

Constraining $f(R)$ -Gravity Using Future Galaxy Cluster Abundance and Weak-Lensing Mass Calibration Datasets

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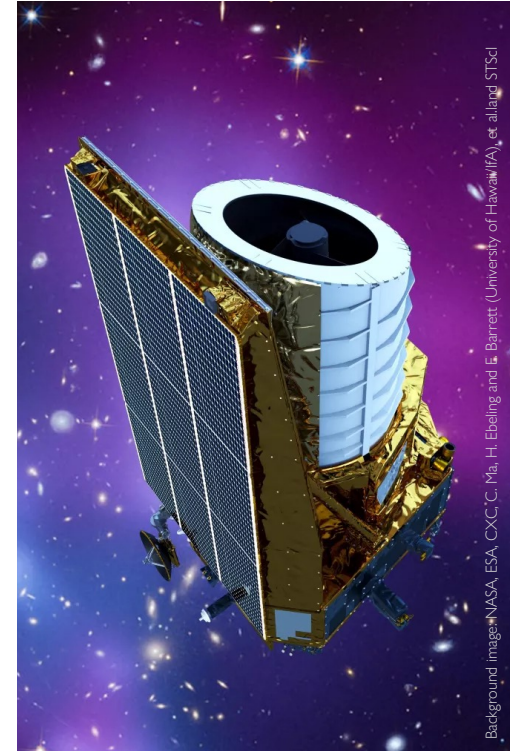
November 6th 2023

New Physics from Galaxy Clustering II, Trieste

with S. Bocquet, C. Davies, J. Mohr, F. Schmidt



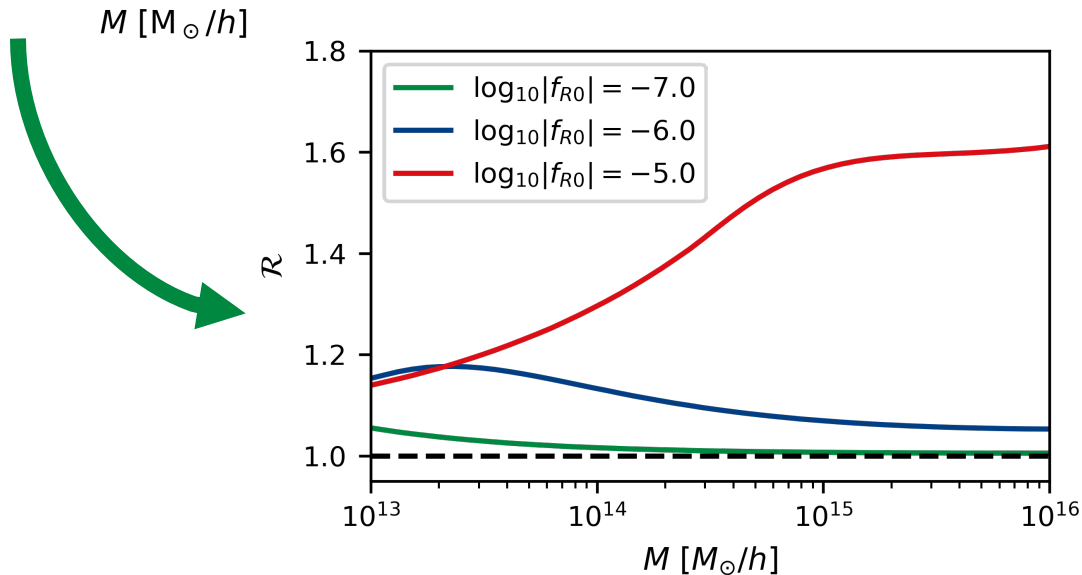
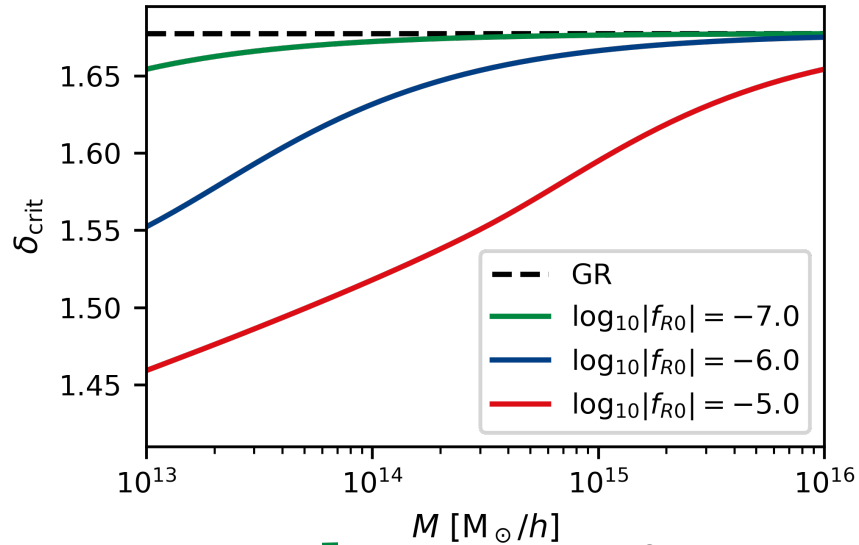
- Modified growth of structure: $\nabla^2 \Phi = 4\pi G \delta\rho - \frac{1}{2} \delta f_R$
 - Scale-dependent structure growth and thus HMF
- Understanding the constraining power of future Stage-III and -IV surveys combining:
 - SZ cluster survey: SPT-3G or CMB-S4
 - Next-generation Stage-IV WL (ngWL) surveys like Euclid or Rubin



Background image: NASA, ESA, CXO, C. Ma, H. Ebeling and E. Barrett (University of Hawaii/IFA), et al./agf STScI

<https://indico.cmb-s4.org><https://rubin.canto.com/v/gallery>

HMF in $f(R)$ -Gravity



$$\frac{dn}{d \ln M} = \left. \frac{dn}{d \ln M} \right|_{\text{Tinker}} \cdot \mathcal{R}$$

$$\mathcal{R} = \frac{\left. \frac{dn}{d \ln M} \right|_{\text{ST}, f(R)}}{\left. \frac{dn}{d \ln M} \right|_{\text{ST}, \text{GR}}}$$

$$\left. \frac{dn}{d \ln M} \right|_{\text{ST}} = \frac{\bar{\rho}_m}{M} f\left(\frac{\delta_c}{\sigma}\right)_{\text{ST}} \left[\frac{d \ln \delta_c}{d \ln M} - \frac{1}{2} \frac{d \ln \sigma^2}{d \ln M} \right]$$

SPT-3G

- 2 fields observed with SPT
- Area: 5,000 deg²
 - Completely covered by ngWL surveys
- SNR: $\xi > 4.25$ and $\xi > 5$
- Redshift: $0.25 < z < 2$

Expected number of clusters in GR
~6000

CMB-S4

- Upcoming Stage-IV survey
- Area: ~21,000 deg²
 - ngWL overlap: ~10,000 deg²
- SNR: $\xi > 5$
- Redshift: $0.1 < z < 2$

Expected number of clusters in GR
~32000



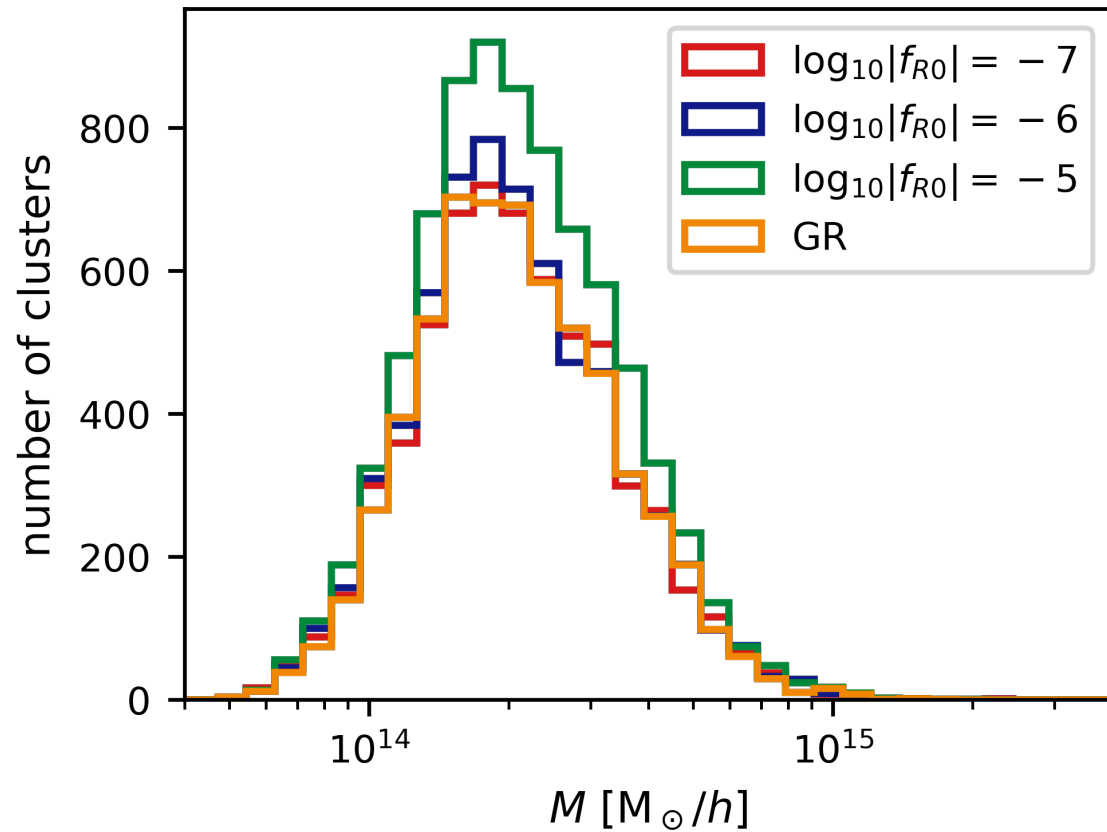
ngWL survey specifications

- Used for mass calibration of the clusters
- Similar to WL data from Euclid or Rubin
- 30 sources / arcmin²
- Ellipticity dispersion of 0.3
- 11 tomographic redshift bins in $z \in [0, 2.6]$
with 6% uncertainty in redshift

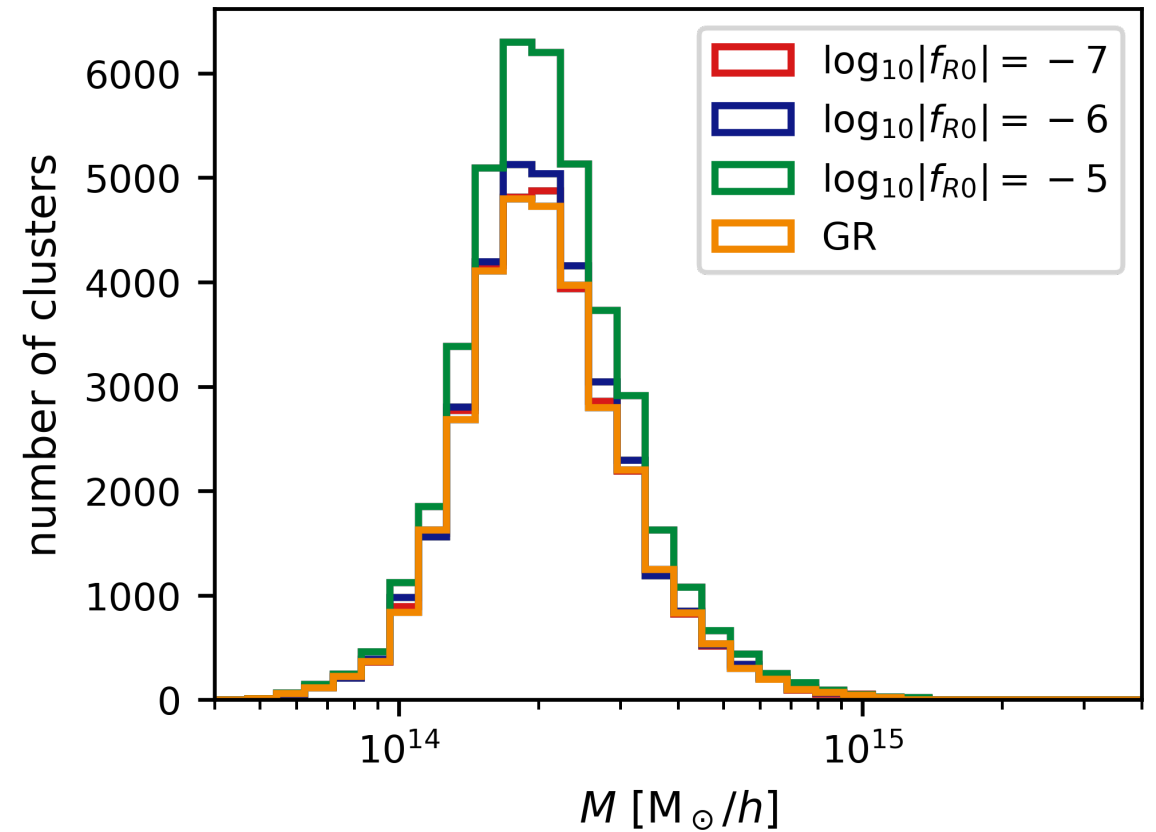
Strong constraints on the
mass observables



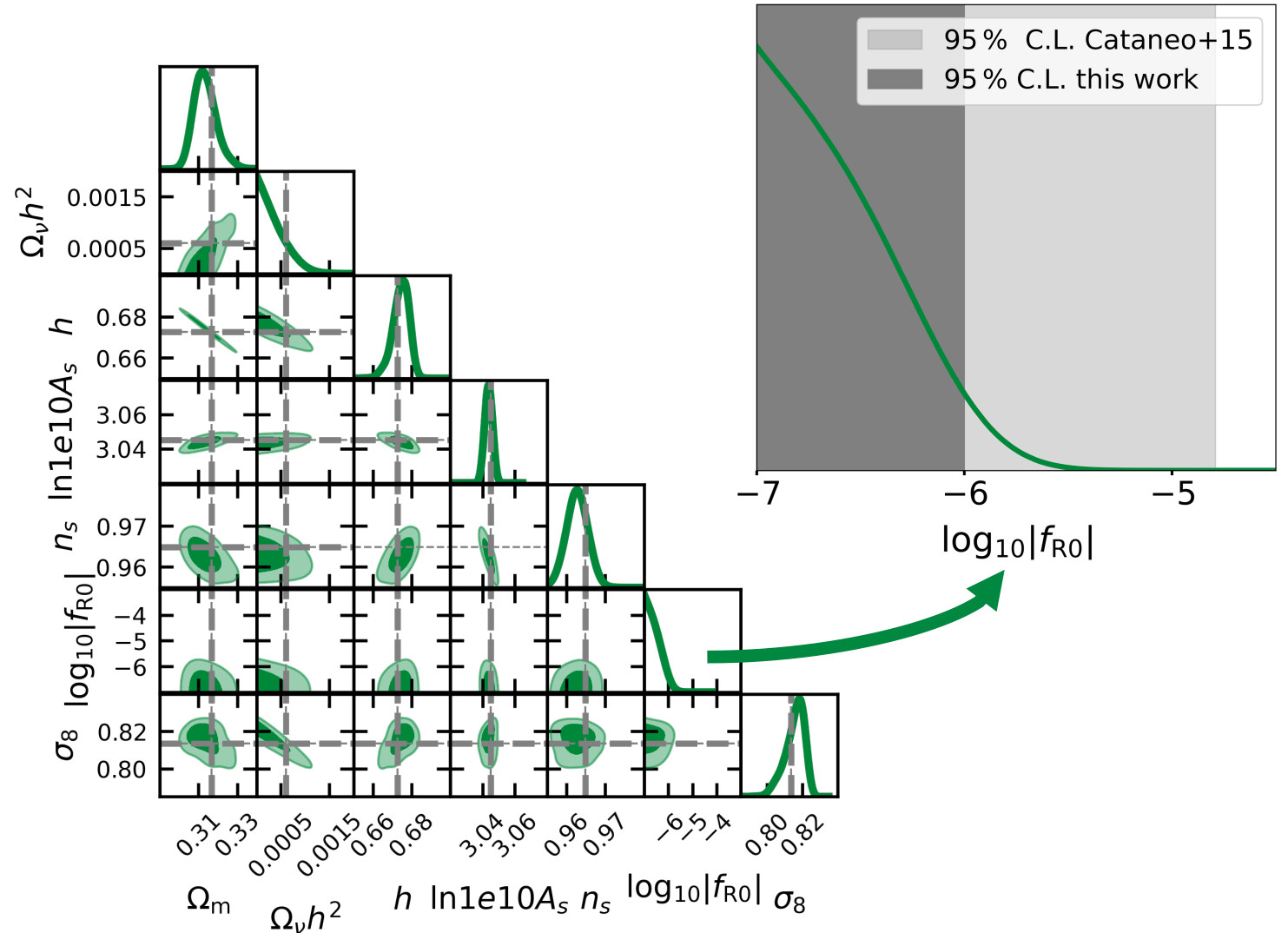
SPT-3G \times ngWL



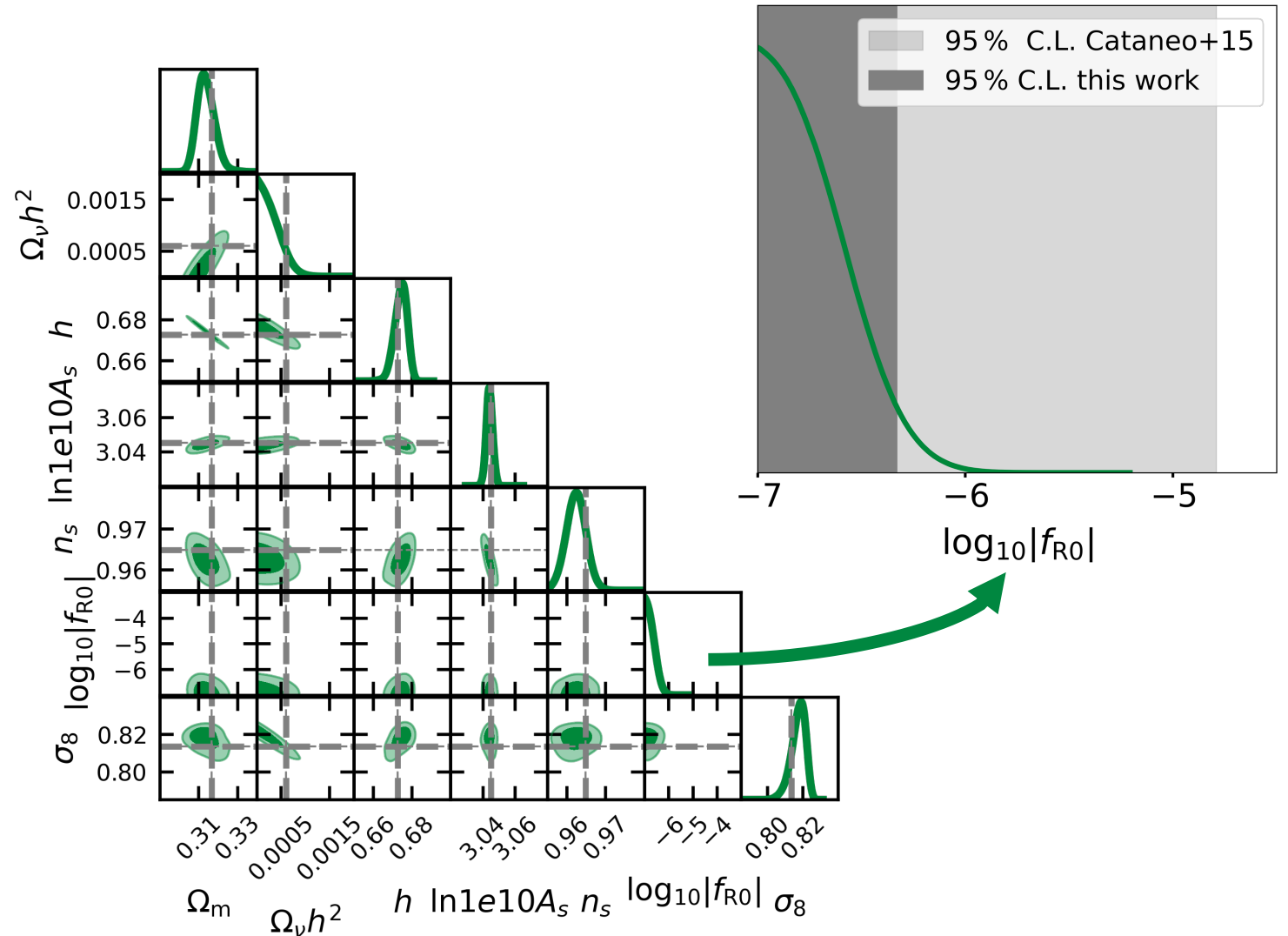
CMB-S4 \times ngWL



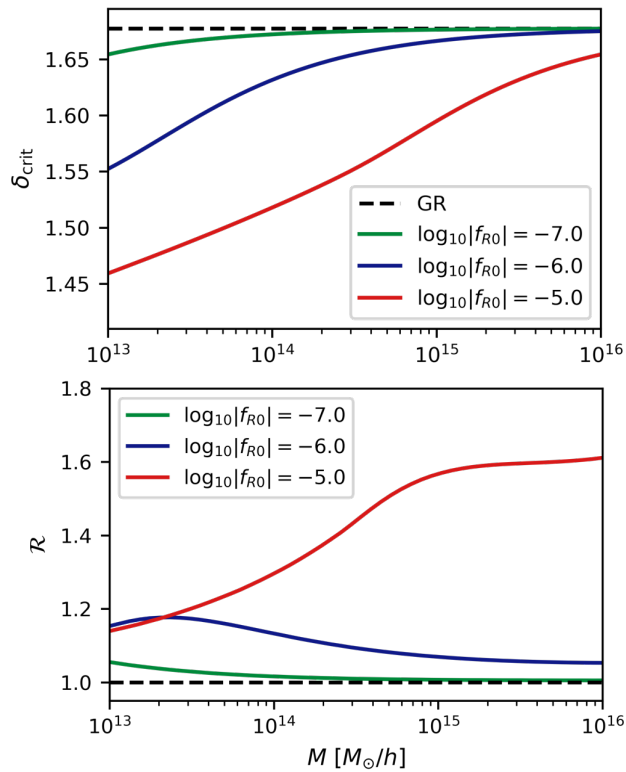
- Cosmology constrains from cluster abundance data using mass calibration from WL data
- Adding primary CMB Planck18 data to break degeneracies, i.e. tight constraints for Ω_m and A_s



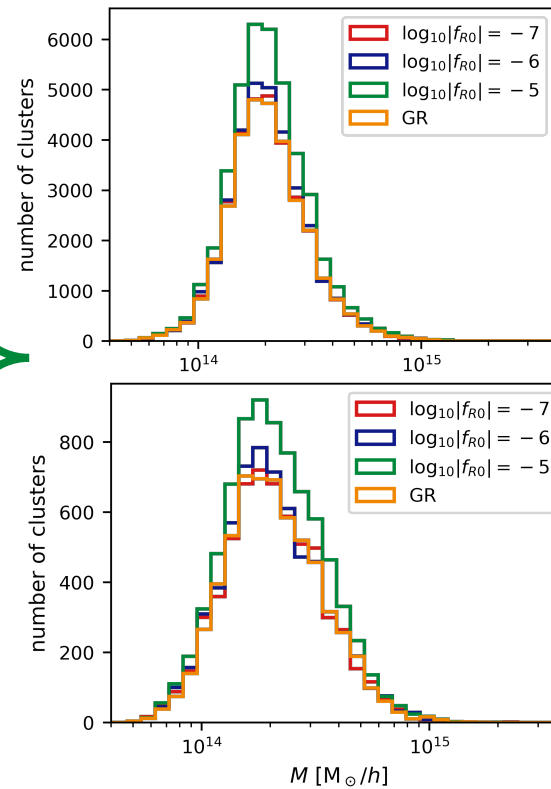
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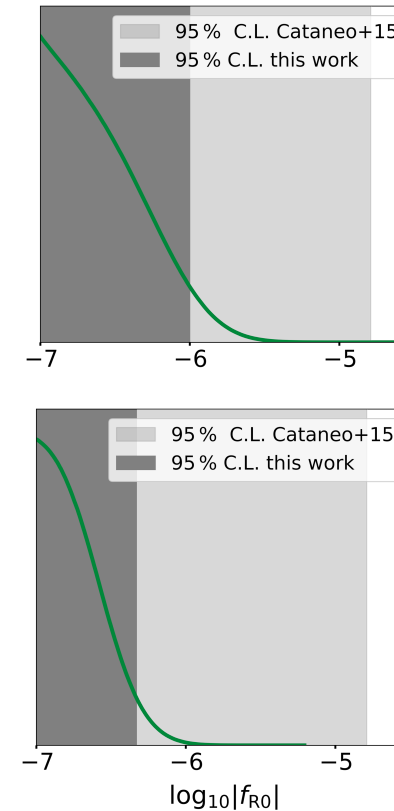
$f(R)$ -gravity: scale dependent growths



Mock catalogues for SPT-3GxngWL and CMB-S4xngWL surveys



Strong constraints from future cluster+WL data



Outlook to next project

Apply analysis to the current SPTxDES Y3 dataset

Analysis in progress