SCET Workshop 2022

Report of Contributions

https://indico.cern.ch/e/scet2022

Contribution ID: **2** Type: **not specified**

Zero-jettiness resummation for top-quark pair production at the LHC

Tuesday, 19 April 2022 13:00 (20 minutes)

The N-jettiness is a useful resolution variable to distinguish between events with a different number of jets in the final state. It has been successfully employed in slicing calculations for colour singlet processes at NNLO and its resummation forms the basis for the GENEVA approach to matching NNLO calculations to parton showers. I will discuss the extension of the zero-jettiness resummation for colour-singlet production to include the production of heavy coloured particles at the LHC. Having derived a factorisation theorem for the observable in this process, we have resummed large logarithms up to approximate NNLL' accuracy. I will describe the resummation framework we have developed and outline future applications to slicing calculations and NNLO+PS event generation.

Primary author: LIM, Matthew (Universita' di Milano-Bicocca)

Co-authors: ALIOLI, Simone (Universita & INFN, Milano-Bicocca (IT)); BROGGIO, Alessandro

Presenter: LIM, Matthew (Universita' di Milano-Bicocca)

Session Classification: Jets and event shapes

Contribution ID: **3** Type: **not specified**

TMD distributions at the next-to-leading power

Wednesday, 20 April 2022 15:30 (20 minutes)

The TMD factorization at the next-to-leading power has an involved structure of singularities. I discuss the definition and properties of transverse momentum dependent (TMD) distributions of the twist-three including evolution, symmetry relations, parametrization, interpretation, and singularities. I demonstrate that the physical TMD distributions (those express cross-sections) require an extra subtraction term. As an example of application, I present the Drell-Yan hadron tensor at the next-to-leading power in the terms of physical distributions and explicitly demonstrate the cancellation of rapidity and end-point divergences. This discussion completes the construction of TMD factorization at the next-to-leading power.

Primary author: VLADIMIROV, Alexey

Presenter: VLADIMIROV, Alexey

Session Classification: TMDs and PDFs

Contribution ID: **4** Type: **not specified**

Effective transverse momentum in multiple jet production at hadron colliders

Thursday, 21 April 2022 15:00 (20 minutes)

We consider the class of inclusive hadron collider processes in which several energetic jets are produced, possibly accompanied by colourless particles (such as Higgs boson(s), vector boson(s) with their leptonic decays, and so forth).
We propose a new variable that smoothly captures the
$N + 1$ to N-jet transition. This variable, that we dub $k_T^{\rm ness}$, represents an effective transverse momentum controlling the singularities of the $N + 1$-jet cross section when the additional jet is unresolved.
The $k_T^{\rm ness}$ variable offers novel opportunities to perform higher-order calculations in Quantum Chromodynamics (QCD) by using non-local subtraction schemes.
We study the singular behavior of the $N+1$-jet cross section as $k_T^{\rm ness} \to 0$ and, as a phenomenological application, we use the ensuing results to evaluate next-to-leading order corrections to H+jet and Z+2 jet production at the LHC.
We show that $k_T^{\rm ness}$ performs extremely well as a resolution variable and appears to be very stable with respect to hadronization and multiple-parton interactions.

Primary authors: SAVOINI, Chiara (University of Zurich); HAAG, Jürg Andreas; BUONOCORE, Luca (University of Zurich); ROTTOLI, Luca (University of Zurich (CH)); GRAZZINI, Massimiliano (University of Zurich (CH))

Presenter: HAAG, Jürg Andreas

Session Classification: NNNLL and NNLO

Contribution ID: **5** Type: **not specified**

Di-lepton Rapidity Distribution in Drell-Yan Production at N3LO in QCD

Thursday, 21 April 2022 09:30 (20 minutes)

The CERN Large Hadron Collider is a precision machine to test the Standard Model and demands equally precise theoretical predictions. State-of-the-art theory calculations at next-to-next-to-next-to-leading order (N3LO) in perturbative QCD are only available for a limited set of processes and observables. We compute for the first time the differential di-lepton rapidity distribution for the Drell-Yan (DY) production mediated via a virtual photon at N3LO. It is also the first time that the qT-subtraction method is being applied at N3LO in a fully self-contained manner.

In this talk, we will first introduce the motivation why we need such precise theoretical predictions for DY production. Second, we explain the different ingredients of qT-subtraction at N3LO, especially the 3-loop transverse momentum-dependent beam function. Third, we explain how we apply the qT-subtraction method to get the differential di-lepton rapidity distribution for the Drell-Yan (DY) production at N3LO. Finally, we give a summary.

Primary author: YANG, Tongzhi

Presenter: YANG, Tongzhi

Session Classification: NNNLL and NNLO

Contribution ID: **6** Type: **not specified**

TMD operator expansion at NLP

Wednesday, 20 April 2022 15:00 (20 minutes)

The understanding of cross sections differential in transverse momenta are known to be factorizable with TMD in the low energy spectrum. In order achieve a complete description it is necessary to explore the power expansion that allows this factorization beyond the leading order. We have have recently considered a systematic method to perform the power expansion and the complete basis of next-to-leading power operators is obtained, together with hard factors and evolution beyond leading order. I will talk about this result. The details of evolution are then discussed by A. Vladimirov in a related talk.

Primary author: SCIMEMI, Ignazio

Co-authors: VLADIMIROV, Alexey; MOOS, Valentin

Presenter: SCIMEMI, Ignazio

Session Classification: TMDs and PDFs

Contribution ID: **7** Type: **not specified**

Soft-collinear gravity beyond leading power

Friday, 22 April 2022 11:00 (20 minutes)

At first sight, perturbative gravity and gauge theory differ quite drastically at the Lagrangian level. Whereas the soft limits of both theories share many similarities, their respective collinear limits are distinct. Notably, unlike gauge theory, gravity does not feature any collinear divergences.
This motivates the construction of the soft-collinear effective theory for gravity in analogy to QCD SCET beyond leading power.

In this talk, I present the all-order construction of this effective theory in powers of the large scattering energy, focusing on the underlying concepts and the gauge symmetry, which provide a clear and intuitive structure.
Employing covariance with respect to the emerging soft gauge symmetry, the Lagrangian can be formulated in terms of a finite number of gauge-covariant and -invariant building blocks and takes a strikingly similar form to the QCD SCET Lagrangian.
I discuss in detail how this emergent gauge symmetry arises and how it constrains the Lagrangian and the operator basis.

Primary authors: BENEKE, Martin (Technische Universitaet Muenchen (DE)); HAGER, Patrick; SZAFRON, Robert (Brookhaven National Laboratory)

Presenter: HAGER, Patrick

Session Classification: Other

Contribution ID: **8** Type: **not specified**

Towards lattice calculations of double parton distributions

Wednesday, 20 April 2022 17:30 (20 minutes)

In a factorization approach to double parton scattering, the initial state is described by double parton distributions (DPDs). These functions are currently poorly constrained by experiment, but provide a view on interesting correlations between partons in the hadron. We show that DPDs can be calculated from first principles using lattice QCD via the quasi-PDF approach, opening up a new way to constrain these distributions. Specifically, we argue that there exists a factorization formula between the physical lightcone-DPDs and the lattice calculable quasi-DPDs that is governed by a perturbative matching kernel and calculate the matching kernel at one-loop. We verify the perturbative nature of the matching kernel at one-loop order by showing that the lightcone- and quasi-DPDs share the same infrared behaviour and that the matching kernel is free of logarithms involving infrared energy scales.

Primary authors: JAARSMA, Max (Universiteit van Amsterdam); RAHN, Rudi; WAALEWIJN, Wouter (University of Amsterdam)

Presenter: JAARSMA, Max (Universiteit van Amsterdam)

Session Classification: TMDs and PDFs

Contribution ID: **9** Type: **not specified**

Precision Phenomenology of Unpolarized Semi-Inclusive Deep Inelastic Scattering in Effective Field Theory

Wednesday, 20 April 2022 14:30 (20 minutes)

Factorization of Semi-Inclusive Deep Inelastic Scattering (SIDIS) has been derived in multiple ways using the methods of perturbative QCD, and more recently soft collinear effective theory (SCET). In this work, we carry out precision phenomenology for Jefferson Lab experiments and possible experiments at the electron-ion collider. We work to next-to-leading order in matching, and next-to-next-to-leading logarithm in the resummation of singular terms. The resummation is carried out in the hybrid formalism which avoids the Landau pole. We introduce profile functions in the renormalization scale and rapidity scale that automatically turn off the resummation in the large transverse momentum region, and result in a smooth transition from the resummation region at small transverse momentum to the collinear factorization region at larger transverse momentum.

Primary authors: Dr JAIN, Amber (Indian Institute of Science Education and Research); LIEFFERS, Justin; FLEMING, Sean (University of Arizona)

Presenter: LIEFFERS, Justin

Session Classification: TMDs and PDFs

Contribution ID: **11** Type: **not specified**

TMDs in dijet and heavy hadron pair production at EIC (remote)

Thursday, 21 April 2022 17:30 (20 minutes)

We discuss the measurement of gluon transverse momentum distribution (TMD) in dijet and heavy hadron pair (HHP) production in semi-inclusive deep inelastic scattering. The factorization of these processes in position space shows the appearance of a specific new soft factor matrix element on top of angular and complex valued anomalous dimensions. We show in detail how these features can be treated consistently and we discuss a scale prescription for the evolution kernel of the dijet soft function. As a result we obtain phenomenological predictions for unpolarized and angular modulated cross-sections for the electron-ion collider (EIC) using current available information on unpolarized TMD.

Primary author: F. DEL CASTILLO, Rafael

Presenter: F. DEL CASTILLO, Rafael

Session Classification: TMDs and PDFs

Contribution ID: **12** Type: **not specified**

Power Counting Energy Flow Polynomials

Tuesday, 19 April 2022 16:00 (20 minutes)

Power counting is a systematic strategy for organizing collider observables and their associated theoretical calculations.In this paper, we use power counting to characterize a class of jet substructure observables called energy flow polynomials (EFPs).

EFPs provide an overcomplete linear basis for infrared-and-collinear safe jet observables, but it is known that in practice, a small subset of EFPs is often sufficient for specific jet analysis tasks.By applying power counting arguments, we obtain linear relationships between EFPs that hold for quark and gluon jets to a specific order in the power counting.

We test these relations in the parton shower generator \Pythia, finding excellent agreement. Power counting allows us to truncate the basis of EFPs without drastically affecting performance, which we corroborate through a study of quark-gluon tagging and regression.

Primary authors: Prof. THALER, Jesse (MIT); CAL, Pedro; Prof. WAALEWIJN, Wouter (University of Amsterdam)

Presenter: CAL, Pedro

Session Classification: Jets and event shapes

Contribution ID: **13** Type: **not specified**

Next-to-next-to-leading order parton distribution functions using LCPT

Thursday, 21 April 2022 10:00 (20 minutes)

We describe the perturbative calculation of the transverse parton distribution functions in the quark-quark channel up to next-to-next-to-leading order, based on the technique of light-cone perturbation theory. The computation consists of separate computation of Feynman diagrams, demonstrating the cancellation of both UV and IR light-cone divergences. The result serves as a check for a previous calculation (1403.6451) by using a different approach, avoiding the use of harmonic polylogarithms. In addition, the new approach allows an improved set of underlying assumptions, thereby including an additional set of terms which were previously neglected.

Primary author: MULIAN, Yair

Presenter: MULIAN, Yair

Session Classification: NNNLL and NNLO

Contribution ID: **14** Type: **not specified**

Dissecting the collinear structure of quark splitting at NNLL

Tuesday, 19 April 2022 14:00 (20 minutes)

Higher-order splitting kernels comprise an essential ingredient for enhancing the logarithmic accuracy of parton showers. Beyond NLL, collinear dynamics of quark and gluon splitting at NLO is encoded in the triple-collinear splitting functions. This talk provides latest insights into various ingredients that enter the construction of higher-order parton showers. First, I will show that suitable integrals of the splitting functions, plus virtual corrections, furnishes a solid understanding of the scale of the coupling beyond the soft limit (CMW scheme). Second, I will establish a relationship between the splitting functions and the familiar NLO DGLAP kernels. Third, I will discuss the construction of a differential version of the coefficient B_2, which controls the next-to-next-to-leading logarithm in the hard-collinear limit. I will show the general structure of the coefficient B_2 and how it arises in resummation approaches such as SCET.

Primary author: EL-MENOUFI, Basem

Presenter: EL-MENOUFI, Basem

Session Classification: Jets and event shapes

Contribution ID: **15** Type: **not specified**

Next-to-leading non-global □logarithms from jet calculus

Wednesday, 20 April 2022 11:00 (20 minutes)

We present a formalism for the resummation of non-global QCD observables beyond leading logarithmic accuracy. We discuss the derivation of a set of integro-differential equations that governs the dynamics of soft radiation in the planar limit, using which we perform a calculation of the out-of-jet transverse energy distributions at lepton colliders. We finally comment on the solution of the evolution equations by means of Monte Carlo methods and discuss future prospects.

Primary authors: BANFI, Andrea (University of Sussex); DREYER, Frederic Alexandre (University of Oxford); MONNI, Pier Francesco (CERN)

Presenter: MONNI, Pier Francesco (CERN)

Session Classification: NGL and Glauber

Contribution ID: **16** Type: **not specified**

Resummmation Beyond Next-to-leading Logarithms at Subleading Power in $h \to \gamma\gamma$ Decay

Thursday, 21 April 2022 12:00 (20 minutes)

Based on our previous series of work, we present the full resummation at RG-improved leading order for $h \to \gamma\gamma$ decay amplitudes induced by light quarks. We analytically show that endpoint divergences cancel in the plus-type subtraction scheme after scale evolution and use a slicing method to do the numerical evaluation. We find logarithms beyond NLL are significant.

Primary authors: NEUBERT, Matthias; WANG, Xing; Dr MECAJ, Bianka (Yale U.); Dr LIU, Zelong (Bern U.)

Presenter: WANG, Xing

Session Classification: NLP

Contribution ID: **17** Type: **not specified**

Factorization connecting TMDs in SCET and lattice QCD

Wednesday, 20 April 2022 14:00 (20 minutes)

SCET enables the factorization of cross-sections into perturbative and non-perturbative components. The resulting non-perturbative functions are typically modeled with essentially no direct input from lattice QCD calculations. The fact that their dynamics are dominated by the lightcone typically renders them inaccessible to direct lattice QCD calculations due to a sign problem, a speculated NP-hard numerical difficulty. To circumvent this issue, one can try to construct lattice-calculable quantities that encode the same infrared physics as the desired functions and then prove a factorization theorem connecting the two distributions. In this talk, I demonstrate how to carry out this lattice factorization program for transverse-momentum-dependent PDFs (TMDs), which are key components of cross-sections for Drell-Yan, SIDIS, and other processes.

Primary authors: SCHINDLER, Stella; EBERT, Markus (MIT); STEWART, Iain; ZHAO, Yong

Presenter: SCHINDLER, Stella

Session Classification: TMDs and PDFs

Contribution ID: **18** Type: **not specified**

Quasi Transverse Momentum Dependent correlator @ next-to-leading power

Wednesday, 20 April 2022 17:00 (20 minutes)

The theory and phenomenology of transverse-momentum dependent parton distributions (TMDs) have seen increasing activity in the past years. Factorization theorems for both leading-power (LP) and next-to-leading power (NLP) scenario has been discussed in the context of experimental processes such as Drell-Yan (DY) or SIDIS.
However, experimental determination of all TMD distributions is an extremely challenging problem. Therefore, lattice simulations of QCD can help bringing complementary information and guiding the phenomelogical parametrizations. On the lattice, since one cannot access directly the TMD correlator, one resorts to study an equal-time 'quasi'-TMD correlator. However, the relation between the quasi-TMDs and the TMDs in non-trivial. In fact, the quasi-TMD correlator can be interpreted as the counterpart of the hadronic tensor in DY or SIDIS.
In this talk, I will present our results for the quasi-TMD correlator both at LP and NLP at one-loop accuracy. I will show how the quasi-TMD correlator can be factorized into the actual TMD distribution and an unknown function.

Primary authors: Dr VLADIMIROV, Alexey (University of Regensburg); RODINI, Simone (University of Regensburg); Prof. SCHÄFER, Andreas (University of Regensburg)

Presenter: RODINI, Simone (University of Regensburg)

Session Classification: TMDs and PDFs

Contribution ID: **19** Type: **not specified**

QCD anatomy of photon-isolation

Tuesday, 19 April 2022 15:00 (20 minutes)

In order to differentiate photons produced from different origins at hadrons collider, it is necessary to impose some isolation requirements. For cones with small radius R, photon isolation effect can be captured by a fragmentation function describing the fragmentation of a parton into a photon accompanied by soft radiation. We computed these fragmentation functions for fixed energy cone and Frixione cone to gain a better understanding of the effect of the isolation parameters on the cross section of $pp \to \gamma + X$. The fragmentation function prediction is compared to the NLO predictions. Finally, we resum the leading logarithms of R and of ϵ_γ the ratio of energy inside the cone to the photon energy and compared it to the measurement performed at ATLAS.

Primary author: FAVROD, Samuel Clément

Presenter: FAVROD, Samuel Clément

Session Classification: Jets and event shapes

Contribution ID: **20** Type: **not specified**

Glauber Resummation

Wednesday, 20 April 2022 09:30 (20 minutes)

The higher-order behavior of logarithmically enhanced contributions in non-global observables is very intricate, in particular as double-logarithmic corrections may arise first at very high orders in perturbation theory. Recently, the resummation of these super-leading logarithms (SLLs) to all orders for generic $2 \to l$ scattering processes at hardron colliders has been achieved [1]. For realistic values of the low energy scale and the partonic center-of-mass energy the contribution of SLLs is comparable to the one of Glauber phases arising from soft parton exchange in initial- or final-state. Surprisingly, it turns out that these Glauber contributions can be resummed analytically to all orders as well, at least for quark-induced processes. Depending on the considered process, the contribution to the cross section can be of the order of a few percent.
[1] T. Becher, M. Neubert, and D. Y. Shao, Phys. Rev. Lett. 127, 212002 (2021)

Primary authors: BÖER, Philipp (JGU Mainz); NEUBERT, Matthias (JGU Mainz); STILLGER, Michel (JGU Mainz)

Presenter: STILLGER, Michel (JGU Mainz)

Session Classification: NGL and Glauber

Contribution ID: **21** Type: **not specified**

Sudakov Shoulders in Thrust and Heavy Jet Mass

Tuesday, 19 April 2022 14:30 (20 minutes)

Sudakov shoulders are large logarithms of event shape observables that occur in the interior of the allowed phase space, in contrast to Sudakov peaks which occur at the boundary of phase space. Starting from a factorization theorem in SCET, we present a resummation of the Sudakov shoulder occurring in heavy jet mass and thrust near the trijet configuration (corresponding to a value of $\frac{1}{3}$). The resummation of these shoulders could be crucial to a precise extraction of the strong coupling constant from the distribution of heavy jet mass and thrust.

Primary author: BHATTACHARYA, Arindam

Co-authors: SCHWARTZ, Matthew; ZHANG, Xiaoyuan (Harvard University)

Presenter: BHATTACHARYA, Arindam

Session Classification: Jets and event shapes

Contribution ID: **22** Type: **not specified**

An EFT derivation of the saturation scale (remote)

Wednesday, 20 April 2022 12:00 (20 minutes)

I will talk about an EFT formulation for understanding the physics of saturation in Deep Inelastic scattering using the Glauber EFT for forward scattering. I ll show how to derive a factorization formula that manifestly decouples the physics of the probe, the Quark-antiQuark Dipole, from the universal physics of the medium, namely a hadron or a large nucleus, by treating the probe as an Open quantum system.
Using this framework, I will, for the first time give the definition of the Saturation scale for small x DIS in terms of a matrix element of a gauge invariant operator in the proton state. The saturation scale can be directly related to an emergent length scale in the EFT- the mean free path for the probe, which yields two emergent expansion parameters. These parameters becoming O(1) can be respectively interpreted as the onset of saturation and the breakdown of independent scattering in the medium. I ll also briefly speculate about how the nonlinear regime of the JIMWLK/BK equations can be recovered in this EFT framework.

Primary author: VAIDYA, Varun

Presenter: VAIDYA, Varun

Session Classification: NGL and Glauber

Contribution ID: **23** Type: **not specified**

An automated framework to calculate jet and beam functions at NNLO (remote)

Thursday, 21 April 2022 14:30 (20 minutes)

We present a novel formalism to calculate beam and jet functions automatically at next-to-next-to-leading order in perturbation theory. By employing suitable phase-space parameterisations in combination with sector-decomposition steps and selector functions, we managed to factorise all divergences in the phase-space integrations and we implemented our framework in the publicly available code pySecDec. Our approach covers a wide class of SCET-1 and SCET-2 observables and we present results for several event-shape observables for both quark and gluon jet functions along with results for p_T-resummation, jet vetoes and hadronic event shapes for quark beam functions.

Primary authors: BELL, Guido (University of Siegen); BRUNE, Kevin (University of Siegen); DAS, Goutam (University of Siegen); WALD, Marcel (University of Siegen)

Presenter: WALD, Marcel (University of Siegen)

Session Classification: NNNLL and NNLO

Contribution ID: **24** Type: **not specified**

Finite-t and Mass Corrections in Deeply Virtual Compton Scattering

Thursday, 21 April 2022 11:30 (20 minutes)

In this talk, I will present our calculation of kinematic power corrections t/Q^2 and m^2/Q^2 to the amplitude of deeply-virtual Compton scattering to the twist-six accuracy.

Phenomenologically, this result reduces an important source of uncertainties in the QCD predictions for intermediate momentum transfers $Q^2 \sim 1-10\,\mathrm{GeV}^2$, which are accessible in the existing and planned EIC experiments. In particular, the finite–t corrections are significant and must be taken into account in the data analysis.

Our calculation is carried out using techniques from conformal theory and the corresponding results are applicable to other processes involving light-ray operators.

Primary authors: Dr MANASHOV, Alexander (Institute for Theoretical Physics, University of Hamburg); Prof. BRAUN, Vladimir (University of Regensburg); JI, Yao

Presenter: JI, Yao

Session Classification: NLP

Contribution ID: **25** Type: **not specified**

The photon energy spectrum in B⊠X$_s$γ at N^{3}LL'

Friday, 22 April 2022 10:00 (20 minutes)

SCET lies at the foundation of our understanding of inclusive B meson decays. It allows us to factorize the spectrum into hard, jet, and hadronic soft functions. The hadronic soft function can be further factorized into perturbative partonic soft function and nonperturbative shape function. The shape function is a necessary ingredient for extraction of $|V_{ub}|$ CKM matrix element from $B \to X_u l\nu$ spectrum, and it can be extracted from inclusive measurements of $B \to X_s\gamma$ spectrum.

I will present our preliminary predictions of $B \to X_s\gamma$ spectrum at $\mathrm{N^3LL'}$+$\mathrm{N^3LO}$, which we implemented in the SCETlib library. Although only the soft and jet functions are fully known at $\mathrm{N^3LO}$, we parameterize the unknown 3-loop hard function coefficient and nonsingular contributions in terms of nuisance parameters. The variation of these nuisance parameters provides a robust estimate of the uncertainty that arises from our ignorance of these 3-loop terms.

In order to arrive at stable predictions it is essential to use a short-distance scheme for the b-quark mass. It is well-known that the pole mass scheme suffers from a renormalon problem, which leads to very poor convergence. We demonstrate that predictions in 1S mass scheme, which has been used for this process in the past, start to break down at $\mathrm{N^3LL'}$ due to a mismatch between the 1S scale and the soft scale of this process. I will show that the MSR mass scheme yields much more stable results.

Primary authors: DEHNADI, Bahman; TACKMANN, Frank (Deutsches Elektronen-Synchrotron (DE)); NOVIKOV, Ivan (Deutsches Elektronen-Synchrotron (DE))

Presenter: NOVIKOV, Ivan (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Other

Contribution ID: **26** Type: **not specified**

NLP Endpoint Factorization and Resummation for Off-Diagonal Channels

Thursday, 21 April 2022 11:00 (20 minutes)

The off-diagonal partonic channels do not contribute at leading power in hard scattering but appear first at next-to-leading power (NLP). In contrast to the diagonal channels, leading logarithms are already non-trivial and resummation requires new, refined methods. Techniques developed at leading power cannot be readily utilized since endpoint divergences spoil NLP factorization. In four dimensions, NLP factorization formulae are only well defined after careful treatment of the endpoint regions.

We present a factorization formula, which is free of endpoint divergences in four dimensions. This factorization formula allows us to resum next-to-leading-power logarithms with (almost) standard RGE methods.

Primary authors: BENEKE, Martin (Technische Universitaet Muenchen (DE)); GARNY, Mathias (Technische Universitaet Muenchen (DE)); JASKIEWICZ, Sebastian (Technical University of Munich); STROHM, Julian; SZAFRON, Robert (Brookhaven National Laboratory); VERNAZZA, Leonardo (Nikhef); WANG, Jian (Shandong University)

Presenter: STROHM, Julian

Session Classification: NLP

Contribution ID: **27** Type: **not specified**

Analytic two-loop soft and beam functions for leading-jet p_T

Thursday, 21 April 2022 14:00 (20 minutes)

We present the calculation of the two-loop soft and beam functions for the transverse-momentum distribution of the leading jet produced in association with any colour-singlet system (e.g. a Higgs or a Z boson). This constitutes a central ingredient for the resummation of the above distribution as well as the jet-vetoed cross section at the next-to-next-to-next-to-leading logarithmic order.

Primary authors: GAUNT, Jonathan Richard (University of Manchester (GB)); MONNI, Pier Francesco (CERN); ABREU, Samuel (CERN); SZAFRON, Robert (Brookhaven National Laboratory)

Presenter: ABREU, Samuel (CERN)

Session Classification: NNNLL and NNLO

Contribution ID: **28** Type: **not specified**

Rapidity evolution of TMDs with running coupling (remote)

Thursday, 21 April 2022 16:30 (20 minutes)

The scale of a coupling constant for rapidity evolution of TMD operators in the Sudakov region is calculated using BLM procedure. The effective scale for a coupling constant
is halfway in logarithmical scale between the transverse momentum and energy of TMD distribution. The resulting rapidity-only evolution equation is solved for quark and gluon TMDs.

Primary authors: Dr CHIRILLI, Giovanni Antonio (University Regensburg); BALITSKY, Ian

Presenter: BALITSKY, Ian

Session Classification: TMDs and PDFs

Contribution ID: **29** Type: **not specified**

Extending Precision Perturbative QCD with Track Functions (remote)

Tuesday, 19 April 2022 13:30 (20 minutes)

Track functions describe the collective effect of the fragmentation of quarks and gluons into charged hadrons, making them a key ingredient for jet substructure measurements at hadron colliders, where track-based measurements offer superior angular resolution. Measurements of higher-point correlations of energy flow necessitate a characterization of fluctuations in the hadronization process, described theoretically by higher moments of track functions. We have analytically derived the NLO renormalization group evolution equations for track function moments up to the six moment, which allow for the study of up to six-point correlations in energy flow using tracks at order-α_s^2 level. Energy conservation gives rise to a shift symmetry that fixes the form of the evolution equations for track function moments at all-loop orders and allows the equations to be written in terms of cumulants or central moments. We find that the evolution for the first three cumulants is approximately DGLAP, while for the fourth moment and beyond, non-linearities in the evolution result in genuinely new behavior beyond DGLAP; and we studied the RG flows of the fourth and the fifth cumulants in pure Yang-Mills theory. Finally, we have initiated a study of track function evolution in momentum-fraction space, and have derived the full NLO evolution equation in $\mathcal{N} = 4$ SYM and preliminary results in QCD, paving the way for precision jet substructure at LHC.

Primary author: LI, Yibei

Co-authors: MOULT, Ian James; JAARSMA, Max (Universiteit van Amsterdam); WAALEWIJN, Wouter (University of Amsterdam); ZHU, HuaXing (Zhejiang University)

Presenter: LI, Yibei

Session Classification: Jets and event shapes

Contribution ID: **30** Type: **not specified**

A new paradigm for precision top mass measurement: Weighing the top with energy correlators

Tuesday, 19 April 2022 17:00 (20 minutes)

One of the most important goals of the precision collider physics program is to push beyond the sub-percent accuracy of the current top quark mass measurement. This involves looking for observables that are both sensitive to the top mass and can be brought under theoretical control. Satisfying both these criterion at the LHC is a challenging task due to contributions from soft physics and the underlying event contamination.

In this talk I will present a novel proposal of measuring the top mass using correlation functions of energy flow operators. These correlation functions are one of the field theoretically simplest observables and typically exhibit a featureless power-law scaling characteristic of asymptotically free Quantum Chromodynamics. On the other hand, the electroweak decay of the top quark imprints itself as a distinct peak in the three-point correlation function at an angle determined by the ratio of top mass and its transverse momentum. I will show how this allows us to simultaneously achieve high sensitivity to the top mass comparable to the state-of-the-art measurements and good theoretical control by evading the above-mentioned challenges at the LHC.

Primary authors: Dr PATHAK, Aditya (University of Manchester); MOULT, Ian James; HOLGUIN, Jack (CPHT Ecole Polytechnique); PROCURA, Massimiliano (University of Vienna (AT))

Presenter: Dr PATHAK, Aditya (University of Manchester)

Session Classification: Jets and event shapes

Contribution ID: **31** Type: **not specified**

Pseudo- and quasi-PDFs in the BFKL approximation (remote)

Thursday, 21 April 2022 17:00 (20 minutes)

To calculate the PDFs from first principles in Lattice gauge theories it is convenient to consider the Ioffe-time distribution defined through gauge-invariant bi-local operators with spacelike separation. Lattice calculations provide values for a limited range of the distance separating the bi-local operators. In order to perform the Fourier transform and obtain the pseudo- and the quasi-PDFs, it is then necessary to extrapolate the large-distance behavior.

I will discuss the formalism one may use to study the behavior of the Ioffe-time distribution at large distances and show that the pseudo-PDF and quasi-PDF are very different in this regime. Using light-ray operators, I will also show that the higher twist corrections of the quasi-PDF come in not as inverse powers of P but as inverse powers of $x_B P$.

Primary author: CHIRILLI, Giovanni Antonio

Presenter: CHIRILLI, Giovanni Antonio

Session Classification: TMDs and PDFs

Contribution ID: **32** Type: **not specified**

Resummation of Super-Leading Logarithms

Wednesday, 20 April 2022 09:00 (20 minutes)

Jet cross sections at high-energy colliders exhibit intricate patterns of logarithmically enhanced higher-order corrections. In particular, so-called nonglobal logarithms emerge from soft radiation emitted off energetic partons inside jets. While this is a single-logarithmic effect at lepton colliders, at hadron colliders phase factors in the amplitudes lead to double-logarithmic corrections starting at four-loop order. This effect was discovered a long time ago, but not much is known about the higher-order behavior of these terms and their process dependence. We derive, for the first time, the all-order structure of these "super-leading logarithms"for generic 2⟶l scattering processes at hadron colliders and resum them in closed form.

Primary authors: SHAO, Dingyu (Fudan University (CN)); NEUBERT, Matthias; BECHER, Thomas (University of Bern)

Presenter: NEUBERT, Matthias

Session Classification: NGL and Glauber

Contribution ID: **33** Type: **not specified**

Factorization for Subleading Power TMD Observables

Wednesday, 20 April 2022 16:30 (20 minutes)

TMD distributions depending on the azimuthal angle provide a non-trivial example of observables that start at O(lambda) in the power expansion. They also have a long history, for example in 1978 Cahn showed that quark transverse momentum gives rise to an azimuthal cos(phi) asymmetry of the outgoing hadrons in semi-inclusive DIS (SIDIS). Such subleading distributions also are an interesting probe of the spin structure of hadrons. In this talk I study the full set of such subleading TMD distributions in SIDIS, Drell-Yan (DY), and e+e- to back-to-back hadrons. Under the assumption that leading power Glauber interactions do not spoil factorization at this power, I provide a complete derivation of factorization for these structure functions using SCET. At SCET 2021 I discussed the contribution of subleading power collinear operators for SIDIS, and this year I will extend the analysis of these contributions to DY and e+e-. A new analysis provided this talk is the full discussion of subleading soft effects, from both SCET II subleading operators, as well as contributions from the subleading dynamic Lagrangian. Interestingly, we show that all the possible subleading soft contributions vanish, and therefore the soft function remains the same as at leading power. Thus the only new distribution functions for these observables at subleading power are a set of the quark-gluon-quark correlators, which come along with only one new Wilson coefficient in SIDIS, DY, and e+e-.

Primary authors: GAO, Anjie; STEWART, Iain; EBERT, Markus (MIT)

Presenter: GAO, Anjie

Session Classification: TMDs and PDFs

Contribution ID: **34** Type: **not specified**

Conformal Colliders Meet the LHC with Fragmenting Jet Functions (remote)

Tuesday, 19 April 2022 17:30 (20 minutes)

Reframing jet substructures in terms of multipoint correlation functions of energy flow light-ray operators offers new means to study the dynamics of QCD jets, providing many interesting phenomenological applications (including QCD fragmentation, track functions, precision measurements, and more) and allowing applications of theoretical developments in the study of conformal field theories.

In order to fully benefit from such a reframing based on energy correlators, it is imperative to develop a theoretical framework to incorporate the complicated initial state of the LHC, which goes beyond what has previously been considered in theoretical studies of energy correlators.

In this talk, I will present a theoretical framework developed using SCET to study energy correlators at the LHC, allowing recent calculations of energy correlators to be seamlessly embedded in the complicated LHC environment.

Using this approach, I will present results for the scaling behavior of multipoint energy correlators and compare with CMS Open Data, opening the door to the quantitative study of energy correlators at the LHC.

Finally, I will discuss the path forward for higher precision calculations at the LHC using the energy correlators.

Primary authors: LEE, Kyle; MOULT, Ian (Yale University); MEÇAJ, Bianka (Yale University)

Presenter: LEE, Kyle

Session Classification: Jets and event shapes

Contribution ID: **35** Type: **not specified**

The Drell-Yan q_T Spectrum and Its Uncertainty at N^{3}LL$'$

Thursday, 21 April 2022 09:00 (20 minutes)

We present state-of-the-art SCETlib predictions for the W and Z/γ^* transverse-momentum (q_T) distributions at the LHC at complete three-loop order in resummed perturbation theory (N^{3}LL$'$) and matched to available fixed order. We pay particular attention to the estimation of theory uncertainties via profile scale variations in such a way that perturbative uncertainties due to PDF evolution, perturbative resummation uncertainties, and nonperturbative uncertainties for $q_T \to 0$ are cleanly disentangled, and compare our predictions to high-precision measurements by the ATLAS and CMS experiments. The speed and versatility of our resummed calculation also allow us to study the dependence on the strong coupling, the PDFs, and their parametric uncertainties at this order. We find intriguing evidence that the normalized ATLAS and CMS Z q_T spectra may prefer a lower strong coupling than the PDG value.

Primary authors: TACKMANN, Frank (Deutsches Elektronen-Synchrotron (DE)); MICHEL, Johannes (MIT CTP); BILLIS, Georgios (Milano-Bicocca/INFN); EBERT, Markus (MPI Munich)

Presenter: MICHEL, Johannes (MIT CTP)

Session Classification: NNNLL and NNLO

Contribution ID: **36** Type: **not specified**

A NNLL Evolution Equation for Regge Amplitudes

Wednesday, 20 April 2022 11:30 (20 minutes)

The exchange of Glauber particles in SCET can be used to study QCD scattering amplitudes in the Regge limit. At NNLL level, the RGE for Regge 2-to-2 scattering amplitudes are not currently known. In this talk, I will use the tools of SCET to study the RGE structure of the three-loop Glauber exchange amplitude, which specifies these terms. SCET consistency relations between the soft and collinear sectors yield two distinct methods of fixing the RGE, each with different advantages. In the collinear sector, the organization of RGE contributions is more difficult but the calculations prove to be simpler. In the soft sector, the organization of RGE contributions is often manifest, but the calculations end up being trickier. Using results from both the soft and collinear sectors, I provide and discuss results for a new RGE equation at three-loop order in the 10 and 10-bar color channels.

Primary authors: GAO, Anjie; STEWART, Iain; RAMAN, Sanjay; RIDGWAY, Gregory (Massachusetts Institute of Technology); MOULT, Ian (Yale University)

Presenter: RAMAN, Sanjay

Session Classification: NGL and Glauber

Contribution ID: **37** Type: **not specified**

Two-loop anomalous dimension for the resummation of non-global observables

Wednesday, 20 April 2022 10:00 (20 minutes)

The soft radiation emitted in jet cross sections can resolve the directions and colors of individual hard partons, leading to a complicated pattern of logarithmically enhanced terms in the perturbative series. Starting from a factorization theorem and solving the renormalization group equations for its ingredients, these large logarithms can be resummed. We extract the two-loop anomalous dimension governing the resummation of subleading logarithms in jet cross sections and other non-global observables. This anomalous dimension can be obtained by considering soft limits of hard amplitudes, but the presence of collinear singularities in intermediate expressions makes its extraction delicate. As a consistency check, we use our results to predict the known subleading non-global logarithms in the two-jet cross section.

Primary author: XIAOFENG, Xu

Co-authors: Prof. THOMAS, Becher; Dr THOMAS, Rauh

Presenter: XIAOFENG, Xu

Session Classification: NGL and Glauber

Contribution ID: **38** Type: **not specified**

Simulating collider physics on quantum computers using SCET

Friday, 22 April 2022 12:00 (20 minutes)

Quantum simulations of the full dynamics of a quantum field theory over a wide range of energies requires exceptionally large resources. Yet for many observables in particle physics, perturbative techniques are sufficient to accurately model all but a constrained range of energies within the validity of the theory. SCET naturally provides an efficient separation of dynamics well-described by pertubation theory from those requiring additional treatment, and we present a formalism to embed the results of quantum calculations into SCET-like theories. As an explicit example we calculate the zero- and one-particle emission contributions to the soft function of an SCET-like treatment of massless scalars and compare to simulations on an IBMQ quantum processor. We also report on preliminary work extending these results to abelian gauge theories.

Primary author: FREYTSIS, Marat (Rutgers University)

Co-authors: BAUER, Christian Walter (Lawrence Berkeley National Lab. (US)); NACHMAN, Ben (Lawrence Berkeley National Lab. (US))

Presenter: FREYTSIS, Marat (Rutgers University)

Session Classification: Other

Contribution ID: **39** Type: **not specified**

Radiative corrections to charged-current neutrino scattering at GeV energies (remote)

Friday, 22 April 2022 11:30 (20 minutes)

SCET is an extremely powerful tool for the evaluation of radiative corrections in neutrino experiments. I am going to highlight two recent advances: 1. Charged-current quasielastic scattering is the signal process in modern neutrino oscillation experiments. Exploiting effective field theory, we factorize neutrino-nucleon cross sections into soft, collinear, and hard contributions. We evaluate soft and collinear functions from QED and provide a model for the hard contribution with expected infrared and collinear behavior. We validate precise relation between electron and muon neutrino cross sections for the experimental setup of modern and future accelerator-based neutrino oscillation experiments. 2. Exchange of Glauber photons with nuclear medium modified neutrino and electron scattering cross sections by a percent level corrections. We evaluate these changes for typical energies of modern and future experimental facilities.

Primary author: TOMALAK, Oleksandr

Presenter: TOMALAK, Oleksandr

Session Classification: Other

Contribution ID: **40** Type: **not specified**

Differential Distributions beyond N3LO (remote)

Thursday, 21 April 2022 15:30 (20 minutes)

In this talk I present upcoming results regarding resummation at 4 loops for differential distributions.

Primary author: Dr VITA, Gherardo (SLAC)

Presenter: Dr VITA, Gherardo (SLAC)

Session Classification: NNNLL and NNLO

Contribution ID: **41** Type: **not specified**

Beautiful and Charming Energy Correlators (remote)

Tuesday, 19 April 2022 16:30 (20 minutes)

Many searches for New Physics and precision measurements in QCD involve the study of jet substructure for final state hadrons. While traditionally the state of the art for studying jets at particle colliders have been event shape observables, recently it has been better understood that measuring correlation functions of energy flow operators inside a jet is in fact a very powerful tool for phenomenology which also naturally stems from first principles of quantum field theory. In many cases this makes it possible to take advantage of certain useful symmetries from the theory.

In this work we use the soft-collinear effective theory to study the energy-energy correlators for charm and bottom quark fragmentation, extending studies on massless QCD jets. The presence of the mass introduces an additional scale, which is detected by the correlator, providing a clean manifestation of the dead cone effect. We compute the heavy-quark jet function and present a factorization formula for the process, which we use to perform a next-to-leading-log resummation of the large logarithms.

Our extension of energy correlators to heavy flavor opens many opportunities for precision studies of fragmentation with jet substructure.

Primary authors: Dr MEÇAJ, Bianka (Yale University); Prof. MOULT, Ian (Yale University); Dr LEE, Kyle

Presenter: Dr MEÇAJ, Bianka (Yale University)

Session Classification: Jets and event shapes

Contribution ID: **42** Type: **not specified**

Weak annihilation in non-leptonic B decays

Exclusive non-leptonic B-meson decays provide a precision laboratory for tests of flavour-changing weak transitions. While the factorization of the decay amplitude is well understood in the heavy-quark limit since more than two decades, very little is known so far about power-corrections. One particular class of such suppressed effects are the so-called weak-annihilation topologies. With the recent advances in the theoretical understanding of sub-leading power SCET, we investigate the factorization of these effects in the annihilation dominated charmless decay $B_d \to K^+K^-$.

Primary authors: NEUBERT, Matthias; BÖER, Philipp (JGU Mainz); STILLGER, Michel (JGU Mainz)

Presenter: BÖER, Philipp (JGU Mainz)

Session Classification: Other

Contribution ID: **43** Type: **not specified**

TBA

We'll try to schedule a talk on the new CDF W-mass measurement in this slot.

Primary author: TBD

Presenter: TBD

Contribution ID: **44** Type: **not specified**

Heaviside functions and the same-hemisphere triple-gluon contribution to the zero-jettiness soft function at N3LO QCD

Friday, 22 April 2022 09:30 (20 minutes)

The advancement of computation techniques enables a number of N3LO calculations in perturbative QCD, which are crucial to reaching percent level accuracy in the LHC (and the upcoming HL-LHC) phenomenology. An important part of this effort involves properly extracting IR singularities at N3LO. The N-jettiness slicing scheme is one of the techniques to deal with this problem, but is only available up to N2LO due to the complexity introduced by the Heaviside functions in the soft function. In this talk, we will discuss how we handle the Heaviside functions in the calculation and report the recent result of the same-hemisphere triple-gluon contribution to the zero-jettiness soft function at N3LO QCD.

Primary author: WANG, Chen-Yu (TTP, KIT)

Presenter: WANG, Chen-Yu (TTP, KIT)

Session Classification: Other

Contribution ID: **45** Type: **not specified**

High-precision measurement of the W-mass at CDF II (remote)

Friday, 22 April 2022 09:00 (20 minutes)

TBA

Primary author: HAYS, Chris (University of Oxford (GB))

Presenter: HAYS, Chris (University of Oxford (GB))

Session Classification: Other