The ESSENCE of Supernovae

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KITP

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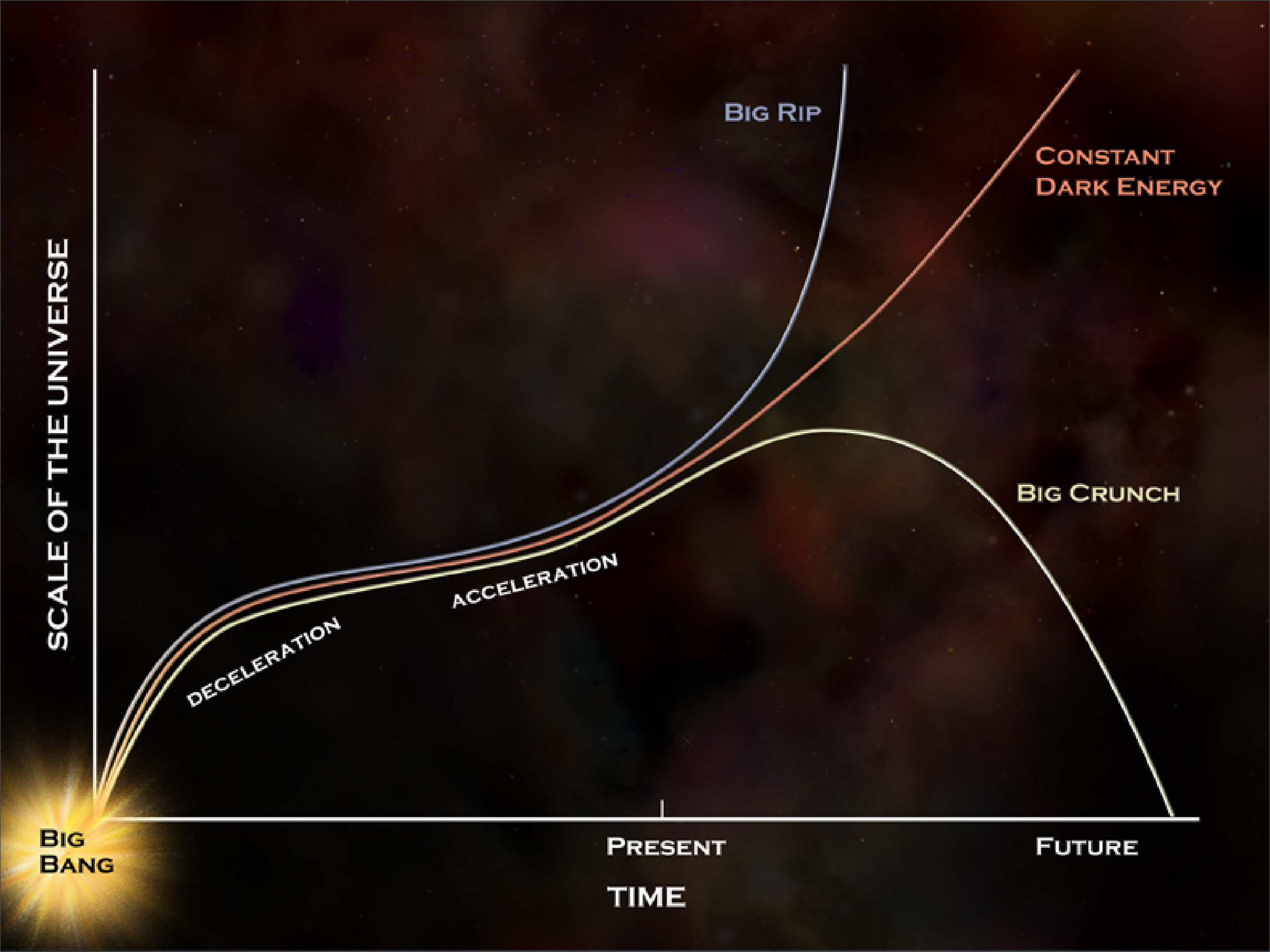

SCALE OF THE UNIVERSE
BIG RIP
CONSTANT DARK ENERGY
BIG CRUNCH
ACCELERATION
DECELERATION
BIG BANG
PRESENT
FUTURE
TIME

The Basic Question:

Is w = -1 ?

The Basic Question:

Is a cosmological constant model consistent with our observations of the Universe?

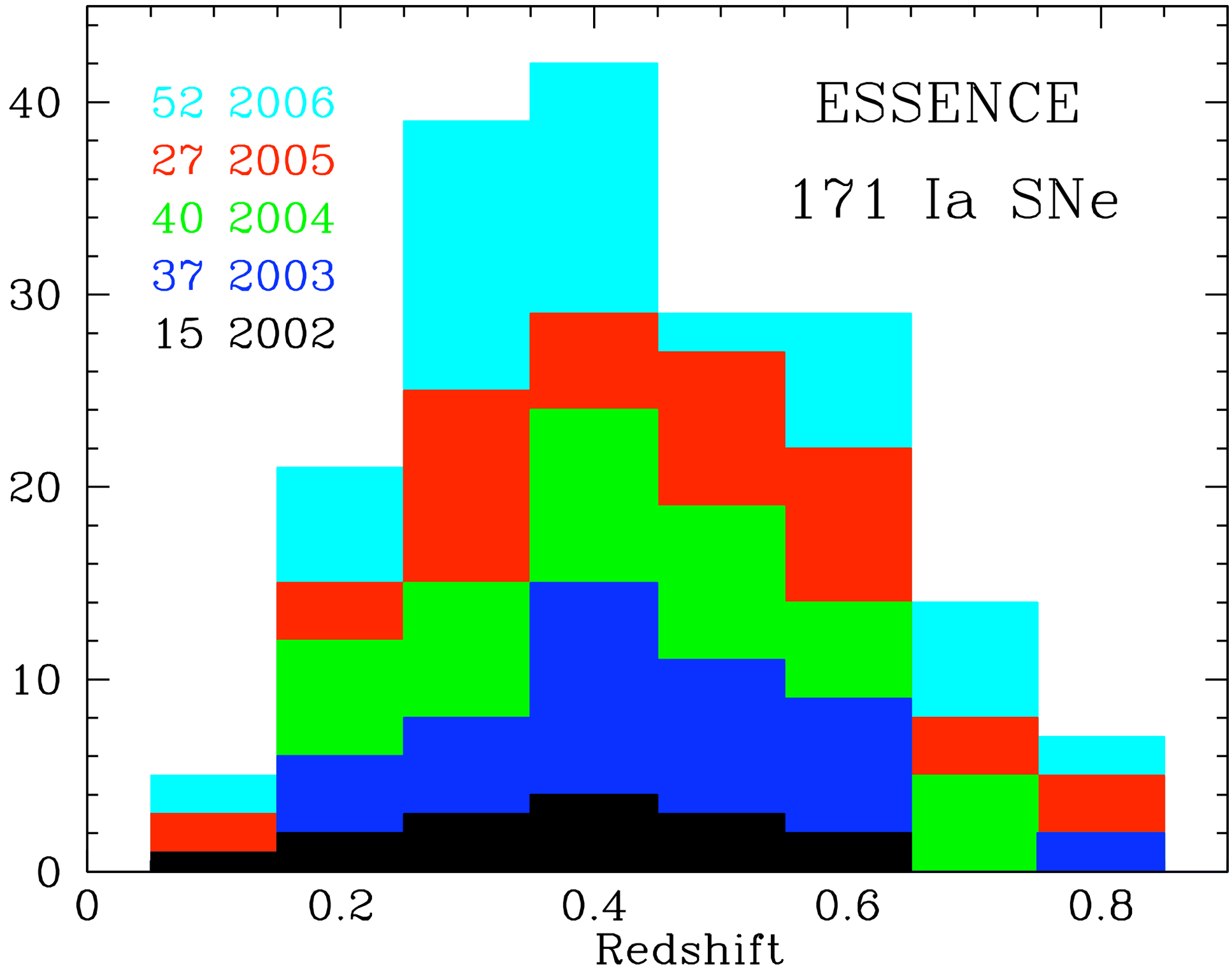
The ESSENCE Survey

- Determine w to 10% or w!=-1
- 6-year project on CTIO 4m telescope in Chile; 12 sq. deg.
- Wide-field images in 2 bands
- Same-night detection of SNe
- Spectroscopy
  - Keck, VLT, Gemini, Magellan
- Goal is 200 SNeIa, 0.2<z<0.8
- Data and SNeIa public real-time

ESSENCE Survey Team

Claudio Aguilera	CTIO/NOAO	Bruno Leibundgut	ESO
Andy Becker	Univ. of Washington	Weidong Li	UC Berkeley
Stéphane Blondin	Harvard/CfA	Thomas Matheson	NOAO
Peter Challis	Harvard/CfA	Gajus Miknaitis	Fermilab
Ryan Chornock	UC Berkeley	Jose Prieto	OSU
Alejandro Clocchiatti	Univ. Católica de Chile	Armin Rest	NOAO/CTIO
Ricardo Covarrubias	Univ. of Washington	Adam Riess	STScI/JHU
Tamara Davis	Dark Cosmology Center	Brian Schmidt	ANU/Stromo/SSO
Alex Filippenko	UC Berkeley	Chris Smith	CTIO/NOAO
Arti Garg	Harvard University	Jesper Sollerman	Stockholm Obs.
Peter Garnavich	Notre Dame University	Jason Spyromilio	ESO
Malcolm Hicken	Harvard University	Christopher Stubbs	Harvard University
Saurabh Jha	SLAC/KIPAC	Nicholas Suntzeff	Texas A&M
Robert Kirshner	Harvard/CfA	John Tonry	Univ. of Hawaii
Kevin Krisciunas	Texas A&M	Michael Wood-Vasey	Harvard/CfA

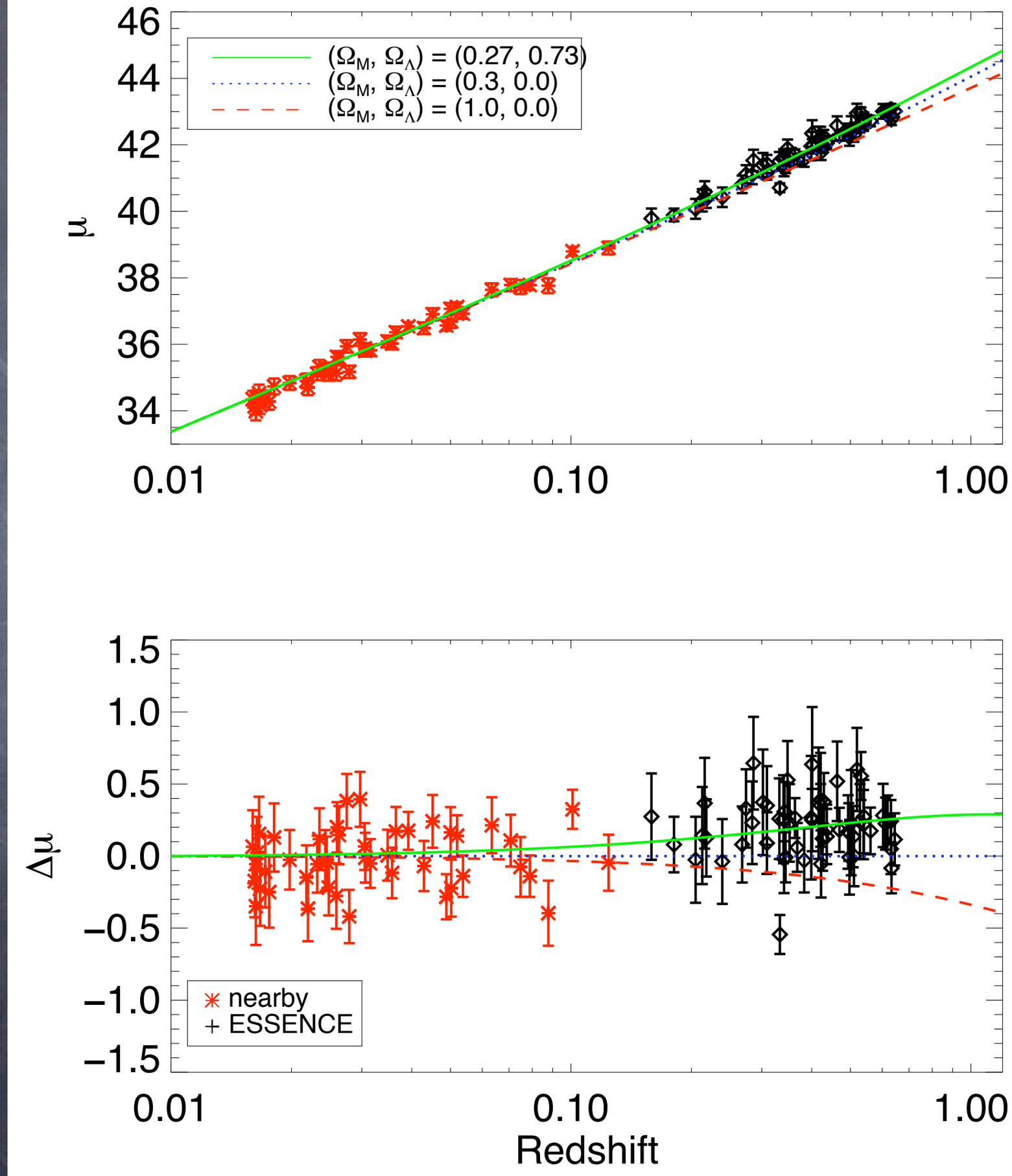
ESSENCE SNeIa To Date



ESSENCE Hubble Diagram

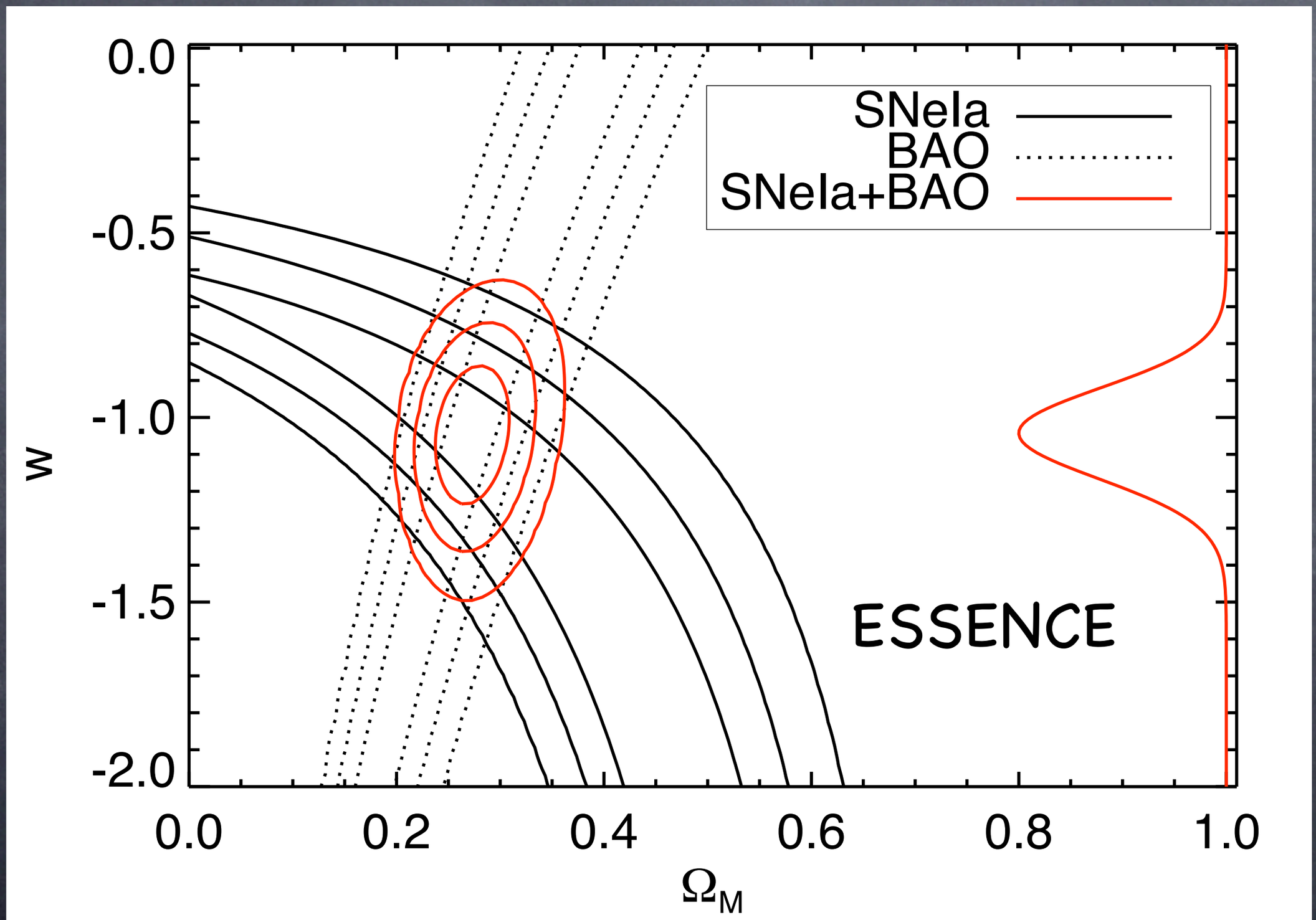
Wood-Vasey et al., astro-ph/0701041, submitted to ApJ

see also Miknaitis et al., astro-ph/0701043, submitted to ApJ

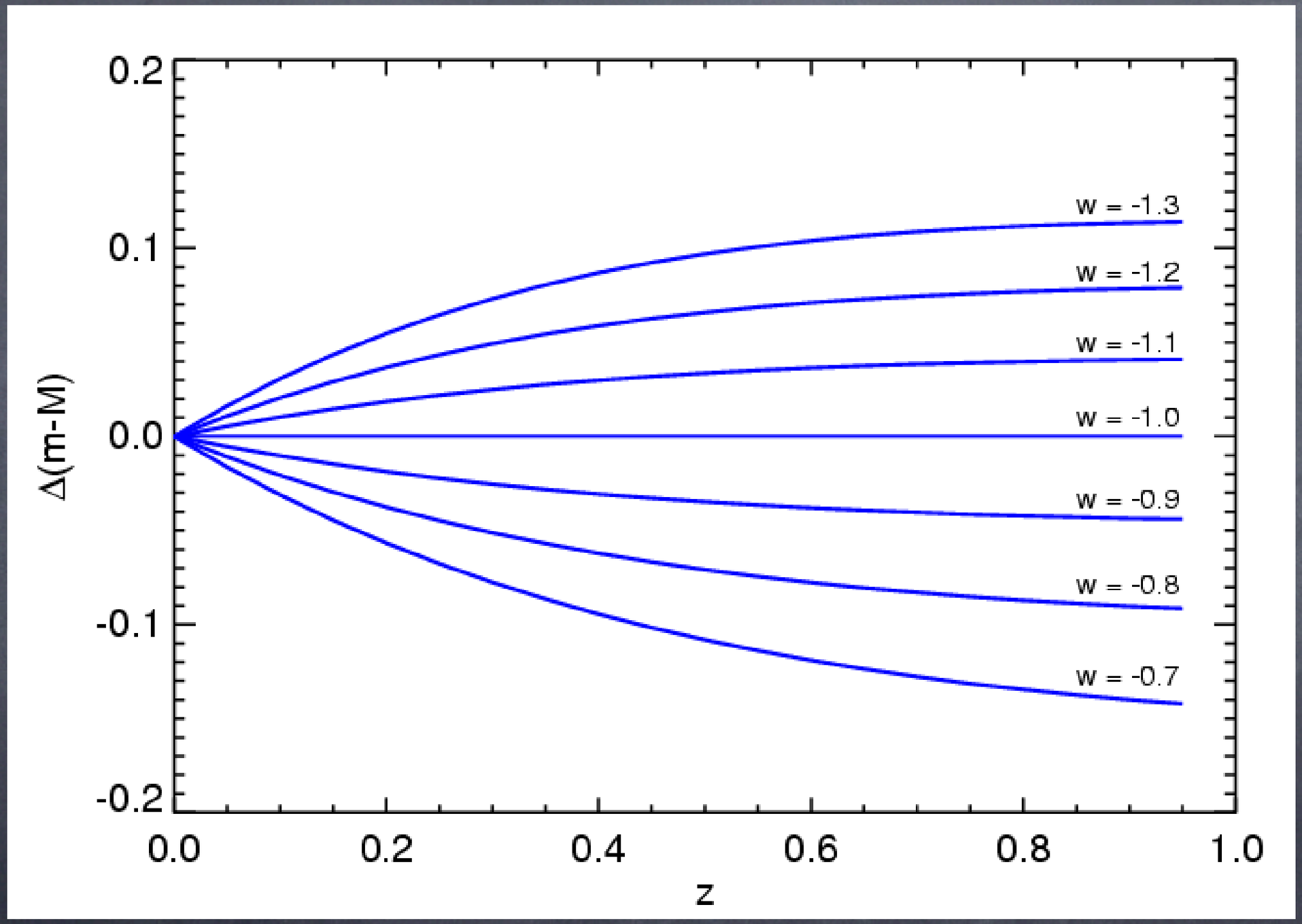


Flat, constant-w

w=-1.05 +- 0.11 +- 0.13



Equation-of-State Signal



Difference in apparent SN brightness vs. z

Ω_Λ=0.70, flat cosmology

Table 5. Potential Sources of Systematic Error on the Measurement of w

Source	dw/dx	Δx	Δ_w	Notes
Phot. errors from astrometric uncertainties of faint objects	1/mag	0.005 mag	0.005	
Bias in diff im photometry	0.5 / mag	0.002 mag	0.001	
CCD linearity	1 / mag	0.005 mag	0.005	
Photometric zeropoint diff in R,I	2 / mag	0.02 mag	0.04	
Zpt. offset between low and high z	1 / mag	0.02 mag	0.02	
K-corrections	0.5 / mag	0.01 mag	0.005	
Filter passband structure	0 / mag	0.001 mag	0	
Galactic extinction	1 / mag	0.01 mag	0.01	
Host galaxy R_V	0.02 / R_V	0.5	0.01	"glosz"
Host galaxy extinction treatment	0.08	prior choice	0.08	different priors
Intrinsic color of SNe Ia	3 / mag	0.02 mag	0.06	interacts strongly with prior
Malmquist bias/selection effects	0.7 / mag	0.03 mag	0.02	"glosz"
SN Ia evolution	1 / mag	0.02 mag	0.02	
Hubble bubble	$3/\delta H_{\rm effective}$	0.02	0.06	
Gravitational lensing	$1/\sqrt{N}$ / mag	0.01 mag	< 0.001	Holz & Linder (2005)
Grey dust	1 / mag	0.01 mag	0.01	
Subtotal w/o extinction+color	···	···	0.082	
Total	···	···	0.13	
Joint ESSENCE+SNLS comparison	···	···	0.02	photometric system
Joint ESSENCE + SNLS Total	···	···	0.13	

(Wood-Vasey et al., astro-ph/070141)

Some Potential Systematics

- Understanding of host galaxy dust
- Hubble bubble trouble
- Gravitational lensing
- Evolutionary effects in SNe
- Biases in low redshift sample
- Search efficiency/selection

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Are Nearby SNeIa the same as Distant SNeIa?

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Yes

Are Nearby SNeIa the same as Distant SNeIa?

Yes

Pretty much . . .

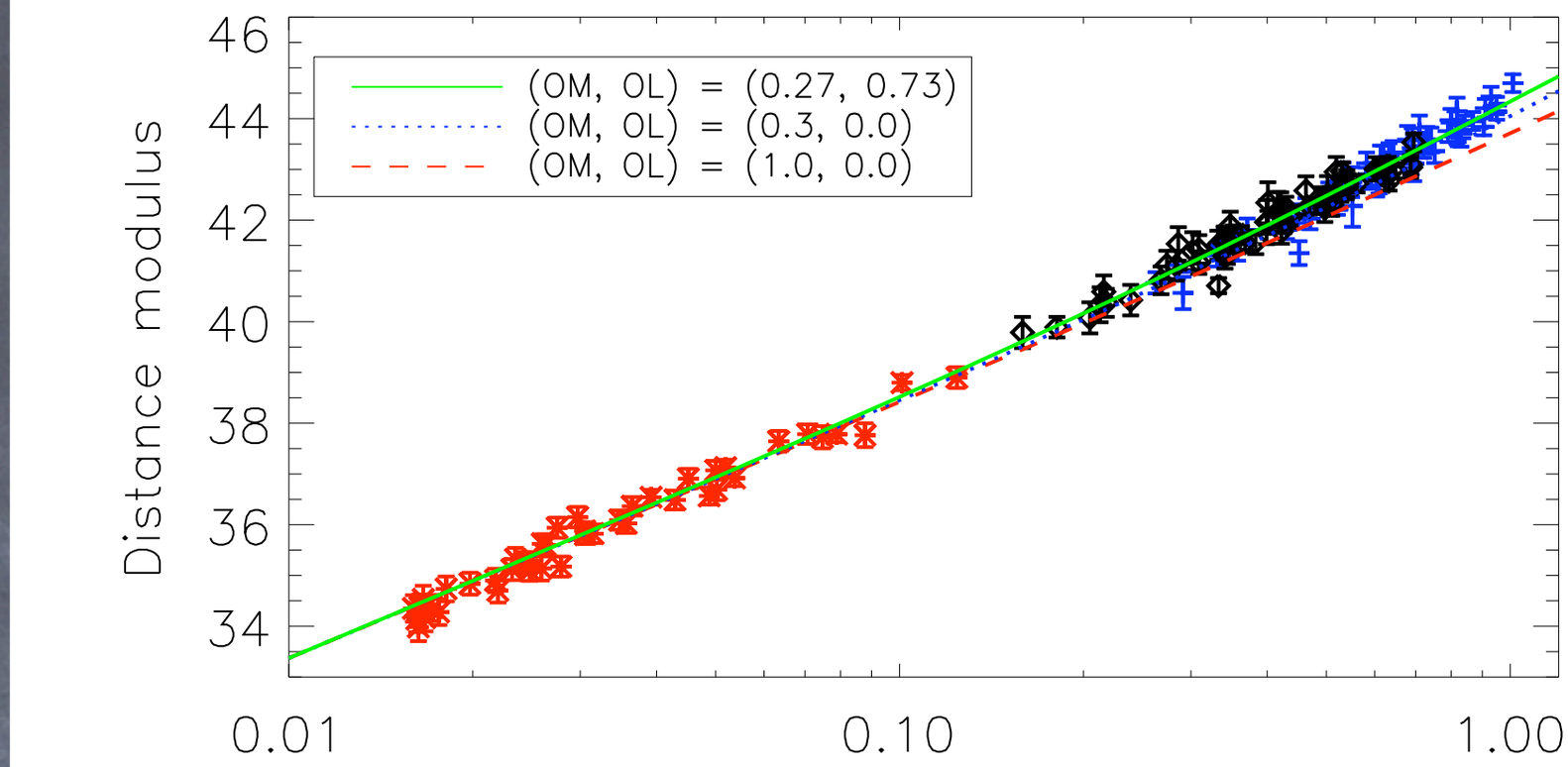
Are Nearby SNeIa the same as Distant SNeIa?

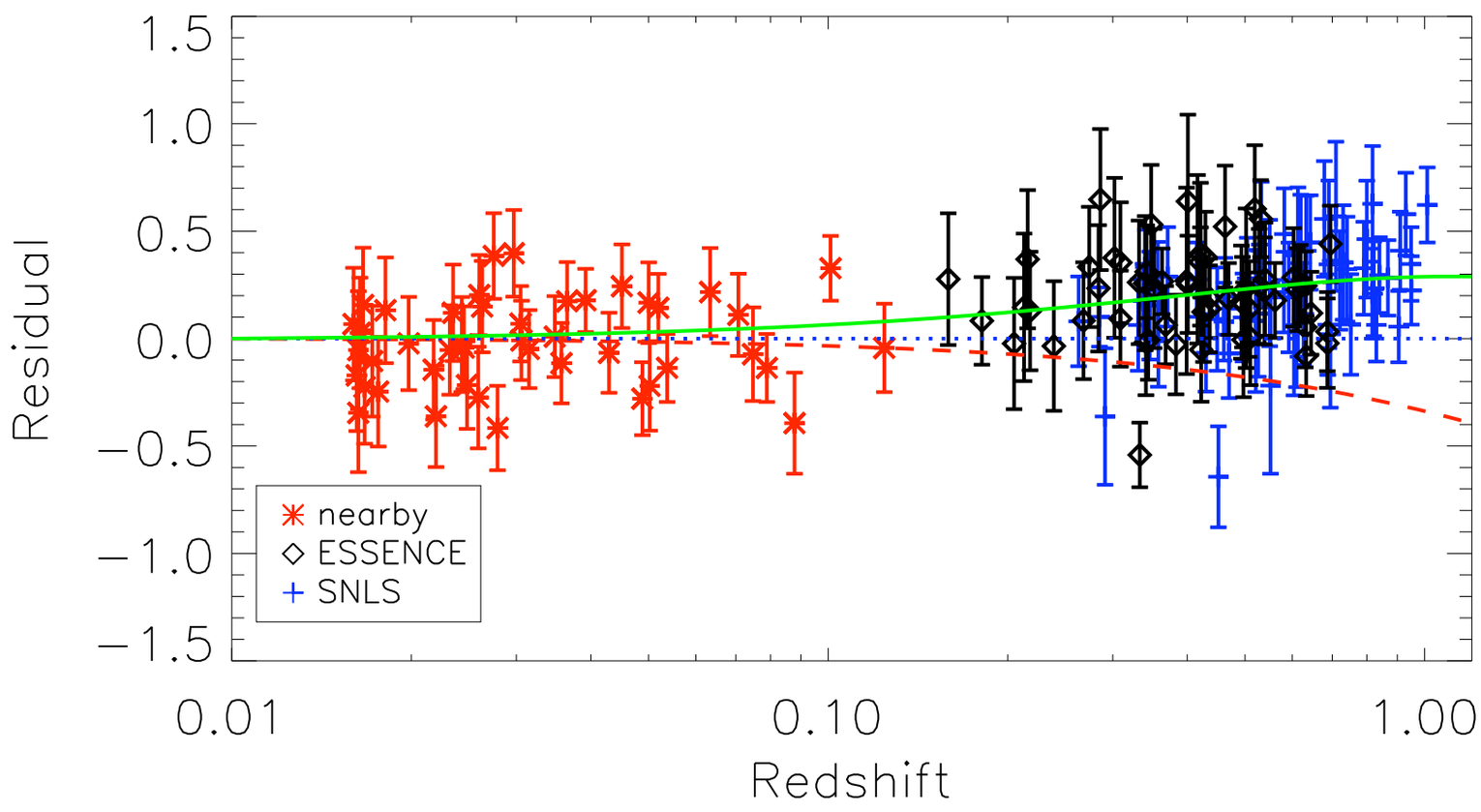
Yes

Pretty much . . .

As far as we can tell . . .

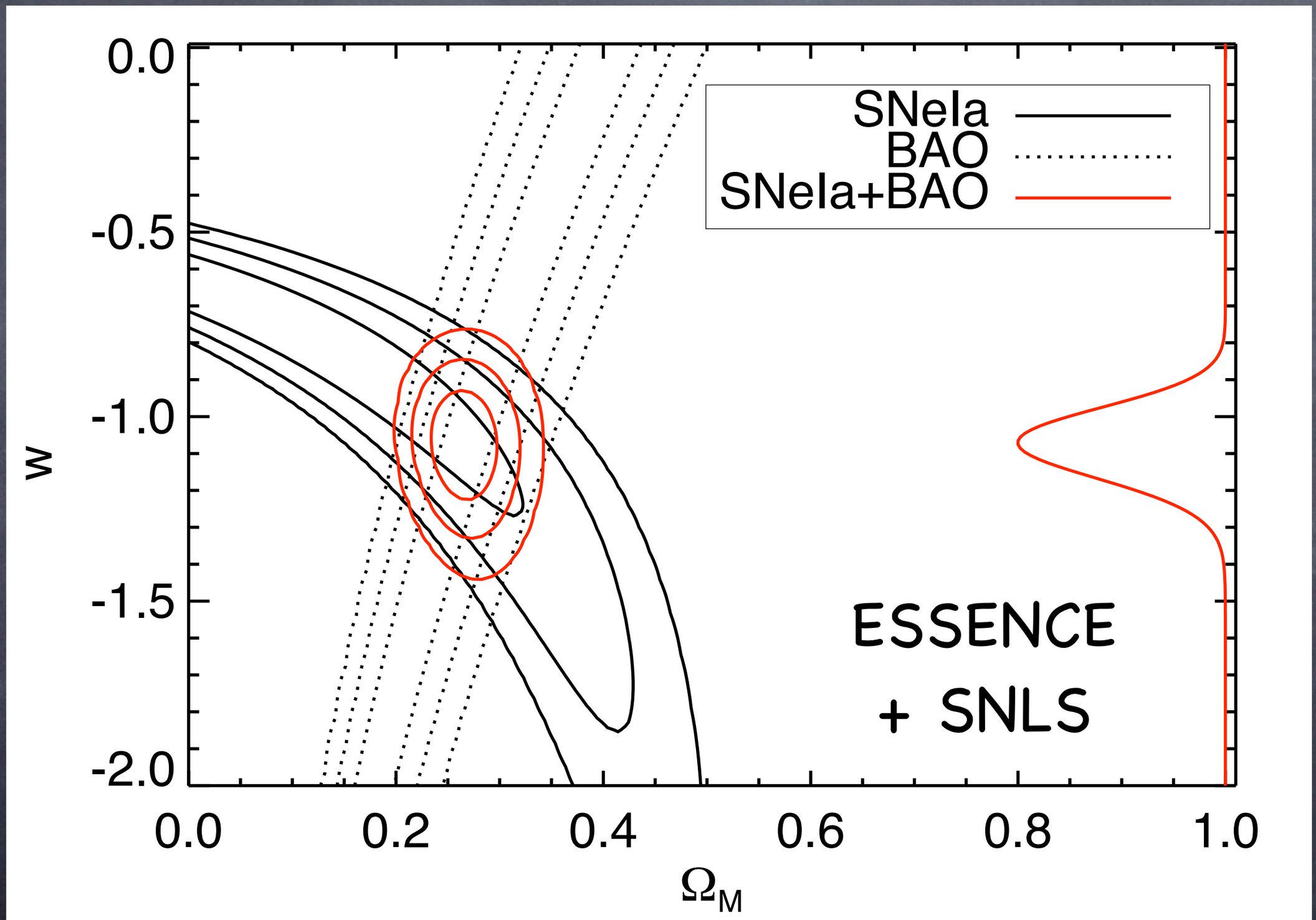
ESSENCE +SNLS Hubble Diagram





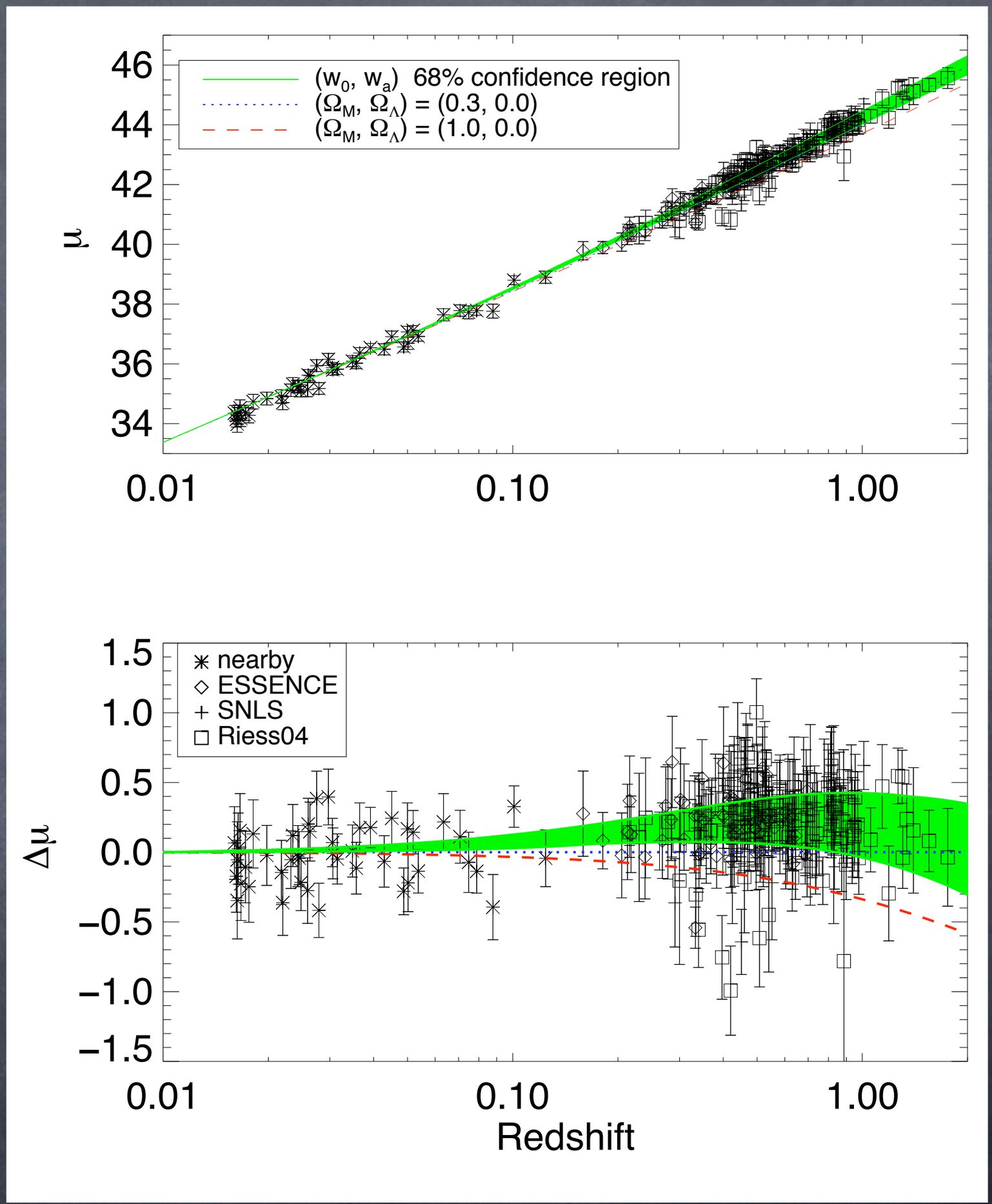
Flat, constant-w

w=-1.07 +- 0.09 +- 0.13

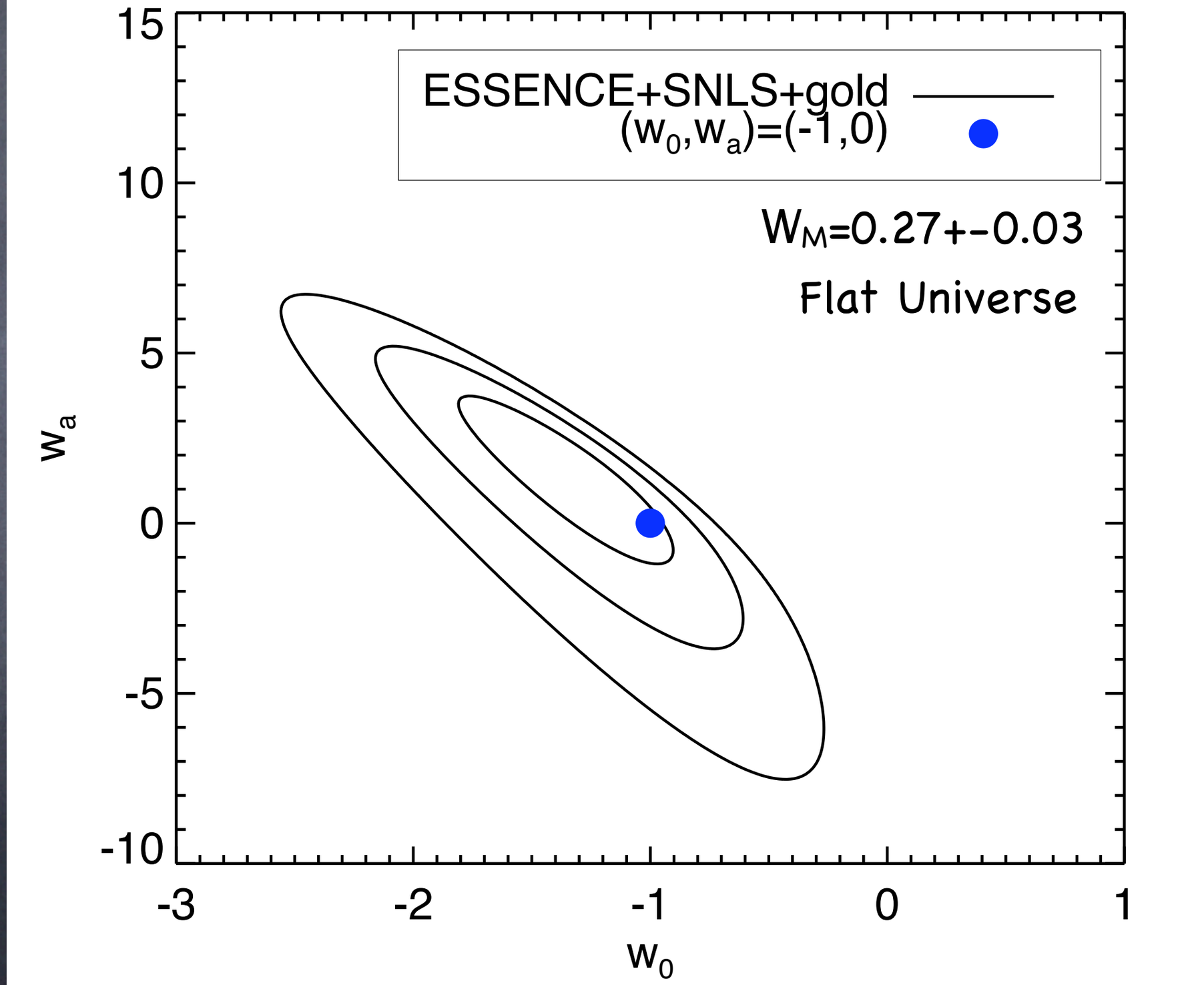


Global SNIa Hubble Diagram

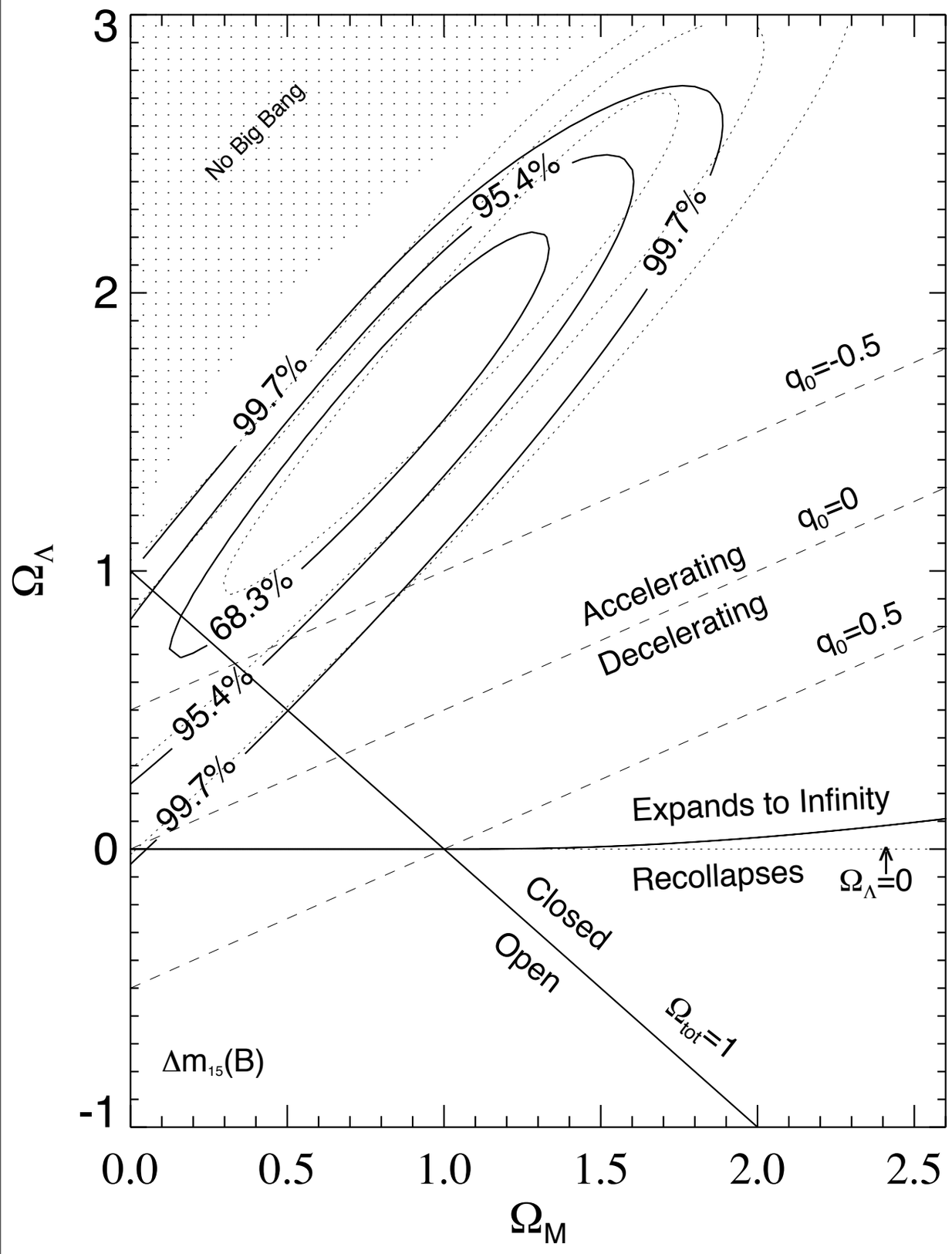
Hamuy 1996a,b
Riess 1998
Perlmutter 1999
Riess 1999
Riess 2001
Tonry 2003
Knop 2003
Barris 2004
Riess 2004
Clochiatti 2005
Astier 2006
Jha 2006



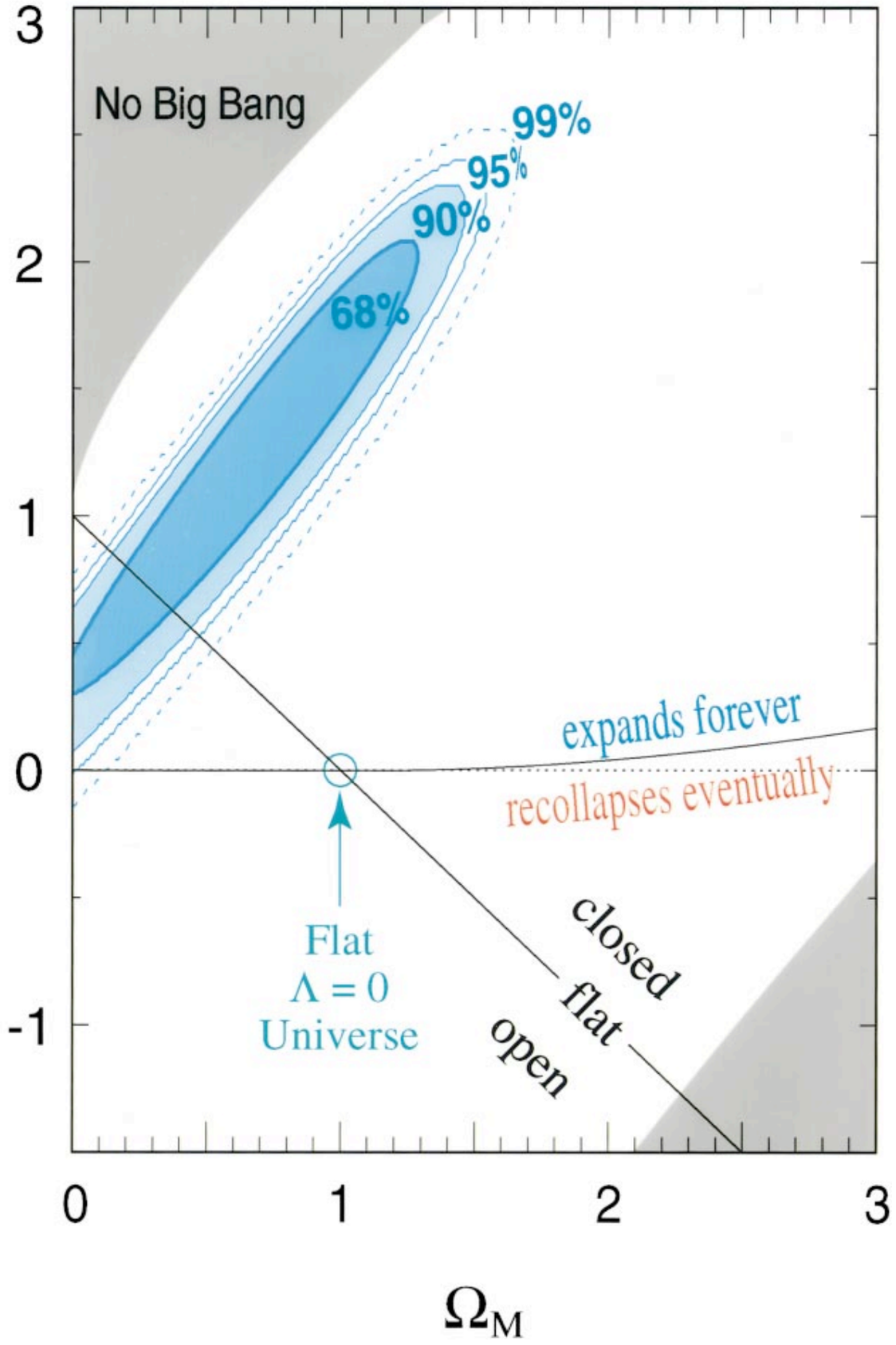
Constraints on $w=w_0+w_a(1-a)$

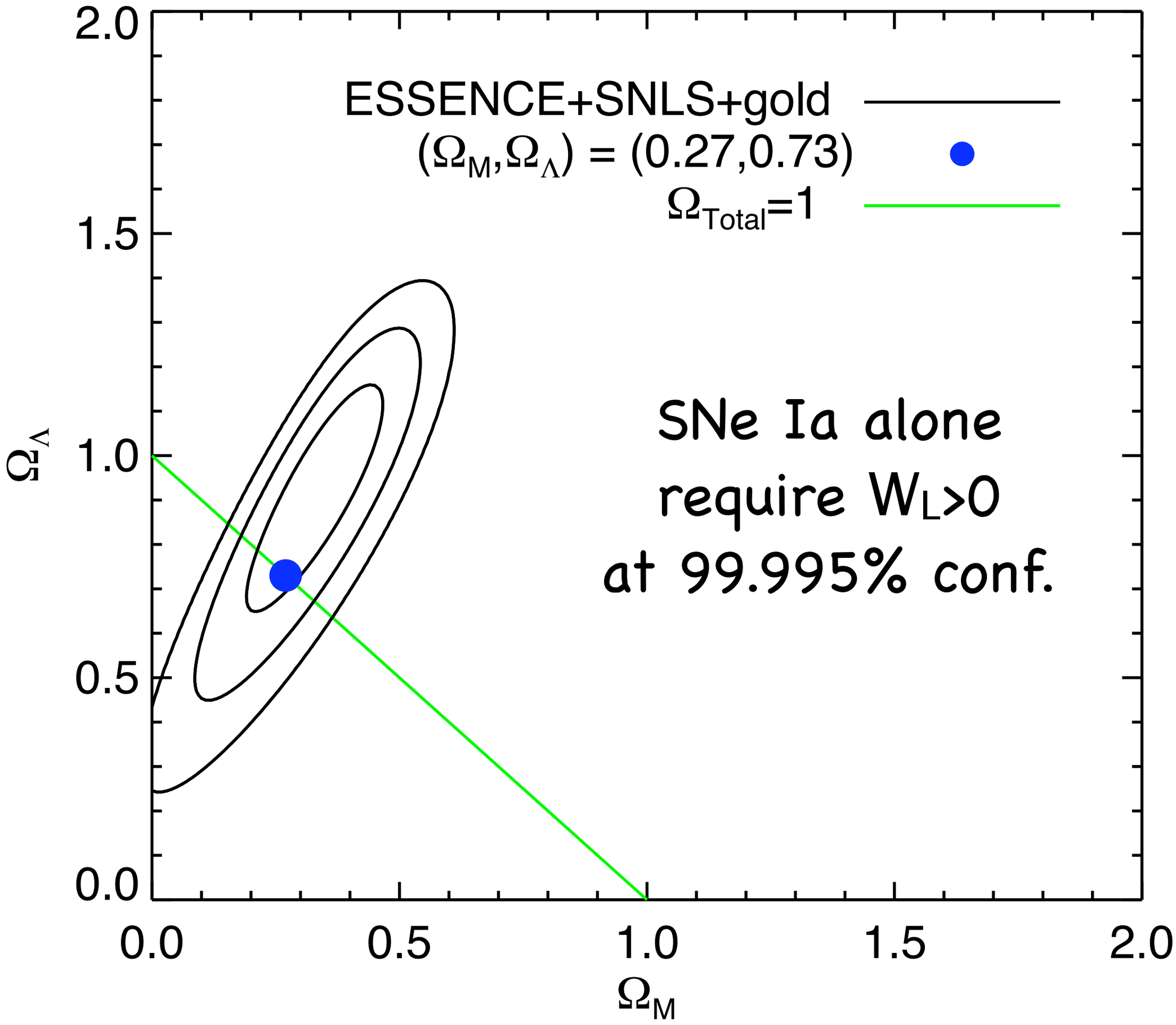


Riess et al. (1998, AJ)



Perlmutter et al. (1999, ApJ)




ESSENCE+SNLS+gold
$(\Omega_M,\Omega_\Lambda) = (0.27,0.73)$
$\Omega_{Total}=1$
SNe Ia alone
require $W_L>0$
at 99.995% conf.
Ω_Λ
Ω_M
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0

Summary

- The accelerating Universe poses a significant challenge to theory, experiment and observation.
- Flat Universe model with a cosmological constant works fine.
- Current goal: w to 10% or w != -1
- Higher redshift, z>1, to go for variable w
- Additional nearby SNIa vital

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- Additional nearby SNIa vital
- Mo' data . . . Mo' better . . .