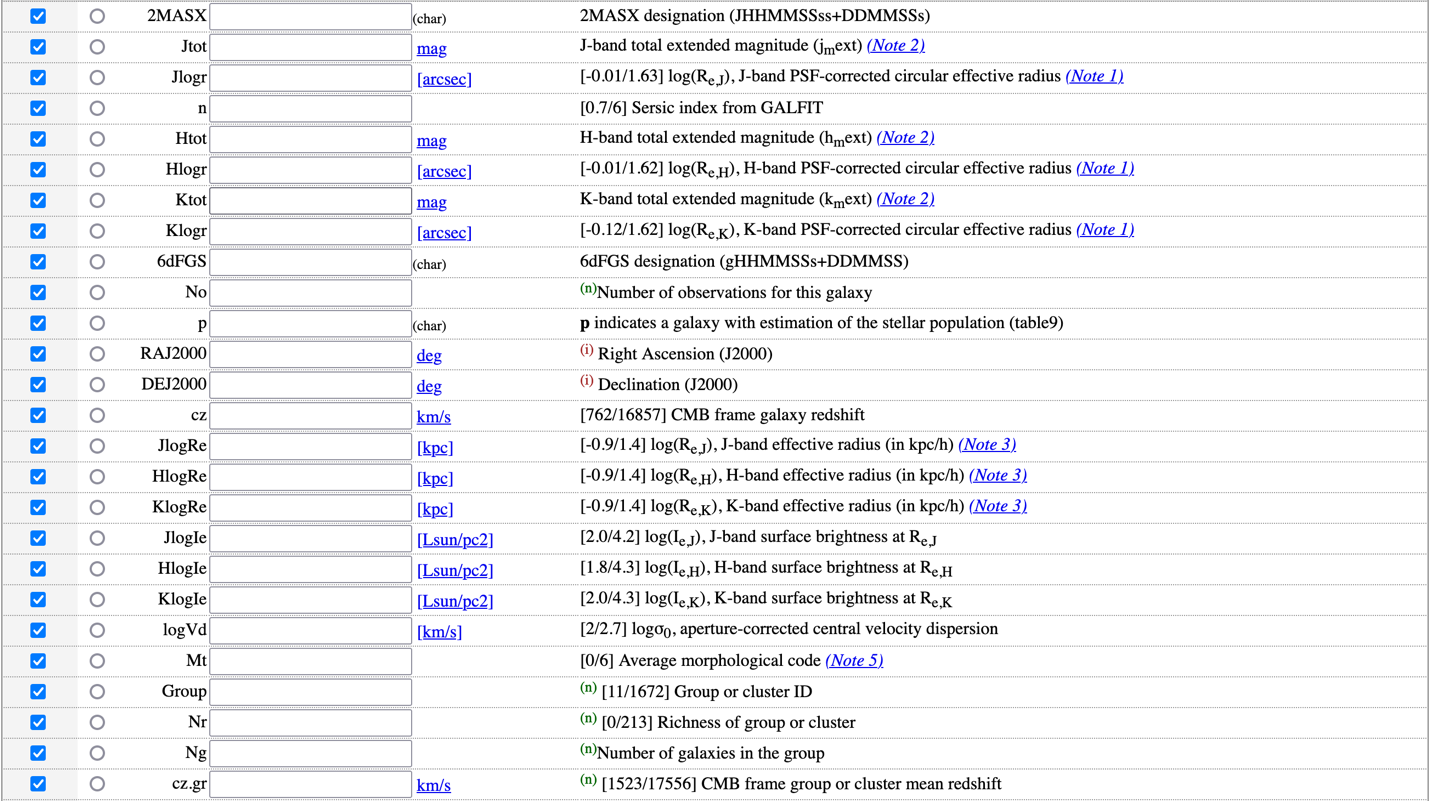
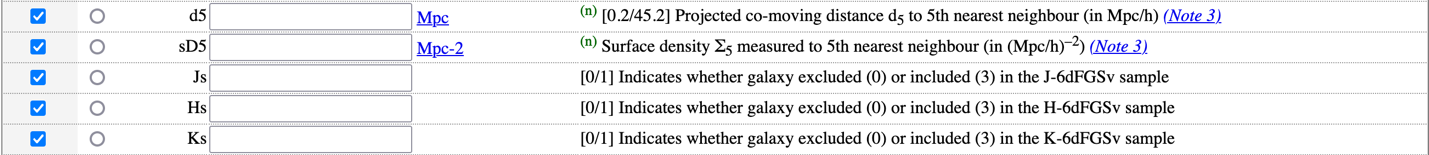
WHAT I HAVE BEEN DOING

1. **Obtaining the raw spectroscopy/velocity dispersions data**
2. 6dFGS (there are two data sources, I have not inspected whether they are different):
   * + 1. First source is what I actually used throughout my thesis, Campbell’s table on Vizier obtained [here](https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=+J%2FMNRAS%2F443%2F1231%2Ftable2&-from=nav&-nav=cat%3AJ%2FMNRAS%2F443%2F1231%26tab%3A%7BJ%2FMNRAS%2F443%2F1231%2FFPsample%7D%26key%3Asource%3DJ%2FMNRAS%2F443%2F1231%2Ftable2%26HTTPPRM%3A%26) . I use two tables, first is FPsample table (FP quantities, 11102 galaxies) with the following schema:





second table is table2 (velocity dispersion, 11503 galaxies) with the following schema:

A screenshot of a computer

Description automatically generated

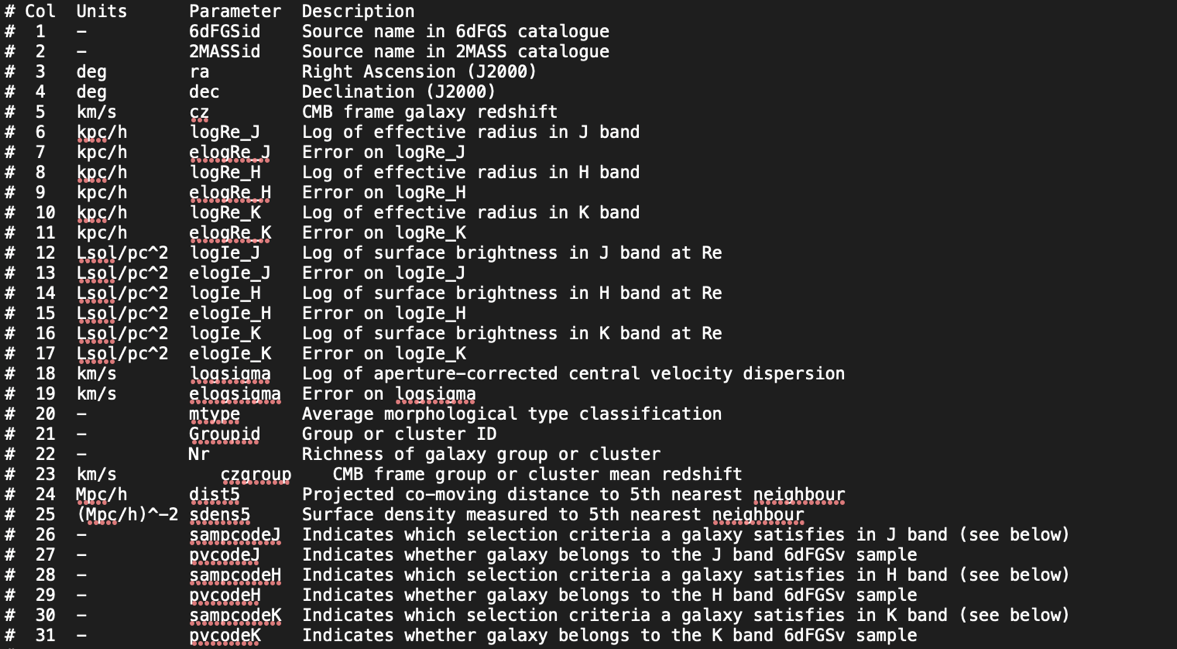
* + - 1. Second source is from Campbell et al. (2014) on MNRAS obtained [here](https://academic.oup.com/mnras/article/443/2/1231/1060810) (supplementary data section). The files are campbell\_table2.ascii (velocity dispersion data), campbell\_table4.ascii (NIR photometry) and campbell\_table8.ascii (derived FP data).
         1. table2 schema (unsure if the descriptions are true):

|  |  |  |  |
| --- | --- | --- | --- |
| column name | type | Unit | description |
| sdf | string |  | 6dFGS id |
| tmass | string |  | 2MASS id |
| mjd | float |  | Modified julian date of the observation |
| Z\_helio | float | Redshift | Heliocentric redshift |
| s2n | float |  | Signal to noise ratio of velocity dispersion measurement |
| Cor\_sigma | float |  | Cross-correlation R parameter? |
| Dex\_error | float | [km/s] | Error of log\_Vd? |

* + - * 1. table4 schema

|  |  |  |  |
| --- | --- | --- | --- |
| column name | type | Unit | description |
| MASS\_name | string |  | 2MASS id |
| J\_m\_ext | string | Mag | Extrapolated J magnitude |
| Fwhm\_j | float | Arcsecond? | Modified julian date of the observation |
| Delta\_r\_j | float | Arcsecond? | PSF correction? |
| Log\_re\_j | float | [arcsecond]? | Log PSF-corrected effective radius |
| nser | float |  | Sersic index |
| H\_m\_ext | float | Mag | Extrapolated H magnitude |
| Fwhm\_h | float | Arcsecond? |  |
| Delta\_r\_h | float | Arcsecond? |  |
| Log\_re\_h | float | [arcsecond]? |  |
| K\_m\_ext | float | Mag | Extrapolated K magnitude |
| Fwhm\_k | float | Arcsecond? |  |
| Delta\_r\_k | float | Arcsecond? |  |
| Log\_re\_k | float | [arcsecond]? |  |

* + - * 1. table8 schema



1. SDSS (281711 galaxies): obtained from SDSS DR14 via the following CasJobs query:

SELECT s.specobjid, p.objID, s.ra, s.dec, s.plate, s.instrument, s.mjd, s.fiberid, p.devMag\_u, p.devRad\_u, devAB\_u, p.devMag\_r, p.devRad\_r, devAB\_r, s.z,s.zErr,s.veldisp,s.veldispErr, em.sigmaStars, em.sigmaStarsErr

into mydb.SDSS\_spectro\_20240219\_02

From SpecObjAll as s

JOIN emissionLinesPort em ON (em.specObjID = s.specobjid)

JOIN PhotoObjAll p ON (p.specObjID = s.SpecObjID)

WHERE

(s.sdssPrimary = 1)

AND (s.z <= 0.1)

AND (em.sigmaStars > 0)

AND (em.sigmaStarsErr > 0)

AND (em.sigmaStarsErr/em.sigmaStars <= 0.5)

1. LAMOST (85861 galaxies): the file lamost\_DR7\_VDcat\_20200825.fits obtained from Khaled. Schema:

A screenshot of a computer error

Description automatically generated

**Note:**

* I used vizier for 6dFGS because the tables on MNRAS do not have the raw velocity dispersions.

1. **Obtaining supplementary data**

* Two supplementary data required: John’s radii measurements and Tempel et al. SDSS DR8 groups and clusters data.
* John provided colours table (data/raw/r\_e\_jrl/colours.ascii), radii measurements (data/raw/r\_e\_jrl/jhk\_r\_e.csv), and LAMOST ETG list (data/raw/r\_e\_jrl/lamost\_good\_pv\_list.csv)
  + Colours table (I didn’t use these, so I don’t know what most of the columns are):

|  |  |  |  |
| --- | --- | --- | --- |
| column name | type | Unit | description |
| tmass | string |  | 2MASS ID |
| Ra | float | deg |  |
| Dec | float | deg |  |
| J\_ext | float |  |  |
| J\_ext\_error | float |  |  |
| G\_r\_ext | float |  |  |
| GAIA3\_B\_R | float |  |  |
| GAIA3\_B\_R\_error | float |  |  |
| PS1\_g\_r\_5 | float |  |  |
| PS1\_g\_r\_5\_error | float |  |  |
| SM3\_g\_r\_5 | float |  |  |
| SM3\_g\_r\_5\_error | float |  |  |
| J\_K\_5 | float |  |  |
| J\_K\_5\_err | float |  |  |
| W2\_W3 | float |  |  |
| W2\_W3\_err | float |  |  |

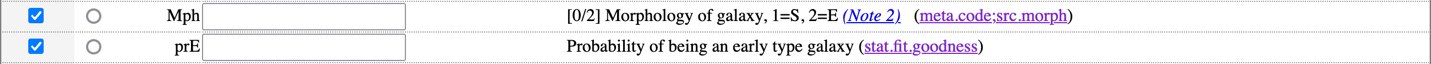
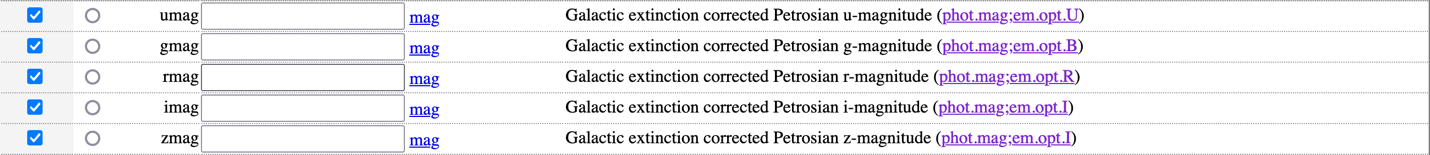
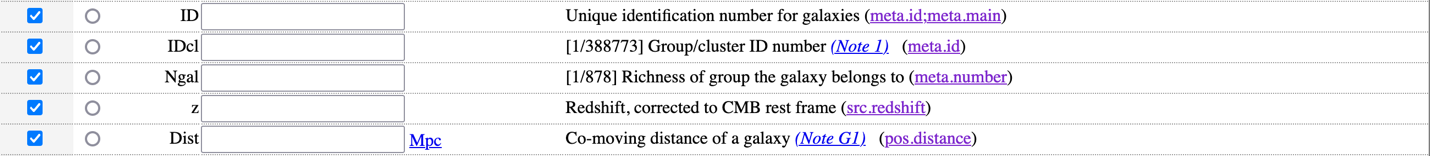
* + Radii measurements

|  |  |  |  |
| --- | --- | --- | --- |
| column name | type | Unit | description |
| tmass | string |  | 2MASS ID |
| Log\_r\_h\_app\_j |  |  |  |
| Log\_r\_h\_smodel\_j |  |  |  |
| Log\_r\_h\_model\_j |  |  |  |
| Red\_chi\_j |  |  |  |
| Galfit\_ser\_j |  |  |  |
| Fwhm\_j |  |  |  |
| Fit\_ok\_j |  |  |  |
| Log\_r\_h\_app\_h |  |  |  |
| Log\_r\_h\_smodel\_h |  |  |  |
| Log\_r\_h\_model\_h |  |  |  |
| Red\_chi\_h |  |  |  |
| Galfit\_ser\_h |  |  |  |
| Fwhm\_h |  |  |  |
| Fit\_ok\_h |  |  |  |
| Log\_r\_h\_app\_k |  |  |  |
| Log\_r\_h\_smodel\_k |  |  |  |
| Log\_r\_h\_model\_k |  |  |  |
| Red\_chi\_k |  |  |  |
| Galfit\_ser\_k |  |  |  |
| Fwhm\_k |  |  |  |
| Fit\_ok\_k |  |  |  |

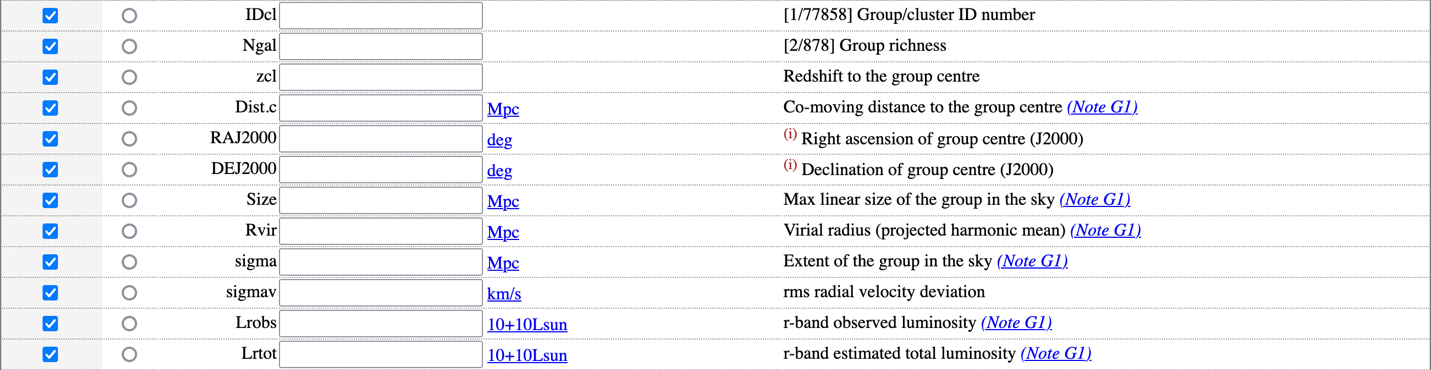
* + lamost\_good\_pv\_list.csv

|  |  |  |  |
| --- | --- | --- | --- |
| column name | type | Unit | description |
| Col1 | string |  | 2MASS ID |
| 2MASS | string |  | 2MASS ID |

* I downloaded Tempel et al. SDSS DR8 groups and clusters from vizier ([here](https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=J/A%2bA/540/A106/dr8gal)). It contains two tables:
  + dr8gal 🡪 individual galaxy data. I filtered Ngal > 1 to exclude groups with only 1 member



* + dr8gr 🡪 groups and clusters data



**Note:** is vizier the correct place to look for astronomical data?

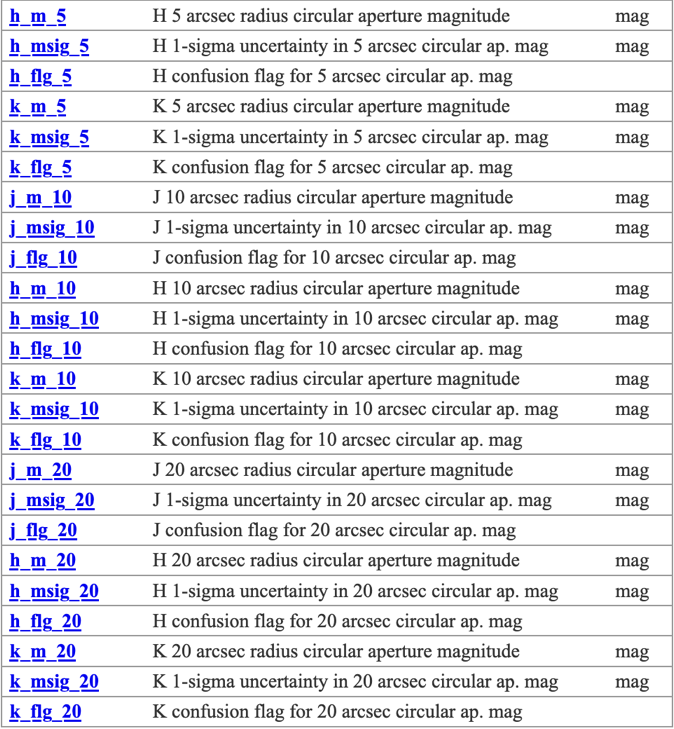
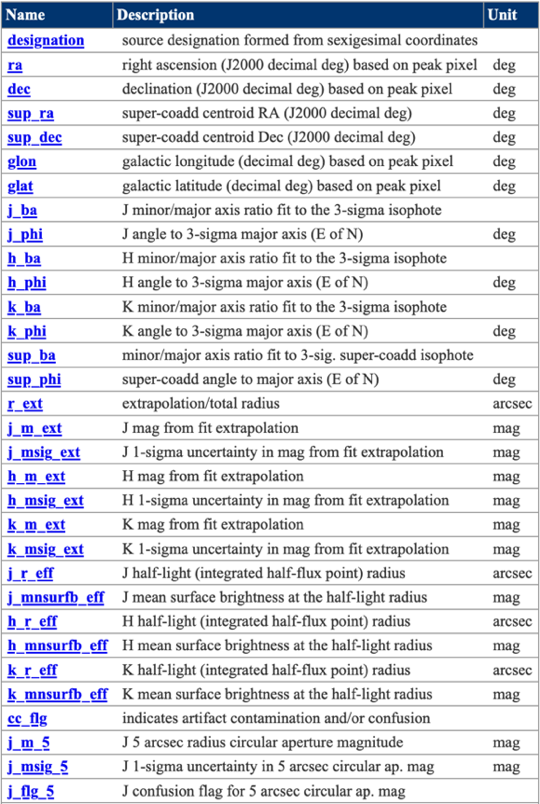
1. **Obtaining the sky coordinates from all the raw galaxies and obtaining 2MASS data**

* I use the get\_coordinates.py script to fetch the (ra, dec) and store them to data/preprocessed/sky\_coord/<survey>.ascii file (IPAC format).
* I had to multiply 6dFGS ra by 15 to get the ra in degrees (it was given in hour), while for SDSS and LAMOST I fetch the ra and dec directly.
* To set the cone search radius, I first queried 6dFGS galaxies to 2MASS XSC. I compared each input galaxy’s ra dec to its 2MASS counterpart’s ra dec. I found that the maximum separation was 2.22”.

A screenshot of a computer

Description automatically generated

* I set the cone search radius to be 2.25 arcsecond (based on the argument above but a bit more relaxed) and checked the ‘One to One Match’ box (basically doing a left join) so that I can simply merge the resulting dataframes later. These are the fields that I queried:



I saved the results at data/raw/2mass/<survey>\_tmass.csv. Also backed up the files in Google Drive (cannot push them to GitHub as they are too large).

* Note: is there a rule of thumb when doing sky cross-matching? How do we know we matched with the correct galaxies without visual inspection?

1. **Merge the original spectroscopy data with all others**
   * This step is done using combine\_spectrophoto.py
   * For 6dFGS (combine\_6df\_spectrophoto function):
     1. Open the 6dFGS FP sample (data/raw/6dfgs/sdfgs\_fp\_vizier.fits) containing 11102 galaxies.
     2. Open the 2MASS data containing 11102 photometry measurements (same number of rows and order as 6dFGS FP above).
     3. Join FP-2MASS by their dataframe indices.
     4. Check if the FP dataframe’s RAJ2000 and DEJ2000 are consistent with 2MASS dataframe’s ra\_01 and dec\_01. If consistent, I drop ra\_01 and dec\_01 from the joined dataframe.
     5. Open the 6dFGS velocity dispersions table (data/raw/6dfgs/sdfgs\_veldisp\_vizier.fits).
     6. 6dFGS veldisp table contains multiple measurements of the same galaxy. I picked the row with the best S\_N and drop the duplicates.
     7. Join 6dFGS FP-2MASS-veldisp.
     8. Save the table to data/preprocessed/spectrophoto.
   * For SDSS and LAMOST (I put them in one function combine\_sdss\_lamost\_spectrophoto as the steps are identical):
     1. Open the SDSS/LAMOST spectroscopy data (data/raw/sdss/SDSS\_spectro.csv and data/raw/lamost/lamost\_DR7\_VDcat\_20200825.fits).
     2. Open the 2MASS data.
     3. Join SDSS/LAMOST-2MASS by their dataframe indices.
     4. Check if SDSS/LAMOST dataframes’ ra and dec are consistent with 2MASS dataframe’s ra\_01 and dec\_01. If consistent, I drop ra\_01 and dec\_01 from the joined dataframe.
     5. Open John’s GALFIT measurements (radii, PSF corrections, other criteria).
     6. Join SDSS/LAMOST-2MASS-JRL on 2MASS id.
     7. Open Tempel’s individual galaxies and clusters data. Then I join them to get each galaxy’s cluster redshift.
     8. Join SDSS/LAMOST-2MASS-JRL-Tempel on galaxy’s ra and dec (Tempel does not provide SDSS objID).
     9. Save the table to data/preprocessed/spectrophoto.

* Note: I was not able to replicate the number of galaxies for SDSS. Last year, the SDSS+2MASS data was around 95000, but this time there are 158000 SDSS galaxies with 2MASS photometry. I don’t remember what CasJobs query I used to obtain SDSS previously.

1. **Derive r, s, i**
   * First, I installed dustmaps package using pip install dustmaps. Then, I run the src/utils/dustmaps\_downloader.py to download dustmaps\_sfd map to calculate Galactic extinction.
   * The r, s, i quantities are calculated using src/derive\_rsi.py script. It has the following steps:
     + 1. Extra step only for SDSS and LAMOST:
          1. append ‘SDSS’ and ‘LAMOST’ to their survey ID’s
          2. Perform the following selection criteria suggested by John:

Select fit\_ok\_j == ‘OK’

Select log\_r\_h\_model\_j > 0

Select red\_chi\_k <= 2

These removed 2212 galaxies from SDSS and 1237 galaxies from LAMOST.

* + - 1. Rename the columns for uniformity. Add ‘tmass’ column to 6dFGS and rename z\_lamost to z.
      2. Derive PSF-corrected radii. For 6dFGS, they are simply 10^Jlogr. For SDSS and LAMOST:
         1. Calculate the PSF correction
         2. Calculate the PSF-corrected radii
      3. Calculate CMB frame redshift for individual galaxies (also rederive for 6dFGS) using Khaled’s perform\_corr script from helio\_cmb.py script.



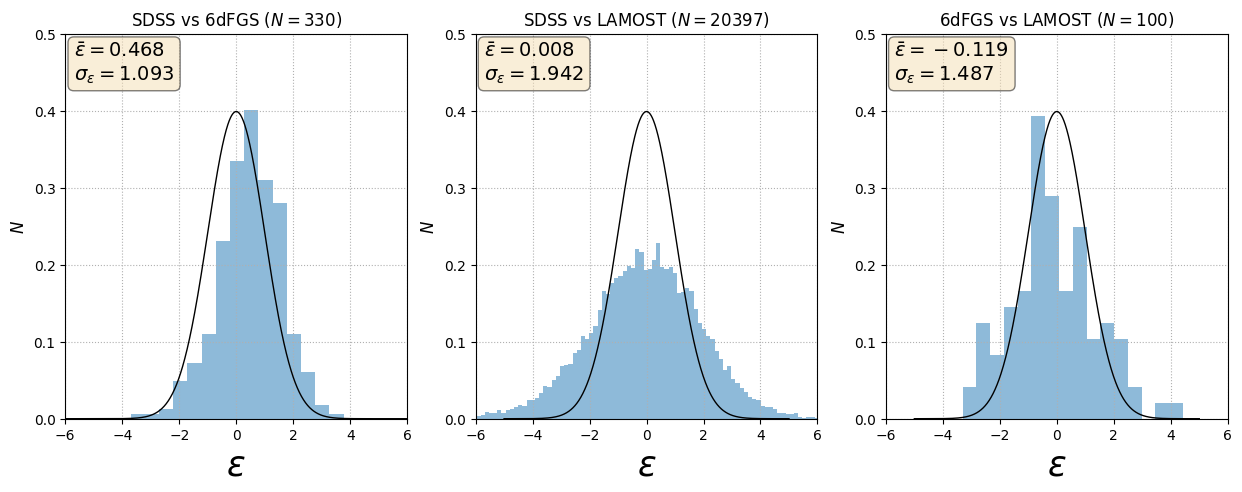
* + - 1. Create a new redshift column (z\_dist\_est) as distance estimator, which uses group or cluster mean CMB redshift if available, else using individual galaxy’s CMB redshift.
      2. Perform aperture size correction to the velocity dispersions.
         1. First, I calculated R-band radii from J-band radii (using circularized radii).
         2. Calculate aperture size-corrected velocity dispersion
      3. Calculate Galactic extinction in the JHK bands using SFD map.
      4. Calculate K-corrections using Chilingarian’s python script.
         1. I calculated the and colors first (corrected for Galactic extinction)
         2. Then I calculated the K-corrections using these colors
      5. Derive r and i
         1. First, I obtained redshift-distance table for to interpolate each galaxy’s estimated distance (dz\_cluster).
         2. Then I calculated circularized radii:
         3. Calculated r as follows:
         4. Calculated i as follows:
      6. Derive s
         1. Calculated s:
         2. Calculated es:
      7. Saved the files at data/processed/rsi\_derived/
  + Note: I compared the rsi results for 6dFGS with Campbell’s values. The veldisp (s) are pretty similar, but r and i are quite different. I think it’s because I used circularized radii, whereas Campbell did not.

A graph of a function

Description automatically generated with medium confidence

1. **Calibrating velocity dispersions**
   * Under the assumption of independence, the pairwise statistic

should follow a standard normal distribution (mean of 0 and variance of 1). But I got the following:



* I calibrated the velocity dispersions using two steps: first I scaled the error, and then I determined the offset.
* Notes:
  1. Should I have compared the linear velocity dispersions (Gaussian error?) instead of log\_Vd?
  2. The order of finding the error scaling affects the results. If I try to determine LAMOST scaling first, I found and . But if I determine SDSS scaling first, I found and . Is this okay?
  3. I think my implementation of Matthew’s sigcorr2.awk script was wrong. Basically we set N number of runs/bootstraps. But the total offset is only determined by the last run.

1. **Applying selection criteria (redshift, magnitude, and veldisp cut)**

* This step is carried out in 5\_apply\_selection.py
* Applied the following criteria with the number of galaxies remaining and excluded at each step:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Selection limit | Ng | Nexc | Descriptions |
| 6dFGS | Full sample | 11102 |  |  |
|  | cz\_cmb\_group <= 16120 |  | 739 | Upper CMB frame group redshift limit |
|  | m\_j - extinction\_j <= 13.65 |  | 626 | Extinction-corrected magnitude upper limit |
|  | s\_scaled > log10(112) - off\_6df |  | 204 | offset-corrected veldisp lower limit |
|  | cz\_cmb\_group >= 3000 |  | 83 | Lower CMB frame group redshift limit |
|  | Final sample | 9450 |  | Final number of 6dFGS galaxies |
| SDSS | Full sample | 88955 |  |  |
|  | cz\_cmb\_group <= 16120 |  | 64285 | Upper CMB frame group redshift limit |
|  | m\_j - extinction\_j <= 13.65 |  | 11528 | Extinction-corrected magnitude upper limit |
|  | s\_scaled > log10(112) - off\_6df |  | 2423 | offset-corrected veldisp lower limit |
|  | cz\_cmb\_group >= 3000 |  | 13 | Lower CMB frame group redshift limit |
|  | Final sample | 10706 |  | Final number of SDSS galaxies |
| LAMOST | Full sample | 61693 |  |  |
|  | cz\_cmb\_group <= 16120 |  | 49692 | Upper CMB frame group redshift limit |
|  | m\_j - extinction\_j <= 13.65 |  | 7690 | Extinction-corrected magnitude upper limit |
|  | s\_scaled > log10(112) - off\_6df |  | 1183 | offset-corrected veldisp lower limit |
|  | cz\_cmb\_group >= 3000 |  | 13 | Lower CMB frame group redshift limit |
|  | Final sample | 3115 |  | Final number of LAMOST galaxies |

* Notes:
  1. Should I use z\_cmb\_group redshift (since this is volume limit, and I used that because that redshift is the distance estimate)
  2. Should I use extinction-corrected magnitude for the limit?
  3. Seems awkward that the veldisp limit is offseted by 6dFGS offset