Fermilab U.S. DEPARTMENT OF ENERGY Office of Science

Understanding the Effects of Overlapping Galaxies in Dark Energy Probes

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Introduction

- How do we observe the Universe?
  - Photometric surveys take (2D) images of the night-sky.
  - The atmosphere blurs the shape of the galaxies, making them look wider.
- Overlapping galaxies
  - Galaxies that are in close lines-of-sight appear blended/overlapping.
  - Sometimes it is easy to distinguish between objects but sometimes it is not.
- Dark Energy measurements
  - We use the positions of galaxies to characterize dark energy (and dark matter).
  - If the position of galaxies are not clear (or if we don't know if there's one galaxy or two) the information that we infer may be incorrect!

What is LSST?

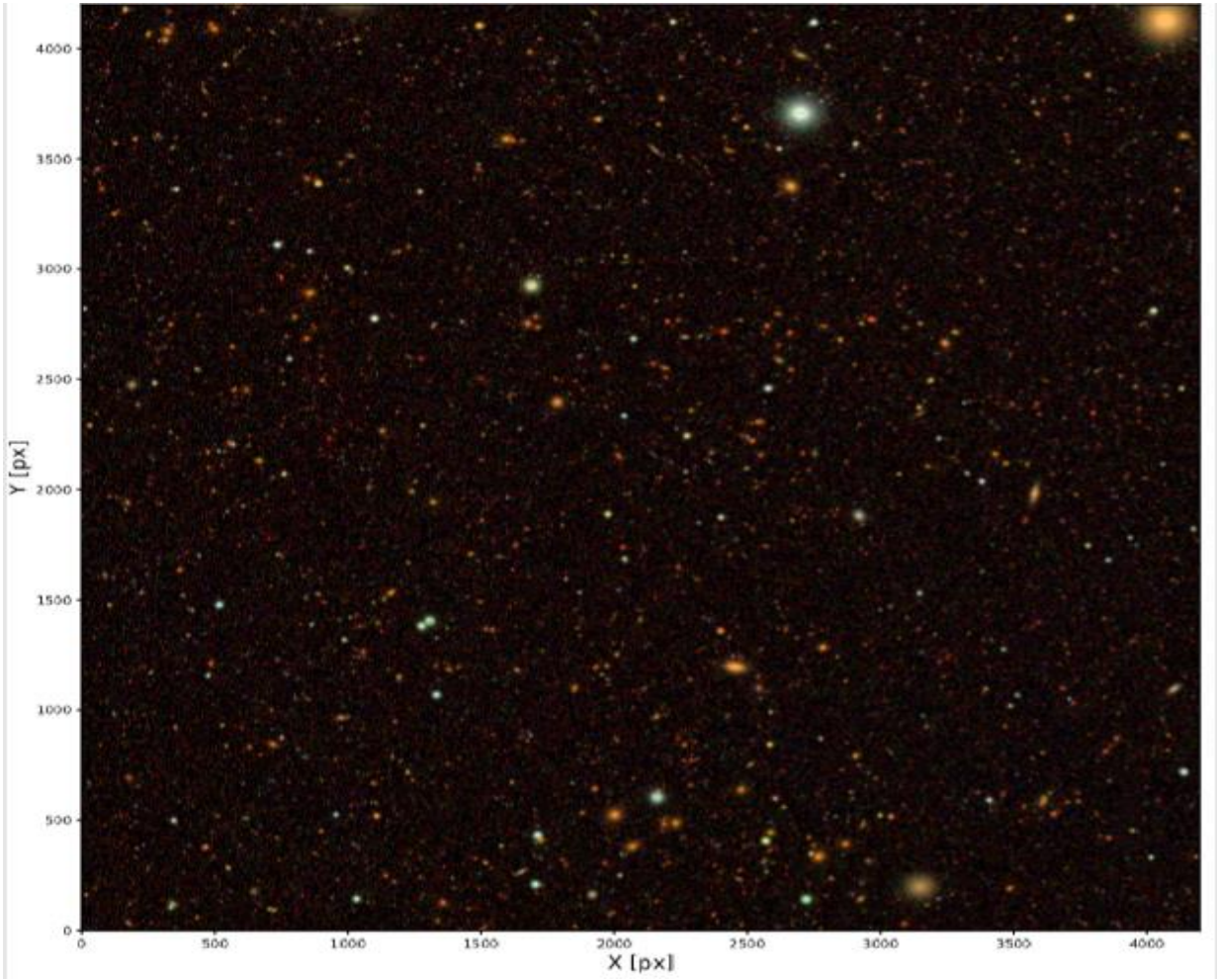
- The Legacy Survey of Space and Time is a photometric survey that will be carried at the Vera C. Rubin Observatory at Cerro Pachón (Chile). Planned to start in 2022.

Status of the site on Apr 14th 2020.
Image credits: lsst.org/ Google Maps

Data Set

- Dark Energy Science Collaboration Data Challenge 2 (DESC DC 2)
  - DC2 is the second of the three planned data challenges
  - DC2 entails the production, validation, and analysis of:
    - 5,000 sq.-deg mock catalog (extragalactic catalog)
    - 300 sq.-deg end to end simulation and image processing (100 M CPU hours)
  - From the DC2 catalog comes:
    - Cosmology simulation output
    - Image files
    - DM catalog
  - Simulation image used:
    - ~ 300 sq-degrees of simulated Rubin Observatory data in 6-band (u, g, r, I ,z, y) at 5-year depth

Image from DC2



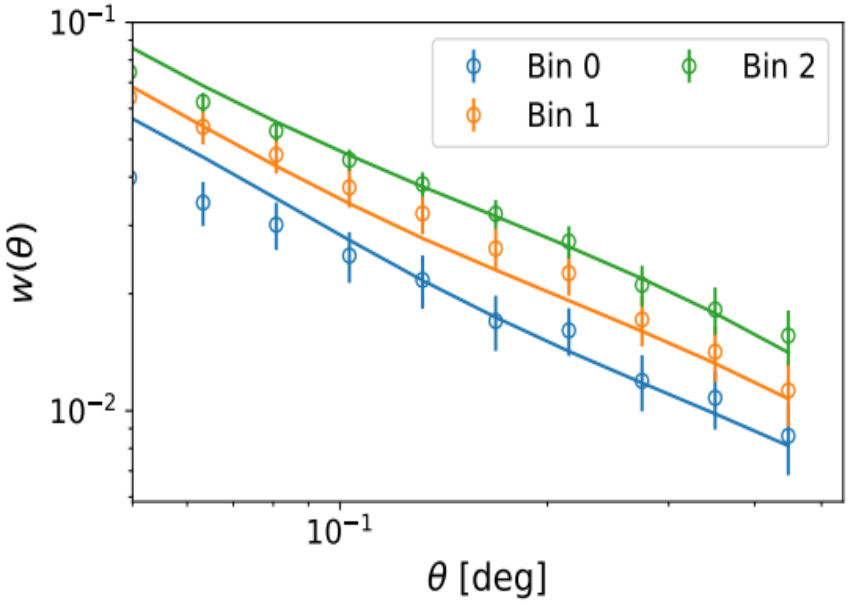
- color composite of a 2.2i-DR3 (2 year) coadd image of the g, r, and i channels using g as blue, r as green and i as red

Two-point correlation function

- The two-point correlation function $\xi(r)$ is defined so that the joint probability of finding galaxies in the volume elements $\delta V1, \delta V2$ separated by a distance r is

$$\delta P = n^2[1 + \xi(r)]\delta V_1 \delta V_2,$$

- Select a circle of radius, r
- We can determine the number of particles inside of the circle
- For every particle we measure the distance with its neighbors and then count the number of pairs within a certain distance



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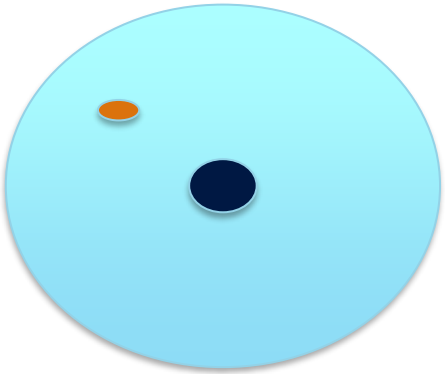
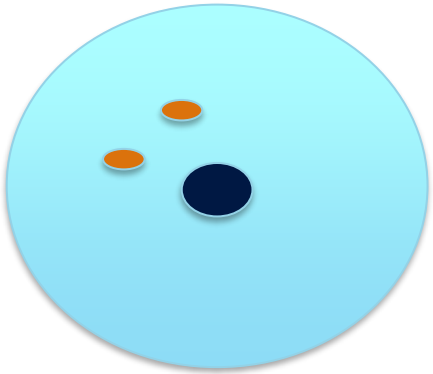
Methods

- Measure the 2-point correlation function using the Landy and Szalay estimator
  - how galaxies cluster together at different angular scales (separation between pairs)
- Matched the samples (1-to-1 vs multiple-to-1 vs all-to-1)
    1. Use a KDTree to find neighbors within 1 arc second radius



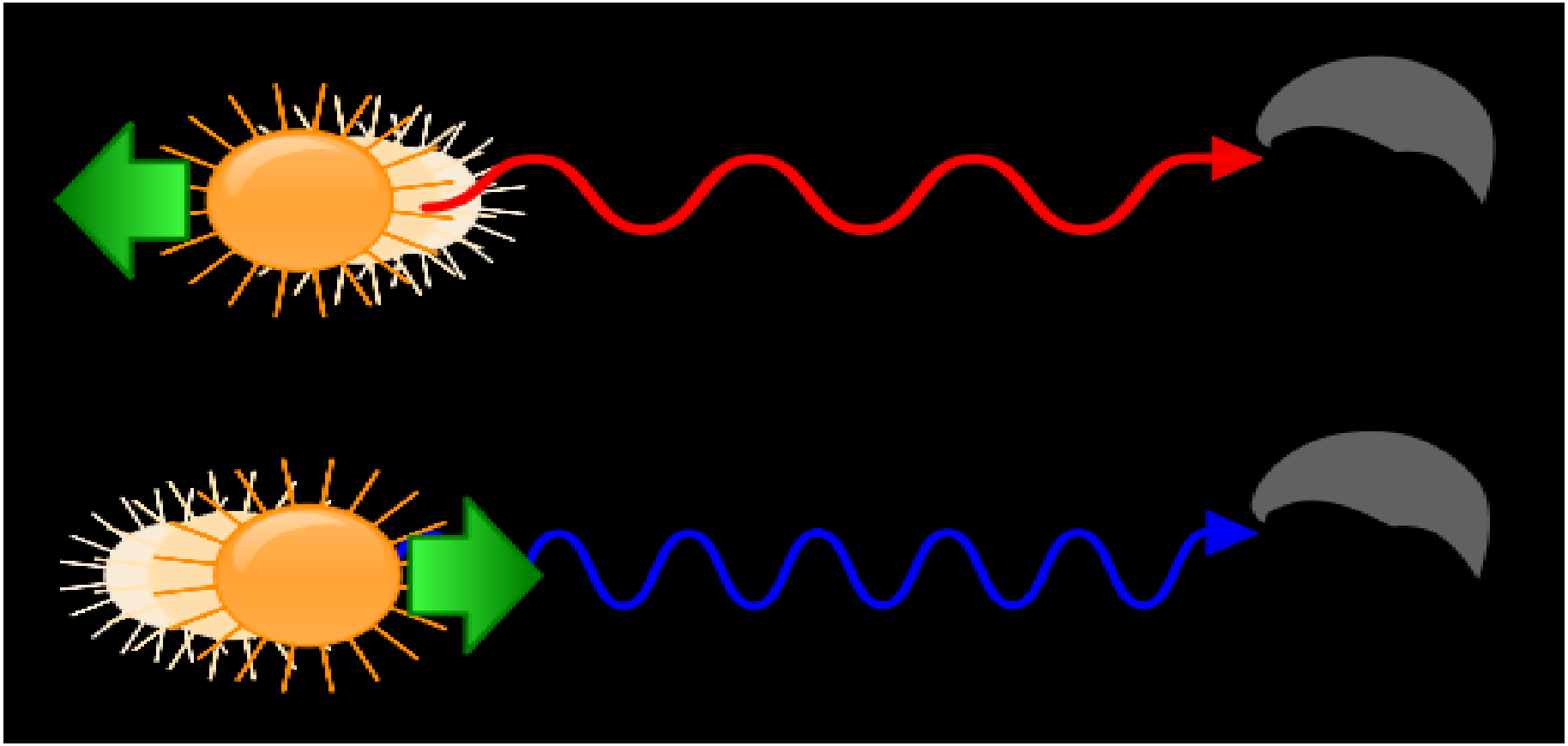
One to one match



Two to one match

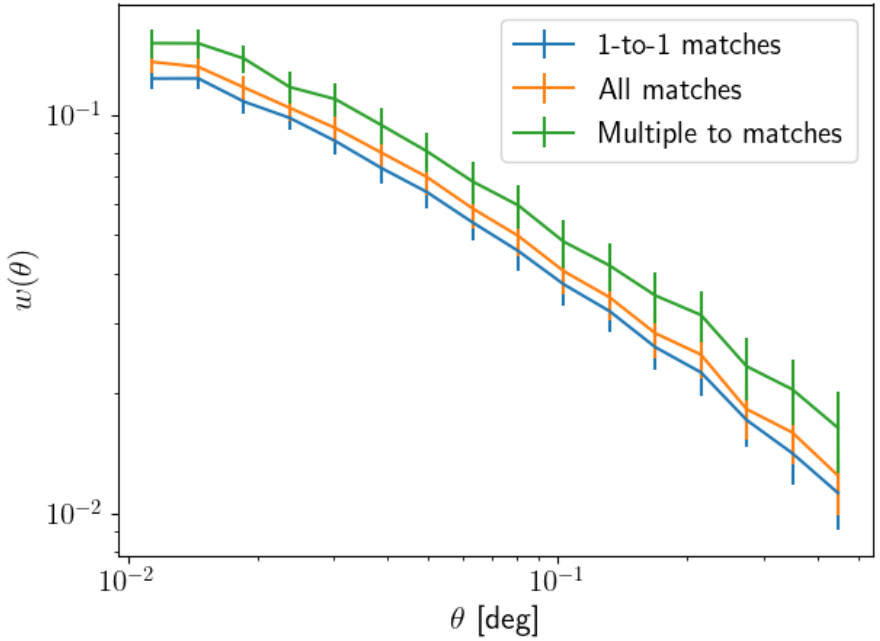
Redshift

- Describes how light shifts toward shorter wavelengths as objects in space move closer to us
- Tells us how fast things are moving, but in cosmology these velocities are identified with “distances”



Results

- Measured the correlation functions
- appreciated some differences between 1-to-1 and others,
  - still have to confirm that this is not due to statistical fluctuations



Comparison of the correlation function of the one-to-one matches and the multiple to one and all the detected objects for the slice $0.3 < z < 0.4$

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Next Steps

- increase statistical power (increasing sampling size)
- translate differences into cosmological parameters

References

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