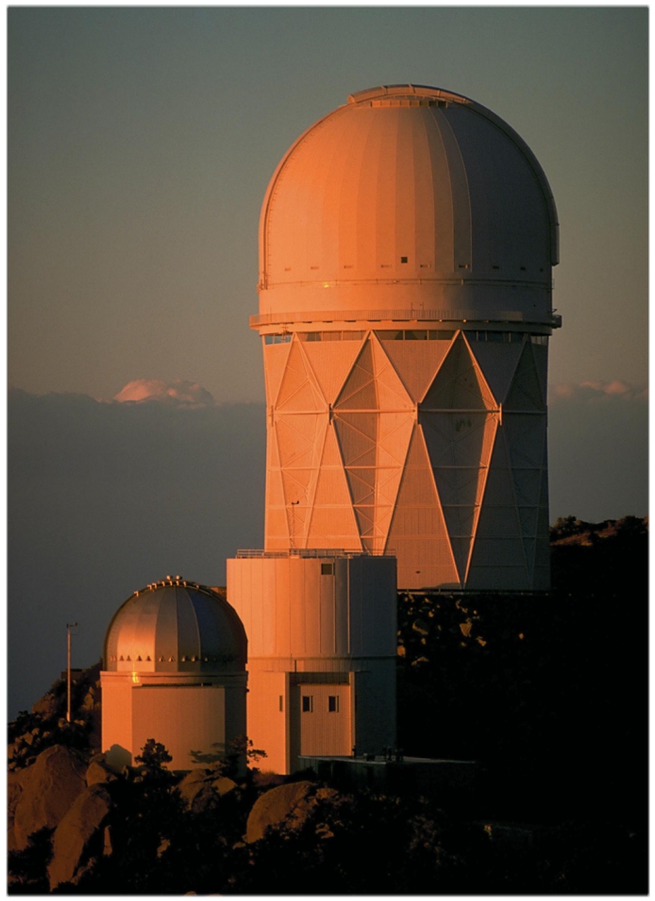
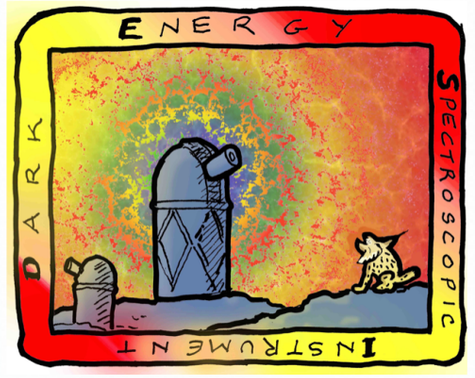


DESI Fibre Assignment

Mitigating redshift incompleteness in the DESI survey

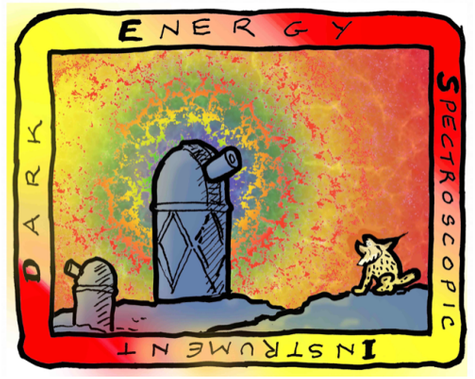
Husni Almoubayyed and Shaun Cole

Outline



- ✦DESI
- ✦DESI's Fibre Assignment
- ✦Correlation Function and Incompleteness
- ✦Weights and Corrections to Correlation Functions
  - ✦Redshift-dependent weights
  - ✦Small-scale correction
  - ✦Large-scale cell correction
  - ✦The combination of corrections

DESI



✦DESI survey will start in 2020 to measure impact of dark energy on the accelerating expansion of the Universe using BAO [measures $d_A(z)$ and $H(z)$]

➡ Accurate measurements of 3D correlation

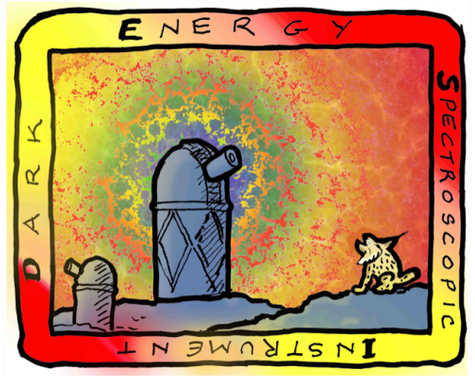
✦Additional science goals: measurements of growth factor, sum of neutrino masses, and inflation spectral index.

✦Will obtain spectra of galaxies and quasars

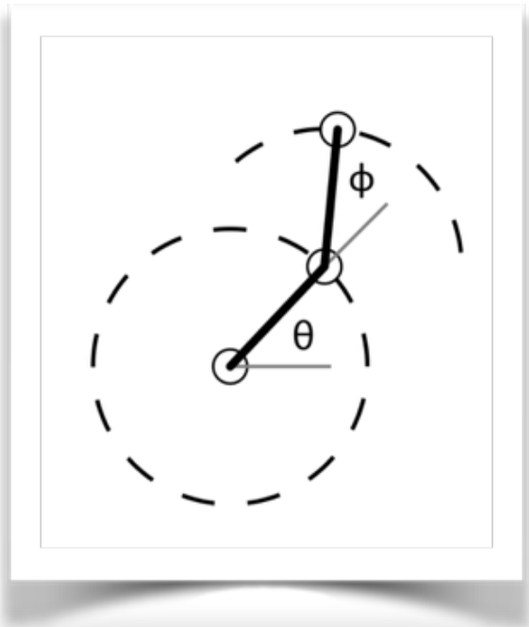
✦14,000 degrees^2 coverage; 25 million targets; 3.2 degree field of view

✦For BGS, 10 million galaxies; magnitude up to r = 19 ~ 20

Fibre Assignment

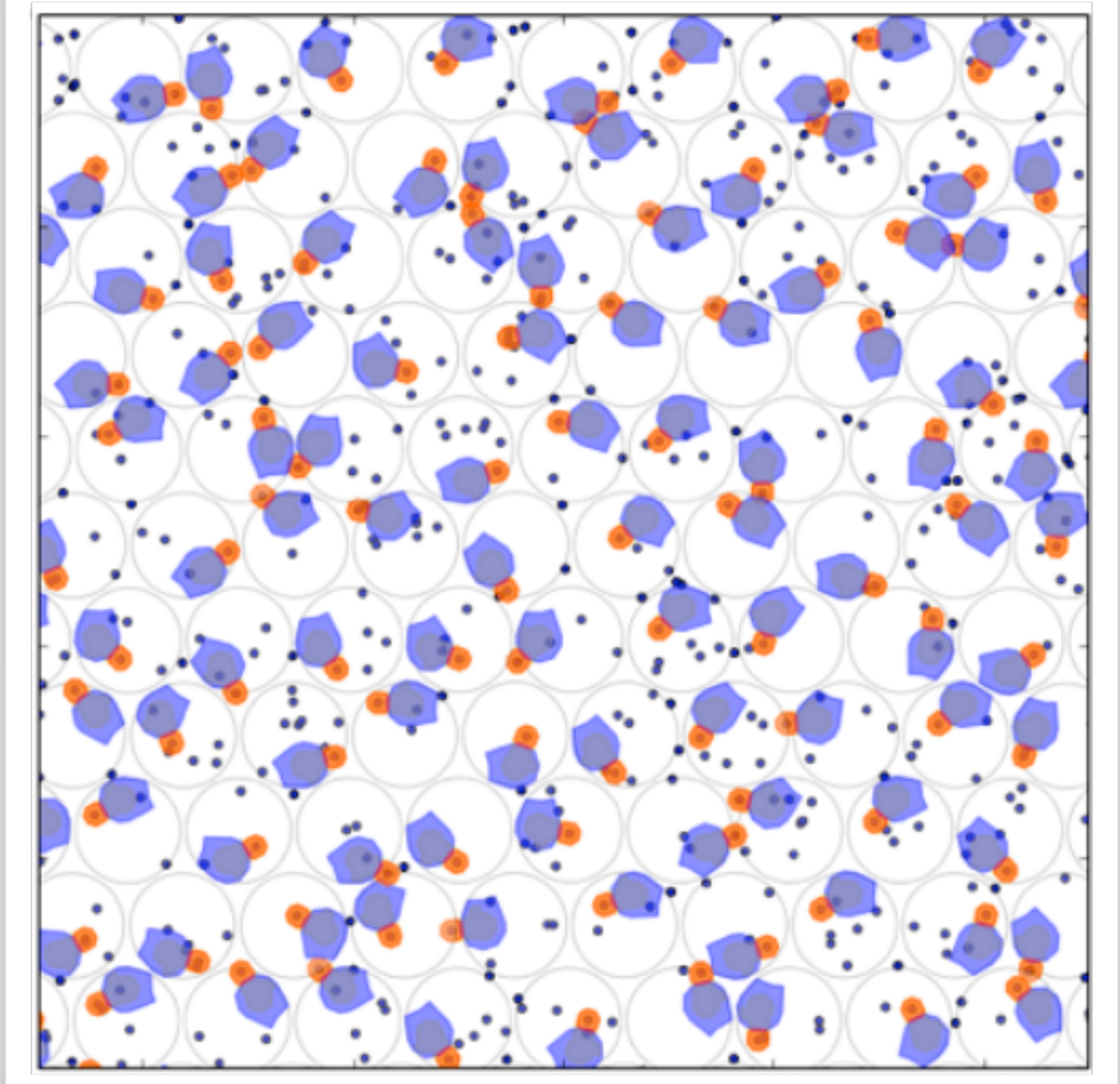


- Spectrograph with 5000 fibre positioners.
- Scans same patch of sky three times + areas of overlap.
- Galaxies will be missed
- Incompleteness 5% ~ 15%



credit: Michael Levi

Fibre Assignment

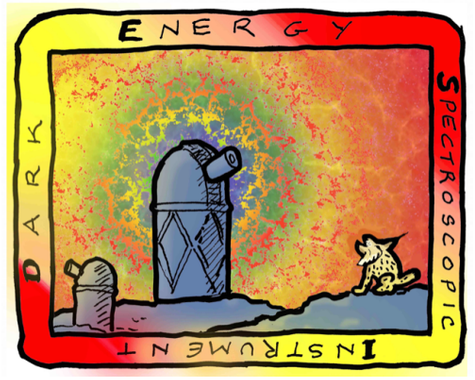


credit: Jaime Forero-Romero

Blue dots: galaxies
Red dots: quasars
Blue blobs: fibre targeting

No priorities for BGS (QSOs prioritised for dark time survey)

Motivation



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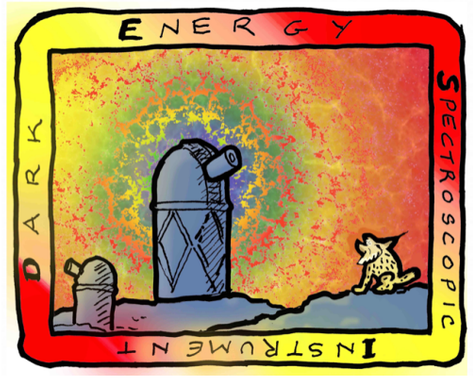
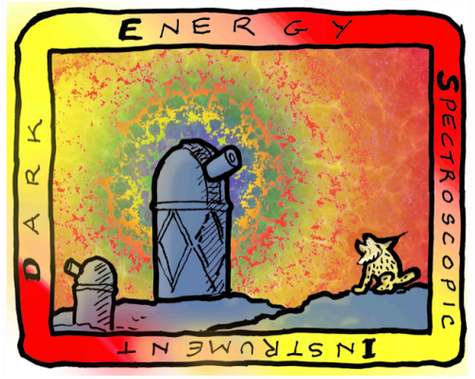


✦Redshift incompleteness is not random

Motivation



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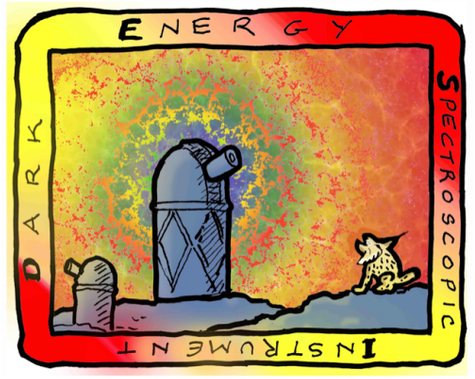

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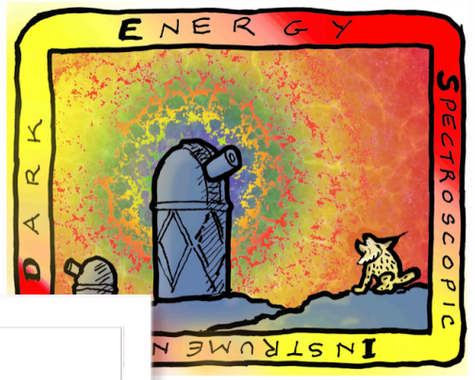
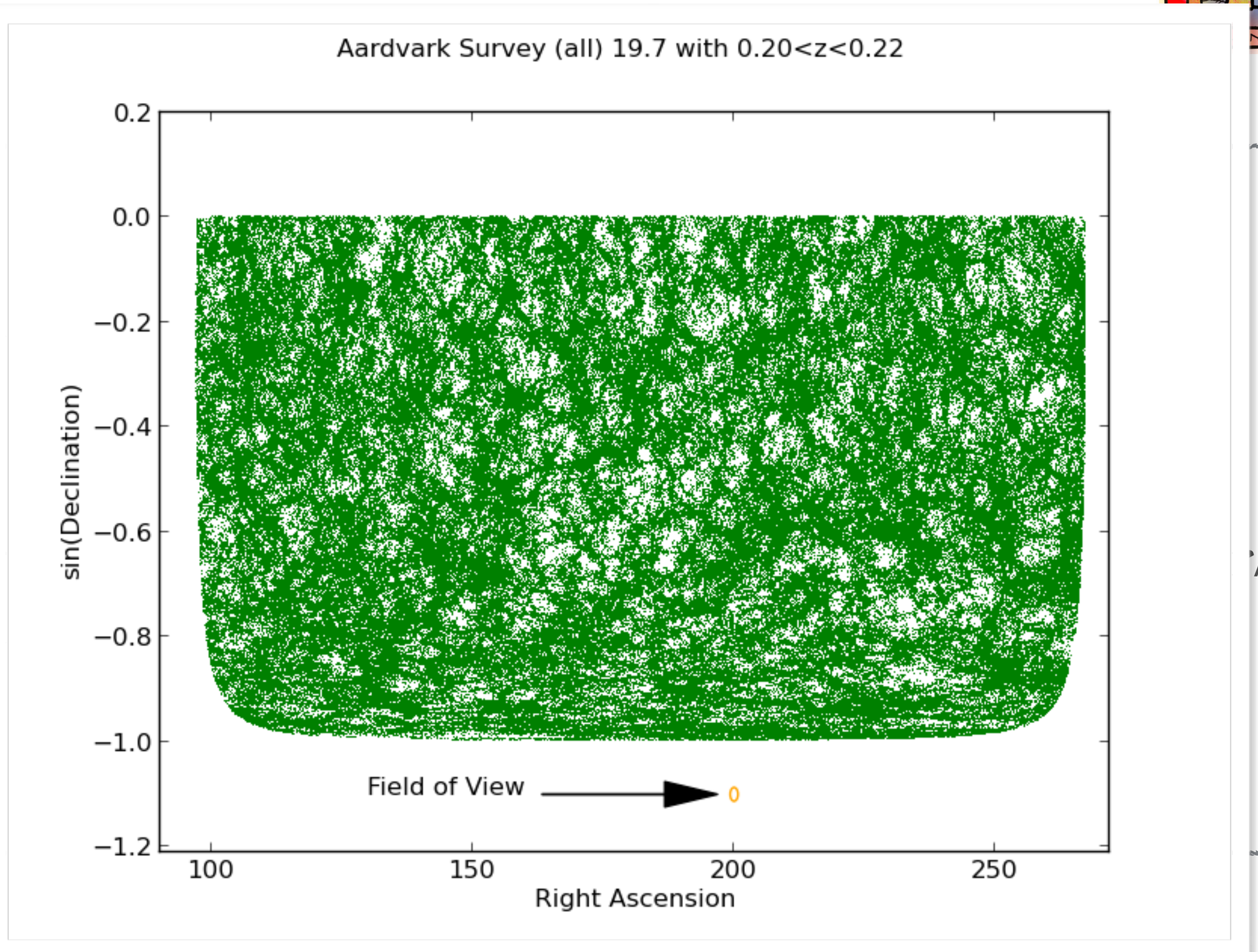
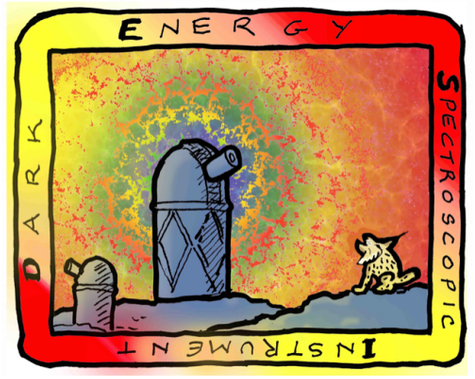

ENERGY
SPECTROSCOPIC
INSTRUME
DARK


Aardvark Survey (all) 19.7 with 0.20<z<0.22
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
sin(Declination)
Field of View
0
100
150
200
250
Right Ascension

Motivation



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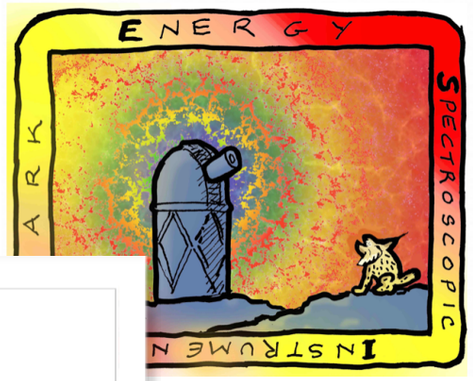
ENERGY
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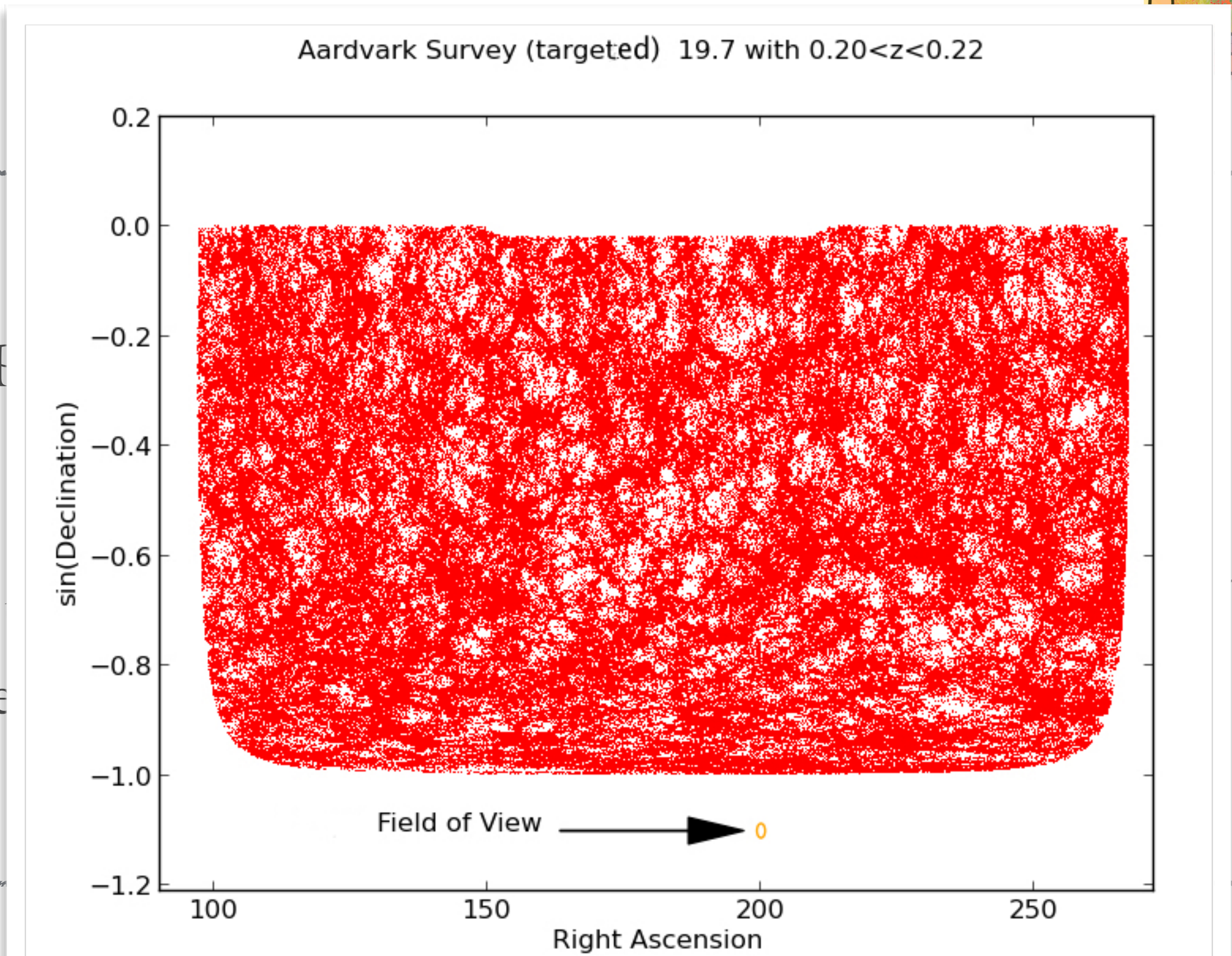
ARK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sin(Declination)
0.2
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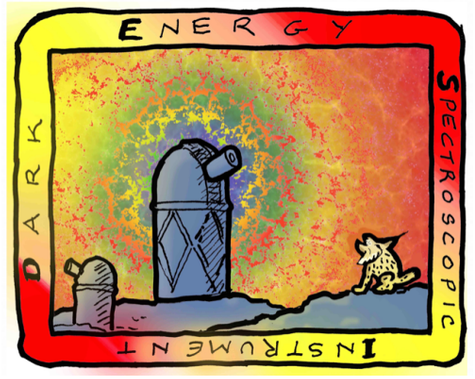

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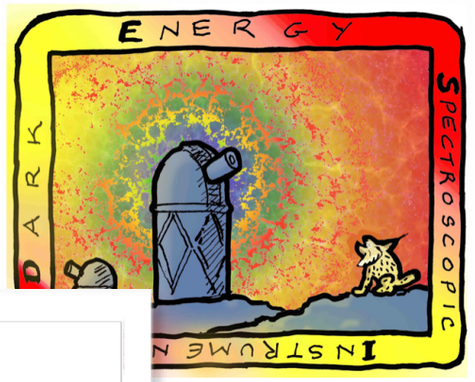
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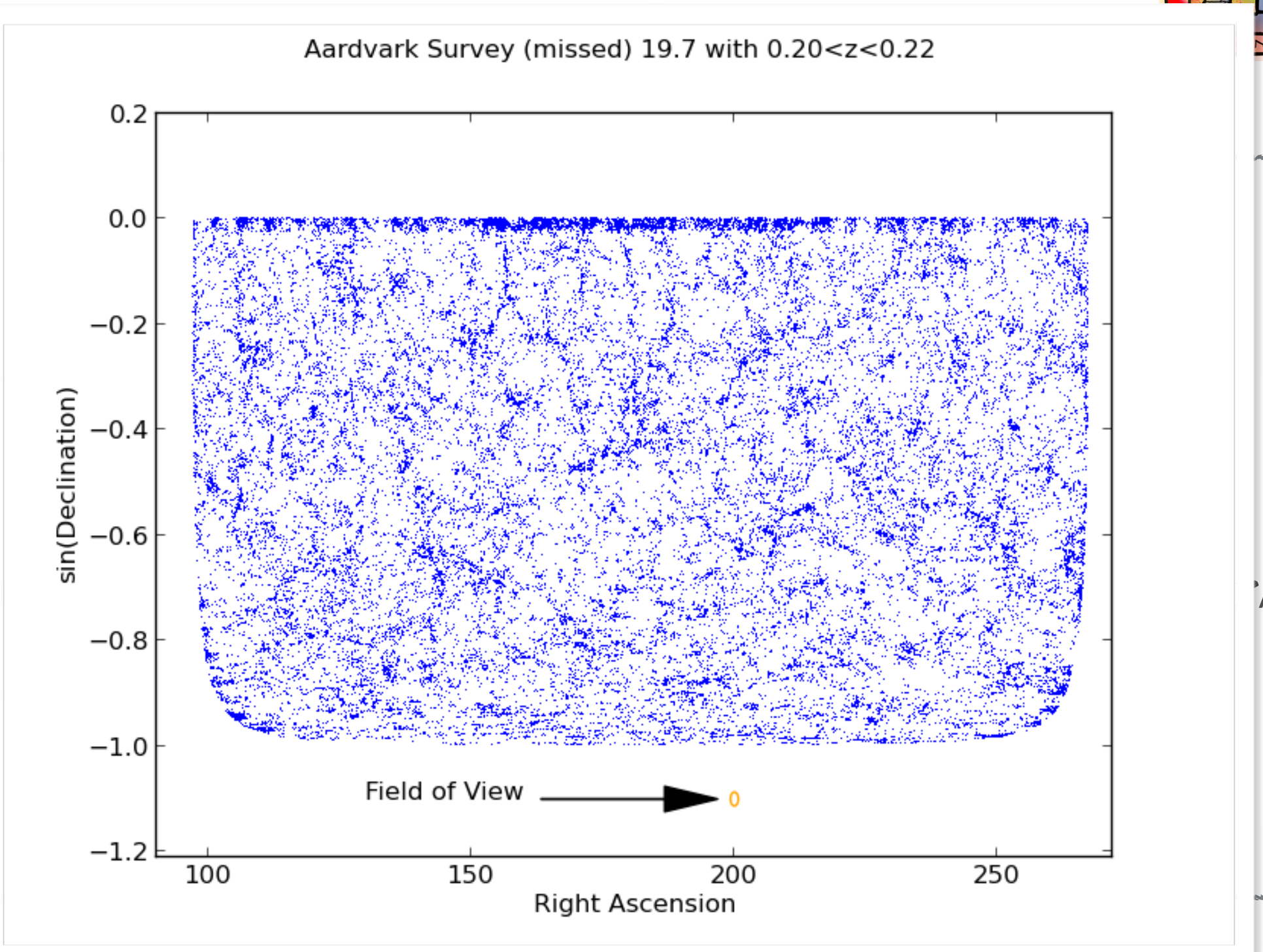
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sin(Declination)
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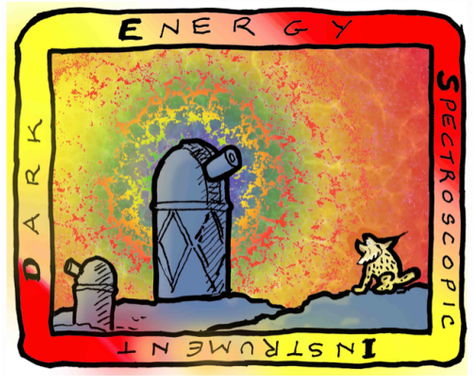

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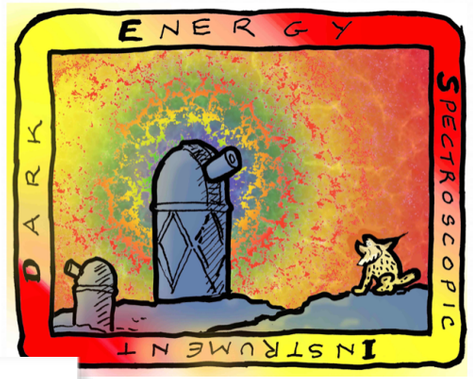

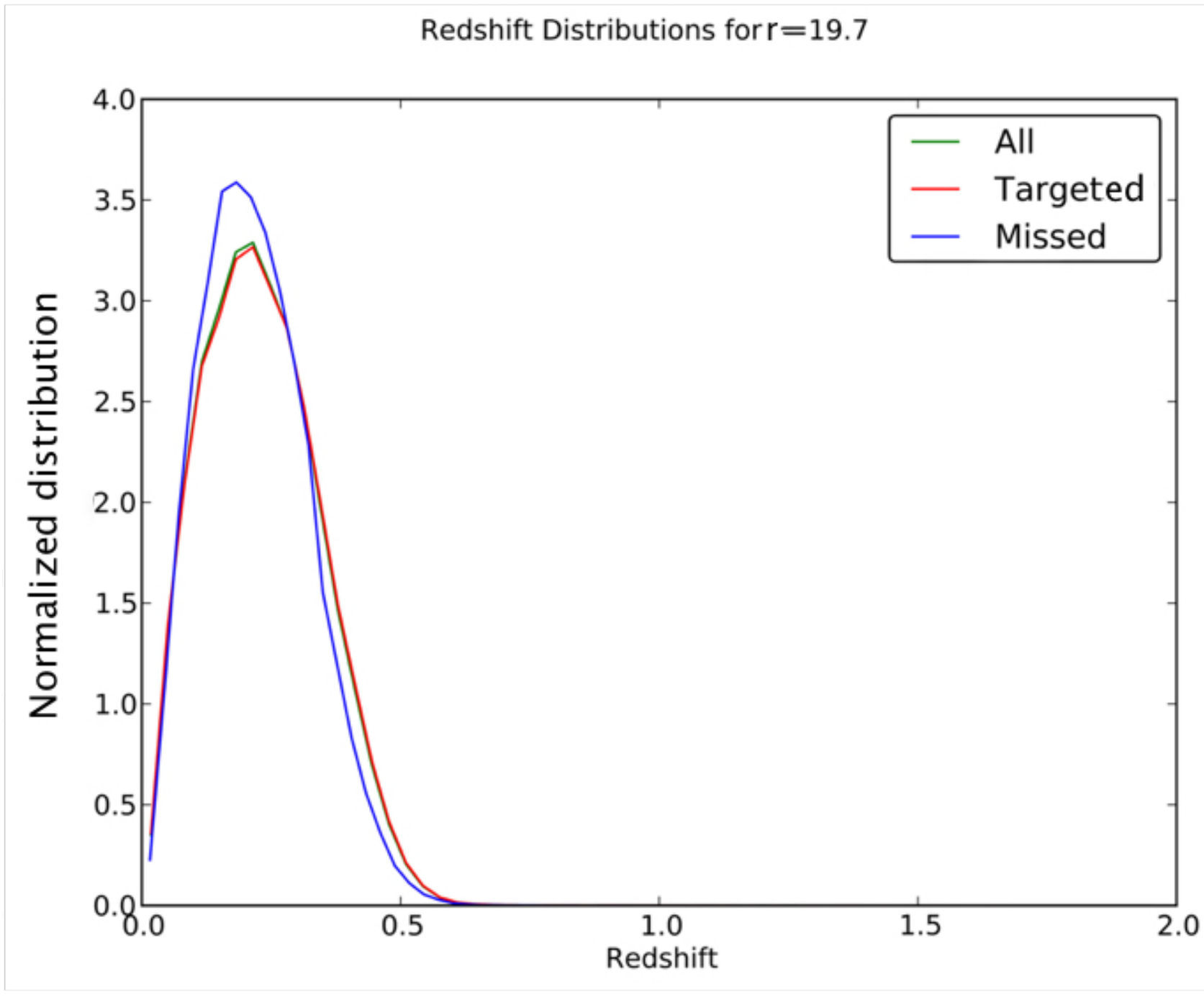

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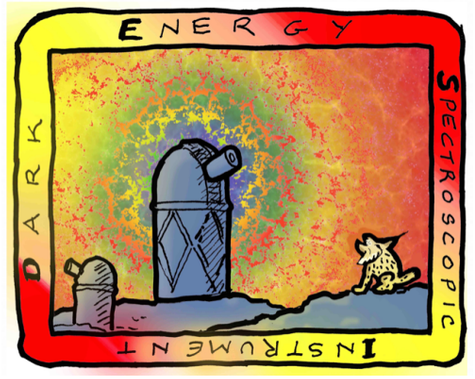

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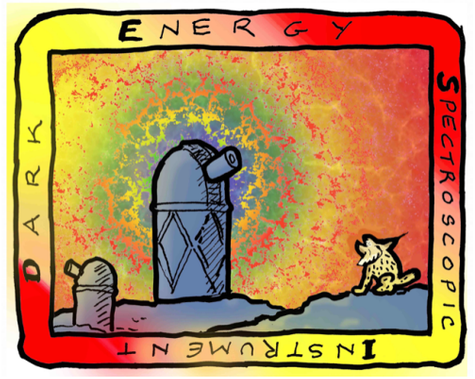
The Correlations

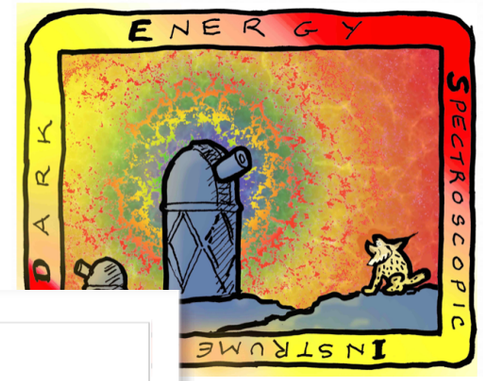


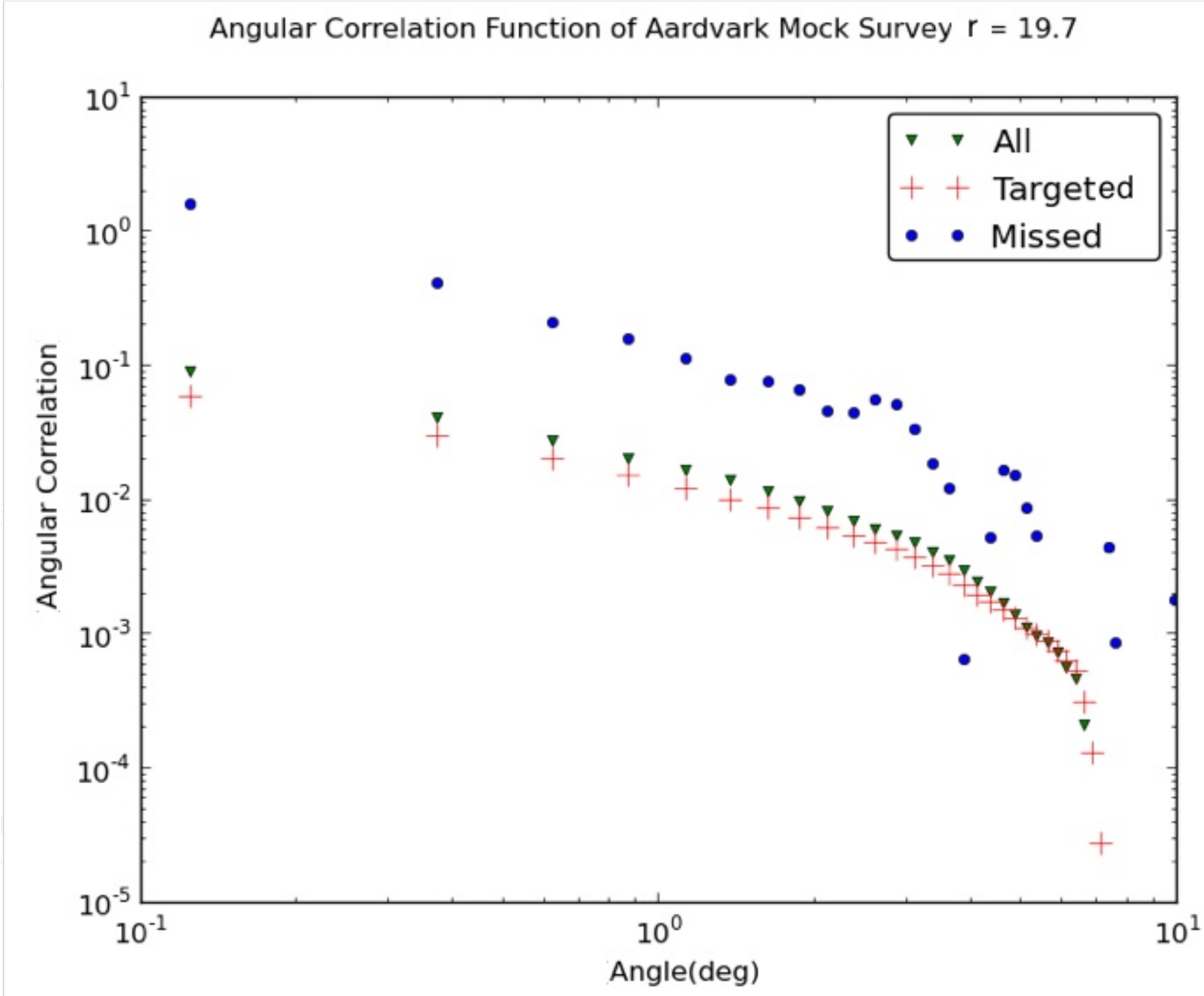
$$\xi(r) = \frac{DD - 2DR + RR}{RR}$$

- Spherically averaged 'Monopole' correlation function and angular correlation function.
- 'DD', 'DR' and 'RR' are data-data, data-random and random-random normalized paircounts.

Landy & Szalay, 1993

The Correlations





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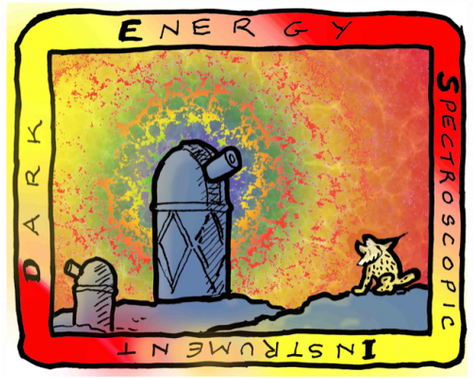

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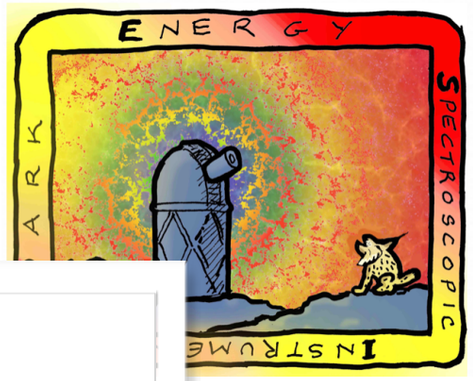

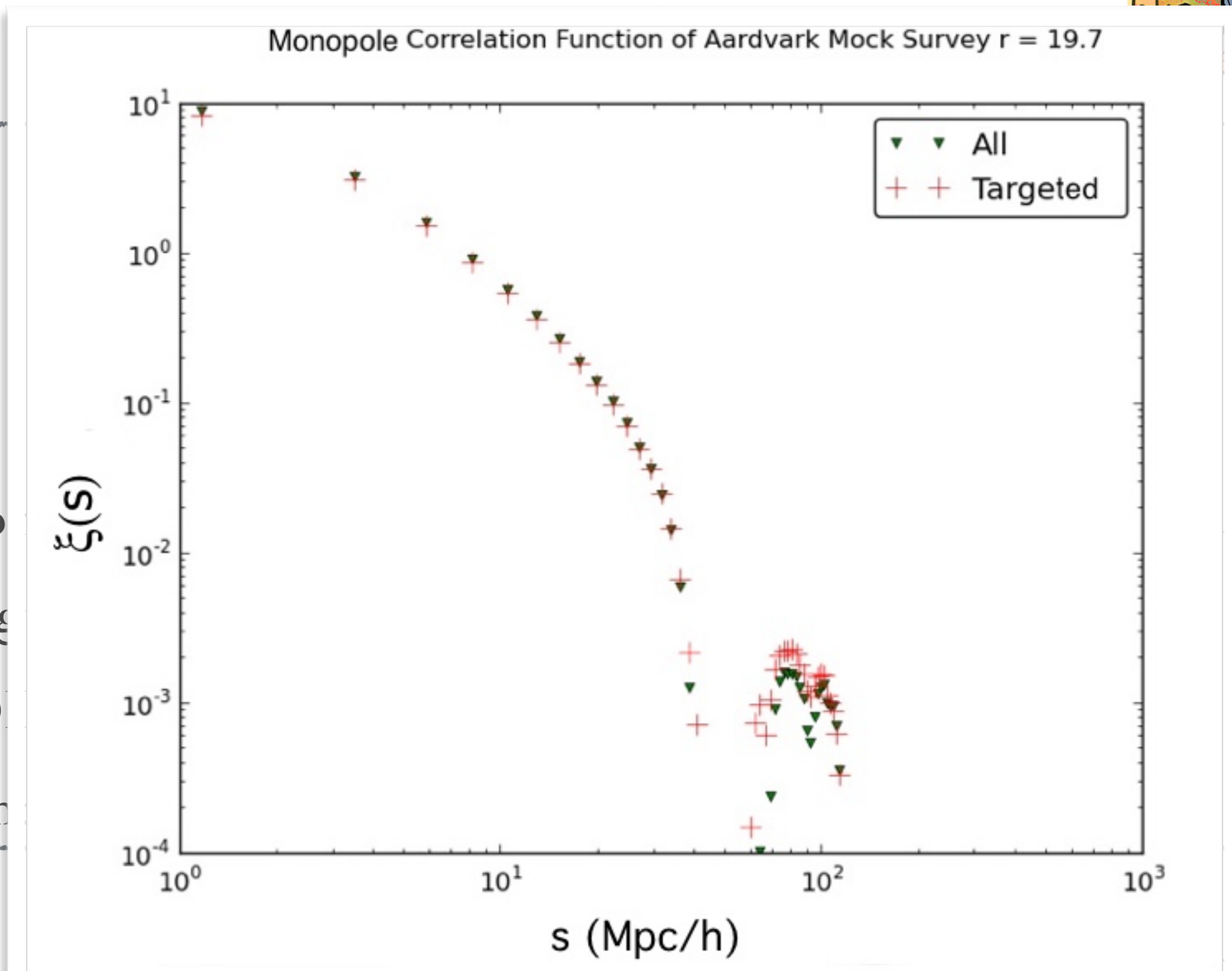

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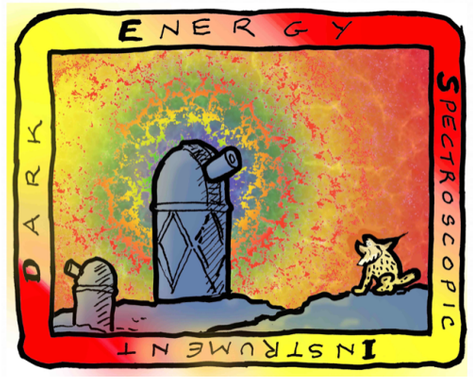

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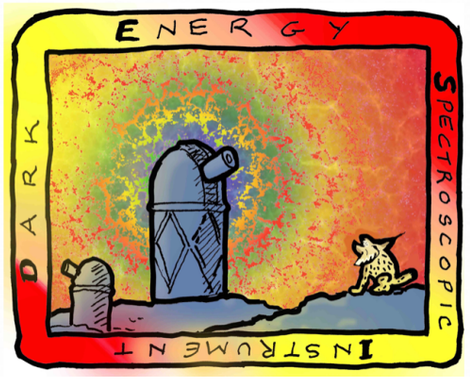
Redshift Dependent Weights

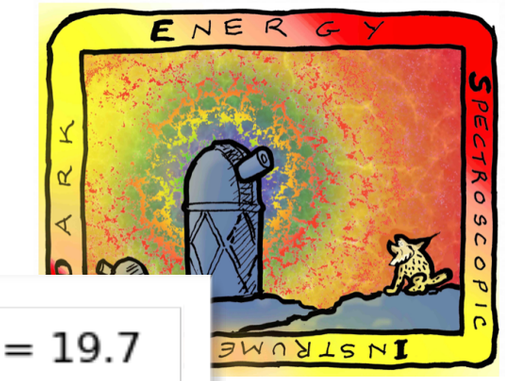


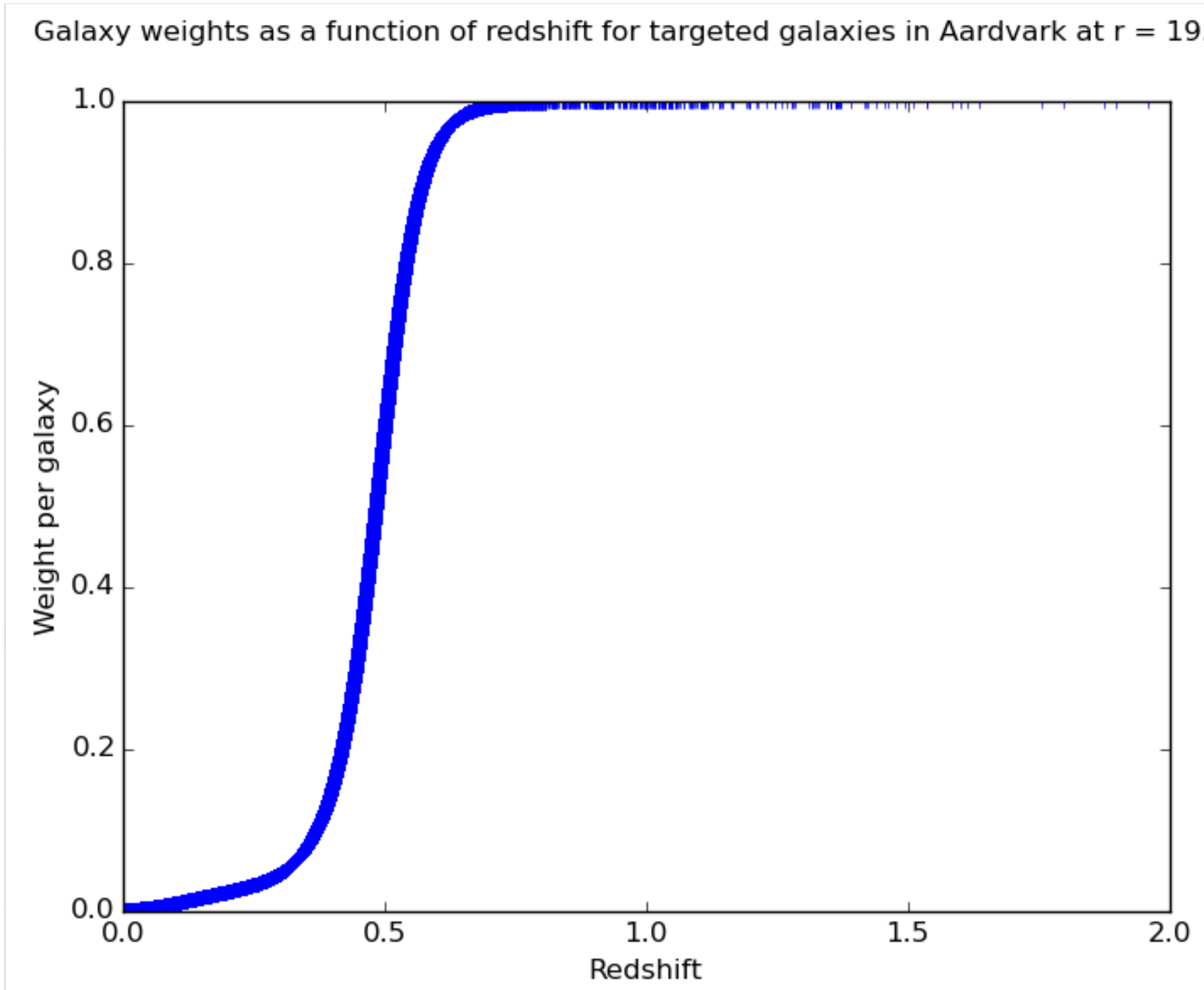
$$w_i = \frac{1}{1 + 4\pi J_3 N(z)}$$

- Used $4 * \pi * J_3 = 3000$
- Increases effective redshift
  - ➡ peak shift from 0.3 to 0.5

Feldman, Kaiser & Peacock 1994

Redshift Dependent Weights





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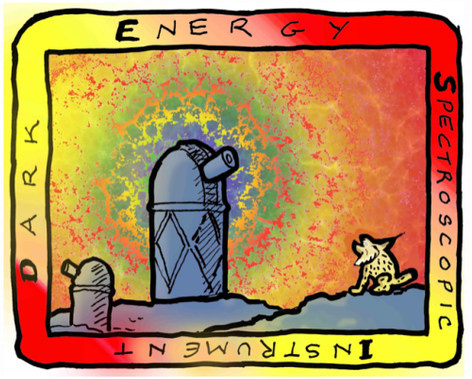

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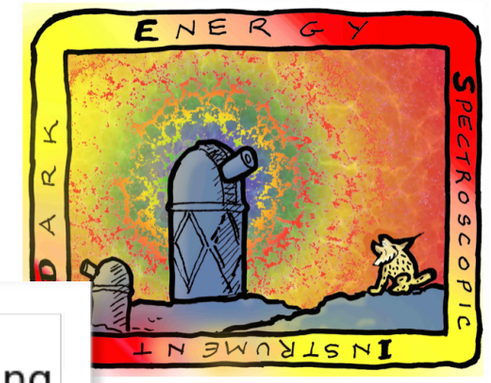

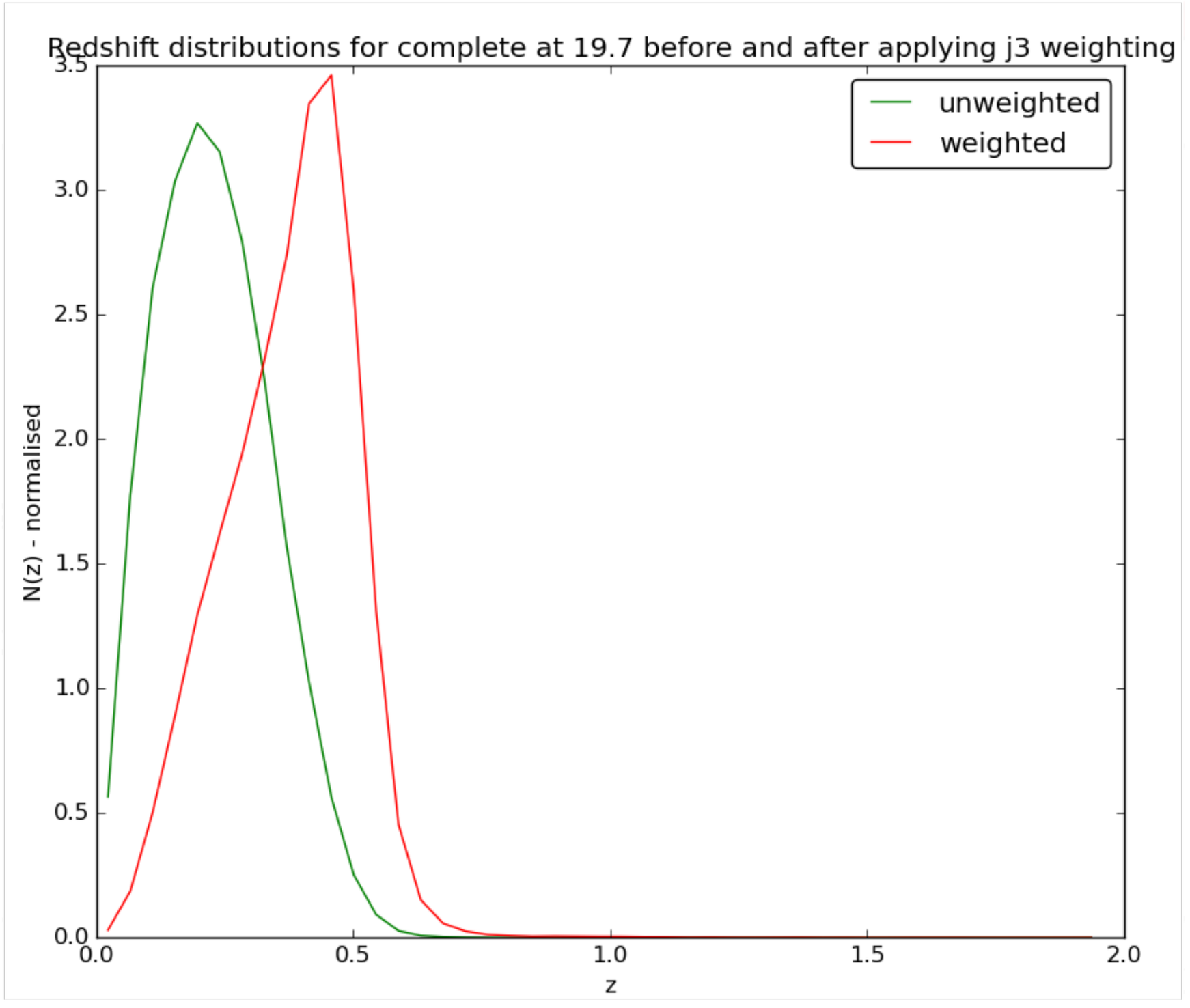

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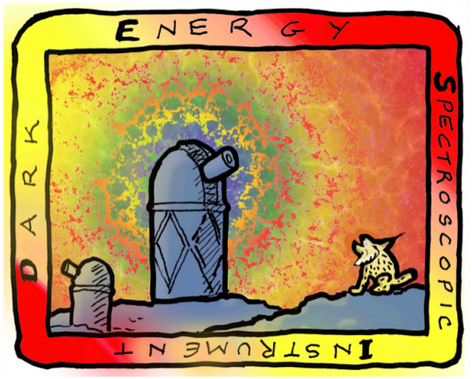

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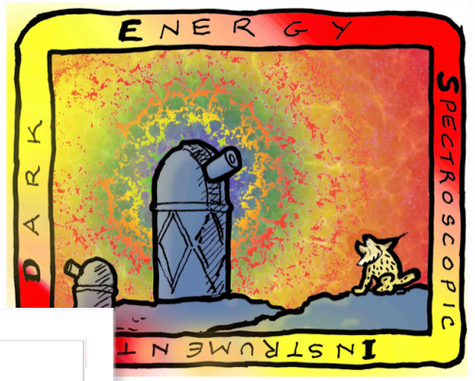

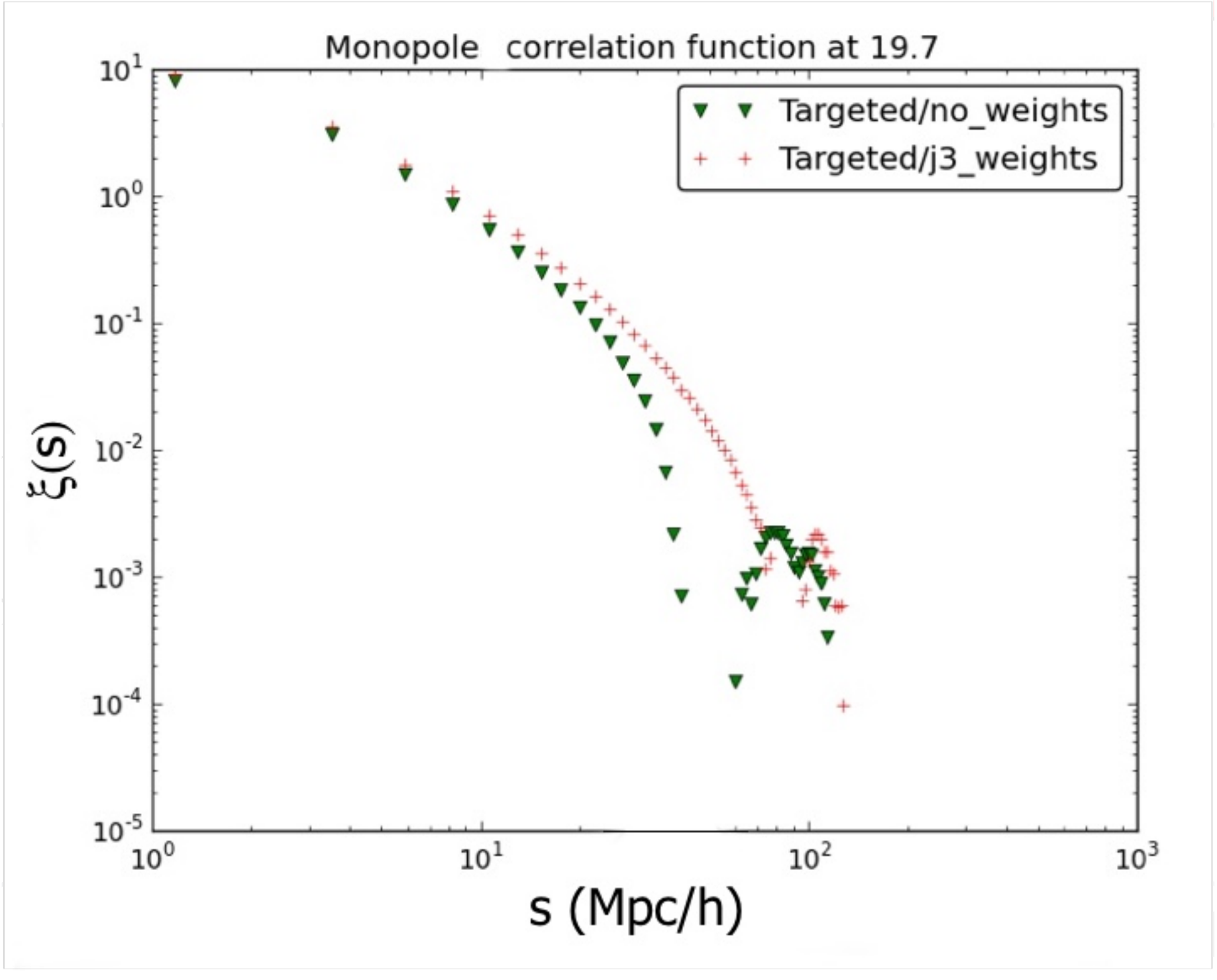

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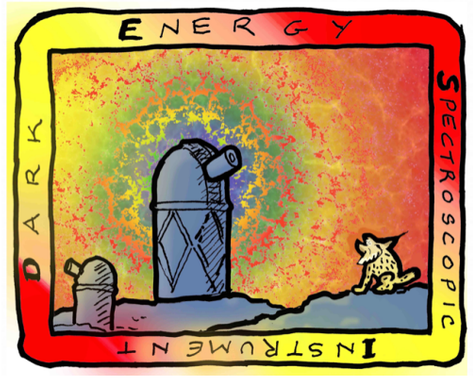
Small Scale Correction

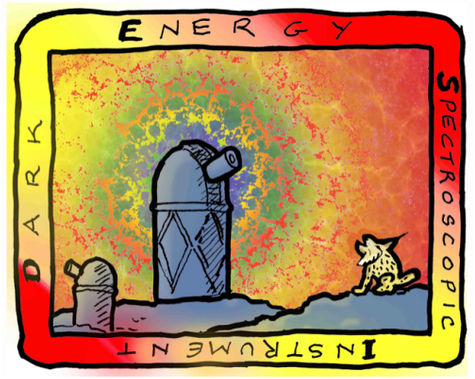


$$w_\theta = \frac{1 + \omega(\theta)|_{all}}{1 + \omega(\theta)|_{targeted}}$$

✦Exact for angular correlation

Hawkins, Maddox, *et al.*, 2003

Small Scale Correction



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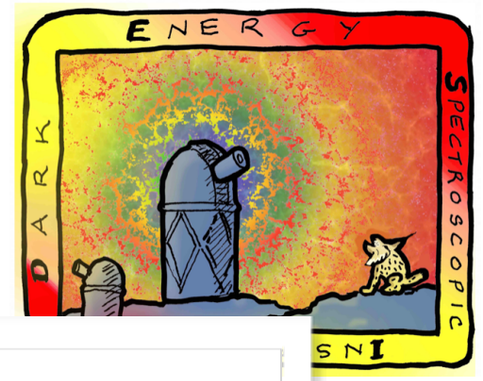

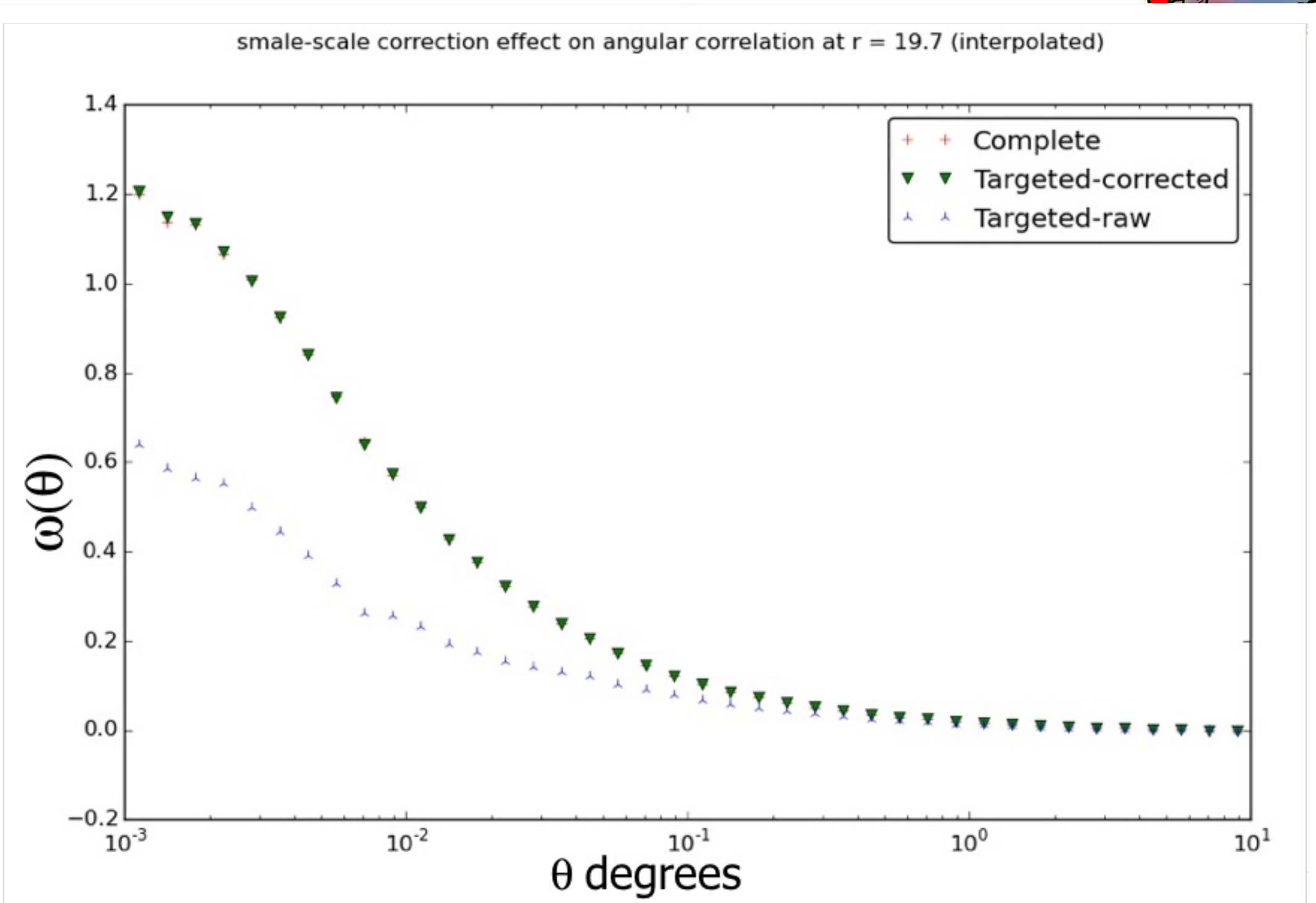

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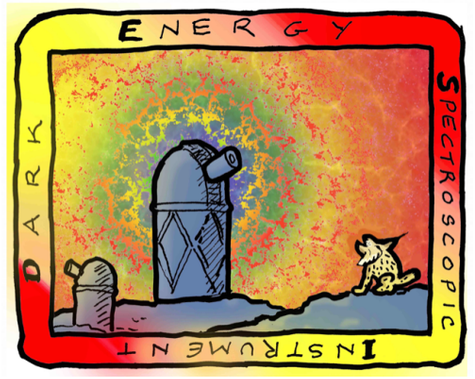
Small Scale Correction



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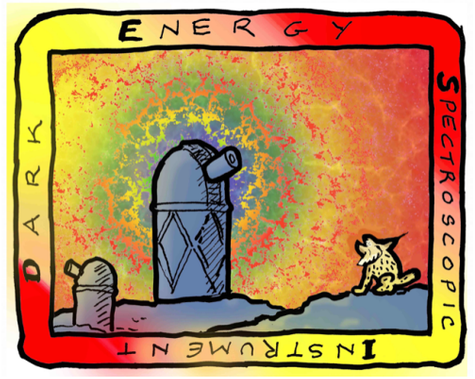

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Not exact for spatial correlation

Hawkins, Maddox, *et al.*, 2003

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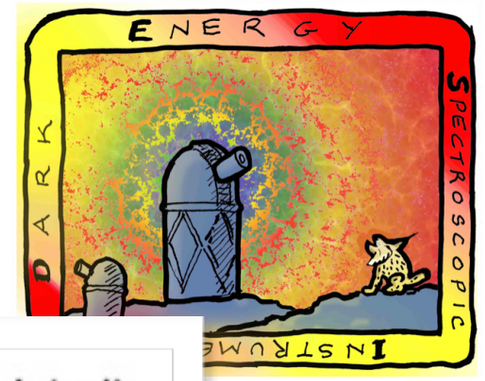

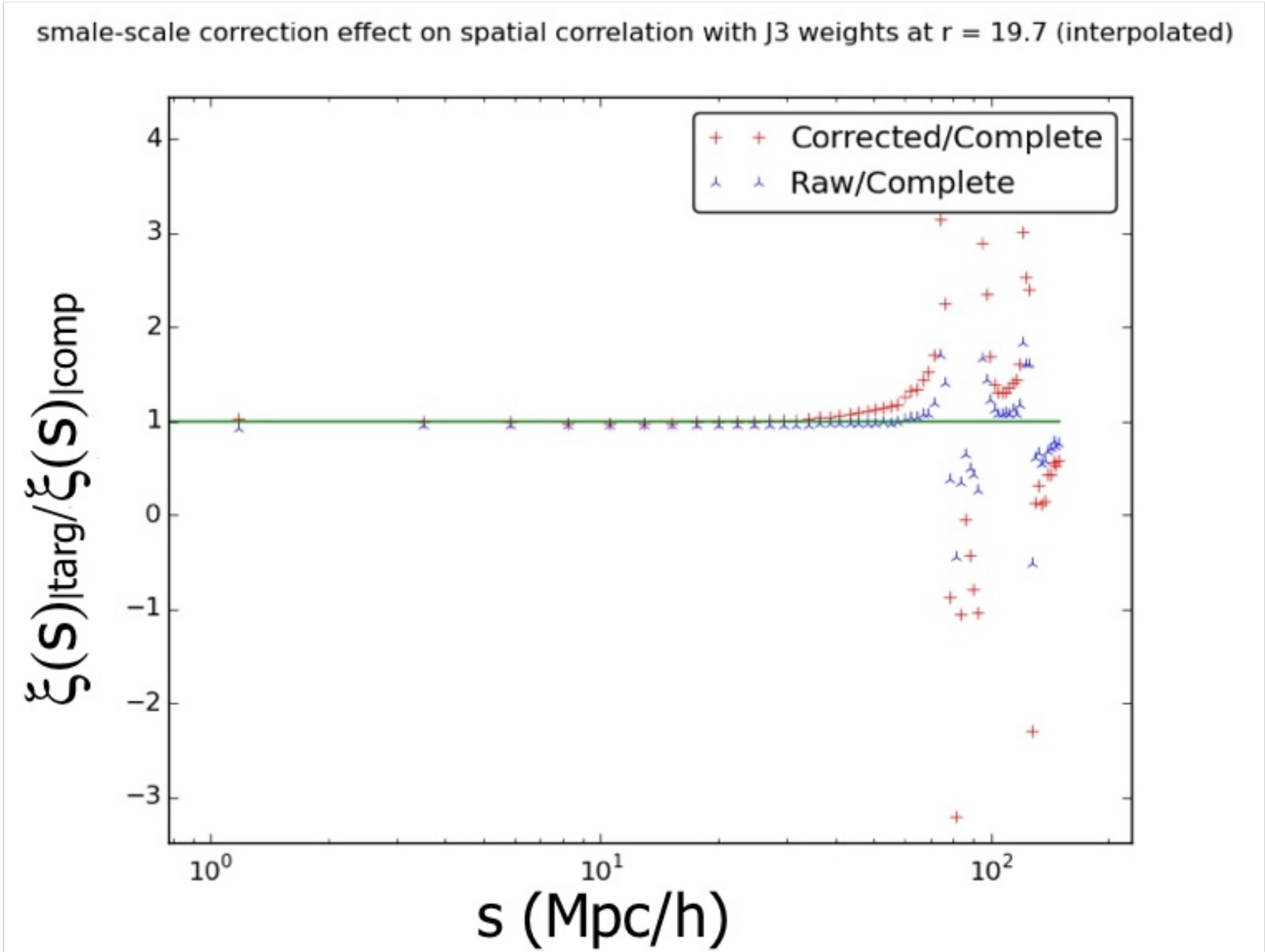

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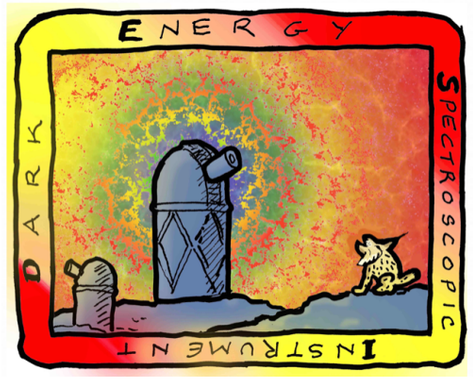
Small Scale Correction



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Not exact for spatial correlation

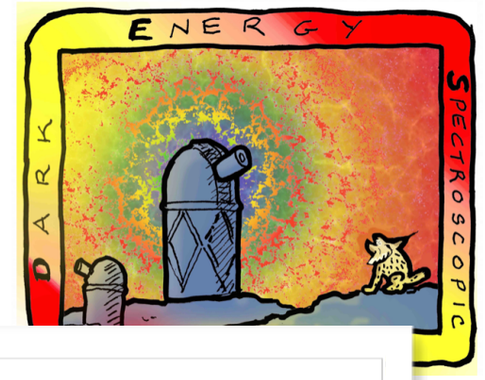
Hawkins, Maddox, *et al.*, 2003

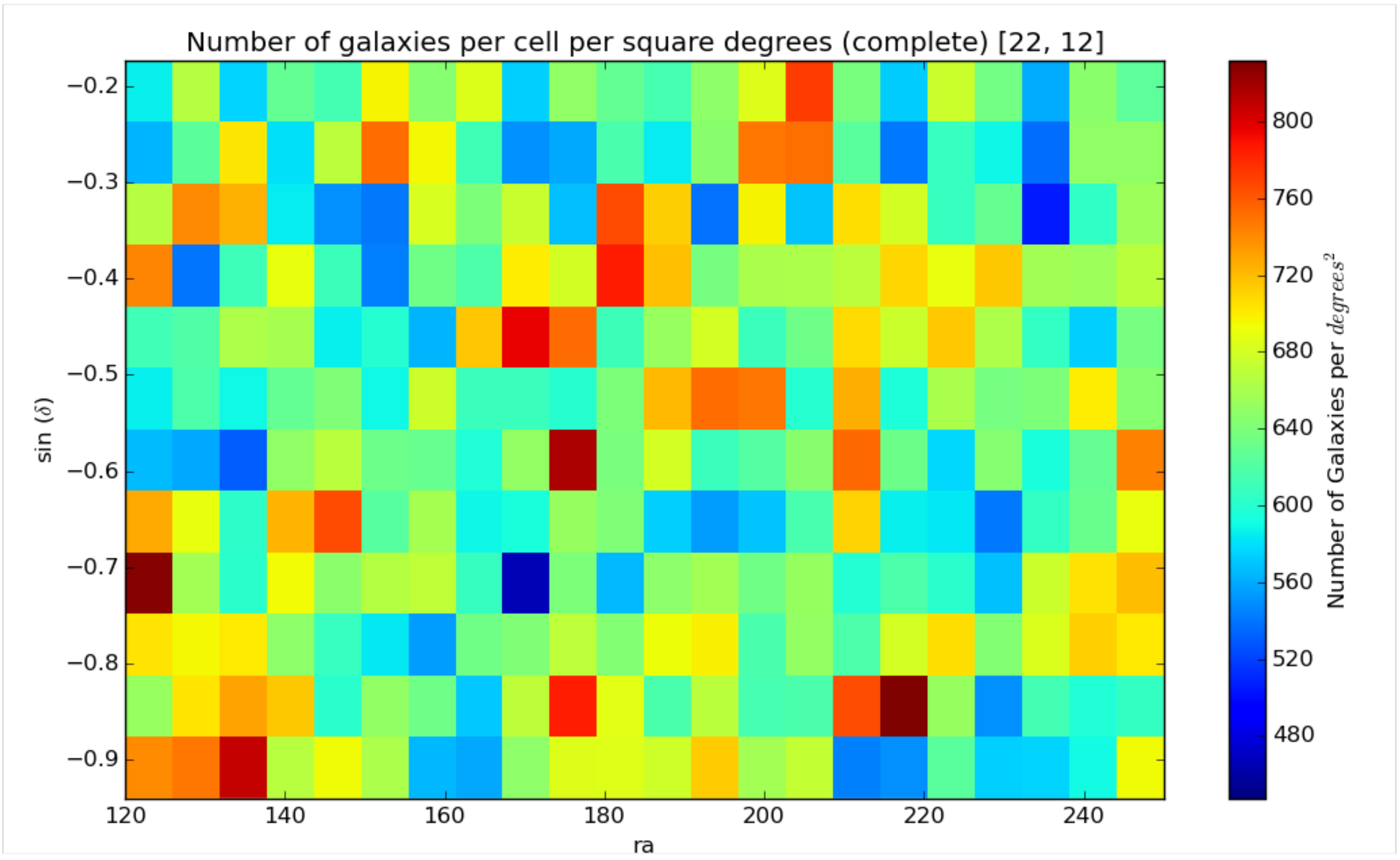
Large-Scale Cell Correction

$$w_c = \frac{\text{Number of galaxies in complete catalogue}}{\text{Number of galaxies in targeted catalogue}}$$

✦ Apply ratio to targeted catalogue to correct on scales larger than ω_θ

Large-Scale Cell Correction



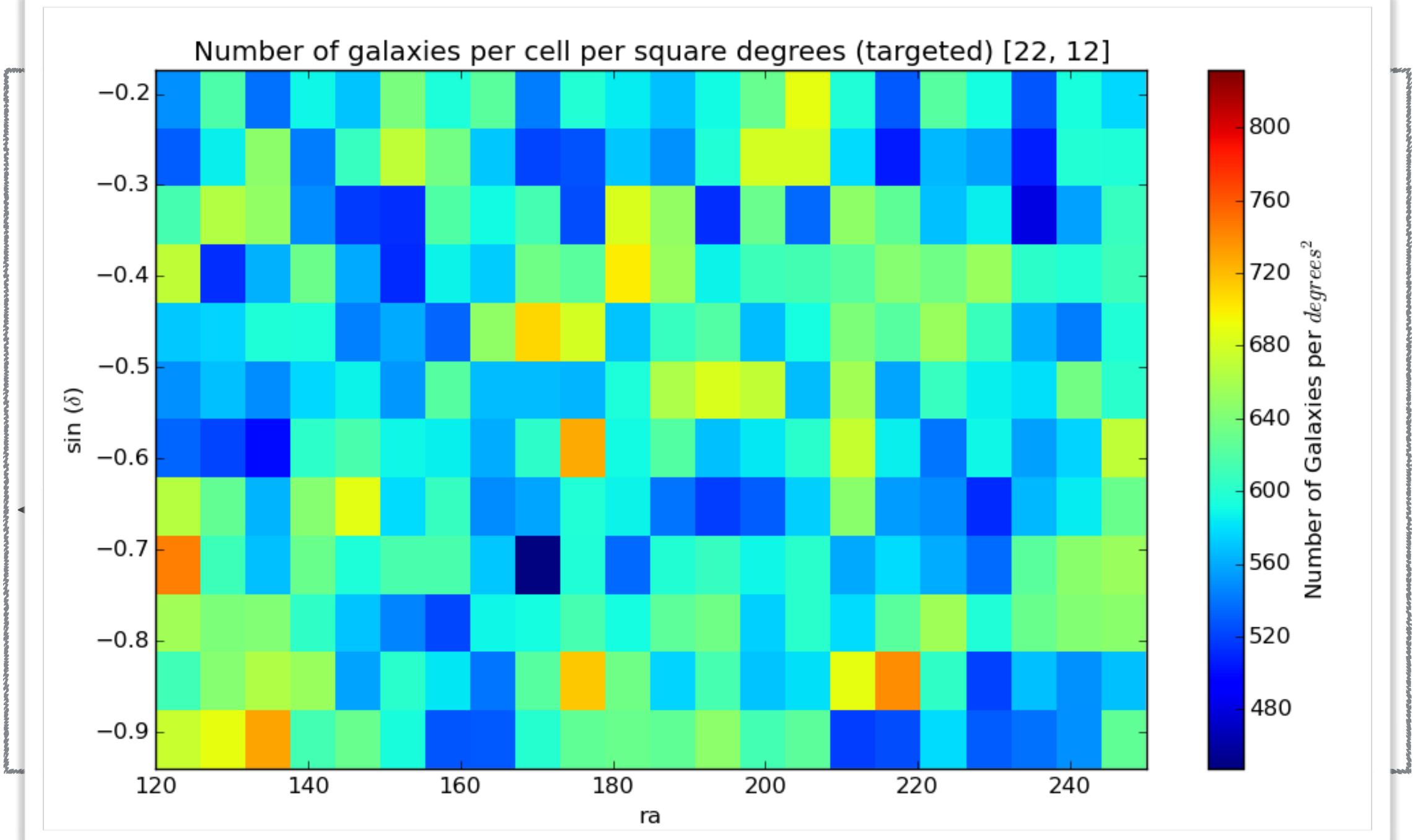


Large-Scale Cell Correction

$$w_c = \frac{\text{Number of galaxies in complete catalogue}}{\text{Number of galaxies in targeted catalogue}}$$

✦ Apply ratio to targeted catalogue to correct on scales larger than ω_θ

Large-Scale Cell Correction



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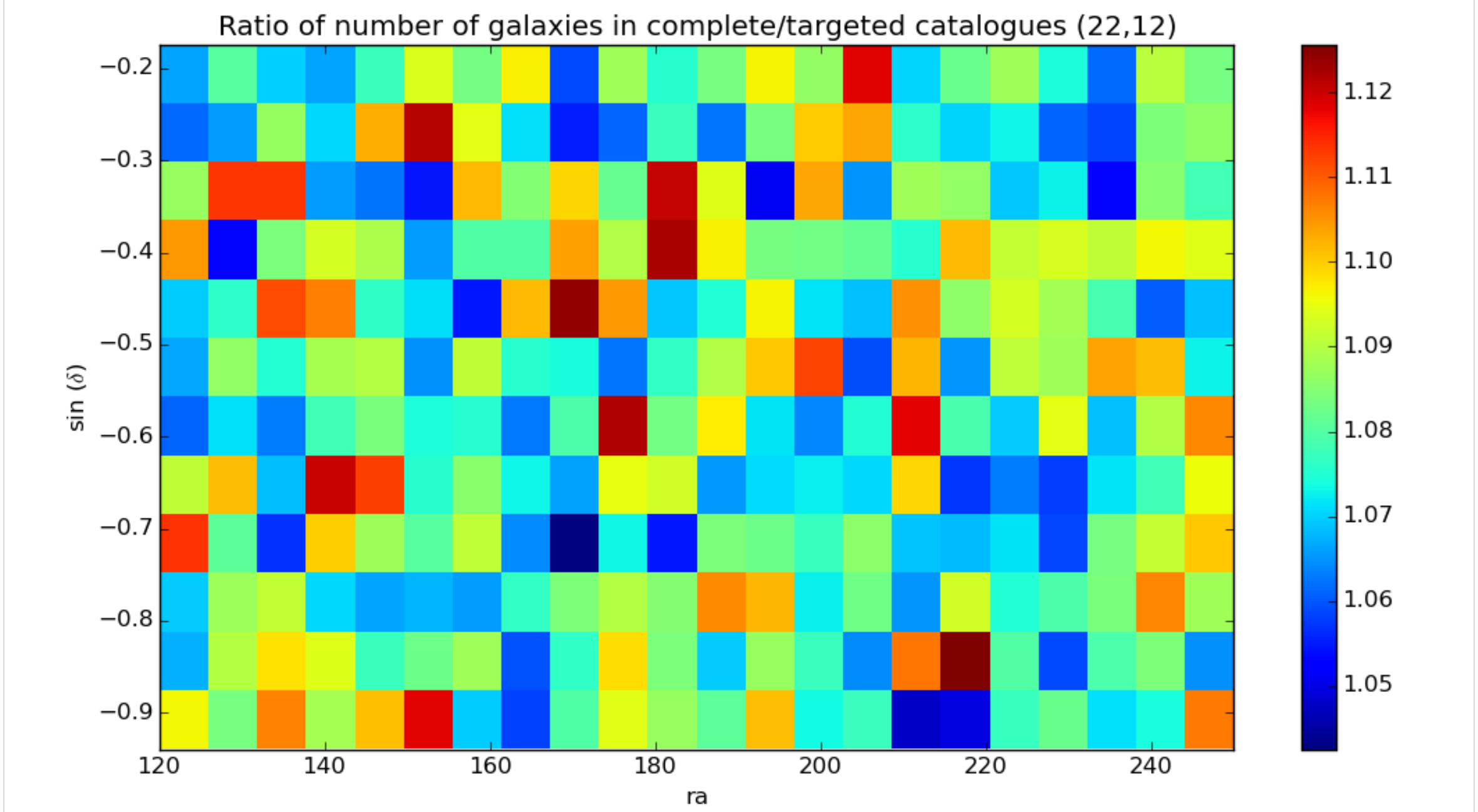
Large-Scale Cell Correction



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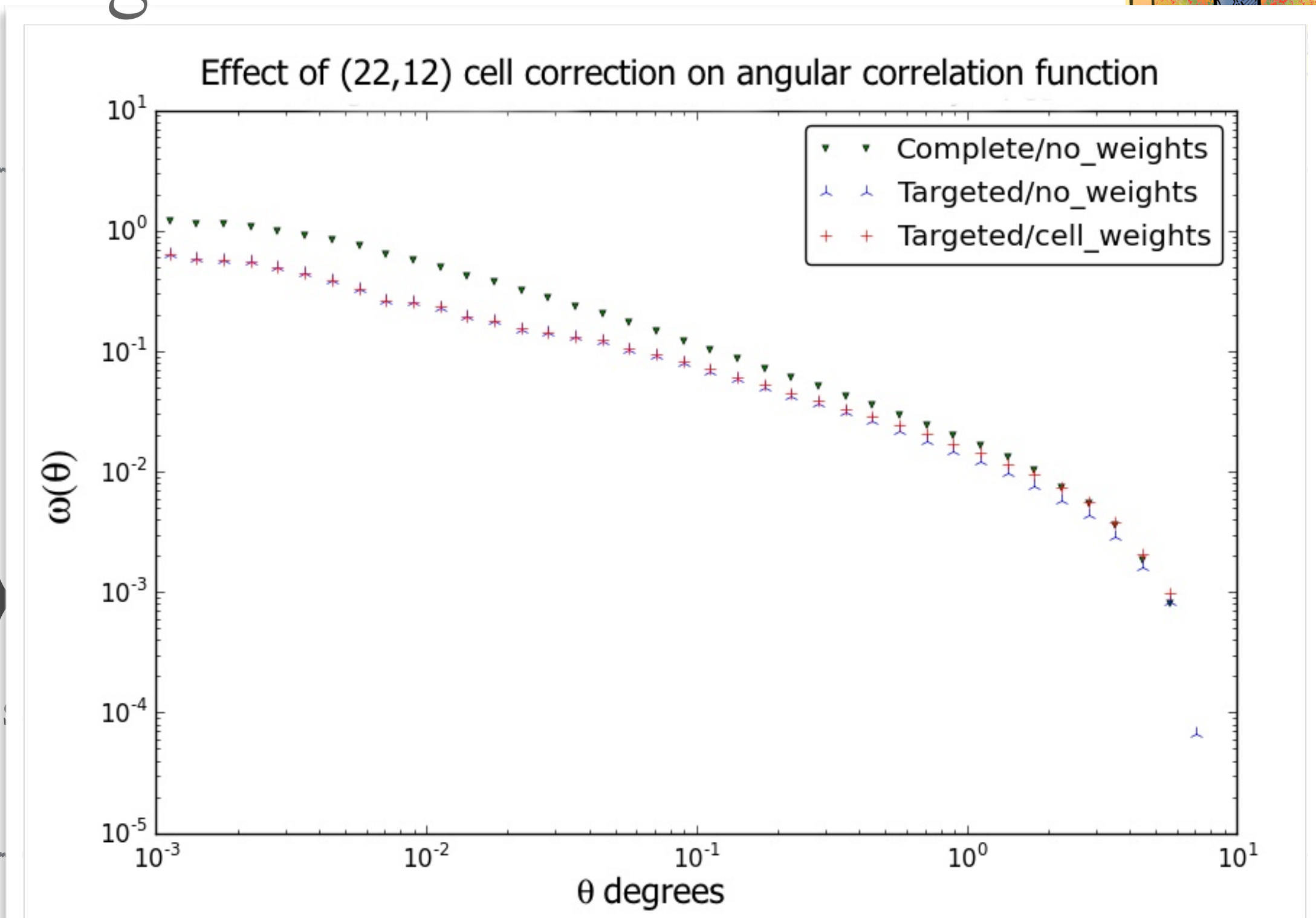

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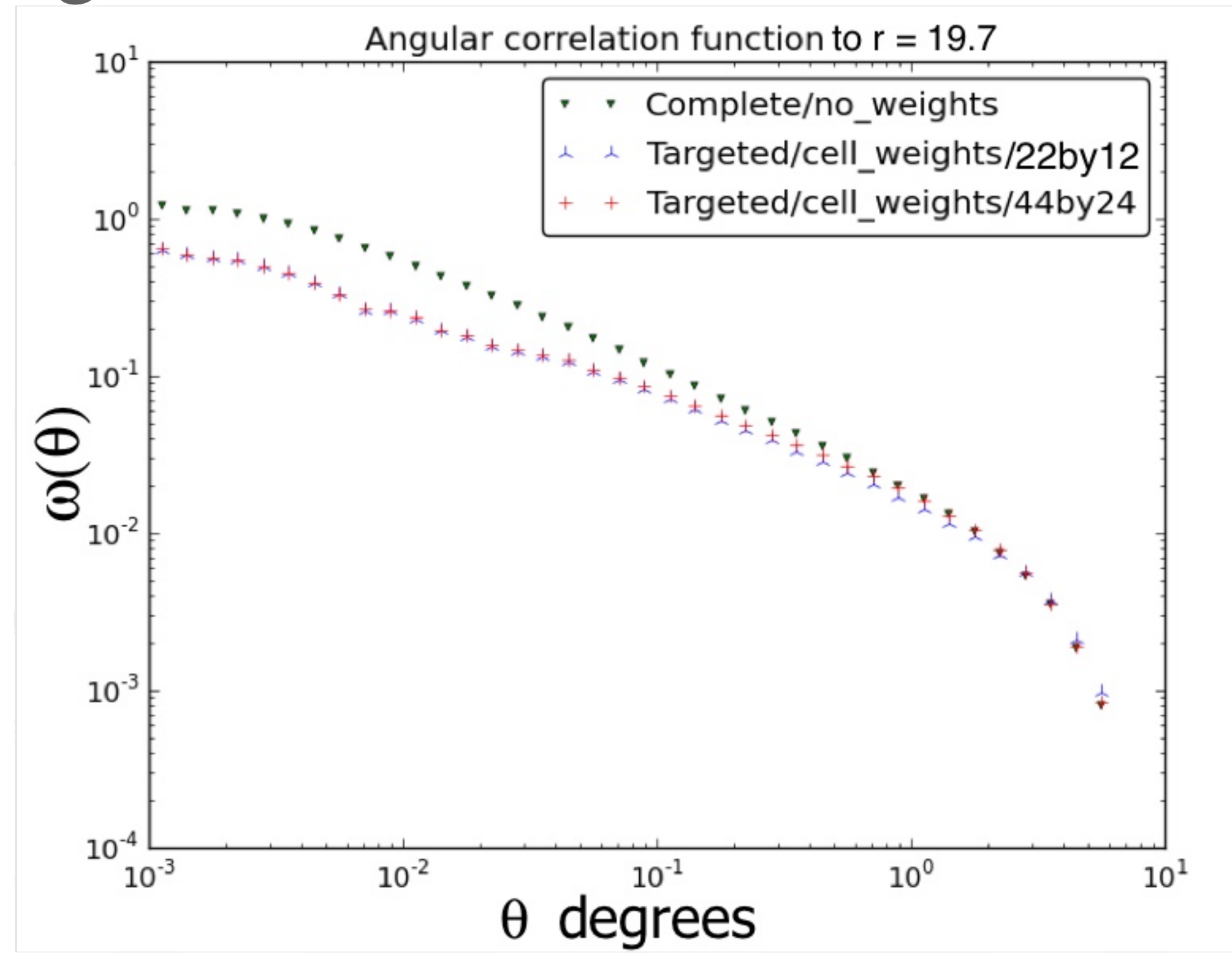
Large-Scale Cell Correction



- A

SC

Large-Scale Cell Correction

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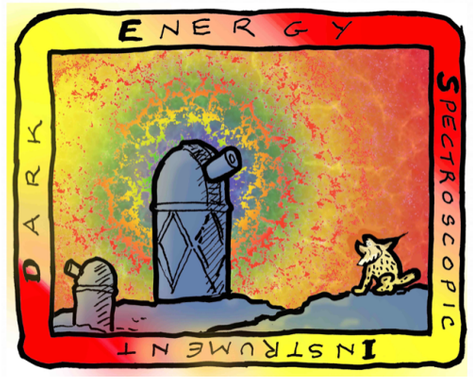
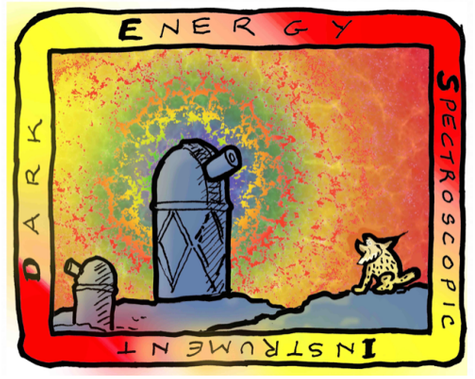
✦ Apply ratio to targeted catalogue to correct on scales larger than ω_θ

Combination of corrections

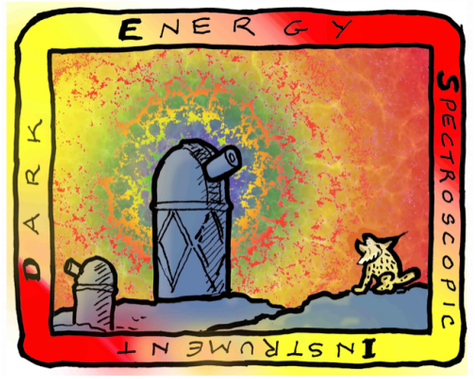


Combination of corrections



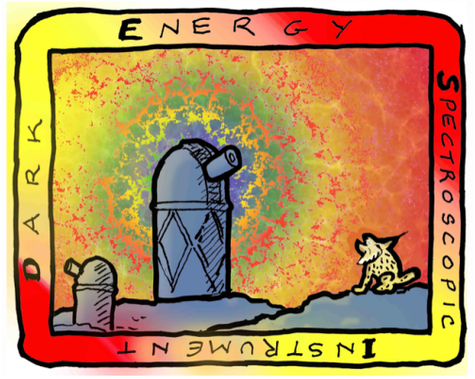
- Apply cell weights first.

Combination of corrections



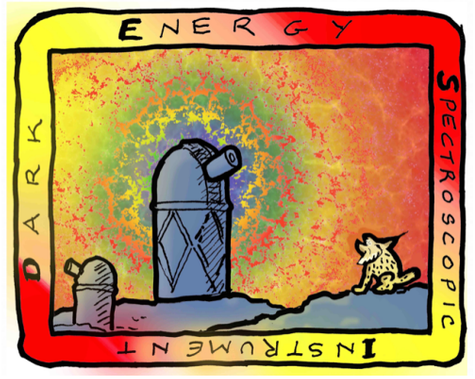
- Apply cell weights first.
- Then measure small-scale weights

Combination of corrections



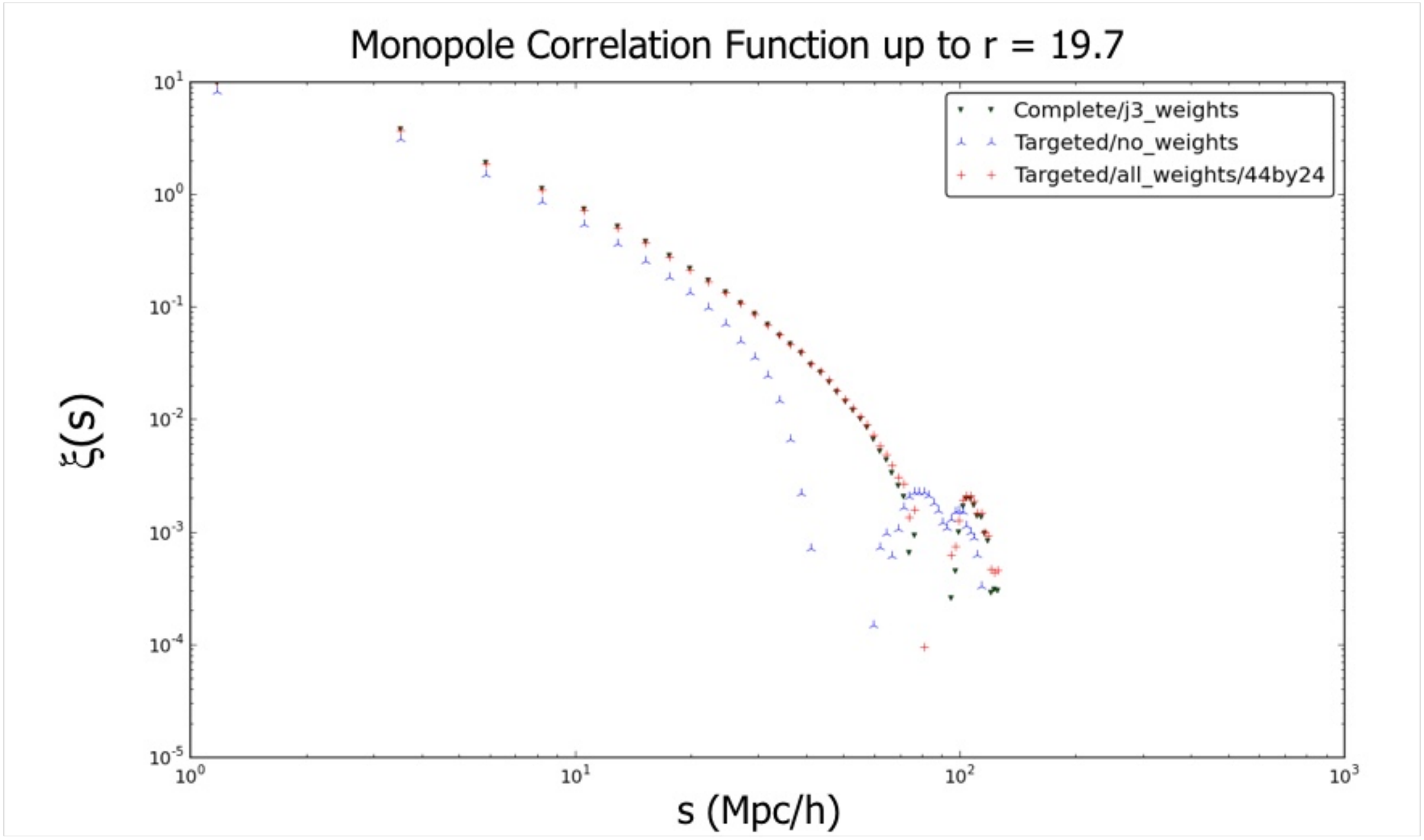
- Apply cell weights first.
- Then measure small-scale weights
- Then apply the combination of weights

Combination of corrections

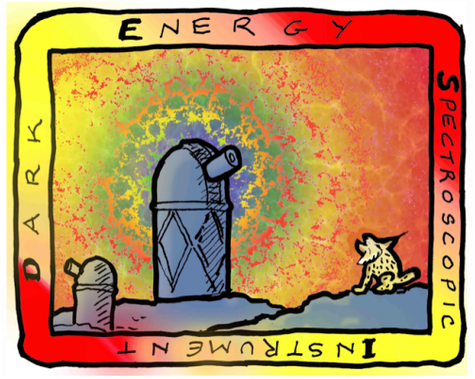


- Apply cell weights first.
- Then measure small-scale weights
- Then apply the combination of weights
  - Total weights for every pair: $w = w_i\, w_j\, w_{c1}\, w_{c2}\, w_\theta$

Combination of corrections



Combination of corrections



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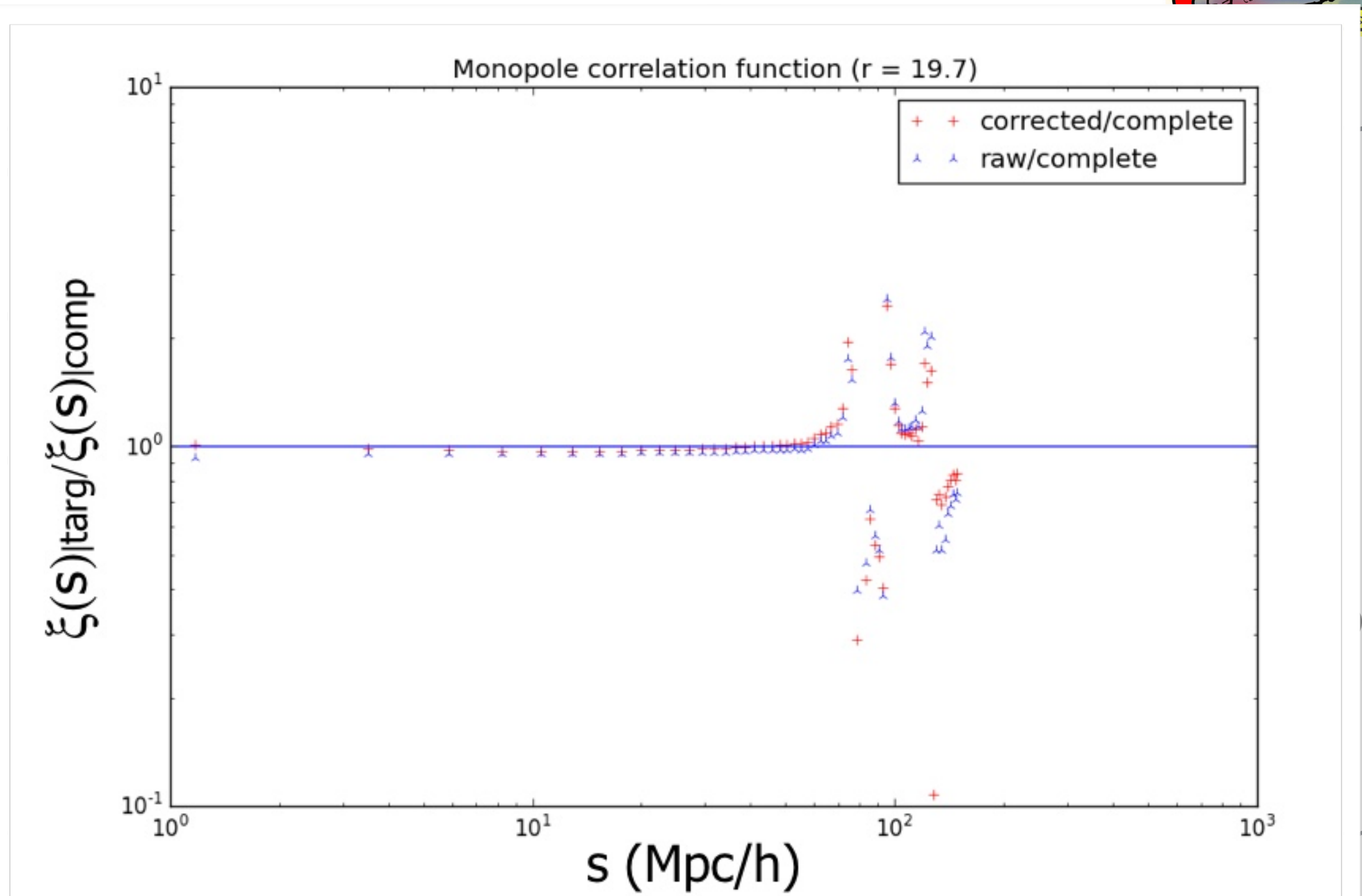
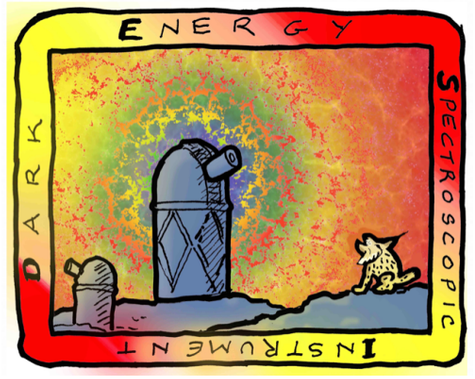


Combination of corrections



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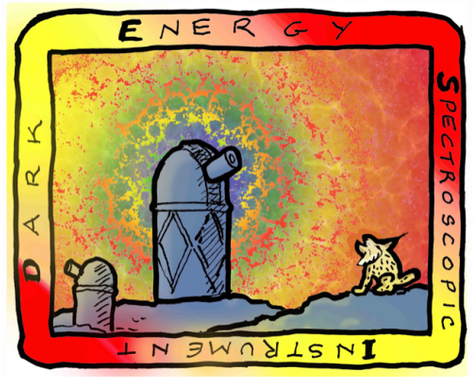
Different Magnitude Limits



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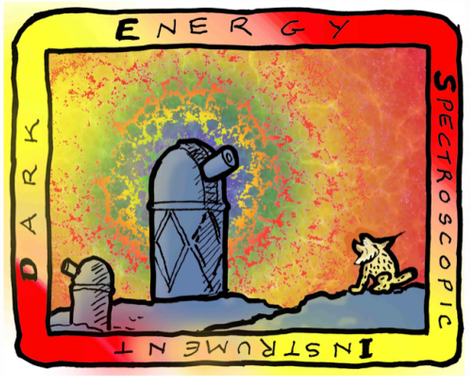

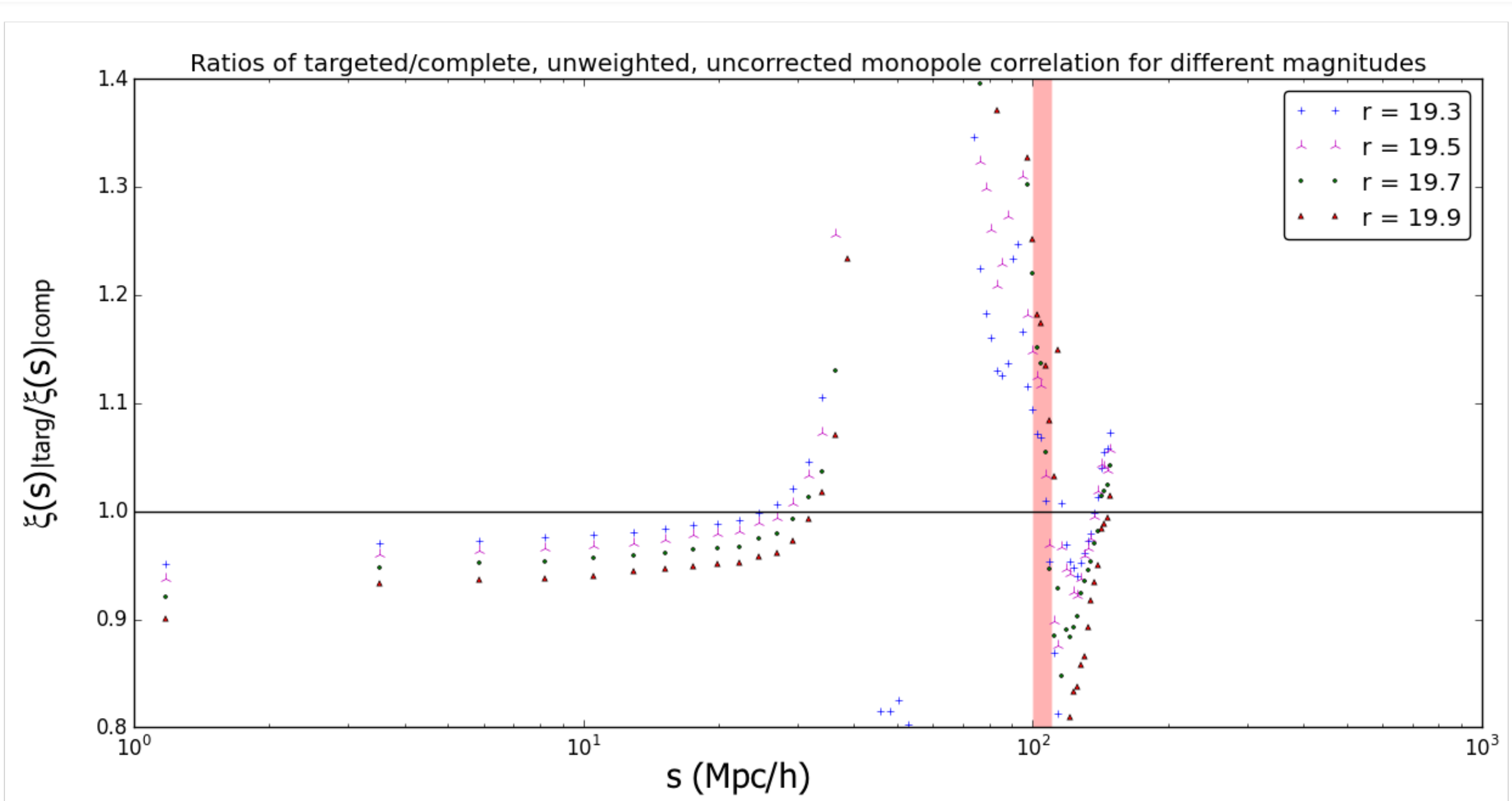

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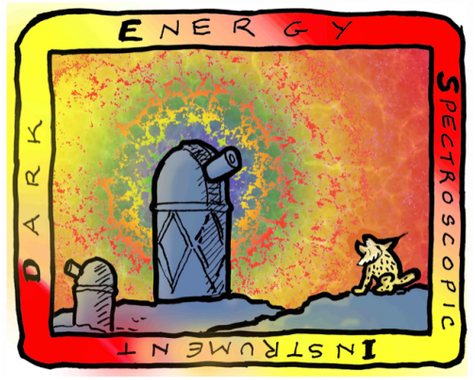
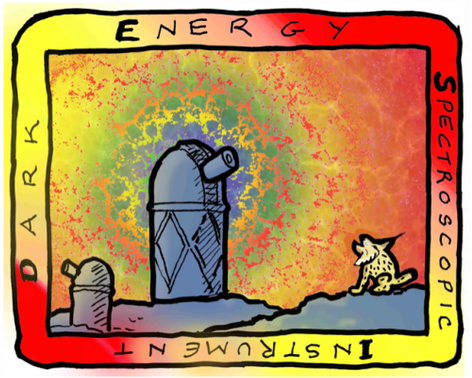
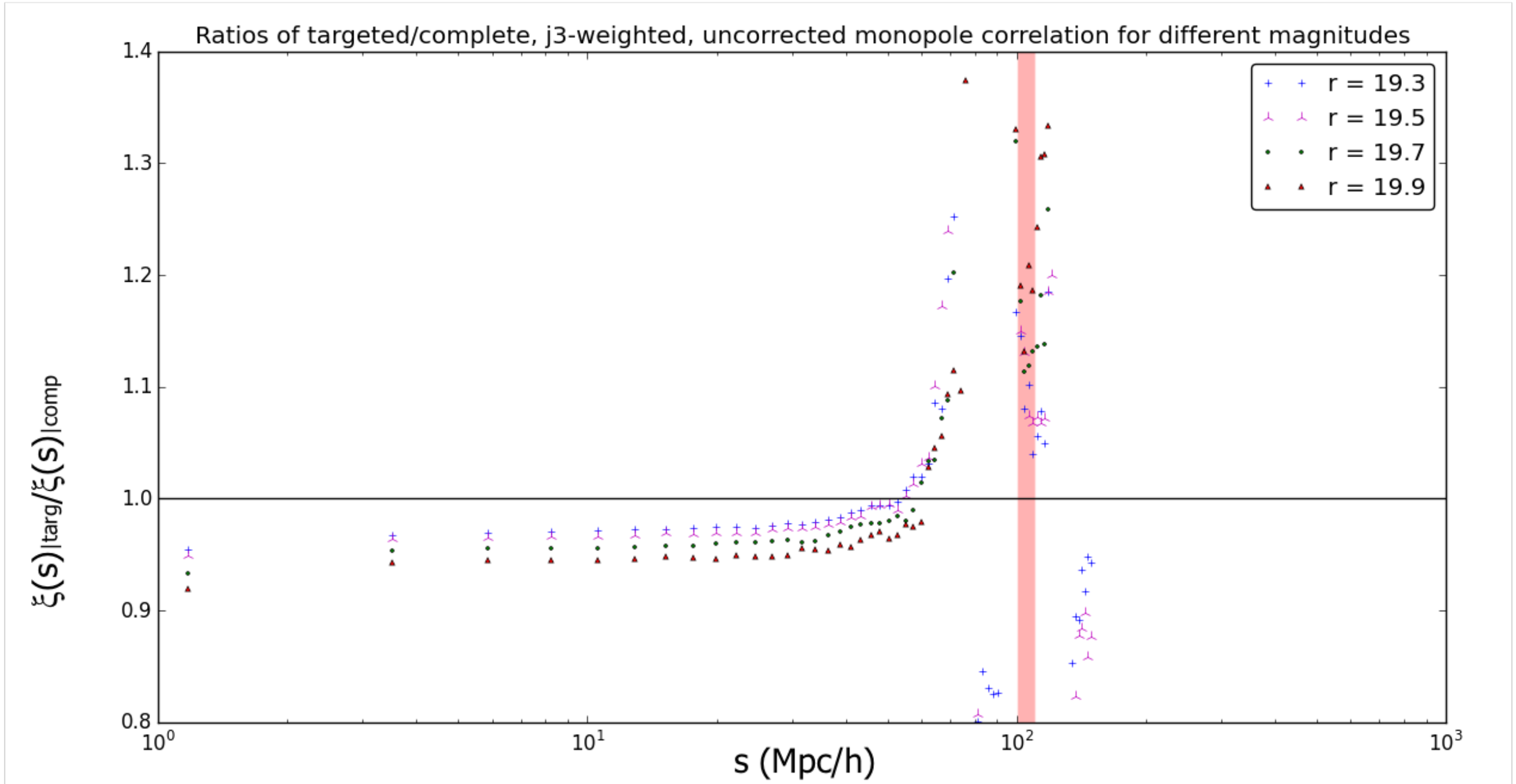


Different Magnitude Limits





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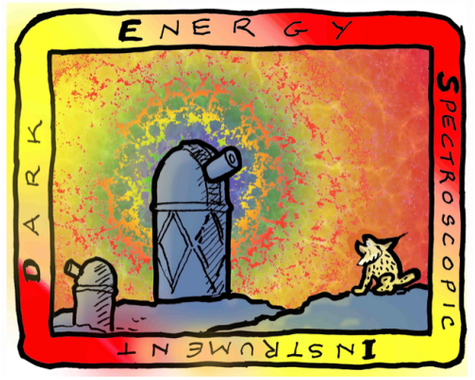

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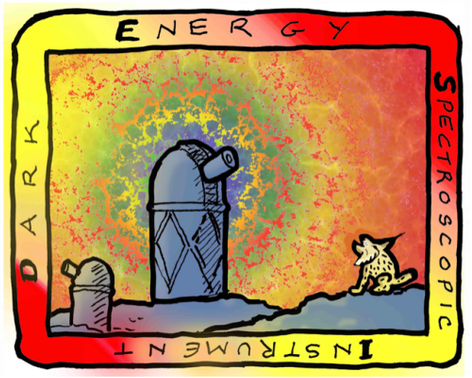
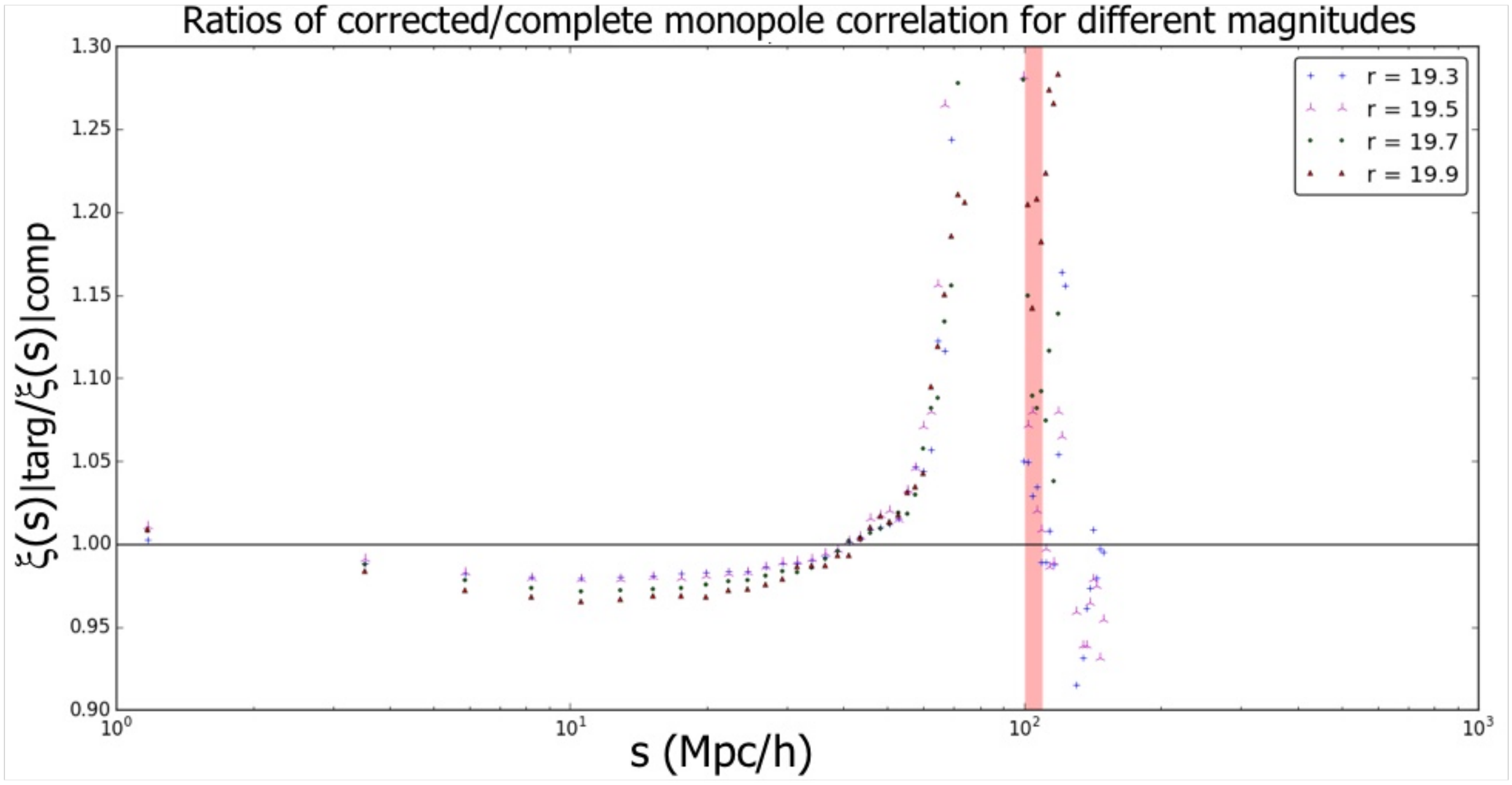
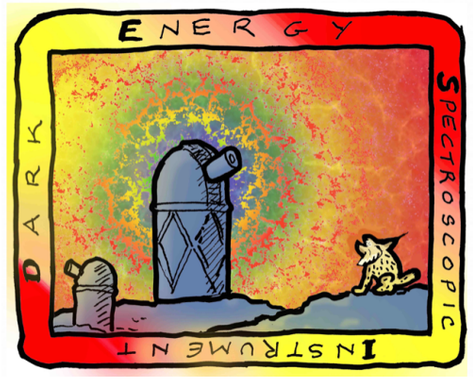
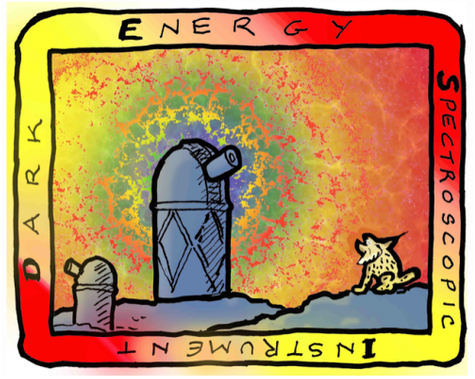




Different Magnitude Limits

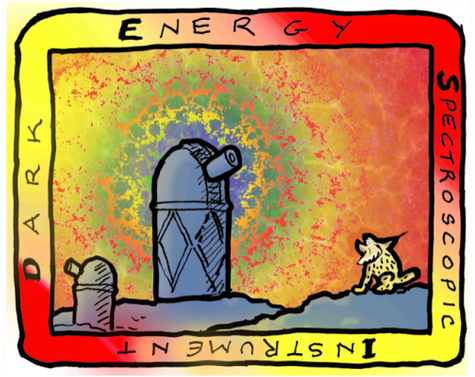


Future Work



- ✦HEALPix grids for cell-correction
- ✦ $\xi(\sigma,\pi)$ for recession velocities and galaxy dynamics
- ✦Test on different mocks and different fibre assignment algorithms

Conclusion



- ✦ Physical constraint on fiber density results in 5-15% redshift incompleteness.
- ✦ Cell and redshift-dependent corrections work well for BAO science (up to r = 19.7); FKP weights work to percent level on very small scales.
- ✦ Needs further improvements and investigations on different catalogues and algorithms.

Remarks

✦Work done in summer 2015 with Shaun Cole at Durham University's Institute for Computational Cosmology which is an institutional member of DESI (whereas Glasgow, my undergrad institution, is not)

✦This is not the only DESI effort in fibre assignment and mitigating incompleteness. Other DESI efforts at Portsmouth, Argonne & Berkeley labs, and elsewhere.

I'd like to thank the Royal Astronomical Society for supporting my attendance to the symposium.