Thoughts on ngCFHT cosmology

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Scope of talk

- BAO survey optimization
- BAO measurements and their cosmological constraining power
- Primordial non-Gaussianity

Not in talk:

- Growth measurements (e.g. redshift space distortions)
- Growth-related cosmological parameters (e.g. neutrino mass)

Galaxy surveys and cosmology

Galaxies (or Lyman-alpha forest flux) used as statistical tracers of large-scale structure

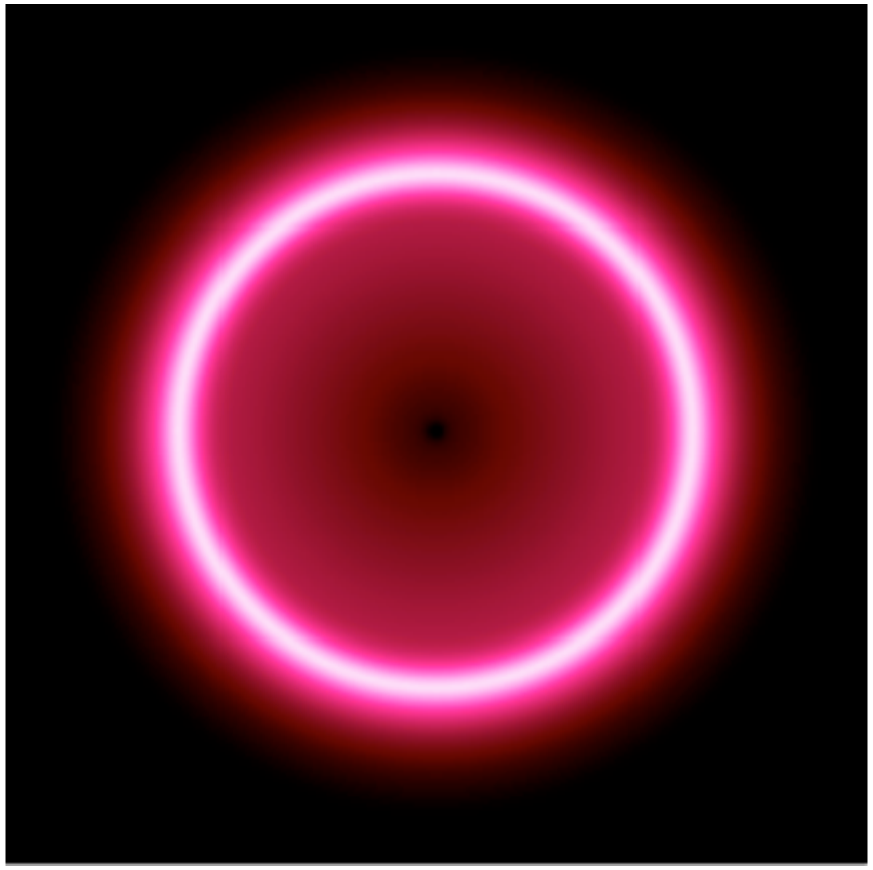
Fundamental tradeoff: a survey strategy which is optimized for cosmology is not well-optimized for galaxy science, and vice versa

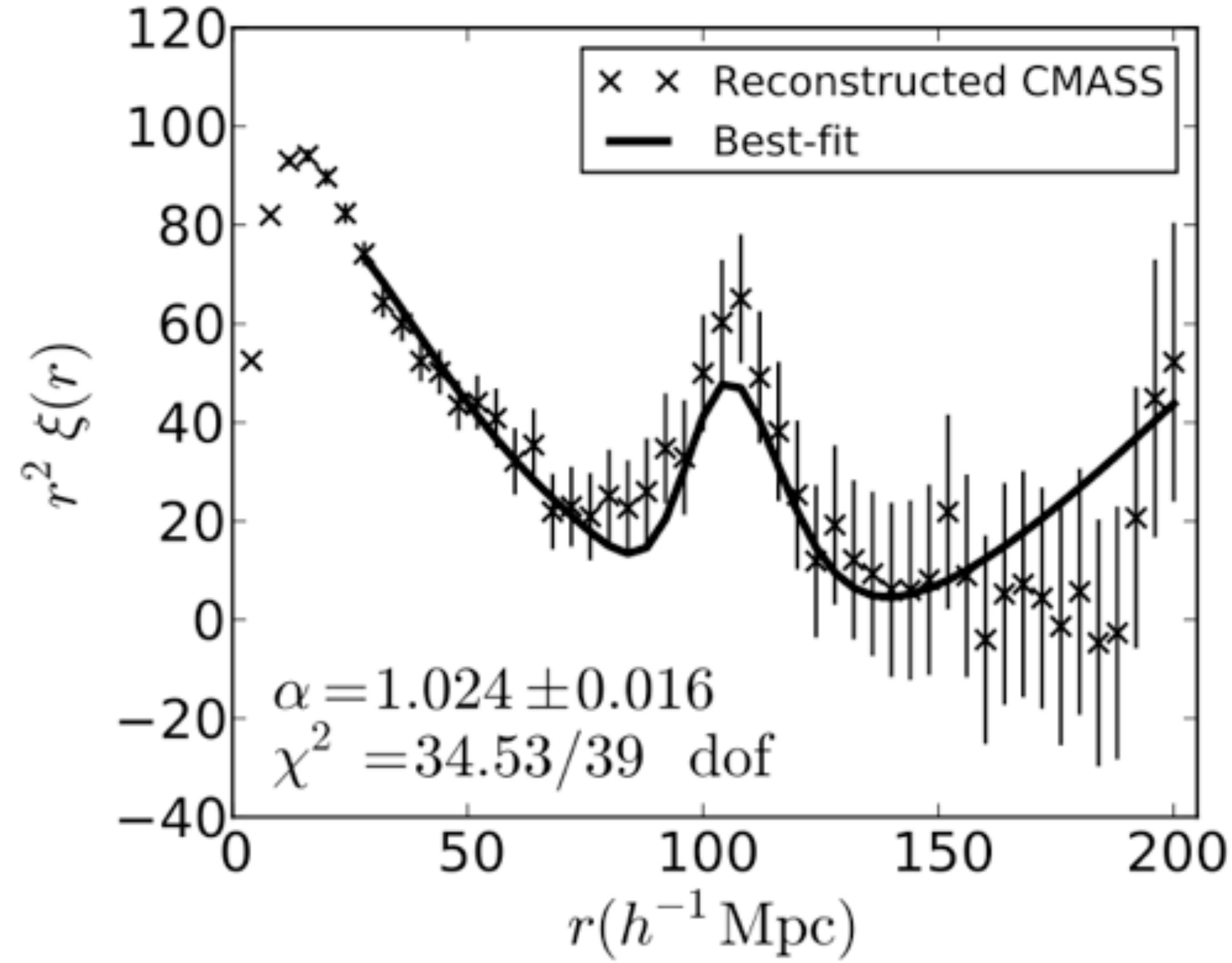
- Galaxies: once a spectrum has been measured well enough to determine a redshift, further integration time is "wasted" as far as cosmology is concerned

- Lyman-alpha: integrating to S/N of order 1 is optimal

- Tradeoff between sky area and depth is different; cosmology tends to favor wide rather than deep

Baryon acoustic oscillations



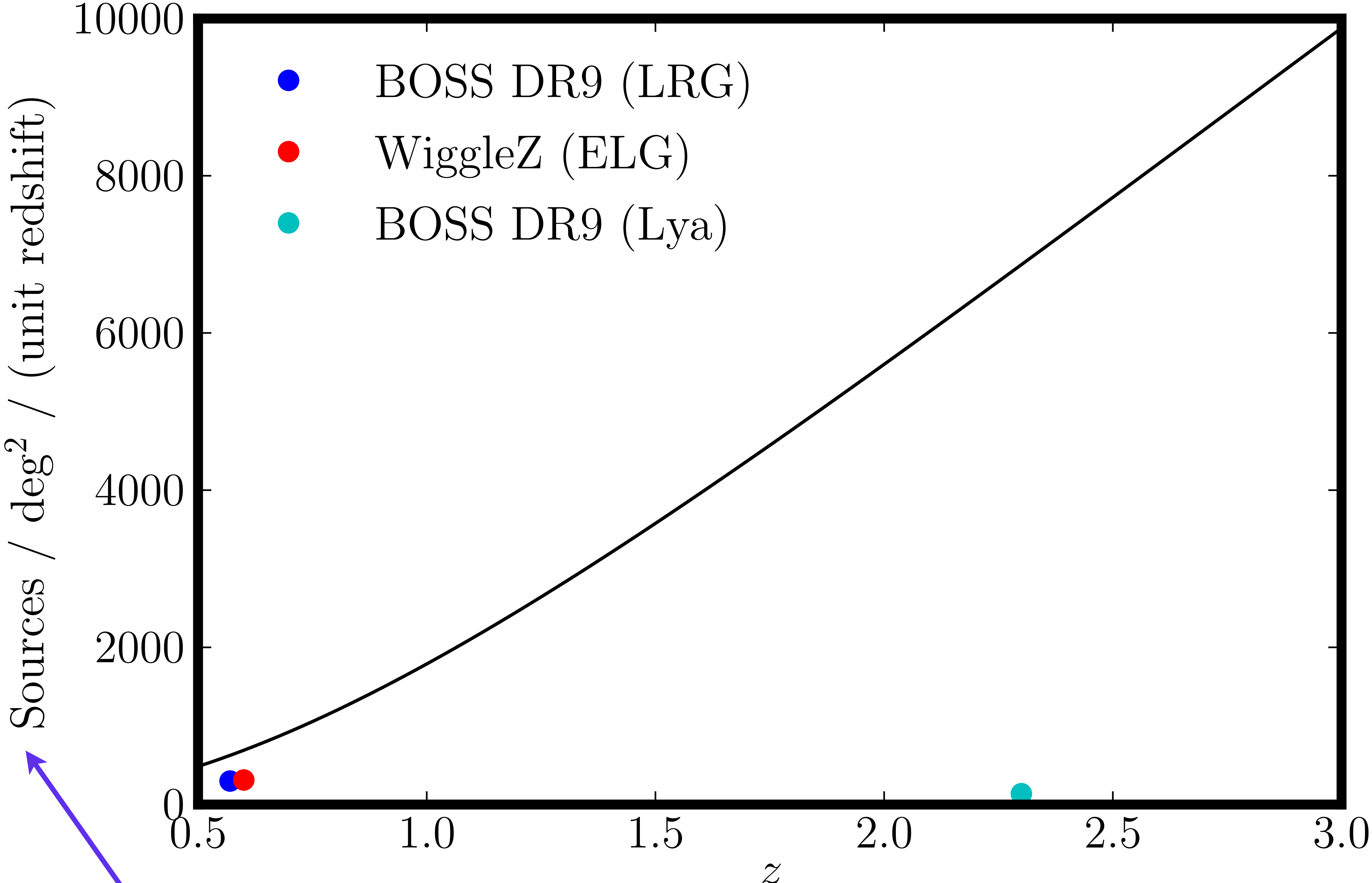


BOSS collaboration (2012)

"Sound horizon" at ~150 Mpc can be measured at different redshifts, used as a standard ruler for constraining expansion history

BAO: cosmic variance limit

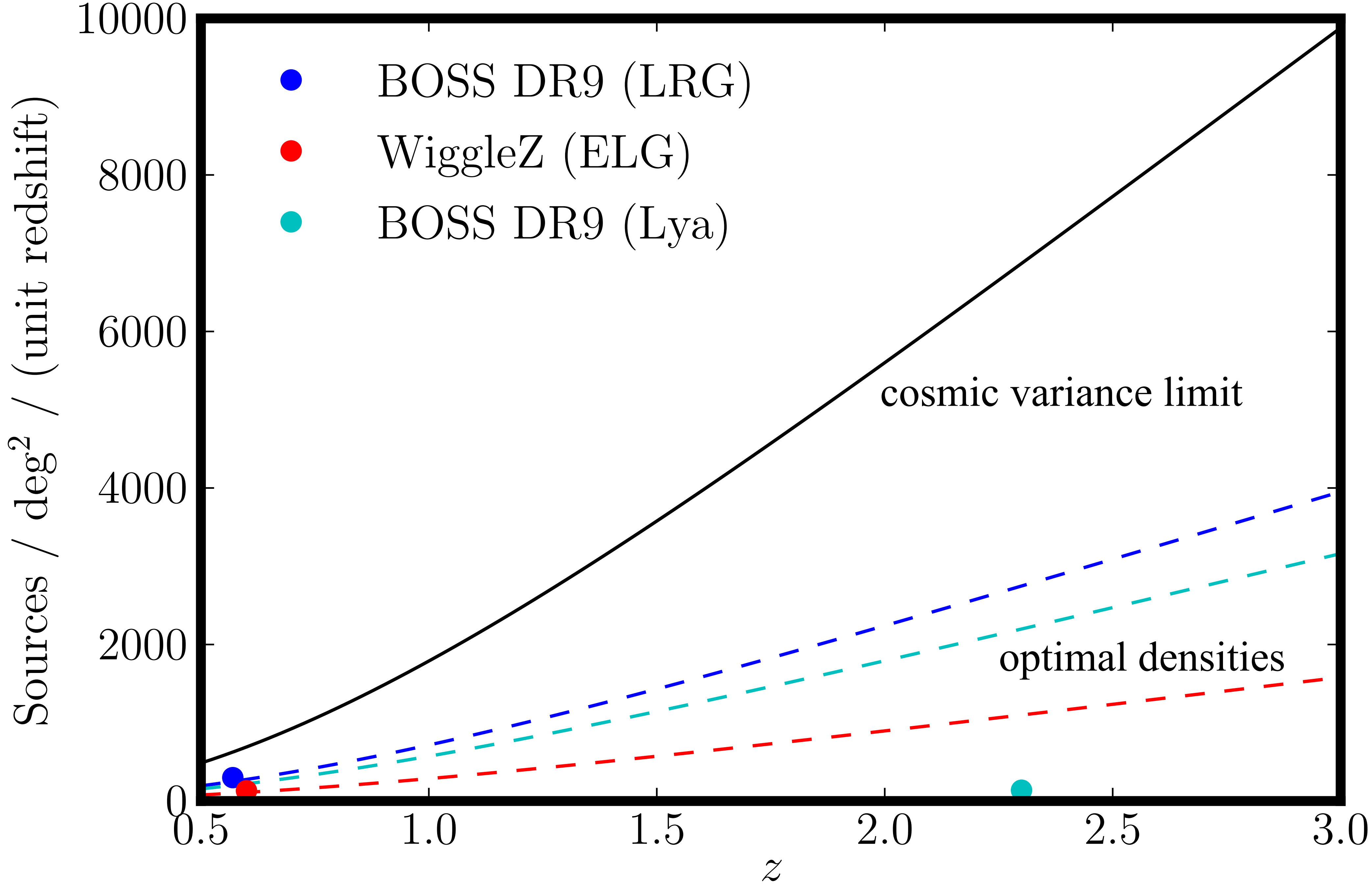
Once a certain number density has been reached, statistical errors do not improve by increasing the number density further



"Effective number of bias-2 tracers"

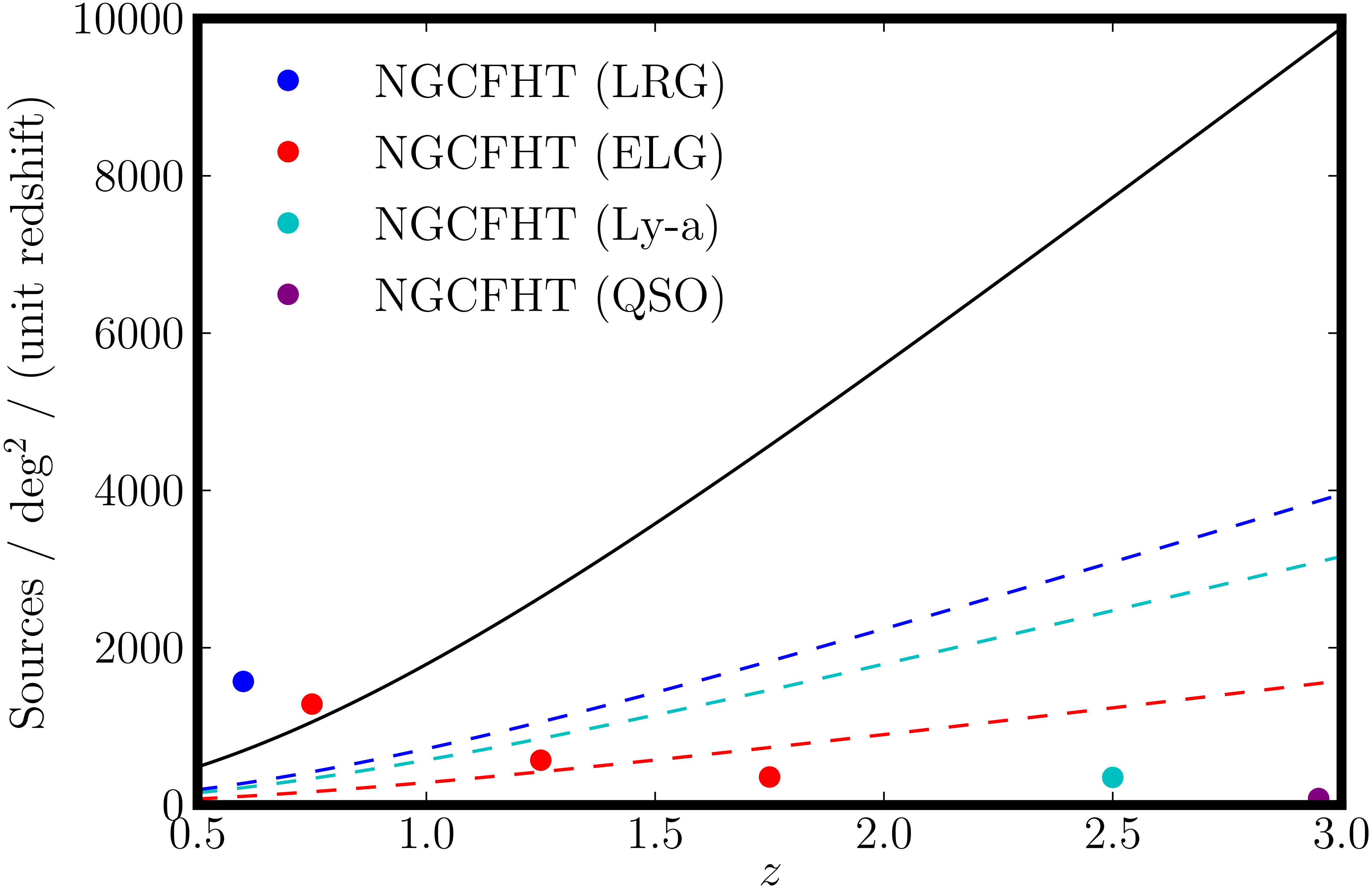
BAO: survey optimization

Optimal number density is tracer-dependent and a factor ~few smaller than the cosmic variance limit



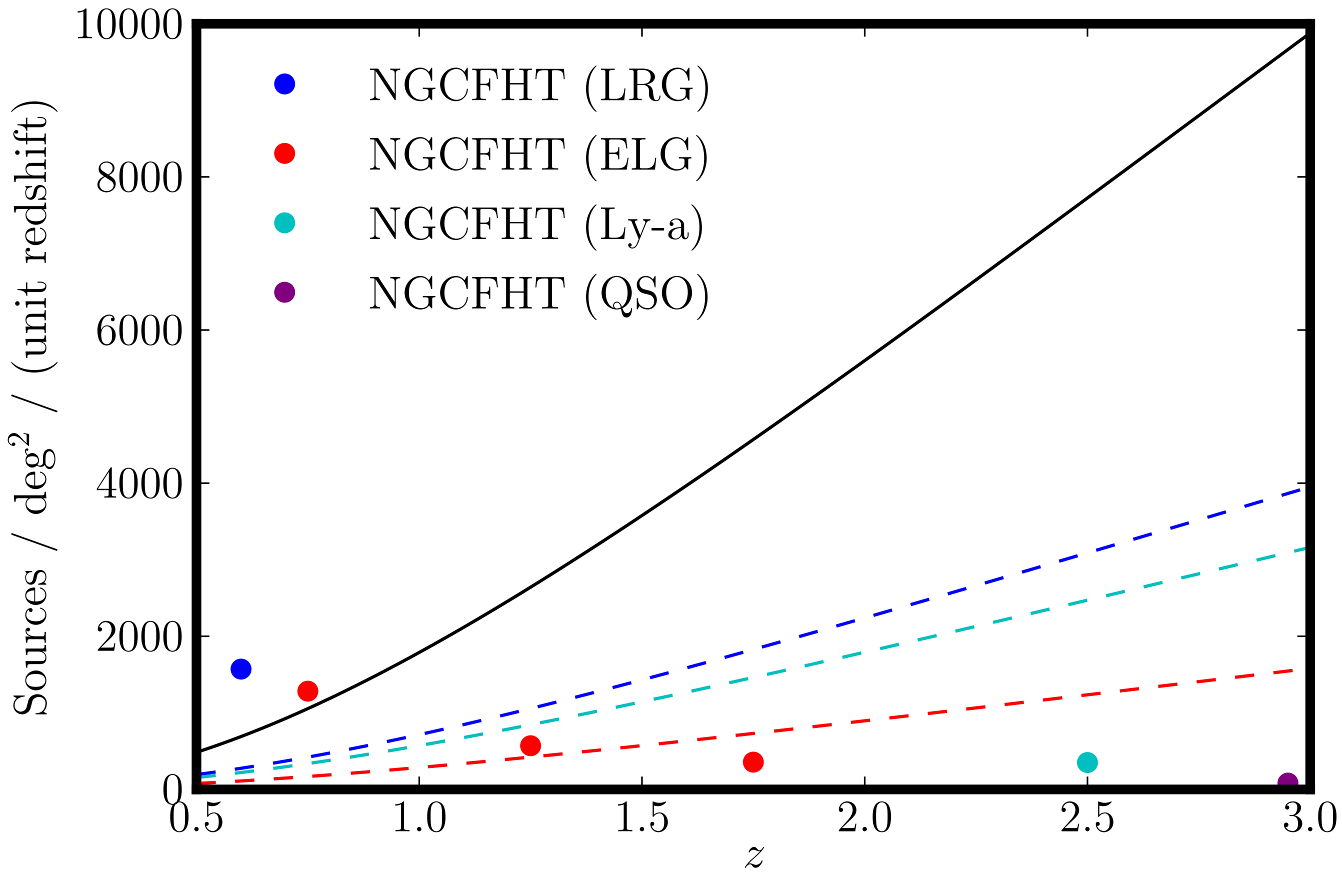
BAO: NGCFHT

In this talk, "NGCFHT" = fiducial 4300 sq deg survey, limiting i-band magnitude 23.5



BAO: wedding cake?

Fiducial survey turns out to be optimal for BAO's at z~1.3
deeper than optimal at low z
wider than optimal at high z

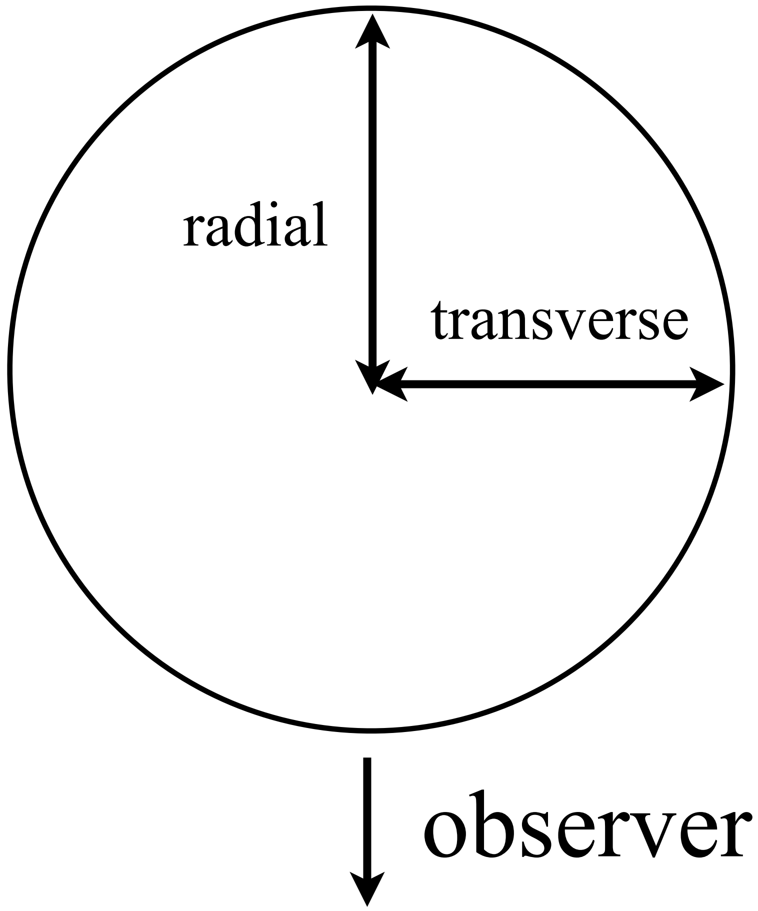


Suggests wedding cake strategy for BAO?

For low z, measure as much sky as possible
For high z, go deeper on ~1000(?) square degrees

Needs further study to find optimum...

What do BAO's measure?



Transverse angular scale: $\Delta\theta = s/D(z)$

Radial scale in redshift space: $\Delta z = sH(z)$

[$s =$ sound horizon]

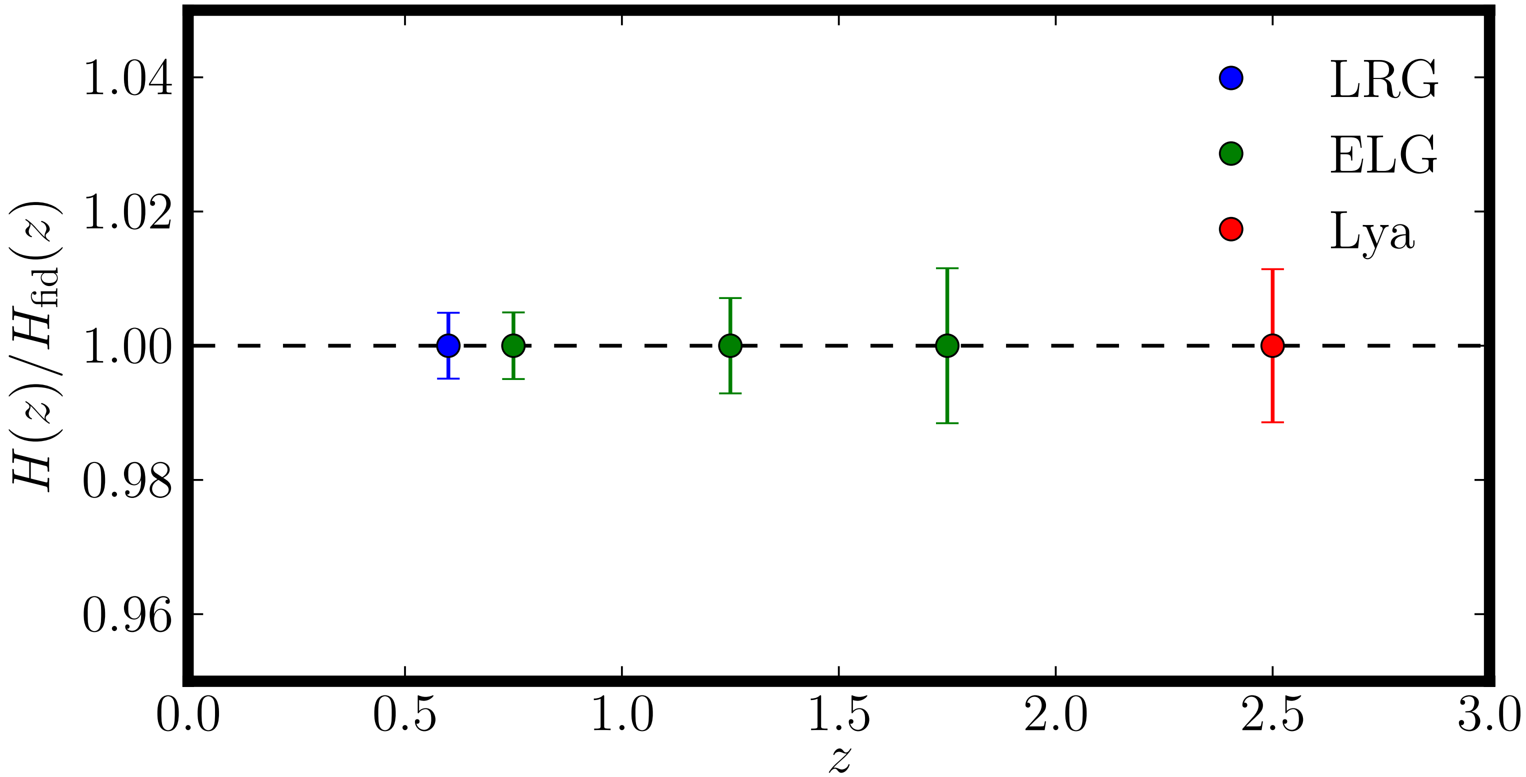
CMB prior gives the following to high precision:

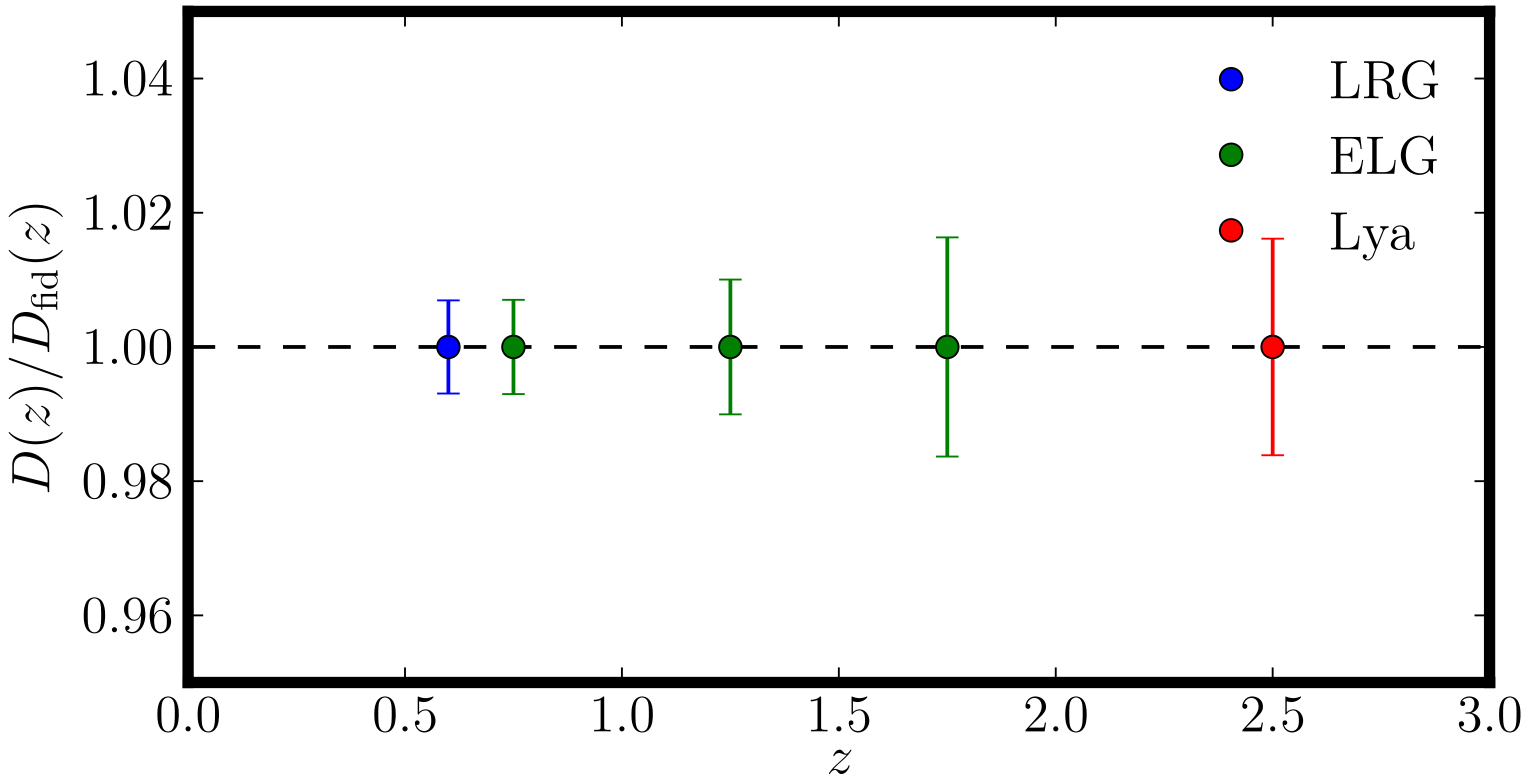
Sound horizon s in physical units (Mpc not h^{-1} Mpc)

$H(z)$ and $D(z)$ at high redshift

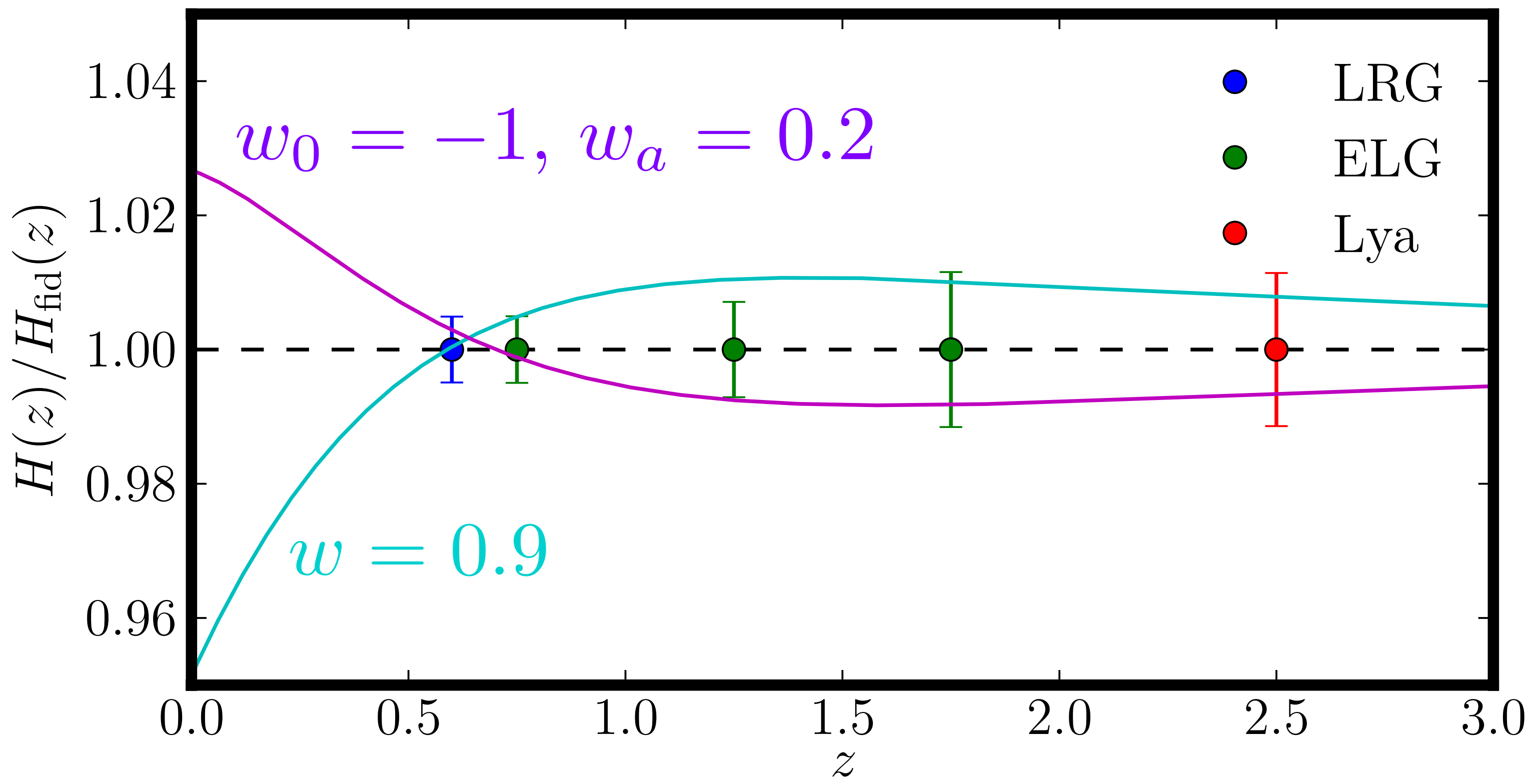
In a flat universe, $H(z) = 1/D'(z)$

NGCFHT forecasts

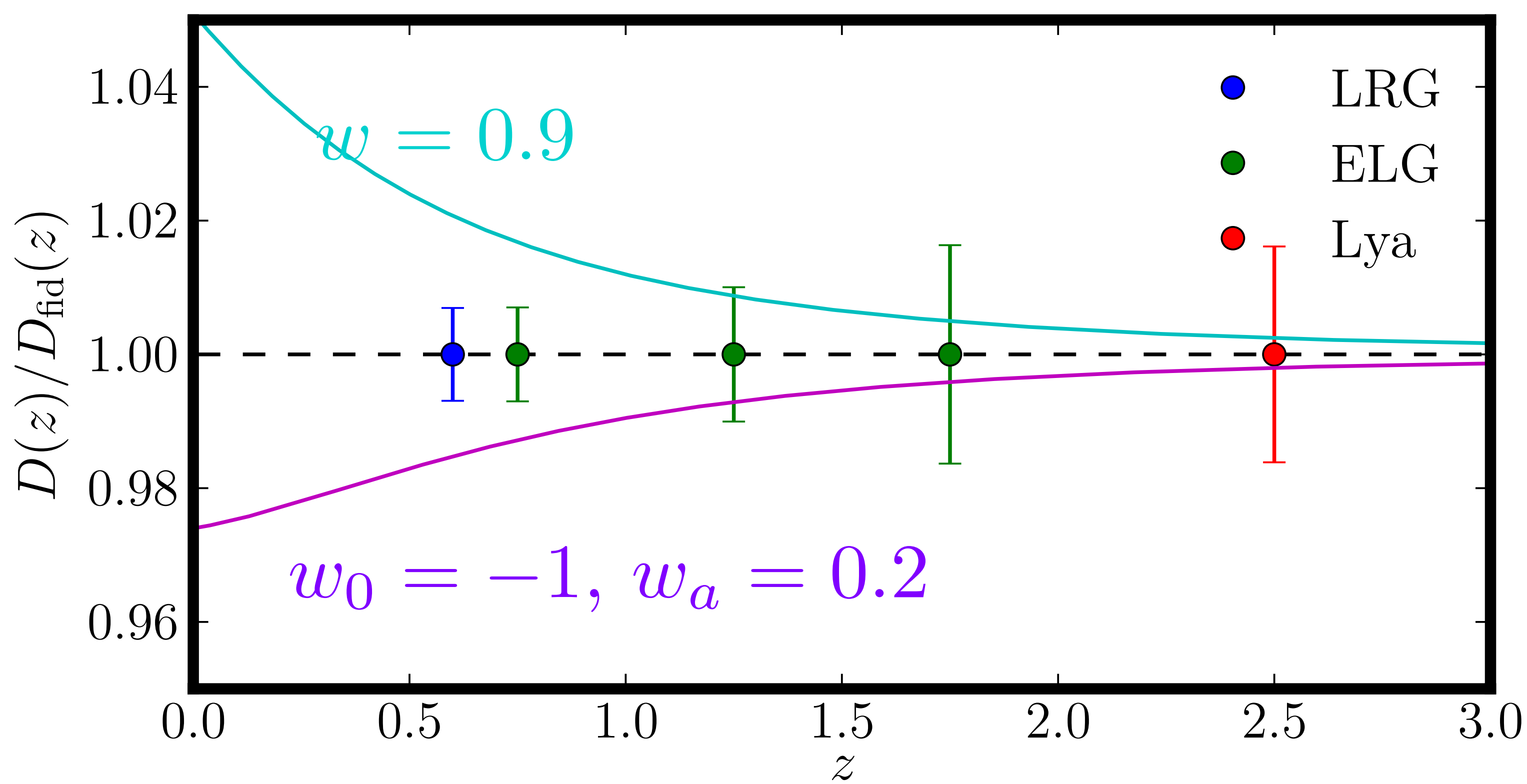




Dark energy



$w_0 = -1,\ w_a = 0.2$
$w = 0.9$
LRG
ELG
Lya
$H(z)/H_{\rm fid}(z)$
1.04
1.02
1.00
0.98
0.96
0.0 0.5 1.0 1.5 2.0 2.5 3.0
z



$w = 0.9$
$w_0 = -1,\ w_a = 0.2$
LRG
ELG
Lya
$D(z)/D_{\rm fid}(z)$
1.04
1.02
1.00
0.98
0.96
0.0 0.5 1.0 1.5 2.0 2.5 3.0
z

Primordial non-Gaussianity

"Local model": $\zeta(\mathbf{x}) = \zeta_G(\mathbf{x}) + f_{NL}\zeta_G(\mathbf{x})^2$

free parameter

$f_{NL} = 0$ in single-field inflation; conversely $f_{NL} \neq 0$ generically occurs in many types of multifield models:

- modulated reheating (inflaton decay mediated by spectator field)
- curvaton model (spectator field with non-flat potential generates ζ)
- "New" Ekpyrosis (two-field model; second field generates ζ)

Primordial non-Gaussianity

"Local model": $\zeta(\mathbf{x}) = \zeta_G(\mathbf{x}) + f_{NL}\zeta_G(\mathbf{x})^2$

↑ free parameter

Planck: $f_{NL} = 2.7 \pm 5.8$ ***(Planck collaboration 2013)***

Best LSS measurement: $f_{NL} = 6 \pm 15$ ***(Giannantonio et al 2013)***

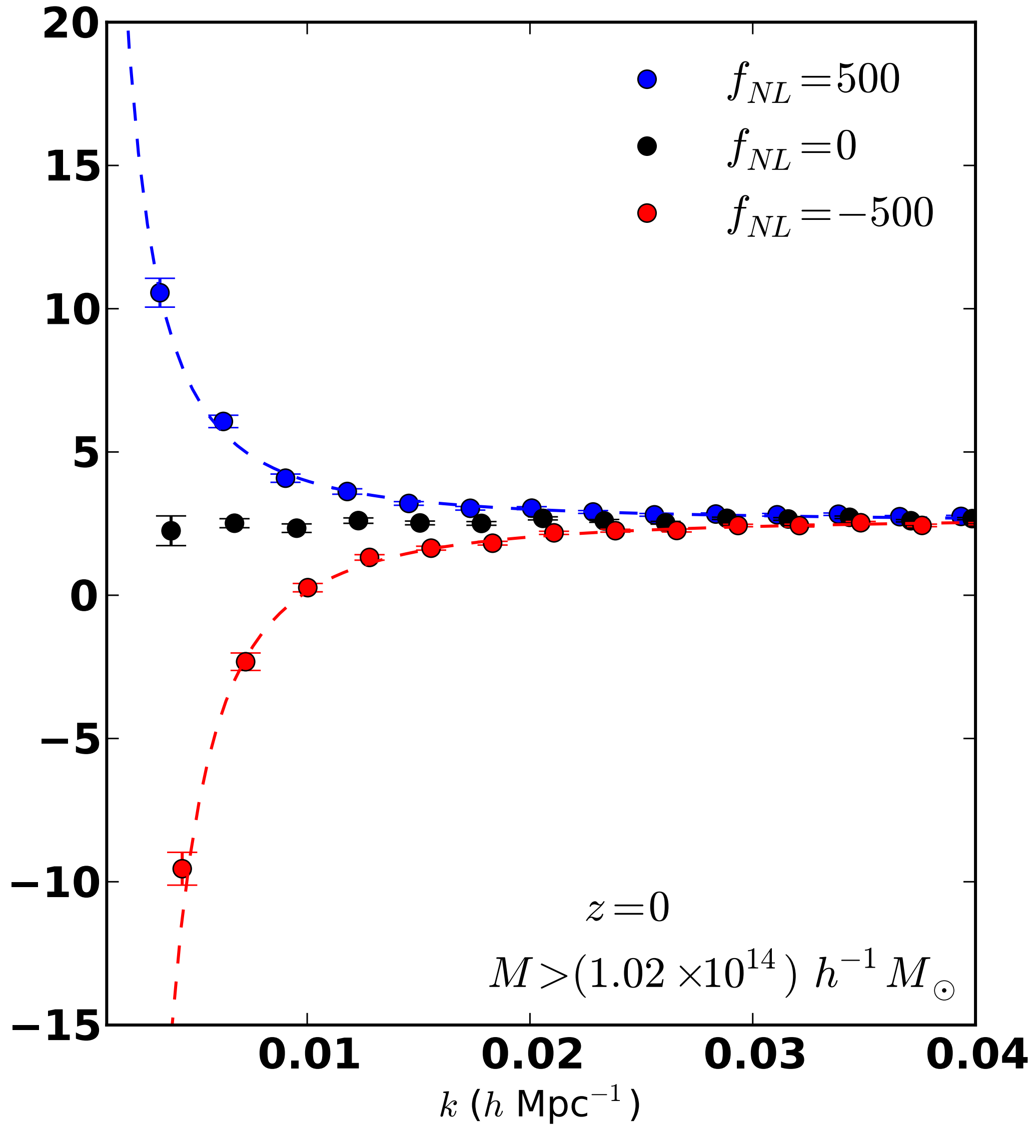
obtained by cross-correlating various photometric datasets

Future CMB measurements will probably not beat Planck; future photometric surveys may be able to go further (e.g. LSST forecast: $\Delta f_{NL} \sim 1$)

Can future spectroscopic surveys like NGCFHT further improve constraints?

Primordial non-Gaussianity

In a Gaussian cosmology, halo abundance linearly traces the dark matter on large scales: $\frac{\rho_h}{\bar{\rho}_h} \approx b \frac{\rho_m}{\bar{\rho}_m}$

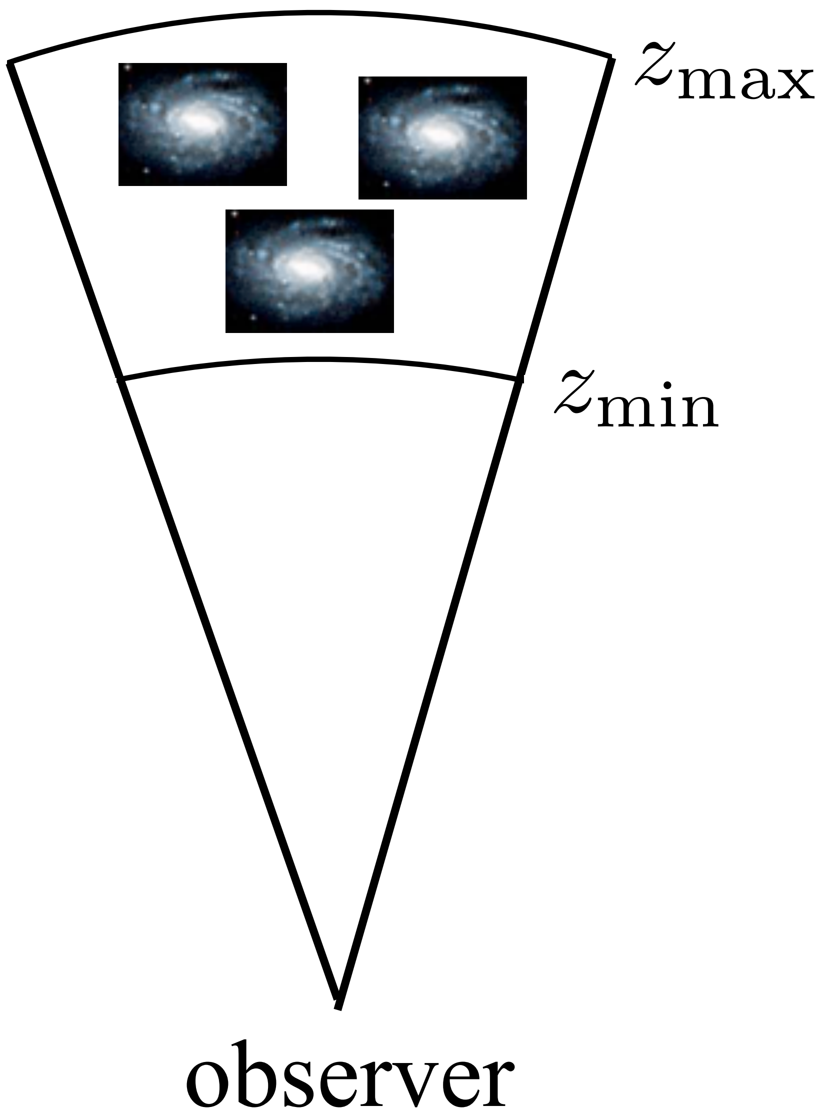


Dalal et al 2007: extra halo clustering in an f_{NL} cosmology

$$b(k) = b_0 + b_{NG} \frac{f_{NL}}{(k/H)^2}$$

Constraining power comes from largest scales and highest redshifts surveyed

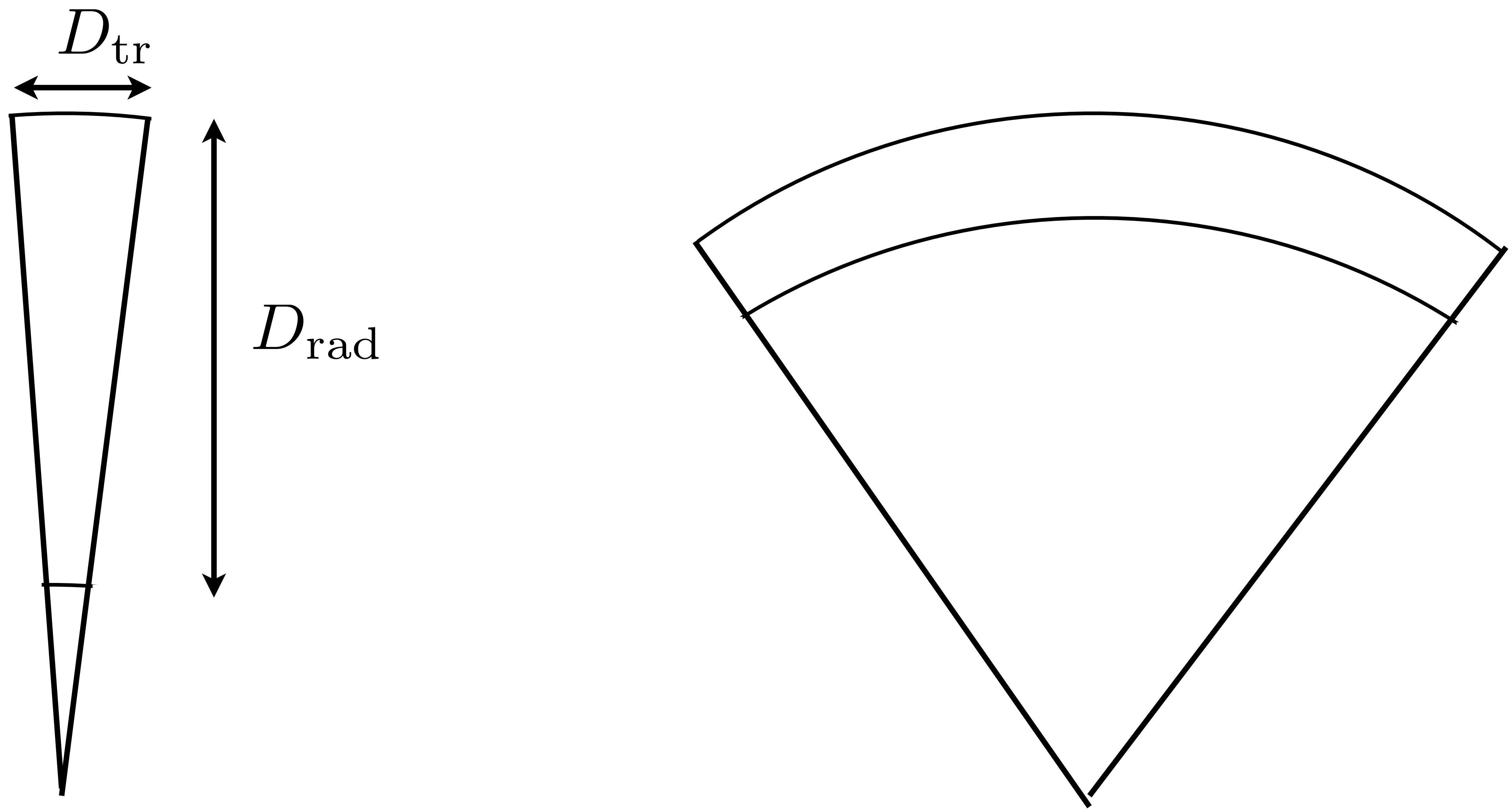
Do spectroscopic redshifts help?



2D vs 3D: how much information is lost in radial projection?

NG: do spectroscopic redshifts help?

Qualitative answer: it depends on ratio $(D_{\rm rad}/D_{\rm tr})$ of radial to transverse survey size



Large $(D_{\rm rad}/D_{\rm tr})$: redshifts help a lot

Small $(D_{\rm rad}/D_{\rm tr})$: redshifts don't help much

NG: do spectroscopic redshifts help?

Approximate LSST forecast with the following assumptions:

- 20000 square degrees
- f_{NL} mainly constrained by photometric quasars with $2 \lesssim z \lesssim 4$

shows that even 100% complete spectroscopic followup would only improve Δf_{NL} by 30%

Spectroscopic redshifts don't improve statistical errors much, but may help with systematics

Unlikely to be a significant driver for NGCFHT survey design