1.1_DECaLS

January 18, 2018

1 GAMA-15 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:
44f1ae0 (Thu Nov 30 18:27:54 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).

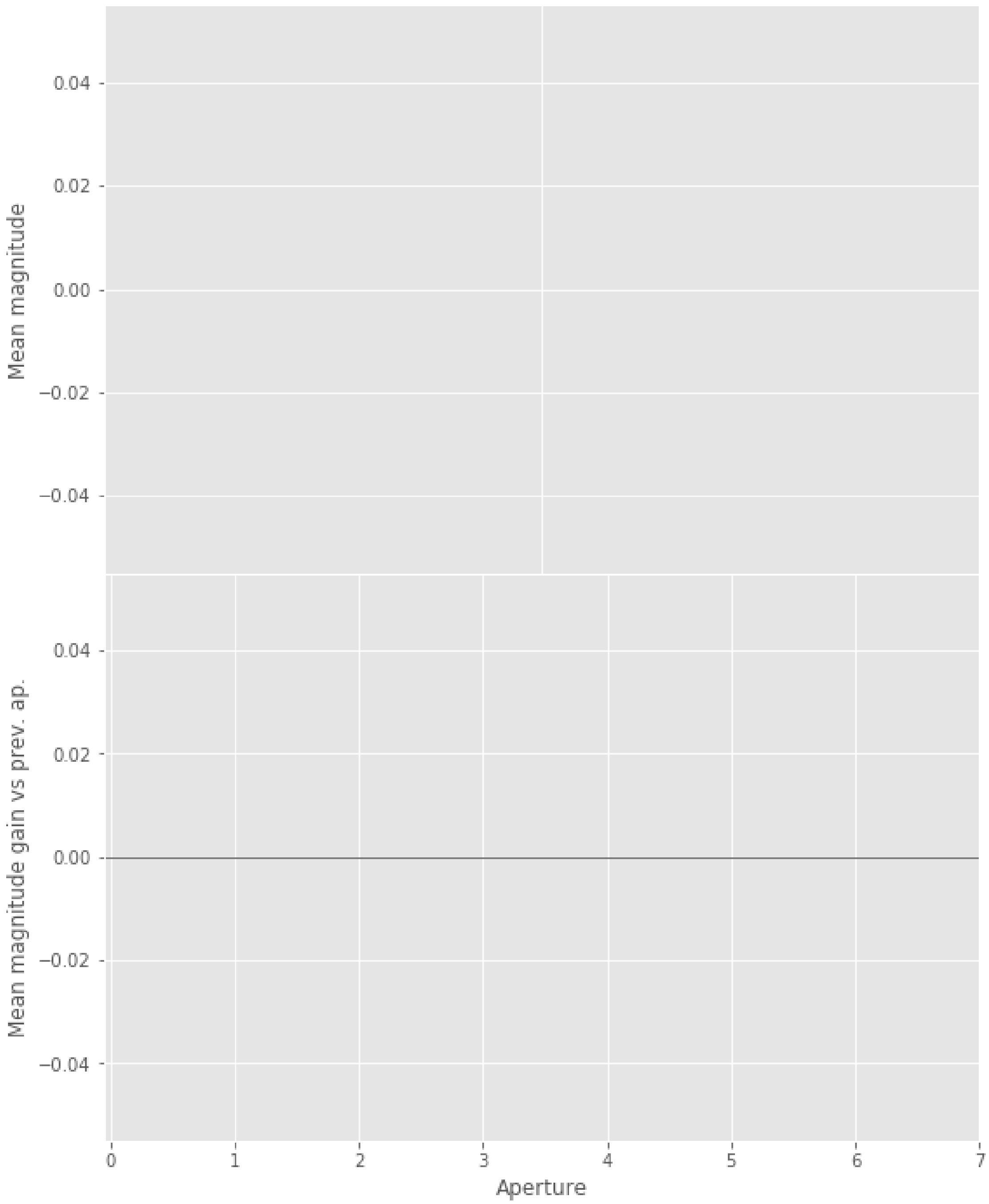
As target aperture, we should use the smallest (i.e. less noisy) aperture for which most of the flux is captures.

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
```

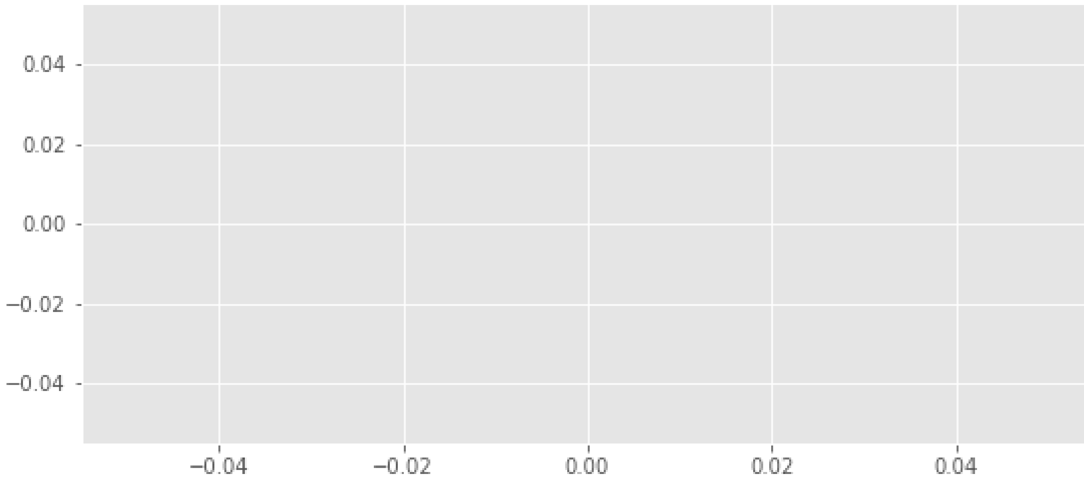
1.2.1 1.a u band

```
/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)
```

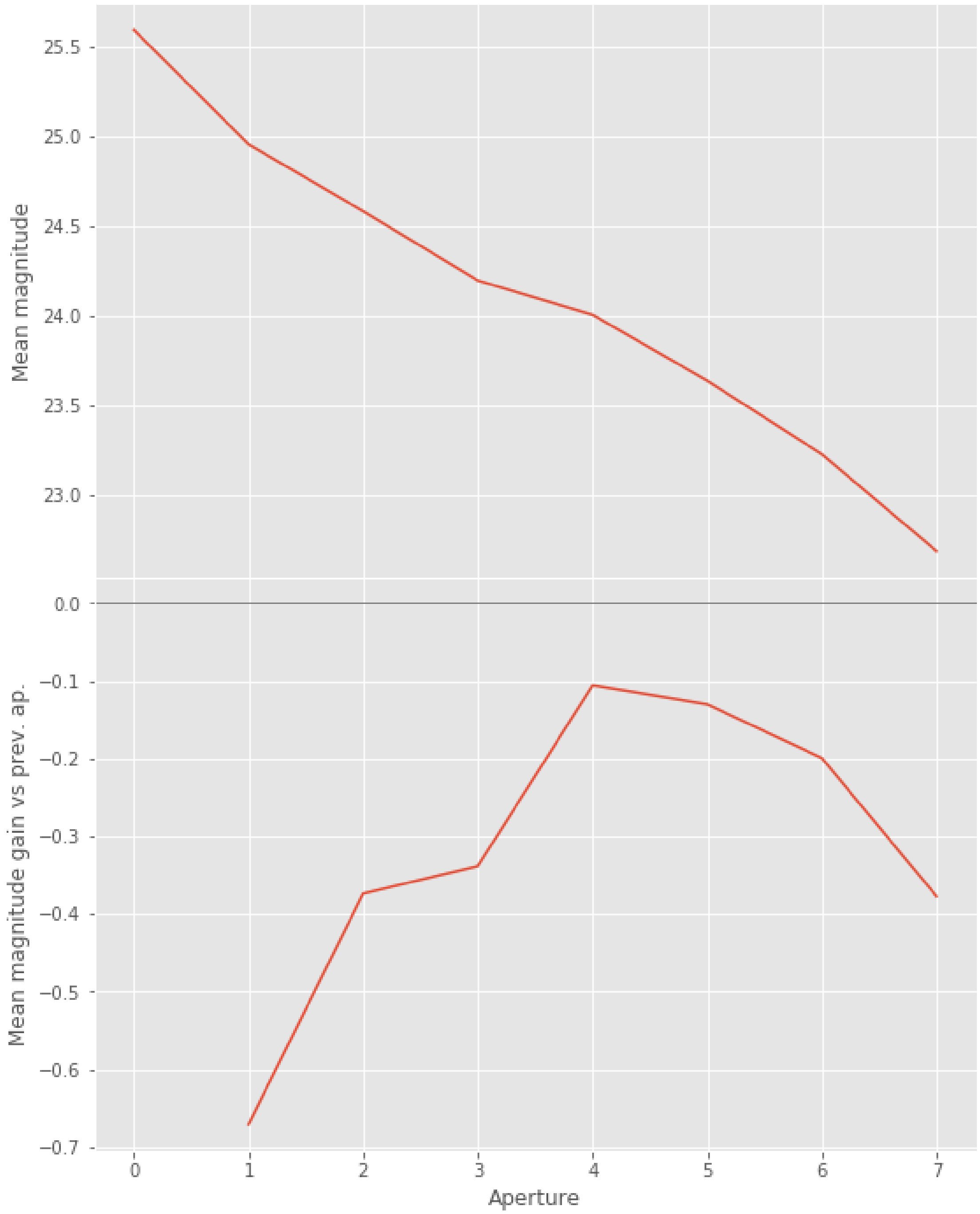


u band is all nan

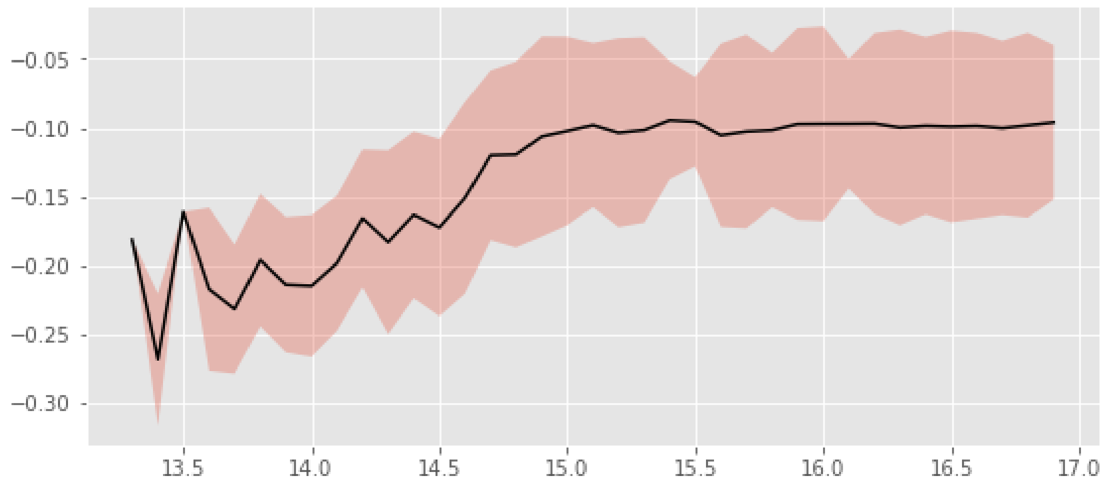
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("All-NaN slice encountered", RuntimeWarning)
```


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

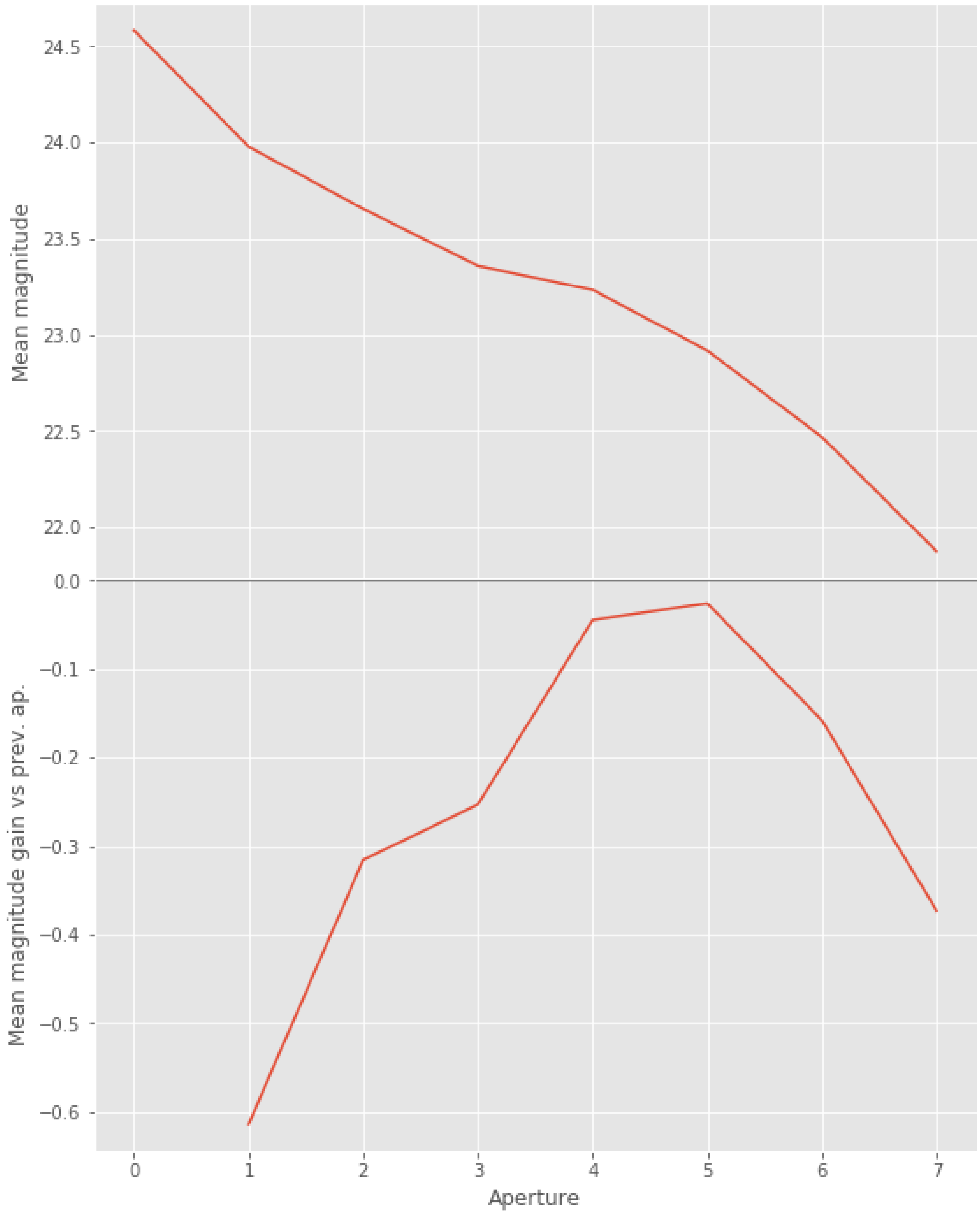


We will use aperture 5 as target.

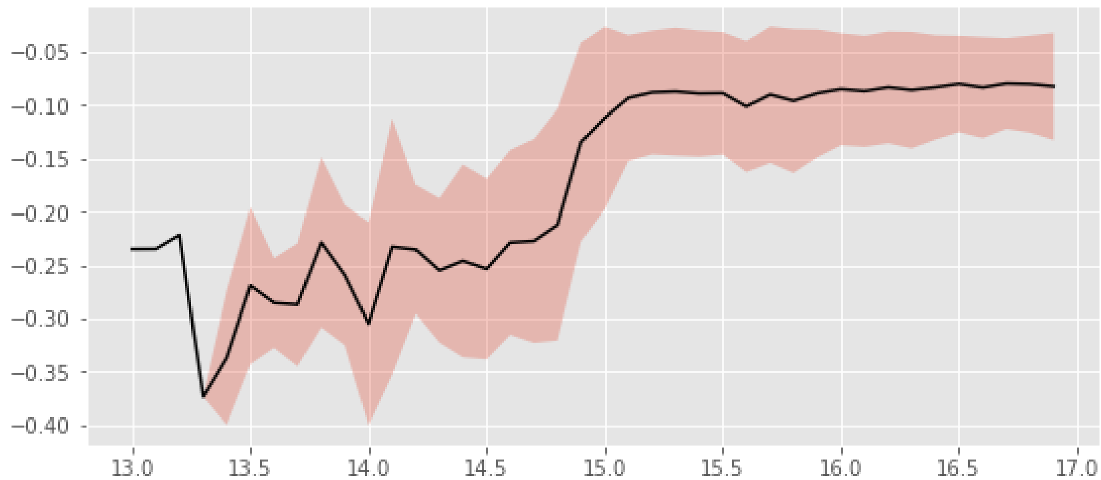


We will use magnitudes between 16.0 and 19.0

1.2.3 I.b - r band



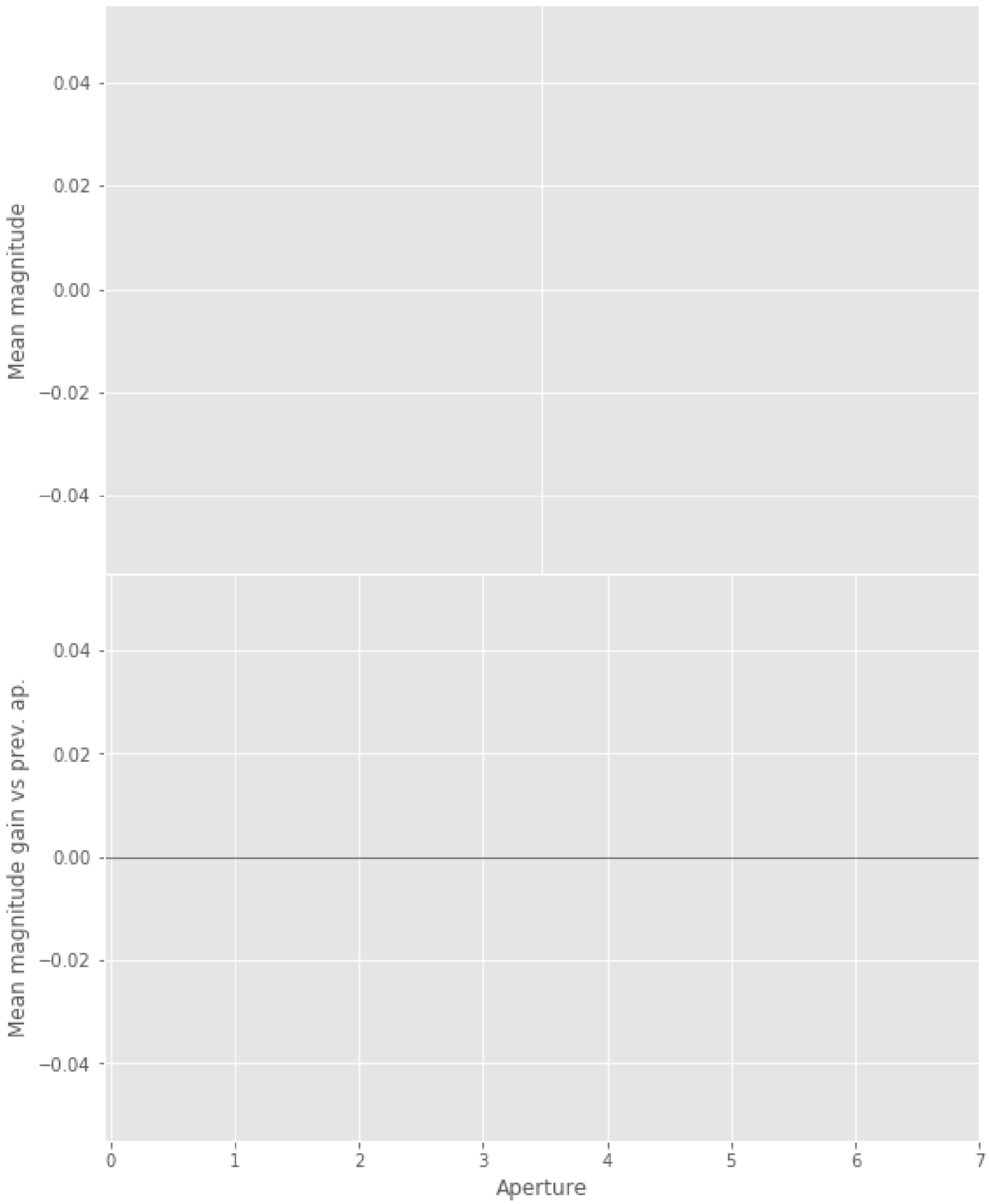
We will use aperture 5 as target.



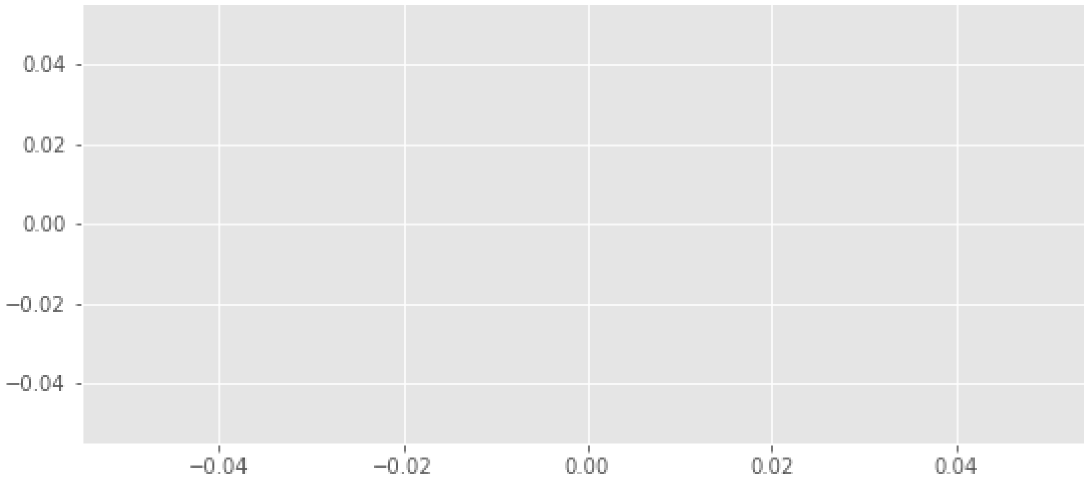
We use magnitudes between 16.0 and 18.0.

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)
```

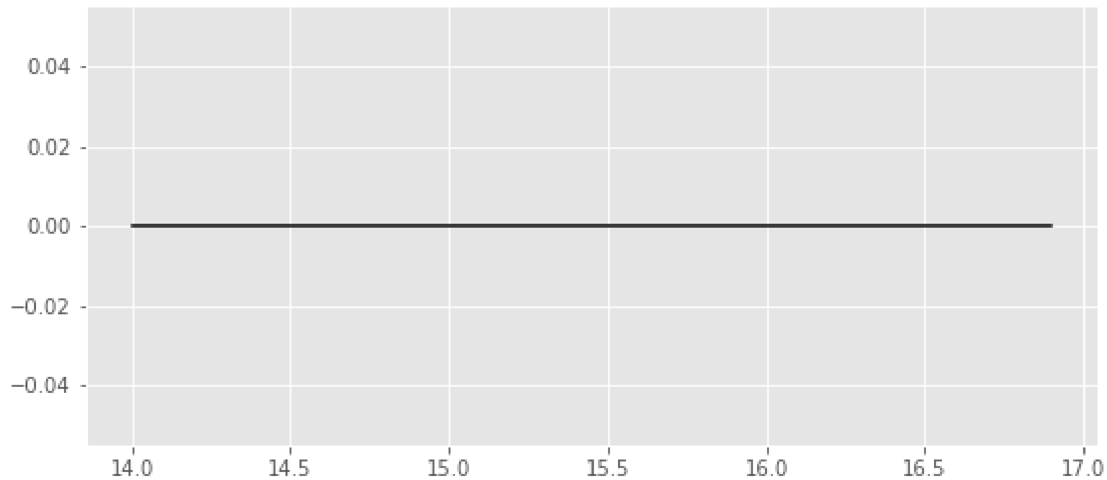



```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("All-NaN slice encountered", RuntimeWarning)
```


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.

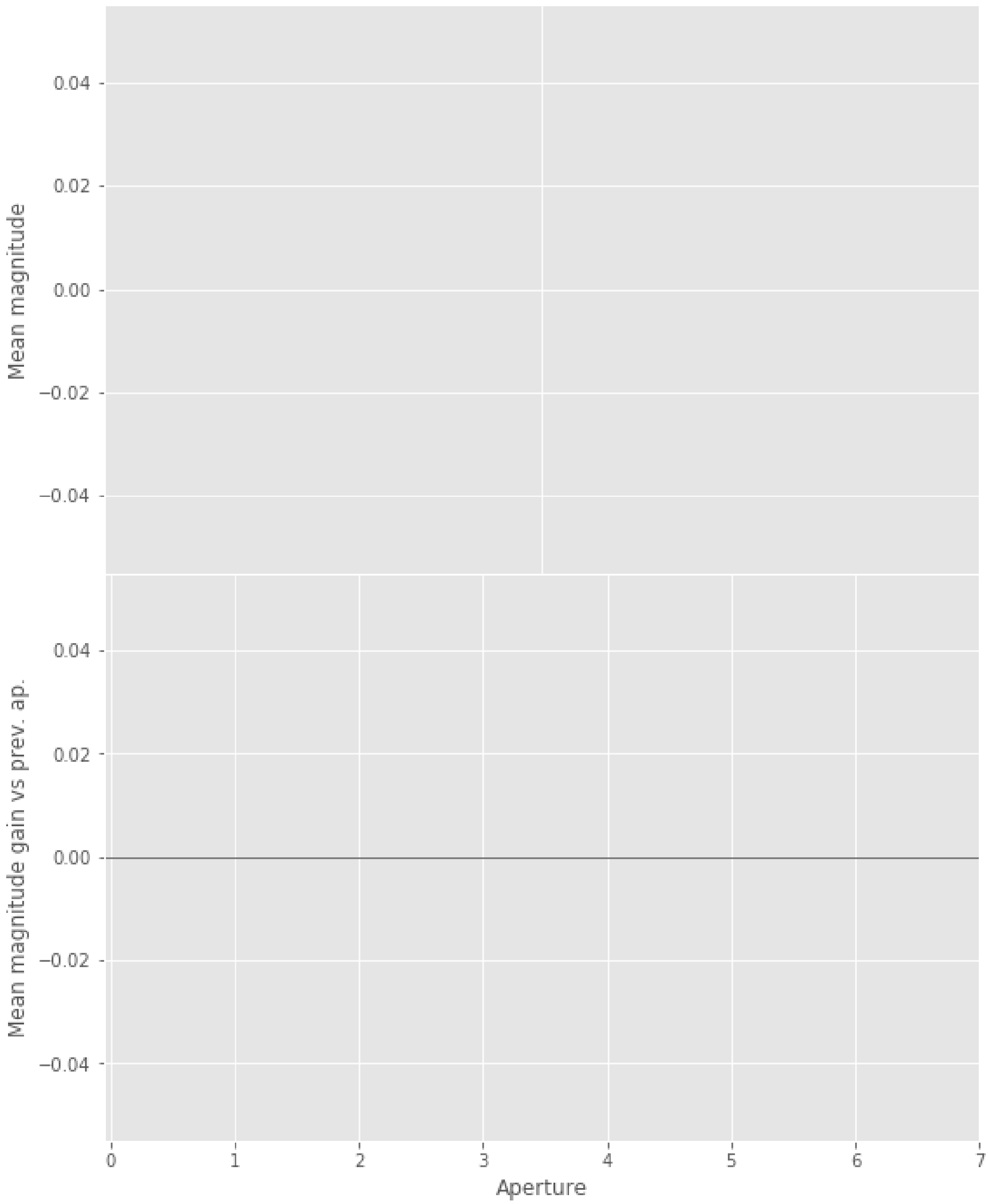


We use magnitudes between 16.0 and 17.5.

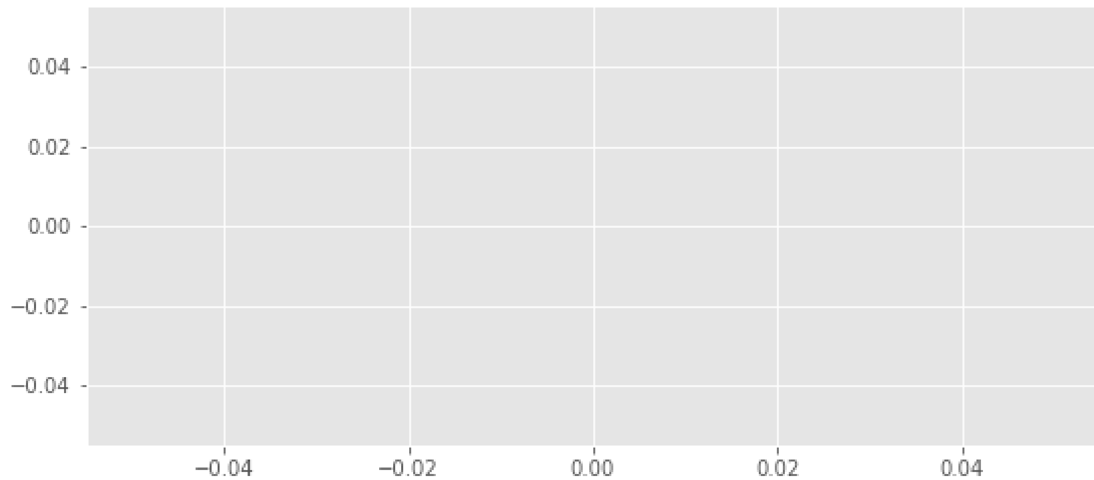
```
Aperture correction for z band:
Correction: 0.0
Number of source used: 53508
RMS: 0.0
```

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

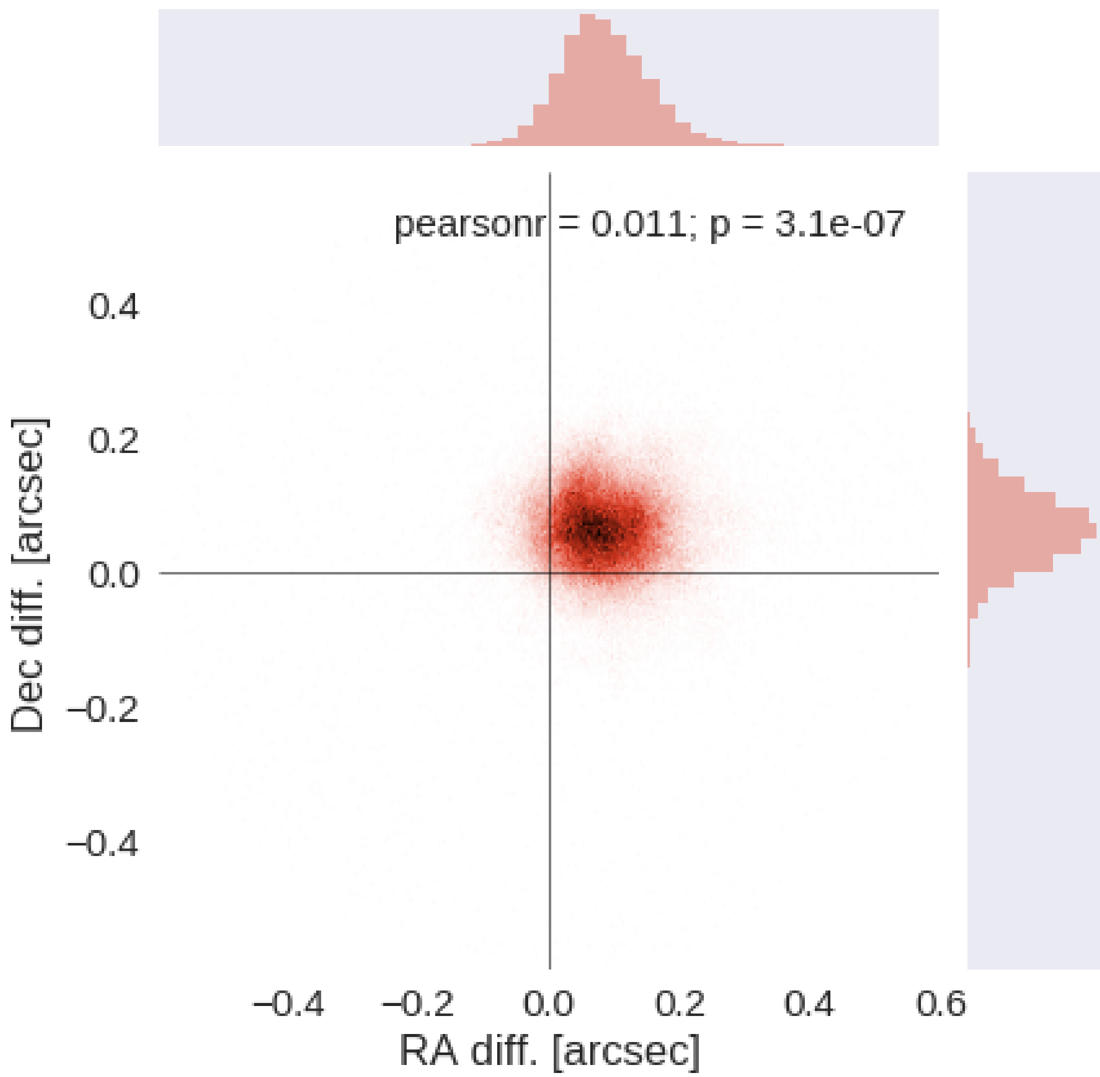
We remove duplicated objects from the input catalogues.

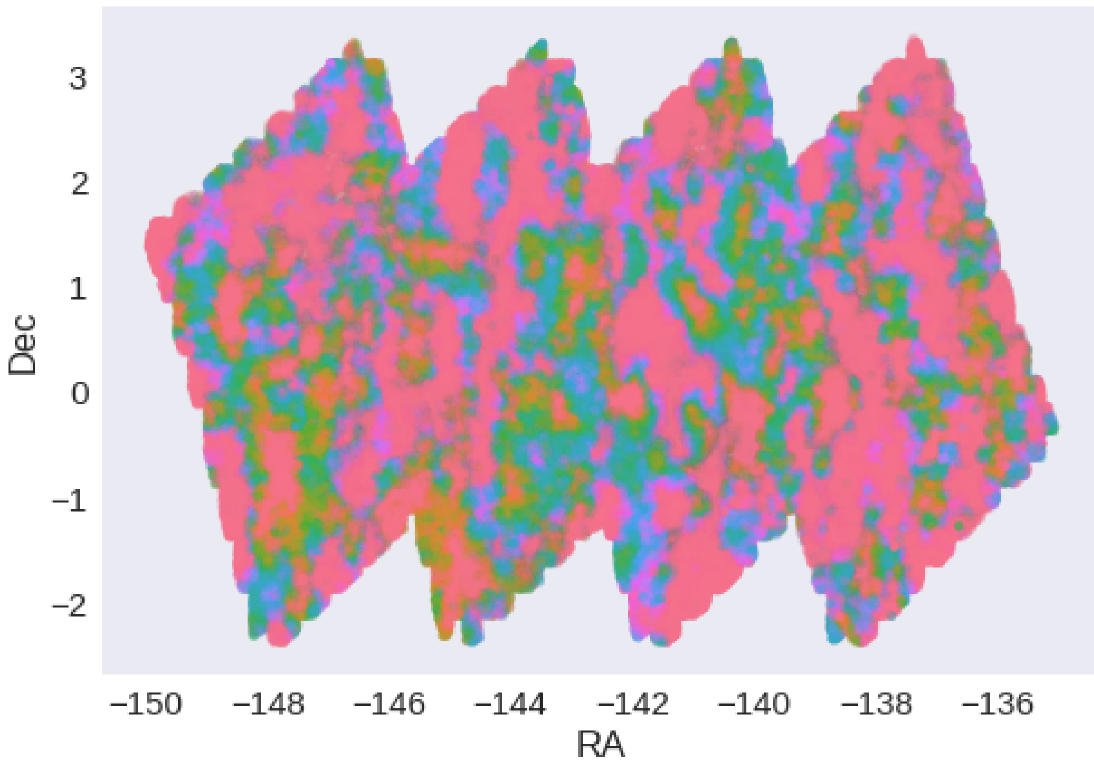
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 3897945 sources.
The cleaned catalogue has 3897084 sources (861 removed).
The cleaned catalogue has 859 sources flagged as having been cleaned
```

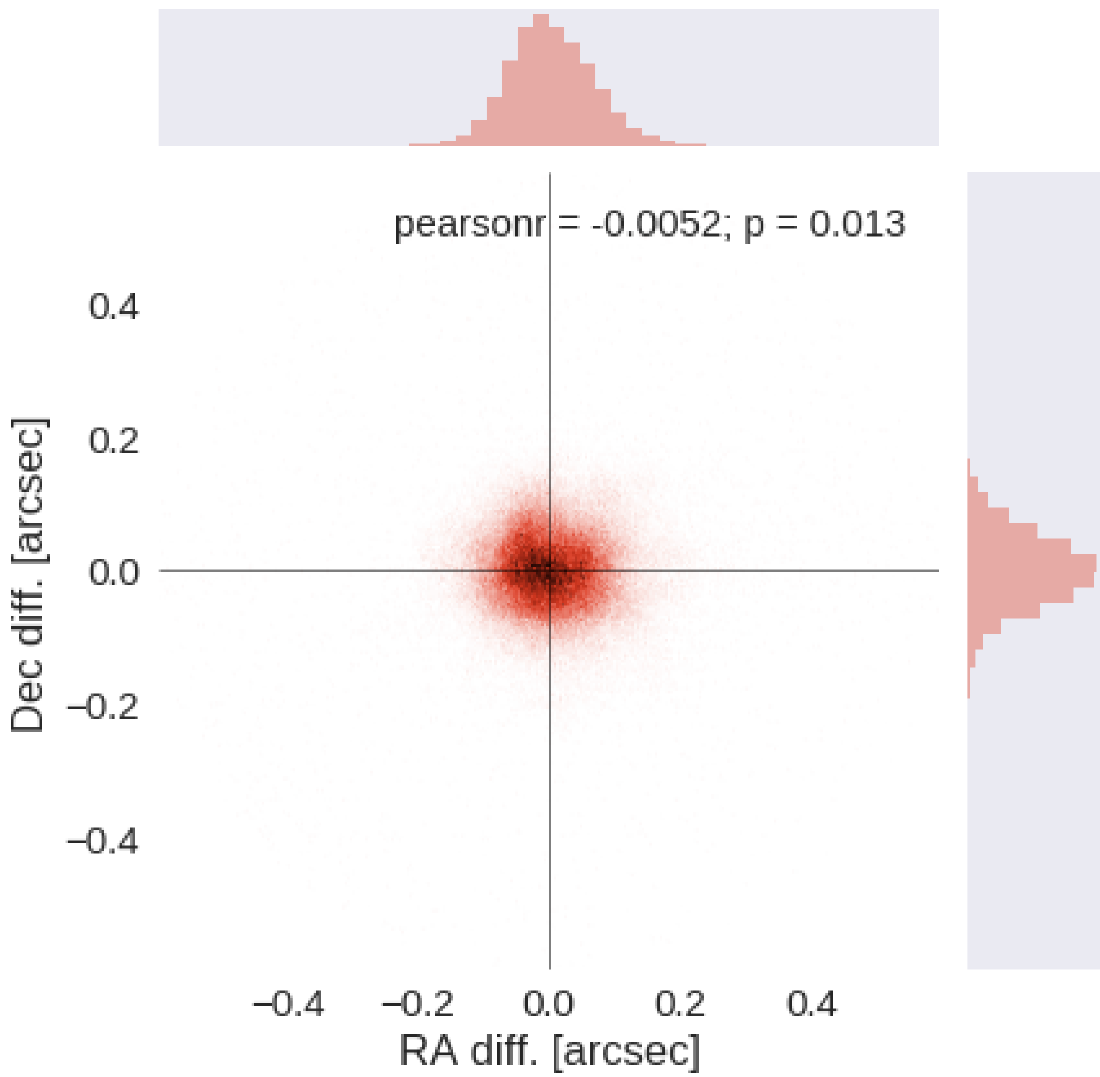
1.6 III - Astrometry correction

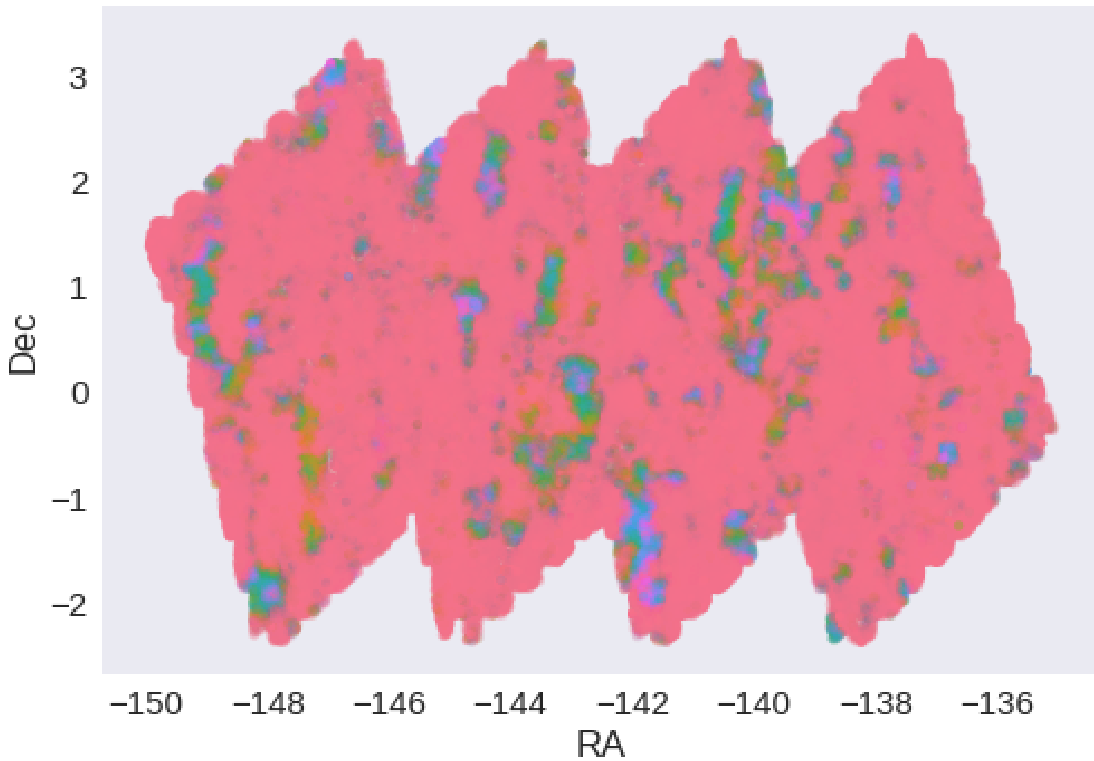
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.


pearsonr = 0.011; p = 3.1e-07
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.4
−0.2
0.0
0.2
0.4
0.6
RA diff. [arcsec]




```
RA correction: -0.08036863038114461 arcsec
Dec correction: -0.06566878237430629 arcsec
```


pearsonr = -0.0052; p = 0.013
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.4
−0.2
0.0
0.2
0.4
RA diff. [arcsec]



1.7 IV - Flagging Gaia objects

```
234282 sources flagged.
```

2 V - Saving to disk

1.2_HSC-SSP

January 18, 2018

1 GAMA-15 master catalogue

1.1 Preparation of Hyper Suprime-Cam Subaru Strategic Program Catalogues (HSC-SSP) data

This catalogue comes from `dmu0_HSC`.

In the catalogue, we keep:

- The `object_id` as unique object identifier;
- The position;
- The g, r, i, z, y (no N921) aperture magnitude in 2" that we aperture correct;
- The g, r, i, z, y (no N921) kron fluxes and magnitudes.
- The extended flag that we convert to a stellariy.

Note: On ELAIS-N1 the HSC-SSP catalogue does not contain any N816 magnitudes.

We use 2016 as the epoch.

```
This notebook was run with herschelhelp_internal version:
44f1ae0 (Thu Nov 30 18:27:54 2017 +0000)
```

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.

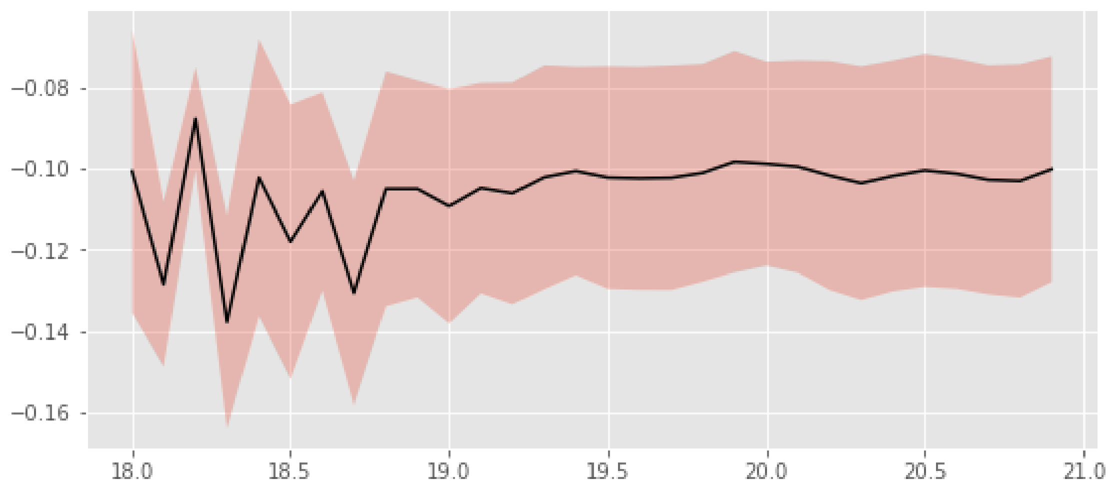
```
No error column for a y band aperture magnitude.
```

1.2.1 I.a - g band

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid valu
  mags = magnitudes[:, stellarity > stel_threshold].copy()
```

We will use aperture 40 as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid valu
  mask = stellarity > .9
/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/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```



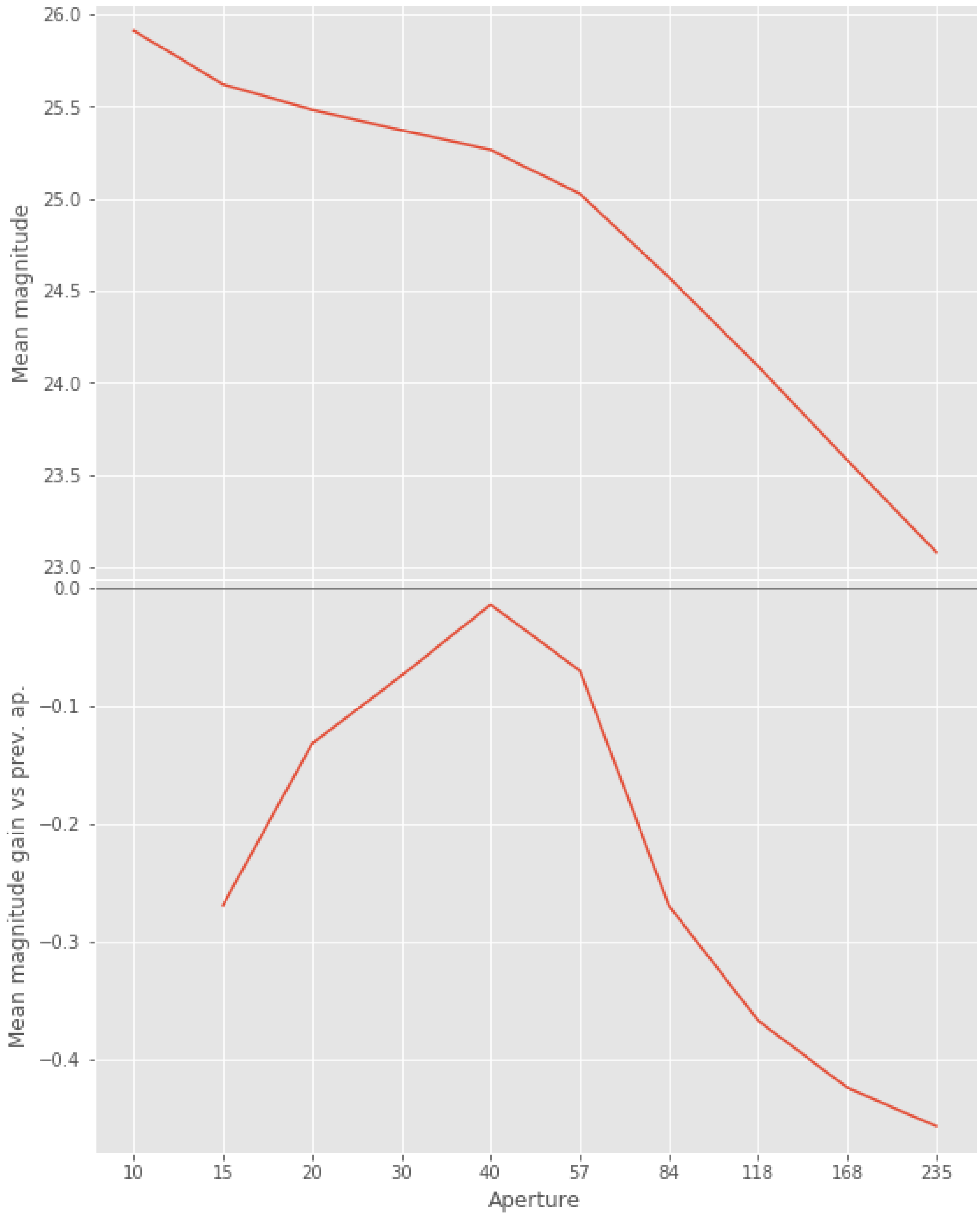
We will use magnitudes between 18.5 and 20.8

```
Aperture correction for g band:
Correction: -0.10141181945800781
Number of source used: 15286
RMS: 0.027612784472519653
```

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```

1.2.2 I.b - r band

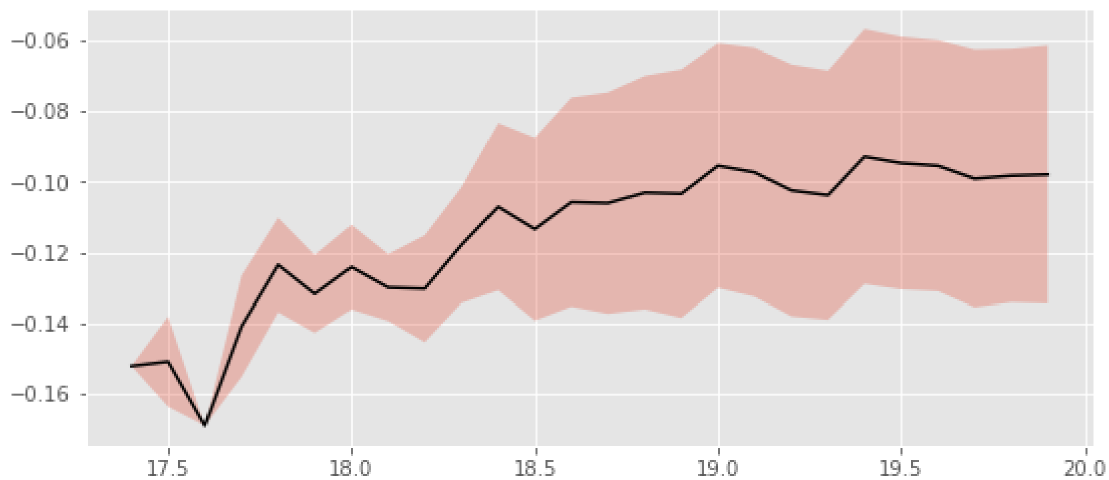
```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid valu
  mags = magnitudes[:, stellarity > stel_threshold].copy()
```



We will use aperture 40 as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid valu
  mask = stellarity > .9
/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/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```



We use magnitudes between 17.6 and 19.7.

```
Aperture correction for r band:
Correction: -0.10055923461914062
Number of source used: 9943
RMS: 0.03515977580827814
```

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```

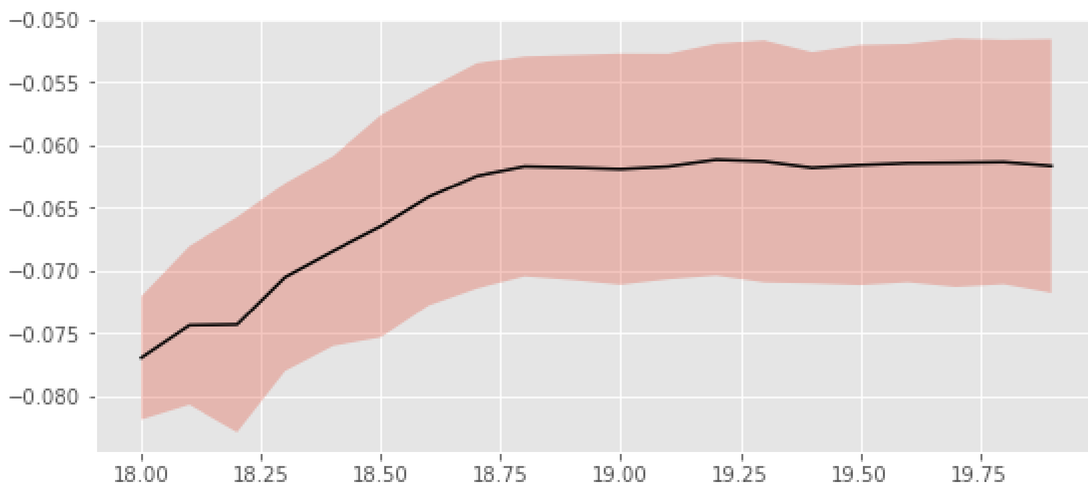
1.2.3 I.c - i band

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid valu
  mags = magnitudes[:, stellarity > stel_threshold].copy()
```

We will use aperture 40 as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid valu
  mask = stellarity > .9
/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/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```



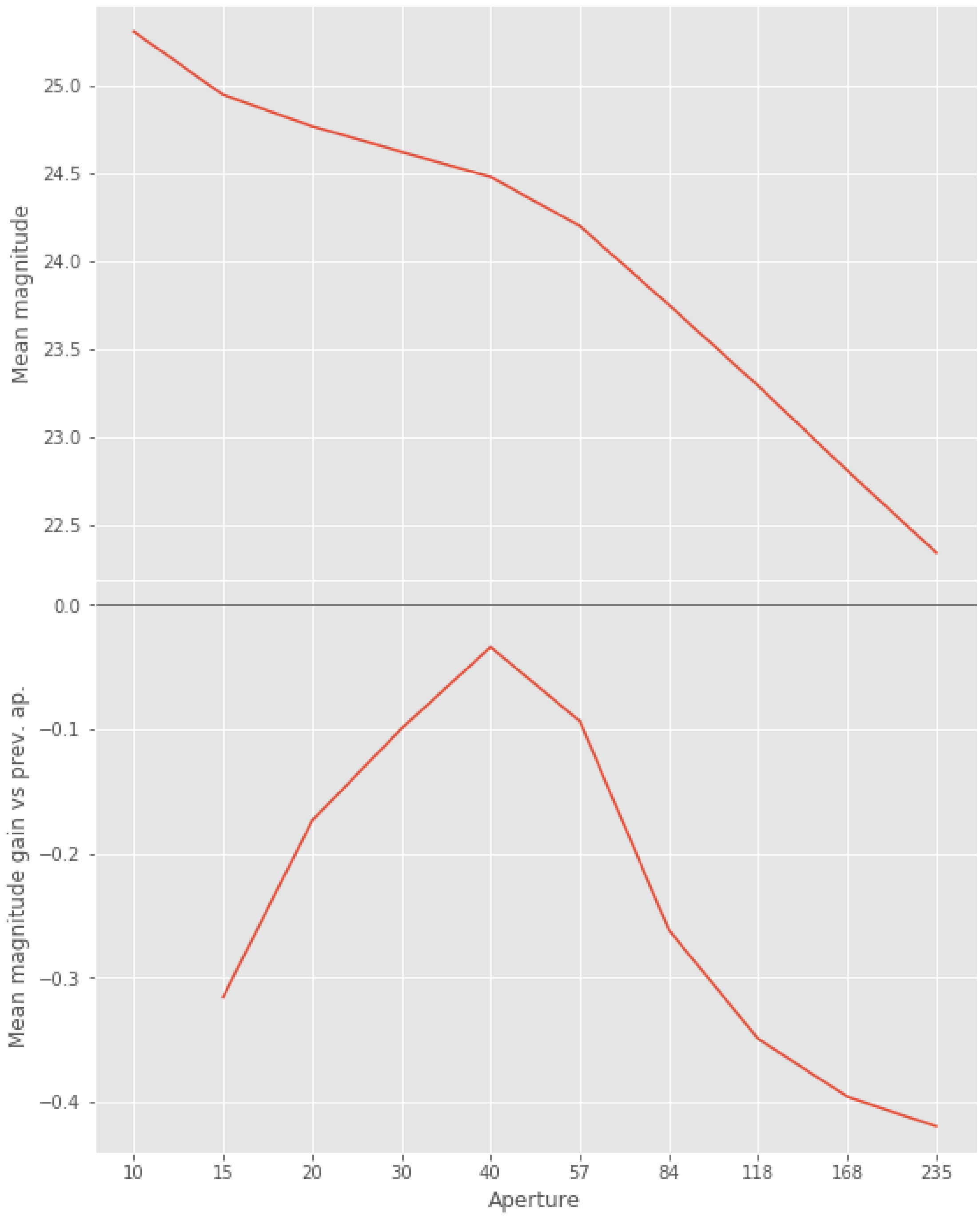
We use magnitudes between 18.5 and 19.8.

```
Aperture correction for i band:
Correction: -0.0619354248046875
Number of source used: 24834
RMS: 0.00930339810580967
```

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```

1.2.4 I.d - z band

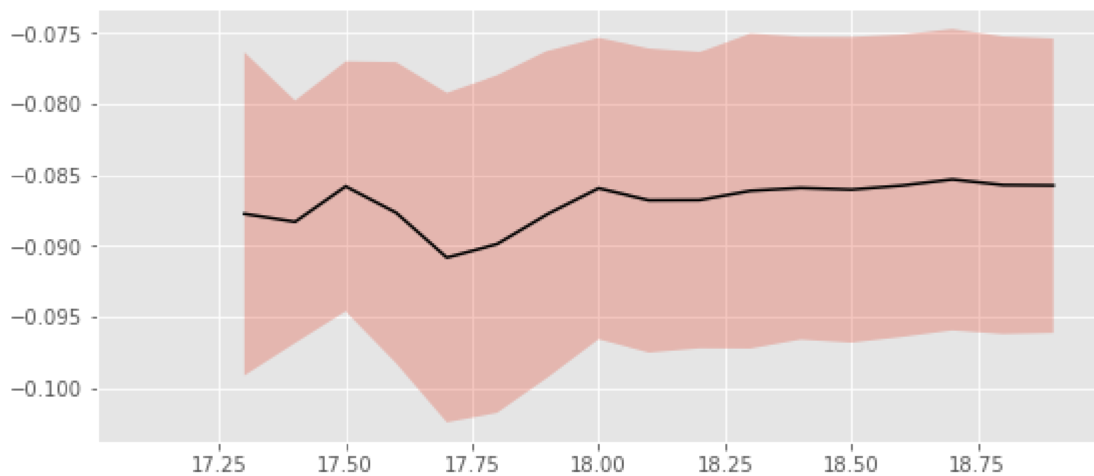
```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid valu
  mags = magnitudes[:, stellarity > stel_threshold].copy()
```



We will use aperture 40 as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid valu
  mask = stellarity > .9
/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/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```



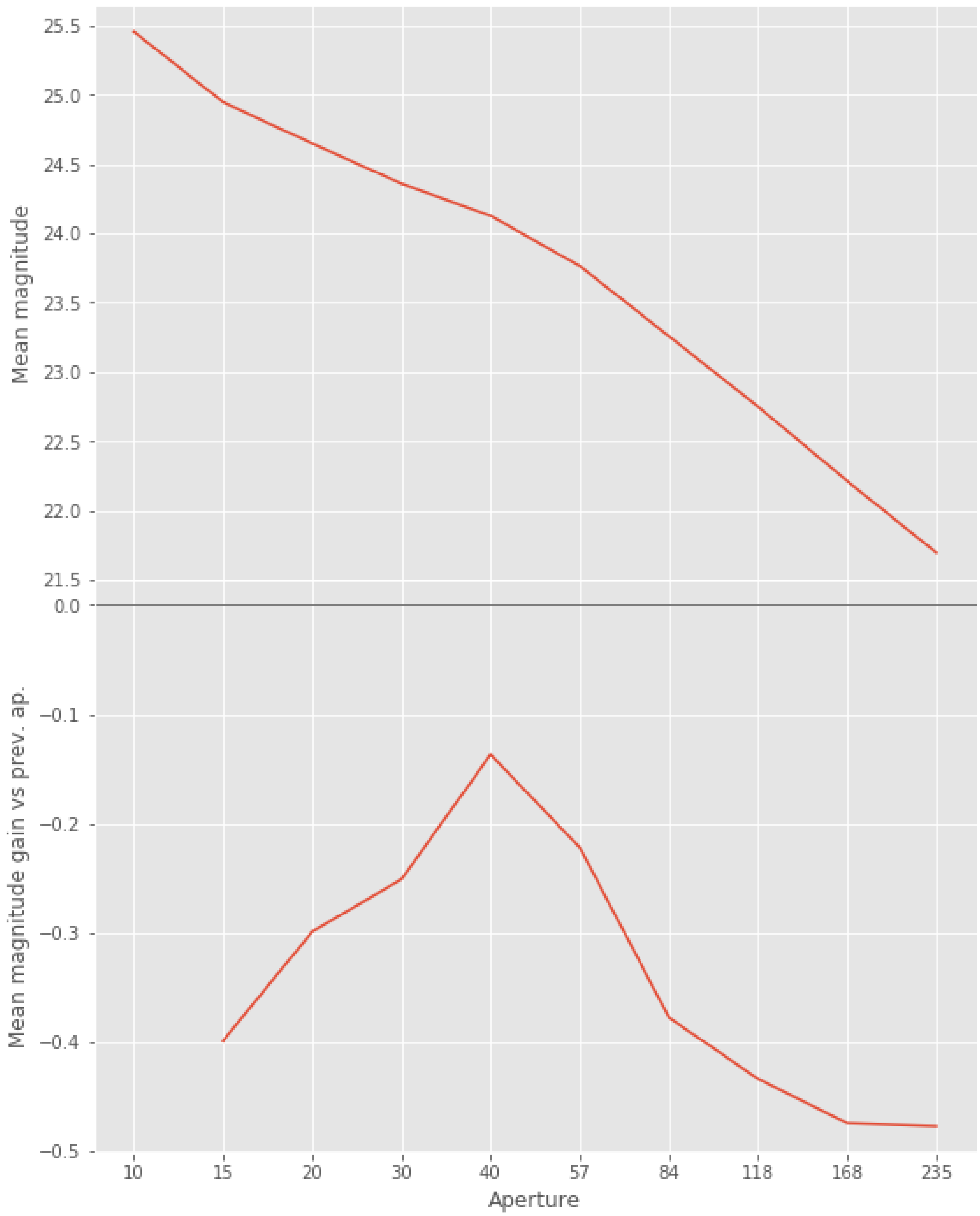
We use magnitudes between 17.5 and 19.8.

```
Aperture correction for z band:
Correction: -0.08566570281982422
Number of source used: 34829
RMS: 0.01121795488087638
```

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```

1.2.5 I.e - y band

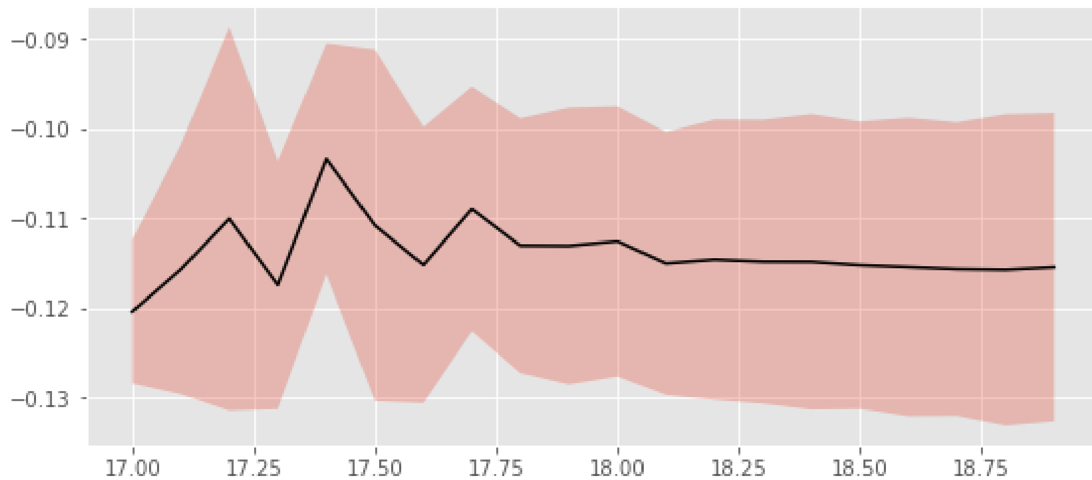
```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid valu
  mags = magnitudes[:, stellarity > stel_threshold].copy()
```



We will use aperture 40 as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid valu
  mask = stellarity > .9
/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/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```



We use magnitudes between 17 and 18.7.

```
Aperture correction for y band:
Correction: -0.11461448669433594
Number of source used: 9295
RMS: 0.015907751991162174
```

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value enc
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value enc
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
  mask &= (mag <= mag_max)
```

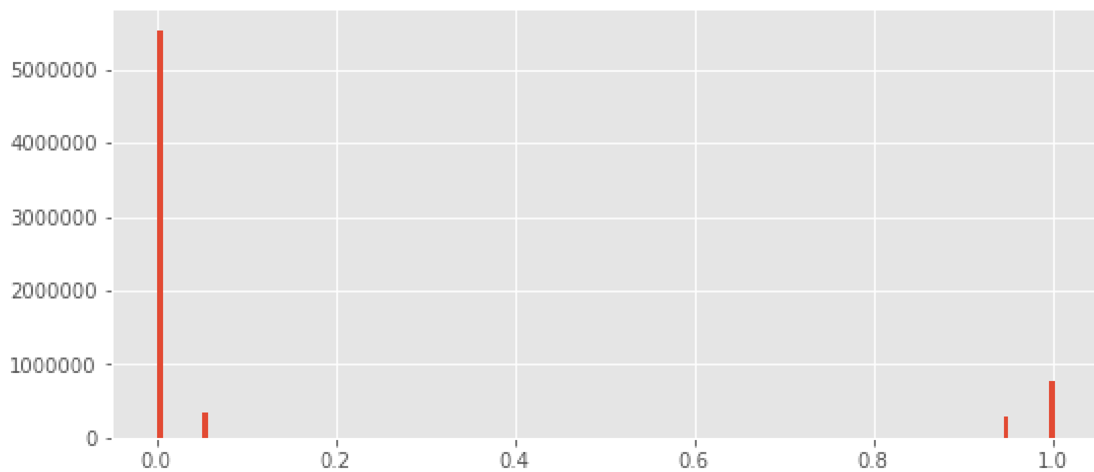
1.3 II - Stellarity

HSC does not provide a 0 to 1 stellarity value but a 0/1 extended flag in each band. We are using the same method as UKIDSS (cf this page) to compute a stellarity based on the class in each band:

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

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

```
Out[29]: <IPython.core.display.HTML object>
```

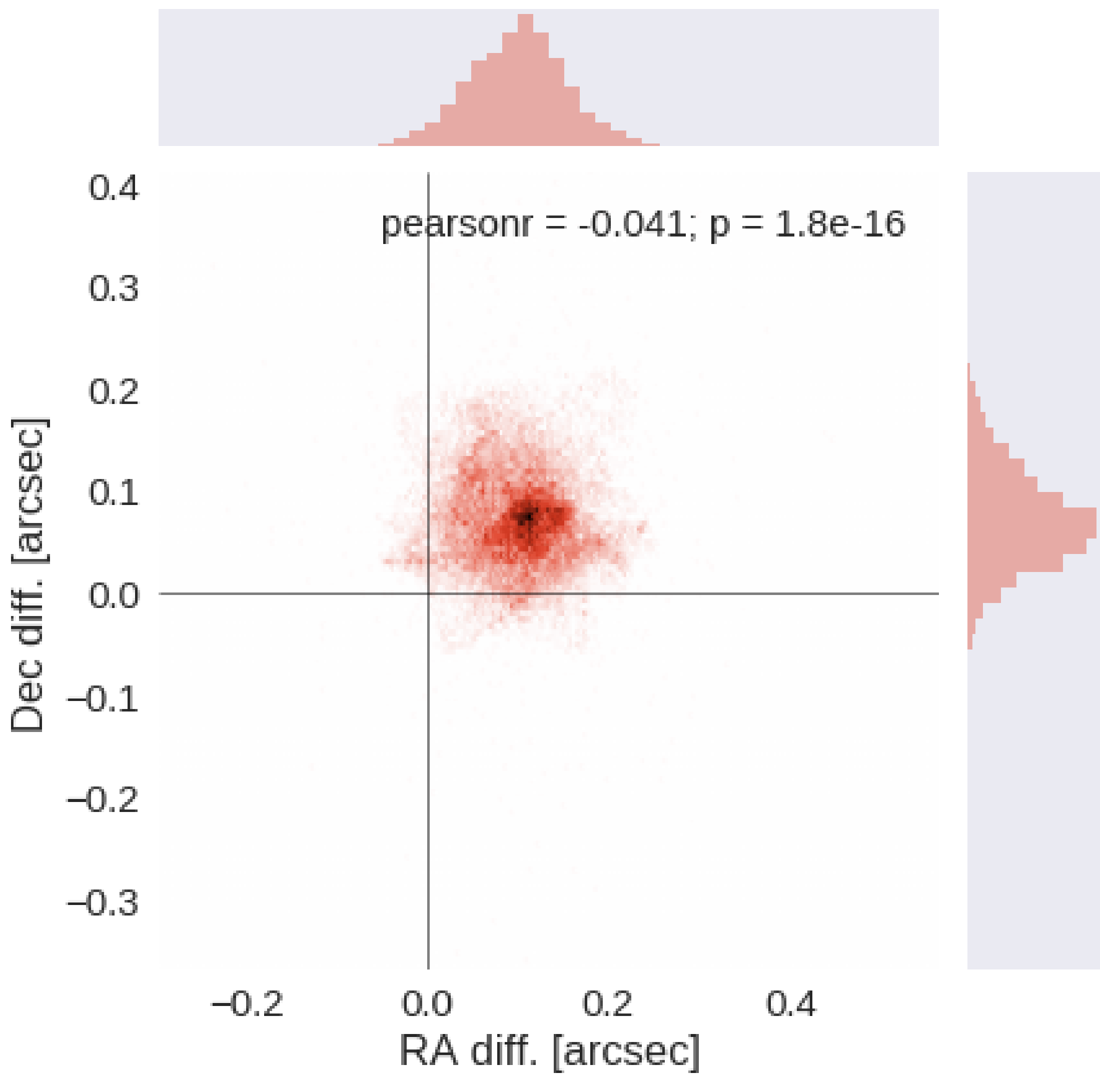
1.5 III - Removal of duplicated sources

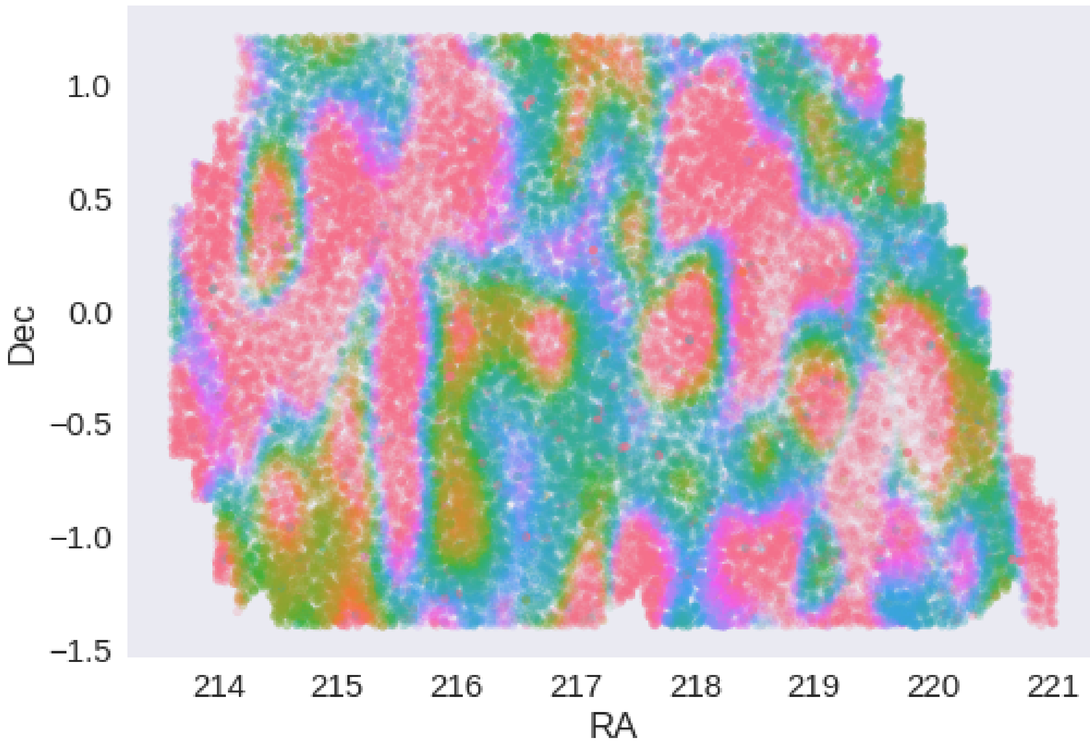
We remove duplicated objects from the input catalogues.

```
/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 6952860 sources.
The cleaned catalogue has 6952601 sources (259 removed).
The cleaned catalogue has 258 sources flagged as having been cleaned
```

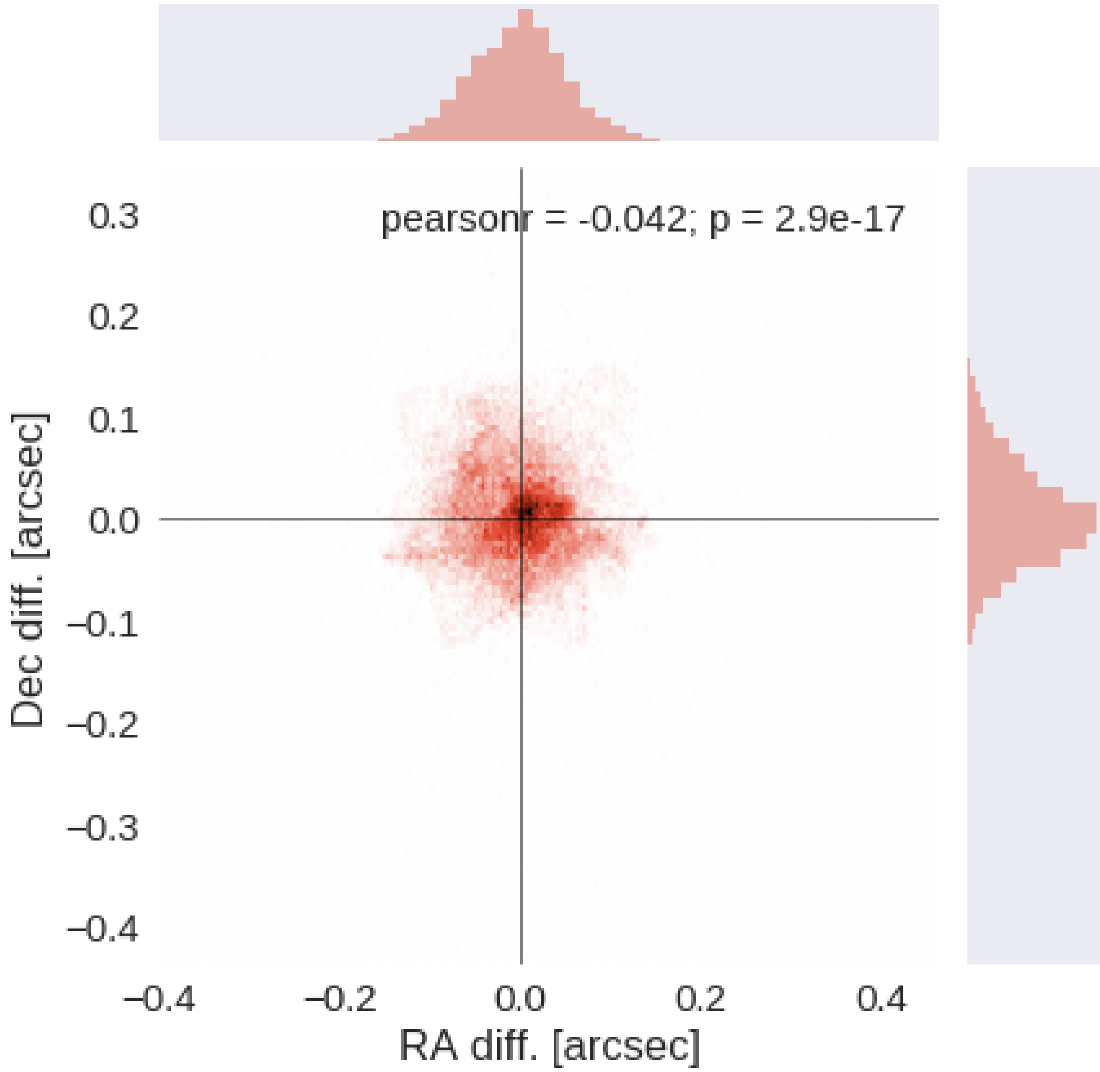
1.6 III - Astrometry correction

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.

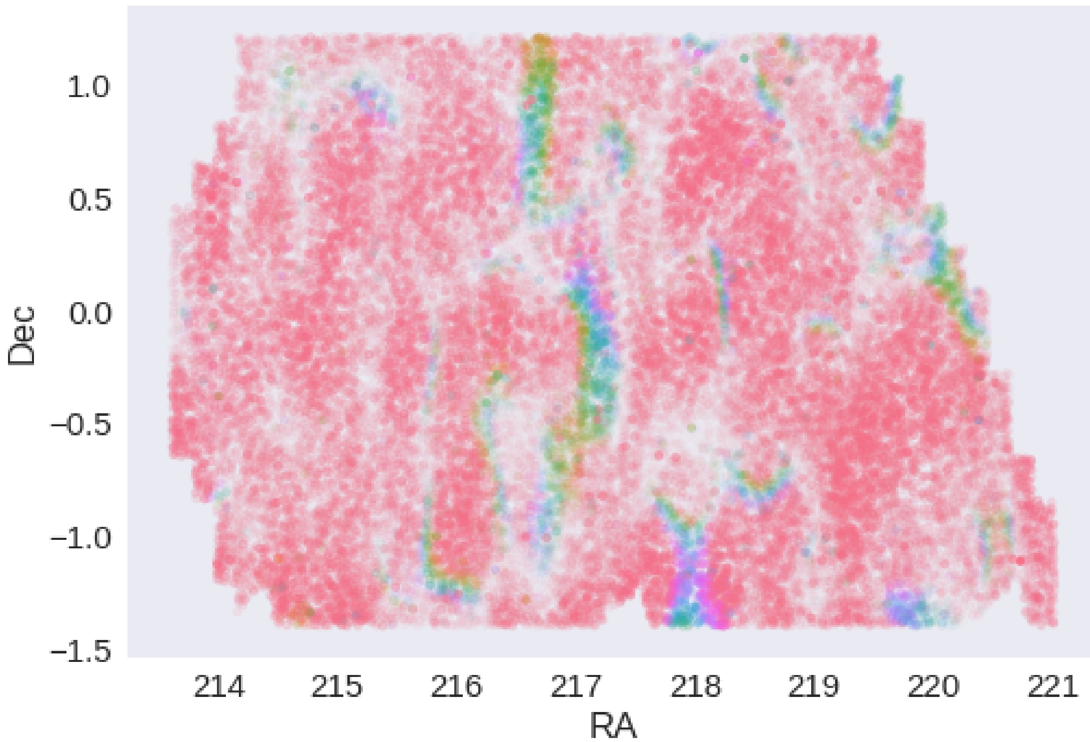

pearsonr = -0.041; p = 1.8e-16
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
Dec diff. [arcsec]
−0.2
0.0
0.2
0.4
RA diff. [arcsec]




```
RA correction: -0.10107775475489689 arcsec
Dec correction: -0.06822208740950853 arcsec
```



pearsonr = -0.042; p = 2.9e-17
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
Dec diff. [arcsec]
−0.4
−0.2
0.0
0.2
0.4
RA diff. [arcsec]



1.7 IV - Flagging Gaia objects

```
43661 sources flagged.
```

1.8 V - Flagging objects near bright stars

2 VI - Saving to disk

1.3_KIDS

January 18, 2018

1 GAMA-15 master catalogue

1.1 Preparation of KIDS/VST data

Kilo Degree Survey/VLT Survey Telescope catalogue: the catalogue comes from `dmu0_KIDS`.
In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The aperture corrected aperture magnitude in each band (10 pixels = 2")
- The Petrosian magnitude to be used as total magnitude (no "auto" magnitude is provided).

We take 2014 as the observation year from a typical image header.

```
This notebook was run with herschelhelp_internal version:
44f1ae0 (Thu Nov 30 18:27:54 2017 +0000)
```

1.2 I - Column selection

```
/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: invalid value enco
  errors = 2.5 / np.log(10) * errors_on_fluxes / fluxes
```

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

1.3 II - Removal of duplicated sources

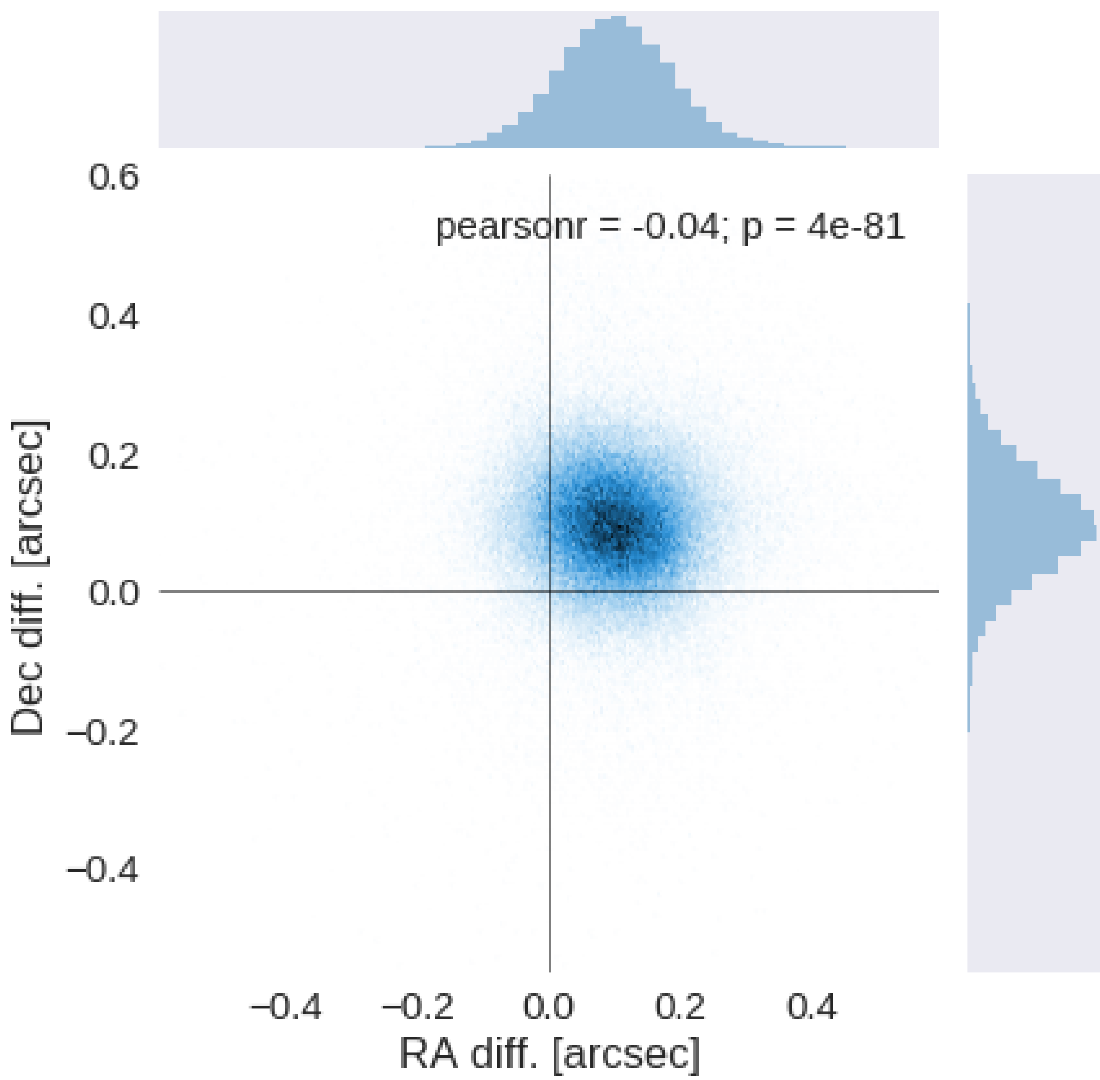
We remove duplicated objects from the input catalogues.

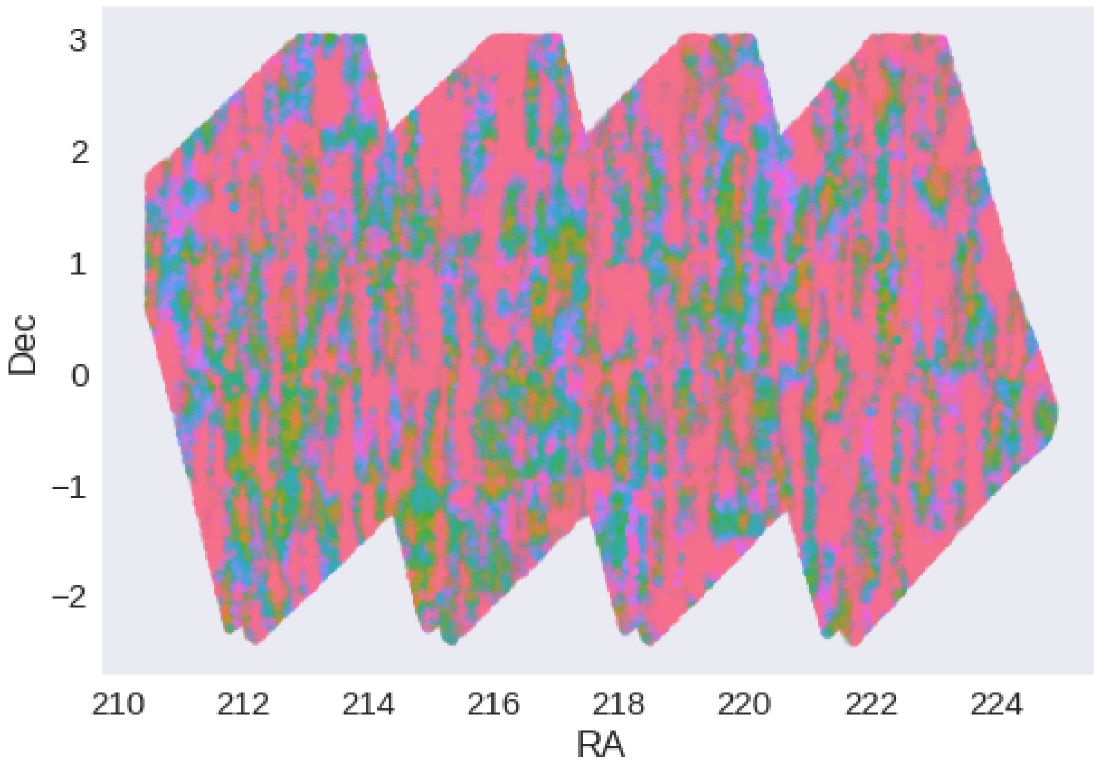
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 6861811 sources.
The cleaned catalogue has 6861671 sources (140 removed).
The cleaned catalogue has 140 sources flagged as having been cleaned
```

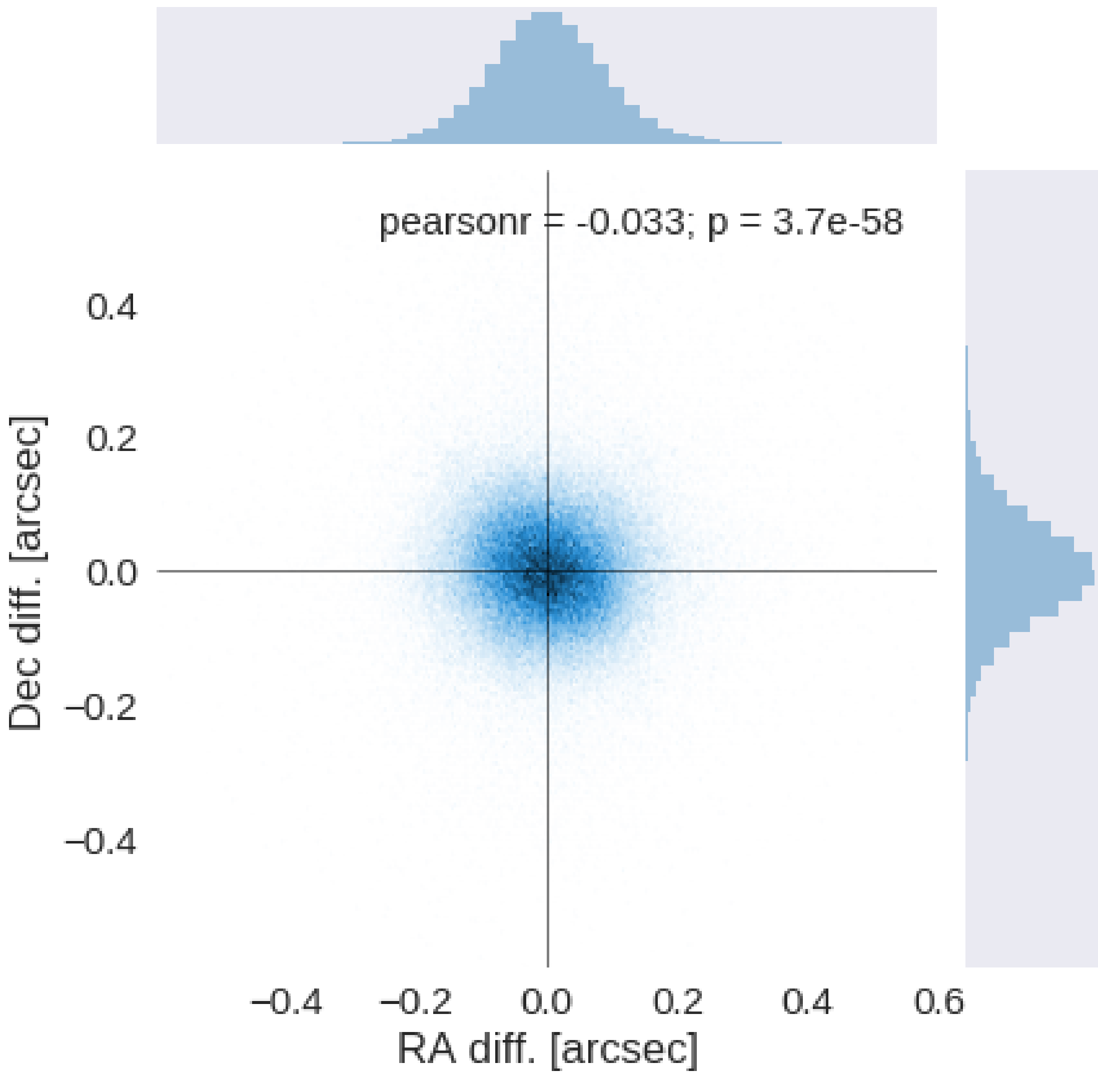
1.4 III - Astrometry correction

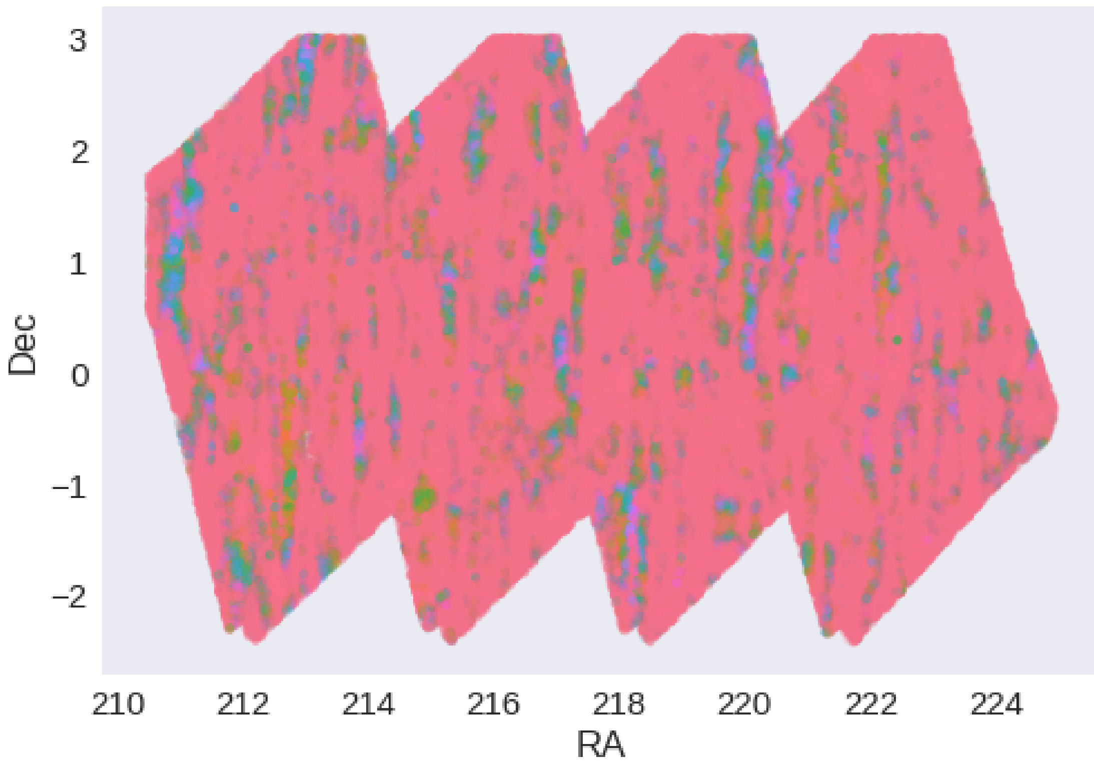
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.






```
RA correction: -0.10032077190089694 arcsec
Dec correction: -0.09517612471143799 arcsec
```


pearsonr = -0.033; p = 3.7e-58
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.4
−0.2
0.0
0.2
0.4
0.6
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
246362 sources flagged.
```

1.6 V - Flagging objects near bright stars

2 VI - Saving to disk

1.4_PanSTARRS

January 18, 2018

1 GAMA-15 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 'F' means we take the forced photometry from chi-squared image priors. We also use an updated catalogue with significatnly fewer duplicates. See DMU_0 for details of how we reduced the duplicate sources.

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:
44f1ae0 (Thu Nov 30 18:27:54 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

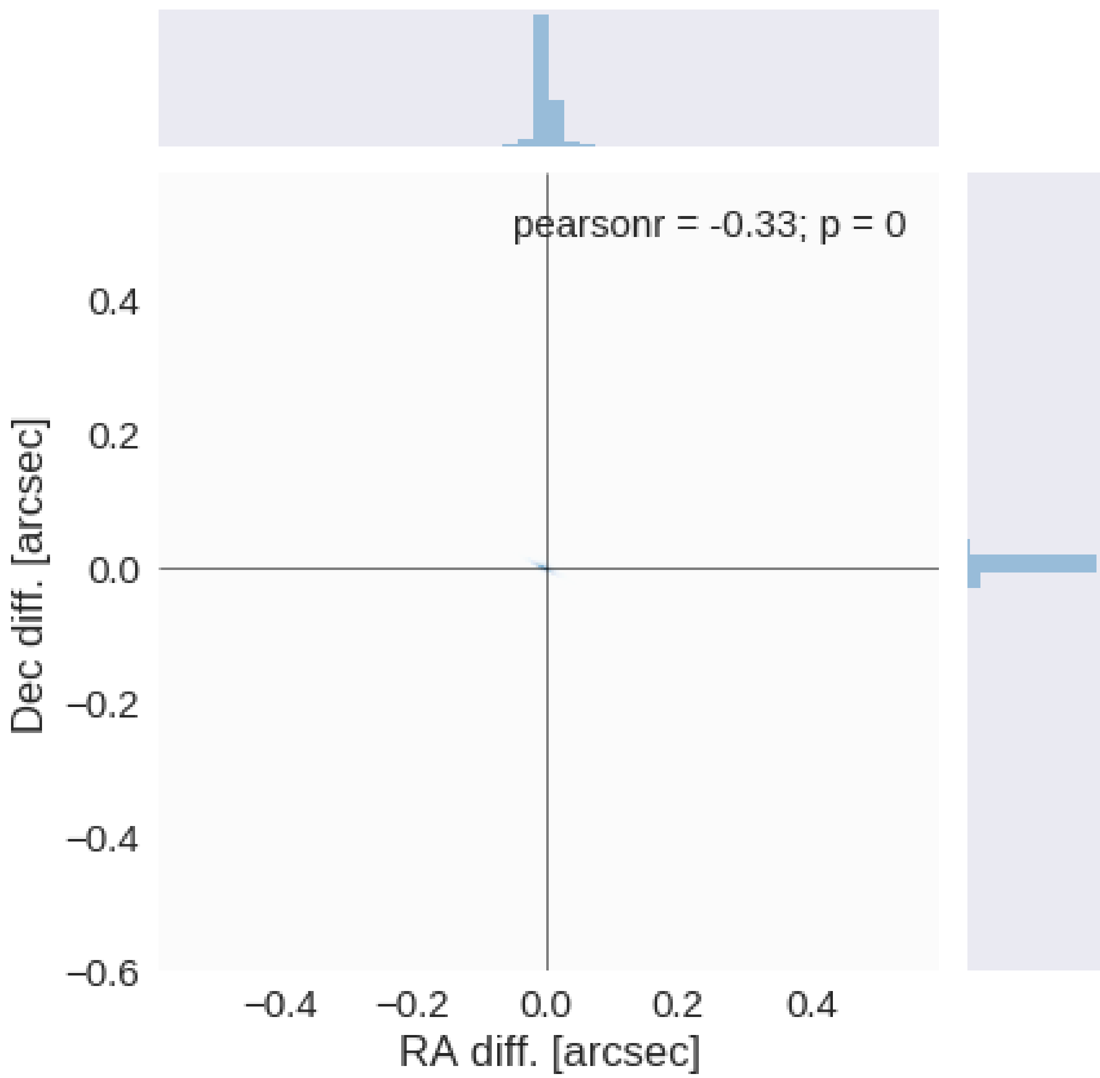
We remove duplicated objects from the input catalogues.

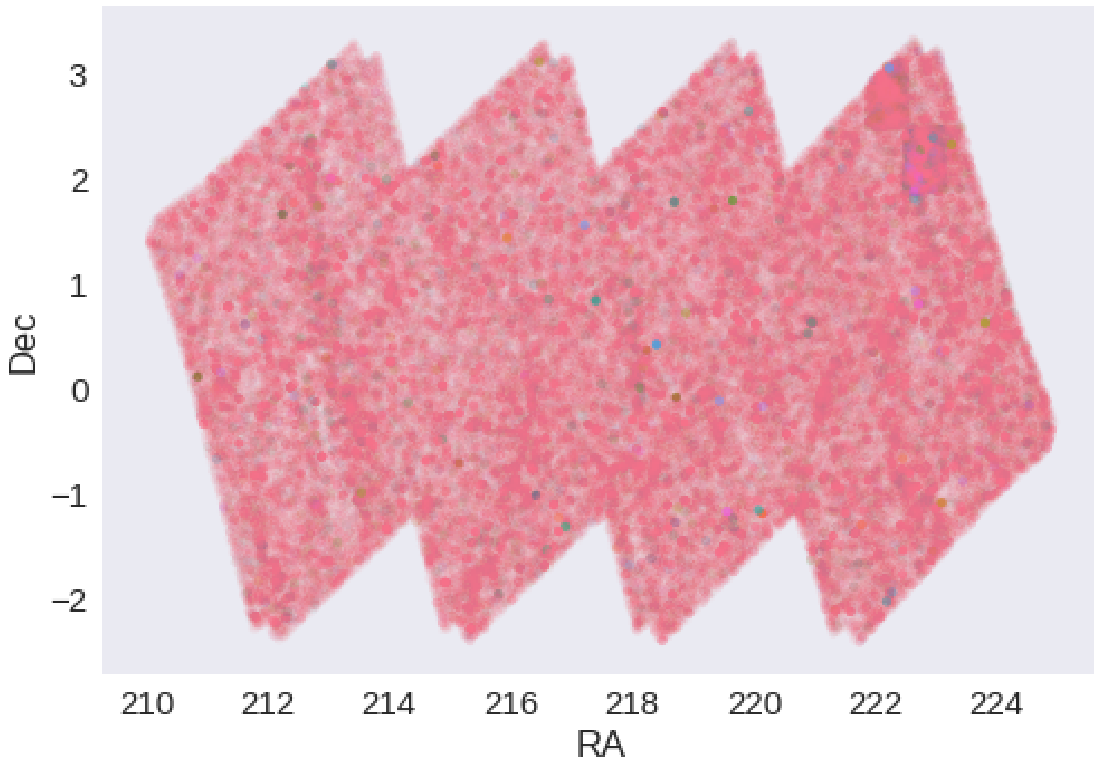
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 1401806 sources.
The cleaned catalogue has 1401443 sources (363 removed).
The cleaned catalogue has 363 sources flagged as having been cleaned
```

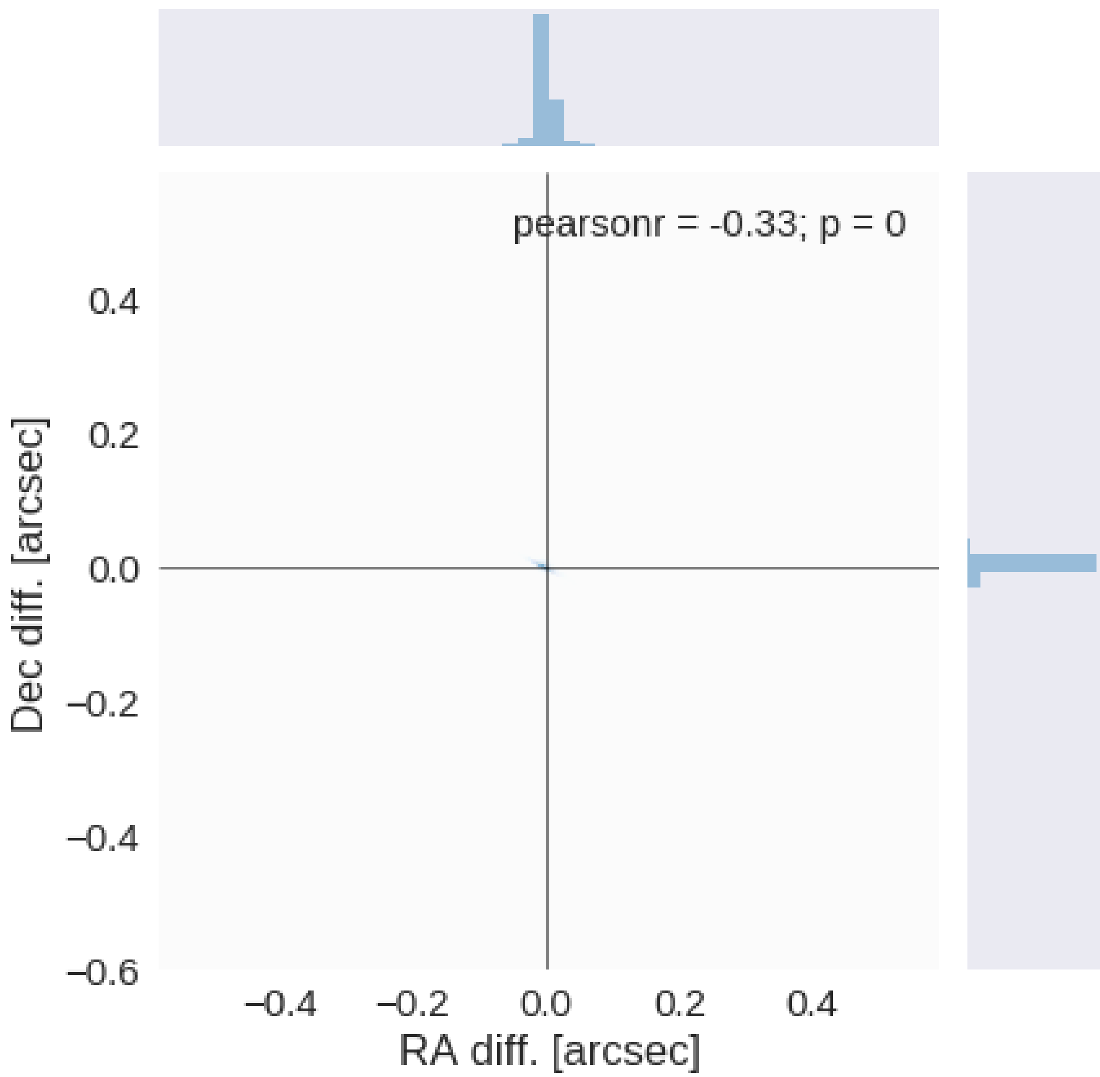
1.4 III - Astrometry correction

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.

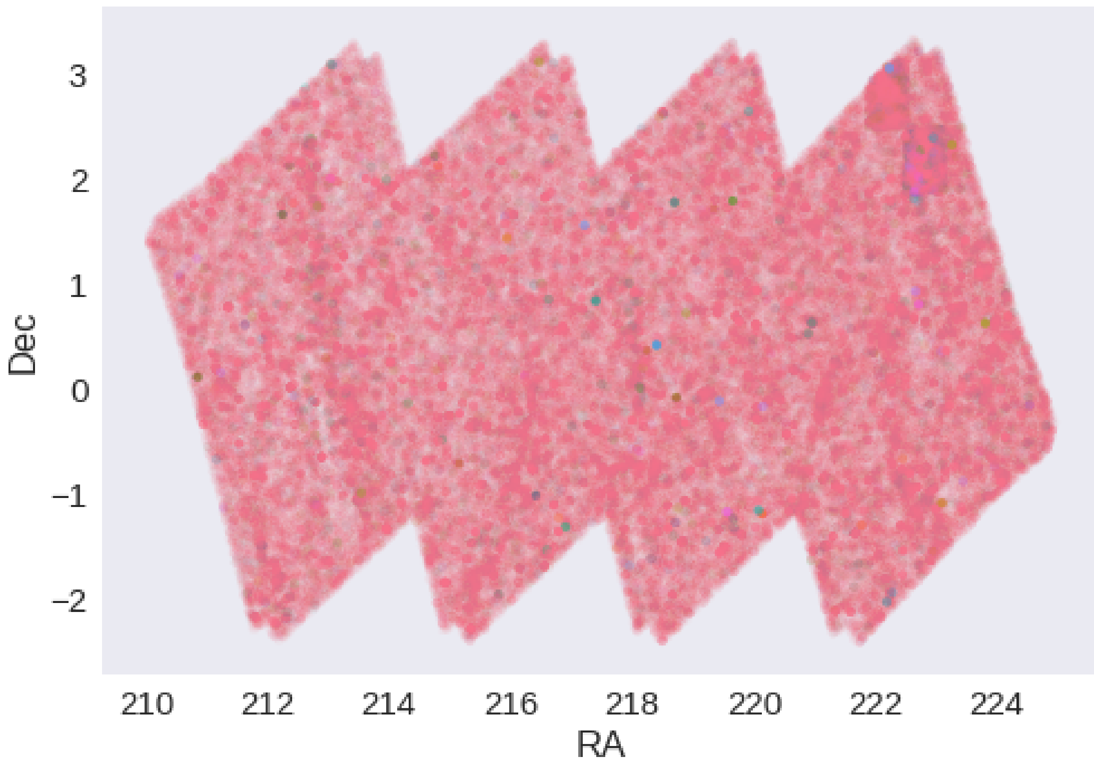





```
RA correction: -0.0005758271811373561 arcsec
Dec correction: -0.0002114812548081879 arcsec
```



pearsonr = -0.33; p = 0
0.4
0.2
0.0
−0.2
−0.4
−0.6
Dec diff. [arcsec]
−0.4
−0.2
0.0
0.2
0.4
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
239049 sources flagged.
```

1.6 V - Flagging objects near bright stars

2 VI - Saving to disk

1.5_UKIDSS-LAS

January 18, 2018

1 GAMA-15 master catalogue

1.1 Preparation of UKIRT Infrared Deep Sky Survey / Large Area Survey (UKIDSS/LAS)

Information about UKIDSS can be found at http://www.ukidss.org/surveys/surveys.html

The catalogue comes from `dmu0_UKIDSS-LAS`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The magnitude for each band in aperture 3 (2 arcsec).
- The hall magnitude is described as the total magnitude.

J band magnitudes are available in two eopchs. We take the first arbitrarily.

The magnitudes are "*Vega like*". The AB offsets are given by Hewett *et al.* (2016):

Band	AB offset
Y	0.634
J	0.938
H	1.379
K	1.900

Each source is associated with an epoch. These range between 2005 and 2007. We take 2006 for the epoch.

```
This notebook was run with herschelhelp_internal version:
44f1ae0 (Thu Nov 30 18:27:54 2017 +0000)
```

1.2 I - Column selection

```
WARNING: UnitsWarning: 'RADIANS' did not parse as fits unit: At col 0, Unit 'RADIANS' not suppor
```

```
/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>
```

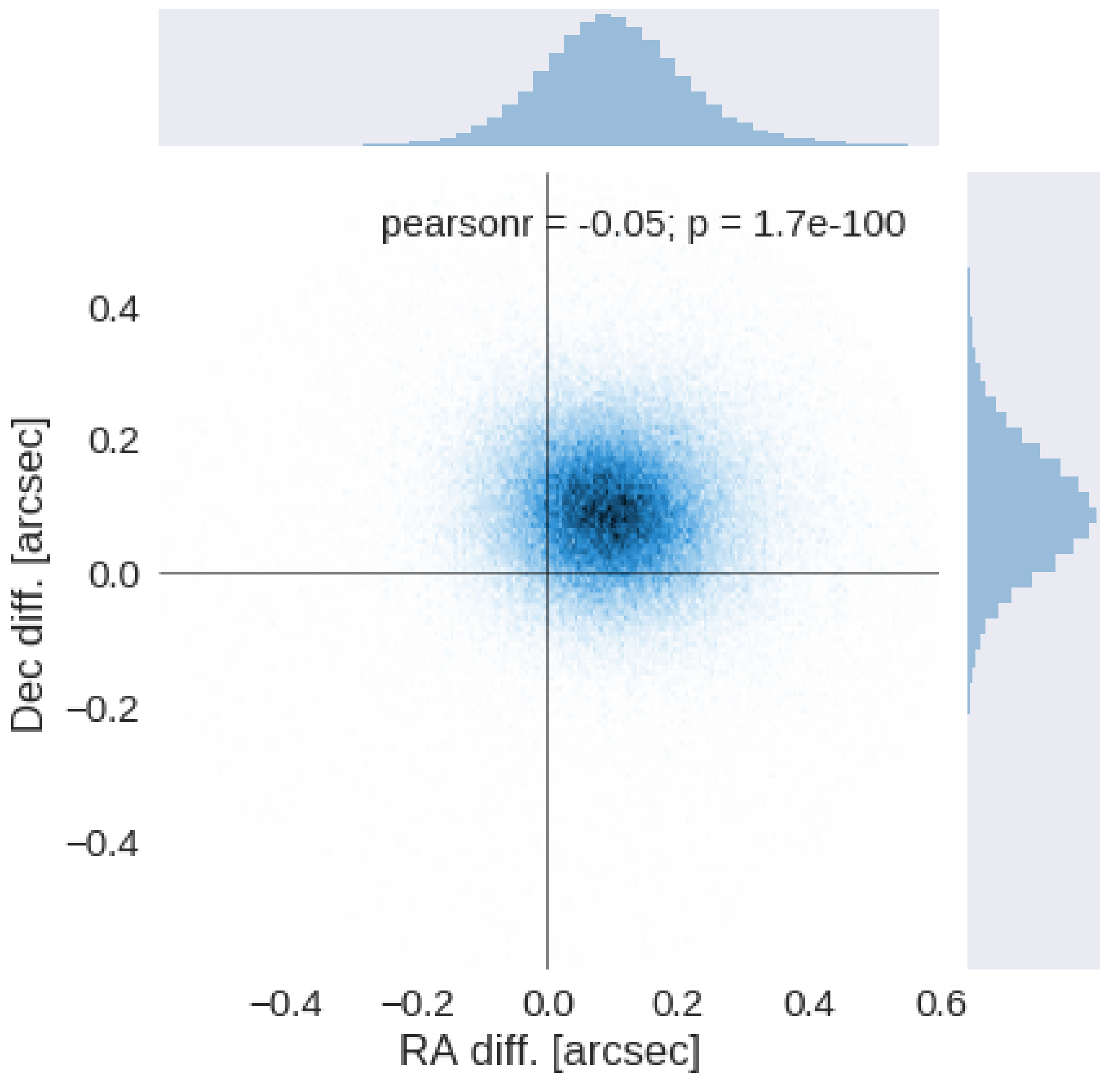
1.3 II - Removal of duplicated sources

We remove duplicated objects from the input catalogues.

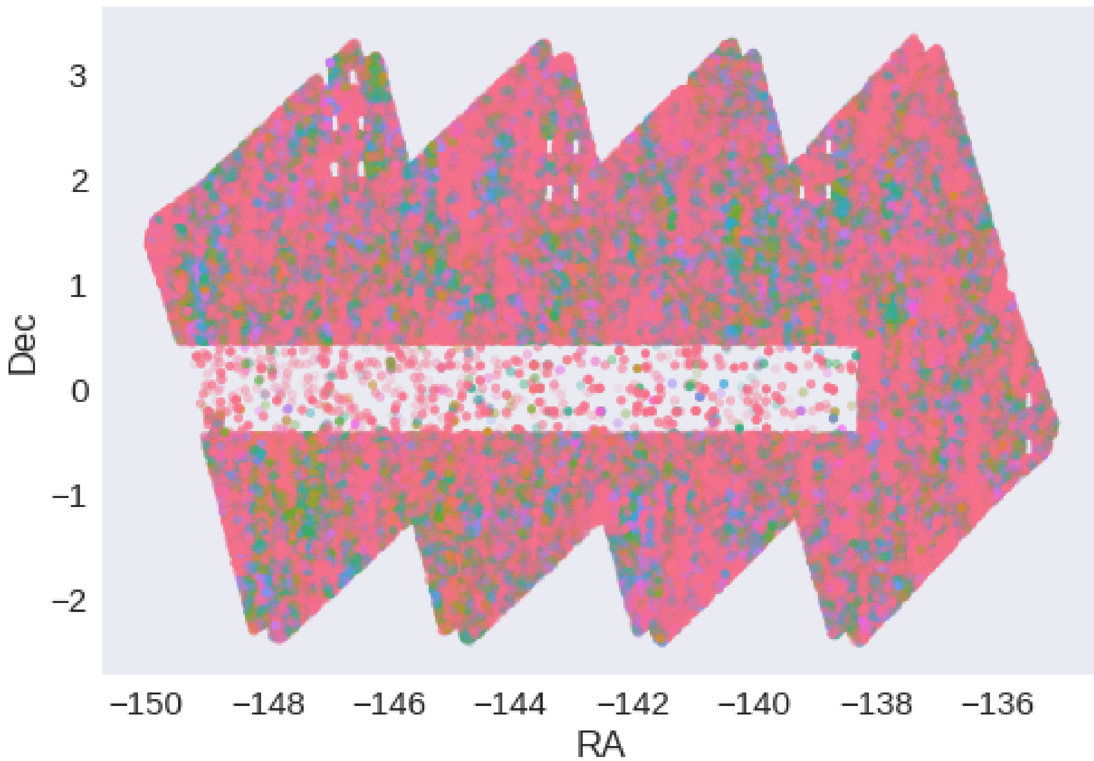
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)


The initial catalogue had 1497654 sources.
The cleaned catalogue has 1497176 sources (478 removed).
The cleaned catalogue has 471 sources flagged as having been cleaned
```

1.4 III - Astrometry correction

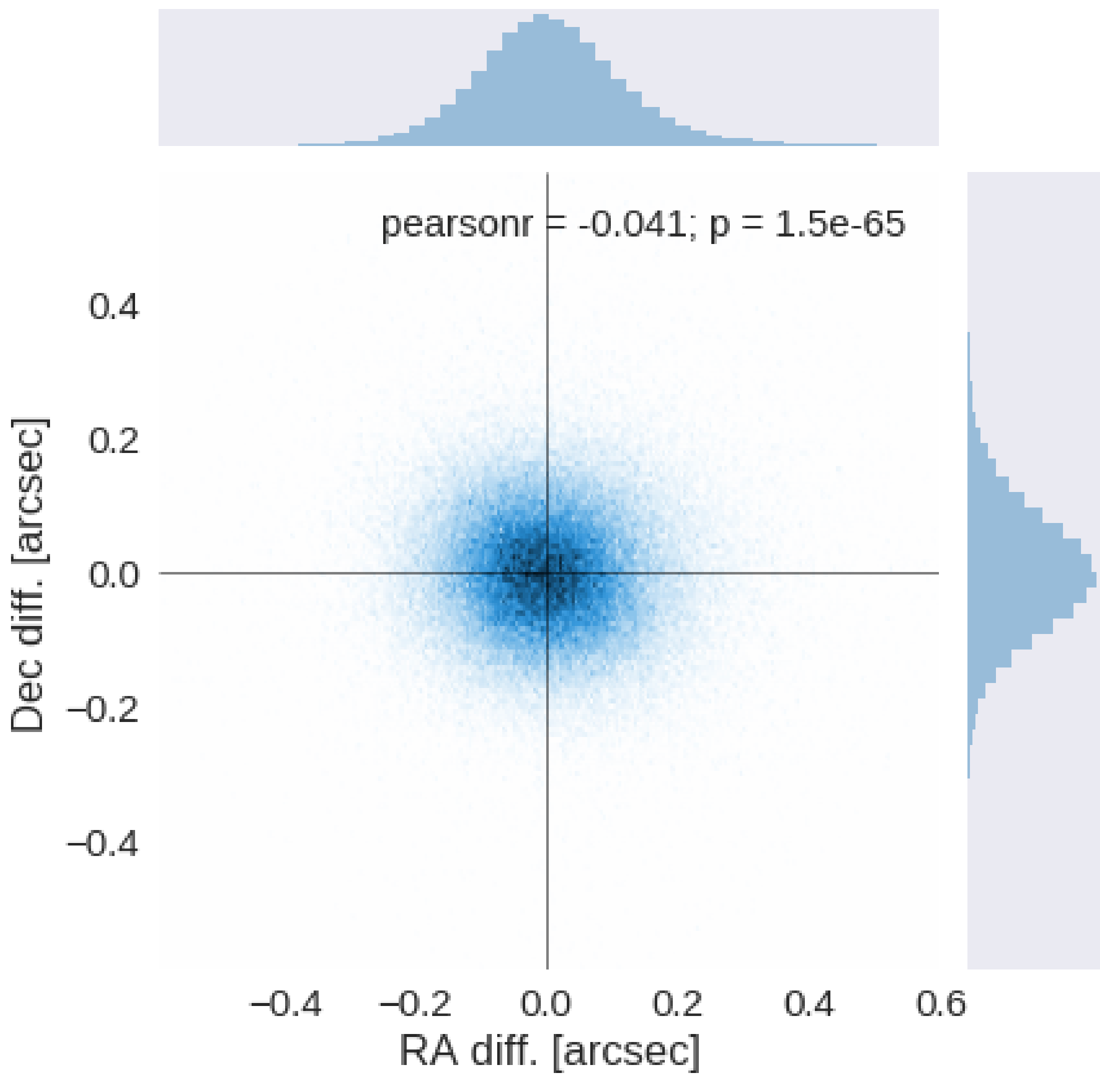
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.



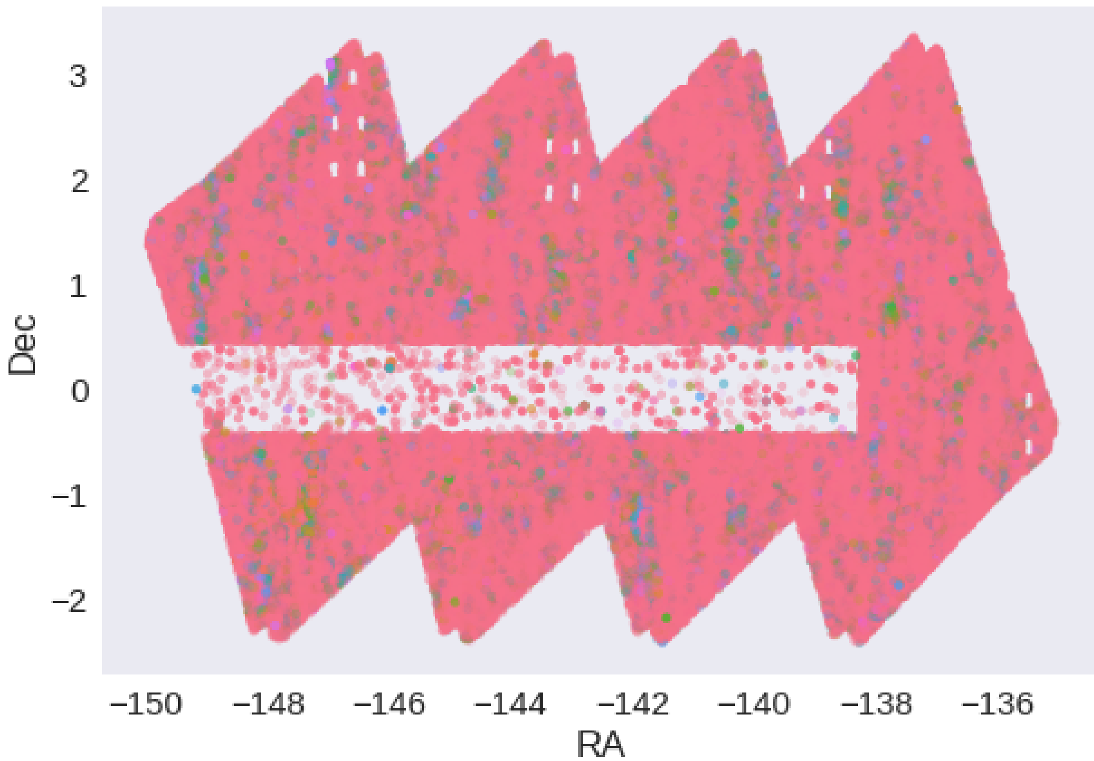
pearsonr = -0.05; p = 1.7e-100
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.4
−0.2
0.0
0.2
0.4
0.6
RA diff. [arcsec]




```
RA correction: -0.09769077962573647 arcsec
Dec correction: -0.09119343336112529 arcsec
```



pearsonr = -0.041; p = 1.5e-65
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.4
−0.2
0.0
0.2
0.4
0.6
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
183382 sources flagged.
```

1.6 V - Flagging objects near bright stars

2 VI - Saving to disk

1.6_VISTA-VIKING

January 18, 2018

1 GAMA-15 master catalogue

1.1 Preparation of VIKING data

VISTA telescope/VIKING catalogue: the catalogue comes from `dmu0_VIKING`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The stellarity;
- The magnitude for each band.
- 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:
44f1ae0 (Thu Nov 30 18:27:54 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[7]: <IPython.core.display.HTML object>
```

1.3 II - Removal of duplicated sources

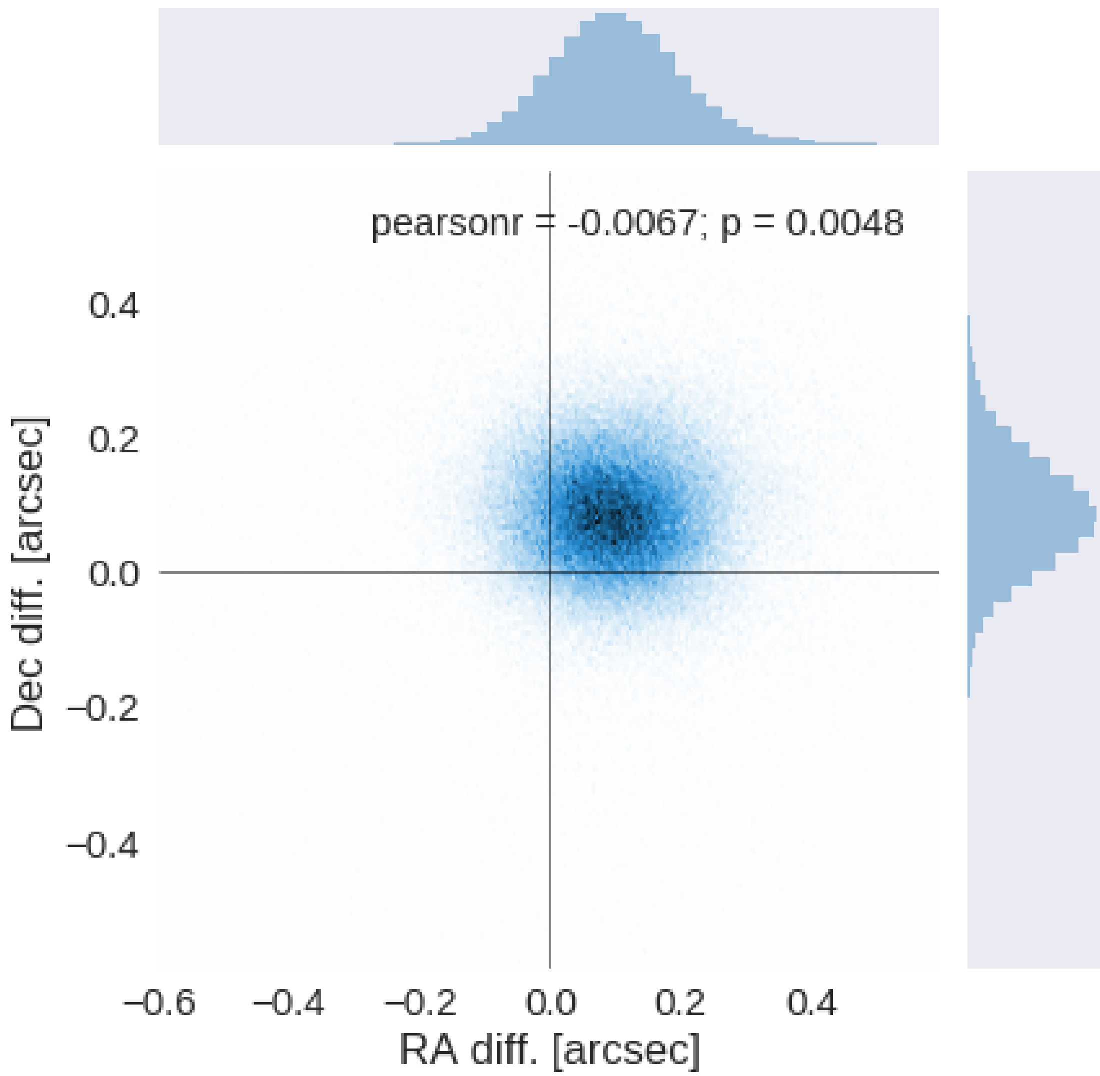
We remove duplicated objects from the input catalogues.

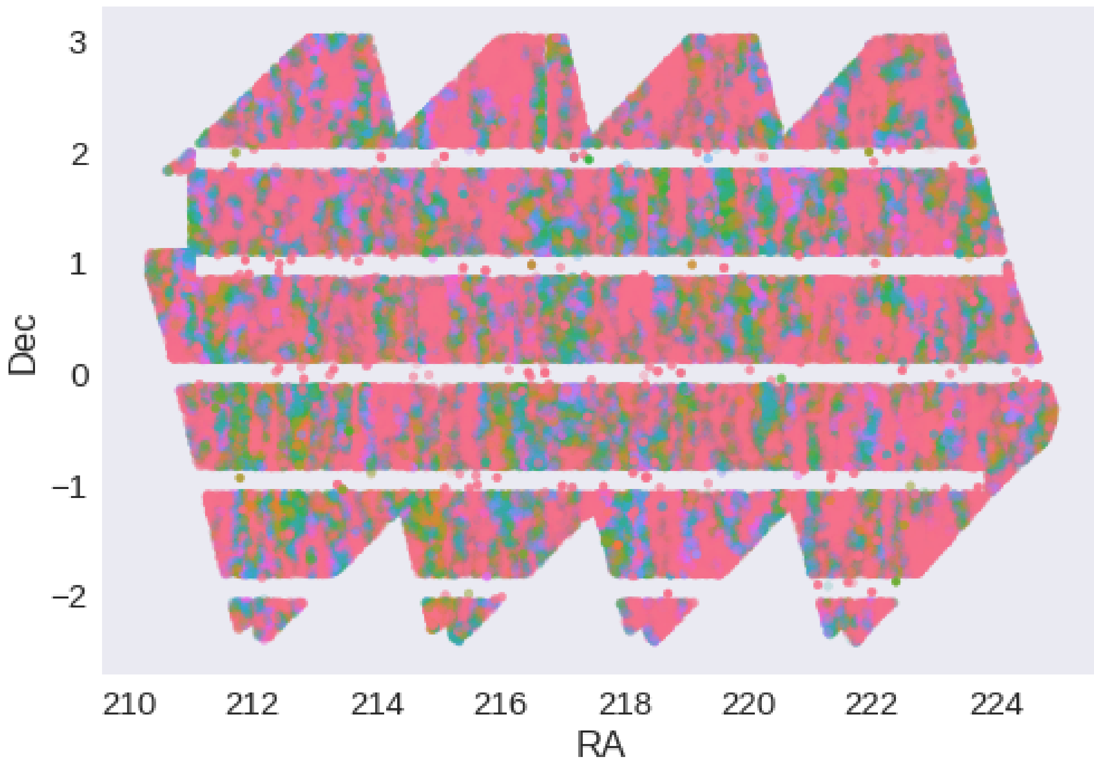
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10
Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 3349591 sources.
The cleaned catalogue has 3348955 sources (636 removed).
The cleaned catalogue has 632 sources flagged as having been cleaned
```

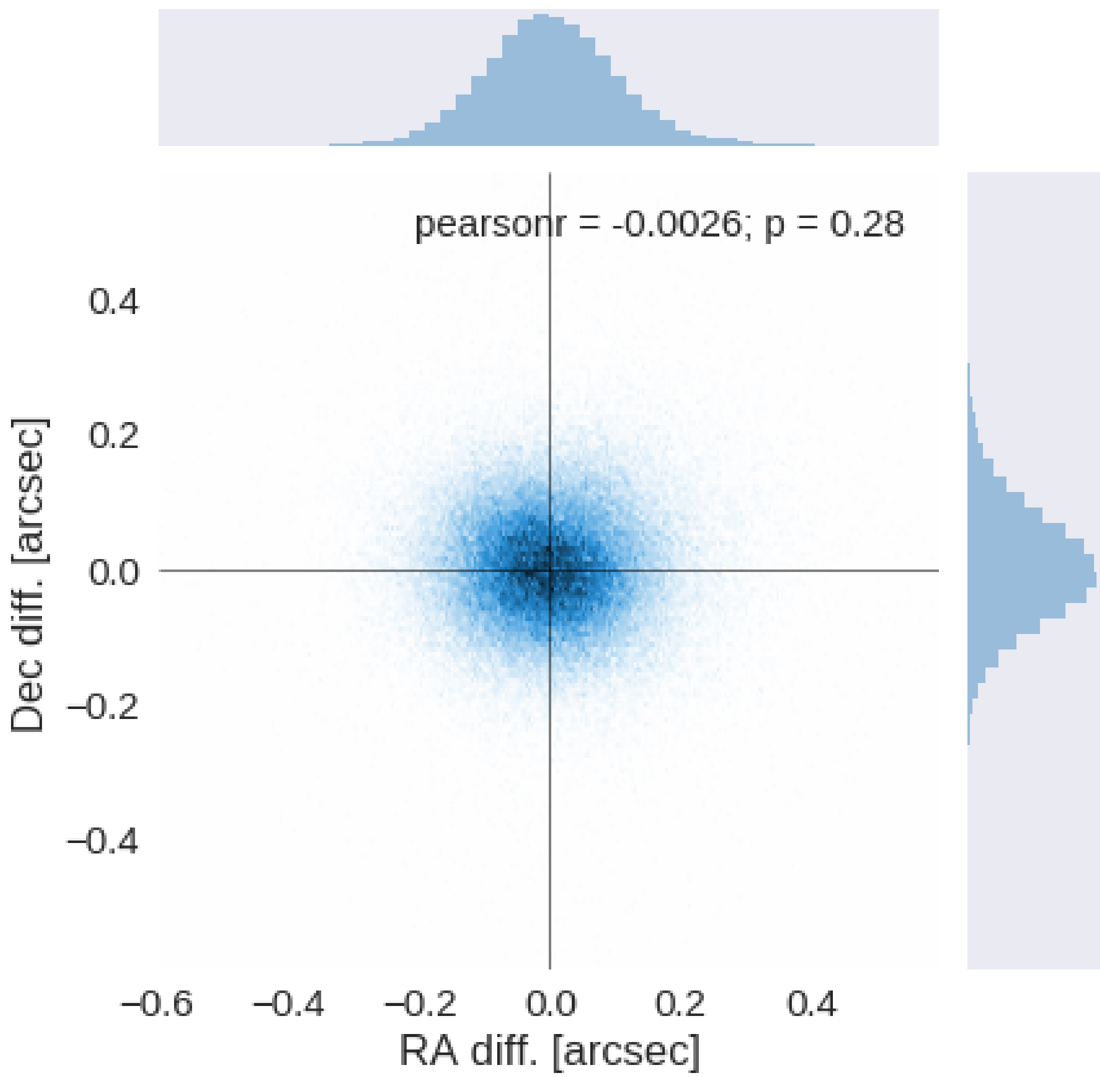
1.4 III - Astrometry correction

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.

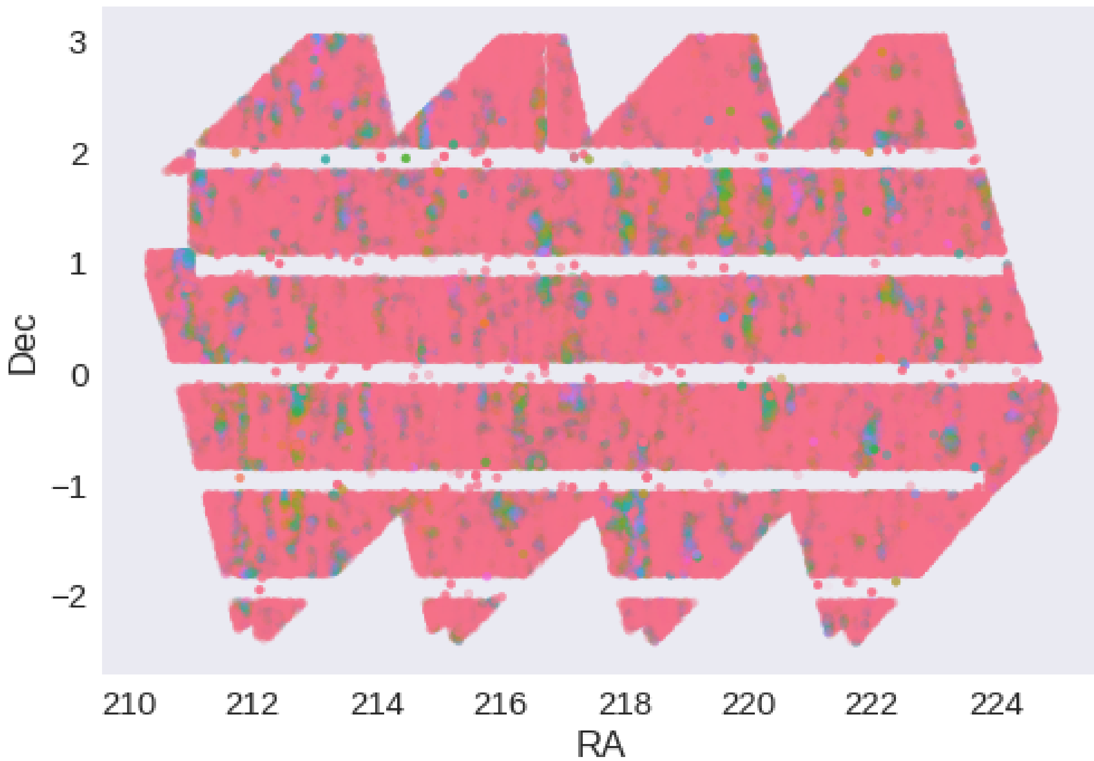





```
RA correction: -0.09687912408935517 arcsec
Dec correction: -0.08577507370057802 arcsec
```



pearsonr = -0.0026; p = 0.28
0.4
0.2
0.0
−0.2
−0.4
Dec diff. [arcsec]
−0.6
−0.4
−0.2
0.0
0.2
0.4
RA diff. [arcsec]



1.5 IV - Flagging Gaia objects

```
178880 sources flagged.
```

1.6 V - Flagging objects near bright stars

2 VI - Saving to disk

2-out

January 18, 2018

1 GAMA-15 master catalogue

This notebook presents the merge of the various pristine catalogues to produce HELP mater catalogue on GAMA-15.

```
This notebook was run with herschelhelp_internal version:
970e176 (Mon Sep 11 16:26:40 2017 +0100) [with local modifications]
```

```
/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/seaborn/apionly.py:6
  warnings.warn(msg, UserWarning)
```

1.1 I - Reading the prepared pristine catalogues

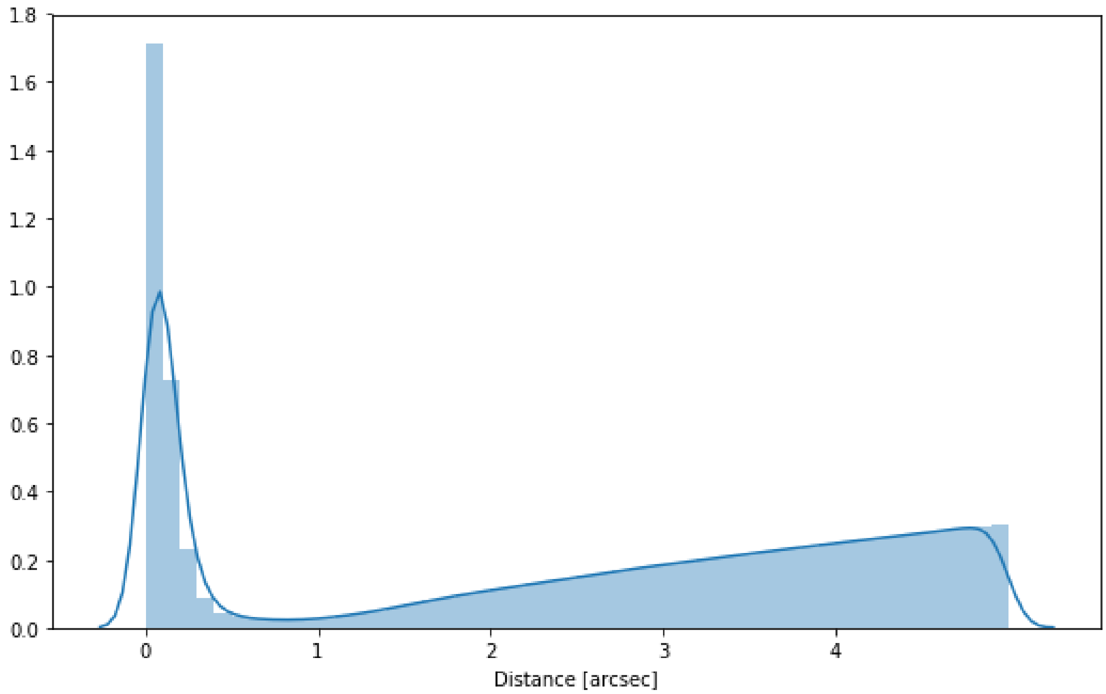
1.2 II - Merging tables

We first merge the optical catalogues and then add the infrared ones: DECaLS, HSC, KIDS, PanSTARRS, UKIDSS-LAS, and VISTA-VIKING.

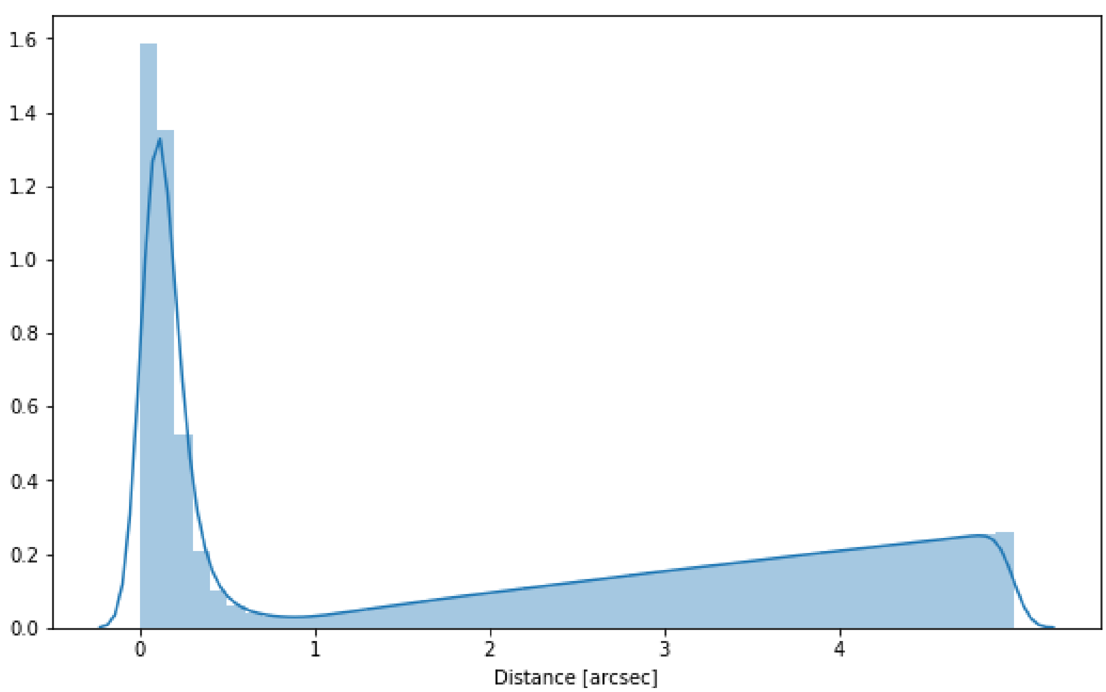
At every step, we look at the distribution of the distances to the nearest source in the merged catalogue to determine the best crossmatching radius.

1.2.1 DECaLS

1.2.2 Add HSC-PSS



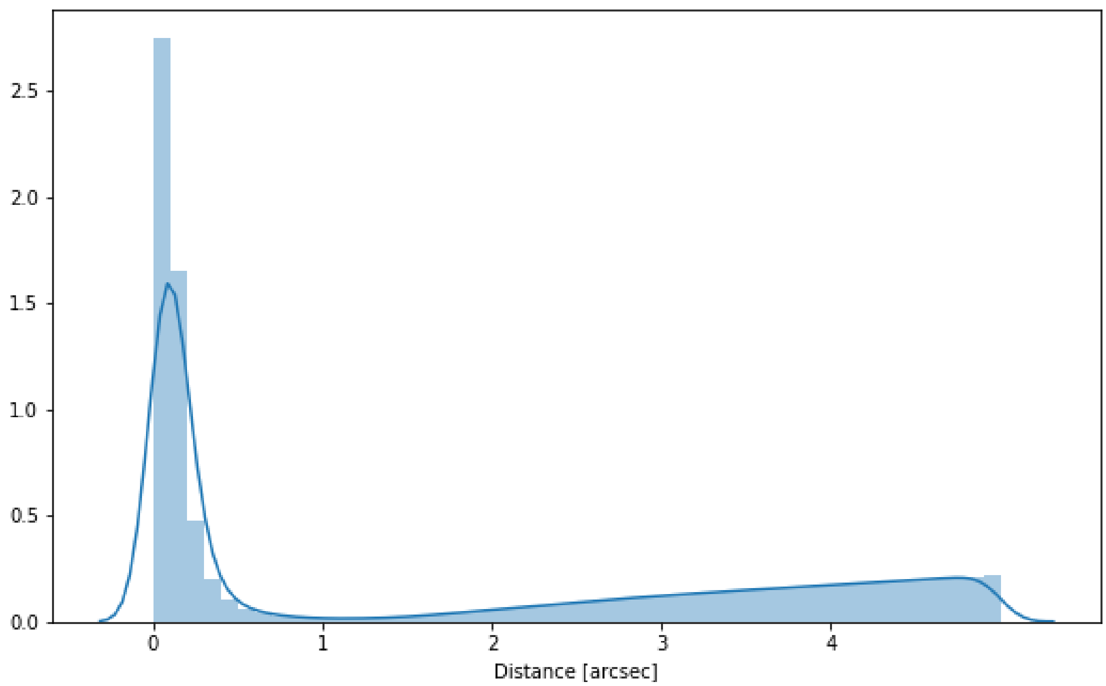
1.2.3 Add KIDS



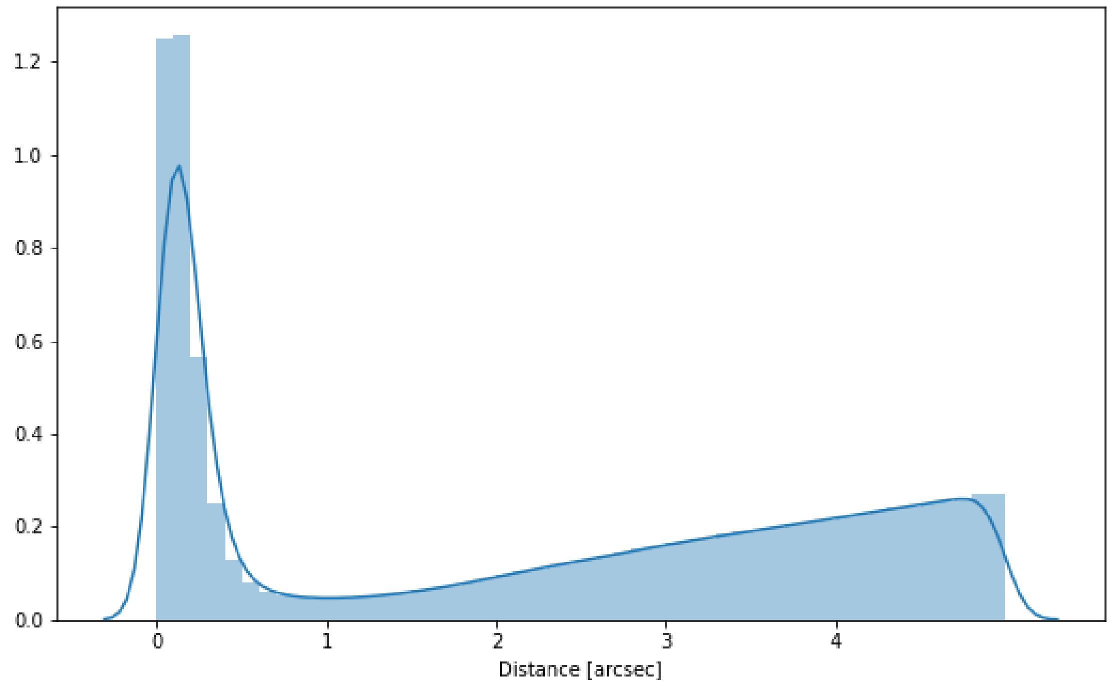
```
---------------------------------------------------------------------------

MemoryError                               Traceback (most recent call last)

<ipython-input-9-cd9839d2fc2a> in <module>()
      1 # Given the graph above, we use 0.8 arc-second radius
----> 2 master_catalogue = merge_catalogues_tiled(master_catalogue, kids, "kids_ra", "kids_d


/research/astro/fir/HELP/help_python/herschelhelp_internal/herschelhelp_internal/masterl
    521             result_table = tmp_result[tmp_tile_mask]
    522         else:
--> 523             result_table = vstack([result_table, tmp_result[tmp_tile_mask]])
    524 
    525     return result_table


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
    188     col_name_map = OrderedDict()
    189 
--> 190     out = _vstack(tables, join_type, col_name_map, metadata_conflicts)
    191 
    192     # Merge table metadata


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
    746                                        .format(col_cls.__name__))
    747         try:
--> 748             out[out_name] = col_cls.info.new_like(cols, n_rows, metadata_conflicts,
    749         except metadata.MergeConflictError as err:
    750             # Beautify the error message when we are trying to merge columns with in


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
    181                                             ('meta', 'unit', 'format', 'description')
    182 
--> 183         return self._parent_cls(length=length, **attrs)
    184 
    185 


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
   1080         self_data = BaseColumn(data, dtype=dtype, shape=shape, length=length, name=n
   1081                                unit=unit, format=format, description=description,
```

```
-> 1082                                meta=meta, copy=copy, copy_indices=copy_indices)
   1083         self = ma.MaskedArray.__new__(cls, data=self_data, mask=mask)
   1084


    /research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
    194         if data is None:
    195             dtype = (np.dtype(dtype).str, shape)
--> 196             self_data = np.zeros(length, dtype=dtype)
    197         elif isinstance(data, BaseColumn) and hasattr(data, '_name'):
    198             # When unpickling a MaskedColumn, ``data`` will be a bare


    MemoryError:
```

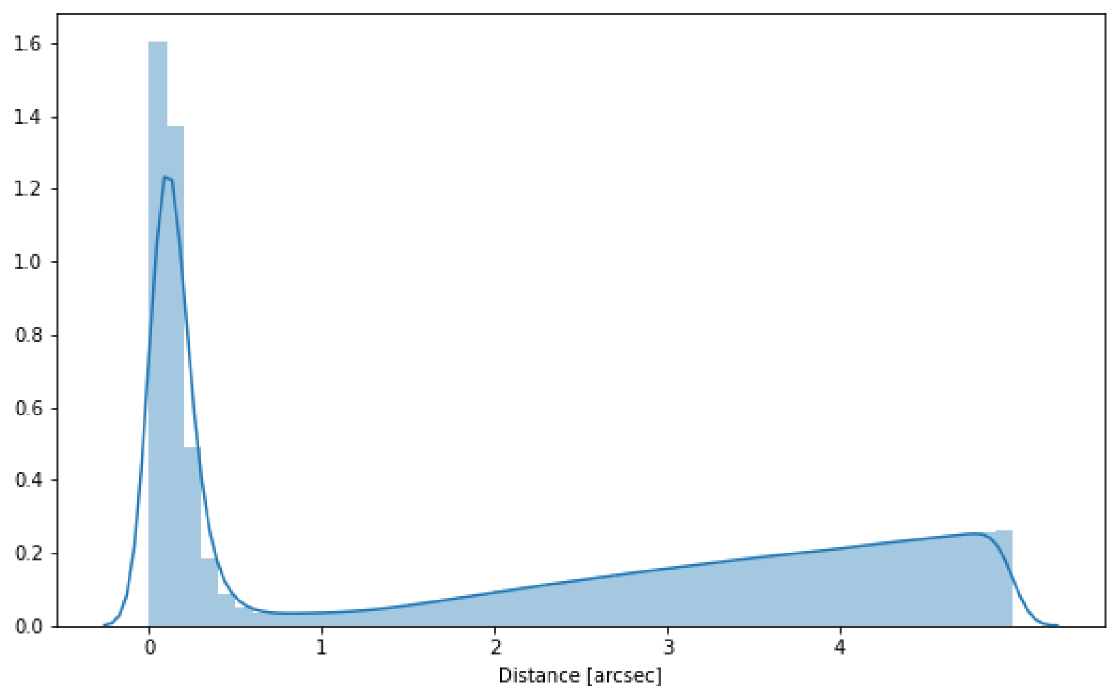
1.2.4 Add PanSTARRS



1.2.5 Add UKIDSS LAS



1.2.6 Add VIKING



1.2.7 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[17]: <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.

```
/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/numpy/lib/nanfunctio
  warnings.warn("All-NaN slice encountered", RuntimeWarning)
```

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

```
    ---------------------------------------------------------------------------

    UnitTypeError                             Traceback (most recent call last)

    <ipython-input-25-f6a9c2adecb3> in <module>()
      1 nb_merge_dist_plot(
      2     SkyCoord(master_catalogue['ra'], master_catalogue['dec']),
----> 3     SkyCoord(specz['ra'] * u.deg, specz['dec'] * u.deg)
      4 )


    /research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/coor
    205         args = list(args)  # Make it mutable
```

```
    206         copy = kwargs.pop('copy', True)
--> 207         kwargs = self._parse_inputs(args, kwargs)
    208 
    209         frame = kwargs['frame']


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/coor
    373                                                                 repr_attr_name
    374                     attr_class = frame.representation.attr_classes[repr_attr_name]
--> 375                     coord_kwargs[frame_attr_name] = attr_class(arg, unit=unit)
    376 
    377             else:


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/coor
    614             raise TypeError("A Longitude angle cannot be created from "
    615                             "a Latitude angle.")
--> 616         self = super(Longitude, cls).__new__(cls, angle, unit=unit, **kwargs)
    617         if wrap_angle is None:
    618             wrap_angle = getattr(angle, 'wrap_angle', self._default_wrap_angle)


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/coor
    113 
    114         return super(Angle, cls).__new__(cls, angle, unit, dtype=dtype,
--> 115                                          copy=copy)
    116 
    117     @staticmethod


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/unit
    297             if type(value) is not cls and not (subok and
    298                                                isinstance(value, cls)):
--> 299                 value = value.view(cls)
    300 
    301             if dtype is None:


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/coor
    656 
    657     def __array_finalize__(self, obj):
--> 658         super(Longitude, self).__array_finalize__(obj)
    659         self._wrap_angle = getattr(obj, '_wrap_angle',
    660                                    self._default_wrap_angle)


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/unit
    401             unit = getattr(obj, '_unit', None)
```

```
    402             if unit is not None:
--> 403                 self._set_unit(unit)
    404
    405         # Copy info if the original had `info` defined.  Because of the way the


    /research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/coor
    135
    136     def _set_unit(self, unit):
--> 137         super(Angle, self)._set_unit(self._convert_unit_to_angle_unit(unit))
    138
    139     @property


    /research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/unit
   1696                 .format(type(self).__name__, self._equivalent_unit) +
   1697                 (", but no unit was given." if unit is None else
-> 1698                  ", so cannot set it to '{0}'.".format(unit)))
   1699
   1700         super(SpecificTypeQuantity, self)._set_unit(unit)


    UnitTypeError: Longitude instances require units equivalent to 'rad', so cannot set it t
```

1.7 VII - Choosing between multiple values for the same filter

In GAMA-15 we don't have any pairs of surveys from the same instruments. All we need to do is rename some columns to the name of the camera

```
    ---------------------------------------------------------------------------

    NameError                                 Traceback (most recent call last)

    <ipython-input-27-2880bd207dbd> in <module>()
      1 #Rename columns for UKIDSS-LAS and VISTA-VIKING
      2
----> 3 for band in [y,j,h,k]:
      4     master_catalogue['f_ap_ukidss_' + band].name = 'f_ap_wfcam_' + band
      5     master_catalogue['ferr_ap_ukidss_' + band].name = 'ferr_ap_wfcam_' + band


    NameError: name 'y' is not defined
```

1.8 VIII.a Wavelength domain coverage

We add a binary `flag_optnir_obs` indicating that a source was observed in a given wavelenght 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.

```
---------------------------------------------------------------------------

NameError                                 Traceback (most recent call last)

<ipython-input-29-93f9321e7e7a> in <module>()
  1 was_observed_optical = inMoc(
  2     master_catalogue['ra'], master_catalogue['dec'],
----> 3     cfhtlens_moc + cfhtls_moc + decals_moc + hsc_moc + ps1_moc)
  4
  5 was_observed_nir = inMoc(


NameError: name 'cfhtlens_moc' is not defined
```

```
---------------------------------------------------------------------------

NameError                                 Traceback (most recent call last)

<ipython-input-30-9a5921d8ea90> in <module>()
  1 master_catalogue.add_column(
  2     Column(
----> 3         1 * was_observed_optical + 2 * was_observed_nir + 4 * was_observed_mir,
  4         name="flag_optnir_obs")
  5 )


NameError: name 'was_observed_optical' is not defined
```

1.9 VIII.b Wavelenght domain detection

We add a binary `flag_optnir_det` indicating that a source was detected in a given wavelenght 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.

```
---------------------------------------------------------------------------

KeyError                                  Traceback (most recent call last)

<ipython-input-31-66288f11f65e> in <module>()
 20     1 * ~np.isnan(master_catalogue['f_kids_u']) +
 21     1 * ~np.isnan(master_catalogue['f_kids_g']) +
---> 22     1 * ~np.isnan(master_catalogue['f_kids_r']) +
 23     1 * ~np.isnan(master_catalogue['f_kids_i'])
 24 )


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
   1222     def __getitem__(self, item):
   1223         if isinstance(item, six.string_types):
-> 1224             return self.columns[item]
   1225         elif isinstance(item, (int, np.integer)):
   1226             return self.Row(self, item)


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
    107         """
    108         if isinstance(item, six.string_types):
--> 109             return OrderedDict.__getitem__(self, item)
    110         elif isinstance(item, (int, np.integer)):
    111             return self.values()[item]


KeyError: 'f_kids_u'
```

```
---------------------------------------------------------------------------

NameError                                 Traceback (most recent call last)

<ipython-input-32-badcad18dcc0> in <module>()
----> 1 has_optical_flux = nb_optical_flux >= 2
      2 has_nir_flux = nb_nir_flux >= 2
      3 has_mir_flux = nb_mir_flux >= 2
      4
      5 master_catalogue.add_column(


NameError: name 'nb_optical_flux' is not defined
```

1.10 IX - Cross-identification table

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

```
---------------------------------------------------------------------------

ValueError                                Traceback (most recent call last)

<ipython-input-33-b0b1b89adac5> in <module>()
      7                  'las_id',
      8                  'viking_id',
----> 9                  'specz_id'
     10                ].write(
     11     "{}/master_list_cross_ident_gama-15{}.fits".format(OUT_DIR, SUFFIX))


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
   1232             if bad_names:
   1233                 raise ValueError('Slice name(s) {0} not valid column name(s)'
-> 1234                                  .format(', '.join(bad_names)))
   1235             out = self.__class__([self[x] for x in item],
   1236                                  meta=deepcopy(self.meta),


ValueError: Slice name(s) kids_id not valid column name(s)
```

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: {'las_id', 'viking_id', 'zspec', 'ps1_id', 'zspec_association_flag', 'zspec_qua
```

```
---------------------------------------------------------------------------

ValueError                                Traceback (most recent call last)

<ipython-input-37-f33ec16bceed> in <module>()
----> 1 master_catalogue[columns].write("{}/master_catalogue_gama-15{}.fits".format(OUT_DIR,


/research/astro/fir/HELP/help_python/miniconda3/lib/python3.6/site-packages/astropy/tabl
   1232             if bad_names:
   1233                 raise ValueError('Slice name(s) {0} not valid column name(s)'
-> 1234                                  .format(', '.join(bad_names)))
   1235             out = self.__class__([self[x] for x in item],
   1236                                  meta=deepcopy(self.meta),


ValueError: Slice name(s) flag_optnir_obs, flag_optnir_det not valid column name(s)
```

2_Merging

January 18, 2018

1 GAMA-15 master catalogue

This notebook presents the merge of the various pristine catalogues to produce HELP mater catalogue on GAMA-15.

```
This notebook was run with herschelhelp_internal version:
44f1ae0 (Thu Nov 30 18:27:54 2017 +0000)
```

1.1 I - Reading the prepared pristine catalogues

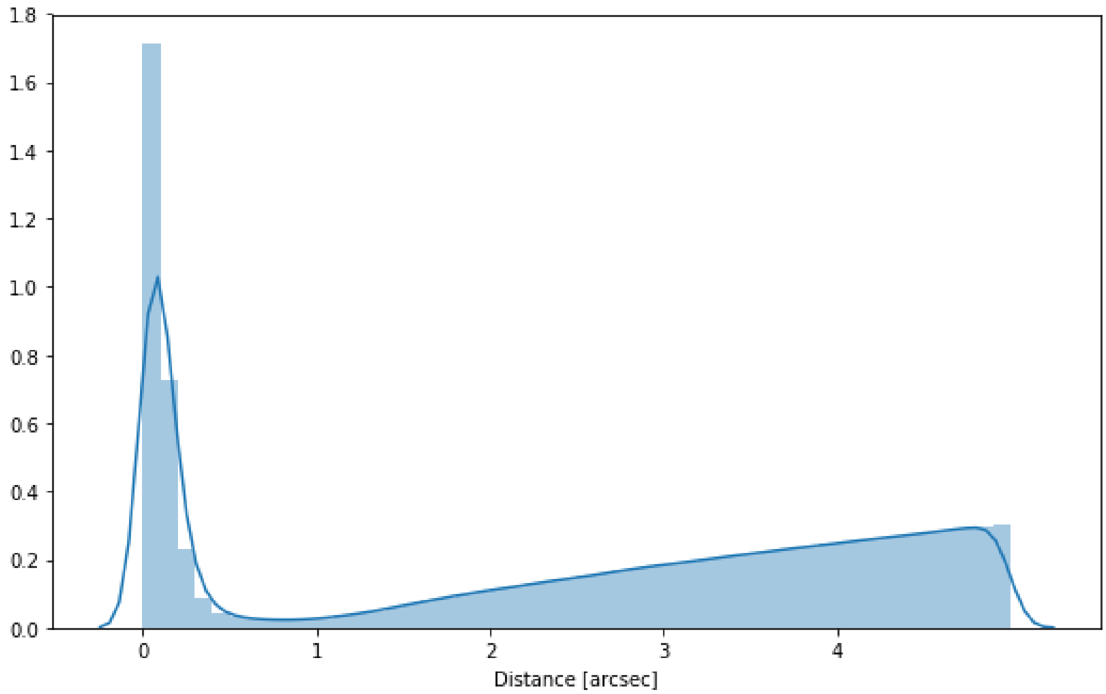
1.2 II - Merging tables

We first merge the optical catalogues and then add the infrared ones: DECaLS, HSC, KIDS, PanSTARRS, UKIDSS-LAS, and VISTA-VIKING.

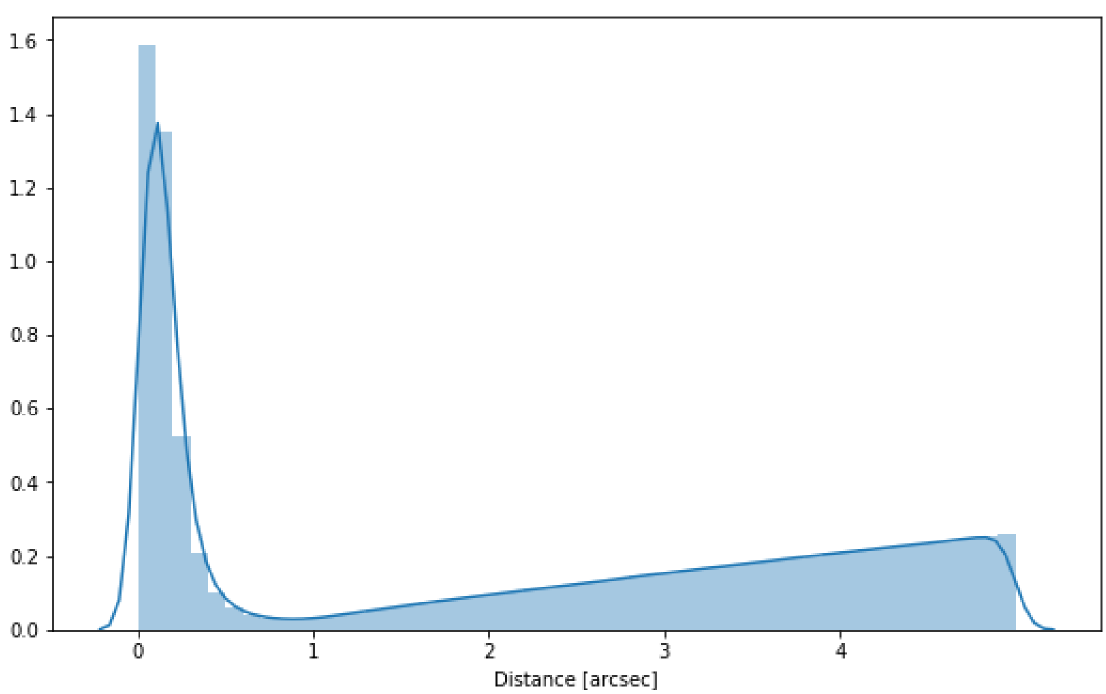
At every step, we look at the distribution of the distances to the nearest source in the merged catalogue to determine the best crossmatching radius.

1.2.1 DECaLS

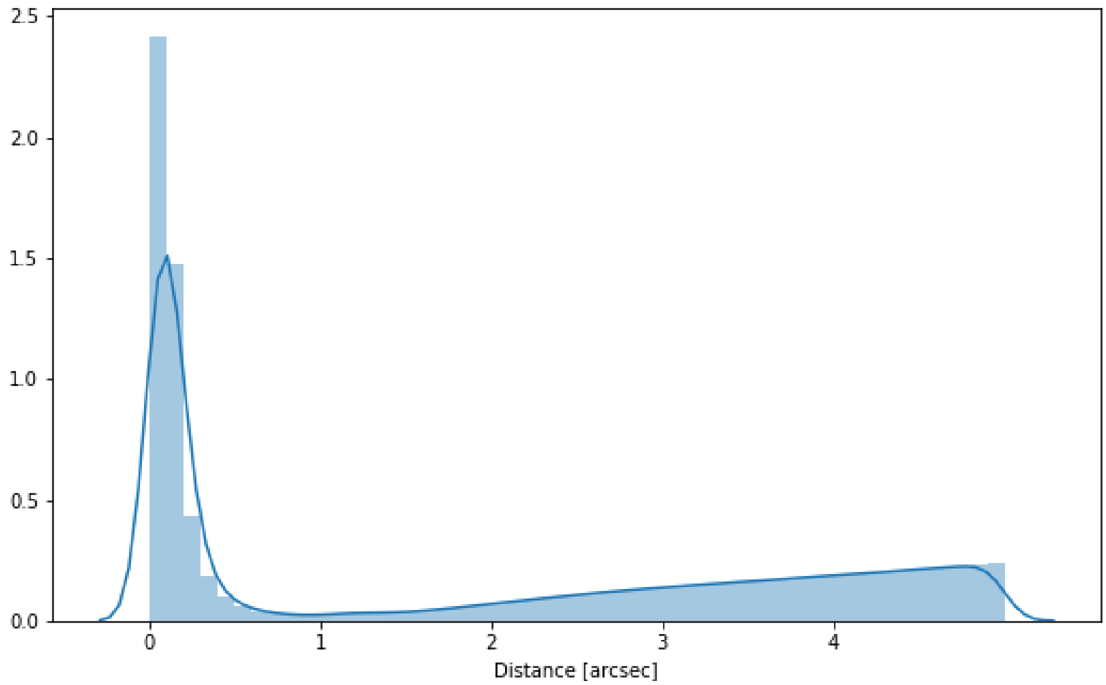
1.2.2 Add HSC-PSS



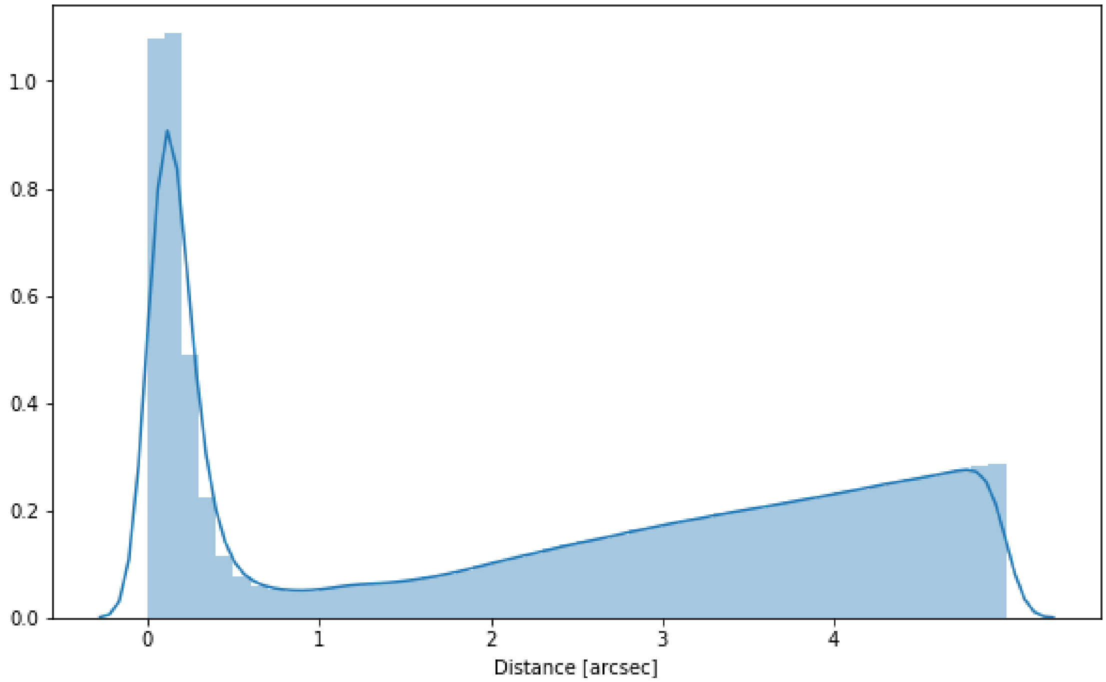
1.2.3 Add KIDS



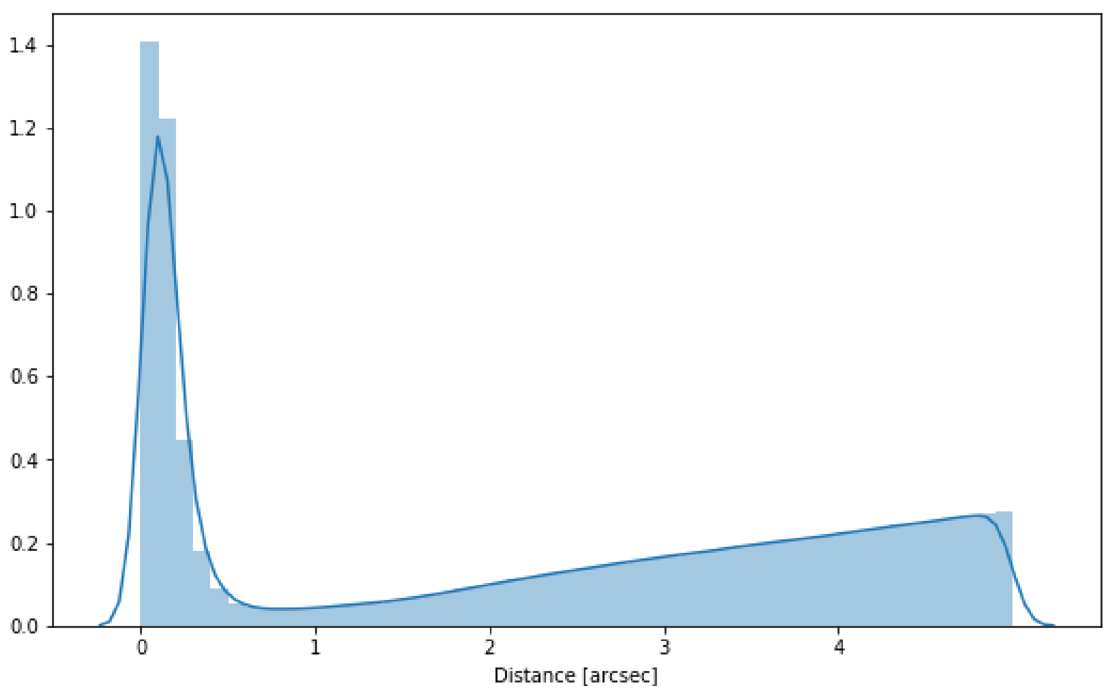
1.2.4 Add PanSTARRS



1.2.5 Add UKIDSS LAS



1.2.6 Add VIKING



1.2.7 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[17]: <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.

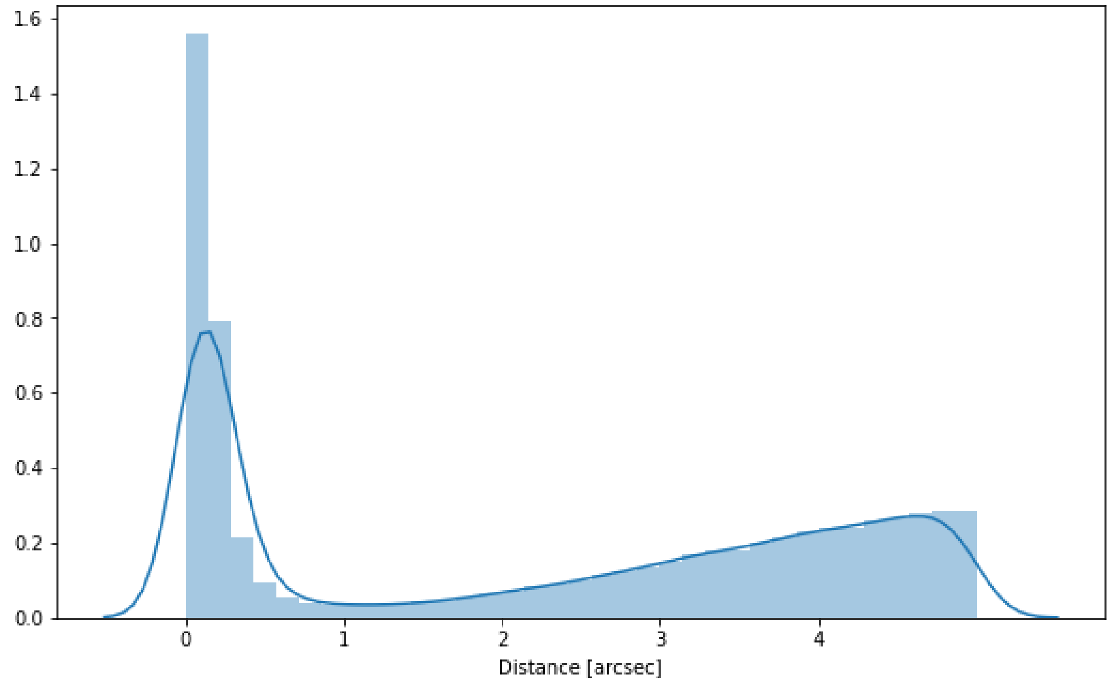
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/lib/nanfunctions.py:
  warnings.warn("All-NaN slice encountered", RuntimeWarning)
```

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

In GAMA-15 we don't have any pairs of surveys from the same instruments. All we need to do is rename some columns to the name of the camera

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 catalogue. This can be used to easily get additional information from them.

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: set()
```

3_Checks_and_diagnostics

January 18, 2018

1 GAMA-15 master catalogue

1.1 Checks and diagnostics

```
This notebook was run with herschelhelp_internal version:
44f1ae0 (Thu Nov 30 18:27:54 2017 +0000)
```

```
Diagnostics done using: master_catalogue_gama-15_20171208.fits
```

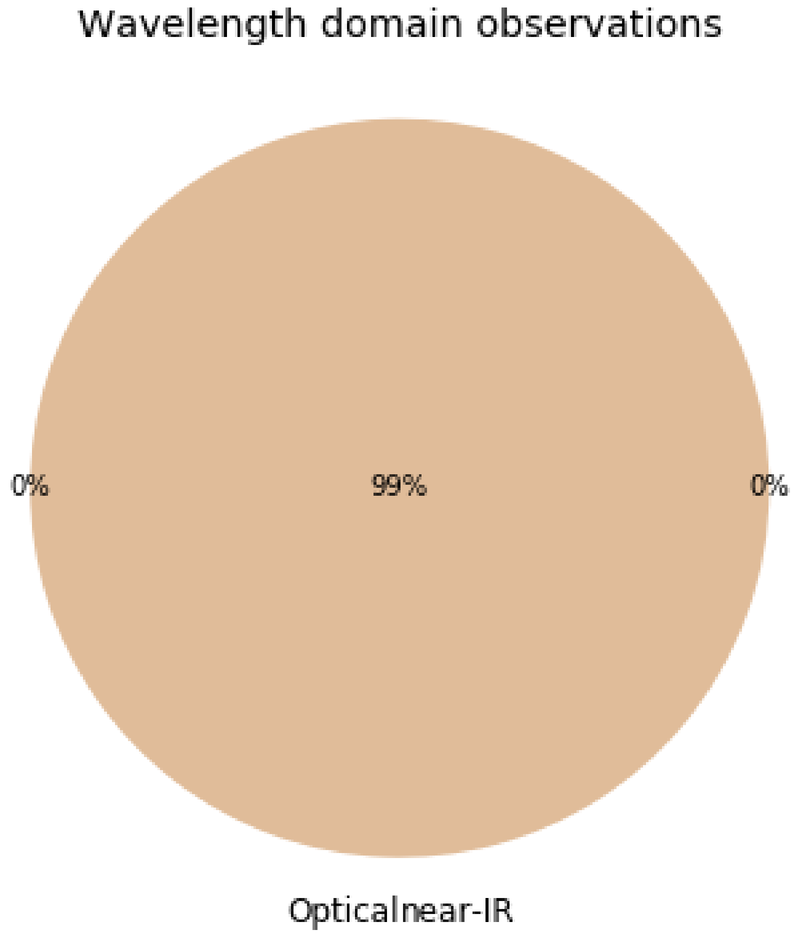
1.2 0 - Quick checks

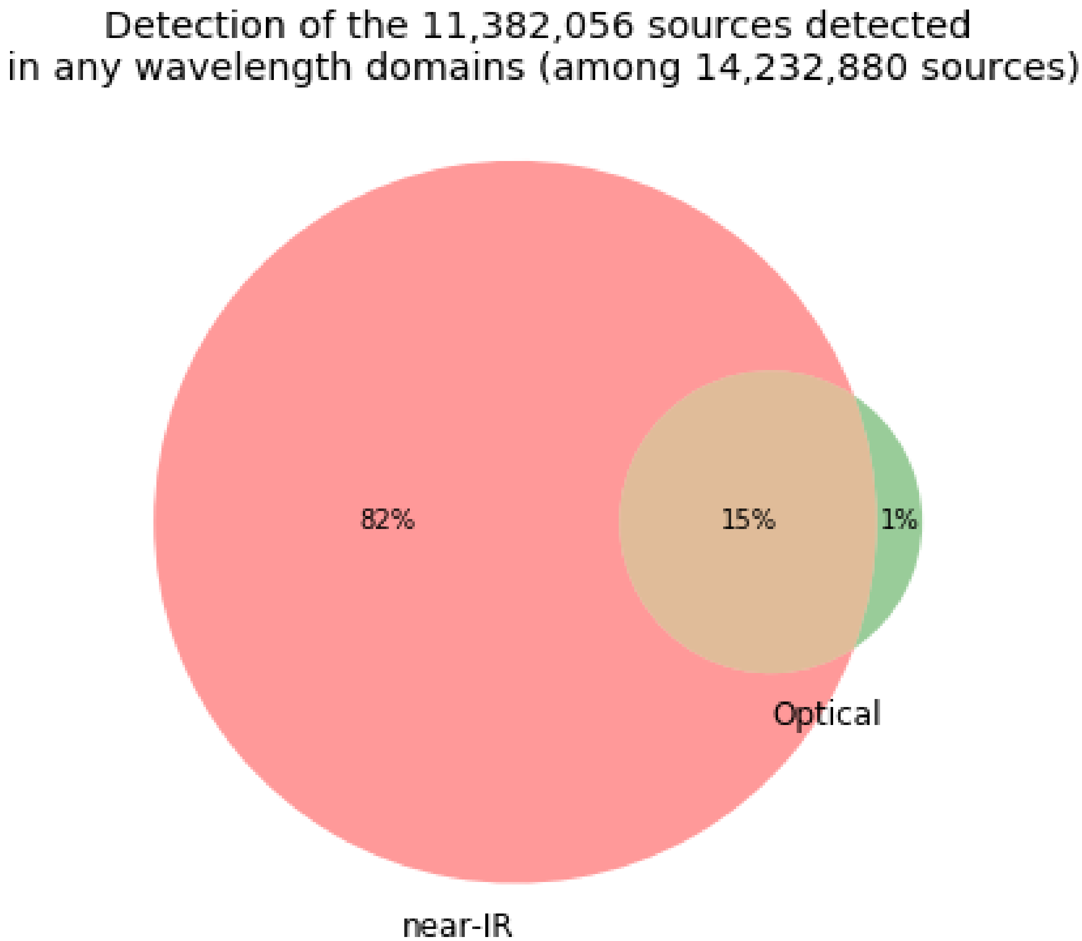
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/core/numeric.py:301:
  format(shape, fill_value, array(fill_value).dtype), FutureWarning)
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/numpy/core/numeric.py:301:
  format(shape, fill_value, array(fill_value).dtype),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

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

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

1.3 I - Summary of wavelength domains



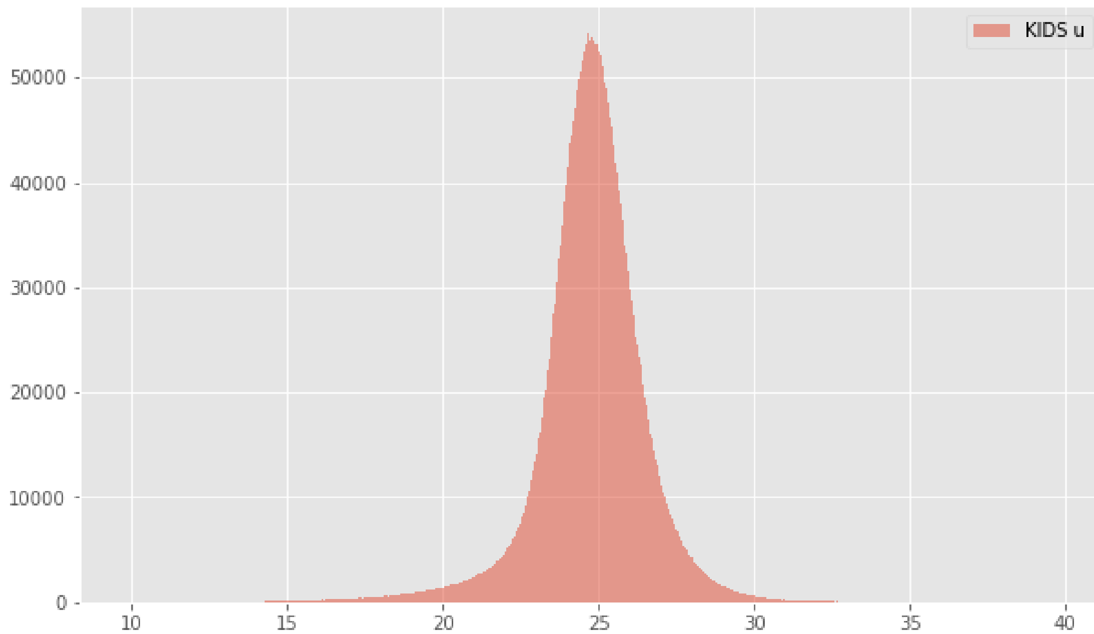


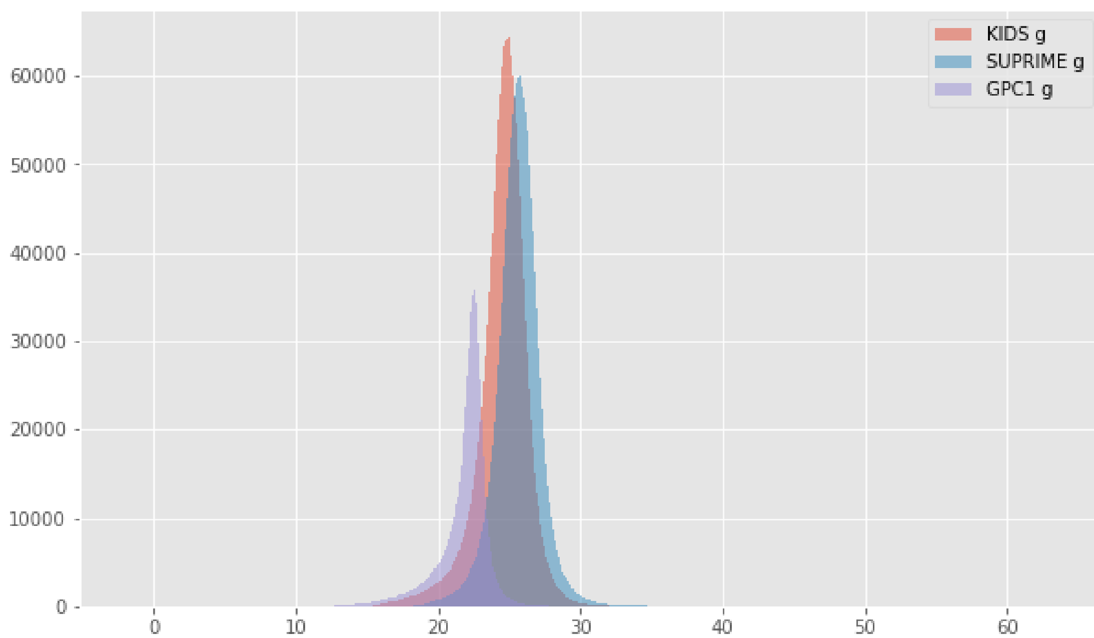
1.4 II - Comparing magnitudes in similar filters

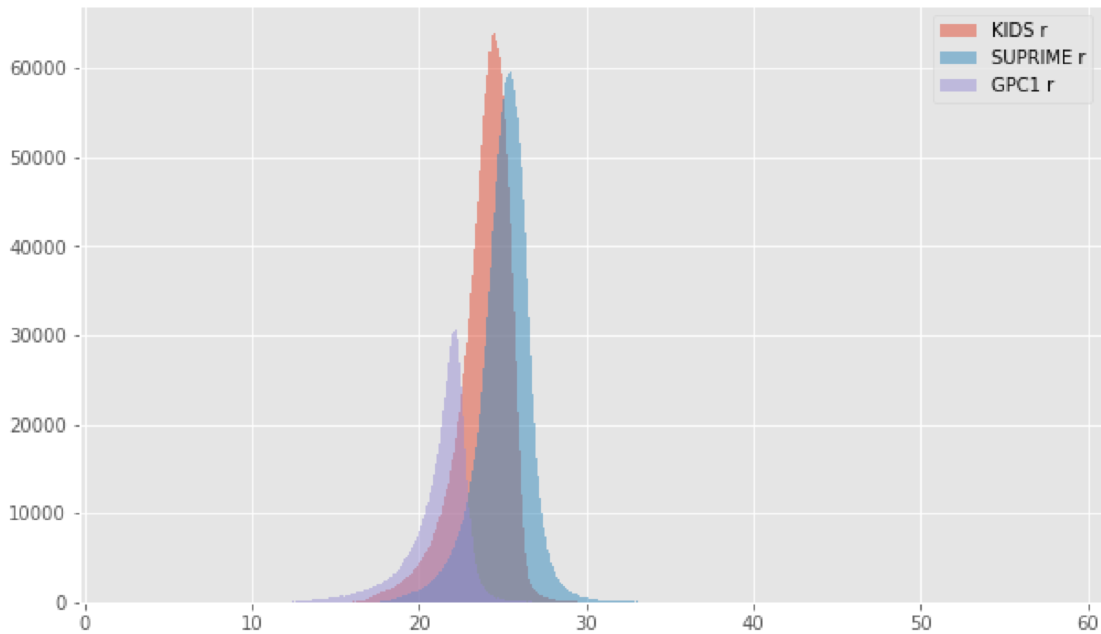
The master list if composed of several catalogues containing magnitudes in similar filters on different instruments. We are comparing the magnitudes in these corresponding filters.

1.4.1 II.a - Comparing depths

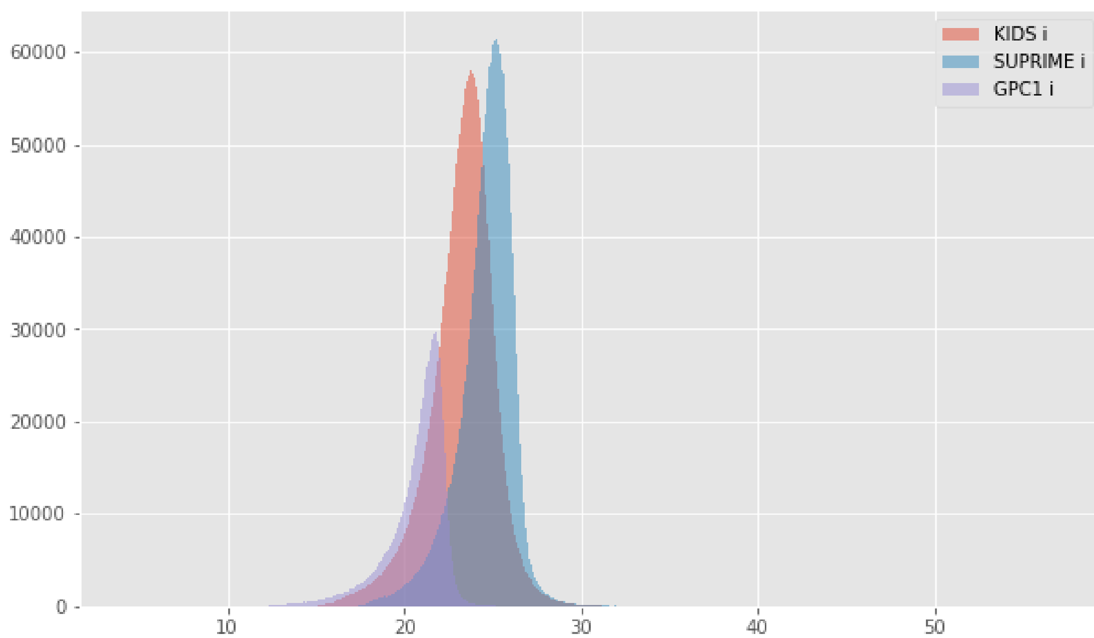
We compare the histograms of the total aperture magnitudes of similar bands.


KIDS u
0
10000
20000
30000
40000
50000
10
15
20
25
30
35
40

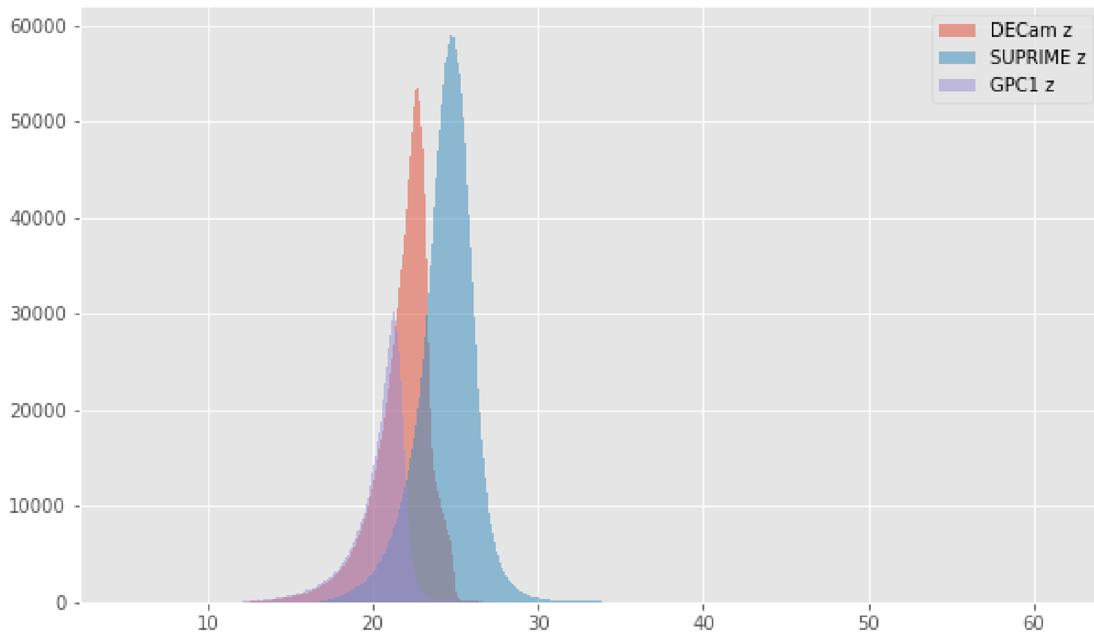

KIDS g
SUPRIME g
GPC1 g
0
10000
20000
30000
40000
50000
60000
0
10
20
30
40
50
60

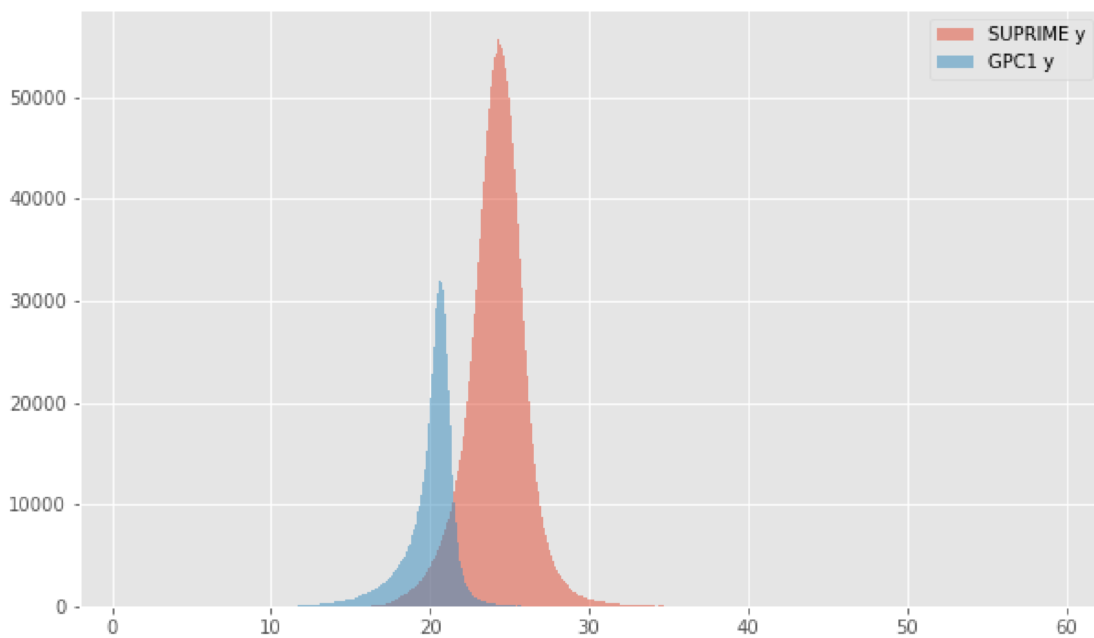


KIDS r
SUPRIME r
GPC1 r



KIDS i
SUPRIME i
GPC1 i

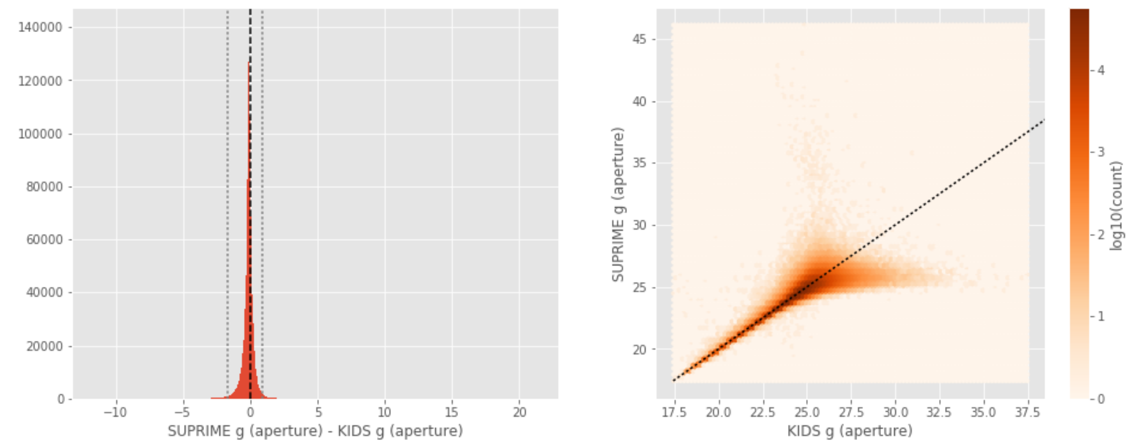




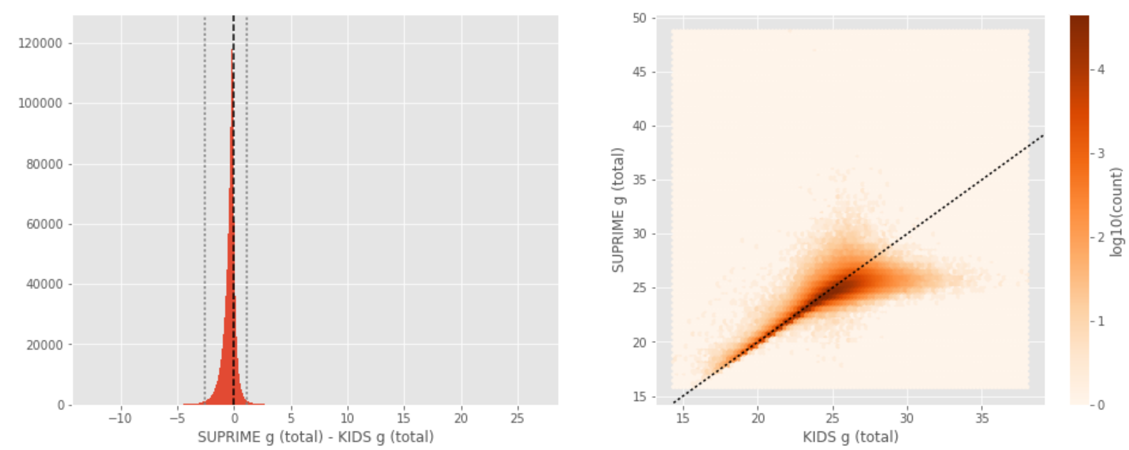
1.4.2 II.b - Comparing magnitudes

We compare one to one each magnitude in similar bands.

SUPRIME g (aperture) - KIDS g (aperture):
- Median: -0.10
- Median Absolute Deviation: 0.15
- 1% percentile: -1.639749526977539
- 99% percentile: 0.9492234992980966

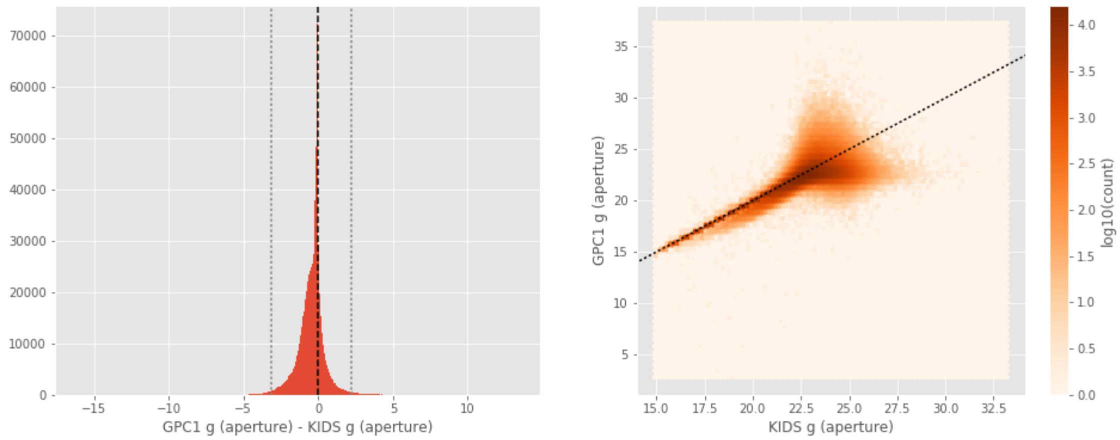


SUPRIME g (total) - KIDS g (total):
- Median: -0.28
- Median Absolute Deviation: 0.25
- 1% percentile: -2.564059658050537
- 99% percentile: 1.128276958465567

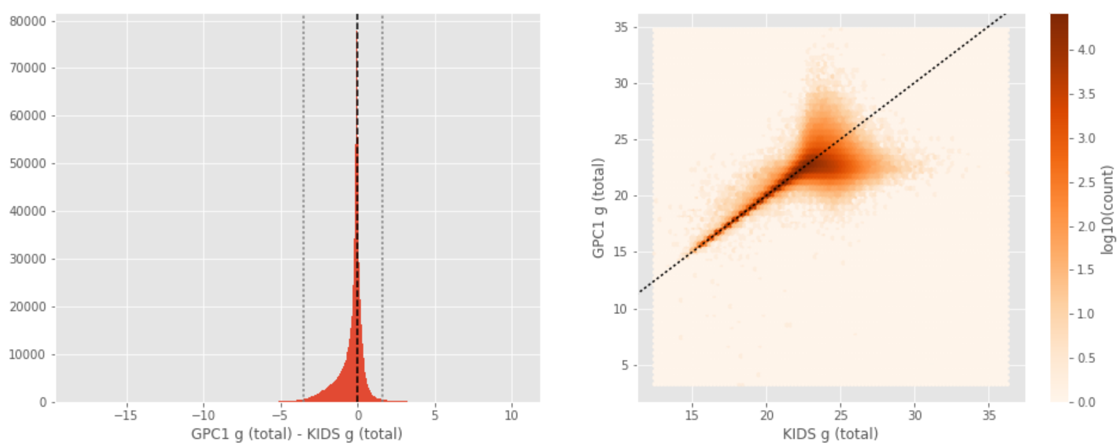


GPC1 g (aperture) - KIDS g (aperture):
- Median: -0.31

- Median Absolute Deviation: 0.38
- 1% percentile: -3.1371237373352048
- 99% percentile: 2.213497180938726

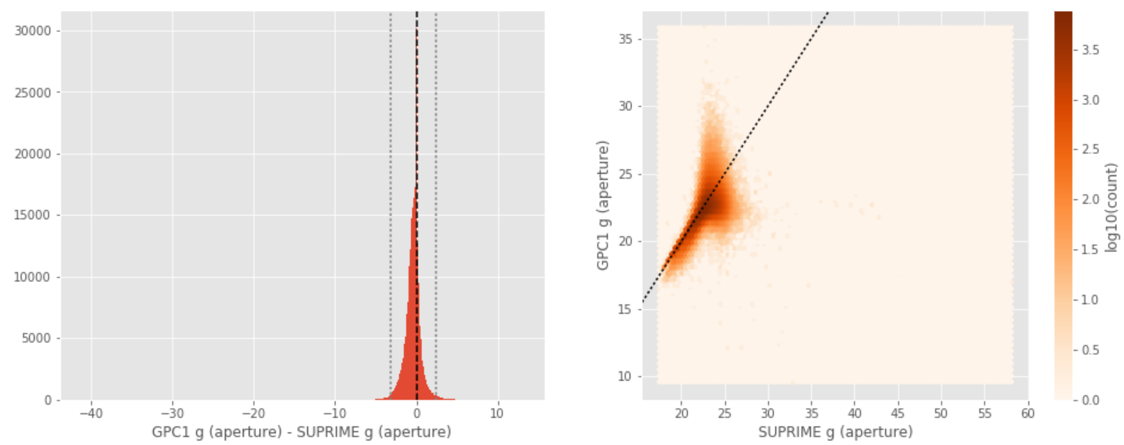


GPC1 g (total) - KIDS g (total):
- Median: -0.12
- Median Absolute Deviation: 0.25
- 1% percentile: -3.543268051147461
- 99% percentile: 1.5813409042358293

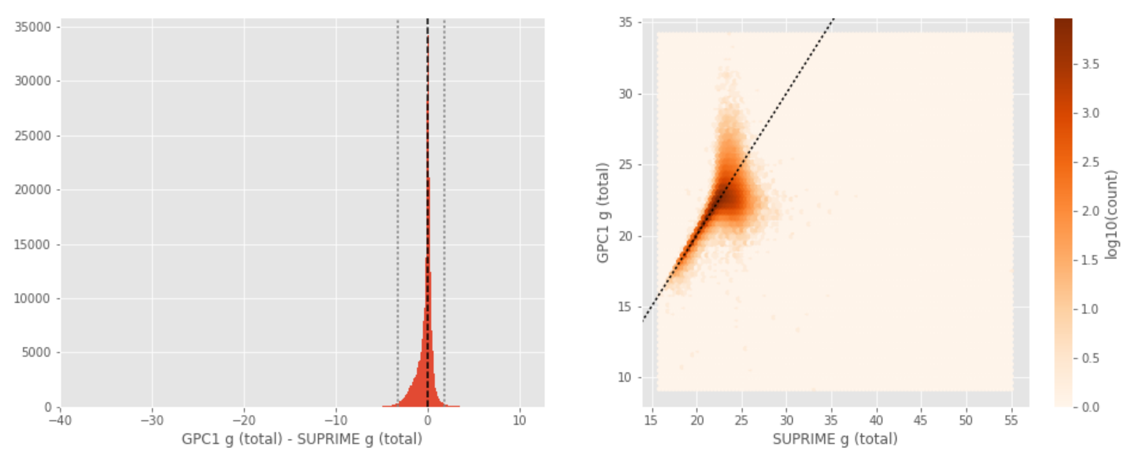


GPC1 g (aperture) - SUPRIME g (aperture):
- Median: -0.28
- Median Absolute Deviation: 0.43
- 1% percentile: -3.1680870056152344

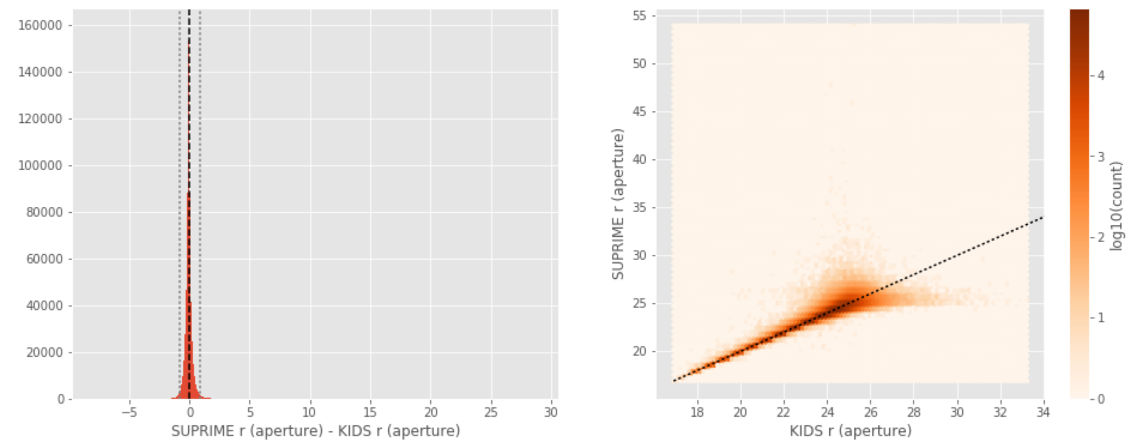
- 99% percentile: 2.4179883003234885



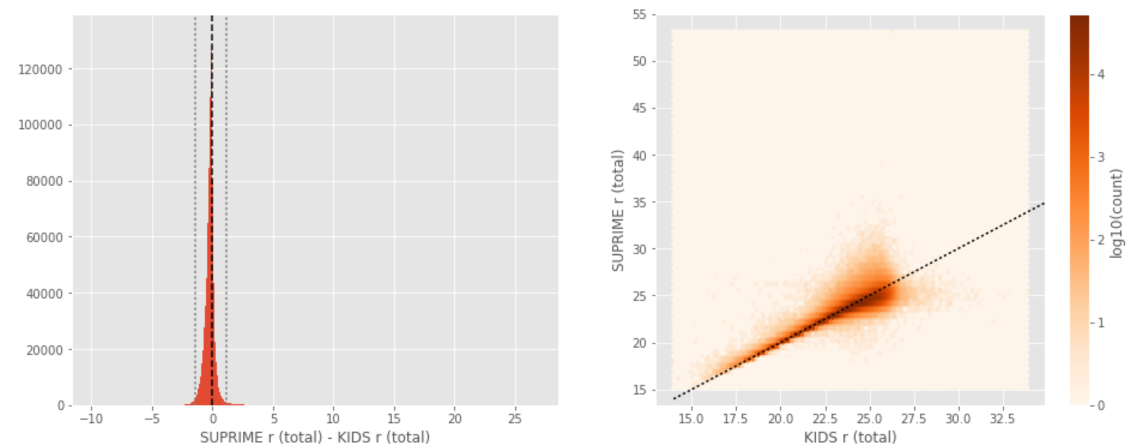
GPC1 g (total) - SUPRIME g (total):
- Median: -0.04
- Median Absolute Deviation: 0.30
- 1% percentile: -3.2857778167724607
- 99% percentile: 1.7586553955078141



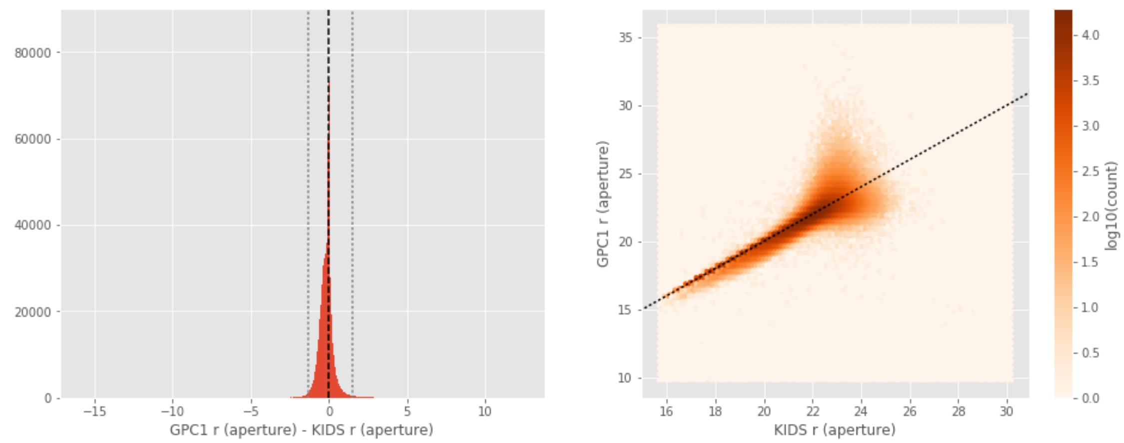
SUPRIME r (aperture) - KIDS r (aperture):
- Median: -0.06
- Median Absolute Deviation: 0.11
- 1% percentile: -0.8526588439941406
- 99% percentile: 0.8960708618164048



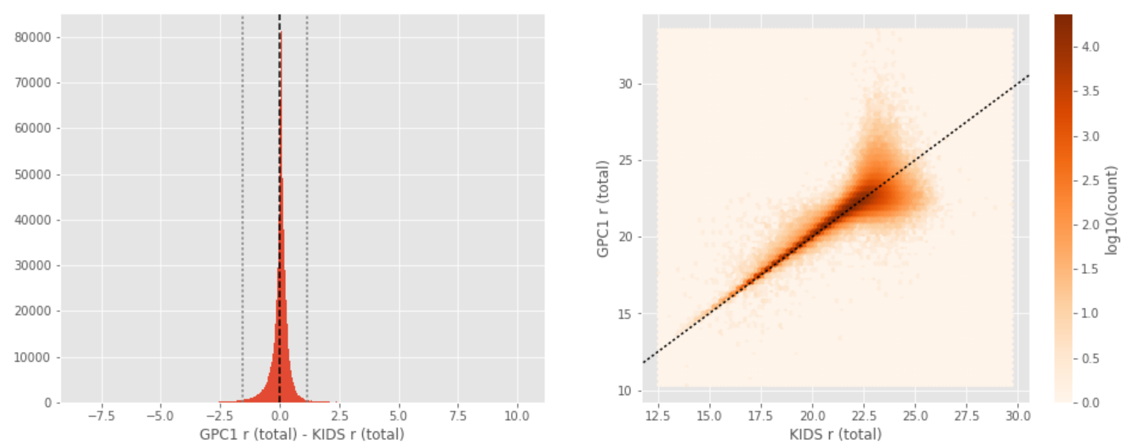
SUPRIME r (total) - KIDS r (total):
- Median: -0.19
- Median Absolute Deviation: 0.18
- 1% percentile: -1.4241687393188478
- 99% percentile: 1.1404187583923342



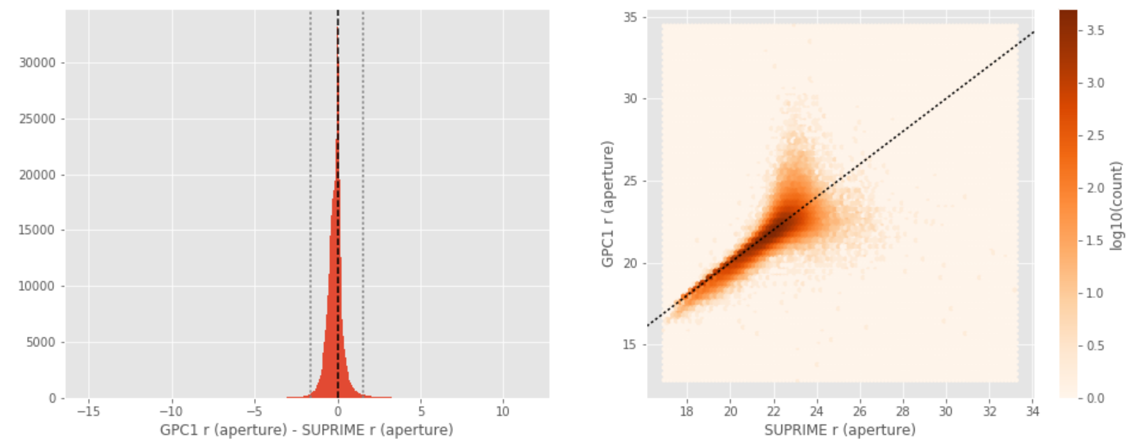
GPC1 r (aperture) - KIDS r (aperture):
- Median: -0.11
- Median Absolute Deviation: 0.21
- 1% percentile: -1.3515098571777342
- 99% percentile: 1.496448478698733



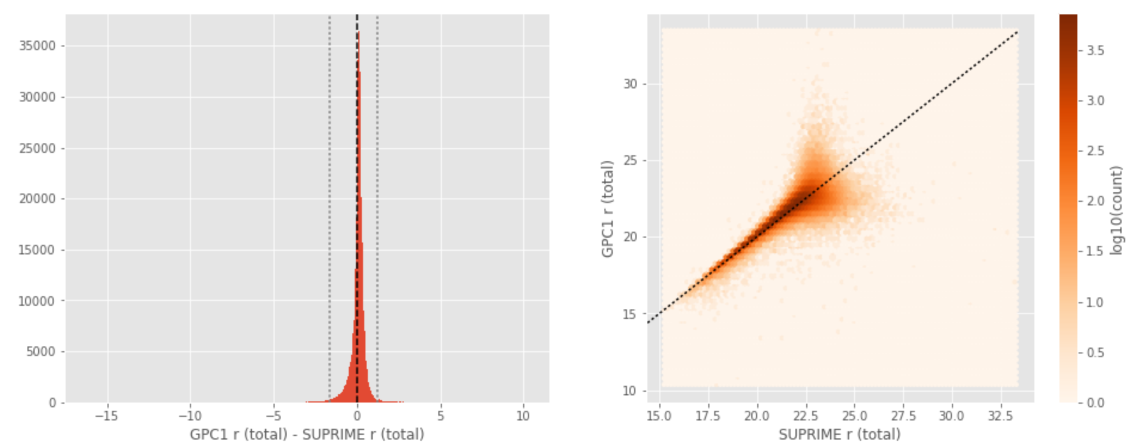
GPC1 r (total) - KIDS r (total):
- Median: 0.05
- Median Absolute Deviation: 0.13
- 1% percentile: -1.5403206634521482
- 99% percentile: 1.1657170867919837



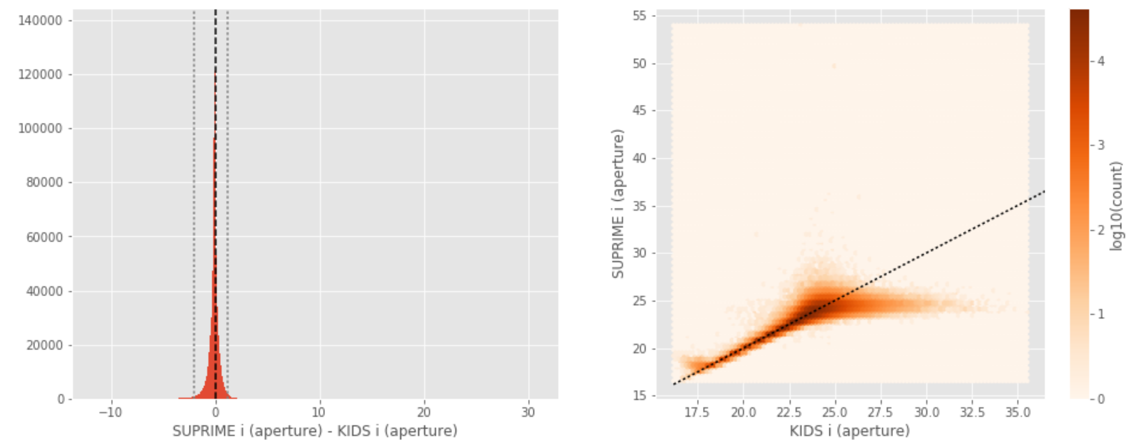
GPC1 r (aperture) - SUPRIME r (aperture):
- Median: -0.10
- Median Absolute Deviation: 0.23
- 1% percentile: -1.5872383117675781
- 99% percentile: 1.525237350463859



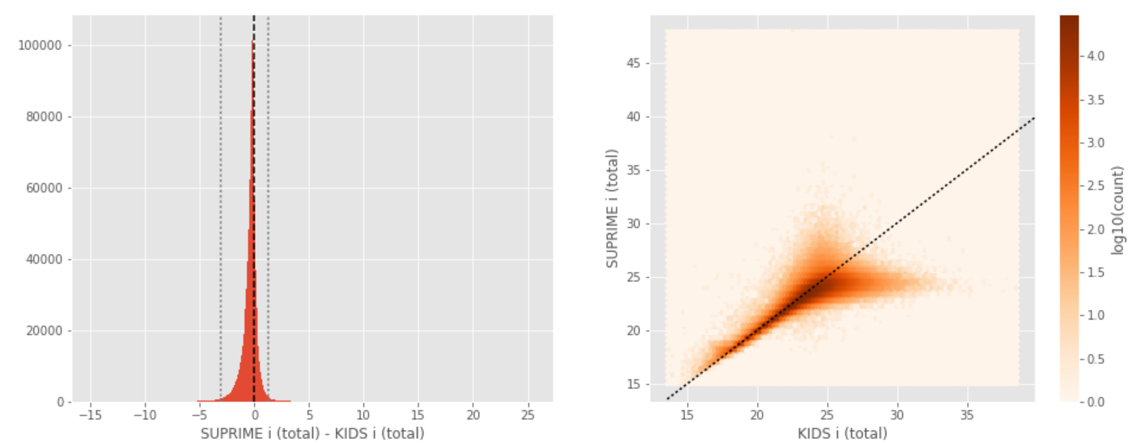
GPC1 r (total) - SUPRIME r (total):
- Median: 0.11
- Median Absolute Deviation: 0.15
- 1% percentile: -1.6637313461303709
- 99% percentile: 1.2613188362121595



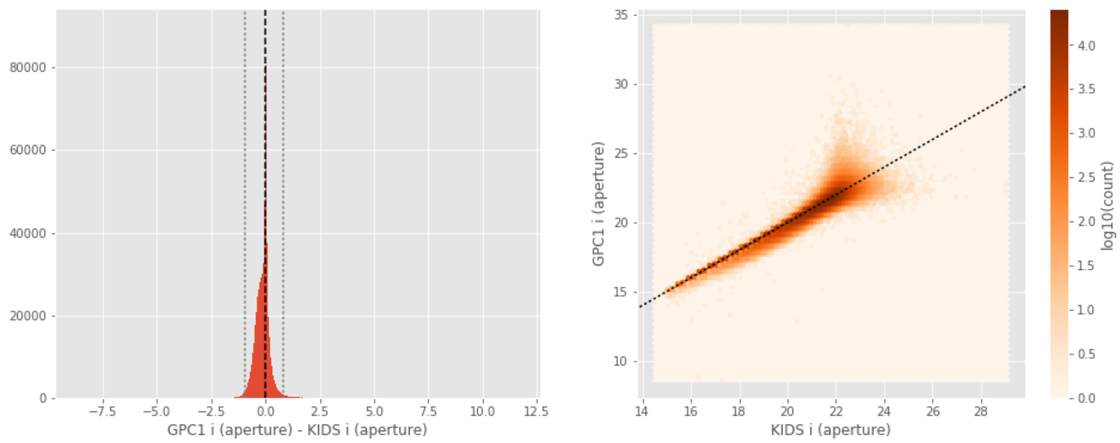
SUPRIME i (aperture) - KIDS i (aperture):
- Median: -0.07
- Median Absolute Deviation: 0.18
- 1% percentile: -2.0469532012939453
- 99% percentile: 1.169138336181641



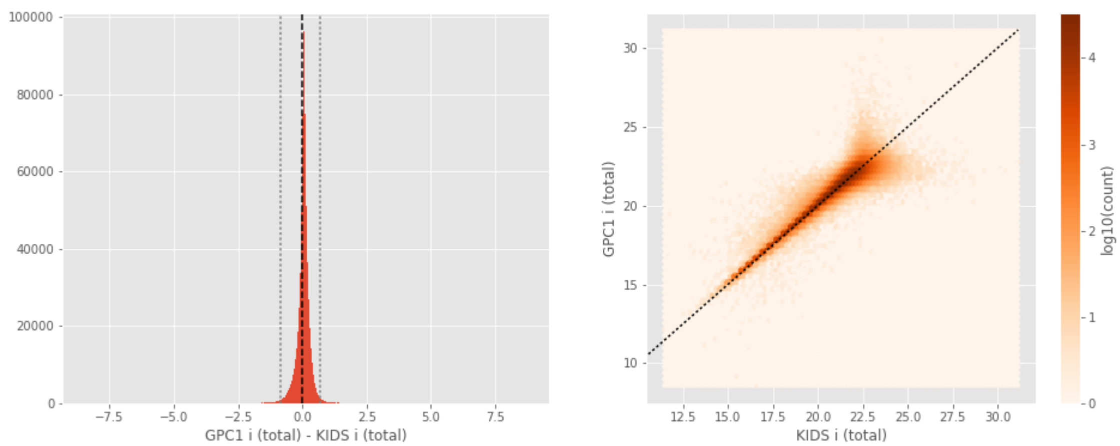
SUPRIME i (total) - KIDS i (total):
- Median: -0.27
- Median Absolute Deviation: 0.27
- 1% percentile: -3.016033172607422
- 99% percentile: 1.297071933746338



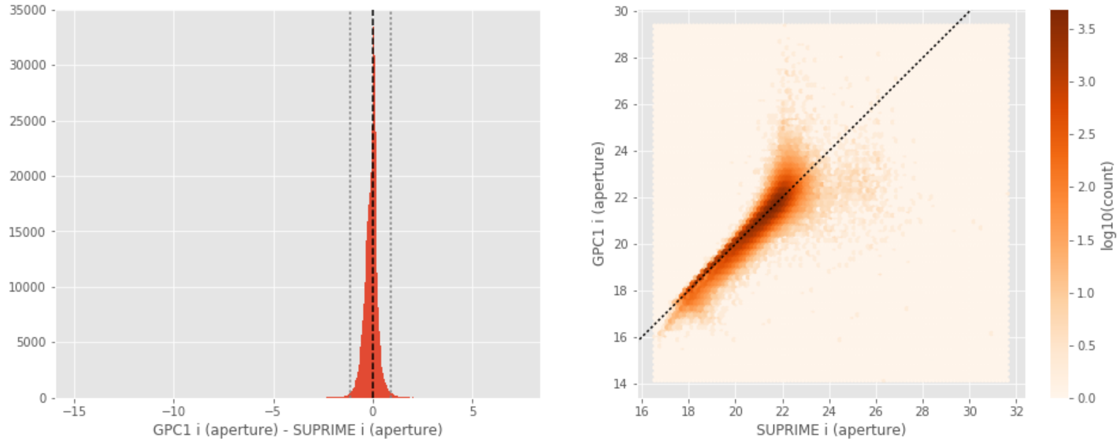
GPC1 i (aperture) - KIDS i (aperture):
- Median: -0.08
- Median Absolute Deviation: 0.16
- 1% percentile: -0.9477043151855469
- 99% percentile: 0.8186016082763672



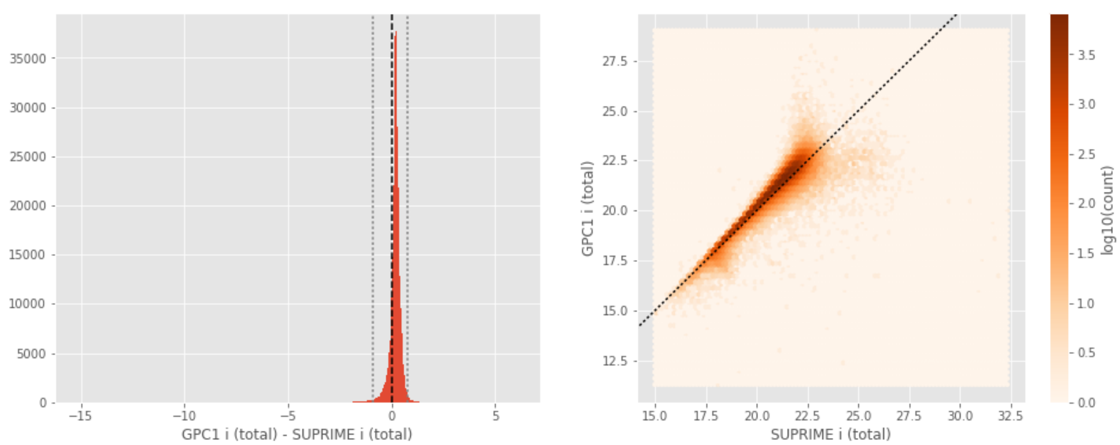
GPC1 i (total) - KIDS i (total):
- Median: 0.05
- Median Absolute Deviation: 0.10
- 1% percentile: -0.8343009567260742
- 99% percentile: 0.6969107818603506



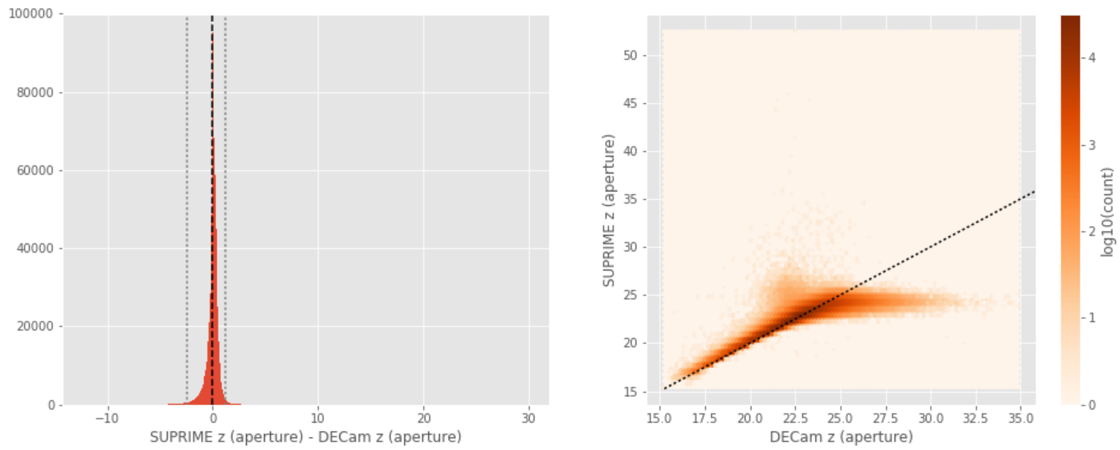
GPC1 i (aperture) - SUPRIME i (aperture):
- Median: -0.03
- Median Absolute Deviation: 0.18
- 1% percentile: -1.1367273139953613
- 99% percentile: 0.9213391876220709



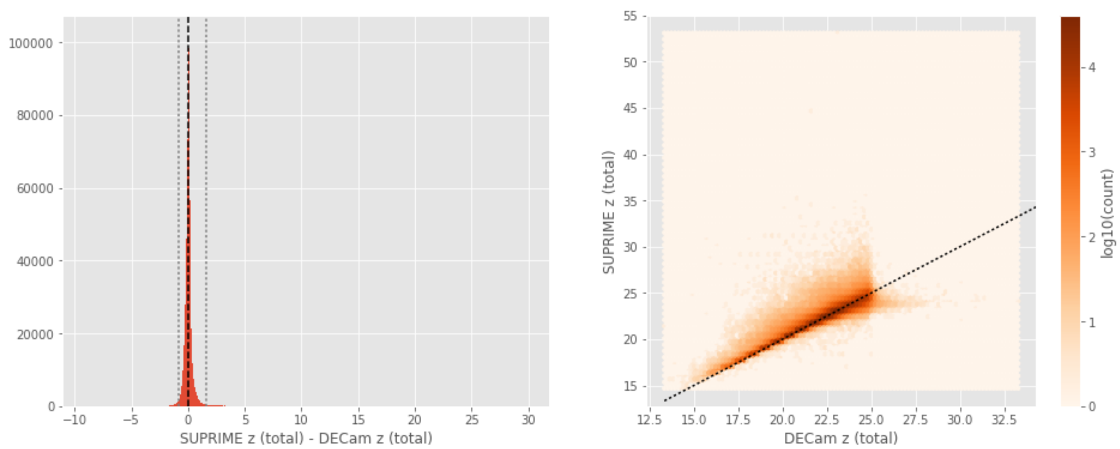
GPC1 i (total) - SUPRIME i (total):
- Median: 0.20
- Median Absolute Deviation: 0.11
- 1% percentile: -0.8914554595947265
- 99% percentile: 0.7686335754394538



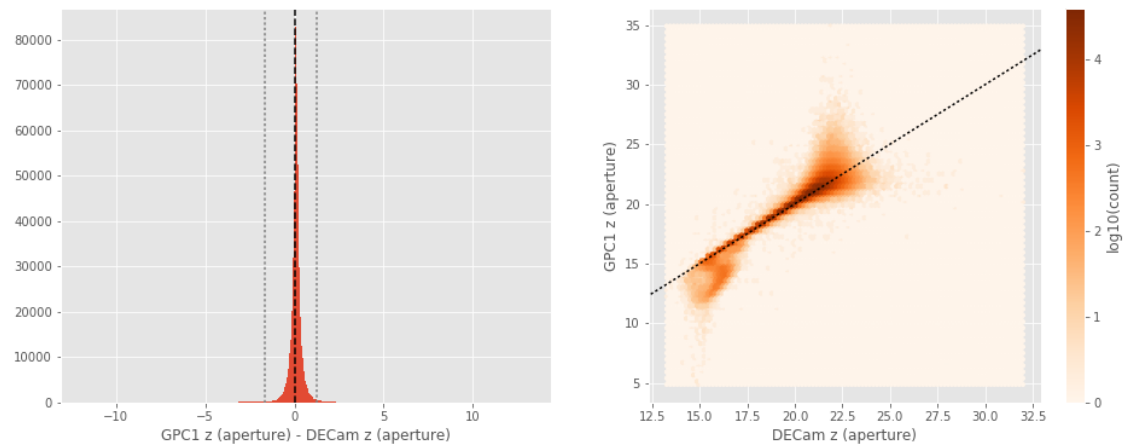
SUPRIME z (aperture) - DECam z (aperture):
- Median: 0.05
- Median Absolute Deviation: 0.22
- 1% percentile: -2.385577850341797
- 99% percentile: 1.2567932891845697



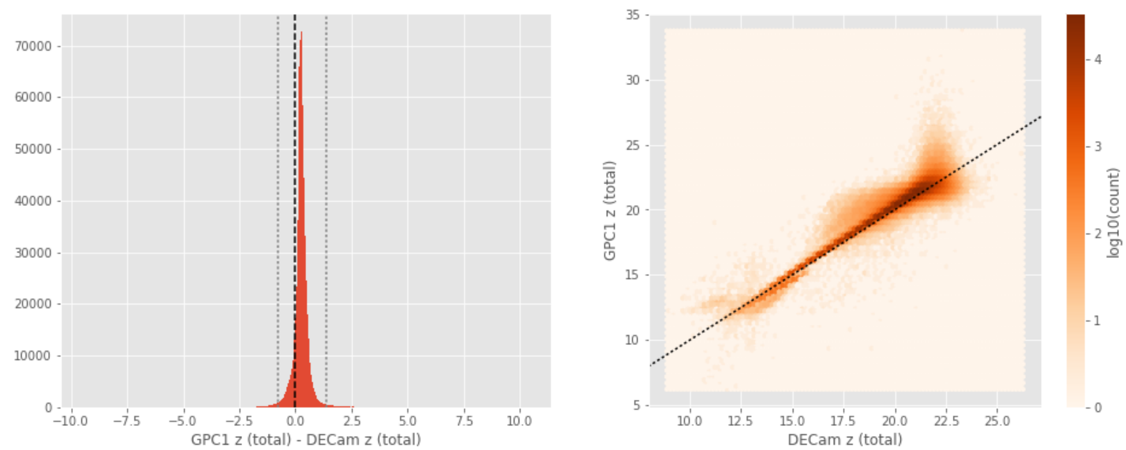

```
SUPRIME z (total) - DECam z (total):
- Median: 0.03
- Median Absolute Deviation: 0.13
- 1% percentile: -0.8609659385681152
- 99% percentile: 1.6053583717346078
```



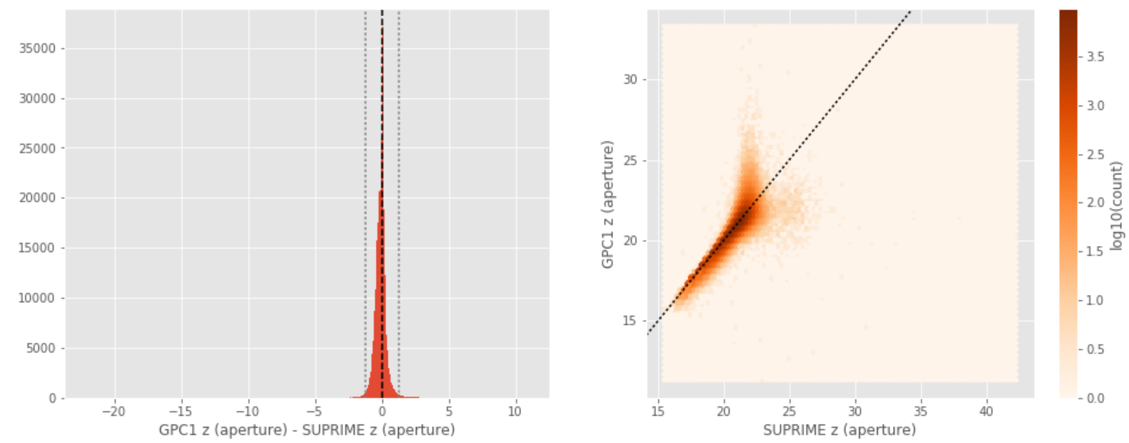

```
GPC1 z (aperture) - DECam z (aperture):
- Median: 0.09
- Median Absolute Deviation: 0.12
- 1% percentile: -1.6480256843566894
- 99% percentile: 1.2552158927917487
```



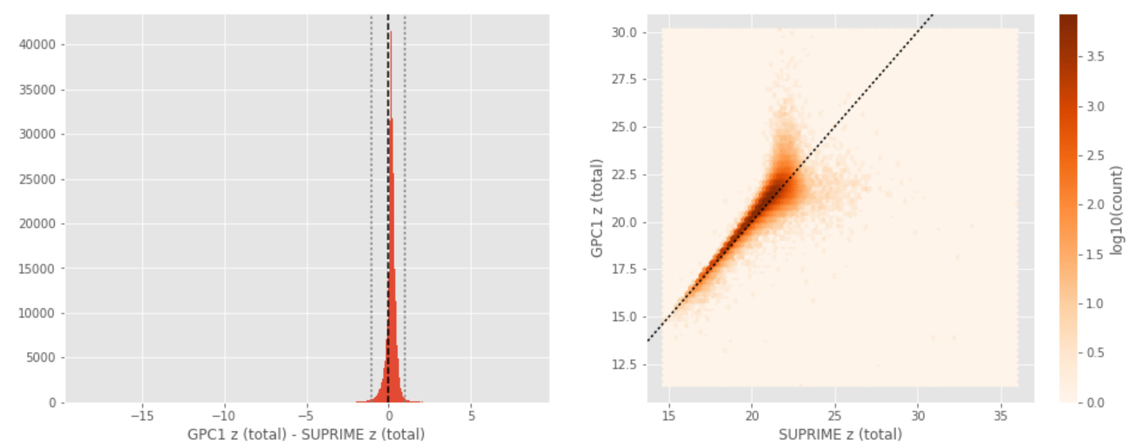
GPC1 z (total) - DECam z (total):
- Median: 0.26
- Median Absolute Deviation: 0.12
- 1% percentile: -0.7882562637329102
- 99% percentile: 1.3734452438354419



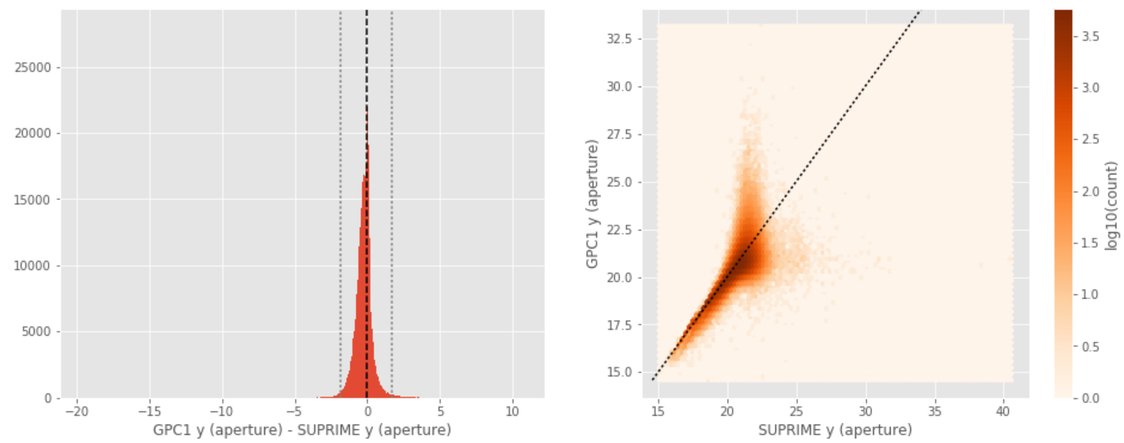
GPC1 z (aperture) - SUPRIME z (aperture):
- Median: -0.04
- Median Absolute Deviation: 0.20
- 1% percentile: -1.1917795181274413
- 99% percentile: 1.2728551101684569



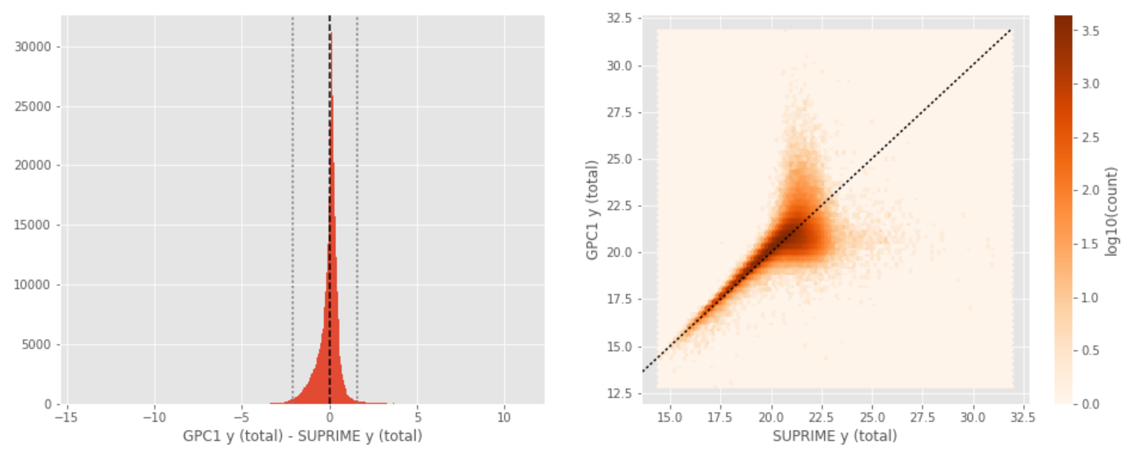
GPC1 z (total) - SUPRIME z (total):
- Median: 0.18
- Median Absolute Deviation: 0.12
- 1% percentile: -1.0532553100585937
- 99% percentile: 0.9818671417236327



GPC1 y (aperture) - SUPRIME y (aperture):
- Median: -0.19
- Median Absolute Deviation: 0.28
- 1% percentile: -1.8443033599853516
- 99% percentile: 1.679386215209945




```
GPC1 y (total) - SUPRIME y (total):
- Median: 0.09
- Median Absolute Deviation: 0.23
- 1% percentile: -2.0898357391357423
- 99% percentile: 1.6052894592285112
```



1.5 III - Comparing magnitudes to reference bands

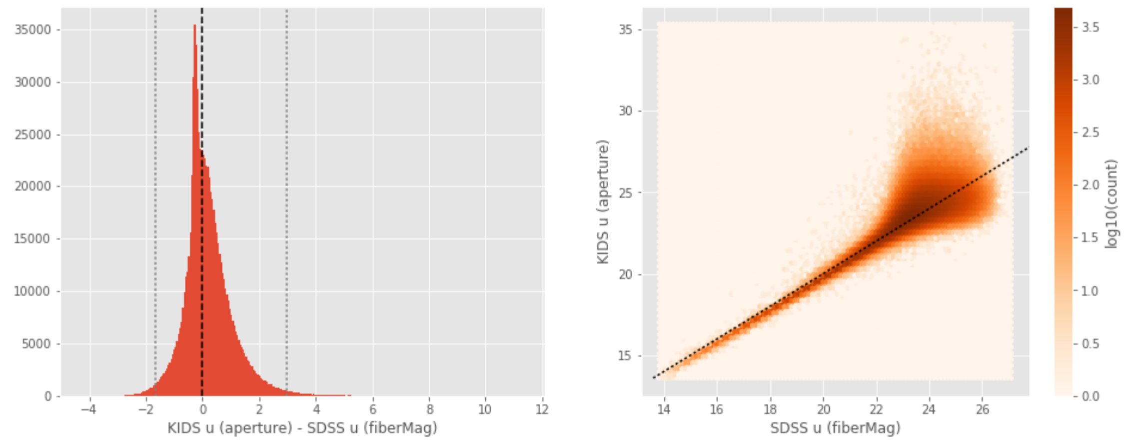
Cross-match the master list to SDSS and 2MASS to compare its magnitudes to SDSS and 2MASS ones.

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

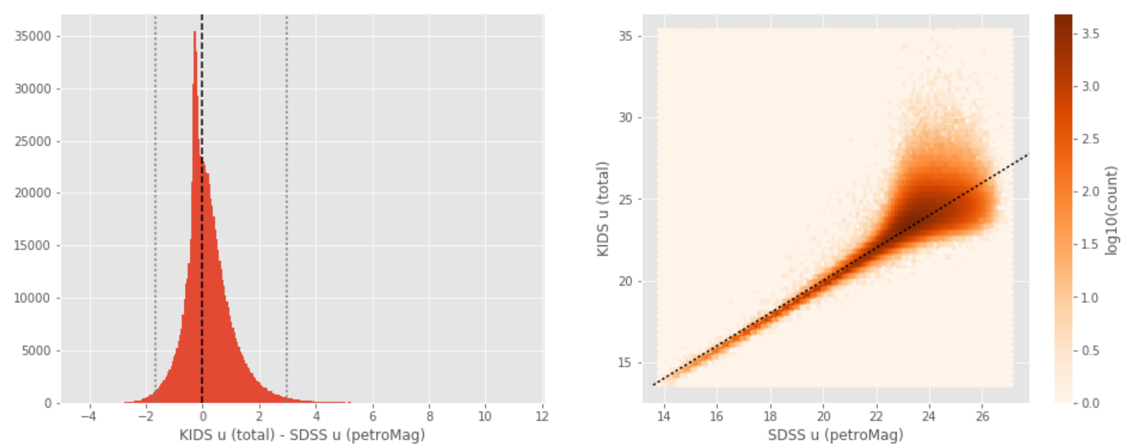
The catalogue is cross-matched to SDSS-DR13 withing 0.2 arcsecond.

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.

KIDS u (aperture) - SDSS u (fiberMag):
- Median: 0.06
- Median Absolute Deviation: 0.42
- 1% percentile: -1.6777435874938966
- 99% percentile: 2.960469150543212

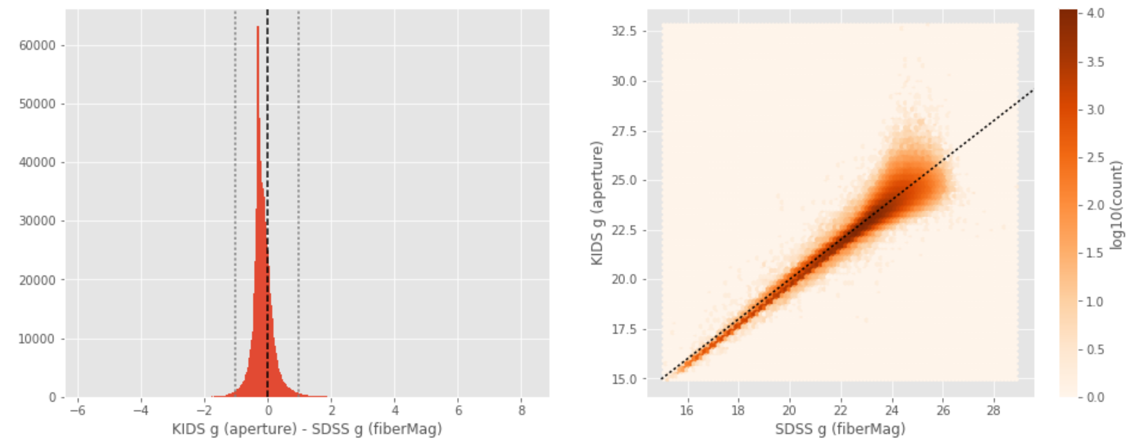


KIDS u (total) - SDSS u (petroMag):
- Median: 0.06
- Median Absolute Deviation: 0.42
- 1% percentile: -1.6777435874938966
- 99% percentile: 2.960469150543212

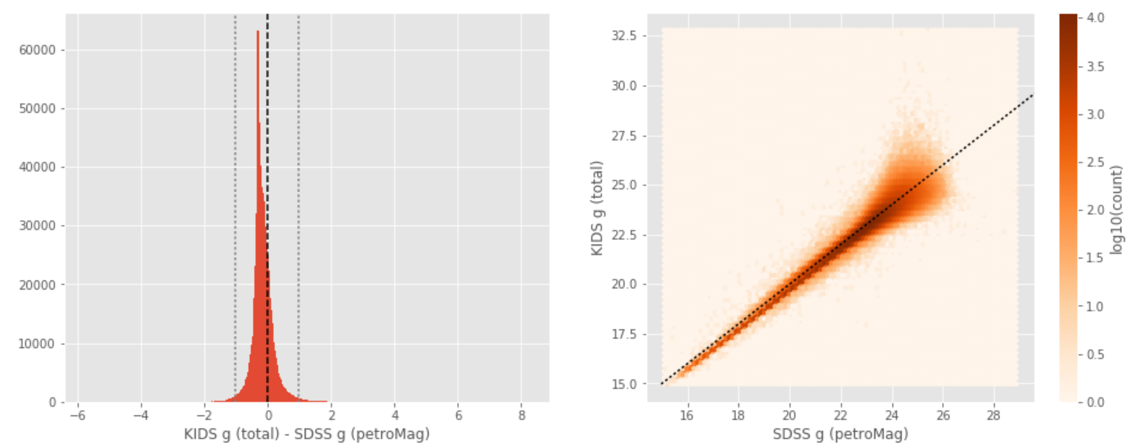


KIDS g (aperture) - SDSS g (fiberMag):
- Median: -0.21

- Median Absolute Deviation: 0.15
- 1% percentile: -1.0146734237670898
- 99% percentile: 0.9639924621582026

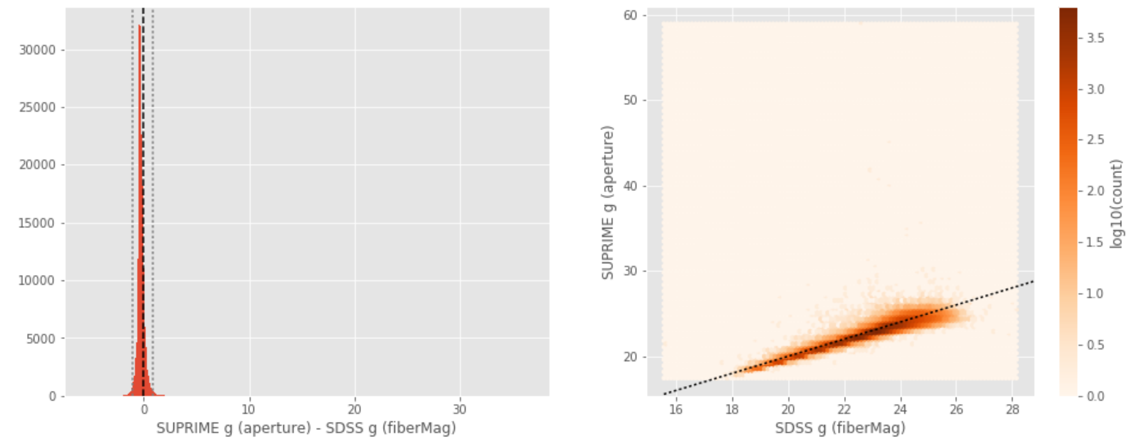


KIDS g (total) - SDSS g (petroMag):
- Median: -0.21
- Median Absolute Deviation: 0.15
- 1% percentile: -1.0146734237670898
- 99% percentile: 0.9639924621582026

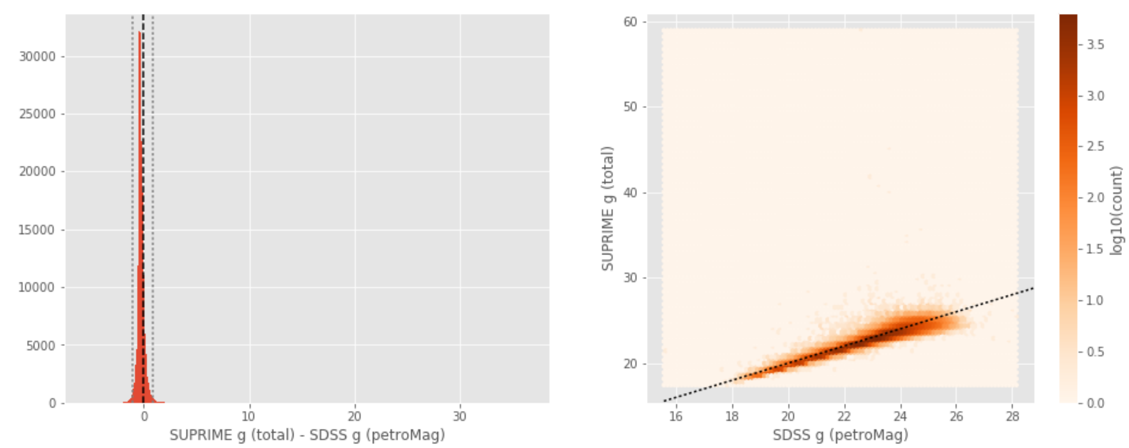



```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:11:
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:12:
```

```
SUPRIME g (aperture) - SDSS g (fiberMag):
- Median: -0.29
- Median Absolute Deviation: 0.16
- 1% percentile: -1.1014499282836914
- 99% percentile: 0.9030055809020996
```

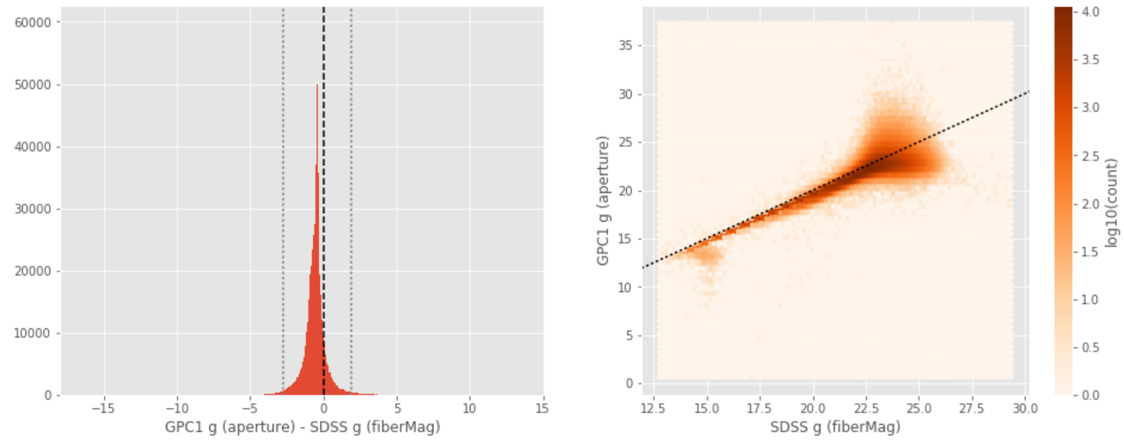



```
SUPRIME g (total) - SDSS g (petroMag):
- Median: -0.29
- Median Absolute Deviation: 0.16
- 1% percentile: -1.1014499282836914
- 99% percentile: 0.9030055809020996
```

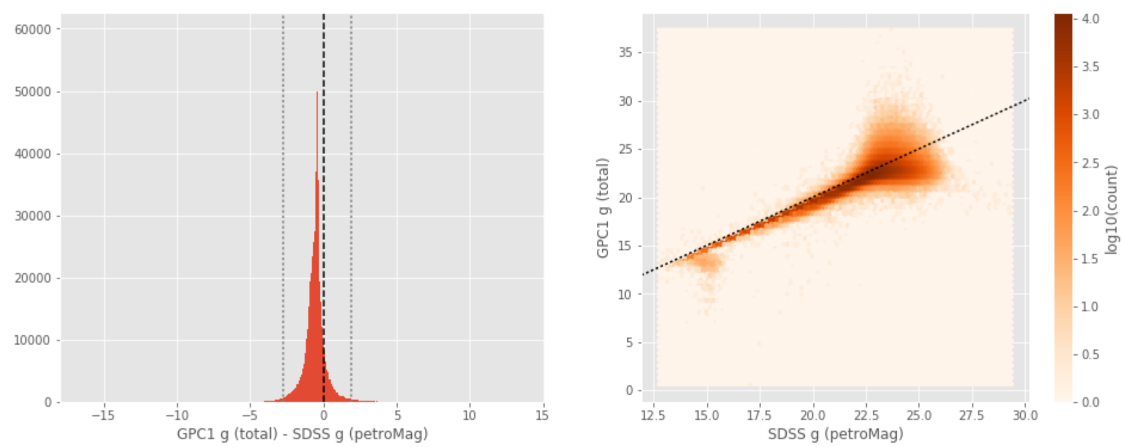



```
GPC1 g (aperture) - SDSS g (fiberMag):
- Median: -0.50
```

- Median Absolute Deviation: 0.29
- 1% percentile: -2.7221382522583006
- 99% percentile: 1.9057488632202144

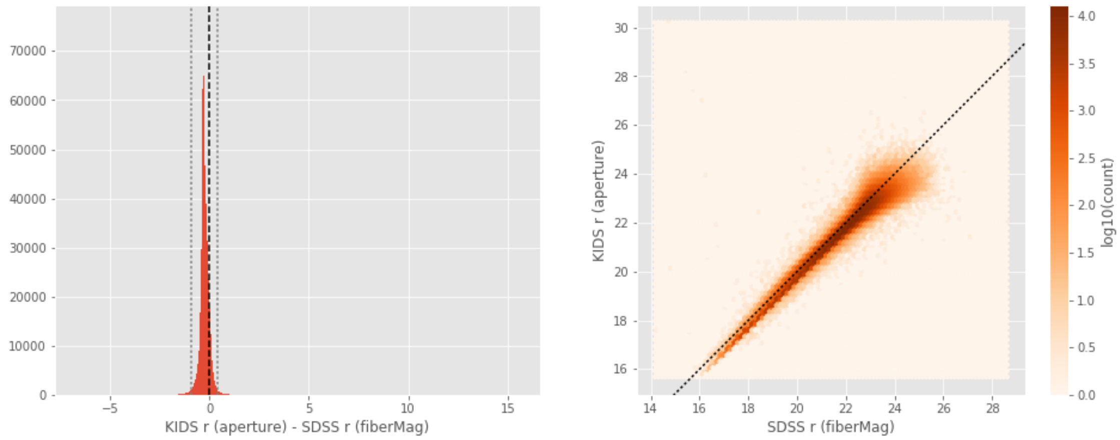


GPC1 g (total) - SDSS g (petroMag):
- Median: -0.50
- Median Absolute Deviation: 0.29
- 1% percentile: -2.7221382522583006
- 99% percentile: 1.9057488632202144

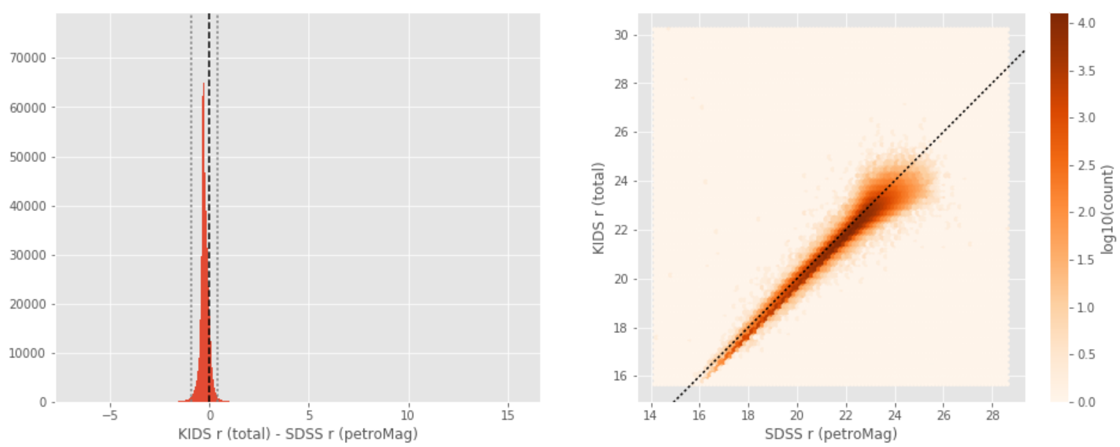


KIDS r (aperture) - SDSS r (fiberMag):
- Median: -0.26
- Median Absolute Deviation: 0.11
- 1% percentile: -0.9293296623229981

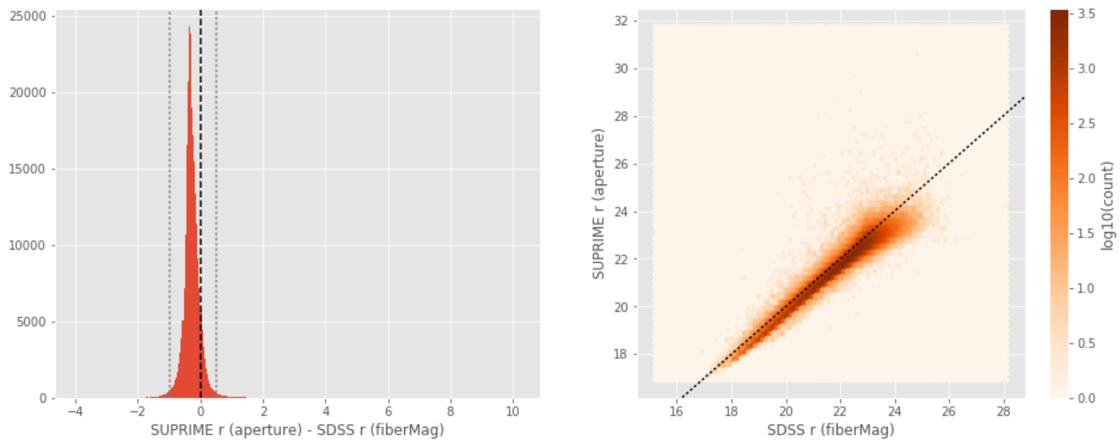
- 99% percentile: 0.3801915359497068



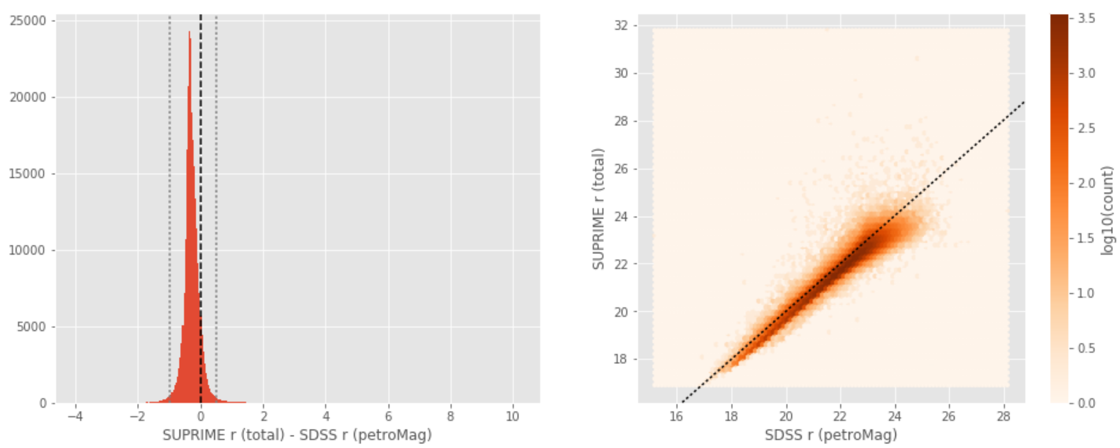
KIDS r (total) - SDSS r (petroMag):
- Median: -0.26
- Median Absolute Deviation: 0.11
- 1% percentile: -0.9293296623229981
- 99% percentile: 0.3801915359497068



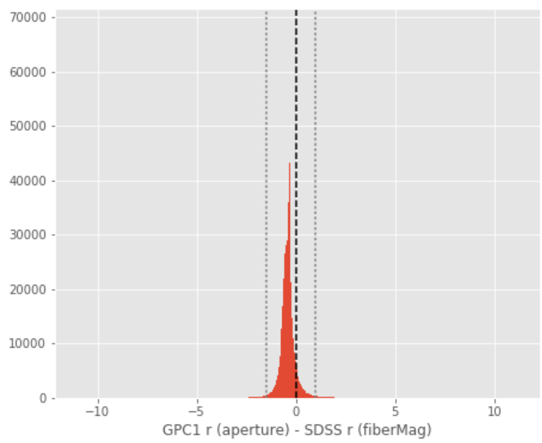
SUPRIME r (aperture) - SDSS r (fiberMag):
- Median: -0.31
- Median Absolute Deviation: 0.13
- 1% percentile: -0.9976704406738282
- 99% percentile: 0.5201725578308096

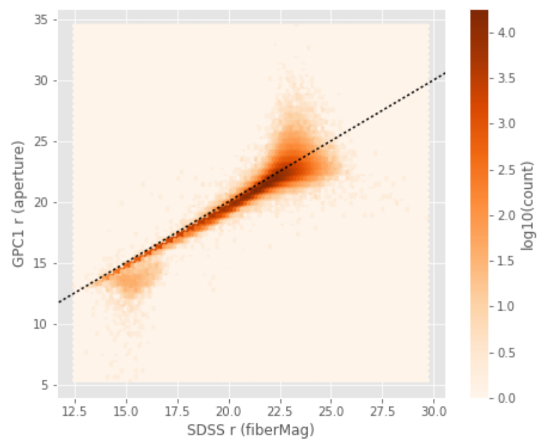


SUPRIME r (total) - SDSS r (petroMag):
- Median: -0.31
- Median Absolute Deviation: 0.13
- 1% percentile: -0.9976704406738282
- 99% percentile: 0.5201725578308096

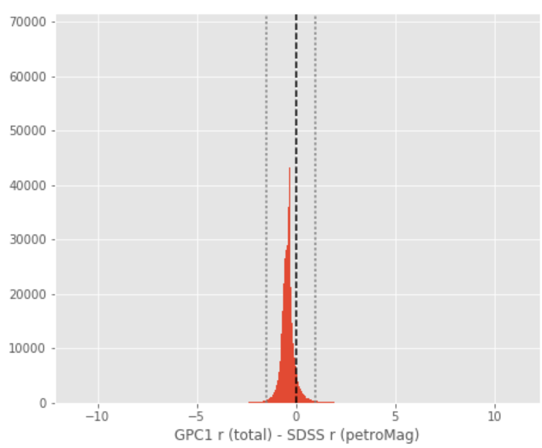


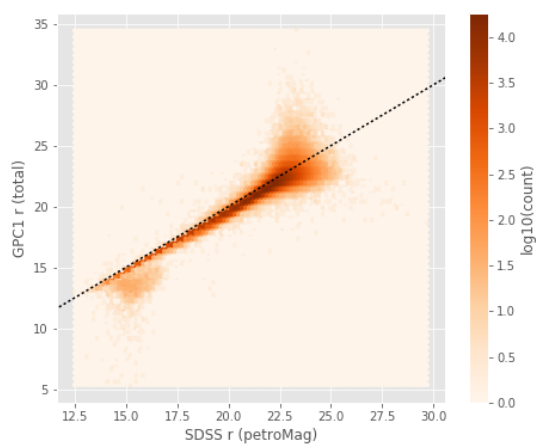
GPC1 r (aperture) - SDSS r (fiberMag):
- Median: -0.38
- Median Absolute Deviation: 0.15
- 1% percentile: -1.4833747577667236
- 99% percentile: 0.9636315536499054



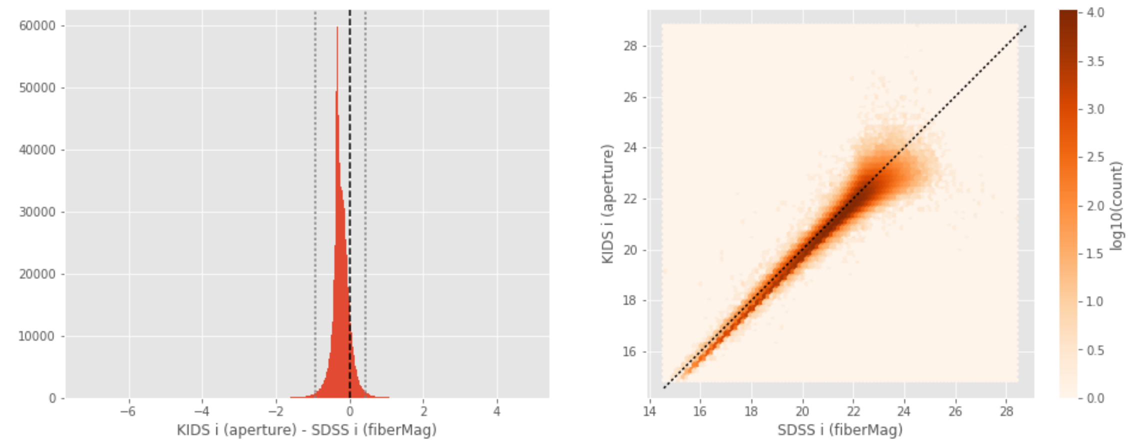


GPC1 r (total) - SDSS r (petroMag):
- Median: -0.38
- Median Absolute Deviation: 0.15
- 1% percentile: -1.4833747577667236
- 99% percentile: 0.9636315536499054

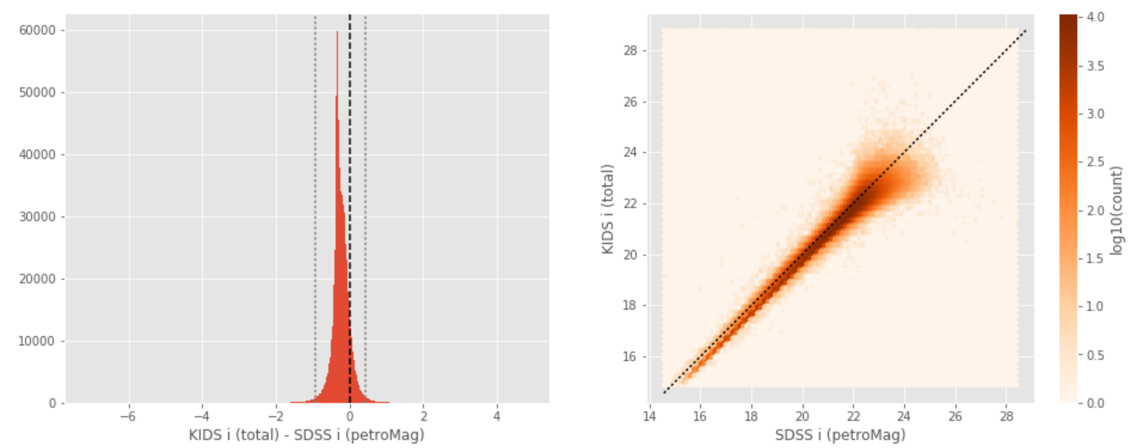




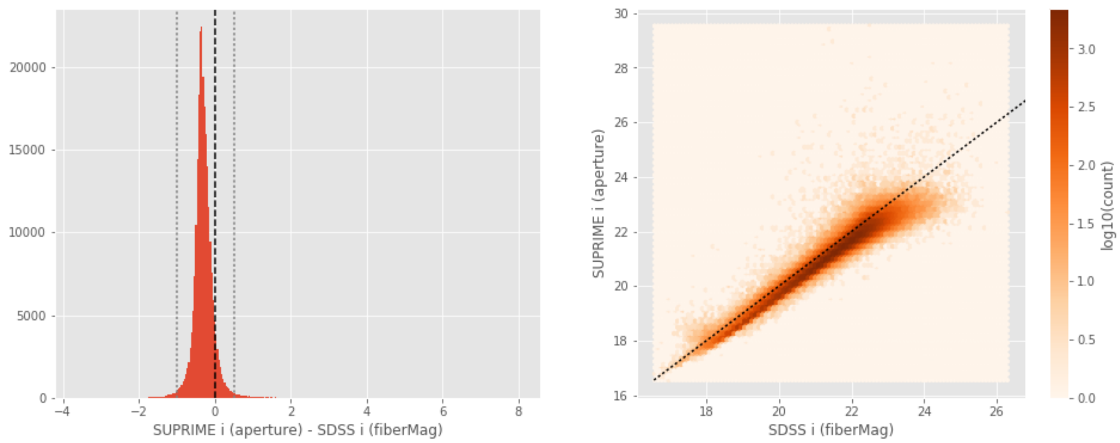
KIDS i (aperture) - SDSS i (fiberMag):
- Median: -0.26
- Median Absolute Deviation: 0.11
- 1% percentile: -0.9333913230895996
- 99% percentile: 0.4504426956176766



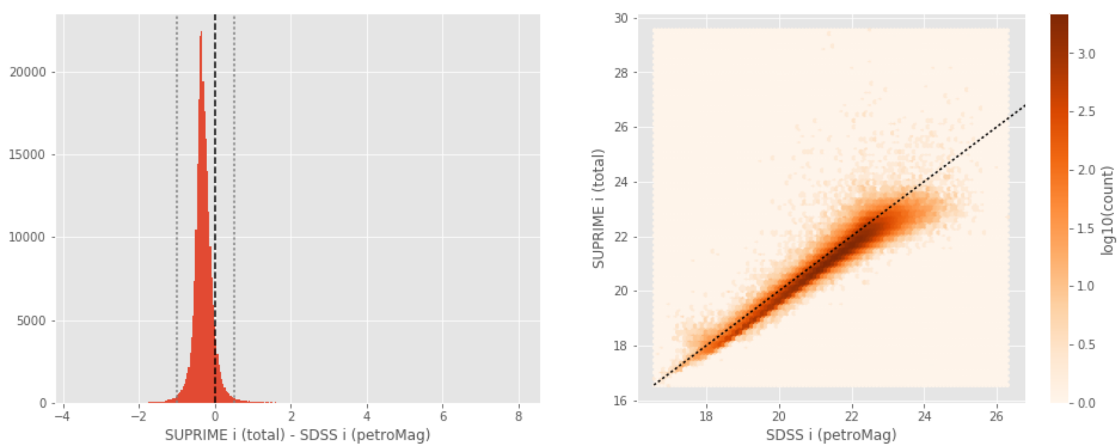
KIDS i (total) - SDSS i (petroMag):
- Median: -0.26
- Median Absolute Deviation: 0.11
- 1% percentile: -0.9333913230895996
- 99% percentile: 0.4504426956176766



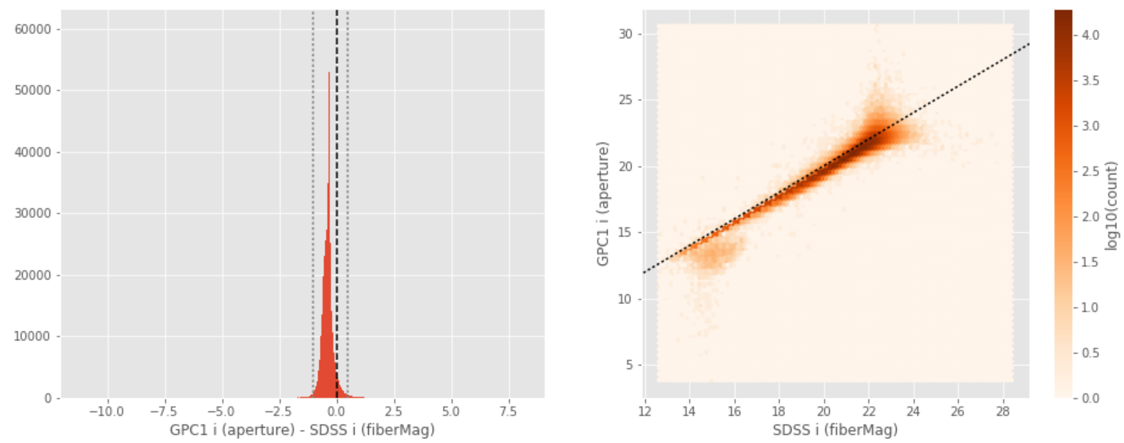
SUPRIME i (aperture) - SDSS i (fiberMag):
- Median: -0.32
- Median Absolute Deviation: 0.12
- 1% percentile: -1.010098304748535
- 99% percentile: 0.5216443252563442



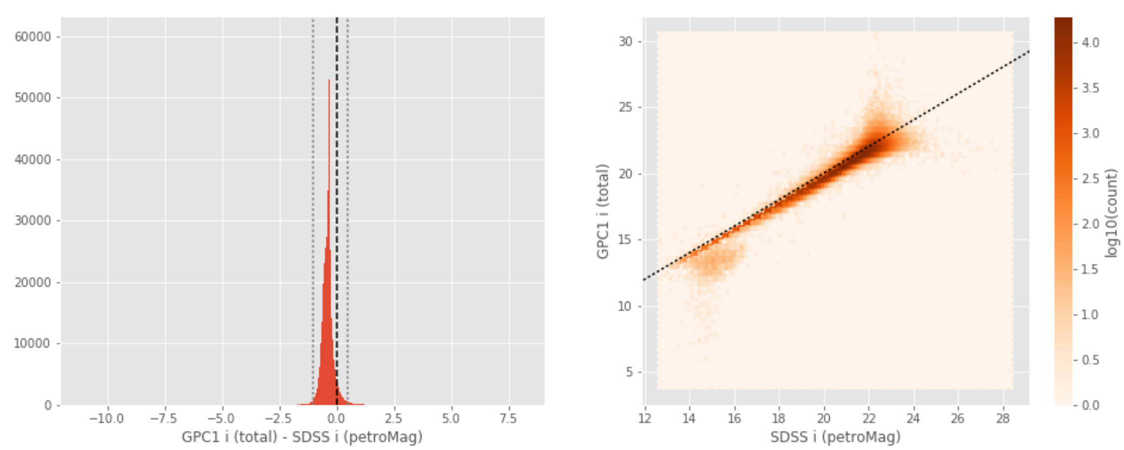
SUPRIME i (total) - SDSS i (petroMag):
- Median: -0.32
- Median Absolute Deviation: 0.12
- 1% percentile: -1.010098304748535
- 99% percentile: 0.5216443252563442



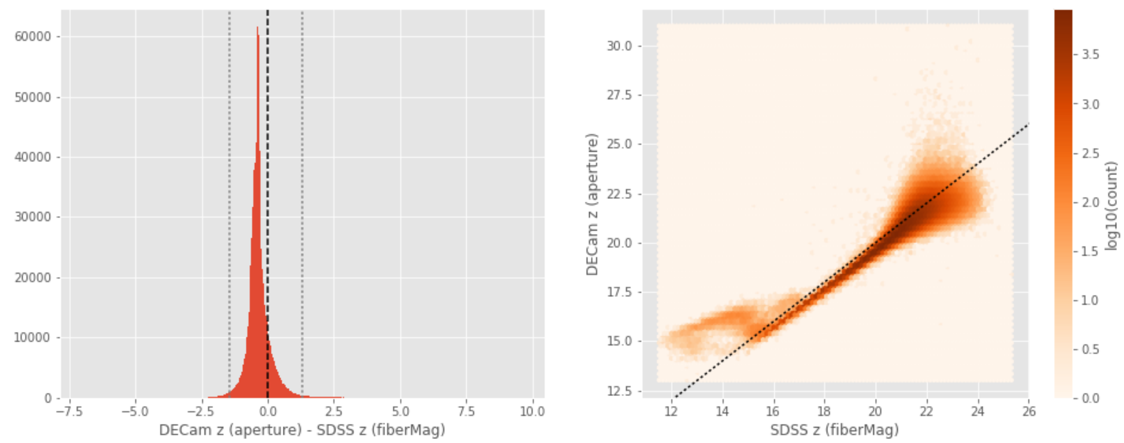
GPC1 i (aperture) - SDSS i (fiberMag):
- Median: -0.36
- Median Absolute Deviation: 0.12
- 1% percentile: -1.0263115501403808
- 99% percentile: 0.4693428230285639



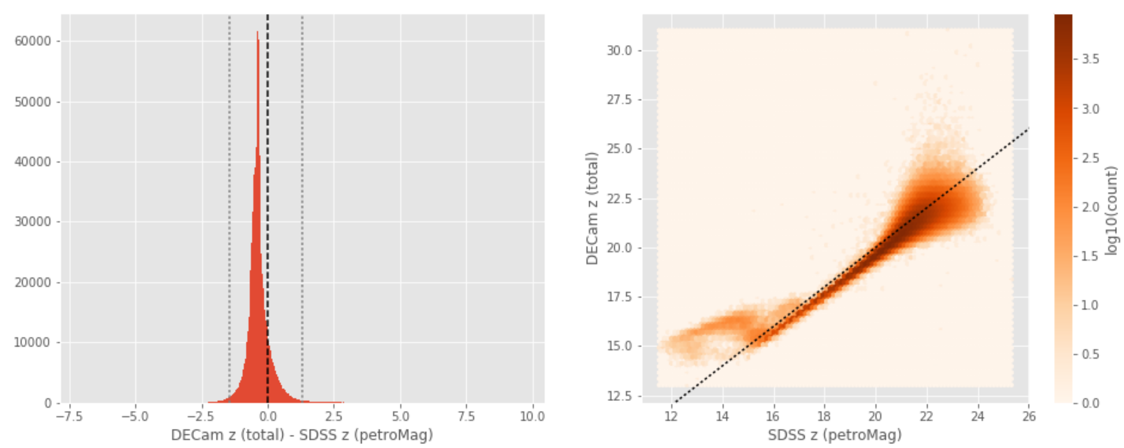
GPC1 i (total) - SDSS i (petroMag):
- Median: -0.36
- Median Absolute Deviation: 0.12
- 1% percentile: -1.0263115501403808
- 99% percentile: 0.4693428230285639



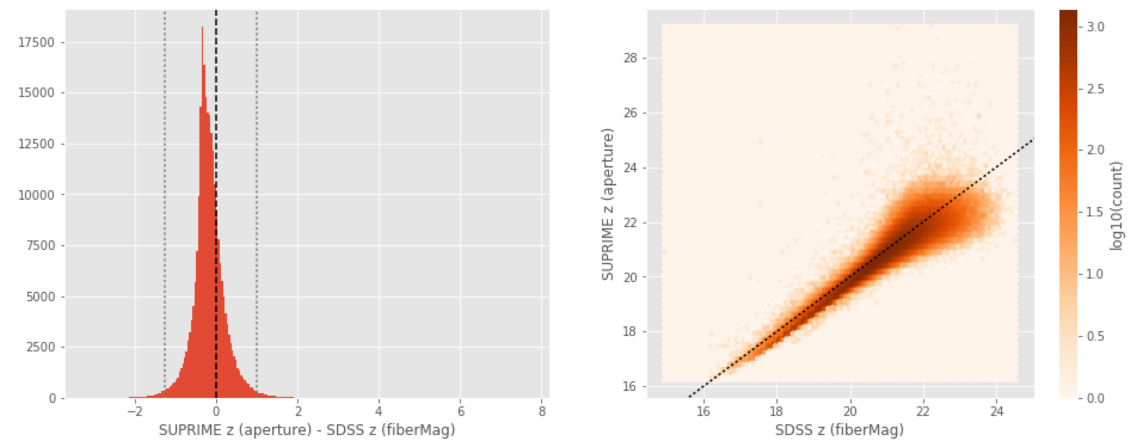
DECam z (aperture) - SDSS z (fiberMag):
- Median: -0.37
- Median Absolute Deviation: 0.18
- 1% percentile: -1.444174976348877
- 99% percentile: 1.322802276611327



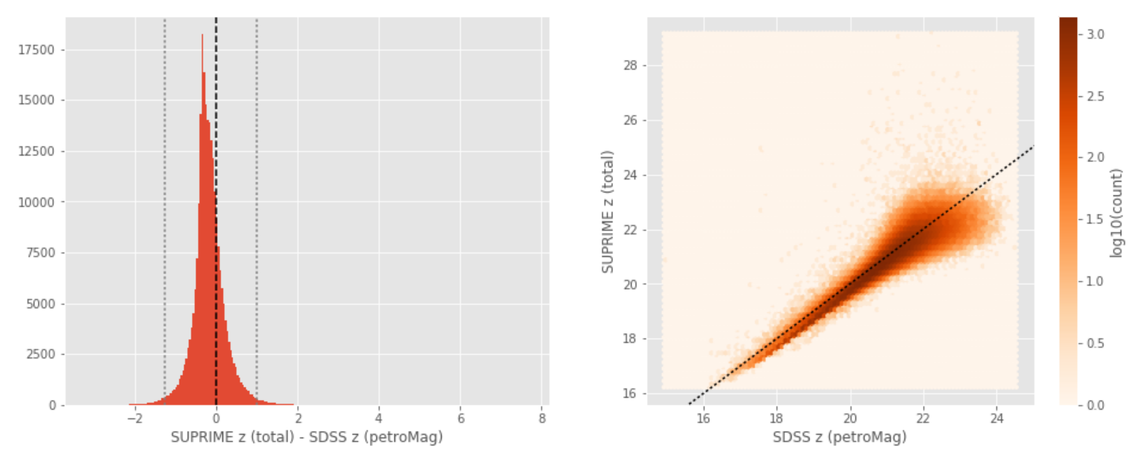
DECam z (total) - SDSS z (petroMag):
- Median: -0.37
- Median Absolute Deviation: 0.18
- 1% percentile: -1.444174976348877
- 99% percentile: 1.322802276611327



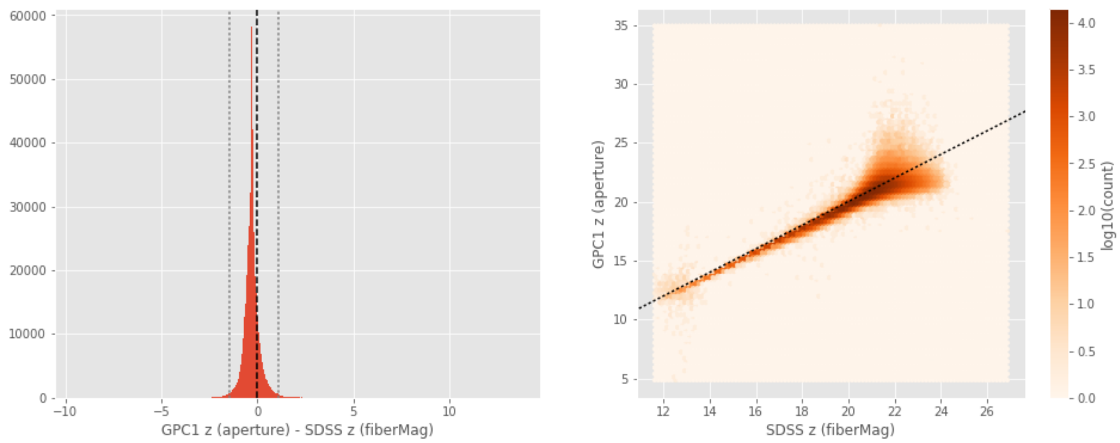
SUPRIME z (aperture) - SDSS z (fiberMag):
- Median: -0.21
- Median Absolute Deviation: 0.19
- 1% percentile: -1.2618183135986327
- 99% percentile: 0.9837712860107417



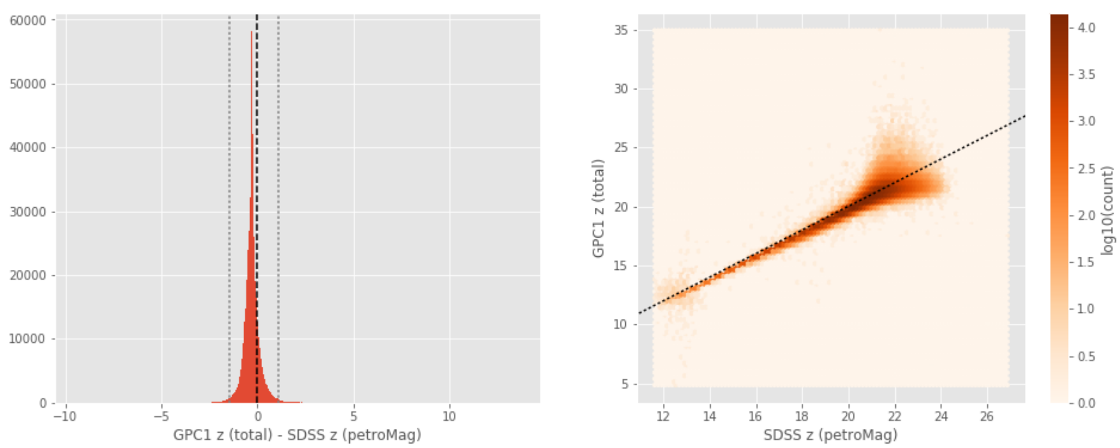
SUPRIME z (total) - SDSS z (petroMag):
- Median: -0.21
- Median Absolute Deviation: 0.19
- 1% percentile: -1.2618183135986327
- 99% percentile: 0.9837712860107417



GPC1 z (aperture) - SDSS z (fiberMag):
- Median: -0.30
- Median Absolute Deviation: 0.18
- 1% percentile: -1.4636115074157714
- 99% percentile: 1.100392208099355



GPC1 z (total) - SDSS z (petroMag):
- Median: -0.30
- Median Absolute Deviation: 0.18
- 1% percentile: -1.4636115074157714
- 99% percentile: 1.100392208099355



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.

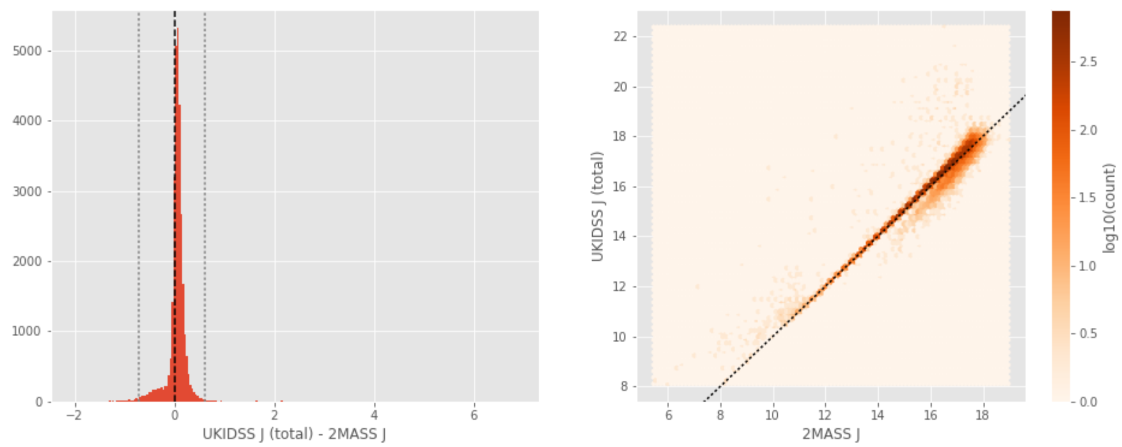
The 2MASS magnitudes are "*Vega-like*" and we have to convert them to AB magnitudes using the zero points provided on this page:

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

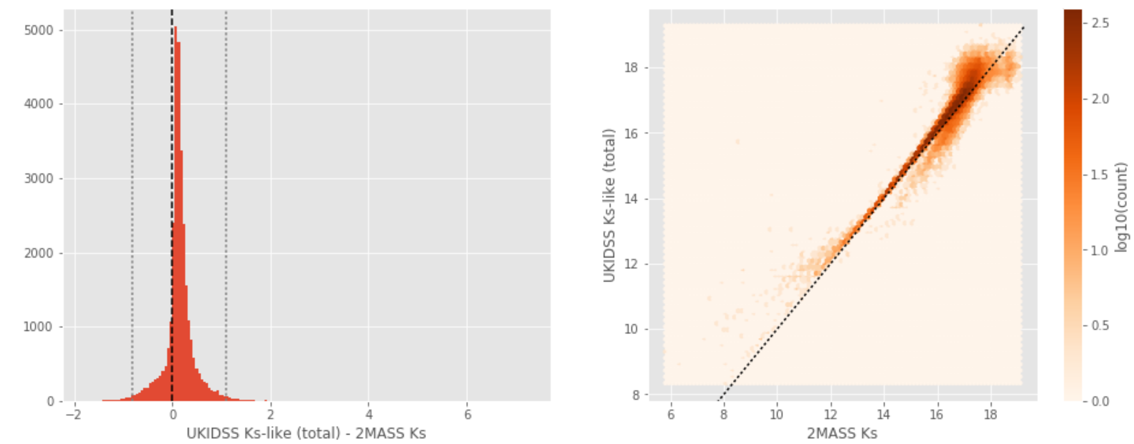
In addition, UKIDSS uses a K band whereas 2MASS uses a Ks ("short") band, this page give a correction to convert the K band in a Ks band with the formula:

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

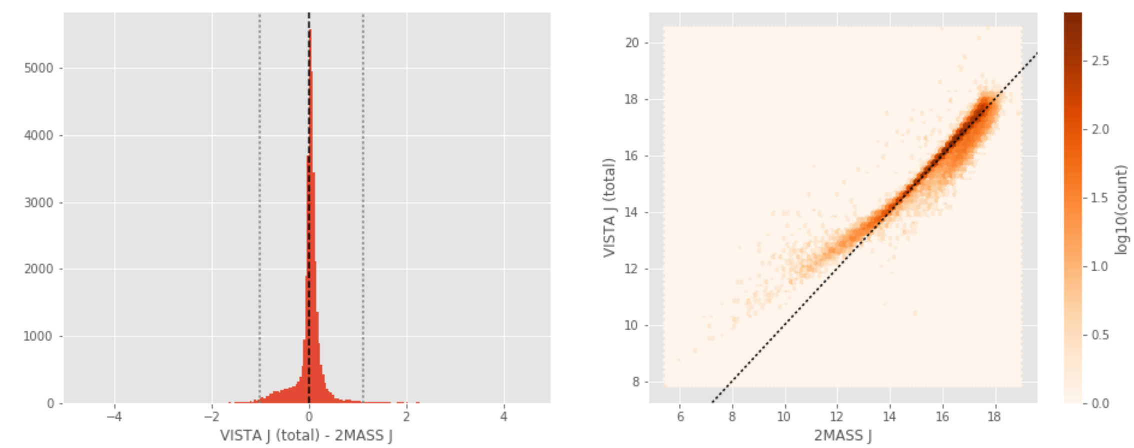
```
UKIDSS J (total) - 2MASS J:
- Median: 0.06
- Median Absolute Deviation: 0.06
- 1% percentile: -0.7037197442533326
- 99% percentile: 0.6006480420015505
```



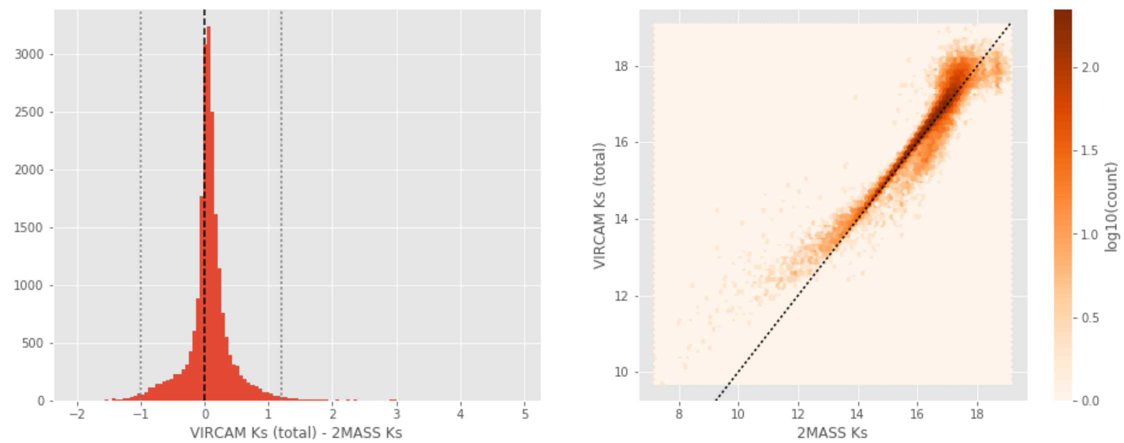

```
UKIDSS Ks-like (total) - 2MASS Ks:
- Median: 0.13
- Median Absolute Deviation: 0.09
- 1% percentile: -0.804199426332334
- 99% percentile: 1.1058544402448145
```



VISTA J (total) - 2MASS J:
- Median: 0.04
- Median Absolute Deviation: 0.07
- 1% percentile: -1.0072000961210075
- 99% percentile: 1.1233207901094577

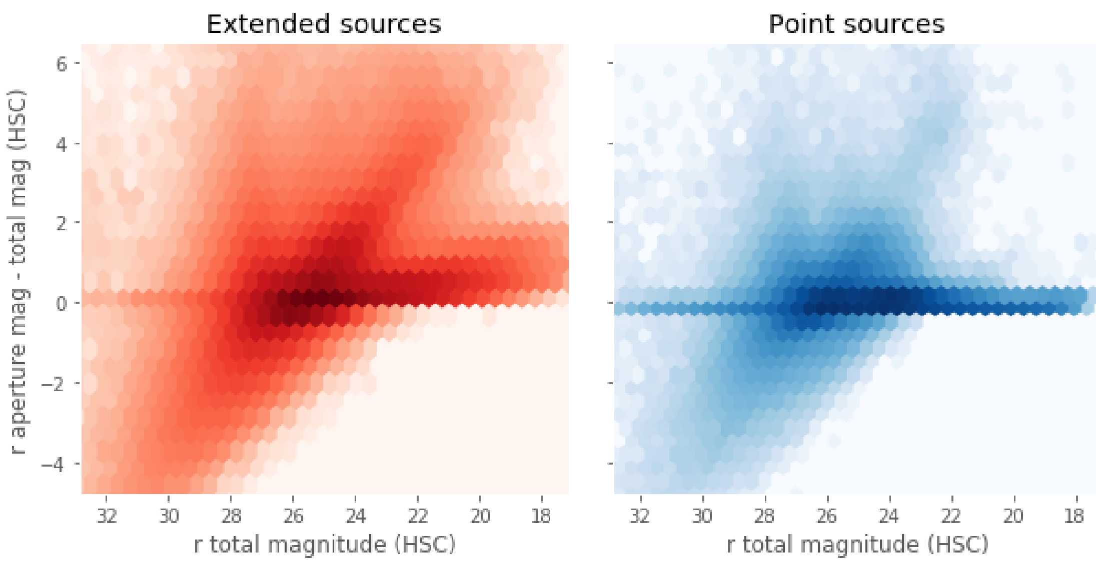


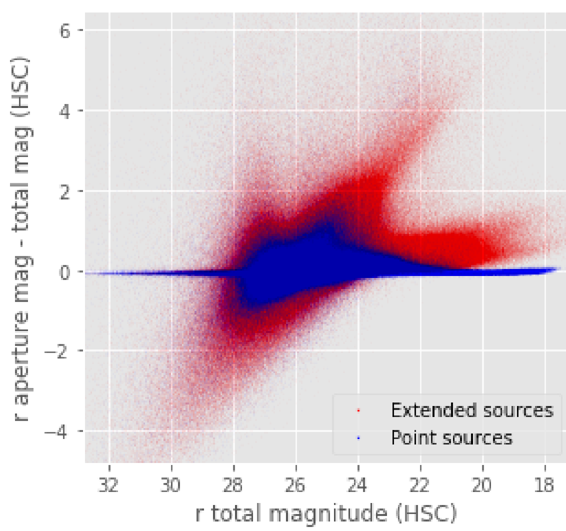
VIRCAM Ks (total) - 2MASS Ks:
- Median: 0.06
- Median Absolute Deviation: 0.11
- 1% percentile: -0.9966990270098248
- 99% percentile: 1.2020145327130711



1.6 IV - Comparing aperture magnitudes to total ones.

```
Number of source used: 5937538 / 14232880 (41.72%)
```

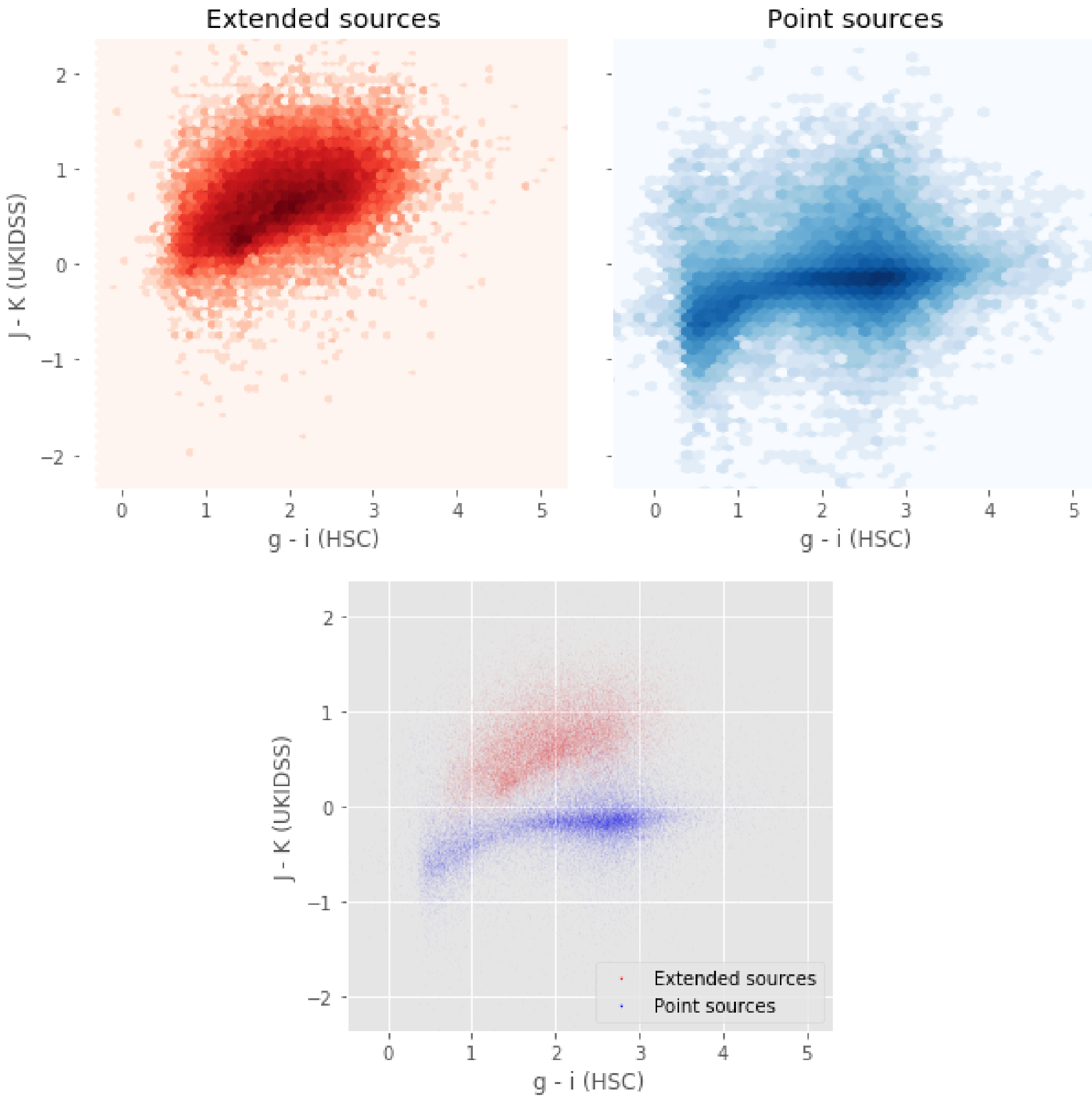




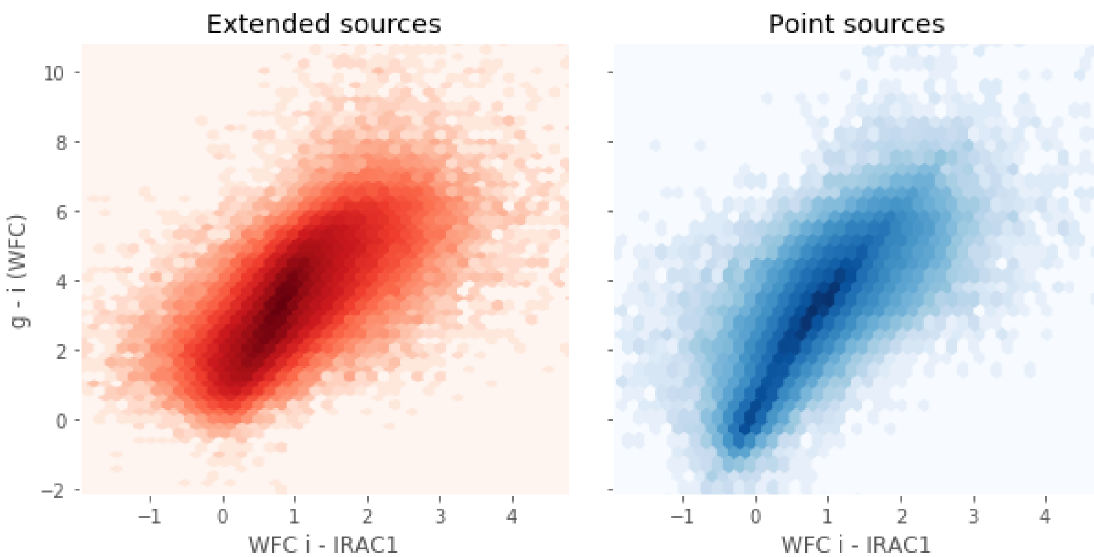
1.7 V - Color-color and magnitude-color plots

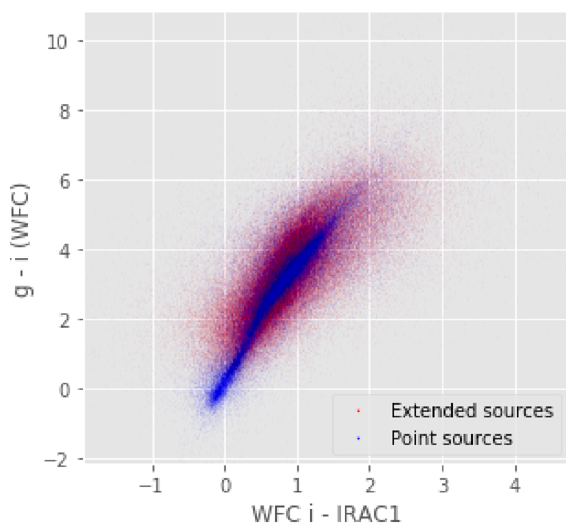
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:2: R
  from ipykernel import kernelapp as app
```

```
Number of source used: 68178 / 14232880 (0.48%)
```

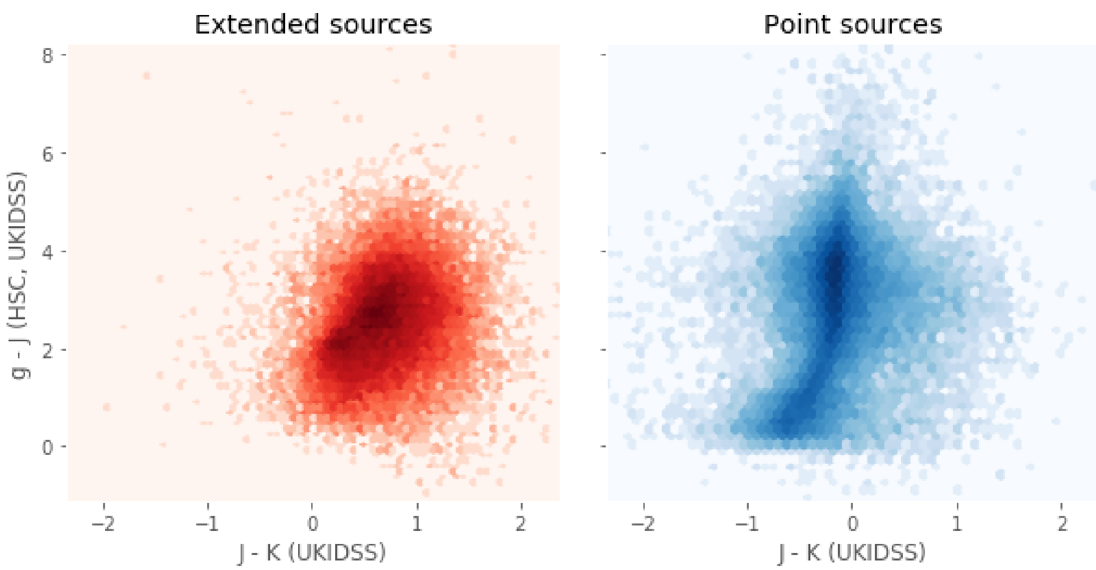


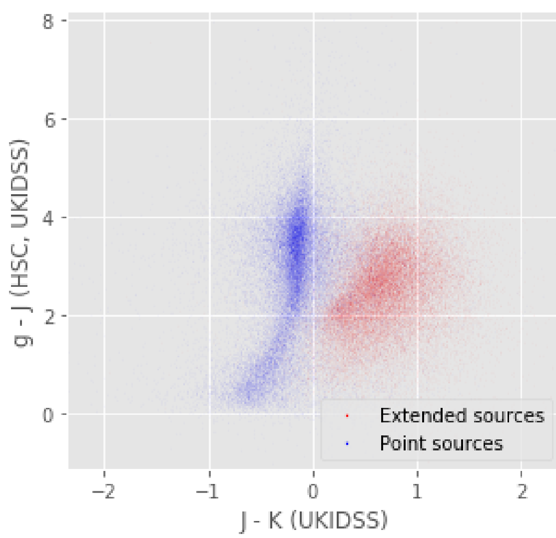

```
Number of source used: 279701 / 14232880 (1.97%)
```





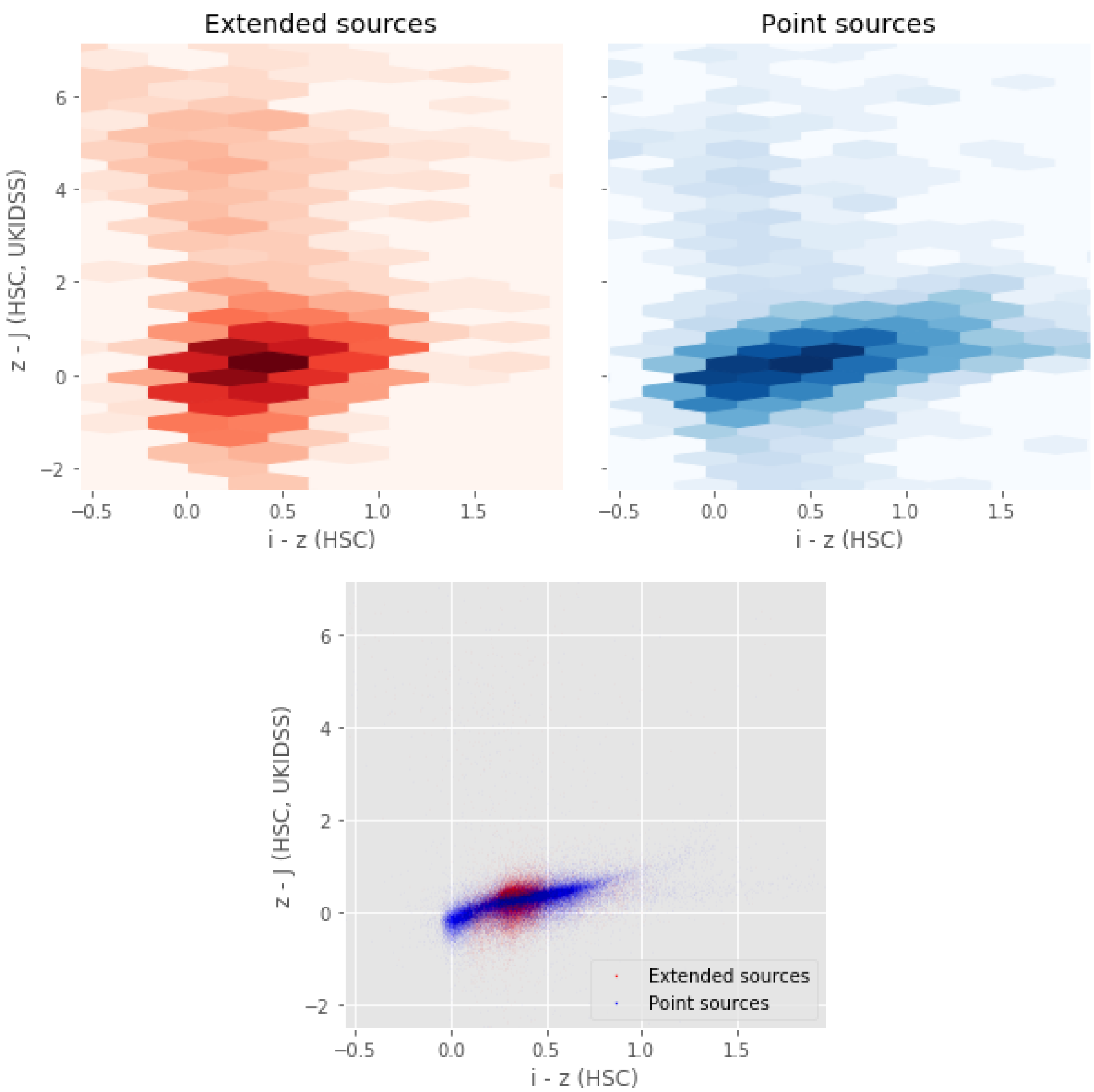

```
Number of source used: 68180 / 14232880 (0.48%)
```






```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/__main__.py:2: R
  from ipykernel import kernelapp as app
```

```
Number of source used: 84746 / 14232880 (0.60%)
```


Extended sources
Point sources
z - J (HSC, UKIDSS)
i - z (HSC)
Extended sources
Point sources