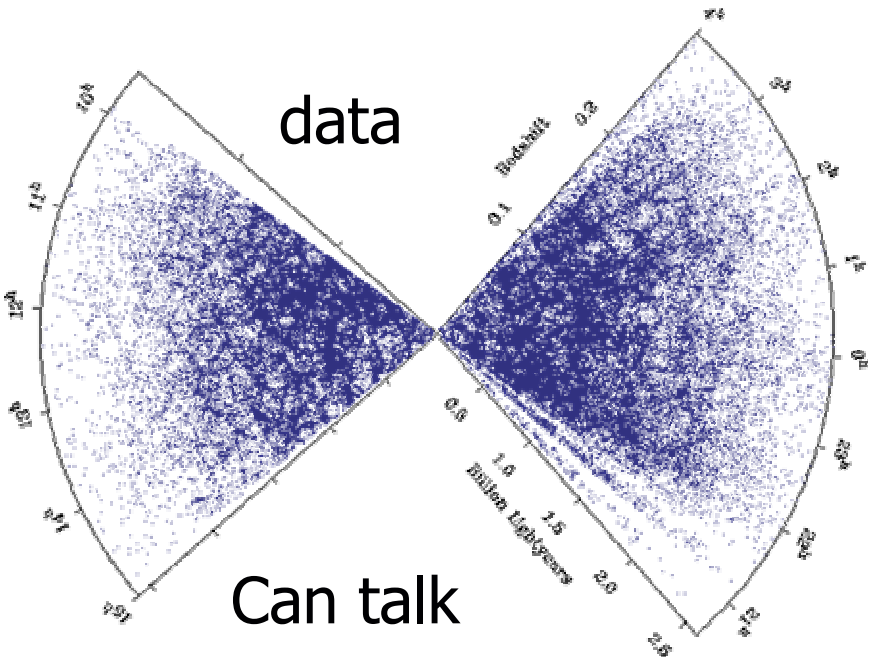
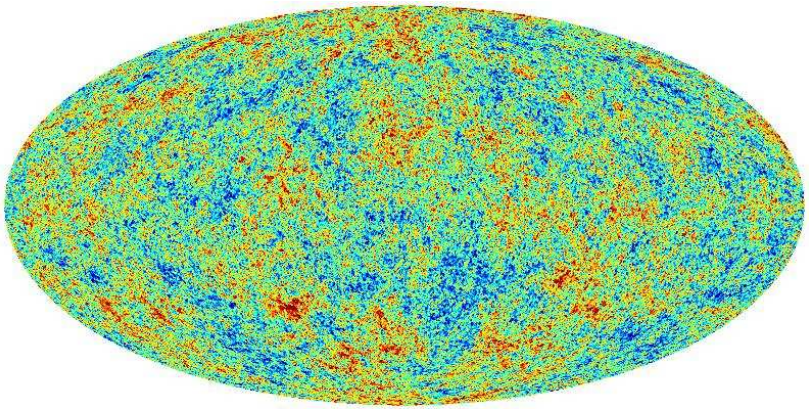
Combining LSS and CMB power spectra



data

Can talk

simulation



Can’t say much yet

Licia Verde

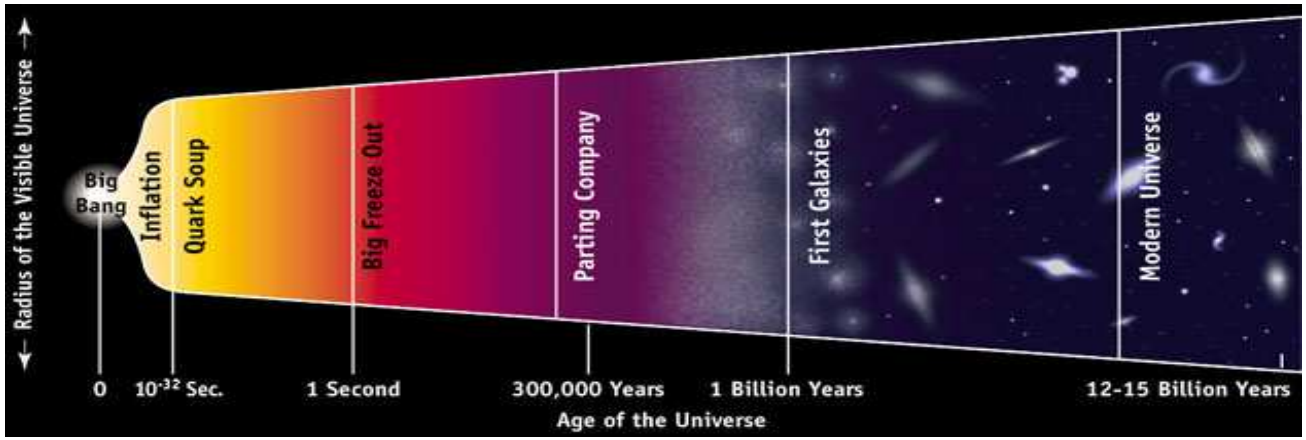
Princeton University

Why?

Even if you are only interested in neutrinos, you can't forget about uncertainties in cosmological parameters!

If fluctuations are Gaussian random field,
Power spectrum tells you all

Longest leverage arm (time and scales)

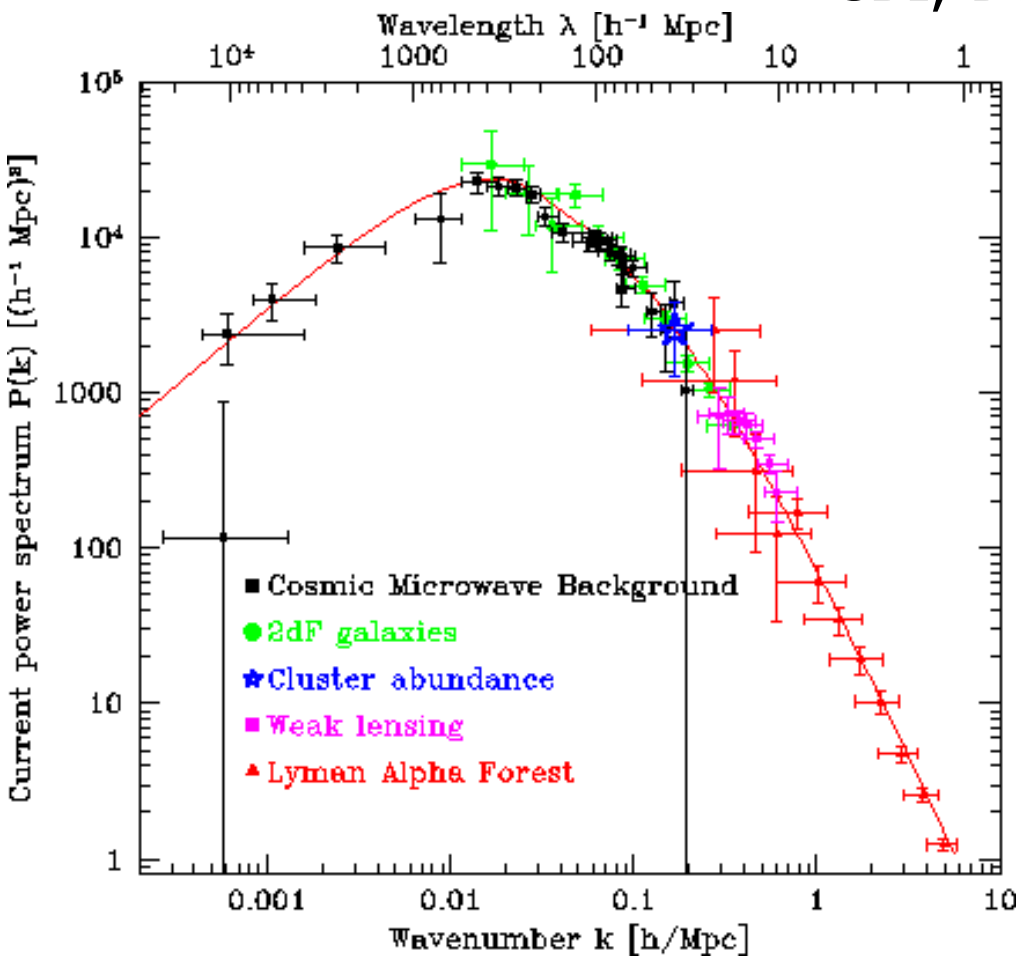


Lift degeneracies (see e.g. Eisenstein et al 99)

Test consistency of cosmological model/test hypothesis

It is a really good time to get involved with such a project:

2dF, SDSS, Boomerang, Maxima, CBI, Dasi, VSA, MAP



From Tegmark & Zaldarriaga 2002

Scales overlap for first time!

Since I can't talk about results….

A general introduction

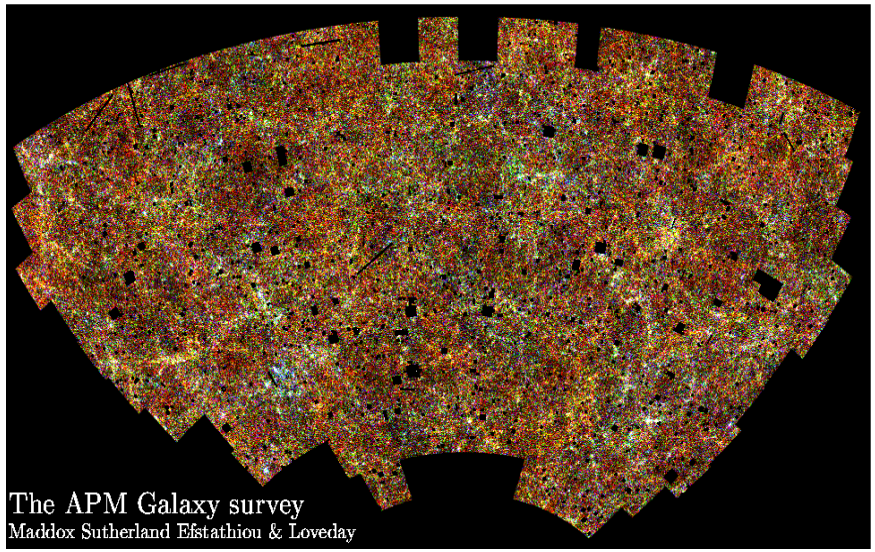
Assume Standard LCDM model
(massless neutrinos unless otherwhise stated)

LSS, what's that?

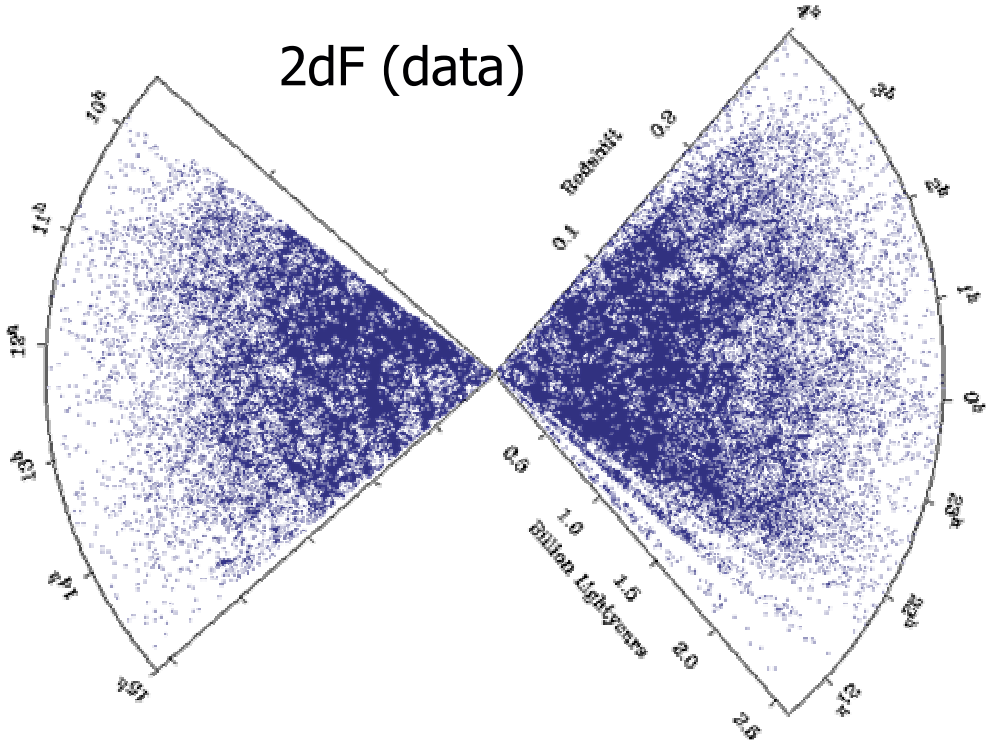
Different probes with pros and cons.

VIRG

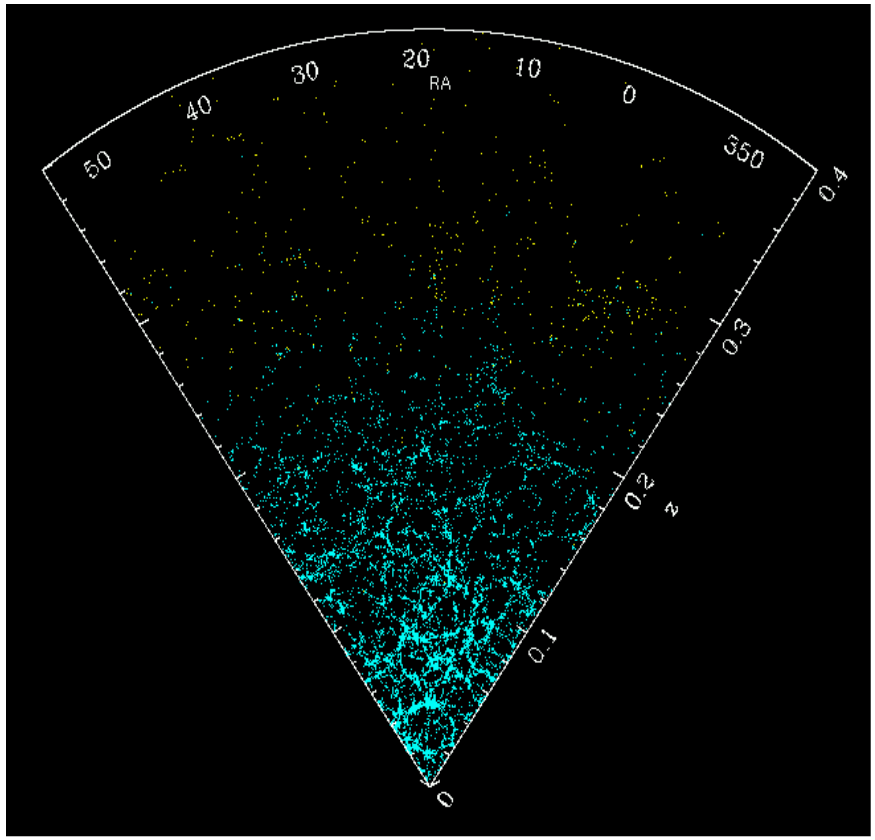
Galaxy surveys: (2D or –better-3D)



2dF (data)



SDSS (simul.)



Pros:

Probe local Universe: $z \sim 0.1$

Power spectrum signal is BIG

Probe linear and non-linear scales

Cosmological information in SHAPE and AMPLITUDE

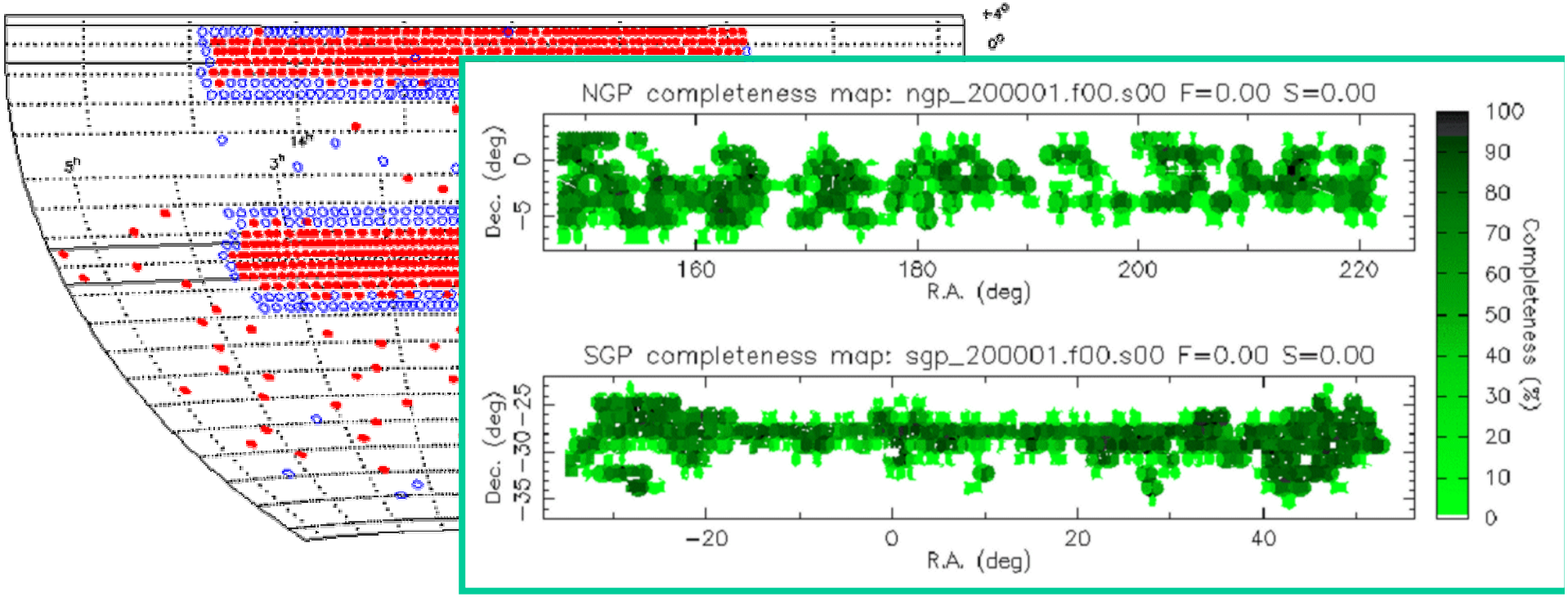
Cons:

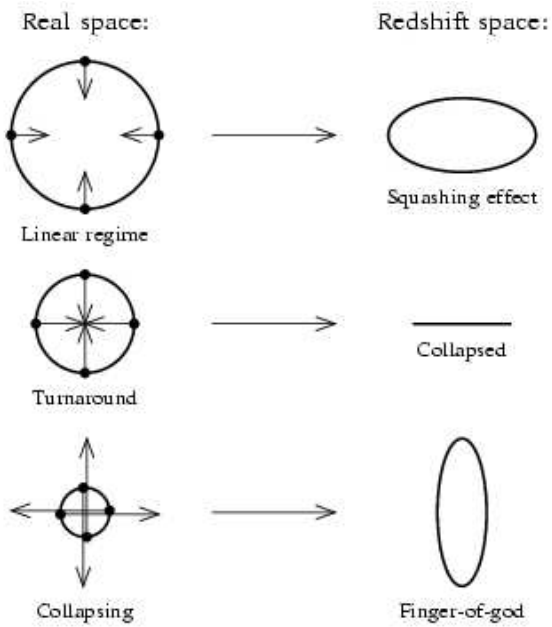
Window function…

Redshift space

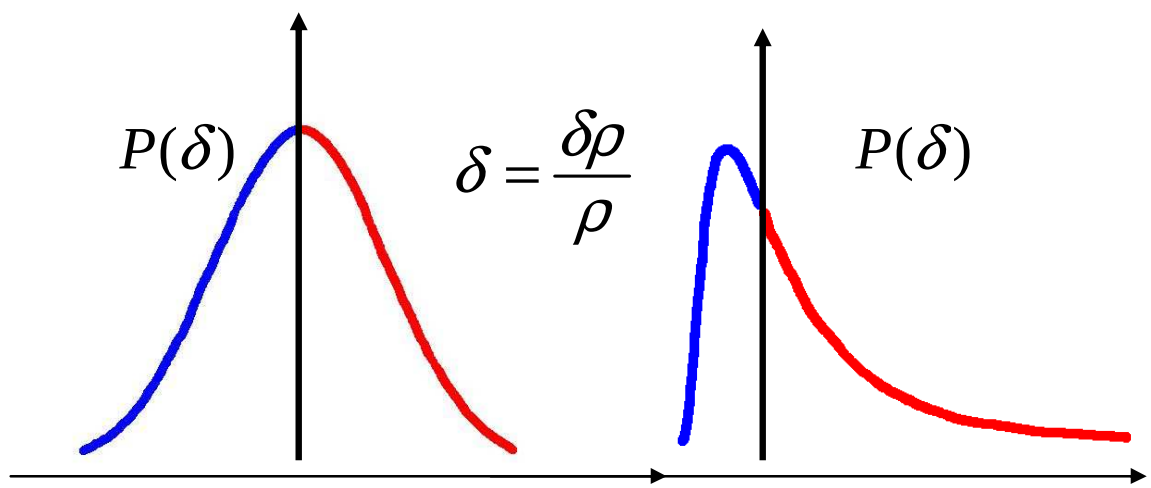
Non-linear evolution

bias

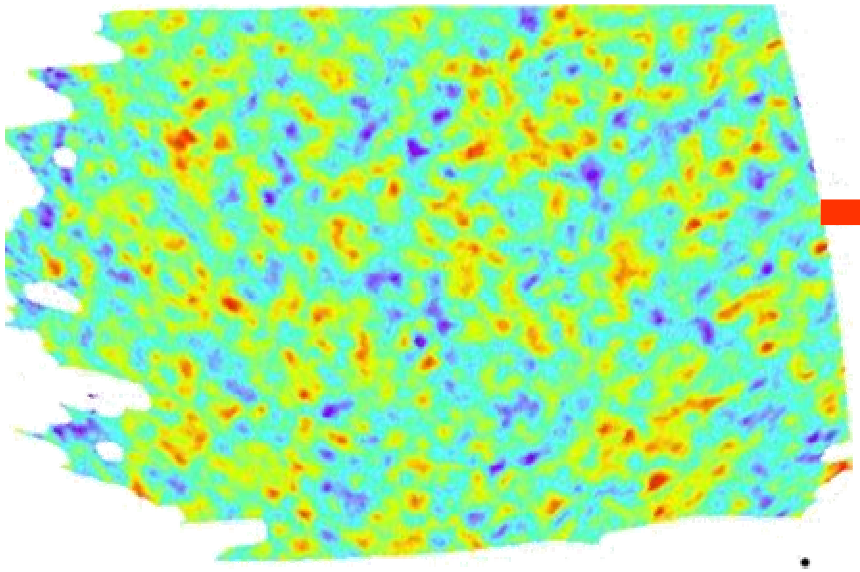


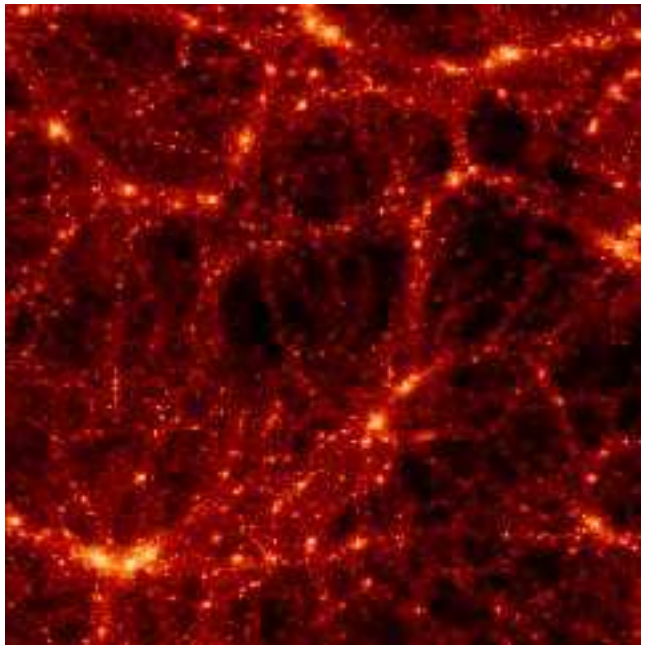


Info about cosmology



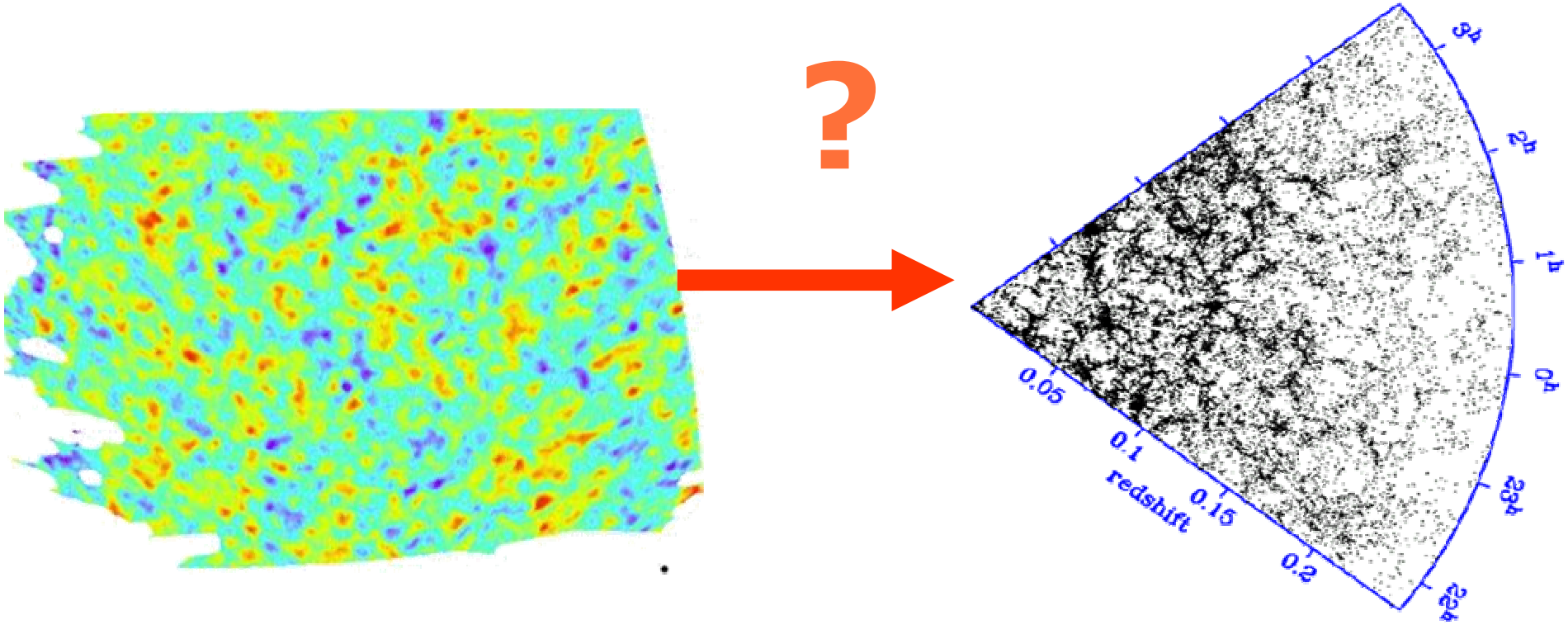
What's bias?





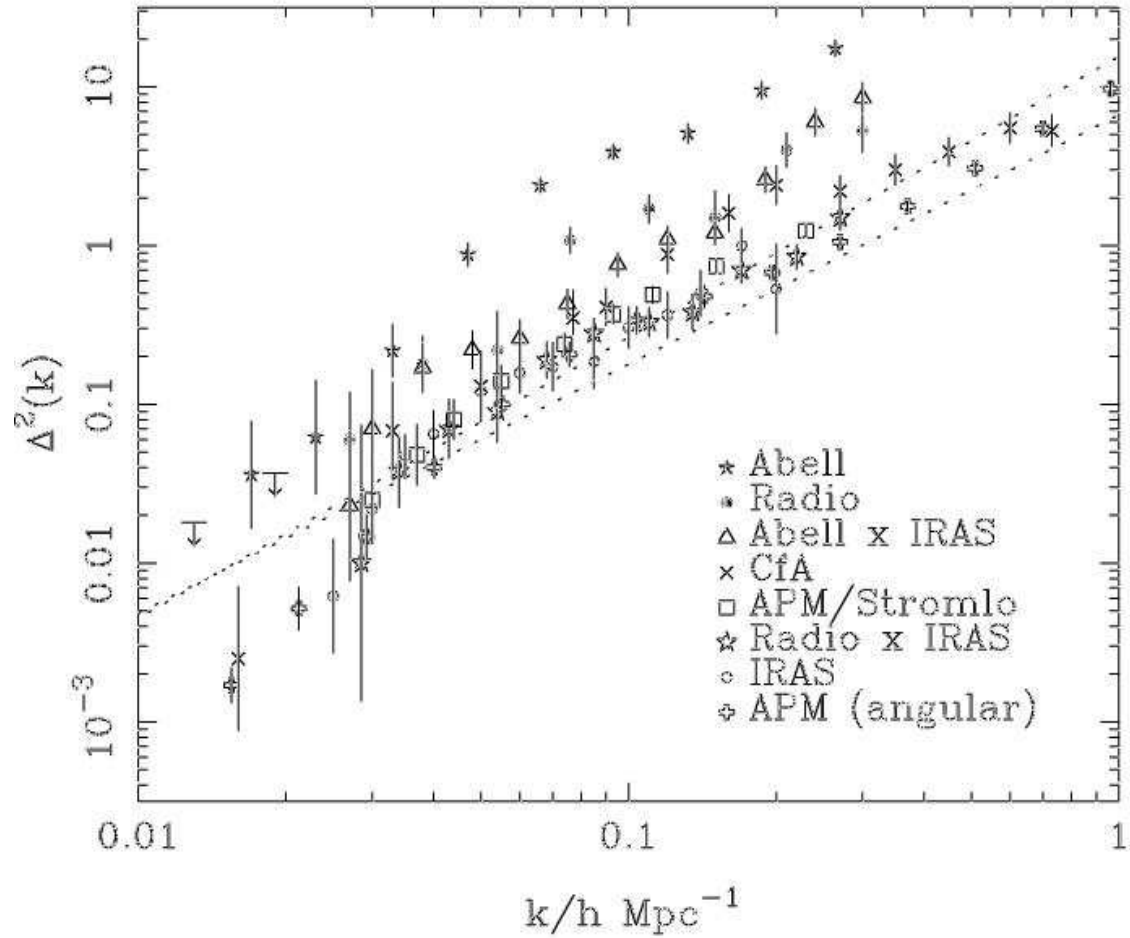
VIRGO

What's bias?



Peacock & Dodds 1994

$$\frac{1}{2\pi^2}P(k)k^3$$



You can say:

bias!

$$b = \sqrt{\frac{P_g(k)}{P(k)}}$$

Not that simple!

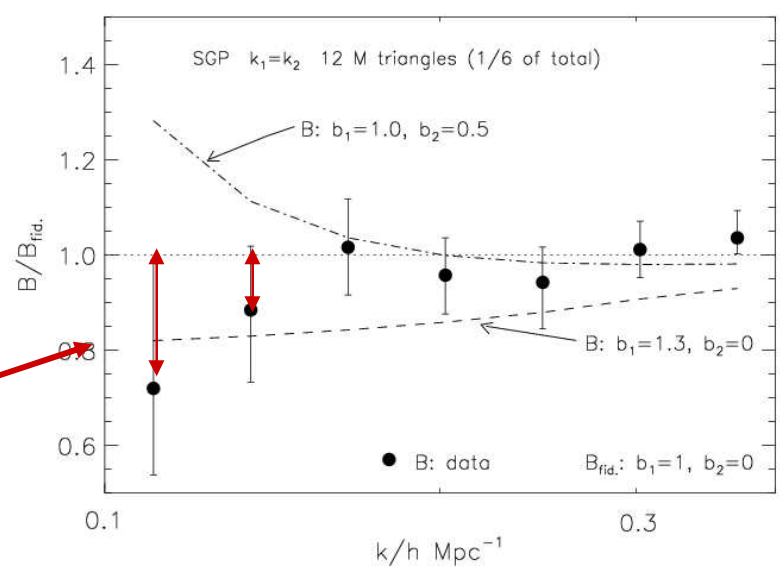
Quick fix:When estimating cosmological parameters, use only information in the power spectrum shape

If you know bias you can:
Use the power spectrum AMPLITUDE not just the SHAPE information

Extract cosmological information i.e. Ω_m
from redshift space distortions

For 2dF (Verde et al 2002) we now know that:
bias is linear, scale independent and ~1 (within the errors)

www.physics.rutgers.edu/~verde
or Verde et al. 2002
for more details



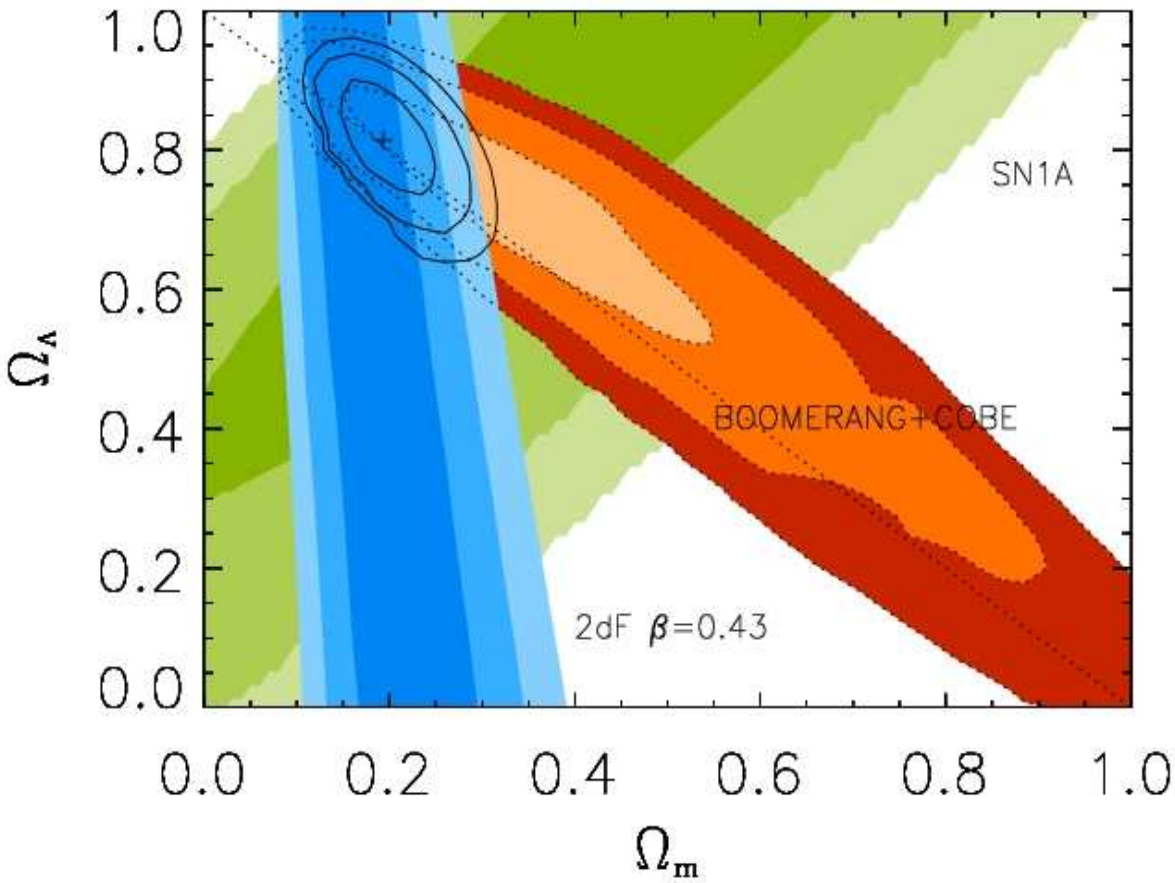
window

See also
Lahav et al. 02

Previous indications of this:
(e.g. Scoccimarro et al 00)

CAVEAT!

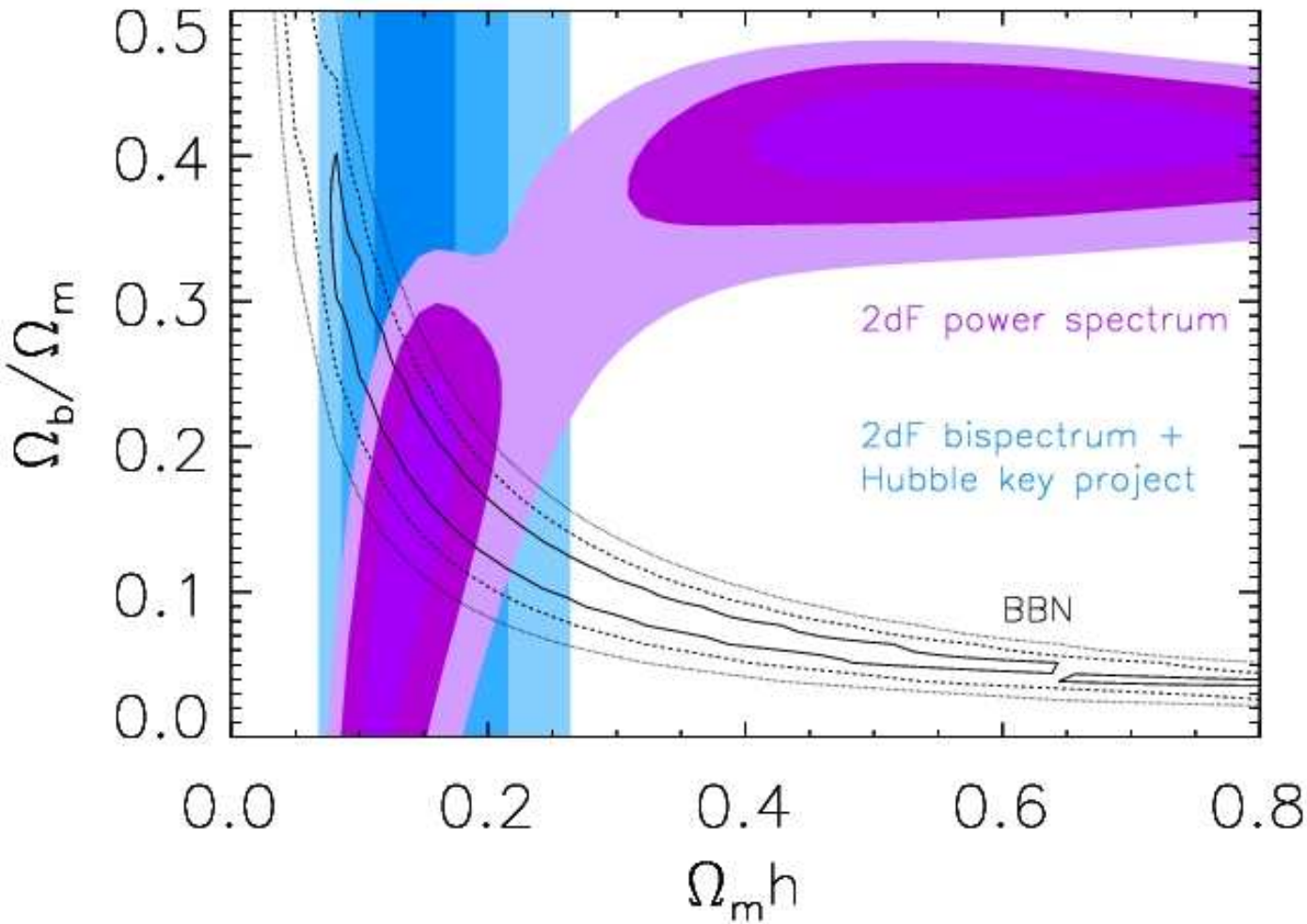
Despite real world effects LSS still useful…



Verde et al 2002

Perlmutter et al. 1998(9)

deBernardis et al. 2001



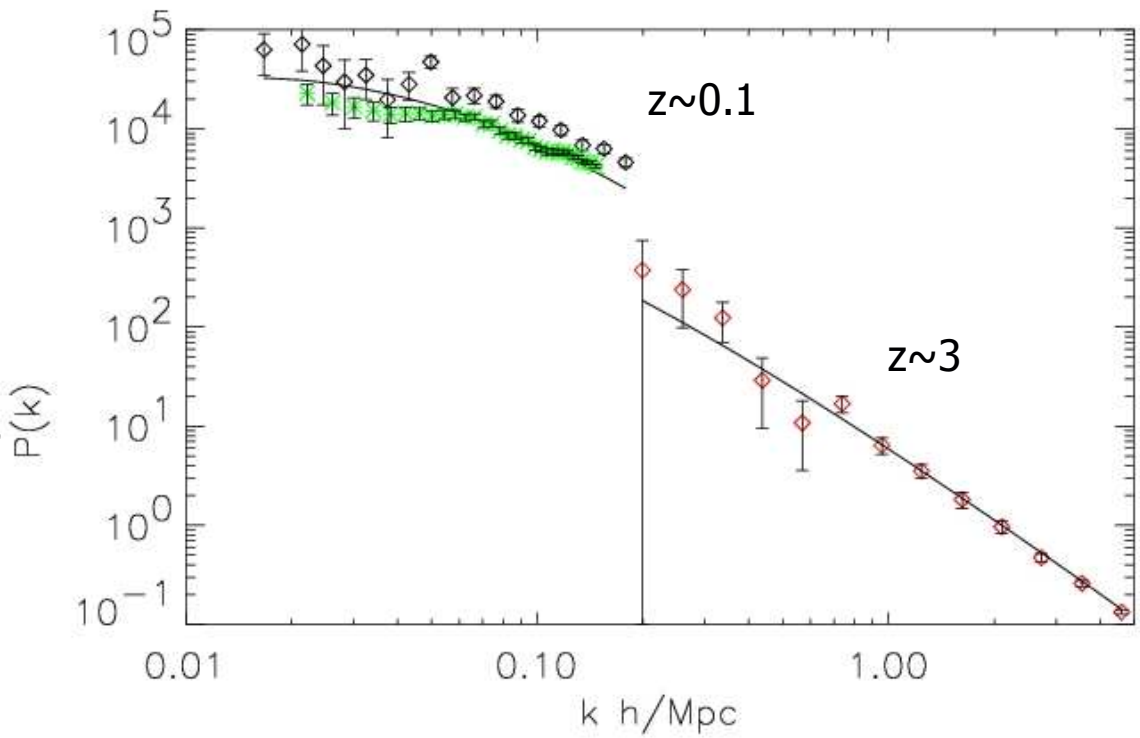
For more details see Verde et al. 2002

Lyman alpha forest:

z~3 LINEAR REGIME, scales: 10 to 1 Mpc /h

Data: Croft et al. 2002

Cons: how to convert transmitted flux into mass power spectrum?



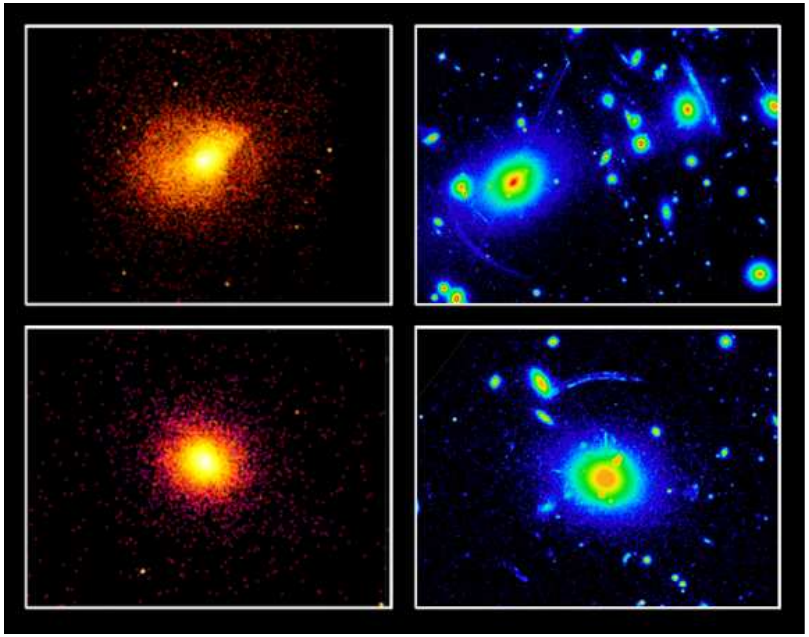
See e.g. Hamilton & Gnedin and McDonald

Cluster abundance:

Probes the mass function, in particular:

$$\sigma_8 = \int \Delta^2(k) W_{R=8}^2(k) d\ell n(k)$$

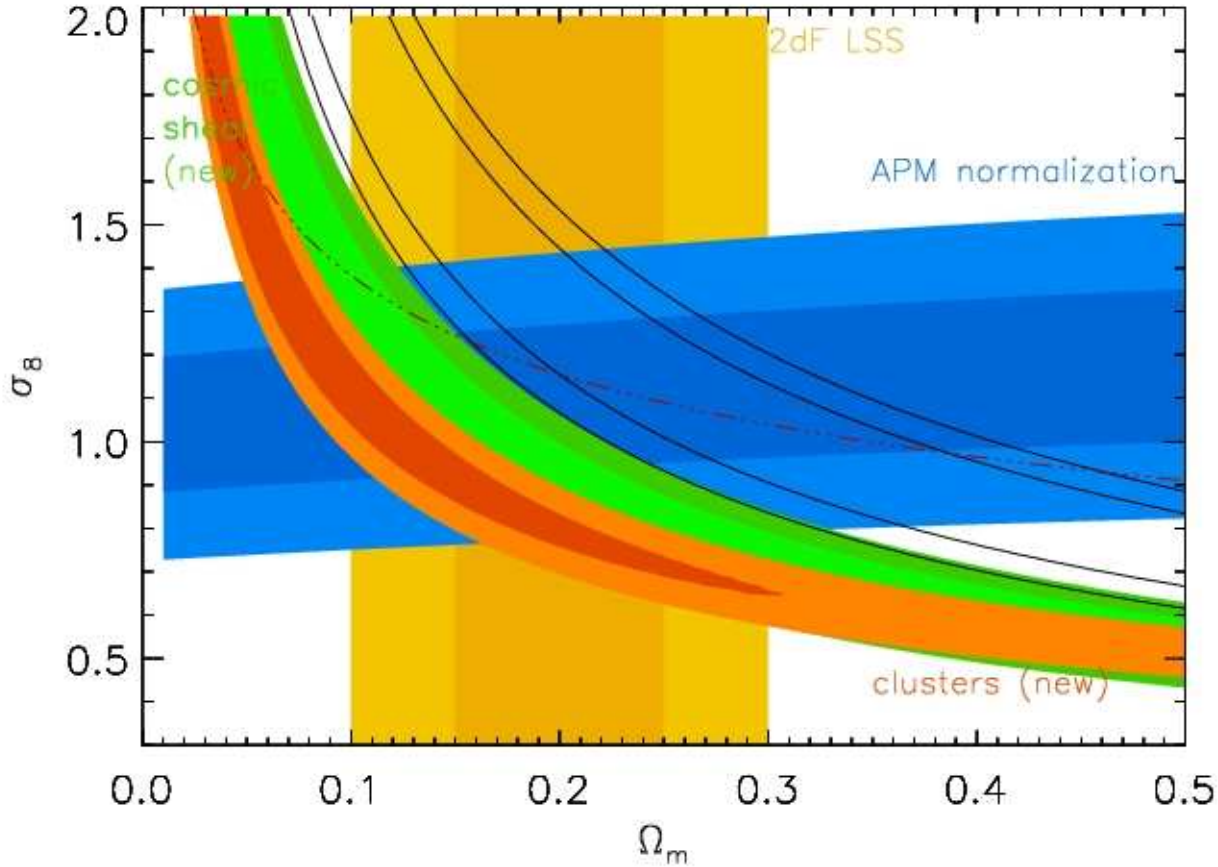
Mass: (temperature, lensing,….)



Weak lensing:

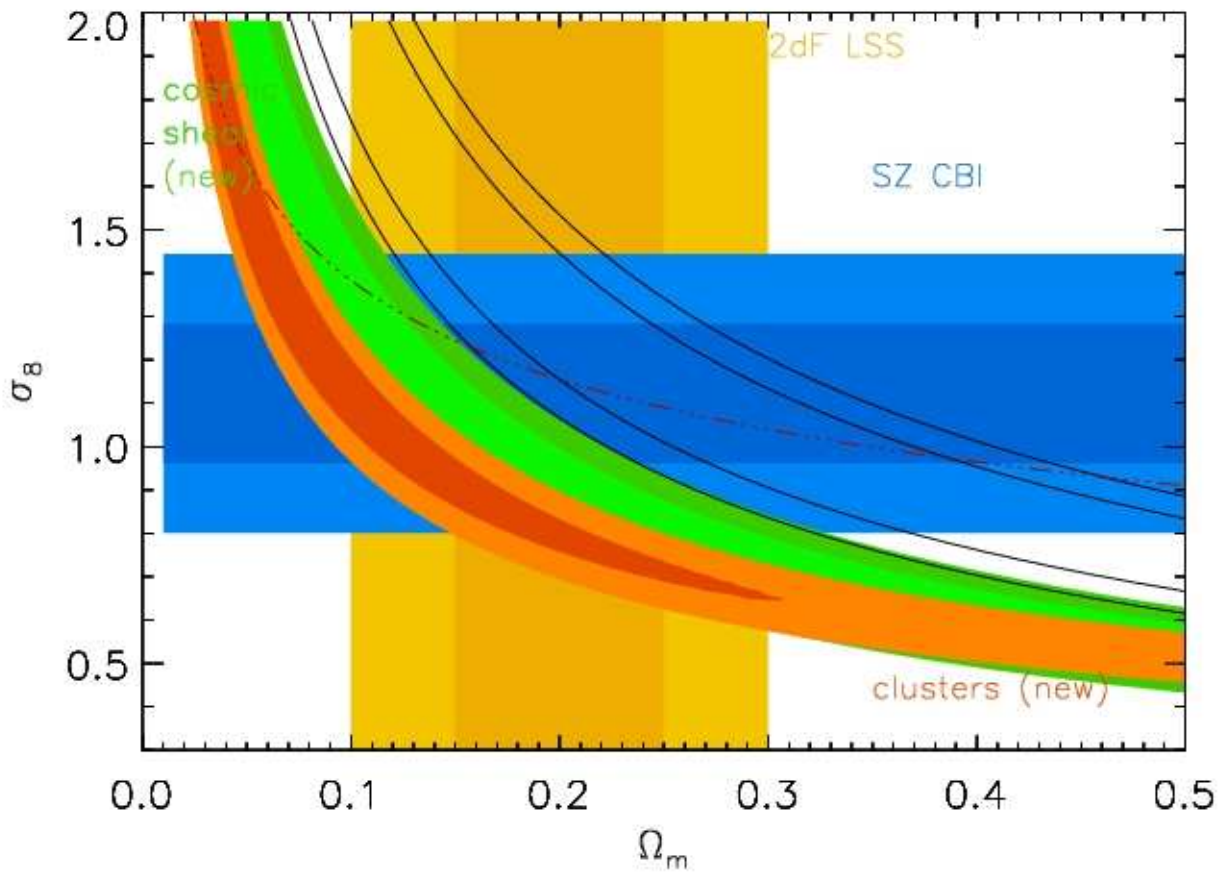
Shear power spectrum

Convolution of P(k) with a kernel



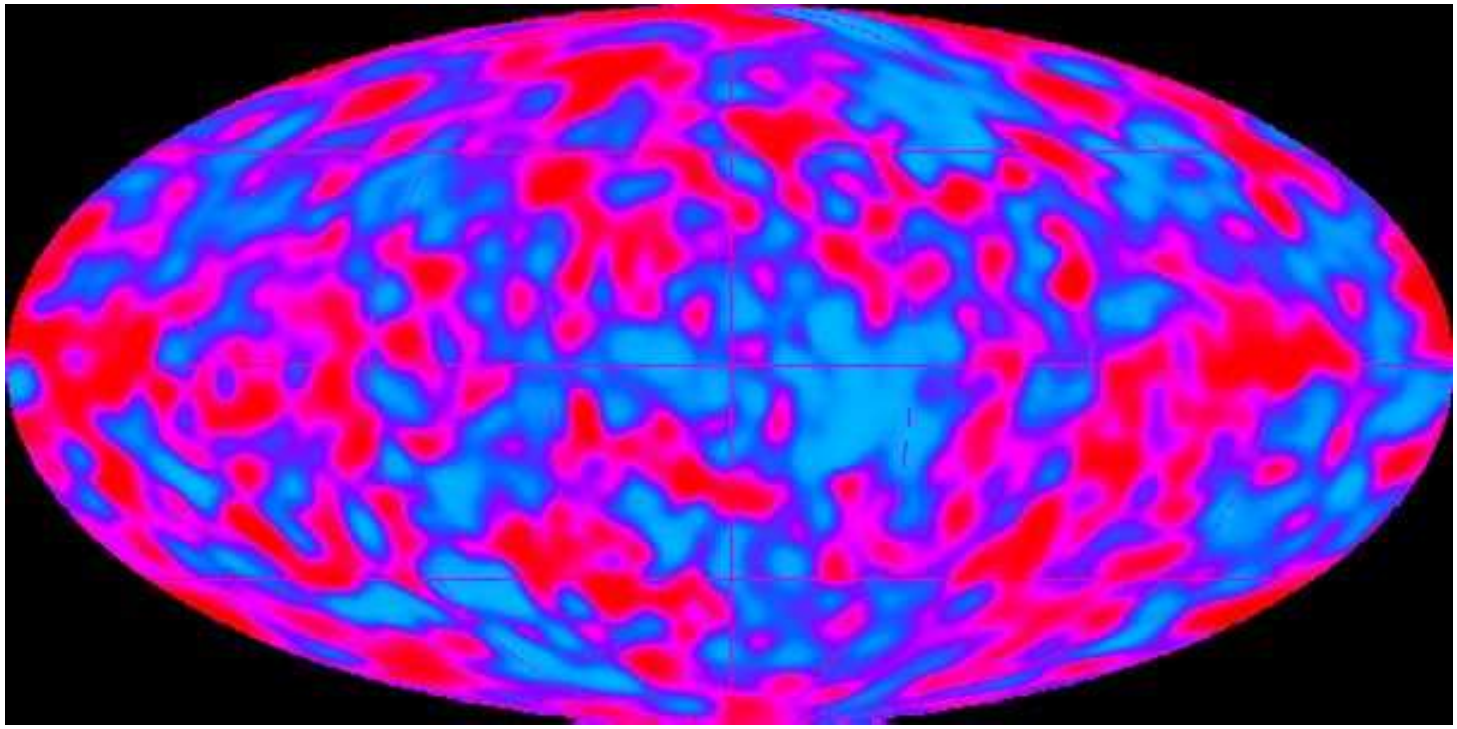
"Old" cluster abundance (Pierpaoli et al)

SZ (?)

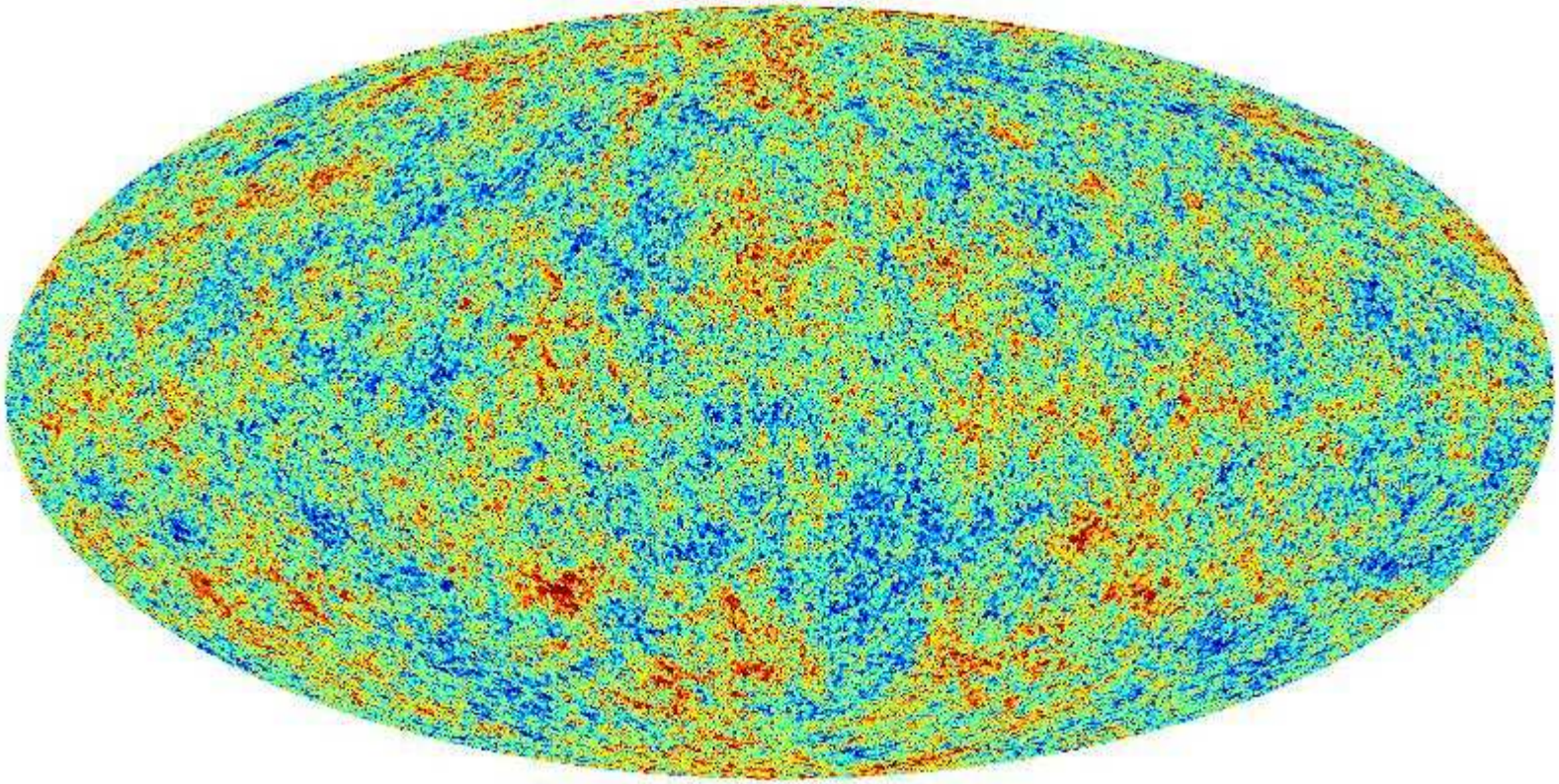


Komatsu & Seljak 2002: $\sim \propto \sigma_8^{\ 7}$

CMB:



COBE: 1992



MAP 2003

http://map.gsfc.nasa.gov/

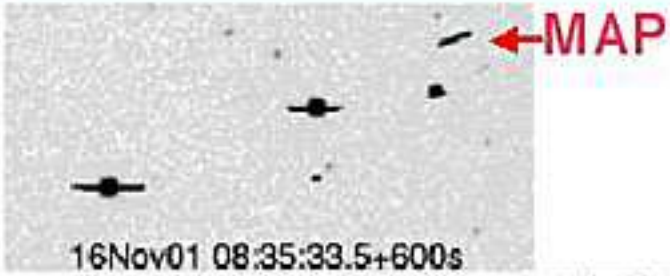
Simulated map

Or Bennett et al. 2003

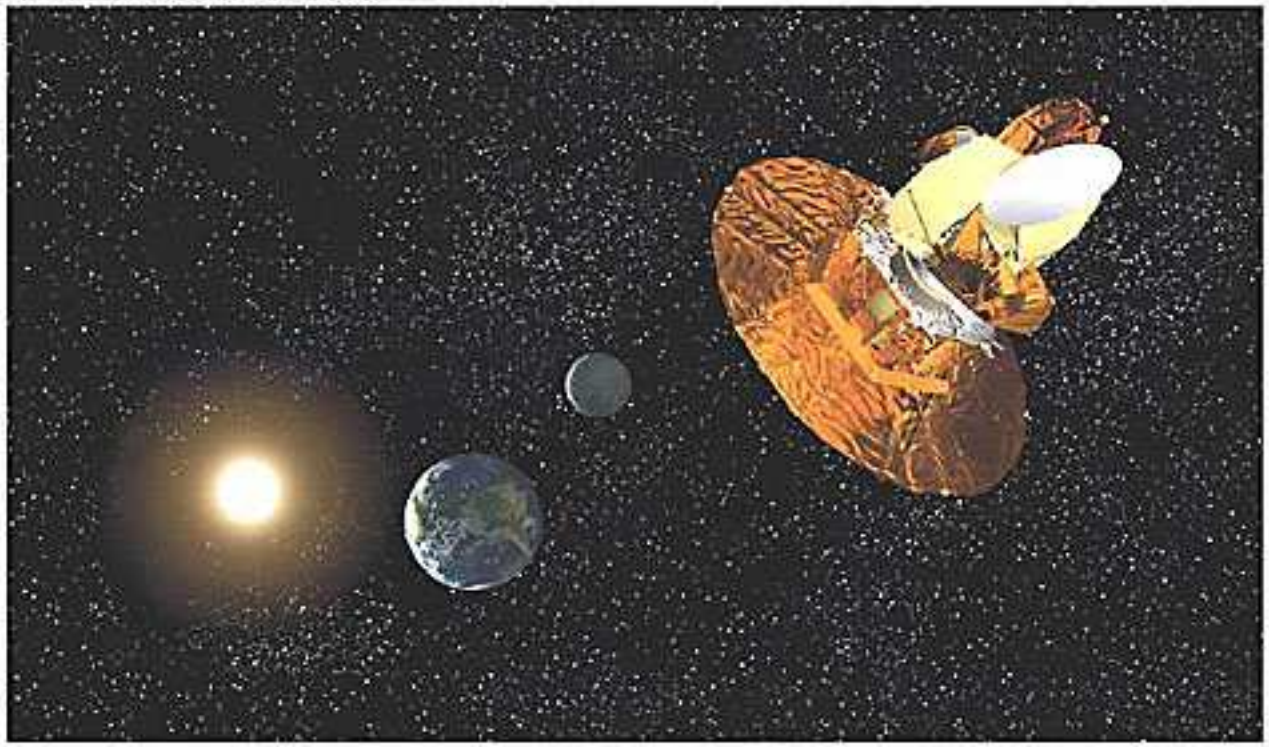
MAP: Picture Perfect Launch

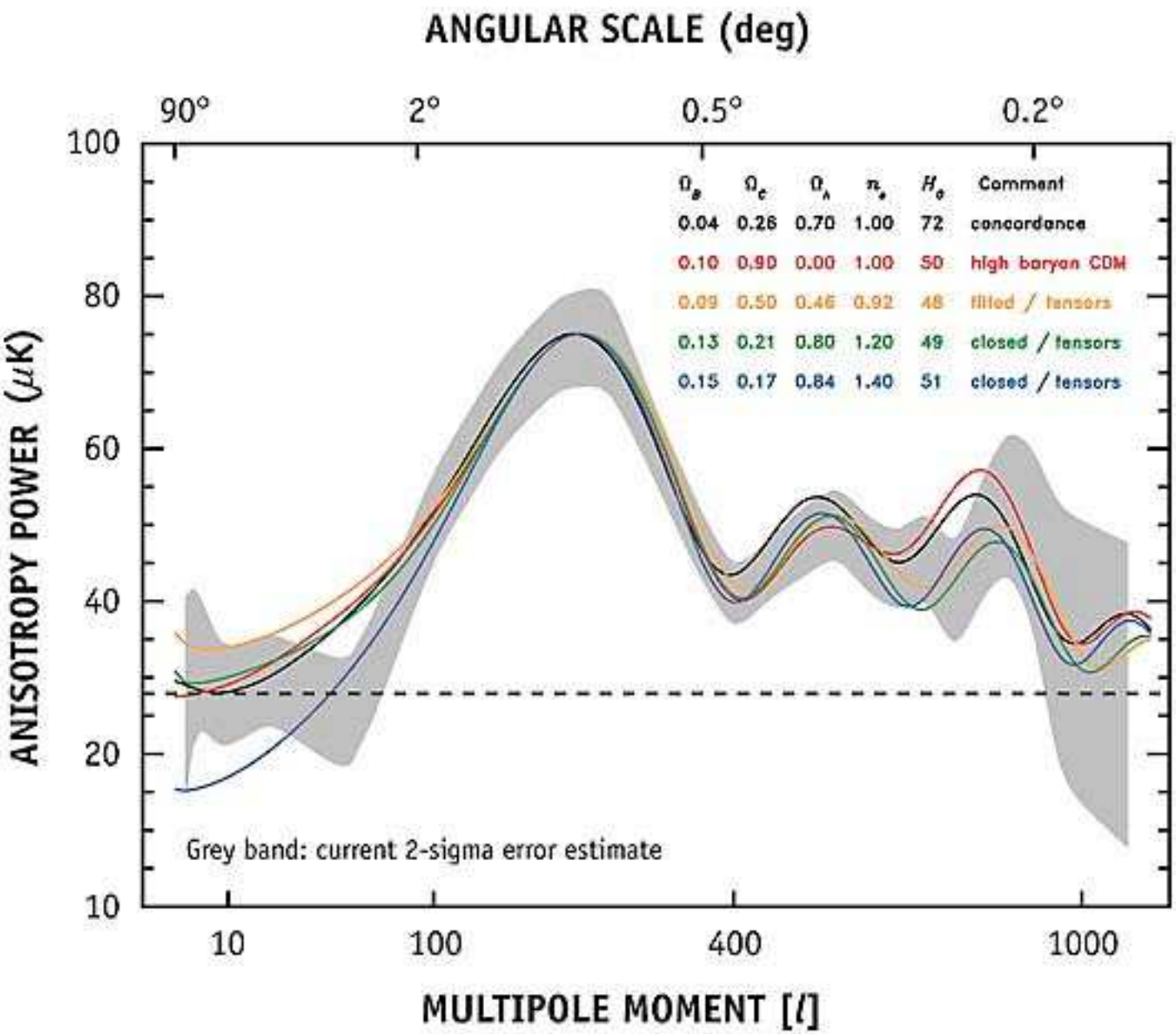
Delta II Model 7425-10
Delta Launch Number 286
Star-48 third stage motor
Cape Canaveral Air Force Station
Pad SLC-17B
June 30, 2001 at 3:47 EDT

Last Photograph of MAP

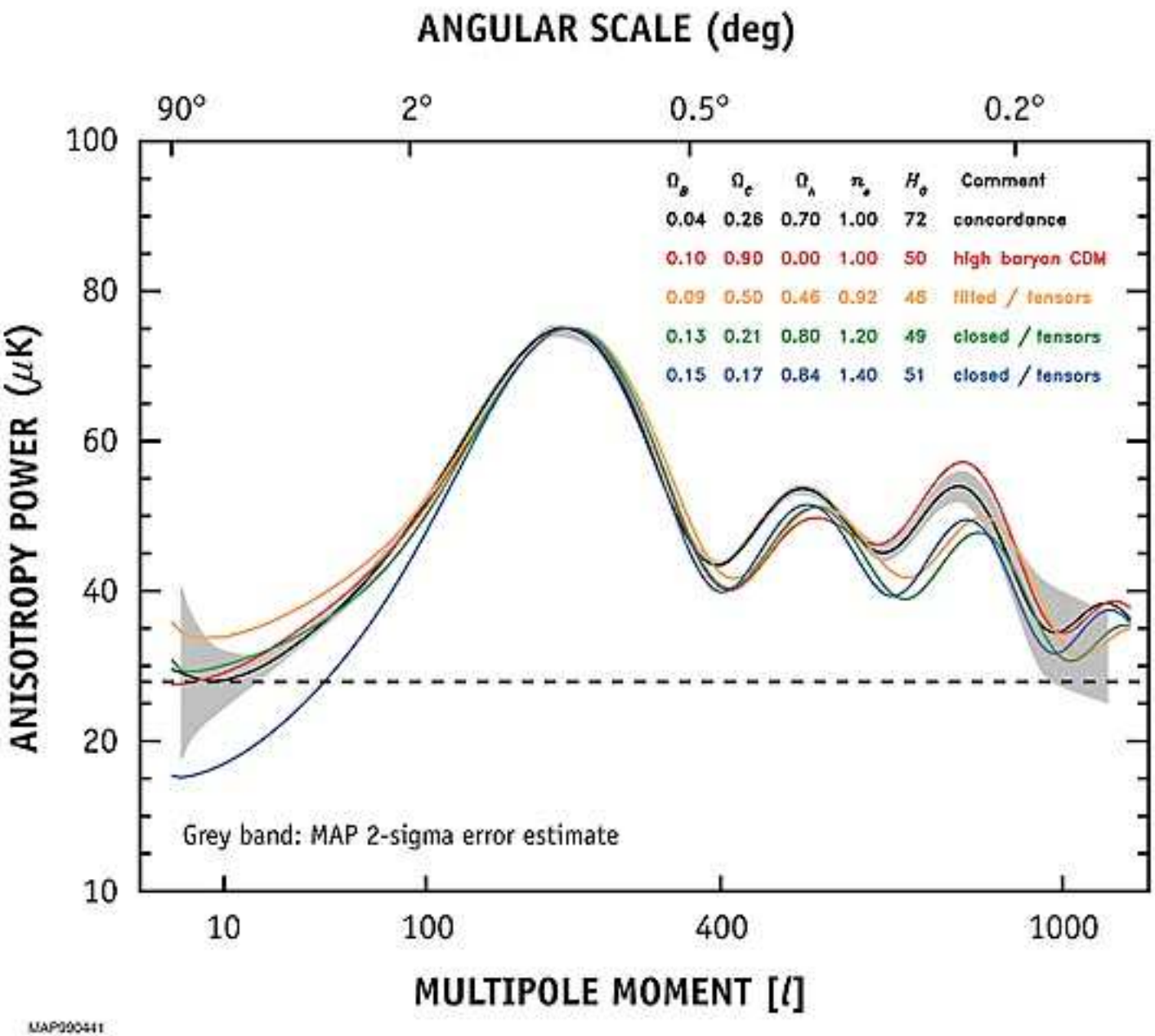


A 10 minute exposure taken with the KPNO 4-meter telescope by Ian Dell'Antonio . North is up and East is to the left in this 115" wide field-of-view. The three bright stars across the middle are, from left to right, 15.19, 15.37, and 17.31 mag.




ANGULAR SCALE (deg)
90°
2°
0.5°
0.2°
100
80
60
40
20
10
ANISOTROPY POWER (μK)
Ω_B Ω_C Ω_Λ n_s H_0 Comment
0.04 0.26 0.70 1.00 72 concordance
0.10 0.90 0.00 1.00 50 high baryon CDM
0.09 0.50 0.46 0.92 48 filled / tensors
0.13 0.21 0.80 1.20 49 closed / tensors
0.15 0.17 0.84 1.40 51 closed / tensors
Grey band: current 2-sigma error estimate
10
100
400
1000
MULTIPOLE MOMENT [l]

MAP990440


ANGULAR SCALE (deg)
90°
2°
0.5°
0.2°
100
80
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20
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ANISOTROPY POWER (μK)
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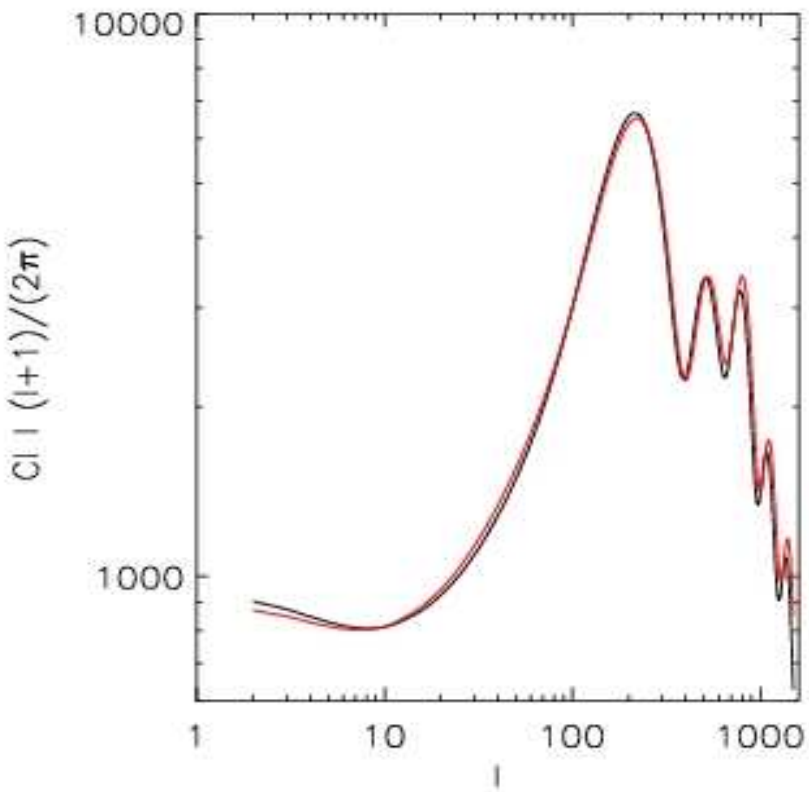
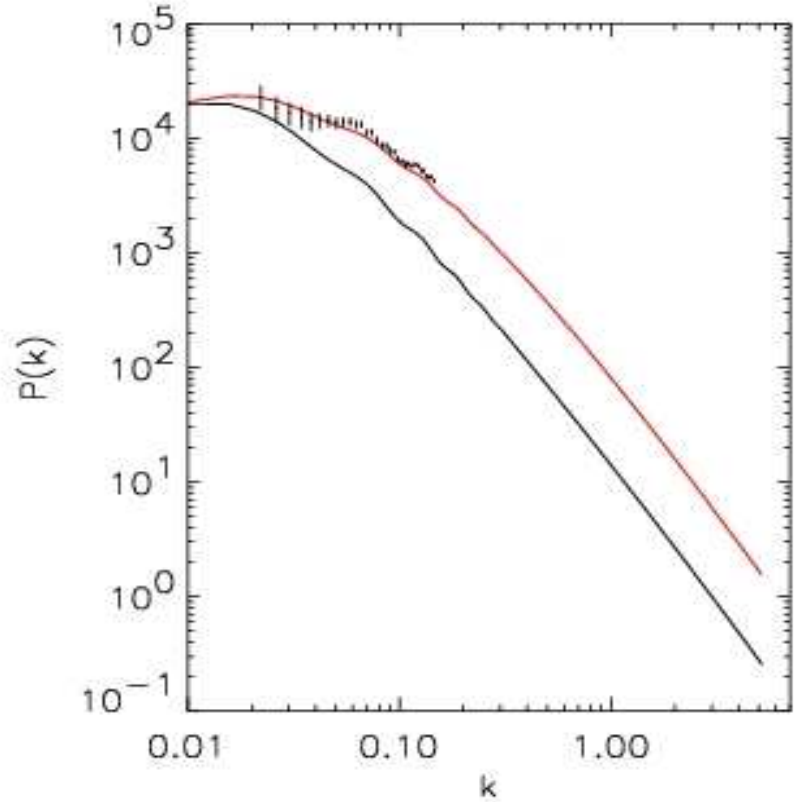
0.13 0.21 0.80 1.20 49 closed / tensors
0.15 0.17 0.84 1.40 51 closed / tensors
Grey band: MAP 2-sigma error estimate
10
100
400
1000
MULTIPOLE MOMENT [l]
MAP990441

Neutrinos effects:



Almost no effect



Big effect esp. in amplitude

Need to know the bias

$f_\nu=0.17$ $f_\nu=0$

How?

Joint likelihood analysis (possible thanks to CMBFAST)

- Brute force: e.g. 11 or more parameters, grid….
  …..too long
- Speed ups tricks (e.g. Tegmark, Zaldarriaga, Hamilton ’00)
- Semi-analytic tricks (e.g. Kosowsky, Milosavljevich, Jimenez ‘02)
- Fisher matrix approach
- Markov Chain Monte Carlo
  (e.g. Christensen et al. 98, Lewis & Bridle ’02)

conclusions

Do not forget about model (cosmology) uncertainties

LSS is not just 2dF and SDSS galaxy P(k)

Beware of bias(es)

Computationally expensive (good value for money)

Extremely powerful way to: lift degeneracy,
check consistency and assumptions

You will have results and numbers after MAP data release