# Weak Lensing by Large-scale Structure

## Results from the CFHT Legacy Survey

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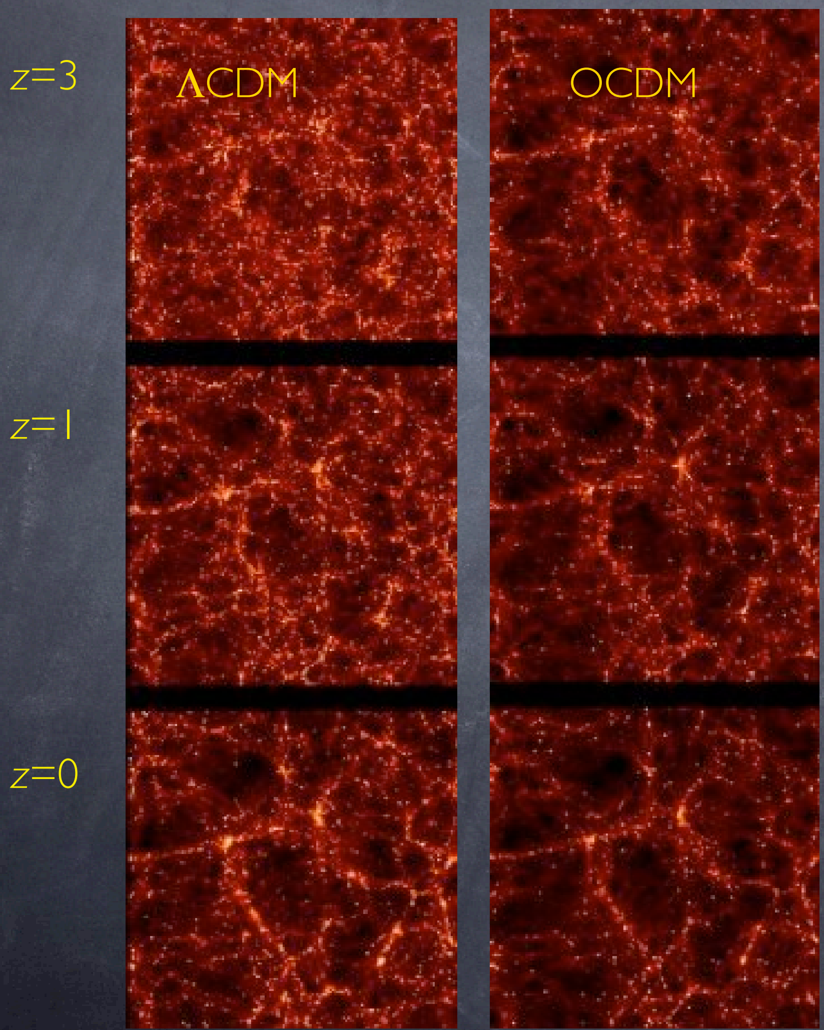
# Spot the difference...



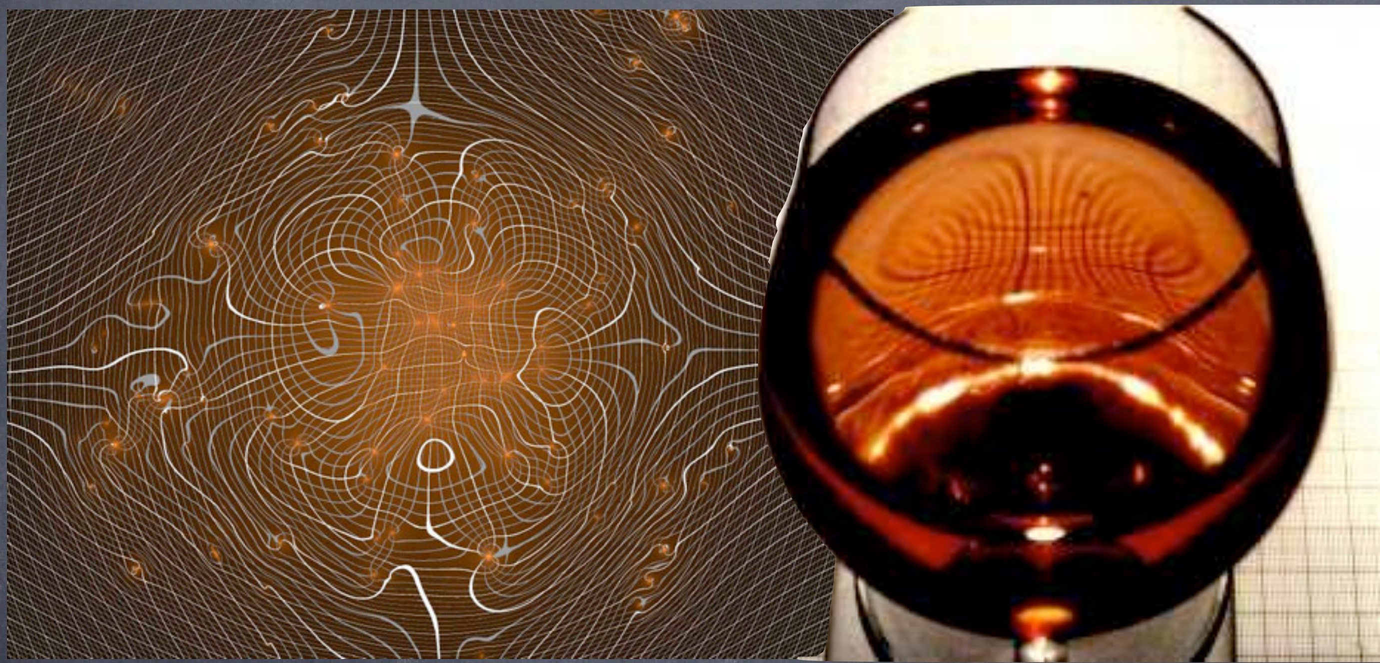

**Different values for cosmological parameters lead to a different distribution of (dark) matter and a different evolution.**

The clustering properties of matter as a function of scale and redshift can be used as a tool to measure the cosmology!

## But... how to measure this?

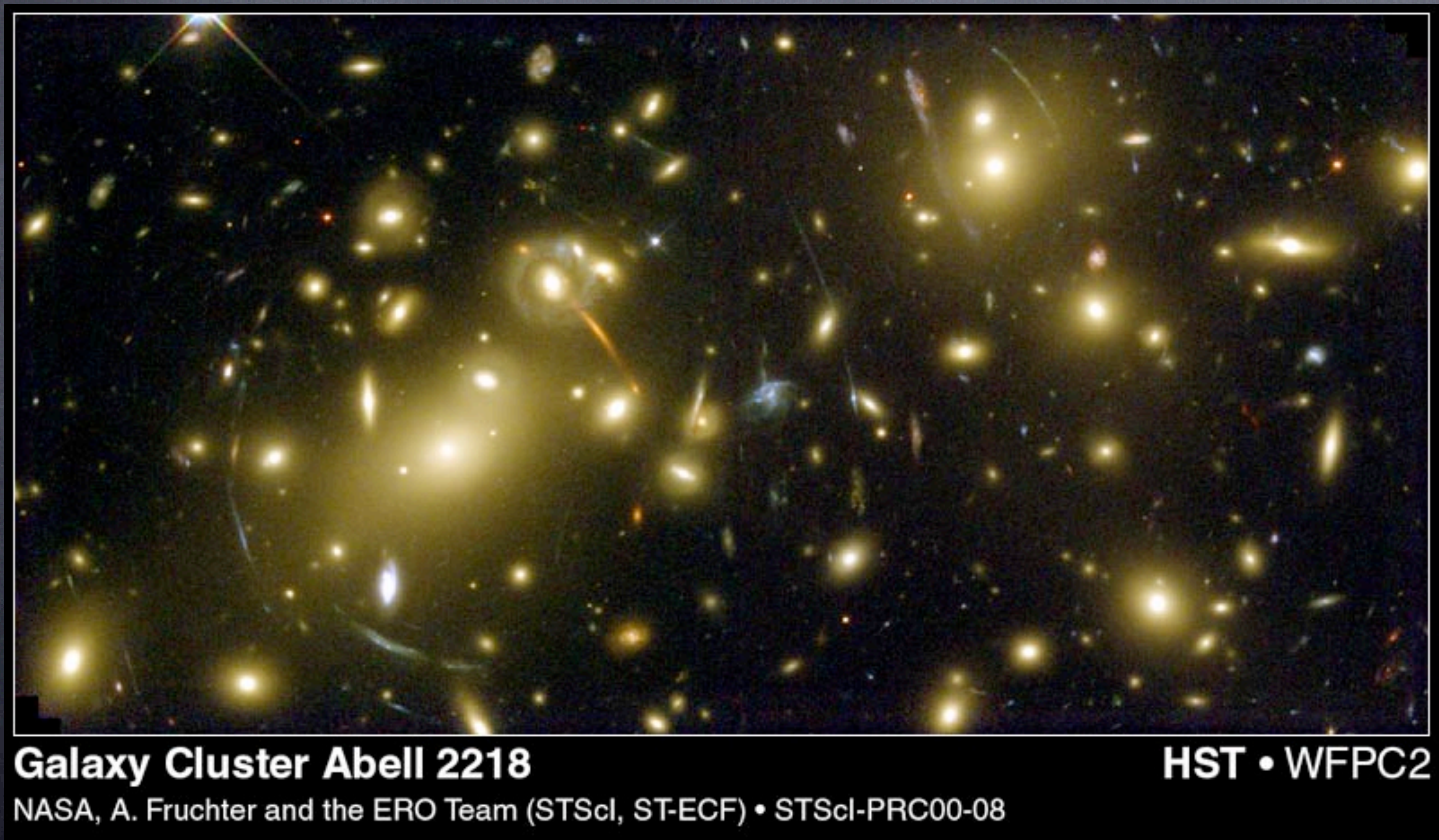
Kauffmann et al.

# Gravitational lensing



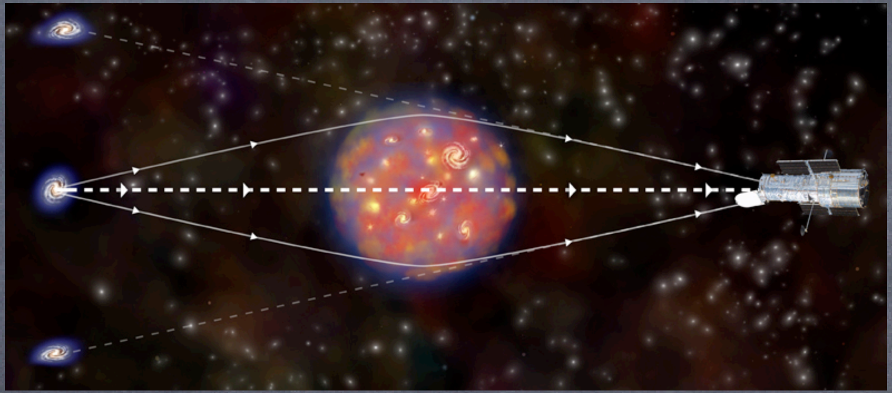
Inhomogeneities in the mass distribution distort the paths of light rays, resulting in a remapping of the sky. This can lead to spectacular lensing examples…

# Gravitational lensing



# Gravitational lensing

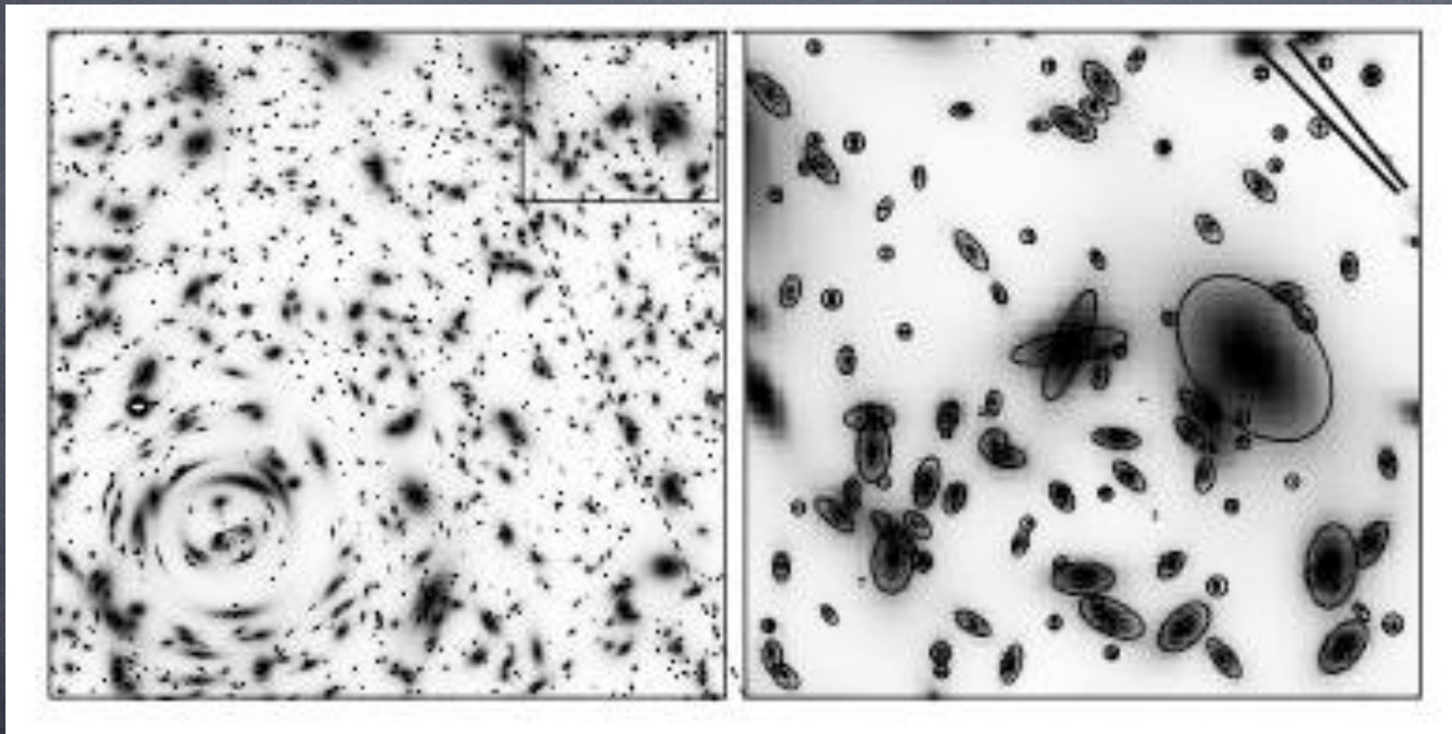
Strong gravitational lensing requires a good alignment of the source and the lens. This doesn't happen often...



The light rays of all objects are perturbed, but the effect is usually just too subtle to see:

- an (unknown) shift in position
- a small distortion of the shapes of the galaxies

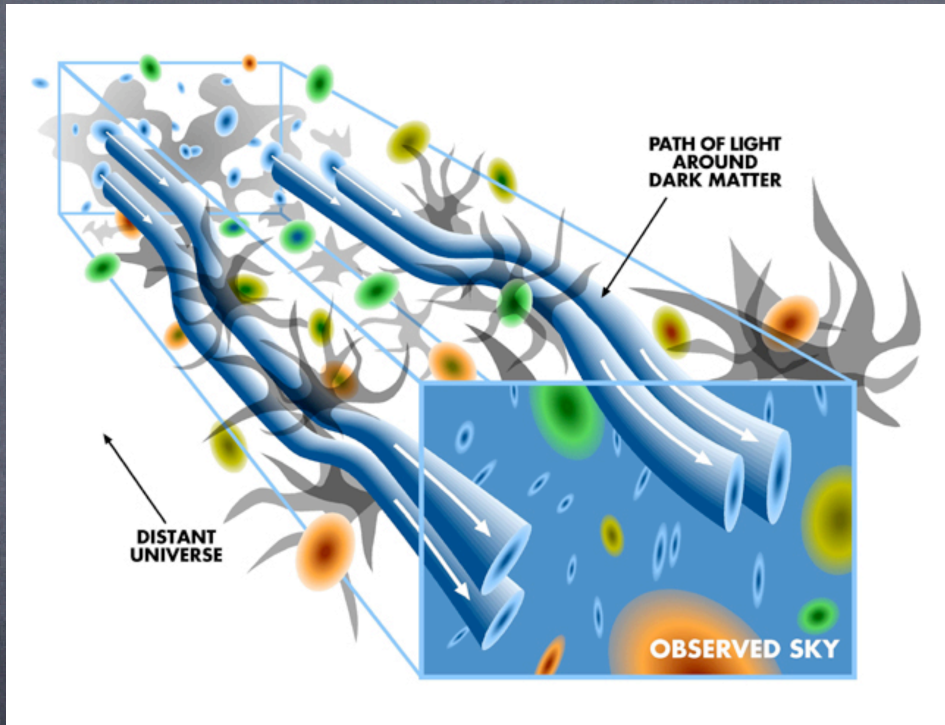
# Weak gravitational lensing



A measurement of the ellipticity of a galaxy provides an unbiased but noisy measurement of the shear, which can be related to the projected density distribution.

# Cosmic shear is everywhere

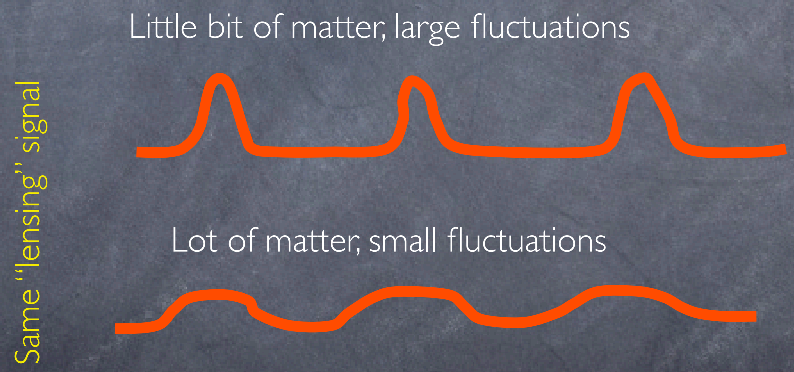
Credit: Tyson et al. (2000)




Cosmic shear is the lensing of distant galaxies by the overall distribution of matter in the universe: it is the most "common" lensing phenomenon.

# What does the signal mean?

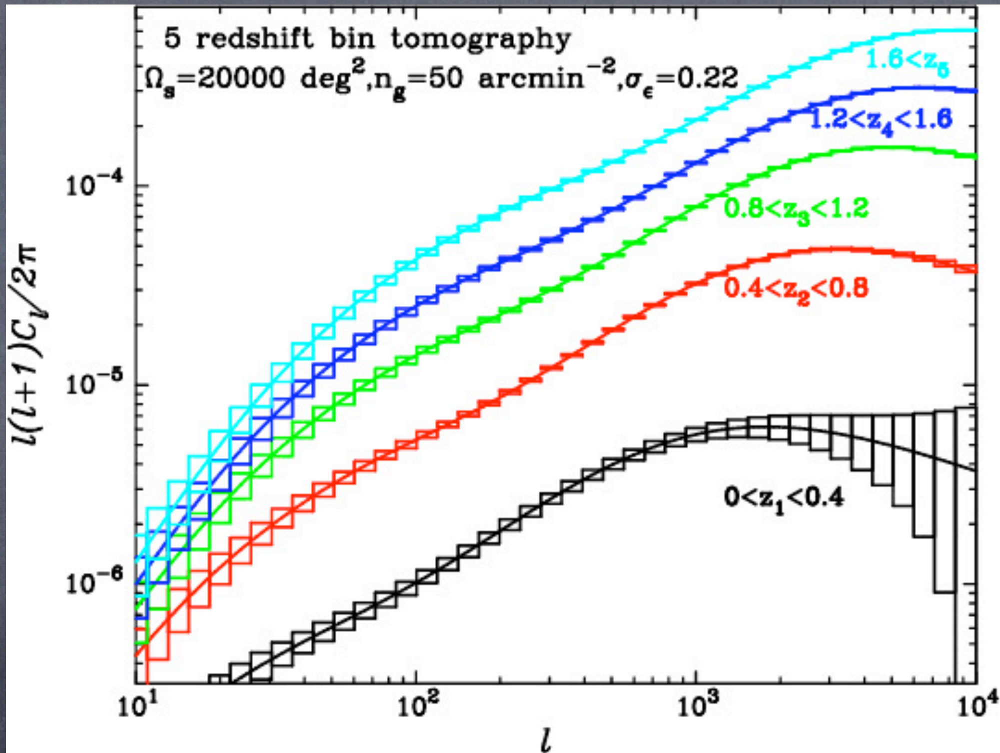
The cosmic shear signal is effectively a measurement of the variance of density fluctuations (as a function of scale).




To first order lensing measures a combination of the amount of matter $\Omega_m$ and the normalisation of the power spectrum $\sigma_8$.

# What does the signal mean?

Lensing Power Spectrum




We can break this degeneracy by measuring the lensing signal as a function of source redshift.

# What do we need to do?

We only need to measure :

- shapes
- redshifts

The background (or source) galaxies are typically very faint and spectroscopic redshifts cannot be obtained. Even determining photometric redshifts can be difficult.

# Systematics

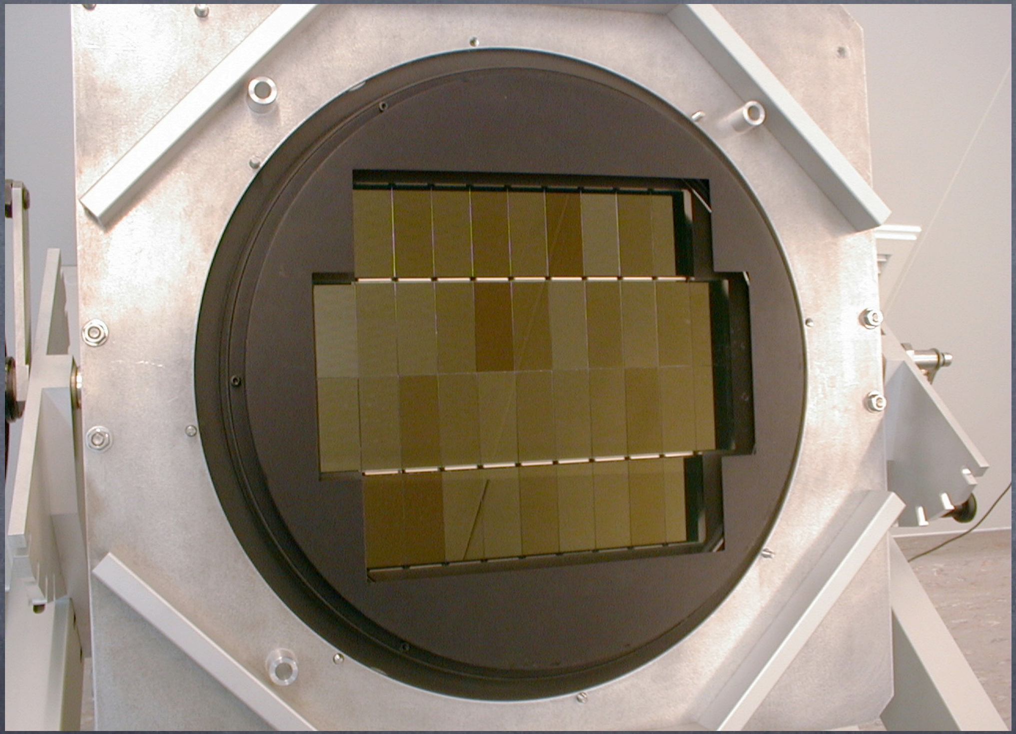
The observational distortions are typically larger than the lensing signal.

The observed shapes of galaxies need to be corrected for

- PSF anisotropy
- Circularisation by seeing

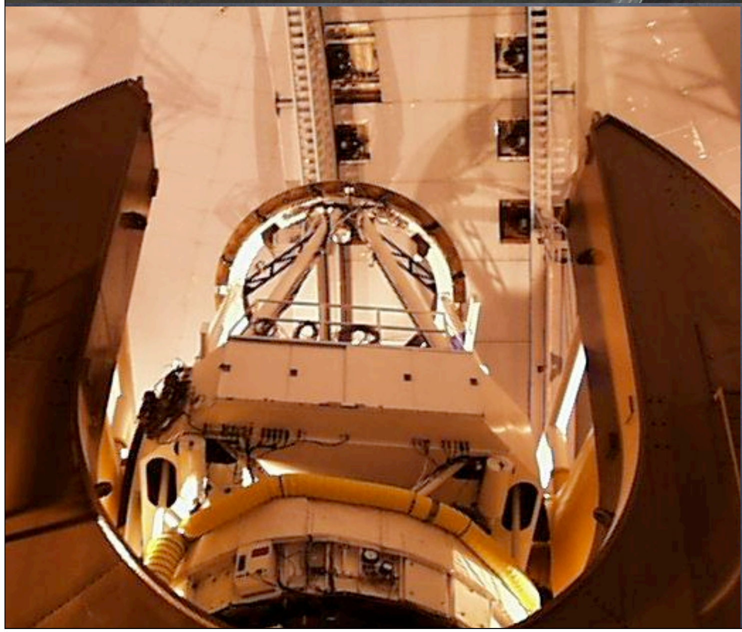
Various correction techniques have been developed and tested extensively. In particular the Kaiser et al. (1995) approach is widely used. This method works fine for current data sets, but we need improved methods for upcoming large surveys.

# Build a big camera ...



**Megacam:**
- ❑ 1 square degree field of view
- ❑ ~350 megapixels

# ... put it on a good telescope ...



Such as the CFHT

or VST, LSST, JDEM/IDECS, etc

# ... and take a lot of data

CFHT:

CFHTLS
RCS2
CCCP
MENeaCS

VST:

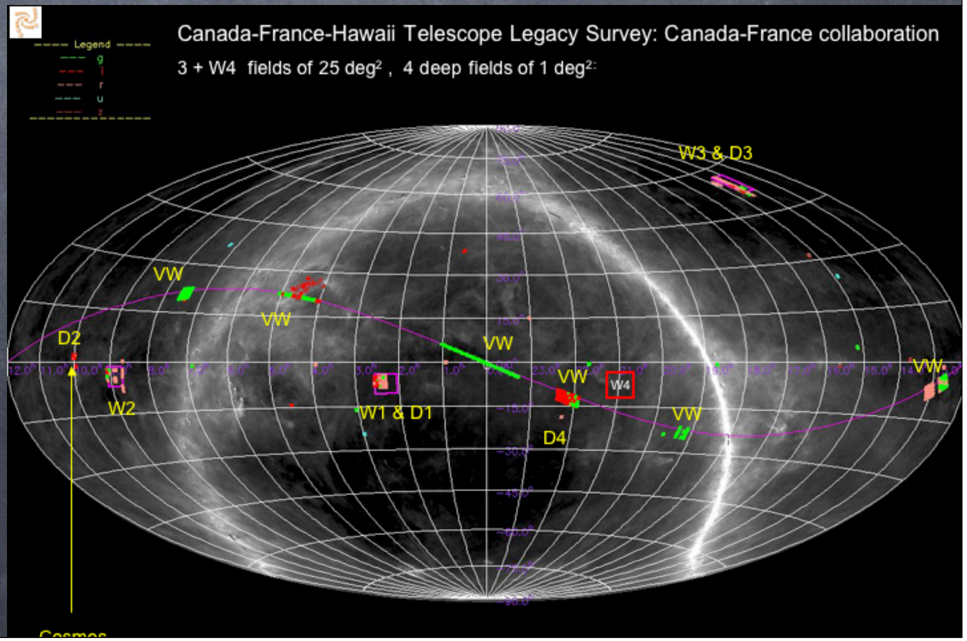
KIDS

# CFHT Legacy Survey

The Canada-France-Hawaii Telescope Legacy Survey is a five year project, with three major components. Observations were completed in the 2008B semester.

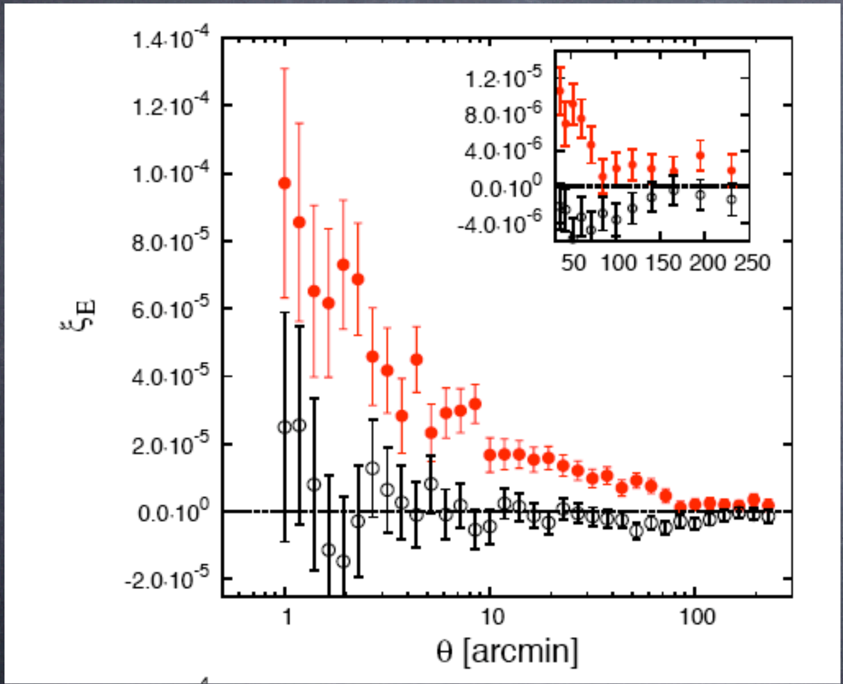
## The Wide Survey focuses on weak lensing.

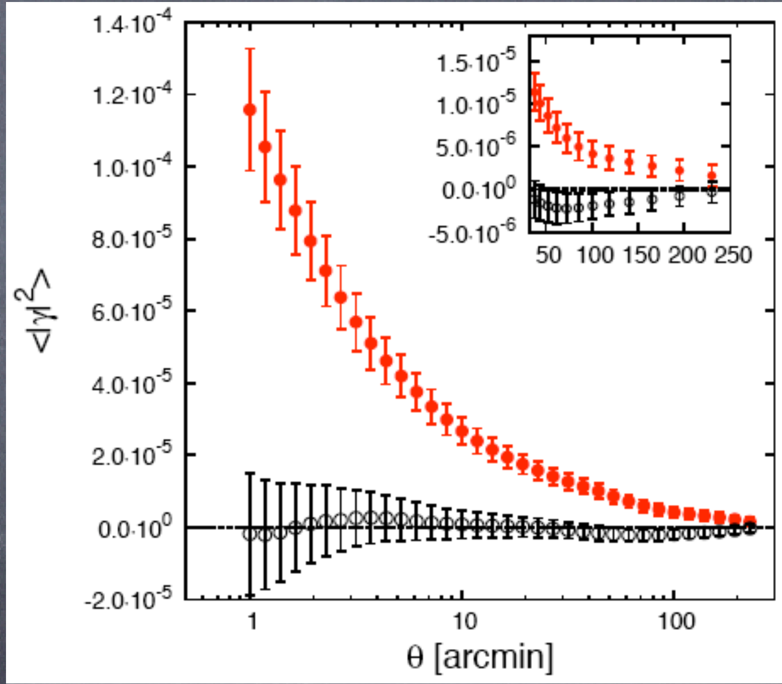
- ~140 square degrees
- 4 fields
- 5 filters (u,g,r,i,z')
- i<24.5



# CFHTLS: recent results

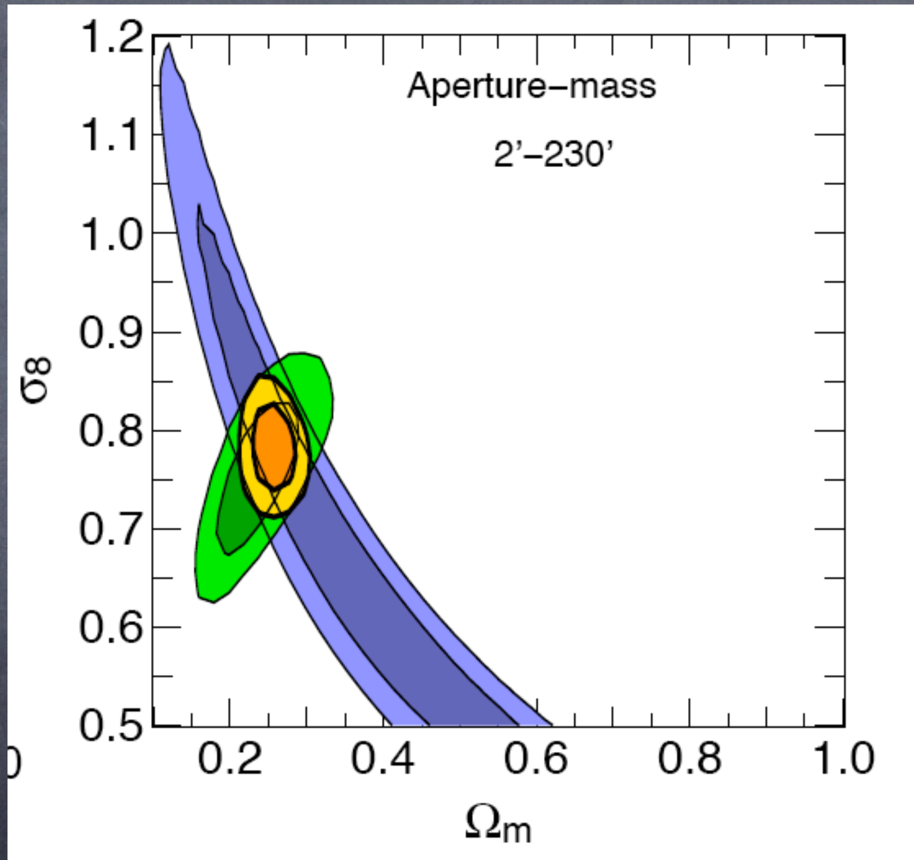
## Measurements out to 4 degree scales!



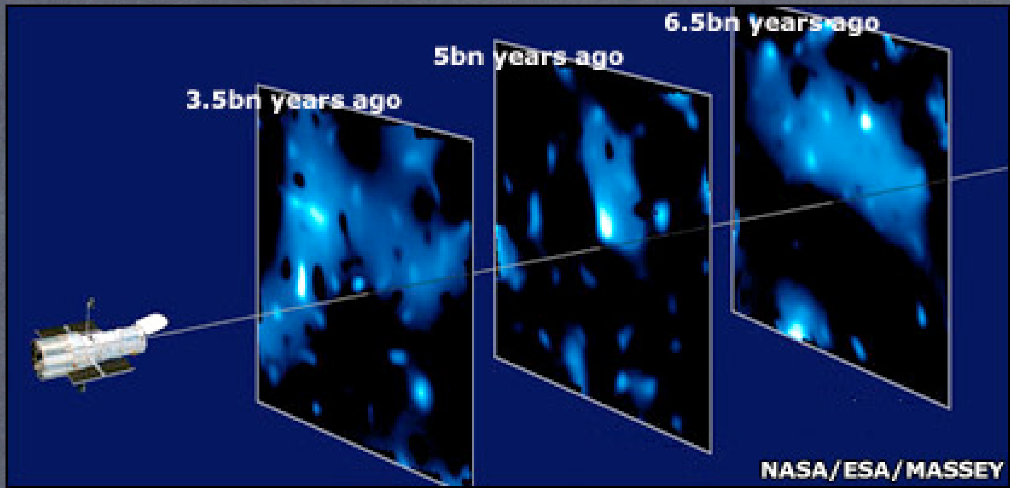

The latest results, based on the analysis of 57 sq. deg. spread over 3 fields have recently been published in Fu et al. (2008)

# CFHTLS: recent results




Results agree well with WMAP3 (and WMAP5…)

# CFHTLS: what is next?




Currently ~140 sq. deg. of data have the full *ugriz* coverage and photometric redshift are being determined.

With photometric redshift information for the sources we can study the growth of structure, which significantly improves the sensitivity to cosmological parameters.

# CFHTLS: the team

To reach the wide range of goals of the CFHTLS requires a substantial team of scientists.

Netherlands:

**Henk Hoekstra**

Tim Schrabback

Hendrik Hildebrandt

Konrad Kuijken

Malin Velander

Edo van Uitert

Merijn Smit

Canada:

**Ludo van Waerbeke**

Jon Benjamin

Sanaz Vafaei

Martha Milkeraitis

**Mike Hudson**

Bryan Gillis

France:

**Yannick Mellier**

Barney Rowe

Jean Coupon

Christopher Bonnet

Raphael Gavazzi

United Kingdom:

**Catherine Heymans**

Tom Kitching

Lance Miller

Emma Grocutt

Germany:

Thomas Erben

**Elisabetta Semboloni**

Karianne Holhjem

Italy:

**Liping Fu**

# Conclusions

The CFHTLS lensing project is progressing well and is producing competitive cosmological results, but it is work in progress.

To achieve the full potential of weak gravitational lensing a number of issues remain...

**...but no show-stopper has been found!**