Systematics Mitigation Strategies for WFIRST Cosmology

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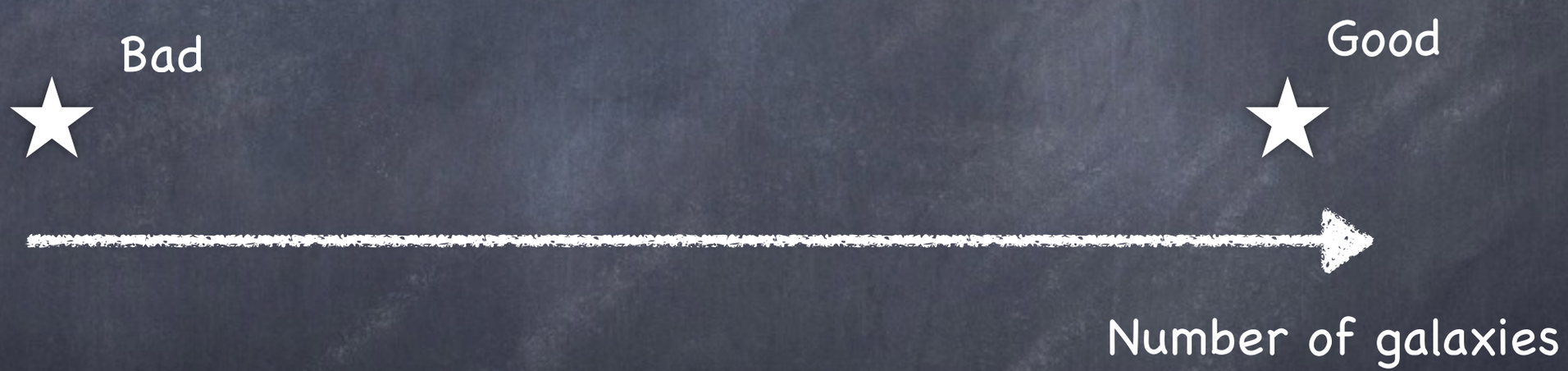
Disclaimer

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



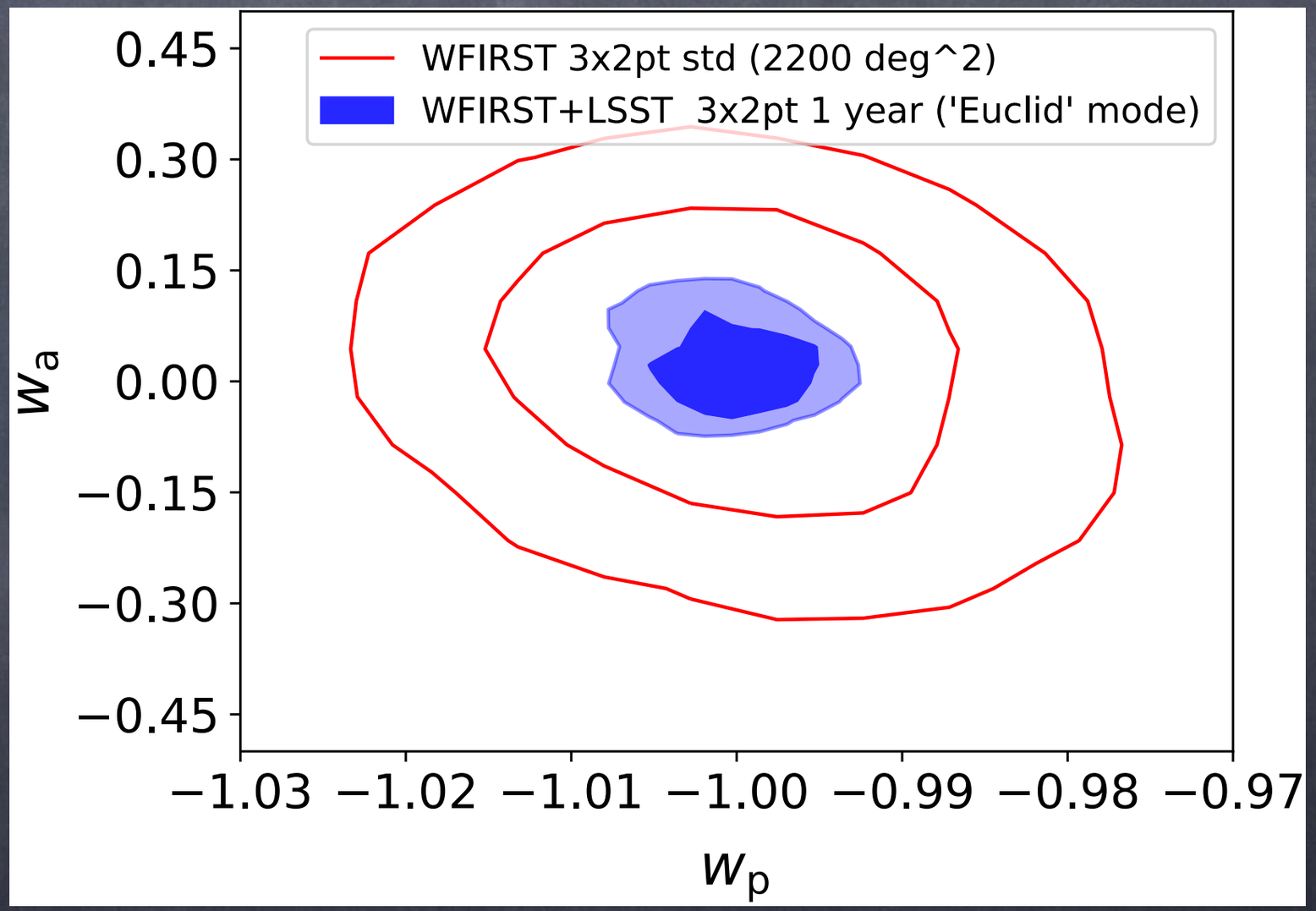
Survey Optimization II

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…

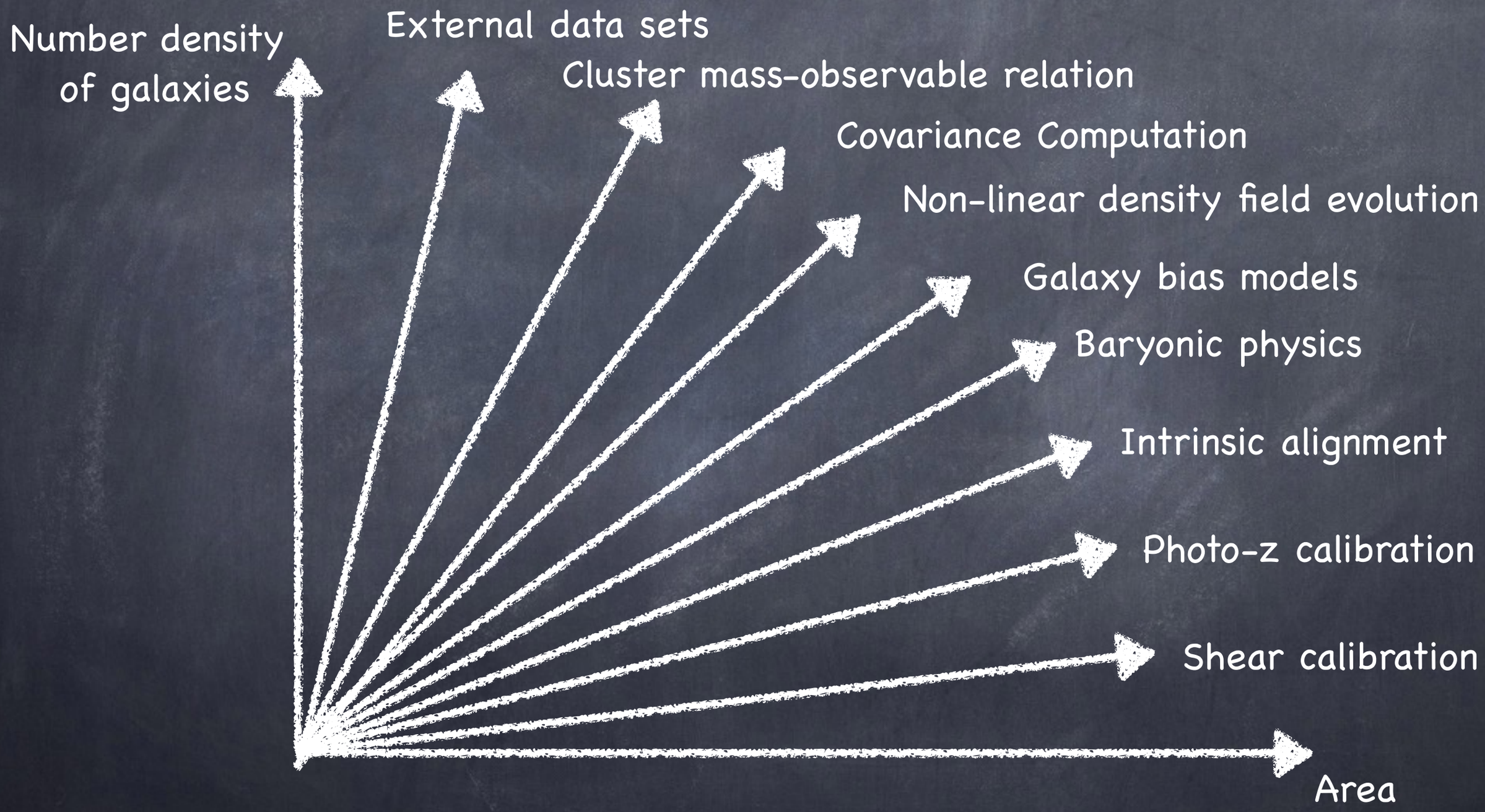
- Use W filter only (Microlensing, 1-2 microns)
- Cover the LSST footprint to LSST/WFIRST depth in 1 Year (Chris Hirata, ETC)
- Get photo-z's from LSST
- Result see right



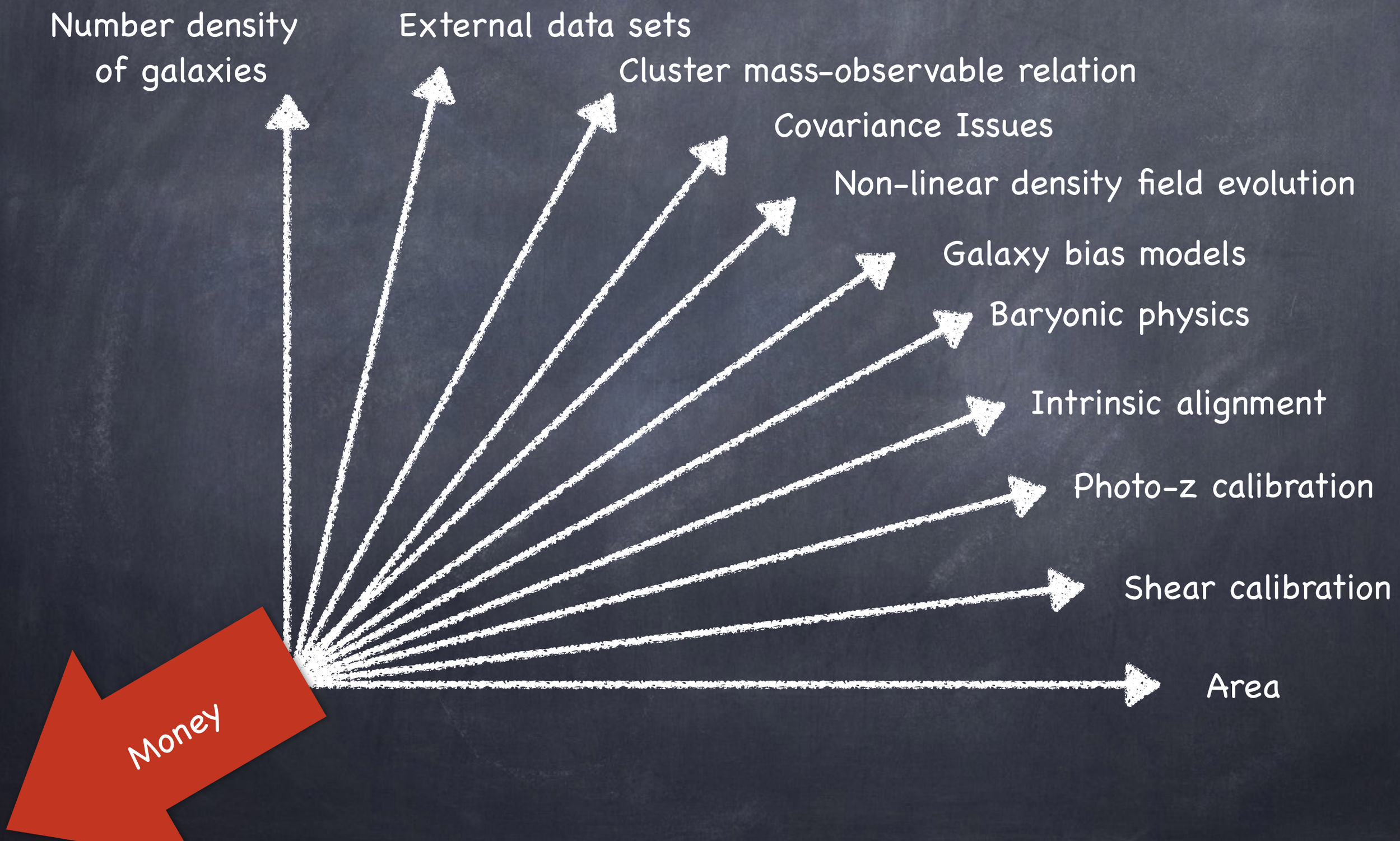
The fact that WFIRST has a survey mode that can cover LSST in just 1 Year illustrates what a fantastic/powerful mission this is!

Why don't we do this…?

Today's Survey Optimization III (HLS)



Today's Survey Optimization III (HLS)



CosmoLike Simulated Analyses

Krause & Eifler 2017

cosmological parameters

cosmo3d.c

transfer function T(k,z)

growth factor D(k,z)

$P_{lin}(k,z)$

Coyote U. Emulator

distances

$P_{nl}(k,z)$

collapse density $\delta_c(z)$

peak height ν (M,z)

halo properties

c(M,z) | b(M,z) | n(M,z)

HOD, bias model

halo.c

clusters.c

scaling relation $M_{obs}(M)$

cluster selection fuction

$P(k,z_j)$

non-linear regime

baryons

cluster finding

galaxy formation

intrinsic alignments

non-Gaussian photo-zs

shear calibration

... .

nuisance.c

z-distr. n(z)

photo-z model

redshift.c

projection functions

Limber approx.

cosmo2d.c

$N(M_{obs};z_i)$

$C^{XY}(l;z_i,z_j)$

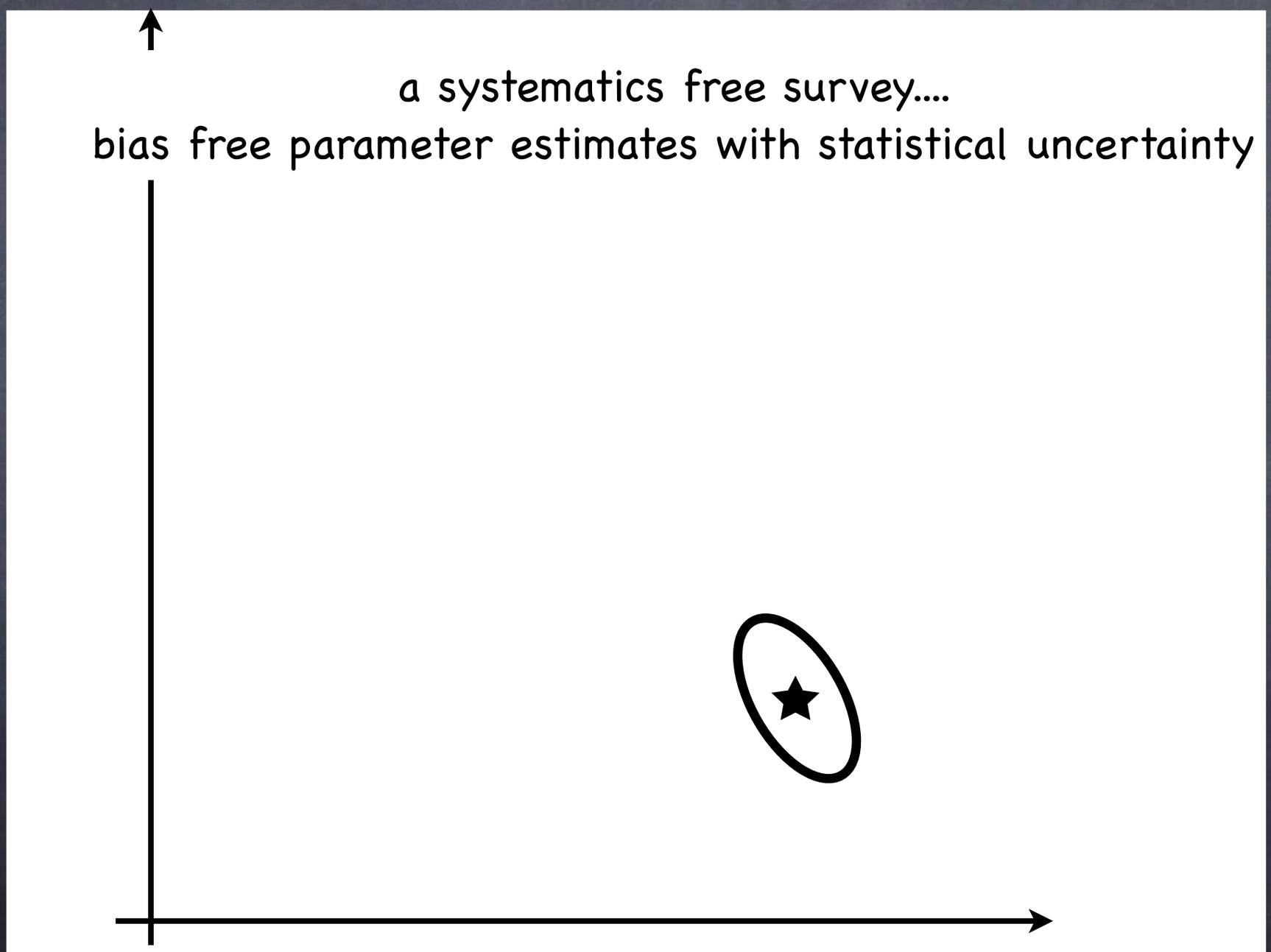
$Cov(z_i,z_j,z_k,z_l,l_1,l_2)$

Likelihood

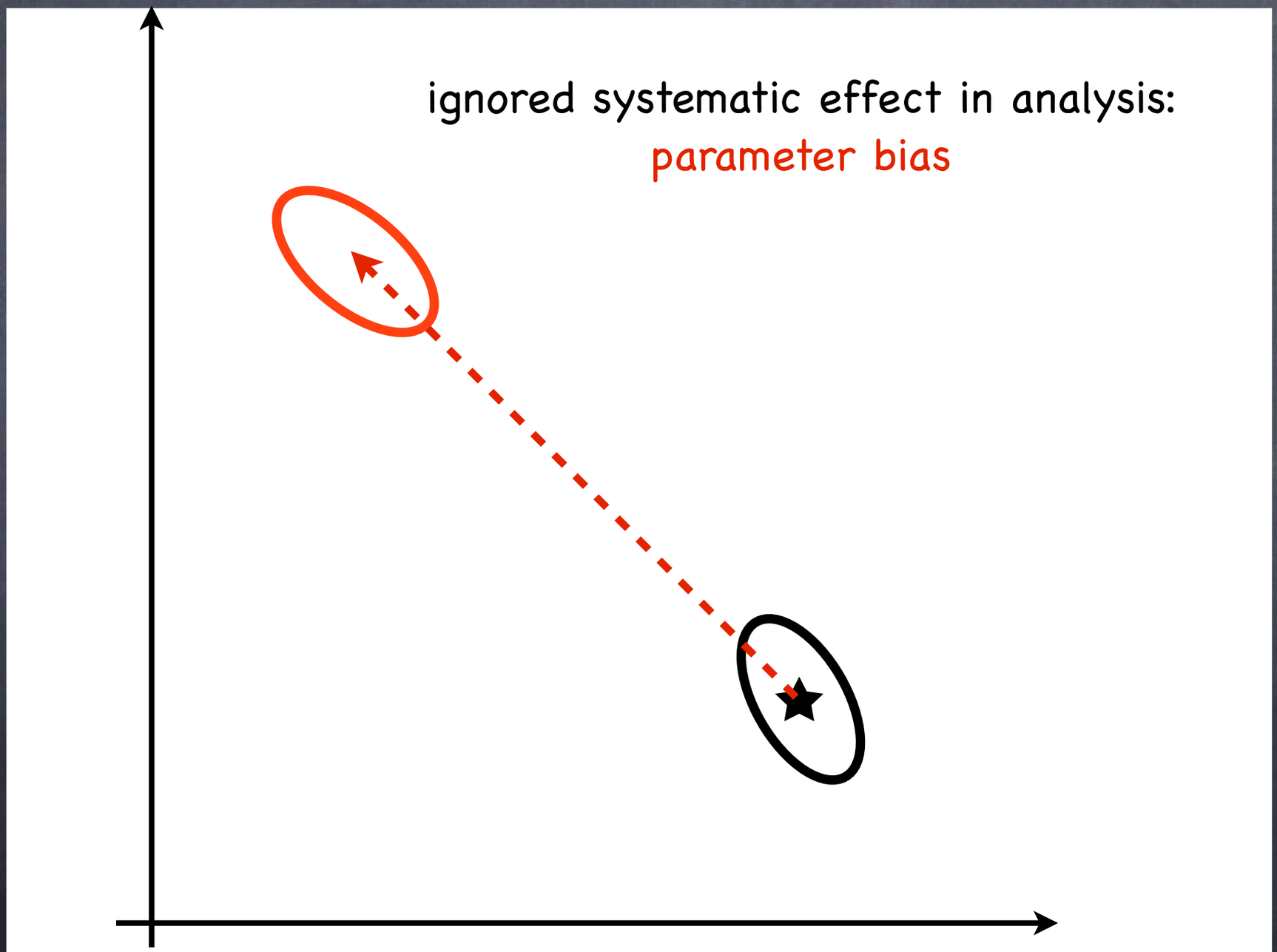
Forecasting Game

- 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…

Level I


a systematics free survey....
bias free parameter estimates with statistical uncertainty

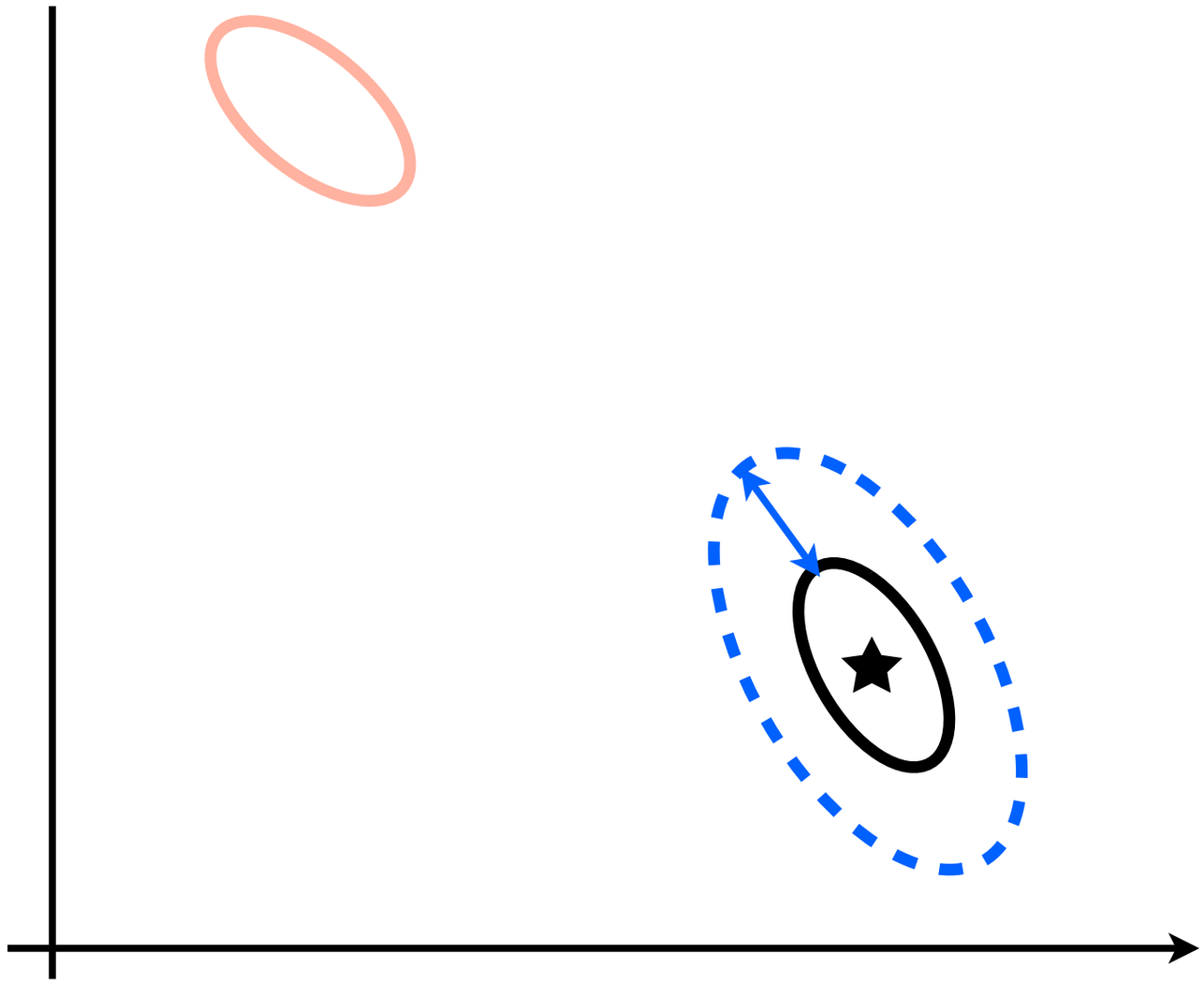
Level 2



Level 3

marginalize systematic effect, correct parameterization

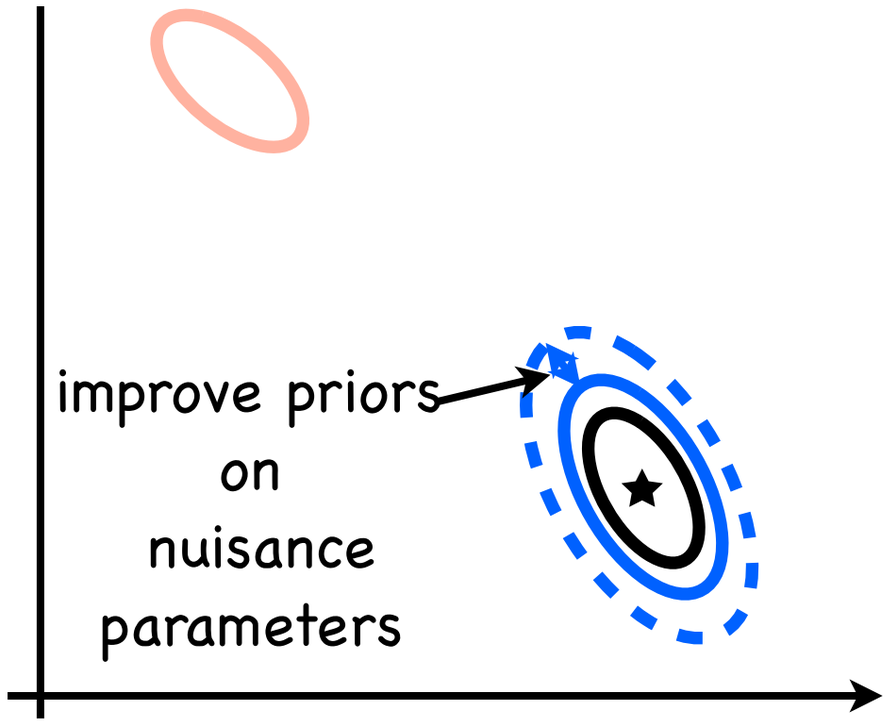
remove parameter bias, increase uncertainty



Level 4

marginalize systematic effect, correct parameterization

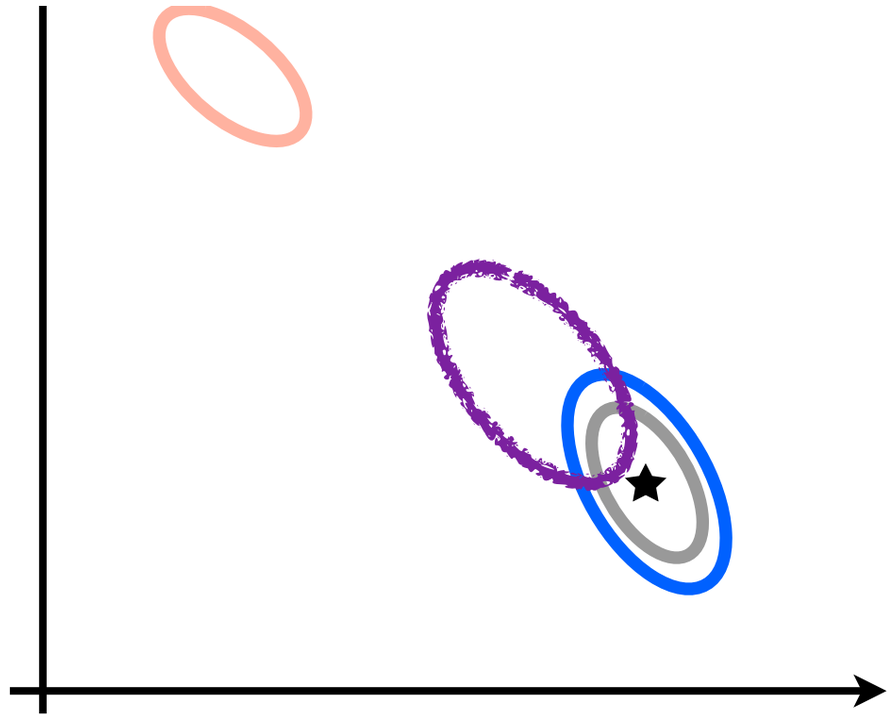
remove parameter bias, increase uncertainty



Level 5

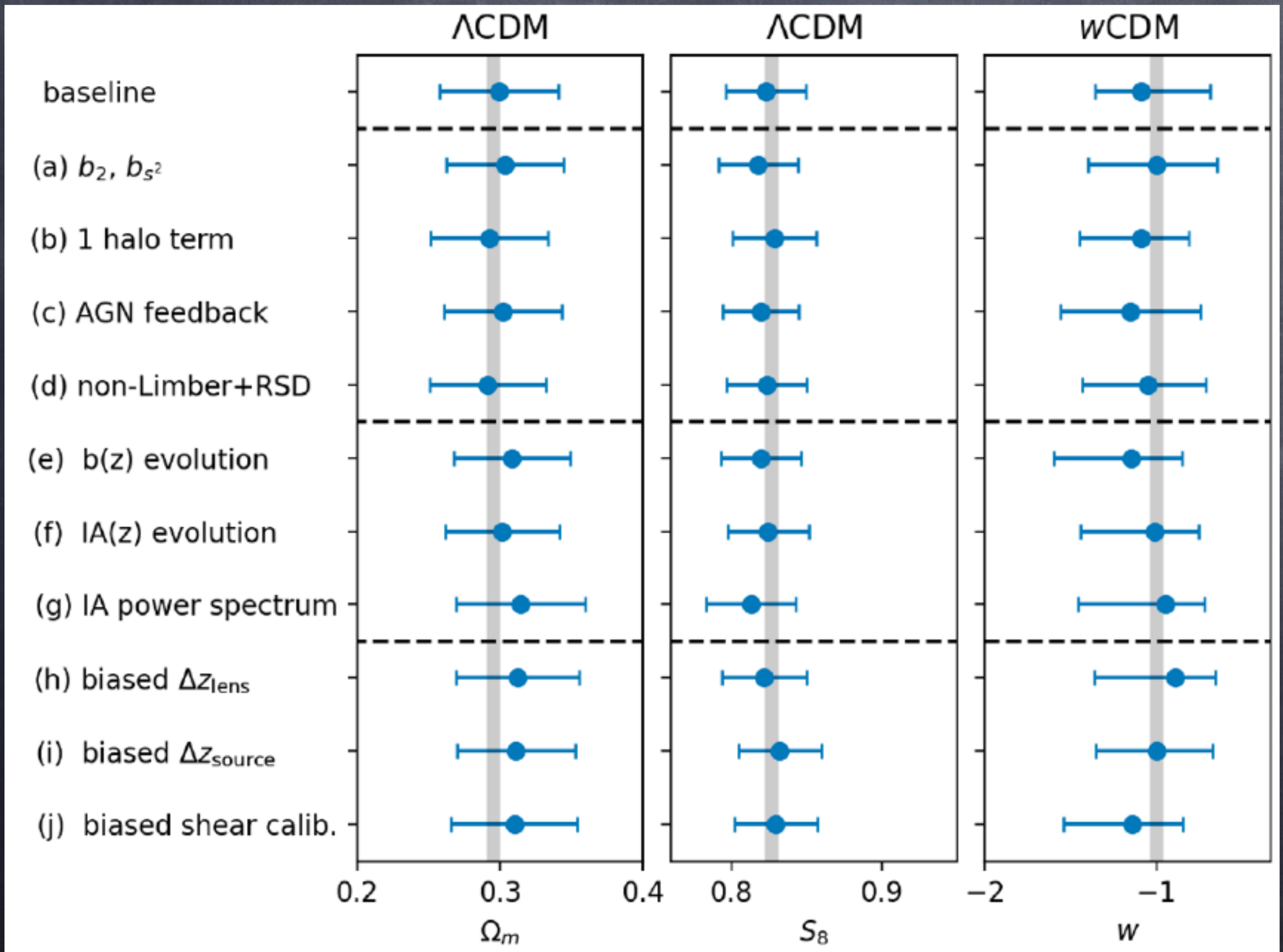
marginalize systematic effect, imperfect parameterization

residual parameter bias, increased uncertainty



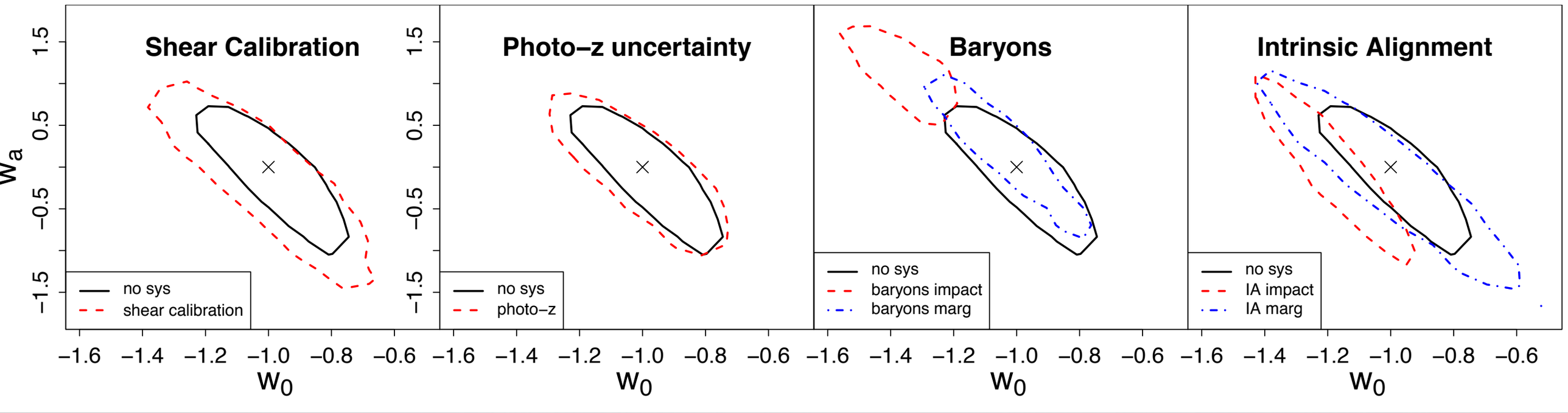
DES Y1 KP Methods Paper

Krause, Eifler et al 2017



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

shear calibration,
photo-z (sources)
IA, baryons

- Galaxy clustering
  - 4 redshift bins (0.2-0.4,0.4-0.6,0.6-0.8,0.8-1.0)
  - compare two samples: σ_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

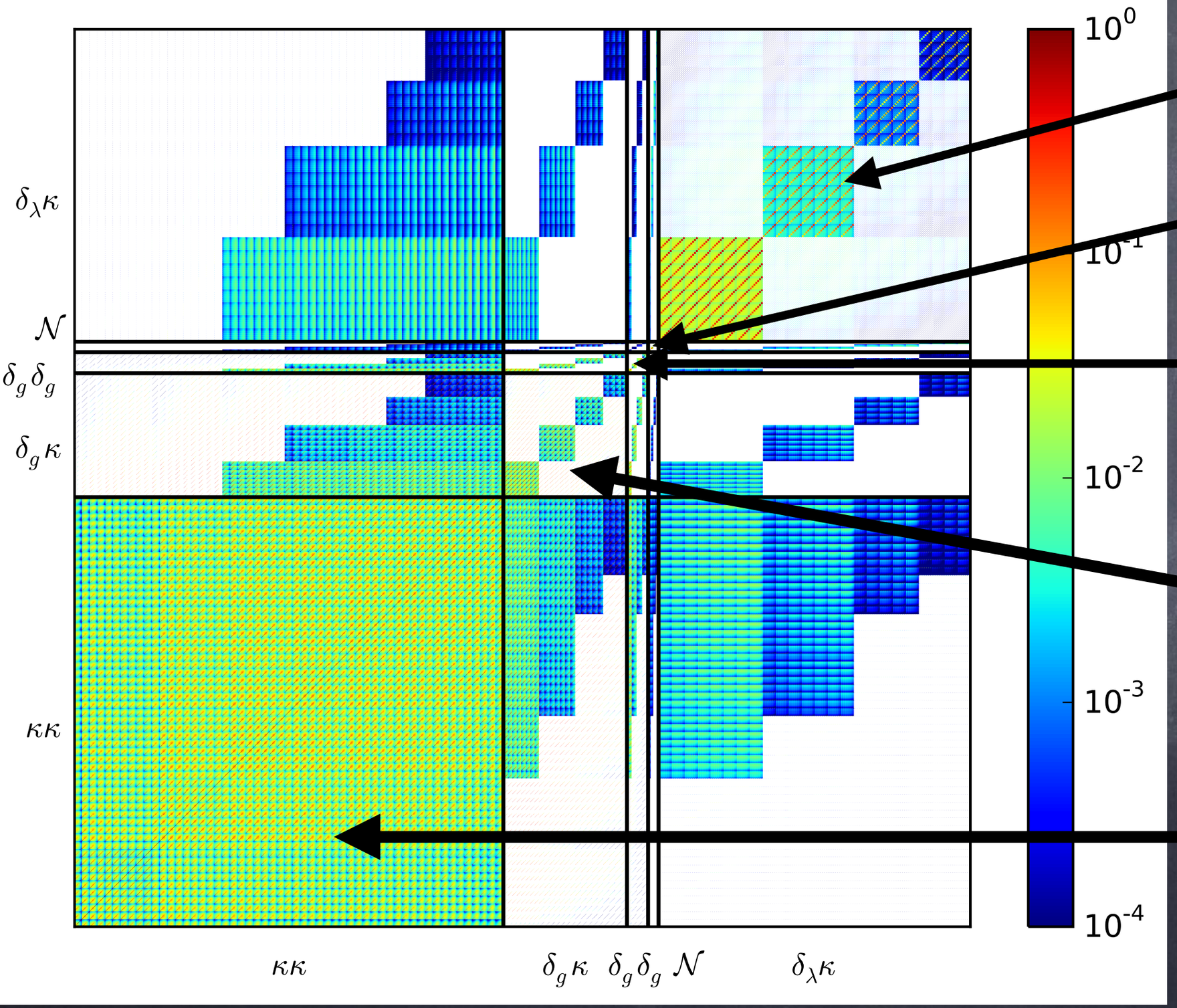
b_1, b_2,...

photo-z (lenses)

- 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)

N-M relation
c-M relation
off-centering

Multi-Probes Forecasts: Covariance



Cluster Lensing

Clusters

Galaxy Clustering

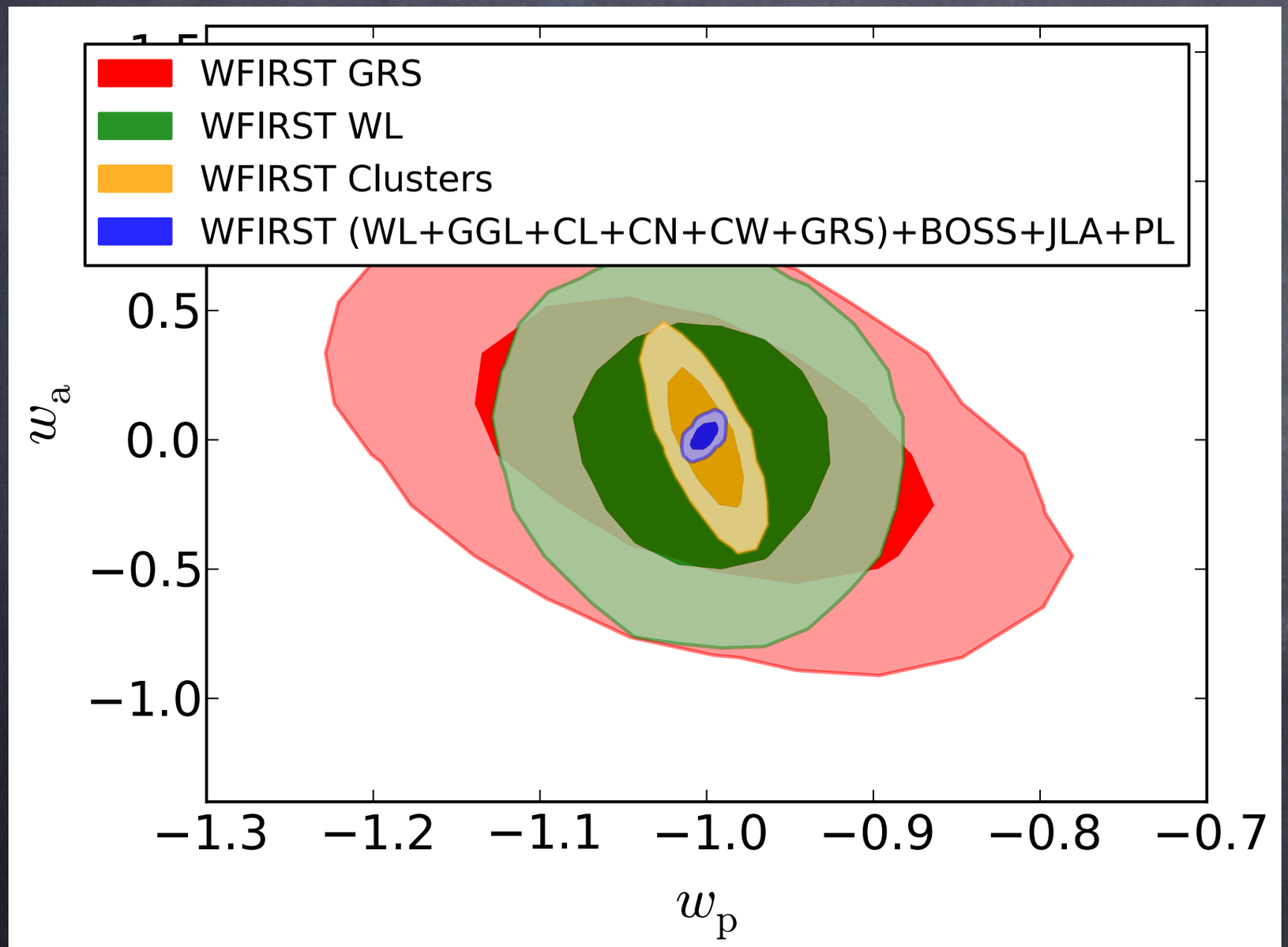
Galaxy-Galaxy Lensing

Cosmic Shear

7+ million elements

details: Krause&Eifler '17

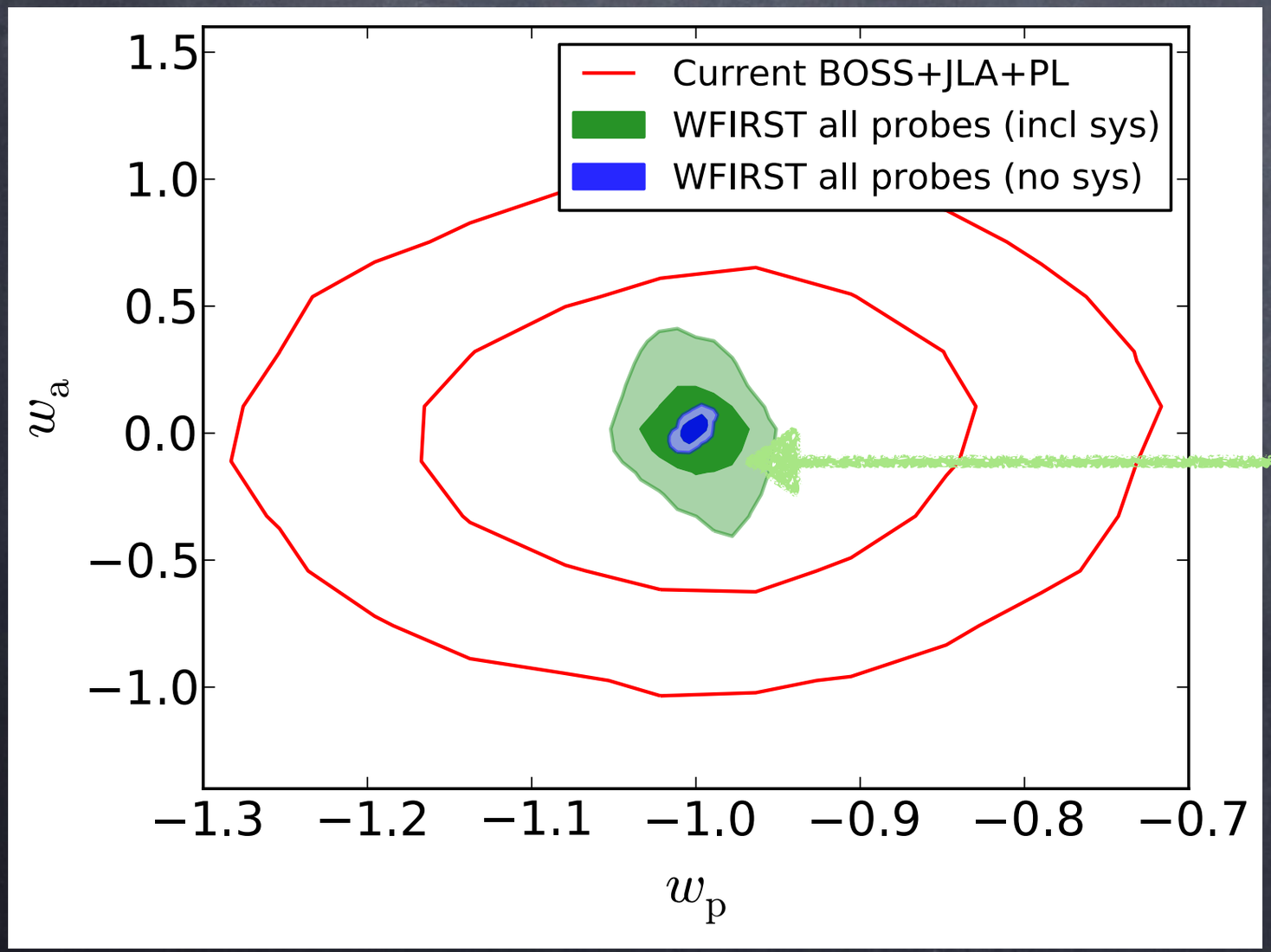
Single vs Multi-Probe Forecasts



- No systematics

Multi-Probes Forecasts

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

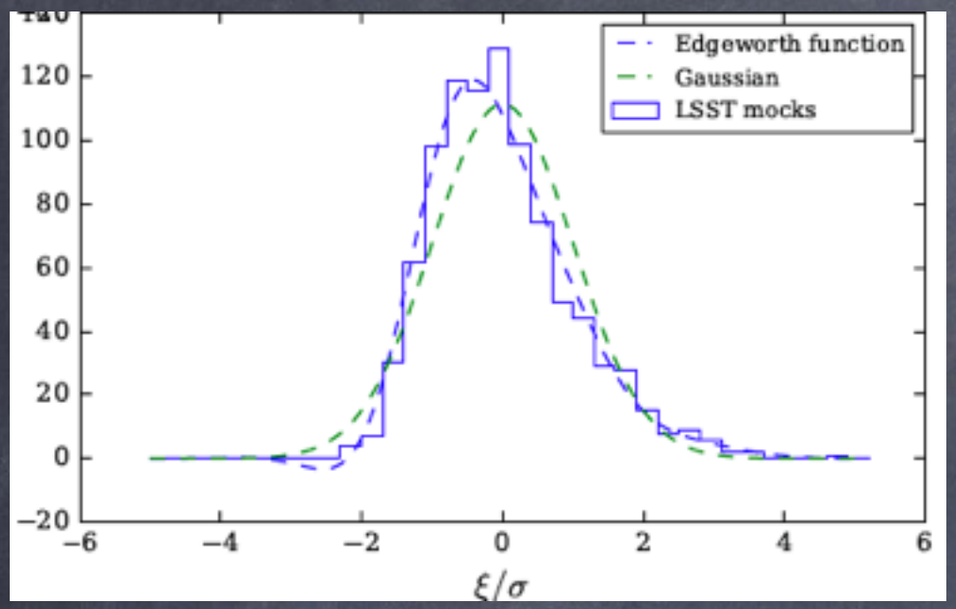


- Shear Calibration
- Lens+Source photo-z
- Linear galaxy bias
- Cluster Mass Calibration
- Intrinsic Alignments

- BAO peak smearing
- Peculiar velocity dispersion
- Spec-z redshift errors

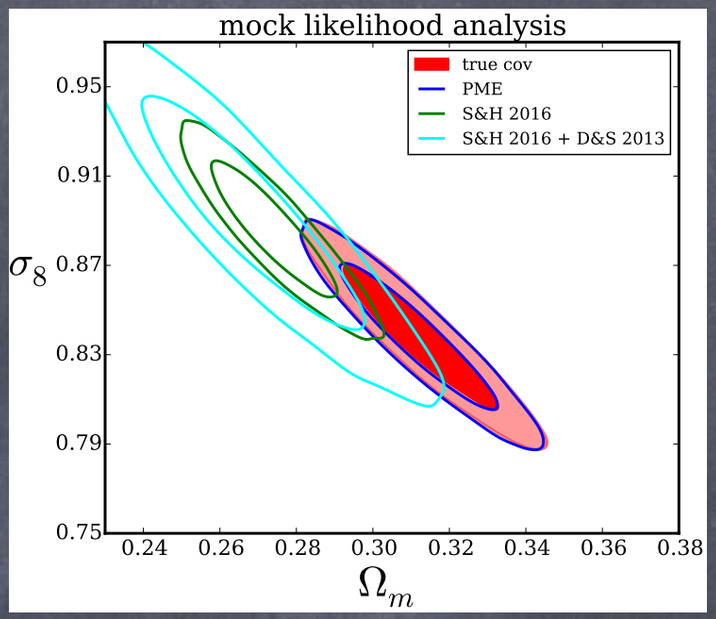
Other Forecasting Projects

Measure likelihood function in sims



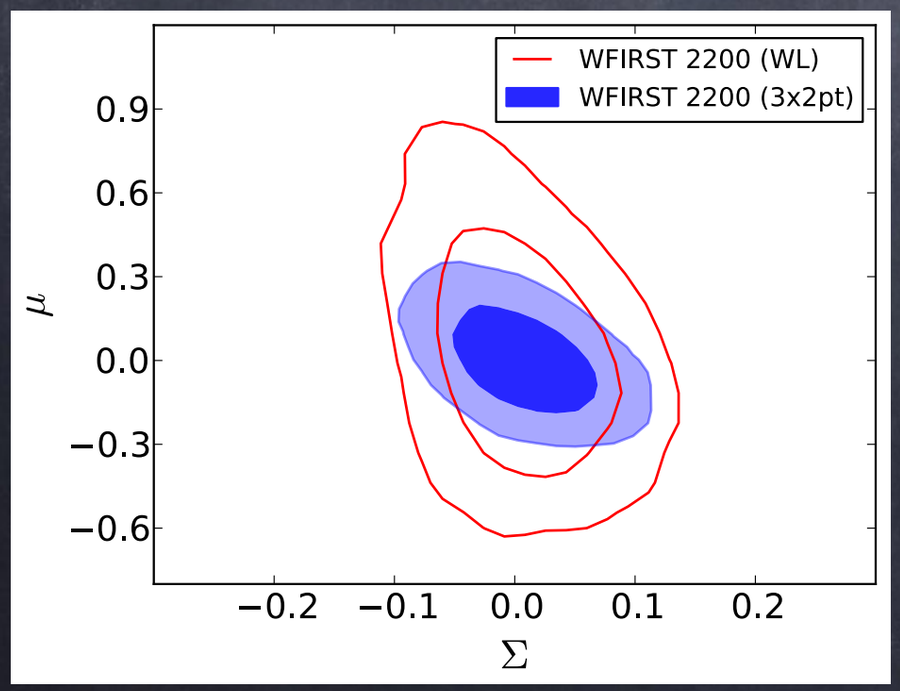
Lin, Harnois-Deraps, Eifler, Mandelbaum in prep

New Covariance Estimator



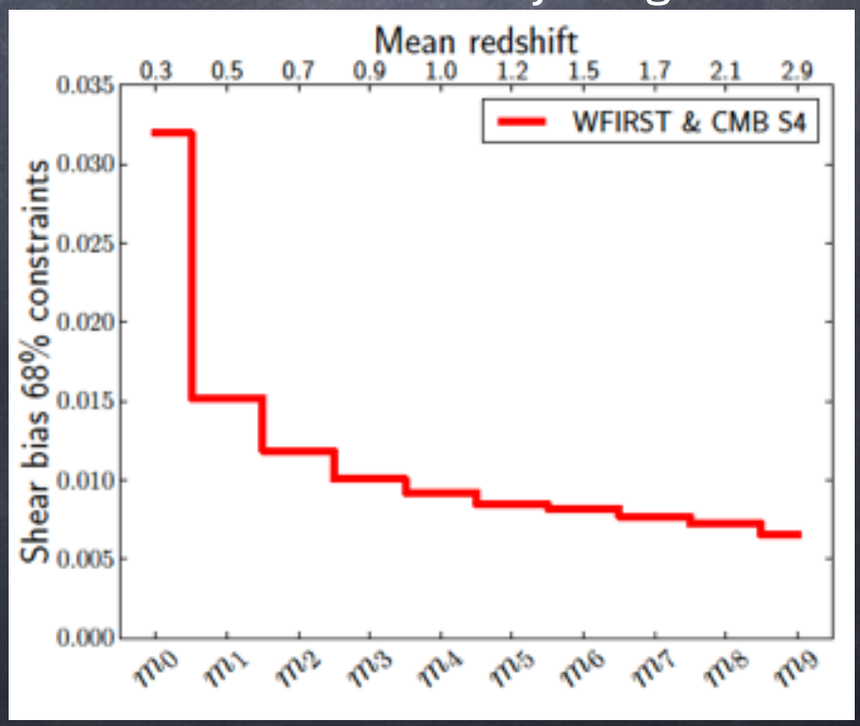
Friedrich & Eifler 2017

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.