Solvay 26 Conference *Oct 8-12 2014 1st astro in 40 yrs*

Planck 2014 Inflation / Low L Bologna Sept 27-Oct 3

Inflation paper, Isotropy & Statistics paper, non-Gaussianity paper

CMB Anomalies & the Early Universe

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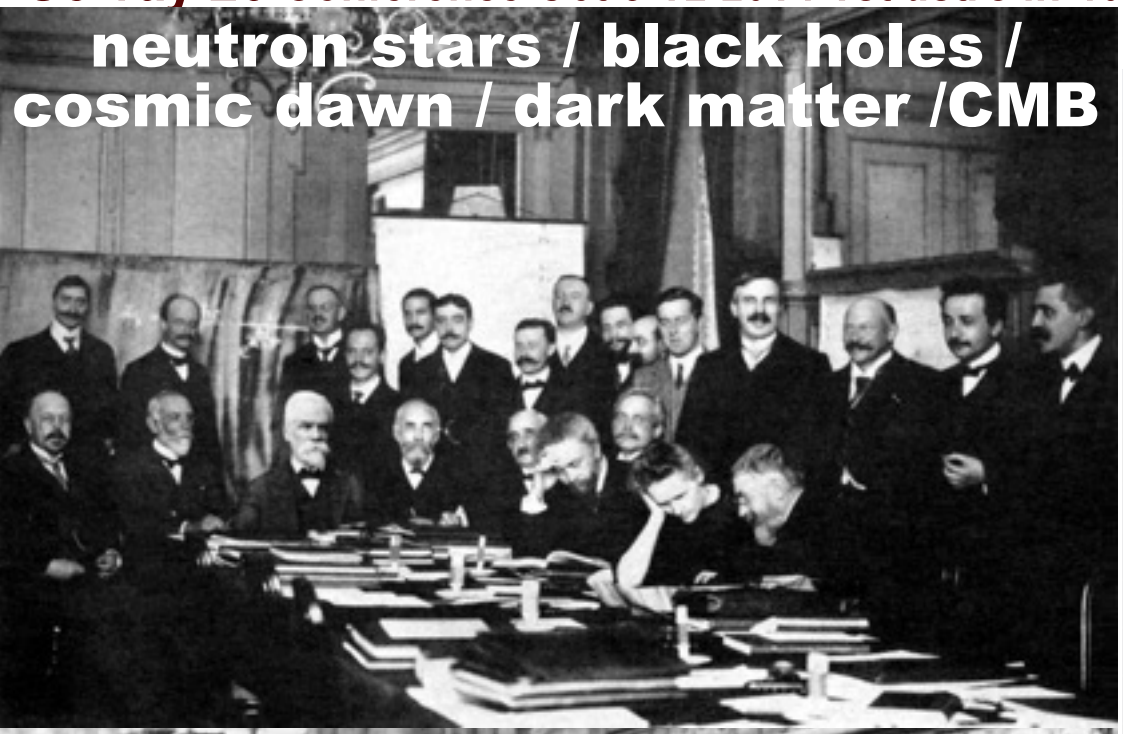

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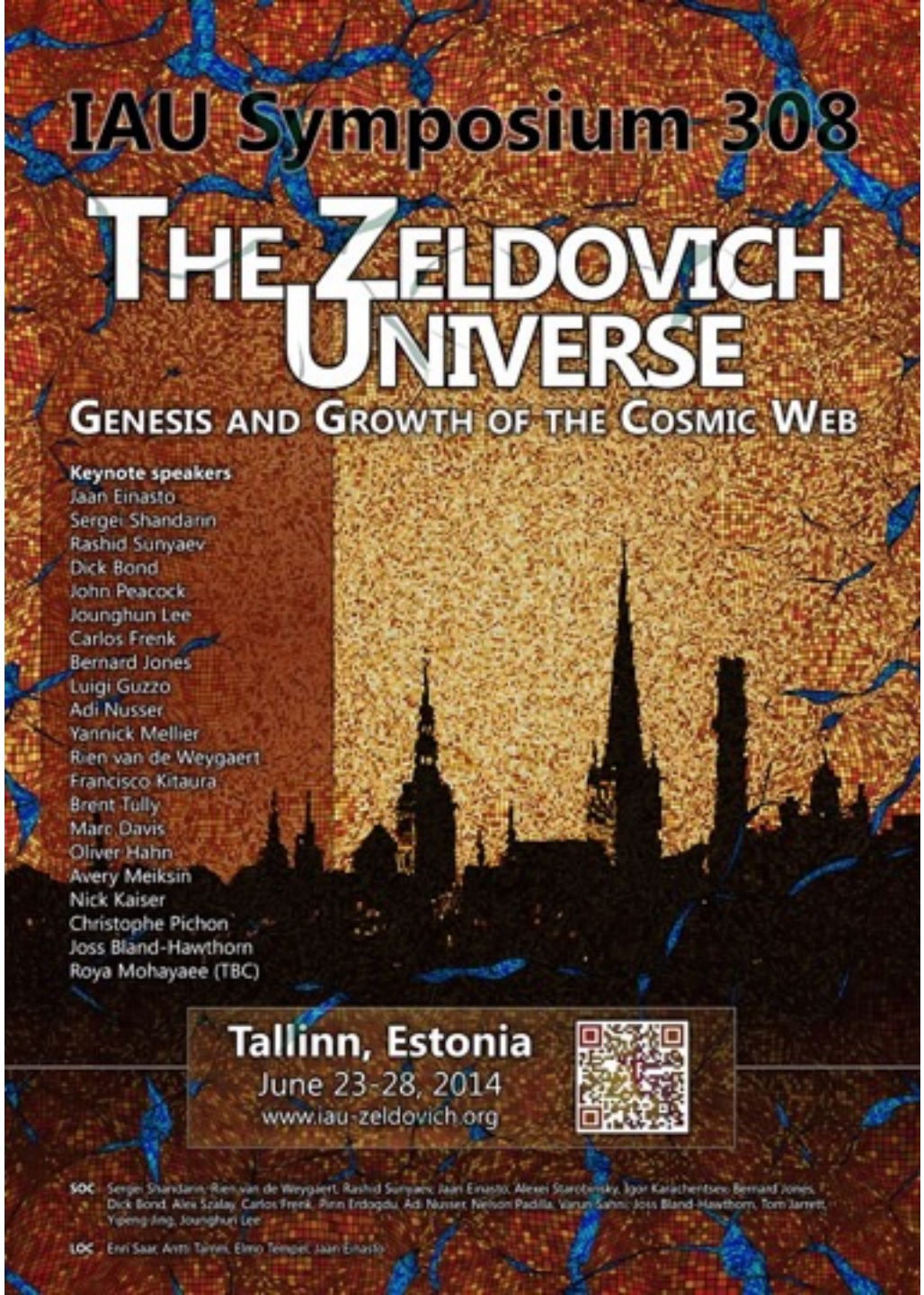
Planck 2014 Papers Mtg Cambridge Sept 1-5



IAU308

Tallin Estonia Jun 23-28

review of theory of the cosmic web

from SuperWeb simplicity to complex Intermittency in the Cosmic Web

Planck 2014 Core Team Paris Jul 5-12

recombination history

dark energy

primordial power spectrum reconstruction

stacked oriented T, E, Q,U, ζ maps

CMB extremum statistics

from SuperWeb simplicity to complex Intermittency in the Cosmic Web

MOCKing HEAVEN

painting the Euler/Lagrange Peak-Patch Picture of Cosmic ACTalogues aka halos (N-body/pp+hydro sims/HOD/obs)

fundamental physics from probes of the Cosmic Web: e.g., Dark Energy (BAO, lens, z-distortions, halo far-field structure), dark matter (halo near-field structure), neutrino masses, primordial non-Gaussianity, primordial power spectrum complexity?

or blockage from gastrophysical indigestion?

Zeldovich 100th, Tallin IAU 308 2014

CIFAR CANADIAN INSTITUTE FOR ADVANCED RESEARCH

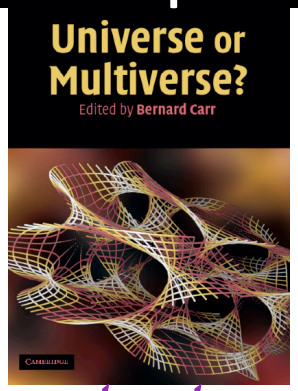
Dick Bond

CITA ICAT Canadian Institute for Theoretical Astrophysics / L'institut Canadien d'astrophysique théorique

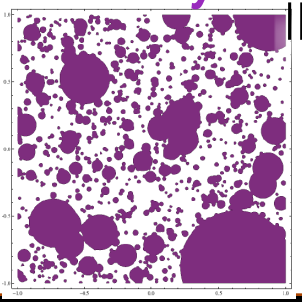
SuperWeb of ultra-Ultra Large Scale Structure of the Universe

Horizons: the ultimate-speed constraint on light & information

a highly strained & stressed state in the universe at large (very, very), randomly simple in our Hubble patch, and highly entangled in the small to medium



quantum tunnels = bubbly-U



END

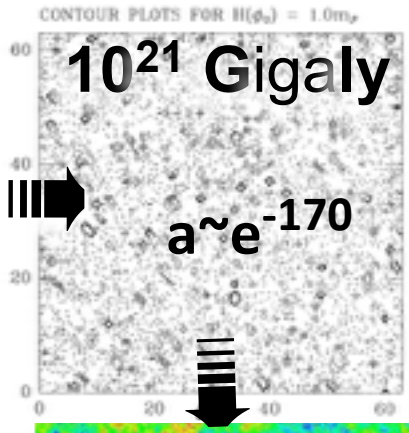
a future DE-Void

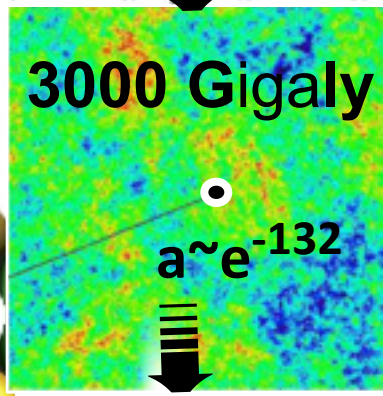
$a \sim e^{+++}$

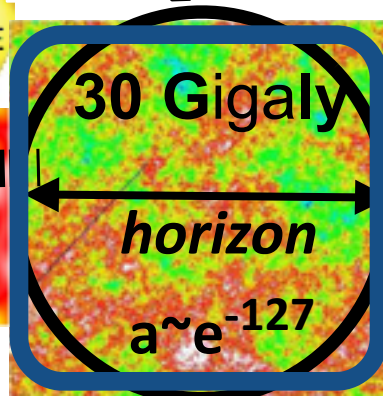
UNIVERSE

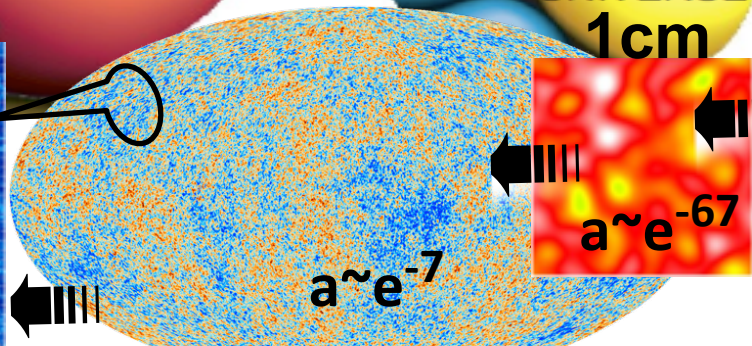
a-bubbles

our horizon



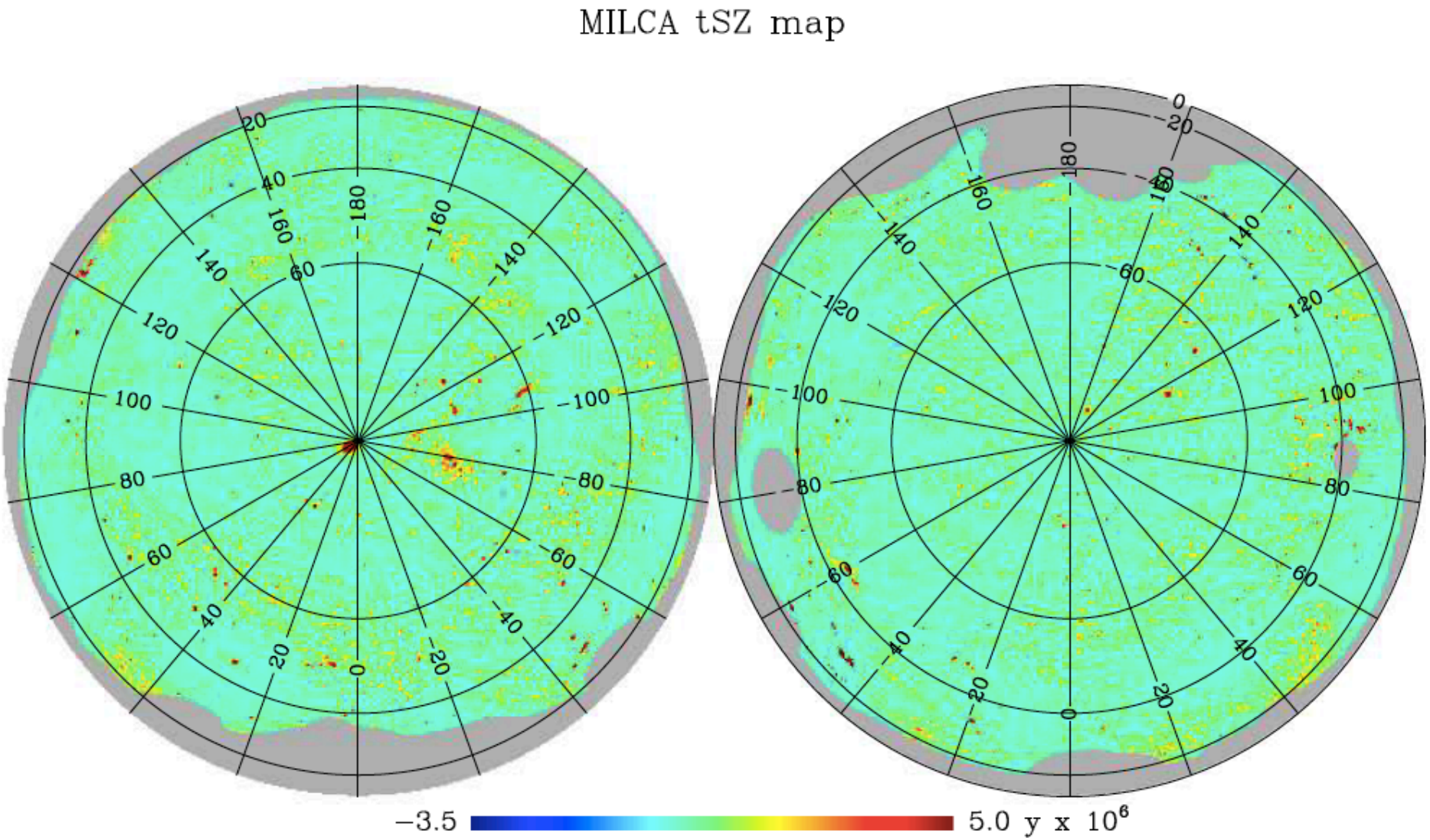






1cm

SZ power spectrum from ymaps Planck2013 XXI; *also van Waerbeke, Hinshaw & Murray 13, Hill & Spergel 13*



Adapted component separation algorithms: NILC & MILCA on all HFI channels 100-857 GHz @ 10' res

SEXtractor + MMF and MHW + SEXtractor detected clusters number & flux consistent with PSZ catalogue

tSZ + clustered CIB + Point sources

how to characterize map errors?
inhomogeneous, CIB contamination, .. ***via Mocks***

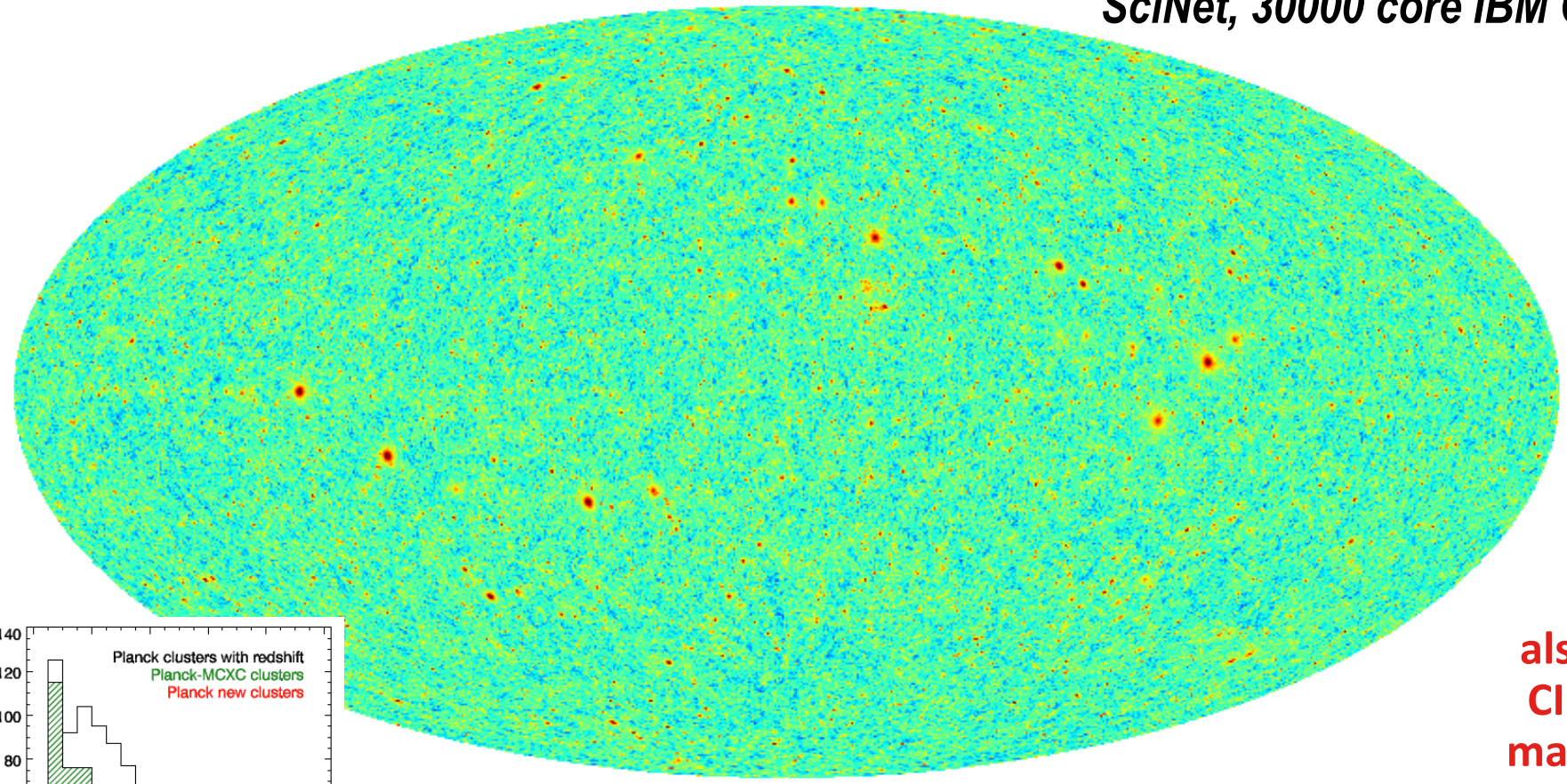
the Cosmic Web of Clusters, seen thru Compton cooling of high pressure electrons by the CMB

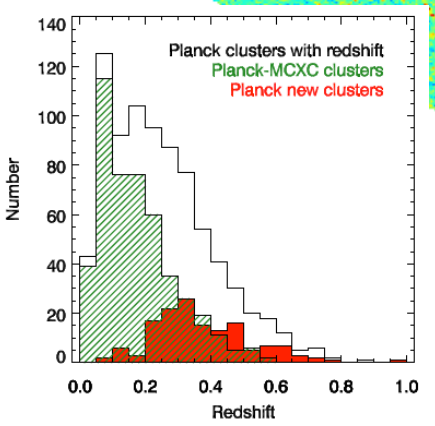
tSZ effect

Lightcone Simulation of Clusters > 1.5×10^{13} M_{sun} to z=1.3 in projected pressure

Alvarez, Bond, Hajian, Stein, Battaglia, Emberson,..2014

~5 hours on 256 cores on SciNet, 30000 core IBM GPC





also CIB maps to do tSZxCIB

how to characterize map errors? by SIMs inhomogeneous, CIB contamination, ..

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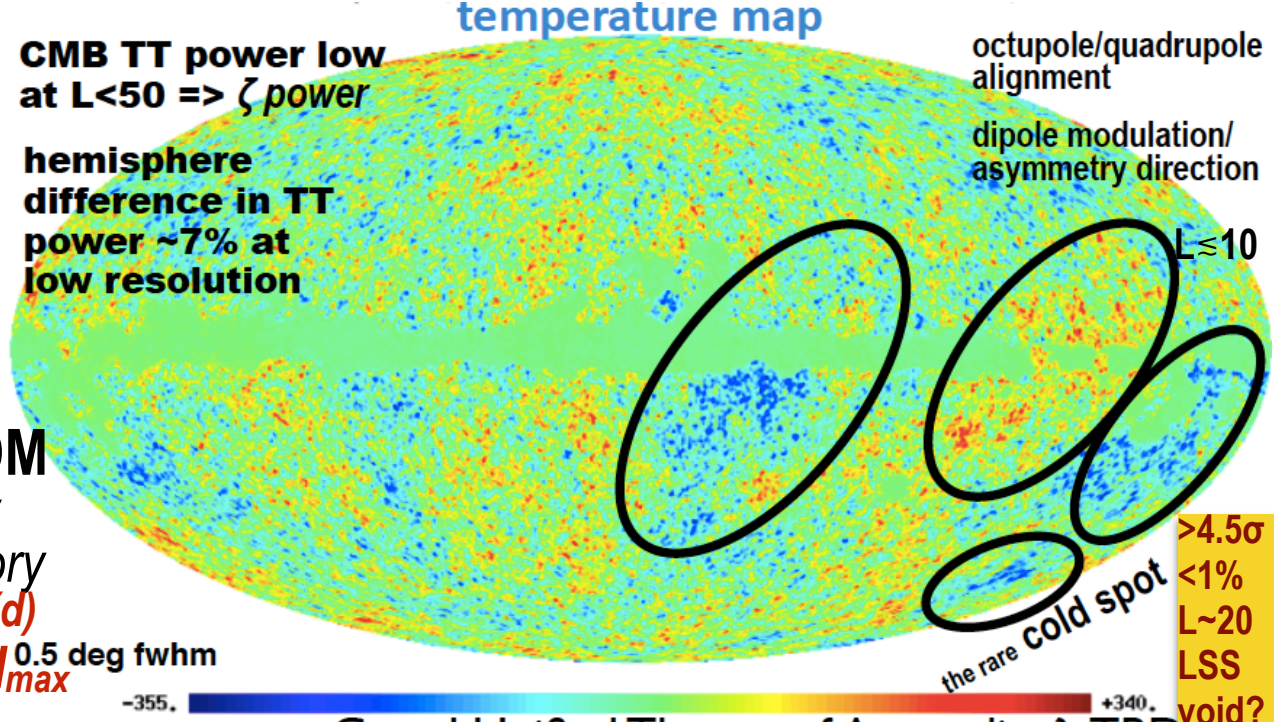
SMc = *tilted*ΛCDM+r (ζ,h_{+x})

BSMc = SMc + primordial anomalies

flat T,Q,U(v) ? a phenomenology
extremum cf. distributed stats
linear, quadratic, trilinear TEB

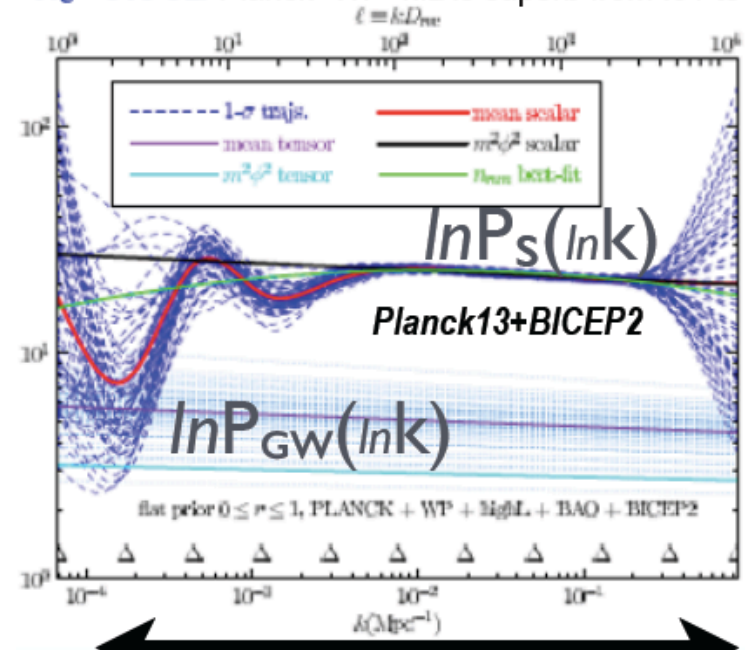
UV complete <=> IR complete
ϵ~0 to ϵ=1 heat => SMpp

≳*5,000,000 modes of tΛCDM*
≲*500 modes of anomaly*
≲*100 modes reionization history*
the vast CMB-un-illuminated $\zeta_{LM}(d)$
LSS tomography $f_{sky}\ L_{max}^2\ k_{max}\ d_{max}$



>4.5σ
<1%
L~20
LSS void?

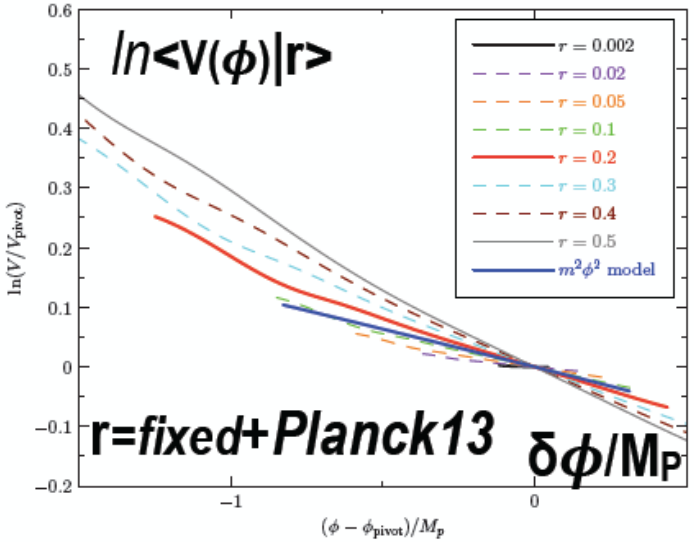
n_s=0.962 Planck+WP+hiL is superb from .01 to .2



9 e-folds

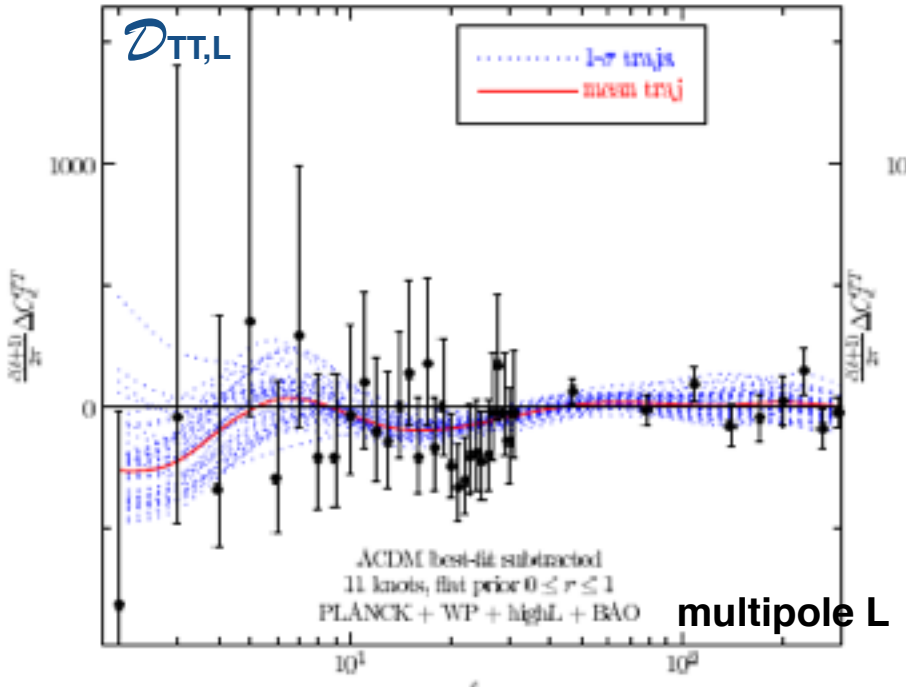
Grand Unified Theory of Anomalies? TBD
intermittent *strain-power bursts (in curvature)?*

running of P_s is a bad fit

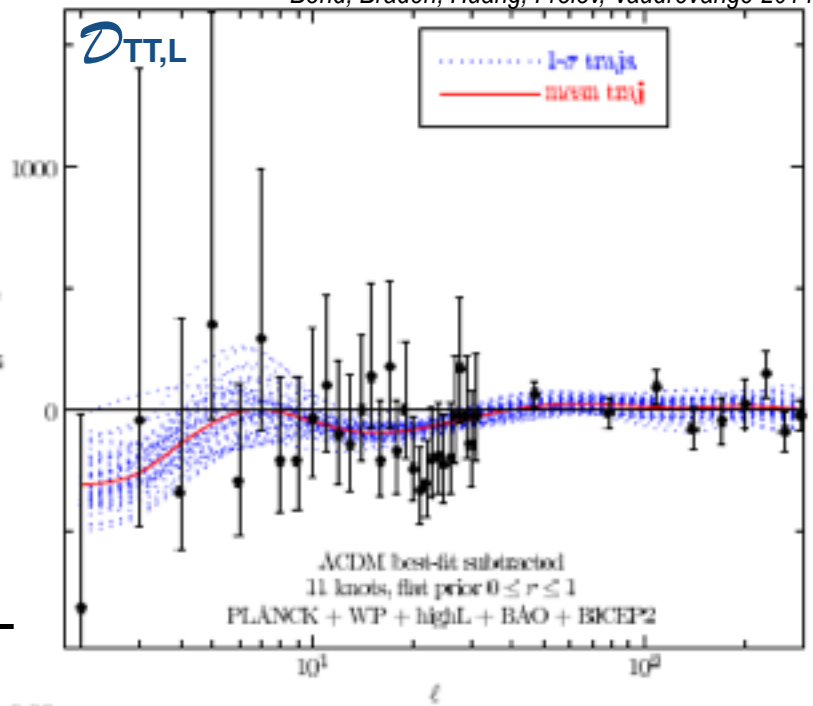


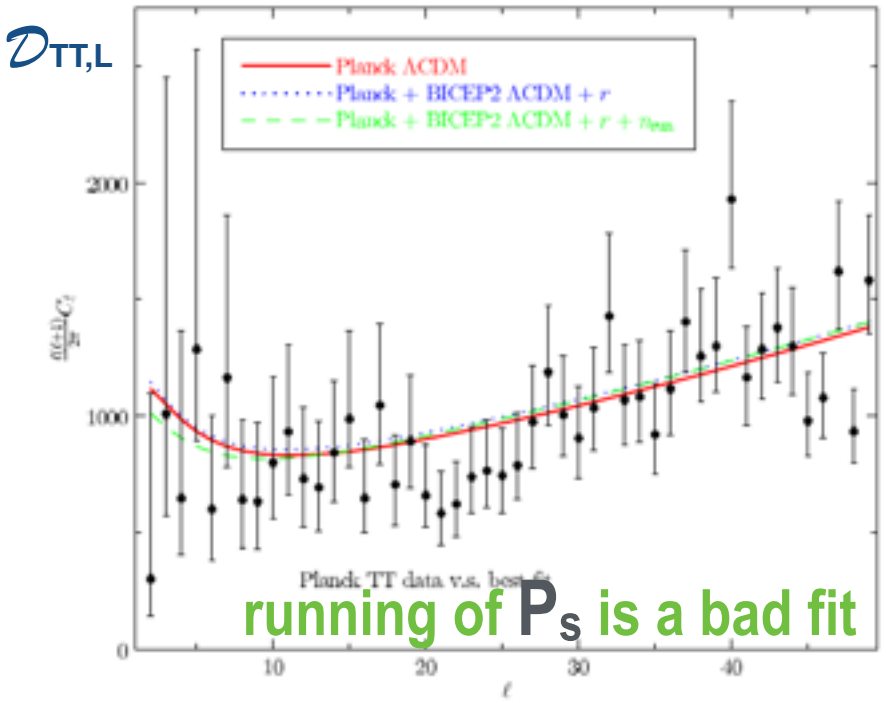
future mean-V
σ(r)~.002
δV small-ish

Bond, Braden, Huang, Frolov, Vaudrevange 2014



multipole L





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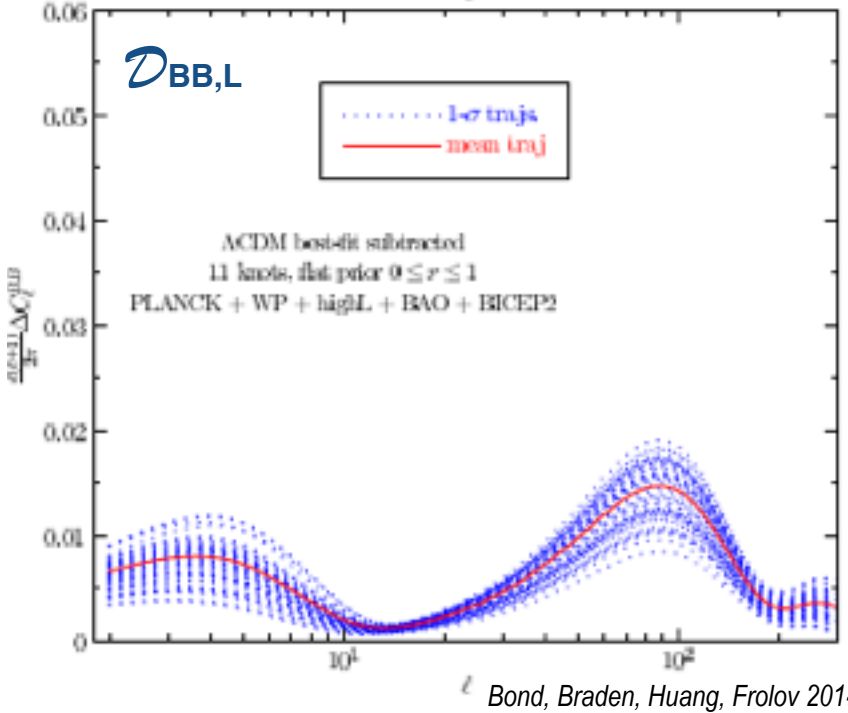

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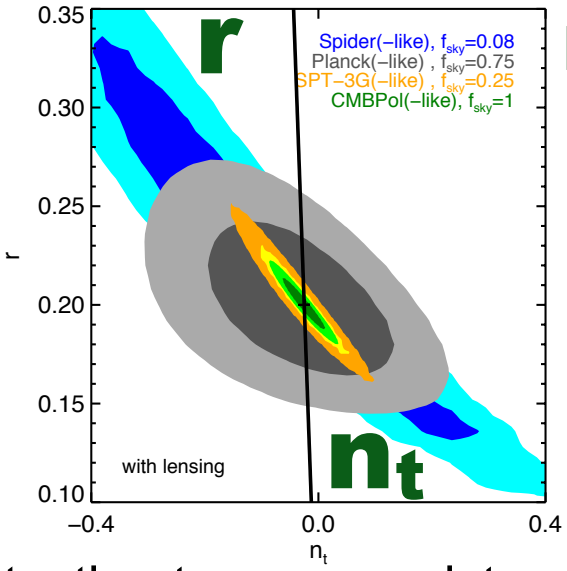
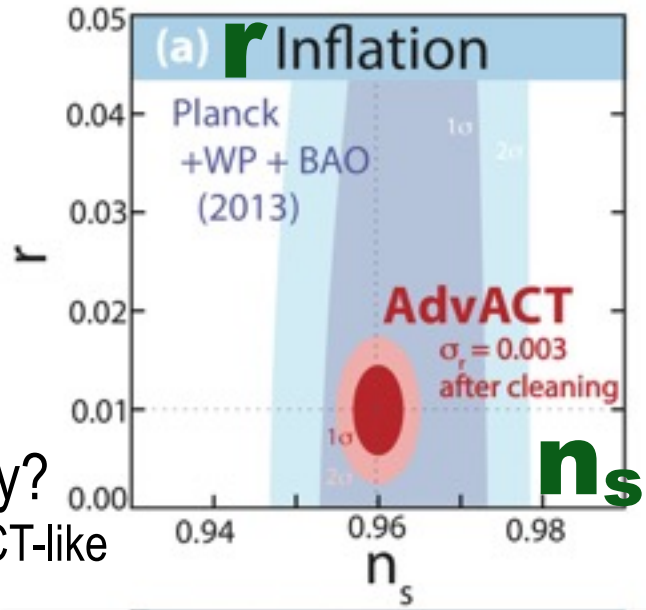
future

AdvACTpol (f_{sky}~50%): *Cosmological Forecasts*

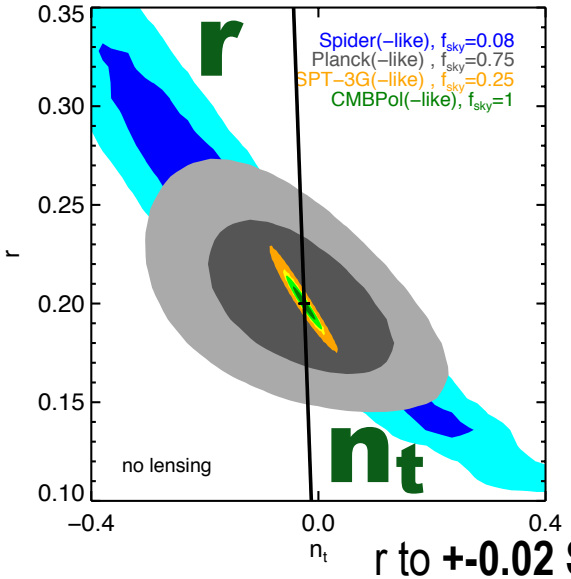
Planck_f, Spider, SPT3g, .. CMBpol (CoRE,Pixie,..)





testing tensor consistency?

better f_{sky}=25% for spt3g/AdvACT-like than current 6% goal for spt3g



r to **+-0.02 Spider** forecast

r to **+-0.003 AdvACTpol** forecast w/ fgnds

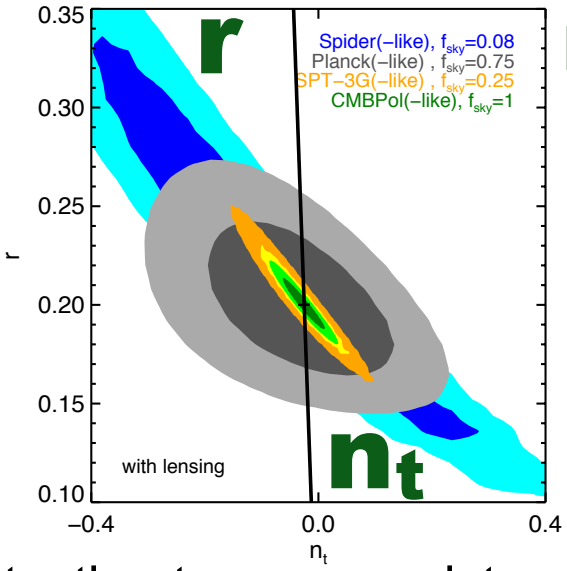
~2015-6 Stage III CMB expts ~10K detectors distributed in a number of expts

~1920: Stage IV CMB expts ~500K detectors distributed in a few expts r, neutrino mass & number, DE

future

AdvACTpol (f_{sky}~50%): *Cosmological Forecasts*

Planck_f, Spider, SPT3g, .. CMBpol (CoRE,Pixie,..)



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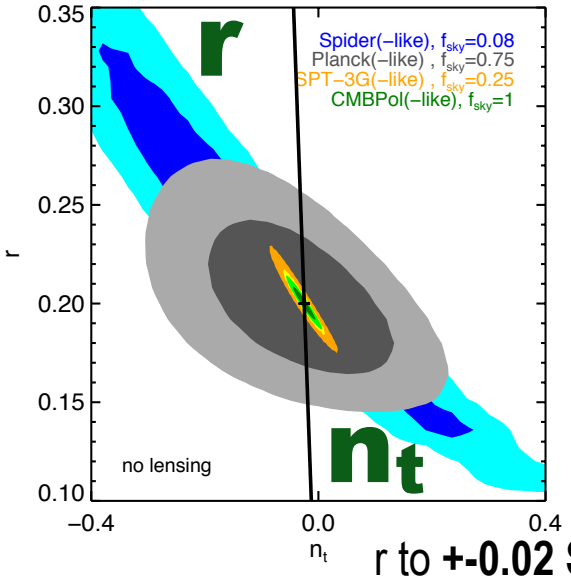

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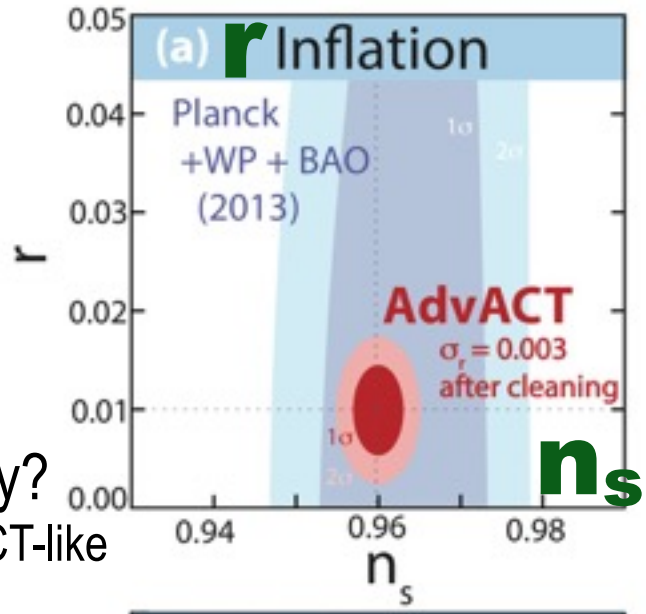
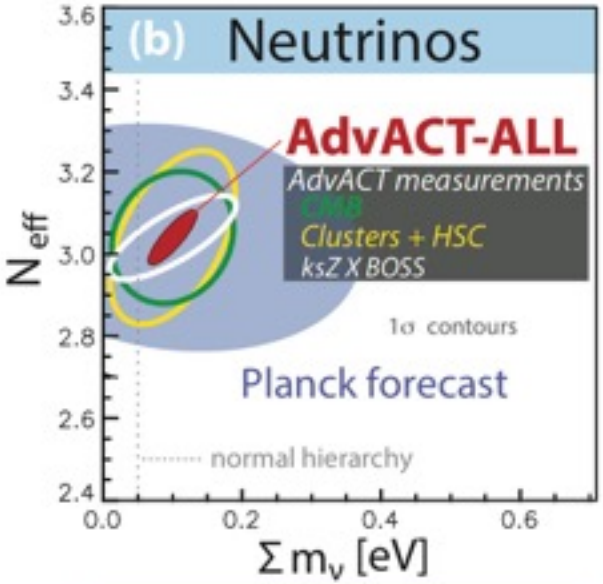
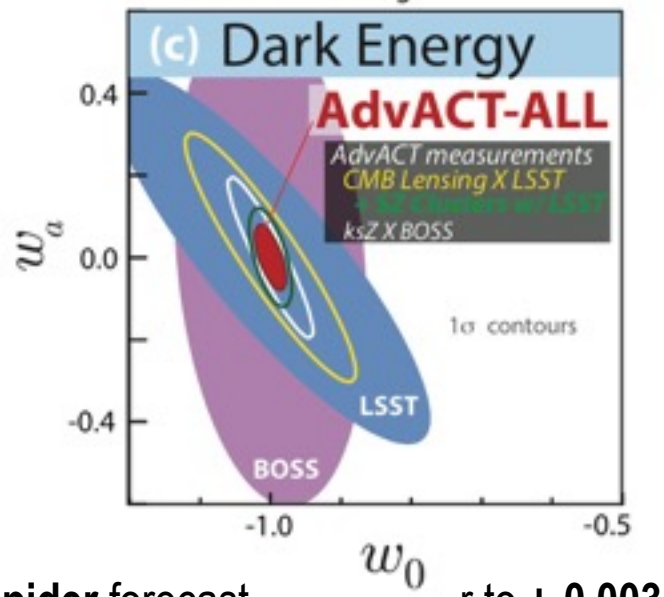
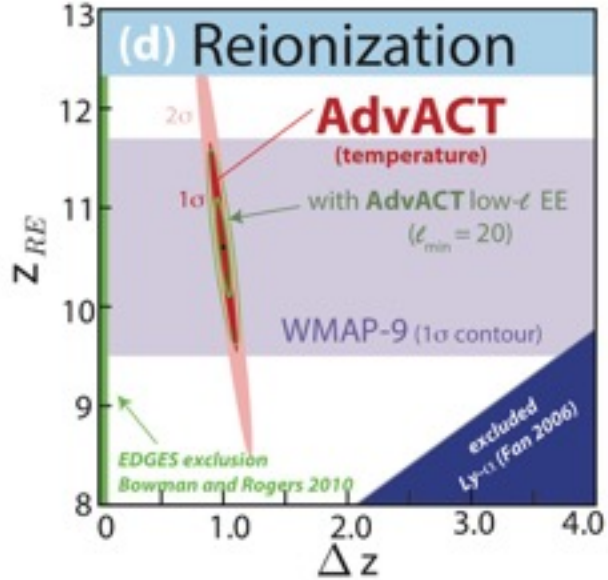






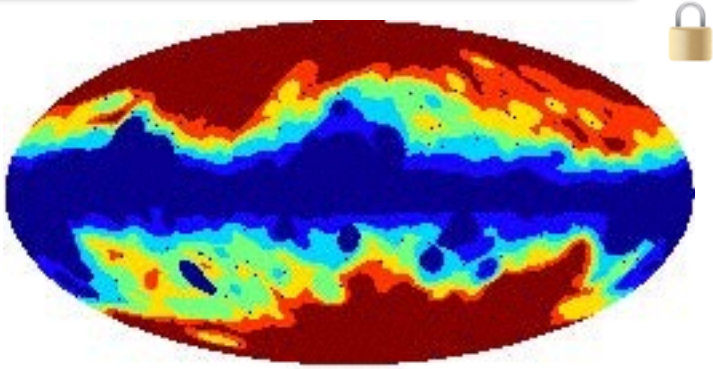


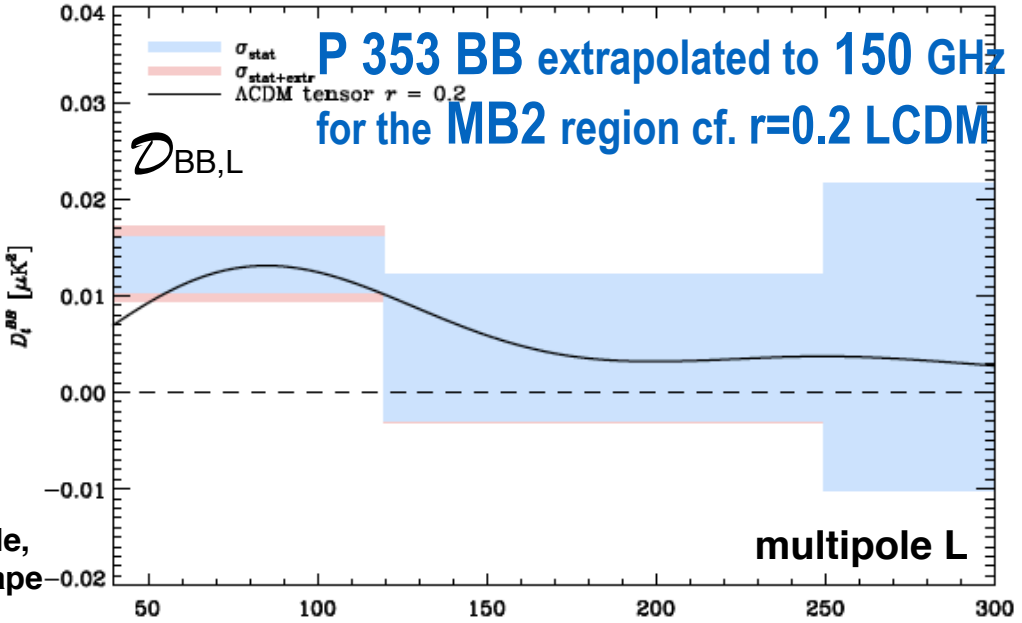
r to **+-0.003 AdvACTpol** forecast w/ fgnds

PIP97: Planck intermediate results XXX arXiv submission 14.09.19, 5th in Galactic dust polarization series

The angular power spectrum of polarized dust emission at intermediate and high Galactic latitudes

unlocked Sunday night





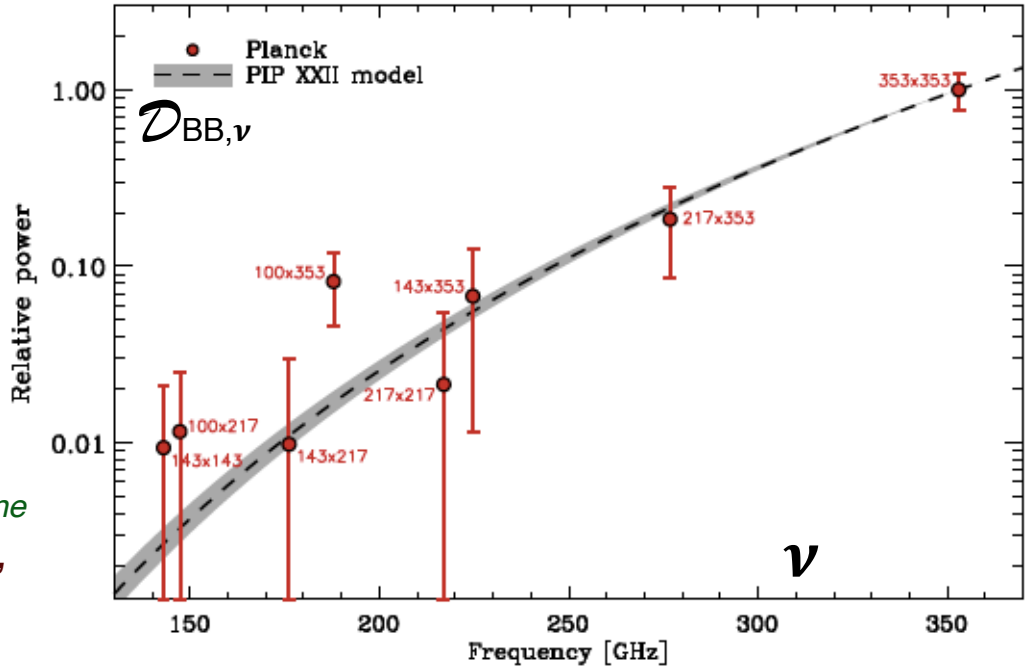
dust pol power is complex even at high Galactic latitude, yet with simplifying trends for emissivity(ν), amp & shape

PIP97 also mimics the Bicep2 region, MB2, 690 cf. 373 sq deg B2 deep. extrapolation from 353 indicates the 150 BB signal may be just dust pol, BUT

Cautions: Planck alone cannot apodize and filter exactly as Bicep2 did without PxB2 joint work. power spectrum analysis is good, but pattern analysis (P 353 cf. B2 150) is better

Hence: **BICEPxPlanck MOU + paper is in the works a goal is a joint likelihood for r for parameter estimation** *=> intense joint work among the two groups, a nice example of how this complex science should be done*

future r-expts must plan for component separation, DUH, and the quest for r is an ISM+cosmology problem i.e., broad frequency coverage



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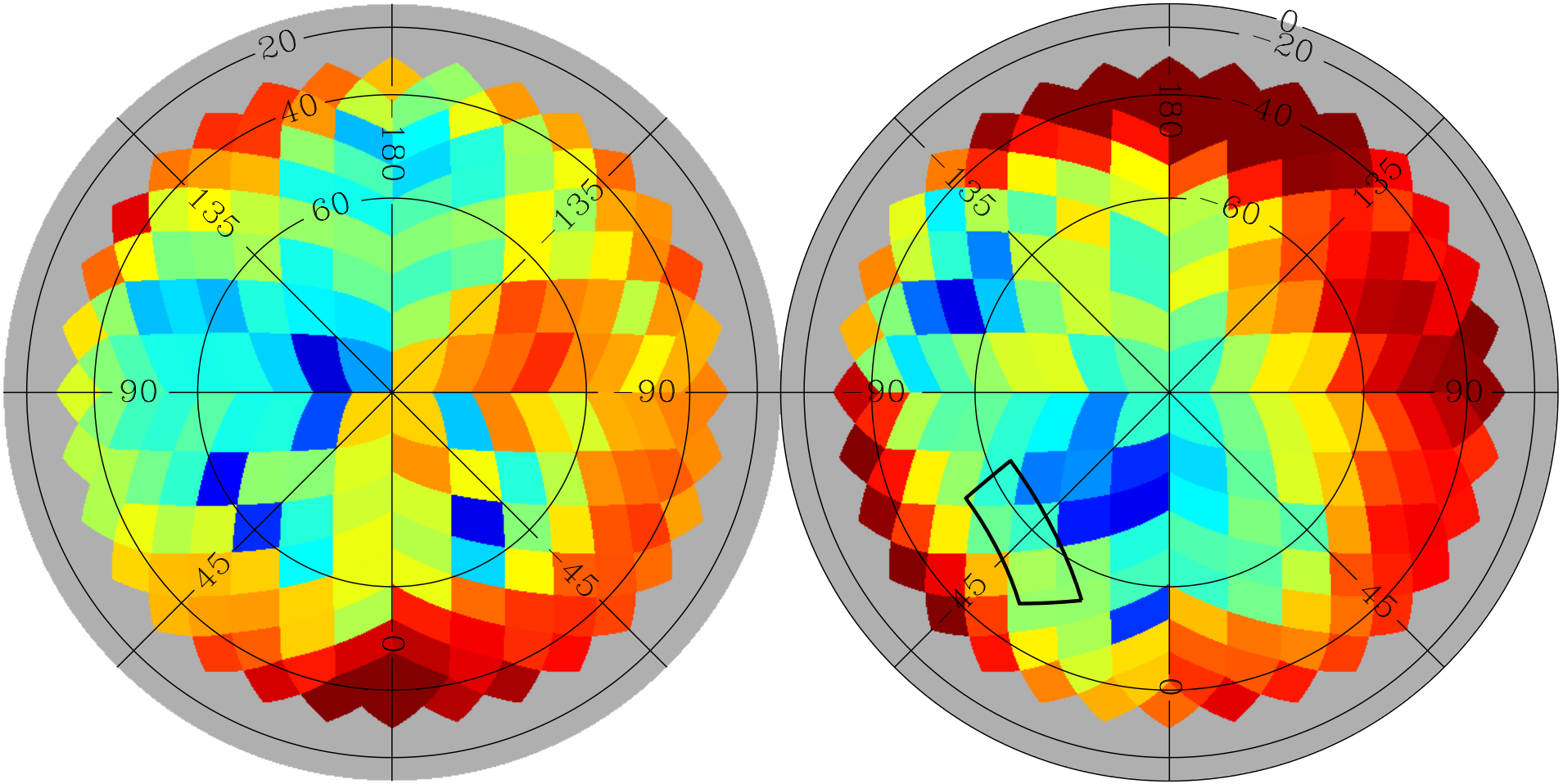
The angular power spectrum of polarized dust emission at intermediate and high Galactic latitudes

Blue = 400 sq deg regions of lowest extrapolated dust B-mode emission

=> *regions to target with small-sky B-mode expts (Bicep2 is low, but others are ~2X lower)*



unlocked Sunday night

CIFAR CANADIAN INSTITUTE FOR ADVANCED RESEARCH

Dick Bond @ POTUS14

Mapping the Early Universe with Planck

CITA ICAT

Planck collaboration results 2013, TBD 2014 1,…,~30, 2015, 1, … N

a Map is an ensemble = mean-map + fluctuation-maps, e.g.,

linear: $\langle T\rangle(\text{pixel}) + C^{TT}(\text{pix, pix}')^{1/2}\ GRD_{\text{pix}'}$; quadratic: $\langle C^{TT}_L\rangle + \langle \Delta C^{TT}_L \Delta C^{TT}_{L'}\rangle^{1/2}\ GRD_{L'}$,

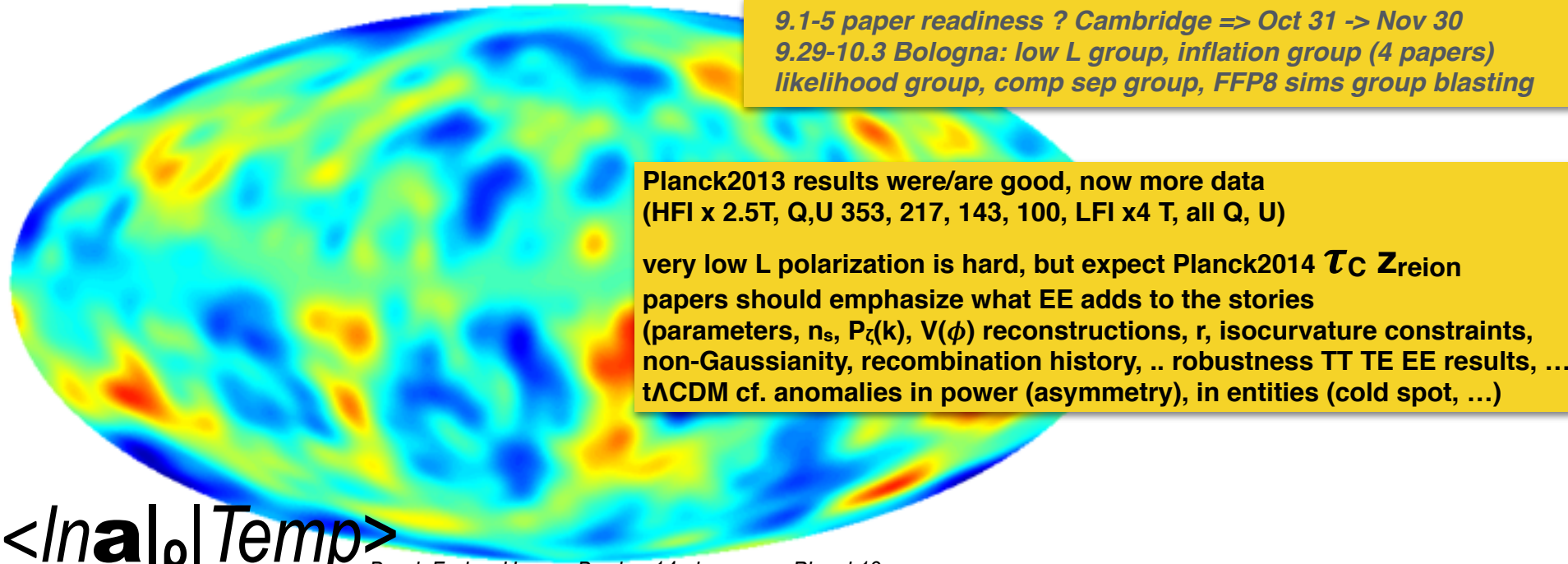
Planck 2013 delivered 9 frequency T maps, component separated CMB T maps using SMICA, n FFP6 simulations (ensemble), data split maps, Likelihood, 30 papers+30PIPs

Planck 2014 will deliver TolS, (9 frequency T maps, 6 Q,U maps)X*splits*, component separated CMB & fgnd maps, ~10K FFP8 simulations (ensemble), all sorts of data split maps, Likelihood in a few modes, CMB lensing, y-map, ~30 papers …

9.1-5 paper readiness ? Cambridge => Oct 31 -> Nov 30
9.29-10.3 Bologna: low L group, inflation group (4 papers)
likelihood group, comp sep group, FFP8 sims group blasting

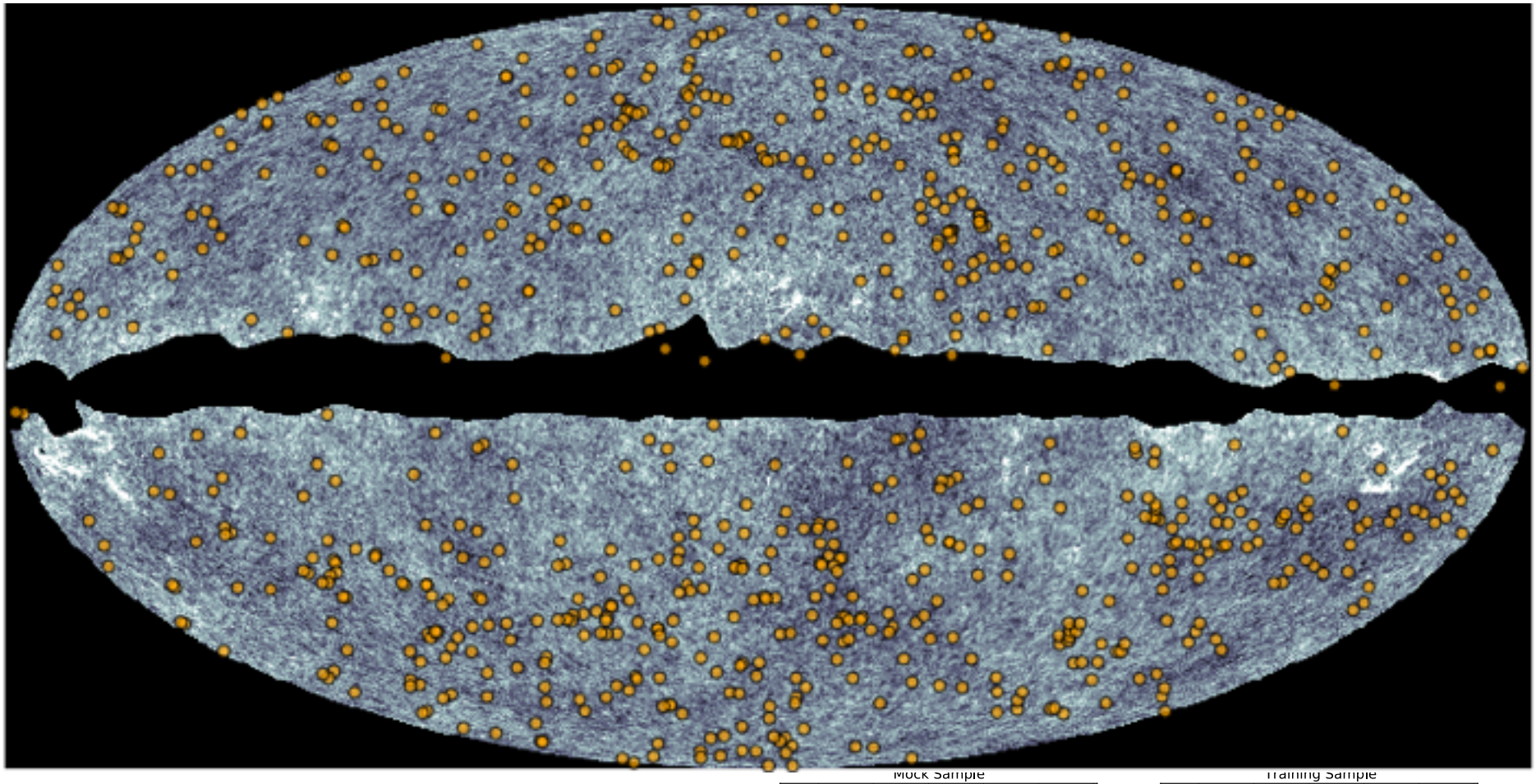
Planck2013 results were/are good, now more data
(HFI x 2.5T, Q,U 353, 217, 143, 100, LFI x4 T, all Q, U)

very low L polarization is hard, but expect Planck2014 τ_C z_{reion}
papers should emphasize what EE adds to the stories
(parameters, n_s, $P_\zeta(k)$, $V(\phi)$ reconstructions, r, isocurvature constraints, non-Gaussianity, recombination history, .. robustness TT TE EE results, …)
tΛCDM cf. anomalies in power (asymmetry), in entities (cold spot, …)

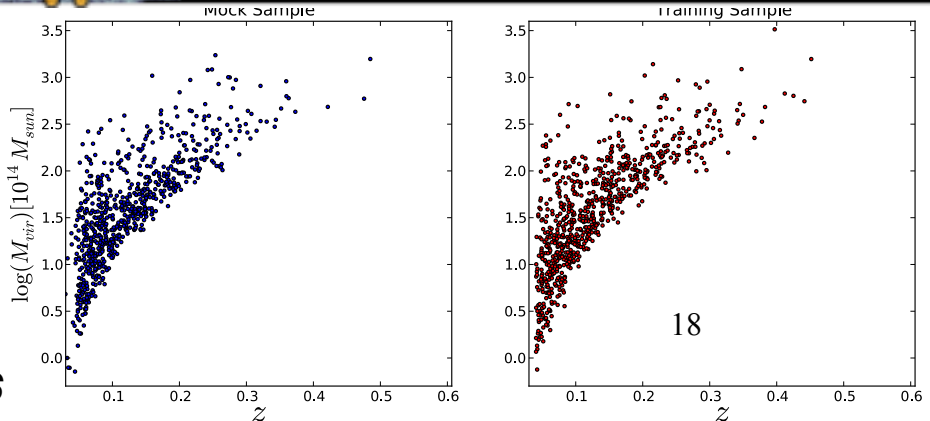


Bond, Frolov, Huang, Braden 14a,b,c,…, on Planck13

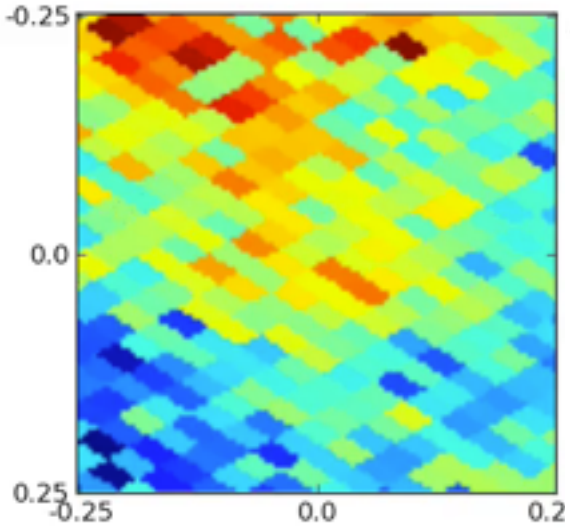
Hajian, Battaglia, Spergel, Bond, Pfrommer, Sievers 2013 **Planck + WMAP9 x ROSAT (RBC subset of MXCC)**



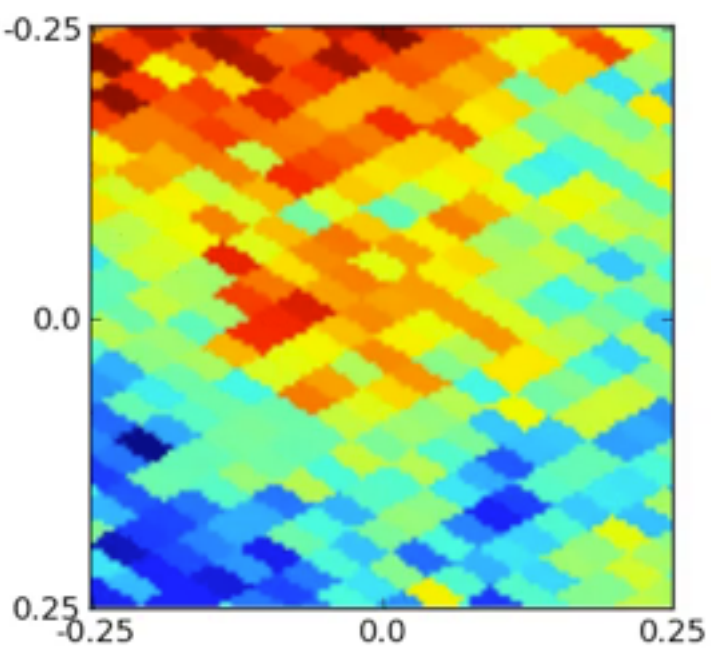
Hajian, Alvarez, Bond 2014:
machine learning of the RBC sample using all sky Planck peak-patch mocks with BPSS p-profiles painted on.



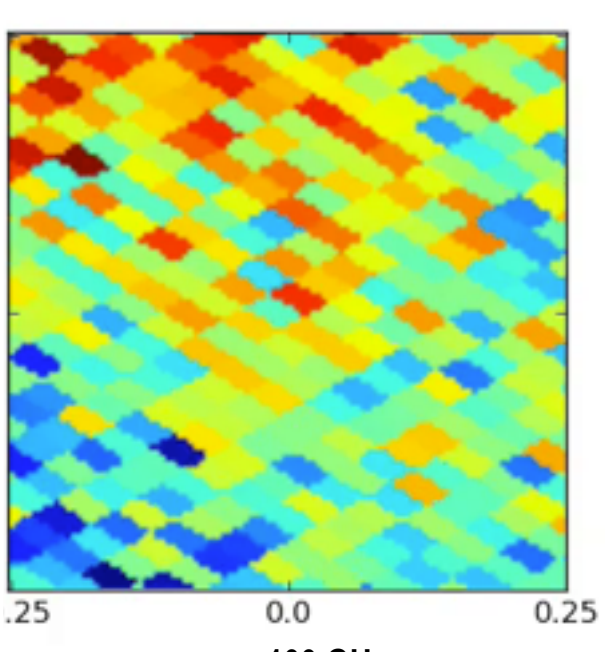
Alvarez, Bond, Hajian, Battaglia + ***2014 peak patches cf. BBPS***



217 GHz

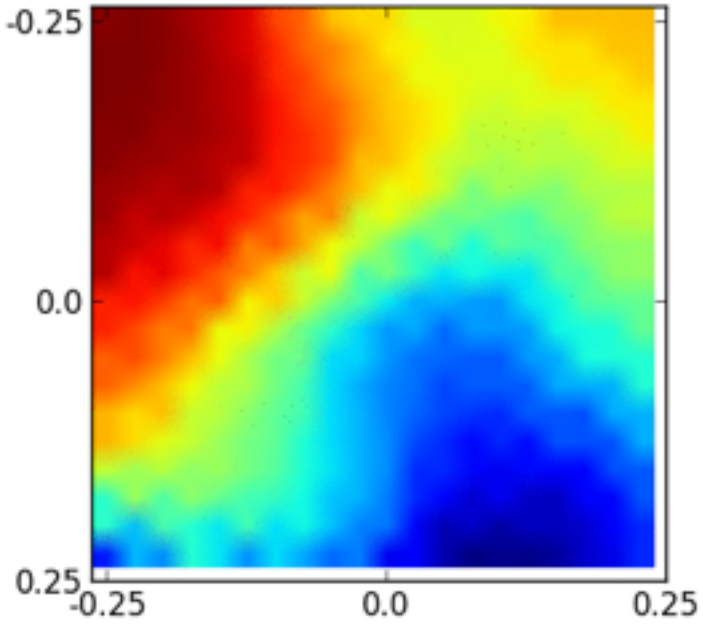


143 GHz



100 GHz

simulated stack of a sample machine-learned RBC catalogue in the Planck213 all-sky BBPS-pressure/X-ray peak-patch cluster/group mock



emergence of the cross-correlation

$$\langle \Delta T_{SZ}(\theta) | cl \in class\text{-}\mathscr{C} = RBC \rangle$$

from (unscaled) stacking of RBC clusters

@ the tSZ null (220), @ 143=best S/N, @ 100

Hajian, Battaglia, Spergel, Bond, Pfrommer, Sievers 2013
Planck + WMAP9 x ROSAT (RBC subset of MXCC)

Alvarez, Bond, Hajian, Battaglia + ***2014 peak patches cf. BBPS***
Hajian, Alvarez, Bond 2014: ***machine learning***

Burst of tSZ papers in 2013 Planck

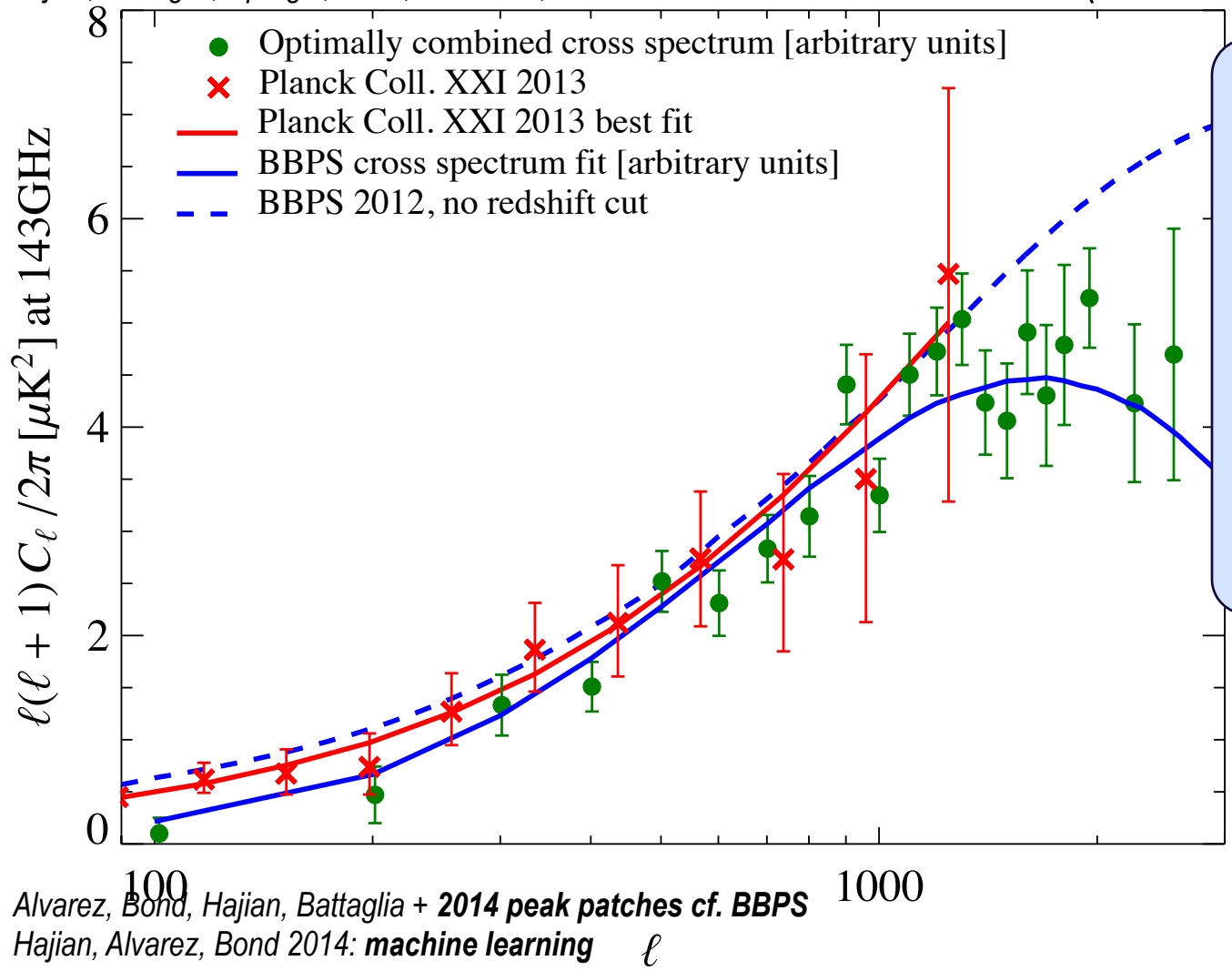
Planck Intermediate Results. XIII. Constraints on peculiar velocities
Planck 2013 results. XXI. Cosmology with the all-sky Planck Compton parameter y-map
Planck 2013 results. XX. Cosmology from Sunyaev–Zeldovich cluster counts
Planck 2013 results. XXIX. Planck catalogue of Sunyaev–Zeldovich sources

$\sim \sigma_{8SZ}^{7.4}\,\Omega_m^{1.9}$ **for L~ 1000**

$\sigma_{8SZ}\,(\Omega_m/0.30)^{0.26}$ **= 0.80 +- 0.02**

e.g., **= 0.796 +- 0.011** for "AGN feedback"

Hajian, Battaglia, Spergel, Bond, Pfrommer, Sievers 2013 **Planck + WMAP9 x ROSAT (RBC subset of MXCC)**



Tension: primary CMB
σ_8=0.826±0.012

cf. **clusters:**
σ_{8SZ} **= 0.77±0.02 Planck13**

cf. **X-ray RBC x Planck13**
σ_{8SZ} **= 0.812 +- 0.010 cl+WMAP9**
= 0.812 +- 0.008 cl+Planck13

P13/WMAP9 primary needed to break $\sigma_{8SZ}\,\Omega_m$ ***degeneracy***

gastrophysical problems for cls?
or higher ν mass
gastrophysical relief

Alvarez, Bond, Hajian, Battaglia + ***2014 peak patches cf. BBPS***
Hajian, Alvarez, Bond 2014: ***machine learning***

fundamental physics from the cluster web? or a gastrophysical indigestion blockage?

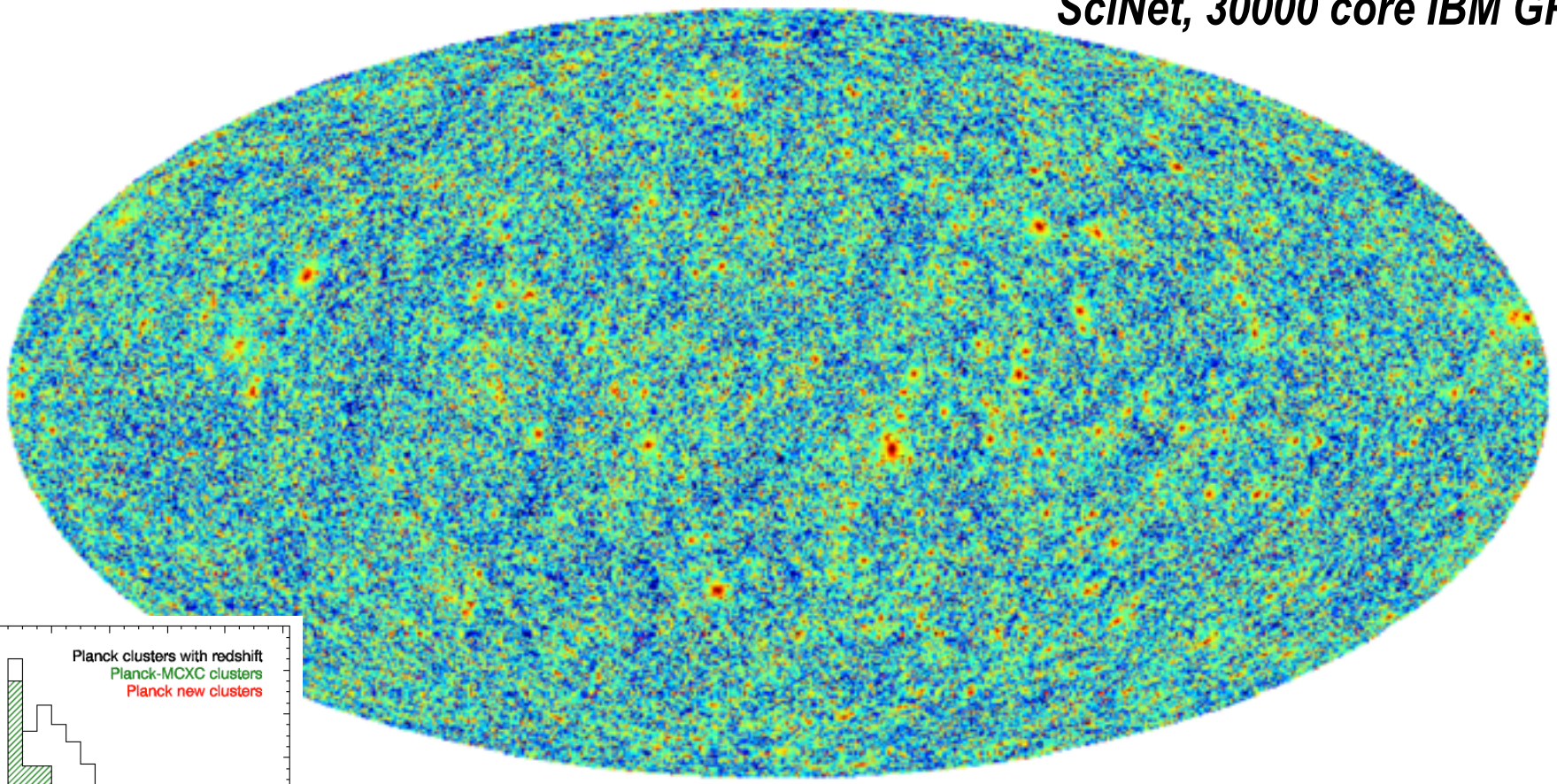
the Cosmic Web of Clusters, seen thru Compton cooling of high pressure electrons by the CMB

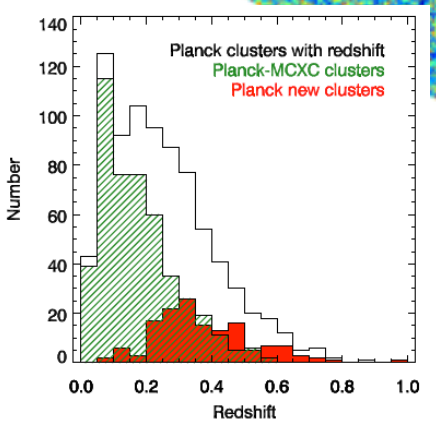
tSZ effect

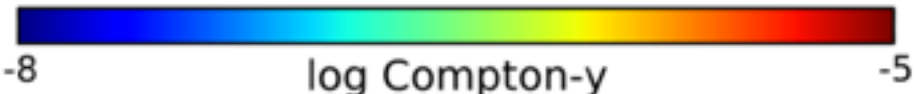
Lightcone Simulation of 35000 Clusters > 1.5×10^{13} M_{sun} to z=0.5 in projected pressure

Alvarez, Bond, Hajian, Stein, Battaglia, Emberson,..2014

1.5 hours on 256 cores on SciNet, 30000 core IBM GPC







how to characterize map errors? by SIMs inhomogeneous, CIB contamination, ..