Where should we be looking post DESI/LSST

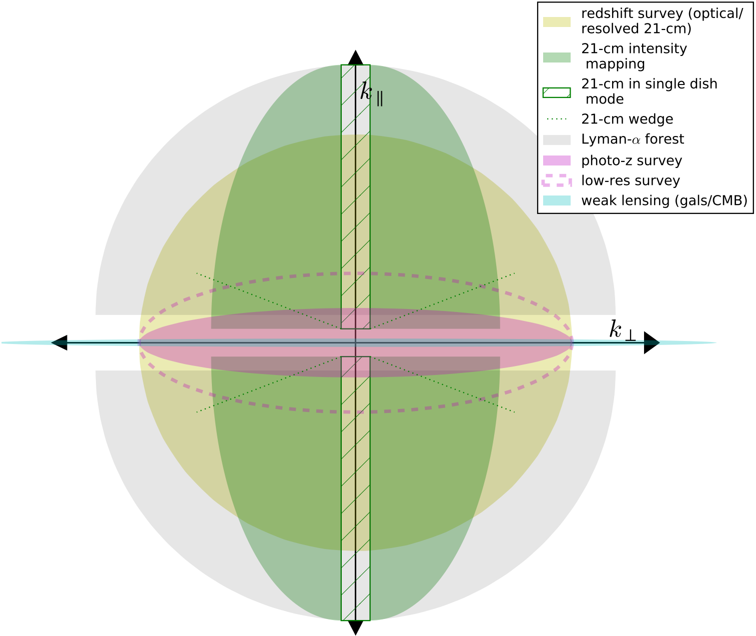
Anže Slosar

Chicago Future Surveys

Introduction

- Parameters will be constrained to some very high precision after CMB S4 + DESI + LSST, but there is more information
- Getting further is hard, both statistically and systematically
- So where should we be looking?
- Two basic ways in which experiments can be complementary:
  - observing the same fields and "cross-correlate"
  - observing independently, but with different parameter degeneracy directions ← *this talk*

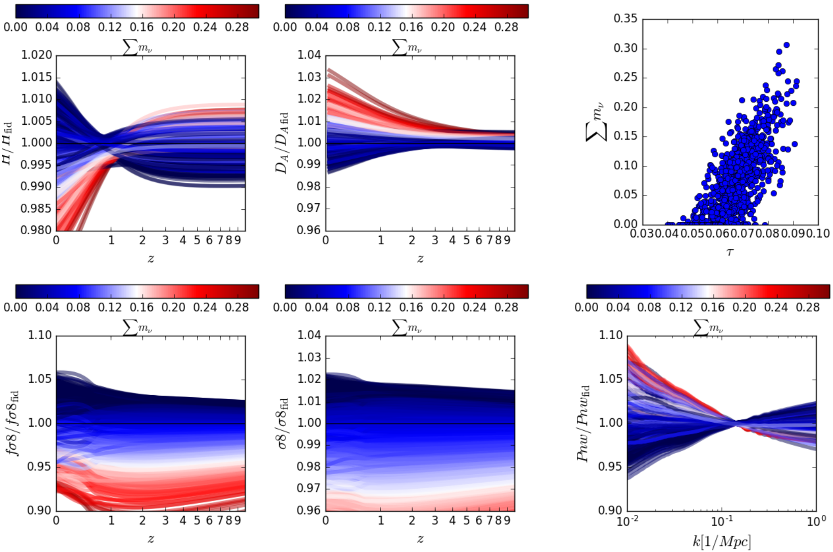
Sharing modes



Parameter degeneracies

- Some degeneracies easy to understand, some are somewhat counter-intuitive.
- Perhaps easiest to take a "fake experiment" driven approach:
  - given Fisher matrix for CMB-S4 + X, generate cosmological models
  - for each model make prediction for *observables* for possible future observations
  - if the spread correlates with a parameter of interest, meauring that observable at the sufficient precision will lower that parameter error
- An example ...

m_ν, S4

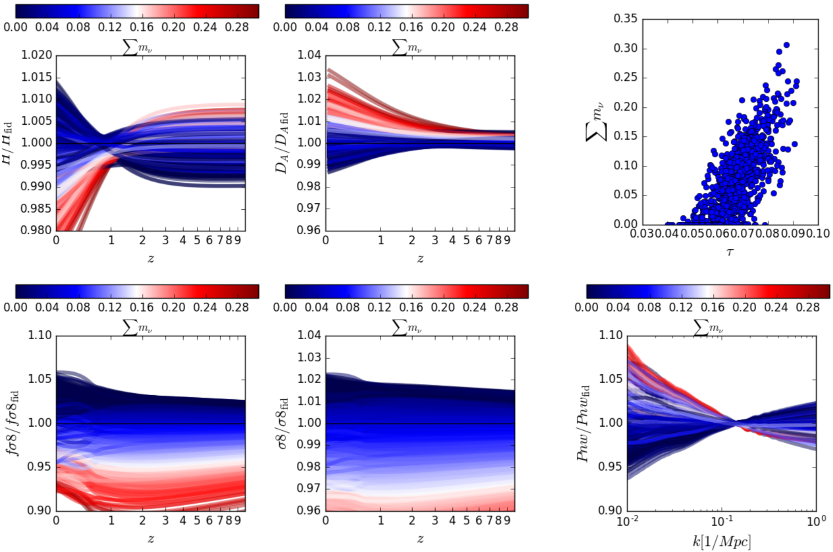


$\sum m_\nu$
0.00 0.04 0.08 0.12 0.16 0.20 0.24 0.28
$H/H_{\rm fid}$
$D_A/D_{A\,\rm fid}$
$f\sigma 8/f\sigma 8_{\rm fid}$
$\sigma 8/\sigma 8_{\rm fid}$
$Pnw/Pnw_{\rm fid}$
z
τ
$k[1/Mpc]$

Input Fisher matrices

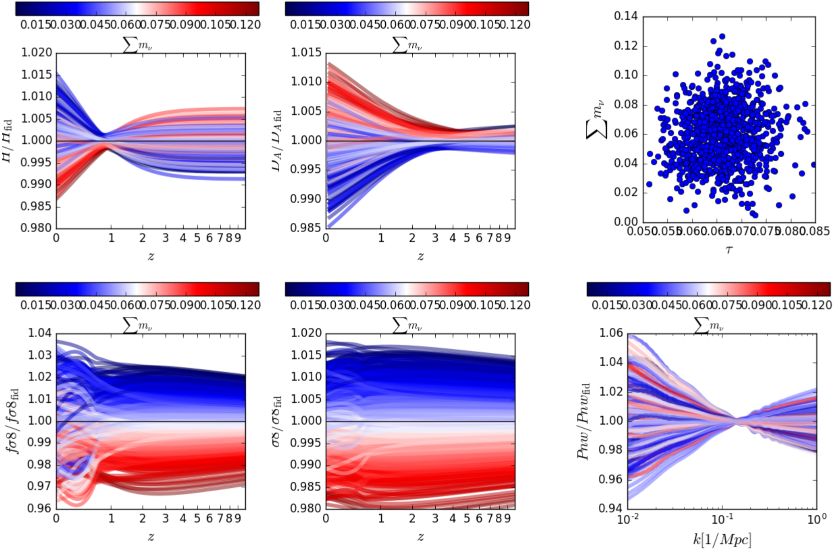
- Got three Fisher matrices for CMB S4:
  - ΛCDM + $\sum m_\nu$ from Joel Meyers
  - ΛCDM + $\sum m_\nu + N_{\rm eff}$ from Joel Meyers
  - wΛCDM from Alessandro Manzotti
- S4 assumes "1 μK-arcmin, 1 arcmin beam, $f_{\rm sky} = 0.4$, with Planck high-ell data on an additional 20% of the sky, and an error of .01 on tau from the low-ell Planck data"
- S4 utilizes primary C_ℓ is temperature (to $\ell = 3000$) and polarization (to $\ell = 5000$) and 4-point lensing reconstruction
- DESI based off Pat McDonald's code, assumes whatever is the latest
- LSST based off Pat McDonald and is for LSS and WL only
- For each combination, I drew 1000 models, so extremes are reaching 3-sigma tails
- Last plots were done this morning, so scope for errors is above average...

m_ν, $S4$



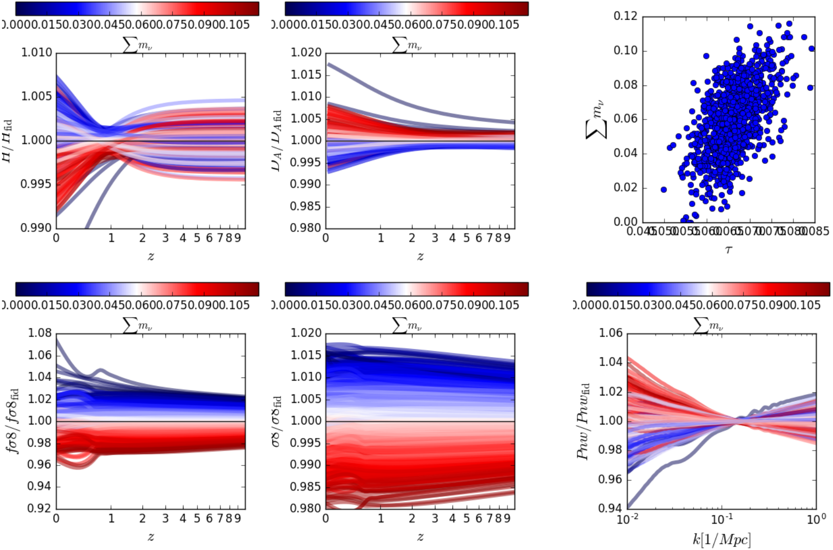
$\sum m_\nu$
$H/H_{\rm fid}$
z
$D_A/D_{A\,\rm fid}$
$\sum m_\nu$
τ
$f\sigma8/f\sigma8_{\rm fid}$
$\sigma8/\sigma8_{\rm fid}$
$Pnw/Pnw_{\rm fid}$
$k[1/Mpc]$

m_ν, S4+LSST



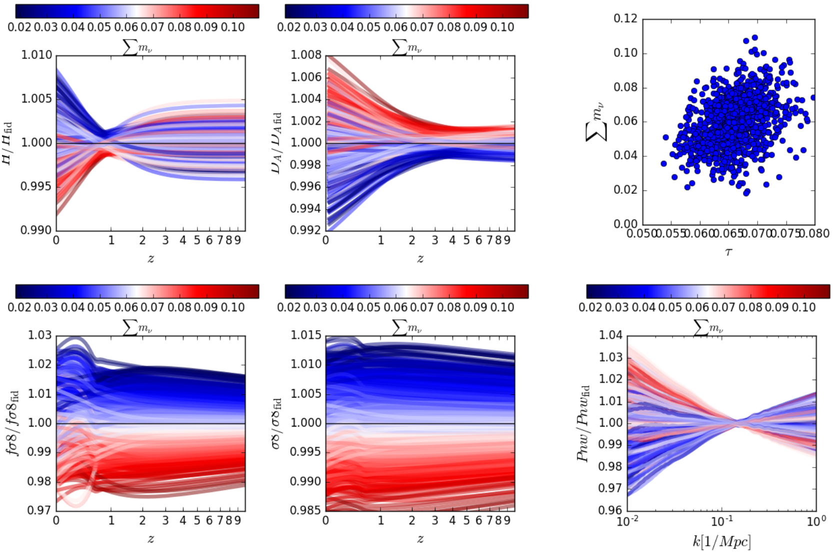
0.015 0.030 0.045 0.060 0.075 0.090 0.105 0.120
$\sum m_\nu$
$H/H_{\rm fid}$
$D_A/D_{A\,\rm fid}$
$\sum m_\nu$
τ
$f\sigma 8/f\sigma 8_{\rm fid}$
$\sigma 8/\sigma 8_{\rm fid}$
$Pnw/Pnw_{\rm fid}$
z
$k[1/Mpc]$

m_ν, S4+DESI

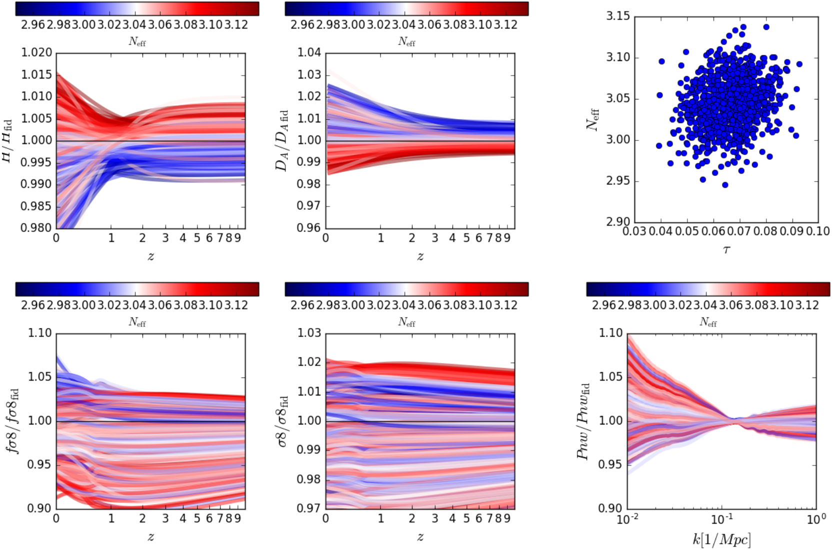


$\sum m_\nu$
$H/H_{\rm fid}$
$D_A/D_{A\,\rm fid}$
$f\sigma 8/f\sigma 8_{\rm fid}$
$\sigma 8/\sigma 8_{\rm fid}$
$Pnw/Pnw_{\rm fid}$
z
τ
$k[1/Mpc]$

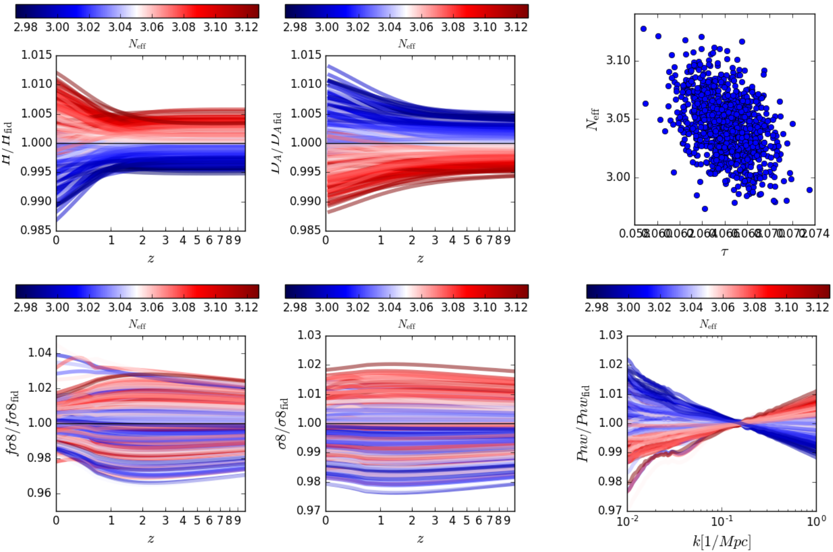
m_ν, S4+LSST+DESI



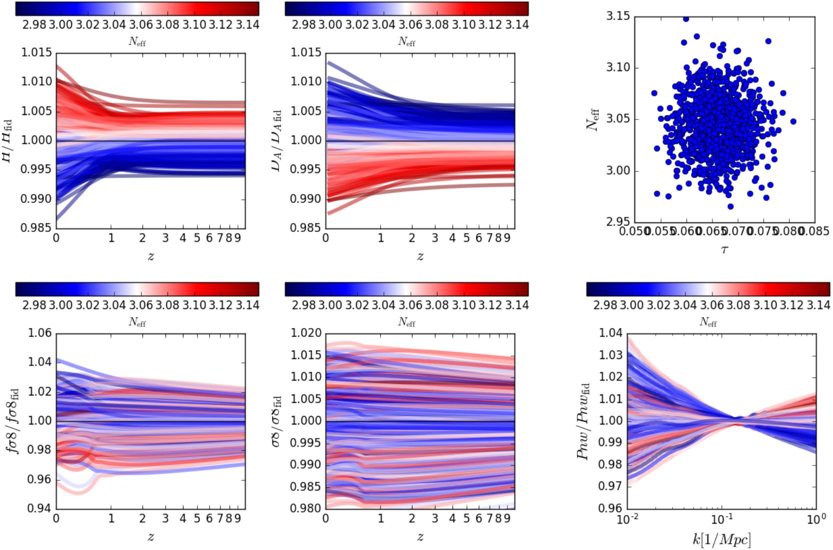
N_{eff}, *S4*



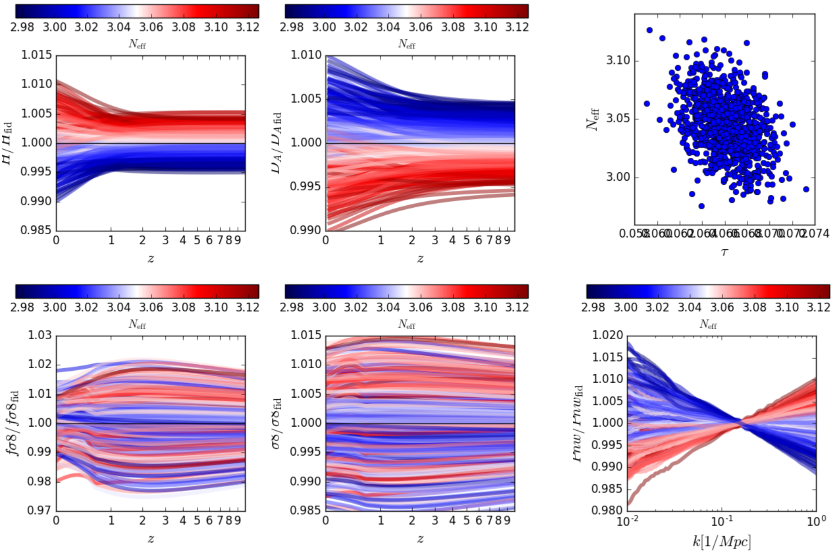
$N_{\rm eff}$, $S4$+$LSST$



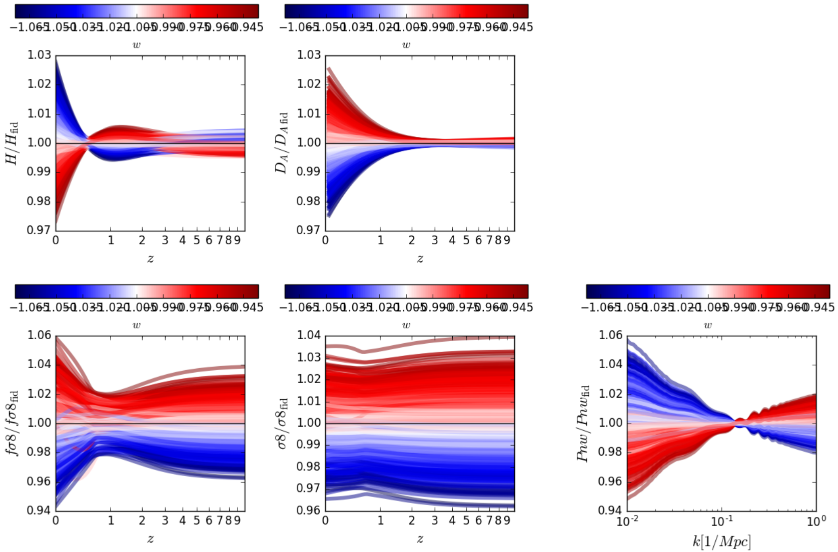
$N_{\rm eff}$, $S4+DESI$



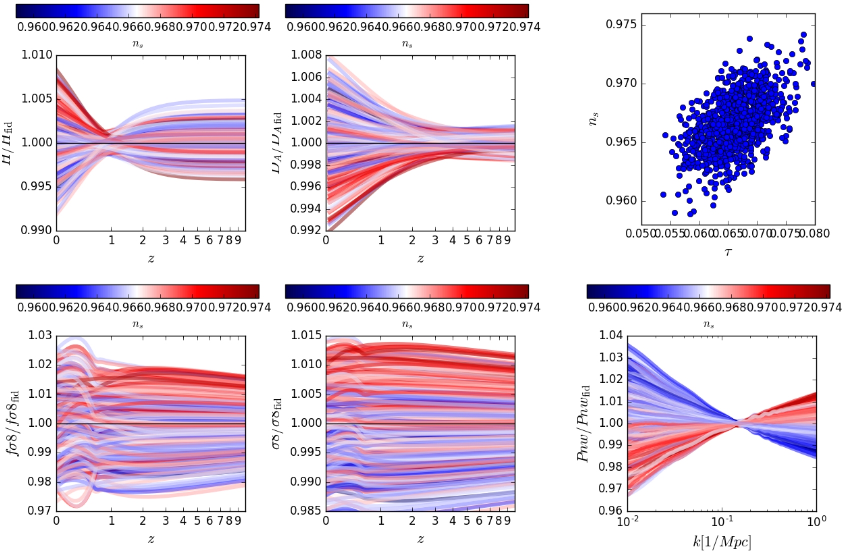
$N_{\rm eff}$, *S4+LSST+DESI*



w (no ν!), S4+DESI



n_s, S4+DESI+LSST



Other parameters

- Inflationary n_s, α_s: small-scale measurements of linear power spetrum, e.g. from Lyman-α forest could help, but not in general
- non-Gaussianity: in cross-correlations, potentially huge opportunities of exploiting Dalal effect sans systematics, but no direct degeneracy breaking
- tensor modes: claims in the literature that 21-cm could do very well ($r \sim 10^{-9}$ Book, Kamionkowski and Schmidt)

Conclusions

- It is 2025, deep inside S4+DESI+LSST, you can do one thing before you die, what do you do?
- For m_ν:
  - Measure σ_8 to sub-percent precision or $f\sigma_8$ to percent precision
  - Measure Hubble parameter to sub-percent precision
  - Measure low-z D_a to sub-percent precision
  - BAO parameters don't add much, τ surprisingly doesn't add much
- For $N_{\rm eff}$:
  - Measure slope of the power spectrum to sub-percent precision
  - Measure BAO parameters at subpercent precision, H_0 would also help
  - τ helps marginally
- Basic survey observables, BAO and RSD, still seem to have a long way to go in terms of helping others achieve their dreams
- $f\sigma_8$ and σ_8 about equally useful – which is easier to measure?
- Power spectrum shape is really just one-parameter