Systematics Mitigation Strategies for WFIRST Cosmology

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Disclaimer

Using $w_0 - w_a$ as a metric, but

Statements do apply to many other cosmology science cases of the HLS survey (modified gravity, neutrino properties, other DE parameterizations)
Survey Optimization I

Number of galaxies

Bad

Good
Statistical error bars only (slightly simplified):

- Area is more important than depth
- Even more true since non-gaussian Covariances became fashionable
Let's play some WFIRST optimization…

- Use W filter only (Microlensing, 1-2 microns)
- Cover the LSST footprint to LSST/WFIRST depth in 1 Year (Chris Hirata, ETC)
- Get photo-z's from LSST
- Result see right

The fact that WFIRST has a survey mode that can cover LSST in just 1 Year illustrates what a fantastic/powerful mission this is!

Why don’t we do this...?
Today’s Survey Optimization III (HLS)

- Number density of galaxies
- External data sets
  - Cluster mass-observable relation
  - Covariance computation
  - Non-linear density field evolution
- Galaxy bias models
- Baryonic physics
- Intrinsic alignment
- Photo-z calibration
- Shear calibration
- Area
Today’s Survey Optimization III (HLS)

- Number density of galaxies
- External data sets
  - Cluster mass-observable relation
  - Covariance Issues
    - Non-linear density field evolution
    - Galaxy bias models
    - Baryonic physics
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Money
CosmoLike Simulated Analyses

Cosmological parameters

cosmo3d.c
- transfer function $T(k,z)$
- growth factor $D(k,z)$
- projected power spectrum $P_{\text{lin}}(k,z)$
- distances $P_{\text{nl}}(k,z)$

Coyote U. Emulator

halo.c
- collapse density $\delta_c(z)$
- peak height $\nu(M,z)$
- halo properties $c(M,z)$, $b(M,z)$, $n(M,z)$
- HOD, bias model

nuisance.c
- scaling relation $M_{\text{obs}}(M)$
- cluster selection function

clusters.c
- non-linear regime
- cluster finding
- galaxy formation
- intrinsic alignments
- non-Gaussian shear calibration
- photo-zs

redshift.c
- $z$-distribution $n(z)$
- photo-z model

projection functions

Limber approx.

cosmo2d.c
- $P(k,z_i)$

Likelihood $C_{XY}(l;\bar{z}_i,\bar{z}_j)$

Krause & Eifler 2017
Forecasting Game

- Define your science case and metric (e.g. cosmic acceleration, w-contours)
- Define survey parameters (area, number density, depth)
- Define your data vector (scale cuts, tomography bins)
- Define your cosmological parameter space
- Define your systematics models (parameterizations, priors)
- Compute covariance
- Compute contaminated and uncontaminated data vector
- Play…
- Repeat…
a systematics free survey....
bias free parameter estimates with statistical uncertainty
ignored systematic effect in analysis:
parameter bias
Level 3

marginalize systematic effect, correct parameterization
remove parameter bias, increase uncertainty
Level 4

marginalize systematic effect, correct parameterization
remove parameter bias, increase uncertainty
improve priors on nuisance parameters

Level 5

marginalize systematic effect, imperfect parameterization
residual parameter bias, increased uncertainty
WFIRST Forecasting Game (Single Player)

- WFIRST Weak Lensing only (2200 deg^2, 45 gal/arcmin^2)
- LSST/WFIRST like choices for systematics and priors, 7 cosmological parameters
WFIRST Forecasting Game (Multi Player)

- Weak Lensing (cosmic shear)  
  - 10 tomography bins
  - 25 l bins, 25 < l < 5000
- Galaxy clustering  
  - 4 redshift bins (0.2-0.4, 0.4-0.6, 0.6-0.8, 0.8-1.0)
  - compare two samples: \( \sigma_z < 0.04 \), redMaGiC
  - linear + quadratic bias only: l bins restricted to \( R > 10 \) Mpc/h
  - HOD modeling going to \( R > 0.1 \) Mpc/h
- Galaxy-galaxy lensing  
  - galaxies from clustering (as lenses) with shear sources
- Clusters - number counts + shear profile  
  - so far, 8 richness, 4 z-bins (same as clustering)
  - tomographic cluster lensing (500 < l < 10000)

shear calibration, \( b_1, b_2, \ldots \)

photo-z (sources)

IA, baryons

photo-z (lenses)

N-M relation

c-M relation

off-centering
Multi-Probes Forecasts: Covariance

Cluster Lensing
Clusters
Galaxy Clustering
Galaxy-Galaxy Lensing
Cosmic Shear

7+ million elements

details: Krause&Eifler ‘17
Single vs Multi-Probe Forecasts

- No systematics
Multi-Probes Forecasts

7 cosmological parameters
49 (HLIS) + 16 (HLSS) nuisance parameters

- Shear Calibration
- Lens+Source photo-z
- Linear galaxy bias
- Cluster Mass Calibration
- Intrinsic Alignments
- BAO peak smearing
- Peculiar velocity dispersion
- Spec-z redshift errors
**Other Forecasting Projects**

**Measure likelihood function in sims**

Lin, Harnois-Deraps, Eifler, Mandelbaum in prep

**New Covariance Estimator**

Friedrich & Eifler 2017

**WFIRST modified gravity**

See talk by Hironao Miyatake (Cosmo HLS SIT)

**WFIRST CMB-S4 synergies**

Schaan et al 2016
Summary

- Multi-Probe analysis avenues pose a substantial gain in constraining power.
- Truly informative forecasts are complex endeavors and mimic an actual analysis.
- They are useful to identify the most important systematics and to implement mitigation strategies.
- Forecasts cannot exist in isolation but need close connections to experts in numerical simulations, survey simulations, observations (all types), statistical methods.

- WFIRST is a fantastic survey for cosmic acceleration. We need to optimize it, and at the same time keep it flexible enough for the unknown.