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Rich dark sectors

The Standard Model (SM) of particle physics provides a very successful description of fundamental particles and their interactions but it is incomplete, as neutrino masses, dark matter and the baryon asymmetry of the Universe indicate. In addition, the origin of masses and of the approximate fundamental symmetries call out for deeper explanations. The hunt for a New SM Theory, that extends the SM to a more general theory, is ongoing. For decades the main focus has been on the TeV scale, but despite an impressive theoretical and experimental effort, no hints of new physics at such scale has been found in experiments.

Dark sectors provide an interesting alternative to TeV scale extensions of the Standard Model to explain the open questions in particle and astroparticle physics. Going beyond minimal models, rich dark sectors extend the SM to a complex theory with multiple particles and interactions, in analogy to the Standard Model. They have a wealth of theoretical and astrophysical/cosmological consequences. They can lead to phenomenological signatures that can be markedly different to that of minimal ones: typically fast decays (instead of long lived particles) and semi-visible signature (instead of purely visible or invisible decays). Given the experimental configurations and analysis strategies, current DS search might miss such signatures.

We advocate a dedicated programme of searches for rich dark sectors that overcomes the assumptions on minimality and on the long lifetime of particles and encompasses a broader range of possibilities. A combined effort between theorists and experimentalists is needed to explore these possibilities and fully exploit the wealth of experimental opportunities available in the Physics Beyond Collider Study at CERN and other experiments sensitive to rich dark sectors.

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