

# SCET 2017



## Report of Contributions

Contribution ID: 2

Type: **not specified**

## Factorization for Jet Substructure

*Tuesday 14 March 2017 09:00 (40 minutes)*

I will discuss recent advances in resummation of observables for probing the substructure of jets. By grooming the jet with soft drop, non-global logarithms in the jet mass can be removed. Extending the factorization theorem for soft drop jet mass, we are able to calculate the distribution of  $D_2$ , an observable that is sensitive to two-prong structure in the jet. The soft dropped  $D_2$  distribution is remarkably robust: we show that it is approximately independent of jet energy, non-perturbative corrections are suppressed by the jet mass, and fixed-order corrections can be formally made arbitrarily small.

**Primary author:** LARKOSKI, Andrew

**Co-authors:** NEILL, Duff (Carnegie Mellon University); MOULT, Ian

**Presenter:** LARKOSKI, Andrew

**Session Classification:** Session 1

Contribution ID: 3

Type: **not specified**

## Jet axes and universal TMD fragmentation

*Wednesday 15 March 2017 09:00 (40 minutes)*

We study the transverse momentum spectrum of hadrons in jets. By measuring the transverse momentum with respect to a judiciously chosen axis, we find that this observable is insensitive to (the recoil of) soft radiation. For small transverse momenta we show that the effects of the jet boundary factorize, leading to a new transverse-momentum-dependent (TMD) fragmentation function. In contrast to the usual TMD fragmentation functions, it does not involve rapidity divergences. We discuss potential applications, including the study of nuclear modification effects in heavy-ion collisions and identifying boosted heavy resonances.

**Primary authors:** WAALEWIJN, Wouter (University of Amsterdam); NEILL, Duff (Carnegie Mellon University); SCIMEMI, Ignazio (Universidad Complutense (ES))

**Presenter:** WAALEWIJN, Wouter (University of Amsterdam)

**Session Classification:** Session 5

Contribution ID: 4

Type: **not specified**

## SCET and radiative corrections for lepton-nucleon scattering

*Thursday 16 March 2017 12:50 (40 minutes)*

I describe the systematic treatment of QED radiative corrections for lepton-nucleon scattering. These corrections are critical for the long baseline neutrino program (quasi elastic neutrino scattering) and for the determination of fundamental constants and the elucidation of the proton radius puzzle (elastic electron-proton scattering).

**Primary author:** HILL, Richard (Perimeter Institute)

**Presenter:** HILL, Richard (Perimeter Institute)

**Session Classification:** Session 10

Contribution ID: 5

Type: **not specified**

## Factorization for the light-jet mass and hemisphere soft function

*Thursday 16 March 2017 12:10 (40 minutes)*

Many collider observables suffer from non-global logarithms not captured by standard resummation techniques. Classic examples are the light-jet mass event shape in the limit of small mass and the related hemisphere soft function. We derive factorization formulas for both of these and explicitly demonstrate that they capture all logarithms present at NNLO. These formulas achieve full scale separation and provide the basis for all-order resummations. A characteristic feature of non-global observables is that the soft radiation is driven by multi-Wilson-line operators, and the ones arising here map onto those relevant for the case of narrow-cone jet cross sections. Numerically, the contributions of non-global logarithms to resummed hemisphere-mass event shapes are sizeable.

**Primary authors:** BECHER, Thomas (University of Bern); Dr SHAO, Dingyu; PECJAK, Ben (IPPP Durham)

**Presenter:** BECHER, Thomas (University of Bern)

**Session Classification:** Session 10

Contribution ID: 6

Type: **not specified**

## Inclusive small radius jets and their substructure

*Tuesday 14 March 2017 09:40 (40 minutes)*

We review the treatment of inclusive small radius jets and their substructure within Soft Collinear Effective Theory (SCET). The cross section for (semi-) inclusive jet observables can be written in a factorized form in terms of hard functions and so-called semi-inclusive jet functions (siJFs). The siJFs satisfy renormalization group (RG) equations which take the form of standard timelike DGLAP evolution equations analogous to collinear fragmentation functions. By solving these RG equations, the resummation of potentially large single logarithms in the jet size parameter  $\alpha_s^n \ln^n R$  can be achieved. In addition, we consider jet substructure observables performed on inclusively identified jets which can be easily measured at the LHC. An important example is the jet fragmentation function, where a specific hadron is identified inside a reconstructed jet. We present numerical results at NLO+NLL<sub>R</sub> accuracy and compare to existing data from the LHC.

**Primary author:** RINGER, Felix (Los Alamos National Laboratory)

**Presenter:** RINGER, Felix (Los Alamos National Laboratory)

**Session Classification:** Session 1

Contribution ID: 7

Type: **not specified**

## Application of SCET with Glauber gluons to heavy ion observables at NLO

*Wednesday 15 March 2017 14:10 (40 minutes)*

The development of a background field approach to parton propagation in matter, building upon soft-collinear effective theory, has allowed us to derive light parton splitting functions and take first steps toward unifying parton showers in proton and heavy ion collisions. In this talk I will describe how the in-medium modification of parton showers can be extended to heavy quark jets. I will further present a consistent calculation of inclusive heavy meson and light jet production at next-to-leading order in nucleus-nucleus collisions. The connection to energy loss heavy ion phenomenology will be elucidated and comparisons presented to recent LHC data.

**Primary author:** VITEV, Ivan

**Presenter:** VITEV, Ivan

**Session Classification:** Session 7

Contribution ID: 8

Type: **not specified**

# Non-global Logarithms and the Limits of Fixed Order Perturbation Theory

*Thursday 16 March 2017 10:50 (40 minutes)*

Non-global Logarithms (NGLs) encode the soft correlations in a cross-section generated by the partonic cascade of a QCD event. Using a resummed expansion in terms of soft jets, I will show how the dynamical phenomena of the buffer region, a region devoid of soft emissions at the edge of an active jet region, causes the fixed order perturbation theory for the NGL series to have a finite radius of convergence, even for the leading log series. This is in marked contrast to the global sudakov logarithms, illuminating their distinct analytic features. The soft jet expansion suffers no such problem, appropriately resumming the phase-space logarithms that generate the buffer region. Then using the analytic insight developed using the soft jet expansion, I will show how one can revive the fixed order perturbation theory into a uniformly convergent series for all values of the logarithm.

**Primary author:** NEILL, Duff (LANL)

**Presenter:** NEILL, Duff (LANL)

**Session Classification:** Session 10



Contribution ID: 9

Type: **not specified**

## Subleading Factorization in SCET: Hard Scattering Operators and Radiative Functions

*Thursday 16 March 2017 09:00 (40 minutes)*

We present a complete basis of power suppressed operators for  $gg \rightarrow H$ , classifying all operators which contribute to the amplitude at  $\mathcal{O}(\lambda^2)$  and identifying the subset of operators which contribute in the cross section at this order. We show how helicity selection rules significantly simplify the construction of the operator basis. We perform matching calculations to determine the tree level Wilson coefficients of our operators. We also analyze the factorization of Lagrangian insertions at subleading power for collider physics processes.

**Primary author:** VITA, Gherardo (Massachusetts Institute of Technology)

**Co-authors:** STEWART, Iain (MIT); MOULT, Ian

**Presenter:** VITA, Gherardo (Massachusetts Institute of Technology)

**Session Classification:** Session 9

Contribution ID: 10

Type: **not specified**

## Features of spin dependent transverse momentum distributions: the Helicity and Transversity case

*Wednesday 15 March 2017 09:40 (40 minutes)*

The factorization theorem for DY and semi-inclusive DIS holds for all leading twist transverse momentum distributions. However a QCD perturbative calculation shows several important characteristics of spin-dependent distributions. We consider the case of Helicity and Transversity, which are the only spin-dependent distributions which can be matched onto integrated twist-2 functions. We show how this matching has a scheme dependence and we evaluate also their power corrections using renormalons. We conclude proposing a general non-perturbative model for these distributions.

**Primary authors:** GUTIÉRREZ REYES, Daniel (Complutense University of Madrid); SCIMEMI, Ignazio (Universidad Complutense (ES)); VLADIMIROV, Alexey

**Presenter:** GUTIÉRREZ REYES, Daniel (Complutense University of Madrid)

**Session Classification:** Session 5

Contribution ID: 11

Type: **not specified**

## Fragmentation to a jet with small radius and in the large $z$ limit

*Tuesday 14 March 2017 10:50 (40 minutes)*

We introduce the jet fragmentation function (JFF) to describe the fragmentation of a parton into a jet, and discuss how these objects are related to the standard jet functions. Calculating the JFF to next-to-leading order, we show that these objects satisfy the standard DGLAP evolution equations, with a natural scale that depends upon  $R$ . By using standard renormalization group evolution, we can therefore resum logarithms of  $R$ .

In the large  $z$  limit, where  $z$  is the ratio of the jet energy to the mother parton energy, large logarithms of both  $R$  and  $1-z$  can appear, requiring resummation in order to have a well defined perturbative expansion. Using soft-collinear effective theory, we study the fragmentation function to a jet (FFJ) in this endpoint region. We derive a factorization theorem for this object, separating collinear and collinear-soft modes. This allows for the resummation using renormalization group evolution of the logarithms  $\ln R$  and  $\ln(1-z)$  simultaneously.

**Primary authors:** DAI, Lin (University of Pittsburgh); KIM, Chul (SeoulTech); LEIBOVICH, Adam (University of Pittsburgh)

**Presenter:** DAI, Lin (University of Pittsburgh)

**Session Classification:** Session 2

Contribution ID: 12

Type: **not specified**

## Subleading Power Corrections for N-Jettiness Subtractions

*Thursday 16 March 2017 09:40 (40 minutes)*

The behavior of amplitudes and cross sections in the soft and collinear limits has played an essential role in our understanding of gauge theories. While often studied at leading power in the soft or collinear expansion, the structure of power corrections is of both formal and phenomenological interest. In this talk I will show how techniques from effective field theory can be used to systematically study subleading power corrections, and subleading power factorization. As an application, I will use these techniques to analytically compute the dominant power corrections for NNLO subtraction schemes based on physical resolution variables (in particular, N-jettiness). I will discuss in detail the case of Drell-Yan like color singlet production, and show how the analytic calculation of the leading power corrections, and an improved choice of the observable, each lead to an order of magnitude improvement of the subtractions.

**Primary author:** MOULT, Ian**Presenter:** MOULT, Ian**Session Classification:** Session 9

Contribution ID: 13

Type: **not specified**

## Transverse momentum spectra of gauge bosons

*Wednesday 15 March 2017 16:00 (40 minutes)*

We study the transverse momentum spectra of gauge bosons ( $Z$ ,  $\gamma^*$ , Higgs) in PP collisions in the regime of low transverse momentum. We develop a scheme of resummation allowing us to choose the factorization scale for virtuality in momentum space which is then applied to obtain the transverse momentum spectra for the Drell-Yan and Higgs at NNLL accuracy. All the schemes of resummation developed so far in literature implement the resummation numerically. Using our scheme, we obtain for the first time, an analytic formula for these resummed cross sections at each order of resummation. Finally, a comparison with other resummation schemes is presented along with a discussion of possible non-perturbative effects.

**Primary author:** Dr VAIDYA, Varun (Los Alamos National Lab)

**Co-authors:** Dr KANG, Daekyoung (Los Alamos National Lab); Dr LEE, Christopher (Los Alamos National Lab)

**Presenter:** Dr VAIDYA, Varun (Los Alamos National Lab)

**Session Classification:** Session 8

Contribution ID: 14

Type: **not specified**

## Splitting functions and jet mass distributions in heavy ion collisions

*Wednesday 15 March 2017 14:50 (40 minutes)*

We calculate the momentum sharing and angular separation distributions between the leading subjets inside a reconstructed jet, as well as the jet mass distribution modification in heavy ion collisions. These observables are sensitive to the early and late stages of the in-medium parton shower evolution and allow us to probe the quark-gluon plasma across a wide range of energy scales. We use the medium-induced splitting functions obtained in the framework of soft-collinear effective theory with Glauber gluon interactions to calculate the subjet distributions. Qualitative and in most cases quantitative agreement between theory and preliminary CMS measurements suggests that the parton shower in heavy ion collisions can be dramatically modified early in the branching history. Predictions for the subjet angular distribution is also presented which will illuminate the nature of the medium-induced radiations. On the other hand, using renormalization group techniques we resum the jet mass at next-to-leading logarithmic accuracy using a process independent jet mass function, with the medium contributions consistently included. We work out the calculations with jet grooming and small jet radii which are necessary in heavy ion collisions. We find that the jet mass modification is sensitive to the medium scale and allows for a precise extraction of the medium properties.

**Primary author:** Dr CHIEN, Yang-Ting (Massachusetts Institute of Technology)

**Presenter:** Dr CHIEN, Yang-Ting (Massachusetts Institute of Technology)

**Session Classification:** Session 7

Contribution ID: 15

Type: **not specified**

## Joint transverse momentum and threshold resummation beyond NLL

*Wednesday 15 March 2017 16:40 (40 minutes)*

In the study of heavy color-singlet production one often encounters large logarithms involving the threshold parameter in the partonic cross-section which need to be resummed. Considering the transverse momentum distributions of such processes leads to additional large logarithms involving  $p_T$ . In this talk a method of doing the simultaneous resummation of both types of logarithms directly in momentum-space will be discussed. Our framework allows for this joint resummation to be performed beyond the previously obtained NLL precision. A comparison to other recent approaches to joint resummation will be made.

**Primary authors:** Mr LUSTERMANS, Gillian (University of Amsterdam/Nikhef); WAALEWIJN, Wouter (University of Amsterdam); ZEUNE, Lisa

**Presenter:** Mr LUSTERMANS, Gillian (University of Amsterdam/Nikhef)

**Session Classification:** Session 8

Contribution ID: 16

Type: **not specified**

## Fermi Liquids as SCET like EFT's

*Tuesday 14 March 2017 16:40 (40 minutes)*

In this talk I will discuss how ideas from SCET can be utilized in the context of Fermi liquids. In particular I will discuss the case of the Hubbard model at half filling where the presence of singular points on the Fermi surface force the EFT to be modal with soft and collinear IR fields.

**Primary author:** Prof. ROTHSTEIN, Ira (CMU)

**Presenter:** Prof. ROTHSTEIN, Ira (CMU)

**Session Classification:** Session 4



Contribution ID: 17

Type: **not specified**

## PDF's at very high energies: effects of electroweak radiation

*Wednesday 15 March 2017 10:50 (40 minutes)*

I will discuss how the evolution of parton distribution functions are affected at very high energies due to logarithmically enhanced terms originating from electroweak symmetry breaking

**Primary author:** BAUER, Christian (CERN / LBNL)

**Presenter:** BAUER, Christian (CERN / LBNL)

**Session Classification:** Session 6

Contribution ID: 18

Type: **not specified**

## Probing Quarkonium Production in Jets using Effective Field Theories

*Tuesday 14 March 2017 11:30 (40 minutes)*

This talk will discuss recent attempts to study the long-outstanding quarkonium polarization puzzle by studying the production of the  $J/\psi$  meson within jets at high transverse momentum. The talk will introduce the basics of how quarkonia are studied in the Non-relativistic QCD (NRQCD) framework and how, in the context of SCET factorization theorems for jet cross-sections, the Fragmenting Jet Function (FJF) formalism can be used to probe the energy distributions of quarkonia within jets. Predictions of the  $J/\psi$  polarization using various extractions of the non-perturbative NRQCD long-distance matrix elements will be discussed. The talk will then show comparisons of resummed analytic calculations of the  $z$ -distributions for  $J/\psi$  in jets with Pythia simulations as well as with recent data from the LHCb experiment.

**Primary author:** BAIN, Reggie**Presenter:** BAIN, Reggie**Session Classification:** Session 2

Contribution ID: 19

Type: **not specified**

## Precision Top Mass Determination at the LHC with Jet Grooming

*Tuesday 14 March 2017 14:10 (40 minutes)*

We show how the top mass can be extracted kinematically using cross sections for event shapes observables calculated using effective field theory methods. With the help of Soft Drop grooming done at a level that does not disturb the radiation that can modify the top mass definition, while still isolating the top jet, we obtain a distribution that is only mildly sensitive to the underlying event and initial state radiation. The data from LHC for top jets can thus be made to look very similar to  $e+e-$  collisions, and we compare Pythia results with those from our effective theory predictions.

**Primary authors:** HOANG, Andre (University of Vienna); STEWART, Iain (MIT); MANTRY, Sonny (University of North Georgia); PATHAK, Aditya (Massachusetts Institute of Technology)

**Presenter:** PATHAK, Aditya (Massachusetts Institute of Technology)

**Session Classification:** Session 3

Contribution ID: 20

Type: **not specified**

## Resummation of Double-Differential Cross Sections: Jet Vetoes and Forward Rapidities

*Wednesday 15 March 2017 17:20 (40 minutes)*

We present a framework for resumming logarithms of the jet veto  $\ln p_T^{\text{cut}}/Q$  in color-singlet production at forward rapidities, where approaching the “lopsided threshold”  $Y \rightarrow Y_{\text{max}}$  imposes additional constraints on the modes present in the usual  $p_T^{\text{jet}}$  factorization. We discuss the relevant regimes and factorization theorems and show how to consistently extend estimates of the resummation uncertainty by  $Y$ -dependent profile scales. We give numerical results for gluon fusion at  $Q = m_H$  as well as for a generic heavy scalar resonance and for Drell-Yan production at selected values of  $Q$ .

**Primary authors:** MICHEL, Johannes (DESY / WWU Muenster); TACKMANN, Frank (Deutsches Elektronen-Synchrotron (DE))

**Presenter:** MICHEL, Johannes (DESY / WWU Muenster)

**Session Classification:** Session 8

Contribution ID: 21

Type: **not specified**

## Automated computations for SCET soft functions in the presence of clustering effects

*Wednesday 15 March 2017 11:30 (40 minutes)*

We will present the final pieces for our automated strategy to evaluate generic dijet soft functions at 2-loop order: the  $C_F^2$  colour structure, enabling us to compute observables breaking non-abelian exponentiation. In the process, we will highlight the problems unique to this colour structure, give results for a few sample observables and show explicit analytic formulae for NNLL resummation ingredients for both SCET1 and SCET2 observables.

**Primary authors:** Prof. BELL, Guido (Universität Siegen); RAHN, Rudi (Bern University); TALBERT, Jim (DESY)

**Presenter:** RAHN, Rudi (Bern University)

**Session Classification:** Session 6

Contribution ID: 22

Type: **not specified**

## Monte Carlo Top Quark Mass Calibrations: Update

*Tuesday 14 March 2017 14:50 (40 minutes)*

The lack of knowledge how the top quark mass parameter in Monte-Carlo event generators (MC) is related to field theoretically well defined mass schemes limits the theoretical interpretation of the most precise top quark mass measurements. At SCET2016 preliminary results for the calibration of Pythia's top quark mass parameter using an effective field theory approach for 2-jettiness were presented. In the first part of this talk I will summarize the final results of this analysis. Afterwards I will talk about recent work concerning a consistency check of this analysis using C-parameter for unstable heavy quarks.

**Primary author:** PREISSER, Moritz (University of Vienna)

**Presenter:** PREISSER, Moritz (University of Vienna)

**Session Classification:** Session 3

Contribution ID: 23

Type: **not specified**

## Manifestly Soft Gauge Invariant Formulation of vNRQCD

*Tuesday 14 March 2017 16:00 (40 minutes)*

Homogeneous power counting in Non-Relativistic QCD with the velocity renormalization group (vNRQCD) necessitates the existence of both soft and ultrasoft gluons. We show that vNRQCD operators involving soft fields can be put in a manifestly gauge invariant form by exploiting gauge invariant gluon building blocks. These building blocks contain Wilson lines and are analogous to those used in SCET. This greatly reduces the size of the operator basis, and hence simplifies calculations at subleading order, including the number of diagrams, and structure of operator running. In this formulation the ghost fields only appear in the soft kinetic Lagrangian and not in interactions with other fields. Also, the contributions from the Coulomb region which can cause pinch singularities are automatically avoided in soft loops.

**Primary authors:** Prof. ROTHSTEIN, Ira (Carnegie Mellon University); Prof. STEWART, Iain (Massachusetts Institute of Technology); SHRIVASTAVA, Prashant (Carnegie Mellon University)

**Presenter:** SHRIVASTAVA, Prashant (Carnegie Mellon University)

**Session Classification:** Session 4

Contribution ID: 26

Type: **not specified**

## SCET-based Factorization and Resummation for Jet Processes

*Thursday 16 March 2017 11:30 (40 minutes)*

From a detailed analysis of cone-jet cross sections in effective field theory, we obtain novel factorization theorems which separate the physics associated with different energy scales present in such processes. The relevant low-energy physics is encoded in Wilson lines along the directions of the energetic particles inside the jets. This multi-Wilson-line structure is present even for narrow-cone jets due to the relevance of small-angle soft radiation. We discuss the renormalization-group equations satisfied by these operators. Their solution resums all logarithmically enhanced contributions to such processes, including non-global logarithms. Such logarithms arise in many observables, in particular whenever hard phase-space constraints are imposed, and are not captured with standard resummation techniques. Our formalism provides the basis for higher-order logarithmic resummations of jet and other non-global observables.

**Primary author:** NEUBERT, Matthias (Johannes Gutenberg Universitat Mainz)

**Presenter:** NEUBERT, Matthias (Johannes Gutenberg Universitat Mainz)

**Session Classification:** Session 10



Contribution ID: 27

Type: **not specified**

# Welcome

*Tuesday 14 March 2017 08:50 (10 minutes)*

**Presenter:** PAZ, Gil (Wayne State University)

**Session Classification:** Welcome