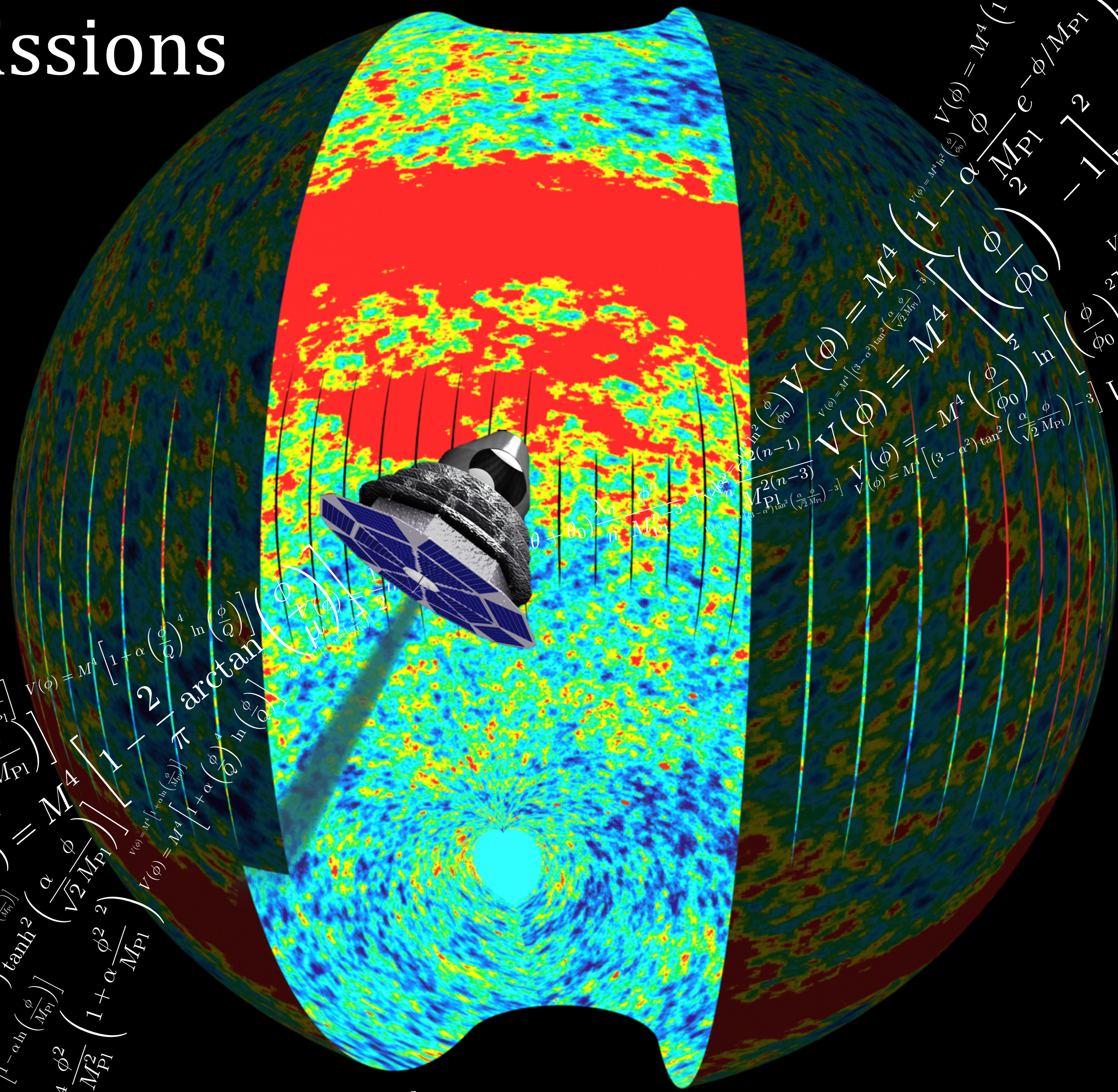
Inflation & Future CMB Missions



30th IAP Colloquium

December 17, 2014

ICG, Portsmouth

Vincent Vennin

Outline

- Methodology: Mock Data and Likelihood Functions
- Posterior Distributions on Inflationary Parameters
- Bayesian Model Comparison of Single-Field Scenarios
- Observing the Inflationary Reheating

Collaborators:
Jérôme Martin (IAP), Christophe Ringeval (Louvain U. CP3), Roberto Trotta (Imp.Coll, London).

Publications:
arXiv:1407.4034, follow up on arXiv:1303.3787, 1312.3529, 1405.7272 and 1410.7958.

Methodology

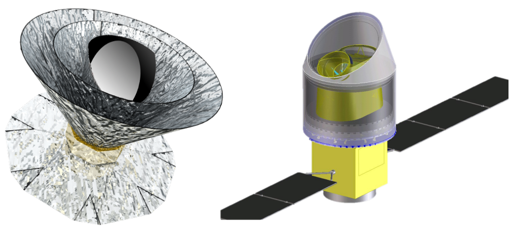
$$\mathcal{L}\left[C_l^{\mathrm{mock}} | C_l^{\mathrm{th}}, \Sigma\right]$$

Bond, Jaffe, Knox, 2000
Perotto, Lesgourgues, Hannestad, Tu, Wong, 2006
Percival, Brown, 2006
Hamimeche, Lewis, 2008

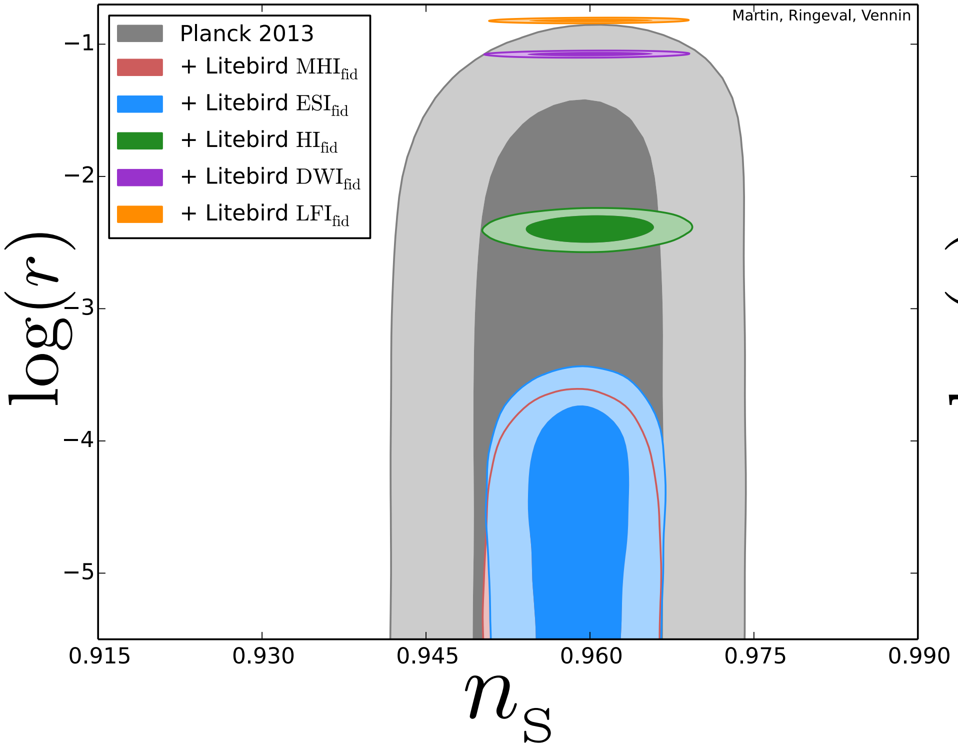
Fiducial Model	$V(\phi)/M^4$	Parameters	n_S	r
$\mathrm{LFI_{fid}}$	$(\phi/M_{\mathrm{Pl}})^2$		0.961	1.52×10^{-1}
$\mathrm{DWI_{fid}}$	$[(\phi/\phi_0)-1]^2$	$\phi_0=25M_{\mathrm{pl}}$	0.962	8.45×10^{-2}
$\mathrm{HI_{fid}}$	$[1-\exp(-\sqrt{2/3}\,\phi/M_{\mathrm{pl}})]^2$		0.961	4.12×10^{-3}
$\mathrm{ESI_{fid}}$	$1-\exp(-q\phi/M_{\mathrm{pl}})$	$q=8$	0.959	5.09×10^{-5}
$\mathrm{MHIf_{id}}$	$1-\mathrm{sech}(\phi/\mu)$	$\mu=0.01M_{\mathrm{pl}}$	0.958	3.40×10^{-7}

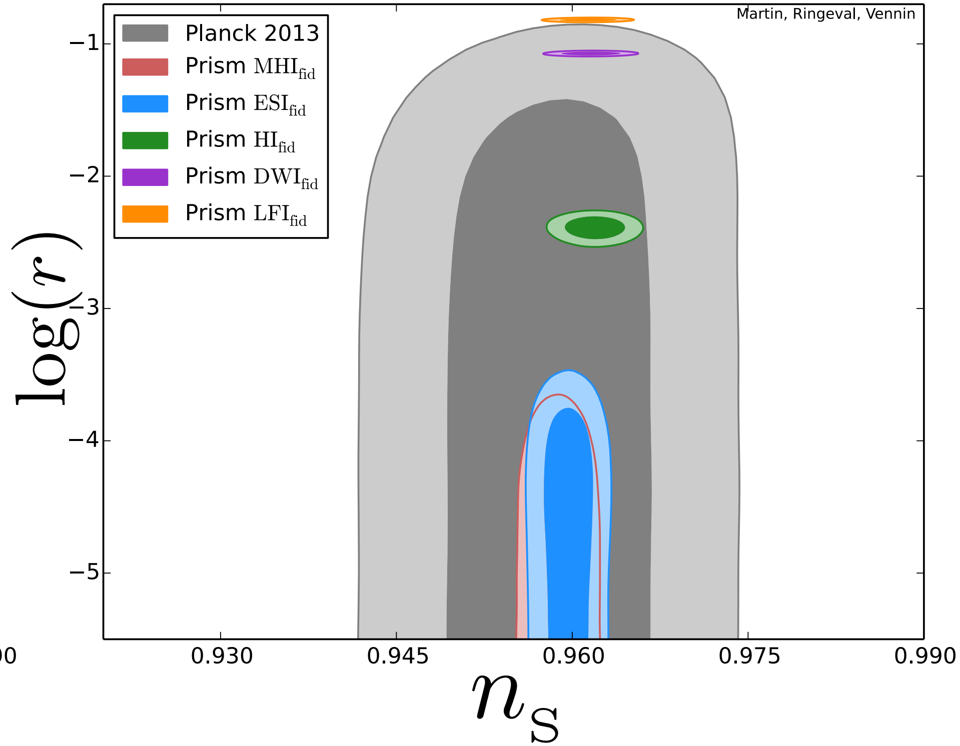
with $\Omega_b h^2=0.0223$, $\Omega_{dm}h^2=0.120$, $\Omega_\nu h^2=0.000645$, $\tau=0.0931$, $h=0.674$, $T_{reh}=10^8$ GeV, $w_{reh}=0$, $P_*=2.203 \times 10^{-9}$.

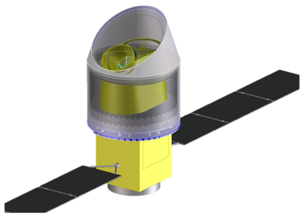
Satellite	C^T_{noise}	C^E_{noise}	C^B_{noise}	θ_{fwhm}	f_{sky}
PRISM	$5 \times 10^{-7}\,\mu K^2$	$2C^T_{\mathrm{noise}}$	$2C^T_{\mathrm{noise}}$	3.2’	0.7
LiteBIRD	$7 \times 10^{-7}\,\mu K^2$	$2C^T_{\mathrm{noise}}$	$2C^T_{\mathrm{noise}}$	38.5’	0.7

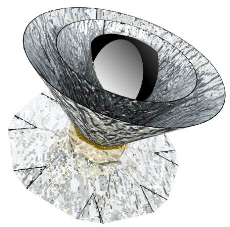


Marginalized Posteriors on Inflationary Parameters









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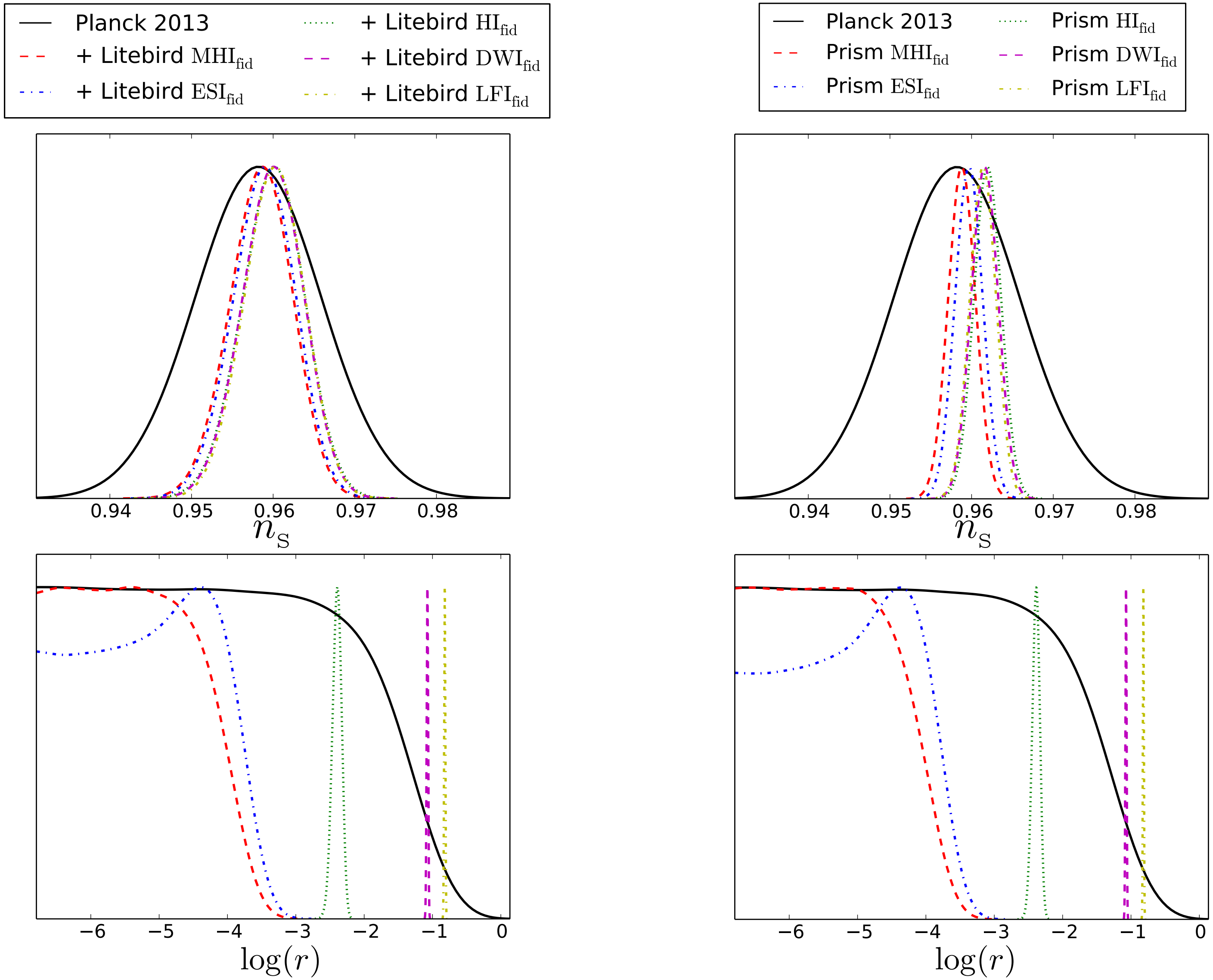
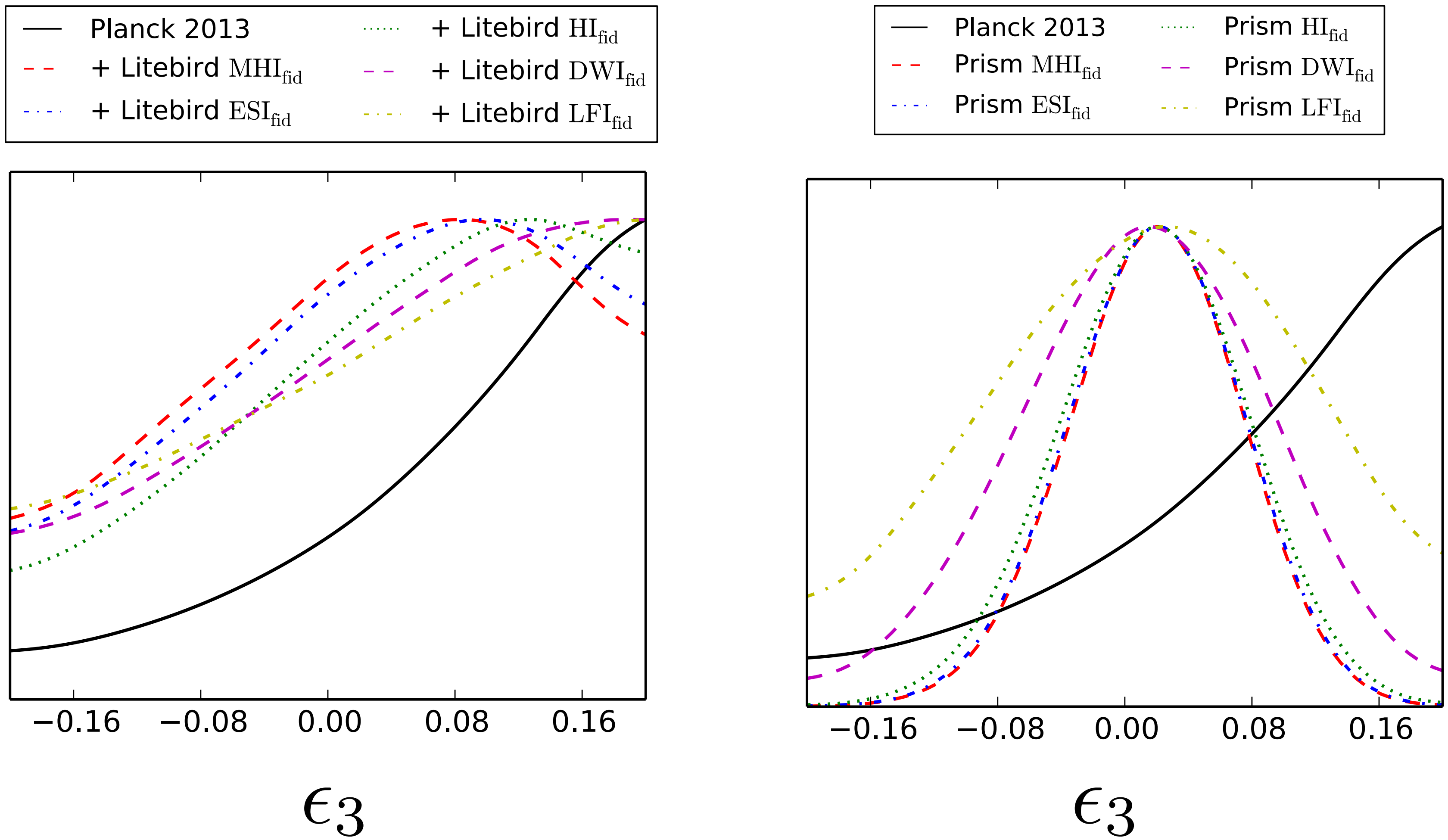
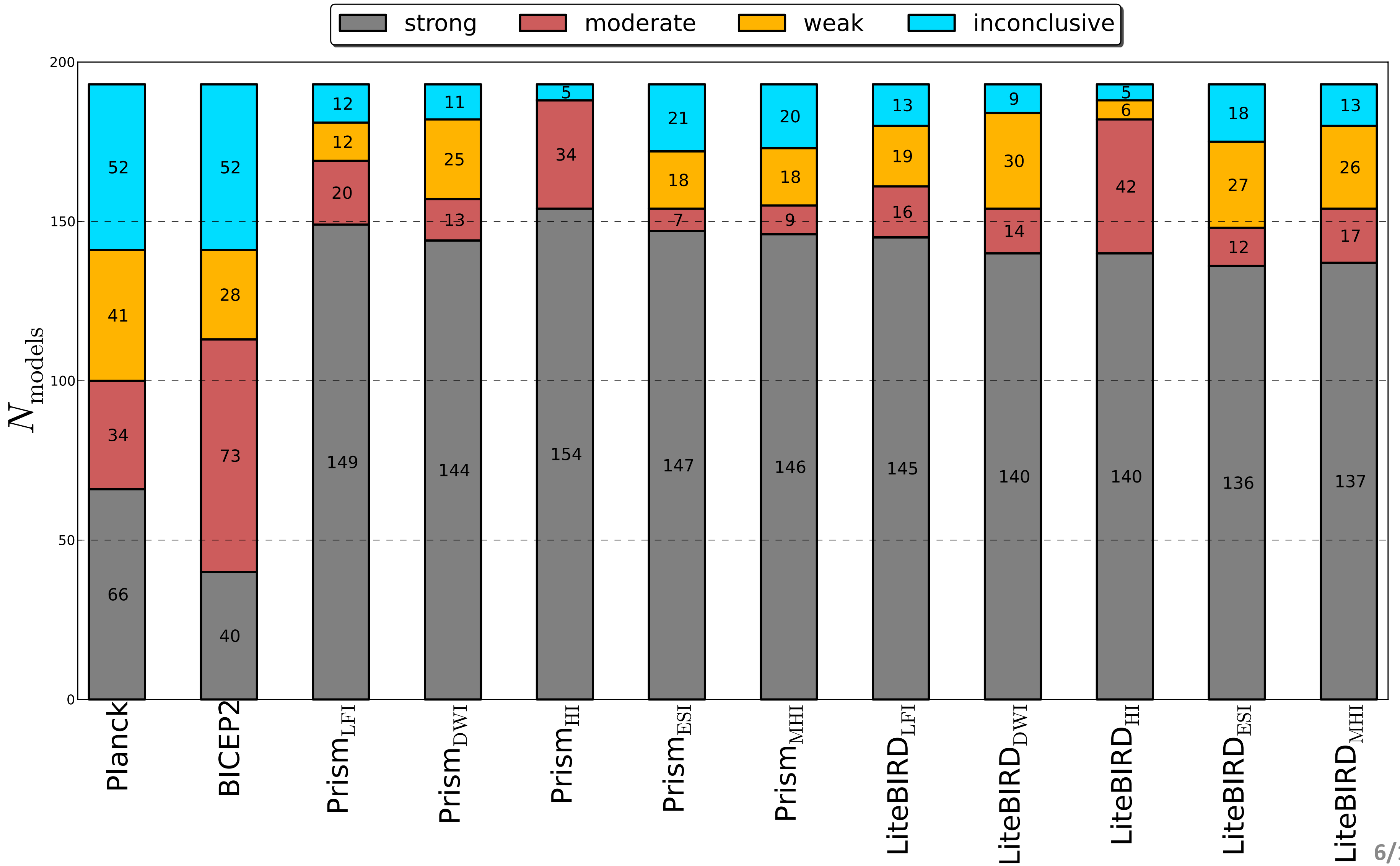


Marginalized Posteriors on Inflationary Parameters
(scalar running)

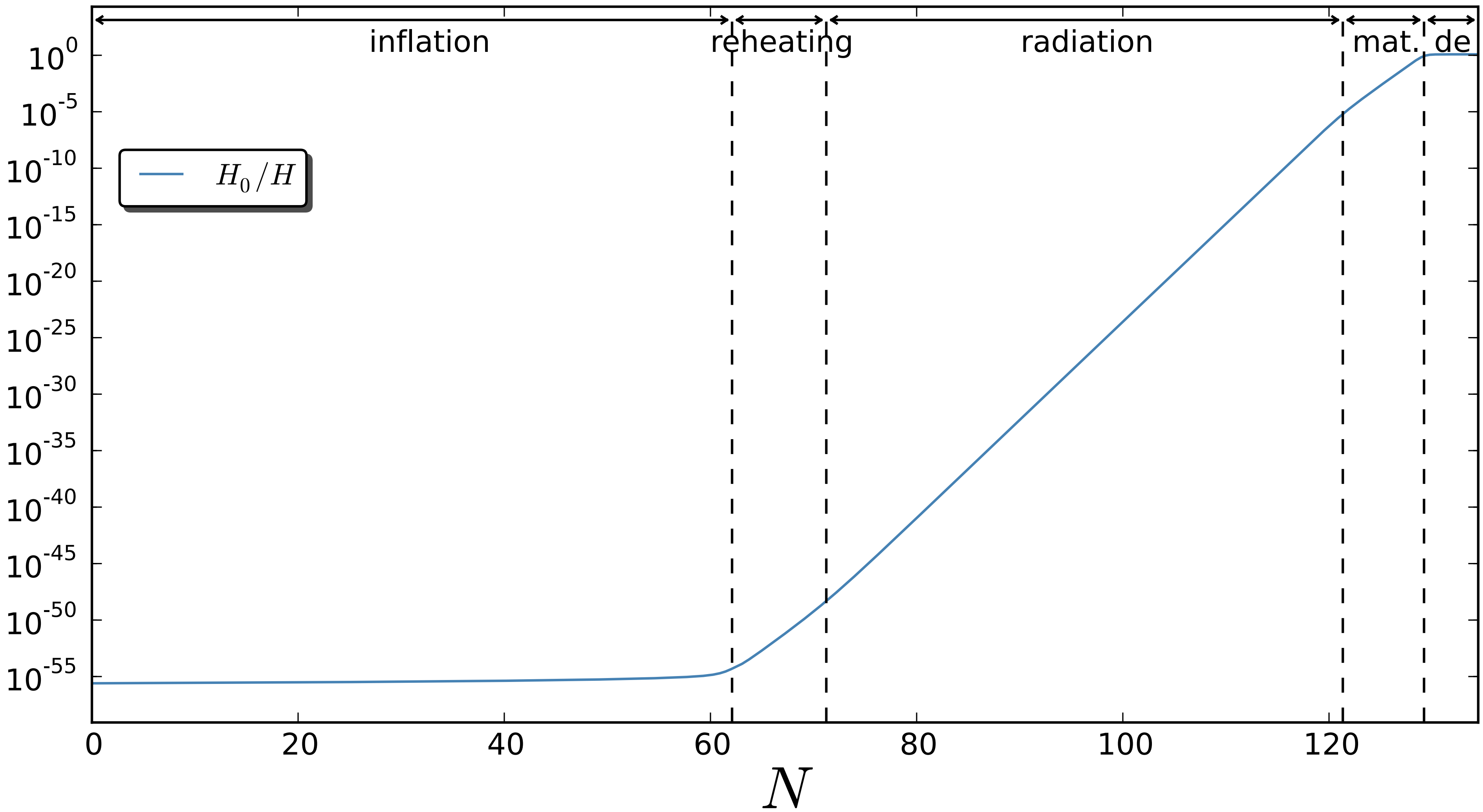


Bayesian Model Comparison

193 models x 5 fiducial models x 2 CMB missions → **2123** Bayesian Evidence Calculations



Observing the Inflationary Reheating



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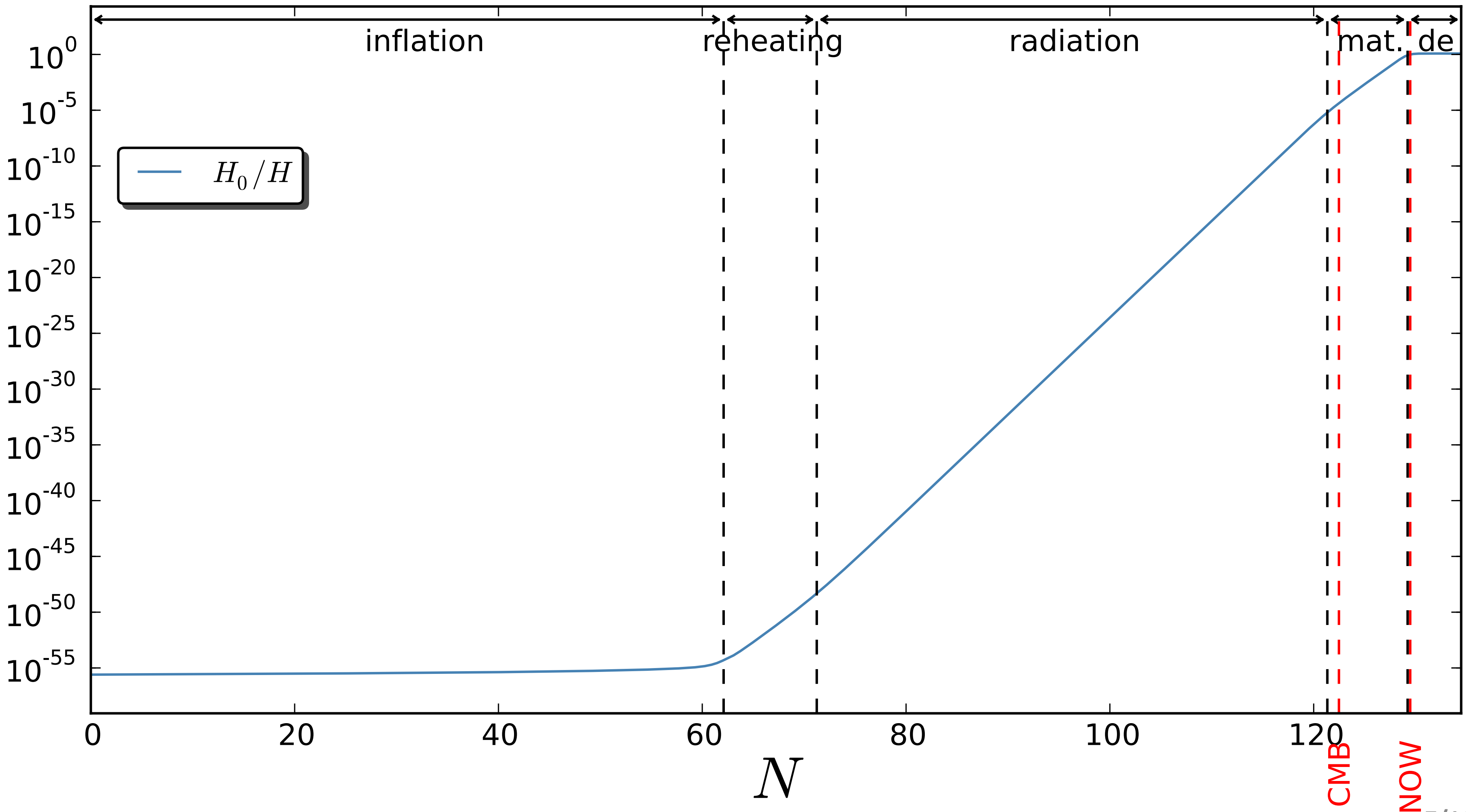

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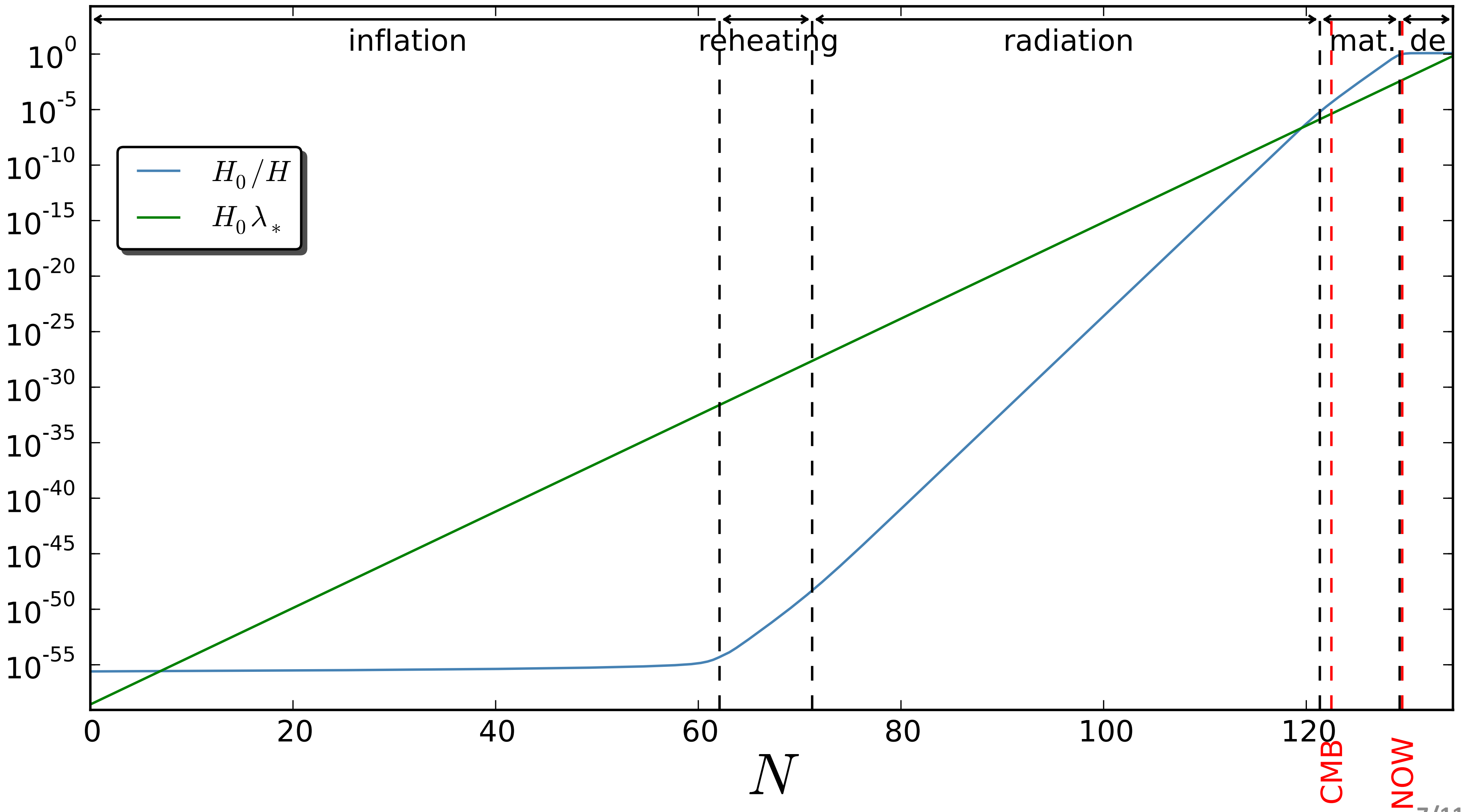

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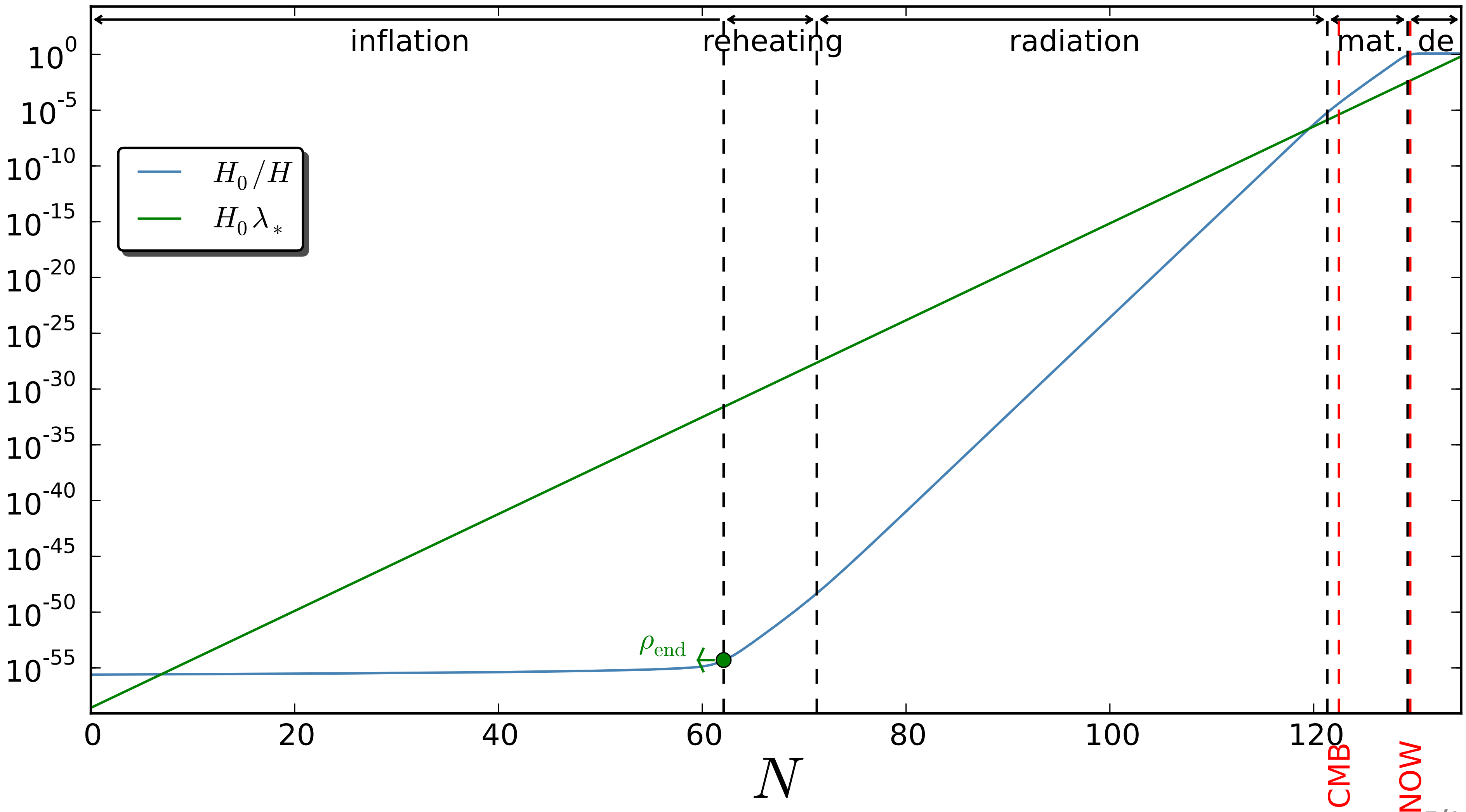

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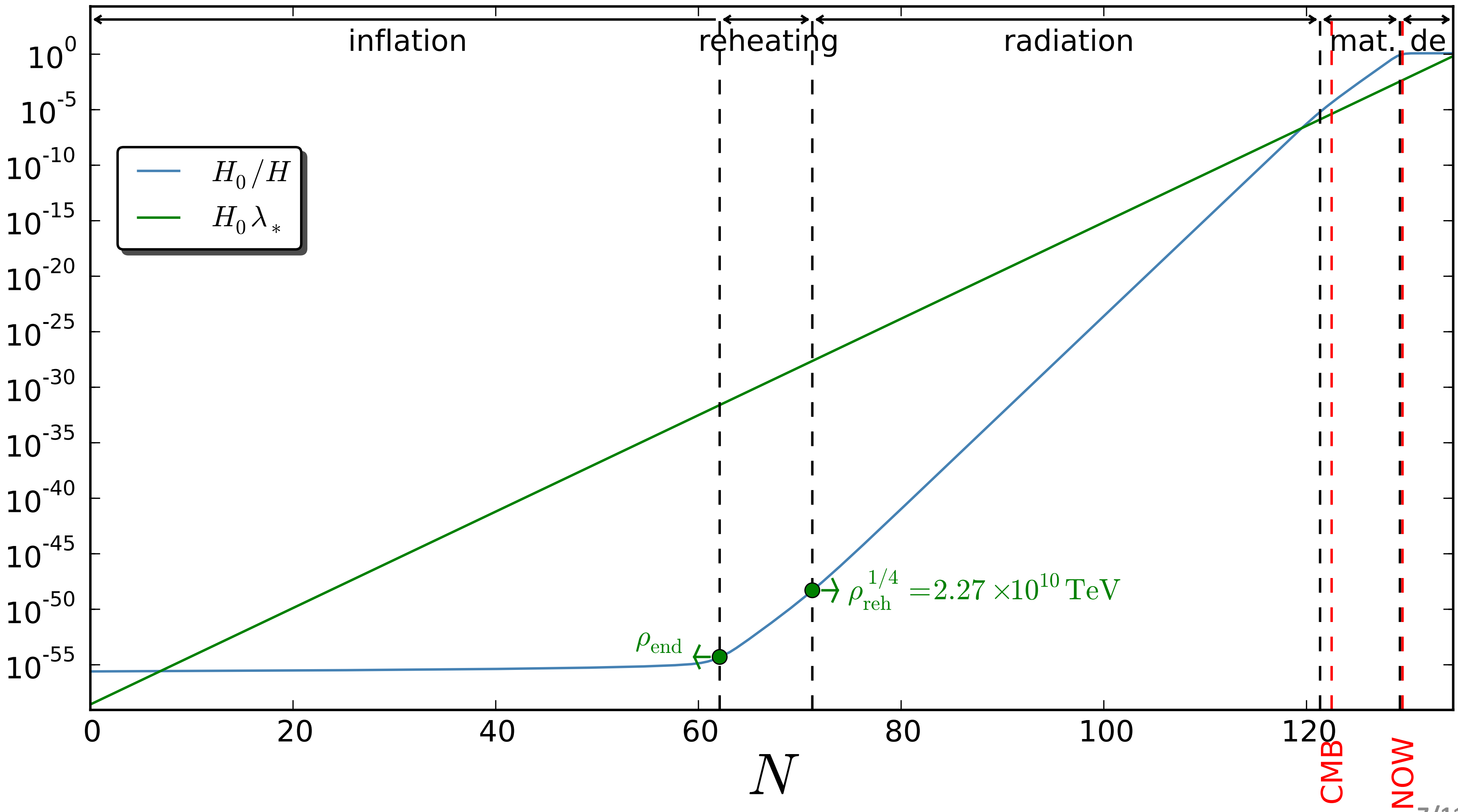

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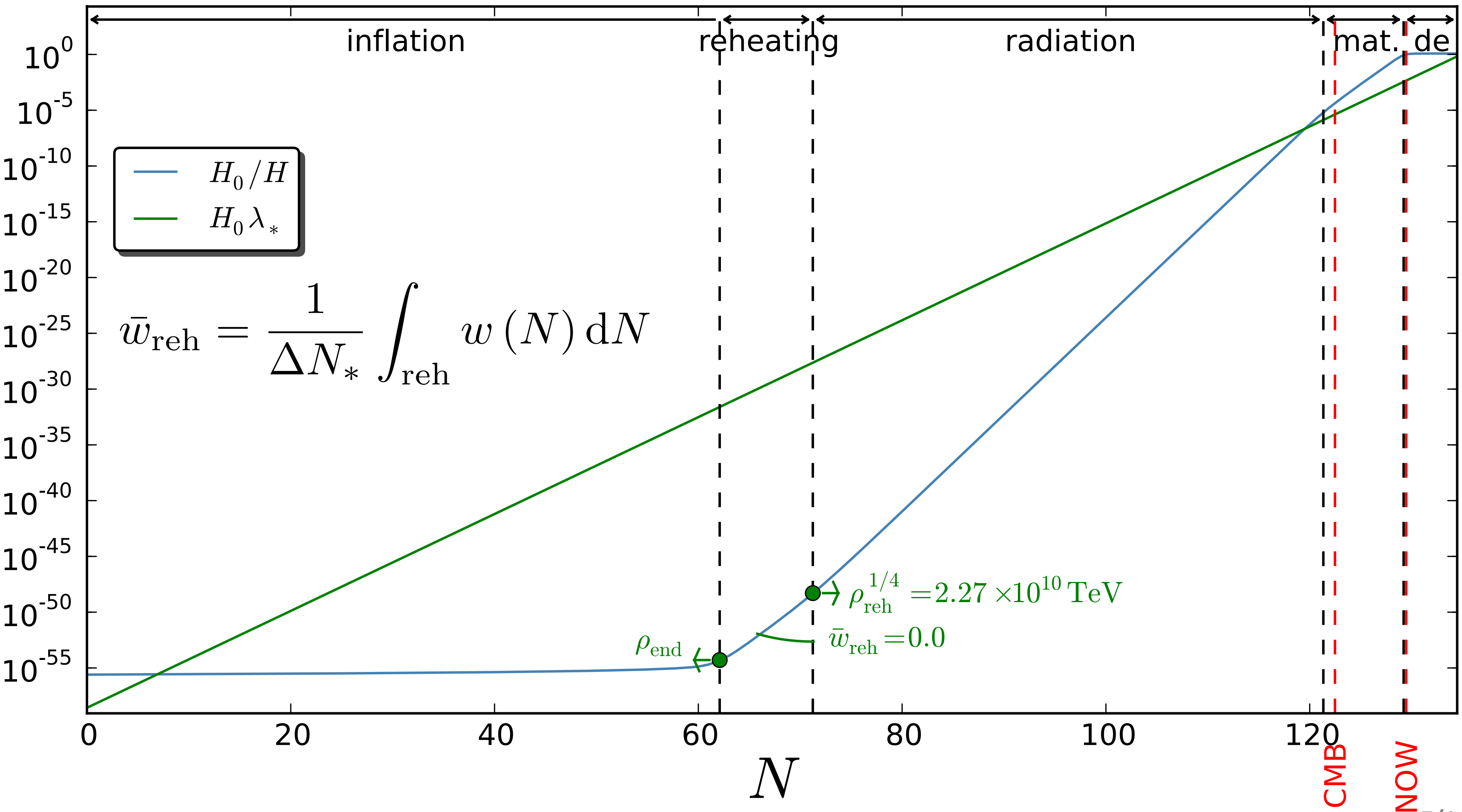

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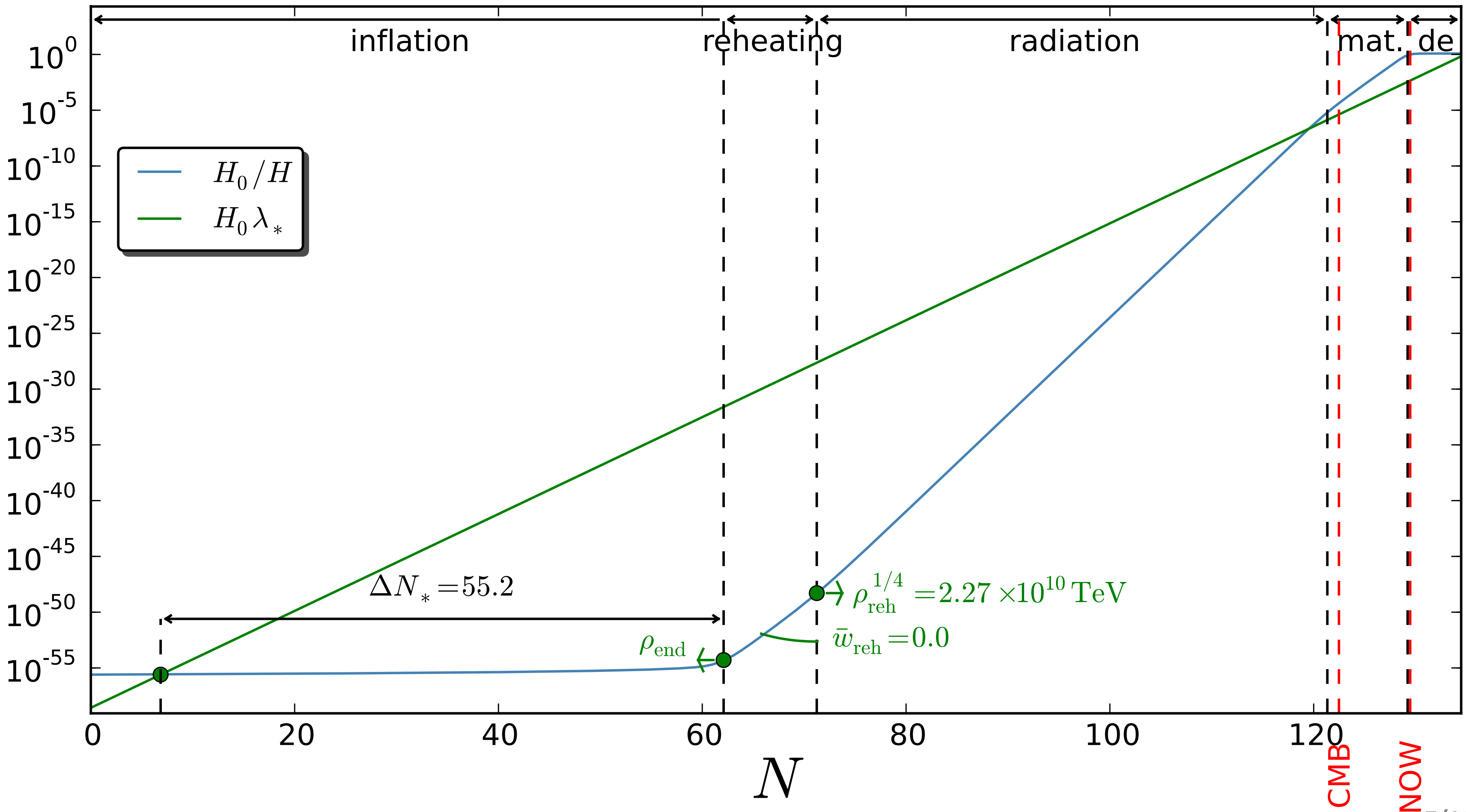
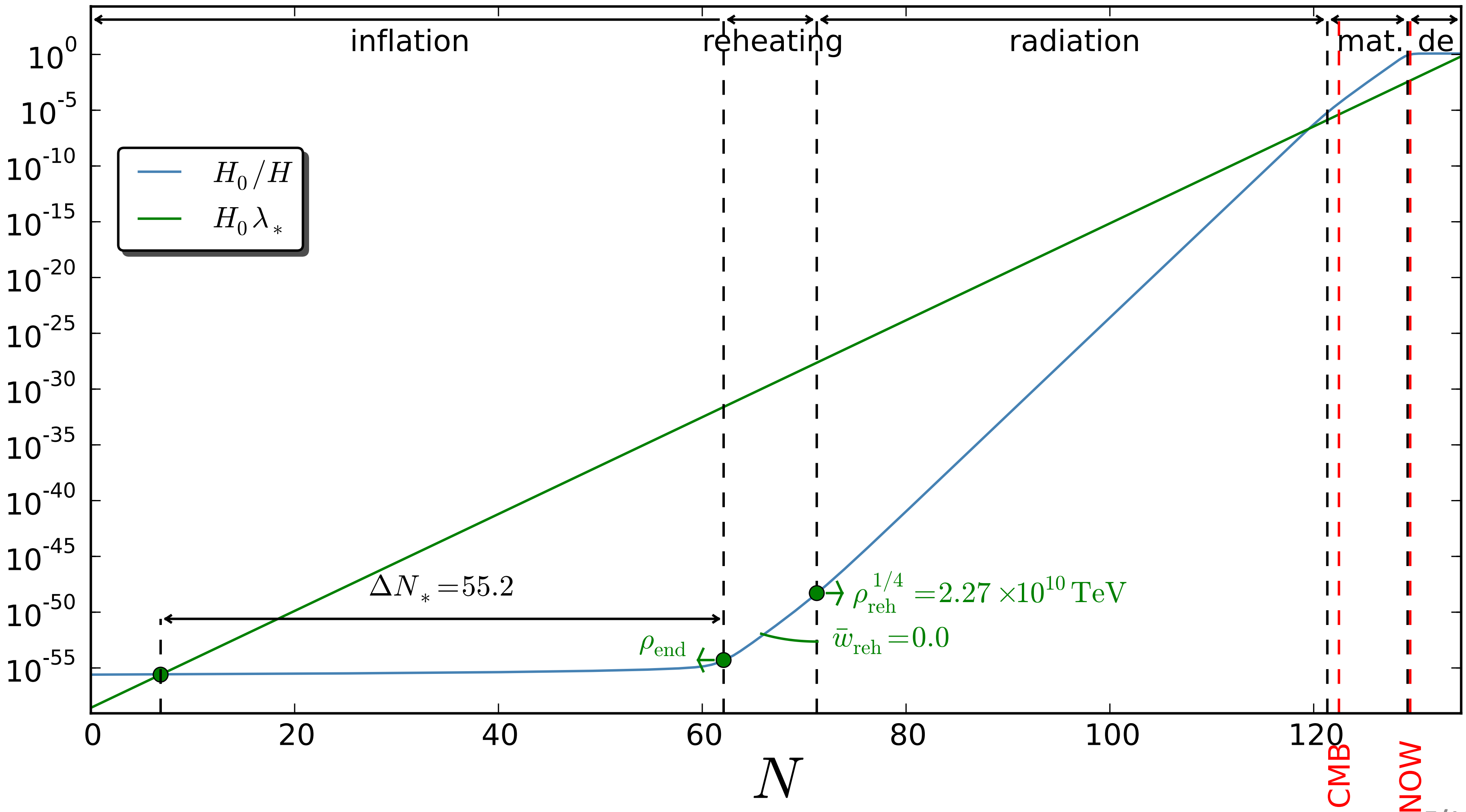


Observing the Inflationary Reheating

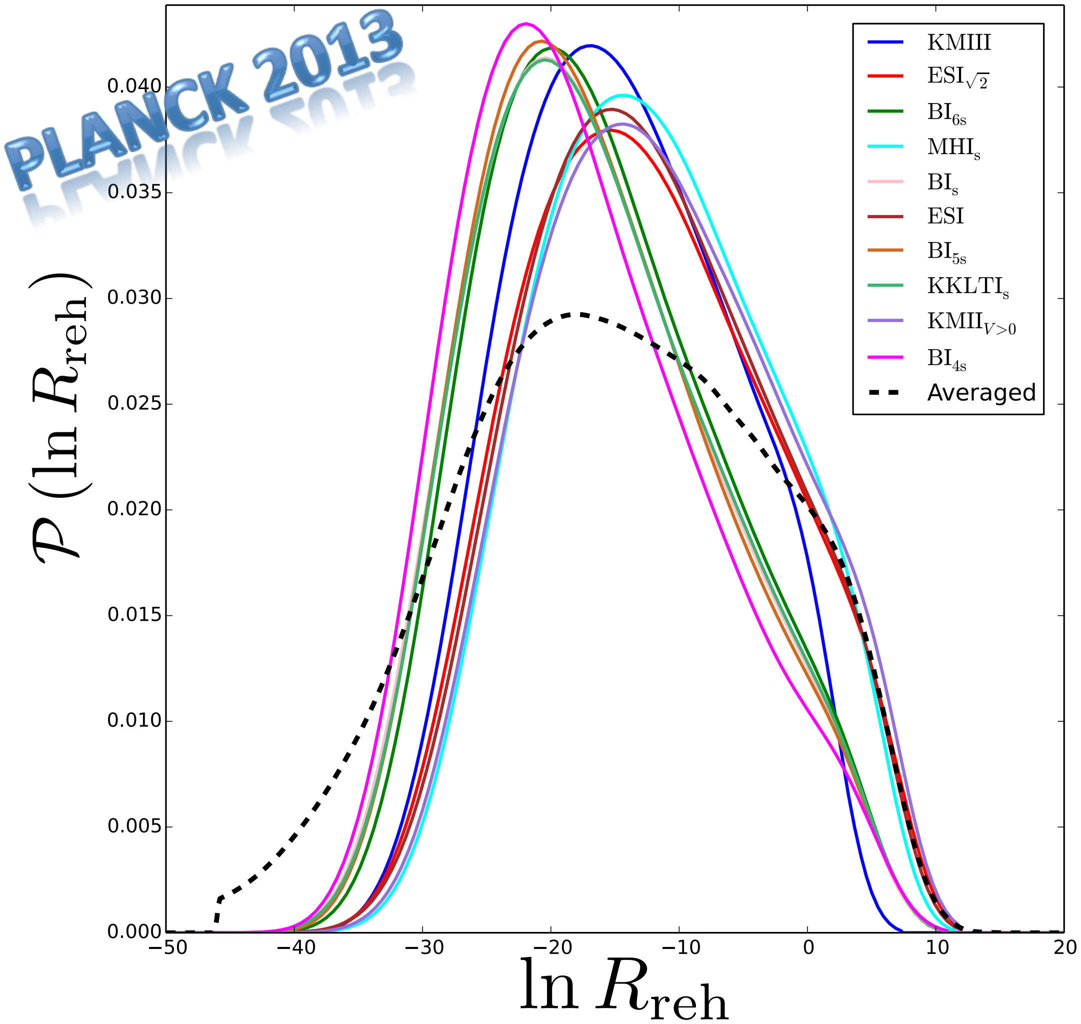
$\rho_{\rm BBN} < \rho_{\rm reh} < \rho_{\rm end}$ $\qquad$ $-1/3 < \bar{w}_{\rm reh} < 1$



Observing the Inflationary Reheating

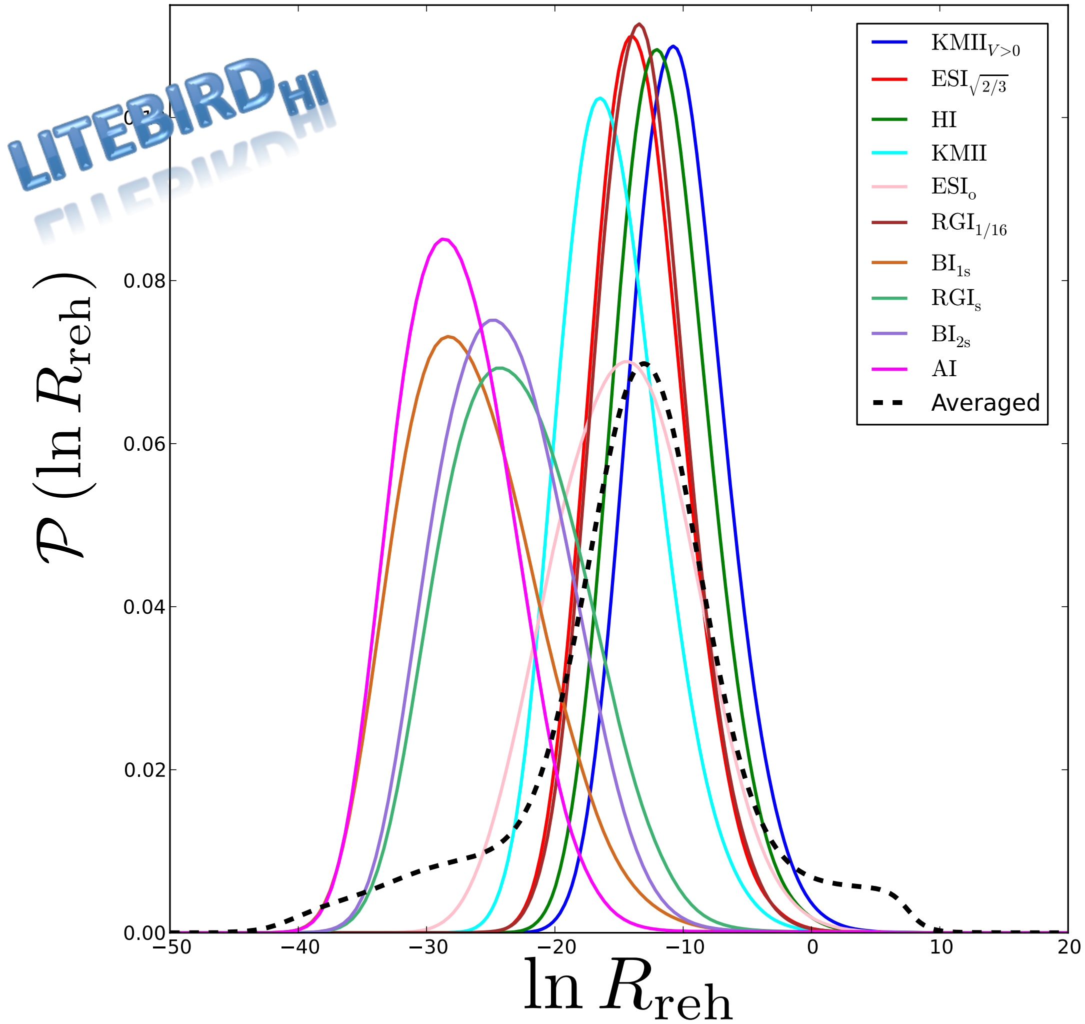
$$\ln R_{\rm reh} = \frac{1-3\bar{w}_{\rm reh}}{12\left(1+\bar{w}_{\rm reh}\right)}\ln\left(\frac{\rho_{\rm reh}}{\rho_{\rm end}}\right) + \ln\left(\frac{\rho_{\rm end}^{1/4}}{M_{\rm Pl}}\right)$$

Martin & Ringeval, 2010



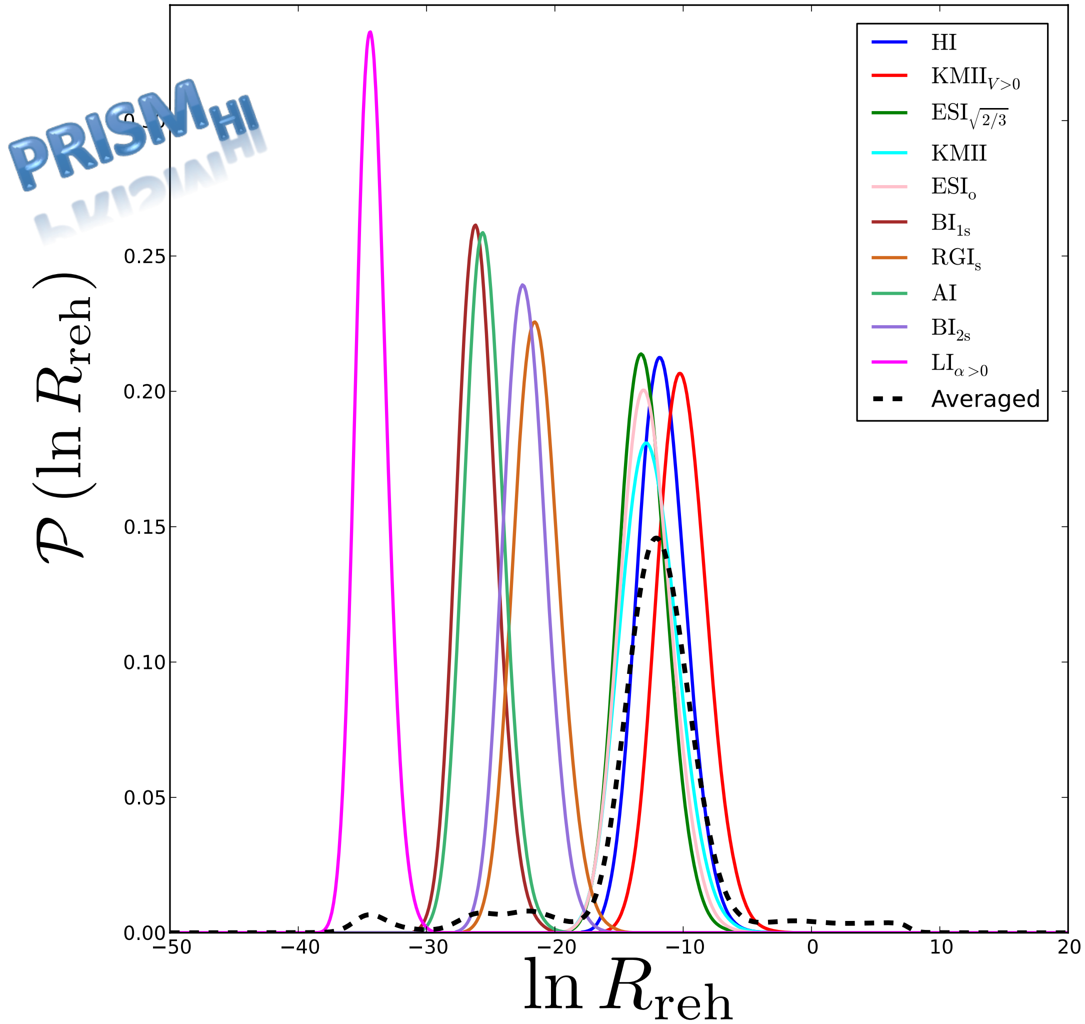
Observing the Inflationary Reheating

$$\ln R_{\mathrm{reh}} = \frac{1 - 3\bar{w}_{\mathrm{reh}}}{12\left(1 + \bar{w}_{\mathrm{reh}}\right)} \ln\left(\frac{\rho_{\mathrm{reh}}}{\rho_{\mathrm{end}}}\right) + \ln\left(\frac{\rho_{\mathrm{end}}^{1/4}}{M_{\mathrm{Pl}}}\right)$$



Observing the Inflationary Reheating

$$\ln R_{\rm reh} = \frac{1-3\bar{w}_{\rm reh}}{12\left(1+\bar{w}_{\rm reh}\right)} \ln\left(\frac{\rho_{\rm reh}}{\rho_{\rm end}}\right) + \ln\left(\frac{\rho_{\rm end}^{1/4}}{M_{\rm Pl}}\right)$$



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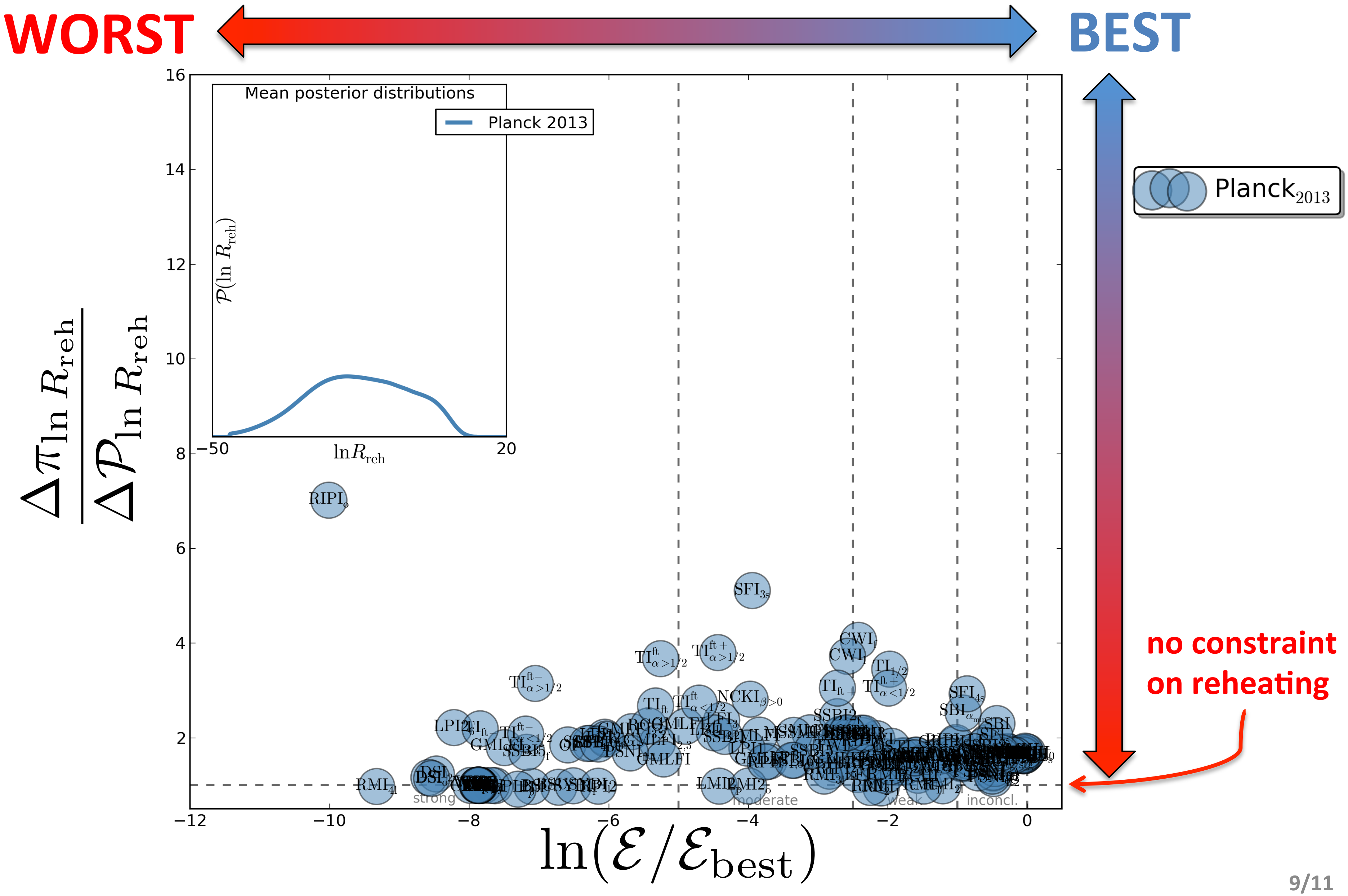
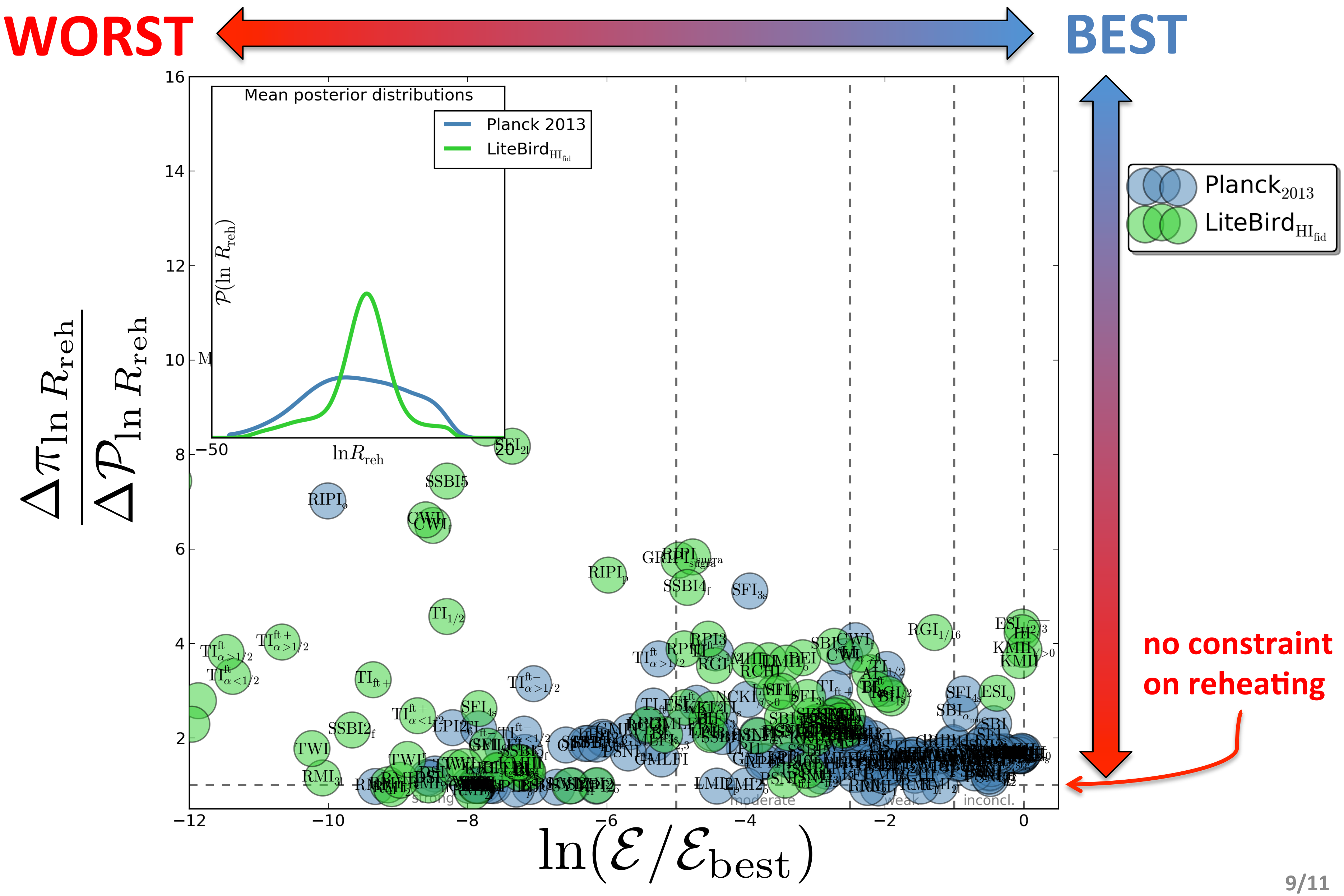
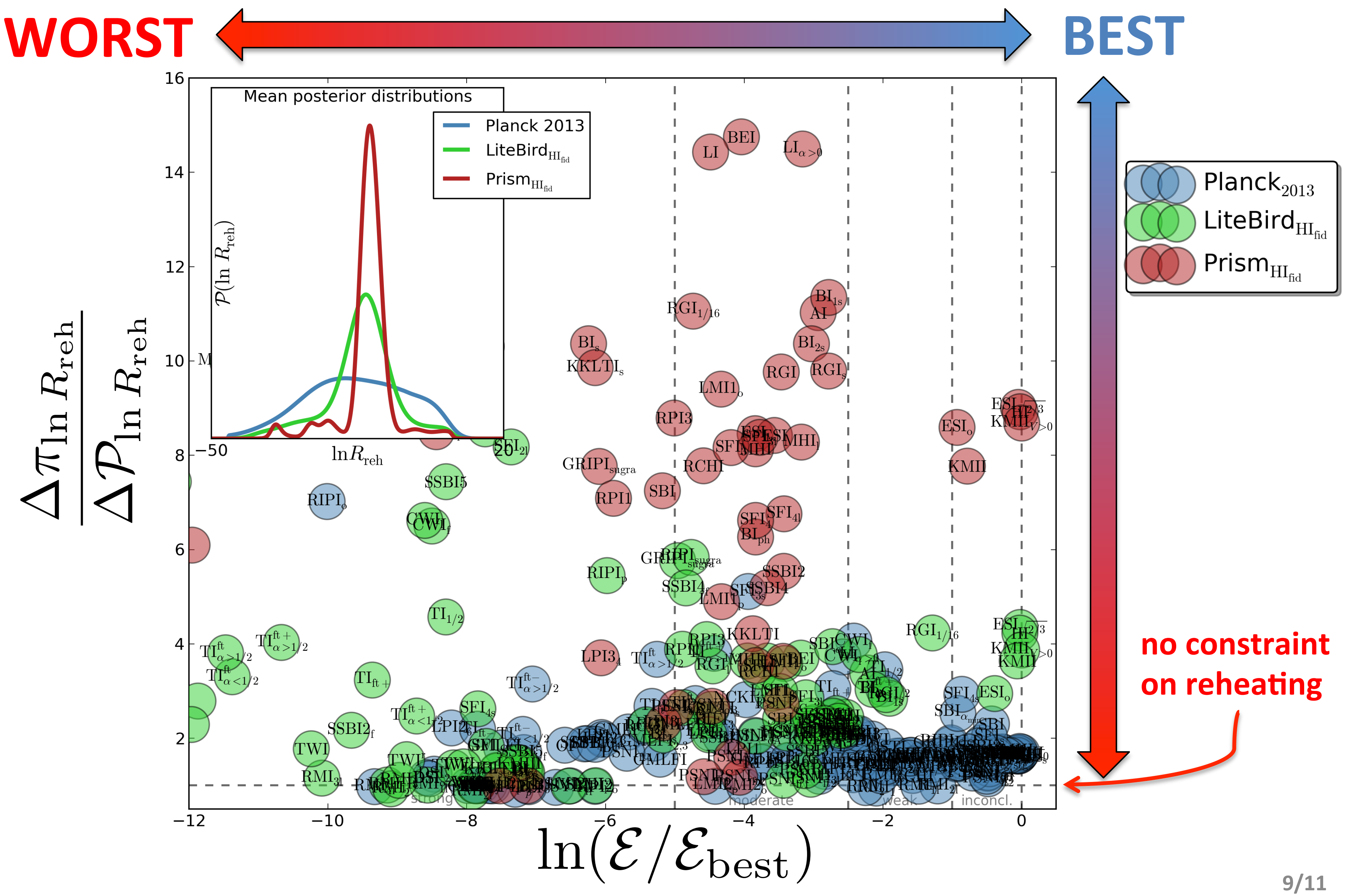


Observing the Inflationary Reheating



Observing the Inflationary Reheating



Observing the Inflationary Reheating

Constraining Power / CMB Mission	$\left\langle \dfrac{\Delta \pi_{\ln R_{\rm reh}}}{\Delta \mathcal{P}_{\ln R_{\rm reh}}} \right\rangle$	Average Reduction of prior volume
Planck2013	1.66	40%
$\text{LiteBird}_{\text{HI}}$	3.68	73%
Prism_{HI}	8.58	88%

Summary

- Future CMB missions could detect gravitational waves down to $r \sim 10^{-3}$
- High resolution surveys would measure the scalar running
- In the hardest to disambiguate situation, number of ruled out models increases from 1/3 to 3/4
- Reduction of the reheating prior volume increases from 40% to 73% (LiteBird) or even to 88% (Prism)
- Reheating now matters!