PE 0000023 NQSTI – Cascade Funding - Proposal Template

1) GENERAL INFORMATION

Project acronym:	QIHEP
Project title (extended name): *Text should be self-explanatory, maximum 300 characters.*	Exploring the foundations of quantum information in particle physics
Spoke:	1
Topic:	5: Development of approaches to quantify fundamental limits and quantum resources related to precision measurement.
Duration (months*): (the duration cannot exceed 18 months)*	18 months
Project location*: (specify region)*	University of Bologna, Department of Physics and Astronomy, Italy
Total project budget (€):	136377
Total grant requested (€):	136377
Project Coordinator:	*Federica, Fabbri* *Department of Physics and Astronomy, University of Bologna* *federica.fabbri26@unibo.it* *3408262066*

Abstract *(max 1500 characters including spaces):*

This project aims to explore foundational aspects of quantum information (QI) in the realm of particle physics. We propose a novel methodology that, by leveraging on QI concepts, introduces quantum observables to investigate the properties of fundamental interactions occurring at scales on the order of 10^{-20} m, where the relevant degrees of freedom are leptons, quarks, bosons and whose interactions are electroweak and strong. Our goal is twofold: first, to scrutinize the behaviour of the fundamental constituents of matter and their interactions when viewed through the lens of QI; second, to assess the possible limitations of current QI tools when applied to particles and interactions beyond those typically encountered at atomic scales. Our approach offers a novel avenue for advancing our understanding of quantum information and fundamental interactions in two distinct directions. First, to overcome the limitations of well-established particle physics methodologies in elucidating the origins of several unexplained phenomena occurring at high energies. Second, we explore the boundaries of a quantum description of nature, testing it at the unprecedented energies reached in collider experiments, by studying in detail how quantum information is formed in pairs of qubits and qutrits and then evolves, under strong and electroweak interactions. In doing so, we aim to push the frontier of our understanding of both quantum information principles and the fundamental nature of the universe.

Keywords *(Free Keywords that mainly characterize the project):*

Particle physics, Quantum information principles, high energy, colliders