Intensity Mapping and the Multi-Tracer Technique To Detect Horizon-Scale Effects

Stefano Camera

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Horizon-Scale Cosmology

- Constraints on the properties of density perturbations on extremely large scales will improve our understanding of gravity and inflation

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- Signatures of modified gravity

  [Clifton *et al.*, 2012]

- Relativistic light-cone projection corrections to cosmological observables

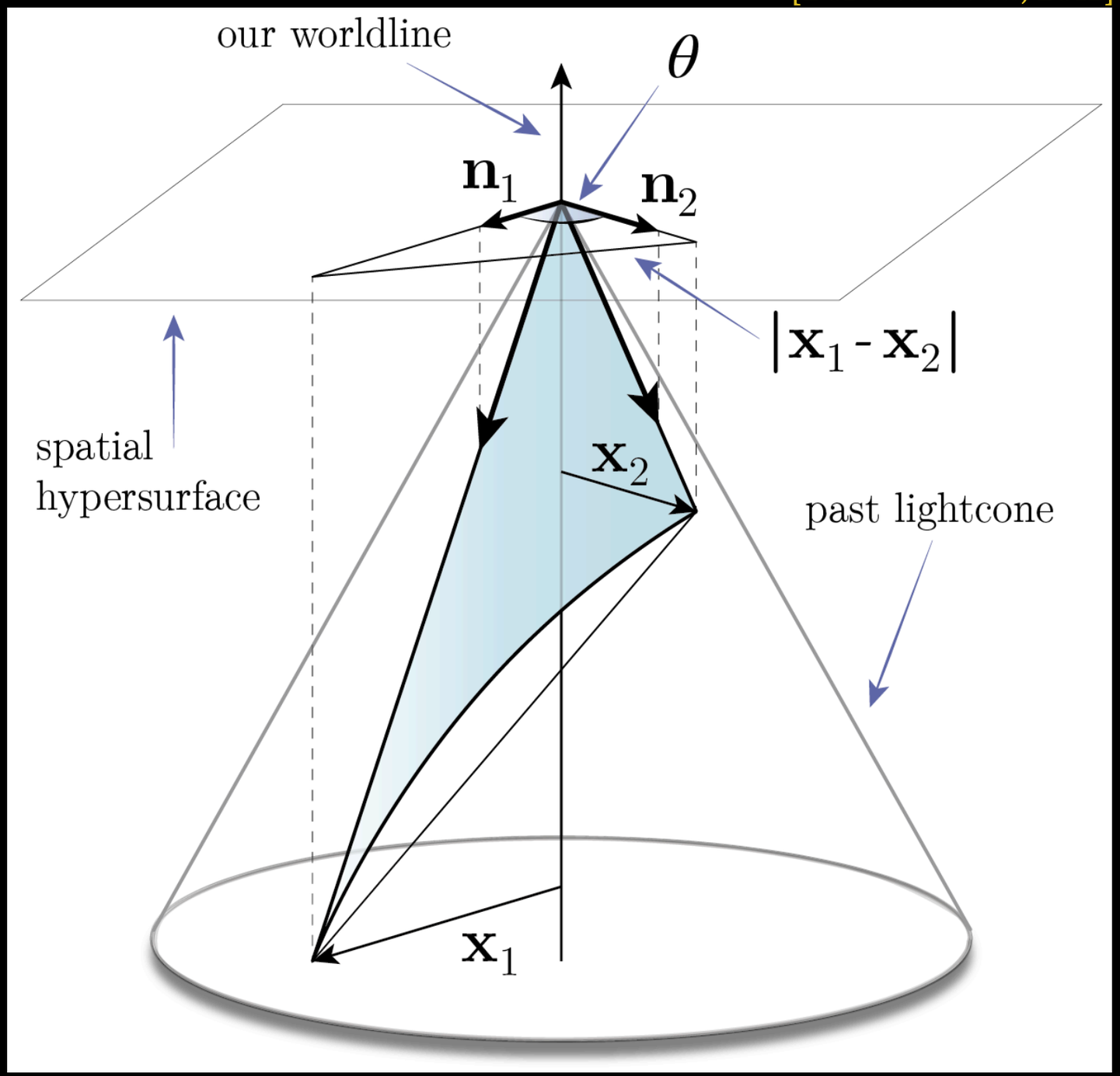
  [Yoo 2010; Bonvin & Durrer, 2011; Challinor & Lewis, 2011]

- Imprints from inflation, e.g. primordial non-Gaussianity

  [Salopek & Bond, 1990; Gangui *et al.*, 1994; Verde *et al.*, 2000]

Relativistic Corrections

[Bertacca *et al.*, 2012]



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Relativistic Corrections

- Induced corrections due to projection effects alter observed redshifts, distances and volumes

[Yoo, 2010; Bonvin & Durrer, 2012; Challinor & Lewis, 2011]

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  - + gravitational redshift + time delay + integrated Sachs-Wolfe

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Primordial Non-Gaussianity

$$\Phi = \phi + f_{\rm NL} * \left(\phi^2 - \left\langle \phi^2 \right\rangle\right)$$

- Predicted in many scenarios of inflation
- Tightest available constraints from CMB: $|f_{\rm NL}| < 10$ [Planck Collaboration, 2015]
- Accuracy of $O(1)$ possible w/ future large-scale galaxy surveys

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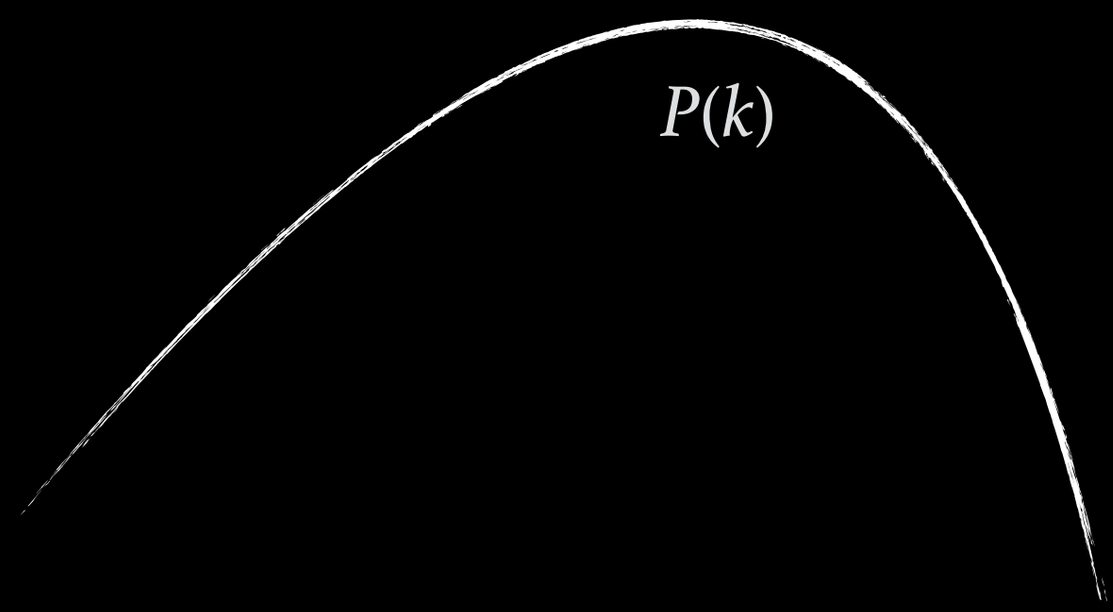

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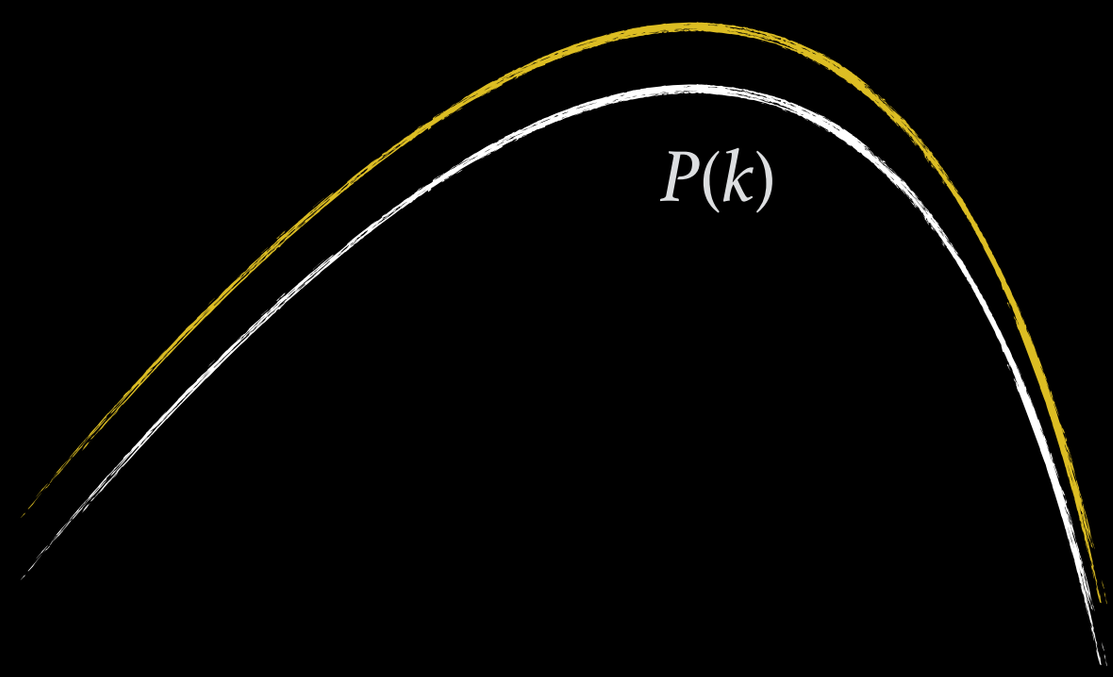

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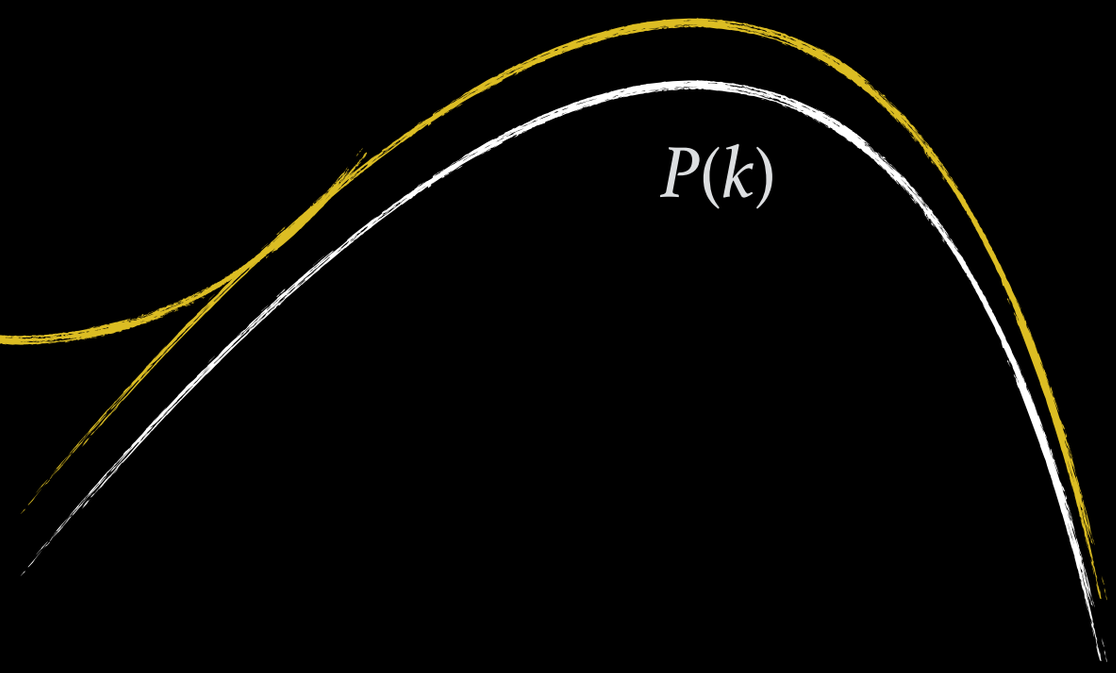

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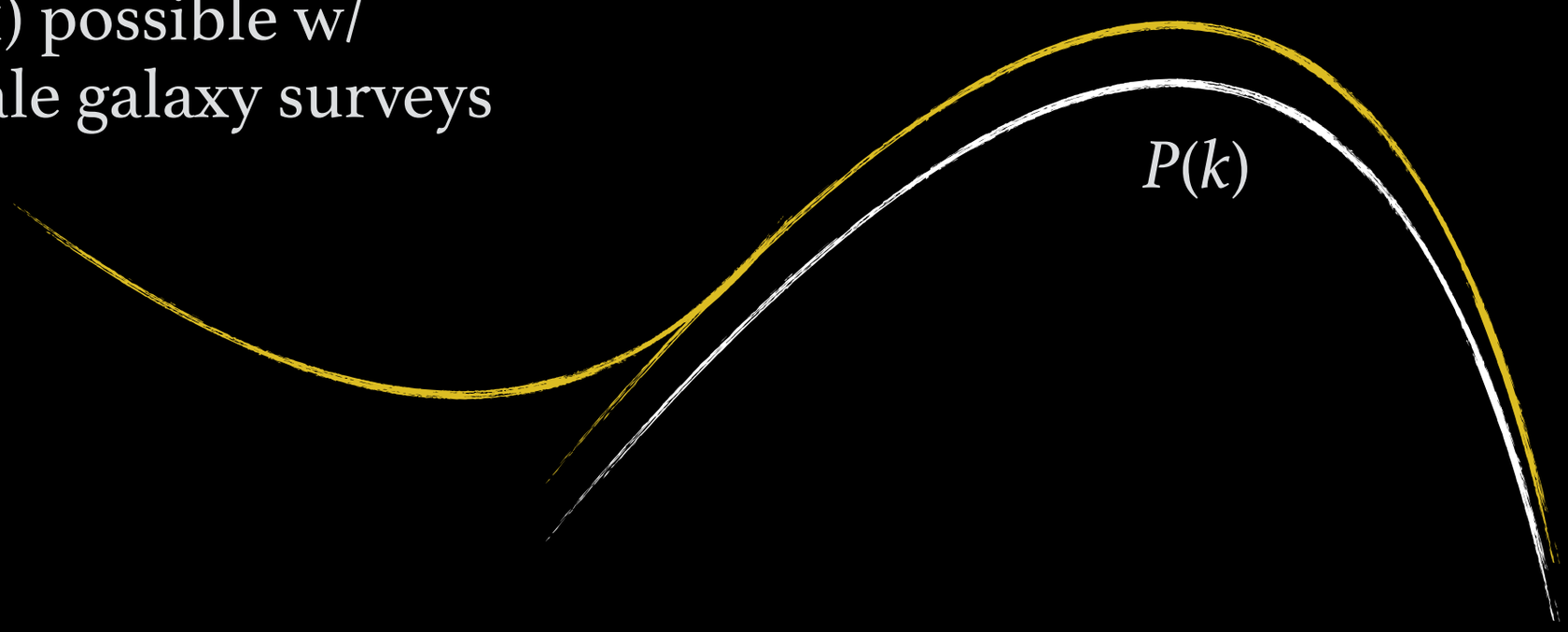

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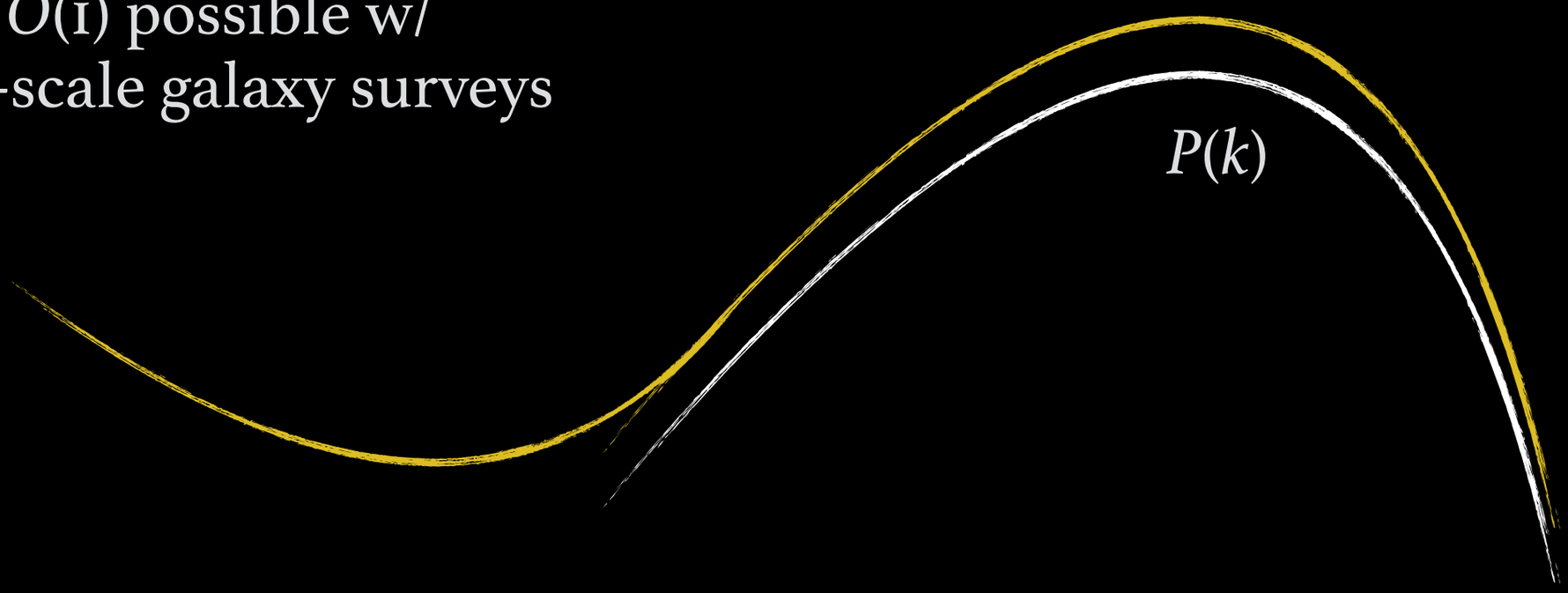

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Accessing the Largest Scales

- Probe huge volumes
- Beat cosmic variance

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- Probe huge volumes *(high sensitivity at high-z over large sky areas)*
- Beat cosmic variance *(we've got only one Universe to observe!)*

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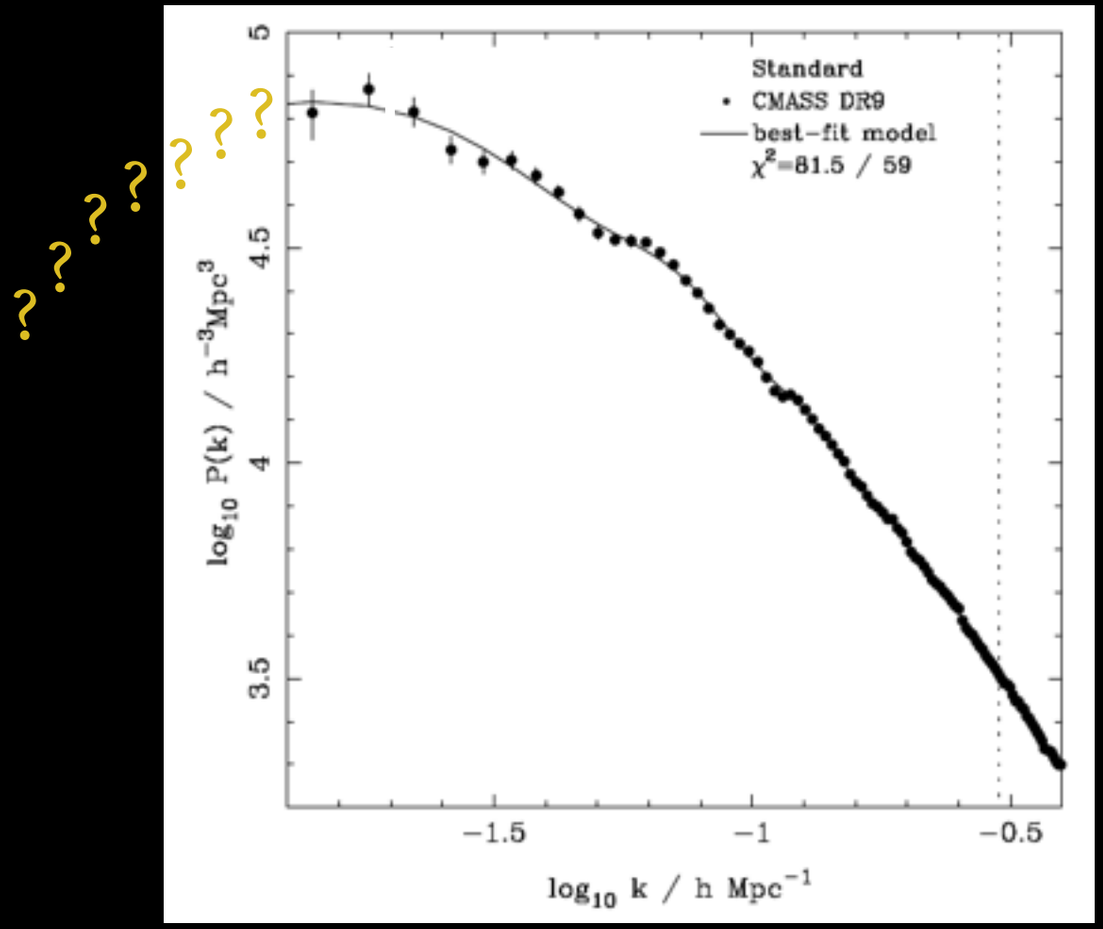
[SDSS-III BOSS, 2012]



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Multi-Tracer Technique

- Comparing the relative clustering of different populations of tracers

[Seljak, 2009; Seljak & McDonald, 2009]

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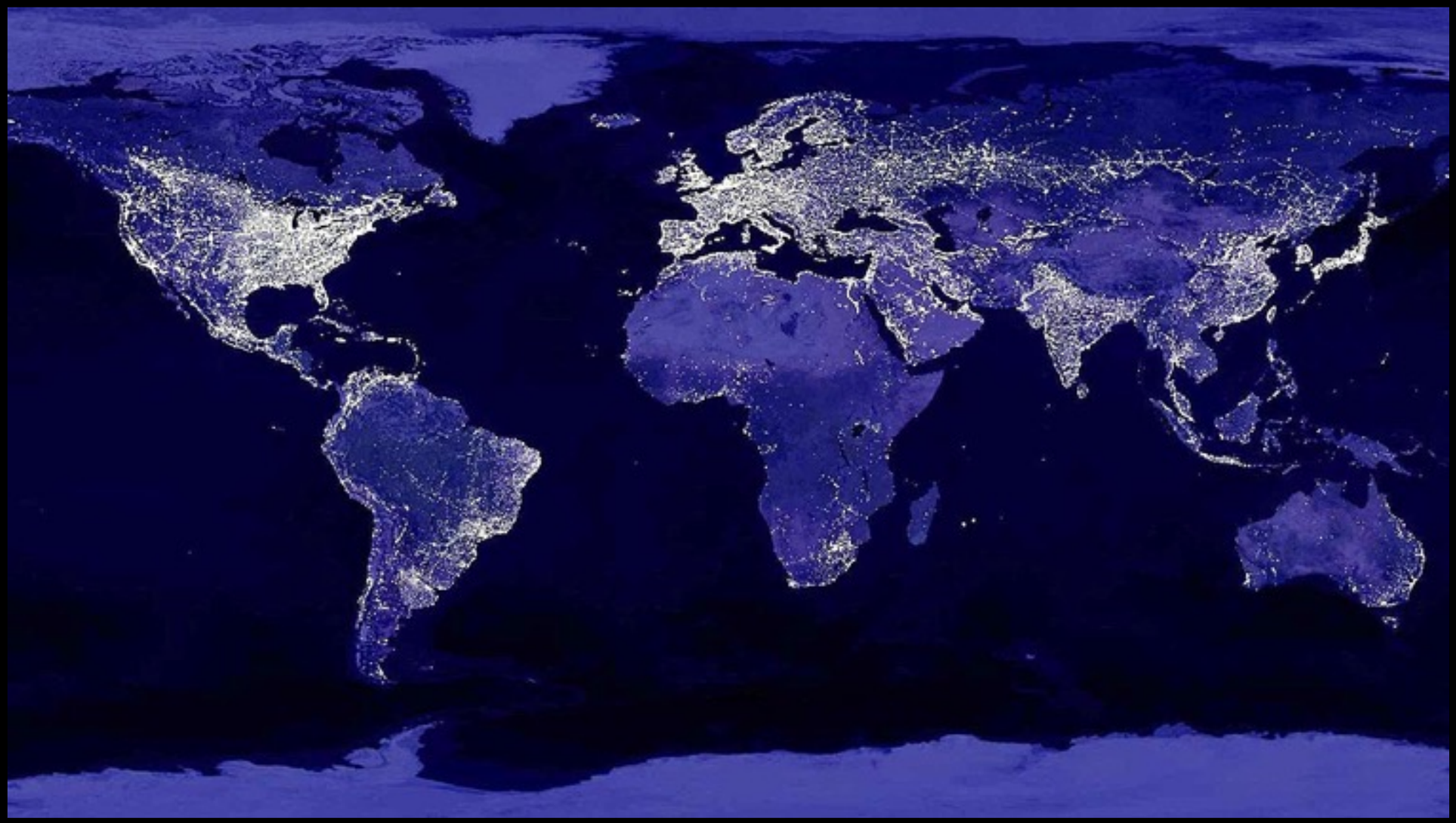

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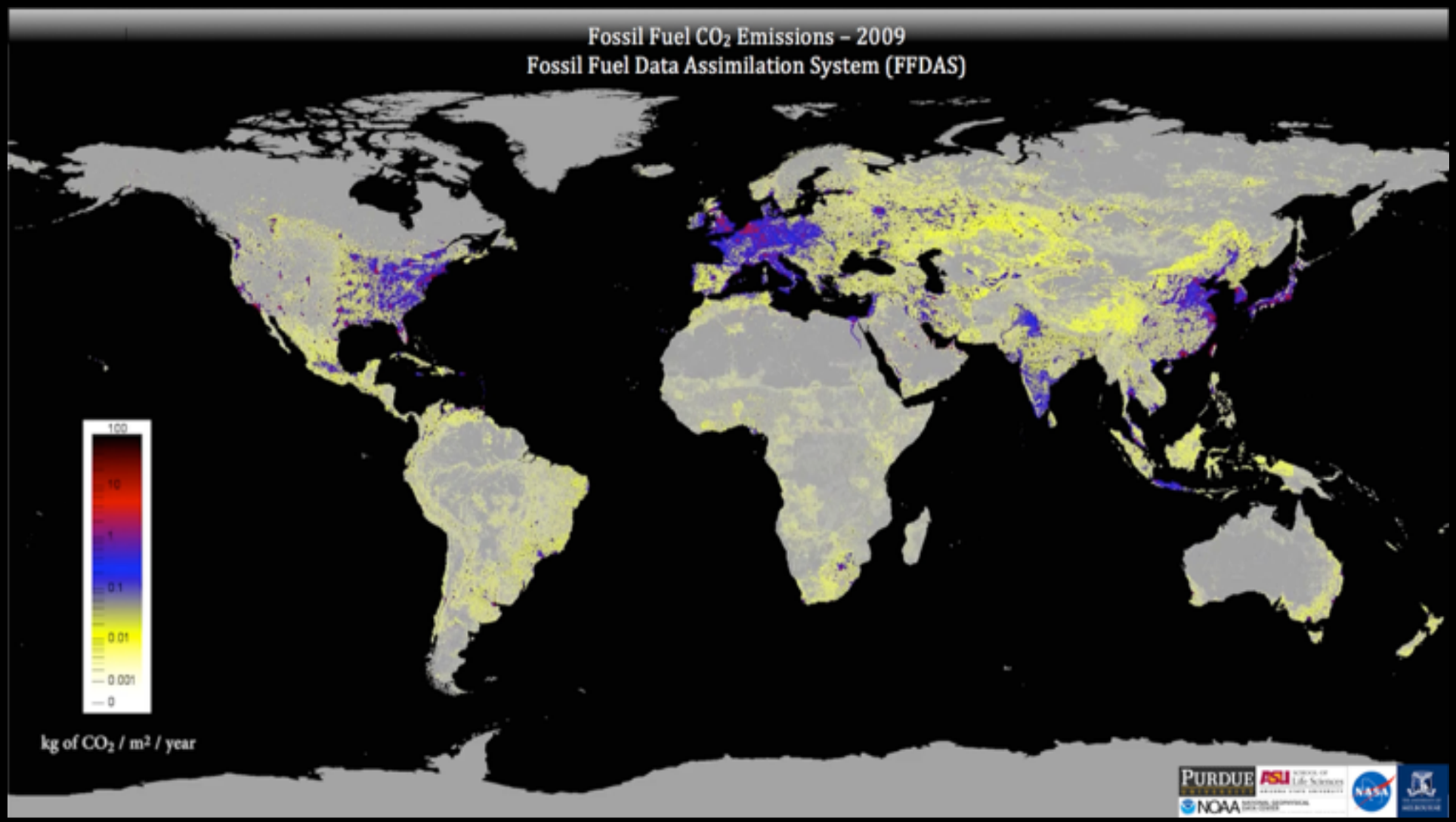

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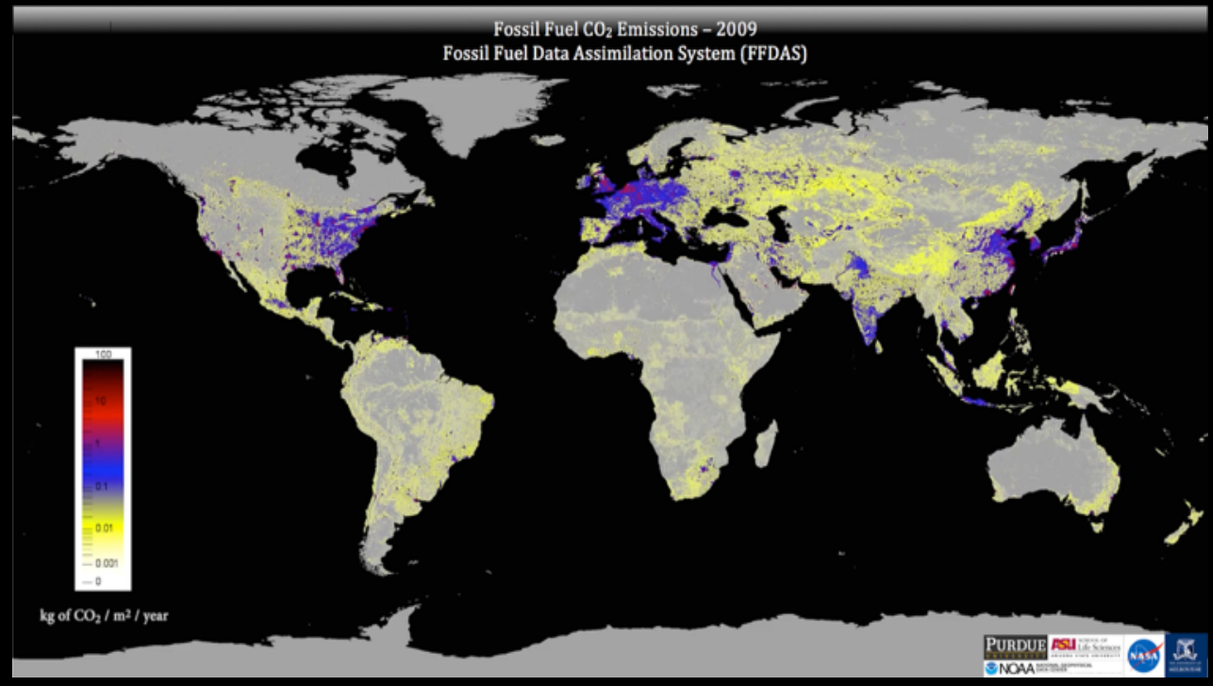
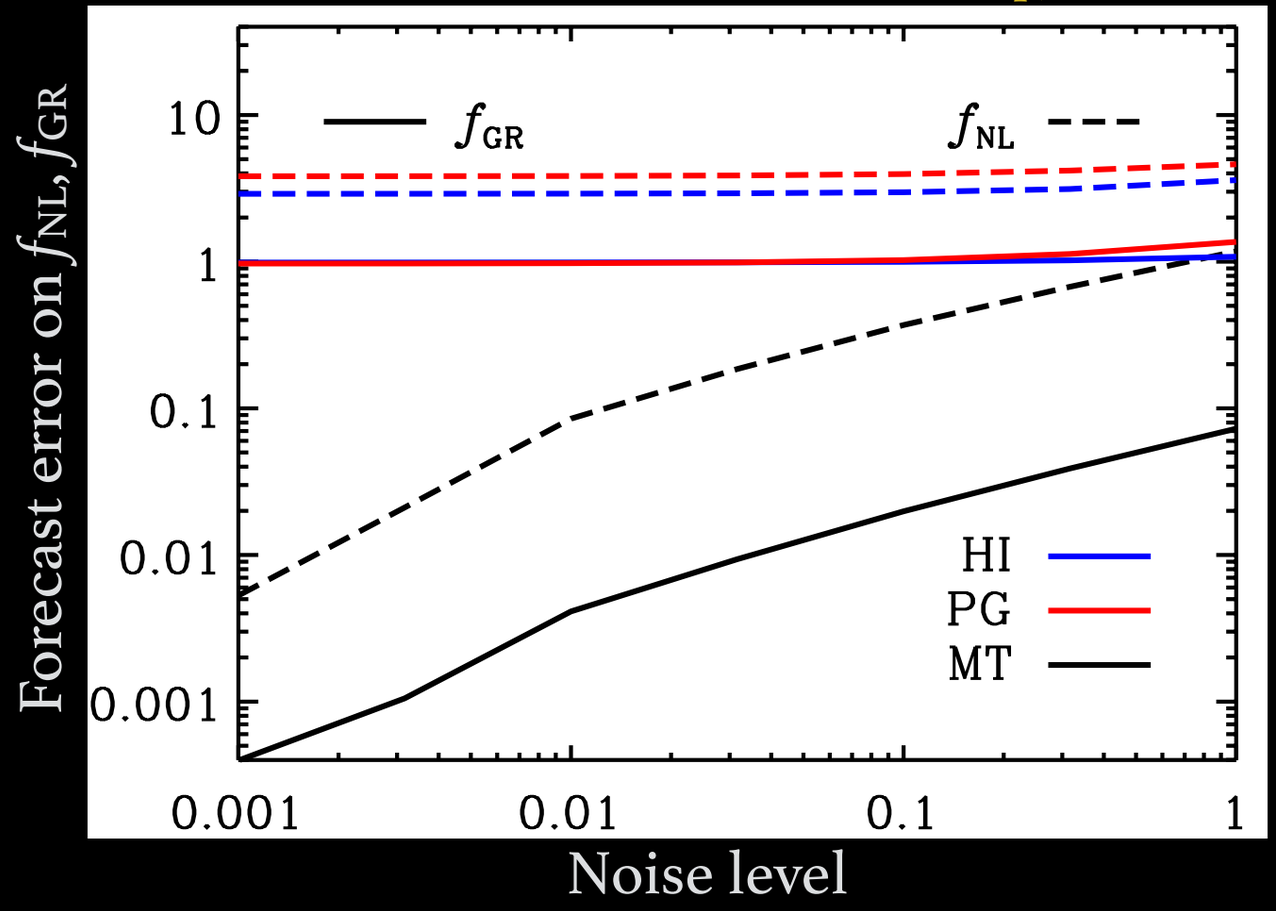


Multi-Tracer Technique

- Comparing the relative clustering of different populations of tracers
  [Seljak, 2009; Seljak & McDonald, 2009]
- Even more promising for multi-wavelength synergies

[Fonseca, SC, Santos & Maartens, ApJ Lett. 2015]



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Ultra-Large Scales Matter!

- Neglecting horizon scale effects can undermine future cosmological experiments' accuracy

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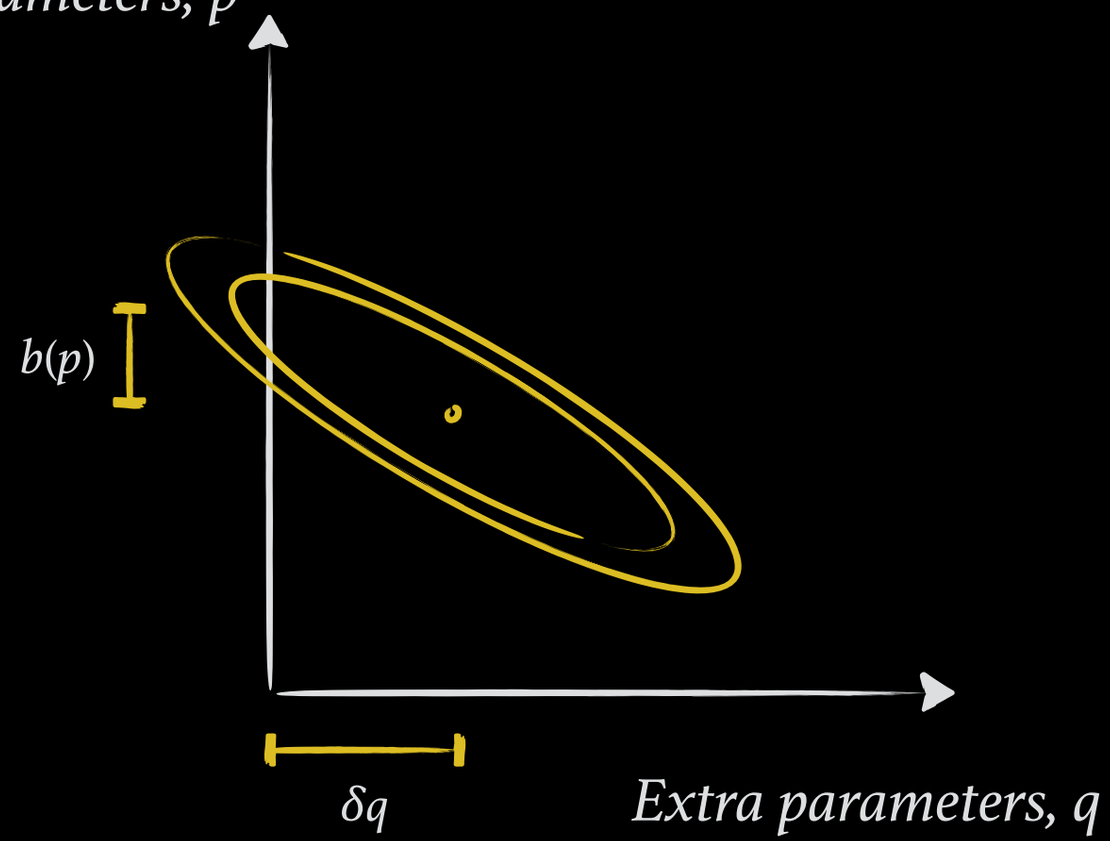
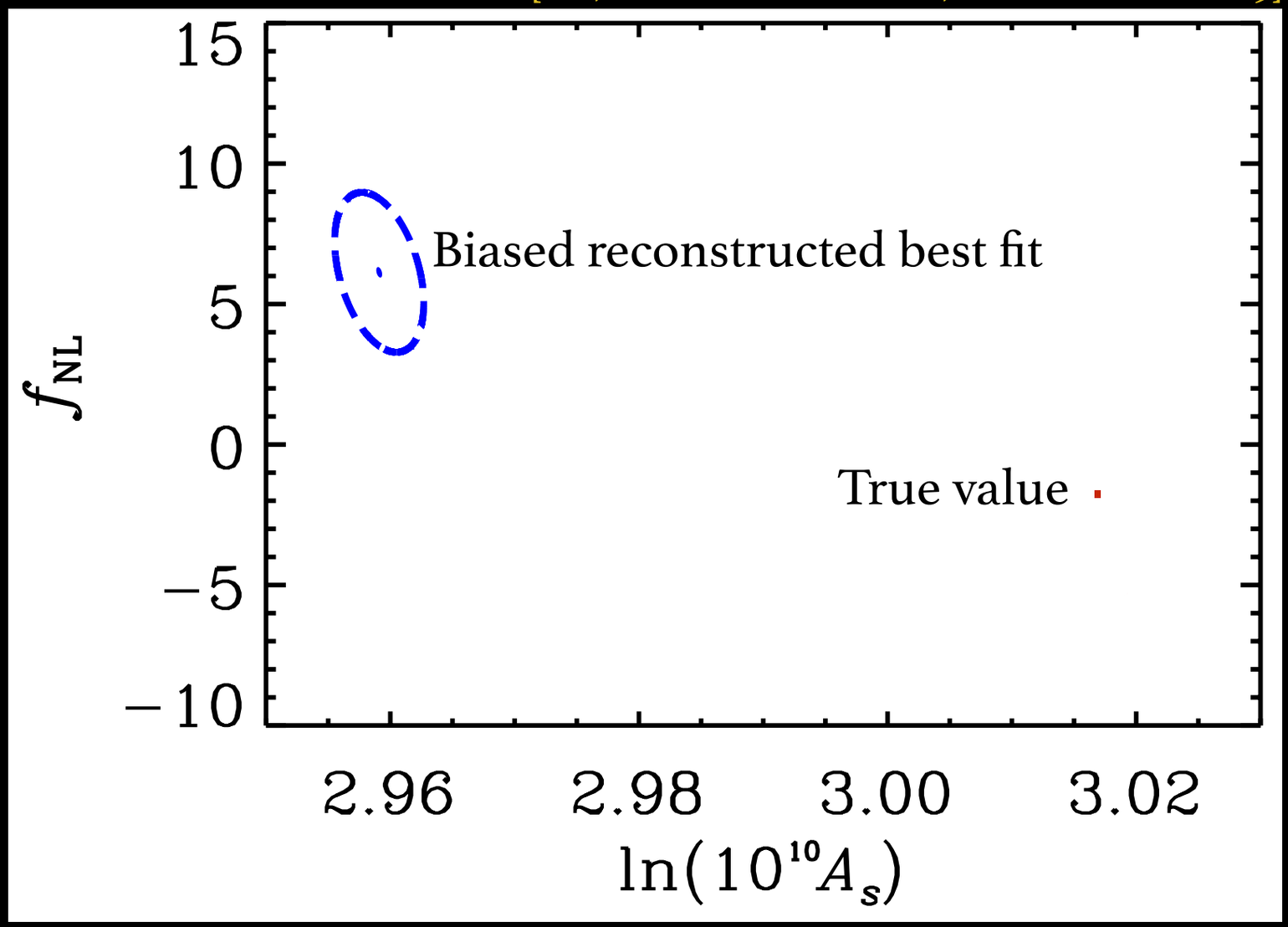
[Heavens, Kitching & Verde, 2007]



Neglecting Relativistic Effects

[SC, Maartens & Santos, MNRAS Lett. 2015]



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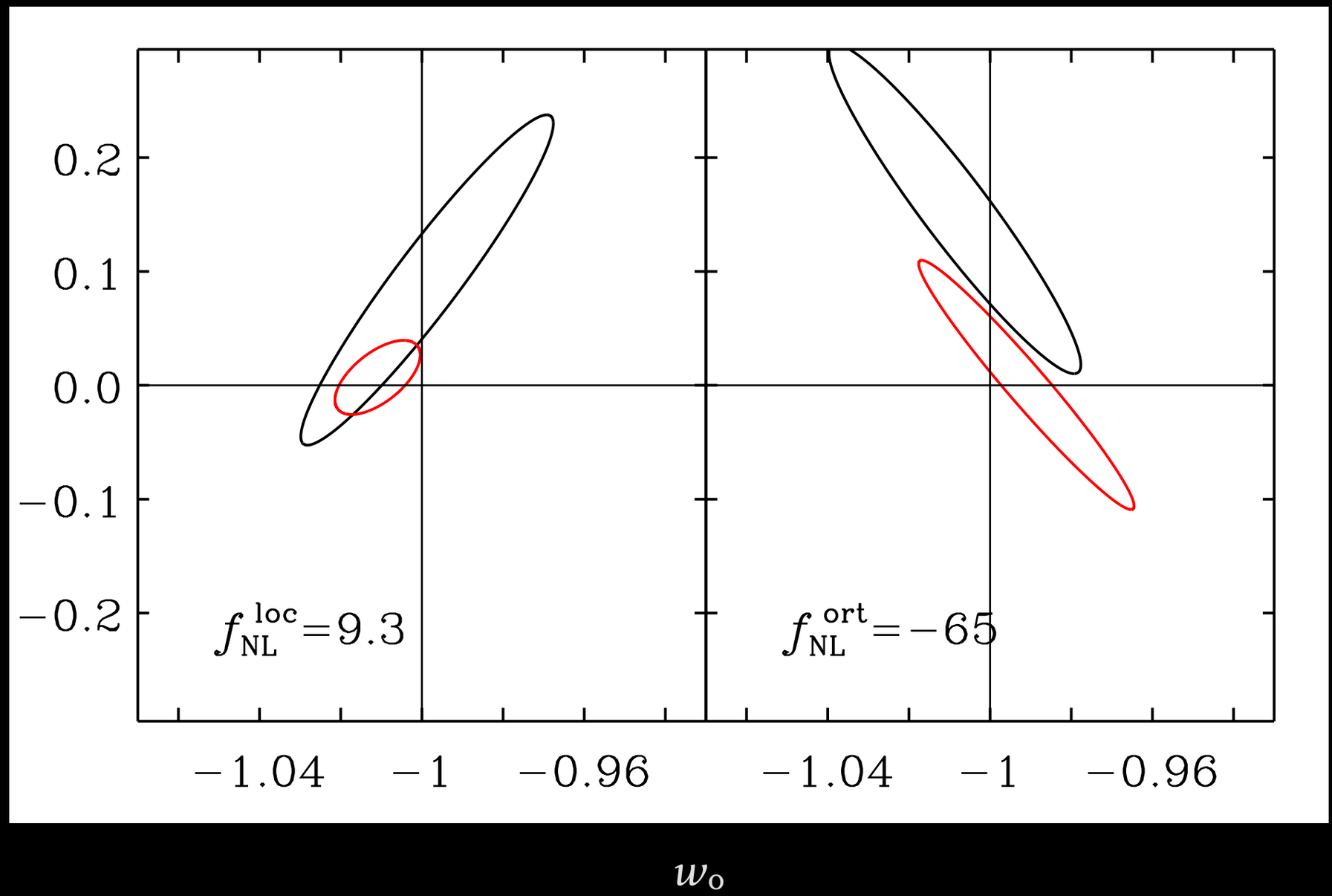
Neglecting non-Gaussianity

[SC, Carbone, Fedeli & Moscardini, 2015]



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Summary

- The largest scales are a playground for possibly unknown physics
  (modified gravity?)

- They can further confirm Einstein's general relativity
  (tests for relativistic corrections)

- They can improve our knowledge of inflation and early Universe
  (e.g. primordial non-Gaussianity)

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Summary

- The largest scales are a playground for possibly unknown physics *(modified gravity?)*
- They can further confirm Einstein's general relativity *(tests for relativistic corrections)*
- They can improve our knowledge of inflation and early Universe *(e.g. primordial non-Gaussianity)*
- An incorrect account for ultra-large scale effects may seriously threaten future large-scale cosmological experiments' accuracy

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Thank You!