Joint 21cm **Parameter Constraints** with Emulators

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Science at Low Frequencies III
December 9th, 2016

Image: Alvarez et al. 2009

How do we interpret a 21cm power spectrum detection?

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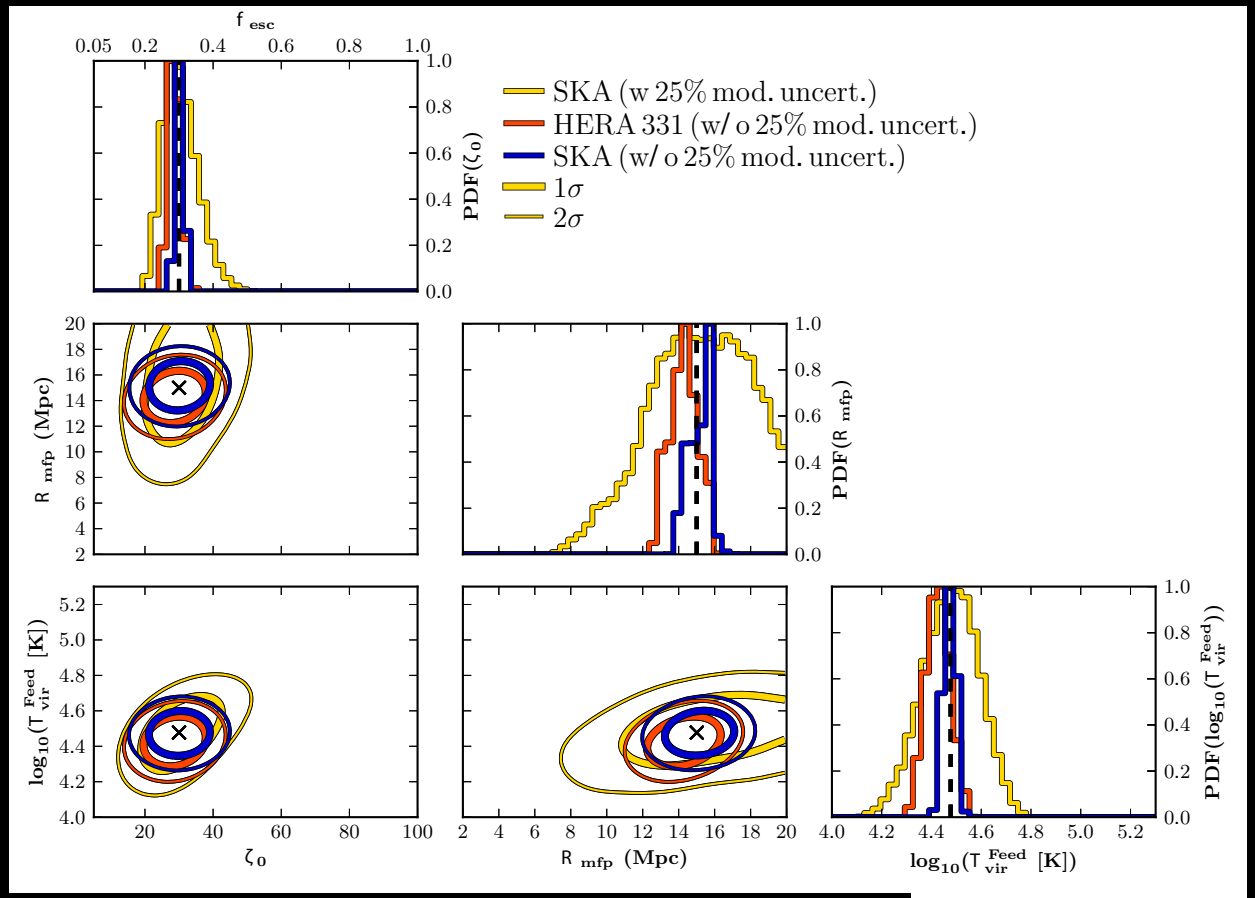
Start with a three parameter model for reionization



$R_{\rm mfp}$

$T_{\rm vir}$

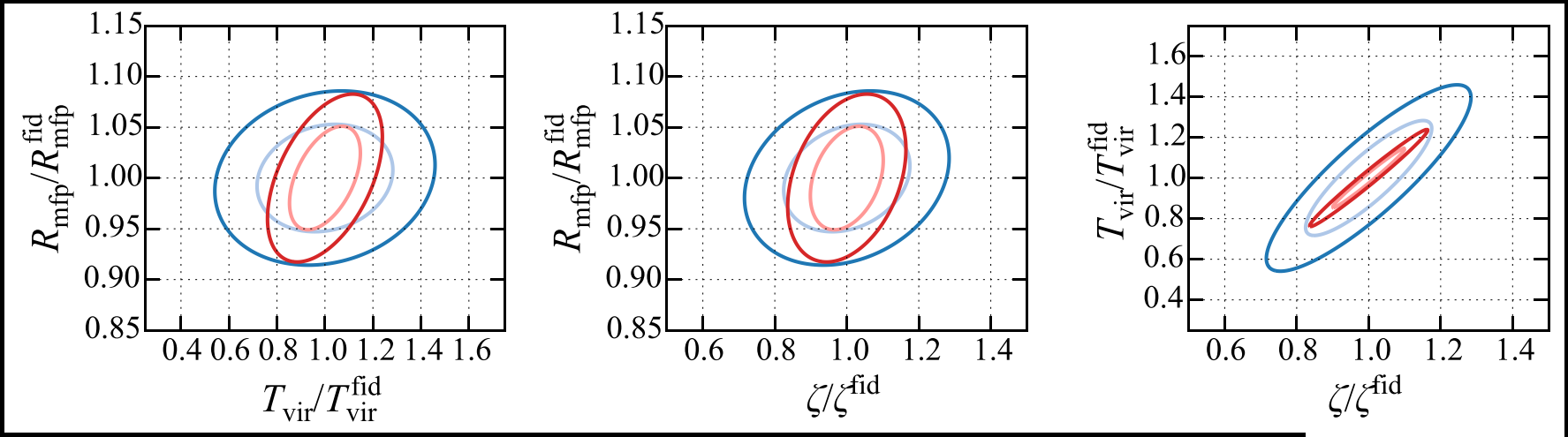
ζ

$R_{\rm mfp}$

Greig et al. 2016

How do we interpret a 21cm power spectrum detection?

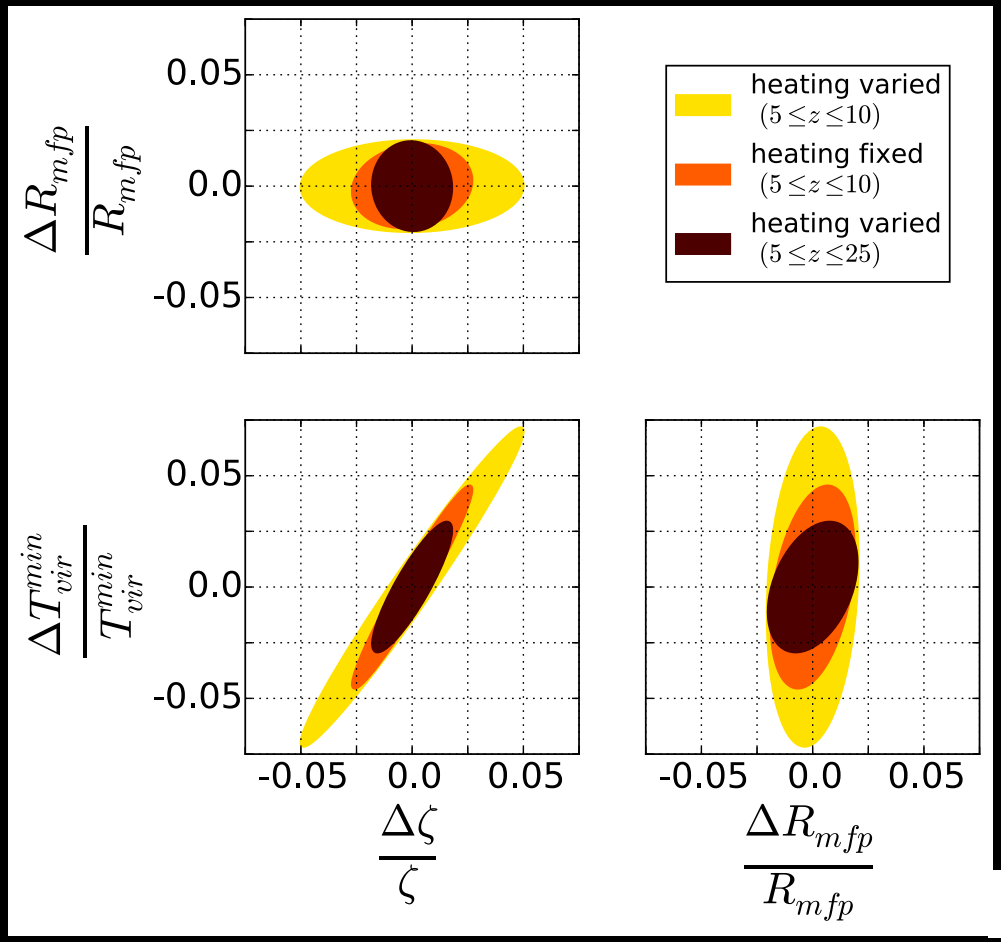
Cannot ignore cosmology



Liu et al. 2016

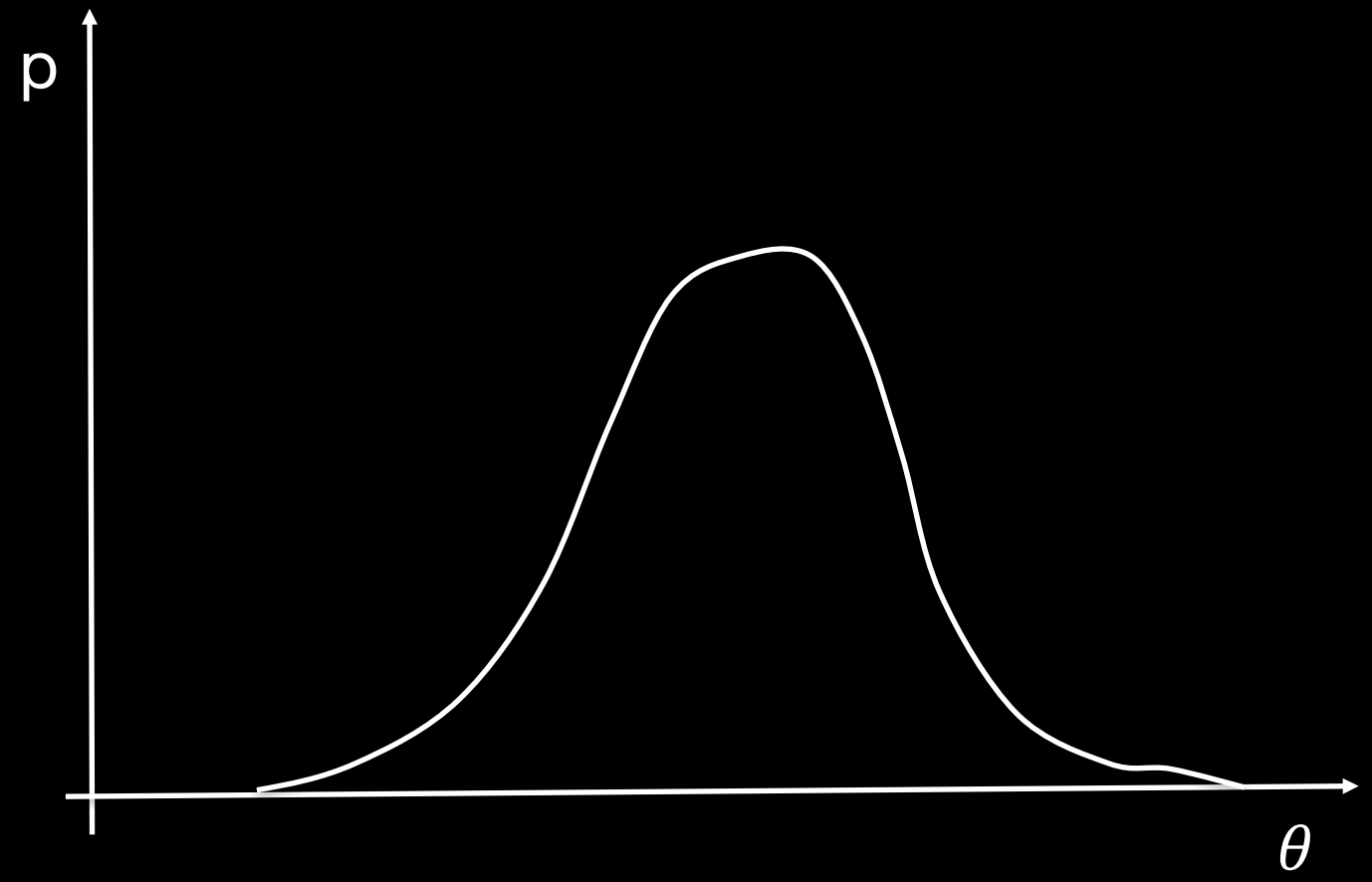
How do we interpret a 21cm power spectrum detection?

Should not ignore IGM heating



Ewall-Wice et al. 2016

Emulators Approximate the Likelihood



Emulators Approximate the Likelihood

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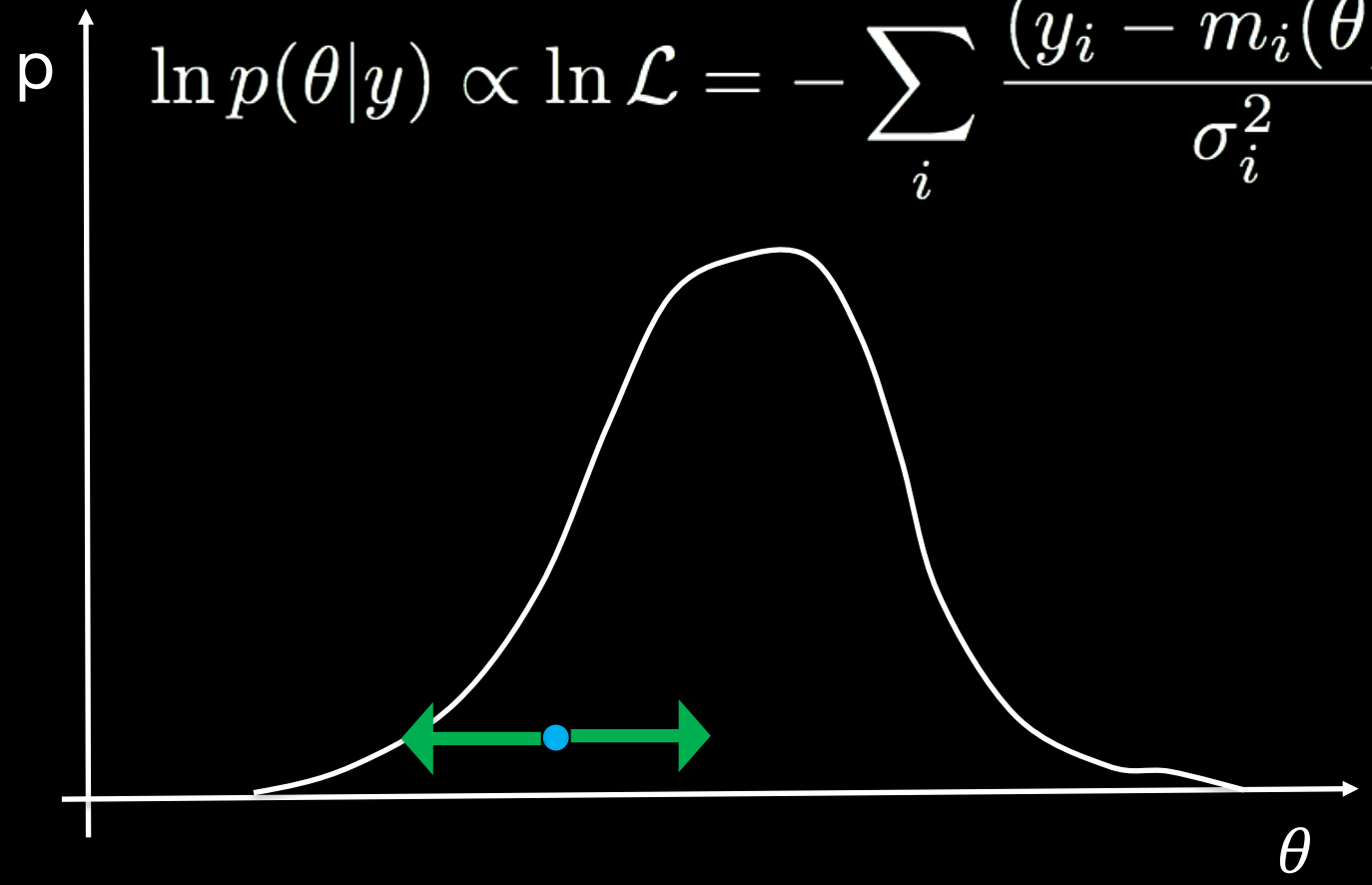

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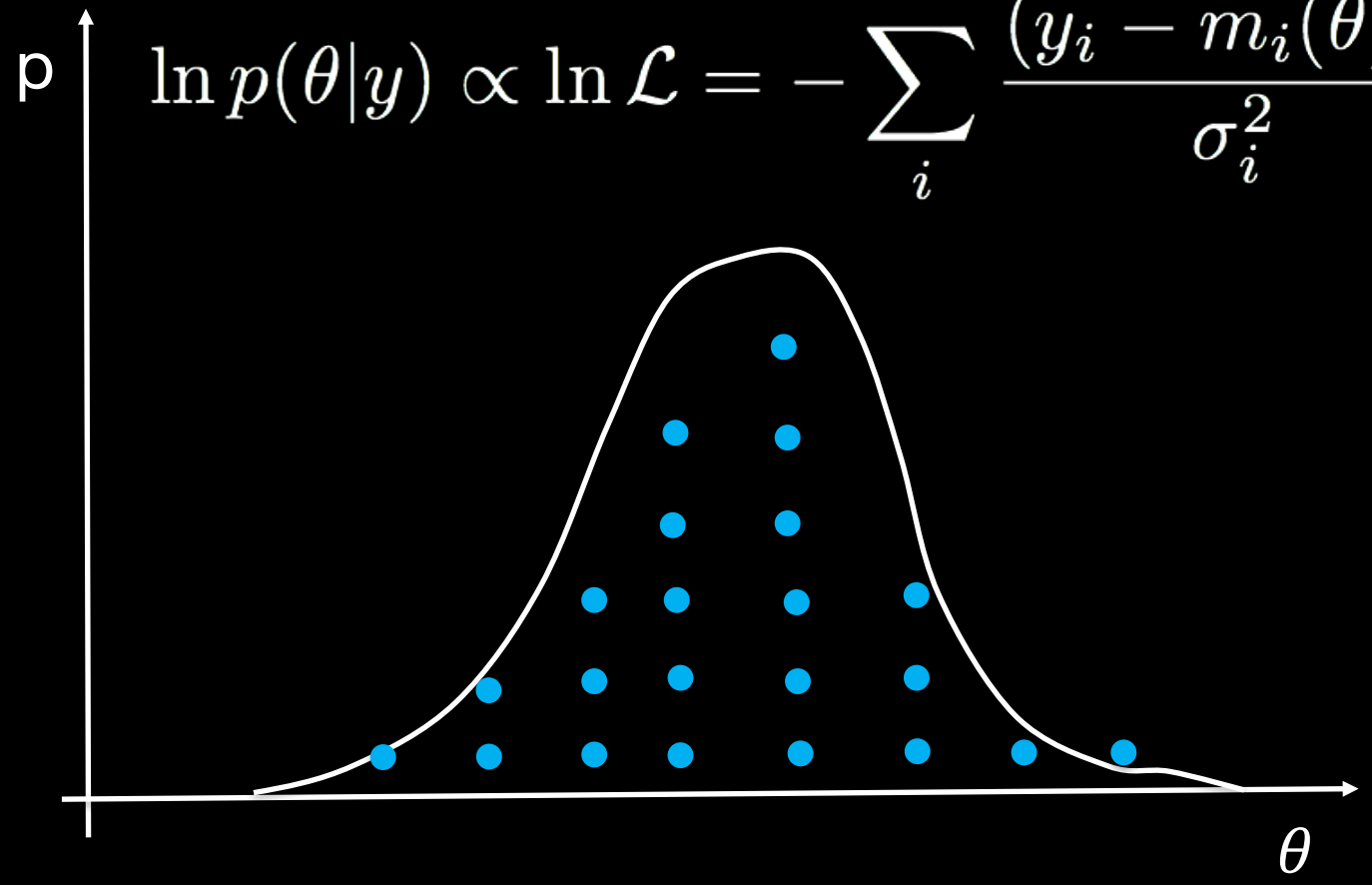

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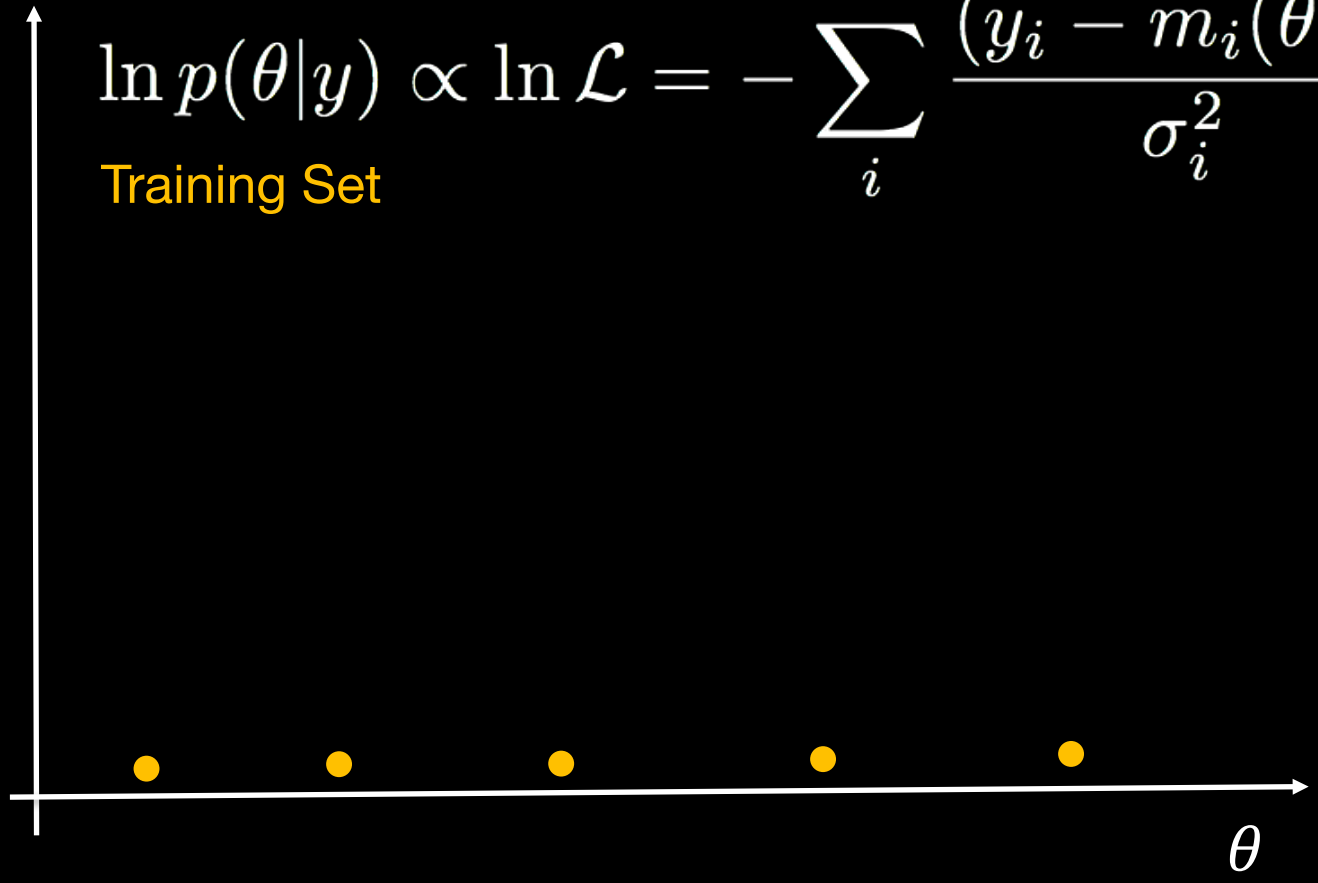
Training Set



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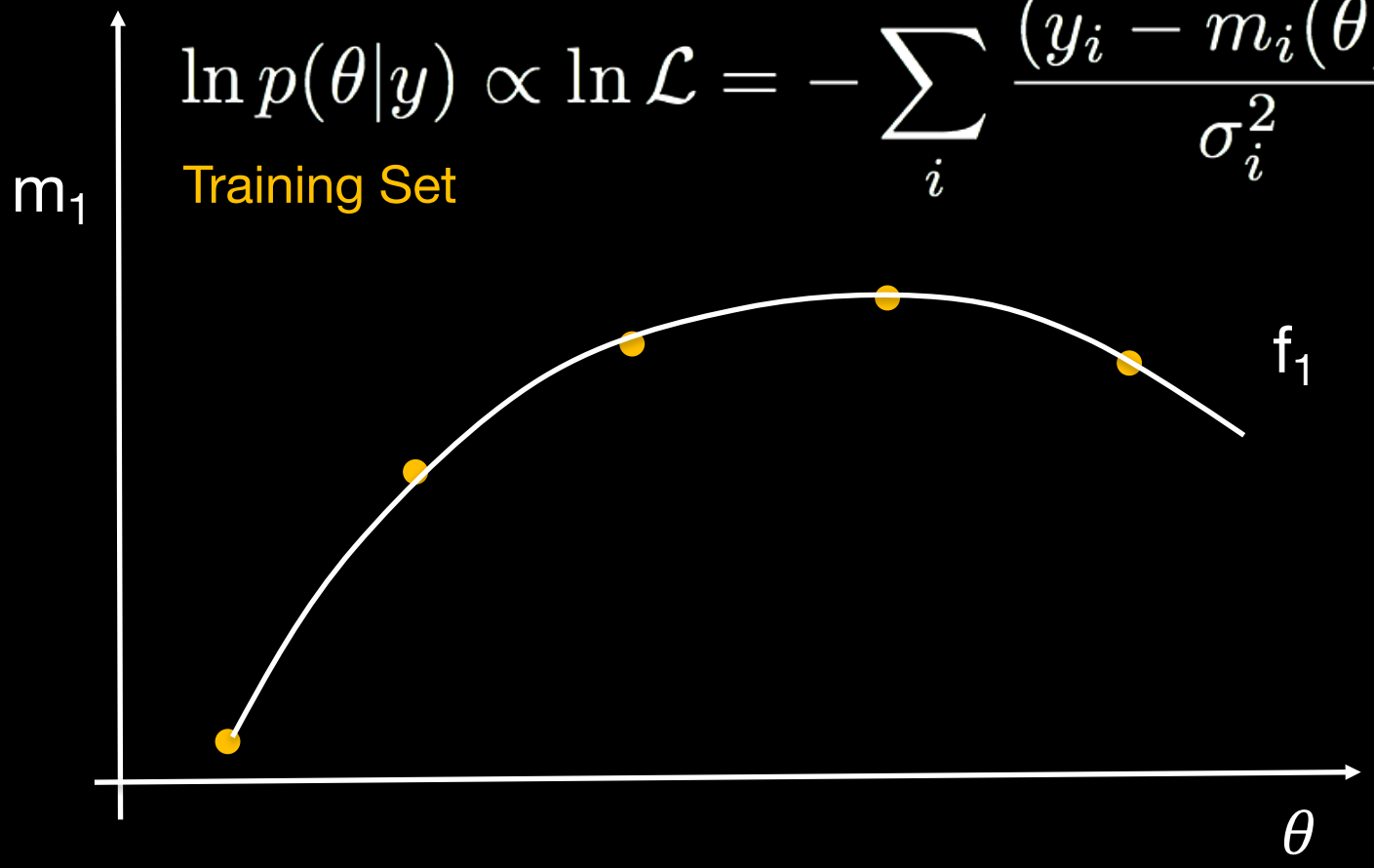

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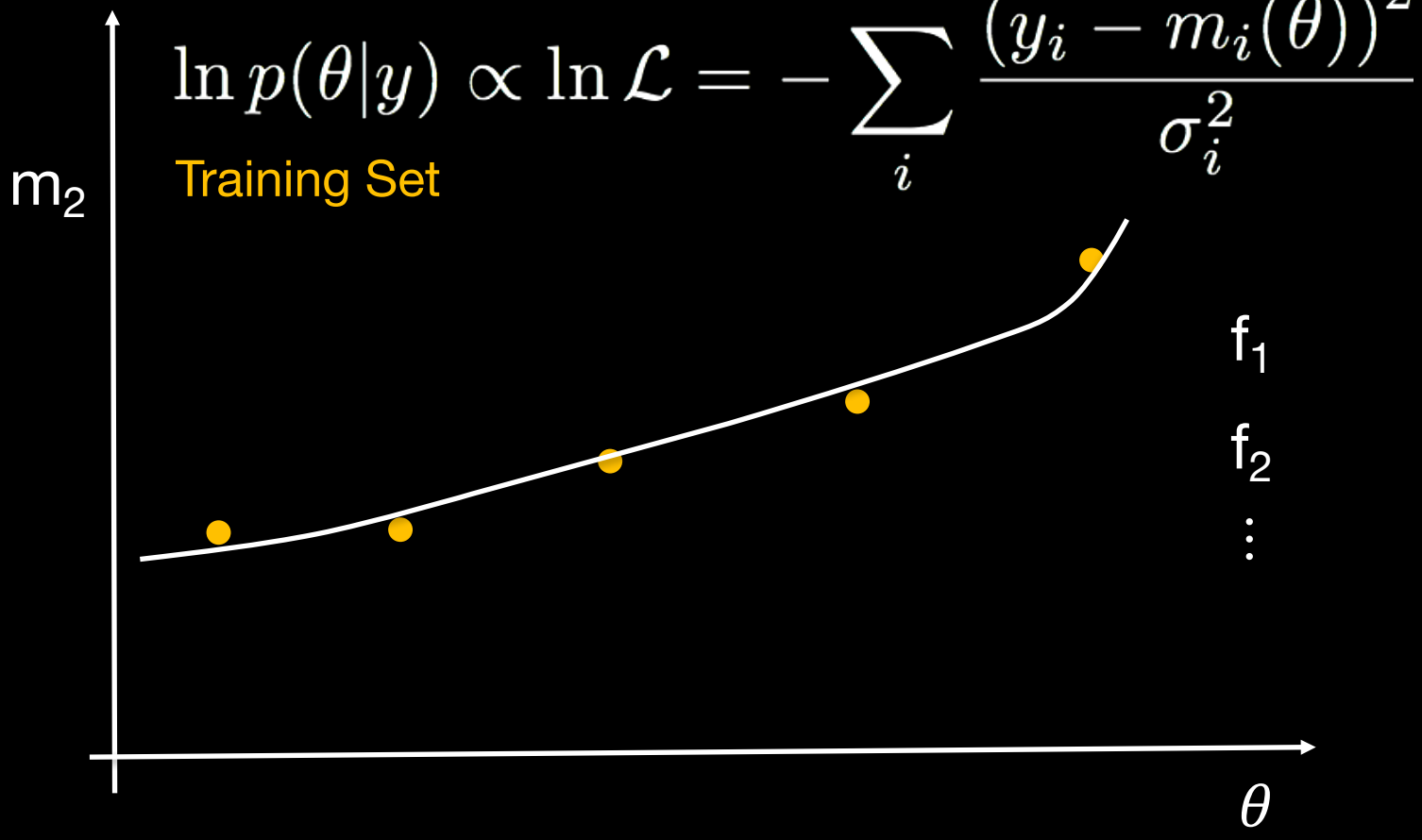

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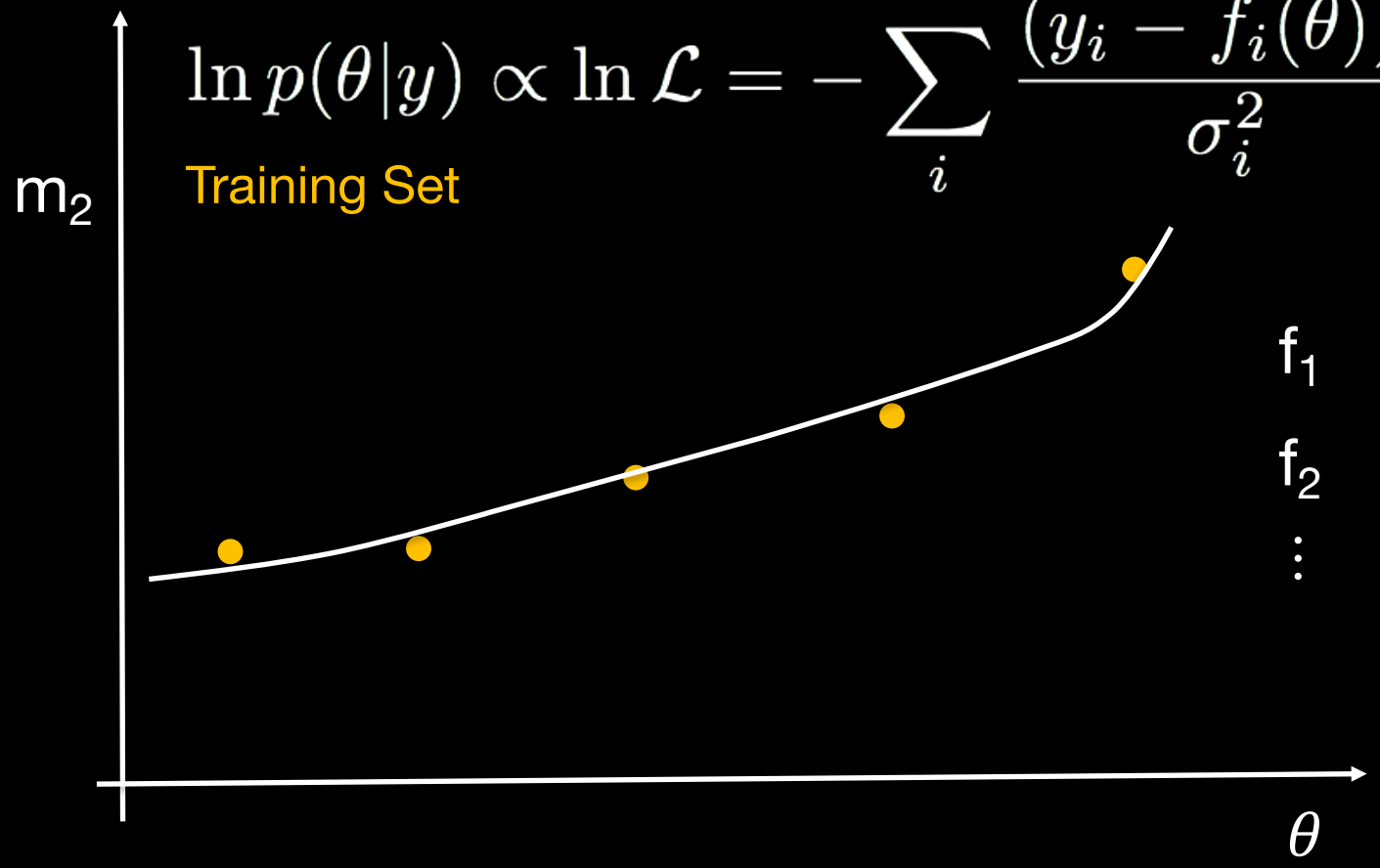

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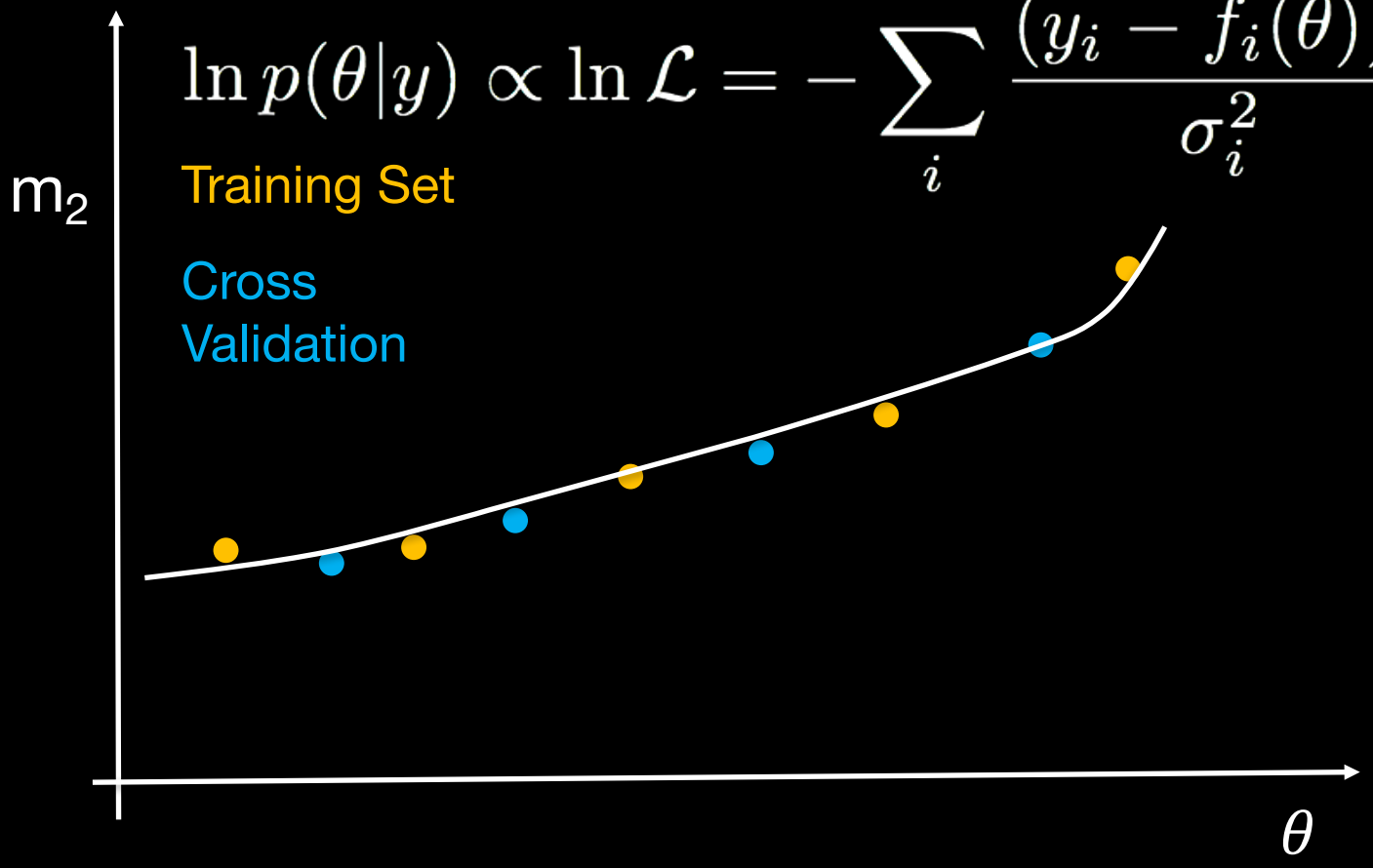

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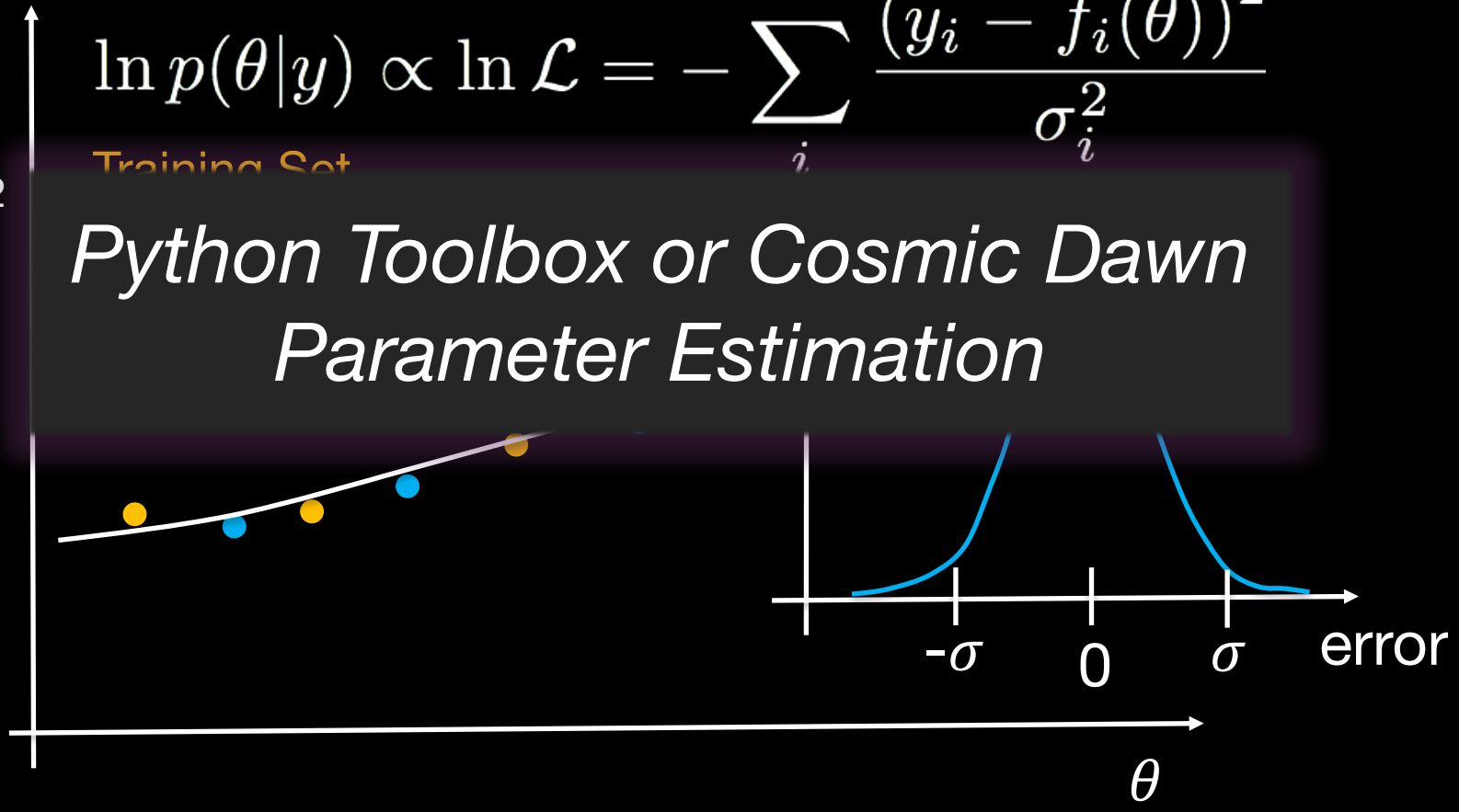
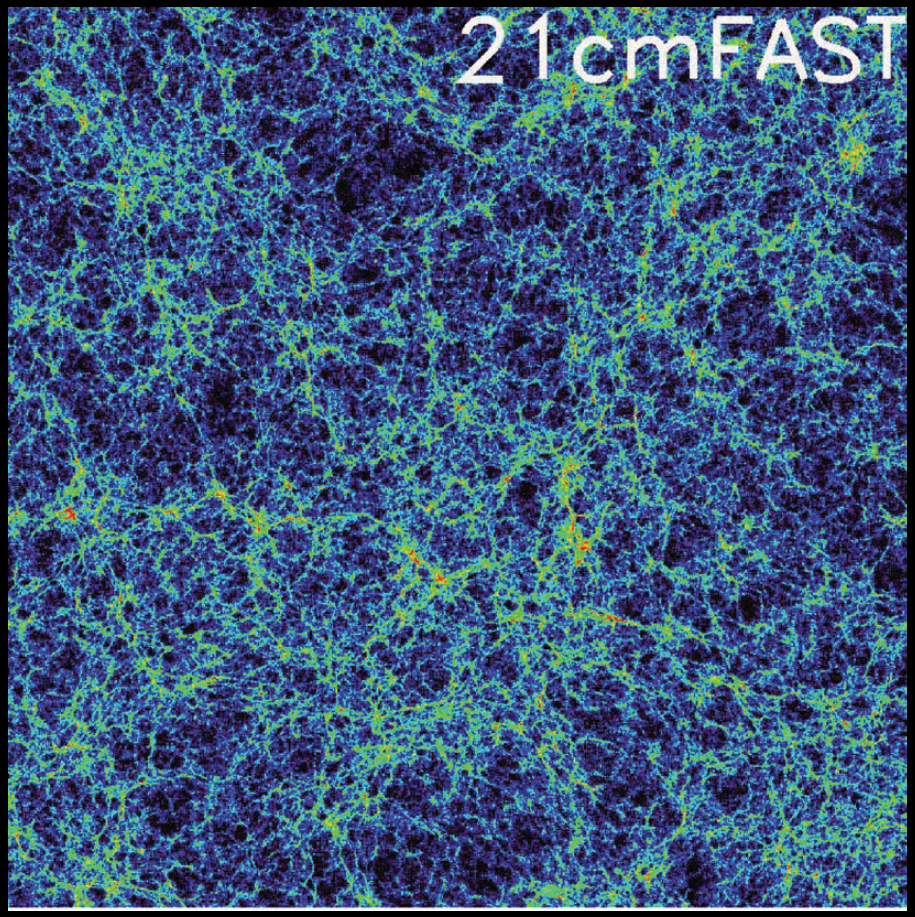
Training Set

Python Toolbox or Cosmic Dawn Parameter Estimation



HERA Parameter Constraint Forecast via Emulation of *21cmFAST*

Training on EoR Simulations



Mesinger et al. 2011

L_{BOX} = 400 cMpc
L_{CELL} = 2 cMpc

Parameters of Interest

Astrophysics

- Ionization Efficiency: ζ
- Mean-free path of UV photons: R_{MFP}
- Min. Virial Temp. of SF Halos: T_{VIR}
- X-ray Efficiency: f_X
- X-ray Spectral Index: α_X
- X-ray Cutoff Frequency: ν_{min}

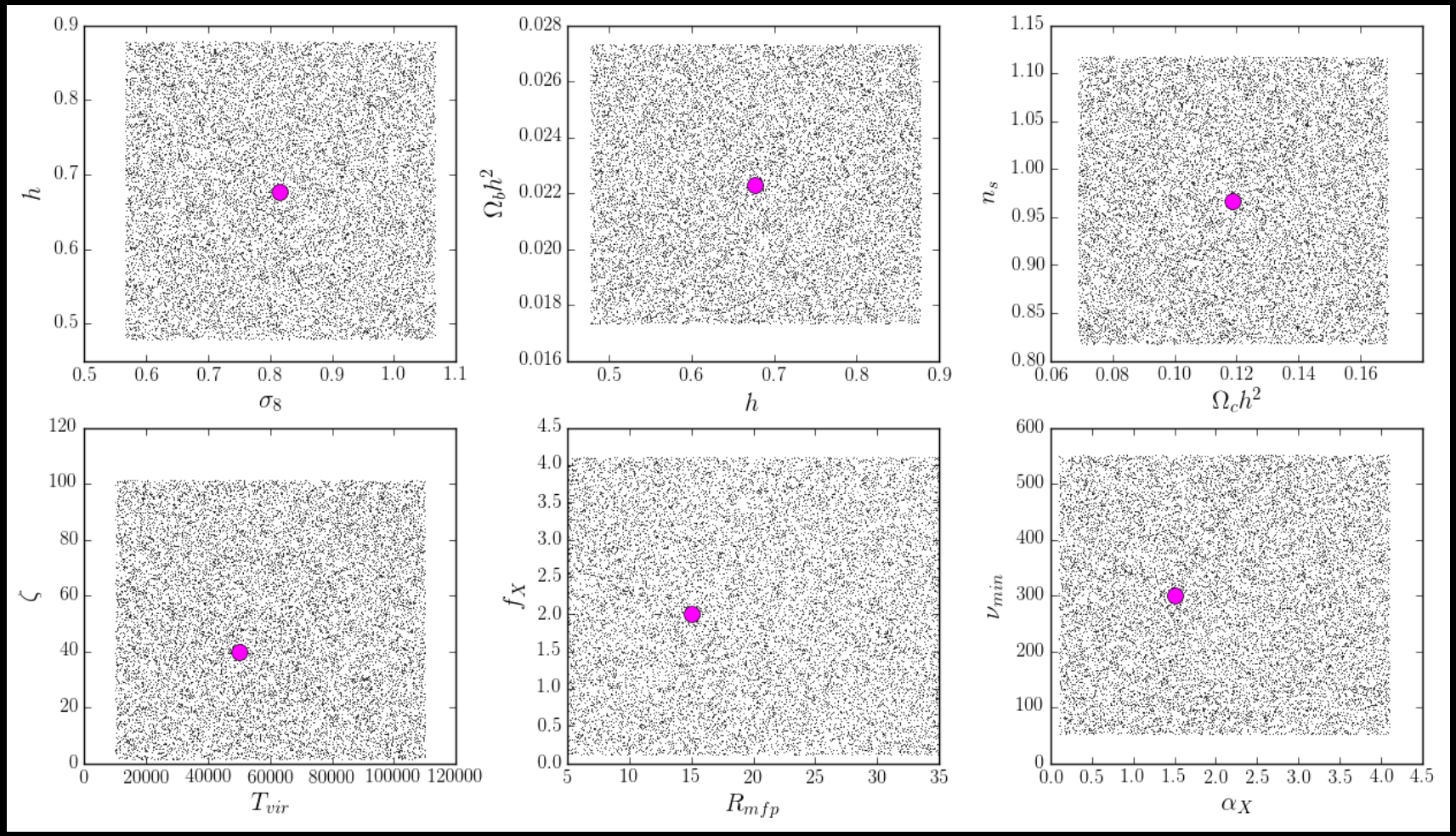
flat priors

Cosmology

- Clustering Amplitude: σ_8
- Primordial PS Slope: n_s
- CDM Fraction: $\Omega_c h^2$
- Baryon Fraction: $\Omega_b h^2$
- Hubble Constant: H_0

planck priors

Emulation of Power Spectra at Percent-Level Accuracy



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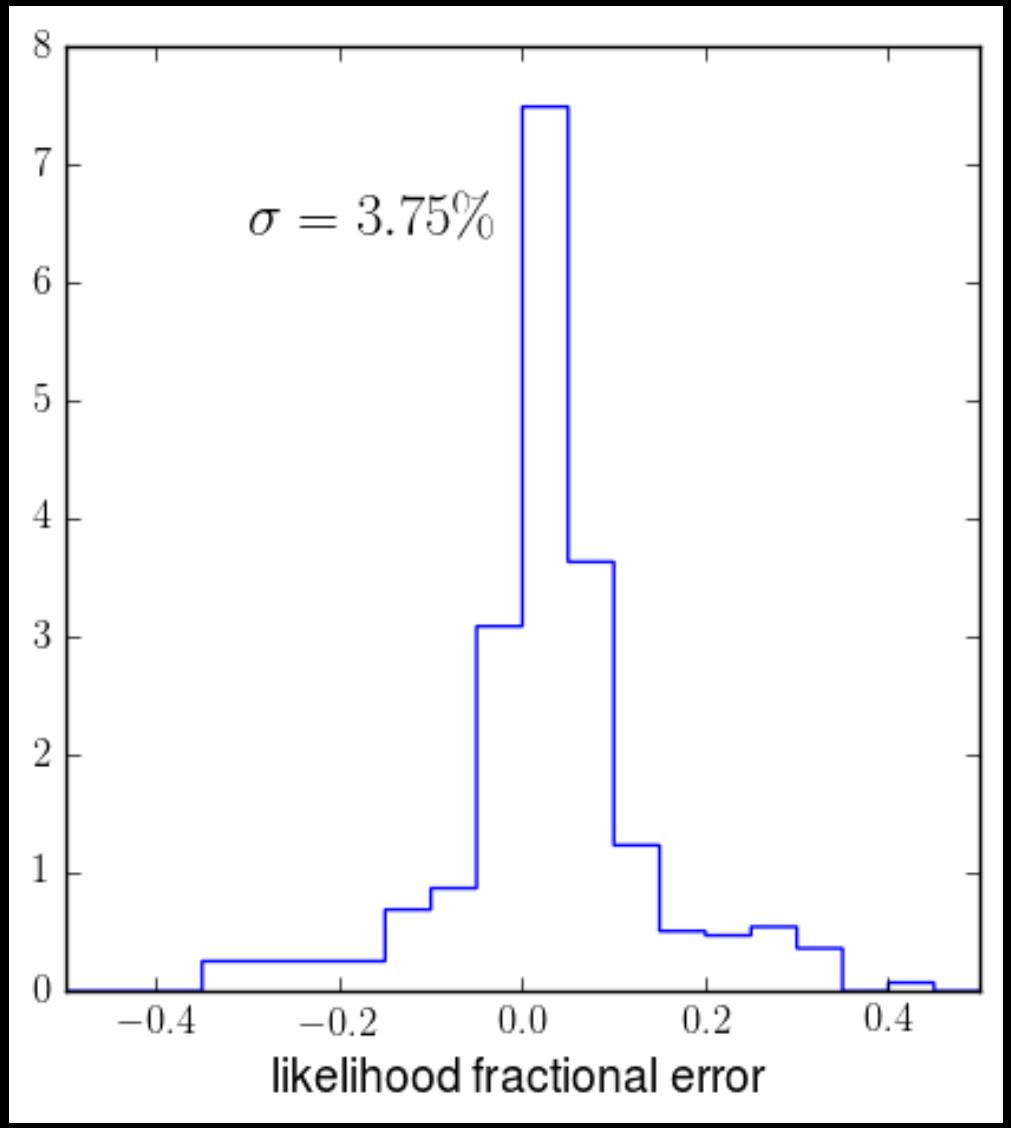
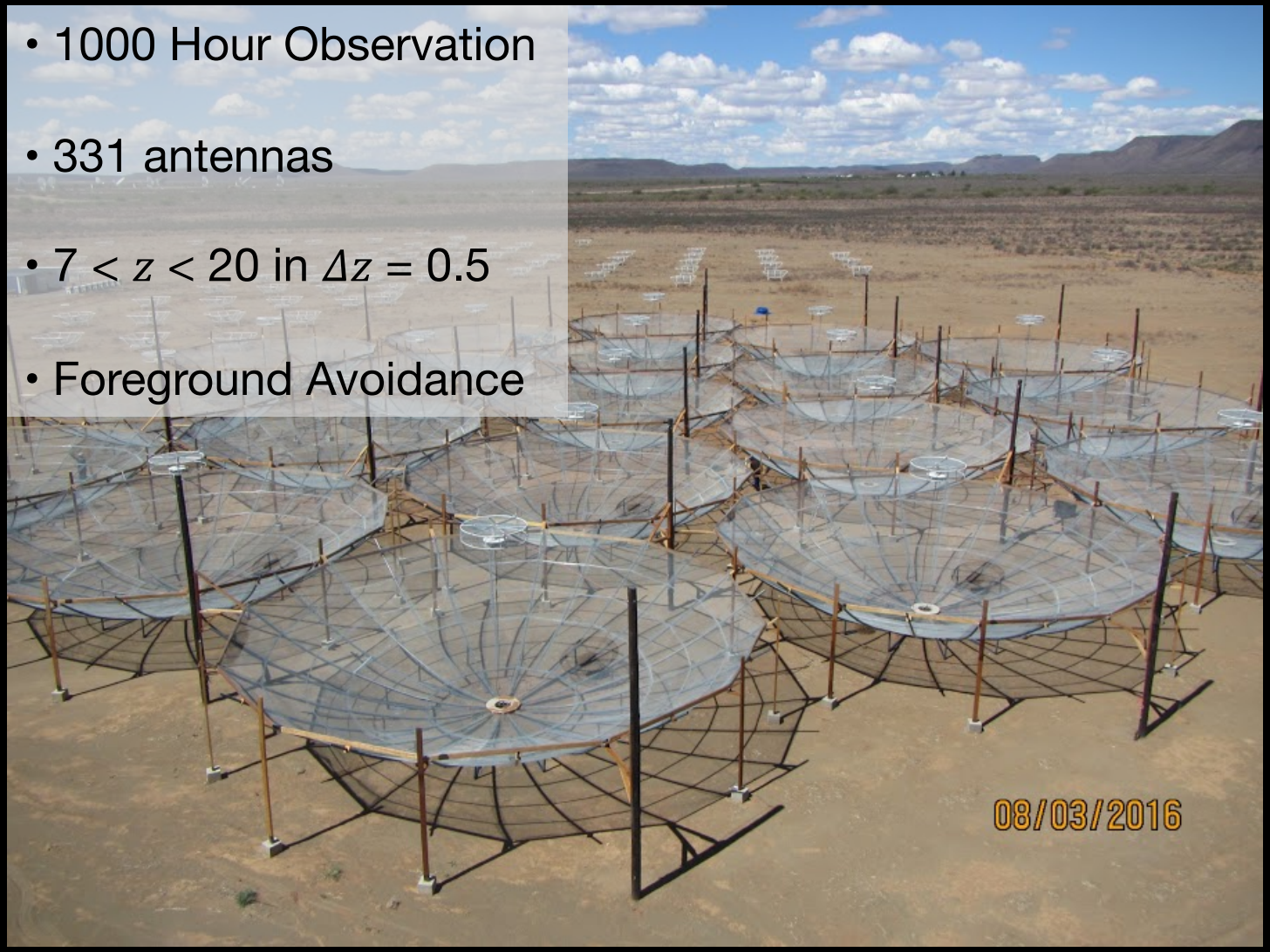
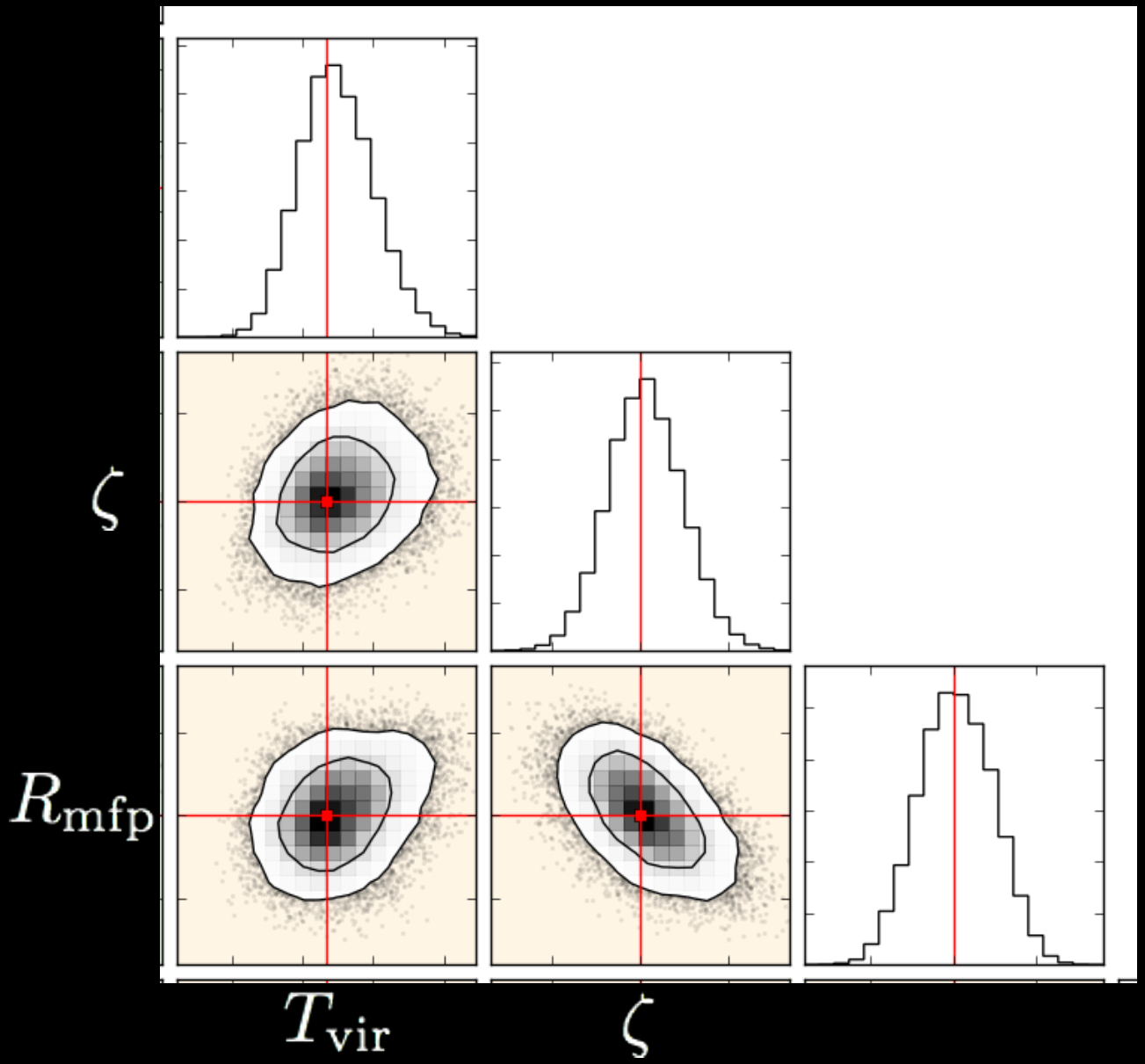


HERA331 Power Spectrum Mock Observation

- 1000 Hour Observation
- 331 antennas
- $7 < z < 20$ in $\Delta z = 0.5$
- Foreground Avoidance

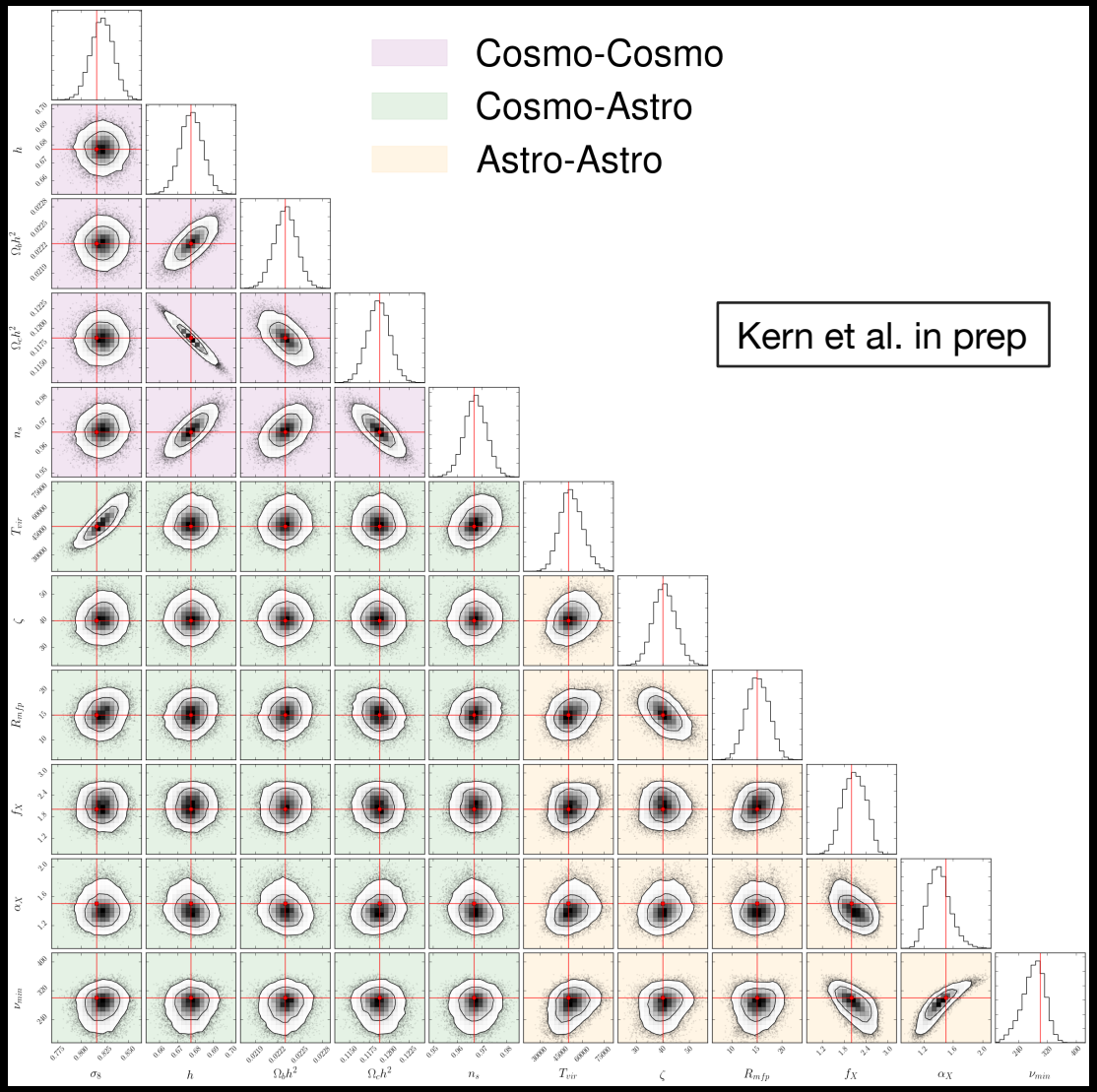


HERA Joint Posterior Distribution

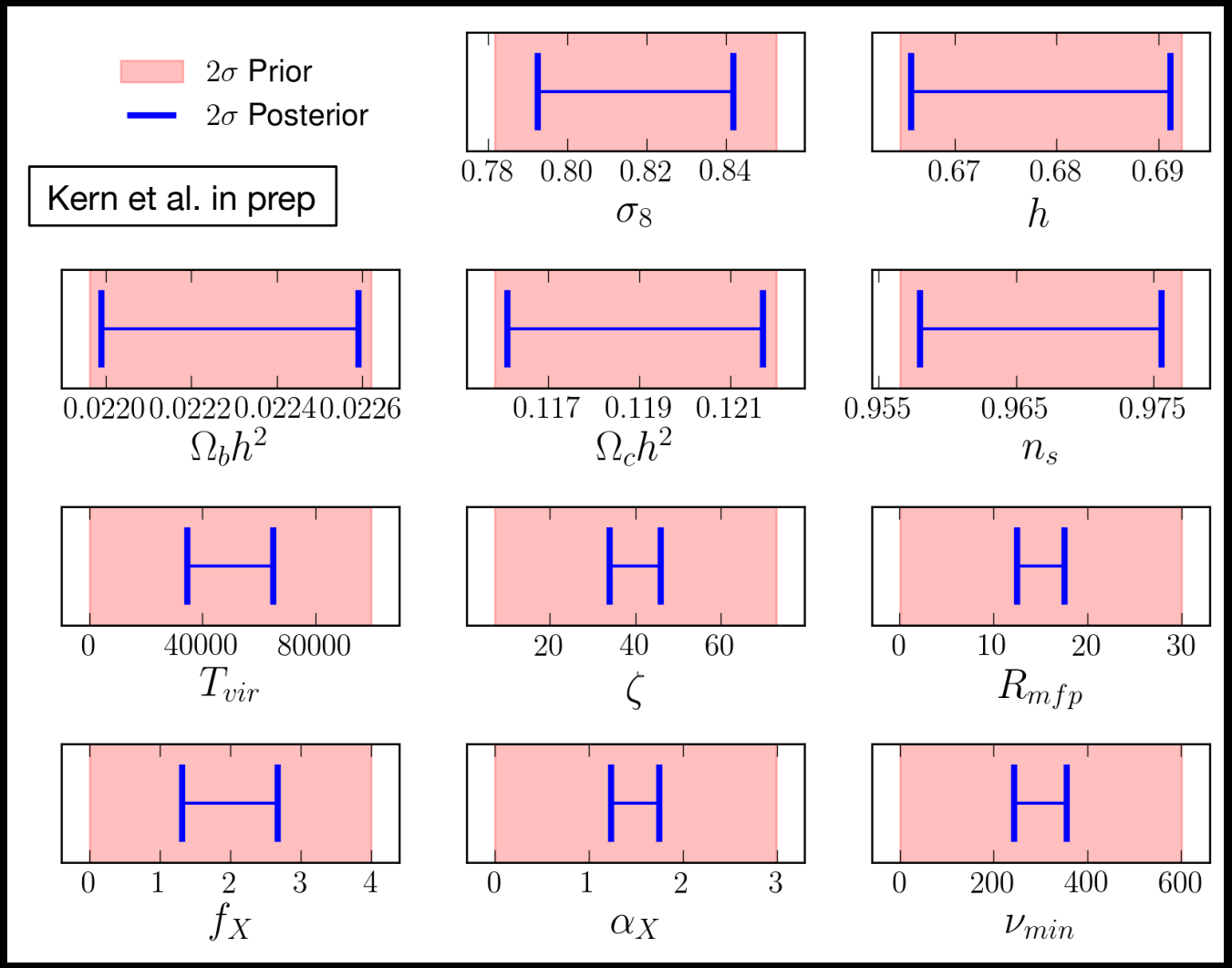


HERA Joint Posterior Distribution

σ_8
h
$\Omega_b h^2$
$\Omega_c h^2$
n_s
$T_{\rm vir}$
ζ
$R_{\rm mfp}$
f_X
α_X
ν_{min}



HERA Marginalized Posterior Widths



Take-Away Points

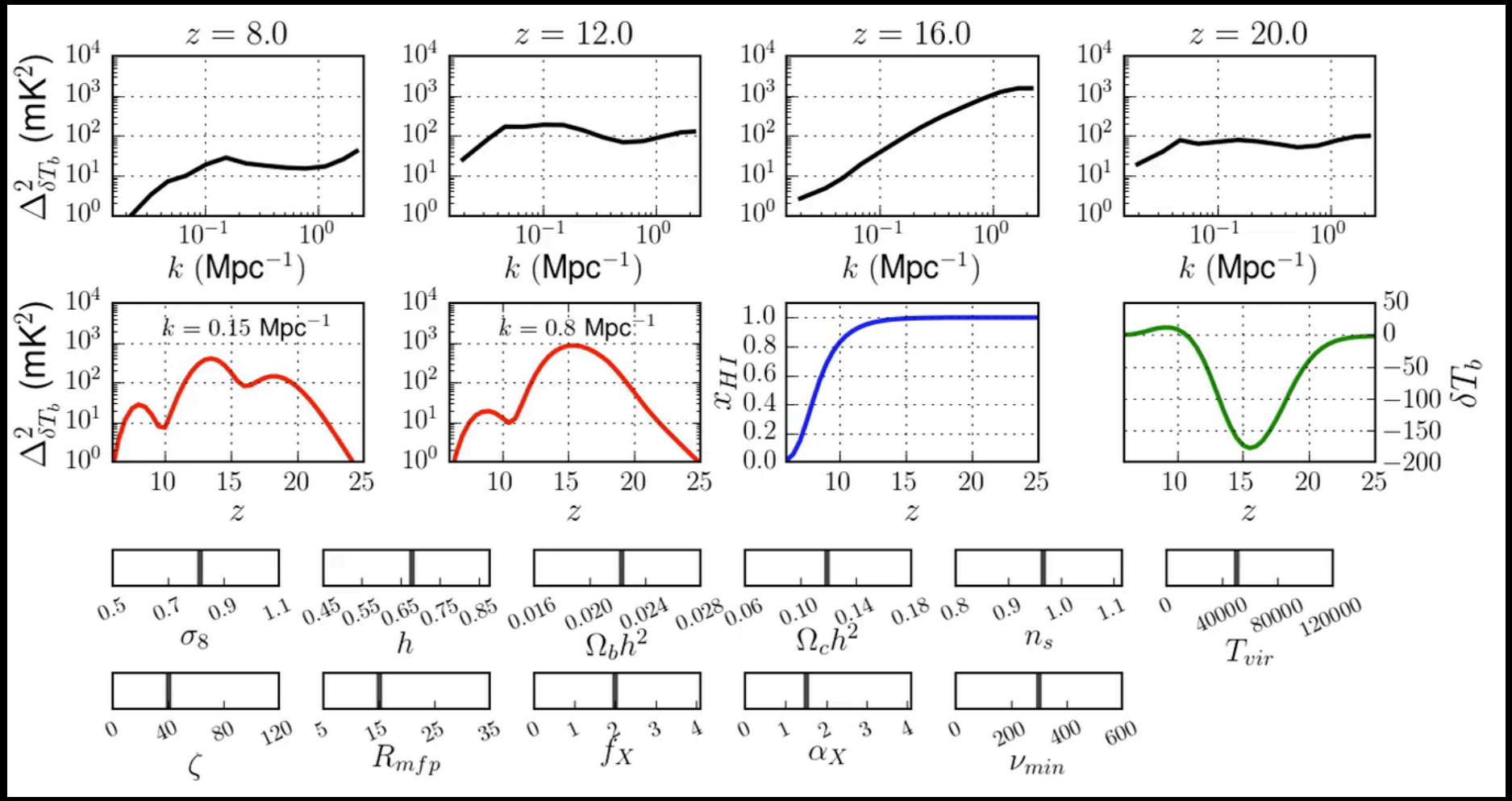
1 Emulators allow us to use more accurate simulations for full MCMC sampling of the posterior distribution

2 Emulators are generalizable to *any* simulation

3 HERA is predicted to put significant constraints on astrophysical parameters governing reionization and the heating epoch

4 The *Python Toolbox for Cosmic Dawn Parameter Estimation* will soon be a publicly available package!

Gaining Intuition



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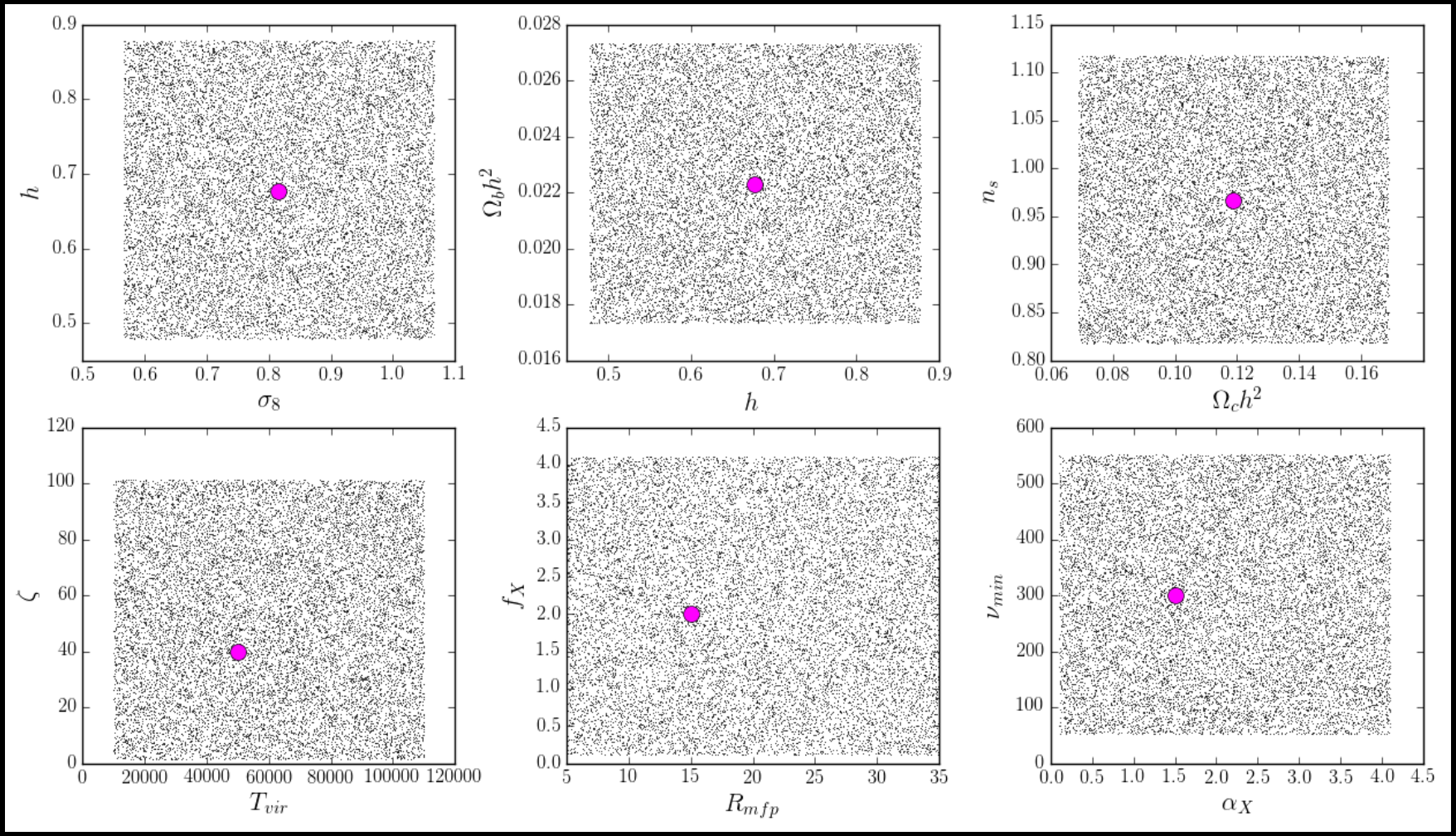

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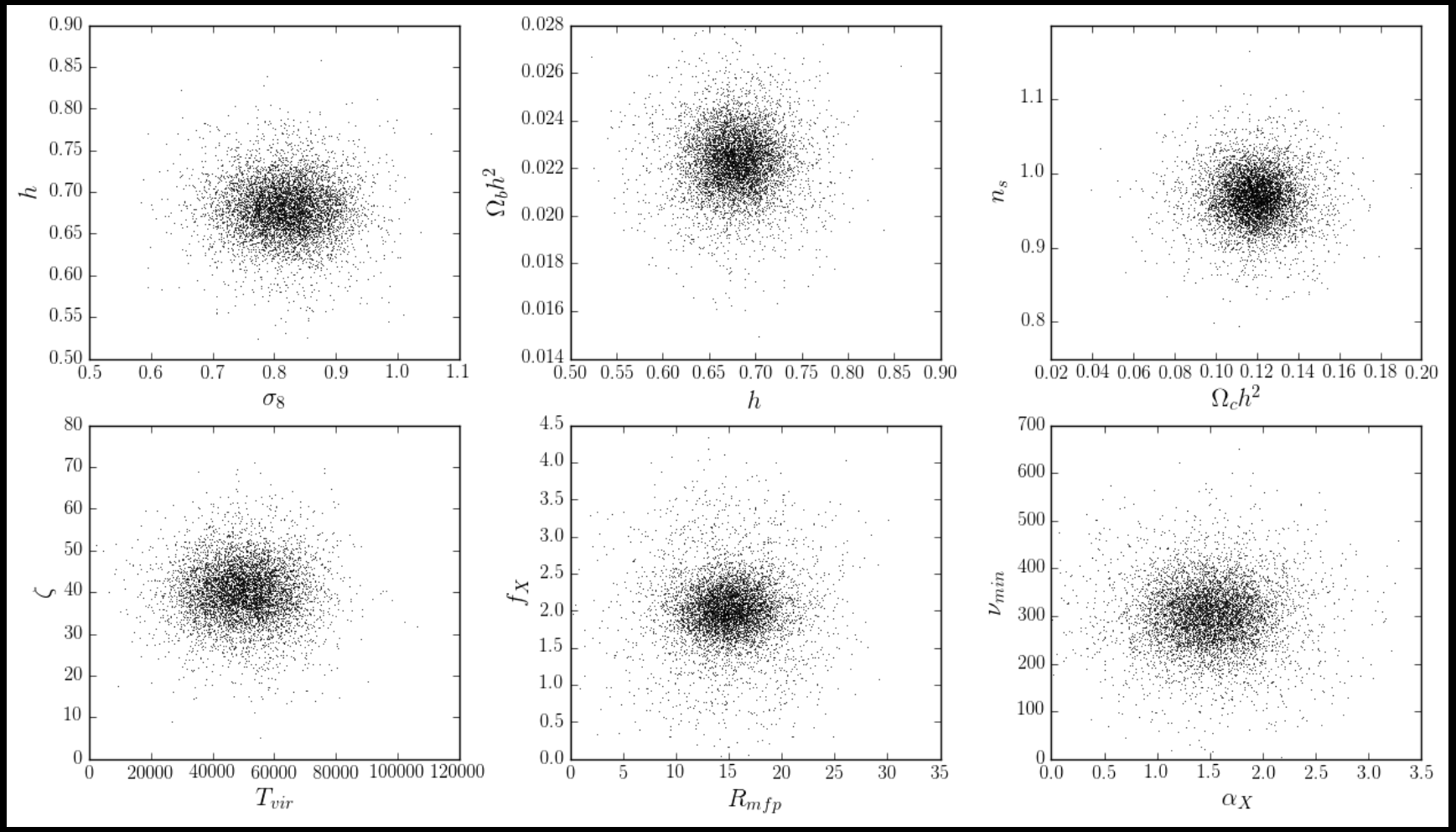
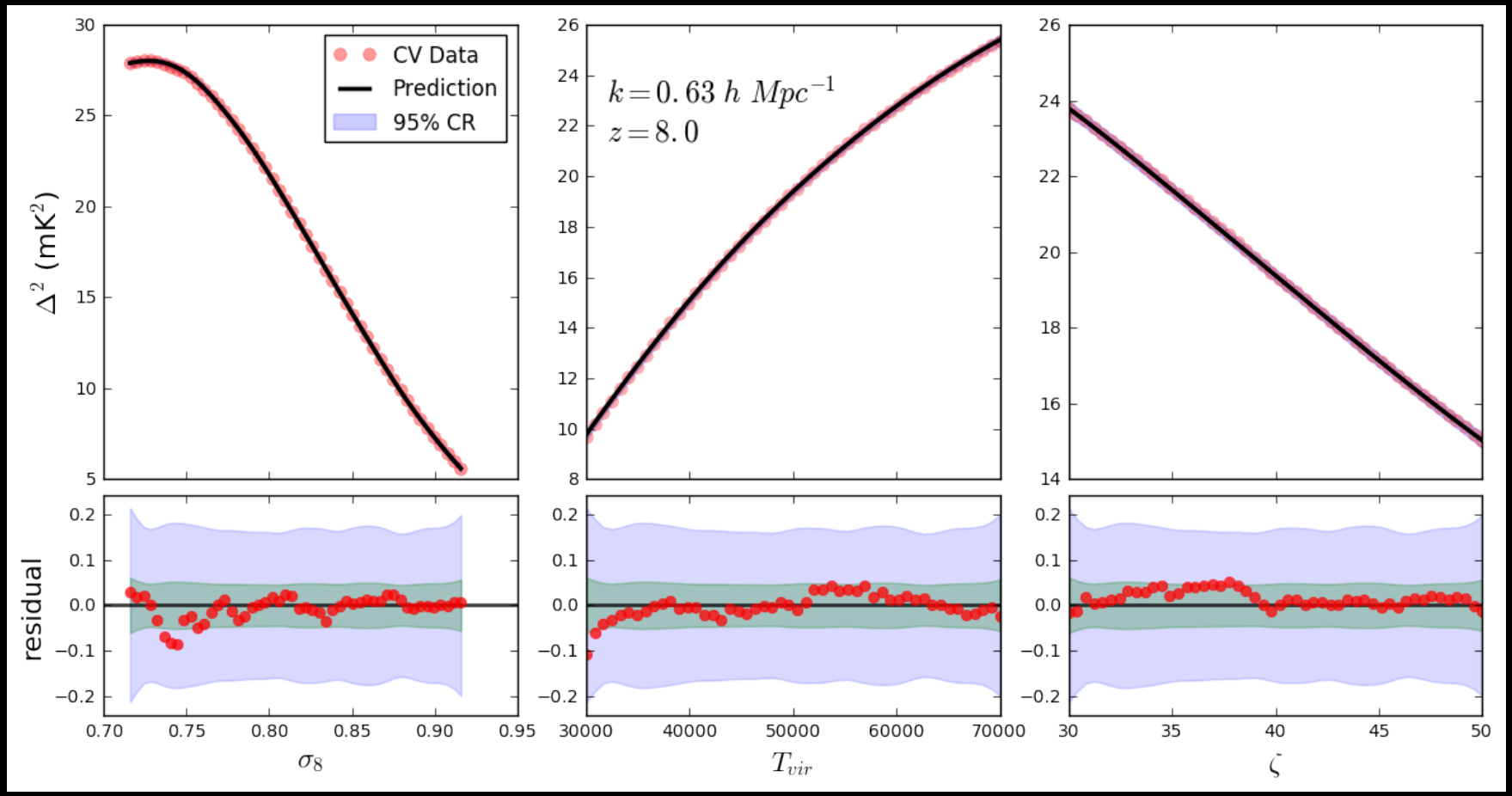
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