Cross correlations with CMB secondaries: constraining cosmological parameters and cluster astrophysics.

# Nick Battaglia

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Penn I AS IN Berkeley Berkeley

#### Planck is a tSZ Machine!

As we heard on Tuesday

Planck is producing exciting SZ results!









Planck Coll. XXIX 2013





#### It's not just the power spectrum



most other low redshift growth of structure constraints are in mild tension with CMB



CITA-SZ with feedback: Battaglia, Bond, Pfrommer, Sievers & Sijacki 2010, BBPS 2011-12 -13 1,2,3,4,5 for AV14SP3+PSnCk O. Ingent Show the cluster theory and a softed Second 07 goal large treePM-sph sims (~1000<sup>3</sup> gas+DM)-NOT 08-12 goal 512<sup>3</sup> & 256<sup>3</sup> & single-hi-res-cls shock heat only "adiabatic"; cool+SN E; cool + SN E + winds; cool + SN E-feedback + winds + CRs from cluster shocks; but because of core evercooling and overproduction of stars, needed a subgrid model of AGN/starburst feedback in halo cores, calibrated with the (small mass) cluster-BH calculations of Sijacki (with Spaingel, ParonaleR, .f) Feedback is the essence of Gastrophysical Cosmology. Energy/Momentum driven winds, Relativistic injection. full Bljacki-pesoletics was/is ~ infeasible for single massive clusters, and certainly strongly infeasible for big-box statistically useful samples, & also itself is just a subgrid model hence our Mass funce matory subgrid BH/Starburst feedback model AGN feedback + cool + SN E + winds:  $\Delta E_{inj} \sim \epsilon \Delta t$  SFR over  $R_{AGN}$  in halo centre, episodic above a SFR threshold,  $\varepsilon_{eff} < \varepsilon$ : most  $E_{ini}$  above z=2, so much freedom to minimize  $\varepsilon_{eff}$  e.g.,  $E_{inj}$  58% at z > 2, 23% in 1 < z < 2 19% z<1 Simplified to bistic area of the system of t conclusion circa Feb2013: A universal panacea to cure cluster cores: highly inhomogeneous, episodic & cluster mistory dependent. If observables are overly sensitive, then we become gastrophysical weather reporters and not cosmological gold-sample miners delivering pure cosmic parameters. BUT most relevant ISZ regions of the state of the sent non the mapped long. Sinetic pressure aka turbulence/internal-bulk-flows, pressure/density clumping, asphericity, ... but we need hydrodynamically-reasonable inner cores hence subgrid feedback (beware of cutouts of overcooled cores) "every cluster is a Bullet cluster" - or was a bullet in its past, el Gordo, A520, ...

Gastrophysics? for tSZ P<sub>th</sub> profile CIB contamination and IR fill in? (Serra's Talk) New physics? Mass function?

Simulated observables Compare to recent observations of other statistical cluster properties

## Planck Pth Profile



# SPT X-ray $P_{th}$ Profile z > 0.3



- Simulations do well to match the observed pressure profile at higher redshifts also

- We understand (can model) the total thermal energy in massive clusters out to high redshift

#### **Cross Correlation with X-ray clusters**



#### Cross spectra



#### Cross spectra constraints



#### **RBC** weak lensing mass calibration



#### Discrepancy at $\ell = 3000$ ?



C(M,z)



# ournal of Cosmology and Astroparticle Physics

#### Detection of thermal SZ-CMB lensing cross-correlation in Planck nominal mission data

J. Colin Hill and David N. Spergel

PHYSICAL REVIEW D 89, 023508 (2014)

Detection of warm and diffuse baryons in large scale structure from the cross correlation of gravitational lensing and the thermal Sunyaev-Zeldovich effect

Ludovic Van Waerbeke,1,\* Gary Hinshaw,1,2,† and Norman Murray3,4,‡

Ma+2014 - Interpretation of results

Several sigma detections of the cross correlations (~ $6\sigma$ )

![](_page_17_Figure_1.jpeg)

![](_page_18_Figure_1.jpeg)

![](_page_19_Figure_1.jpeg)

# Cross correlate with lensing forecast

![](_page_20_Figure_1.jpeg)

AdvACT

![](_page_21_Figure_1.jpeg)

Funded, large area, multiple frequency bands Potential for cross correlations is huge!

#### New mocks

![](_page_22_Figure_1.jpeg)

Gastrophysics? Not for high mass or low redshift CIB contamination and IR fill in? Not at low redshift New physics? Maybe? Mass function? Probably not...

Cross correlations are the tools for: Constraining 'gastrophysics' Constraining cosmology, maybe