



Weak Lensing from Space with SNAP

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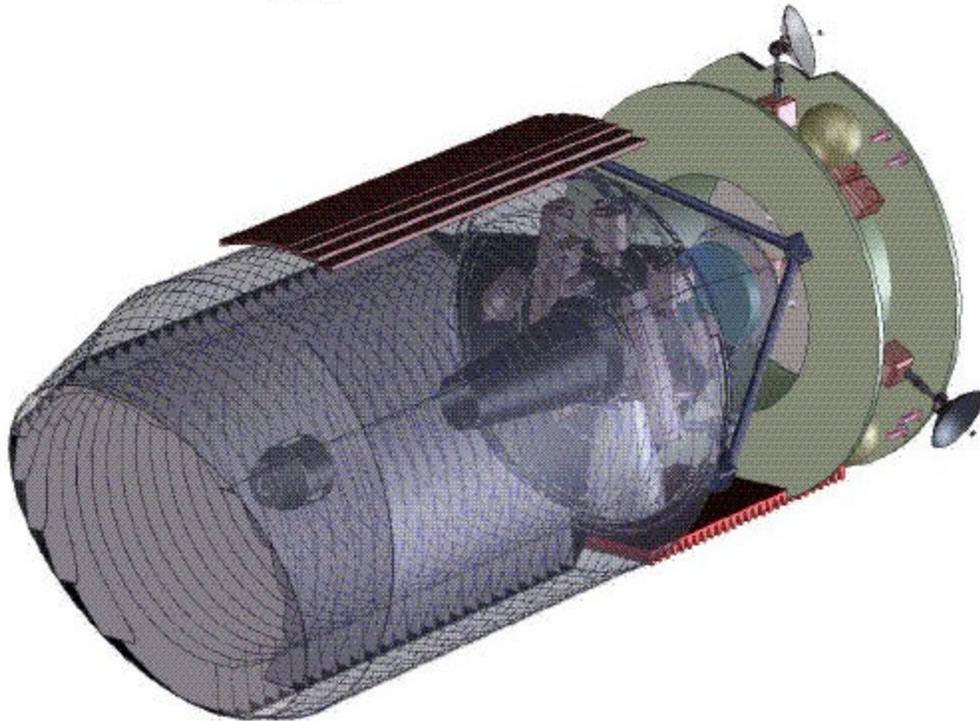
for the SNAP Lensing Working Group

Cambridge Workshop - July 2001

SNAP: SuperNova Acceleration Probe



SNAP SuperNova
Acceleration
Probe



SNAP:

- ~2 m telescope in space
 - 1 sq. degree field of view
 - 0.35-1.7 μ m imaging and (low-res) spectroscopy
 - 0.1" PSF (FWHM)
 - dedicated survey mode
- Wide field imaging from space

Institutions: LBNL (P.I.), U. Berkeley, CNRS/IN2P3/CEA/CNES, U. Paris VI & VII, U. Michigan, U. Maryland, Caltech, U. Chicago, STScI, U. Stockholm, ESO, Instituto Superior Tecnico

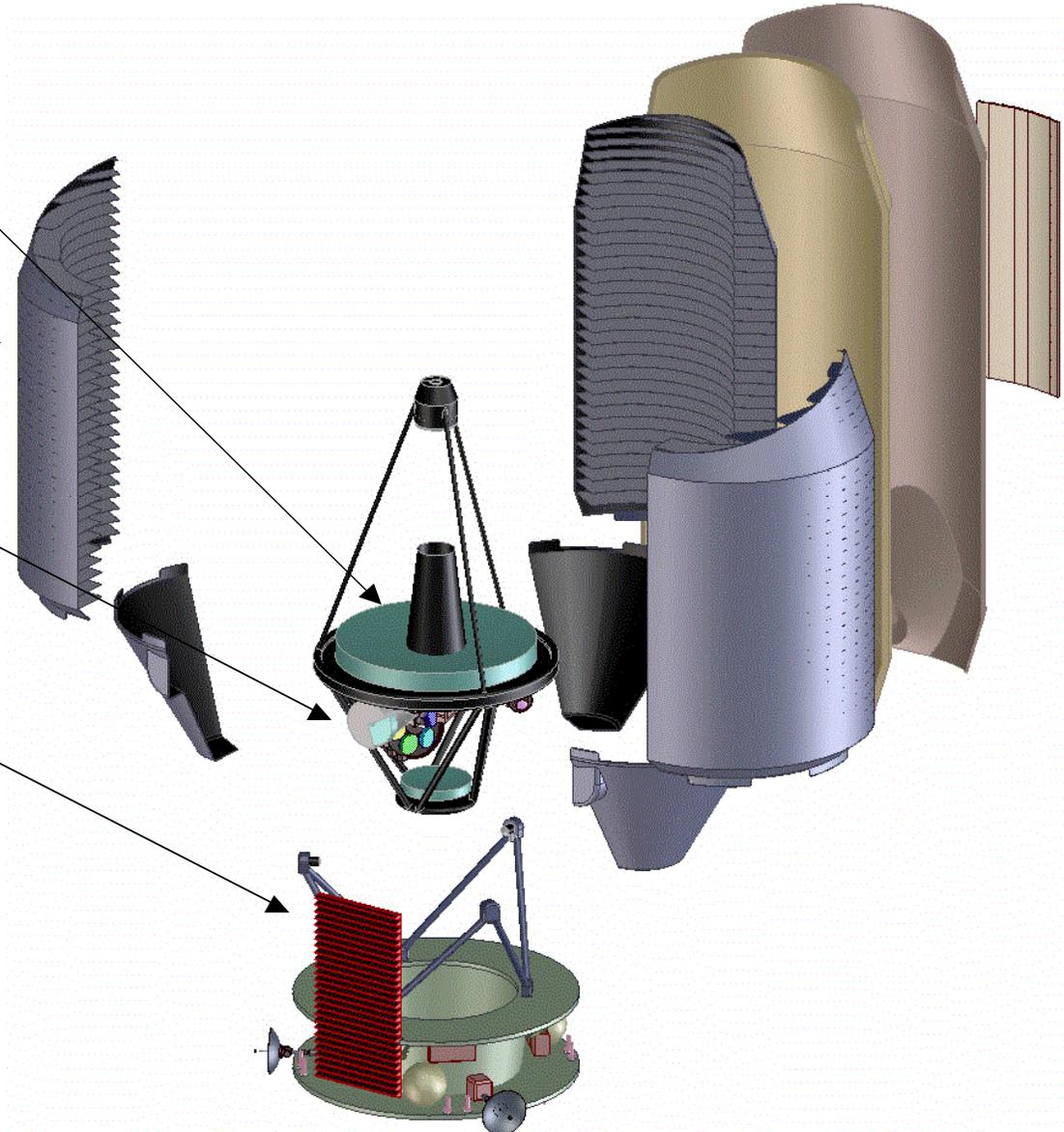
Mission Overview



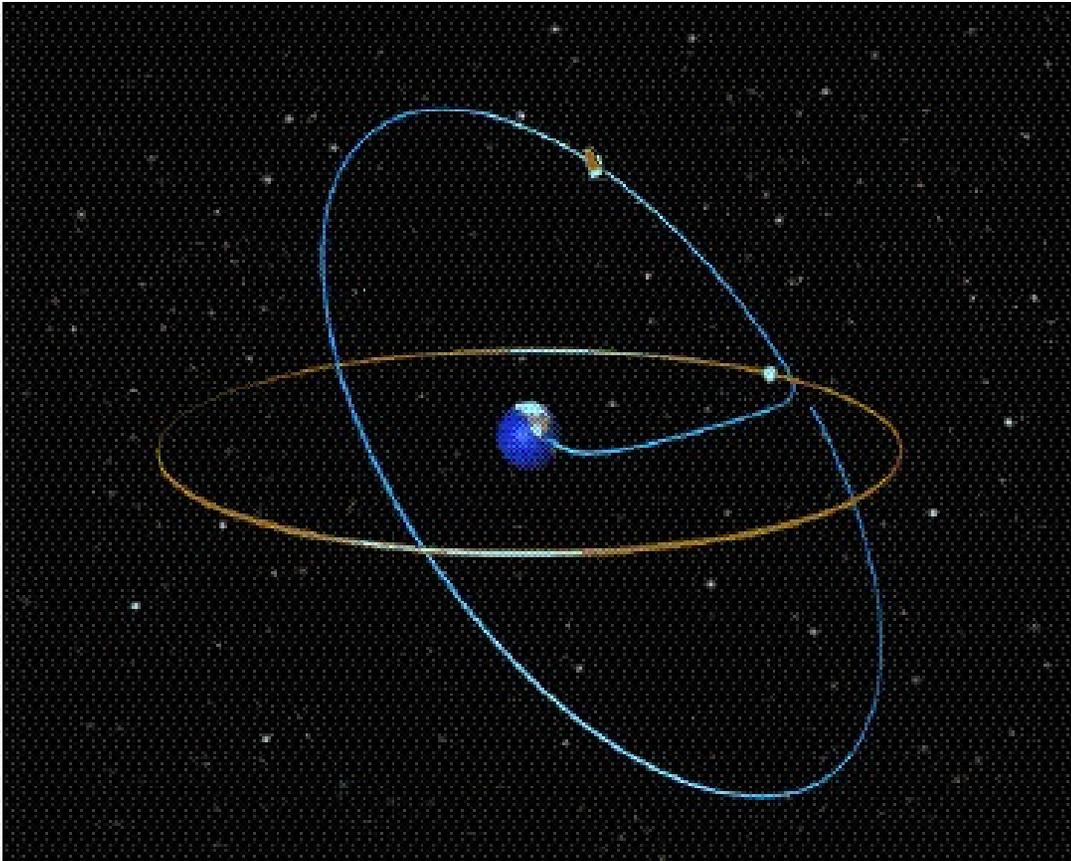
Simple Observatory consists of :

- 1) 3 mirror telescope w/ separable kinematic mount
- 2) Baffled Sun Shade w/ body mounted solar panel and instrument radiator on opposing side
- 3) Instrument Suite
- 4) Spacecraft bus supporting telemetry (multiple antennae), propulsion, instrument electronics, etc

Almost no moving parts (ex. filter wheels), rigid simple structure.



Orbit

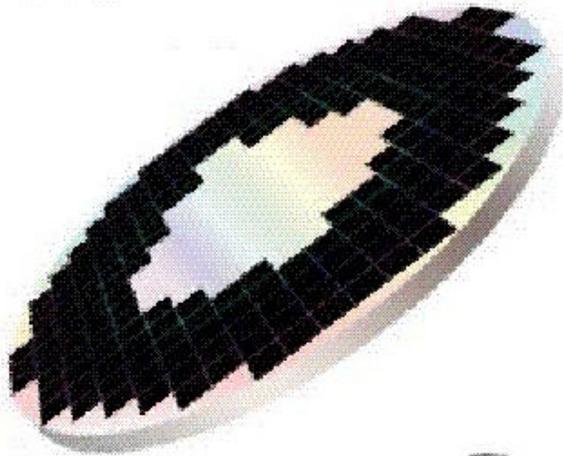


High Earth Orbit (38 Earth radii):

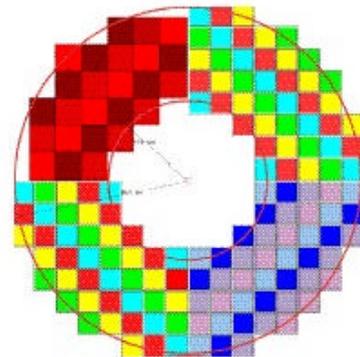
- Minimal thermal Changes
- Excellent telemetry (all the data is sent down to 3 ground stations)

→ reduced and controlled systematics

GigaCAM



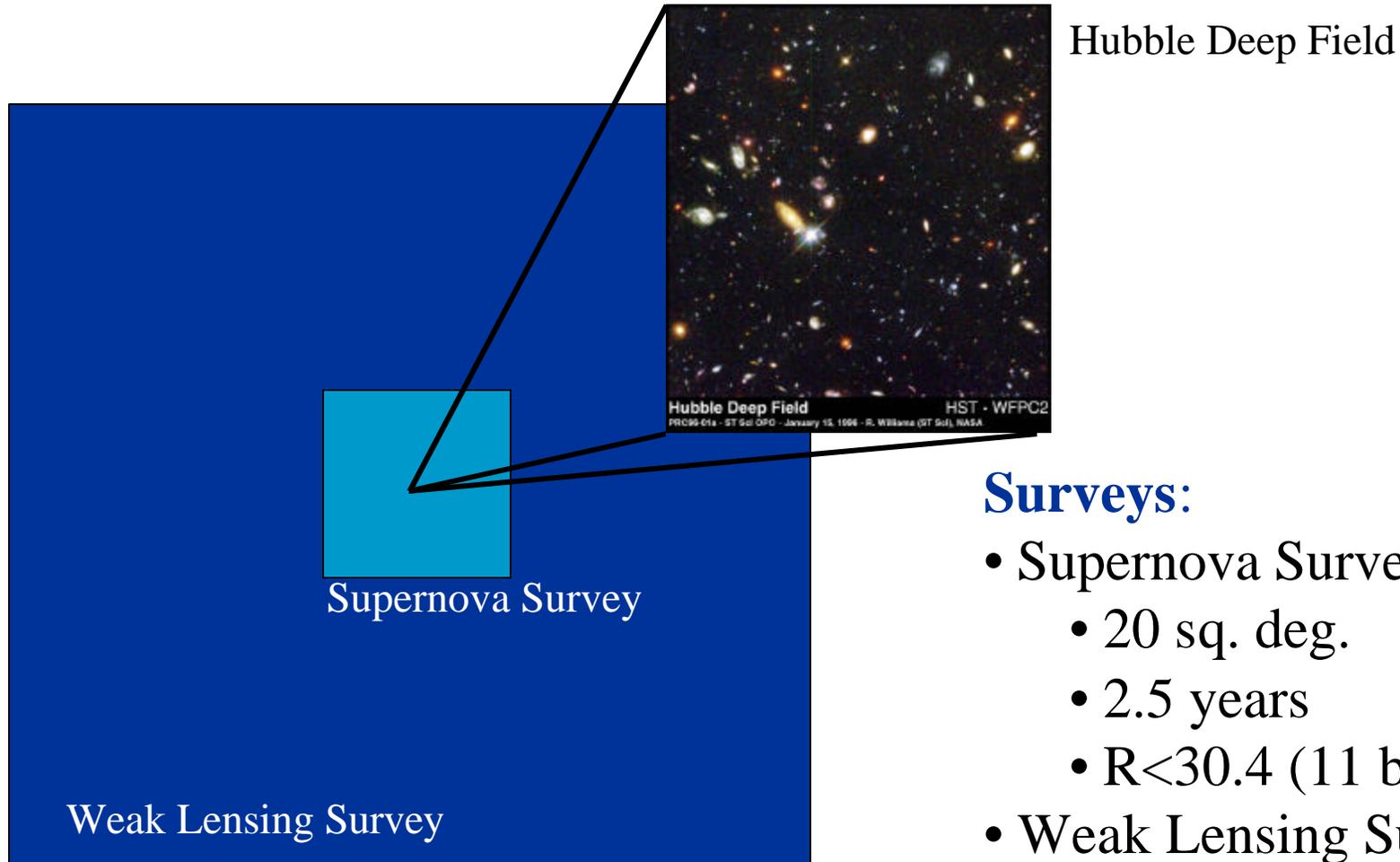
The Moon
(for scale)



3 IR filters on HgCdTe
8 visible filters on CCD

- 132 large format CCDs and 25 HgCdTe devices
- ~0.1'' pixels
- 8 visible and 3 IR filters
- About 1 billion pixels
- Field of view; 1 sq. deg.

SNAP Surveys



Hubble Deep Field

Supernova Survey

Weak Lensing Survey

Large number of exposures
(1 frame every ~4 days)

Surveys:

- Supernova Survey:
 - 20 sq. deg.
 - 2.5 years
 - $R < 30.4$ (11 bands)
- Weak Lensing Survey
 - 300 sq. deg.
 - 0.5-1 year
 - $R < 28.8$ (11 bands)

Mission Status



- Currently in the Study Phase of the project (funding from DoE and NSF)
- Feasibility was demonstrated (reviewed by Goddard Integrated Mission Design Center, NASA)
- Reviewed by a number of Agency committees (DoE, NSF, NASA) and by Peer Committees (ex. NRC committee on the Physics of the Universe)
- Expect to submit the proposal within a year or two
- Goal: fly by 2008 (about 4 years from approval to launch)
- Mission duration: 3 years, but expected to continue for several further years if funded
- Public archival data

Advantage of Space for Weak Lensing



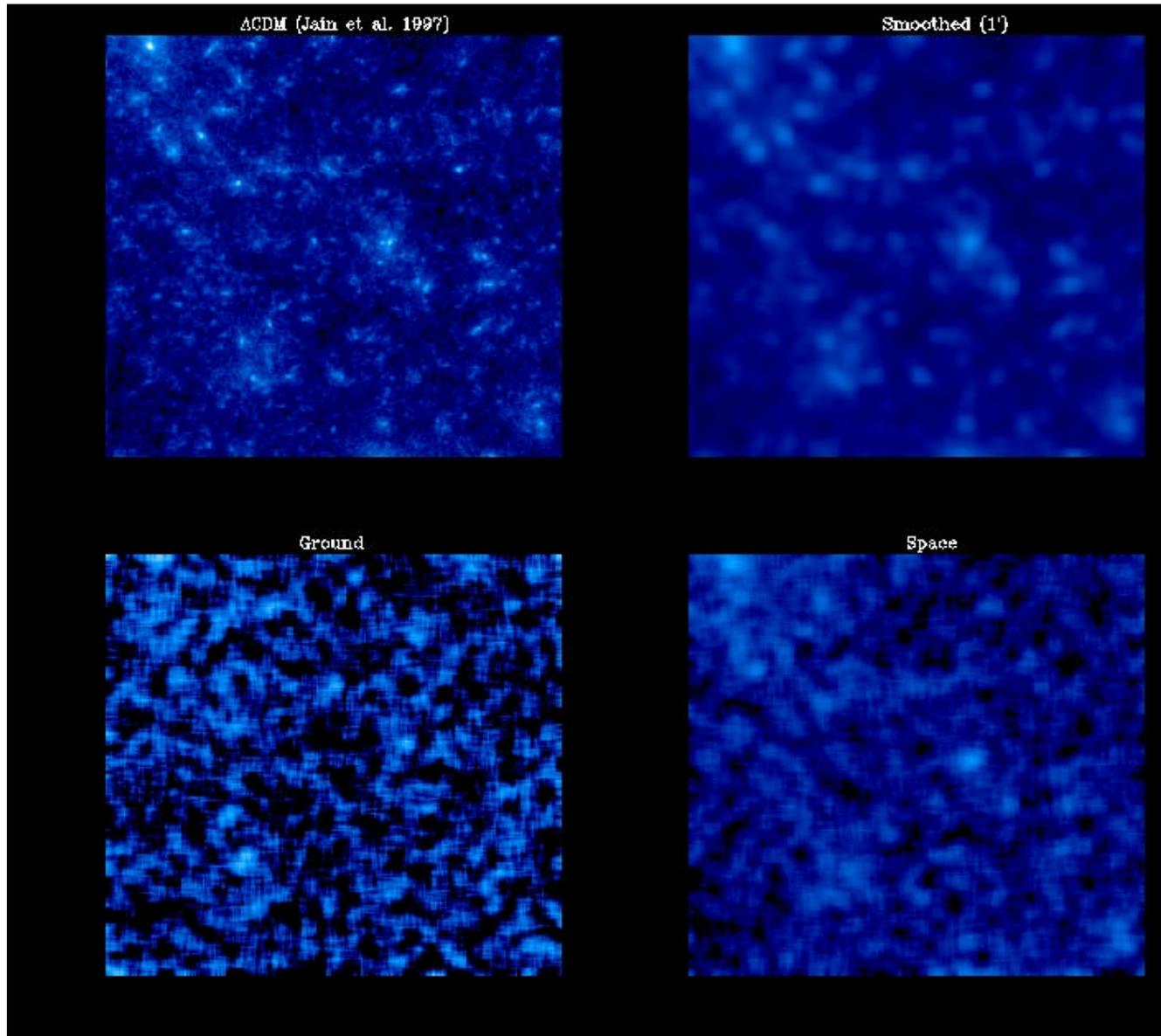
- larger surface density of resolved galaxies
- very reduced impact of the PSF smearing
- more shape information

Strengths of SNAP for Weak Lensing



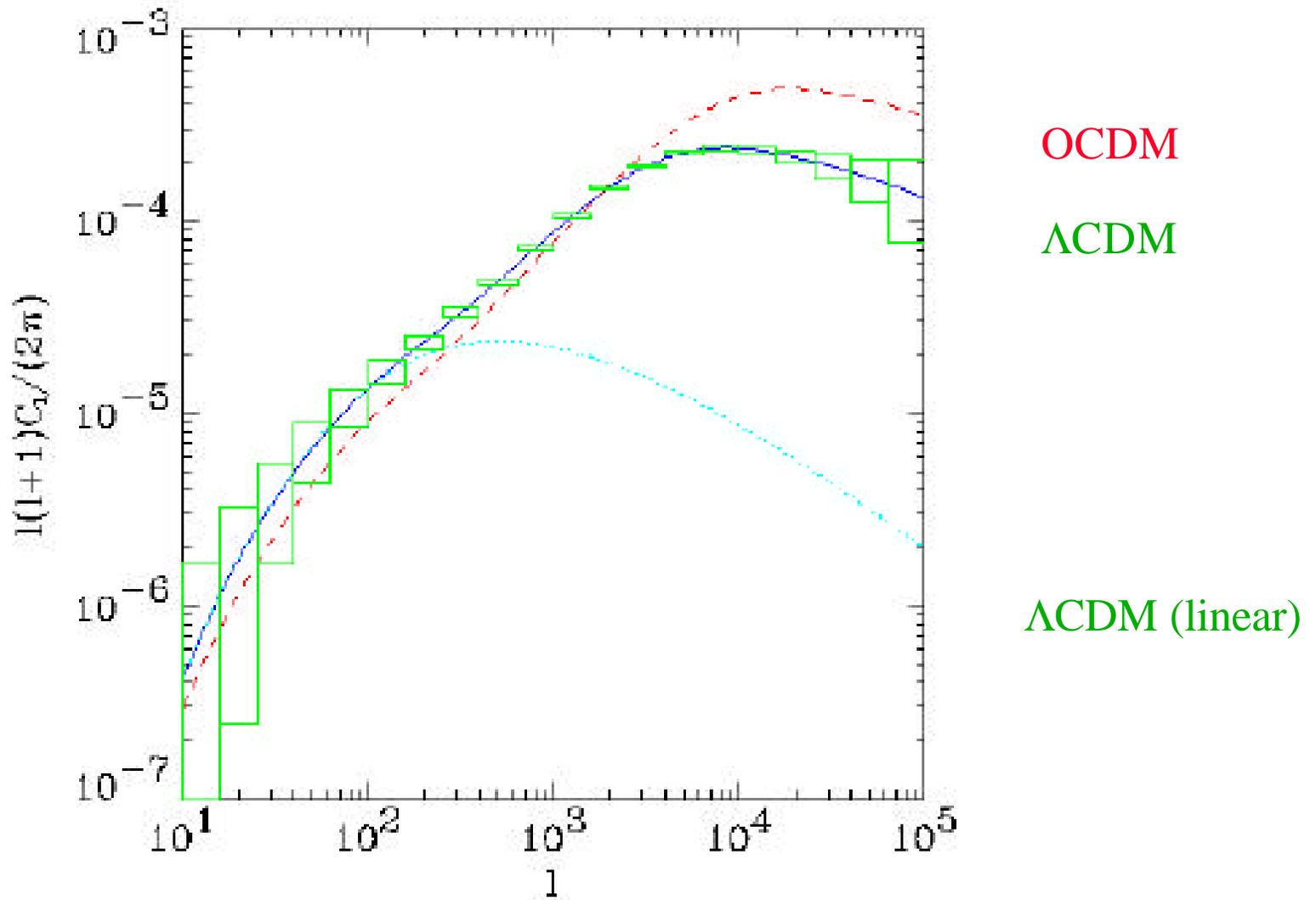
- Wide field in space - large survey area with exquisite image quality
- Depth of survey - reduced shot noise and mapping resolution
- Many photometric bands - evolution of structure as function of redshift
- Small PSF, Thermal stability, stringent optical requirements, multiple exposures - greatly reduced systematics

Mapping the Dark Matter



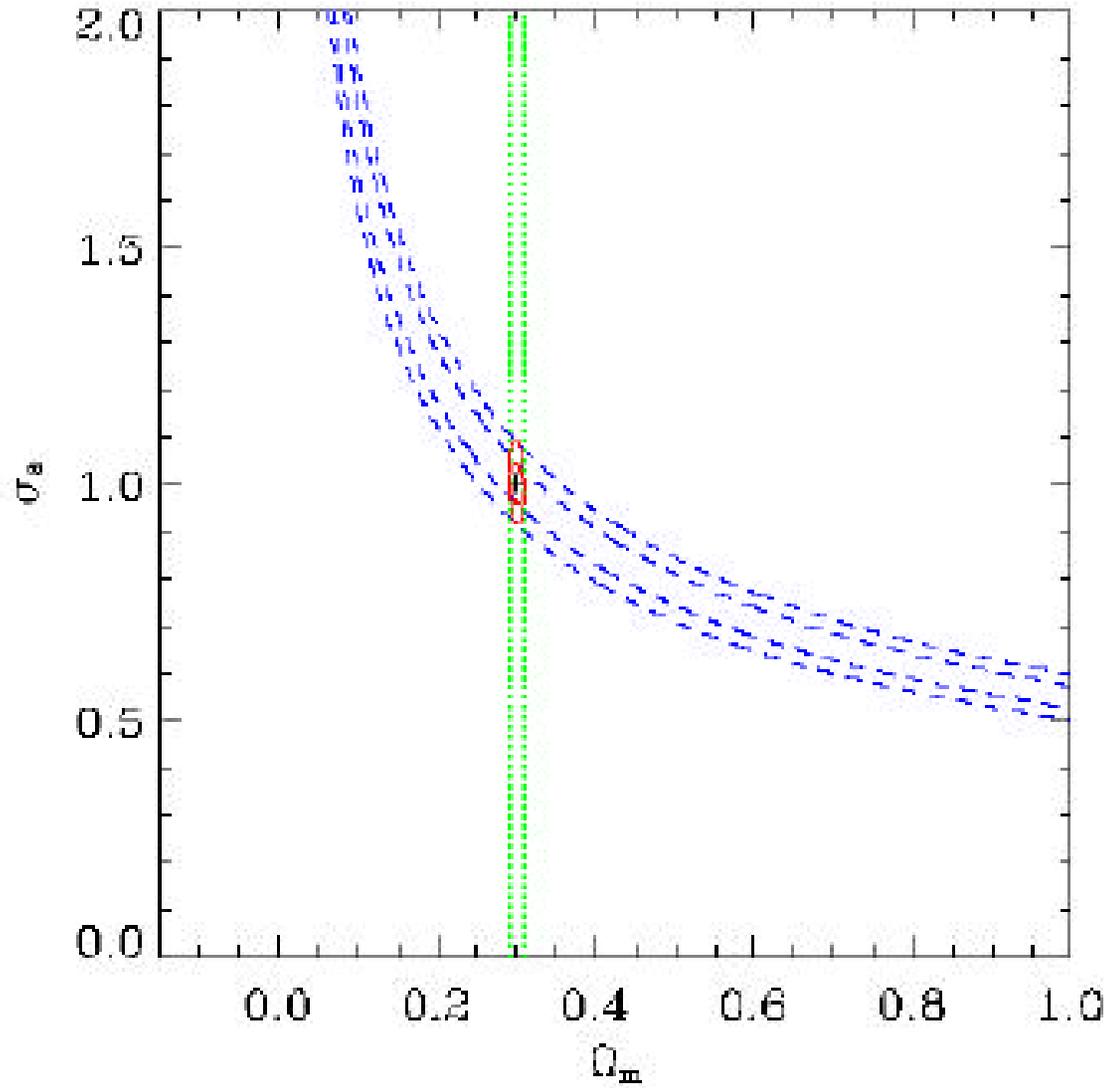
LCDM
0.5x0.5 deg
Jain et al. 1998

Lensing Power Spectrum



SNAP WF survey [300 deg² ; 100 g arcmin⁻²; HST image quality]

New cosmological constraints



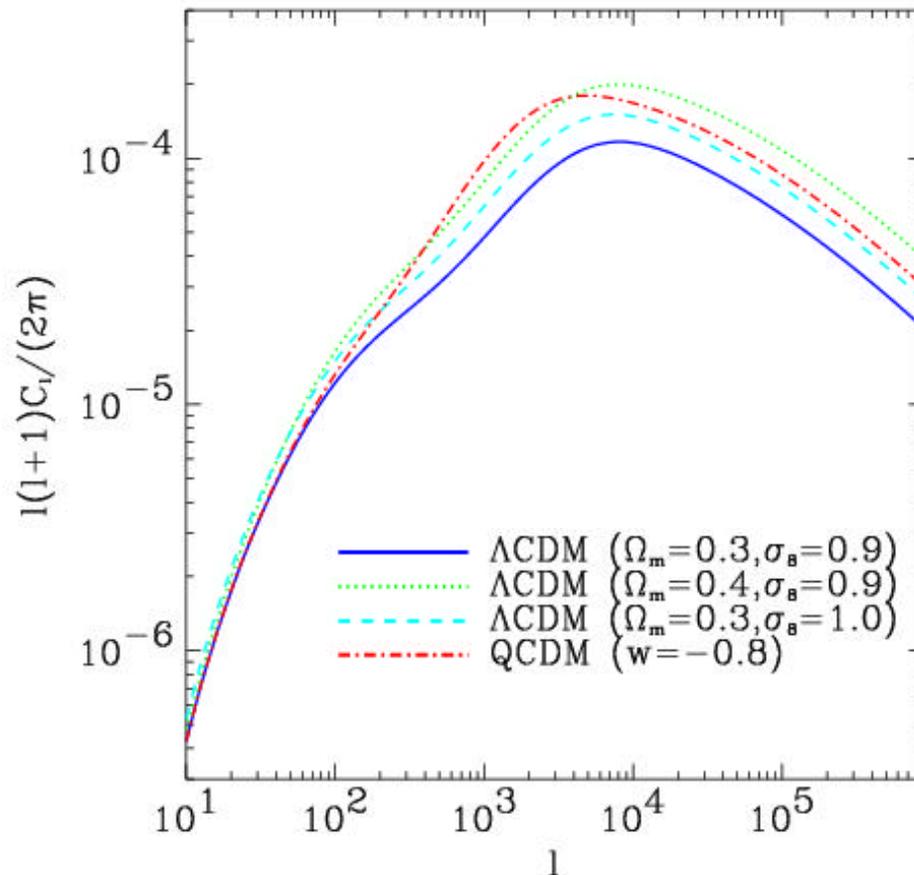
Cf. Bernardeau et al. 1997

Variance: $\langle k^2 \rangle$

Skewness: $\langle k^3 \rangle$

Data will break current degeneracies (e.g. \mathbf{W}_M and \mathbf{s}_8 ; \mathbf{W}_M and w)

Power Spectrum with Dark Energy



Use the non-linear power spectrum for quintessence models of [Ma, Caldwell, Bode & Wang \(1999\)](#)

→ The Dark Energy equation of state ($w=p/\rho$) can be measured from the lensing power spectrum

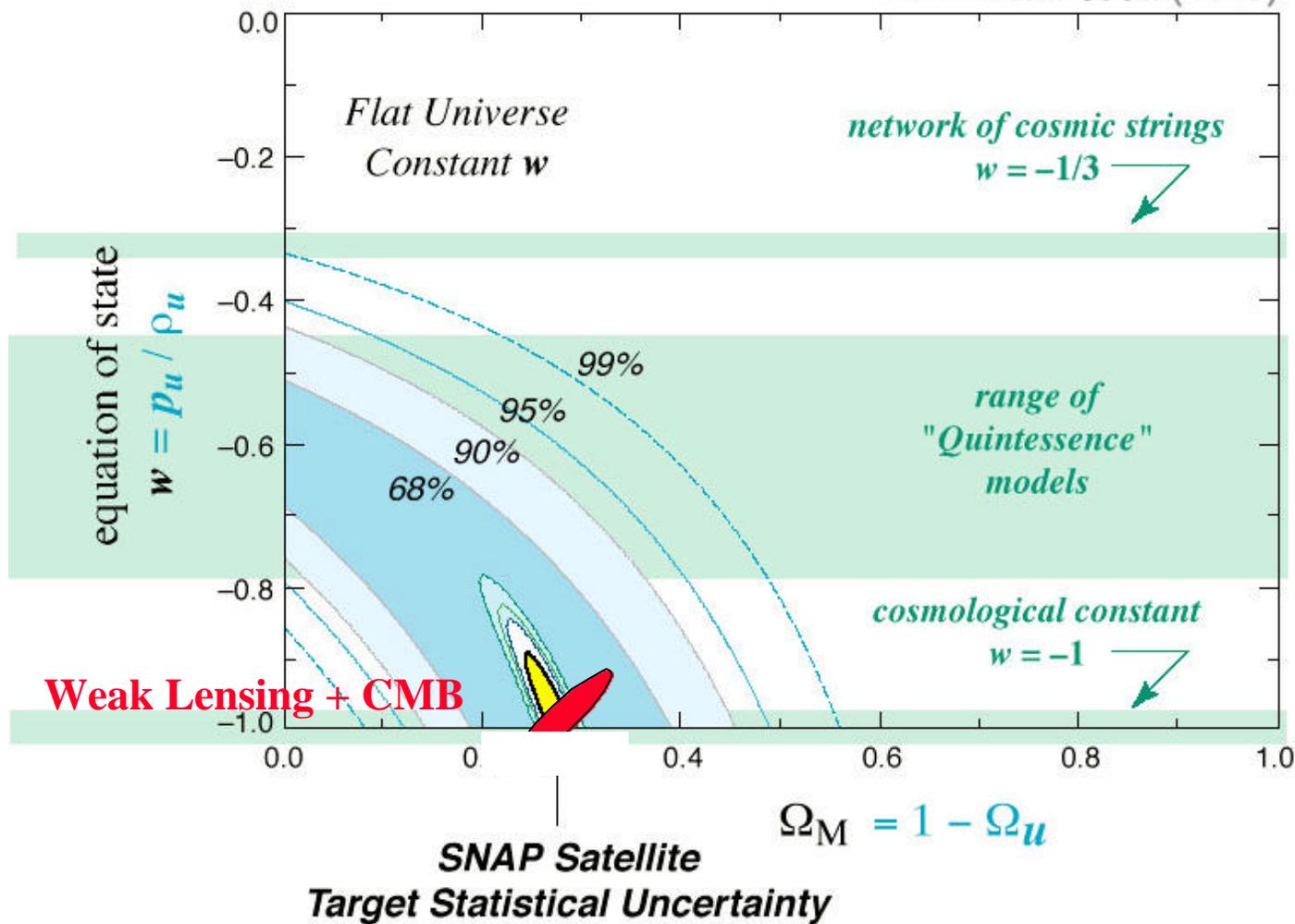
→ But, there is some degeneracy between w , Ω_M and σ_8

Complementarity of Weak Lensing and Supernovae

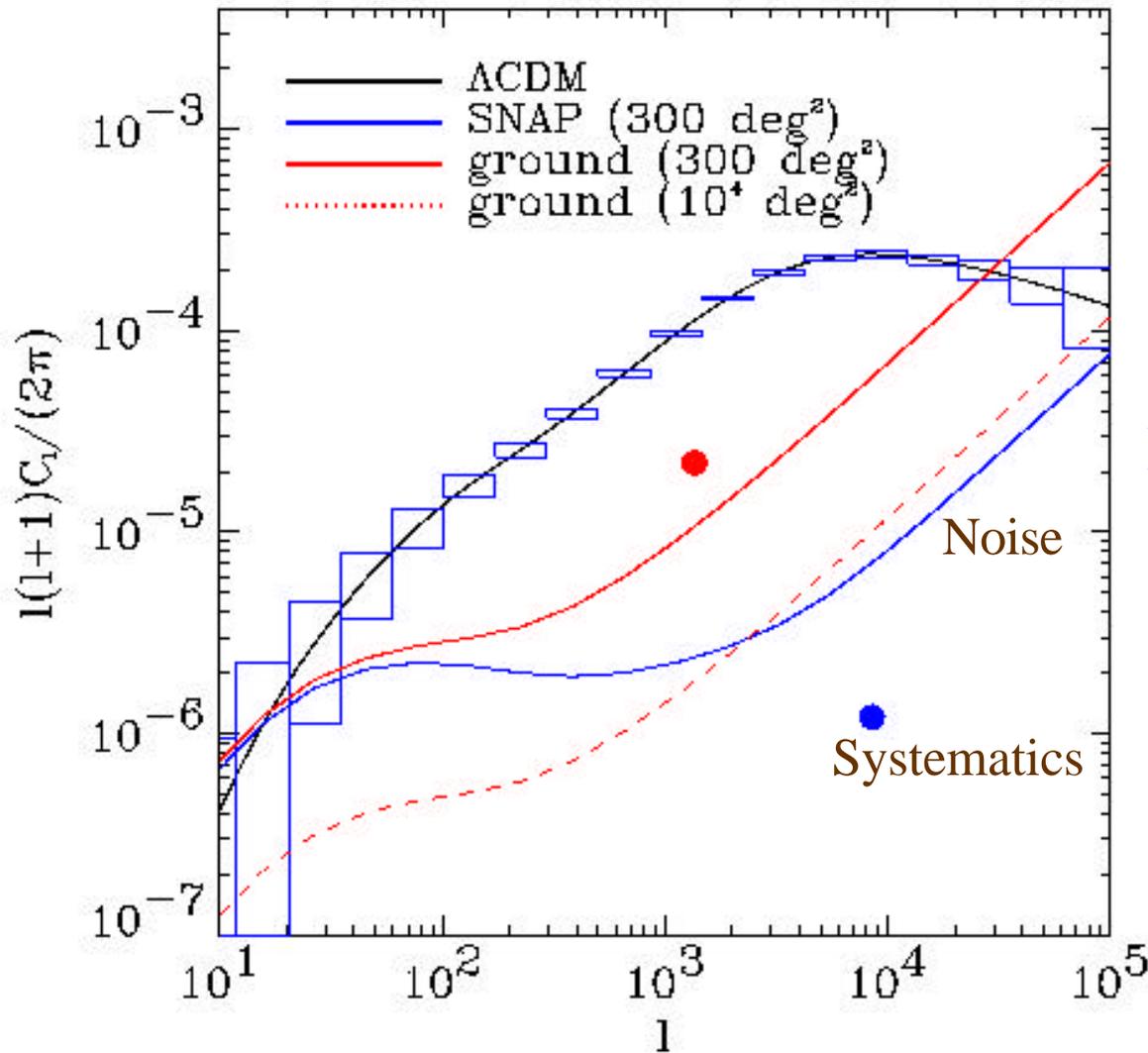


Weak Lensing breaks degeneracies in w - Ω_M plane. Does w vary?

Supernova Cosmology Project
Perlmutter *et al.* (1998)



Systematics: Ground vs Space



$$\mathbf{g}_{\text{sys}} \propto \left(\frac{\mathbf{q}_{\text{psf}}}{\mathbf{q}_{\text{gal}}} \right)^2 \mathbf{e}_{\text{psf}}$$

Noise and Systematics are greatly reduced in space

Conclusions



- SNAP will open the window of wide field imaging from space
- Ideal instrument for weak lensing, which complements Sne (Dark Energy+Dark Matter)
- Systematics are likely to be much reduced
- SNAP will yield a map of the dark matter, and a precise measurement of the evolution of structures
- Complementary to wide-field ground based survey