- Starobinsky-like models of inflation
- Impact of BICEP2
- Effect of HDOs in inflation

Starobinsky-like models

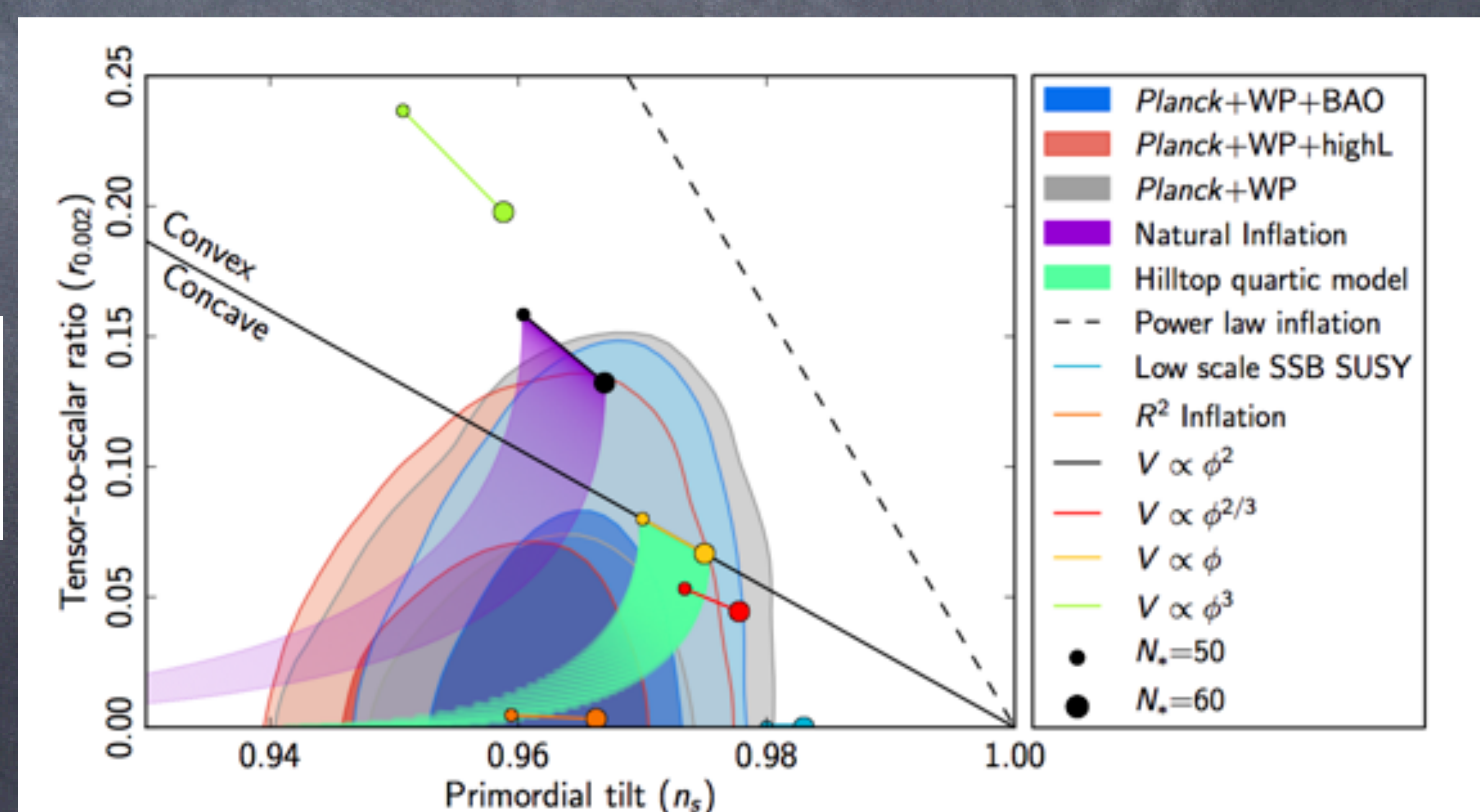
Kehagias, Dizgah & Riotto
1312.1155
Giudice & Lee
1402.2129

The model

$$S_{\rm S} = \frac{1}{2}\int {\rm d}^4x\sqrt{-g}\,\left(M_{\rm p}^2 R + \frac{1}{6M^2}R^2\right)$$

leads to

$$n_s - 1 \approx -\frac{2}{N}, \quad r \approx \frac{12}{N^2}$$



Starobinsky-like models

Not a single model, but a class

Example: Higgs inflation

$$S_{\mathrm{HI}} = \int \mathrm{d}^4 x \sqrt{-g} \left(\frac{M_{\mathrm{P}}^2}{2} R + \frac{1}{2}\xi h^2 R - \cancel{\frac{1}{2}\partial_\mu h \partial^\mu h} - \frac{\lambda}{4} h^4 \right)$$

integrate out the scalar

$$\xi h R - \lambda h^3 = 0,$$

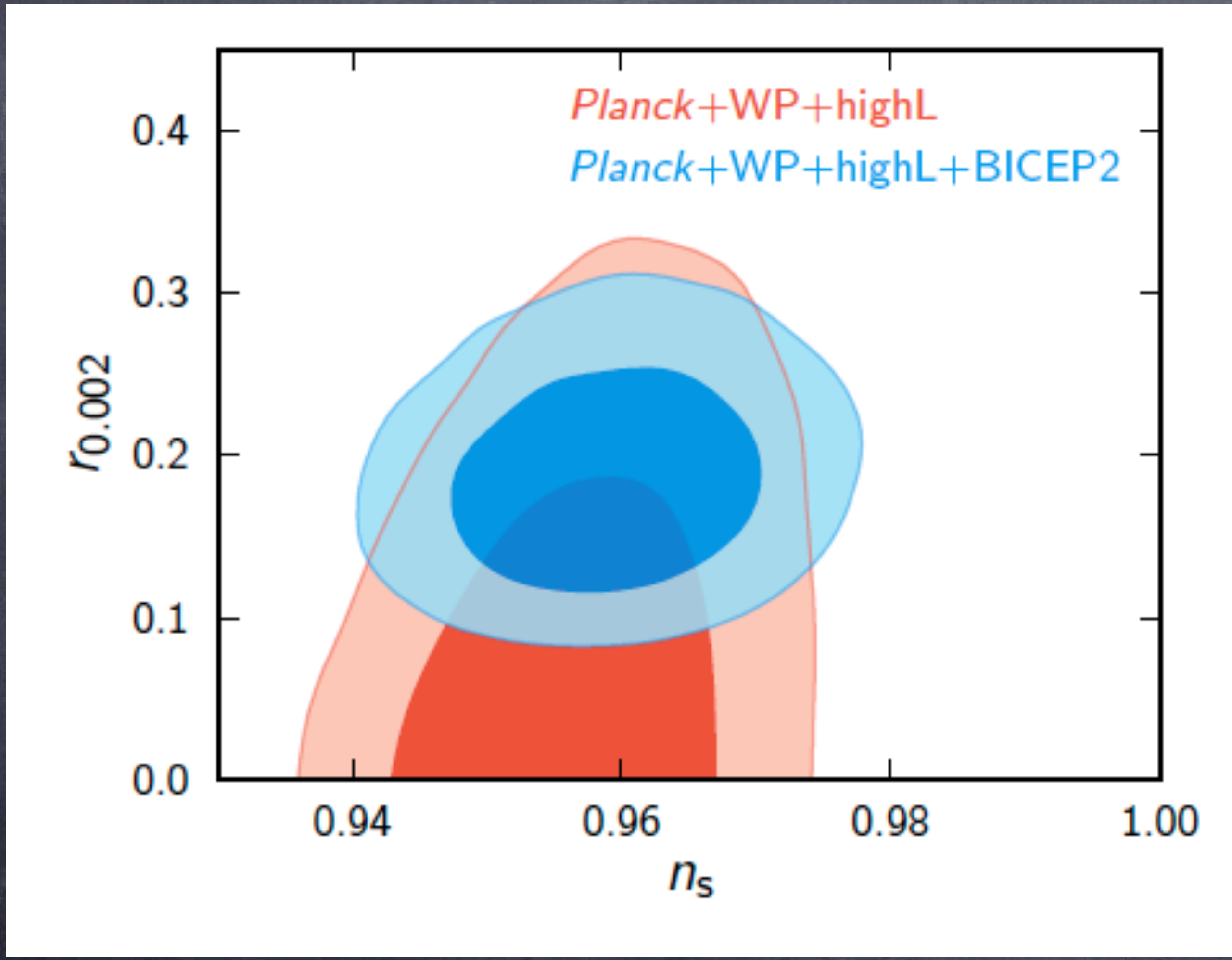
$$h^2 = \frac{\xi R}{\lambda}.$$

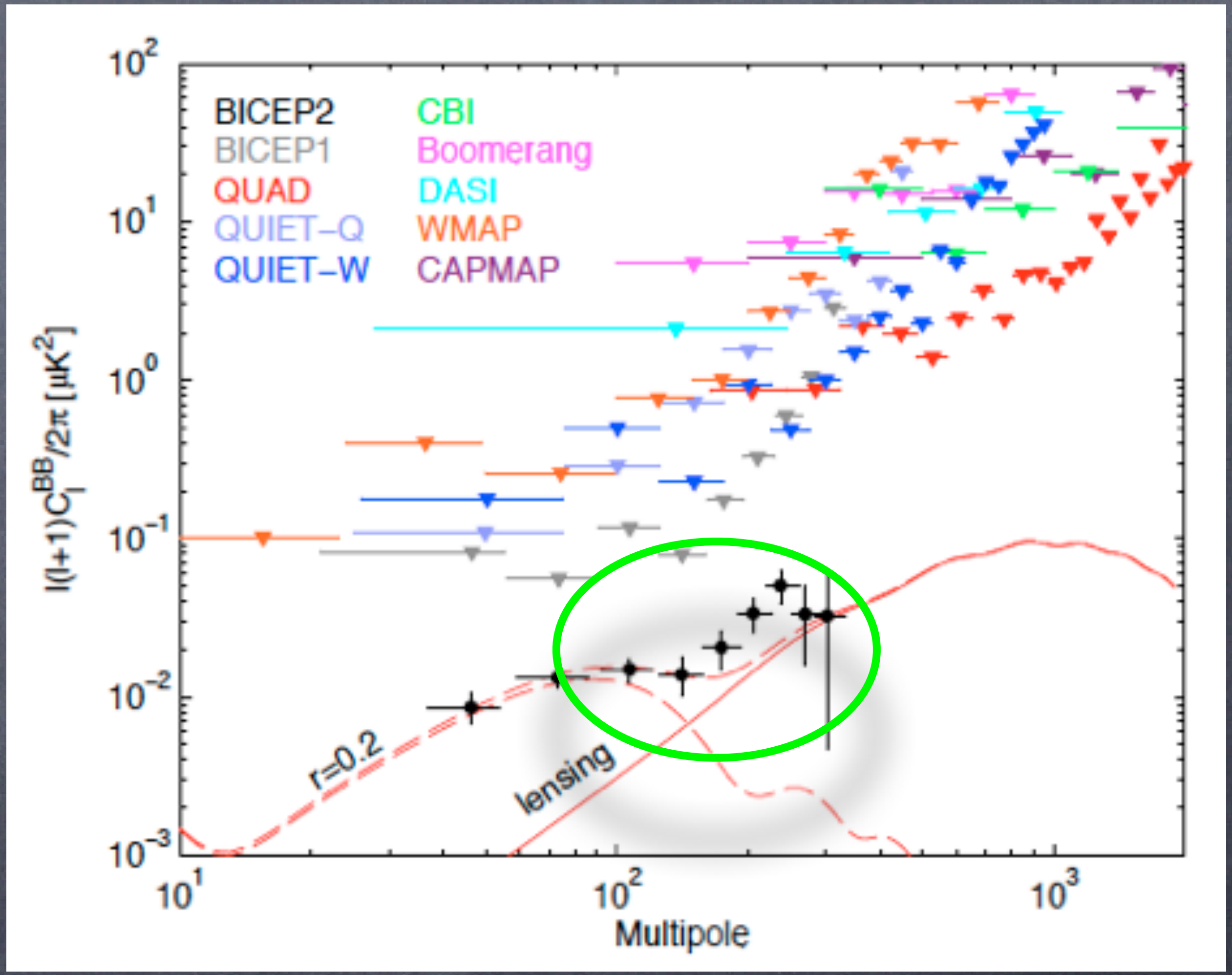
$$S_{\mathrm{HI}} = \int \mathrm{d}^4 x \sqrt{-g} \left(\frac{M_{\mathrm{P}}^2}{2} R + \frac{\xi^2}{4\lambda} R^2 \right)$$

this is the case for many models:
S-inflation, gravity induced...
Same inflation, but unitarity and other properties can be different

$$A_T = 8 \left(\frac{H_I}{2\pi M_{pl}} \right)^2$$

The impact of BICEP2





The impact of BICEP2

chaotic inflation is a winner

BUT

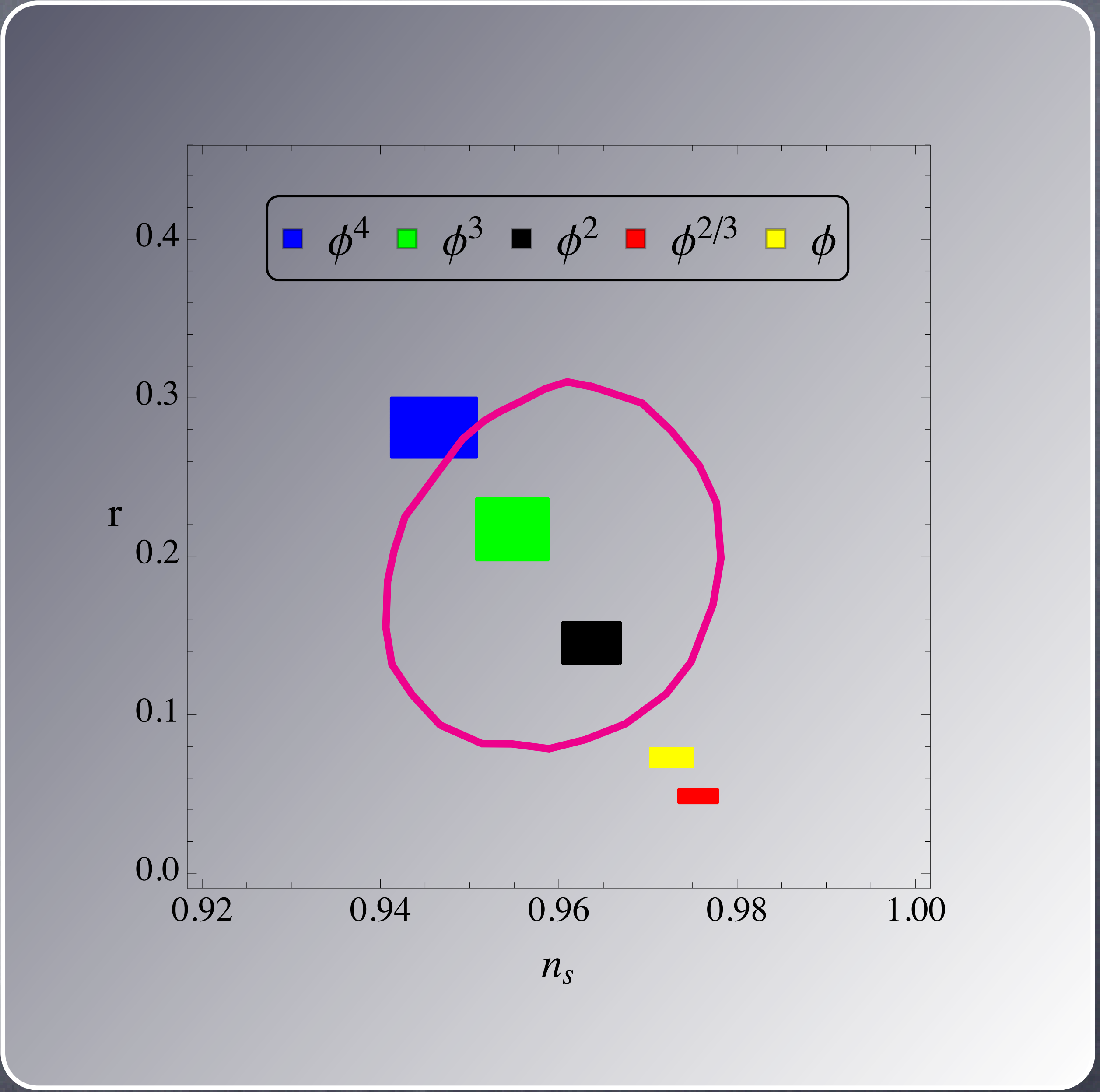
needs trans-Planckian excursions of the field

$$V(\tilde{\phi})_{CI} = \bar{M}_P^4 \tilde{m}^2 \tilde{\phi}^2$$

$$\tilde{\phi} = \phi / M_{Pl}$$

$$\tilde{m} = m / M_{Pl}$$

$$\tilde{\phi}_N = N/2\pi$$



$$N \in [50, 60]$$

Effect of Higher-Dimensional operators in Inflation

Calmet, VS
1403.5100

These trans-Planckian excursions must come at a price

Quantify these effects?

BHs, graviton exchange, more exotic stuff...

Higher-order operators

$$V(\phi) = V_{ren}(\phi) + \sum_{n=5}^{\infty} c_n \frac{\phi^n}{\bar{M}_P^{n-4}}$$

Effect of Higher-Dimensional operators in Inflation

Example: Impact on chaotic inflation

$$V(\tilde{\phi}) = \bar{M}_P^4 \left(\tilde{m}^2 \tilde{\phi}^2 + c_n \tilde{\phi}^n \right)$$

Effect of Higher-Dimensional operators in Inflation

Example: Impact on chaotic inflation

$$\boxed{V(\tilde{\phi}) = \bar{M}_P^4 \left(\tilde{m}^2 \tilde{\phi}^2 + c_n \tilde{\phi}^n \right)}$$

$$c_6 = \alpha_m \tilde{m}^2 \rightarrow V(\tilde{\phi}) = \bar{M}_P^4 \tilde{m}^2 \tilde{\phi}^2 \left(1 + \alpha_m \tilde{\phi}^4 \right)$$

naively

$$|\alpha_m| \tilde{\phi}^4 < 1$$

$$\epsilon = \frac{1}{16\pi} \left(\frac{V'(\tilde{\phi})}{V(\tilde{\phi})} \right)^2 = \frac{1}{4\pi} \frac{1}{\tilde{\phi}^2} \left(\frac{1 + 3\,\alpha_m \tilde{\phi}^4}{1 + \alpha_m \tilde{\phi}^4} \right)^2 = \epsilon_{CI} + \frac{\alpha_m \tilde{\phi}^4}{\pi \tilde{\phi}^2} + \mathcal{O}(\alpha_m \tilde{\phi}^4)^3$$

the largest value of phi is at the beginning of inflation

Effect of Higher-Dimensional operators in Inflation

Example: Impact on chaotic inflation

$$V(\tilde{\phi}) = \bar{M}_P^4 \left(\tilde{m}^2\tilde{\phi}^2 + c_n\tilde{\phi}^n\right)$$

$$c_6 = \alpha_m\tilde{m}^2 \to V(\tilde{\phi}) = \bar{M}_P^4\tilde{m}^2\tilde{\phi}^2\left(1+\alpha_m\tilde{\phi}^4\right)$$

naively

$$|\alpha_m|\tilde{\phi}^4 < 1$$

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the largest value of phi is at the beginning of inflation

$$\tilde{\phi}_N^2 \simeq \tilde{\phi}_{N,CI}^2 + \frac{N^3}{12\pi^3}\alpha_m \simeq \frac{N}{2\pi}\left(1+\frac{N^2\alpha_m}{6\pi^2}\right)$$

$$|\alpha_m|\tilde{\phi}_N^4 \simeq \frac{N^2|\alpha_m|}{4\pi^2} \lesssim 1 \to \boxed{|\alpha_m|^{EFT} \lesssim 2\times 10^{-2}}$$

Effect of Higher-Dimensional operators in Inflation

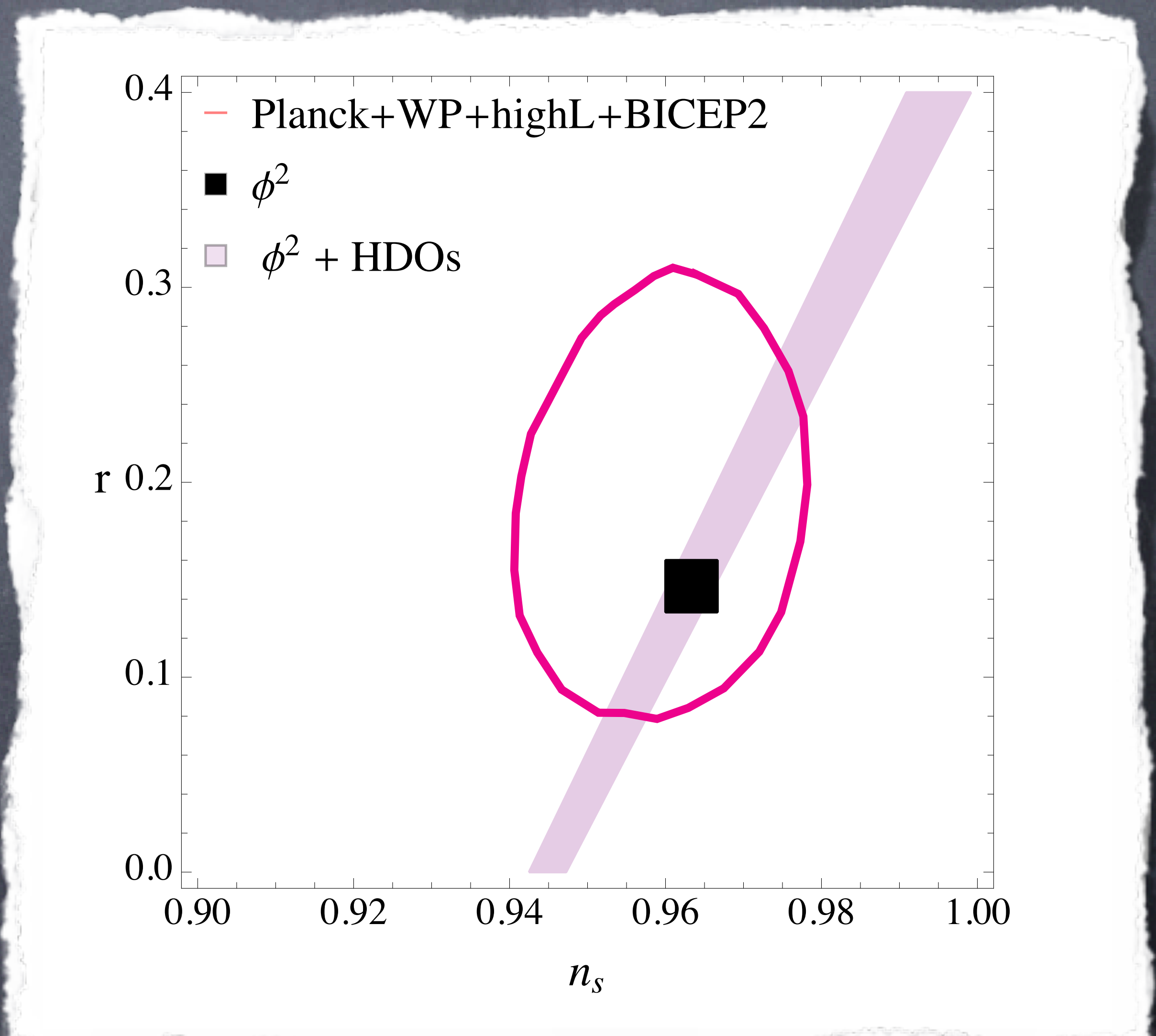
$$n_s - 1 = (n_s - 1)_{CI} \left(1 - \frac{5}{3}\frac{N^2 \alpha_m}{4\pi^2}\right)$$

$$r = r_{CI} \left(1 + \frac{10}{3}\frac{N^2 \alpha_m}{4\pi^2}\right)$$

$$\alpha_m^{BICEP2} \in [-2, 3] \times 10^{-3}$$

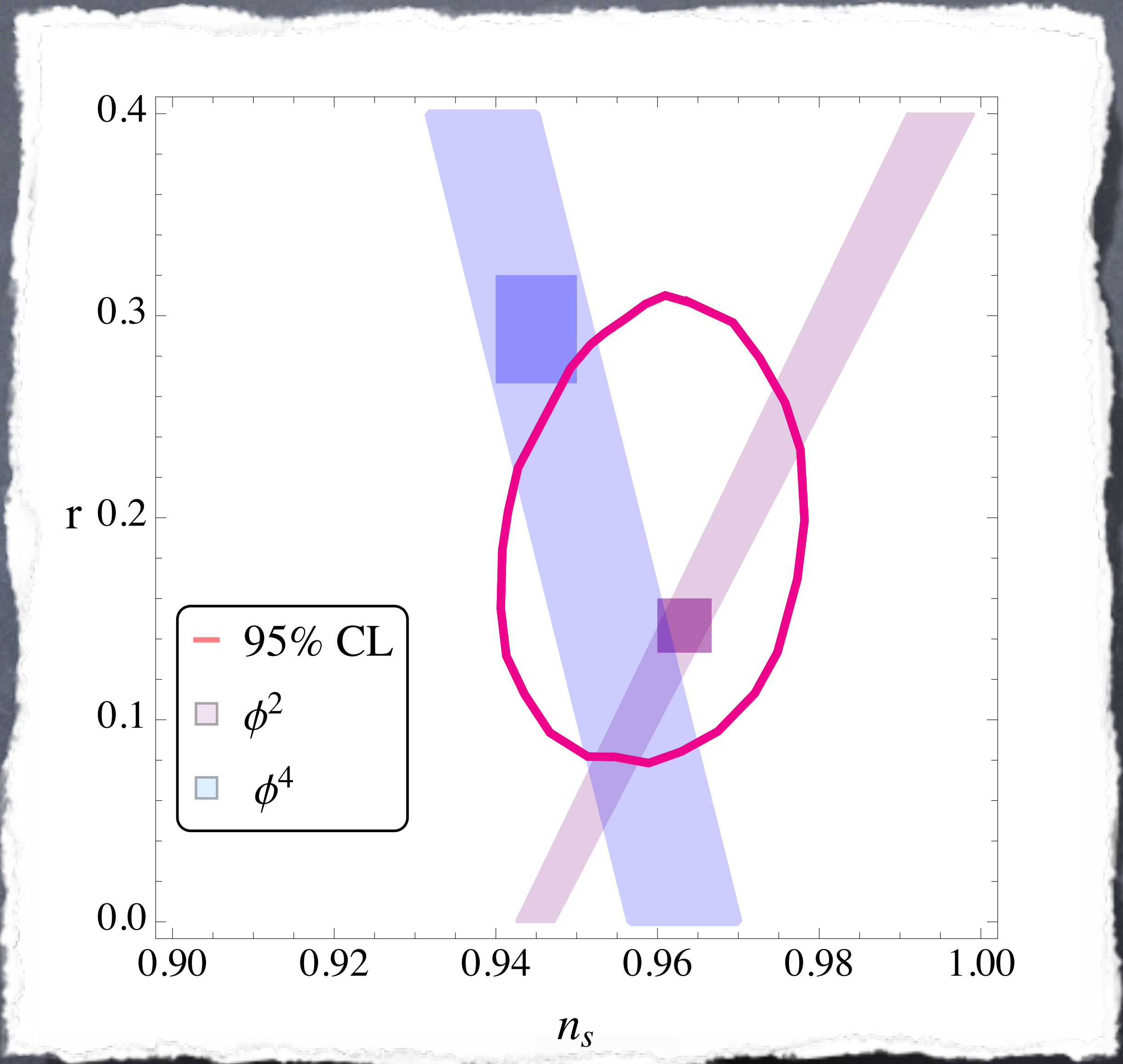
$$c_6 \lesssim 10^{-9}$$

If MPl->MGUT, even stronger constraints



Effect of Higher-Dimensional operators in Inflation

models can be 'rescued'



with HDOs well within the EFT validity region

$$\boxed{\alpha_\lambda^{BICEP} \in [-0.06, 0] \to c_6 < 10^{-15}}$$