

Starobinsky in Stereo: SKA-CMB Synergies with SBI

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Goal:

- Science: Use SKA EoR 21 cm tomography to constrain inflation (Starobinsky) jointly with EoR astrophysics, and quantify synergy with Planck.
- Why SBI: 21 cm light cones are high-dimensional and non-Gaussian. ML can capture more information and enable simple joint inference.

Data:

- 9 Parameters:
Inflation: M, N_\star
Cosmology: $\Omega_m, \Omega_{\text{CDM}}, h, \tau_{\text{reio}}$
Astrophysics: $\zeta, T_{\text{vir}}, L_X, E_0$
- SKA: Mock SKA1-Low $z = 5 - 35$ with 21cm Sense
- Planck: high ℓ C_ℓ^{TT} with plik

Method:

- Couple CLASS and 21cmFAST to include Inflation
- NPE with conditional flow matching
- Estimate the quality of the summary with mutual information
- Validate with statistical tests (SBC, TARP)

SKA's EoR 21 cm tomography can deliver Planck-competitive constraints on Starobinsky inflation and Cosmology — when we use neural simulation-based inference to unlock non-Gaussian information.

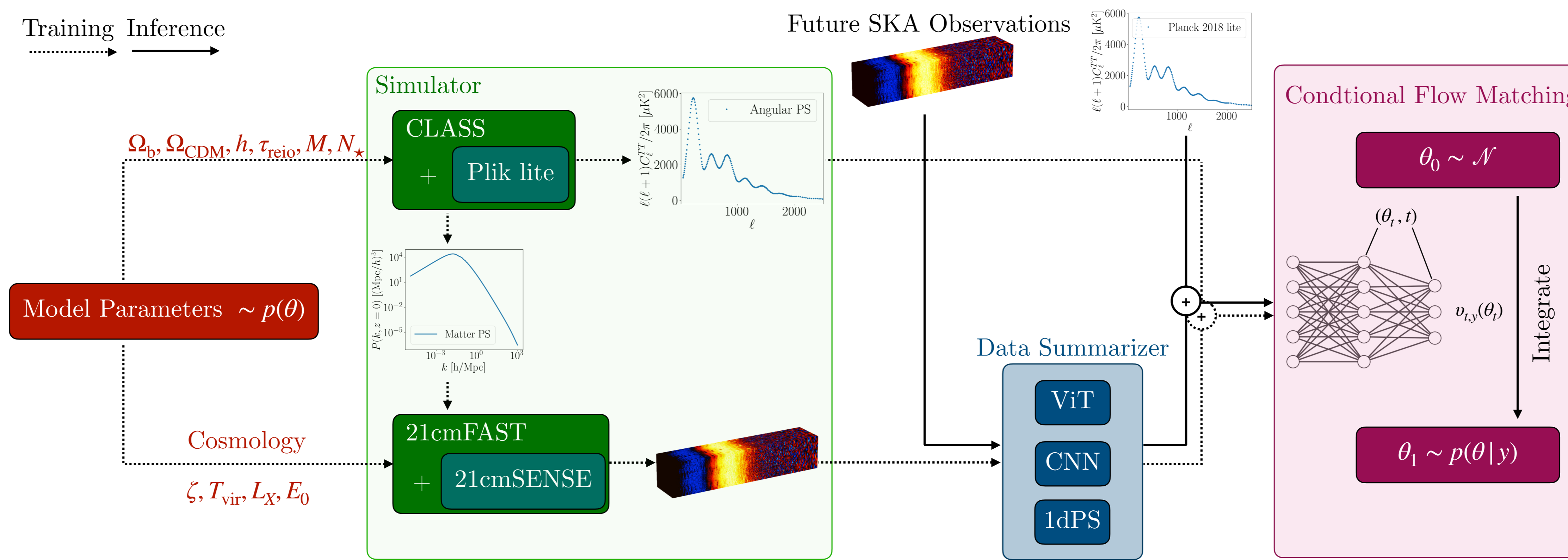
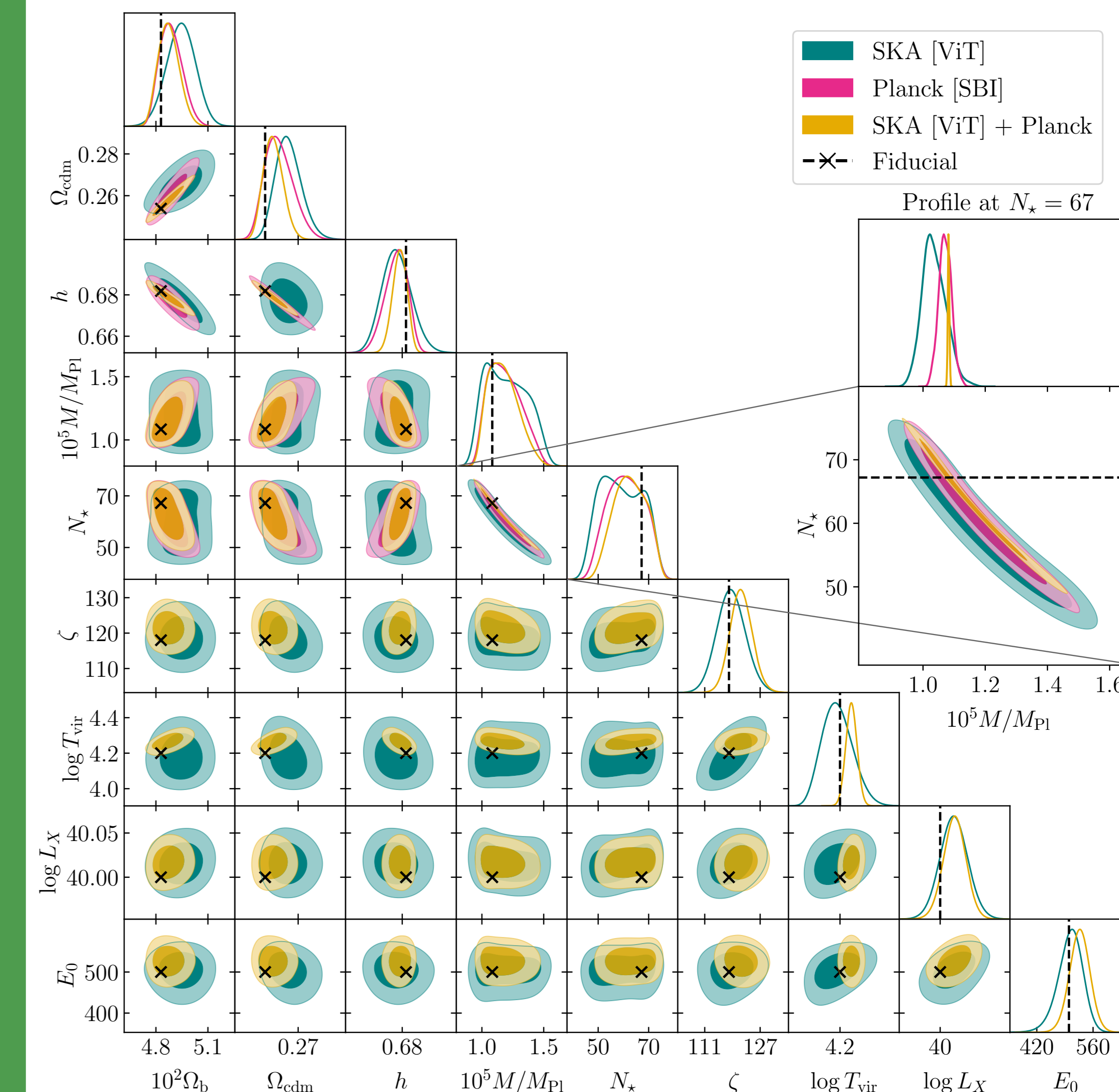
- SKA + Planck tightens inflation + reionization jointly.
- Up to $\sim 9\times$ tighter profiled constraint on Starobinsky mass parameter (vs. Planck alone).
- ViT/CNN summaries $> P(k)$ in mutual information

Results:

$$\text{MI}(\theta, T(y)) = \mathbb{E} \left[\log \frac{p(\theta | T(y))}{p(\theta)} \right]$$

Summary	MI \uparrow
1dPS	11.202 ± 0.082
CNN	14.712 ± 0.077
VIT	15.882 ± 0.087

- Forecasted Constraints:
SKA is competitive with Planck for Cosmology (except Ω_b)
Planck helps with constraints on EoR parameters



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Pipeline \longrightarrow