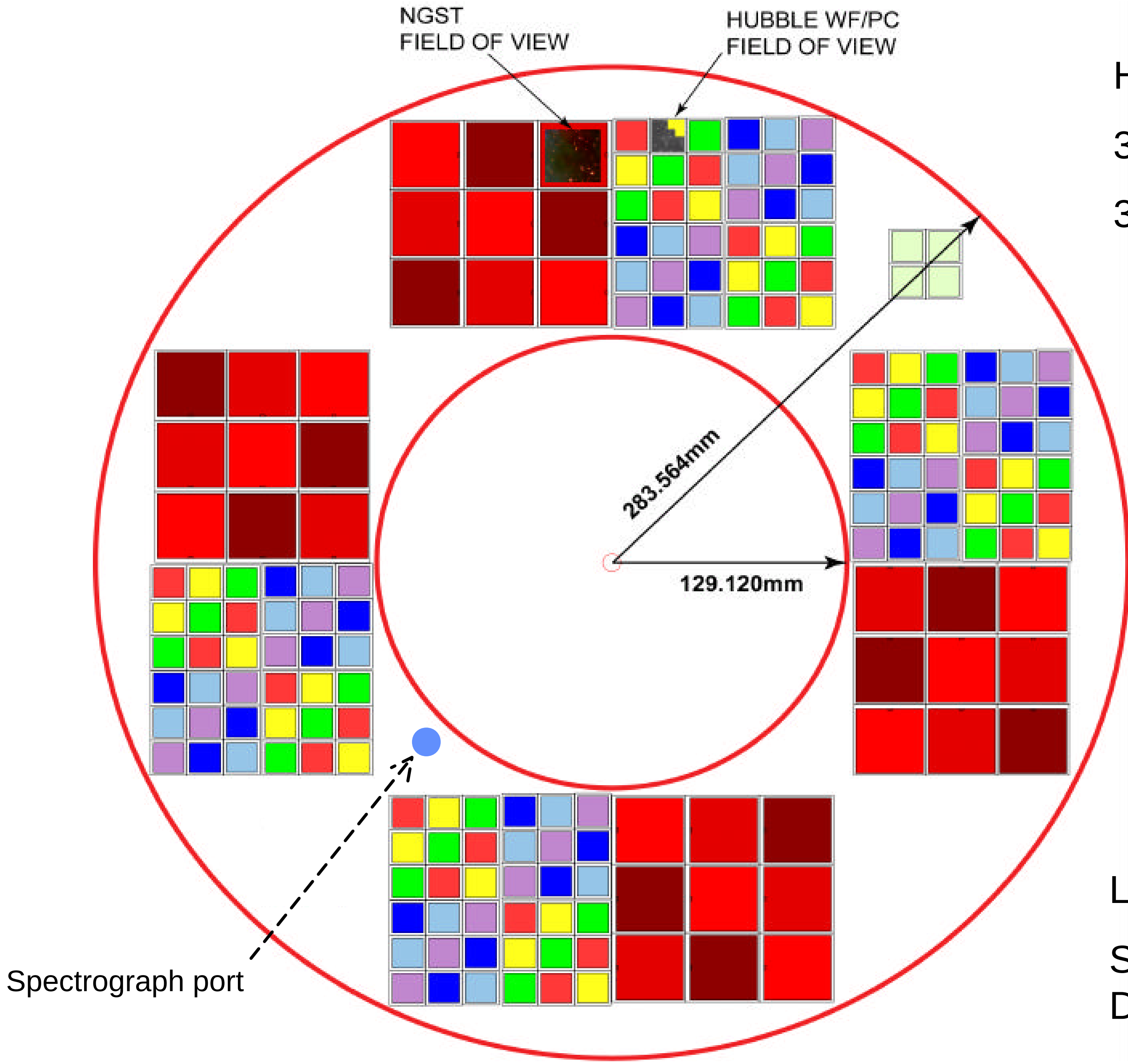
Focal Plane Layout with Fixed Filters



Half billion pixel array

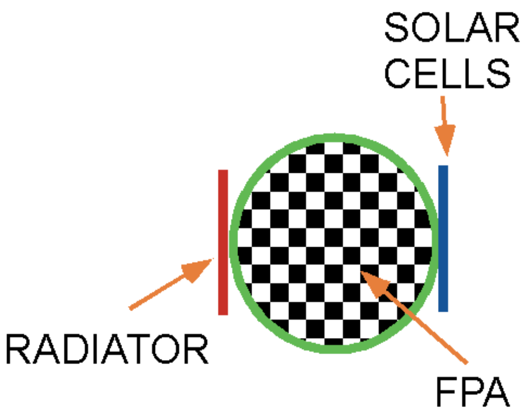
36 optical CCDs

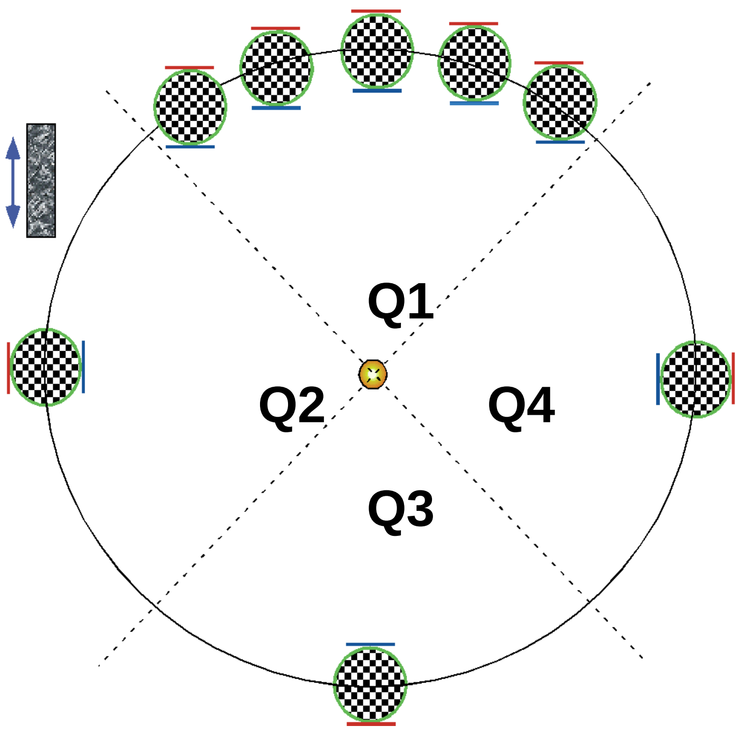
36 near infrared detectors

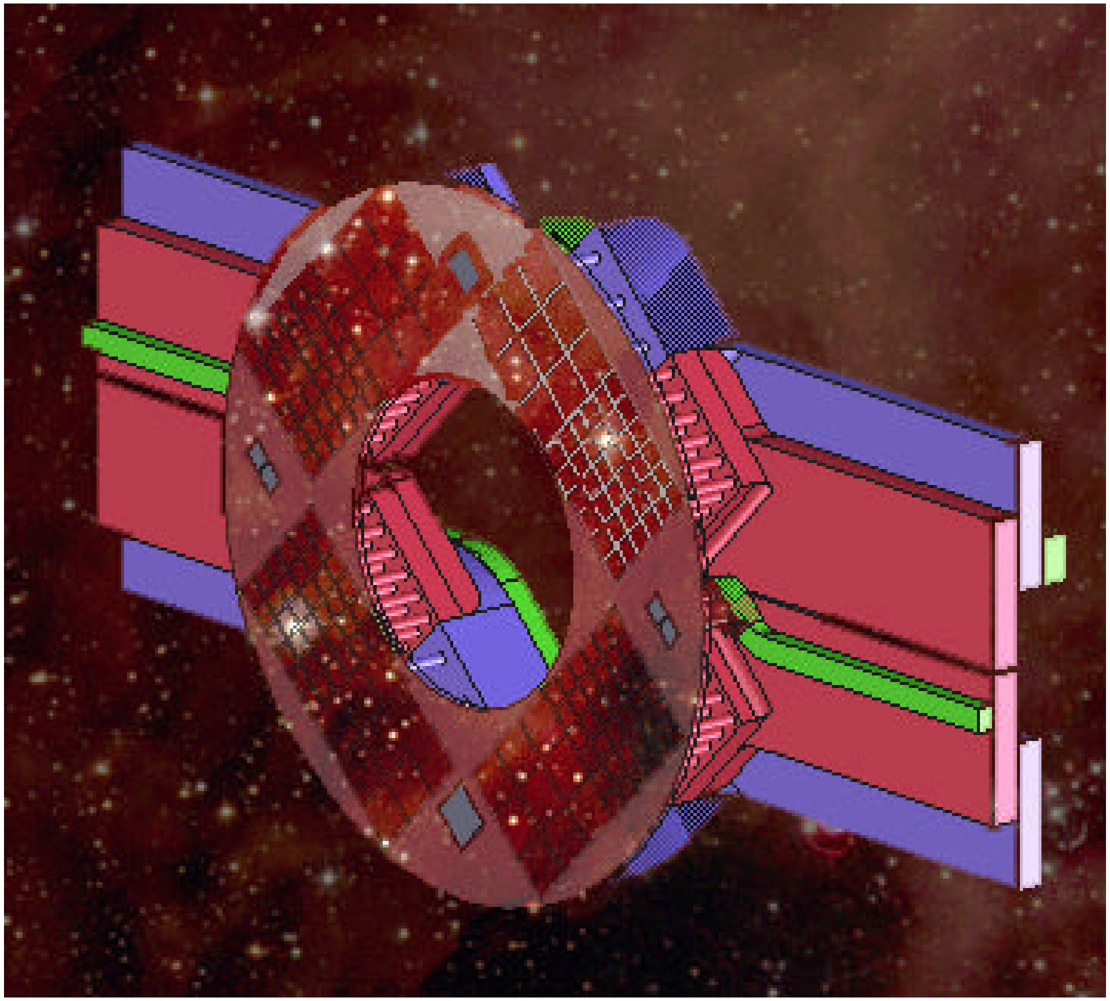
Larger than Sloan camera

Smaller than HEP Vertex Detector

Step and Stare and Rotation

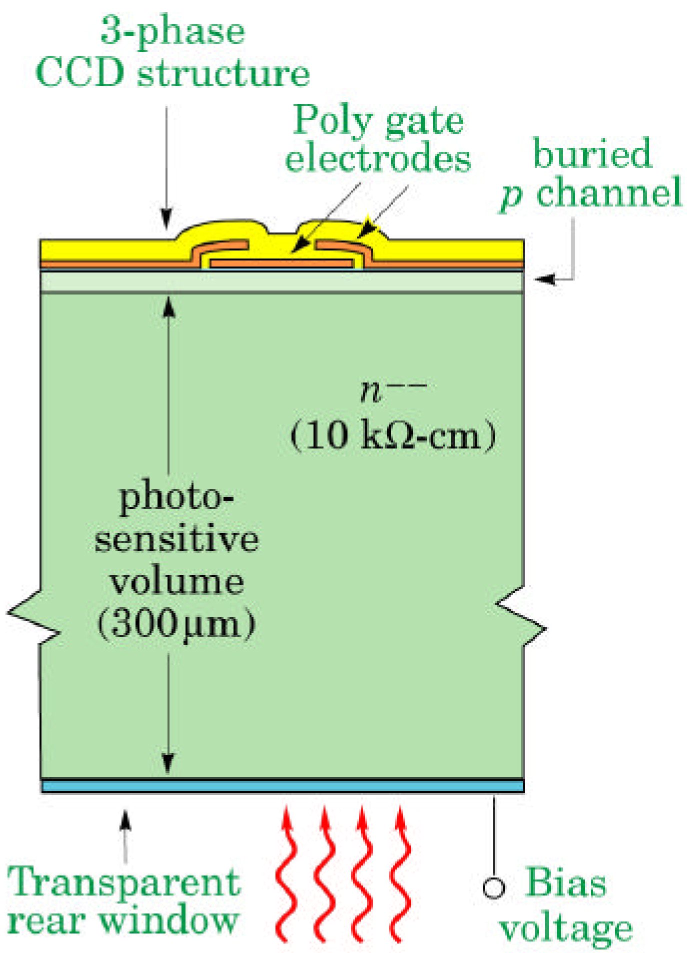


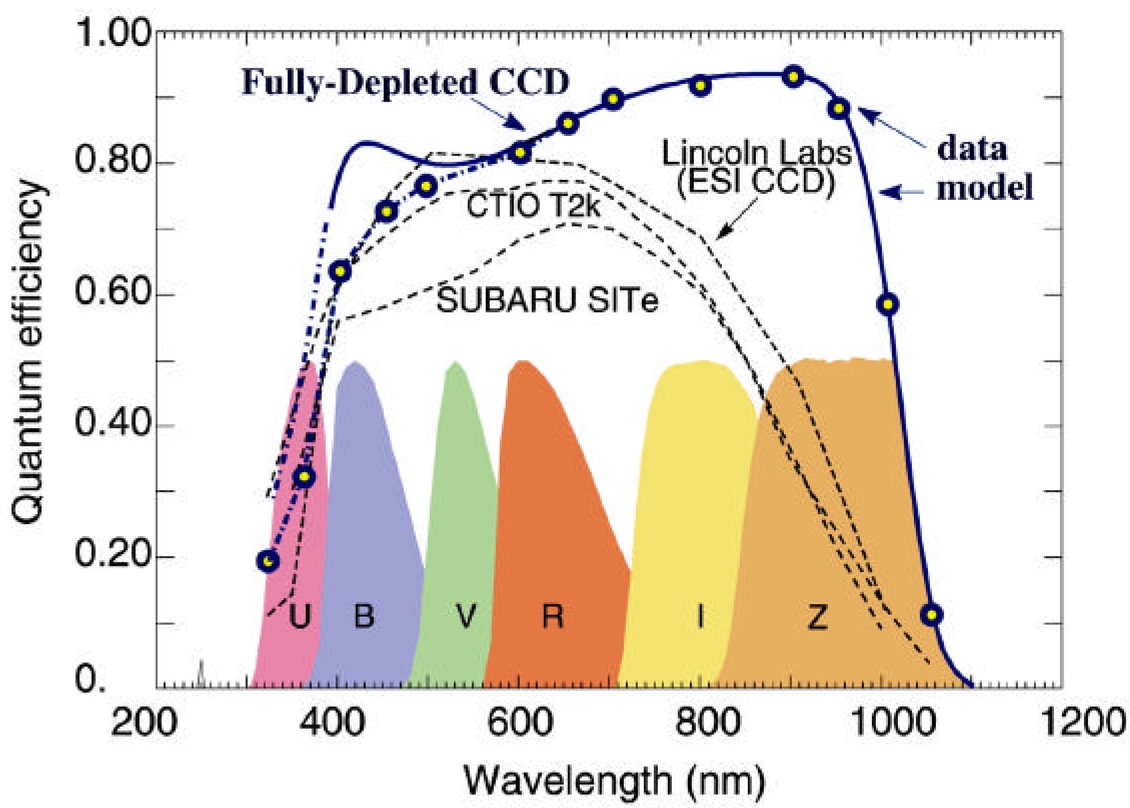




New Technology CCD's

- New kind of CCD developed at LBNL
- Better overall response than more costly "thinned" devices in use
- High-purity silicon has better radiation tolerance for space applications
- CCD's can be abutted on all four sides enabling very large mosaic arrays
- Measured Quantum Efficiency at Lick Observatory (R. Stover):





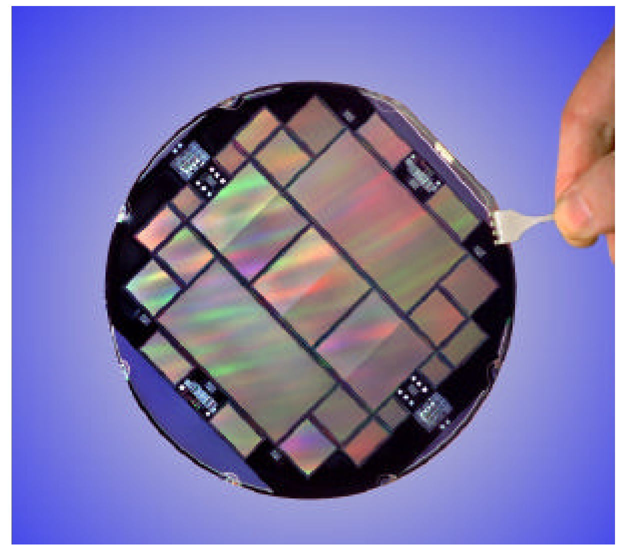
LBNL CCD's at NOAO


National Optical Astronomy Observatory
Cerro Tololo • Kitt Peak • U.S. Gemini Program
National Solar Observatory
GONG • Kitt Peak • Sacramento Peak
Newsletter 67
September 2001

Cover picture taken at WIYN 3.5m with LBNL 2048 x 2048 CCD (Dumbbell Nebula, NGC 6853)

Science studies to date at NOAO using LBNL CCD's:

1) Near-earth asteroids
2) Seyfert galaxy black holes
3) LBNL Supernova cosmology

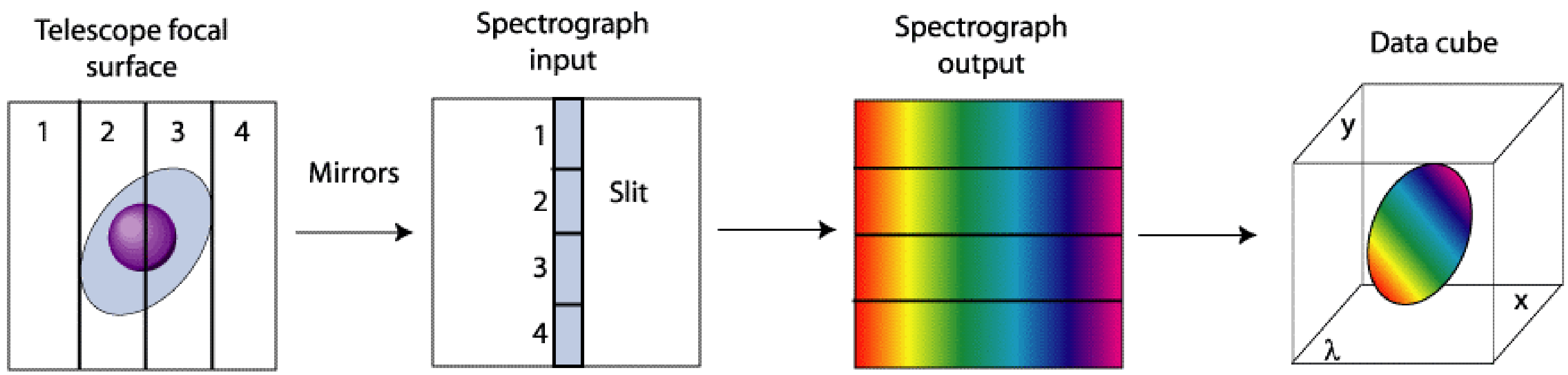


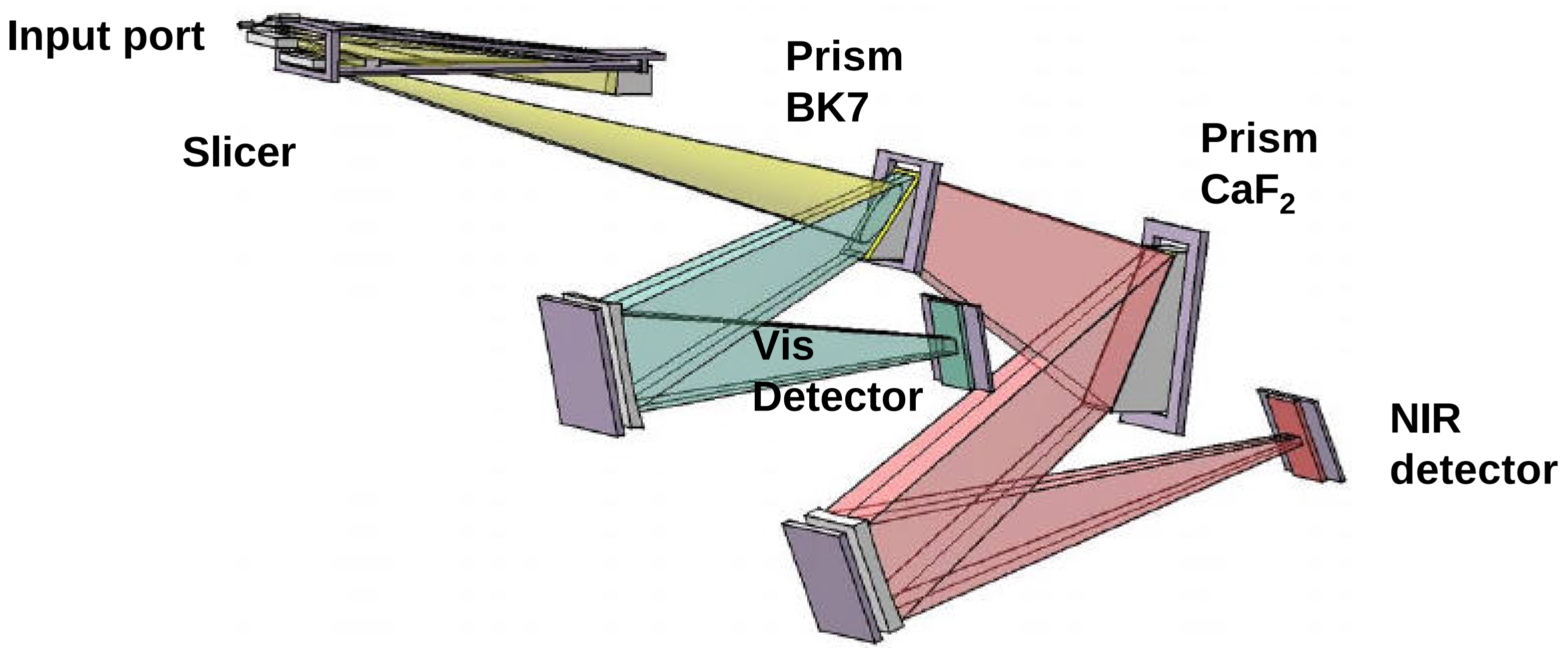
Blue is H-alpha
Green is SIII 9532Å
Red is HeII 10124Å.

See September 2001 newsletter at http://www.noao.edu

Integral Field Unit Spectrograph

- Integral field unit based on an imager slicer- Data cube.
- Input aperture is 3” x 3” – reduces pointing accuracy req.
- Simultaneous SNe and host galaxy spectra.
- Internal beam split to visible and NIR: 3500-17000Å.



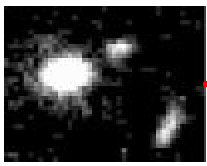


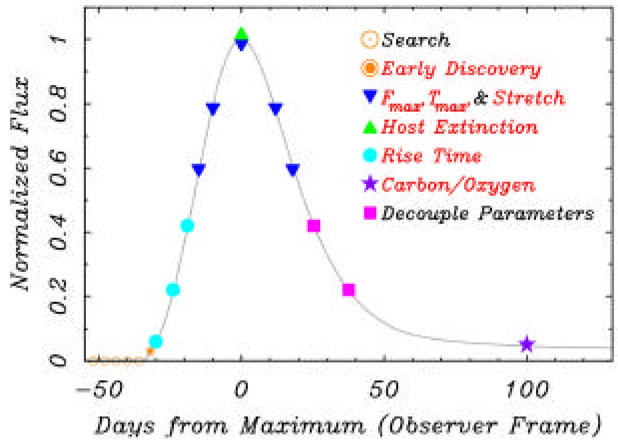
What makes the SN measurement special? Control of systematic uncertainties

At every moment in the explosion event, each individual supernova is “sending” us a rich stream of information about its internal physical state.

Lightcurve & Peak Brightness

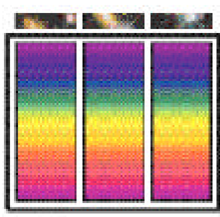
Images

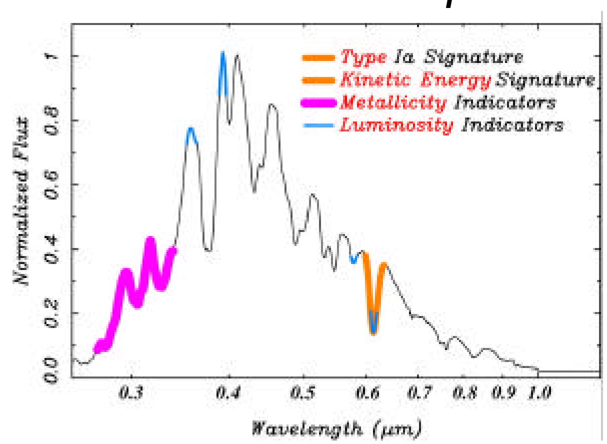




Redshift & SN Properties

Spectra





Ω_M **and** Ω_Λ

Dark Energy Properties

data → **analysis** → **physics**

Science Reach

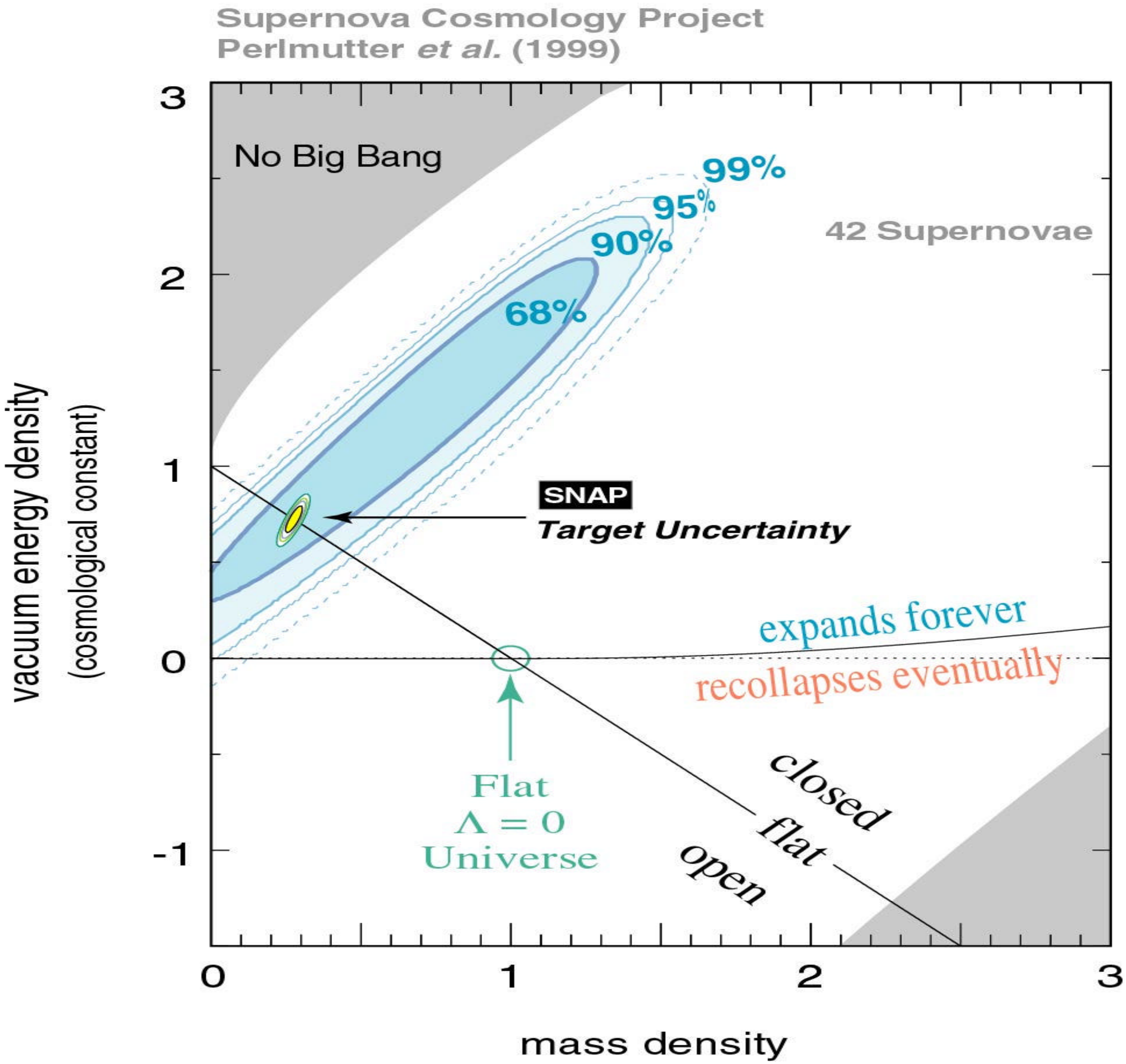
SNAP parameters from 2000 supernovae *including systematics*

	$s(W_M)$	$s(W_w)$	$s(\mathbf{w})$	$s(\mathbf{w'})$
w=–1	0.02	0.04		
w=–1; flat		0.01		
w=const; flat		0.02	0.08	
flat; Ω_M known; w=const			0.03	
flat; Ω_M known; $w(z)=w_0+w'z$			0.06	0.19

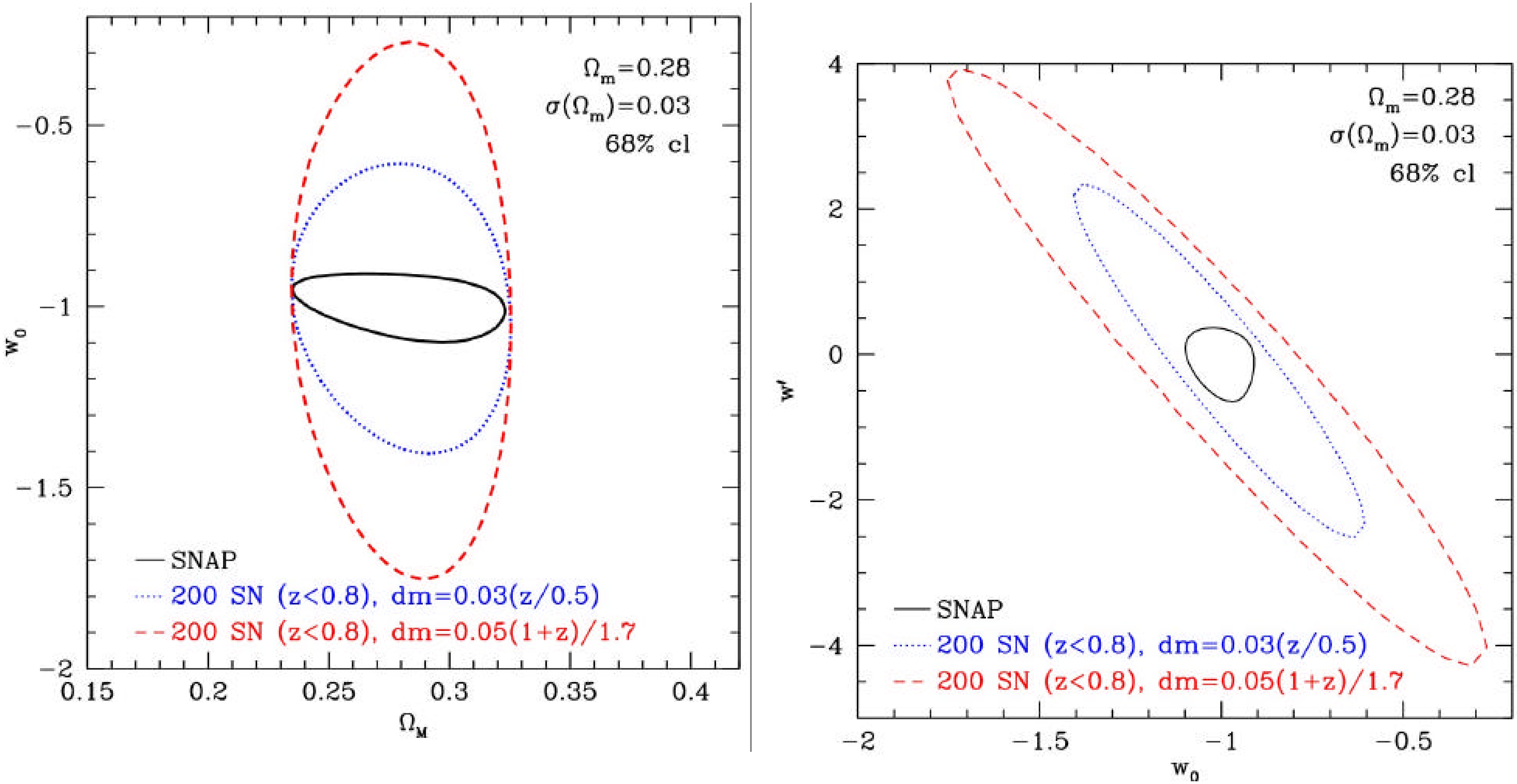
Key Cosmological Studies

- Type II supernovae
- Weak lensing
- Strong lensing
- Galaxy clustering
- Structure evolution
- Star formation / reionization

SNAP: The Third Generation



From Ground to Space



SNAP Cosmology Fitting Working Group

Deep SN surveys represent a major advance in understanding dark energy

New Parametrization for Dark Energy EOS

Time variation w´ is a critical clue to fundamental physics.

- **Deep surveys of galaxies and SN to $z>1$**
- **Large scale structure formation**
- **CMB constraints from $z_{lss}=1100$**

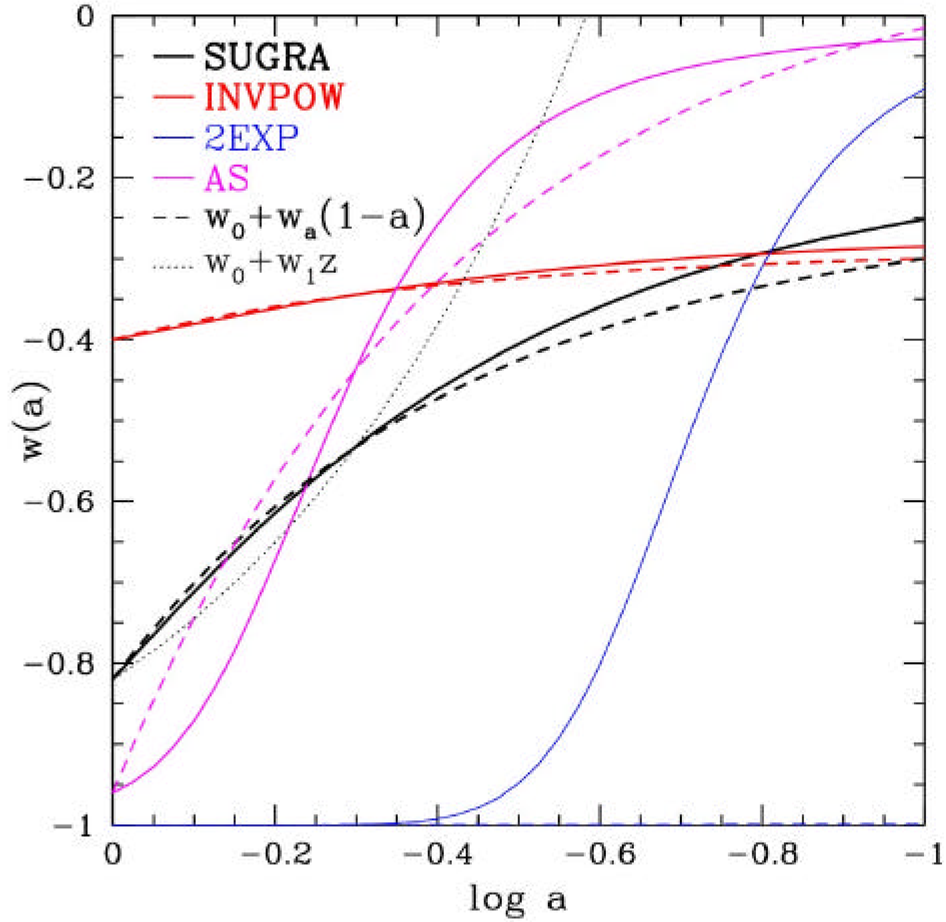
New parametrization

Linder 2002
PRL; astro-ph/0208512

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

- **Model independent, 2D phase space**
- **Well behaved at high z**
- **More accurate reconstruction**
- **More sensitive to data!**

Evolving Equation of State



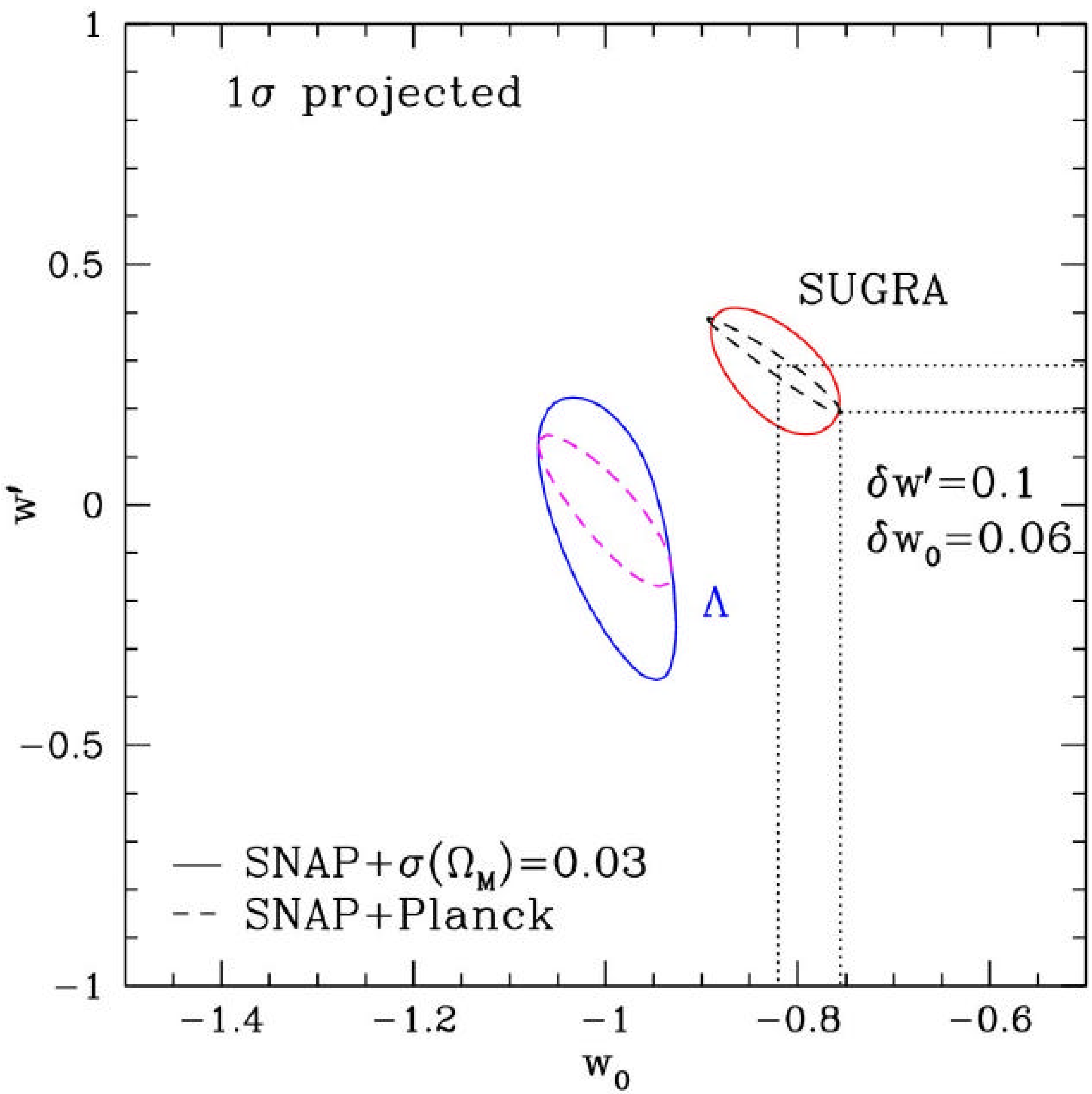
Linder 2002, astro-ph/0210217
following
Corasaniti & Copeland 2002

$w(a) = w_0+w_a(1\text{-}a)$

Accurate to 3% in EOS back to $z=1.7$ (vs. 27% for w_1).

Accurate to 0.2% in distance back to $z_{lss}=1100$!

SN + CMB Complementarity



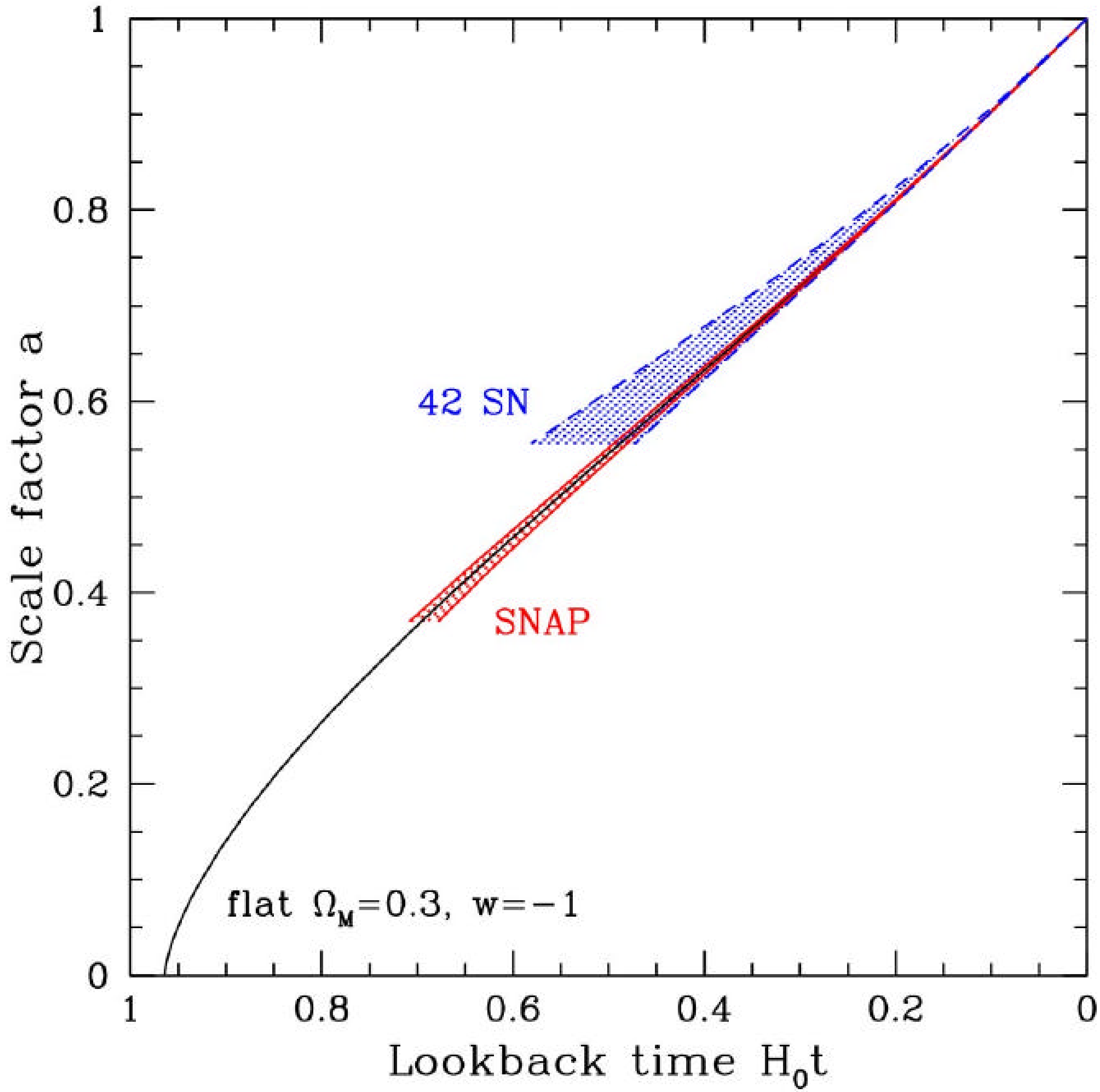
SNAP tightly constrains dark energy models.

SNAP+Planck have excellent complementarity, equal to a prior $s(W_M)$£0.01.

Frieman, Huterer, Linder, & Turner 2002

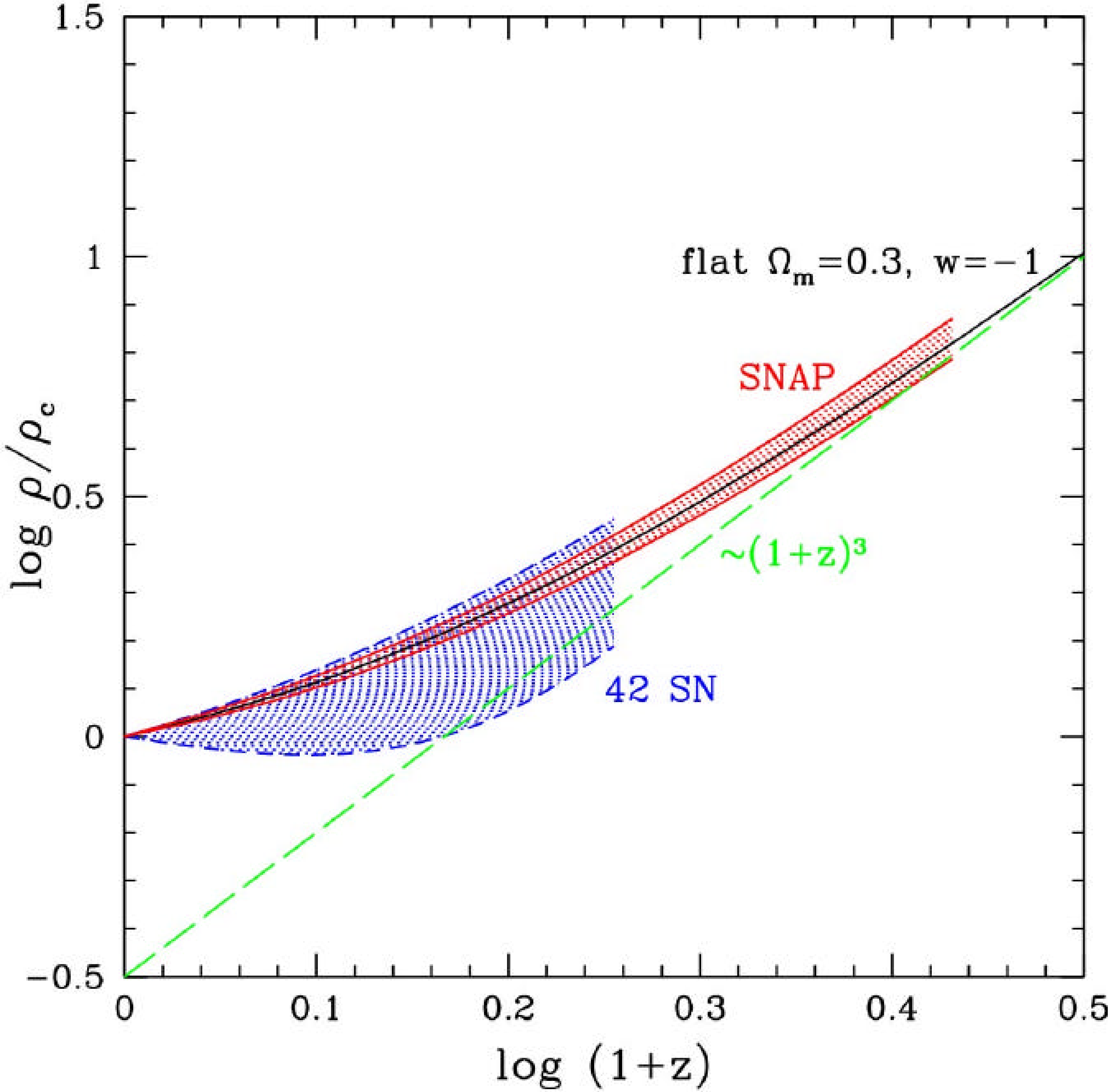
SNAP+Planck can detect time variation w´ at 99% cl (e.g. SUGRA).

Expansion History of the Universe



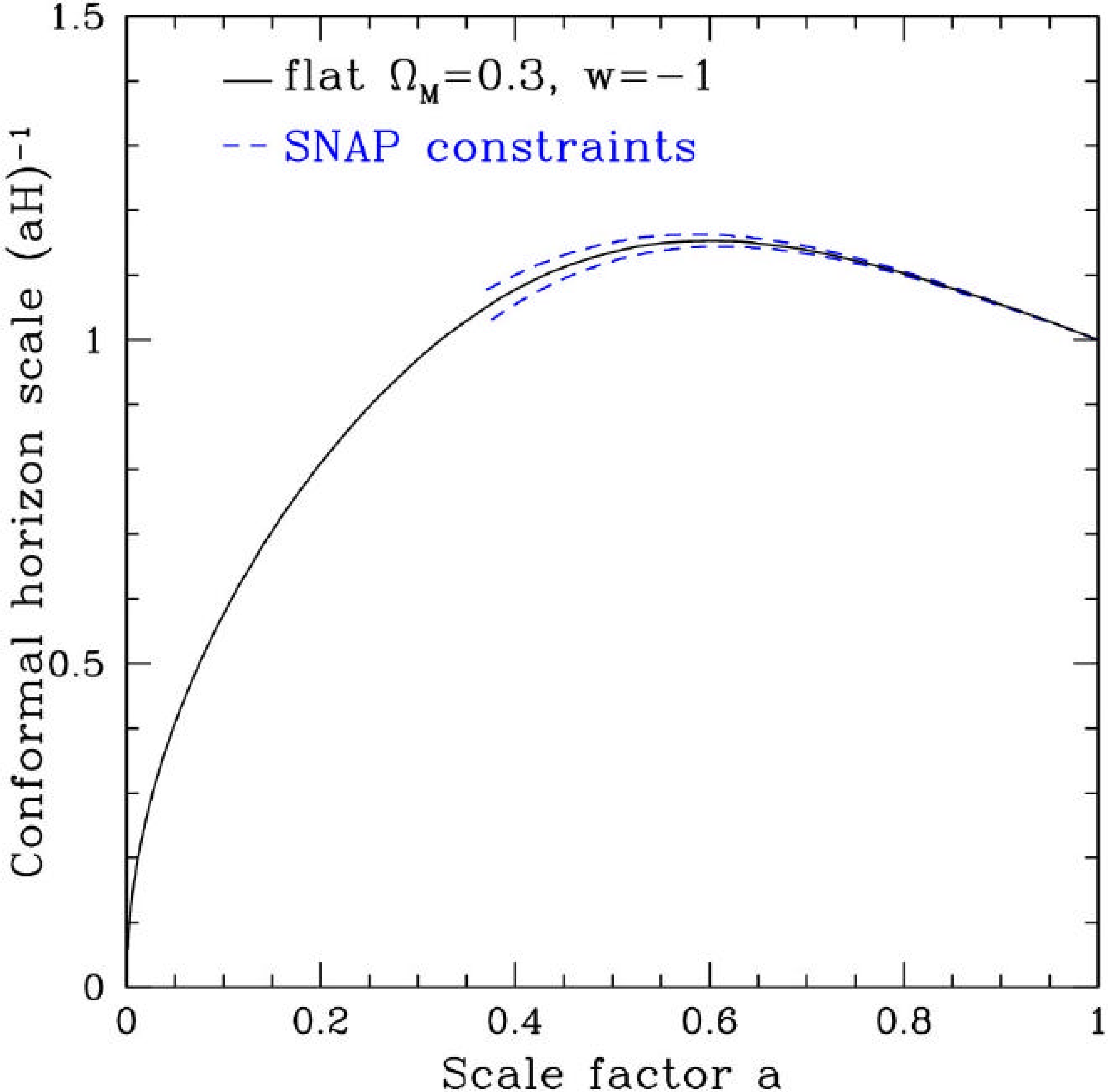
SNAP will map the expansion history, uncovering physics just like the thermal history revealed early universe physics.

Density History of the Universe



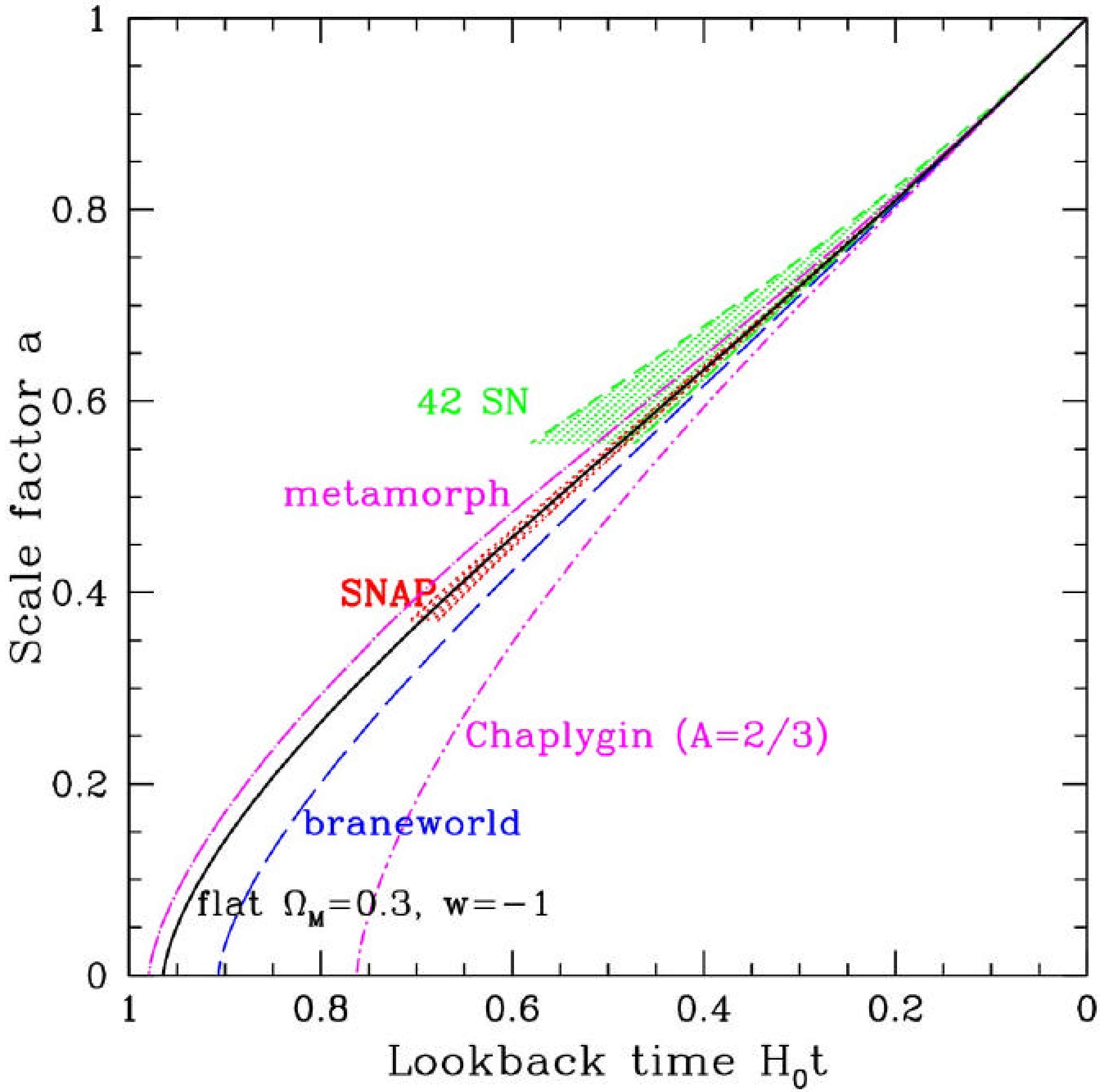
SNAP will map the density history precisely, back to the matter dominated epoch.

Present Day Inflation



SNAP will map the expansion history precisely and see the transition from acceleration to deceleration.

Beyond Dark Energy



SNAP can not only determine dark energy parameters, but test the cosmology framework – alternative gravitation, higher dimensions, etc.

Primary Science Mission Includes…

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

Type Ia supernova calibrated candle:
Hubble diagram to $z = 1.7$

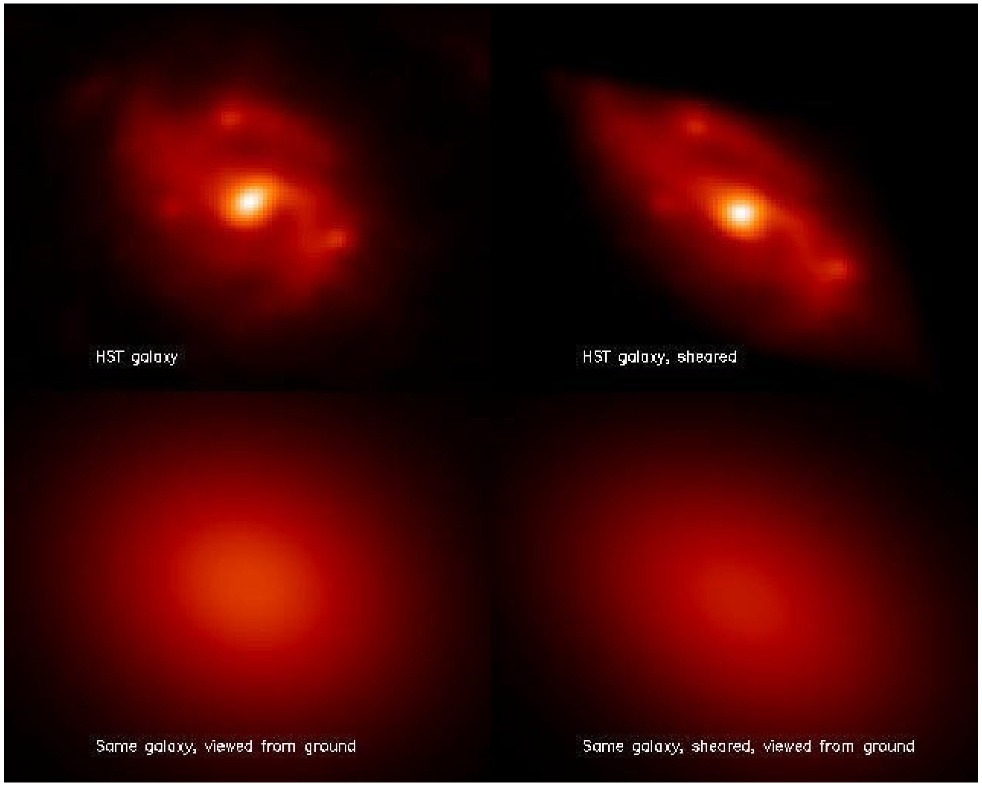
Type II supernova expanding photosphere:
Hubble diagram to $z = 1$ and beyond.

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

Weak lensing galaxy shear observed from space vs. ground



Bacon, Ellis, Refregier 2000

Wide, Deep, Colorful

- **9000 times the area of Hubble Deep Field**
- **15 sq.deg. to AB mag R=30 (scan 28, coadd 31)**
- **300 sq.deg. to AB mag R=28**
- **9 bands from 3500-17000Å**
- **Time domain survey**
- **Feed NGST, CELT** (as Palomar 48” to 200”, SDSS to 8-10m)
- ***Guest Survey* program**

  Quasars to z=10

  Galaxy morphology, evolution studies, merger rate to coadd m=31

  Stellar populations, distributions, evolution

  Epoch of reionization thru Gunn-Peterson effect

  Low surface brightness galaxies in H´ band, luminosity function

  Ultraluminous infrared galaxies

  Kuiper belt objects; Proper motion, transient, rare objects

SNAP and the Community

Resource Book on

Contributions from the Snowmass 2001 Workshop
on the Future of Particle Physics

edited by Eric Linder
Lawrence Berkeley National Laboratory

APS/DPF meeting – April 2003

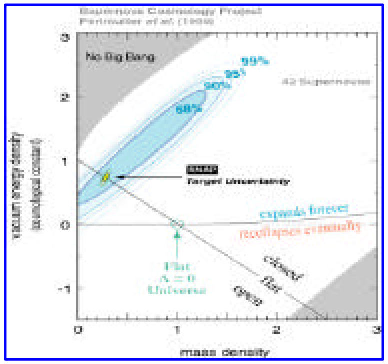
Dark Energy in the Next Generation **(session U12)**

- **Kallosh & Linde**
- **Albrecht**
- **Seljak**
- **Jain**
- **Bernstein**
- **Linder**
- **Caldwell**
- **Haiman**
- **Tegmark**

Resource for the Science Community

For Cosmologists

- Mapping the expansion history of the universe through the accelerating phase back into the decelerating epoch
- Precision determination of cosmological parameters



For Astronomers

- SNAP main survey will be 5000x larger (and as deep) than the biggest HST deep survey, the ACS survey
- Complementary to NGST: target selection for rare objects
- Can survey 300 sq. deg. in a year to J=28 (AB mag)
- Archive data distributed
- Guest Survey Program

Whole sky can be observed every few months

For Fundamental Physicists

- Exploring the nature of dark energy
- Testing higher dimension theories
- Testing alternate theories of gravitation