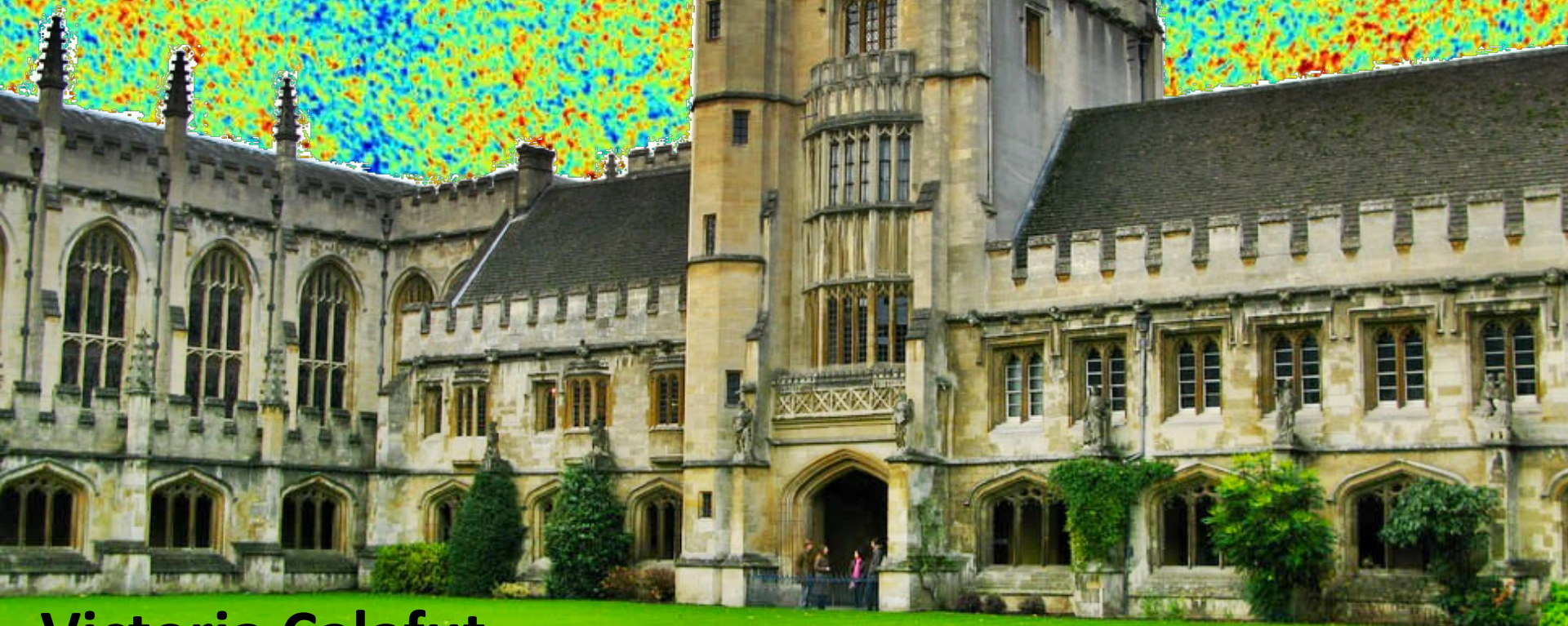


# Cluster Mislocation in kinematic Sunyaev-Zel'dovich (kSZ) effect extraction



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# kSZ pairwise momentum

- Secondary anisotropies in CMB due to hot gas at galaxy cluster center
  - Doppler shift of photons from electrons due to their bulk *peculiar motion*
- Measuring cluster peculiar motions with the kSZ effect can constrain cosmology
- Find *pairwise momentum* between galaxy clusters
  - Pairwise: clusters are individually equally likely to be moving towards or away
  - Momenta: proportional to velocity & electron number density

$$\frac{\delta T_{kSZ}}{T_0}(\hat{r}) = - \int dl \sigma_T n_e \frac{\mathbf{v} \cdot \hat{\mathbf{r}}}{c} \quad \frac{\delta T_{kSZ}}{T_0}(\hat{r}) = -\tau \frac{v_r}{c}$$

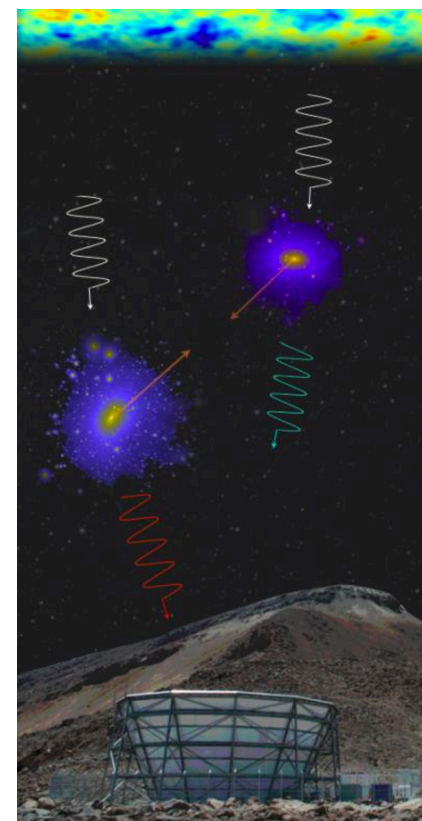
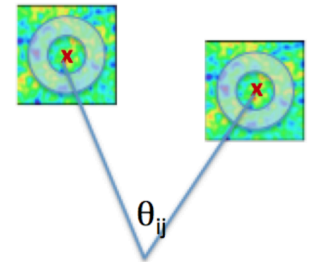


Image: Sudeep Das, University of California-Berkeley

# Testing the Central Galaxy Paradigm

- The brightest halo galaxies (BHG) have been used as proxies to locate the centers of galaxy clusters
- redMaPPer studies: ~20% to ~40% of the BHGs off-centered, considering ranked centering and cluster membership probabilities
- Use aperture photometry to extract the kSZ temperature from the CMB at the location of the brightest galaxy LSS proxy
- Additional systematics: covariance methods, photo-z error, aperture size



# Datasets

We cross-correlate *Planck* CMB maps x LSS samples, where we choose the cluster center proxy based on the:

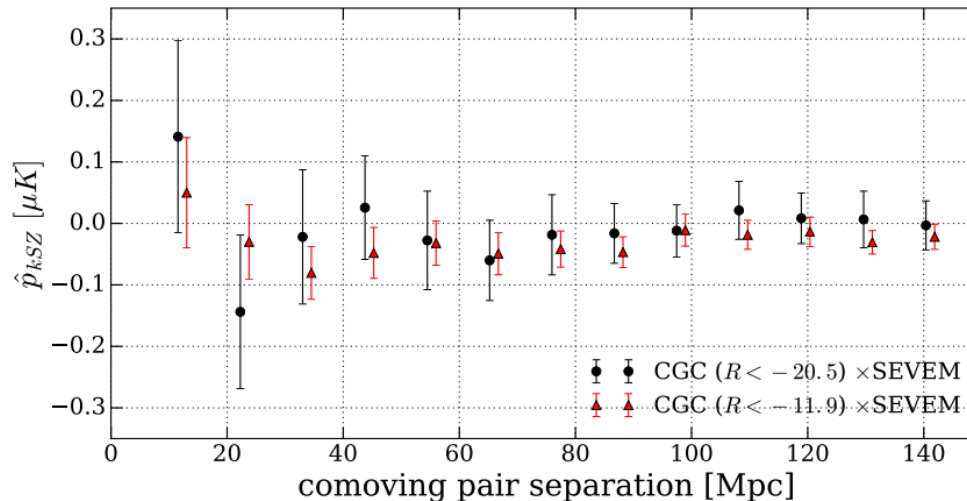
- Brightest galaxy, for three primarily spectroscopic samples
- RedMaPPer central galaxy, including photometric redshifts

*Brightest Galaxy Catalogs:*

Sample	$N_{gal}$	$\bar{z}$	$\sigma_z$	$\Theta(\bar{z})$
SDSS CGC	262,671	0.13	0.05	8.0'
WISE	24,731	0.27	0.24	4.8'
CMASS+LOWZ	555,307	0.46	0.15	3.2'

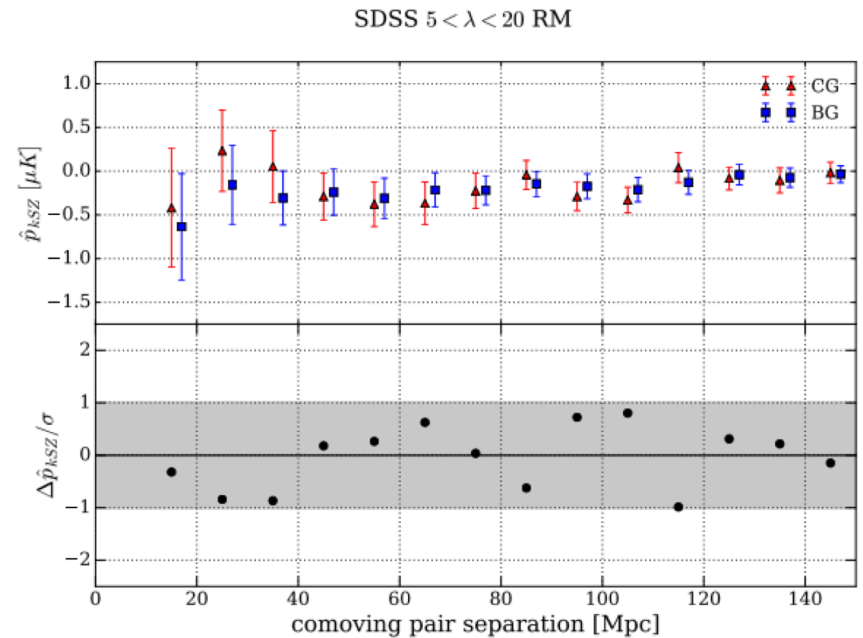
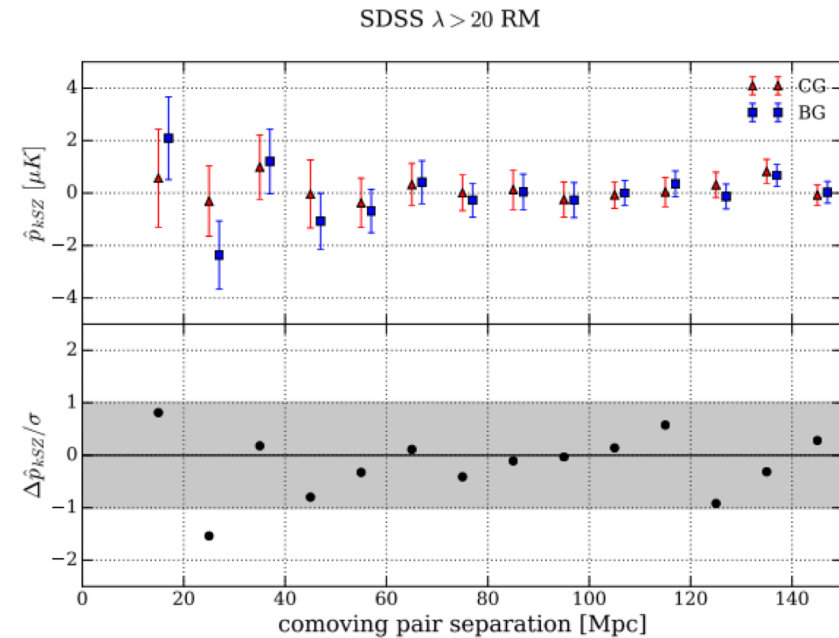
*redMaPPer-derived Catalogs:*

Sample	$N_{gal}$	$\bar{z}$	$\sigma_z$	$\Theta(\bar{z})$
SDSS ( $5 < \lambda < 20$ )	22,492	0.25	0.05	4.7'
SDSS ( $\lambda > 20$ )	5,818	0.26	0.05	4.6'
DECaLs	5,870	0.47	0.13	3.1'



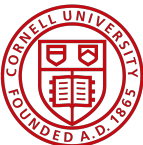
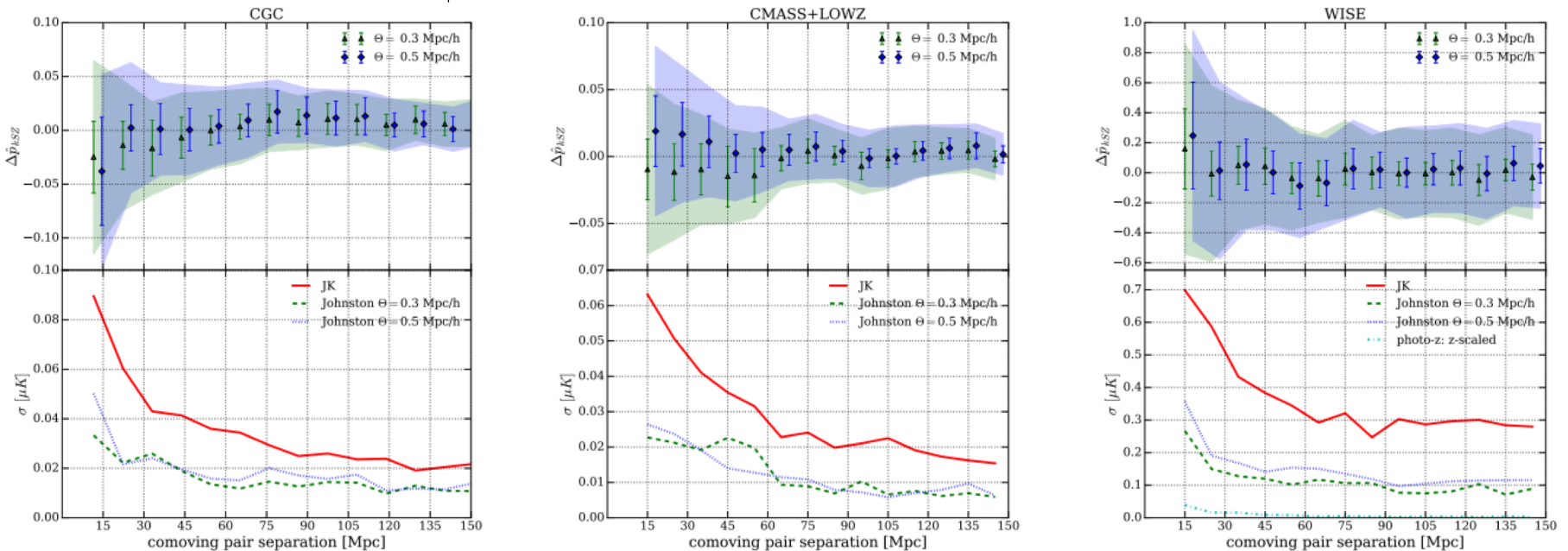
# LRG transverse miscentering: redMaPPer

We compare the pairwise signal using the redMaPPer-selected most likely central galaxy vs. the brightest galaxy



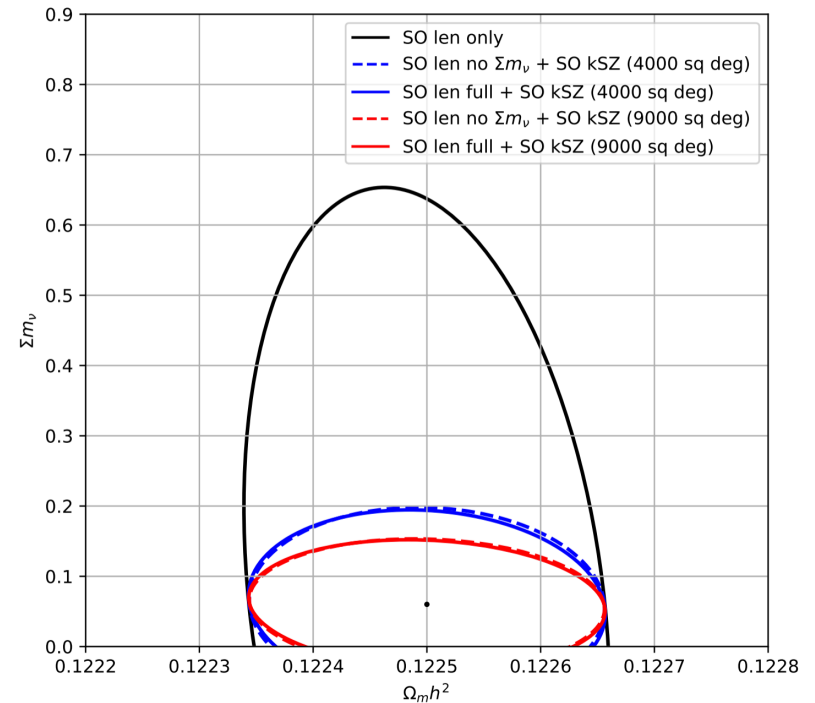
# LRG transverse miscentering: Gaussian offset modelling

We find the pairwise signal based on 50 trials, in which a different random 25% of the galaxy proxy positions are offset based on a Gaussian distribution of width  $\theta_j = 0.3, 0.5$  Mpc/h (Johnston et al)



# Current work

- Expanding miscentering analysis for ACT+ACTPol data
- kSZ forecasting for cosmological constraints
  - Adapting pairwise kSZ forecasts (E.-M. Mueller et al. 2014) for next generation CMB and LSS data
  - Implementing LSST: DESC Core Cosmology Library subroutines



# Conclusions

- Miscentering increases the kSZ error budget both in redMaPPer and offset modeling analyses, inducing uncertainties comparable to the current statistical errors:  $\sim 0.7, 0.6, 0.4\sigma$
- We find JK covariance estimates more conservative than CMB map rotations; do not find a substantial difference based on reasonable aperture selections
- Statistical errors will decrease with new LSS surveys - DESI, LSST, Euclid + improved CMB data - CMB-S4, Advanced ACTPol, SPT-4G, Simons Observatory, so mitigating miscentering will become increasingly important

