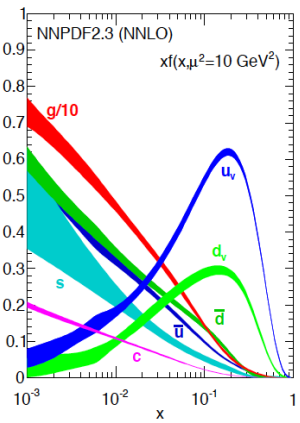
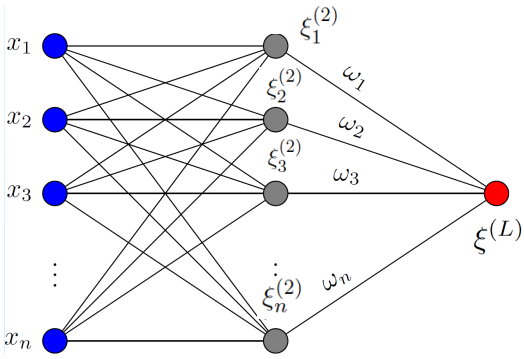
A three-dimensional imaging of the proton with Neural Networks

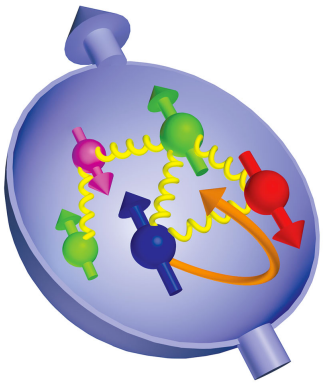
Master project, Theoretical Physics track, MSc Physics and Astronomy

The non-perturbative dynamics that determine the energy distribution of quarks and gluons inside protons, the so-called parton distribution functions (PDFs) [1], cannot be computed from first principles from Quantum Chromodynamics (QCD), and need to be determined from experimental data. Unpolarized PDFs are an essential ingredient for the physics program at the Large Hadron Collider (LHC), from Higgs characterization to searches for New Physics beyond the Standard Model. Recent progress from the theory and experimental points of view has provided a rather compelling picture of these PDFs in the unpolarized case.

On the other hand, our understanding of the transverse momentum dependence of PDFs [2, 3] is in a much less advanced stage, specially from the phenomenological point of view. TMD-PDFs encode non-perturbative information on hadron structure, including transverse momentum and polarization degrees of freedom, essential in the context of QCD factorization theorems for multi-scale, non-inclusive collider observables. In this project, a three-dimensional imaging of the proton by means of a model-independent determination of TMD-PDFs from a global analysis of hard-scattering data will be performed. This goal will be achieved by means of the NNPDF fitting framework [4, 5], based on machine learning techniques such as artificial neural networks and genetic algorithms. The implications for the LHC and for future electron-colliders will also be studied.







For more information about this project, please contact Dr. Juan Rojo at j.rojo@vu.nl.

References

[1] S. Forte and G. Watt, Progress in the Determination of the Partonic Structure of the Proton, Ann.Rev.Nucl.Part.Sci. 63 (2013) 291, [arXiv:1301.6754].

[2] R. Angeles-Martinez et al., Transverse Momentum Dependent (TMD) parton distribution functions: status and prospects, Acta Phys. Polon. B46 (2015), no. 12 2501–2534, [arXiv:1507.05267].

[3] A. Signori, A. Bacchetta, M. Radici, and G. Schnell, Investigations into the flavor dependence of partonic transverse momentum, JHEP 11 (2013) 194, [arXiv:1309.3507].

[4] The NNPDF Collaboration, R. D. Ball et al., A determination of parton distributions with faithful uncertainty estimation, Nucl. Phys. B809 (2009) 1–63, [arXiv:0808.1231].

[5] NNPDF Collaboration, R. D. Ball et al., Parton distributions for the LHC Run II, JHEP 04 (2015) 040, [arXiv:1410.8849].