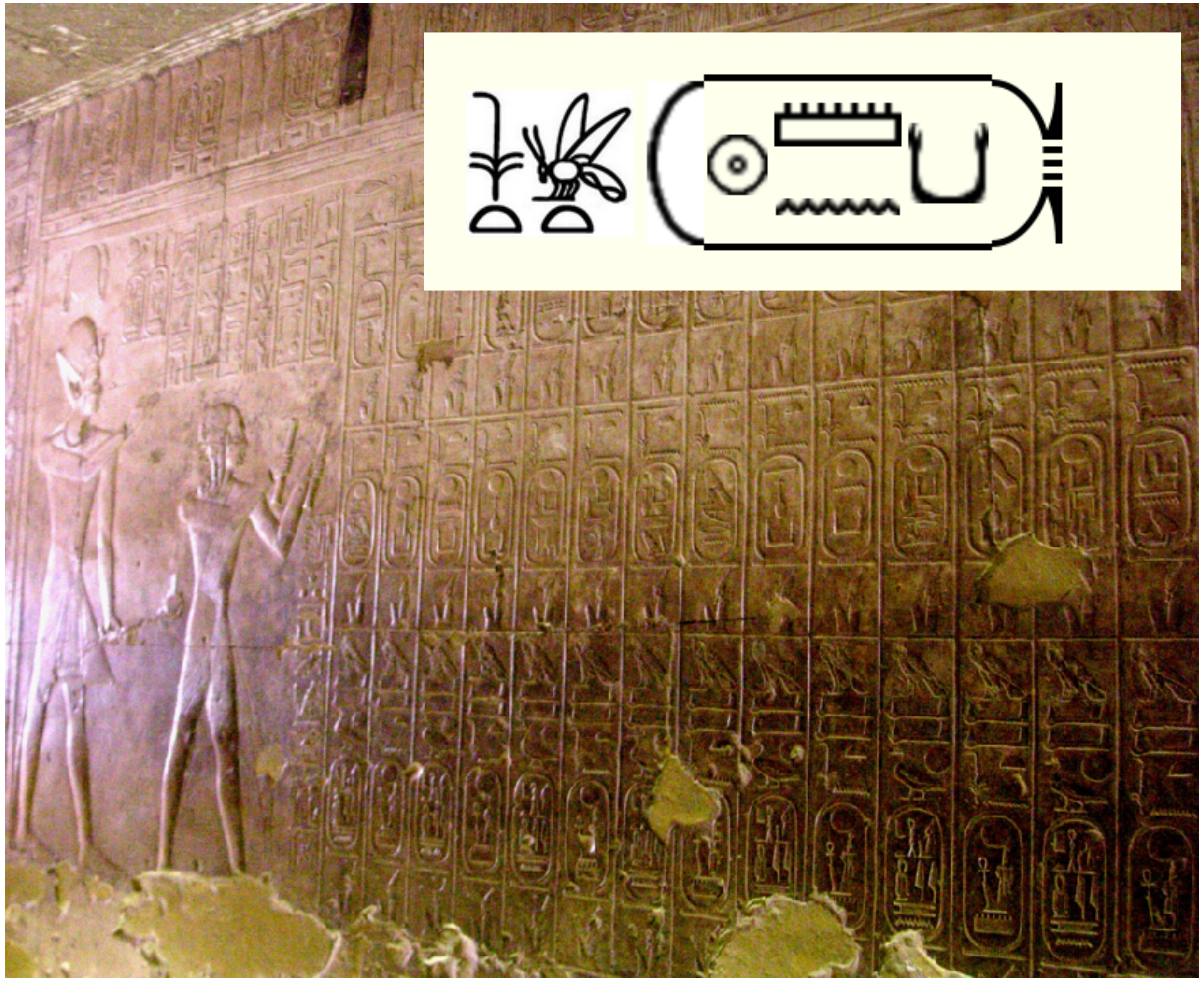
Models for Inflation and Early Universe Cosmology

Adriana Menkara

Menkara (2181 b.C.)

The **Abydos King List** (Seti I and Ramses II)

Menkara



The **Abydos King List** (Seti and Ramses II)

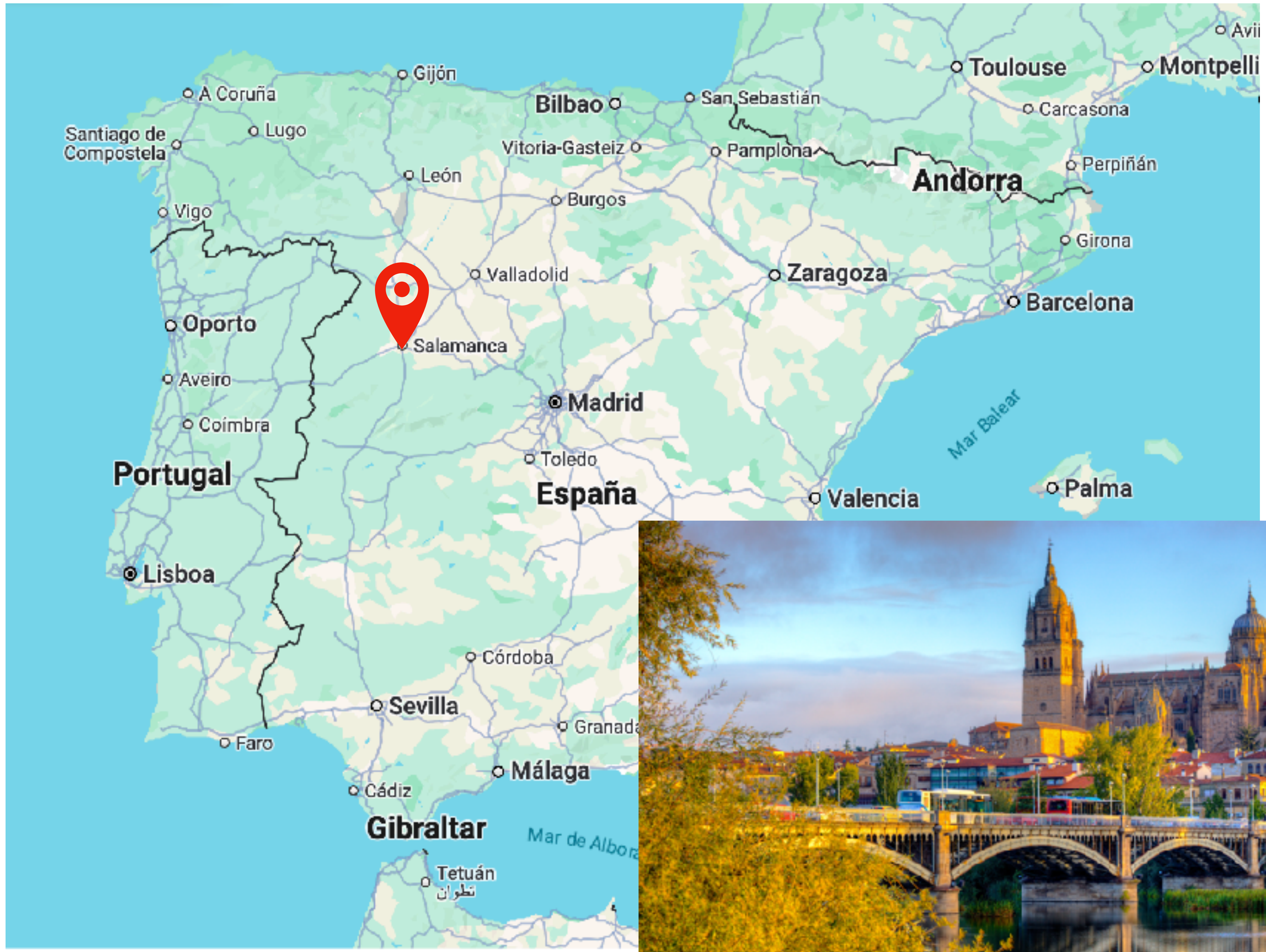
mn= Long-lasting

k3= Soul

rʿ=

Las Palmas de Gran Canaria

Bachelor



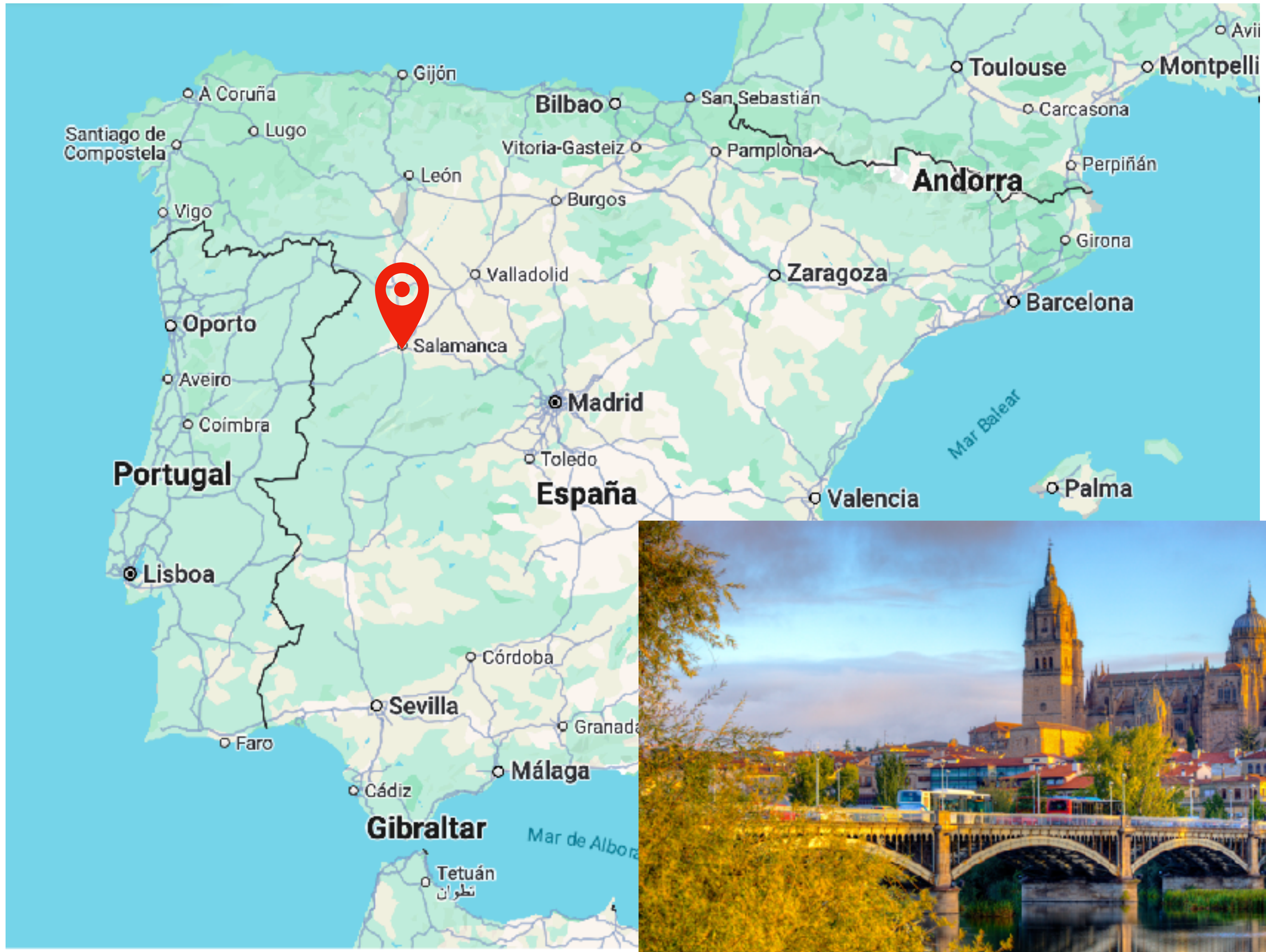
Bachelor thesis: BBN

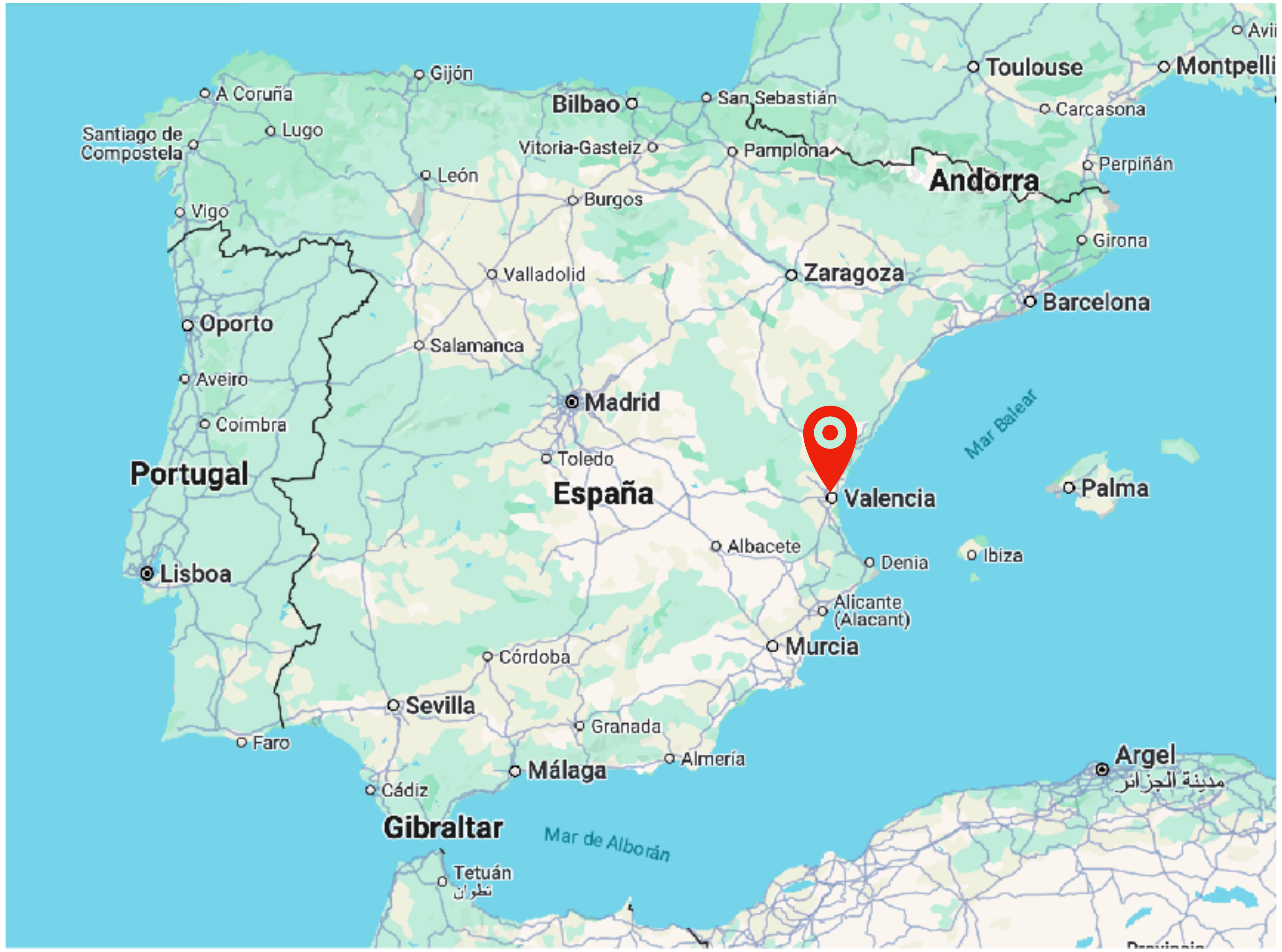
Bachelor

Bachelor thesis: BBN

Hobbies: Skating

I would look weird at people who run.



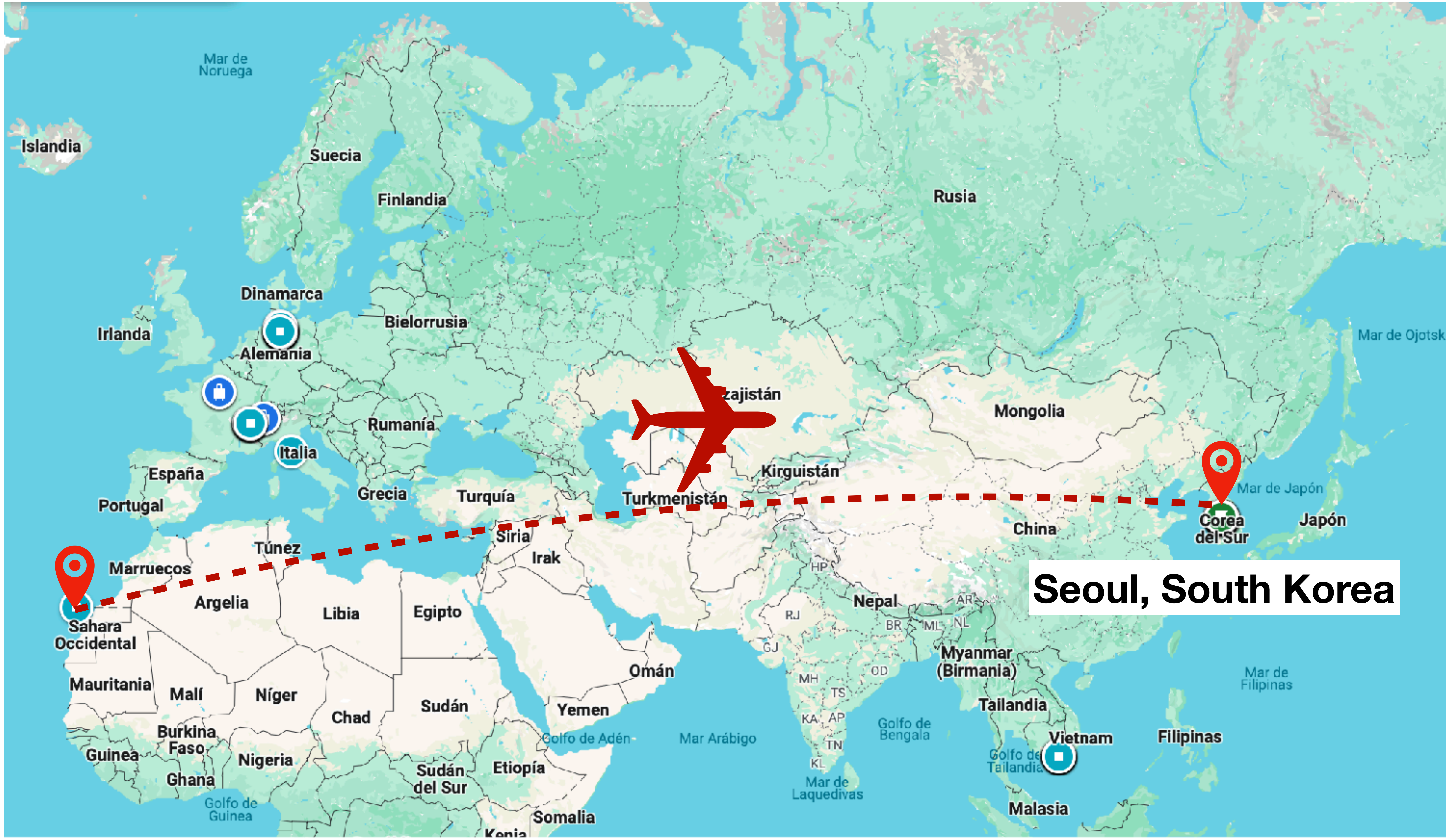


Trabajo Fin de Máster

Superprojective embeddings of extended supersymmetry

Apparently I now happily run up to 10K.

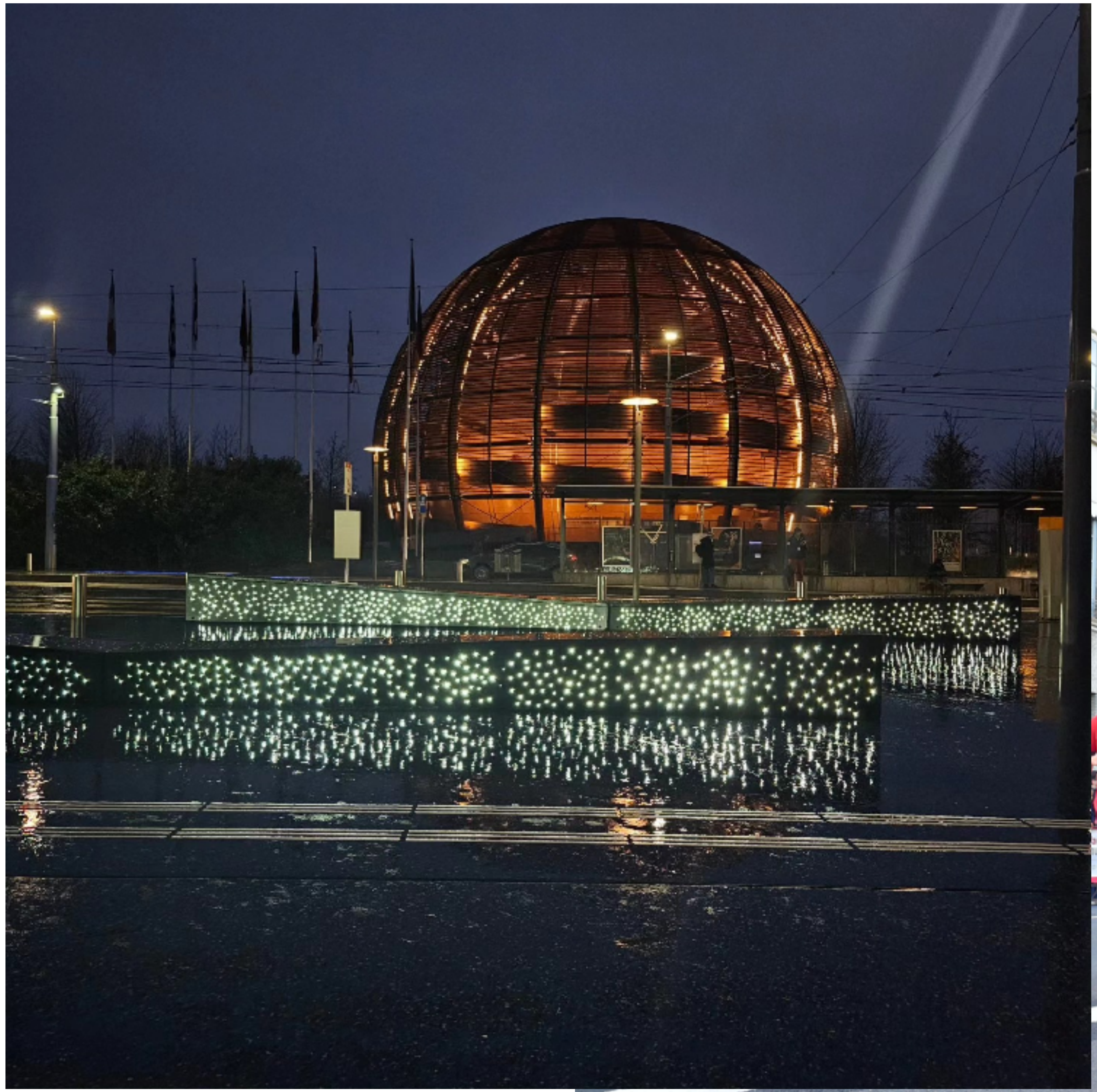
Ph.D: I thought it was a good idea to go to the antipodes to write a PhD thesis on inflation



Ph.D: I thought it was a good idea to go to the antipodes to write a PhD thesis on inflation

And I also let myself be convinced that running half marathons was fun

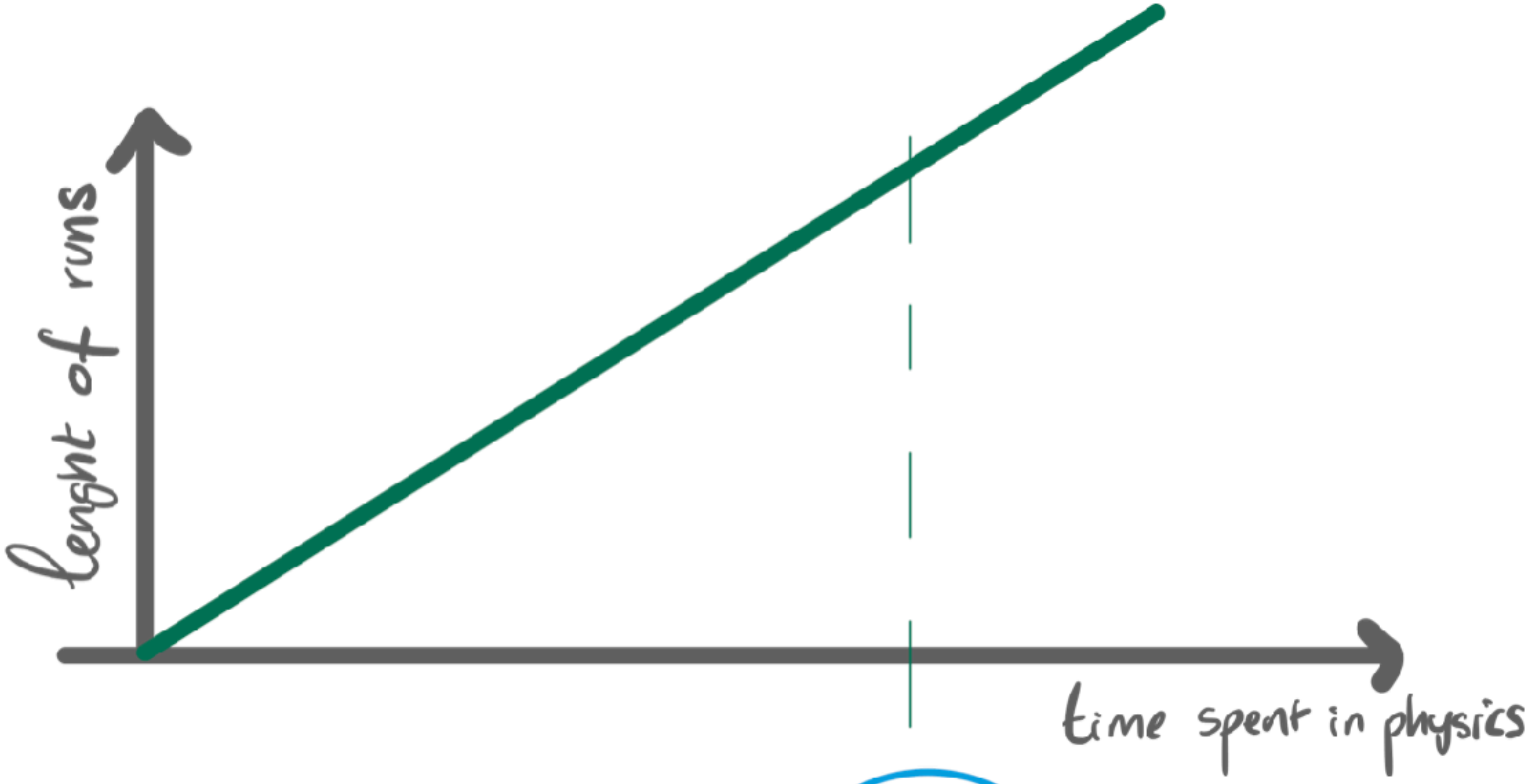
6 months at CERN



Now I work on the hierarchy problem

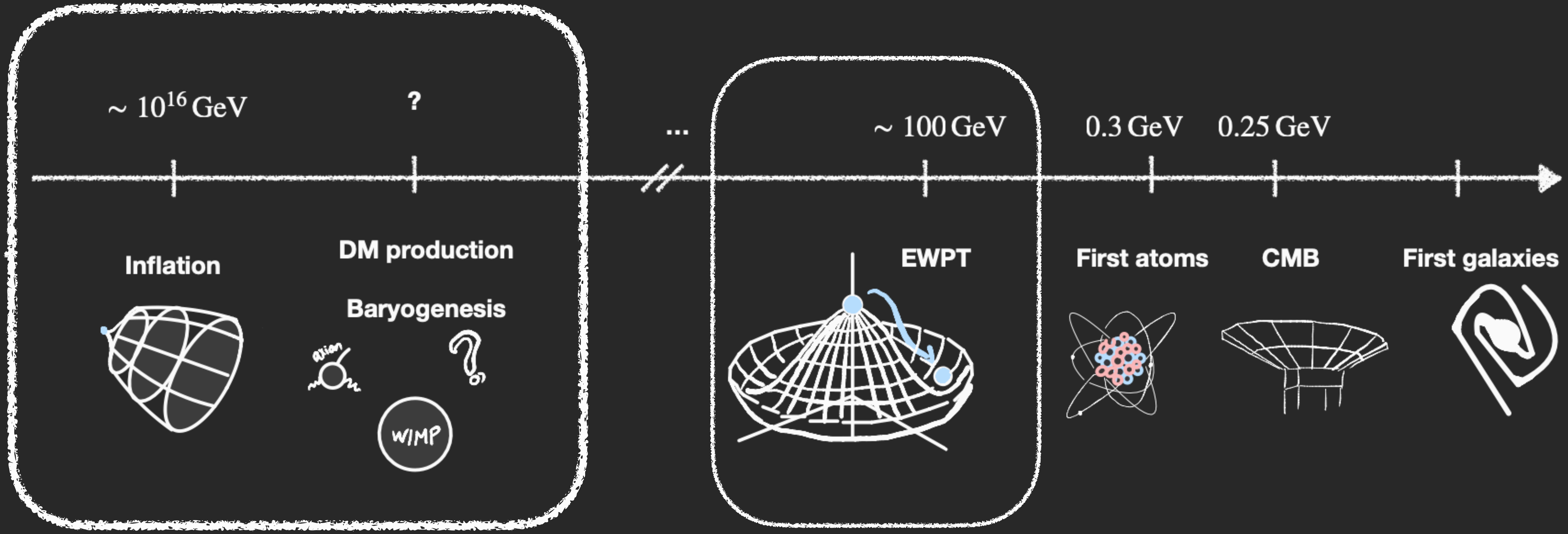
…and maybe a marathon is not that much?

The logical conclusion



= Ultramarathons

About my work



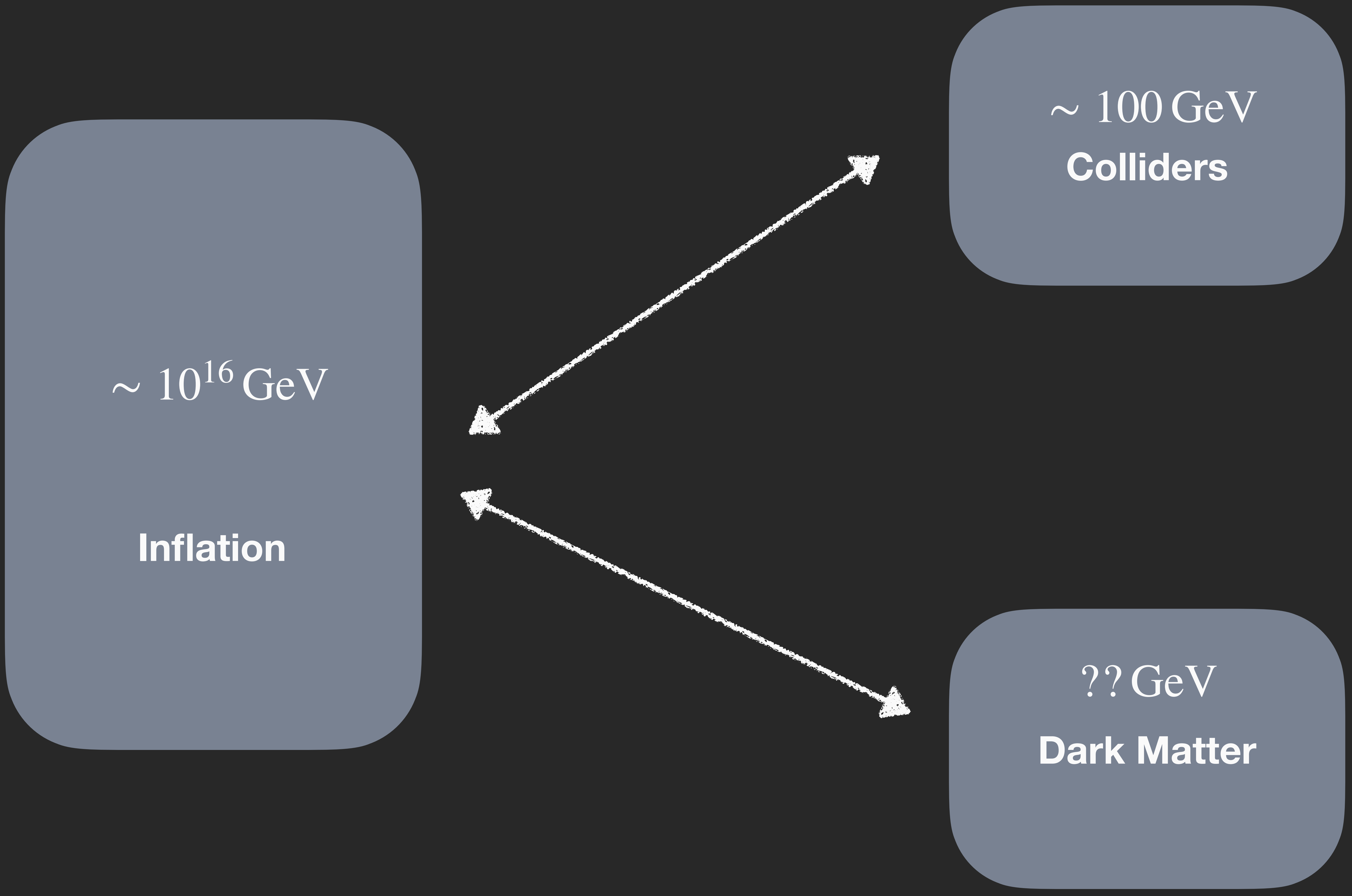
Inflation

Reheating

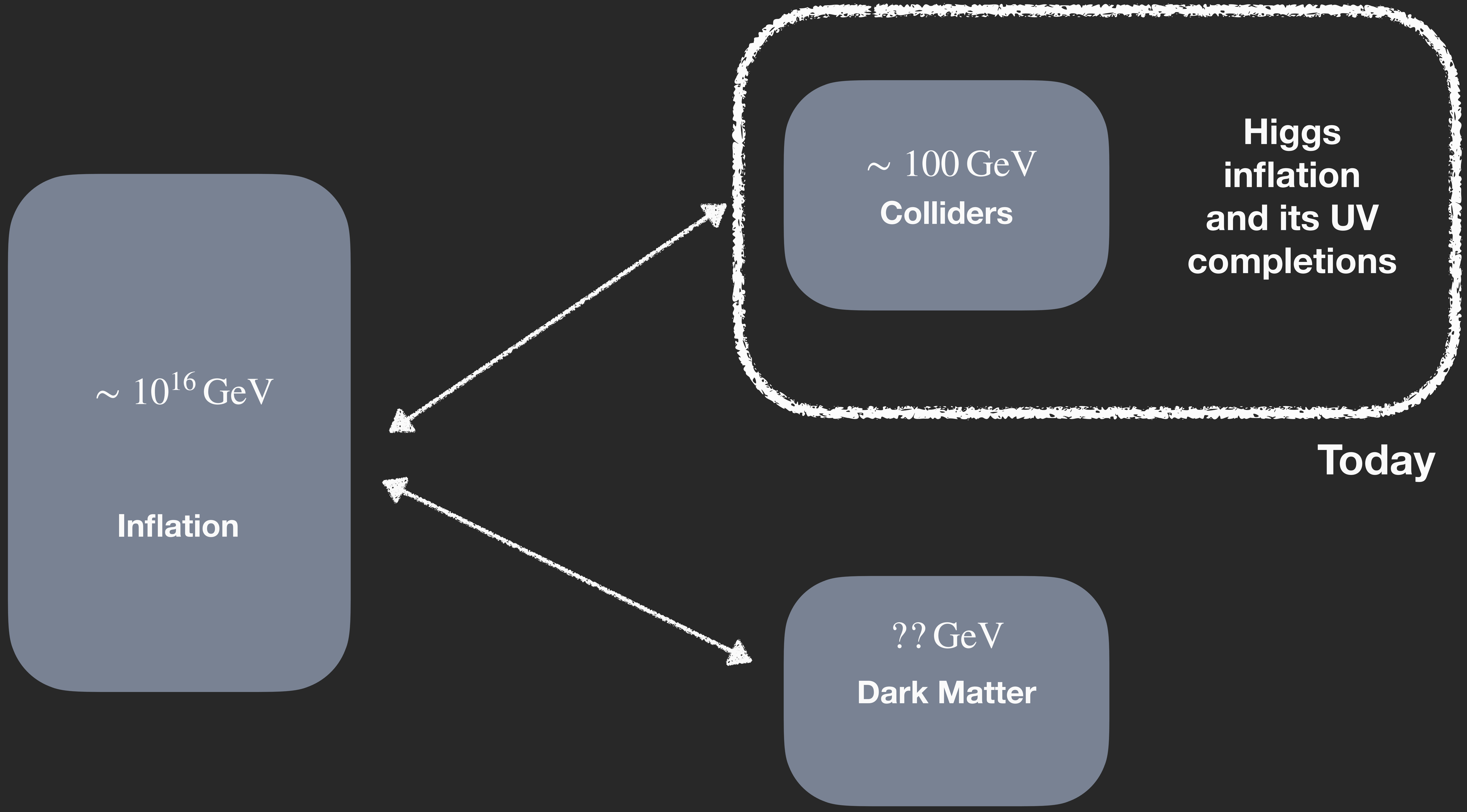
Dark Matter

Naturalness

Cosmology and particle Physics

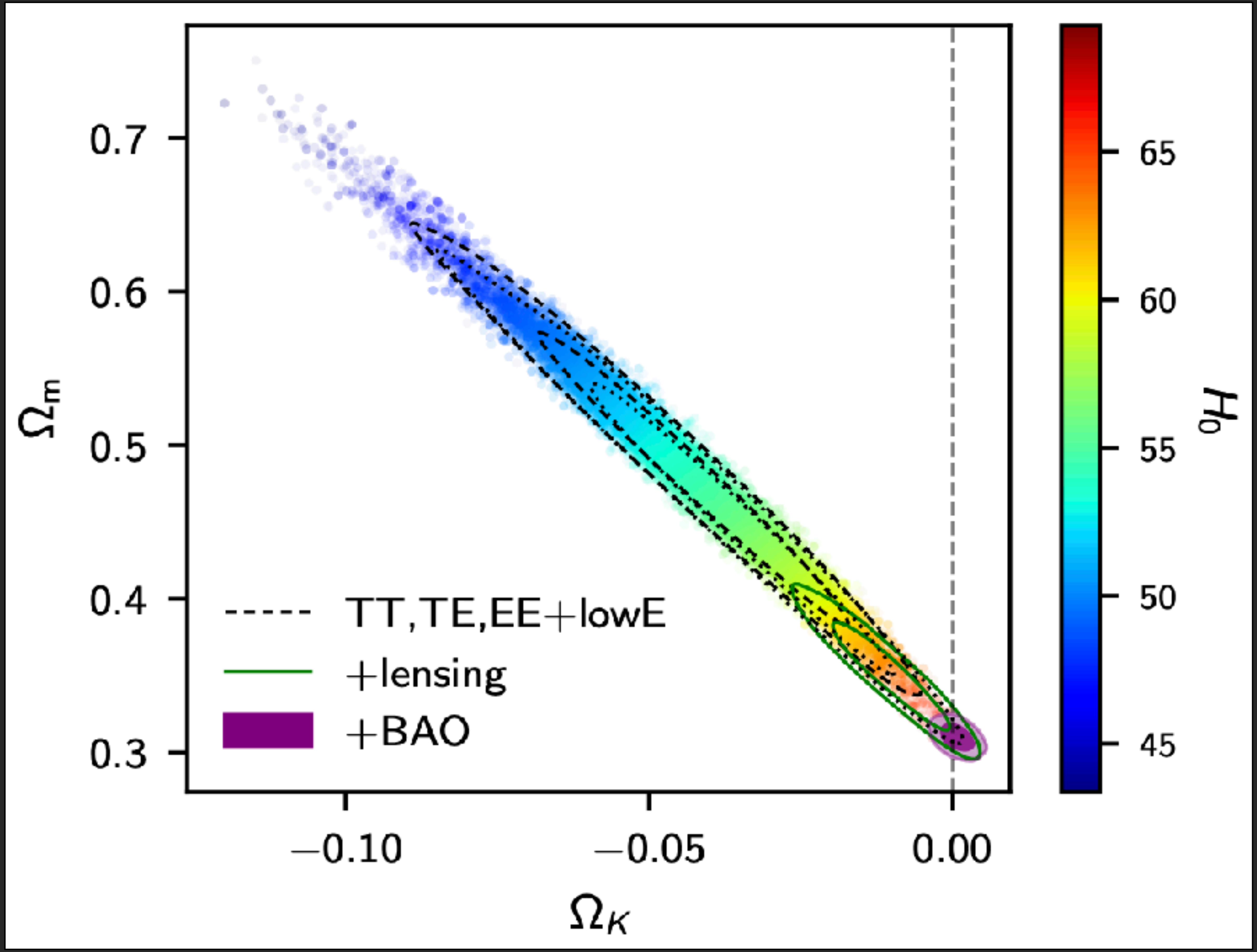


Cosmology and particle Physics



What do we (not) know about the universe?

Remarkably well described by a **flat** FLRW

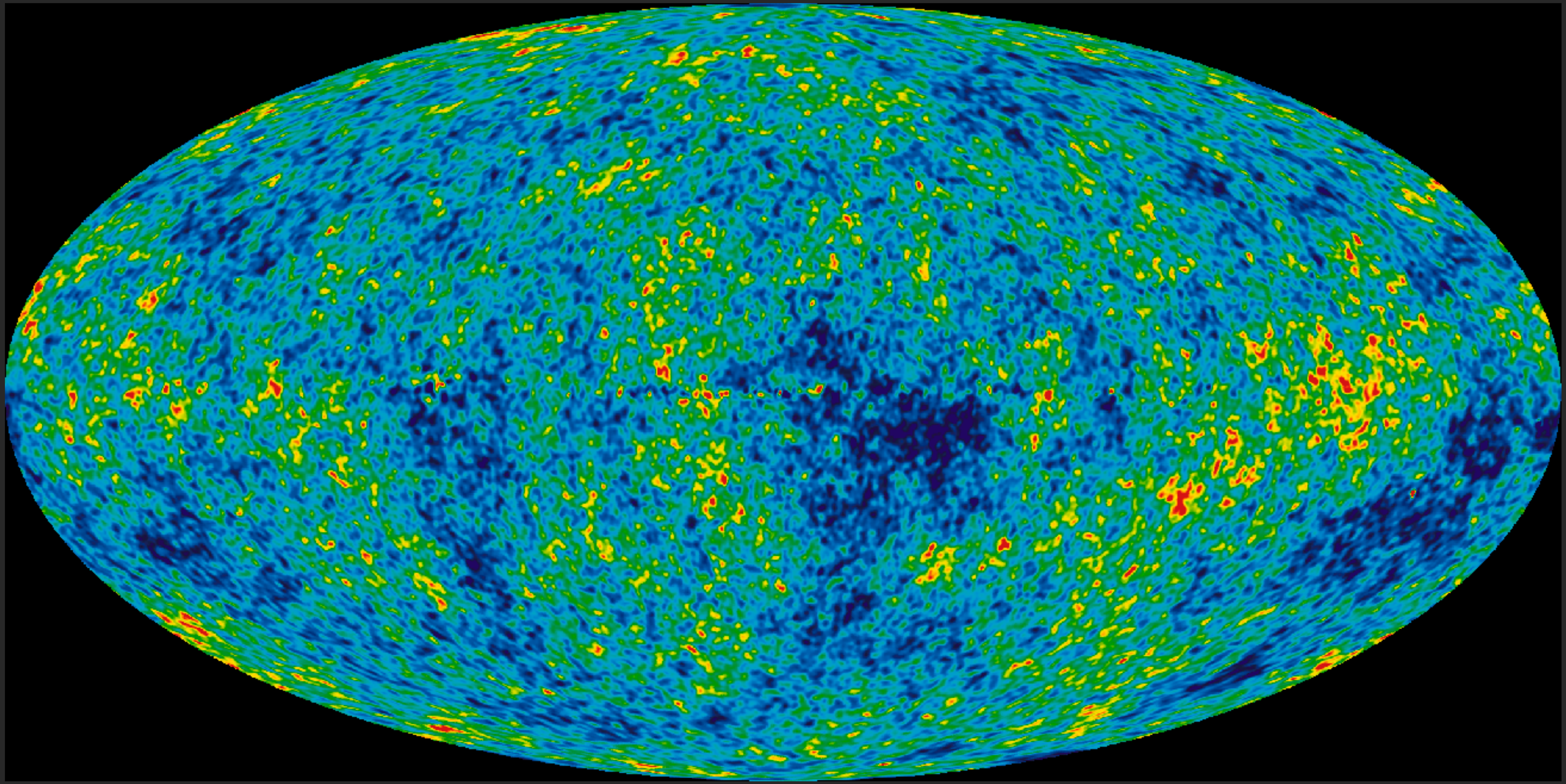


$$\Omega_K = 0.0007 \pm 0.0019$$

68%, TT, TE, EE +lowE +lensing + BAO

Requires incredible fine-tuning

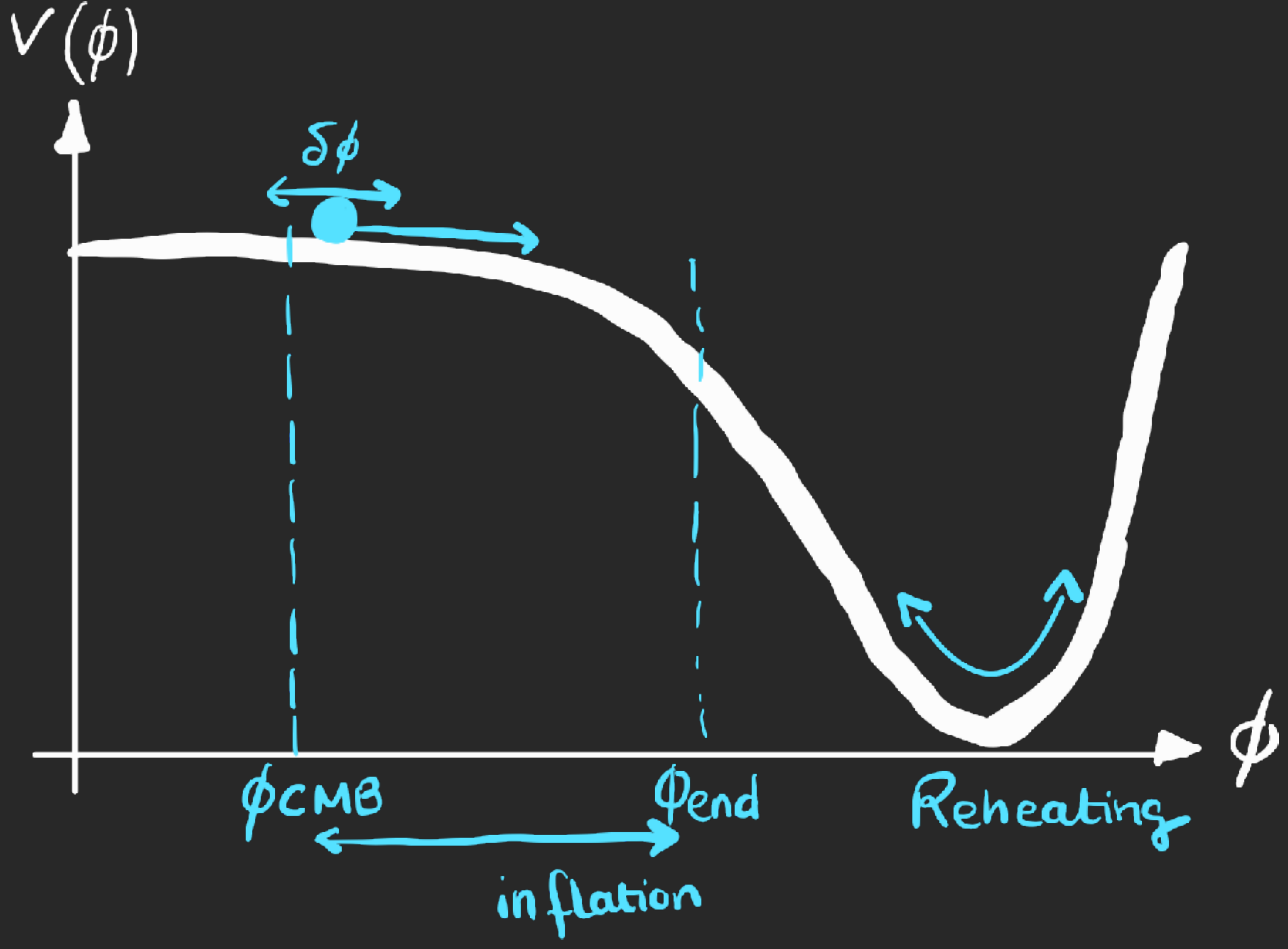
Why is the universe so **homogeneous**?



$$\frac{\delta T}{T} \sim 10^{-4}$$

Why **inflation**?

Inflation provides a solution to the flatness and horizon problems AND provides the seeds for structure formation



Higgs Inflation

No new evidence of physics BSM $\Longrightarrow$ Inflaton = SM Higgs boson??
If true, we could test the the early universe with our accessible EW data.

$$V = \underbrace{\lambda_H}_{\mathcal{O}\left(10^{-12}\right)} \left(H^\dagger H - \frac{v_H}{2} \right)^2$$

Overproduction of density fluctuations

Unfortunately, the Higgs SM potential doesn't work to explain inflation

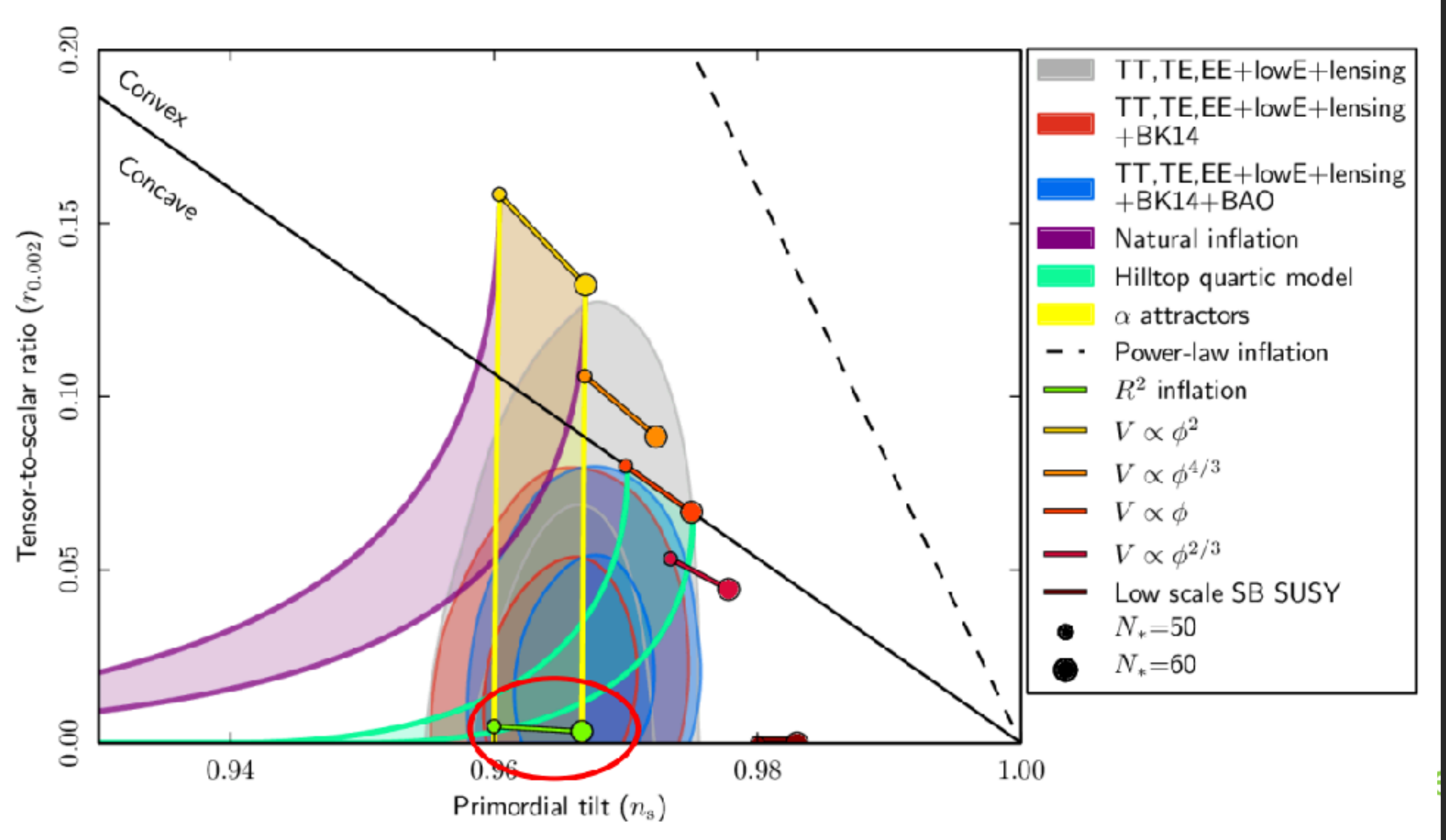
Higgs Inflation + non-minimal coupling

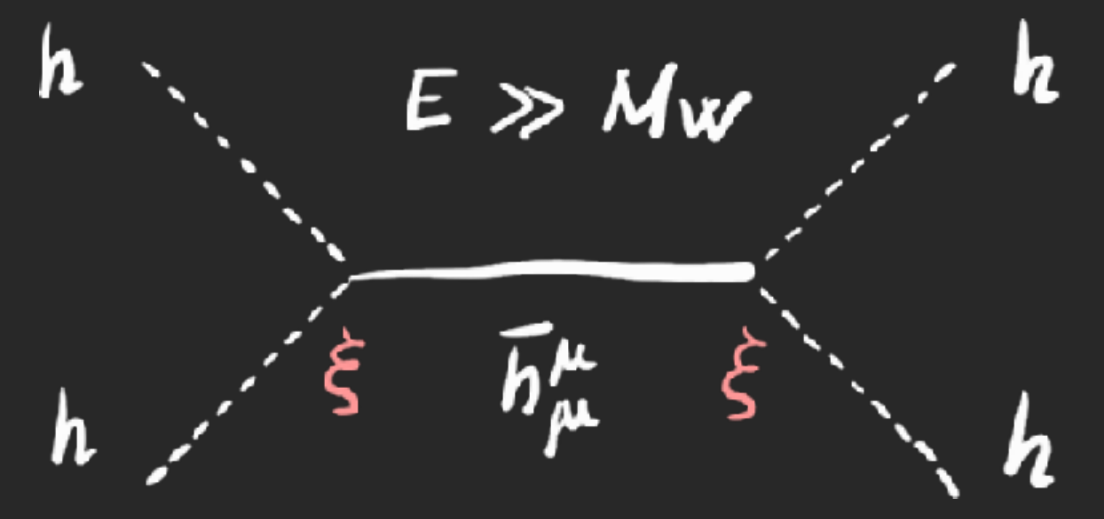
[Bezrukov, Shaposnikov]

$$\mathscr{L} = \sqrt{-g_J}\left[-\frac{1}{2}\left(1+\xi h^2\right)R_J + \frac{1}{2}g_J^{\mu\nu}\partial_\mu h \partial_\nu h - \frac{\lambda}{4}h^4\right]$$

Non minimal coupling

$$\xi^2/\lambda \sim 10^{10} \implies \xi \sim 10^4$$





$\Lambda_{\mathrm{cutoff}} = M_P/\xi$ is a **low cutoff** scale

Higgs-σ models

[**AM**, Hyun Min Lee]

$$\mathscr{L}/\sqrt{-g_L} = \frac{M_p^2}{2}\left(1 - \frac{h^2}{6M_p^2} - \frac{\sigma^2}{6M_p^2}\right)R_L - \frac{1}{2}\left(\partial_\mu \sigma\right)^2 - \frac{1}{2}\left(\partial_\mu h\right)^2 - \frac{\lambda}{4}h^4 - \frac{\kappa}{4}\left[\sigma(\sigma + \sqrt{6}M_p) + 3\left(\xi + \frac{1}{6}\right)h^2\right]^2$$

UV completion of Higgs inflation, valid up to the Planck scale.

- From the potential we can directly read the perturbativity conditions

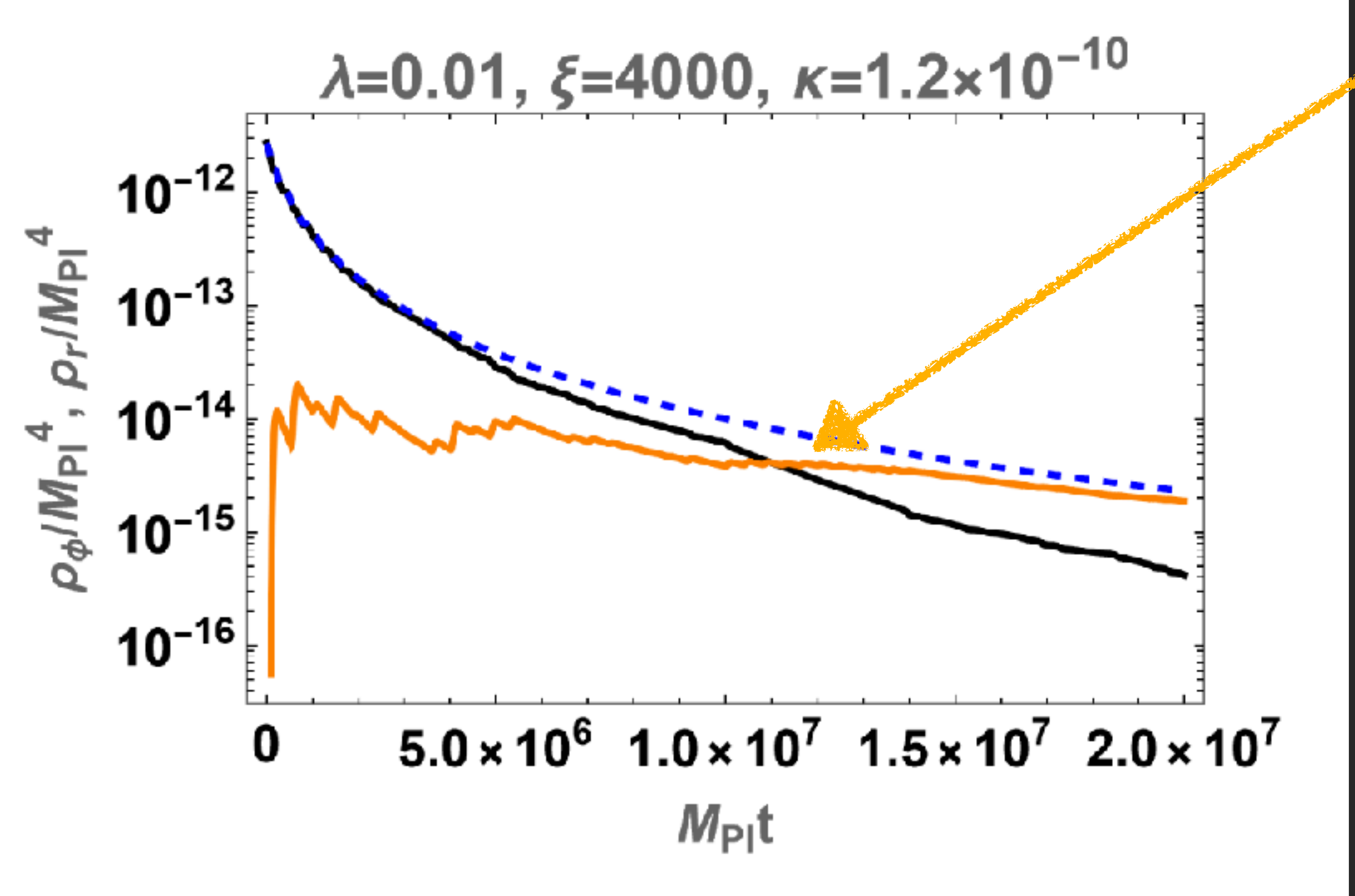
$$\kappa \lesssim 1, \quad \lambda + 9\kappa\left(\xi + \frac{1}{6}\right)^2 \lesssim 1, \quad 6\kappa\left(\xi + \frac{1}{6}\right) \lesssim 1$$

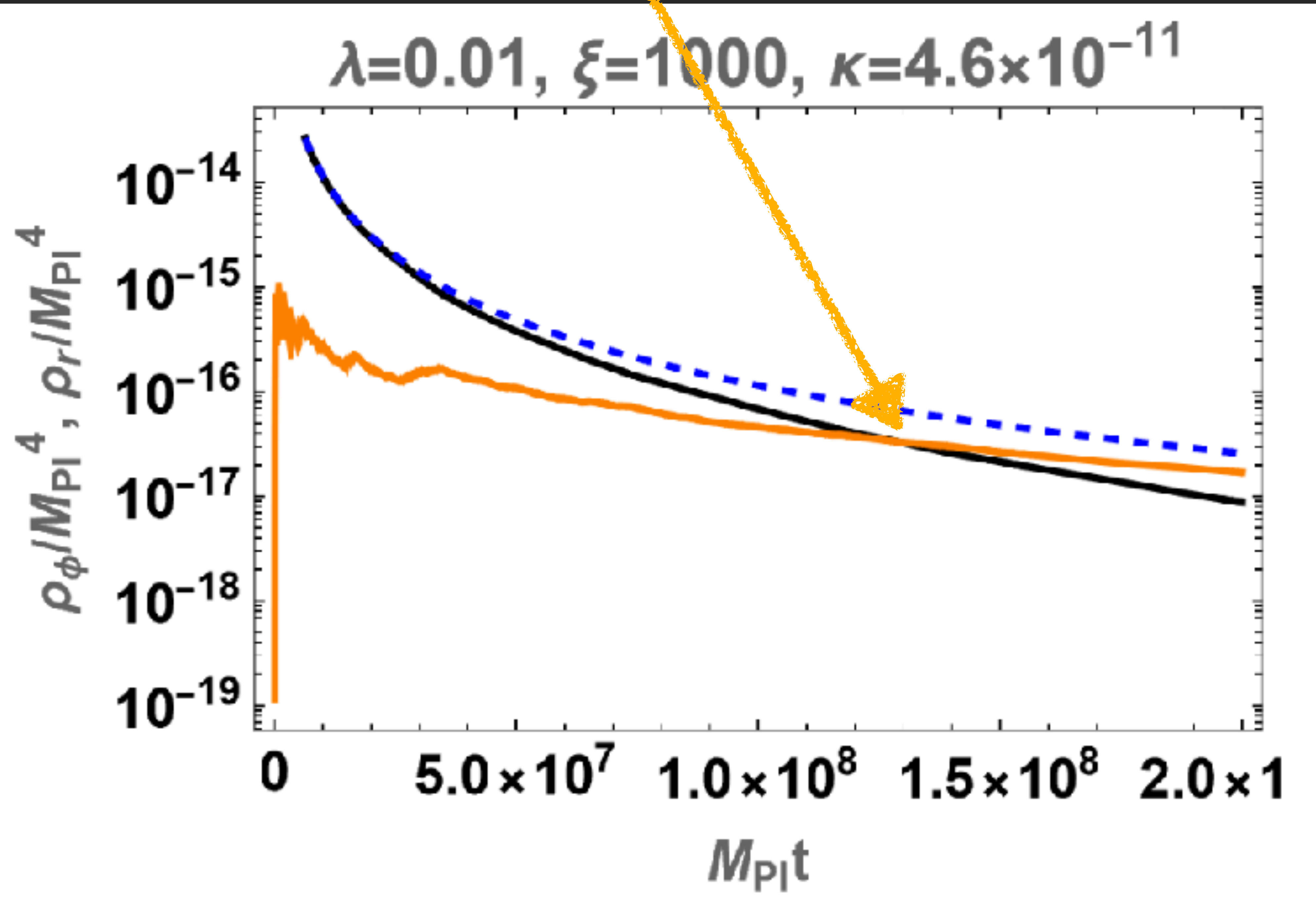
- The stability of the electroweak vacuum is guaranteed due to the tree-level shift in λ.

$$\lambda_{\text{eff}} = \lambda + 9\kappa\left(\xi + \frac{1}{6}\right)^2$$

Reheating from Higgs-sigma

Reheating is delayed for lower ξ





My research overview

Higgs inflation

JHEP 09 (2021) 018 *JHEP* 10 (2021) 178

JHEP 05 (2022) 121

Naturalness and inflation

Phys.Rev.D 107 (2023)

Phys.Lett.B 834 (2022)

Conformal symmetry

Inflation at the Pole → **Higgs** *JHEP* 10 (2023) 144

Inflation at the Pole → **Peccei Quinn** *JHEP* 05 (2024) 295

Cosmological relaxation and Dark Matter

JHEP 06 (2021) 013

Phys.Rev.D 106 (2022)