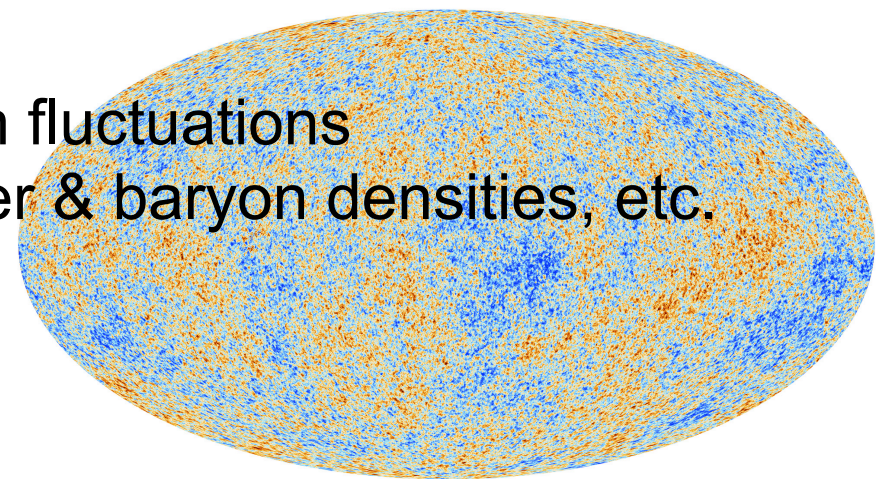


SWG

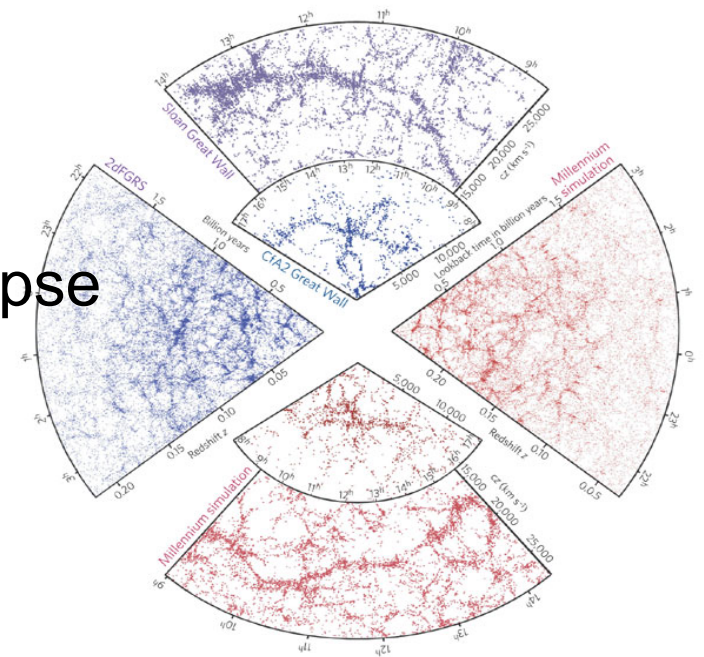
Cross-correlation with CMB

Coordinators: N. Aghanim & C. Baccigalupi

Initial density perturbations → quantum fluctuations
Cosmological framework → Dark Matter & baryon densities, etc.



Evolution and growth → gravitational collapse



Formation of cosmic structures galaxies/stars
→ complex baryonic physics



Dark matter

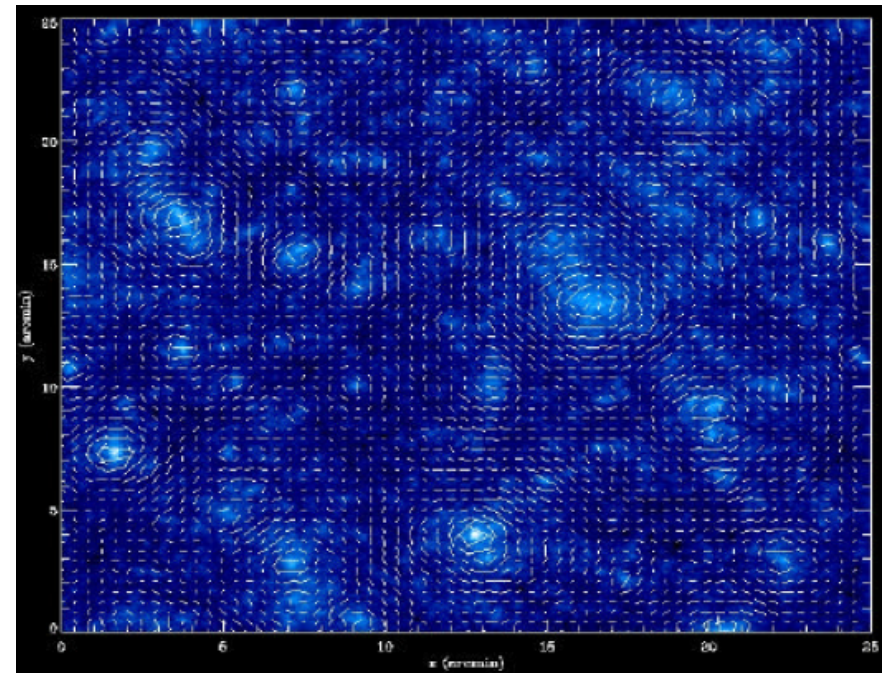
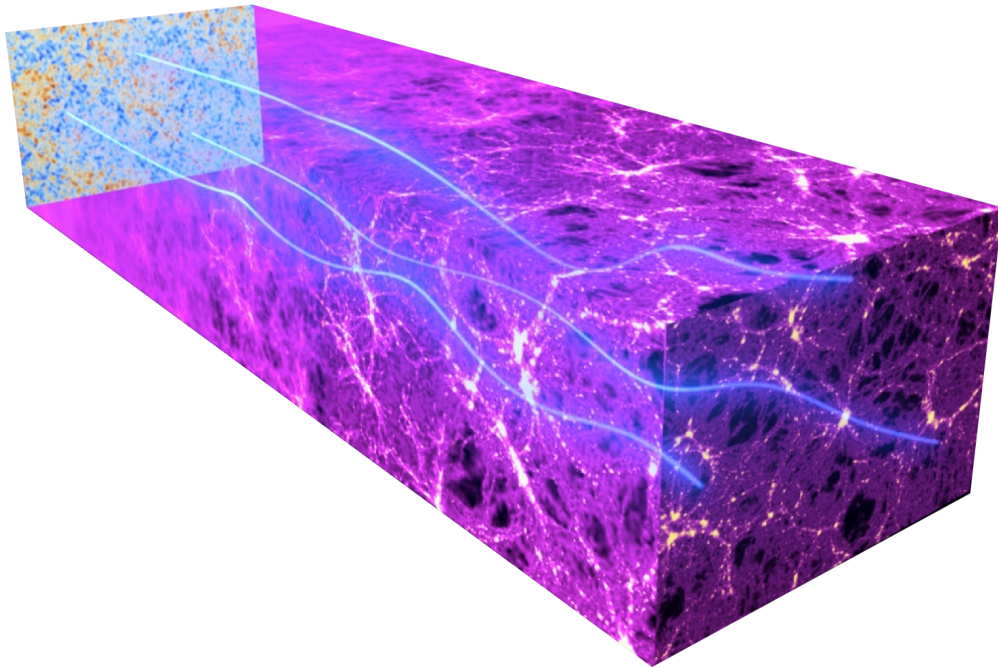


Dominant component detected indirectly

DM \rightarrow lenses CMB photons sources at high redshifts & background source population at low z

CMB lensing: anisotropy displacements

Galaxy lensing: shape modifications



Baryonic matter

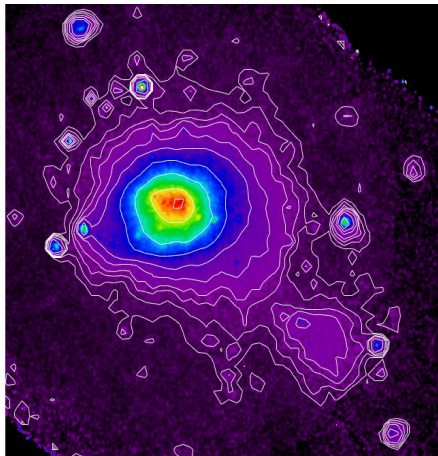


Galaxies
Hot gas

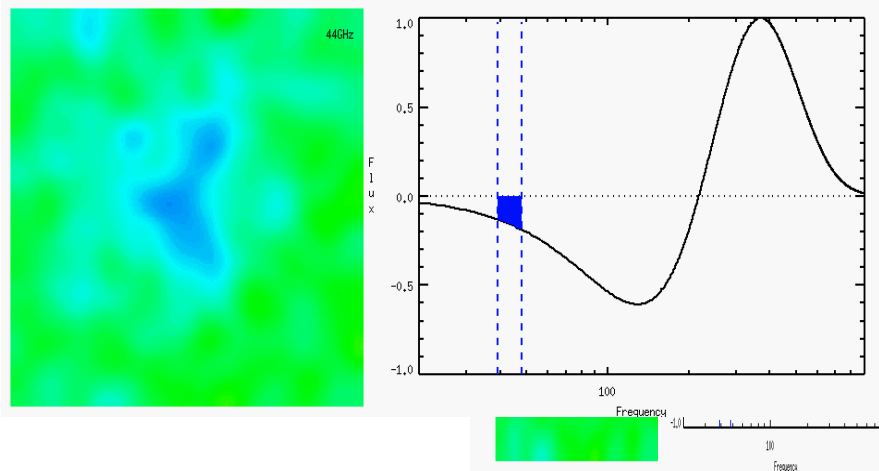
Hot gas → X-ray emission & Sunyaev-Zeldovich

Galaxy distribution

Coma in ROSAT



A2318 in Planck HFI



Cross-correlation with CMB

Combination of data and likelihoods

Traditionally XCMB = Integrated Sachs-Wolfe effect

Probes derivative of growth function → acceleration of expansion and modified gravity, and cosmological parameters

$$\Delta_t^{\text{ISW}}(\hat{\mathbf{n}}) \equiv \left(\frac{\Delta T(\hat{\mathbf{n}})}{T} \right) = -2 \int dz e^{-\tau(z)} \frac{d\Phi}{dz}(\hat{\mathbf{n}}, z) \quad \dot{\Phi} \equiv \partial/\partial z[(1+z)D(z)] \equiv \partial g/\partial z$$

$$g(z) \equiv f[\Omega_m(z), E(z)]$$

$$E(z)^2 \equiv \Omega_m(1+z)^3 + \Omega_K(1+z)^2 + \Omega_{\text{DE}}(1+z)^3 \exp\left[3 \int_0^z dz' \frac{w(z')}{(1+z')}\right]$$

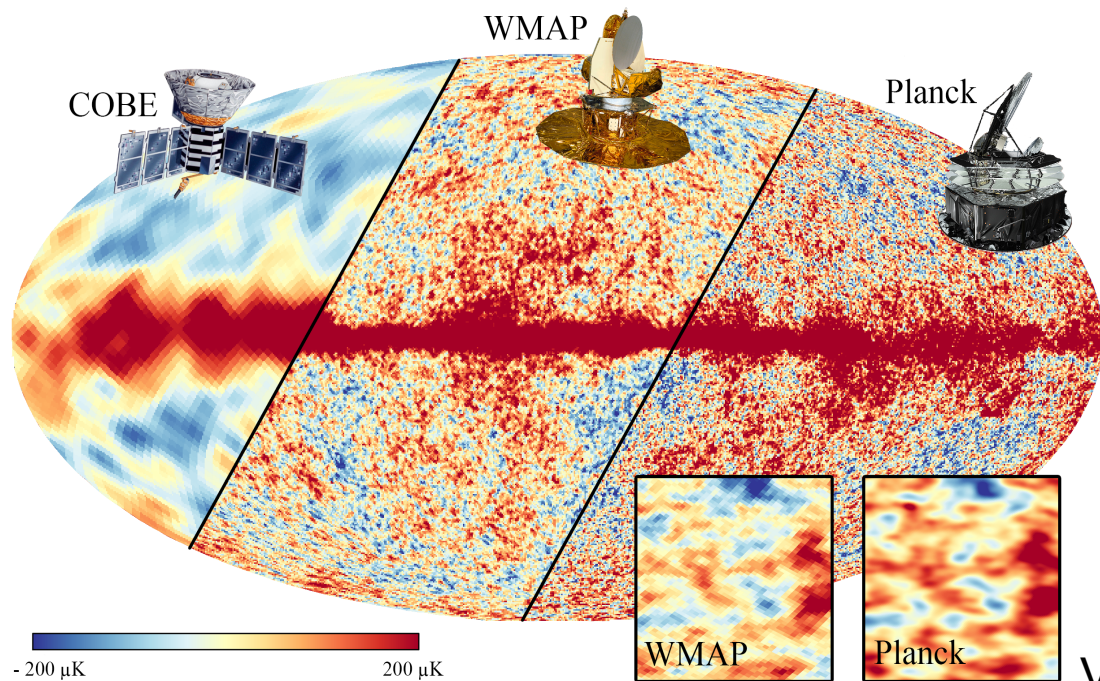
E.g. galaxy-CMB correlation

$$C_l^{\text{ISW-G}} = \frac{2}{\pi} \int dk k^2 P_{\delta\delta}(k) I_l^{\text{ISW}}(k) I_l^{\text{G}}(k)$$

Probes the distribution of matter at large scales
(DM/galaxy bias, hydrostatic bias, etc.)

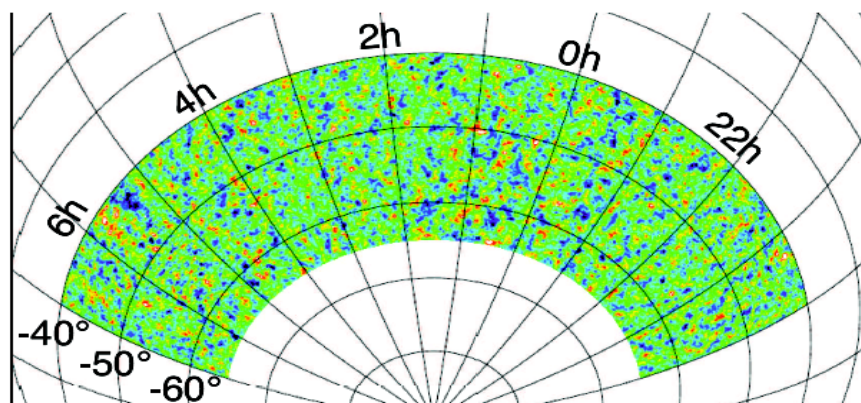
→ Explore higher-order correlation estimators

Primary CMB data status

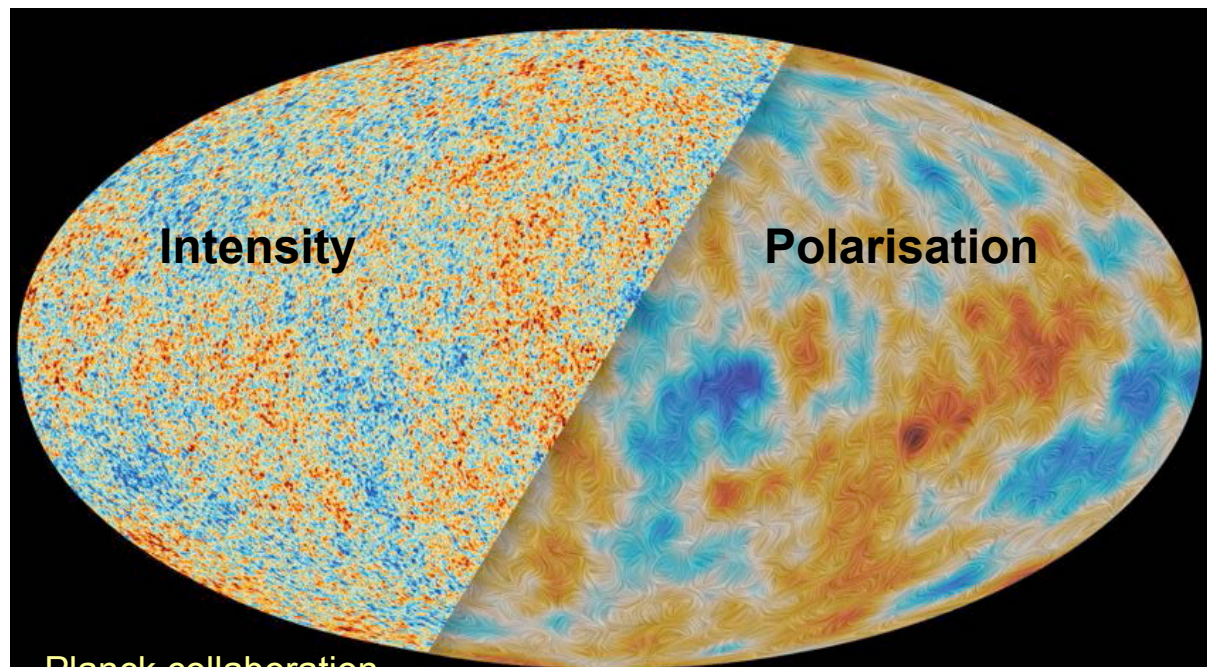


Very large to small scales

Very small scale intensity/polarisation



SPT, Story et al 2013

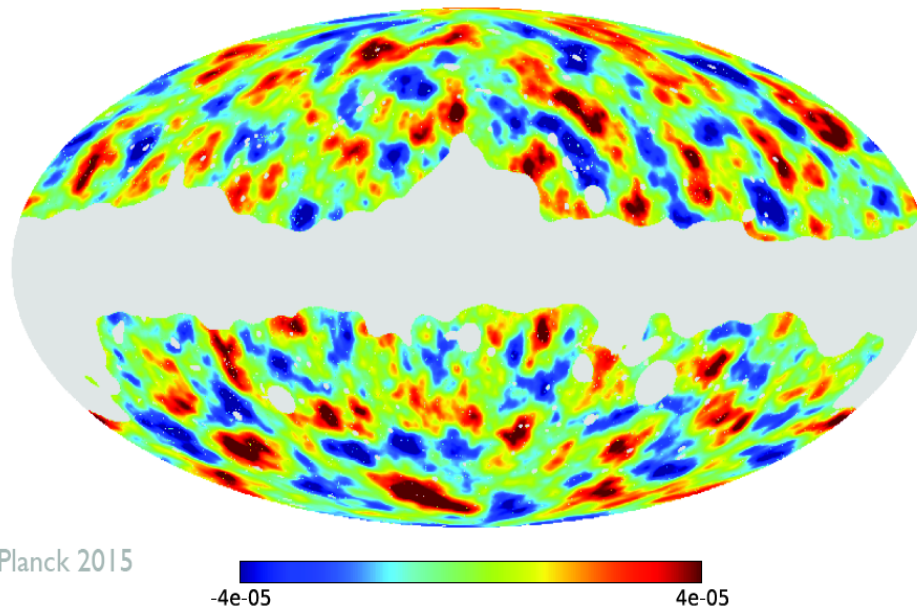
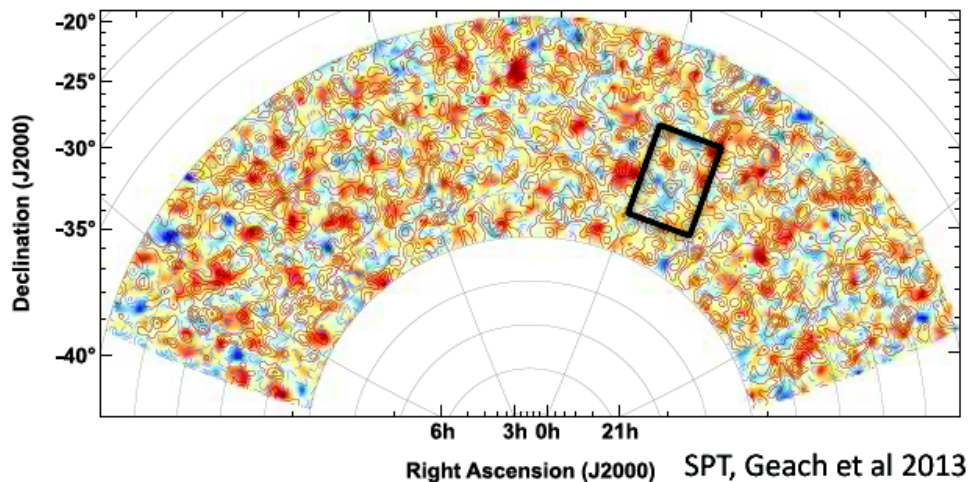


Planck collaboration

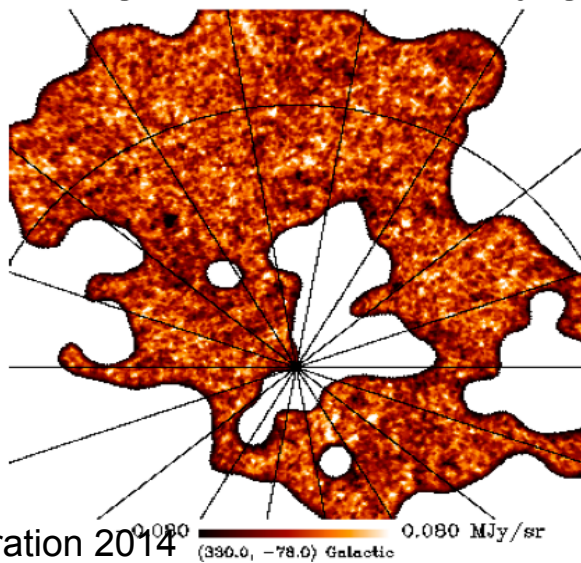
Secondary CMB data status

CMB lensing maps from the largest to the smallest scales

Planck collaboration 2014, 2015



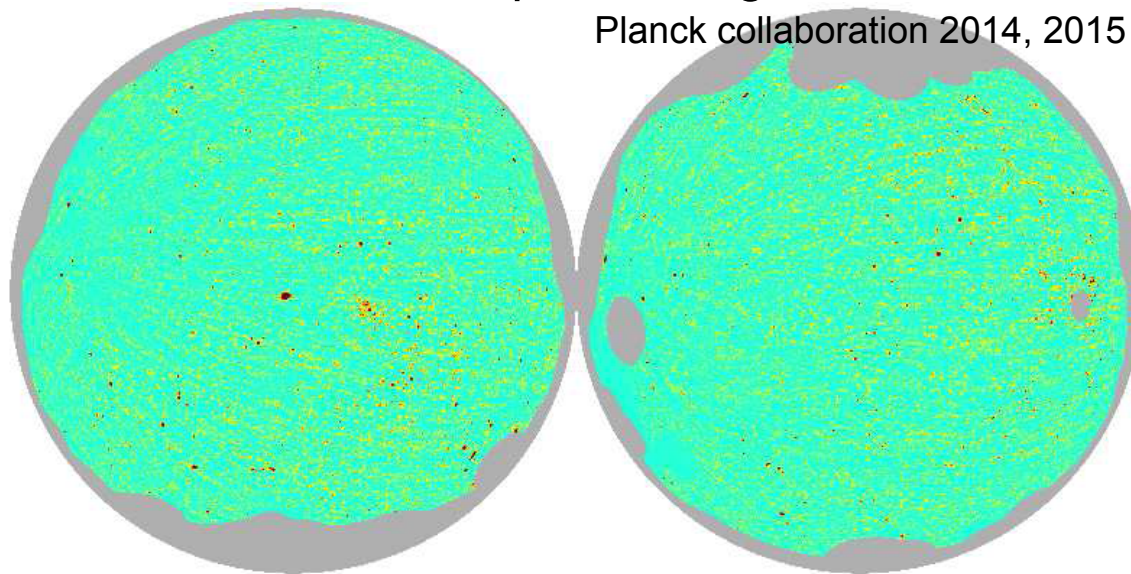
Comic IR background from dusty gal.



Planck collaboration 2014

SZ reconstructed map from large to small scales

Planck collaboration 2014, 2015



Integrated Sachs-Wolfe

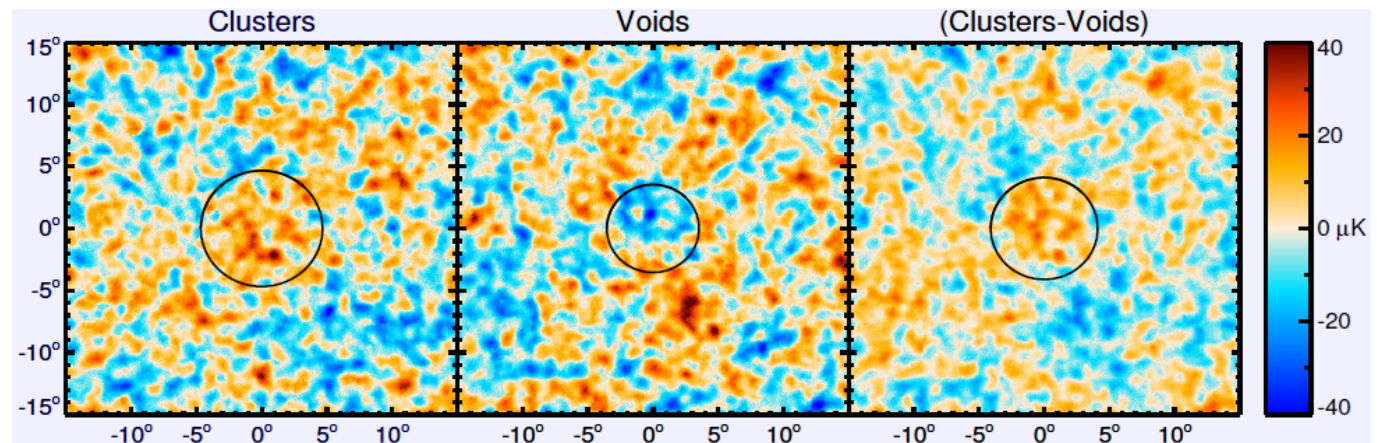
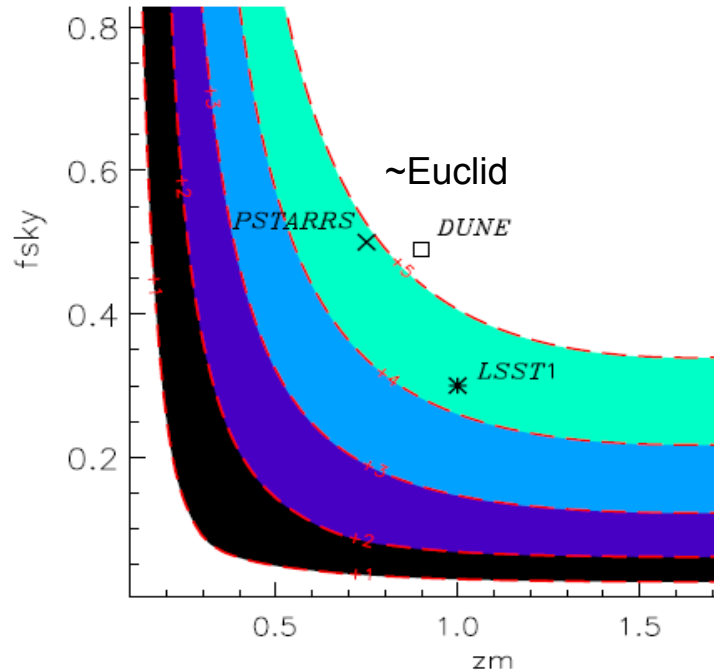
Present status: detection of iSW through X-correlation or stacking at 4 σ at most

Planck Collaboration 2014, 2015

LSS data	COMMANDER		NILC		SEVEM		SMICA		Expected
	$A \pm \sigma_A$	S/N	$A \pm \sigma_A$	S/N	$A \pm \sigma_A$	S/N	$A \pm \sigma_A$	S/N	S/N
NVSS	0.95 ± 0.36	2.61	0.94 ± 0.36	2.59	0.95 ± 0.36	2.62	0.95 ± 0.36	2.61	2.78
WISE-AGN	0.95 ± 0.60	1.58	0.96 ± 0.60	1.59	0.95 ± 0.60	1.58	1.00 ± 0.60	1.66	1.67
WISE-GAL	0.73 ± 0.53	1.37	0.72 ± 0.53	1.35	0.74 ± 0.53	1.38	0.77 ± 0.53	1.44	1.89
SDSS-CMASS/LOWZ	1.37 ± 0.56	2.42	1.36 ± 0.56	2.40	1.37 ± 0.56	2.43	1.37 ± 0.56	2.44	1.79
SDSS-MphG	1.60 ± 0.68	2.34	1.59 ± 0.68	2.34	1.61 ± 0.68	2.36	1.62 ± 0.68	2.38	1.47
lensing	1.04 ± 0.33	3.15	1.04 ± 0.33	3.16	1.05 ± 0.33	3.17	1.06 ± 0.33	3.20	3.03
NVSS+ lens.	1.04 ± 0.28	3.79	1.04 ± 0.28	3.78	1.05 ± 0.28	3.81	1.05 ± 0.28	3.81	3.57
WISE	0.84 ± 0.45	1.88	0.84 ± 0.45	1.88	0.84 ± 0.45	1.88	0.88 ± 0.45	1.97	2.22
SDSS	1.49 ± 0.55	2.73	1.48 ± 0.55	2.70	1.50 ± 0.55	2.74	1.50 ± 0.55	2.74	1.82
NVSS+WISE+SDSS	0.89 ± 0.31	2.87	0.89 ± 0.31	2.87	0.89 ± 0.31	2.87	0.90 ± 0.31	2.90	3.22
All	1.00 ± 0.25	4.00	0.99 ± 0.25	3.96	1.00 ± 0.25	4.00	1.00 ± 0.25	4.00	4.00

Ilic et al. 2014

Douspis et al. 2008



$0.49 < \Omega_\Lambda < 0.78$ (68%), best-fit $\Omega_\Lambda = 0.67$, $\Omega_\Lambda > 0$ at 3σ
 $-4.45 < w < -1.07$ (68%), best-fit $w = -1.01$

- Controlled survey & Reconstruction of iSW
- Exploration of theoretical models for DE and Modified gravity

Galaxy/CMB X-correlation

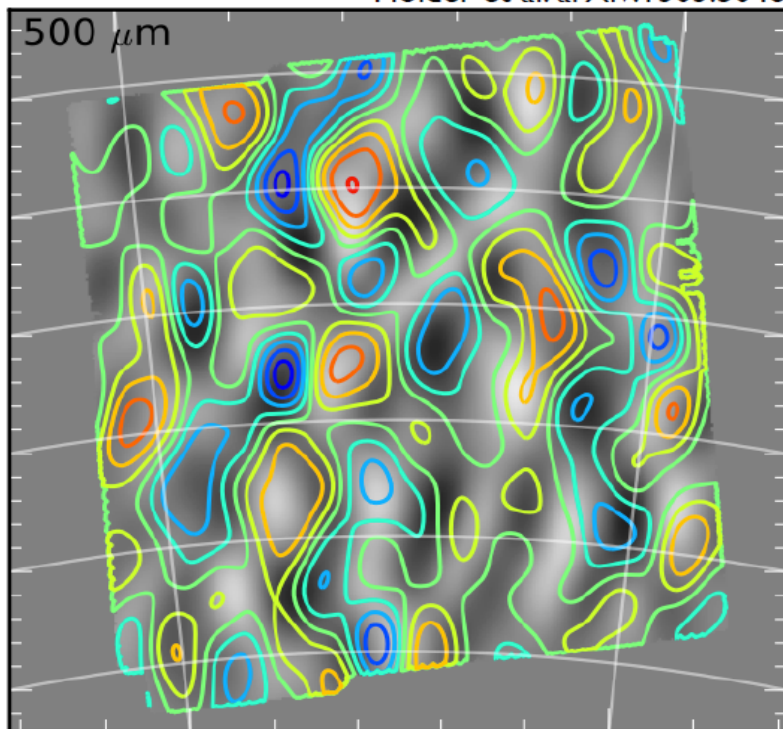
Detected @ $\sim 3\sigma$ (e.g. Hand et al. 2013). Future Euclid $\sim 30-40\sigma$

→ Bias measurement

$$C_{\ell}^{\kappa g} = \int_0^{z_*} \frac{dz}{c} \frac{H(z)}{\chi^2(z)} W^{\kappa}(z) b(z) \frac{dN}{dz} P(k, z)$$

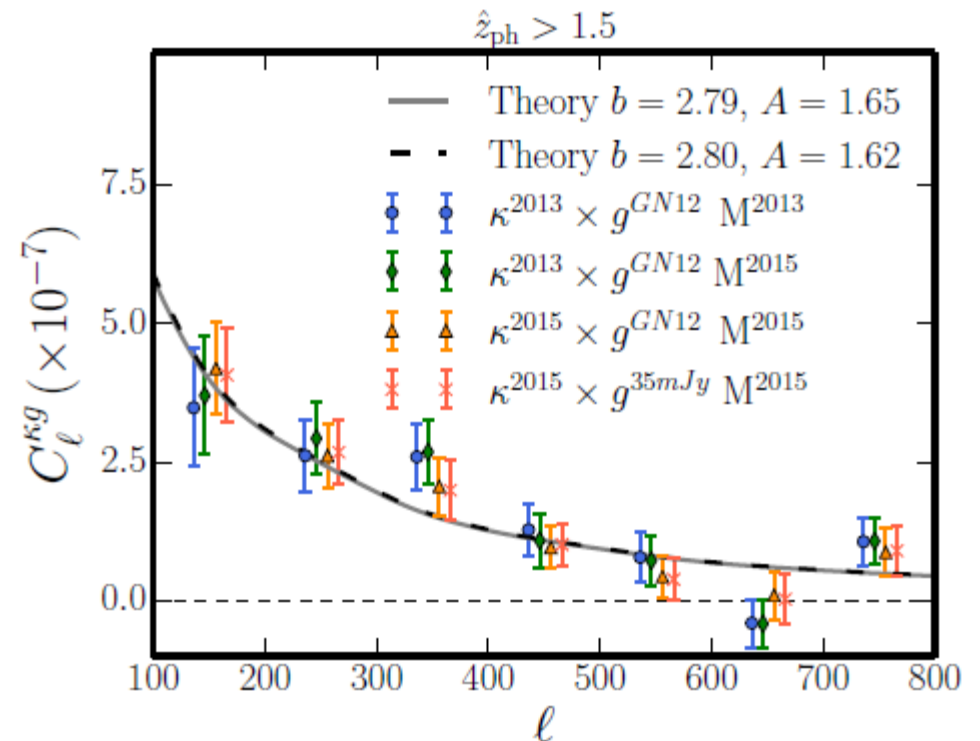
Cross-correlation between CMB lensing and high- z galaxies ($z > 1.5$) of the H-ATLAS galaxy density maps → bias measurement ~ 3.5 + bias in 2 bins

Holder et al. arXiv:1303.5048



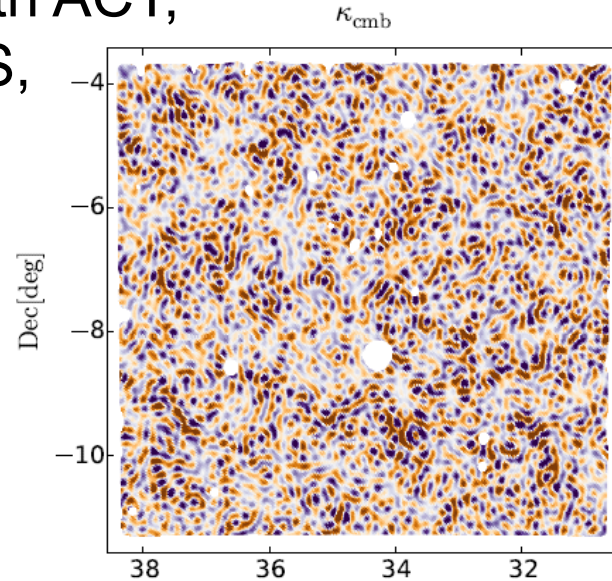
Correlation of matter traced by SPT CMB lensing (contours) and distribution of high z galaxies (grayscale; Herschel 500 μm)

Bianchini et al. 2015



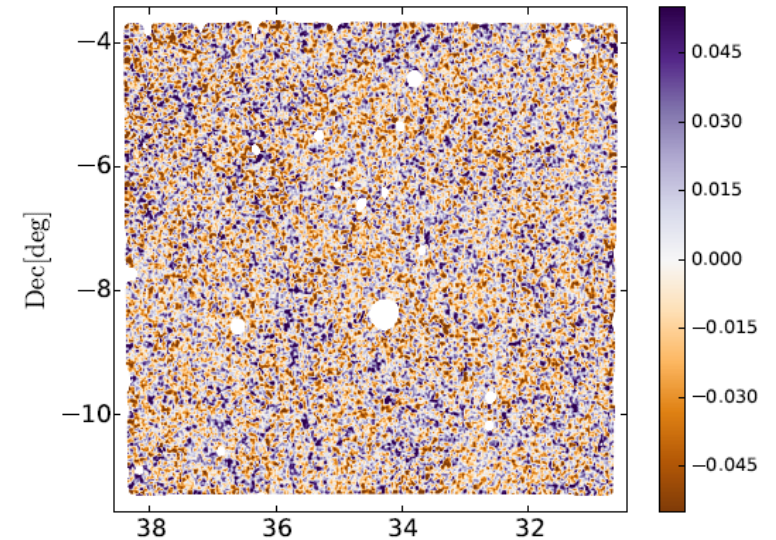
Galaxy lensing/CMB lensing X-correlation

Detection @~3-46 with ACT,
Planck, SPT and DES,
CFHTLenS, S82



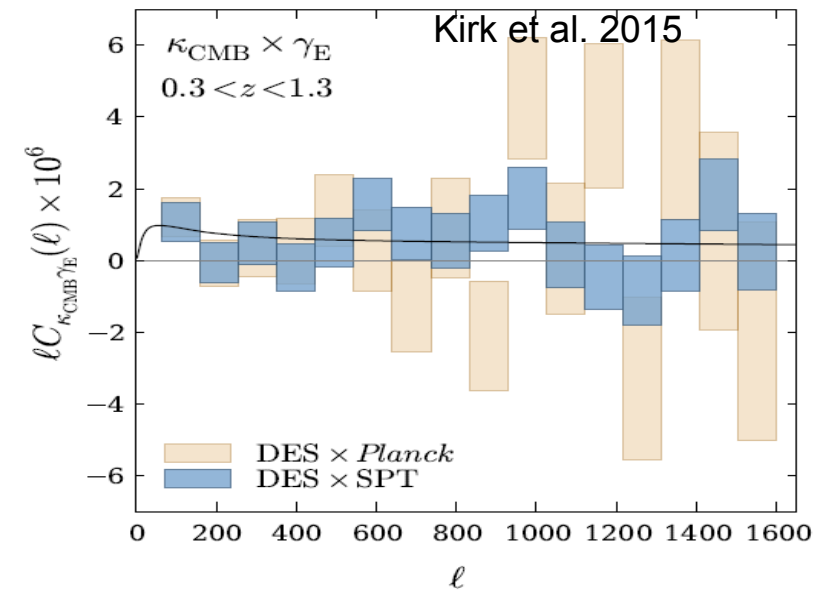
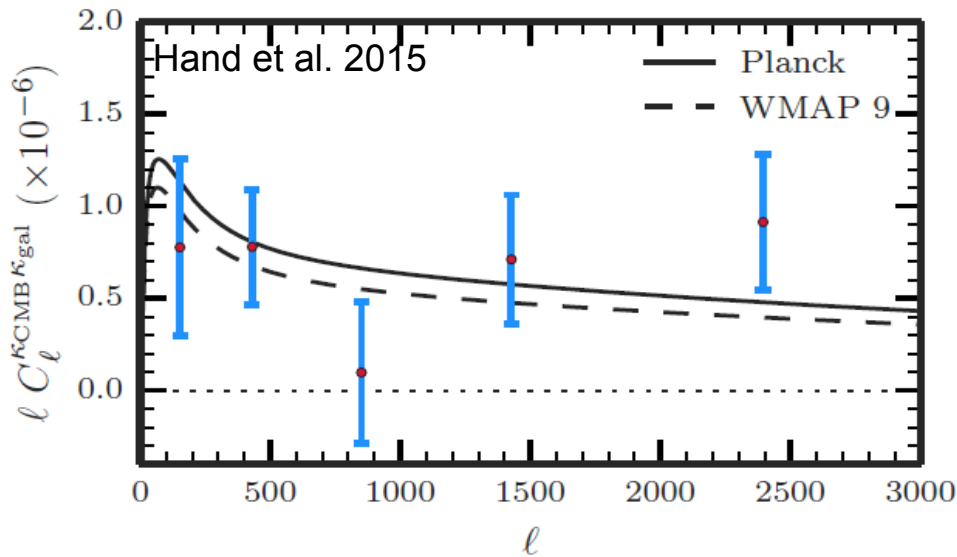
CMB lensing @ Planck

Liu & Hill 2015
 κ_{gal}



CFHTLenS

Intrinsic alignment ~10-18% X-correlation (e.g. Hall & Taylor 2014, Troxel & Ishak 2014)
→ prospective for self calibration of IA?



CIB/Galaxy X-correlation

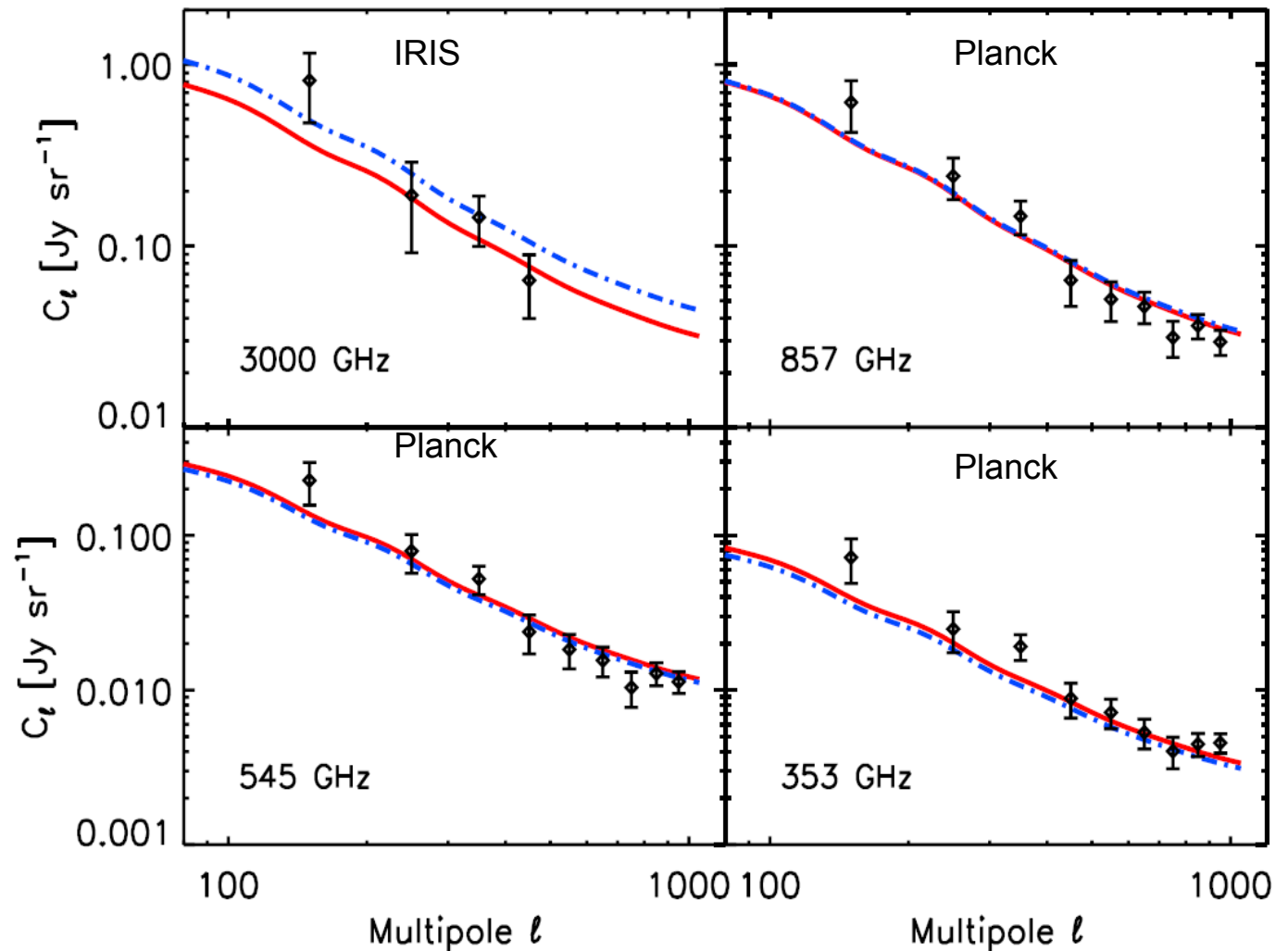
Measured cross spectra of CIB maps with CMASS LRGs with best fits for 2 SEDs

→ Constraints on the halo model parameters e.g. dust temperature

26K @ $z \sim 0.55$; most efficient halo containing star-forming galaxies Serra et al. 2014

$\log(M) = 12.84$; bias = 1.45

→ Future Euclid:
possible tomographic
analyses by binning
sources?



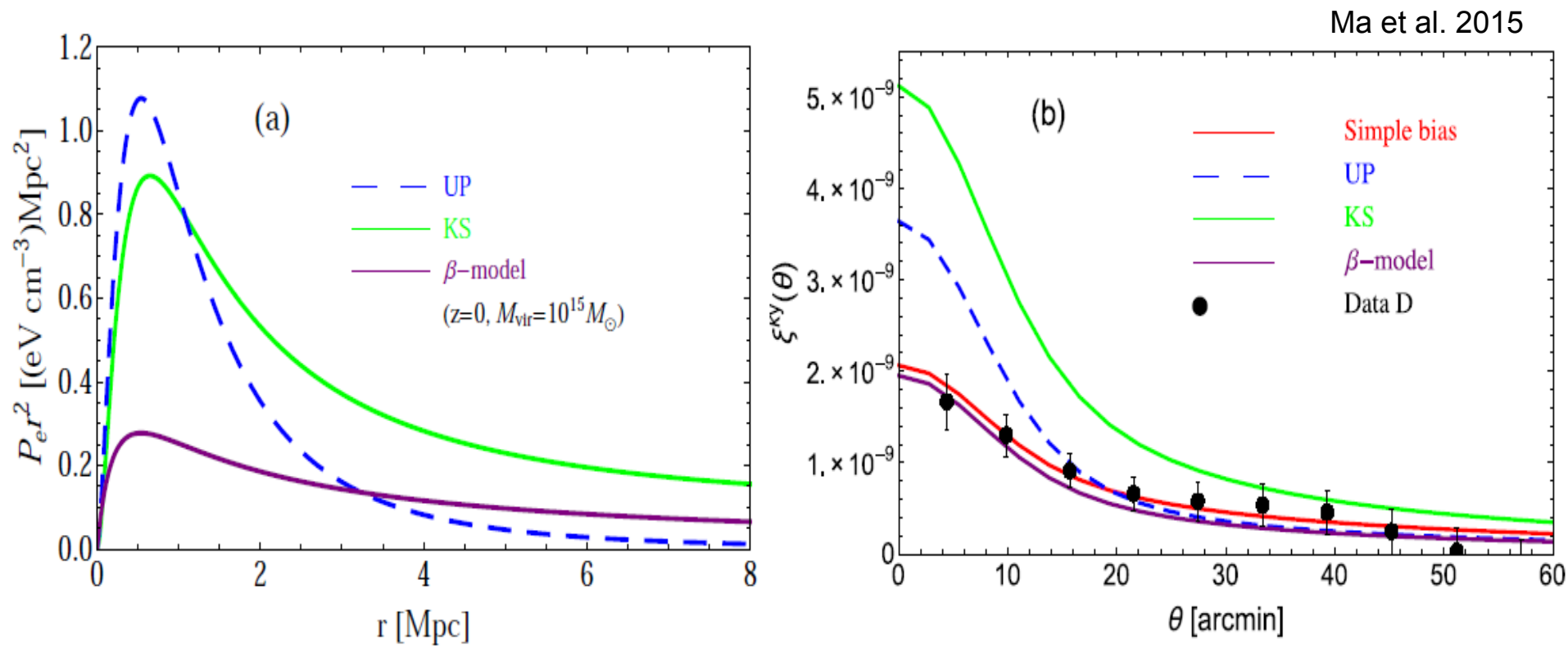
SZ/Galaxy lensing X-correlation

Galaxy lensing tSZ cross correlation with Planck and CFHTLenS

→ constraints on hydrostatic mass bias ($b_{\text{hyd}} \sim 0.78$)

→ Future Euclid: constraints on pressure profile parameters and mass-scaling relation

→ Contamination by tSZ/CIB correlation (e.g. Hurier 2015, Planck collaboration 2015)



Cross-correlation with CMB

Strengths:

- CMB data in hand or being taken (availability of very small scale CMB?)
- First results with present surveys
- Full expertise in CMB + some galaxy surveys

Weaknesses:

- First results with present surveys
- Expertise in CMB + galaxy surveys
 - Not enough engagement in Euclid
 - No common/validated analysis tools *yet*

WP1: Integrated Sachs-Wolfe effect [Rassat, *llic*]

WP2: Rees-Sciama [Carbone, Baldi]

WP3: New CMB-Lensing extraction methods [Benoit-Levy]

WP4: CMB lensing likelihood [Benabed]

WP5: Correlation of CMB lensing maps with Tracers [Baccigalupi]

WP6: Correlation of tSZ maps & data with Tracers [Aghanim]

WP7: CMBXC data processing validation [Aghanim, Baccigalupi]

Dedicated SWG 1.5 day meeting January 12-13 @IAS Orsay

Objectives:

Report work/progress

Update/add WP and prioritize them

Definition of specific/concrete tasks per WP

Discuss common data analysis tools