Weak Lensing & LSS with DESpec

Enrique Gaztanaga & Martin Eriksen
Instituto de Ciencias del Espacio (IEEC/CSIC), Barcelona

London, Marc 2011

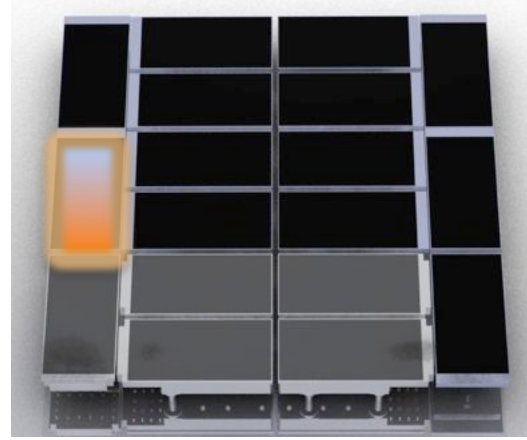
FoM
- BAO x1
- P(k) shape x10
- P(k) shape+amplitude (+bias) x5

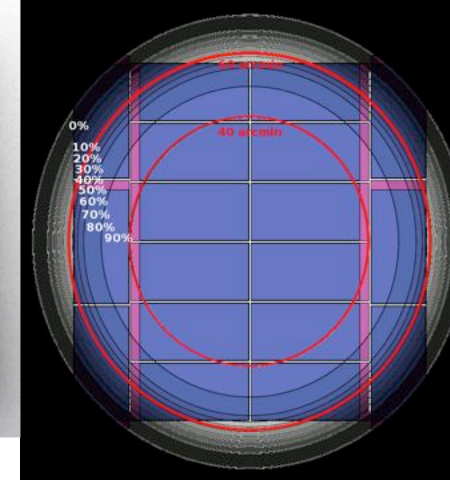
Motivation: DESpec and PAU

F.Castander, M. Crocce, P.Marti, R.Miquel

PAU Camera
(@ WHT)

See talk by
Francisco Castander

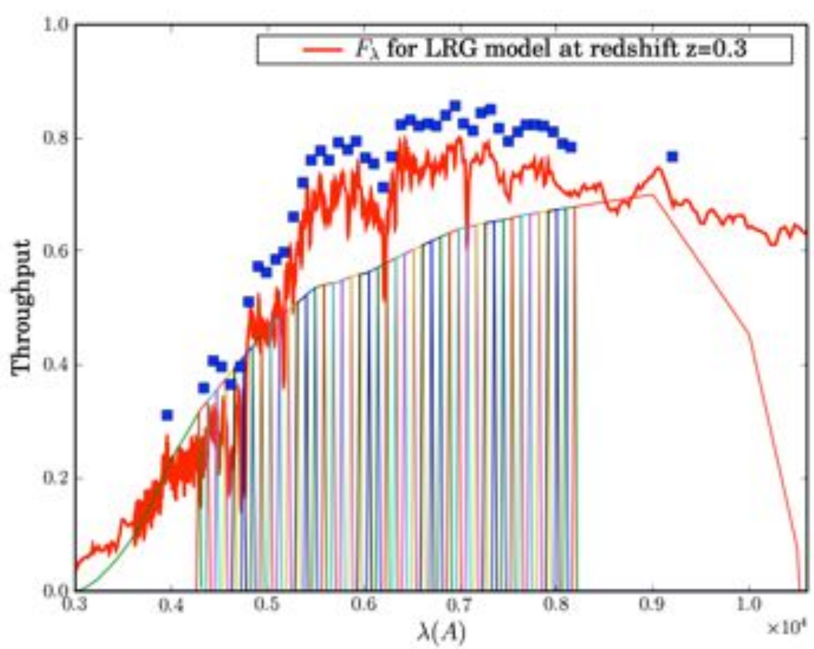


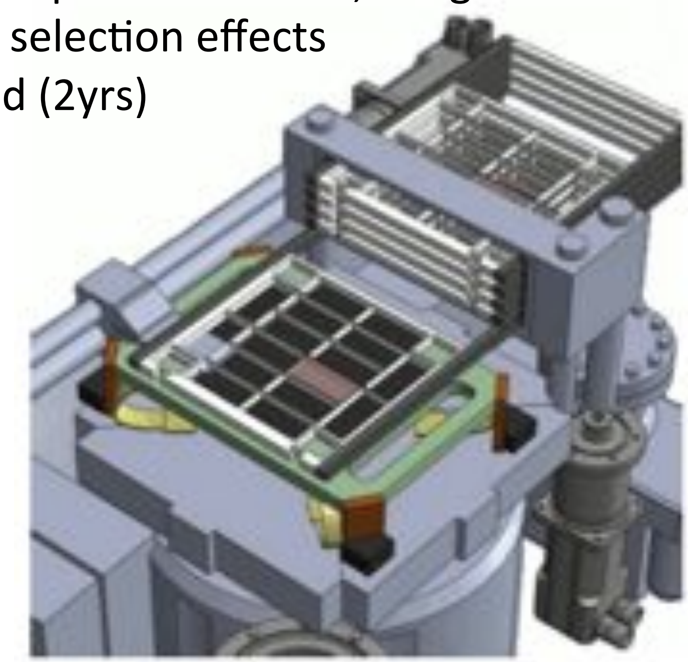


Narrow Band filters
A Plan-B for DESpec?

In 1 night can do 2 sqr.deg. to i~22.5
in 40 narrow + 6 broad (i~24 survey)
To get R=1/100 spectra (900 Km/s)
for 30,000 galaxies
And R=1/10 photo-z for 120,000 galax
No galaxy selection effects
Being build (2yrs)

Photo-z of 0.003 or 10Mpc/h
For linear P(k) reconstruction





DESpec

2 galaxy populations: faint and bright

- Faint: DES: i<24 to z<2, photo-z ~ 0.05 shapes and good photometry
- Bright: Spec: mag.lim. i<22.5 to z<1, spec-z

(no selection in PAU)

Unique set for cross-correlation analysis:

foreground galaxies are well located, source galaxies don't need such good location for lensing

Galaxy-galaxy Magnification
or
Galaxy-shear
are 3D with z

$$C_{GiKj} \simeq b_{n_i} p_{ij} \mathcal{P}_i$$
$$C_{GiGj} \simeq b_{n_i}^2 \frac{\delta_{ij}}{\Delta_i} \mathcal{P}_i$$

Cross-correlation Ratios:

Measure bias, ie from Cii/Cij
Measure pij, ie from Cij/Cik
Measure P(k) ie from Cij^2/Cii

Shear-shear
Is 2D

$$C_{\kappa_i \kappa_j} \simeq \int_0^{\bar{z}_i} \frac{dz}{\chi_H} \left(\frac{3\Omega_m H_0}{2 H a \chi_{H0}} \right)^2 \frac{(\chi_i - \chi)(\chi_j - \chi)}{\chi_i \chi_j} P(k, z)$$

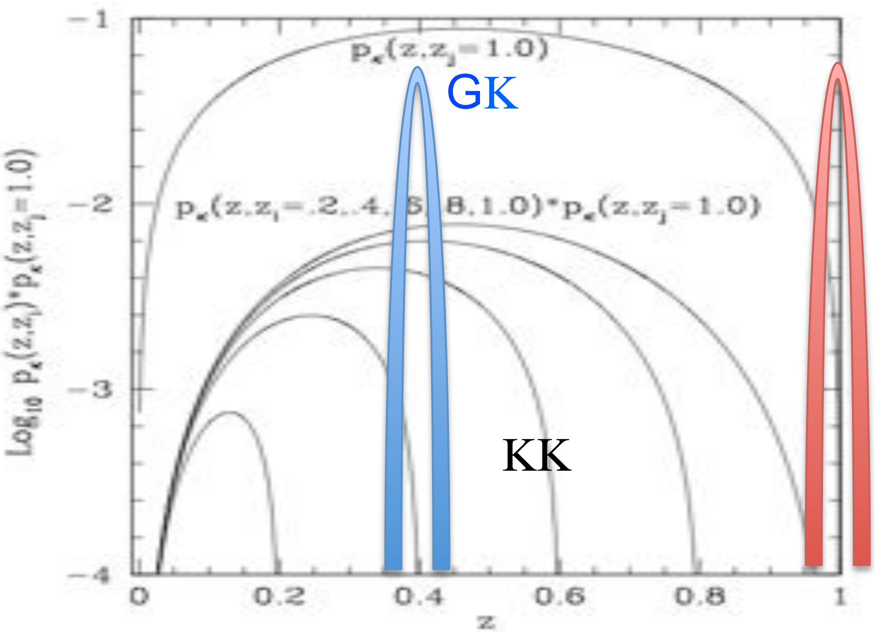


FIG. 2.— Weak lensing efficiency for shear-shear power $p_\kappa(z,\bar{z}_i)p_\kappa(z,\bar{z}_j)$ for $\bar{z}_j = 1.0$ and $\bar{z}_i = 0.2, 0.4, 0.6, 0.8$ and 1.0. Top line corresponds to $p_\kappa(z,\bar{z}_j = 1.0)$, for galaxy-shear lensing.

$$\mathcal{P}_i \equiv \frac{P(k_i, \bar{z}_i)}{\chi_i^2 \chi_{H_i}}$$

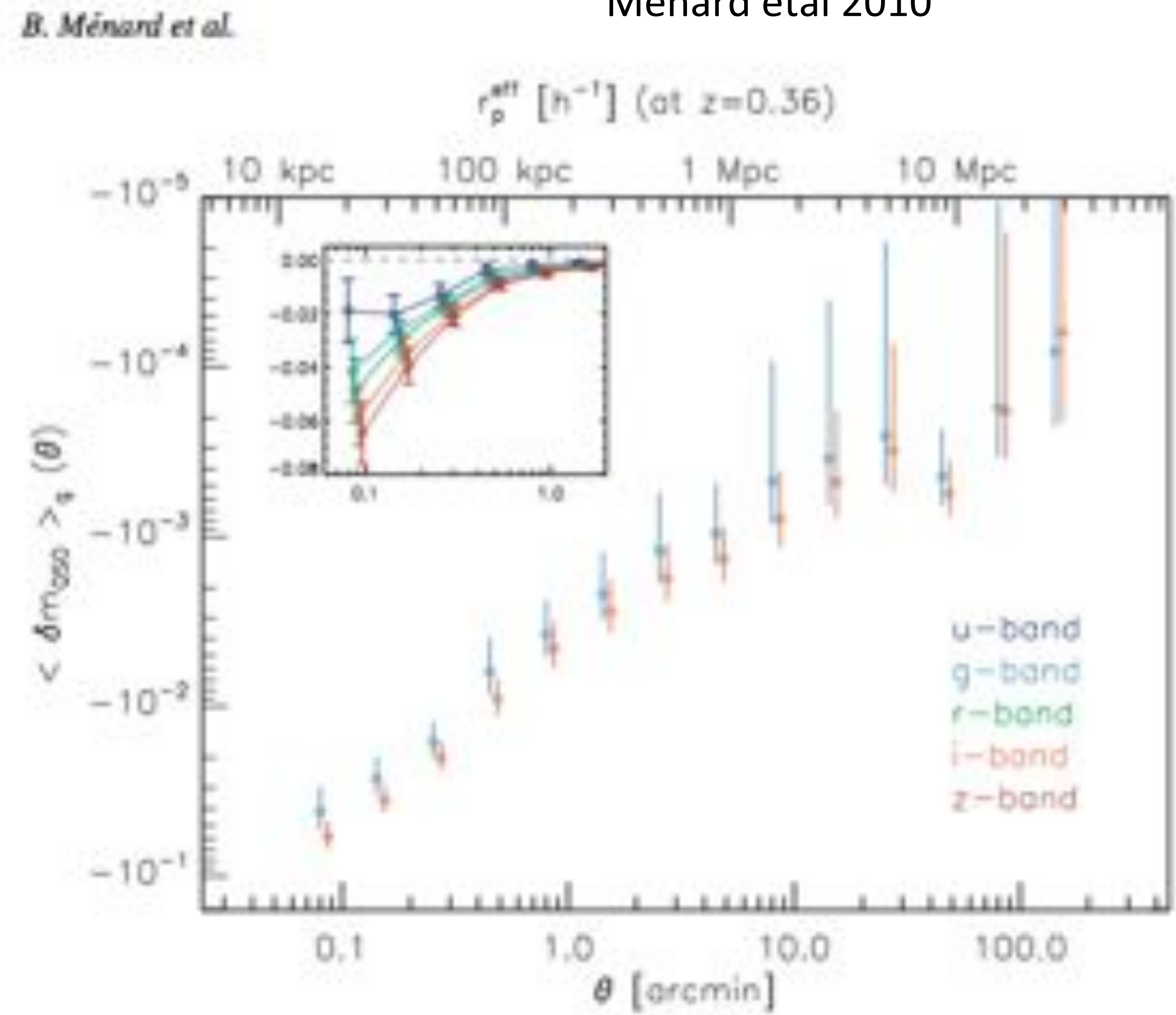
$k_i = \ell / \chi_i$

$$p_{ij} \equiv p_{\kappa_j}(z_i) \simeq \begin{cases} \frac{3\Omega_m H_0}{2H(z_i)a_i} \; \frac{\chi_i(\chi_j - \chi_i)}{\chi_{H0}\chi_j} & \text{for} \quad i < j \\ 0 & \text{for} \quad i \geq j \end{cases}$$

$$\chi_H(z) \equiv c/H(z)$$

Current measurements

SDSS: galaxy position with QSO magnitude
Menard etal 2010



Current measurements

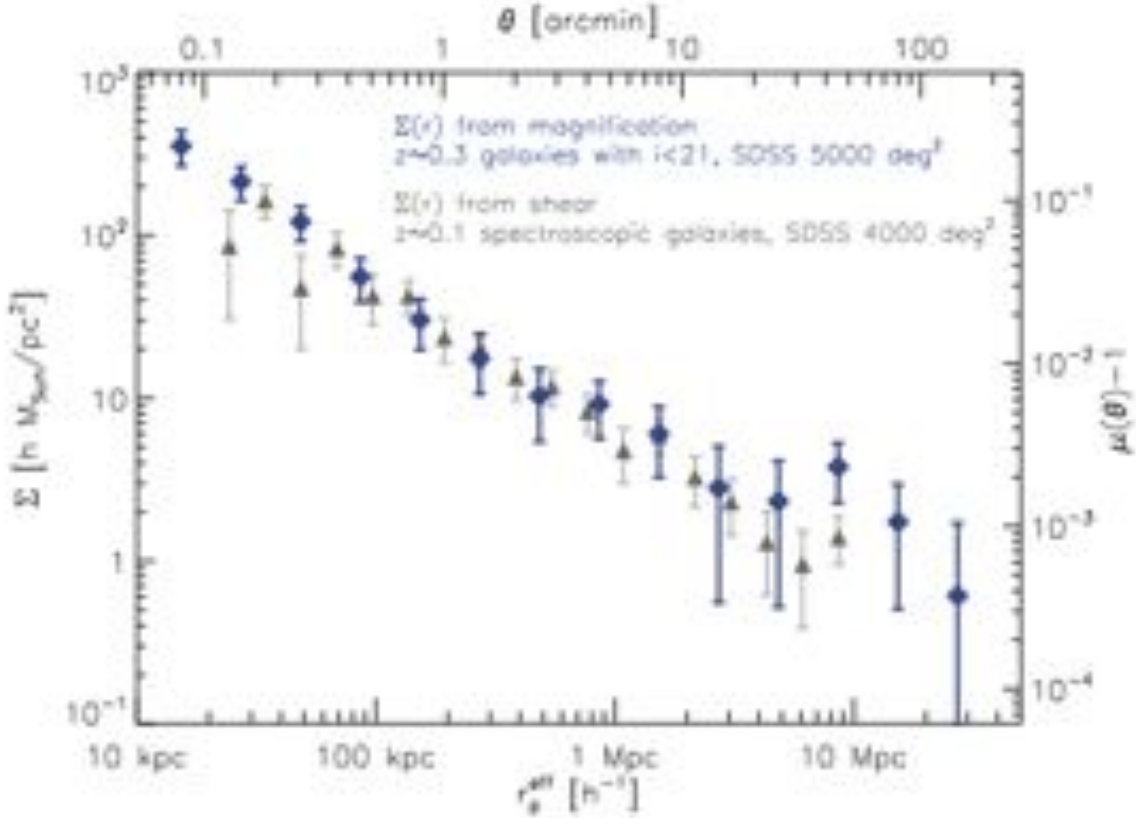


Figure 7. The mean surface density of galaxies (with $i < 21$) measured through the magnification of background quasars and corrected for dust extinction (blue points). In comparison, we show the mean surface density of a sample of $\sim L^*$ galaxies at $z \sim 0.1$ obtained from the gravitational shear of background galaxies from Sheldon et al. (2004). Non-linear magnification effects have not been included and result in an overestimation of the mass on the smallest scales.

Assumptions

Follow Hu & Jain 2004

- Use non-linear theory, but to l_max=k_max*chi(z), where k_max=0.1 at z=0 and chi(z) radial comoving disntance to redshift z (see plot in next slide)

$$\Delta \ell \simeq 2/f_{sky}$$

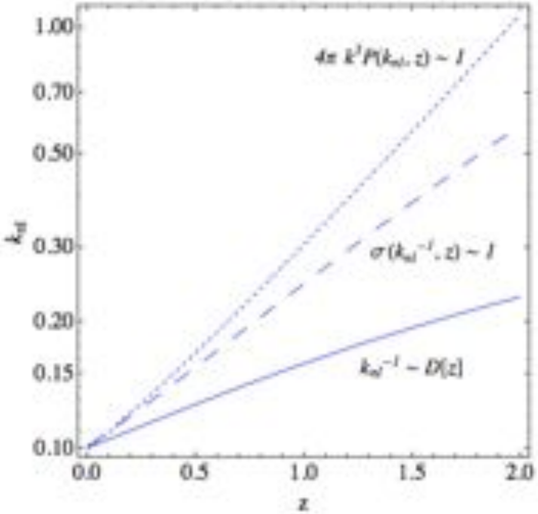
- Use Limber and small z-bin approximations: top-hat bins(*)
- For DES we use z-bins of width: 0.20(1+z)
- For DESpec we use z-bins of width 0.012(1+z) for z<0.7 and 0.20(1+z) for z>0.7
- For PAU we use z-bins of width 0.012(1+z) all the way
- Neglect intrinsic galaxy-galaxy cross correlation between z-bins(*)
- IGNORE any systematic effects(*), except photo-z errors
- Assume GR: growth history -> w(z), or allow growth index gamma
- Marginalized over 8 Planck priors (+ Stage-II SN priors)
- Assume linear bias with redshift evolution in b(z) given by 2/4 global free parameters which are marginalized over (*)
- Compare these cases:
  - KK: shear-shear (KK) alone
  - GK: galaxy-shear (GK) plus galaxy-galaxy (GG) autocorrelation
  - MAG: Galaxy-galaxy cross-correlation, ie magnification (MAG)
  - RSD: redshift space distortions

(*) we are currently working on generalizattions to this approximation and already have some results outside these approximations.

Forecast for DES & PAU

(with M.Eriksen & Spain DES/PAU team)

$$F_{\mu\nu} = \sum_{ij,mn,\Delta\ell} \frac{\partial C_{ij}}{p_\mu} \Theta^{-1}_{ij;mn} \frac{\partial C_{mn}}{p_\nu}$$



L_max= k_max X(z)

DES :

$f_{sky} = 0.125$ (5000 sqr deg)
$0.1 < z < 1.5$
$dn/dz = A(z/z_0)^\alpha \exp\left[-(z/z_0)^\beta\right]$ (all galaxies $m_{AB} \sim 24$)
$A = 5.63 \times 10^8, z_0 = 0.65, \alpha = 1.07, \beta = 1.77$
$z_m = 0.5$
$N_{gal} = 1.84 \times 10^8$ (all)
photo $- z = 0.035(1+z)$ (LRGs) - $0.07(1+z)$ (all)
$b_1 = 1.52$, $dbdz_1 = 0.6423$, $b(0) = 1.2$
$b_2 = 2.53$, $dbdz_2 = 1.07$, $b(0) = 2$

Dz= 4*photo-z error

$$b(z) = b(z_m) + \frac{db}{dz}|_{z=z_m}(z - z_m).$$

Our fiducial cosmology is given by,

Baryon density today, $\Omega_b = 0.044$
Matter density today, $\Omega_m = 0.25$
Dark-energy density today, $\Omega_\Lambda = 0.75$
Scalar spectral index, $n_s = 0.95$
Rms matter fluctuation amplitude, $\sigma_8 = 0.8$
Hubble parameter (in units of 100 km/sec/Mpc), $h = 0.7$
Dark-energy eq. of state, $w = -1$

Planck Fisher Matrix (8)
Jochen Weller
Ω_m, Ω_DE h σ8 Ω_b w0 wa ns

+ bias dbdz

Hu & Jain 2004

Survey Specifications

PAU : *all-galaxies*

$f_{sky} = 0.0048$ (200 sqr deg)
$0.1 < z < 1.4$
$N_{gal} = 4 \times 10^6$
$\text{photo} - z = 0.005(1 + z)$
$b = 1.2264,\ db/dz = 0.5266,\ z_m = 0.$
$b(0) = 1$

PAU : *LRGs*

$f_{sky} = 0.0048$ (200 sqr deg)
$0.1 < z < 1.1$
$N_{gal} = 3.66 \times 10^5$
$\text{photo} - z = 0.0035(1 + z)$
$b = 2.88,\ db/dz = 1.13,\ z_m = 0.78$
$b(0) = 2$

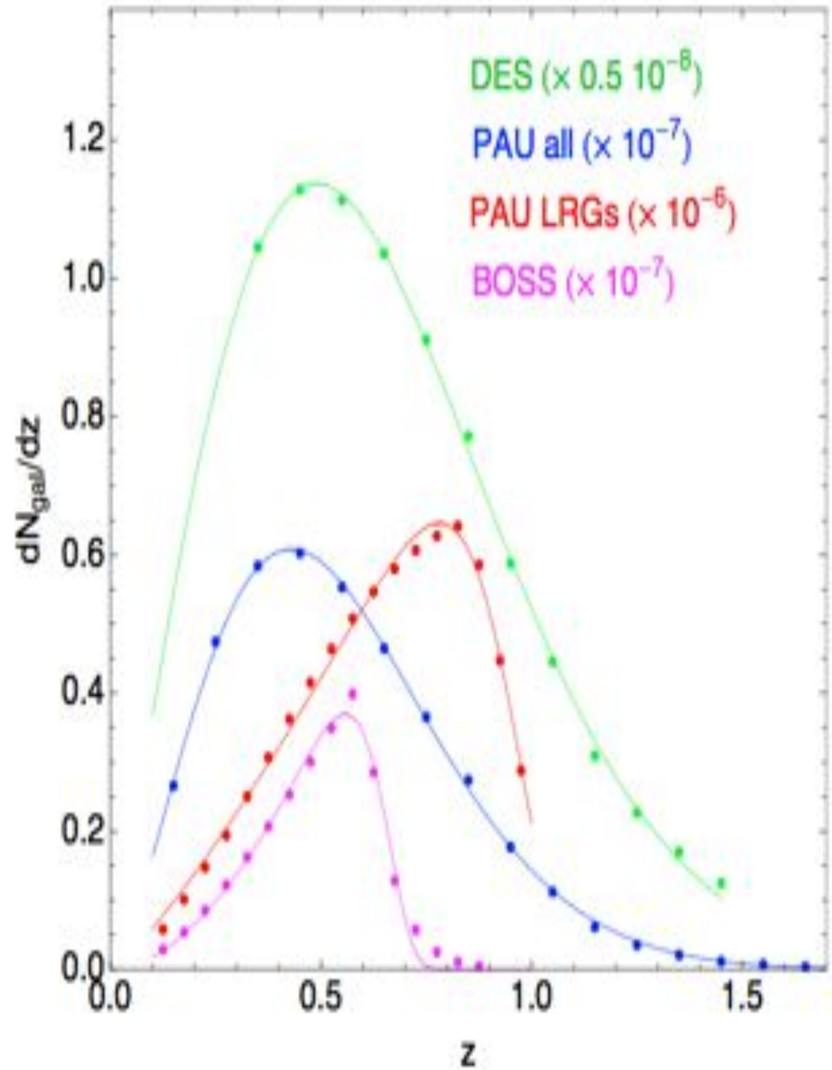
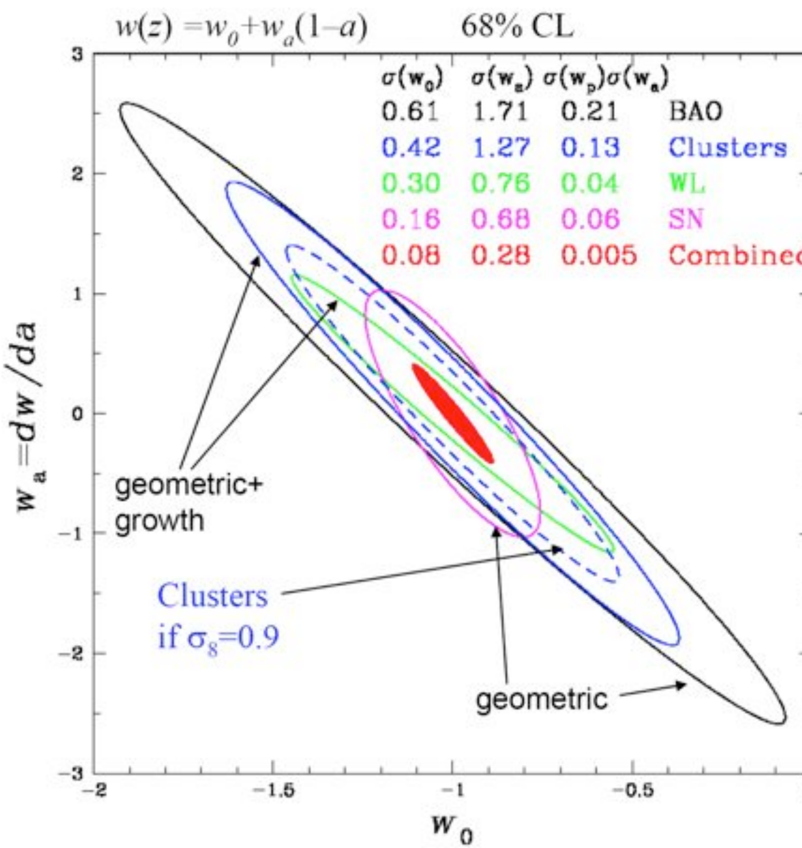


FIG. 4: *Galaxy Redshift Distribution assumed for the surveys considered.*

FOM	1/σ(w0) σ(wa)	1/σ(γ)	1/σ(w0) σ(wa)σ(γ)
DES (MAG)	47 (109)	35 (48)	1.6 (5) x 10^3
DESpec (MAG)	116 (401)	77 (84)	9 (34) x 10^3
DESpec (MAG+RSD)	1430 (1736)	127 (141)	182 (245) x 10^3
PAU200 (MAG+RSD)	171 (195)	31 (33)	5 (6) x 10^3

+Planck+ Stage-SN II (assume bias is known)

Om - ODE - h - sig8 - Ob - w0 - wa - gamma - ns - b1- db1dz- b2- db2dz



FoM
5
8
25
17
200

DESpec/DES:
Factor of 4 in Growth & 30 in DE
factor of 10 in joinned FoM

Conclusion

- Cross-correlation (MAG or galaxy-shear GK) can trace 3D clustering, while shear-shear (KK) only 2D. So there is more to be gained in cross-correlation than in KK from having better redshift information (DESpec).
- Cross-correlation can be used to simultaneously measured bias and give a FoM similar to KK for broad, 4*sigmaz=0.20(1+z), z-bins. This seems in agreement with Hu & Jain 2004. Knowning the bias can also be usefull for RSD and fNL constraints.
- For very accurate photo-z (or spectroscopic z) we can use 10x thiner bins: cross-correlation can give 10 times larger join FoM (growth & cosmic history) when combined with RSD.
- This is for magnification (galaxy-galaxy or galaxy-magnification), Inclusion of shear should improve S/N.
- No systematics and no optmization

END

Additional Slides