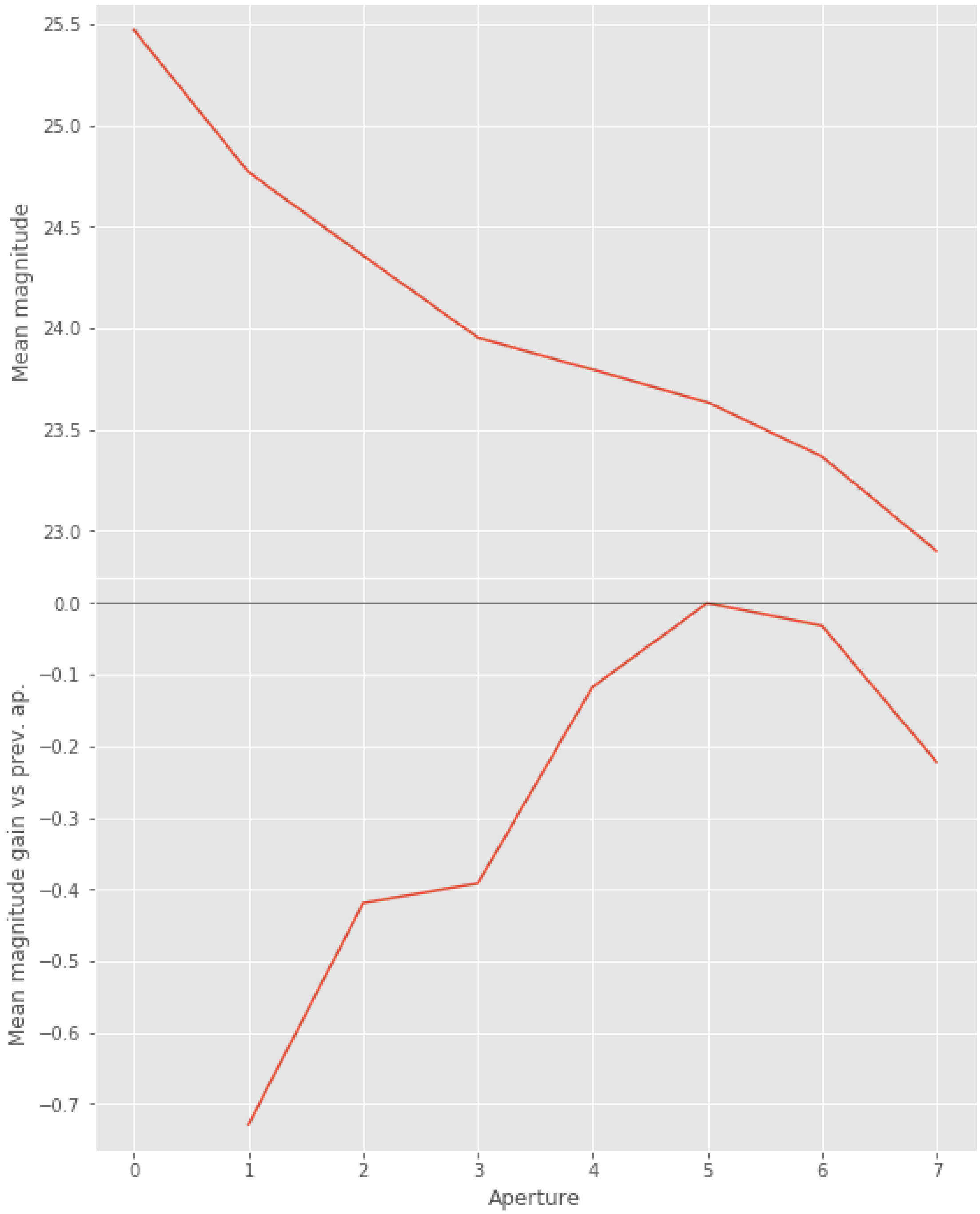


u band is all nan

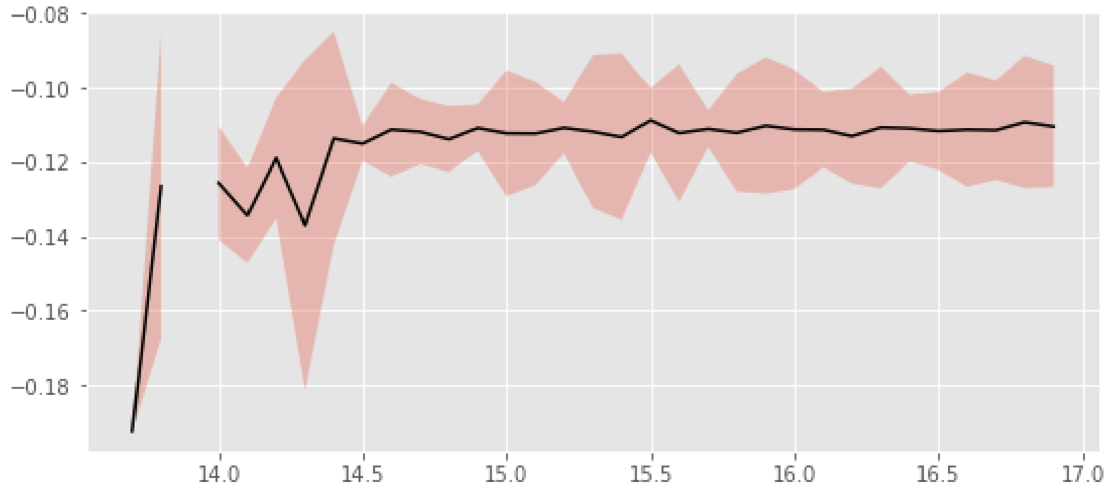
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("All-NaN slice encountered", RuntimeWarning)
```


0.04
0.02
0.00
−0.02
−0.04
−0.04
−0.02
0.00
0.02
0.04

1.2.2 I.a - g band



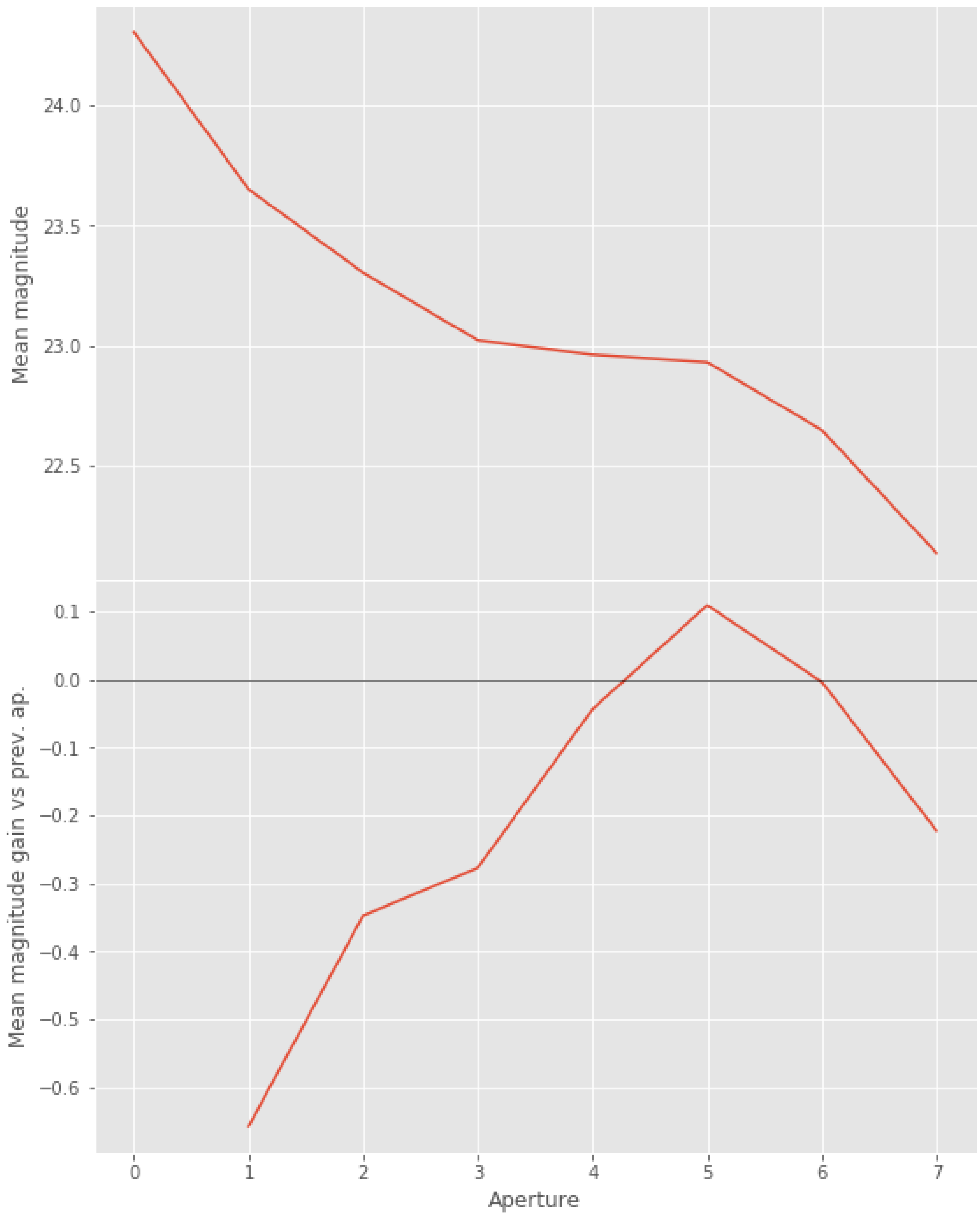
We will use aperture 5 as target.



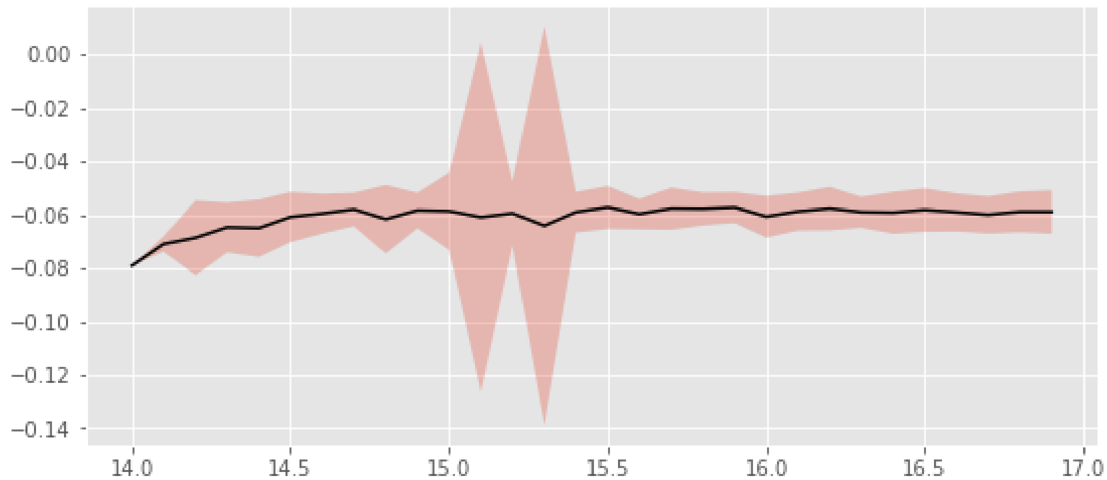
We will use magnitudes between 16.0 and 19.0

```
Aperture correction for g band:
Correction: -0.11073624215552513
Number of source used: 2953
RMS: 0.013882524930034707
```

1.2.3 I.b - r band



We will use aperture 5 as target.

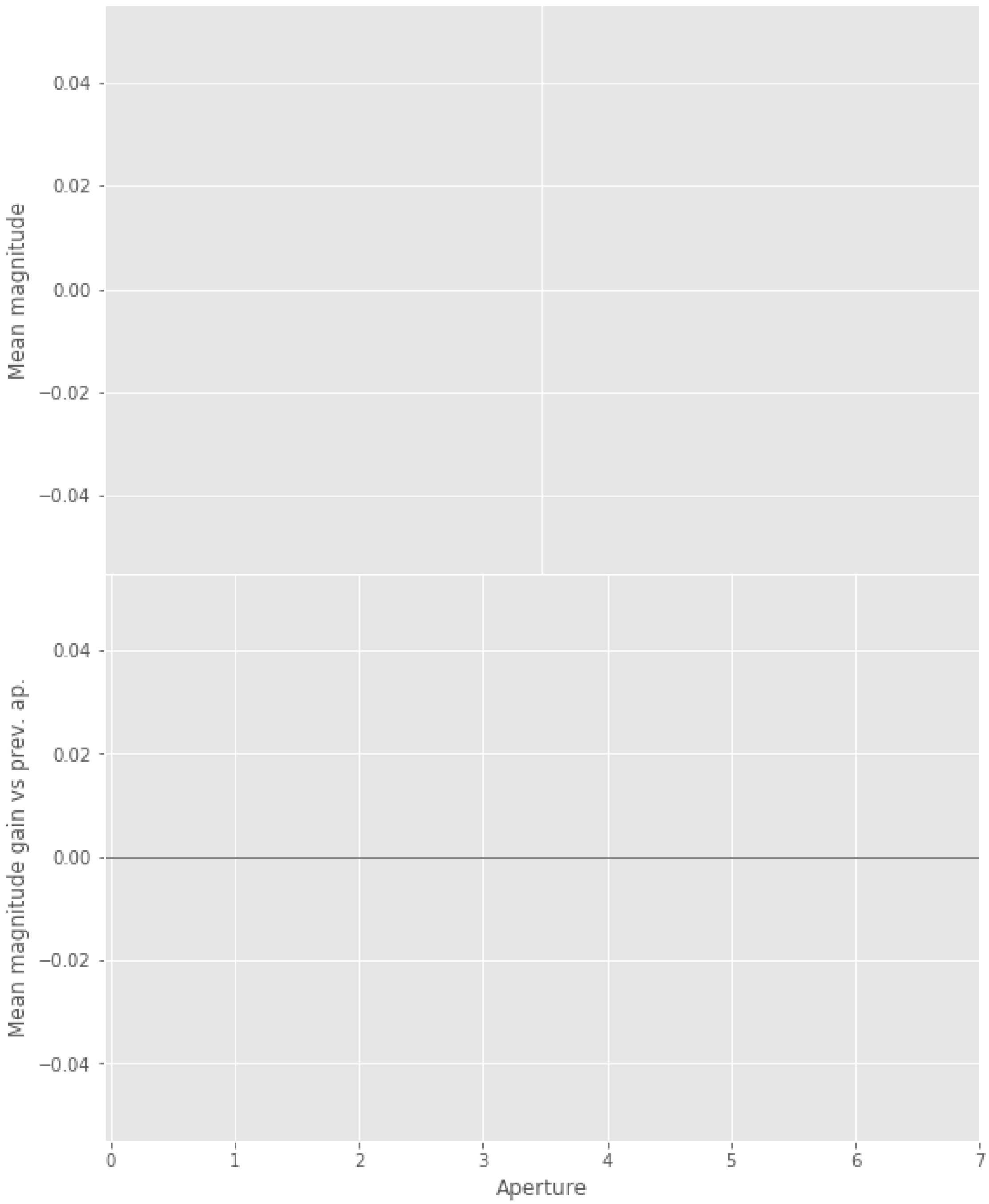


We use magnitudes between 16.0 and 18.0.

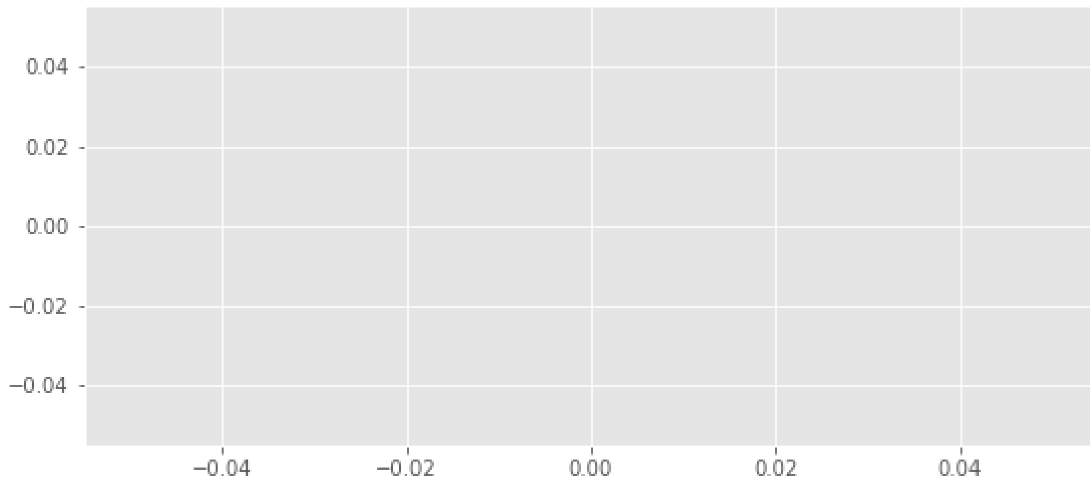
```
Aperture correction for r band:
Correction: -0.058869338118242354
Number of source used: 2426
RMS: 0.007863470741114361
```

1.2.4 I.d - i band

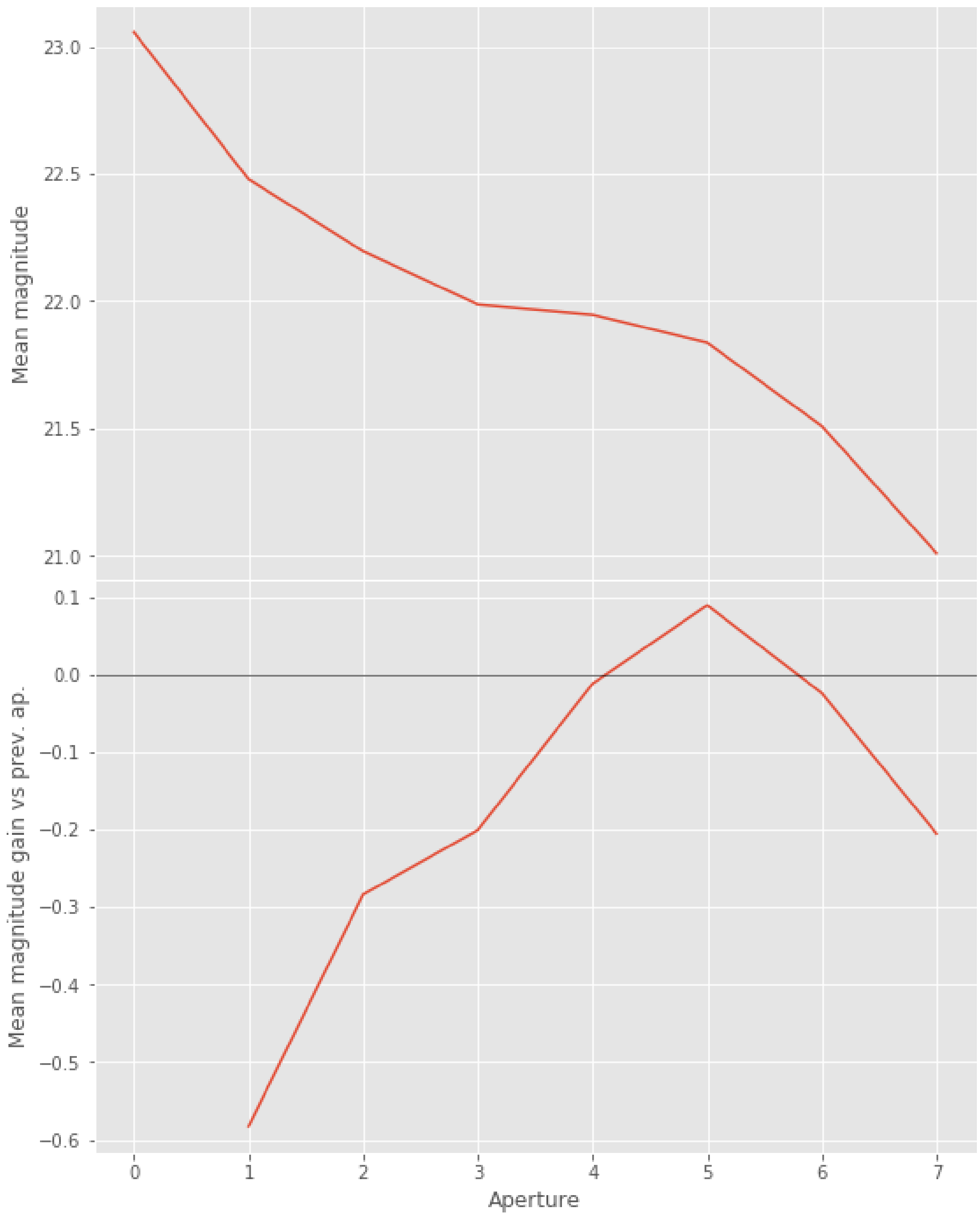
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("Mean of empty slice", RuntimeWarning)
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("Mean of empty slice", RuntimeWarning)
```



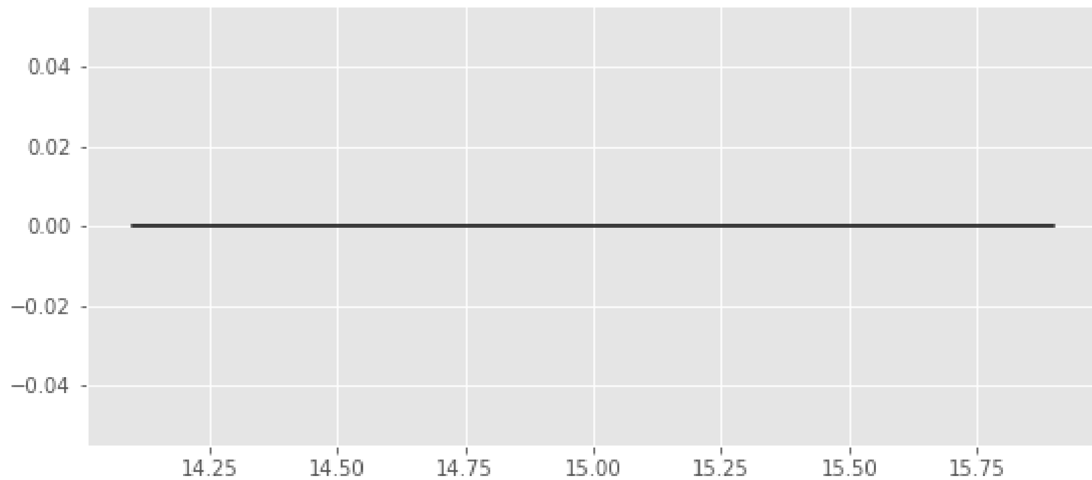

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("All-NaN slice encountered", RuntimeWarning)
```


0.04
0.02
0.00
−0.02
−0.04
−0.04
−0.02
0.00
0.02
0.04

1.2.5 I.e - z band



We will use aperture 4 as target.

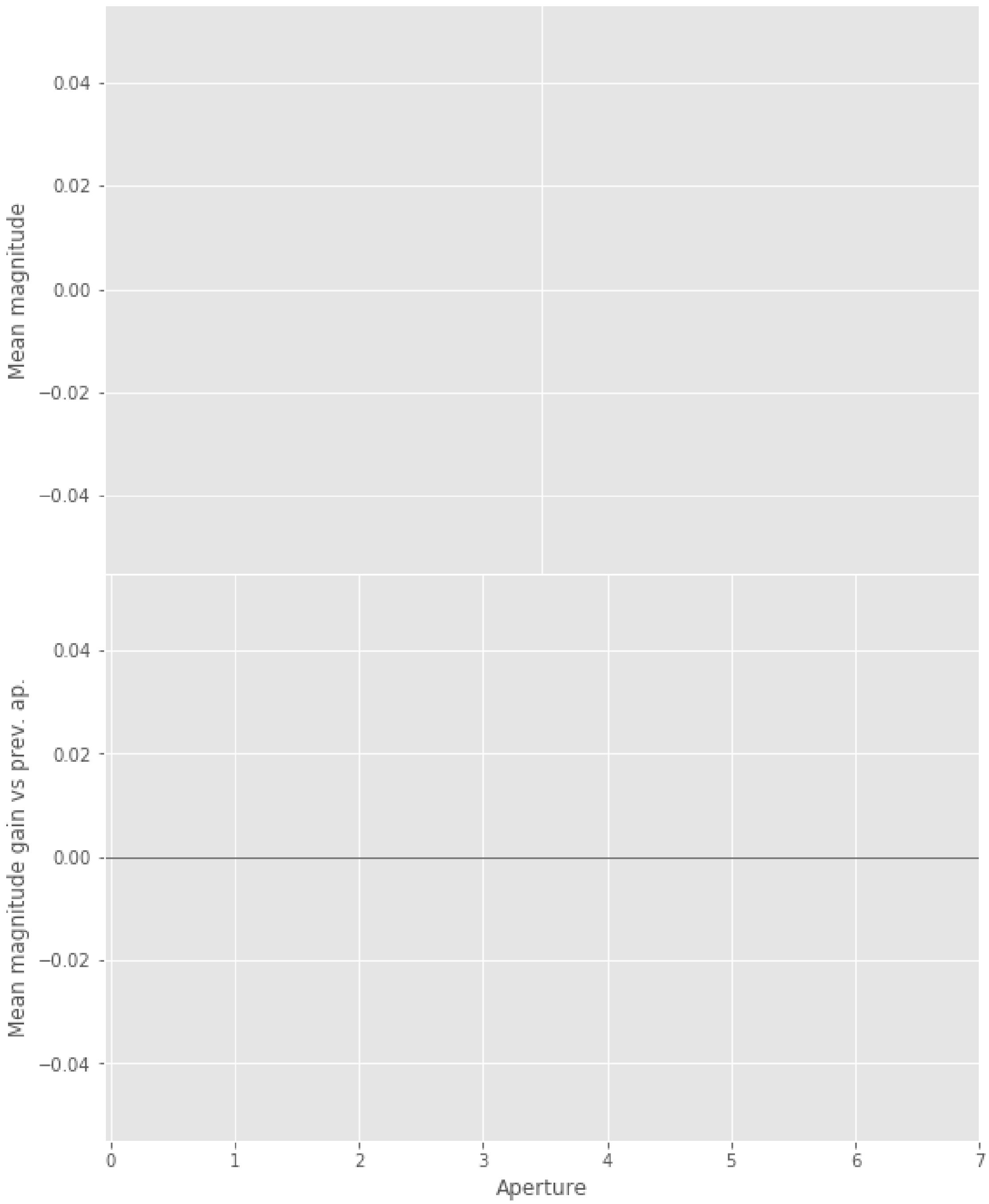


We use magnitudes between 16.0 and 17.5.

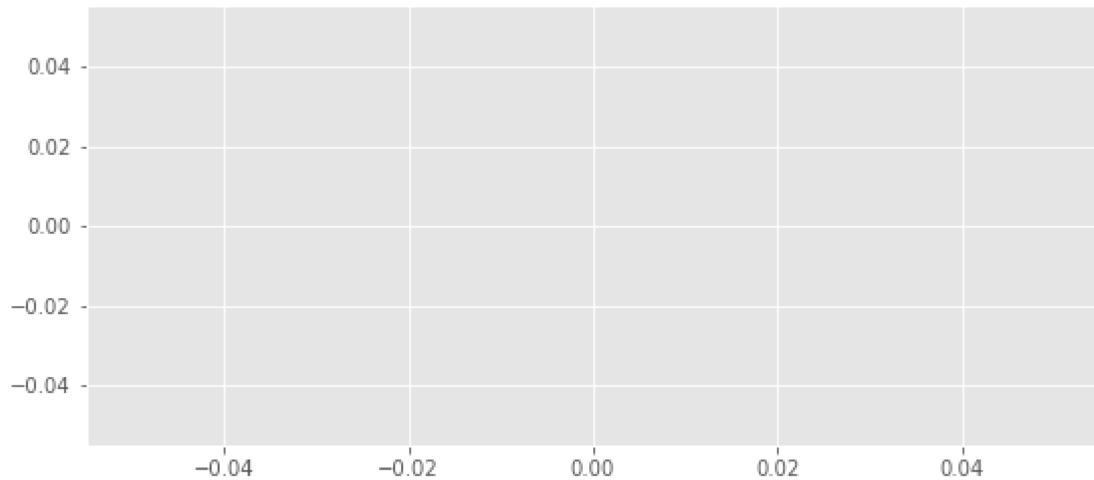
```
Aperture correction for z band:
Correction: -0.054092454637959975
Number of source used: 4630
RMS: 0.016963778211100684
```

1.2.6 I.f - Y band

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("Mean of empty slice", RuntimeWarning)
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("Mean of empty slice", RuntimeWarning)
```




```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("All-NaN slice encountered", RuntimeWarning)
```



1.3 II - Stellarity

Legacy Survey does not provide a 0 to 1 stellarity so we replace items flagged as PSF accpording to the following table:

$$P(star) = \frac{\prod_i P(star)_i}{\prod_i P(star)_i + \prod_i P(galaxy)_i}$$

where i is the band, and with using the same probabilities as UKDISS:

HSC flag	UKIDSS flag	Meaning	P(star)	P(galaxy)	P(noise)	P(saturated)
	-9	Saturated	0.0	0.0	5.0	95.0
	-3	Probable galaxy	25.0	70.0	5.0	0.0
	-2	Probable star	70.0	25.0	5.0	0.0
0	-1	Star	90.0	5.0	5.0	0.0
	0	Noise	5.0	5.0	90.0	0.0
1	+1	Galaxy	5.0	90.0	5.0	0.0

1.4 II - Column selection

```
WARNING: UnitsWarning: '1/deg^2' did not parse as fits unit: Numeric factor not supported by FIT
WARNING: UnitsWarning: 'nanomaggy' did not parse as fits unit: At col 0, Unit 'nanomaggy' not su
WARNING: UnitsWarning: '1/nanomaggy^2' did not parse as fits unit: Numeric factor not supported
WARNING: UnitsWarning: '1/arcsec^2' did not parse as fits unit: Numeric factor not supported by


/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: invalid value enco
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
```

```
Out[27]: <IPython.core.display.HTML object>
```

1.5 III - Removal of duplicated sources

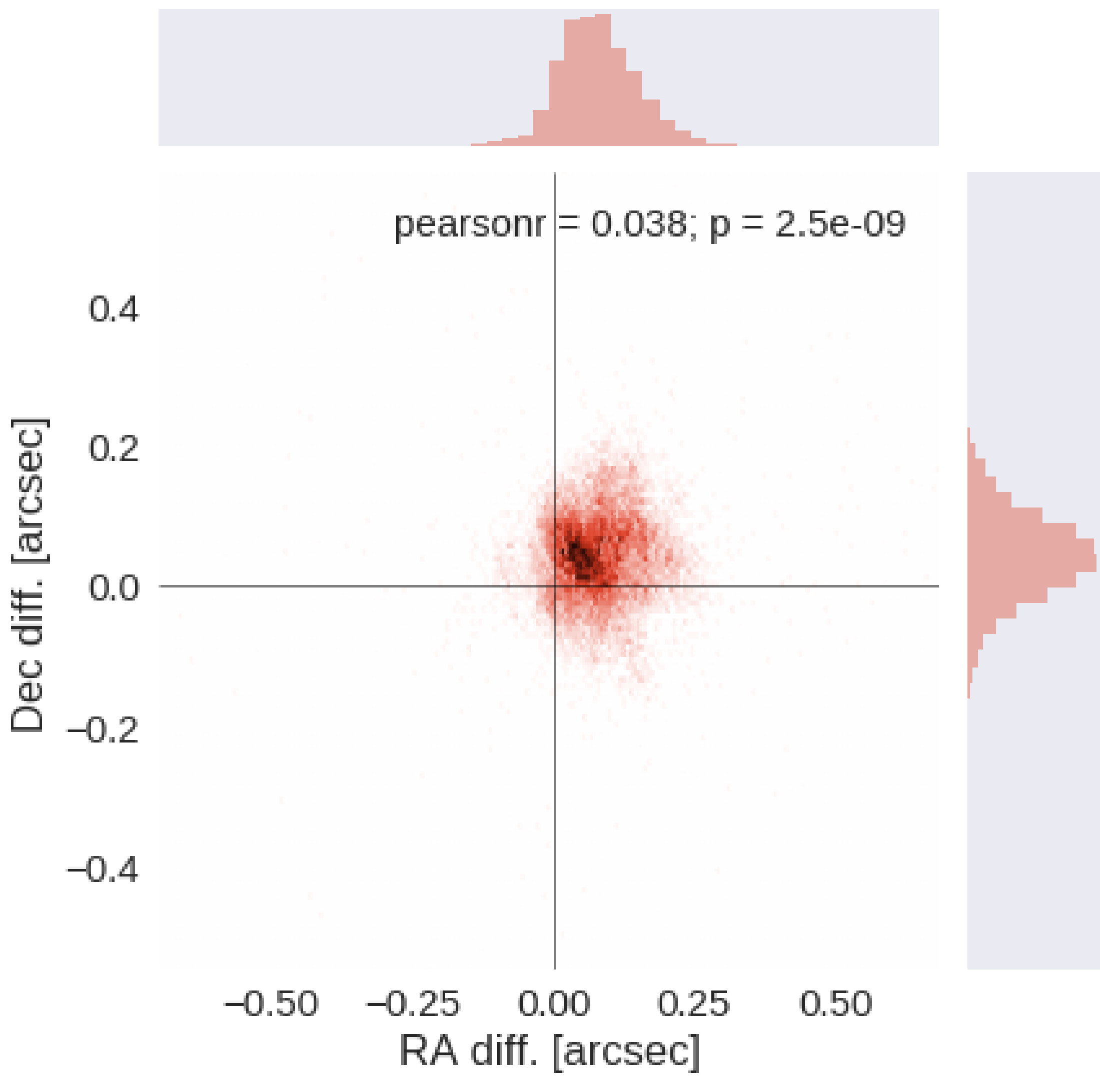
We remove duplicated objects from the input catalogues.

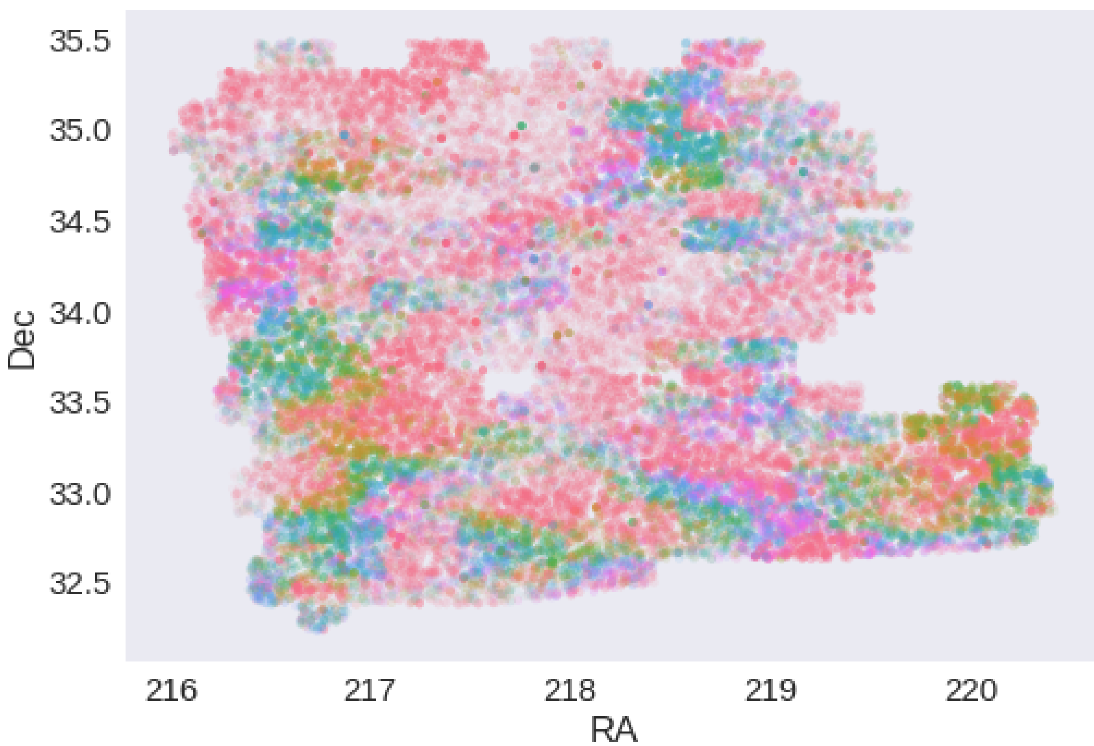
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 362677 sources.
The cleaned catalogue has 362638 sources (39 removed).
The cleaned catalogue has 39 sources flagged as having been cleaned
```

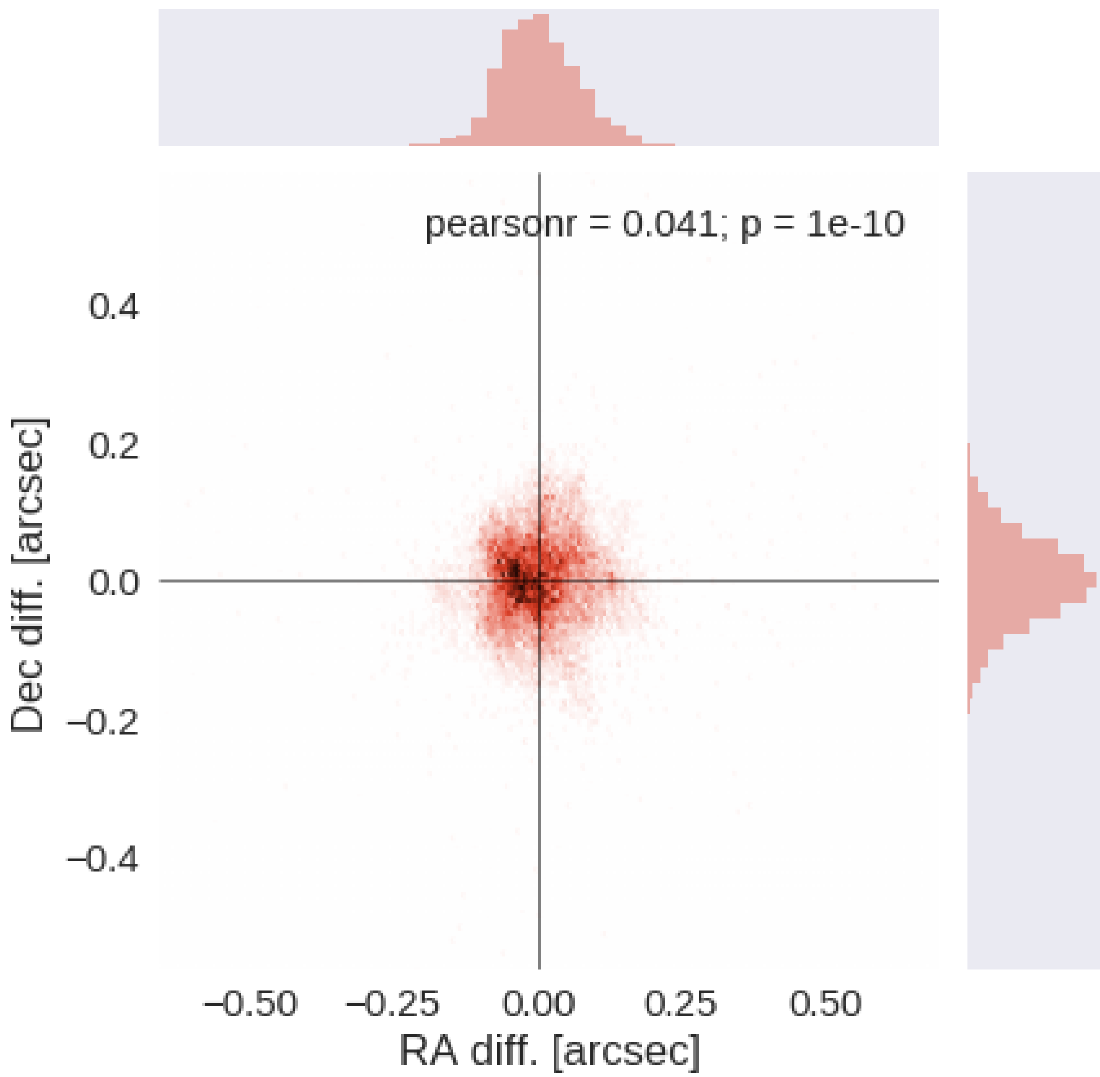
1.6 III - Astrometry correction

We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.


pearsonr = 0.038; p = 2.5e-09
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]




```
RA correction: -0.07634788760242373 arcsec
Dec correction: -0.04301923179923506 arcsec
```


pearsonr = 0.041; p = 1e-10
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]

1.7 IV - Flagging Gaia objects

```
25228 sources flagged.
```

2 V - Saving to disk

1.2_DataFusion-Spitzer

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of Spitzer datafusion data

The Spitzer catalogues were produced by the datafusion team are available in `dmu0_DataFusion-Spitzer`. Lucia told that the magnitudes are aperture corrected.

In the catalouge, we keep:

- The internal identifier (this one is only in HeDaM data);
- The position;
- The fluxes in aperture 2 (1.9 arcsec);
- The "auto" flux (which seems to be the Kron flux);
- The stellarity in each band

A query of the position in the Spitzer heritage archive show that the SERVS-ELAIS-N1 images were observed in 2009. Let's take this as epoch.

```
This notebook was run with herschelhelp_internal version:
33f5ec7 (Wed Dec 6 16:56:17 2017 +0000)
```

1.2 I - Column selection

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: invalid value enco
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
```

```
Out[6]: <IPython.core.display.HTML object>
```

1.3 II - Removal of duplicated sources

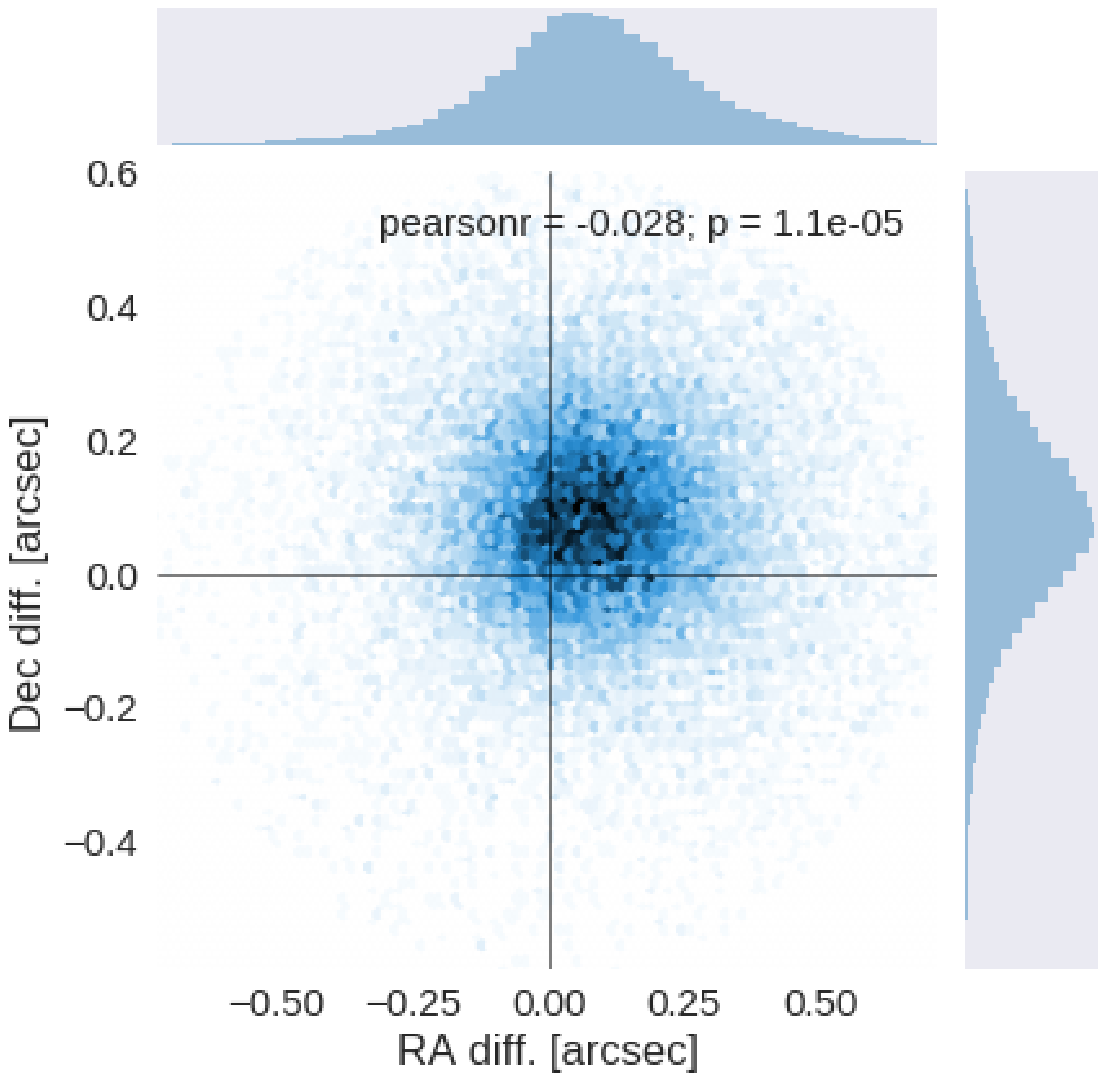
We remove duplicated objects from the input catalogues.

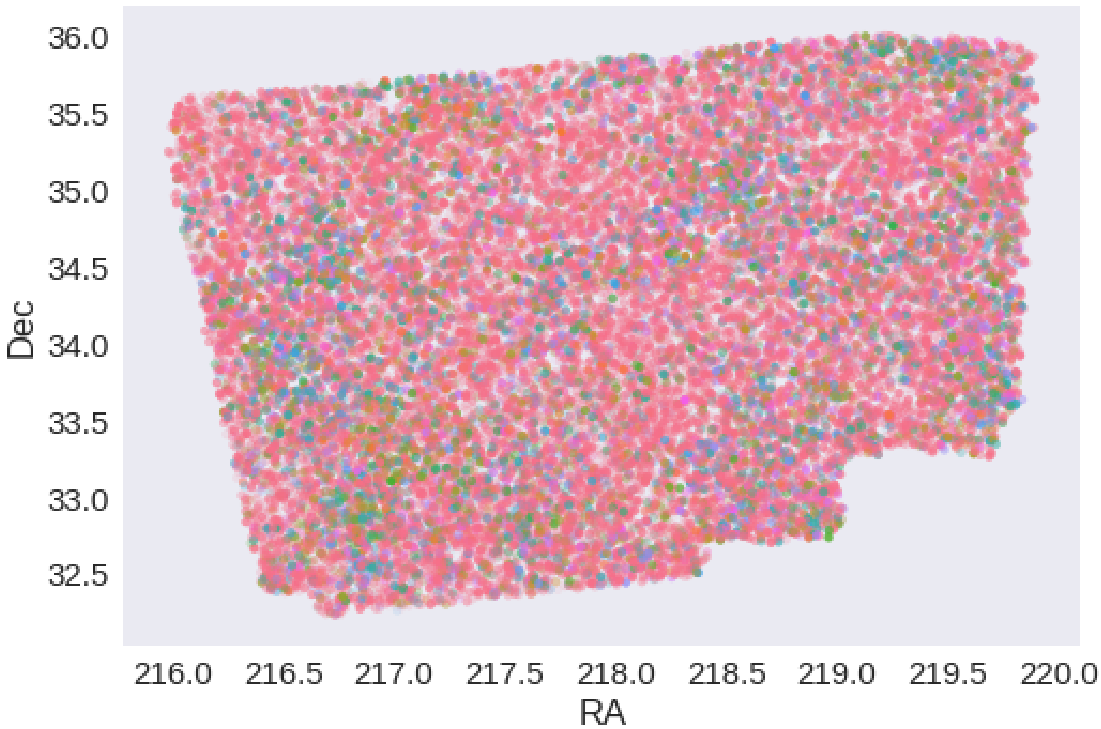
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 1142840 sources.
The cleaned catalogue has 1142840 sources (0 removed).
The cleaned catalogue has 0 sources flagged as having been cleaned
```

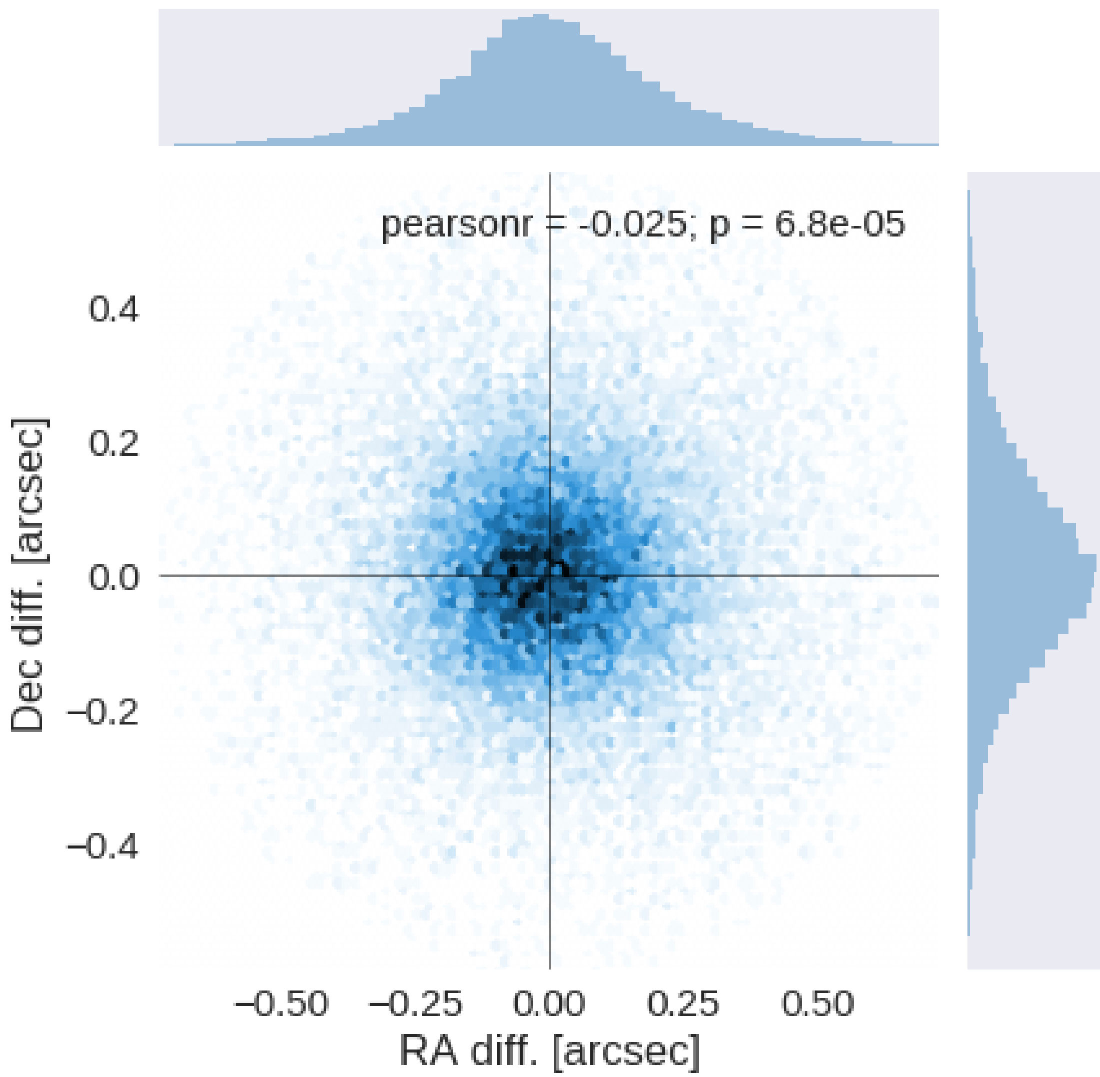
1.4 III - Astrometry correction

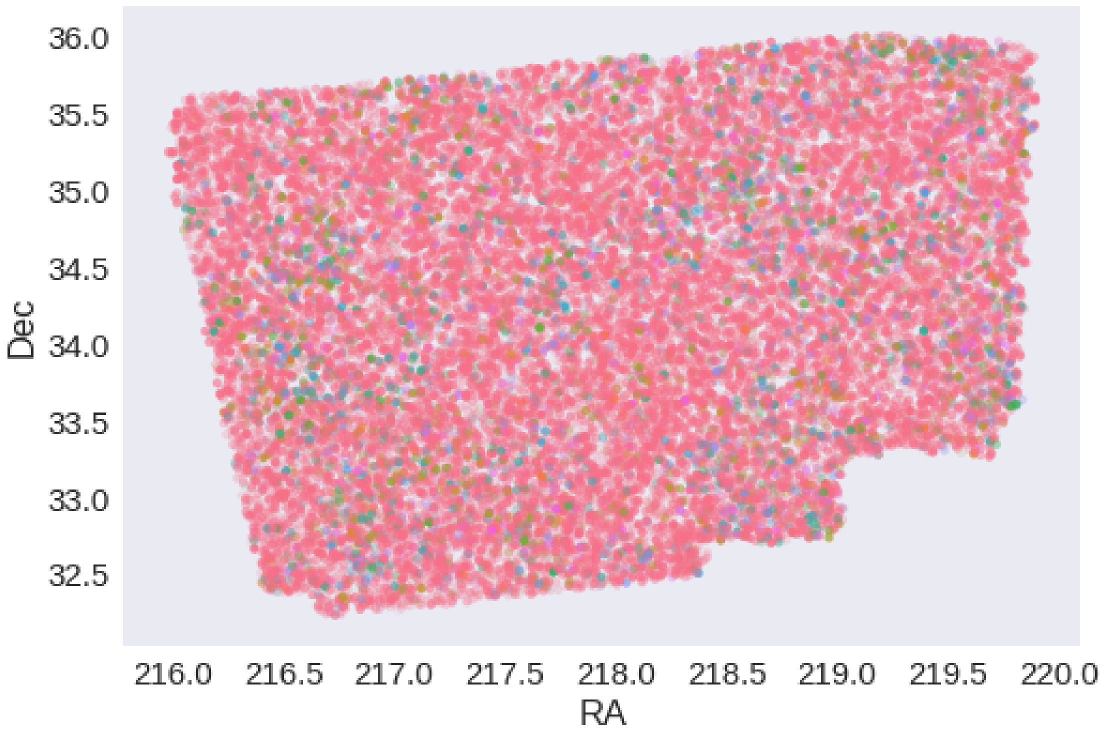
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.






```
RA correction: -0.0809307827921657 arcsec
Dec correction: -0.08064486934244997 arcsec
```


pearsonr = -0.025; p = 6.8e-05
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
28423 sources flagged.
```

1.6 V - Saving to disk

1.3_IBIS

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of IBIS data

The catalogue comes from `dmu0_IBIS`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The magnitude for each band in apertude 4 ($1.2 * \sqrt{2}$ arcsec = 1.7 arcsec).
- The kron magnitude to be used as total magnitude (no "auto" magnitude is provided).

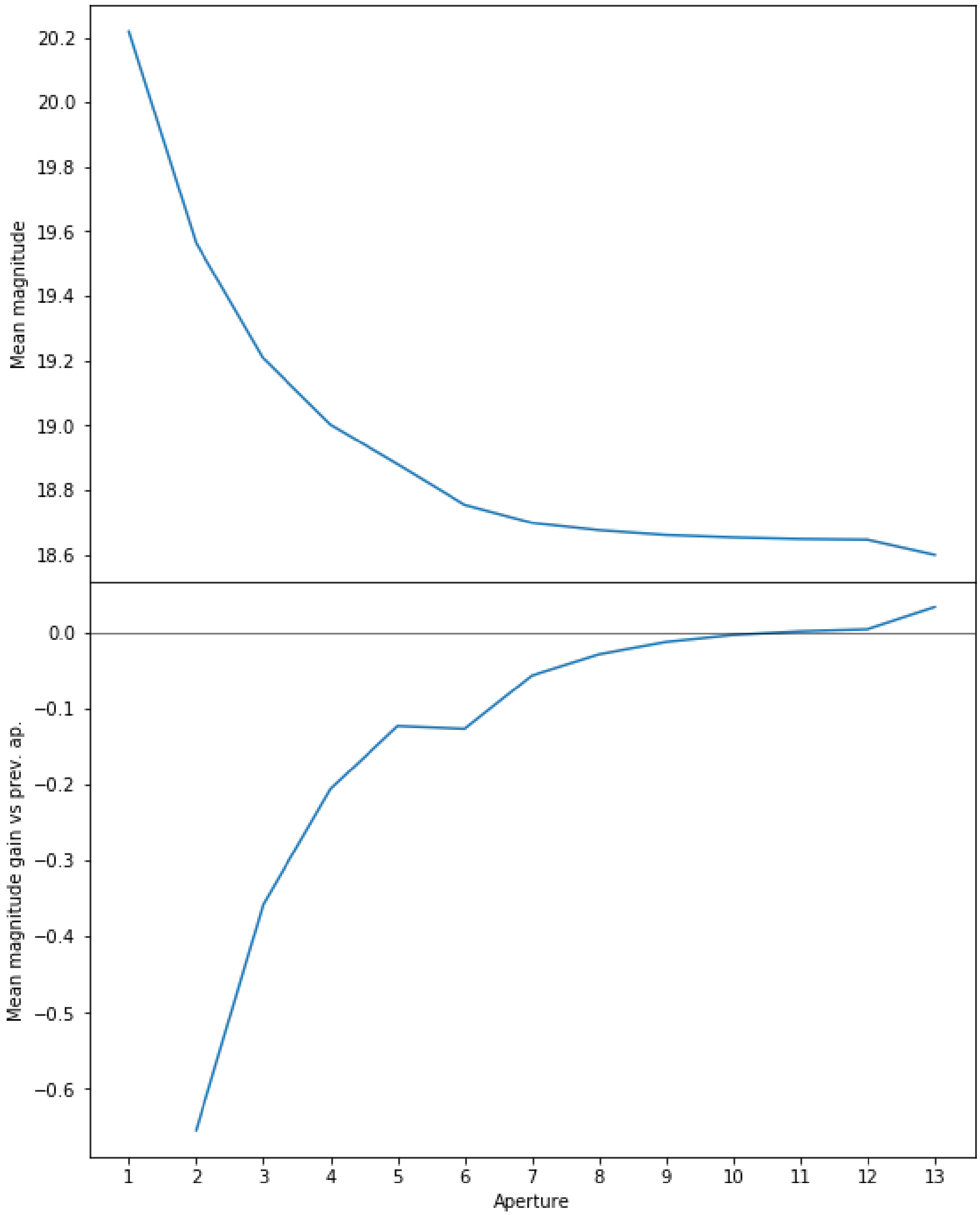
We don't know when the maps have been observed. We will use the year of the reference paper.

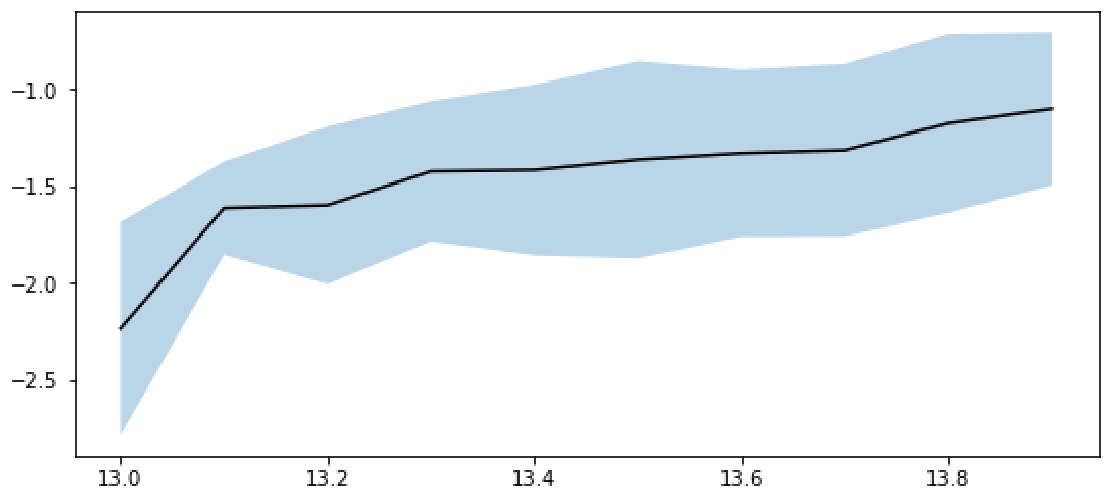
```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
This notebook was executed on:
2018-02-15 13:49:16.811795
```

1.2 I - Column selection

1.2.1 I.i - Aperture correction

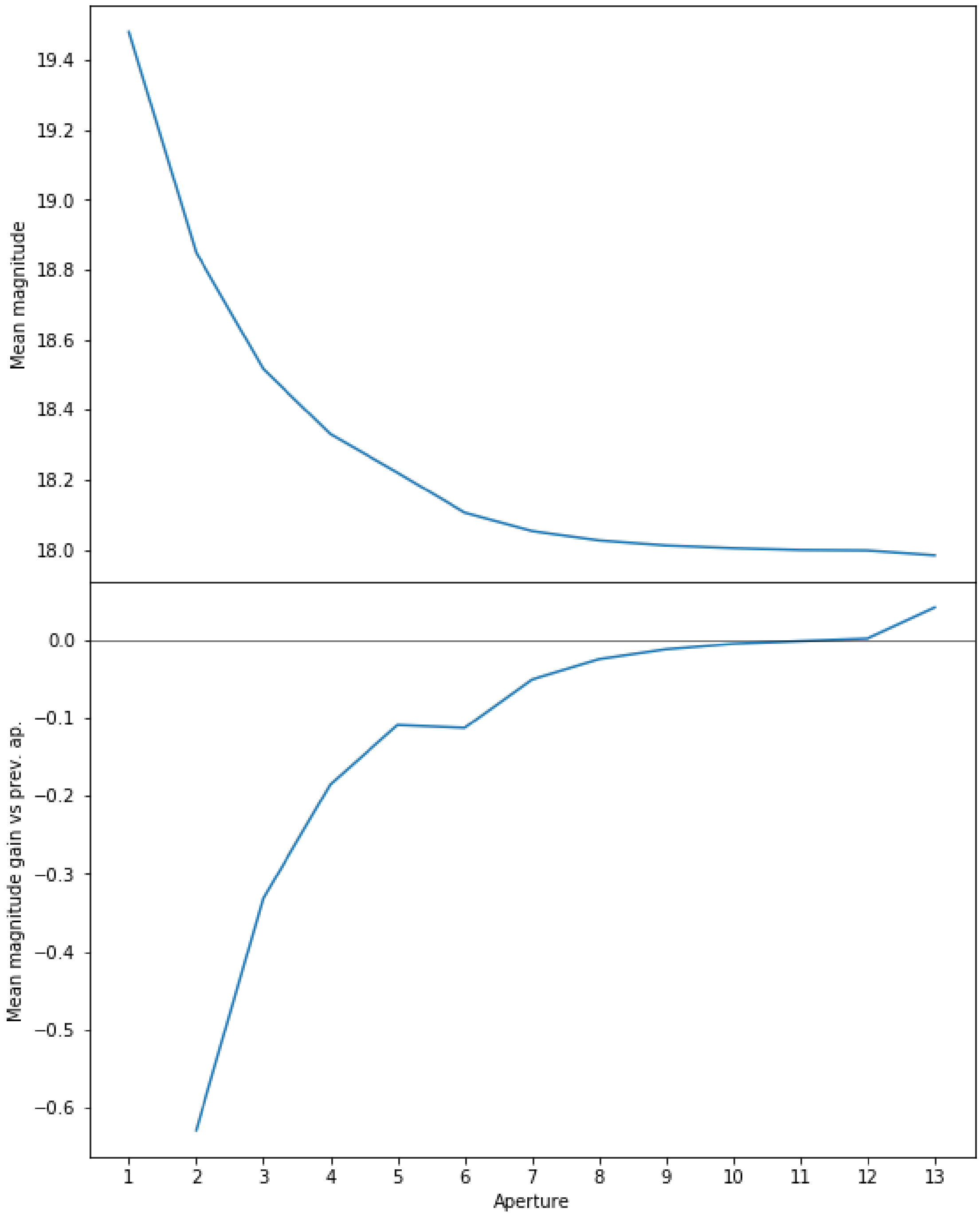
J


Mean magnitude
20.2
20.0
19.8
19.6
19.4
19.2
19.0
18.8
18.6
Mean magnitude gain vs prev. ap.
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
1
2
3
4
5
6
7
8
9
10
11
12
13
Aperture

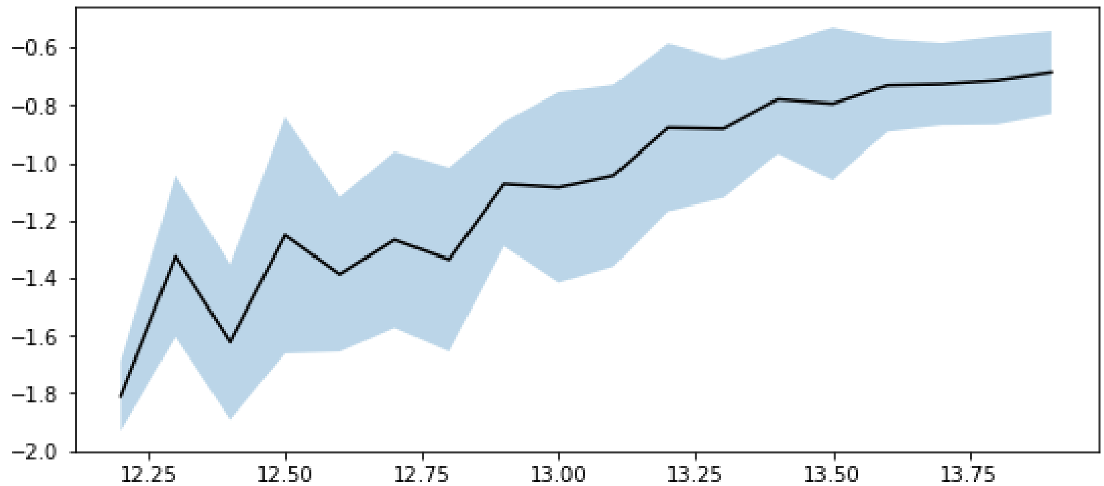



```
Aperture correction for j band:
Correction: -1.3177995681762695
Number of source used: 768
RMS: 0.4462176013078398
```

1.3 H

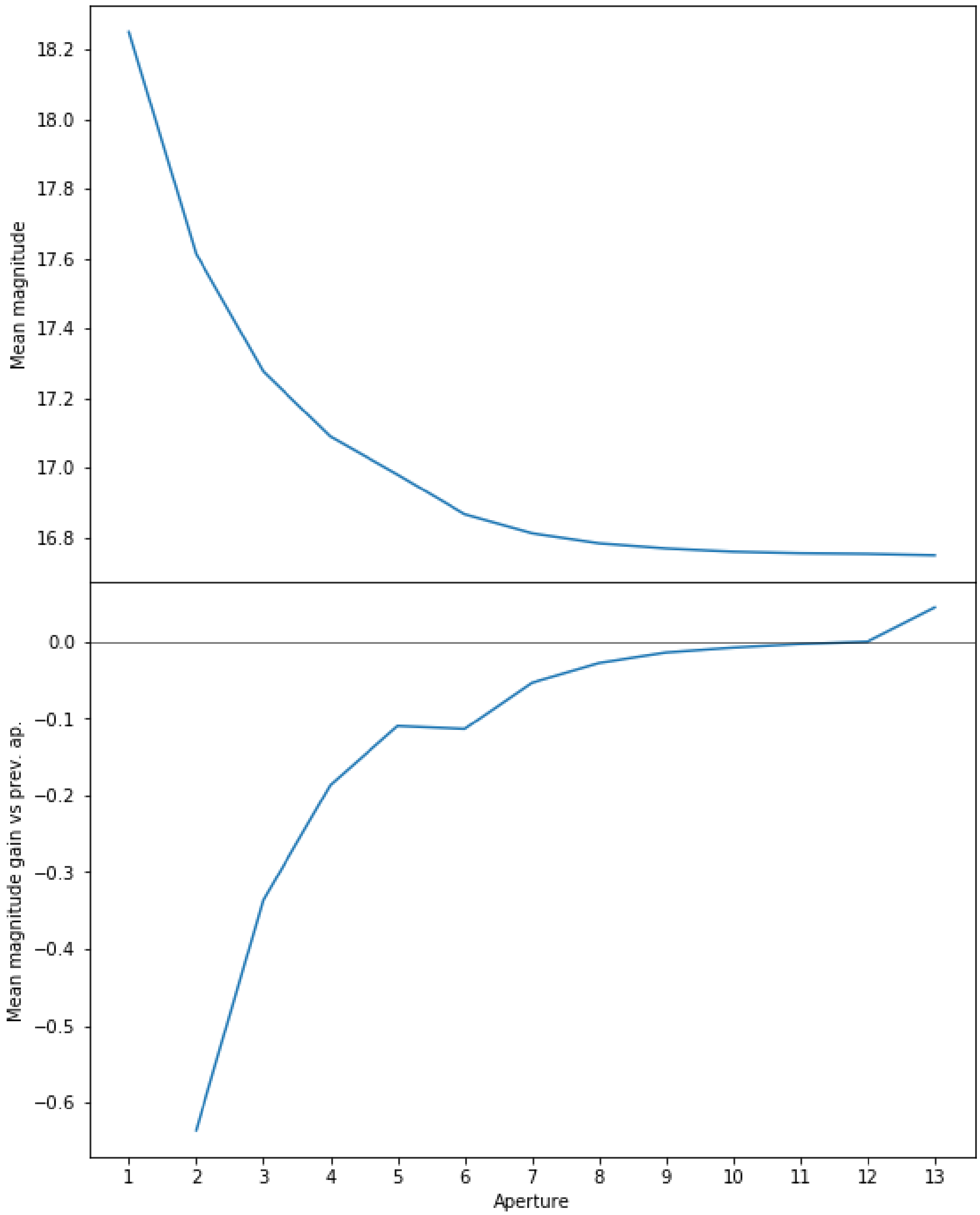


19.4
19.2
19.0
18.8
18.6
18.4
18.2
18.0
Mean magnitude
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
Mean magnitude gain vs prev. ap.
1
2
3
4
5
6
7
8
9
10
11
12
13
Aperture

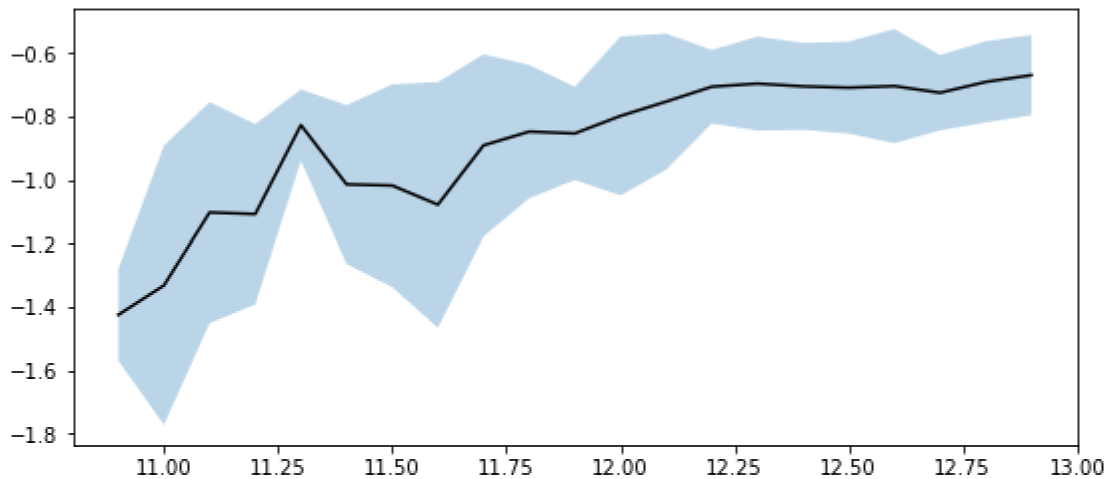



```
Aperture correction for h band:
Correction: -0.7972502708435059
Number of source used: 1417
RMS: 0.24215363892231234
```

1.4 K



Mean magnitude
18.2
18.0
17.8
17.6
17.4
17.2
17.0
16.8
Mean magnitude gain vs prev. ap.
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
1 2 3 4 5 6 7 8 9 10 11 12 13
Aperture




```
Aperture correction for k band:
Correction: -0.7923002243041992
Number of source used: 556
RMS: 0.2164772172129723
```

1.4.1 1.ii - Vega-like to AB

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
Out[19]: <IPython.core.display.HTML object>
```

1.5 II - Removal of duplicated sources

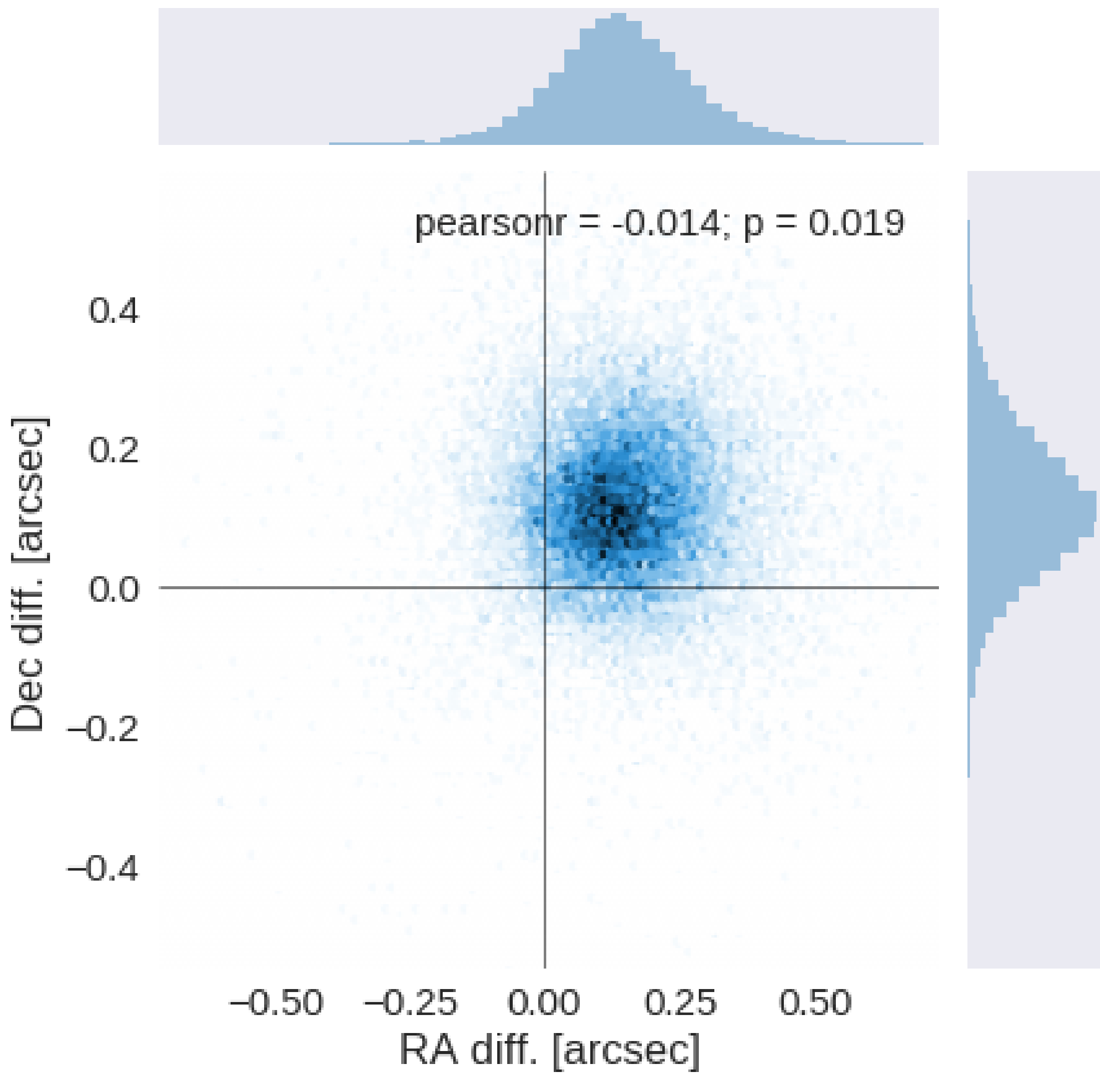
We remove duplicated objects from the input catalogues.

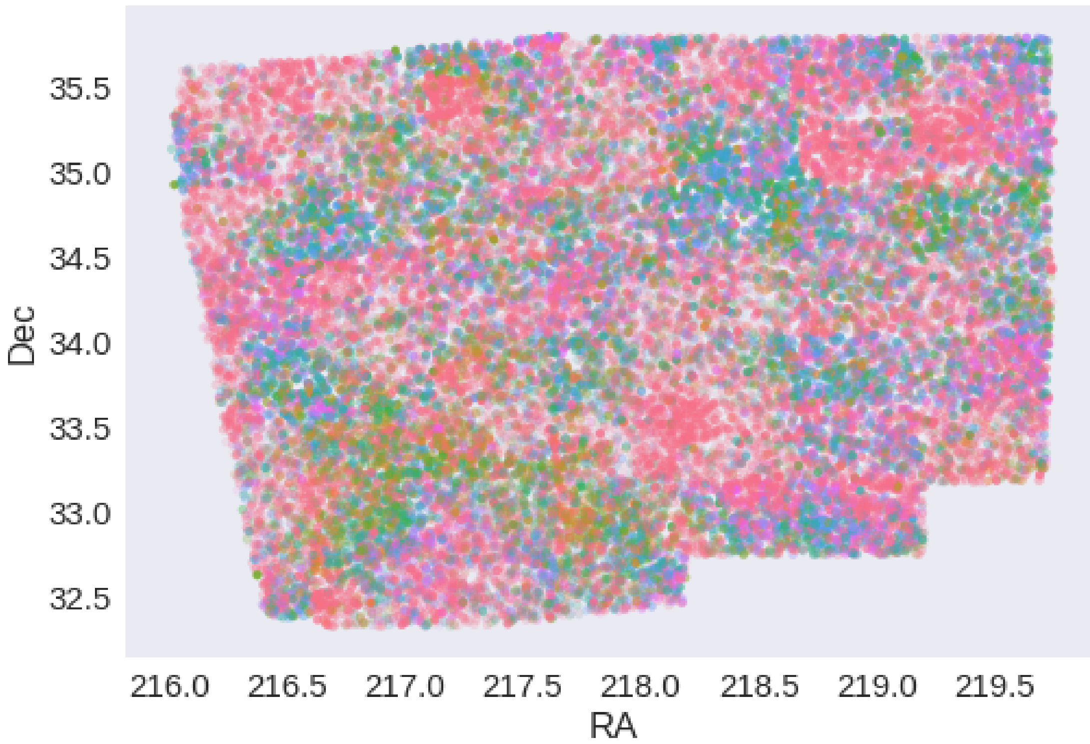
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 389594 sources.
The cleaned catalogue has 389594 sources (0 removed).
The cleaned catalogue has 0 sources flagged as having been cleaned
```

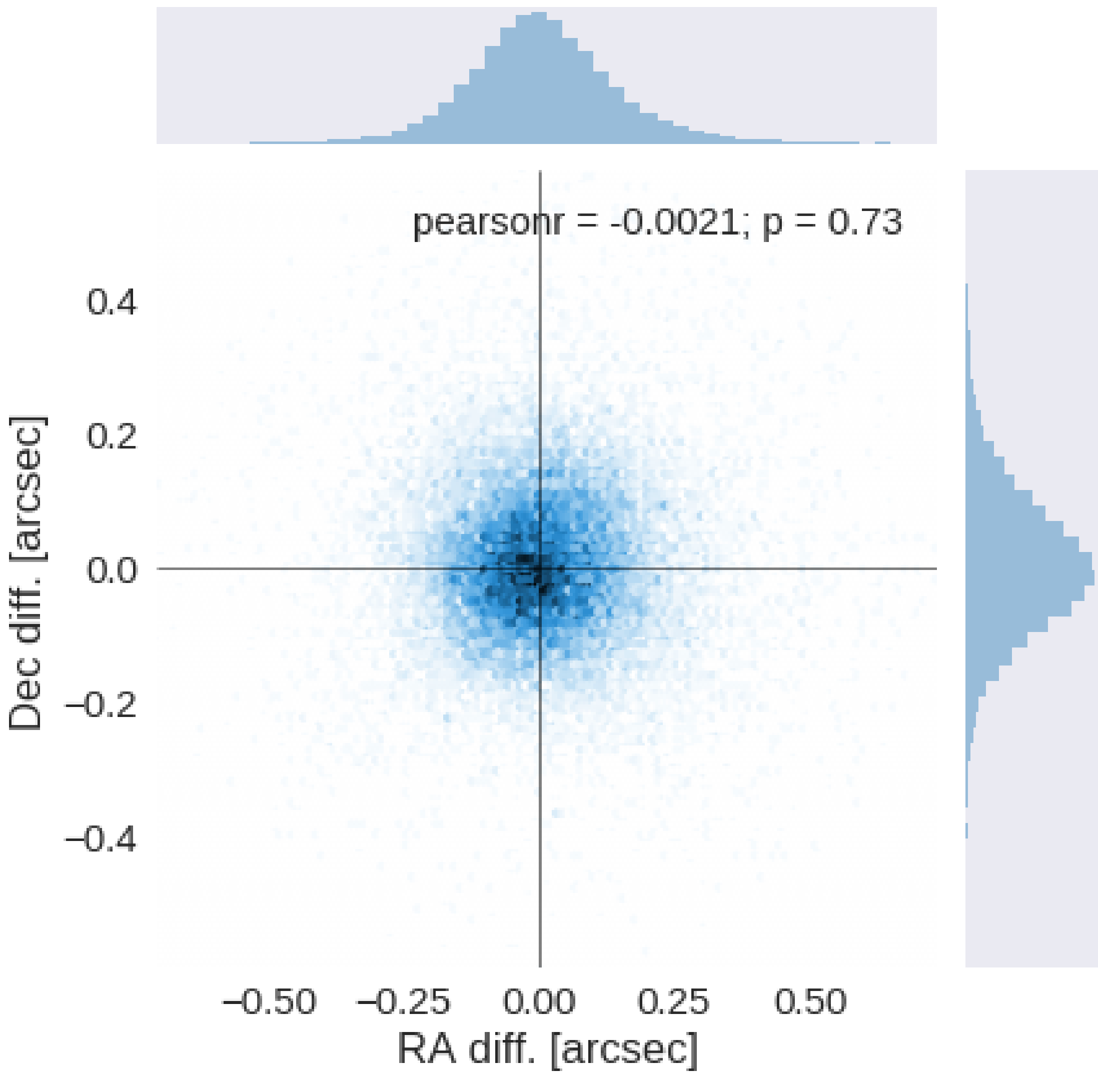
1.6 III - Astrometry correction

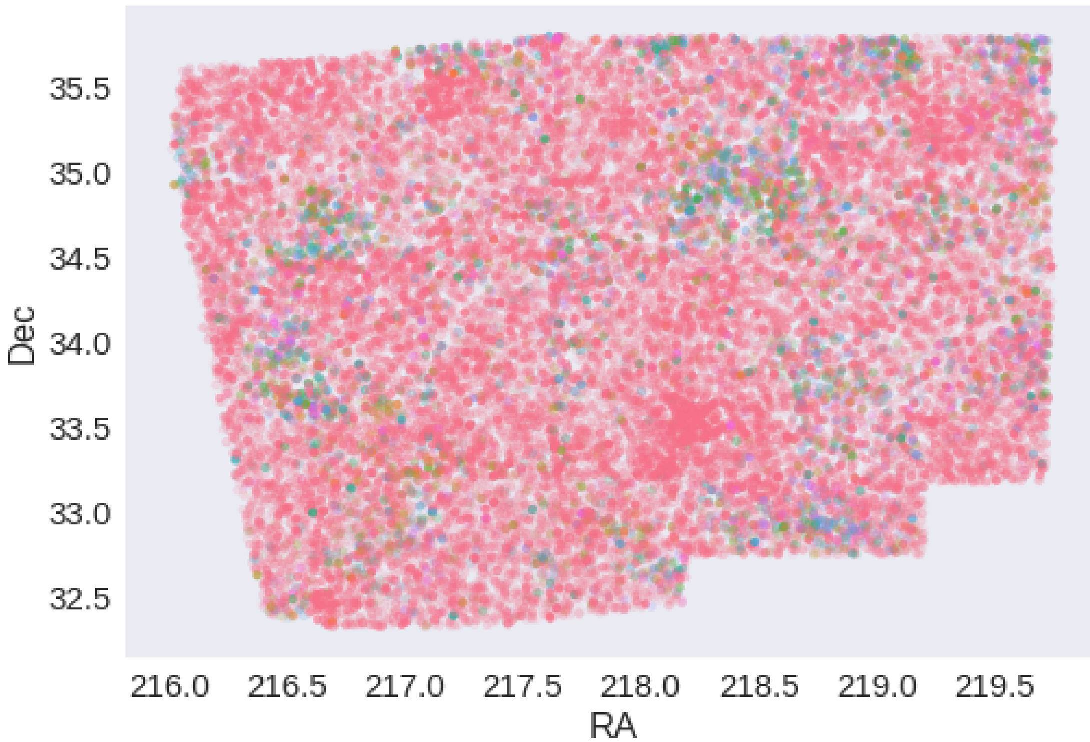
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.






```
RA correction: -0.14042821500197533 arcsec
Dec correction: -0.11290194161972522 arcsec
```


pearsonr = -0.0021; p = 0.73
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.7 IV - Flagging Gaia objects

```
28013 sources flagged.
```

2 V - Saving to disk

1.4_LegacySurvey

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of Legacy Survey data

The catalogue comes from `dmu0_LegacySurvey`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The aperture fluxes. Are these aperture corrected?
- The kron magnitude to be used as total magnitude (no "auto" magnitude is provided).

We don't know when the maps have been observed. We will use the year of the reference paper.

```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
```

```
WARNING: UnitsWarning: '1/deg^2' did not parse as fits unit: Numeric factor not supported by FIT
WARNING: UnitsWarning: 'nanomaggy' did not parse as fits unit: At col 0, Unit 'nanomaggy' not su
WARNING: UnitsWarning: '1/nanomaggy^2' did not parse as fits unit: Numeric factor not supported
WARNING: UnitsWarning: '1/arcsec^2' did not parse as fits unit: Numeric factor not supported by
```

1.2 I - Aperture correction

To compute aperture correction we need to dertermine two parametres: the target aperture and the range of magnitudes for the stars that will be used to compute the correction.

Target aperture: To determine the target aperture, we simulate a curve of growth using the provided apertures and draw two figures:

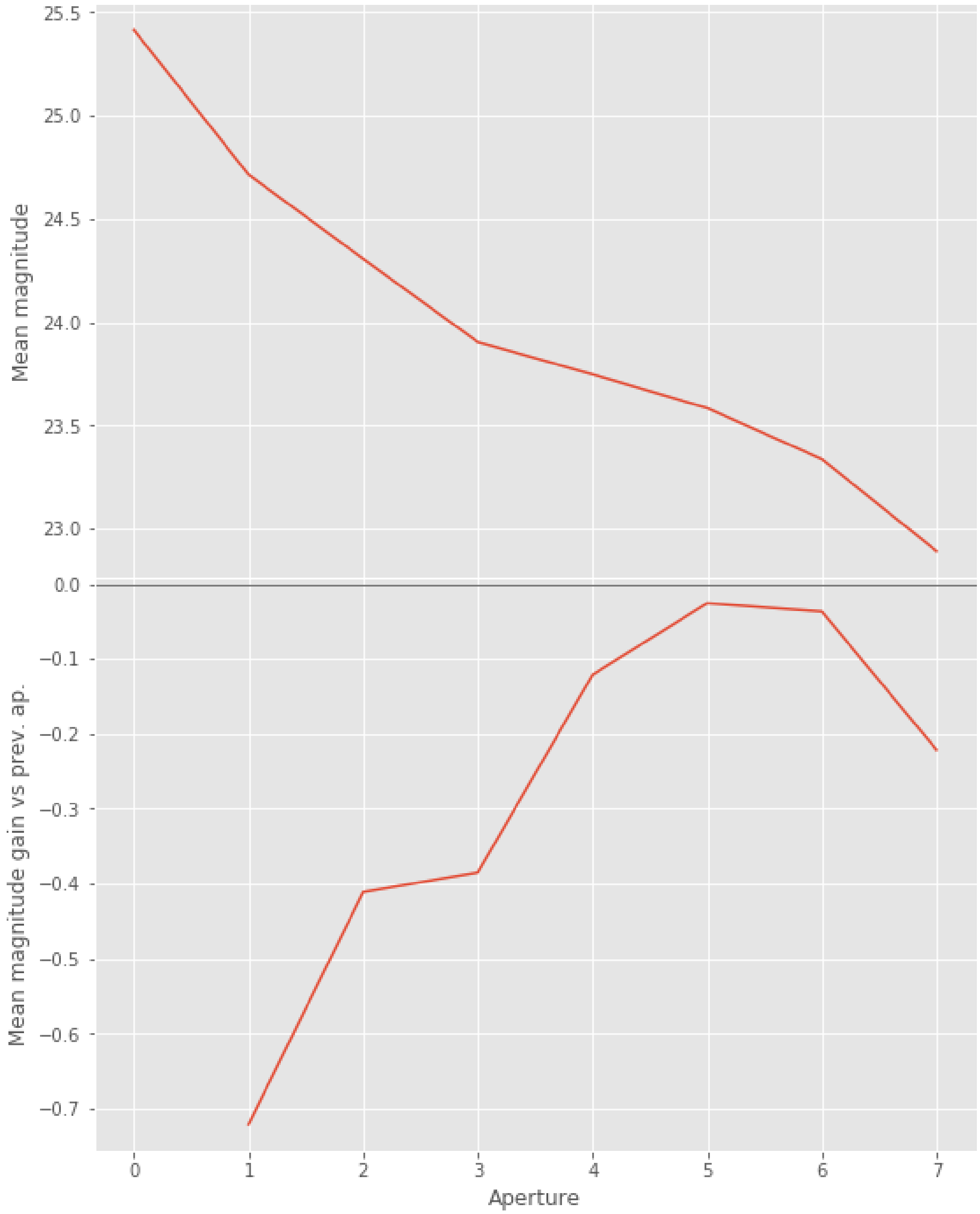
- The evolution of the magnitudes of the objects by plotting on the same plot aperture number vs the mean magnitude.
- The mean gain (loss when negative) of magnitude is each aperture compared to the previous (except for the first of course).

As target aperture, we should use the smallest (i.e. less noisy) aperture for which most of the flux is captures.

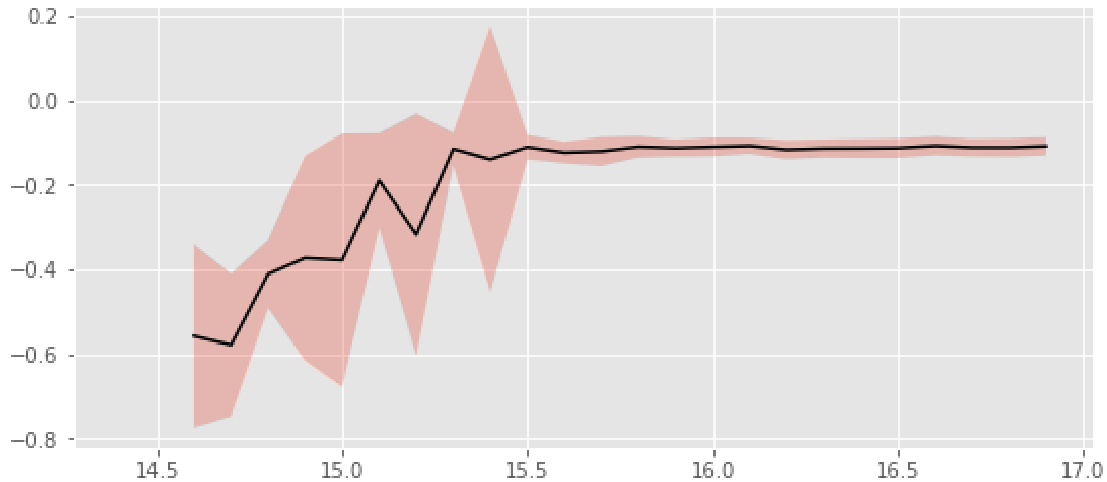
Magnitude range: To know what limits in aperture to use when doing the aperture correction, we plot for each magnitude bin the correction that is computed and its RMS. We should then use the wide limits (to use more stars) where the correction is stable and with few dispersion.

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: invalid value enco
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: divide by zero enc
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:80: RuntimeWarning: invalid value enco
  errors = 2.5 / np.log(10) * errors_on_fluxes / fluxes
```

1.2.1 I.a - g band



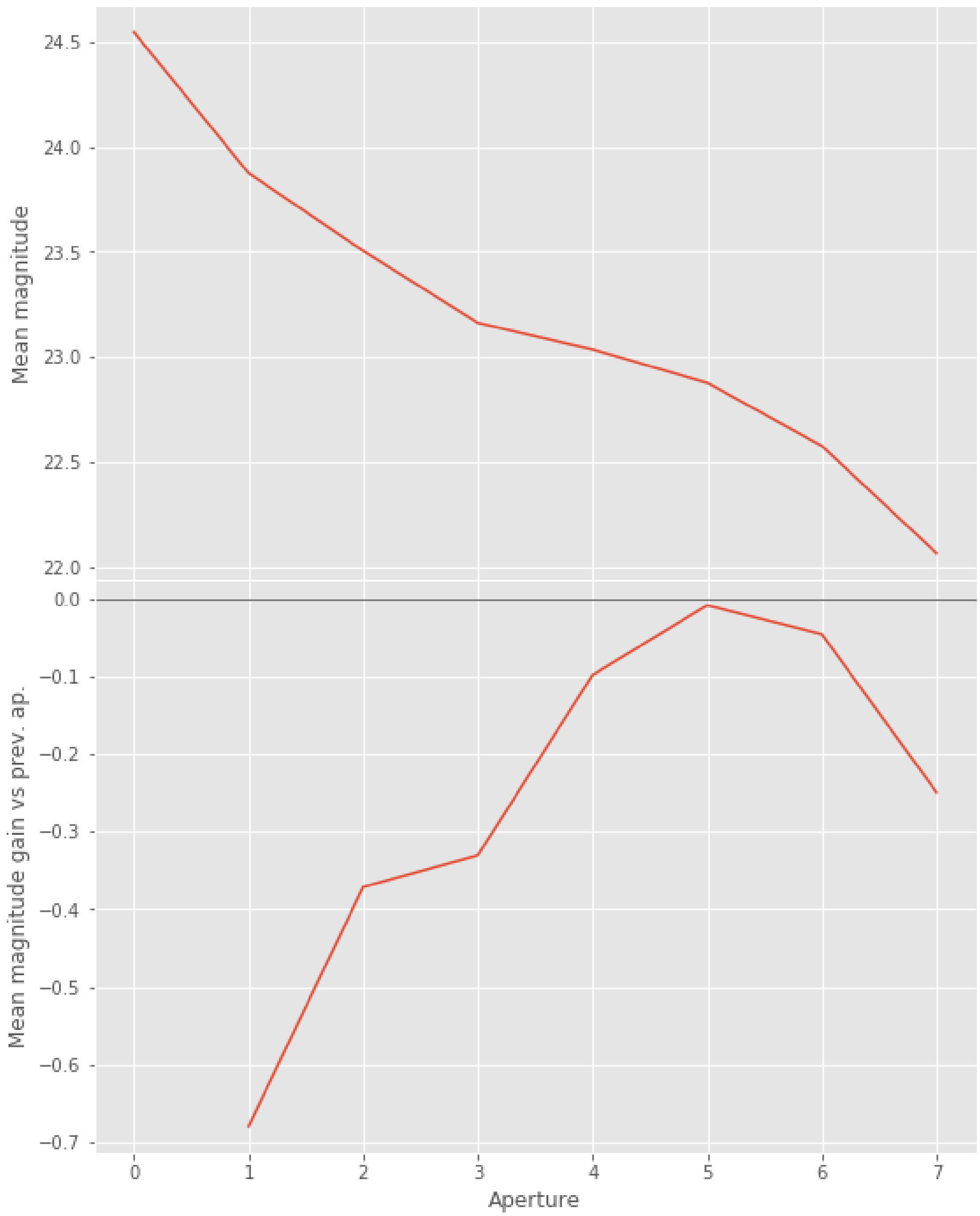
We will use aperture 5 as target.



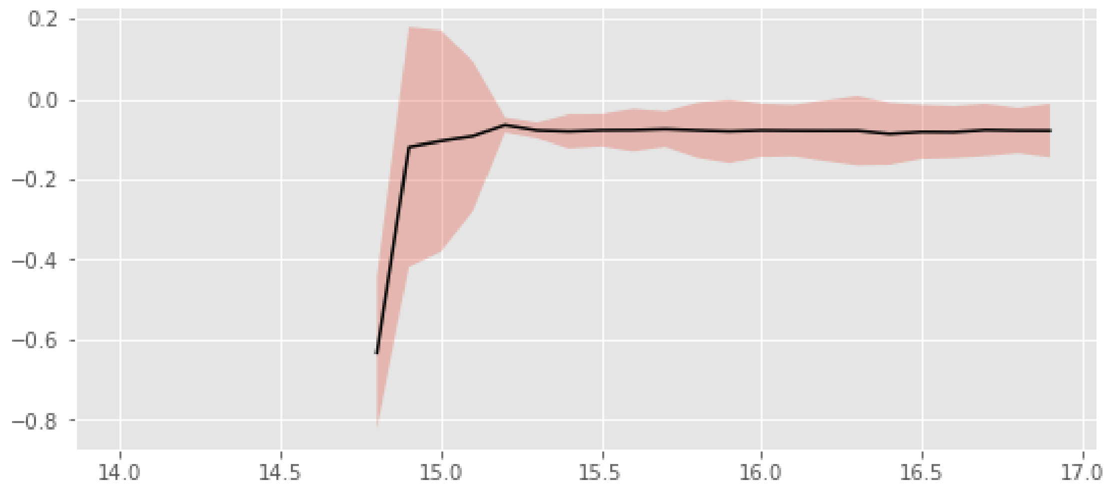
We will use magnitudes between 17.0 and 18.5

```
Aperture correction for g band:
Correction: -0.1112329500973459
Number of source used: 3560
RMS: 0.022124753607535737
```

1.2.2 I.b - r band



We will use aperture 5 as target.

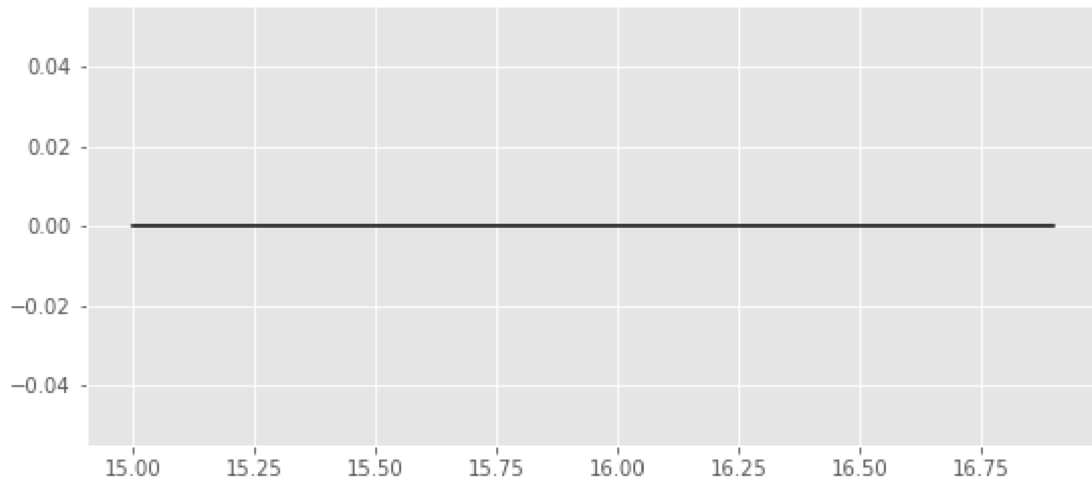


We use magnitudes between 17.0 and 18.5.

```
Aperture correction for r band:
Correction: -0.07934247926094429
Number of source used: 5270
RMS: 0.06568411657907589
```

1.2.3 I.c - z band

We will use aperture 4 as target.



We use magnitudes between 16.0 and 17.5.

```
Aperture correction for z band:
Correction: -0.04477088405269569
Number of source used: 3874
RMS: 0.022095969378372594
```

1.3 II - Stellarity

Legacy Survey does not provide a 0 to 1 stellarity so we replace items flagged as PSF accpording to the following table:

$$P(star) = \frac{\prod_i P(star)_i}{\prod_i P(star)_i + \prod_i P(galaxy)_i}$$

where i is the band, and with using the same probabilities as UKDISS:

HSC flag	UKIDSS flag	Meaning	P(star)	P(galaxy)	P(noise)	P(saturated)
	-9	Saturated	0.0	0.0	5.0	95.0
	-3	Probable galaxy	25.0	70.0	5.0	0.0
	-2	Probable star	70.0	25.0	5.0	0.0
0	-1	Star	90.0	5.0	5.0	0.0
	0	Noise	5.0	5.0	90.0	0.0
1	+1	Galaxy	5.0	90.0	5.0	0.0

1.4 II - Column selection

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:19:
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: divide by zero enc
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
```

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: invalid value enco
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:80: RuntimeWarning: divide by zero enc
  errors = 2.5 / np.log(10) * errors_on_fluxes / fluxes
```

```
Out[19]: <IPython.core.display.HTML object>
```

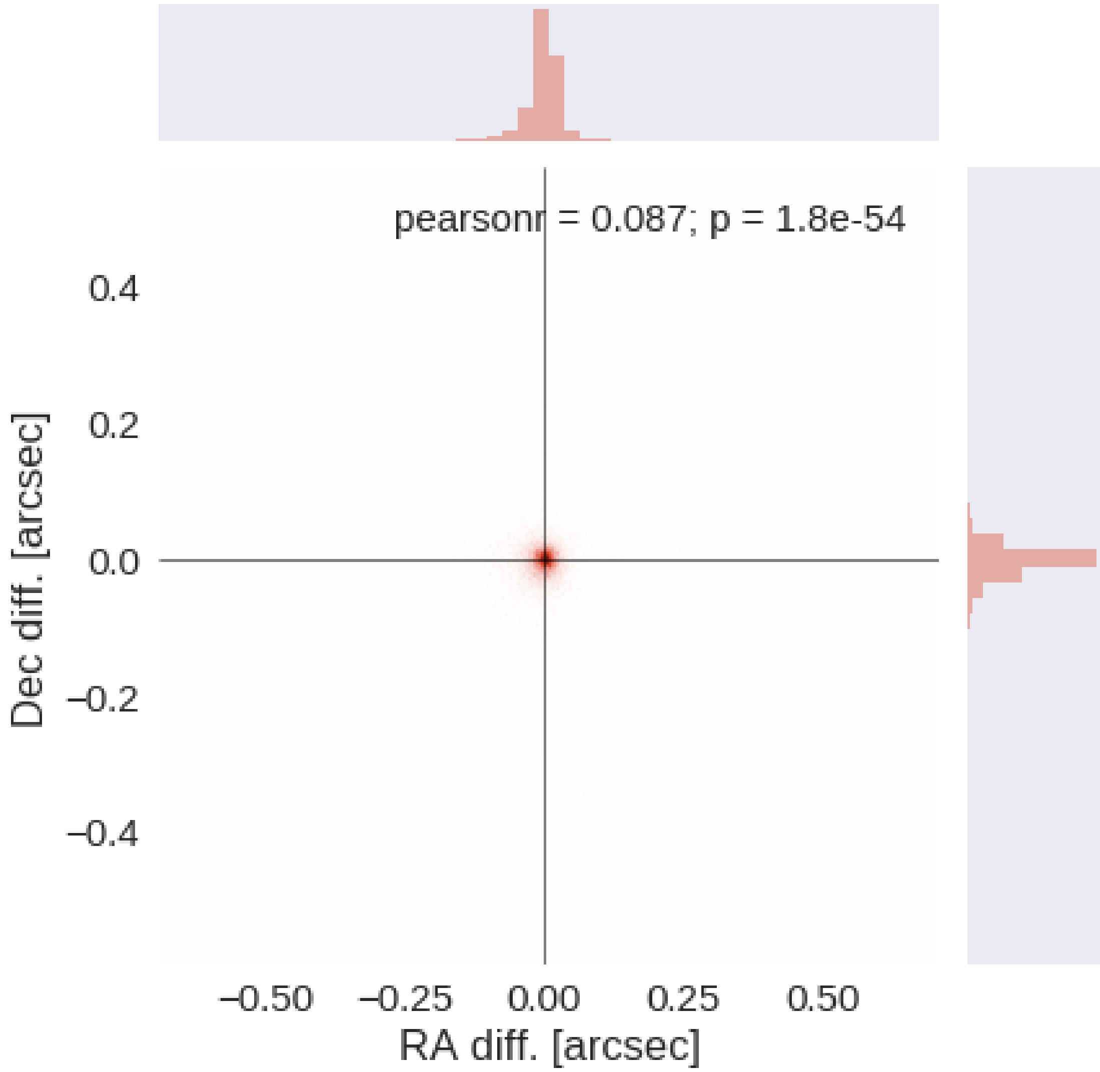
1.5 III - Removal of duplicated sources

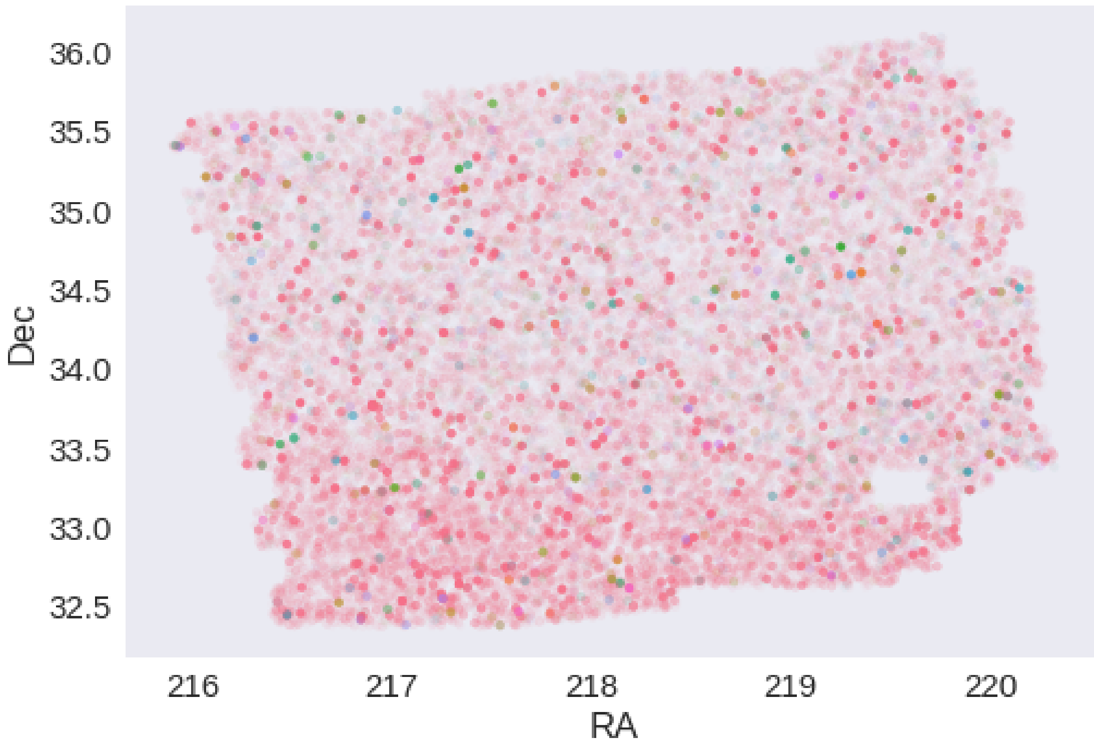
We remove duplicated objects from the input catalogues.

```
The initial catalogue had 561690 sources.
The cleaned catalogue has 549975 sources (11715 removed).
The cleaned catalogue has 11557 sources flagged as having been cleaned
```

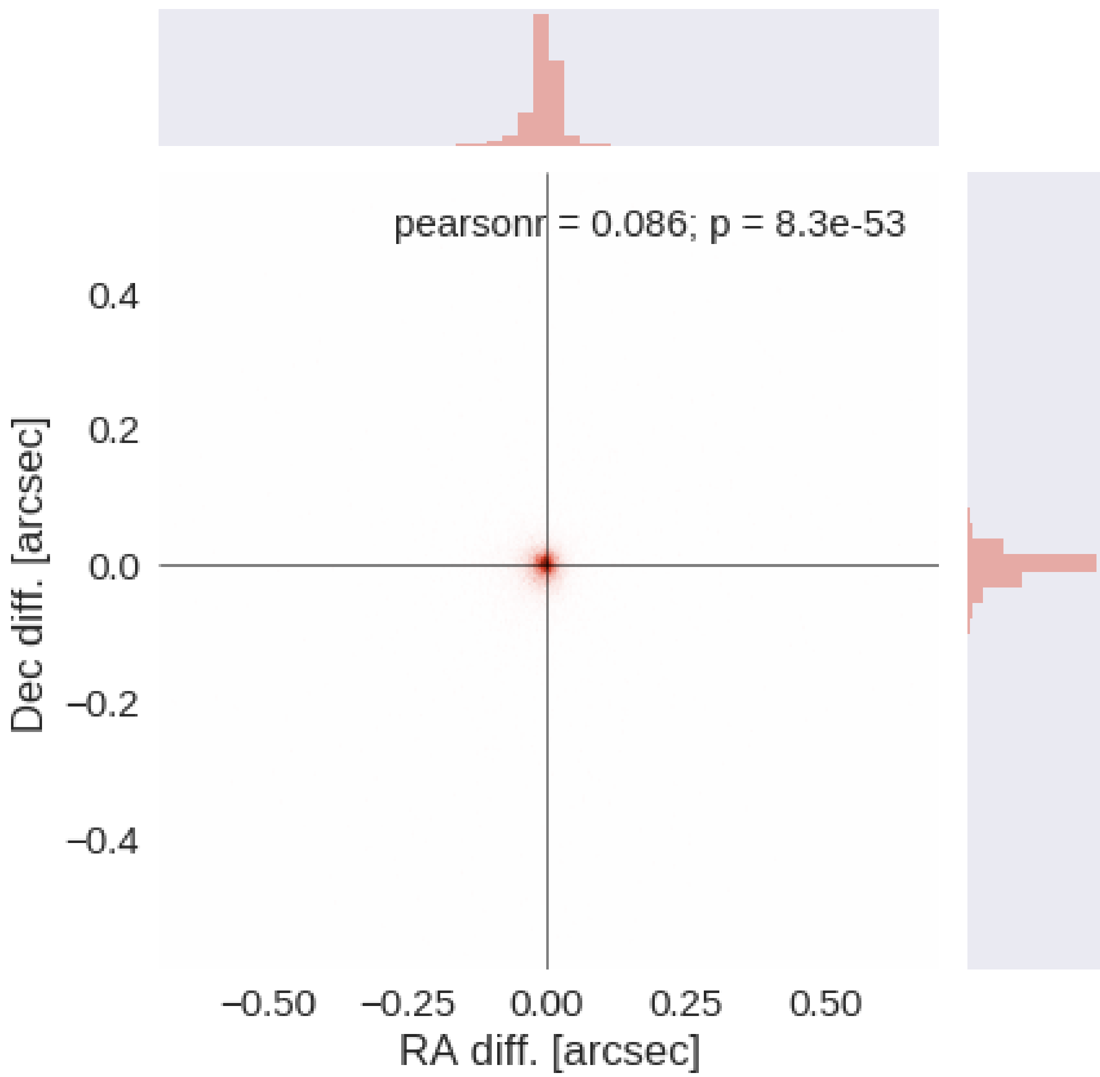
1.6 III - Astrometry correction

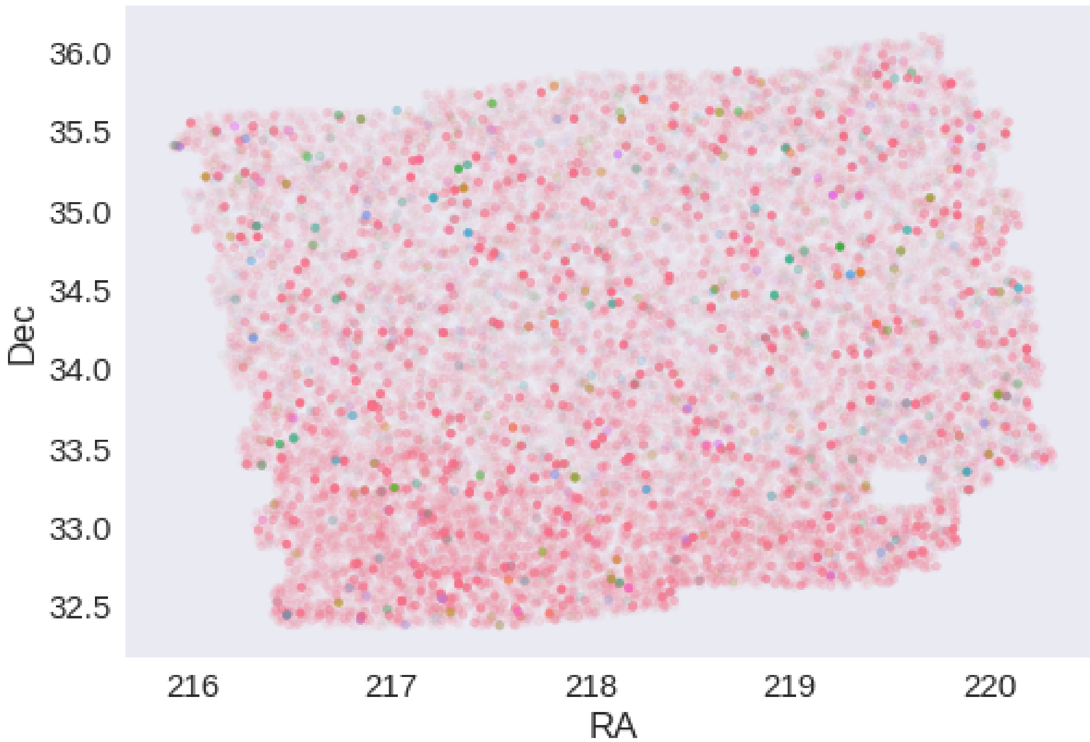
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.


pearsonr = 0.087; p = 1.8e-54
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]




```
RA correction: -0.0025231083782273345 arcsec
Dec correction: 0.0016053232087642755 arcsec
```


pearsonr = 0.086; p = 8.3e-53
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.7 IV - Flagging Gaia objects

```
32886 sources flagged.
```

2 V - Saving to disk

1.5_NDWFS

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of NDWFS data

The catalogue comes from `dmu0_NDWFS`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The magnitude for each band in 2 arcsec aperture.
- The kron magnitude to be used as total magnitude (no "auto" magnitude is provided).

We don't know when the maps have been observed. We will use the year of the reference paper.

```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
This notebook was executed on:
2018-02-16 14:55:54.137896
```

```
/Users/rs548/anaconda/envs/herschelhelp_internal/lib/python3.6/site-packages/seaborn/apionly.py:
  warnings.warn(msg, UserWarning)
```

1.2 I - Column selection

1.3 1.i - Aperture correction

TODO

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
Out[6]: <IPython.core.display.HTML object>
```

1.4 II - Removal of duplicated sources

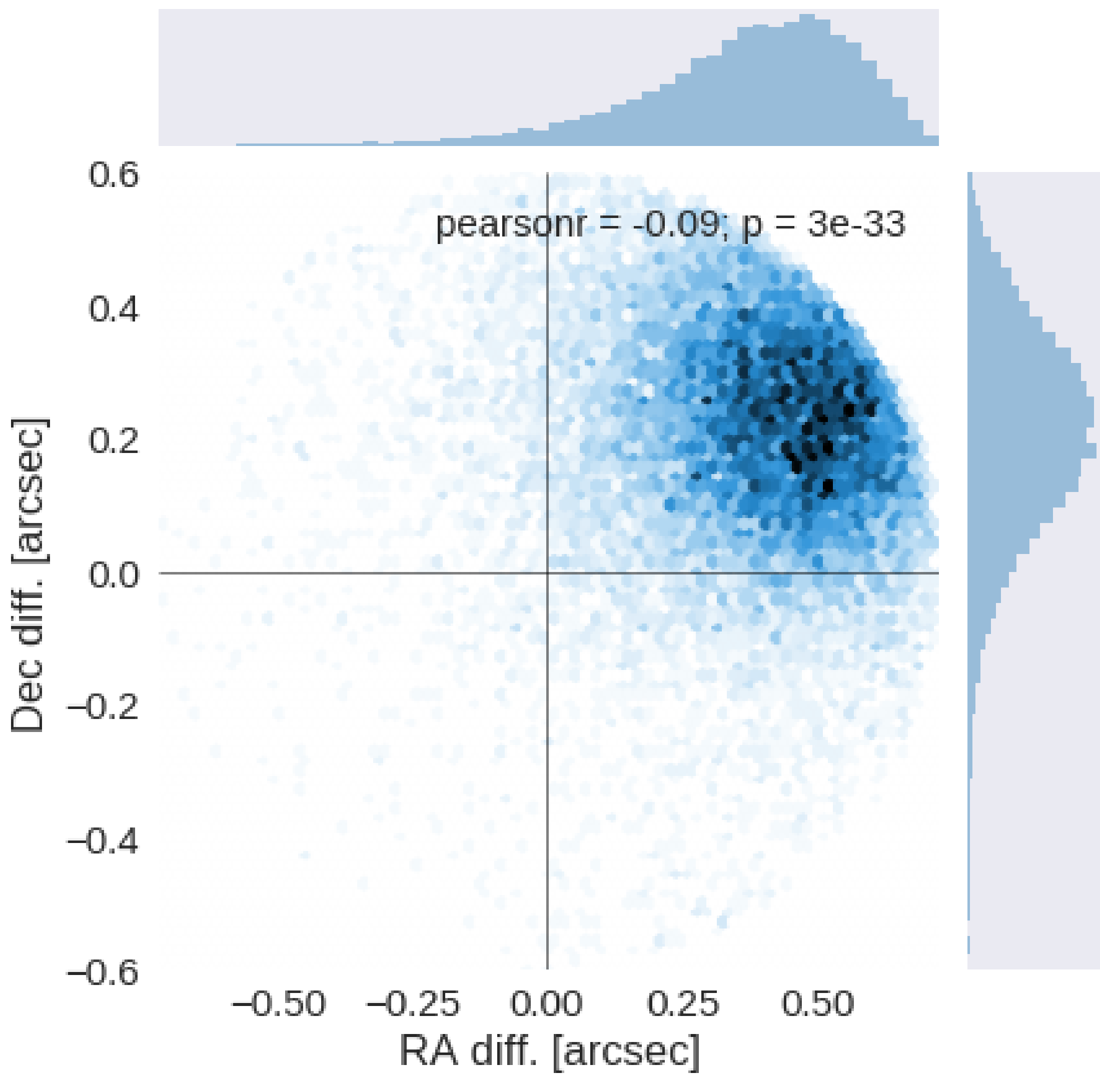
We remove duplicated objects from the input catalogues.

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

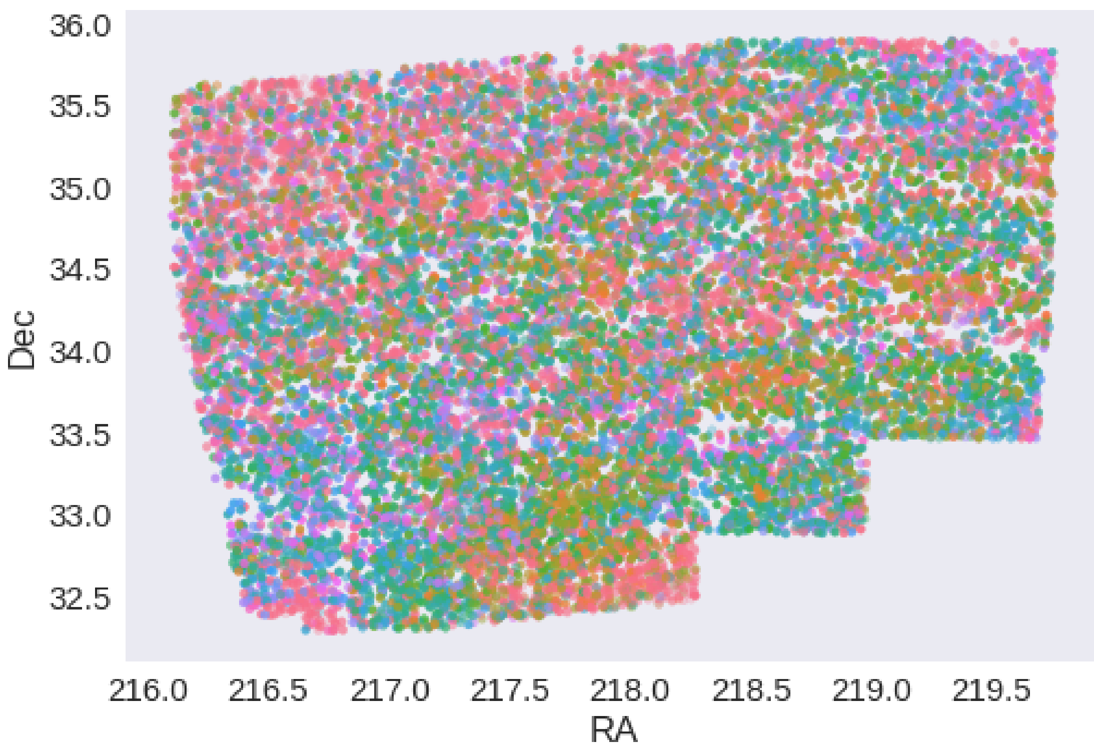
```
The initial catalogue had 2834130 sources.
The cleaned catalogue has 2834130 sources (0 removed).
The cleaned catalogue has 0 sources flagged as having been cleaned
```

1.5 III - Astrometry correction

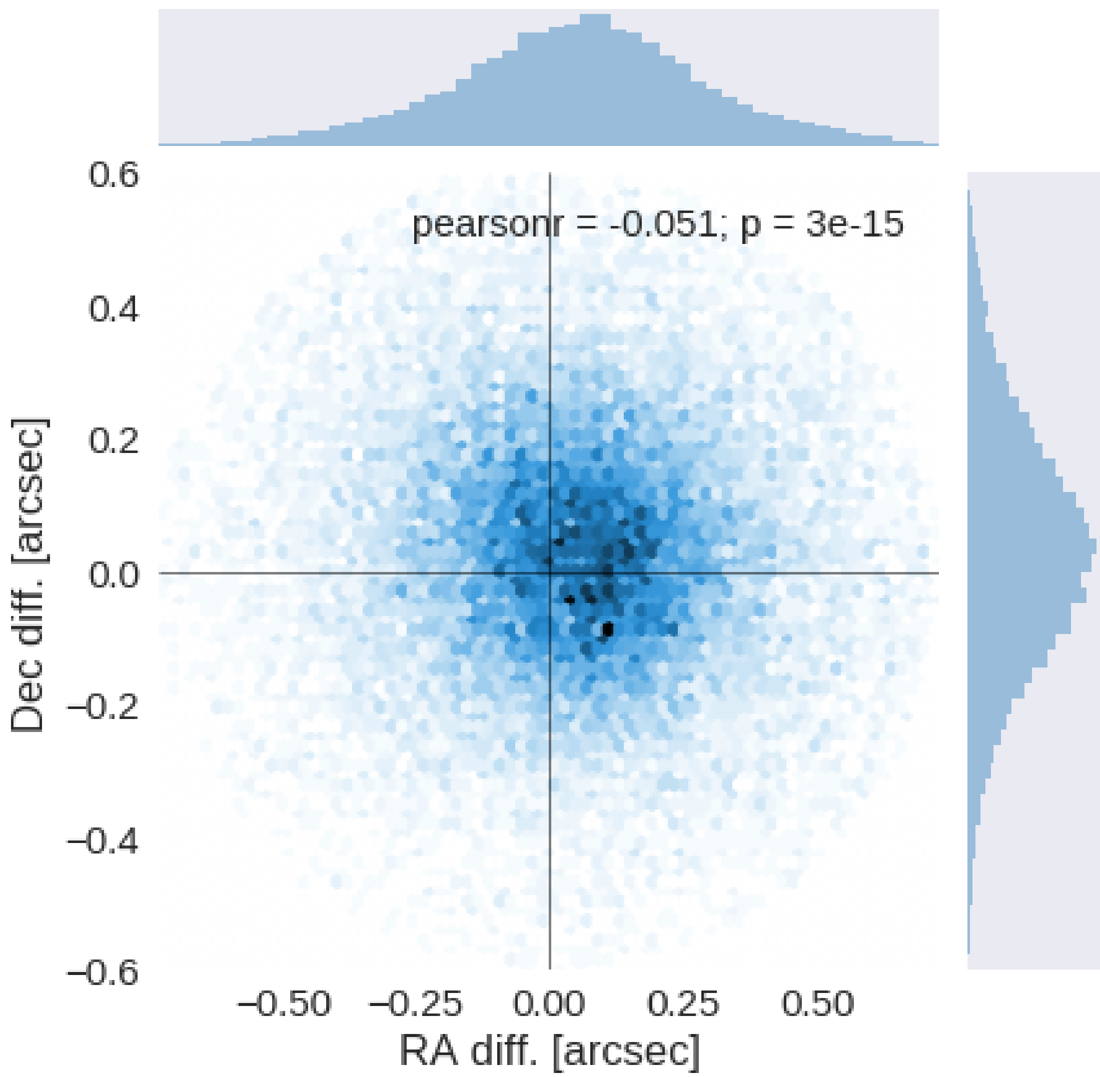
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.

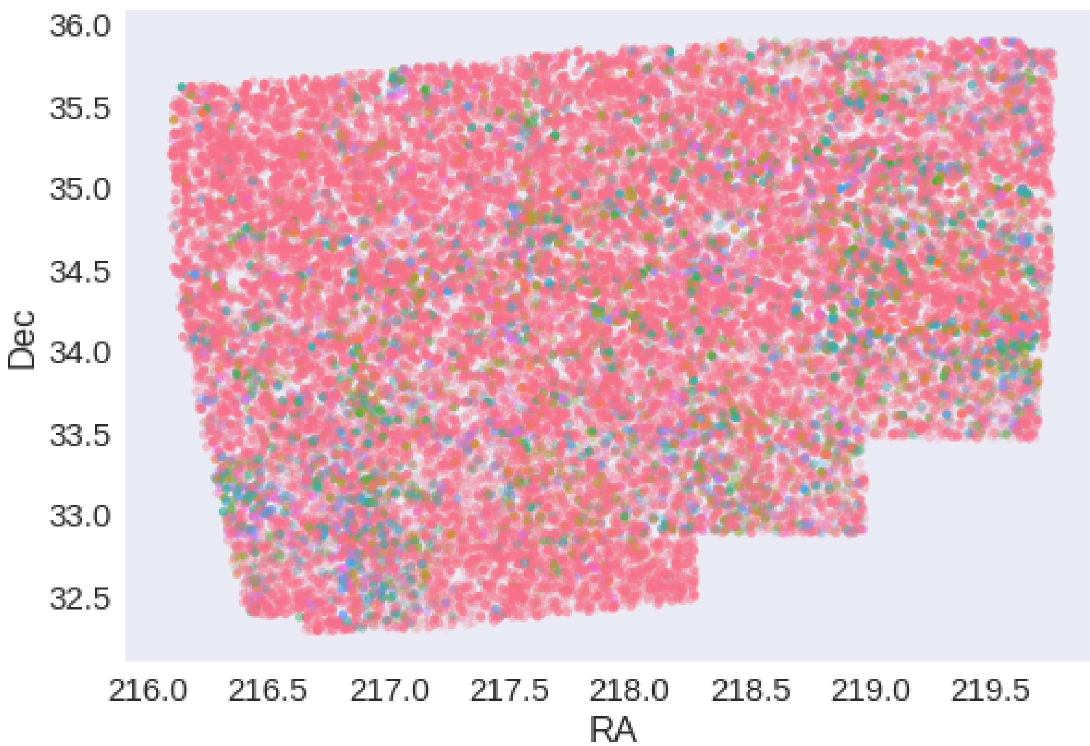


pearsonr = -0.09; p = 3e-33
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]




```
RA correction: -0.40784830923712434 arcsec
Dec correction: -0.2130986199659901 arcsec
```


pearsonr = -0.051; p = 3e-15
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.6 IV - Flagging Gaia objects

```
30503 sources flagged.
```

2 V - Saving to disk

1.6_PanSTARRS-3SS

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of Pan-STARRS1 - 3pi Steradian Survey (3SS) data

This catalogue comes from `dmu0_PanSTARRS1-3SS`.

In the catalogue, we keep:

- The `uniquePspsSTid` as unique object identifier;
- The r-band position which is given for all the sources;
- The grizy `<band>FApMag` aperture magnitude (see below);
- The grizy `<band>FKronMag` as total magnitude.

The Pan-STARRS1-3SS catalogue provides for each band an aperture magnitude defined as "In PS1, an 'optimal' aperture radius is determined based on the local PSF. The wings of the same analytic PSF are then used to extrapolate the flux measured inside this aperture to a 'total' flux."

The observations used for the catalogue where done between 2010 and 2015 (ref).

```
This notebook was run with herschelhelp_internal version:
33f5ec7 (Wed Dec 6 16:56:17 2017 +0000)
```

1.2 I - Column selection

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
Out[6]: <IPython.core.display.HTML object>
```

1.3 II - Removal of duplicated sources

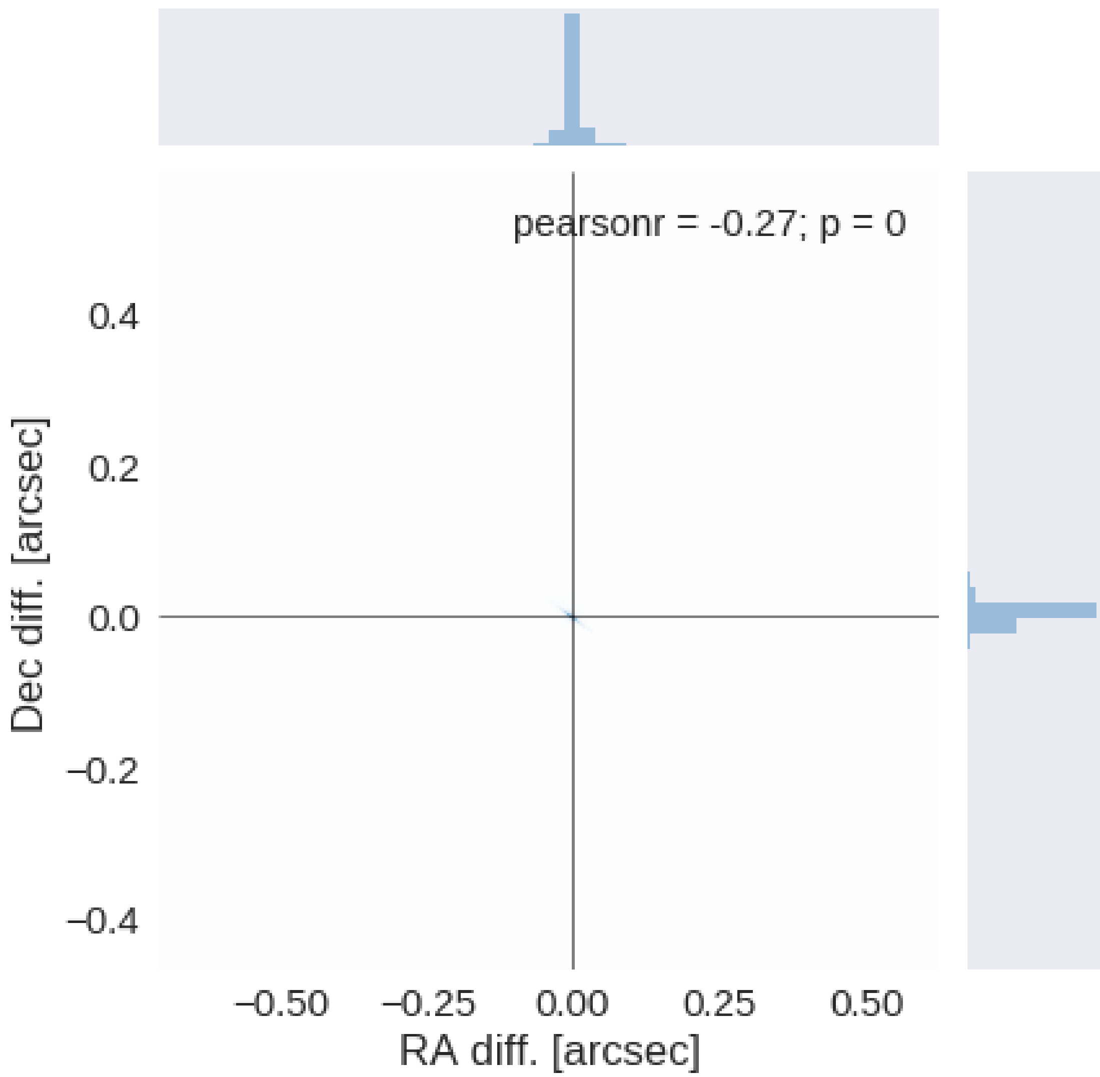
We remove duplicated objects from the input catalogues.

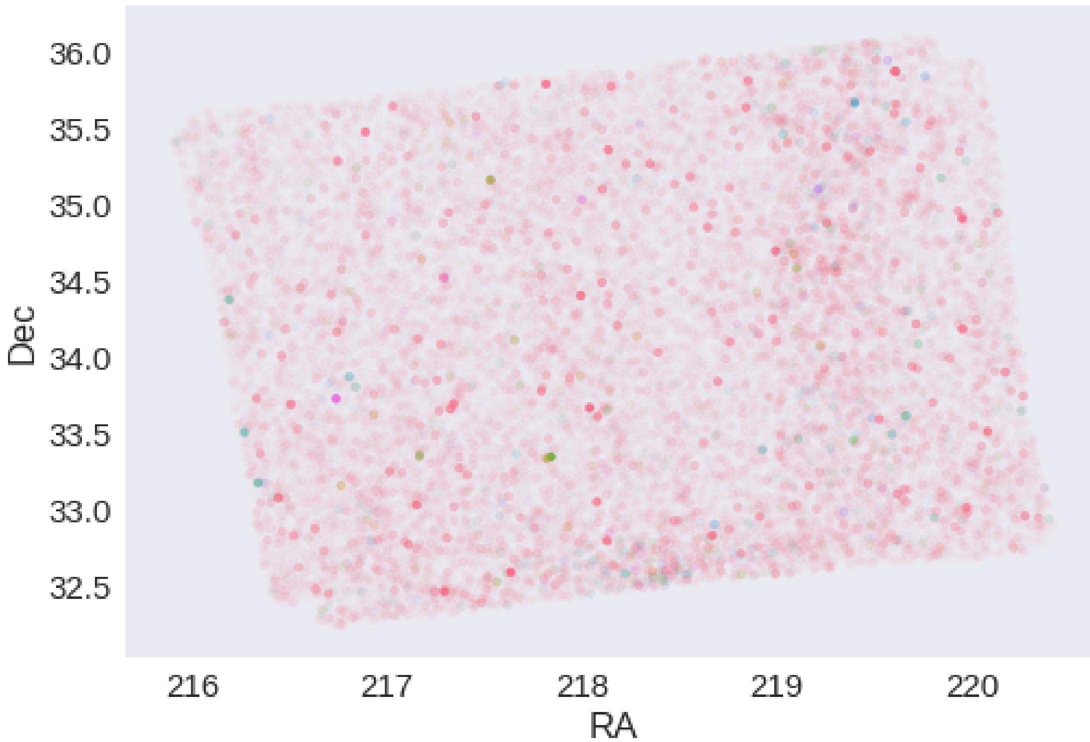
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 230699 sources.
The cleaned catalogue has 230626 sources (73 removed).
The cleaned catalogue has 73 sources flagged as having been cleaned
```

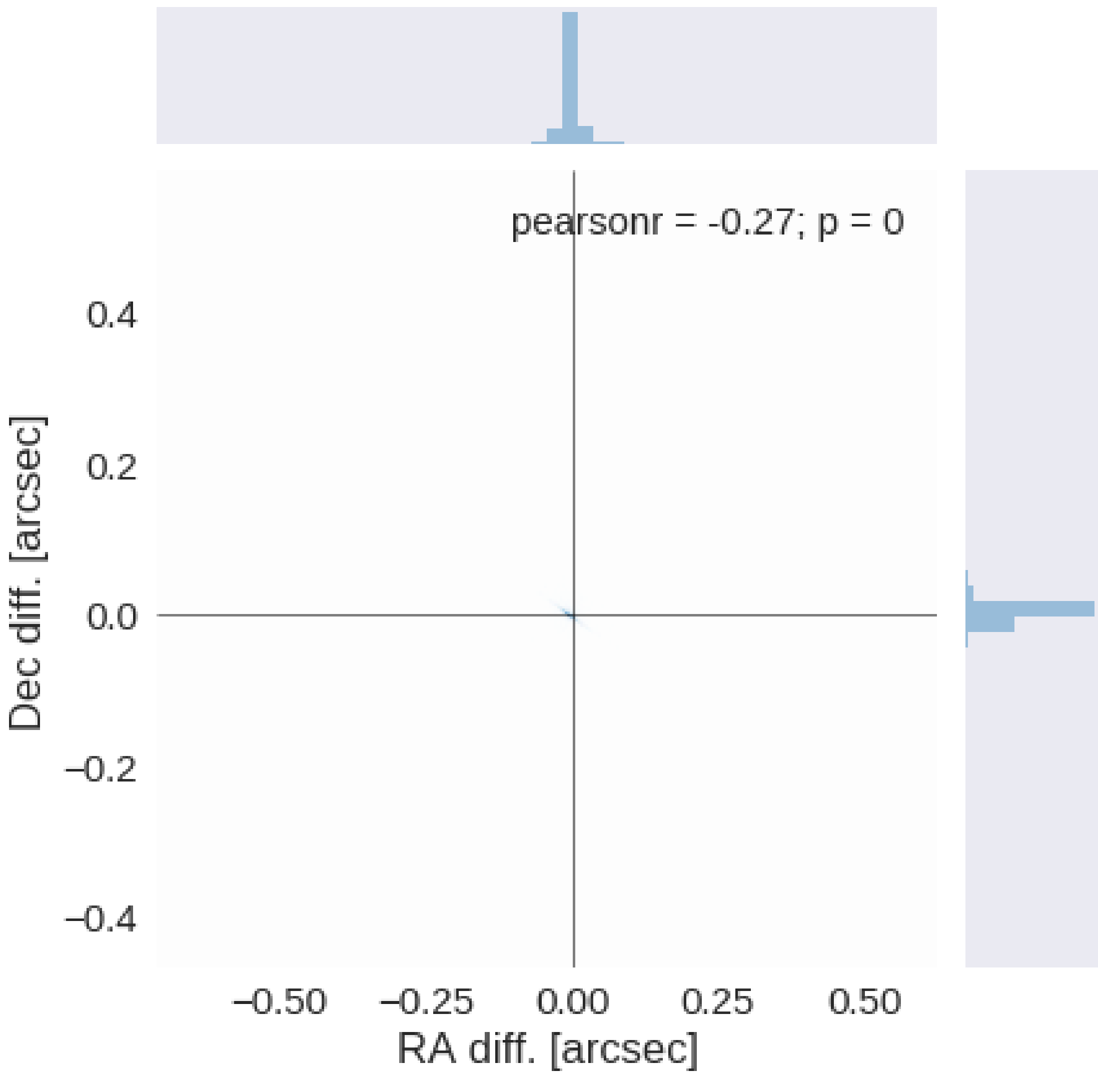
1.4 III - Astrometry correction

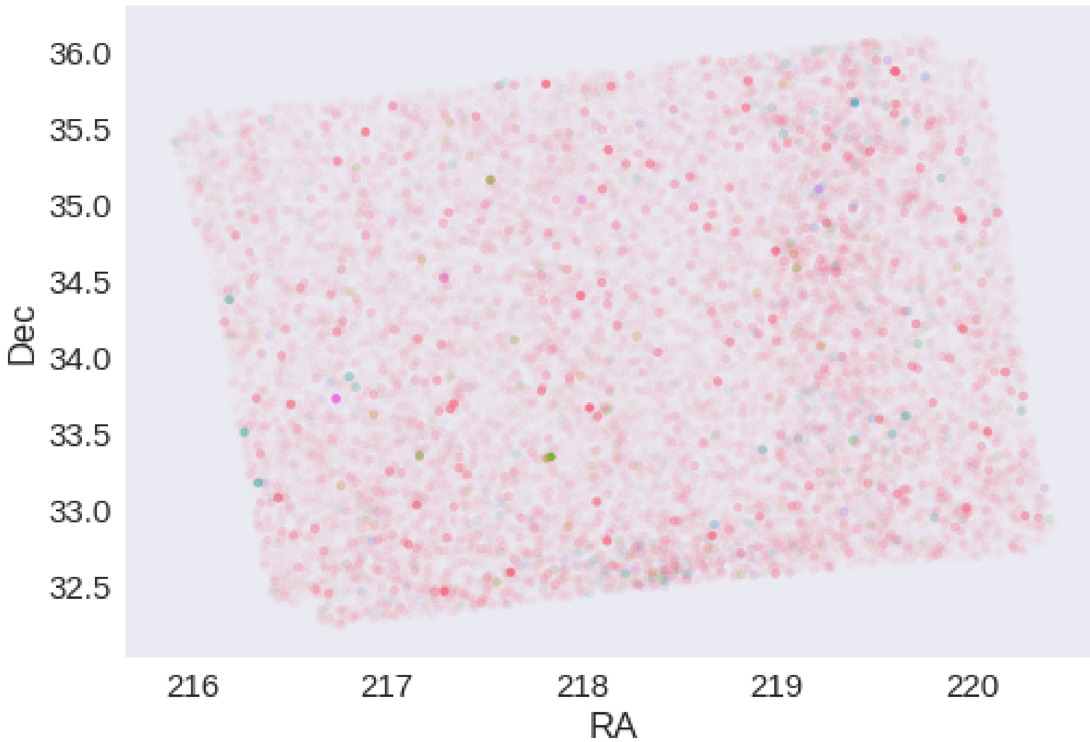
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.






```
RA correction: -0.00015850442878218018 arcsec
Dec correction: -0.0003453544650255935 arcsec
```


pearsonr = -0.27; p = 0
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
34850 sources flagged.
```

1.6 V - Flagging objects near bright stars

2 VI - Saving to disk

1.7_SDWFS

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of SDWFS data

The catalogue comes from `dmu0_SDWFS`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- There is no stellarity;
- The magnitude for each band in 2 arcsec aperture.
- The auto magnitude.

We don't know when the maps have been observed. We will use the year of the reference paper.

```
This notebook was run with herschelhelp_internal version:
33f5ec7 (Wed Dec 6 16:56:17 2017 +0000)
```

1.2 I - Column selection

```
WARNING: UnitsWarning: 'vega' did not parse as fits unit: At col 0, Unit 'vega' not supported by
```

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:8: R
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:9: R
```

```
Out[6]: <IPython.core.display.HTML object>
```

1.3 II - Removal of duplicated sources

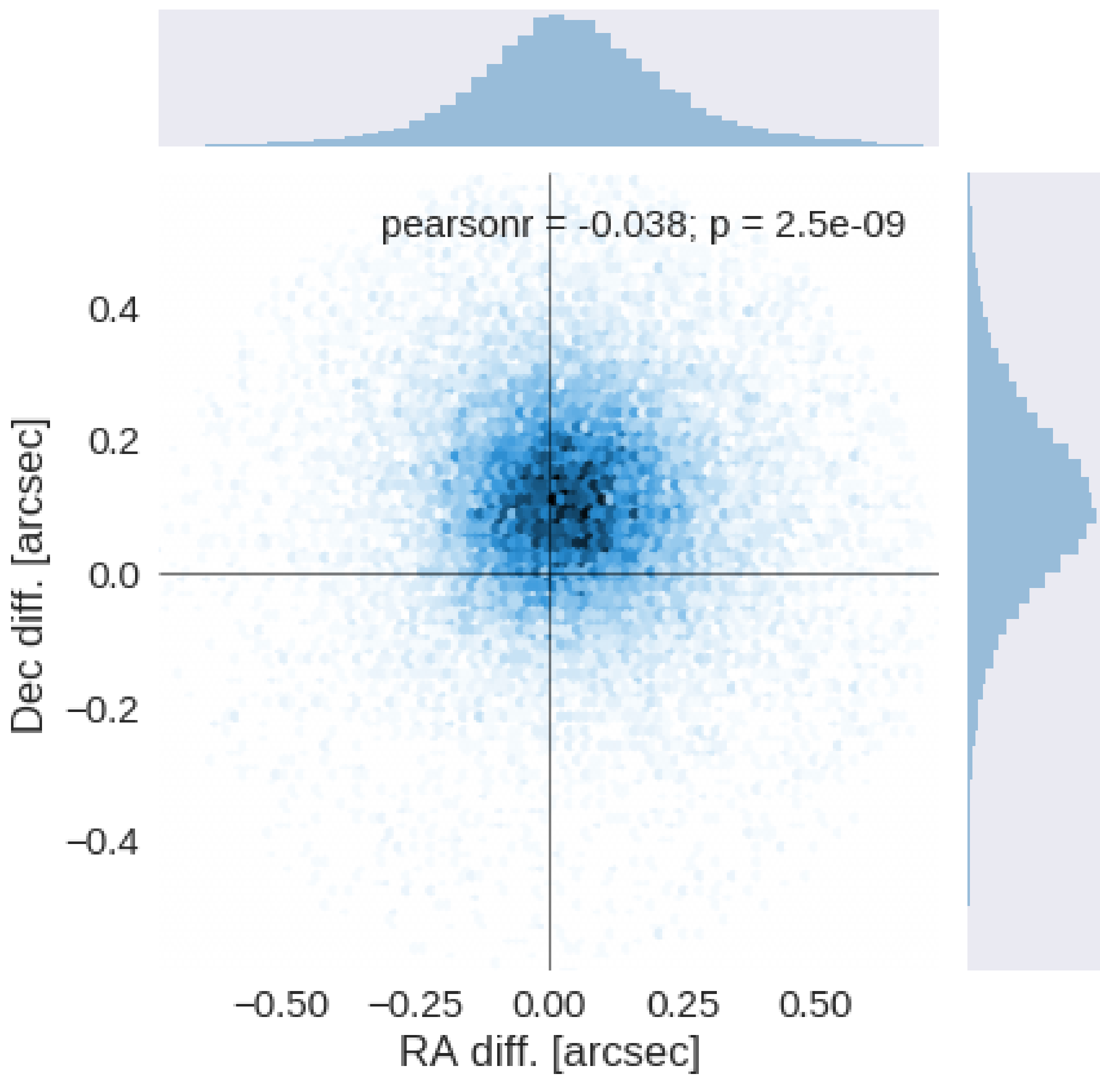
We remove duplicated objects from the input catalogues.

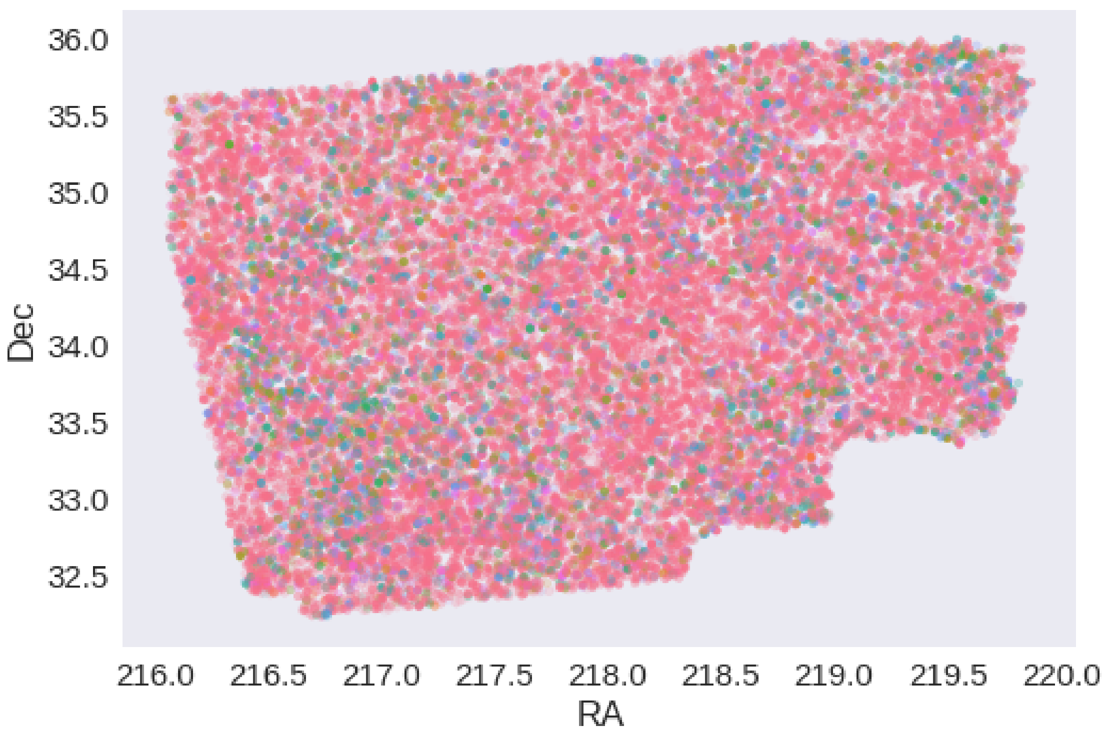
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 614263 sources.
The cleaned catalogue has 614263 sources (0 removed).
The cleaned catalogue has 0 sources flagged as having been cleaned
```

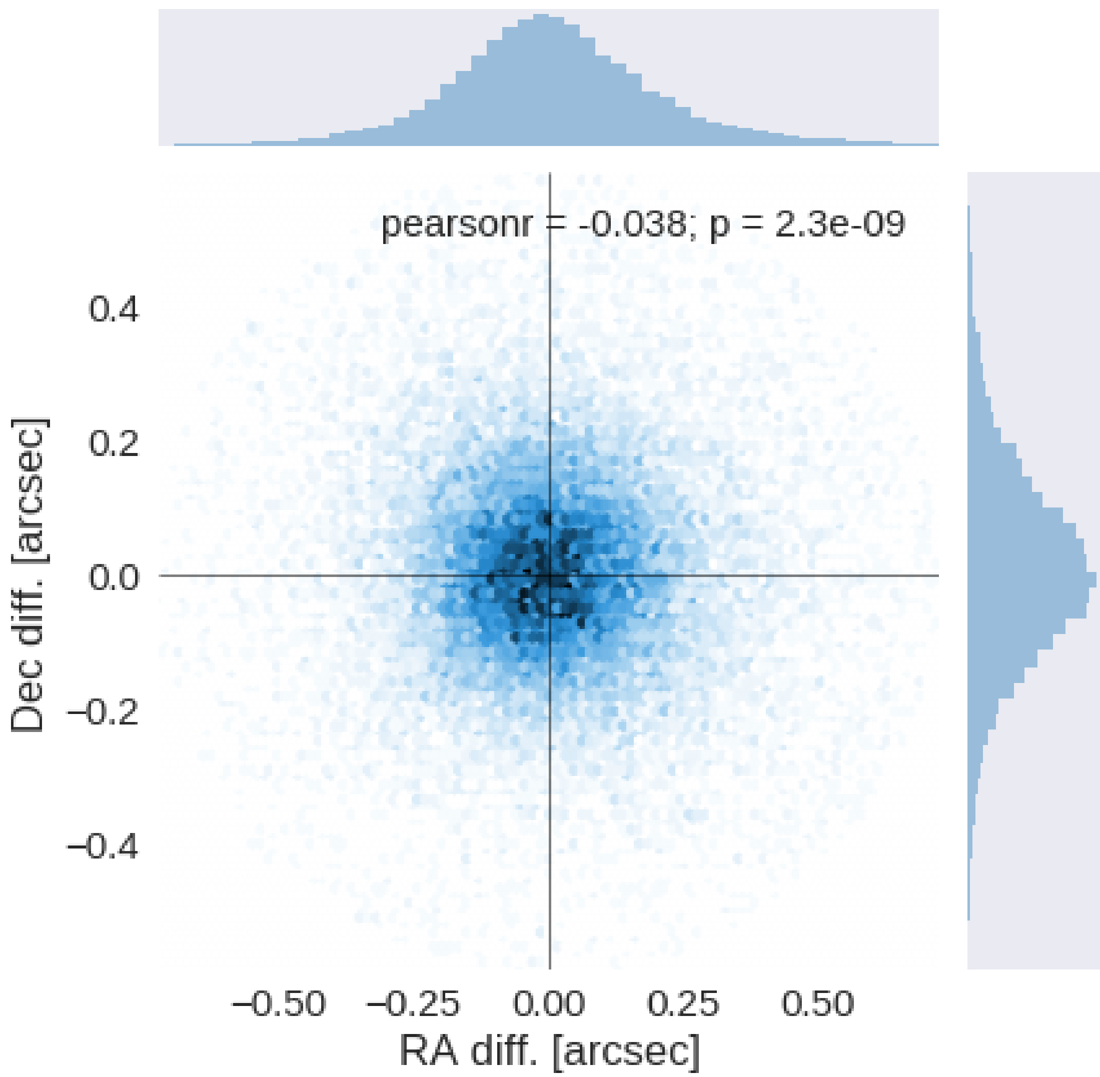
1.4 III - Astrometry correction

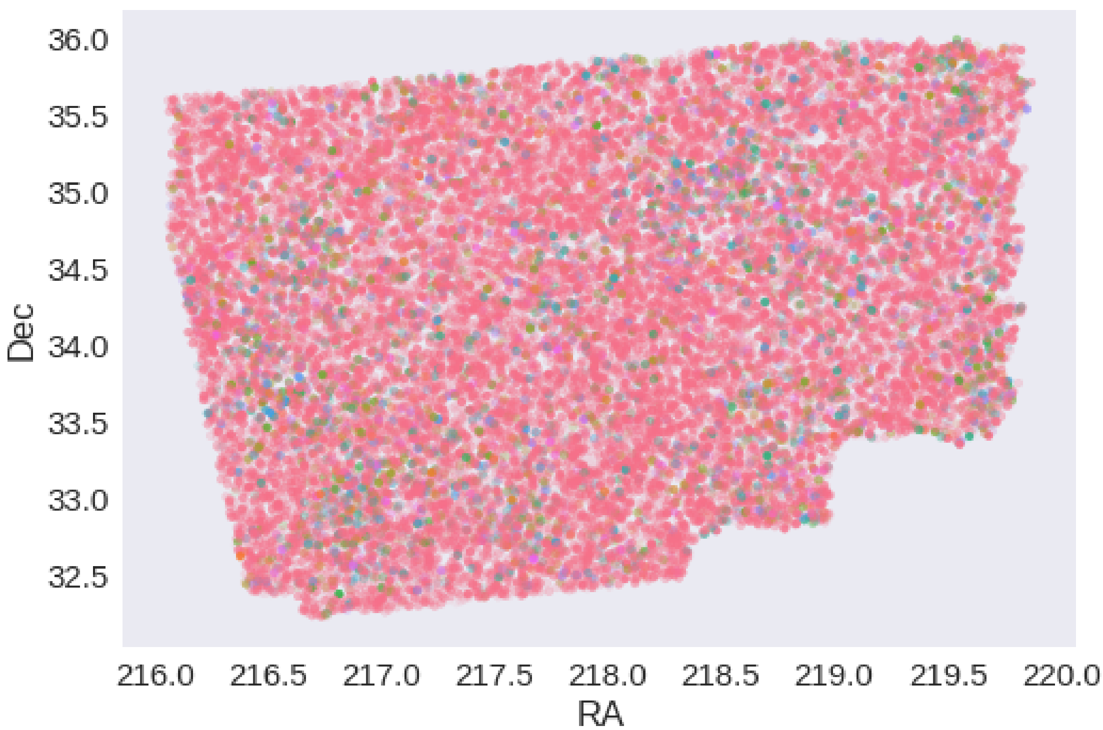
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.






```
RA correction: -0.03827762104720023 arcsec
Dec correction: -0.10533761135036457 arcsec
```


pearsonr = -0.038; p = 2.3e-09
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
27537 sources flagged.
```

2 V - Saving to disk

1.8_UHS

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of UKIRT Hemisphere Survey (UHS) data

The catalogue comes from `dmu0_UHS`. This is a J band only survey documented in https://arxiv.org/pdf/1707.09975.pdf

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The magnitude for each band in aperture 4 (2 arcsec aperture corrected).
- The kron magnitude to be used as total magnitude (no "auto" magnitude is provided).

We don't know when the maps have been observed. We will use the year of the reference paper.

```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
This notebook was executed on:
2018-02-15 13:51:03.217346
```

1.2 I - Column selection

```
0.925175419285
```

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
Out[7]: <IPython.core.display.HTML object>
```

1.3 II - Removal of duplicated sources

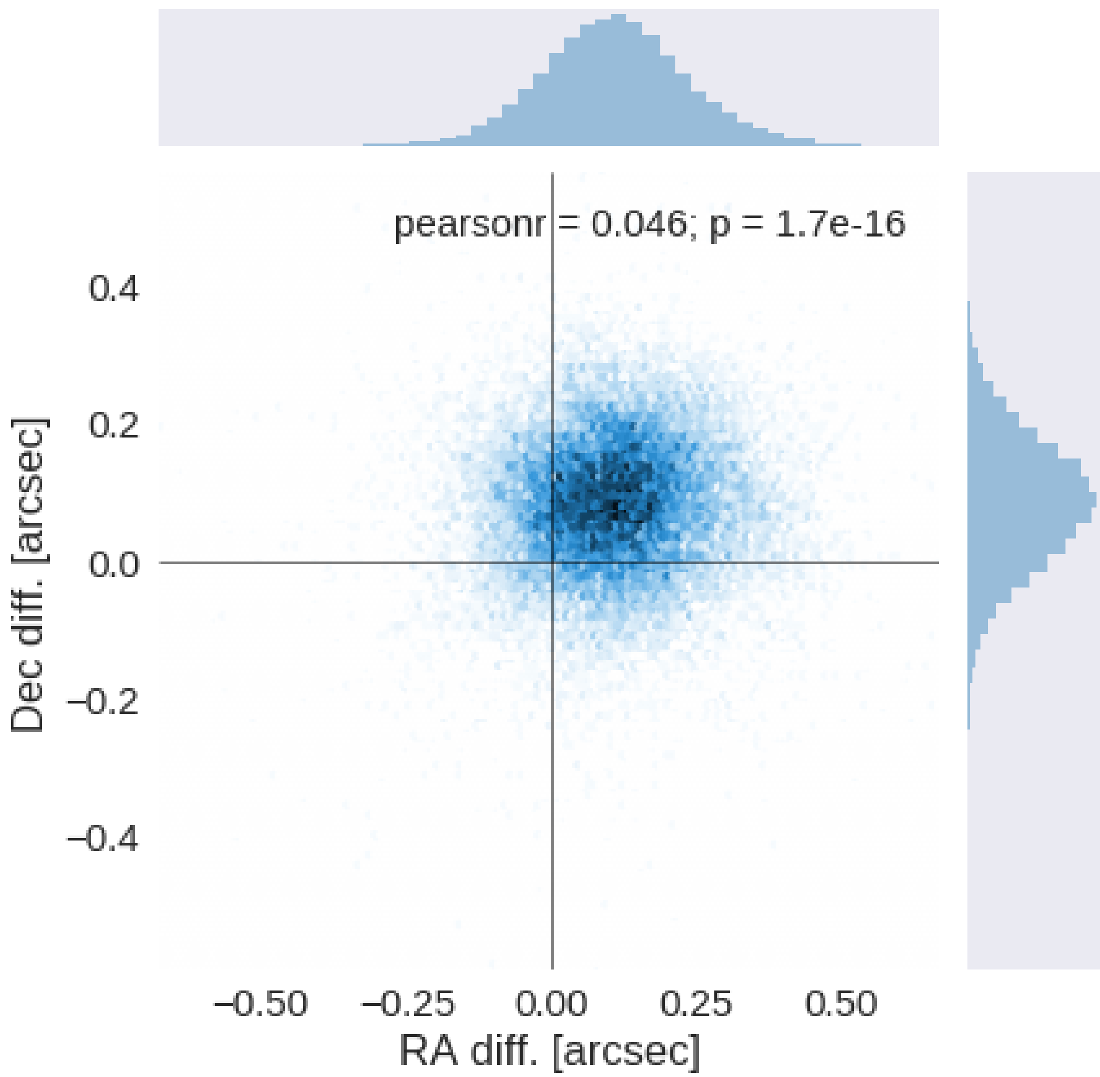
We remove duplicated objects from the input catalogues.

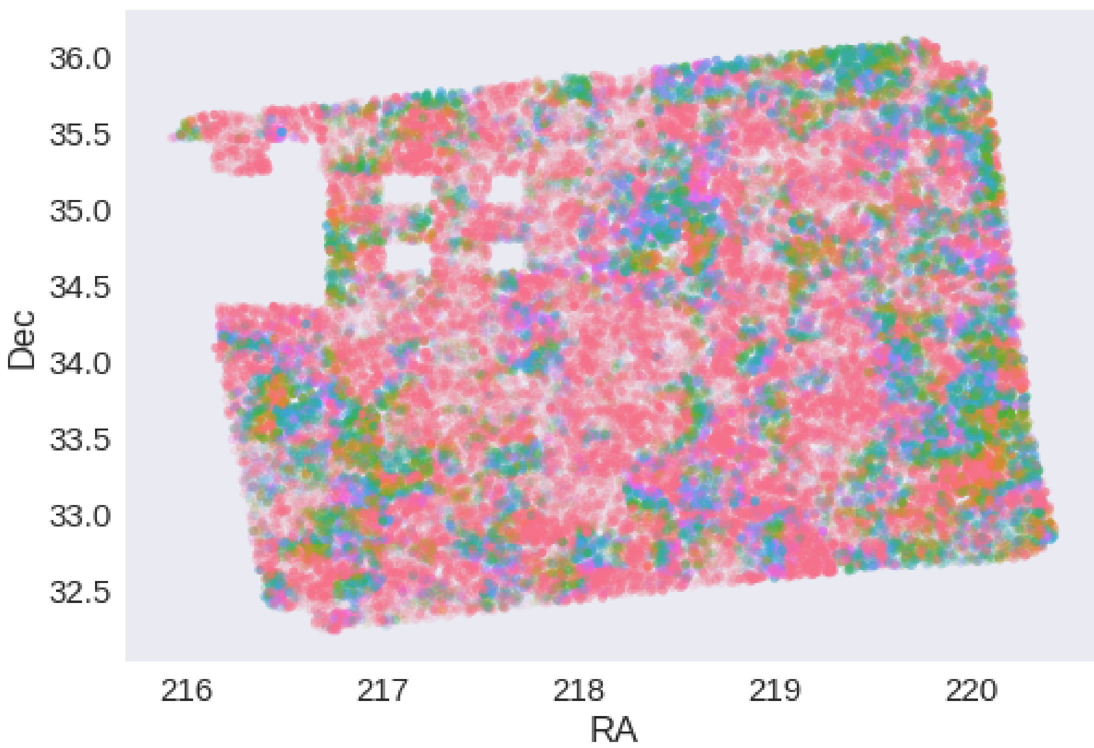
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 110730 sources.
The cleaned catalogue has 102722 sources (8008 removed).
The cleaned catalogue has 7642 sources flagged as having been cleaned
```

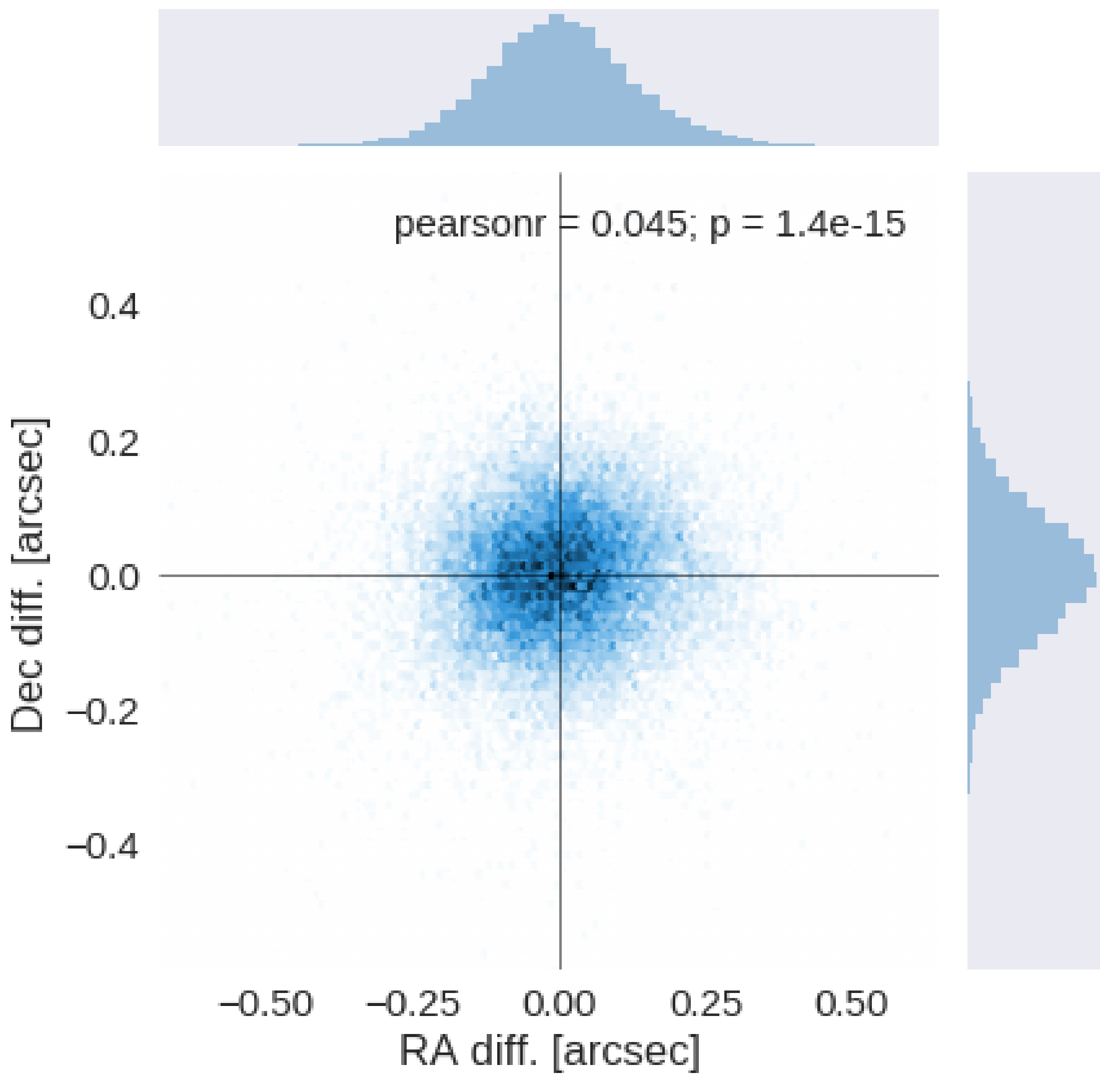
1.4 III - Astrometry correction

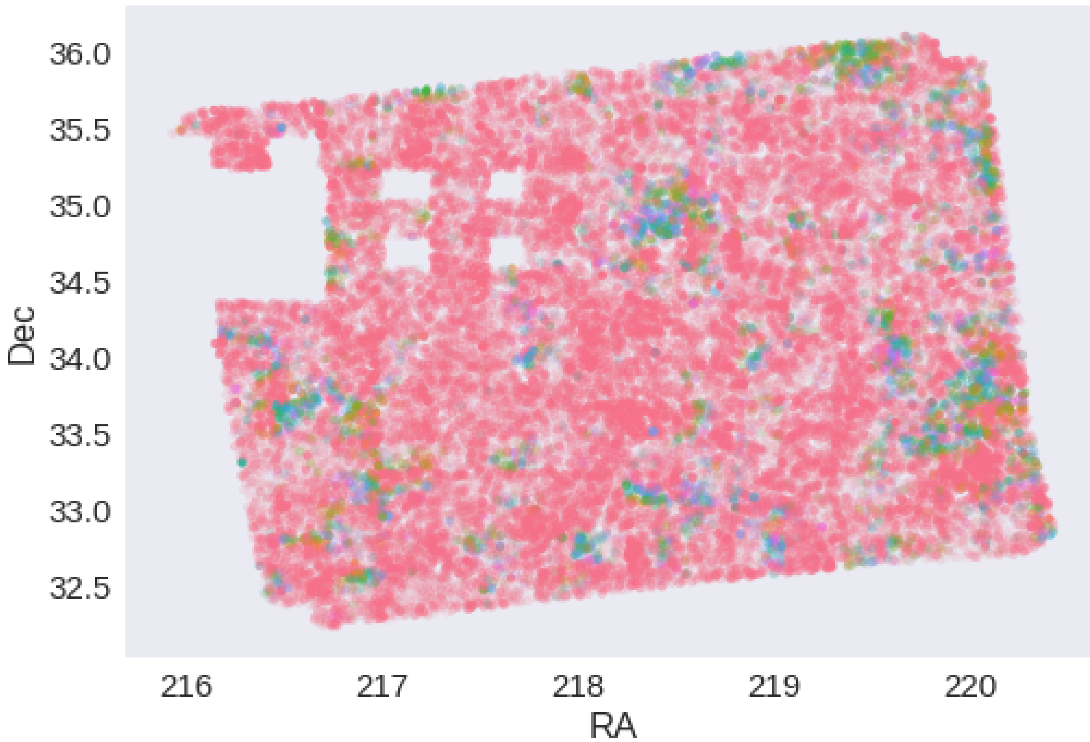
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.


pearsonr = 0.046; p = 1.7e-16
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]




```
RA correction: -0.10771486696512511 arcsec
Dec correction: -0.08473485251698776 arcsec
```


pearsonr = 0.045; p = 1.4e-15
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
31777 sources flagged.
```

2 V - Saving to disk

1.9_zBootes

March 8, 2018

1 Bootes master catalogue

1.1 Preparation of zBootes data

The catalogue comes from `dmu0_zBootes`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The magnitude for each band in 2 arcssec aperture.
- The auto magnitude.

We don't know when the maps have been observed. We will use the year of the reference paper.

```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
This notebook was executed on:
2018-02-15 13:52:08.711290
```

1.2 I - Column selection

1.3 1.i Aperture correction]

TODO

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
Out[6]: <IPython.core.display.HTML object>
```

1.4 II - Removal of duplicated sources

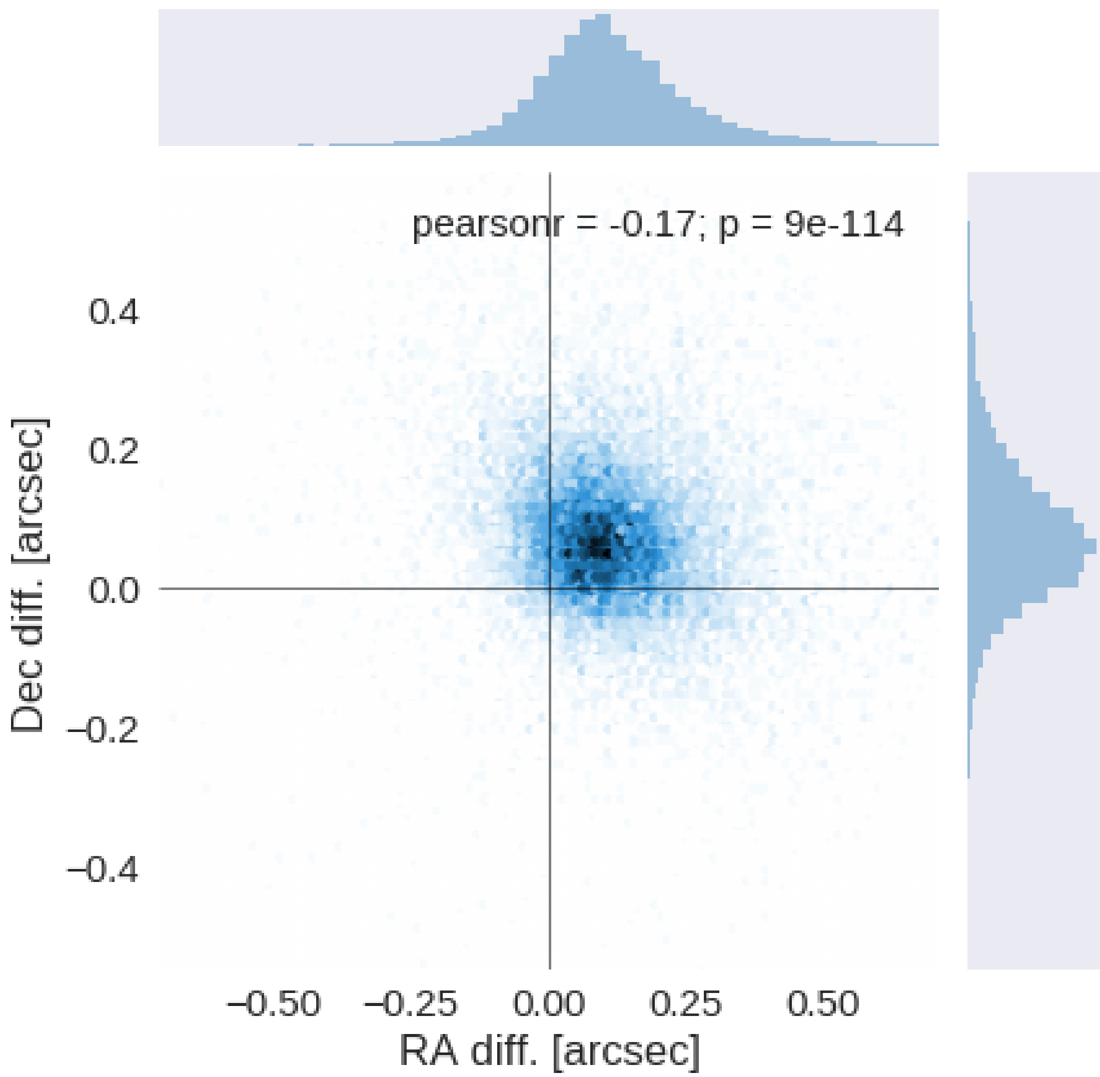
We remove duplicated objects from the input catalogues.

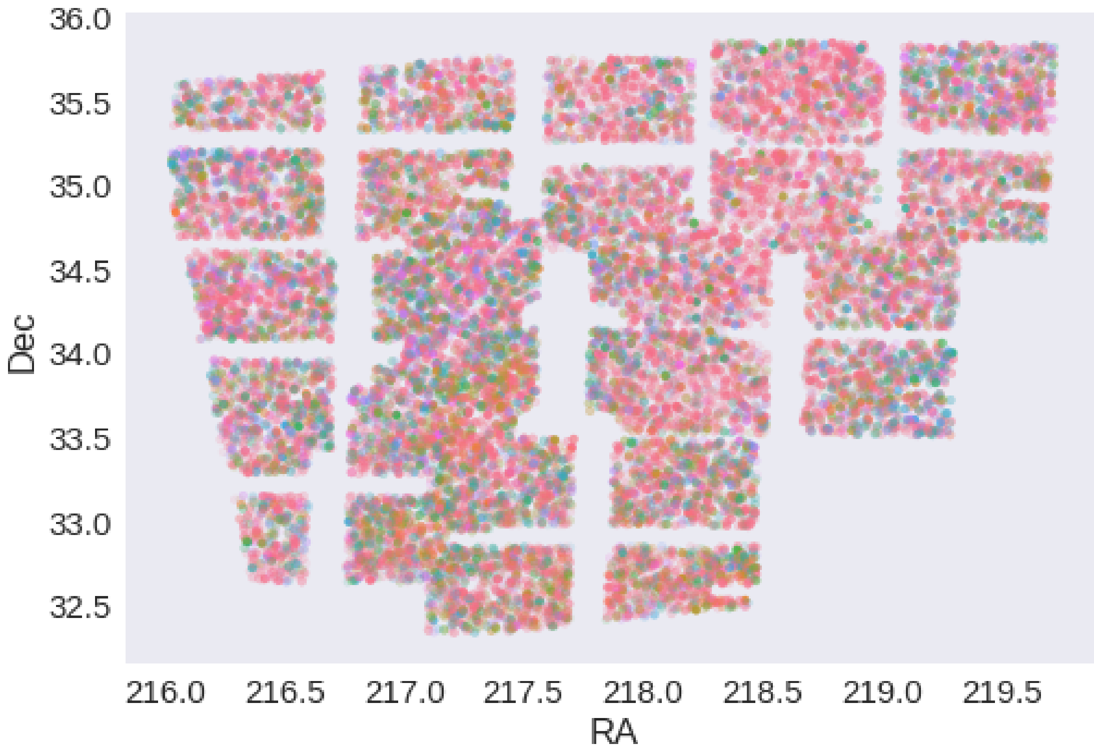
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 187628 sources.
The cleaned catalogue has 187628 sources (0 removed).
The cleaned catalogue has 0 sources flagged as having been cleaned
```

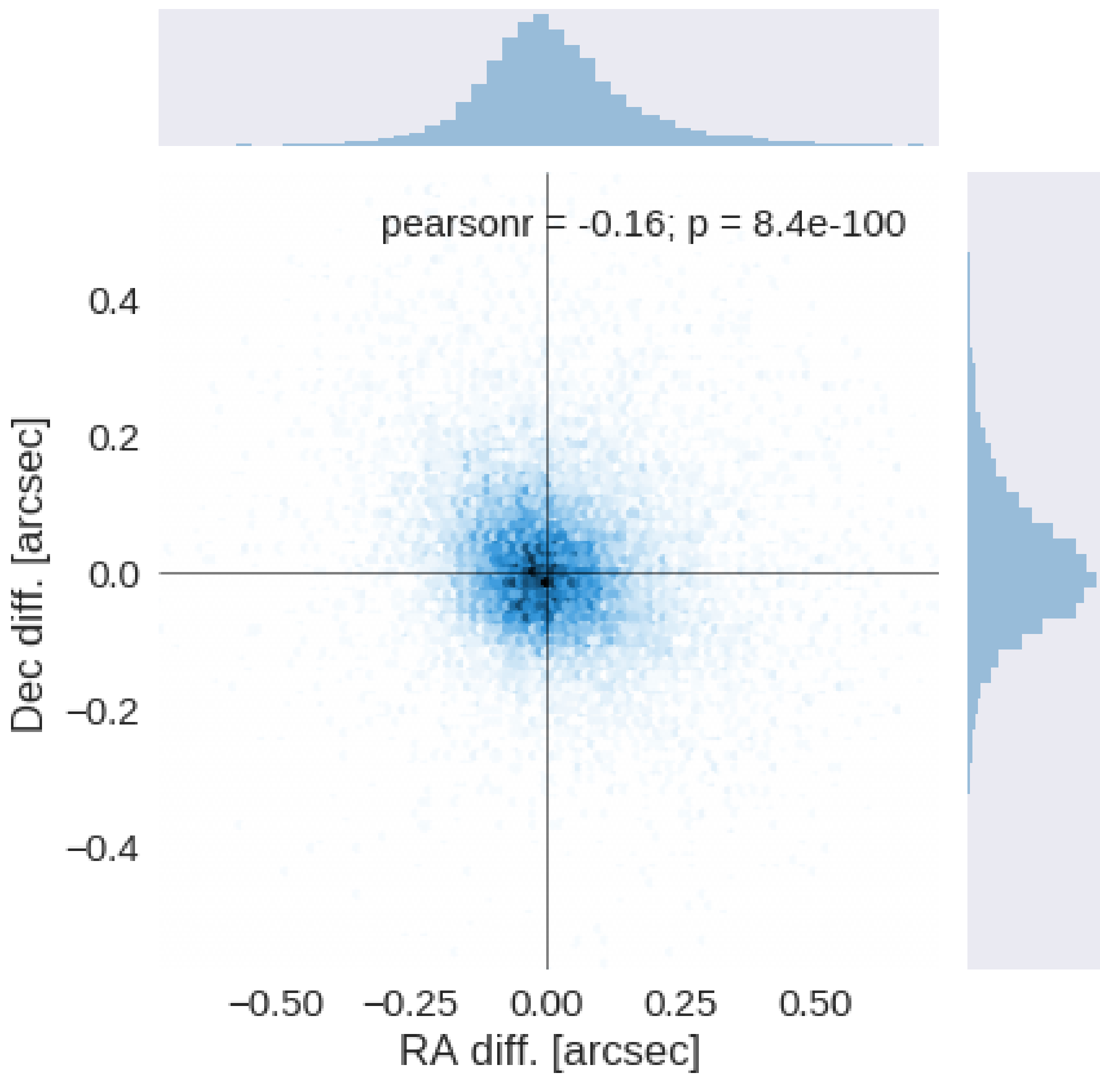
1.5 III - Astrometry correction

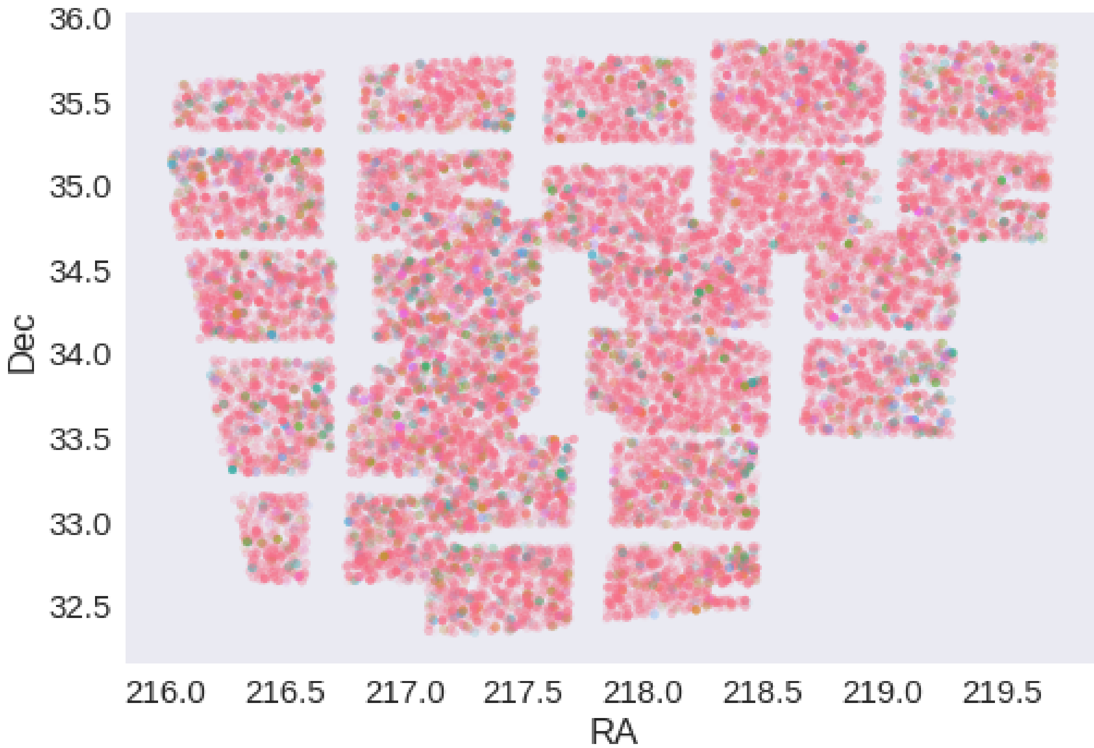
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.


pearsonr = -0.17; p = 9e-114
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]




```
RA correction: -0.10194170581598883 arcsec
Dec correction: -0.06714873594120263 arcsec
```


pearsonr = -0.16; p = 8.4e-100
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.50
−0.25
0.00
0.25
0.50
RA diff. [arcsec]



1.6 IV - Flagging Gaia objects

```
18176 sources flagged.
```

2 V - Saving to disk

2_HELP_Merging

March 8, 2018

1 Bootes master catalogue

This notebook presents the merge of the various pristine catalogues to produce HELP mater catalogue on ELAIS-N1.

```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
This notebook was executed on:
2018-02-27 15:38:19.147682
```

1.1 I - Reading the prepared pristine catalogues

1.2 II - Merging tables

We first merge the optical catalogues and then add the infrared ones.

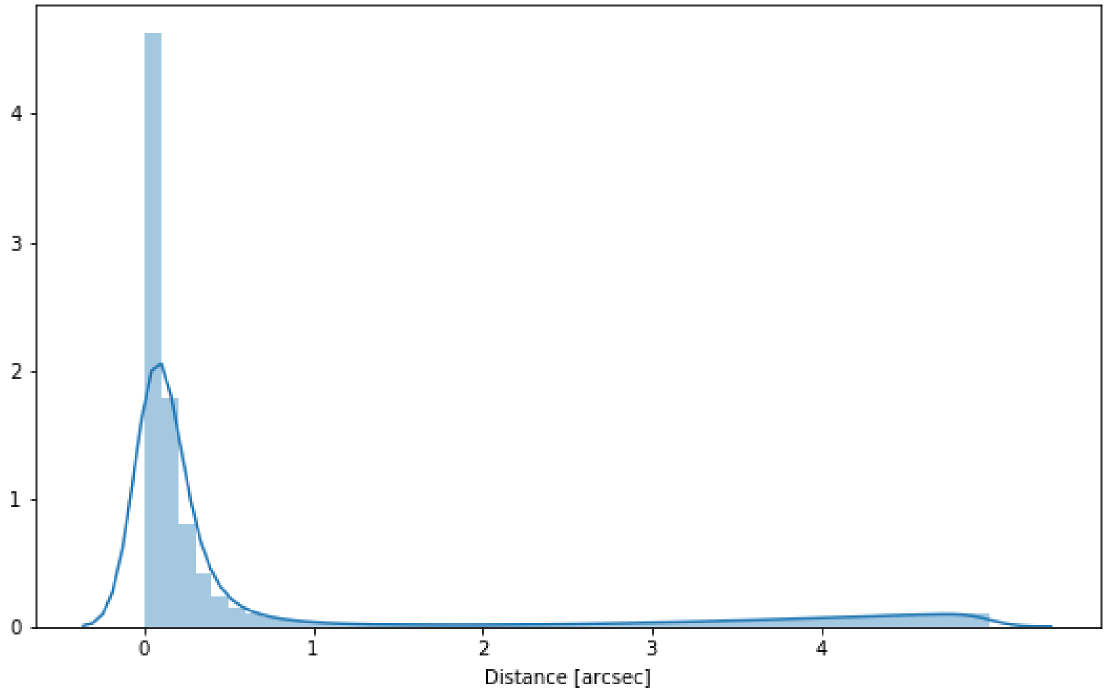
At every step, we look at the distribution of the distances to the nearest source in the merged catalogue to determine the best crossmatching radius.

1.2.1 PanSTARRS

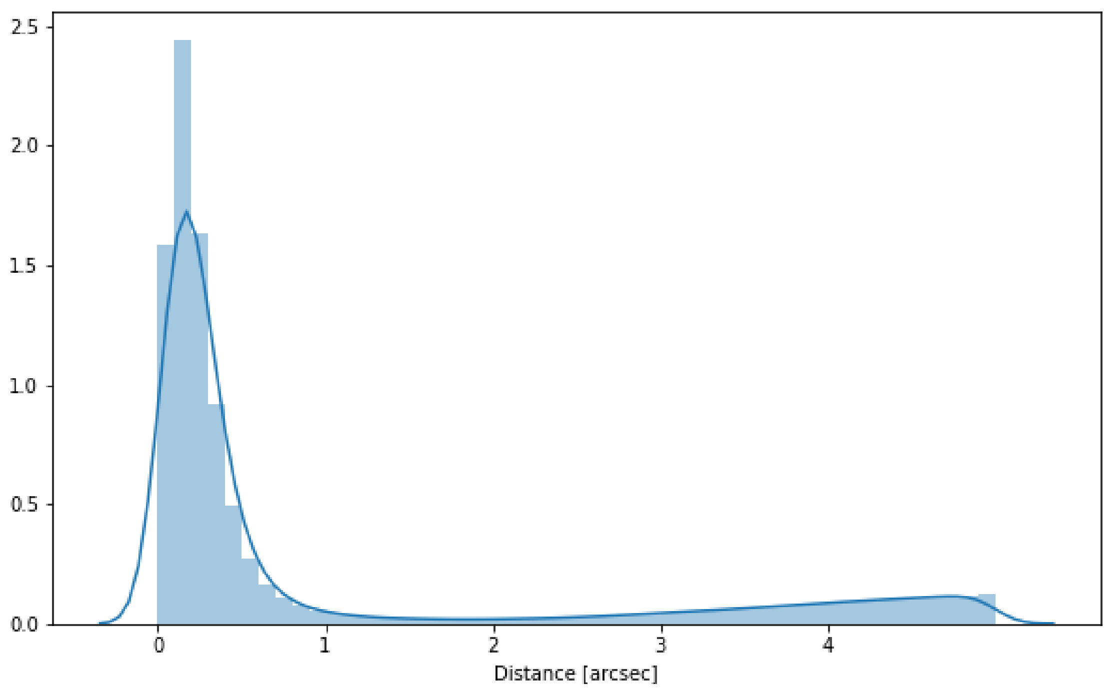
1.2.2 Add DECaLS

DECaLS contains the LegacySurvey data so is not included again

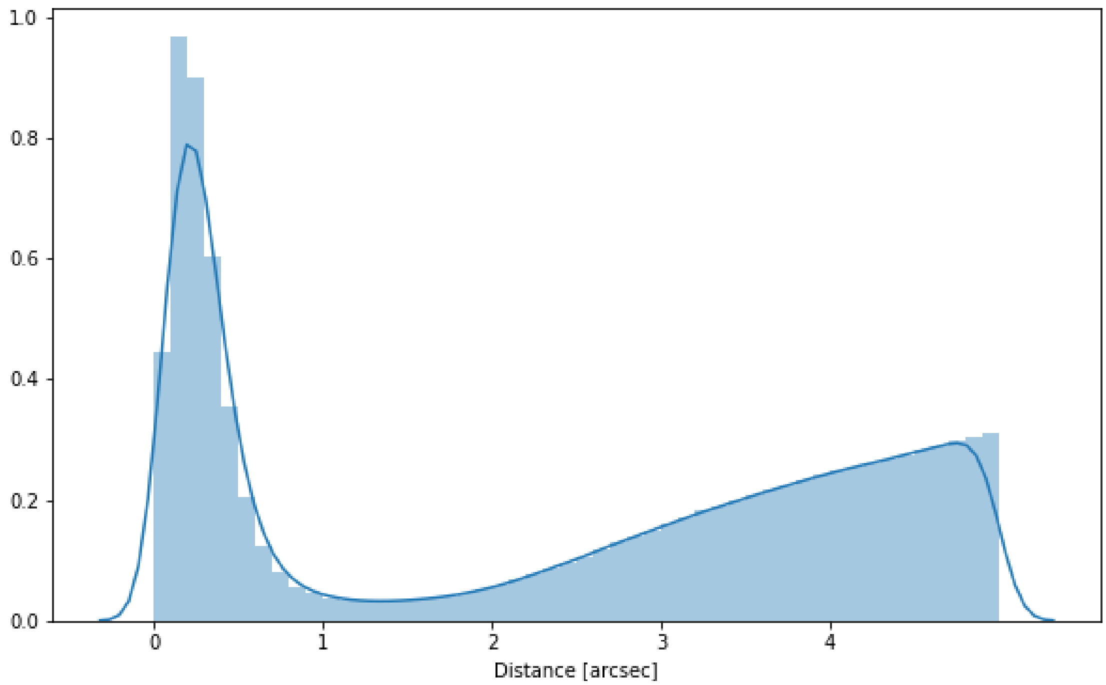
1.2.3 Add Legacy Survey



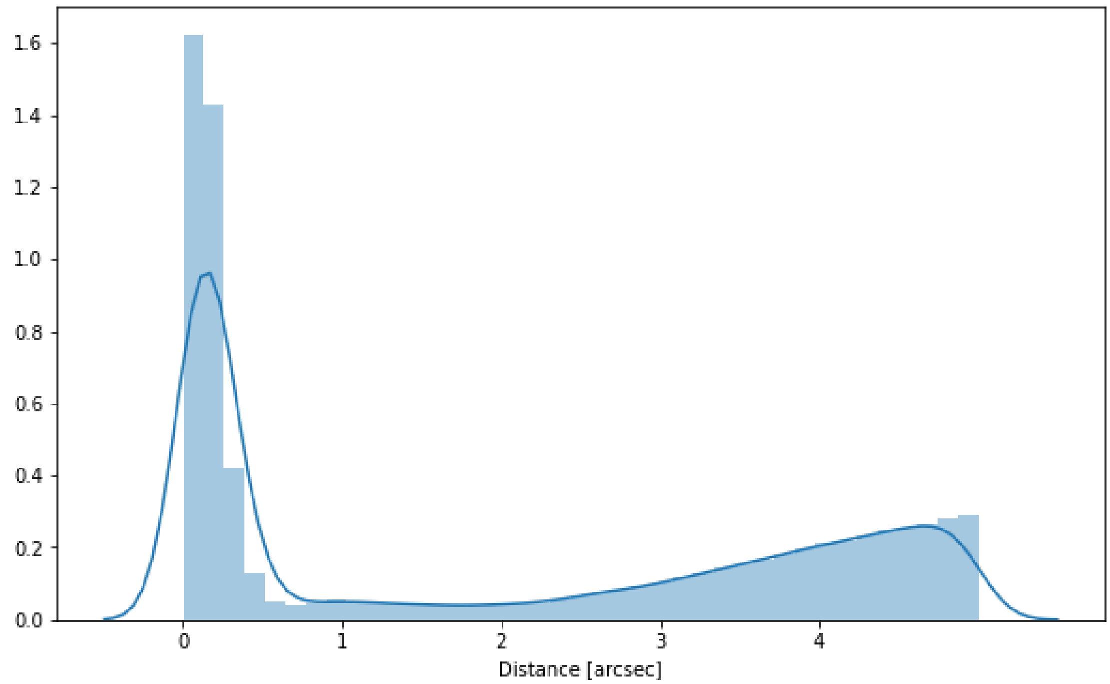
1.2.4 Add IBIS



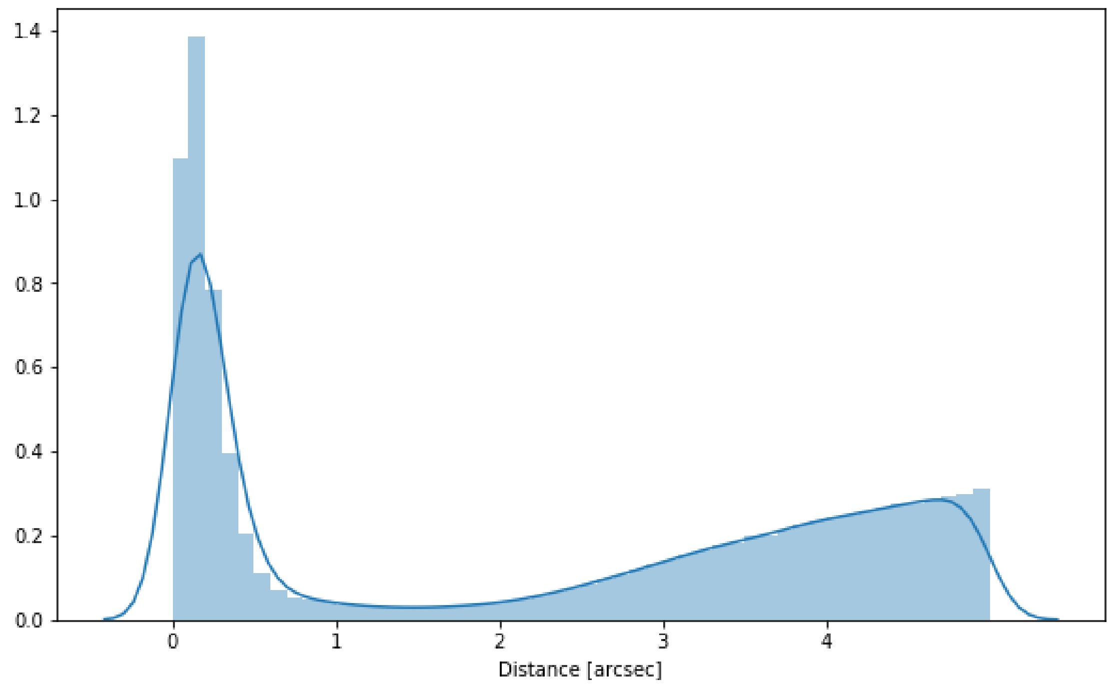
1.2.5 Add NDWFS



1.2.6 Add UHS



1.2.7 Add zBootes

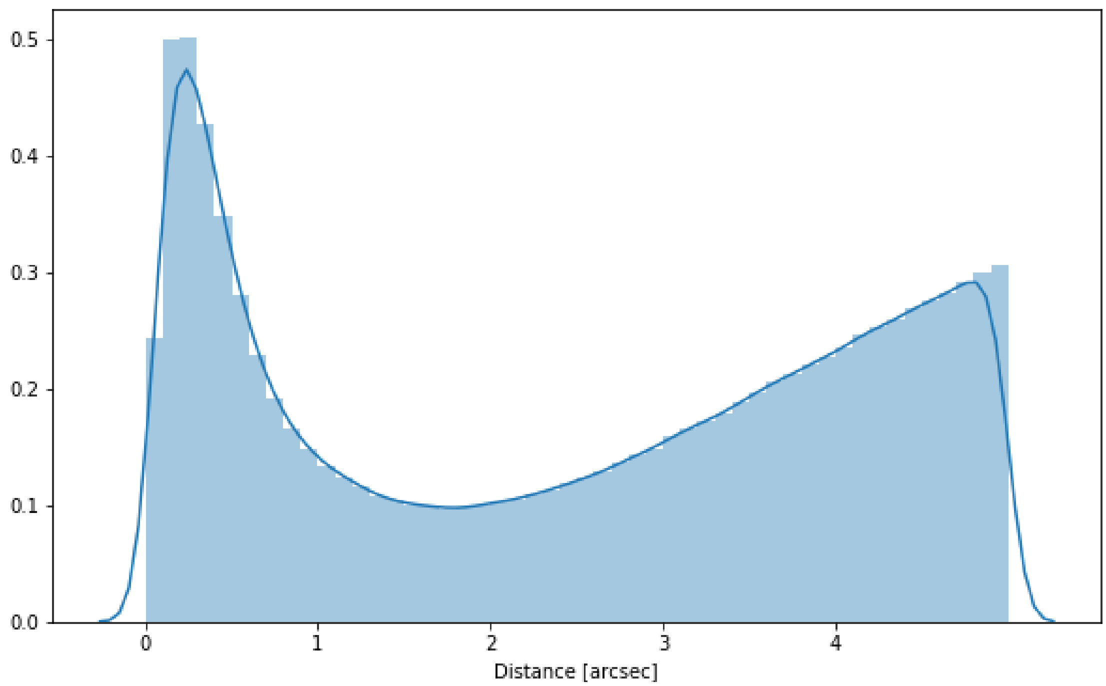


1.2.8 Add SDWFS

nb_merge_dist_plot(SkyCoord(master_catalogue['ra'], master_catalogue['dec']), SkyCoord(sdwfs['sdwfs_ra'], sdwfs['sdwfs_dec']))

#Given the graph above, we use 1 arc-second radius master_catalogue = merge_catalogues(master_catalogue, sdwfs, "sdwfs_ra", "sdwfs_dec", radius=1.*u.arcsec)

1.2.9 Add Datafusion



1.2.10 Cleaning

When we merge the catalogues, astropy masks the non-existent values (e.g. when a row comes only from a catalogue and has no counterparts in the other, the columns from the latest are masked for that row). We indicate to use NaN for masked values for floats columns, False for flag columns and -1 for ID columns.

```
Out[21]: <IPython.core.display.HTML object>
```

1.3 III - Merging flags and stellarity

Each pristine catalogue contains a flag indicating if the source was associated to a another nearby source that was removed during the cleaning process. We merge these flags in a single one.

Each pristine catalogue contains a flag indicating the probability of a source being a Gaia object (0: not a Gaia object, 1: possibly, 2: probably, 3: definitely). We merge these flags taking the highest value.

Each prisitine catalogue may contain one or several stellarity columns indicating the probability (0 to 1) of each source being a star. We merge these columns taking the highest value. We keep trace of the origin of the stellarity.

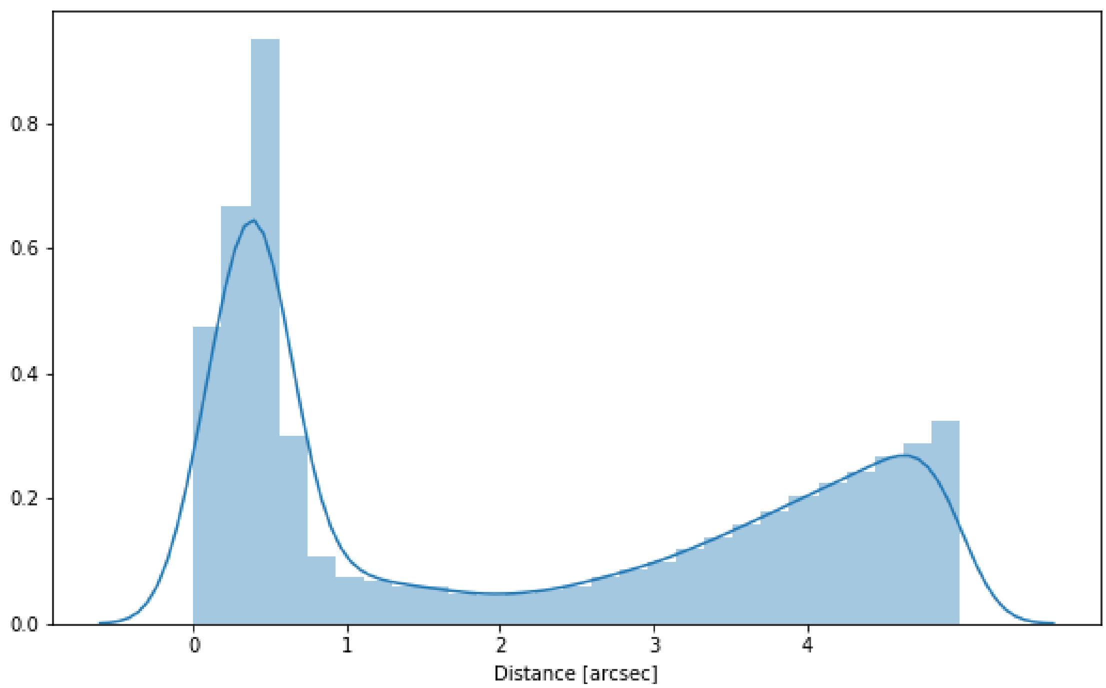
```
legacy_stellarity, ibis_stellarity, ndwfs_stellarity, uhs_stellarity, zbootes_stellarity, datafu
```

1.4 IV - Adding E(B-V) column

1.5 V - Adding HELP unique identifiers and field columns

```
OK!
```

1.6 VI - Cross-matching with spec-z catalogue



1.7 VII - Choosing between multiple values for the same filter

We take DataFusion Spitzer instead of SDWFS which is shallower.

1.8 VIII.a Wavelength domain coverage

We add a binary `flag_optnir_obs` indicating that a source was observed in a given wavelength domain:

- 1 for observation in optical;
- 2 for observation in near-infrared;
- 4 for observation in mid-infrared (IRAC).

It's an integer binary flag, so a source observed both in optical and near-infrared by not in mid-infrared would have this flag at 1 + 2 = 3.

Note 1: The observation flag is based on the creation of multi-order coverage maps from the catalogues, this may not be accurate, especially on the edges of the coverage.

Note 2: Being on the observation coverage does not mean having fluxes in that wavelength domain. For sources observed in one domain but having no flux in it, one must take into consideration de different depths in the catalogue we are using.

1.9 VIII.b Wavelength domain detection

We add a binary `flag_optnir_det` indicating that a source was detected in a given wavelength domain:

- 1 for detection in optical;
- 2 for detection in near-infrared;
- 4 for detection in mid-infrared (IRAC).

It's an integer binary flag, so a source detected both in optical and near-infrared by not in mid-infrared would have this flag at 1 + 2 = 3.

Note 1: We use the total flux columns to know if the source has flux, in some catalogues, we may have aperture flux and no total flux.

To get rid of artefacts (chip edges, star flares, etc.) we consider that a source is detected in one wavelength domain when it has a flux value in **at least two bands**. That means that good sources will be excluded from this flag when they are on the coverage of only one band.

1.10 IX - Cross-identification table

We are producing a table associating to each HELP identifier, the identifiers of the sources in the pristine catalogues. This can be used to easily get additional information from them.

For convenience, we also cross-match the master list with the SDSS catalogue and add the objID associated with each source, if any. **TODO: should we correct the astrometry with respect to Gaia positions?**

```
242 master list rows had multiple associations.
```

```
['ps1_id', 'legacy_id', 'ibis_id', 'ndwfs_id', 'uhs_id', 'zbootes_id', 'datafusion_intid', 'help
```

1.11 X - Adding HEALPix index

We are adding a column with a HEALPix index at order 13 associated with each source.

1.12 XI - Saving the catalogue

```
Missing columns: {'flag_newfirm_h', 'flag_newfirm_j', 'flag_irac_i1', 'flag_mosaic_ks', 'flag_90
```

3.0_Brown_Checks_and_diagnostics

March 8, 2018

1 Bootes master catalogue

This is to run checks on the catalogue from Michael Brown. It is possible this will not be used for HELP. ## Checks and diagnostics

```
This notebook was run with herschelhelp_internal version:
33f5ec7 (Wed Dec 6 16:56:17 2017 +0000)
```

```
Diagnostics done using: master_catalogue_bootes_20171212.fits
```

1.1 0 - Quick checks

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/core/numeric.py:301:
  format(shape, fill_value, array(fill_value).dtype), FutureWarning)
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/core/numeric.py:301:
  format(shape, fill_value, array(fill_value).dtype), FutureWarning)
```

```
Table shows only problematic columns.
```

```
Out[4]: <IPython.core.display.HTML object>
```

1.2 I - Summary of wavelength domains

1.3 II - Comparing magnitudes in similar filters

The master list if composed of several catalogues containing magnitudes in similar filters on different instruments. We are comparing the magnitudes in these corresponding filters.

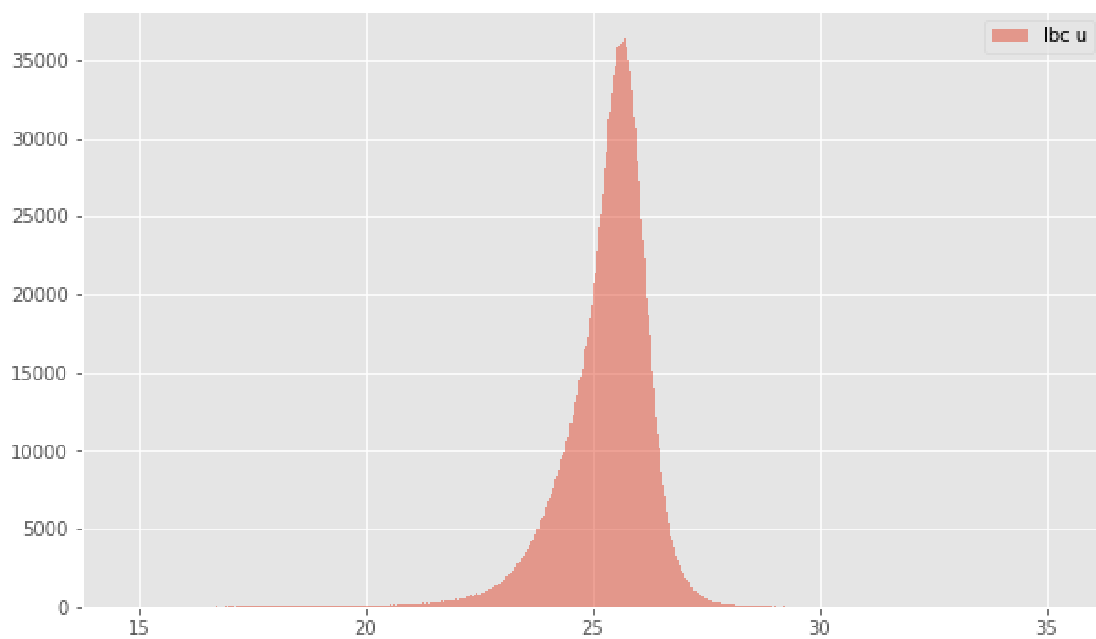
```
Out[8]: ['ra',
         'dec',
         'stellarity',
         'm_ap_lbc_u',
         'merr_ap_lbc_u',
         'f_ap_lbc_u',
```

```
'ferr_ap_lbc_u',
'm_ap_mosaic_bw',
'merr_ap_mosaic_bw',
'f_ap_mosaic_bw',
'ferr_ap_mosaic_bw',
'm_ap_mosaic_r',
'merr_ap_mosaic_r',
'f_ap_mosaic_r',
'ferr_ap_mosaic_r',
'm_ap_mosaic_i',
'merr_ap_mosaic_i',
'f_ap_mosaic_i',
'ferr_ap_mosaic_i',
'm_ap_prime90_z',
'merr_ap_prime90_z',
'f_ap_prime90_z',
'ferr_ap_prime90_z',
'm_ap_suprime_z',
'merr_ap_suprime_z',
'f_ap_suprime_z',
'ferr_ap_suprime_z',
'm_ap_lbc_y',
'merr_ap_lbc_y',
'f_ap_lbc_y',
'ferr_ap_lbc_y',
'm_ap_newfirm_j',
'merr_ap_newfirm_j',
'f_ap_newfirm_j',
'ferr_ap_newfirm_j',
'm_ap_newfirm_h',
'merr_ap_newfirm_h',
'f_ap_newfirm_h',
'ferr_ap_newfirm_h',
'm_ap_onis_k',
'merr_ap_onis_k',
'f_ap_onis_k',
'ferr_ap_onis_k',
'm_ap_newfirm_k',
'merr_ap_newfirm_k',
'f_ap_newfirm_k',
'ferr_ap_newfirm_k',
'm_ap_irac_ch1',
'merr_ap_irac_ch1',
'f_ap_irac_ch1',
'ferr_ap_irac_ch1',
'm_ap_irac_ch2',
'merr_ap_irac_ch2',
'f_ap_irac_ch2',
```

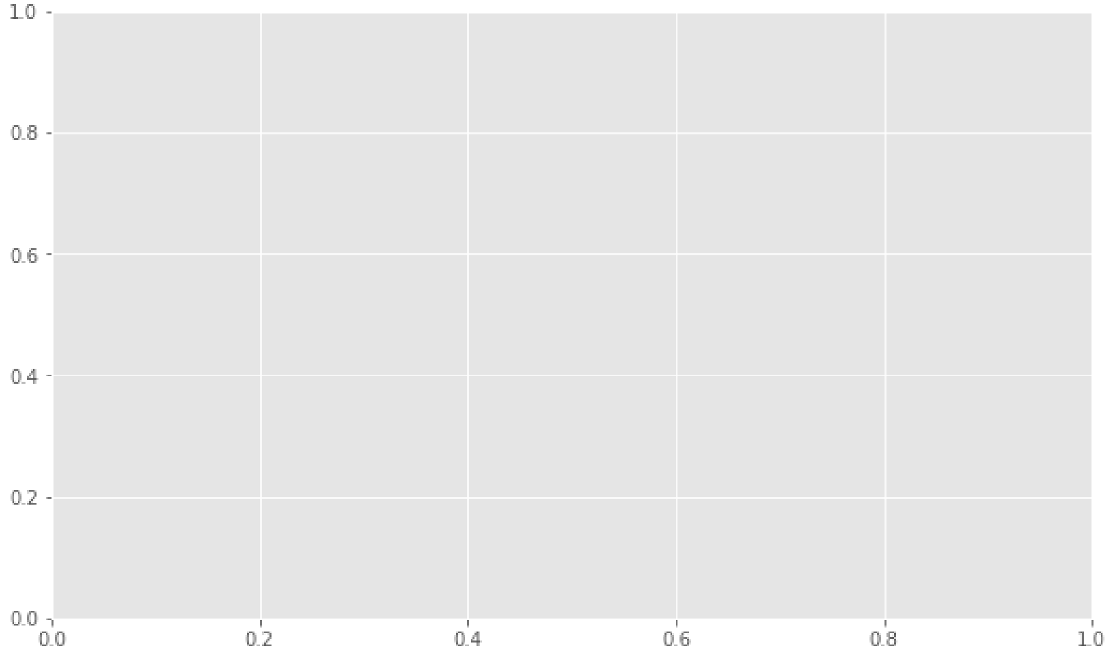
```
'ferr_ap_irac_ch2',
'm_ap_irac_ch3',
'merr_ap_irac_ch3',
'f_ap_irac_ch3',
'ferr_ap_irac_ch3',
'm_ap_irac_ch4',
'merr_ap_irac_ch4',
'f_ap_irac_ch4',
'ferr_ap_irac_ch4',
'flag_merged',
'bootes_flag_gaia',
'help_id',
'field']
```

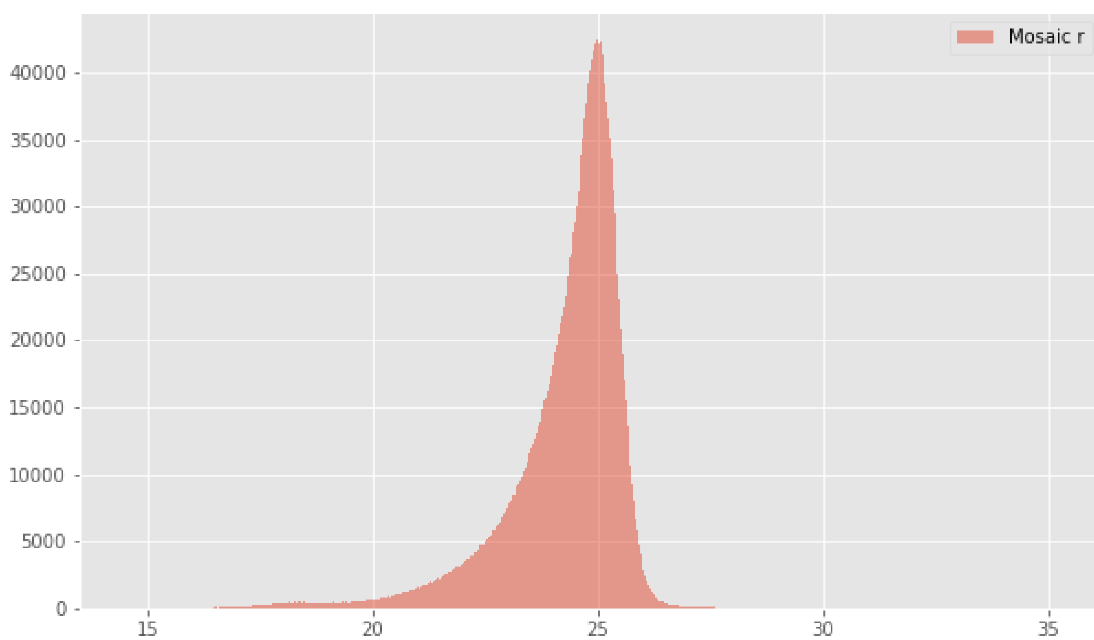
1.3.1 II.a - Comparing depths

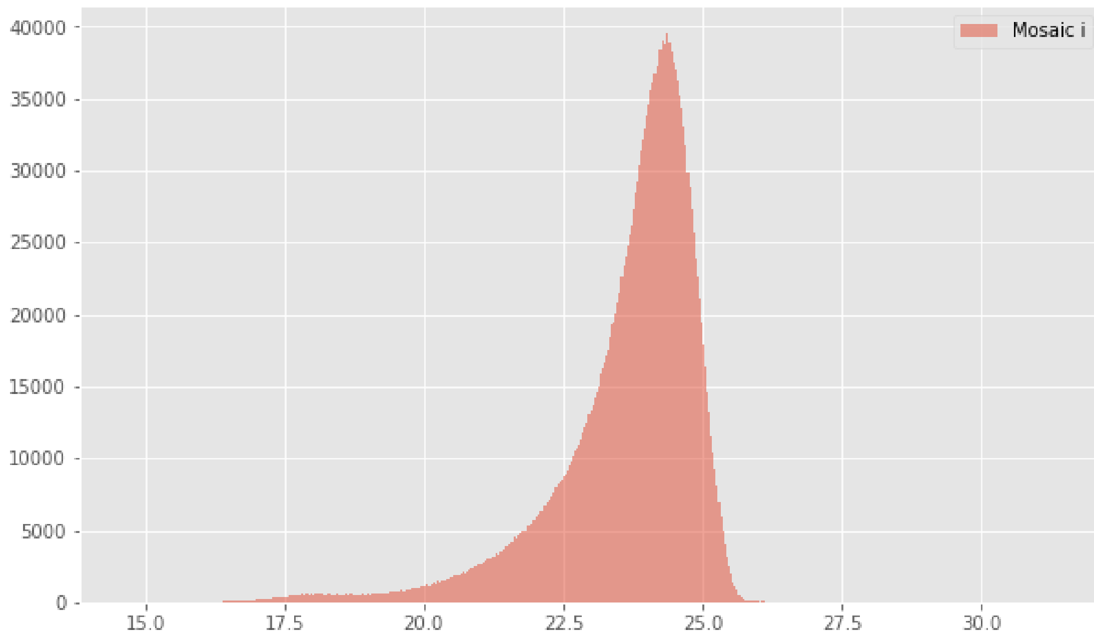
We compare the histograms of the total aperture magnitudes of similar bands.

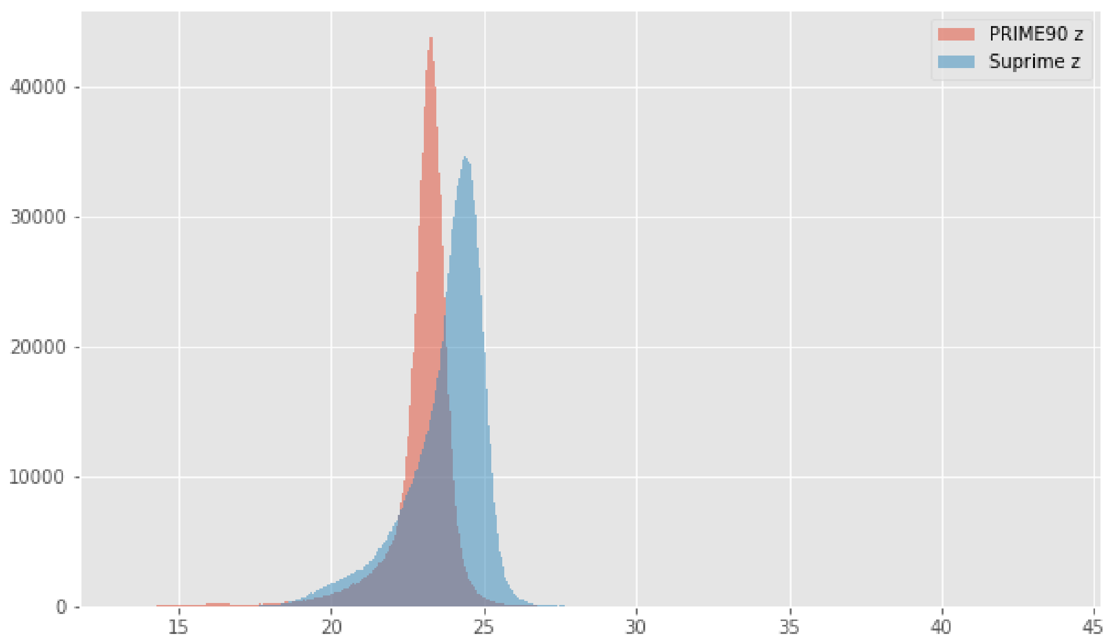


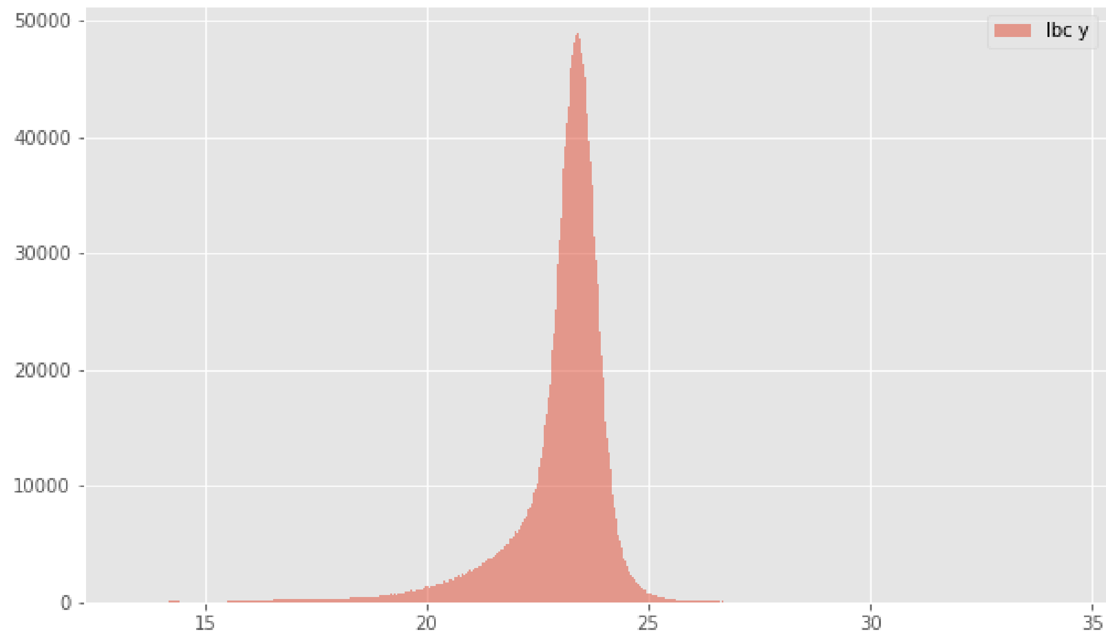

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/matplotlib/axes/_axes.py:5
  warnings.warn("No labelled objects found. "
```


1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Mosaic r
40000
35000
30000
25000
20000
15000
10000
5000
0
15
20
25
30
35


Mosaic i
40000
35000
30000
25000
20000
15000
10000
5000
0
15.0
17.5
20.0
22.5
25.0
27.5
30.0

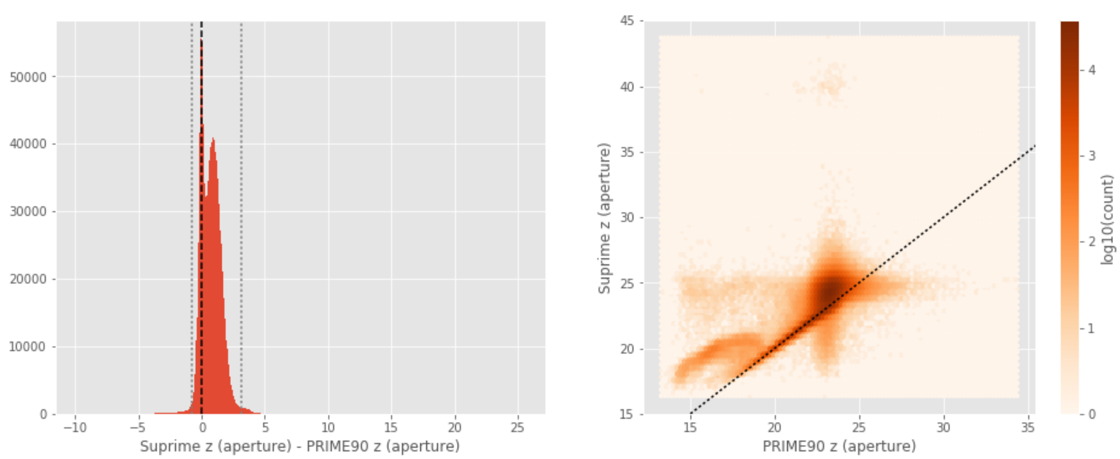

PRIME90 z
Suprime z
40000
30000
20000
10000
0
15
20
25
30
35
40
45



1.3.2 II.b - Comparing magnitudes

We compare one to one each magnitude in similar bands.

```
Suprime z (aperture) - PRIME90 z (aperture):
- Median: 0.70
- Median Absolute Deviation: 0.58
- 1% percentile: -0.7906162536703729
- 99% percentile: 3.127203865051266
```



```
One of  m_prime90_z  and  m_suprime_z  does not exist.
```

1.4 III - Comparing magnitudes to reference bands

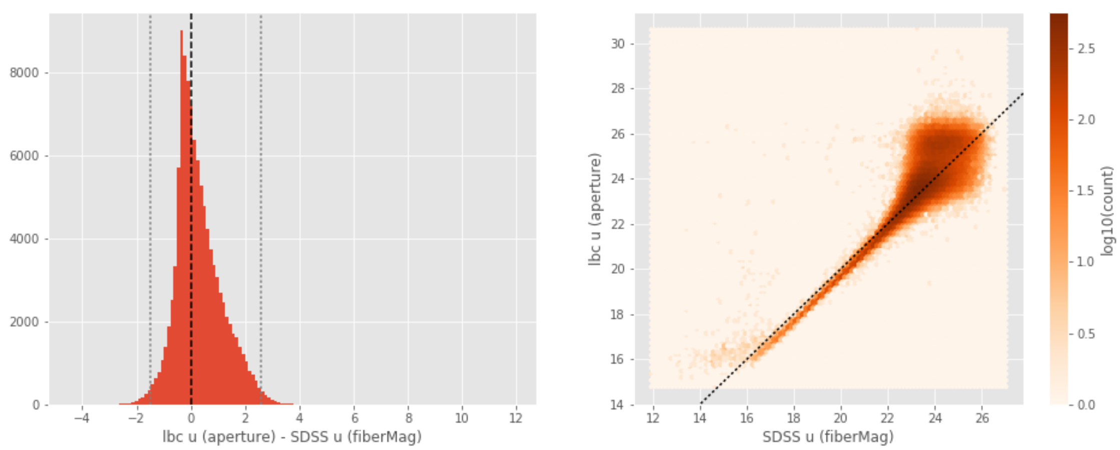
Cross-match the master list to SDSS and 2MASS to compare its magnitudes to SDSS and 2MASS ones.

1.4.1 III.a - Comparing u, g, r, i, and z bands to SDSS

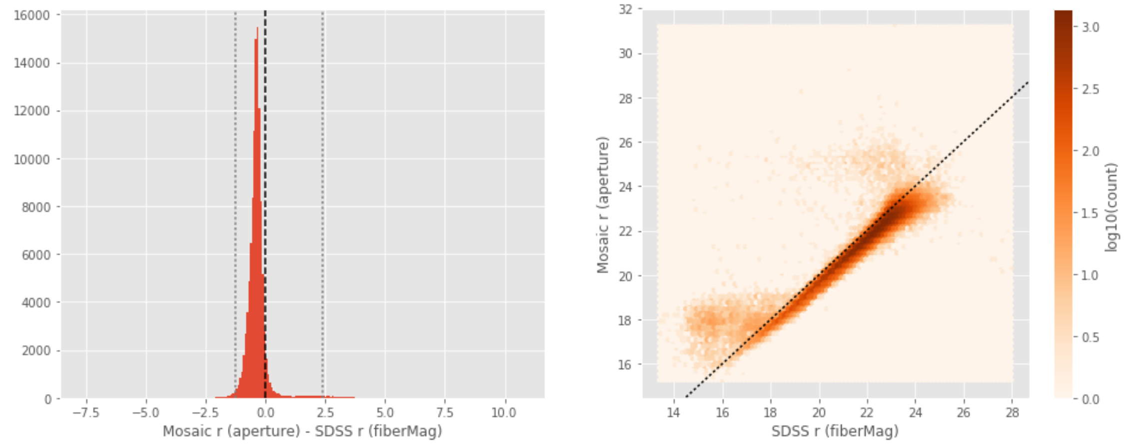
The catalogue is cross-matched to SDSS-DR13 withing 0.2 arcsecond.

We compare the u, g, r, i, and z magnitudes to those from SDSS using `fiberMag` for the aperture magnitude and `petroMag` for the total magnitude.

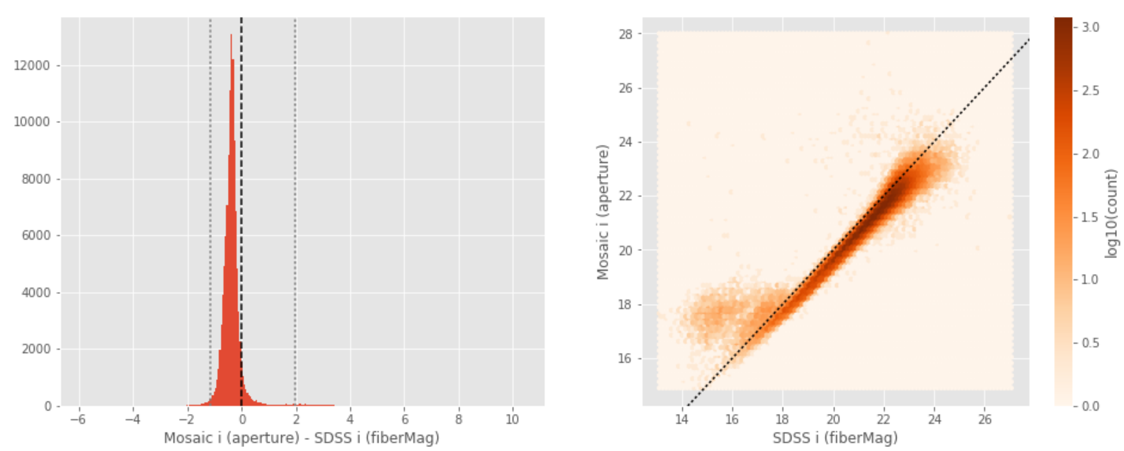
```
lbc u (aperture) - SDSS u (fiberMag):
- Median: 0.13
- Median Absolute Deviation: 0.48
- 1% percentile: -1.4935266494750976
- 99% percentile: 2.5912899017333997
```



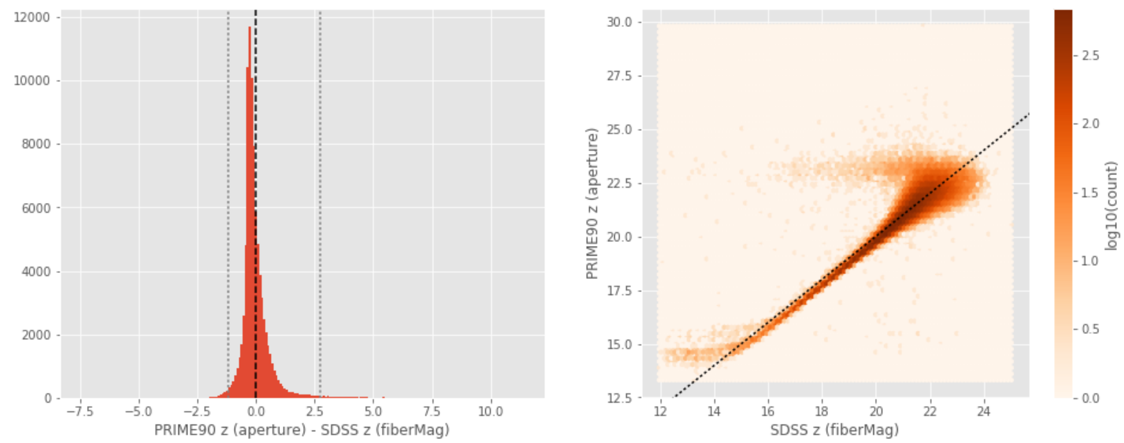

```
No  m_lbc_u
No sources have both SDSS u (petroMag) and lbc u (total) values.
Mosaic r (aperture) - SDSS r (fiberMag):
- Median: -0.38
- Median Absolute Deviation: 0.15
- 1% percentile: -1.2427162170410158
- 99% percentile: 2.388106526517424
```



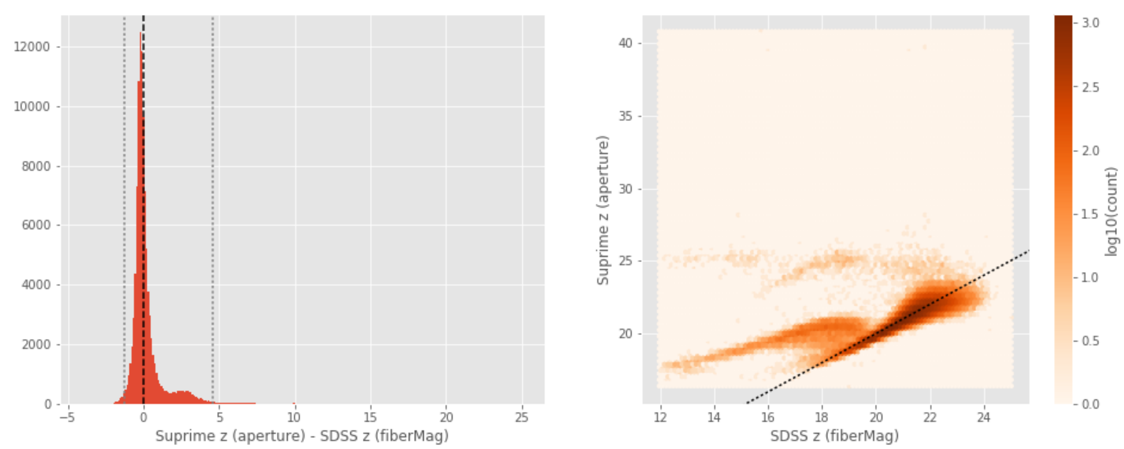
No m_mosaic_r
No sources have both SDSS r (petroMag) and Mosaic r (total) values.
Mosaic i (aperture) - SDSS i (fiberMag):
- Median: -0.38
- Median Absolute Deviation: 0.14
- 1% percentile: -1.1454618072509766
- 99% percentile: 1.975587410362594



No m_mosaic_i
No sources have both SDSS i (petroMag) and Mosaic i (total) values.
PRIME90 z (aperture) - SDSS z (fiberMag):
- Median: -0.17
- Median Absolute Deviation: 0.21
- 1% percentile: -1.2076813316345214
- 99% percentile: 2.707011108398442




```
No  m_prime90_z
No sources have both SDSS z (petroMag) and PRIME90 z (total) values.
Suprime z (aperture) - SDSS z (fiberMag):
- Median: -0.09
- Median Absolute Deviation: 0.27
- 1% percentile: -1.2514193153381348
- 99% percentile: 4.580278812588574
```




```
No  m_suprime_z
No sources have both SDSS z (petroMag) and Suprime z (total) values.
```

1.4.2 III.b - Comparing J and K bands to 2MASS

The catalogue is cross-matched to 2MASS-PSC withing 0.2 arcsecond. We compare the UKIDSS total J and K magnitudes to those from 2MASS.

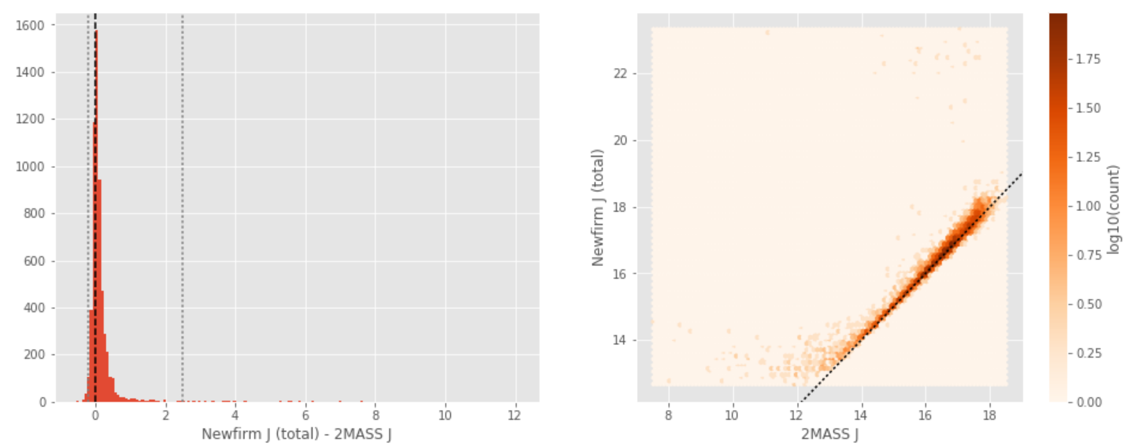
The 2MASS magnitudes are "*Vega-like*" and we have to convert them to AB magnitudes using the zero points provided on this page:

Band	F - 0 mag (Jy)
J	1594
H	1024
Ks	666.7

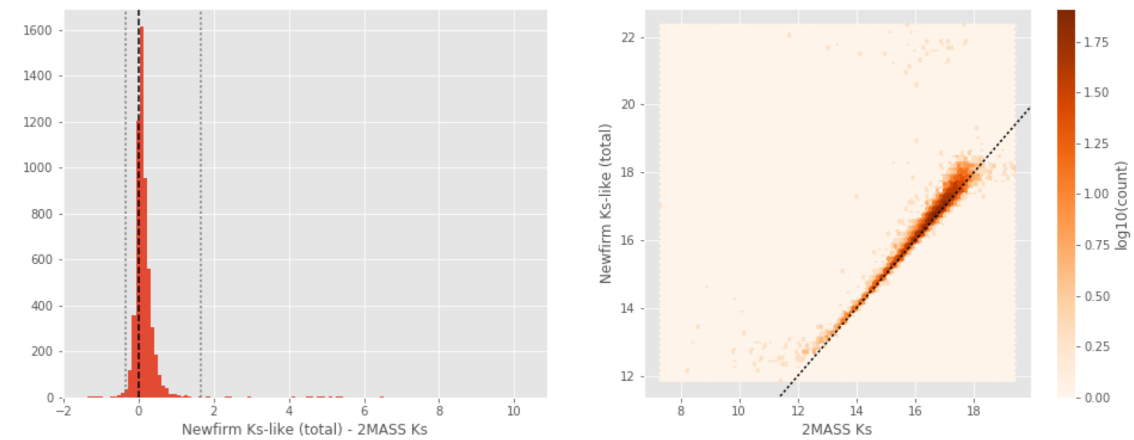
In addition, UKIDSS uses a K band whereas 2MASS uses a Ks ("short") band, this page give a correction to convert the K band in a Ks band with the formula:

$$K_{s(2MASS)} = K_{UKIRT} + 0.003 + 0.004 * (JK)_{UKIRT}$$

```
Newfirm J (total) - 2MASS J:
- Median: 0.06
- Median Absolute Deviation: 0.08
- 1% percentile: -0.20999463988321493
- 99% percentile: 2.499920256823075
```




```
Newfirm Ks-like (total) - 2MASS Ks:
- Median: 0.09
- Median Absolute Deviation: 0.10
- 1% percentile: -0.36023741652093016
- 99% percentile: 1.6431110585128939
```



1.5 Keeping only sources with good signal to noise ratio

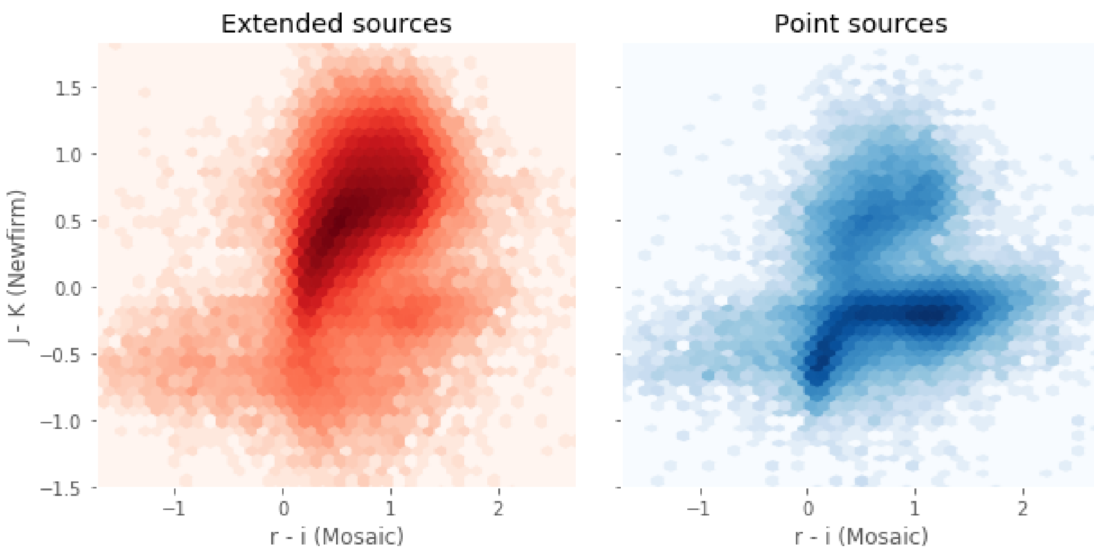
From here, we are only comparing sources with a signal to noise ratio above 3, i.e. roughly we a magnitude error below 0.3.

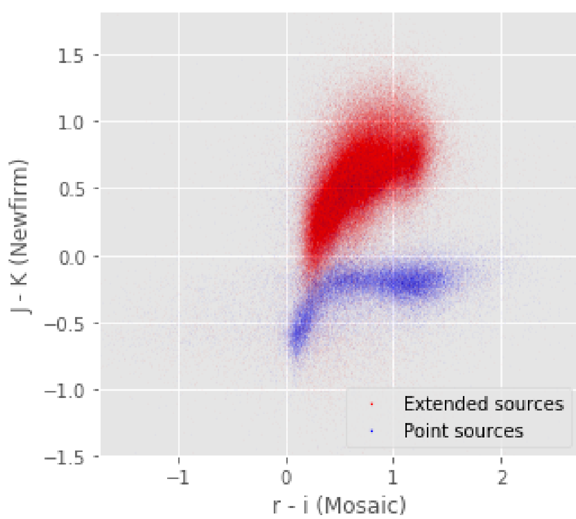
To make it easier, we are setting to NaN in the catalogue the magnitudes associated with an error above 0.3 so we can't use these magnitudes after the next cell.

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:4: M
Check the NumPy 1.11 release notes for more information.
```

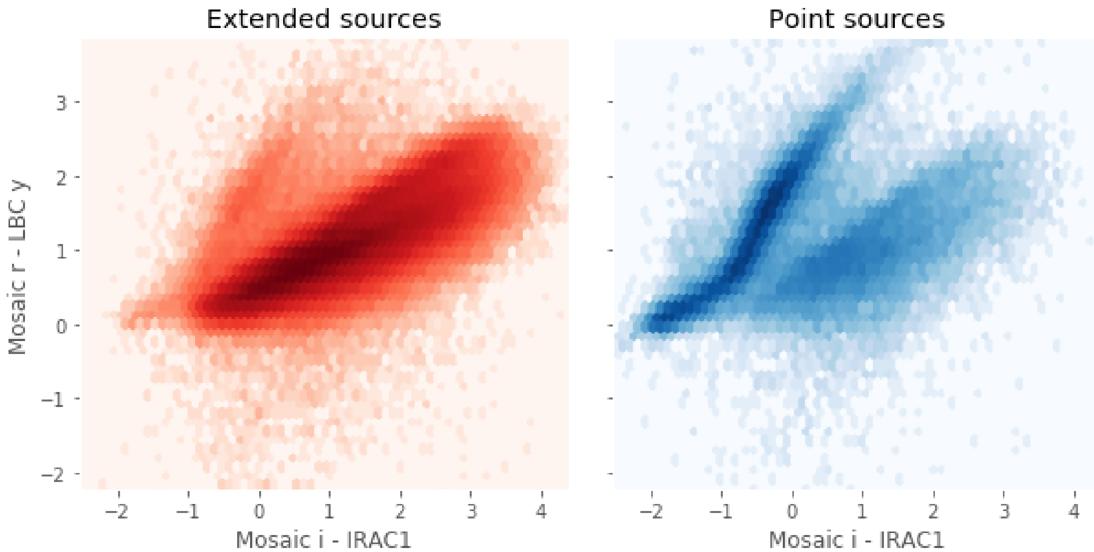
1.6 V - Color-color and magnitude-color plots

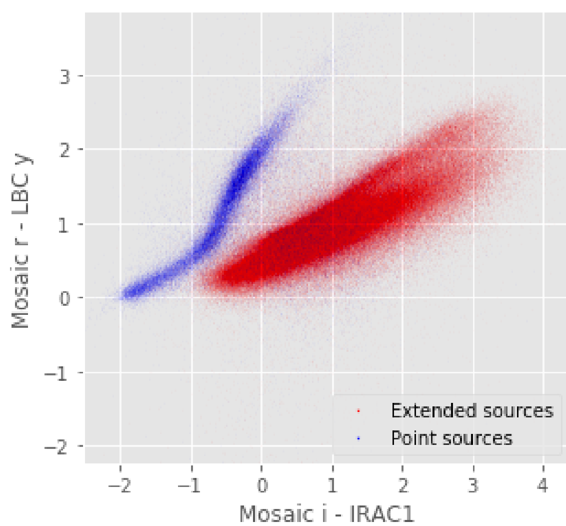
```
Number of source used: 275707 / 2252093 (12.24%)
```



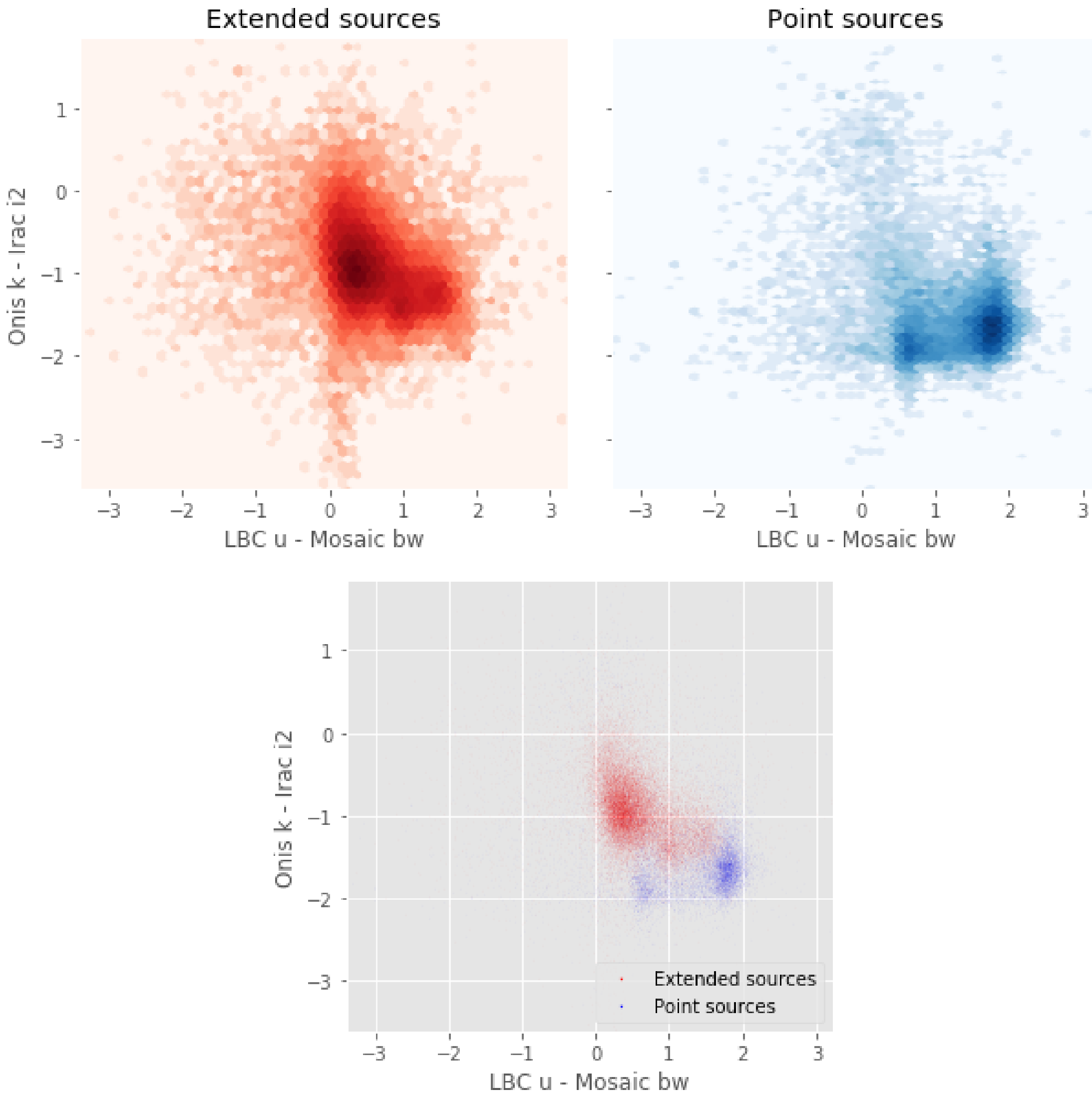



```
Number of source used: 406736 / 2252093 (18.06%)
```

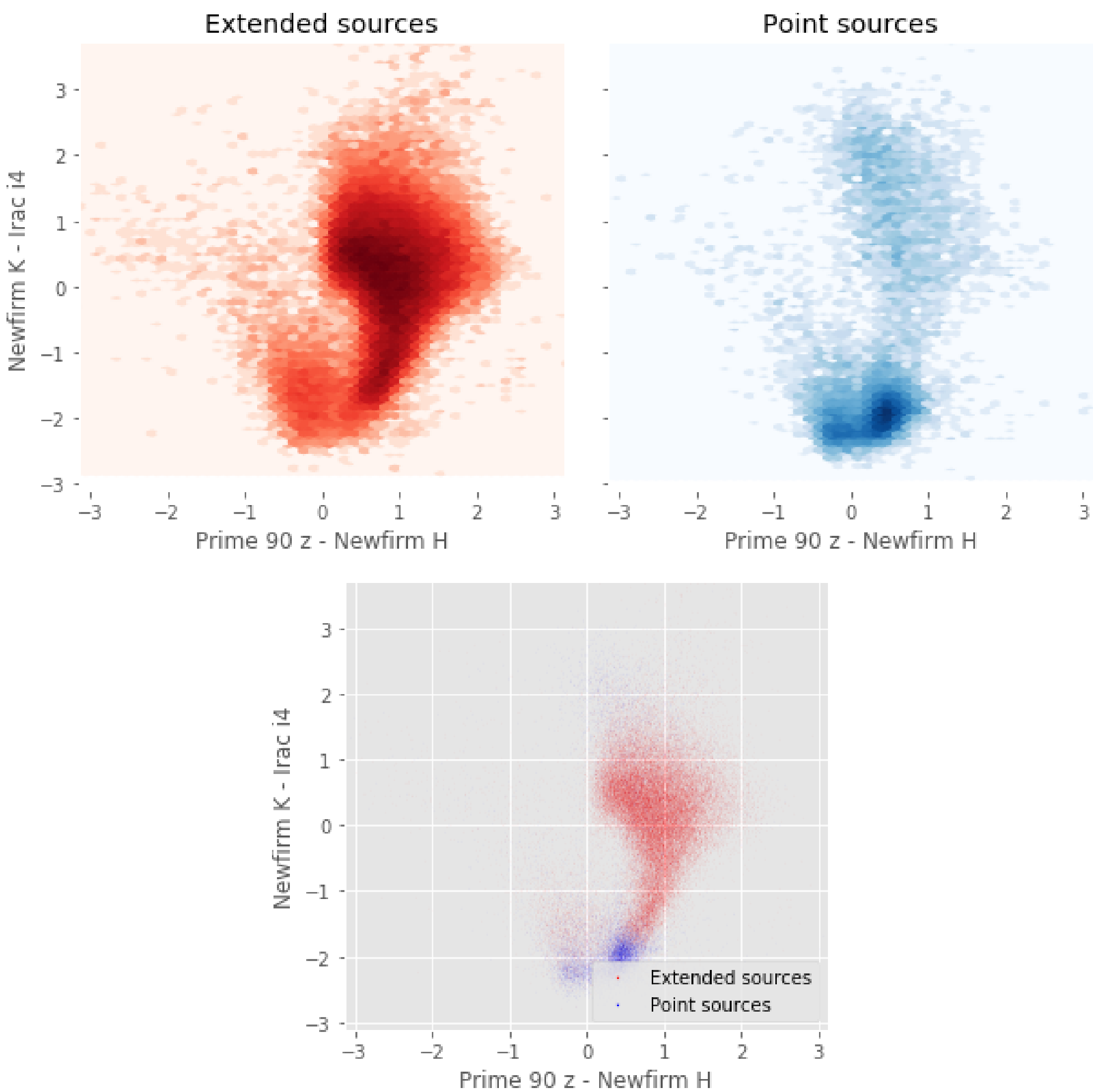





```
Number of source used: 41857 / 2252093 (1.86%)
```




```
Number of source used: 74417 / 2252093 (3.30%)
```


Extended sources
Point sources
Newfirm K - Irac i4
Prime 90 z - Newfirm H
Newfirm K - Irac i4
Prime 90 z - Newfirm H
Extended sources
Point sources

3.1_HELP_Checks_and_diagnostics

March 8, 2018

1 Bootes master catalogue

1.1 Checks and diagnostics

```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
This notebook was executed on:
2018-02-16 15:32:09.543265
```

```
Diagnostics done using: master_catalogue_bootes_20180216.fits
```

1.2 0 - Quick checks

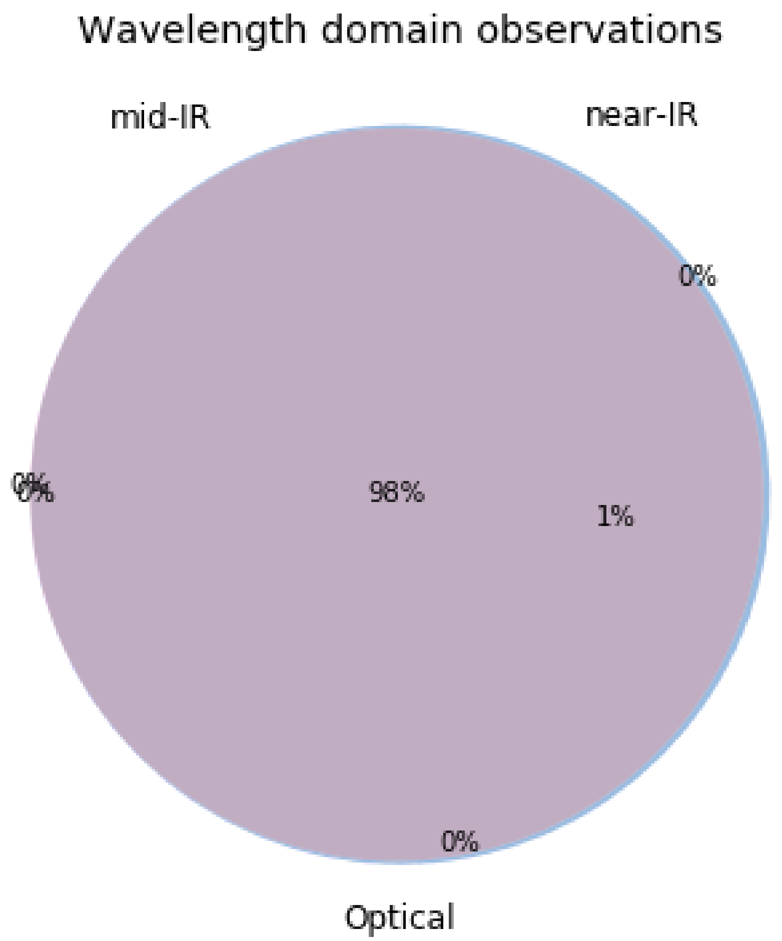
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/core/numeric.py:301:
  format(shape, fill_value, array(fill_value).dtype), FutureWarning)
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/core/numeric.py:301:
  format(shape, fill_value, array(fill_value).dtype), FutureWarning)
```

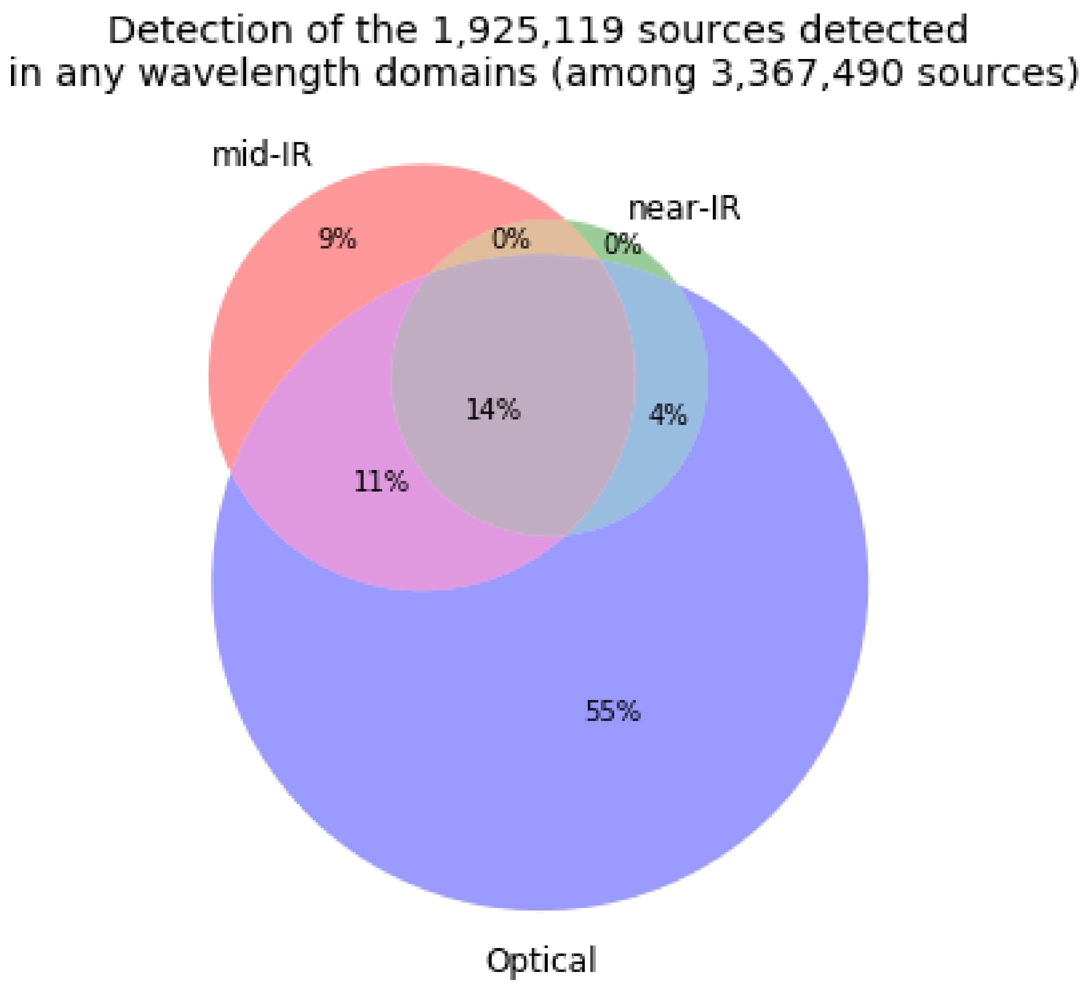
```
Table shows only problematic columns.
```

```
Out[4]: <IPython.core.display.HTML object>
```

1.3 I - Summary of wavelength domains

```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/matplotlib_venn/_venn3.py:
  warnings.warn("Bad circle positioning")
```


Wavelength domain observations
mid-IR
near-IR
0%
0%
0%
98%
1%
0%
Optical

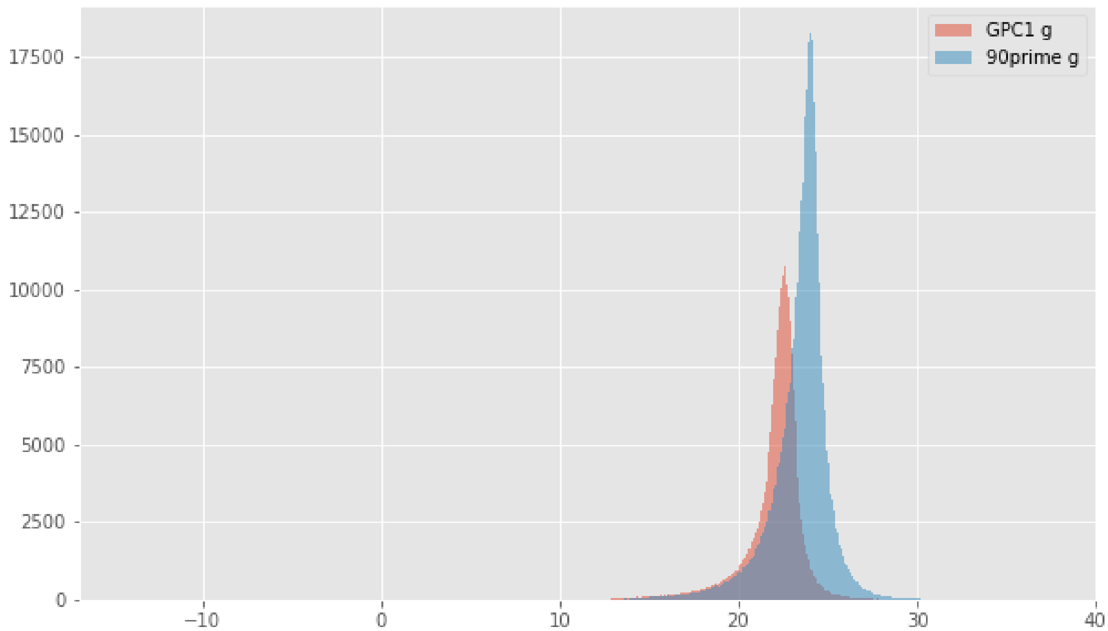


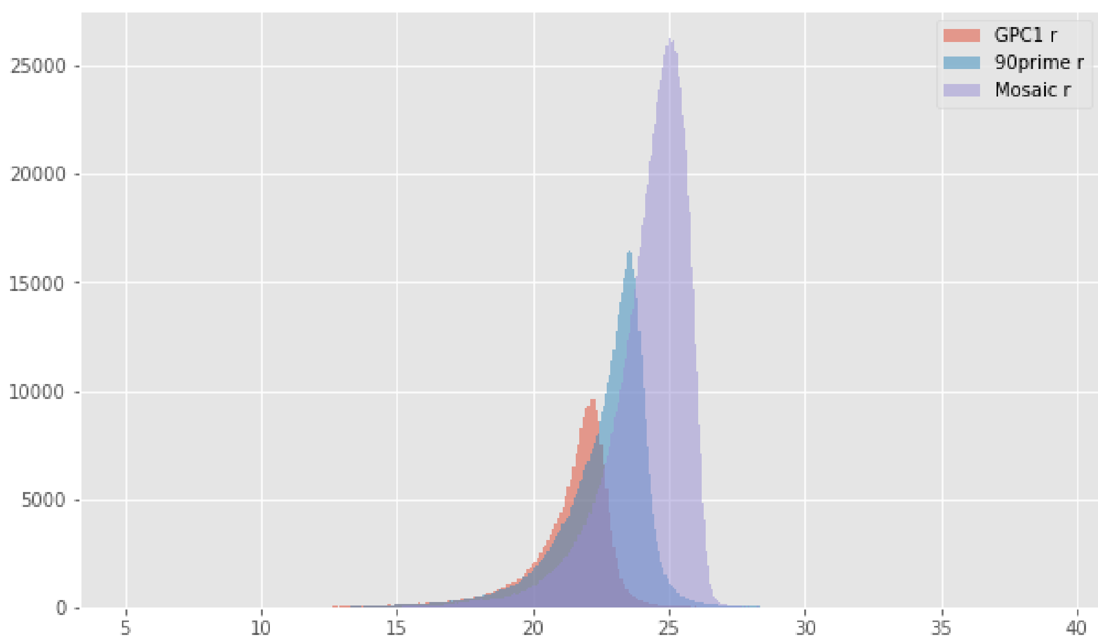
1.4 II - Comparing magnitudes in similar filters

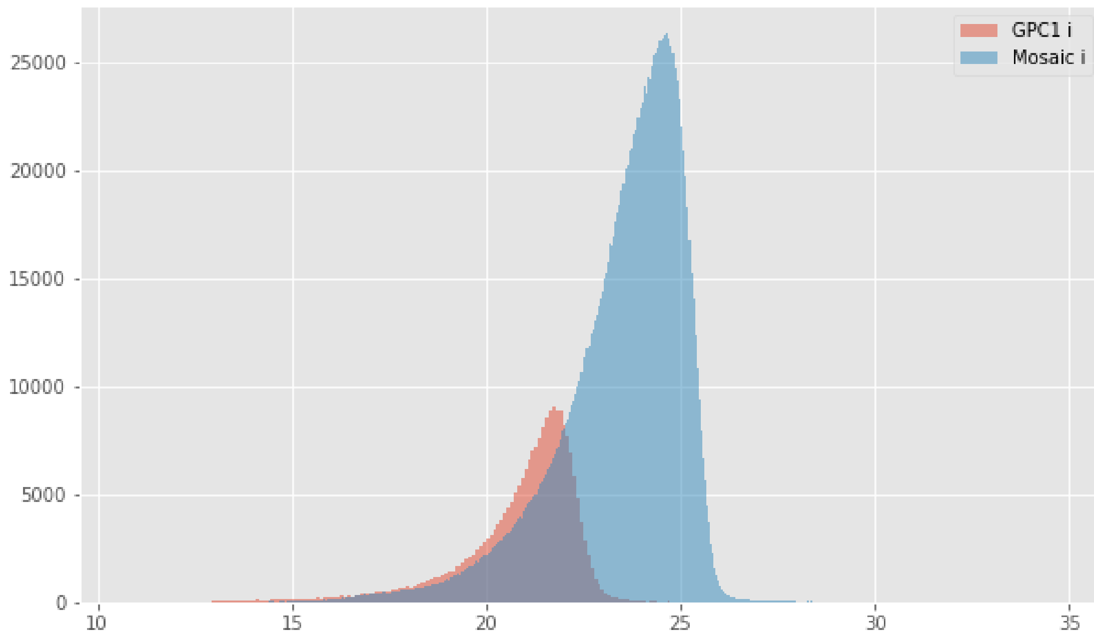
The master list if composed of several catalogues containing magnitudes in similar filters on different instruments. We are comparing the magnitudes in these corresponding filters.

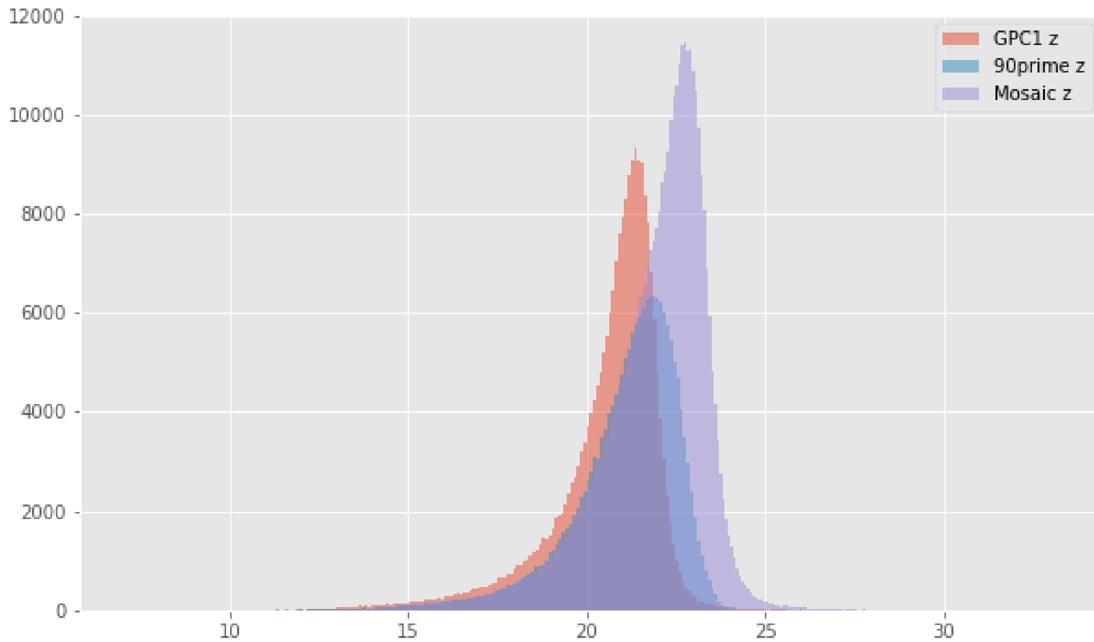
1.4.1 II.a - Comparing depths

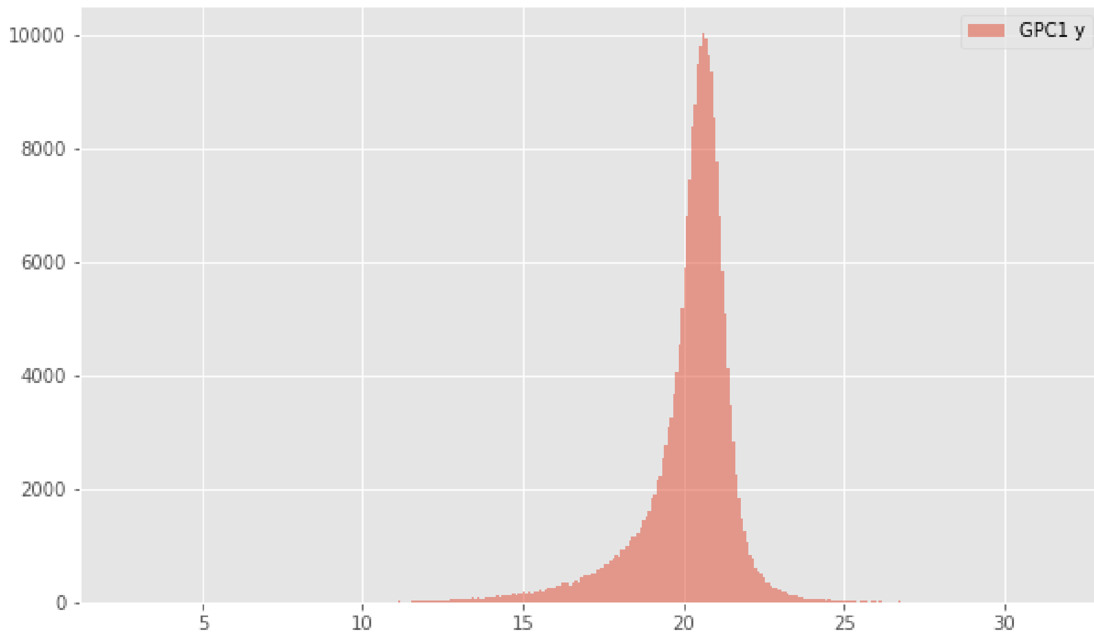
We compare the histograms of the total aperture magnitudes of similar bands.

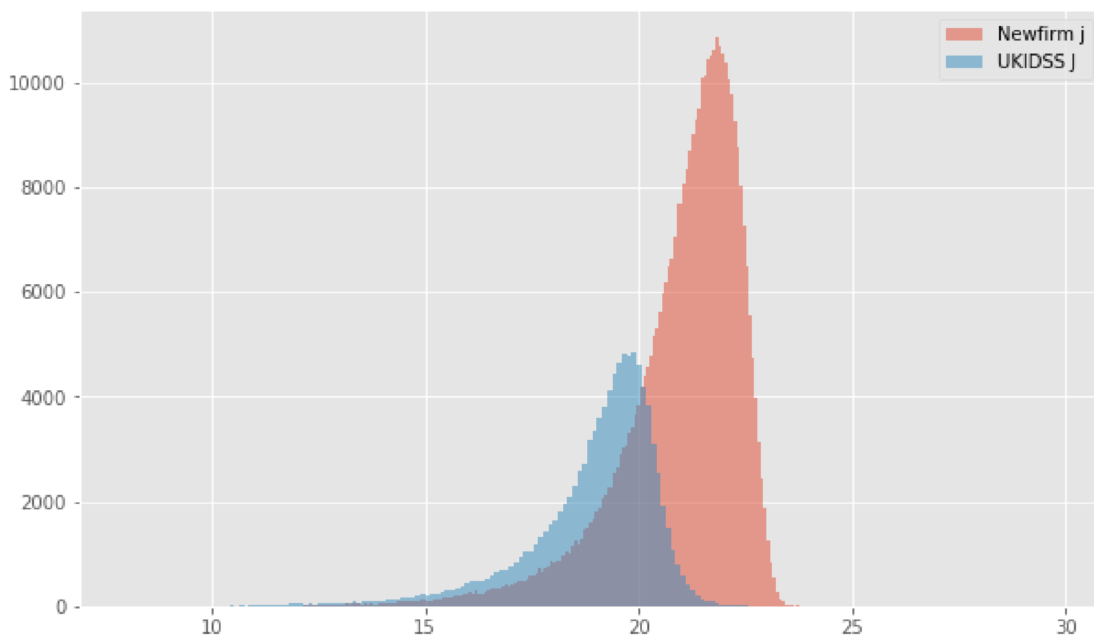

GPC1 g
90prime g

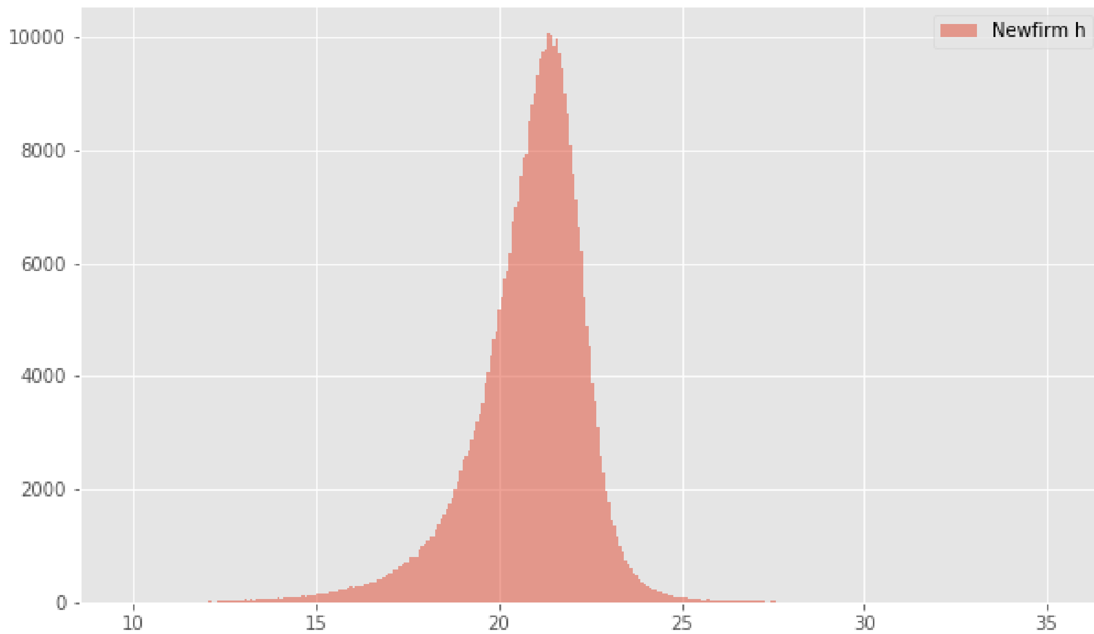

GPC1 r
90prime r
Mosaic r

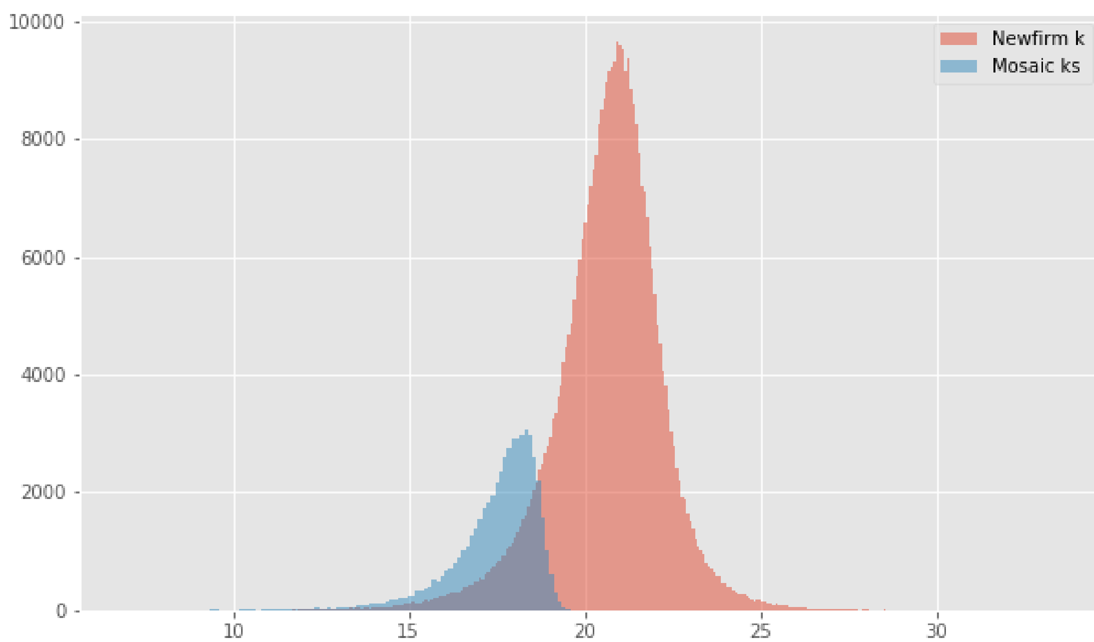

GPC1 i
Mosaic i
0
5000
10000
15000
20000
25000
10
15
20
25
30
35


GPC1 z
90prime z
Mosaic z
0
2000
4000
6000
8000
10000
12000
10
15
20
25
30


GPC1 y
10000
8000
6000
4000
2000
0
5
10
15
20
25
30


Newfirm j
UKIDSS J
10000
8000
6000
4000
2000
0
10
15
20
25
30

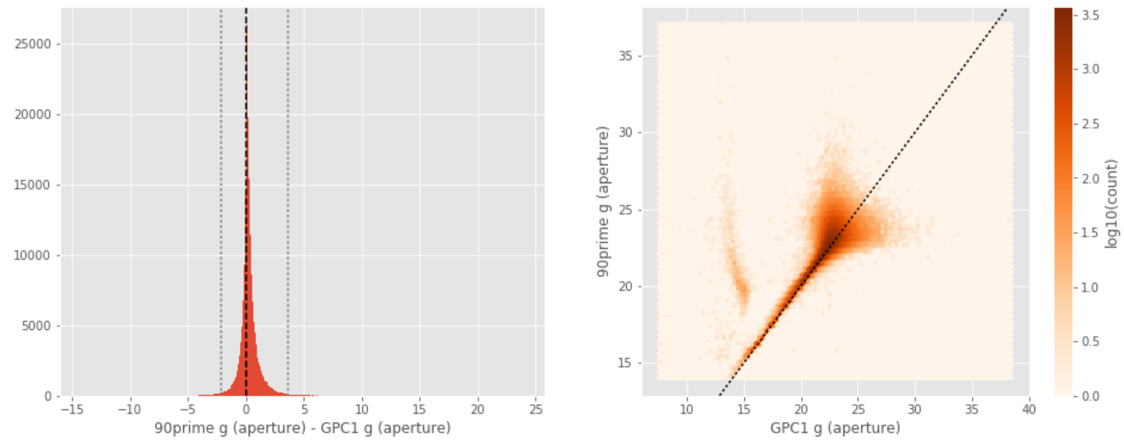




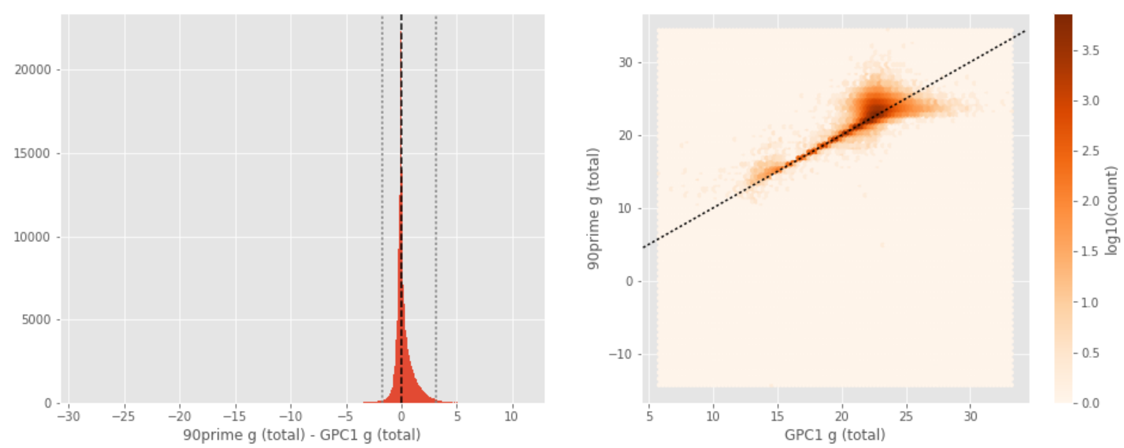
1.4.2 II.b - Comparing magnitudes

We compare one to one each magnitude in similar bands.

90prime g (aperture) - GPC1 g (aperture):
- Median: 0.13
- Median Absolute Deviation: 0.28
- 1% percentile: -2.155585498809814
- 99% percentile: 3.624781532287597

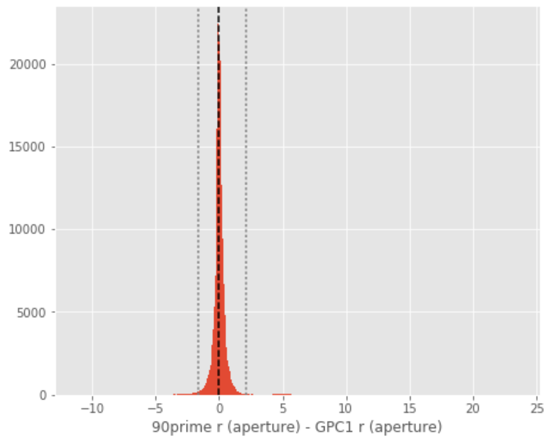


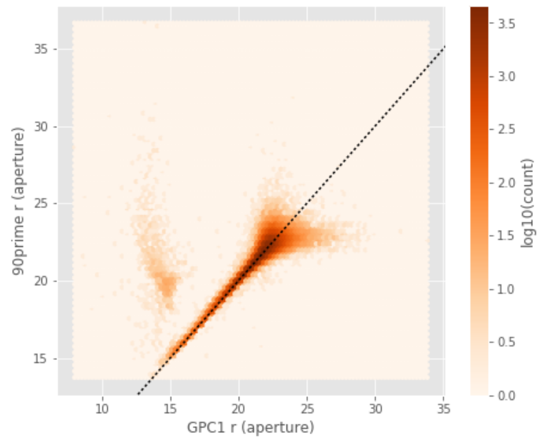
90prime g (total) - GPC1 g (total):
- Median: 0.01
- Median Absolute Deviation: 0.27
- 1% percentile: -1.7590976715087892
- 99% percentile: 3.169687080383299



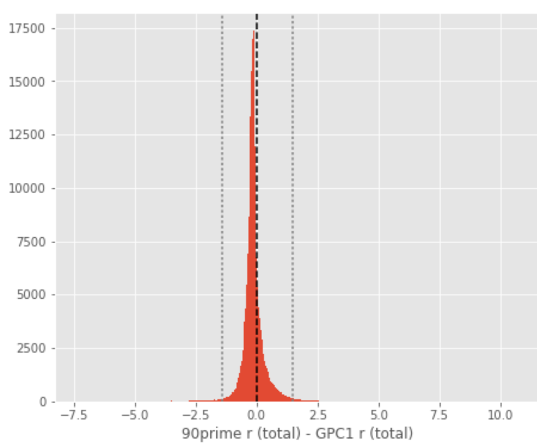
90prime r (aperture) - GPC1 r (aperture):
- Median: 0.01

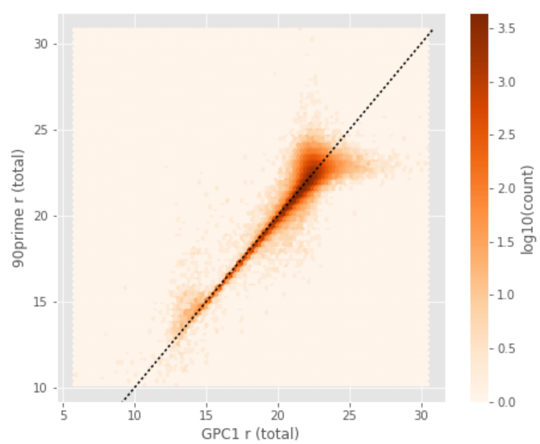
- Median Absolute Deviation: 0.19
- 1% percentile: -1.6502815246582032
- 99% percentile: 2.0886983489990416





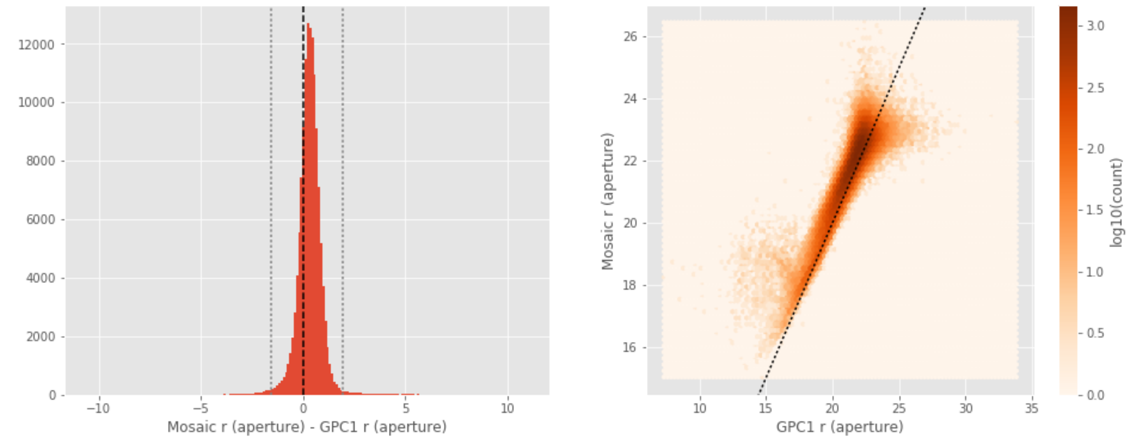
90prime r (total) - GPC1 r (total):
- Median: -0.16
- Median Absolute Deviation: 0.15
- 1% percentile: -1.4110116958618164
- 99% percentile: 1.4679595470428541



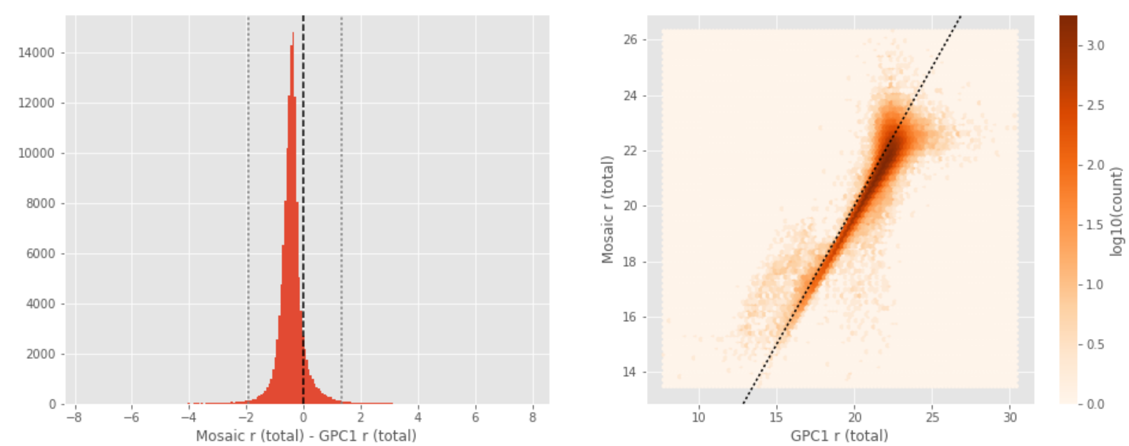


Mosaic r (aperture) - GPC1 r (aperture):
- Median: 0.32
- Median Absolute Deviation: 0.30
- 1% percentile: -1.5544843161315907

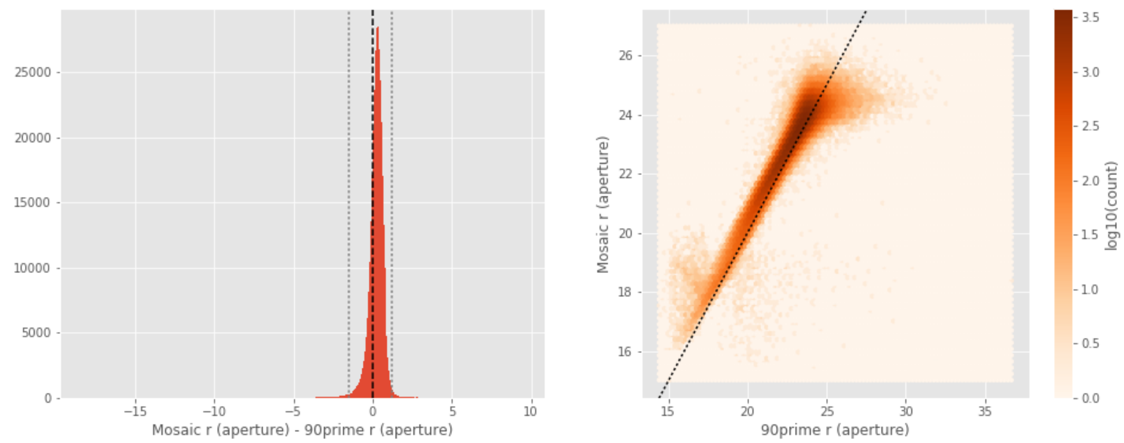
- 99% percentile: 1.9548135873107895



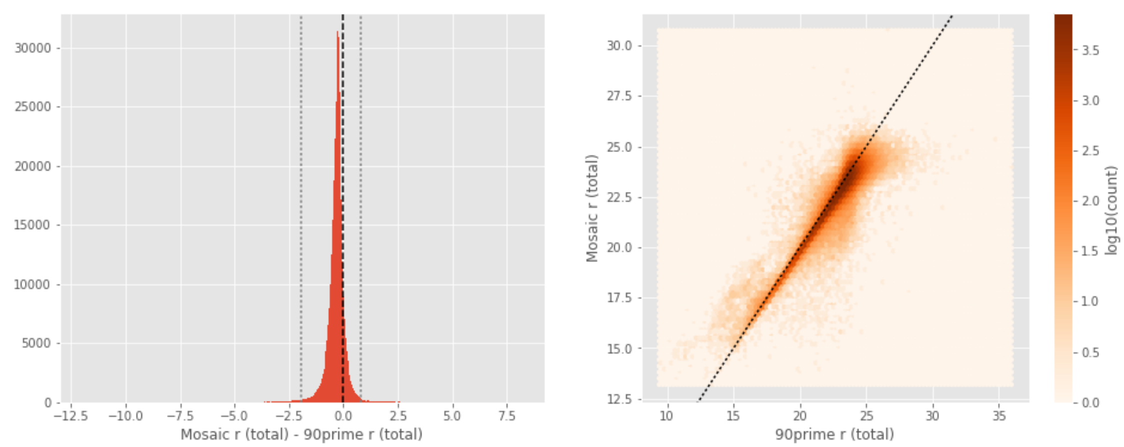
Mosaic r (total) - GPC1 r (total):
- Median: -0.42
- Median Absolute Deviation: 0.18
- 1% percentile: -1.943467480041504
- 99% percentile: 1.329669850311278



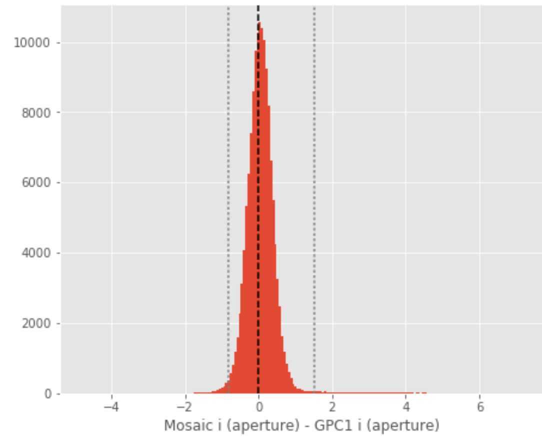
Mosaic r (aperture) - 90prime r (aperture):
- Median: 0.26
- Median Absolute Deviation: 0.24
- 1% percentile: -1.5054437175292976
- 99% percentile: 1.1909500275878915

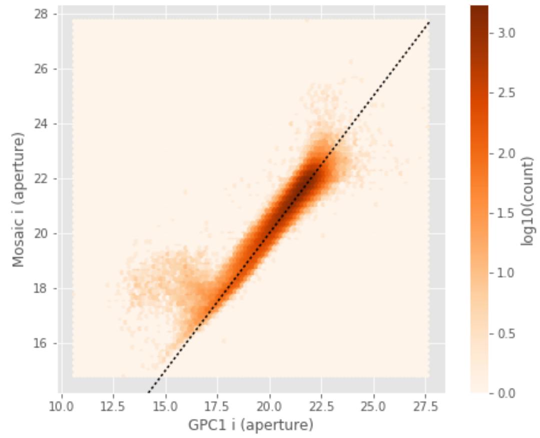


Mosaic r (total) - 90prime r (total):
- Median: -0.29
- Median Absolute Deviation: 0.16
- 1% percentile: -1.9401695947265618
- 99% percentile: 0.8002936804199177

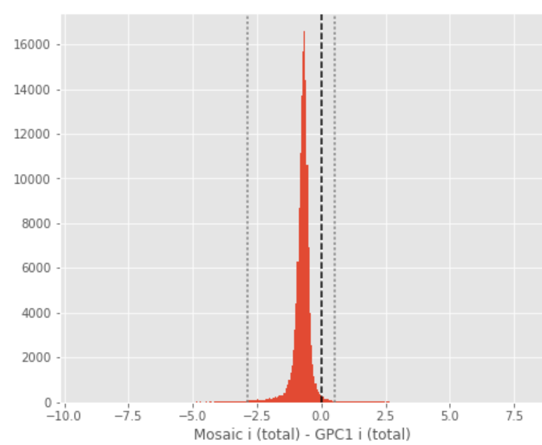


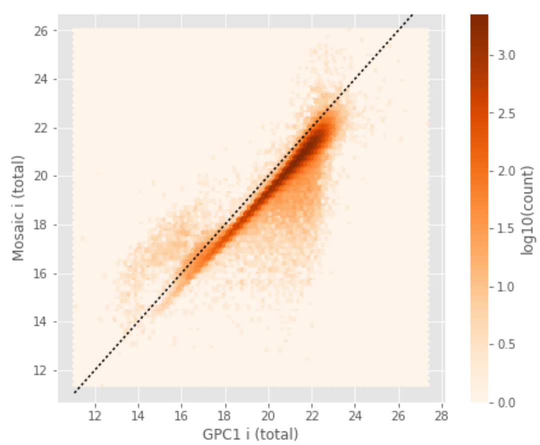
Mosaic i (aperture) - GPC1 i (aperture):
- Median: 0.05
- Median Absolute Deviation: 0.22
- 1% percentile: -0.8176070034484872
- 99% percentile: 1.530052434539797



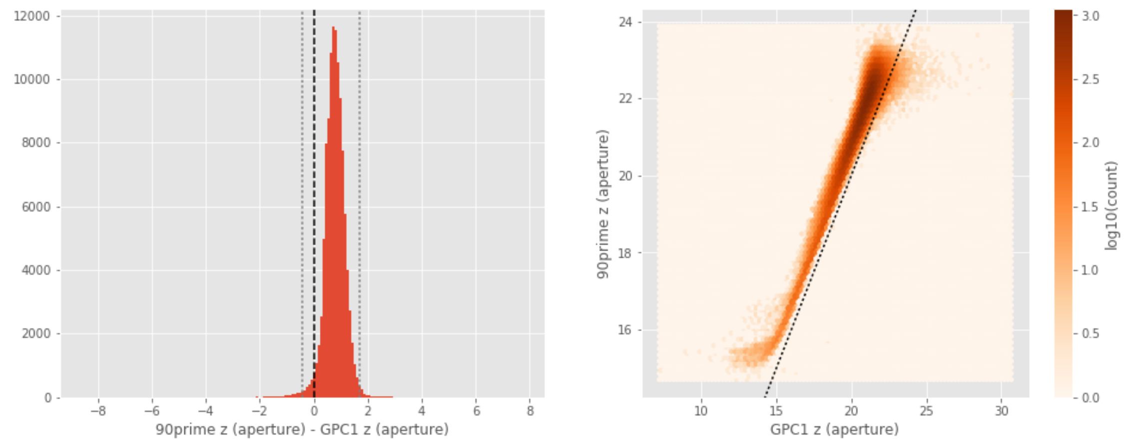



```
Mosaic i (total) - GPC1 i (total):
- Median: -0.70
- Median Absolute Deviation: 0.13
- 1% percentile: -2.8846997500000002
- 99% percentile: 0.5335755195922849
```

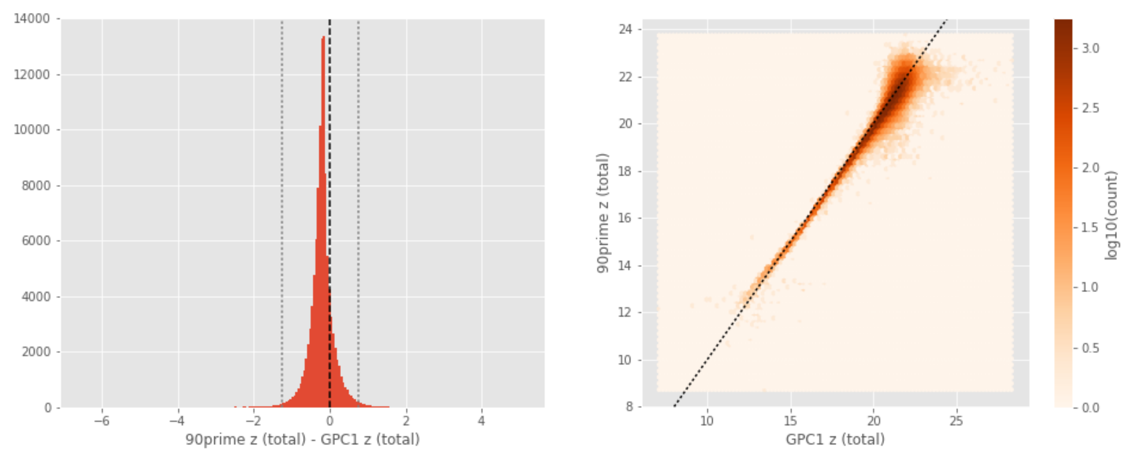




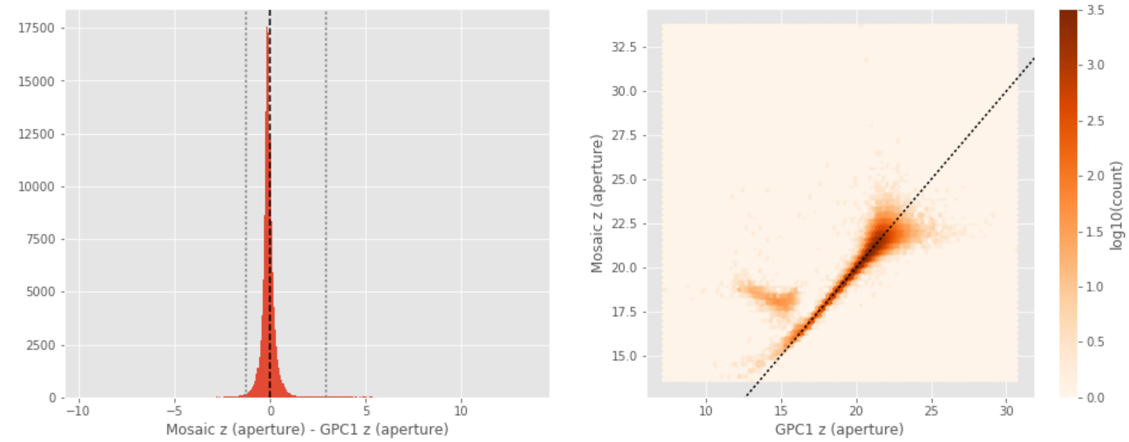

```
90prime z (aperture) - GPC1 z (aperture):
- Median: 0.80
- Median Absolute Deviation: 0.23
- 1% percentile: -0.4324053764343262
- 99% percentile: 1.6814002990722656
```



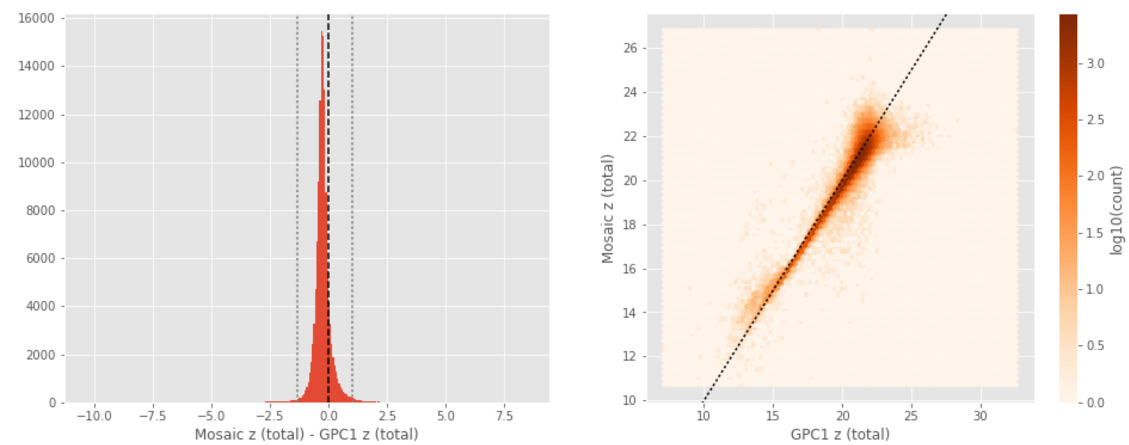
90prime z (total) - GPC1 z (total):
- Median: -0.20
- Median Absolute Deviation: 0.13
- 1% percentile: -1.2465244674682616
- 99% percentile: 0.7506563568115232



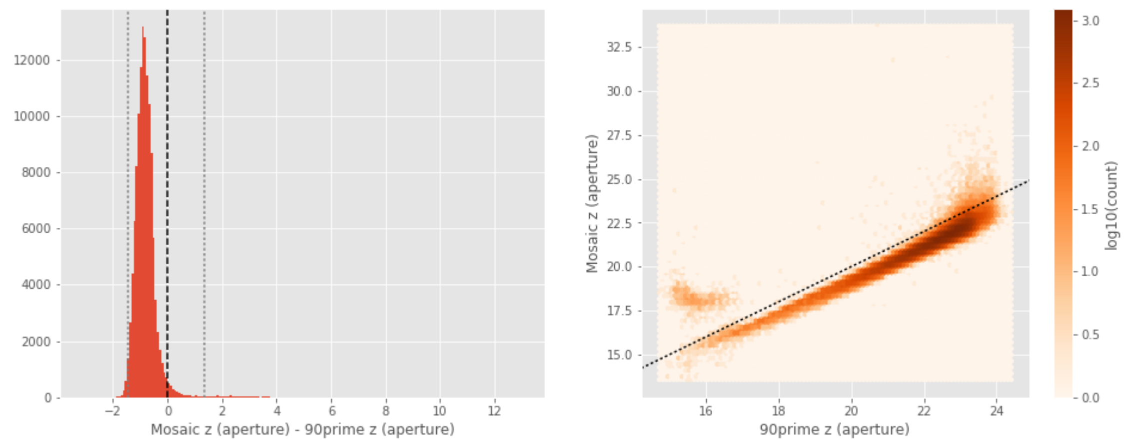
Mosaic z (aperture) - GPC1 z (aperture):
- Median: -0.10
- Median Absolute Deviation: 0.14
- 1% percentile: -1.273350944519043
- 99% percentile: 2.943321847915648



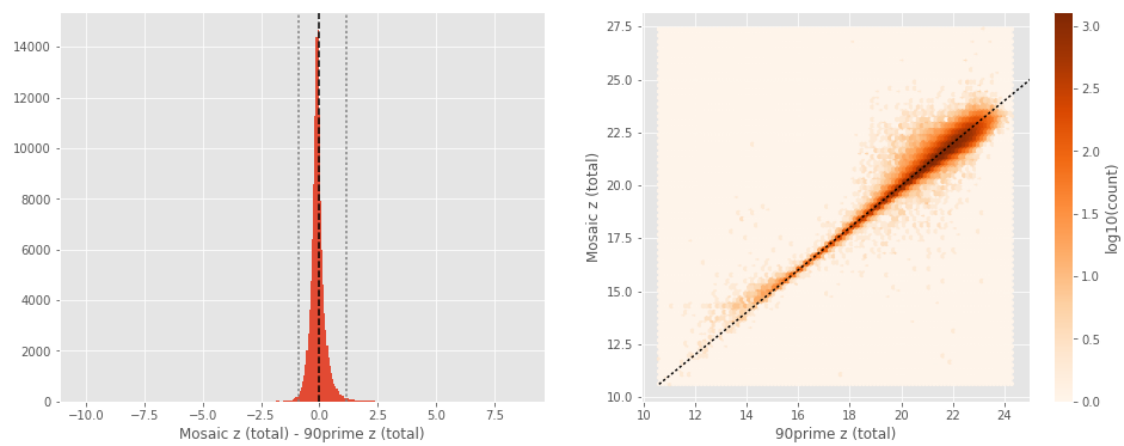
Mosaic z (total) - GPC1 z (total):
- Median: -0.28
- Median Absolute Deviation: 0.14
- 1% percentile: -1.3329715728759766
- 99% percentile: 0.9828605651855469



Mosaic z (aperture) - 90prime z (aperture):
- Median: -0.85
- Median Absolute Deviation: 0.20
- 1% percentile: -1.4725195503234862
- 99% percentile: 1.348368835449227




```
Mosaic z (total) - 90prime z (total):
- Median: -0.09
- Median Absolute Deviation: 0.15
- 1% percentile: -0.8643741989135741
- 99% percentile: 1.1813443374633783
```



1.5 III - Comparing magnitudes to reference bands

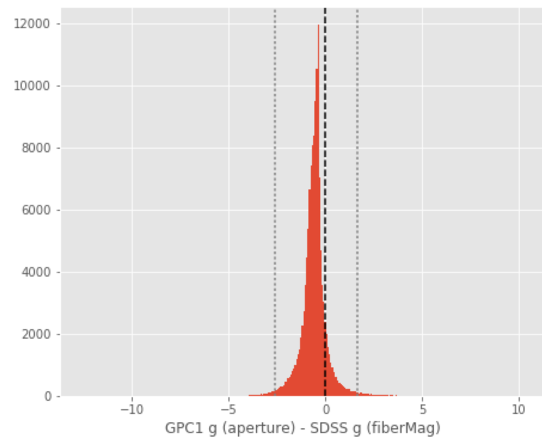
Cross-match the master list to SDSS and 2MASS to compare its magnitudes to SDSS and 2MASS ones.

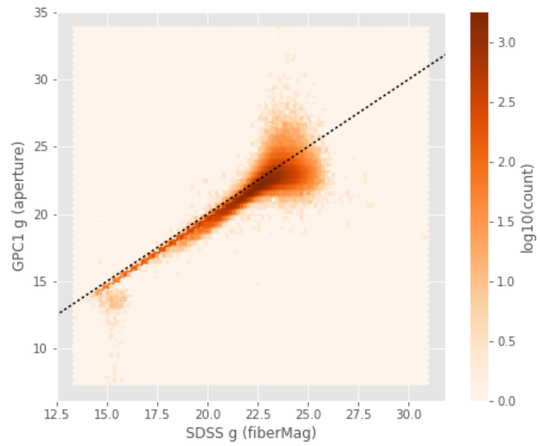
1.5.1 III.a - Comparing u, g, r, i, and z bands to SDSS

The catalogue is cross-matched to SDSS-DR13 withing 0.2 arcsecond.

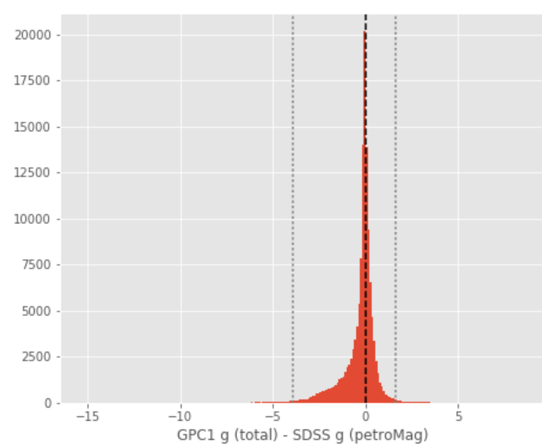
We compare the u, g, r, i, and z magnitudes to those from SDSS using `fiberMag` for the aperture magnitude and `petroMag` for the total magnitude.

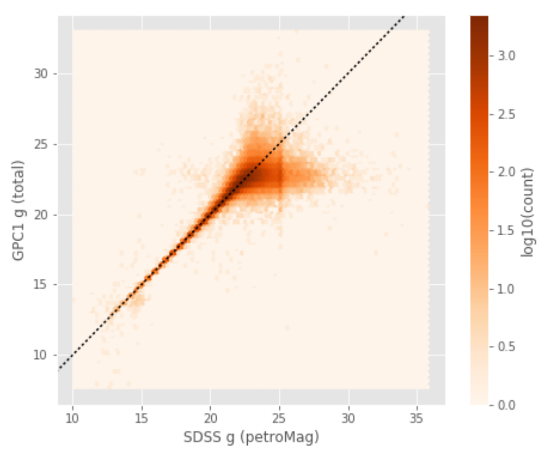
GPC1 g (aperture) - SDSS g (fiberMag):
- Median: -0.55
- Median Absolute Deviation: 0.27
- 1% percentile: -2.6034235382080078
- 99% percentile: 1.6591714096069339





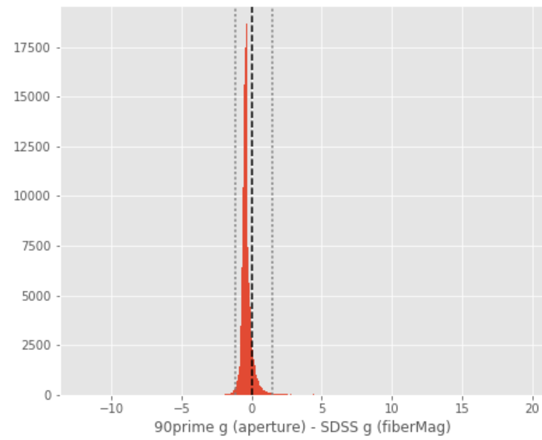
GPC1 g (total) - SDSS g (petroMag):
- Median: -0.07
- Median Absolute Deviation: 0.26
- 1% percentile: -3.896455383300781
- 99% percentile: 1.6326969146728527

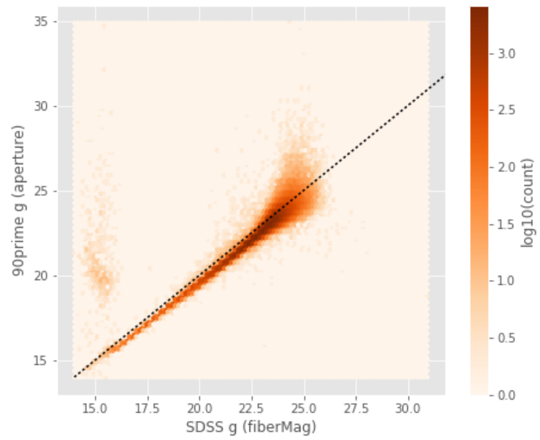




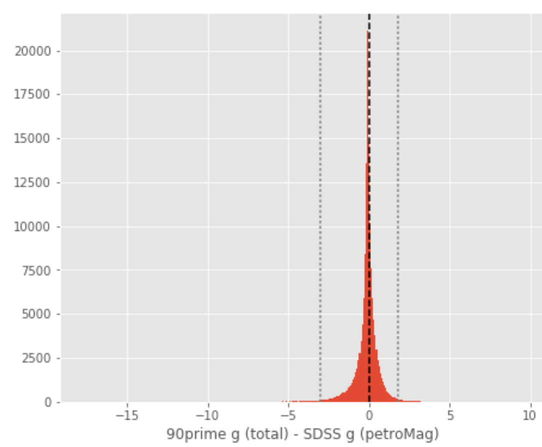
90prime g (aperture) - SDSS g (fiberMag):
- Median: -0.41

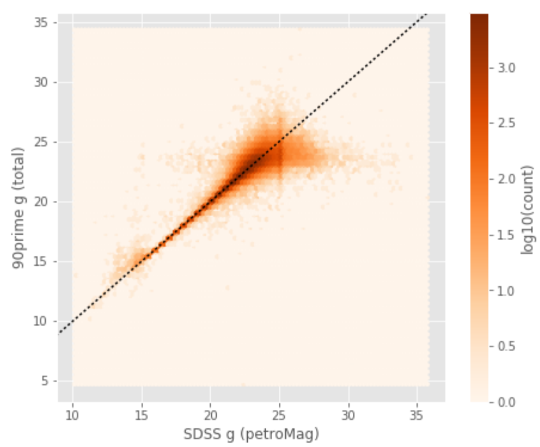
- Median Absolute Deviation: 0.15
- 1% percentile: -1.141006317138672
- 99% percentile: 1.5004376983642955





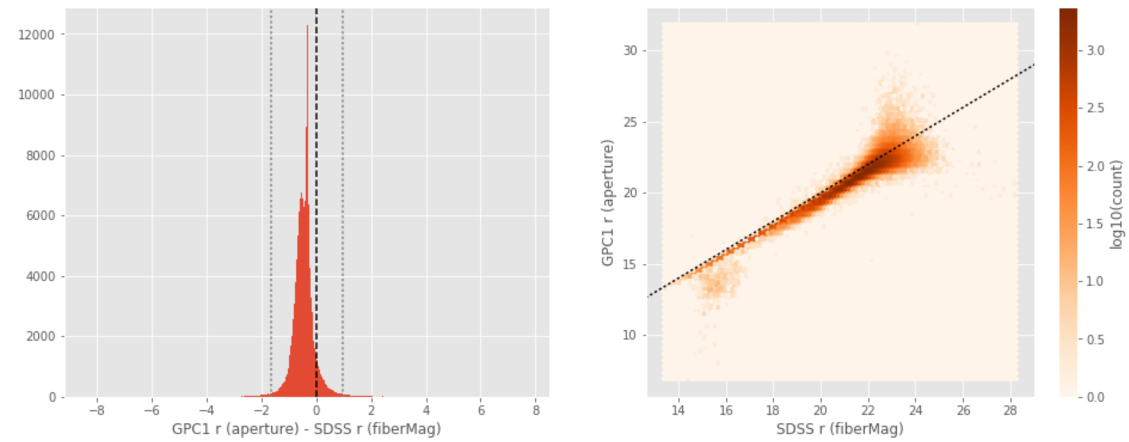
90prime g (total) - SDSS g (petroMag):
- Median: -0.08
- Median Absolute Deviation: 0.22
- 1% percentile: -3.02459077835083
- 99% percentile: 1.7892504882812421



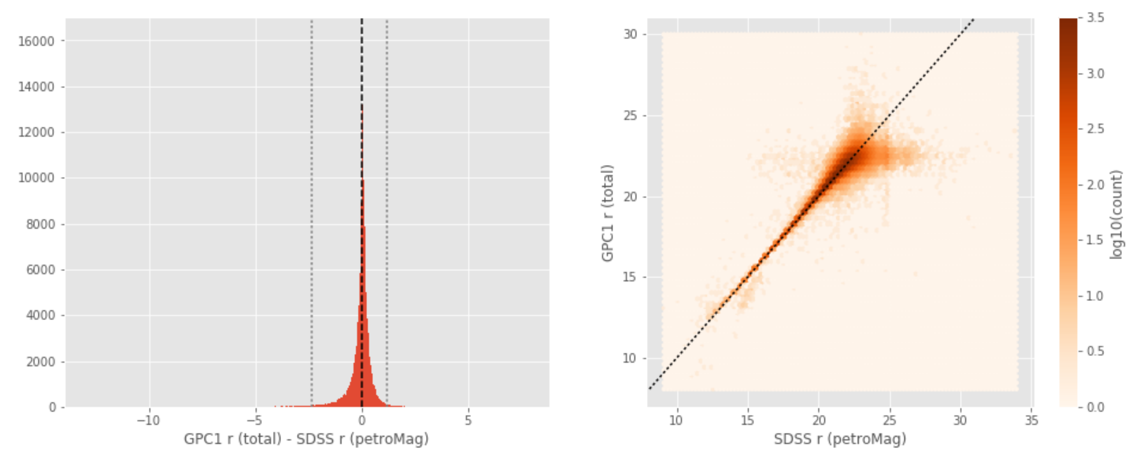


GPC1 r (aperture) - SDSS r (fiberMag):
- Median: -0.45
- Median Absolute Deviation: 0.18
- 1% percentile: -1.6361807250976563

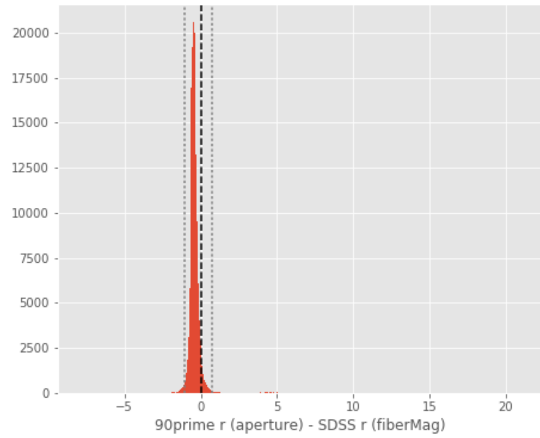
- 99% percentile: 0.9835488510131456

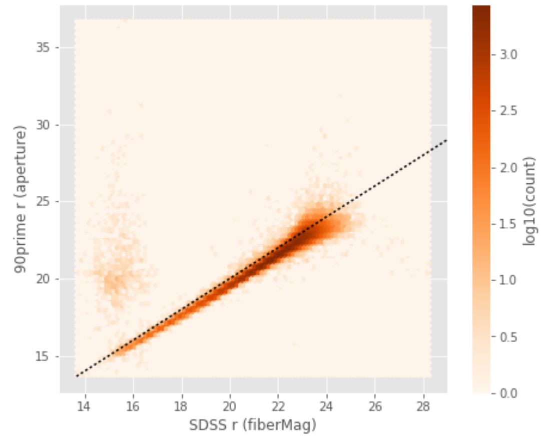


GPC1 r (total) - SDSS r (petroMag):
- Median: 0.03
- Median Absolute Deviation: 0.15
- 1% percentile: -2.361153564453125
- 99% percentile: 1.1698699951171851

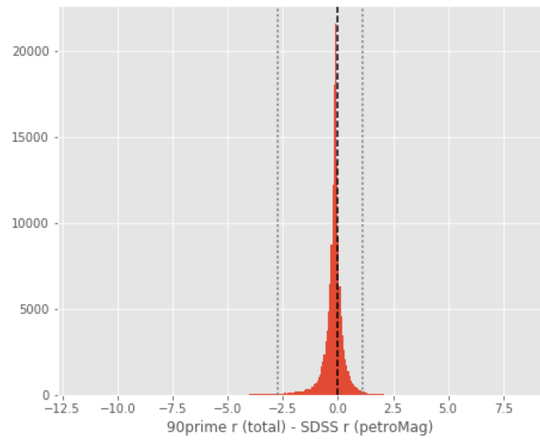


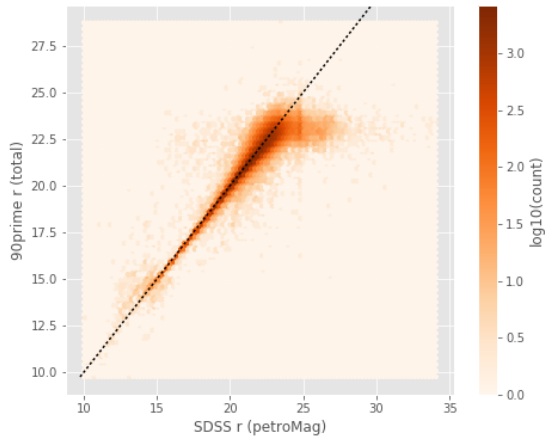
90prime r (aperture) - SDSS r (fiberMag):
- Median: -0.45
- Median Absolute Deviation: 0.14
- 1% percentile: -1.0851825714111327
- 99% percentile: 0.7316936492919939



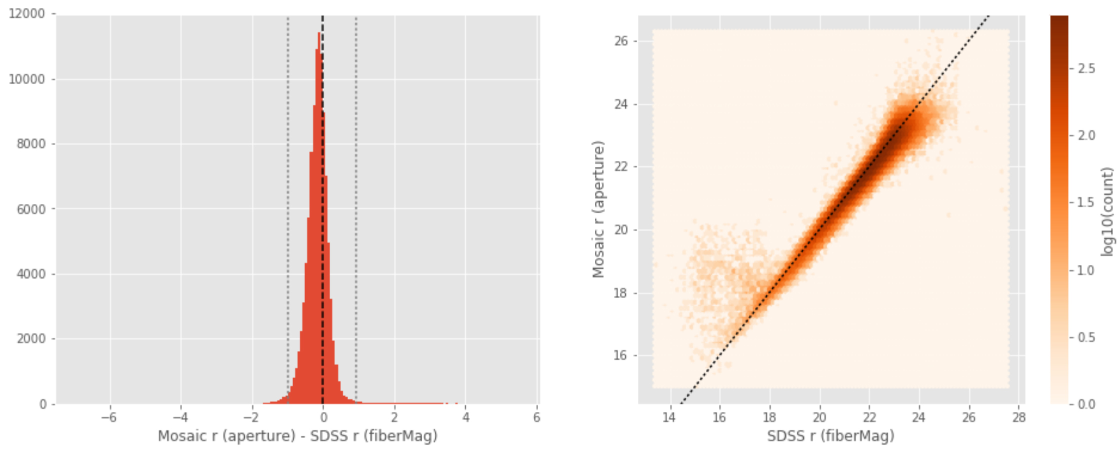


90prime r (total) - SDSS r (petroMag):
- Median: -0.14
- Median Absolute Deviation: 0.15
- 1% percentile: -2.719879722595215
- 99% percentile: 1.1122964859008788

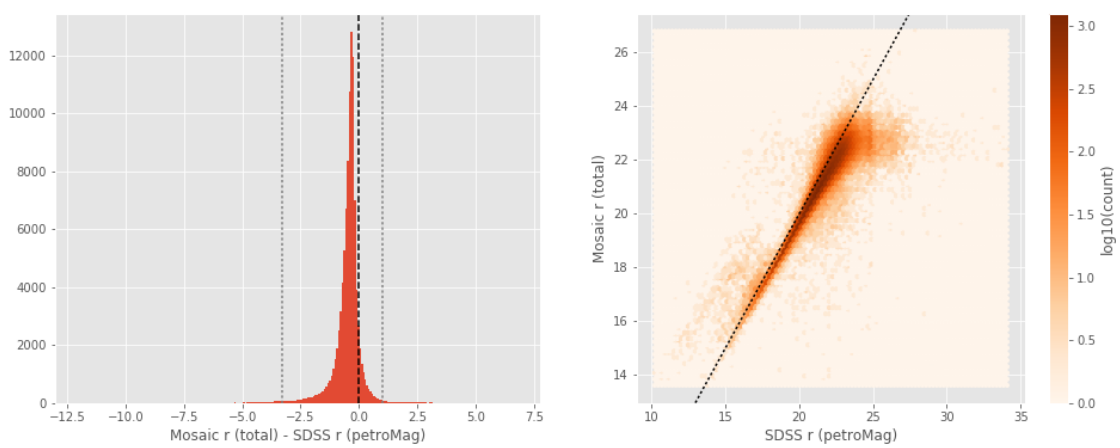




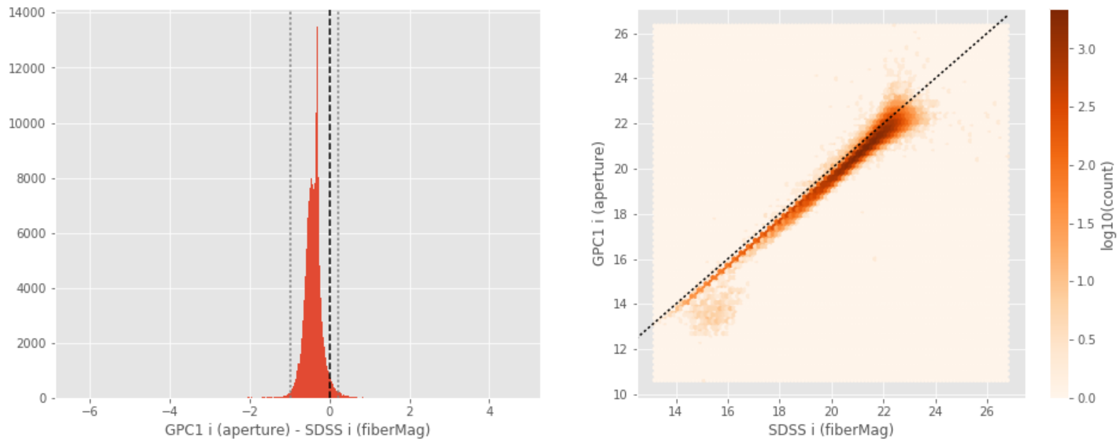
Mosaic r (aperture) - SDSS r (fiberMag):
- Median: -0.14
- Median Absolute Deviation: 0.17
- 1% percentile: -0.992687671081544
- 99% percentile: 0.9426418008422859



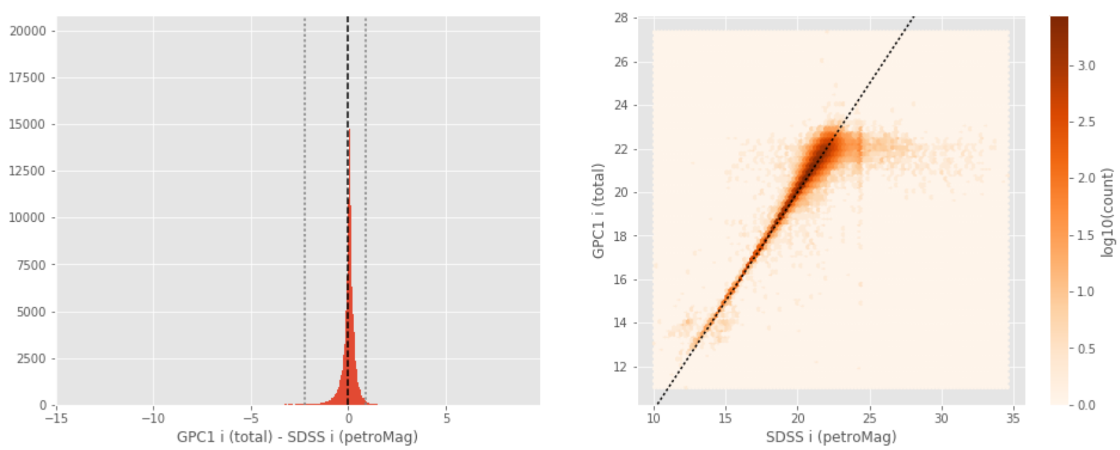
Mosaic r (total) - SDSS r (petroMag):
- Median: -0.39
- Median Absolute Deviation: 0.19
- 1% percentile: -3.2769409339904785
- 99% percentile: 1.0008374284362809



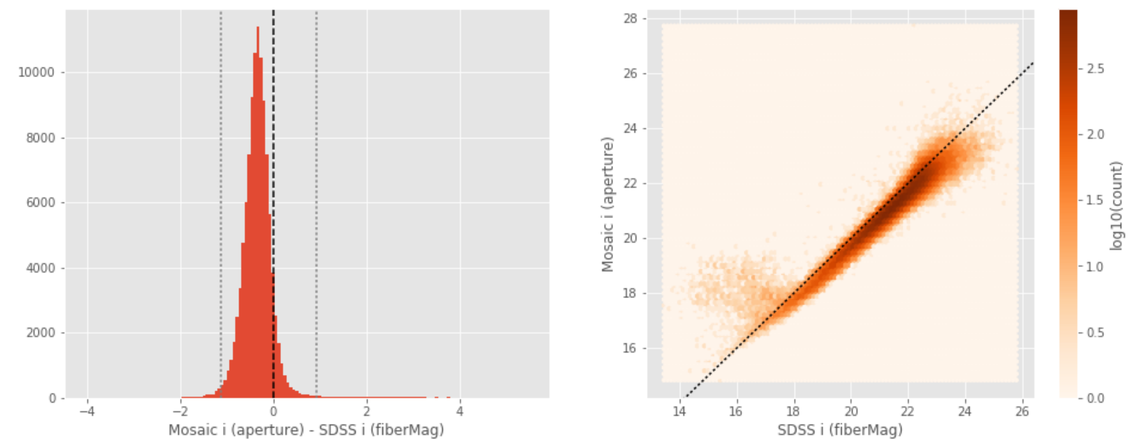
GPC1 i (aperture) - SDSS i (fiberMag):
- Median: -0.41
- Median Absolute Deviation: 0.11
- 1% percentile: -0.9914297962188721
- 99% percentile: 0.2297468376159671



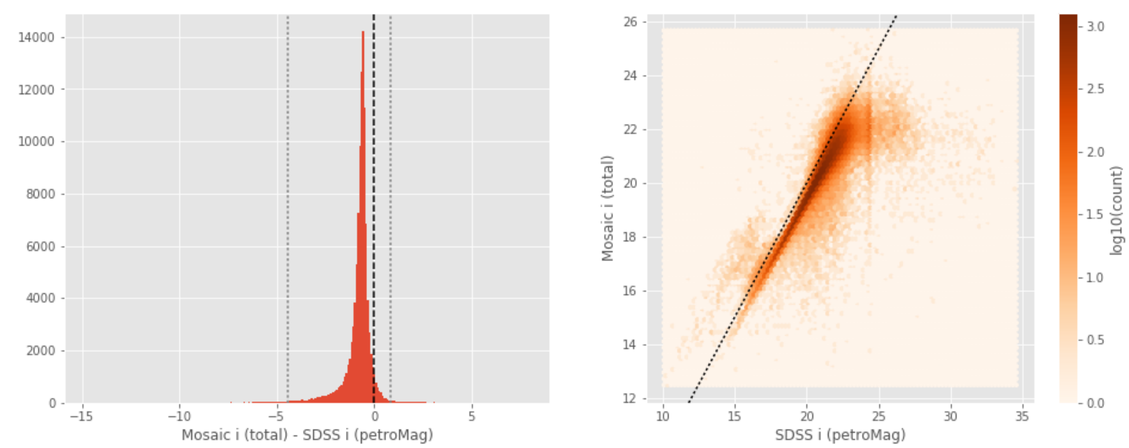
GPC1 i (total) - SDSS i (petroMag):
- Median: 0.05
- Median Absolute Deviation: 0.12
- 1% percentile: -2.2184738159179687
- 99% percentile: 0.8837654113769535



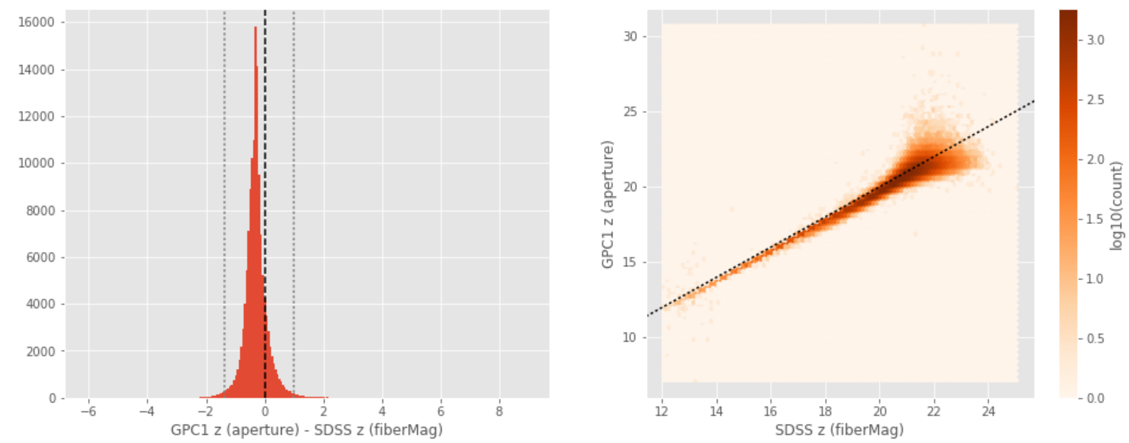
Mosaic i (aperture) - SDSS i (fiberMag):
- Median: -0.35
- Median Absolute Deviation: 0.17
- 1% percentile: -1.1286938219909677
- 99% percentile: 0.9205190791931039



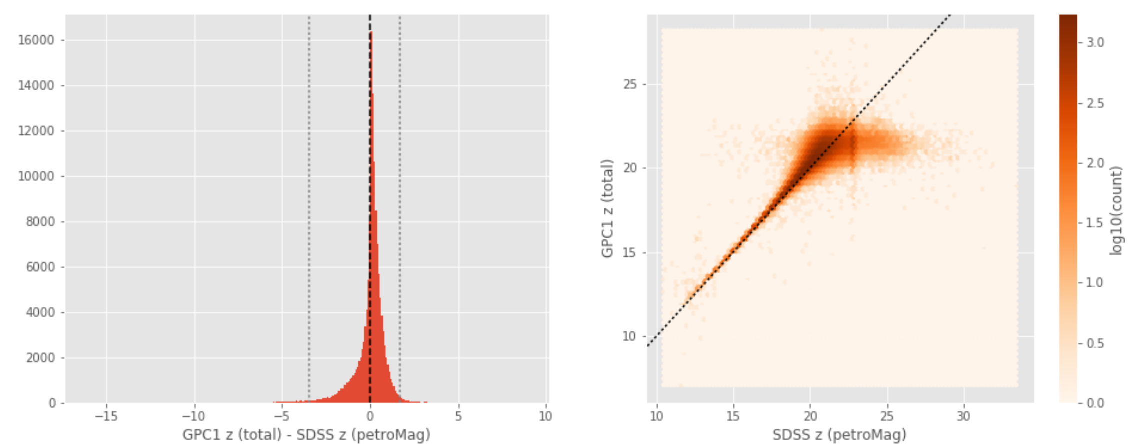
Mosaic i (total) - SDSS i (petroMag):
- Median: -0.64
- Median Absolute Deviation: 0.20
- 1% percentile: -4.426645225555419
- 99% percentile: 0.8262593407287586



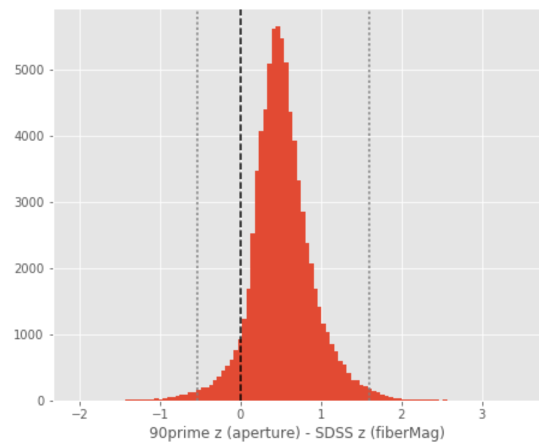
GPC1 z (aperture) - SDSS z (fiberMag):
- Median: -0.30
- Median Absolute Deviation: 0.18
- 1% percentile: -1.356192569732666
- 99% percentile: 0.9832890510559065

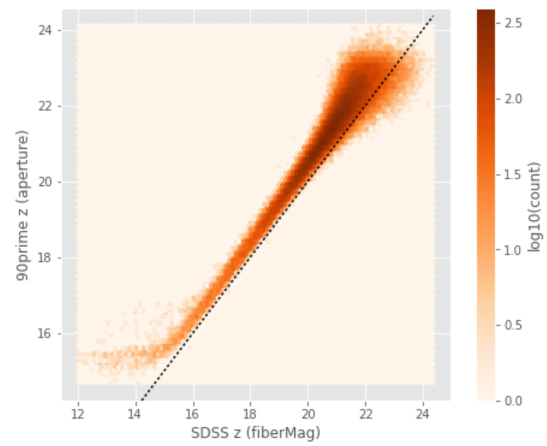


GPC1 z (total) - SDSS z (petroMag):
- Median: 0.13
- Median Absolute Deviation: 0.29
- 1% percentile: -3.4653361892700194
- 99% percentile: 1.7037193870544391

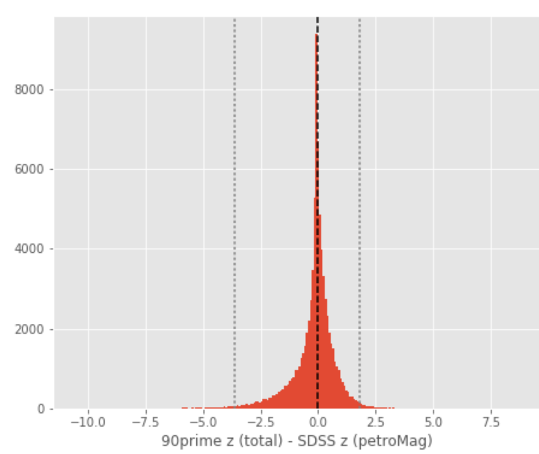


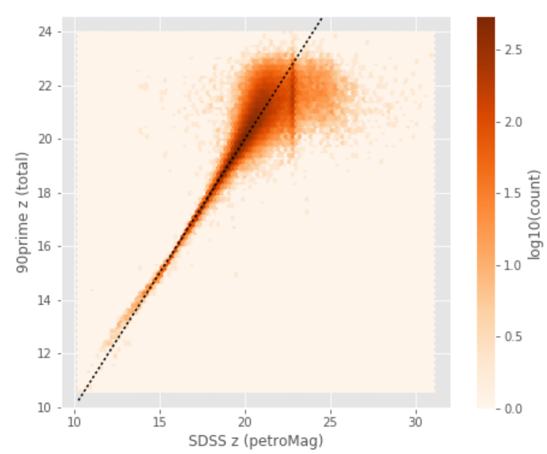
90prime z (aperture) - SDSS z (fiberMag):
- Median: 0.49
- Median Absolute Deviation: 0.21
- 1% percentile: -0.5398445129394531
- 99% percentile: 1.6009175300598149



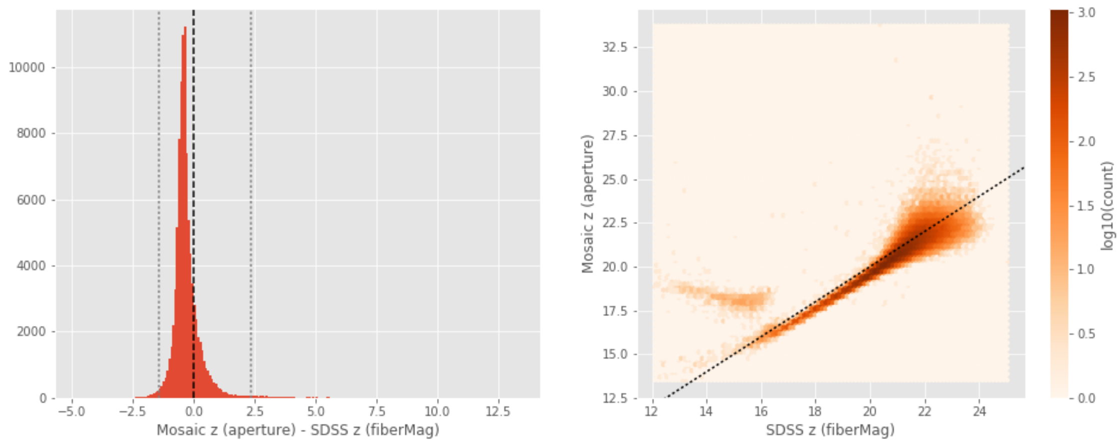


90prime z (total) - SDSS z (petroMag):
- Median: -0.05
- Median Absolute Deviation: 0.33
- 1% percentile: -3.641415214538574
- 99% percentile: 1.8106690406799348

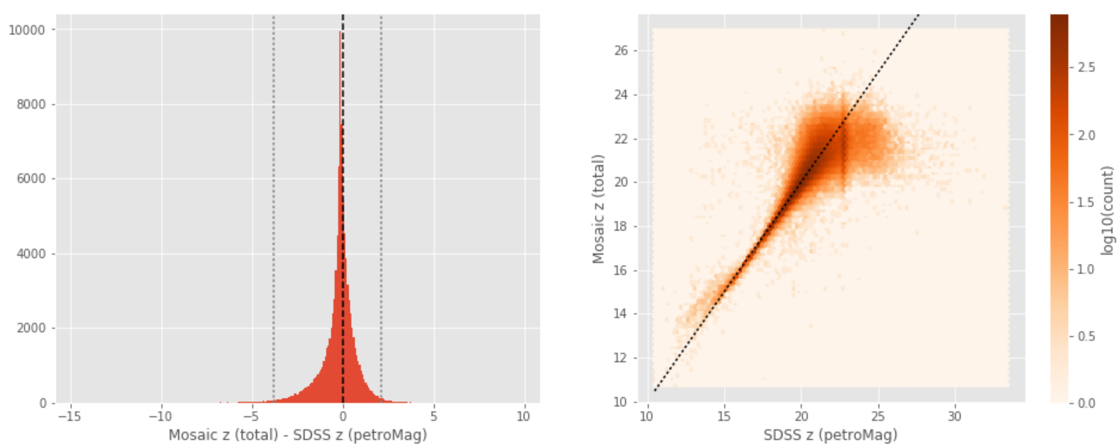




Mosaic z (aperture) - SDSS z (fiberMag):
- Median: -0.38
- Median Absolute Deviation: 0.21
- 1% percentile: -1.4303787994384767
- 99% percentile: 2.3451140403747566




```
Mosaic z (total) - SDSS z (petroMag):
- Median: -0.11
- Median Absolute Deviation: 0.36
- 1% percentile: -3.817288665771484
- 99% percentile: 2.1045574188232425
```



1.5.2 III.b - Comparing J and K bands to 2MASS

The catalogue is cross-matched to 2MASS-PSC withing 0.2 arcsecond. We compare the UKIDSS total J and K magnitudes to those from 2MASS.

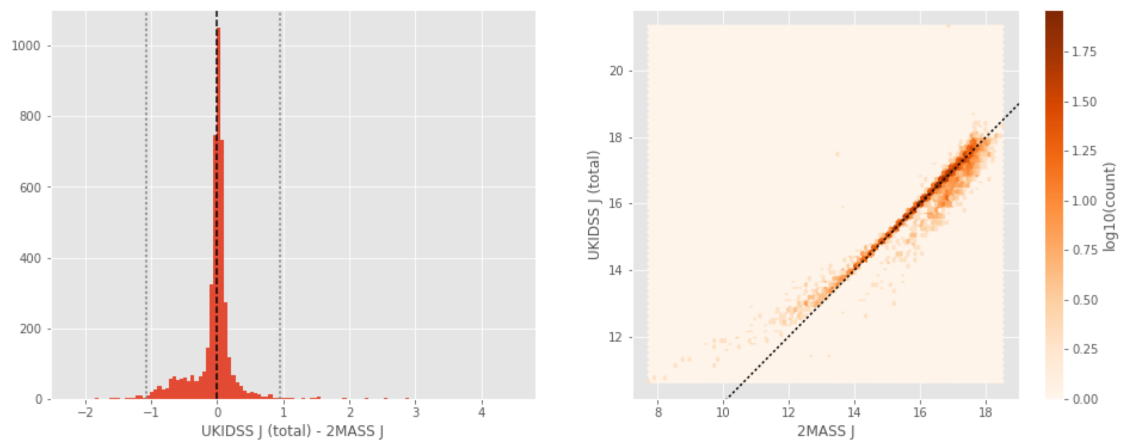
The 2MASS magnitudes are "*Vega-like*" and we have to convert them to AB magnitudes using the zero points provided on this page:

Band	F - 0 mag (Jy)
J	1594
H	1024
Ks	666.7

In addition, UKIDSS uses a K band whereas 2MASS uses a Ks ("short") band, this page give a correction to convert the K band in a Ks band with the formula:

$$K_{s(2MASS)} = K_{UKIRT} + 0.003 + 0.004 * (JK)_{UKIRT}$$

```
UKIDSS J (total) - 2MASS J:
- Median: 0.01
- Median Absolute Deviation: 0.07
- 1% percentile: -1.0741553665067496
- 99% percentile: 0.948345327768152
```



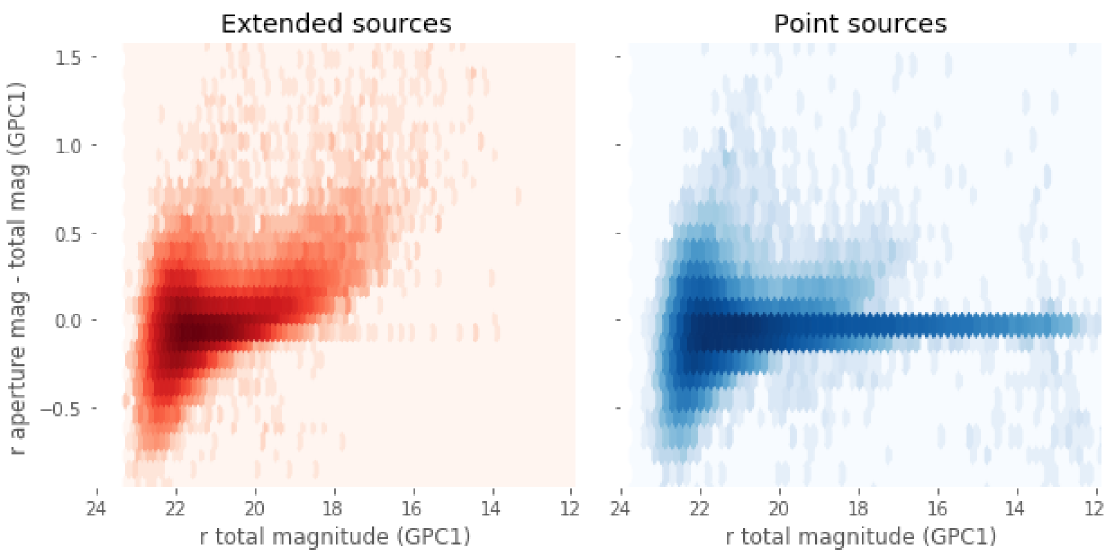
1.6 Keeping only sources with good signal to noise ratio

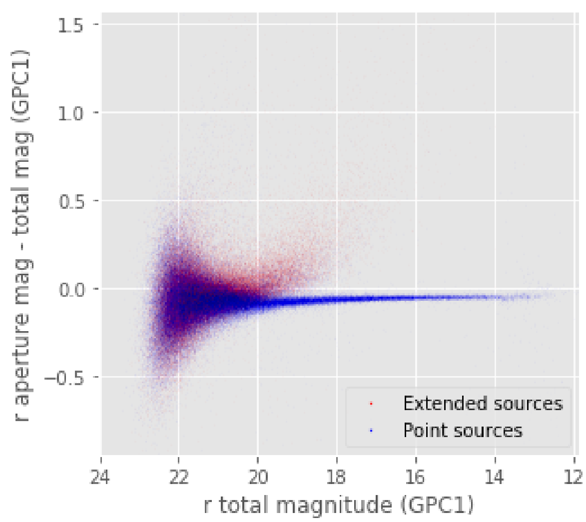
From here, we are only comparing sources with a signal to noise ratio above 3, i.e. roughly we a magnitude error below 0.3.

To make it easier, we are setting to NaN in the catalogue the magnitudes associated with an error above 0.3 so we can't use these magnitudes after the next cell.

1.7 IV - Comparing aperture magnitudes to total ones.

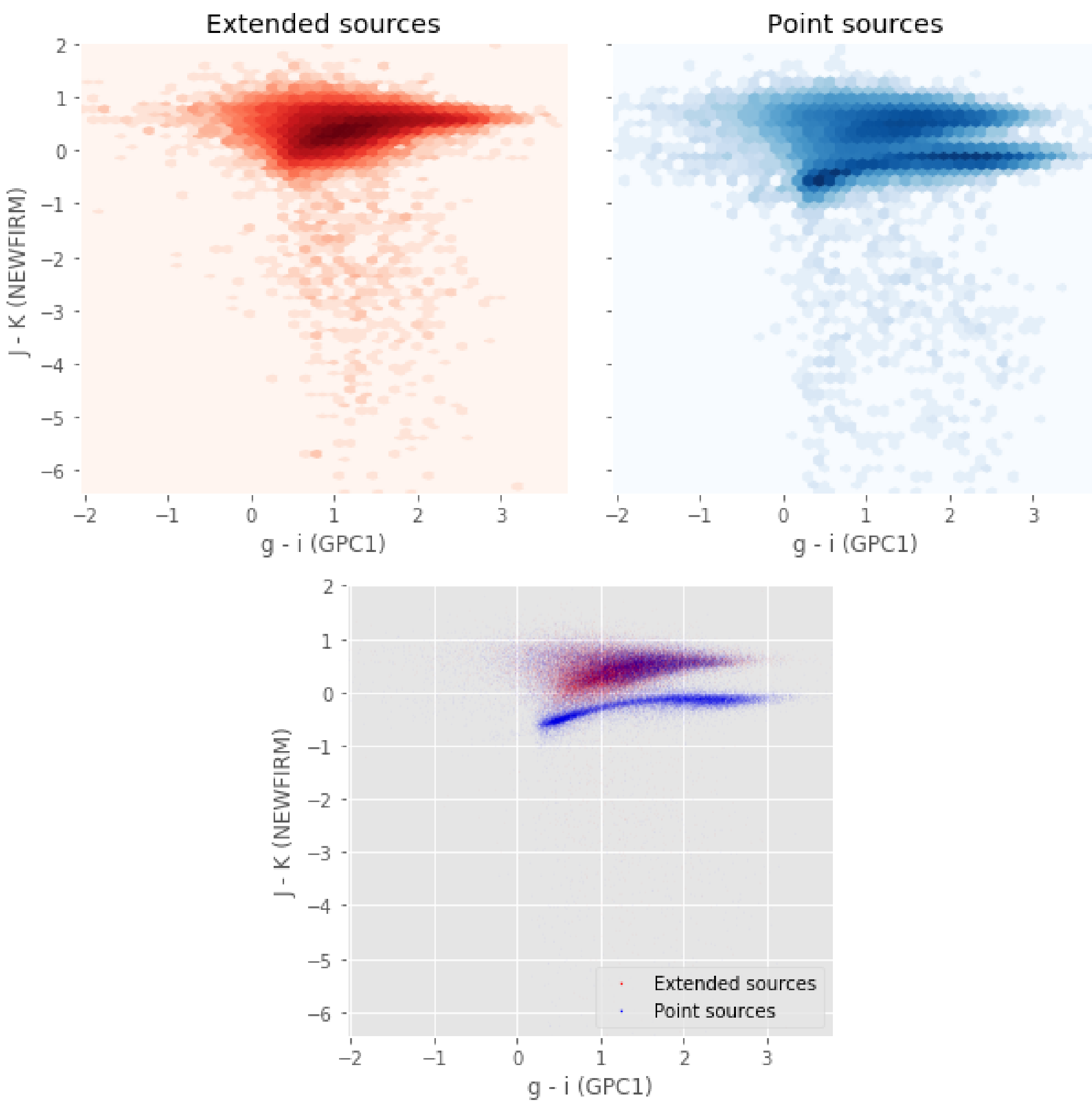
```
Number of source used: 164232 / 3367490 (4.88%)
```



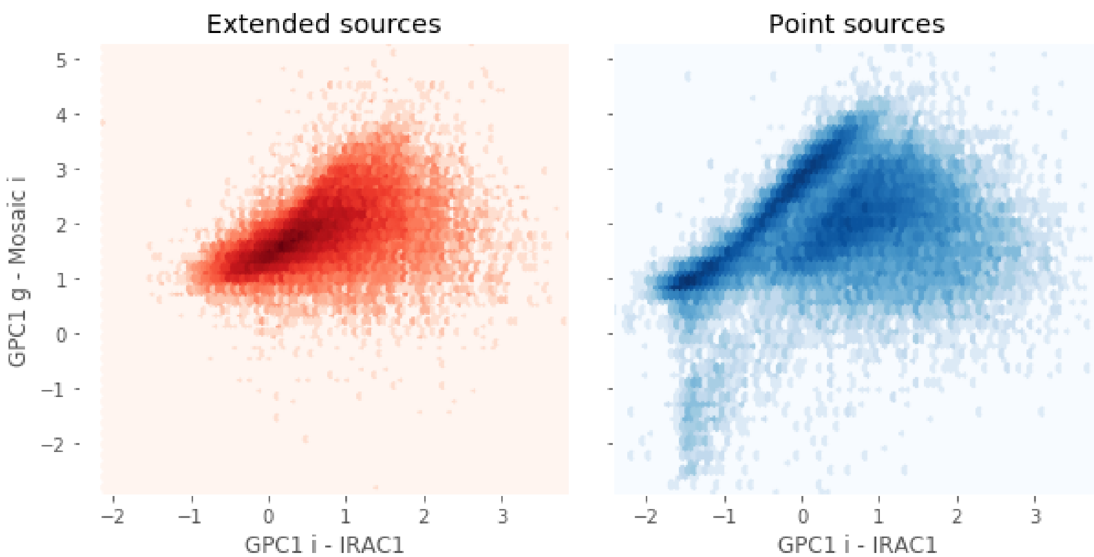


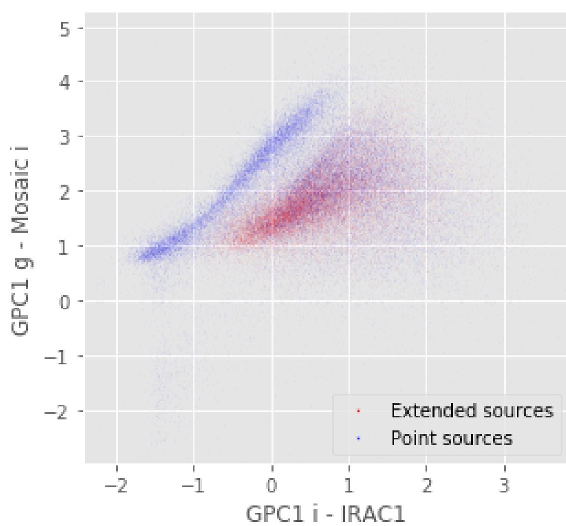
1.8 V - Color-color and magnitude-color plots

```
Number of source used: 91677 / 3367490 (2.72%)
```

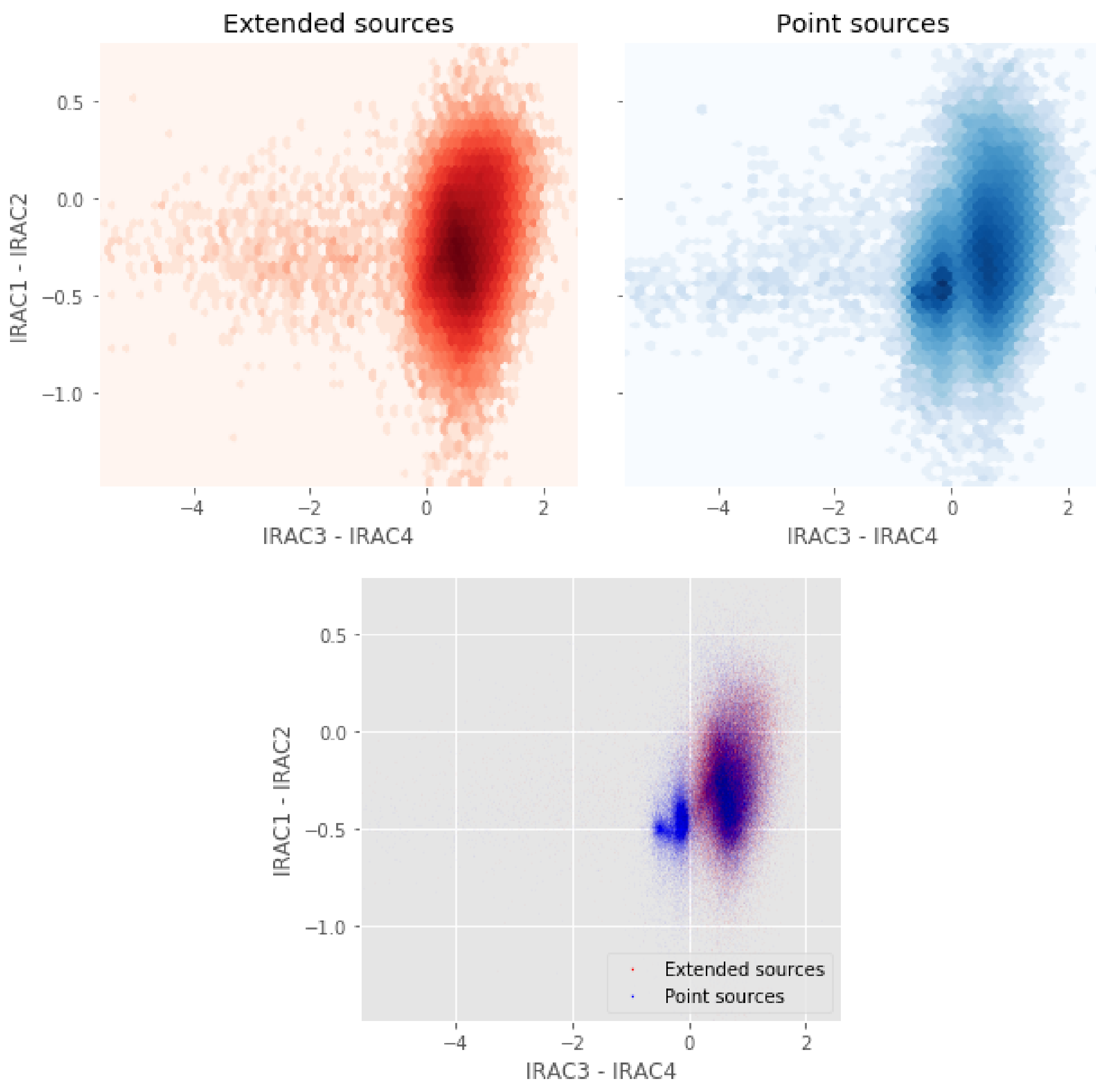


Number of source used: 67964 / 3367490 (2.02%)






```
Number of source used: 175865 / 3367490 (5.22%)
```



Extended sources
Point sources
IRAC1 - IRAC2
IRAC3 - IRAC4
0.5
0.0
−0.5
−1.0
−4
−2
0
2
Extended sources
Point sources

4_Selection_function

March 8, 2018

1 Bootes Selection Functions

1.1 Depth maps and selection functions

The simplest selection function available is the field MOC which specifies the area for which there is Herschel data. Each pristine catalogue also has a MOC defining the area for which that data is available.

The next stage is to provide mean flux standard deviations which act as a proxy for the catalogue's 5σ depth

```
This notebook was run with herschelhelp_internal version:
0246c5d (Thu Jan 25 17:01:47 2018 +0000) [with local modifications]
This notebook was executed on:
2018-02-27 17:55:59.890208
```

```
Depth maps produced using: master_catalogue_bootes_20180227.fits
```

1.2 I - Group masterlist objects by healpix cell and calculate depths

We add a column to the masterlist catalogue for the target order healpix cell per object.

1.3 II Create a table of all Order=13 healpix cells in the field and populate it

We create a table with every order=13 healpix cell in the field MOC. We then calculate the healpix cell at lower order that the order=13 cell is in. We then fill in the depth at every order=13 cell as calculated for the lower order cell that that the order=13 cell is inside.

```
Out[9]: <IPython.core.display.HTML object>

Out[11]: <IPython.core.display.HTML object>

Out[12]: <IPython.core.display.HTML object>
```

1.4 III - Save the depth map table

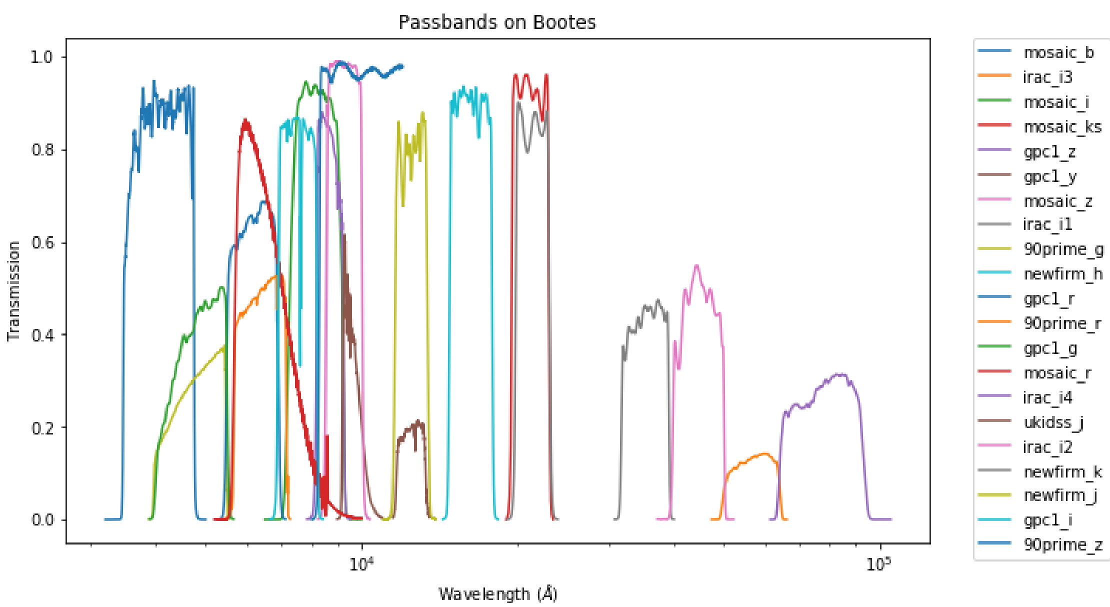
1.5 IV - Overview plots

1.5.1 IV.a - Filters

First we simply plot all the filters available on this field to give an overview of coverage.

```
Out[14]: {'90prime_g',
          '90prime_r',
          '90prime_z',
          'gpc1_g',
          'gpc1_i',
          'gpc1_r',
          'gpc1_y',
          'gpc1_z',
          'irac_i1',
          'irac_i2',
          'irac_i3',
          'irac_i4',
          'mosaic_b',
          'mosaic_i',
          'mosaic_ks',
          'mosaic_r',
          'mosaic_z',
          'newfirm_h',
          'newfirm_j',
          'newfirm_k',
          'ukidss_j'}
```

```
Out[15]: <matplotlib.text.Text at 0x7f791a590da0>
```



1.5.2 IV.a - Depth overview

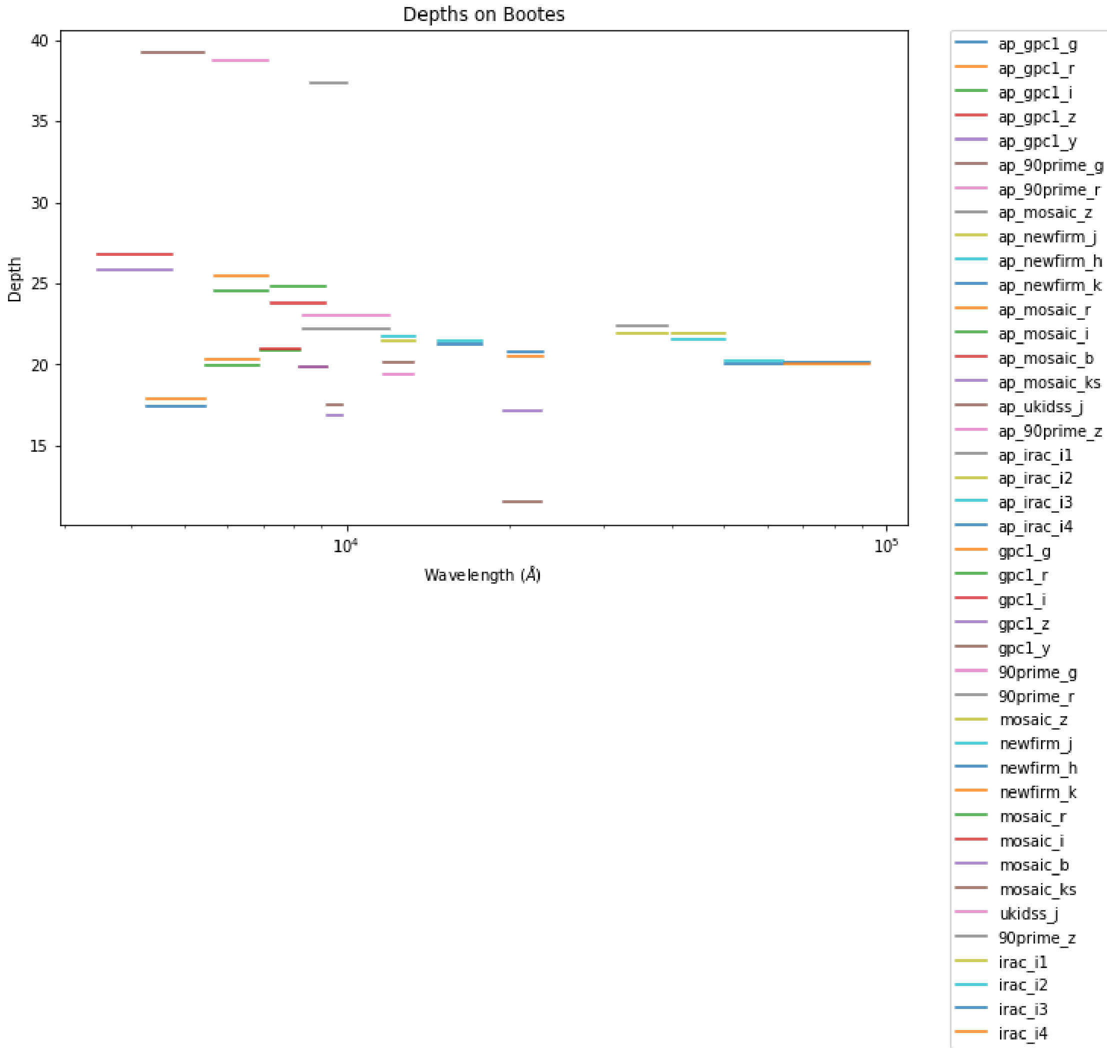
Then we plot the mean depths available across the area a given band is available

```
gpc1_g: mean flux error: 78.35341132970565, 3sigma in AB mag (Aperture): 17.972052089669994
gpc1_r: mean flux error: 5.608380063028198, 3sigma in AB mag (Aperture): 20.83510327123809
gpc1_i: mean flux error: 3.294636540901748, 3sigma in AB mag (Aperture): 21.41267808597231
gpc1_z: mean flux error: 8.156978058777419, 3sigma in AB mag (Aperture): 20.428373627919846
gpc1_y: mean flux error: 133.42562221159162, 3sigma in AB mag (Aperture): 17.39409877132214
90prime_g: mean flux error: 1.4475234877409093e-07, 3sigma in AB mag (Aperture): 39.805632814734
90prime_r: mean flux error: 2.217169594587176e-07, 3sigma in AB mag (Aperture): 39.3426995776672
mosaic_z: mean flux error: 8.159818207786884e-07, 3sigma in AB mag (Aperture): 37.92799565511351
newfirm_j: mean flux error: 1.9920644783208605, 3sigma in AB mag (Aperture): 21.958938384751526
newfirm_h: mean flux error: 1.9551437933166618, 3sigma in AB mag (Aperture): 21.979250104206834
newfirm_k: mean flux error: 3.561749252425101, 3sigma in AB mag (Aperture): 21.328038508651495
mosaic_r: mean flux error: 0.048491326290924994, 3sigma in AB mag (Aperture): 25.99303670643065
mosaic_i: mean flux error: 0.08426473880224247, 3sigma in AB mag (Aperture): 25.393082165880948
mosaic_b: mean flux error: 0.014692461561881521, 3sigma in AB mag (Aperture): 27.28946045521196
mosaic_ks: mean flux error: 104.16919877482903, 3sigma in AB mag (Aperture): 17.66284855378607
ukidss_j: mean flux error: 6.271228790283203, 3sigma in AB mag (Aperture): 20.71381525013785
90prime_z: mean flux error: 0.43331223726272583, 3sigma in AB mag (Aperture): 23.61519447767565
irac_i1: mean flux error: 0.8435492493538453, 3sigma in AB mag (Aperture): 22.89192075496259
irac_i2: mean flux error: 1.219861296780025, 3sigma in AB mag (Aperture): 22.49142073214427
irac_i3: mean flux error: 5.617809582683499, 3sigma in AB mag (Aperture): 20.833279326762884
irac_i4: mean flux error: 6.40979676701557, 3sigma in AB mag (Aperture): 20.690086213882317
gpc1_g: mean flux error: 50.77079180002355, 3sigma in AB mag (Total): 18.443162021869774
gpc1_r: mean flux error: 7.435501713803244, 3sigma in AB mag (Total): 20.528921168048207
gpc1_i: mean flux error: 3.017675282355672, 3sigma in AB mag (Total): 21.508015599211127
gpc1_z: mean flux error: 8.238000346267343, 3sigma in AB mag (Total): 20.417642348513162
gpc1_y: mean flux error: 69.78801698836591, 3sigma in AB mag (Total): 18.097744717910693
90prime_g: mean flux error: inf, 3sigma in AB mag (Total): -inf
90prime_r: mean flux error: inf, 3sigma in AB mag (Total): -inf
mosaic_z: mean flux error: inf, 3sigma in AB mag (Total): -inf
newfirm_j: mean flux error: 1.4202177051359357, 3sigma in AB mag (Total): 22.32630955701044
newfirm_h: mean flux error: 2.29147416266833, 3sigma in AB mag (Total): 21.80690945131061
newfirm_k: mean flux error: 4.47924484727495, 3sigma in AB mag (Total): 21.079184856277514
mosaic_r: mean flux error: 0.11428581881008466, 3sigma in AB mag (Total): 25.062216002755513
mosaic_i: mean flux error: 0.22661046700227497, 3sigma in AB mag (Total): 24.318996948716624
mosaic_b: mean flux error: 0.03341500761993288, 3sigma in AB mag (Total): 26.397342951961072
mosaic_ks: mean flux error: 17725.31932045733, 3sigma in AB mag (Total): 12.08571169392085
ukidss_j: mean flux error: 12.440642356872559, 3sigma in AB mag (Total): 19.970089850247355
90prime_z: mean flux error: 0.9289851188659668, 3sigma in AB mag (Total): 22.787174970160116
irac_i1: mean flux error: 1.2320176267807181, 3sigma in AB mag (Total): 22.480654559622444
irac_i2: mean flux error: 1.7494851512520315, 3sigma in AB mag (Total): 22.099921211295957
irac_i3: mean flux error: 6.911614700229151, 3sigma in AB mag (Total): 20.608248064056603
```

```
irac_i4: mean flux error: 6.999899899230954, 3sigma in AB mag (Total): 20.594467289423214

ap_gpc1_g (4260.0, 5500.0, 1240.0)
ap_gpc1_r (5500.0, 6900.0, 1400.0)
ap_gpc1_i (6910.0, 8190.0, 1280.0)
ap_gpc1_z (8190.0, 9210.0, 1020.0)
ap_gpc1_y (9200.0, 9820.0, 620.0)
ap_90prime_g (4180.0, 5470.0, 1290.0)
ap_90prime_r (5680.0, 7150.0, 1470.0)
ap_mosaic_z (8552.0, 10018.0, 1466.0)
ap_newfirm_j (11600.0, 13387.0, 1787.0)
ap_newfirm_h (14795.0, 17860.0, 3065.0)
ap_newfirm_k (19845.0, 23060.0, 3215.0)
ap_mosaic_r (5692.0, 7176.0, 1484.0)
ap_mosaic_i (7270.0, 9180.0, 1910.0)
ap_mosaic_b (3474.0, 4750.0, 1276.0)
ap_mosaic_ks (19500.0, 23000.0, 3500.0)
ap_ukidss_j (11695.0, 13280.0, 1585.0)
ap_90prime_z (8290.0, 12000.0, 3710.0)
ap_irac_i1 (31754.0, 39164.801, 7410.8008)
ap_irac_i2 (39980.102, 50052.301, 10072.199)
ap_irac_i3 (50246.301, 64096.699, 13850.398)
ap_irac_i4 (64415.199, 92596.797, 28181.598)
gpc1_g (4260.0, 5500.0, 1240.0)
gpc1_r (5500.0, 6900.0, 1400.0)
gpc1_i (6910.0, 8190.0, 1280.0)
gpc1_z (8190.0, 9210.0, 1020.0)
gpc1_y (9200.0, 9820.0, 620.0)
90prime_g (4180.0, 5470.0, 1290.0)
90prime_r (5680.0, 7150.0, 1470.0)
mosaic_z (8552.0, 10018.0, 1466.0)
newfirm_j (11600.0, 13387.0, 1787.0)
newfirm_h (14795.0, 17860.0, 3065.0)
newfirm_k (19845.0, 23060.0, 3215.0)
mosaic_r (5692.0, 7176.0, 1484.0)
mosaic_i (7270.0, 9180.0, 1910.0)
mosaic_b (3474.0, 4750.0, 1276.0)
mosaic_ks (19500.0, 23000.0, 3500.0)
ukidss_j (11695.0, 13280.0, 1585.0)
90prime_z (8290.0, 12000.0, 3710.0)
irac_i1 (31754.0, 39164.801, 7410.8008)
irac_i2 (39980.102, 50052.301, 10072.199)
irac_i3 (50246.301, 64096.699, 13850.398)
irac_i4 (64415.199, 92596.797, 28181.598)
```

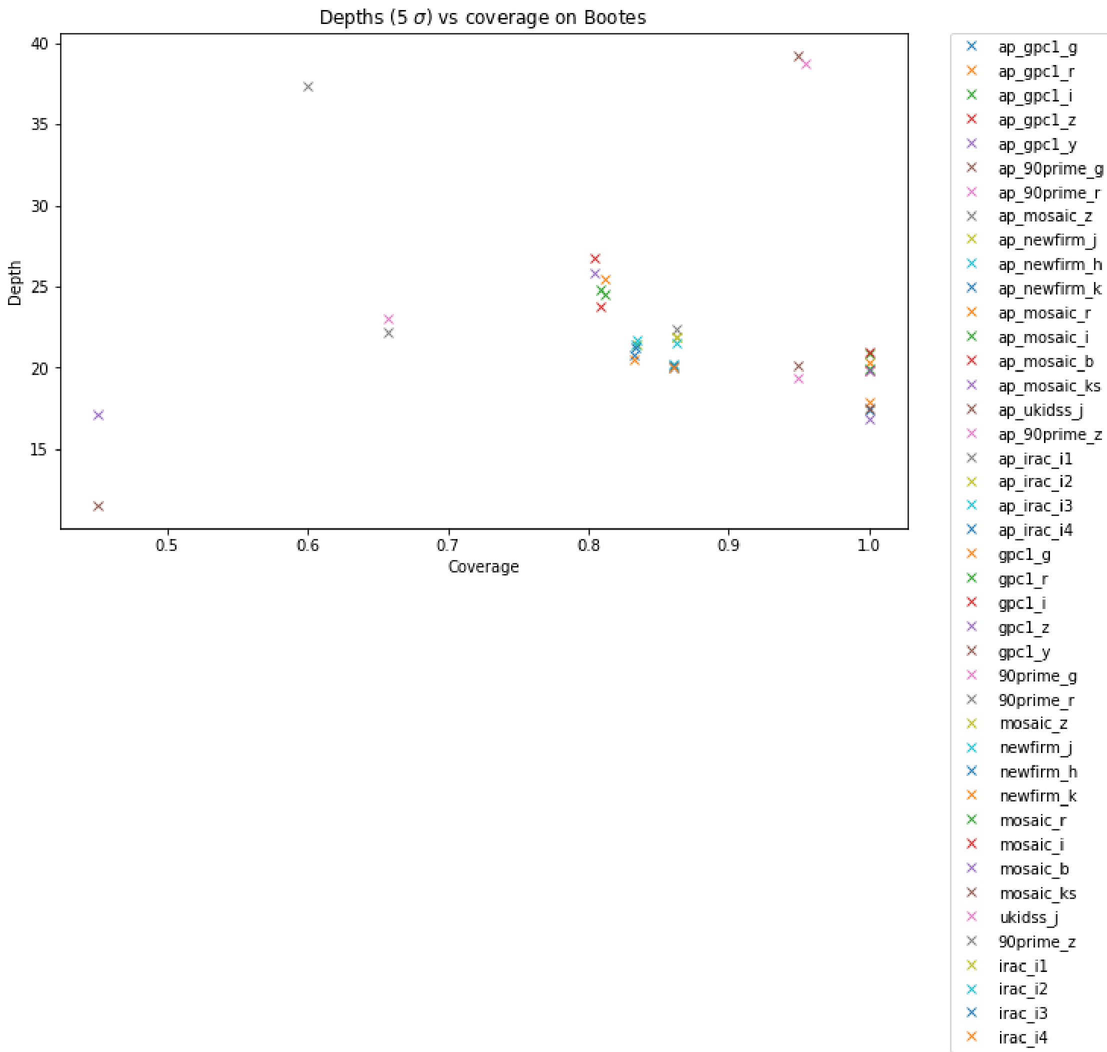
```
Out[20]: <matplotlib.text.Text at 0x7f7818e4c860>
```



1.5.3 IV.c - Depth vs coverage comparison

How best to do this? Colour/intensity plot over area? Percentage coverage vs mean depth?

```
Out[21]: <matplotlib.text.Text at 0x7f781918a2e8>
```



Depths (5 σ) vs coverage on Bootes
Depth
Coverage
40
35
30
25
20
15
0.5
0.6
0.7
0.8
0.9
1.0
ap_gpc1_g
ap_gpc1_r
ap_gpc1_i
ap_gpc1_z
ap_gpc1_y
ap_90prime_g
ap_90prime_r
ap_mosaic_z
ap_newfirm_j
ap_newfirm_h
ap_newfirm_k
ap_mosaic_r
ap_mosaic_i
ap_mosaic_b
ap_mosaic_ks
ap_ukidss_j
ap_90prime_z
ap_irac_i1
ap_irac_i2
ap_irac_i3
ap_irac_i4
gpc1_g
gpc1_r
gpc1_i
gpc1_z
gpc1_y
90prime_g
90prime_r
mosaic_z
newfirm_j
newfirm_h
newfirm_k
mosaic_r
mosaic_i
mosaic_b
mosaic_ks
ukidss_j
90prime_z
irac_i1
irac_i2
irac_i3
irac_i4