Optimizing the XXL survey design for cluster cosmological studies

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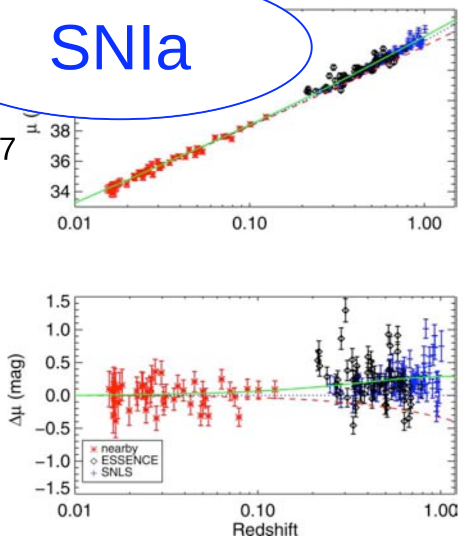
April 15 2008

Contents

- Cosmological context
- Clusters & Cosmology: identified issues
- Constraints from various XXL survey designs

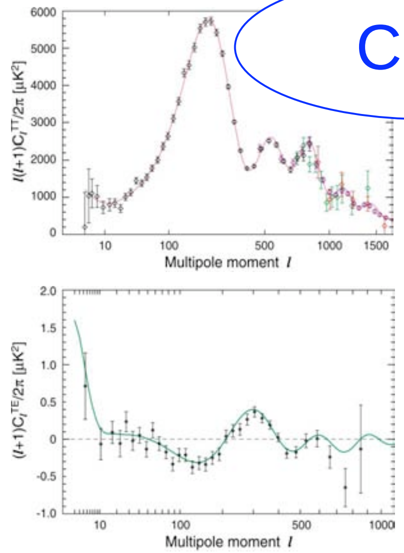
Cosmological context

SNIa



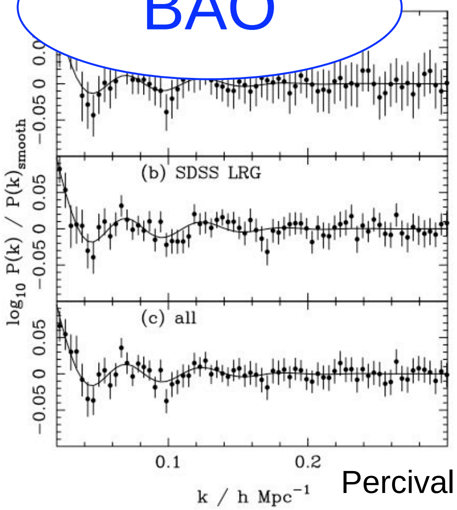
Wood-Vasey et al. 2007

CMB



Nolta et al. 2008

BAO



Percival et al. 2007

ΛCDM

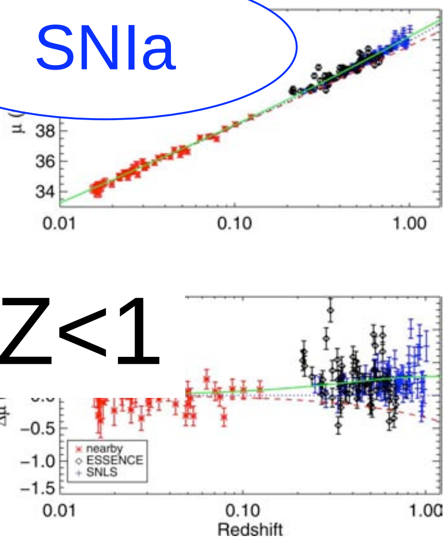
?

Cluster counts
Correlation function

Cosmological context

SNIa

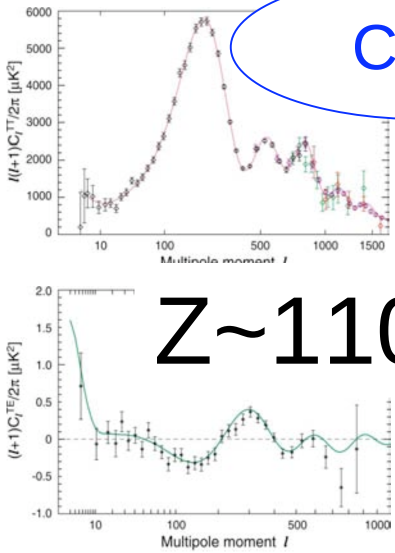
Wood-Vasey et al. 2007



Z<1

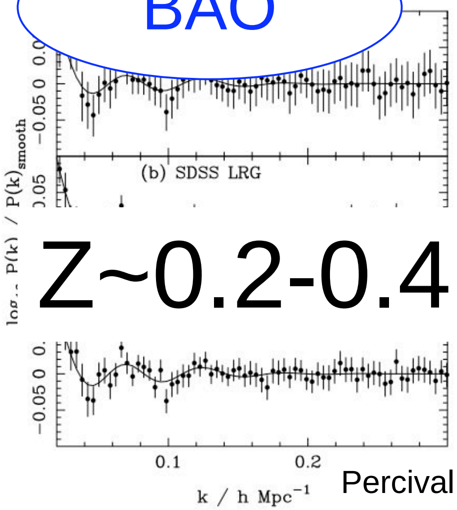
CMB

Nolta et al. 2008



Z~1100

BAO



Z~0.2-0.4

Percival et al. 2007

ΛCDM

Z<3

Cluster counts
Correlation function

Independent measurement
&
Different physical processes

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Linking observations with theory

Observations

$$\frac{d^3 N_{obs}}{dF_X d\theta_v dz} \quad \xi_{obs}(r)$$

F_x, Y, θ_v, z, …

Theory

$$\frac{d^2 N}{dM dz} \quad \xi(r)$$

M, z, …

Selection function

Cosmology with clusters : challenges

[see G. Holder's contribution]

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[see G. Holder's contribution]

- Individual masses to high precision

- Well controlled mass-observable relations

Cosmology with clusters : challenges

- Individual masses to high precision

    - requires multi-frequency observations

    X, SZ, lensing *How to combine them ?*

[see M. Maturi's talk]

Cosmology with clusters : challenges

- Individual masses to high precision

  - requires multi-frequency observations
  - very expensive

  Not achievable for all clusters of wide surveys (e.g. SPT, ACT, AMiBA, AMI, APEX)

[see T. Crawford's talk]
[see J. Hughes' talk]
[see J.-H. P. Wu's talk]
[see R. Saunders' talk]
[see R. Kneissl's talk]

Cosmology with clusters : challenges

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  - suitable for a limited area (<100deg^2)

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[see G. Bryan’s contribution]

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$$Y = Y^* M^{\frac{5}{3}+\beta} \left(\frac{\Delta_c}{178}\right)^{\frac{1}{3}} E^{\frac{2}{3}} (H_o D_{ang})^{-2} (1+z)^{\gamma}$$

Cosmology with clusters : challenges

2 ways

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normalization, **non gravitational physics**, **evolution**

[see D. Nagai’s contribution]

Cosmology with clusters : challenges

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Cosmology with clusters : challenges

2 ways

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  - suitable for a limited area ($<100\text{deg}^2$)

- Well controlled mass-observable relations
  - "calibration" and/or "self-calibration"
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$$Y = Y^* \, M^{\frac{5}{3}+\beta} \left(\frac{\Delta_c}{178}\right)^{\frac{1}{3}} E^{\frac{2}{3}} (H_o D_{ang})^{-2} (1+z)^{\gamma}$$

$$\theta_v = \theta_v^* \ldots$$

scatter, covariance

[see A. Evrard's talk]

Cosmology with clusters : challenges

- Individual masses to high precision
  - requires multi-frequency observations
  - very expensive
  - suitable for a limited area (<100deg^2)

- Well controlled mass-observable relations
  - “calibration” and/or “self-calibration”
  - normalization, non grav. physics, evolution
  - scatter, covariance between observables

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Goals

Constrain cosmological parameters (σ_8, Ω_M,...) using **only clusters** in a self-sufficient approach

What's the importance of the mass-observable uncertainties in the analysis ?

↓

Fisher analysis

Working hypotheses

Free parameters

σ_8, Ω_M, Ω_Λ, h

α: “mass calibration” parameter

(M $\Rightarrow$ αM in the selection function)

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Assumptions

XMM-LSS C1 selection function

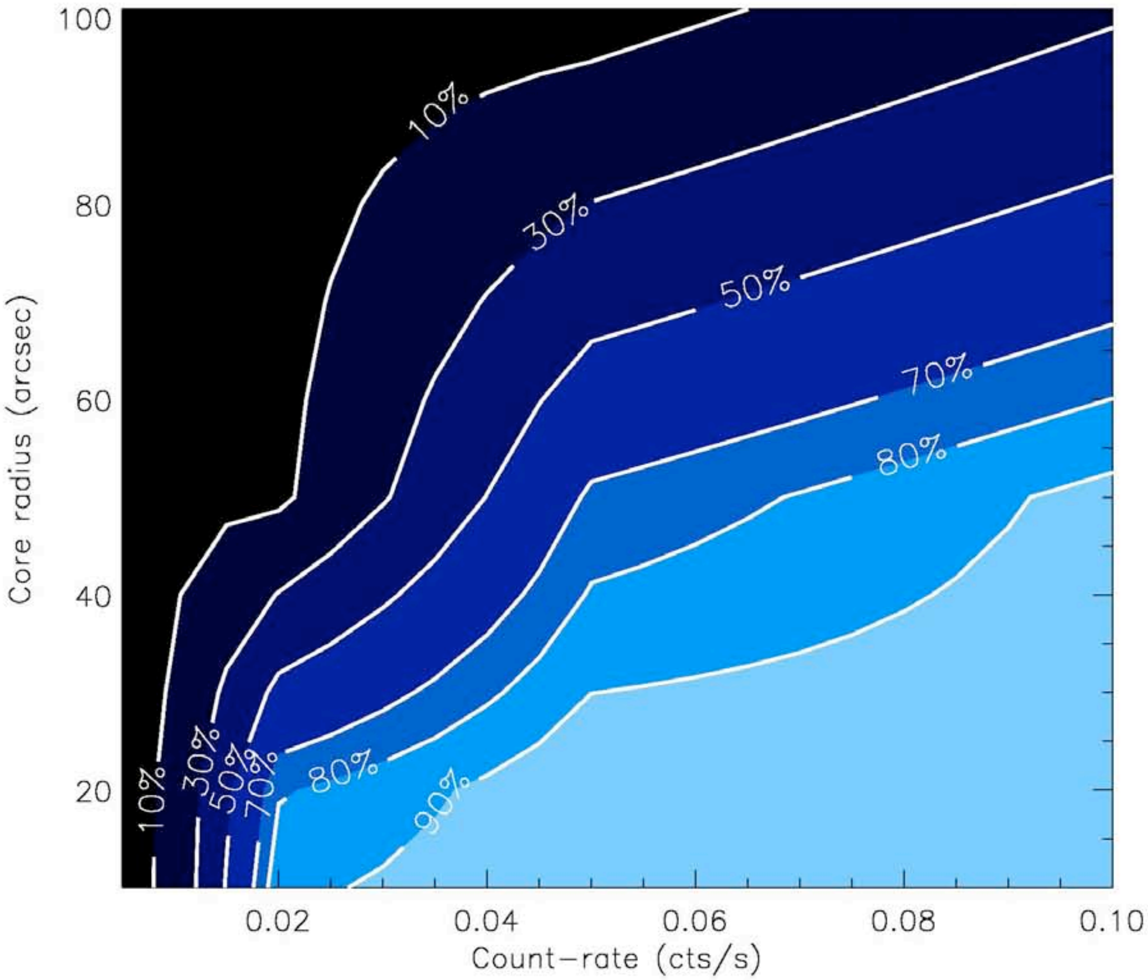
[10ks XMM exposure, ~6 clusters/deg^2]

Γ=f(Ω_M,h) from Sugiyama (1995)

$\Omega_M+\Omega_\Lambda\neq1$, h unknown

(No assumption on flatness or h unless specified)

The C1 cluster selection function



Not flux limited

Selection depends on cluster size

[see F. Pacaud's talk]

Working hypotheses

Free parameters

σ_8, Ω_M, Ω_Λ, h

α: "mass calibration" parameter

(M $\Rightarrow$ αM in the selection function)

Assumptions

XMM-LSS C1 selection function

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Observables

Cluster counts: **dN/dz**

Correlation function: ξ

Studied XXL designs

<u>Design 1</u>

200 deg²

[10ks XMM exposure]

VS

<u>Design 2</u>

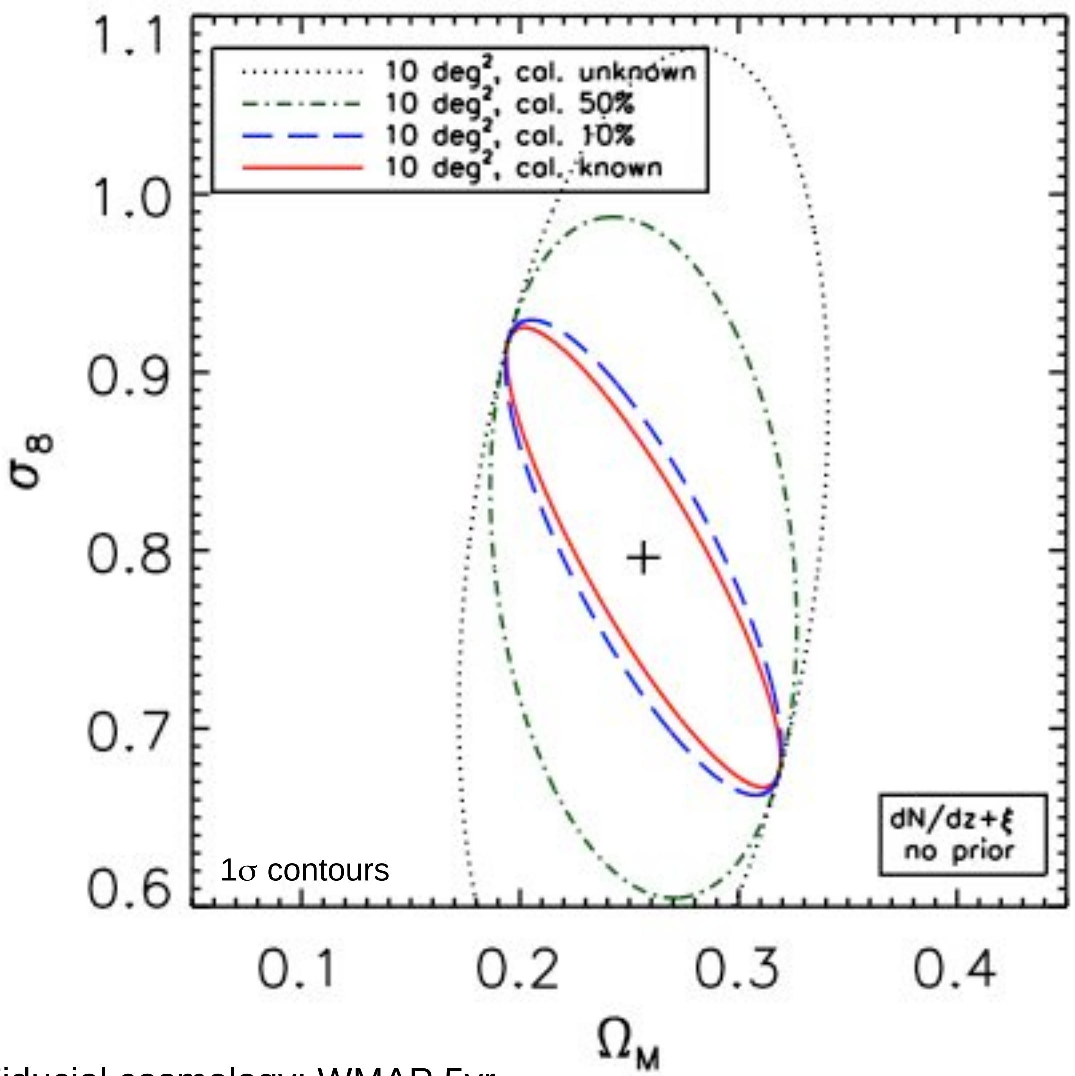
50 deg²

[40ks XMM exposure]

For this study, we keep the same selection function
in both cases
(XMM-LSS C1 selection function)

More exposure time will help for mass determination
(α parameter)

The current XMM-LSS design [10 deg^2]

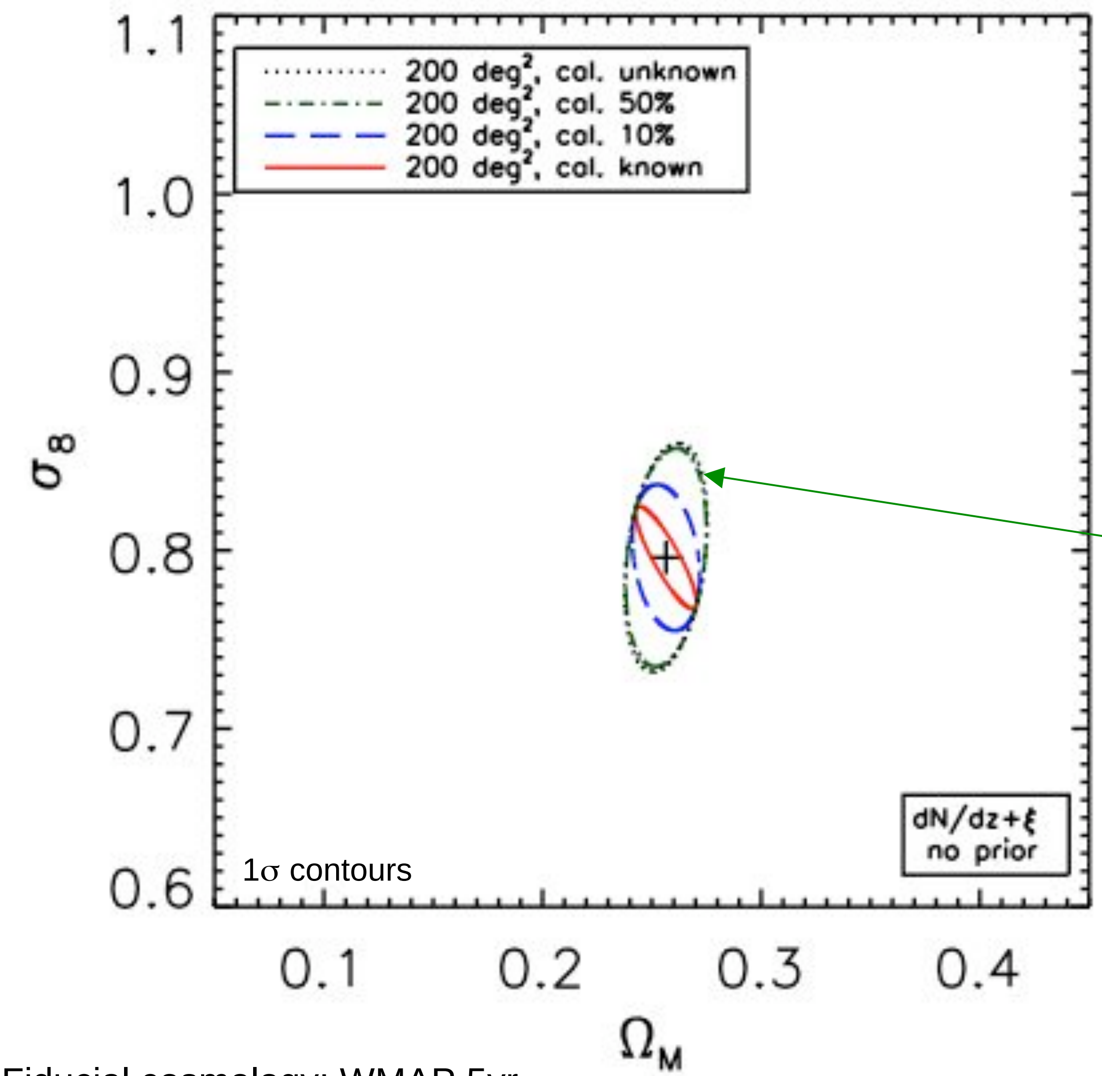


Fiducial cosmology: WMAP 5yr

Cluster scaling laws **unknown** in XMM-LSS [10 deg^2]

Weak contraints on σ_8

Increasing the survey area by a factor of 20...



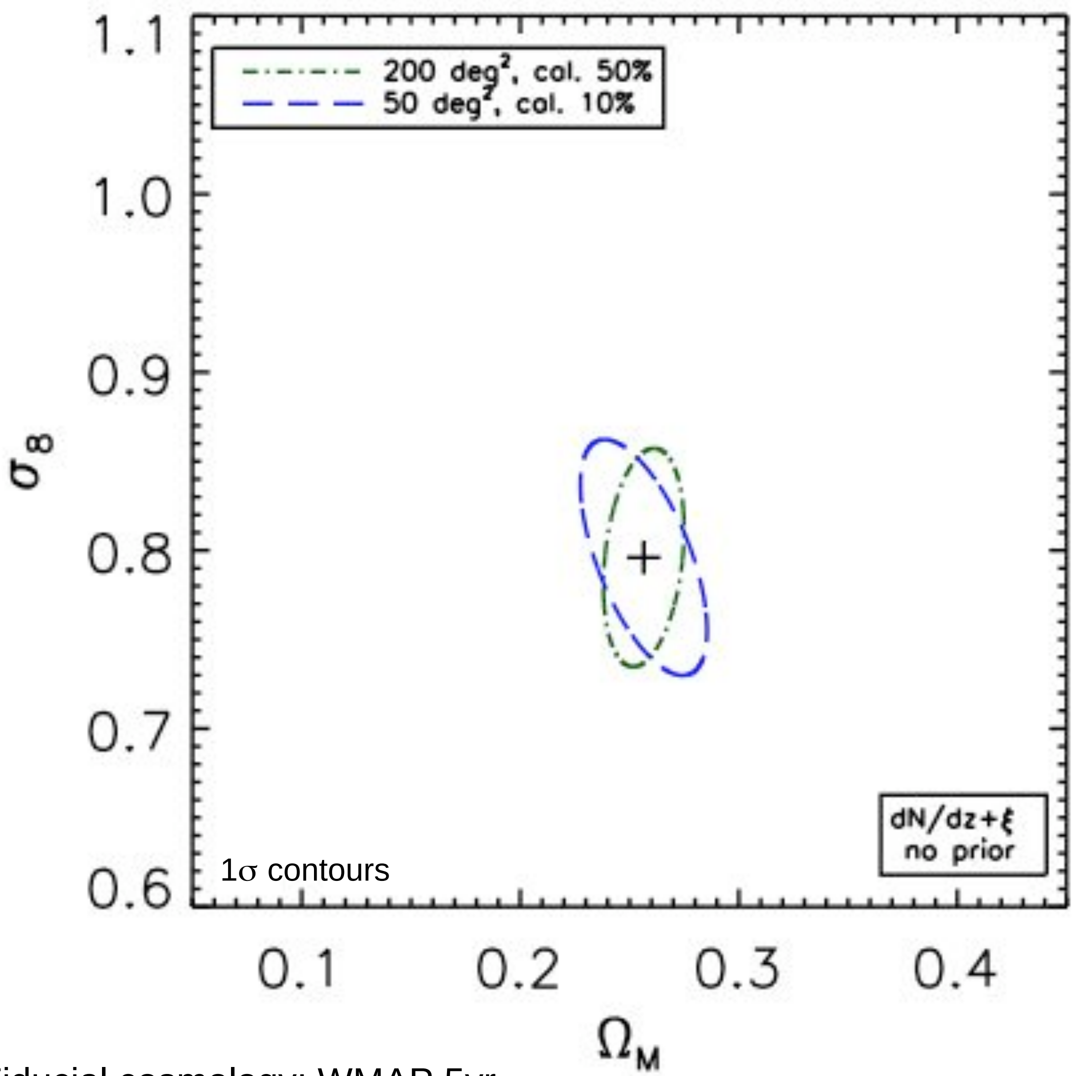
Now, some constraints on σ_8 (5%)

cal. unknown ~ cal. 50%

"self-calibration" effect thanks to survey area

Fiducial cosmology: WMAP 5yr

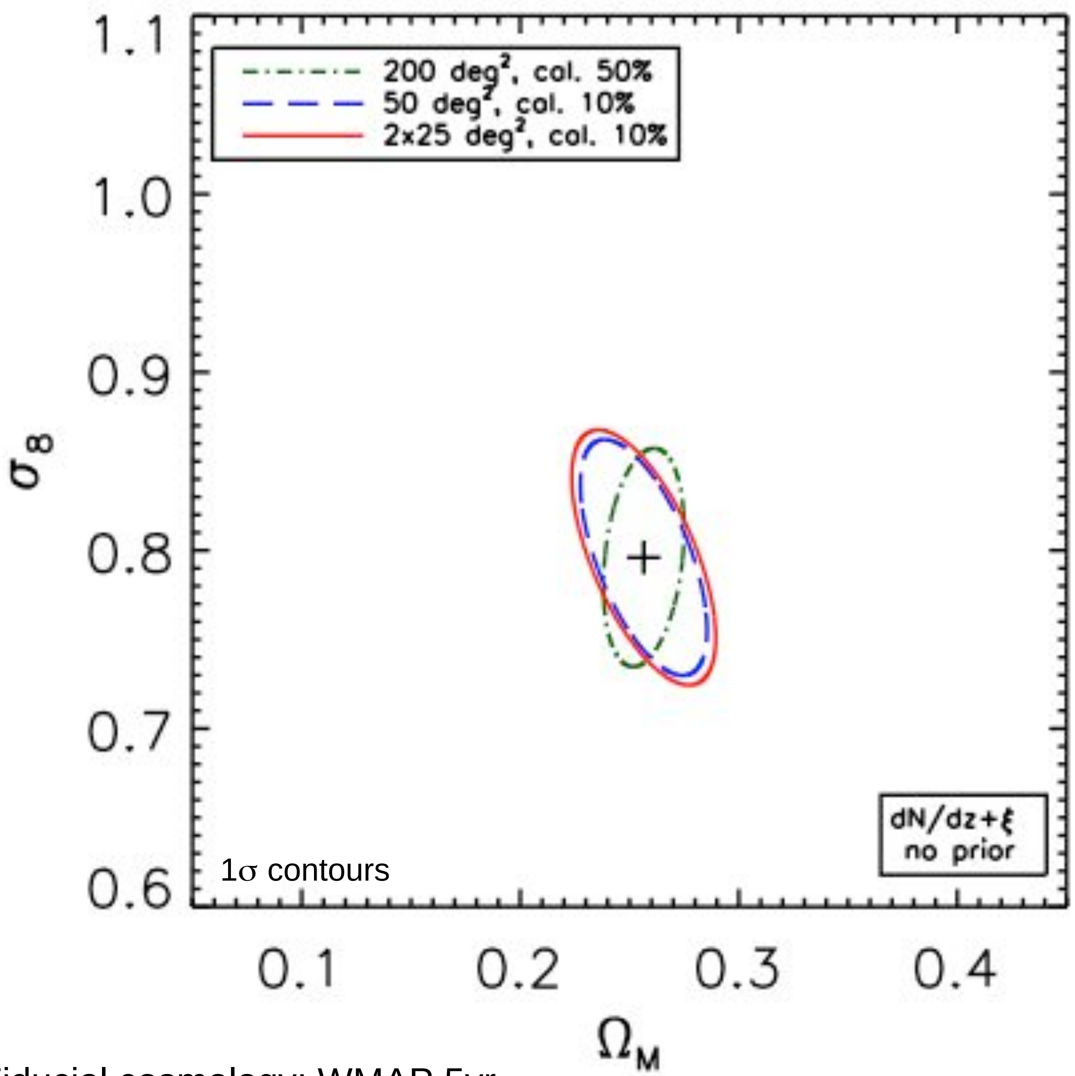
Survey area: 200 deg^2 or 50 deg^2 ?



Fiducial cosmology: WMAP 5yr

Very similar constraints on both σ_8 (~5%) and Ω_M (<10%)

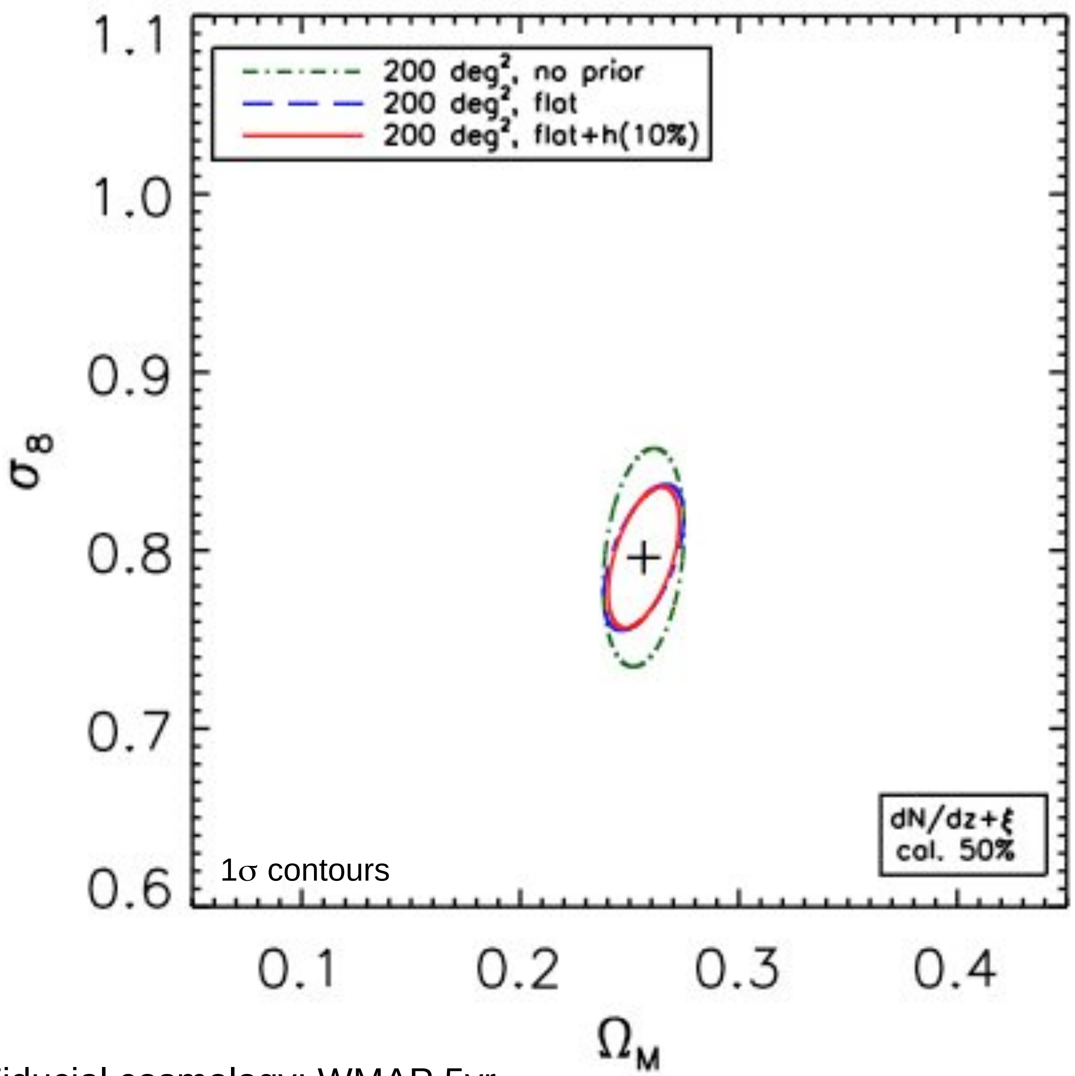
200 deg^2 or 50 deg^2 ? or 2 x 25 deg^2 ?



Fiducial cosmology: WMAP 5yr

The loss of accuracy from 50 deg^2 to 2x25 deg^2 is small

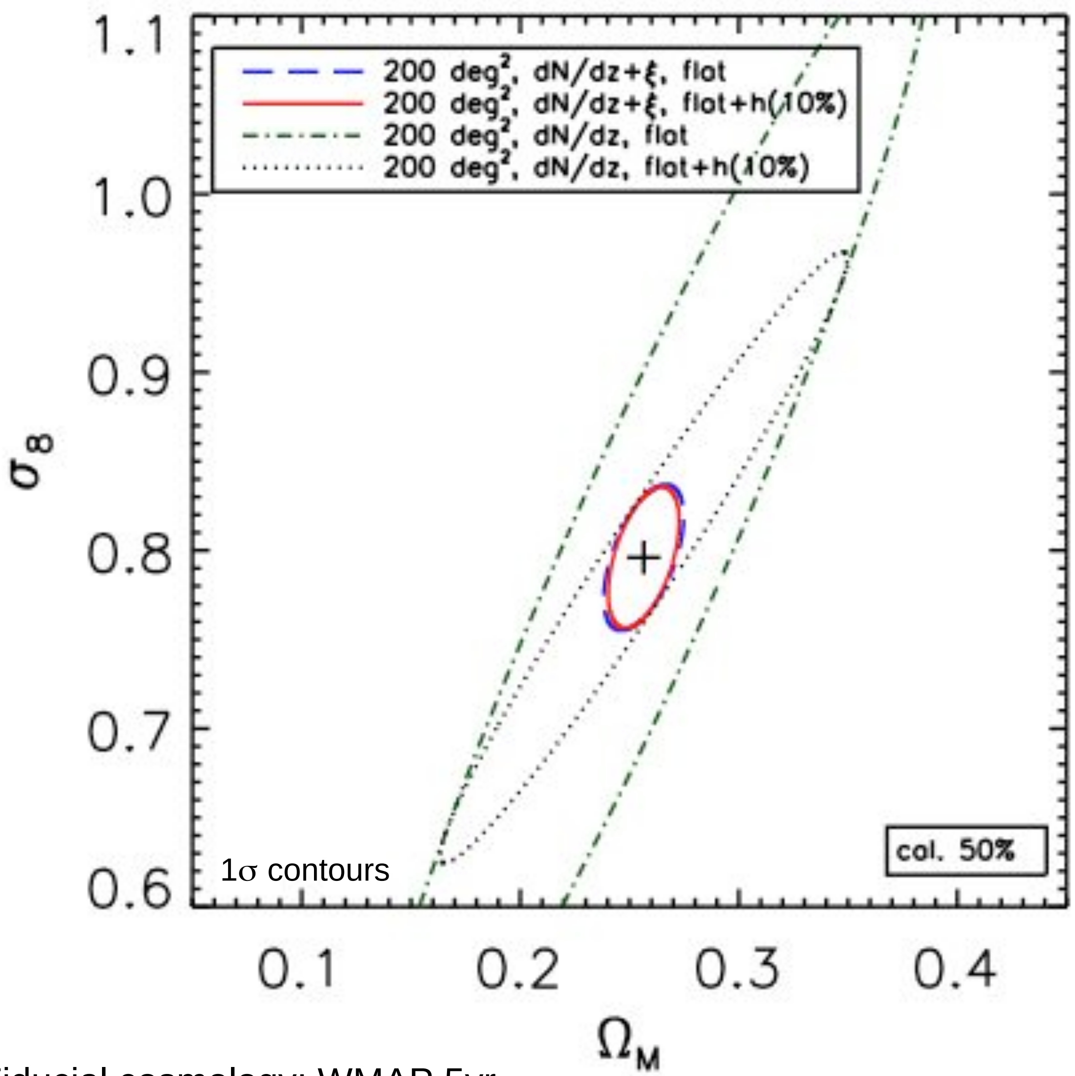
And if we include weak priors...



Fiducial cosmology: WMAP 5yr

Flat prior strengthens cosmological constraints

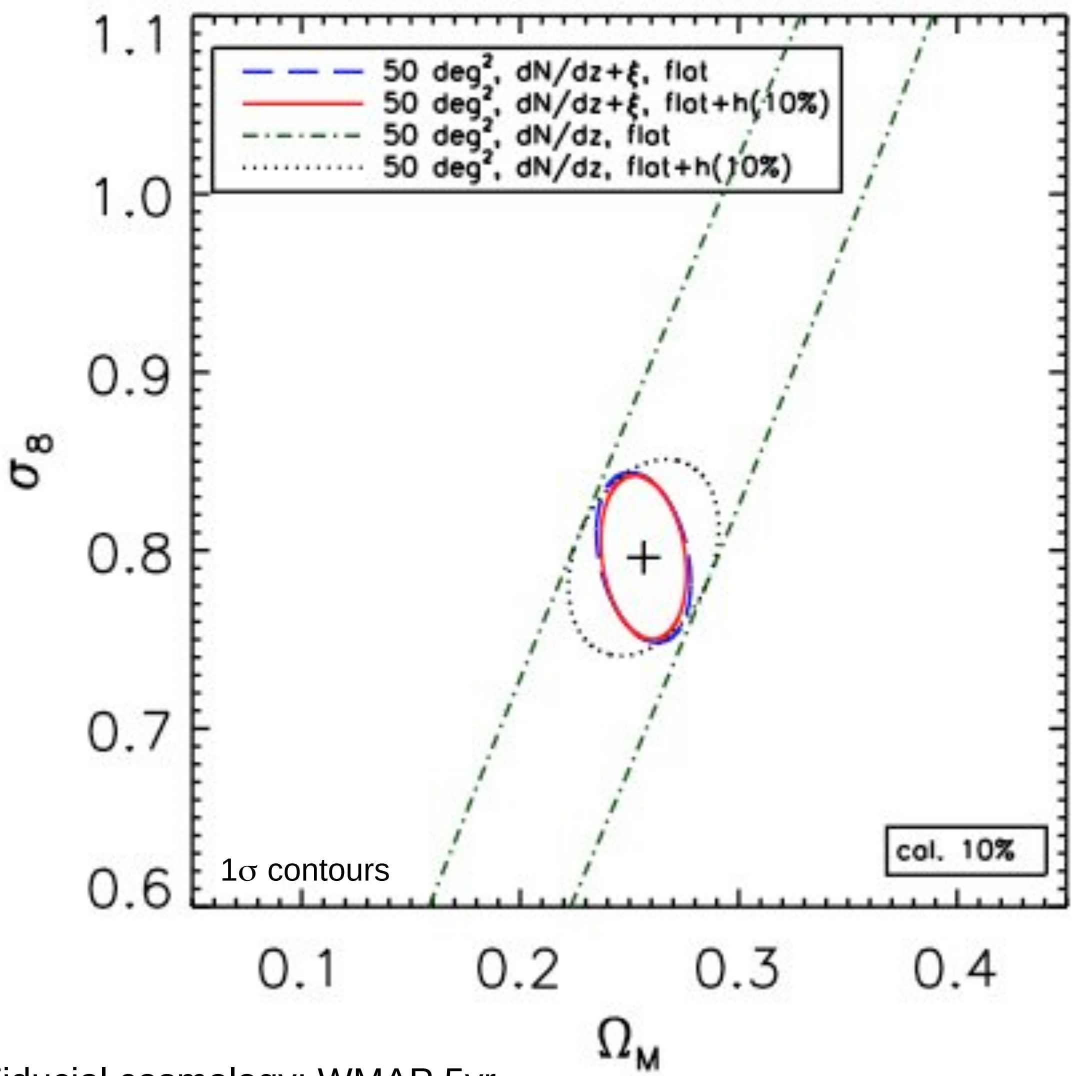
Knowing the correlation function or not



Correlation function is essential for a 200 deg^2 survey …

Fiducial cosmology: WMAP 5yr

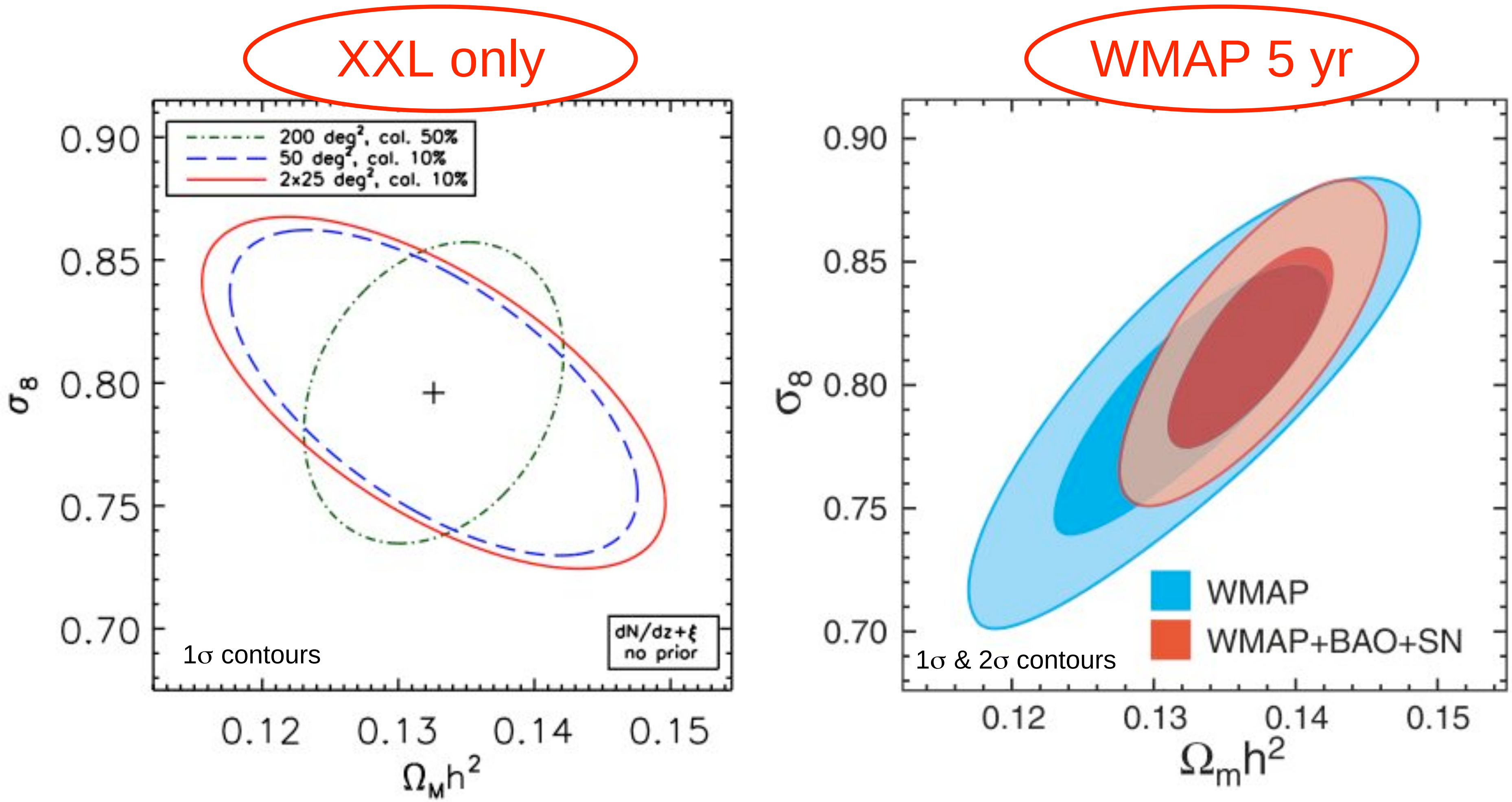
Knowing the correlation function or not



Fiducial cosmology: WMAP 5yr

… and also
for a 50 deg^2 survey
if no prior assumed

XXL survey only versus CMB constraints



Komatsu et al. 2008

Discussions and Conclusions

- (Self-)calibration of scaling laws and/or accurate mass determination is now the main issue to get precise cosmological parameter estimations with clusters only.

- 200 deg^2 (10ks expo., 50% cal. uncertainties) and 50 deg^2 (40ks expo., 10% cal. uncertainties) allow to reach ~the same precision on σ_8 and Ω_M.
Which design to choose ?

- The correlation function is required in order to break degeneracies between parameters for cluster only studies.

- (Self-)calibration of scaling laws and/or individual cluster mass measurements ? What approach must we choose ?

- How to reach the 10% (or less ?) mass accuracy on individual clusters ? Multiple wavelength observations needed (X, SZ, lensing) ?