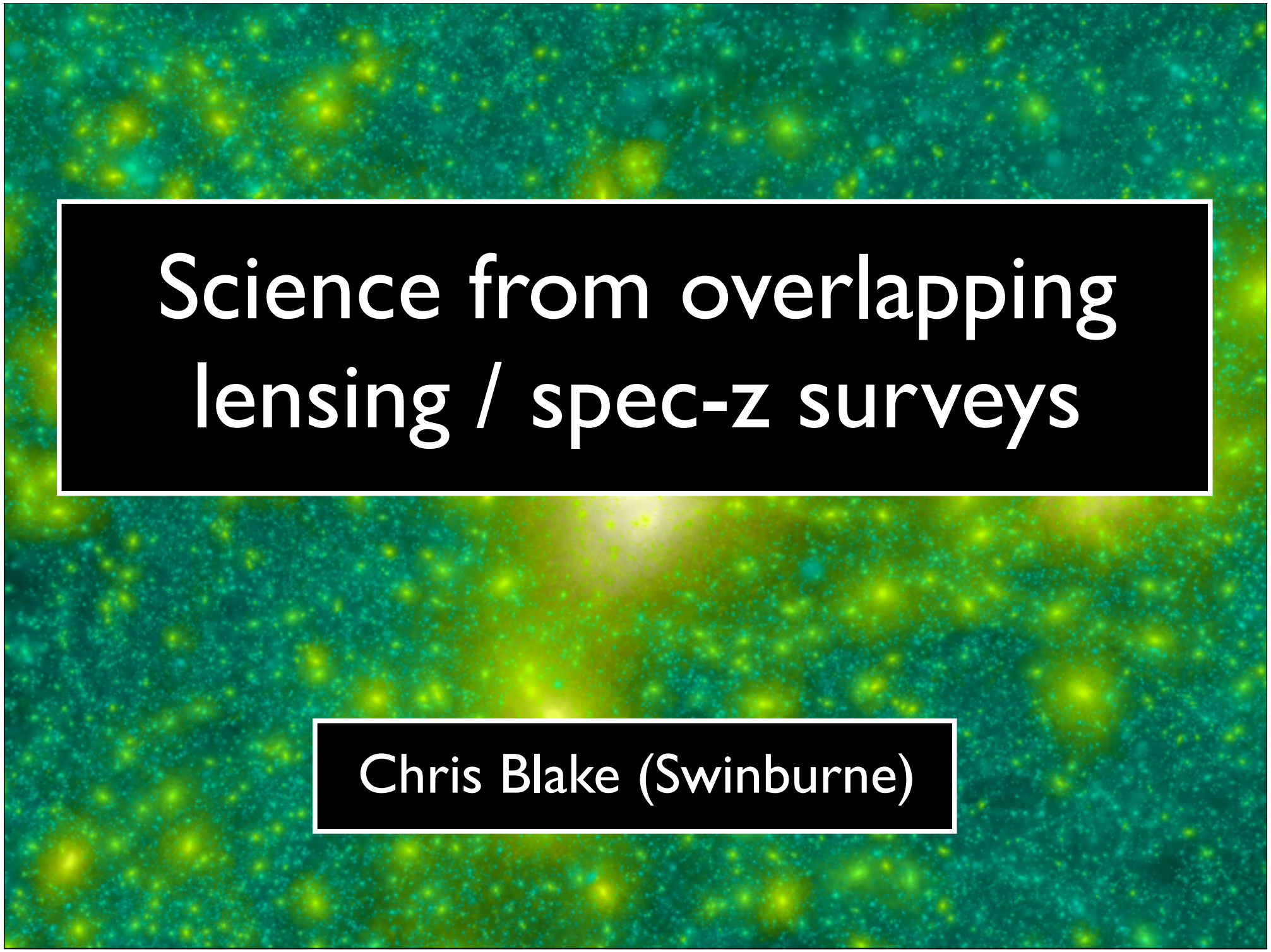
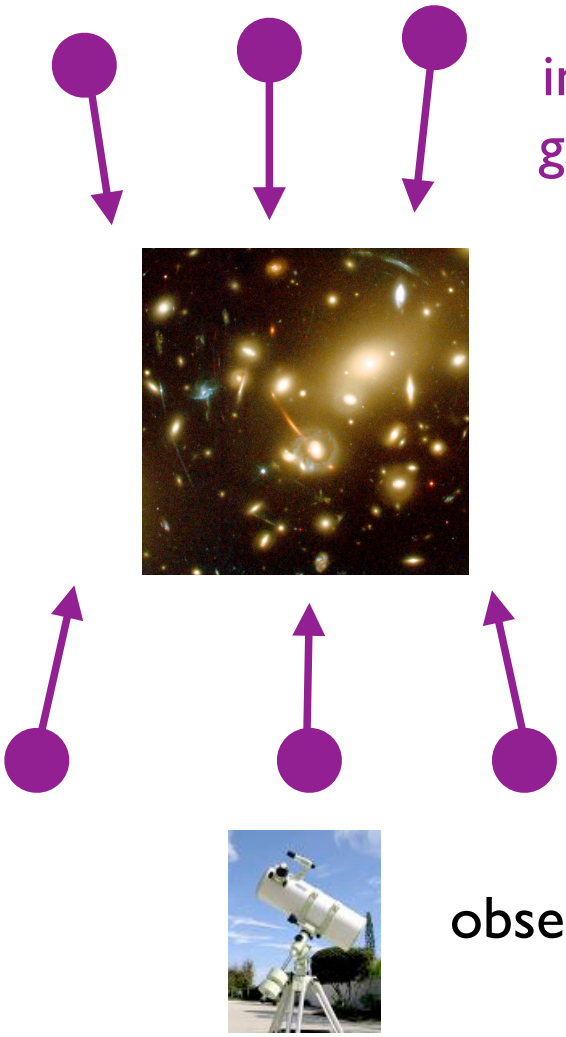
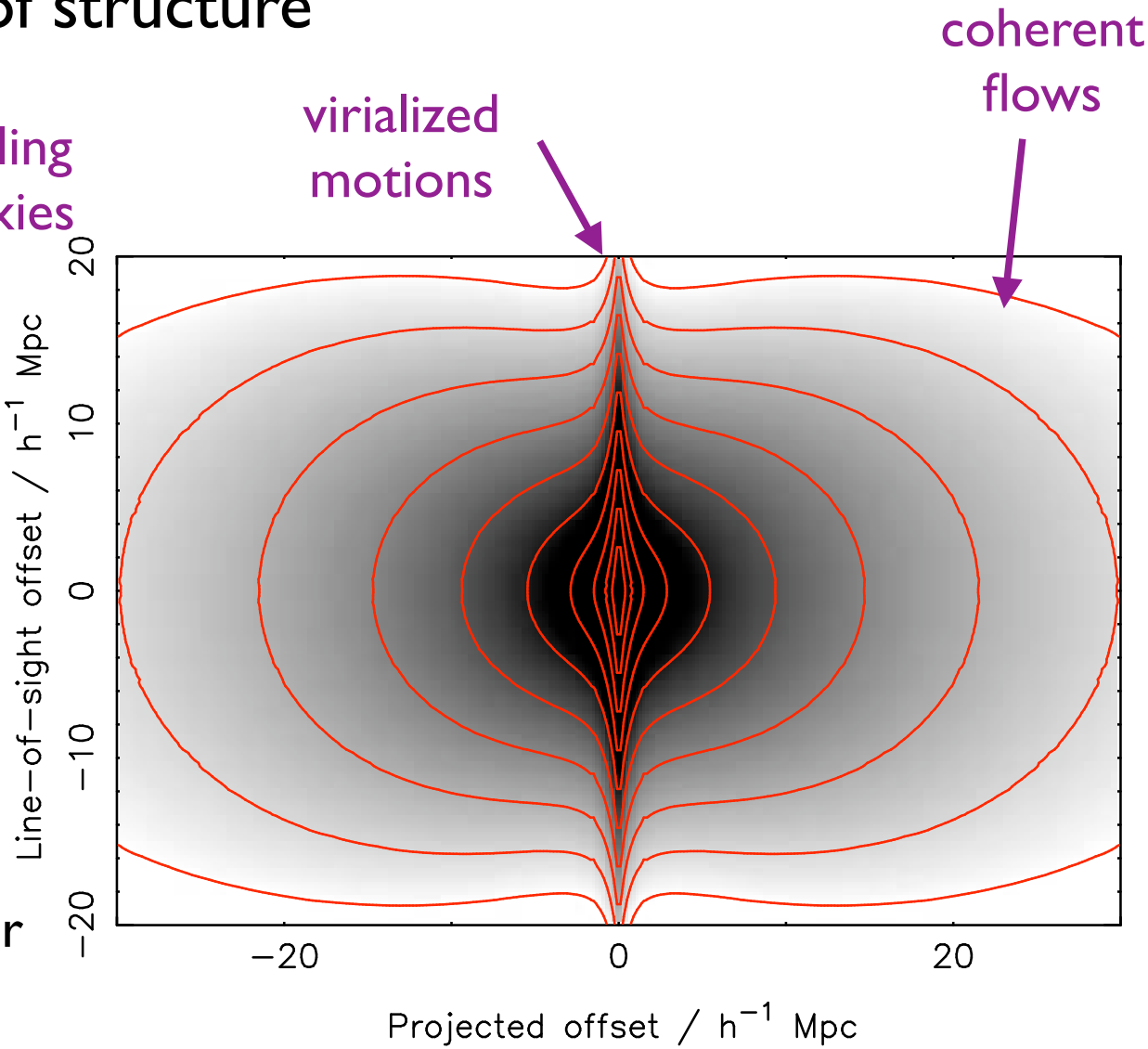

Science from overlapping lensing / spec-z surveys
Chris Blake (Swinburne)

Redshift-space distortions

- RSD allow spectroscopic galaxy surveys to measure the growth rate of structure





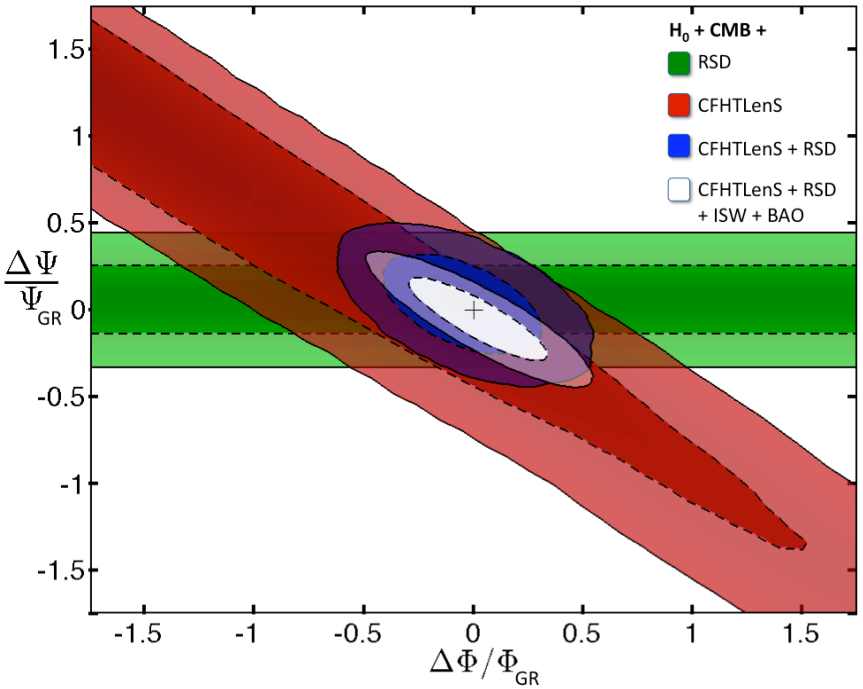
Why combination of lensing and RSD?

- Sensitive to theories of gravity in complementary ways
- General perturbations to FRW metric:

$$ds^2 = [1+2\psi(x,t)]\,dt^2 - a^2(t)\,[1-2\phi(x,t)]\,dx^2$$

- (ψ, ϕ) are metric gravitational potentials, identical in General Relativity but can differ in general theories
- Relativistic particles (e.g. light rays for lensing) collect equal contributions and are sensitive to $(\psi + \phi)$
- Non-relativistic particles (e.g. galaxies infalling into clusters) experience the Newtonian potential ψ

Applications



arXiv:1003.2185

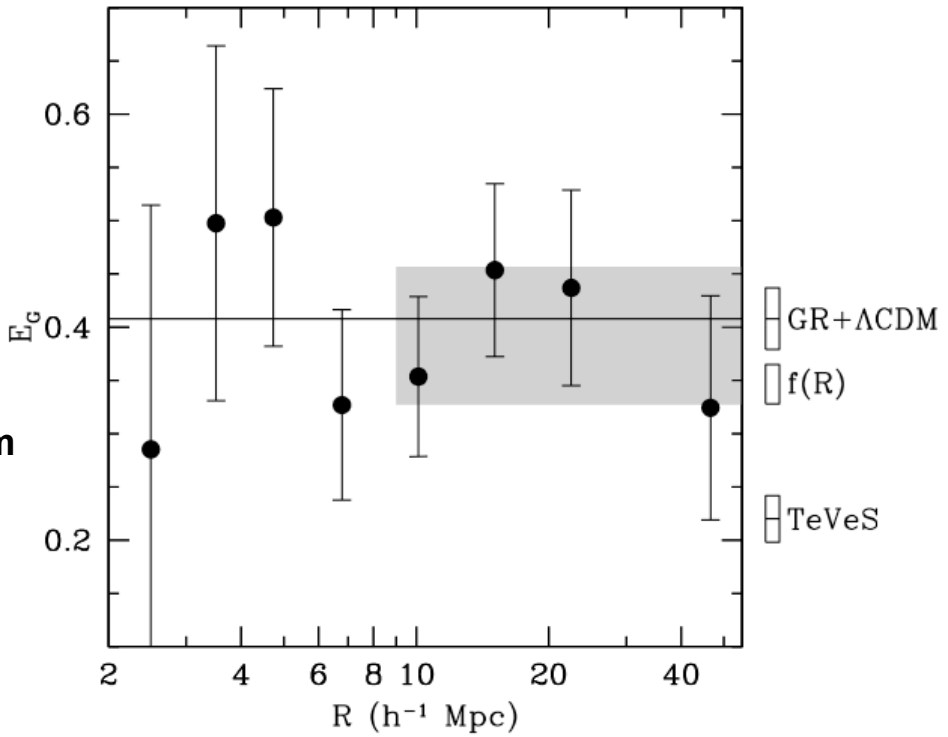
Confirmation of general relativity on large scales from weak lensing and galaxy velocities[1]

Reinabelle Reyes[1], Rachel Mandelbaum[1], Uros Seljak[2-4], Tobias Baldauf[2], James E. Gunn[1], Lucas Lombriser[2], Robert E. Smith[2]

arXiv:1212.3339

CFHTLenS: Testing the Laws of Gravity with Tomographic Weak Lensing and Redshift Space Distortions

Fergus Simpson[1⋆], Catherine Heymans[1], David Parkinson[2], Chris Blake[3], Martin Kilbinger[4,5,6], Jonathan Benjamin[7], Thomas Erben[8], Hendrik Hildebrandt[7,8], Henk Hoekstra[9,10], Thomas D. Kitching[1], Yannick Mellier[11], Lance Miller[12]

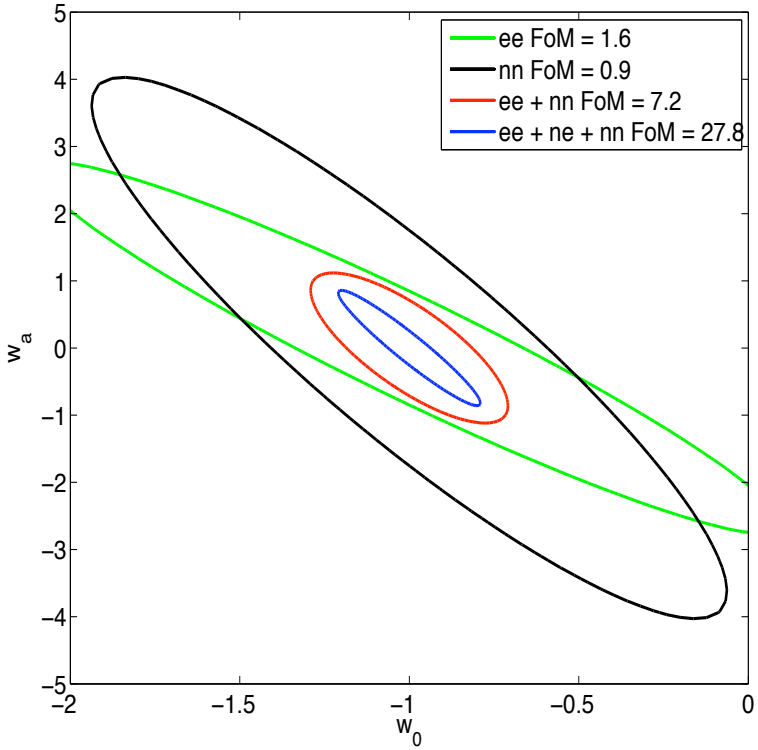


Overlaps of lensing and spec-z surveys

- Improvement of cosmological measurements through addition of galaxy-galaxy lensing
- [e.g. determines bias of lens sample which improves RSD measurements of lenses, especially when using multiple-tracer techniques, e.g. Cai & Bernstein (2012)]
- Spec-z survey allows definition of lens samples (e.g. groups, galaxy types) enabling a range of studies
- Understanding, calibration and risk mitigation of systematic errors (photo-z errors including outliers, intrinsic alignments, cosmic shear)

Overlaps of lensing and spec-z surveys

- Many recent papers considering impact for cosmology of same-sky vs. different-sky lensing/spec-z surveys



arXiv:1307.8062

Optimising Spectroscopic and Photometric Galaxy Surveys: Same-sky Benefits for Dark Energy and Modified Gravity

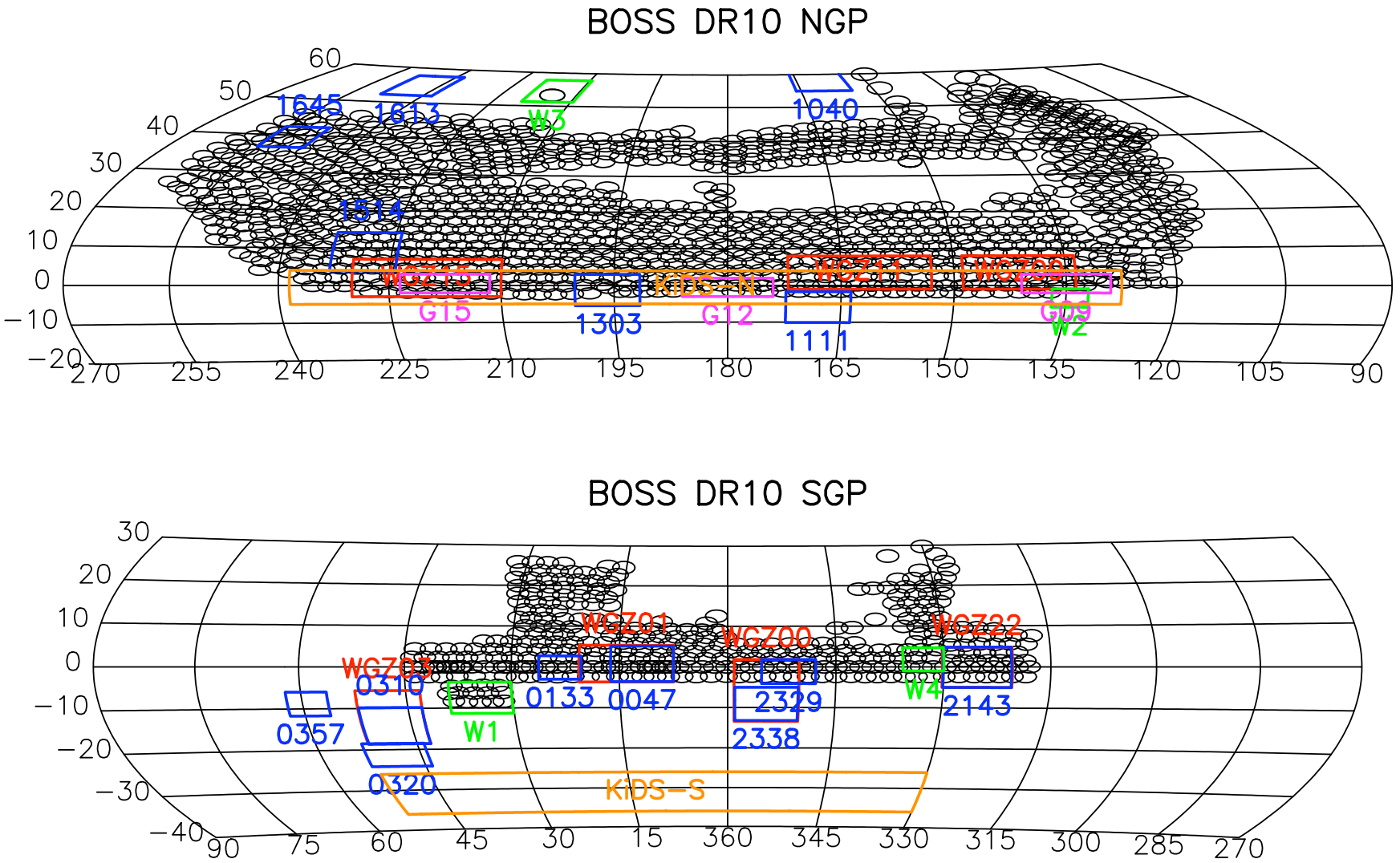
Donnacha Kirk[1], Ofer Lahav[1], Sarah Bridle[2], Stephanie Jouvel[3], Filipe B. Abdalla[1], Joshua A. Frieman[4]

on the sky, producing a joint data vector and full covariance matrix. We calculate a same-sky improvement factor, from the inclusion of these cross-correlations, relative to non-overlapping surveys. We find nearly a factor of 4 for dark energy and more than a factor of 2 for modified gravity. The exact forecast figures of merit and same-sky benefits can be radically affected by a range of forecasts assumption, which we explore

- For me a key issue is systematic error control

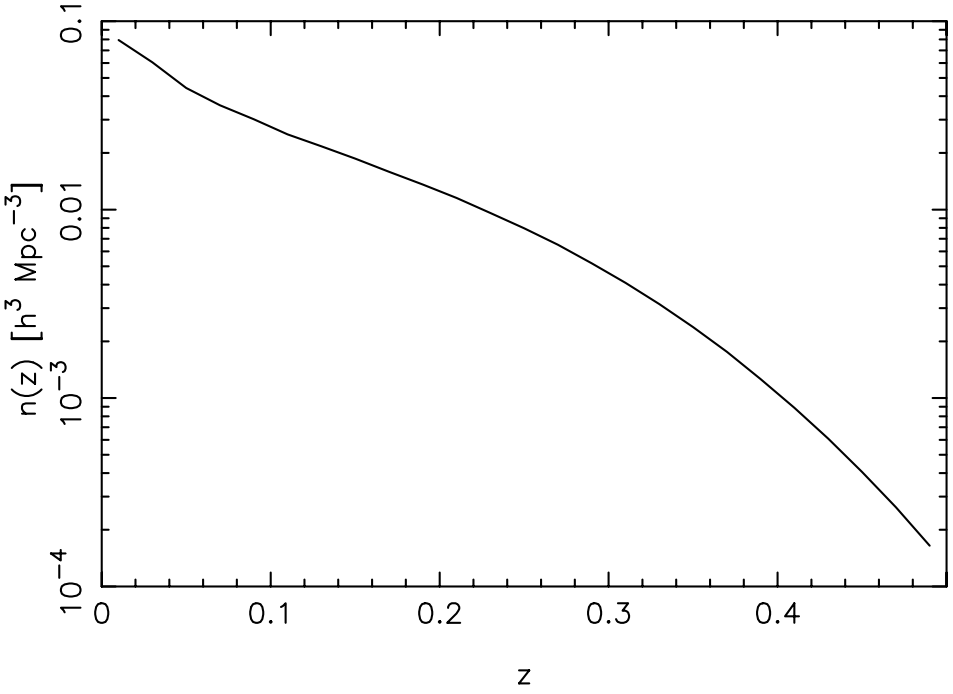
Overlaps of lensing and spec-z surveys

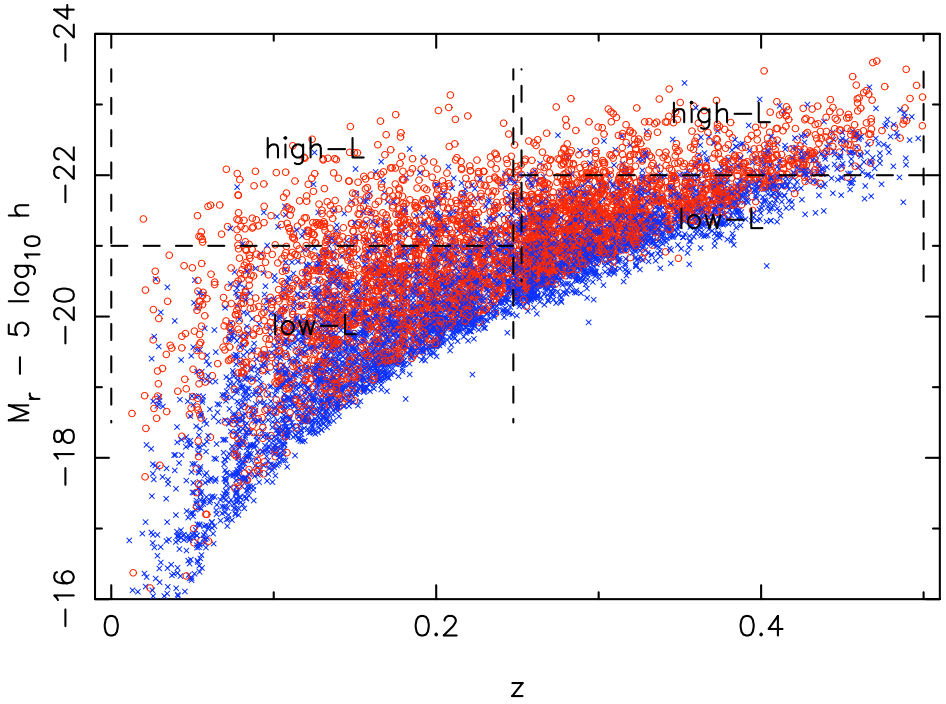
- KiDS shares an overlap with GAMA and BOSS



Galaxy And Mass Assembly (GAMA) survey

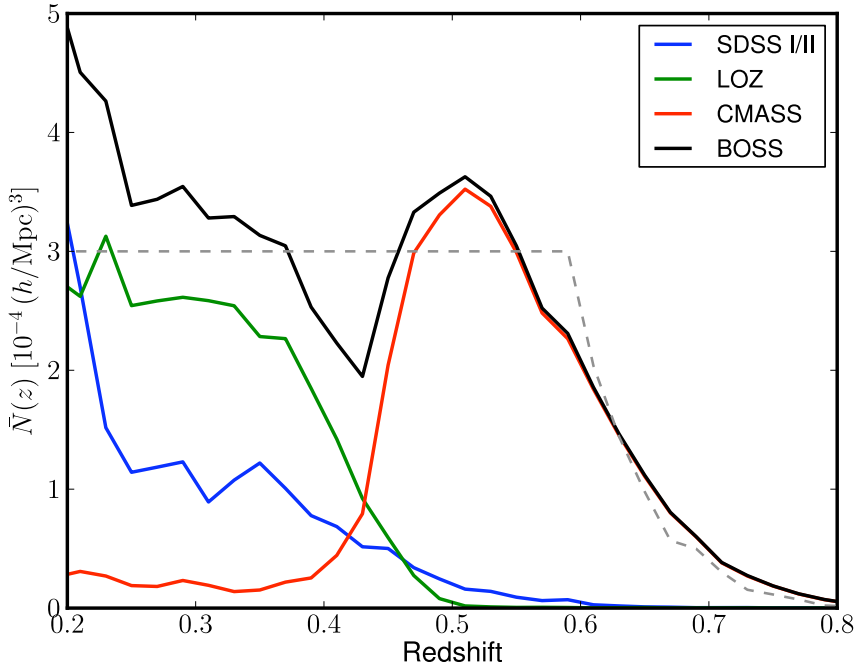
- Highly-complete (97%) r<19.8 (z<0.5) AAT spec-z survey
- GAMA2 NGP sample (180 sq deg over 09, 12, 15hr)
- Construction of group catalogue is key GAMA science





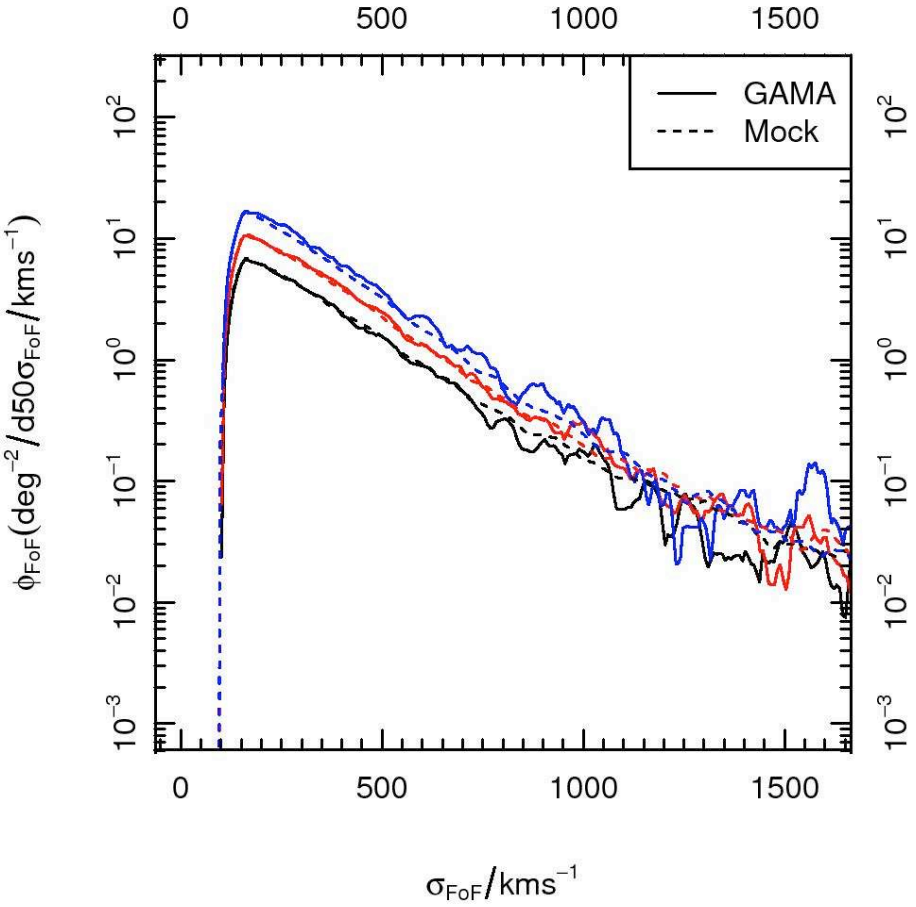
Baryon Oscillation Spectroscopic Survey (BOSS)

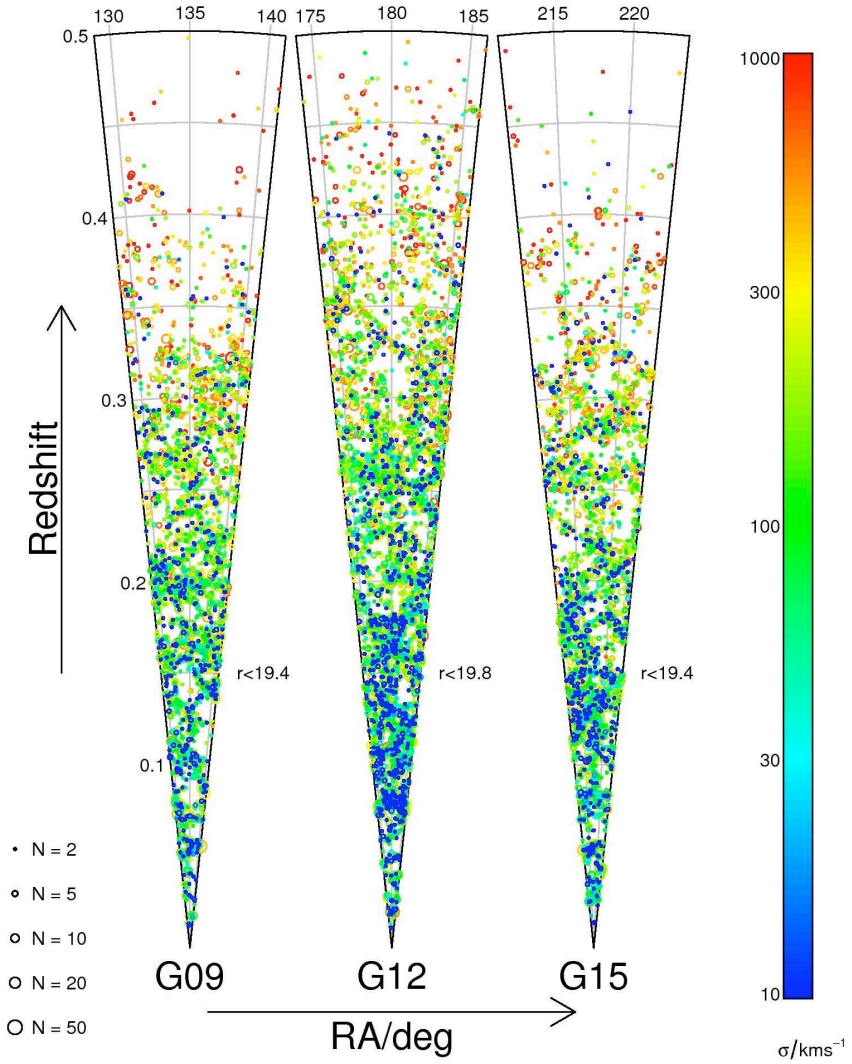
- SDSS spec-z survey of Luminous Red Galaxies covering $0.2<z<0.7$, 10,000 deg^2 (~500 deg^2 overlap with KiDS)
- DR10 sample soon to become available (LOZ, CMASS)
- Highly-biased sample so high signal in cross-correlations



GAMA data products

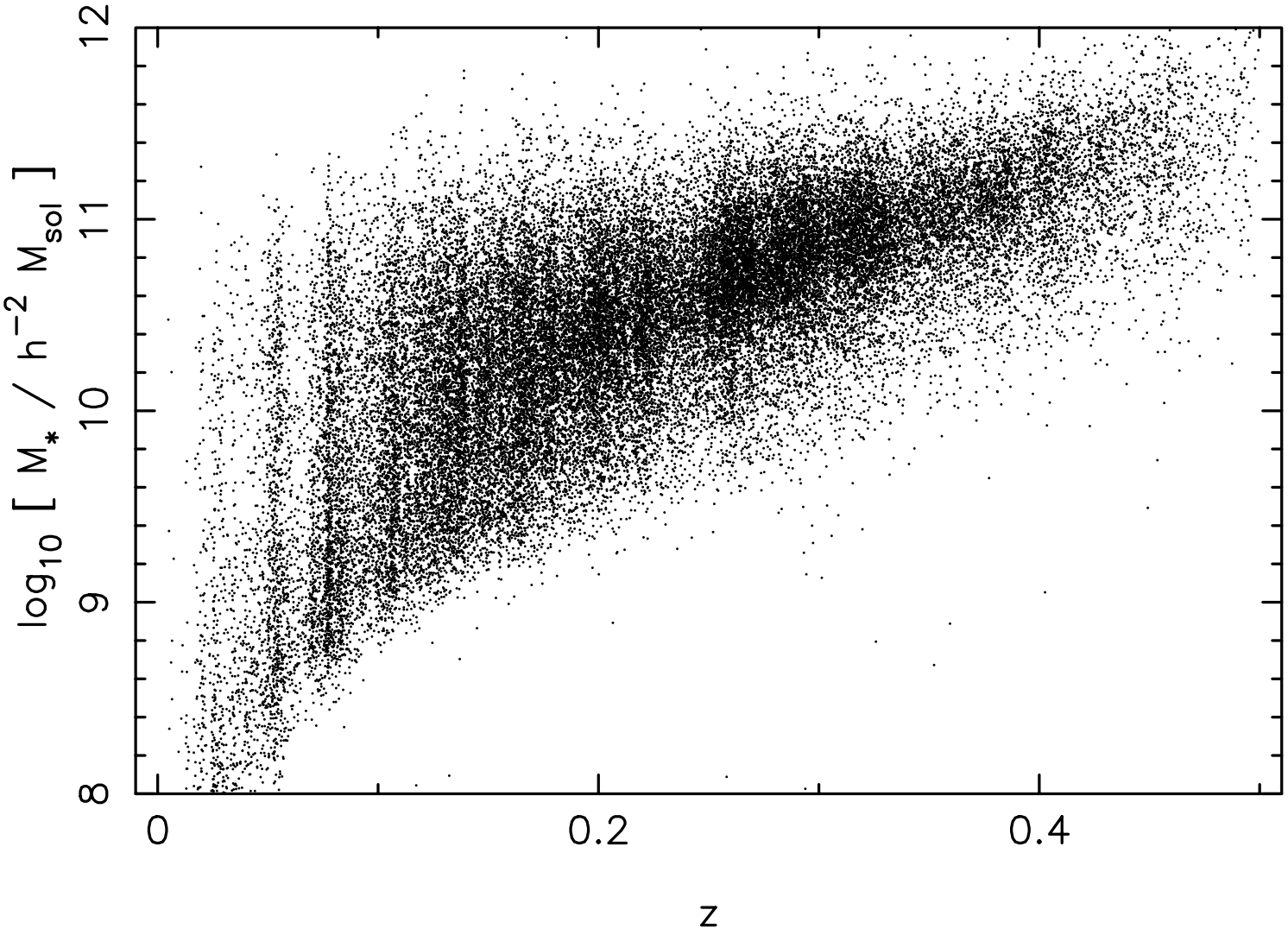
- Group catalogue (Robotham et al. 2011) arXiv:1106.1994





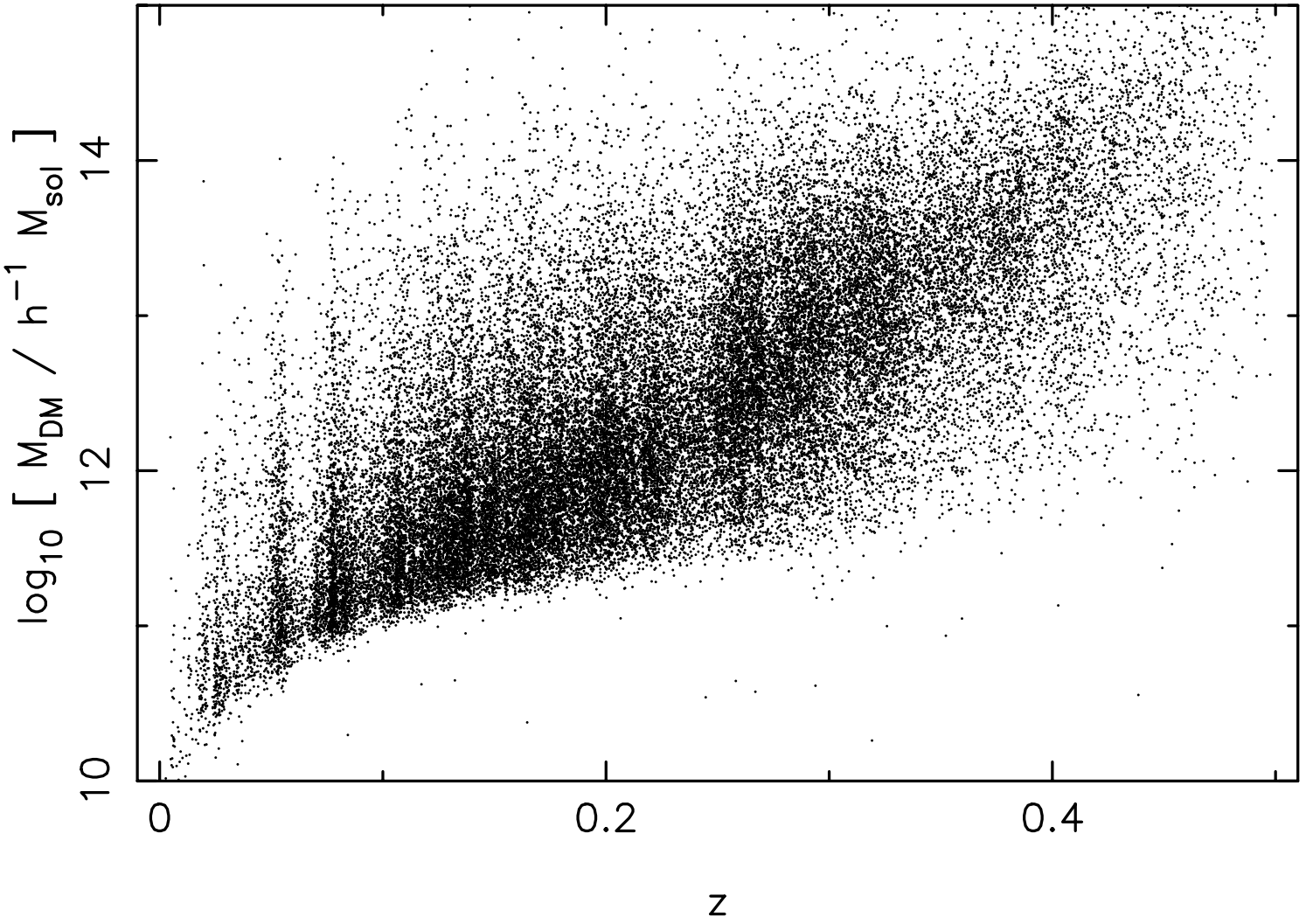
GAMA data products

- Stellar masses (Taylor et al. 2011) arXiv:1108.0635



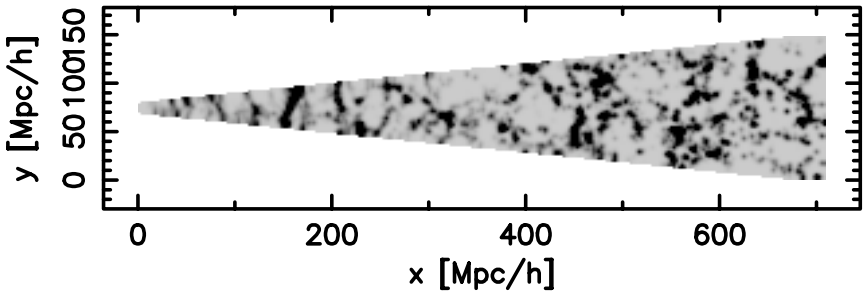
GAMA data products

- Dark matter halo masses [uses Moster et al. 2009]

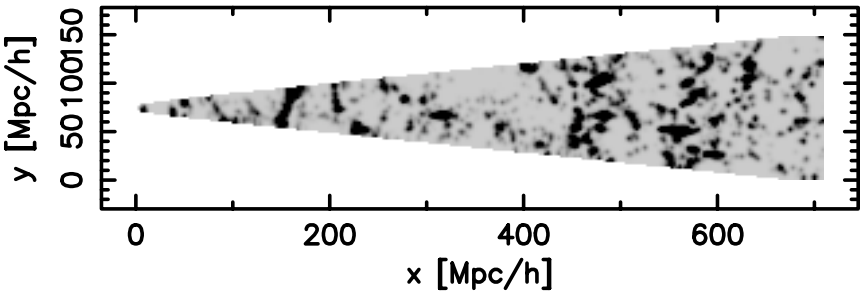


GAMA multiple-tracer RSD

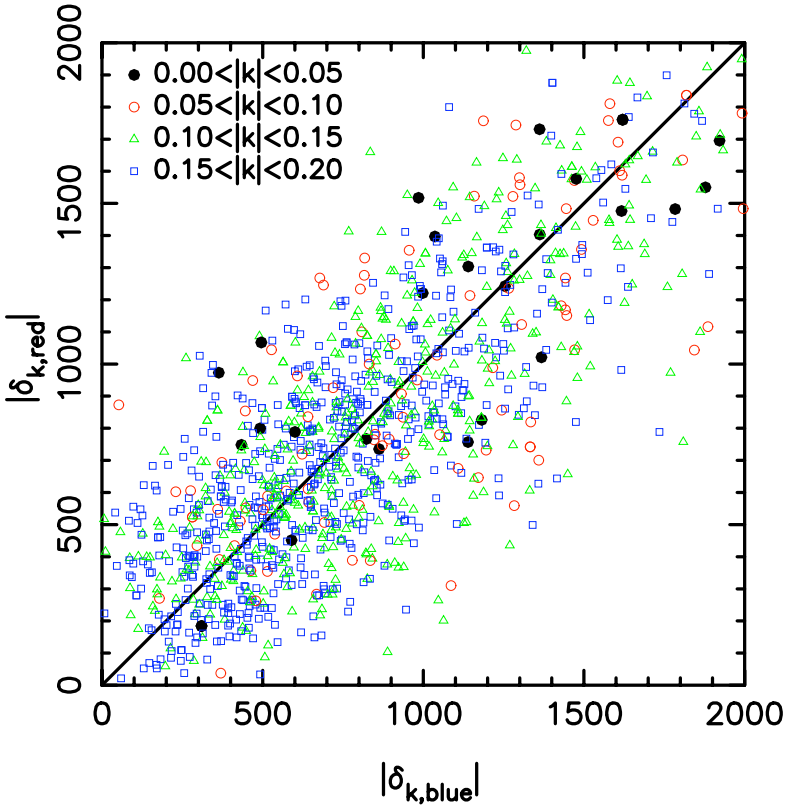
G09 blue galaxies λ=2 Mpc/h



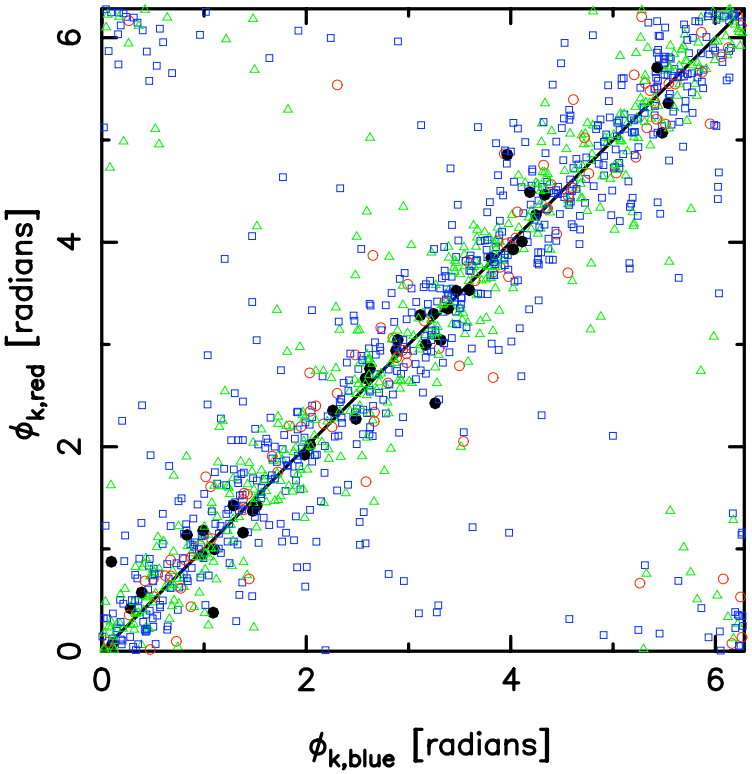
G09 red galaxies λ=2 Mpc/h



Amplitudes of Fourier modes

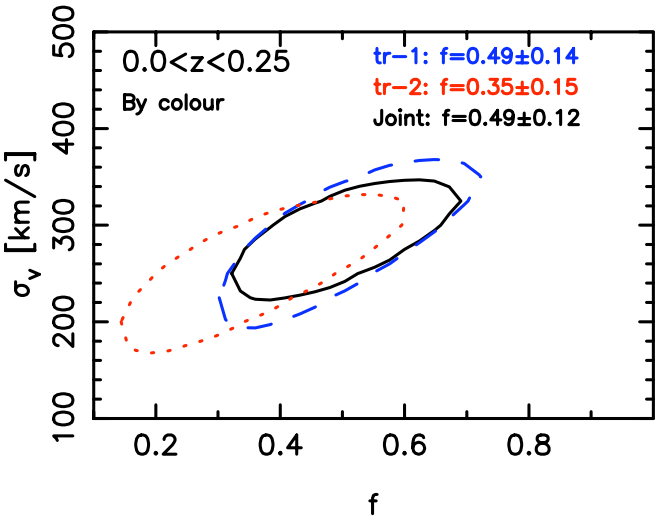


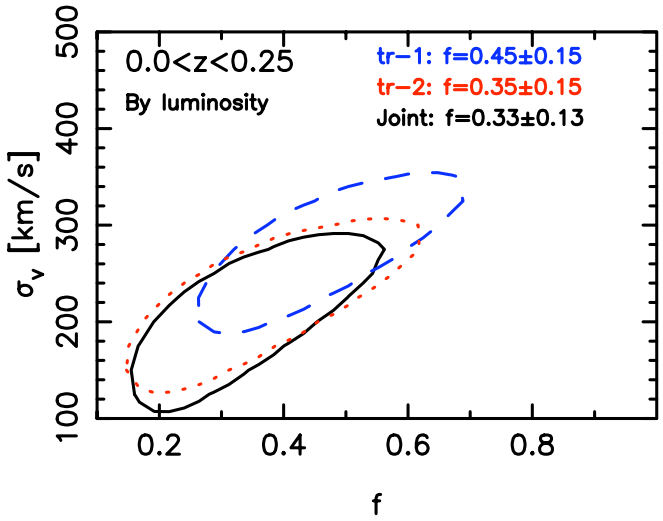
Phases of Fourier modes

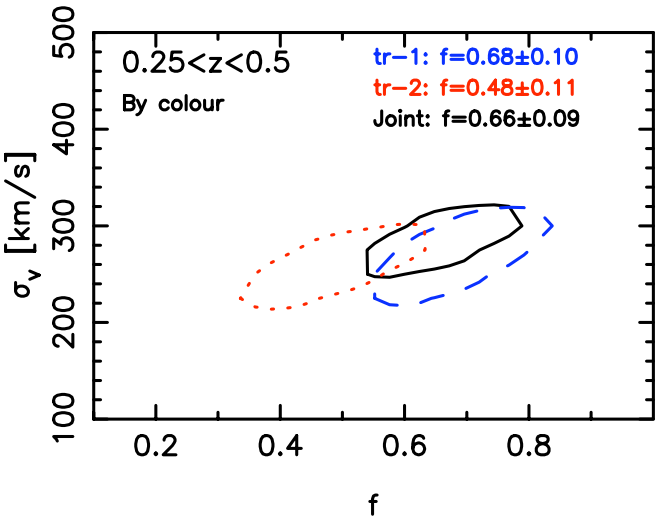


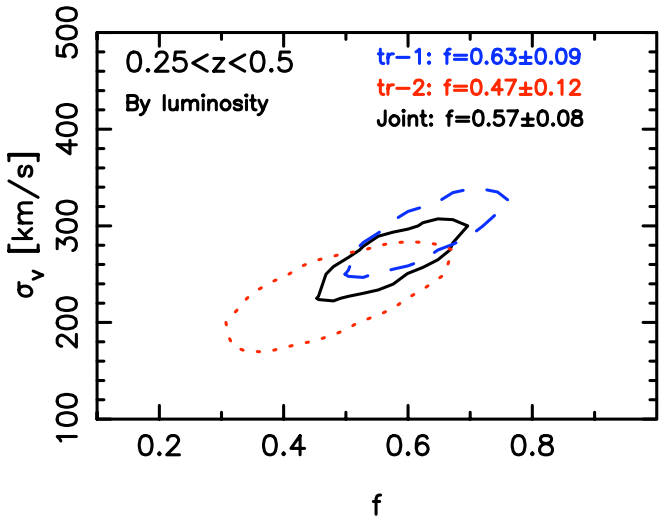
GAMA multiple-tracer RSD

- Multiple-tracer growth rate fits



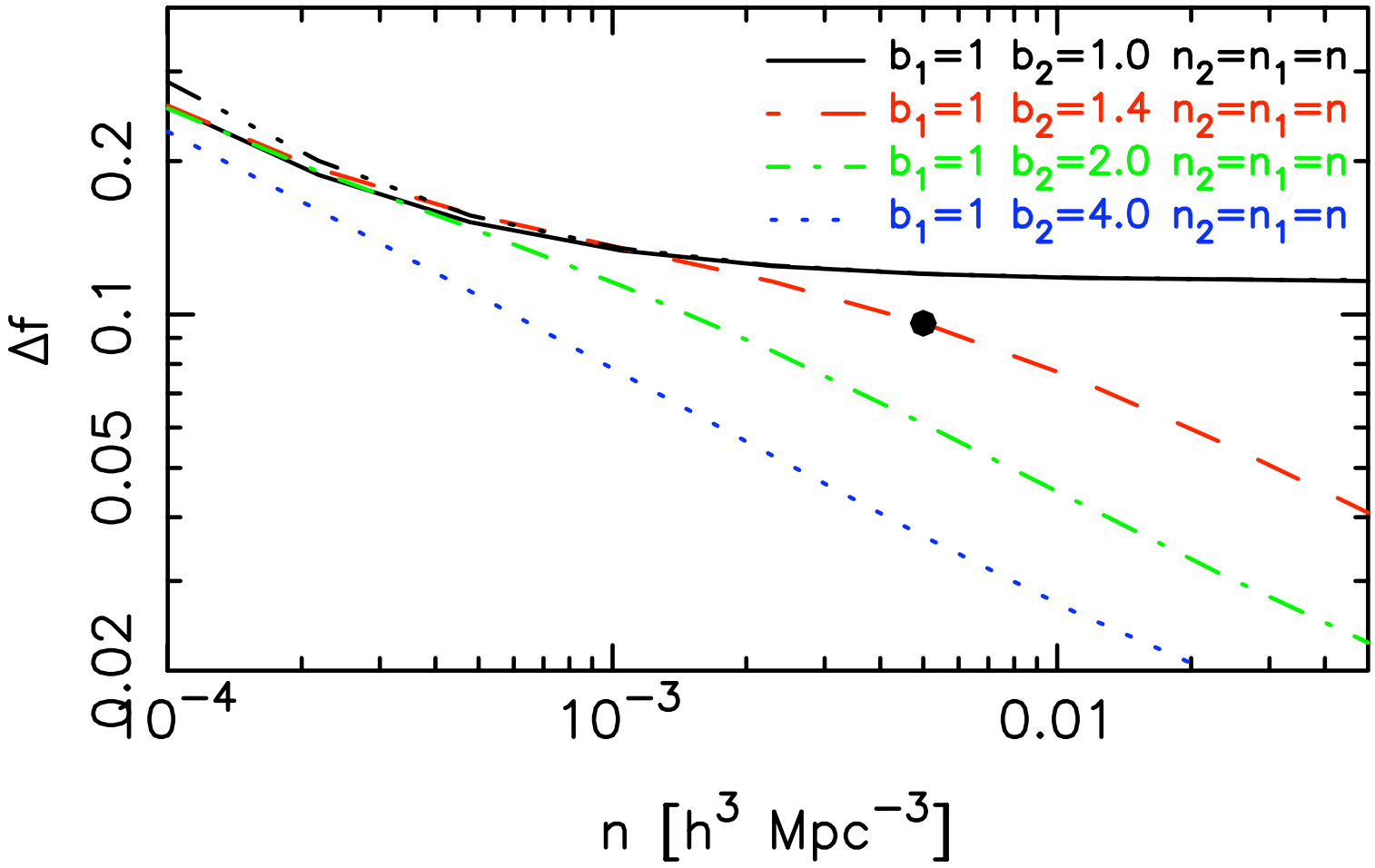




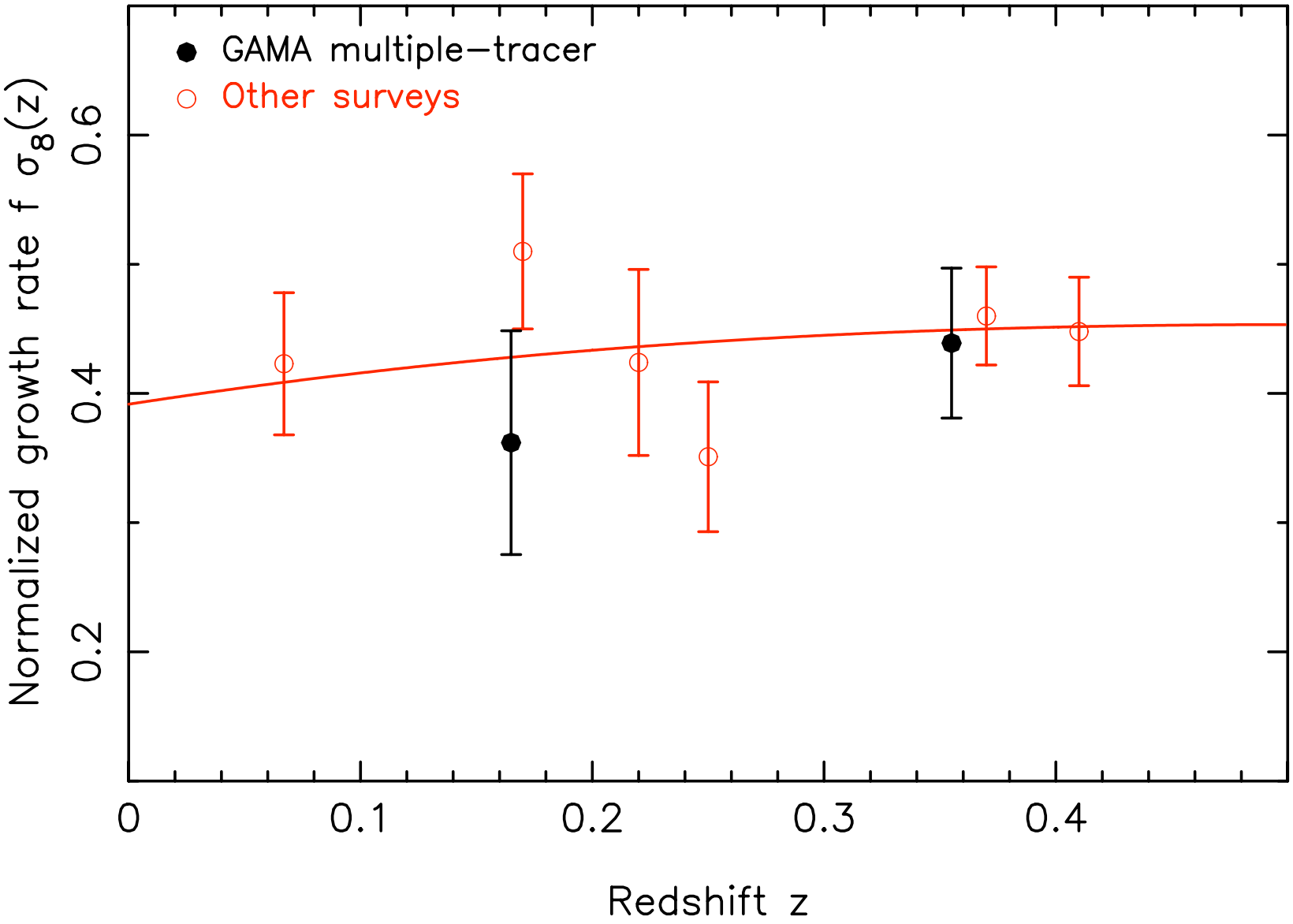


GAMA multiple-tracer RSD

- Fisher matrix forecasts for multiple-tracer RSD : very high galaxy number densities required!

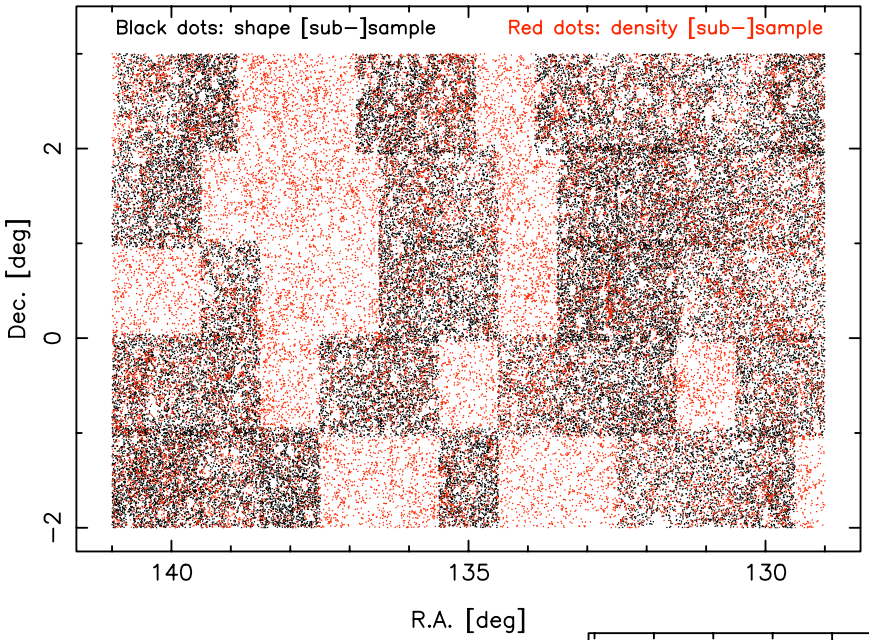


GAMA multiple-tracer RSD

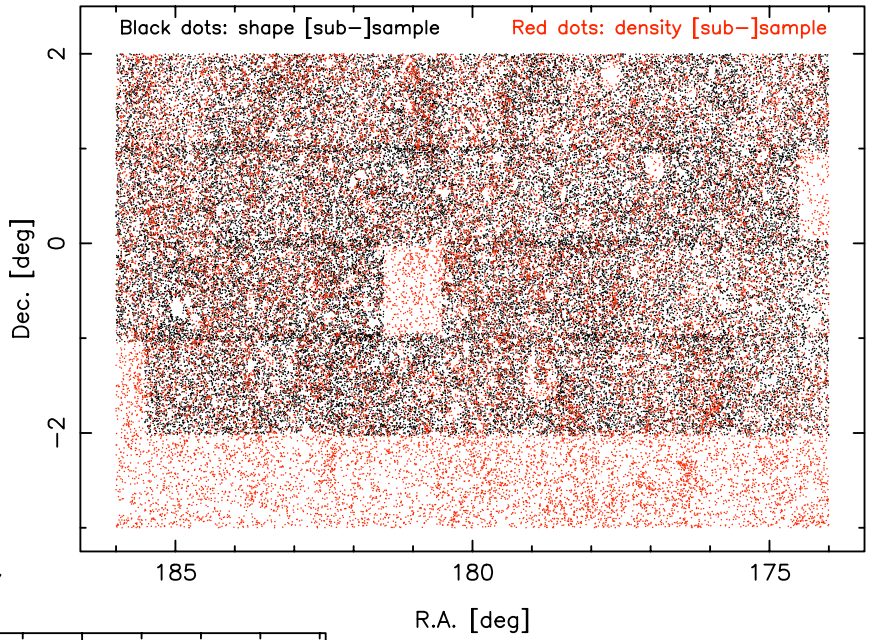


KiDS-GAMA cross-correlations

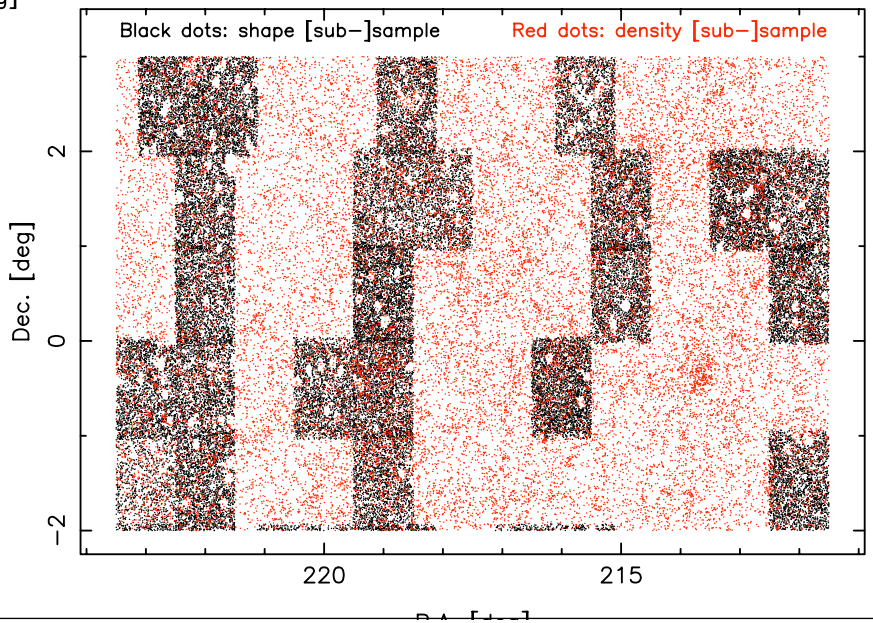
9-hr



12-hr

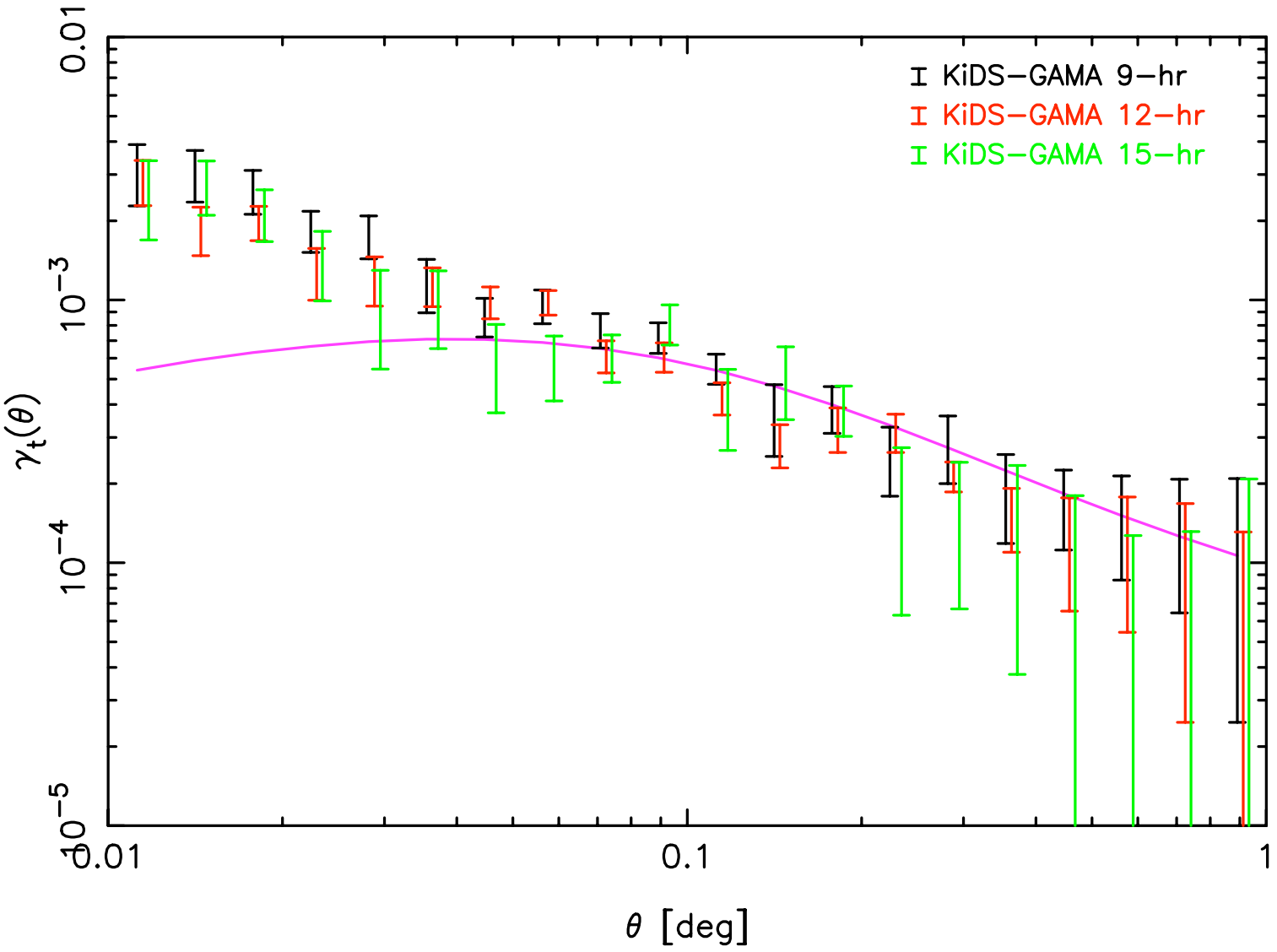


15-hr



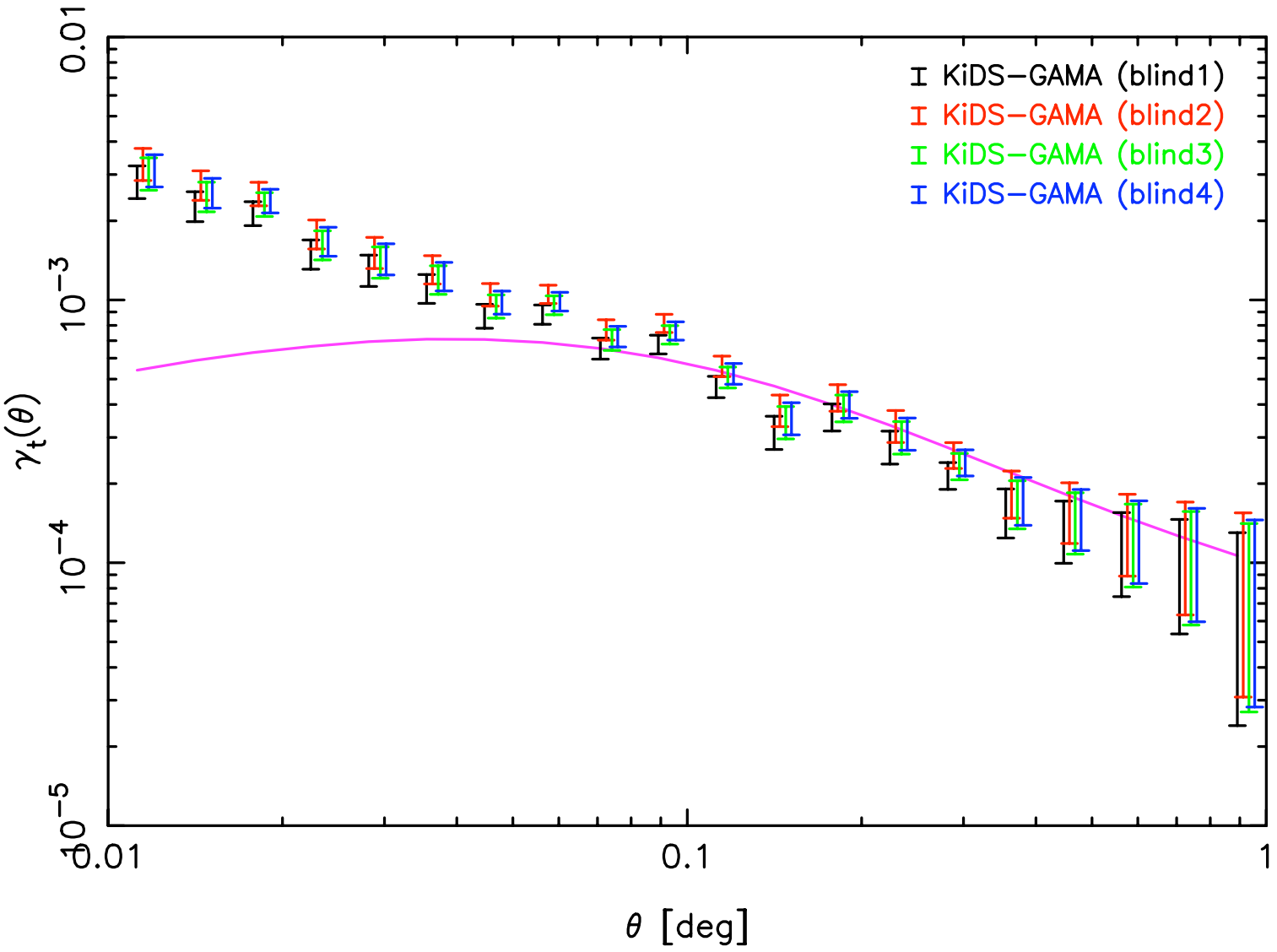
KiDS-GAMA cross-correlations

- Galaxy-galaxy lensing measurements in each region



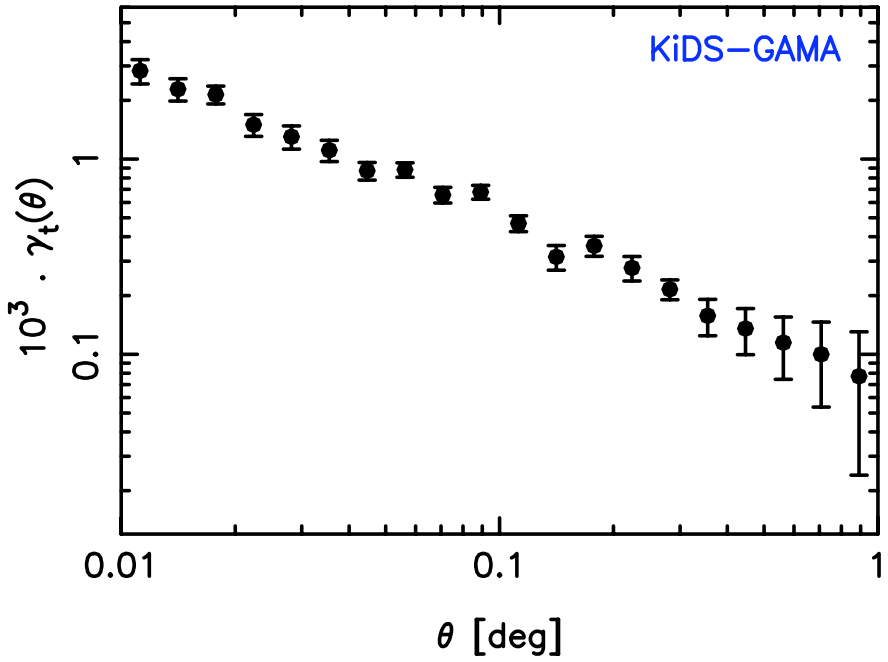
KiDS-GAMA cross-correlations

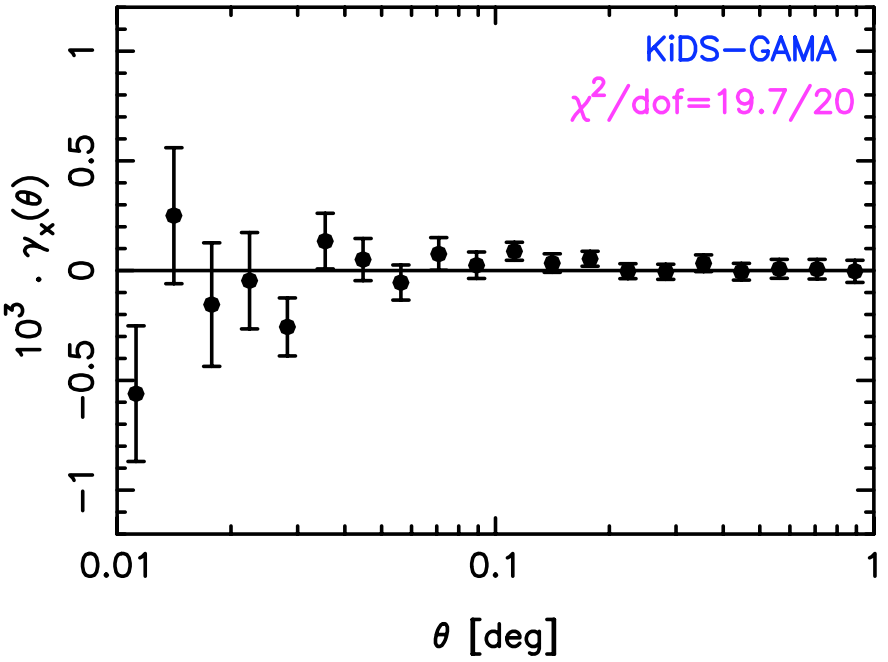
- Combined galaxy-galaxy lensing measurements



KiDS-GAMA cross-correlations

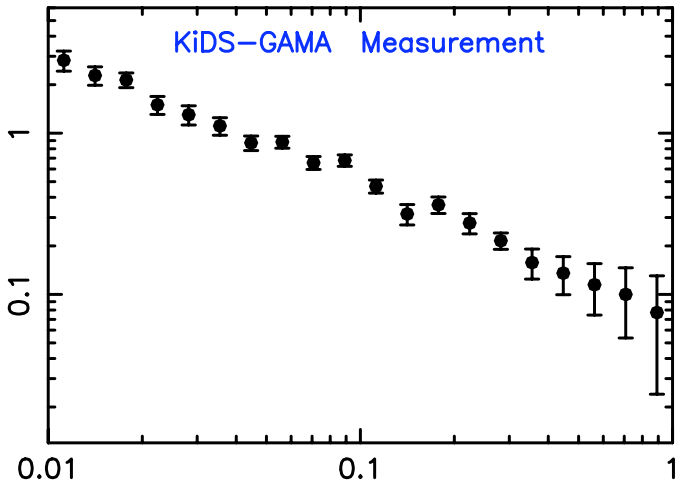
- Shape measurement systematics tests (1)

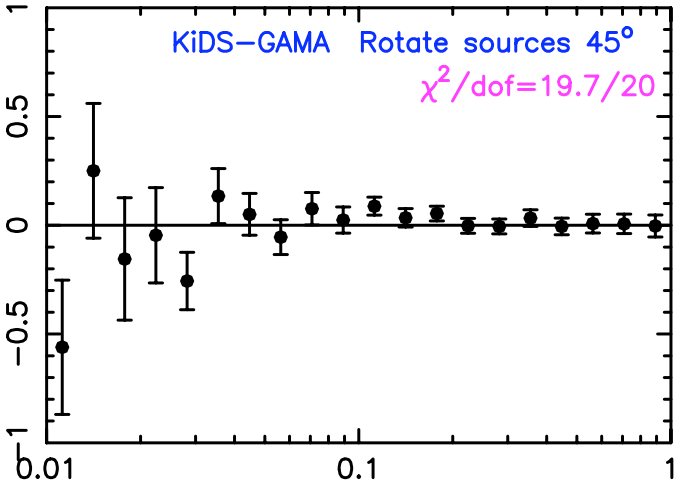


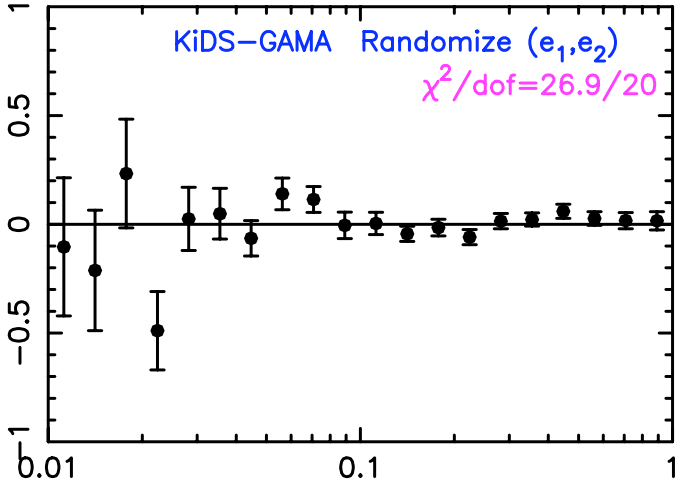


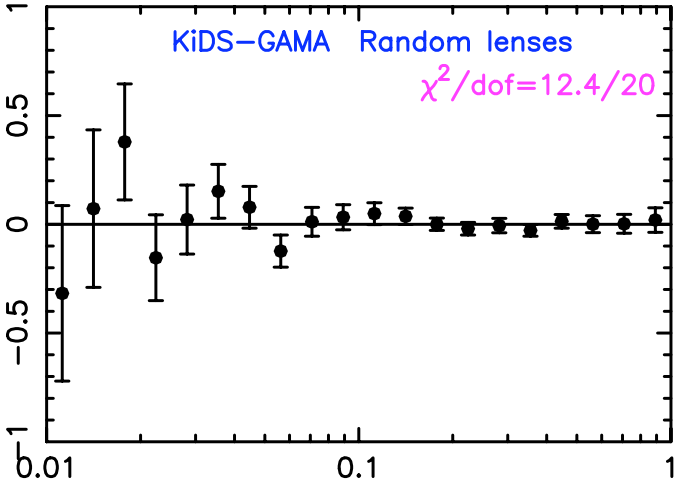
KiDS-GAMA cross-correlations

- Shape measurement systematics tests (2)



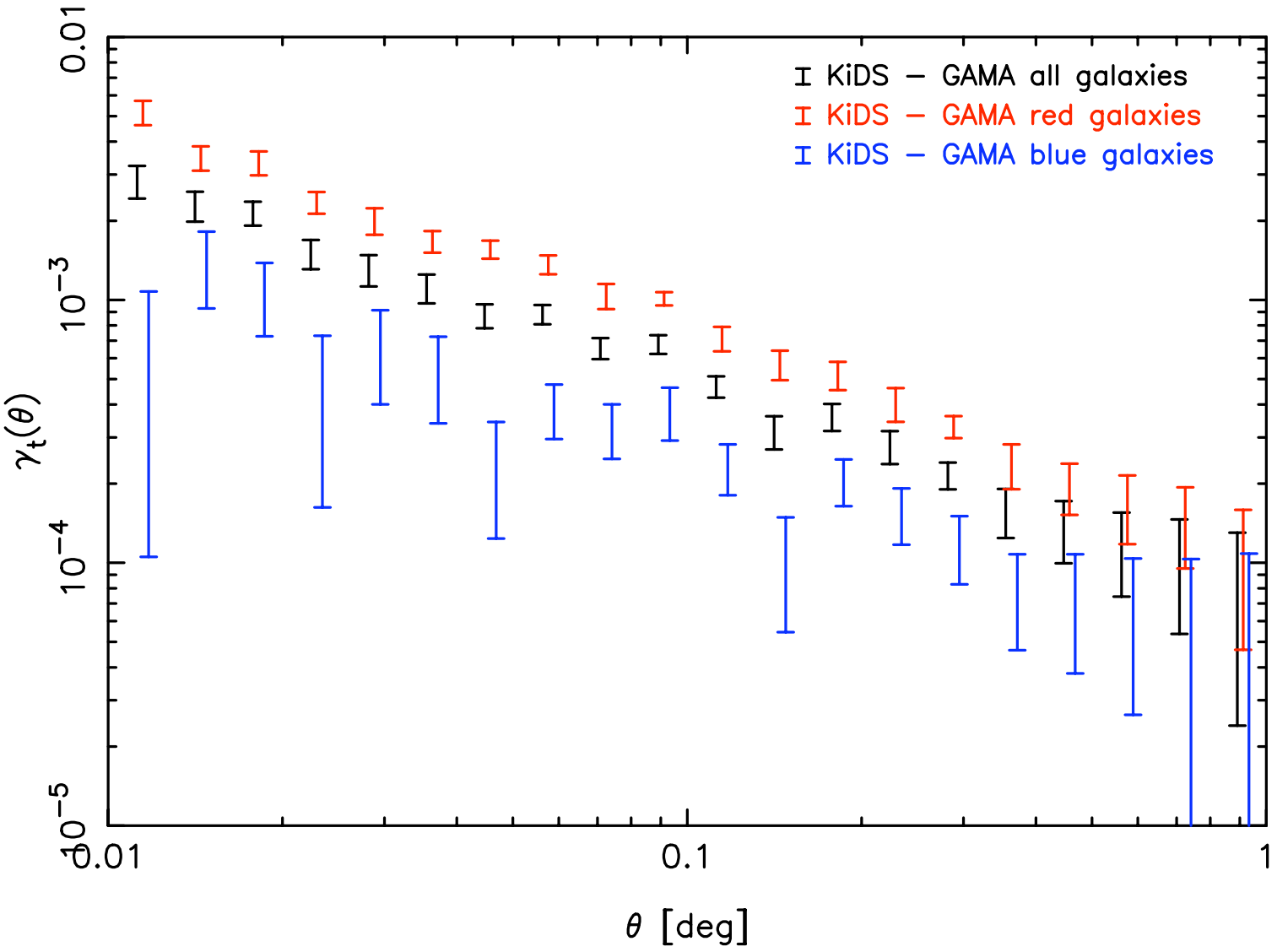






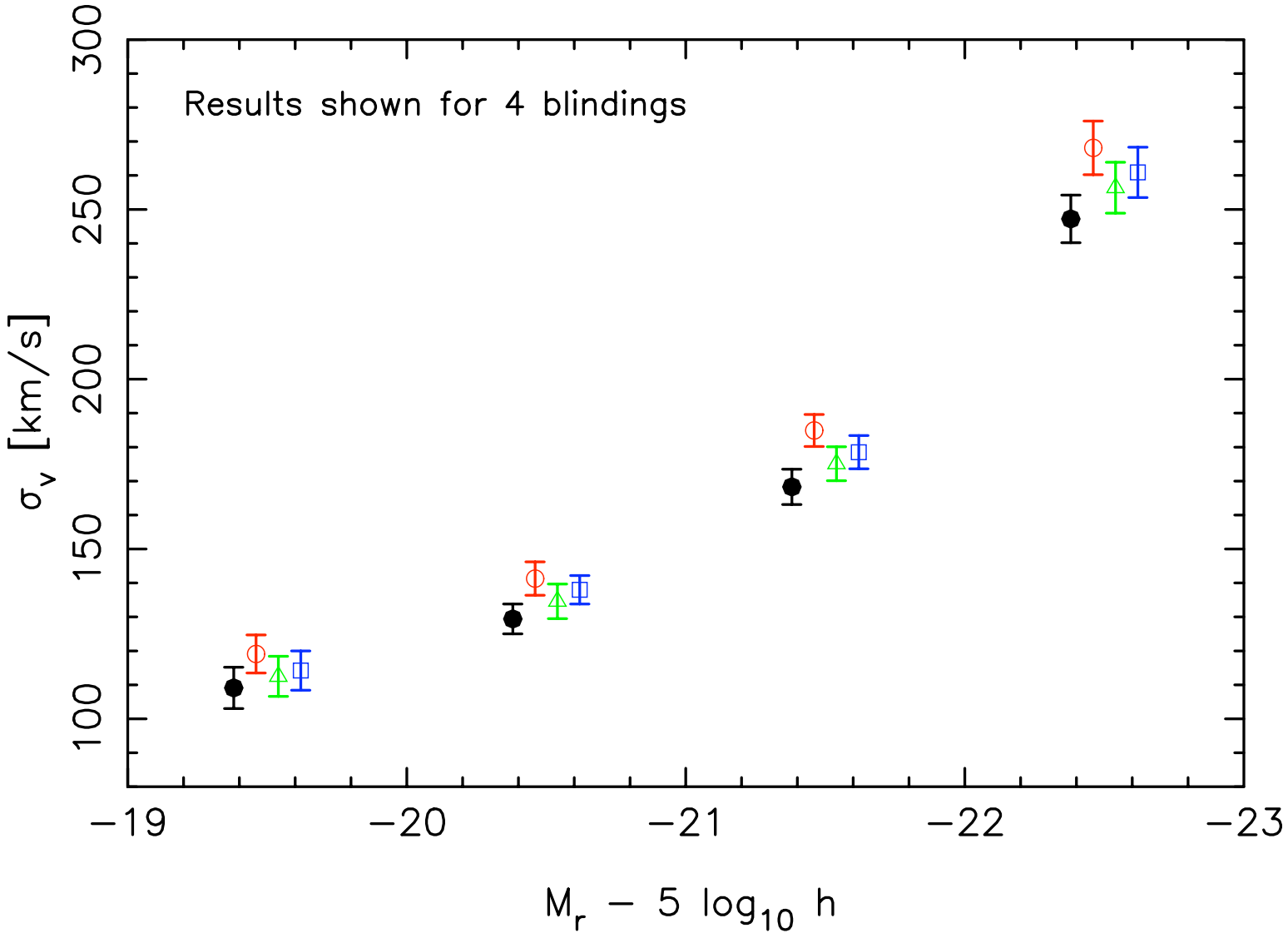
KiDS-GAMA cross-correlations

- Galaxy-galaxy lensing split by lens colour



KiDS-GAMA cross-correlations

- Galaxy-galaxy lensing split by lens luminosity



Use of N-body simulations

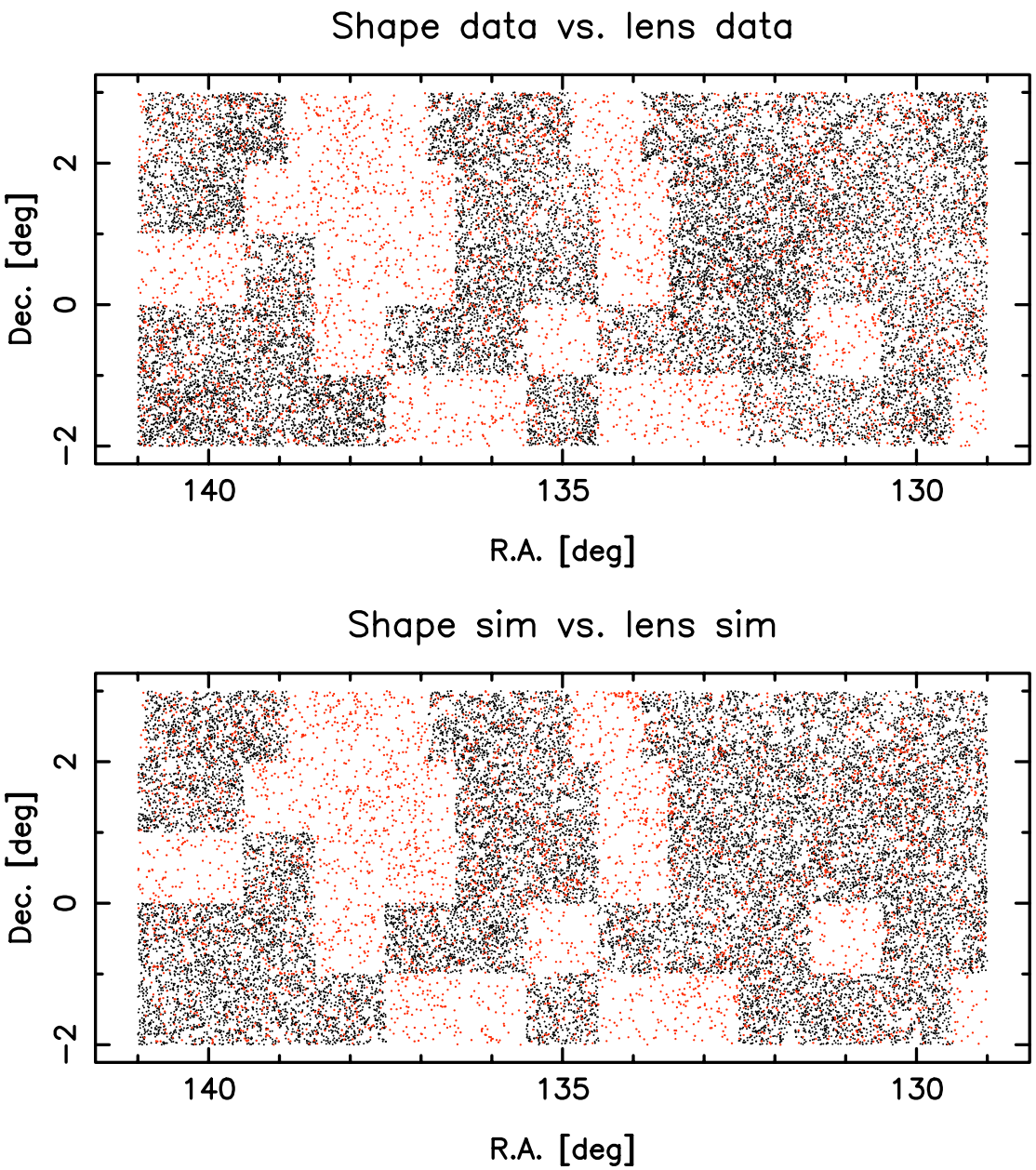
arXiv:1202.2332

Gravitational Lensing Simulations I : Covariance Matrices and Halo Catalogues

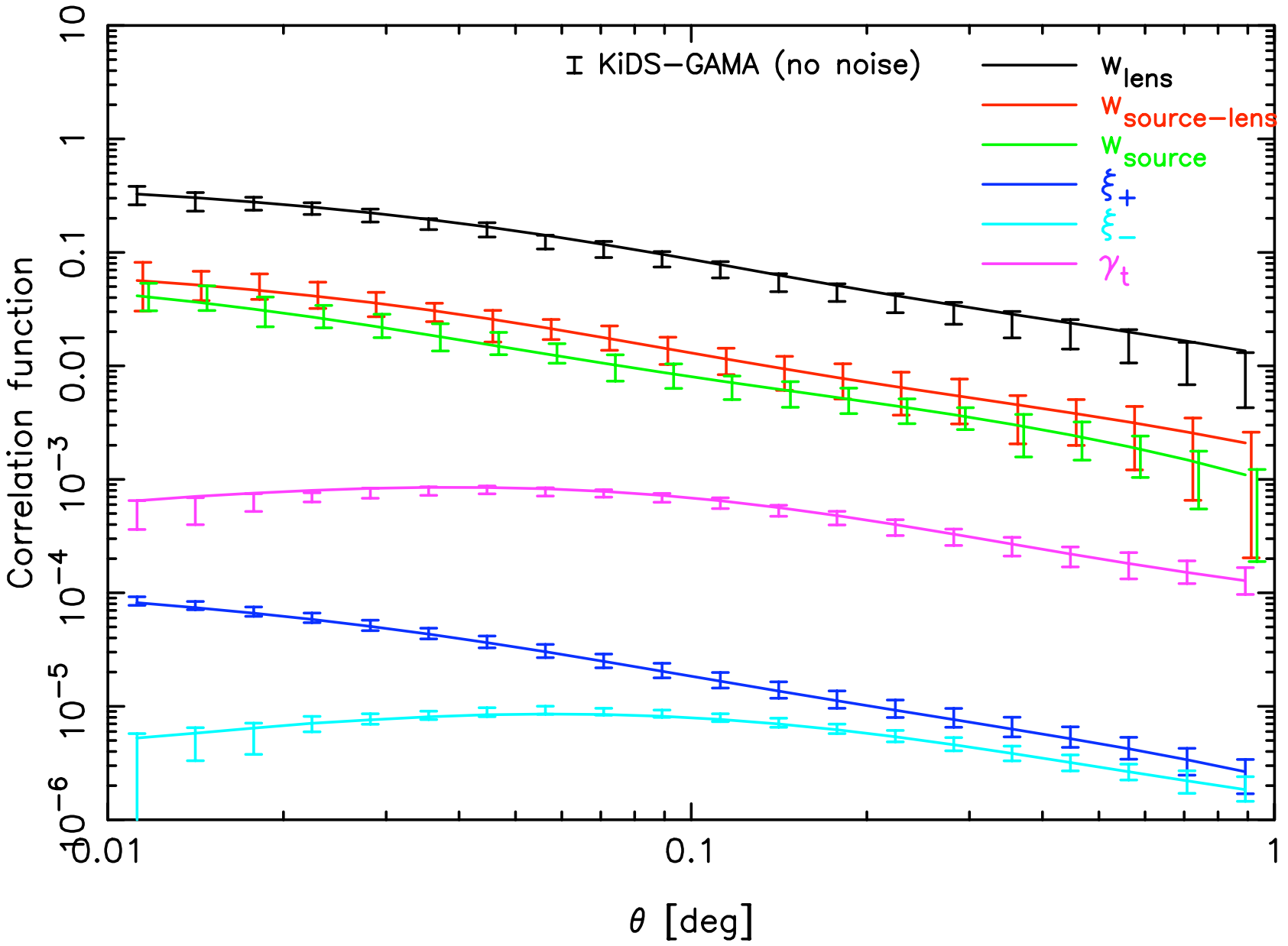
Joachim Harnois-Déraps[1,2⋆], Sanaz Vafaei[3]† and Ludovic Van Waerbeke[3]‡
[1] *Canadian Institute for Theoretical Astrophysics, University of Toronto, M5S 3H8, Canada*
[2] *Department of Physics, University of Toronto, M5S 1A7, Ontario, Canada*
[3] *Department of Physics and Astronomy, University of British Columbia, Vancouver, V6T 1Z1, B.C., Canada*

- Harnois-Deraps & van Waerbeke are generating ~1000 500 Mpc/h P^3M simulations with ray-tracing
- I subsample the simulations to generate mock catalogues matching source and lens N(z)'s, number densities, angular selection functions, photo-z errors
- Simulations used for constructing covariance matrices, pipeline/modelling tests ...

Use of N-body simulations



Use of N-body simulations



KiDS project interests ...

- Self-consistent gravity fits combining KiDS-GAMA cross-correlations with GAMA multiple-tracer RSD
- Development of general cosmology pipelines including Planck, cosmic shear, galaxy-galaxy lensing, etc.
- Construction of mock catalogues from KiDS simulations including selection functions and HOD
- Photo-z / spec-z cross-correlations applying latest techniques to determine photo-z distributions, such as McQuinn & White (2013)