COSMOS
(cosmic evolution survey)

Richard Massey

with

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The view from Hubble

Hubble Space Telescope data

N. Scoville et al. (ApJ 2007)

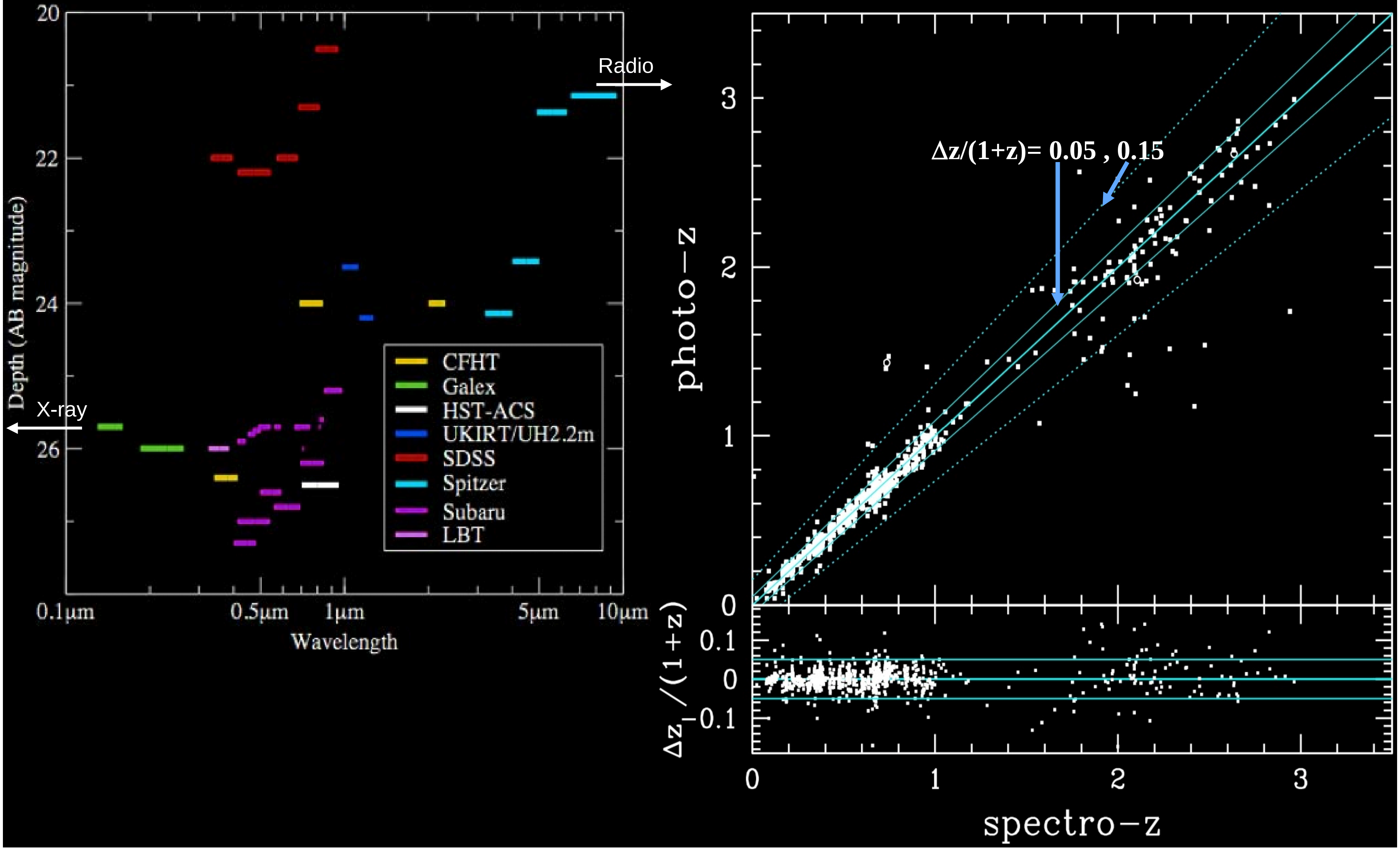
Largest ever HST survey

- 577 contiguous ACS pointings
- 1.6 square degrees in I_{F814W} band (V_{SDSS} at z=1)
- Depth I_{F814W}<26.6 (at 5)
- 2 million galaxies
- ~80 resolved galaxies/arcmin^2

http://irsa.ipac.caltech.edu/Missions/cosmos.html

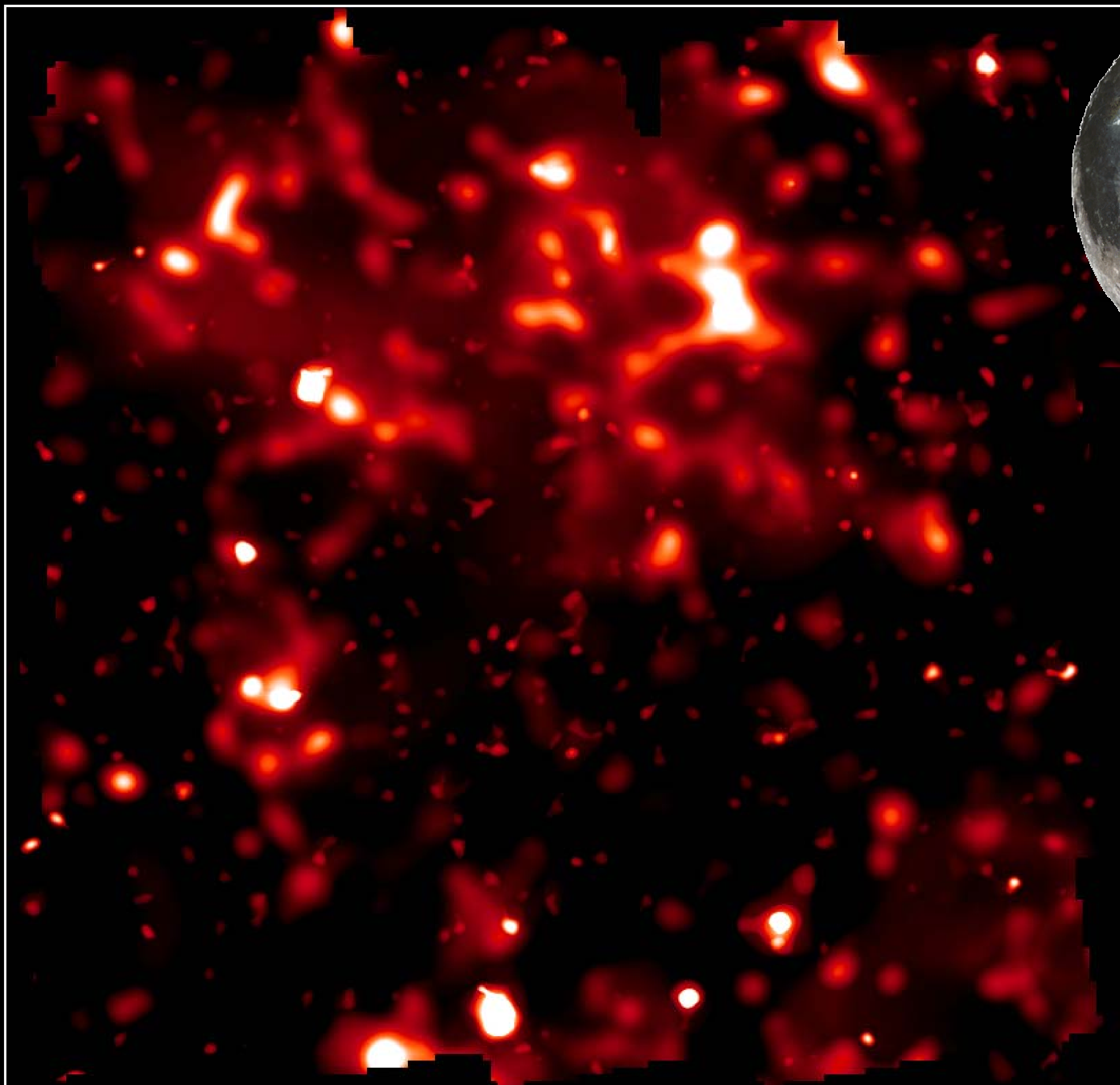
Multicolour followup of COSMOS field

P. Capak et al. (ApJ 2007), B. Mobasher et al. (ApJ 2007)



Large-scale distribution of baryonic material

N. Scoville et al. (ApJ 2007)



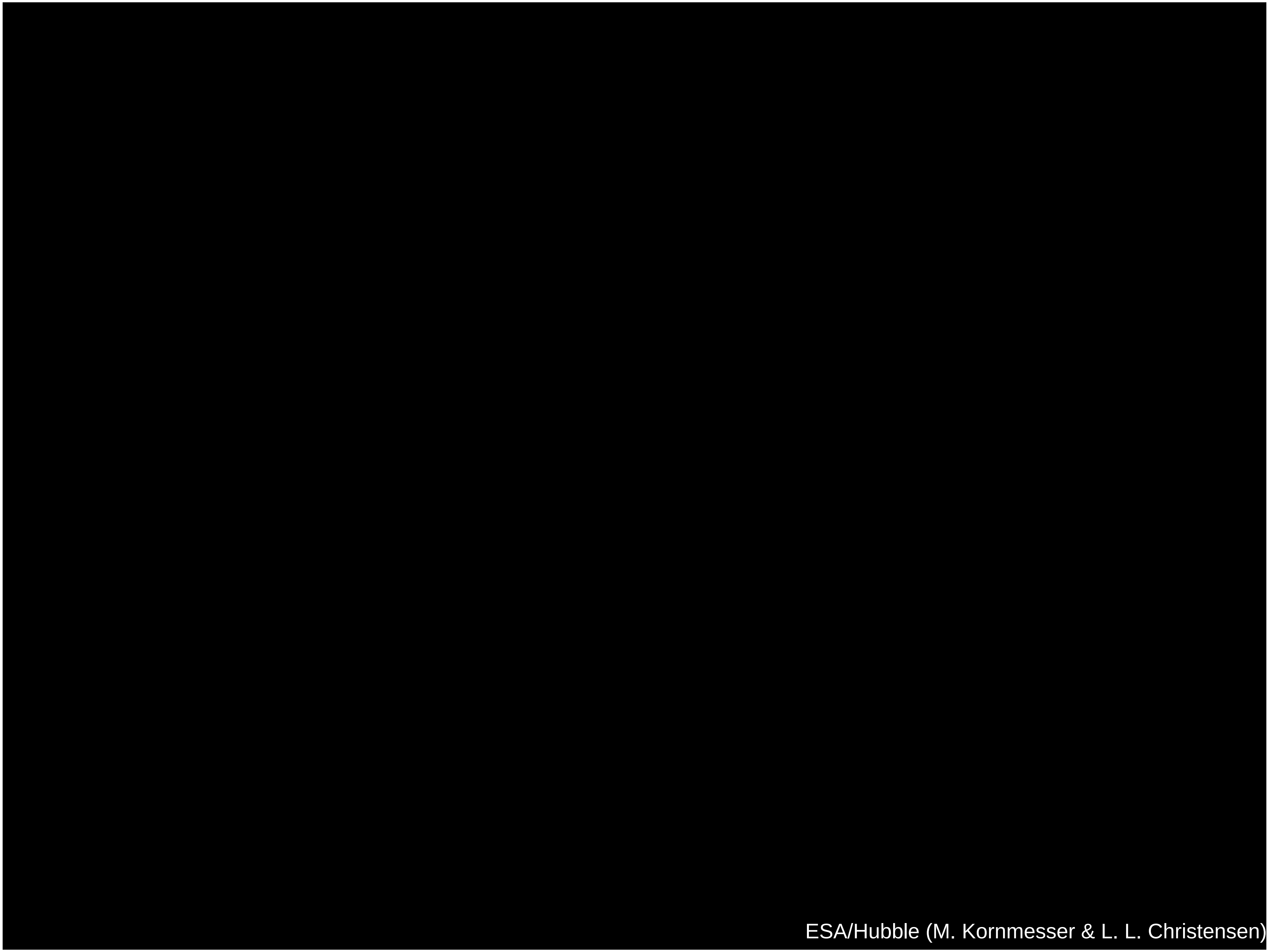
Large-scale distribution of baryonic material

Galaxy number density

Weighted by stellar mass

-scale distribution of baryonic material

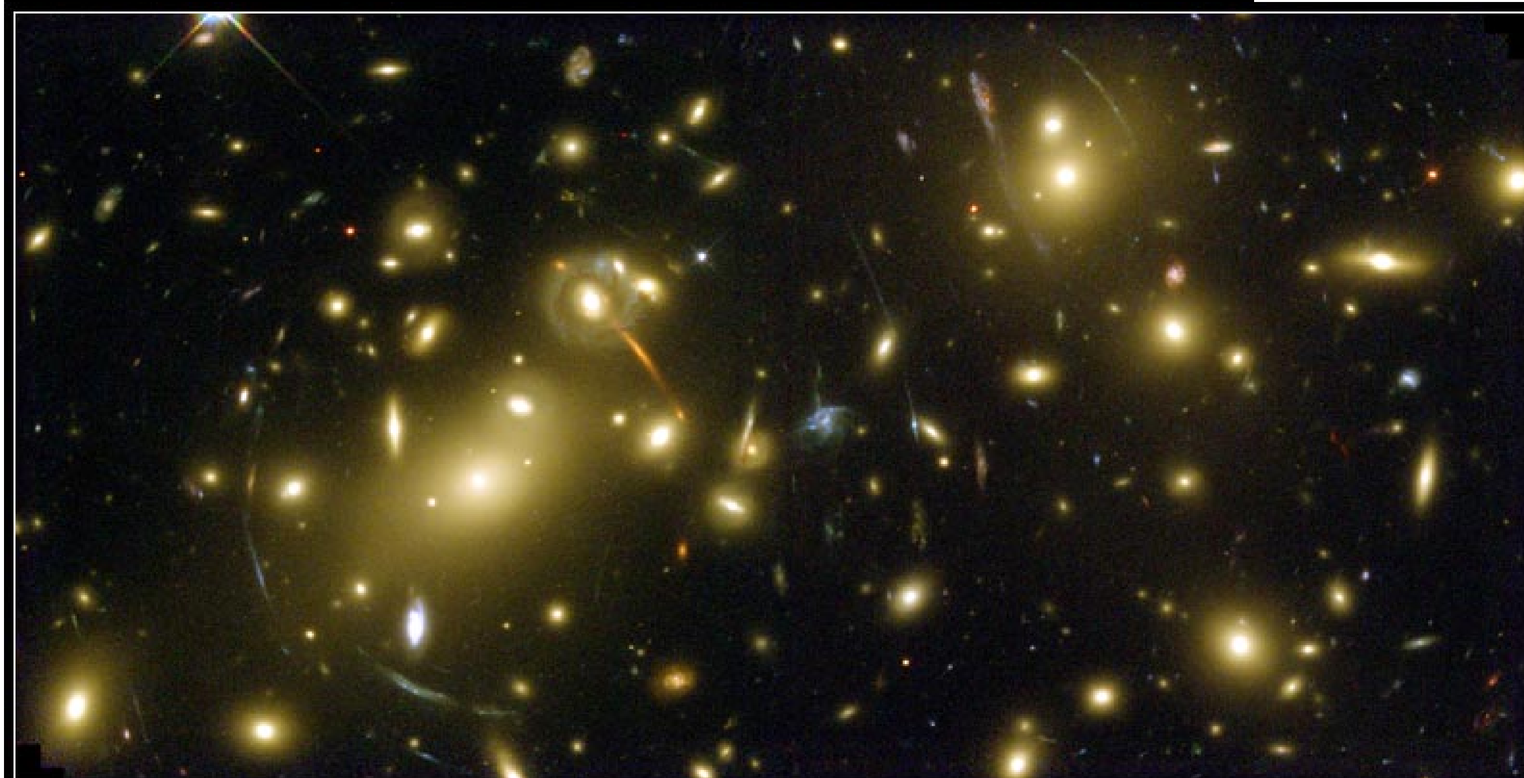
Nick Scoville



ESA/Hubble (M. Kornmesser & L. L. Christensen)

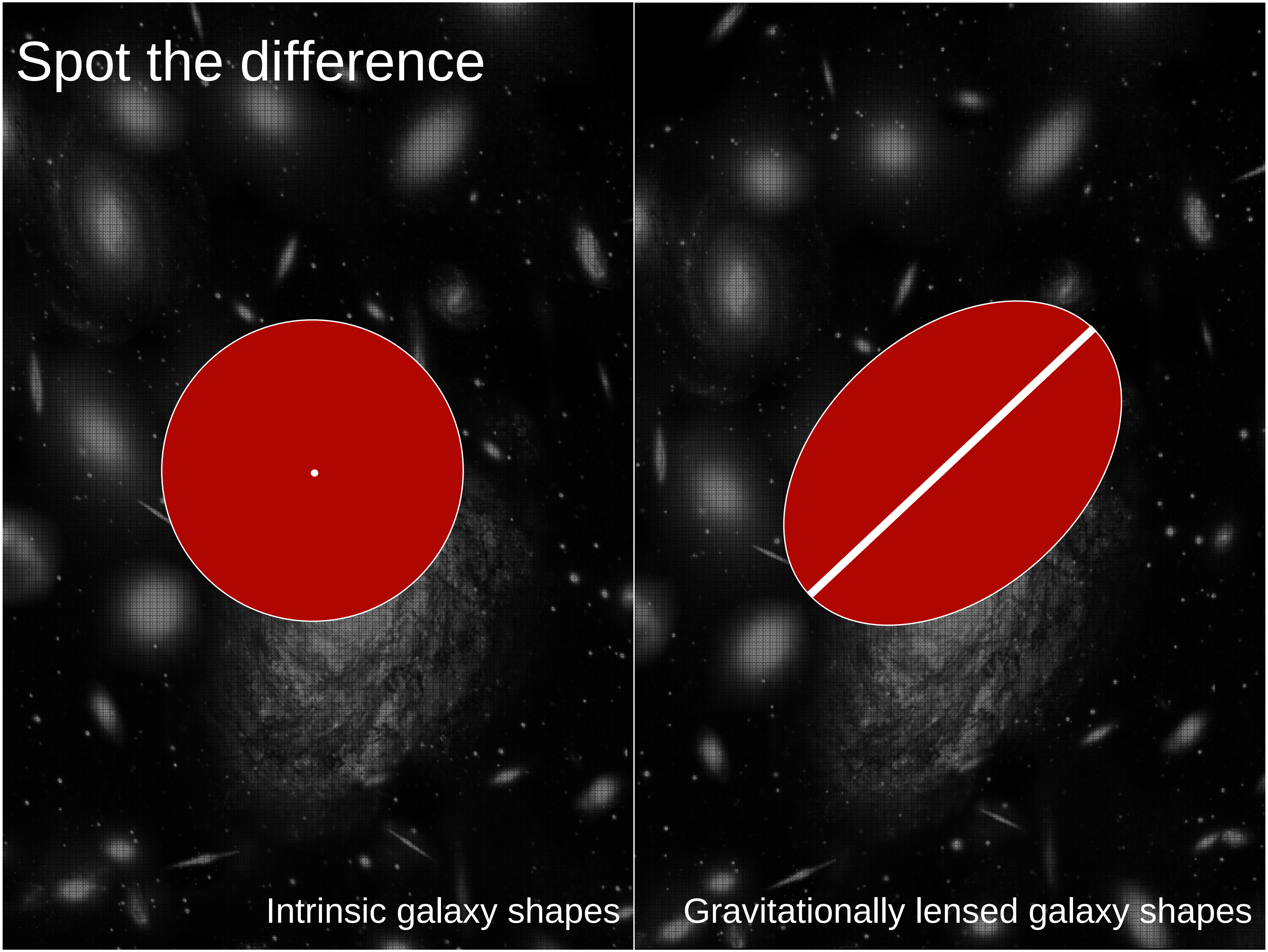
Strong lensing

NASA and A. Fruchter (STScI)

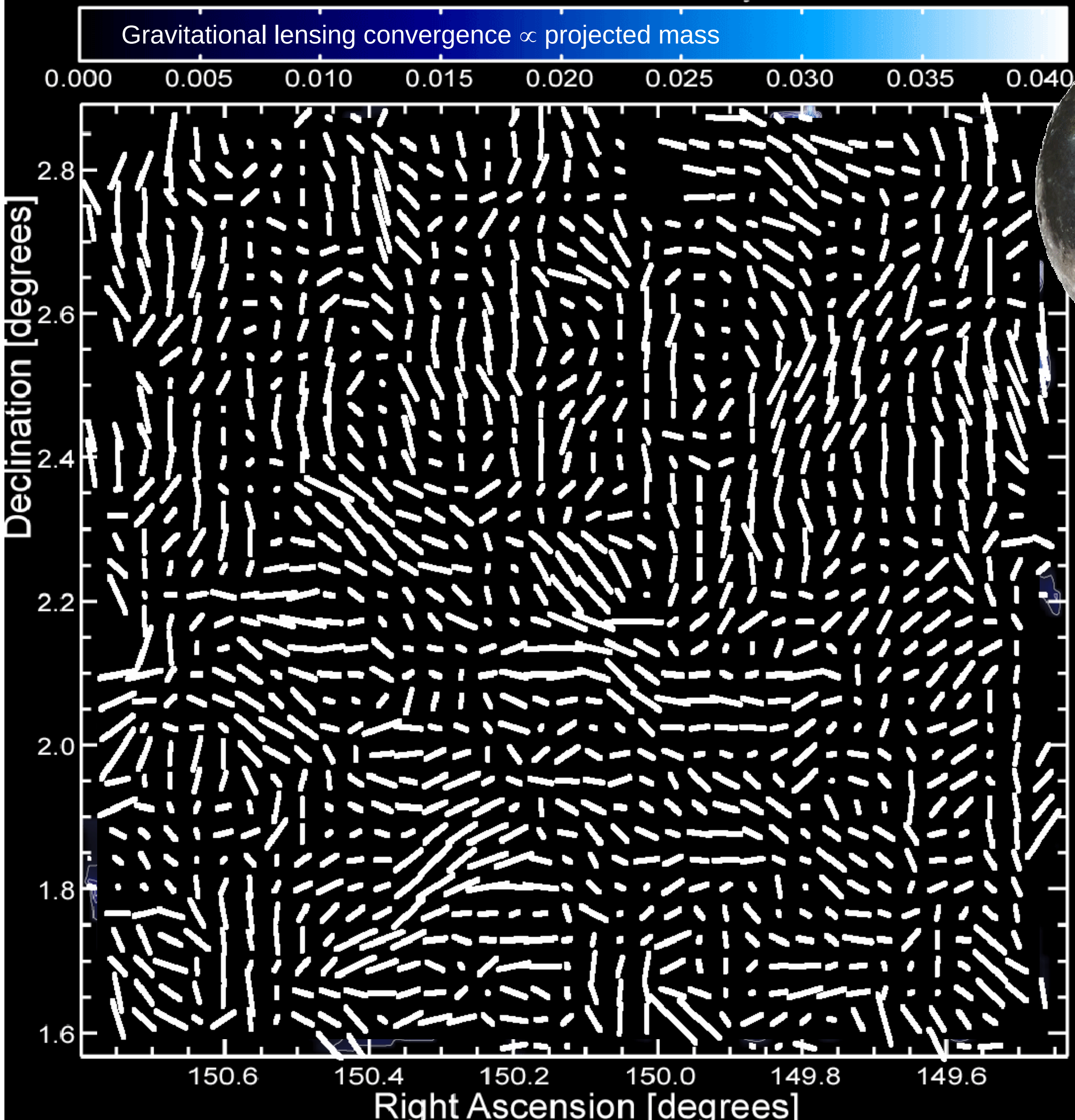


Galaxy Cluster Abell 2218 **HST** • WFPC2

NASA, A. Fruchter and the ERO Team (STScI) • STScI-PRC00-08

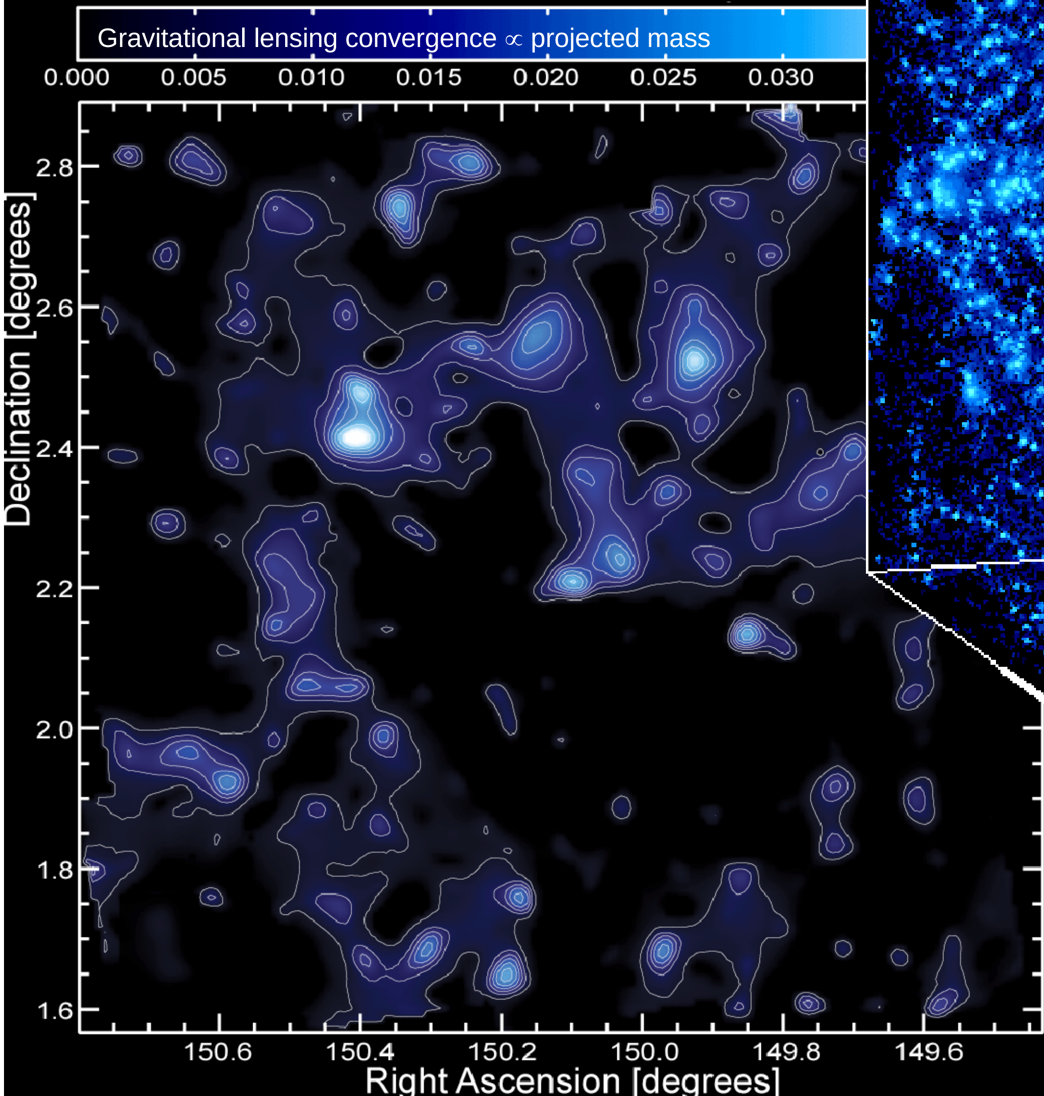

Spot the difference
Intrinsic galaxy shapes
Gravitationally lensed galaxy shapes

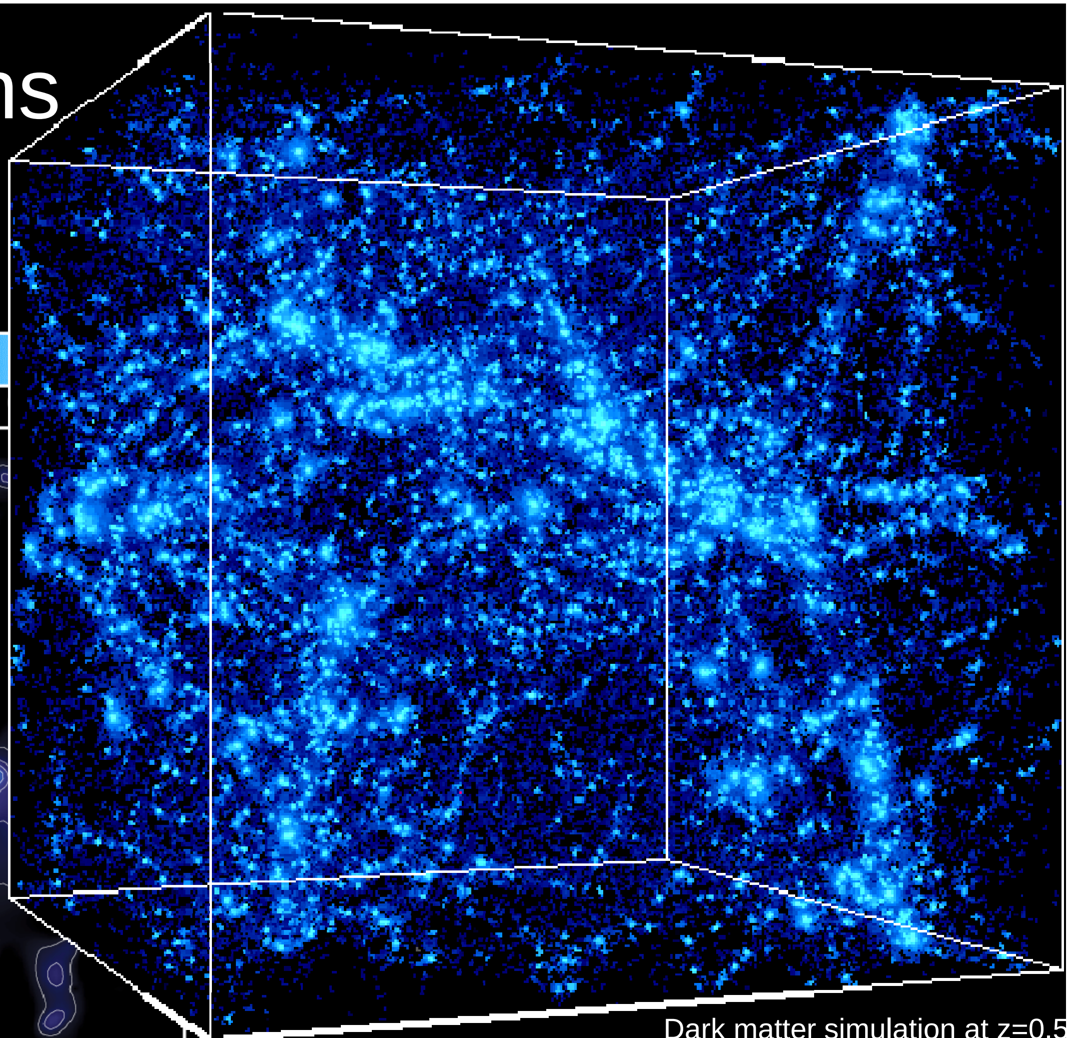
COSMOS mass map



- Each tick mark shows the averaged ellipticity of >100 galaxies
- Density of resolved galaxies sets the resolution of a mass map
- 71 galaxies/arcmin^2 from space
- ~20 galaxies/arcmin^2 from ground

Compare to simulations

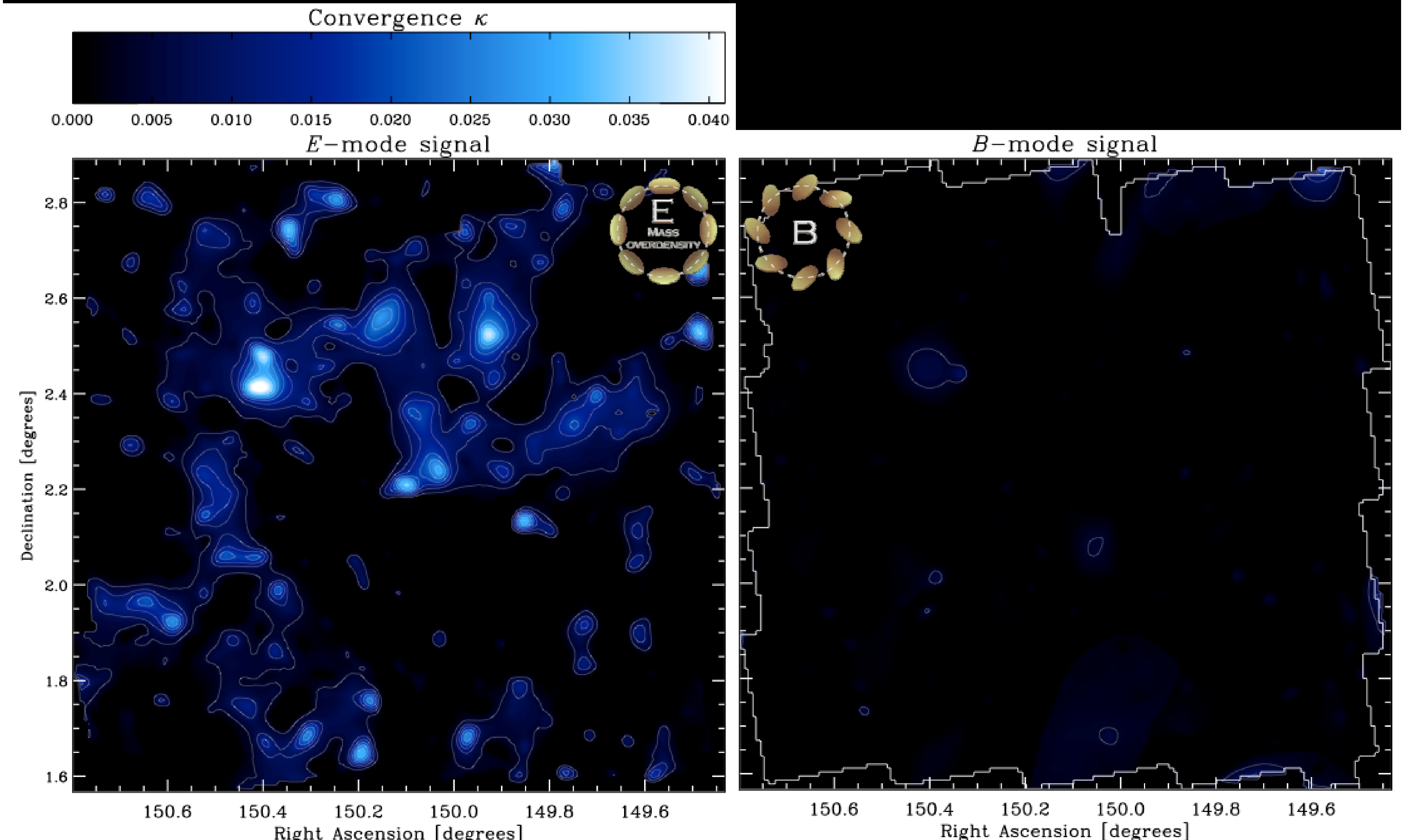




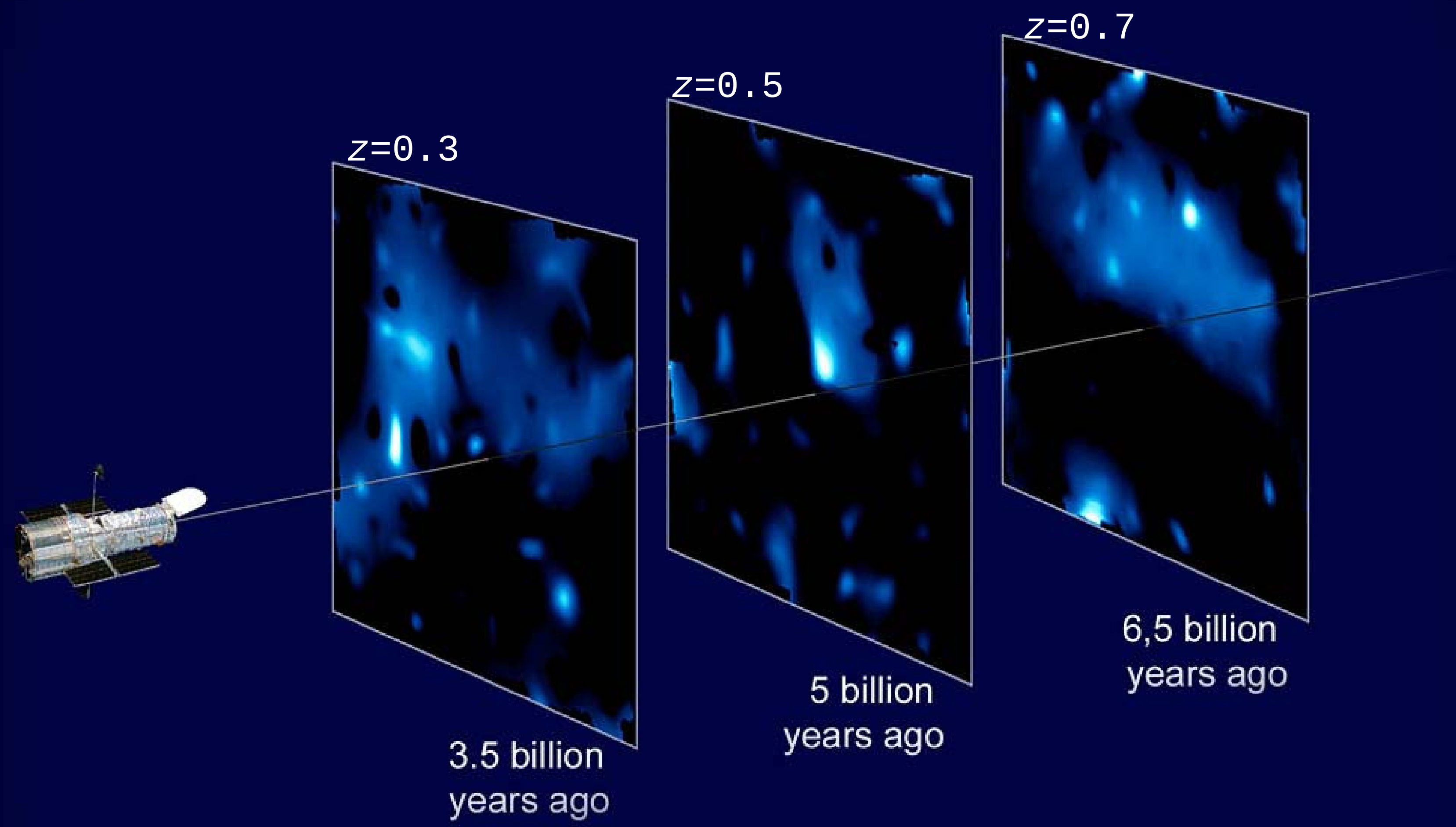
Dark matter simulation at z=0.5
Andrey Kravtsov and Anatoly Klypin
(National Center for Supercomputer Applications)

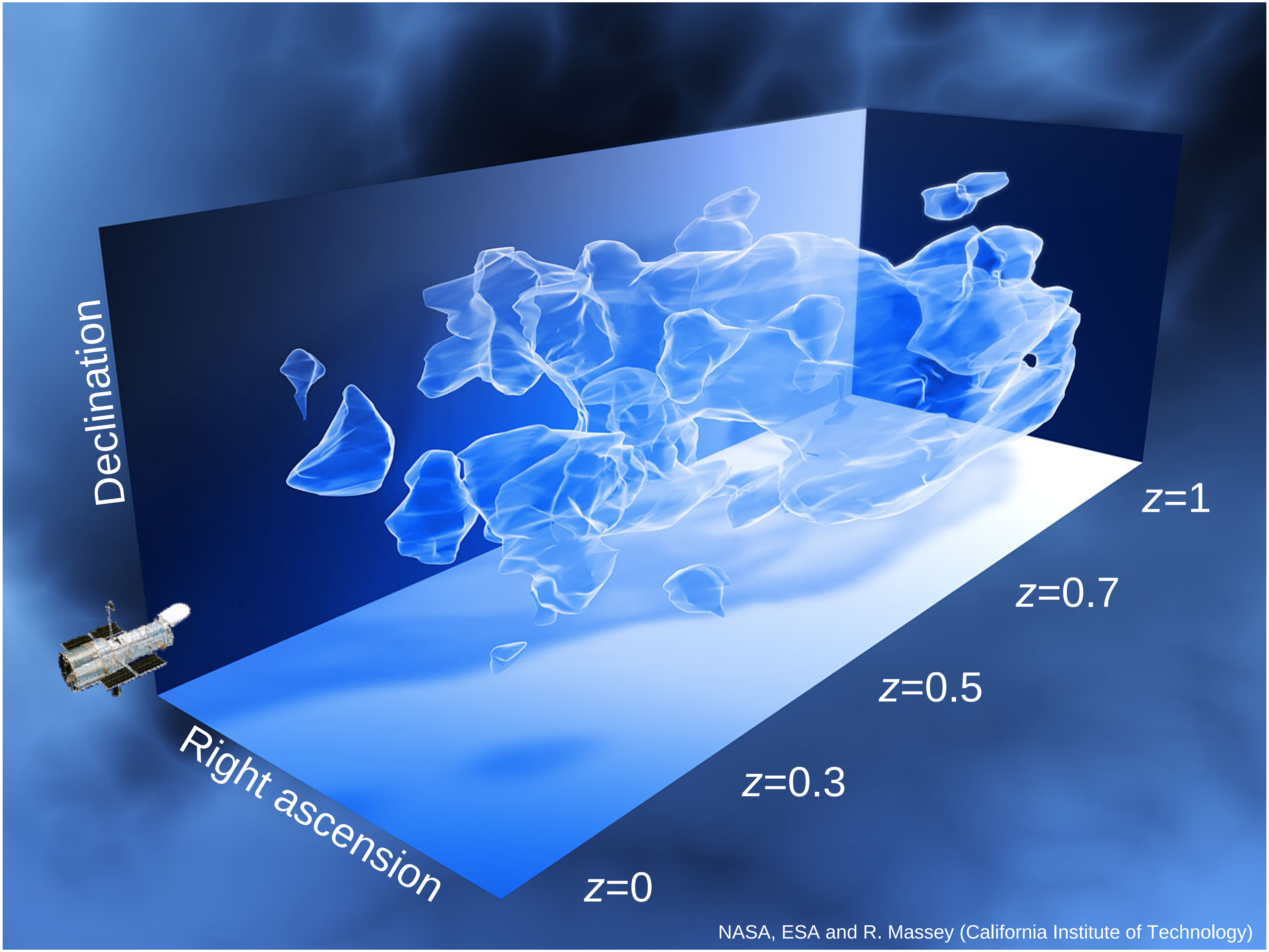
B-mode check for residual systematics

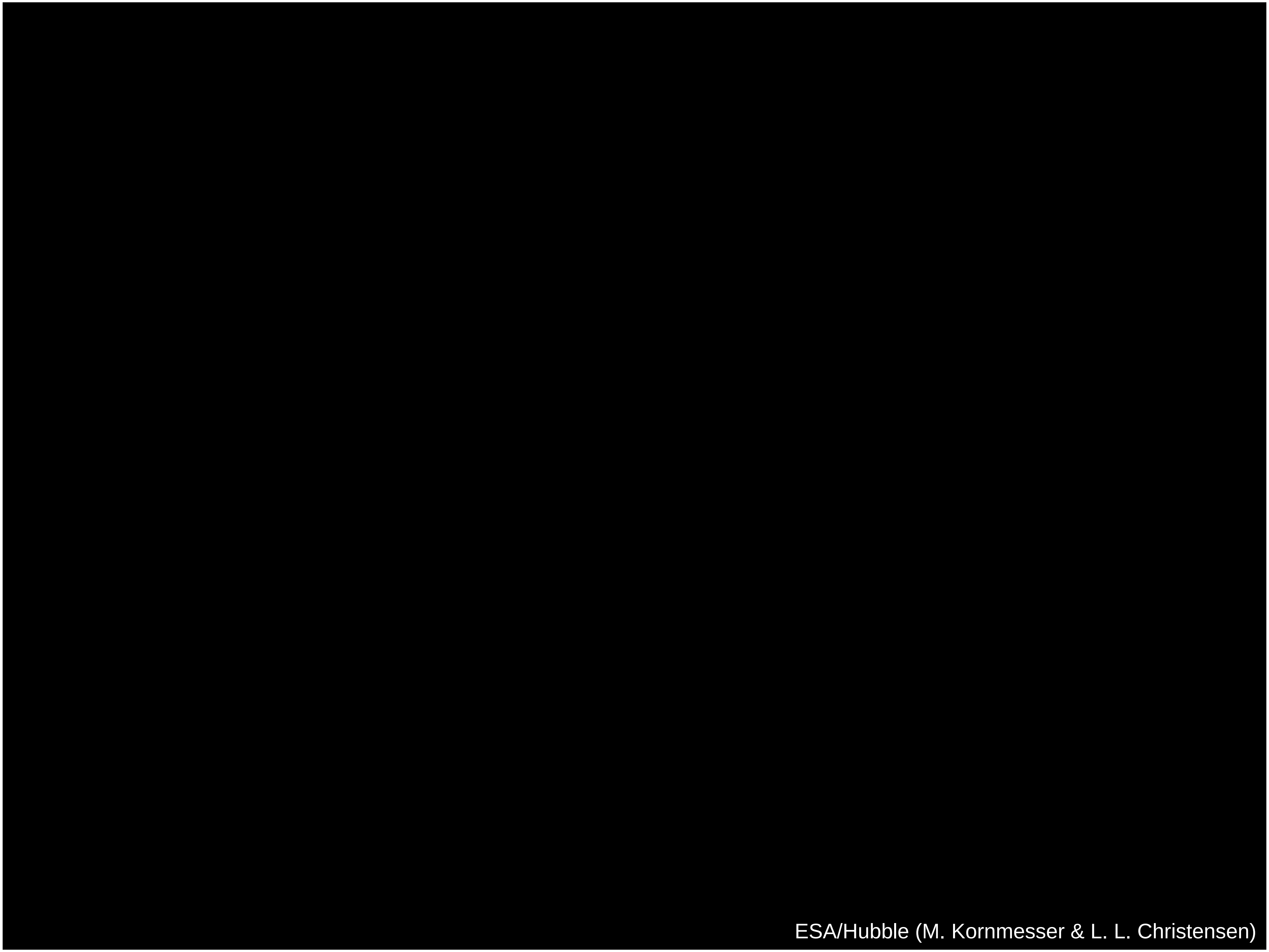
R. Massey et al. (Nature 2007)



Redshift tomography (palaeocosmology)

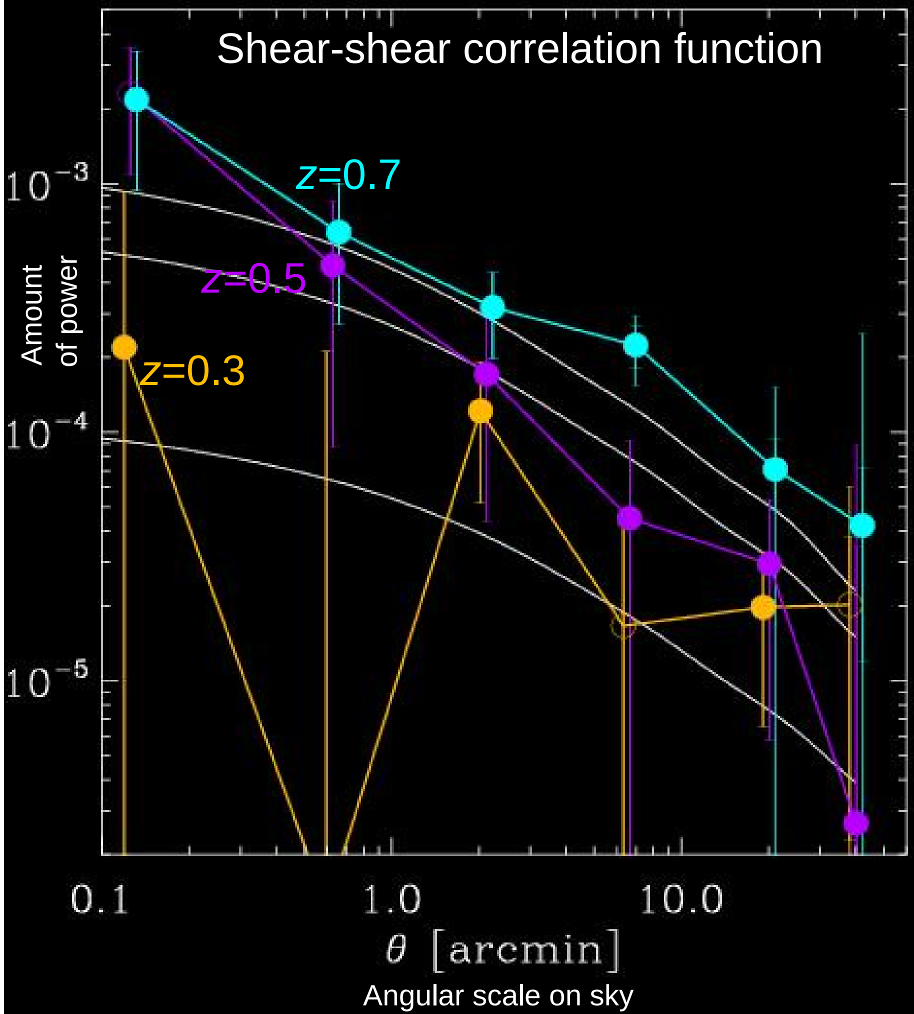


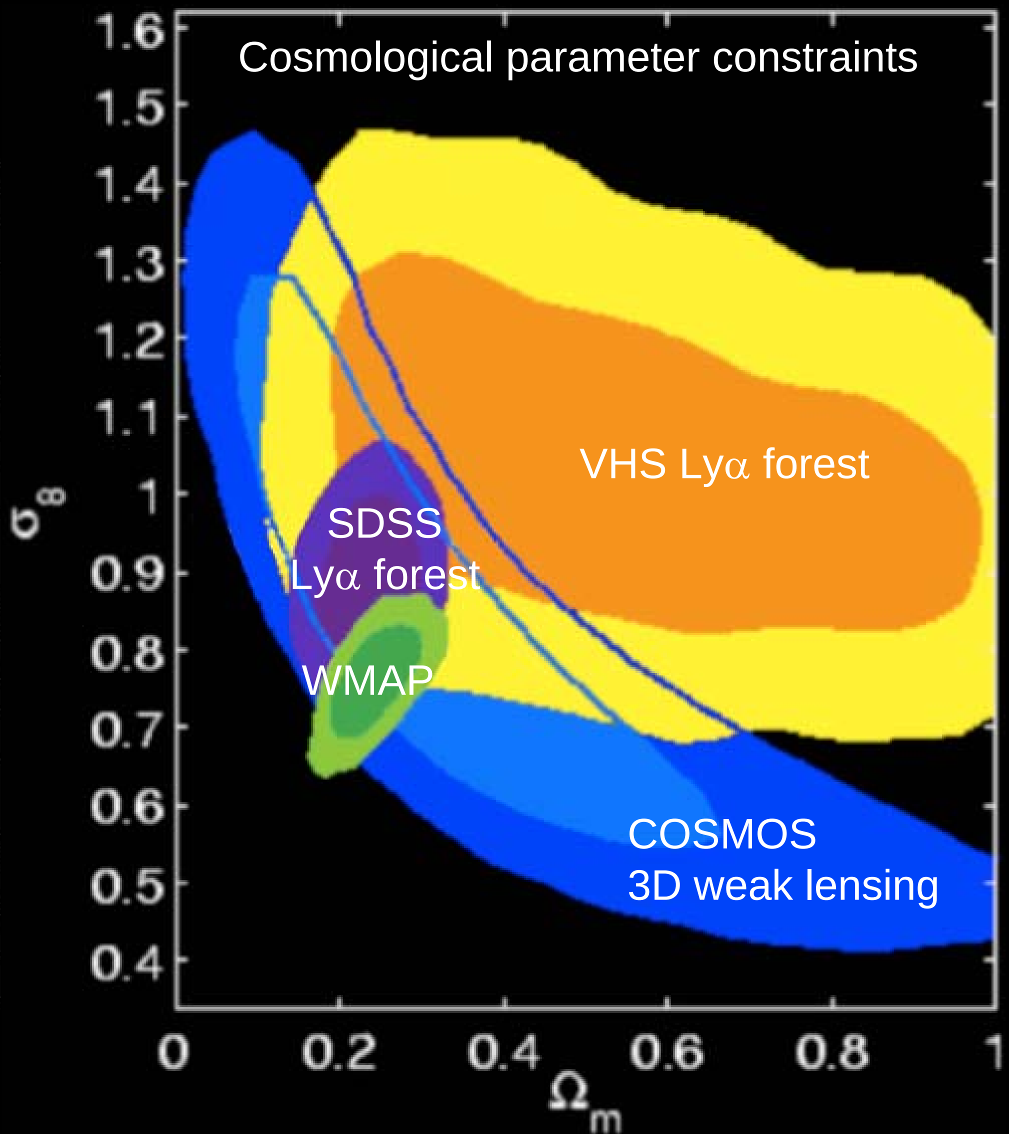

Declination
Right ascension
z=0
z=0.3
z=0.5
z=0.7
z=1
NASA, ESA and R. Massey (California Institute of Technology)


ESA/Hubble (M. Kornmesser & L. L. Christensen)

Statistical analysis of 3D mass distribution

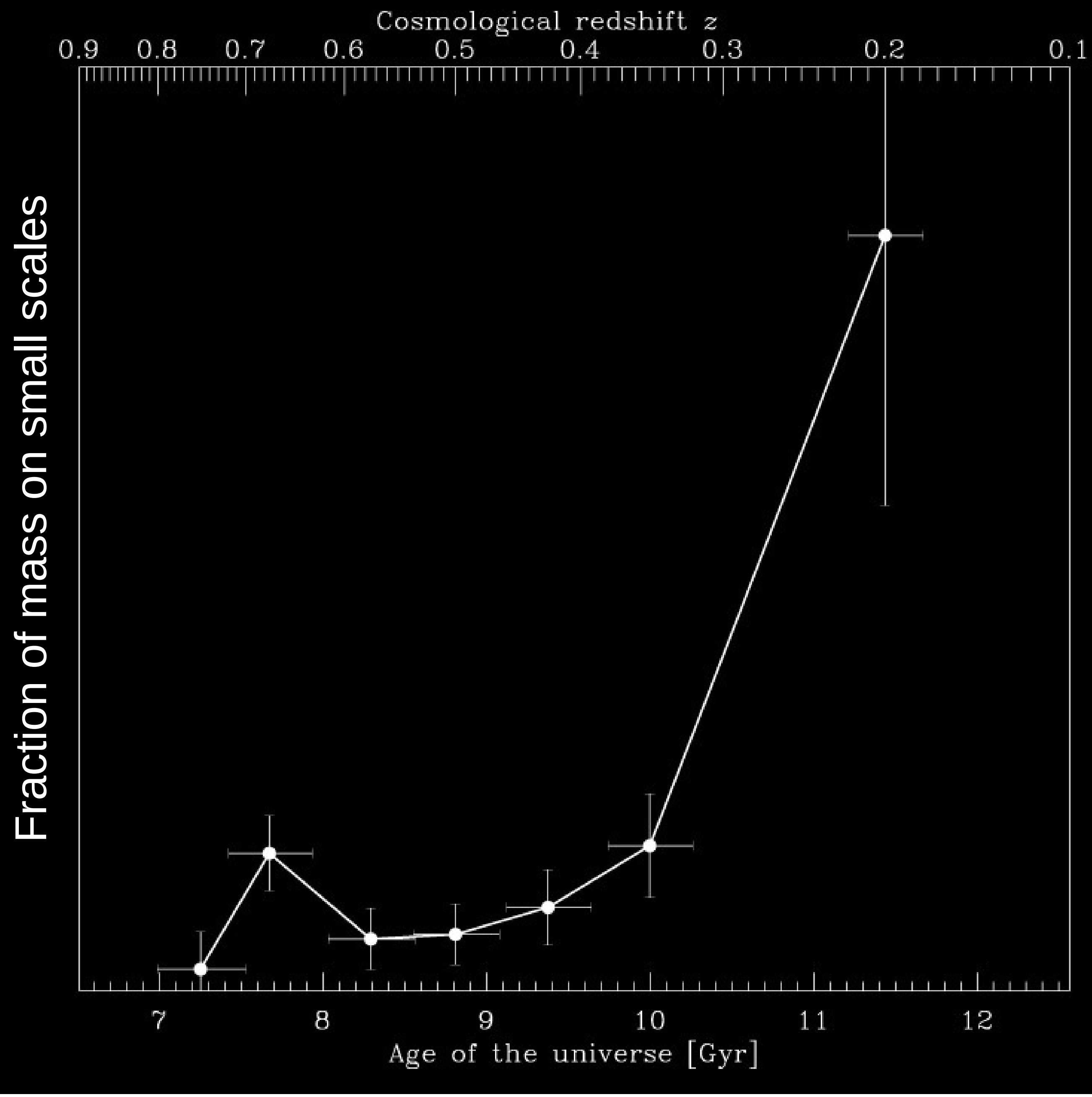
R. Massey et al. (ApJ 2007), J. Lesgourgues et al. (arXiv:0705.0533)





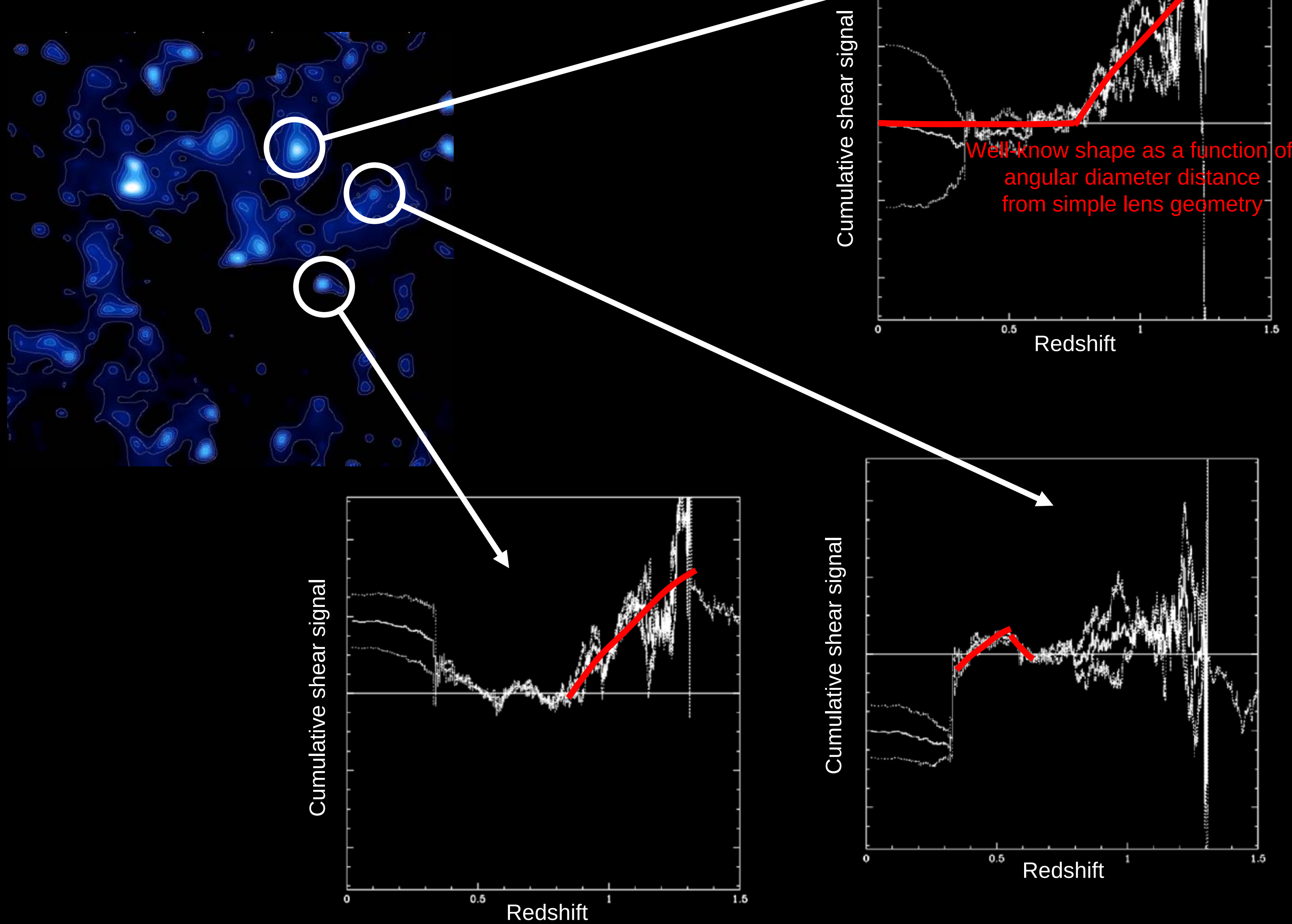
Growth of structure over cosmic time

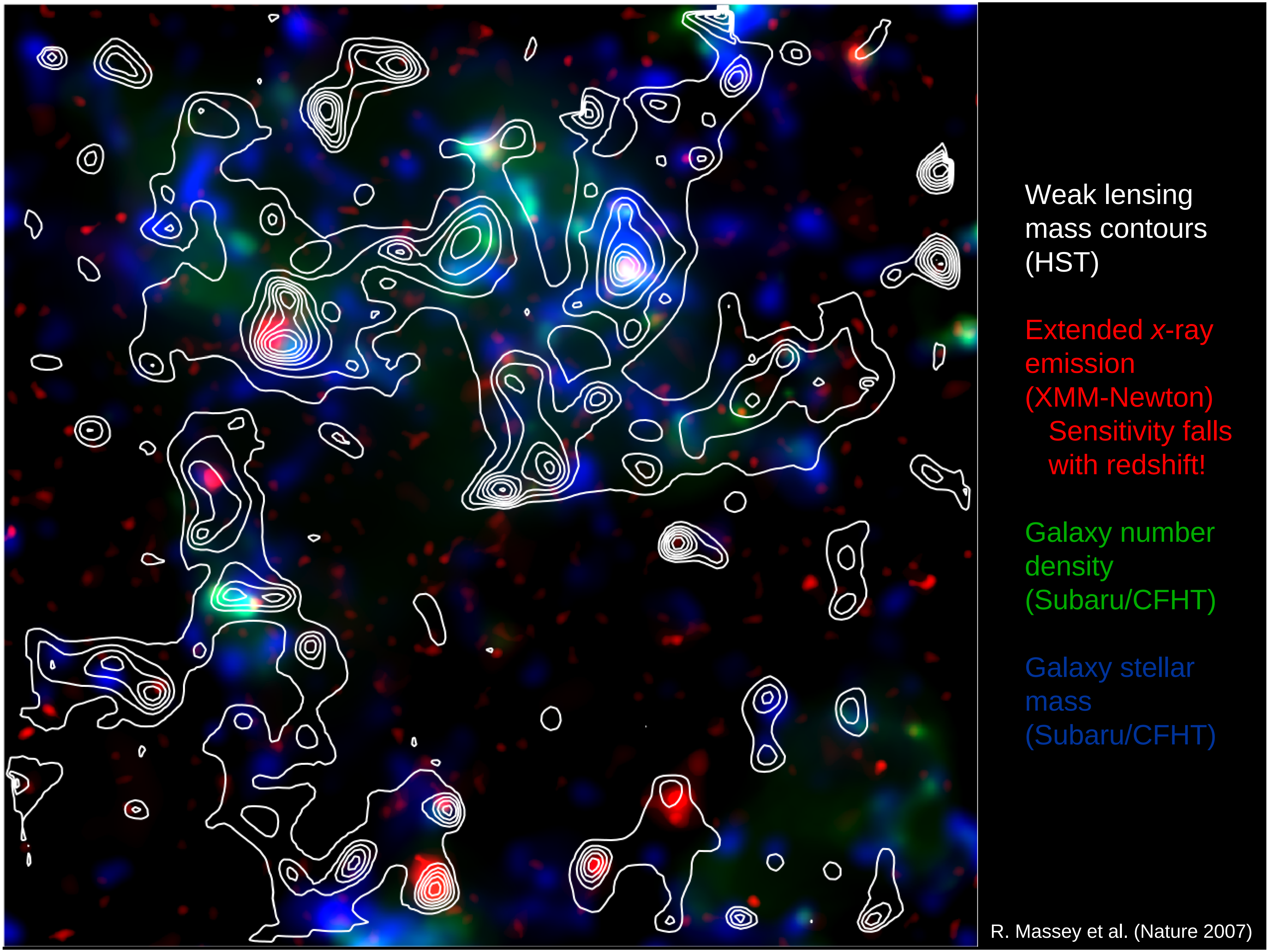
R. Massey et al. (ApJ 2007)



Redshift-distance relation

James Taylor et al. (in prep)



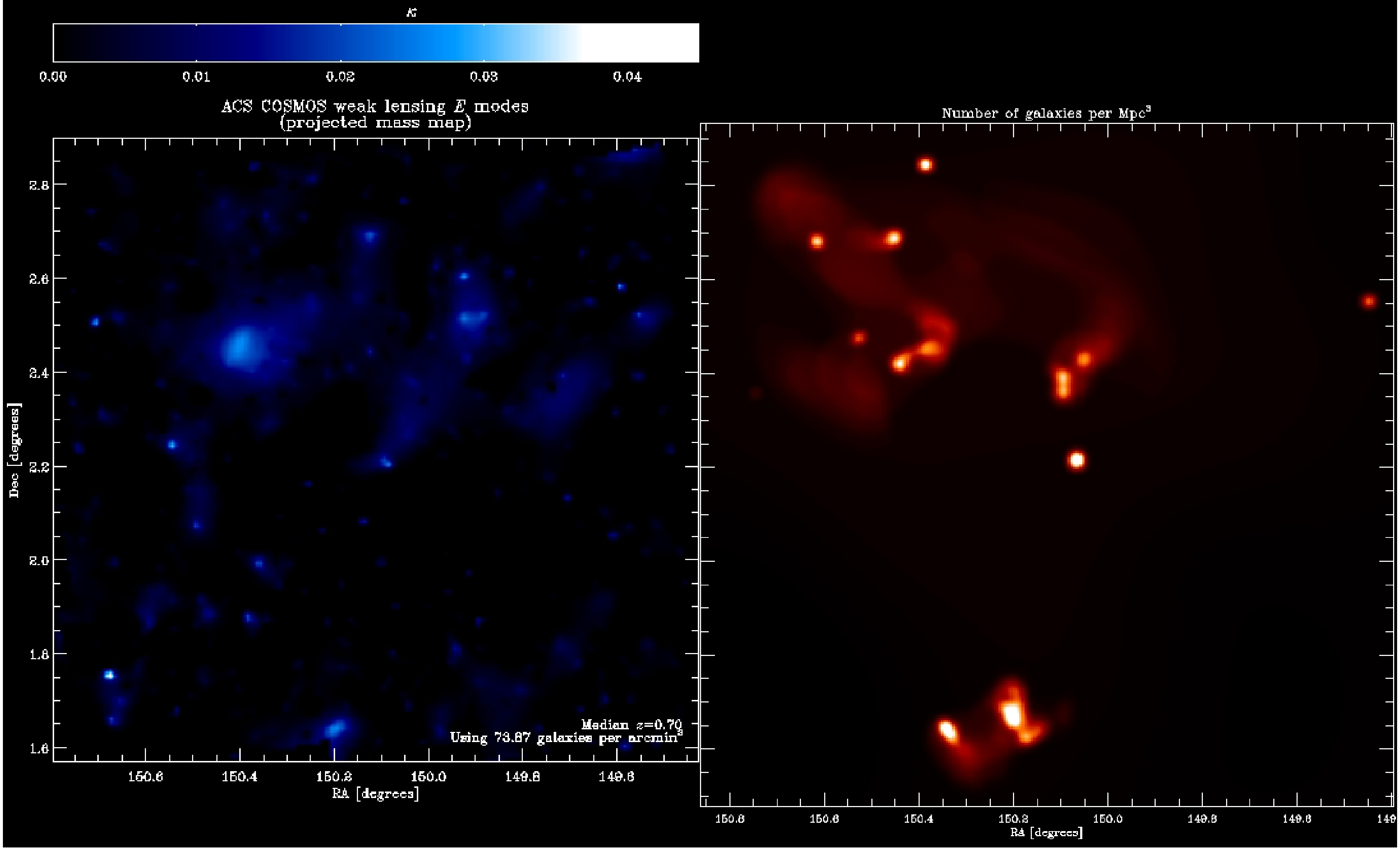


Weak lensing mass contours (HST)
Extended *x*-ray emission (XMM-Newton)
Sensitivity falls with redshift!
Galaxy number density (Subaru/CFHT)
Galaxy stellar mass (Subaru/CFHT)
R. Massey et al. (Nature 2007)

Mass vs light tomography (z~0.3)

R. Massey et al. (Nature 2007)

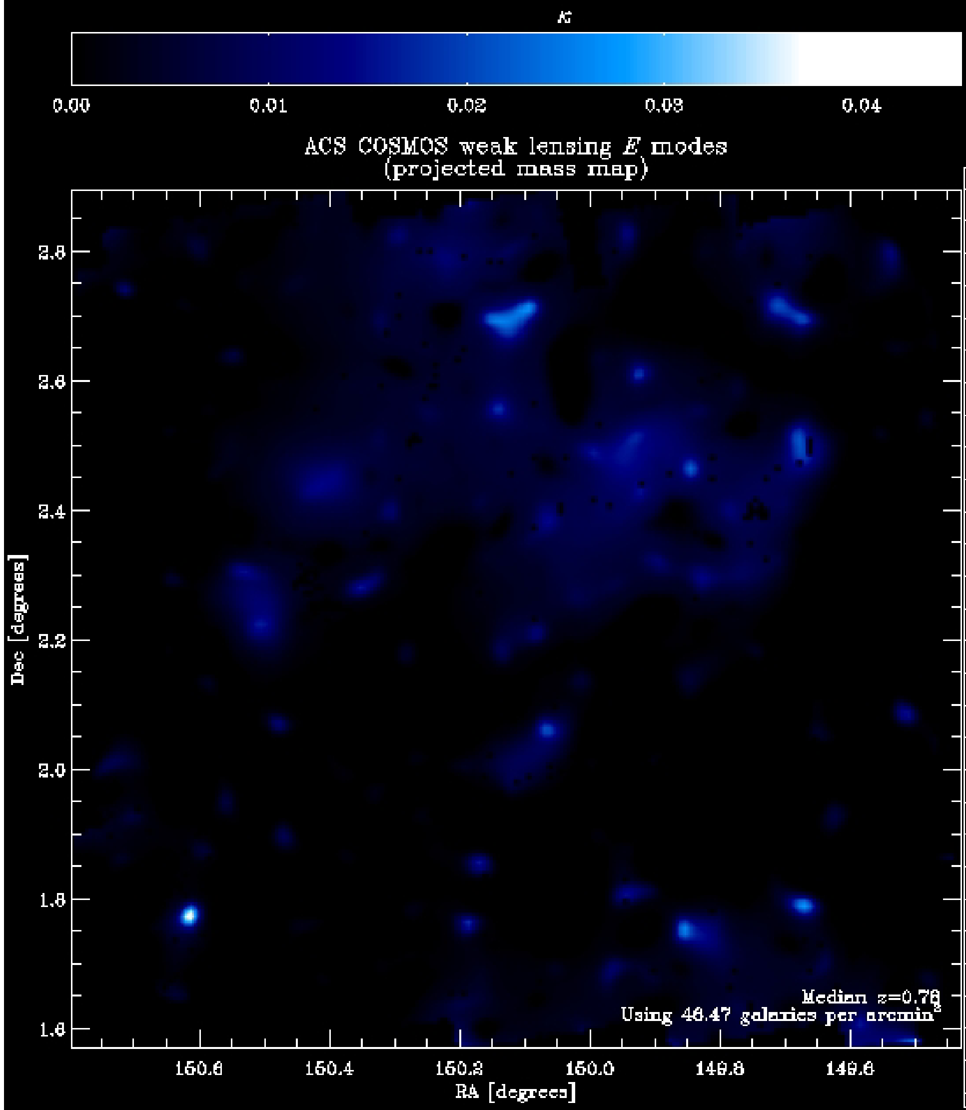
~19Mpc × 19Mpc

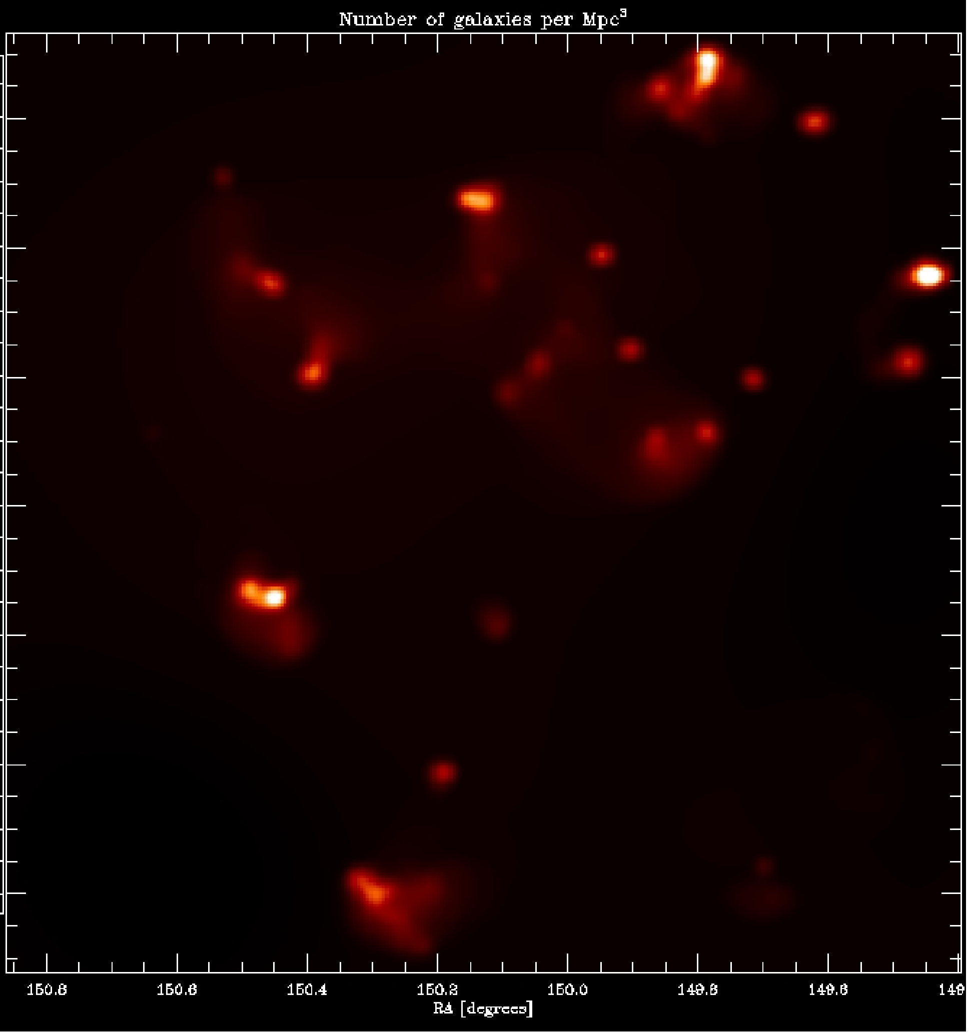


Mass vs light tomography (z~0.5)

R. Massey et al. (Nature 2007)

~26Mpc × 26Mpc

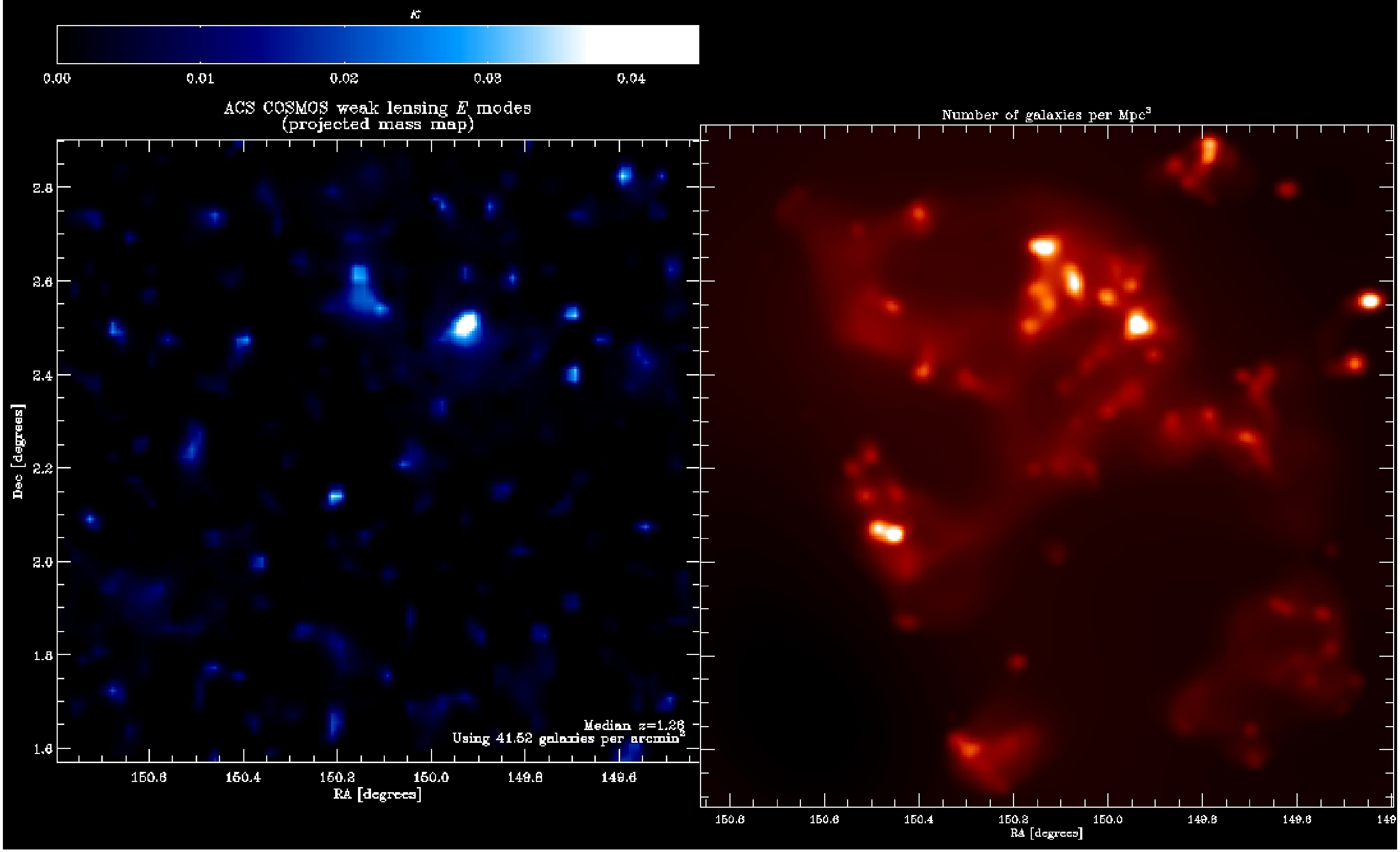


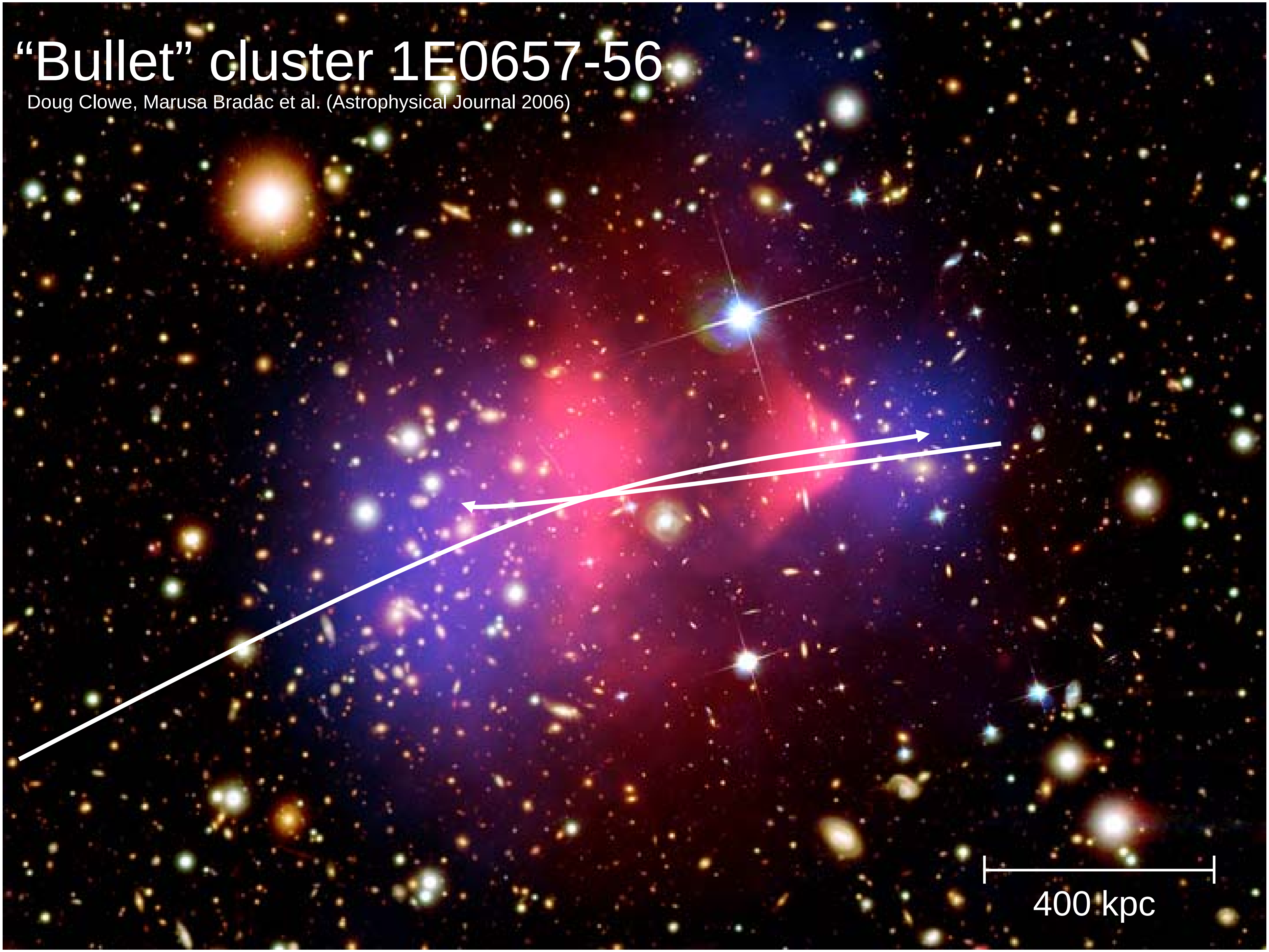


Mass vs light tomography (z~0.7)

R. Massey et al. (Nature 2007)

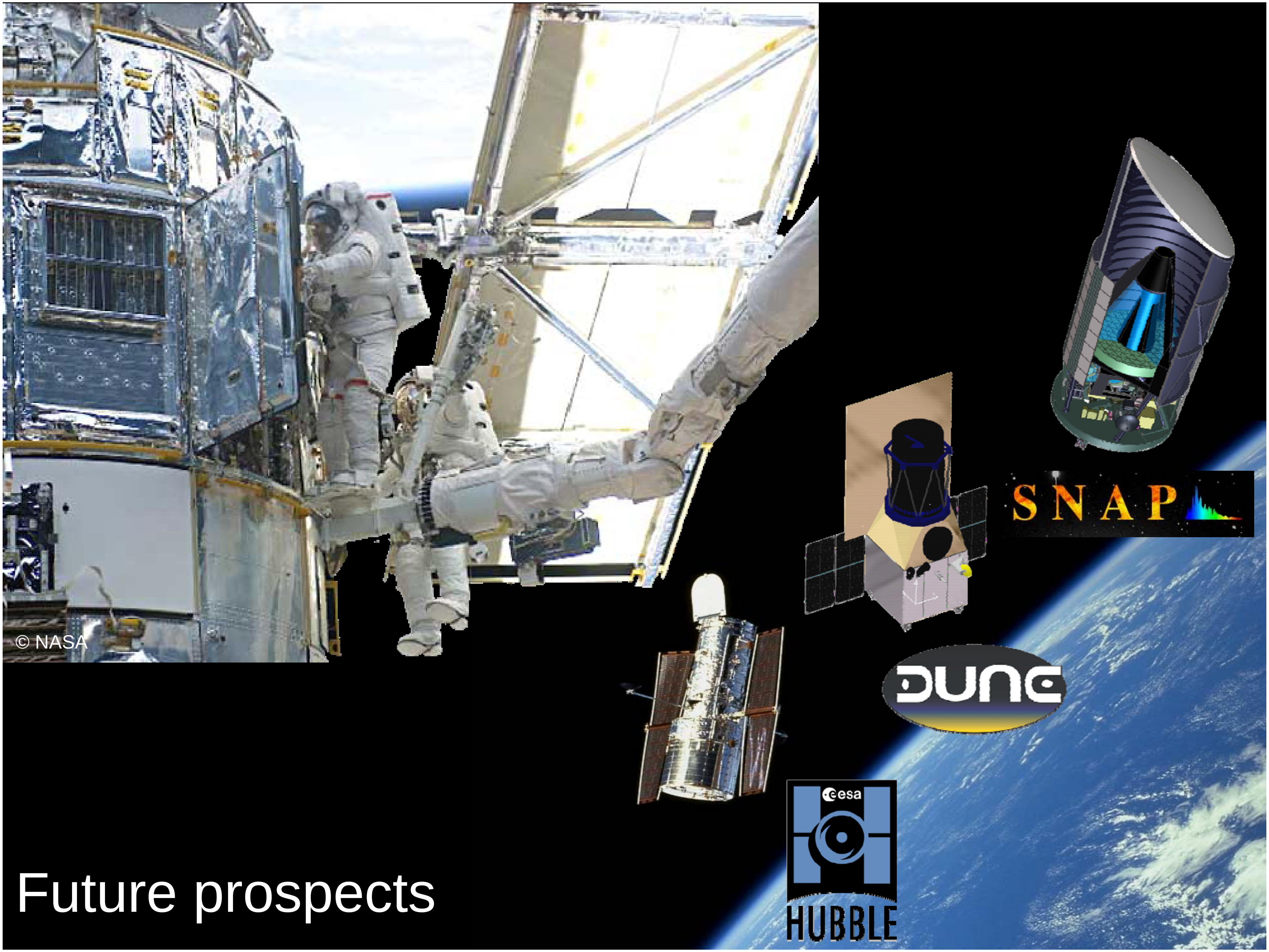
~31Mpc × 31Mpc





“Bullet” cluster 1E0657-56
Doug Clowe, Marusa Bradac et al. (Astrophysical Journal 2006)
400 kpc

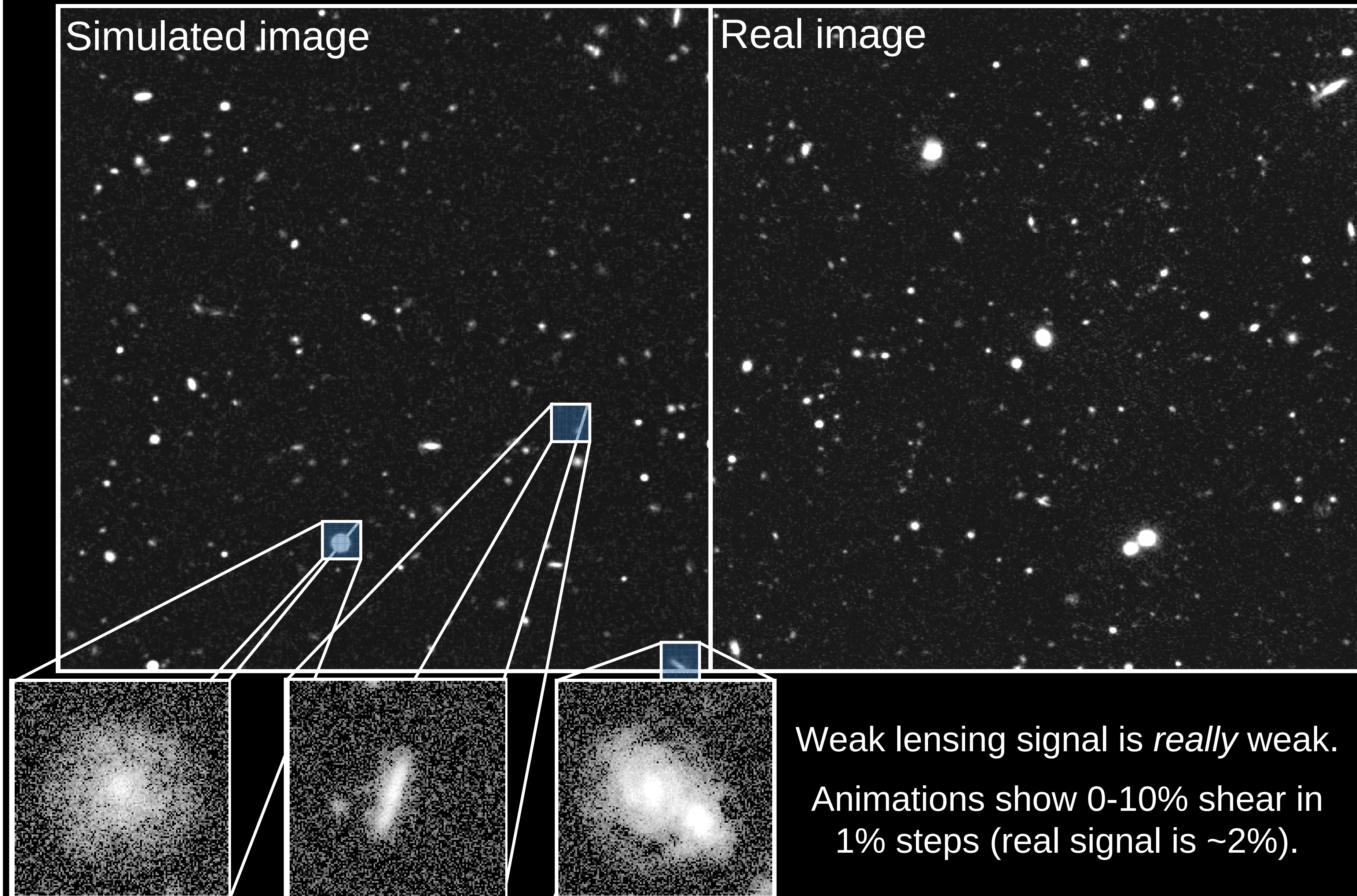
Largest particle accelerator in the Universe



Future prospects

Shear TEsting Programme (STEP) simulations

R. Massey et al. (MNRAS 2004)

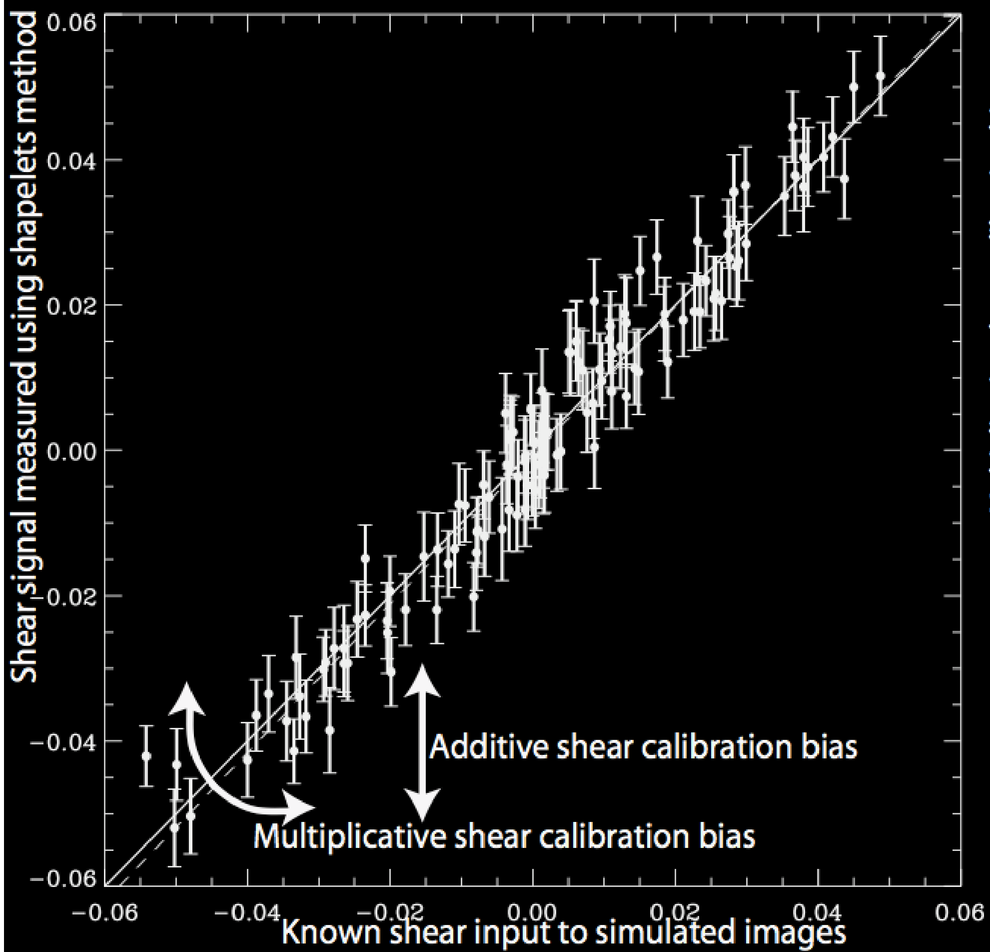


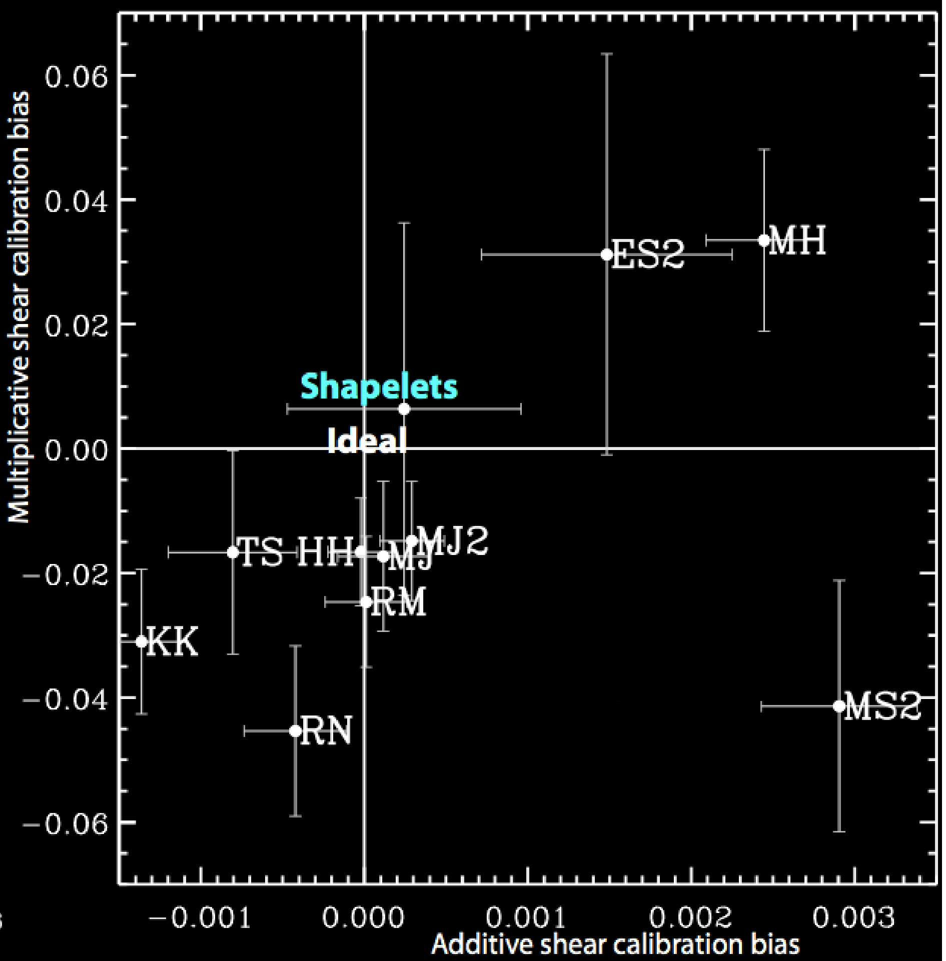
Weak lensing signal is *really* weak.

Animations show 0-10% shear in 1% steps (real signal is ~2%).

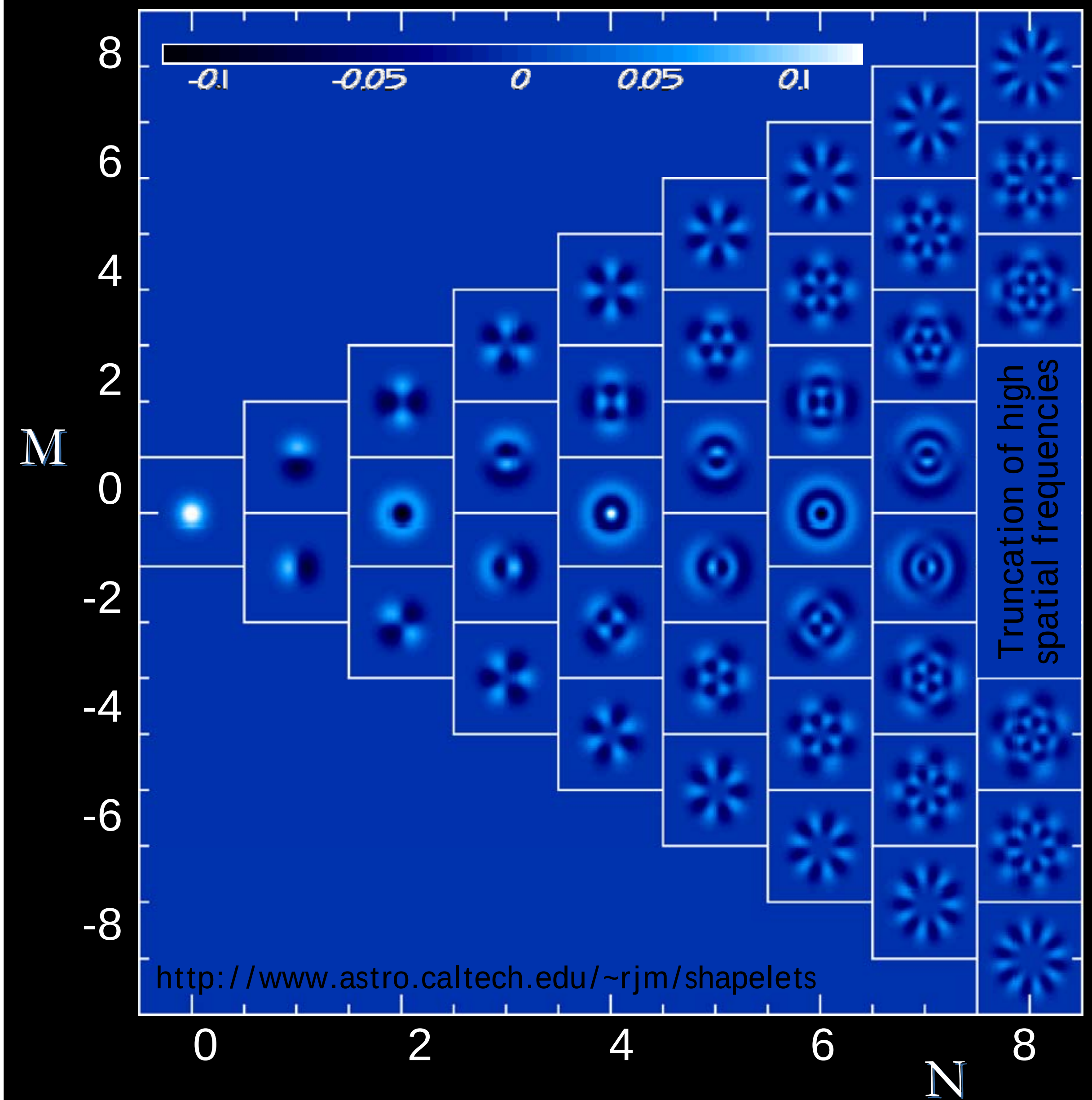
Shear TEsting Programme (STEP) results

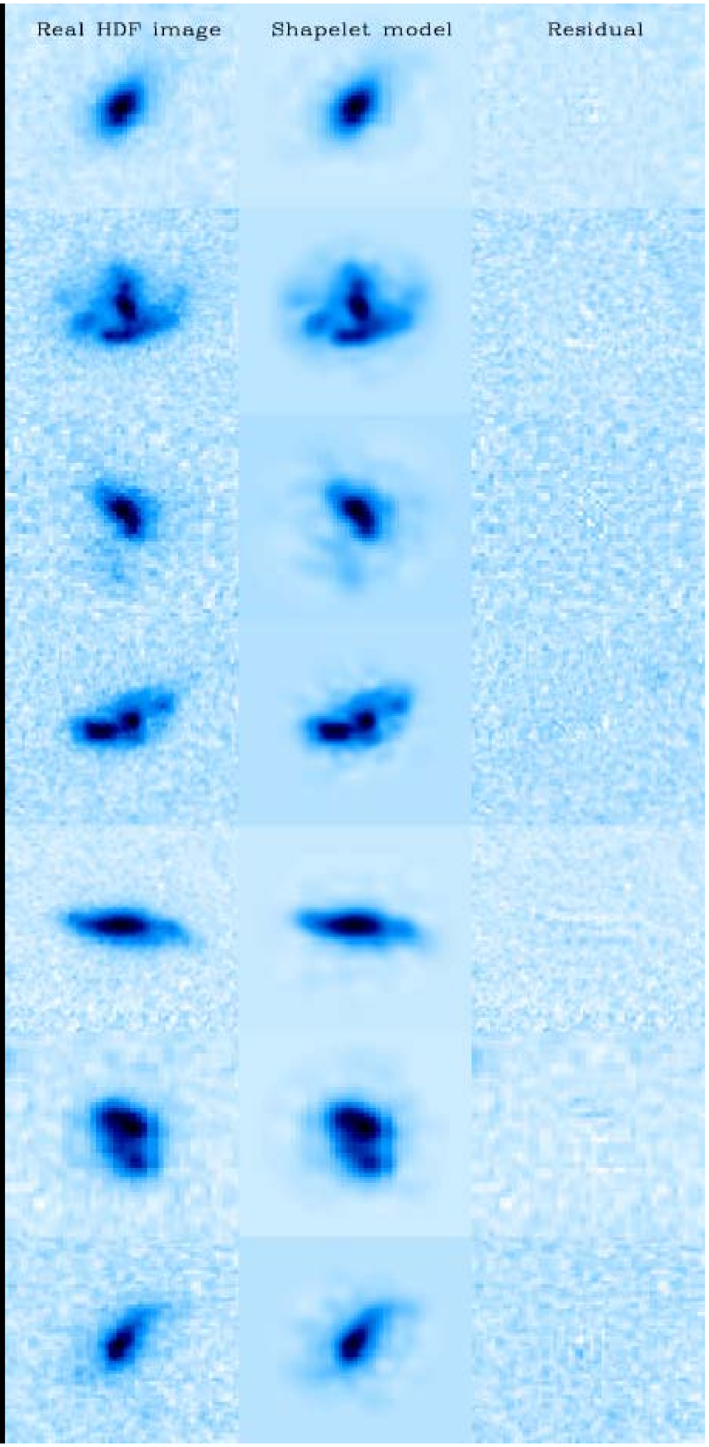
C. Heymans et al. (MNRAS 2006)
R. Massey et al. (MNRAS 2007)





Shapelets basis functions



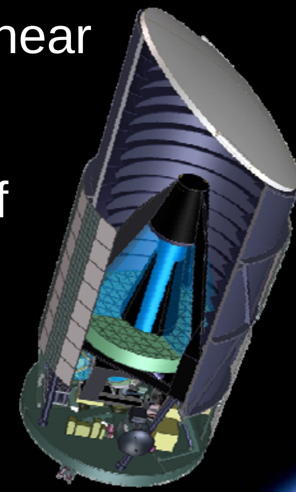


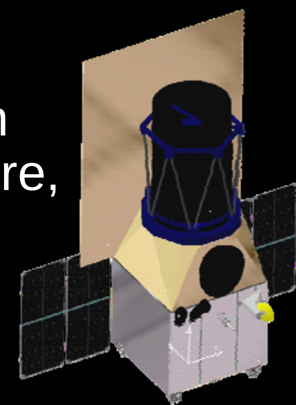
Conclusions

Remarkably fast progress since first statistical detections of cosmic shear in 2000. Gravitational lensing is now a major tool in cosmology.

We can now compare the large-scale distribution of baryons to that of mass. In general, baryonic structures are built inside a dark matter scaffold. Discrepancies on small scales reveal the different (e.g. non-interacting) properties of dark matter.

Statistical analyses of the mass distribution constrain cosmological parameters, trace the growth of structure, and measure the expansion history of the universe.





Could not have been done from the ground. Imaging from space (+photozs) is essential for high resolution mass reconstruction and redshift tomography over wider timescales. The untimely failure of ACS is heartbreaking. Hubble provides a unique proof of concept for ambitious, dedicated missions in the future.

Fin

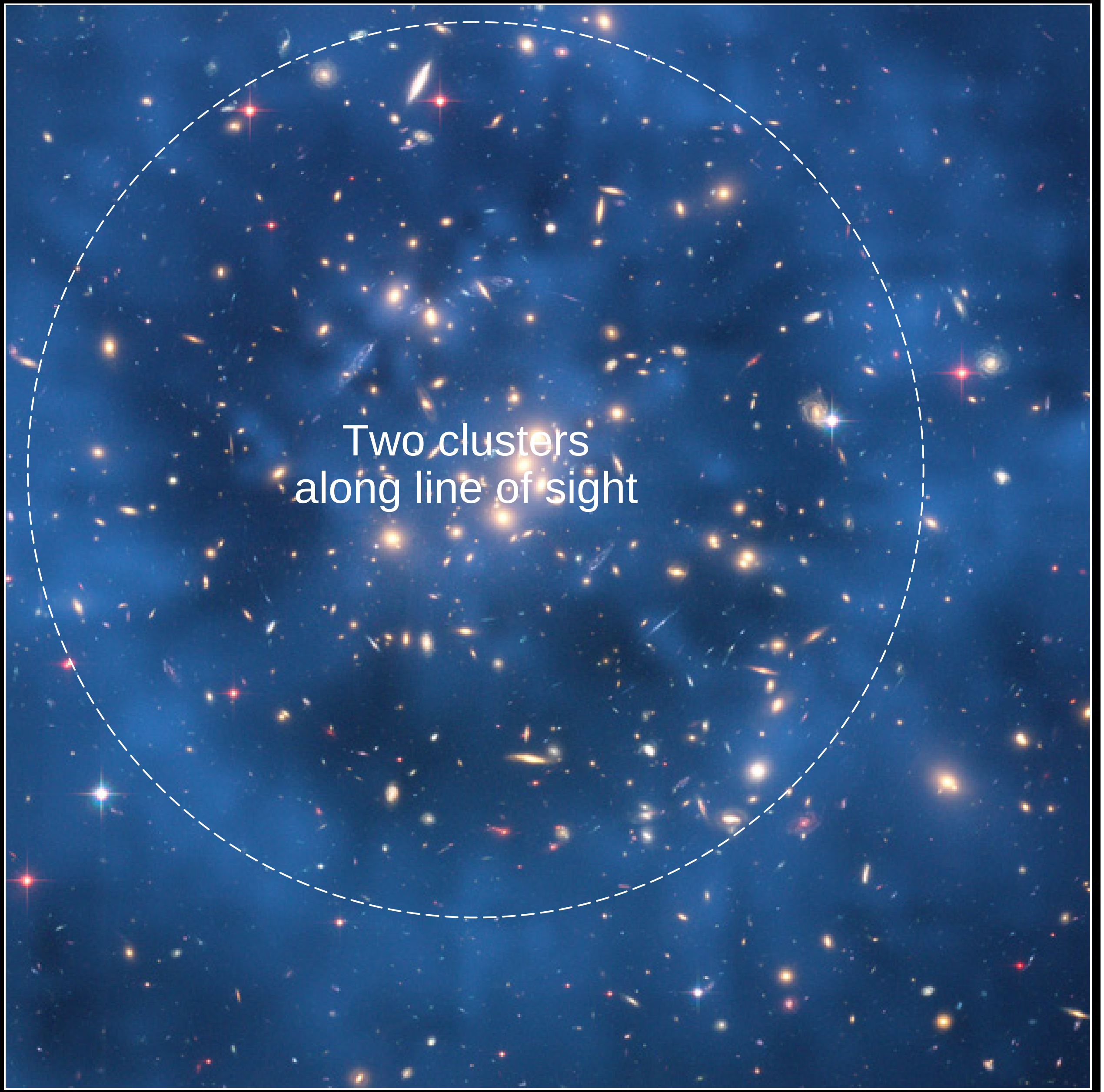
Face-on bullet

James Jee et al. (Astrophysical Journal 2007))

Cartwheel Galaxy

PR95-02 · ST ScI OPO · January 1995 · K. Borne (ST ScI), NASA

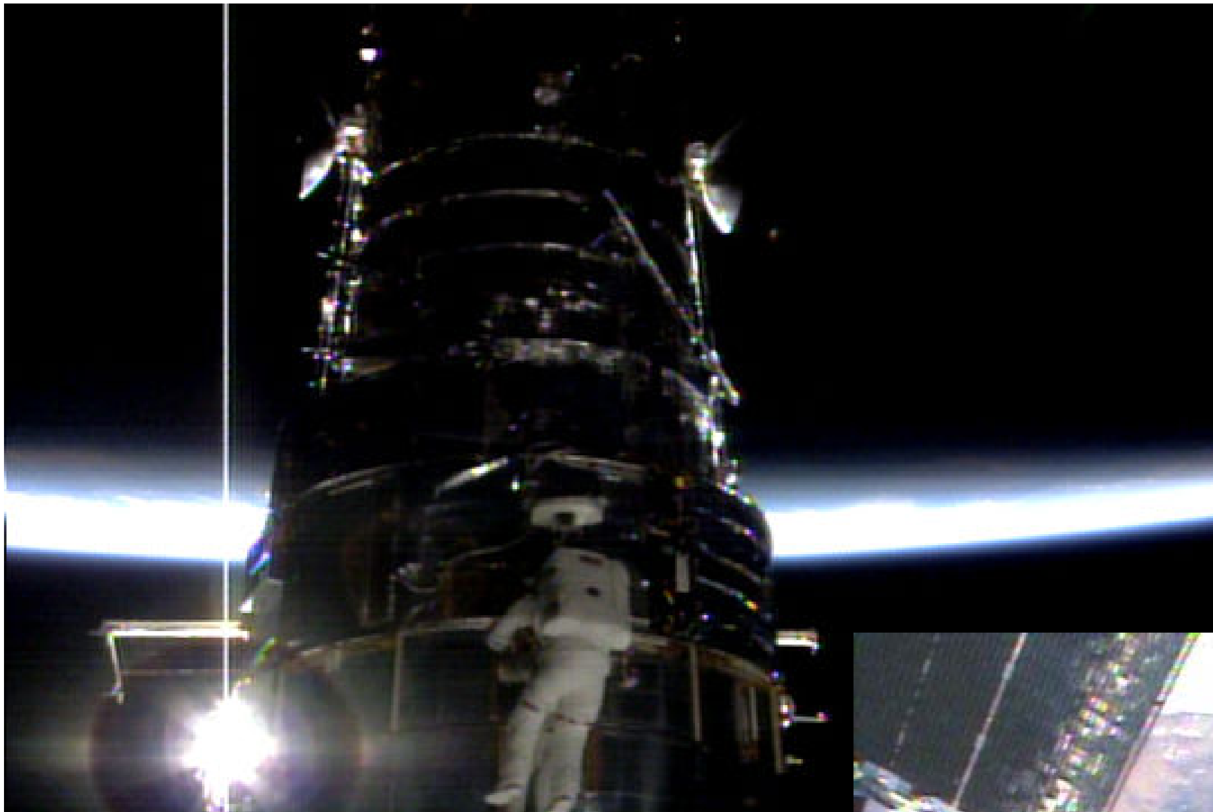
Dark Matter Ring in CL 0024+17 (ZwCl 0024+1652) *HST* • ACS/WFC

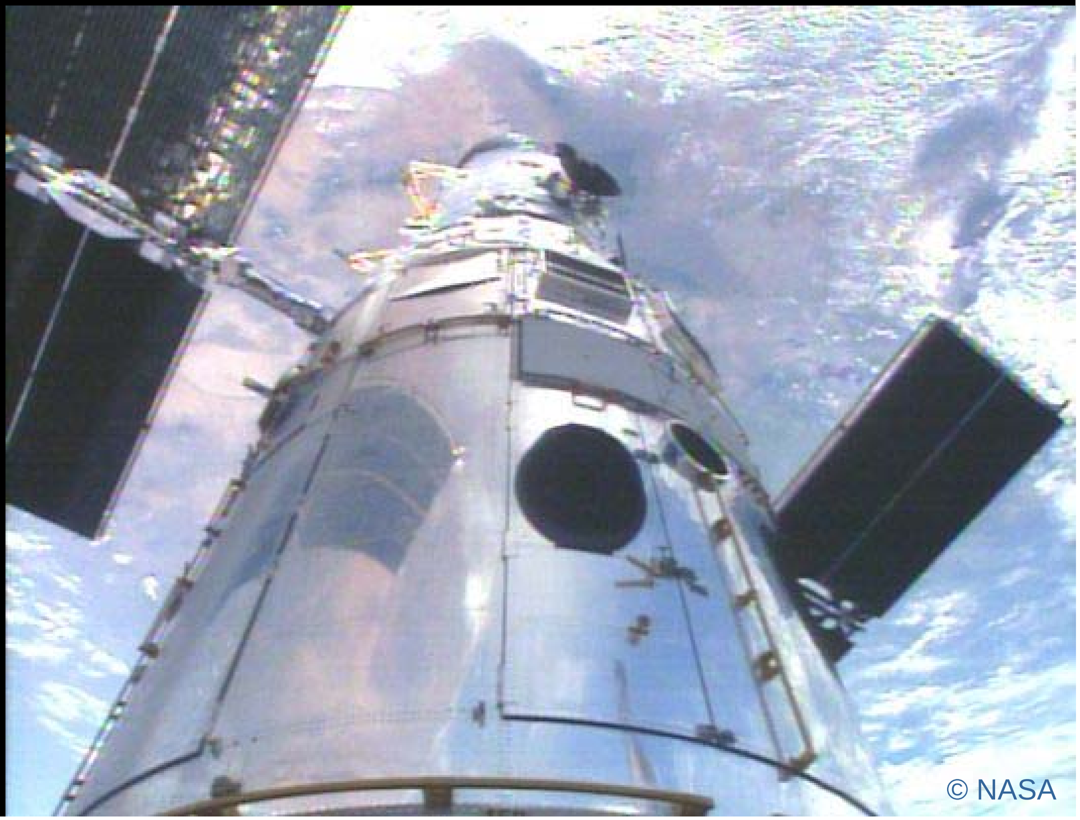


NASA, ESA, and M.J. Jee (Johns Hopkins University) STScI-PRC07-17b

Face-on bullet

NASA, ESA and M. J. Jee (Johns Hopkins University)

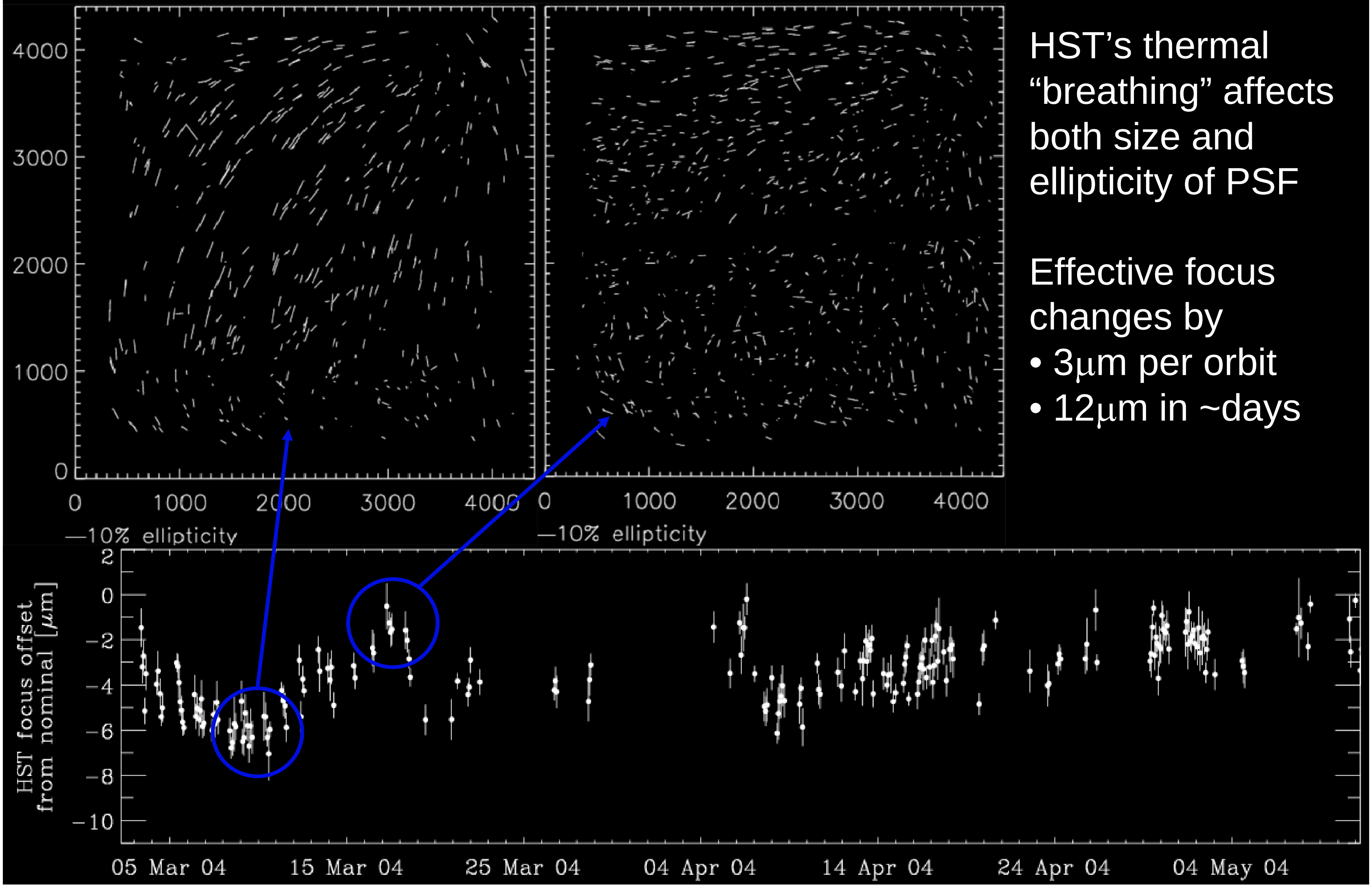




In and out of the shadow of the Earth

PSF variation

J. Rhodes (ApJ 2007), J. Jee (ApJ 2005)

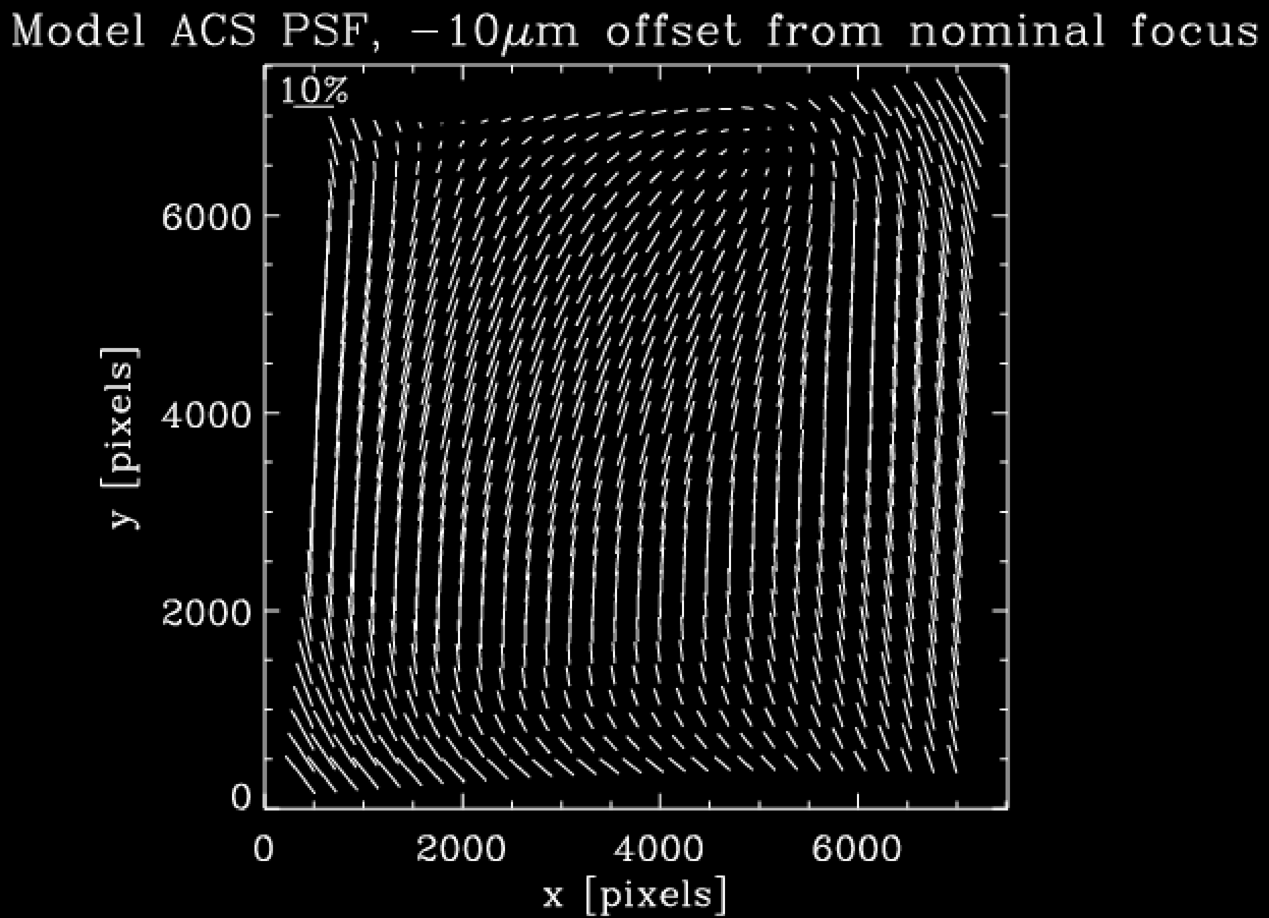


HST's thermal "breathing" affects both size and ellipticity of PSF

Effective focus changes by
- 3μm per orbit
- 12μm in ~days

PSF variation

J. Rhodes (ApJ 2007)

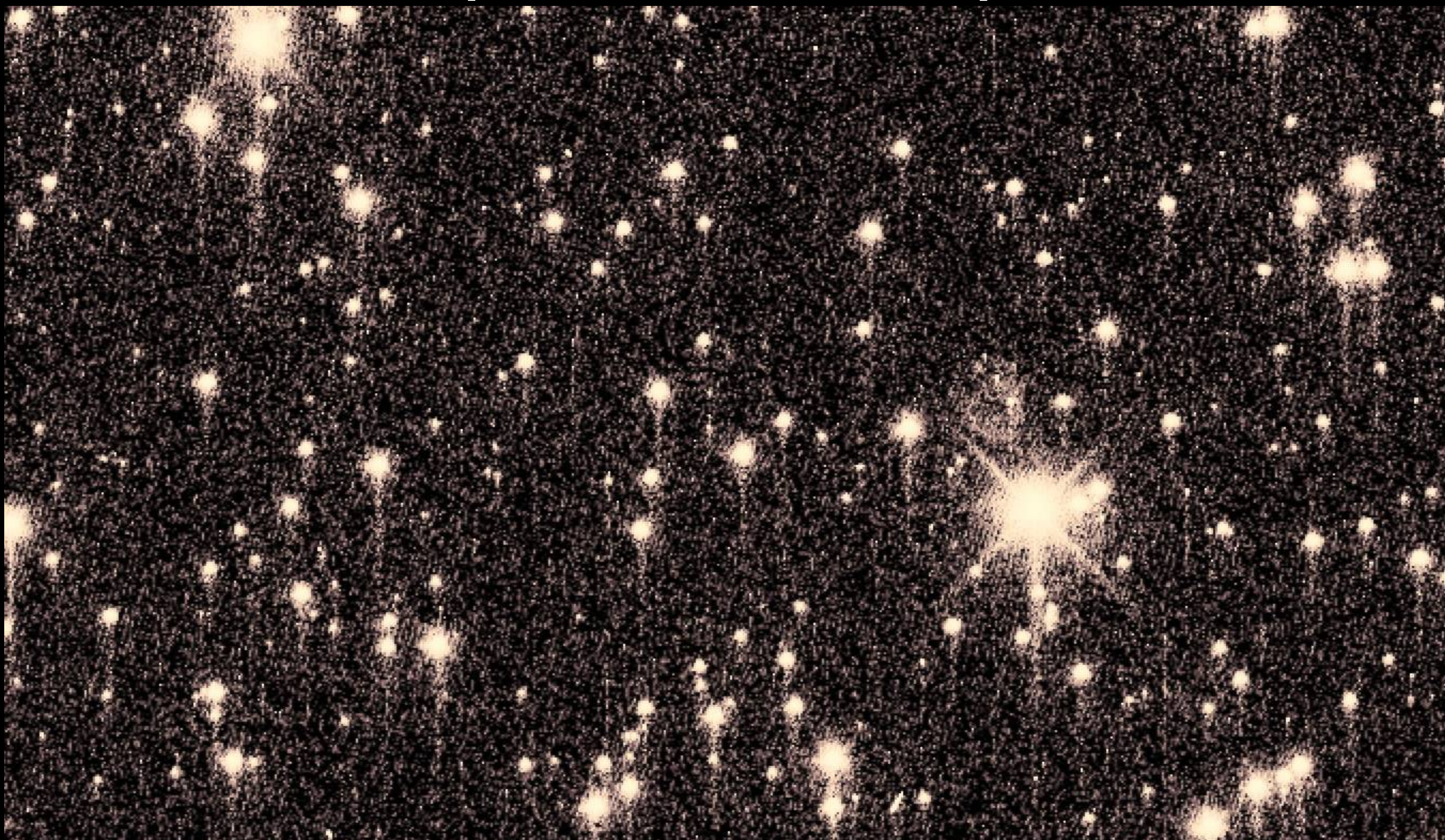


HST is really simple

Charge Transfer (in)Efficiency

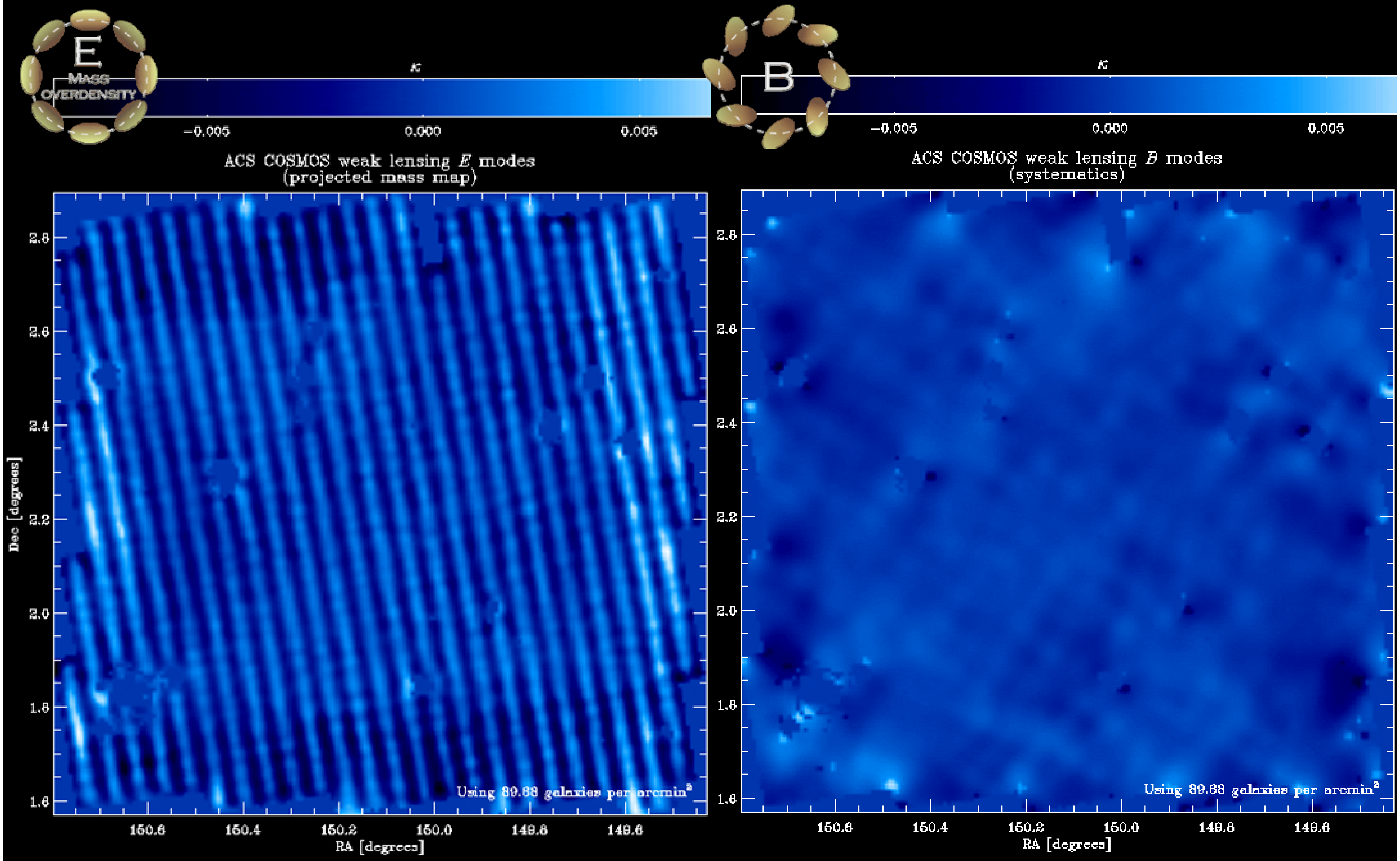
STIS image, courtesy Paul Bristow

↑ CCD readout register ↑



Trailing during CCD readout creates a spurious, coherent ellipticity.
Affects photometry, astrometry and morphology of faint galaxies.

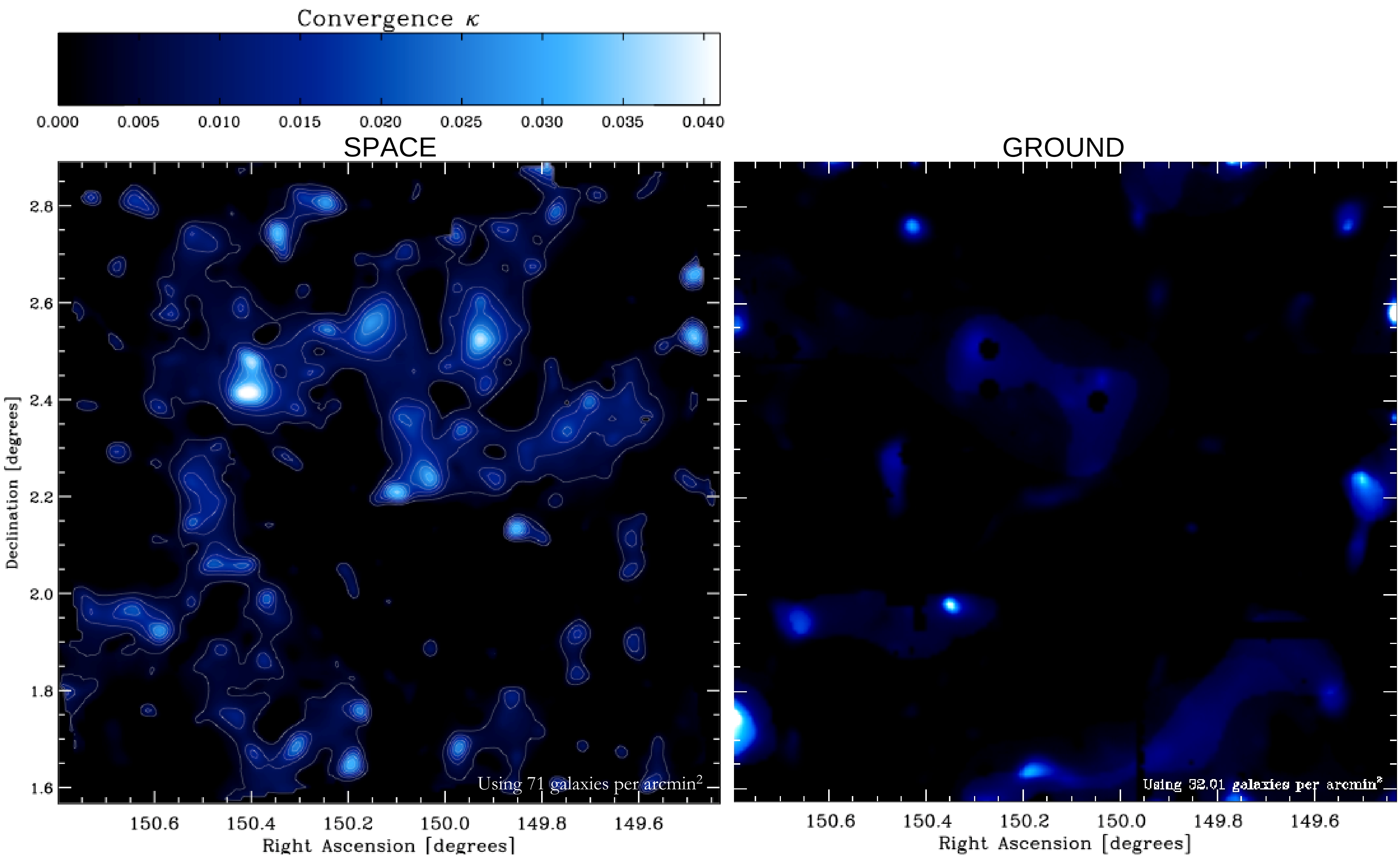
Effect of CTE trailing on the mass map



Ground versus space

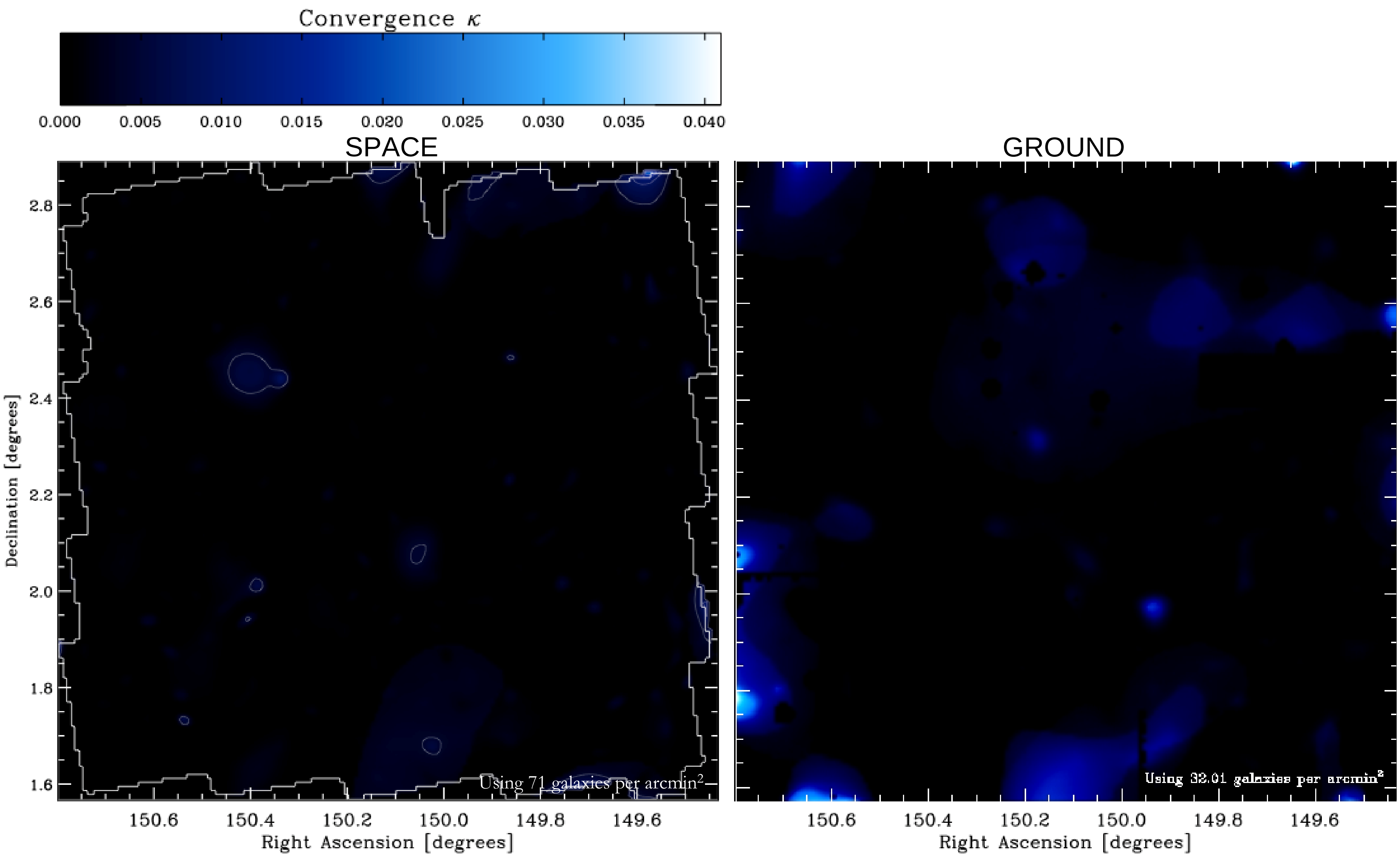
Ground vs space (mass maps)

R. Massey et al. (Nature 2007), M. Kasliwal et al. (Proc. AAS 2007)



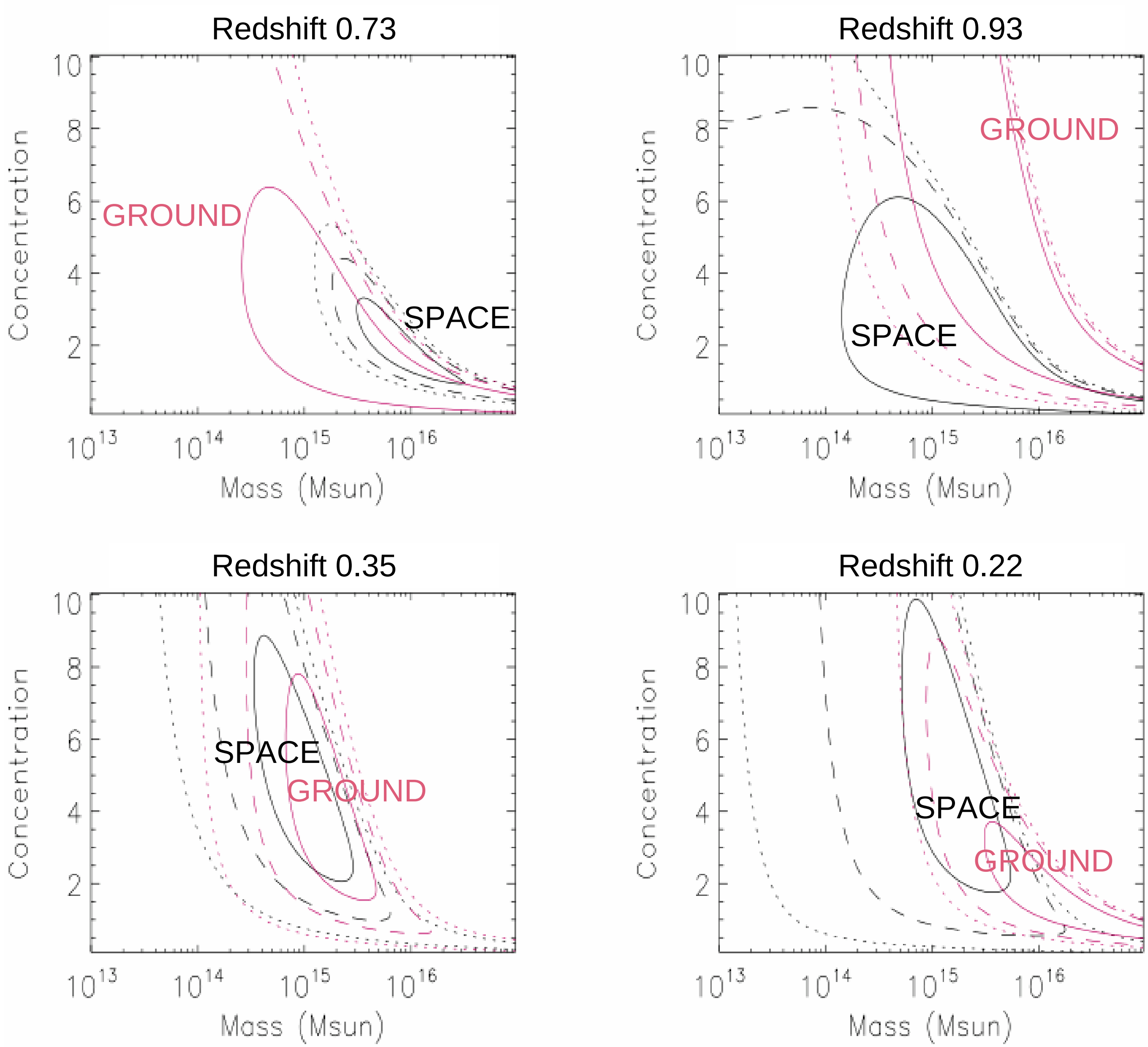
Ground vs space (B-mode/noise in mass maps)

R. Massey et al. (Nature 2007), M. Kasliwal et al. (Proc. AAS 2007)



Ground vs space (cluster detection over z range)

M. Kasliwal et al. (Proc. AAS 2007)



Lensing sensitivity with redshift