21th Sep, 2022

El Gordo Galaxy Cluster taken by the DECam

PNG with *Dark Energy Survey*

PNG & Beyond workshop

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THE DARK ENERGY SURVEY

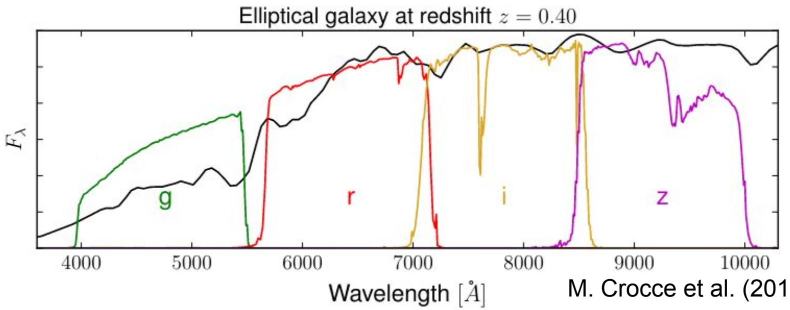
Obra Social "la Caixa"

Dark Energy Survey (DES)

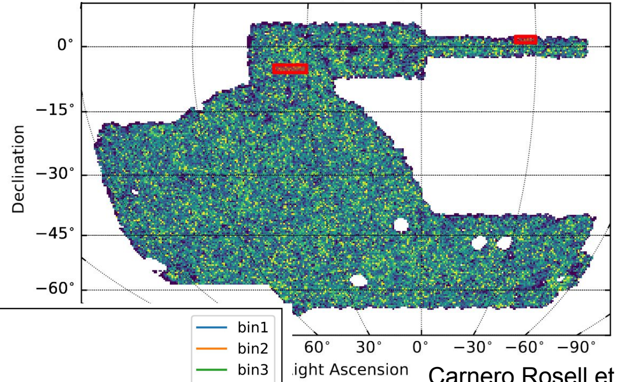
- ★ Area of ~5000 deg2 and ***Photometric*** in ~4 color bands. (similar to VR's LSST) (I. Sevilla-Noarbe et al. 2020)

- ★ Combination of colors are used to estimate the redshift of galaxies. (for example, De Vicente et al. 2016)

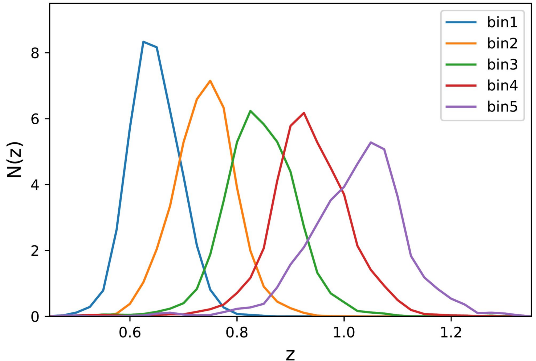
- ★ **Colors selections** can be used to define **different galaxy samples:**
  - **BAO**: Optimized for BAO… (A. Carnero Rosell et al. 2021)
  - **MagLim**: Optimized for weak lensing (A. Porredon et al. 2021)
  - redMagic: Luminous red galaxies (E. Rozo et al. 2016)



M. Crocce et al. (2018)



Carnero Rosell et al. (2018)



Primordial non-Gaussianity in DES

Ongoing projects:

★ Angular Power Spectrum.
H. Camacho et al. Ongoing research

★ **Angular Correlation Function methodology (this presentation).**
W. Riquelme, S. Avila, J. Garcia-Bellido, et al.

Other active members: A. Porredon, K. Chan, I. Ferrero, N.Weaverdyck...

Starting projects :

- Systematics for PNG: N. Weaverdyck, M. R. Monroy
- **Sample optimisation: W. Riquelme, Anna Porredon**

Primordial non-Gaussianity with Angular correlation function: Integral constraint and validation for DES

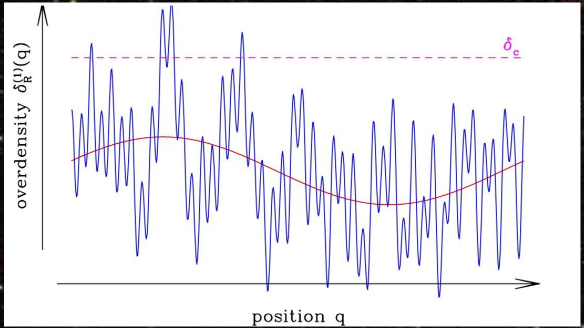
Walter Riquelme,[1,2]* Santiago Avila,[1,2]† Juan García-Bellido,[1,2]‡ Anna Porredon,[3] Ismael Ferrero,[4] Kwan Chuen Chan, [5] Rogerio Rosenfeld, [6] Hugo Camacho,[7] Adrian G. Adame, [1,2] [-and more-]

The work has three main parts:

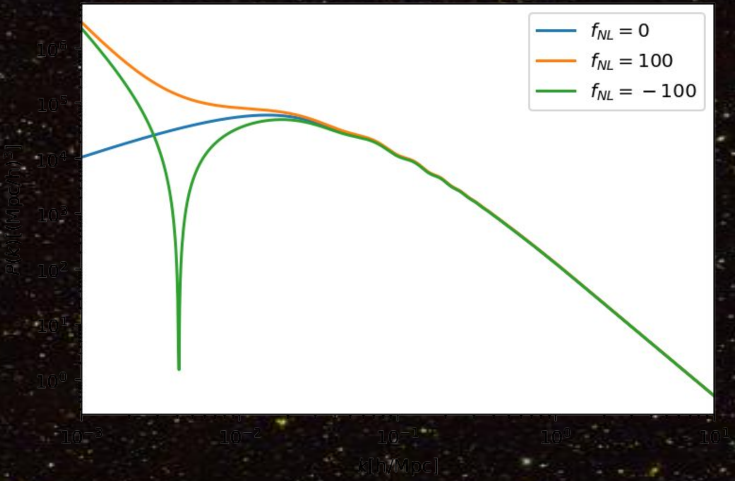
1. Angular correlation function with PNG
2. Integral constraint impact
3. Robustness test for DES

https://arxiv.org/abs/2209.07187

Scale dependent bias



$$P(k, f_{NL}) = b^2(k, f_{NL}) P_{DM}(k)$$



$$b(k) = b_g + \frac{f_{\rm NL}(b_g - p) M(k,z)}{k^2}$$

[Dalal et al. (2008)]
[Slosar et al. (2008)]

Angular correlation function (ACF)

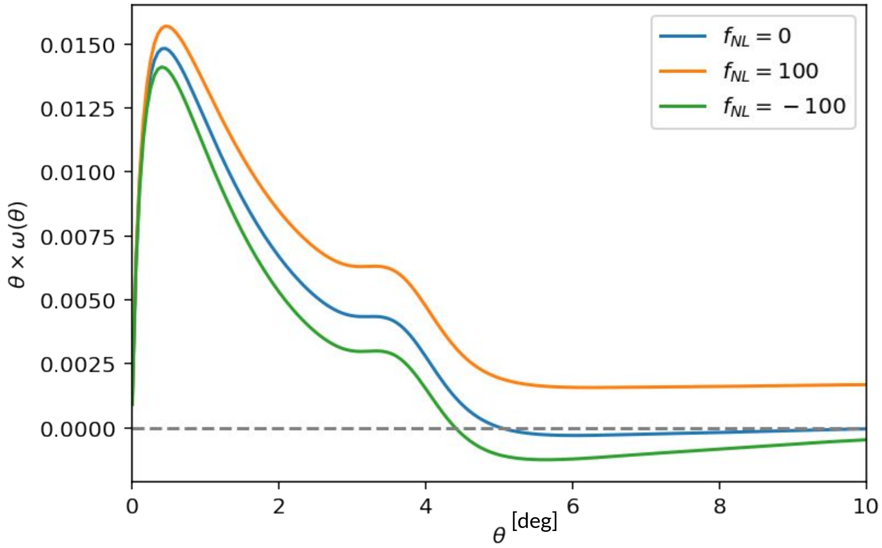
Summary statistic of clustering of galaxies, or other biased tracers.

$$w(\theta, f_{\mathrm{NL}}) = \int dz_1 \int dz_2 \; n(z_1) n(z_2) \xi(r(z_1, z_2, \theta), f_{\mathrm{NL}})$$

- The ACF is a 2D projection of 2PCF using **n(z) distributions**.
- The ACF is ***also affected by fNL*** via scale-dependent bias.

At large scales

$$w(\theta, f_{\mathrm{NL}}) \propto f_{\mathrm{NL}}^2 \cdot \infty$$



Integral constraint

For limited windowed surveys, the number of galaxies in the universe is estimated from the mean density of the survey, implying:

$$N_g = \bar{n}\int dV_s + \bar{n}\int \xi(r)dV_s$$

$$\Downarrow$$

$$\int w_{\rm obs}(\theta)d\Omega = 0$$

$$\Downarrow$$

$$\sum RR(\theta)w_{\rm obs}(\theta) = 0$$

Integral Constraint cond.

Imposing integral constraint to theory:

$$w^*_{th}(\theta, f_{\rm NL}) = w_{th}(\theta, f_{\rm NL}) - I(f_{\rm NL}) \Longrightarrow \boxed{I(f_{\rm NL}) = \frac{\sum RR(\theta)w_{th}(\theta, f_{\rm NL})}{\sum RR(\theta)}}$$

Simulations

In order to tests our methods we used two sets of simulations, with and without PNG.
From each of these, we compute the ACF.

ICE-COLA mocks

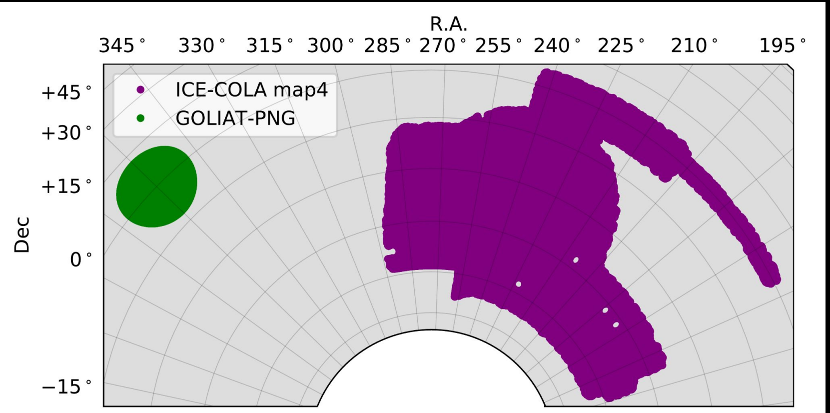
[I. Ferrero et al. 2021]

- 1952 Quasi-NBODY sims.
- fNL = 0 (p=1)
- Redshift 0.6 < z < 1.1 divided in 5 redshift bins
- Follows Y3 BAO redshift error and angular distribution.

GOLIAT-PNG mocks

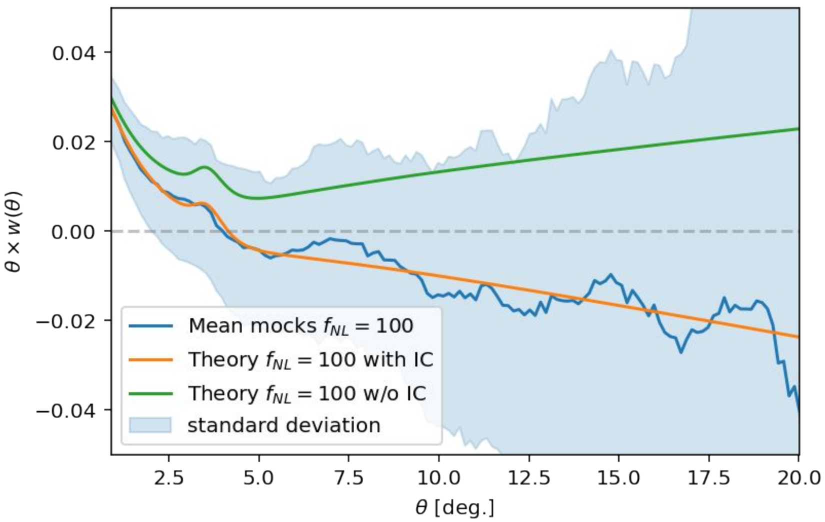
[S. Ávila & A. Adame 2022]

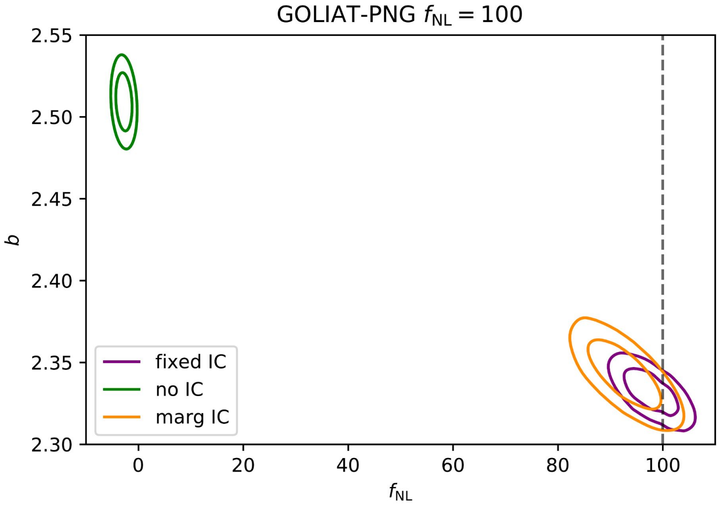
- 246 NBODY sims.
- fNL = [-100, 100] (p~0.9)
- Semi-aperture of 11.2 deg.
- Survey like redshift dist. 0.6 < z < 1.1 in 5 bins



GOLIAT-PNG and integral constraint

From all simulations, we perform a joint likelihood measurement of **fNL**



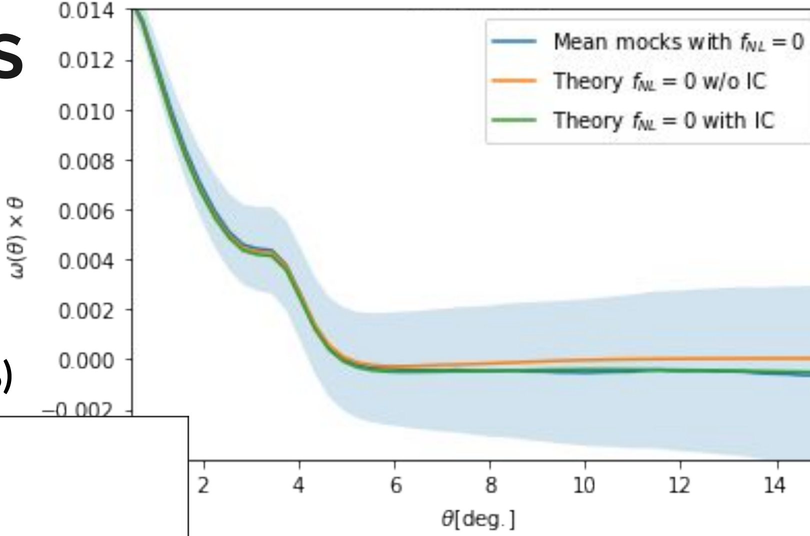


The **integral constraint (IC)** helps to avoid biased values for fNL

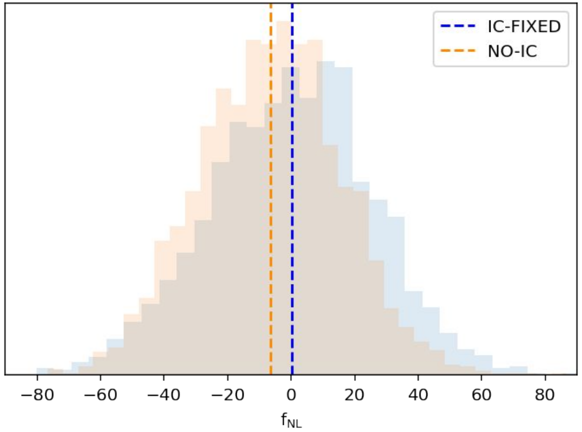
➢ **We recover fNL=100 within 1σ**

Robustness and forecast for DES

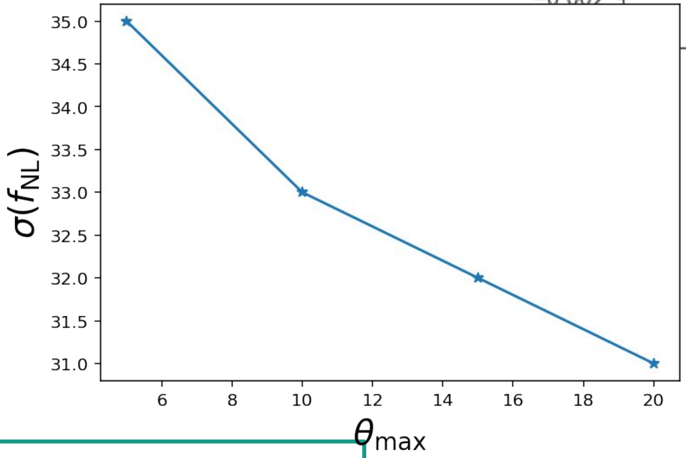
Using ICE-COLA mocks we test the robustness of our method on a DES-like scenario



1. IC improves **accuracy** (**ΔfNL~7**)



2. Large angular scales improves **precision (11%)**



The ACF with PNG and including the **Integral constraint** can be used to measure fNL within DES.

We forecast ***σ(fNL)~31*** using the **Y3 BAO sample**

Sample optimization for fNL

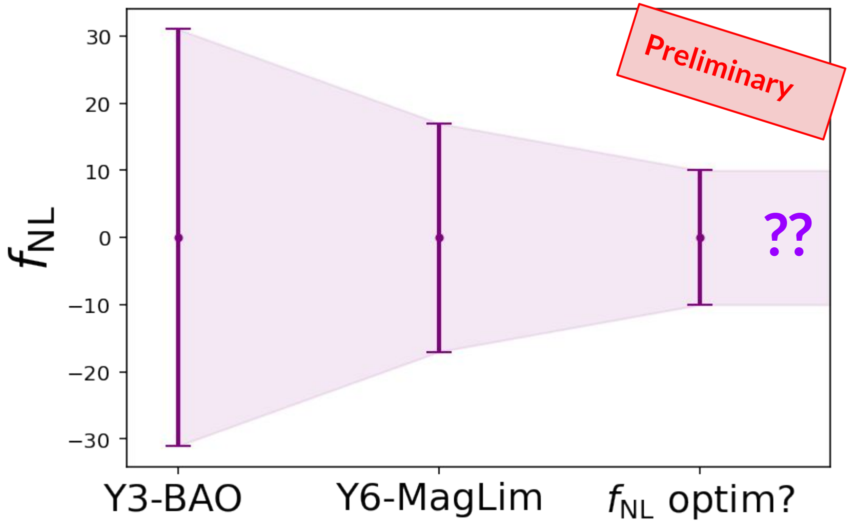
with Anna Porredon (work in progress...)

- Forecast with a theory-data vector

Modifying color cuts in i-band.
Looking for an optimal sample for fNL.

$$i < a z_{\mathrm{phot}} + b$$

Optimize ***a*** and ***b*** to lower fNL errors



- Largest difference between samples?
  Number density at high redshift...
  - BAO Y3 sample ~ 900k (z~1)
  - MagLim sample ~ 1.4M (z~1)
  - fNL optimi1 ~ 1.6M (z~1.2)

Similar method used for the MagLim sample (WL, 3x2pt)

Conclusions and prospects

- We presented the methods to use the Angular correlation function with scale-dep. bias to measure fNL

- We need to include the integral constraint to avoid biased fNL values.

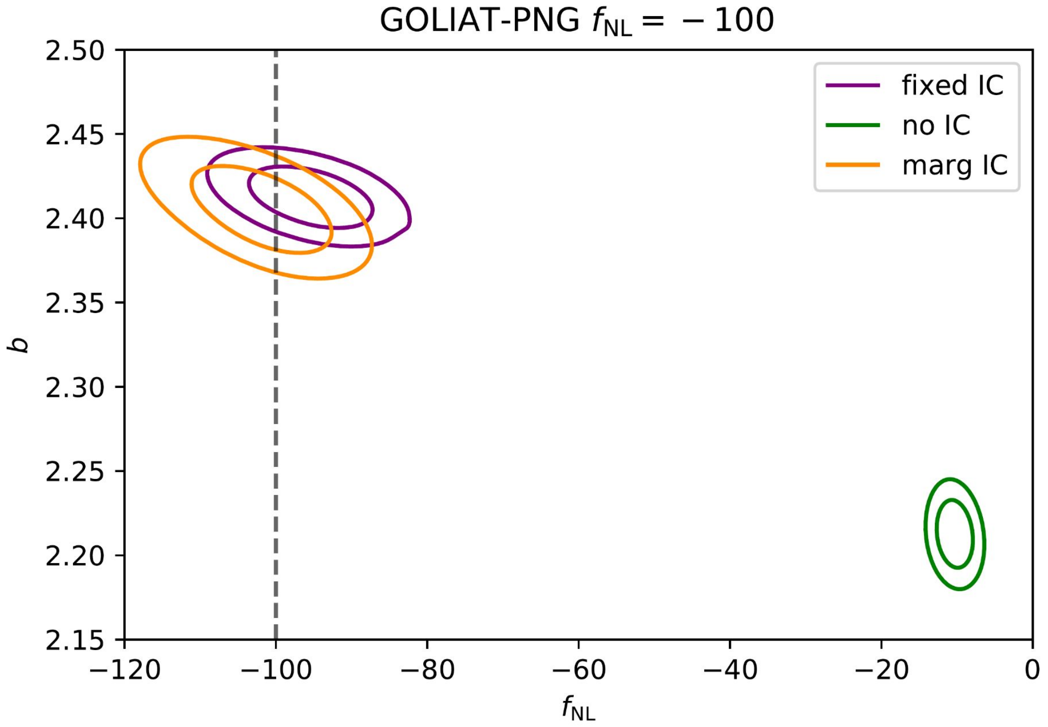
- Using **ICE-COLA** simulations, we have validated the methods to measure fNL with DES.

- Some future prospects will include:
  - Systematics impact and mitigation (this is one of the main challenges for fNL)
  - Sample optimization and application to data

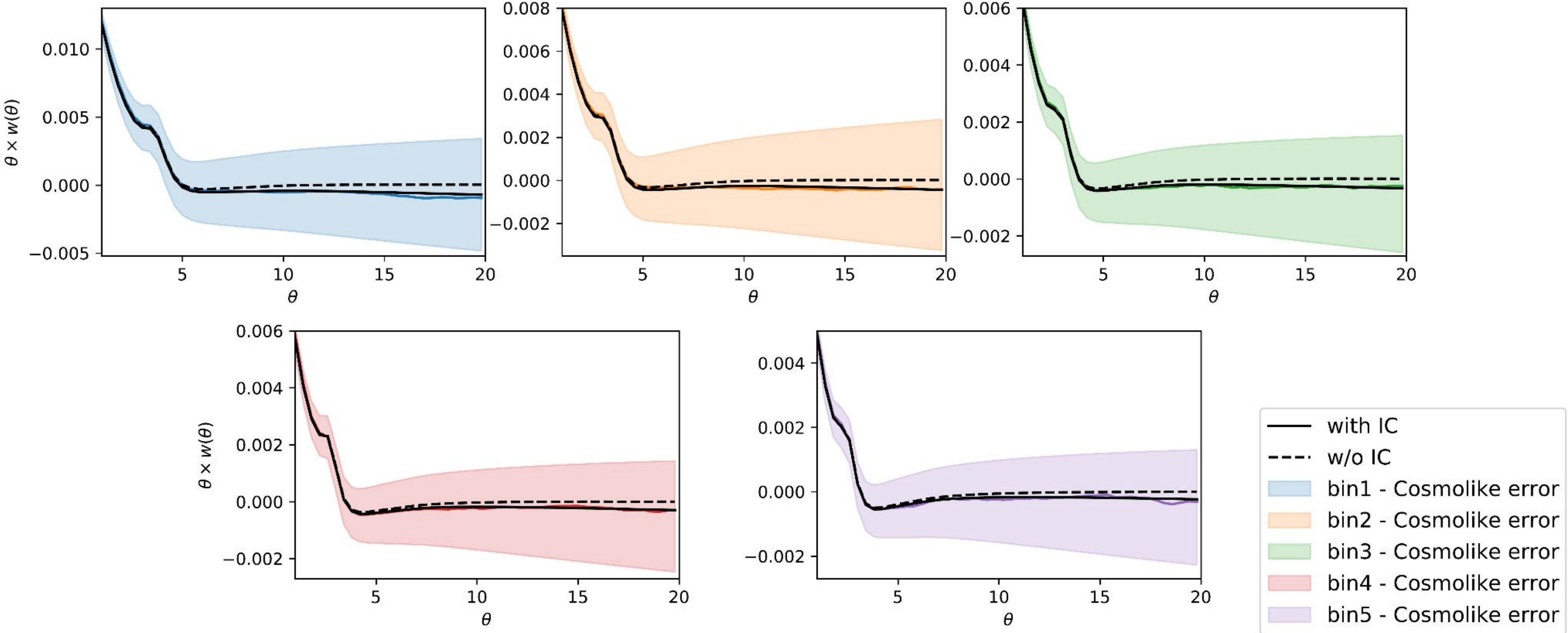
Looking for jobs for next year

Extra slides

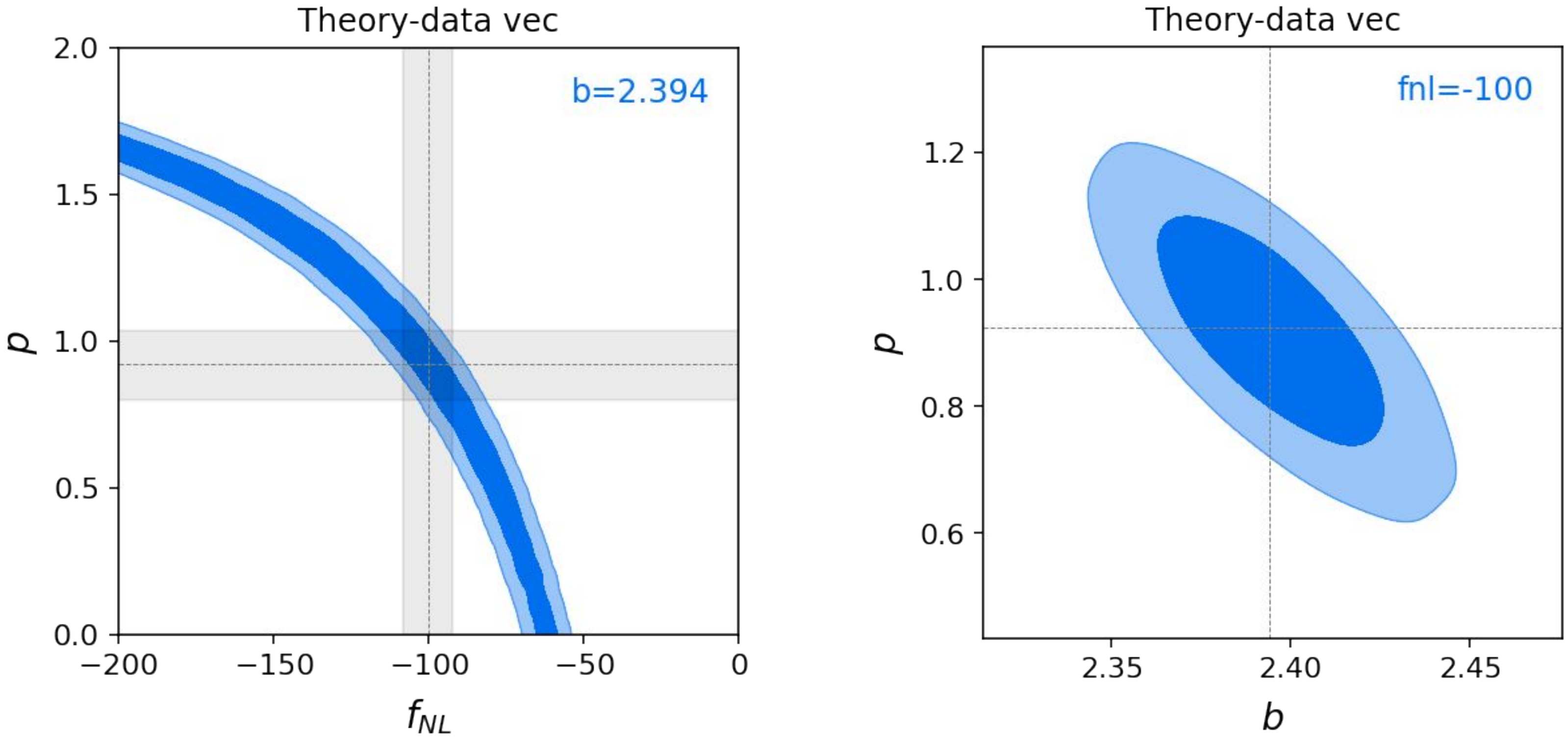
fNL=-100 GOLIAT png



ICE-COLA 5bins



Impact of p


Theory-data vec
b=2.394
2.0
1.5
1.0
0.5
0.0
−200
−150
−100
−50
0
p
f_{NL}
Theory-data vec
fnl=-100
1.2
1.0
0.8
0.6
2.35
2.40
2.45
p
b