

## 1.1\_VISTA-VIDEO

March 8, 2018

### 1 ELAIS S1 Master List Creation

#### 1.1 Preparation of VIDEO/VISTA/VIRCAM data

The catalogue comes from dmu0\_VISTA\_VIDEO-private.

There is an old public version of the catalogue but we are using the newer private version in the hope that it will be public by the time we publish the masterlist.

Filters: YJ,H,Ks

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position (degrees);
- The stellarity;
- The magnitude for each band in aperture 3, which is 2 arcsec (rs548 presumes same for private catalogue).
- The “auto” magnitude is provided, we presume this is standard SExtractor units etc.

Yannick said the dates of observation for VIDEO are from 2009/11 to 2016/12. There is a paper from 2012 (Jarvis et al). So will use 2012.

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

Out[3] : 'en\_GB'

#### 1.2 I - Column selection

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

#### 1.3 II - Removal of duplicated sources

We remove duplicated objects from the input catalogues.

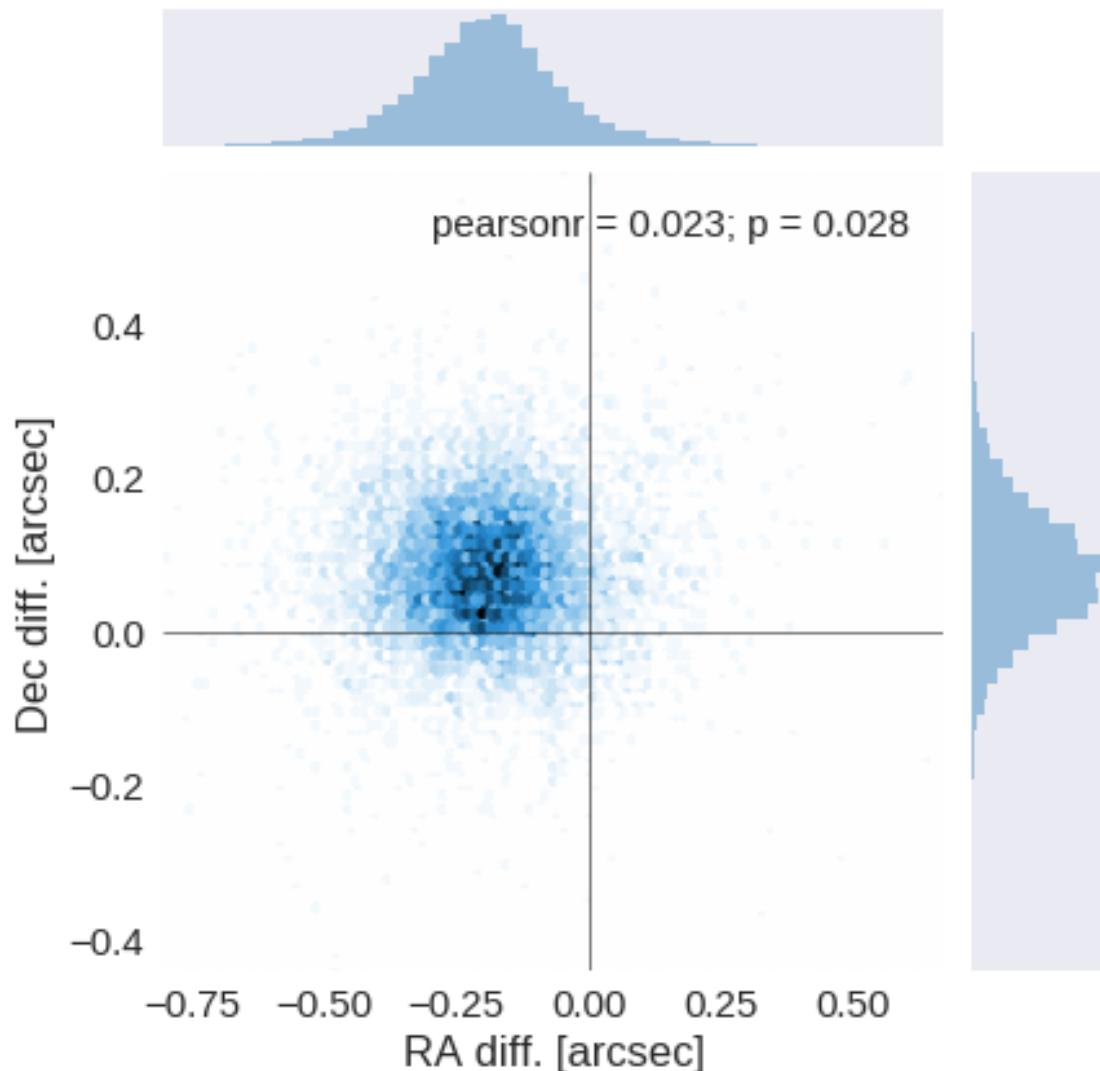
The initial catalogue had 831778 sources.

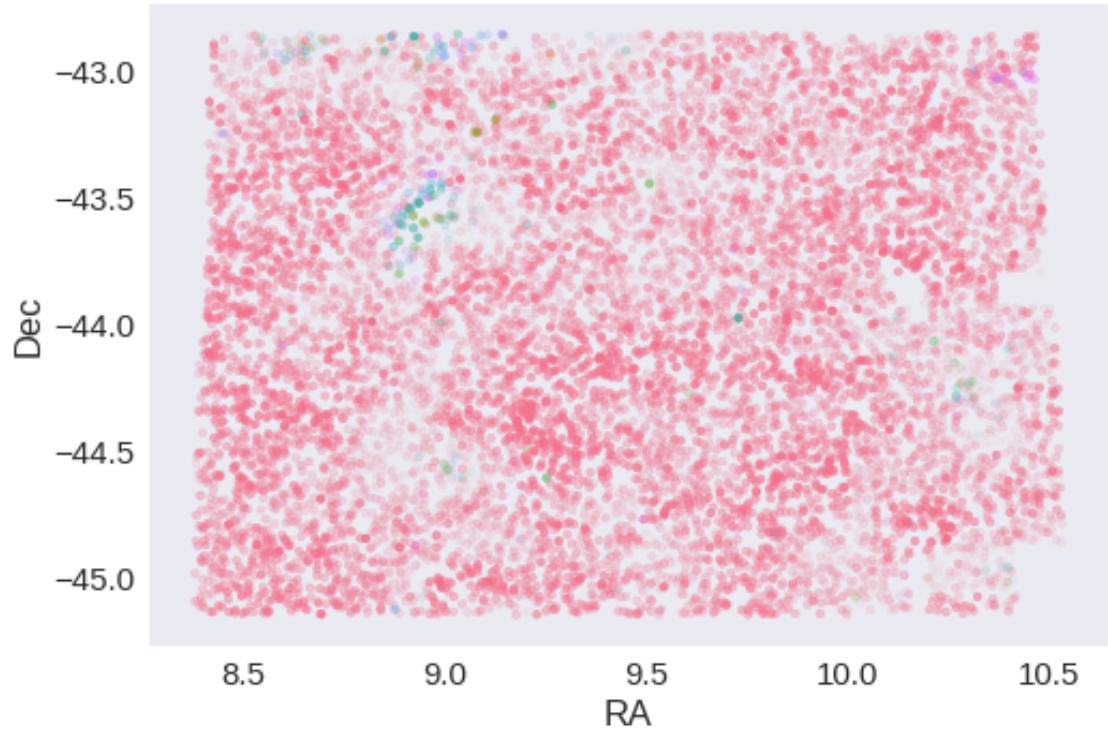
The cleaned catalogue has 830089 sources (1689 removed).

The cleaned catalogue has 1680 sources flagged as having been cleaned

## 1.4 III - Astrometry correction

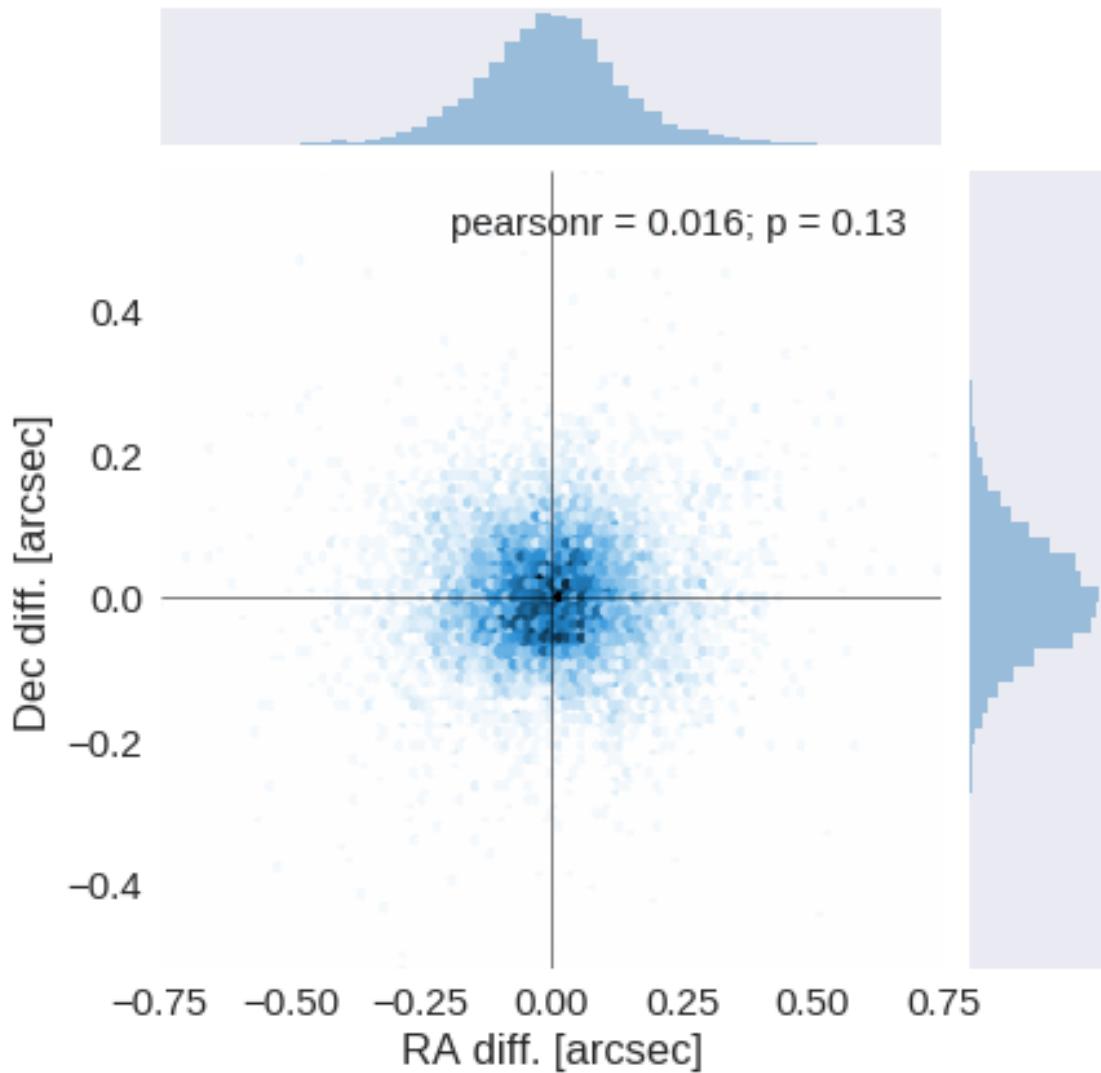
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.

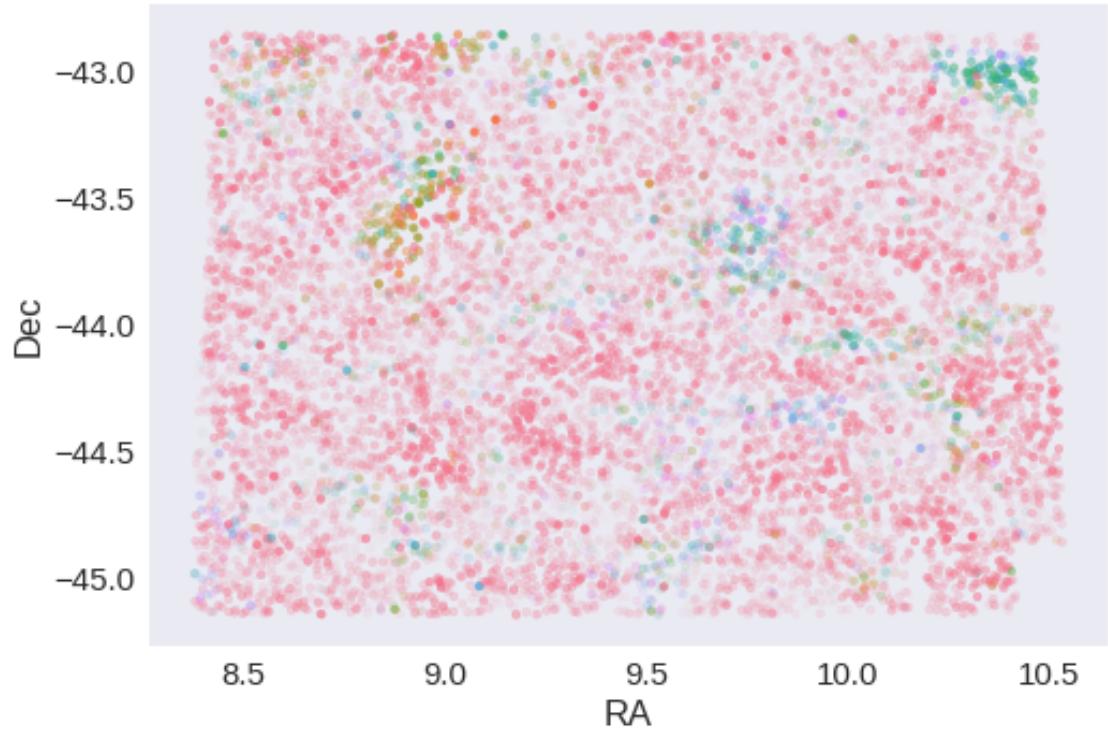




RA correction: 0.19172828544000708 arcsec

Dec correction: -0.07611326062857415 arcsec





## 1.5 IV - Flagging Gaia objects

9698 sources flagged.

## 1.6 IV - Flagging objects near bright stars

## 1.7 V - Saving to disk

## 1.2\_VISTA-VHS

March 8, 2018

### 1 ELAIS S1 master catalogue

#### 1.1 Preparation of VHS data

VISTA telescope/VHS catalogue: the catalogue comes from `dmu0_VHS`.

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)
```

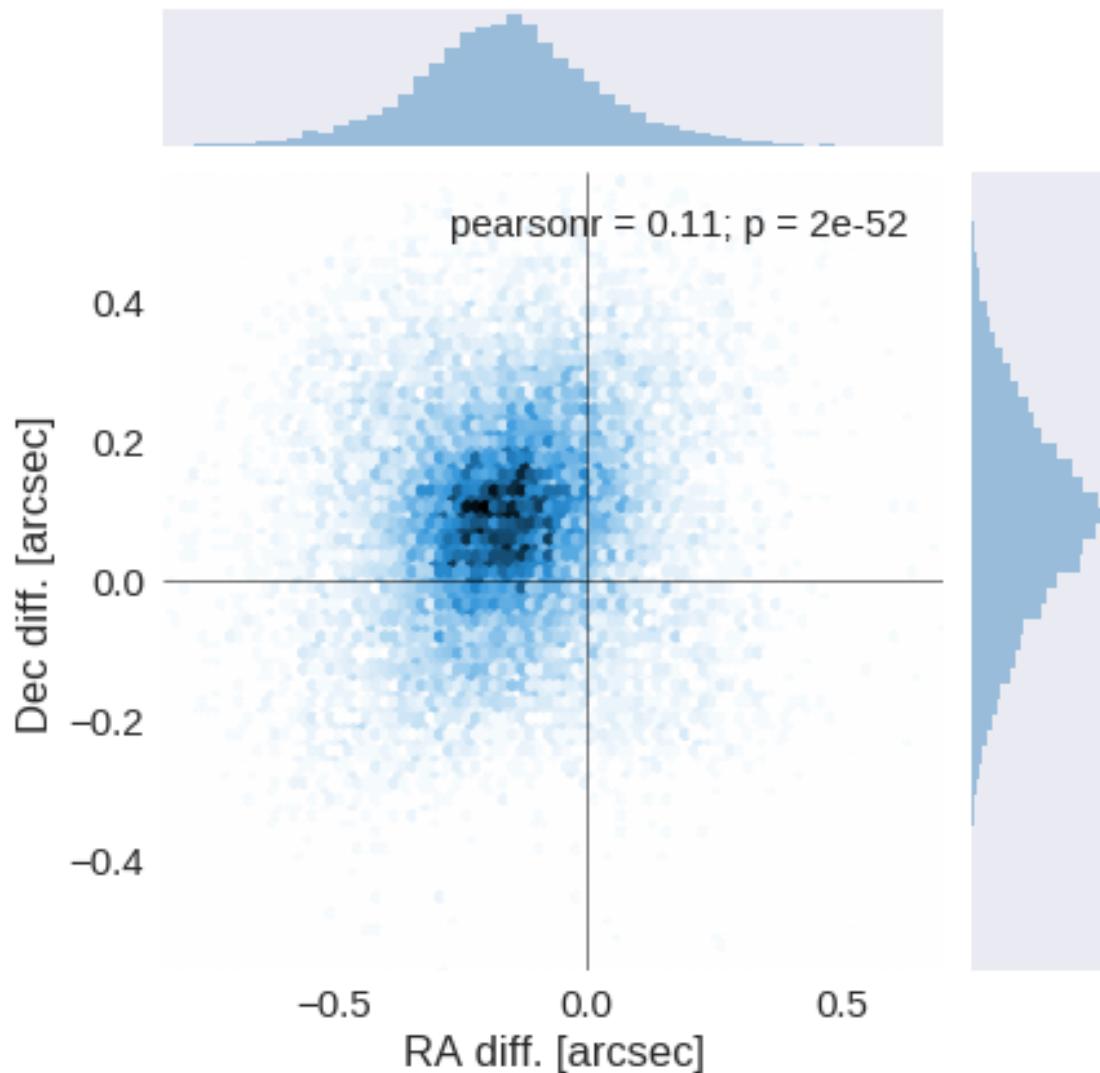
The initial catalogue had 242383 sources.

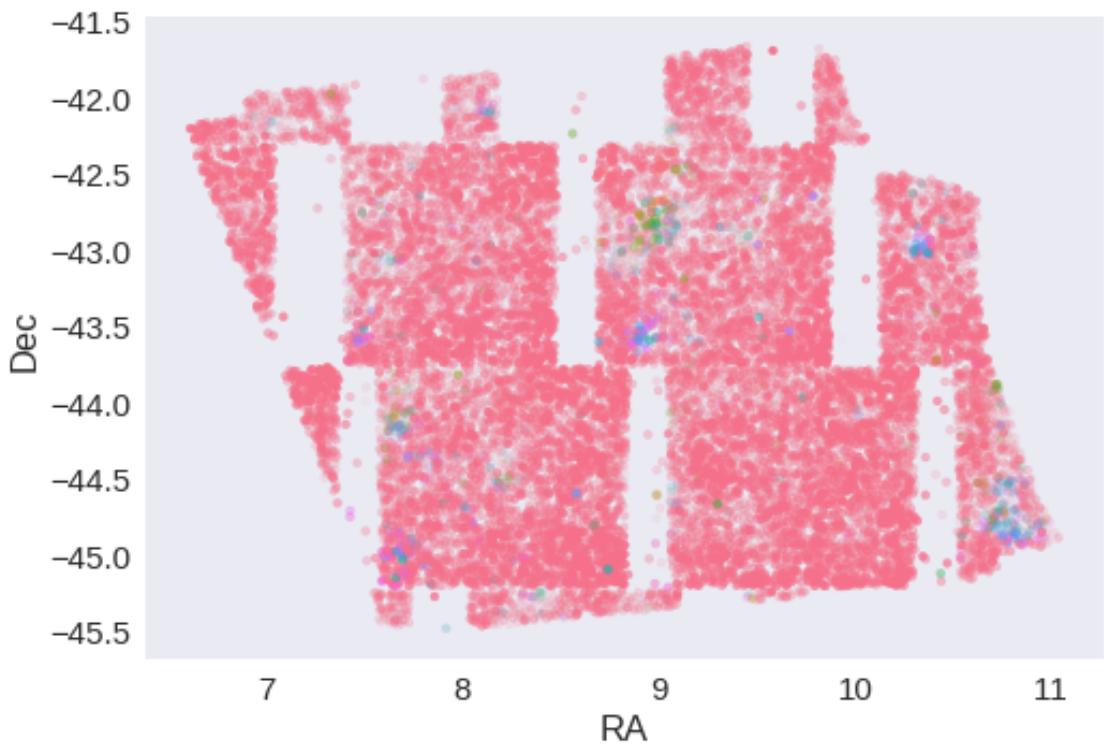
The cleaned catalogue has 242269 sources (114 removed).

The cleaned catalogue has 112 sources flagged as having been cleaned

## 1.4 III - Astrometry correction

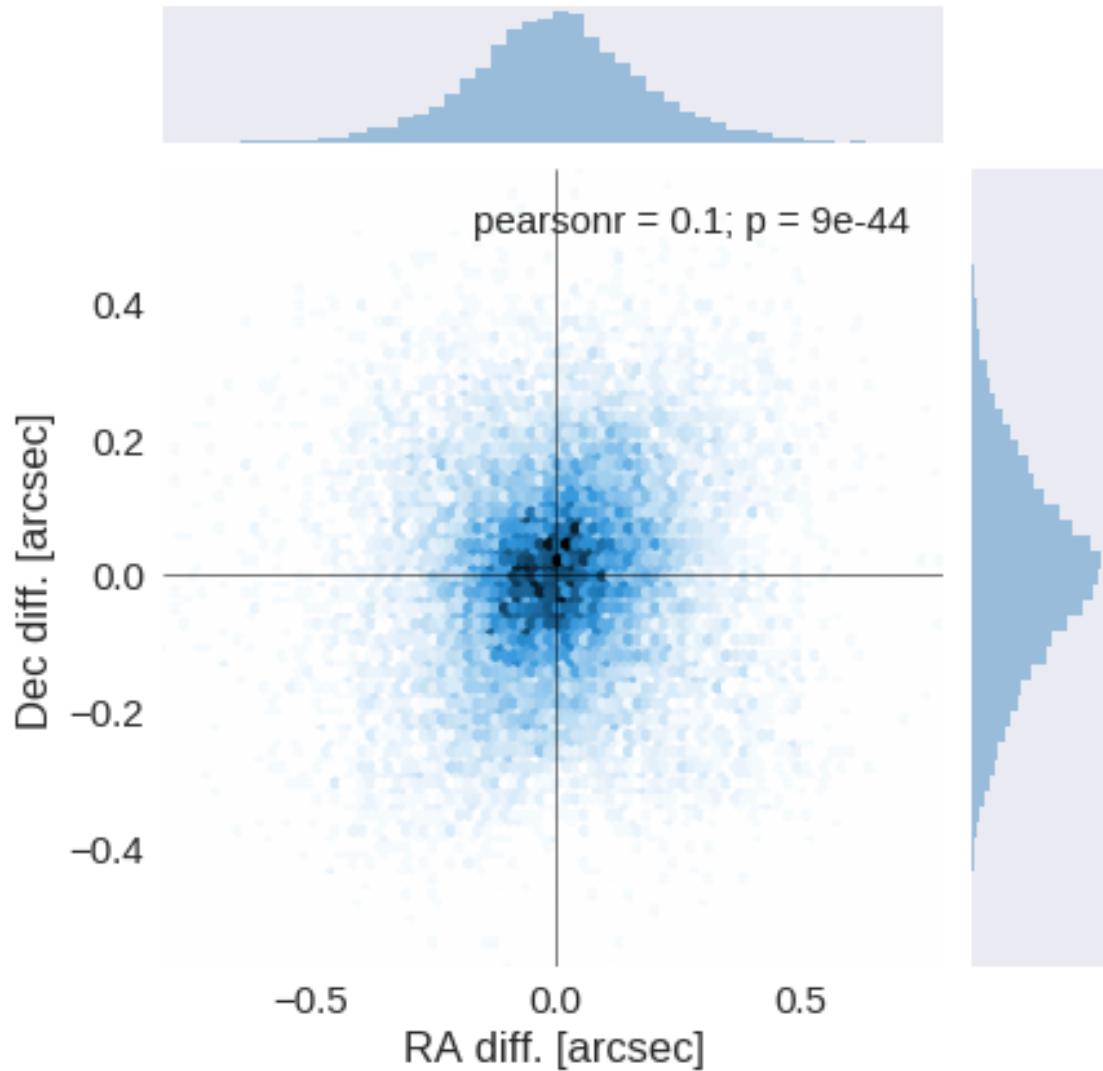
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.

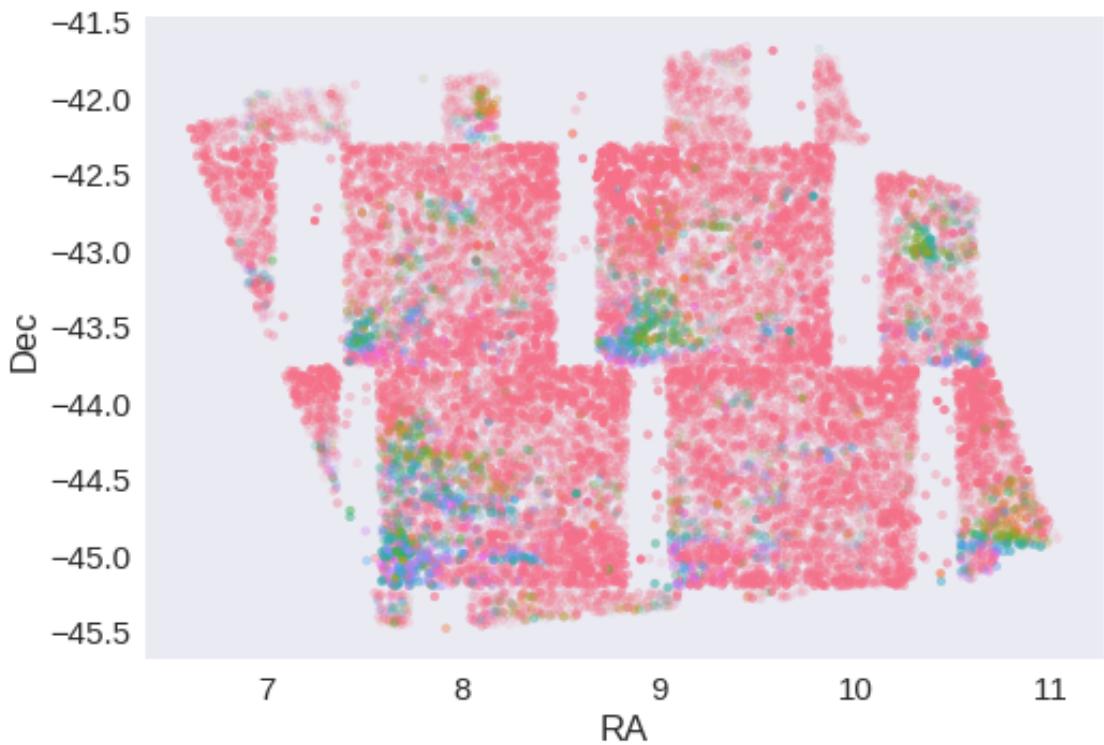




RA correction: 0.15926903843137552 arcsec

Dec correction: -0.08703663225020364 arcsec





## 1.5 IV - Flagging Gaia objects

18175 sources flagged.

## 1.6 V - Flagging objects near bright stars

## 2 VI - Saving to disk

## 1.3\_ESIS-VOICE

March 8, 2018

### 1 ELAIS-S1 master catalogue

#### 1.1 Preparation of ESO-Spitzer Imaging extragalactic Survey (ESIS) / 2.2-m MPG/ESO telescope at La Silla

The catalogue comes from dm0\_ESIS-VOICE.

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''). These are now corrected.
- The total (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:  
44f1ae0 (Thu Nov 30 18:27:54 2017 +0000)

#### 1.2 0 - Parameters for aperture correction

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

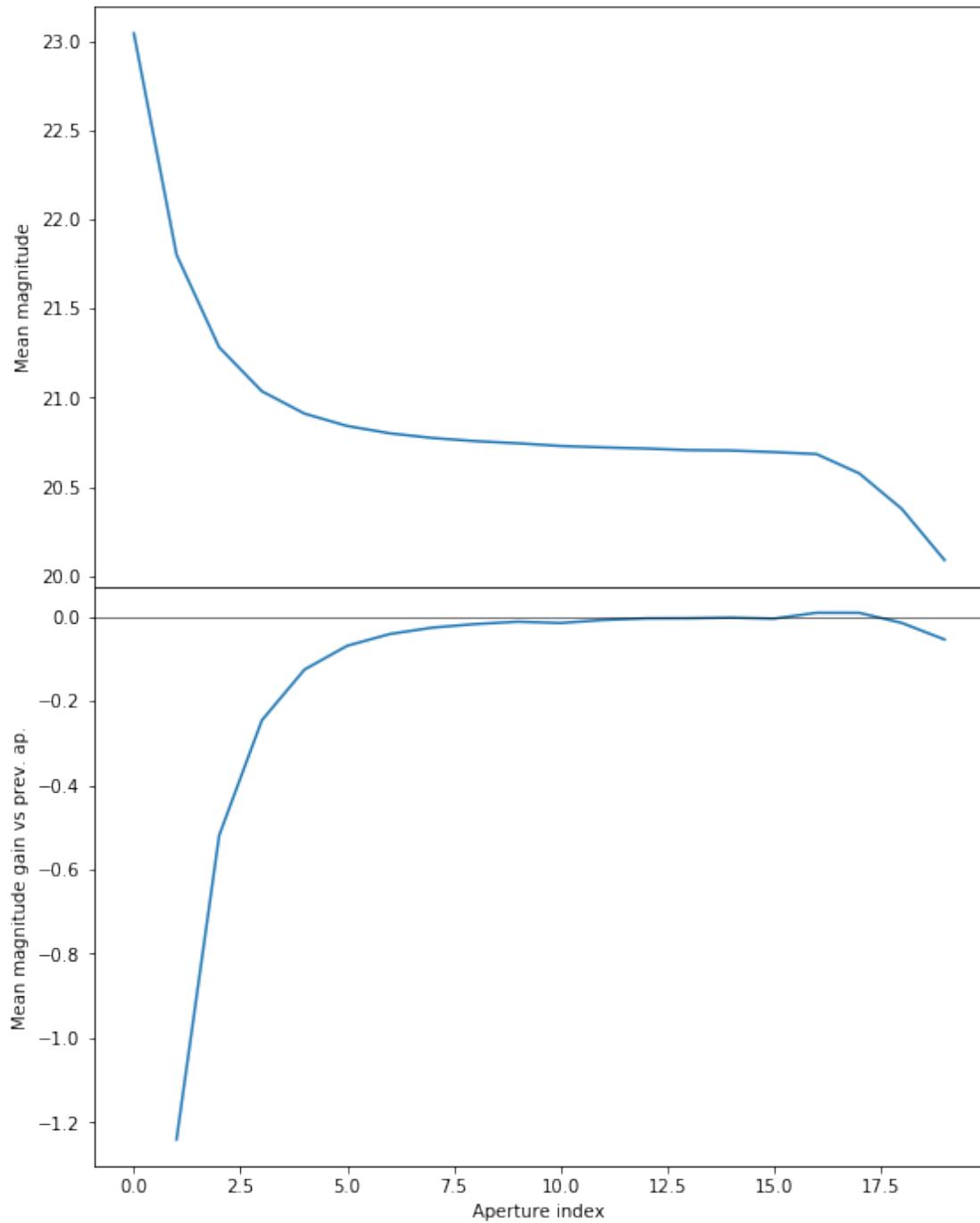
**Target aperture:** To determine the target aperture, we simulate a curve of growth using the provided apertures and draw two figures: - The evolution of the magnitudes of the objects by plotting on the same plot aperture number vs the mean magnitude. - The mean gain (loss when negative) of magnitude 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 captured.

**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.

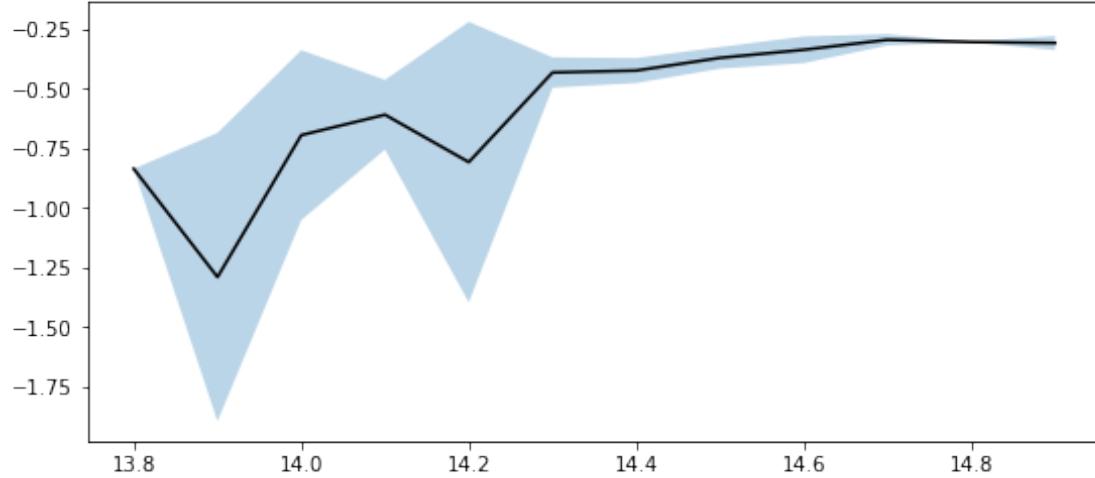
### 1.2.1 I.a b99-band

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid value encountered in less than  
mags = magnitudes[:, stellarity > stel_threshold].copy()
```



We will use the 13th (12+1) (aperture number above begin at 0) aperture as target.

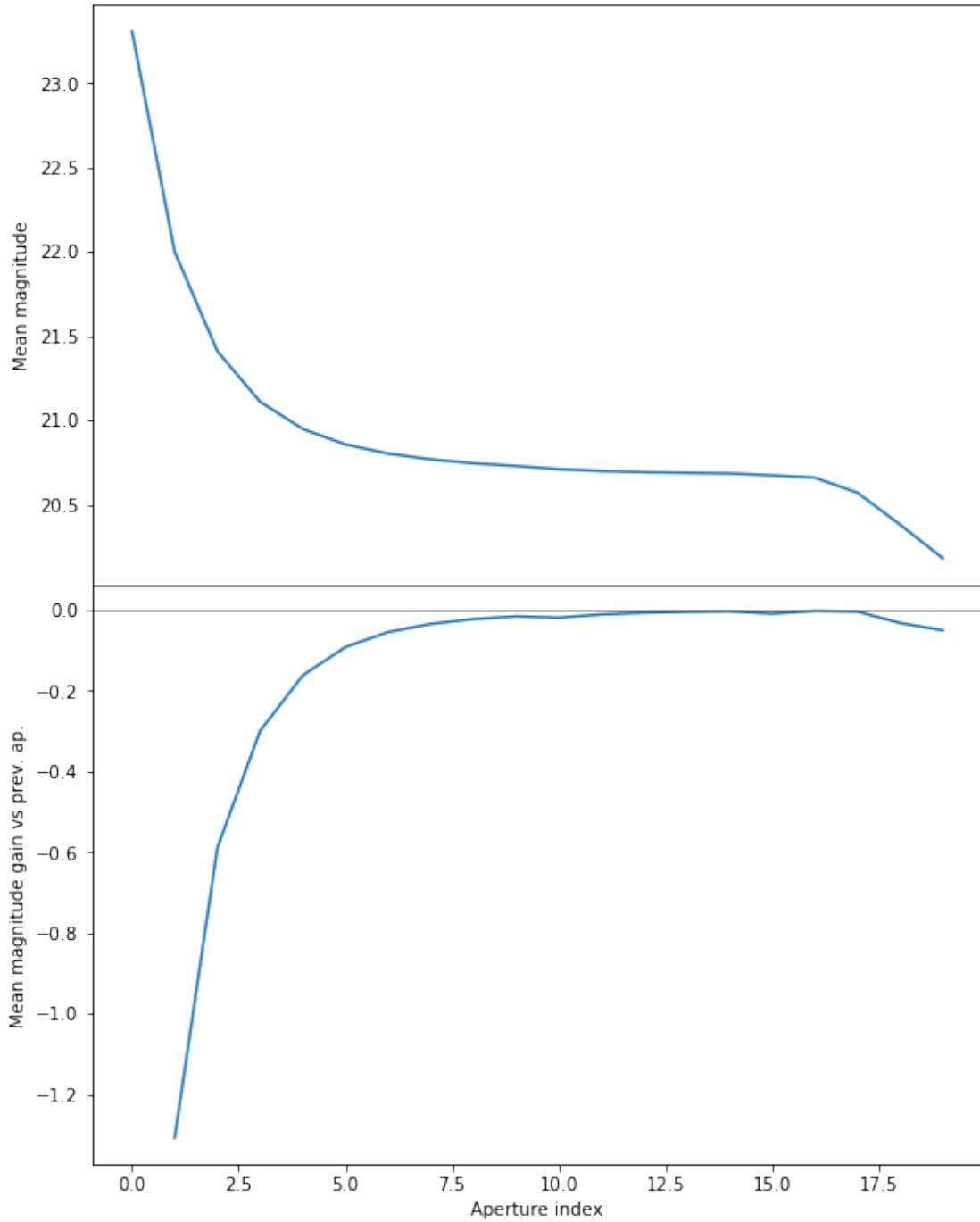
```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid value encountered in greater than
  mask = stellarity > .9
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:129: RuntimeWarning: invalid value encountered in less than or equal to
  mask &= (stellarity > 0.9)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:131: RuntimeWarning: invalid value encountered in greater than or equal to
  mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value encountered in less than or equal to
  mask &= (mag <= mag_max)
```



We use magnitudes between 14.3 and 14.6.

### 1.2.2 I.b b123-band

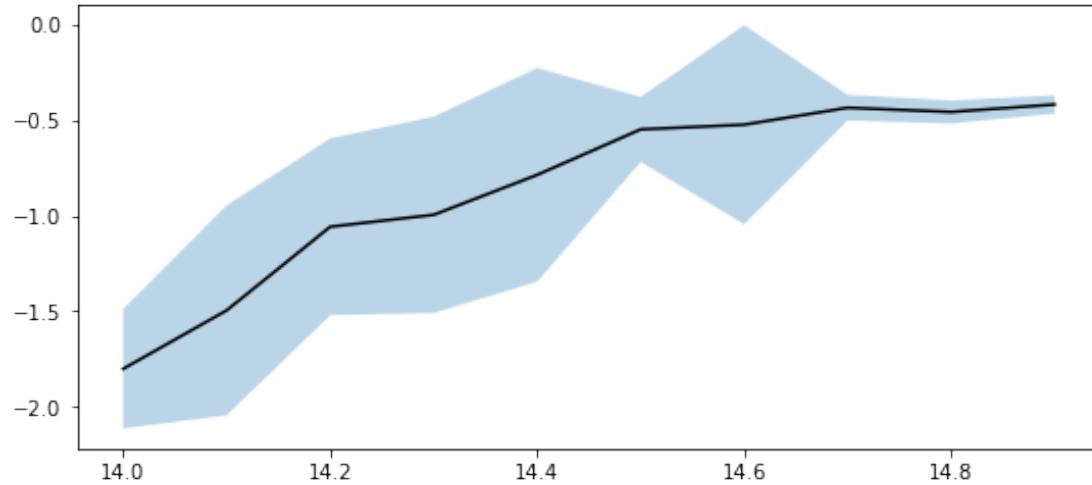
```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid value encountered in greater than
  mags = magnitudes[:, stellarity > stel_threshold].copy()
```



We will use the 13th (12+1) (aperture number above begin at 0) aperture as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid value
  mask = stellarity > .9
/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
```

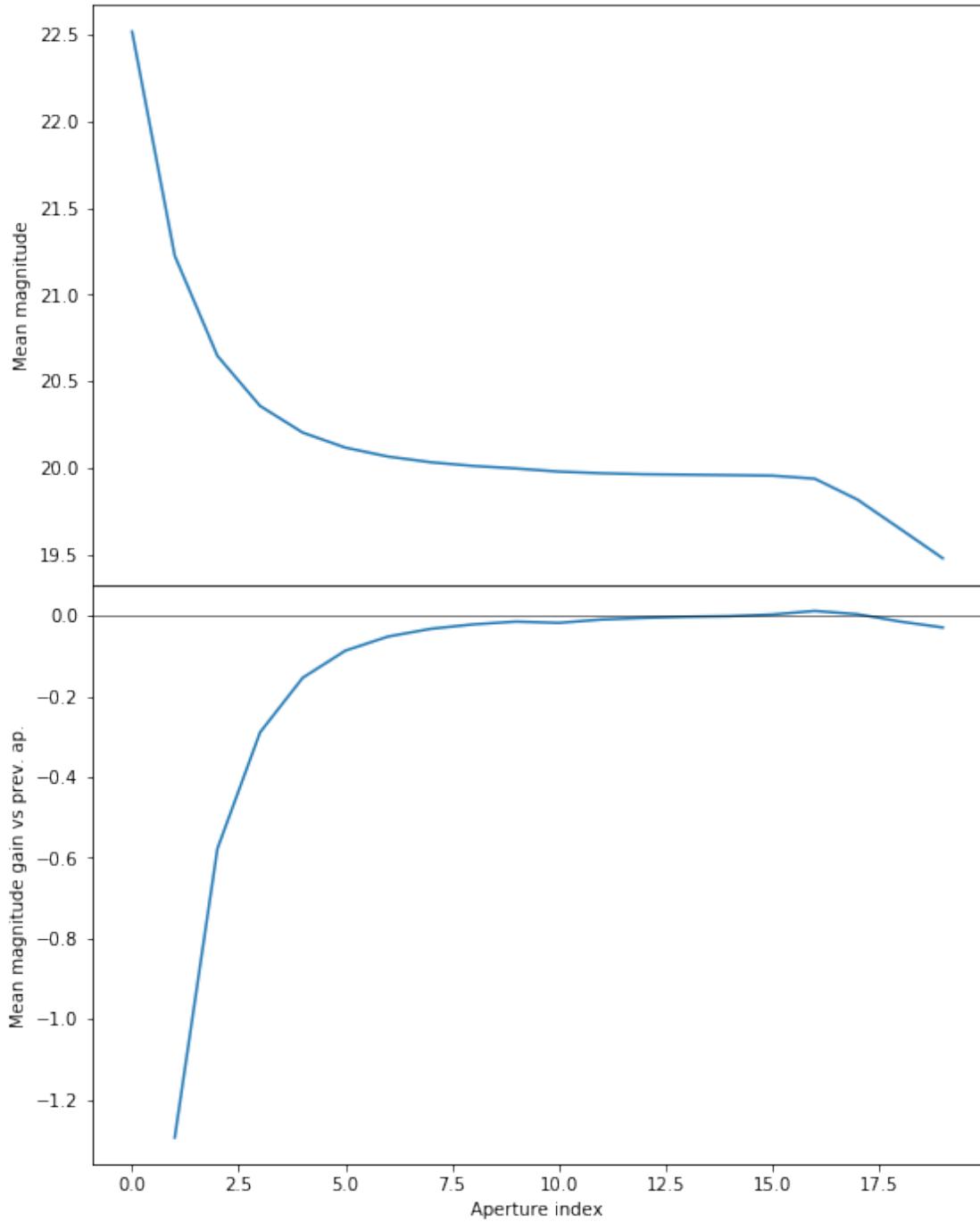
```
mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
mask &= (mag <= mag_max)
```



We use magnitudes between 14.0 and 16.0.

### 1.2.3 I.c v-band

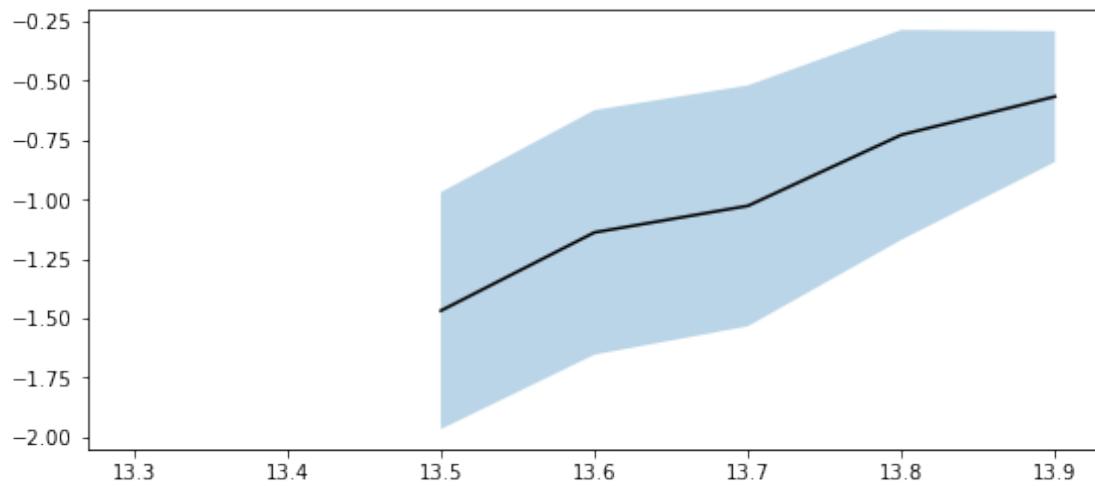
```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:850: RuntimeWarning: invalid value
mags = magnitudes[:, stellarity > stel_threshold].copy()
```



We will use the 13th (12+1) (aperture number above begin at 0) aperture as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid value
  mask = stellarity > .9
/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
```

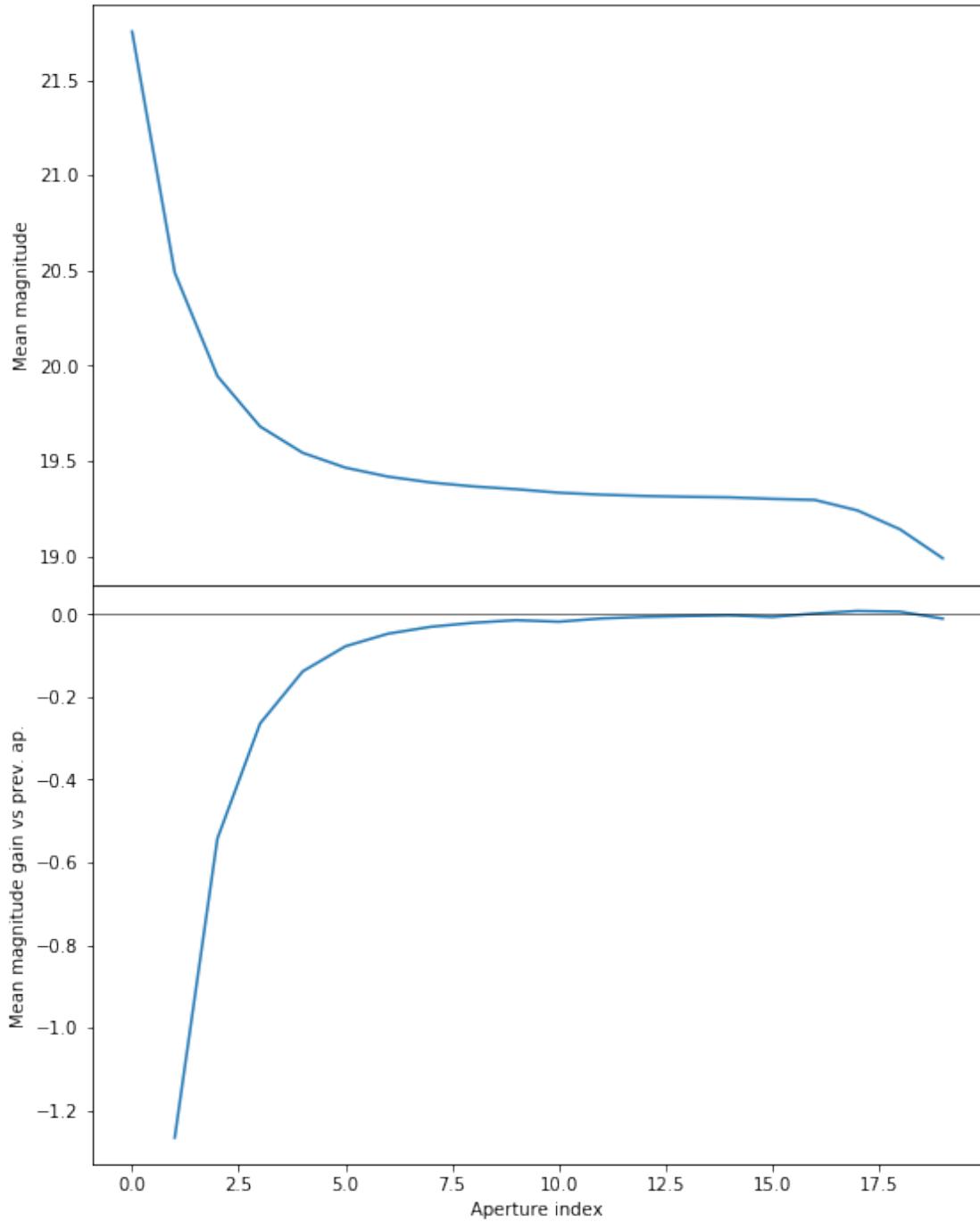
```
mask &= (mag >= mag_min)
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:133: RuntimeWarning: invalid value enc
mask &= (mag <= mag_max)
```



We use magnitudes between 14.0 and 16.0.

#### 1.2.4 I.d r-band

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



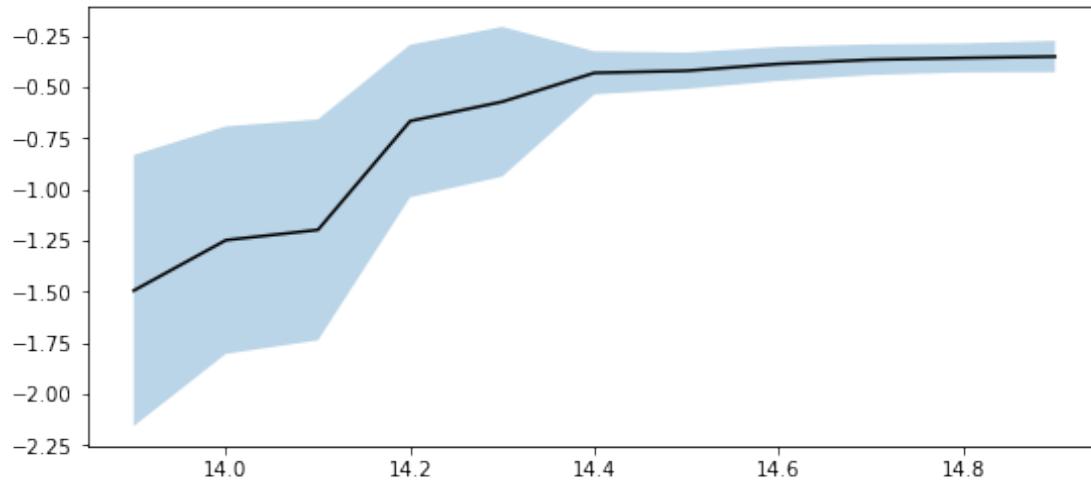
We will use the 13th (12+1) (aperture number above begin at 0) aperture as target.

```
/opt/herschelhelp_internal/herschelhelp_internal/masterlist.py:903: RuntimeWarning: invalid value
  mask = stellarity > .9
/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 14.0 and 16.0.

### 1.3 I - Column selection

```

/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/_main__.py:65:
/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)

```

Aperture correction for VOICE band b99:

Correction: -0.27787113189697266

Number of source used: 83

RMS: 0.04831492984158891

```

/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/ipykernel/_main__.py:99:

```

```
Aperture correction for VOICE band b123:  
Correction: -0.4382314682006836  
Number of source used: 711  
RMS: 0.11412357895179506
```

```
Aperture correction for VOICE band v:  
Correction: -0.3730955123901367  
Number of source used: 791  
RMS: 0.09074258714442375
```

```
Aperture correction for VOICE band r:  
Correction: -0.36531543731689453  
Number of source used: 1325  
RMS: 0.12346733267578548
```

Out[15]: <IPython.core.display.HTML object>

## 1.4 II - Removal of duplicated sources

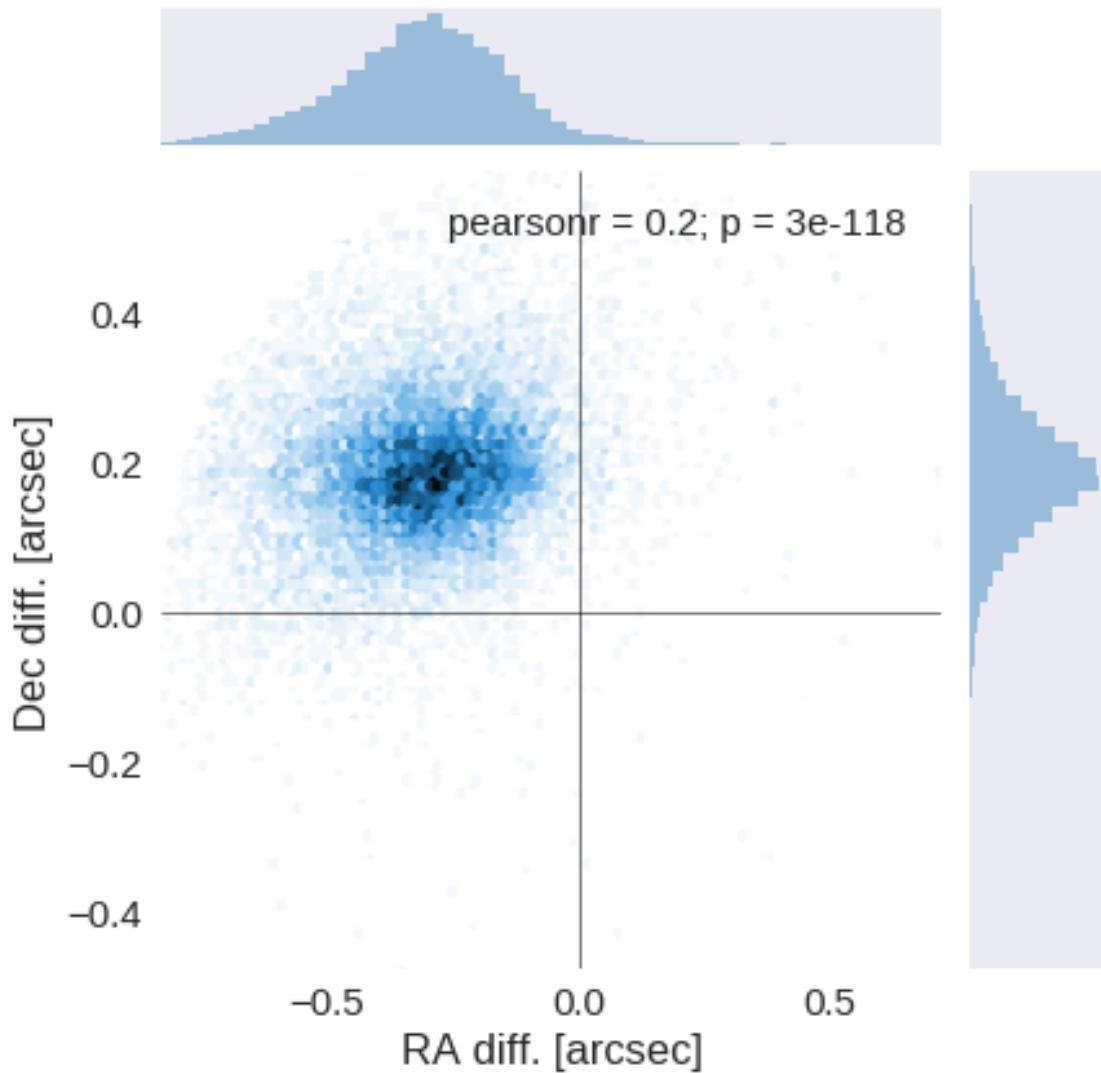
We remove duplicated objects from the input catalogues.

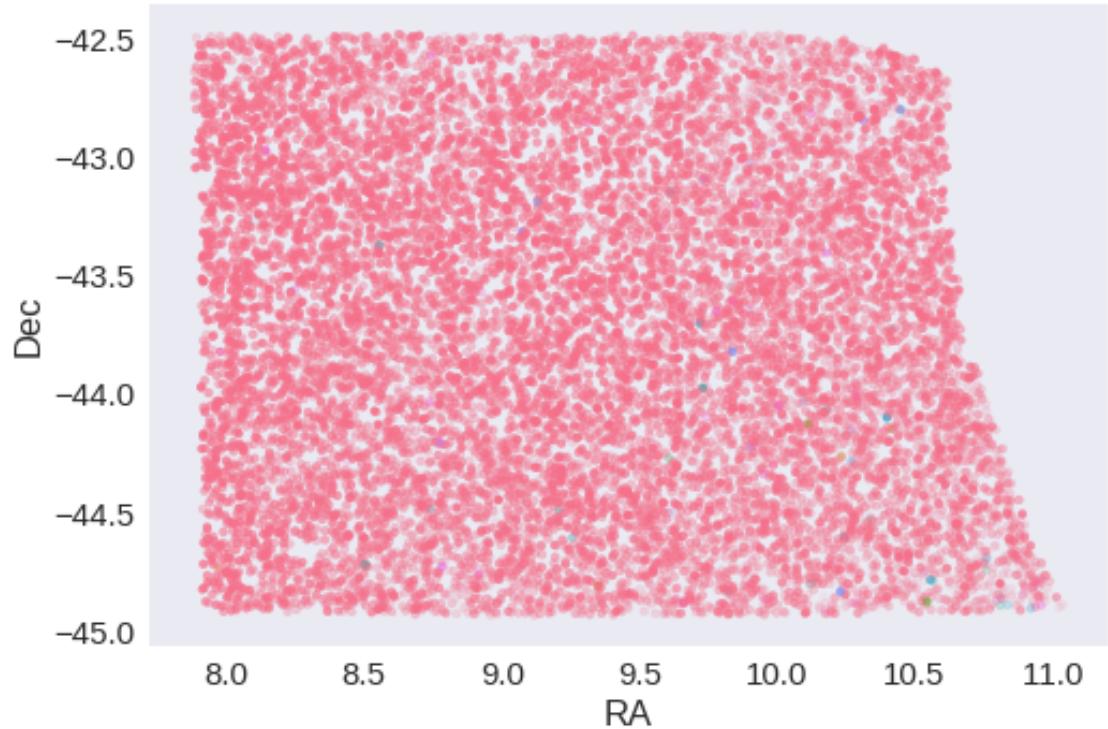
```
/opt/anaconda3/envs/herschelhelp_internal/lib/python3.6/site-packages/astropy/table/column.py:10  
Check the NumPy 1.11 release notes for more information.  
ma.MaskedArray.__setitem__(self, index, value)
```

```
The initial catalogue had 524564 sources.  
The cleaned catalogue has 521143 sources (3421 removed).  
The cleaned catalogue has 2873 sources flagged as having been cleaned
```

## 1.5 III - Astrometry correction

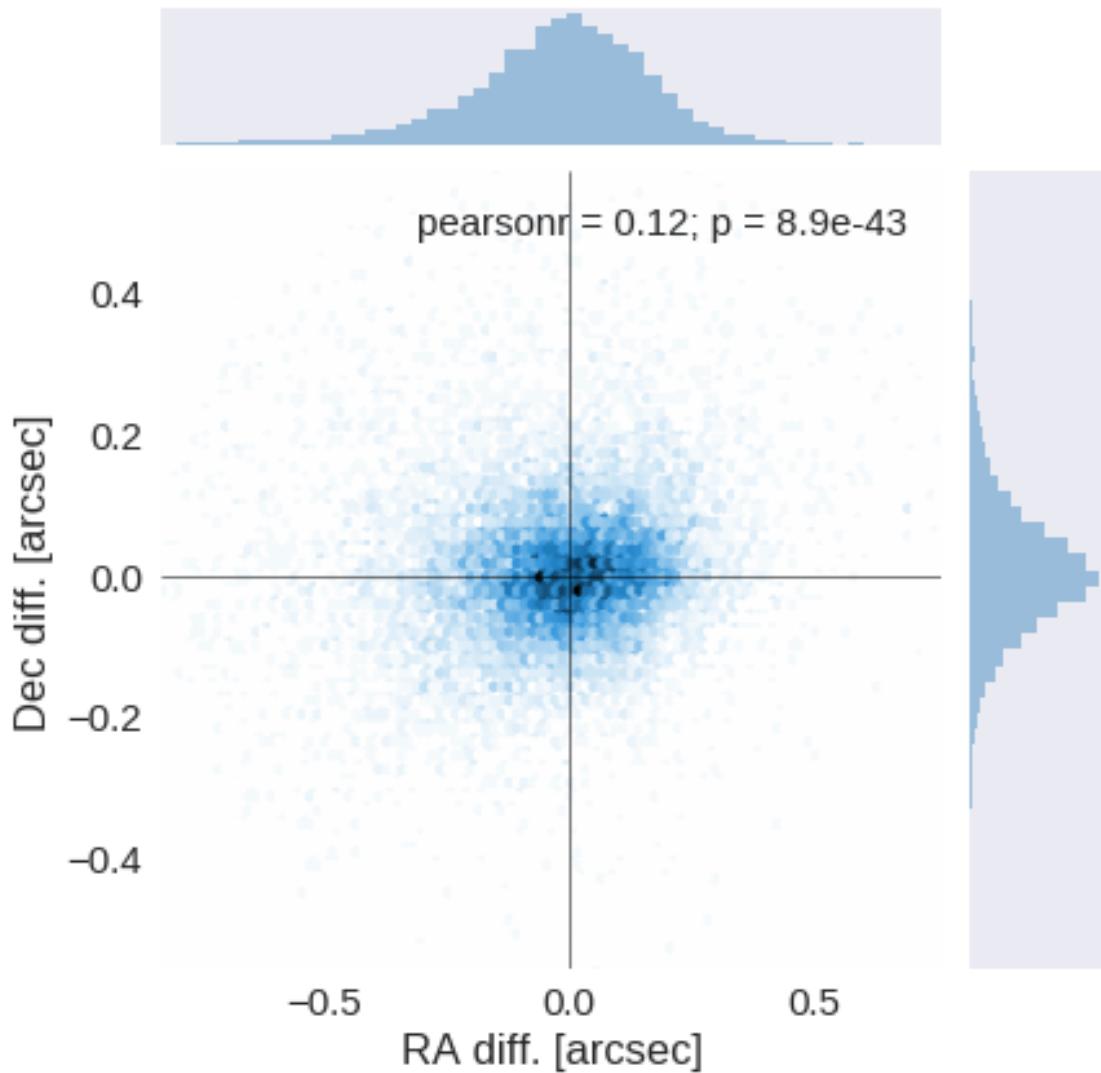
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.

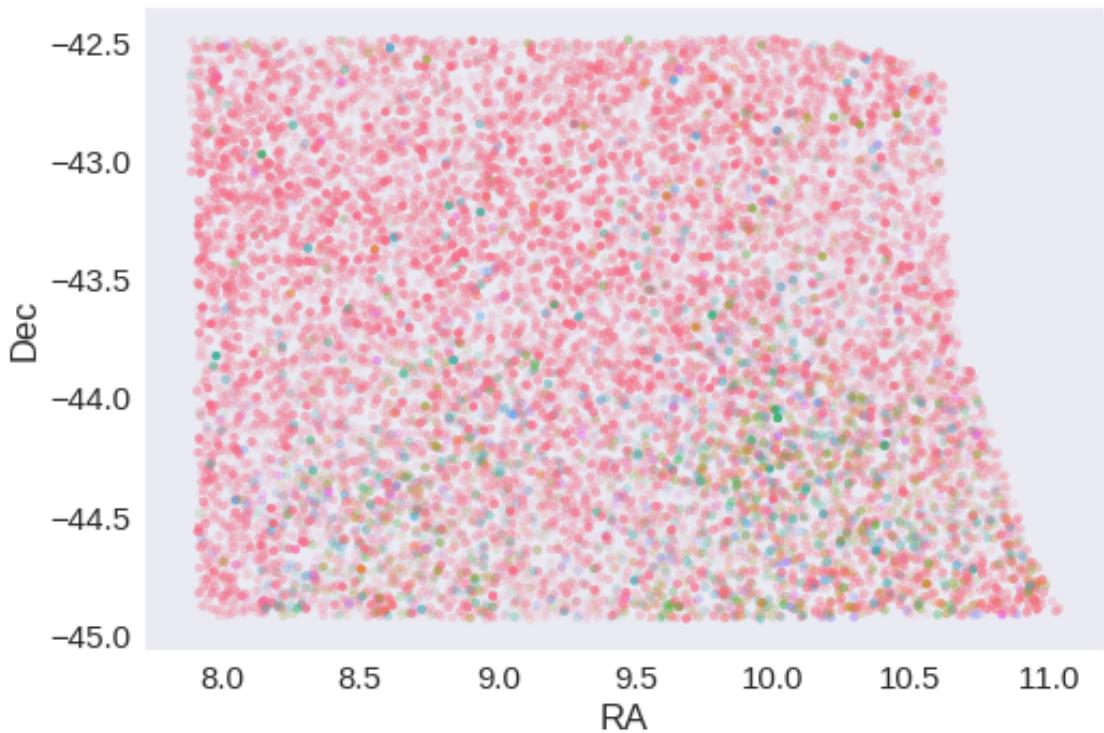




RA correction: 0.3032766990468616 arcsec

Dec correction: -0.18594075015698763 arcsec





## 1.6 IV - Flagging Gaia objects

13627 sources flagged.

## 1.7 V - Flagging objects near bright stars

## 2 VI - Saving to disk

## 1.4\_SWIRE

March 8, 2018

### 1 ELAIS-S1 master catalogue

#### 1.1 Preparation of Spitzer datafusion SWIRE 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 catalogoue, we keep:

We keep: - The internal identifier (this one is only in HeDaM data); - The position; - The fluxes in aperture 2 (1.9 arcsec) for IRAC bands. - The Kron flux; - The stellarity in each band

A query of the position in the Spitzer heritage archive show that the ELAIS-N1 images were observed in 2004. Let's take this as epoch.

We do not use the MIPS fluxes as they will be extracted on MIPS maps using XID+.

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

#### 1.2 I - Column selection

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: divide by zero encountered in log
  magnitudes = 2.5 * (23 - np.log10(fluxes)) - 48.6
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:80: RuntimeWarning: divide by zero encountered in log
  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:100: UserWarning: Check the NumPy 1.11 release notes for more information.
  ma.MaskedArray.__setitem__(self, index, value)
```

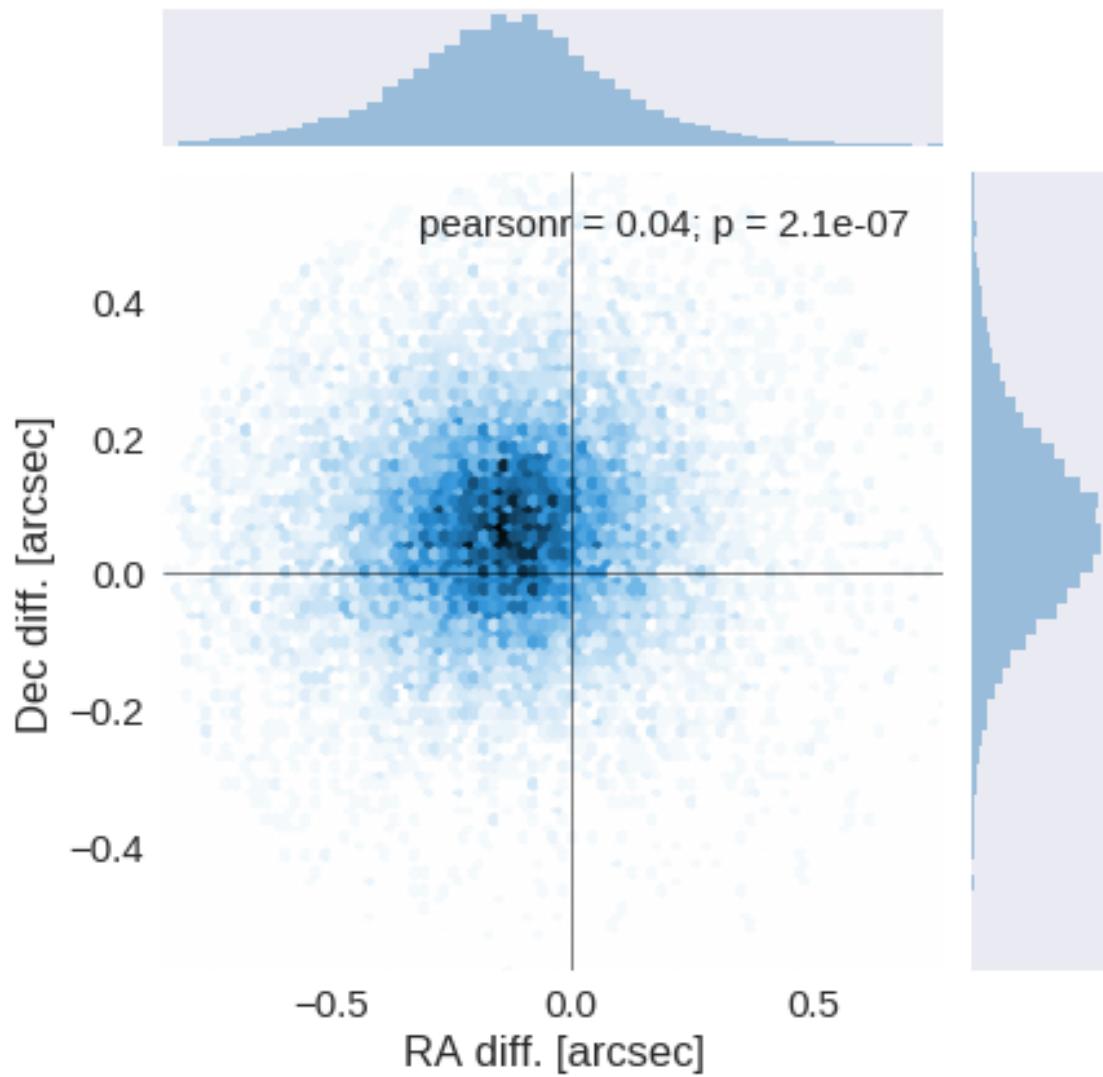
The initial catalogue had 368900 sources.

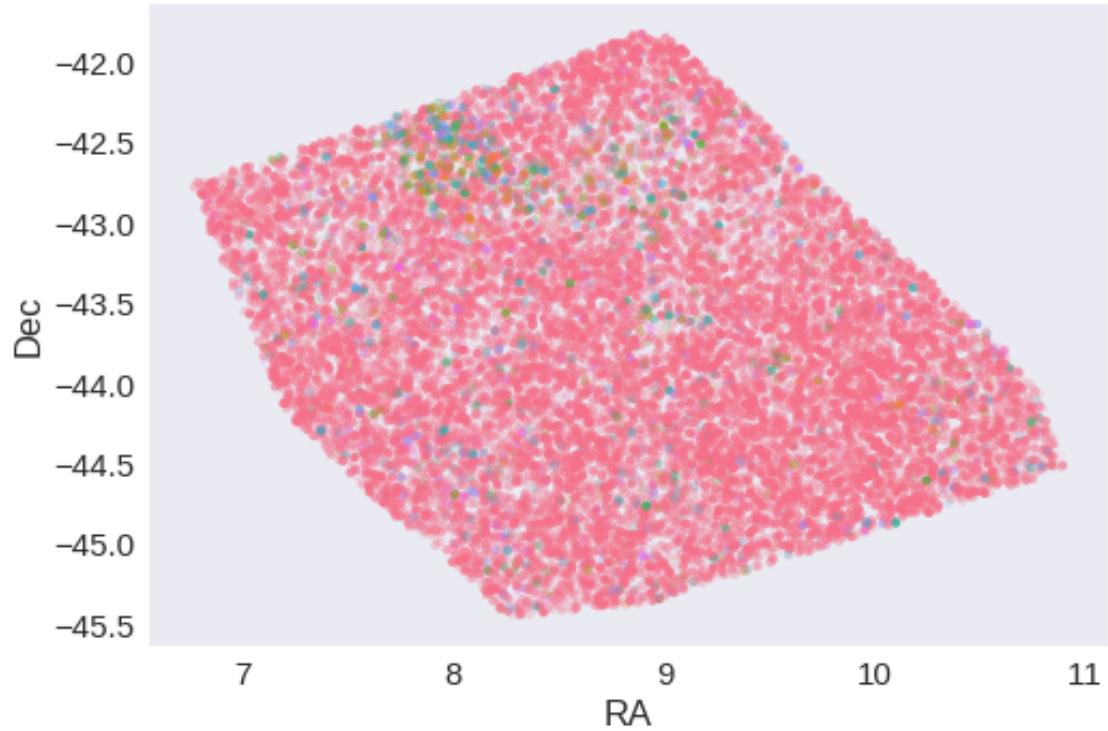
The cleaned catalogue has 368884 sources (16 removed).

The cleaned catalogue has 16 sources flagged as having been cleaned

## 1.4 III - Astrometry correction

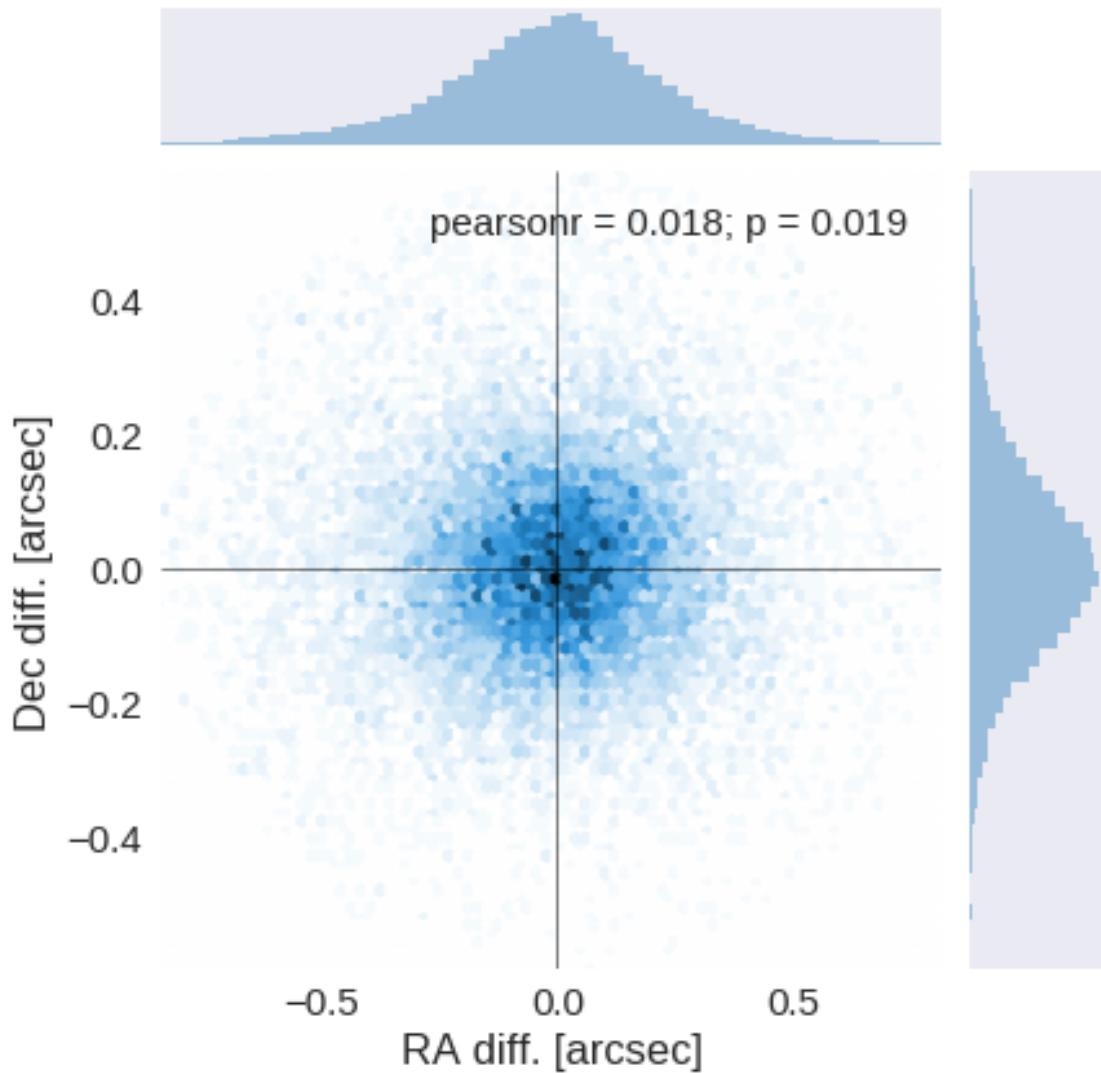
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.

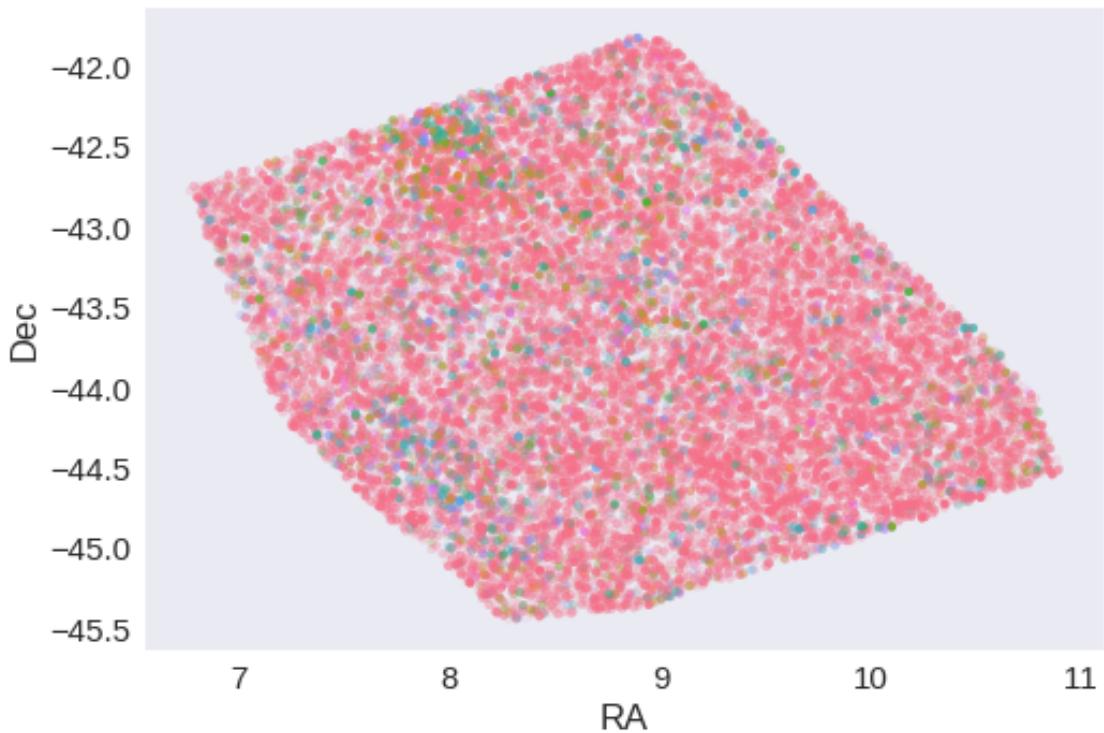




RA correction: 0.13695796841588503 arcsec

Dec correction: -0.06500249892269494 arcsec





## 1.5 IV - Flagging Gaia objects

17650 sources flagged.

## 1.6 V - Flagging objects near bright stars

## 2 VI - Saving to disk

# 1.5\_SERVS

March 8, 2018

## 1 ELAIS-S1 master catalogue

### 1.1 Preparation of Spitzer datafusion SERVS 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 catalog, 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:  
44f1ae0 (Thu Nov 30 18:27:54 2017 +0000)

### 1.2 I - Column selection

```
/opt/herschelhelp_internal/herschelhelp_internal/utils.py:76: RuntimeWarning: invalid value encountered in log
  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)
```

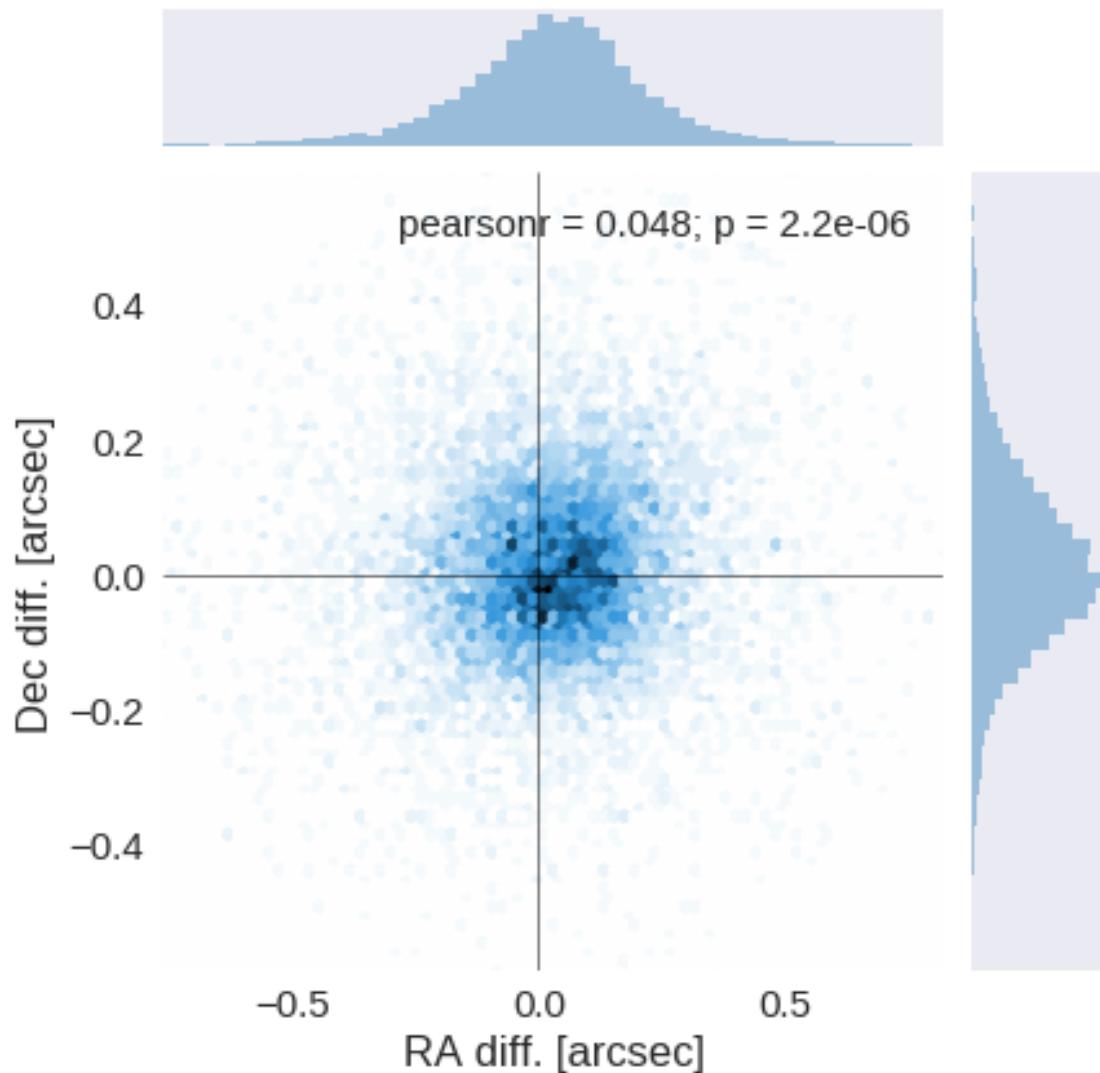
The initial catalogue had 605425 sources.

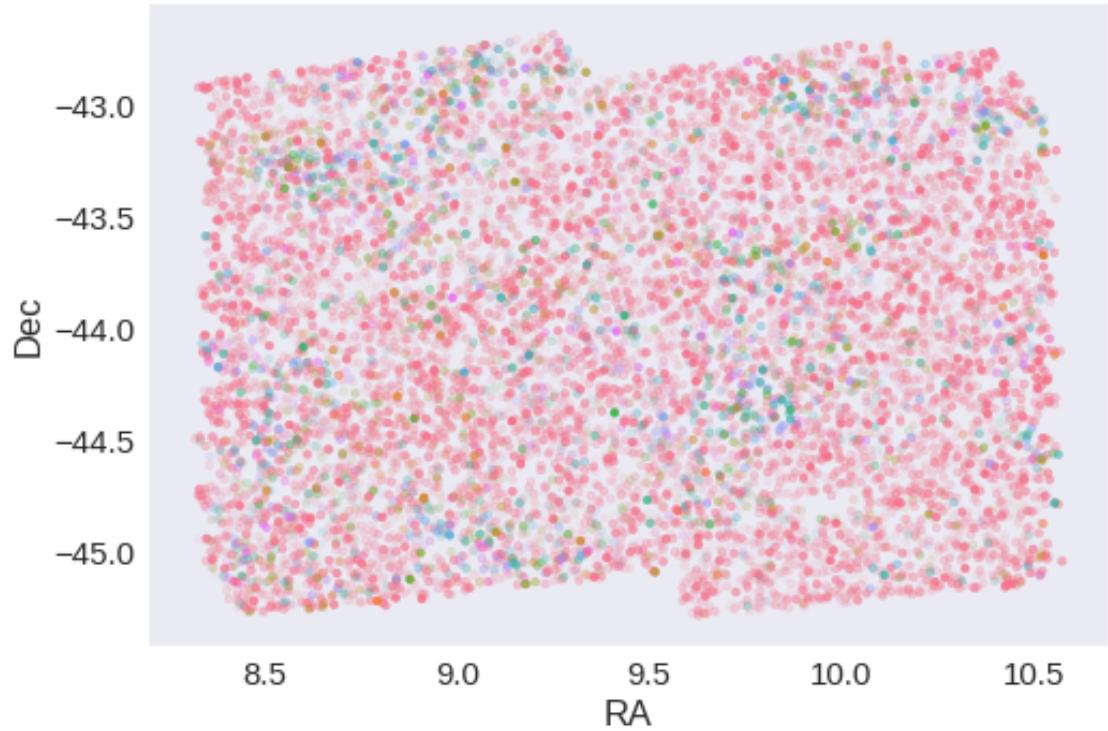
The cleaned catalogue has 605425 sources (0 removed).

The cleaned catalogue has 0 sources flagged as having been cleaned

## 1.4 III - Astrometry correction

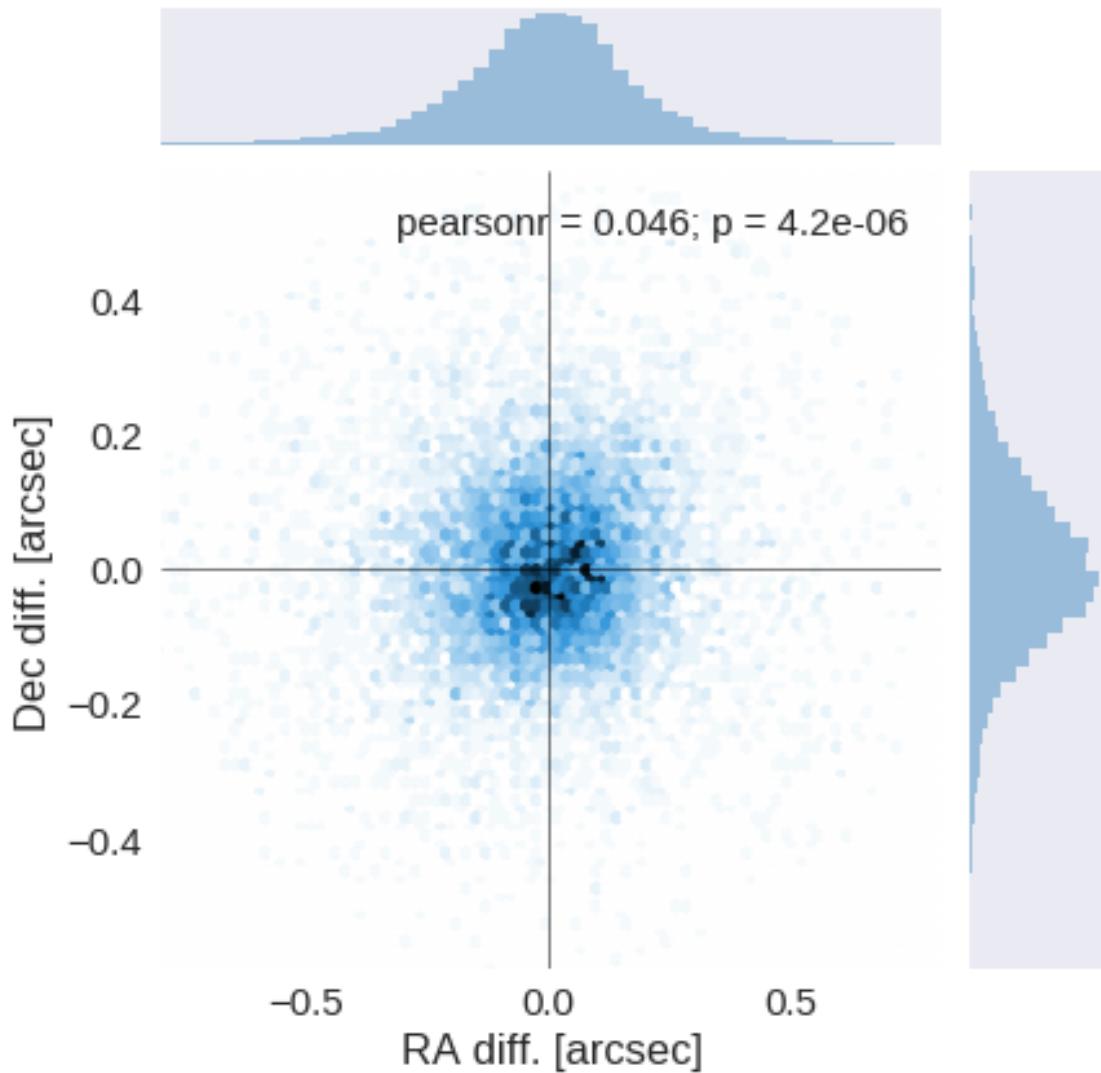
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.

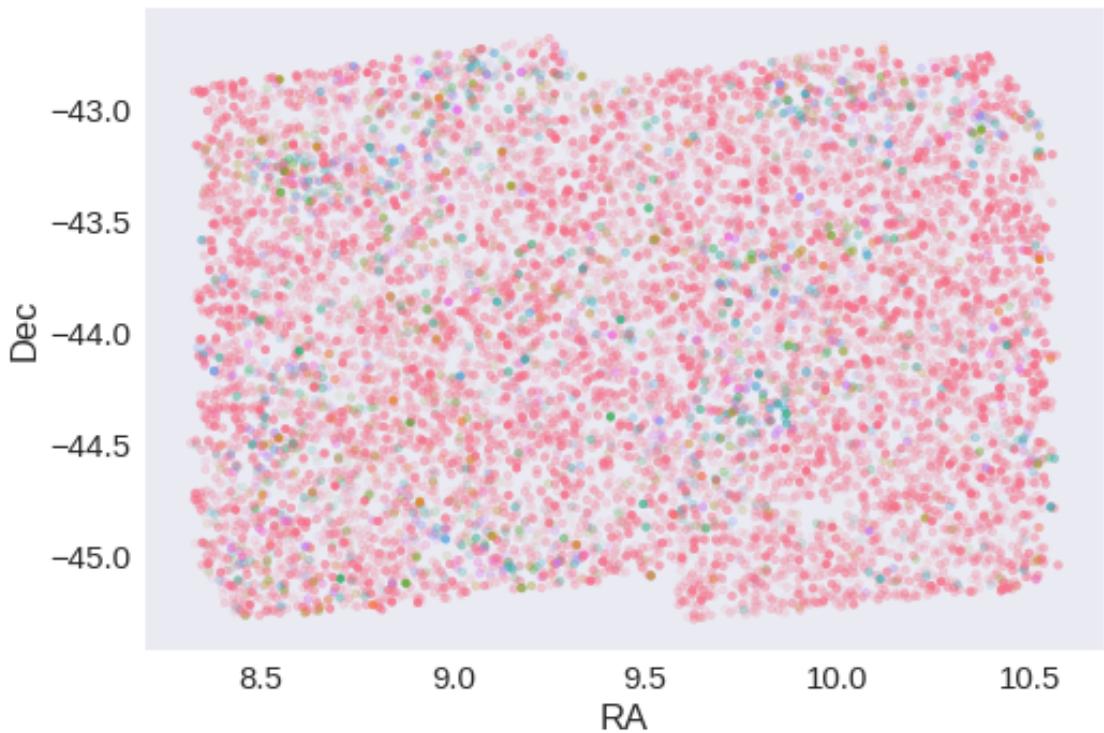




RA correction: -0.0358870084561147 arcsec

Dec correction: -0.00565381727994918 arcsec





## 1.5 IV - Flagging Gaia objects

10348 sources flagged.

## 1.6 V - Flagging objects near bright stars

## 1.7 VI - Saving to disk

# 1.6 DES

March 8, 2018

## 1 ELAIS-S1 master catalogue

### 1.1 Preparation of DES data

Blanco DES catalogue: the catalogue comes from `dmu0_DES`.

In the catalogue, we keep:

- The identifier (it's unique in the catalogue);
- The position;
- The G band stellarity;
- The magnitude for each band.
- The auto/kron magnitudes/fluxes to be used as total magnitude.
- The aperture magnitudes, which are used to compute a corrected 2 arcsec aperture magnitude.

We don't know when the maps have been observed. We will take the final observation date as 2017.

```
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:  
2018-02-21 16:16:42.634105
```

### 1.2 1 - Aperture correction

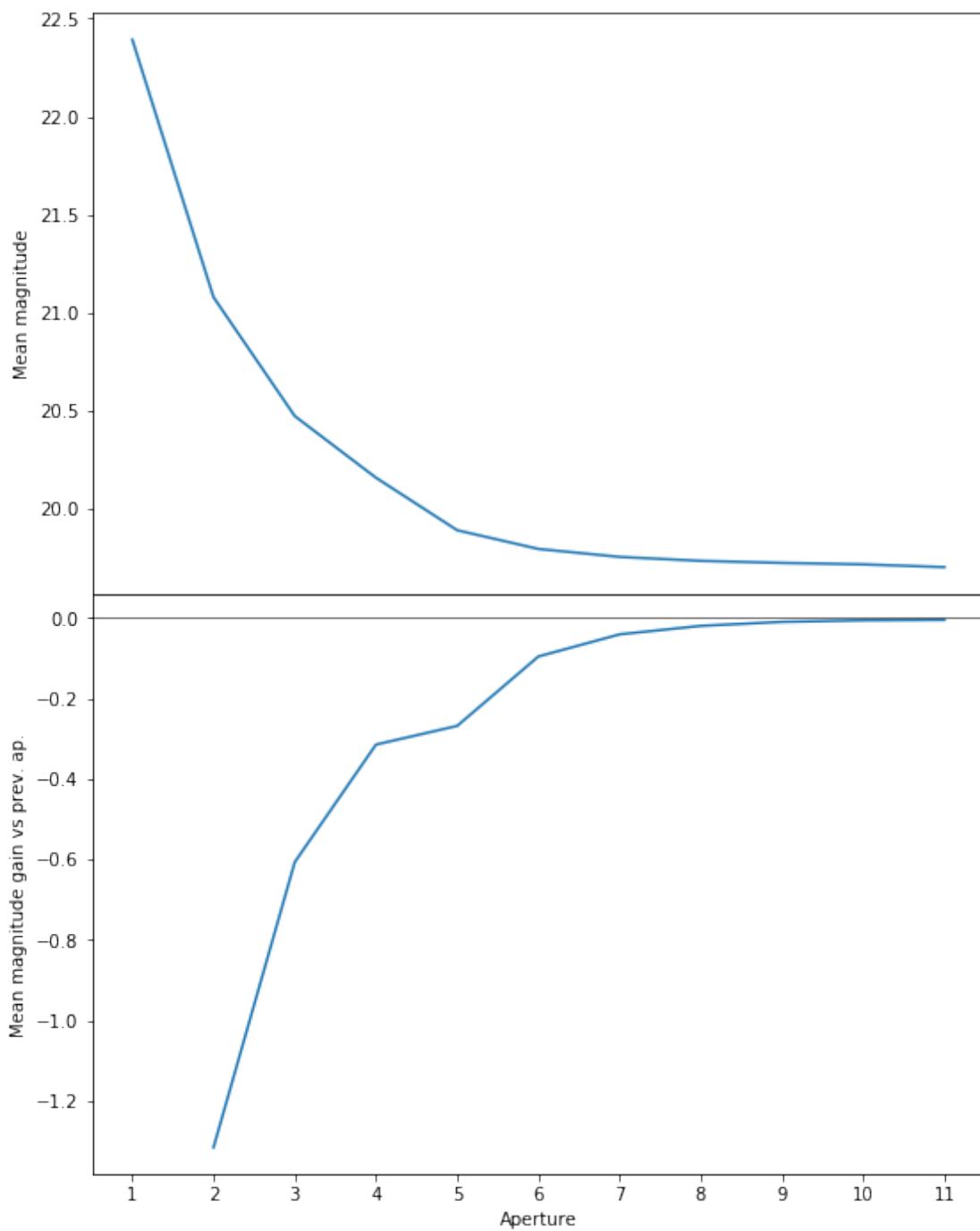
To compute aperture correction we need to determine two parameters: the target aperture and the range of magnitudes for the stars that will be used to compute the correction.

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

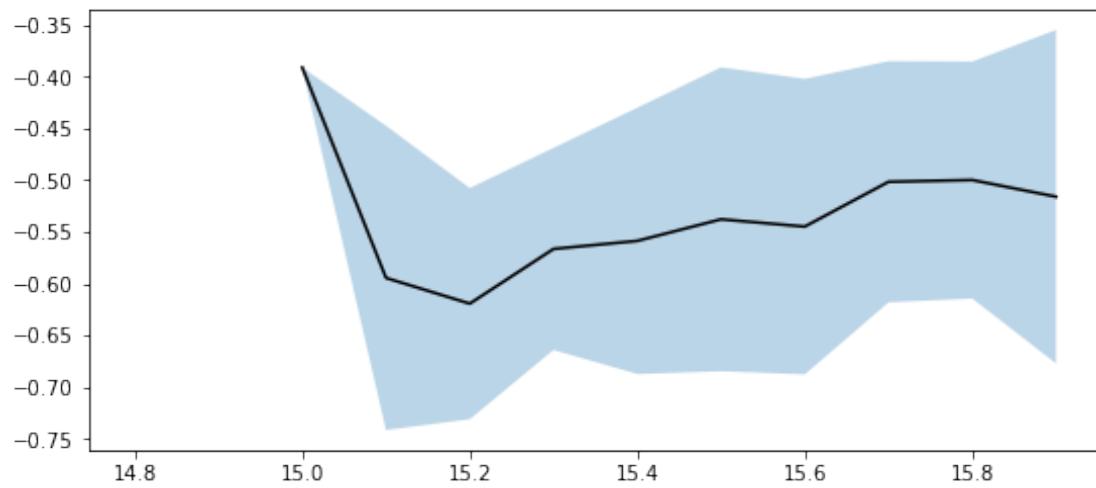
The evolution of the magnitudes of the objects by plotting on the same plot aperture number vs the mean magnitude. The mean gain (loss when negative) of magnitude is each aperture compared to the previous (except for the first of course). As target aperture, we should use the smallest (i.e. less noisy) aperture for which most of the flux is captured.

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.

### 1.2.1 I.a - g band



We will use aperture 10 as target.



We will use magnitudes between 15.0 and 16.0

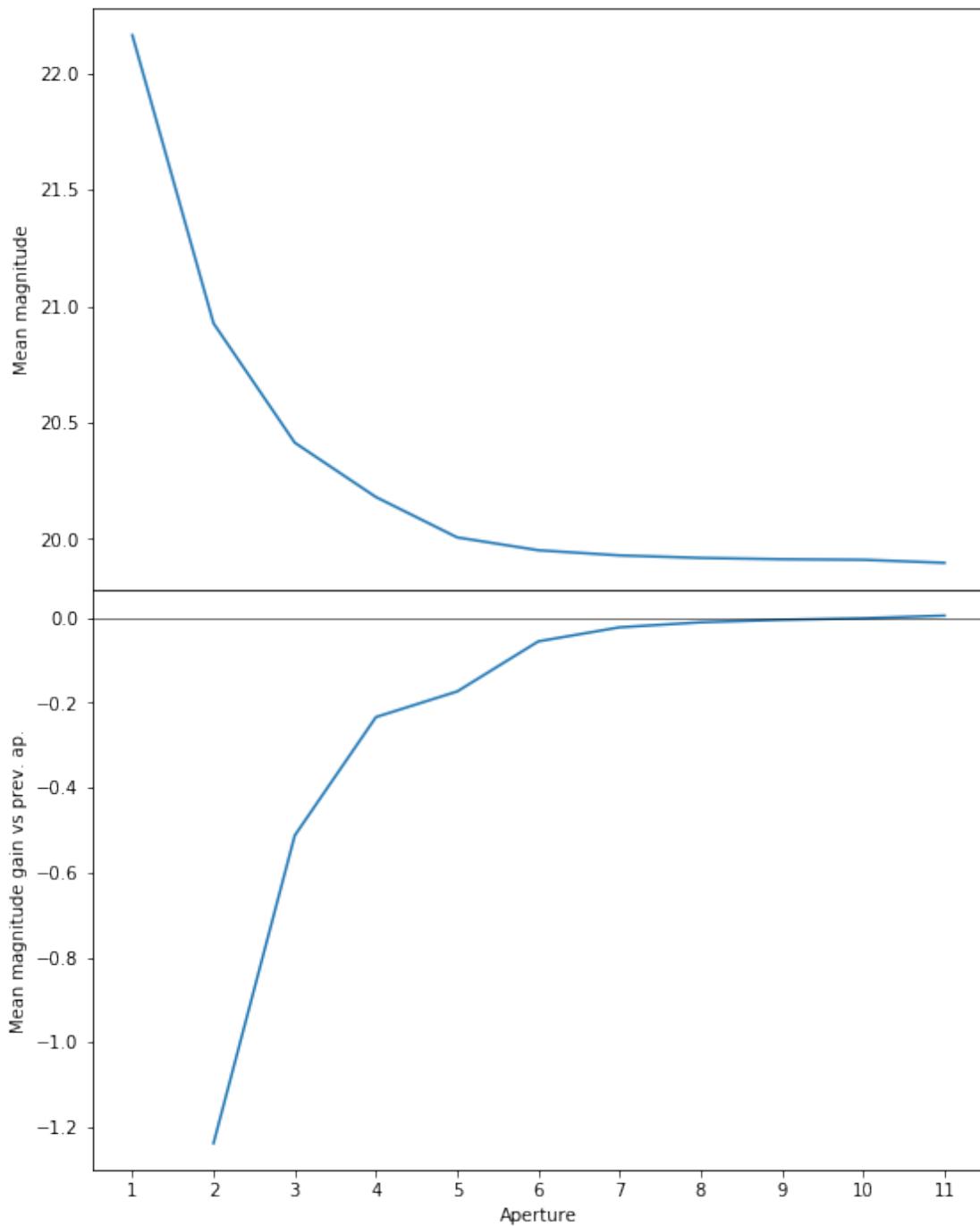
Aperture correction for g band:

Correction: -0.525202751159668

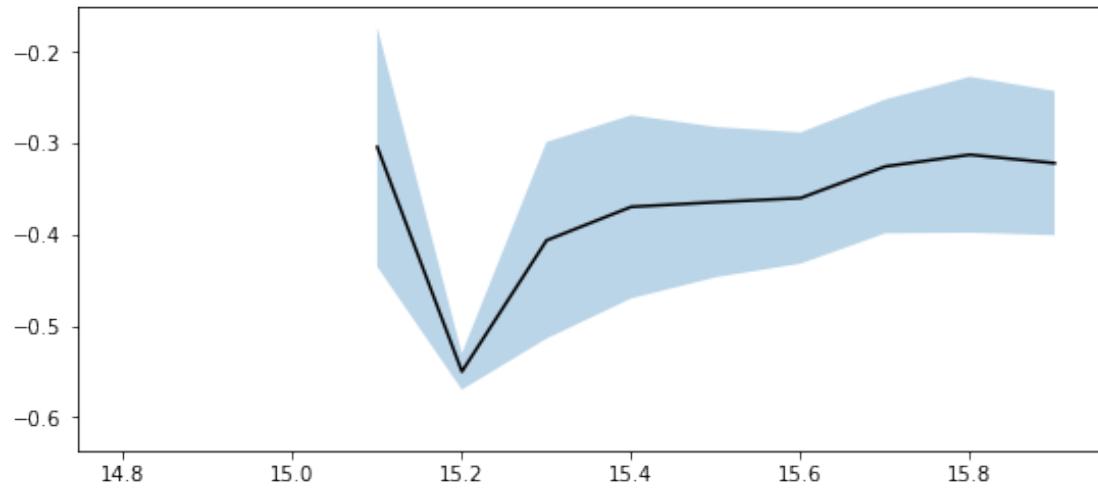
Number of source used: 620

RMS: 0.13607589224056446

### 1.2.2 I.b - r band



We will use aperture 10 as target.



We use magnitudes between 15.0 and 16.0.

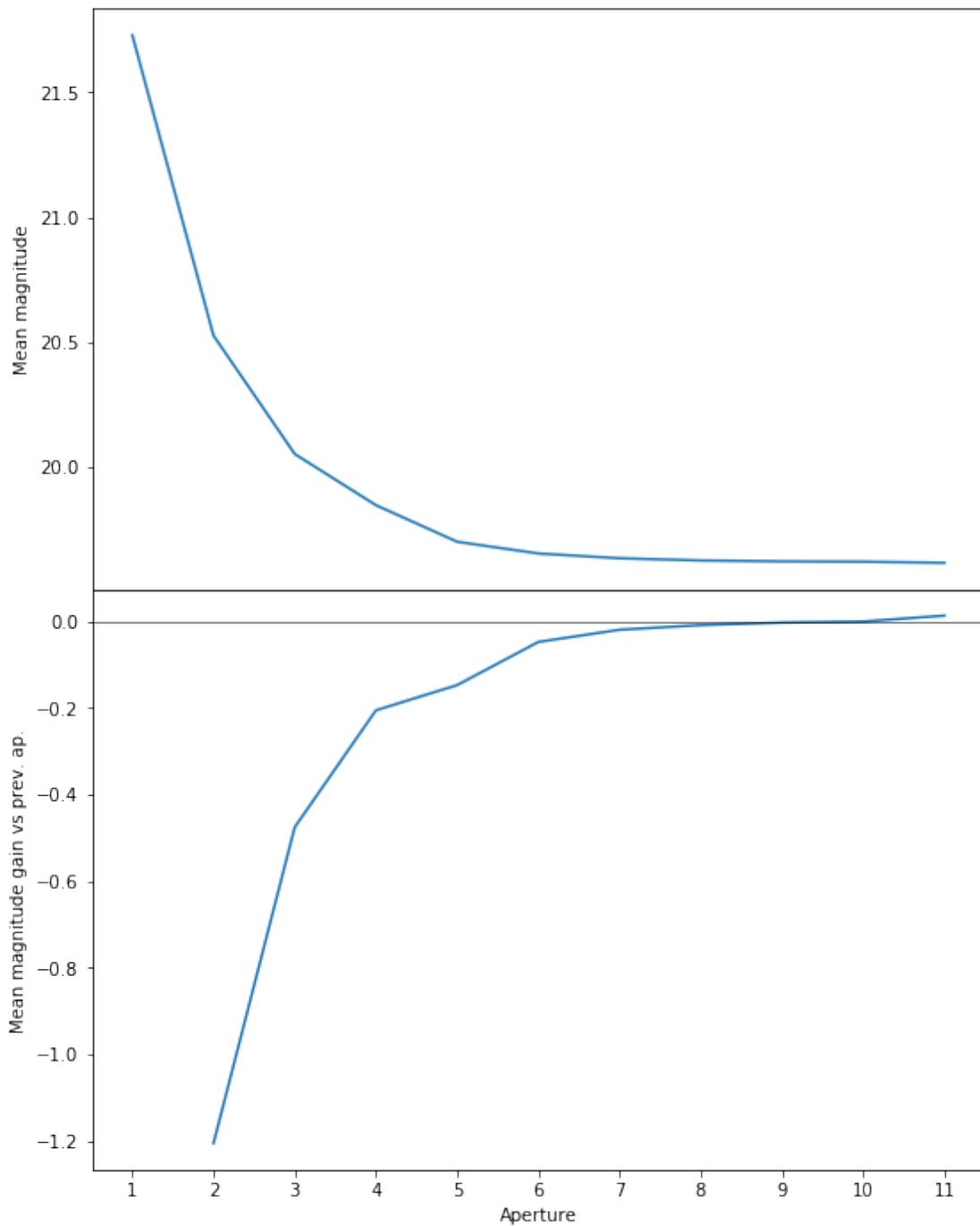
Aperture correction for r band:

Correction: -0.32874298095703125

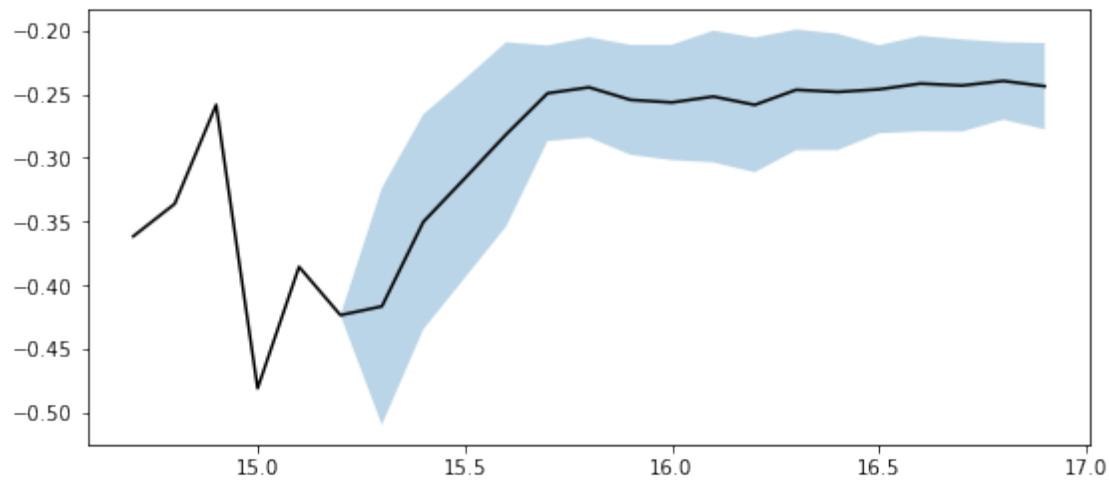
Number of source used: 384

RMS: 0.08128685867476818

### 1.2.3 I.b - i band



We will use aperture 10 as target.



We use magnitudes between 15.0 and 16.0.

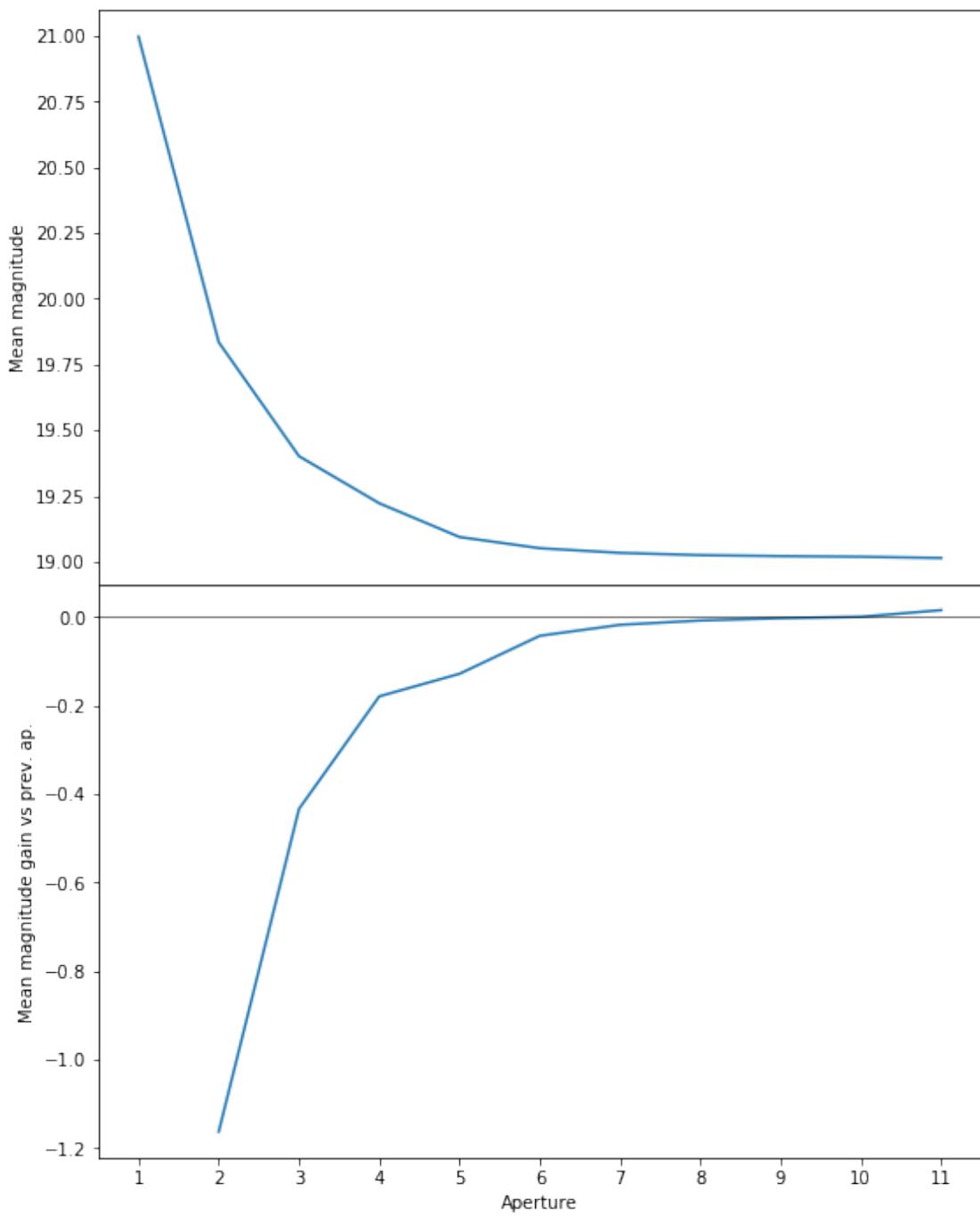
Aperture correction for i band:

Correction: -0.2553844451904297

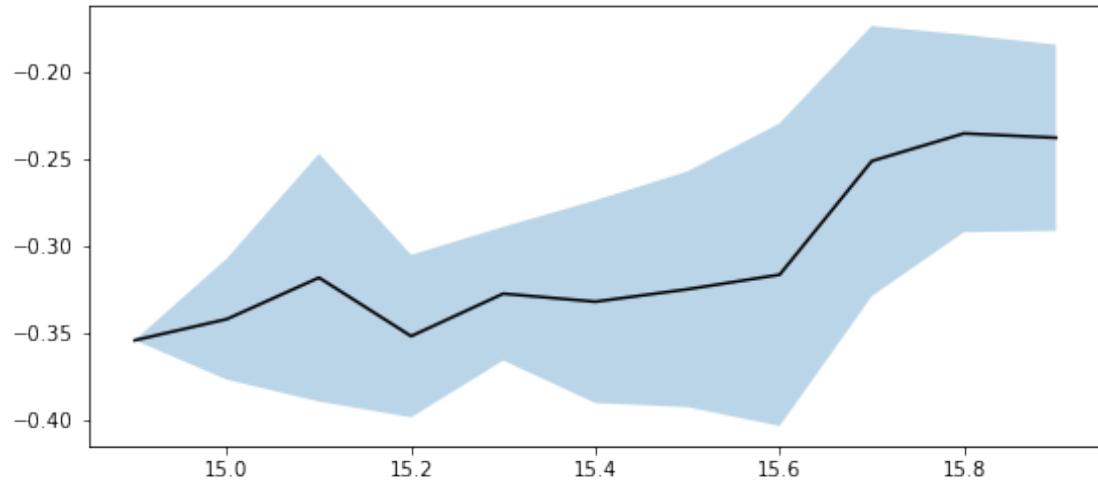
Number of source used: 282

RMS: 0.04623693846377647

#### 1.2.4 I.b - z band



We will use aperture 57 as target.



We use magnitudes between 15.0 and 16.0.

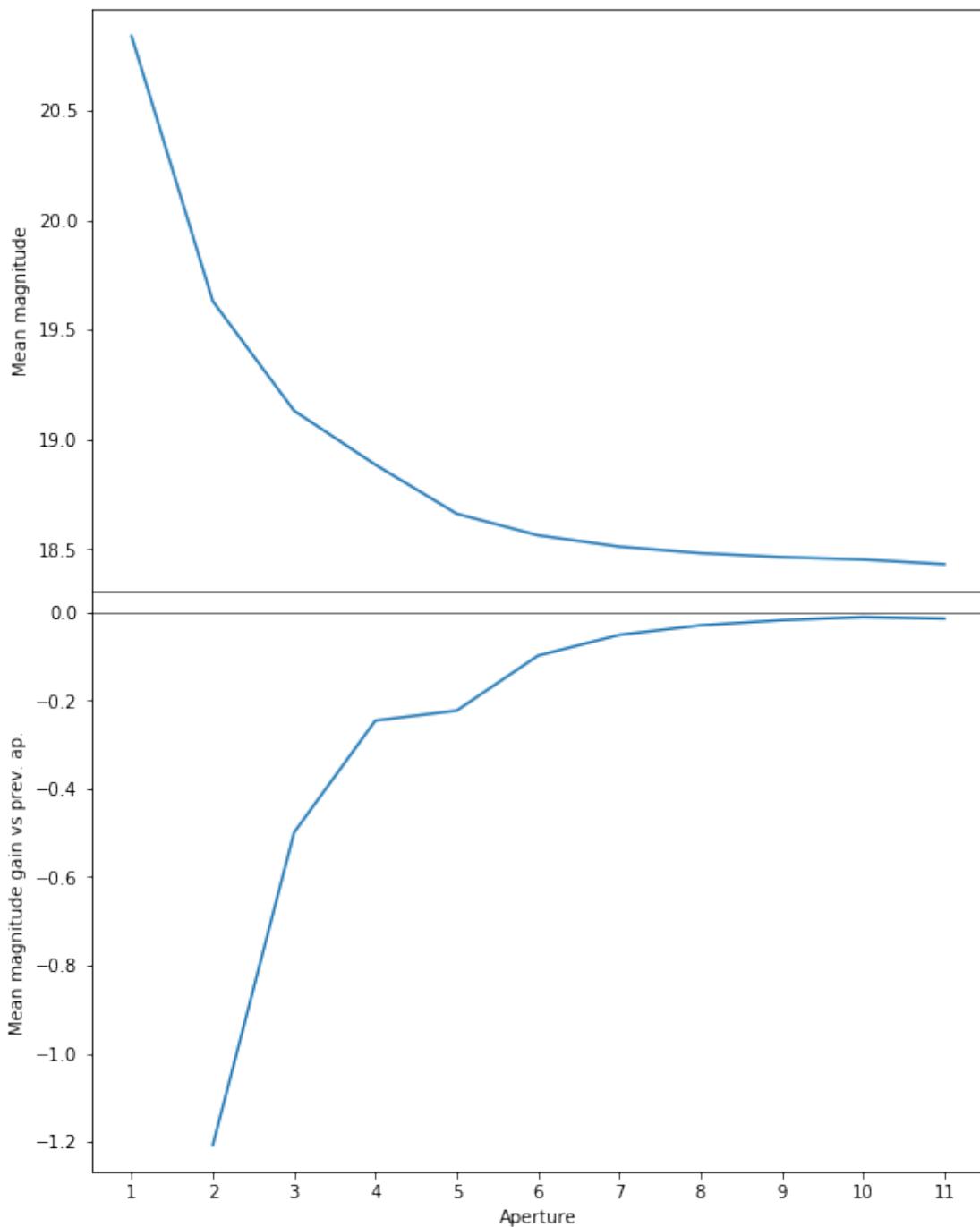
Aperture correction for z band:

Correction: -0.25116443634033203

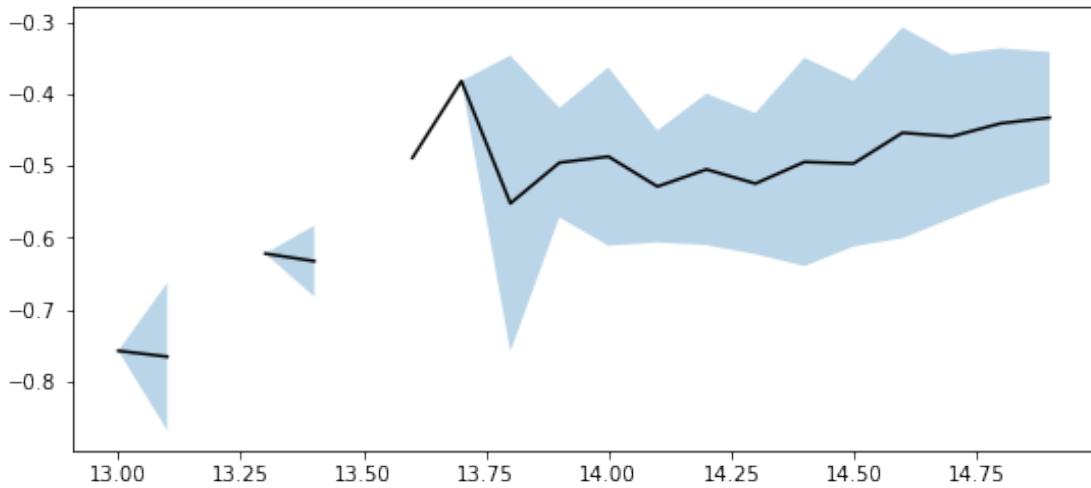
Number of source used: 526

RMS: 0.06914383864772361

### 1.2.5 I.b - y band



We will use aperture 10 as target.



We use magnitudes between 15.0 and 16.0.

Aperture correction for y band:

Correction: -0.4382658004760742

Number of source used: 438

RMS: 0.07197219185453677

### 1.3 2 - 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 [24]:** <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)
```

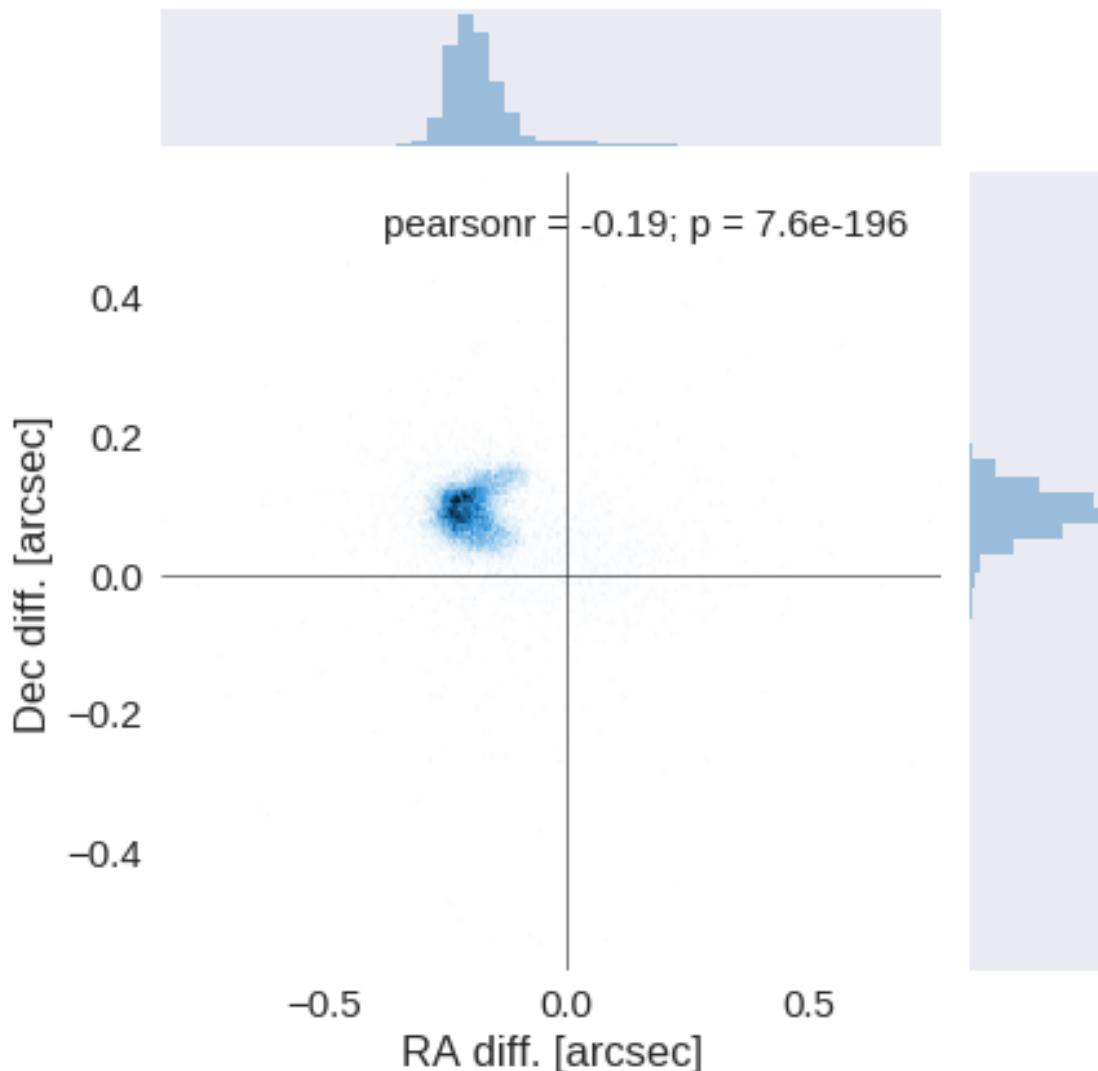
The initial catalogue had 600224 sources.

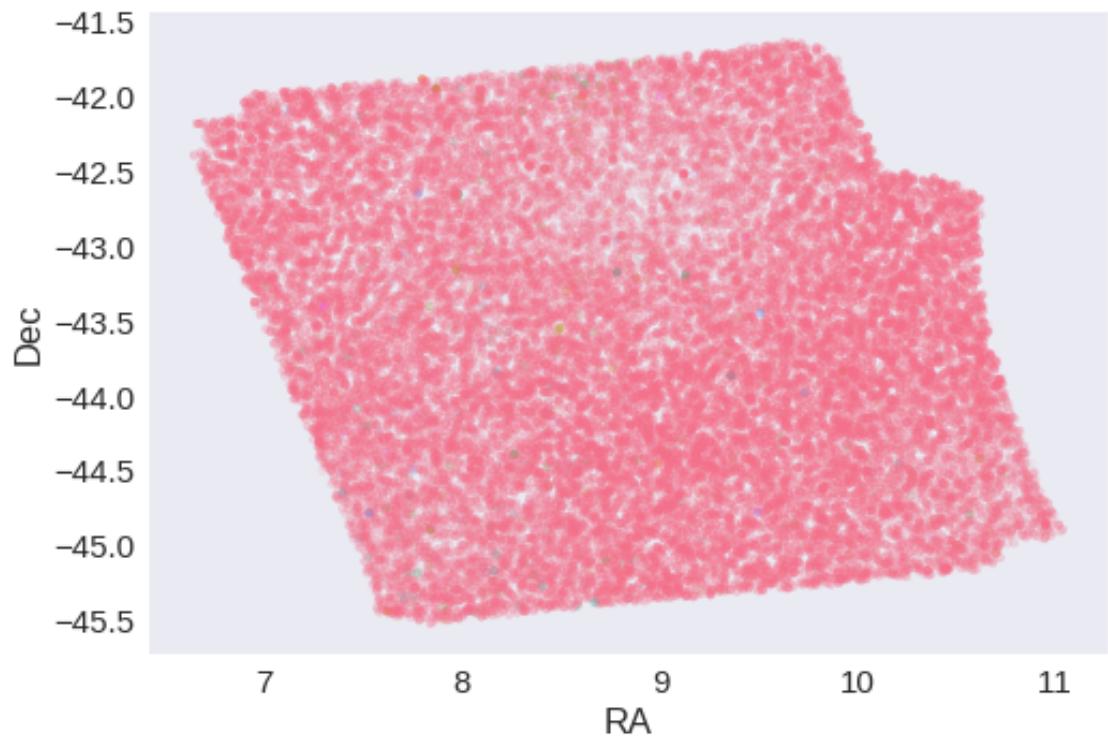
The cleaned catalogue has 600219 sources (5 removed).

The cleaned catalogue has 5 sources flagged as having been cleaned

## 1.5 III - Astrometry correction

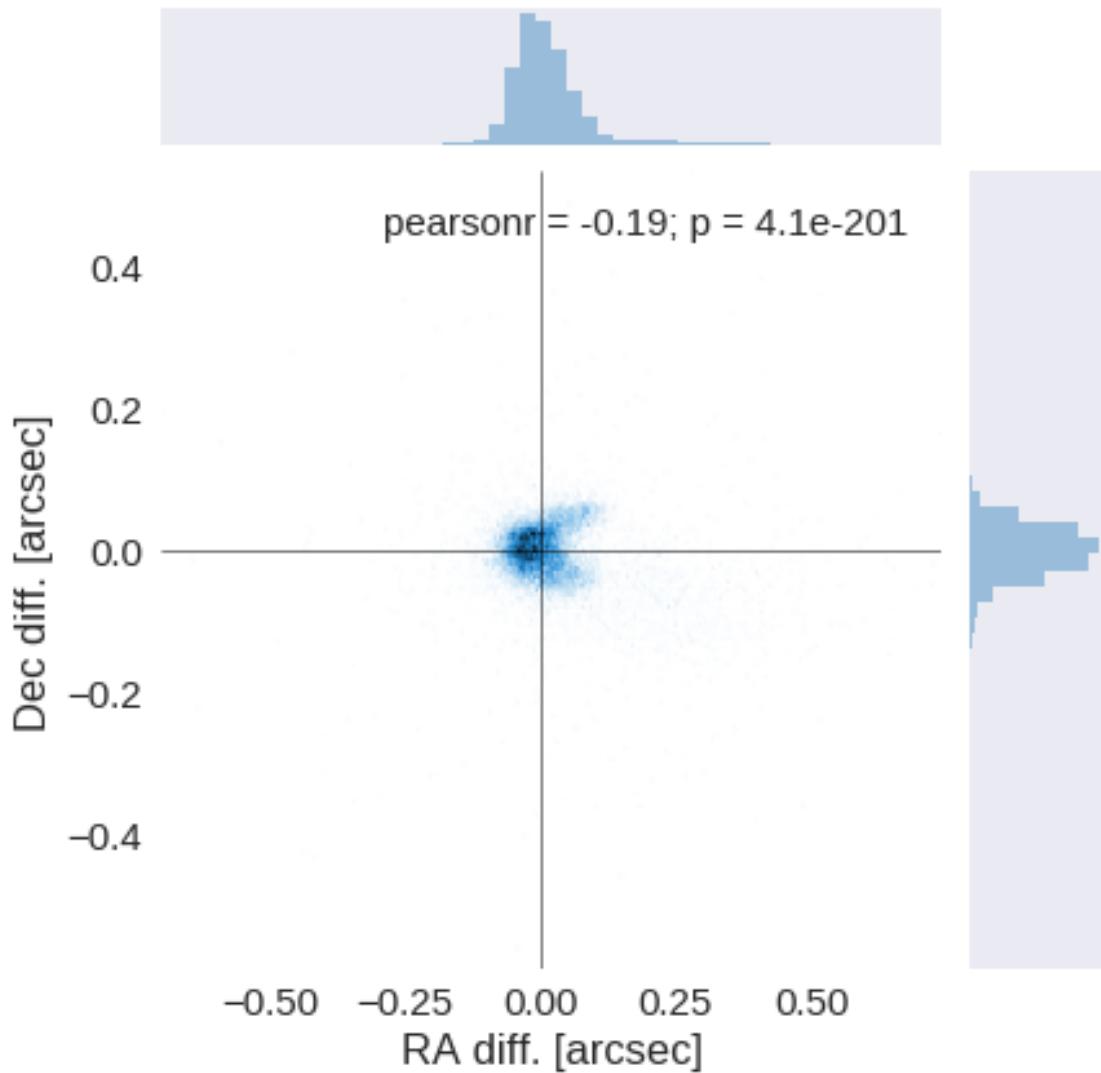
We match the astrometry to the Gaia one. We limit the Gaia catalogue to sources with a g band flux between the 30th and the 70th percentile. Some quick tests show that this give the lower dispersion in the results.

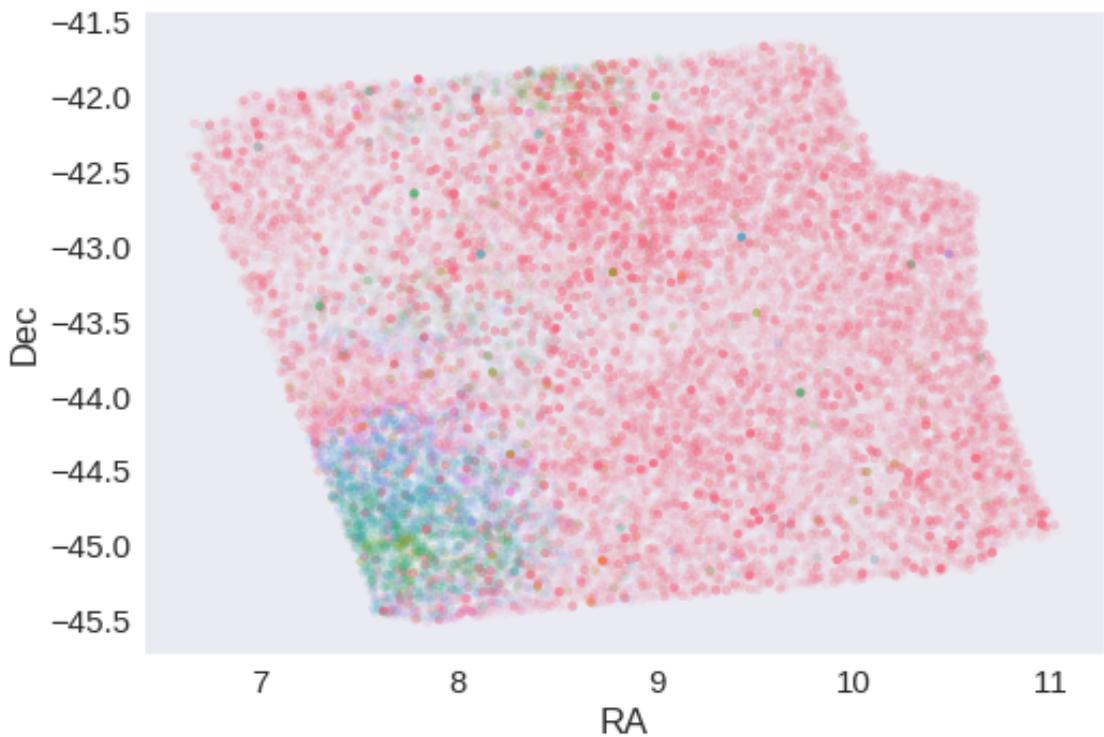




RA correction: 0.1966126211662811 arcsec

Dec correction: -0.09022019166309292 arcsec





## 1.6 IV - Flagging Gaia objects

24303 sources flagged.

## 1.7 V - Flagging objects near bright stars

## 2 VI - Saving to disk

# 2\_Merging

March 8, 2018

## 1 ELAIS-S1 master catalogue

This notebook presents the merge of the various pristine catalogues to produce HELP master catalogue on ELAIS-S1.

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

### 1.1 I - Reading the prepared pristine catalogues

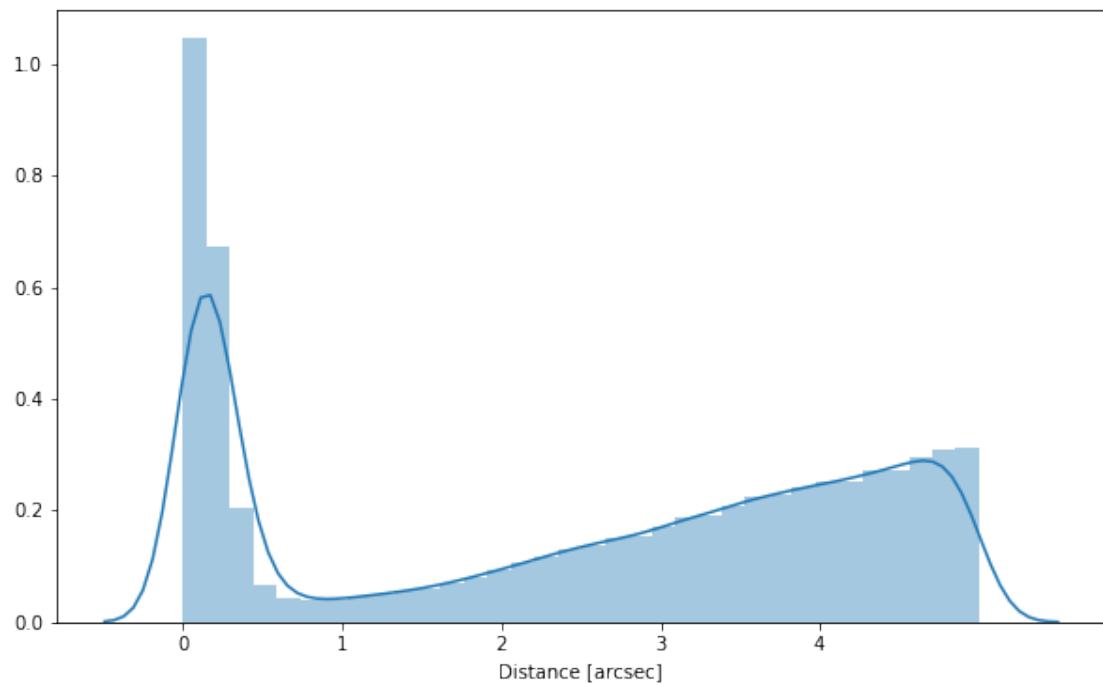
### 1.2 II - Merging tables

We merge in order of increasing wavelength: VIDEO, VHS, VOICE, SERVS, SWIRE.

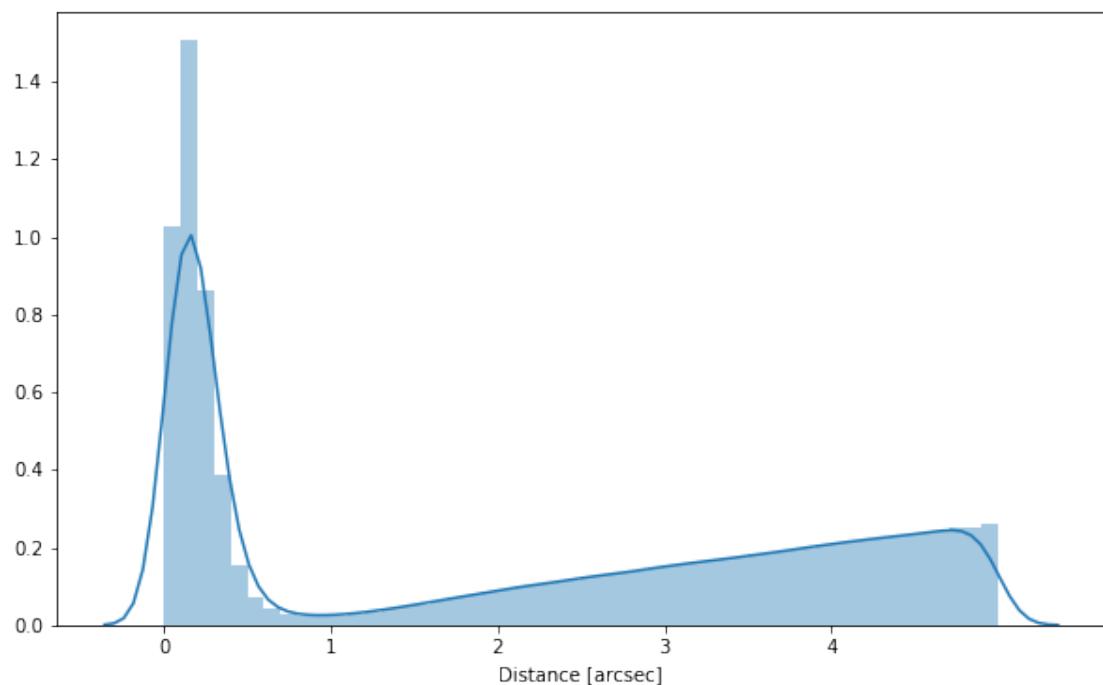
At every step, we look at the distribution of the distances to the nearest source in the merged catalogue to determine the best crossmatching radius.

### **1.2.1 VIDEO**

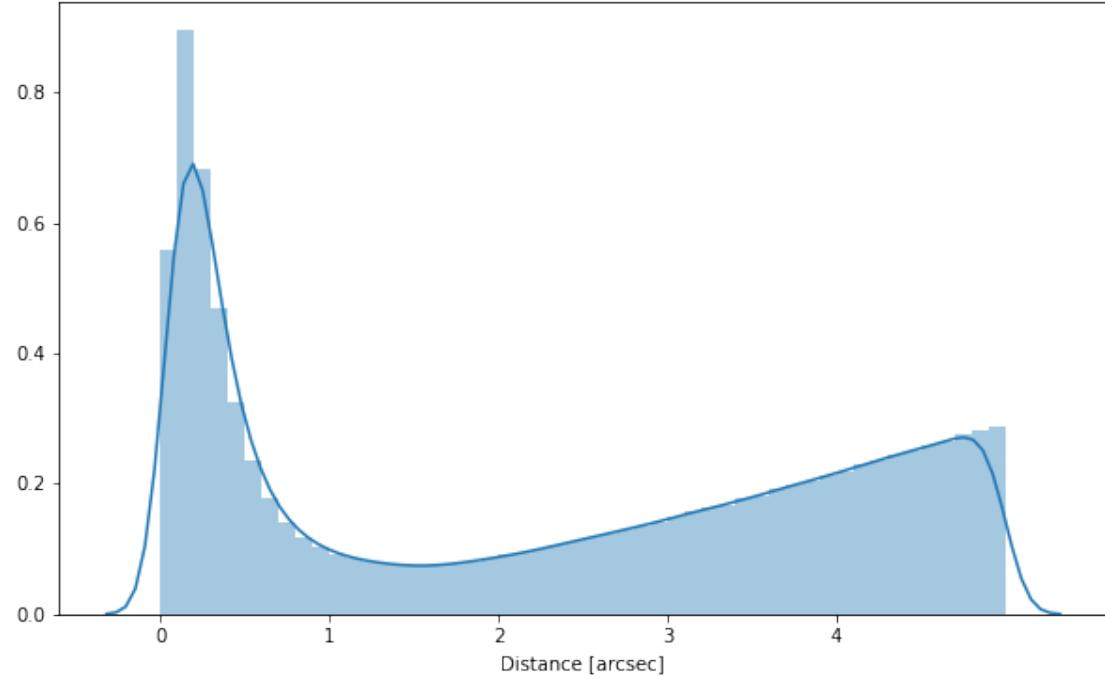
### **1.2.2 Add VHS**



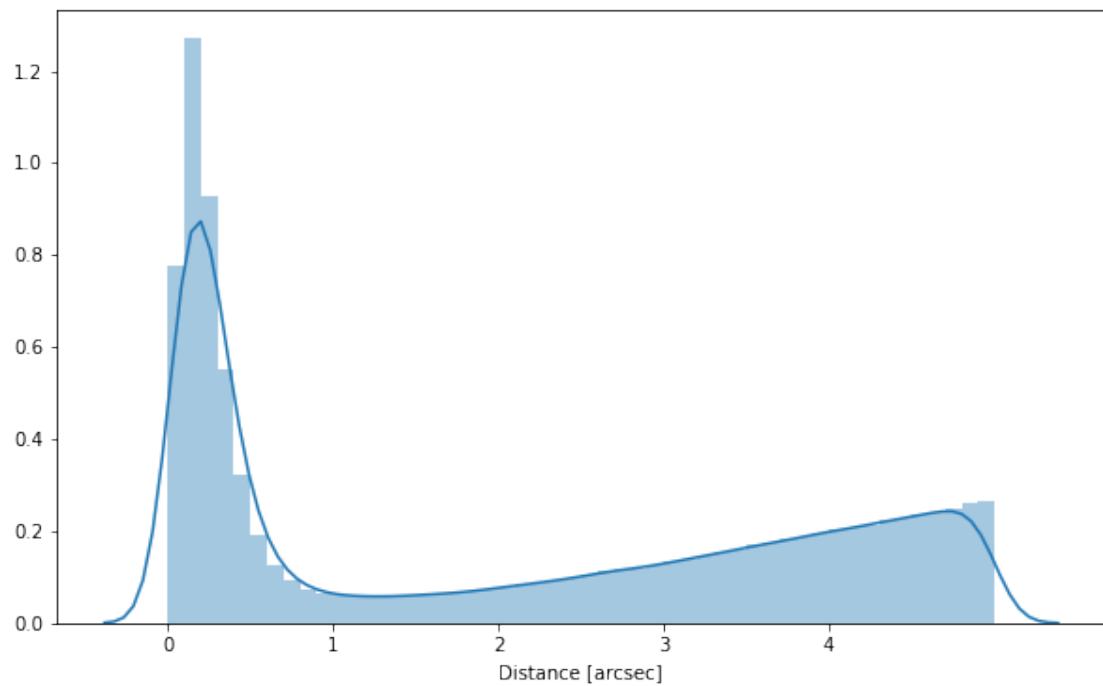
### **1.2.3 Add ESIS VOICE**



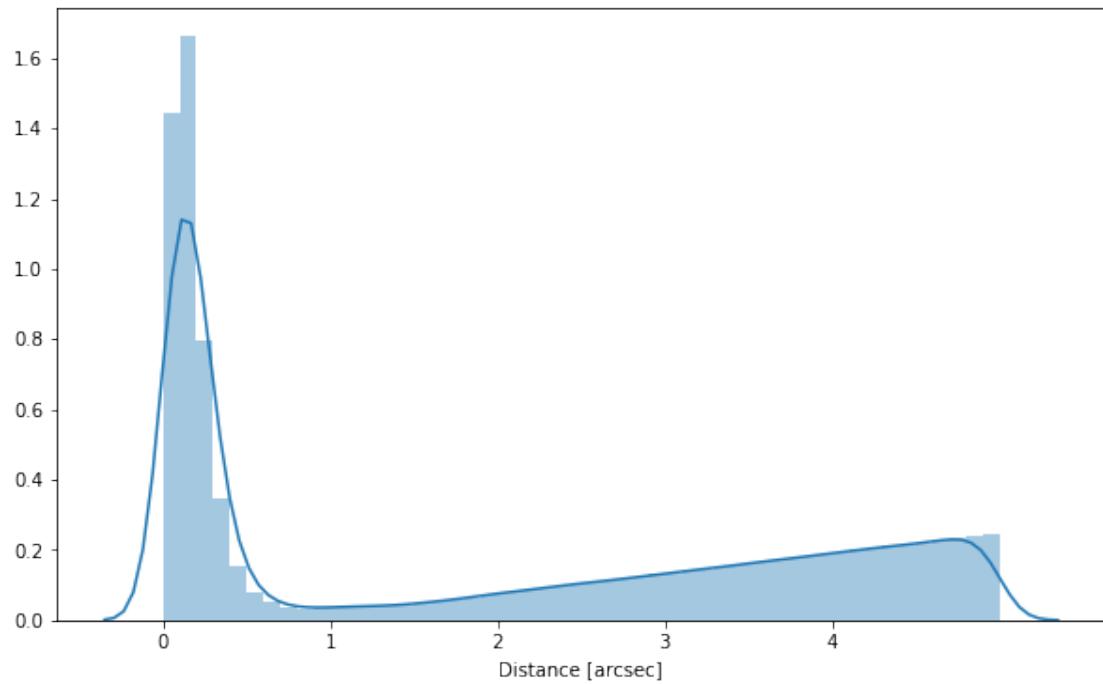
#### 1.2.4 Add SERVS



### 1.2.5 Add SWIRE



### 1.2.6 Add DES



### 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 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 pristine 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.

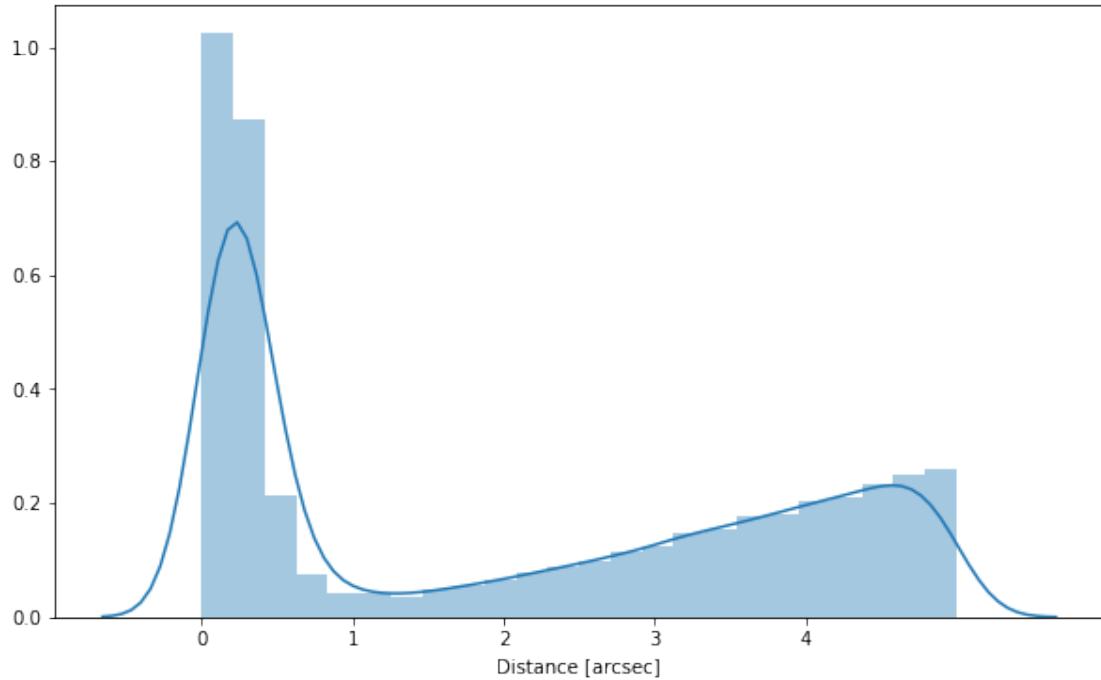
video\_stellarity, vhs\_stellarity, voice\_stellarity, servs\_stellarity\_irac1, servs\_stellarity\_irac2

## 1.4 IV - Adding E(B-V) column

## 1.5 V.a - Adding HELP unique identifiers and field columns

OK!

## 1.6 V.b - Adding spec-z



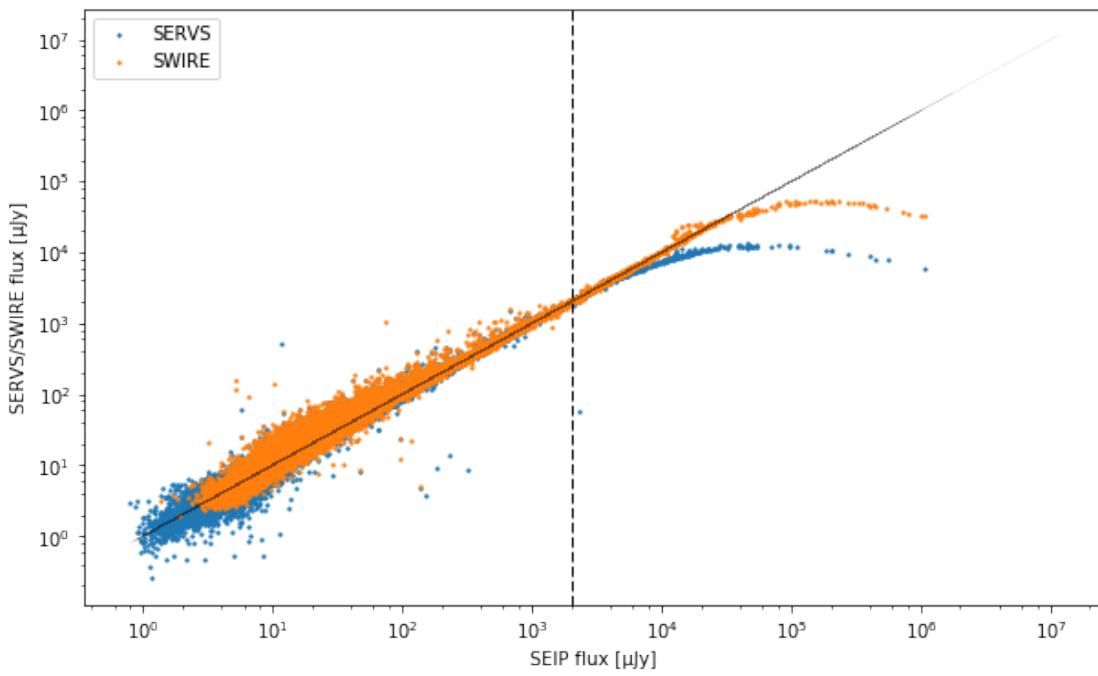
## 1.7 VI - Choosing between multiple values for the same filter

### 1.7.1 VI.a SERVS and SWIRE

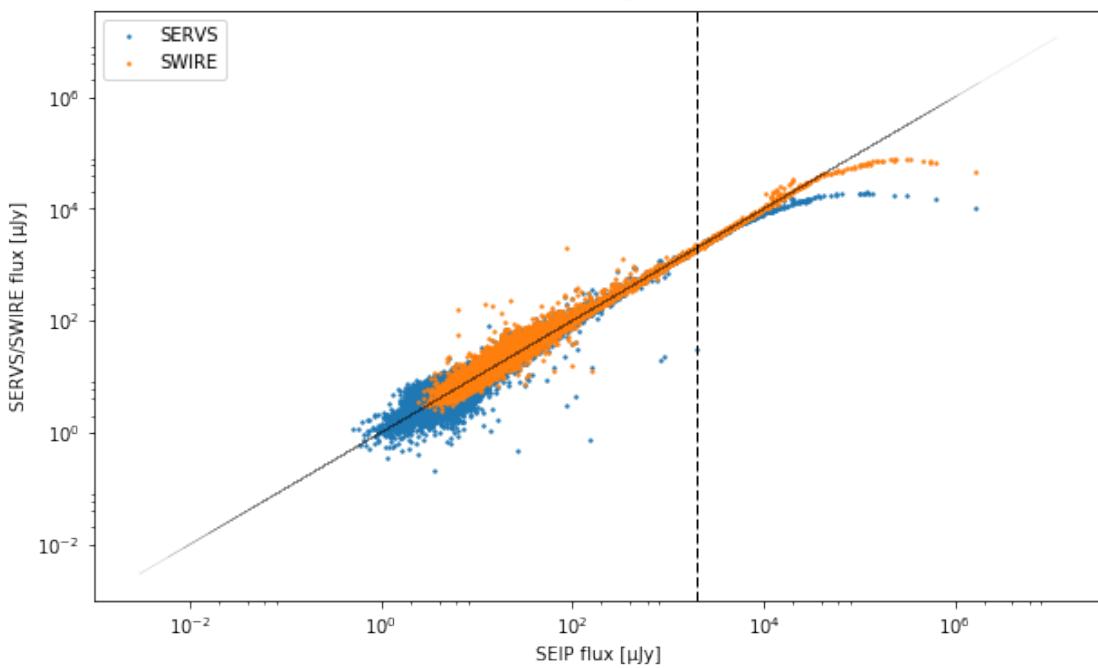
Both SERVS and SWIRE provide IRAC1 and IRAC2 fluxes. SERVS is deeper but tends to underestimate flux of bright sources (Mattia said over 2000 tJy) as illustrated by this comparison of SWIRE, SERVS, and Spitzer-EIP fluxes.

WARNING: UnitsWarning: 'e/count' did not parse as fits unit: At col 0, Unit 'e' not supported by  
WARNING: UnitsWarning: 'image' did not parse as fits unit: At col 0, Unit 'image' not supported

IRAC 1



IRAC 2



When both SWIRE and SERVS fluxes are provided, we use the SERVS flux below 2000 Jy and the SWIRE flux over.

We create a table indicating for each source the origin on the IRAC1 and IRAC2 fluxes that will be saved separately.

```
450197 sources with SERVS flux
345740 sources with SWIRE flux
152731 sources with SERVS and SWIRE flux
449622 sources for which we use SERVS
193584 sources for which we use SWIRE
```

```
450197 sources with SERVS flux
345719 sources with SWIRE flux
152731 sources with SERVS and SWIRE flux
449600 sources for which we use SERVS
193585 sources for which we use SWIRE
```

```
457089 sources with SERVS flux
244560 sources with SWIRE flux
104641 sources with SERVS and SWIRE flux
456721 sources for which we use SERVS
140287 sources for which we use SWIRE
```

```
457089 sources with SERVS flux
244544 sources with SWIRE flux
104639 sources with SERVS and SWIRE flux
456701 sources for which we use SERVS
140293 sources for which we use SWIRE
```

## 1.7.2 VI.b VIDEO and VHS

According to Mattia Vacari VIDEO is deeper than VHS so we take the VIDEO flux if both are available

## 1.7.3 Vista origin overview

For each band show how many objects have fluxes from each survey for both total and aperture photometries.

```
Out[40]: <IPython.core.display.HTML object>
```

## 1.7.4 Column renaming

## 1.8 VII.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 VII.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 VIII - 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.

```
['video_id', 'vhs_id', 'voice_id', 'servs_intid', 'swire_intid', 'des_id', 'help_id', 'specz_id']
```

## 1.11 IX - Adding HEALPix index

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

## 1.12 IX - Saving the catalogue

Missing columns: set()

# 3\_Checks\_and\_diagnostics

March 8, 2018

## 1 ELAIS-S1 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:  
2018-02-21 17:27:07.507336
```

Diagnostics done using: master\_catalogue\_elais-s1\_20180221.fits

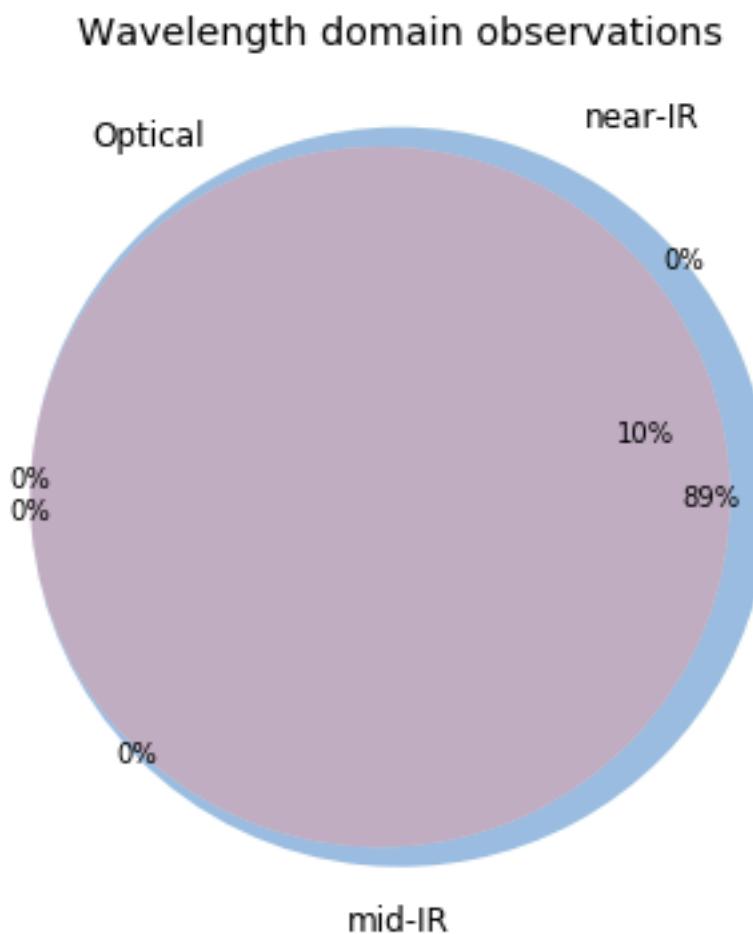
### 1.2 0 - Quick checks

```
/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)
```

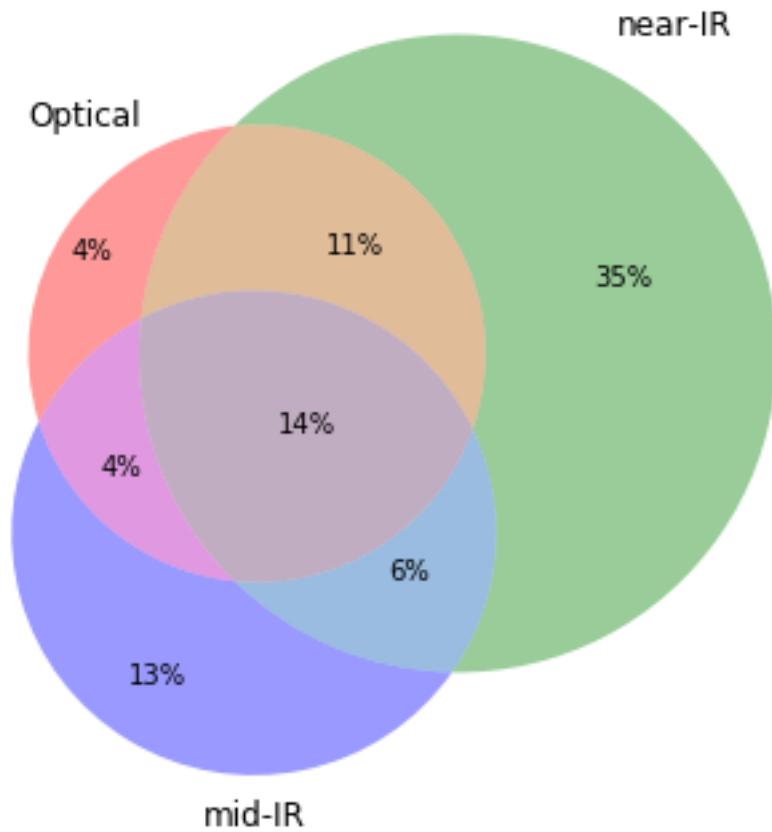
Table shows only problematic columns.

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

### 1.3 I - Summary of wavelength domains



Detection of the 1,239,088 sources detected  
in any wavelength domains (among 1,655,564 sources)

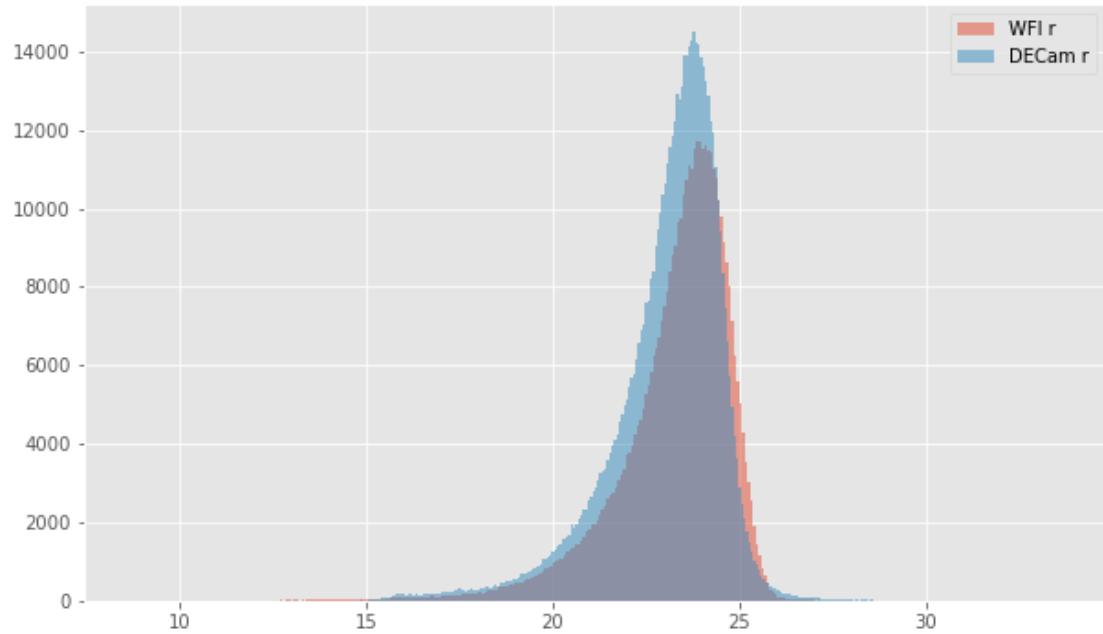
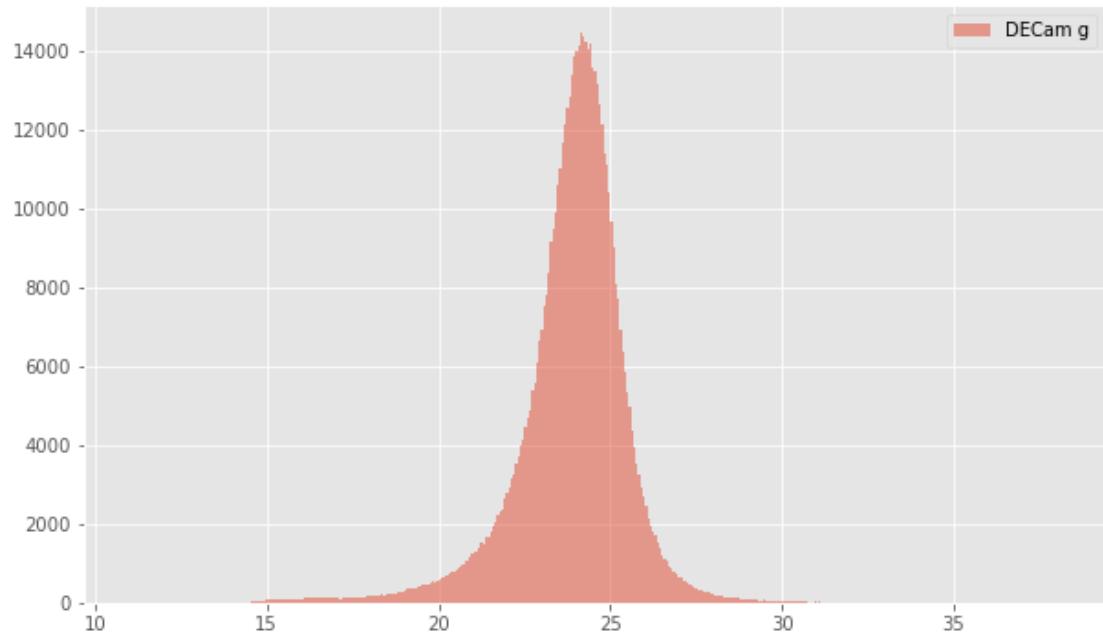


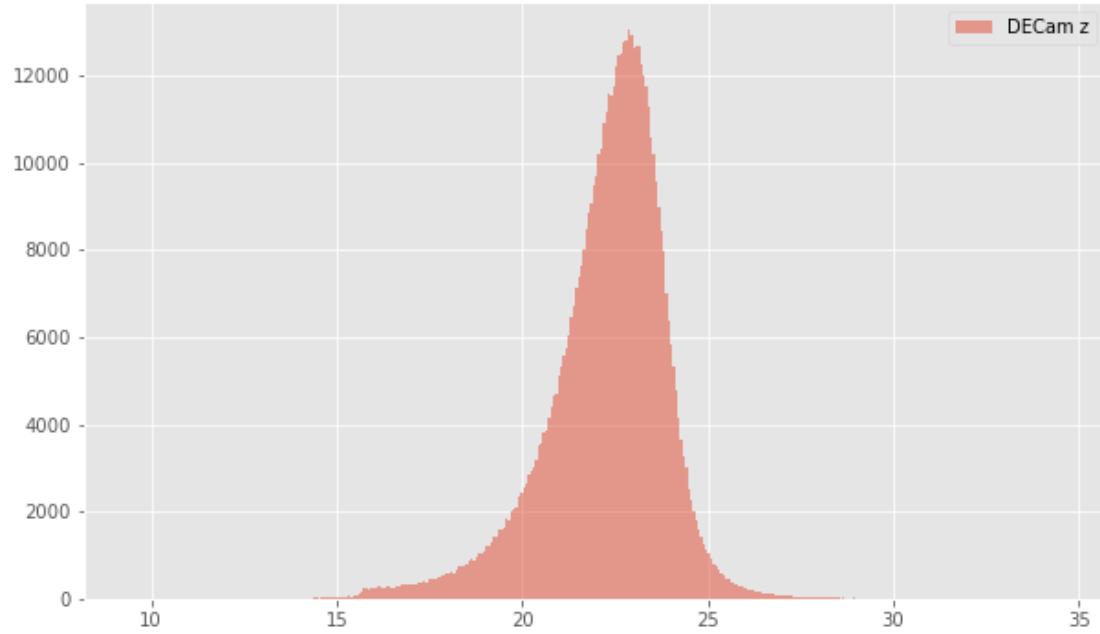
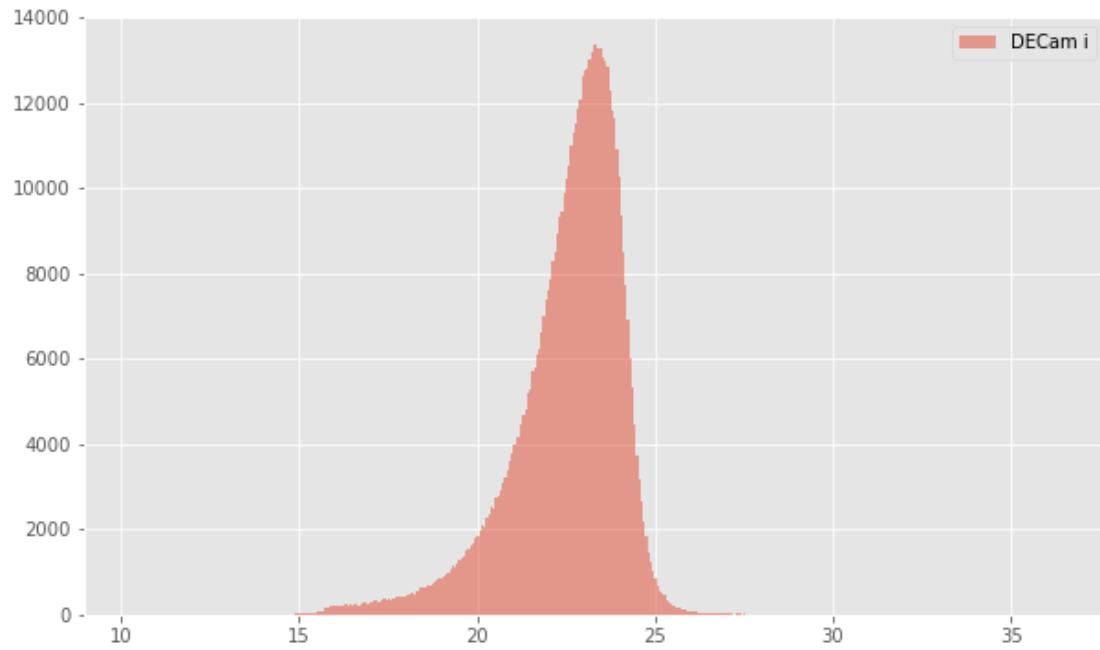
## 1.4 II - Comparing magnitudes in similar filters

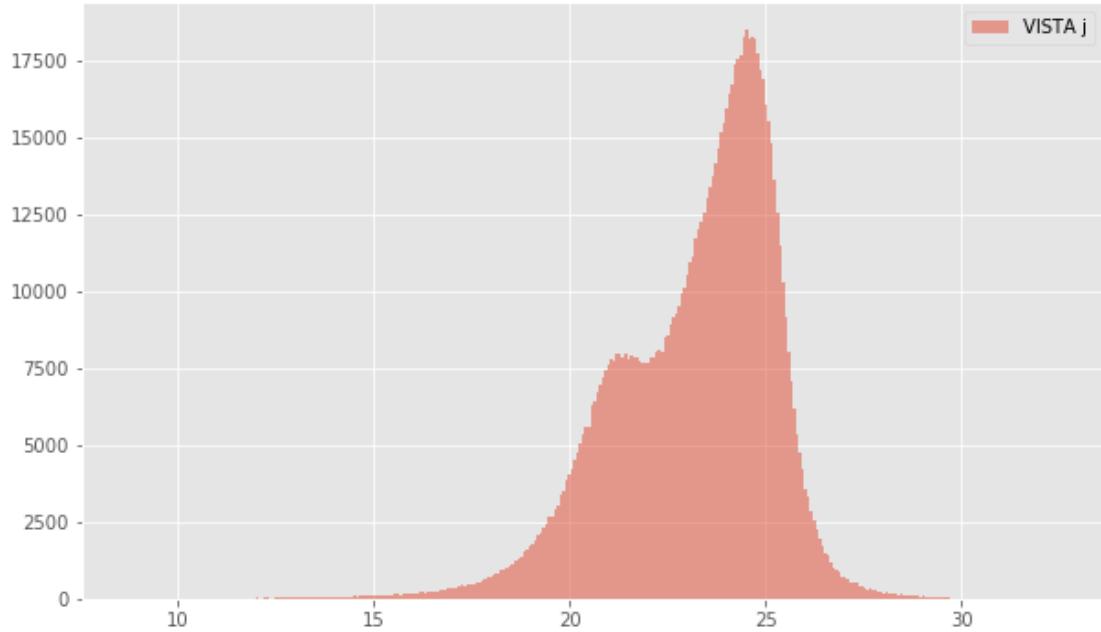
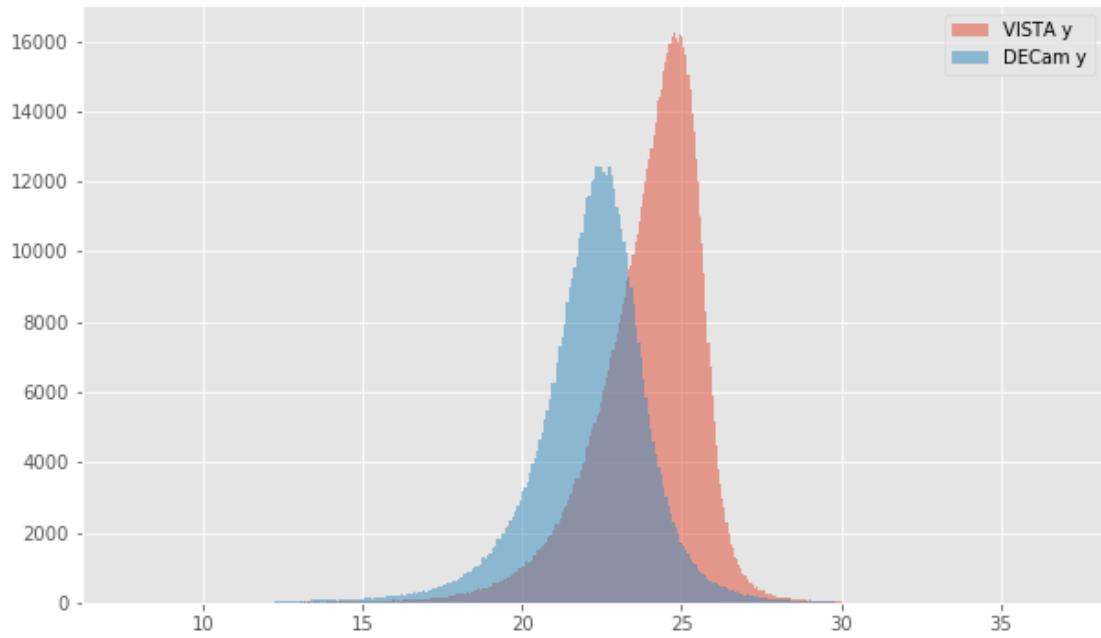
The master list is composed of several catalogues containing magnitudes in similar filters on different instruments. We are comparing the magnitudes in these corresponding filters.

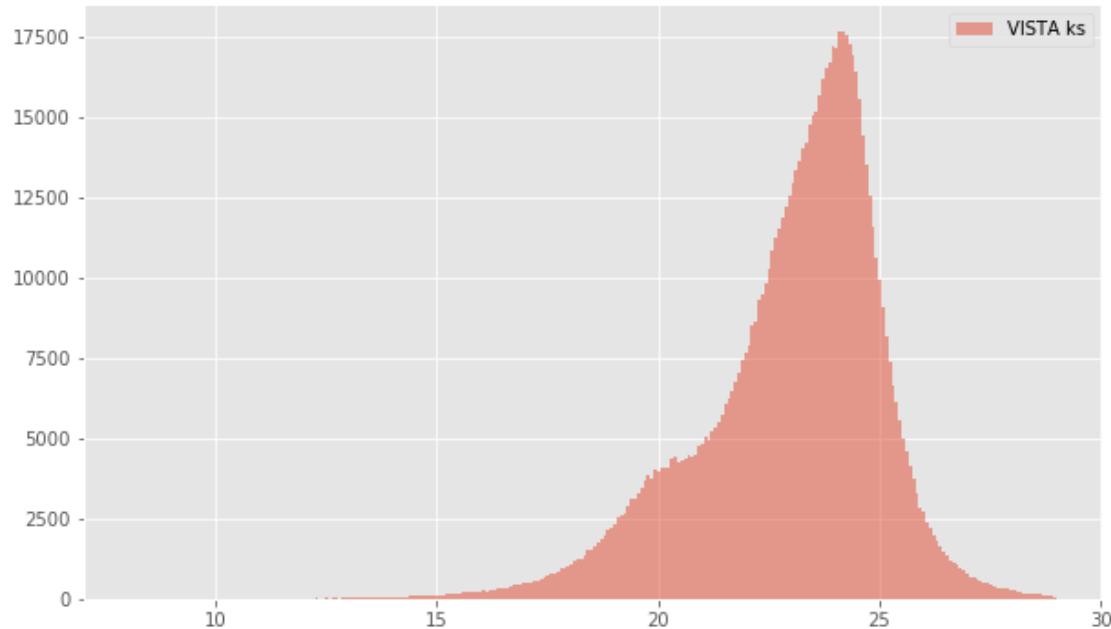
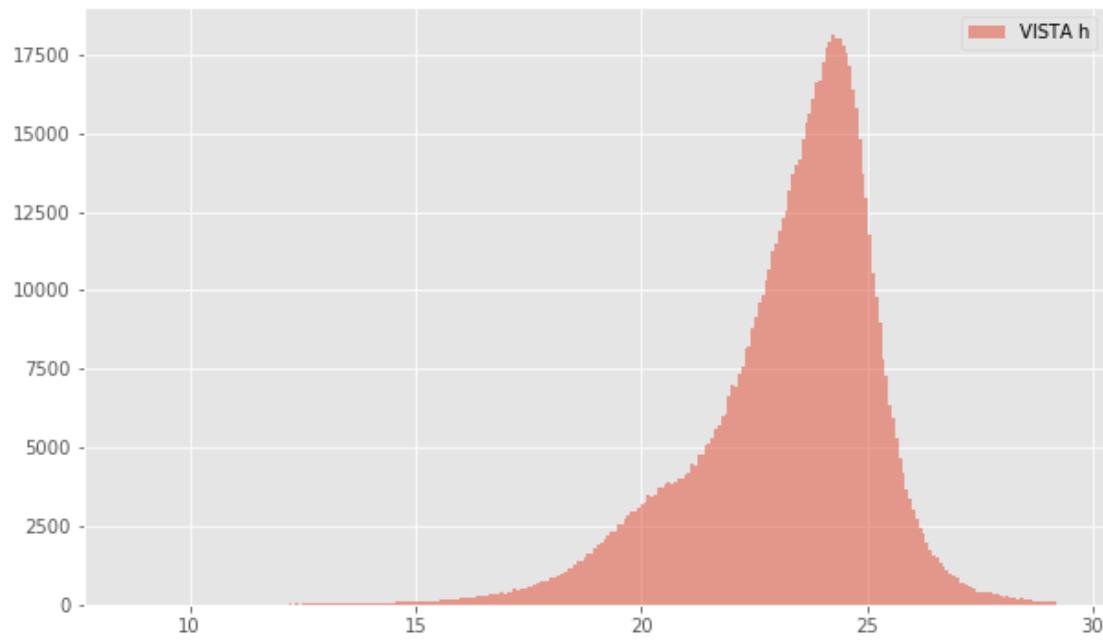
### 1.4.1 II.a - Comparing depths

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







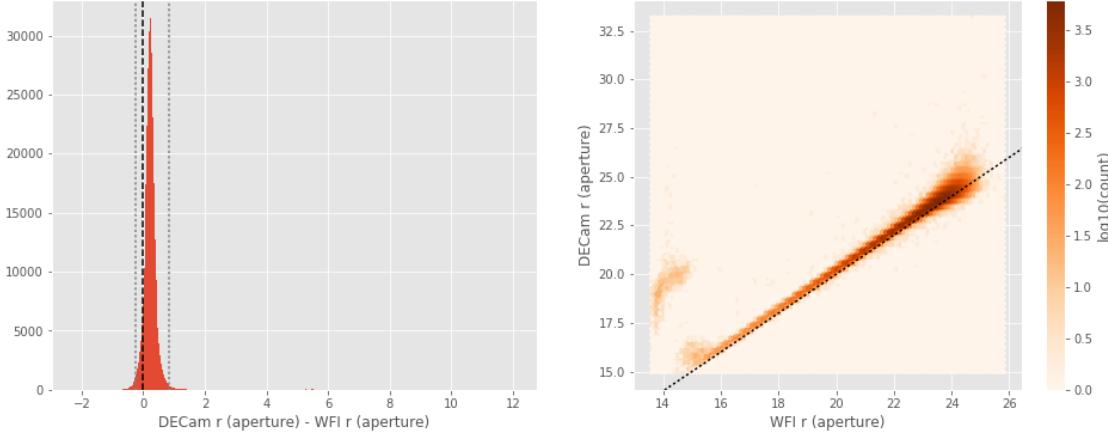


#### 1.4.2 II.b - Comparing magnitudes

We compare one to one each magnitude in similar bands.

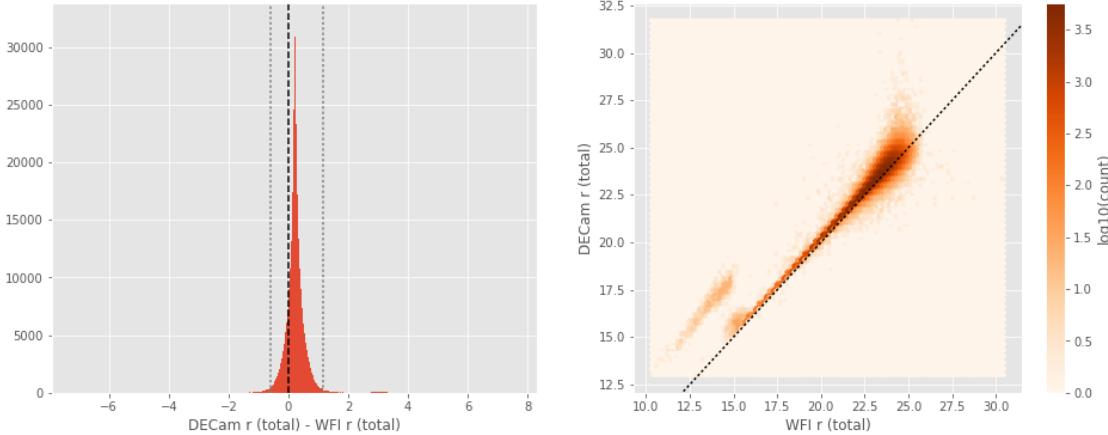
DECam r (aperture) - WFI r (aperture):

- Median: 0.22
- Median Absolute Deviation: 0.10
- 1% percentile: -0.26562957763671874
- 99% percentile: 0.8308322906494157



DECam r (total) - WFI r (total):

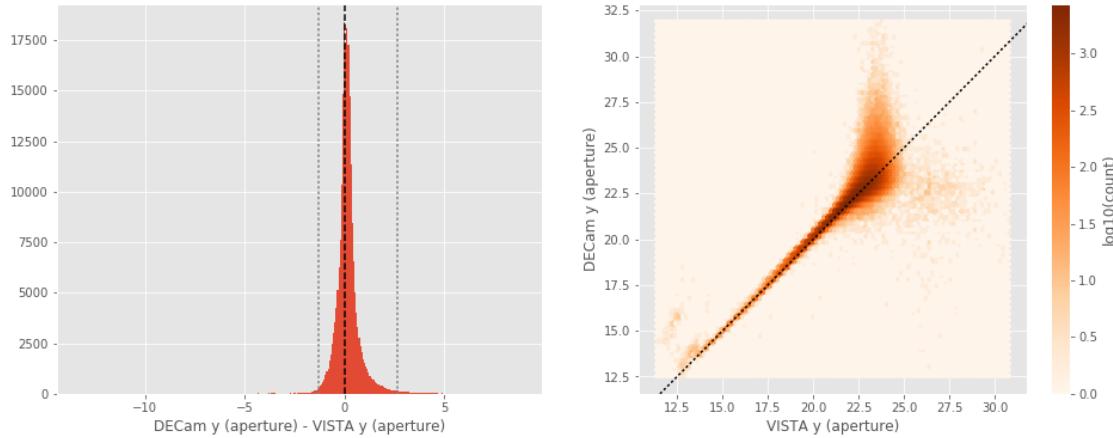
- Median: 0.22
- Median Absolute Deviation: 0.12
- 1% percentile: -0.5846313667297364
- 99% percentile: 1.162789611816407



DECam y (aperture) - VISTA y (aperture):

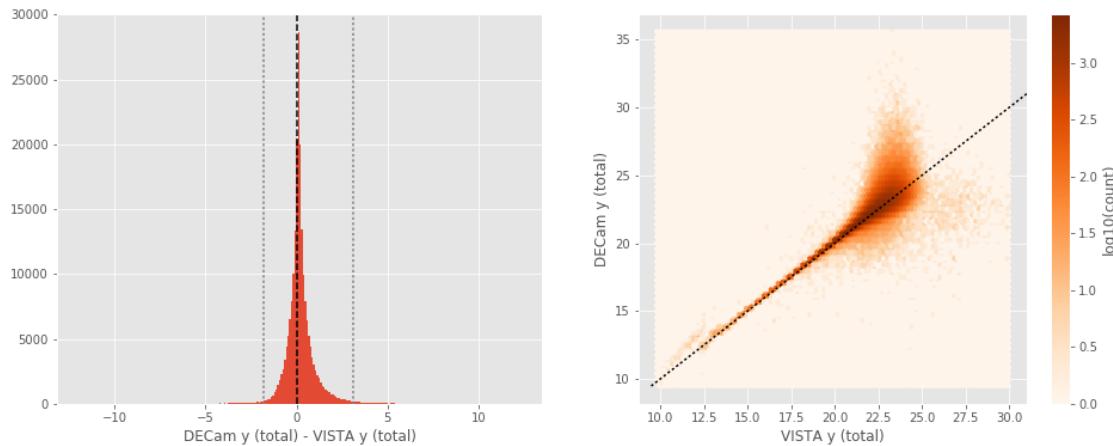
- Median: 0.11

- Median Absolute Deviation: 0.23
- 1% percentile: -1.2914987182617188
- 99% percentile: 2.6335643386840744



$\text{DECam } y \text{ (total)} - \text{VISTA } y \text{ (total)}:$

- Median: 0.13
- Median Absolute Deviation: 0.28
- 1% percentile: -1.8201082038879397
- 99% percentile: 3.115583019256591



## 1.5 III - Comparing magnitudes to reference bands

Cross-match the master list to 2MASS magnitudes.

### 1.5.1 III.a - 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](#):

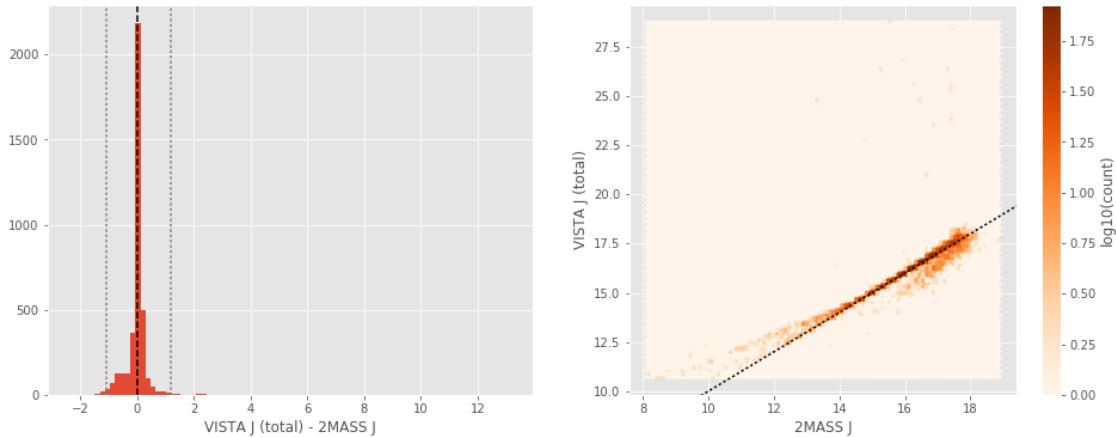
Band	F - 0 mag (Jy)
J	1594
H	1024
Ks	666.7

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:

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

VISTA J (total) - 2MASS J:

- Median: 0.02
- Median Absolute Deviation: 0.07
- 1% percentile: -1.0788754369260627
- 99% percentile: 1.1727617344759185



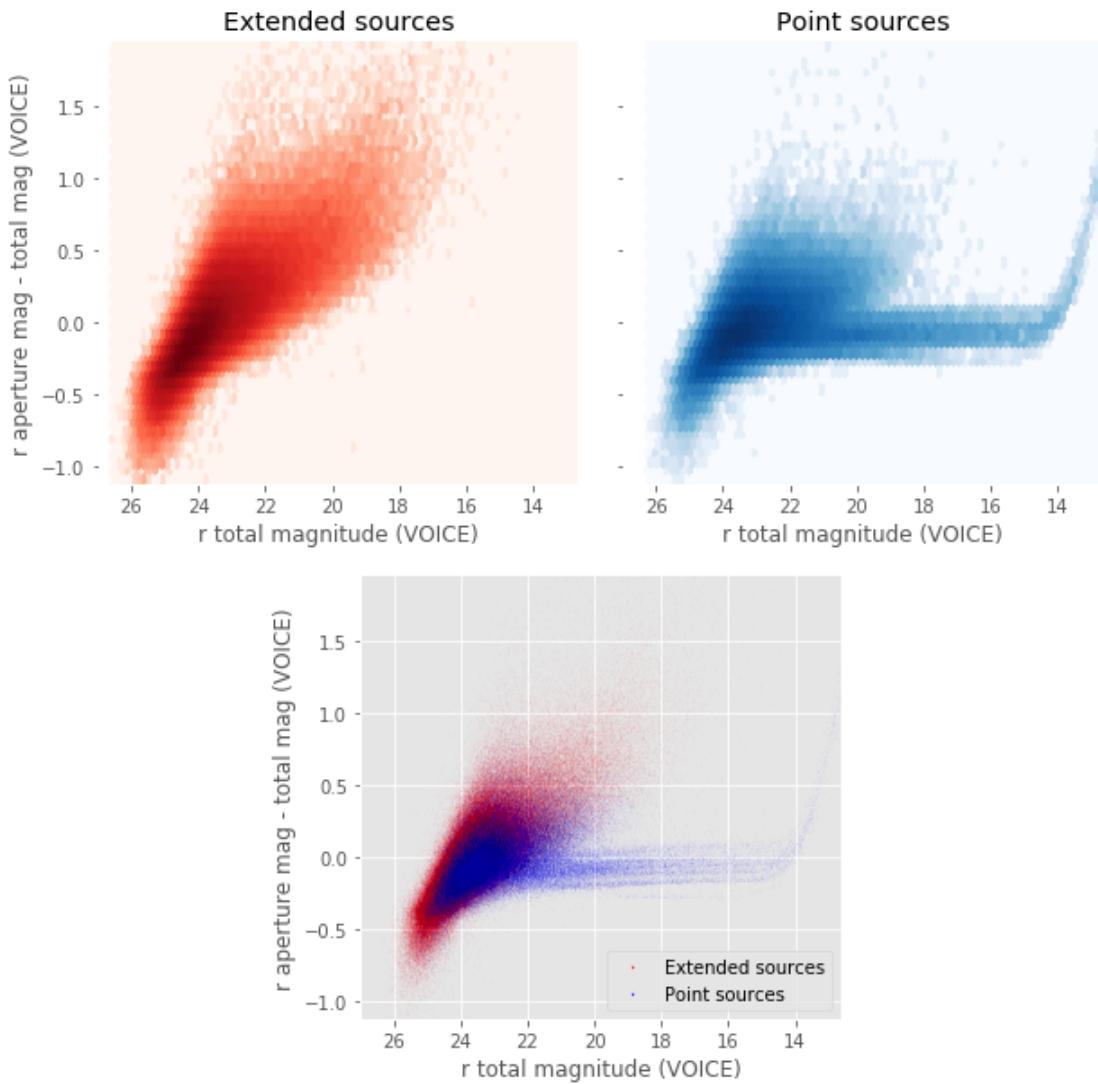
## 1.6 Keeping only sources with good signal to noise ratio

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.*

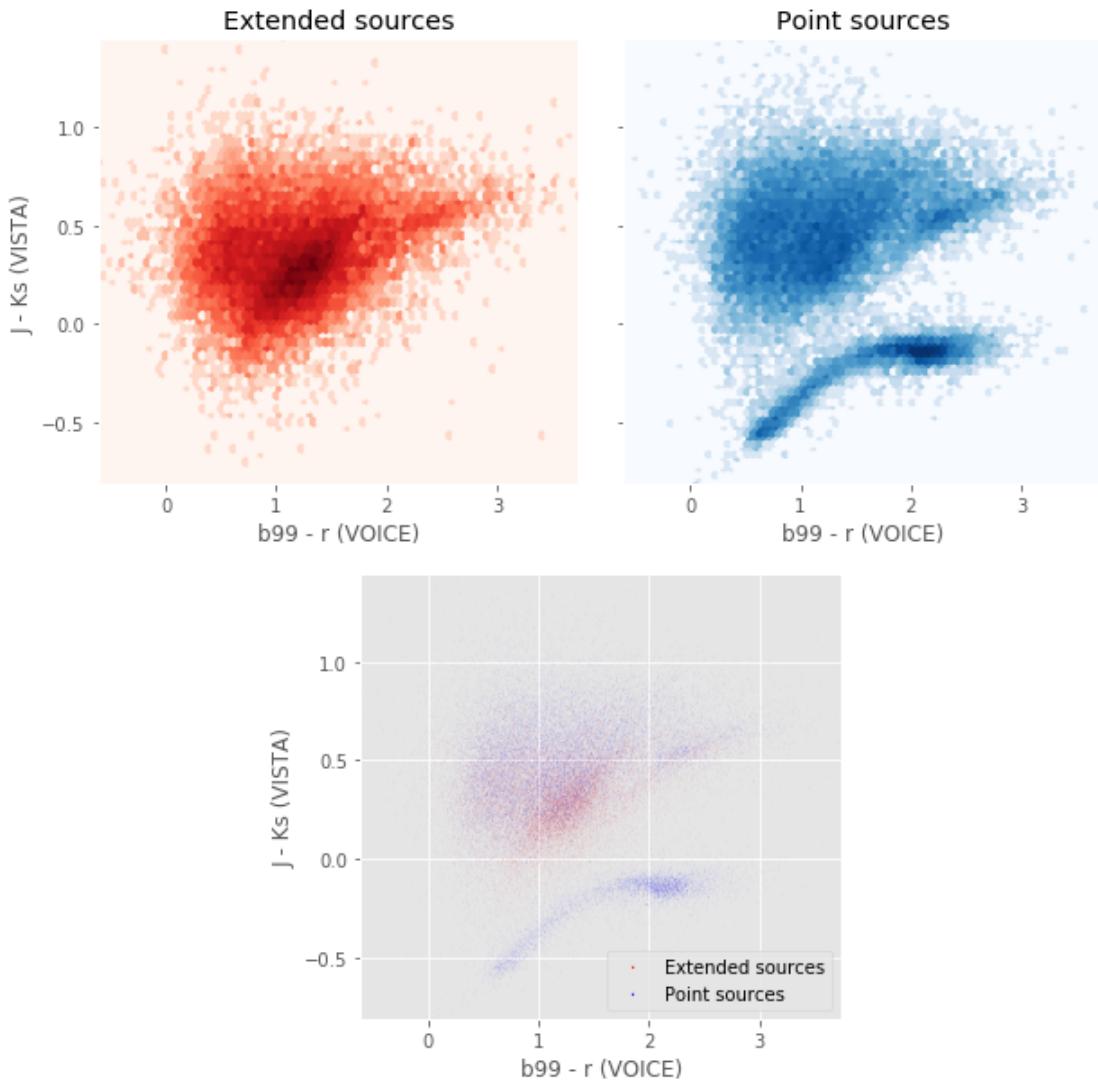
## 1.7 IV - Comparing aperture magnitudes to total ones.

Number of source used: 418415 / 1655564 (25.27%)

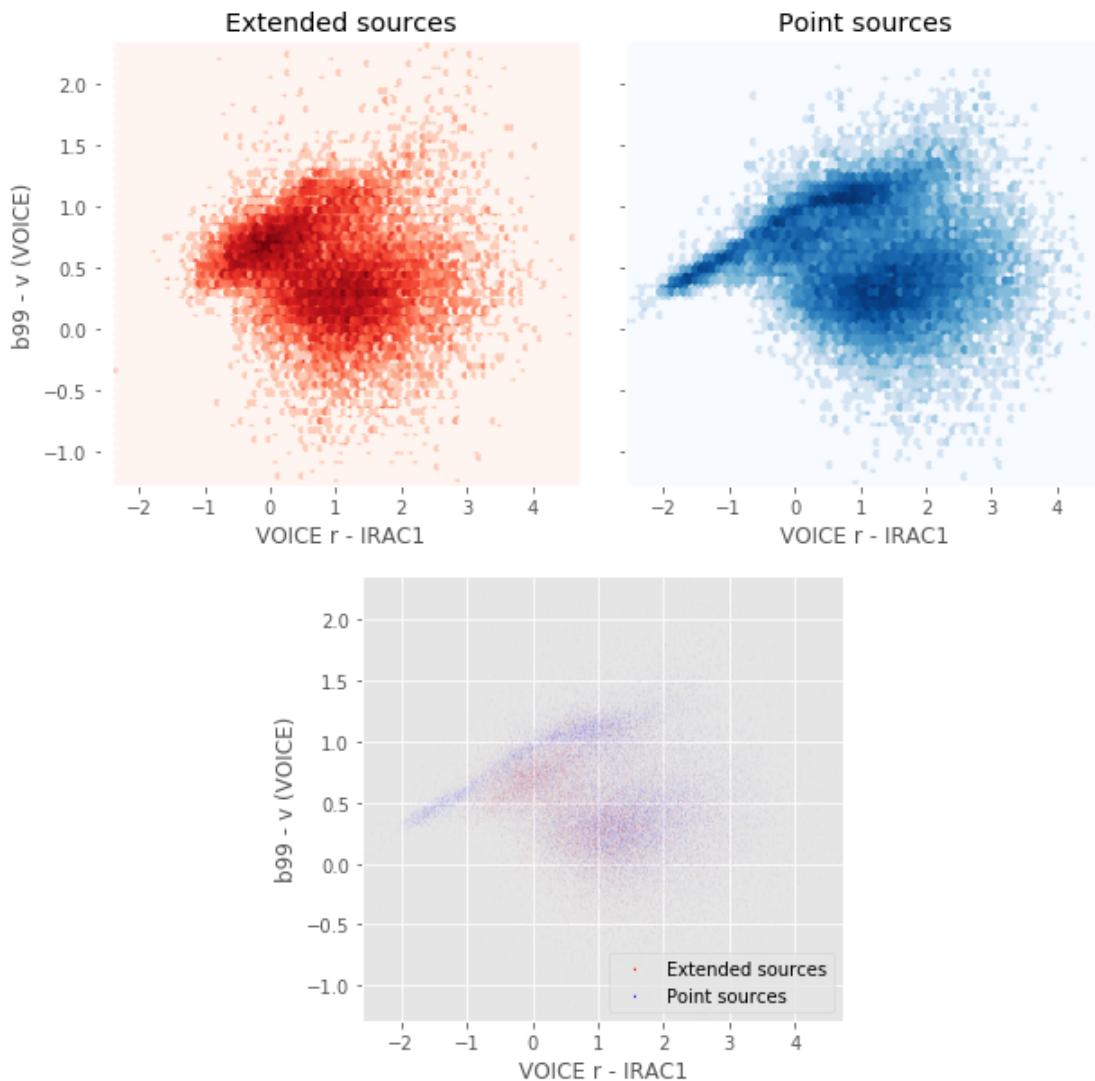


## 1.8 V - Color-color and magnitude-color plots

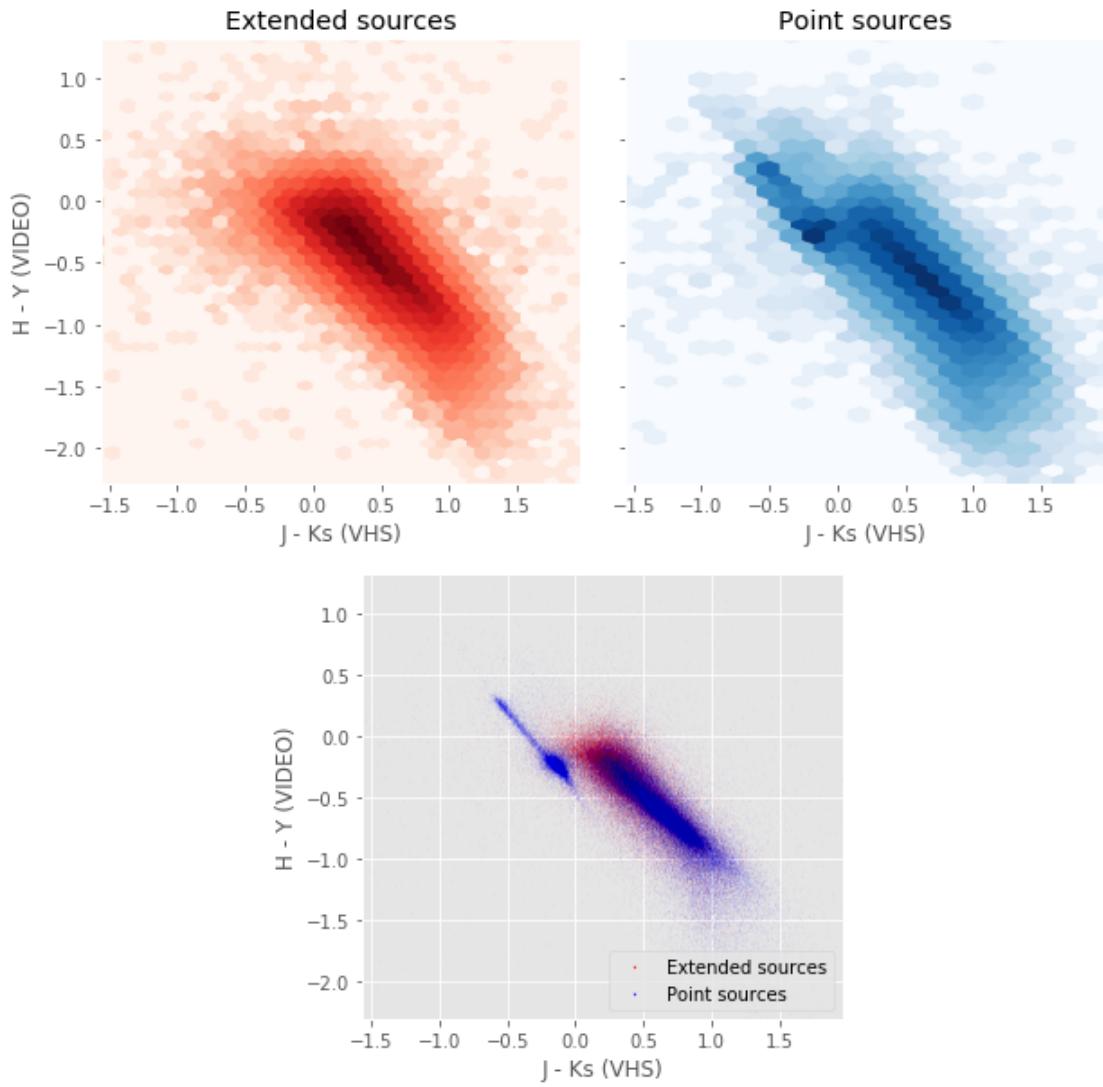
Number of source used: 46512 / 1655564 (2.81%)



Number of source used: 39667 / 1655564 (2.40%)



Number of source used: 213520 / 1655564 (12.90%)



# 4\_Selection\_function

March 8, 2018

## 1 ELAIS-S1 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  $5\sigma$  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 20:54:48.861561
```

Depth maps produced using: master\_catalogue\_elais-s1\_20180221.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 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

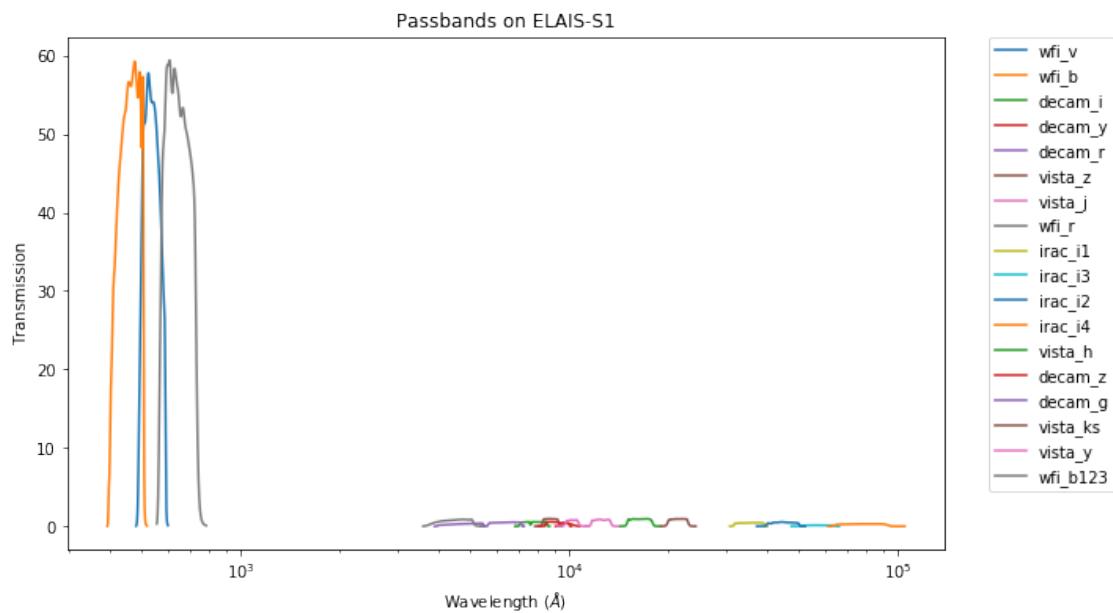
## 1.5 IV - Overview plots

### 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]: {'decam_g',
 'decam_i',
 'decam_r',
 'decam_y',
 'decam_z',
 'irac_i1',
 'irac_i2',
 'irac_i3',
 'irac_i4',
 'vista_h',
 'vista_j',
 'vista_ks',
 'vista_y',
 'vista_z',
 'wfi_b',
 'wfi_b123',
 'wfi_r',
 'wfi_v'}
```

```
Out[15]: <matplotlib.text.Text at 0x7f979f19ef98>
```



## 1.5.2 IV.a - Depth overview

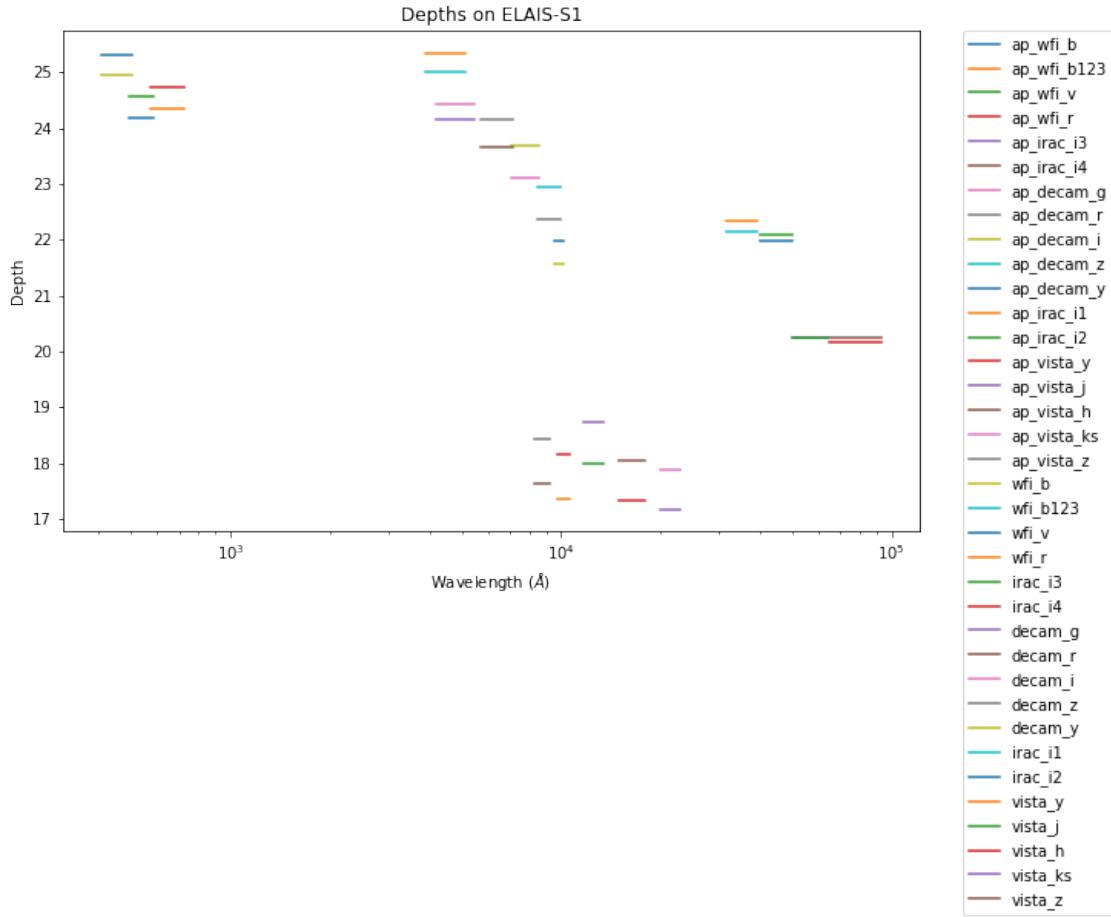
Then we plot the mean depths available across the area a given band is available

```
wfi_b: mean flux error: 0.054401807487010956, 3sigma in AB mag (Aperture): 25.868163540031013
wfi_b123: mean flux error: 0.05324237421154976, 3sigma in AB mag (Aperture): 25.891553329403074
wfi_v: mean flux error: 0.10746744275093079, 3sigma in AB mag (Aperture): 25.129004576412946
wfi_r: mean flux error: 0.09391207247972488, 3sigma in AB mag (Aperture): 25.275393301217242
irac_i3: mean flux error: 5.8527259007131, 3sigma in AB mag (Aperture): 20.788801399744038
irac_i4: mean flux error: 5.78632855538187, 3sigma in AB mag (Aperture): 20.801189138634122
decam_g: mean flux error: 0.12168966494844545, 3sigma in AB mag (Aperture): 24.994062624824856
decam_r: mean flux error: 0.15984290092380252, 3sigma in AB mag (Aperture): 24.697963481232442
decam_i: mean flux error: 0.24659686578722279, 3sigma in AB mag (Aperture): 24.227227982024026
decam_z: mean flux error: 0.4820690610782045, 3sigma in AB mag (Aperture): 23.49942371419764
decam_y: mean flux error: 1.1746954519327797, 3sigma in AB mag (Aperture): 22.53238364495531
irac_i1: mean flux error: 0.8373222812628816, 3sigma in AB mag (Aperture): 22.899965243203603
irac_i2: mean flux error: 1.070826479498174, 3sigma in AB mag (Aperture): 22.632899108394376
vista_y: mean flux error: 40.19167216093442, 3sigma in AB mag (Aperture): 18.696856675093265
vista_j: mean flux error: 23.417885121131587, 3sigma in AB mag (Aperture): 19.283327685217294
vista_h: mean flux error: 44.20951206900277, 3sigma in AB mag (Aperture): 18.59340755890998
vista_ks: mean flux error: 51.53201321739501, 3sigma in AB mag (Aperture): 18.427004089421224
vista_z: mean flux error: 31.054807839908253, 3sigma in AB mag (Aperture): 18.976874747514962
wfi_b: mean flux error: 0.07563285529613495, 3sigma in AB mag (Total): 25.51042062265787
wfi_b123: mean flux error: 0.07156137377023697, 3sigma in AB mag (Total): 25.570500190285223
wfi_v: mean flux error: 0.15549196302890778, 3sigma in AB mag (Total): 24.72792699719563
wfi_r: mean flux error: 0.1313200145959854, 3sigma in AB mag (Total): 24.911369557379935
irac_i3: mean flux error: 5.839967250197483, 3sigma in AB mag (Total): 20.791170834074983
irac_i4: mean flux error: 6.198815773303567, 3sigma in AB mag (Total): 20.726425039553156
decam_g: mean flux error: 0.15755736996434655, 3sigma in AB mag (Total): 24.713600056422187
decam_r: mean flux error: 0.24832557664463079, 3sigma in AB mag (Total): 24.21964323161631
decam_i: mean flux error: 0.41516537499062856, 3sigma in AB mag (Total): 23.661644048291272
decam_z: mean flux error: 0.825016533179737, 3sigma in AB mag (Total): 22.916040233653966
decam_y: mean flux error: 1.7063437262444947, 3sigma in AB mag (Total): 22.127030563157653
irac_i1: mean flux error: 1.0062078712067173, 3sigma in AB mag (Total): 22.70047758736468
irac_i2: mean flux error: 1.1883765497745837, 3sigma in AB mag (Total): 22.519811679984663
vista_y: mean flux error: 82.88112724821083, 3sigma in AB mag (Total): 17.911057740235215
vista_j: mean flux error: 46.338121852285894, 3sigma in AB mag (Total): 18.542350795053558
vista_h: mean flux error: 85.47538478432637, 3sigma in AB mag (Total): 17.8775942018623
vista_ks: mean flux error: 97.98309534834651, 3sigma in AB mag (Total): 17.729318975760528
vista_z: mean flux error: 64.75798996166226, 3sigma in AB mag (Total): 18.178963462893513
```

```
ap_wfi_b (408.5, 505.5, 97.0)
ap_wfi_b123 (3875.0, 5105.0, 1230.0)
ap_wfi_v (495.0, 583.5, 88.5)
ap_wfi_r (570.5, 729.0, 158.5)
ap_irac_i3 (50246.301, 64096.699, 13850.398)
ap_irac_i4 (64415.199, 92596.797, 28181.598)
ap_decam_g (4180.0, 5470.0, 1290.0)
```

```
ap_decam_r (5680.0, 7150.0, 1470.0)
ap_decam_i (7090.0, 8560.0, 1470.0)
ap_decam_z (8490.0, 9960.0, 1470.0)
ap_decam_y (9510.0, 10170.0, 660.0)
ap_irac_i1 (31754.0, 39164.801, 7410.8008)
ap_irac_i2 (39980.102, 50052.301, 10072.199)
ap_vista_y (9740.0, 10660.0, 920.0)
ap_vista_j (11670.0, 13380.0, 1710.0)
ap_vista_h (15000.0, 17900.0, 2900.0)
ap_vista_ks (19930.0, 23010.0, 3080.0)
ap_vista_z (8300.0, 9260.0, 960.0)
wfi_b (408.5, 505.5, 97.0)
wfi_b123 (3875.0, 5105.0, 1230.0)
wfi_v (495.0, 583.5, 88.5)
wfi_r (570.5, 729.0, 158.5)
irac_i3 (50246.301, 64096.699, 13850.398)
irac_i4 (64415.199, 92596.797, 28181.598)
decam_g (4180.0, 5470.0, 1290.0)
decam_r (5680.0, 7150.0, 1470.0)
decam_i (7090.0, 8560.0, 1470.0)
decam_z (8490.0, 9960.0, 1470.0)
decam_y (9510.0, 10170.0, 660.0)
irac_i1 (31754.0, 39164.801, 7410.8008)
irac_i2 (39980.102, 50052.301, 10072.199)
vista_y (9740.0, 10660.0, 920.0)
vista_j (11670.0, 13380.0, 1710.0)
vista_h (15000.0, 17900.0, 2900.0)
vista_ks (19930.0, 23010.0, 3080.0)
vista_z (8300.0, 9260.0, 960.0)
```

Out [20]: <matplotlib.text.Text at 0x7f979eba52e8>



### 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 0x7f979e92be48>

Depths (5  $\sigma$ ) vs coverage on ELAIS-S1

