Study the large-scale structure of the universe using galaxy clusters

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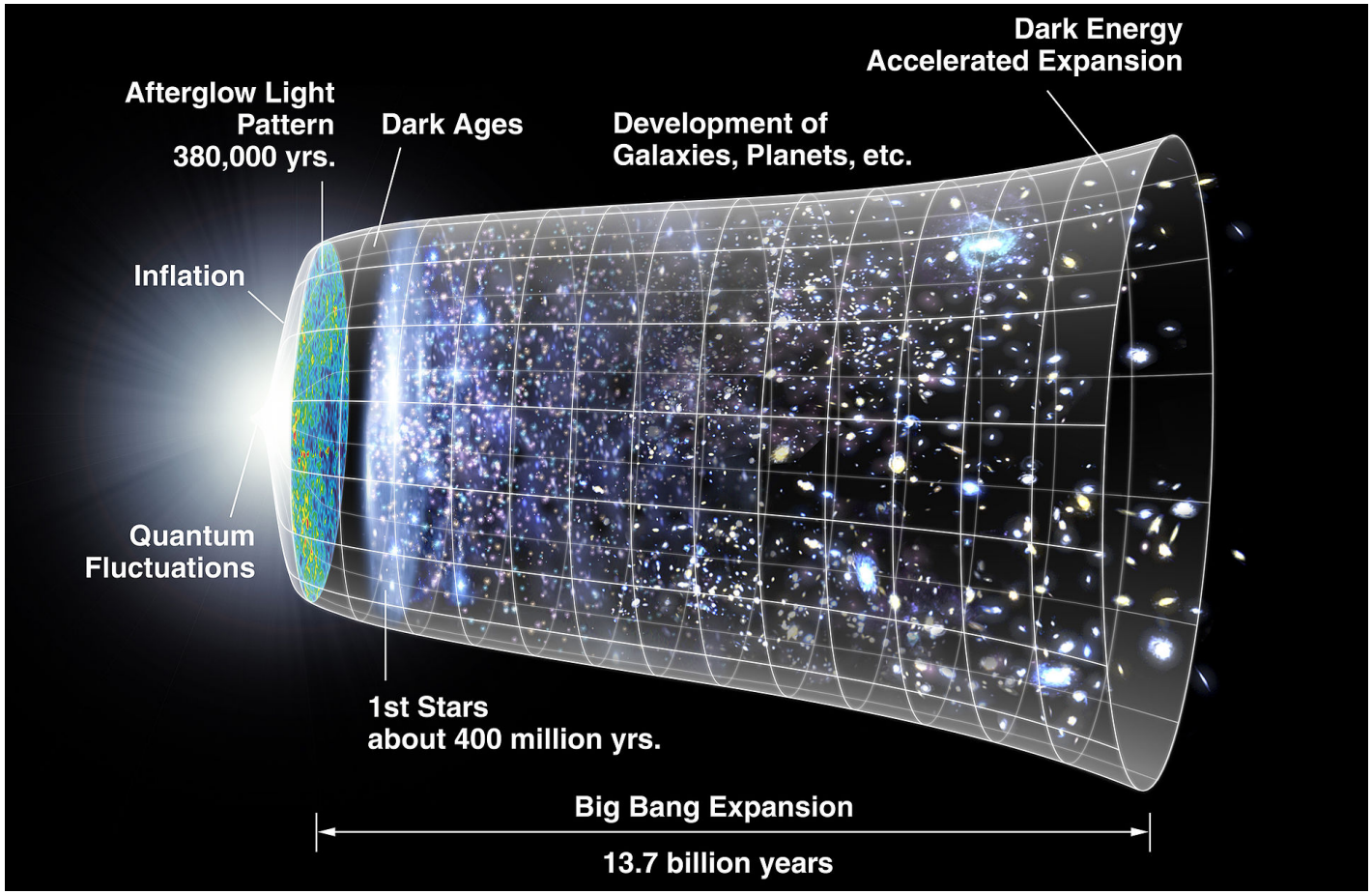
Outline

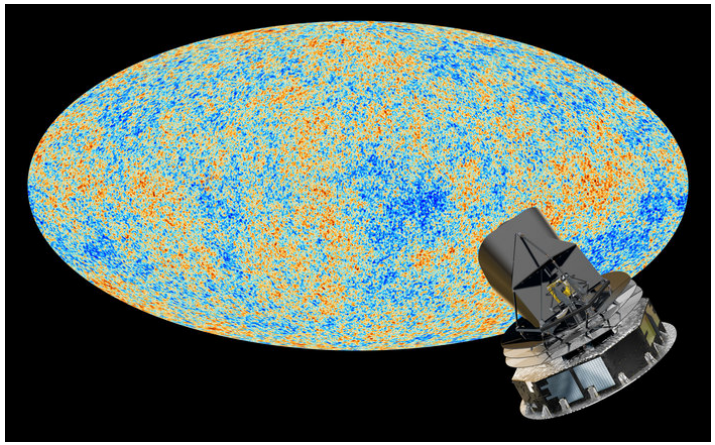
Standard model of cosmology



The large-scale structure

Galaxies, cluster of galaxies, super-clusters and filaments are the largest structures in the universe.

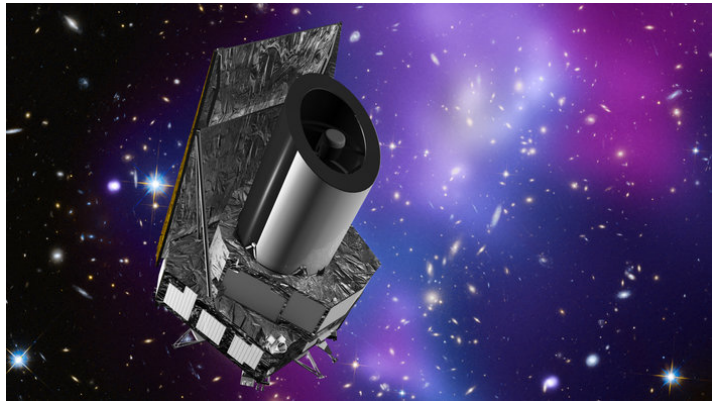
Planck mission



Credit: ESA.

- Planck is a space mission by ESA. (2009 - 2013)
- Mission: All-sky CMB survey using millimeter wavelengths; Primordial universe (inflation) and dark universe.

Euclid mission

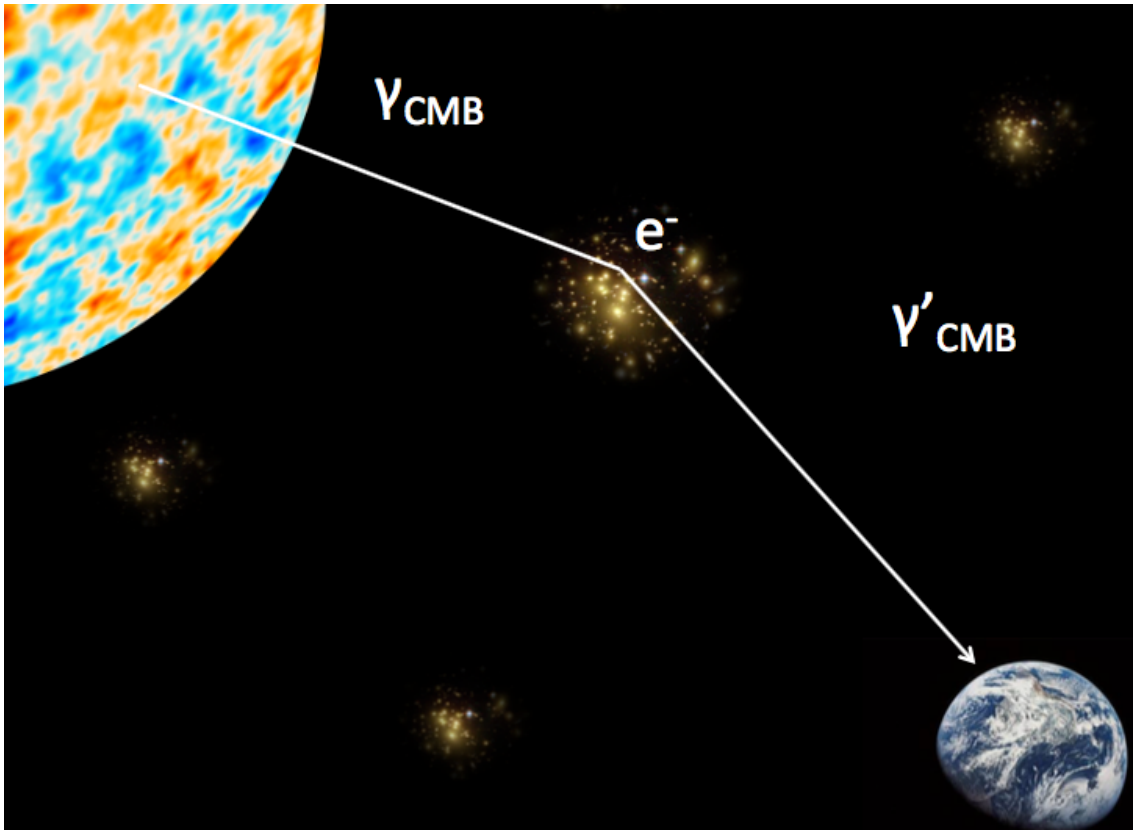


Credit: ESA.

- Launch date: 2020.
- Mission: galaxy surveys (1.5 billions galaxies) for studying the dark universe using visible and near infra-red wavelengths.

Data: Planck SZ cluster catalog

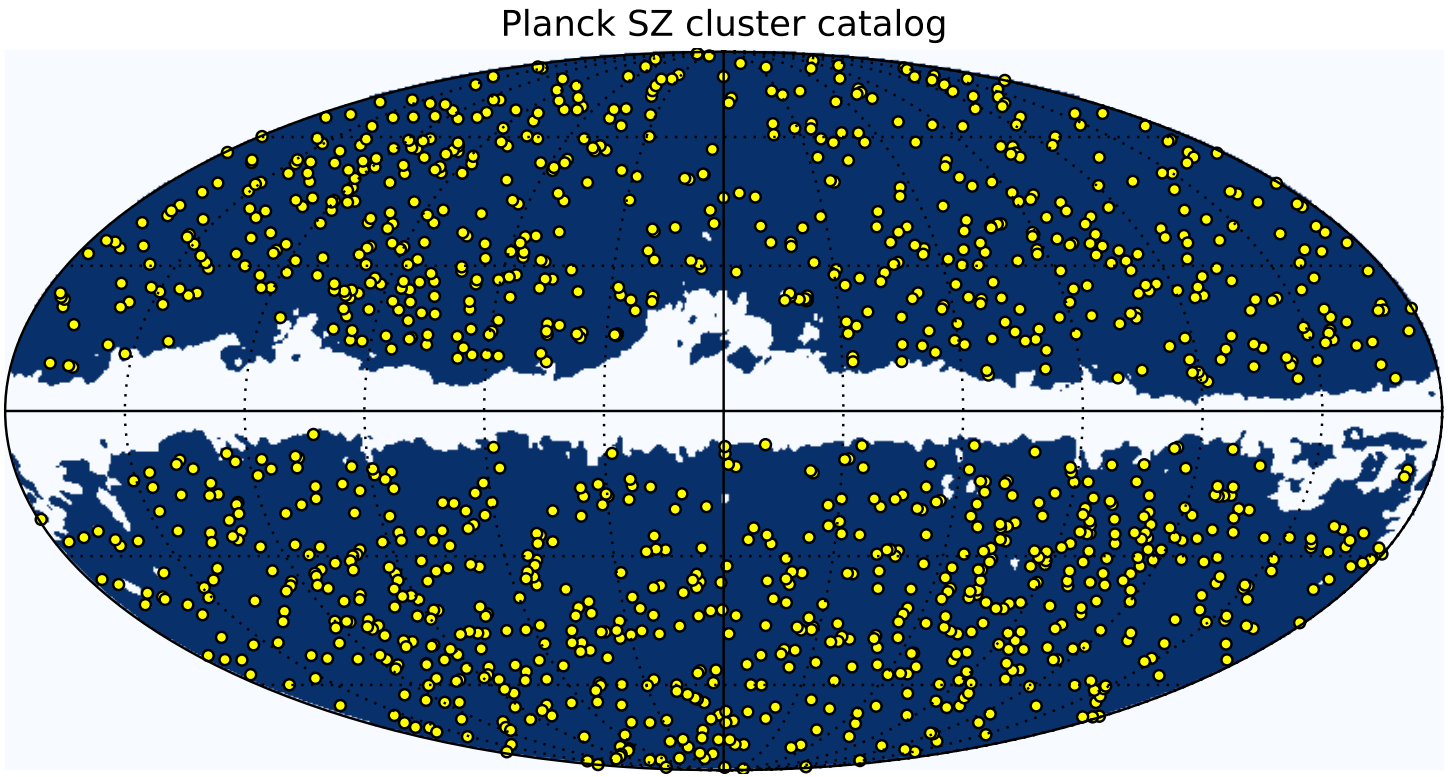
- Sunyaev-Zel'dovich effect



Credit: Roman's these

Data: Planck SZ cluster catalog

- Planck Sunyaev-Zel'dovich cluster catalog (1271 clusters) and the Planck mask map (white area)



Estimators of two-point correlation function

- Measure the excess probability respect to the uniform distribution of finding a galaxy in a sphere area $S(\theta)$ at an angular separation θ from another galaxy.

  Peebles & Hauser (1974):

$$1 + \hat{w}_1(\theta) = \frac{DD}{RR} \tag{1}$$

  Davis & Peebles (1983):

$$1 + \hat{w}_2(\theta) = \frac{DD}{DR} \tag{2}$$

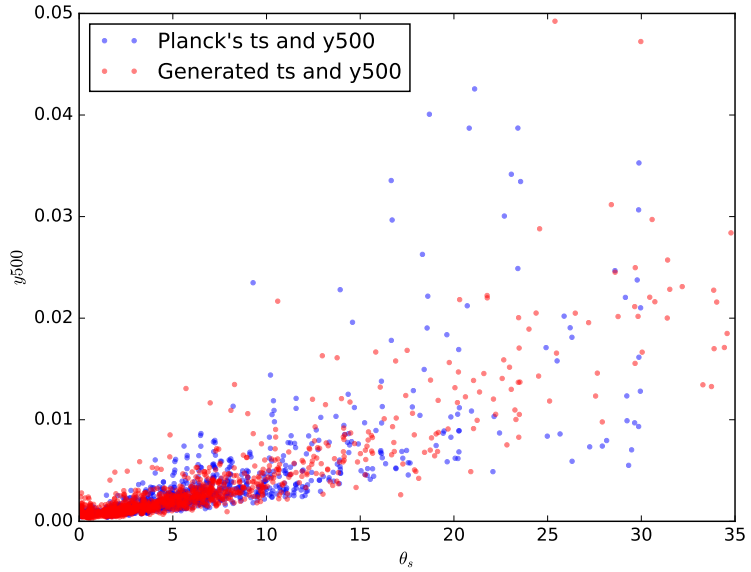
  Landy and Szalay (1993):

$$\hat{w}_{LS}(\theta) = \frac{DD - 2DR + RR}{RR} \tag{3}$$

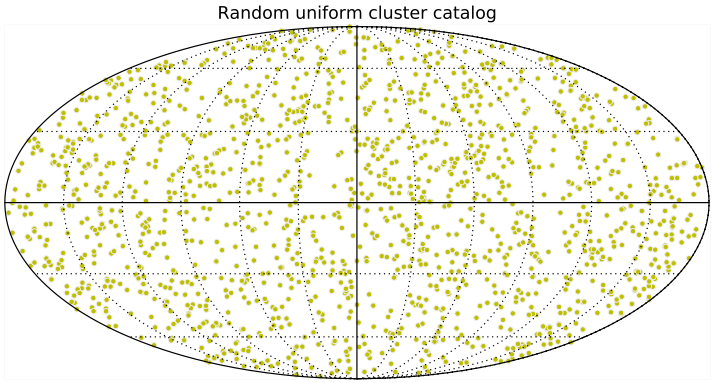
Random galaxy cluster catalogs

- Apply the Planck mask to random uniform clusters.
- Each random cluster has angular size θ_s that corresponds to a noise map σ_{y500} (32 noise maps of θ_s from 0.94 to 35.32 arcmin)
- Keep clusters have generated $y > 4 * \sigma_{y500}$.

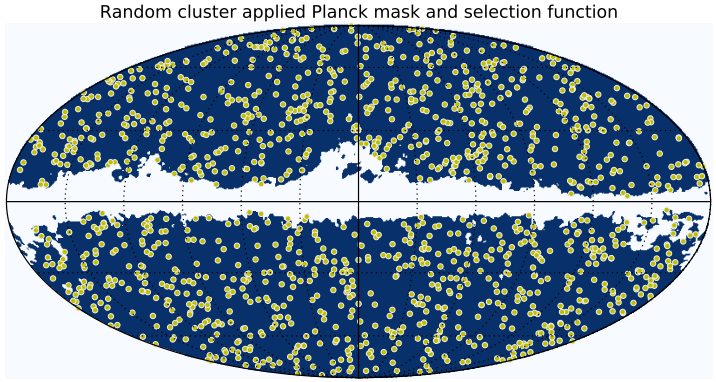
Generated θ_s and $y500$



Random galaxy cluster catalogs

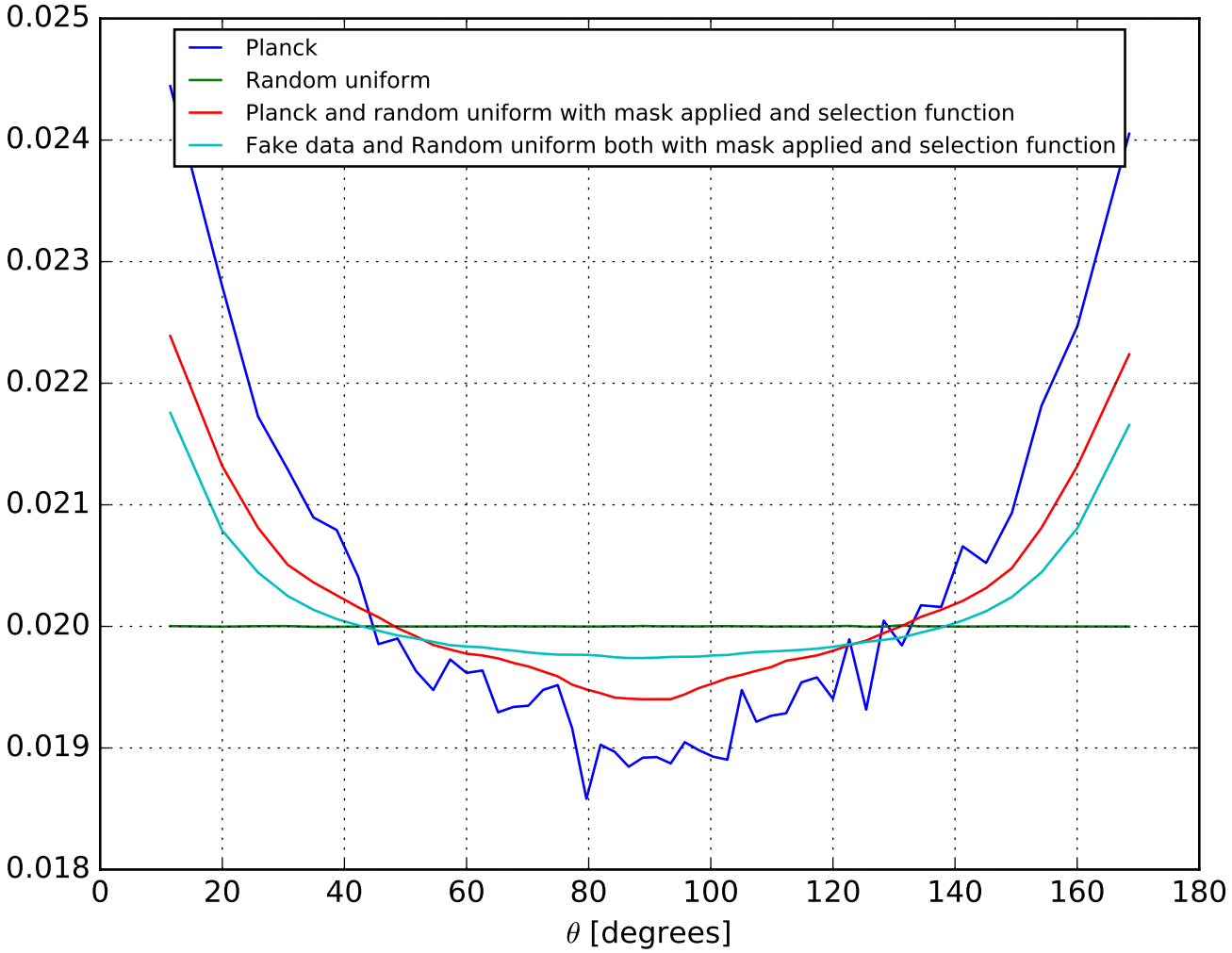


Random uniform catalog



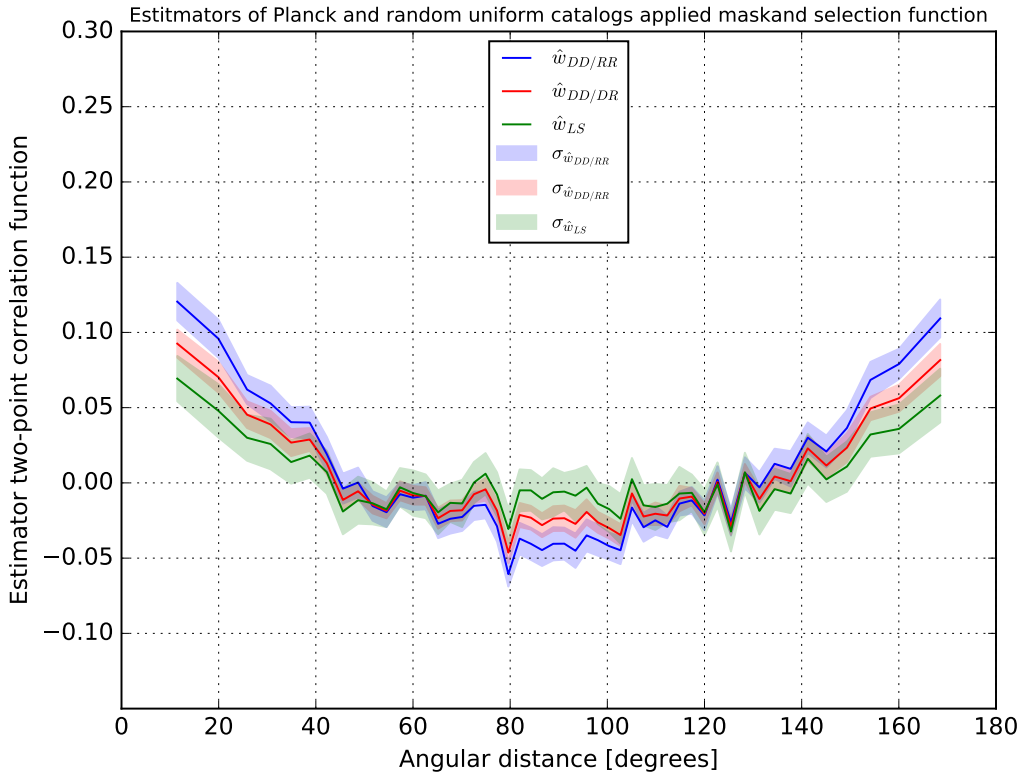
Random uniform with Planck mask applied and selection function

Angular distance of pairs statistics



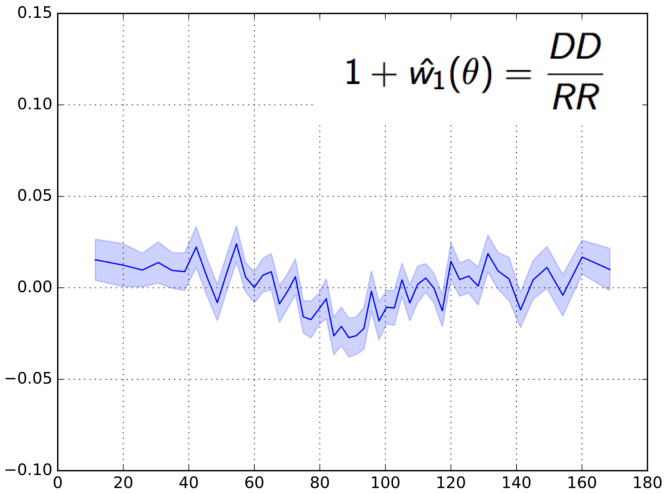
Estimators of Planck catalog and random catalogs

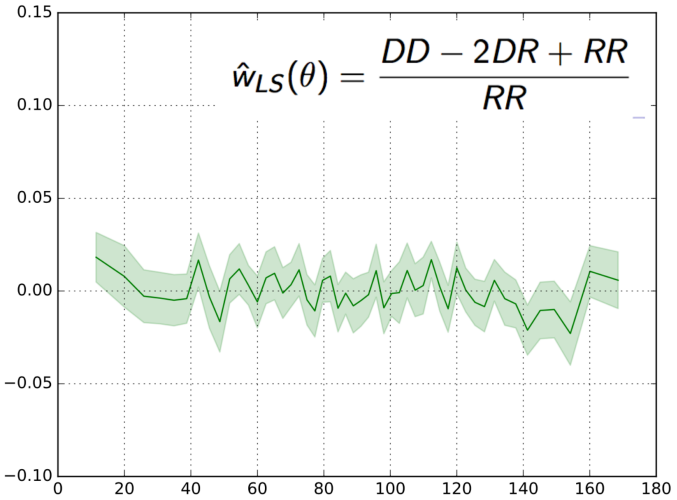
- Correlation function of Planck catalog and random catalogs with Planck mask applied and selection function.

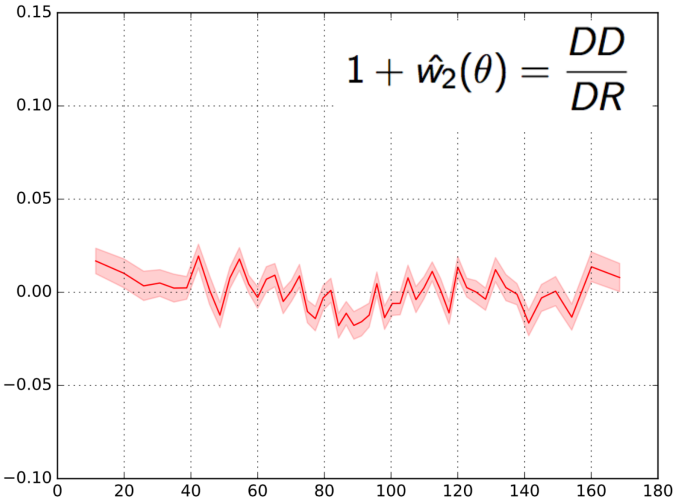


Comparing 3 estimators

Fake cluster catalog and random cluster catalogs, both with the Planck mask applied and selection function.

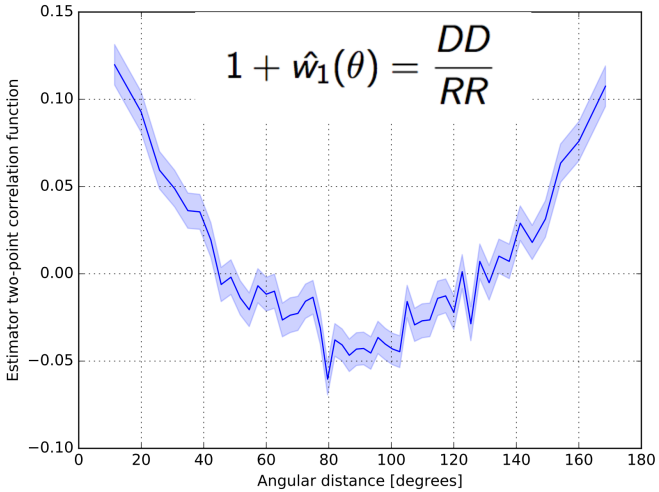


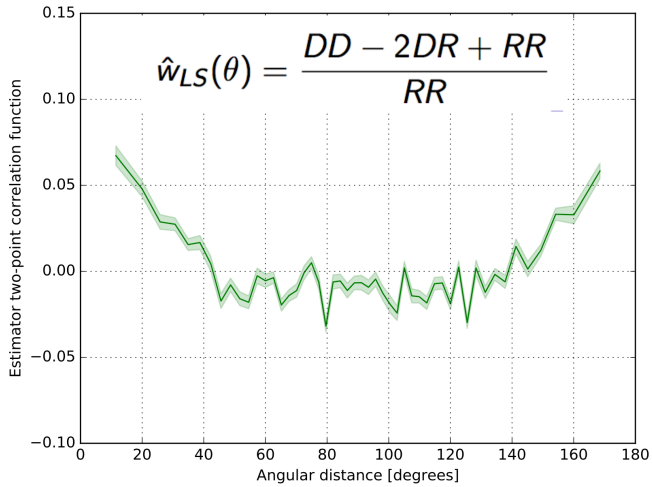


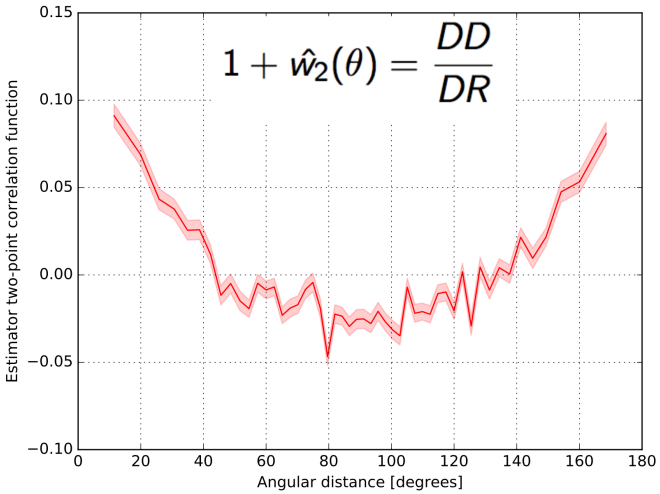


Comparing 3 estimators

Planck cluster catalog and random catalogs with the Planck mask applied and selection function

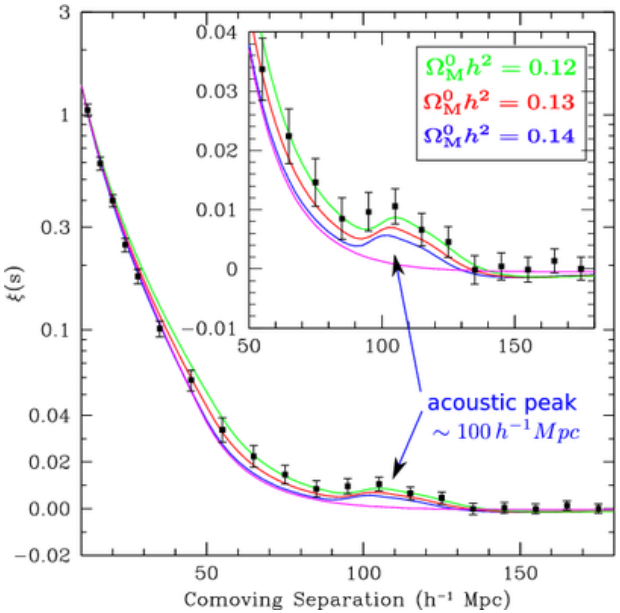




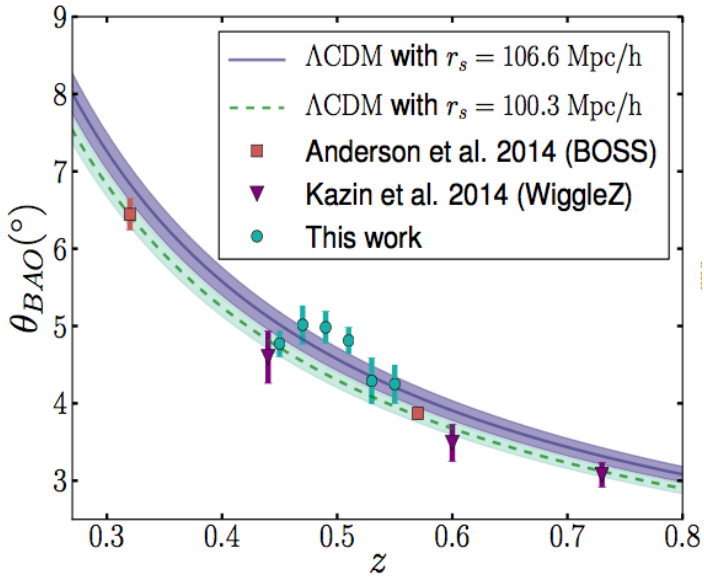


Expect for detection of Baryon acoustic oscillations

- Acoustic wave propagating in the early universe due to the counteracting forces of radiation pressure and gravity.
- The standard ruler for length scale in cosmology.
- Study the dark energy by constraining cosmological parameters.



(SDSS) - Eisenstein et al., 2005



(SDSS) - G. C. Carvalho et al., 2015

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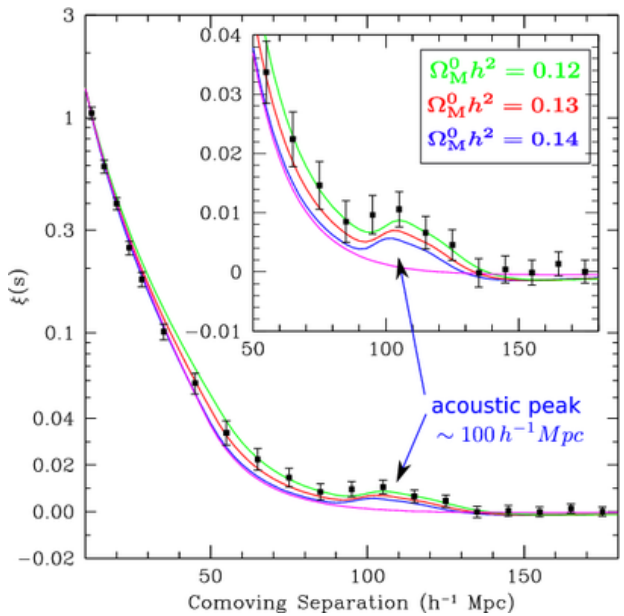
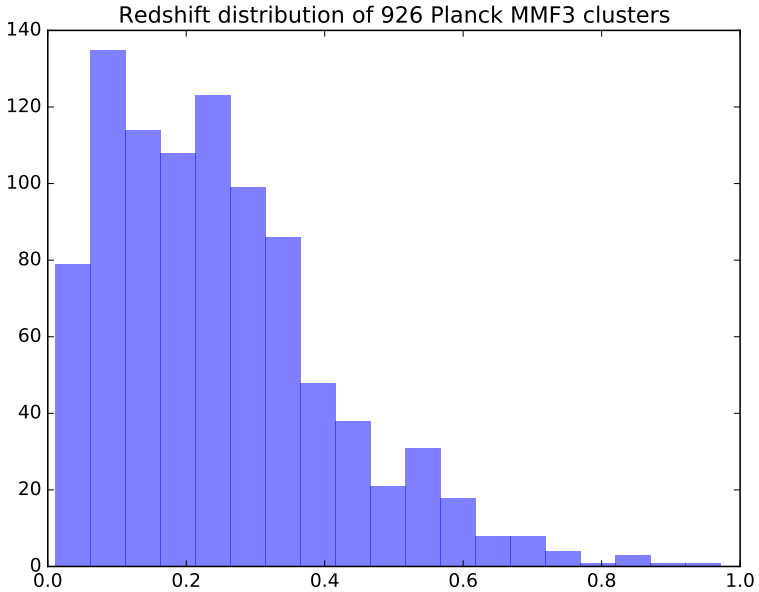
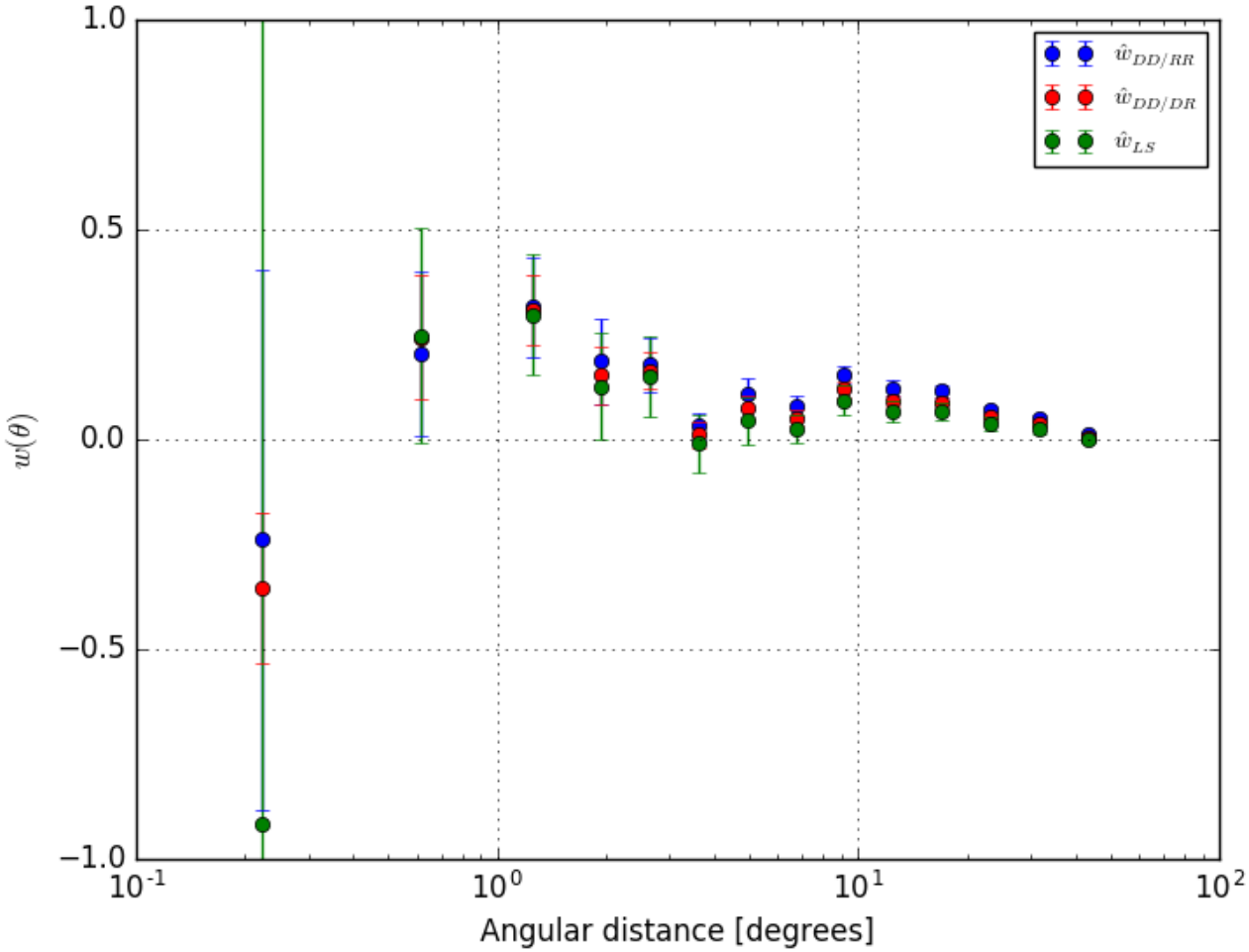




(SDSS) - Eisenstein et al., 2005

Ongoing work: Two-point correlation at smaller scale



High correlation around 10 degrees -> Expect to find the BAO signal

- High correlation of clusters at small angular scale.
- The distribution of Planck cluster catalog produce significant signal from the departure of the uniform distribution.
- The DD/DR estimator has the smallest dispersion, then following by the estimator DR, and the Landy-Szalay estimator respectively.
- Expect for the detection of BAO signal at angular scale around 10 degrees.

Future work

Estimating the angular correlation function with Euclid requires many steps (as work was needed to produce the Planck cluster catalog) :

- Calibrate and clean images
- Find galaxies in images and measure their photometry
- Measure their distances (or redshift) using spectroscopic and photometric redshift methods.
- Identify clusters

Thank you for your attention!