

Mitigating Systematics in Galaxy Surveys

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When did I cross CCAPP?

In 2013 Fall - 2014 Spring as a CCAPP fellow, spending 1 year before going to Ohio University.

Worked with David Weinberg on Aubourg et al. 2015 the BOSS cosmology paper.

Worked with Chris Hirata on Foreground effect on 21cm BAO.

Worked as the SDSS IV tiling coordinator.

Worked on the DES shear power spectrum.

Mentoring from Klaus and John!

CCAPP really helped me gain the momentum and settle down firmly at Ohio University.

Some past and current work

BOSS power spectrum, BAO and full shape analysis.

DESI clustering working group, and Y1 BAO work. Reconstruction. Observational systematics.

DESI-II WG co-chair.

Roman GRS PIT - 2pt and 3pt infrastructure and observational systematics.

RSC Cosmology WG co-chair.



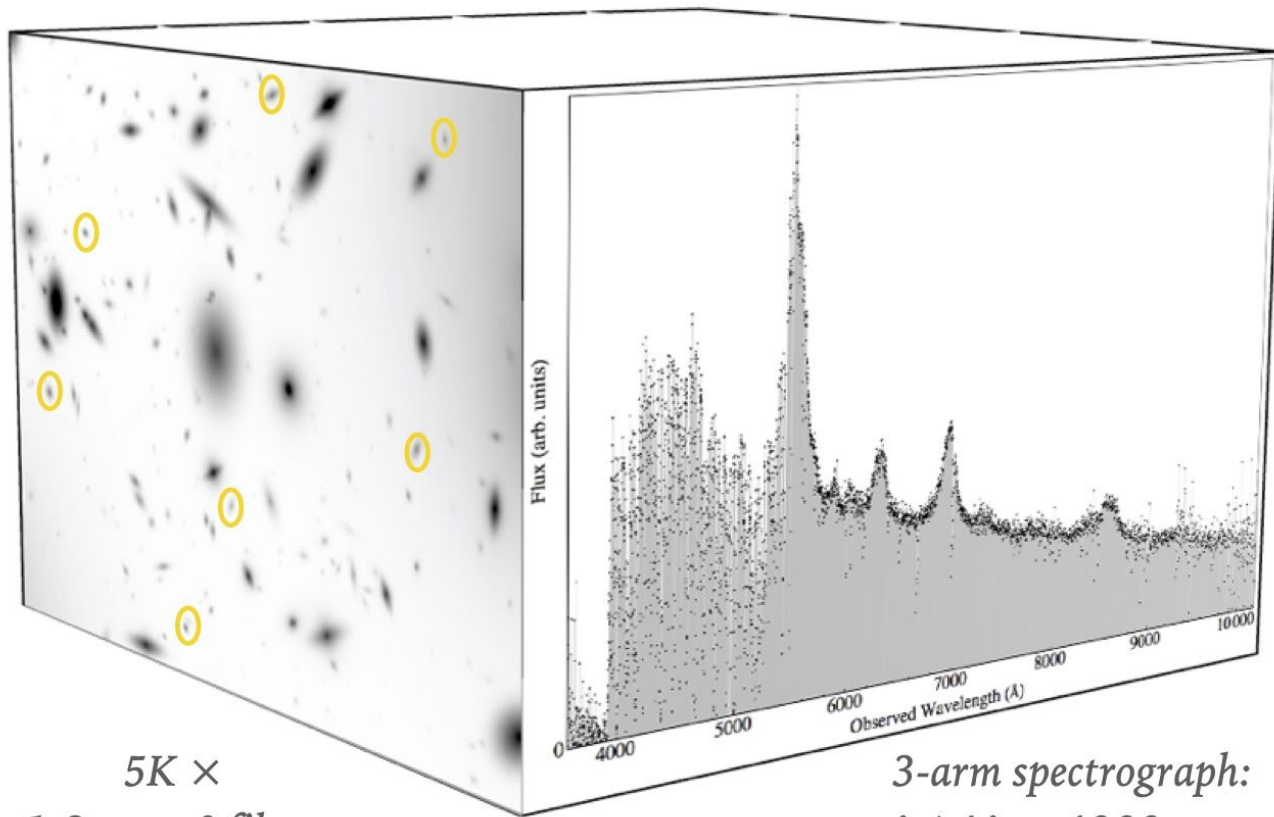
1. Observational systematics - Imaging systematics



Observed

True

Credit: Rongpu Zhou, the Blanco telescope, Chile



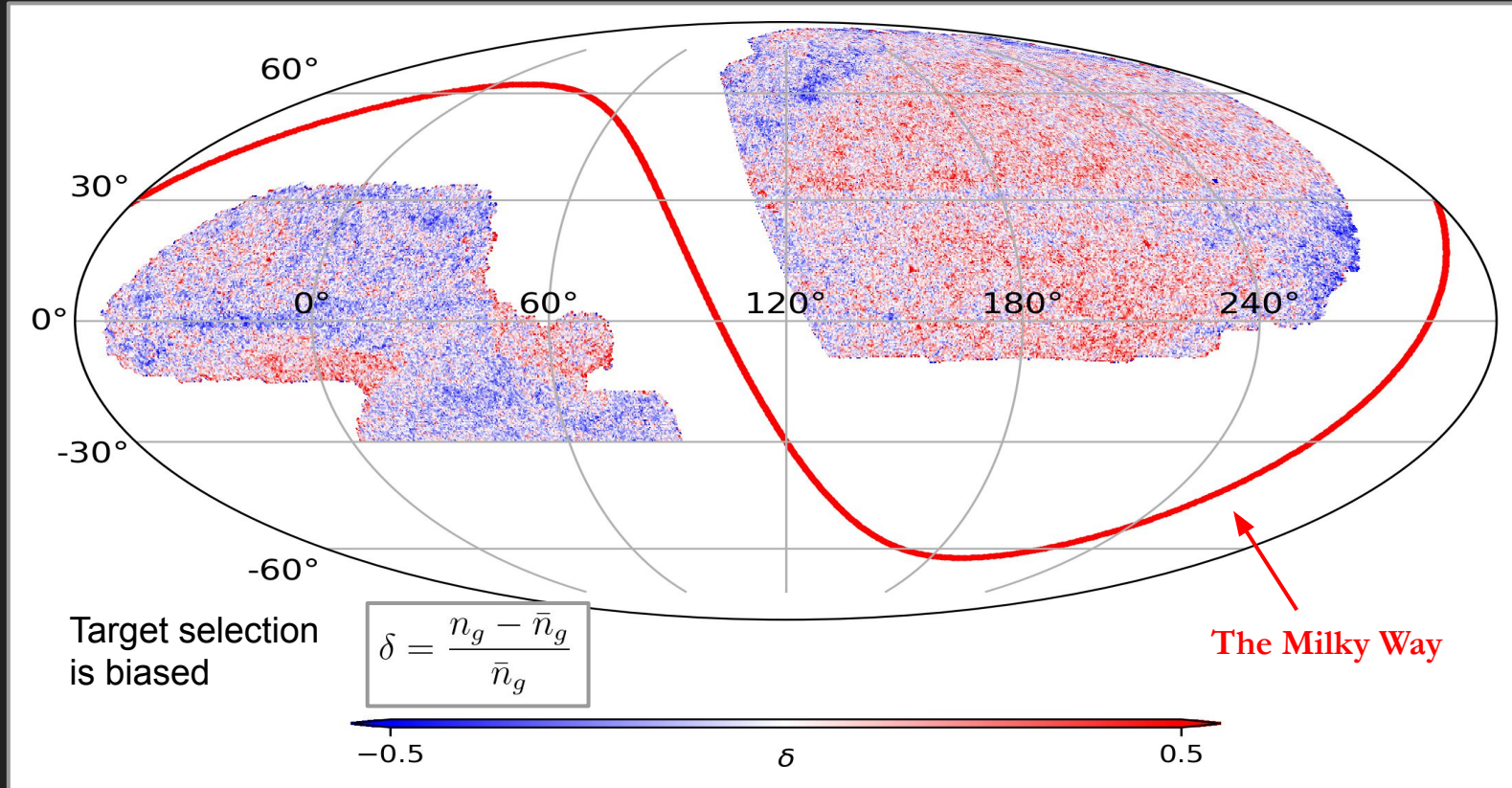
$5K \times$
 $1.8 \text{ arcsec}^2 \text{ fibers}$

3-arm spectrograph:
 $\lambda / \Delta\lambda \sim 4000$

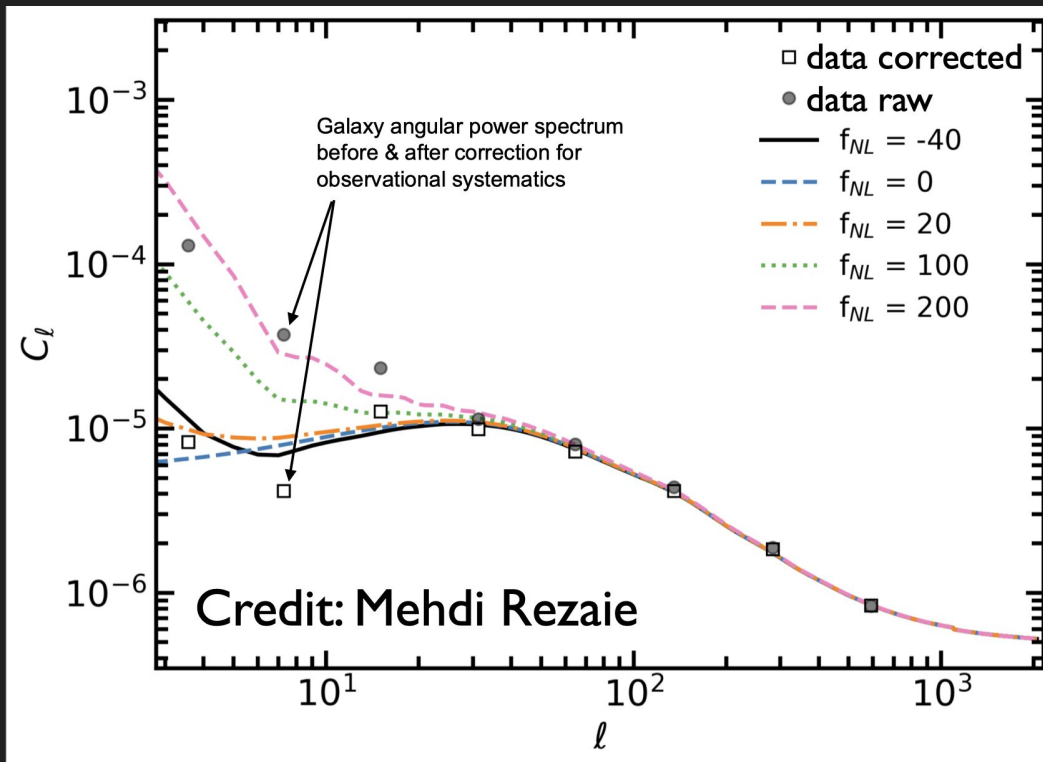
Galaxy survey spectroscopy, e.g. DESI

Credit: David Kirkby

DESI Emission Line Galaxies ($0.6 < z < 1.5$)

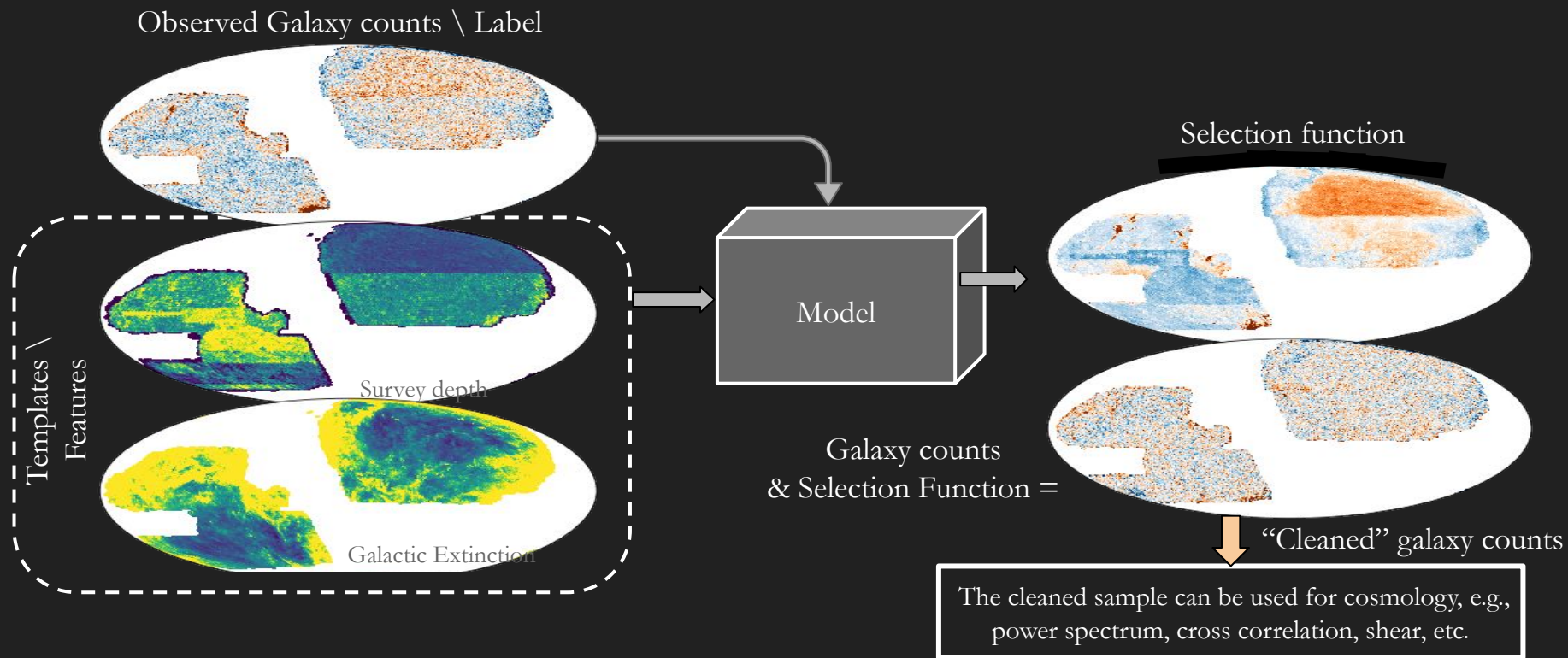


Observational systematics and local f_{NL}



DESI Legacy Survey
DR9
BASS/MzLS LRG

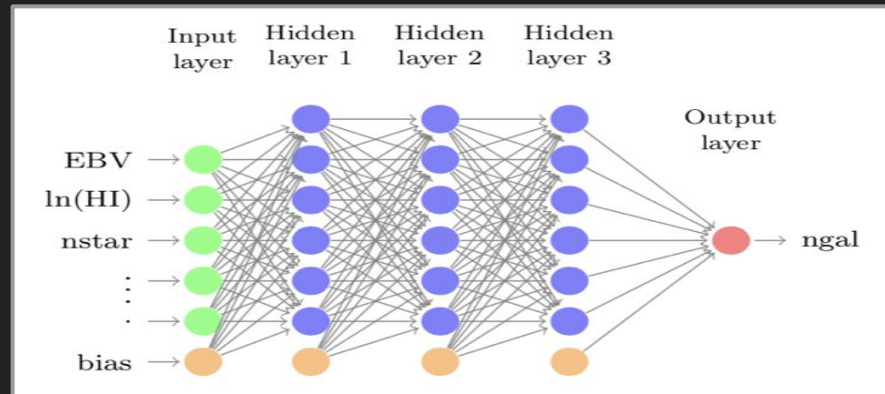
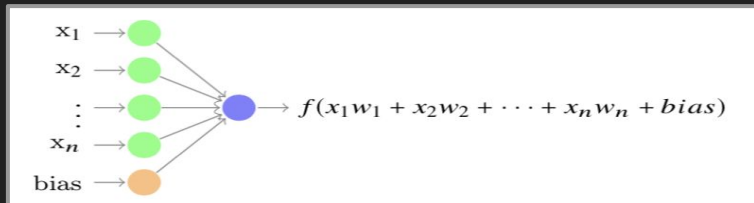
Regression-based Mitigation of Systematics



Cf. Forward modeling: Obiwan for DESI

Fully Connected Neural Networks: SySNet

(Rezaie, Seo, Ross, Bunesu 2020)



Advantage:

Both linear and nonlinear effect can be modelled.

Training/validation/test sets can reduce overfitting (some caveats, though!)

The network learns the mapping from imaging attributes to galaxy counts.

The parameters are trained by minimizing a 'cost' function

$$n(\vec{x}, \vec{p}) / f(\vec{p}) - \bar{n}(\vec{x})$$

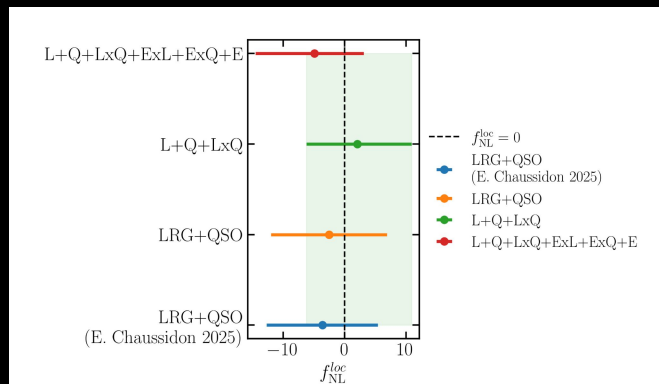
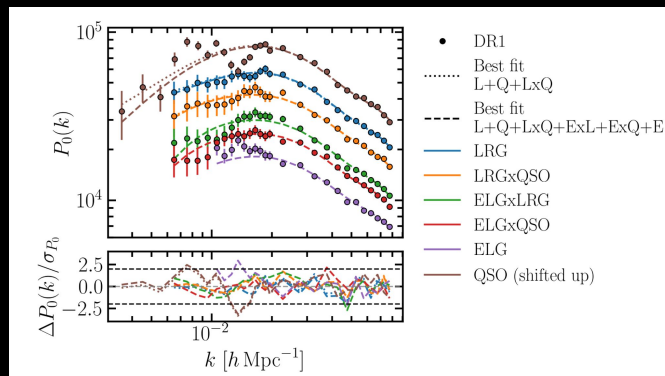
Residual systematics versus overcorrection (systematics on fnl and full shape)

The decision tree intrinsically depends on cosmology assumptions.

Local primordial non-gaussianity using cross-correlations of DESI tracers (Rosado-Marin, Ross, Seo et al. 2026)

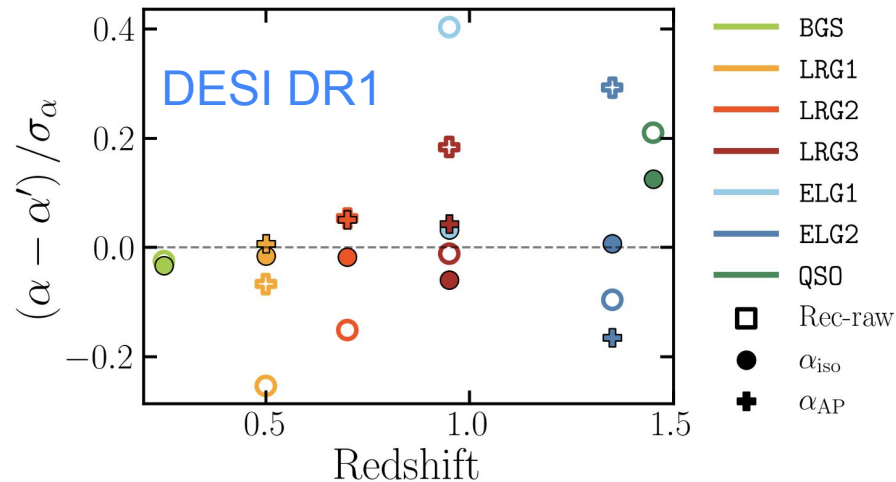
Currently working on Optimal feature selection from forward modeling and regression (Sam Bringman, Rosado-Marin et al. in prep)

Holistic treatment of cosmological information and systematics (Sam Bringman, Rosado-Marin et al. in prep)



2. Systematics on BAO

Imaging systematics on BAO?

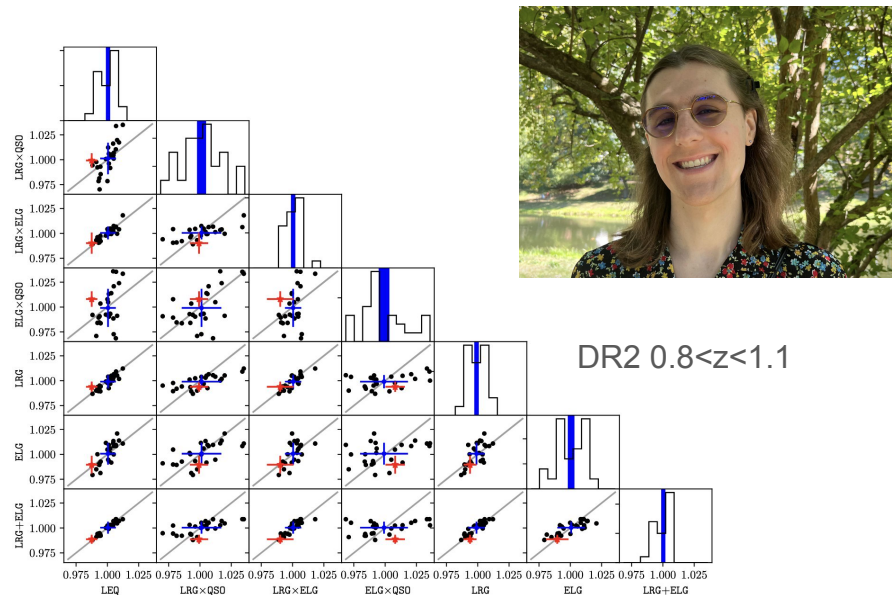


Rosado-Marin et al. 2025

Look at the solid points

It is not the case!

Tracer-dependent systematics on BAO?



The Unified tracer analysis of DESI DR2 (Nick Sanders et al. ready for DESI CWR)

2. Systematics on BAO

DESI DR2
Unified and
rebinned

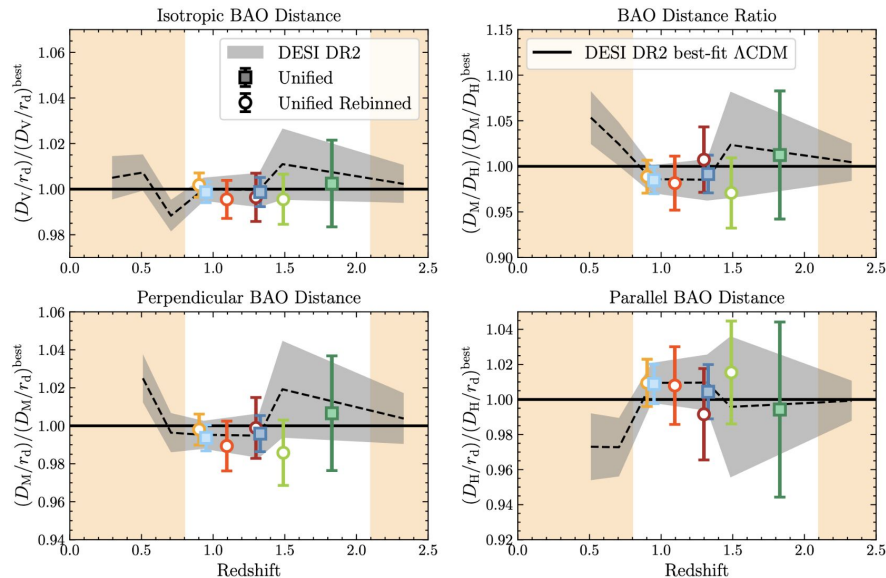


FIG. 6. Hubble Diagram of DESI DR2 with the baseline analysis shown as the gray bands, the unified tracer as the square points, and the rebinned unified tracer as the circle points. The highest redshift point corresponds to the Q501 bin, and is common between both binnings. The shaded regions are redshifts where the unified tracer analysis is identical to the baseline analysis. Both binnings demonstrate strong agreement with the baseline distance measurements.



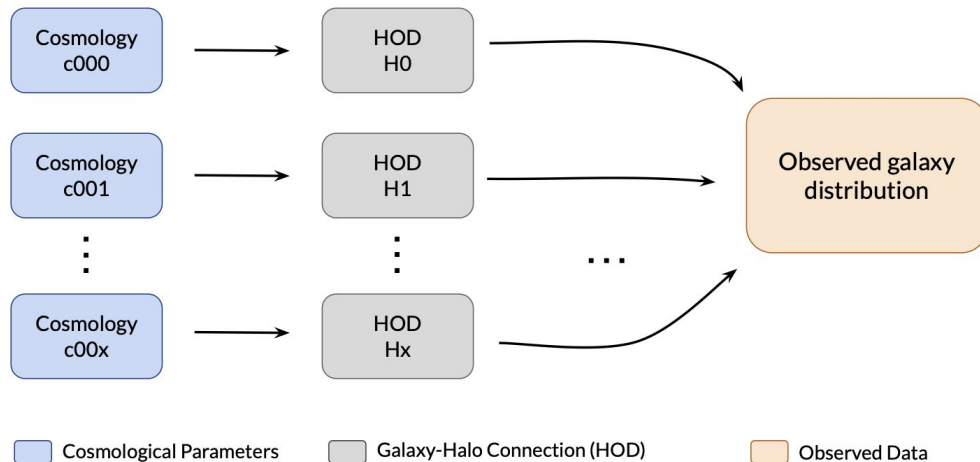
DR2 $0.8 < z < 1.1$

The Unified tracer analysis of DESI DR2
(Nick Sanders et al. ready for DESI
CWR)

3. Systematics from the theory modeling: 2pt+3pt

True Cosmology and HOD Degeneracy

Many cosmology and HOD pairs can produce the same observed galaxy distribution

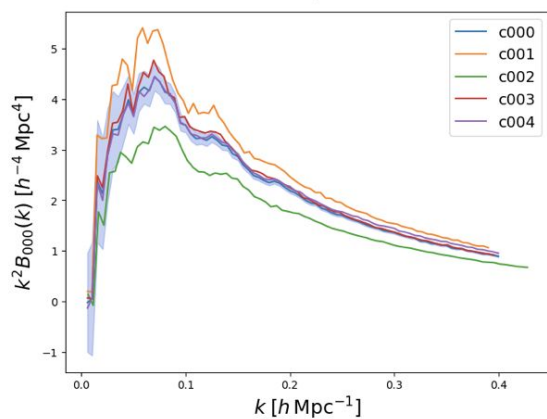
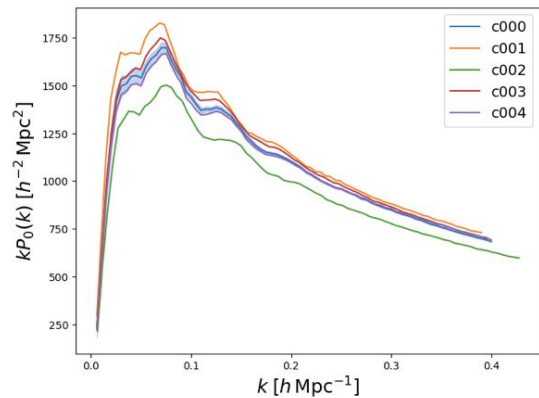


x



Systematics from Cosmology Assumptions for the DESI DR2 2pt+3pt Full Shape Analysis
(Jaide Swanson in prep)

True Clustering

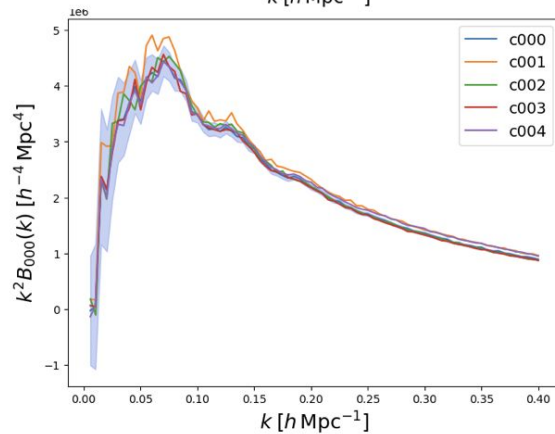
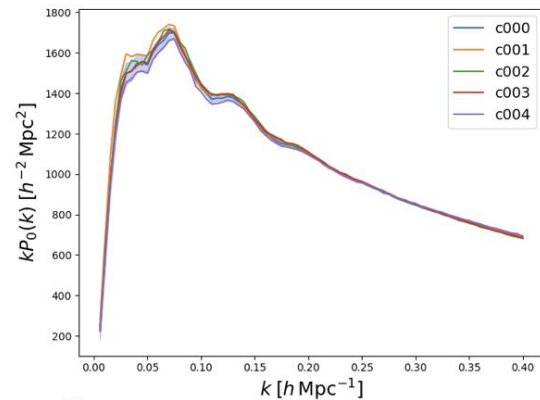


$$D_{c00x}^{-1}$$

RA, DEC,
z

c000 grid
cosmology

Observed Clustering

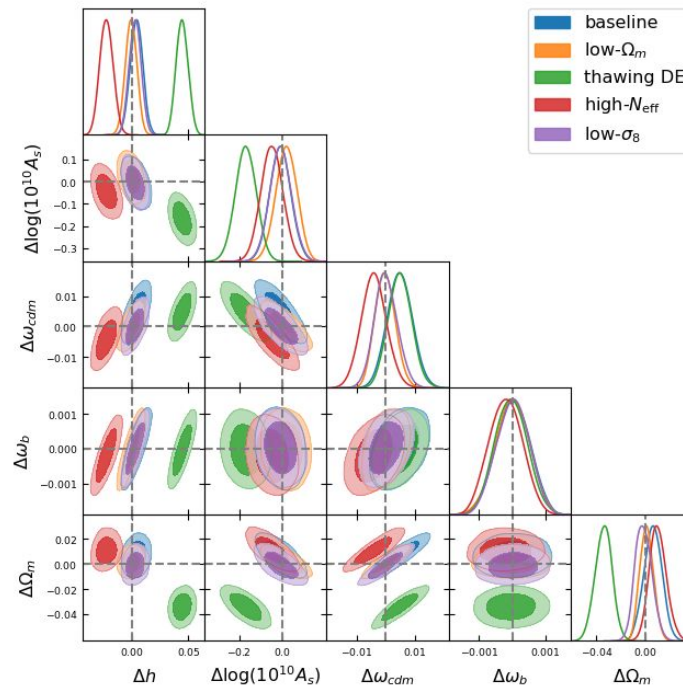


x

Can we recover the correct cosmology?

A more rigorous fiducial cosmology test

Quantify the systematics for DESI DR2 2pt+3pt

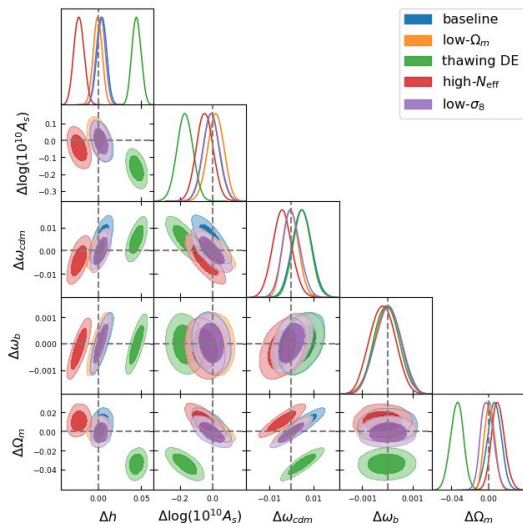


LCDM theory model

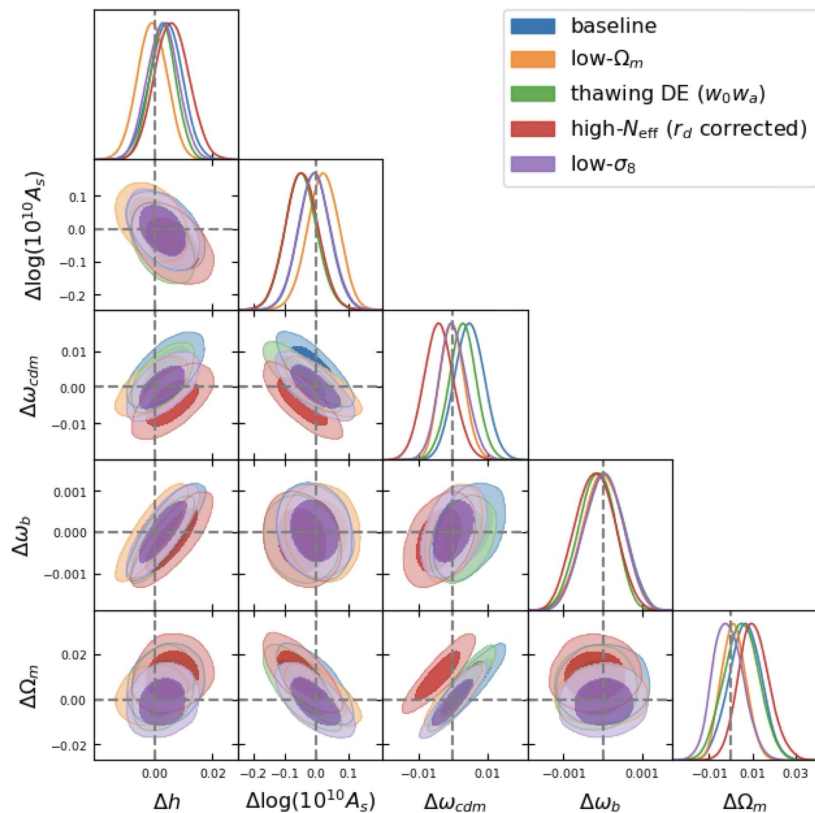
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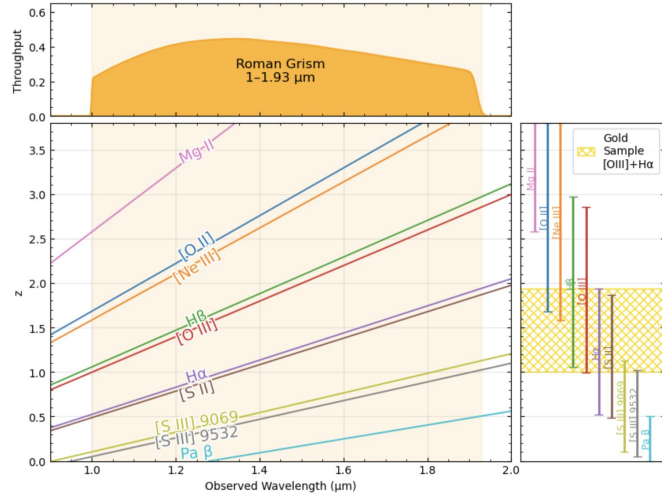
LCDM theory model



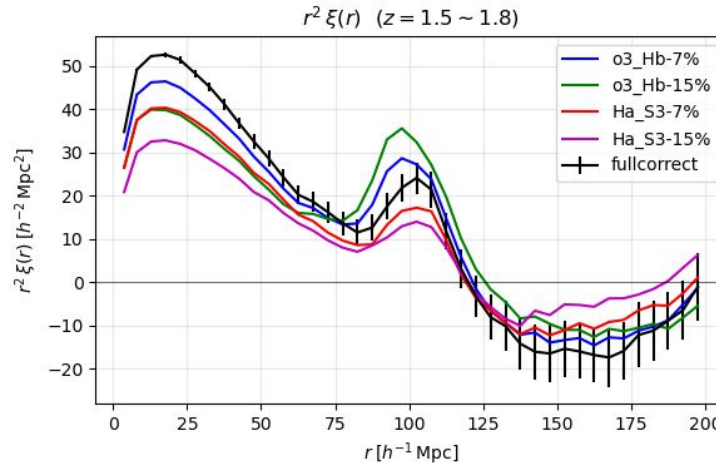
Corrected theory model (Cf. Neff)

Roman Galaxy Redshift Survey - Line interlopers

Grism survey: We need to deal with the line interlopers.



Credit: Kalina Nedkova



Yuyu Wang, Ferzem Khan
et al, in prep

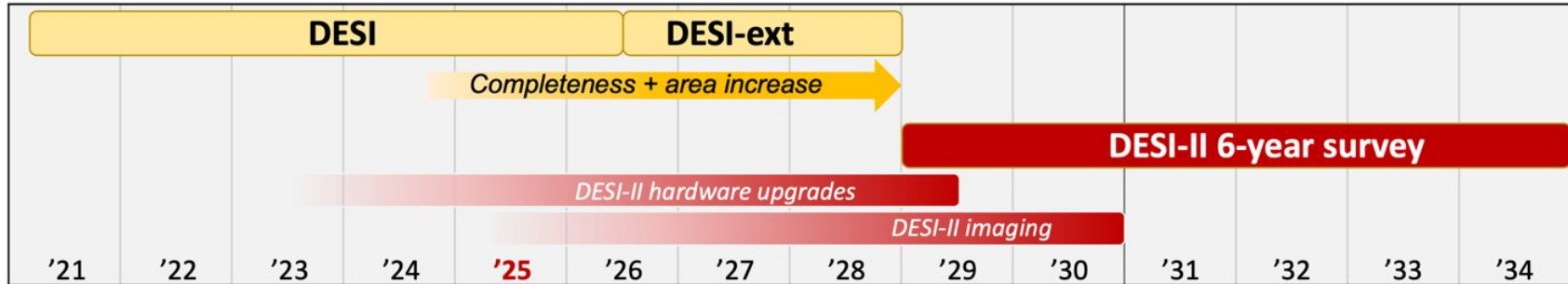




DARK ENERGY
SPECTROSCOPIC
INSTRUMENT

DESI Run-2 building upon success of DESI

U.S. Department of Energy Office of Science



DESI Run-2 a 4-fold program

- High redshift ($z > 2$) Dark Energy survey
- Cosmic Growth Survey ($z < 1$)
- Dark Matter Survey
- DESI-II/LSST Synergy

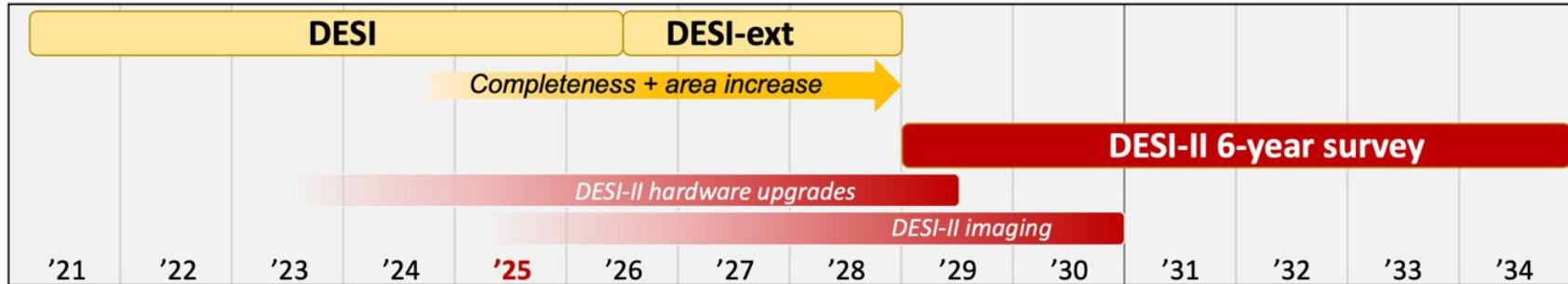
The white paper will be in public soon.



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*Thank you and nice to
meet you all (again)!*