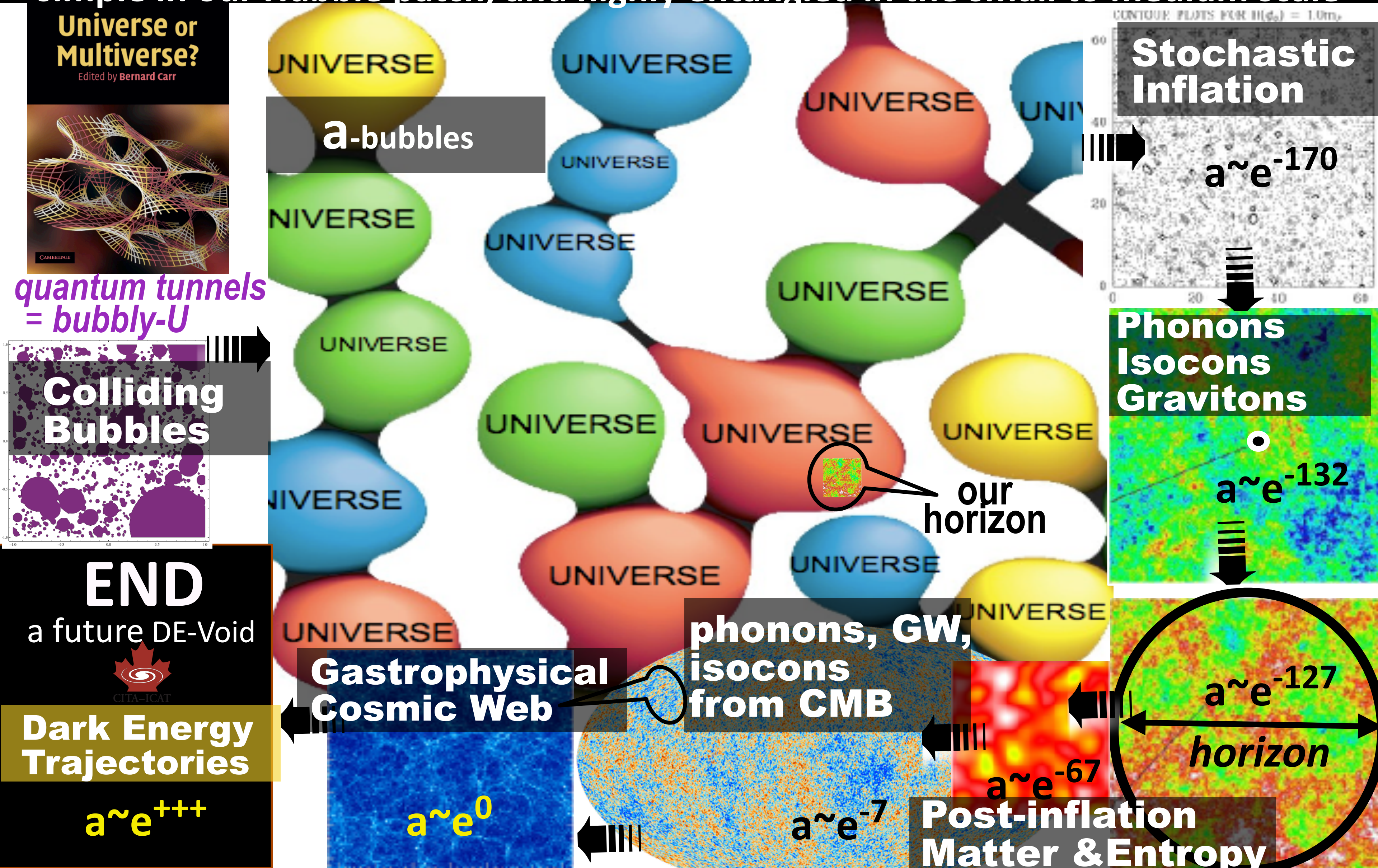
# Dick Bond CITA & CIFAR: Aspects of Inflation ζ-Phenomenology

## SuperWeb of ultra-Ultra Large Scale Structure of the Universe

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 scale



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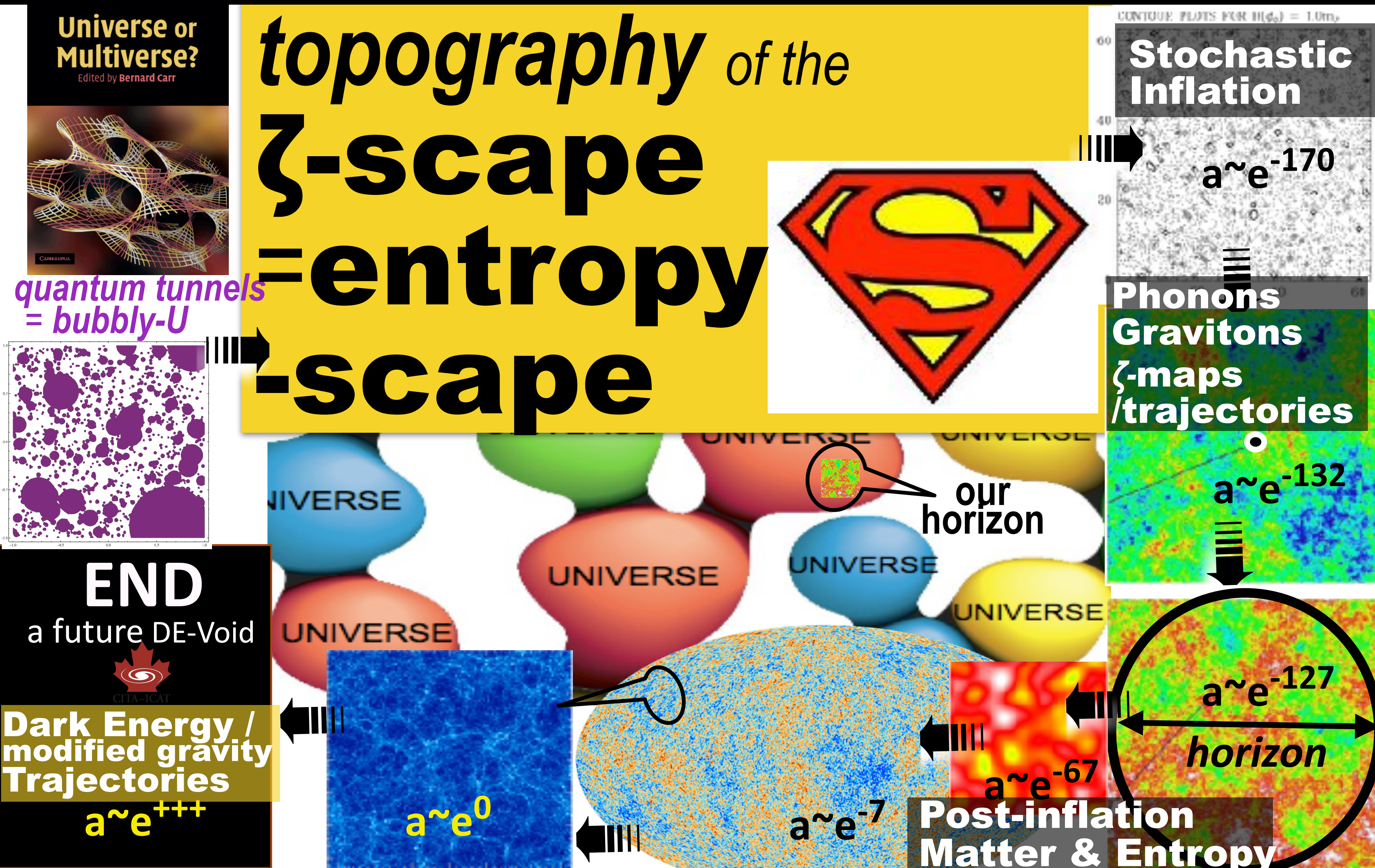
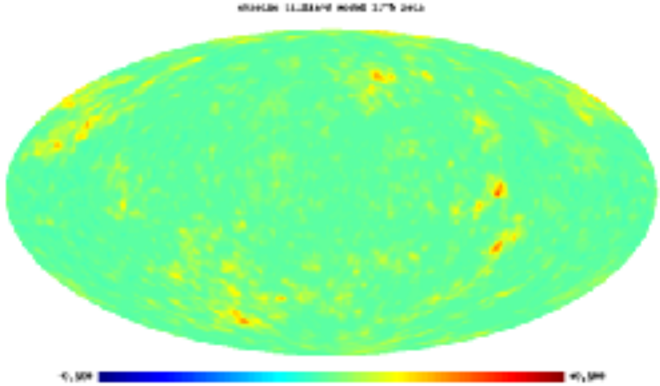
**SuperWeb:** a highly strained & stressed state at large *(very)*, randomly simple in our Hubble patch, and *(now)* highly entangled in the small to medium scale



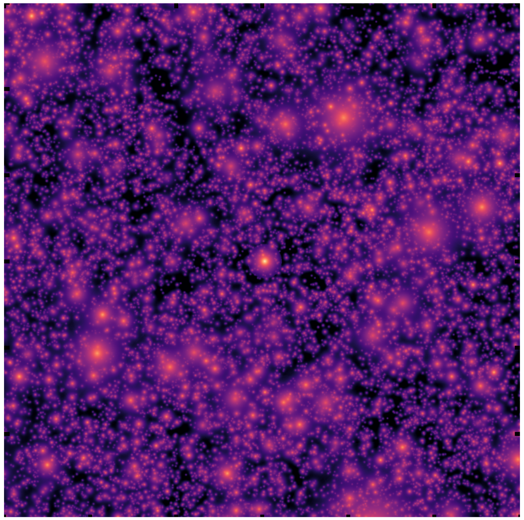
# ζ & entropy
# & adiabatic trajectories
# stochastic “coarse grain” S
# ballistics caustics
# corrugated shock-in-time
# => S intermittent nonG

CMB: std inflaton ζ +
subdominant uncorrelated ζ from
modulated preheating

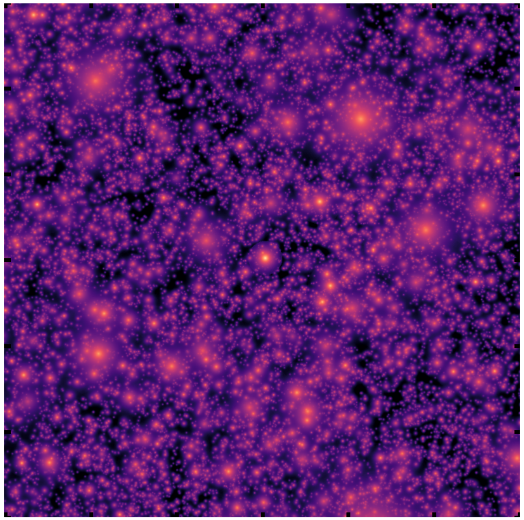


*BBFH, b+braden+frolov+huang*

LSS tSZ: Gaussian std



LSS tSZ: Gaussian std +
subdominant uncorrelated ζ



*ABSB+FH, alvarez+b+stein+frolov+huang*

# the Super-WEB aka the primordial 3-curvature web aka the phonon/isotropic strain= *volume deformation* web

$ln\,\boldsymbol{\rho}(x,t)/\langle\rho\rangle|_V$ $\quad ln\,\mathbf{V}/\langle V\rangle|_\rho = 3\; ln\; \mathbf{a}(x,t)/\langle a\rangle|_\rho$ $\quad \mathbf{d}\zeta \sim T\,\mathbf{dS}\,/\,3(E+PV)$

$\zeta(x,t) = \int (dE+pdV)\,/\,E \quad /\langle 3(1+p/\rho)\rangle(t)$ *BST83, SBB89, SB90,91, B95, Bond+Braden2017 ζ for preheating*

$\zeta(x,t) = ln\,\boldsymbol{\rho}(x,t)\,/\langle 3(1+p/\rho)\rangle(t) + \int (1+p/\boldsymbol{\rho})(x,t)\; d\,ln\,\mathbf{a}(x,t)\;/\langle 1+p/\rho\rangle(t)$

or: $\zeta(x,t) = ln\,\boldsymbol{\rho}(x,t)/\rho_b\,/\,3(1+p_b/\rho_b) + ln\,\mathbf{a}(x,t)/a_b$

**gradient / Morse flow** ***+stochastic jitter,*** **simple Hamilton principle function S~H($\phi_b$)**

*along coarse-grain trajectories* $\mathbf{d}\zeta = \mathbf{d}\,ln\,\boldsymbol{\rho}/\rho_b\,/3(1+p/\rho) + \mathbf{d}\,ln\,\mathbf{a}/a_b = [\mathbf{d}\,\bar{\zeta}](fg\to cg)$

early preheating: **gradient / Morse flow, complicated Hamilton principle function S**

**ballistic /caustic phase => ΔS nonlinear** ζ lattice sims

*cf.* late-time **density web ~ strain web -** $ln\,\boldsymbol{\rho}/\langle\rho\rangle$ **= Trace** $ln\; \mathbf{e}_J{}^j = ln\; V/\langle V\rangle|_\rho$

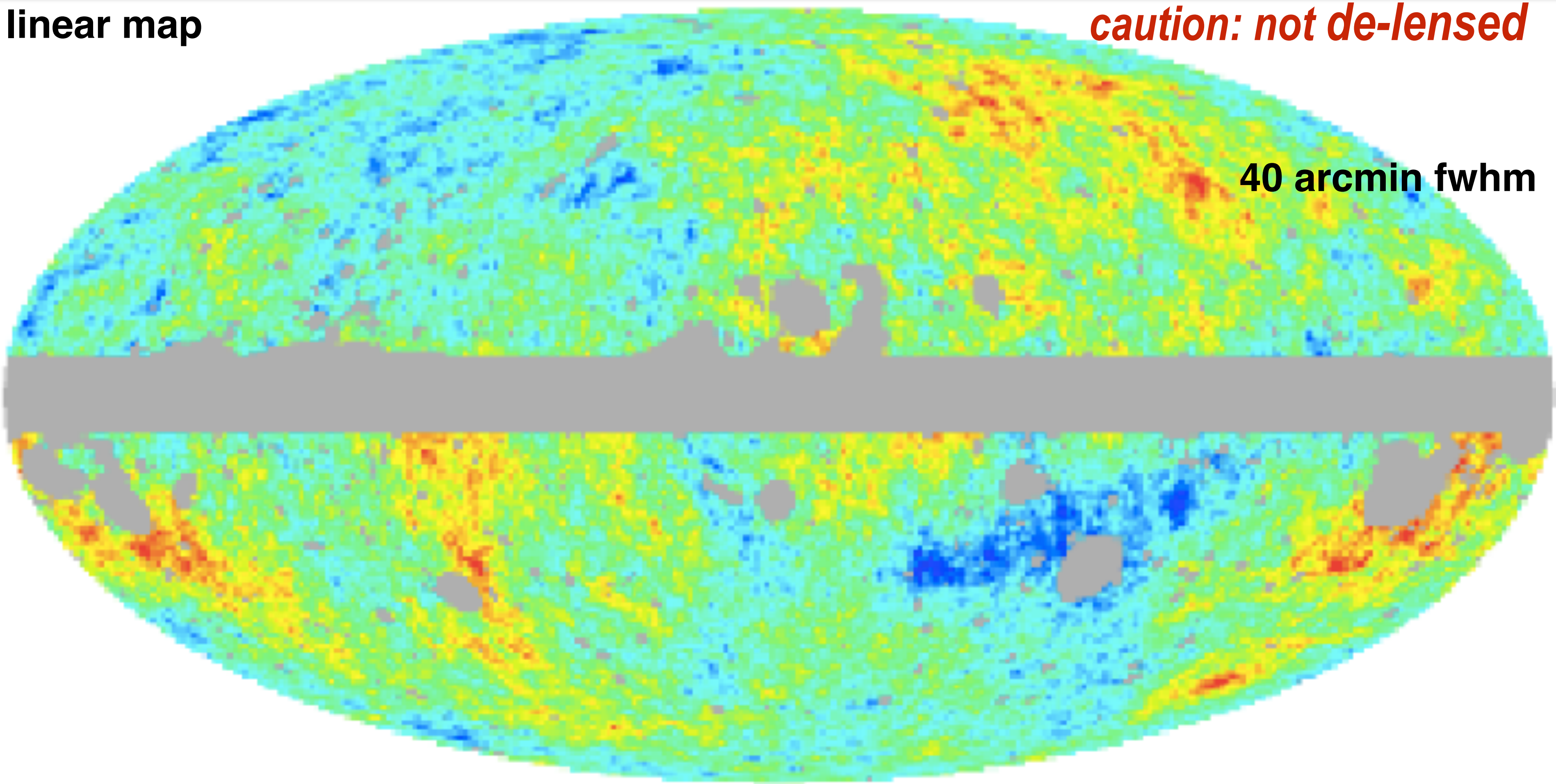
***cold*** $\langle p/\rho\rangle \sim 0 \Rightarrow \zeta(x,t\,|cdm)$ *conserved before shell crossing (preheating)*

# Reconstructing the Early Universe

$\int d$ ***visibility****(distance)* $\langle \zeta \,|\, Temp,\ E\ pol \rangle$ *(angles, distance)*

*sb89, bb15* $\zeta_{NL} = \ln(\rho\, a^{3(1+w)})/3(1+w) \Leftarrow dE + pdV \sim dEntropy$ ***phonons / strain***

**linear map** ***caution: not de-lensed***




**visibility mask**

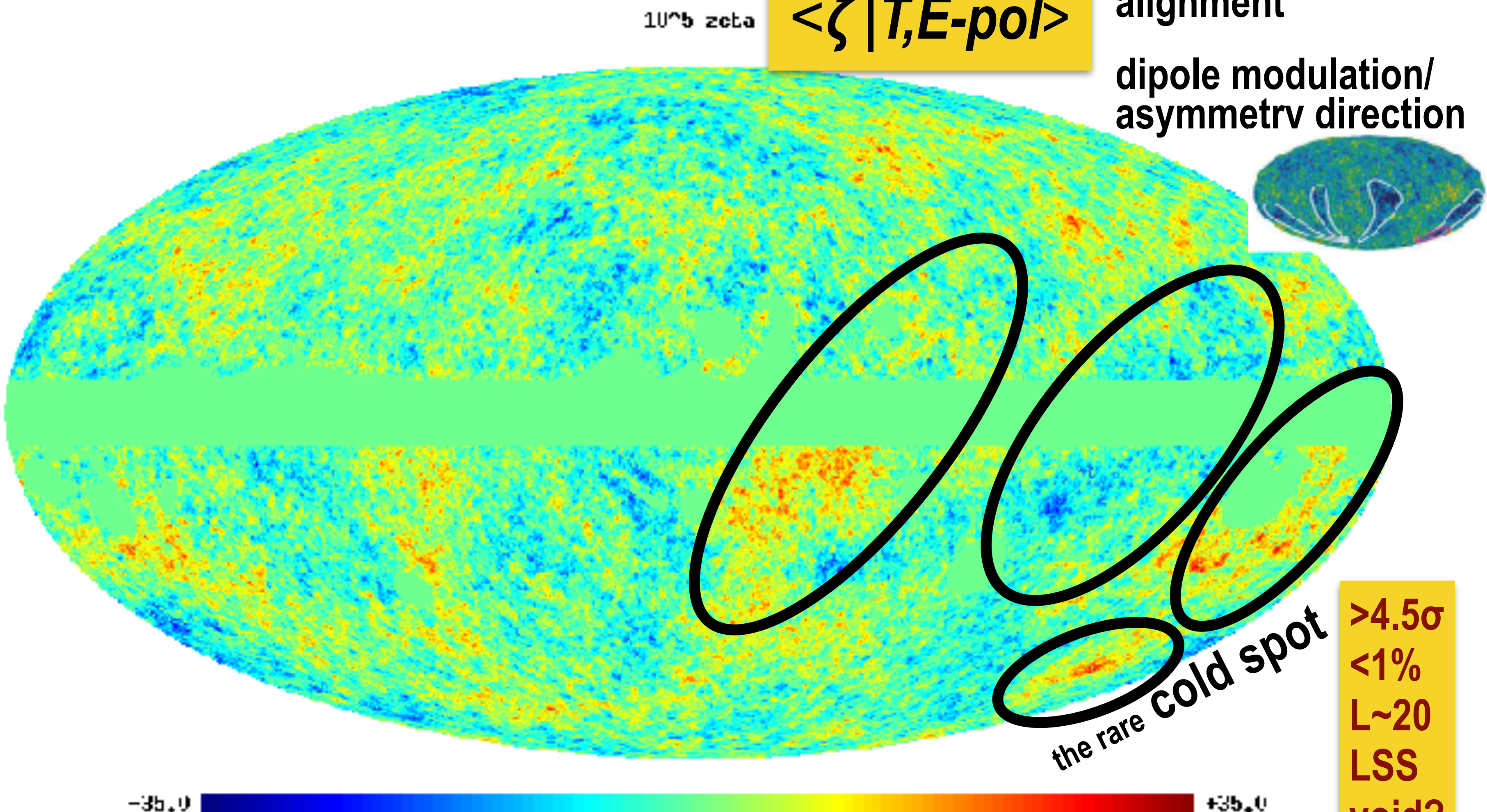
***Beyond the Standard Model of cosmology?*** SMc = *tilted*ΛCDM+r ($\zeta, h_{+x}$)

# BSMc = SMc + primordial anomalies

$\langle \zeta \,|\, T,E\text{-}pol \rangle$

**octupole/quadrupole alignment**

**dipole modulation/ asymmetry direction**




$>4.5\sigma$
$<1\%$
L~20
LSS
void?

**GUTA = Grand Unified Theory of Anomalies? TBD** ***intermittent?***

## ζ-Maps of the Early Universe

*a* ***Map*** *is an* ***ensemble = mean-map + fluctuation-maps****, encoding correlated errors*

**Maps** = *(radical)* **compressions** *of the* ***time ordered information*** **ToI** **onto**

***a parameterized space*** $q^A$***:*** *Linear maps, Quadratic maps (power), cosmic parameter maps*

***Prob(q| Data, Th prior) =>*** $\langle q^A | D,Th\rangle$, $\langle \Delta q^A \Delta q^B | D,Th\rangle$,.. or q_maxL

# TOPOGRAPHY & CARTOGRAPHY

## *of our Hubble-patch* ***aka our bit of the universe***

reconstructing $\zeta = \ln a(x,t)$ ***@uniform density,***

***aka*** primordial ***scalar curvature*** $^{(3)}R = -4\ ^{(3)}\Delta \ln a$

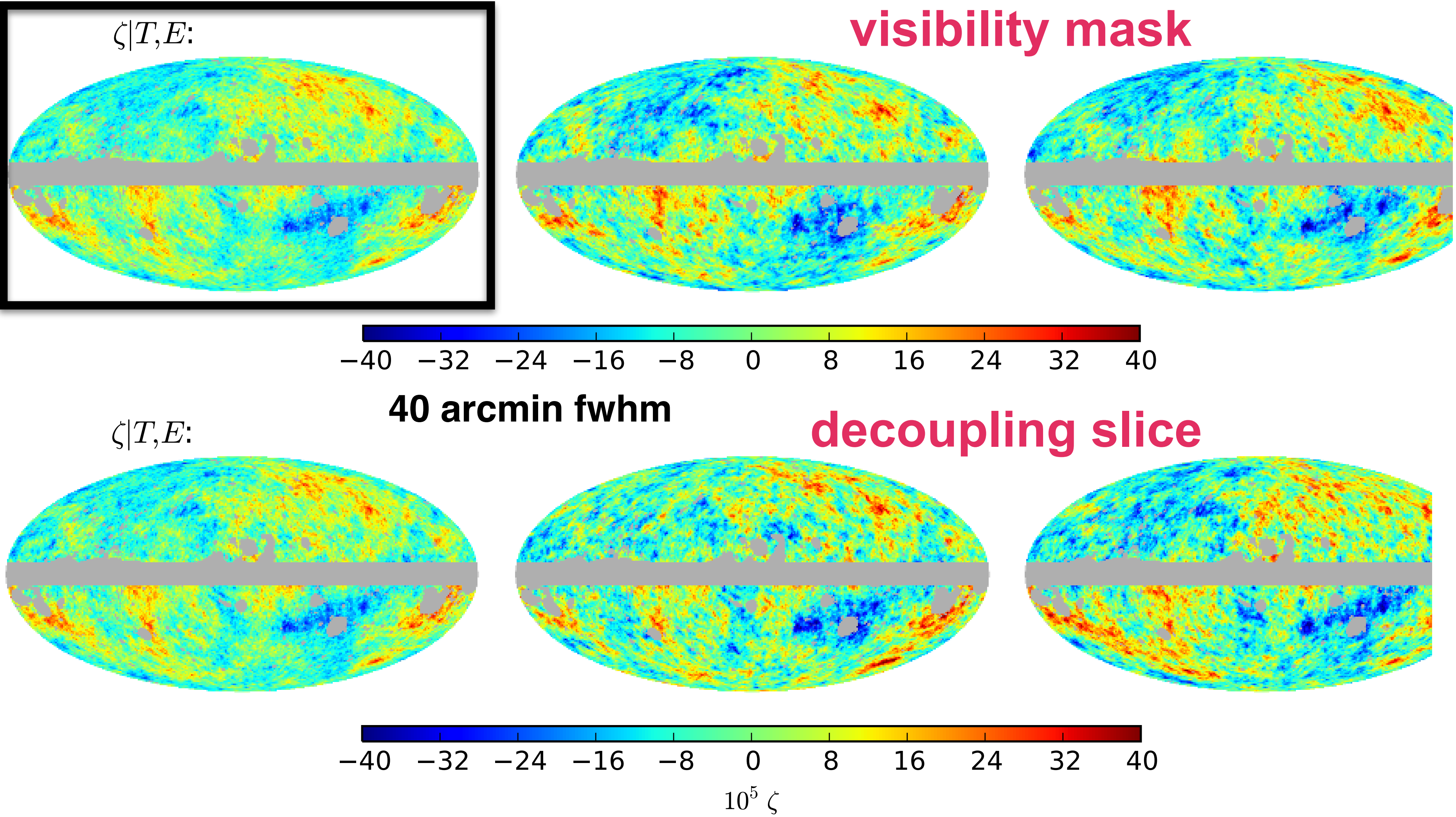
**Wiener-filtered ζ maps** make $\zeta_{LM}(\chi), \chi = |\mathbf{x}|$ instead of $\zeta(\mathbf{x})$

$T_{LM\,c,s}\ /\ E_{LM\,c,s} = \int \mathbf{e}_{\zeta}{}^{T/E}{}_{L\chi\,c,s}\ \zeta_{LM\,c,s}(\chi)\ d\chi$, susceptibility **e** depends on cosmic parameters

=> Linear response $\zeta_{LM\,c,s}(\chi) = \mathbf{e}_{*\zeta}{}^{T}{}_{L\chi\,c,s}\ T_{LM\,c,s} + \mathbf{e}_{*\zeta}{}^{E}{}_{L\chi\,c,s}\ E_{LM\,c,s} + \delta\zeta_{LM\,c,s}$

susceptibility of ***ζ to T/E:*** $\mathbf{e}_{*\zeta}{}^{T/E}$ *interpolates T/E to ζ, if no info relax to δζ*

project ***ζ*** *to minimize fluctuations:* ∫d***visibility****(distance)* (<***ζ*** *|Temp, E pol>* +δ***ζ*** )

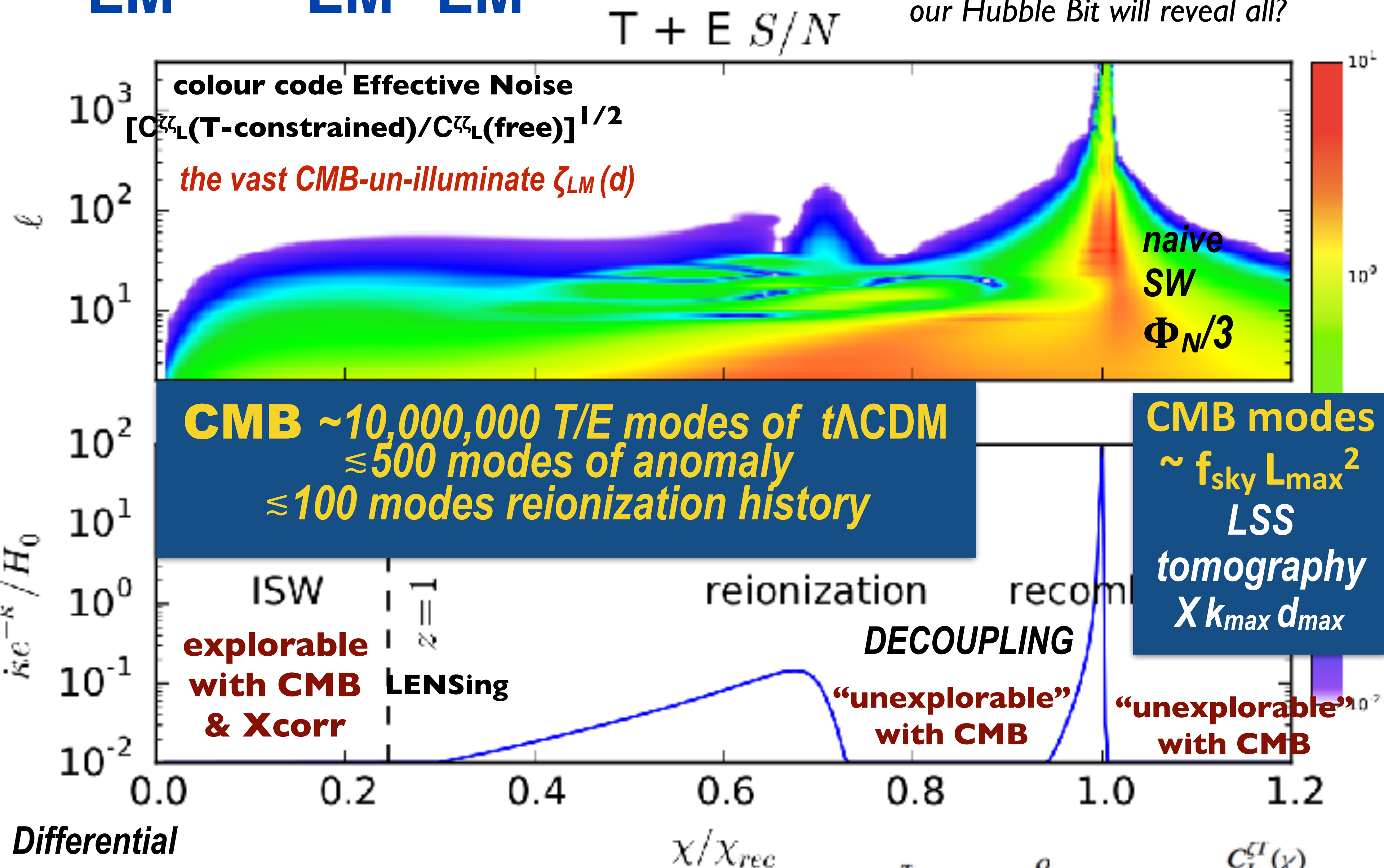



**allowed fluctuations are less noisy with E pol (extra mode/LM)**

***caution: not de-lensed****, but the Wiener filter does partially de-lens*

# $\langle\zeta_{LM}(\chi)|T_{LM}E_{LM}\rangle$

**the unexplorable ζ-scape,**
**explore with landscape++ ideas**
*our Hubble Bit will reveal all?*




*Differential Visibility*

**limits to our knowledge**

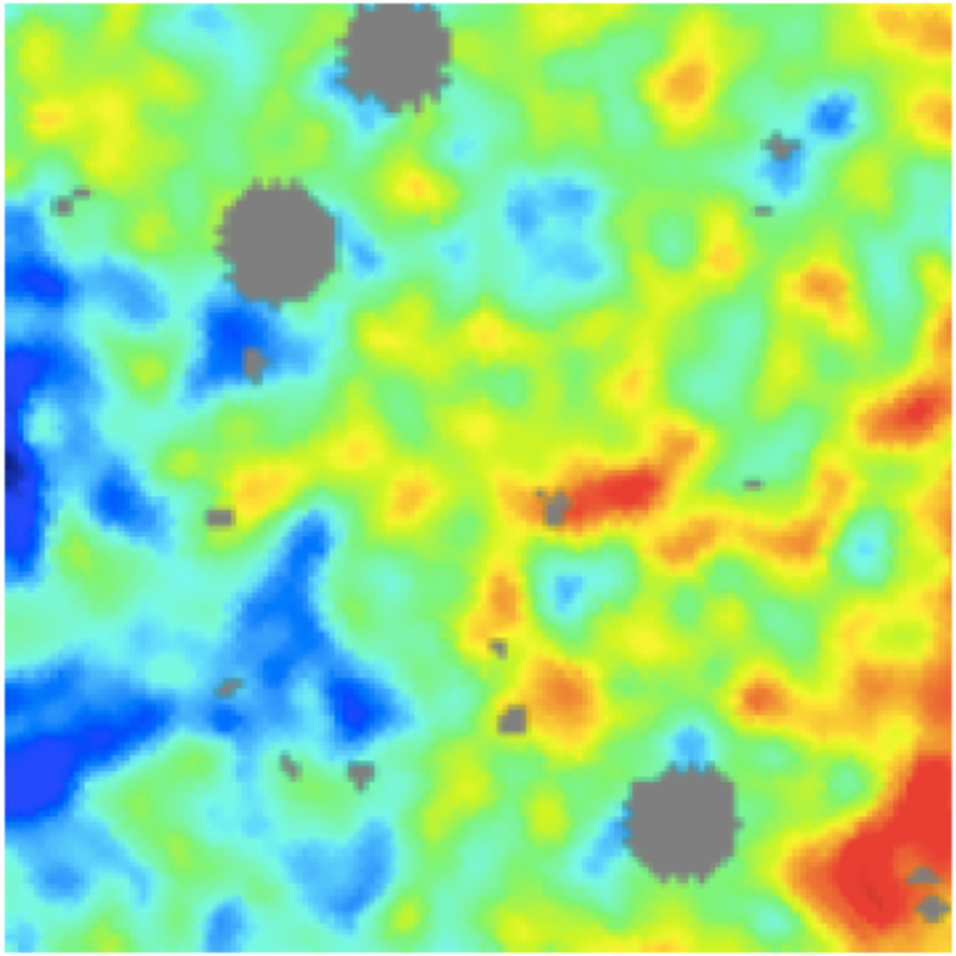
$$[S/N]^T_L(\chi) = \frac{\rho}{\sqrt{(1-\rho^2)}}\,;\ \rho \equiv \frac{C_L^{\zeta T}(\chi)}{\sqrt{C_L^{TT} C_L^{\zeta\zeta}(\chi,\chi)}}$$

# Reconstructing the Early Universe

$\int d$ ***visibility****(distance)* $<\zeta\,|$*Temp, E pol*$>$ *(angles, distance)*

***sb89, bb15*** $\zeta_{NL} = \ln(\rho\, a^{3(1+w)})/3(1+w)$ $<= dE+pdV \sim dEntropy$ ***phonons / strain***

**linear map** $\zeta|T,E$: ***caution: not de-lensed***



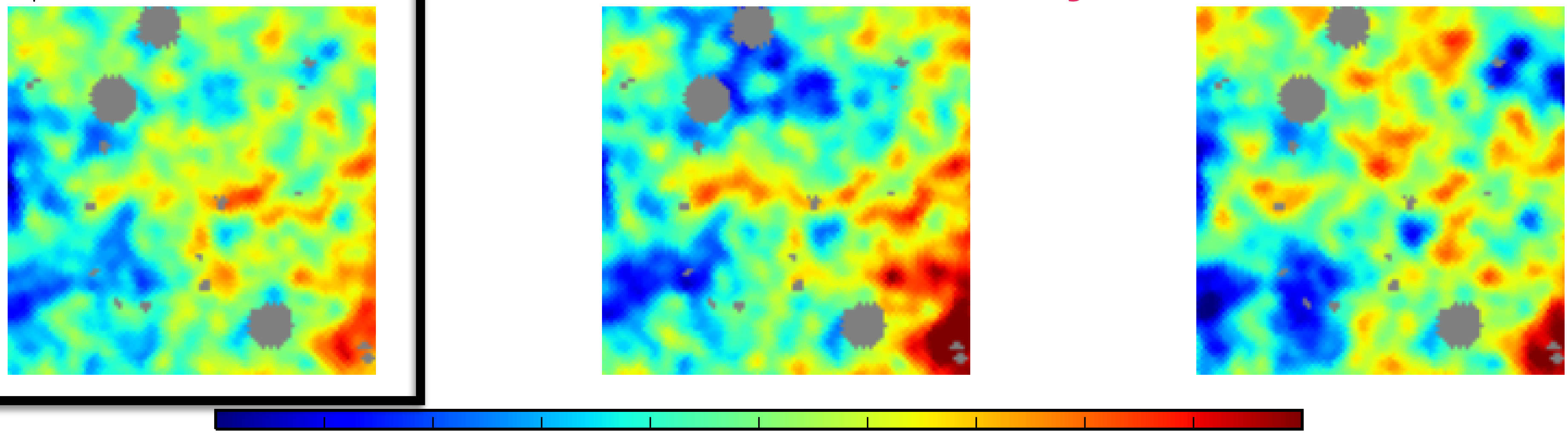
**20x20 sq deg**

**20 arcmin fwhm**

**visibility mask**

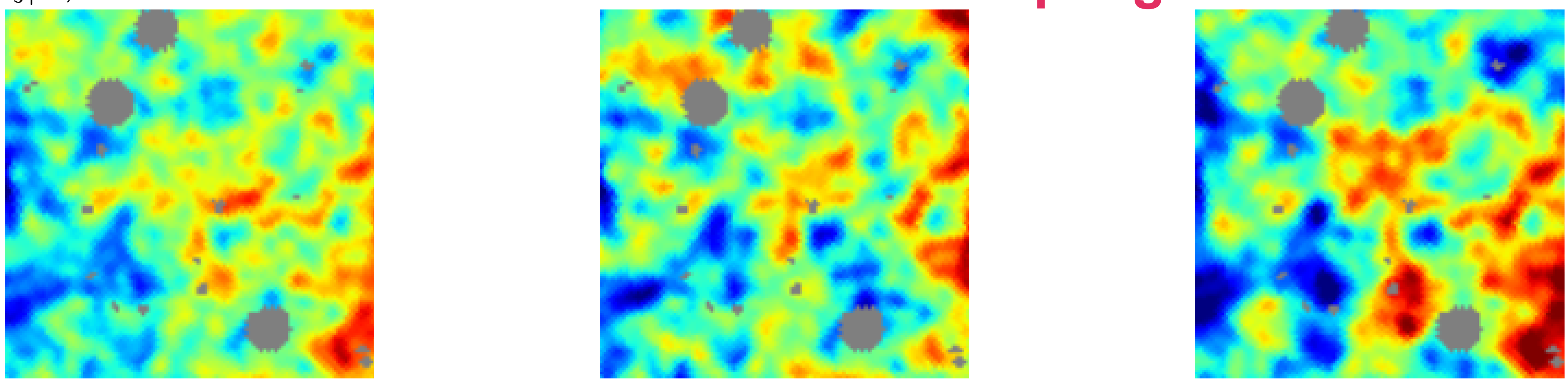
$\zeta|T,E$:

## visibility mask



$\zeta|T,E$:

## decoupling slice



**20 arcmin fwhm**

**20x20 sq deg**

**allowed fluctuations are less noisy with E pol (extra mode/LM)**

***caution: not de-lensed****, but the Wiener filter does partially de-lens*

# SIMPLICITY

at $a \sim e^{-7} \sim 1/1100$ =>

at $a \sim e^{-67-60} \sim 1/10^{30+25}$

stacked linear map aka mean-field map

## Planck2015 early U structure map

*reveals primordial* ***sound waves in matter***

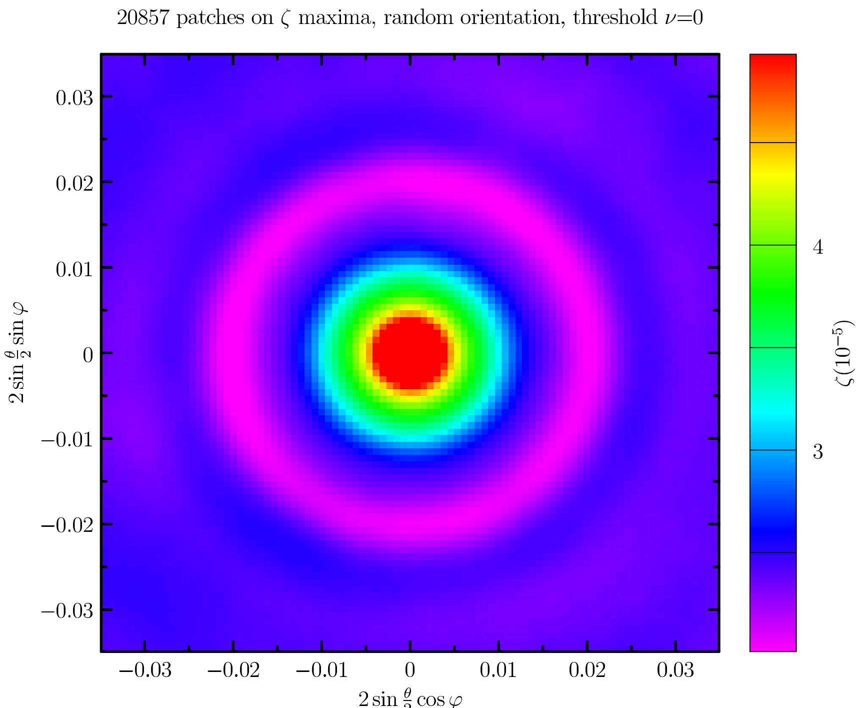
=> *learn* ***contents*** & ***structure*** *at 380000 yr,* $a \sim e^{-7}$

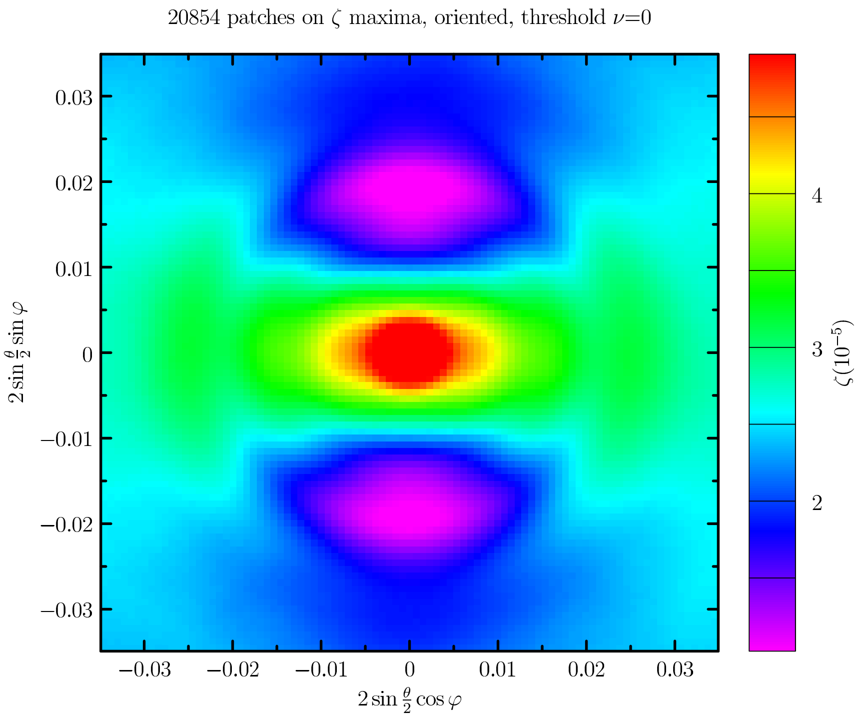
=> *infer the sound structure far far earlier* $a \sim e^{-67-60}$

***2⁺ numbers***

stacked $\langle \zeta_{dv} \mid \zeta_{dv\text{-}pk} \rangle$

stacked $\langle \zeta_{dv} \mid \text{oriented } \zeta_{dv\text{-}pk} \rangle$




*BFH, b+frolov+huang*

***ζ stacks of P13 & WMAP9 look similar***

**simulations look very similar**

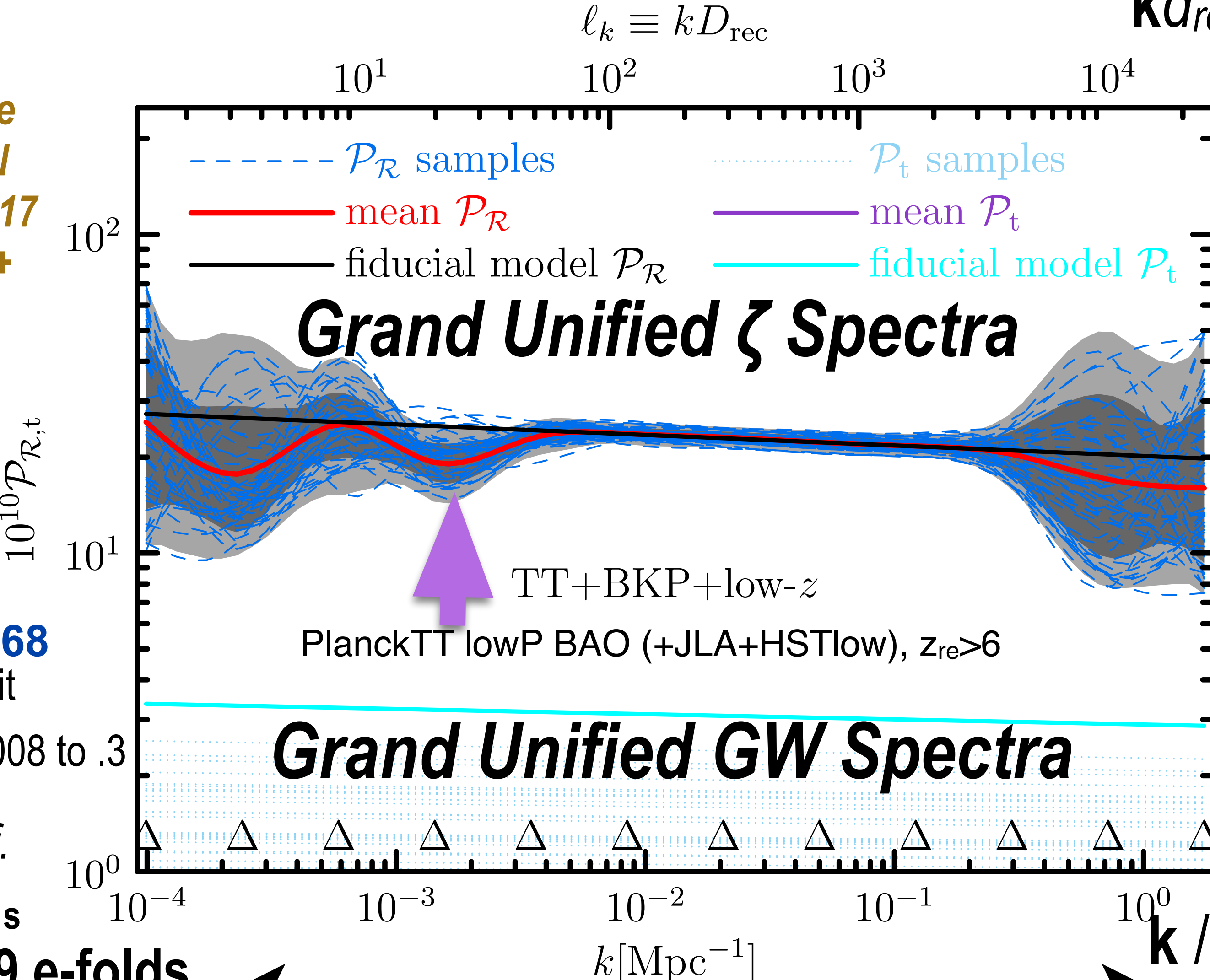
# quadratic map of the ζ-**scape**

*even more (radical)* **compression** ***in quadratic space, using Planck likelihood rather than linear*** (**<ζ**|*Temp, E pol*> +**δζ** ) *maps, e.g., onto 12 bands in k-space (LM projection)*

**=> a quadratic map, fully includes lensing & BB from BKP**

**k***$d_{rec}$* ≳*L*

***the exploration of the L=20-30 anomaly will improve in Planck2017 + BICEP/KECK2017 + Spider 201x***




uniform **$n_s$=0.968**
P15+LSS best fit

superb 12-knot fit k~ .008 to .3

**r<.11 95%CL** *cf.*
**r<0.09 uniform $n_s$**

**9 e-folds**

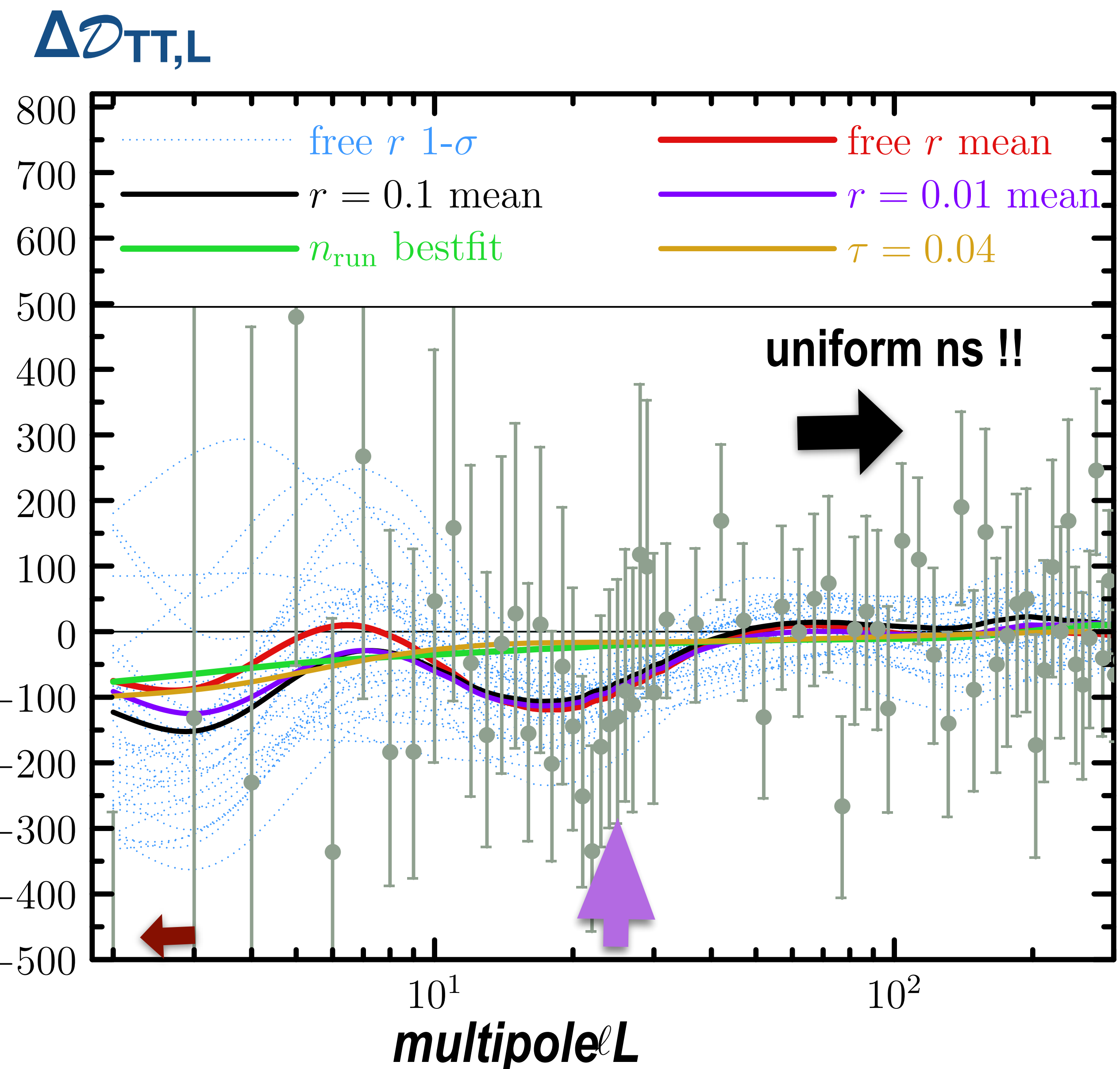
**k** /Mpc

**EE (L>30) looks similar**

**=> V(ϕ)**

## trajectories of $\mathcal{D}_{TT,L}$
## cf. Planck 2014 Commander Low L spectrum with Blackwell-Rao errors

12 knots, cubic spline




**running of $\mathcal{P}_\zeta$**
**≡ 3 Chebyshev modes**
**=> very stiff**
**=> not what the data wants**
**Lower $\tau$ => shape similar to running at low L**

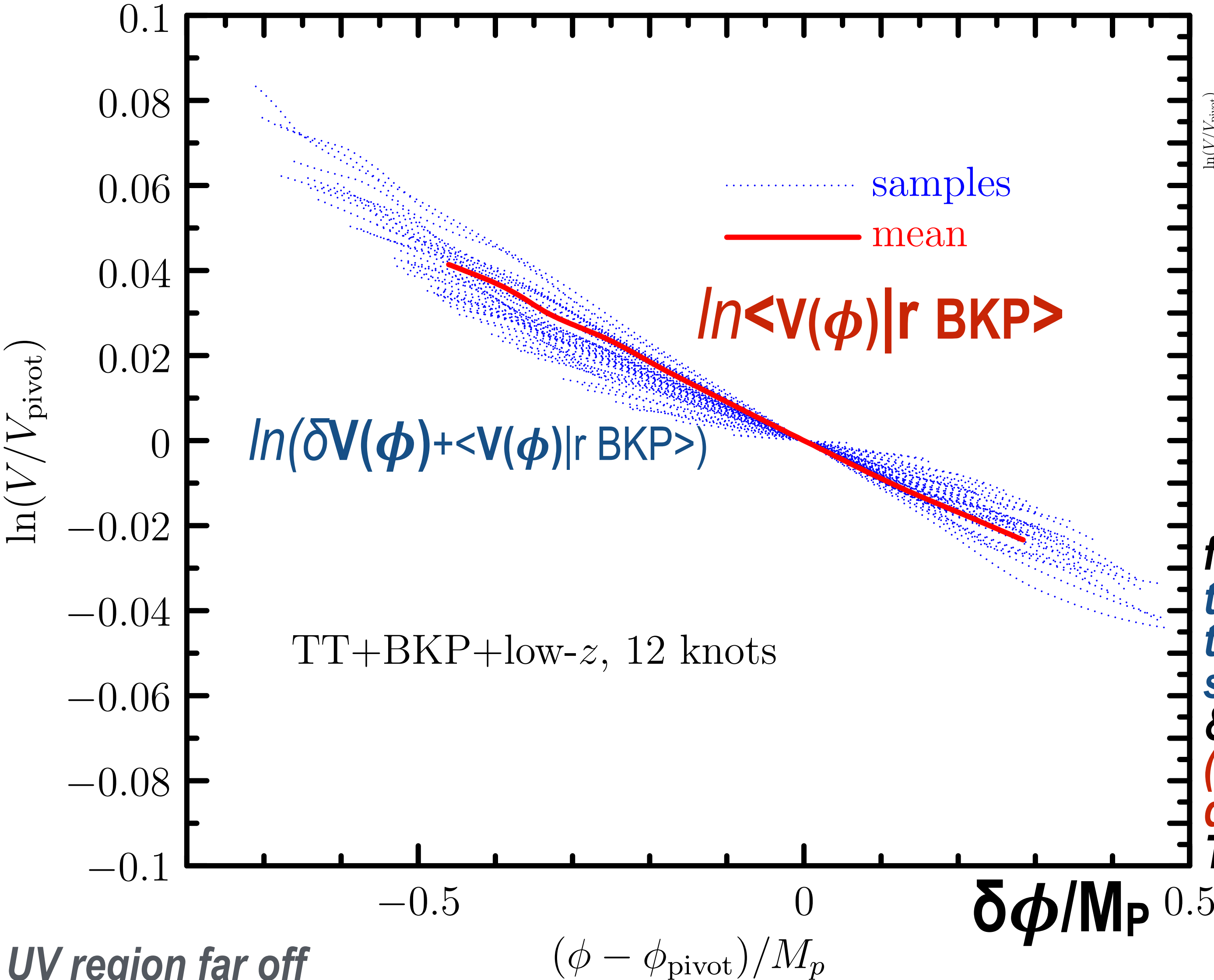
**similar response on $\mathcal{D}_{TT,L}$ for constrained & free r**
**modified by $\tau$ freedom**

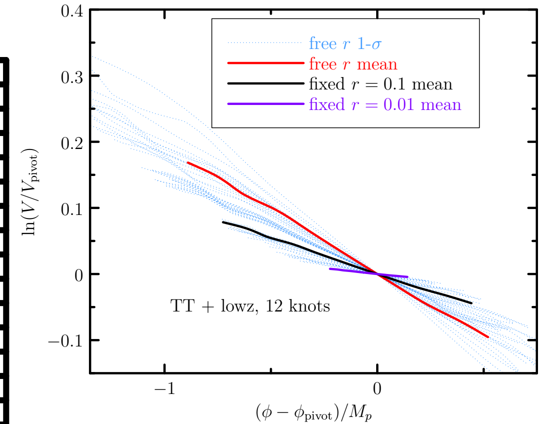
**running of $\mathcal{P}_\zeta$**
**NOT wanted**

***the down-up-down tendency***
***is here to stay,***
***2014-2022-…***

# inflaton $V(\phi)$-maps $=3M_P^2 H^2 (1-\varepsilon/3)$ *HJ eqn*, $d\phi/M_P / d\ln a = \pm\mathrm{sqrt}(2\varepsilon)$

***along the gradient / Morse flow***




***IR heating region is far off => many ways to extrapolate***

***fit into a UV-complete theory (ultra-high energy to the Planck scale) strings, landscape, .. & IR-complete theory (post-inflation heating -> quark/gluon plasma)??? TBD***

***UV region far off => many ways to extrapolate***

r to **+-0.02 Spider** forecast

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

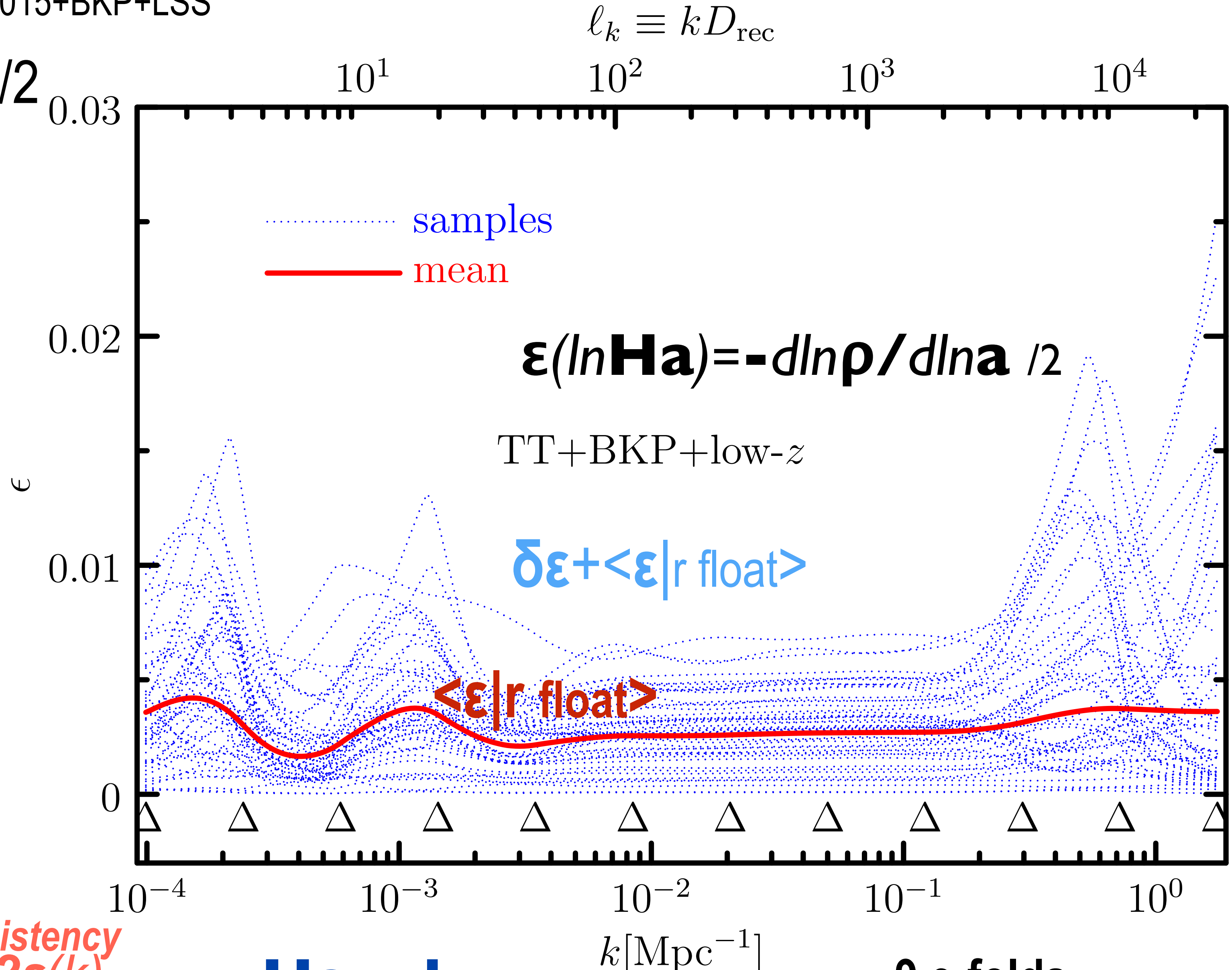
# *early universe* acceleration histories = EOS histories *3(1+w)/2*

Planck 2015+BKP+LSS

$\epsilon = 3(1+w)/2$

$\approx r(k)/16$

$\sim \mathcal{P}_{GW}/\mathcal{P}_{\zeta}$




*inflation consistency*

$-n_t \approx r/8 \approx 2\epsilon(k)$

$1-n_s \approx 2\epsilon + d\ln\epsilon/d\ln Ha$

**Ha ~ k**

**9 e-folds**

*Will any*

# Anomalies in the CMB

# or Tensions with the CMB

*turn into*

# BSMc Subdominant Physics?

*Planck2015+LSS some tension released. still Ho tension but not bad agreement+a bright future*

*Galaxy Lensing tension persists, systematics? CMB lensing $A_L$*

*Cluster $\sigma_{8SZ}$ cf $\sigma_{8primary}$ tension relaxing, with large $KE_{bulk}/KE_{thermal}$ corrections, hydro expected tho*

*Beyond the Standard Model of cosmology?* SMc = *tilted*ΛCDM+r *(ζ,h₊ₓ)*

**BSMc = SMc + primordial anomalies**

*~10,000,000 T/E modes* = *t*ΛCDM, ≲500 modes of anomaly
vast unexplored parts of the *ζ-scape* CMB is 2D
hope to use 3D **LSS tomography** $\mathbf{f_{sky}}$ $\mathbf{L_{max}^2}$ $\mathbf{k_{max}}$ $\mathbf{d_{max}}$

**CMB TT power L~ 20-30 dip =>**
**Grand Unified ζ-Spectrum k-dip**

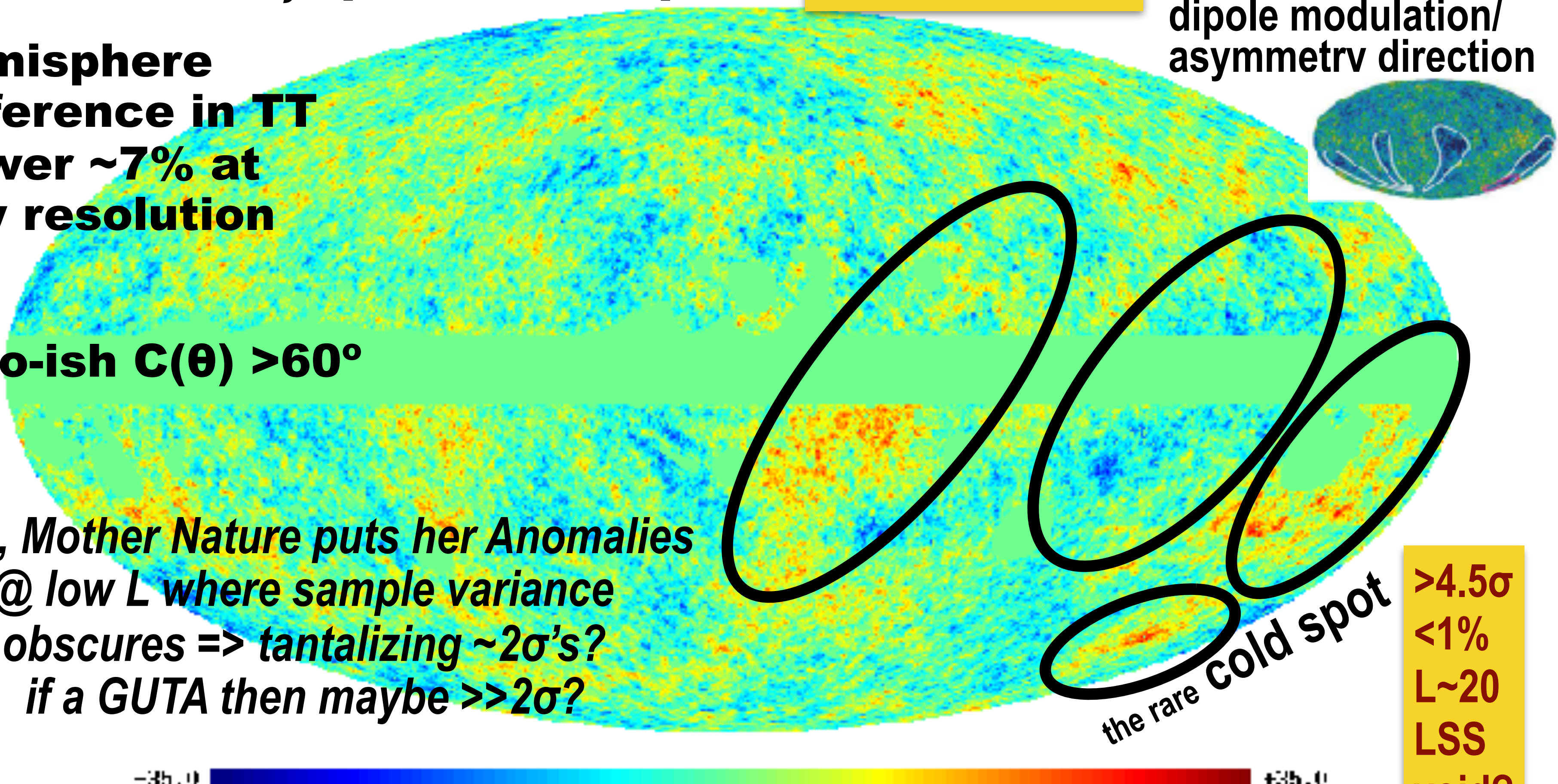
*<ζ |T,E-pol>*

octupole/quadrupole alignment

dipole modulation/ asymmetrv direction

**hemisphere difference in TT power ~7% at low resolution**

**zero-ish C(θ) >60º**




*sigh, Mother Nature puts her Anomalies*
*@ low L where sample variance*
*obscures => tantalizing ~2σ's?*
*if a GUTA then maybe >>2σ?*

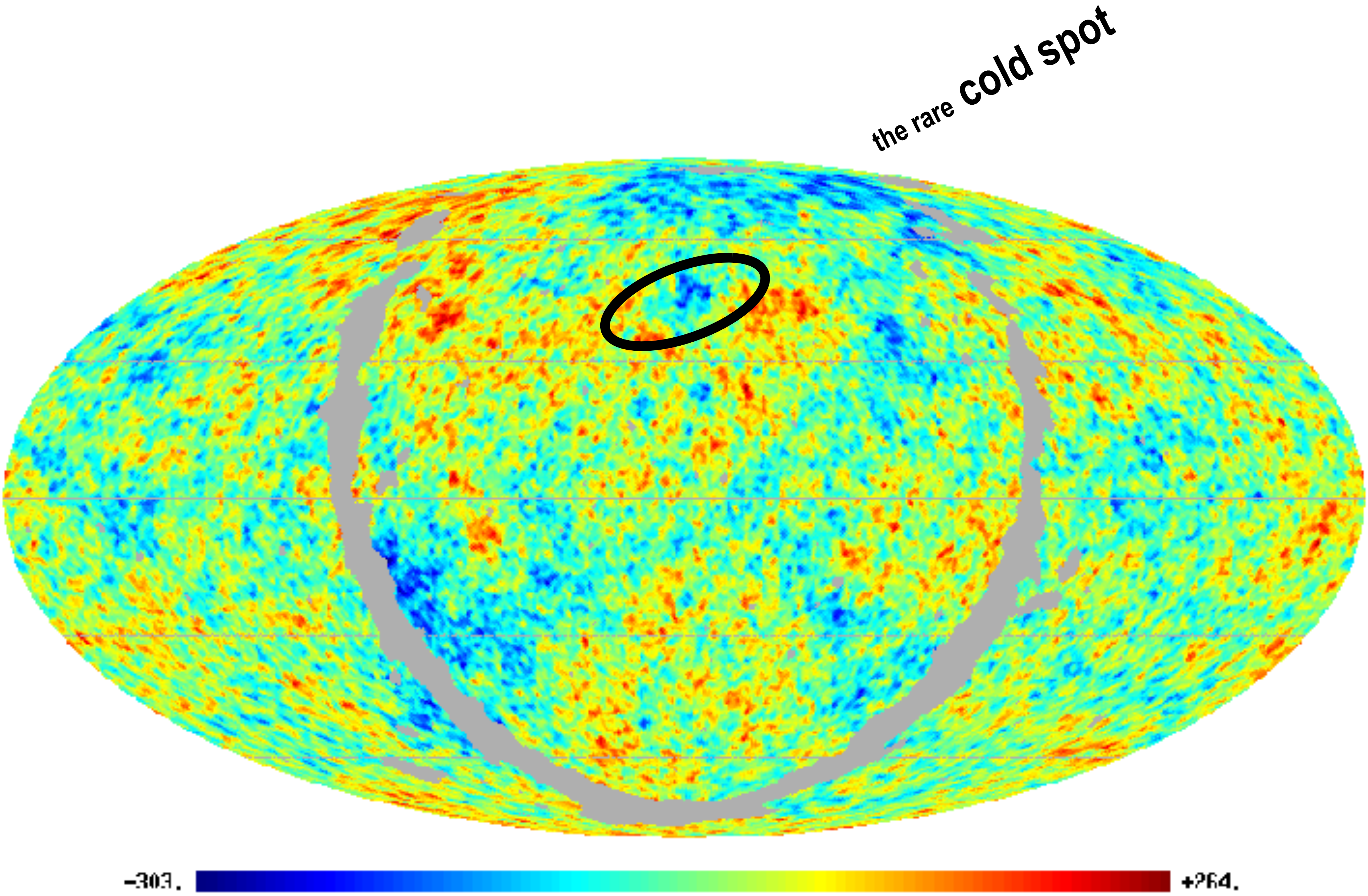
>4.5σ
<1%
L~20
LSS
void?

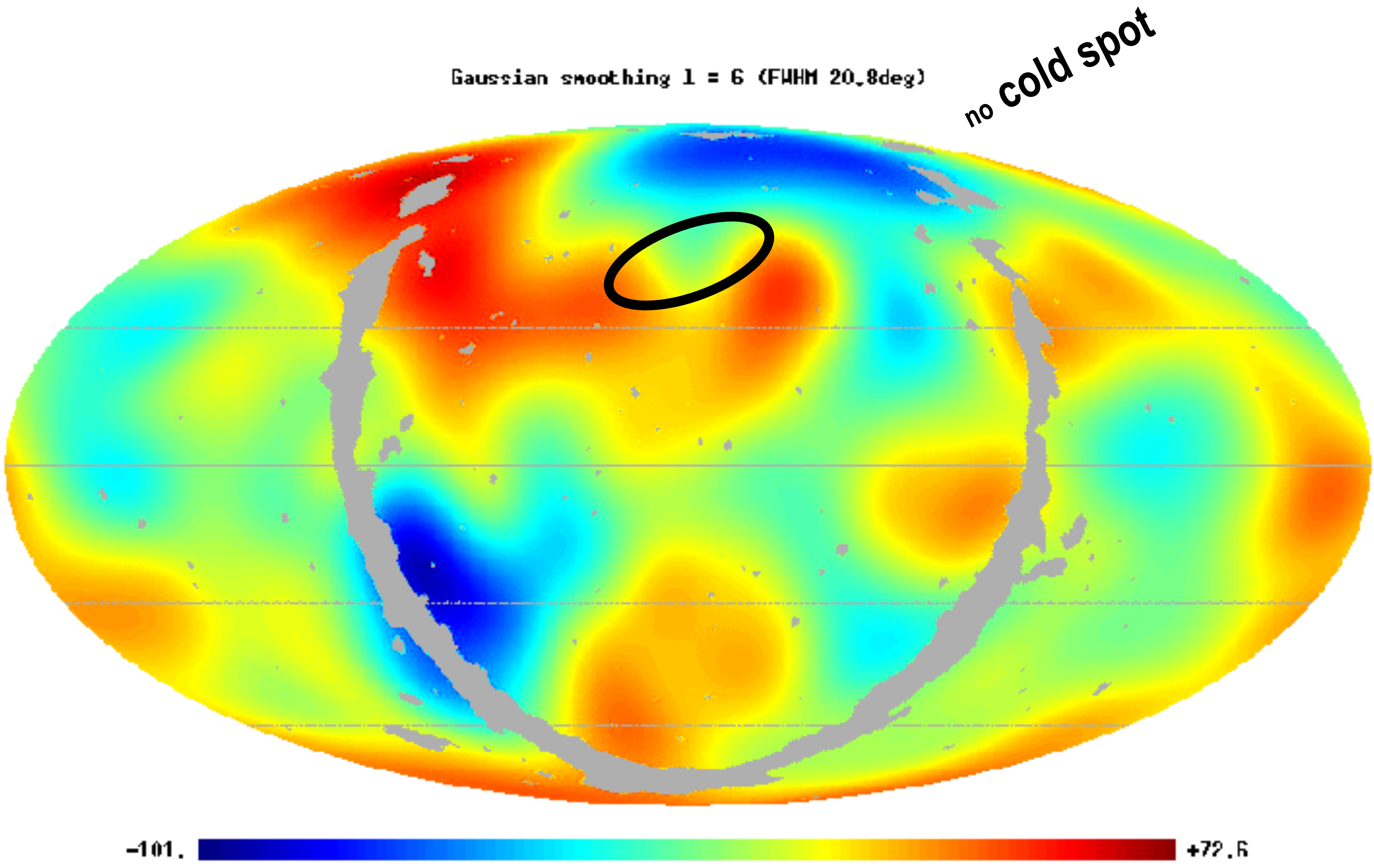
GUTA = Grand Unified Theory of Anomalies? TBD **intermittent**?

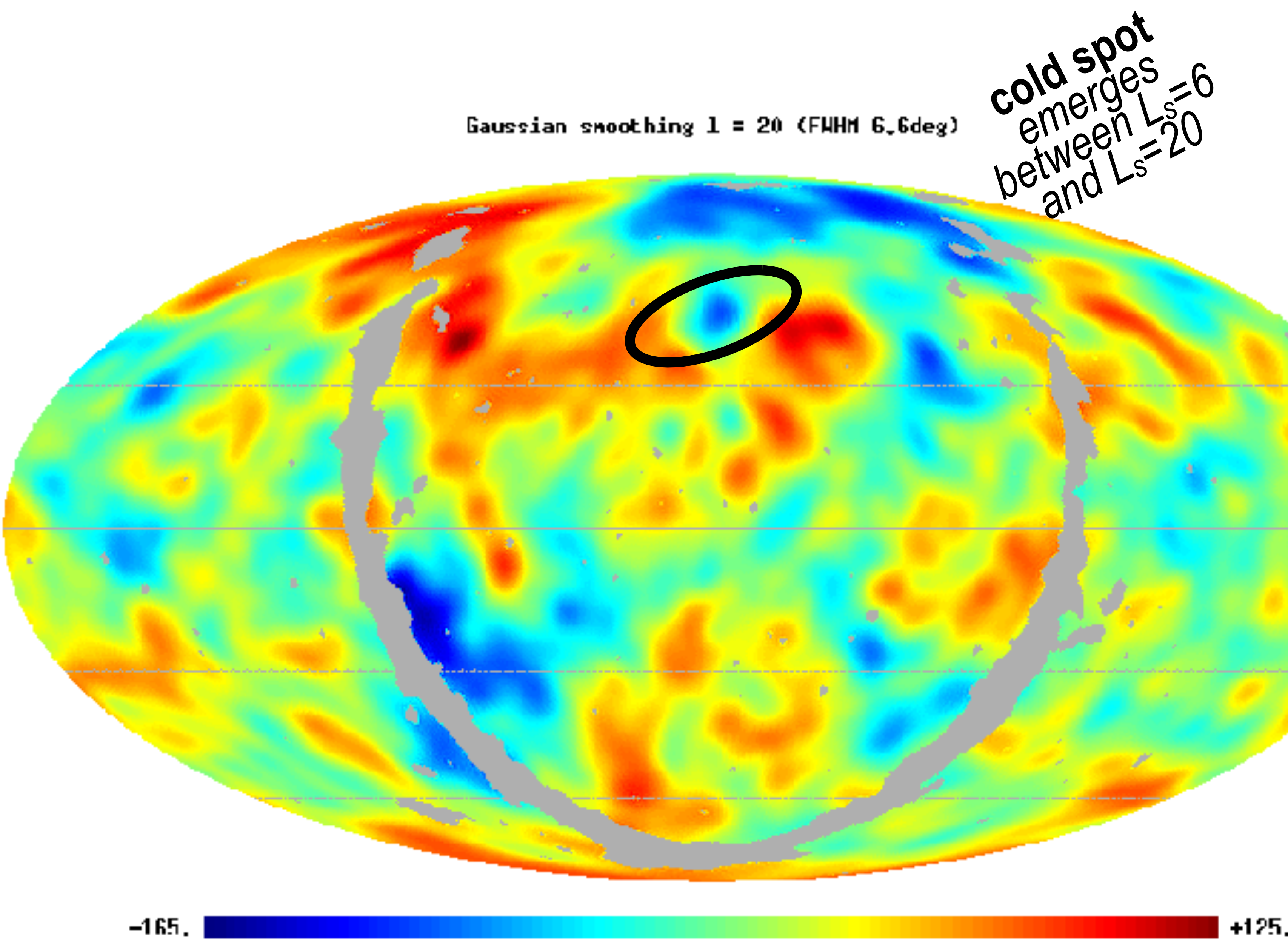
# **looking at the CMB cold spot again** as an anomaly example

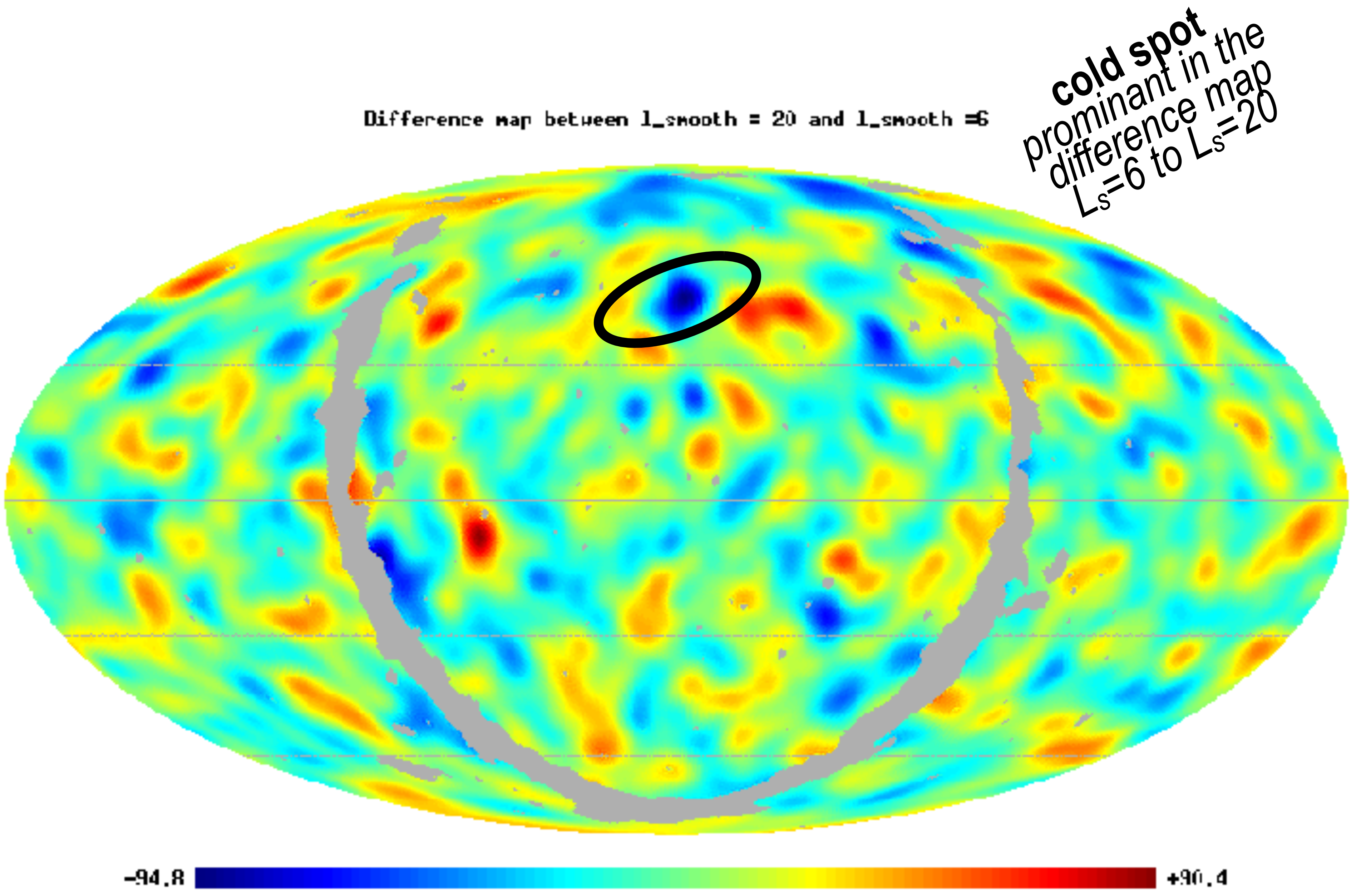
**$>4.5\sigma$ $<1\%$ $L\sim20$ ….. LSS void?**

***B+Huang tried hard to make a GUTA = Grand Unified Theory of Anomalies? new ways of looking at the anomalies (comparing harmonic and real space in various ways) but no GUTA … TBD***


the rare cold spot
-303.
+264.


Gaussian smoothing l = 6 (FWHM 20.8deg)
no cold spot
-101.
+72.6


Gaussian smoothing l = 20 (FWHM 6.6deg)
**cold spot**
emerges
between $L_s$=6
and $L_s$=20
-165.
+125.


Difference map between l_smooth = 20 and l_smooth =6
cold spot
prominant in the
difference map
$L_s$=6 to $L_s$=20
-94.8
+90.4

$$W(\ell) = e^{-\frac{\ell(\ell+1)}{2(l_2+1/2)^2}} - e^{-\frac{\ell(\ell+1)}{2(l_1+1/2)^2}} \; (l_2 > l_1)$$

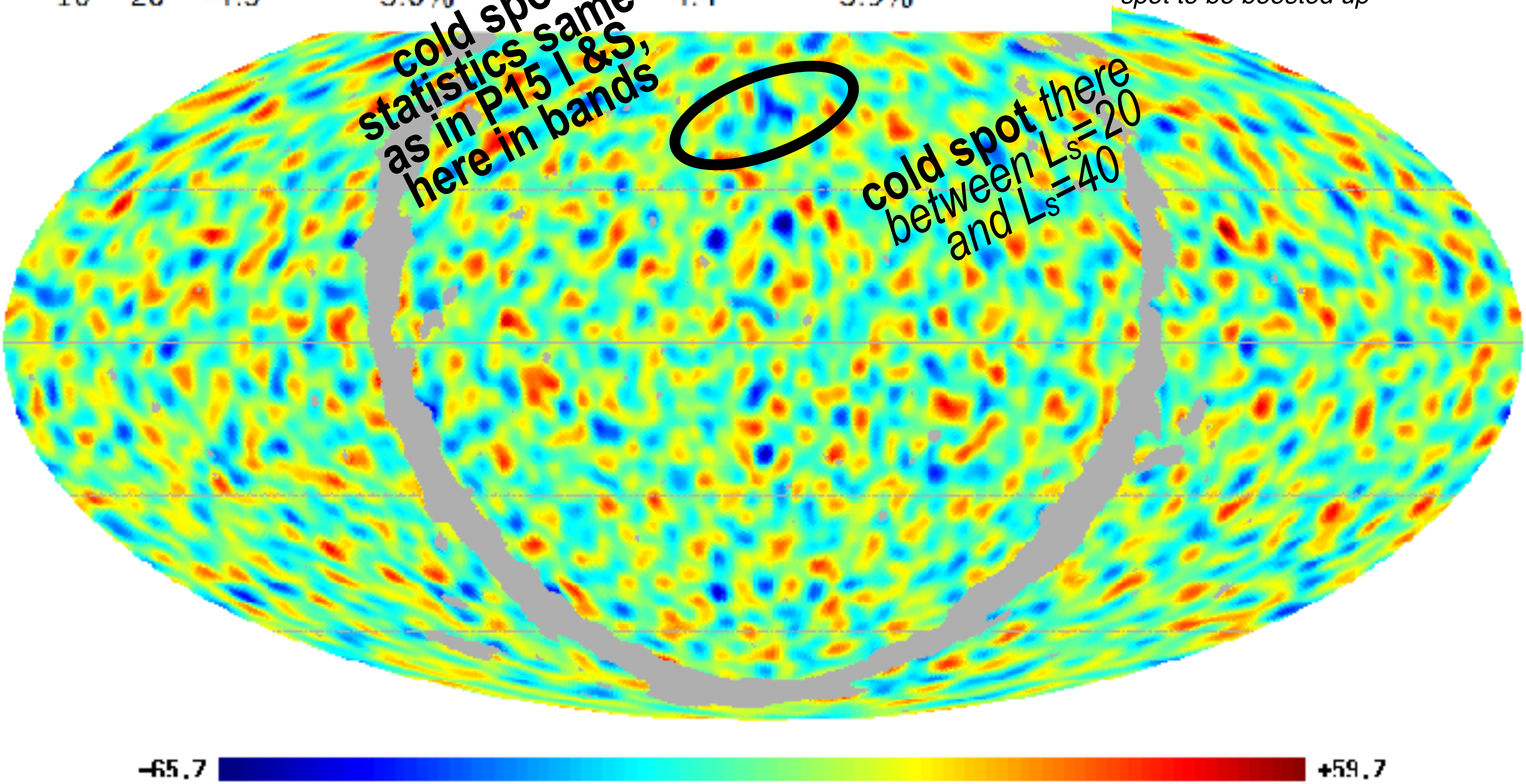
| $l_1$ | $l_2$ | $T_{\rm cold}/\sigma_T$ | cold-spot p value | $T_{\rm hot}/\sigma_T$ | hot-spot p value |
|---|---|---|---|---|---|
| 2 | 20 | -3.5 | 29.9% | 3.2 | 60.2% |
| 4 | 20 | -4.0 | 10.1% | 3.9 | 13.9% |
| 6 | 20 | -4.5 | 2.0% | 4.2 | 4.7% |
| 8 | 20 | -4.5 | 2.1% | 4.3 | 4.5% |
| 10 | 20 | -4.5 | 3.0% | 4.4 | 3.9% |

*tantalizing that the cold spot is the same L-band range as the L pspec dip, but all of our tools have not teased out a relation*

*B+Huang 2015*

0

*e.g. low L constrained fields do not make a nice low-L cavity for the cold spot to be boosted up*

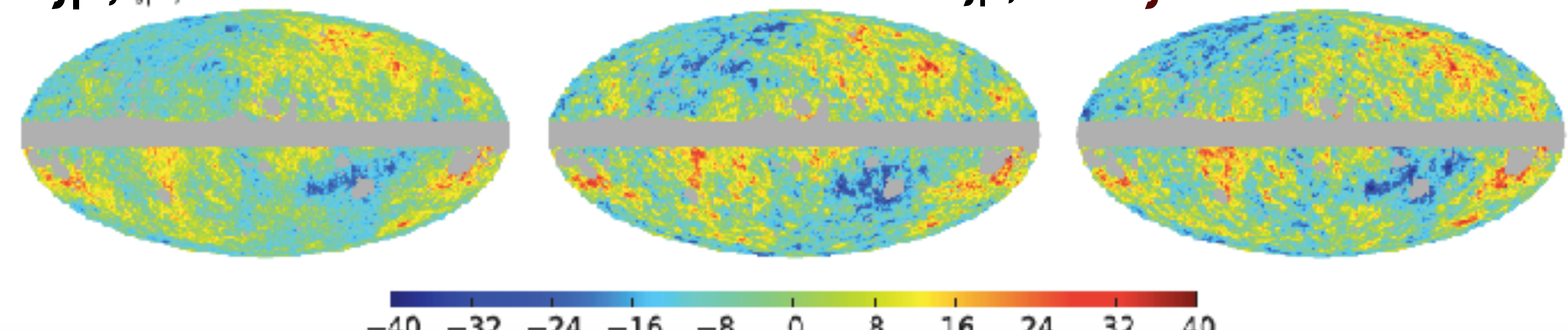


# how intermittency could amplify the cold spot to statistical correctness

from >4.5σ Gaussian random field anomaly

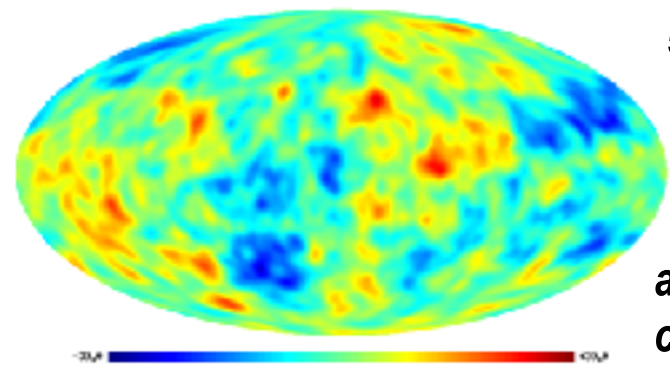
# Planck 2015 XVII nonG

$\langle\zeta|T,E\rangle$ $\langle\zeta|T,E\rangle+\delta\zeta$

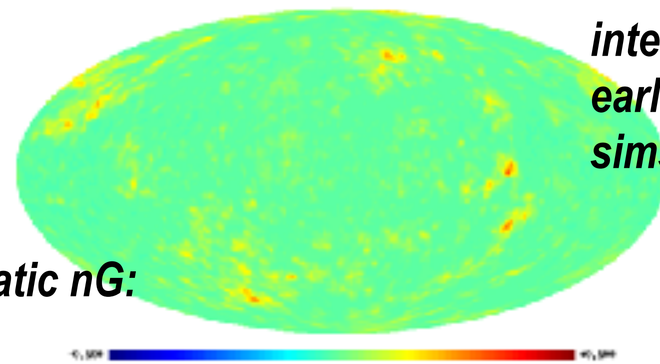



*caution: not de-lensed*

**visibility mask**

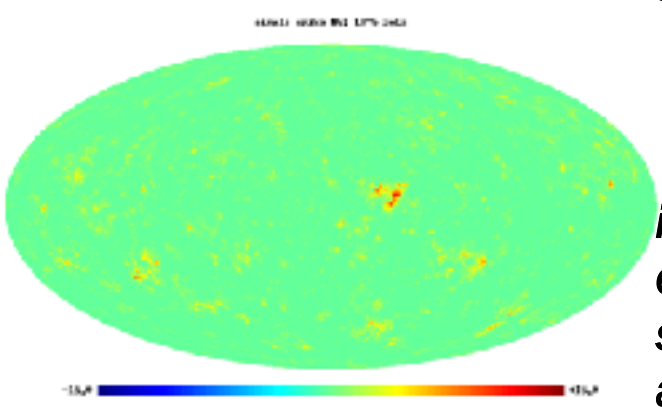


**5deg fwhm**



*intermittent nG from early U preheating sims - too small*

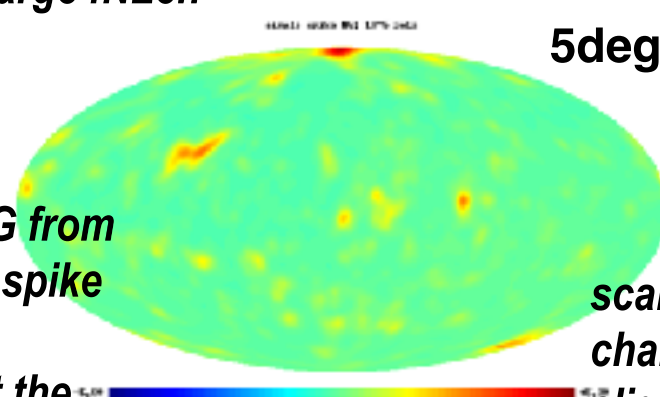
*also cf. quadratic nG: correlated fNL uncorrelated large fNLeff*



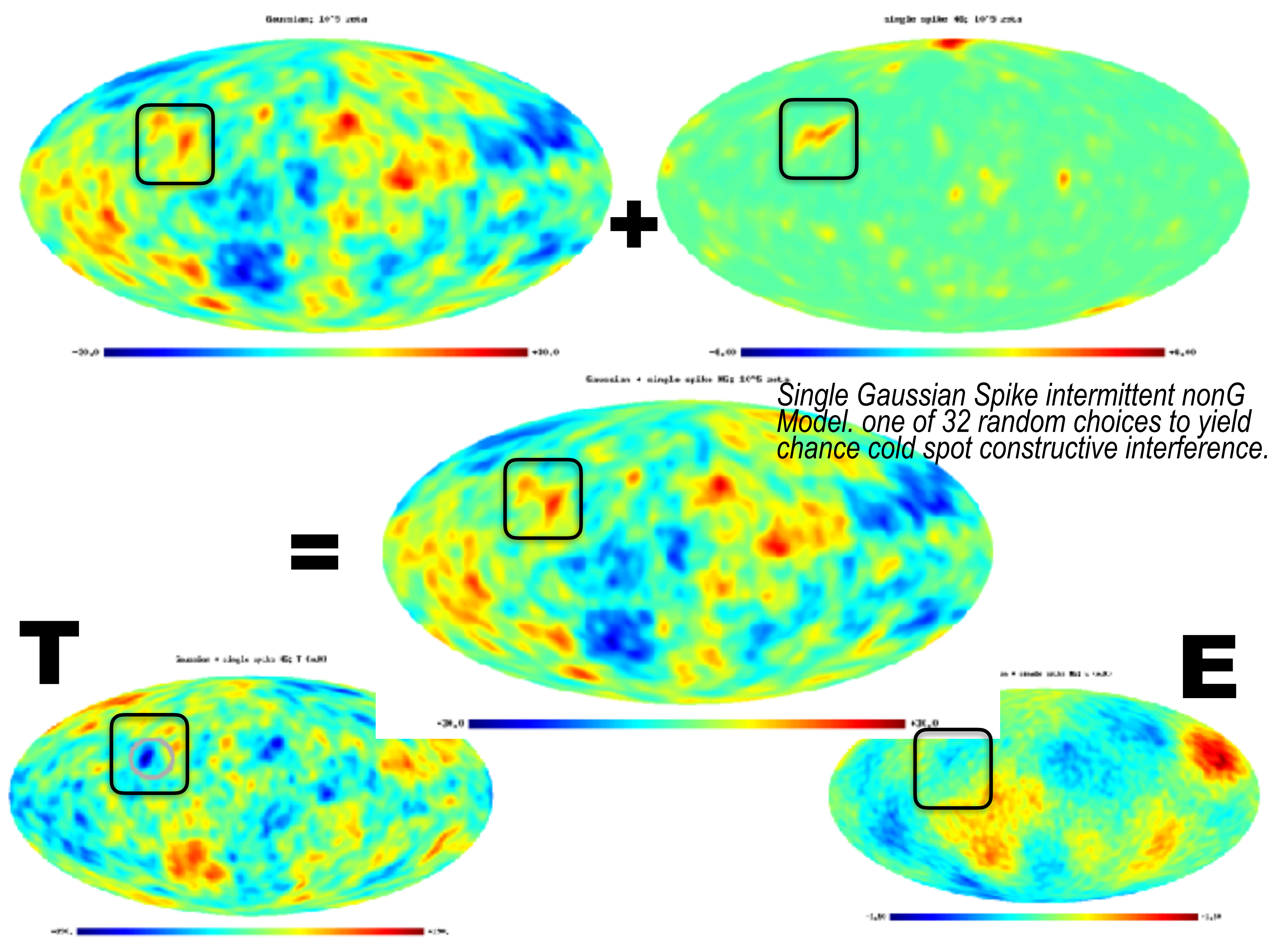
**40 arcmin fwhm**

*intermittent nG from early U single spike sims - tunable amplitude, get the "cold spot" etal*

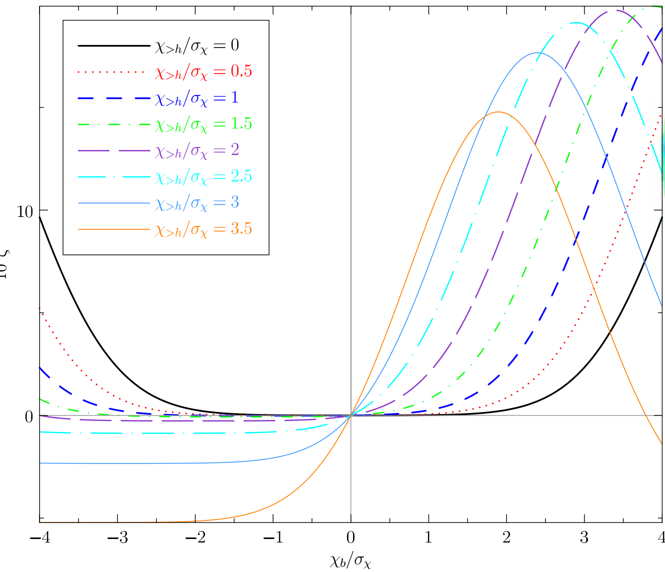
**5deg fwhm**

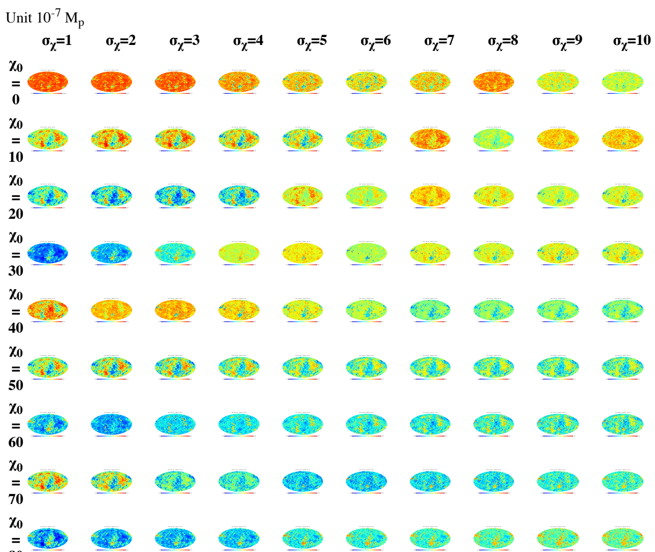


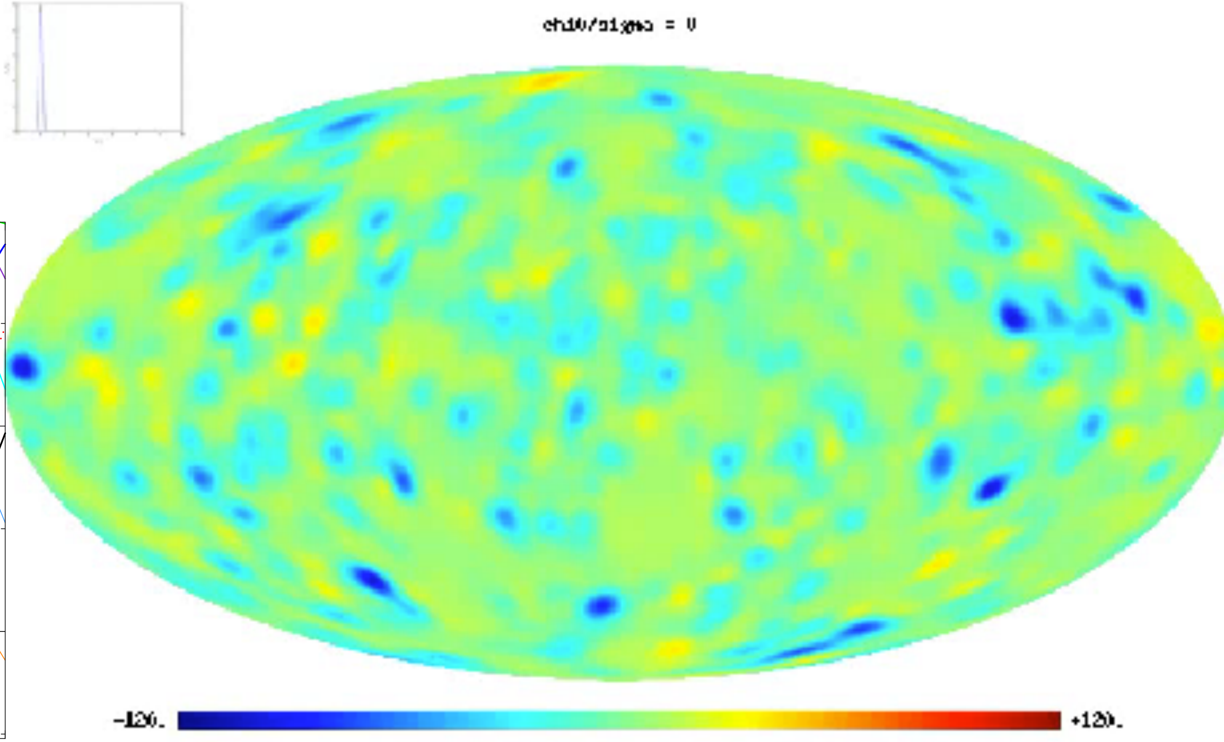
*scan sims to get chance intermittent alignment to get a "cold spot"*

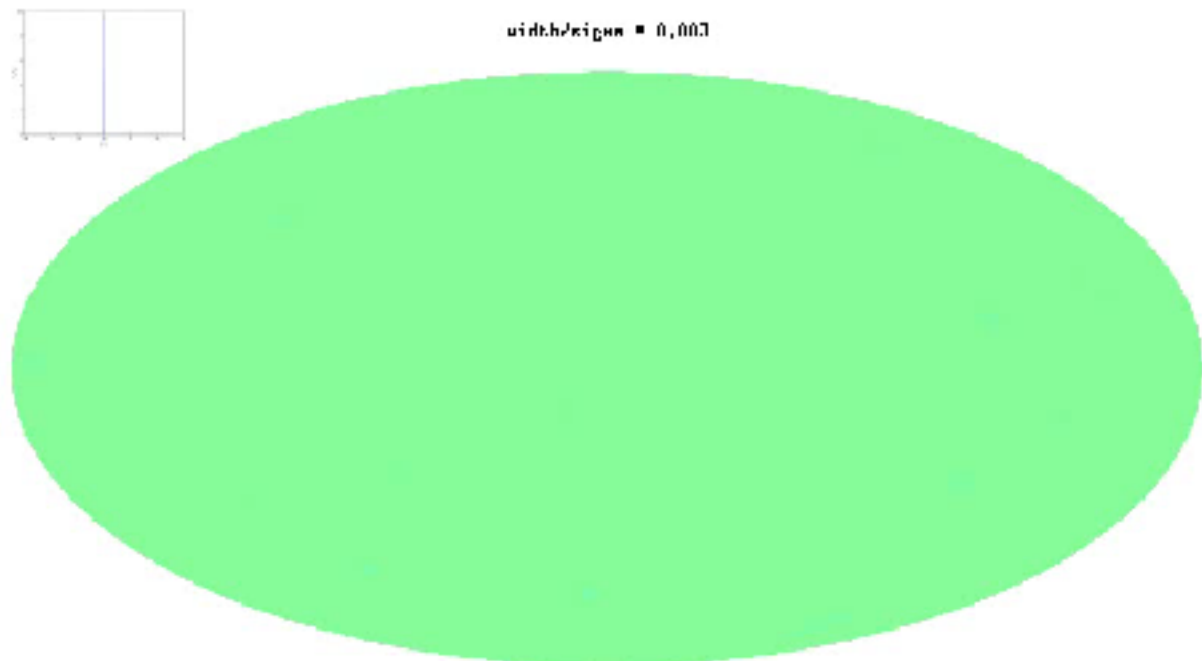

Single Gaussian Spike intermittent nonG
Model. one of 32 random choices to yield
chance cold spot constructive interference.
T
E

# *Single Gaussian Spike intermittent nonG Model: 3 parameters*



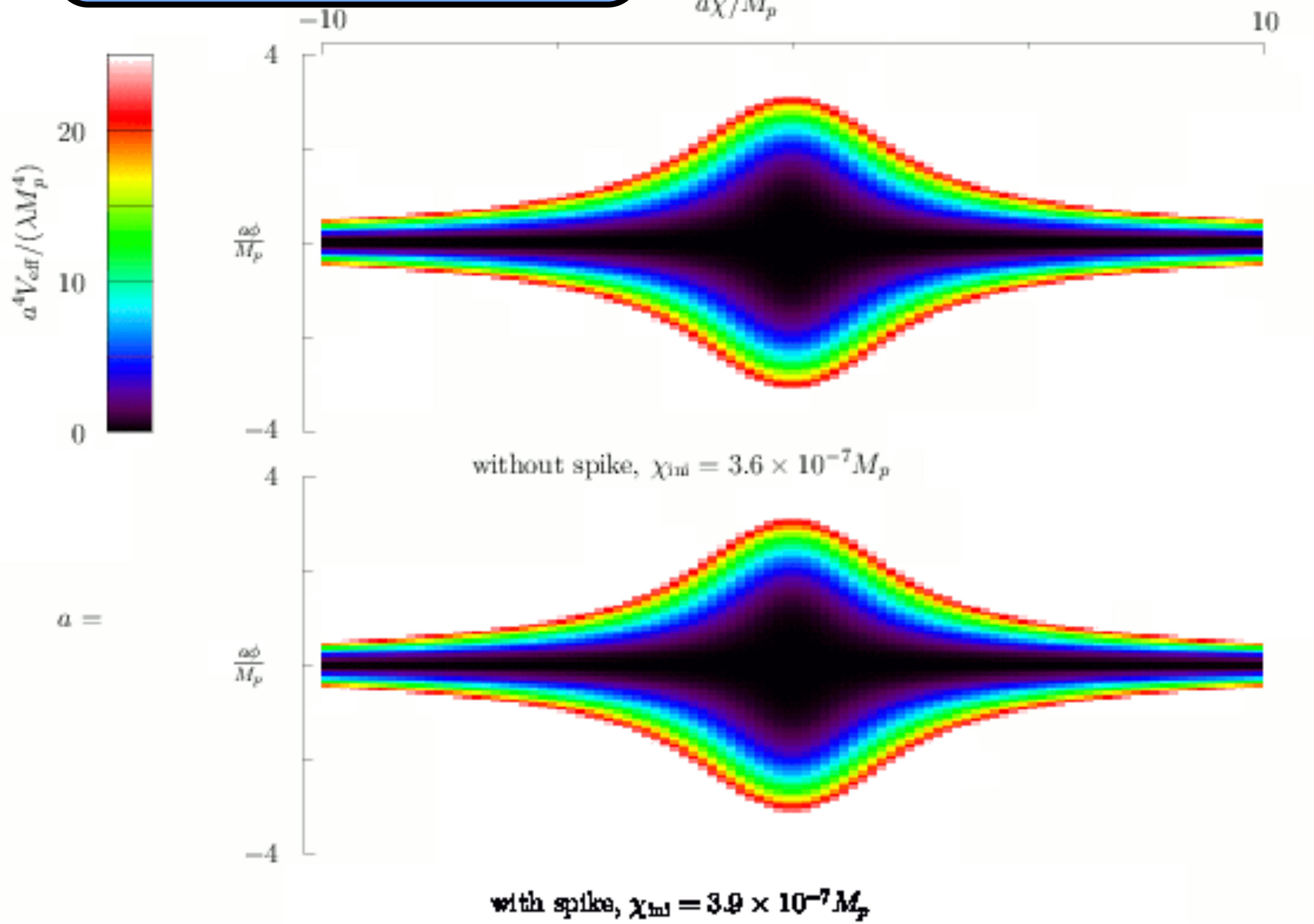



# caustics in ballistic orbits

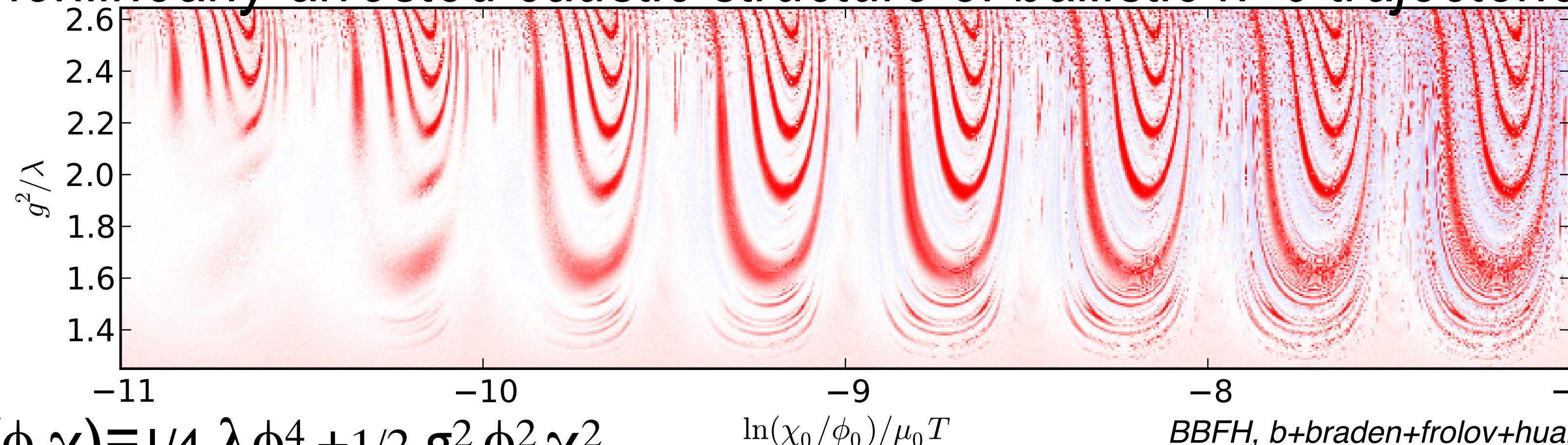
caustics are ubiquitous: **LSS/cosmic web & preheating**

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



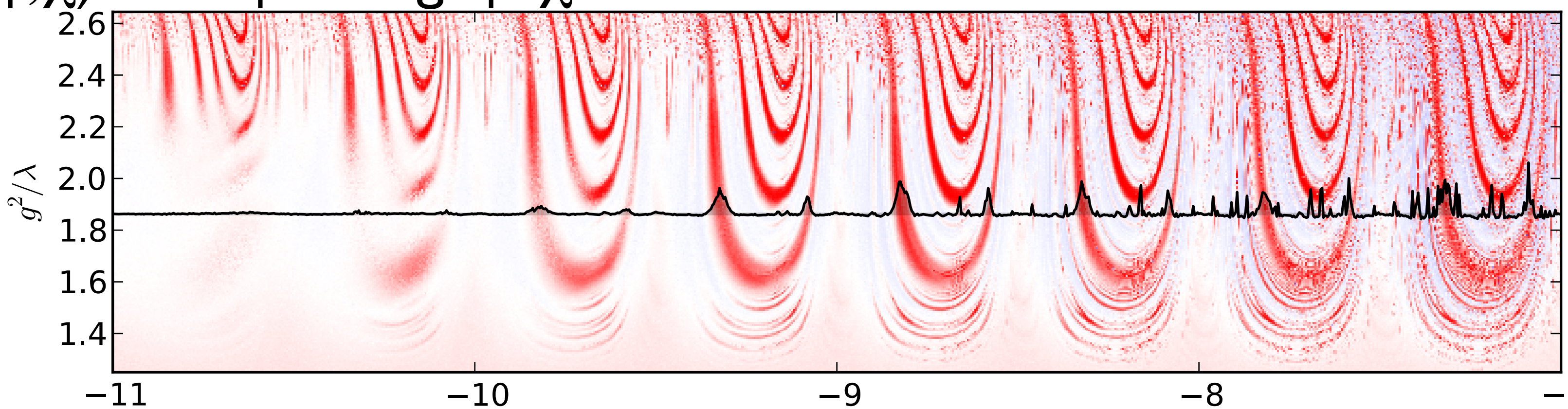

**$V_{eff}$ is trajectory dependent**

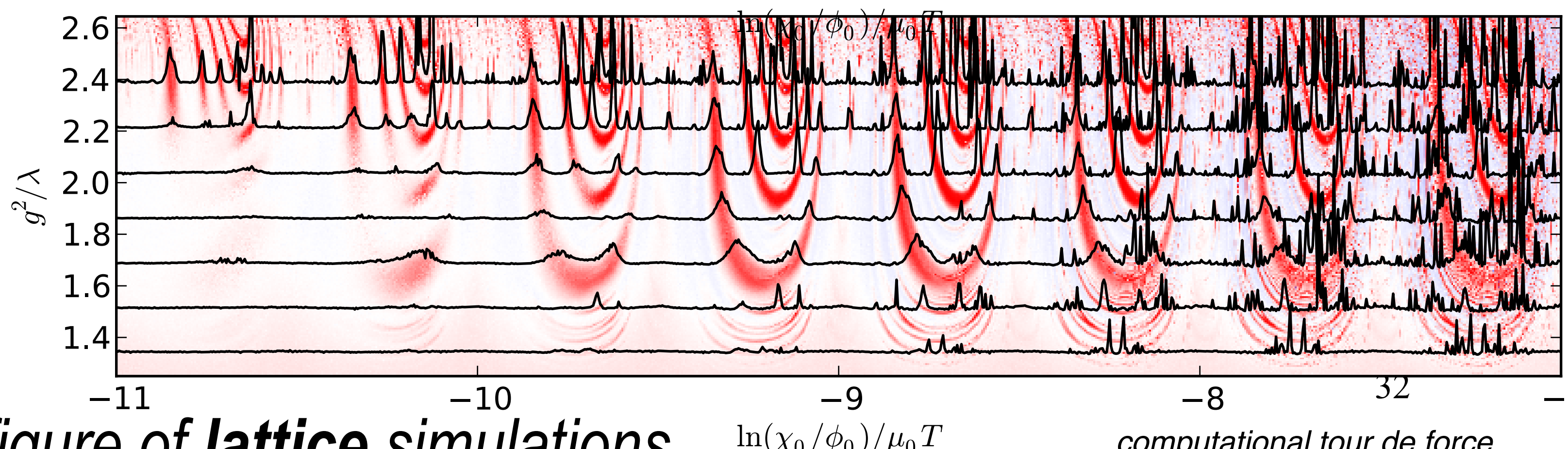
# *nonlinearly-arrested caustic structure of ballistic k=0 trajectories*




*BBFH, b+braden+frolov+huang*

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





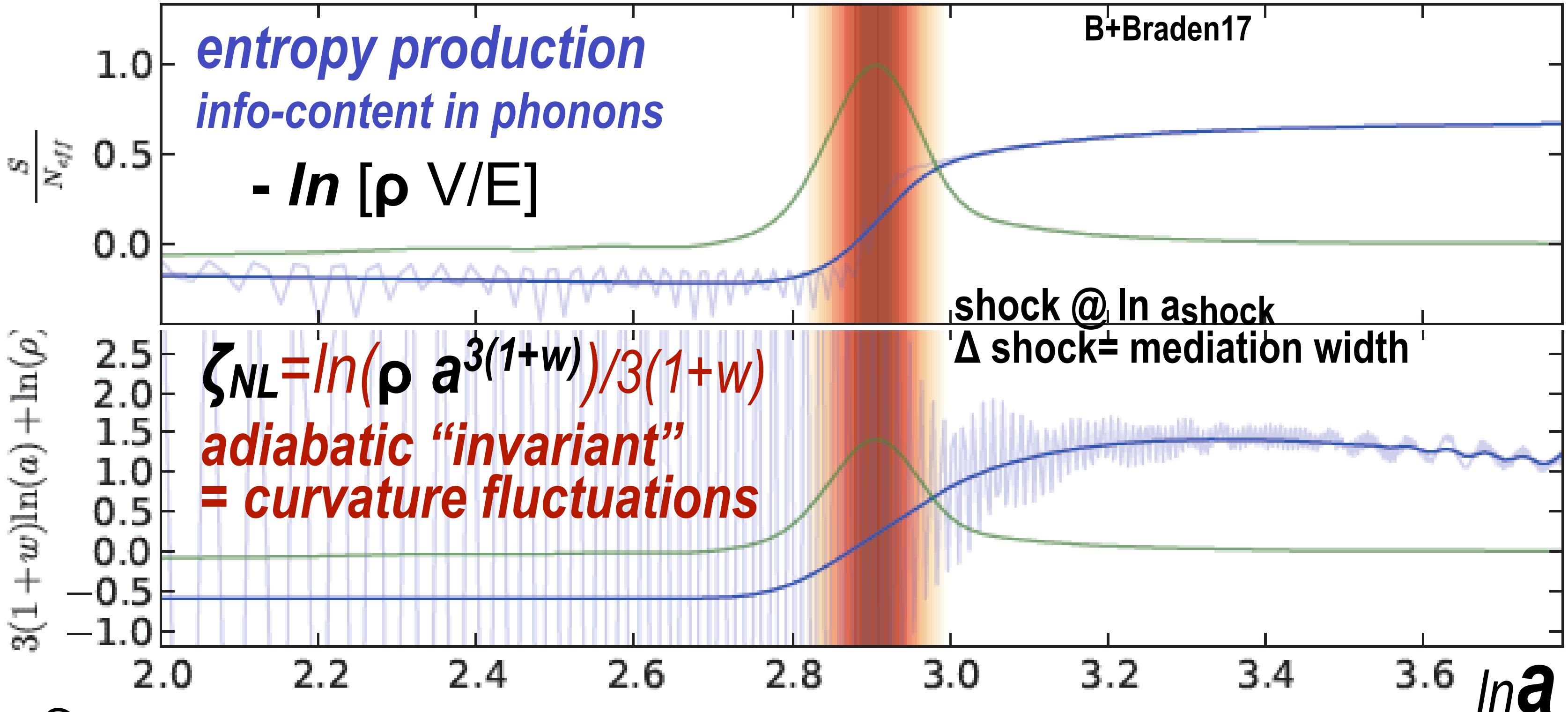

*gigafigure of **lattice** simulations*

*computational tour de force*

**arresting the caustic orbits via a shock in time, incoherent cf. coherent trajectory bundles**

*understanding the $\zeta$ -spike structure, qualitatively YES and quantitatively MAYBE*

# nonG from large-scale modulations of the shock-in-times of preheating




true thermal equilibrium far off ➤ & on to coupling to standard model degrees of freedom

$\delta\zeta_{NL shock}$ (**g**(σ(**x**)) => modulated non-G

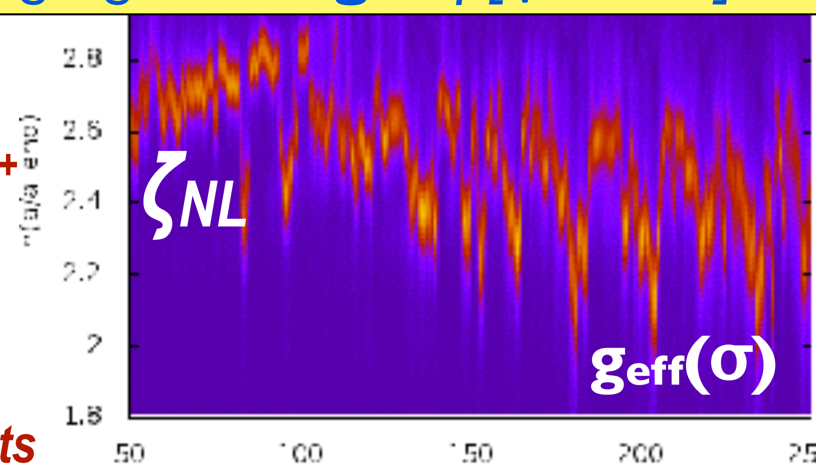
$g_0+g_1\ \sigma/M_P$ , $g_0 \exp[\gamma_1\ \sigma/M_P]$, ..

$V(\phi,\chi)=1/2\ m^2\phi^2 + 1/2\ g_{eff}(\sigma)^2\phi^2\chi^2$

$\delta\zeta_{NL shock}(\chi_i(\mathbf{x})\ |g^2/\lambda))$ => *NonG cold spots ++*

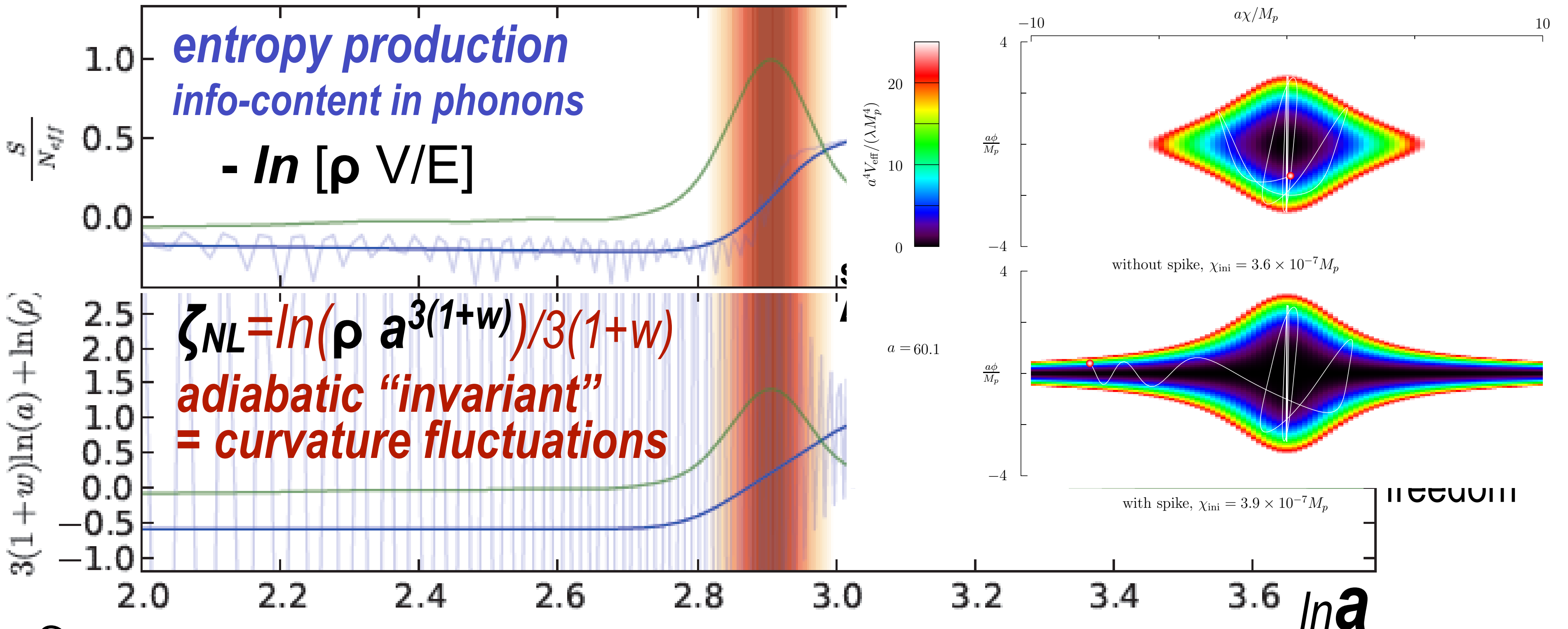
$V(\phi,\chi)=1/4\ \lambda\phi^4 + 1/2\ g^2\phi^2\chi^2$

**$V_{eff}$ is dynamical** *Bond,Braden,Frolov,Huang17*




*unconventional local non-G: no scale built into V;*
*perturbative isocon-based $f_{NL}$; rare event cold spots*

# nonG from large-scale modulations of the shock-in-times of preheating




$\delta\zeta_{NL\,\mathbf{shock}}\ (\mathbf{g}(\sigma(\mathbf{x}))$ => modulated non-G

$g_0 + g_1\, \boldsymbol{\sigma}/M_P,\ \mathbf{g_0} \exp[\gamma_1\, \boldsymbol{\sigma}/M_P]$, ..

$V(\phi,\chi) = 1/2\, m^2\phi^2 + 1/2\, g_{\rm eff}(\sigma)^2\phi^2\chi^2$

$\delta\zeta_{NL\,\mathbf{shock}}(\chi_i(\mathbf{x})\ |g^2/\lambda))$ => *NonG cold spots ++*

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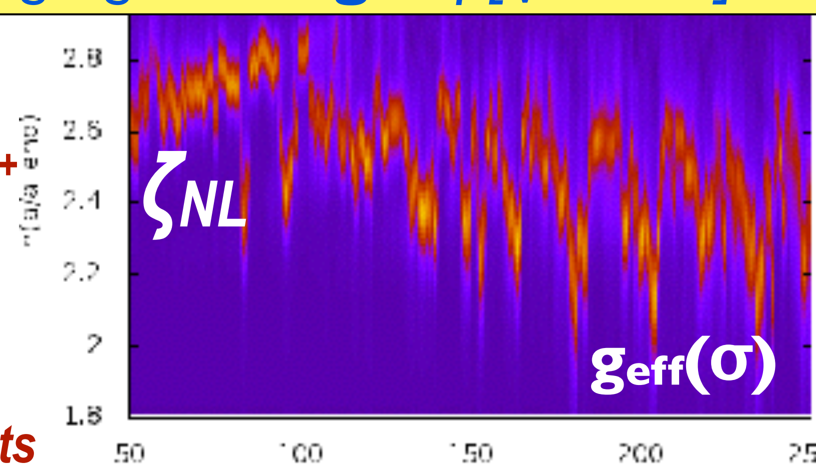
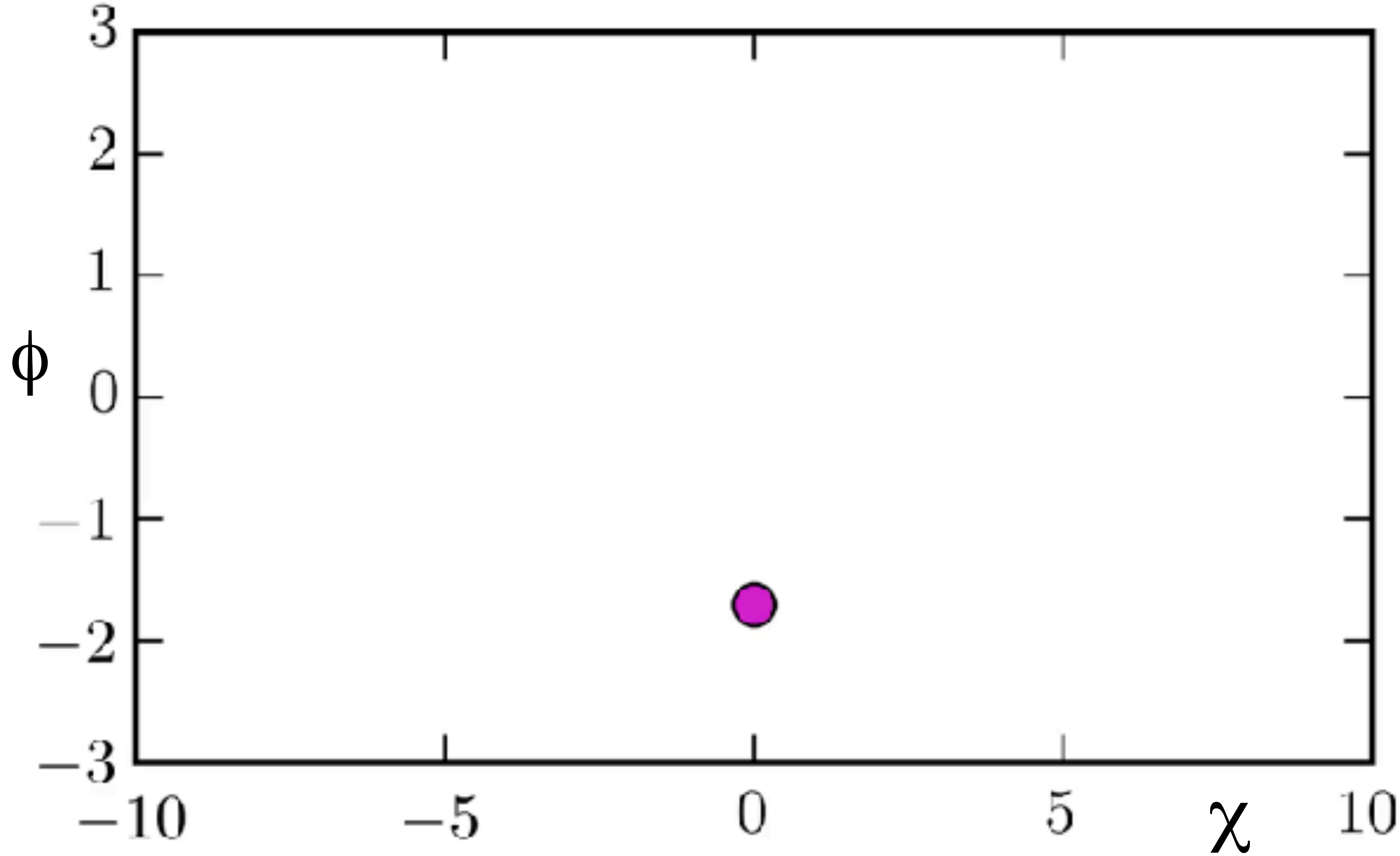



**$V_{\rm eff}$ is dynamical** *Bond,Braden,Frolov,Huang17*

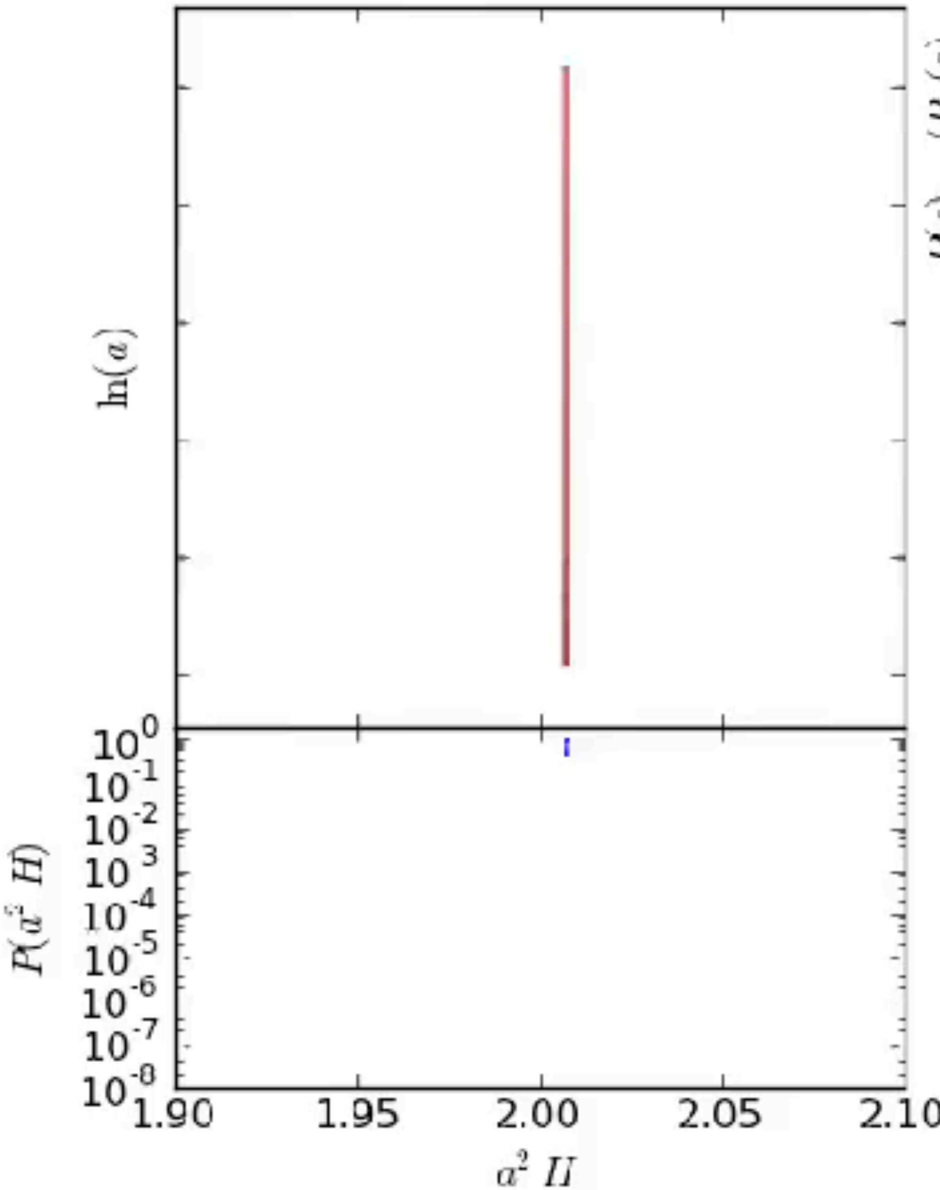
*unconventional local non-G: no scale built into V;*
*perturbative isocon-based $f_{NL}$; rare event cold spots*

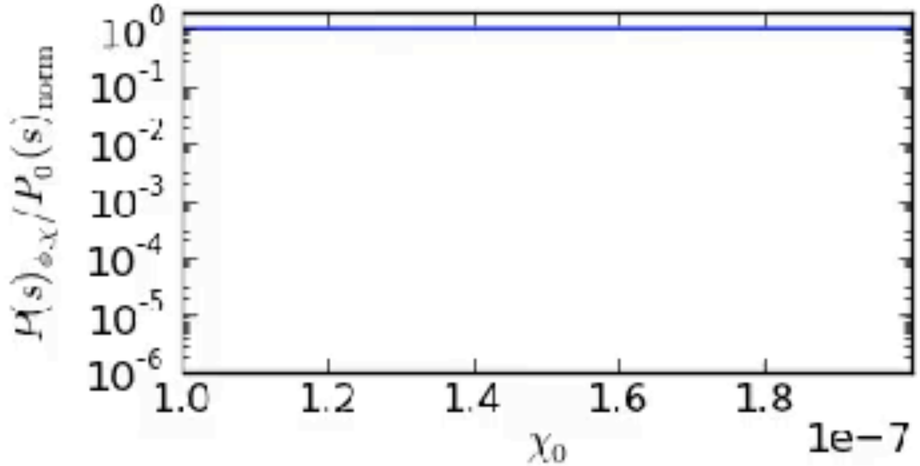
**ballistic billiards k=0 mode phase space string evolution.**
stopping criterion when coarse-grained entropy of field variables rises

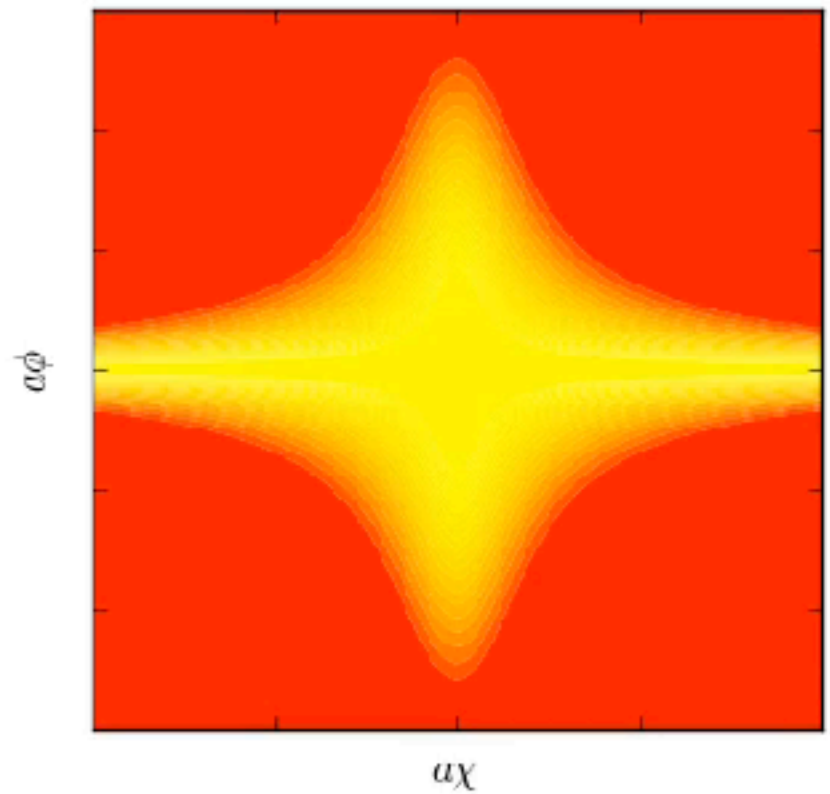



$$V = 1/4\ \lambda\phi^4 + 1/2\ g^2\phi^2\chi^2$$

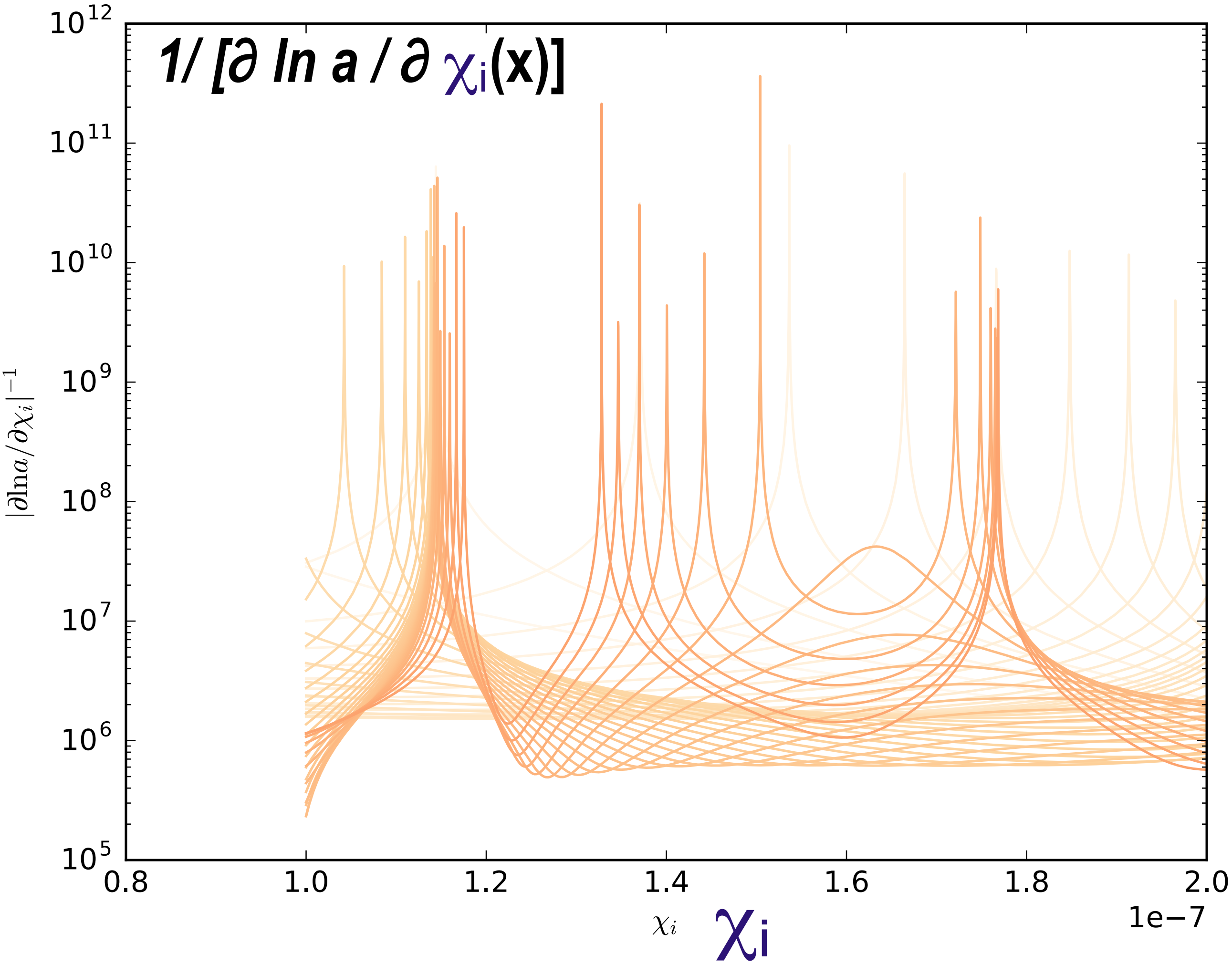
# caustics are ubiquitous



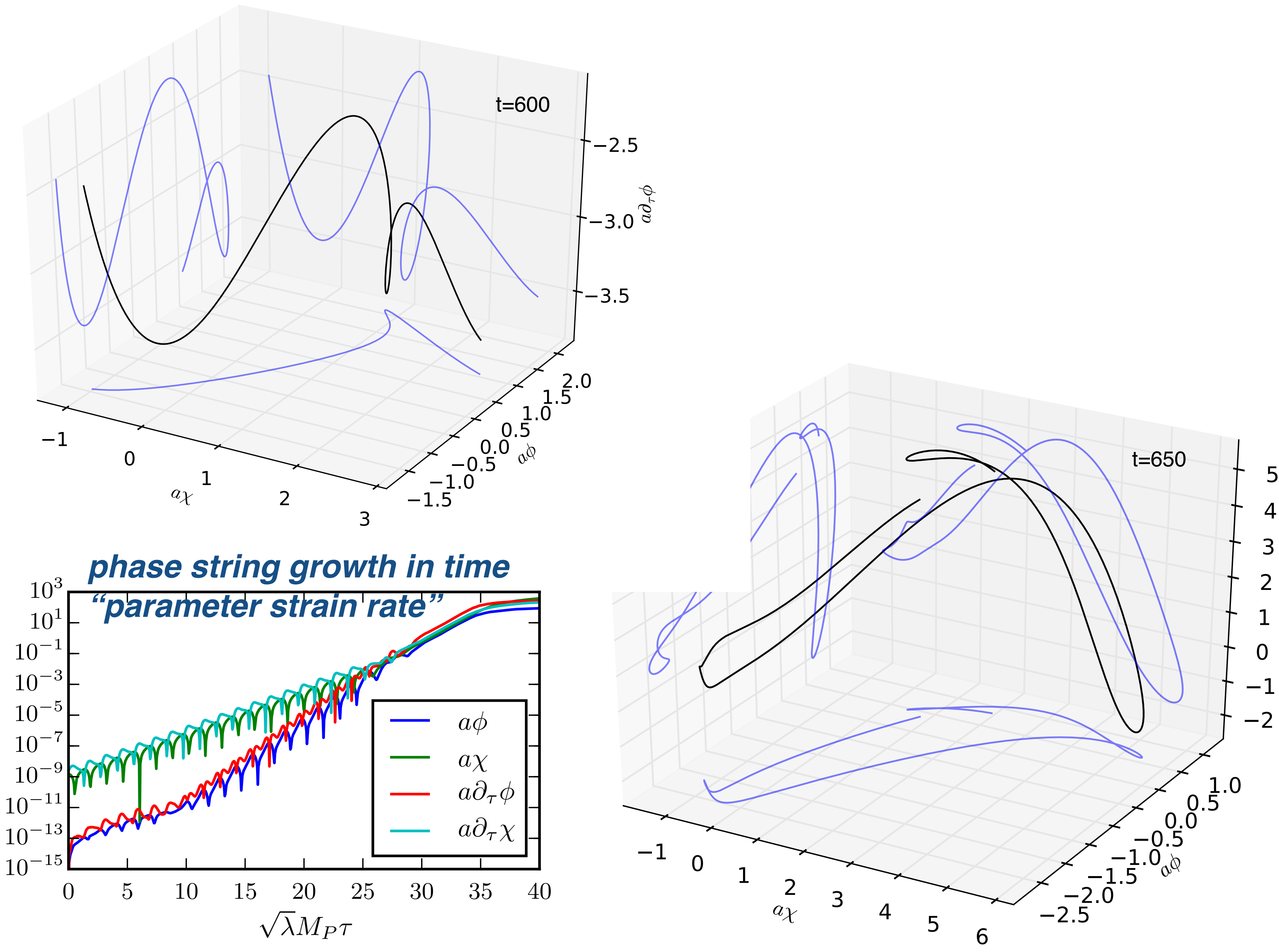
## *calculating ballistic evolution to caustics gives the spikes in good agreement with full nonlinear lattice simulations*




*B2FH, b+braden+frolov+huang*

***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***

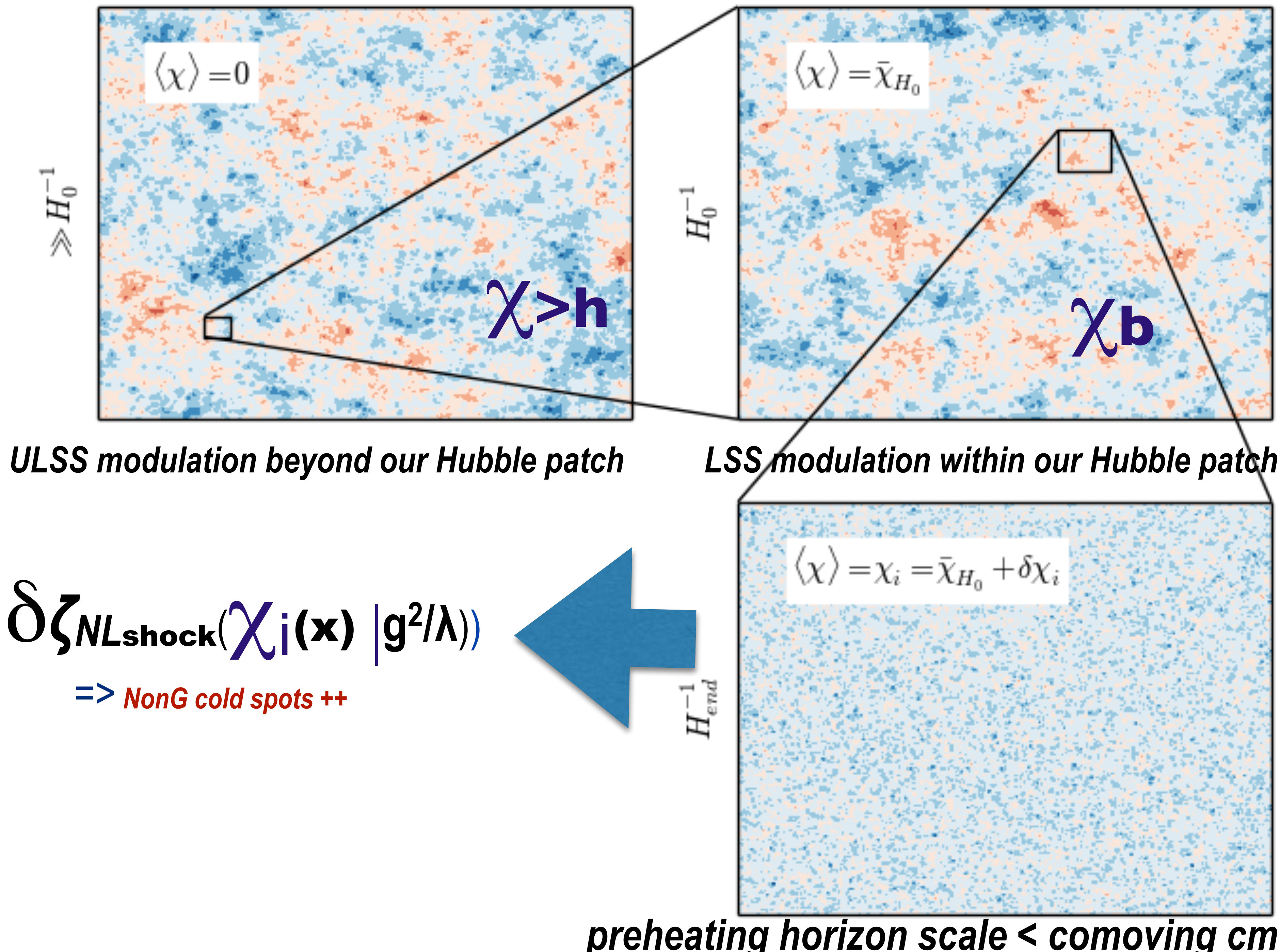
**eg $\partial \ln a / \partial \chi_i(x)$ , $\partial \ln a / \partial g(x)$ => $P[\ln a(x),\ t_{shock}\ |\ \chi_i(x),\ g(x), t_{end\text{-}of\text{-}inflation}]$**



t=600
$a\partial_\tau\phi$
$a\chi$
$a\phi$
phase string growth in time
"parameter strain rate"
$a\phi$
$a\chi$
$a\partial_\tau\phi$
$a\partial_\tau\chi$
$\sqrt{\lambda}M_P\tau$
t=650
$a\chi$
$a\phi$

**how modulated caustics in preheating could give observable intermittency**

**modulating the caustics on large scales & super-horizon scales via isocons**



$\langle\chi\rangle = 0$
$\gg H_0^{-1}$
$\chi > h$
$\langle\chi\rangle = \bar{\chi}_{H_0}$
$H_0^{-1}$
$\chi b$
ULSS modulation beyond our Hubble patch
LSS modulation within our Hubble patch
$\langle\chi\rangle = \chi_i = \bar{\chi}_{H_0} + \delta\chi_i$
$H_{end}^{-1}$
$\delta\zeta_{NLshock}(\chi_i(\mathbf{x})\ |g^2/\lambda))$
=> NonG cold spots ++
preheating horizon scale < comoving cm

**how generic will caustic preheating be? structure around minima:**

**filamentary potentials**

**define channels**

***multi-filaments may lead to caustics***

# modulating post-inflation entropy generation shocks *via* long range fields

isocon

$\chi$**(x)**

or

**g**($\sigma$(**x**))

or..

$\phi$

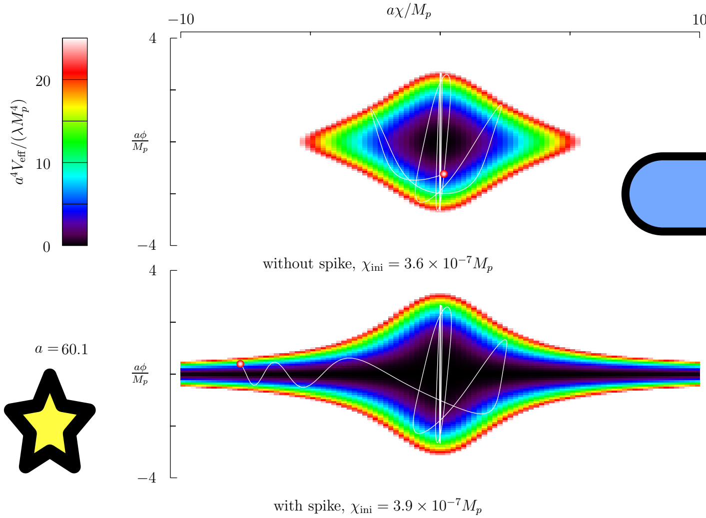
inflaton

pre-heating patch (~1cm)

**$S_{U,m+r}$**

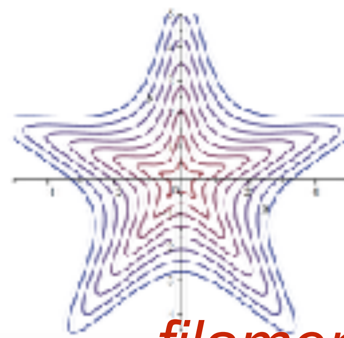
**~$10^{88.6}$**

*How generic is the intermittent caustic phenomenon? Holds for many basin potentials at the end of inflation. but not if rapid heating*

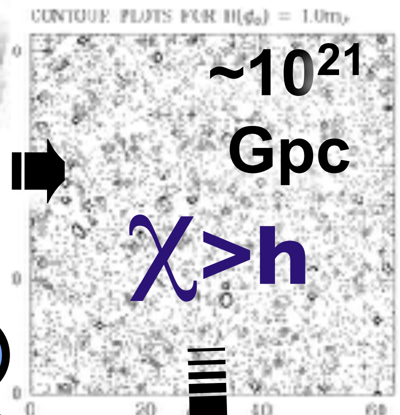


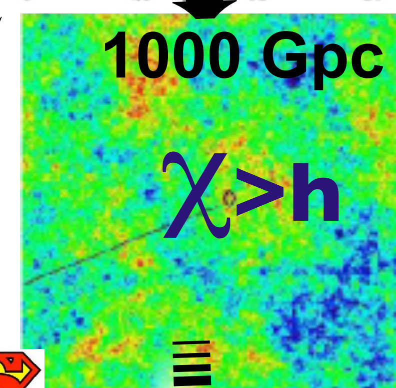

$1/4\ \lambda\phi^4 + 1/2\ g^2\phi^2\chi^2$,

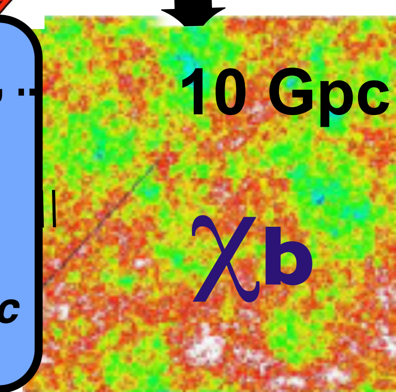
$1/2 m^2\phi^2 + 1/2\ g^2(\sigma)\phi^2\chi^2$



**Su,uuUULSS**




$1/4\ \lambda\ (r^2 - v^2)^2\ U$

$V(r)U(\cos\theta),\ r^2 = \phi^2+\chi^2$

*filaments!*

**angular variables** pNGB natural inflation, racetrack, monodromy, ..

$V(r,\theta) = \sum_M V_M(r)\cos(m\theta)$ *pNGB, Roulette r~hole size*

3D $\varphi\ \chi\ \sigma$ fields $V(r,n) = \sum_{LM} V_{LM}(r) Y_{LM}(n)$

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

***conformally transformed potentials a la Higgs/R², modified kinetic terms, flattened potentials of all sorts*** *B2FH, b+braden+frolov+huang*

**mocking heaven** to explore 3D intermittency from modulating preheating, bubble collisions, etc

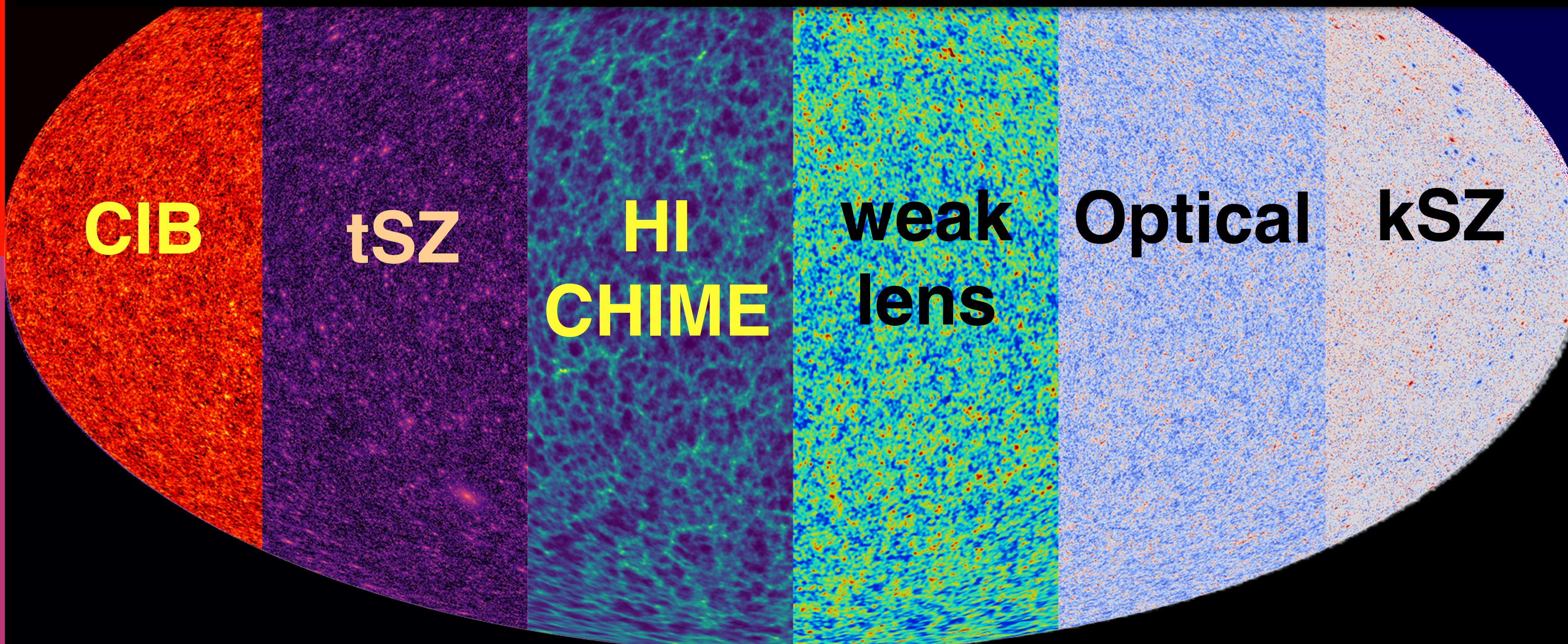
**a quest for the apparent breakdown of LSS homogeneity - but NOT**

# **Mocking Heaven** @ *CITA*

*Alvarez Bond Stein Battaglia ..*

*Peak Patch Full Sky Models for* ***Planck, AdvACT, SO, CMB-S4, CCATp, CHIME, HIRAX, SKA, COMAP, EUCLID, LSST, …***

*need* ***End to End mocks, fully correlated to draw out:***
***BSMc, DE/modG, Mnu, nonG (correlated, uncorrelated, intermittent),…***

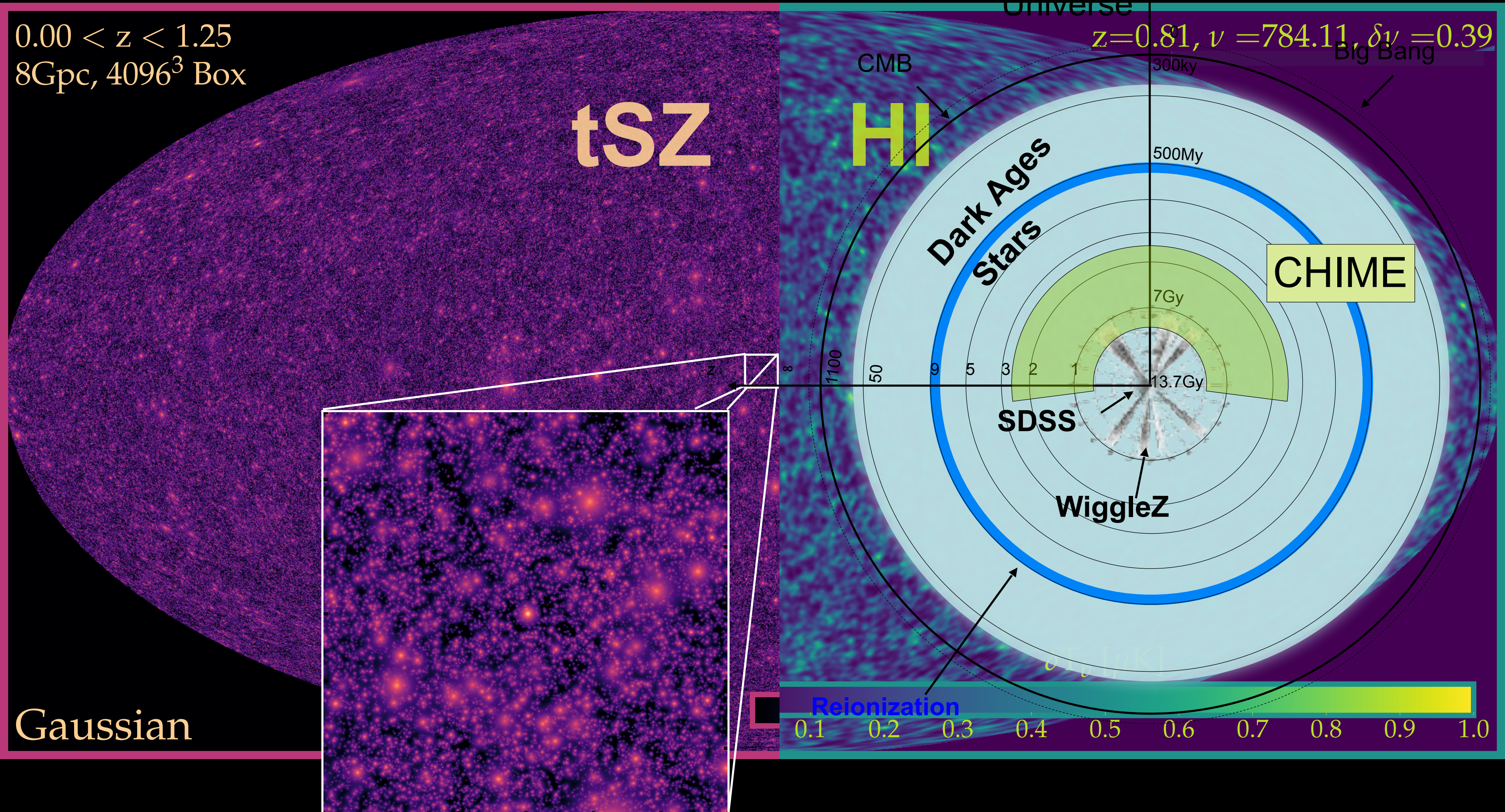



*Planck 2015 XII: Full Focal Plane Sims (Nov): FFP8 ensemble of10K* ***End****to****End*** *mission realizations in 1M maps. instrument noise + CMB + PSM + .. (25M NERSC CPU hrs)*

Compton Scattering (Sunyaev-Zeldovich) Simulations for ACT, Planck, Simons Obs &CMB Stage 4 Cluster Observations

**Using high res Gas Hydro Sims**

**HI Intensity Mapping simulations of CHIME / HIRAX .. z=0.8-2.5, ~(8 Gpc)$^3$**




ABS Berger +FH

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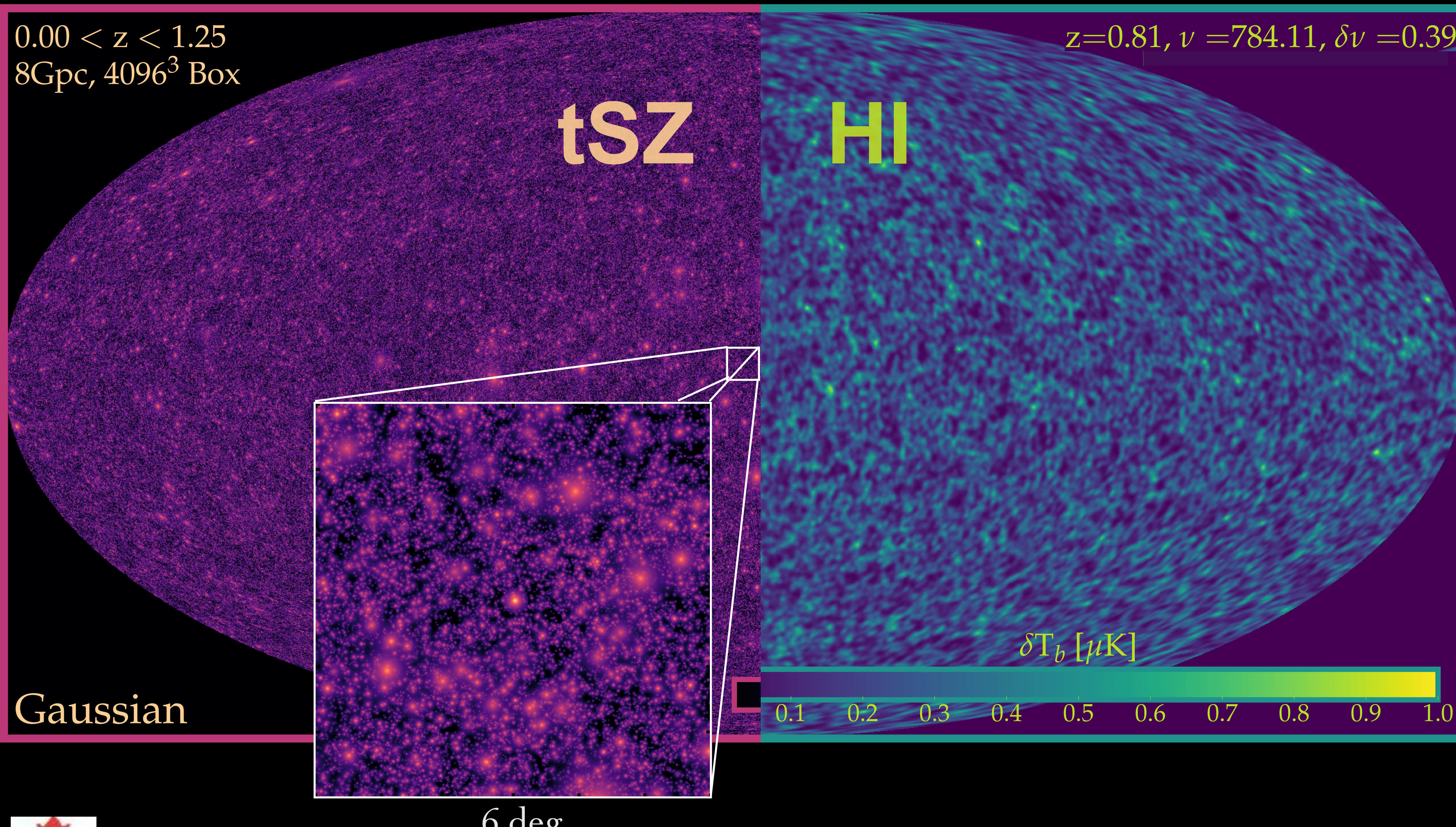

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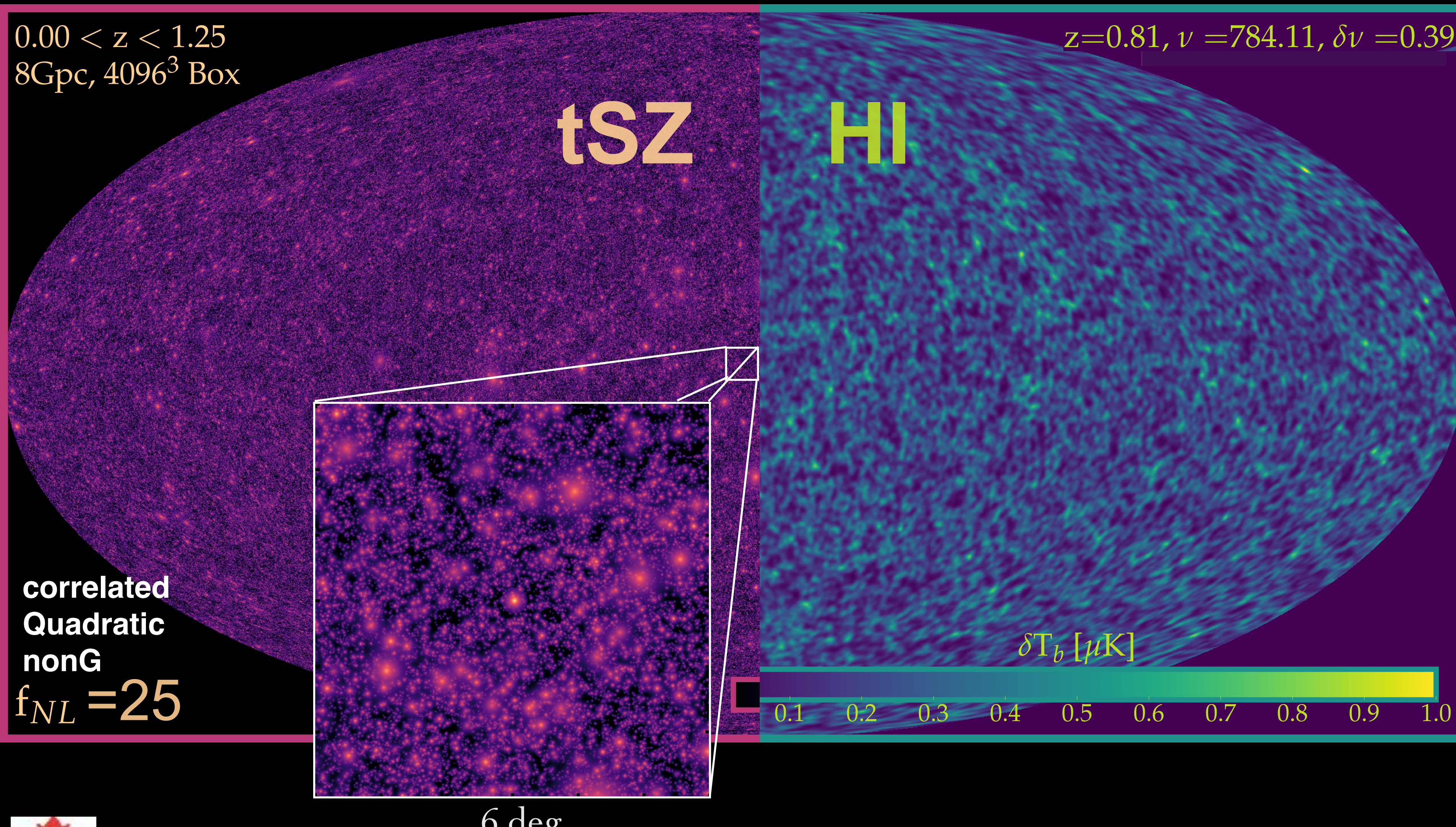


*ABSB+FH, alvarez+b+stein+frolov+huang*

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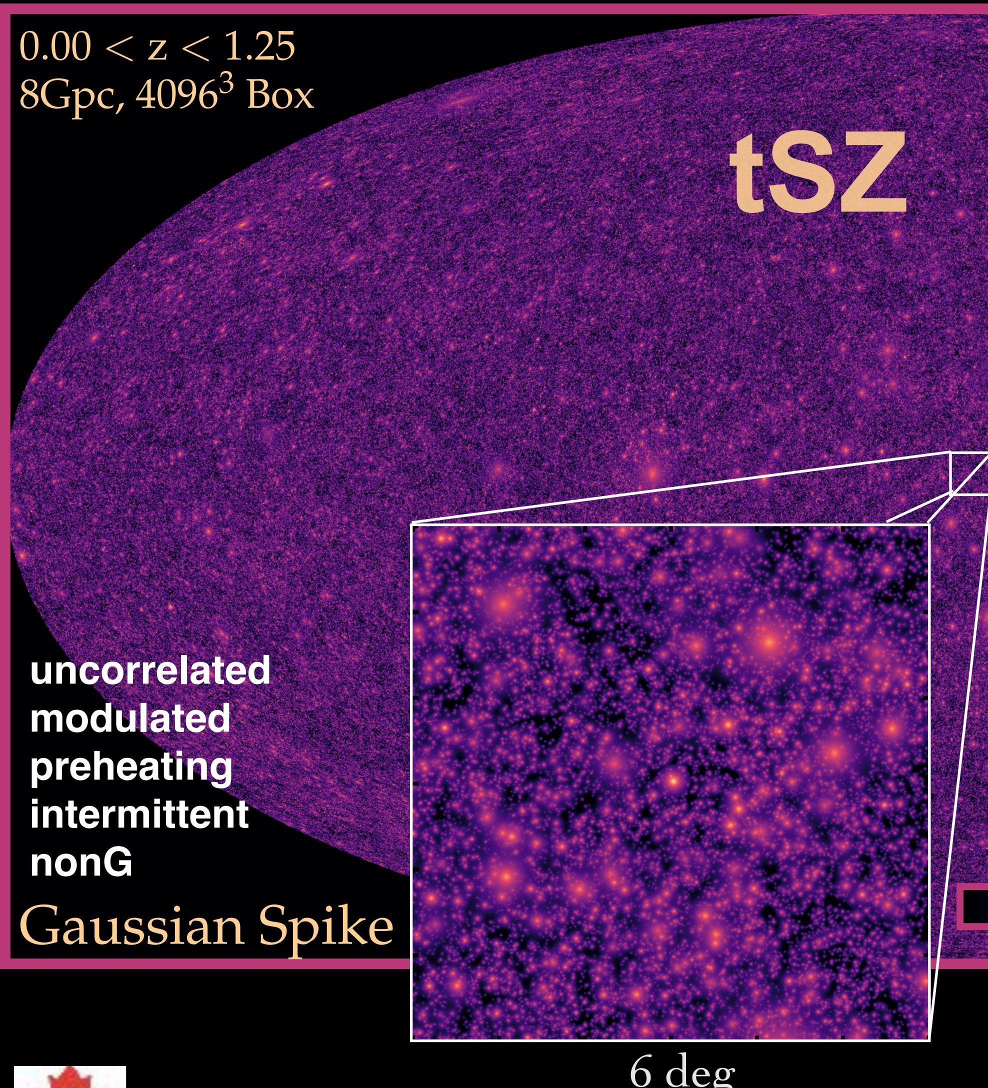
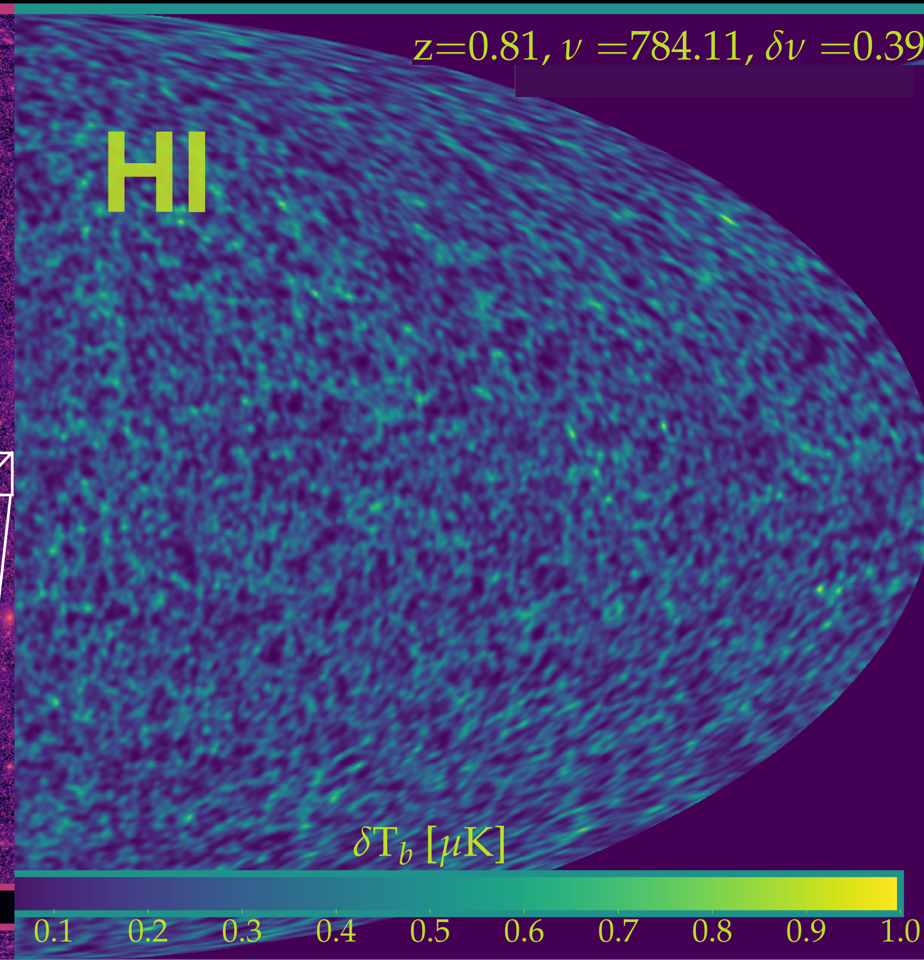


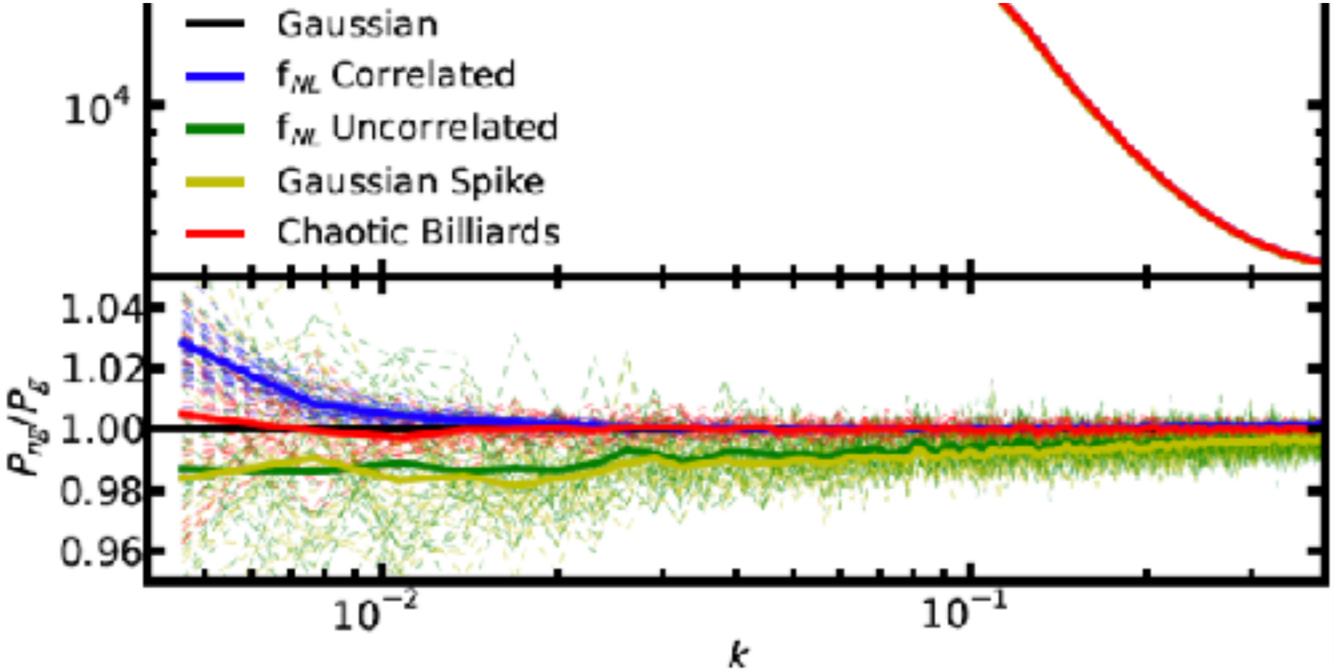




*ABSB+FH, alvarez+b+stein+frolov+huang*

*this is a very quantitative exercise*

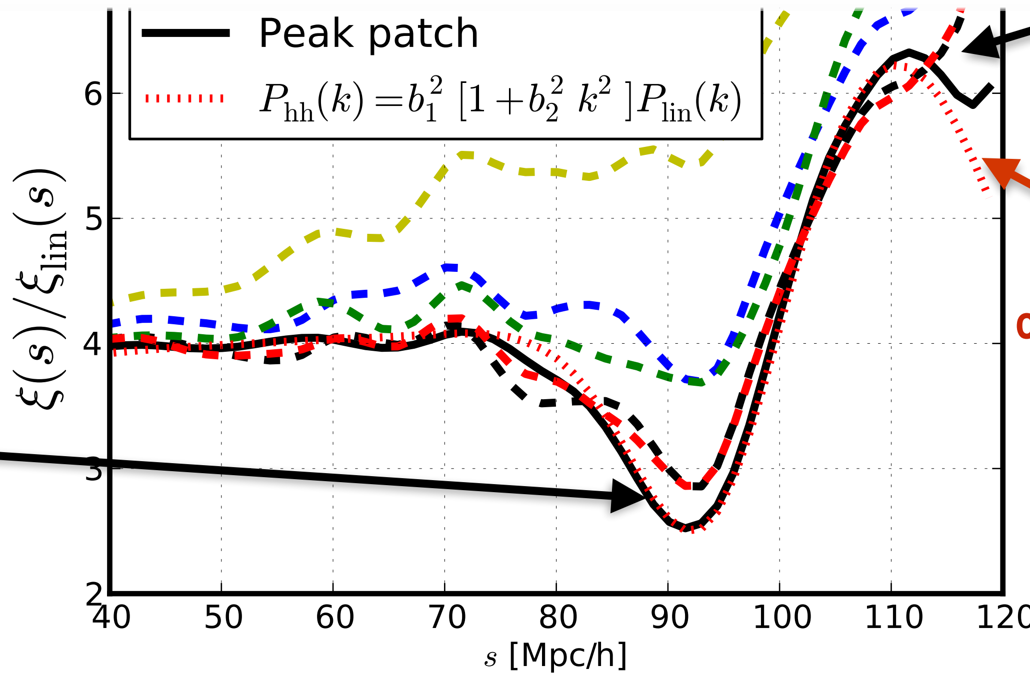
e.g., **response of BAO and biasing of halos to forms of nonG - correlated cf. uncorrelated, intermittent cf. perturbative**

e.g., **search for rare superBIAS events** > supercluster-scale




*intermittent nG from early U single spike*

**Positive Curvature: Overabundance of Negative Extrema**




**Positive Curvature: Overabundance of Negative Extrema**

**cf. fit to N-body results: without any tuning it comes out from peak patches naturally**



*ABSB+FH, alvarez+b+stein+frolov+huang*

# highly nonlinear field evolutions happened (EoI, bubble collisions)!

## *amusing subdominant patterns do arise!*

## *lead to observable rare-event CMB/LSS anomalies?*

*light isocons cf. heavy isocons, the heavy can lighten up = original SBB nG*

*isocon modulators, coupling(isocon) modulators, isocon tunneling, isocon oscillons, isocon short-lived fuzzy-strings, + very long-lived strings*

**or just to *weak* constraints on multifield potentials, >horizon fields, nucleation rates**, *etc.*

***alas*** **a 2-number $A_s$-$n_s$ early universe so far**

**intermittency frustration: statistical variance is large cf. 2-3 parameter search**

**CMB** ***restricts us to a*** **projected 2D ζ-scape to reconstruct phonon/isotropic-strain power,** ***the future may look much the same as now for*** **ζ=>potential $V(\phi)$=>acceleration $\varepsilon(a)$**

we **mock** the LSS future ***end-to-end*** *to probe the* **mode-rich 3D ζ-scape**