DES: Weak Lensing shape measurements from SV

Vinu Vikram
Argonne

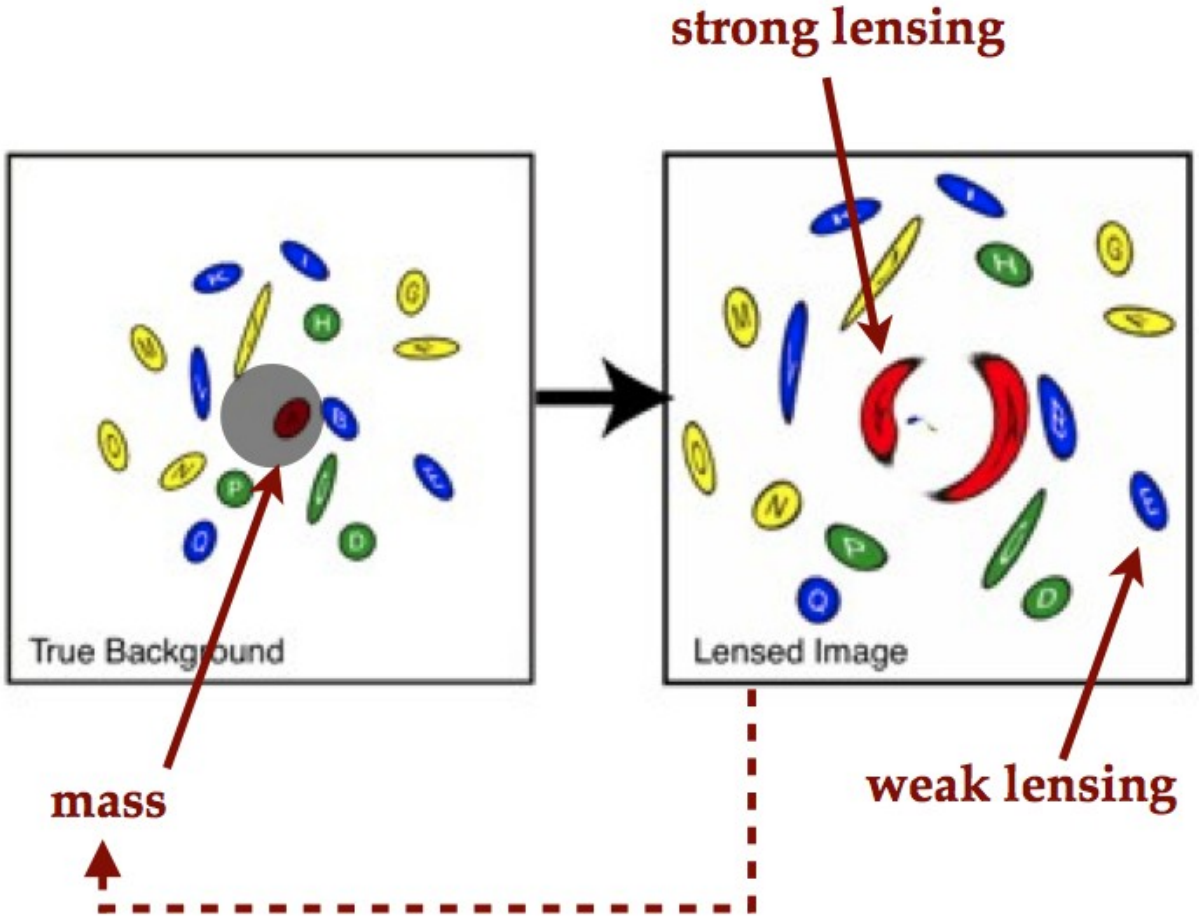
WL Working Group

Jarvis et al (in prep)
Vikram et al (in prep)

Plan

- Introduction
- Shape catalogs
- Summarize tests of measured shape
- ***Preliminary*** WL mass map which is the largest contiguous map to date

Weak lensing



Picture courtesy: C. Chang

- Foreground mass distribution magnifies and distort the shapes of randomly oriented background galaxies

Weak lensing

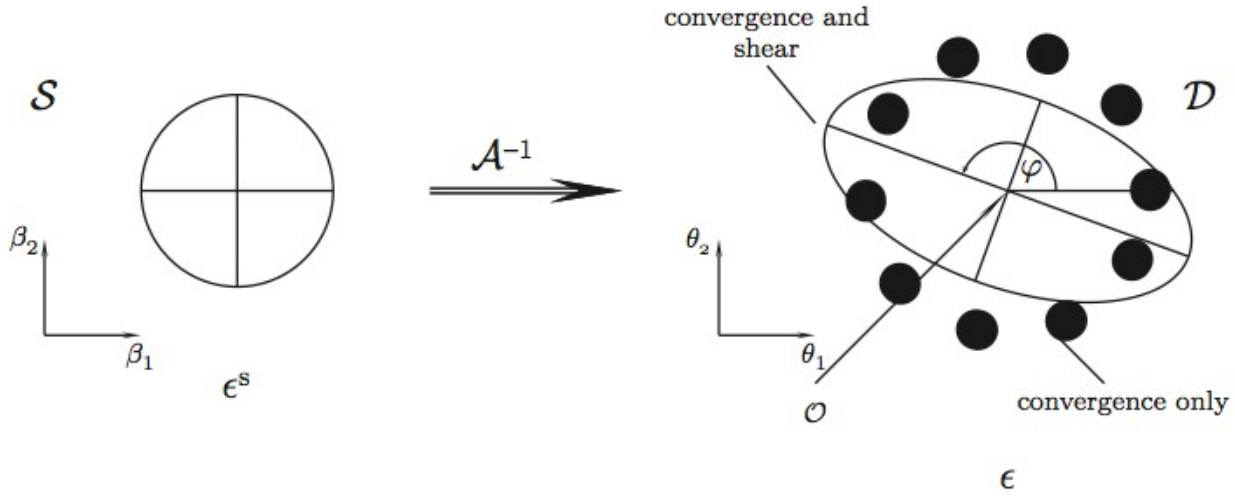
Coordinate on Source plane

Coordinate on Lens plane

$$\boldsymbol{\beta} - \boldsymbol{\beta}_0 = \mathcal{A}(\boldsymbol{\theta}_0) \cdot (\boldsymbol{\theta} - \boldsymbol{\theta}_0) \qquad \mathcal{A}(\boldsymbol{\theta}) = (1-\kappa)\begin{pmatrix} 1-g_1 & -g_2 \\ -g_2 & 1+g_1 \end{pmatrix}$$

$$g \equiv \frac{\gamma}{1-\kappa} = \frac{|\gamma|}{1-\kappa} e^{2i\varphi} \qquad WL : \kappa \ll 1 \Rightarrow g \approx \gamma$$

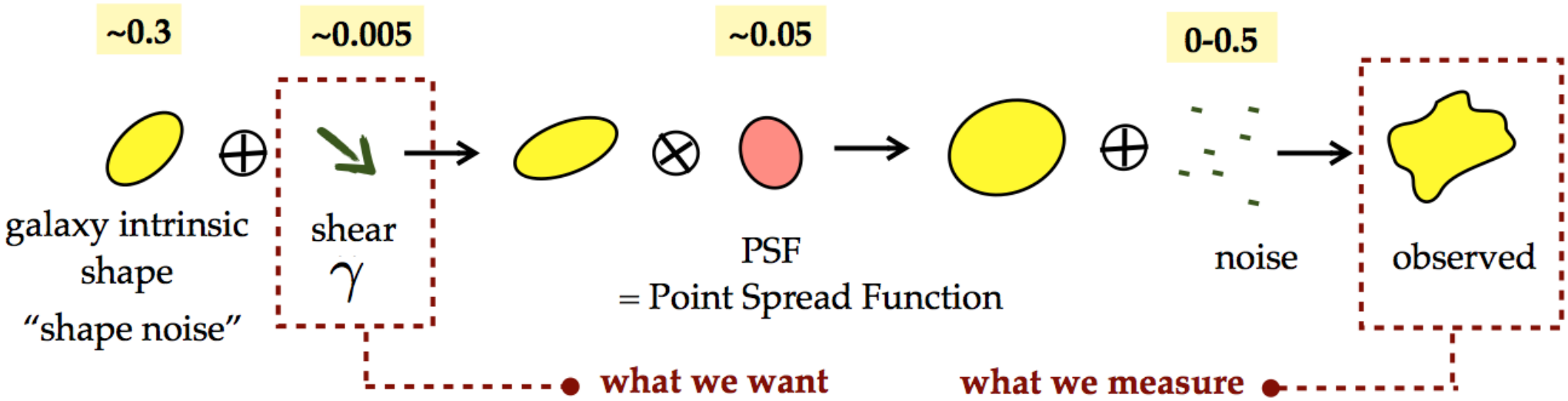
Shear and convergence depend on:
1. the potential along the line of sight and
2. distance to the source and lens and therefore cosmology!



$$|g| = \frac{1-b/a}{1+b/a}$$

P. Scheider 2001

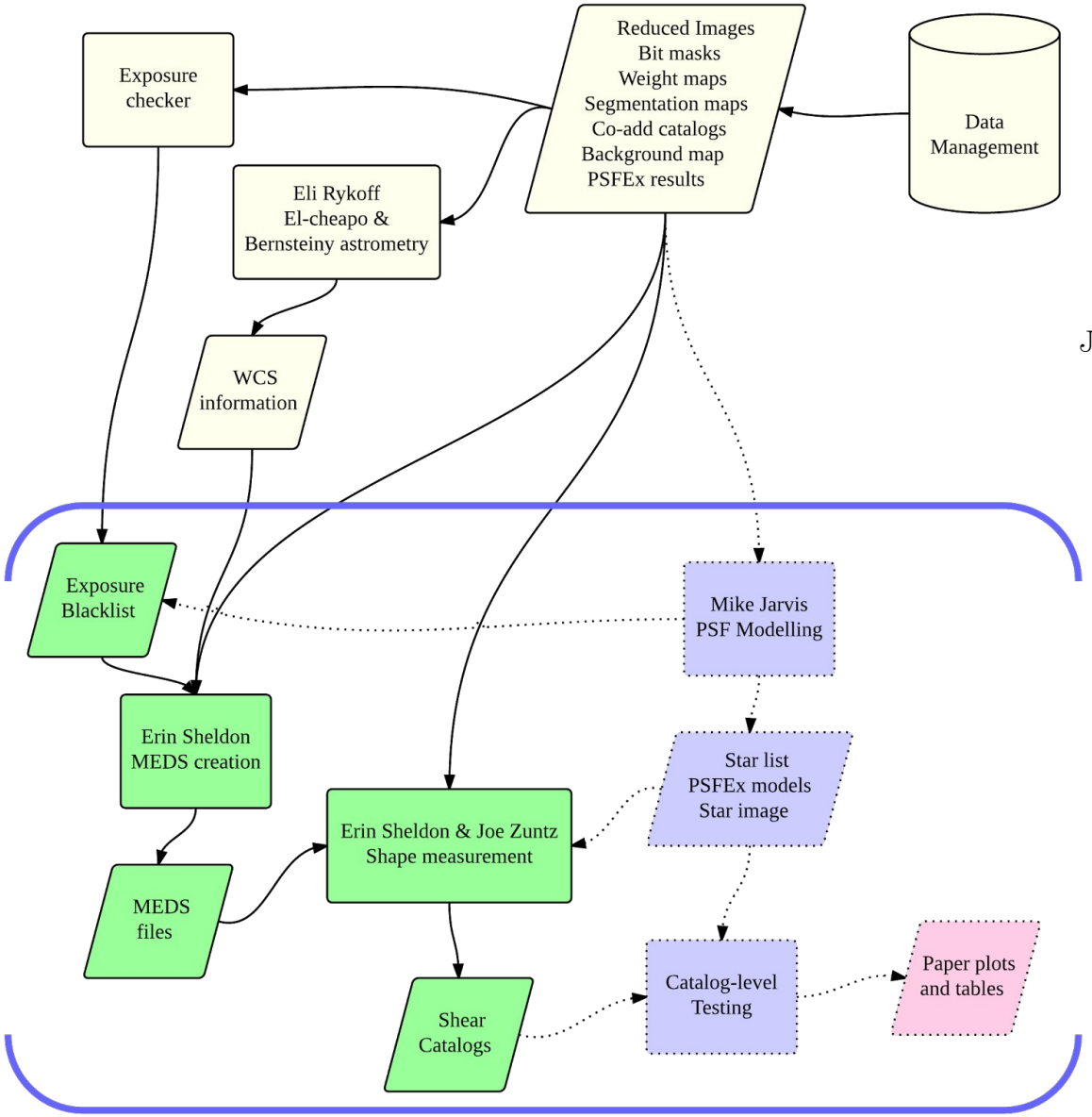
Shape in reality



$$No\,lensing \Rightarrow \langle e_i \rangle = 0\,;\; WL \Rightarrow \langle e_i \rangle = \gamma \pm \frac{\sigma_e}{\sqrt{N_{gal}}}$$

Picture courtesy: C. Chang

DES shape measurement pipeline



Jarvis et al. (in prep)

Im3shape:v7 & ngmix-009

- Im3shape (Zuntz et al 2011)
  - Bulge + Disk model for galaxy
  - Maximum likelihood method
  - ~10M (pre-selected), ~4 per sq. arcmin (default flag, mask, radius, S/N, MODEST_CLASS)
- ngmix (Erin Sheldon)
  - Mix of Gaussians
  - Bayesian
  - ~24M, ~12 per sq. arcmin (default flag, S/N)

Shear testing

- Looks good
  - PSF - Galaxy correlation

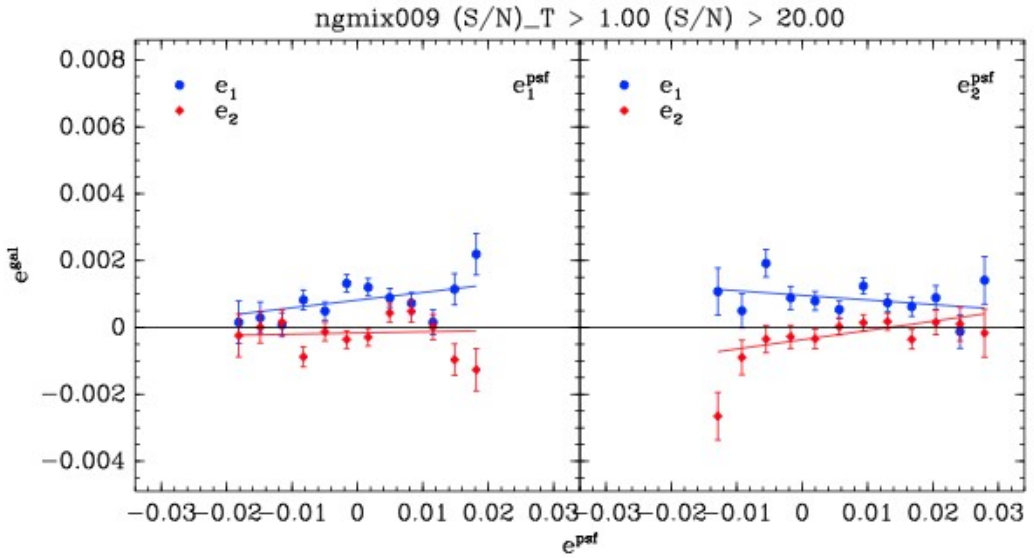
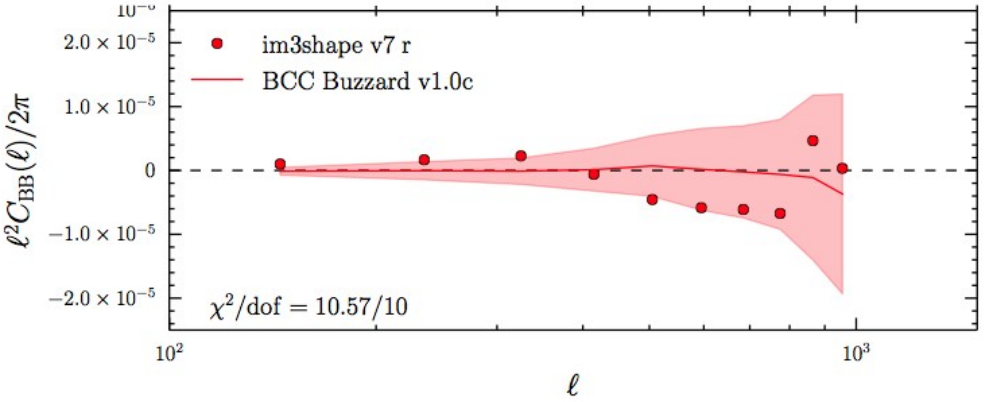


Figure: Erin Sheldon

Slope ~ 2.5e-2 (7e-2 for SV)

Shear testing

- Looks good
  - 2-pt B-mode consistent with zero



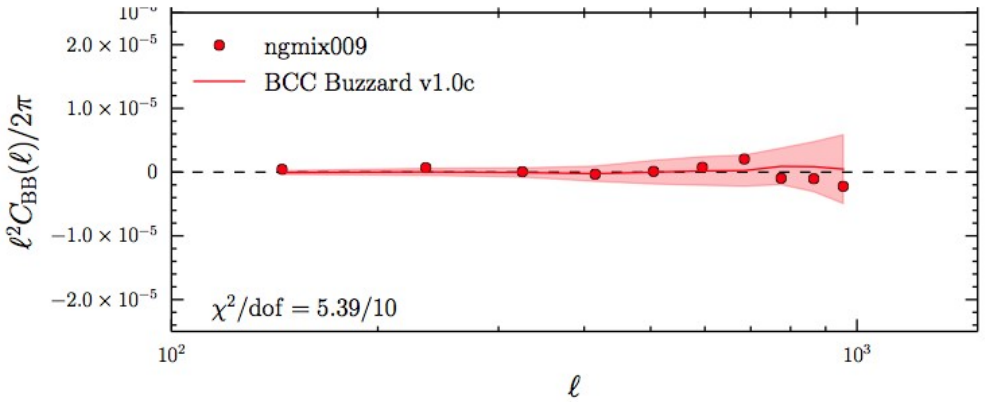
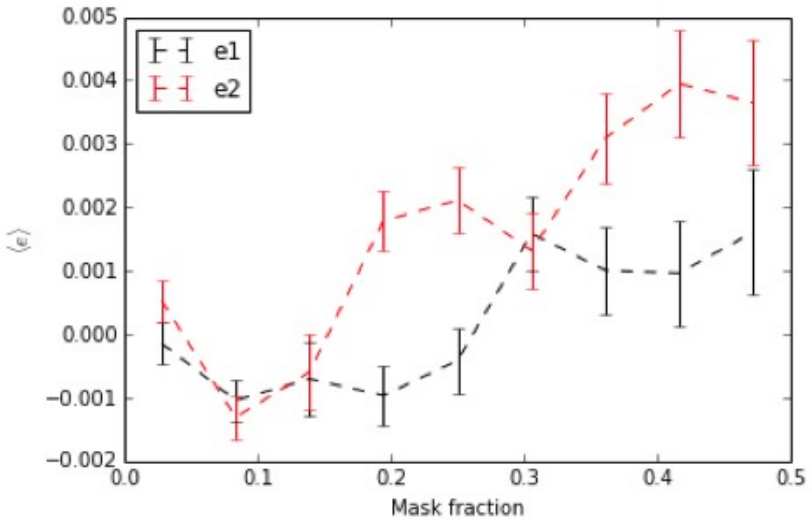


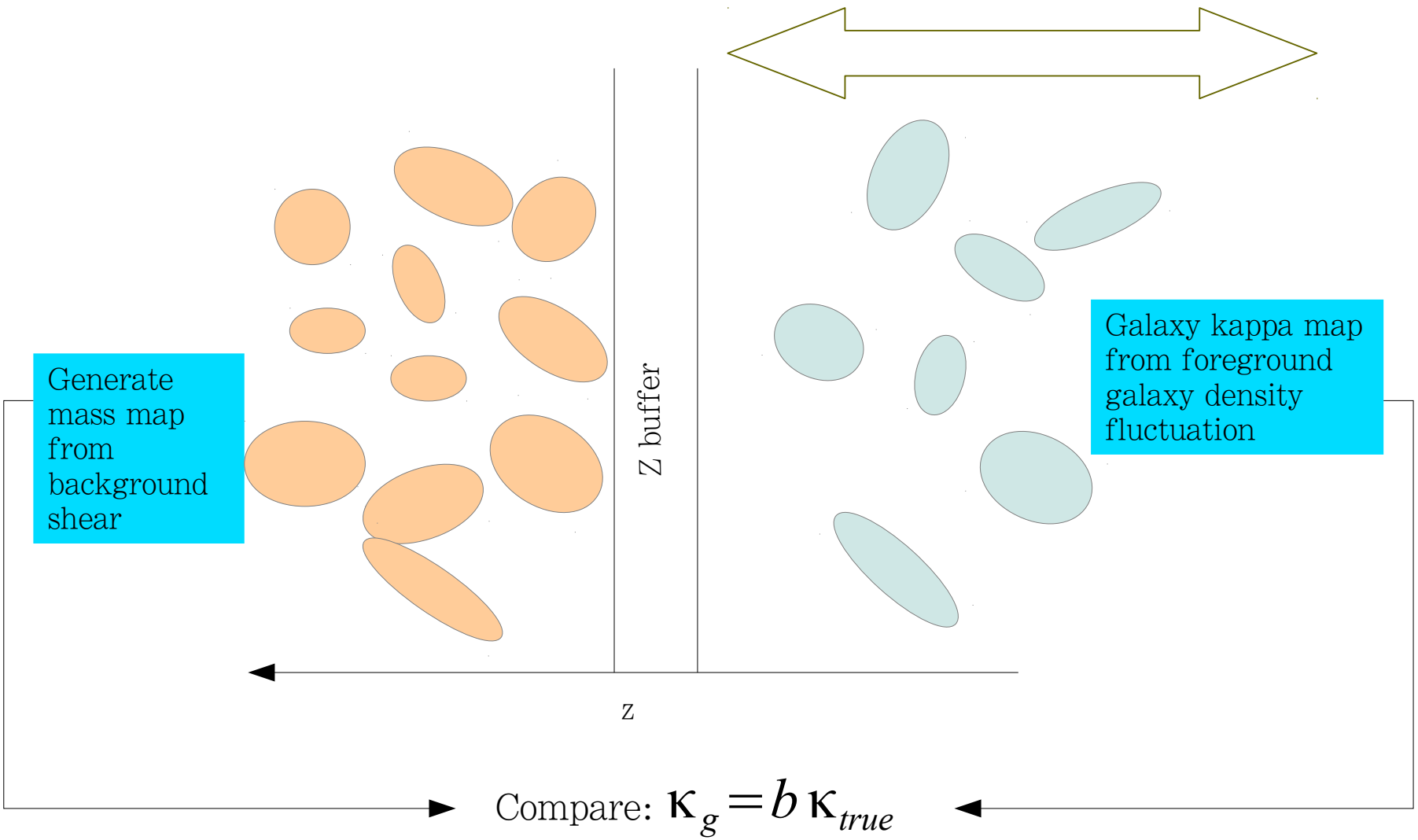
Figure: Matt Becker

Shear testing

- Remaining known issues
  - Some dependence with mask fraction, possibly due to the residual light from neighbors
  - Some dependence with stamp size
- Conservative selection can be made



Mass map and foreground galaxy kappa



Data: Mass at $0.1 < z < 0.5$

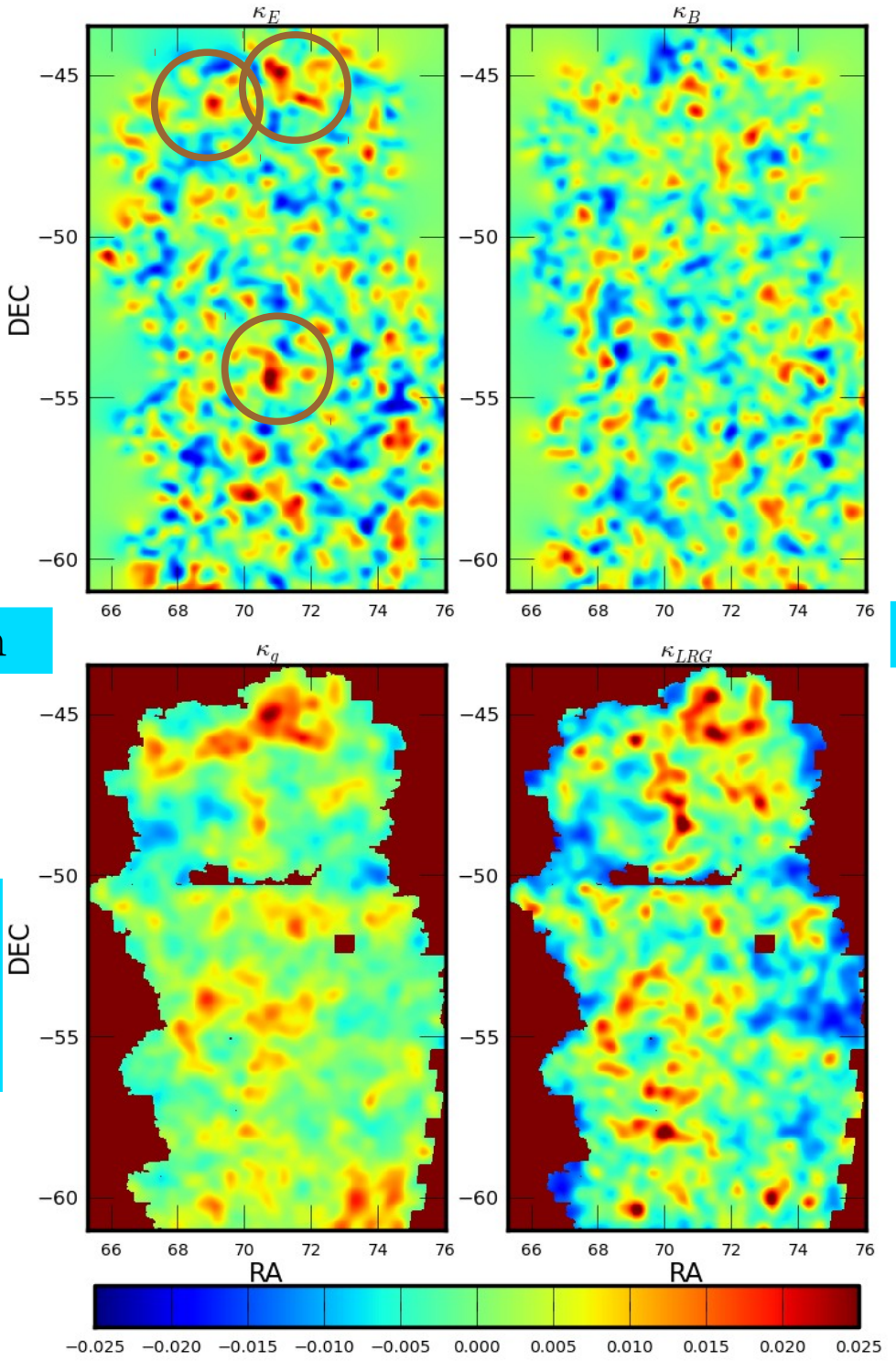
- Background: $0.6 < z < 1.2$ & Foreground: $0.1 < z < 0.5$
- Photoz based on DESDM neural network
- Source density ~2 to 8 objects per sq. arcmin
- Shape measurements objects with $S/N > 20$
- Noise bias correction
- Conservative cuts to reduce mask fraction & stamp size effect
- Foreground objects
    - Magnitude limited sample ($i < 22$)
    - RedMaPPer clusters and LRGs (Rykoff et al, in prep)

10 arcmin Gaussian smoothing

Signal E-mode

Must have correlation

Kappa based on foreground galaxy/LRG distributions

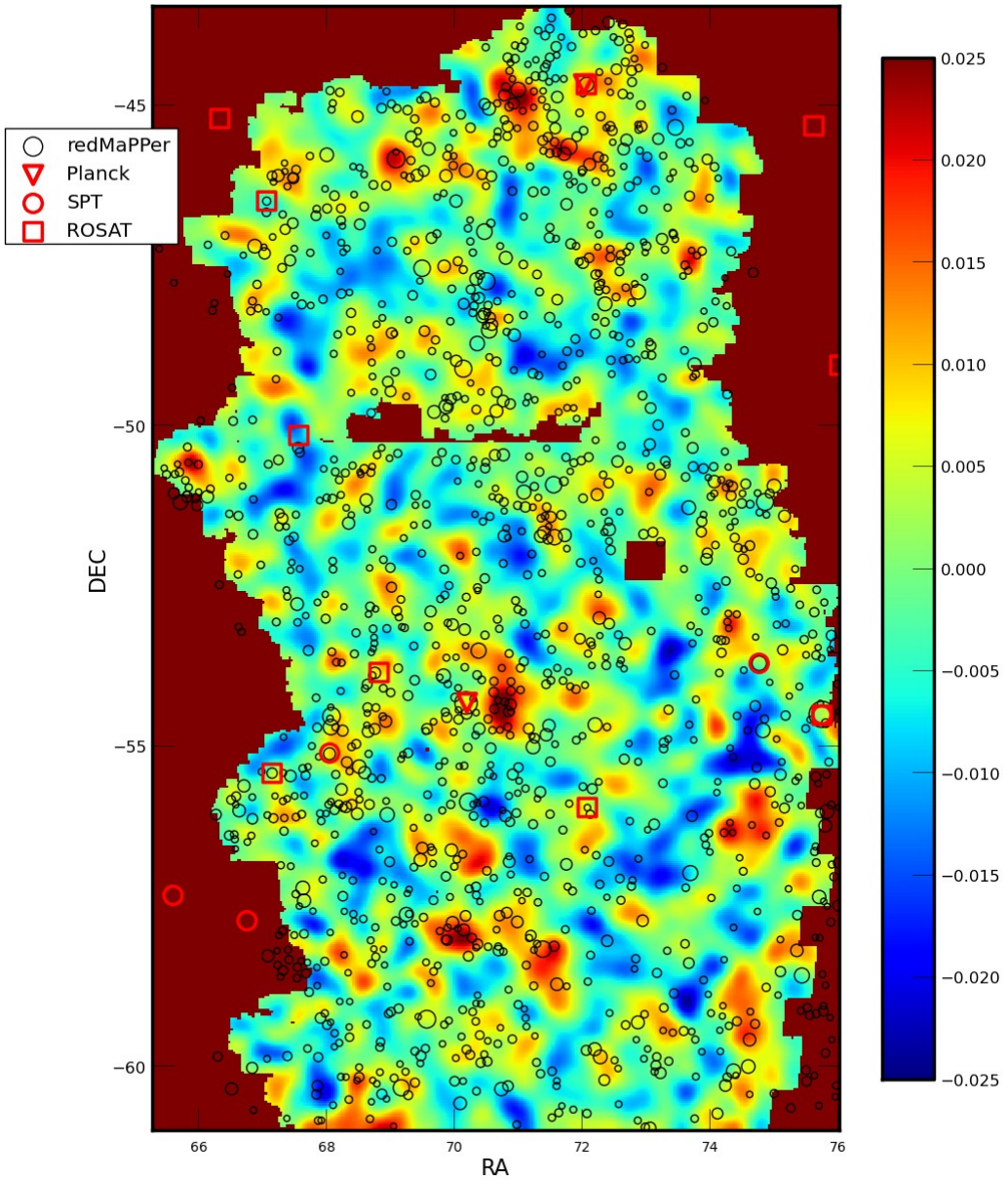


Systematics B-mode

No correlation

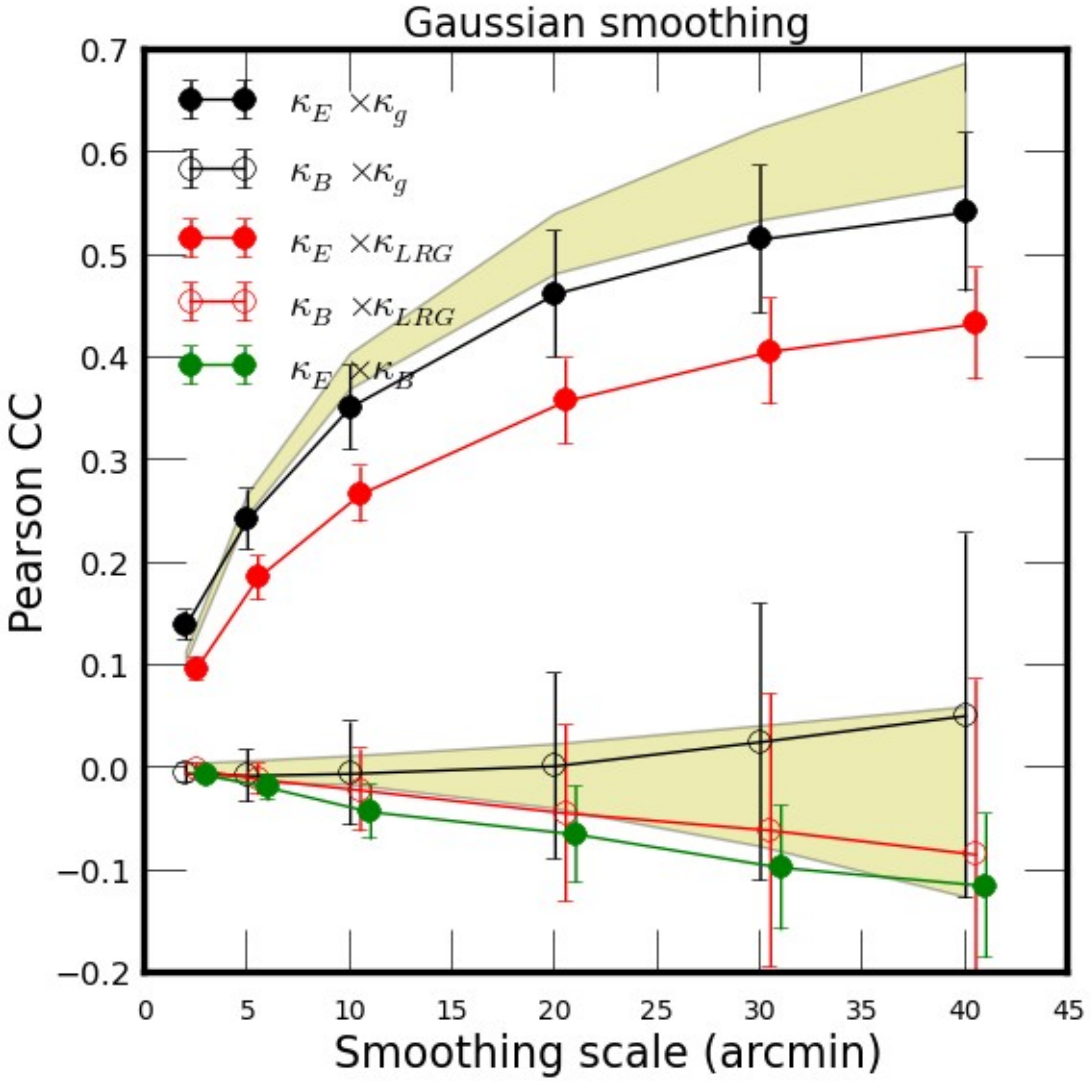
Kappa based on foreground galaxy/LRG distribution

Mass map and redMaPPer clusters



Cross correlation

Correlating lensing mass map with galaxy map

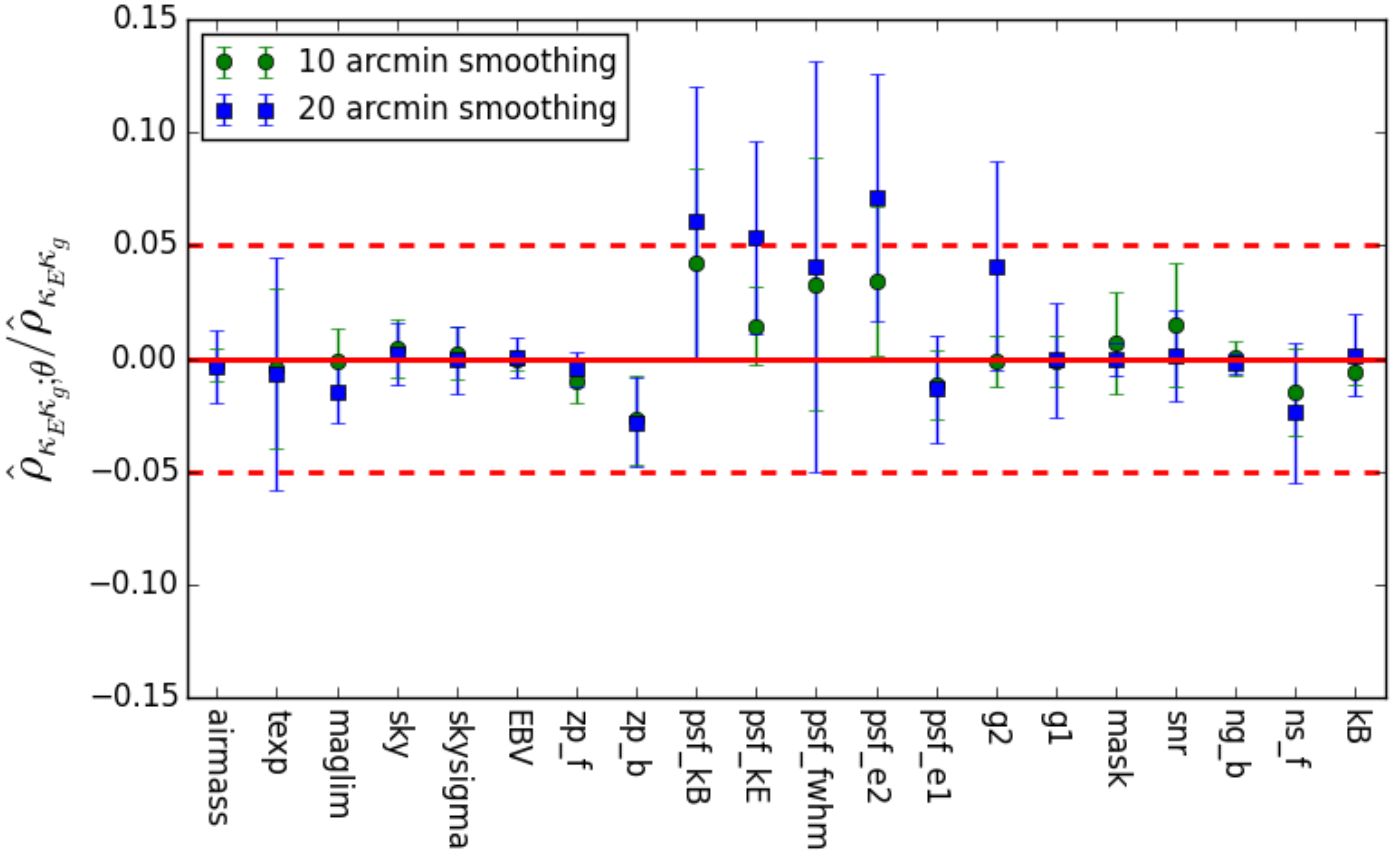


8-10 σ detection (null)

Systematic Error

$$\psi_o = \psi_t + \epsilon_1 \theta \,;\, \phi_o = \phi_t + \epsilon_2 \theta$$

$$\hat{\rho}_{\phi\psi;\theta} = \frac{\hat{\rho}_{\phi\theta}\hat{\rho}_{\psi\theta}}{\hat{\rho}_{\theta\theta}}$$



Conclusion

- Shapes measured for SV data
- Shape measurement pass many null tests
- 8-10 sigma detection between lensing and galaxy maps
- Keep improving

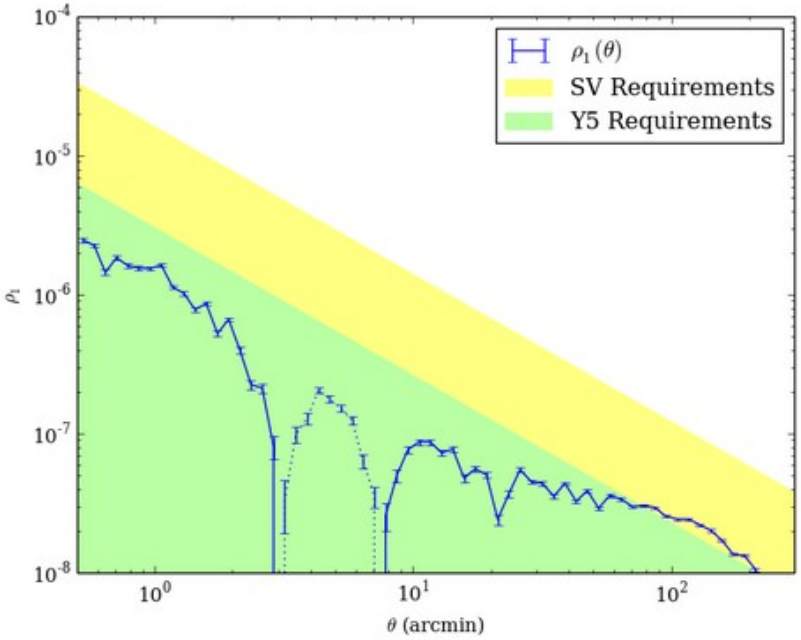
Thanks!

Additional slides

Shear testing

- Looks good
  - PSF residual correlation (a.k.a Rowe statistics)

Residual-Residual



Shape-Residual

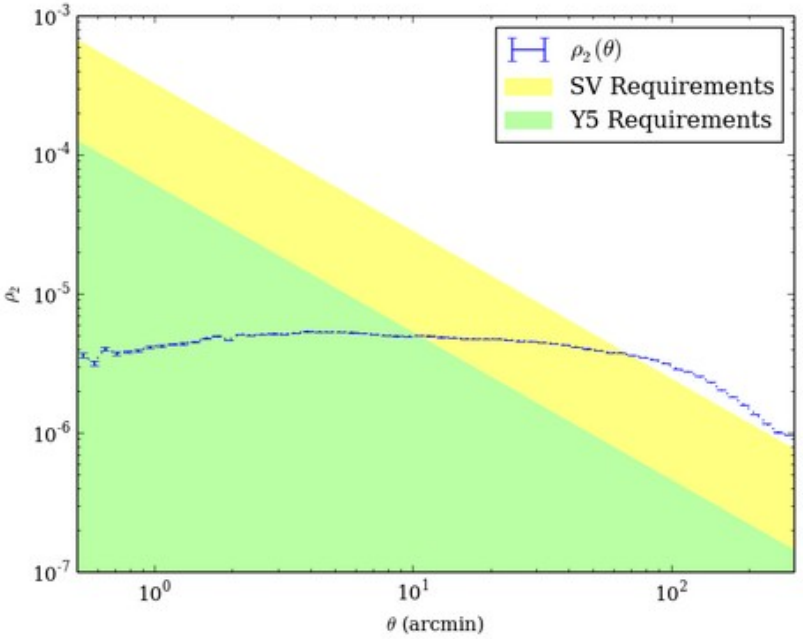


Figure: Mike Jarvis

Shear testing

- Look good
  - Tangential shear around stars
  - Stacking around random locations
  - Stacking around image center
  - Etc.

Jarvis et al. (in prep)

Weak lensing convergence map: a.k.a mass map

- The projected total mass distribution in the Universe
- Galaxy bias
- How the total matter distribution w.r.t. to baryonic matter
    - Correlation analysis with ROSAT/Planck/SPT
    - Already seeing strong correlation between x-ray and mass map
- Cosmology based on peak statistics & higher order moments
- Detect voids, filaments and super structures

Mass mapping methods

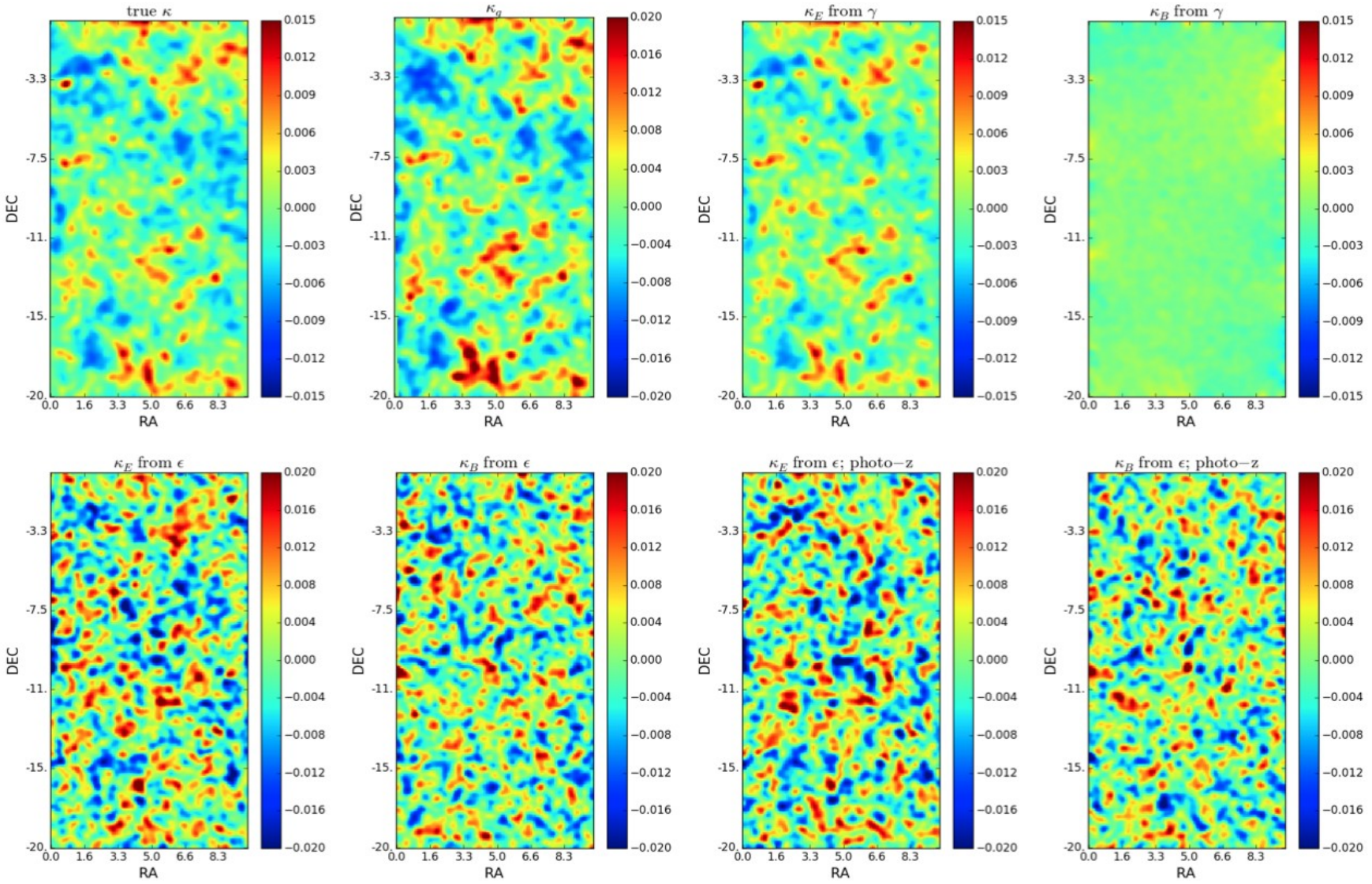
- Kaiser-Squires inversion (Kaiser & Squires 1993)

$$\gamma(\boldsymbol{\theta}) = \frac{1}{\pi}\int_{\mathbb{R}^2} \mathrm{d}^2\theta'\, \mathcal{D}(\boldsymbol{\theta}-\boldsymbol{\theta}')\,\kappa(\boldsymbol{\theta}')\,,$$

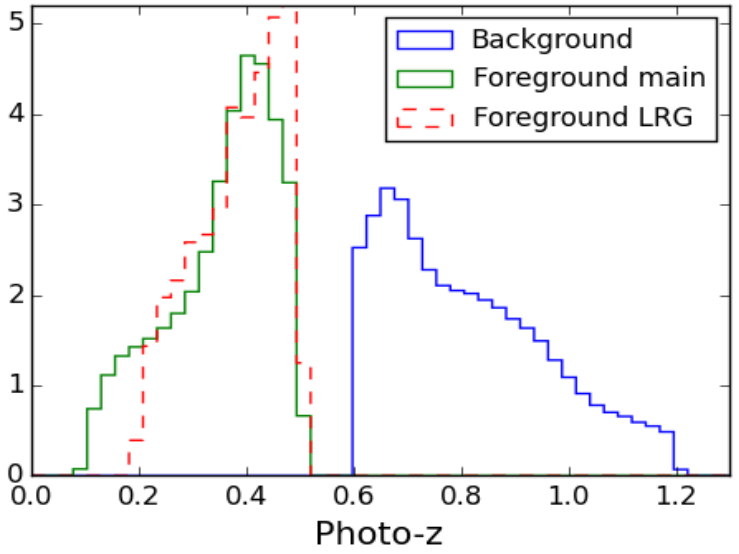
$$\mathcal{D}(\boldsymbol{\theta}) \equiv \frac{\theta_2^2-\theta_1^2-2\mathrm{i}\theta_1\theta_2}{|\boldsymbol{\theta}|^4} = \frac{-1}{(\theta_1-\mathrm{i}\theta_2)^2}$$

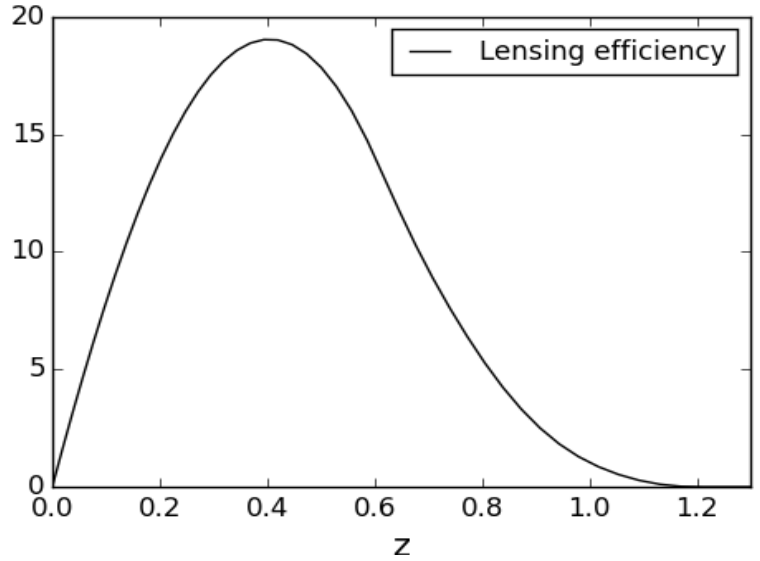
- B-mode can be measured with 45 degree rotated shapes
- Phase prior method based on foreground galaxy distribution (Szepietowski et al. 2014)

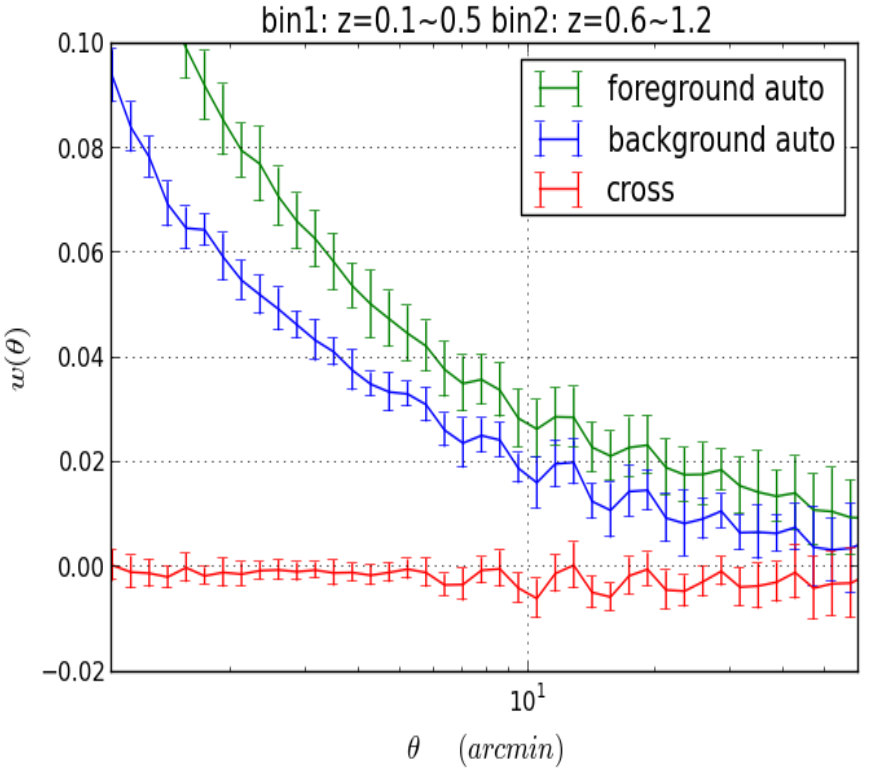
BCC Simulation



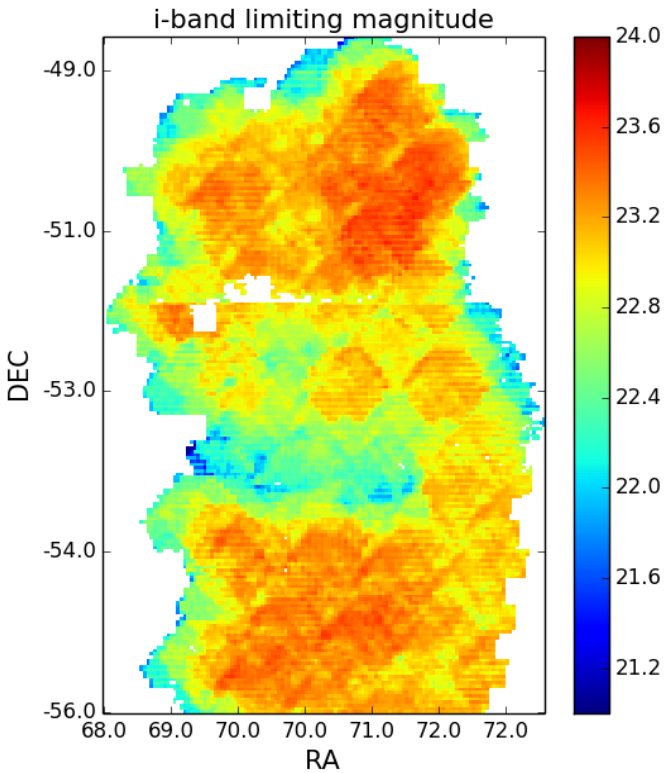
Systematic analysis: photoZ

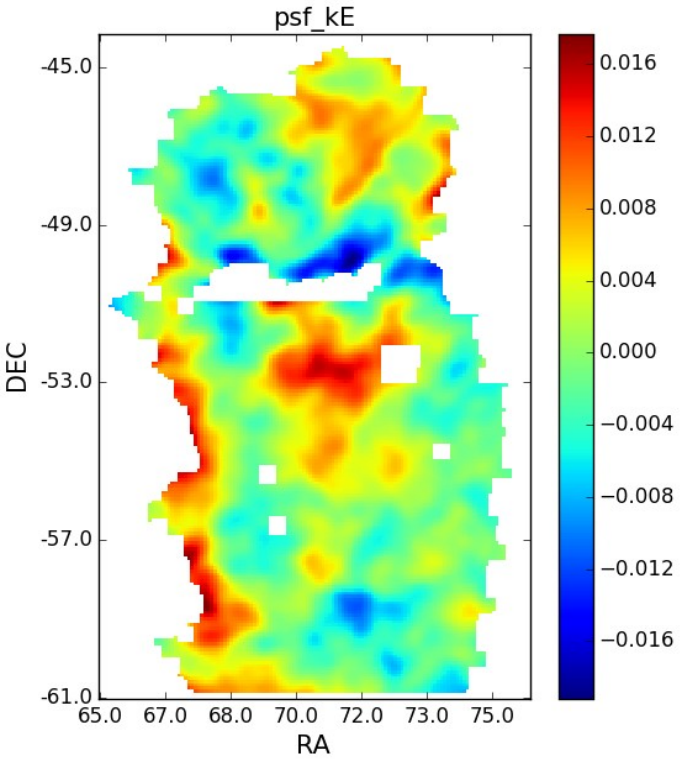


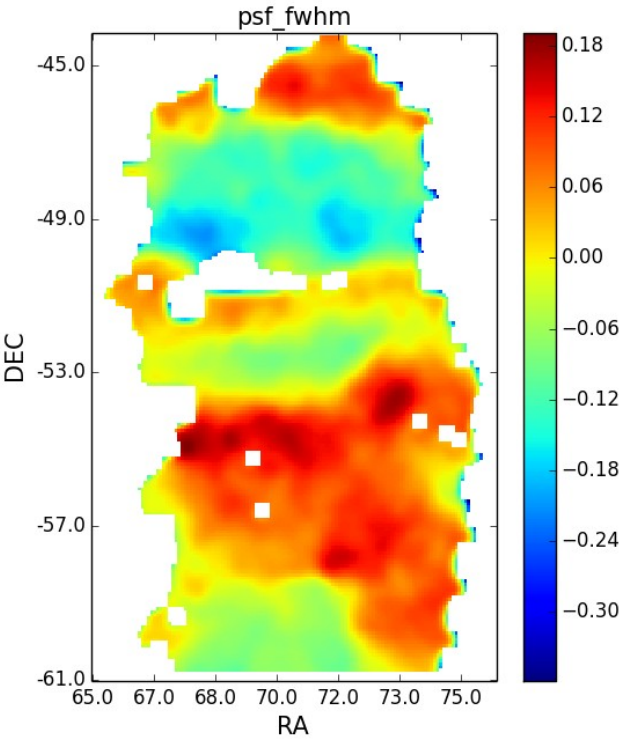




Systematic analysis







Conclusion

- Measured and tested ~130 sq. degree weak lensing data from DES SV
- Systematics in shapes are within statistical error : very encouraging
- Generated largest weak lensing mass map to date with ~10 sigma correlation between foreground
- Improving!
- Detail talk on January 30th!

Ongoing

Understanding the super structures in the WL map and where is the mass comes from?

- Counting peaks in the map
- Estimating moments
- Cross correlation analysis with ROSAT, Planck and SPT maps
-

Following tests

- Source selection & density
- Changes between im3shape versions (v6 to v7)
  - Maps
  - Cross Correlation
  - RM Clusters on maps
  - Stacked cluster & LRG profiles
- Maps based on ngmix
- Systematics in the selection of background objects

Draft

Wide-Field Lensing Mass Maps from DES Science Verification Data

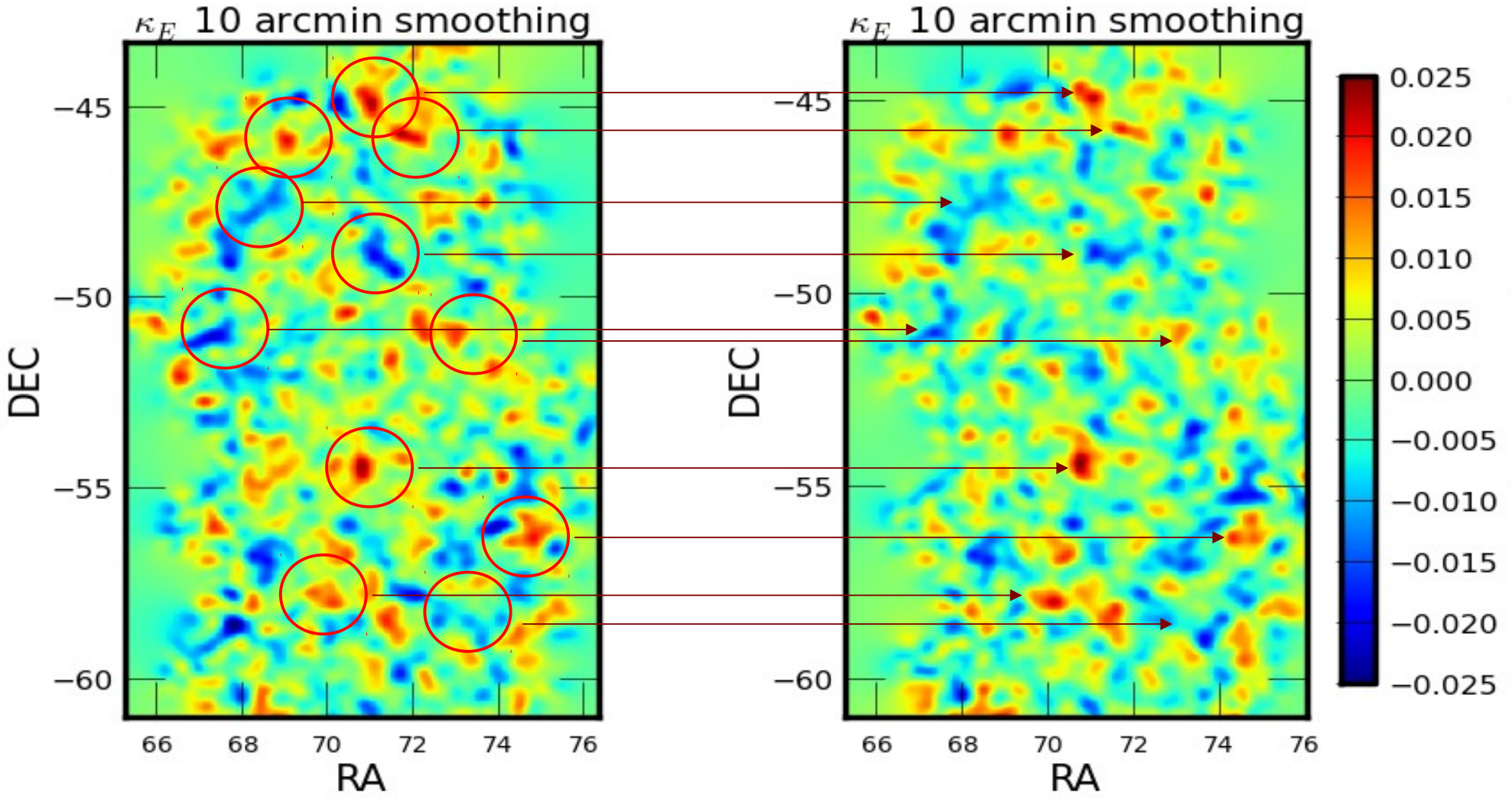
V. Vikram,[1] C. Chang,[2] B. Jain,[1] D. Bacon,[3] A. Amara,[2]
M. Becker,[4] S. Bridle,[5] D. Brout,[1] M. Busha,[4] M. Jarvis,[1] H. Lin,[6] P. Melchior,[7]
E. Rozo,[4] E. Rykoff, [4] C. Sánchez, [8] E. Sheldon,[9] R. Wechsler,[4] J. Zuntz,[5] + ...

[1] *Department of Physics and Astronomy, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104, USA*
[2] *ETH Zurich, Department of Physics, Wolfgang-Pauli-Strasse 27, 8093 Zurich, Switzerland*
[3] *Institute of Cosmology and Gravitation, University of Portsmouth, Burnaby Road, Portsmouth PO1 5AR, United Kingdom*
[4] *KIPAC, Stanford University, 452 Lomita Mall, Stanford, CA 94309, USA*
[5] *University College London*
[6] *Fermilab*
[7] *Ohio State University*
[8] *Institut de Fisica d'Altes Energies*
[9] *Brookhaven National Laboratory*

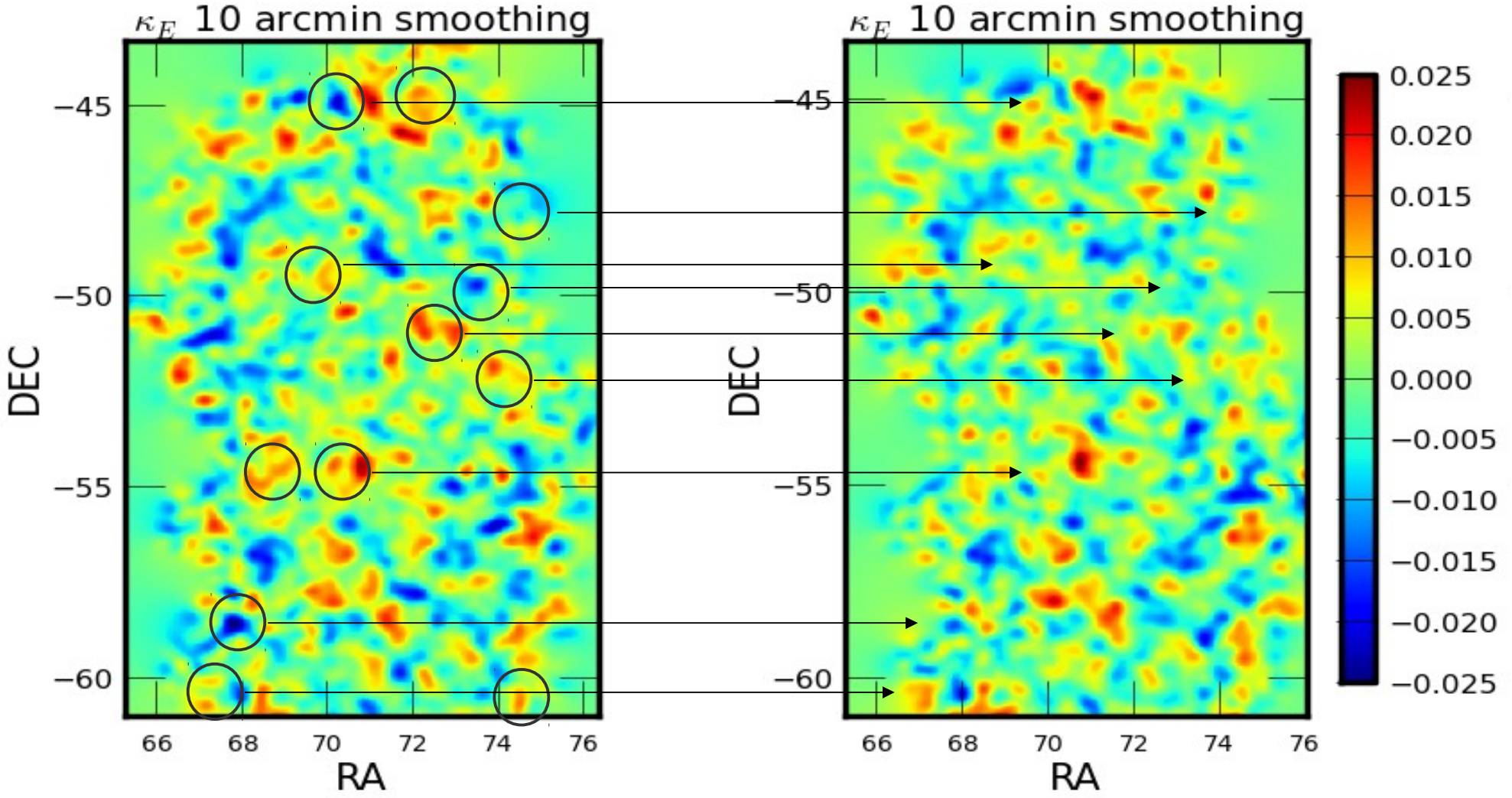
Source selection (Fiducial sample)

- Im3shape-v7
  - ~130 sq. degrees
  - 1869787 objects with ERROR_FLAG = 0 & INFO_FLAG=0
  - These objects have S/N > 20 and noise bias may be minimal
  - MAG_AUTO_r < 25
  - Redshift (DESDM) between 0.6 and 1.2 → gives 800411 objects
  - ~1.7 objects per sq. arcmin
- Ngmix-009
  - ~130 sq. degrees
  - Redshift (DESDM) between 0.6 and 1.2 → gives 3409357 objects
  - ~7.3 objects per sq. arcmin

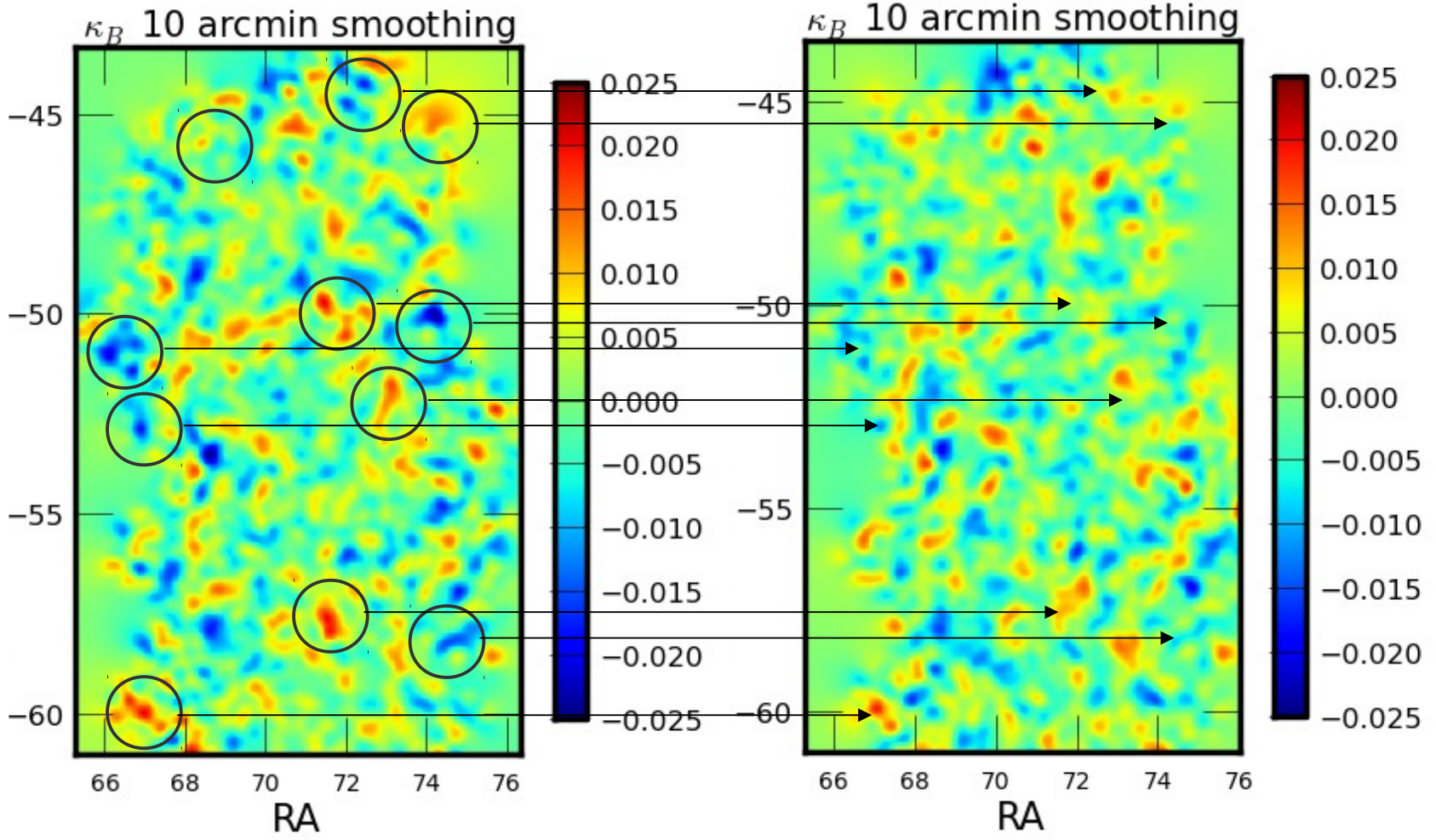
im3shape v6 to v7
Structures don´t change



im3shape v6 to v7
Changes in E mode

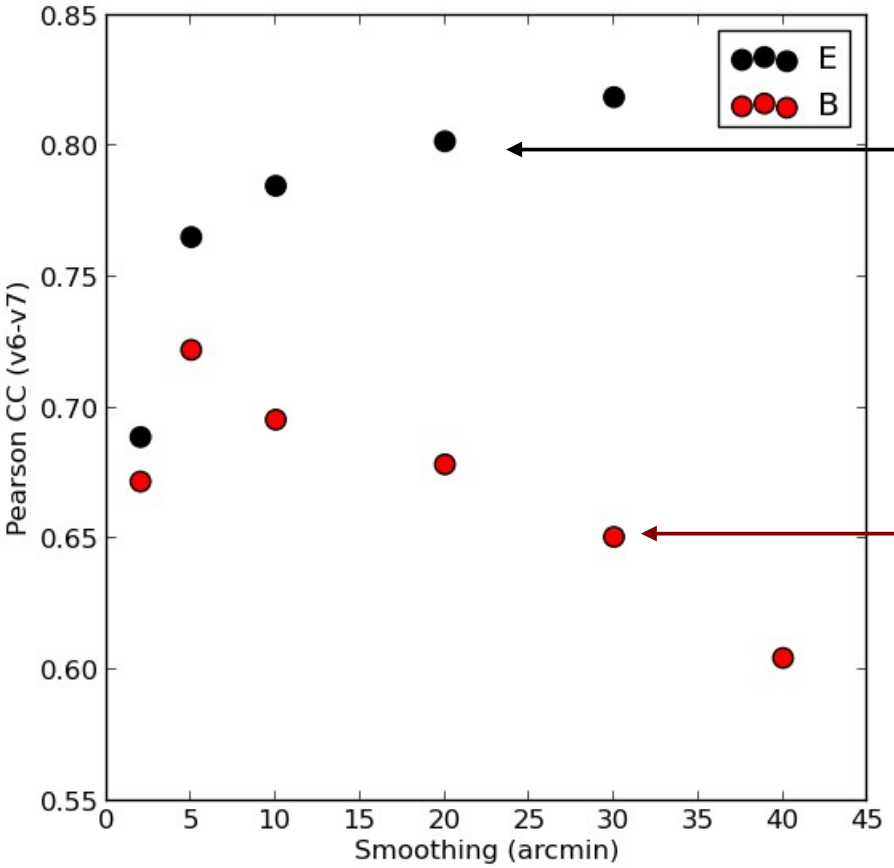


v6 to v7
Kappa B



v6 vs v7

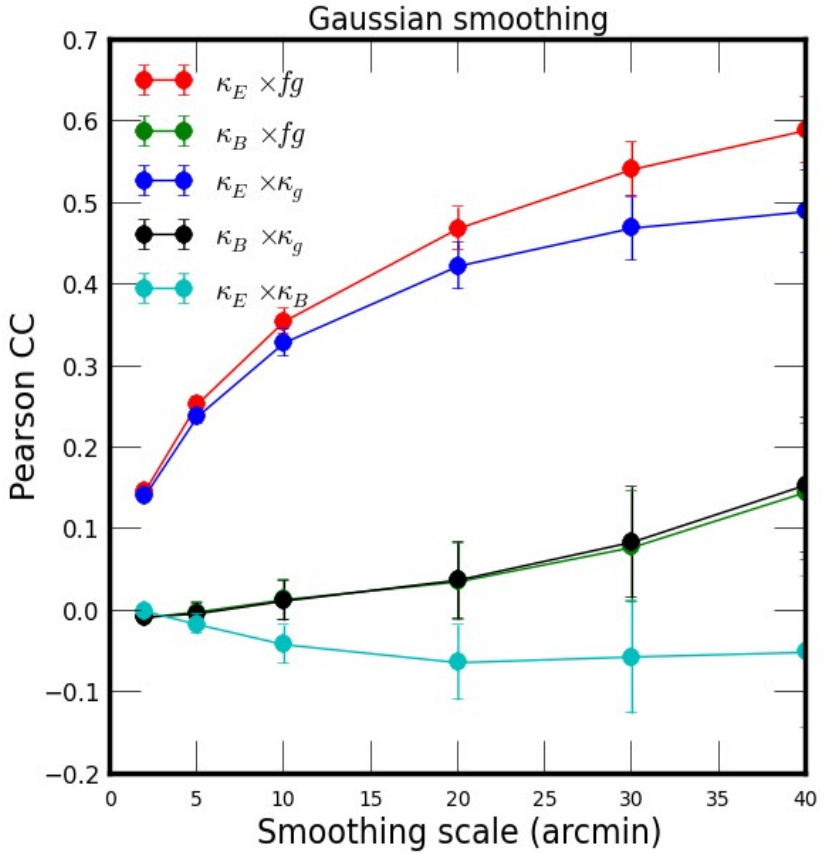
- sigma_e / sigma_b = 0.995 to 1.031
- CC between v6 and v7

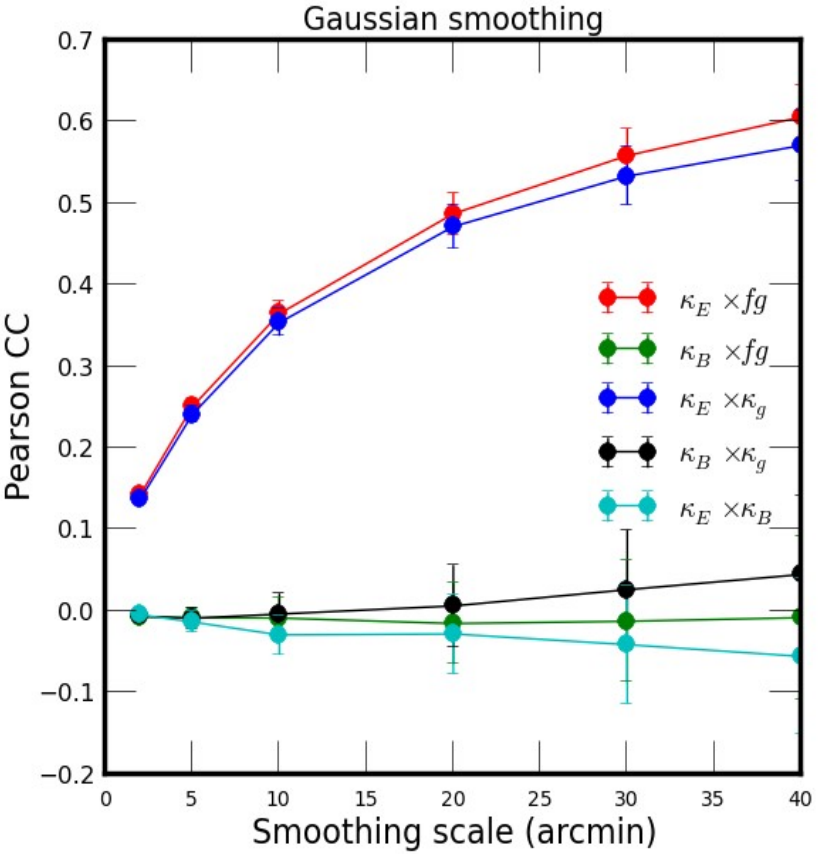


Good correlation between v6 & v7

What does this behavior implies?

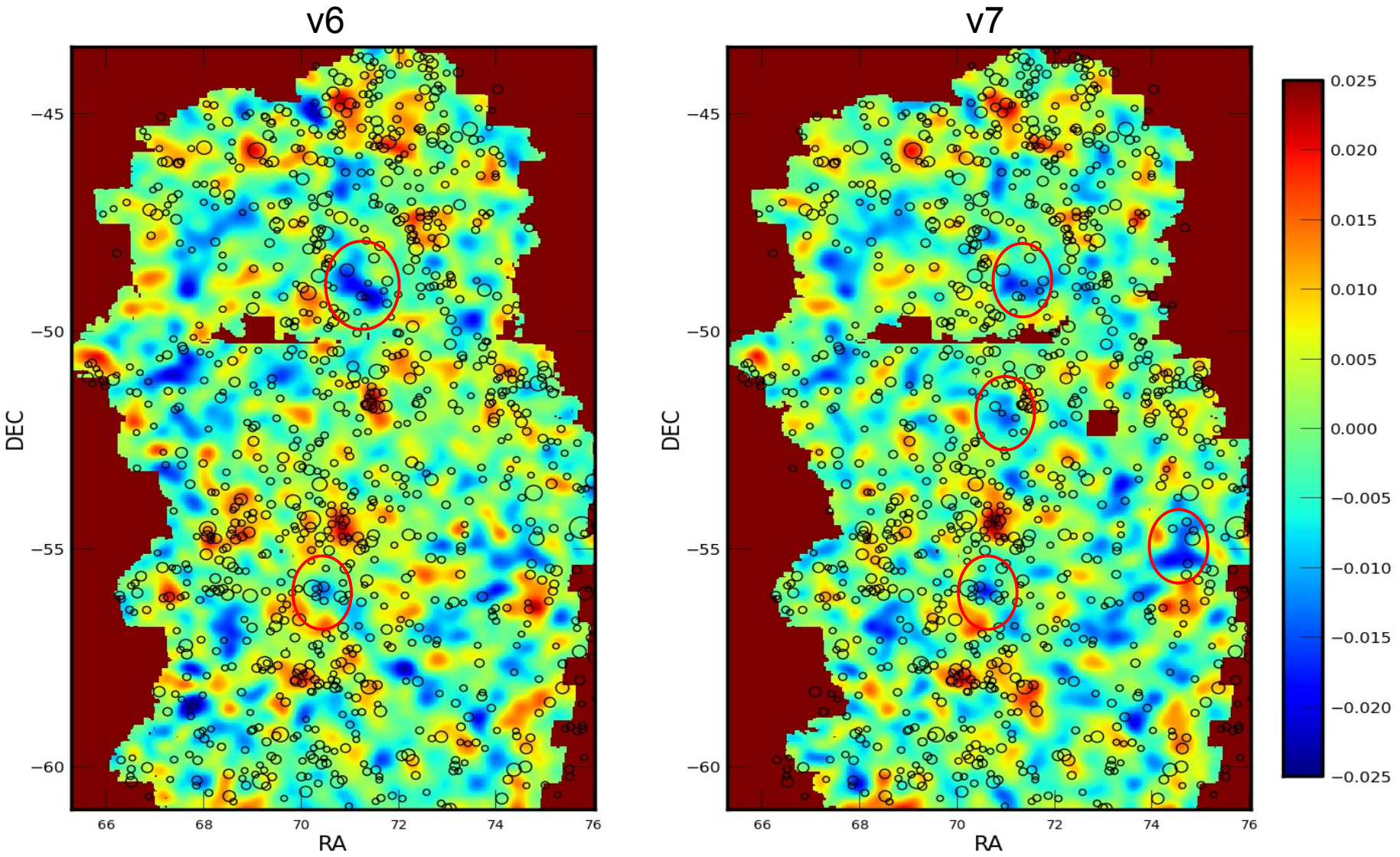
CC v6 to v7



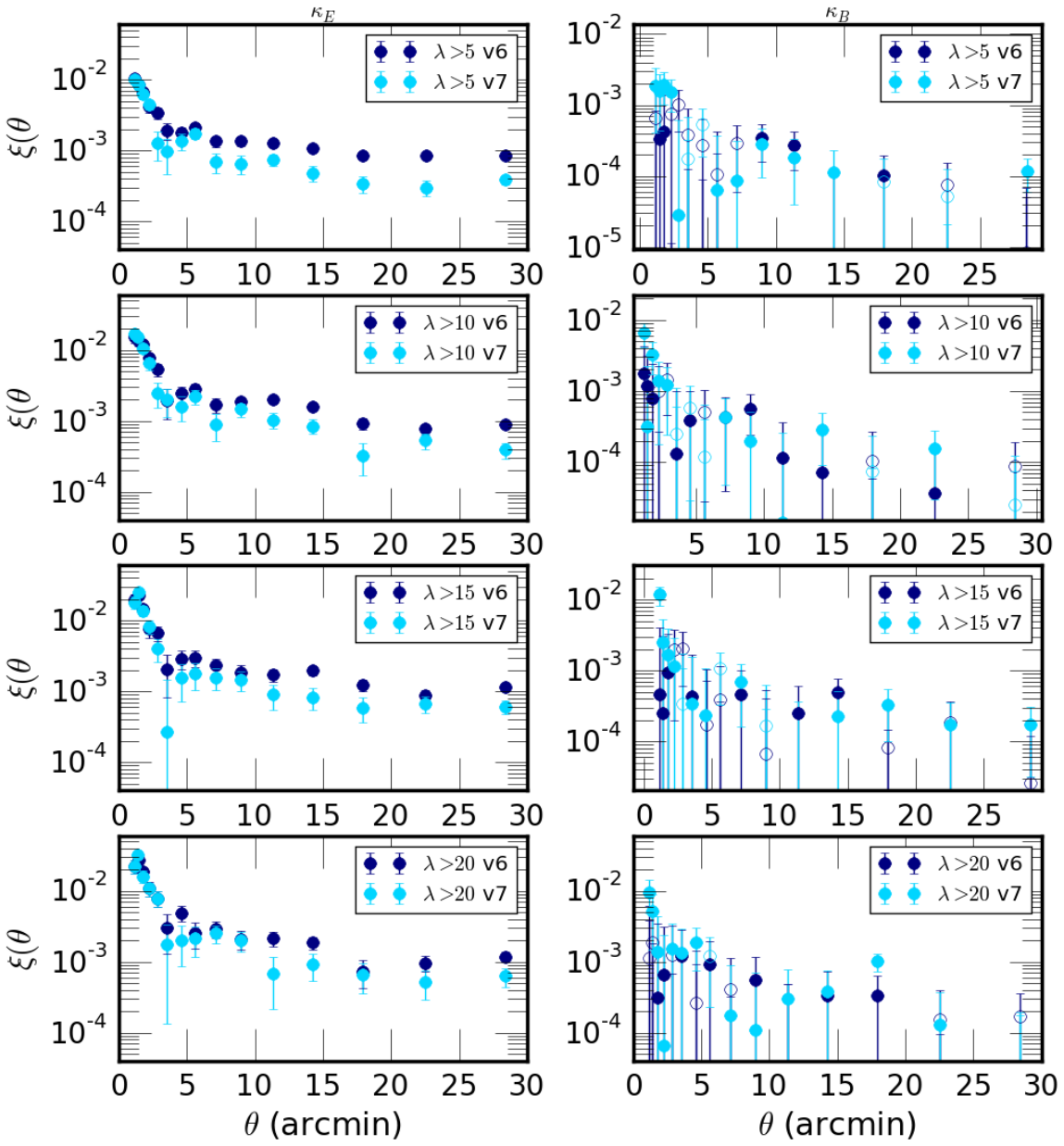


1. kg vs kE increases at large scale
2. Correlation between B-modes decreases at large scale

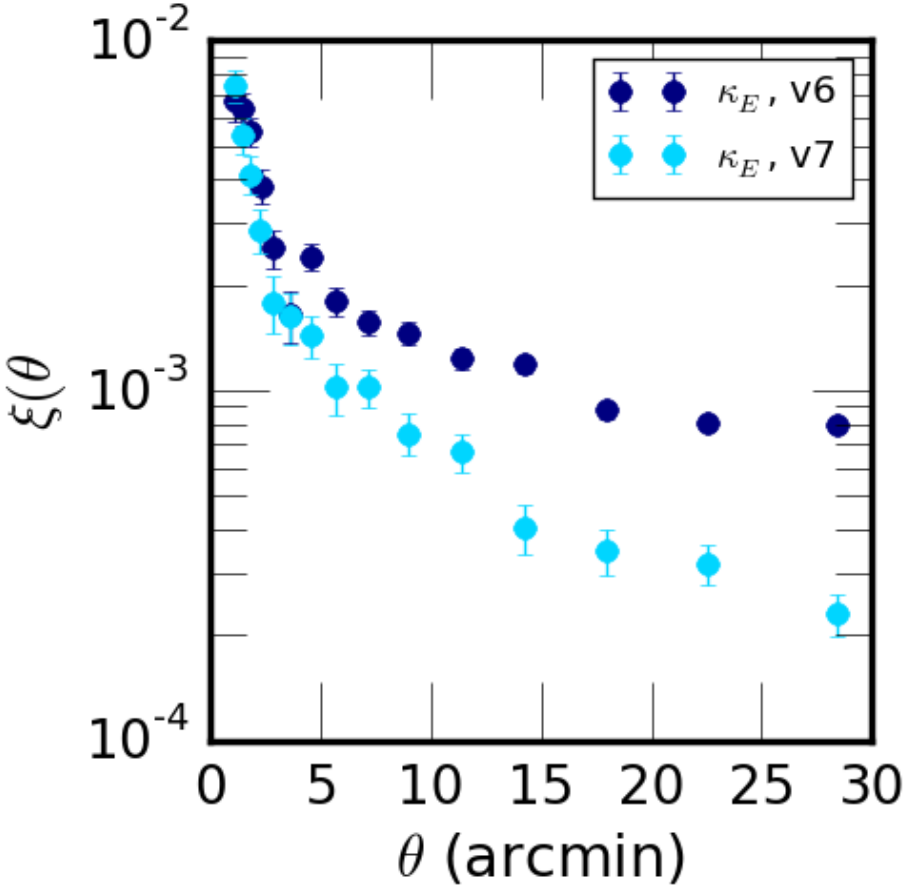
RM Clusters

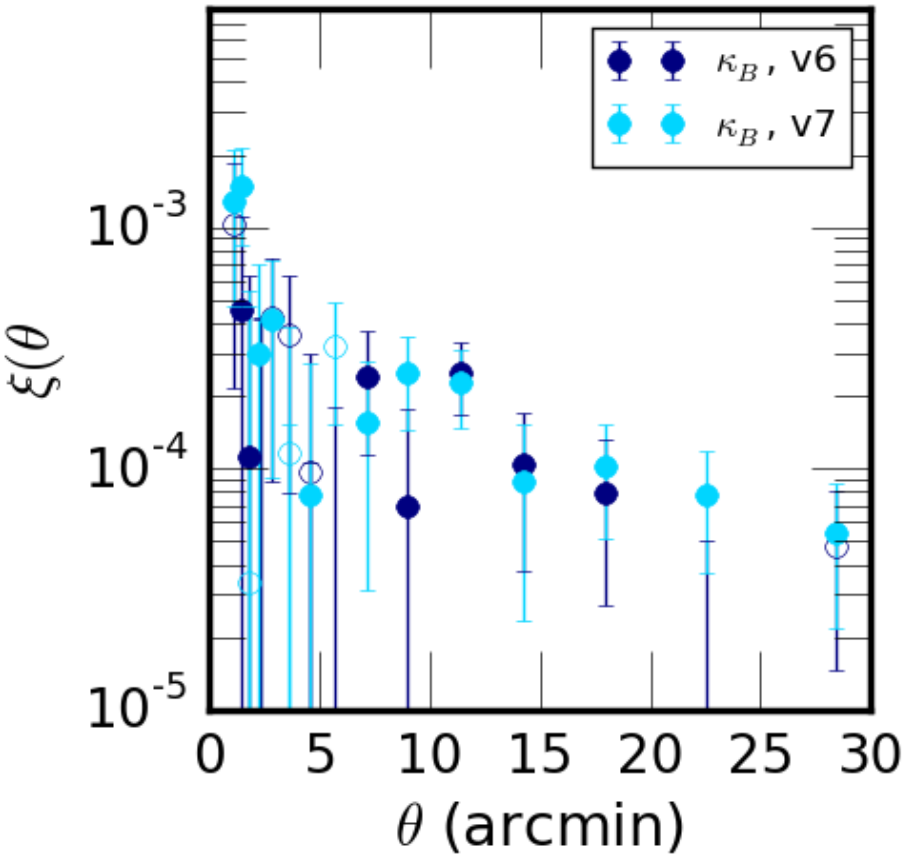

v6
v7
DEC
RA
−45
−50
−55
−60
66
68
70
72
74
76
0.025
0.020
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
−0.020
−0.025

Stacked RM cluster profiles



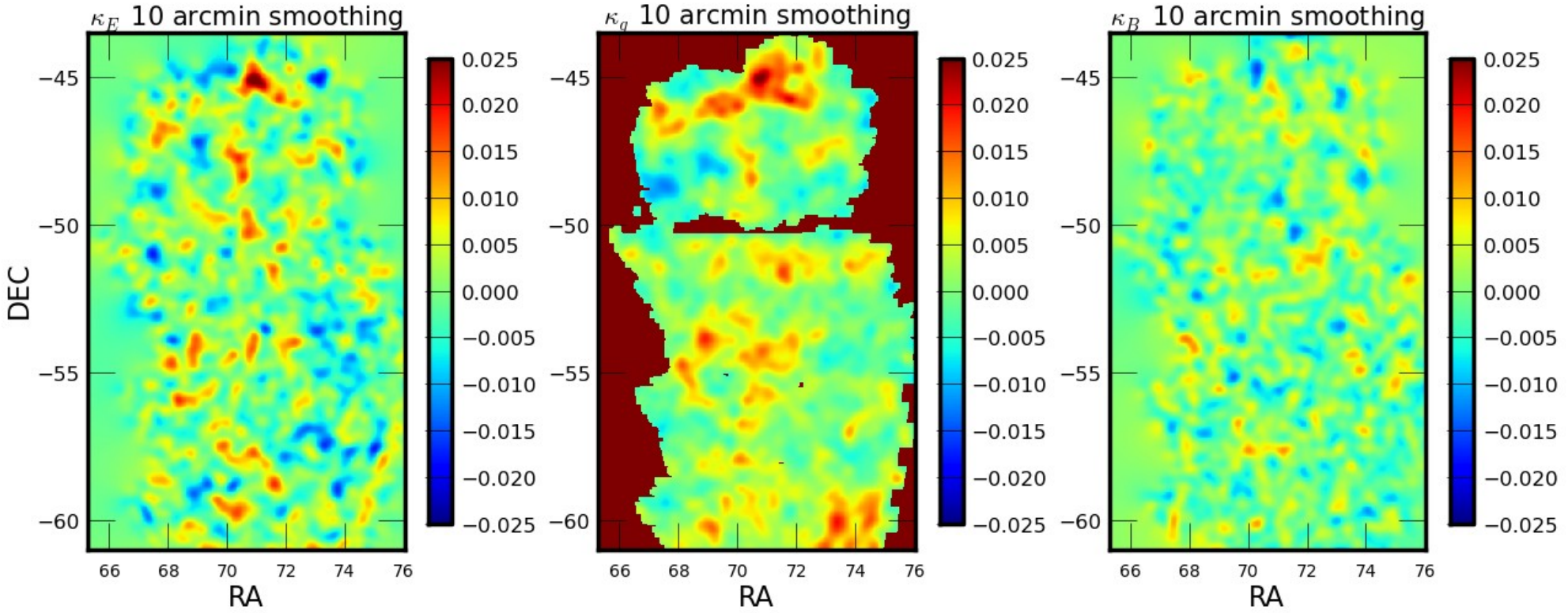
Stacked RedMaGiC LRG profiles





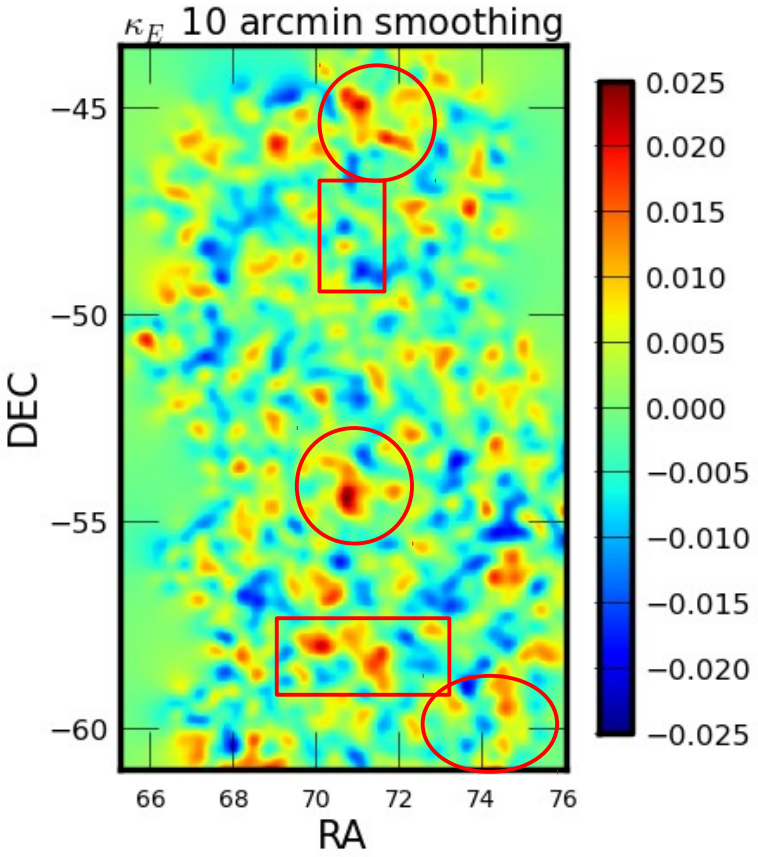
Ngmix 009 (preliminary)

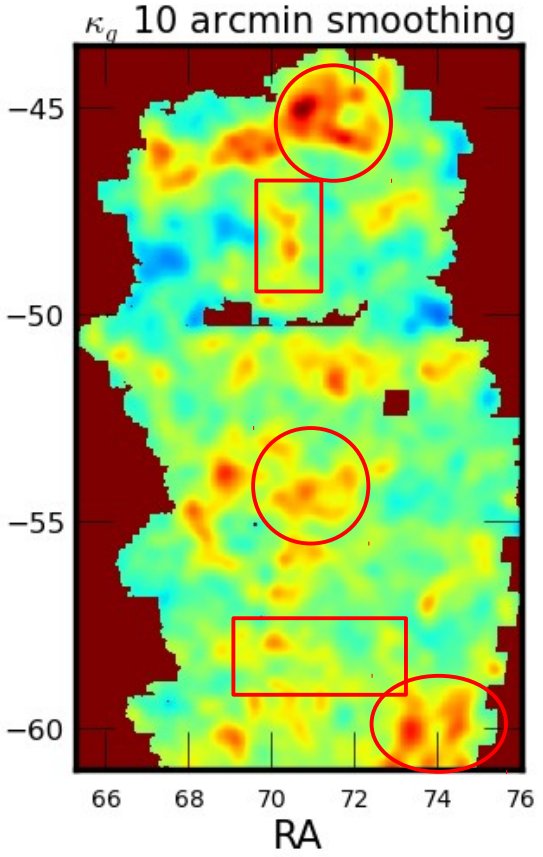
- Looks like it works well!
- Low B-mode
- Large correlation between E and B mode at large scale



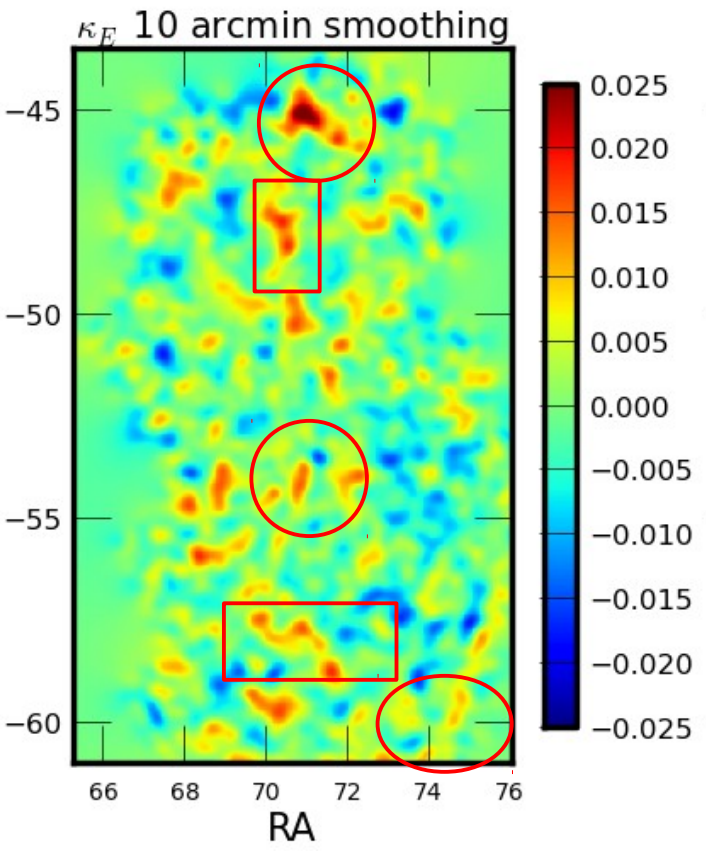
Im3shape v7 & Ngmix 009

Im3shape v7



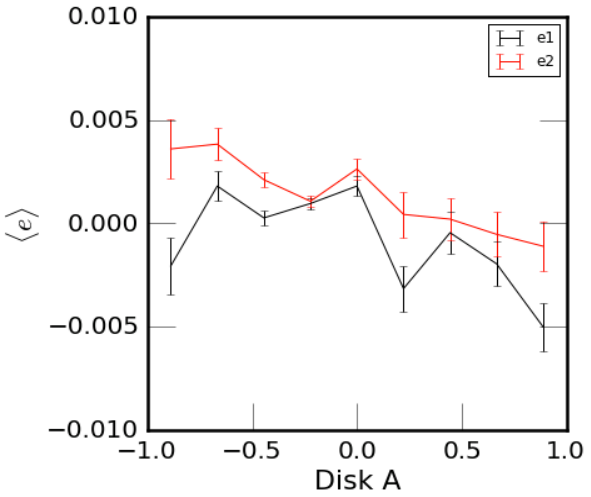


Ngmix 009



Systematics in source selection

- Flags fA to fF based on negative disc component (may be a proxy for background)

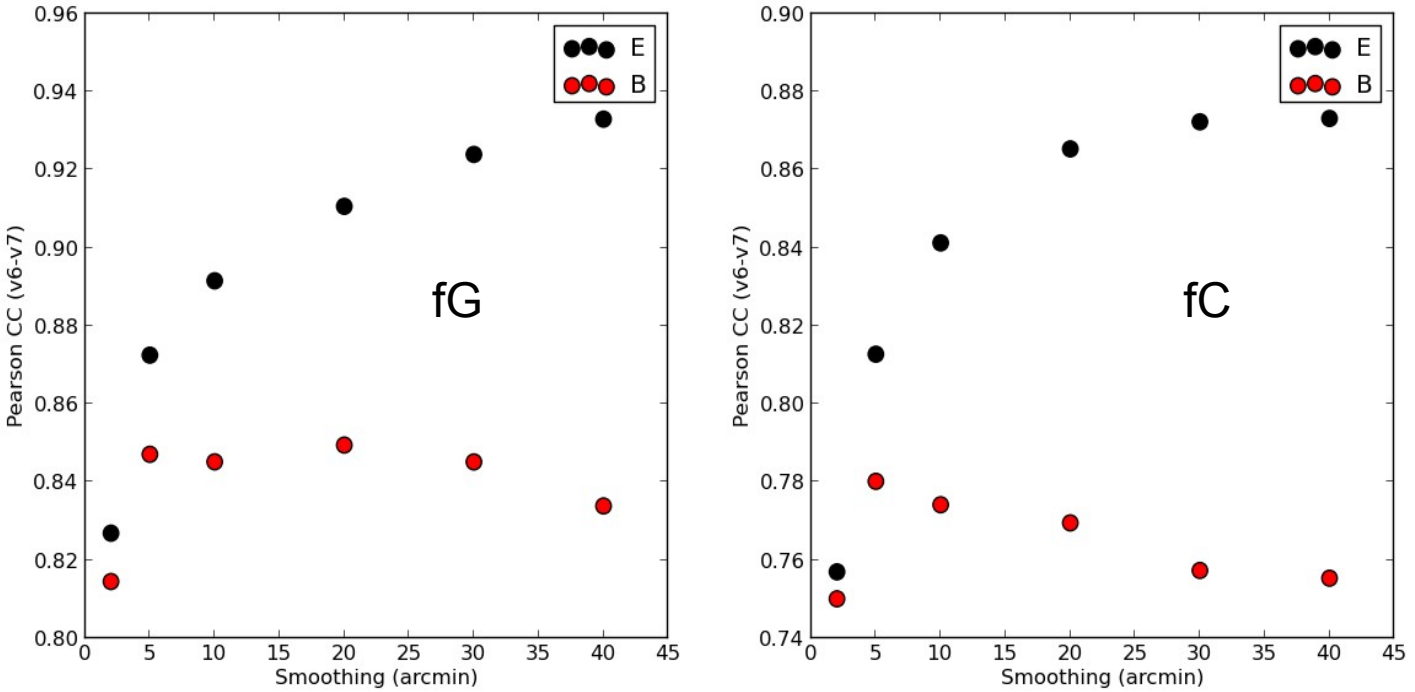


- Disk_A=-0.65 <e1>=-3.96e-04 <e2>=6.95e-04 fraction=0.93
- Disk_A=-0.60 <e1>=-4.14e-04 <e2>=6.17e-04 fraction=0.91
- Disk_A=-0.55 <e1>=-4.84e-04 <e2>=5.87e-04 fraction=0.89
- Disk_A=-0.50 <e1>=-5.51e-04 <e2>=4.96e-04 fraction=0.86

Systematics in source selection

- Flag fG is based stamp_size = 48 & radius > 3.5

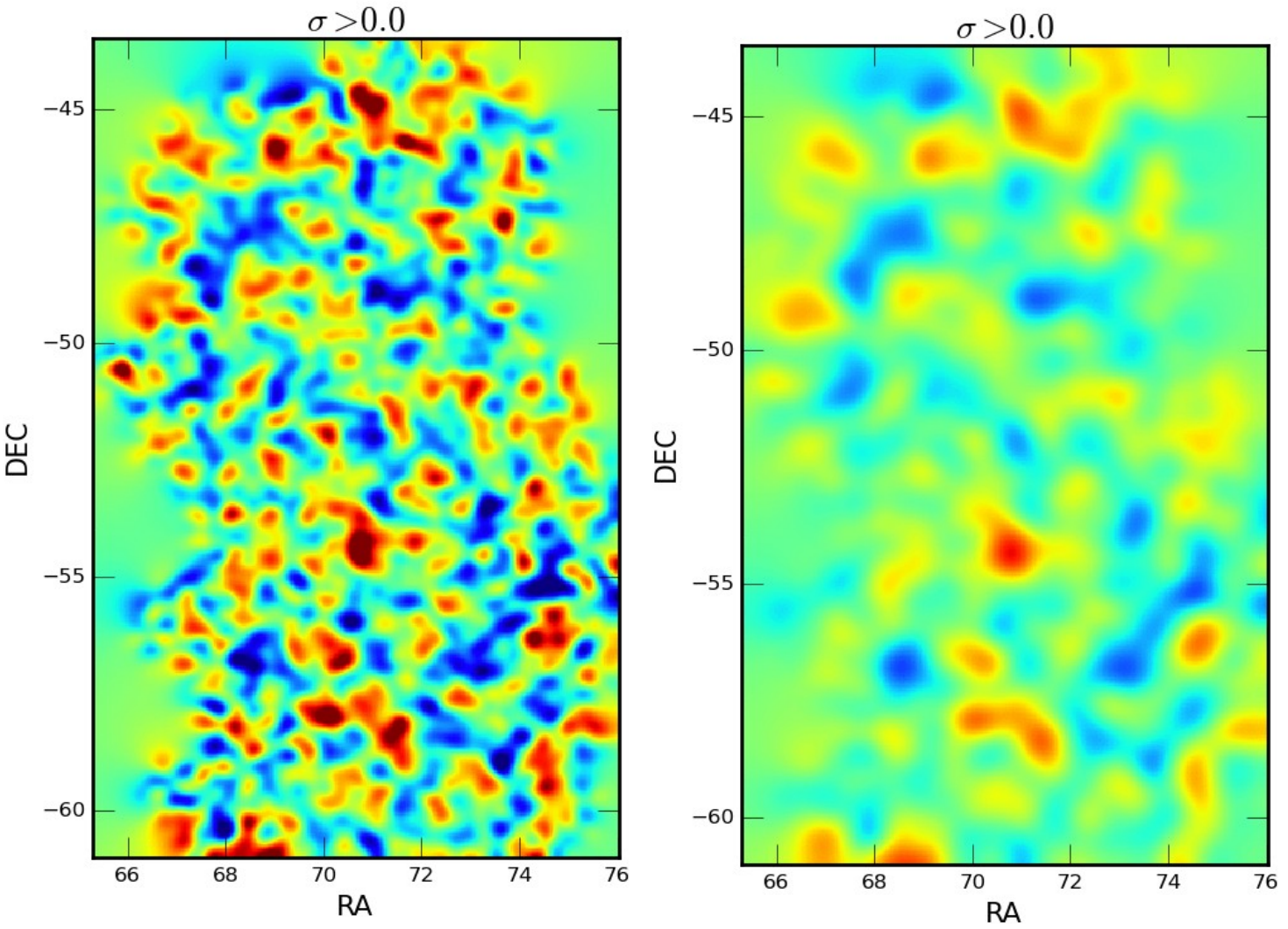
<e1>=-5.52e-04 <e2>=5.64e-04 fraction=0.95



- Map as a function of mask fraction
- Map as a function of stamp size
- Which is the better metric is access the quality of the map?

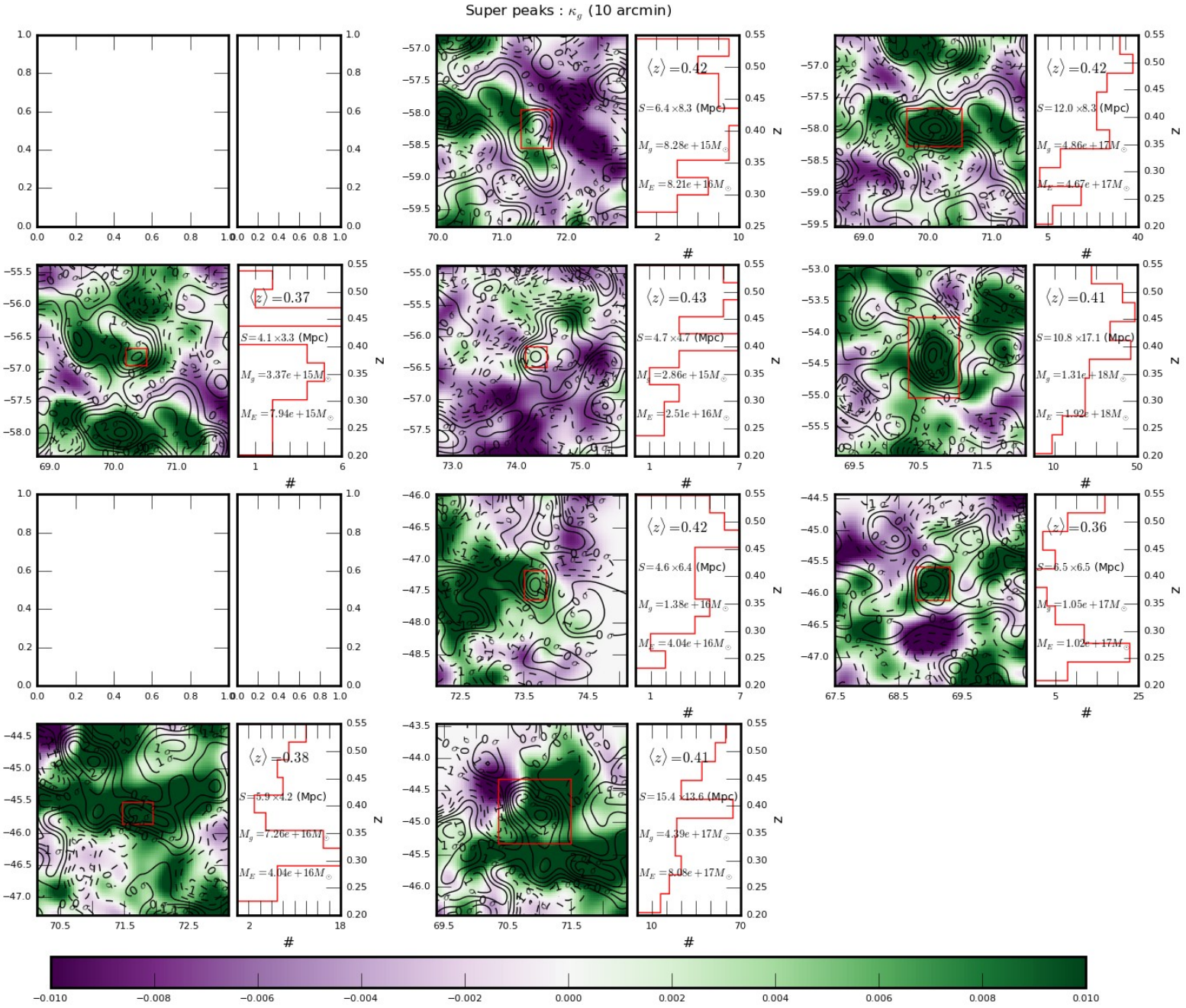
Super Structures

- $\sigma_e = 0.3$
- NOT peaks!

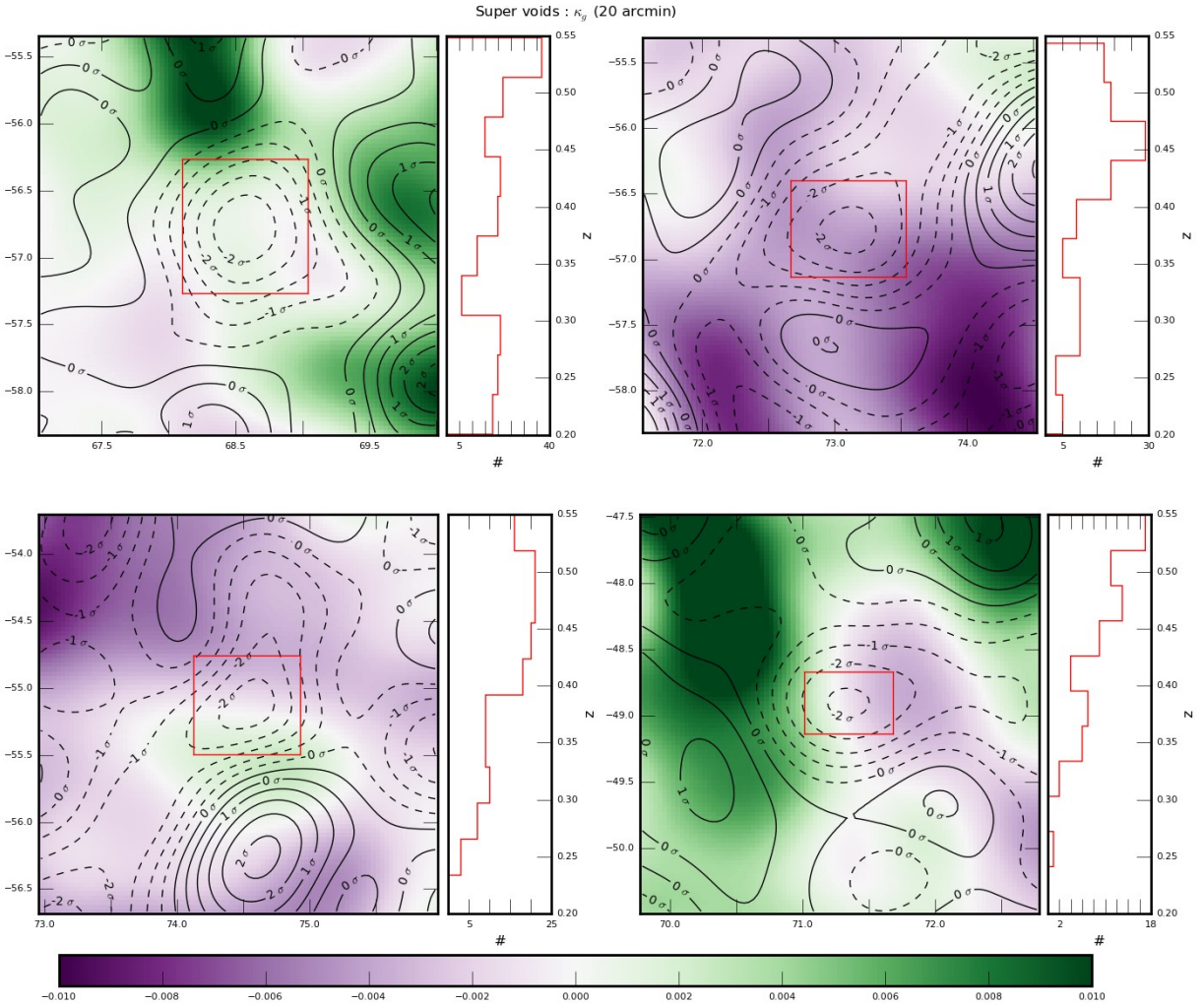


Super Clusters (10 arcmin)

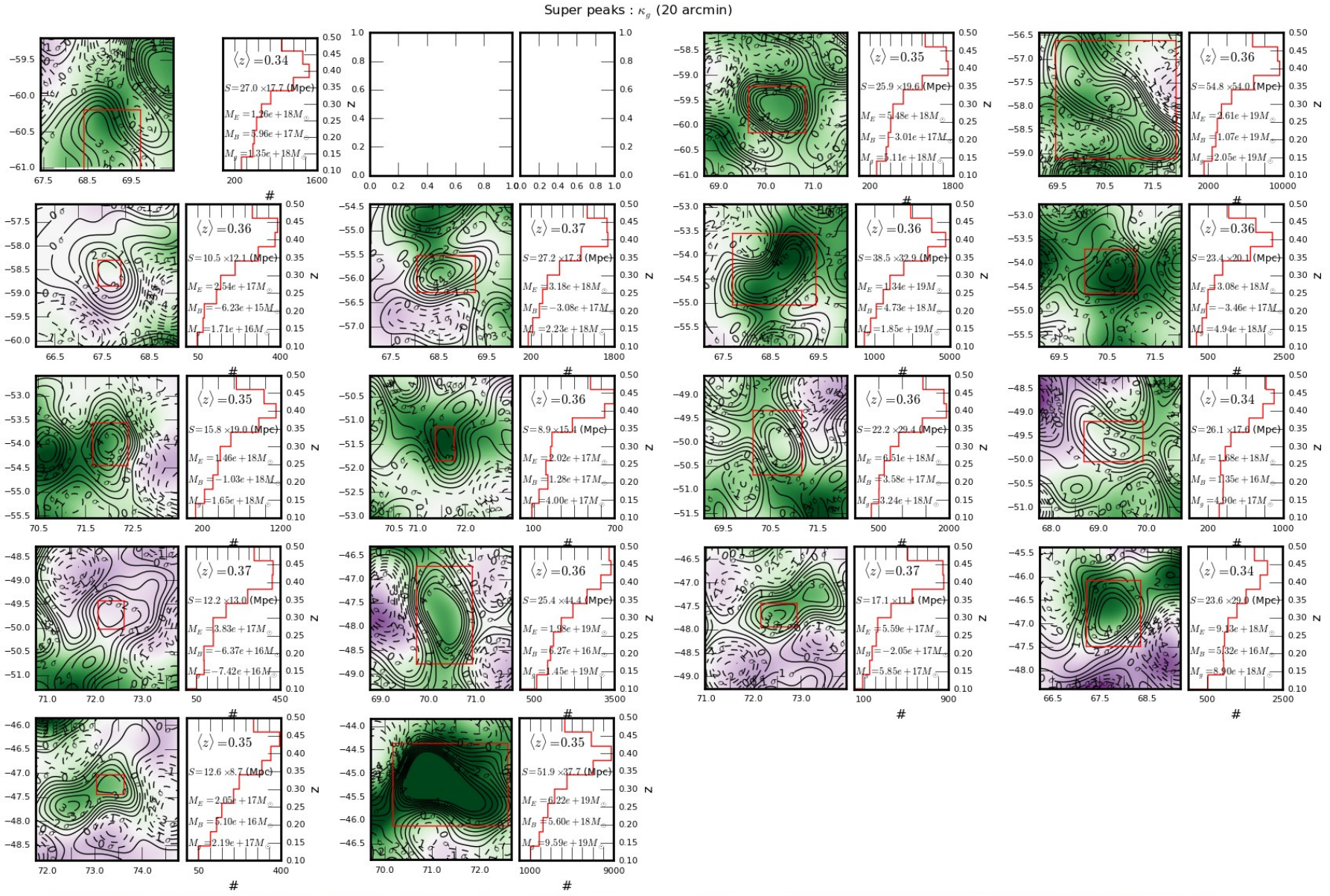
- Mass from shear & galaxies matches very closely
- There are issues sometimes



(Super) voids (20 arcmin)



Super clusters (ngmix-009)



Map repository

- Several xcorr projects are identified based on mass map
- A repository of mass maps with different parameters
- Easy to use and communicate