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H

DISENTANGLING

D_A

Motivation

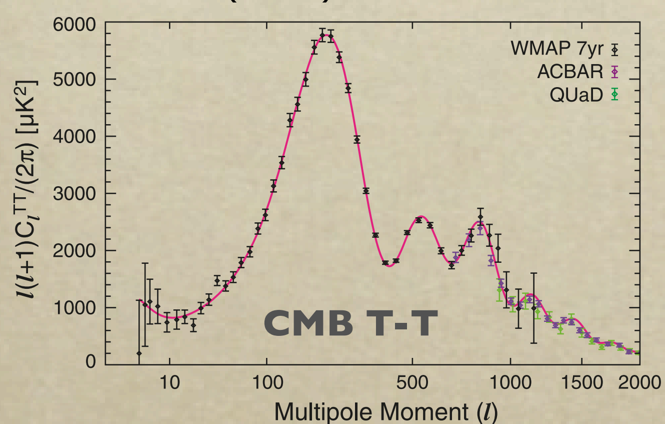
- *The Baryonic Acoustic Feature has been detected to a significance of* $\boldsymbol{5\sigma}$ *(WiggleZ+SDSS-II+6dFGRS; Blake et al. 2011c)*
- *So far the feature has been mostly used to measure the degenerate combination:* D_A^2/H
- *The ultimate holy grail is measuring H(z) independently in order to examine the nature of the accelerating Universe*

Disentanglement Discussion

- Within redshift clustering - *going under the hood*
- With various data sets (SNe, photometric clustering and other distance measures)

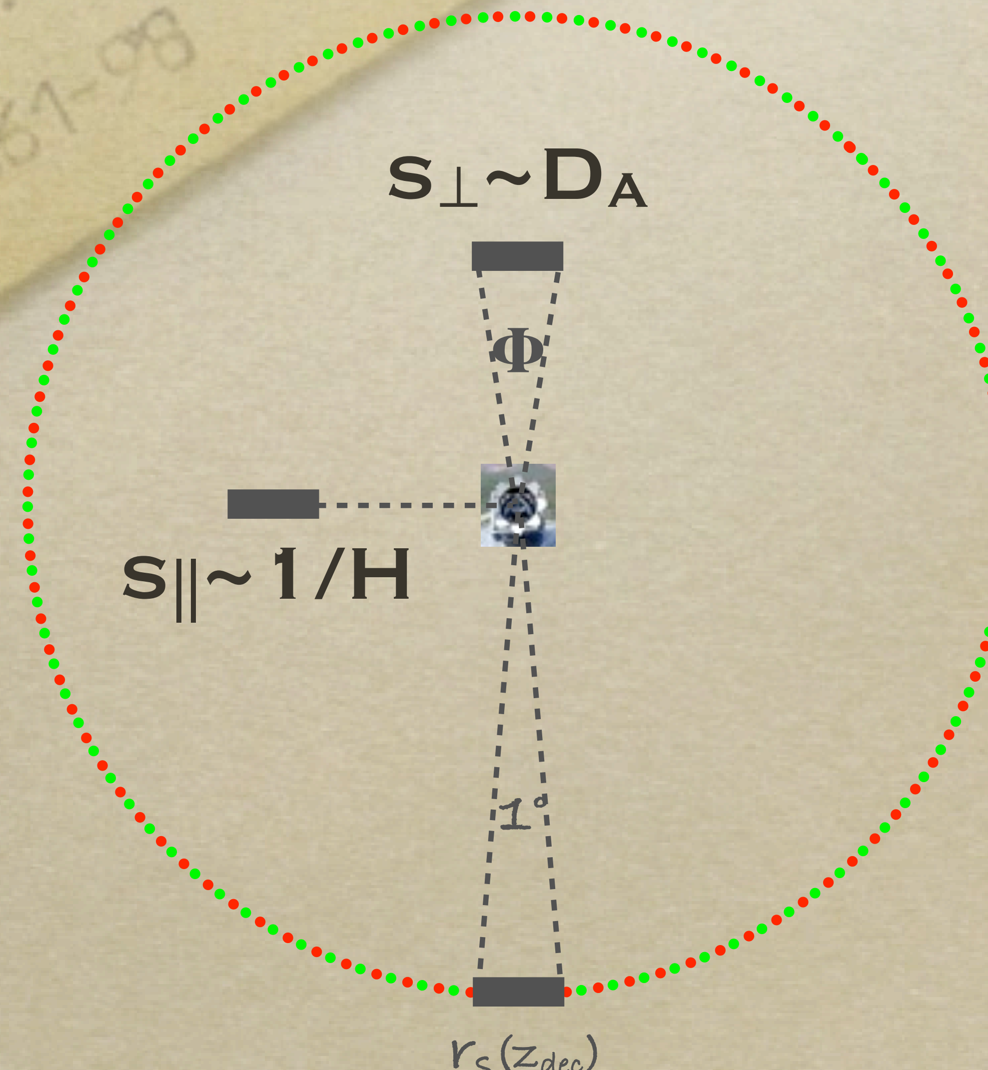
The Baryonic Acoustic Feature as a Standard Ruler

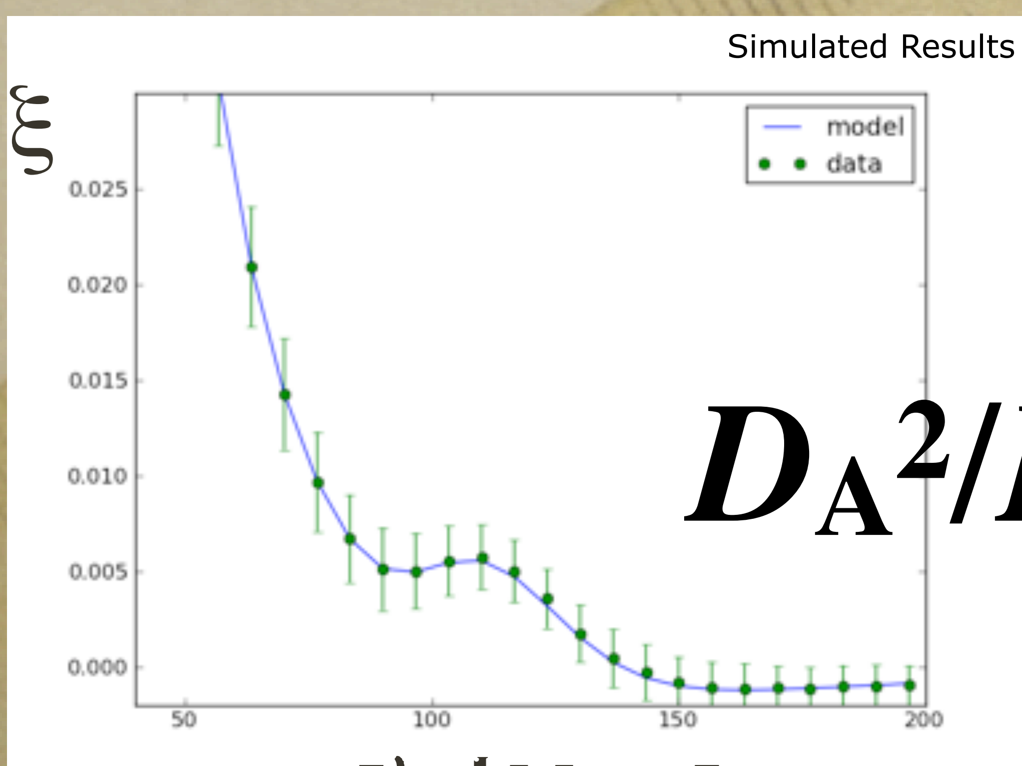
Larson et al. (2010)



$$r_s \rightarrow D_A\,(z_{dec})$$

Surface of last scattering
z~1100





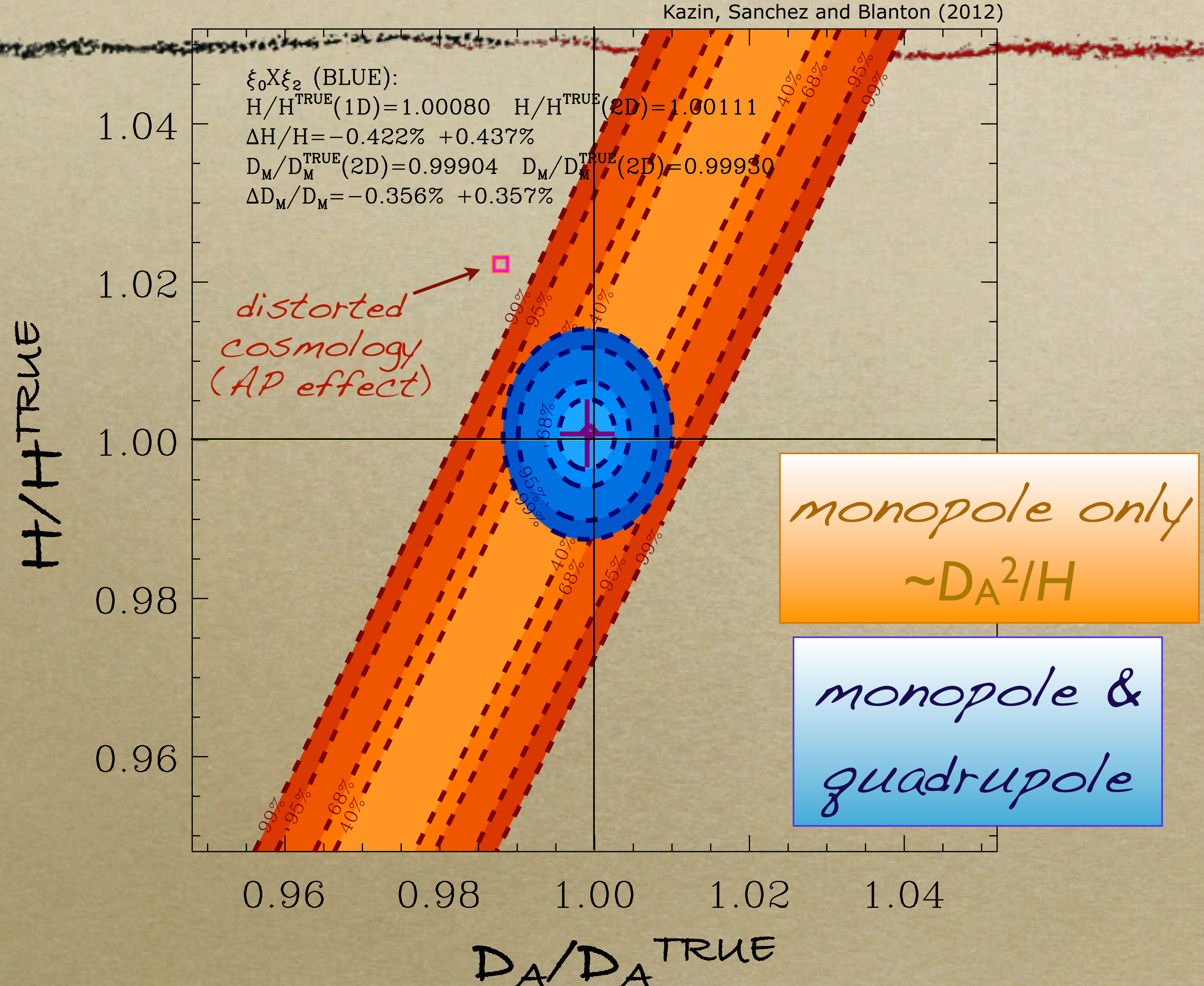
$$D_A^2/H\,(\langle z \rangle)$$

s [h^{-1}Mpc]

Doing better than D_A^2/H

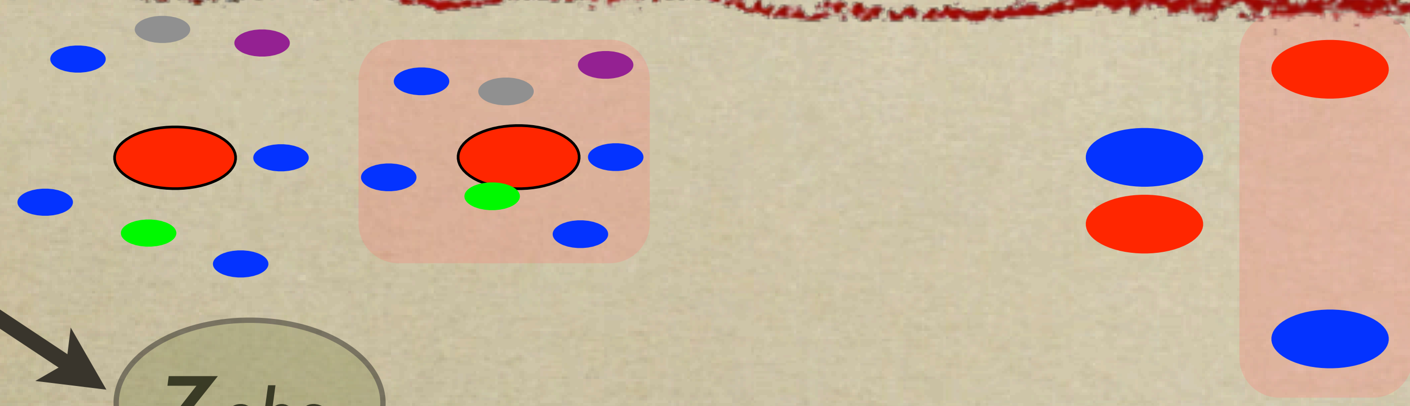
- *For S/N reasons, most observational studies focus on angle averaged ξ_0 signals*
- *Due to geometric arguments, the information in ξ_0 is degenerate: D_A^2/H*
- *Anisotropic clustering constrains $D_A H$:*
  2D plane ("π-r_p"), 1D statistics (ξ_2 or $\xi(\Delta\mu)$)

Disentangling H-D_A Degeneracy
(simulated results)



Redshift Distortions: Dynamical vs. Geometrical

Dynamical: squashing (Kaiser 1987), Finger of God



comoving distance

$$\chi(z) = c\int_0^{z_{obs}} \frac{dz'}{H(z',\Omega)}$$

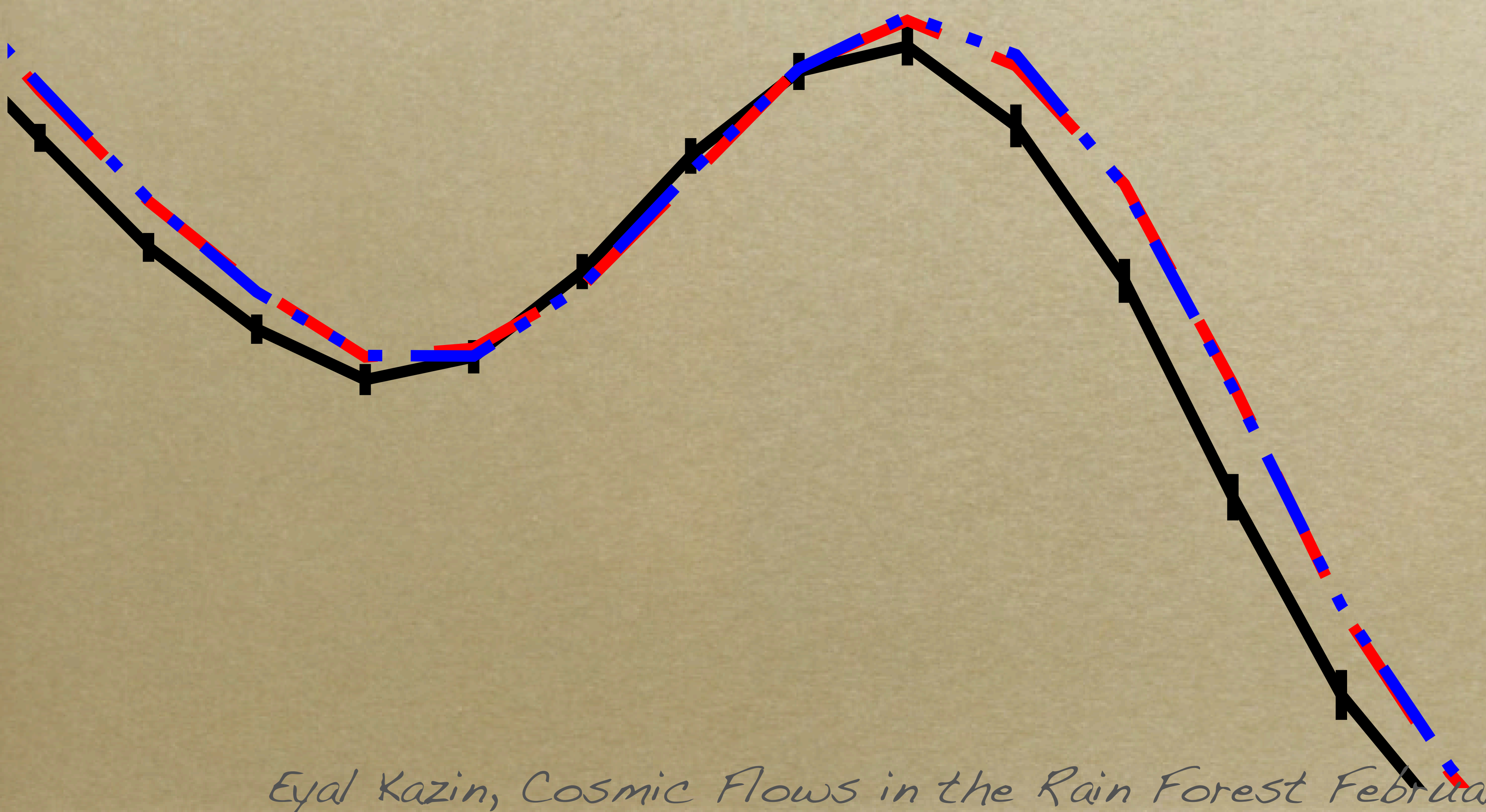
Geometrical: AP effect (Alcock&Paczynski 1979)

The Alcock Paczynski effect

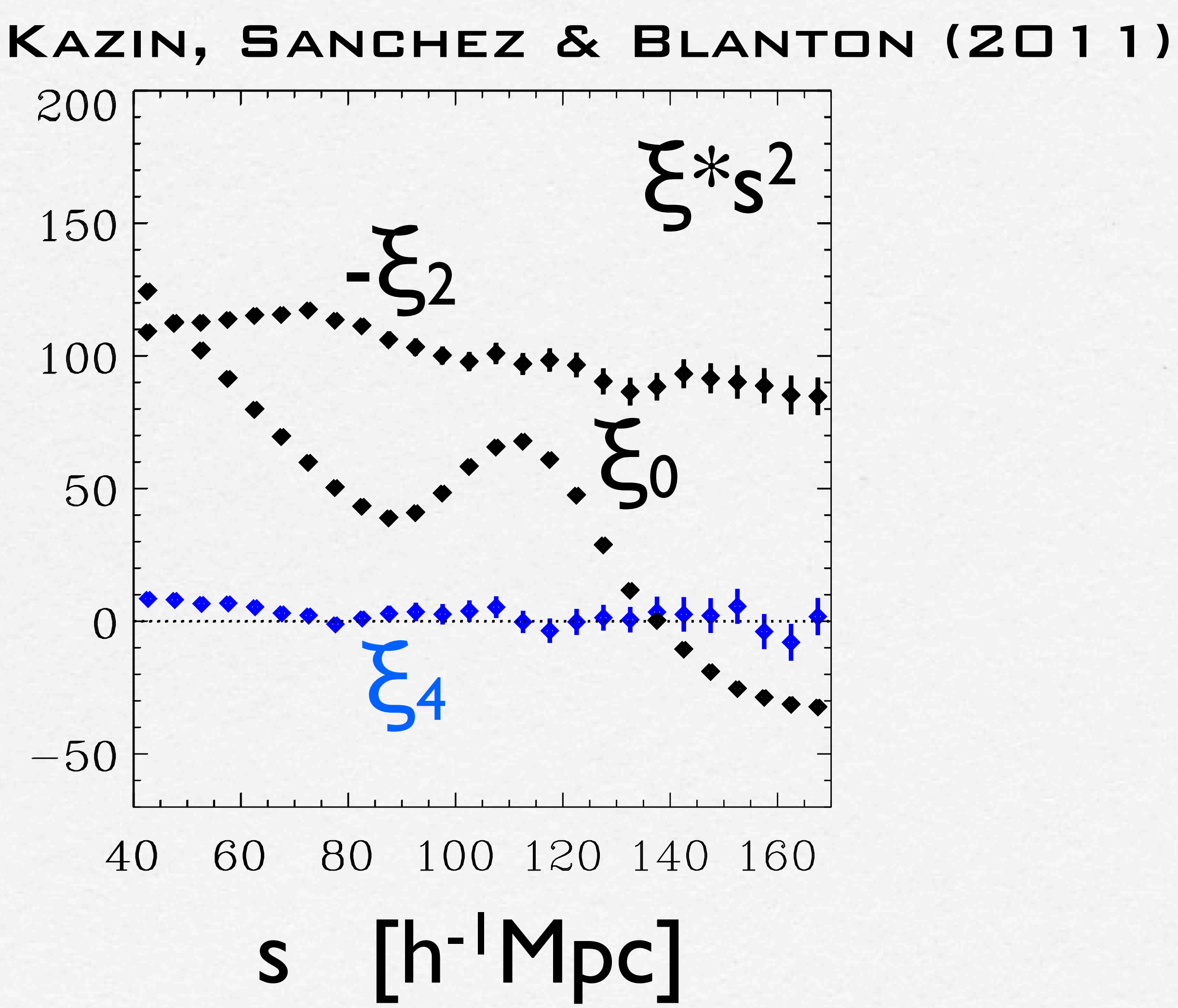
Template (here I use mock true signal)

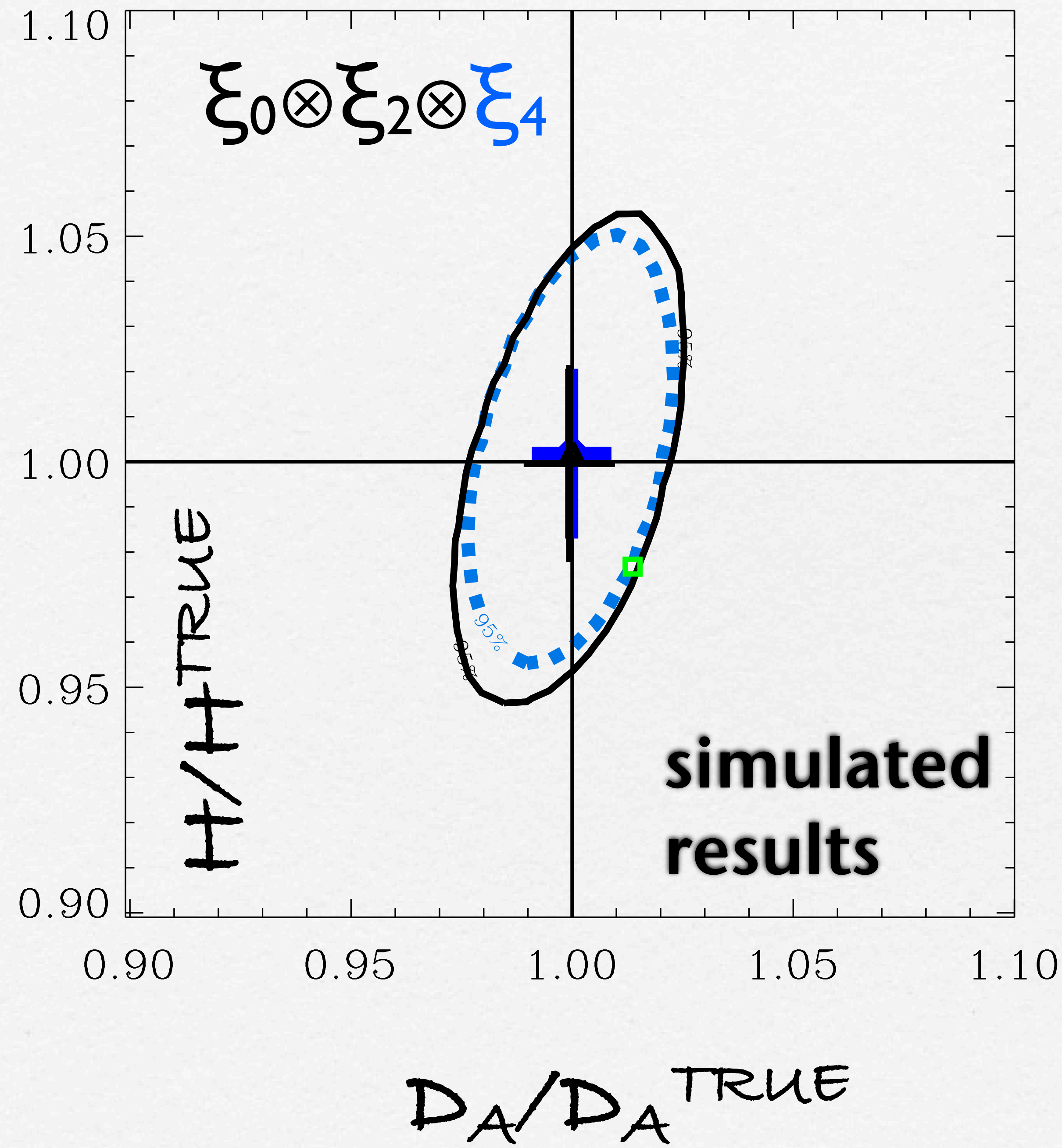
``data" (here I use mock signal affected by AP)

fit (here I fit Template to ``data" varing H and D_A)



Disentangling H-D_A Degeneracy
(mock galaxy results)





Hexadecapole ξ_4 improves H constraints (See also Taruya et al. 2011)

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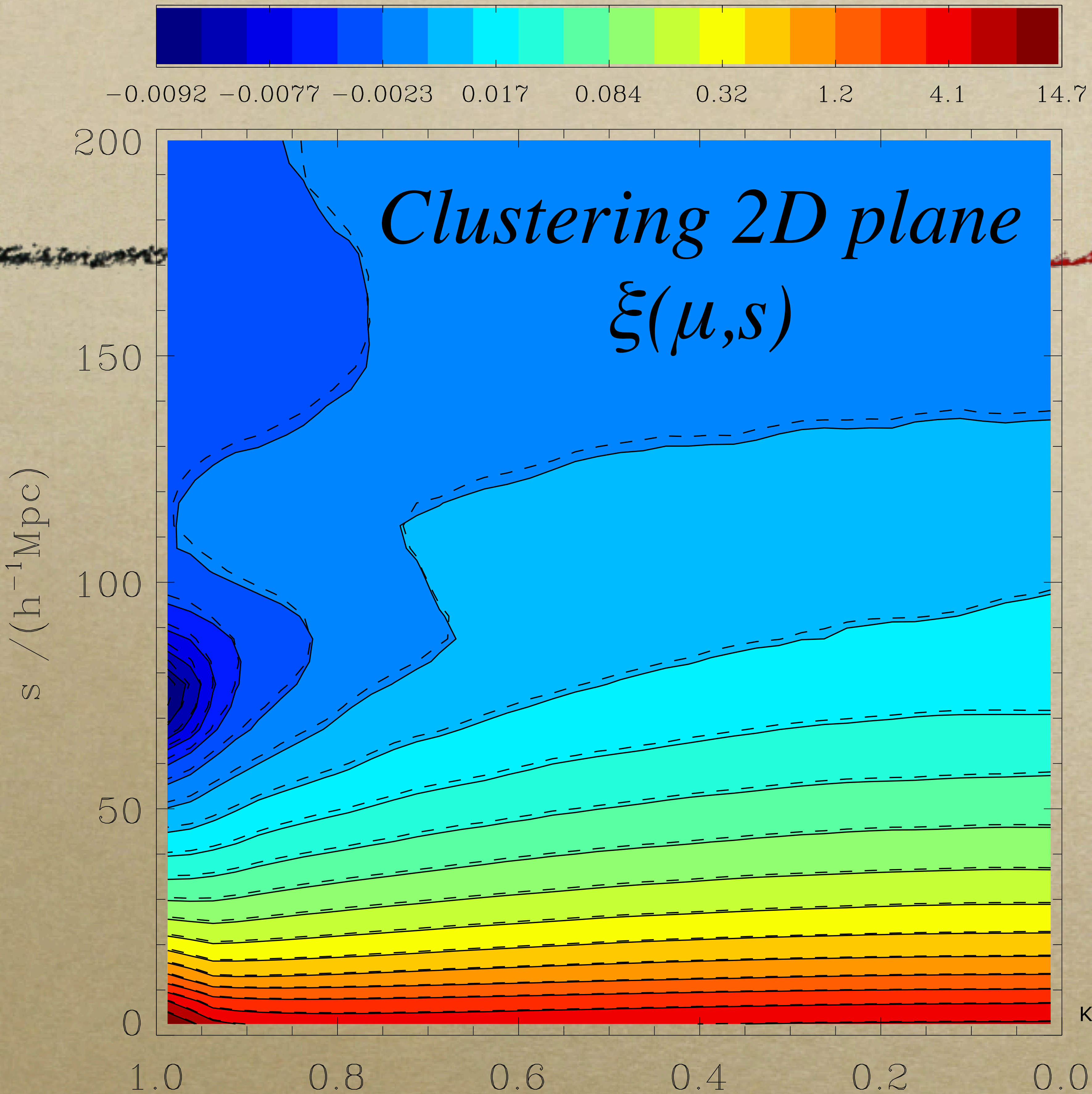
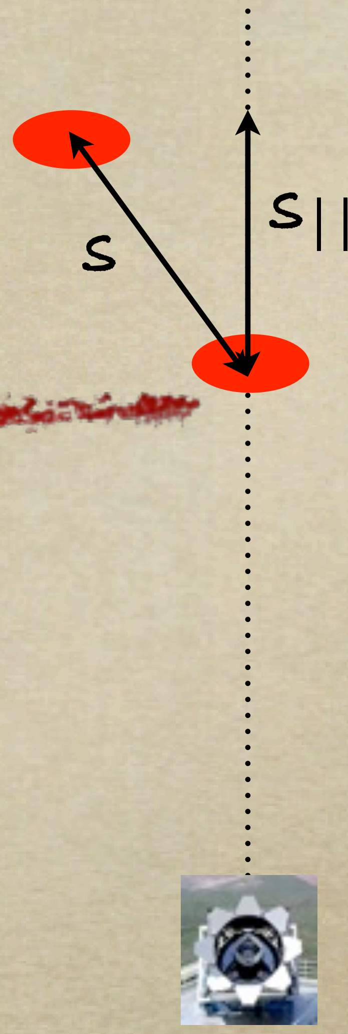
Clustering 2D plane $\xi(\mu,s)$



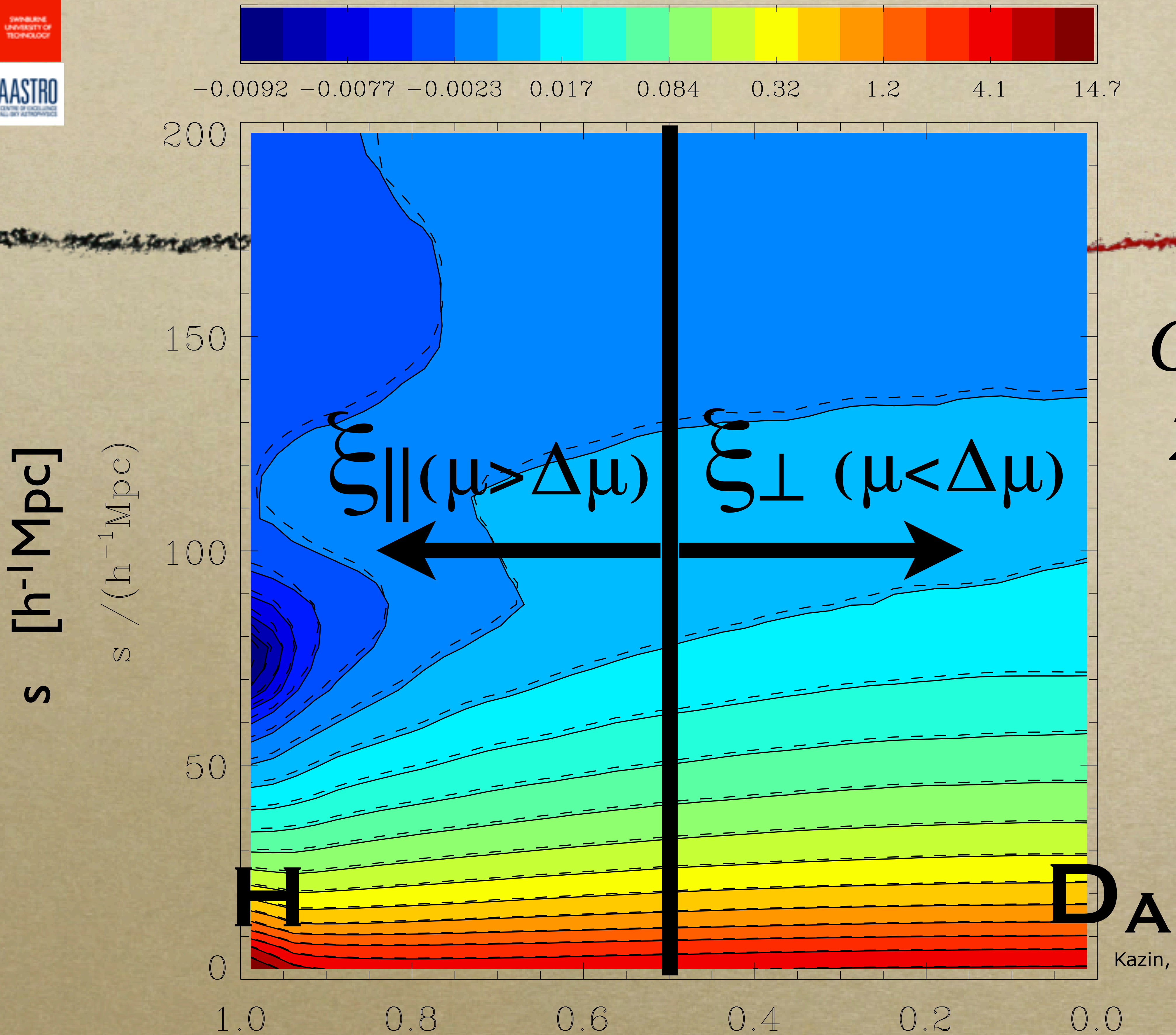


$s \ [h^{-1}\mathrm{Mpc}]$

$\mu = s_{||}/s$

Kazin, Sanchez & Blanton (2011)

Clustering 2D plane $\xi(\mu,s)$



Kazin, Sanchez & Blanton (2011)

Line-of-sight $\mu = s_{||}/s$ *Transverse*

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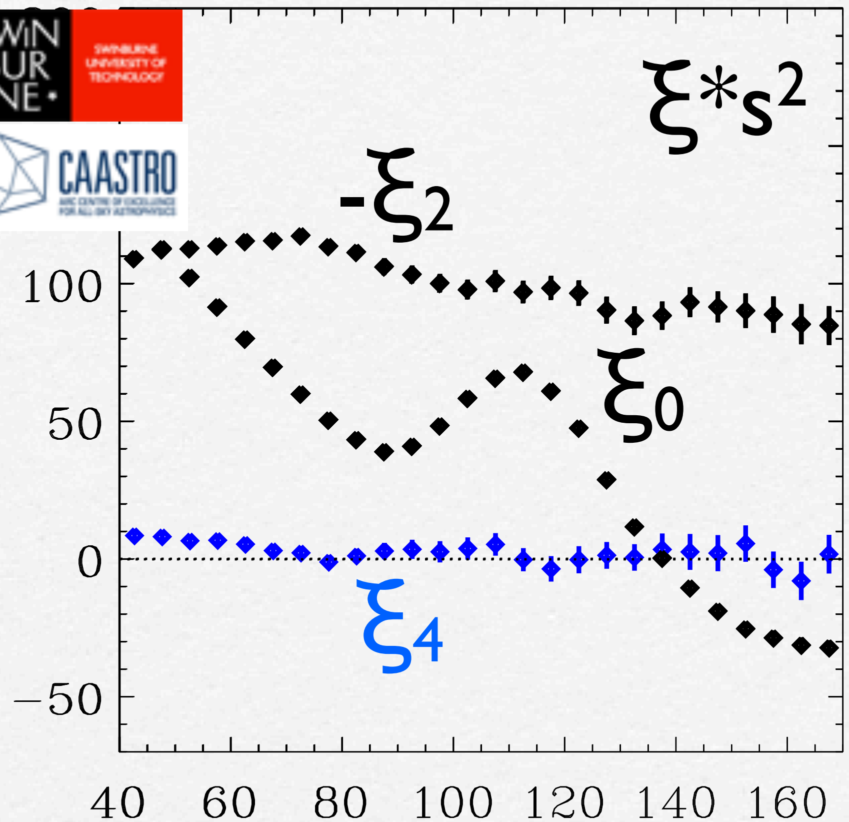
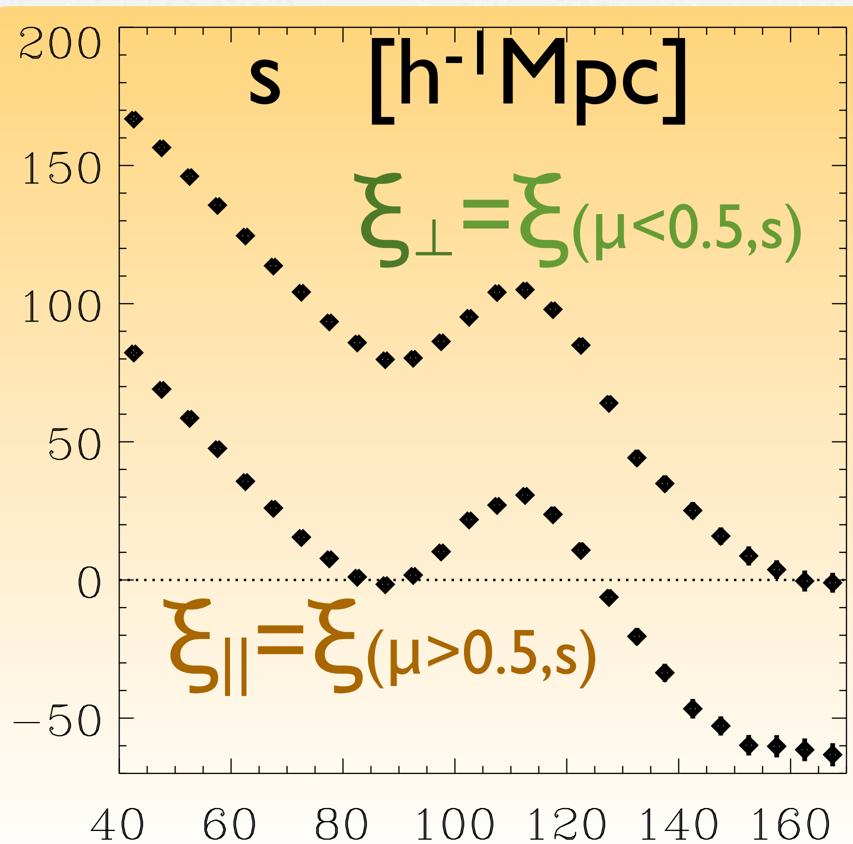
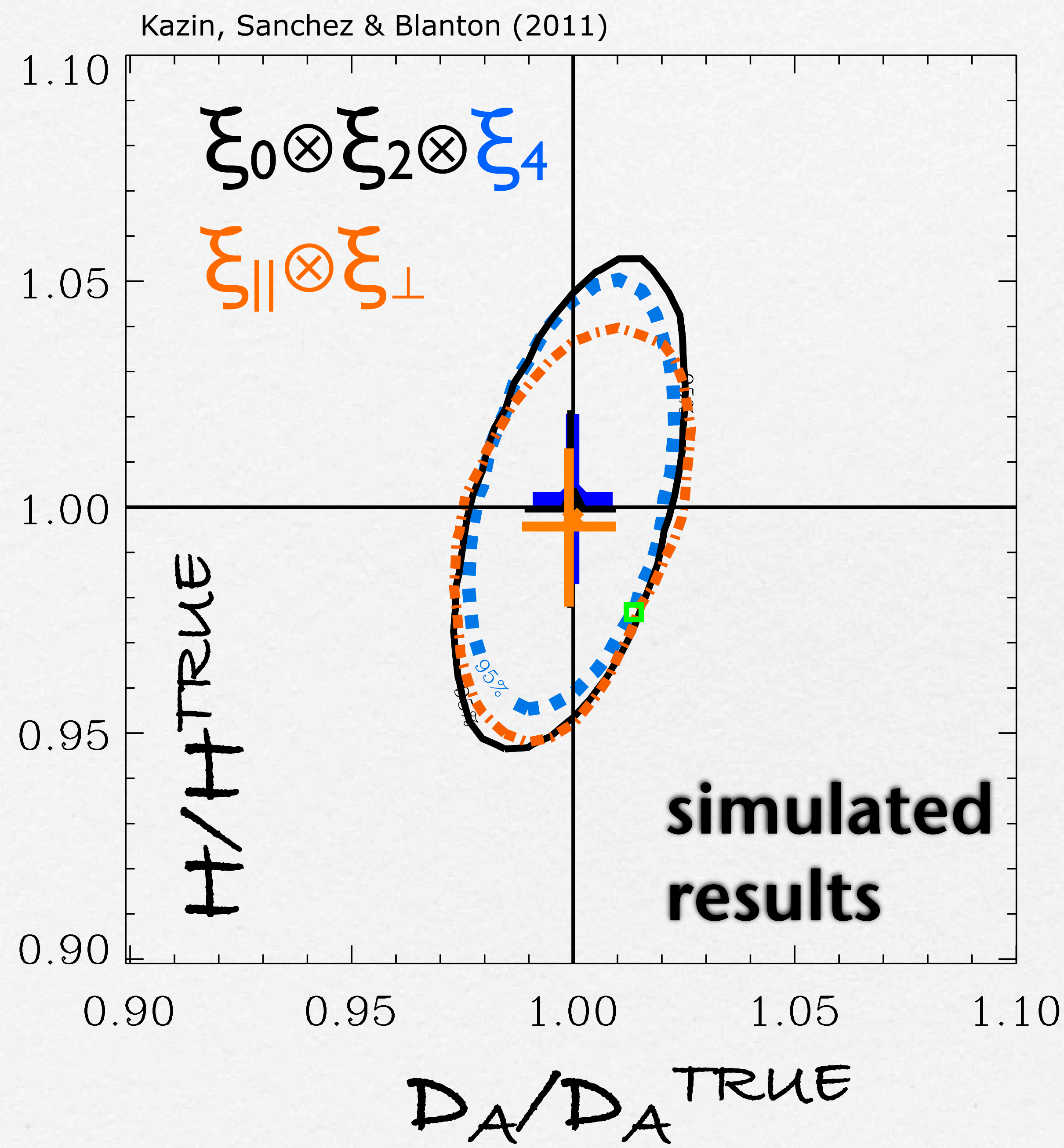
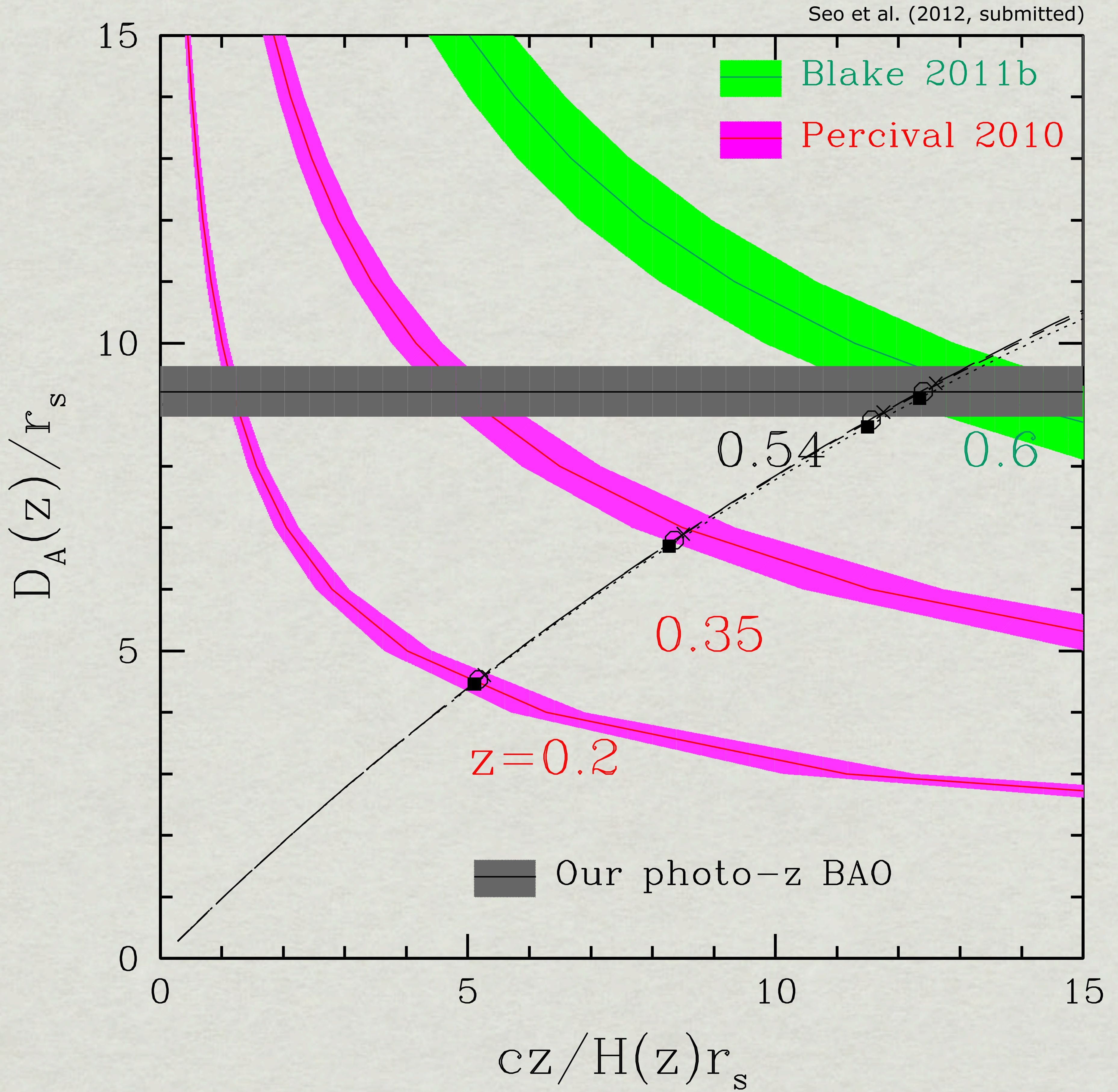
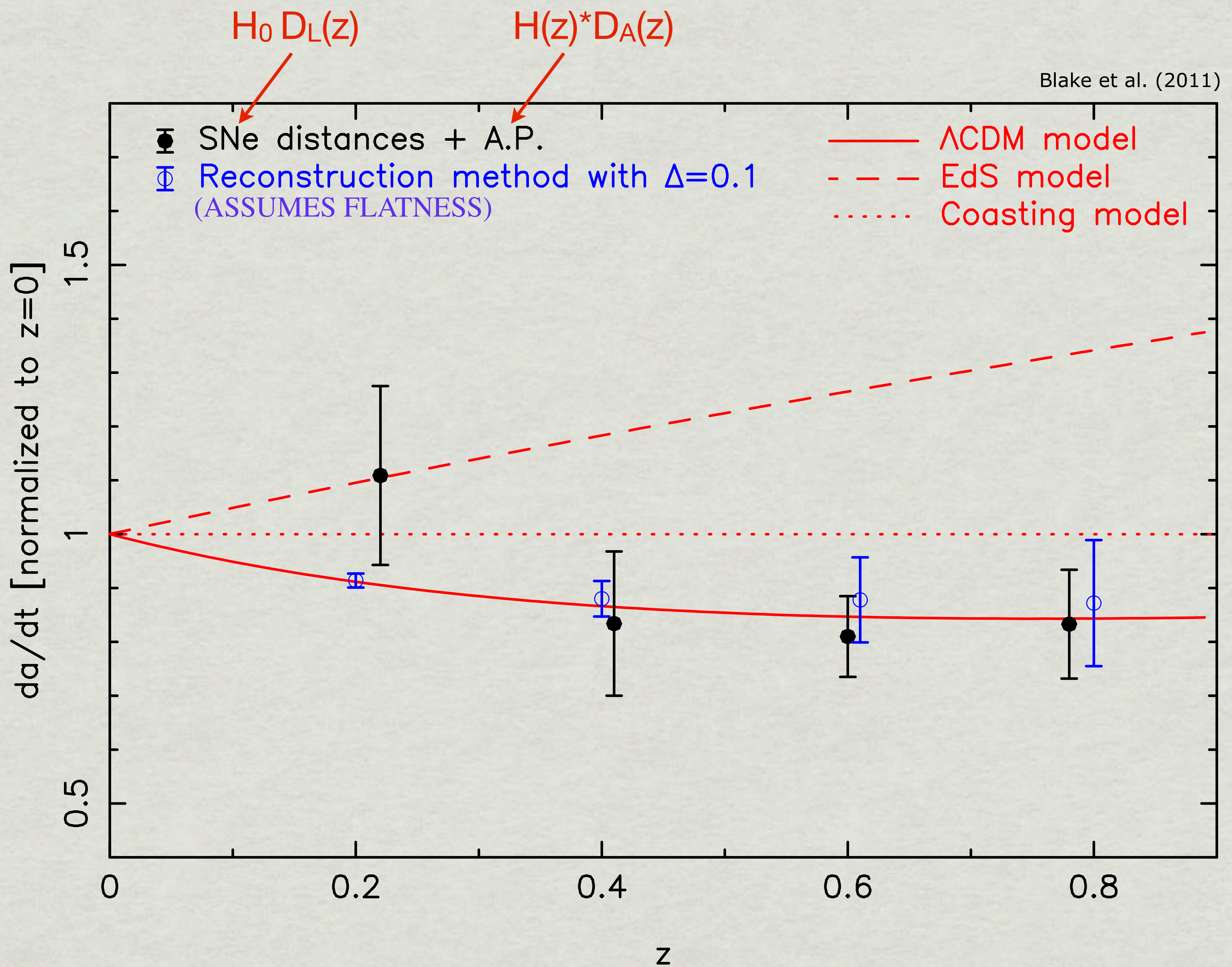






Clustering Wedges $\xi_{||}, \xi_\perp$ are complementary to multipoles


Seo et al. (2012, submitted)
Blake 2011b
Percival 2010
0.54
0.6
0.35
z=0.2
Our photo-z BAO
$D_A(z)/r_s$
$cz/H(z)r_s$
0
5
10
15



H0 DL(z)
H(z)*DA(z)
Blake et al. (2011)
SNe distances + A.P.
Reconstruction method with Δ=0.1
(ASSUMES FLATNESS)
ΛCDM model
EdS model
Coasting model
da/dt [normalized to z=0]
1.5
1
0.5
0
0.2
0.4
0.6
0.8
z

What methods & data are out there?

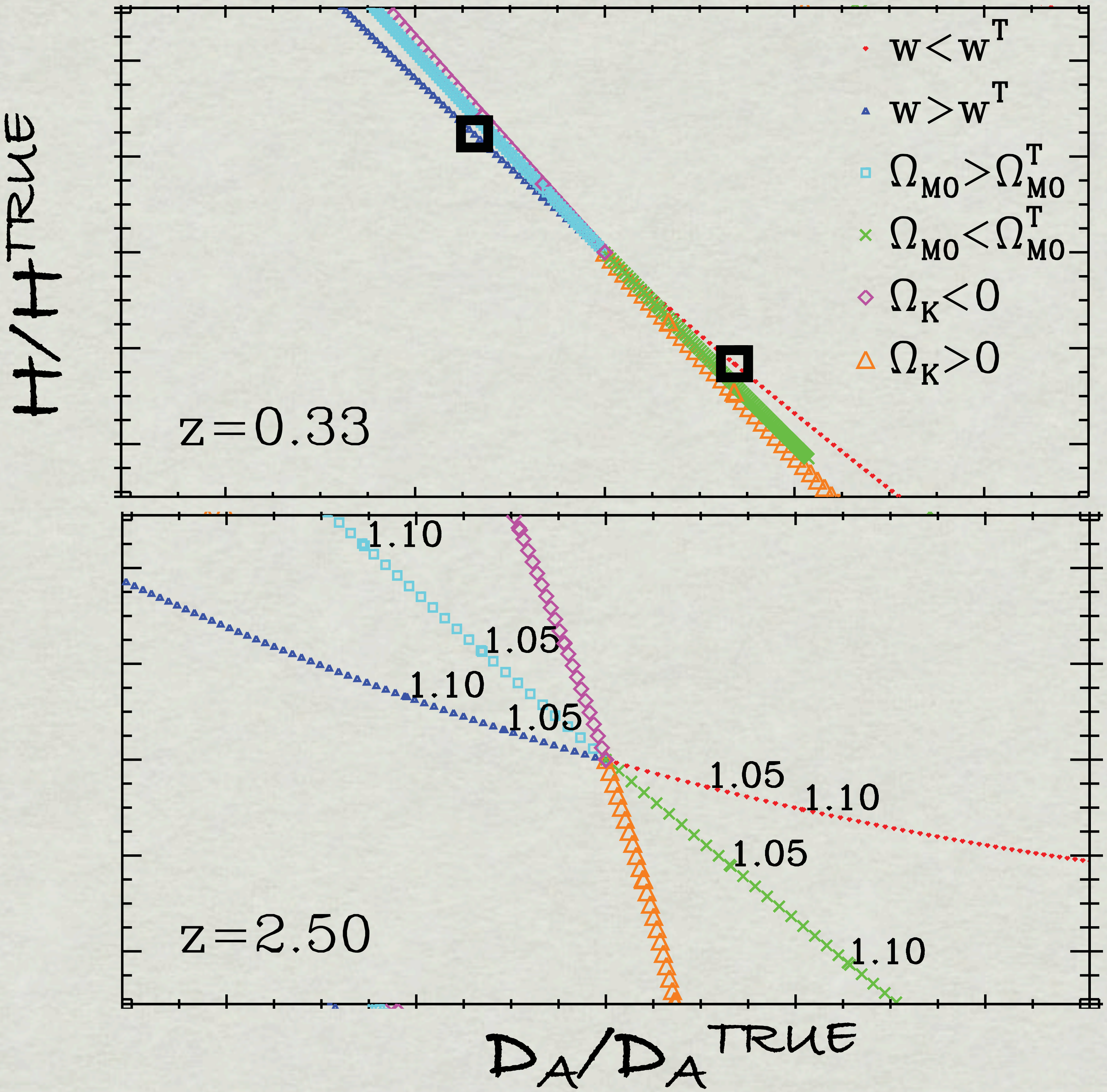
data type	measures	survey, z
z clustering	$(D_A^2/H(z))/r_s^3$, $H(z)*D_A$, D_A/r_s, $H*r_s$	SDSS-II <0.5, SDSS-III <0.7, <3.5, WiggleZ<0.8, HetDex 1.9<z<3.5
other Alcock Paczynski: stacking voids, pair count orientation	$H(z)*D_A$	SDSS-III<0.7
photometric clustering	D_A/r_s	SDSS-III<0.7, DES, Panstarrs
CMB DT/T	$r_s \propto 1/\sqrt{(\Omega_M H_0^2)}$, $D_A(z^*)$	WMAP, Planck etc z~1100
SNe	low z: H_0, high z: D_L*H_0	HST, Union 2 etc.
other low z: Cepheid Variables, Masers, Tully-Fisher, Surface brightness fluctuations	H_0	
f_{gas} (assumed constant in z)	$D_L* \sqrt{D_A}$	XEUS
Active Galactic Nuclei ``reverberation"	$D_L= (1+z)^2D_A$	
Radio galaxies accretion disks		
futuristic: lensed CMB	$D_A(z)/D_A(z^*)$	
futuristic: gravitational waves as standard sirens	D_L	

Combinations

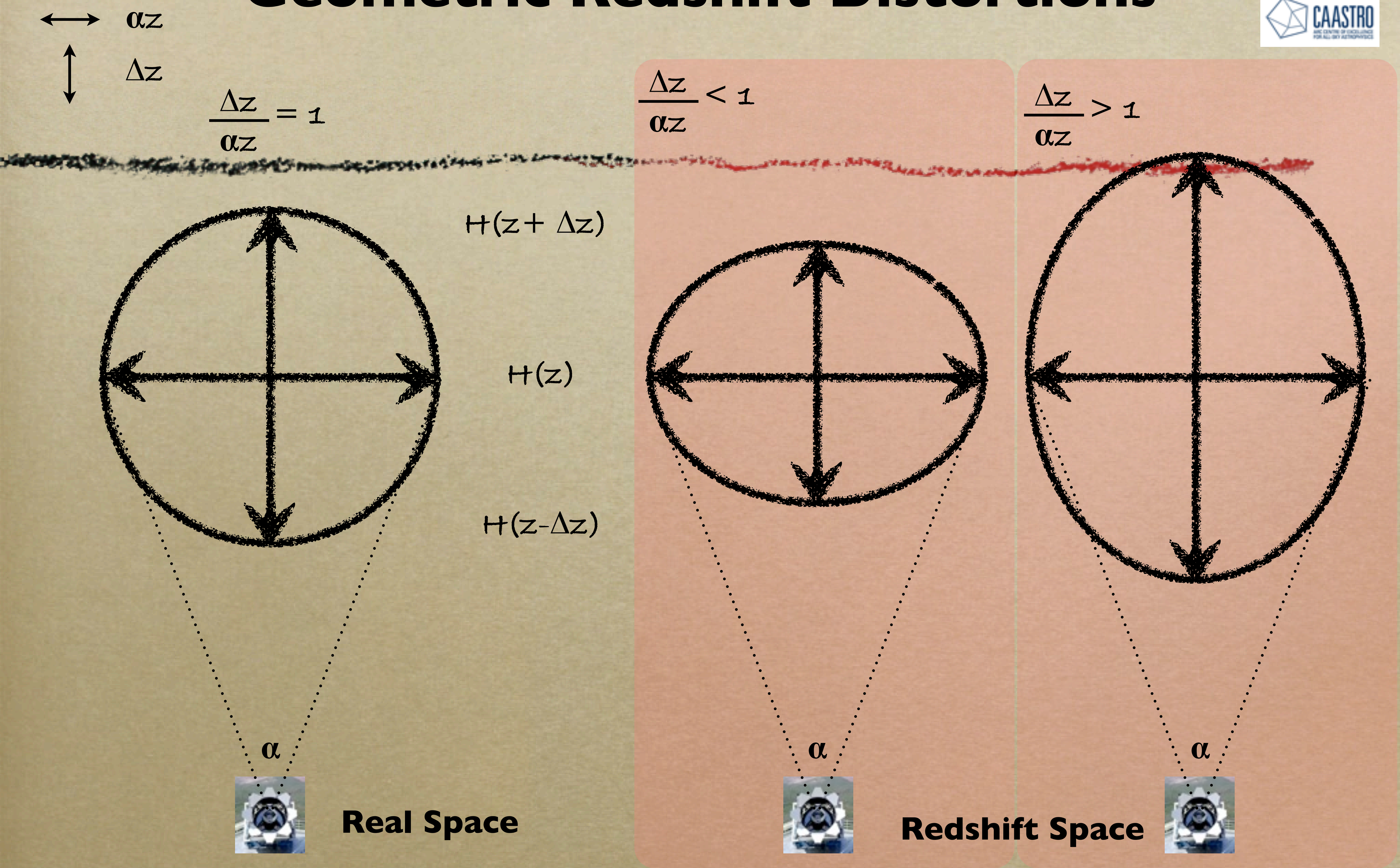
- z-clustering at high z+ CMB -> $D_A^2/H(z)$, $D_A(z)$, $H(z)$
- z-clustering at low z + CMB -> H_0 (Beutler et al. 2011)
- z-clustering + S/N: $H(z)/H_0 \sim \text{å}/\text{å}_0$ (Blake et al. 2011)
- tests of $D_L(z)=(1+z)^2 D_A$? Learn about dust, photon decay to axion?
- H(z,R.A,Dec)? Back-reaction?

Parameter Degeneracy

Kazin, Sanchez and Blanton (2012)

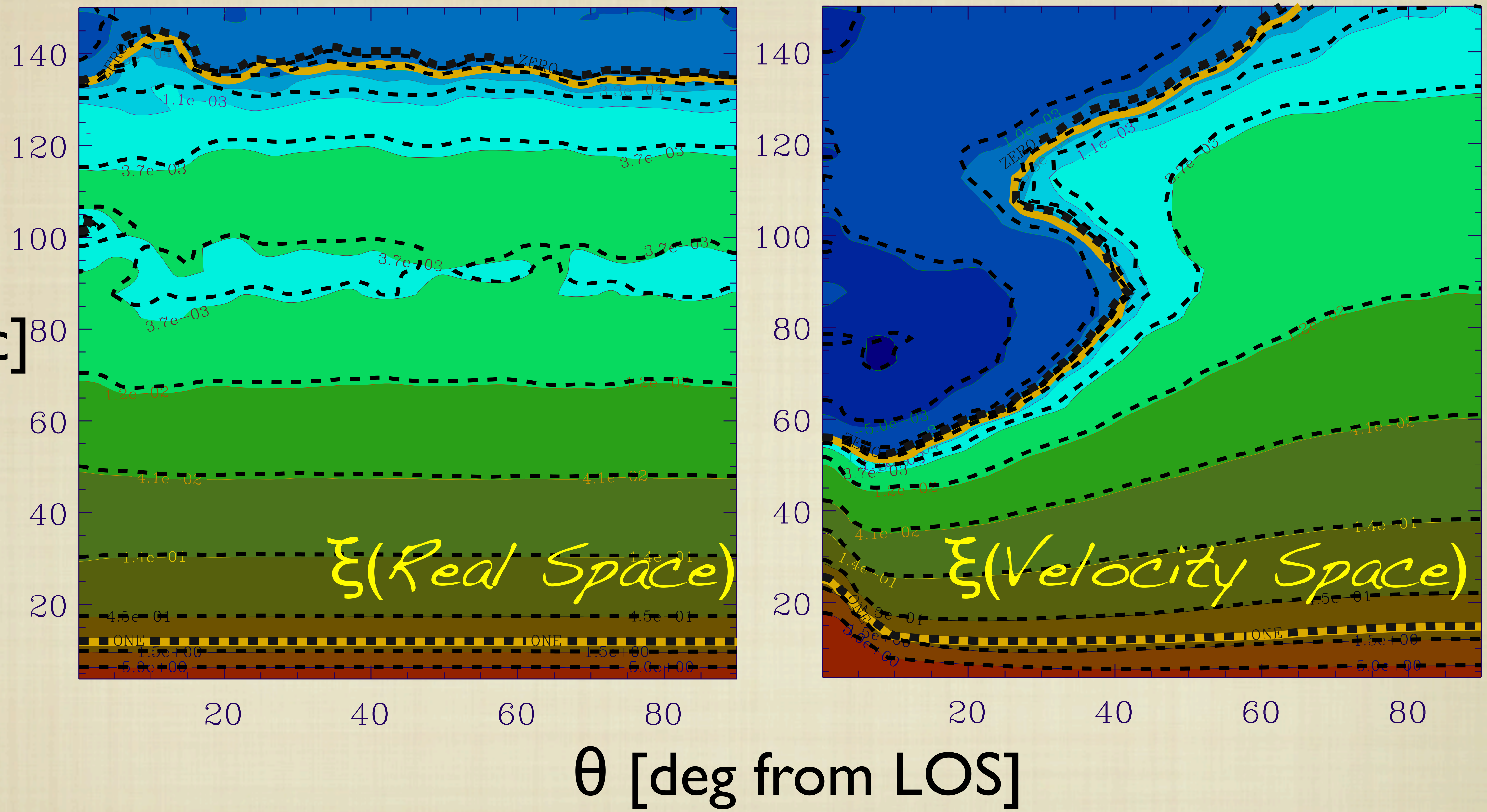


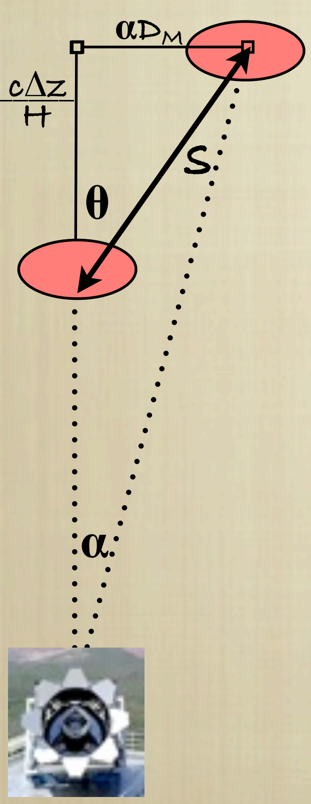
Geometric Redshift Distortions



Dynamical vs. Geometrical:

Testing LasDamas mock LRGs



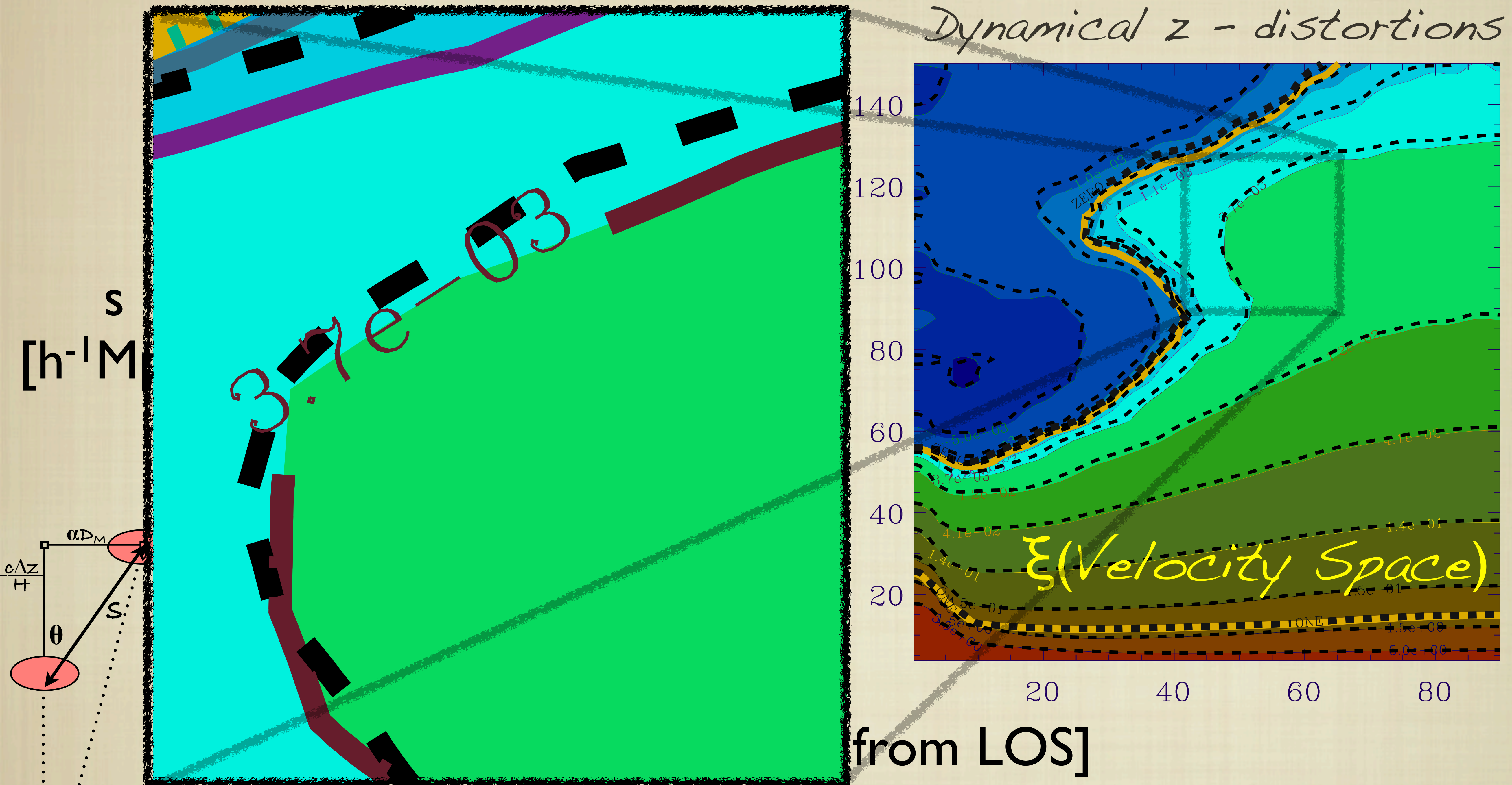


true signal

geometrically distorted signal (ω_{DE}=−1.1; instead of ω_{DE}=−1)

DYNAMICAL VS. GEOMETRICAL:

Testing LasDamas mock LRGs



true signal

geometrically distorted signal ($\omega_{DE}=-1.1$; instead of $\omega_{DE}=-1$)