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| **Scientific Area** | High Energy Physics | | |
| **Project Title** | Detector Simulation and Jet Clustering for HL LHC with Quantum Computing | | |
| **Recruiting Institution** | DESY - Hamburg | | |
| **PhD awarding Institution** | RWTH Aachen University | **PhD Duration** | 36 Months |
| **Supervisor/Institution** | Prof. Dr. Kerstin Borras / DESY-Hamburg and RWTH Aachen University | | |
| **Co-Supervisor/Institution** | Prof. Dr. Simone Montangero / University of Padova | | |
| **Secondment(s)** | University of Padova | | |

**Project Description**

In the analyses of particle physics data from the LHC very computing resource intensive detector simulations are needed to determine efficiencies and acceptances. In the High Luminosity phase of the LHC these demands cannot be fulfilled with classical computing and Machine Learning (ML) methods are developed. In the analyses so-called jets are a very crucial tool. These collimated bunches of particles can be viewed as a proxy to the initial particles produced in the beam collisions. The jets are reconstructed with clustering algorithms, whose combinatorial effort is very large and represent again a formidable challenge for classical computers.
With the employment of entanglement and superposition Quantum Computers have the potential to solve complex problems more efficiently. Therefore, Quantum Machine Learning models for detectors simulations and, if the remaining time allows, also for jet reconstruction, will be developed.
One additional potential approach is given the employment of tensor networks.

**Project Objectives**

a) Assess present Quantum Machine Learning (QML) models for detector simulations
b) Select the optimal algorithms which are suitable to be implemented for Quantum Computer application
c) Develop a QML model, assess the achieved precision and necessary Quantum Computer resources
d) Run the problem on a Quantum Computer simulator without noise and with noise switched on.
e) Run the problem on real quantum computers
f) If the remaining time allows address the problem of jet clustering in the same procedure a)-e)

**Secondment:** Training on Tensor Networks at University of Padova

**Required Candidate Qualifications**

- Experience with scientific data methods and knowledge of data analysis in particle physics.
- Preferably, knowledge of Machine Learning and Deep Learning methods.
- Preferably, knowledge in Quantum Computing and Quantum Information.
- Programming experience, preferably in Python.