
UNIVERSITÀ
DI TORINO

# The Relativistic Galaxy Bispectrum: Big Data Demands Big Accuracy

Samantha Rossiter

Università di Torino

Big Data, Big Questions: The Future of Cosmological Surveys

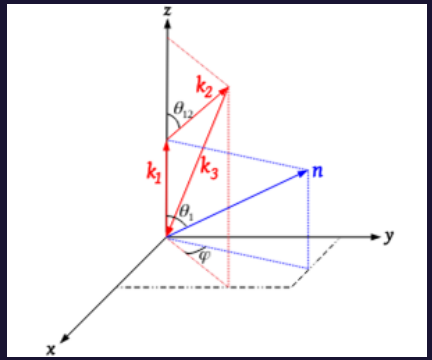
MIABpB 2025

# Why does this matter?

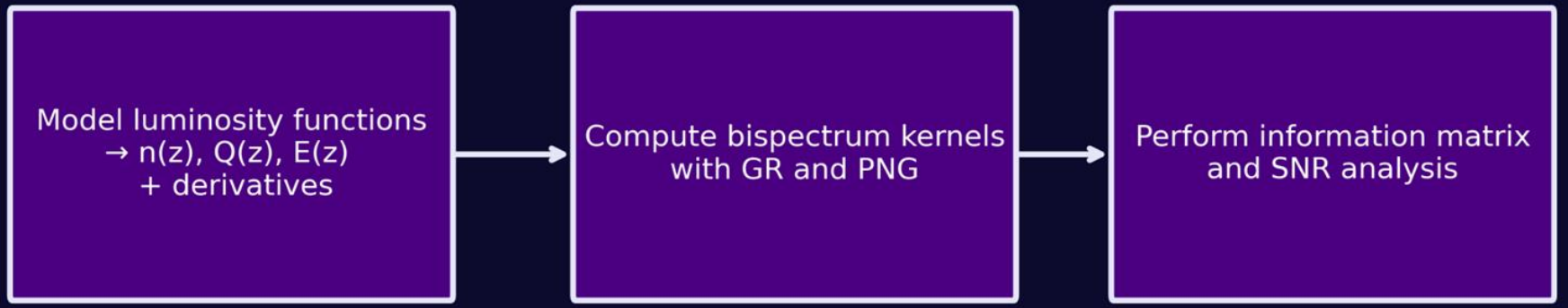
- Cosmology is entering a new phase: from precision to complexity
- Surveys will map billions of galaxies
- Key science goals: detect fNL, test inflation, constrain gravity
- But! modeling must keep up — data alone isn’t enough

# But why the Galaxy Bispectrum?

- Lowest order statistic sensitive to primordial non-Gaussianity
- Local fNL appears at leading order in the bispectrum
- Vs Power Spectrum: only enters via scale-dependent bias
- The bispectrum probes GR effects which mimic local PNG signals
- Neglecting GR terms risks biasing constraints on PNG



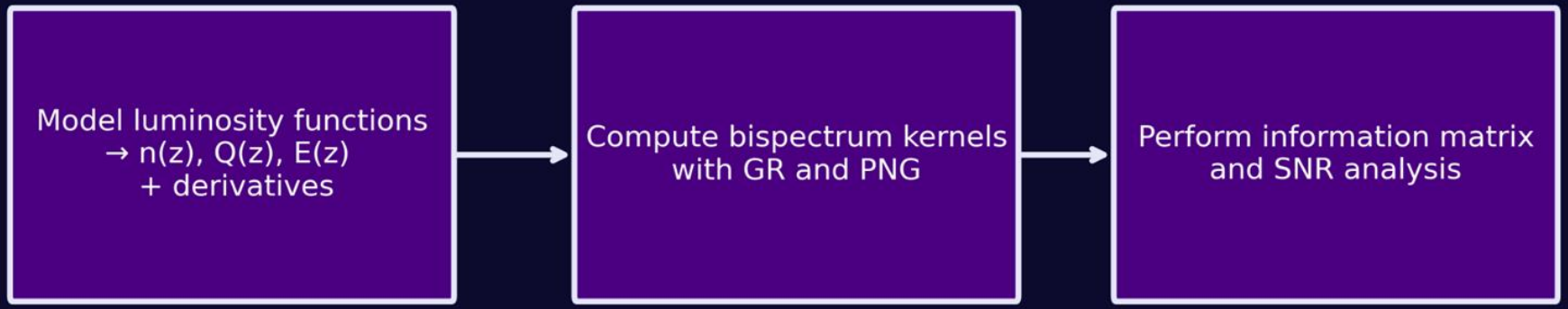
# Forecast Pipeline



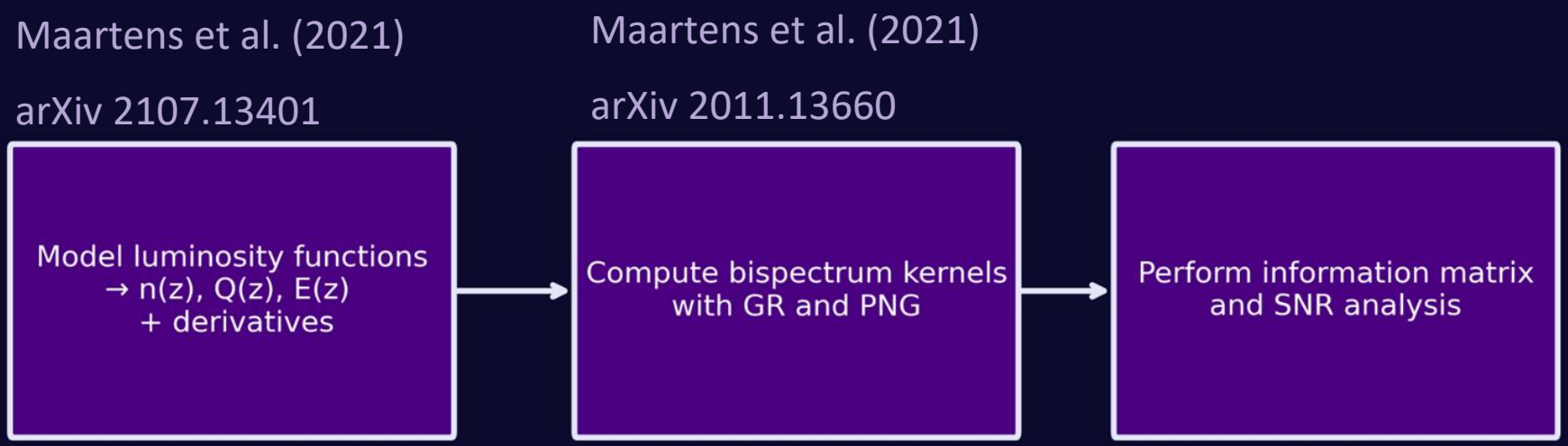
# Forecast Pipeline

Maartens et al. (2021)

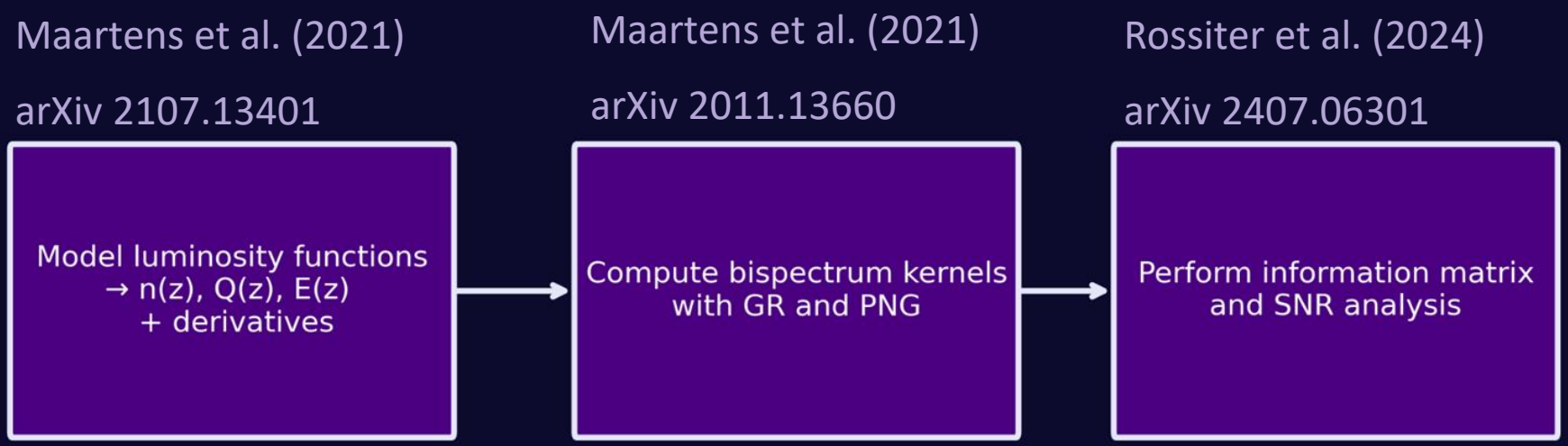
arXiv 2107.13401



# Forecast Pipeline



# Forecast Pipeline



# Surveys Modelled

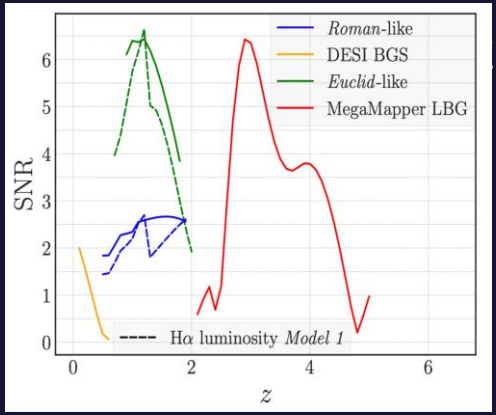
**Roman** - H$\alpha$ spectroscopic survey from the Wide Field Instrument (WFI)

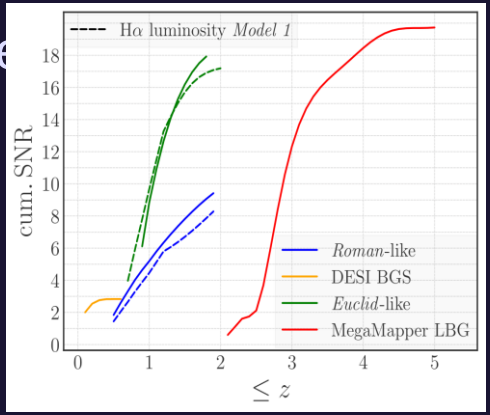
**DESI** - Bright Galaxy Sample (BGS)

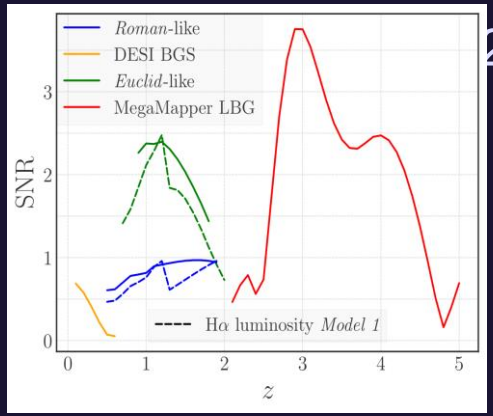
**Euclid** - H$\alpha$ sample from the Near Infrared Spectroscopic and Photometric (NISP) instrument

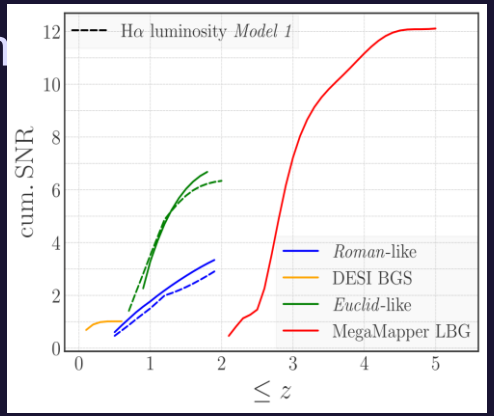
**MegaMapper** - Future ground based wide field spectroscopic instrument

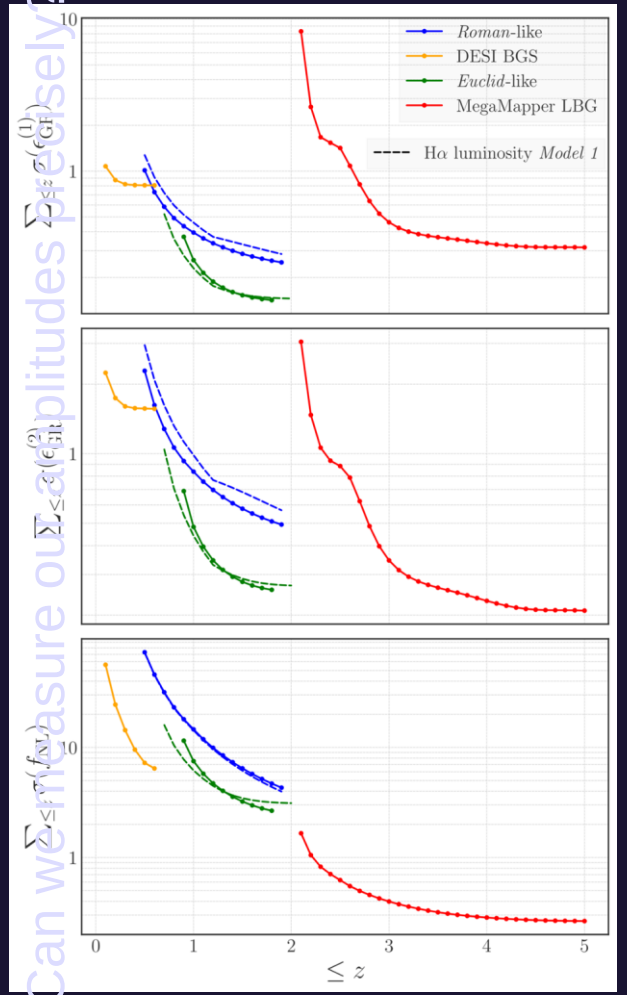
| Survey | Redshift range | Sky fraction ($f_{\rm sky}$) |
|---|---|---|
| *Roman*-like | *Model 1 & 3:* $0.5 \leq z \leq 1.9$ | 0.05 |
| DESI BGS | $0 \leq z \leq 0.6$ | 0.34 |
| *Euclid*-like | *Model 1*: $0.7 \leq z \leq 2$<br>*Model 3*: $0.9 \leq z \leq 1.8$ | 0.36 |
| MegaMapper LBG | $2.1 \leq z \leq 5$ | 0.50 |



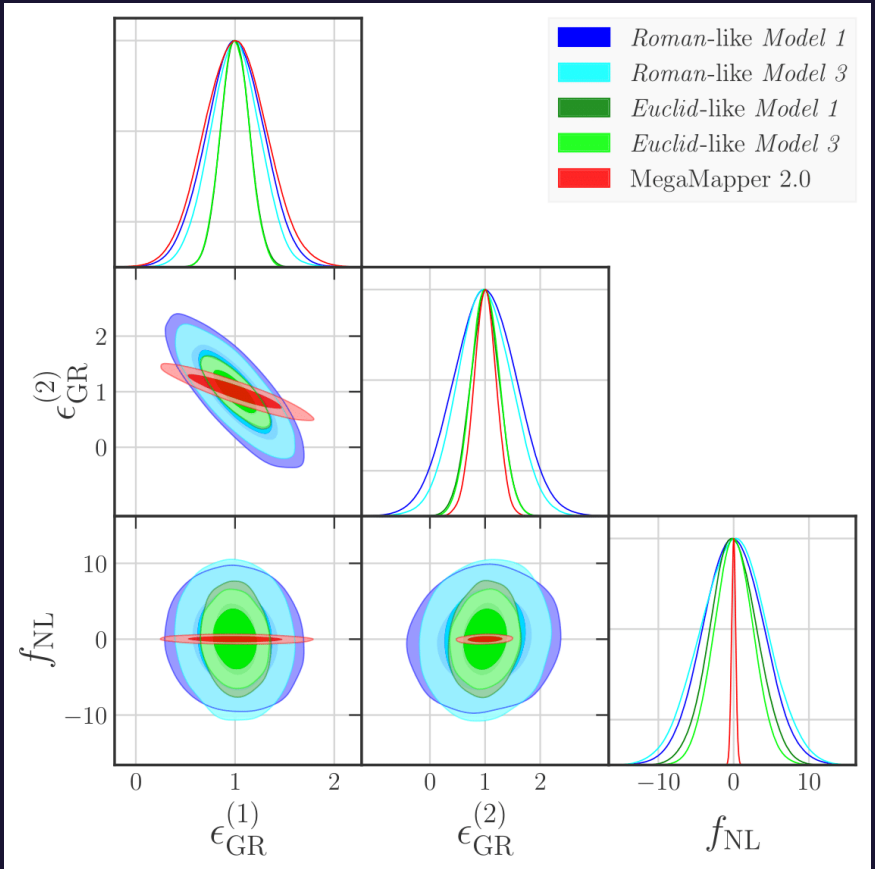




Can we measure our amplitudes precisely?

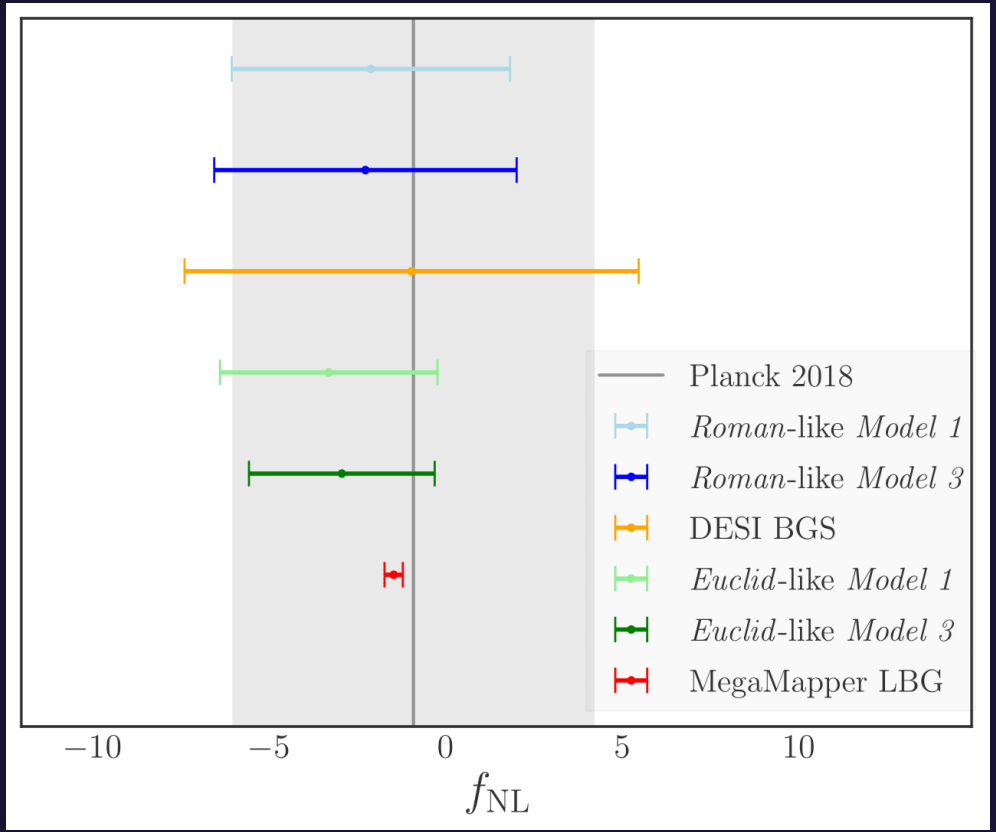
# Can we disentangle GR and PNG?




- GR amplitudes are degenerate
- Decoupling between GR and local PNG
- Good constraints with stage IV
- MegaMapper has huge potential

# What if we neglect GR?

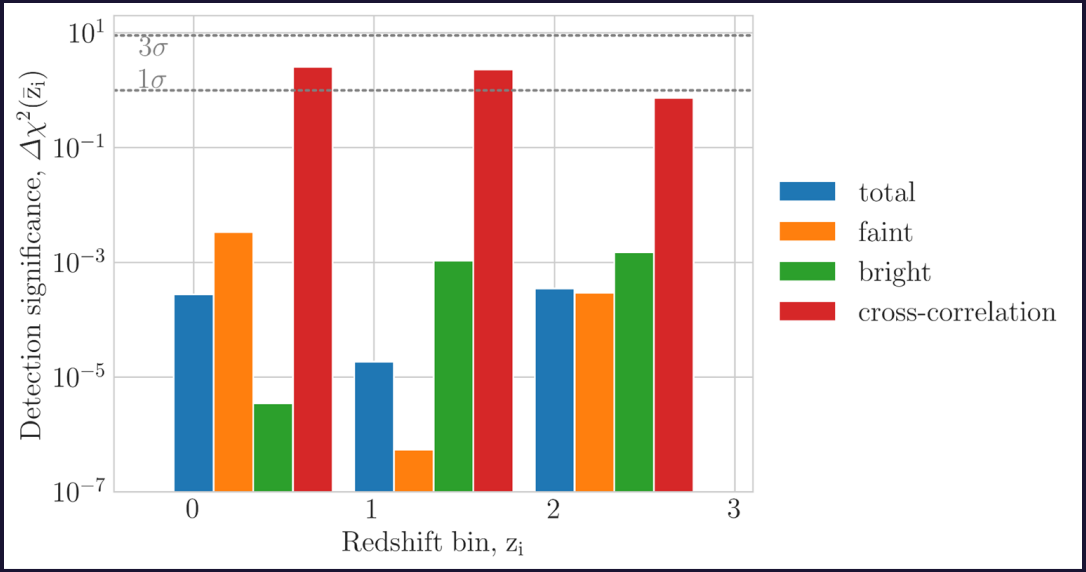
- Shift on measurements from neglecting GR corrections.
- Fiducial fNL=-0.9 (Planck 2018)
- MegaMapper has $\sim 2\sigma$ shift



# Can we get more out of one survey?

# Can we get more out of one survey?

Montano and Camera (2023) arXiv 2309.12400

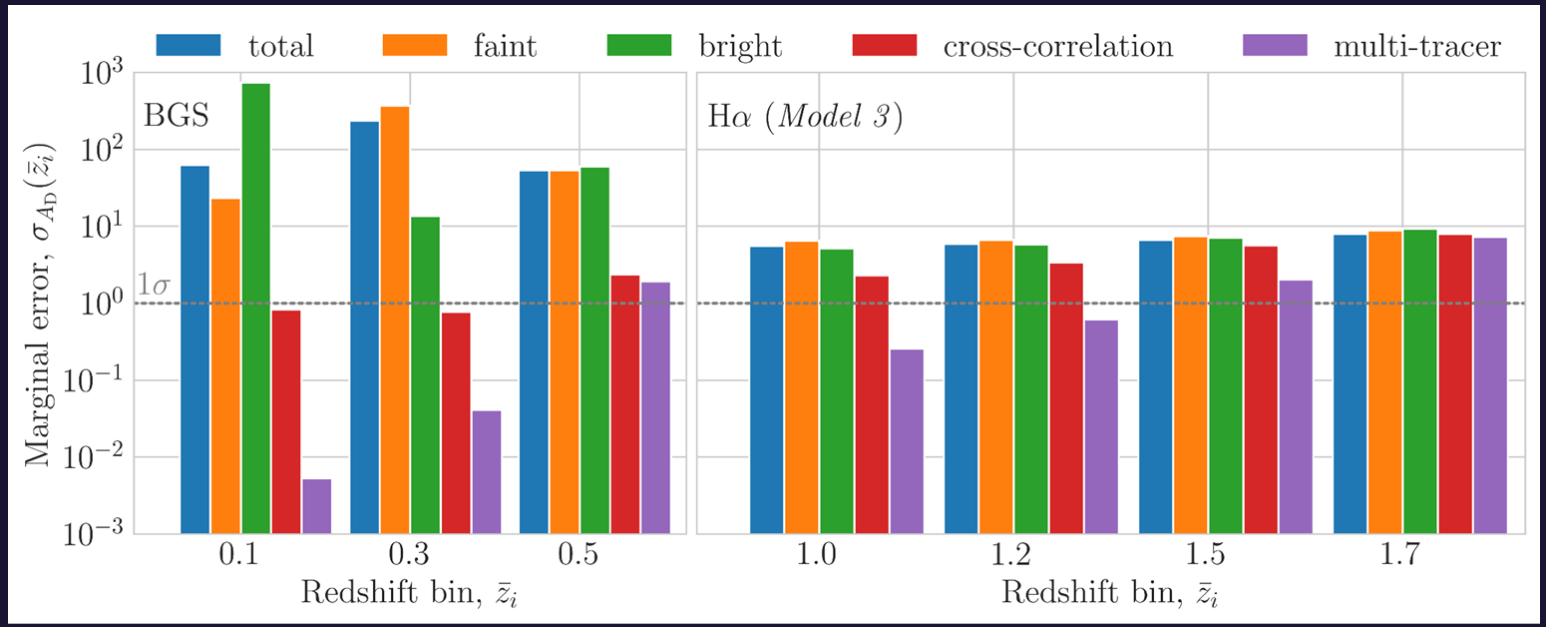



- Faint-Bright sample splitting
- Cross-Power Spectrum
- DESI BGS using a HOD model

# Can we get more out of one survey?

## Full Multi-Tracer

Montano and Camera (2024) arXiv 2407.06284



# Can we expect the same improvement?

# Can we expect the same improvement?

Not Exactly …

# Can we expect the same improvement?

Not Exactly …

$$\mathcal{K}^{(1)}_{\mathrm{GR}}(\boldsymbol{k}_a) = \mathrm{i}\,\mu_a\,\frac{\gamma_1}{k_a} + \frac{\gamma_2}{k_a^2}$$

# Can we expect the same improvement?

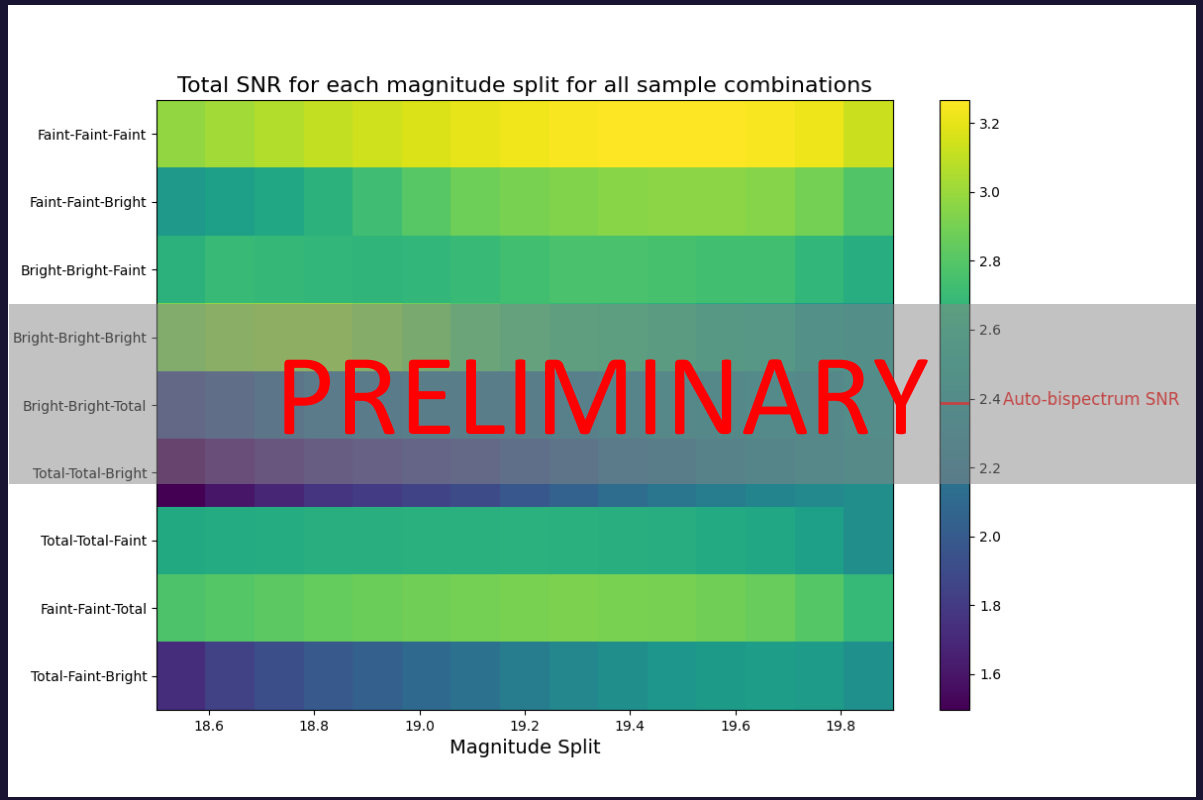
## Not Exactly …

$$\mathcal{K}^{(1)}_{\mathrm{GR}}(\boldsymbol{k}_a) = \mathrm{i}\,\mu_a\,\frac{\gamma_1}{k_a} + \frac{\gamma_2}{k_a^2}$$

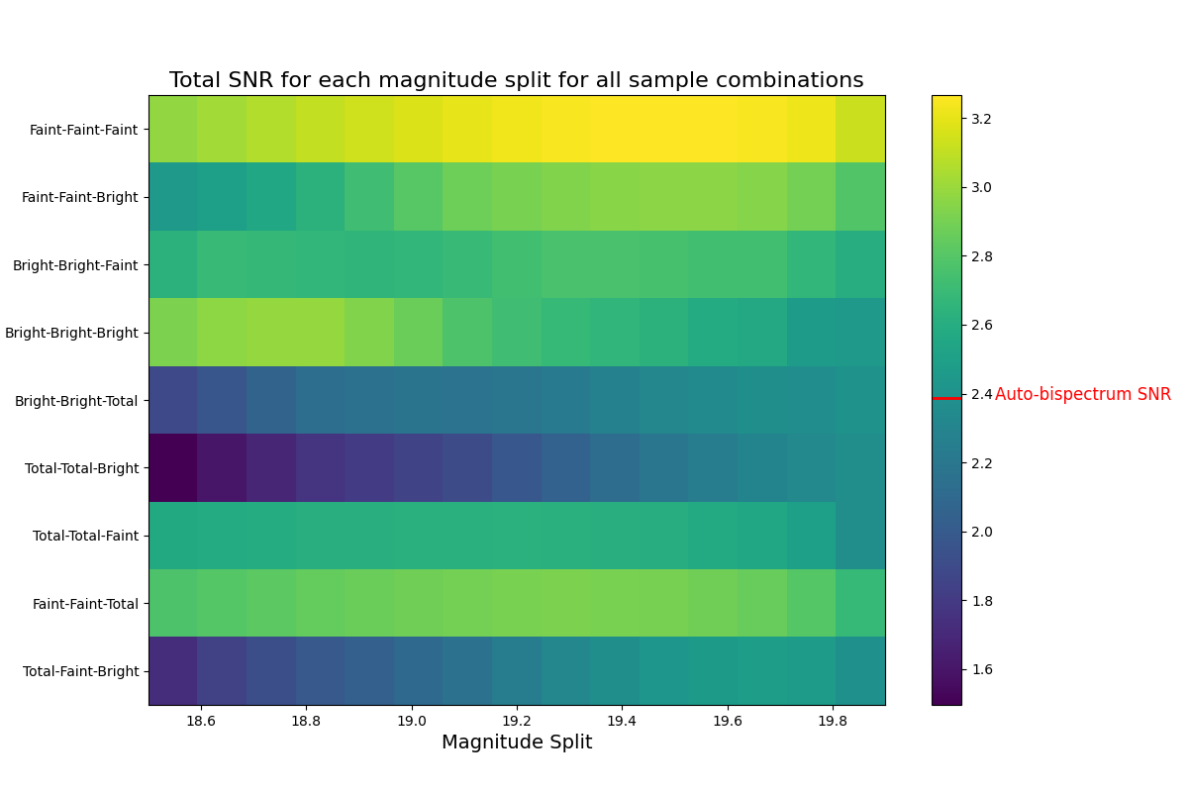
## Smoking Gun Dipole like in the Bispectrum!

Roy Maartens et al. (2020) arXiv 1911.02398

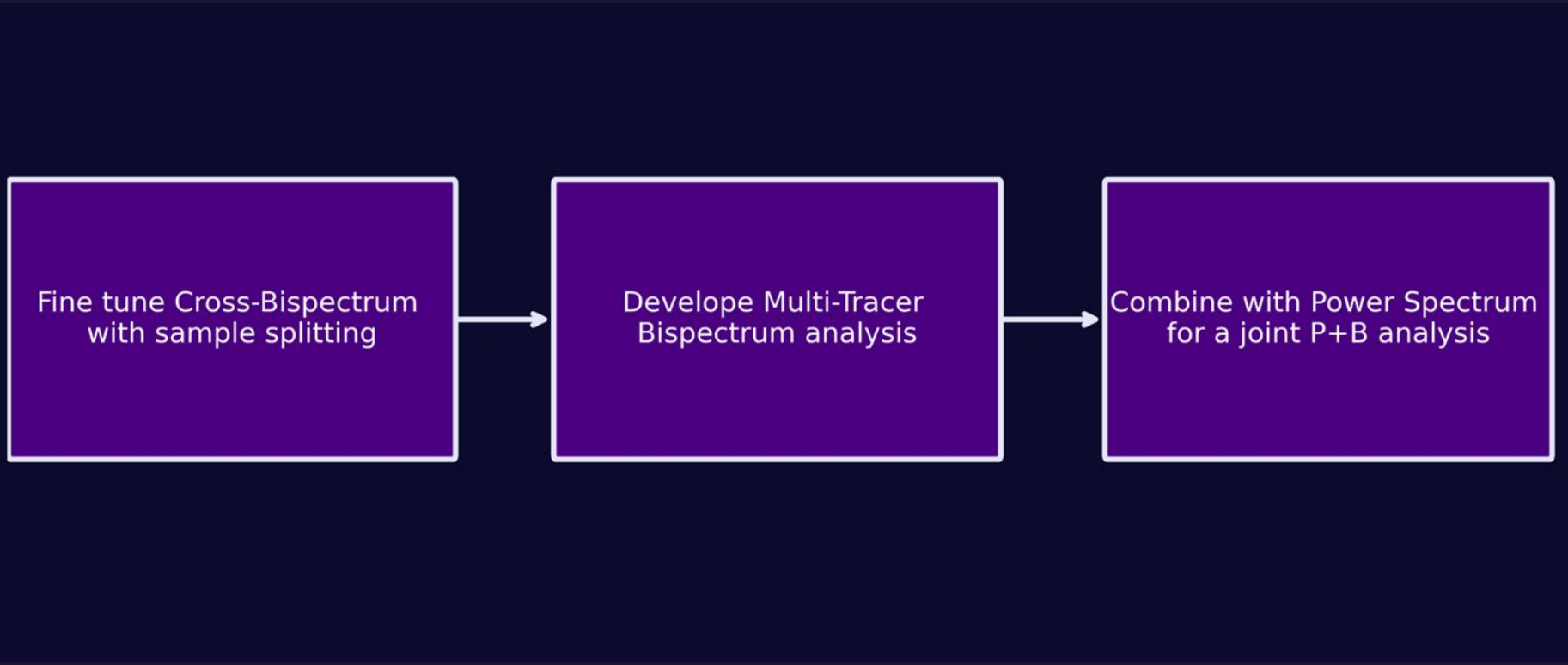
# What do we see initially?



# What do we see initially?



# What’s the plan?



# Summary & Takeaways

- The relativistic galaxy bispectrum is essential for interpreting PNG at high precision
- Neglecting GR effects can bias fNL by >1–2σ
- Euclid and MegaMapper are sensitive enough to detect GR terms directly
- Multi-tracer techniques offer promising insights into GR effects and PNG
- Precision may be achieved with the Newtonian treatment, but accuracy requires GR .