Inflation = phenomenology of a collective mode, the phonon, fundamental field but composed of many *fundamental* **fields. in linear theory phonon~∑** *fundamental;*

in nonlinear theory, **phonon~** $\ln(\rho\, a^{3(1+w)})/3(1+w)=\zeta_{NL}$

Geometrical view, a theory of condensed strain & strain waves $\varepsilon_{ij}=[1/2 \ln^{(3)} g]_{ij}$**, phonons~Trace (**$\varepsilon$**), gravity waves** ε^{TT}**.**

Inflaton = phonon condensate, fluctuations are phonons. *relativistic negative-pressure EOS.*

Stochastic inflation works: ballistic trajectories for fields q_X **with kicks from sub-horizon waves** dW_X **causing nearby trajectories to deviate,** ζ_{NL} **like dE+pdV a near-adiabatic invariant, sourced by stress*strain-rate & energy currents (regularizer between nearby X).**

fundamental **scalar fields (inflaton, isocons) & effective potentials & kinetic energies**

$\varepsilon = -3/2\, d\ln\rho / d\ln a^3 = 1$ **defines End of Inflation, but not a magic boundary, dragged trajectories break into (spatially independent) oscillations. weak point-to-point coupling until ...**

HEATING: how to damp coherent ballistic trajectories into high-k entropy. old, *eg SBB87* **Γ (KE+PE). still used! post KLS93: via inflaton self-couplings; isocon-inflaton field couplings, gauge fields FFdual, fermion-bar fermion**

new picture: ballistic until the shock-in-time = huge time-localized non-eq entropy generation; slow S-evolution after which is V-dependent. only weak-coupling of nearby points before. ULSS & LSS & SSS modulator field ζ_{NL}**(modulator(x)), e.g. modulator =** $\chi_i(x)$, $g(x)$

nonG from post-inflation but pre-entropy generation ballistic trajectories can lead to pre-shock-in-time caustics and other phase space convergences in the deformations (!) Zeldovich map-ish

eg $\partial \ln a / \partial \chi_i(x)$, $\partial \ln a / \partial g(x) \Rightarrow P[\ln a(x), t_{shock} \mid \chi_i(x), g(x), t_{end\text{-}of\text{-}inflation}]$

spikes persist with flattened effective potentials

only the potential bowl at the bottom matters

calculating ballistic evolution to caustics gives the spikes in perfect agreement with full nonlinear lattice simulations

(now being done for a suite of flattened potentials to better deal with the shock-in-time)

nonG from post-inflation but pre-entropy generation ballistic trajectories can lead to pre-shock-in-time caustics and other phase space convergences in the deformations (!) Zeldovich map-ish

eg $\partial \ln a / \partial \chi_i(x)$, $\partial \ln a / \partial g(x)$ => $P[\ln a(x),\ t_{shock} \mid \chi_i(x),\ g(x), t_{end\text{-}of\text{-}inflation}]$

$dS/dt(t,g)$ => *the Shock-in-time: entropy production rate*

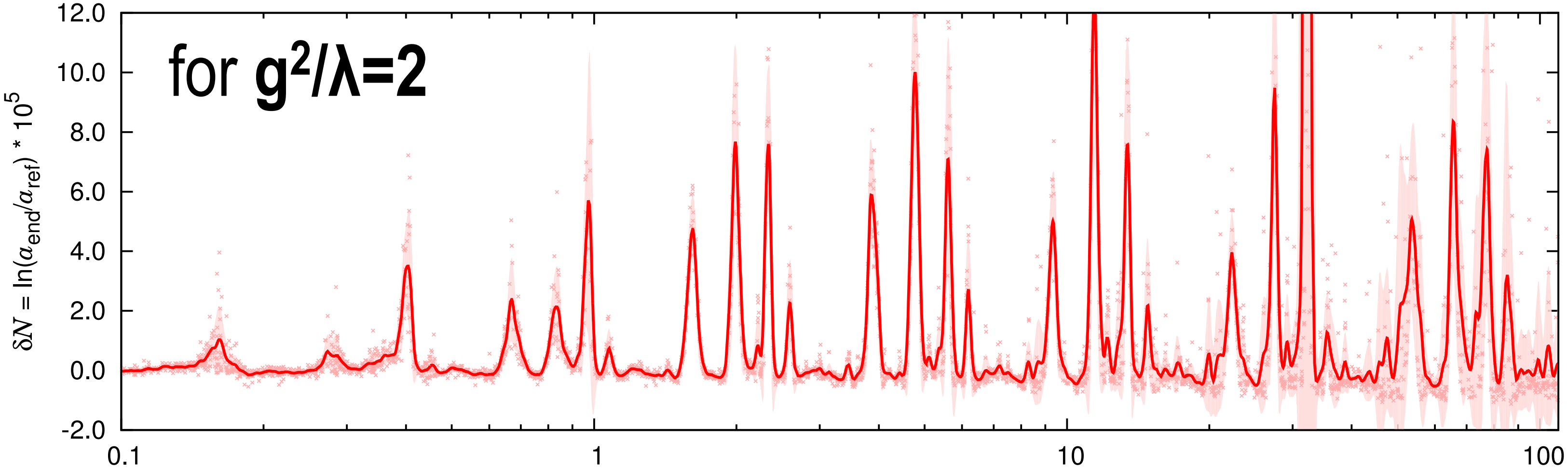
non-Gaussianity
(WMAP, **Planck**, LSS)
spiky nG preheating

$\delta \ln a_{shock}(\chi_i(x) \,|\, g^2/\lambda)$ => ***Chaotic Billiards: NonG from Parametric Resonance in Preheating***

B+Frolov, Huang, Kofman 09
B+Braden, Frolov, Huang 14

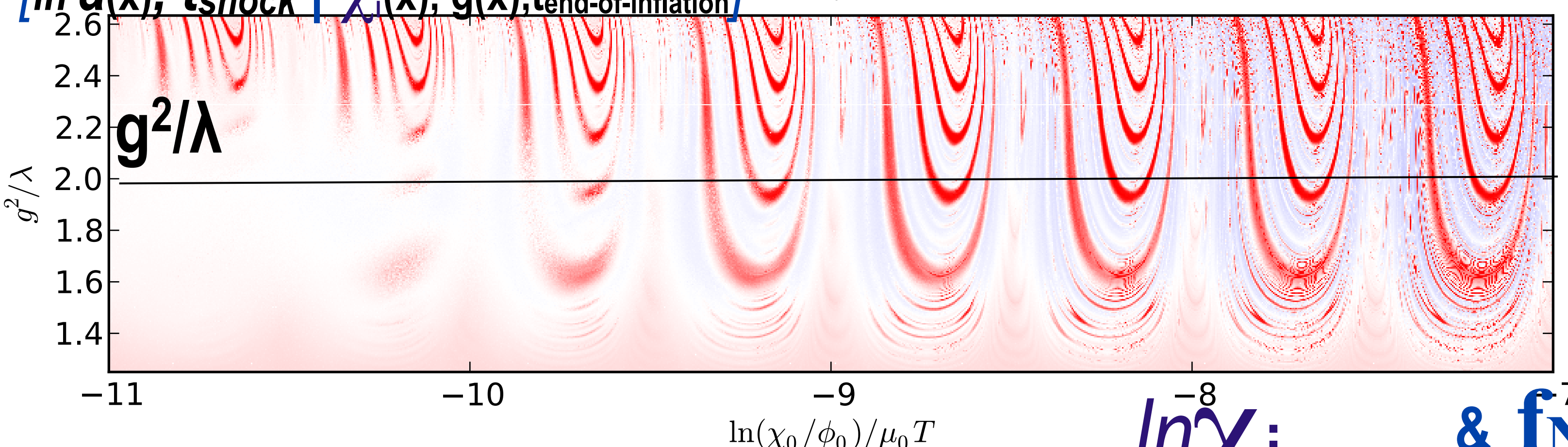
$V(\phi,\chi) = 1/4\ \lambda\phi^4 + 1/2\ g^2\phi^2\chi^2$

*ln*a



$(\chi_{ini}/m_{pl}) * 10^7$

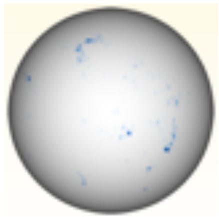
P[*ln* **a**(x), ***t*****shock** | χ_i(x), g(x), $t_{end\text{-}of\text{-}inflation}$]



lnχ_i

huge number of 64^3 ***sims to show the wondrous complexity of***

*ln*a(χ_i, g^2/λ)



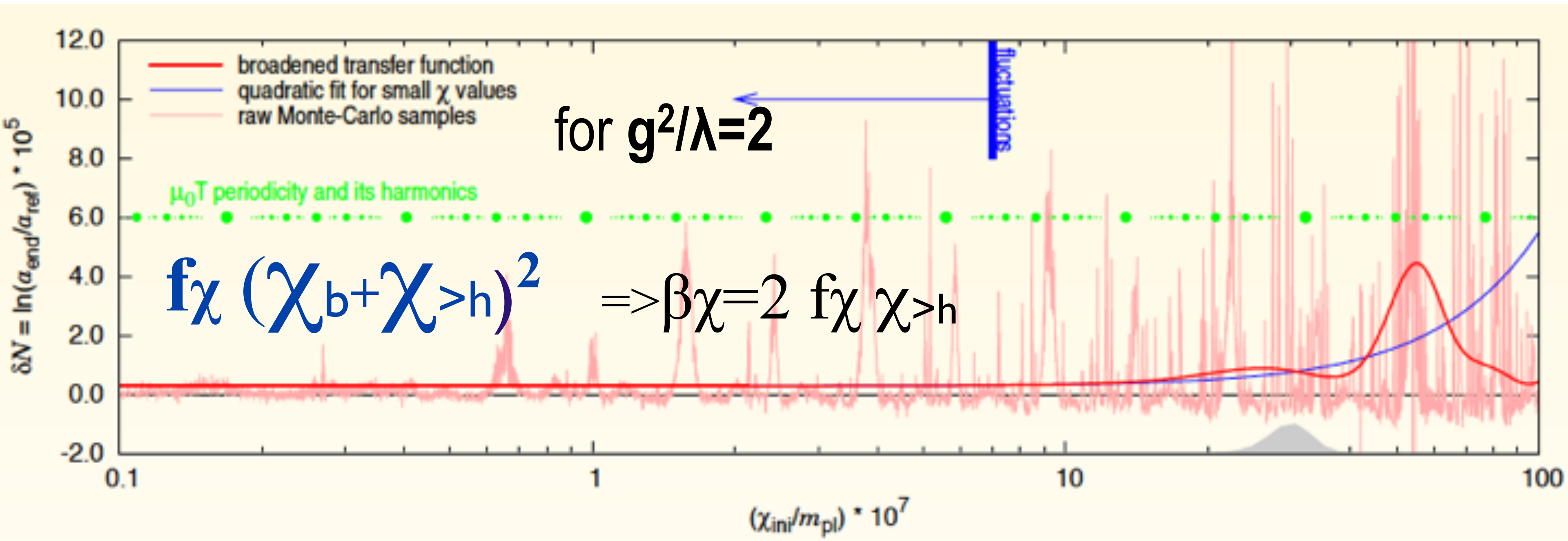
& f_{NL}^{equiv}

field smoothing over χHF over ~50 e-folds of HF structure

$$\langle F_{NL} | \chi_b + \chi_{>h} \rangle \sim \beta\chi(\chi_{>h})\, \chi_b + f\chi(\chi_{>h})\, \chi_b^2 + \ldots$$

cf. $F(x) = F_G(x) + f_{NL*} F_G^2(x)$

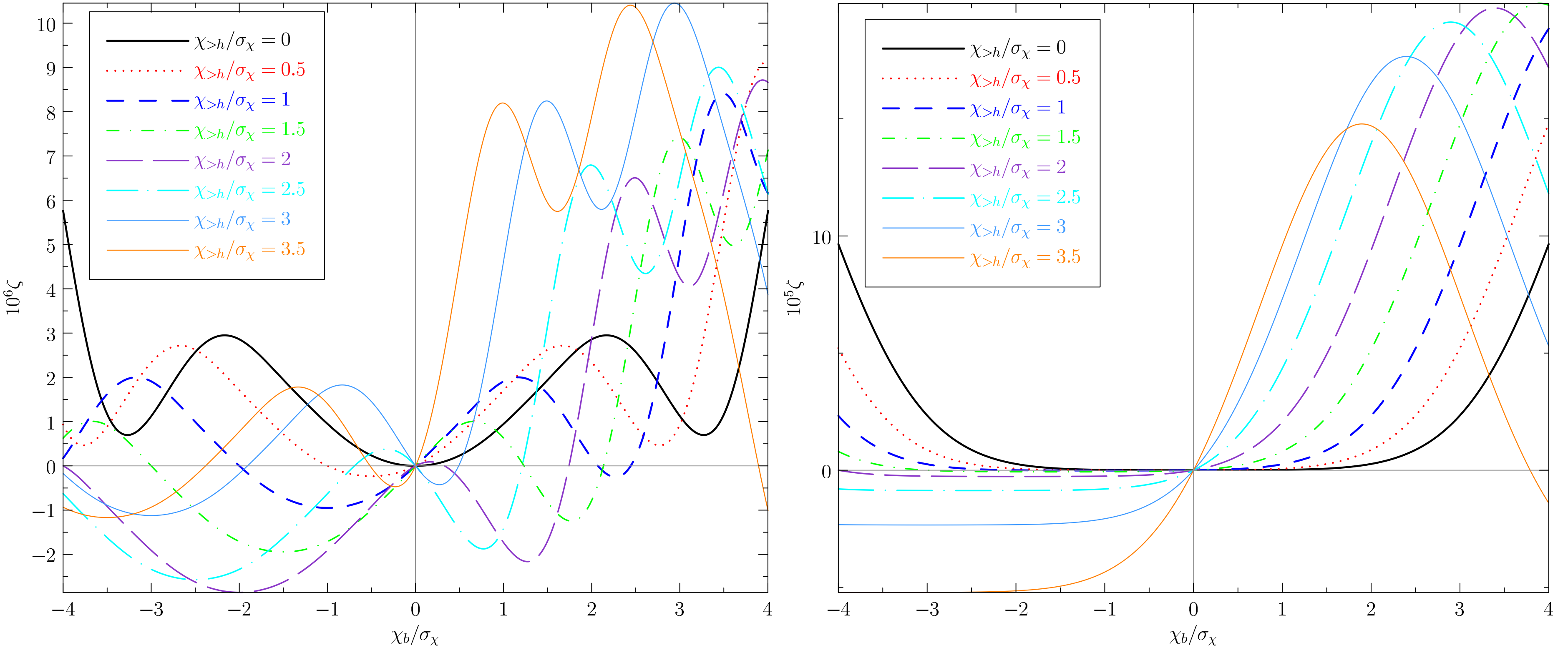
$1/4\, \lambda\phi^4 + 1/2\, g^2 \phi^2 \chi^2$



$f_{NL}^{equiv} = \beta\chi^2 f\chi\, [P\chi/P\phi]^2(k_{pivot})$ **Local f_{NL}=2.7 ± 5.8 Planck1.3**

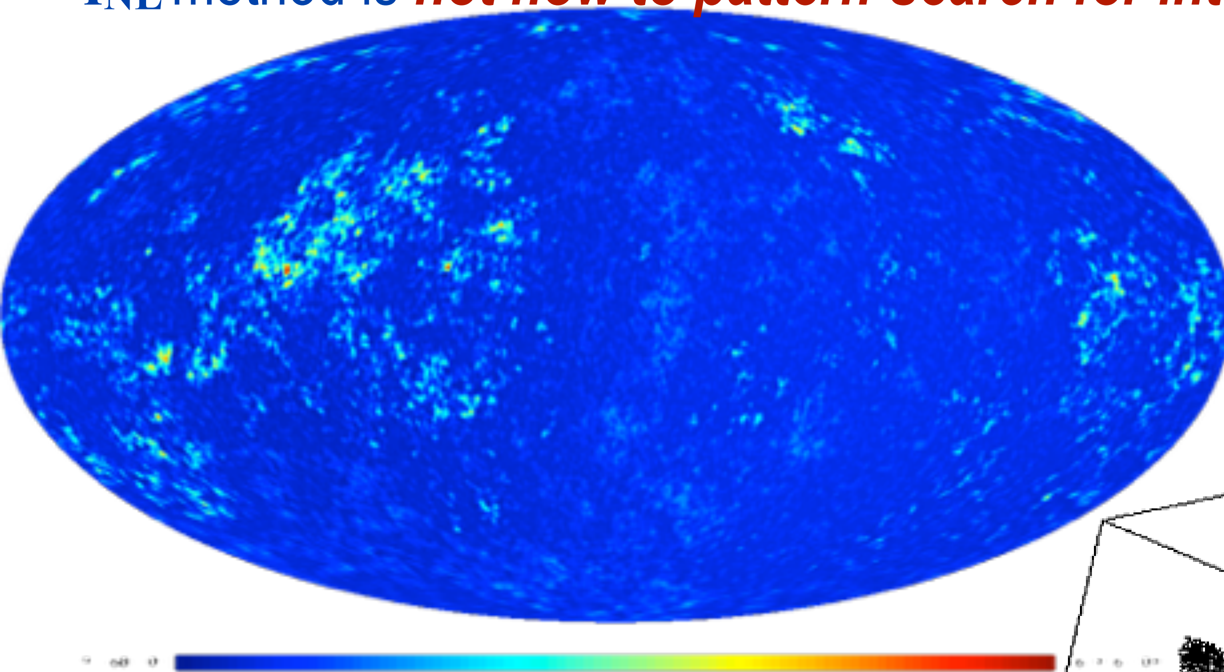
=> constrain $f\chi^3\, \chi_{>h}^2$ ($P\chi/P\phi \sim 2\varepsilon$ => ***relaxed limit***) simulated sky with Gaussian inflaton-induced + **uncorrelated subdominant non-Gaussian isocon-modulated preheating**. Landscape-accessing super-horizon control variable = $\chi_{>h}$ => ***super-bias, intermittent, extended source-like*** **rare event tails**

Bond,Braden,Frolov,Huang14

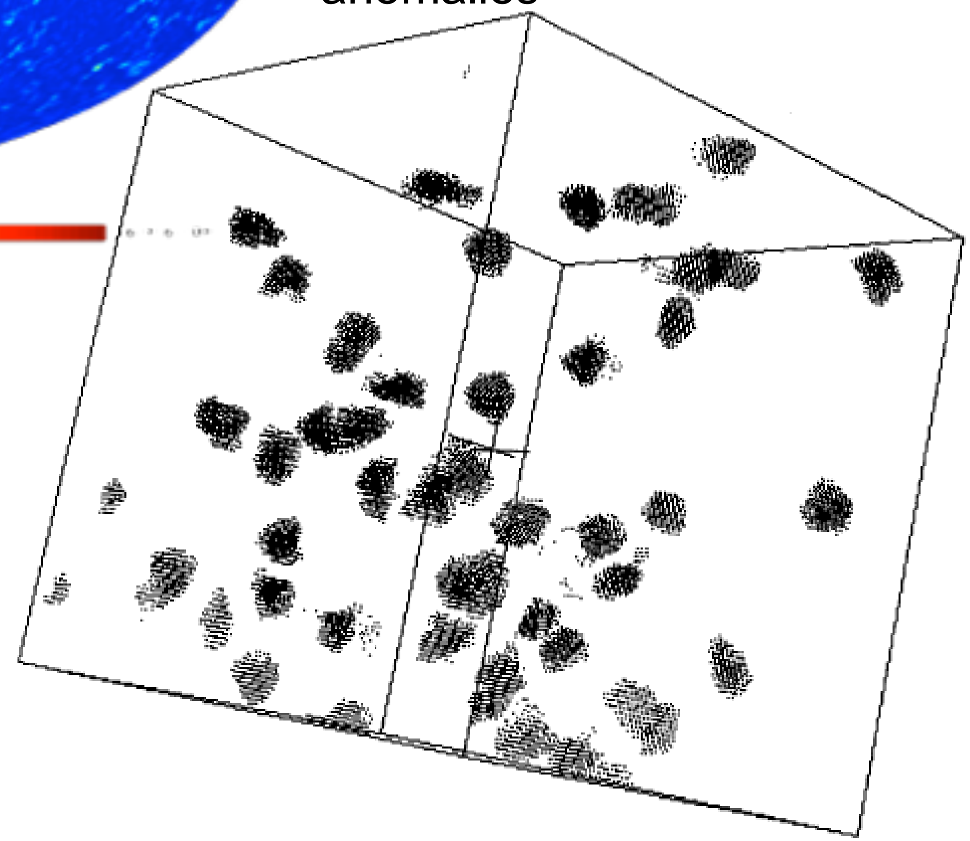


bispectrum & 3-point ~ $f_{sky,patches}^{3}$ => not overly constraining & standard f_{NL} method is *not how to pattern-search for intermittent power bursts*

Bond,Braden,Frolov,Huang13



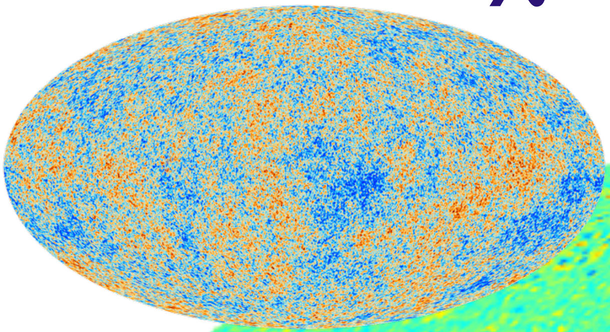
intermittency from steep threshold functions acting on a slightly red curvature field (gravitational potential) lead to very-large-scale splotch "anomalies"

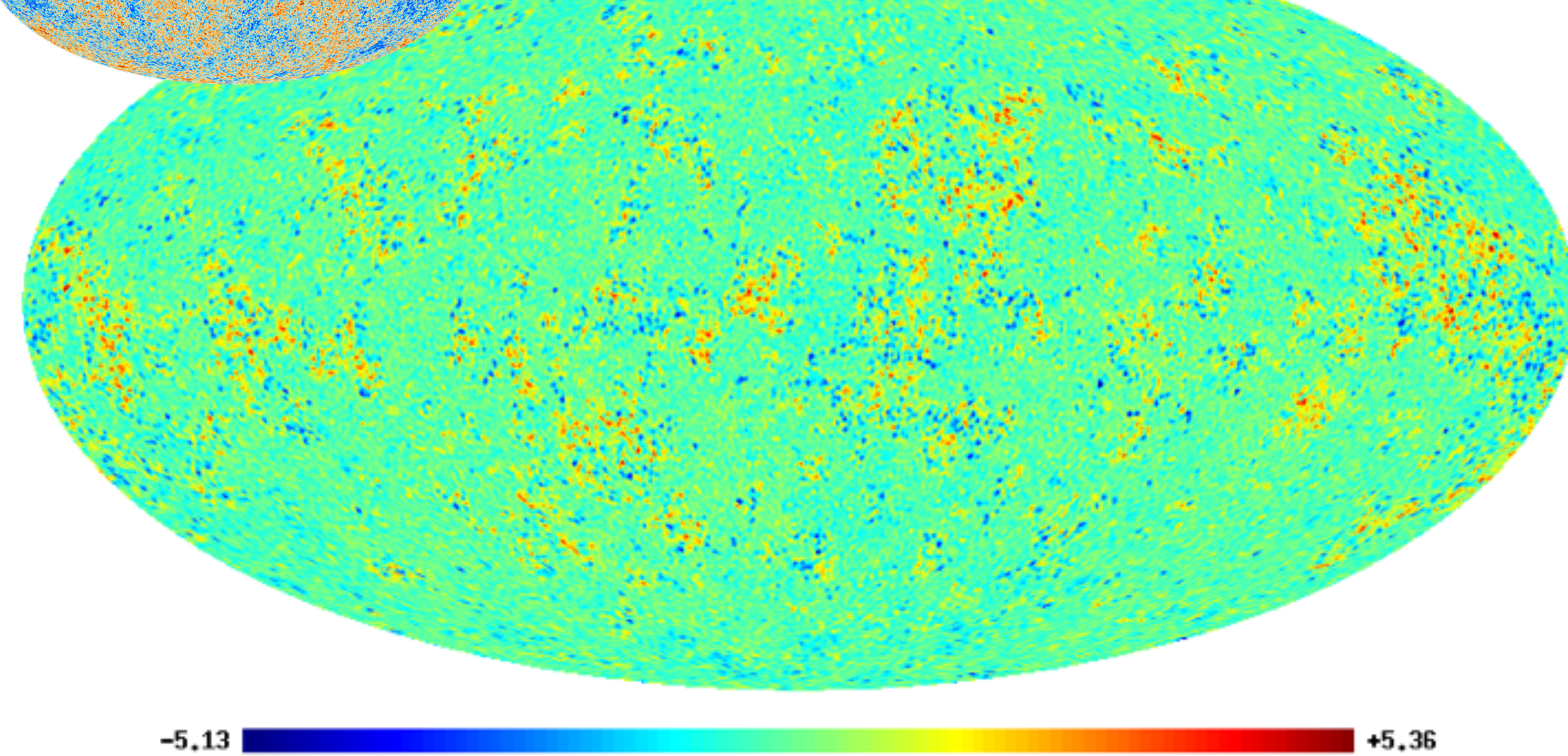


cf. the more localized Lagrangian space **intermittency** from steep cluster-threshold functions acting on the **density field**. **Cluster-patches** lead to pressure intermittency and SZ sources in the CMB simulated sky with Gaussian inflaton-induced + **uncorrelated subdominant non-Gaussian isocon-modulated preheating**. Landscape-accessing super-horizon control variable = $\chi > h$ => ***super-bias, intermittent, extended source-like***

rare event tails

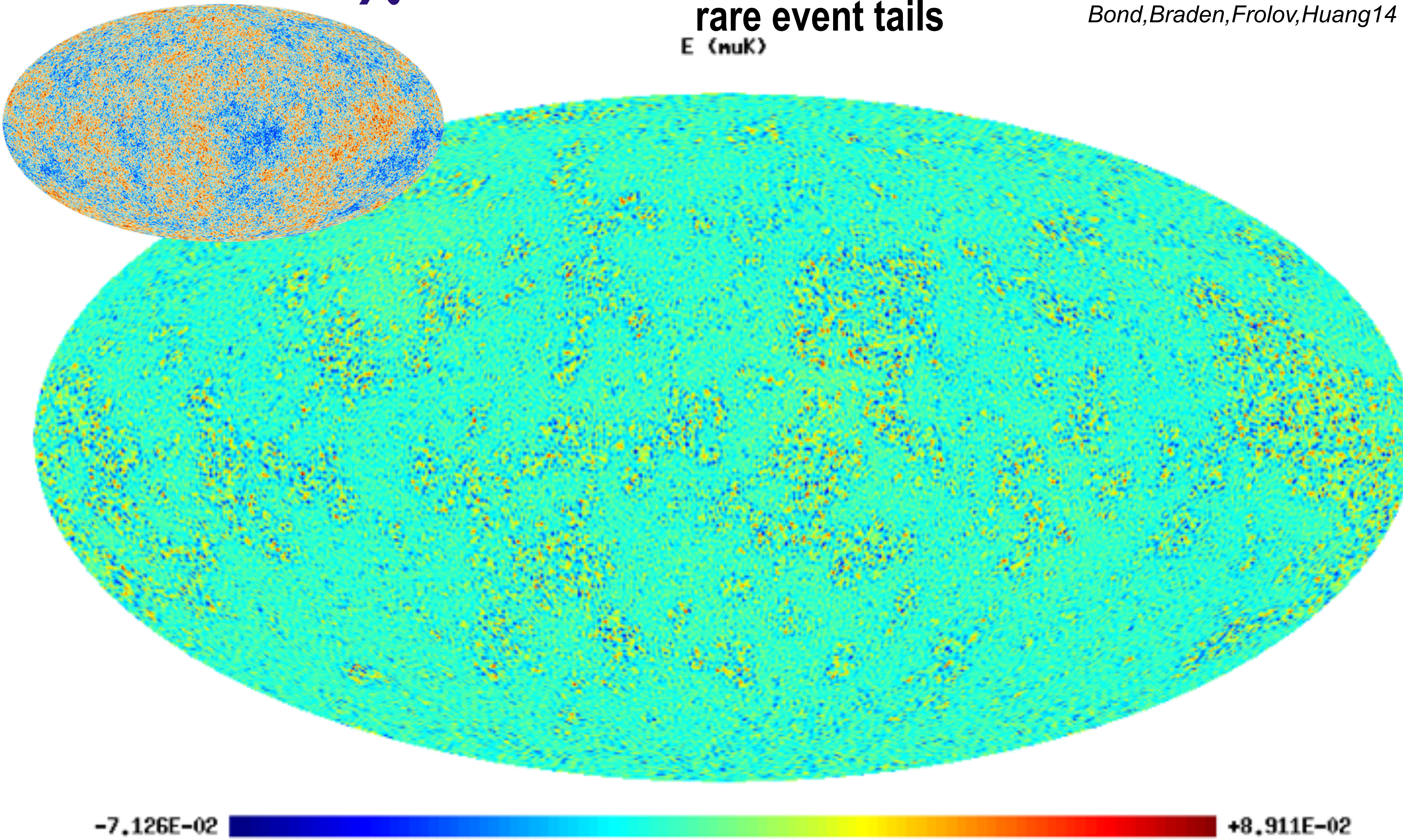
Bond,Braden,Frolov,Huang 14





simulated sky with Gaussian inflaton-induced + **uncorrelated subdominant non-Gaussian isocon-modulated preheating**. Landscape-accessing super-horizon control variable = χ>h => ***super-bias, intermittent, extended source-like* rare event tails**

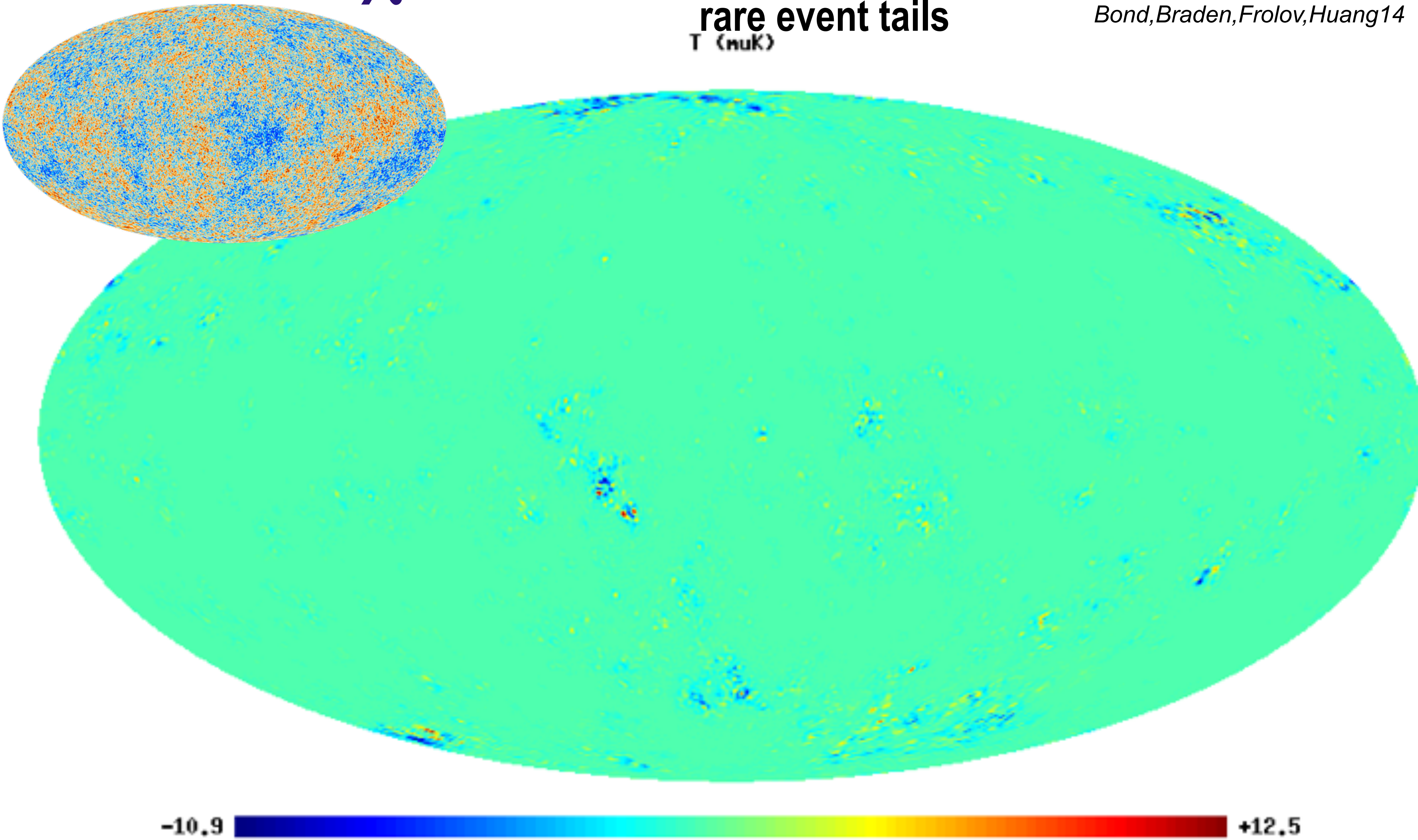
Bond,Braden,Frolov,Huang14



simulated sky with Gaussian inflaton-induced + **uncorrelated subdominant non-Gaussian isocon-modulated preheating**. Landscape-accessing super-horizon

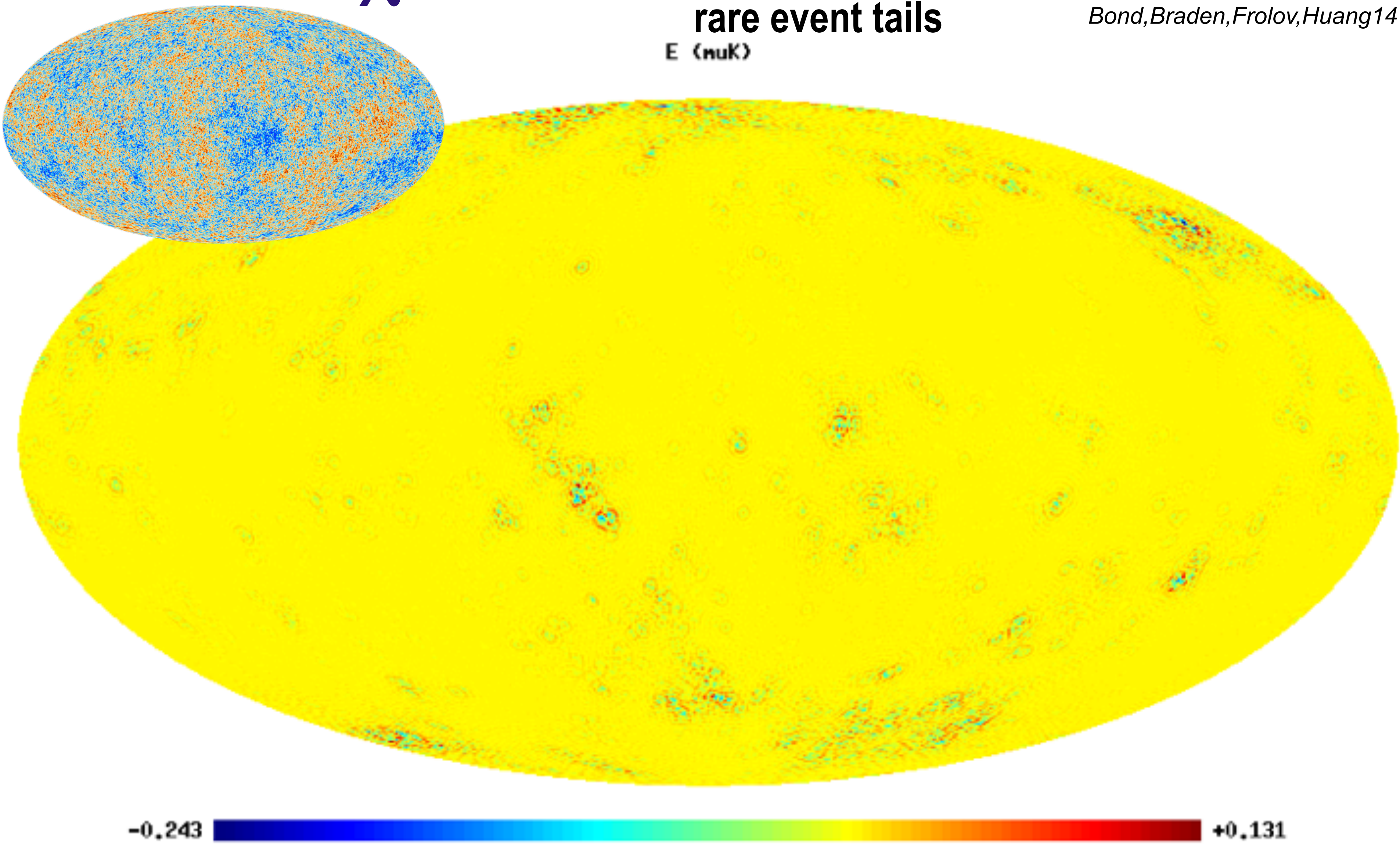
control variable = $\chi > h$ => ***super-bias, intermittent, extended source-like* rare event tails**

Bond,Braden,Frolov,Huang14



simulated sky with Gaussian inflaton-induced + **uncorrelated subdominant non-Gaussian isocon-modulated preheating**. Landscape-accessing super-horizon control variable = $\chi > h$ => ***super-bias, intermittent, extended source-like*** **rare event tails**

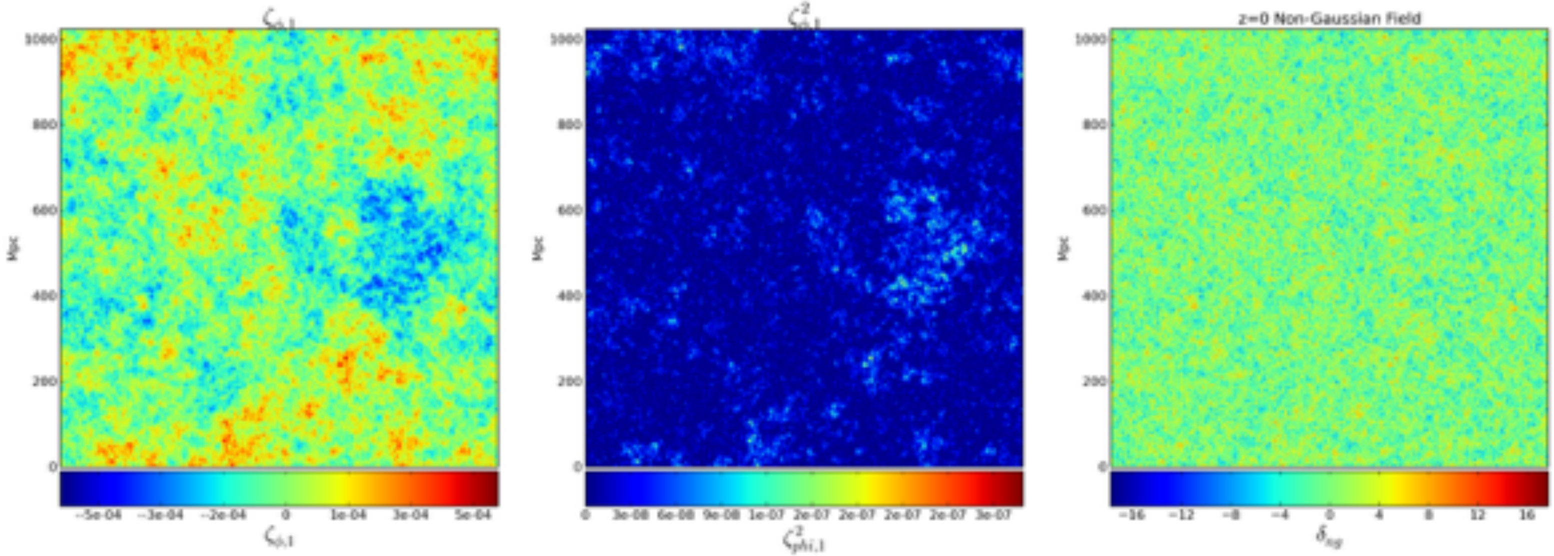
Bond,Braden,Frolov,Huang14



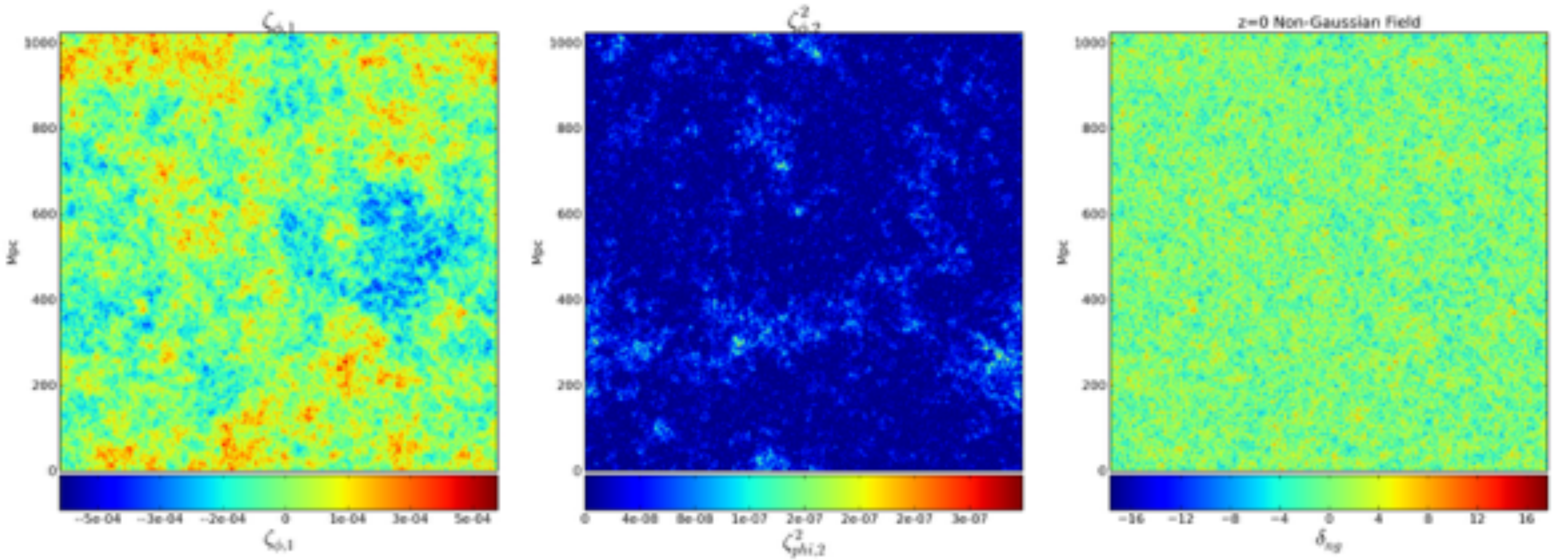
alatt=1Mpc, N=1024

Alvarez,Bond,Huang,Stein,Braden,Frolov14

correlated zeta_inf^2



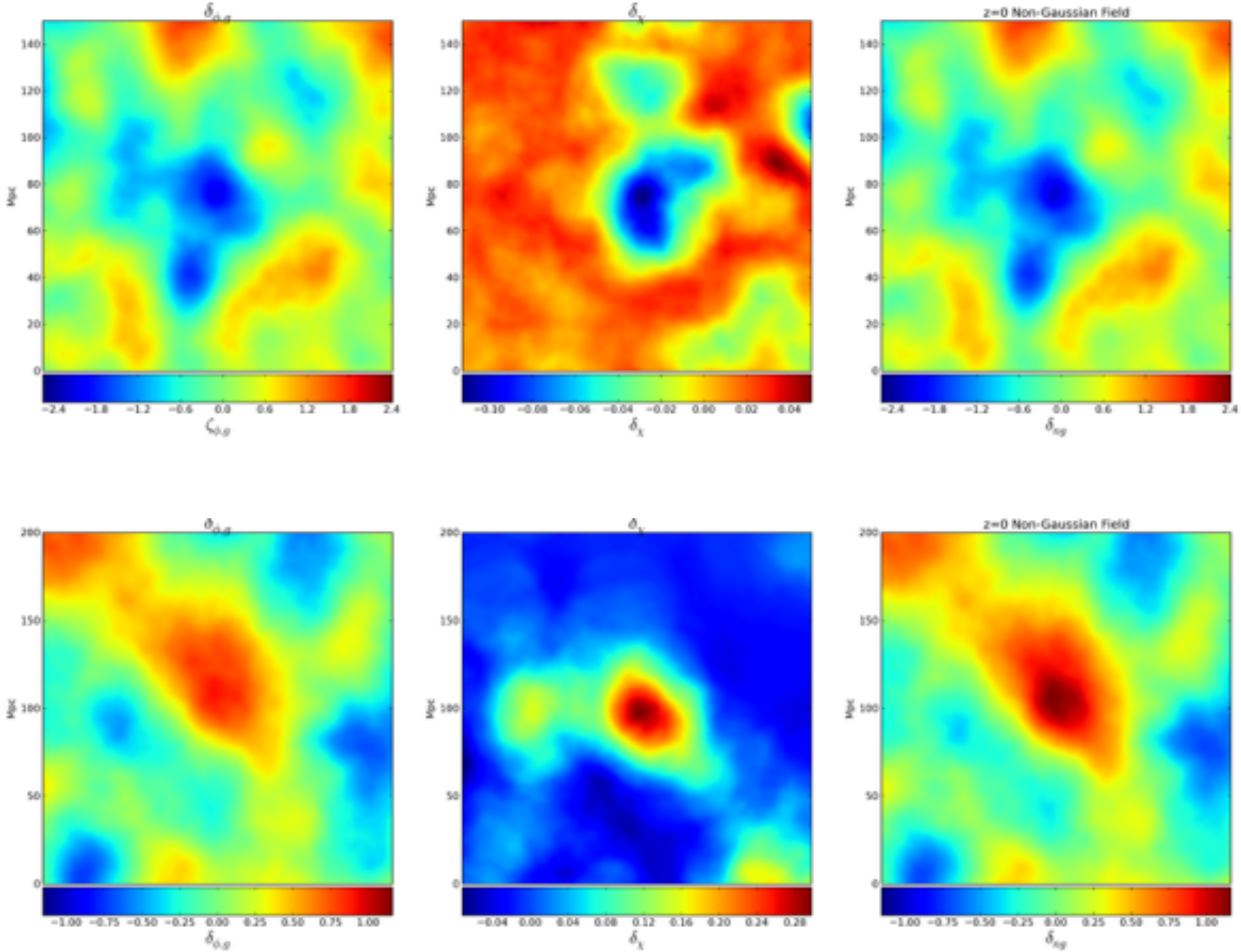
uncorrelated zeta_isoc^2



alatt=1Mpc, N=1024

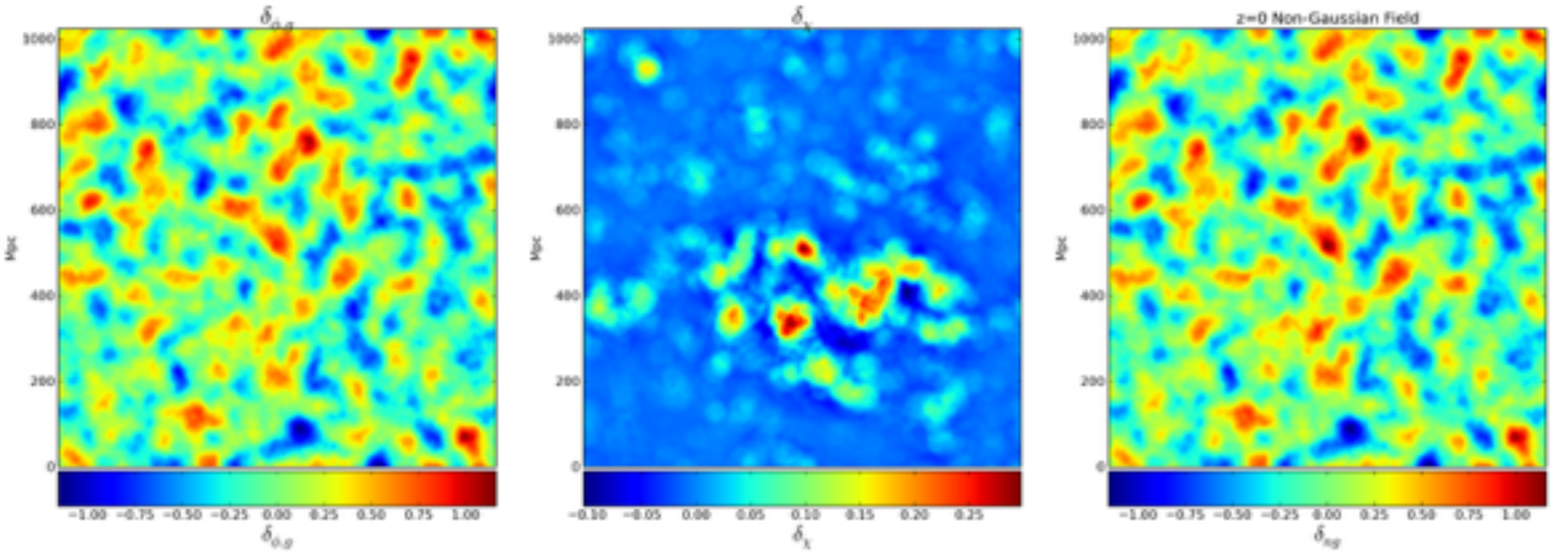
Alvarez,Bond,Huang,Stein,Braden,Frolov14

Chaotic Billiard Model Smoothed on R=16Mpc

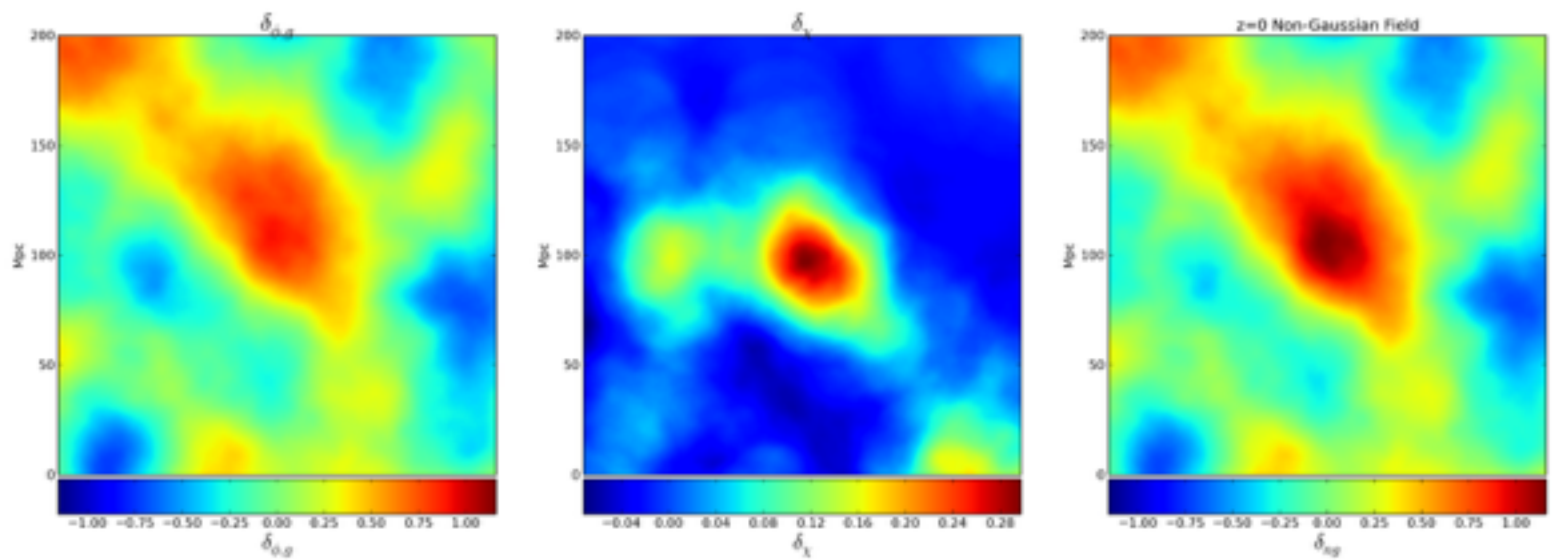


alatt=1Mpc, N=1024 *Alvarez,Bond,Huang,Stein,Braden,Frolov14*

Gaussian Spike Model Smoothed on R=32Mpc

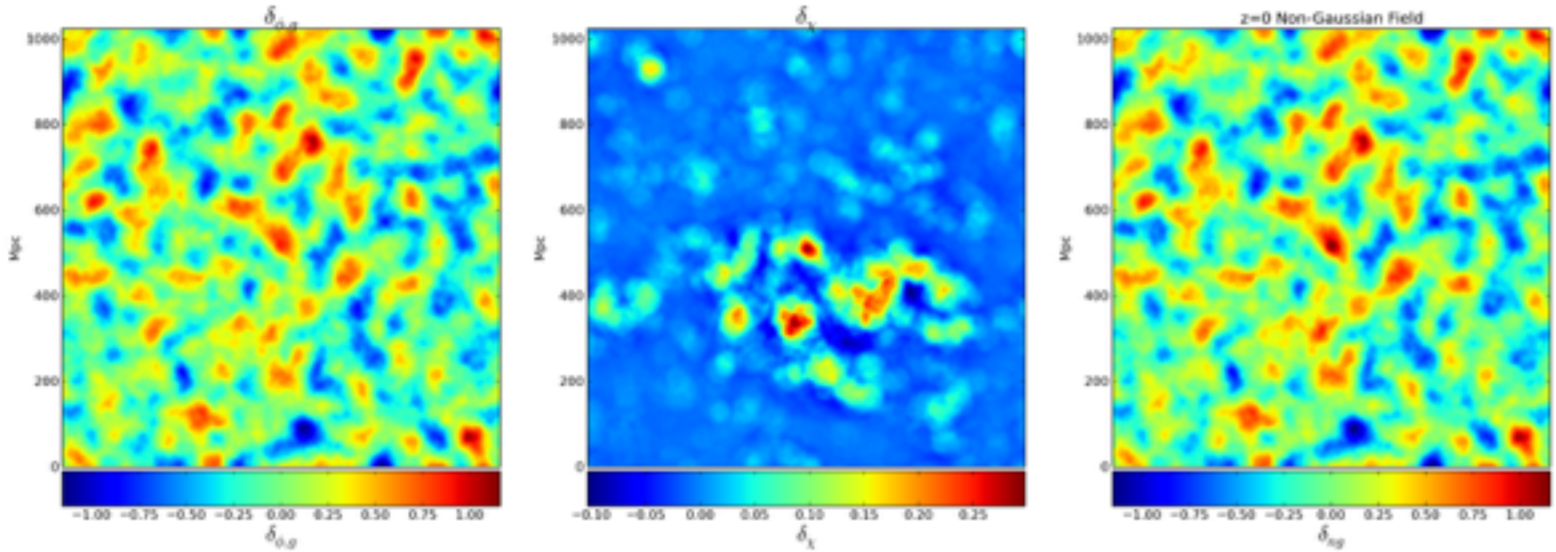


Gaussian Spike Model Smoothed on R=32Mpc

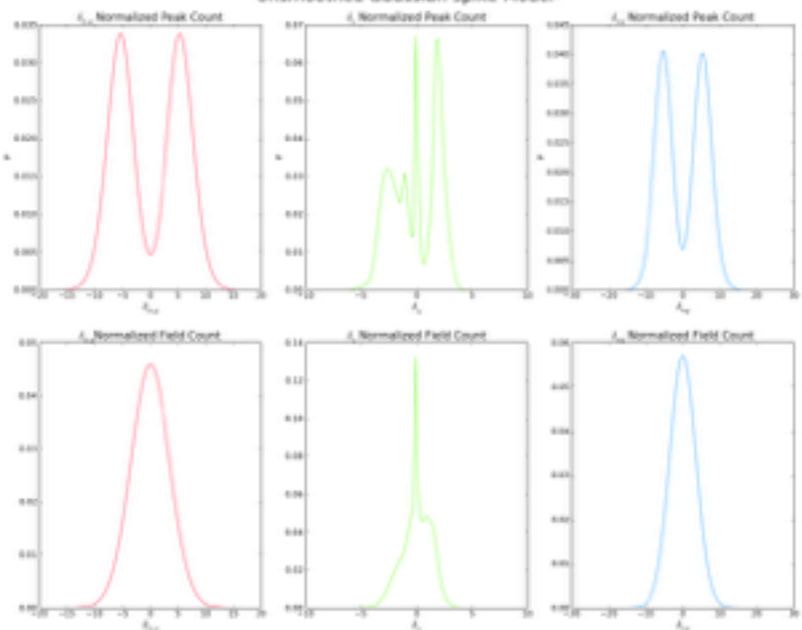


alatt=1Mpc, N=1024 *Alvarez,Bond,Huang,Stein,Braden,Frolov14*

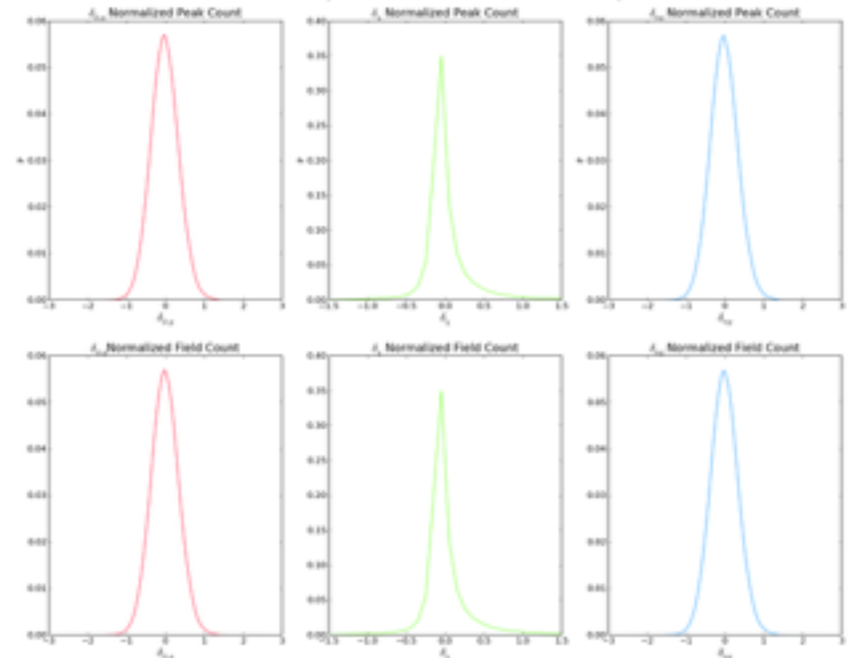
Gaussian Spike Model Smoothed on R=32Mpc



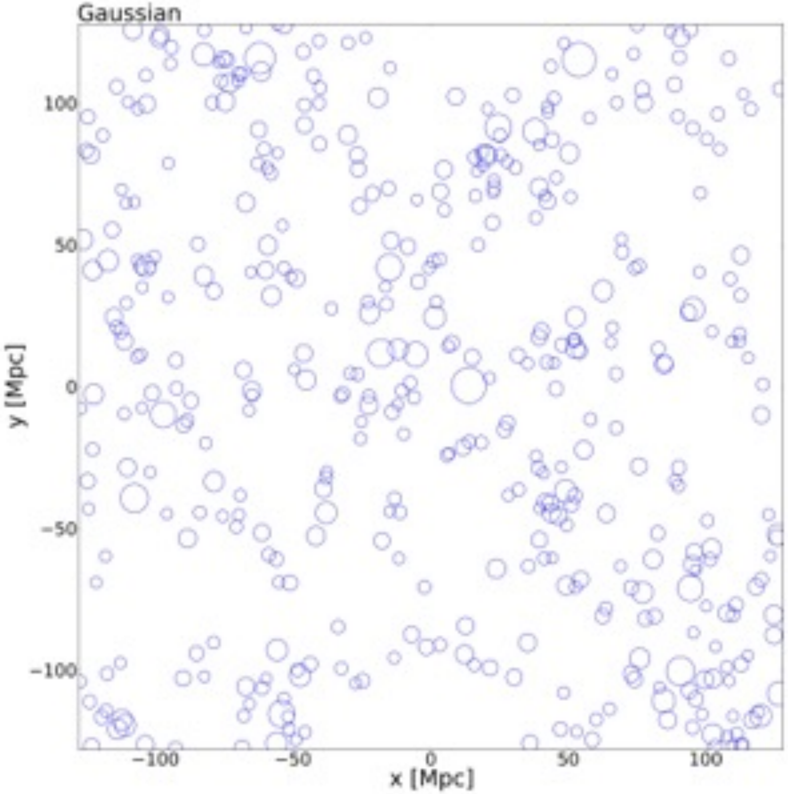
Unsmoothed Gaussian Spike Model

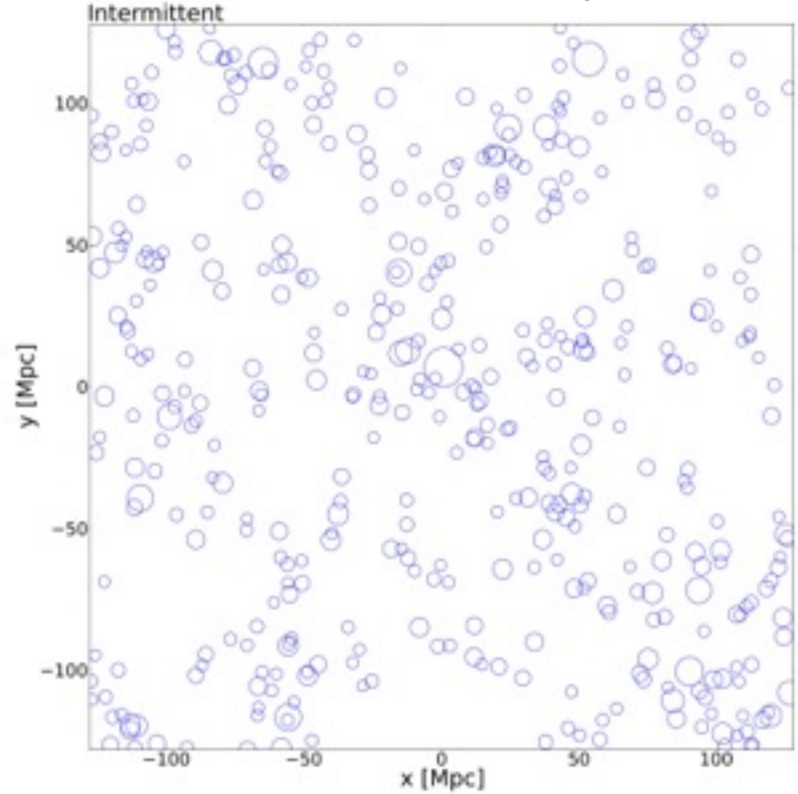


Gaussian Spike Model Smoothed on R=32Mpc

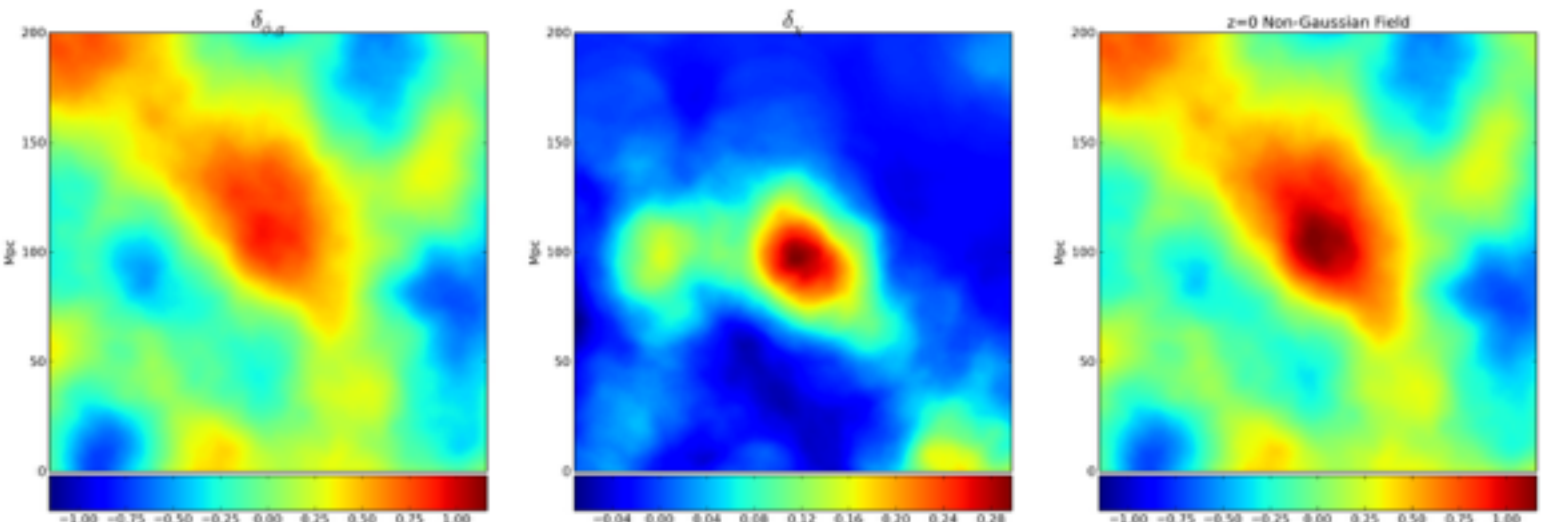


Alvarez,Bond,Huang,Stein,Braden,Frolov14





Gaussian Spike Model Smoothed on R=32Mpc



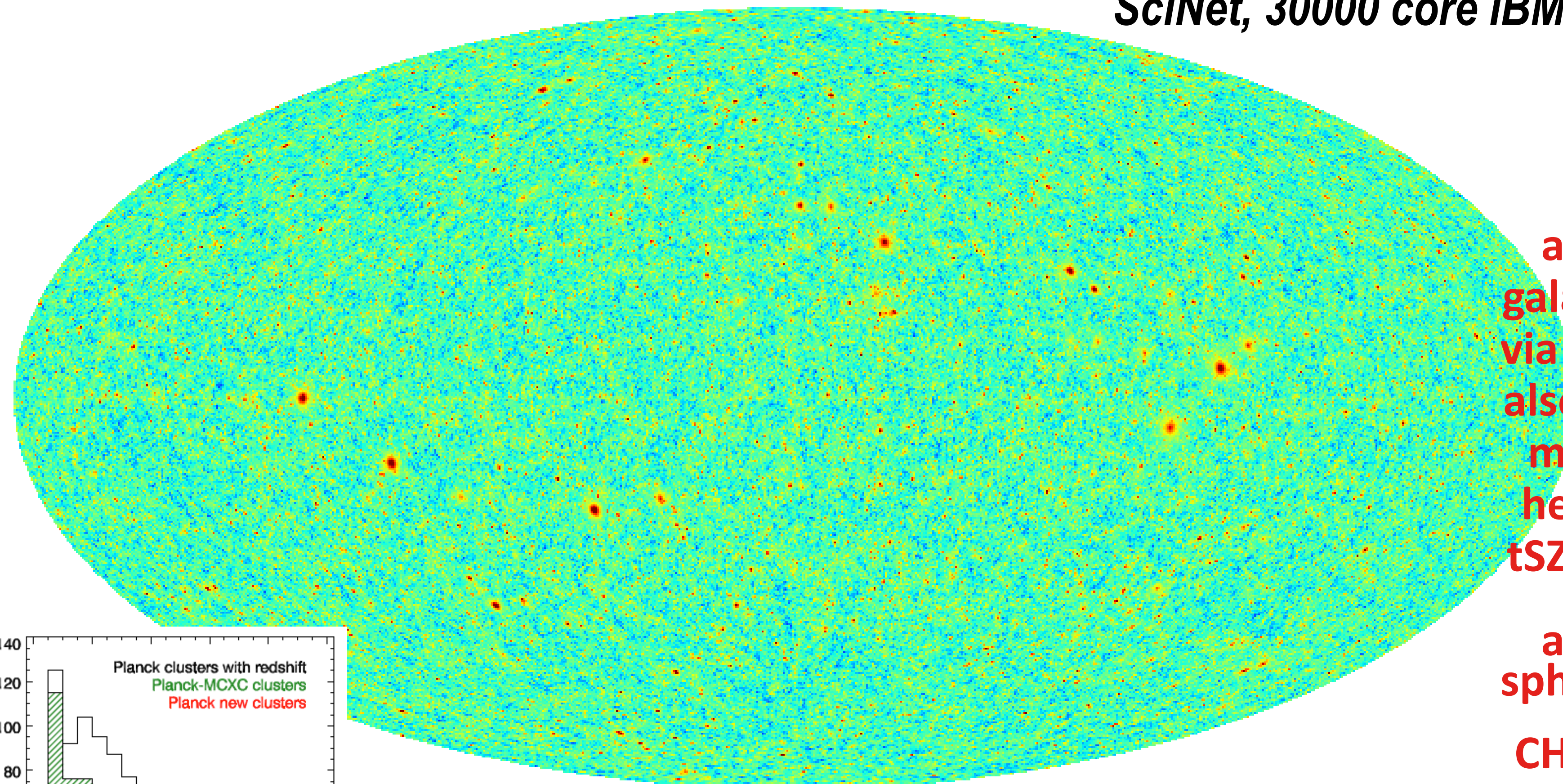
the Cosmic Web of Clusters, seen thru Compton cooling of high pressure electrons by the CMB

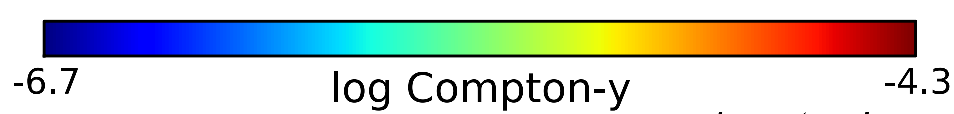
tSZ effect

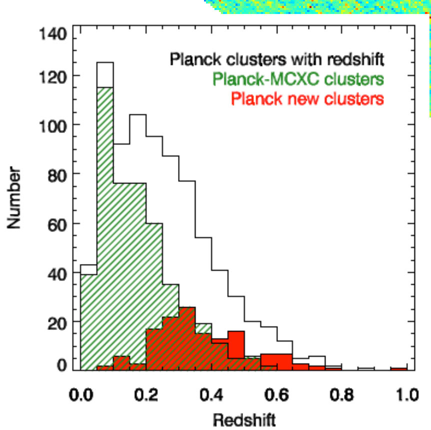
Lightcone Simulation of Clusters > 1.5×10^{13} M_{sun} to z=1.3 in projected pressure

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

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







also galaxies via HOD

also CIB maps

hence tSZxCIB

also sphereX

CHIME

COMA mocks

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

END

linear regime of zero-modes:

$\phi_0(t+T) = \phi_0(t)$

$\chi_0(t+T) = \chi_0(t) \exp[\mu_0 T]$

$\Rightarrow$ ***spikes are***

log χ_i spaced