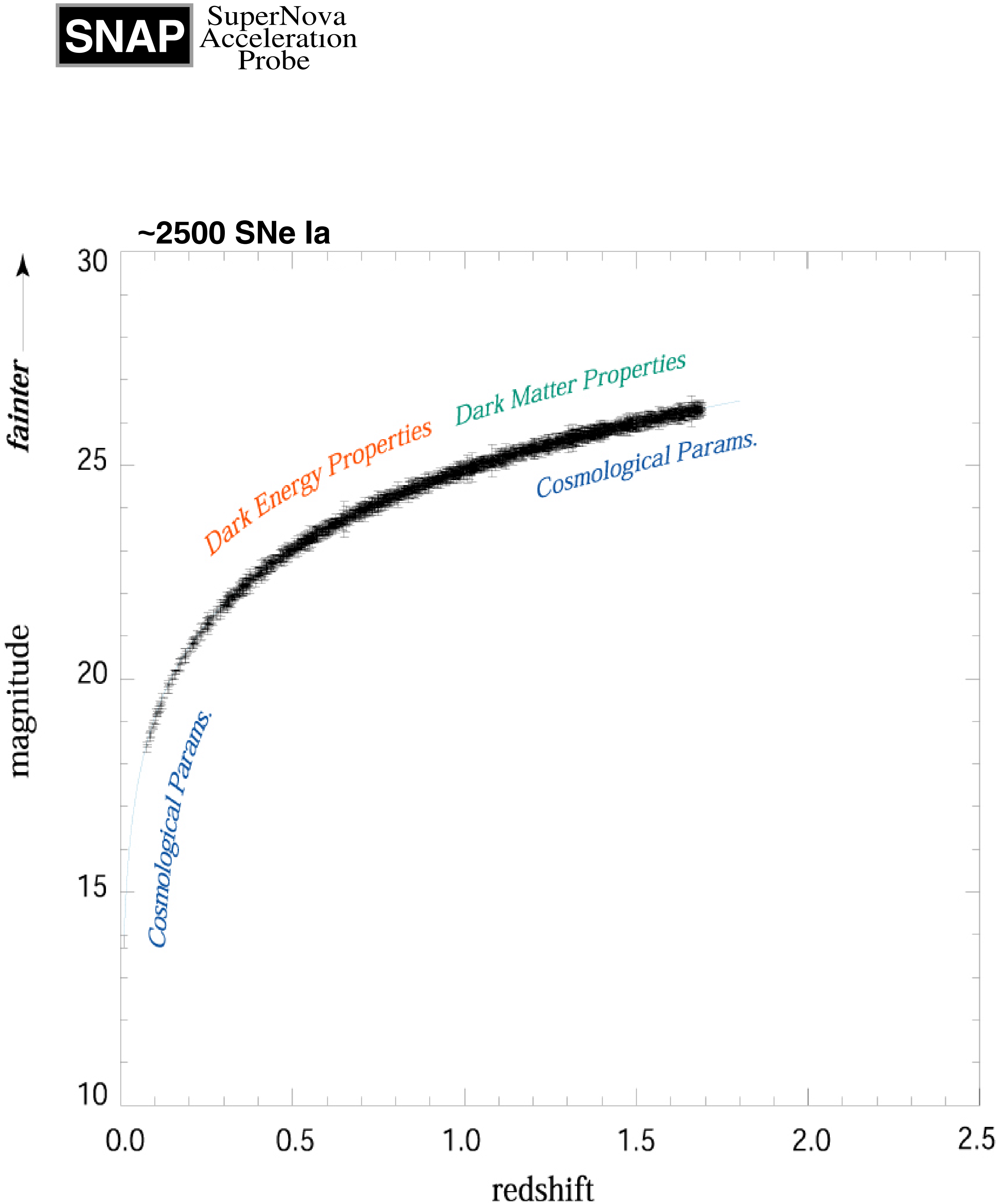
The Primary Science Mission of SNAP

American Astronomical Society Meeting
January 2002

Saul Perlmutter

A really hard goal: $w'(z)$



SNAP
SuperNova Acceleration Probe
~2500 SNe Ia
fainter
magnitude
30
25
20
15
10
0.0
0.5
1.0
1.5
2.0
2.5
redshift
Dark Energy Properties
Dark Matter Properties
Cosmological Params.
Cosmological Params.

What makes the supernova measurement special?

An exhautive accounting of sources of SN systematic uncertainties:

SN Ia Evolution

- o shifting distribution of
  progenitor mass/metallicity/C-O
- o shifting distibution of SN physics params:
  - -- amount of Nickel fused in explosion
  - -- distribution of Nickel
  - -- kinetic energy of explosion
  - -- opacity of atmosphere's inner layers
  - -- metallicity

Gravitational Lensing (de)amplification

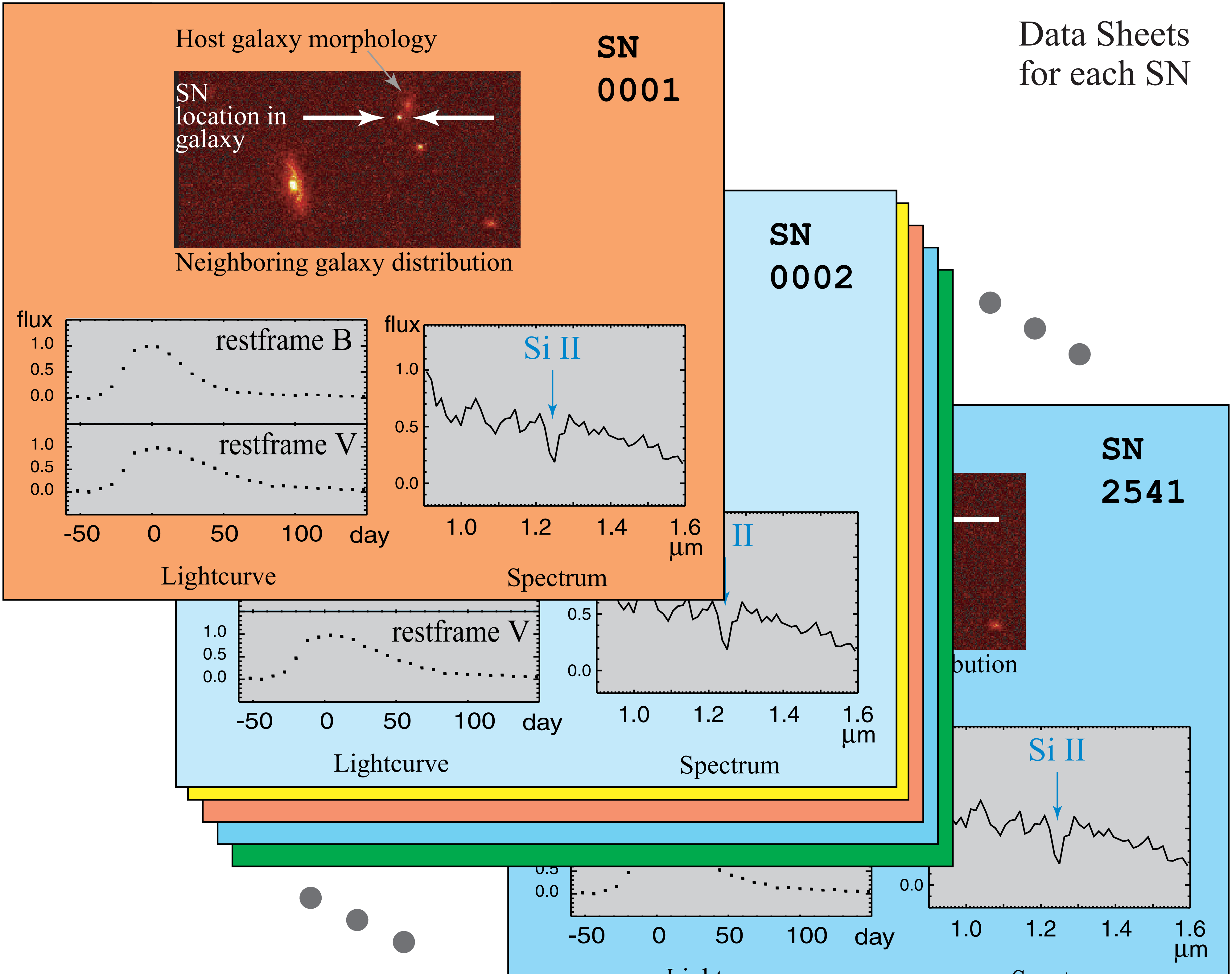
Dust/Extinction

- o dust that reddens
- o evolving gray dust
  - -- clumpy
  - -- homogeneous
- o Galactic extinction model

Observational biases

- o Malmquist bias differences
- o non-SN Ia contamination
- o K-correction uncertainty
- o color zero-point calibration

Perlmutter et al. (1999)



Data Sheets
for each SN
SN
0001
Host galaxy morphology
SN
location in
galaxy
Neighboring galaxy distribution
flux
1.0
0.5
0.0
restframe B
restframe V
-50
0
50
100
day
Lightcurve
flux
Si II
1.0
1.2
1.4
1.6
µm
Spectrum
SN
0002
SN
2541

1

Sort into Like Subsets

Group A:
* Si II in spectrum: type Ia
* elliptical host
* bright UV: low metallicity
* fast rise time: low Ni56 mass
* spectral feature velocities 9000 < v < 10000 km/s

⋮

Group B:
* Si II in spectrum: type Ia
* in core of late-type spiral host
* faint UV: high metallicity
* fast rise time: low Ni56 mass
* spectral feature velocities 9000 < v < 10000 km/s

⋮

Group C:
* Si II in spectrum: type Ia
* in outskirts of late-type spiral host
* bright UV: low metallicity
* long rise time: high Ni56 mass
* spectral feature velocities 8000 < v < 9500 km/s

⋮

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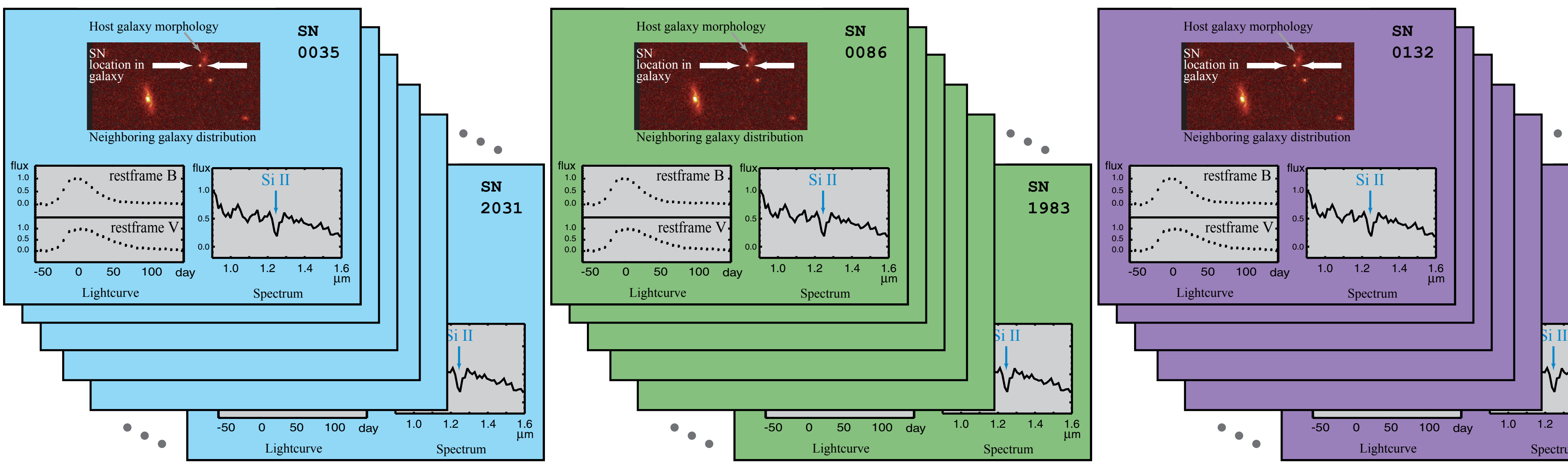
Gro
* Si II i
* in core
* brigh
* short
* spect

8000



2

Each subset gets its own extinction-corrected Hubble diagram:

Group A:
* Si II in spectrum: type Ia
* elliptical host
* bright UV: low metallicity
* fast rise time: low Ni56 mass
* spectral feature velocities 9000 < v < 10000 km/s

⋮

Group B:
* Si II in spectrum: type Ia
* in core of late-type spiral host
* faint UV: high metallicity
* fast rise time: low Ni56 mass
* spectral feature velocities 9000 < v < 10000 km/s

⋮

Group C:
* Si II in spectrum: type Ia
* in outskirts of late-type spiral host
* bright UV: low metallicity
* long rise time: high Ni56 mass
* spectral feature velocities 8000 < v < 9500 km/s

⋮

• • •

Gro
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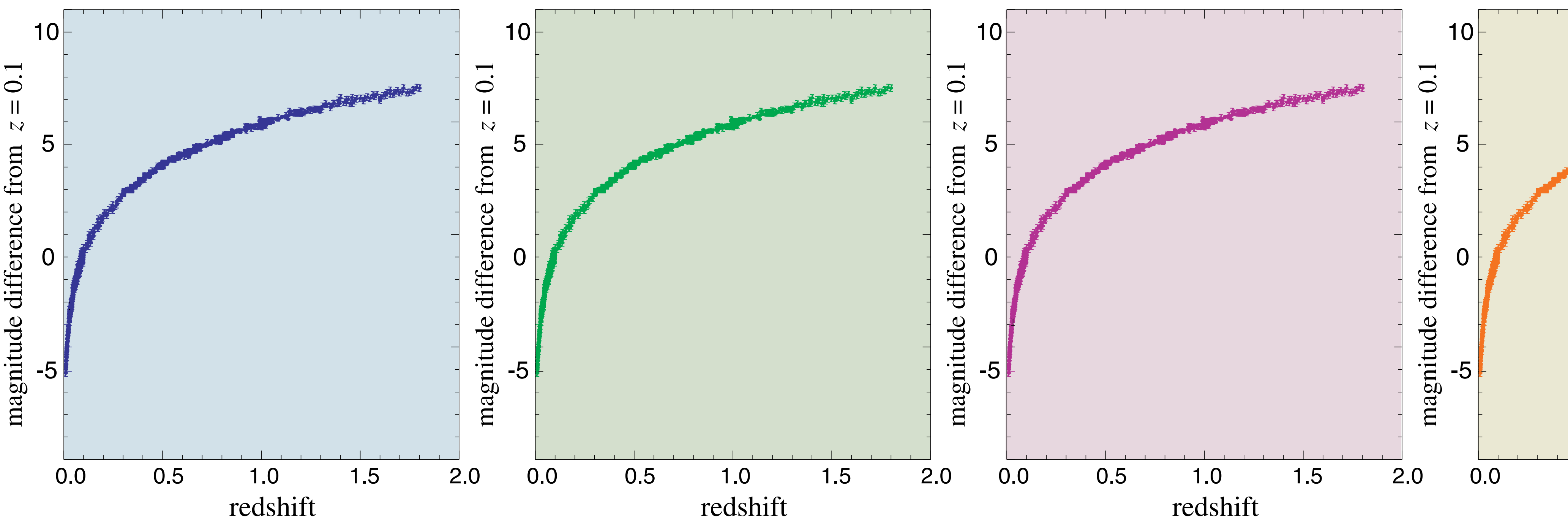
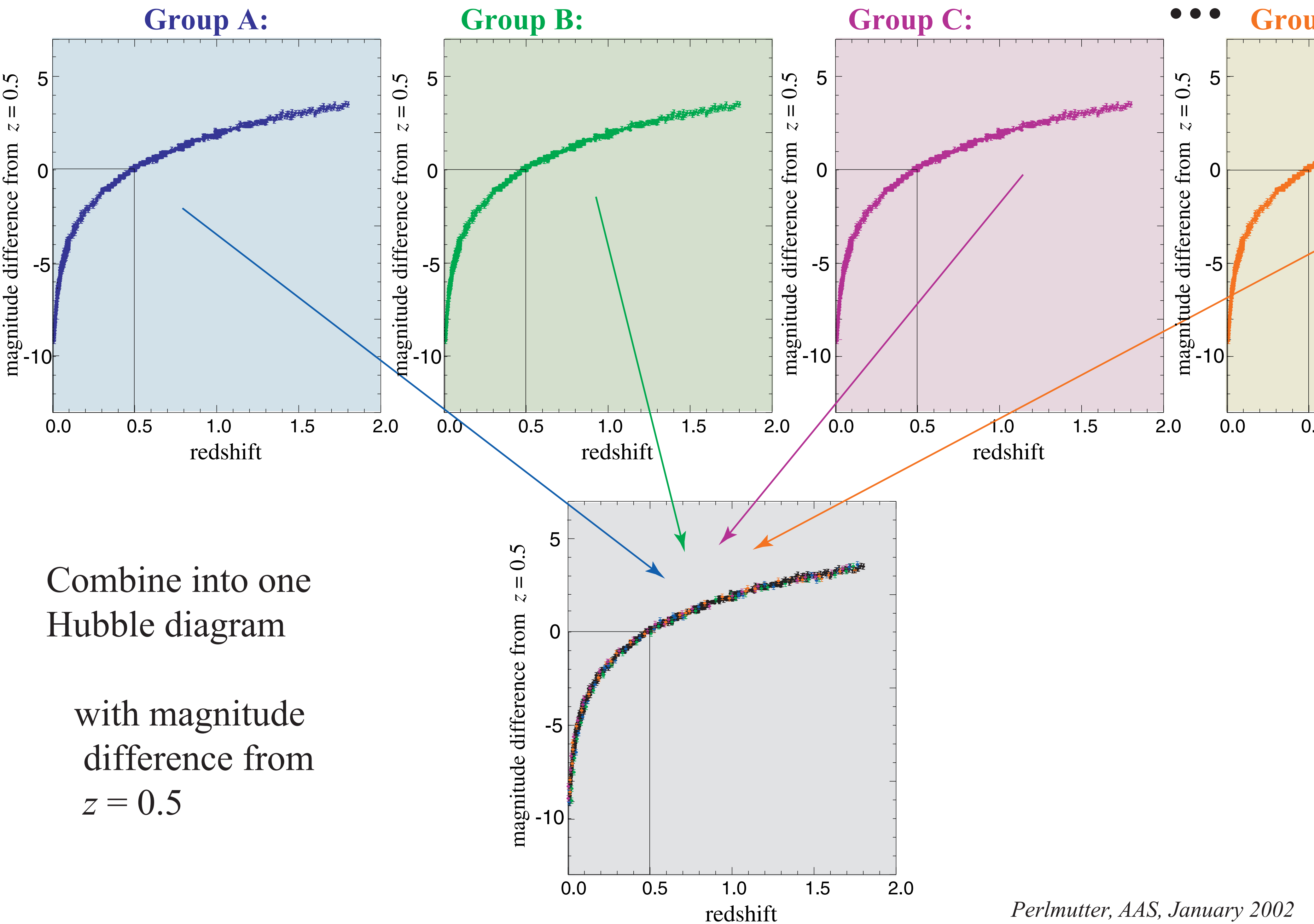


2

Each subset gets its own extinction-corrected Hubble diagram:

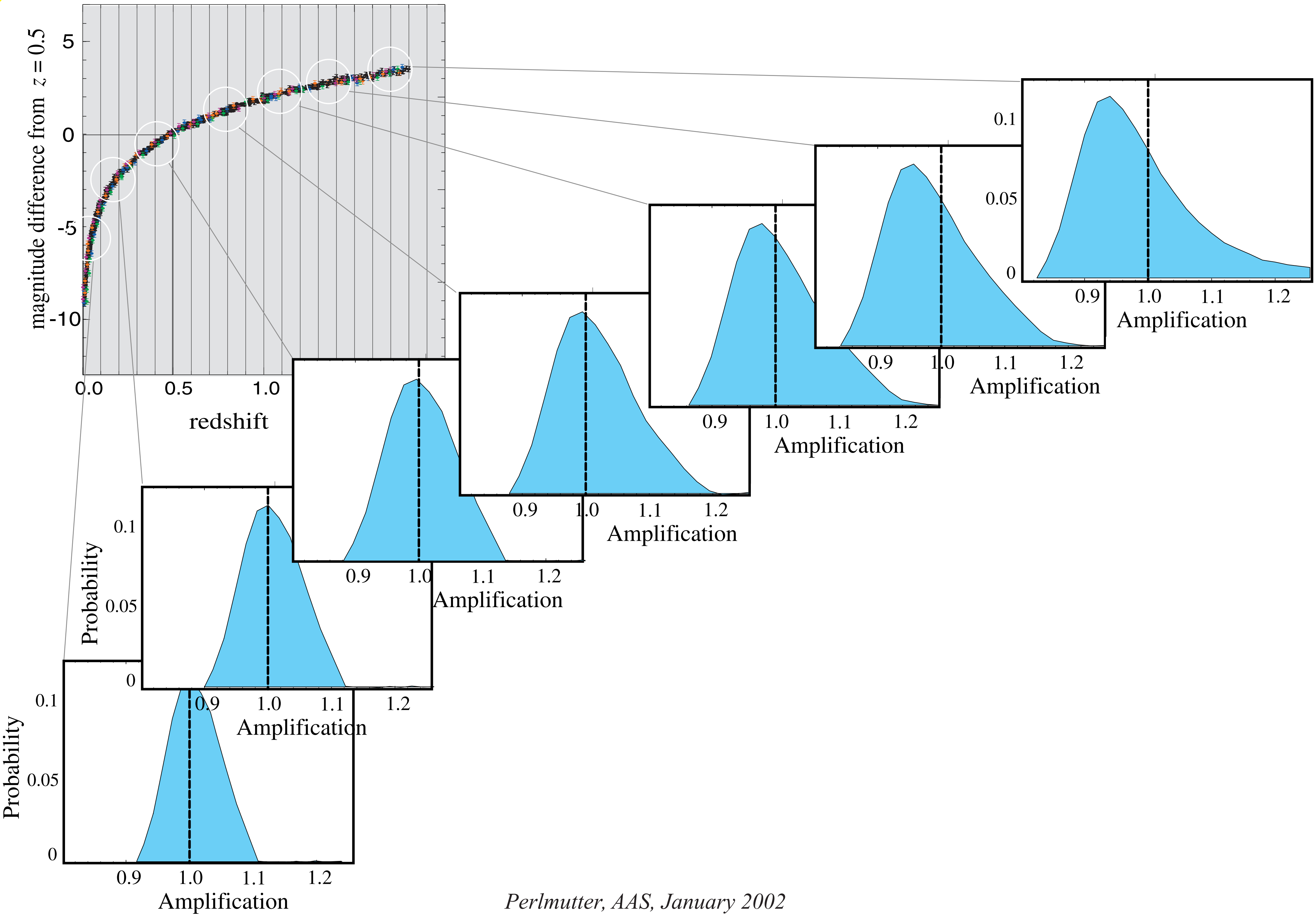


Combine into one Hubble diagram

with magnitude difference from $z = 0.5$

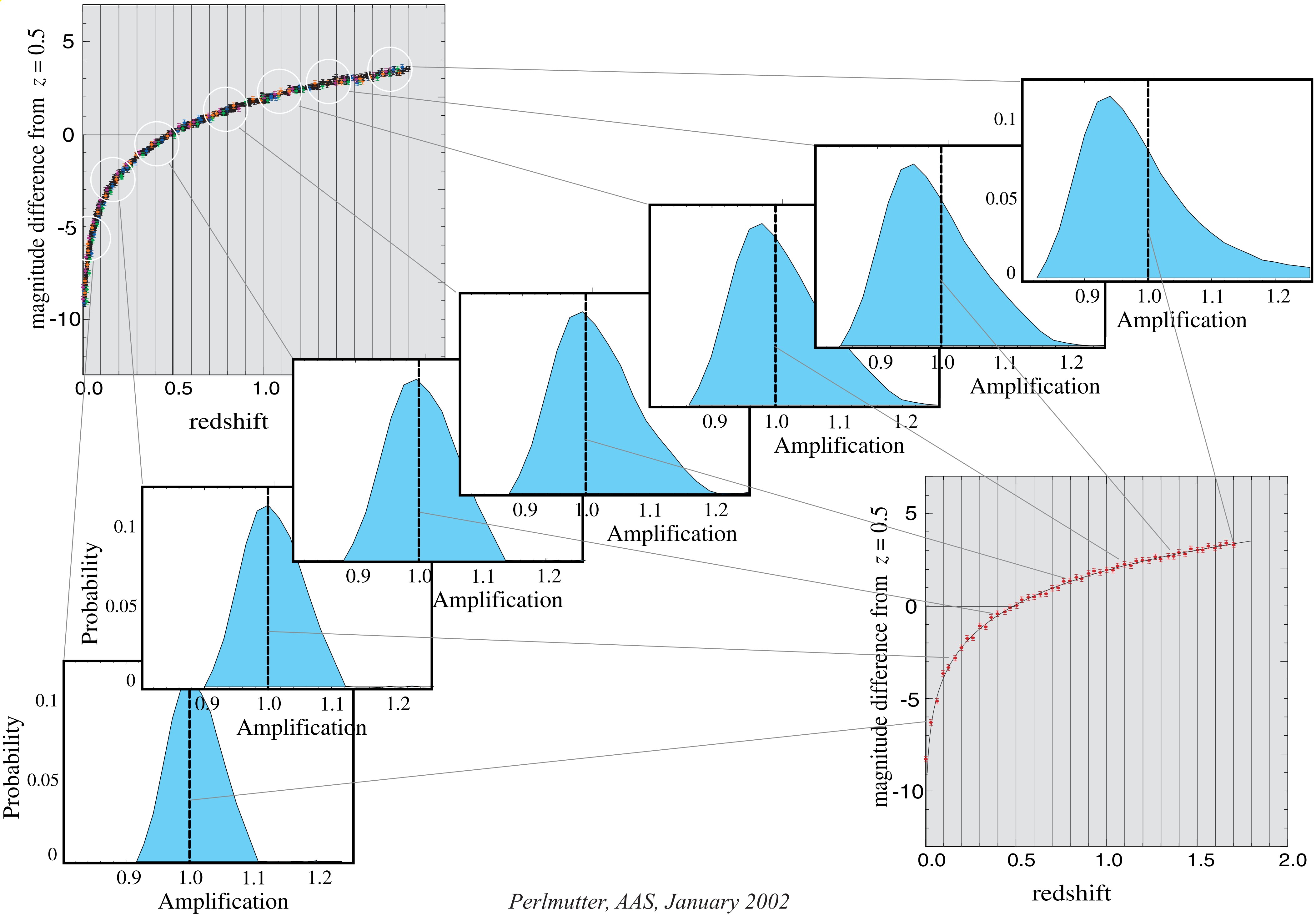
Perlmutter, AAS, January 2002

3 Break Hubble diagram into z slices to study lensing (de)amplification distribution:



Perlmutter, AAS, January 2002

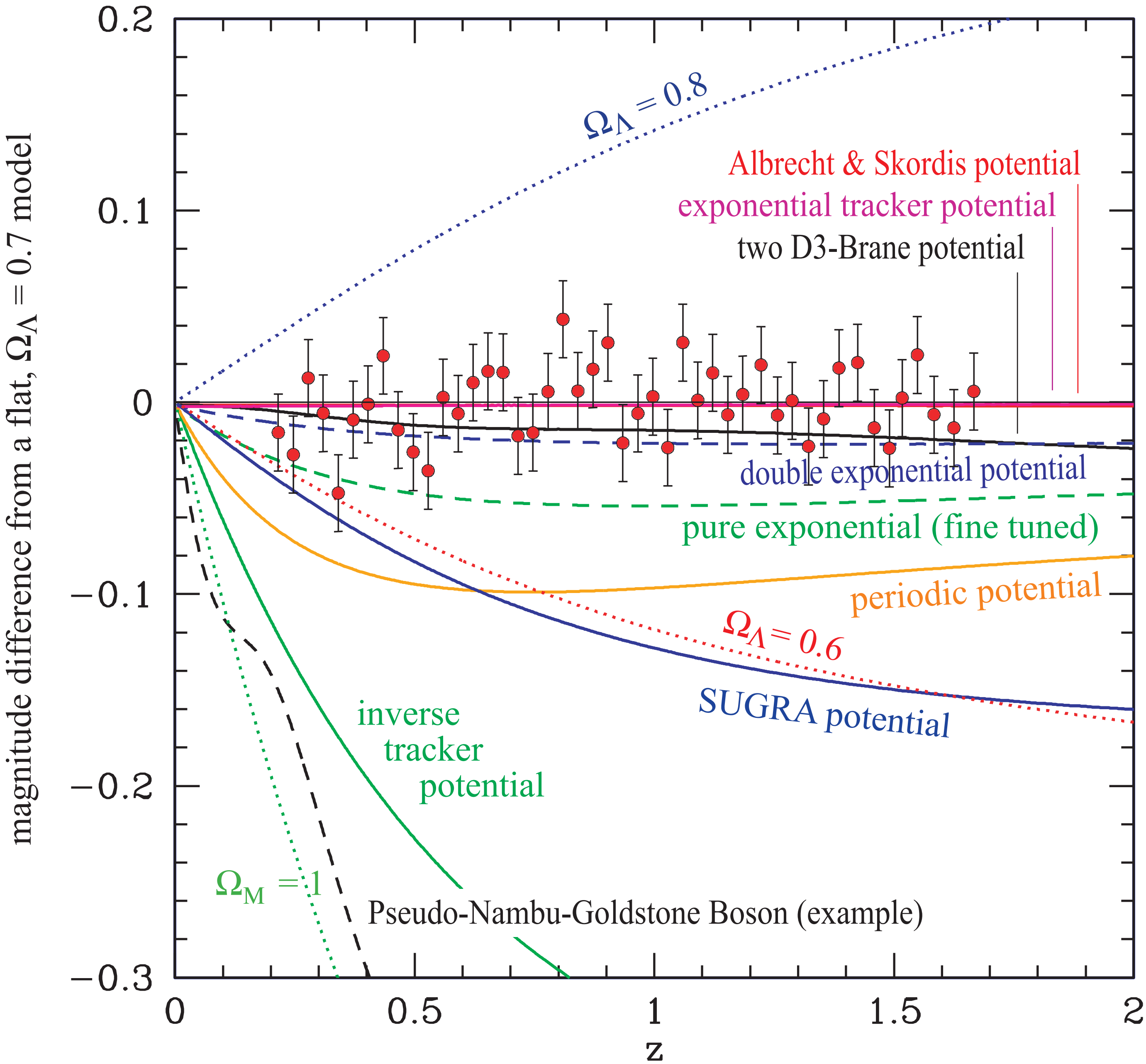
3 Fit/average lensing distributions to construct redshift-binned Hubble diagram:



Perlmutter, AAS, January 2002

SNAP SuperNova Acceleration Probe

Binned simulated SNAP data compared with Dark Energy models currently in the literature.



based on

Weller & Albrecht (2001)

Example Measurement Requirements for Each Step

Sort into Like Subsets

1

Spectrum:

Si II feature 15σ per bin with 30A restframe resolution

UV features 5σ per bin

Lightcurve:

Rise time 3σ measurement 3.8 mag before max

Peak fit 15σ measurement 2 mag after max

Image:

Host galaxy morphology <0.1" dithered resolution

Extinction-corrected Hubble diagram

2

Spectrum & Lightcurve:

Cross-wavelength calibrated colors for photometry and spectroscopy from near-UV to near-IR (0.4 -- 1.7 μm)

Correct for lensing distributions

3

Image quality:

<0.1" dithered resolution for neigboring galaxy gravitational lensing map

Redshift range & statistics:

>~50 SNe per bin to obtain lensing distribution

SNAP SuperNova Acceleration Probe

Primary Science Mission

Requiring complementary measurements of cosmological parameters, Dark Matter, Dark Energy,...

Type Ia supernova calibrated candle:

Hubble diagram to $z = 1.7$

Type II supernova expanding photosphere:

Hubble diagram to $z = 1$ and beyond.

Weak lensing:

Direct measurements of $P(k)$ vs z

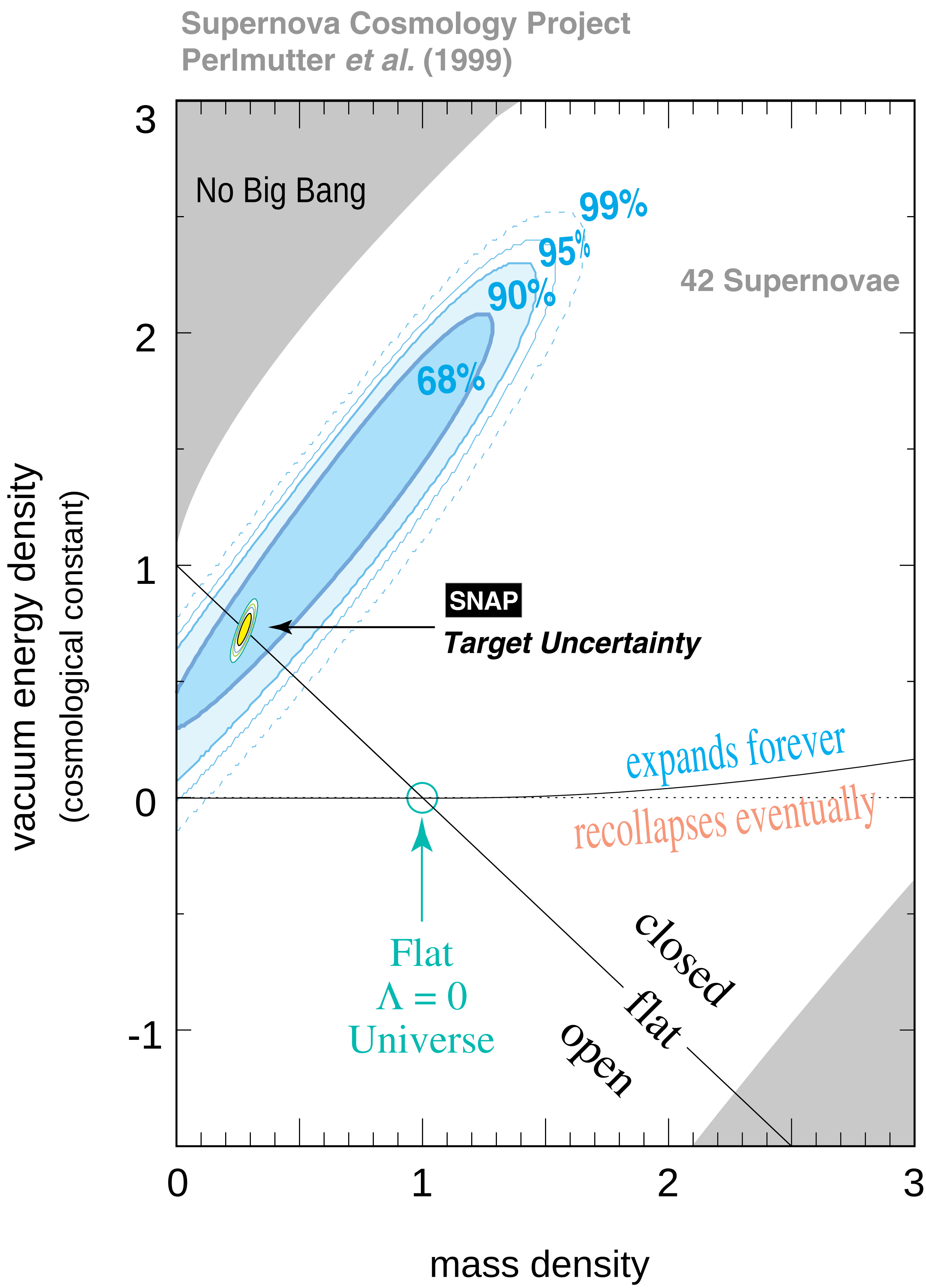
Mass selected cluster survey vs z

Strong lensing statistics: Ω_Λ

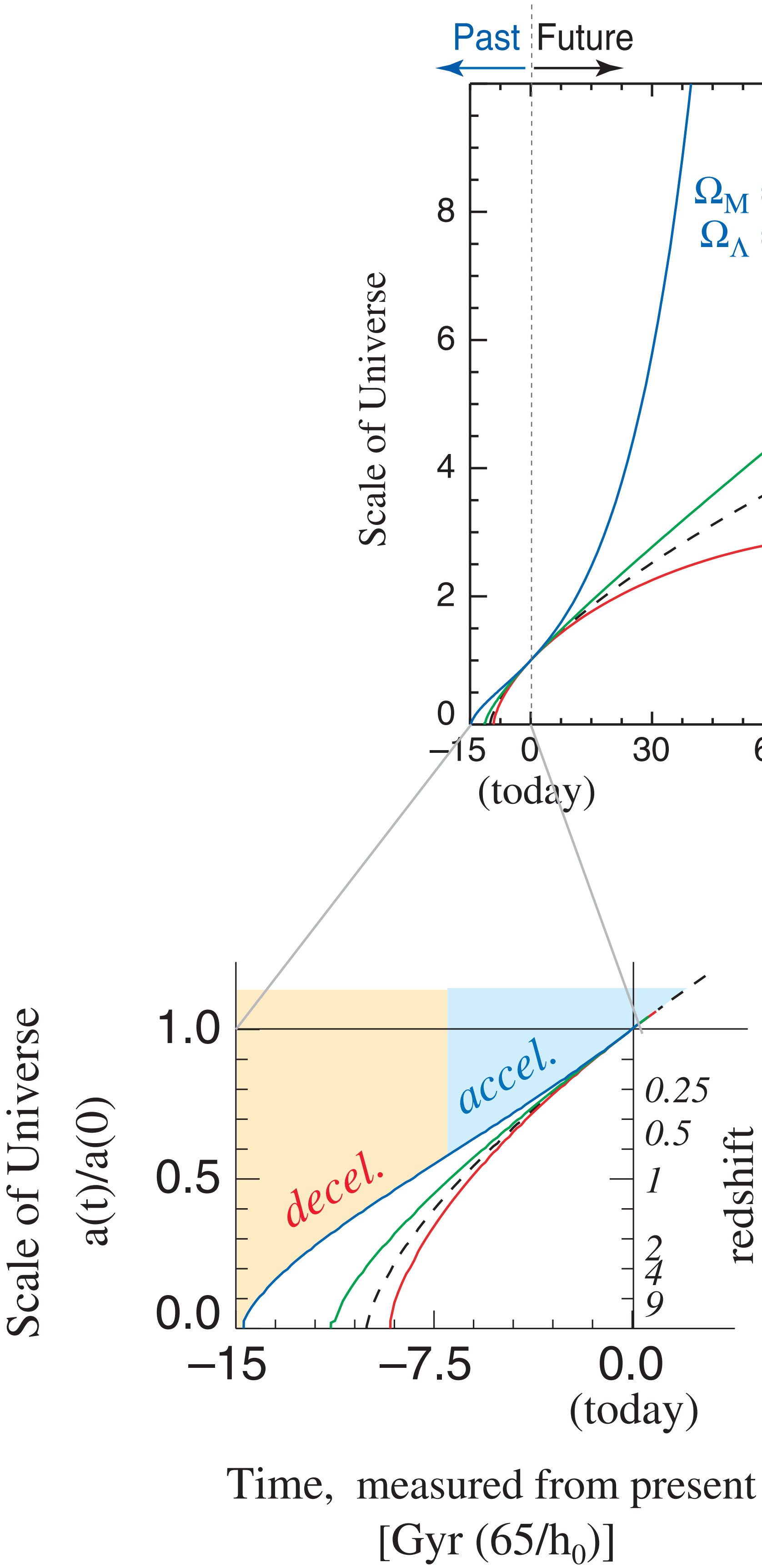
10x gains over ground based optical resolution, IR channels + depth.

Galaxy clustering:

$W(\Theta)$ angular correlation vs redshift from 0.5 to 3.0


Supernova Cosmology Project
Perlmutter et al. (1999)
No Big Bang
99%
95%
90%
68%
42 Supernovae
SNAP
Target Uncertainty
expands forever
recollapses eventually
closed
flat
open
Flat
Λ = 0
Universe
3
2
1
0
-1
0
1
2
3
vacuum energy density
(cosmological constant)
mass density

Expansion History of the Universe



Perlmutter, AAS Jan 2002