

# Executive Summary of MITP Program Higher orders and jets for the LHC

During the workshop we had on average one presentation per day on the topics of the program, i.e. on shower algorithms, fixed-order calculations at NLO and NNLO, resummations and jets. Thus ample space was left for discussions and collaborative work.

In the framework of interfacing shower Monte Carlos with next-to-leading order (NLO) calculations, a presentation has been given on the problem of processes involving strong interaction corrections to the decays of resonances. Several problems arise in this case in the computation of NLO corrections and in the construction of the interface to the parton shower (PS). A novel approach was presented based upon the classification and separation of all possible resonance histories allowed by the process. Preliminary results were presented for single top production and further work was carried out during the workshop in order to address the more complex (and interesting) top-pair production case. With this method it is clear that double logarithms of the resonance widths are treated correctly, while the fate of single logarithms was questioned during the workshop and discussed in several occasions.

In the framework of NLO calculations, results for WW+1jet production were presented, that are based on pure analytic results for the virtual correction, meaning that the virtual result is given in terms of linear combinations of master integrals where analytic expressions are given both for the integrals and the coefficients. This is in contrast to the widely used methods, where a numerical procedure is given to compute the coefficients. This problem has a certain relevance because numerical methods often encounter unstable phase space points, thus requiring to resort to quadruple precision, which slows down the calculation considerably. The problem becomes even more important when the NLO result is used in the context of a NNLO calculation and is required in regions where the Born momenta become soft or collinear. The example presented in the workshop suggests that this problem is certainly an important one, and it is far from having a satisfactory answer.

In the context of NNLO calculations, recent results for Higgs plus one jet were presented. The seminar triggered discussions with regard to the subtraction/slicing methods used in these calculations. Although traditionally subtraction methods are now dominant as far as the NLO calculations are concerned, it appears that, because of its intrinsic simplicity, slicing methods should be also considered for NNLO calculations. In particular, slicing methods based on the N-jettiness seem to be now a promising venue for these applications. We had several discussions on how to best fix the value of the slicing parameter, since too low a choice leads to large numerical instabilities, while a cut that is too loose leads to too rough an approximation for the NNLO result.

A good part of the workshop was also dedicated to resummation problems. We had two presentations on  $q_T$  resummation, one based upon the traditional method, and the

other based upon Soft Collinear Effective Theory (SCET). Furthermore, the treatment of jets in SCET, the automation of resummation in SCET and the prospect of treating non-global logarithms in this framework were discussed. Still on resummation we had one more presentation on the impact of logarithms related to the presence of a small jet-radius. The results presented suggest that the "small R" logarithms are not as phenomenologically relevant as thought in the past.

A longstanding open question is the estimate of theoretical errors due to unknown missing higher-order corrections. We had a presentation of a recent method based upon a bayesian approach to the problem, where one formulates priors on the behaviour of the series beyond what is known given what is known, and extracts a posterior distribution that gives a credibility density profile for the value of the uncalculated remainder of the series. The difficulty of the exercise resides in finding priors that are at the same time general enough, so as not to 'guess' the uncalculated higher orders, but also sufficiently appropriate for the process that is being considered. Discussions took place on what a correct approach may be, but the issue is still far from settled and the bayesian approach will certainly require more work before it can become a commonly used tool.

Besides the technical discussions, we had a number of review seminars, e.g. on the status of vector boson fusion studies at the LHC, on the prospects for Higgs physics, in both gluon-gluon fusion and vector boson fusion, on Dark Matter searches at the LHC, and on the general status of particle physics and its connection to cosmology.

Given that we had about one seminar per day, participants had a lot of time to work on the topics above, and others. Furthermore, several discussions took place about Standard Model physics at a 100 TeV Future Circular Collider. As a result of this, many participants of the MITP workshop started to work on this topic and will be involved in the writeup of a comprehensive report on this.