Probing Unification Scenarios with Big Bang Nucleosynthesis

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Numerical Analysis

PRyMordial: The First Three Minutes, Within and Beyond the Standard Model

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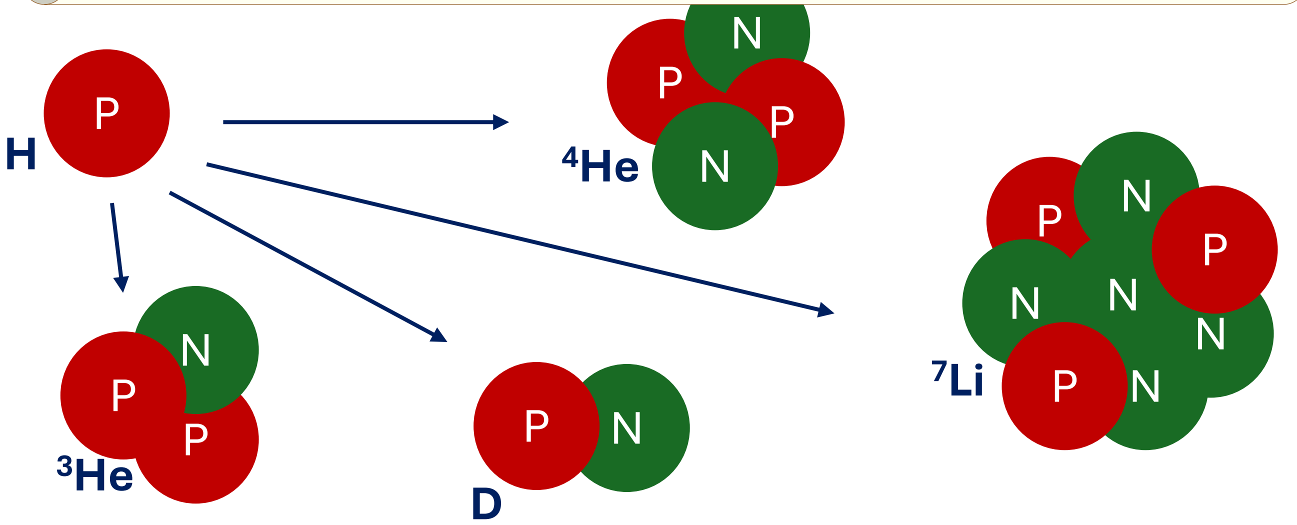
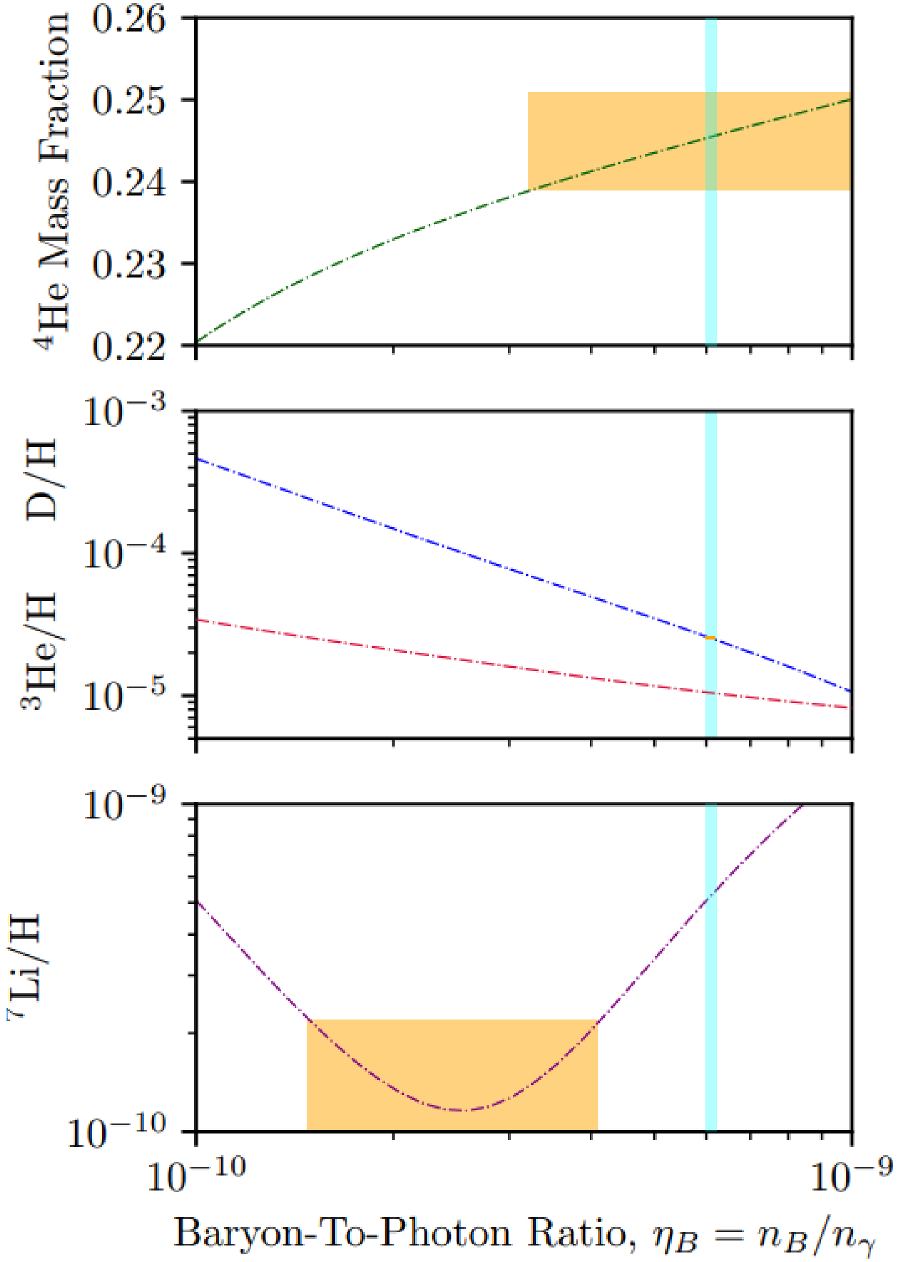
Abstract. In this work we present PRyMordial: A package dedicated to efficient computations of observables in the Early Universe with the focus on the cosmological era of Big Bang Nucleosynthesis (BBN). The code offers fast and precise evaluation of BBN light-element abundances together with the …

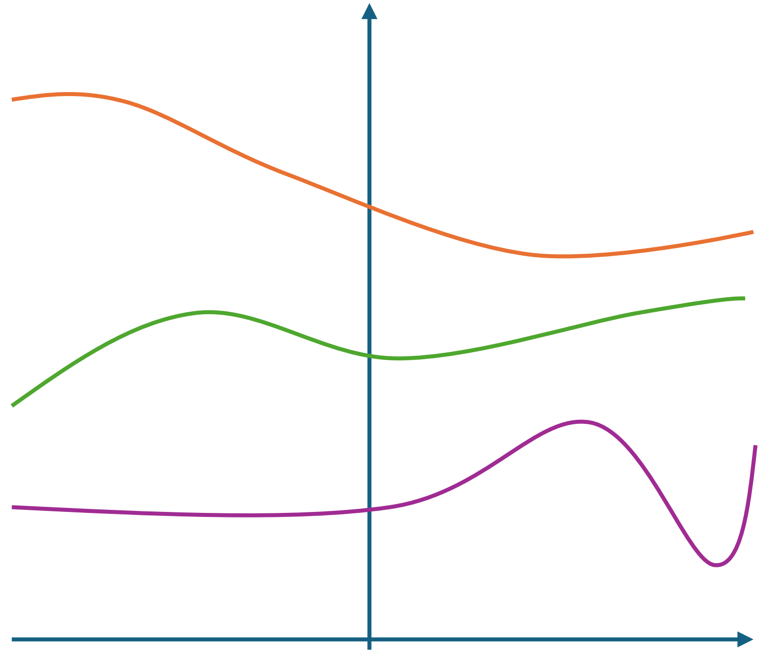




Perturbative Approach

$$\frac{\Delta x}{x} = f_x(R, S)\,\frac{\Delta\alpha_{EM}}{\alpha_{EM}}$$

- $\frac{\Delta v}{v} = S\,\frac{\Delta h}{h}$ → Electroweak effects
- $\frac{\Delta\Lambda_{QCD}}{\Lambda_{QCD}} = R\,\frac{\Delta\alpha_{EM}}{\alpha_{EM}}$ + EW terms → QCD effects



M. T. Clara and C. J. A. P. Martins. "Primordial Nucleosynthesis with Varying Fundamental Constants: Improved Constraints and a Possible Solution to the Lithium Problem". In: Astronomy& Astrophysics 633 (Jan. 2020), p. L11. DOI: 10.1051/0004- 6361/201937211. arXiv: 2001.01787 [astro-ph.CO].

Code Adaptation

$$x = x_0\left(1 + f_x \frac{\Delta\alpha_{EM}}{\alpha_{EM}}\right)$$

```python
if(not PRyMvar.variable_flag):
    PRyMvar.dalpha = 0. # this will impose that no changes are made
# Variation functions of S and R
f_tau_n = -0.2 - 2.*PRyMvar.S + 3.8*PRyMvar.R
f_gp = 0.1*PRyMvar.R - 0.04*(1+PRyMvar.S)
f_gn = 0.12*PRyMvar.R - 0.05*(1+PRyMvar.S)
if(PRyMvar.GFfromTauN_flag):
    f_GF = -0.5*f_tau_n
else:
    f_GF = -PRyMvar.S
if(PRyMvar.massesNotGN_flag):
    f_me = 0.5*(1.+PRyMvar.S)
    f_mZ = 0.5*(2.+PRyMvar.S)
    f_mp = 0.2*(1.+PRyMvar.S) + 0.8*PRyMvar.R
    f_Q = 0.1 + 0.7*PRyMvar.S - 0.6*PRyMvar.R # Q = mn-mp
    f_mn = f_Q + (PRyMvar.mp0/PRyMvar.mn0)*(f_mp-f_Q)
    f_GN = 0.
else:
    f_me, f_mZ, f_mp, f_mn = 0., 0., 0., 0.
    f_GN = 2.*(0.2*(1.+PRyMvar.S) + 0.8*PRyMvar.R)
# Values after variations relative to dalpha
alphaem = PRyMvar.alphaem0*(1.+PRyMvar.dalpha) # fine structure constant
tau_n = PRyMvar.tau_n0*(1.+f_tau_n*PRyMvar.dalpha) # neutron's lifetime
```

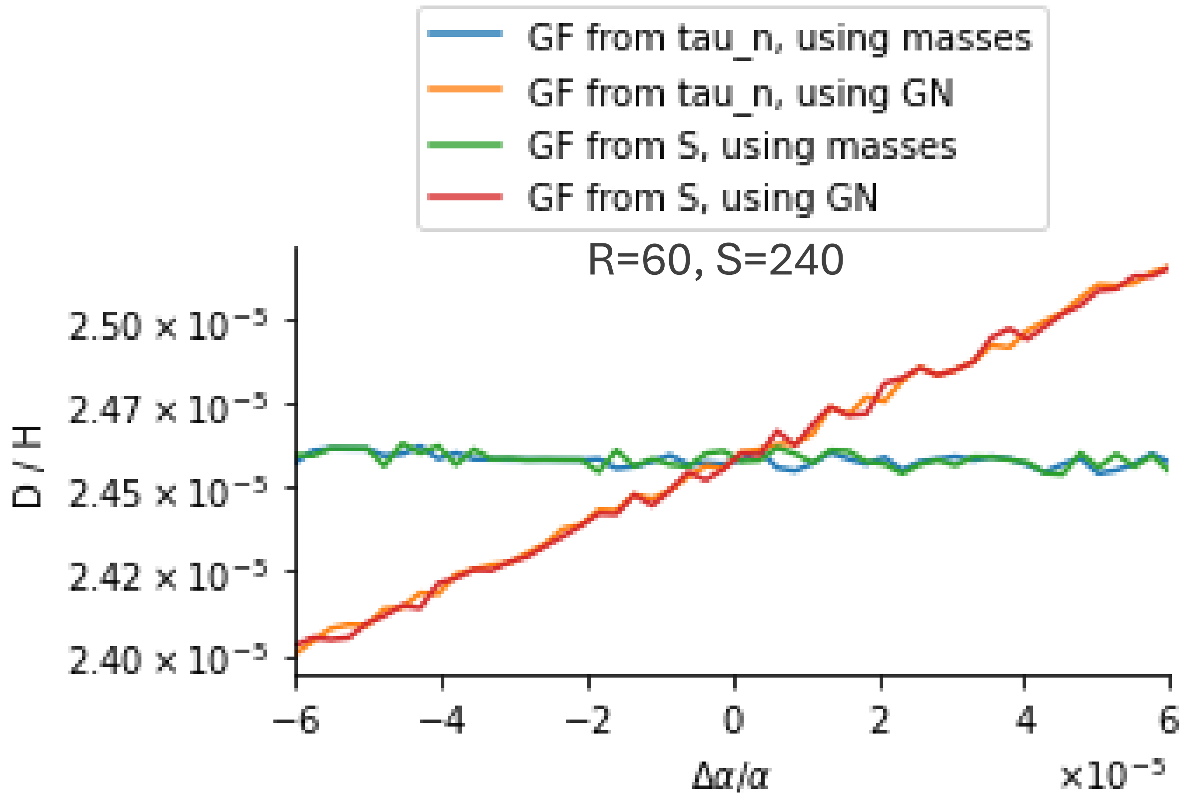
- alphaem
- GF
- mZ
- me
- mn
- mp
- GN
- kappa_p
- kappa_n
- radproton
- tau_n
- gA
- Vud

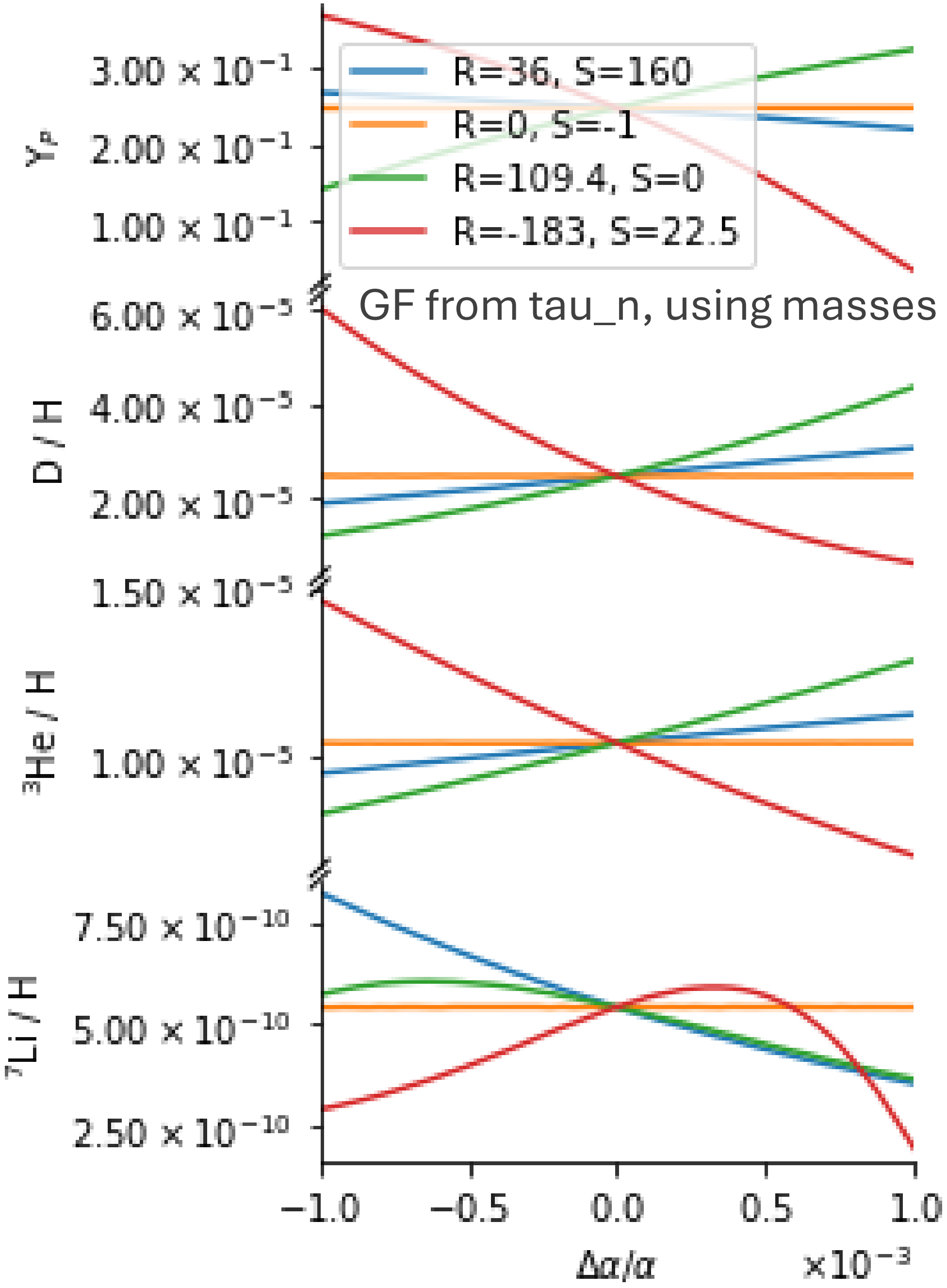
- fannFD
- fscatFD

- mA
- Agndecay
- Cndecay
- deltandecay
- Lndecay
- Sndecay
- NLLndecay

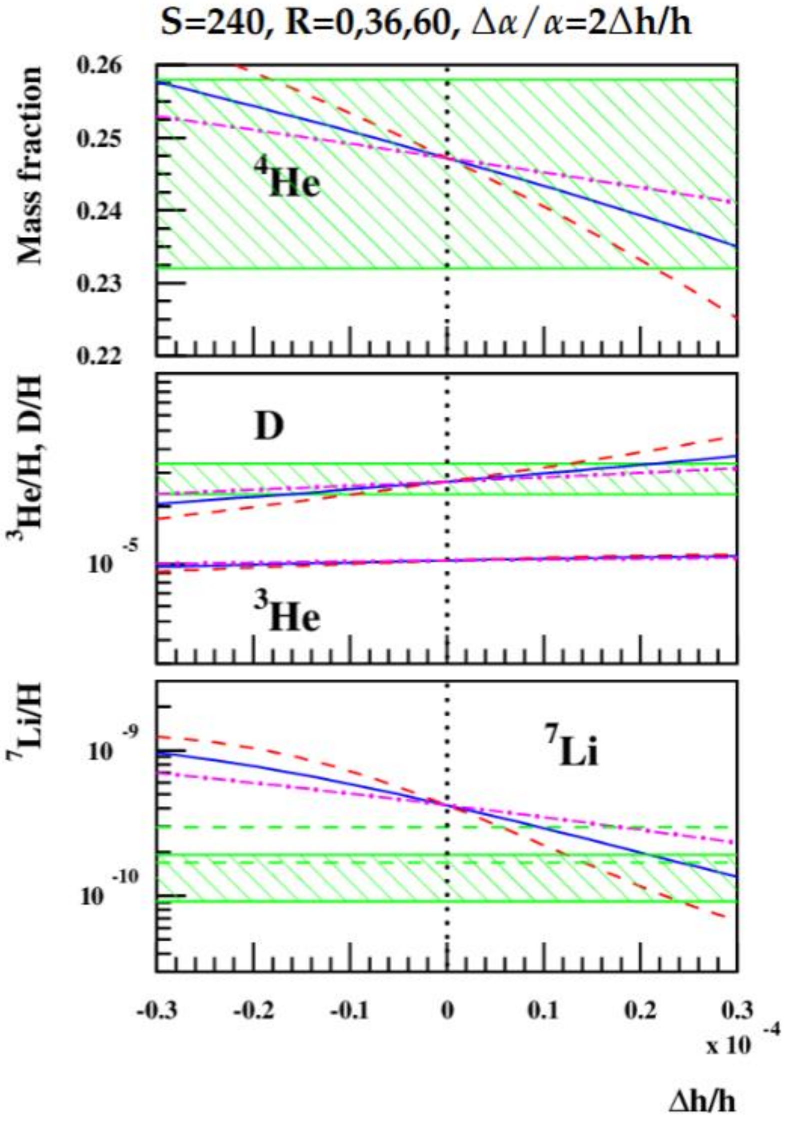
- nue_ann.txt, nue_scatt.txt, numu_ann.txt, numu_scat.txt
- QED_d2P_intdT2.txt, QED_dP_intdT.txt, QED_P_int.txt

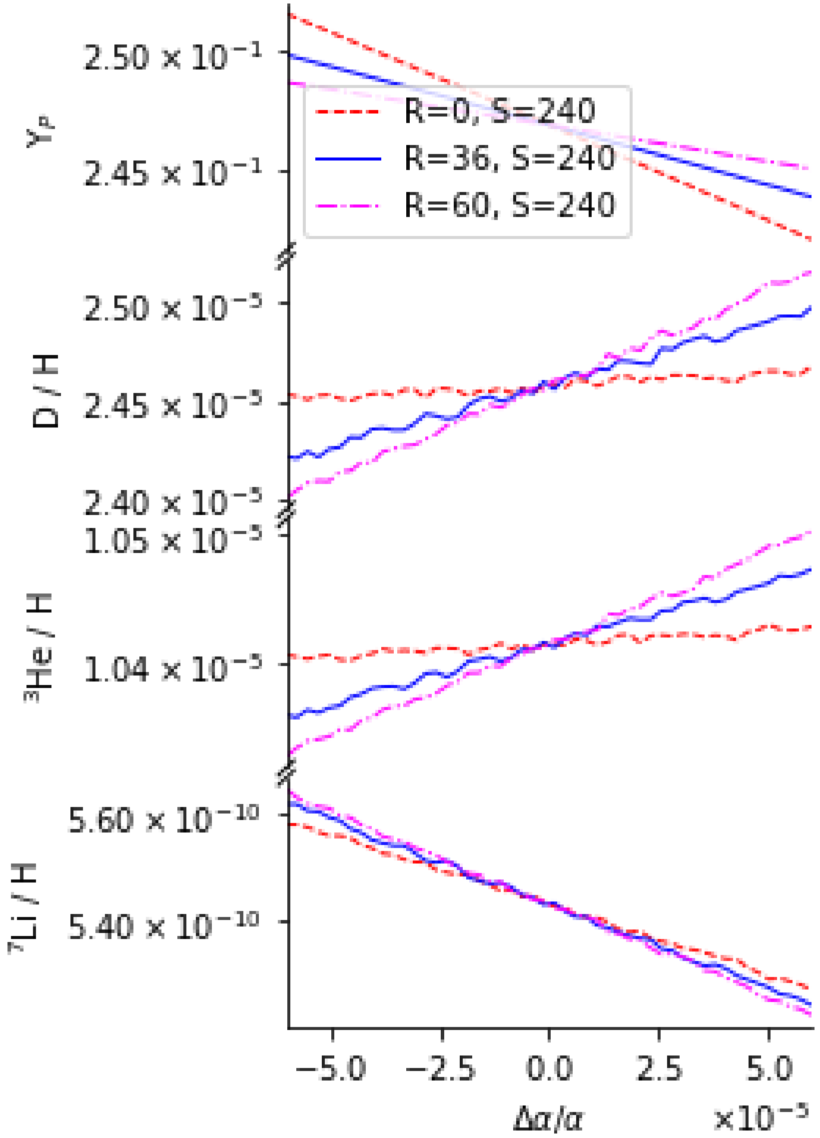
Different Models and Parametrisations





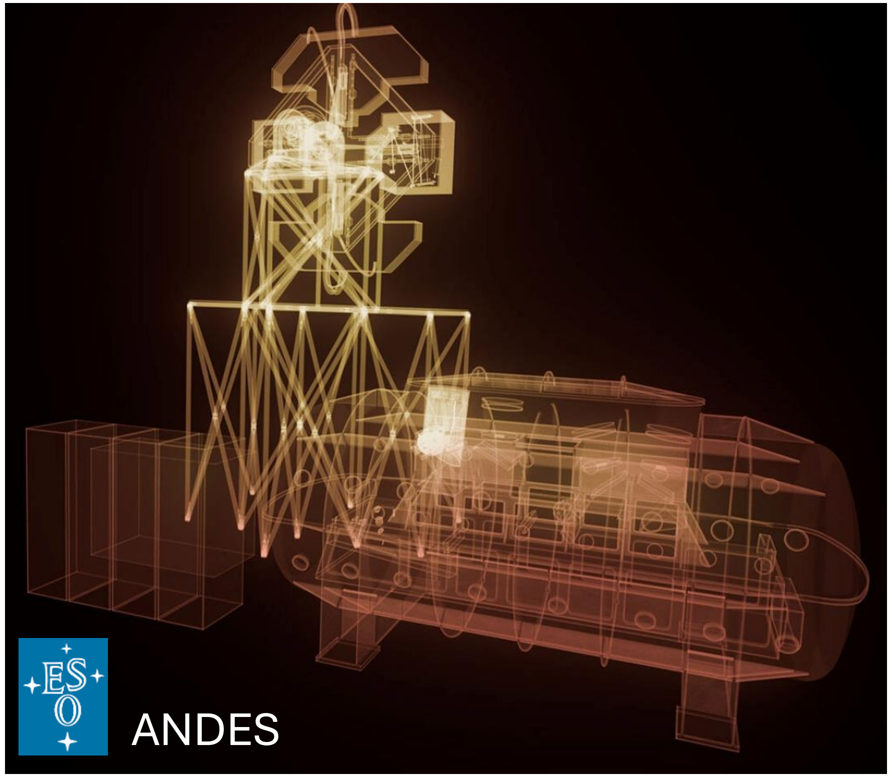
Comparing to Existing Results





Next Steps

- Interpreting results
- Filtering models
- Comparing to observational data
  - → Including new and future data
- Restricting certain values
- Testing a broader set of parameters
- Proposing new models



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...						

Thank You!