ENP: Exploring New Physics

G. Corcella (Resp.), V. Del Duca, G. Pancheri (Ass. Senior)

The research undertaken within the ENP project concerns the phenomenology of particle physics at present and future colliders: precision tests of the Standard Model (SM) as well as investigation of new physics signals at the LHC and future accelerators.

We studied the phenomenology of top quarks at the LHC and the theoretical error on the top-mass determination, taking particular care about the uncertainty due to the description of bottom-quark fragmentation. Work is in progress on the inclusion of hadronization corrections to top decays, by using NNLO calculations matched with NNLL soft and collinear resummations. One will use phenomenological models tuned first to data on B-hadron production in e^+e^- annihilation at LEP and SLD, using perturbative calculations in the same approximation as top decays. Extension of this work to describe direct B- and D-hadron production at LHC is under way too. We continued previous work on the phenomenology of the 331 model which is based on a $SU(3)_C \times SU(3)_L \times U(1)_X$ gauge symmetry and predicts doubly-charged vectors and scalars, so-called bileptons, with lepton number $L = \pm 2$, as well as exotic quarks, with charge 4/3 or 5/3. We investigated non-leptonic decays of vector bileptons and found that they can give a visible signal at a future 100 TeV hadron collider (FCC-hh), while the LHC statistics are too low, even in the high-luminosity phase. The production of vector-like heavy quarks with charge 5/3, with subsequent decays into doubly- and singly-charged bileptons, was explored in the framework of simplified models and then mapped into the 331 model. Furthermore, a CMS search for vector-like top-quarks with charge 5/3 was recast. (G. Corcella)

We computed one-loop five-point QCD amplitudes in next-to-multi-Regge kinematics and evaluated the one-loop impact factor for the emission of two gluons. In fact, this is the last ingredient necessary to obtain the gluon-jet impact factor at NNLO accuracy. The three-loop leading-colour corrections to the Yang-Mills Regge trajectory and gluon impact factor were also calculated. The dependence on the Regge factorization scale was also studied, for the sake of future applications in BFKL theories at NNLL. (V. Del Duca)

We worked on soft resummation and elastic diffractive cross section at the LHC, paying special attention to the role played by the colour condensate in determining the diffraction peak. Outreach activities were also undertaken to commemorate Bruno Touschek's centenary. (G. Pancheri)

The main achievements are summarized in the following publications:

1. G. Corcella, A. Costantini, M. Ghezzi, L. Panizzi and G.M. Pruna, 'Vector-like quarks decaying into singly and doubly charged bosons at LHC', JHEP 10 (2021) 108.

2. G. Corcella, C. Corianò, A. Costantini and P.H. Frampton, 'Non-leptonic decays of bileptons', Phys. Lett. B826 (2022) 136904.

3. M. Canay and V. Del Duca, 'One-loop impact factor for the emission of two gluons', JHEP 06 (2021) 034.

4. V. Del Duca, R. Marzucca and B. Verbeek, 'The gluon Regge trajectory at three loops from planar Yang-Mills theory', JHEP 01 (2022) 149.