CMB-France

Tensor-to-scalar ratio and beyond with CMB and gravitational waves

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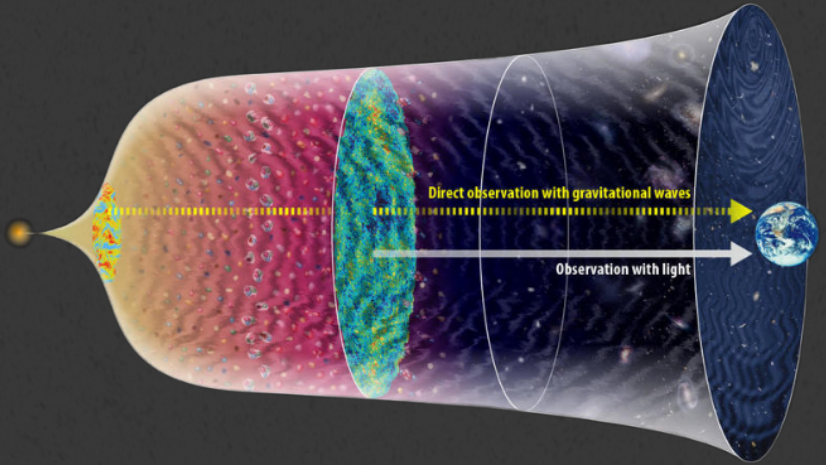
Based on:

Giacomo Galloni, Nicola Bartolo, Sabino Matarrese, Marina Migliaccio, Angelo Ricciardone and Nicola Vittorio, *Updated constraints on amplitude and tilt of the tensor primordial spectrum*, JCAP04(2023)062

2208.00188

Inflation


Direct observation with gravitational waves
Observation with light

Scalar and tensor primordial spectra

Scalar

$$\Downarrow$$

$$P_s(k) = A_s \left(\frac{k}{k_*}\right)^{n_s - 1}$$

$$\Downarrow$$

$$\{A_s, n_s\}$$

Tensor

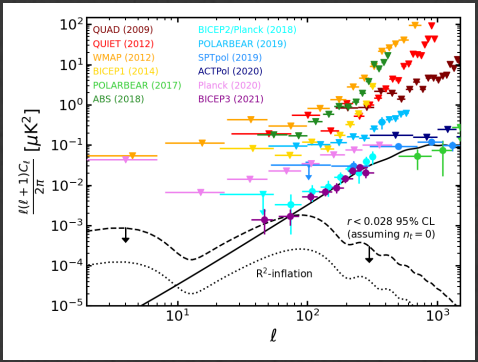
$$\Downarrow$$

$$P_t(k) = r A_s \left(\frac{k}{k_*}\right)^{n_t}$$

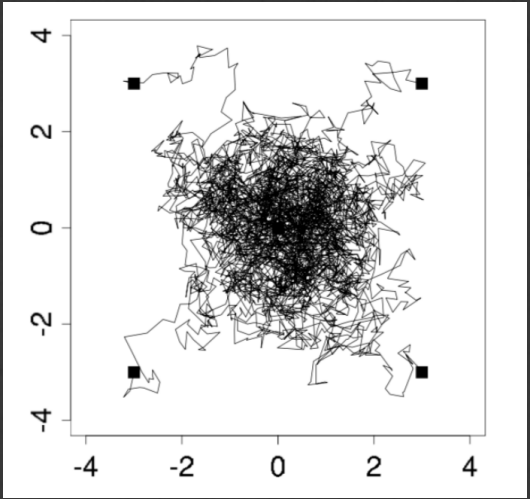
$$\Downarrow$$

$$\boxed{\{r, n_t\}}$$

Observations



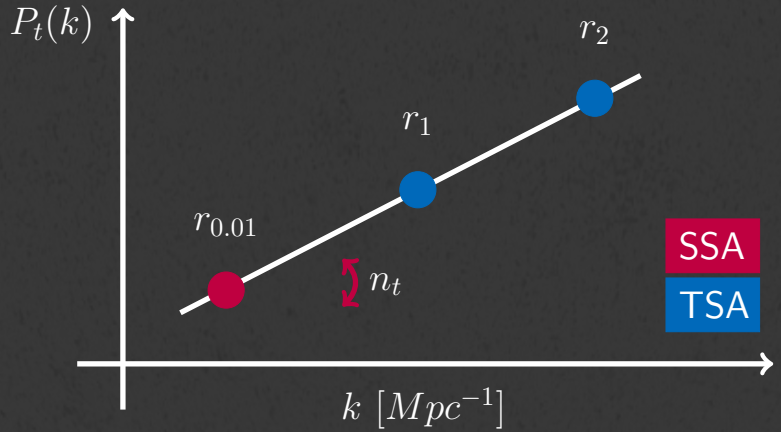
Results? MCMC



Some details

ΛCDM	$+$	r, n_t
$\Downarrow$	.	$\Downarrow$
6 $+\mathcal{O}(10)$	.	2 $+\mathcal{O}(10)$
$\Downarrow$	.	$\Downarrow$
Flat priors	VS	???

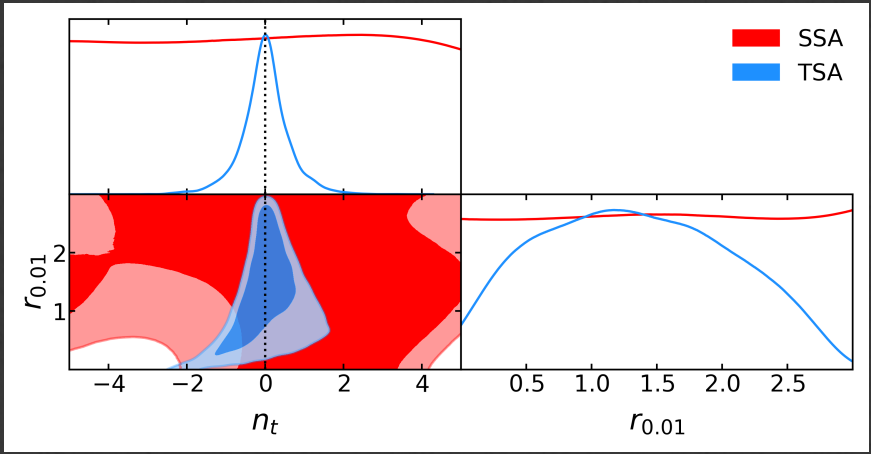
Single- and Two- Scale Approaches



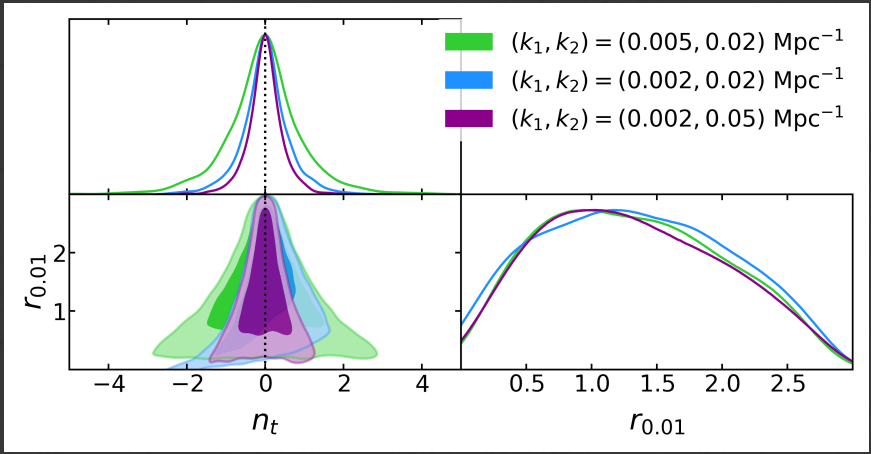
Cabass et al. - 1511.05146

Planck Collaboration - 1502.02114

Robustness test: priors

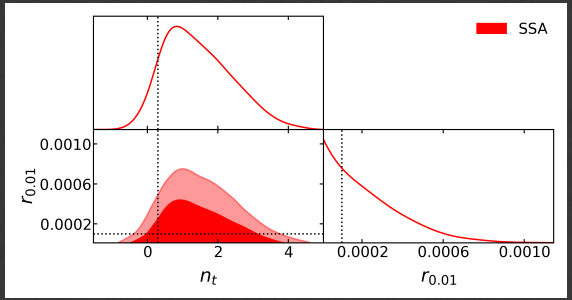


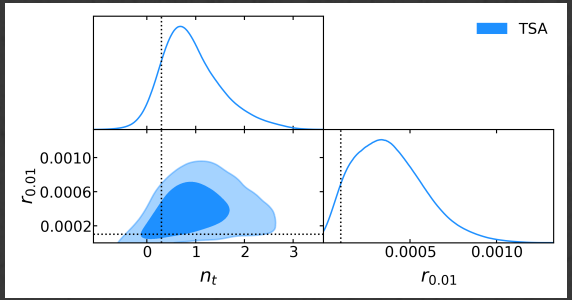
Robustness test: changing scales



Robustness test: mock dataset

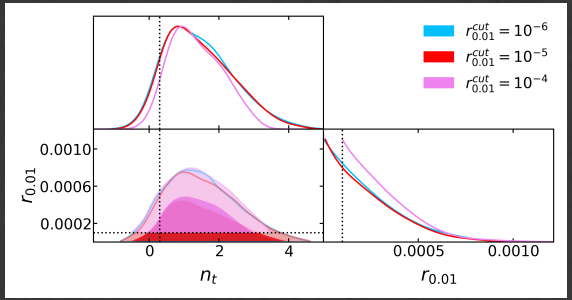
$$-2\log\mathcal{L} = \sum_{\ell}(2\ell+1)\left[\frac{C_\ell^{\rm obs}}{C_\ell^{\rm th}} - \log\left(\frac{C_\ell^{\rm obs}}{C_\ell^{\rm th}}\right) - 1\right]$$



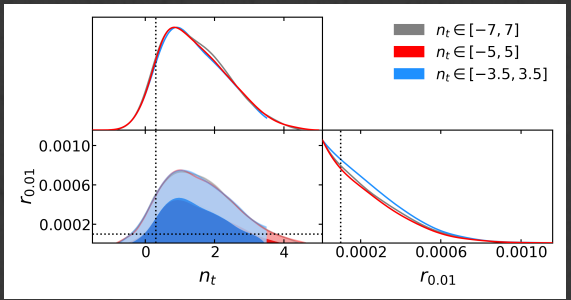


Robustness test: mock dataset

Cut-offs



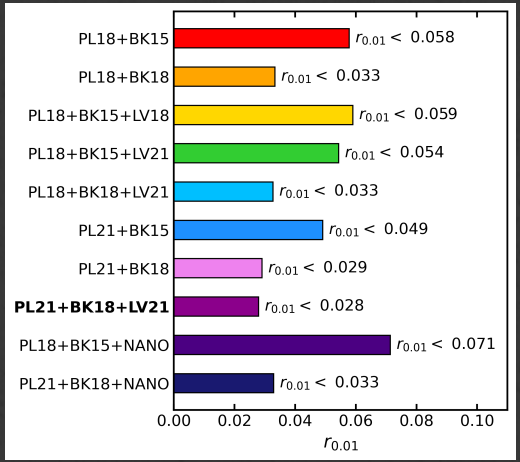
n_t prior

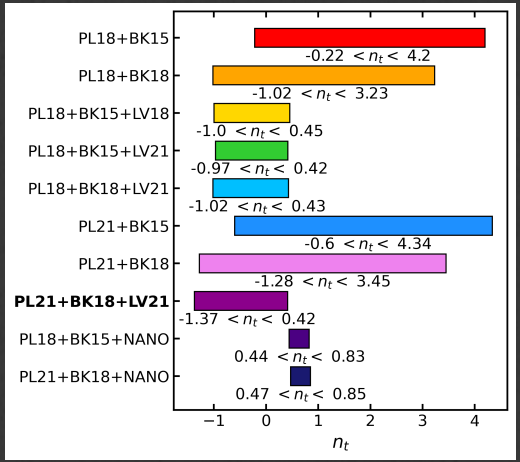


Dataset

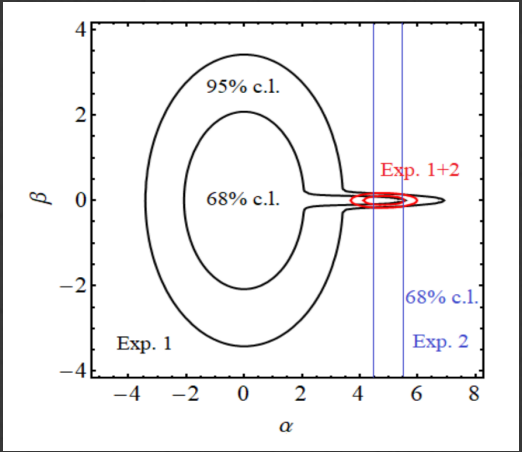
- Planck 2018 lowl TT, highl TTTEEE and lensing
- LoLLiPoP (PR4) EEEBBB
- BICEP3/Keck BB
- LIGO-Virgo-KAGRA interferometers

Results


PL18+BK15
PL18+BK18
PL18+BK15+LV18
PL18+BK15+LV21
PL18+BK18+LV21
PL21+BK15
PL21+BK18
PL21+BK18+LV21
PL18+BK15+NANO
PL21+BK18+NANO
$r_{0.01} < 0.058$
$r_{0.01} < 0.033$
$r_{0.01} < 0.059$
$r_{0.01} < 0.054$
$r_{0.01} < 0.033$
$r_{0.01} < 0.049$
$r_{0.01} < 0.029$
$r_{0.01} < 0.028$
$r_{0.01} < 0.071$
$r_{0.01} < 0.033$
0.00
0.02
0.04
0.06
0.08
0.10
$r_{0.01}$

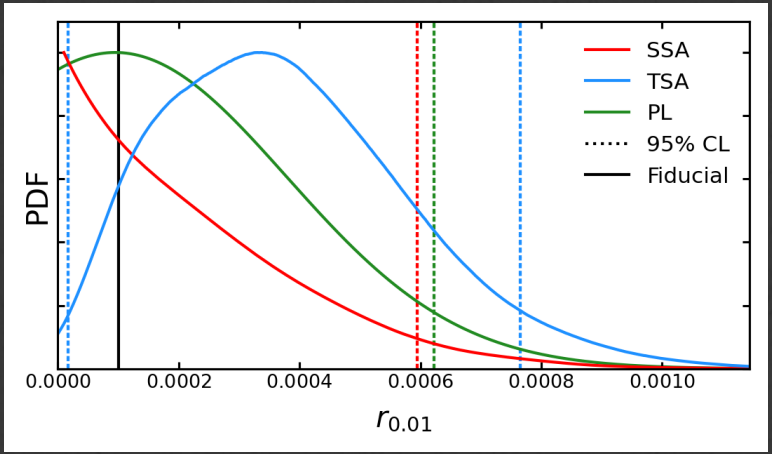

PL18+BK15
PL18+BK18
PL18+BK15+LV18
PL18+BK15+LV21
PL18+BK18+LV21
PL21+BK15
PL21+BK18
PL21+BK18+LV21
PL18+BK15+NANO
PL21+BK18+NANO
-0.22 $< n_t <$ 4.2
-1.02 $< n_t <$ 3.23
-1.0 $< n_t <$ 0.45
-0.97 $< n_t <$ 0.42
-1.02 $< n_t <$ 0.43
-0.6 $< n_t <$ 4.34
-1.28 $< n_t <$ 3.45
-1.37 $< n_t <$ 0.42
0.44 $< n_t <$ 0.83
0.47 $< n_t <$ 0.85
−1
0
1
2
3
4
n_t

Volume effects?

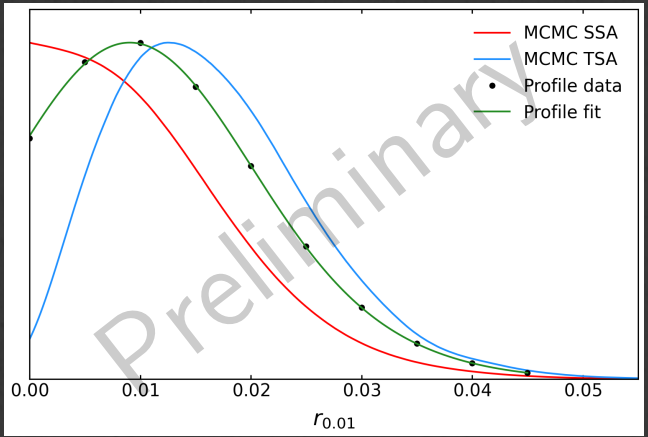


Credits: Gomez-Valent 2022

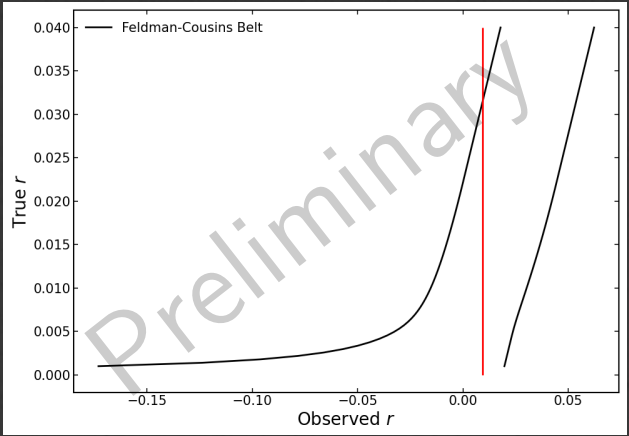
Profile Likelihood: mock dataset



Profile Likelihood: actual dataset



Feldman - Cousins belt



Conclusions

- Bayesian and frequentist methods answer very different but complementary questions
- Both SSA and TSA are affected by different volume effects
- Since TSA mimics a detection, we choose SSA to study the tensor sector
- At IJCLab, we are exploring the Profile Likelihood (PL) on PR4

The choice of the methodology is of crucial importance!
Performing both an MCMC and a PL can give a complete picture

Backup

Robustness test: Jacobian