Shape measurement systematics and cluster masses

(or: what can STEP do for us

...and what do we need to do ourselves?)

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Always significantly more stringent constraints on systematics of cosmic shear measurements (~1% for current data sets), than for weak cluster lensing

Can the cluster lensing community just piggyback on their efforts ?

Unfortunately, not entirely…

The Shear TEsting Program

- Original motivation: Discrepant σ_8 values from different cosmic shear measurements.
- Blind test on simulated data
- Initial goals (STEP1 and STEP2):

  - Verify that shear measurement methods were sufficiently accurate for existing data sets (statistical errors > systematics).

  - Better understanding of the properties of each method (STEP1 as training for STEP2)
- Current goal (GREAT08 and STEP4):

  - Method sufficiently accurate for planned surveys (DES, Pan-STARRS, Euclid, JDEM, LSST,…)

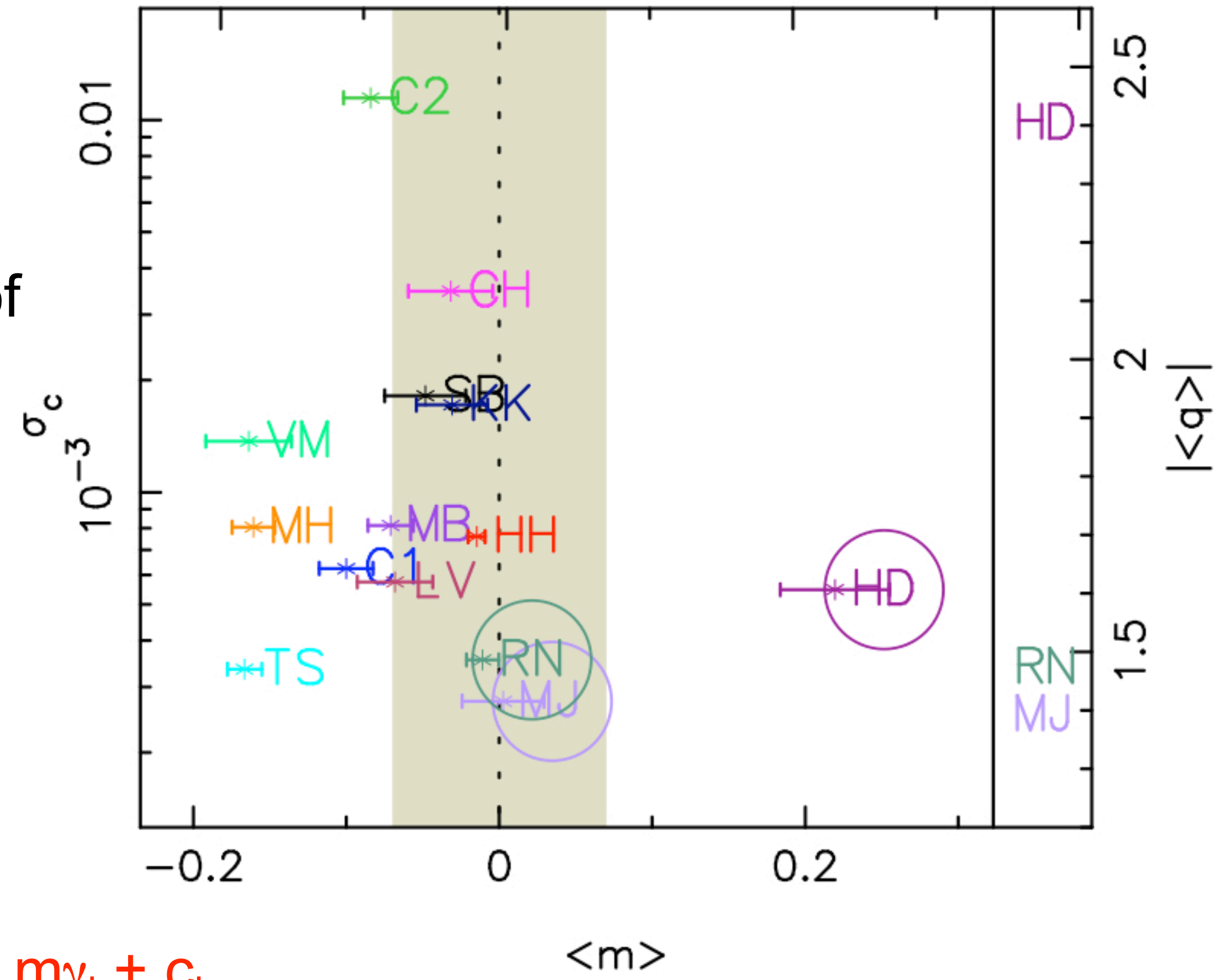
STEP1

- Similar to ~1h exposure on ~4m class ground-based telescope, FWHM= 0.9”
- Galaxies modeled as deVaucouleurs bulge + exponential disk
- 5 different shear values γ_1 = (0, 0.005, 0.01, 0.05, 0.1); γ_2 = 0, constant across each field
- 6 different PSFs, spatially constant (but we were not allowed to use this fact)

PSF ID	PSF type	Ellipticity
0	no anisotropy	0.00
1	coma	$\sim$ 0.04
2	jitter, tracking error	$\sim$ 0.08
3	defocus	$\sim$ 0.00
4	astigmatism	$\sim$ 0.00
5	triangular (trefoil)	0.00

(Heymans et al. 2006)

Some implementations of the KSB+ method (CH, HH) do as well as the best of the newer methods



$\gamma_i - \gamma_i^{true} = q\,(\gamma_i^{true})^2 + m\gamma_i + c_i$

(i=1,2)

|<q>|: non-linear response to shear

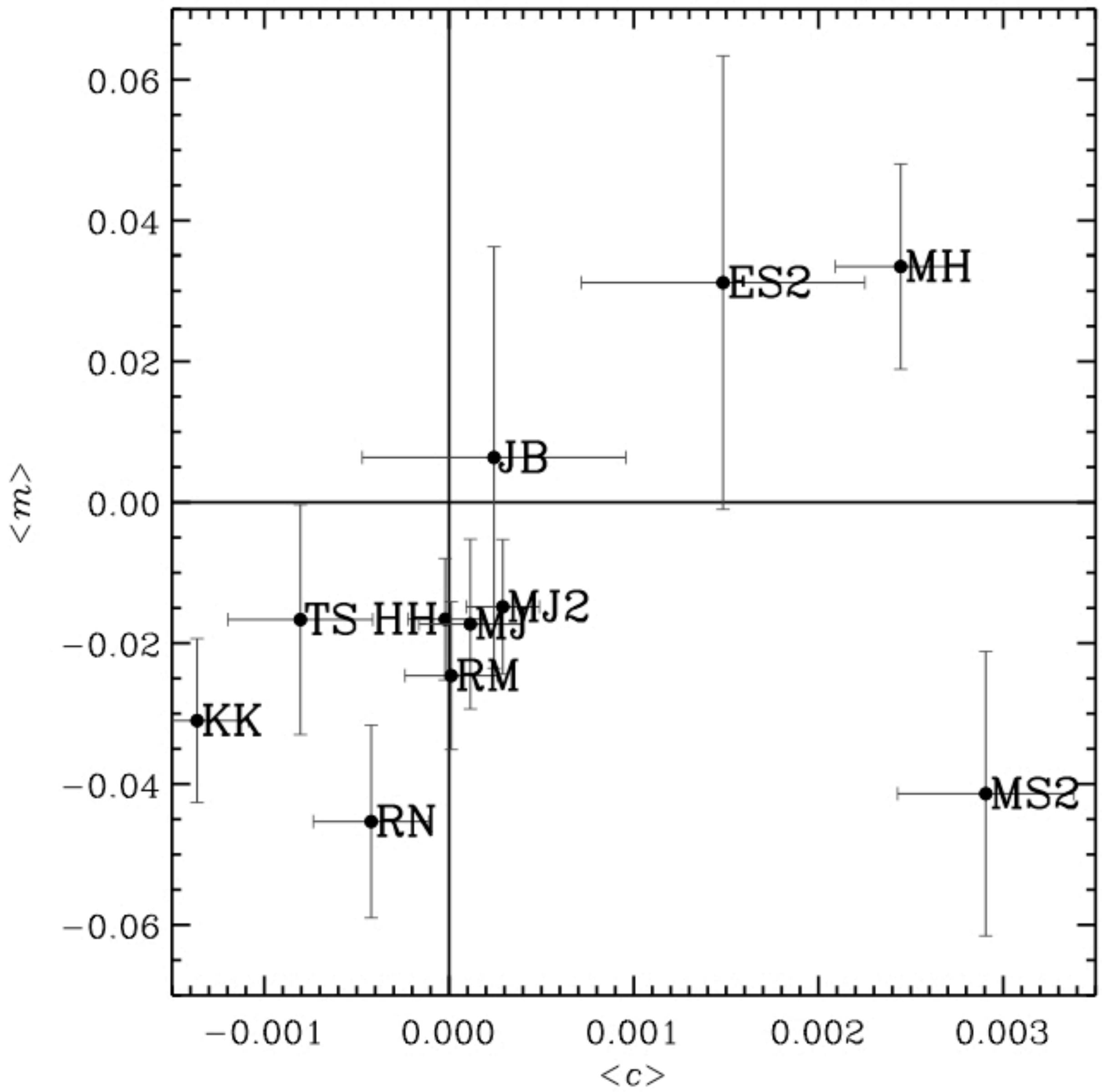
<m>: calibration bias

σ_c: additive PSF systematics

STEP2

- Making more realistic simulations
- New blind test after allowing people to train their methods on STEP1 data for ~6 months
- Galaxies “cloned from UDF” using shapelets (+ one set with pure exponential disks)
- Many different shear values (γ_1, γ_2) with $|\gamma| < 0.06$; 6 different (typical Subaru) PSFs
- Overcoming the noise from intrinsic ellipticities by producing rotated pairs of galaxies in the simulations. This yields more accurate constraints on the performance of each method than with STEP1 (without producing a much larger simulated data set)
- Investigating effects of complex galaxy morphology, galaxy size and magnitude, selection effects related to galaxy ellipticity, direction of shear signal relative to the pixel grid, PSF size and PSF ellipticity

STEP2 results



Clear improvement from STEP1. Several different methods do very well (bias at 2% or less)

No single method does everything best

(Massey et al. 2007)

Future of STEP

- Even higher precision required for future cosmic shear surveys
- STEP1 -> STEP2 : Adding complexity/realism to the simulations
- Move towards smaller sub-projects
- Current approach: Isolating shape measurement problem. Simpler simulations (postage stamps)
- Involving larger community (machine learning, inverse problem) through challenge posed within the PASCAL EU network: GREAT08

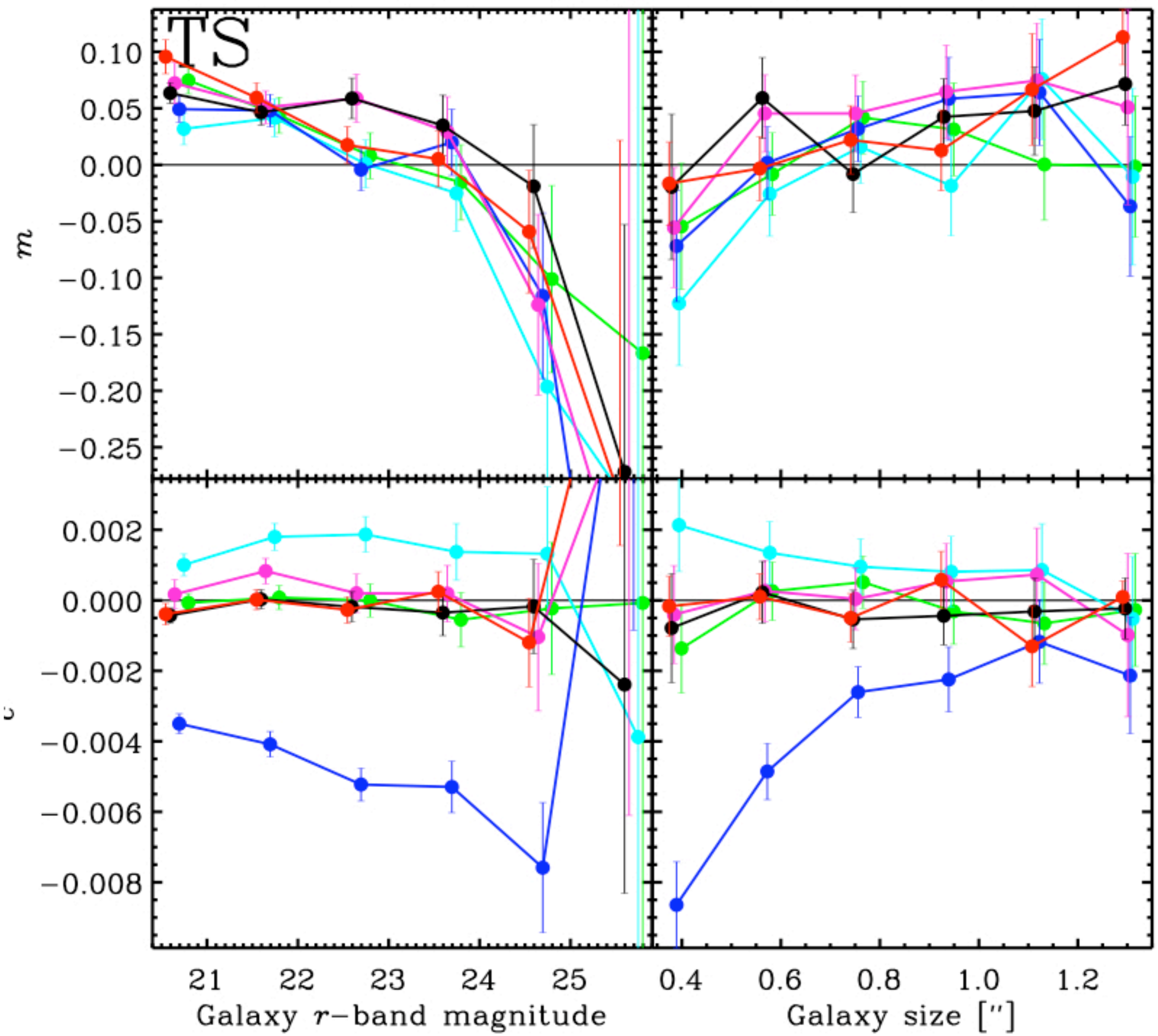
www.physics.ubc.ca/~heymans/step.html

Deficiencies of STEP for cluster weak lensing

- No simulations with stronger shears than 0.1 (STEP1) / 0.06 (STEP2)
- STEP: “Yes, we have no bananas” (flexion not included in the simulations)
- Issues such as contamination/background galaxy selection not addressed (but ongoing STEP-like blind tests of photo-z algorithms)

- How bad are these problems -- and what should we do to solve them?

The bad news…



Calibration bias dependent on galaxy magnitude and galaxy size

Typical behaviour !

Magnitude (S/N) and size-dependent bias

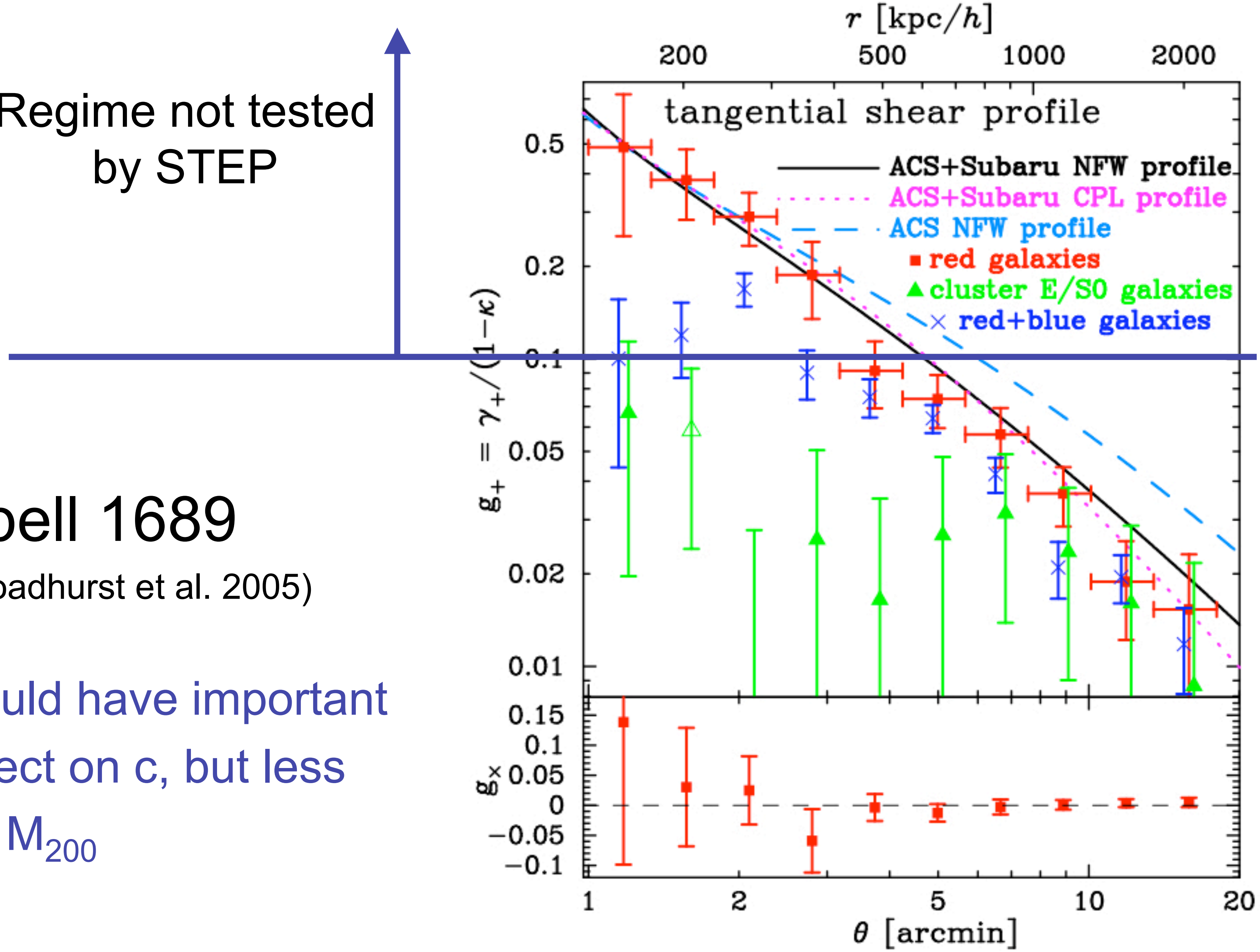
•Particularly worrying when combining data from high-z and low-z clusters (evolution of scaling relations, cluster MF,…)

•Possible solutions?

- Apply high-SN/large size cut
- Tailor each data set (depth, PSF size) to the cluster redshift
- Develop a better method which does not display this effect

Note: This is an even more urgent problem for the cosmic shear community (for precise DE constraints), would affect the perceived redshift evolution of the matter power spectrum

Regime not tested by STEP

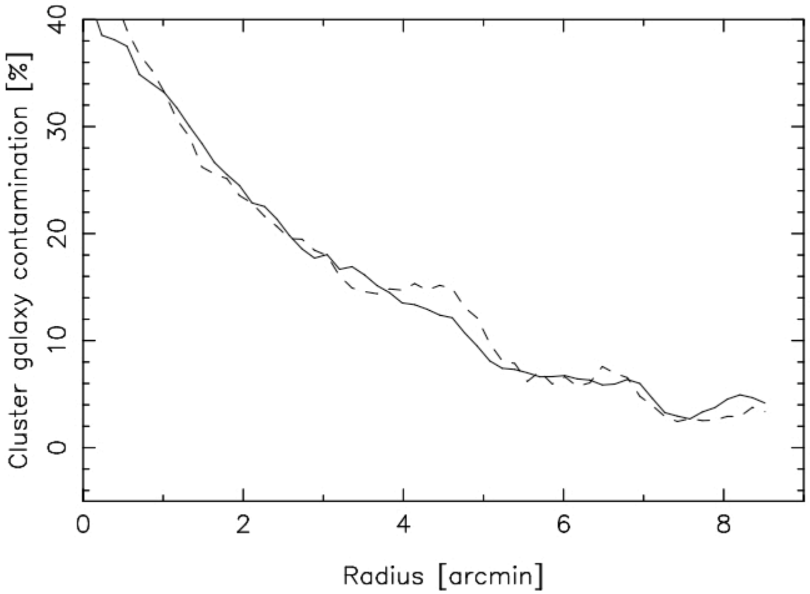


Abell 1689

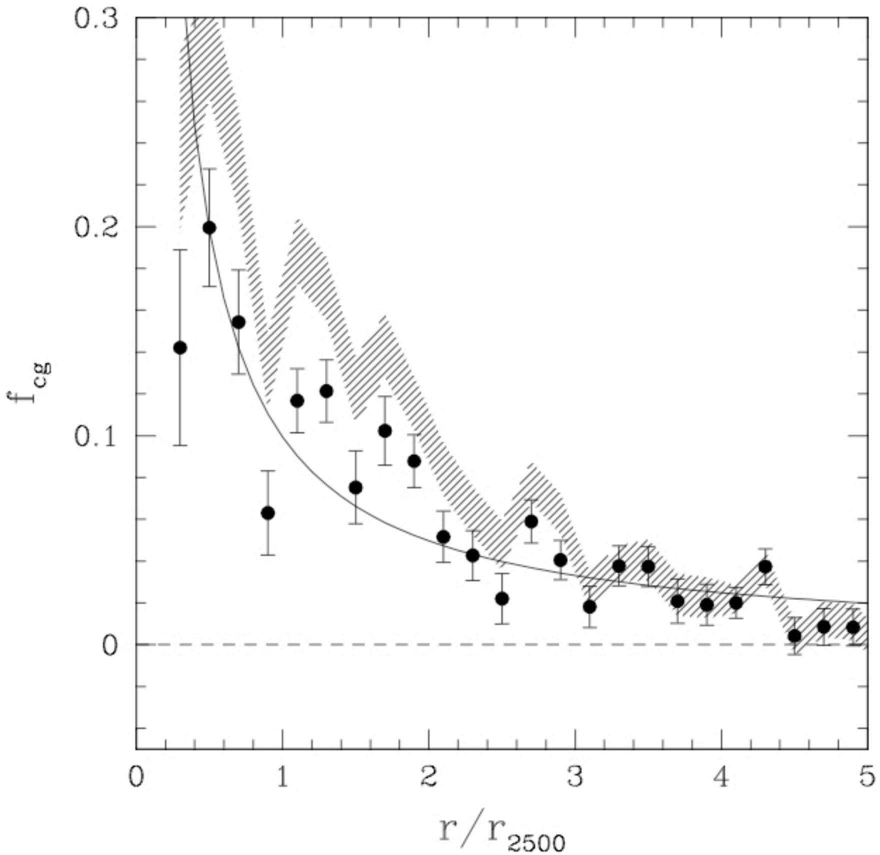
(Broadhurst et al. 2005)

Could have important effect on c, but less on M_{200}

Cluster galaxy contamination



(Pedersen & Dahle 2007, Hoekstra 2007)
Stack of clusters



Residual contamination after correction could have similar effect as mesaurement bias of strong shears

Note small effect at large radii

Wish list for a“Cluster-STEP”:

1. Both real data (start from “raw” data ?) with all complexities included and simulated data where the answer is known (the bias could be similar for different methods)
2. Stronger shears than with STEP (up to g~0.5)
3. Flexion added
4. STEP2-like simulation properties? (Real Subaru PSFs, realistic galaxy morphologies)