Distinguishing between dark energy models: Big issues & SNAPpy details

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COSMOLOGICAL PROBES OF DARK ENERGY

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Outline

Big Issues

1. Not just another parameter
2. Challenges for theorists
3. What are the right parameters to measure?
4. Cosmic confusion

SNAPpy details

1. The value of large Sn data sets
2. The Ω_m issue
3. Varying the specifications

Weller & AA 2001 (x2), see also Huterer & Turner 2001

1) Not just another parameter

- The most exciting issue in contemporary physics
- Reasons come mainly from HEP
- Data mainly astronomical (but many do not realize how exciting the cosmic acceleration really is
- Need to proselytize!

2) Challenges for theorists

- Super deep problems !? (Tractable?)
- Also: The serious issues for quintessence

    1) Quantum corrections to $m_Q \approx 10^{-33} eV$

    2) 5th force bounds

Tractable!, could provide important constraints.

**Frieman *et al* (1995)

**AA, Burgess, Ravndal & Skordis (2001)

3) What are the right parameters to measure?

Goal: Have an impact.

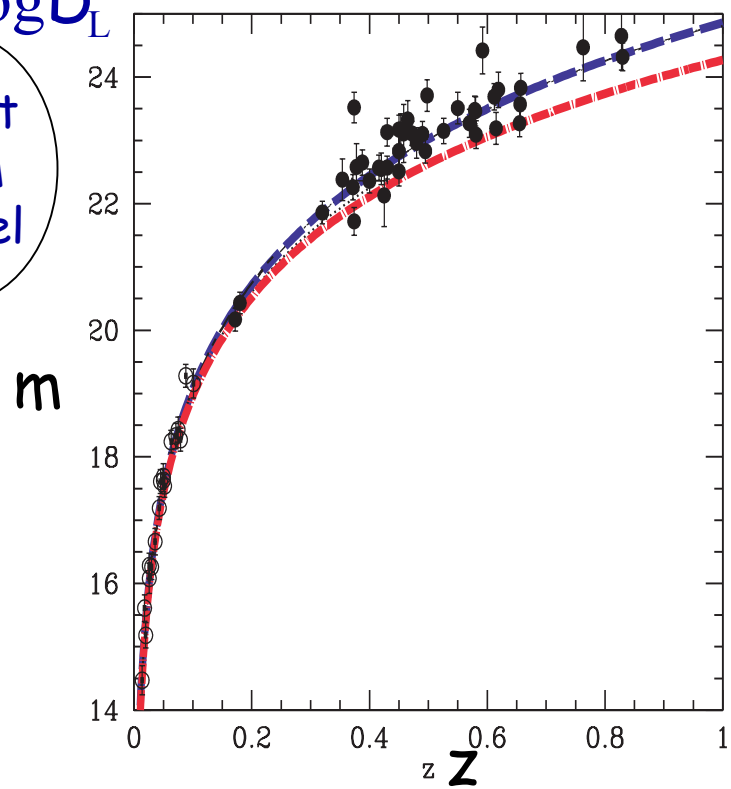
Illustration: SNe "table of {m, z}"

- m(z) comes from: $m(z) = M + 5\log D_L$

$$D_L = H_0 d_L = H_0 (1+z) \int_0^z \frac{c}{H(z')} dz'$$

Input from model

- If we only were comparing two models, we would not "parameterize". Just compare data with $m_1(z)$ and $m_2(z)$



Problem: Huge space of models

➔ Parameterize dark energy.

Best parameters are those that produce the best fit m(z)

From a comparison of parameterization schemes (Weller & AA 2001):

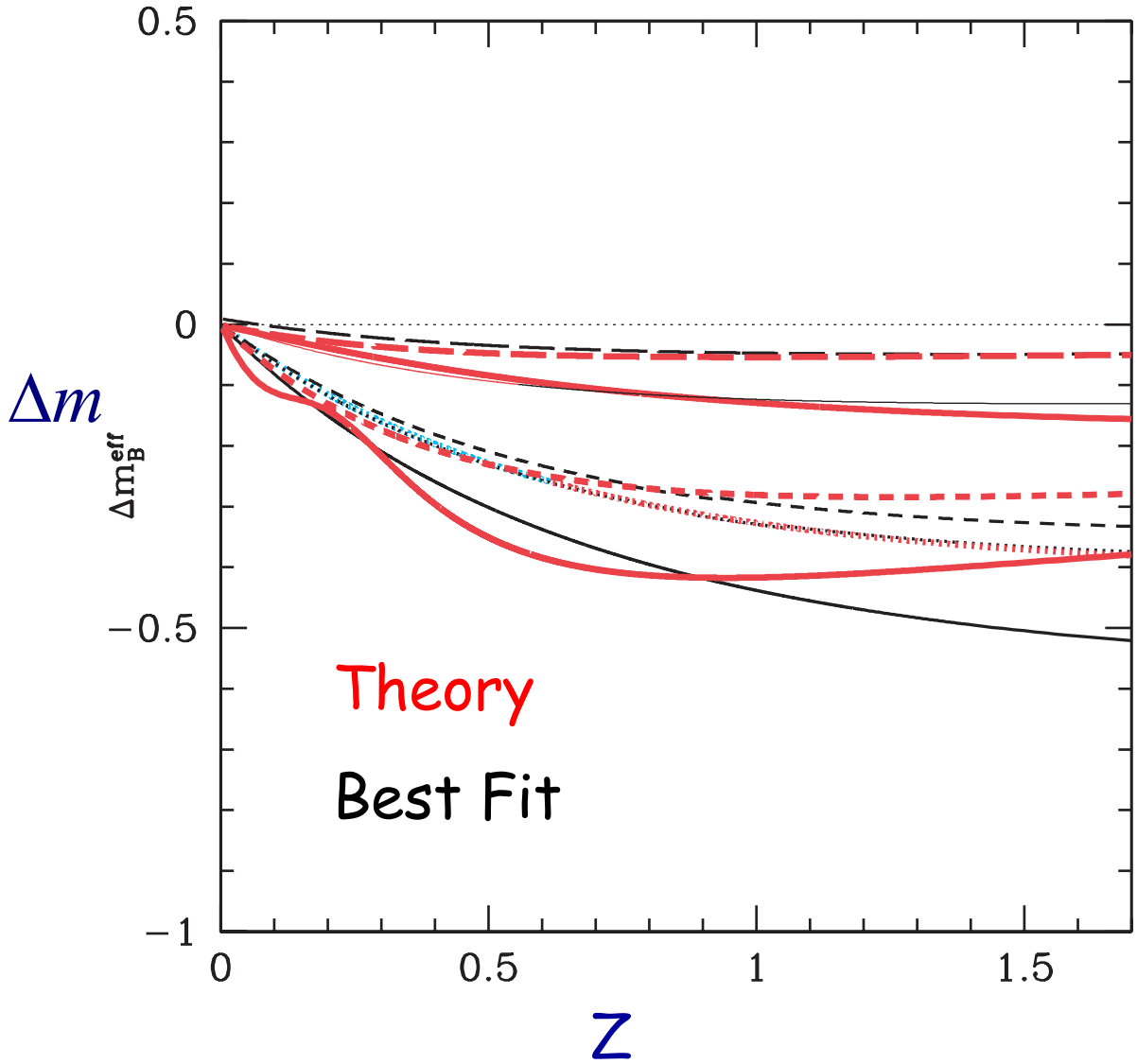
"equation of state" parameters give best fit to MOST existing models

$$p_Q = w\rho_Q \qquad w(z) = w_0 + w'z + \ldots$$

Equation of state fits of m(z)

$$p_Q = w\rho_Q$$

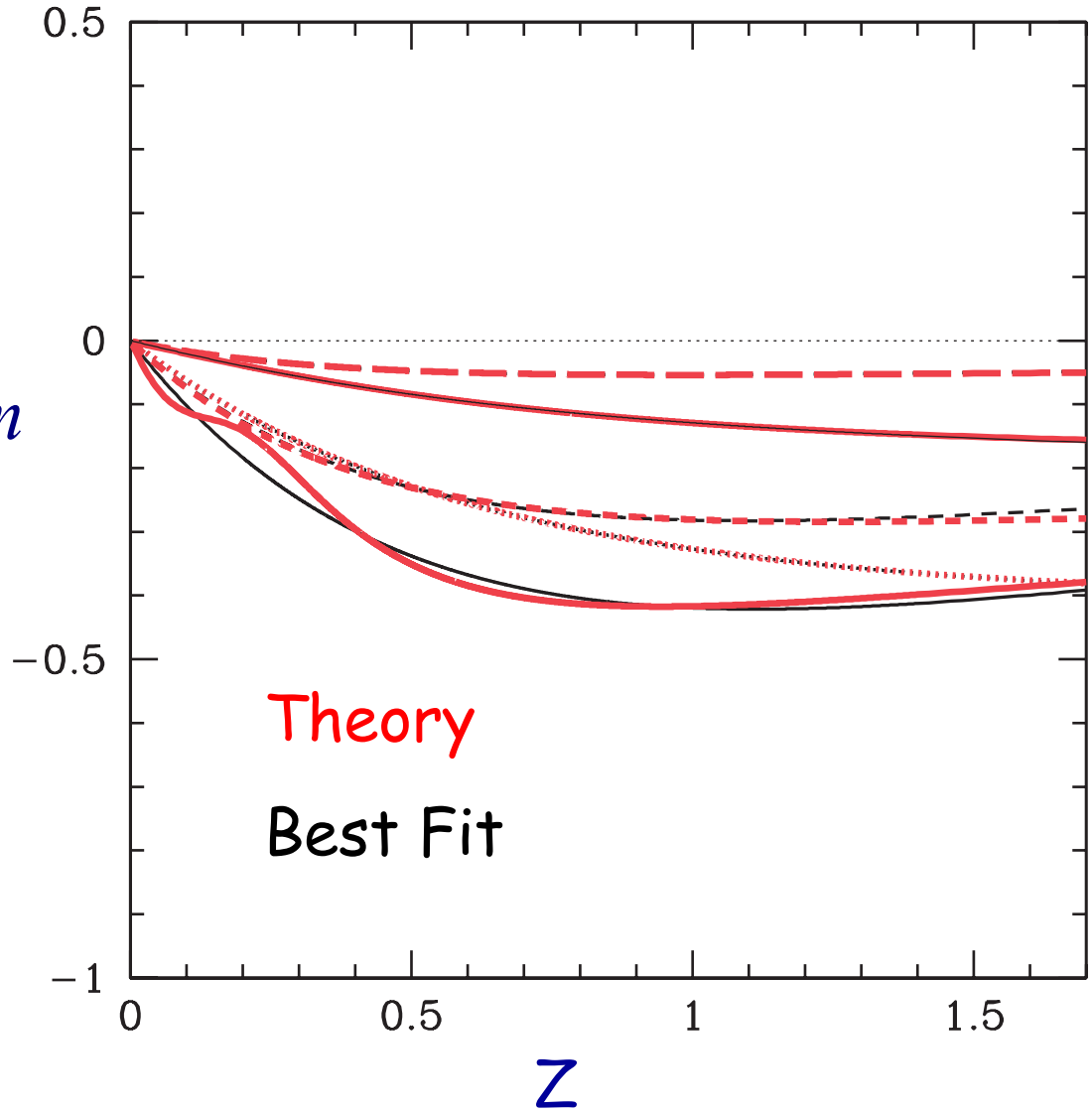
$$w(z) = w_0$$



Equation of state fits of m(z)

$$p_Q = w\rho_Q$$

$$w(z) = w_0 + w_1 z$$



Comparing different parameterizations

➔w(z) expansion (1,2 par.):

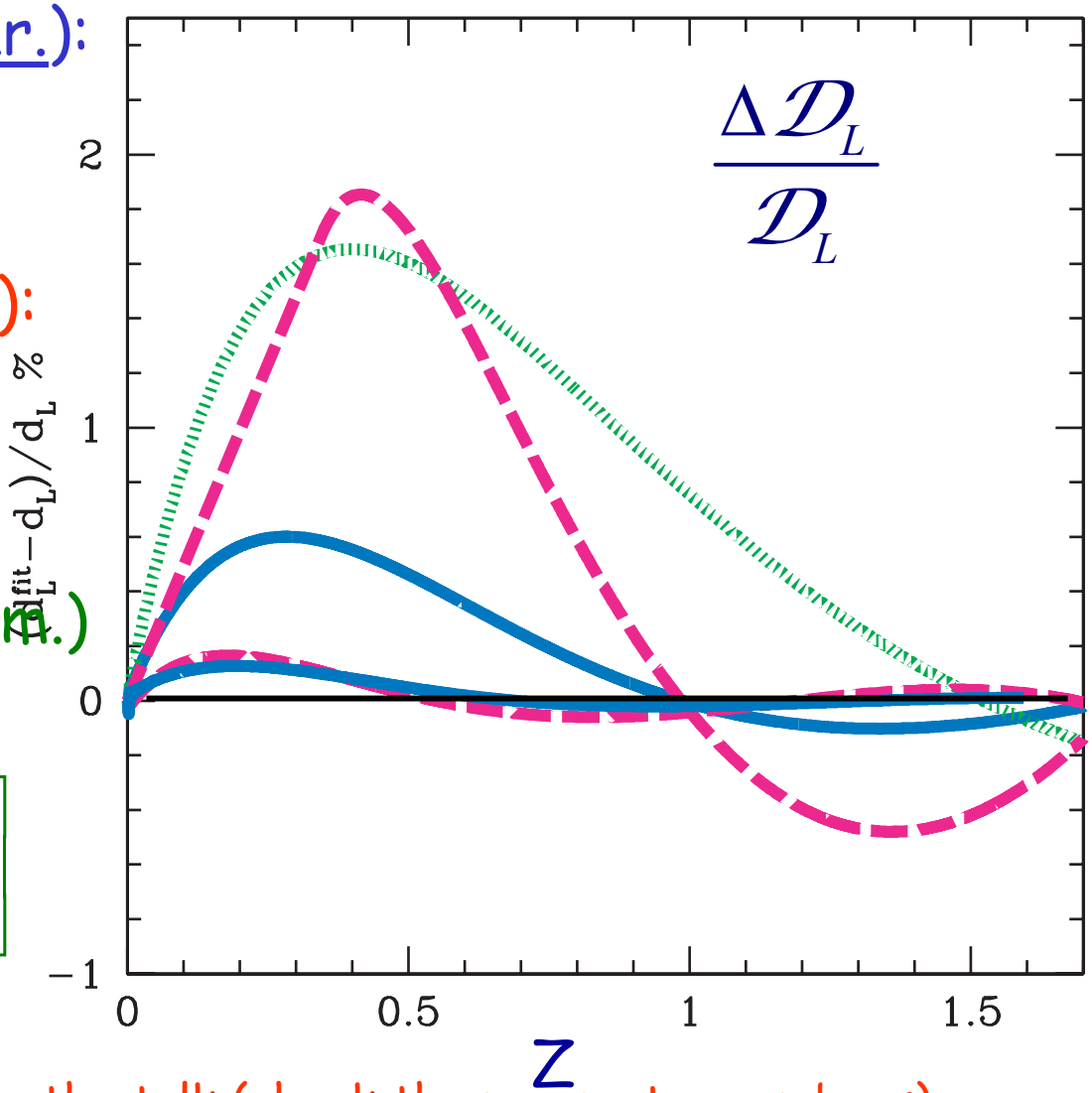
$$w(z) = \sum_{i=0}^{N} w_i (1+z)^i$$

➔Polynomial (2,3 param):

$$\mathcal{D}_L(z) = \sum_{i=0}^{N} c_i z^i$$

➔ "Rational" fit (3 param.)

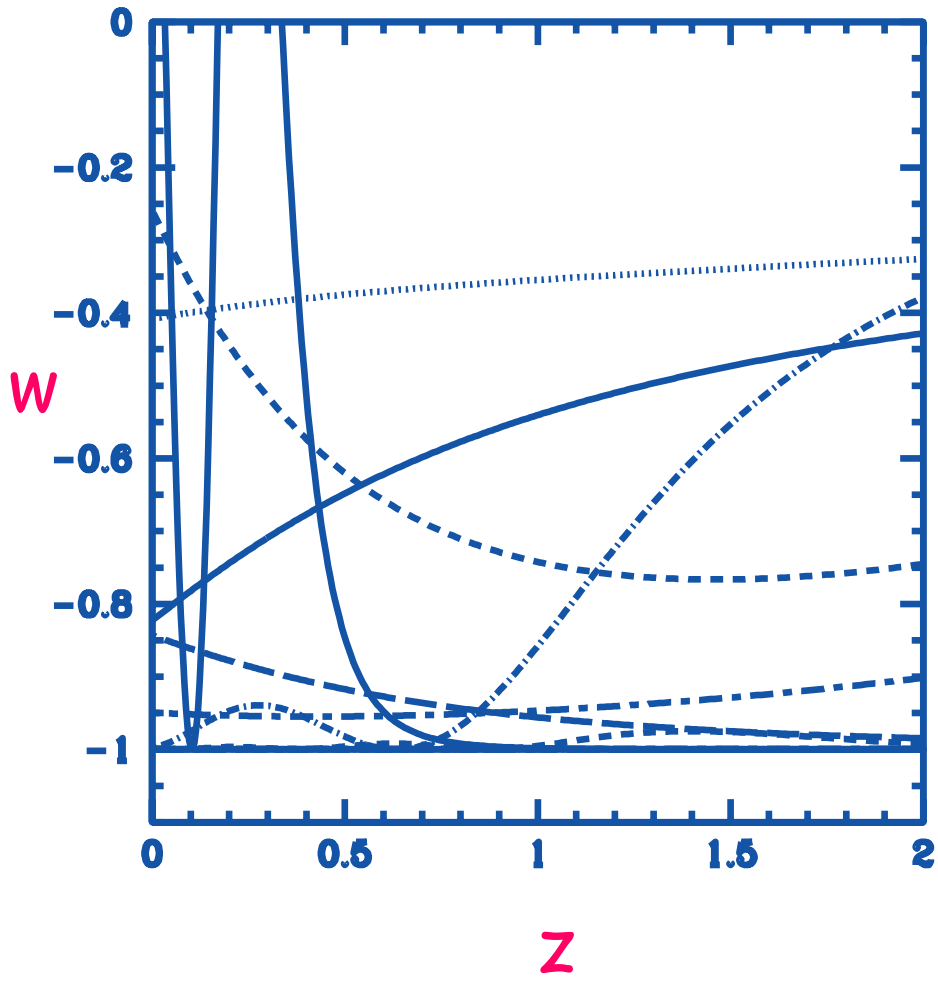
$$\mathcal{D}_L(z) = 2(1+z) \times \left[\frac{z - \alpha\sqrt{1+z} + \alpha}{\beta + \gamma\sqrt{1+z} + 2 - \alpha - \gamma} \right]$$



*This page was corrected after the talk (check the parameter numbers)

Fitting $D_L(z)$ is *different* from determining $w(z)$

All these models have $D_L(z)$ well fit by a *linear* or even *constant* $w(z)$

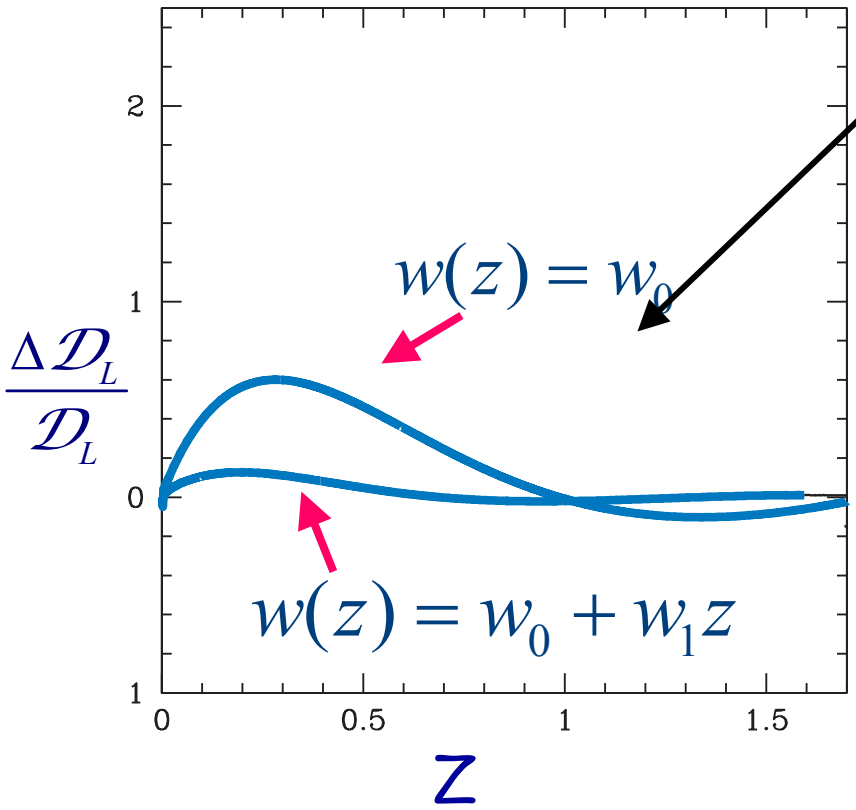


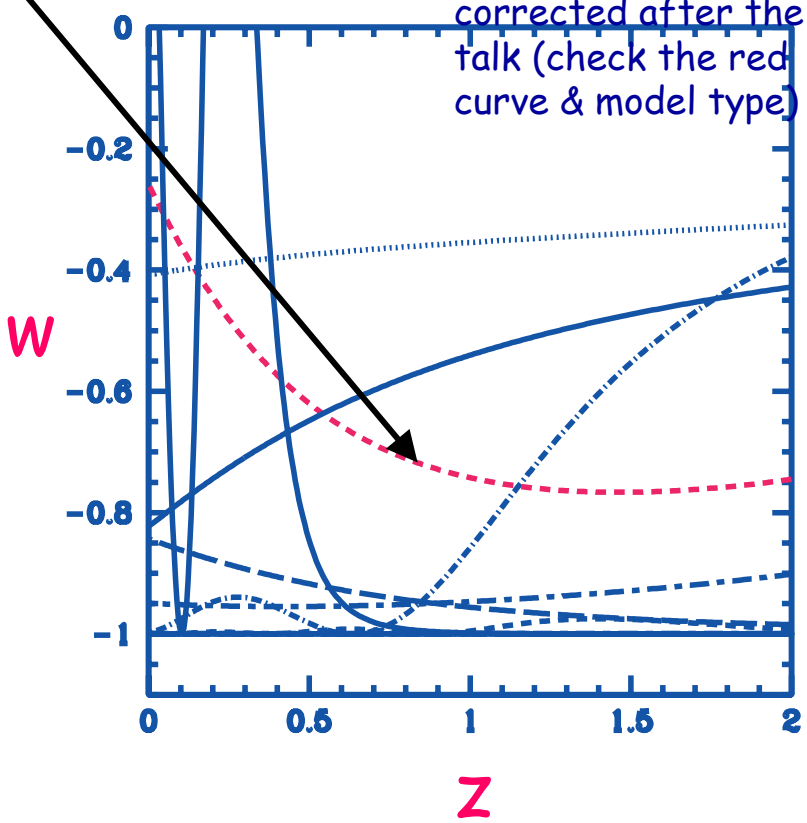
Fitting $D_L(z)$ is *different* from determining $w(z)$

Many different functions $w(z)$ can can have the same D_L.

Eaxample (PNGB potential):

**This page was corrected after the talk (check the red curve & model type)





$$\mathcal{D}_L = H_0 d_L = H_0 (1+z) \int_0^z \frac{c}{H(z')} dz'$$

Input from model

4) Cosmic confusion

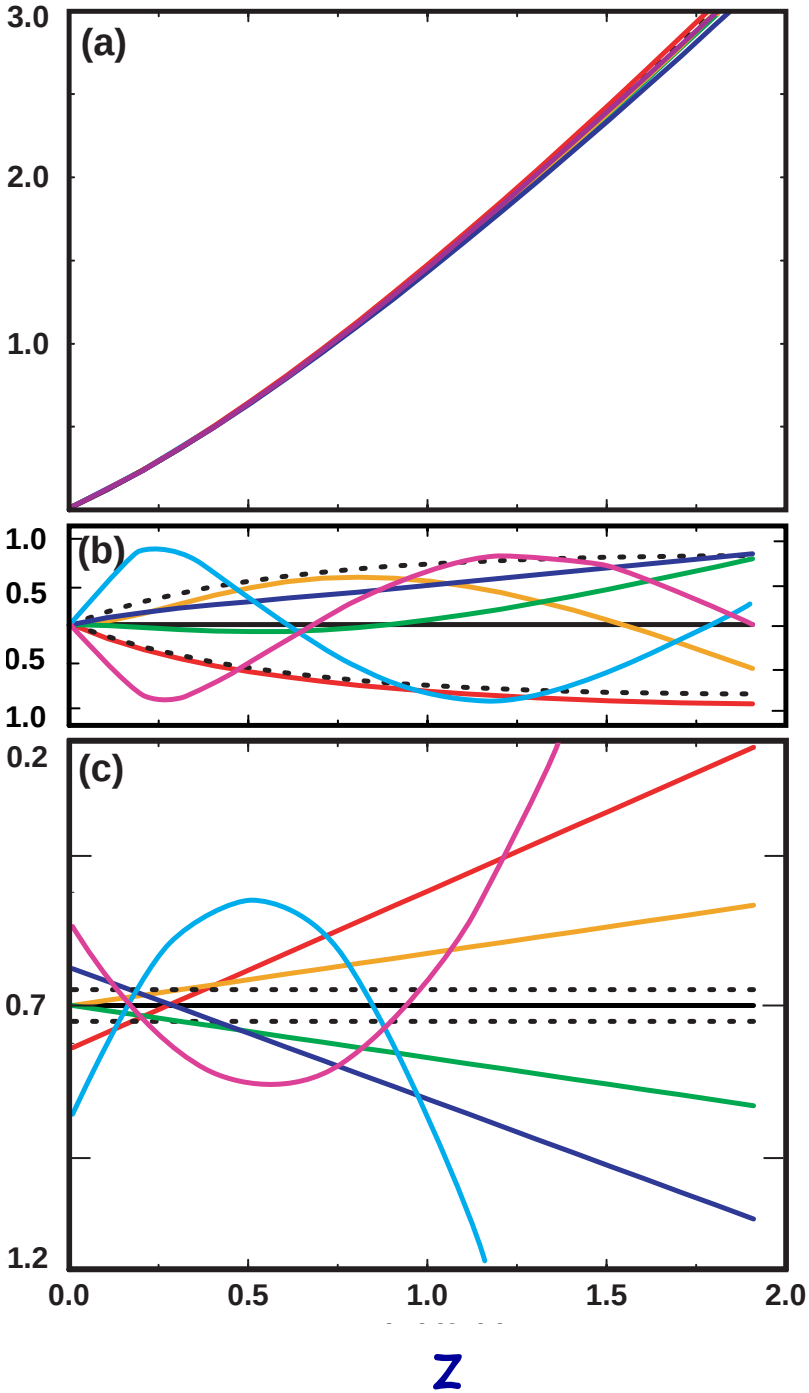
- *Every* data set can be fit by many different theories.
- With the introduction of suitable additional theoretical parameters, large uncertainties can be introduced in all parameters due to degeneracy.
- These facts do *not* prevent data from discriminating among theories.

Maor *et al* (2001) have constructed degenerate sets of models:

$\mathcal{D}_L$

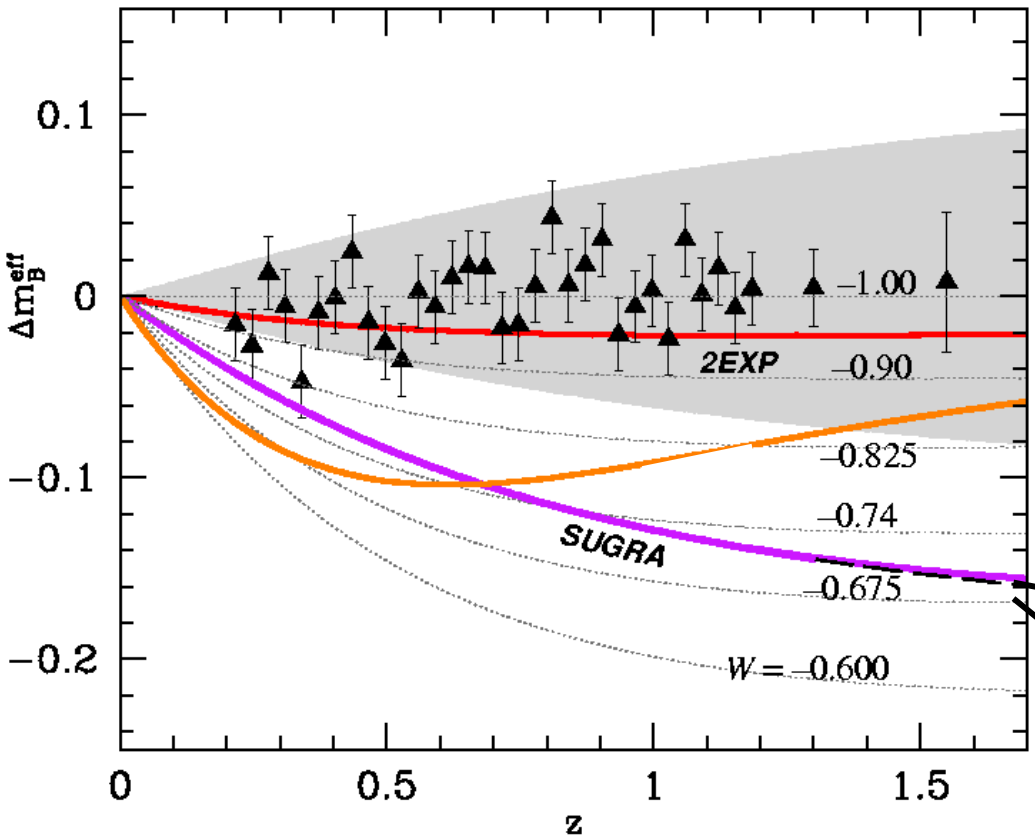
% deviation

$w(z)$



So what?

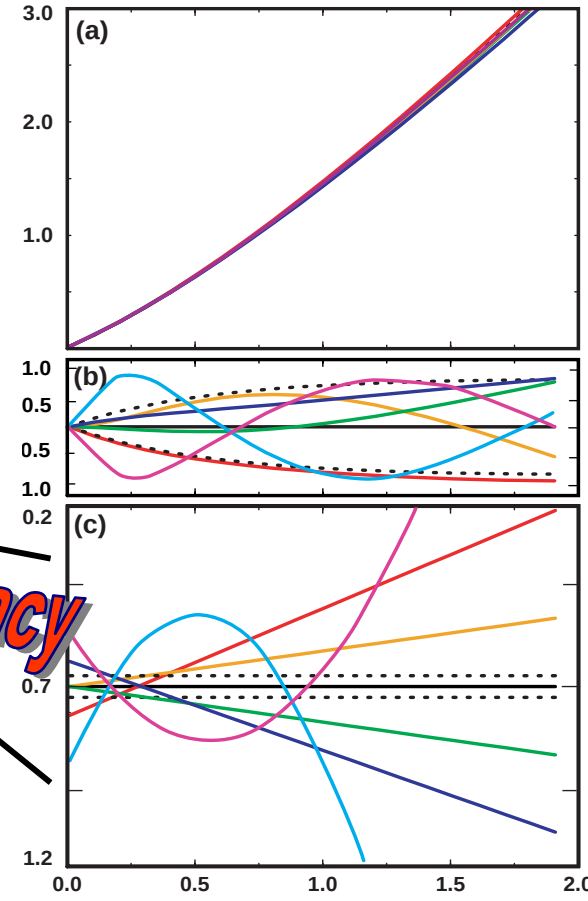
Data can still distinguish among models



% deviation

Degeneracy

$w(z)$



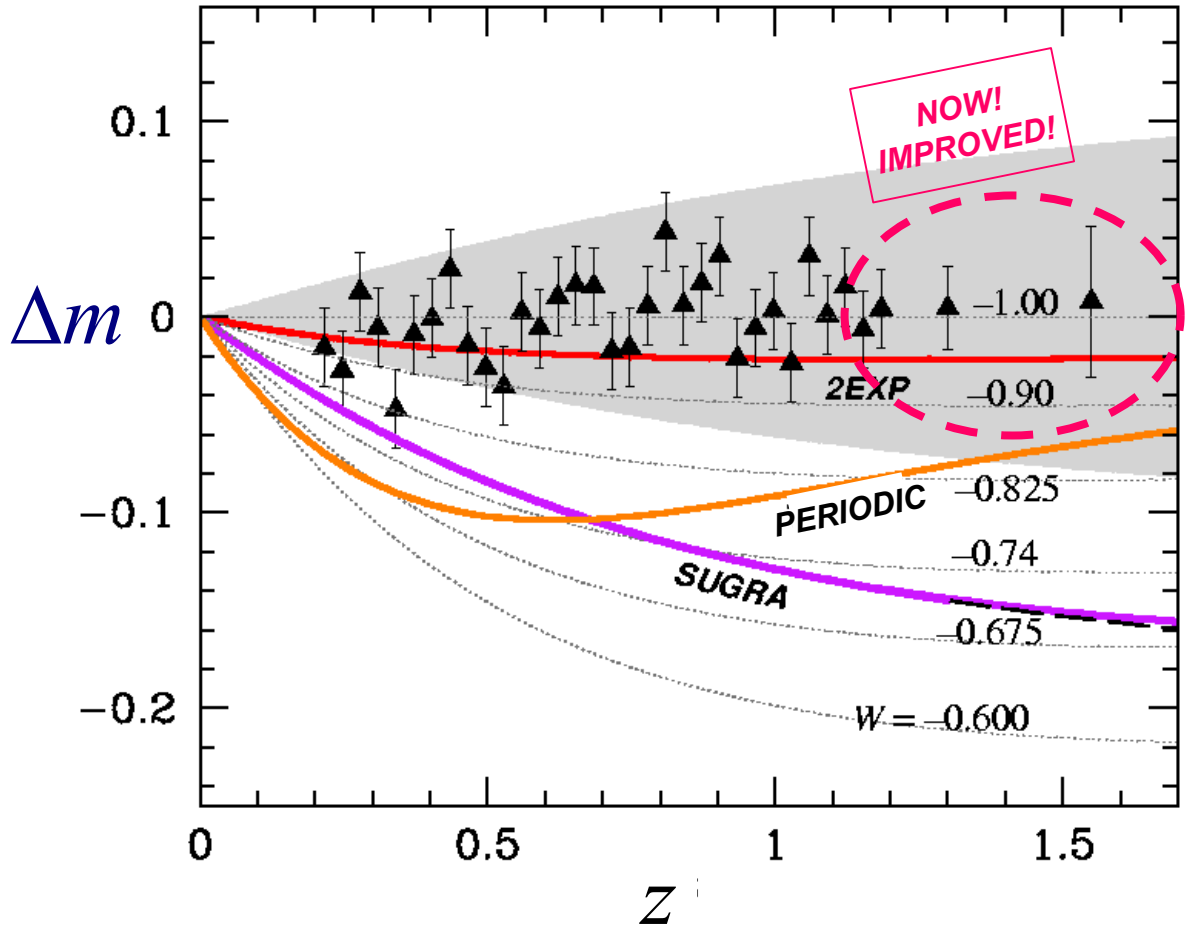
SNAPpy* details

1. The value of large Sn data sets
2. The Ω_m issue
3. Varying the specifications

*of or pertaining to large deep SN data sets

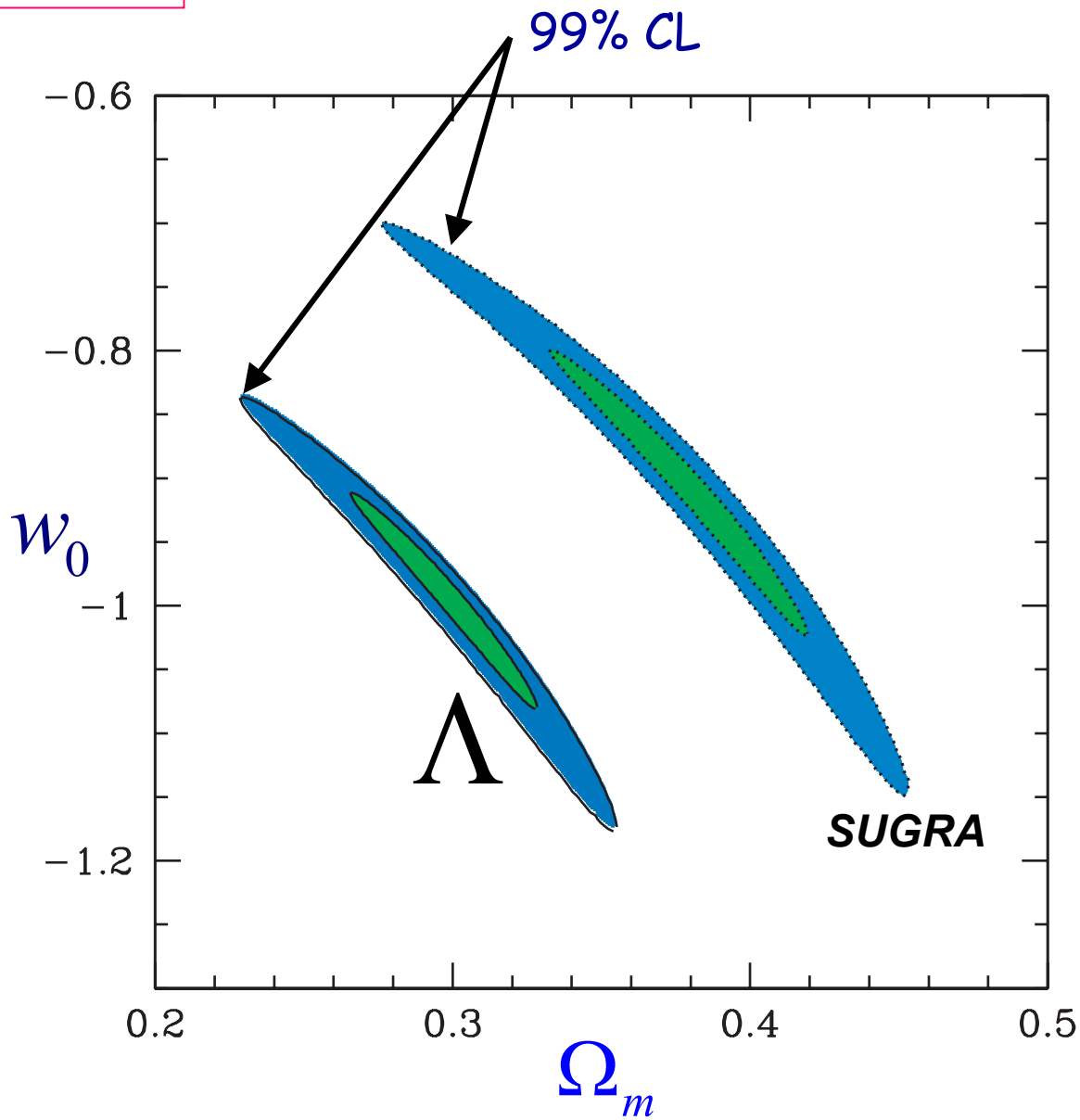
1) The value of large Sn data sets

Can discriminate among existing models



2) The Ω_m issue

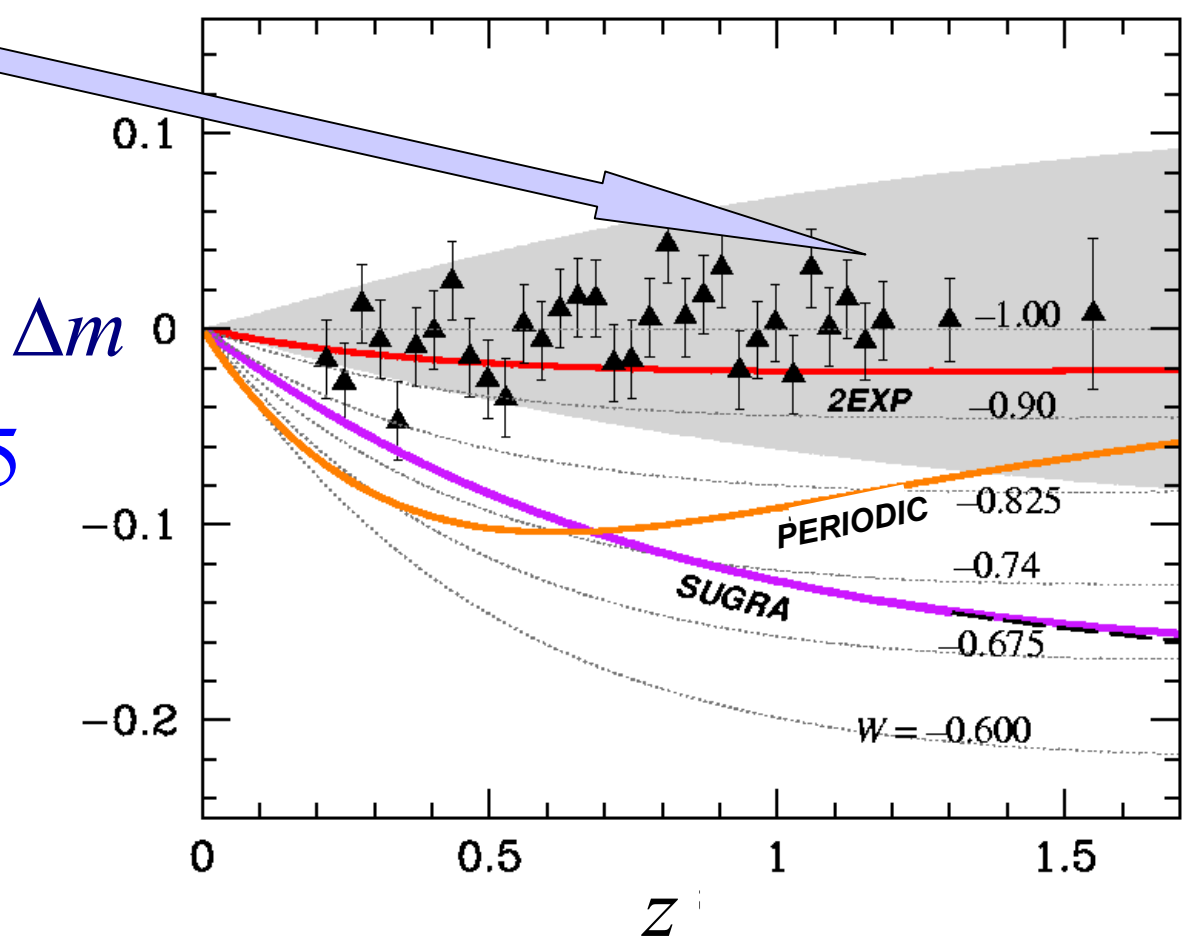
Typically plot:



The problem:

The shaded area shows identical dark energy model with

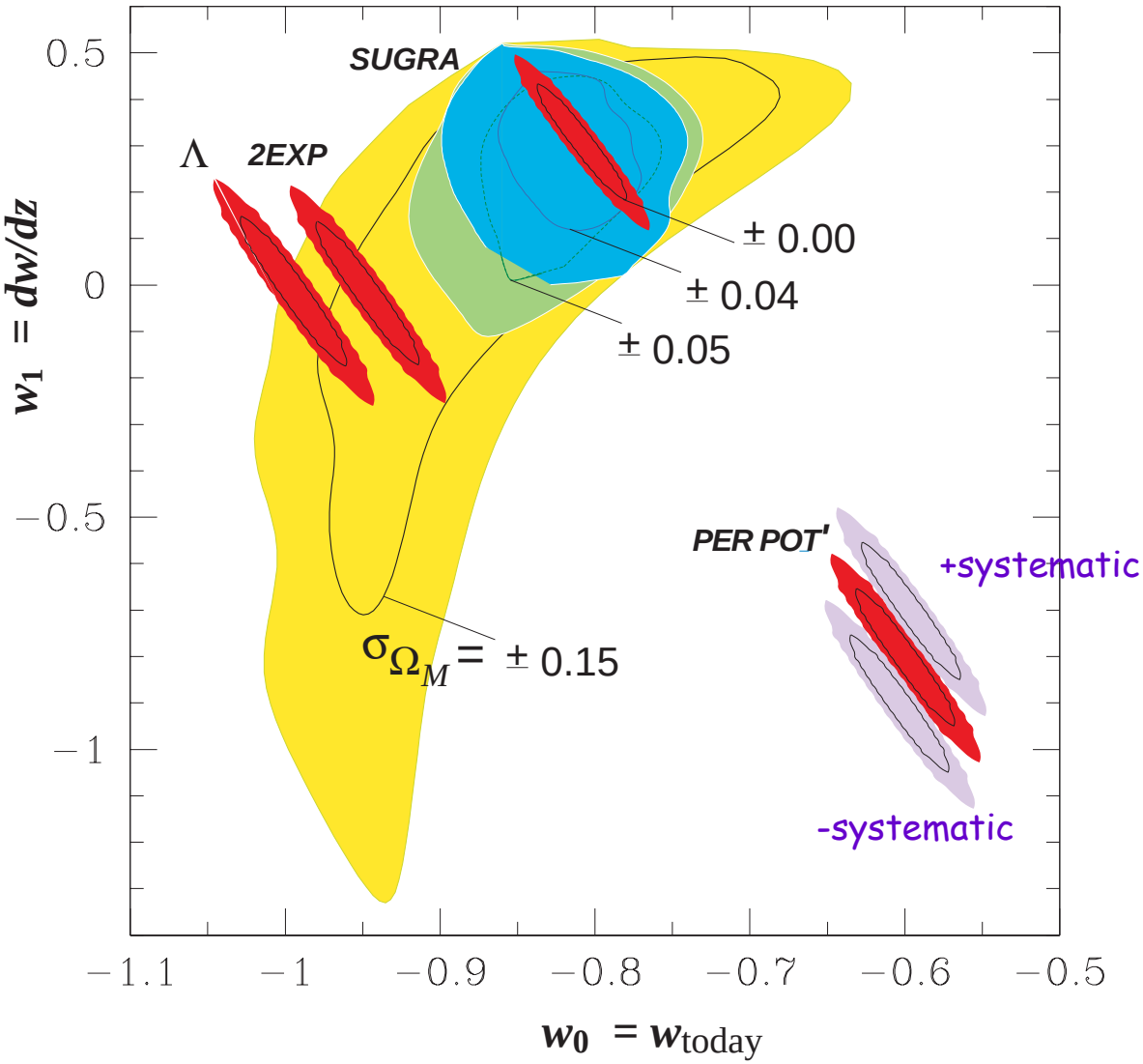
$$.0.25 < \Omega_m < 0.35$$



Independent priors on Ω_m increase resolving power

See also Maor et al and Astier

Weller & Albrecht (2000)



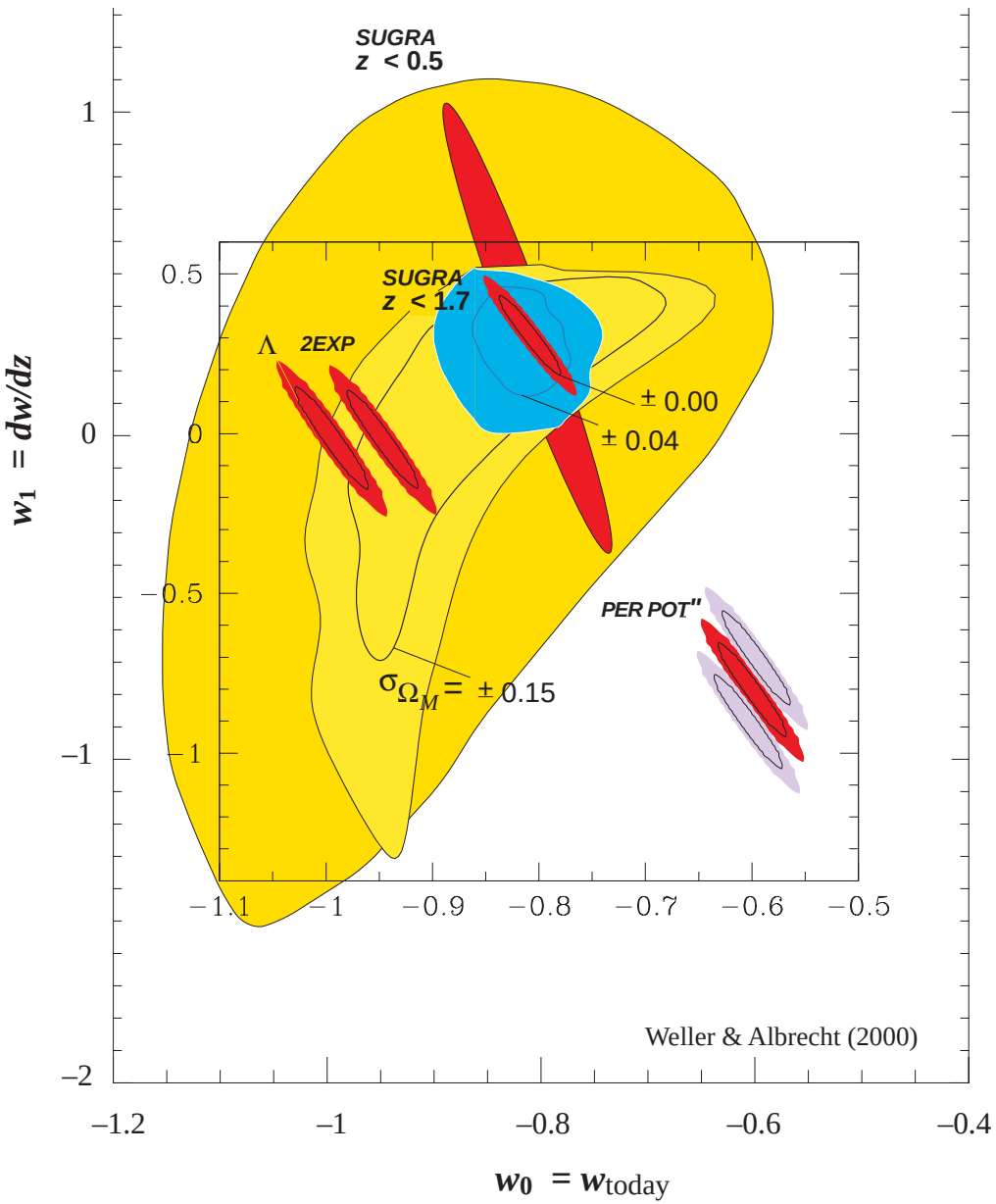
Color = 1-sigma

Black curve = marginalized

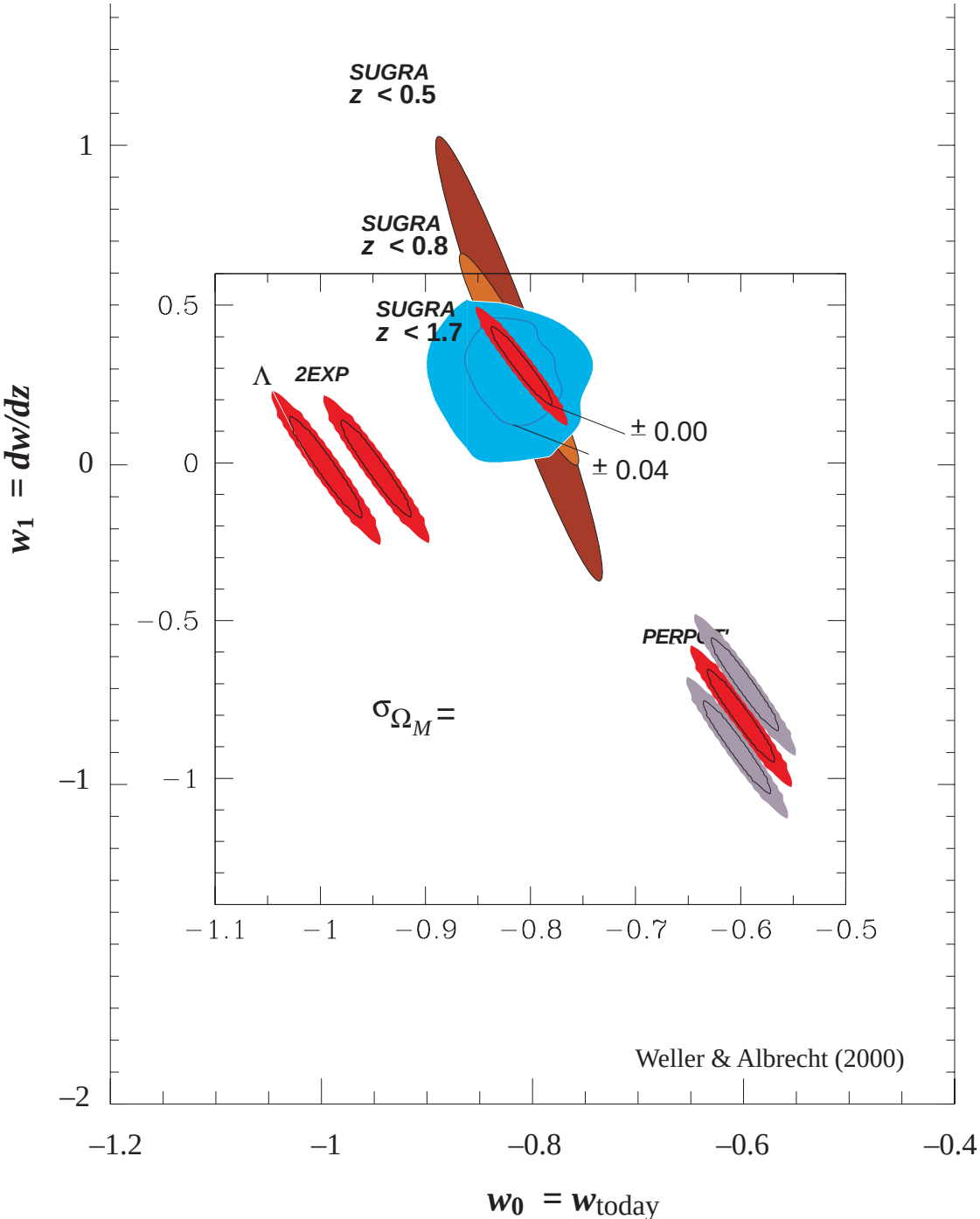
NB: Simulation used 2k Sne, vs 3k (@higher z) in current projections

3) Varying the specifications

New plots with 2k SNe spread uniformly up to z_{max}



New plots with 2k SNe spread uniformly up to z_{max}



Conclusions

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On each topic, real progress is being made… on this tremendously exciting subject.