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MATHUSLA: A Detector Proposal to Explore the Lifetime Frontier at the HL-LHC (Addendum)

Input to the update process of the European Strategy for Particle Physics
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I. INTERESTED COMMUNITY

The general nature of MATHUSLA's LLP physics case, the fact that it can take advantage of the full LHC energy, and its secondary physics goal of cosmic ray physics, makes MATHUSLA extremely versatile and attractive to scientists in a wide variety of subdisciplines:

- High energy experimental physics: MATHUSLA is not only capable of a wide variety of LLP discoveries, it also represents unique challenges in detector design and data analysis due to its large size, necessary simplicity, low data rate, ubiquitous cosmic ray background, and excellent timing and position resolution which open up new analysis pathways.

- Beyond the Standard Model High Energy Theory: LLPs are strongly motivated on both top-down and bottom-up theoretical grounds. Any exploration of the hierarchy problem, as well as solutions to the problem of baryogenesis, dark matter or neutrino masses without a thorough LLP search program is incomplete, and MATHUSLA is required to fully utilize the discovery potential of the LHC.

- Electroweak Physics: The electroweak sector of the SM is a highly motivated source of BSM LLP signals, such as via the process of exotic Higgs decays. Any characterization of the newly discovered Higgs boson has to include a thorough search program to directly search for small exotic branching fractions into LLPs, since coupling measurements and closure tests will have many orders of magnitude worse reach than direct searches, and MATHUSLA extends the sensitivity of the main detectors to rare LLP signals by further orders of magnitude.

- Dark Matter: LLPs are a natural component of hidden sectors that might contain dark matter. Any discoveries made by MATHUSLA could have direct consequences on our understanding of DM by deciphering the structure of this hidden sector, or could directly lead to the discovery of dark matter as a final state of LLP decay.

- Neutrino physics: MATHUSLA is sensitive to long-lived right-handed neutrino scenarios and has complementary sensitivity to experiments like SHiP, expanding both the discovery potential and diagnosis capability of any discovered new states.

- Cosmic ray physics and astro-particle physics: MATHUSLA is able to perform unique cosmic ray observations that would improve our understanding of the primary cosmic ray spectrum and shed light on astrophysical phenomena like supernovae, the galactic magnetic field, and the intergalactic medium.

II. TIMELINE

Our goal is to finish a design for a demonstrator unit in 2019 and contemporaneously seek funding to build the demonstrator in 2021–2012 to test design and module assembly procedures. The goal is to have a MATHUSLA detector in place by 2025–2026.

III. CONSTRUCTION AND OPERATING COSTS

Our efforts are focused on keeping the cost of the MATHUSULA detector with optimized detector geometry under 100 MCHF. Our current benchmark technologies and DAQ designed for the low-rate operating conditions convince us that this is possible. More detailed accounting of the costs will be available following design and construction of the demonstrator unit that will test various cost reducing ideas.