Geometrical constraints from galaxy clustering measurements based on Euclid spectroscopy

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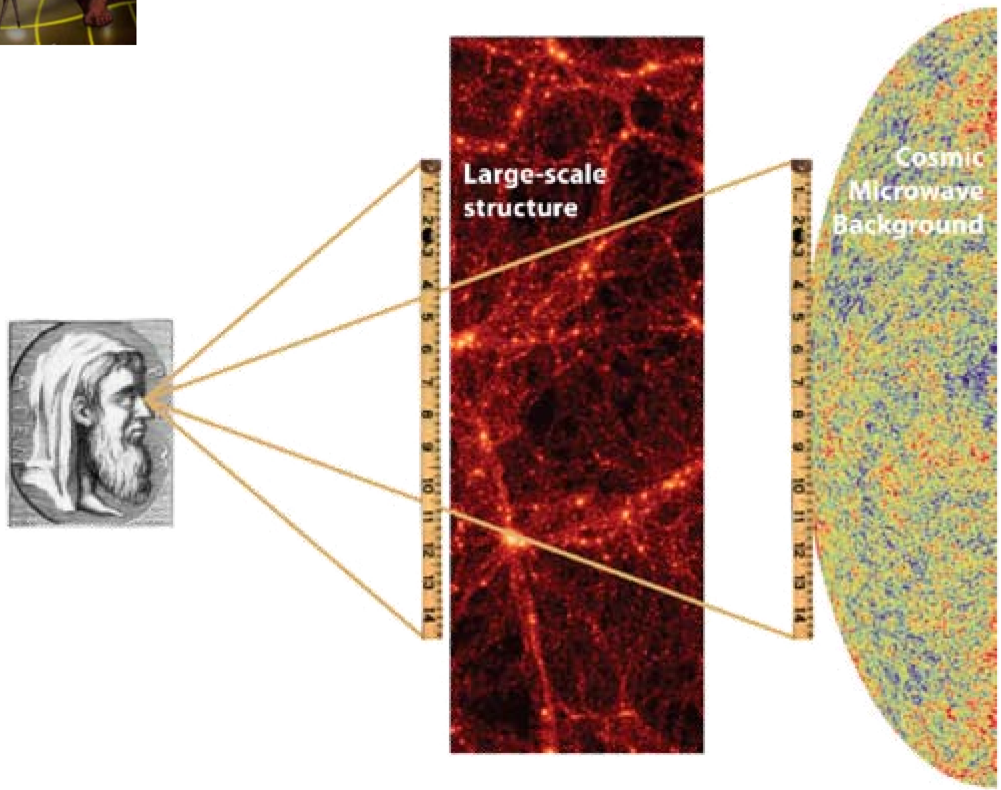
work by the Euclid Cosmology Working Group

Galaxy clustering gives cosmological standard ruler



BAO scale measurements (Δθ, Δz) linked to physical scale predicted by theory (Δd):

Radial direction

$$\frac{c}{H(z)}\Delta z$$

Angular direction

$$(1+z)D_A\Delta\theta$$

Can use full galaxy clustering signal rather than just BAO as standard ruler

Requires accurate modeling of evolution of galaxy bias

Hu & Haiman 2003; PRD, 68, 3004
Blake & Glazebrook 2003; ApJ 594, 665
Seo & Eisenstein 2003; ApJ 598, 720

Euclid

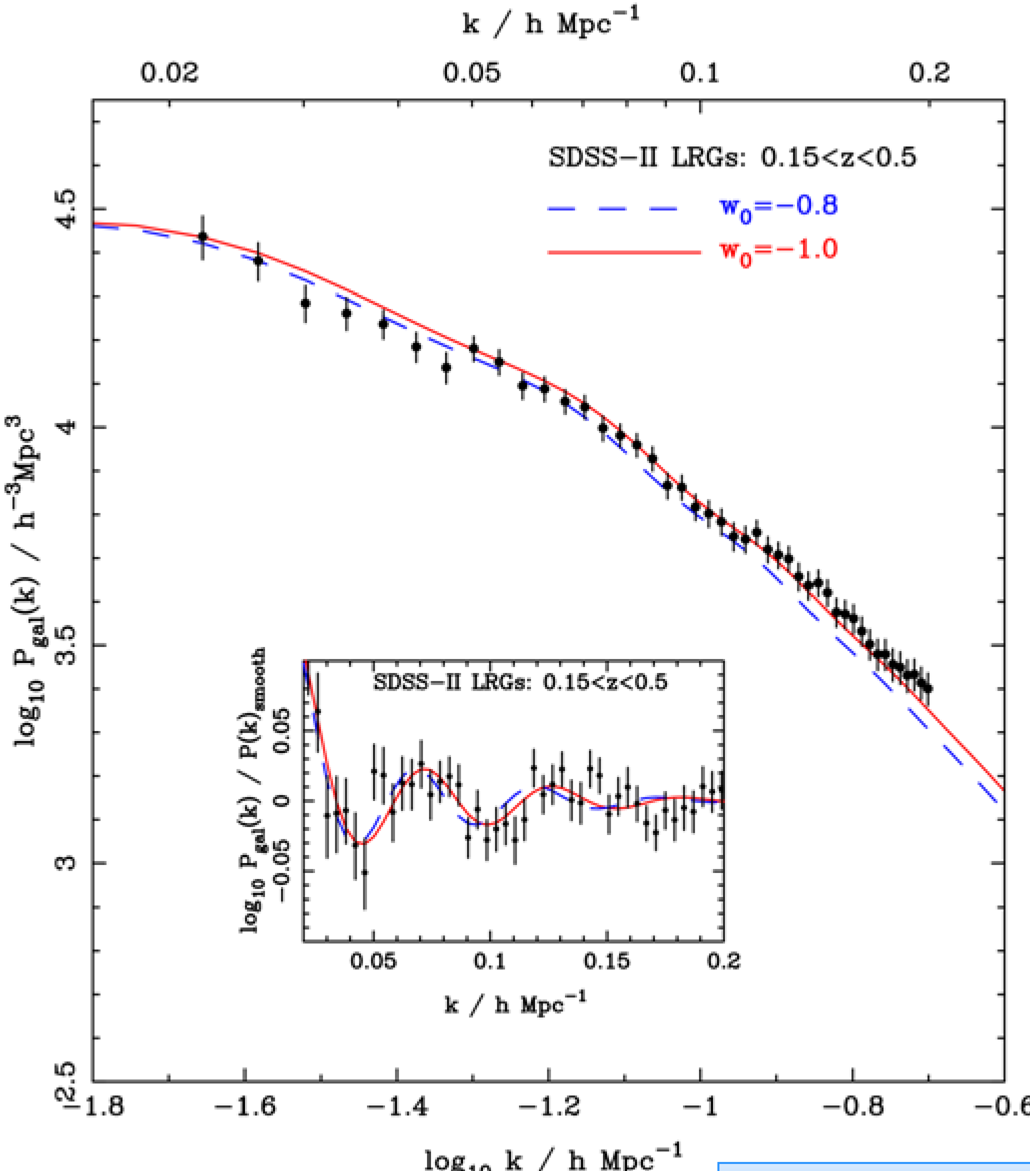
Current large-scale galaxy clustering measurements

SDSS LRGs at z~0.35

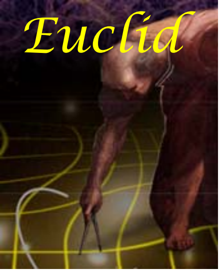
The largest volume of the Universe currently mapped

Total effective volume
V_{eff} = 0.26 Gpc^3h^{-3}

Power spectrum gives amplitude of Fourier modes, quantifying clustering strength on different scales



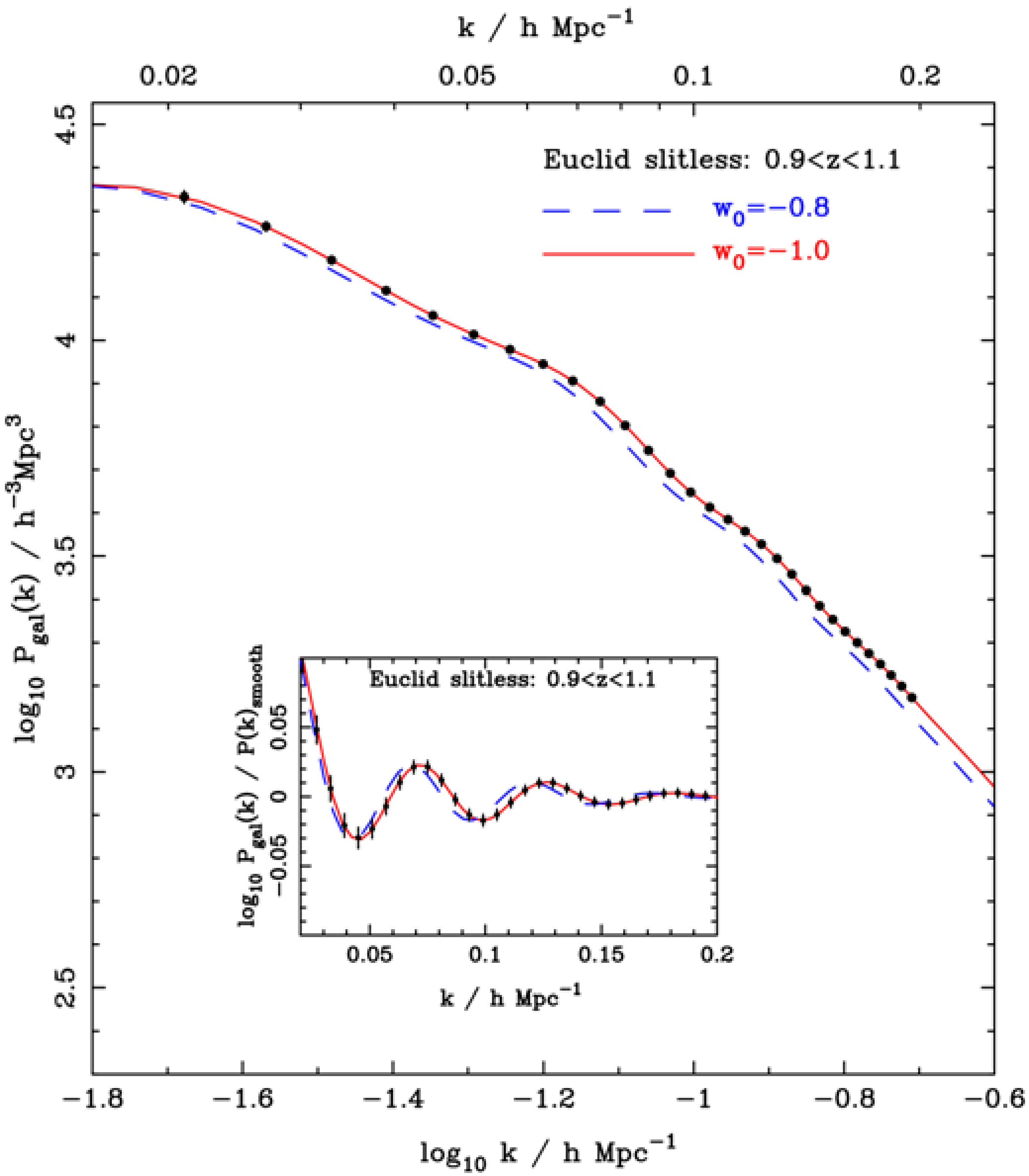
Percival et al. 2009; arXiv:09071660

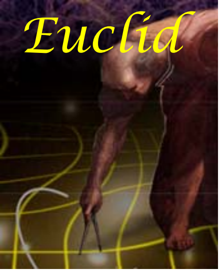


Predicted galaxy clustering measurements by Euclid

20% of the Euclid data, assuming the slitless baseline at z~1

Total effective volume (of Euclid) V_{eff} = 19.7 Gpc^3h^{-3}





Making predictions for Euclid

Fisher matrix allows us to translate between

- expected errors on power spectrum (easily estimated)
- errors on cosmological parameters (showing how good Euclid will be)

$$F_{ij} \equiv \left\langle \frac{\partial^2 \mathcal{L}}{\partial\theta_i \partial\theta_j} \right\rangle$$

Sir Ronald Aylmer Fisher
(1890-1962)

For a galaxy survey we have that

$$F_{ij} = \frac{1}{2}\int \frac{d^3k}{(2\pi)^3}\left(\frac{\partial \ln P}{\partial\theta_i}\right)\left(\frac{\partial \ln P}{\partial\theta_j}\right) V_{\rm eff}(\mathbf{k})$$

$$V_{\rm eff}(k) \equiv \int \left[\frac{\bar{n}(\mathbf{r})P(k)}{1+\bar{n}(\mathbf{r})P(k)}\right]^2 d^3r$$

Tegmark (1997; PRL, 79, 3806)

DETF Figure-of-merit is area of 1σ confidence region for 2-parameter DE model, with equation of state:

$$\begin{aligned} w(z) &= w_0 + (1-a)w_a \\ &= w_p + w_a(a_p - a) \end{aligned}$$

For publically available code, see Seo & Eisenstein 2007; astro-ph/0701079

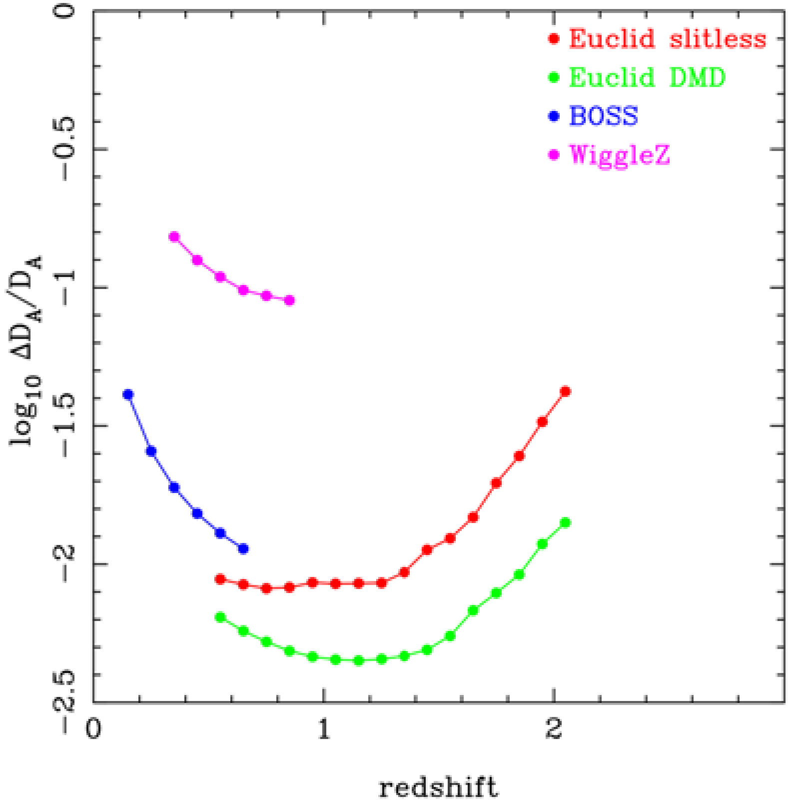
Euclid BAO & P(k) Figures of Merit

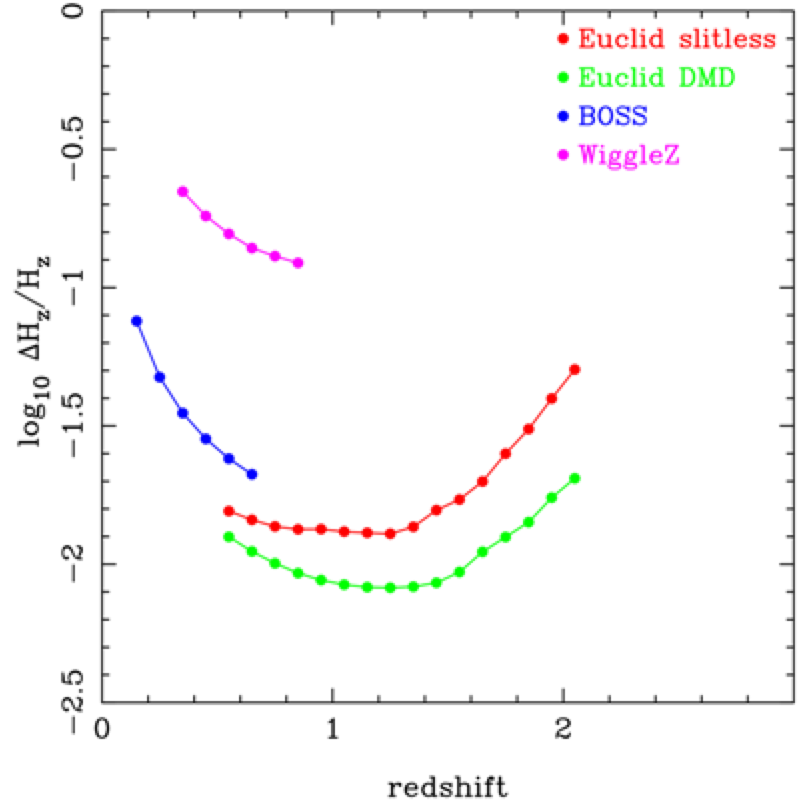
	SDSS-II LRGs	BOSS BAO	Slitless BAO	Slitless P(k)	DMD BAO	DMD P(k)
N(galaxies)	**1×10^5**	**1.5×10^6**	**6.1x10^7**		**2.1x10^8**	
V_{eff} / h^{-3} Gpc^3	**0.26**	**2.4**	**19**		**50**	
redshift	**0<z<0.5**	**0<z<0.7**	**0.5<z<2.1**		**0.0<z<2.1**	
epsilon	**1**	**1**	**0.5**		**0.35**	
Sky area / deg^2	**8000**	**10000**	**20000**		**20000**	
Redshift error	**0.001**	**0.001**	**0.001**		**0.001**	
FoM	**negligible**	**0.2**	**11**	**43**	**49**	**79**
FoM (+Planck)	**negligible**	**8**	**136**	**314**	**467**	**511**
FoM (+Planck+BOSS)			**183**			

Slitless baseline: 50% of galaxies with $F>4\times10^{-26}$ erg $cm^{-1}s^{-2}$

DMD baseline: 35% of galaxies selected to H<22.0

Euclid compared with on-going surveys

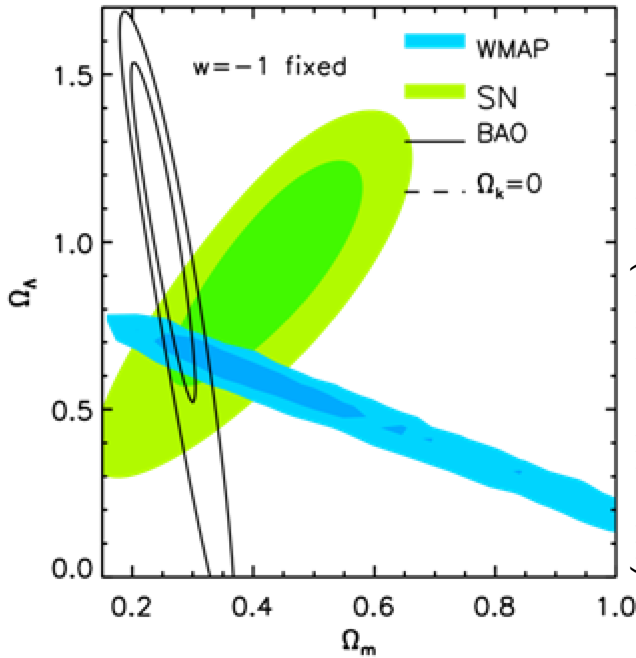




Euclid gives an order-of-magnitude improvement over constraints from ongoing surveys

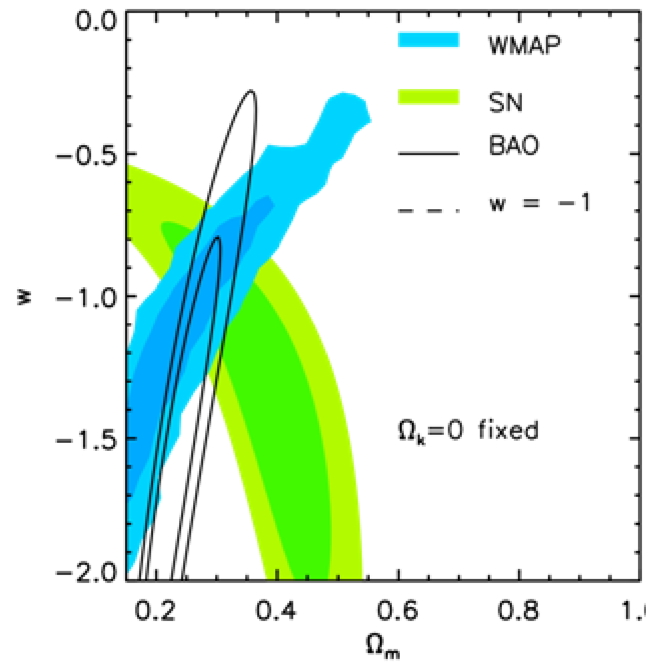
Current BAO constraints vs other data

ΛCDM models with curvature



Percival et al. (2009: arXiv:0907.1660)

flat wCDM models



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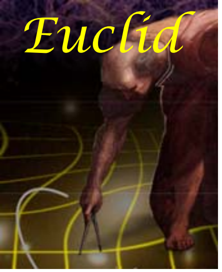
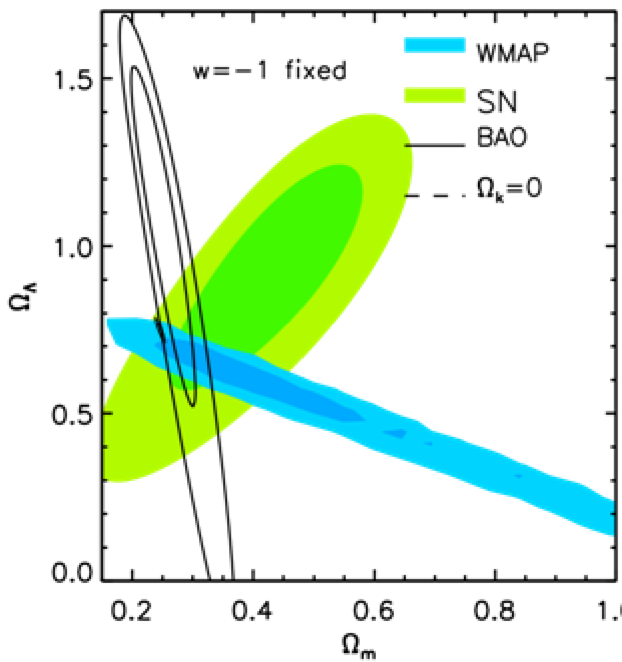
- Union supernovae
- WMAP 5year
- SDSS-II BAO Constraint on $r_s(z_d)/D_V(0.2)$ & $r_s(z_d)/D_V(0.35)$



How does Euclid BAO compare?

ΛCDM models with curvature



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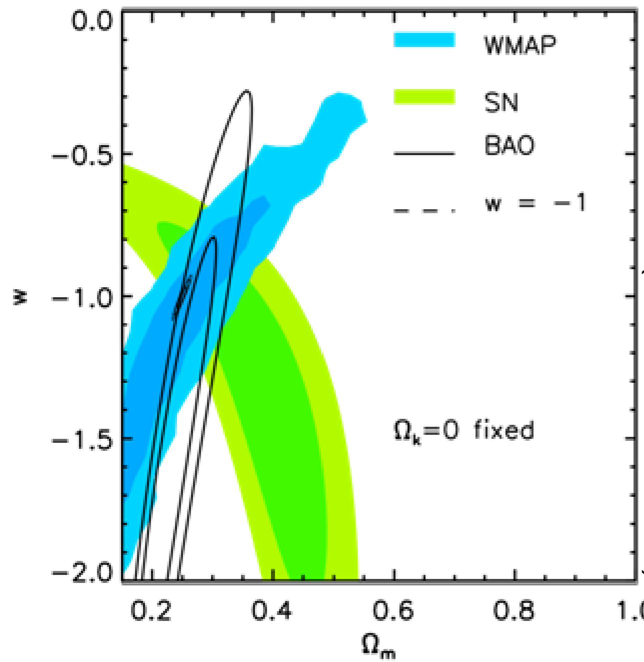

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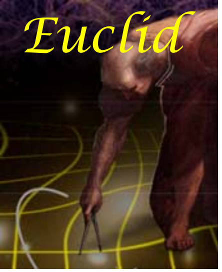

The power of Euclid: Summary

- Map of the Universe 75 times larger than available currently
- Homogeneous sampling of galaxies
- Will provide tight dark energy constraints
  - BAO constraints have very low levels of systematics
  - P(k) constraints are tighter, but require bias modeling
- Get complementary constraints from redshift-space distortions (see talk by Guzzo later)
- Enhanced dark energy measurement precision with slit spectra (using DMD)