Why overlapping spectrometric and photometric surveys?

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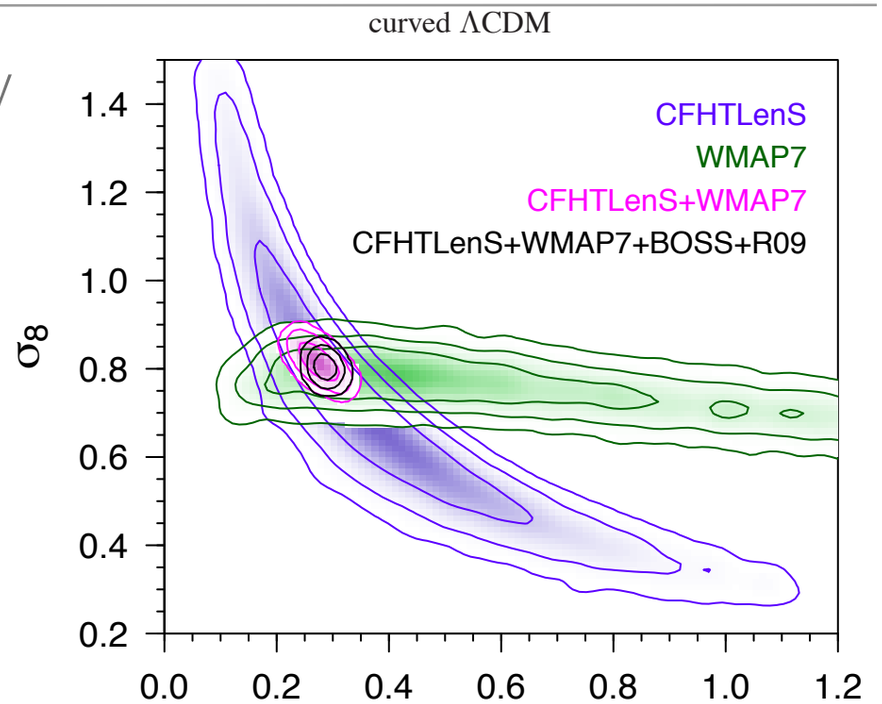
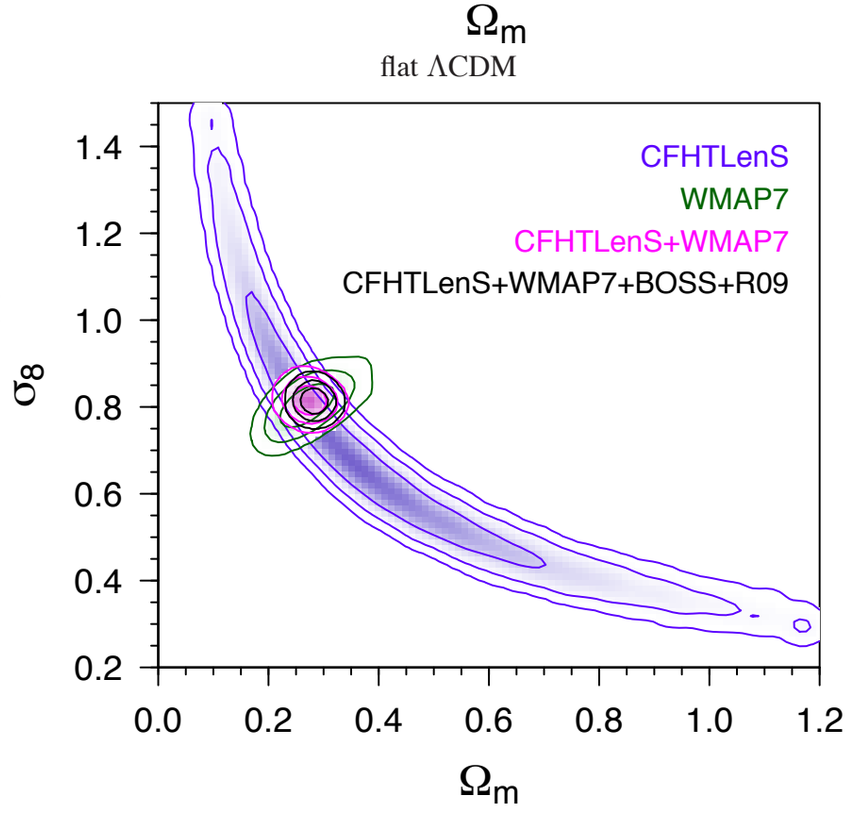
(work in progress)

Cosmic Complementarity

- The complementarity of photometric and spectroscopic survey has been recognized and is defining the present and future large scale cosmological surveys.
- Deep photometric surveys allow for gravitational lensing measurements:
  - A direct probe of the growth of (projected) dark matter perturbations
  - This projection is weighted by distance ratios and *n(z)*
- Spectroscopic surveys gives us access to the full 3D structure of galaxies. It offers:
  - A direct and robust geometrical test (BAO)
  - A direct probe of the growth of structures through Redshift Space Distortion (RSD)
  - The latter requires to relate galaxies and dark matter (*bias*)
- This complementarity motivates the current and future generation of Dark Energy probes:
  - DES, HSC, Euclid
  - BOSS, PFS, BigBOSS/DESpec/MS-DASY, Euclid





Kilbinger++12

Is There More To It?

- It was recently suggested that by overlapping WL and Spectroscopic surveys, one could have substantial gains in cosmological informations when comparing to non-overlapping surveys (Bernstein & Cai 2011; Gaztanaga++2011; Cai & Bernstein 2012). Factors of 100 gains in FOM were quoted in Gatzanaga et al. so it lead to some excitement.

$$P_g(k,\mu) = b_g^2(1+\beta\mu^2)^2 P_m(k) \qquad \beta = \frac{f}{b_g} = \frac{1}{b_g}\frac{d\ln D}{d\ln a}$$

Kaiser 87

- Combining the ***k*** and μ dependence one can measure the growth rate, f, and also the bias, b_g .

- The idea articulated in these papers is that WL survey will lead to a strong absolute bias determination which could in turn lead to a better measurement of f and the Pm(k) shape information.

- But with P_g alone, one can also measure b_g in principle (Song & White 08, White++08).

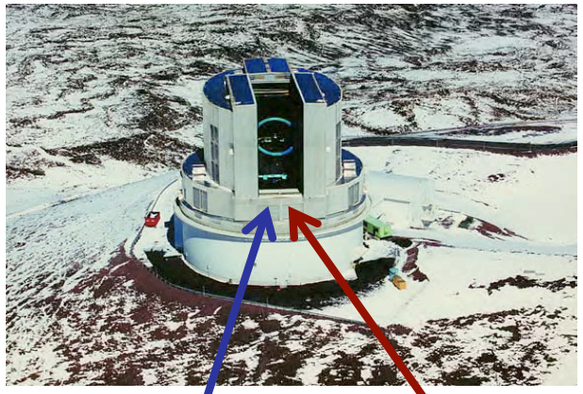
- We revisit this promissing idea using two well defined surveys:

  - SuMIRe

  - Euclid

SuMIRe: Subaru Measurement of Images and Redshifts

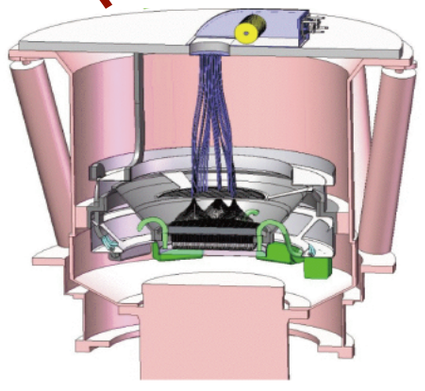
- Goal: to build a wide-field camera (Hyper SuprimeCam) and wide-field multi-object spectrograph (Prime Focus Spectrograph) for the Subaru Telescope (8.2m)



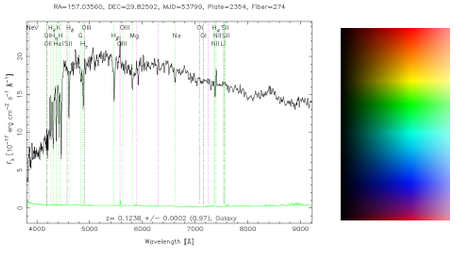
Subaru (NAOJ)

- HSC baseline design:
  - Wide FoV: 1.5° in diameter, i.e., 10×Suprime-Cam
  - Deep multi-band imaging (grizy; i~26, y~24)
  - Wide 1500 sq. deg. survey

HSC



PFS

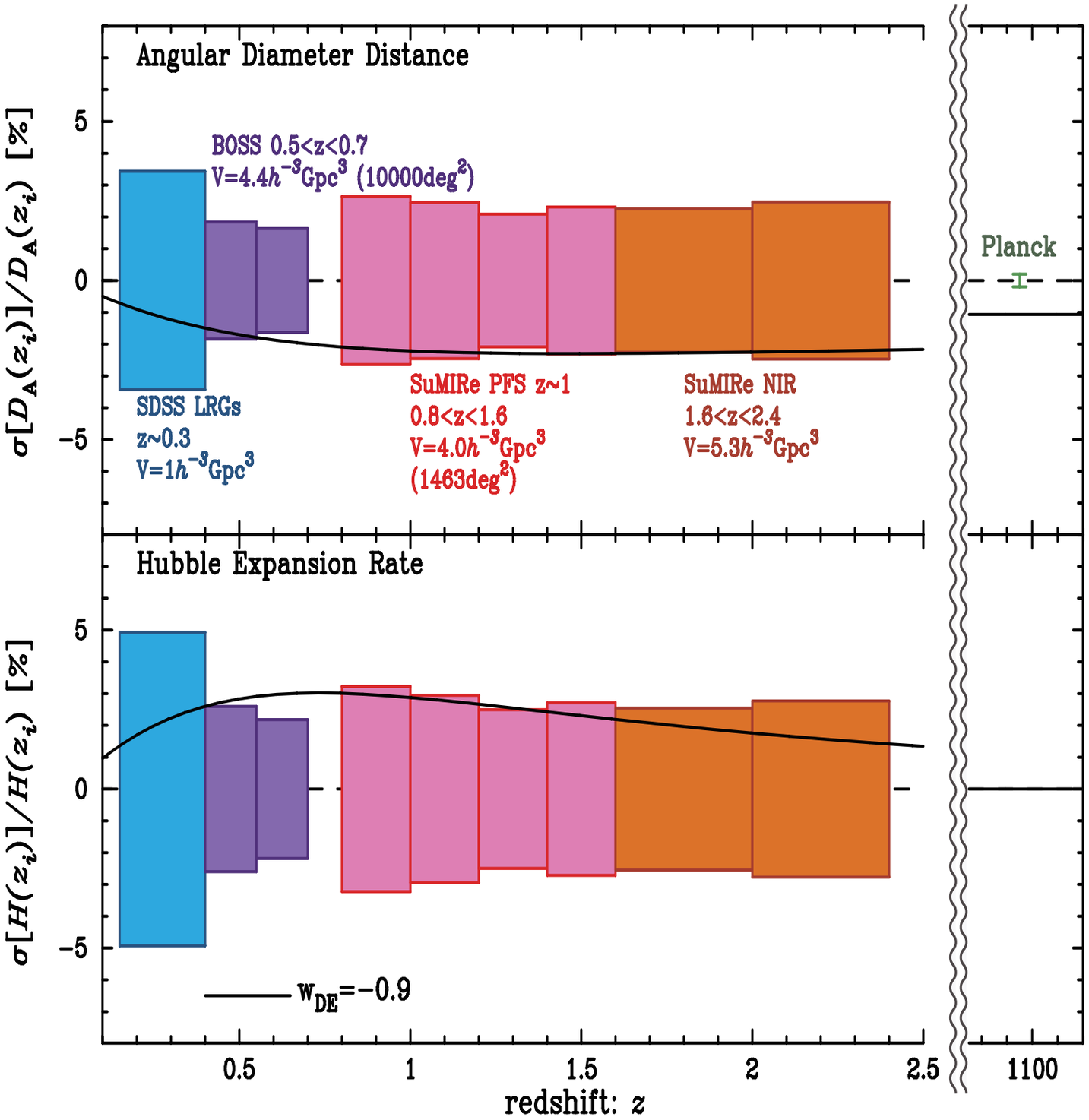


- PFS baseline design:
  - The same optics as HSC
  - Use HSC for target selection
  - 2400 fibers
  - 380-1300 nm wavelength coverage
  - Wide 1500 sq. deg. survey
  - R~2000,3000,5000 (blue,red,NIR)

SuMIRe Project Status

- Hyper Suprime Cam (HSC) project:
  - Collaboration: Japan – Princeton – Taiwan
  - Already fully funded (~$50M in total); started in 2006
  - The instrumentation has been led by NAOJ (Satoshi Miyazaki)
  - The science survey will start in 2013 and last for 5 years
  - Commissioning on-going. Image quality of roughly 0.6 arcsec (FWHM) throughout the full FOV demonstrated recently.
  - Main science driver: Weak lensing for DM and DE, Galaxy clusters out to z~1.5 (WL+SZ+optical), QSO to z~7
  - Update can be fund http://anela.mtk.nao.ac.jp/hscblog/builder/ (in Japanese only for now...)
- Prime Focus Spectrograph (PFS) project:
  - Collaboration: Japan, Caltech/JPL, Princeton, LAM (France), Taiwan, Brazil, JHU
  - Total cost about ~$70M, partially funded. Consortium optimistic and construction under-way.
  - Considered as one of the mid-scale projects in Japan
  - Preliminary Design Review (PDR) successfully passed two weeks ago.
  - The PFS survey should start in 2017 and last 5 years
  - Main scientific drivers: Cosmology, Galaxy Evolution, Galactic Archeology (Ellis++1206.0737)

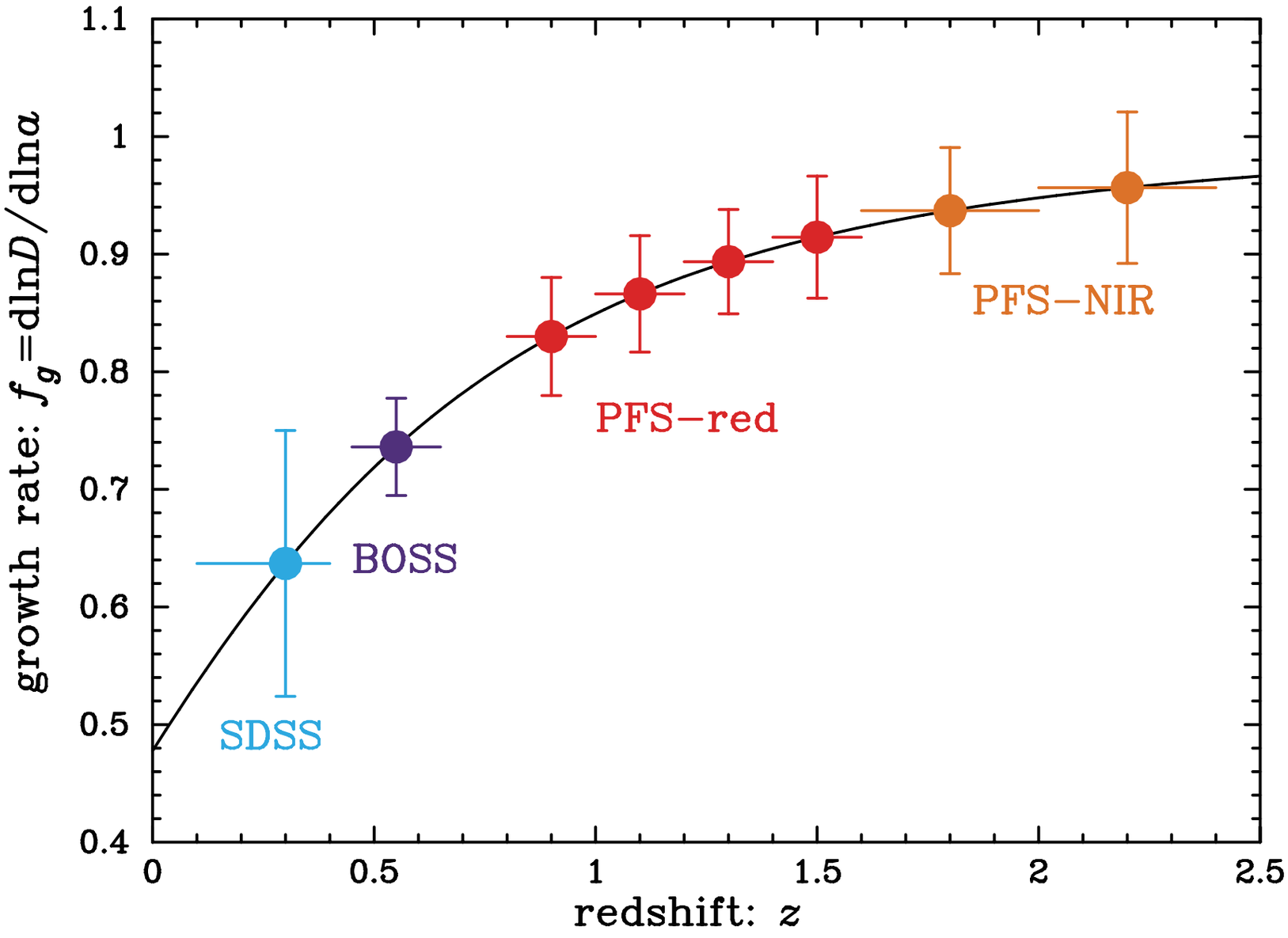
PFS Cosmology Survey Goals - I



- The PFS survey design allows a few % accuracy of measuring $D_A(z)$ and $H(z)$ in each redshift (each of 6 bins)
- Comparable with BOSS, but in different redshift range
  - BOSS (2.5m): 5 yrs
  - PFS (8.2m): 100 nights
- BOSS Ly-alpha also probes BAO at z=2-3 (e.g., Slozar++12)

PFS White paper: Ellis++1206.0737

PFS Cosmology Survey Goals - II

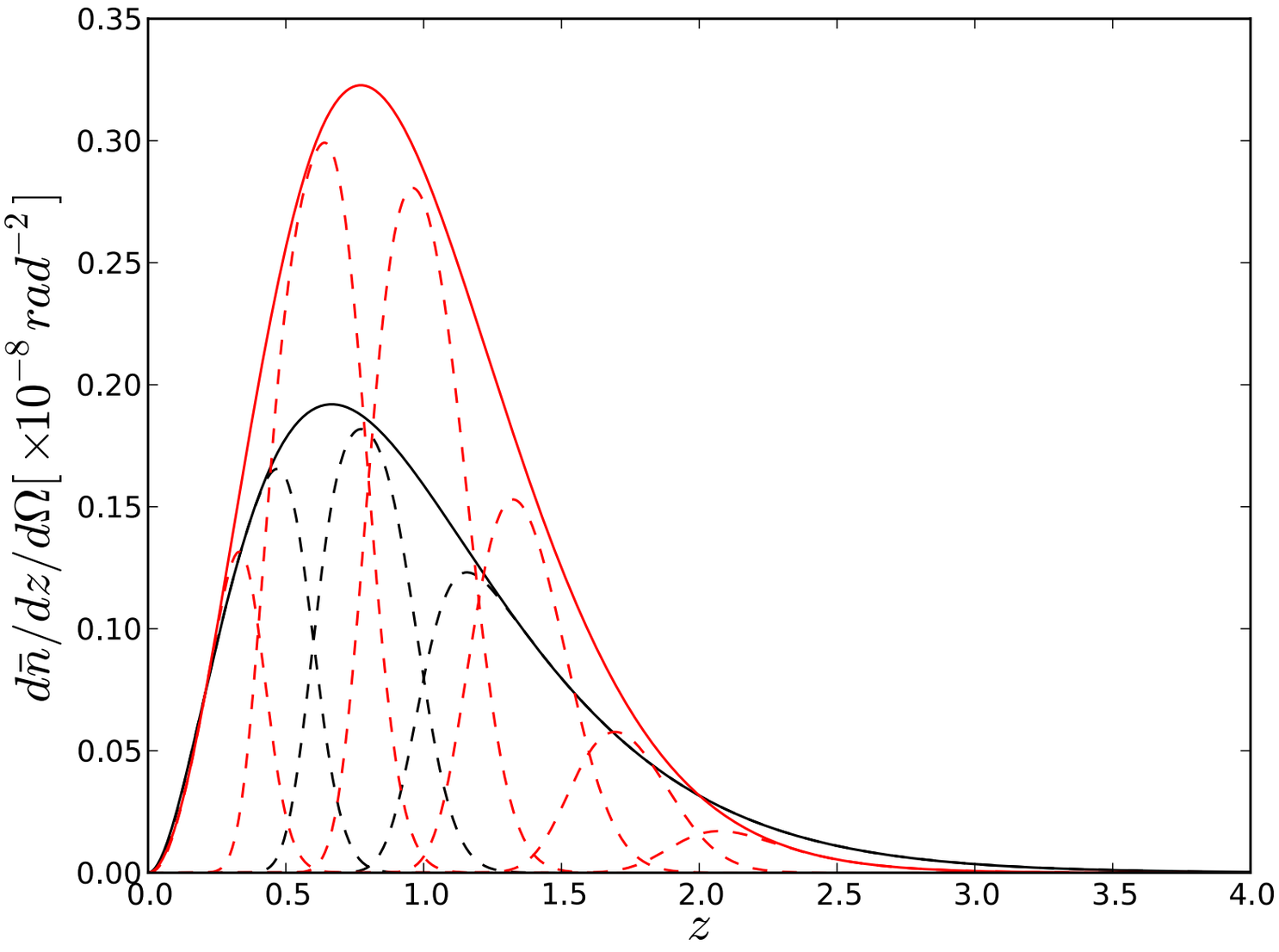


- The PFS survey design allows a 5% accuracy when constraining the growth rate in each redshift (each of 6 bins)
- Again complementary to BOSS

PFS White paper: Ellis++1206.0737

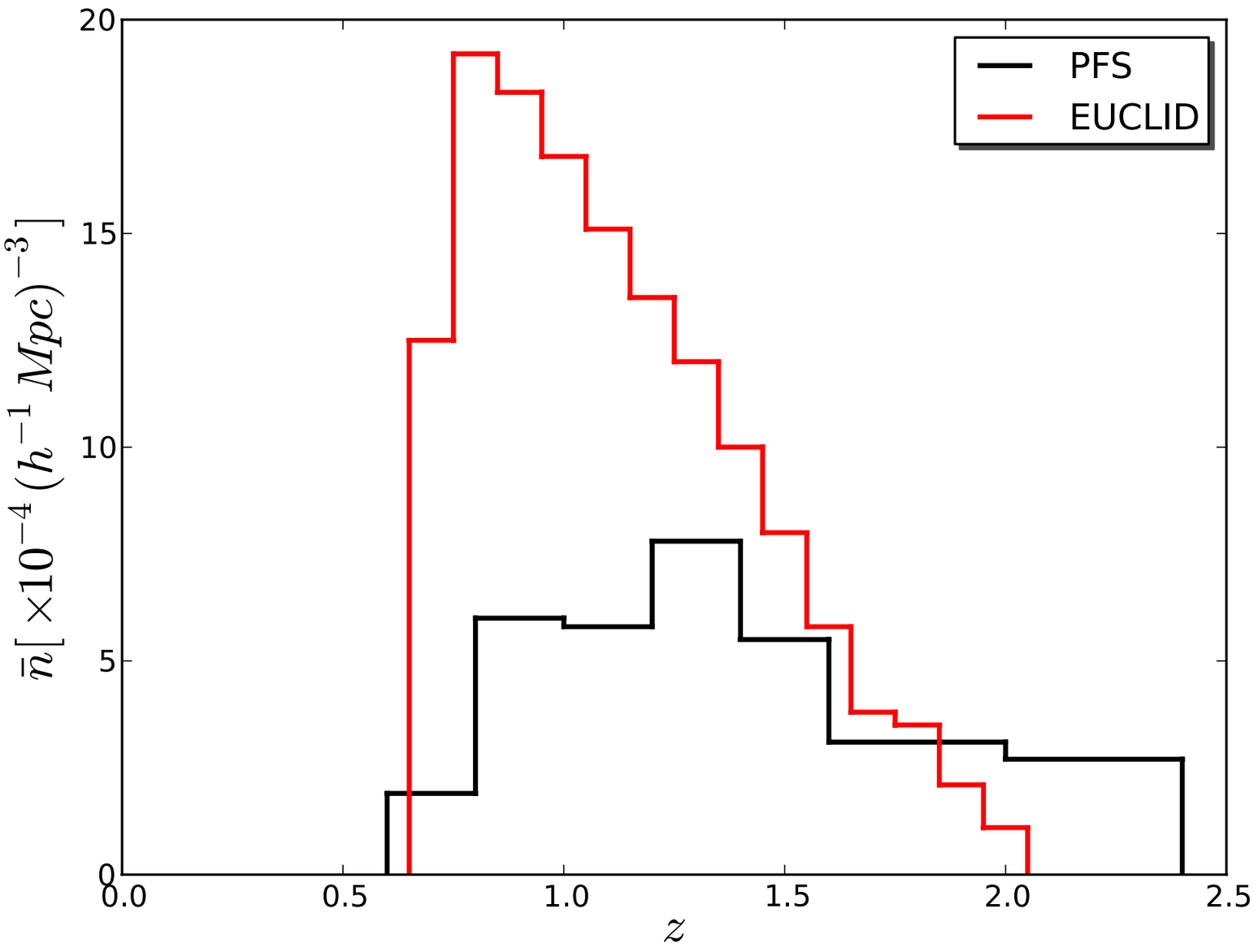
Redshift Binning and Distribution for Lensing

- The underlying dn/dz is assumed to be perfectly known
- We consider either 3 bins (SuMIRE) or 6 bins (Euclid) for lensing

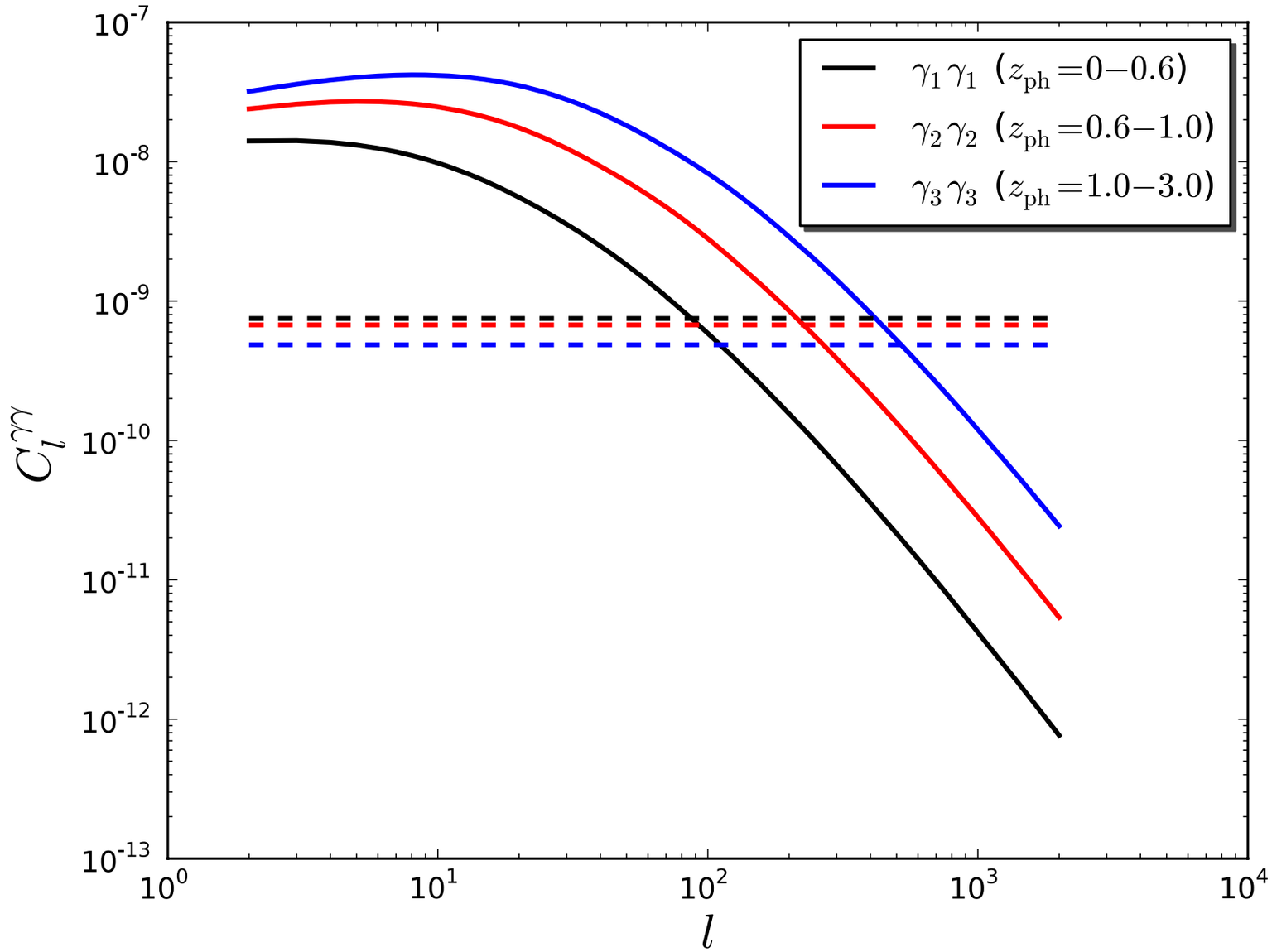


Redshift Binning and Distribution for Spectroscopy

- For Euclid we follow Amendola++12
- For SuMIRE we follow Ellis++1

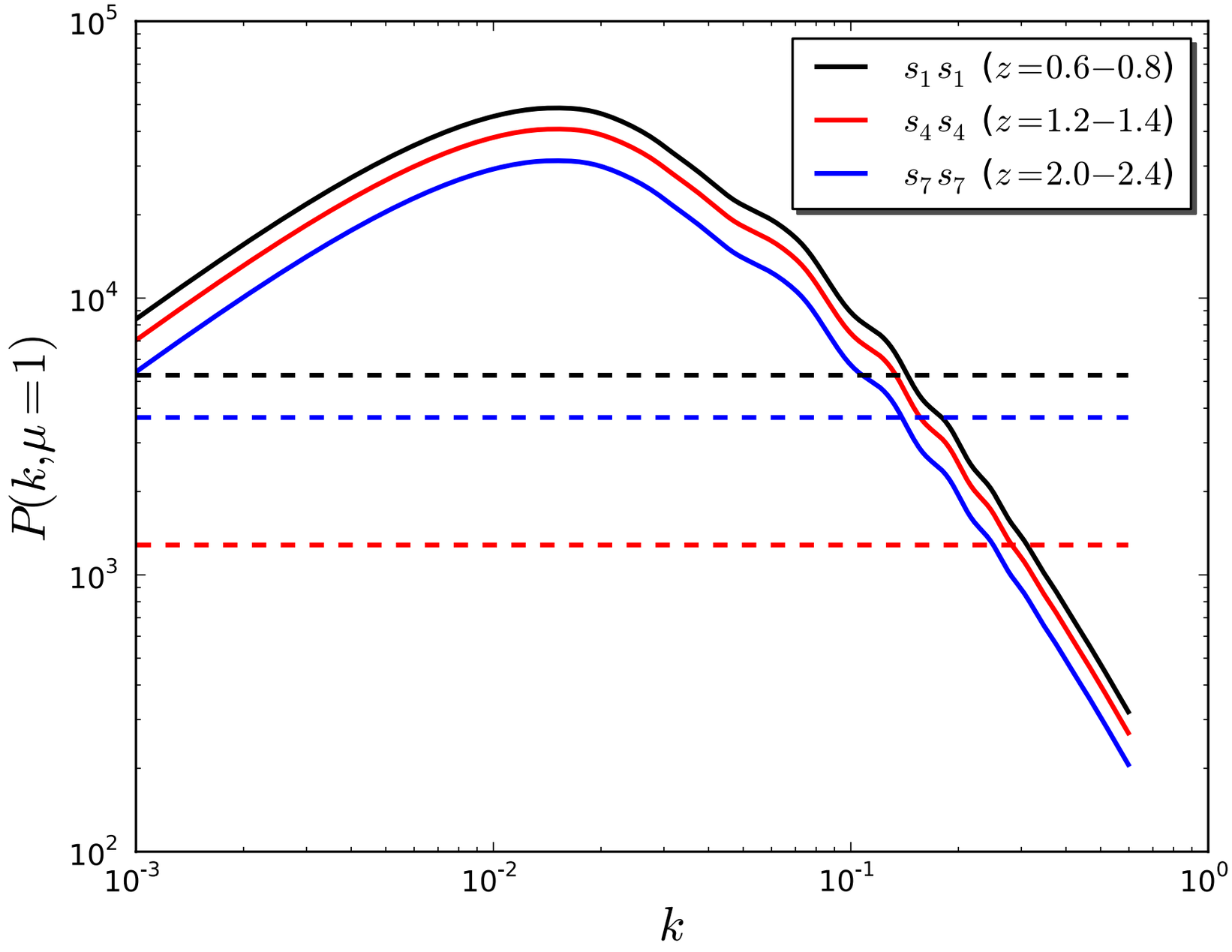


SuMIRe Shear Angular Power Spectra



- Shape noise dominates above *l*~100-1000 according to redshift slices

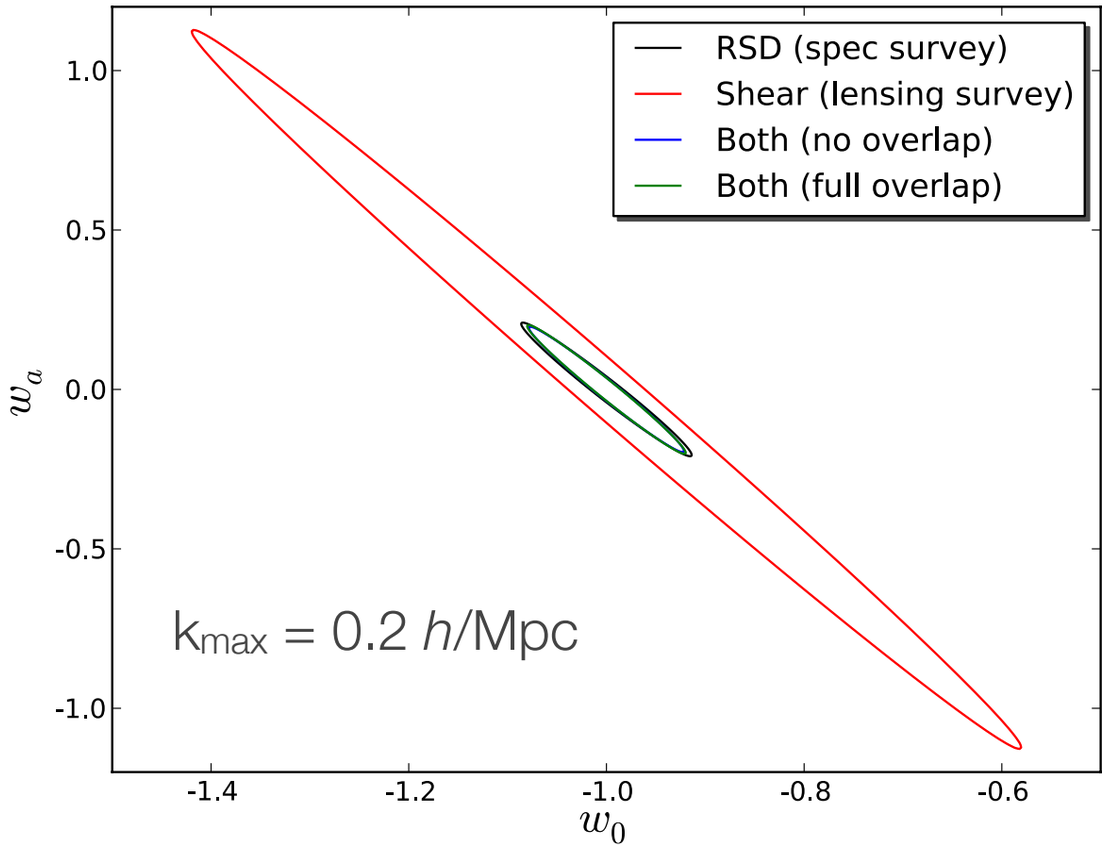
SuMIRe Galaxy Power Spectra



- Shot noise starts to dominate above k_{max}~0.1-0.3 h/Mpc

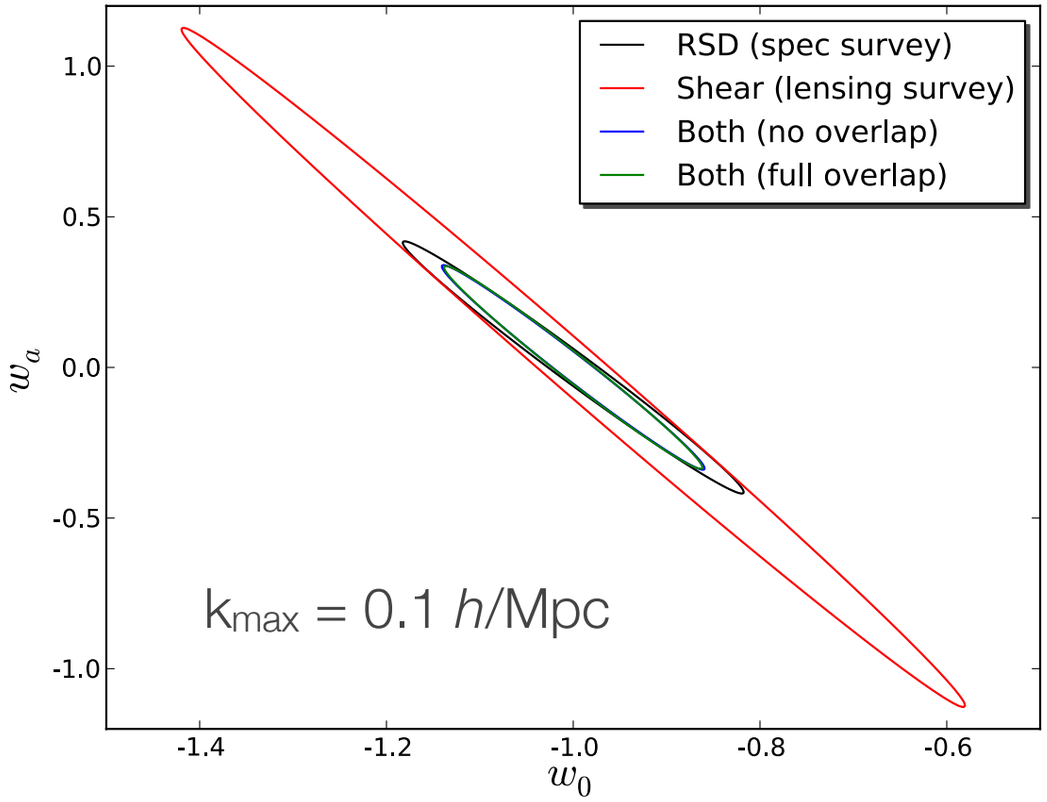
Full SuMIRe Cosmological Constraints

- Use standard Fisher methodology. Linear spectra only and Gaussian covariances.
- Spectroscopic forecast use “Full Spectrum” method, e.g., Seo & Eisenstein 03, with varying k_{max}
- Lensing forecast uses photo-z errors, e.g., Ma & Huterer 99, with l_{max}~2000
- Planck prior is included.



Dark Energy Figure of Merit:

3D Galaxy Clustering only:	119
2D lensing only:	52
Combined:	134

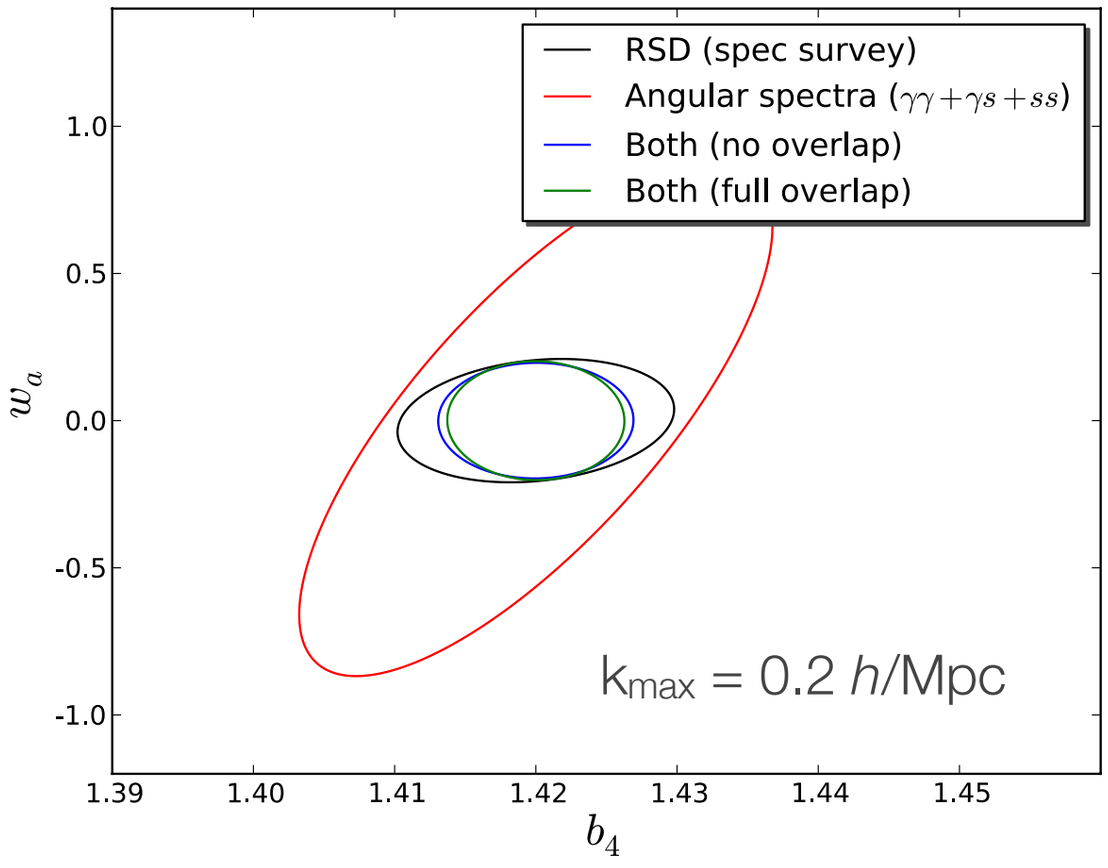


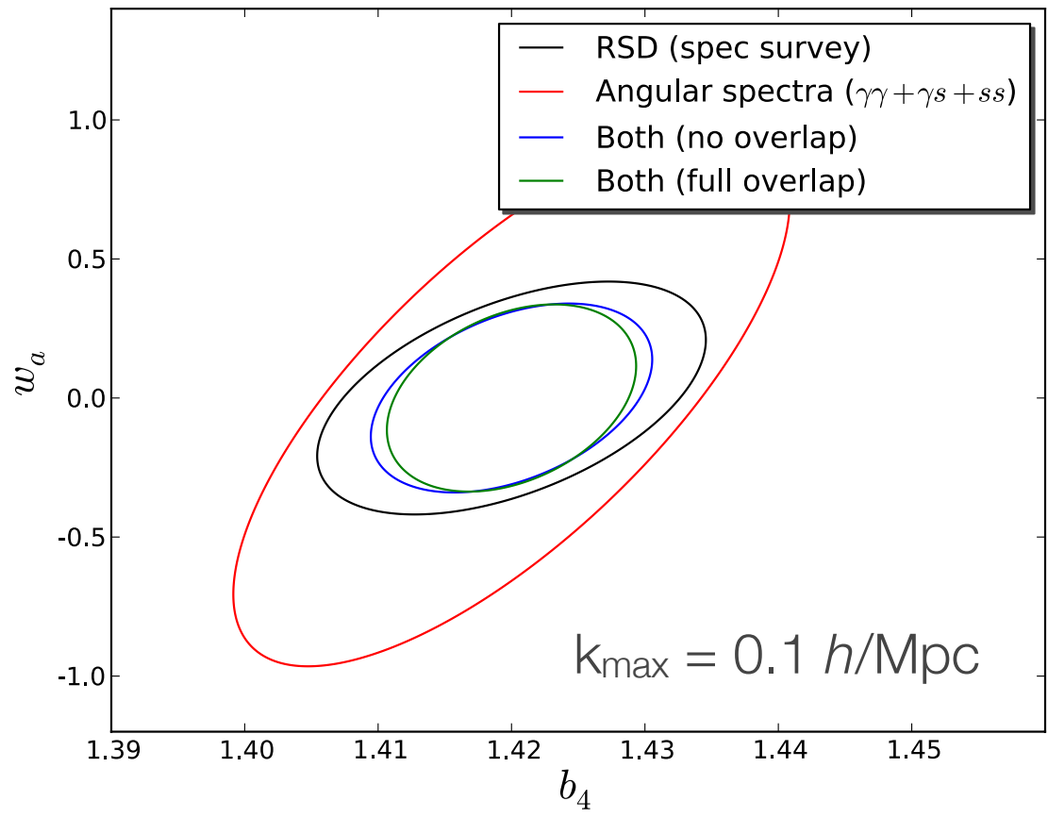
Dark Energy Figure of Merit:

3D Galaxy Clustering only:	28
2D lensing only:	52
Combined:	39

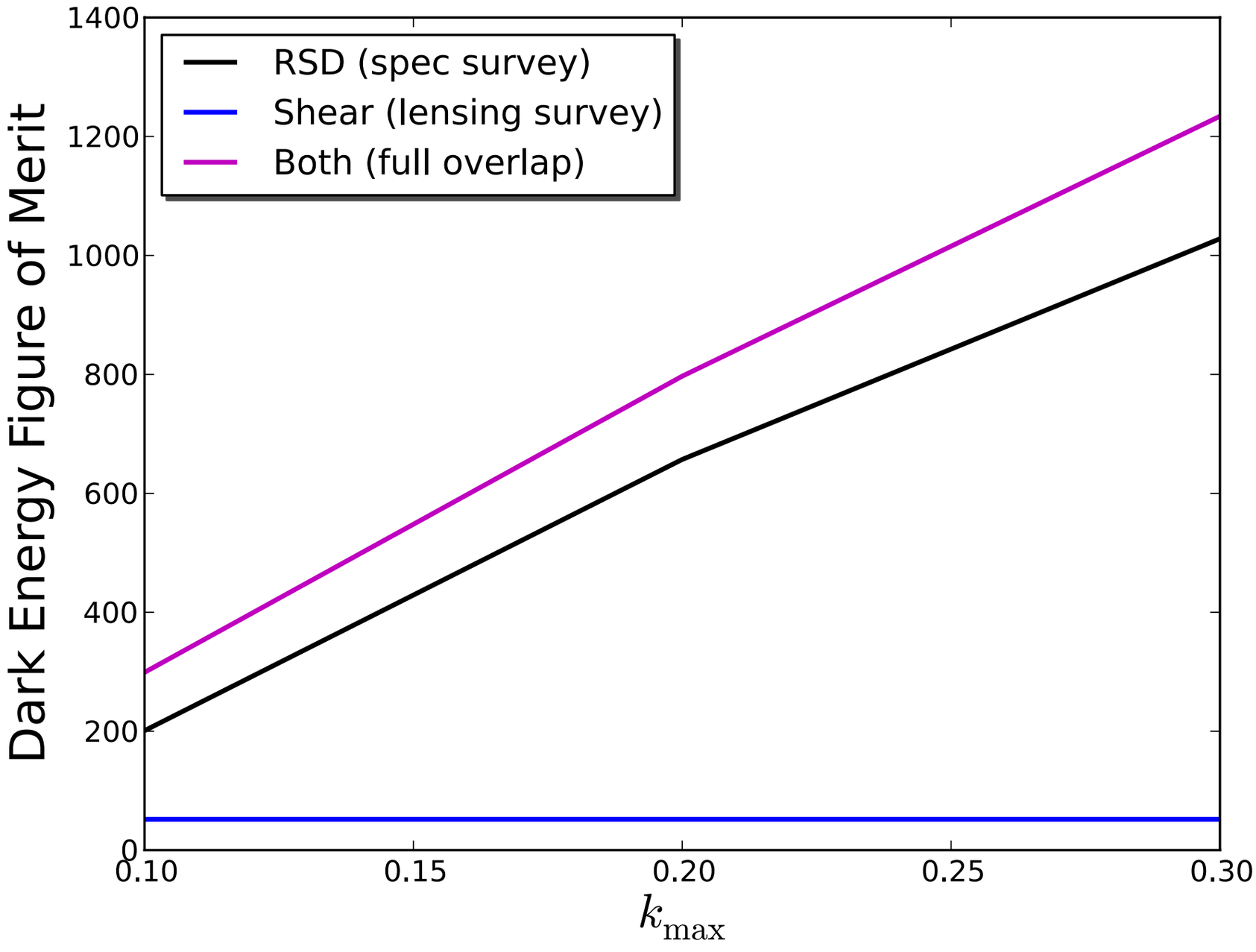
SuMIRe galaxy bias - Dark Energy degeneracy

- Planck prior is included.
- Lensing uses l_{max}~2000

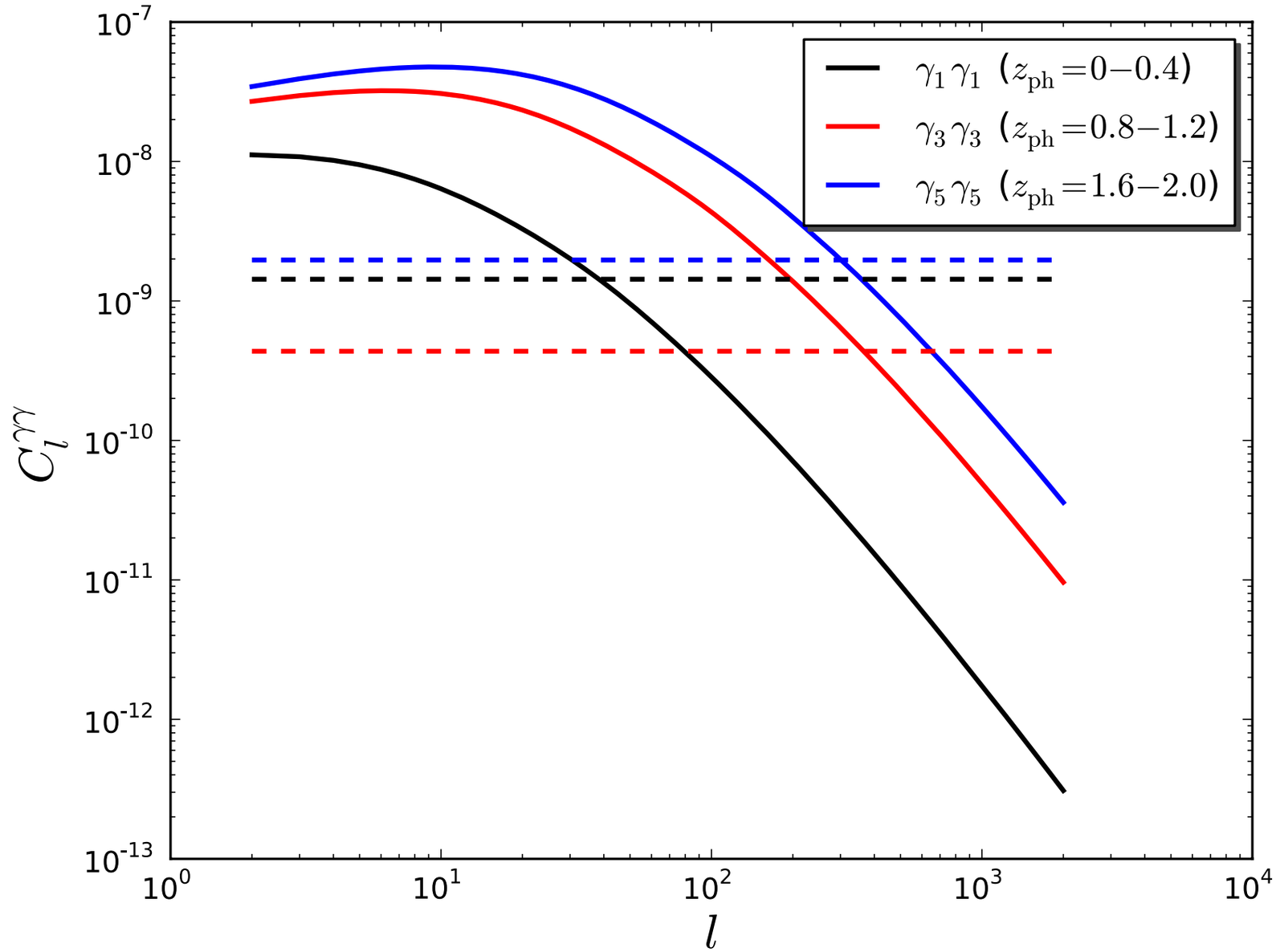




FOM *k*-dependence

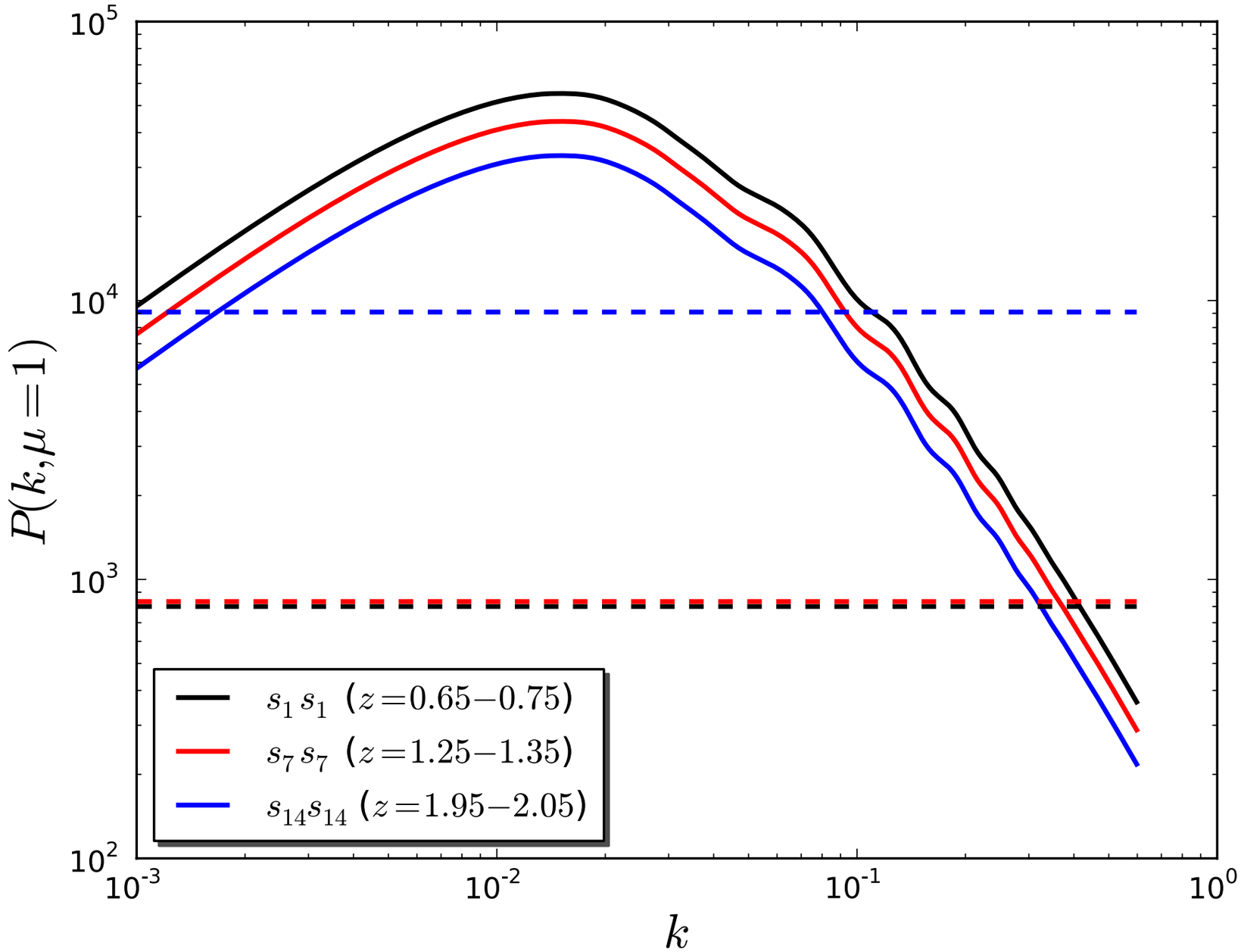


EUCLID Shear Angular Power Spectra



- Shape noise dominates above *l*~30-600 according to redshift slices

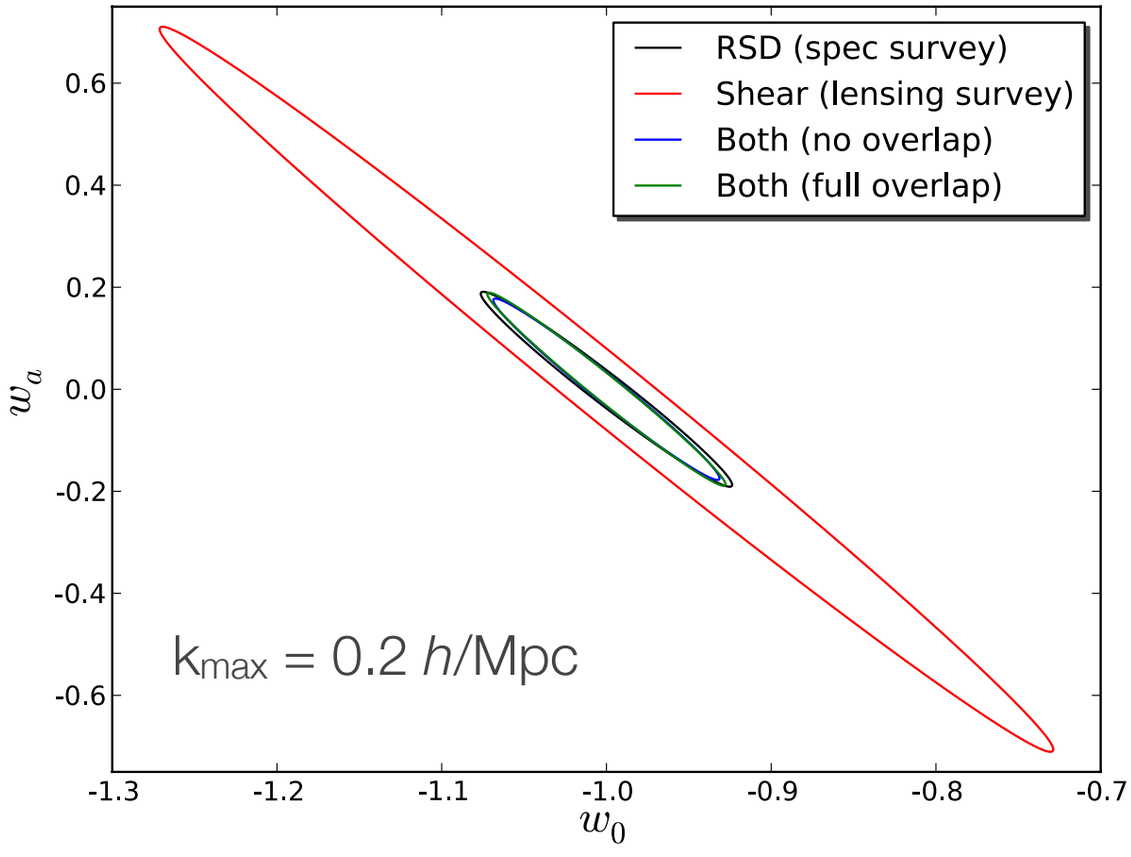
EUCLID Galaxy Power Spectra

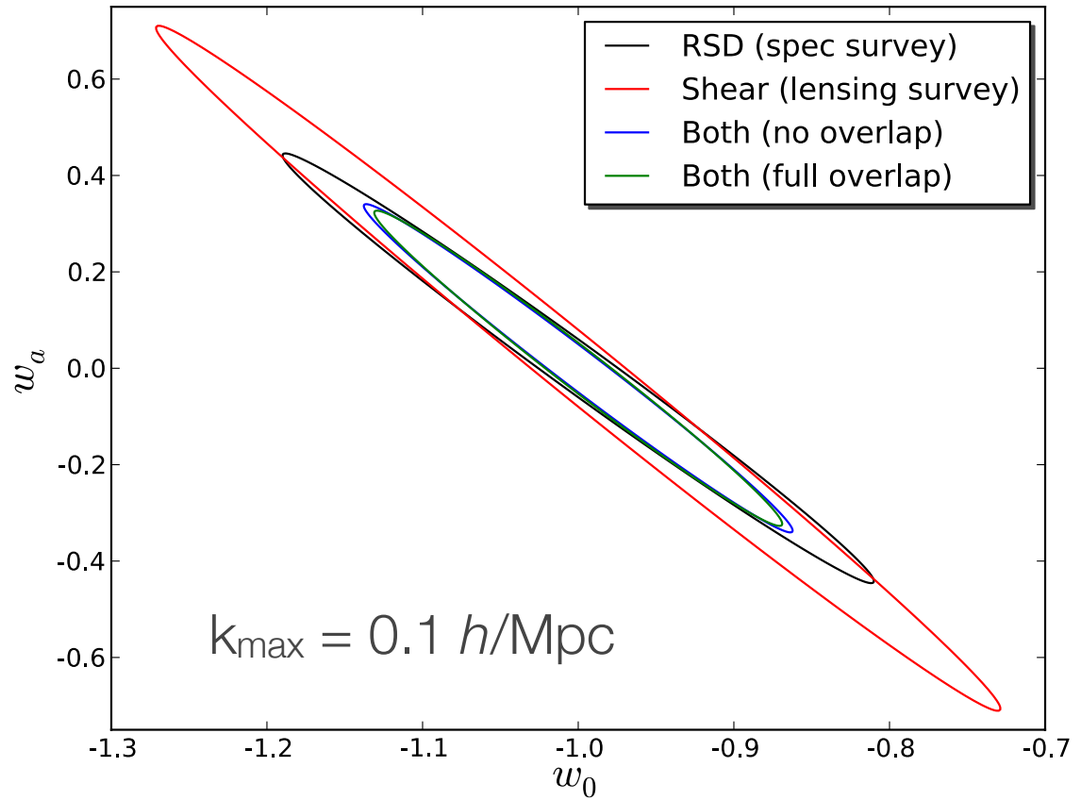


- Shot noise dominates above *k*~0.1-0.6 according to redshift slices

Full EUCLID Cosmological Constraints

- Forecasts include by default a Planck prior
- Lensing uses l_{max}~2000





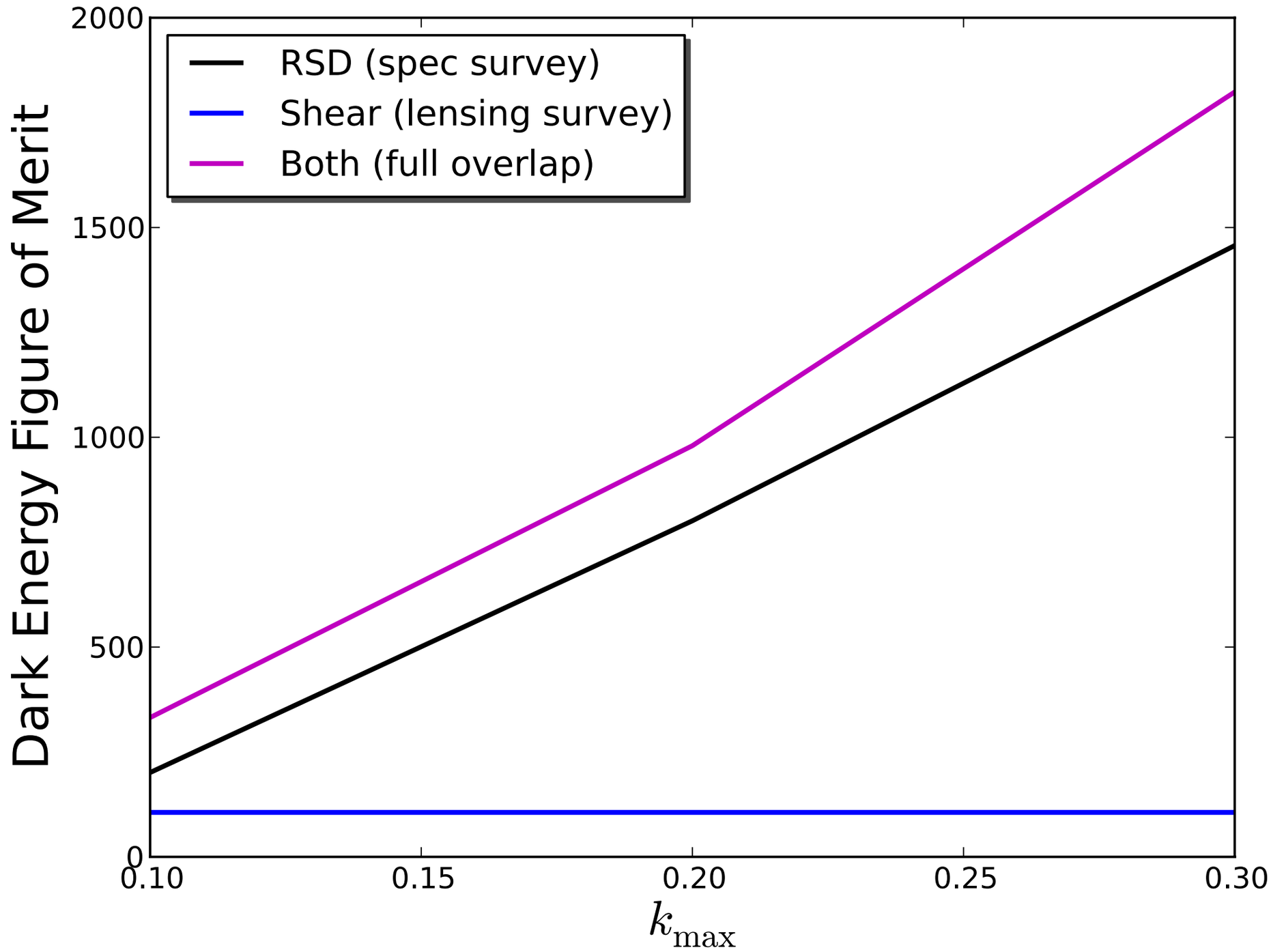
Dark Energy Figure of Merit:

3D Galaxy Clustering only:	801
2D lensing only:	106
Combined:	980

Dark Energy Figure of Merit:

3D Galaxy Clustering only:	201
2D lensing only:	106
Combined:	332

Euclid FOM *k*-dependence



Overlapping Surveys are still Promising

- Results from simple modelization with realistic (but simple) survey specification do not lead to spectacular gains in terms of DE FOM when overlapping photometric and spectroscopic surveys.
- This is assuming Planck priors and wCDM model.
- The key reason is that the redshift space surveys now envisioned can constrain the bias “too” well by themselves (see also P. McDonald’s talk)
- However, overlapping surveys will certainly turn very valuable. It will allow various cross-checks and will add great robustness to both probes:
  - Help the modeling of non-linearities on small scale (Hikage++11).
  - Allow new tests of modified gravity, e.g., Reyes++10.
  - Help calibrate photometric redshift (I will quantify this)

SuMIRe: Calibrating Photometric Redshifts

- We now consider photometric redshift uncertainties, supposed to be Gaussian and characterized by a dispersion, σ_z, and a mean bias b_z.
- Photometric redshift are an important limitation of WL surveys

$\sigma(p)$	Planck (ΛCDM)	Planck + $\gamma\gamma$ (known dn/dz)	Planck + $\gamma\gamma$ ("free" dn/dz)
ω_b	0.00024	0.00018	0.00024
ω_c	0.0019	0.00090	0.0019
Ω_Λ	0.21	0.056	0.21
n_s	0.0063	0.0041	0.0062
σ_8	0.24	0.046	0.23
w_0	1.8	0.73	1.8
w_a	4.3	1.9	4.4
FOM= $1/\sqrt{\text{DetCov}}$	0.34	6.6	0.35

Reference

Self-calibrated

- Now, considering the cross-correlation between spectroscopic and 11 pairs of photo-z parameters (σ_z, b_z) specified at equally spaced redshifts in range z = 0 – 3 (and interpolated in between).
- The photo-z parameters determine the source redshift distributions in three tomographic bins: z = 0 – 0.6 – 1.0 – 4

Adding ps + pp + ss (to case of "free" dn/dz, i.e. 3rd column), but no ss cosmology:

k_{max}=0.1 h/Mpc: FOM = 0.35 --> 1.1 --> 1.4 (if galaxy bias of source galaxies known)
k_{max}=0.2 h/Mpc: FOM = 0.35 --> 1.6 --> 1.9 (if galaxy bias of source galaxies known)
k_{max}=0.3 h/Mpc: FOM = 0.35 --> 1.9 --> 2.1 (if galaxy bias of source galaxies known)

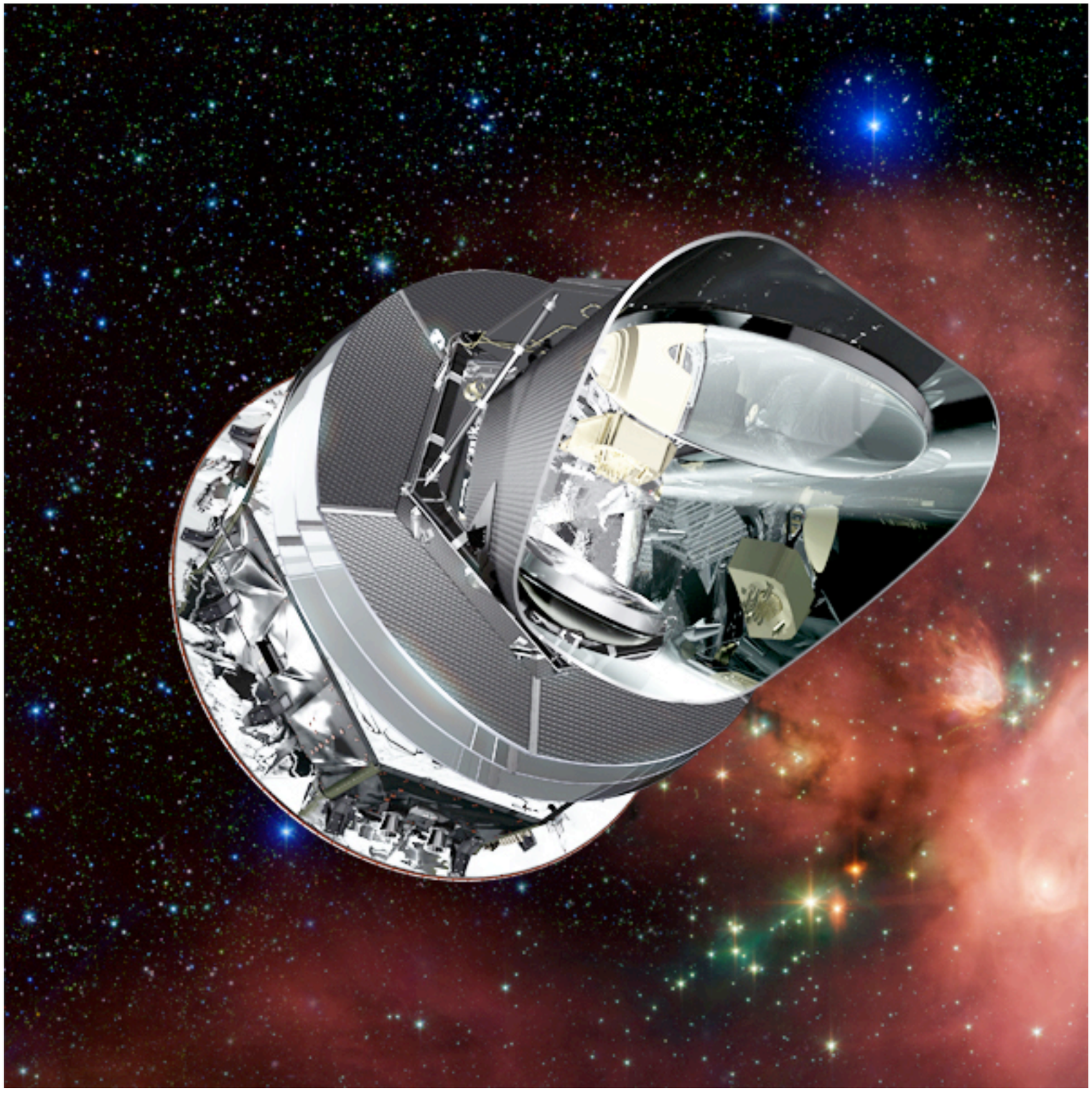
Ma++05, Newman 08
De Putter, OD, in prep

Conclusions

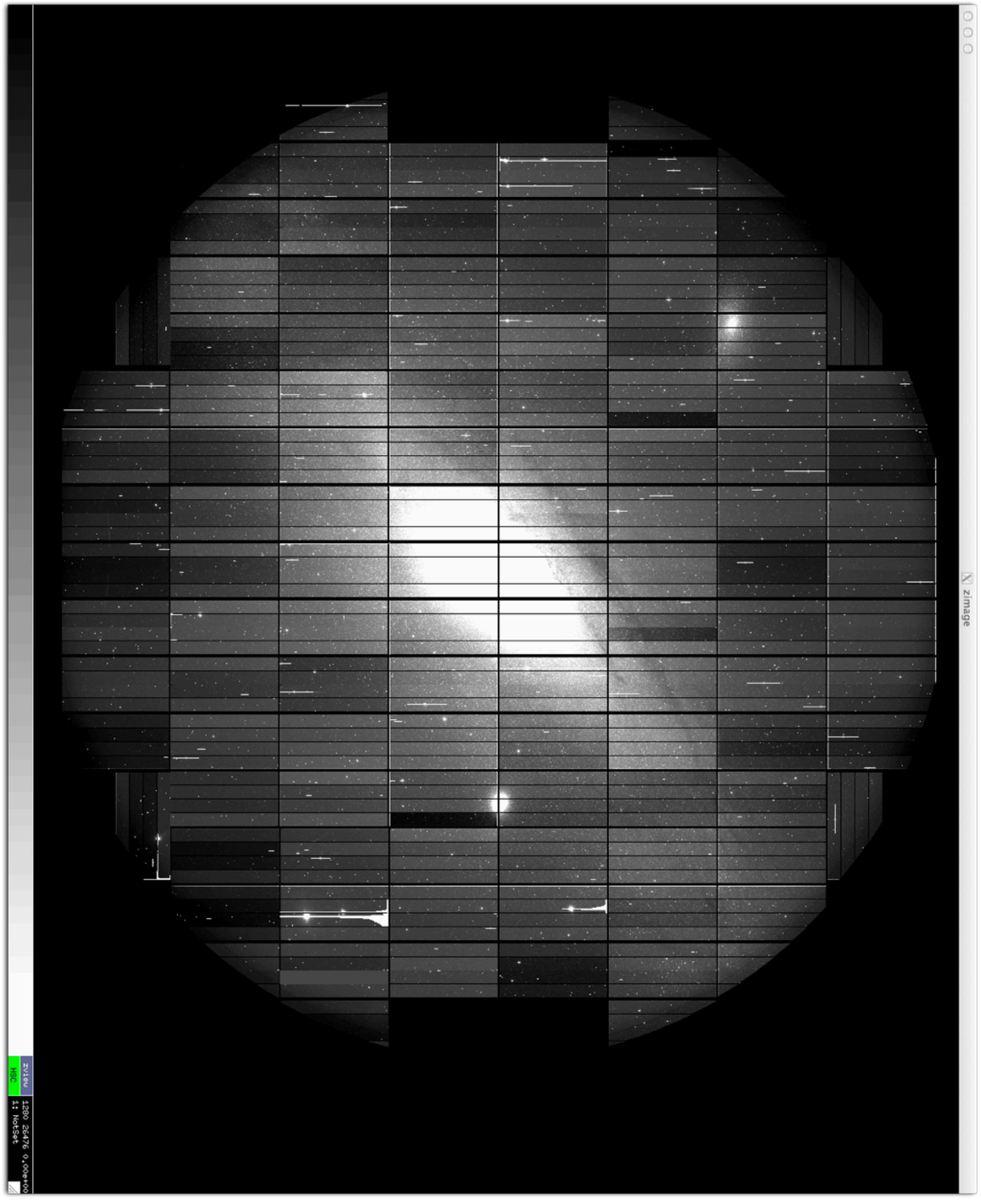
- Overlapping wide and deep photometric and spectroscopic surveys does not give the FOM boost “expected”.
- This conclusion was reached considering a simple model and a simple modelization, i.e., wCDM, linear model, no systematics.
- Allowing for more systematics will certainly nuance this picture, e.g., the calibration of photometric redshifts.
- Allowing for more general models, i.e., modified gravity, will also nuance this picture
- The gain in systematic mitigation for spectroscopic redshifts (non-linearities, scale dependent bias) and lensing surveys (IA, non-linearities, shear calibration) has to be evaluated and is certainly non-negligible
- Other interesting ways to combine these probes beyond the straightforward cross-correlation exist (3 points, etc.).
- There is no doubts this overlap will offer new control of systematics, new consistency tests.
- Overlapping surveys will happen soon and will lead to new science.

ArXiv:astro-ph.CO Overload Warning!

- First cosmological results from Planck will be released on March 21st, 15 days from now...
- Expect:
  - 31 cosmology papers
  - A very large data release (more than 200 full sky maps...)
- It will include your required Planck prior...
- Press conference at ESA and NASA HQ @ 11am EST



HSC is being commissioned as we speak...



- A tile of raw CCD images of HSC covering Andromeda galaxy (M31) was taken on 02/01/13

- Image quality is roughly 0.6 arcsec (FWHM) all over the field of view.

- 2 min exposure i-band.