Physics motivation (I)

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Why keep exploring the energy frontier?

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Exploring the energy frontier is important for several reasons:

1. Discovering new particles and phenomena: High-energy colliders allow us to discover new particles and phenomena that are not currently accessible with existing colliders. This includes studying the Higgs boson in more detail, searching for new physics beyond the Standard Model, and potentially discovering dark matter candidates.
2. Improving our understanding of the universe: High-energy colliders allow for precise measurements of known particles, which can help to further constrain theories and improve our understanding of the fundamental nature of the universe.
3. Testing the Standard Model: High-energy colliders can be used to test the Standard Model of particle physics, which is currently the most successful theory of fundamental particles and forces. Finding deviations from the Standard Model predictions would indicate new physics beyond it.
4. Solving open questions: High-energy colliders can help solve some of the open questions in physics such as the hierarchy problem, the nature of dark matter and the unification of forces.
5. Advancements in technology and spin-offs: High-energy colliders also have the potential for technological advancements and scientific spin-offs that can benefit society in many fields such as medicine, energy, materials science, and environment.

In summary, exploring the energy frontier is important because it allows us to discover new particles and phenomena, improve our understanding of the universe, test the Standard Model, solve open questions and have advancements in technology and scientific spin-offs that can benefit society.

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$$+Y\bar{\psi}\psi' H + \mu^2|H|^2 - \lambda|H|^4$$

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structural weaknesses
(flavour hierarchies, strong CP, weak-scale and CC naturalness)

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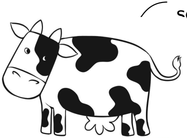

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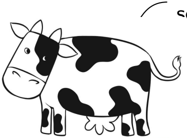

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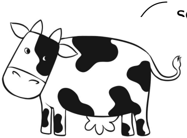

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It contains only terms surviving the $E \ll \Lambda$ limit,

and basically all of them,
built from the fields and symmetries we know.

SM as a low-energy EFT

$$\mathcal{L}_{d\leq4} + \mathcal{L}_5/\Lambda + \mathcal{L}_6/\Lambda^2 + \cdots$$

Naturally accounts for observed suppressions...
(neutrino masses, proton decay, tree-level FCNCs, etc.)

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... but not for:

- $y_e, \theta_{13}, \text{etc.} \ll 1$ in $Y\bar{\psi}\psi' H$
- $\theta_{\text{QCD}} \ll 1$ in $\frac{\theta_{\text{QCD}}}{32\pi^2} G^{a\mu\nu}\tilde{G}^a_{\mu\nu}$
- $\mu^2/\Lambda^2 \ll 1$ in $\mu^2|H|^2$
- $\Lambda^4_{\text{CC}}/\Lambda^4 \ll 1$ in Λ^4_{CC}

which we would want to be calculable, quantum-mechanically.

SM as a low-energy EFT

EFT not only points at the weak-scale naturalness puzzle

but also formalises and organises systematically SM structural tests,

breaking correlations between observables QFT-consistently.

Probing weak-scale naturalness

Higgs precision measurements & direct searches

Taking up on the LHC which is already forcing a compromise between unexplained suppressions and model minimality.

Explanations for the weak scale without energy-frontier implications have also been explored.

Still, colliders are unique and indispensable tools for covering new ground, and refining our fundamental understanding of nature.

Why keep exploring the energy frontier?

No guaranteed new-physics discovery

But no measurements for the sake of measurements

Unseen phenomena as proposed targets

Prioritise where the unexpected is the least unlikely

Based on theory biases

The weak-scale puzzle as prime motivation!