ENP: EXPLORING NEW PHYSICS

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ENP (Exploring New Physics) is a so-called 'Iniziativa Specifica' of the INFN 'Commissione IV' (Theoretical Physics), investigating the phenomenology of elementary particles at present and future colliders, within and beyond the Standard Model.

1 Phenomenology of top quarks, heavy vectors and Axion Like Particles (G. Corcella)

We worked on top-quark mass determination and uncertainties at the LHC, in particular, the error due to bottom-quark fragmentation in top decays and the relation between the measured mass, relying on Monte Carlo simulations, and the pole mass. We also investigated the feasibility to tune the shower codes to top-quark data, yielding parametrizations, with central values and standard deviations, in the same manner as in the parton-distribution fits, to be used in possible top-quark analyses. We followed as ACE (Analysis Consultant and Expert) the ATLAS analysis on the top-mass extraction by looking at fully leptonic final states, namely the B hadrons decay into muons and the W's leptonically. The overall uncertainty in this measurement turned out to be about 800 MeV, with relevant contributions due to fragmentation (200 MeV) and B-hadron decay modelling (400 MeV).

We studied vector-like quark production at the LHC in a peculiar version of the 331 model, which is anomaly free, as long as the number of generations is equal to the colour number, and treats differently the third quark family from the other two, hence justifying the heaviness of the top quark. Such exotic quarks have charge 4/3 or 5/3 and can decay into singly- and doubly-charged (scalar or vector) bosons (among the main features of the 331 model) plus heavy quarks (tops and bottoms). Afterwards, we plan to tackle vector-like quark production at the LHC in a model-independent approach, hence within Effective Field Theories.

We investigated Axion Like Particle (ALP) production in the environment of the PADME experiment, namely positrons on a fixed electron target. The process under exam is $e^+e^- \to \mathrm{ALP}\gamma$, followed by $\mathrm{ALP} \to \gamma\gamma$, and the goal of the analysis is the determination of the reach of PADME on the discovery of ALPs, in terms of the ALP mass and its couplings to photons and electrons.

2 Higher-order computations of QCD amplitudes (V. Del Duca)

We calculated a family of non-planar master integrals which contribute to the two-loop scattering amplitudes for Higgs+jet, including heavy-quark mass dependence. Such a computation is relevant for NNLO inclusive Higgs production and NLO Higgs+jet.

We tackled the issue of momentum mappings, namely parametrisations of the phase space that factorise the variables that describe the particles becoming unresolved in some infrared or collinear limit from the variables that describe an on-shell phase space for the resolved particles. New momentum mappings were introduced for the purpose of final-collinear and soft counterterms.

The new mappings work with massive particles and an arbitrary number of soft particles or of clusters of collinear particles.

We proposed an all-loop expression for scattering amplitudes in planar $N = 4$ super Yang–Mills theory in multi-Regge kinematics valid for all multiplicities, all helicity configurations and arbitrary logarithmic accuracy.

We computed in dimensional regularisation the tree-level splitting amplitudes with a parent quark in the limit with four partons collinear to each other, which is part of NNNLO matrix elements. We also explored the limit with m massless partons collinear to each other in a bigger set of n collinear partons, as well as the cases with one gluon or a qqbar pair or two gluons which are soft in a set of n collinear partons.

3 Double-parton scattering at the LHC (G. Pancheri)

We explored data on double-parton scattering at LHC and different models for the effective cross section. In particular, we investigated $pp \to 4$ jets or $pp \to$ quarkonium pairs processes, showing that the effective cross section increases with the energy. Special attention was paid to models including soft-gluon resummation in the partonic impact-parameter space.

References

1. G. Corcella, The top-quark mass: challenges in definition and determination, Front. in Phys. **7** (2019) 54 [arXiv:1903.06574 [hep-ph]].

2. P. Azzi, G. Corcella *et al.*, Report from Working Group 1 : Standard Model Physics at the HL-LHC and HE-LHC," CERN Yellow Rep. Monogr. **7** (2019) 1 [arXiv:1902.04070 [hep-ph]].

3. G. Corcella, E. De Lucia, P. Di Nezza, P. Gianotti and G. Pancheri, Proceedings, Satellite Workshop: Photon Physics and Simulation at Hadron Colliders, International Conference on the Structure and the Interactions of the Photon (Photon 2019) : Frascati, Italy, June 3-7, 2019, Frascati Phys. Ser. **69** (2019).

4. X. Cid Vidal, G. Corcella *et al.*, Report from Working Group 3 : Beyond the Standard Model physics at the HL-LHC and HE-LHC, CERN Yellow Rep. Monogr. **7** (2019) 585 [arXiv:1812.07831 [hep-ph]].

5. A. Abada, G. Corcella *et al.* [FCC Collaboration], FCC-ee: The Lepton Collider : Future Circular Collider Conceptual Design Report Volume 2, Eur. Phys. J. ST **228** (2019) no.2, 261.

6. A. Abada, G. Corcella *et al.* [FCC Collaboration], FCC-hh: The Hadron Collider : Future Circular Collider Conceptual Design Report Volume 3, Eur. Phys. J. ST **228** (2019) no.4, 755.

7. A. Abada, G. Corcella *et al.* [FCC Collaboration], HE-LHC: The High-Energy Large Hadron Collider : Future Circular Collider Conceptual Design Report Volume 4, Eur. Phys. J. ST **228** (2019) no.5, 1109.

8. A. Abada, G. Corcella *et al.* [FCC Collaboration], FCC Physics Opportunities : Future Circular Collider Conceptual Design Report Volume 1, Eur. Phys. J. C **79** (2019) no.6, 474.

9. V. Casconi, M. Becchetti, R. Bonciani, F. Moriello and V. Del Duca, Planar Master Integrals for the two-loop light-fermions electroweak corrections to Higgs plus jet production, PoS RADCOR **2019** (2019) 069.

10. V. Del Duca, C. Duhr, R. Haindl, A. Lazopoulos and M. Michel, Tree-level splitting amplitudes for a quark into four collinear partons, JHEP **2002** (2020) 189 [arXiv:1912.06425 [hep-ph]].

11. V. Del Duca, S. Druc, J. M. Drummond, C. Duhr, F. Dulat, R. Marzucca, G. Papathanasiou and B. Verbeek, All-order amplitudes at any multiplicity in the multi-Regge limit, arXiv:1912.00188 [hep-th].

12. V. Del Duca, N. Deutschmann and S. Lionetti, Momentum mappings for subtractions at higher orders in QCD, JHEP **1912** (2019) 129 [arXiv:1910.01024 [hep-ph]].

13. R. Bonciani *et al.*, Evaluating a family of two-loop non-planar master integrals for Higgs + jet production with full heavy-quark mass dependence, JHEP **2001** (2020) 132 [arXiv:1907.13156 [hep-ph]].

14. C. Anastasiou, V. del Duca, E. Furlan, B. Mistlberger, F. Moriello, A. Schweitzer and C. Specchia, Mixed QCD-electroweak corrections to Higgs production via gluon fusion in the small mass approximation, JHEP **1903** (2019) 162 [arXiv:1811.11211 [hep-ph]].

15. V. Del Duca, S. Druc, J. Drummond, C. Duhr, F. Dulat, R. Marzucca, G. Papathanasiou and B. Verbeek, Amplitudes in the Multi-Regge Limit of $\mathcal{N}$=4 SYM, Acta Phys. Polon. Supp. **12** (2019) no.4, 961 [arXiv:1811.10588 [hep-th]].

16. V. Del Duca, C. Duhr, F. Dulat and B. Penante, All two-loop MHV remainder functions in multi-Regge kinematics, JHEP **1901** (2019) 162 [arXiv:1811.10398 [hep-th]].

17. G. Pancheri, A. Grau, S. Pacetti and Y. N. Srivastava, Modeling Double Parton Scattering at LHC, arXiv:1911.06672 [hep-ph].

18. A. Grau, S. Pacetti, G. Pancheri and Y. N. Srivastava, The elastic differential pp cross-section at 13 TeV: an empirical model analysis, EPJ Web Conf. **206** (2019) 06003.