Which redshift surveys for cosmology: new data, new challenges

Luigi (Gigi) Guzzo

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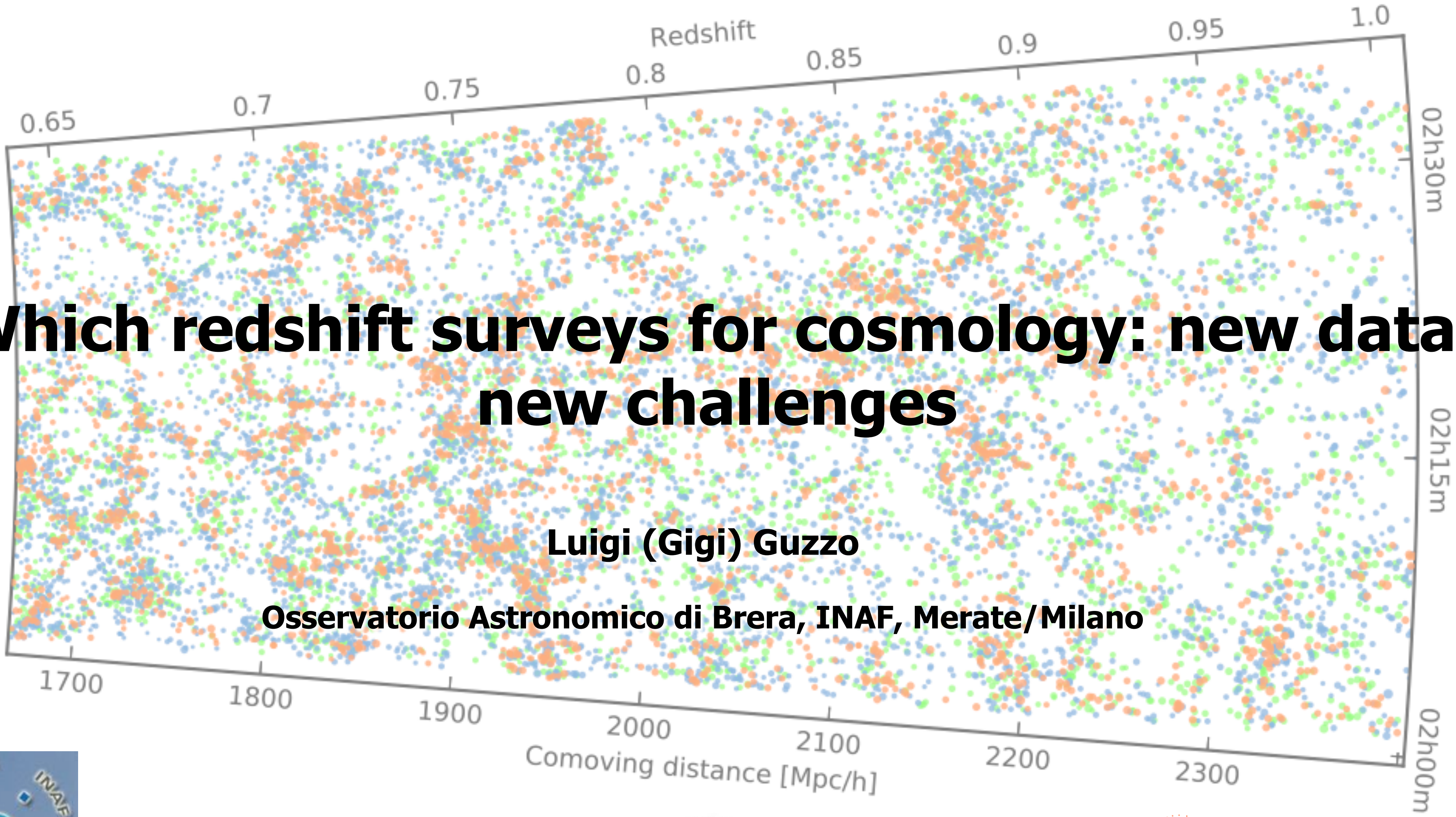
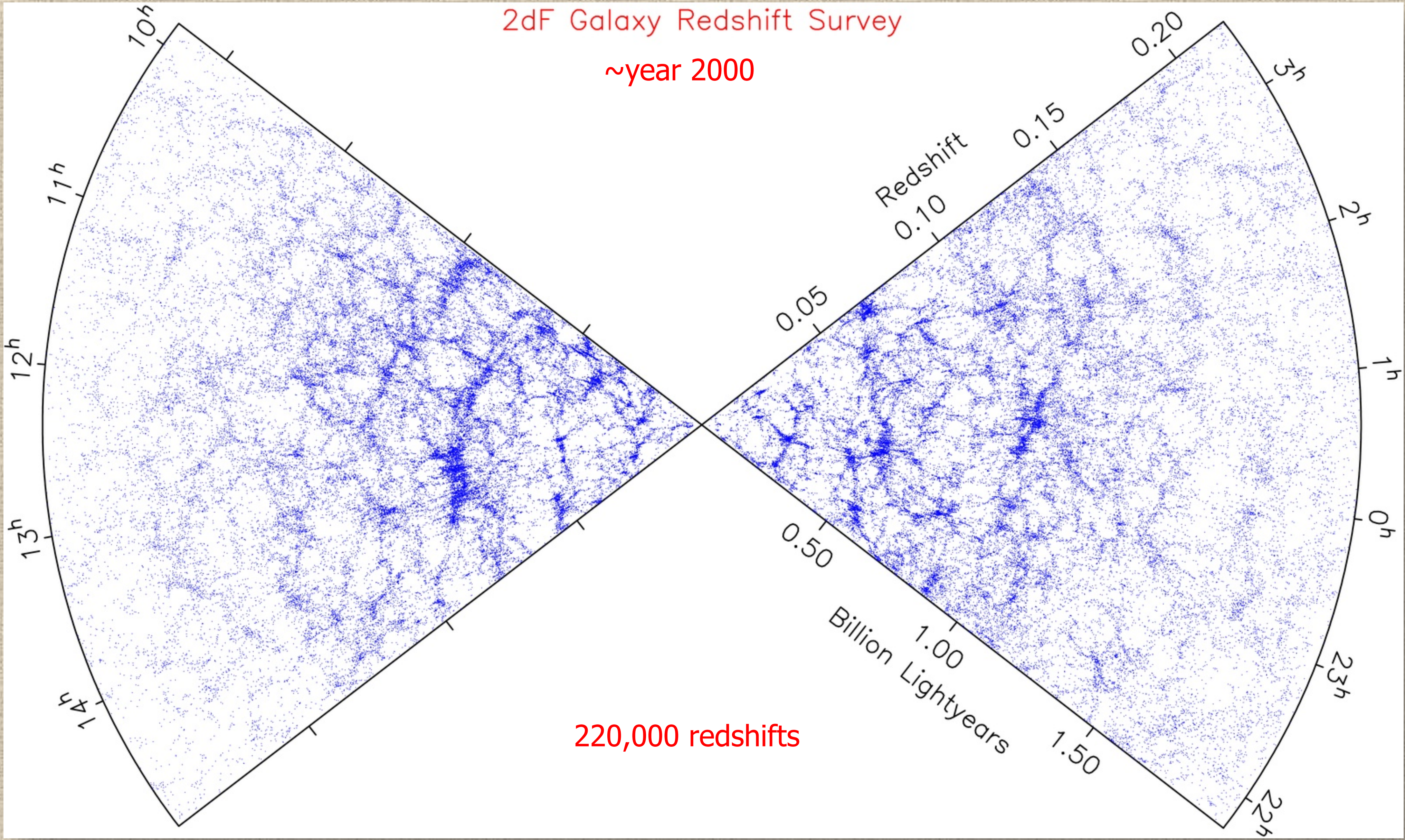
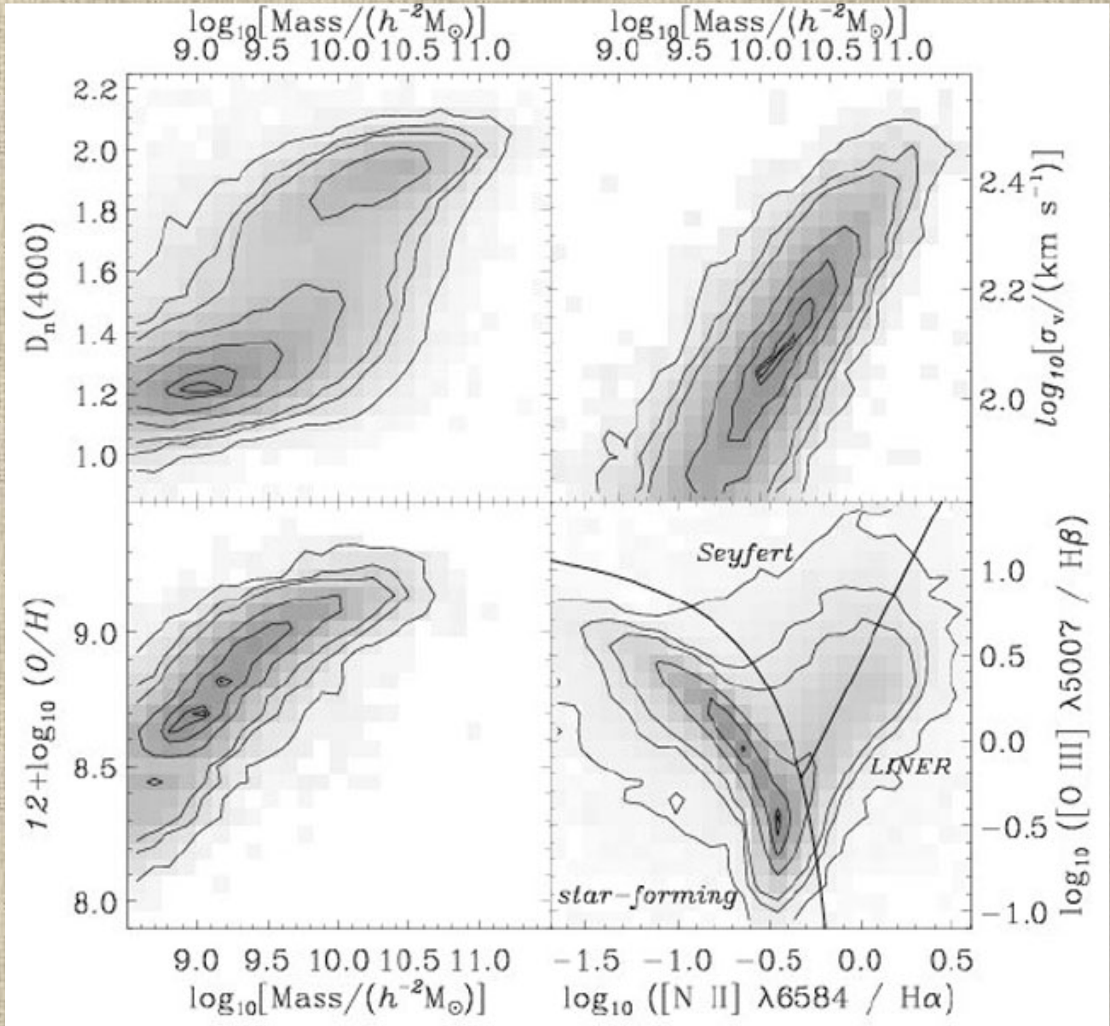


Galaxy redshift surveys: a major pillar of the cosmological model…

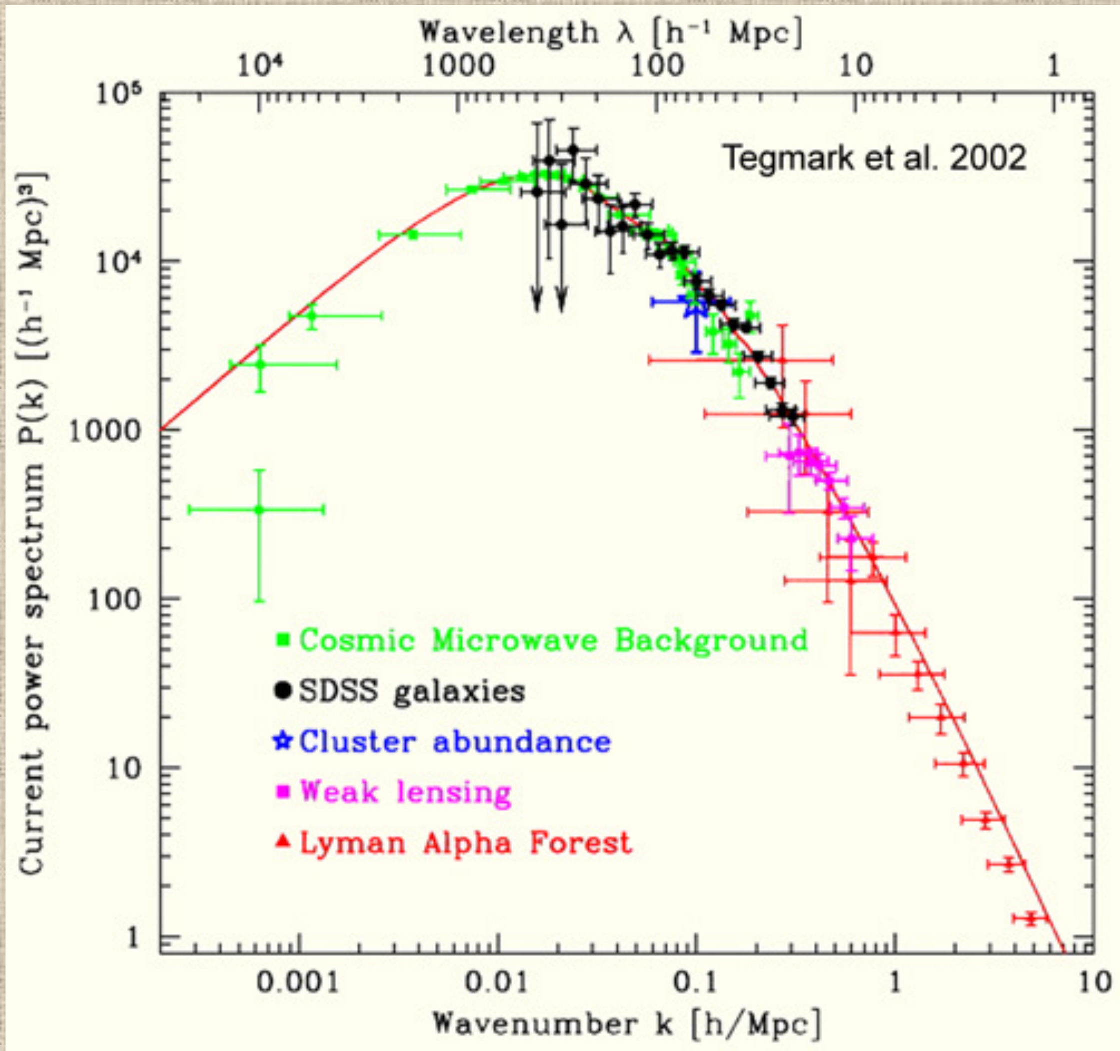


…but also of our understanding of how galaxies form and evolve…

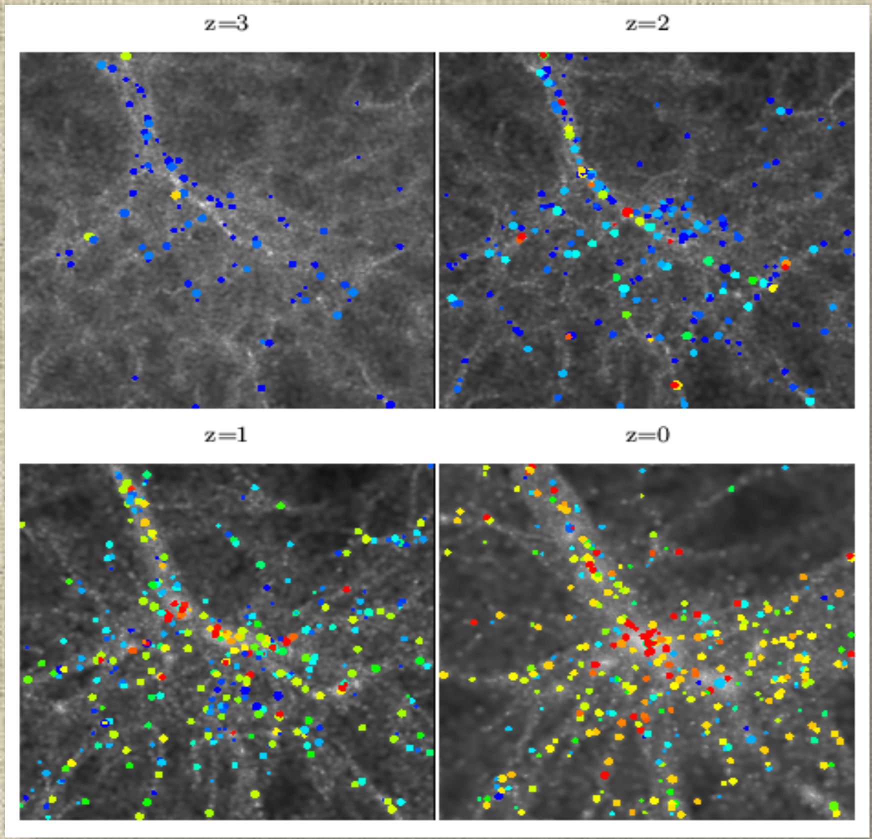


- SDSS: statistical distribution of galaxy properties for ~10^6 galaxies

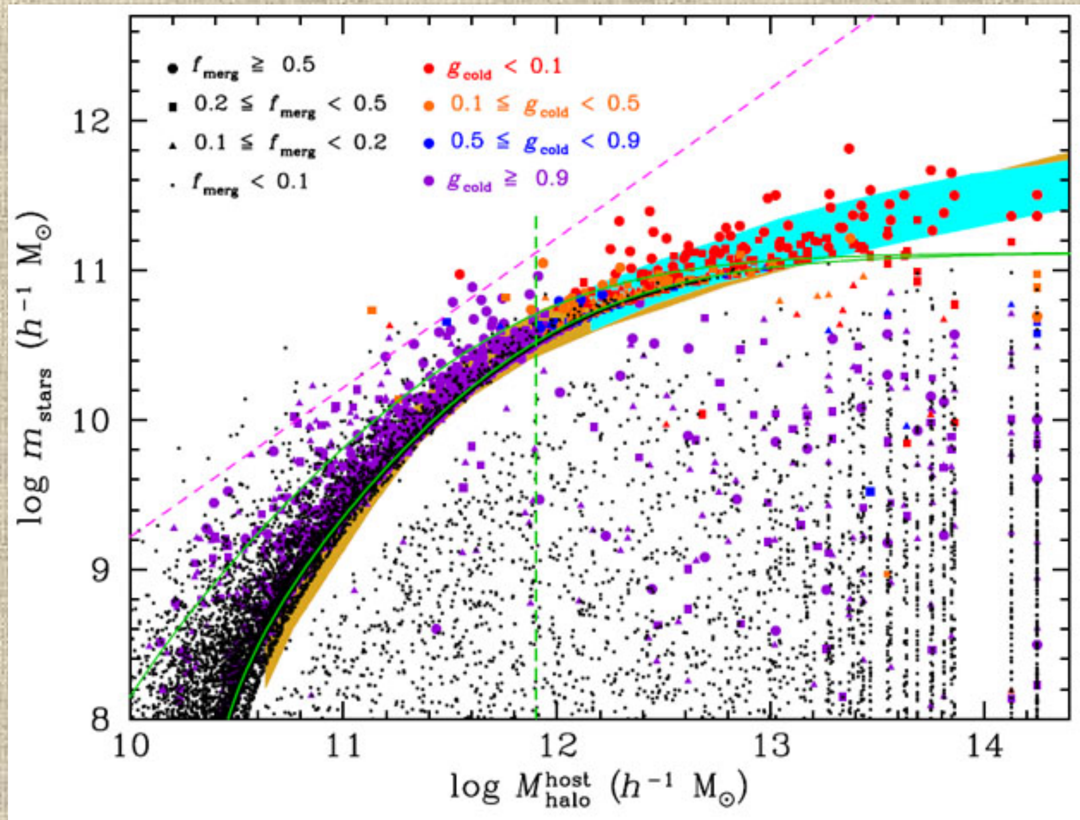
The clustering power spectrum: a probe of the underlying cosmology



We need to understand galaxies, to do cosmology…

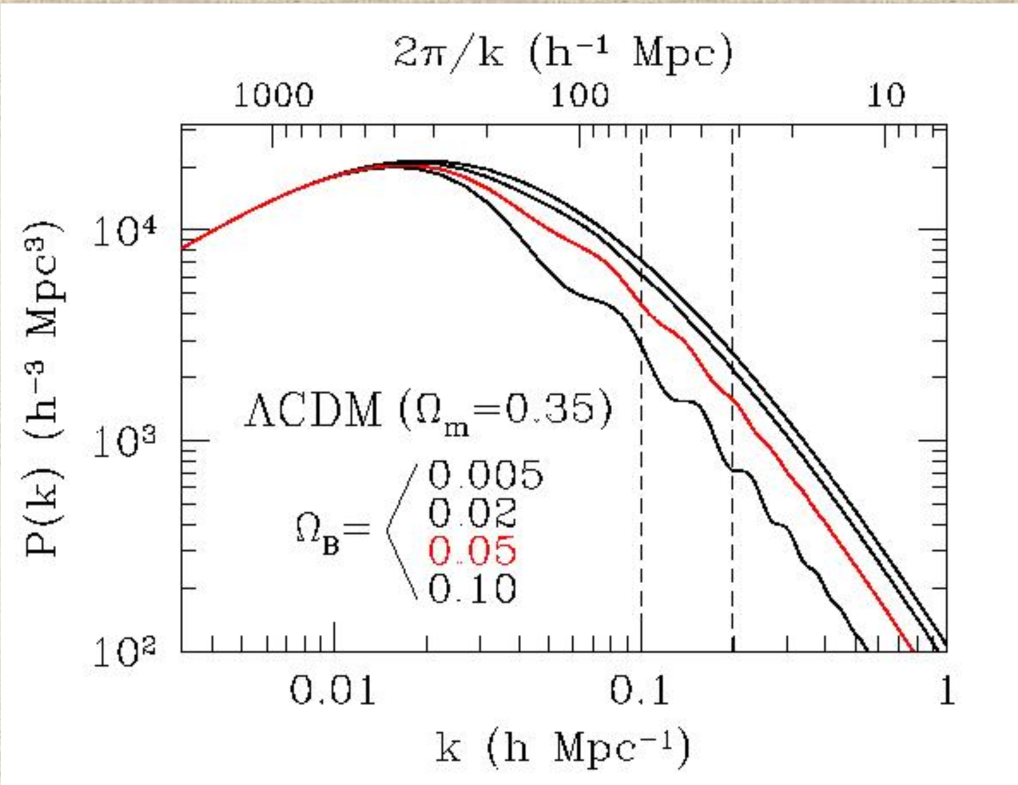


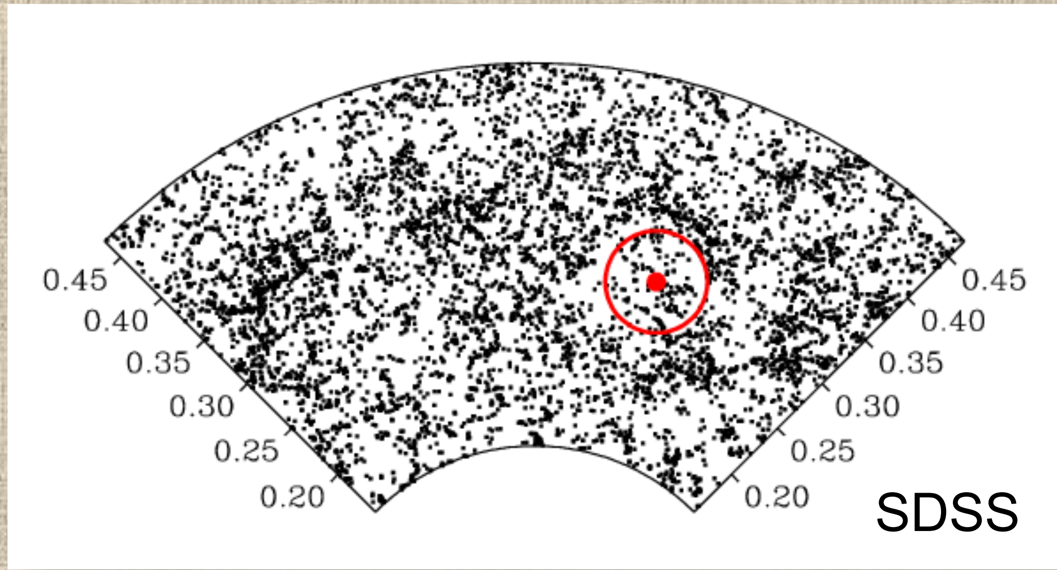
Kauffman & Diaferio 1998



Cattaneo et al. 2011 – halo mass vs stellar mass;
(toy model on high-resolution simulation DM halos)

Baryonic Acoustic Oscillations: a standard ruler to measure H(z)

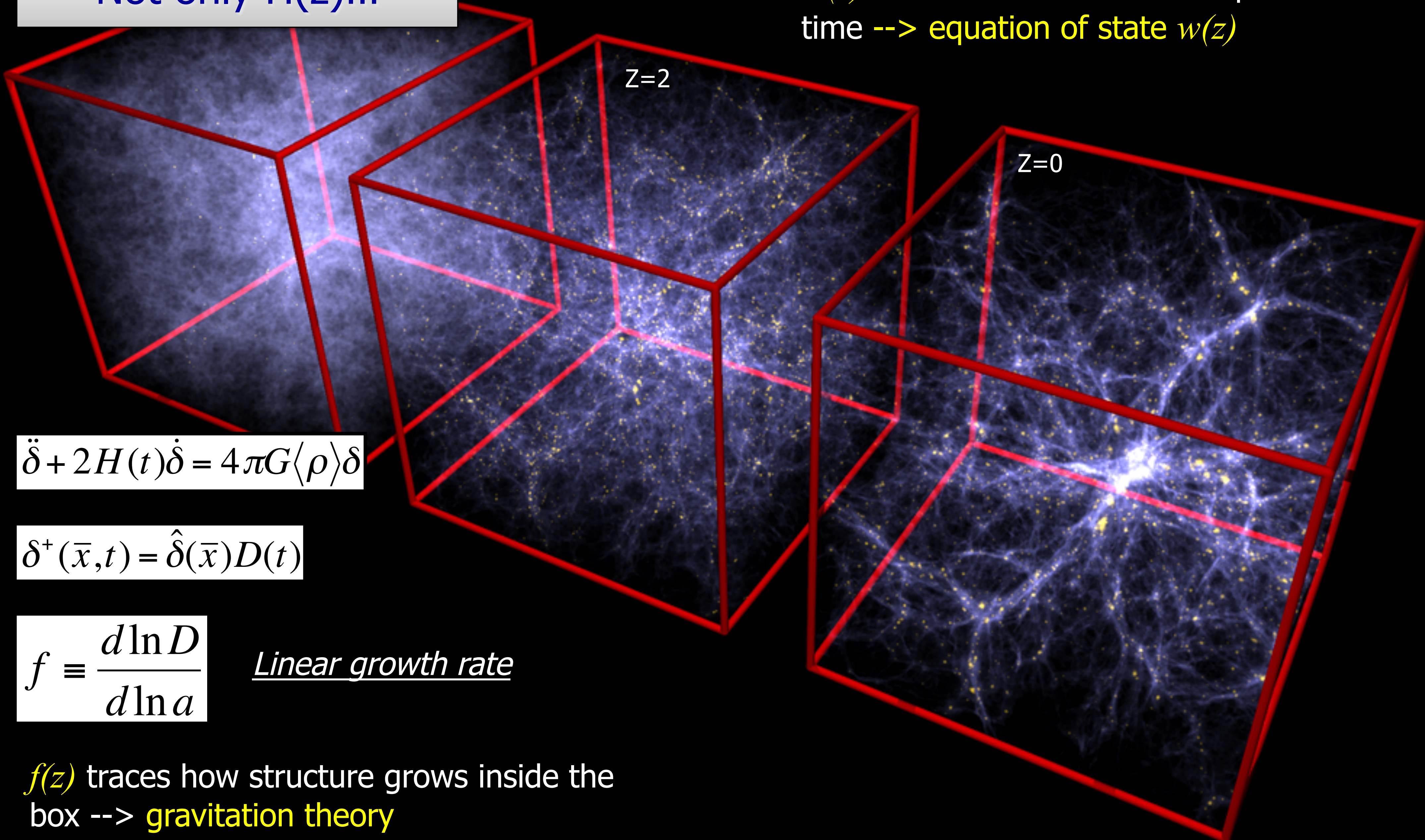




D. Eisenstein 2007

Not only H(z)…

H(z) measures how the box expands with time --> equation of state *w(z)*



$$\ddot{\delta} + 2H(t)\dot{\delta} = 4\pi G\langle\rho\rangle\delta$$

$$\delta^{+}(\bar{x},t) = \hat{\delta}(\bar{x})D(t)$$

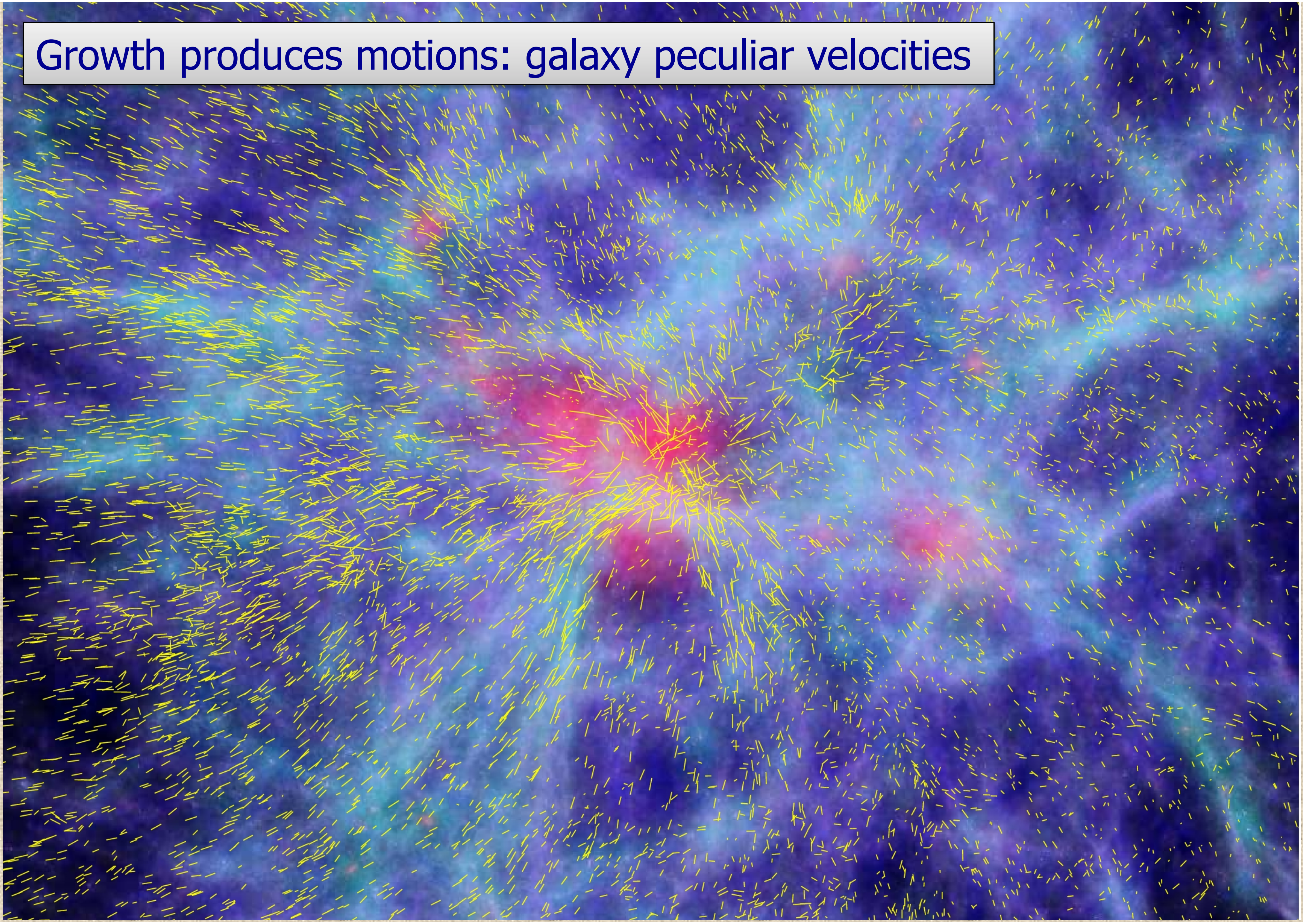
$$f \equiv \frac{d\ln D}{d\ln a}$$

Linear growth rate

f(z) traces how structure grows inside the box --> gravitation theory

Springel et al.

Growth produces motions: galaxy peculiar velocities



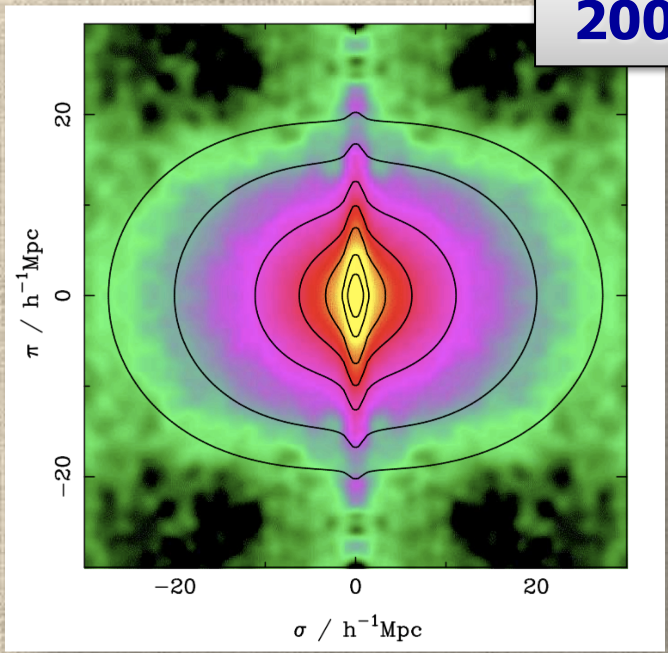
Redshift-Space Distortions: an old way to look at a new thing…

Nature 410, 169 (2001)

A measurement of the cosmological mass density from clustering in the 2dF Galaxy Redshift Survey

John A. Peacock[1], Shaun Cole[2], Peder Norberg[2], Carlton M. Baugh[2], Joss Bland-Hawthorn[3], Terry Bridges[3], Russell D. Cannon[3], Matthew Colless[4], Chris Collins[5], Warrick Couch[6], Gavin Dalton[7], Kathryn Deeley[6], Roberto De Propris[6], Simon P. Driver[8], George Efstathiou[9], Richard S. Ellis[9,10], Carlos S. Frenk[2], Karl Glazebrook[11], Carole Jackson[4], Ofer Lahav[9], Ian Lewis[3], Stuart Lumsden[12], Steve Maddox[13], Will J. Percival[1], Bruce A. Peterson[4], Ian Price[4], Will Sutherland[1,7] & Keith Taylor[3,10]

2001



Vol 451|31 January 2008|doi:10.1038/nature06555 nature

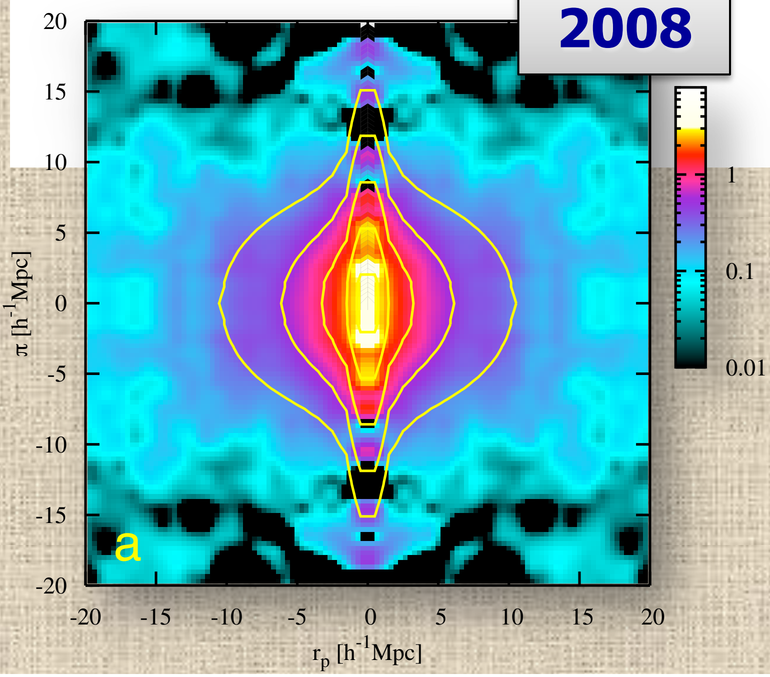
Nature 451, 541 (2008)

LETTERS

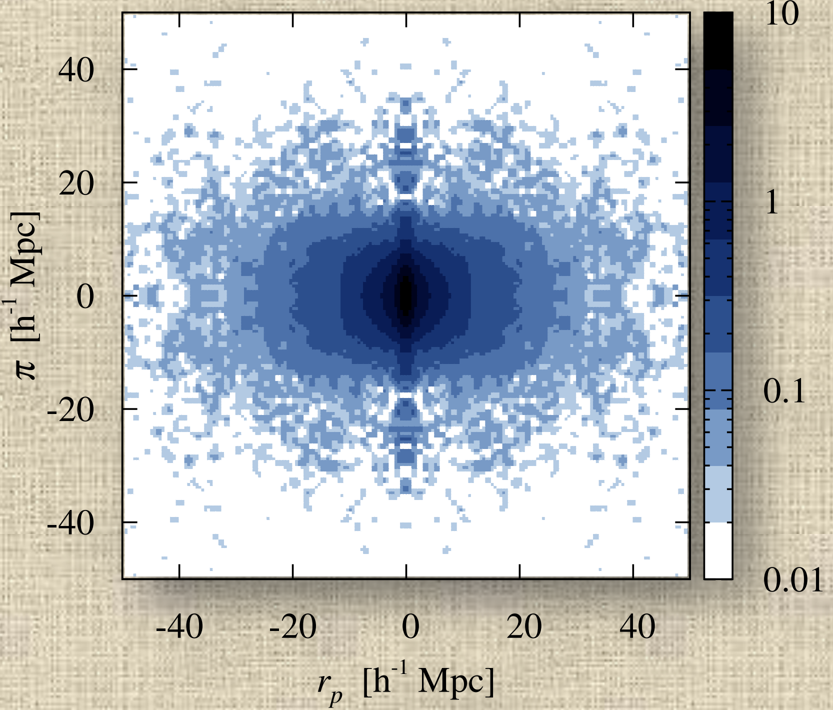
A test of the nature of cosmic acceleration using galaxy redshift distortions

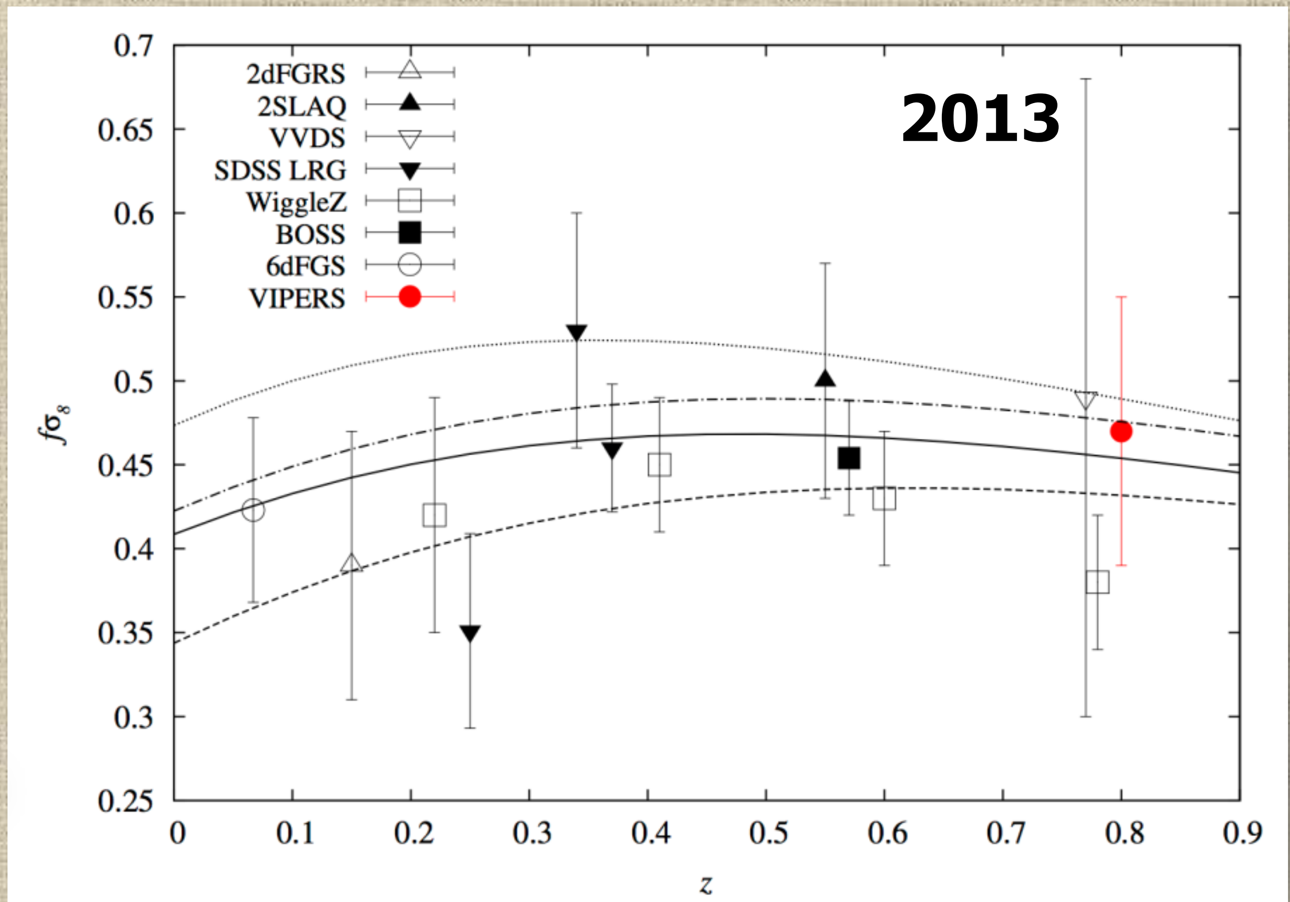
L. Guzzo[1,2,3,4], M. Pierleoni[3], B. Meneux[5], E. Branchini[6], O. Le Fèvre[7], C. Marinoni[8], B. Garilli[5], J. Blaizot[3], G. De Lucia[3], A. Pollo[7,9], H. J. McCracken[10,11], D. Bottini[5], V. Le Brun[7], D. Maccagni[5], J. P. Picat[12], R. Scaramella[13,14], M. Scodeggio[5], L. Tresse[7], G. Vettolani[13], A. Zanichelli[13], C. Adami[7], S. Arnouts[7], S. Bardelli[15], M. Bolzonella[15], A. Bongiorno[16], A. Cappi[15], S. Charlot[10], P. Ciliegi[15], T. Contini[12], O. Cucciati[1,17], S. de la Torre[7], K. Dolag[3], S. Foucaud[18], P. Franzetti[5], I. Gavignaud[19], O. Ilbert[20], A. Iovino[1], F. Lamareille[15], B. Marano[16], A. Mazure[7], P. Memeo[5], R. Merighi[15], L. Moscardini[16,21], S. Paltani[22,23], R. Pellò[12], E. Perez-Montero[12], L. Pozzetti[15], M. Radovich[24], D. Vergani[5], G. Zamorani[15] & E. Zucca[15]

2008



Redshift-space distortions as a dark energy test





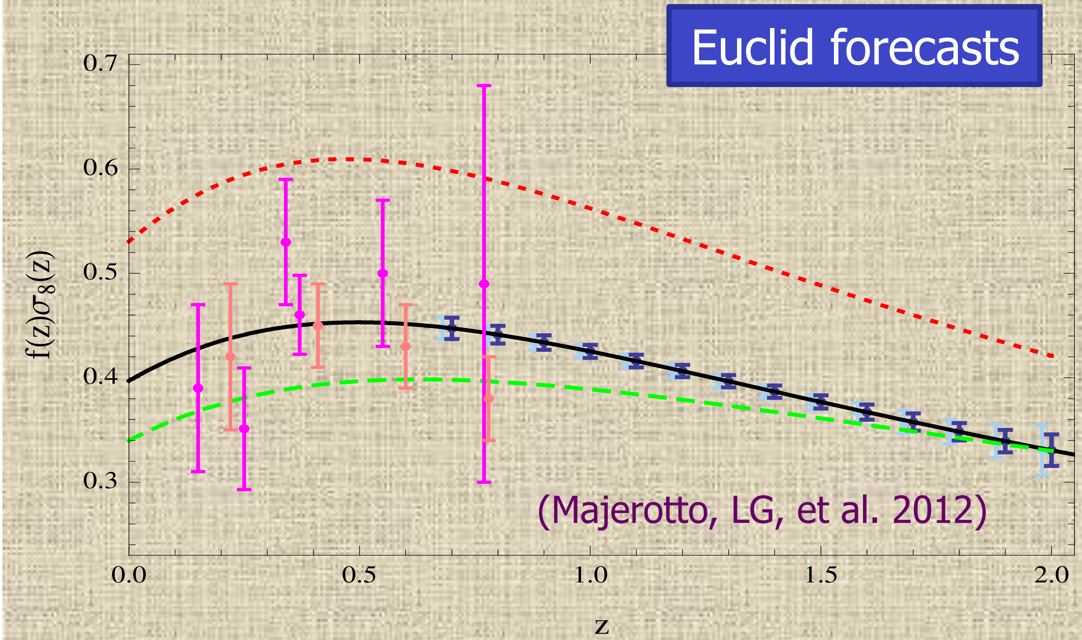
BOSS: $f\sigma_8(z=0.57) = 0.447 \pm 0.028$ Samushia et al. 2014

VIPERS: $f\sigma_8(z=0.8) = 0.47 \pm 0.08$ De la Torre, LG et al. 2013

Systematic effects on Redshift-Space Distortions…

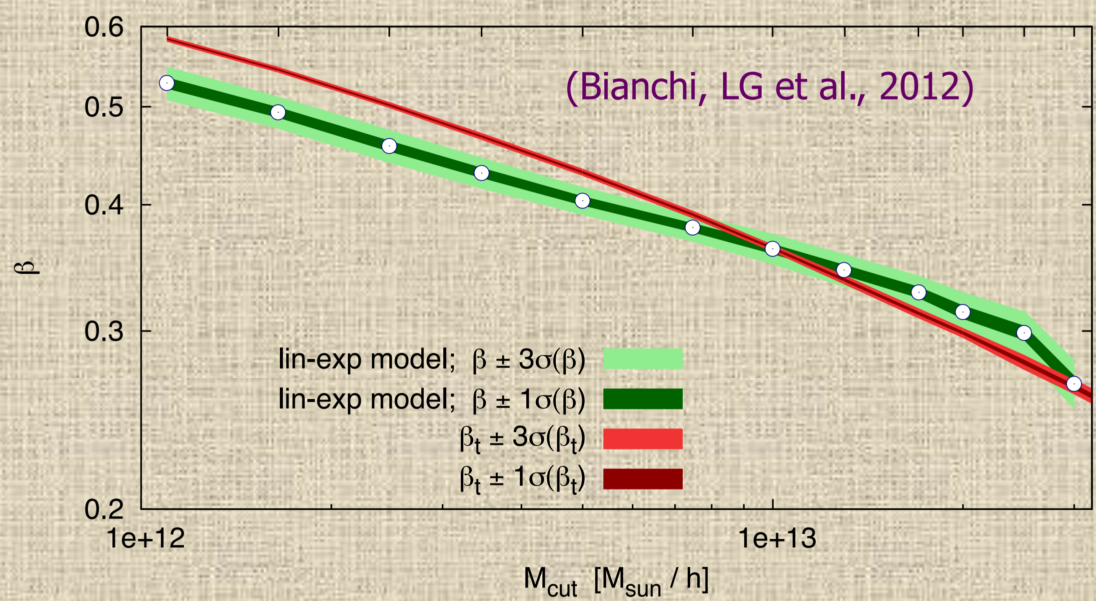
Need to improve modelling to enter *"precision RSD era"*

→ e.g. EUCLID: 1-3% precision on $f\sigma_8$



→ A lot of modelling work ongoing (Scoccimarro, Taruya+, Kwan+, Reid+, Samushia+, Seljak+, Bianchi+, Kopp+, …

→ "Standard" RSD dispersion model: up to 10% systematic error



(also Okumura & Jing, 2011)

Galaxy clustering: a primary probe to answer the high-level questions…

- Nature of Dark Matter ?
- Nature of Dark Energy ?
- Behaviour of gravity at the largest scales (did Einstein have final word)?
- Physics of the initial conditions (inflation) ?

Implications for physics

→ the Standard Model of cosmology (ΛCDM)

→ the Standard Model of particle physics

…if a galaxy redshift survey is properly designed

STATISTICAL ERRORS (not an issue nowadays?):

- Sample bigger volumes to push down sample variance, but being sufficiently dense to stay away from shot noise regime on the scales of interest
- Use multiple populations? (seemed more promising) → survey design

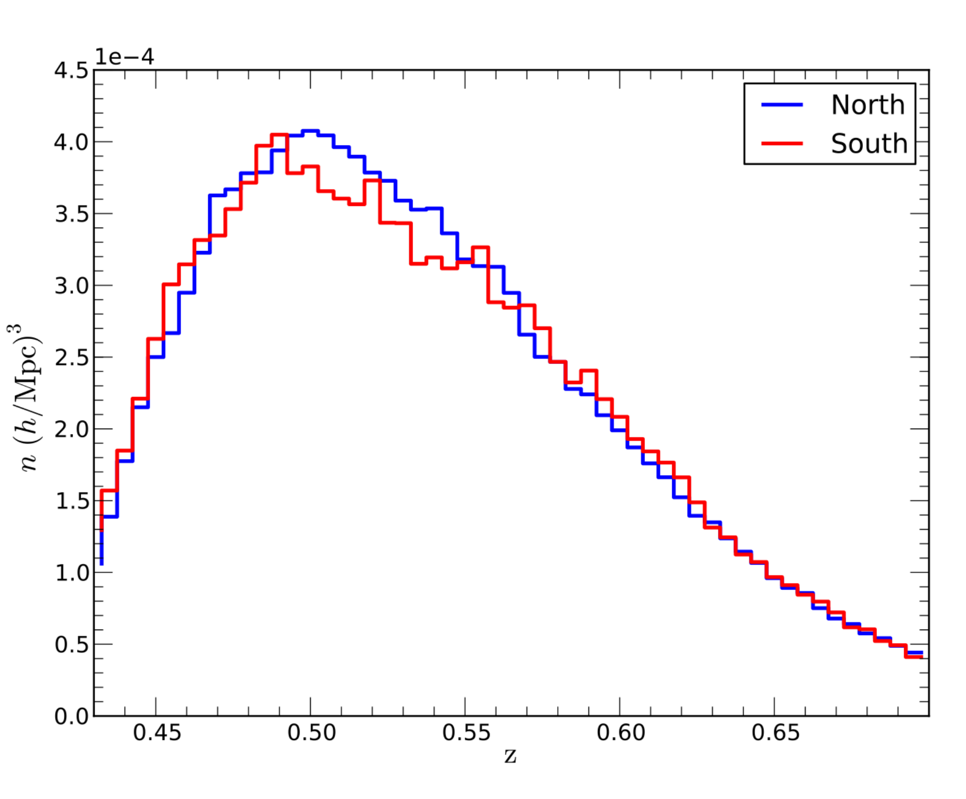
SYSTEMATIC ERRORS:

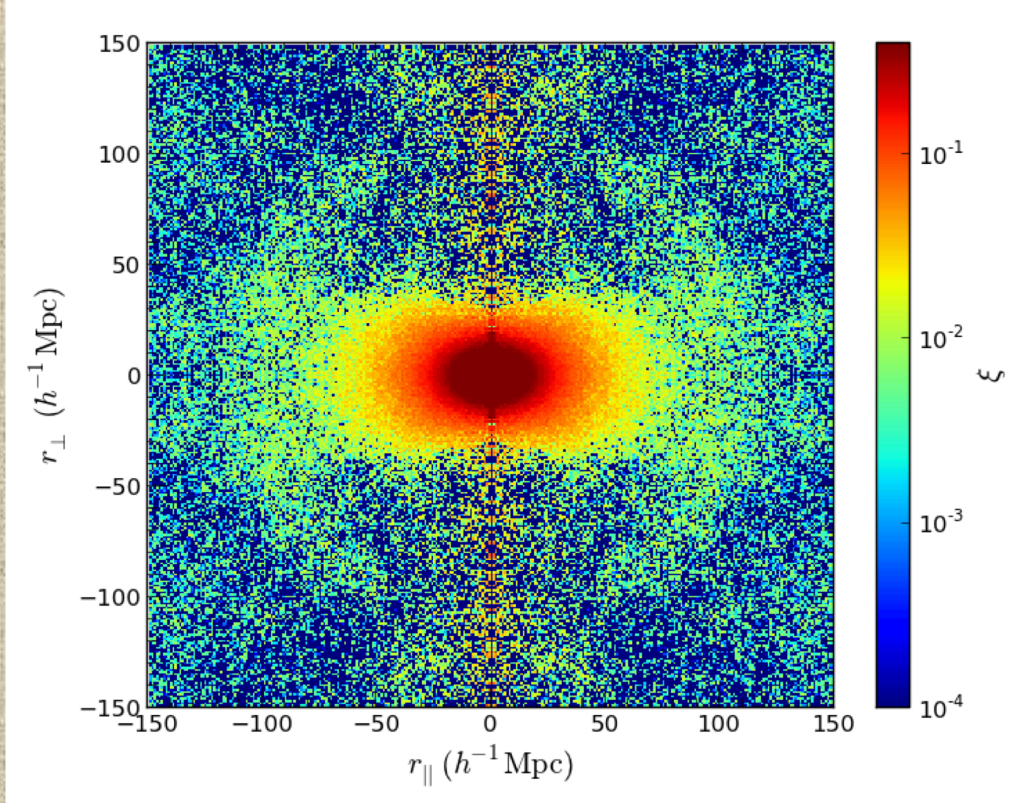
- How do my galaxy tracers sample dark-matter distribution? DM-baryon connection (**bias**) → survey design (type of tracers, …)
- Minimize impact of **non-linear clustering** → survey design (largest possible volume)
- Accuracy of **modelling** (e.g. RSD), to match requirements of precision cosmology → technical advances, but also survey design (some tracers may be less affected than others)
- Use multiple populations, as a cross-check of systematic effects → survey design

Enlarge volume using a sparse “special” galaxy population…

E.g. SDSS-LRG, and **BOSS** (see also **Wigglez** – Blake et al.):

- BOSS: “CMASS” LRG-like col-col selection, “loosely selecting constant mass galaxies”, **z<0.7**
- **Area=8500 deg^2 , Volume~6 h^{-3} Gpc, Ngal = 690,000 → <n>~10^{-4} h^3 Mpc^{-3}**
- Optimized for BAO measurement, excellent (a posteriori) for Redshift Space Distortions
- See e.g. Samushia et al. (2014) and references therein





…or push to higher redshift, but aiming at a volume **and density** comparable to 2dFGRS and SDSS, with similarly broad selection function

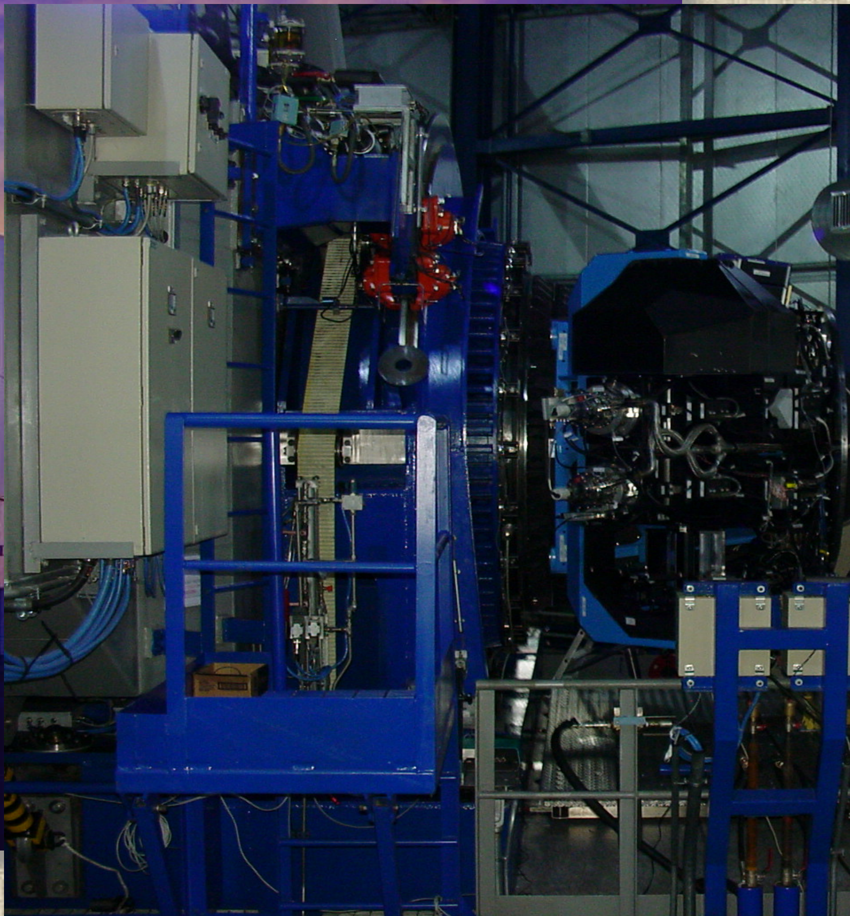
VIPERS

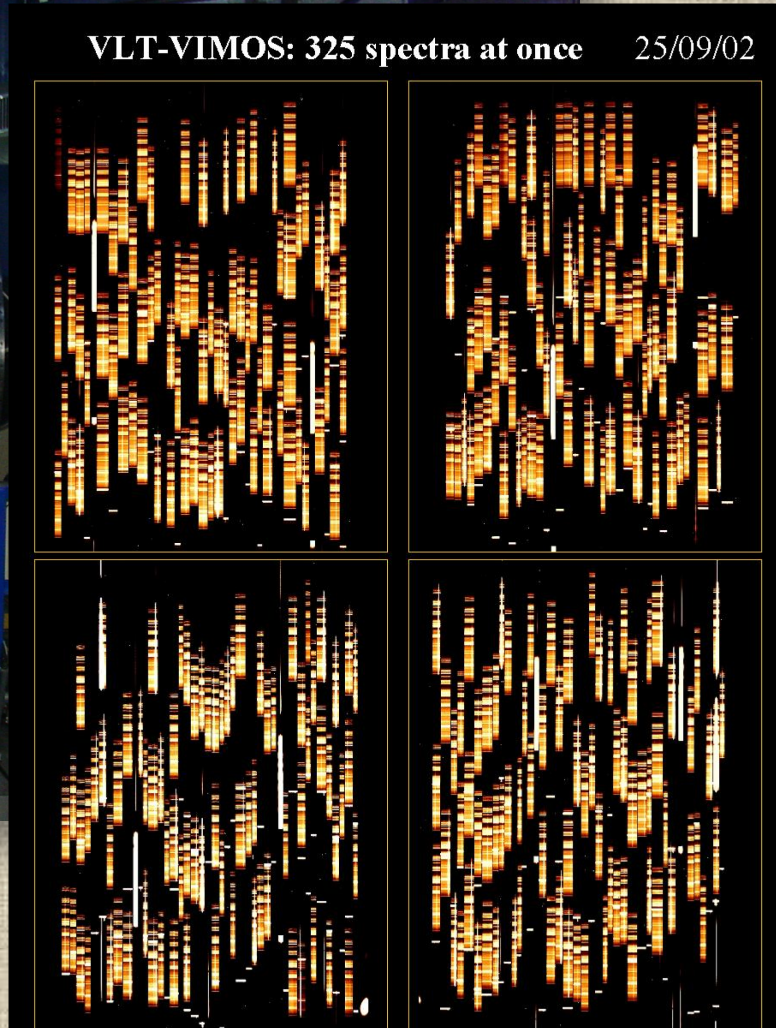
VIMOS PUBLIC EXTRAGALACTIC REDSHIFT SURVEY

VIPERS headline science goals

- **Galaxy clustering at z~1 with comparable precision to z~0:**
  - Evolution of $\xi(r)$ and P(k) (Ω_m, Ω_b at z~1)
  - Dependence on galaxy properties
  - Galaxy-DM relations (HOD modeling)
- **Growth rate from redshift-space distortions at z~1**
- **Evolution and non-linearity of galaxy biasing**
- **Evolution of galaxy colors and environmental effects**
- **Bright/massive/rare galaxies at z~1 and evolution of the galaxy luminosity and stellar mass functions**
- Combined clustering / weak-lensing analysis (photo-z calibr., CFHTLenS match)
- Multi-wavelength studies (SWIRE, XMM-XXL, UDS, VIDEO,...)

VIMOS @ VLT fills unique niche in density-area space





At VIPERS depth: ~100 gal/quadrant →
400/224 gal/arcmin^2 ~ **6500 gal/deg^2**

VIPERS strategy

- **Want volume and density comparable to a survey like 2dFGRS, but at z=[0.5-1]:** cosmology driven, but with broader legacy return
- **Means Vol~5 x 10^7 h^{-3} Mpc^3, ~100,000 redshifts, close to full sampling**
- Implies **I_{AB}<22.5, ~24 deg^2**
- Improve sampling within redshift range of interest through **z>0.5 robust color-color pre-selection** (+star-galaxy separation), with also better match to VIMOS multiplexing: **>40% sampling**
- **CFHTLS Wide** (W1 and W4 fields, ~16 + 8 deg^2) provides accurate multi-band photometry to support this
- VIMOS LR Red grism, **45 min exposure**
- 288 pointings, **440.5 VLT hours (~55 night-equivalent)**

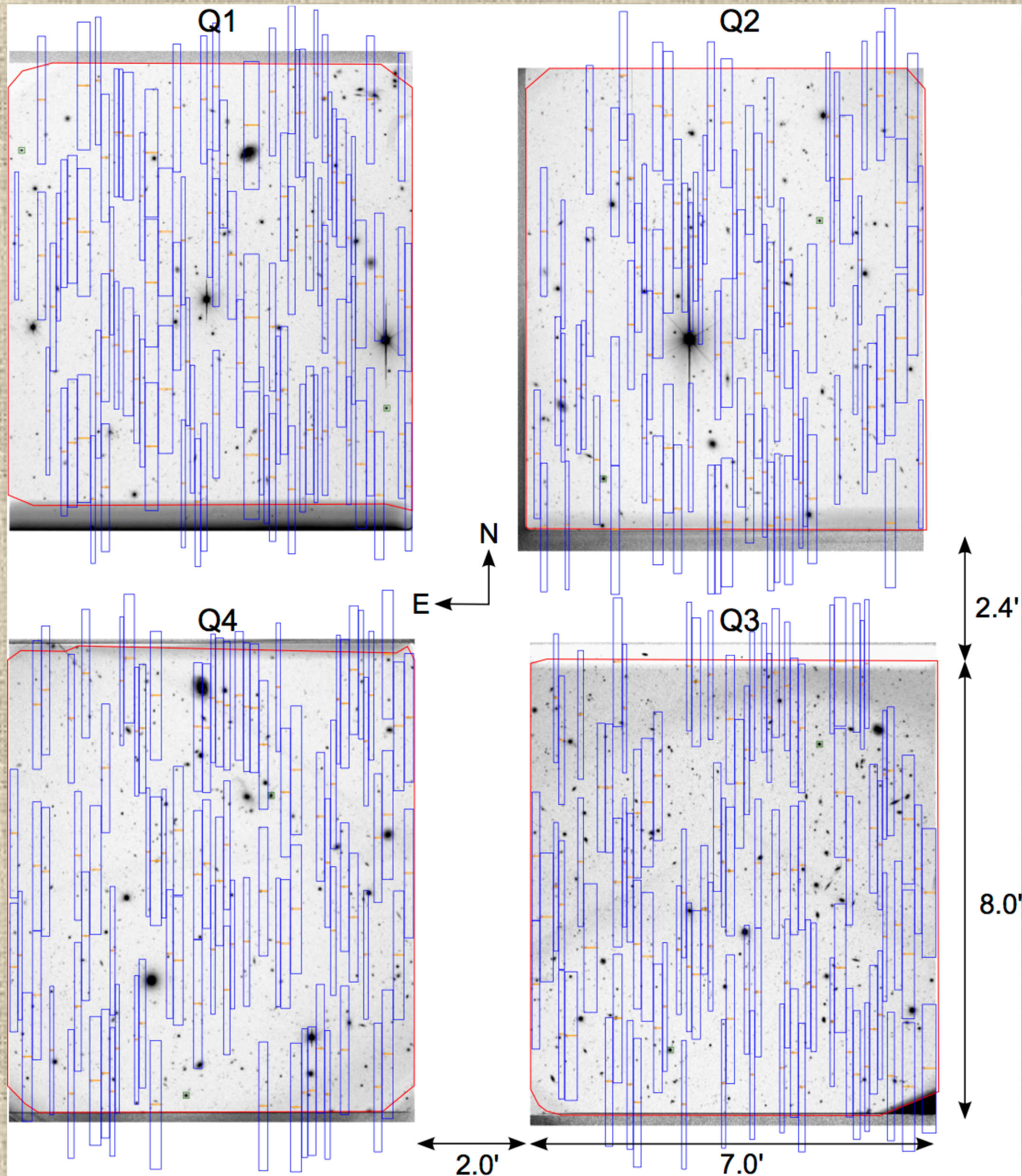
VIPERS Team

(see http://vipers.inaf.it)

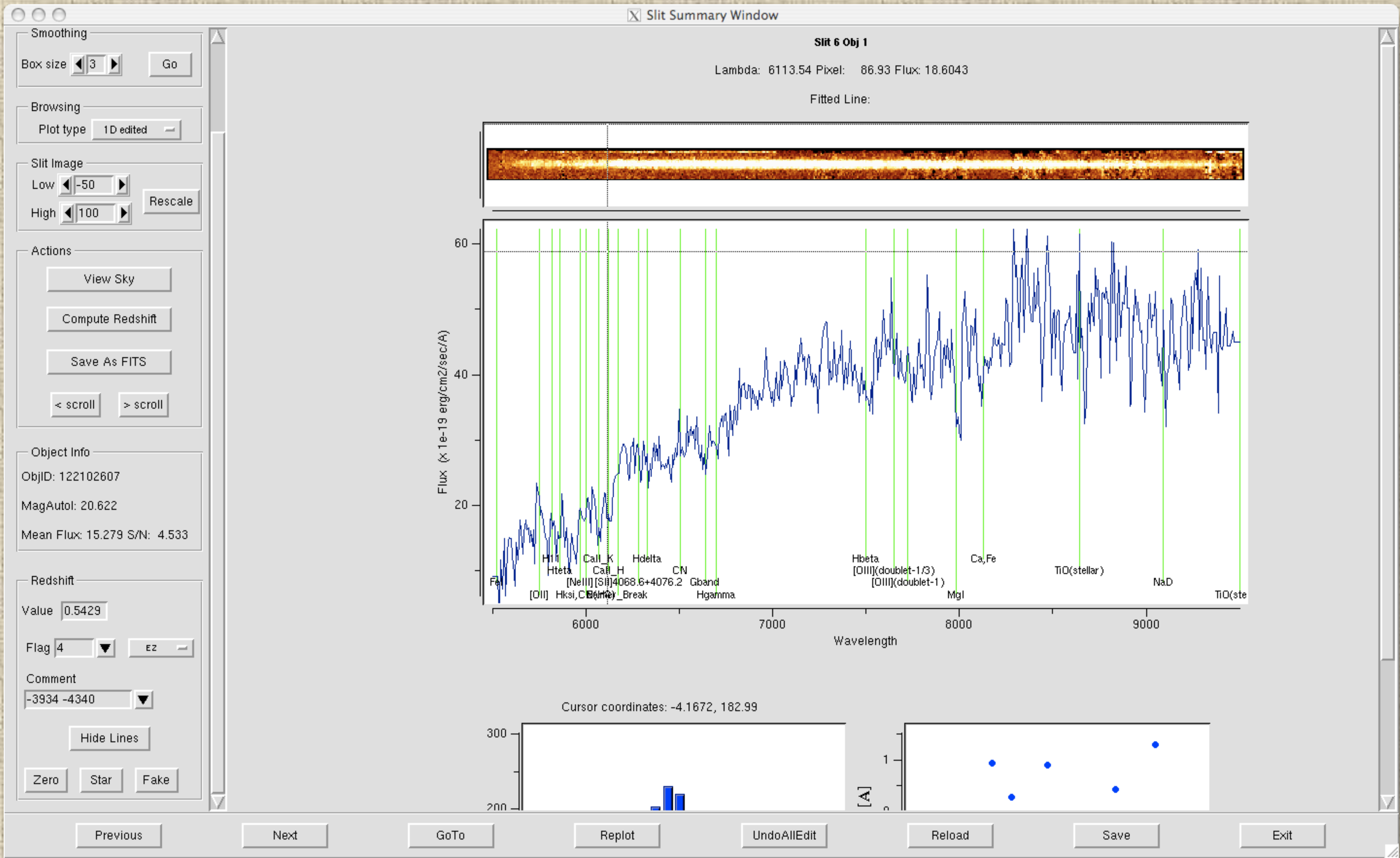
VIPERS single-shot footprint on the sky

- **On average, 360 spectra observed per VIMOS pointing, given VIPERS target sample surface density and clustering**

- **VIPERS strategy yields mean spatial density $<n>\sim10^{-2}\ h^{3}\ Mpc^{-3}$ within the range of interest**

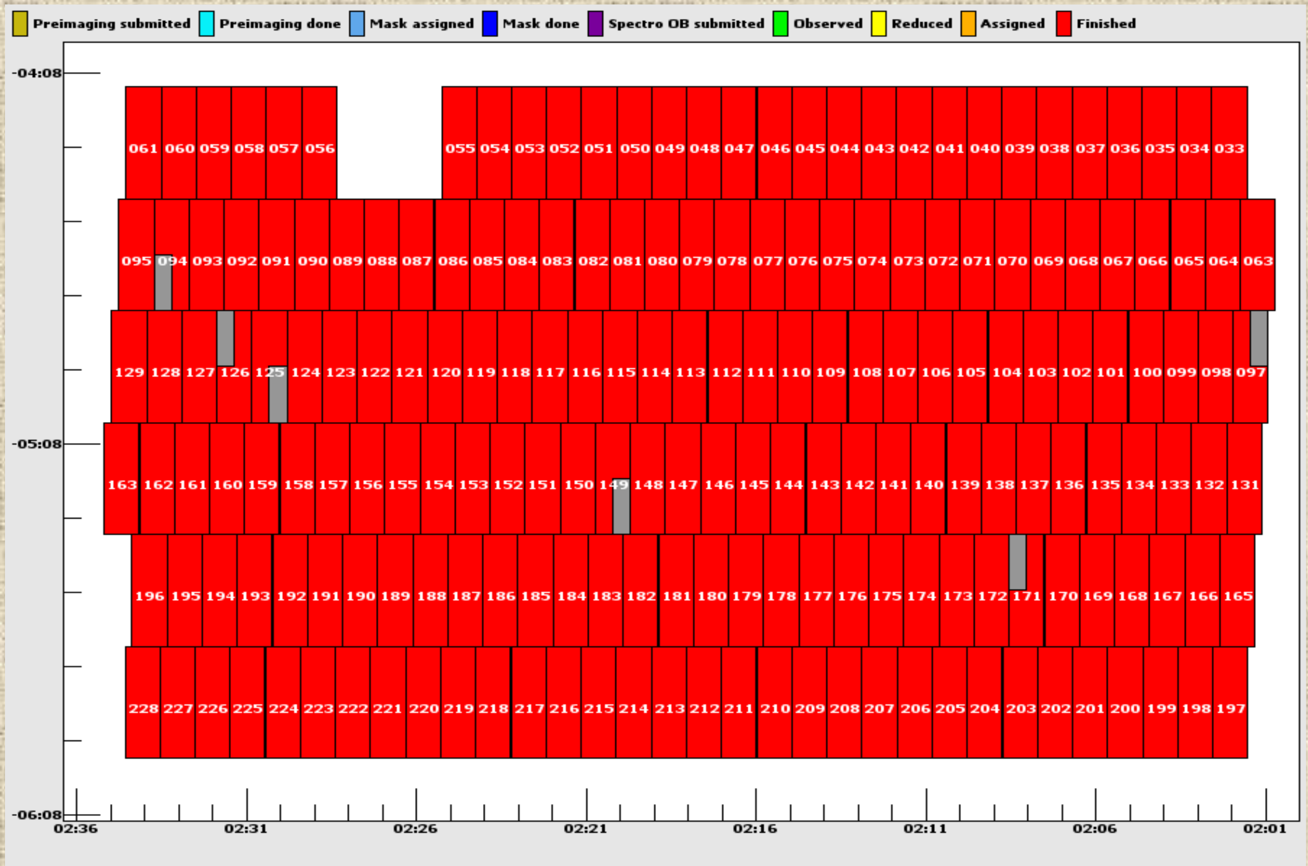


1. Automatic spectral extraction/calibration + redshift measurement: ***EasyLife*** pipeline running at INAF- IASF Milano (Garilli et al. 2012, PASP, 124)
2. Redshift review and validation: ***VIPGI*** (Scodeggio et al. 2005, PASP, 117) ***& EZ*** (Garilli et al. 2010, PASP, 122)

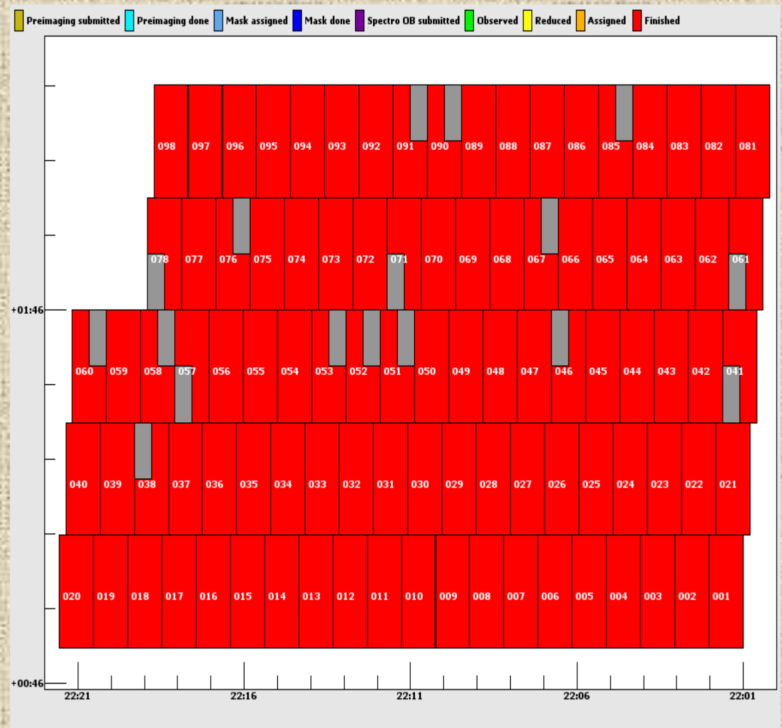


Sky coverage today: VIPERS is finished!

W1



W4



VIPERS Status

- **Survey completed in January 2015; all data now reduced and validated: internal final (V6.0) catalogue available to team:**

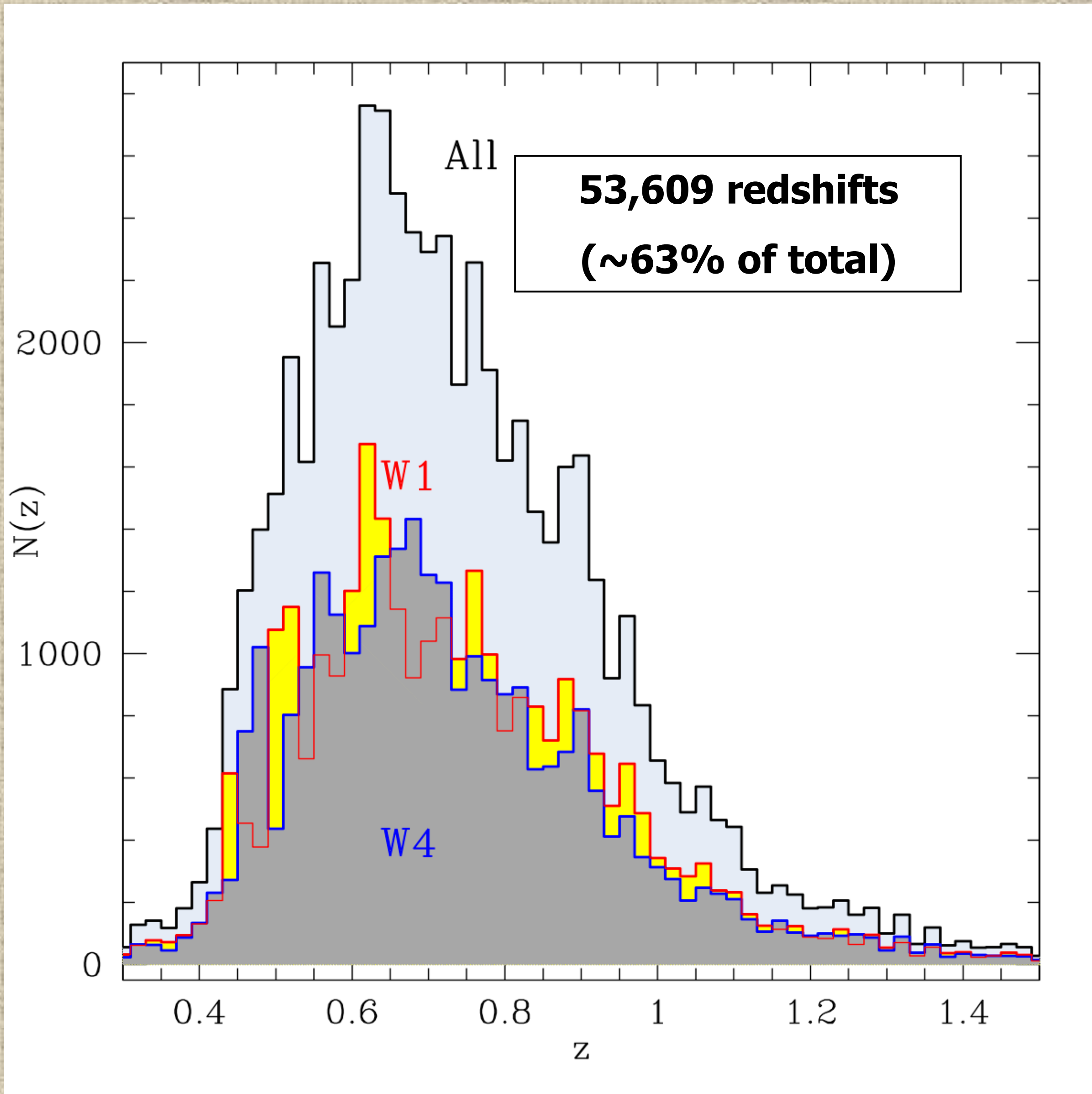
SURVEY STATUS AS OF 14/05/2015

EFFECTIVE TARGETS	MEASURED REDSHIFTS	STELLAR CONTAMINATION	COVERED AREA
93252	88901	2265 (2.5 %)	100.0 %

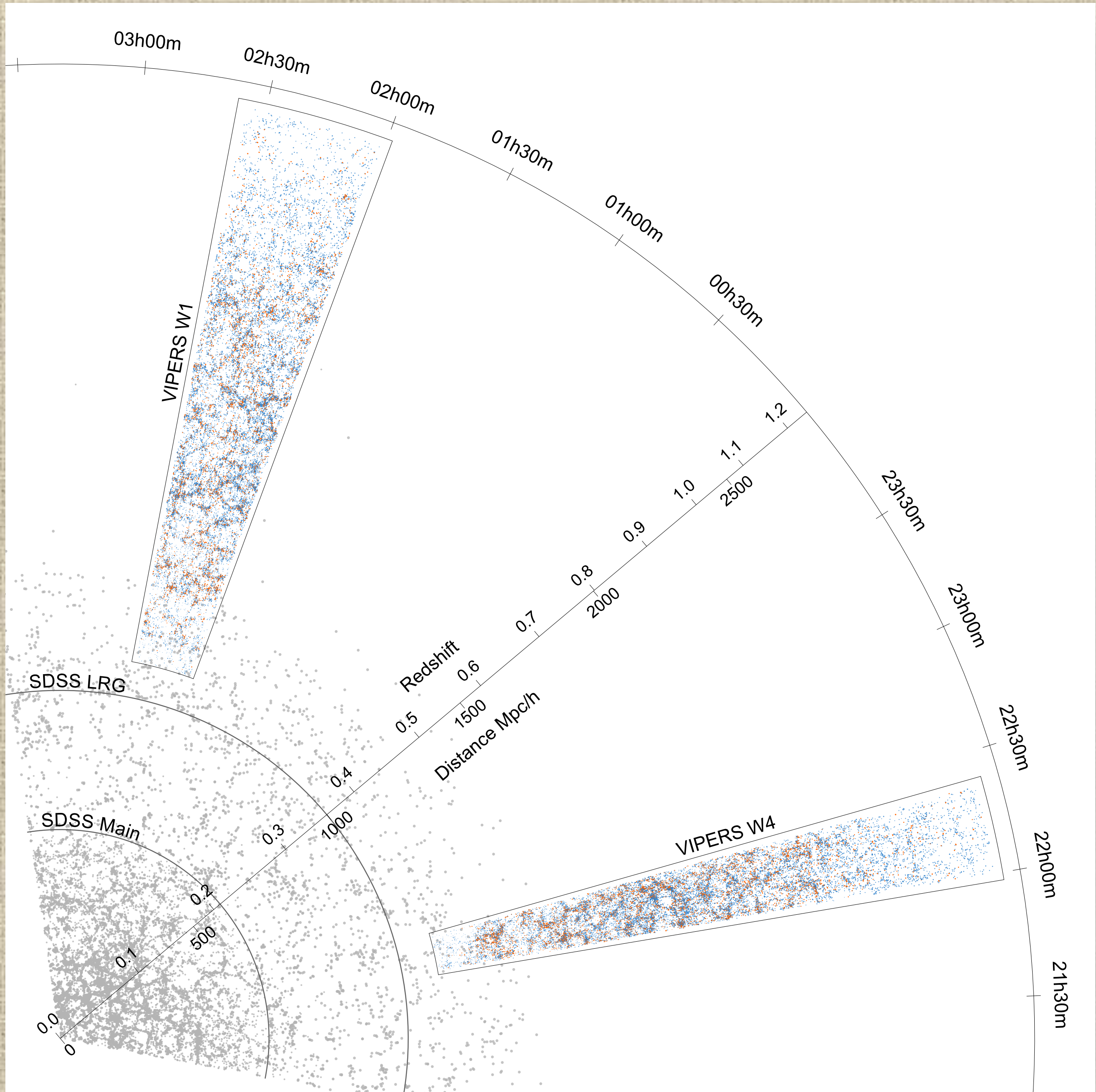
EFFECTIVE TARGETS (ET) are all the primary targeted objects with the exclusion of the ones flagged as -10 (undetected). MEASURED REDSHIFTS (MR) are the fraction of ET for which a redshift has been measured. STELLAR CONTAMINATION are the MR objects which have been identified as stars.

- **Summer 2016: public release of full data set**

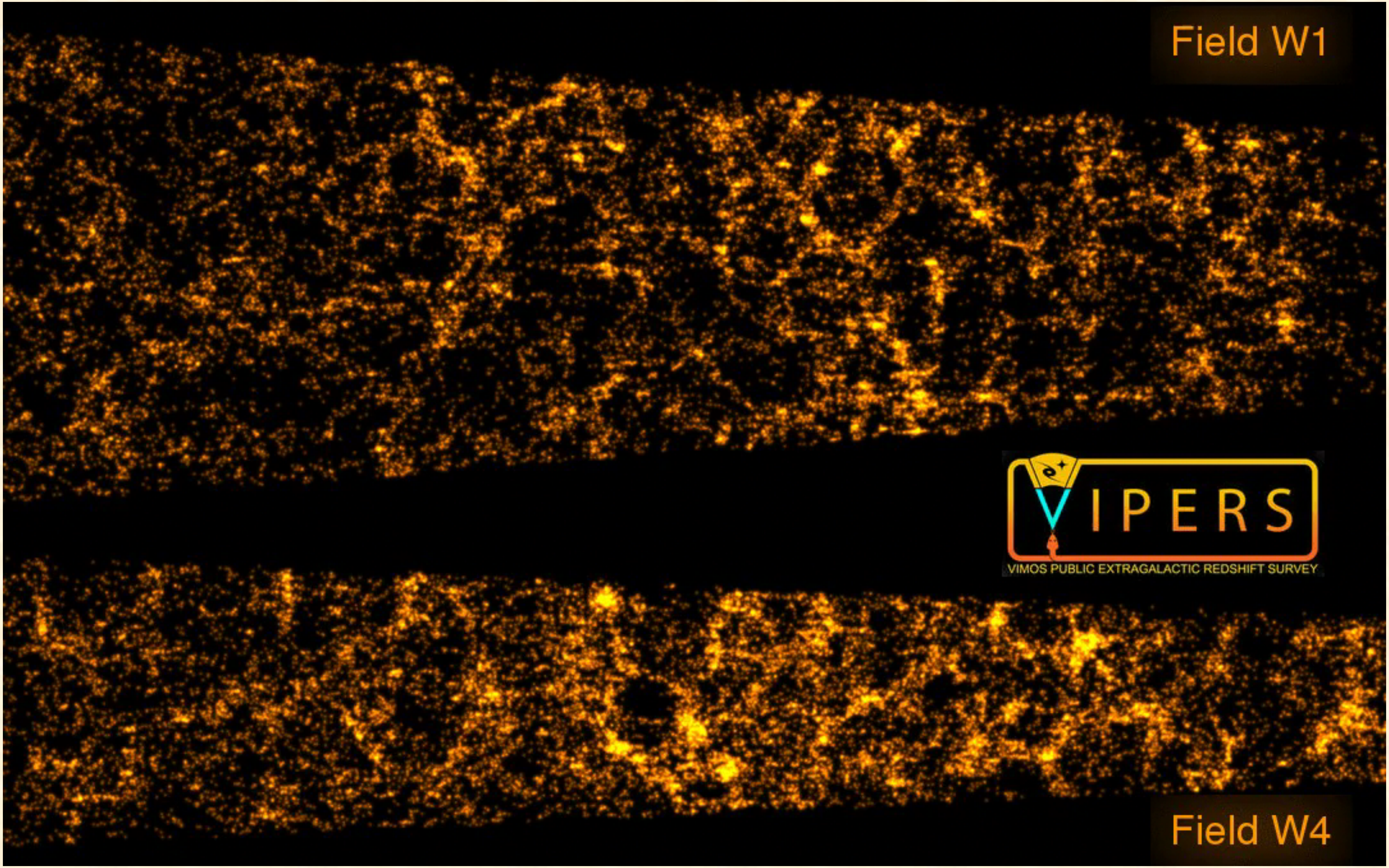
PDR-1 redshift distribution



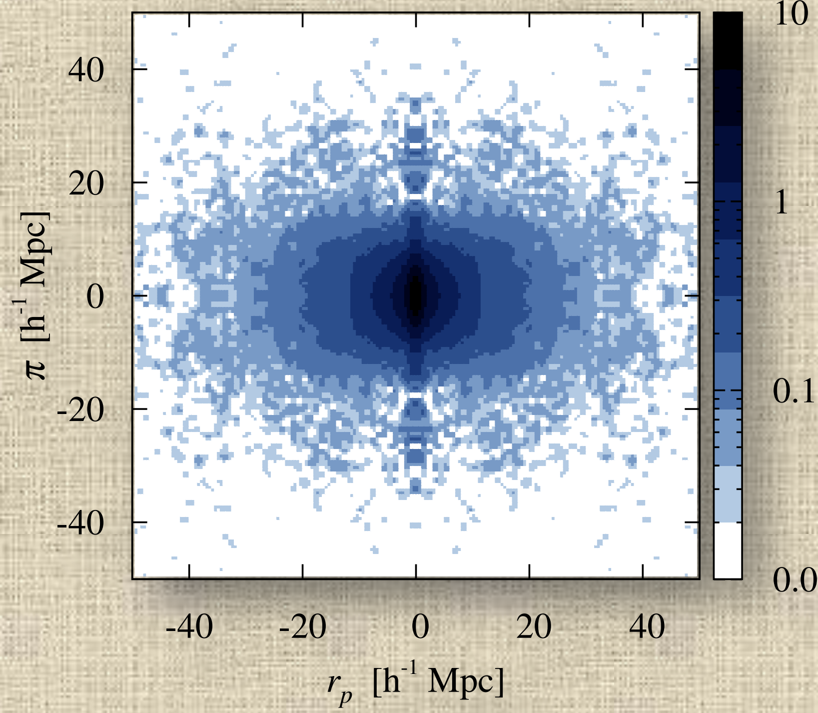
(Guzzo et al. 2014)

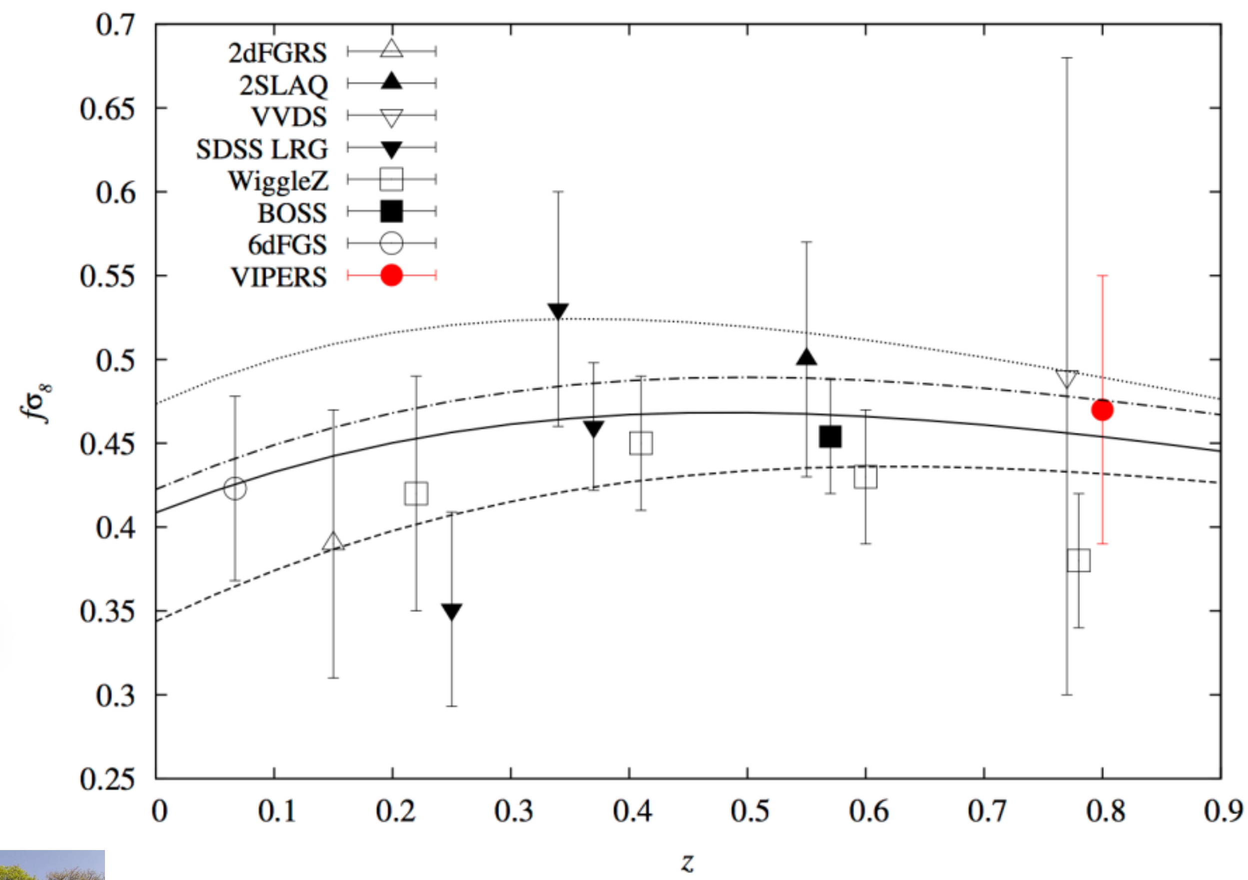


03h00m
02h30m
02h00m
01h30m
01h00m
00h30m
23h30m
23h00m
22h30m
22h00m
21h30m
VIPERS W1
VIPERS W4
SDSS LRG
SDSS Main
Redshift
Distance Mpc/h
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
0
500
1000
1500
2000
2500

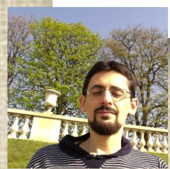

Field W1
VIPERS
VIMOS PUBLIC EXTRAGALACTIC REDSHIFT SURVEY
Field W4

Redshift-space clustering and growth rate of structure from the PDR-1



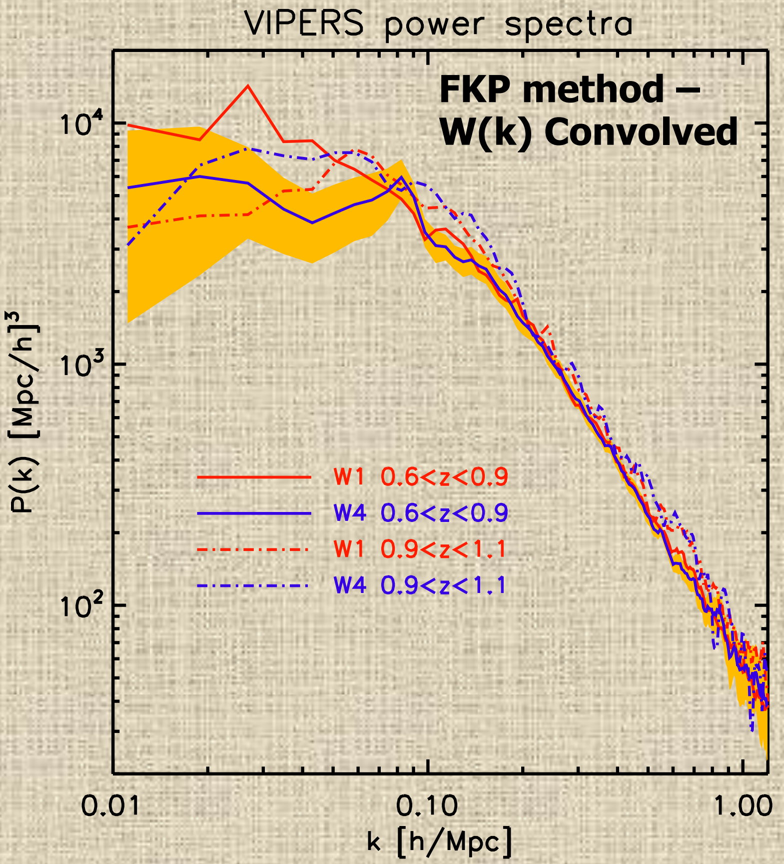


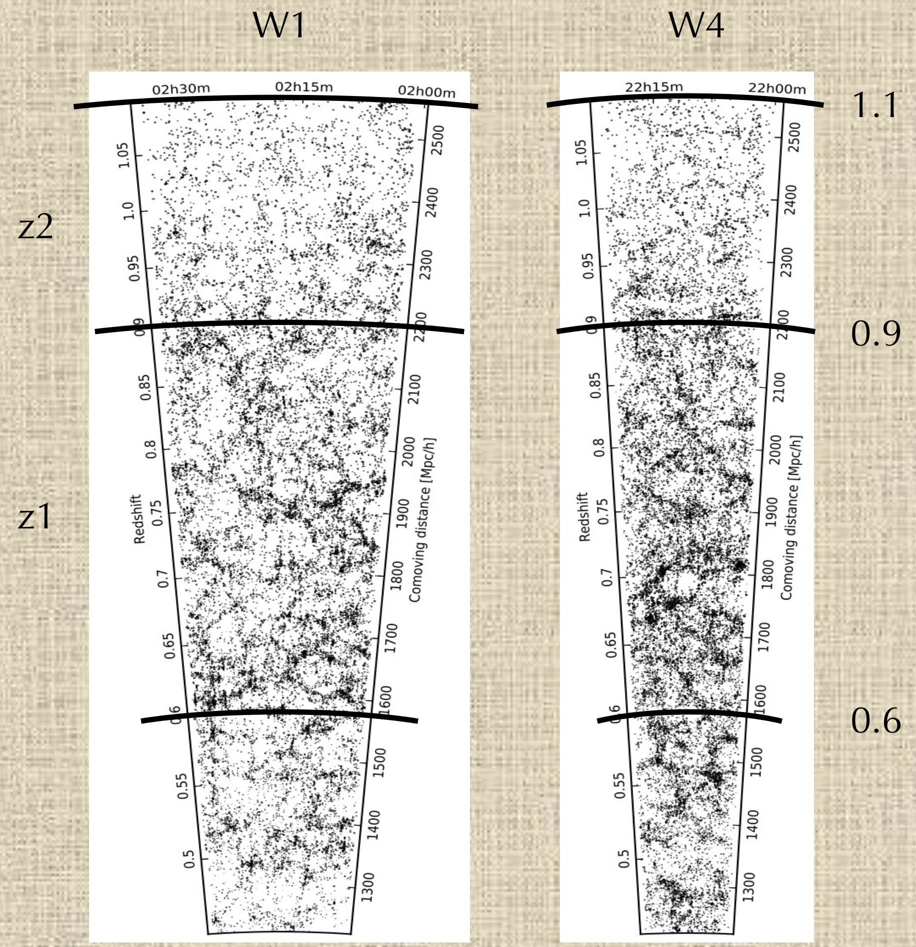
VIPERS: $f\sigma_8(z=0.8) = 0.47 \pm 0.08$



De la Torre et al. 2013

The power spectrum of the galaxy distribution at z=0.5-1.1 from VIPERS (S. Rota PhD work)



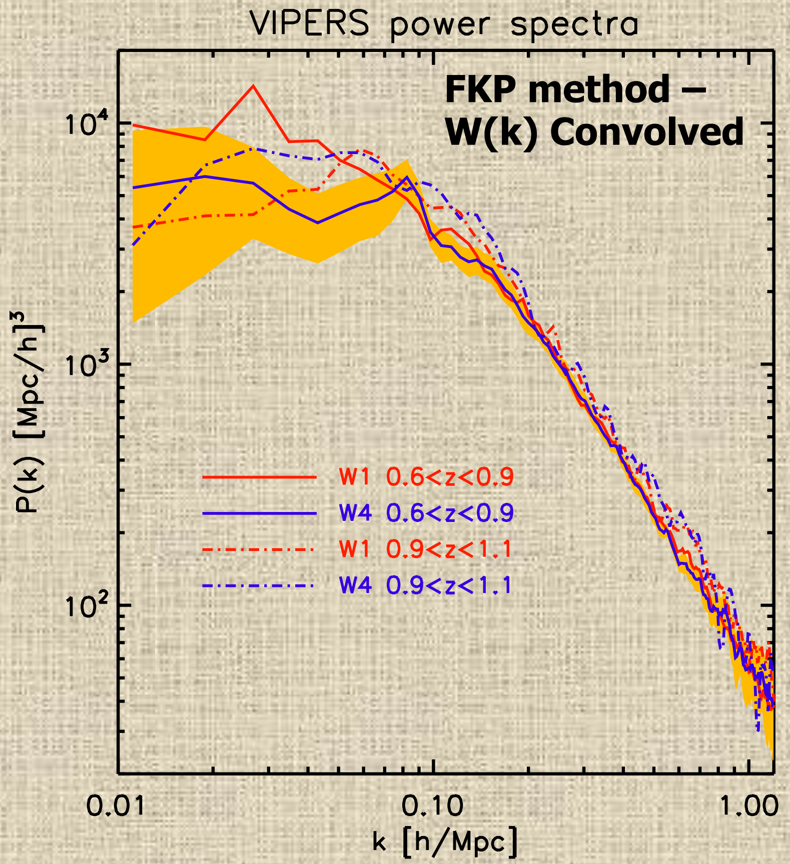


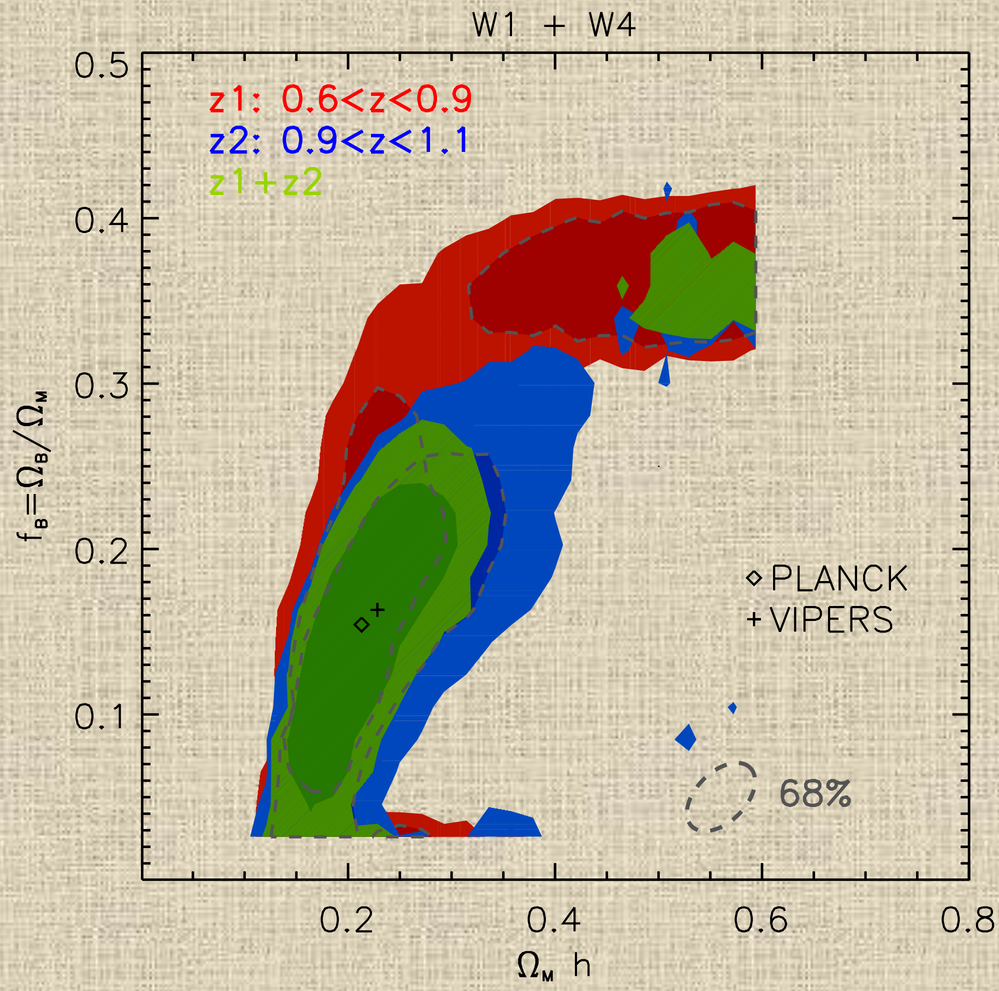
- Very careful treatment of window function

(Rota, Bel, Granett, LG & VIPERS Team, to be submitted)

- 4 independent estimates: 2 z bins in 2 independent fields (W1 and W4)

The power spectrum of the galaxy distribution at z=0.5-1.1 from VIPERS (S. Rota PhD work)





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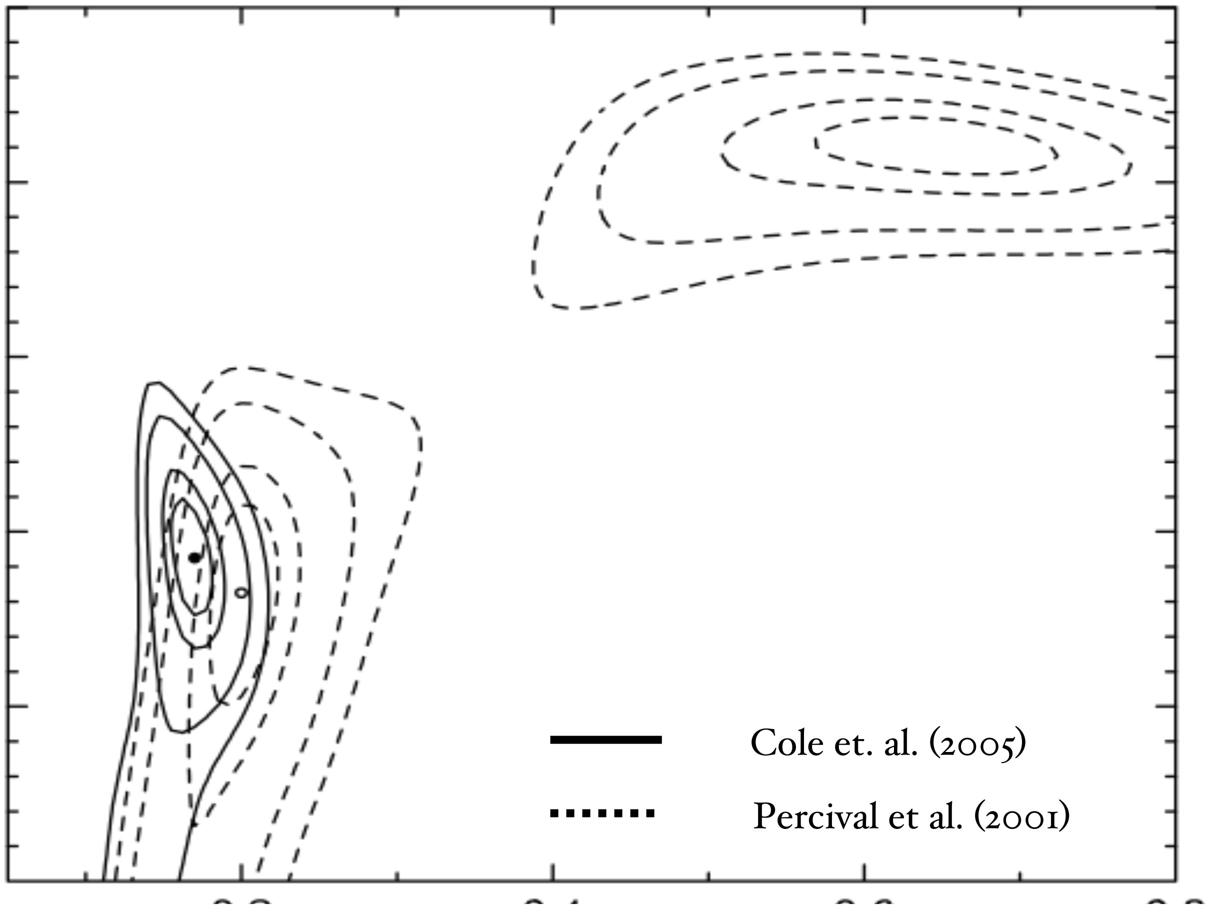
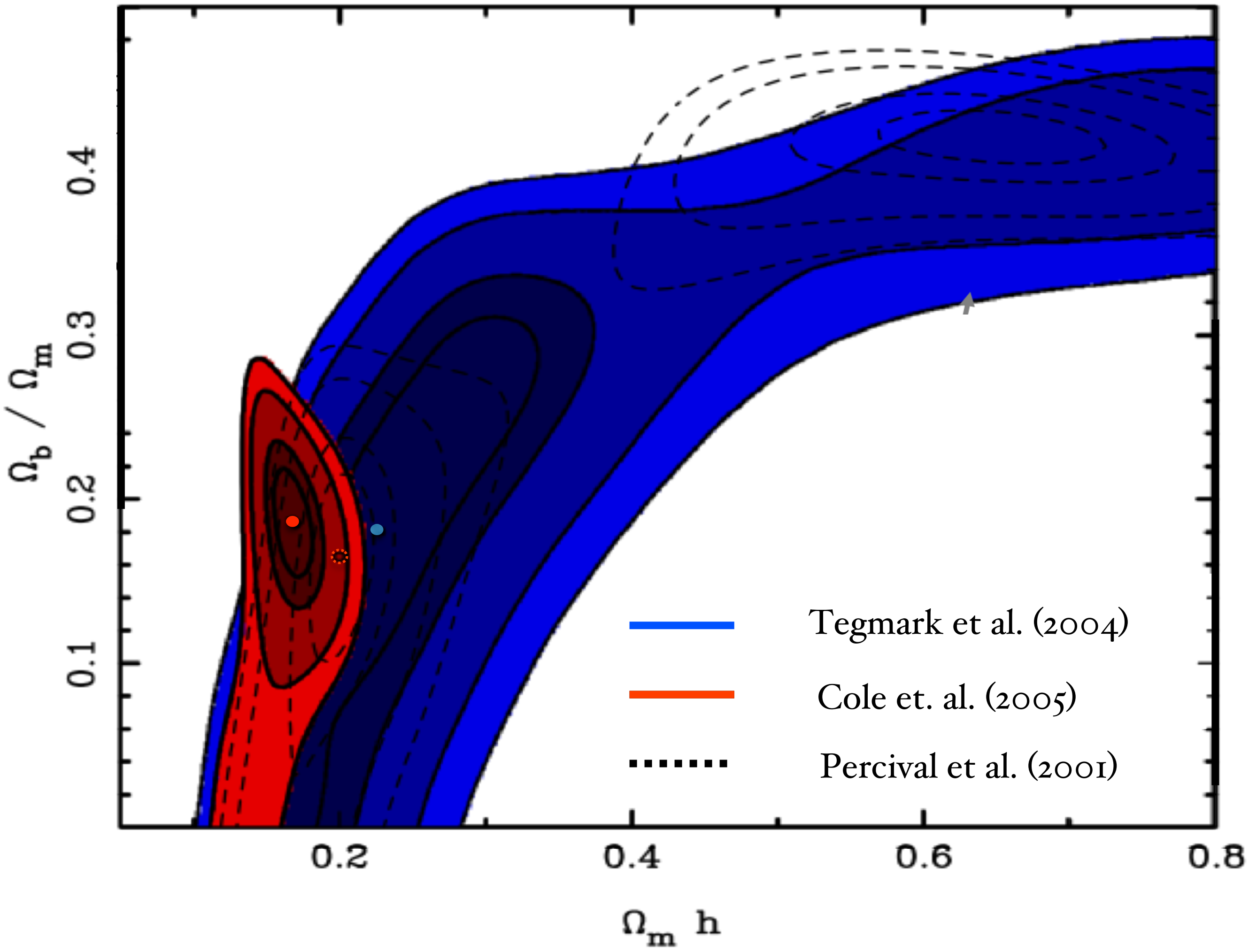
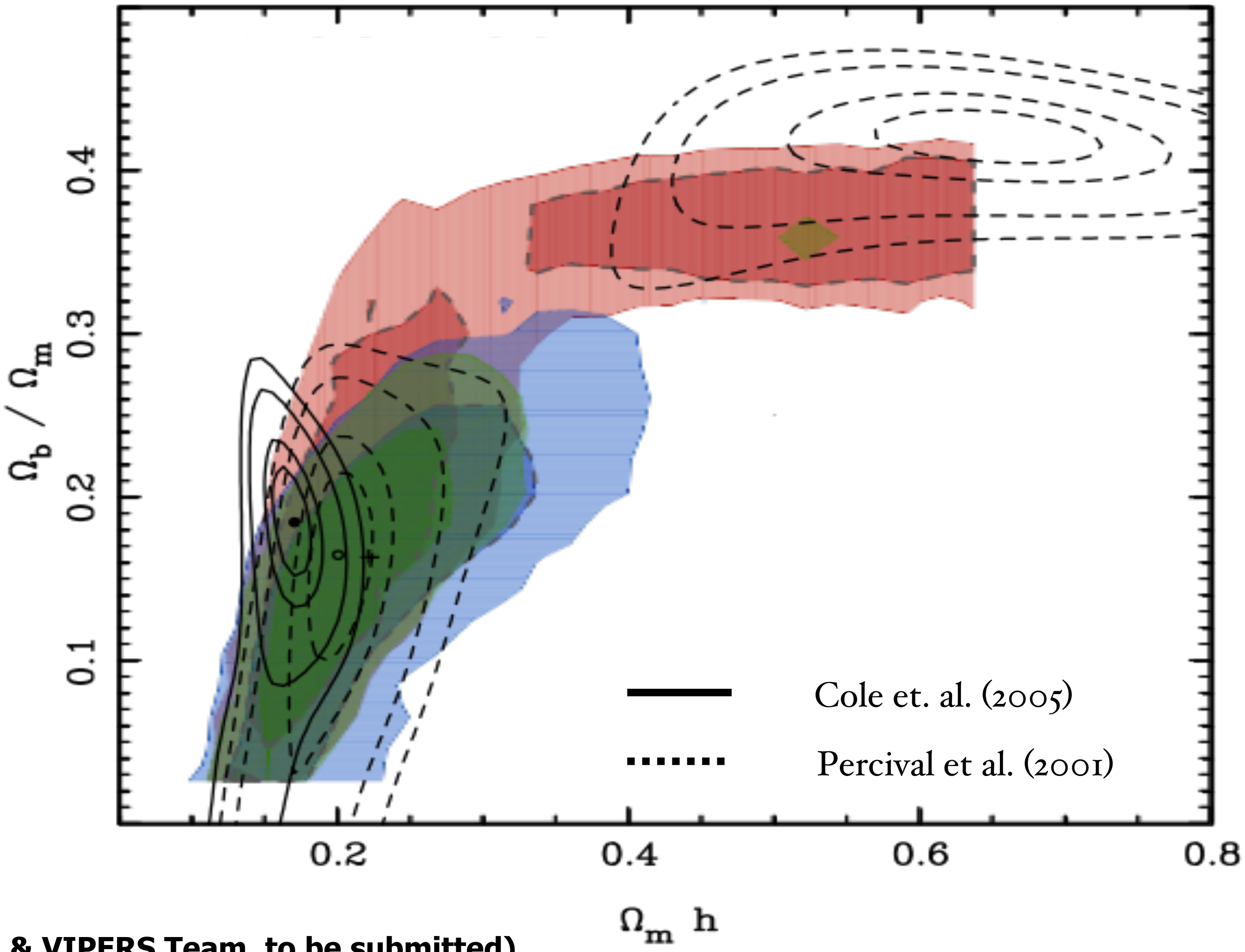
Comparison to z~0, 2dFGRS



Comparison to z~0, 2dFGRS vs SDSS

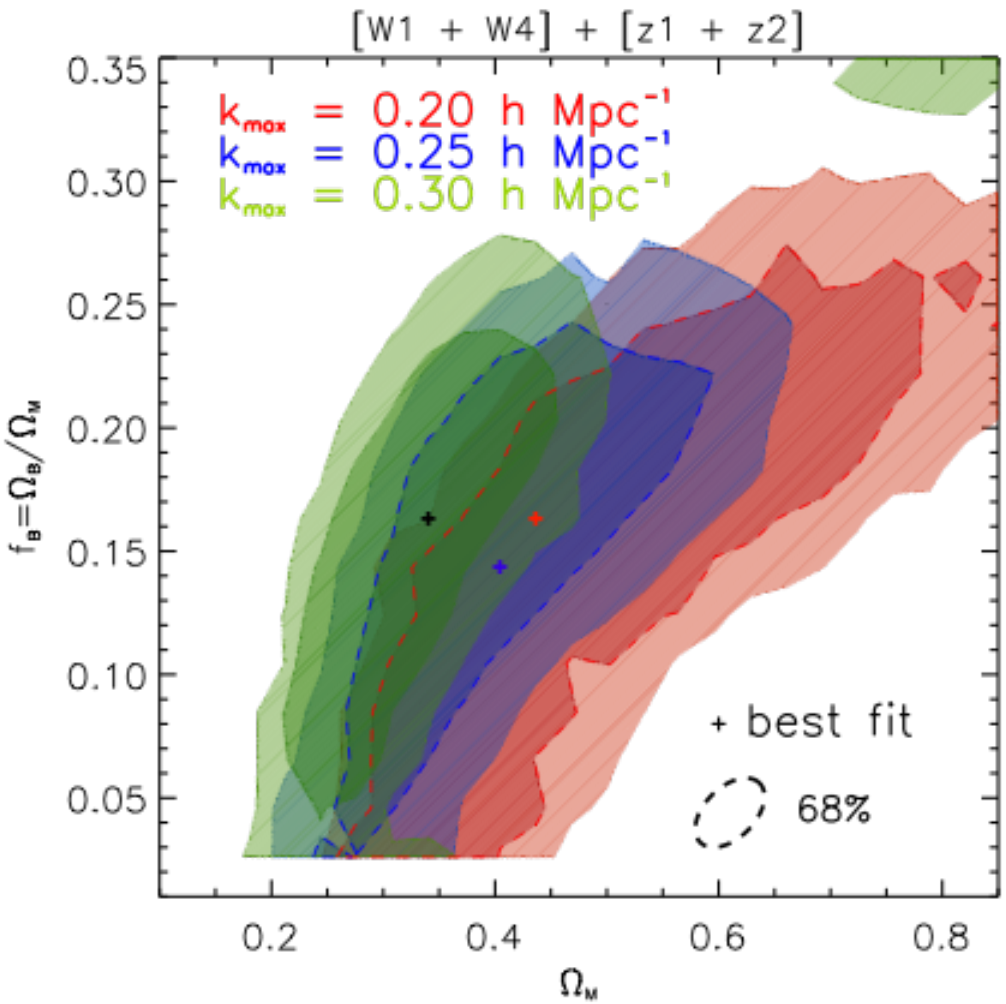


Comparison to z~0, VIPERS vs 2dFGRS



(Rota, Bel, Granett, LG & VIPERS Team, to be submitted)

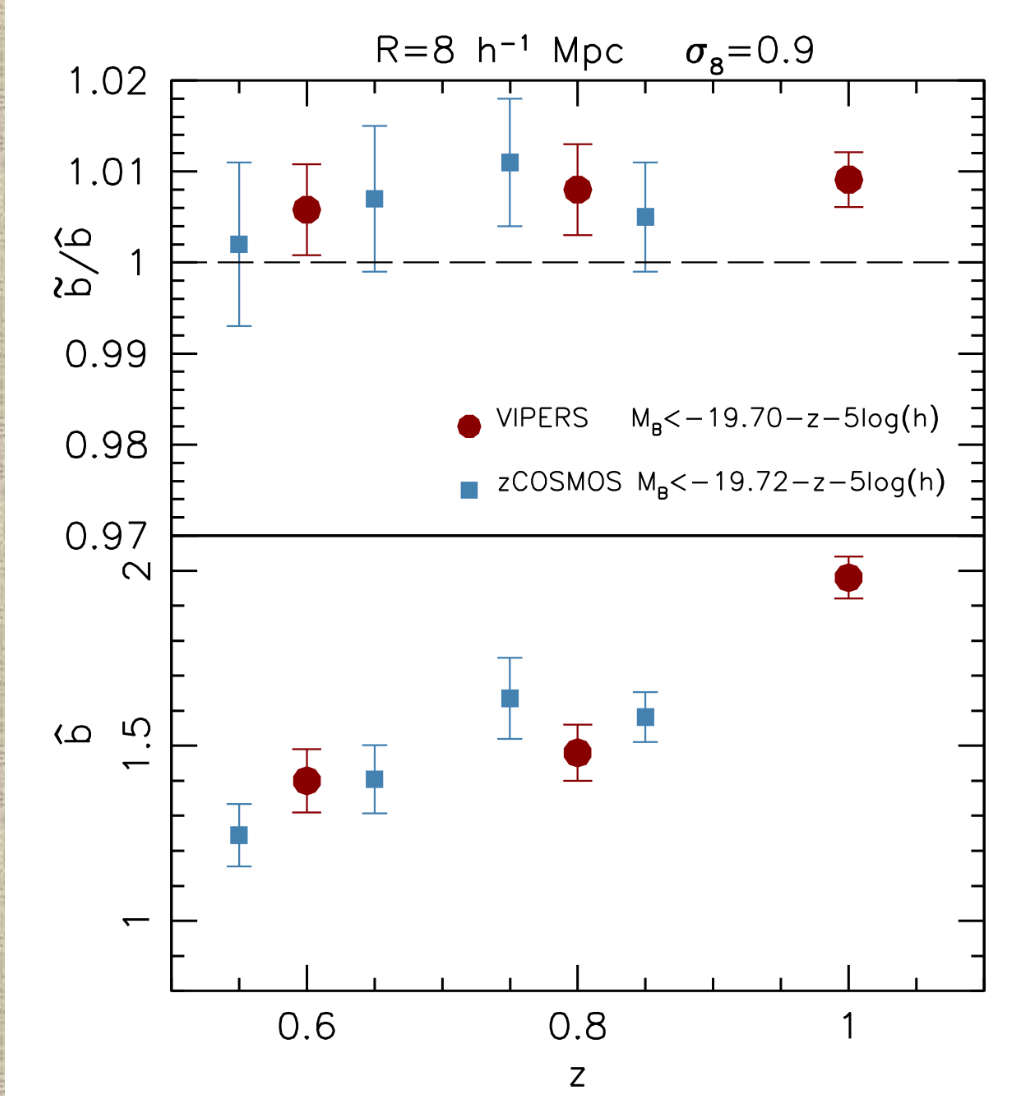
Relevance of systematic effects: dependence on k_{max} in the fit



(Higher-z → less non-linearity → push to higher k_{max})

Non-linearity of galaxy bias and its evolution

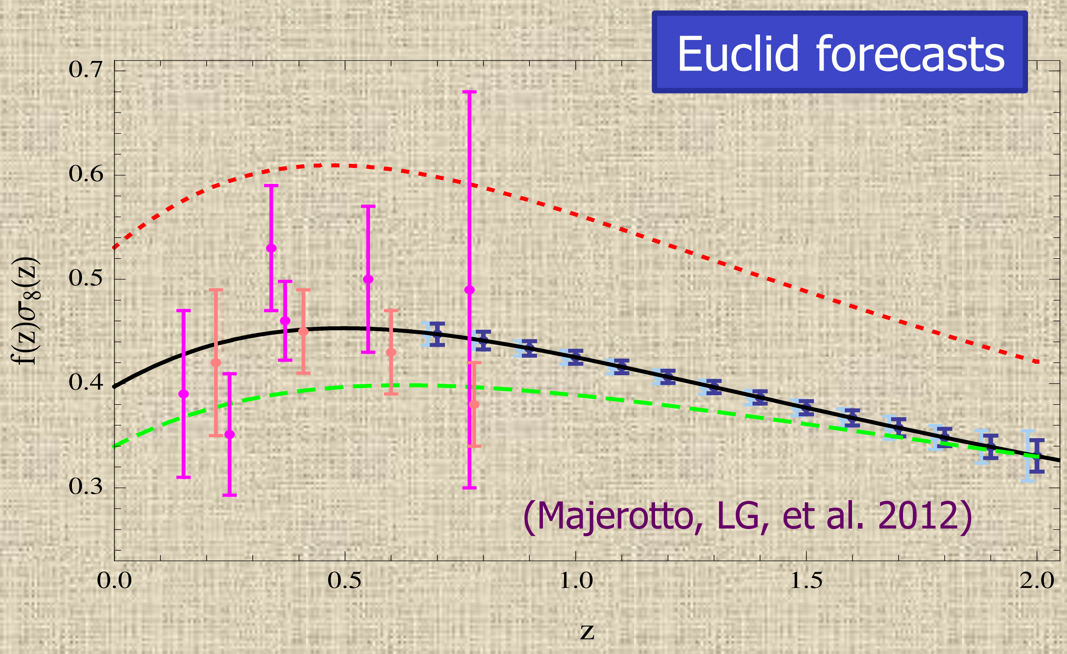
Using Sigad, Branchini & Dekel (2000) inversion technique

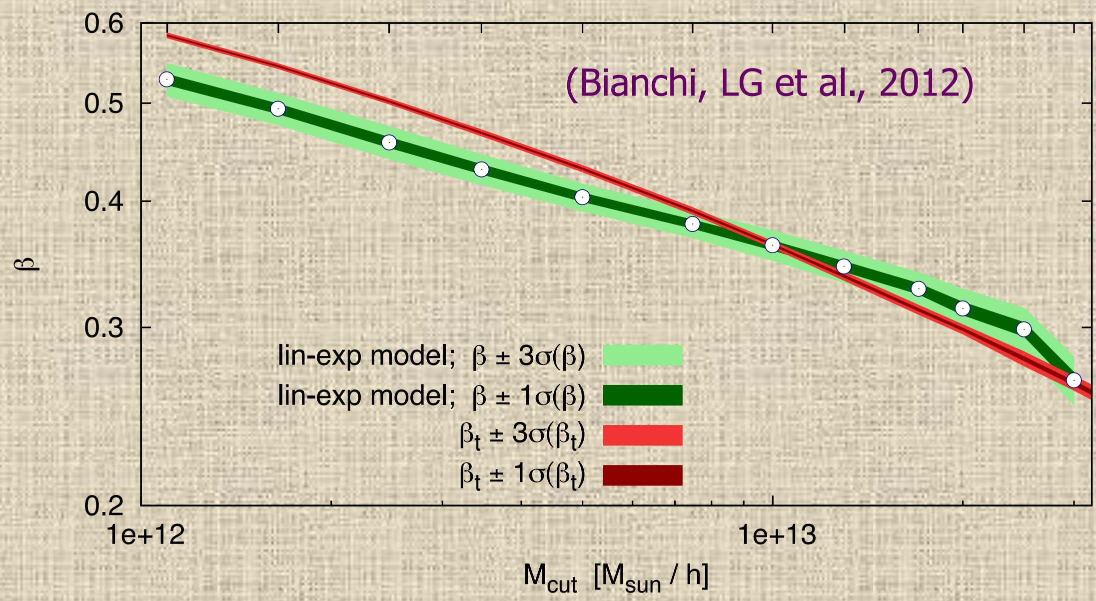


(Di Porto, Branchini & VIPERS Team 2014)

Reducing systematic effects on galaxy clustering measurements

(e.g. on RSD)



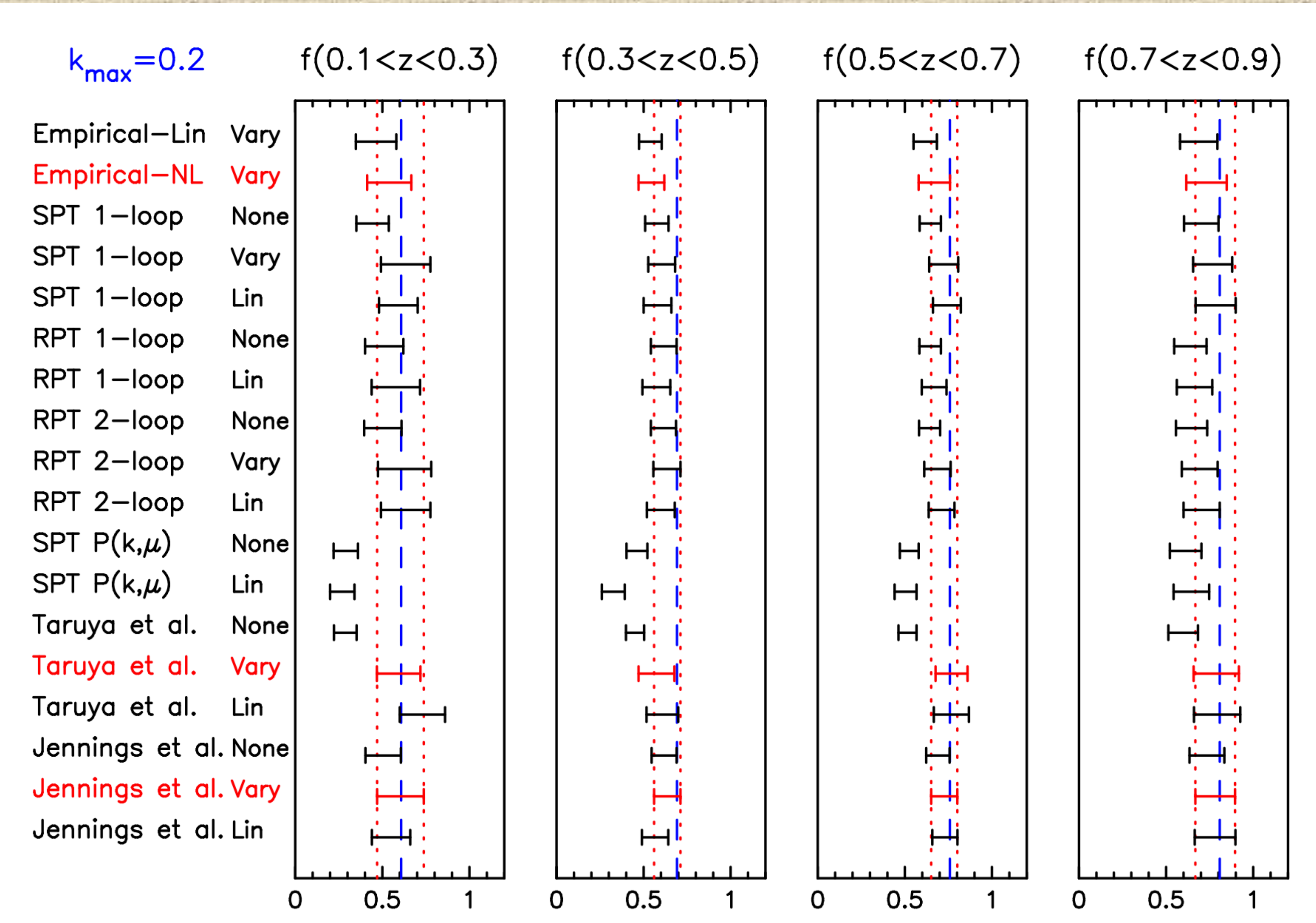


(also Okumura & Jing, 2011)

erc DARK LIGHT

Reducing systematics: better RSD models?

Blake et al. (2011) → Test of various models on WiggleZ data



Better RSD models: understand pairwise f(v)

D. Bianchi (now @ICG Portsmouth) PhD work – Bianchi, Chiesa & LG, 2014, MNRAS 446, 75

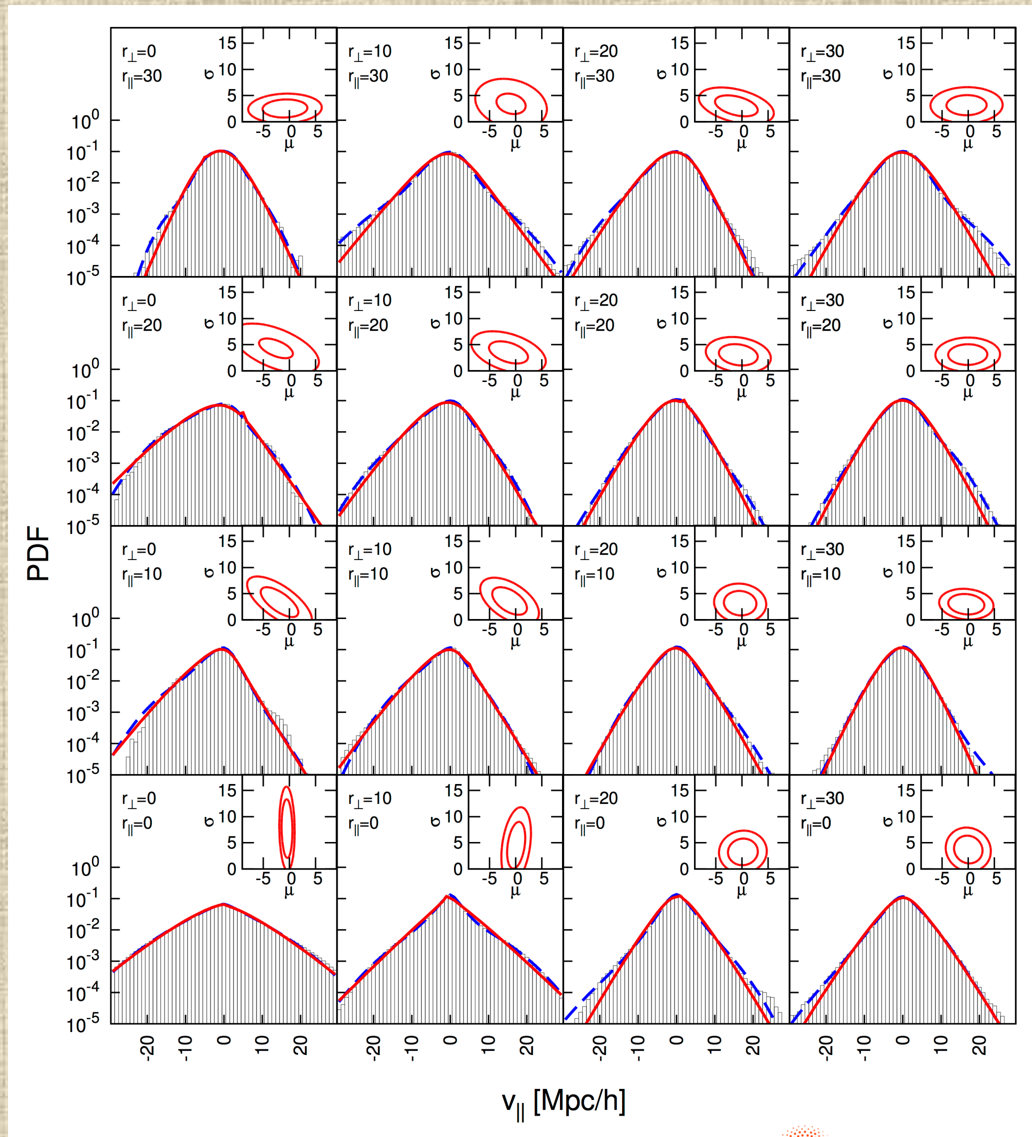
- Goal: reduce degrees of freedom on description of the pairwise velocity PDF in the context of the ***streaming model***

$$1 + \xi_S(s_\perp, s_\parallel) = \int dr_\parallel \; [1 + \xi_R(r)] \; \mathcal{P}(r_\parallel - s_\parallel | \mathbf{r})$$

- PDF described as weighted sum of Gaussians, whose mean and dispersion are described in turn by bivariate Gaussian

$$\mathcal{P}(v_\parallel) = \int d\mu d\sigma \; \mathcal{P}_L(v_\parallel|\mu, \sigma) \; \mathcal{F}(\mu, \sigma)$$

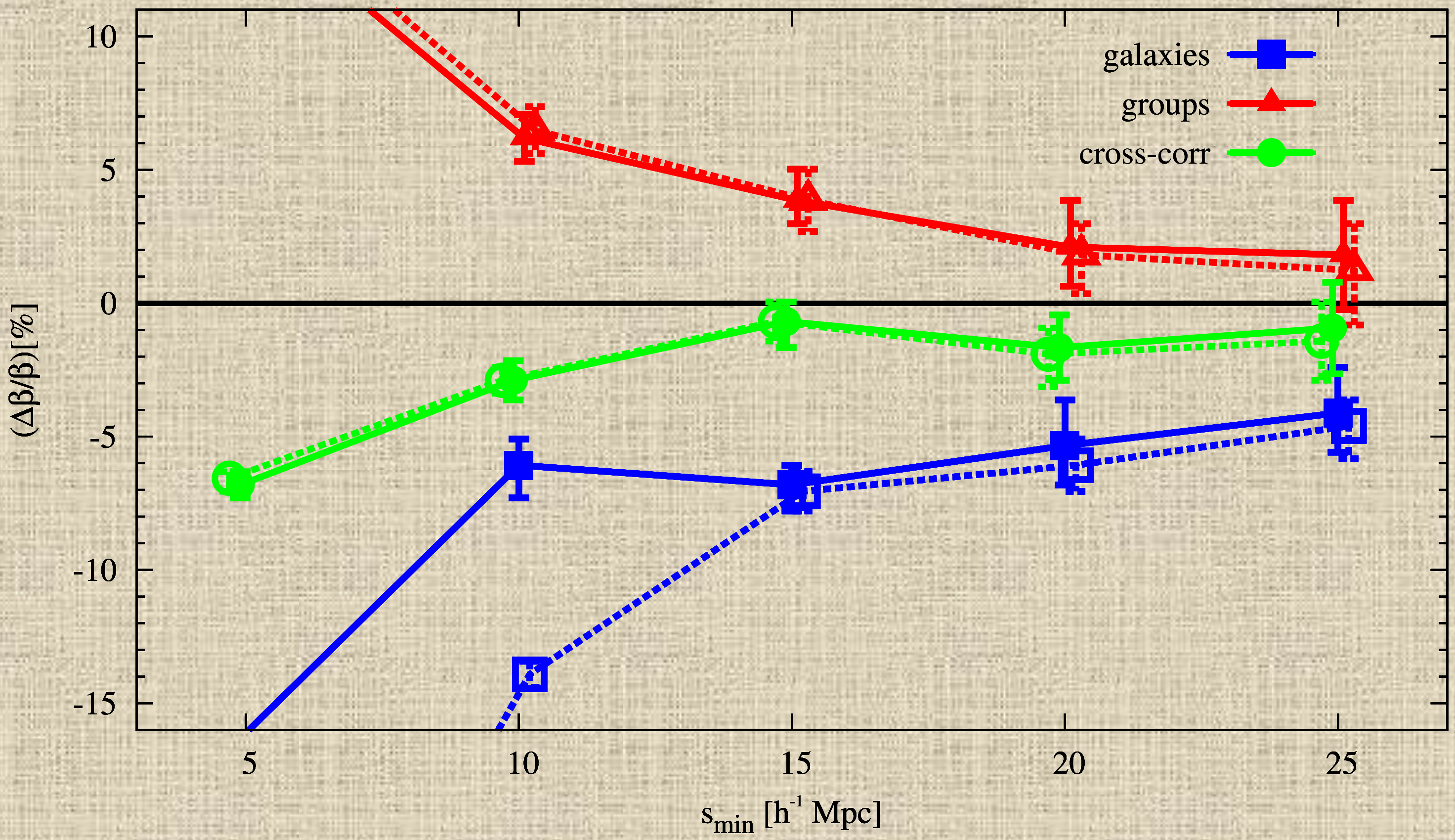
- Works extremely well: naturally provides exponential/Gaussian/skewed PDFs, depending on separation



erc DARK LIGHT

Improving RSD measurements: better tracers of LSS and v

F. Mohammad PhD project: **RSD from the group-galaxy cross-correlation** (Mohammad, et al., submitted), plus define **customized multipole expansion** ("truncated multipoles") to reduce weight of nonlinear scales



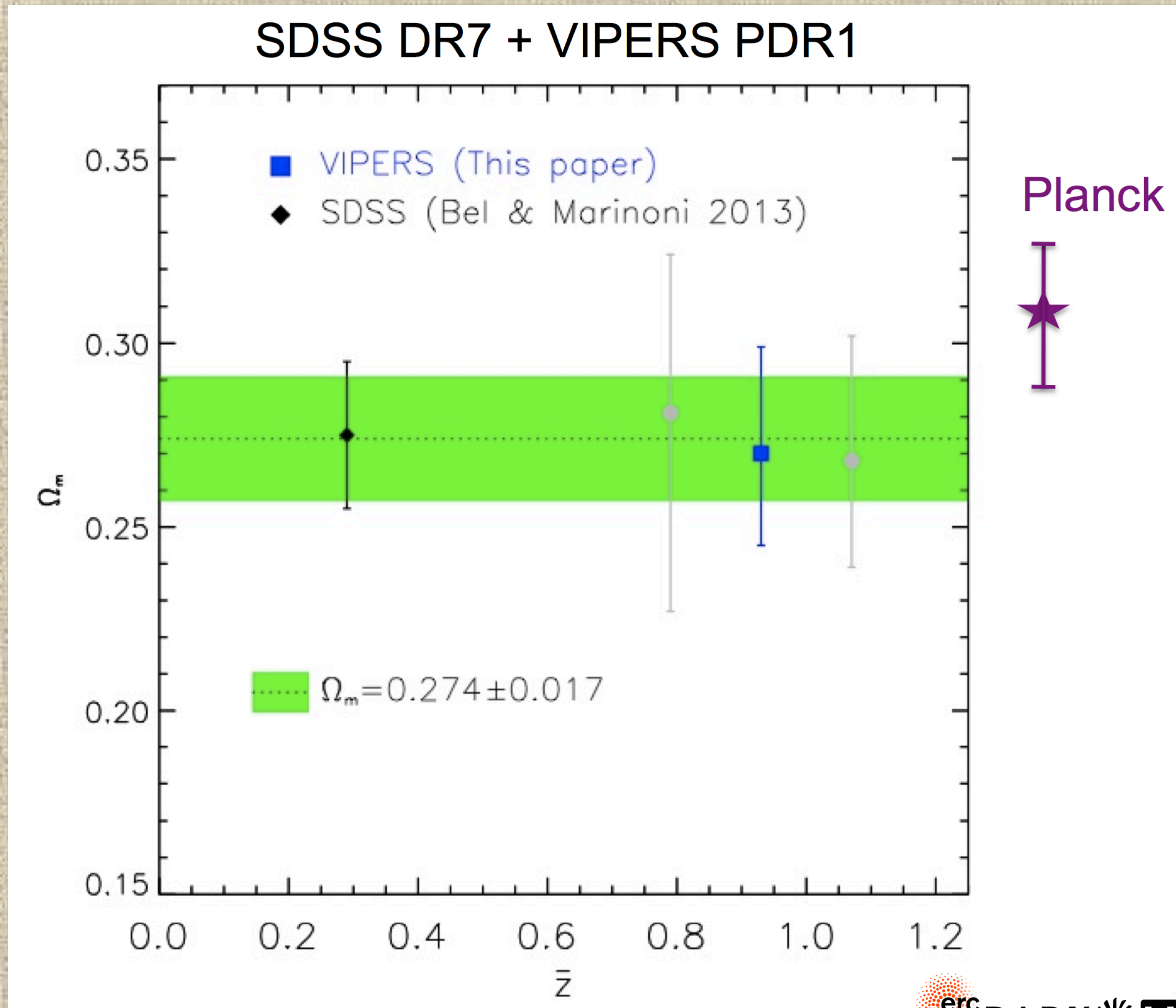
(3) "Optimized" statistics: the "clustering ratio" from counts in cells (Bel et al.), an implicit probe of P(k) shape

The clustering ratio: $\eta_R(r) \equiv \dfrac{\xi_R(r)}{\sigma_R^2}$

where:

- R=smoothing radius of galaxy field
- r=nR (n=3,4,5) i.e. correlated on larger scales
- Ratio has favourable propertites wrt to quasi-linear/mildly nonlinear effects on the P(k): most of these factor out
- Essentially a ratio of power in two different k bands

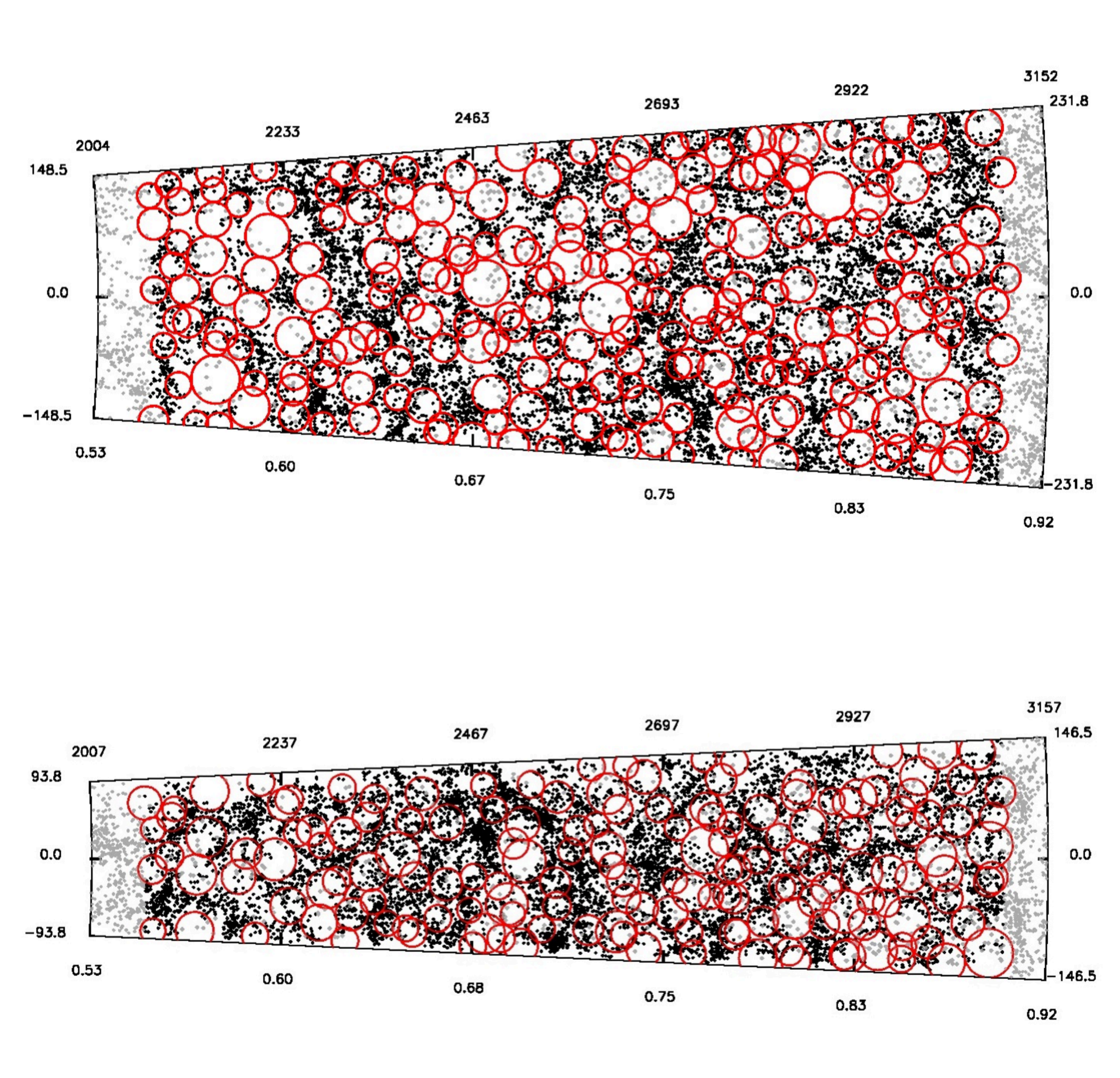
→ **Reduce the effect on P(k) shape of the "Big Three", i.e. nonlinearity, bias and RSD**



Bel et al. 2014, A&A, 563, 37

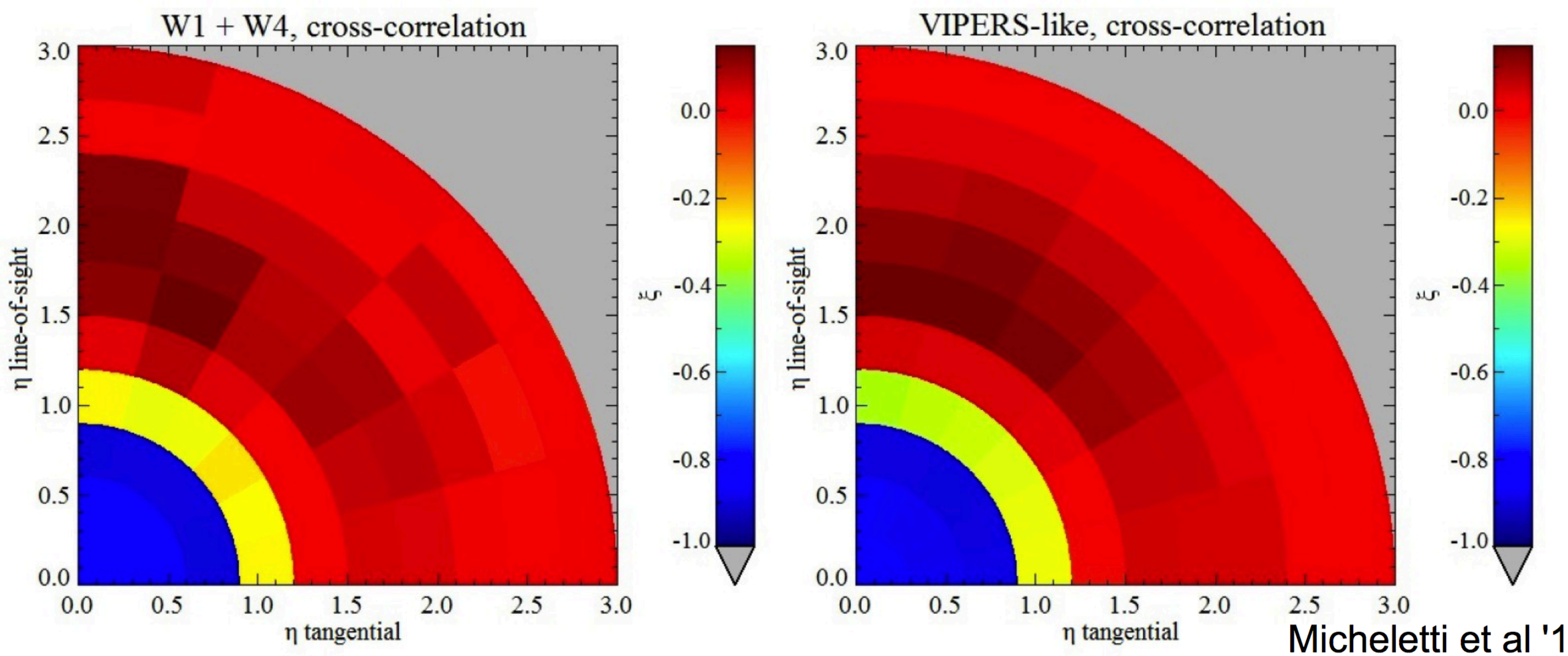
Identify new cosmological probes: cosmic voids at z~1

Micheletti, Iovino, Hawken, Granett & VIPERS team, 2014



Identify new cosmological probes: cosmic voids at z~1

The void-galaxy cross correlation function



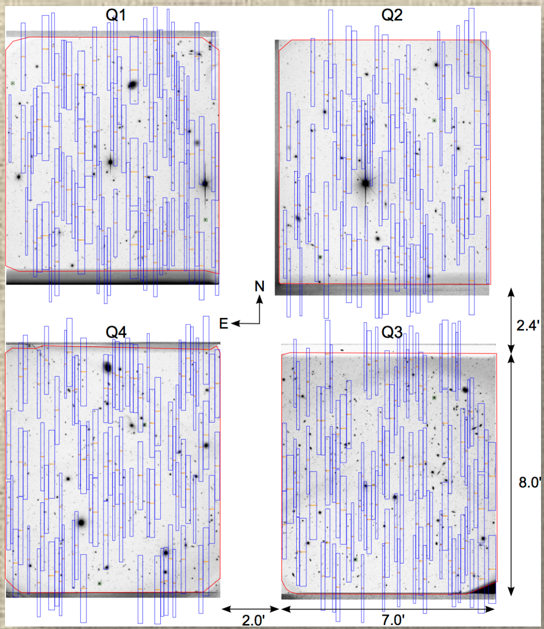
Micheletti et al '14

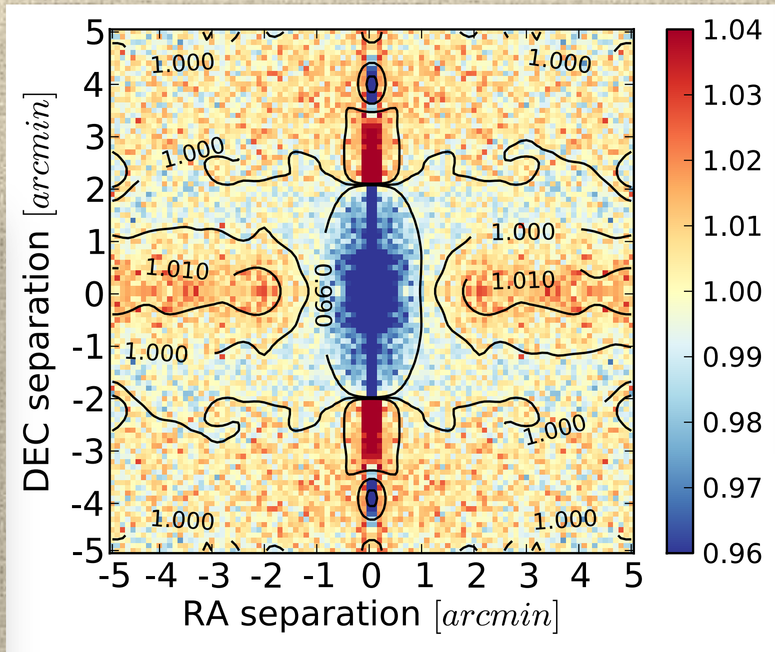
Modelling the cross-correlation function: A. Hawken et al., in preparation

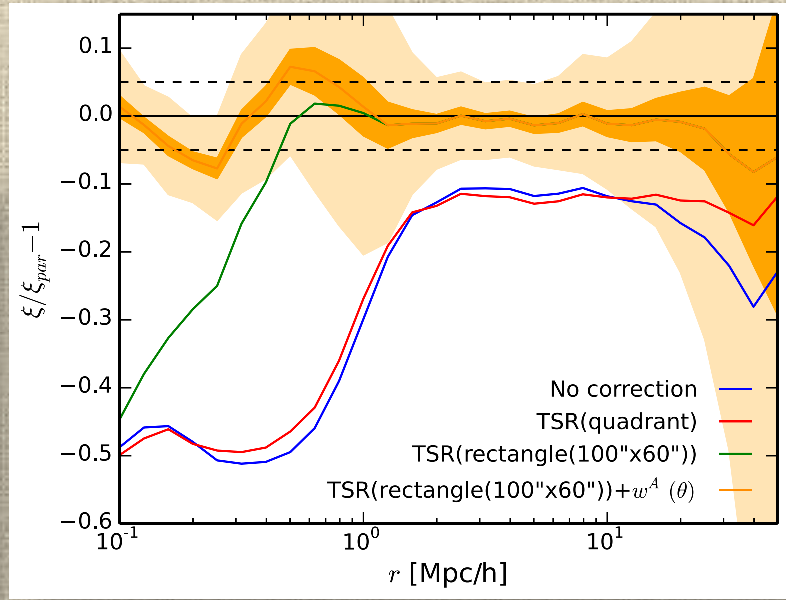
→ How precise and accurate can this method be?
→ Needs highly-samples surveys like GAMA and VIPERS

Minimize observational effects (not obvious at 1% level!)

E.g. detailed correction of masking effects in the VIPERS data on the estimate of two-point correlations (A. Pezzotta PhD work)



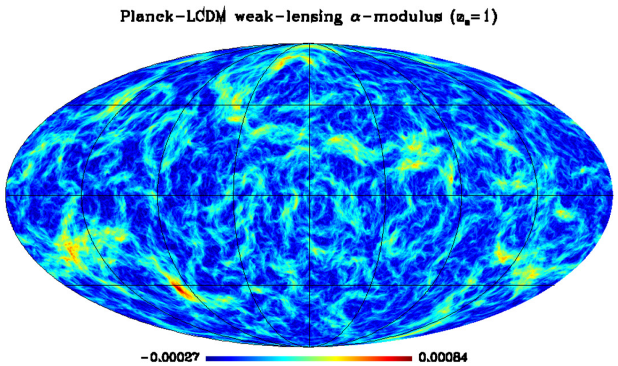




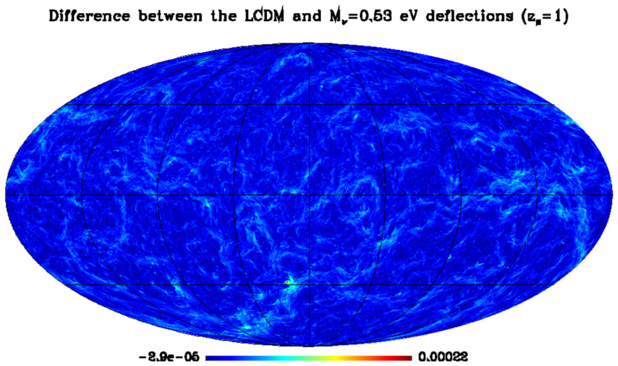
→ **This will be very relevant for Euclid slitless spectroscopic mode**

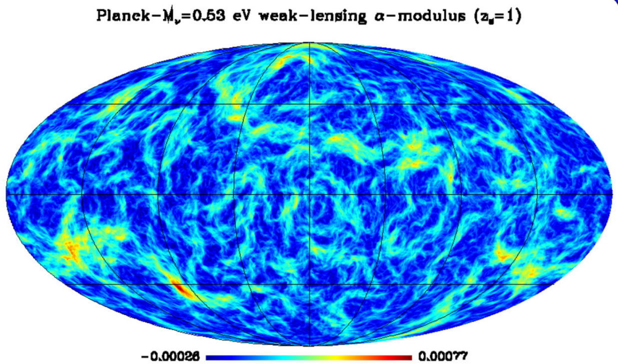
Account for all existing components: neutrinos!

Carbone et al., DEMNUni simulations



Deflection angle maps for z_s=1
(Carbone et al. in prep)



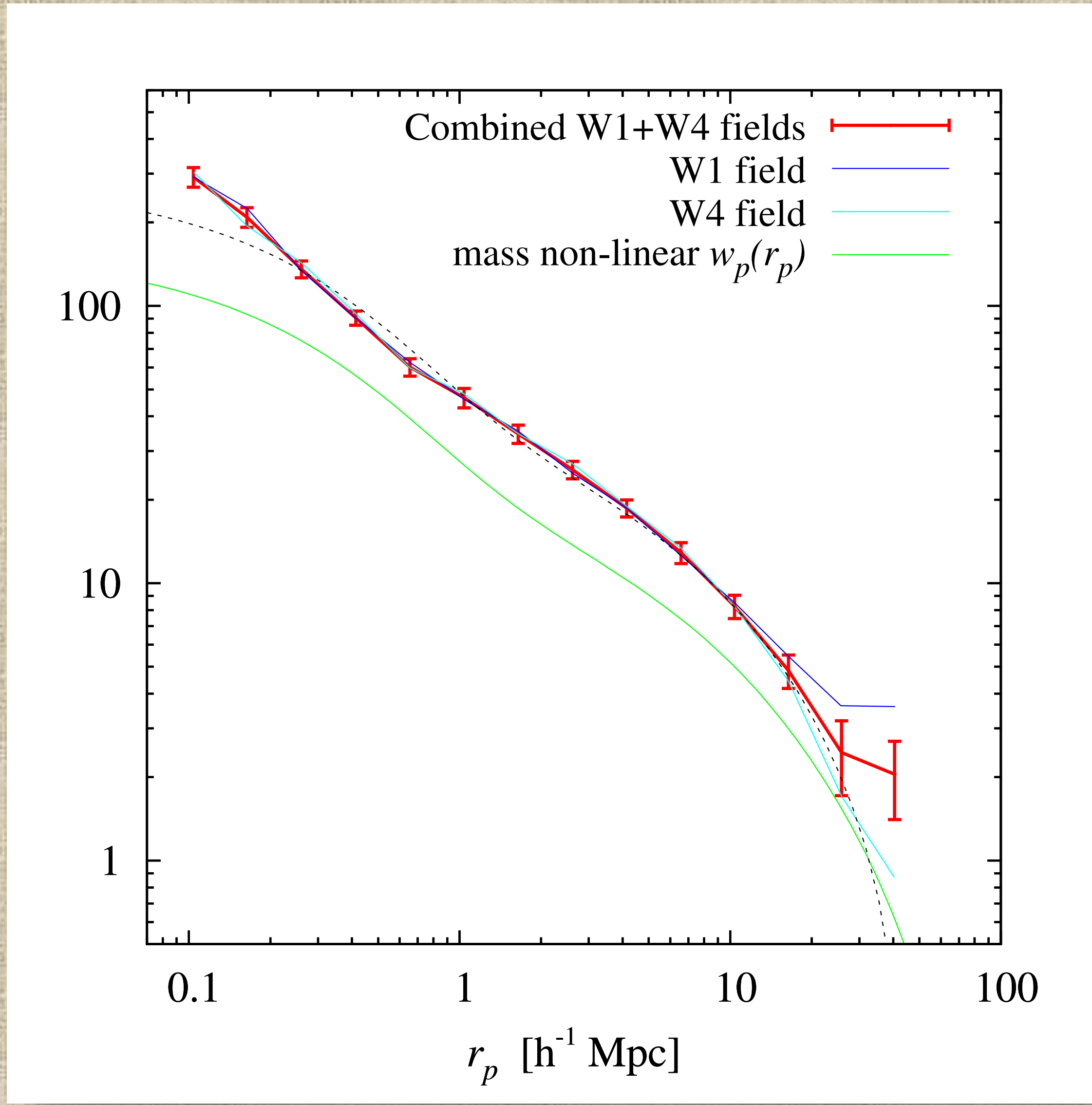


Ray-tracing across the matter distribution of the DEMNUni simulations: L=2 Gpc/h, N_{part}=2x(2048)^3 (including massive neutrino particles)

Improve understanding relation between DM and baryons

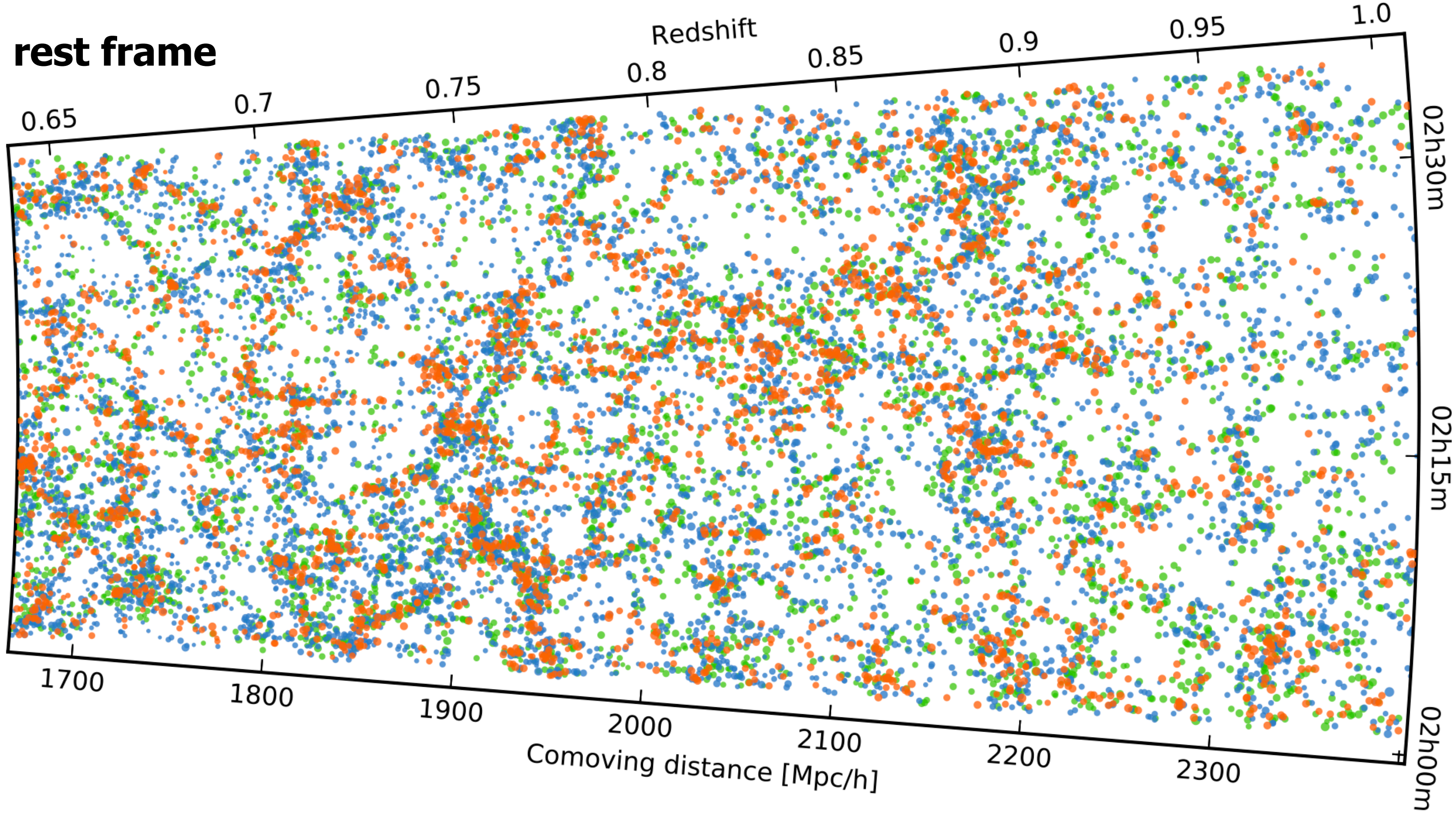
- **Halo Occupation Distribution modelling of VIPERS correlation function**

(De la Torre & VIPERS team 2015, in preparation)



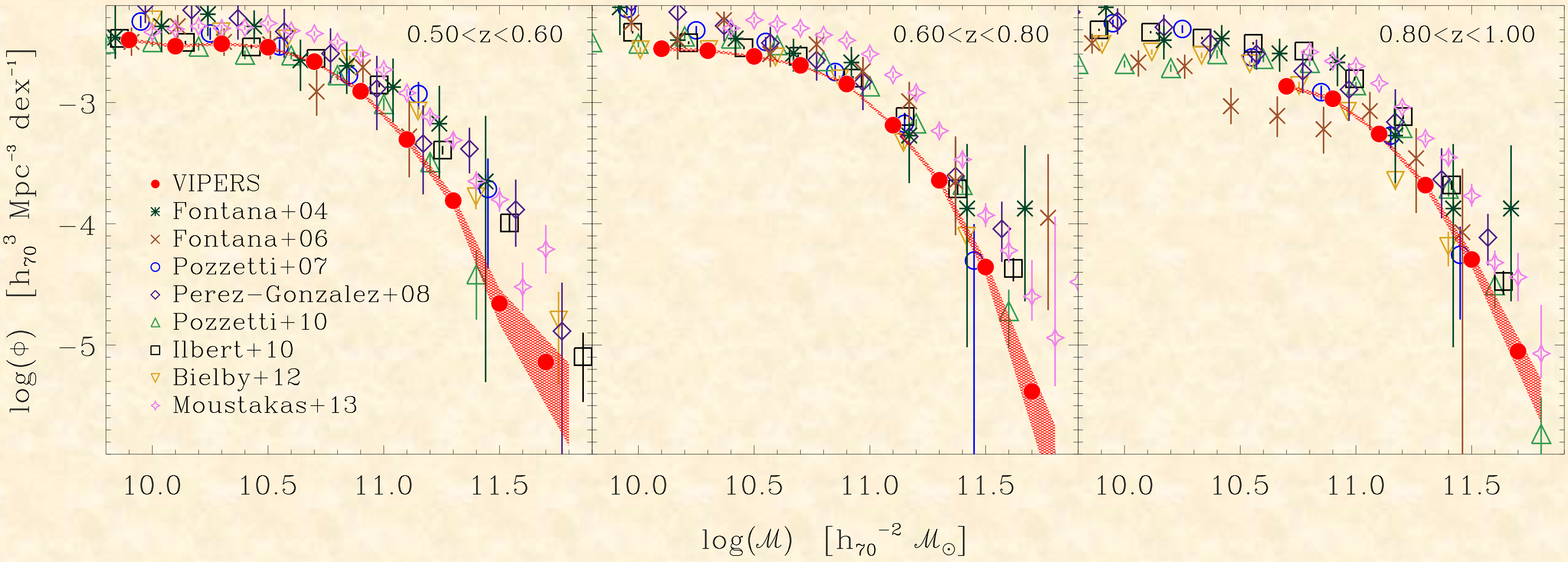
VIPERS provides detailed structure AND galaxy properties

(U-B) rest frame



Color-density relation: Cucciati et al., in prep.

Galaxy Stellar Mass Function



MOST PRECISE MEASUREMENT EVER OF THE NUMBER DENSITY OF MASSIVE GALAXIES AT Z~1

I. Davidzon, Bolzonella et al. 2013, A&A, 558, 23
II. Fritz et al. (CM diagram + LF), 2014, A&A, 563, 92

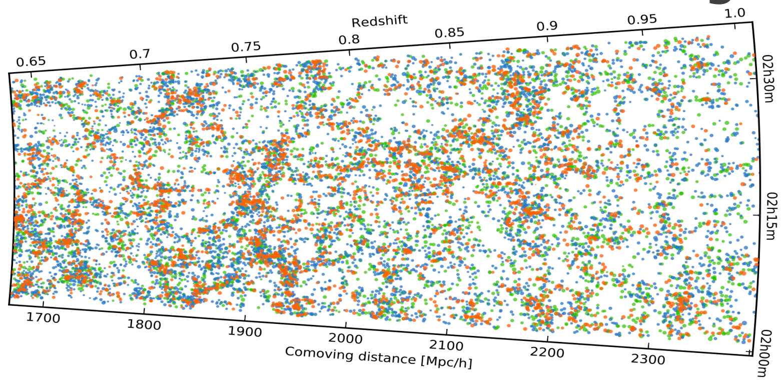
Combining imaging and spectroscopy: the importance of photometry

$$ds^2 = -a^2(\tau)\left[(1+2\Psi)\,d\tau^2 - (1-2\Phi)\,d\vec{x}^2\right]$$

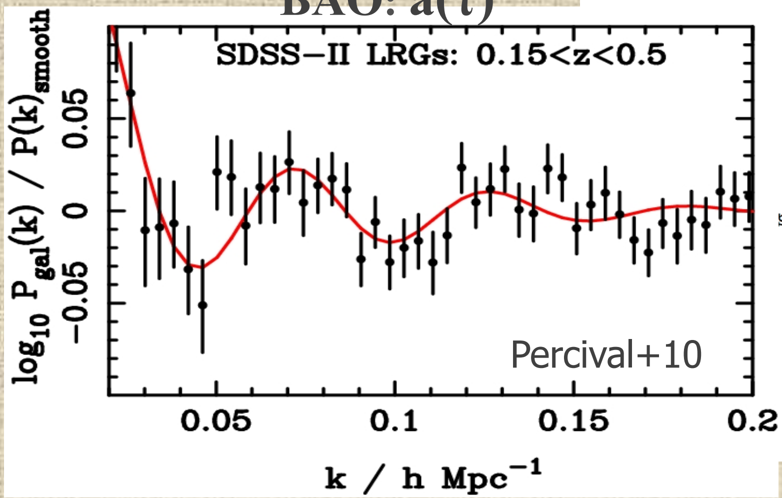
Φ : governs motion of matter

Ψ : governs motion of light

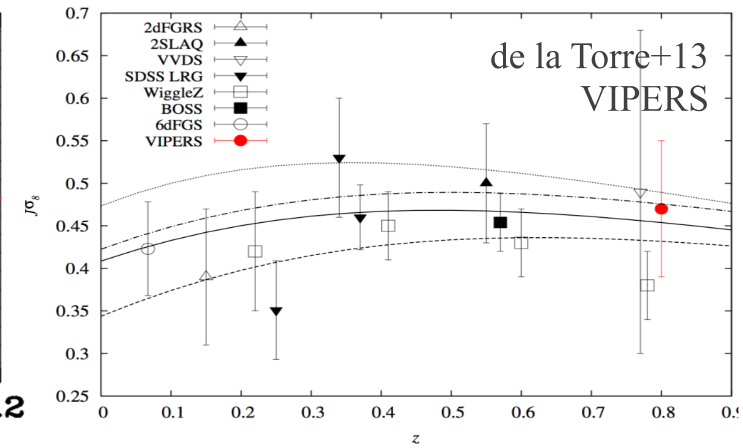
$\Phi = \Psi$ for GR



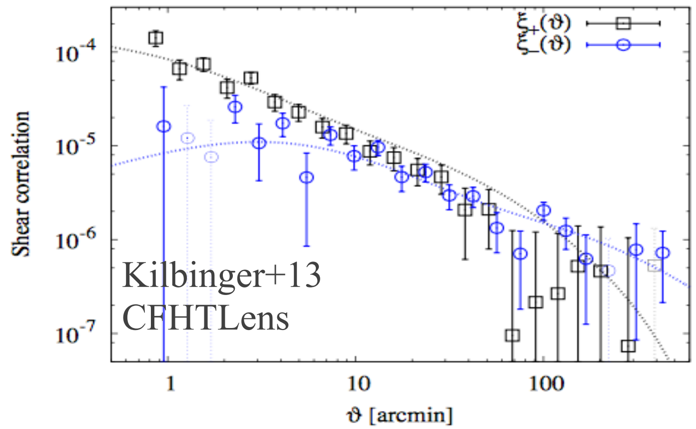
BAO: a(τ)



RSD: Φ



Cosmic shear: $\Phi + \Psi$



De la Torre, Jullo & VIPERS Team, in preparation

Summary

- **Design of redshift surveys for "cosmology" has important implications:**
  1. Either maximize volume with **low density tracers (<n>~10^{-4} Mpc^{-3})**: very effective for cosmological applications; typically difficult selection function (pre-selection), limited use beyond primary cosmological goals (e.g. **BOSS, Wigglez**). Normally based on **fibre-fed spectrographs** with ~10^3 fibres over 1-2 degrees radius field. Forthcoming **e-BOSS** and **DESI** surveys will be of this kind.
  2. Or use fully **representative galaxy population (<n>~10^{-2} Mpc^{-3})**: important extra leverage on the details of the cosmic web (voids, filaments), non-linear small-scale structure (groups), galaxy properties and population statistics (LF, MF, colours) and their relation to environment (e.g. **VIPERS**, and, at lower redshift, **GAMA**). VIMOS has ideal combination of area and sensitivity (VLT) to efficiently do such surveys at z~1.
- Both types of surveys are important
- Nearly fully-sampled redshift surveys with "simple" selection function and good spectral coverage are crucial to understand how the tracers we are using relate to the underlying DM
- Do much more than BAO/RSD, also in cosmological terms: new probes, discovery space…

Remarks

1. z~0 and z~1 clustering measurements are getting close to similar precision: how to best exploit these snapshots at different epochs, beyond the obvious combination of their measurements?
2. Combine redshift and angular "parent" larger samples?
3. Halo-galaxy connection?
4. Alternative statistics? (voids, etc.)
5. All these points require a high sampling of the population, understanding the bias and its evolution and detailed understanding of selection function
6. This implies that high-sampling redshift surveys of the "complete" population of galaxies, with "simple" selection functions (like VIPERS, GAMA, 2dFGRS) will remain fundamental (let alone all the specific galaxy evolution implications)
7. Allow for "discovery space"!

Large-scale multi-band imaging surveys

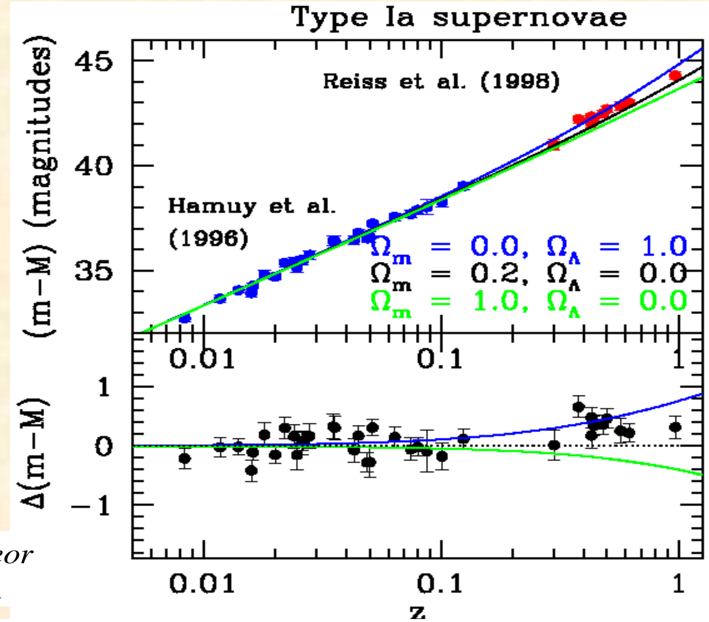
- **CFHTLS** (F): completed, 140 deg^2 in 5 bands, (e.g. CFHT-Lens project and weak-lensing shear results – basis for VIPERS)
- **Dark Energy Survey** (DES: US/UK/E + Munich LMU, ETH Zurich): started, 5000 deg^2 in 5 bands
- **VST-KIDS + VISTA-VIKING** (NL, I, D, …): started, 1500 deg^2 in 9 bands (from U to K)
- **LSST** (US-led consortium): dedicated 8m telescope, 20000 deg^2 (southern sky), in 6 bands (0.3-1.1 m), with time information
- **SUMIRE-PFS** (Japan + others): Subaru 8m prime focus, both imaging and spectroscopy, being defined
- [**Pan-STARRS**? (US, UK, D, …)]: started, but unclear future developments

Dark Energy

Why?
WHY
To explain accelerated expansion

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right) \qquad p = w\rho c^2 \;;\quad w < -1/3$$

$w = -1$: Cosmological constant
Agrees with all data



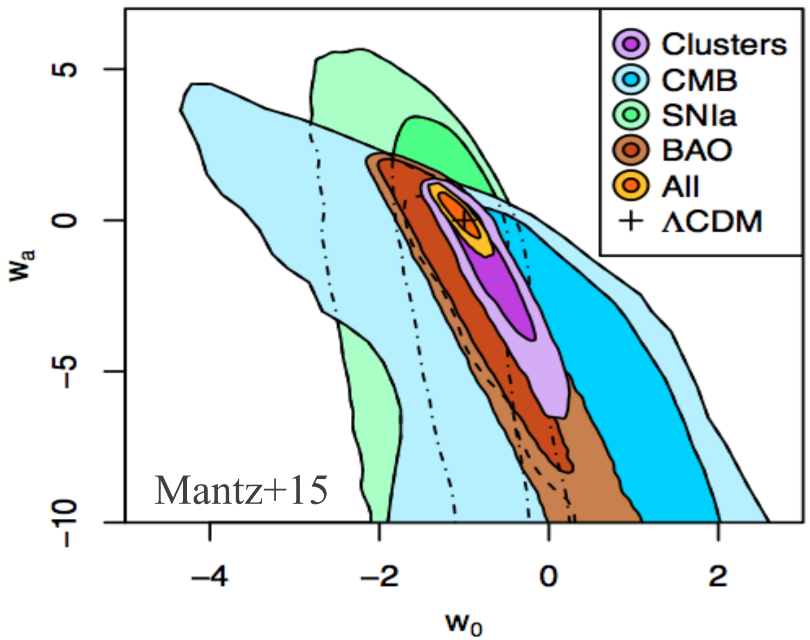
Which physics?
Don't know, but should explain why

$$\rho_\Lambda^{oss} \simeq 10^{-120}\,\rho_\Lambda^{teor}$$

$w(z) \neq -1$ as a signature of this physics

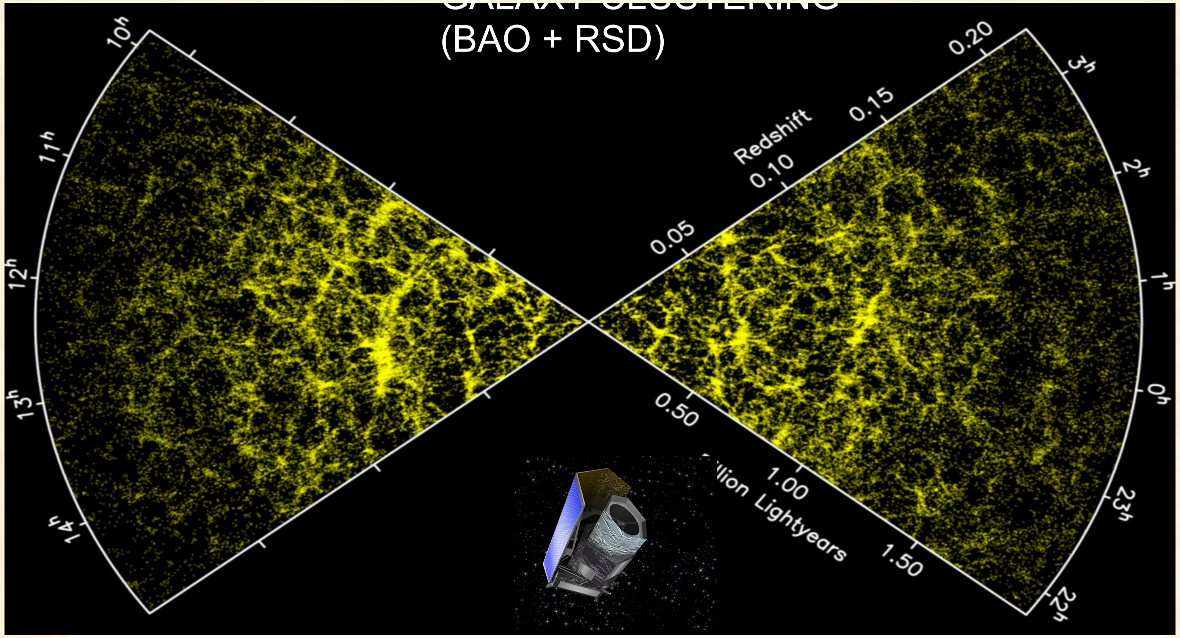
Signatures:
- expansion rate: SN-Ia, BAO, CMB
- evolution of density inhomogeneities: RSD, cosmic shear, galaxy clusters, ISW, ...

Key science driver of all ongoing and future surveys:
DES, eROSITA, DESI, LSST, **Euclid**, **SKA**, WFIRST

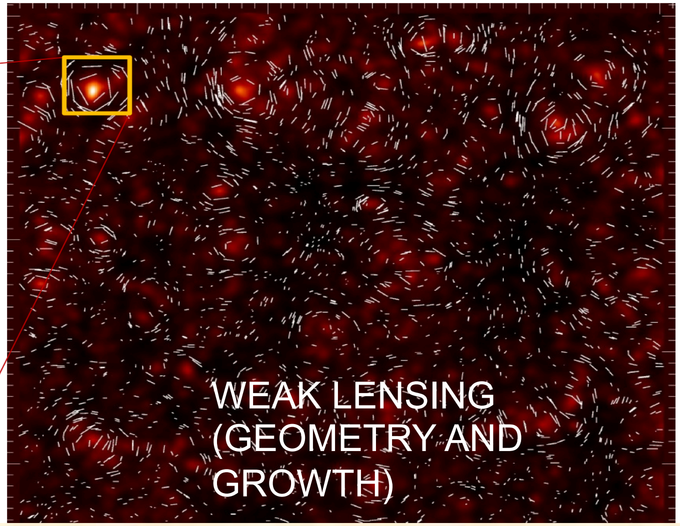


Euclid – THE cosmology experiment

GALAXY CLUSTERING
(BAO + RSD)



GALAXY CLUSTERS
(GEOMETRY AND
GROWTH)



WEAK LENSING
(GEOMETRY AND
GROWTH)

- Visible imaging (1 band)
- Infrared imaging (Y,J,H)
- Infrared slitless spectroscopy
- Launch 2020

- 15,000 deg^2 survey
- Images for 2×10^9 galaxies
- Spectra for ~5×10^7 galaxies (0.9<z<1.8)

Objectives:

- Build a map of dark and luminous matter over 1/3 of the sky and to z~2
- Unveil the nature of dark matter
- Trace the origin of cosmic acceleration
- Use multiple probes → max control over systematic errors

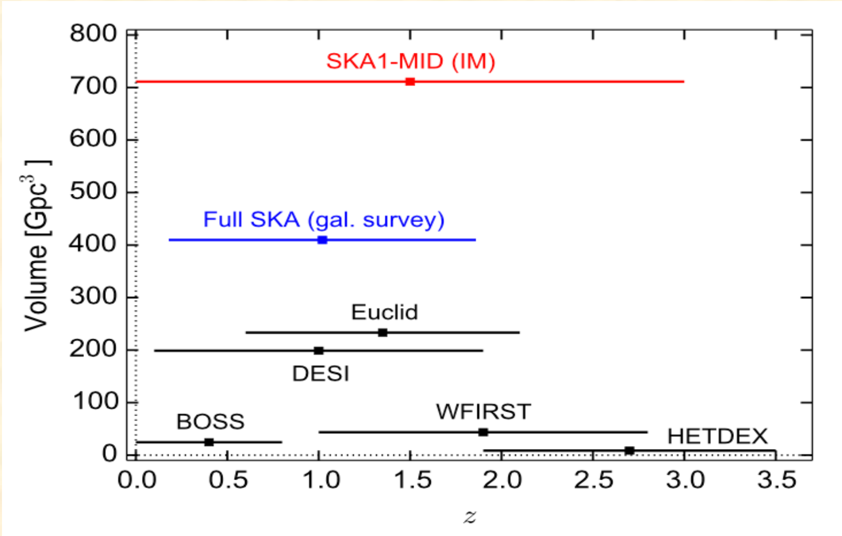
SKA – Surveys for Cosmology

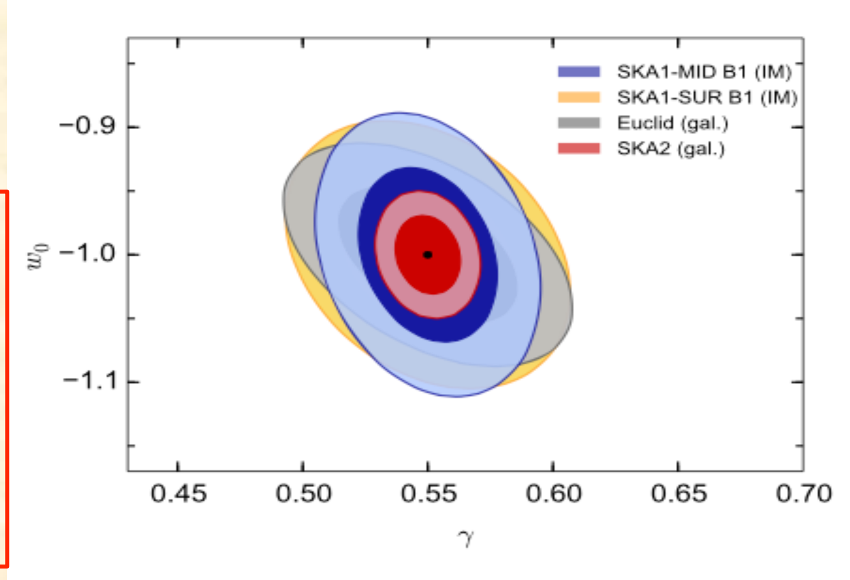
1. **HI Intensity Mapping** [BAO, super-horizon, etc.]
   All-sky (3π sr); low-res. >30’; 0<z<3

2. **HI Threshold:** galaxy redshift survey [BAO, RSD]
   SKA1: 5 10^6 gals @ z<0.5
   SKA2: ~10^9 gals @ z<2

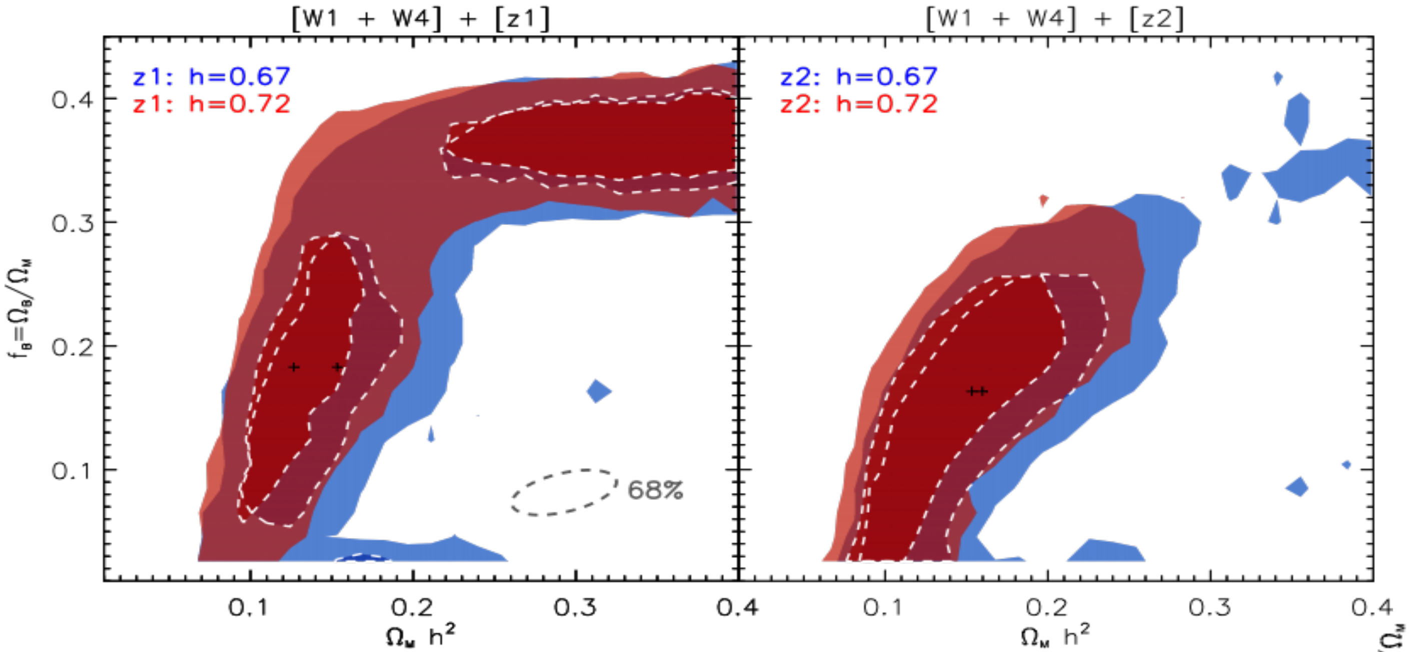
3. **Continuum** [weak lensing, angular clustering, ISW]:
   → All-Sky Survey (~ 1-2” res.)
   → Weak Lensing Survey (0.5” res.):
   NB: Commensality with HI/Continuum surveys for galaxy evolution

Euclid + SKA: huge synergies
→ Scientific: beat systematics, complementary constraints, multi-tracers, etc.
→ Programmatics: e.g. simulations, likelihood definitions and coding, etc.



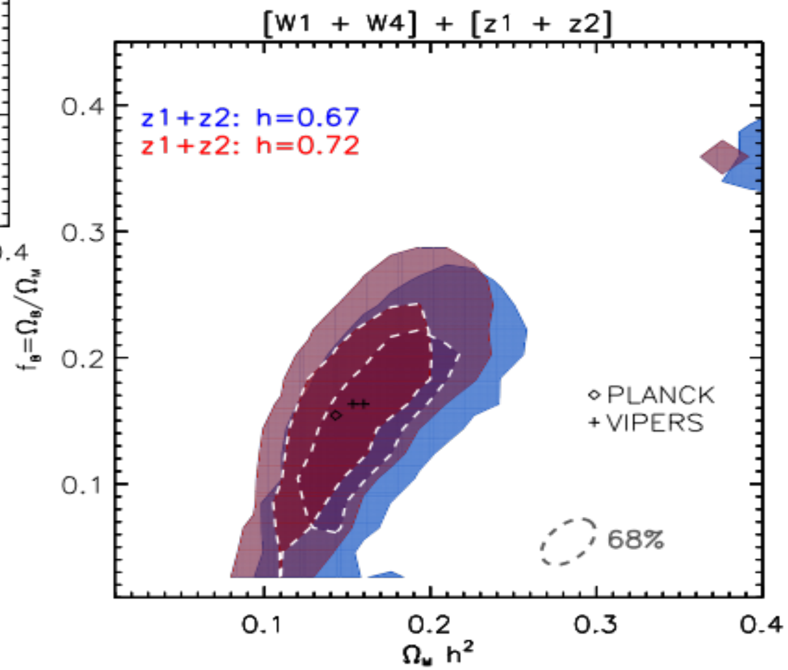


Consistency with Planck

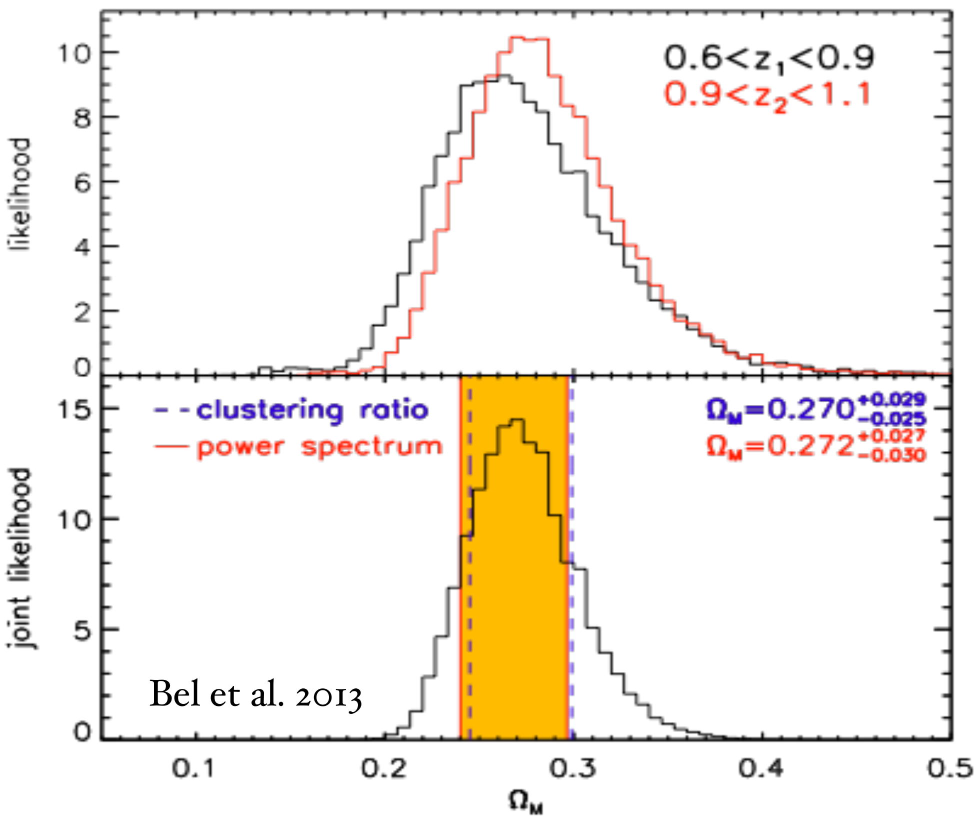


h=0.67 (Planck)

h=0.72



Fixing the baryon fraction to BBN, to compare to Bel et al. estimate from counts-in-cells "clustering ratio":



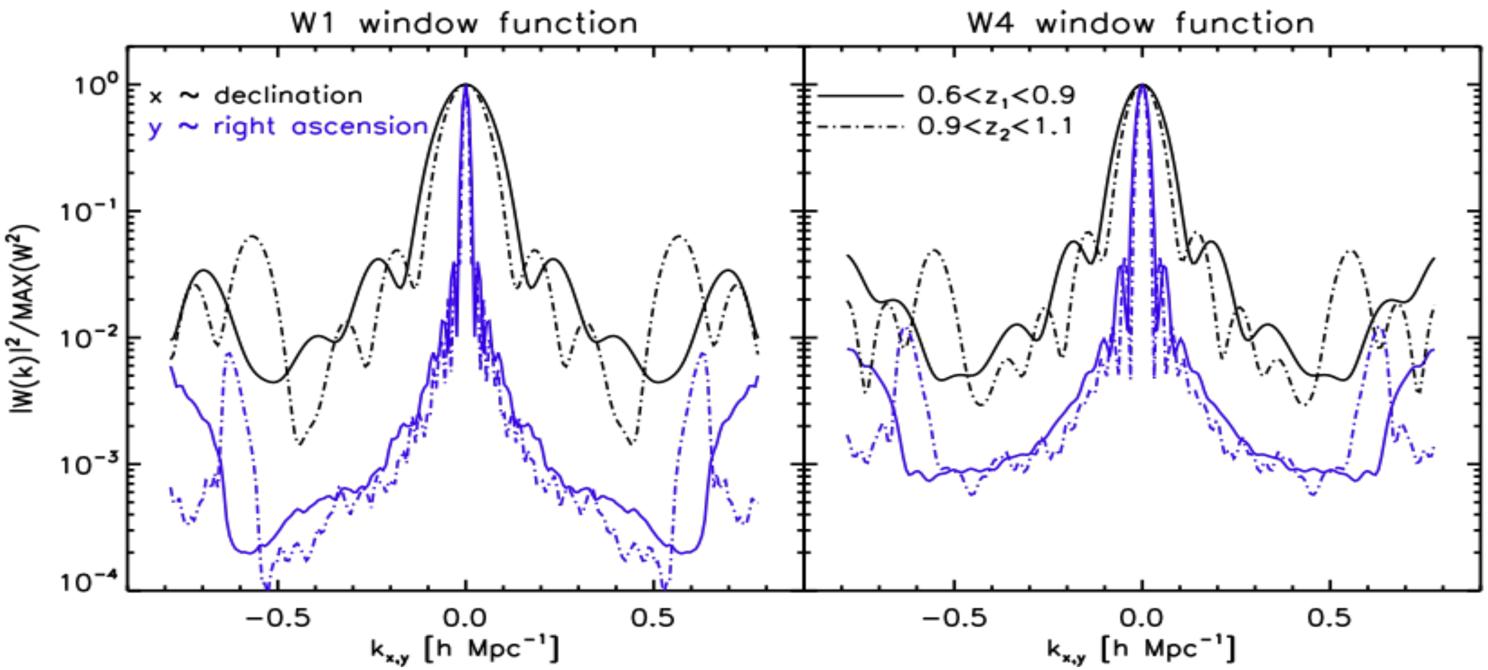
Gaussian priors on:
h=0.738 (HST)
$\Omega_B h^2$ (BBN)
n_s,A_s (Planck)

- The two methods in Fourier and configuration space give equivalent results
- Note that value of Ω_m =0.272 is in fact compatible with Planck if one considers h=0.67 used there and thus an enhancement factor of $(0.738/0.67)^2$

	Ω_M	$\Omega_b h^2$	h	n_s	$\ln(10^{10}A_s)$	σ_{TOT} [km s^{-1}]	b (z1 / z2)
prior	0.1 – 0.9	0.0213 ± 0.0010	0.738 ± 0.024	0.9616 ± 0.0094	3.103 ± 0.072	514 ± 24	0 – 2
best fit	$0.272^{+0.027}_{-0.031}$	$0.0211^{+0.0010}_{-0.0004}$	$0.735^{+0.018}_{-0.016}$	$0.9630^{+0.0054}_{-0.0088}$	$3.096^{+0.046}_{-0.057}$	522^{+16}_{-18}	$1.13^{+0.21}_{-0.18}$ / $1.25^{+0.20}_{-0.15}$

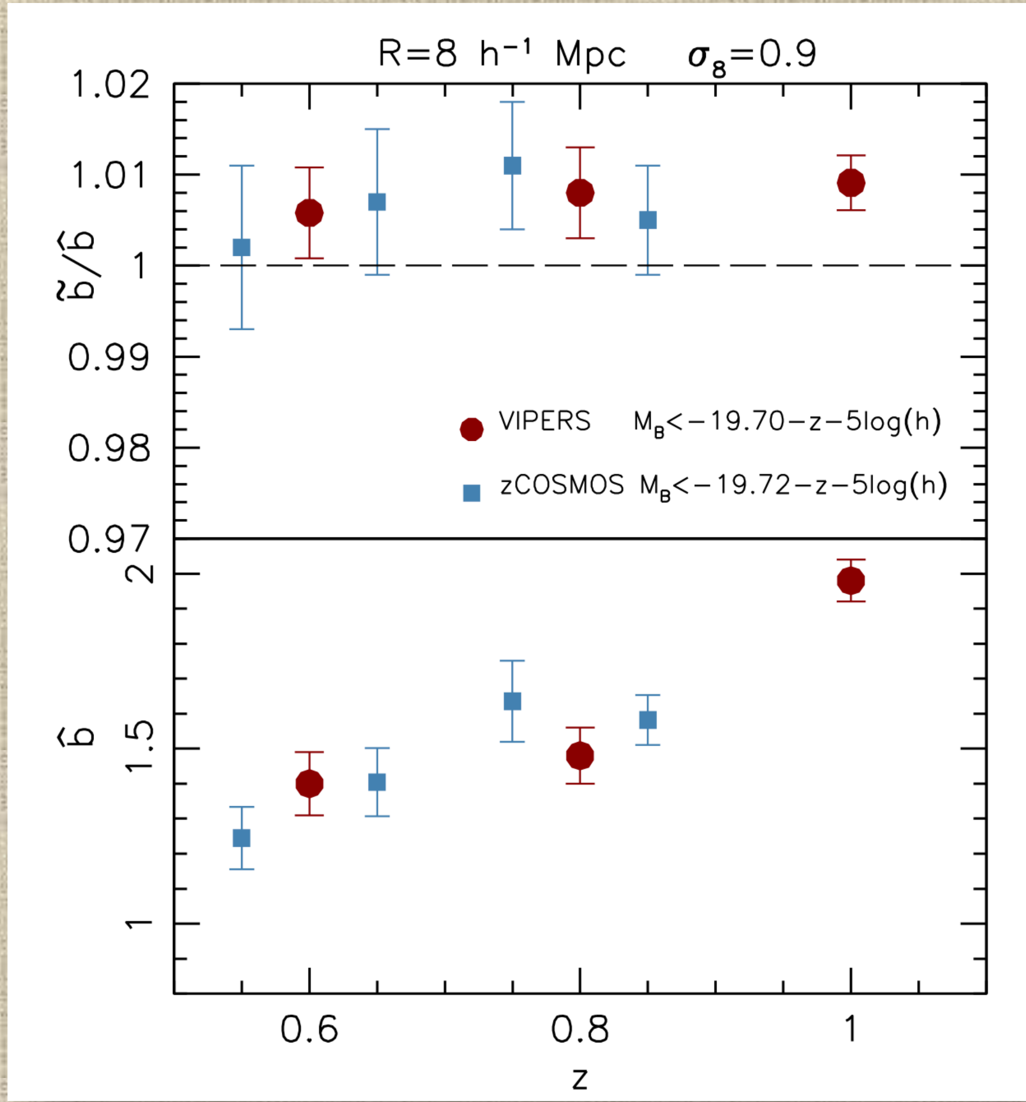
Cosmological results

- CAMB (ΩM,fB) + HALOFIT non-linearities
- bias (b)
- redshift-space distortions: KAISER + DISPERSION MODEL (σv)
- window function



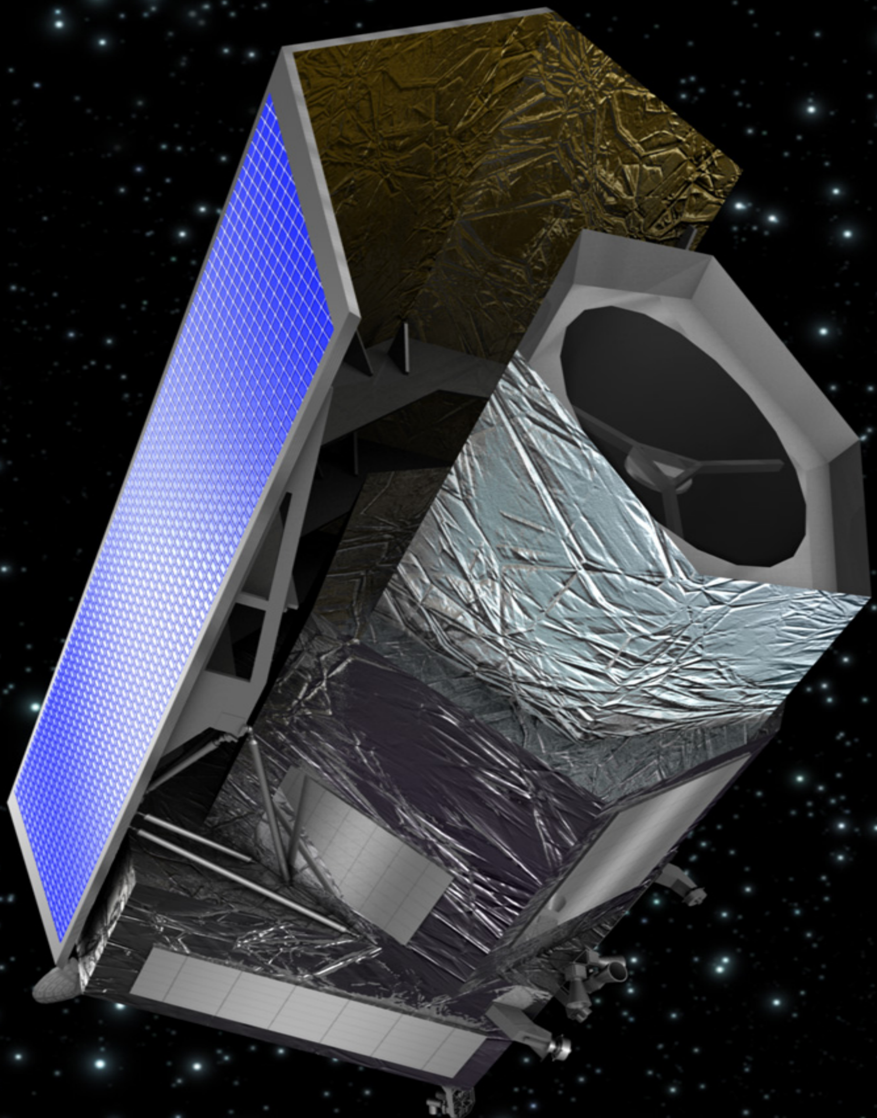
Nonlinear bias evolution

Using Sigad, Branchini& Dekel (2000) inversion technique



(Di Porto, Branchini & VIPERS Team, submitted)

Euclid



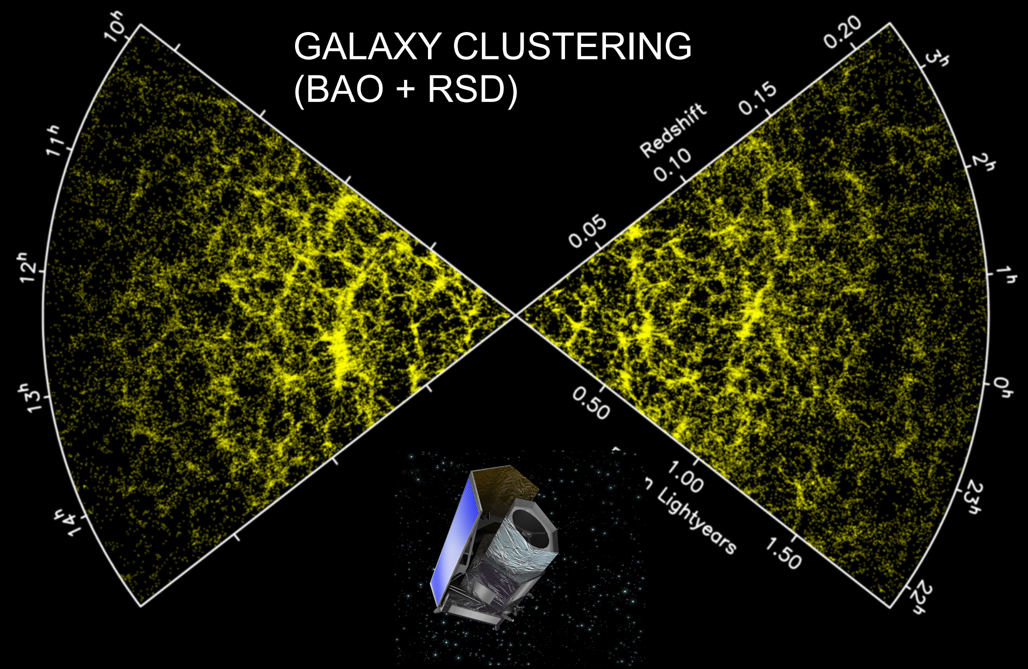
- ESA mission + extra contribution by national agencies (legacy of parent DUNE+SPACE projects)

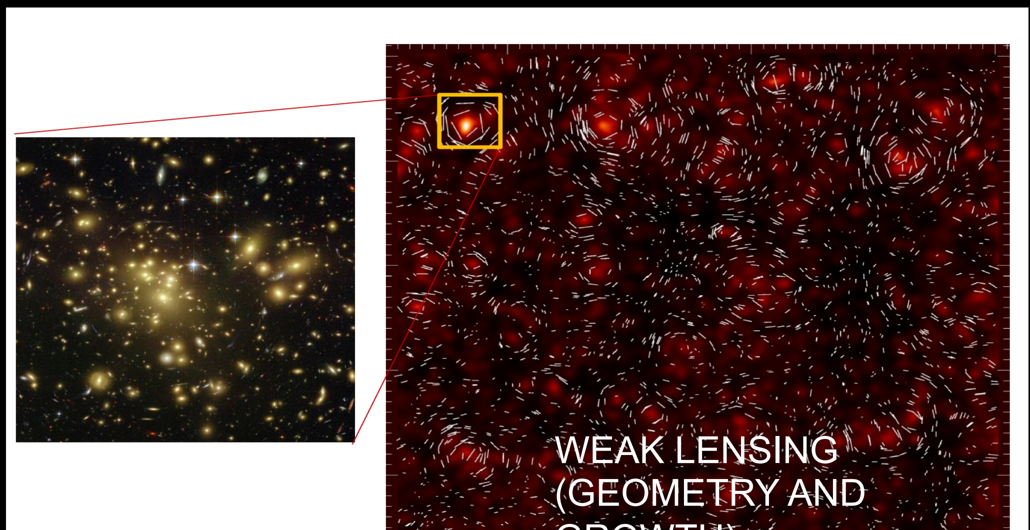
- Euclid Consortium Lead: Yannick Mellier (IAP)

- 1.2 m telescope
- Visible imaging (1 band)
- Infrared imaging (Y,J,H)
- Infrared slitless spectroscopy
- Launch 2020

- 15,000 deg^2 survey
- Images for 2x10^9 galaxies
- Spectra for ~5 x 10^7 galaxies (0.9<z<1.8)

Euclid





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- Unveil the nature of dark matter
- Solve the mystery of dark energy (cosmic acceleration)
- Use multiple probes → max control over systematic errors

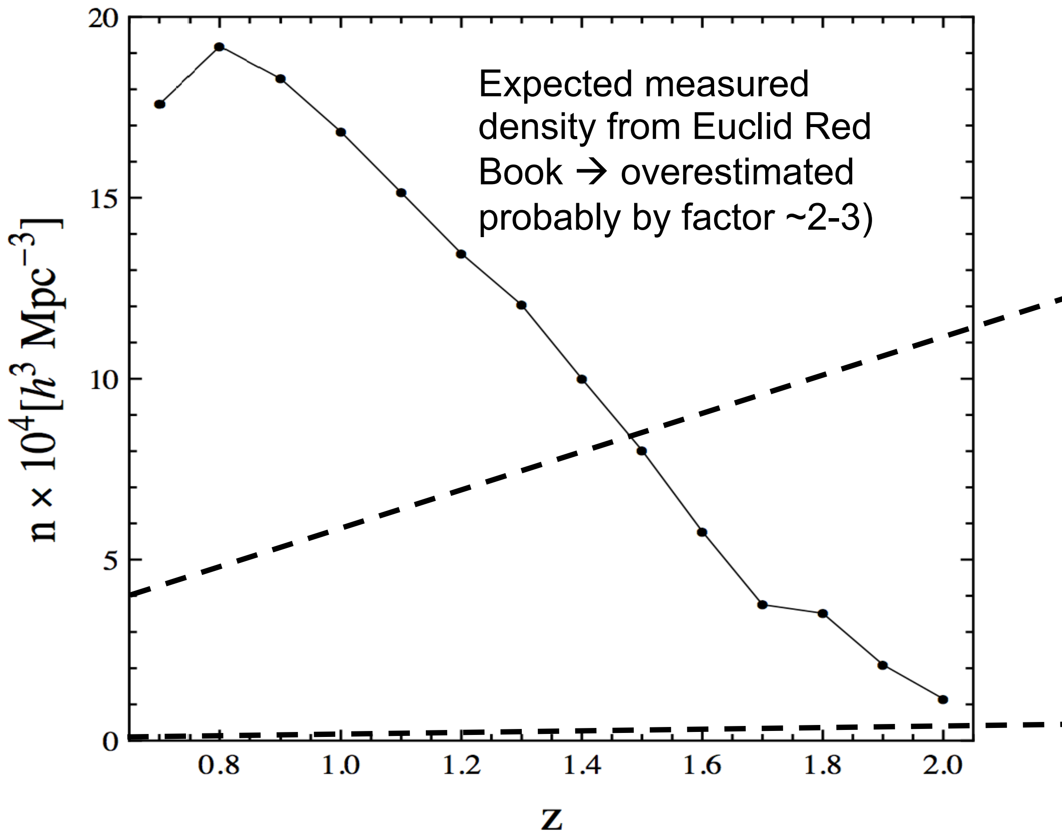
The Euclid "Red Book"

http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=48983#

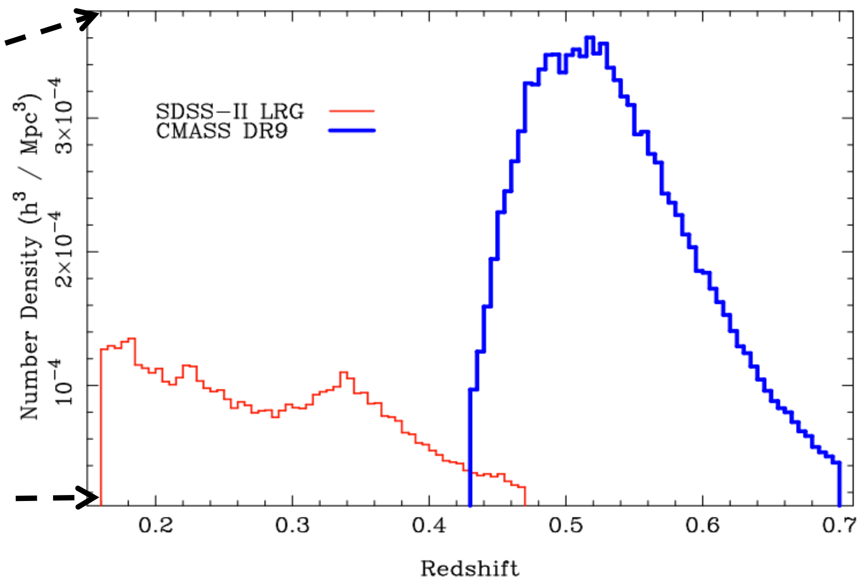
Galaxy density in Euclid redshift survey

Euclid Consortium

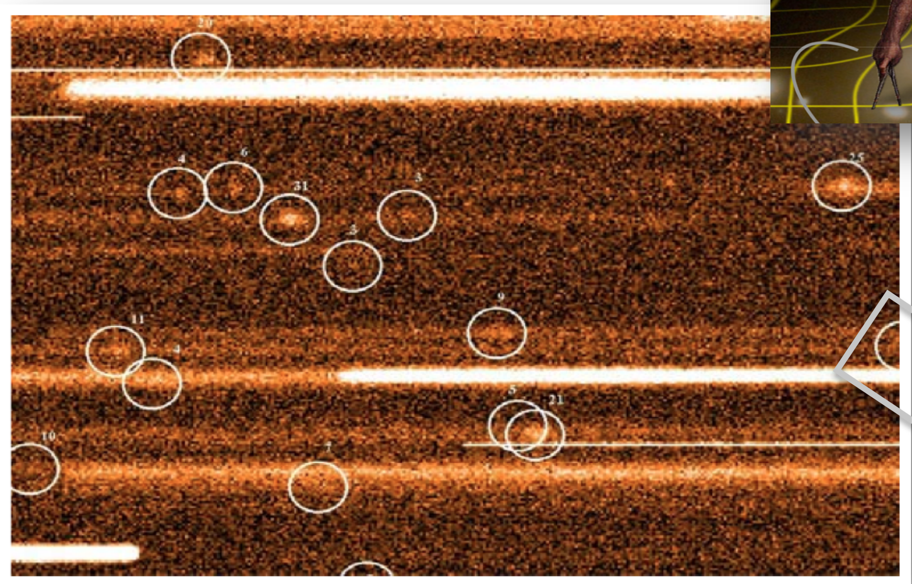
- NIR **slitless spectroscopy** mainly targeting **H-alpha emission at 0.9 < z < 1.8, to a line flux of 2 x 10^{-16} erg s^{-1} cm^{-2})**
- **Euclid will trace sites of strongest star formation**
- **Expected density is not outstanding (but volume is huge and dominate error budget over most of the range → prefer z~1 range over z~2 for cosmology**

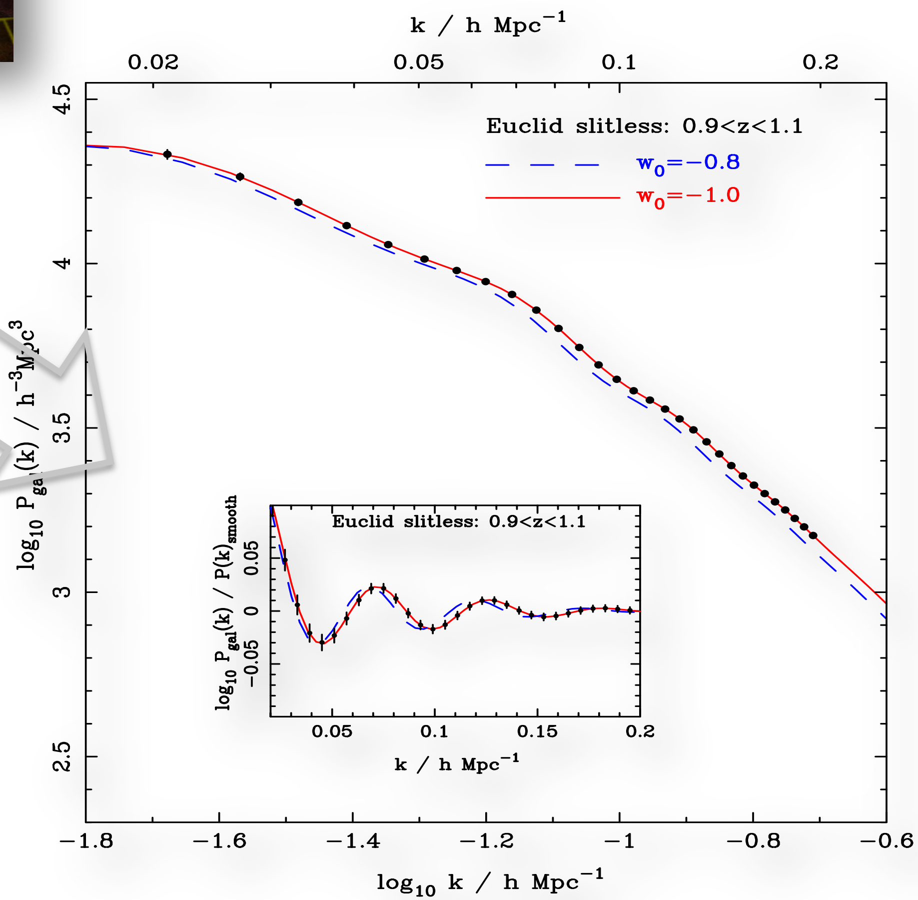


As a comparison: BOSS CMASS (Anderson et al. 2012)



A long way from raw data to cosmology...





COSMIC VOIDS in the Euclid survey?