Peculiar velocities with SNela

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LSST France - June 4st - LPC Clermont

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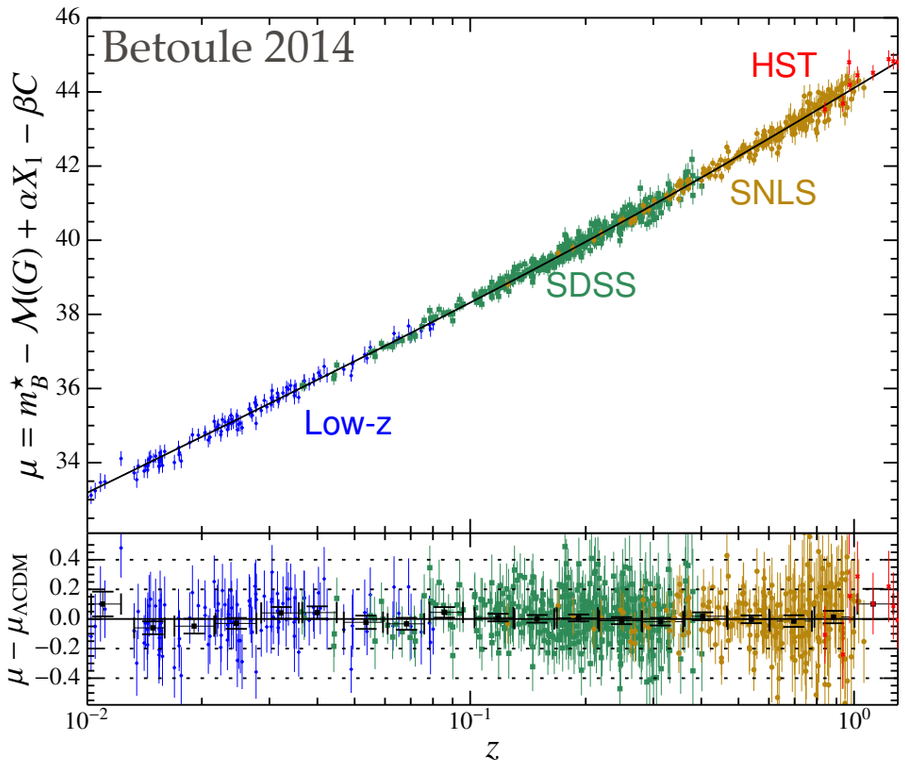
Cosmology at 1st order

The Universe is homogeneous

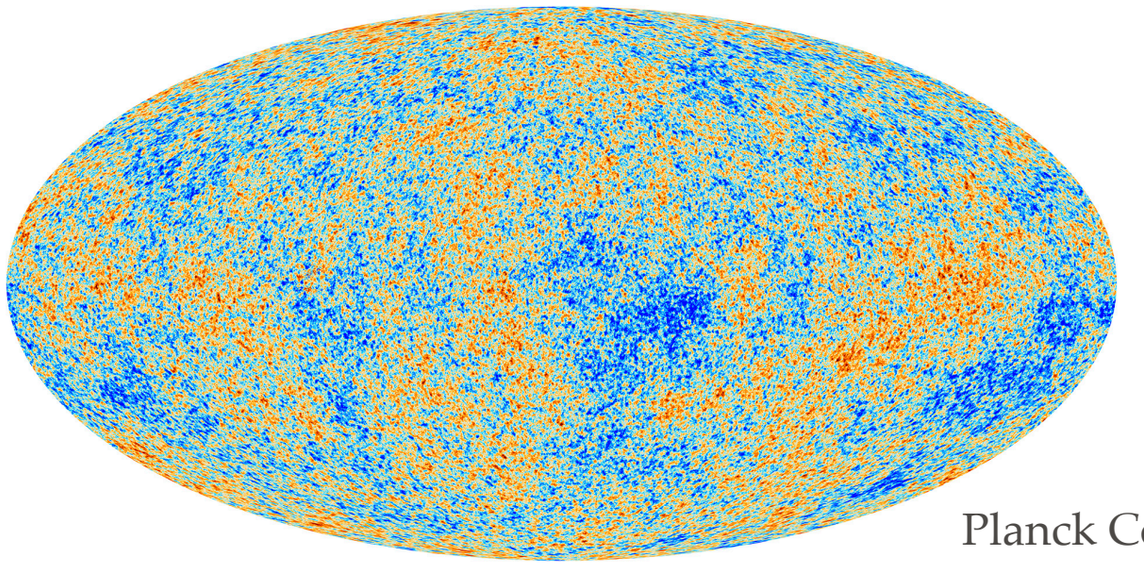
The Universe is expanding

$$H_0\chi(\bar{z}) = c\int_0^{\bar{z}} \frac{\mathrm{d}z}{(\Omega_m(1+z^3)+\Omega_\Lambda)^{\frac{1}{2}}}$$



Cosmology at 2nd order

The Universe is inhomogeneous



Planck Collab.

Structures perturb the Hubble flow

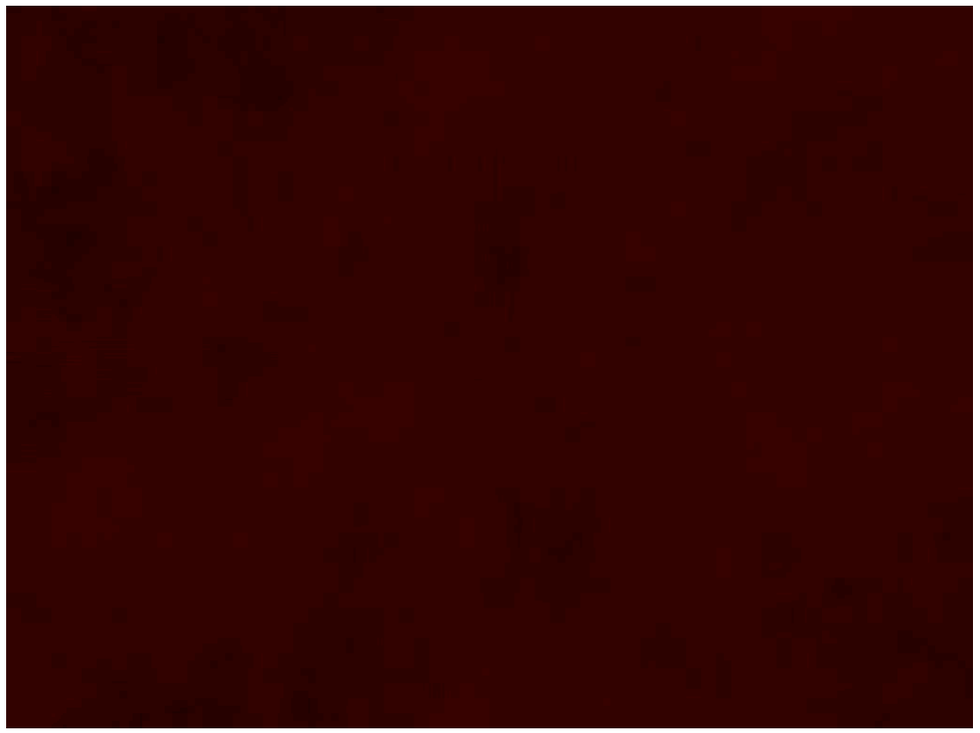
$$\delta$$

$$\downarrow$$

$$\vec{\nabla}\vec{v} = -H_0 f \delta$$

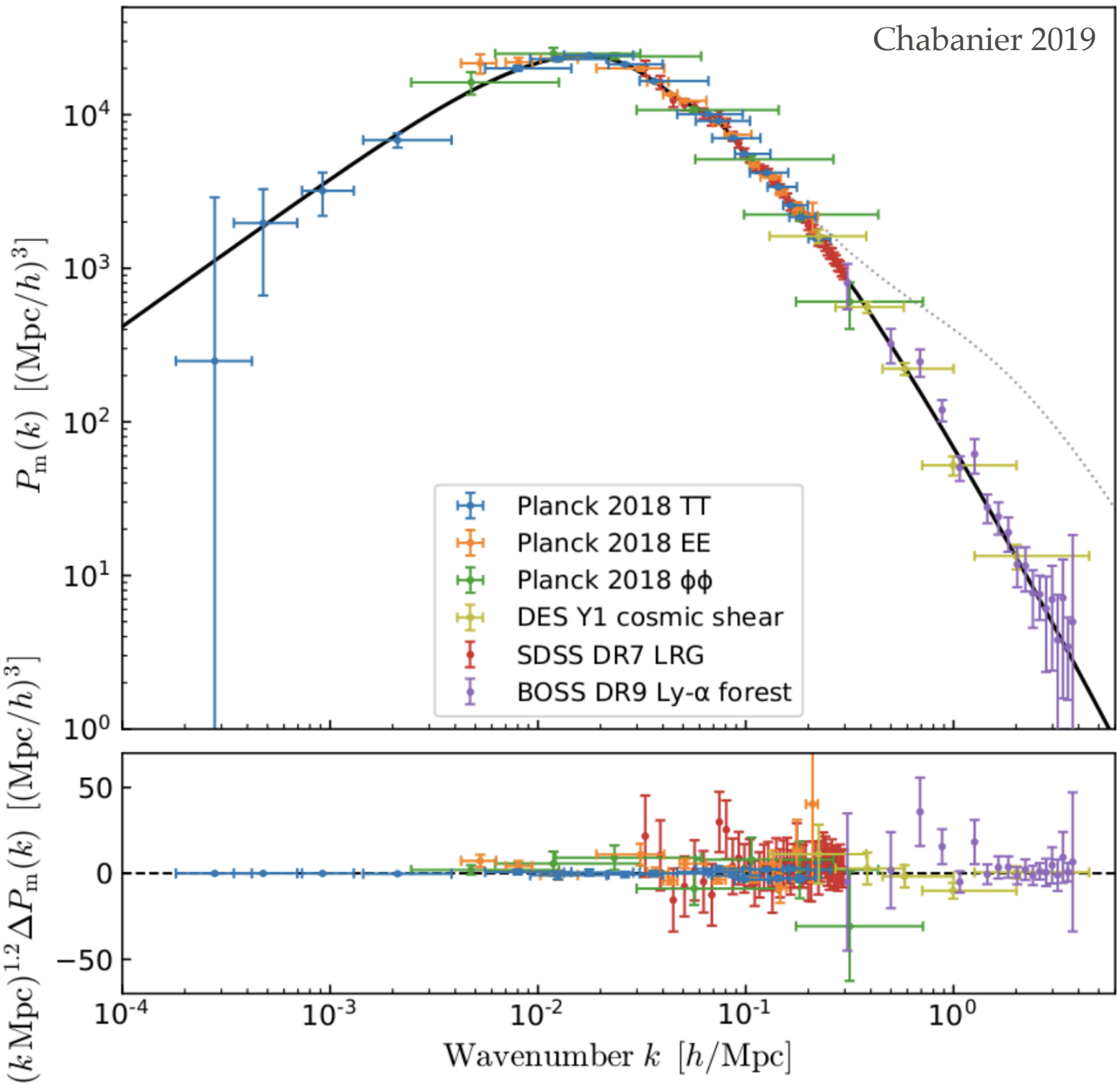
$$\downarrow$$

$$(1+z) = \left(1 + \frac{v^r}{c}\right)(1+\bar{z}(d))$$

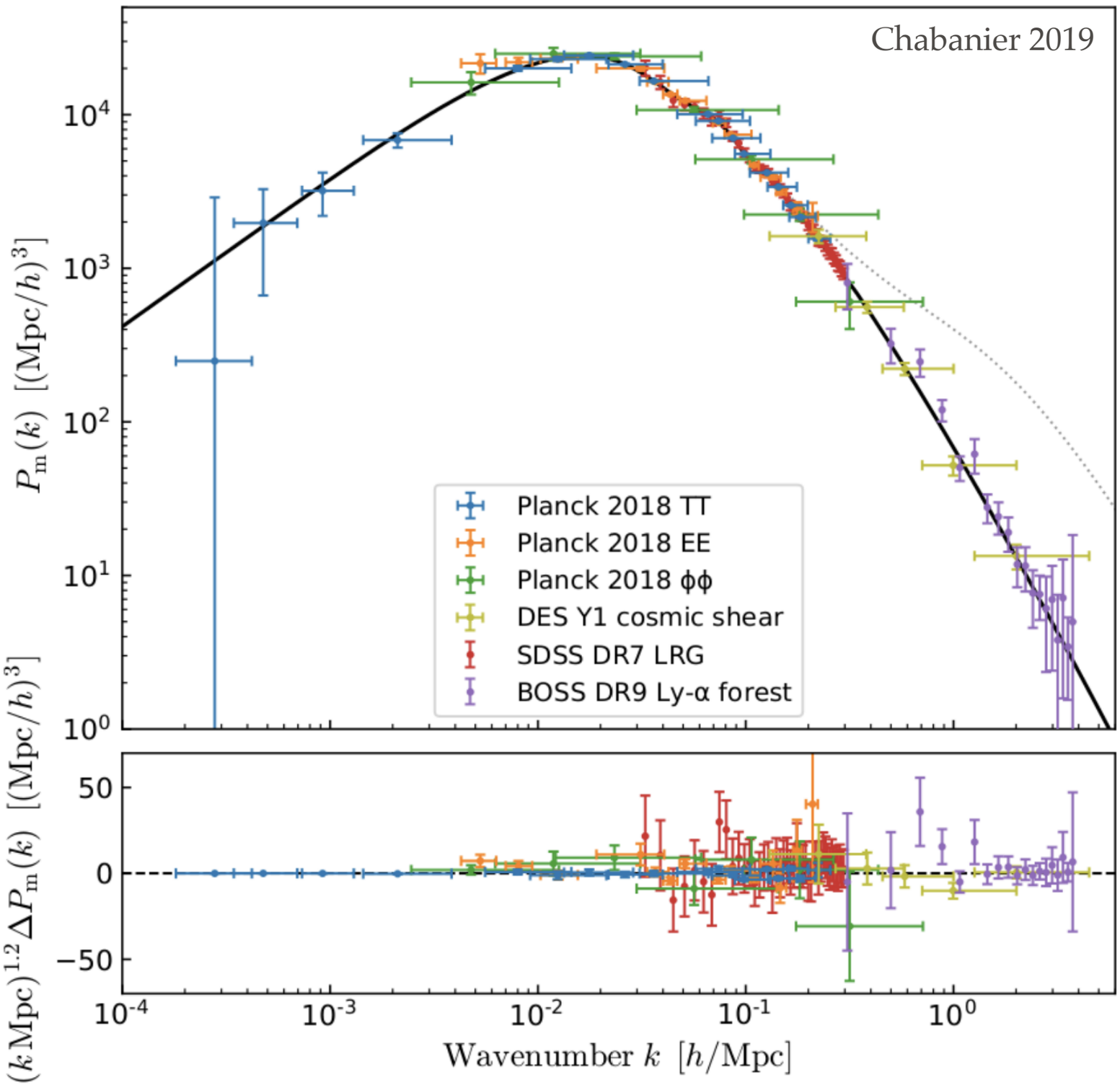


CLUES

Large scale structures statistics



Large scale structures statistics



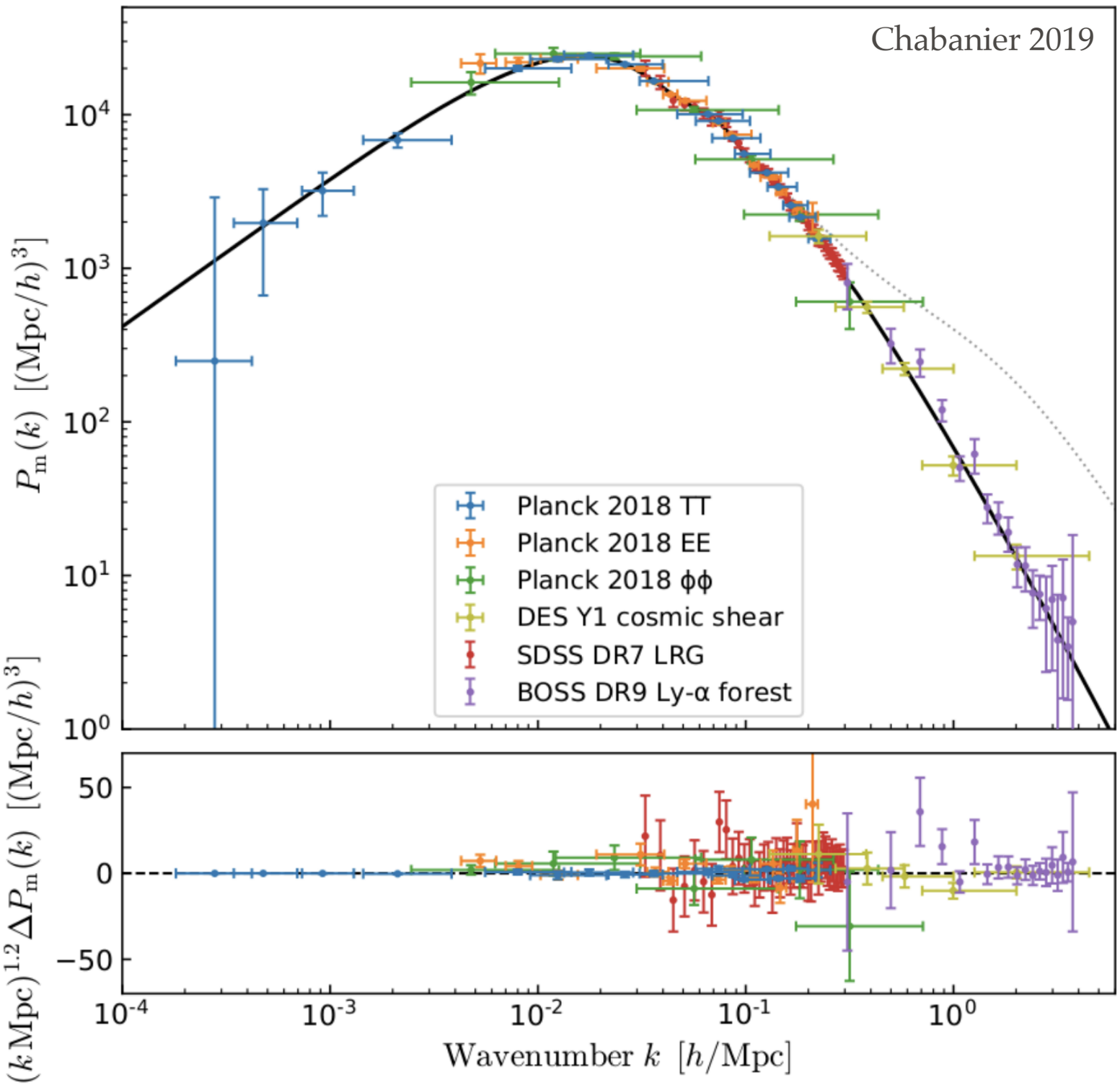
The over density field of matter is a Gaussian random field

$$\langle \delta \rangle = 0$$

$$\langle \delta^2 \rangle = \sigma_8^2 P_0(k)$$

Amplitude of fluctuations

Large scale structures statistics



The over density field of matter is a Gaussian random field

$$\langle \delta \rangle = 0$$

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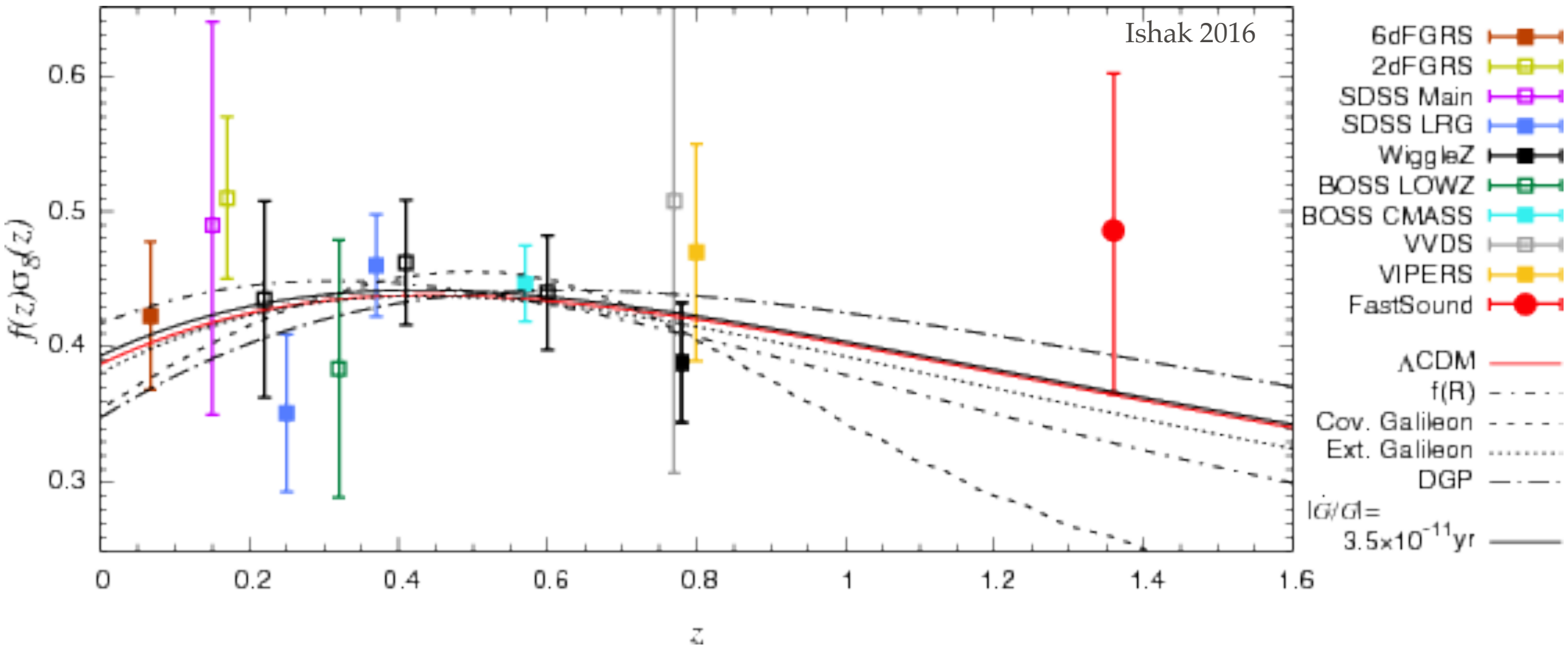
$$\langle v_\alpha \rangle = 0$$

$$\langle v_\alpha^2 \rangle = (f\sigma_8)^2 \frac{k_\alpha^2}{k^4} P_0(k)$$

Growth rate

Growth rate


Ishak 2016
6dFGRS
2dFGRS
SDSS Main
SDSS LRG
WiggleZ
BOSS LOWZ
BOSS CMASS
VVDS
VIPERS
FastSound
ΛCDM
f(R)
Cov. Galileon
Ext. Galileon
DGP
|Ġ/G|=
3.5×10^-11yr
f(z)σ8(z)
z
0.3
0.4
0.5
0.6
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

Measuring the growth rate

Galaxy redshifts
(DESI?)

$$(1+z) = \left(1 + \frac{v^r}{c}\right)(1+\bar{z}(d))$$

Type Ia SNe From LSST

$$\mathcal{L} = -\frac{1}{2} v^{r,T} \mathbf{C}^{-1} v^r - \frac{1}{2} \log |\mathbf{C}|$$

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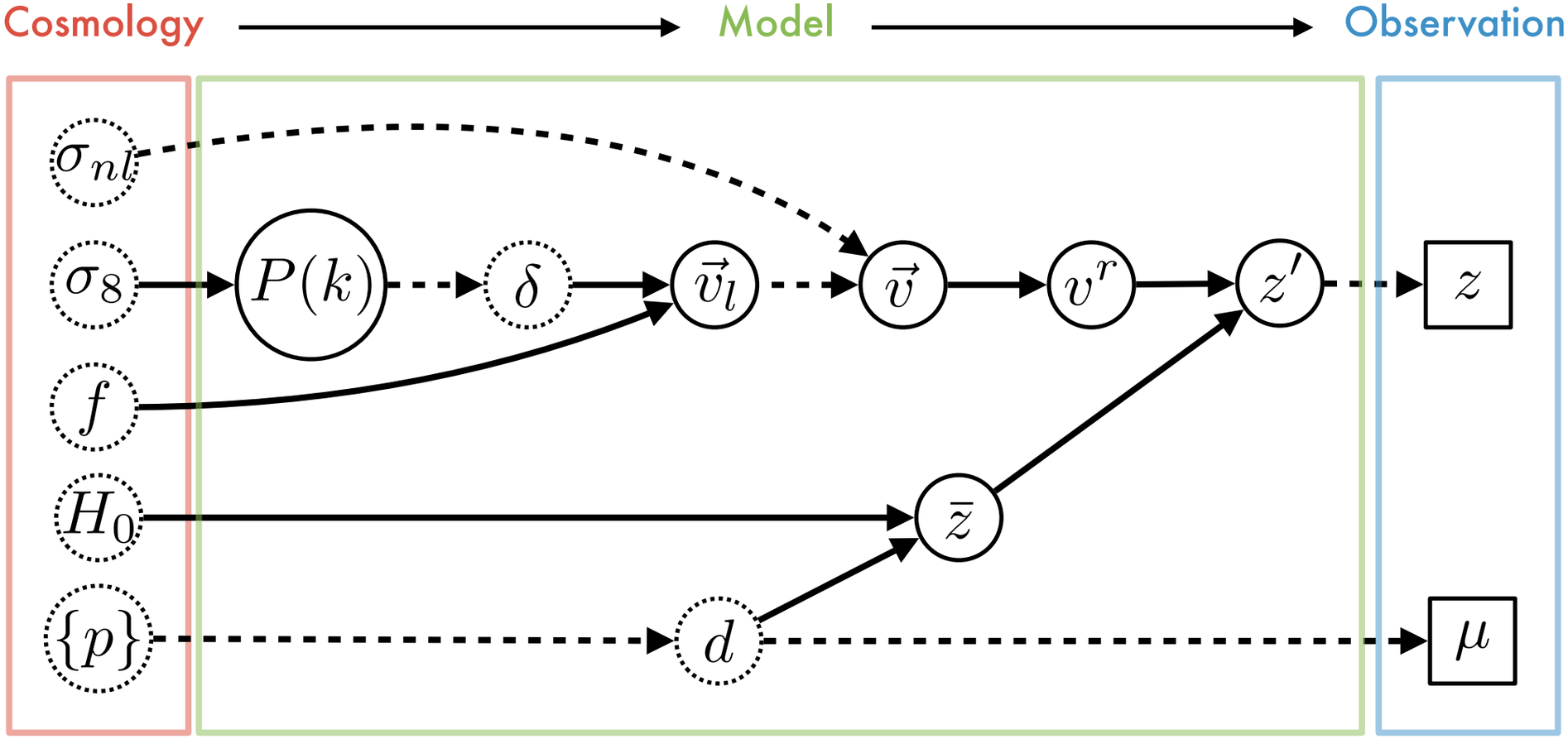
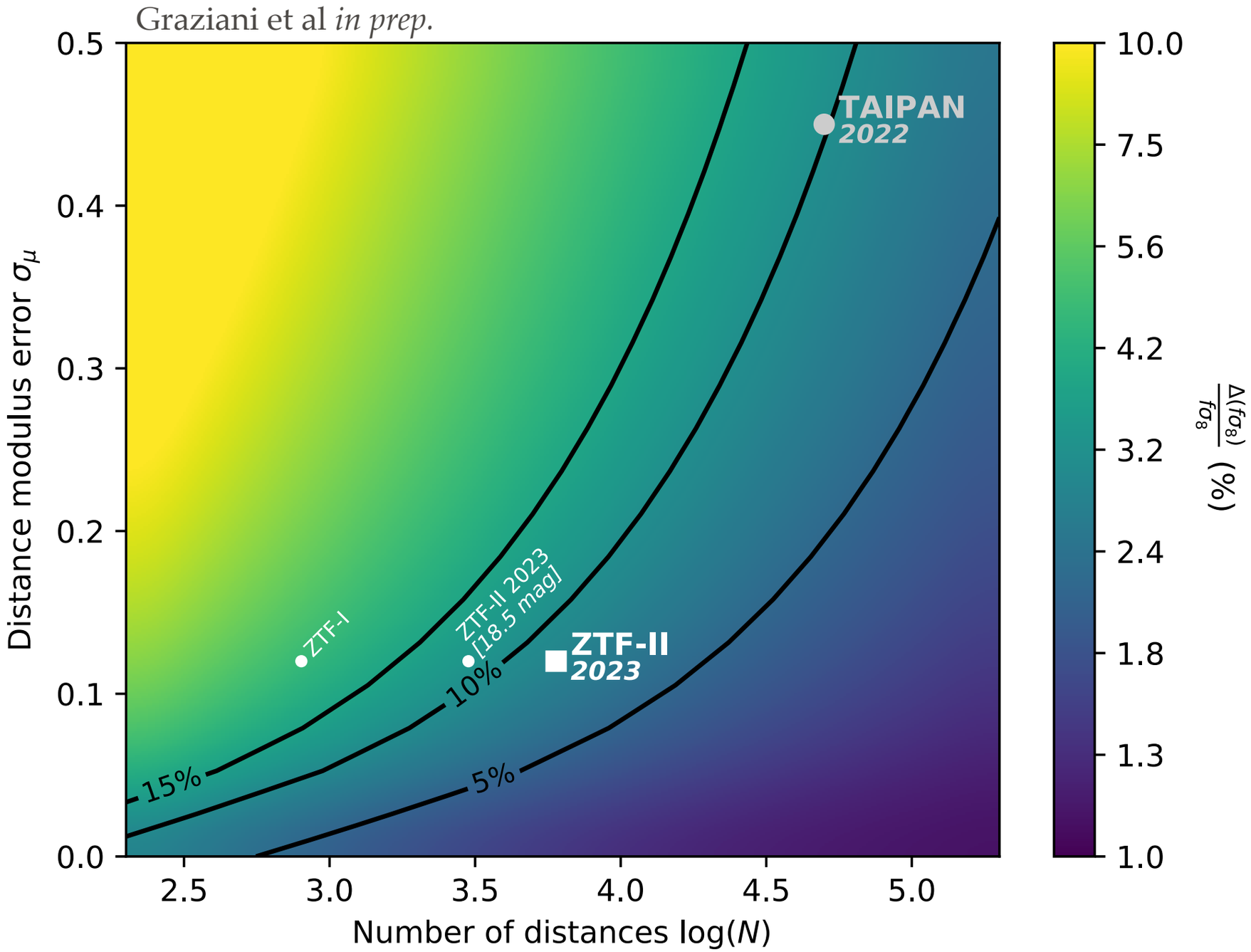
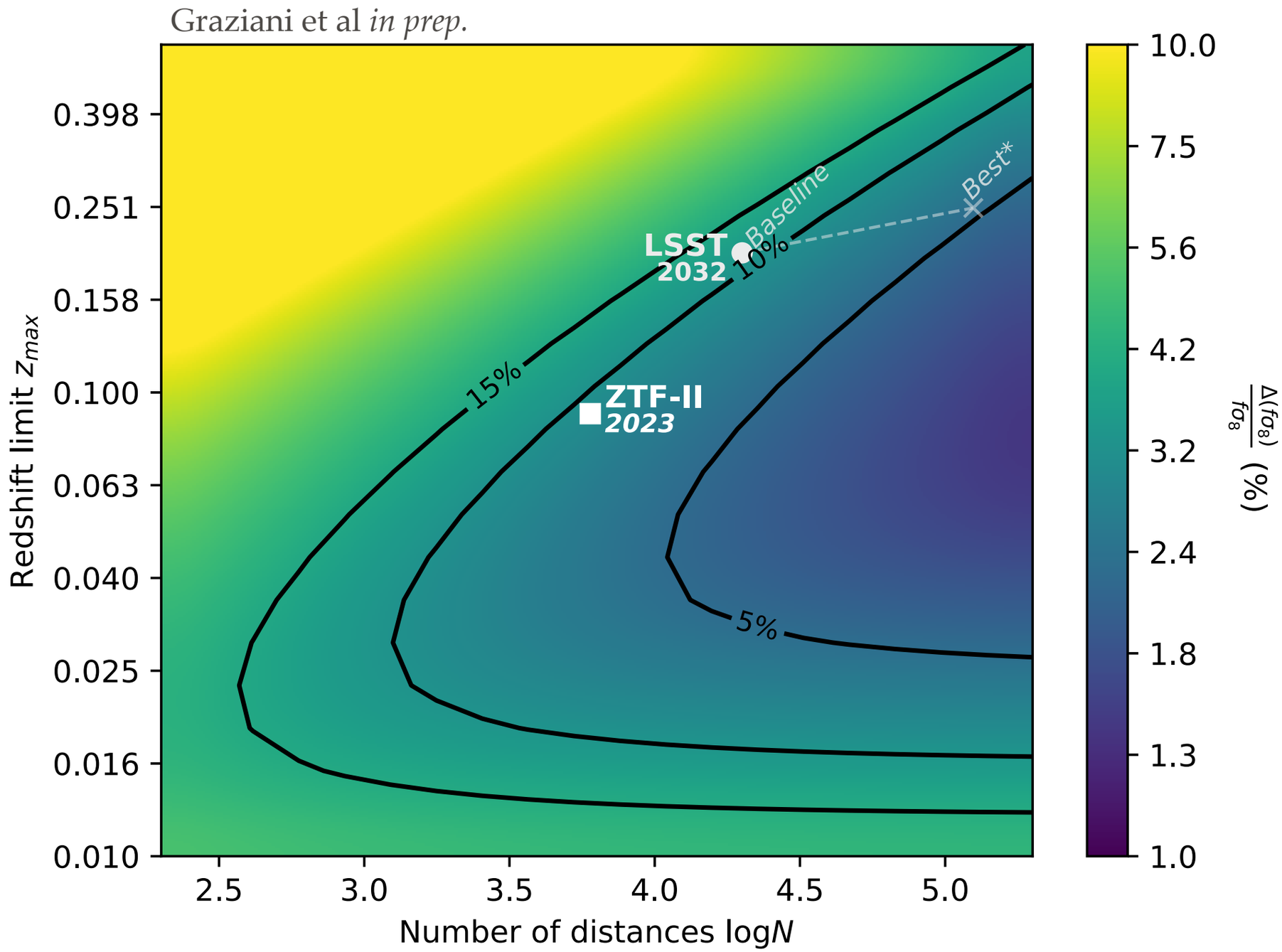


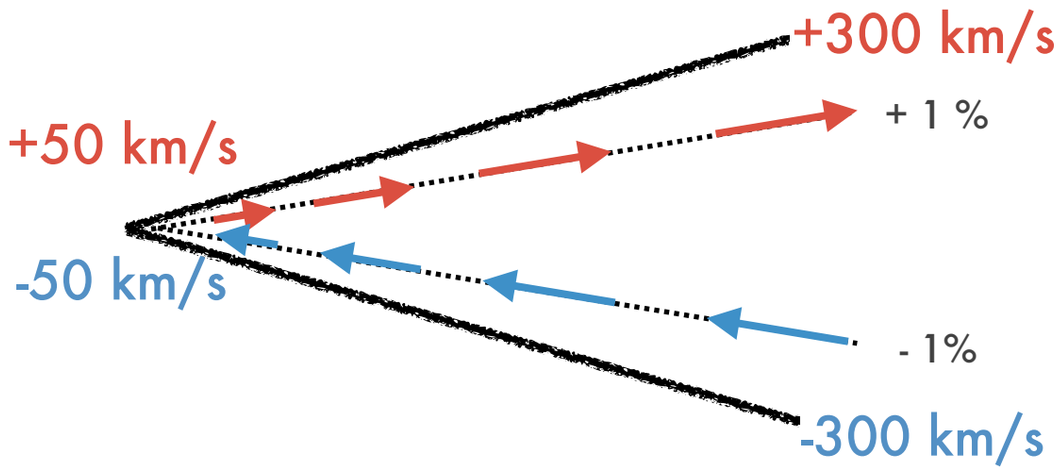
Forecasts


Graziani et al *in prep.*
Distance modulus error σ_μ
Number of distances log(N)
$\frac{\Delta(f\sigma_8)}{f\sigma_8}$ (%)
TAIPAN 2022
ZTF-II 2023
ZTF-I
ZTF-II 2023 [18.5 mag]
15%
10%
5%
0.0
0.1
0.2
0.3
0.4
0.5
2.5
3.0
3.5
4.0
4.5
5.0
1.0
1.3
1.8
2.4
3.2
4.2
5.6
7.5
10.0

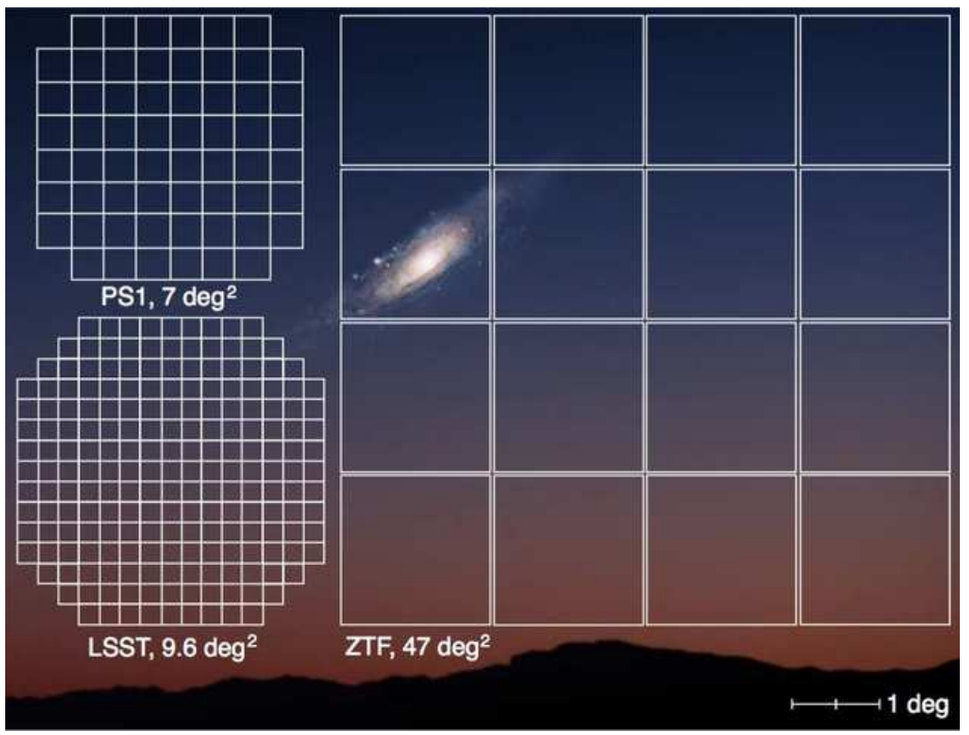
Forecasts


Graziani et al *in prep.*
0.398
0.251
0.158
0.100
0.063
0.040
0.025
0.016
0.010
Redshift limit z_{max}
2.5
3.0
3.5
4.0
4.5
5.0
Number of distances log$N$
LSST
2032
Baseline
Best*
10%
15%
5%
ZTF-II
2023
10.0
7.5
5.6
4.2
3.2
2.4
1.8
1.3
1.0
$\frac{\Delta(f\sigma_8)}{f\sigma_8}$ (%)

Example of systematic



Photometric inhomogeneity → Spurious Angular correlations → Biais on $f\sigma_8$



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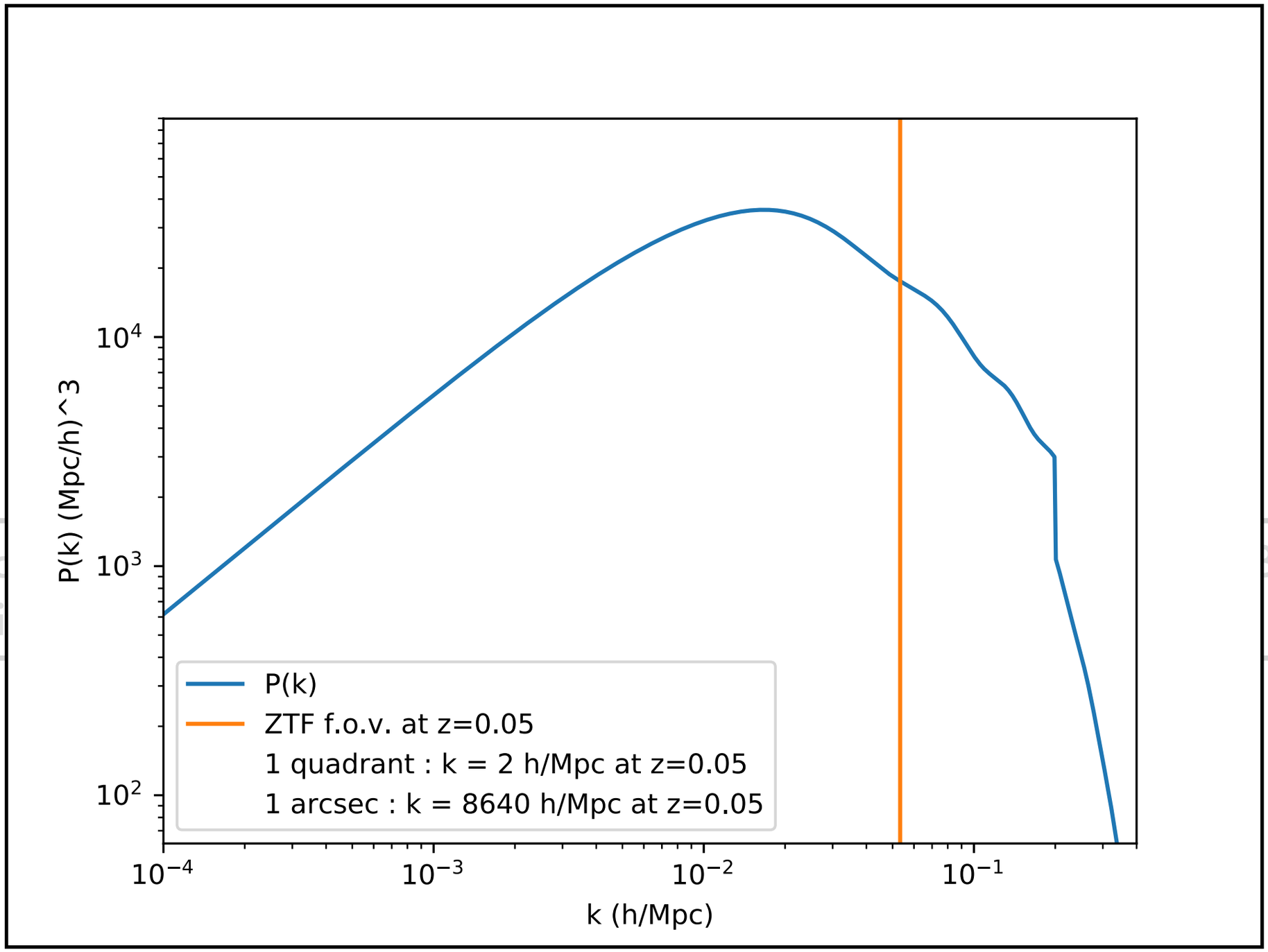
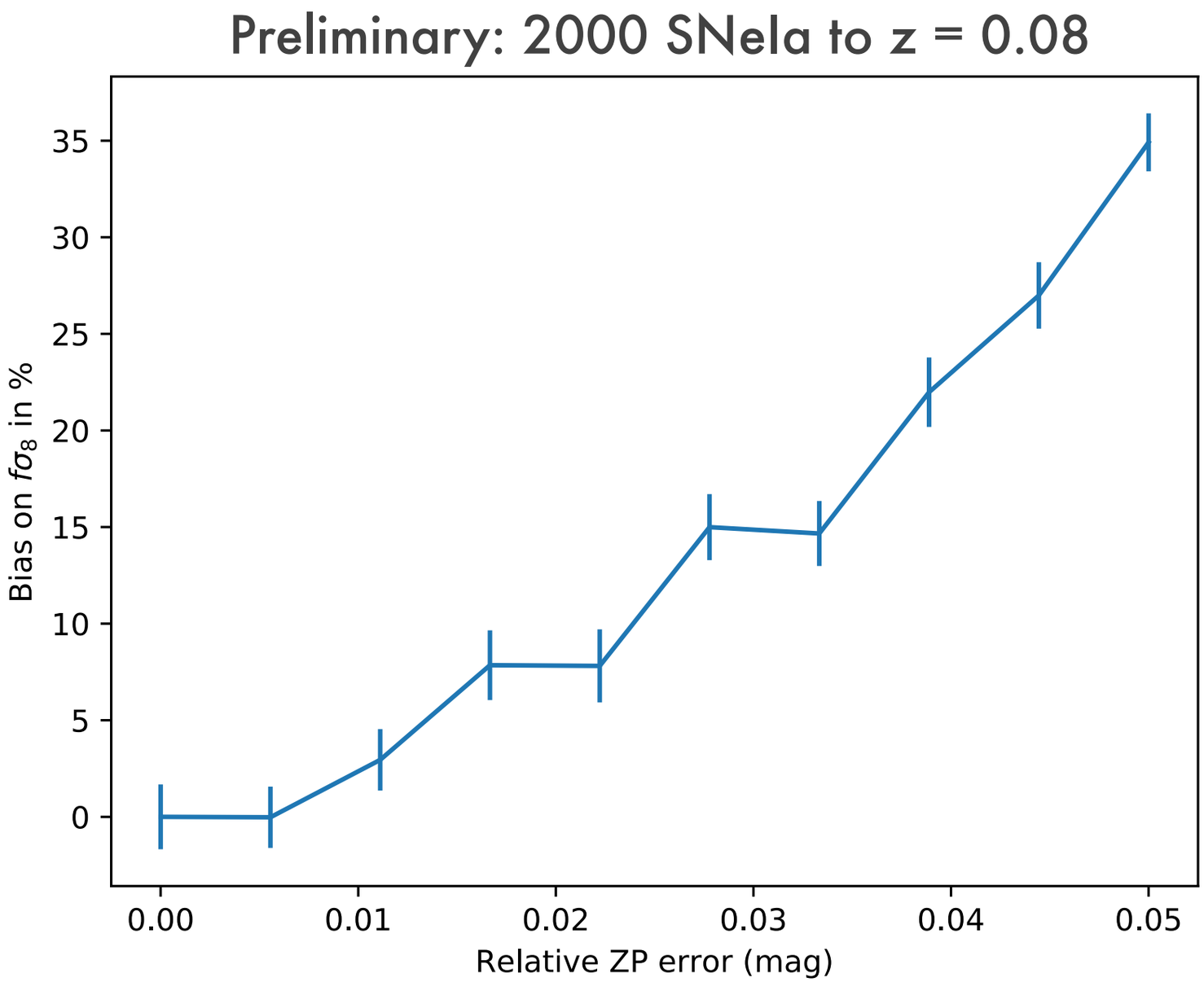


Photometric
inhomogenei

Biais on
$f\sigma_8$

Relative calibration



Possible systematics

Systematics	Status	Importance
Inhomogeneity	✓	**Medium?**
Saturation	✗	**?**
Non-linear model		**Medium?**
Contamination		**Small**
Inhomogeneous Malmquist bias	✓	**High**
Selection effects	✗	**?**