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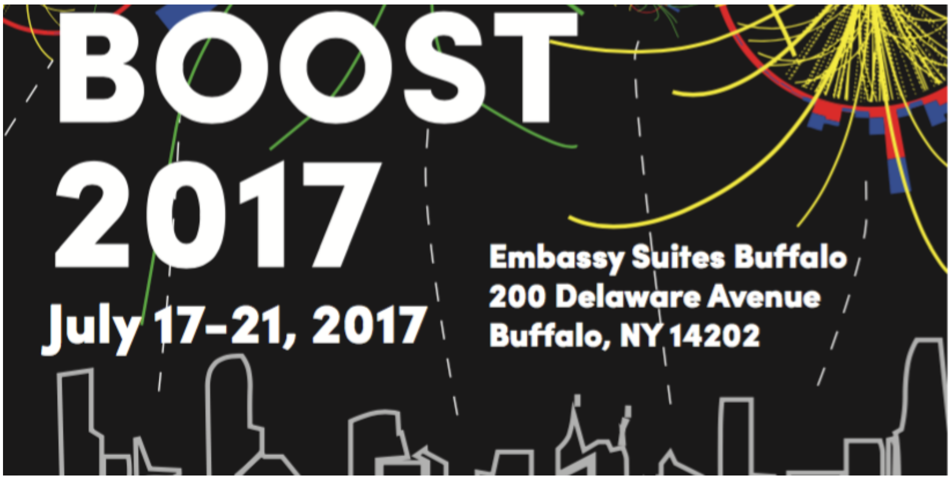

Book of Abstracts

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A new scale-invariant jet clustering algorithm for the substructure era

Joel Walker[1] ; Andrew Larkoski[2] ; Denis Rathjens[3]

[1] *Sam Houston State University*

[2] *Reed Collge*

[3] *Texas A & M University (US)*

Corresponding Author(s): larkoski@reed.edu, denis.rathjens@cern.ch, jwalker@shsu.edu

We introduce a new scale-invariant jet clustering algorithm which does not impose a fixed cone size on the event. The proposed construction maintains excellent object discrimination for very collimated partonic systems. Nevertheless, it is able to asymptotically recover favorable behaviors of the standard anti-KT algorithm. Additionally, it is intrinsically suitable for the tagging of highly boosted objects. Because of these properties, this algorithm may prove to be useful for the continuing study of jet substructure.

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A study of jet mass distributions with grooming

Gregory Soyez[1] ; Laís Sarem Schunk[2] ; Simone Marzani[3]

[1] *IPhT, CEA Saclay*

[2] *IPhT, CEA - Saclay*

[3] *SUNY Buffalo*

Corresponding Author(s): smarzani@buffalo.edu, gregory.soyez@cern.ch, lais.sarem.schunk@gmail.com

We perform a phenomenological study of the invariant mass distribution of hadronic jets produced in pp collisions, in conjunction with a groomer, in particular the modified MassDrop Tagger (equivalent to Soft Drop with angular exponent $\beta = 0$). Our calculation resums large logarithms of the jet mass and includes the full dependence on the groomer's energy threshold z_{cut} , and it is matched to fixed-order QCD matrix elements at next-to-leading order. We accounted for non-perturbative contributions by including a correction factor derived from Monte Carlo parton-shower simulations. Furthermore, we consider two different possibilities for the jet transverse momentum: before or after grooming. We show that the former should be preferred for comparisons with upcoming experimental data essentially because the mMDT transverse momentum spectrum is not collinear safe.

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ATLAS High Luminosity LHC studies

Corresponding Author(s): anna.kathryn.duncan@cern.ch

The High-Luminosity LHC aims to provide a total integrated luminosity of 3000/fb from proton-proton collisions at sqrt(s) = 14 TeV over the course of ~10 years, reaching instantaneous luminosities of up to L = 7.5 x 10^34/cm^2/s, corresponding to an average of 200 inelastic p-p collisions per bunch crossing (mu = 200). Fast simulation studies have been carried out to evaluate the prospects of various benchmark physics analyses to be performed using the upgraded ATLAS detector with the full HL-LHC dataset. The performance of the upgrade has been estimated in full simulation studies, assuming

expected HL-LHC conditions. This talk will focus on the results of physics prospects studies for benchmark analyses involving in particular boosted hadronic objects (e.g. ttbar resonances, HH resonances (HH->bbbb) and dijet resonances), and on results of Jet/EtMiss studies of jet performance and pileup mitigation techniques that will be critical in HL-LHC analyses.

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ATLAS quark/gluon tagging

Corresponding Author(s): francesco.rubbo@cern.ch

Distinguishing quark-initiated from gluon-initiated jets is useful for many measurements and searches at the LHC. We present a quark-initiated versus gluon-initiated jet tagger from the ATLAS experiment using the number of reconstructed charged particles inside the jet. The measurement of the charged-particle multiplicity inside jets from Run 1 is used to derive uncertainties on the tagger performance for Run 2. With an efficiency of 60% to select quark-initiated jets, the efficiency to select gluon-initiated jets is between 10 and 20% across a wide range in jet p_T up to 1.5 TeV with about an absolute 5% systematic uncertainty on the efficiencies. In addition, we also present preliminary studies on a tagger for the ATLAS experiment using the full radiation pattern inside a jet processed as images in deep neural network classifiers.

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ATLAS standard Model Measurements using Jet grooming and substructure

Corresponding Author(s): giulia.ucchielli@cern.ch

Boosted topologies allow to explore Standard Model processes in kinematical regimes never tested before. In such LHC challenging environments, standard reconstruction techniques quickly hit the wall. Targeting hadronic final states means to properly reconstruct energy and multiplicity of the jets in the event. In order to be able to identify the decay product of boosted objects, i.e. W bosons, tt pairs or Higgs produced in association with tt pairs, the ATLAS experiment is currently exploiting several algorithms using jet grooming and jet substructure. This contribution will cover the following ATLAS measurements: the production of W plus high transverse momentum jets, tt differential cross section production and the search for ttH production with boosted top quarks final states. Standard Model measurements offer the perfect field to test the performances of new jet tagging techniques which will become even more important in the search for new physics in highly boosted topologies.

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B-tagging without tracks in highly boosted TeV Jets using an Artificial Neural Network

Todd Brian Huffman[1] ; Jeffrey Tseng[1]

[1] *University of Oxford (GB)*

Corresponding Author(s): todd.huffman@physics.ox.ac.uk, jeff.tseng@physics.ox.ac.uk

The performance of standard tagging algorithms begins to fall in the case of highly boosted B hadrons (γβ=p/m>200). This work builds on our previous study that uses the jump in hit multiplicity among the pixel layers of an ATLAS or CMS-like detector when a B hadron decays within the detector volume. Consequently, tracking is not required.

First, multiple pp interactions within a finite luminous region were found to have little effect. Second, the study has been extended to use the multivariant techniques of an artificial neural network (ANN). After training, the ANN shows significant improvements to the ability to reject light-quark and charm jets; thus increasing the expected significance of the technique.

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BOOST 2018 (Paris) Status

Corresponding Author(s): soyez@lpthe.jussieu.fr, gregory.soyez@cern.ch

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BSM Theory with Boosted Objects

Corresponding Author(s): bdob@fnal.gov

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CMS quark/gluon tagging

Corresponding Author(s): yuta.takahashi@cern.ch

Distinguishing between quark and gluon initiated jets relies on differences in the QCD shower patterns and is an important ingredient for a number of physics analyses. We present the current status of quark gluon tagging in CMS including comparisons using 13 TeV collision data.

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Casimir Meets Poisson: Improved Quark/Gluon Discrimination with Counting Observables

Christopher Frye[1] ; Andrew Larkoski[2] ; Jesse Thaler[3] ; Kevin Zhou[3]

[1] *Harvard*

[2] *Reed Collge*

[3] *MIT*

Corresponding Author(s): larkoski@reed.edu, christopher.robert.frye@gmail.com, jthaler@mit.edu, knzhou@mit.edu

Charged track multiplicity is among the most powerful observables for discriminating quark- from gluon-initiated jets. Despite its utility, it is not infrared and collinear (IRC) safe, so perturbative calculations are limited to studying the energy evolution of multiplicity moments. While IRC-safe observables, like jet mass, are perturbatively calculable, their distributions often exhibit Casimir scaling, such that their quark/gluon discrimination power is limited by the ratio of quark to gluon color factors. In this paper, we introduce new IRC-safe counting observables whose discrimination performance exceeds that of jet mass and approaches that of track multiplicity. The key observation is that track multiplicity is approximately Poisson distributed, with more suppressed tails than the Sudakov peak structure from jet mass. By using an iterated version of the soft drop jet grooming algorithm, we can define a "soft drop multiplicity" which is Poisson distributed at leading-logarithmic accuracy. In addition, we calculate the next-to-leading-logarithmic corrections to this Poisson structure. If we allow the soft drop groomer to proceed to the end of the jet branching history, we can define a collinear-unsafe (but still infrared-safe) counting observable. Exploiting the universality of the collinear limit, we define generalized fragmentation functions to study the perturbative energy evolution of collinear-unsafe multiplicity.

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Confronting jet quenching with jet grooming: splitting function and jet mass distribution in heavy ion collisions

Yang-Ting Chien[1]

[1] *Massachusetts Institute of Technology*

Corresponding Author(s): ytchien@mit.edu

We present the first calculations of 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 for groomed jets with small radii, and we include the medium contributions consistently. We find that the jet mass modification is sensitive to the medium scale and allows for a precise extraction of the medium properties.

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Deep-learning Top Taggers and No End to QCD

Gregor Kasieczka[1]

[1] *Eidgenoessische Technische Hochschule Zuerich (CH)*

Corresponding Author(s): gregor.kasieczka@cern.ch

Machine learning based on convolutional neural networks can be used to study jet images from the LHC. Top tagging in fat jets offers a well-defined framework to establish our DeepTop approach and compare its performance to QCD-based top taggers. We optimize a network architecture to identify top quarks in Monte Carlo simulations of the Standard Model production channel. Using standard fat jets we then compare its performance to a multivariate QCD-based top tagger. We show that both approaches lead to comparable performance, establishing convolutional networks as a promising new approach for multivariate hypothesis-based top tagging. Finally, we will comment on new results using machine-learning-based subjet methods.

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Electro-weak splitting functions and electro-weak shower

Corresponding Author(s): juc44@pitt.edu

We derive the electroweak (EW) collinear splitting functions up to single logs. Especially we systematically incorporate EW symmetry breaking (EWSB), by imposing a particularly convenient gauge choice (dubbed "Goldstone Equivalence Gauge") that disentangles the effects of Goldstone bosons and gauge fields in the presence of EWSB. As a result, we are able to derive splitting functions up to leading power corrections in v/kT. We also implement a comprehensive, practical EW showering scheme based on these splitting functions using a Sudakov evolution formalism. The implementation of EW showering includes novel features such as "ultra-collinear" splitting , matching between shower and decay, and mixed-state evolution of neutral bosons (γ/Z/h) using density-matrices, kinematic back-reaction corrections in multi-stage showers. We demonstrate those new phenomena and features at O(1−10 TeV) energies with some examples.

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Electroweak corrections

Corresponding Author(s): dow@ubpheno.physics.buffalo.edu

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Corresponding Author(s): christoph.falk.anders@cern.ch

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Corresponding Author(s): lilyasquith@gmail.com

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Exploring the DNN performance in Jet Physics

Taoli Cheng[1]

[1] *University of Chinese Academy of Sciences*

Corresponding Author(s): chengtaoli.1990@gmail.com

Since the machine learning techniques are improving rapidly, it has been shown that the image recognition technique can be used to detect jet substructure. And it turns out that deep neural networks can match or outperform traditional approach. To push it further, we investigate the Recursive Neural Networks (RecNN), which embeds jet clustering history recursively as in natural language processing, with particle flow information implemented. In this way, we can have the data input in a most complete and effective way. We show its performance in jet observables and indicate its potential in help detect Higgs signals at the LHC.

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Generative Adversarial Networks for Jet Simulation

Michela Paganini[1] ; Luke Percival De Oliveira[None] ; Ben Nachman[2]

[1] *Yale University (US)*

[2] *Lawrence Berkeley National Lab. (US)*

Corresponding Author(s): luke.percival.de.oliveira@cern.ch, michela.paganini@cern.ch, benjamin.philip.nachman@cern.ch

We introduce the first use of deep neural network-based generative modeling for high energy physics (HEP). Our novel Generative Adversarial Network (GAN) architecture is able cope with the key challenges in HEP images, including sparsity and a large dynamic range. For example, our Location-Aware Generative Adversarial Network learns to produce realistic radiation patterns inside high energy jets simultaneously for boosted W boson and generic quark and gluon jets. The pixel intensities of the GAN-generated images faithfully span many orders of magnitude and reproduce the distributions of important low-dimensional physical properties (e.g. jet mass, n-subjettiness, etc.). We provide many visualizations of what the GAN has learned, to build additional confidence in the algorithm. Our results demonstrate that high-fidelity, fast simulation through GANs is a promising application of deep neural networks for solving one of the most important challenges facing HEP, and in particular jet-substructure, today.

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HL-LHC Developments from CMS

Corresponding Author(s): jmhogan806@gmail.com, j.hogan@cern.ch, jmhogan@fnal.gov

The prospects for boosted physics and jet substructure at the HL-LHC are presented, along with technical capabilities and updates to the detector that will assist in these measurements and searches.

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Higgs to light jets

Zhuoni Qian[1]

[1] *University of Pittsburgh*

Corresponding Author(s): zhq8@pitt.edu

We study the Higgs boson (h) decay to two light jets at the 14 TeV High-Luminosity-LHC (HL-LHC), where a light jet (j) represents any non-flavor tagged jet from the observational point of view. The decay mode h⟶gg is chosen as the benchmark since it is the dominant channel in the Standard Model (SM), but the bound obtained is also applicable to the light quarks (j=u,d,s). We estimate the achievable bounds on the decay branching fractions through the associated production Vh (V=W±,Z). Events of the Higgs boson decaying into heavy (tagged) or light (un-tagged) jets are correlatively analyzed. We find that with 3000 fb−1 data at the HL-LHC, we should expect approximately 1σ statistical significance on the SM Vh(gg) signal in this channel. This corresponds to a reachable upper bound BR(h⟶jj)≤4 BRSM(h⟶gg) at 95% confidence level. A consistency fit also leads to an upper bound BR(h⟶cc)<15 BRSM(h⟶cc) at 95% confidence level. The estimated bound may be further strengthened by adopting multiple variable analyses, or adding other production channels.

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Higher-order effects in parton showers

Corresponding Author(s): marek.schoenherr@cern.ch

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How Much Information is in a Jet?

Author(s): Kaustuv Datta[1]

Co-author(s): Andrew Larkoski [2]

[1] *Reed College*

[2] *Reed Collge*

Corresponding Author(s): dattak@reed.edu, larkoski@reed.edu

Machine learning techniques are increasingly being applied toward data analyses at the Large Hadron Collider, especially with applications for discrimination of jets with different originating particles. Previous studies of the power of machine learning to jet physics has typically employed image recognition, natural language processing, or other algorithms that have been extensively developed in computer science. While these studies have demonstrated impressive discrimination power, often exceeding that of widely-used observables, they have been formulated in a non-constructive manner and it is not clear what additional information the machines are learning. In this paper, we study machine learning for jet physics constructively, expressing all of the information in a jet onto sets of observables that completely and minimally span N-body phase space. For concreteness, we study the application of machine learning for discrimination of boosted, hadronic decays of Z bosons from jets initiated by QCD processes. Our results demonstrate that the information in a jet that is useful for discrimination power of QCD jets from Z bosons is saturated by only considering observables that are sensitive to 4-body (8 dimensional) phase space.

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Identification of Hadronically-Decaying W Boson Top Quarks Using High-Level Features as Input to Boosted Decision Trees and Deep Neural Networks in ATLAS at #sqrt{s} = 13 TeV

Corresponding Author(s): tatsumi.nitta@cern.ch

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Identification of Ultra-Boosted Higgs–>bb Jets Using Subjet B-Tagging with ATLAS

Corresponding Author(s): smeehan12@gmail.com

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Identification of boosted top quarks and W bosons with Machine learning in ATLAS

Corresponding Author(s): oliver.majersky@cern.ch

We present techniques for the identification of hadronically-decaying W bosons and top quarks using high-level features as inputs to boosted decision trees and deep neural networks in the ATLAS experiment at sqrt(s)=13 TeV. The performance of these machine learning based taggers is compared in Monte Carlo simulation with various different tagging algorithms. An improvement in background rejection with respect to different taggers is observed. In addition, the performance of the machine learning taggers is examined in full Run-II data set in top quark pair, dijet and photon+jet topologies.

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Improving jet substructure performance in ATLAS with unified tracking and calorimeter inputs

Corresponding Author(s): steven.schramm@cern.ch

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Jet Fragmentation and Fractal Observables

Benjamin Elder[1] ; Jesse Thaler[2] ; Wouter Waalewijn[3] ; Massimiliano Procura[4] ; Kevin Zhou[2]

[1] *Massachusetts Institute of Technology*

[2] *MIT*

[3] *University of Amsterdam*

[4] *CERN*

Corresponding Author(s): w.j.waalewijn@uva.nl, belder13@mit.edu, massimiliano.procura@cern.ch, jthaler@mit.edu, knzhou@mit.edu

I will discuss fractal jet observables, which are collinear-unsafe but can be described by generalizing the formalism of fragmentation functions. Generalized fragmentation functions (GFFs) are non-perturbative objects with a calculable RG running. In contrast to the linear DGLAP equations for ordinary fragmentation functions, GFFs evolve nonlinearly, since they encode correlations among subsets of hadrons in a jet. I review some special cases of generalized fragmentation functions already in the literature, including jet charge and track functions. I then present new fractal observables based on hierarchical clustering trees, which exhibit promising performance for discriminating quark jets from gluon jets.

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Jet Mass Differential Cross Section

Corresponding Author(s): annefort@buffalo.edu

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Jet Substructure Analysis with CMS Open Data

Aashish Tripathee[1]

[1] *Massachusetts Institute of Technology*

Corresponding Author(s): aashisht@mit.edu

In this talk, I present the first analysis of the substructure of jets using the 2010 CMS Open Data. Our analysis is based on 36/pb of 7 TeV proton-proton collisions, where in each event the leading jet has a transverse momentum larger than 150 GeV. We measure classic jet substructure observables like jet mass and multiplicity and compare the results to parton shower generators. We find excellent agreement even before accounting for the impact of detector effects. We then perform a substructure analysis using soft drop declustering to study the two-prong substructure of jets and test the 1->2 splitting function of QCD. I discuss how our analysis strategy can be used as a starting point for other particle physicists to explore novel analysis opportunities that are now possible with this open data release.

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Jet energy resolution

Corresponding Author(s): cihar29@fnal.gov

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Jet energy scale and resolution measurements at CMS

Corresponding Author(s): anastasia.karavdina@desy.de

Measurement of jet energy scale corrections and resolution, and performance of jet mass scale and resolution based on data collected at a center-of-mass energy of 13 TeV are presented in this report. Jet energy scale corrections at CMS accounts for the effects of pileup, and dependencies of response of jets on transverse momenta and detector non-uniformity. The differences in response measured in data and MC are extracted using QCD multijet, Z+jets, photon+jets and zero bias events. A measurement of differential jet production cross section as a function of groomed jet mass is also presented in this report.

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Jet reclustering & close-by effects in ATLAS run II

Corresponding Author(s): matthew.edgar.leblanc@cern.ch

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Jet reconstruction and boosted object tagging at the Compact Linear Collider

Lars Rickard Strom[1]

[1] *CERN*

Corresponding Author(s): lars.rickard.stroem@cern.ch

The Compact Linear Collider project envisages an electron-positron collider with a low-energy stage at sqrt(s) = 380 GeV and an ultimate center-of-mass reach up to 3 TeV. Detailed Monte Carlo simulation studies of the detector are performed to optimize the design of the experiment and to understand the physics potential. CLIC aims to meet the challenging requirements on jet reconstruction performance with a highly granular calorimeter and particle-flow reconstruction. In this contribution we present studies of the jet reconstruction performance and new results on the capability of the experiment to identify highly boosted objects.

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Jet substructure measurements at CMS, including heavy ions

Corresponding Author(s): philip.coleman.harris@cern.ch

A number of measurements are presented that utilize and/or investigate jet substructure.

The measurement of top production and the investigation of its properties in the boosted regime is gaining increasing attention with the rapid increase of the production cross sections at 13 TeV. The CMS experiment has measured the production cross section as function of the transverse momentum and rapidity of the (anti)top quark in final states containing one charged lepton at 8 TeV and no leptons at 13 TeV. These measurements extend the reach of the ones performed in the regime

where the objects from the top quark decays are resolved and are compared to the latest fixed order prediction calculations as well as to state-of-the-art MCs. In addition to these the first measurement of the differential cross section as function of the top jet mass, and the extraction of the top quark mass in the boosted regime is presented.

Measurements of the differential cross section of dijets with respect to jet mass and pt, as well as the measurement of the jet charge, are also presented. These provide important tests of QCD in the jetty regime. The jet mass measurement is computed for ungroomed jets, and also for jets groomed with the soft drop algorithms, providing the capability to compare to theoretical predictions of the jet mass for the first time at a hadron collider.

Results using jet substructure are also included from heavy ion collisions, including the jet fragmentation and mass.

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Jet substructure modifications in heavy-ion collisions

Author(s): Konrad Tywoniuk[1]

Co-author(s): Yacine Mehtar-Tani

[1] *CERN*

Corresponding Author(s): konrad.tywoniuk@cern.ch, ymehtar@gmail.com

Significant experimental and theoretical activity at the LHC is dedicated to the study of hot and dense QCD matter created in head-on heavy-ion collisions. Measurements of fully reconstructed jets in these collisions allow to examine new aspects of this exotic state via its coupling to perturbative degrees of freedom. The potential sensitivity of jet substructure observables to modifications in the plasma has recently sparked an intense theoretical activity leading to an improved understanding of jet fragmentation and the dynamics of the underlying medium. In this talk, I will review the recent advances and highlight the role of quantum and colour decoherence processes that govern how jets are resolved and, subsequently, lose energy through medium-induced bremsstrahlung. These processes have a profound effect on the jet sample and lead to substructure modifications. I will also discuss how these modifications can be observed in experiments, focussing on aspects of the hardest splitting in the jet cone, as well as provide an overview of possible contamination of non-perturbative processes.

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Large R jet reconstruction and calibration algorithms (ATLAS)

Corresponding Author(s): joseph.taenzer@cern.ch

Large-R jets are used by many ATLAS analyses working in boosted regimes. ATLAS Large-R jets are reconstructed from locally calibrated calorimeter topoclusters with the Anti-k_{t} algorithm with radius parameter R=1.0, and then groomed to remove pile-up with the trimming algorithm with f_{cut} 0.05 and subjet radius R=0.2. Monte Carlo based energy and mass calibrations correct the reconstructed jet energy and mass to truth, followed by in-situ calibrations using a number of different techniques. Large-R jets can also be reconstructed using small-R jets as constituents, instead of topoclusters, a technique called jet reclustering, or from track calo clusters (TCCs), which are constituents constructed using both tracking and calorimeter information. An overview of large-R jet reconstruction will be presented here, along with selected results from the jet mass calibrations, both Monte Carlo based an insitu, from jet reclustering, and from track calo clusters.

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Machine Learning at CMS

Corresponding Author(s): jan.kieseler@cern.ch

Machine learning has become an important tool in particle physics, and in jet substructure and boosted objects in particular. This presentation shows the breadth of applications from CMS, from "DeepFlavor" b-tagging to new techniques of substructure applications.

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Monte Carlo tuning using jet observables

Corresponding Author(s): prestel@slac.stanford.edu

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Pile up mitigation in CMS jets and MET objects

Corresponding Author(s): minna.leonora.vesterbacka@cern.ch

We present tools developed by CMS for LHC Run II designed for pileup mitigation in the context of jets, MET, lepton isolation, and substructure tagging variables. Pileup mitigation techniques of "Pileup per particle ID" (PUPPI), and pileup jet identification are presented in detail along with the validation in data.

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Pileup Mitigation with Machine Learning

Eric Metodiev[1] ; Patrick Komiske[1] ; Ben Nachman[2] ; Matthew Schwartz[None]

[1] *Massachusetts Institute of Technology*

[2] *Lawrence Berkeley National Lab. (US)*

Corresponding Author(s): eric.metodiev@gmail.com, benjamin.philip.nachman@cern.ch, schwartz@physics.harvard.edu, pkomiske@mit.edu

We develop a new pileup mitigation technique based on multi-channel jet images using convolutional neural nets. The input to the network is a three-channel jet image: the calorimeter "pixel" information of charged leading vertex particles, charged pileup particles, and neutral particles . We compare our algorithm to existing methods on a wide range of simple and complex jet observables up to 140 collisions per bunch crossing. In addition, we investigate what aspects of the event our algorithms are utilizing and also test the method robustness.

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Pileup Offset Jet Energy Corrections at 13 TeV

Corresponding Author(s): broozbah@buffalo.edu

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Pileup mitigation (ATLAS)

Corresponding Author(s): jroloff2@gmail.com

Simultaneous proton-proton collisions, or pileup, at the LHC has a significant impact on jet reconstruction, requiring the use of advanced pileup mitigation techniques. Pileup mitigation may occur at several stages of the reconstruction process, and ATLAS uses a combination of schemes, including constituent reconstruction methods, constituent-level pileup-mitigation techniques, and jet-level pileup-mitigation algorithms. This talk describes the two constituent-reconstruction methods for jets used on ATLAS: TopoClustering and Particle Flow. This talk also has a first look at the performance of several constituent-level pileup mitigation techniques on ATLAS, including Constituent Subtraction, Voronoi Subtraction, SoftKiller, and the Cluster Vertex Fraction. Finally, other developments in tagging pileup jets is discussed, such as the forward jet vertex tagger (fJVT), which uses jet shapes and topological information to tag jets.

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Precision Top Mass Determination at the LHC with Jet Grooming

Aditya Pathak[1] ; Iain Stewart[2] ; Andre Hoang[3] ; Sonny Mantry[4]

[1] *Massachusetts Institute of Technology*

[2] *MIT*

[3] *University of Vienna*

[4] *University of North Georgia*

Corresponding Author(s): iains@mit.edu, adityap@mit.edu, andre.hoang@univie.ac.at, mantry147@gmail.com

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.

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QCD at NNLO

Corresponding Author(s): johnmc@fnal.gov

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Quark/Gluon Discrimination with Jet-Images and Deep Learning

Patrick Komiske[1] ; Eric Metodiev[2] ; Matthew Schwartz[3]

[1] *MIT*

[2] *Massachusetts Institute of Technology*

[3] *Harvard*

Corresponding Author(s): eric.metodiev@gmail.com, pkomiske@mit.edu, schwartz@physics.harvard.edu

I will discuss recent work addressing light-quark/gluon jet discrimination using image recognition techniques from deep learning. The usual jet-image framework is supplemented by adding "color" to the images in the form of local energy deposit and count information. Overall, this approach outperforms multivariate analyses of traditional jet observables and provides a theoretical upper bound of the discrimination performance of IRC-safe information. Though different Monte Carlo programs are known to produce different quark and gluon jets, the deep learning techniques are found to be surprisingly insensitive to these differences.

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Radiative Decays of the Higgs Boson to a Pair of Fermions

Xing Wang[1]

[1] *University of Pittsburgh*

Corresponding Author(s): xiw77@pitt.edu

We present a phenomenological study of the Higgs radiative decay to a fermion pair. We include the chirality-flipping diagrams via the Yukawa couplings at the order $\mathcal{O}(y_f^2\alpha)$, the chirality-conserving contributions via the top-quark loops of the order $\mathcal{O}(y_t^2\alpha^3)$, and the electroweak loops at the order $\mathcal{O}(\alpha^4)$. All the leptonic radiative decays are potentially observable at the LHC Run 2 or the HL-LHC. The lepton pairs that come from virtual photon conversions are highly boosted and tend to merge into clusters, which may require special treatments for identification. We also study the process $h \to c\bar{c}\gamma$ and evaluate the observability at the LHC. We find it potentially comparable to the other related studies and better than the $h \to J/\psi\,\gamma$ channel in constraining the charm-Yukawa coupling.

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Recursive Soft Drop

Frederic Alexandre Dreyer[1] ; Jesse Thaler[None] ; Gregory Soyez[2] ; Lina Necib[1]

[1] *MIT*

[2] *IPhT, CEA Saclay*

Corresponding Author(s): gregory.soyez@cern.ch, fdreyer@mit.edu, jthaler@jthaler.net, lnecib@mit.edu

In this talk, we introduce a new jet substructure method based on a recursive iteration of the Soft Drop algorithm through both branches of the clustering tree.

Recursive soft drop uses an additional parameter N to define the number of layers of soft drop declustering, providing an optimized grooming strategy for boosted objects with (N+1)-prong decays, as well as improved stability in high pileup conditions. We discuss the infinite N limit, where groomed jets have a null area, and investigate the robustness of recursive soft drop to non-perturbative effects.
We show promising applications to jet mass resolution in boosted top and W bosons, and demonstrate how recursive soft drop grooming can improve pileup mitigation when used in conjunction with existing pileup-removal methods.

Poster Session / 70

Reducing the Top Quark Mass Uncertainty with Jet Grooming

Anders Andreassen[1] ; Matthew Schwartz[None]

[1] *Harvard University*

Corresponding Author(s): schwartz@physics.harvard.edu, andersjohanandreassen@gmail.com

The measurement of the top quark mass has large systematic uncertainties coming from the Monte Carlo simulations that are used to match theory and experiment. We explore how much that uncertainty can be reduced by using jet grooming procedures. We estimate the inherent ambiguity in what is meant by Monte Carlo mass to be around 530 MeV without any corrections. This uncertainty can be reduced by 60% to 200 MeV by calibrating to the W mass and a further 33% to 140 MeV by applying soft-drop jet grooming (or by 20% more to 170 MeV with trimming). At e+e- colliders, the associated uncertainty is around 110 MeV, reducing to 50 MeV after calibrating to the W mass. By analyzing the tuning parameters, we conclude that the importance of jet grooming after calibrating to the W mass is to reduce sensitivity to the underlying event.

Searches / 6

Search for diboson resonances at CMS

Corresponding Author(s): jennifer.ngadiuba@cern.ch

Beyond the standard model theories like Extra-Dimensions and Composite Higgs scenarios predict the existence of very heavy resonances compatible with a spin 0 (Radion),spin 1 (W', Z') and spin 2 (Graviton) particle with large branching fractions in pairs of standard model bosons and negligible branching fractions to light fermions. We present an overview of searches for new physics containing photons, W, Z or H bosons in the final state, using proton-proton collision data collected with the CMS detector at the CERN LHC. Many analyses use techniques to identify and reconstruct highly boosted final states that are created in these topologies.

Poster Session / 78

Search for light dijet resonances produced in association with a jet

Corresponding Author(s): cristina.ana.mantilla.suarez@cern.ch

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Search for low-mass pair-produced dijet resonances using jet substructure techniques in proton-proton collisions at s=13 TeV

Corresponding Author(s): alejandro.gomez@cern.ch

Searches / 8

Search for new resonances coupling to third generation quarks at CMS, and Dark Matter

Corresponding Author(s): thomas.peiffer@cern.ch

We present a search for new massive particles (such as Z prime and W prime resonances) decaying to heavy-flavour quarks with the CMS detector at the LHC, and dark matter signatures involving boosted jets. Resonant ttbar, tb, and heavy quark plus vector-like quark production, along with missing pt plus boosted objects, are investigated. We use proton-proton collision data recorded at a centre-of-mass energy of 13 TeV. The search is performed in both hadronic and semileptonic decay channels of the top quark or of the top-partners. Due to the high momentum range in which these objects are produced, specific reconstruction algorithm and selections are employed to address the identification of these boosted signatures.The results are presented in terms of upper limits on the model cross section.

Searches / 10

Search for vector-like quarks, excited quarks and squarks in boosted final states at CMS

Corresponding Author(s): daniel.gonzalez@cern.ch

We present results of searches for massive top and bottom quark partners using proton-proton collision data collected with the CMS detector at the CERN LHC at a center-of-mass energy of 8 and 13 TeV. These considered models include vector-like quarks, excited quarks and supersymmetric quark partners. These particles can be produced singly or in pair and their decays result in a variety of final states, containing top and bottom quarks, gauge and Higgs bosons. We search using several categories of reconstructed objects, from multi-leptonic to fully hadronic final states. In the latter, substructure techniques are used to identify hadronically decaying top quarks and bosons, to resolve these boosted final states and to increase the sensitivity of the searches. We set exclusion limits on the mass and cross sections of the hypothetical BSM particles

Searches / 7

Searches for exotic resonances and dark matter with boson tagging (ATLAS)

Corresponding Author(s): daniel.isaac.narrias.villar@cern.ch

Several theories beyond the standard model predict new particles decaying resonantly into dibosons or coupling to dark matter particles. Jet substructure and boson tagging techniques play a crucial role in searches for dark matter and diboson resonances in boosted topologies. In this talk, the application of these techniques at ATLAS will be discussed in the context of recent searches for dark matter and diboson resonances. Latest results for these searches in pp collisions at 13 TeV using an integrated luminosity of 36/fb will be presented.

Searches / 9

Searches for exotic resonances with top tagging (ATLAS)

Corresponding Author(s): junpei.maeda@cern.ch

Several models of physics beyond the Standard Model contain preferential couplings to top quarks. We present an overview of searches for new physics containing boosted top quarks in the final state, using proton-proton collision data collected with the ATLAS detector at the LHC at a centre-of-mass energy of 13 TeV. These results cover heavy gauge bosons, excited third generation quarks, or decay channels to vector-like top partner quarks.

Searches / 5

Searches for new physics using jet grooming and substructure (ATLAS)

Corresponding Author(s): jonathan.thomas.burr@cern.ch

Models predicting the production and decay of supersymmetric (SUSY) particles often have promising search channels involving decays through heavy intermediate states such as top quarks and heavy bosons. However, unlike in most exotics scenarios these heavy states are only moderately boosted which can make traditional substructure techniques less useful and motivates the development of alternative techniques. The results of several SUSY analyses using substructure techniques are presented.

Future Colliders / 41

Simulations of detector response for multi-TeV physics at a 100 TeV pp collider

Author(s): Sergei Chekanov[1]

Co-author(s): Ashutosh Kotwal [2] ; Shin-Shan Yu [3] ; Nhan Viet Tran [4] ; James Proudfoot [1] ; Marcel Demarteau [5] ; Jose Repond [5] ; Jinlong Zhang [1]

[1] *Argonne National Laboratory (US)*

[2] *Duke University (US)*

[3] *National Central University (TW)*

[4] *Fermi National Accelerator Lab. (US)*

[5] *Argonne National Laboratory*

Corresponding Author(s): proudfoot@anl.gov, marcel.demarteau@cern.ch, jinlong.zhang@cern.ch, shin-shan.yu@cern.ch, repond@hep.anl.gov, sergei.chekanov@cern.ch, nhan.viet.tran@cern.ch, ashutosh.kotwal@cern.ch

We discuss performance requirements for future detectors in the context of reconstruction of multi-TeV objects (single particles and jets) at a 100 TeV collider. A software framework based on a Geant4 simulation together with a realistic reconstruction of tracks and calorimeter clusters is presented. Using this framework, we discuss response and momentum resolution of the tracker and the calorimeter for single particles and hadronic jets in the energy range from 1 GeV to 30 TeV. In addition, lateral cell segmentation was studied by reconstructing substructure variables for jets at 10 and 20 TeV in transverse momentum.

Algorithms / **28**

Small R jet reconstruction and calibration algorithms (ATLAS)

Corresponding Author(s): loch@physics.arizona.edu

Small radius jets with R = 0.4 are standard tools in ATLAS for physics analysis. They are calibrated using a sequence of Monte Carlo simulation-derived calibrations and corrections followed by in-situ calibrations based on the transverse momentum balance between the probed jets and well-measured reference signals. In this talk the inputs to jet reconstruction in LHC Run 2 comprising calorimeter cell clusters, reconstructed charge particle tracks, and particle flow objects, are discussed together with the jet energy calibration scheme. Selected results from the performance of the procedure and the associated systematic uncertainties are presented.

Algorithms / **52**

Soft Puppi

Jennifer Kathryn Roloff[1] ; Philip Coleman Harris[2] ; Nhan Viet Tran[3] ; Gavin Salam[2] ; Gregory Soyez[4] ; Matteo Cacciari[5] ; Satoshi Hasegawa[3]

[1] *Harvard University (US)*

[2] *CERN*

[3] *Fermi National Accelerator Lab. (US)*

[4] *IPhT, CEA Saclay*

[5] *LPTHE Paris*

Corresponding Author(s): nhan.viet.tran@cern.ch, satoshi.hasegawa@cern.ch, gregory.soyez@cern.ch, philip.coleman.harris@cern gavin.salam@cern.ch, matteo.cacciari@cern.ch, jroloff2@gmail.com

Pileup is one of the biggest challenges facing the LHC and HL-LHC physics programs. Many reconstruction methods have been proposed for mitigating its effects across a broad range of physics metrics such as jet and jet substructure response and resolution, missing transverse energy performance, and lepton identification. Among the most successful are the SoftKiller and Pileup Per Particle Identification (PUPPI) algorithms which operate on the event constituents and have been demonstrated to holistically improve these physics metrics. In this talk, we explore the complementarity of these algorithms in order to optimize an algorithm for both simplicity and performance.

Introductory Talks / **2**

Theory Overview

Corresponding Author(s): larkoski@reed.edu

Poster Session / 67

Theory Predictions for Pull

Larkoski Andrew[None] ; Simone Marzani[None] ; Chang Wu[None]

In this project, we apply the QT resummation on Pull Vector, which is which is a tool applied on the QCD color connection and this tool can help us to separate the background and signal for the process of Higgs and gluon decay to b\bar{b}.

And in the presentation, I will show some of our works like the result of resummation and try to compare it with the next-to-leading fix-order dipole calculations and the Event2, which is a Monte Carlo code for next-to-leading order corrections to two and three jet event observables in e^{+}e^{-}

Summaries and Discussion / 37

Theory Summary

Corresponding Author(s): soyez@lpthe.jussieu.fr

Algorithms / 33

Top tagging at CMS

Corresponding Author(s): torben.dreyer@desy.de

An overview of methods for identifying decays of boosted top quarks with the CMS detector in Run II is presented.

Public Event / 43

Universal: A guide to the cosmos

Corresponding Author(s): jeffrey.forshaw@cern.ch

Poster Session / 69

Using Boosted Event Shapes for Heavy Object Classification

Justin Pilot[1] ; John Conway[2] ; Robin Erbacher[1] ; Maia Clarice Paddock[1] ; Ramya Bhaskar[None]

[1] *University of California Davis (US)*

[2] *University of California, Davis*

Corresponding Author(s): conway@physics.ucdavis.edu, rbhaskar@ucdavis.edu, justin.pilot@cern.ch, robin.erbacher@cern.ch, maia.clarice.paddock@cern.ch

We present a novel approach to the problem of discriminating jets produced from the hadronic decays of highly-boosted heavy particles (top, W, Z, H) from light jets. By hypothesizing different particle origins for the jets and boosting all jet constituents into the corresponding rest frames, angular and kinematic distributions of reconstructed particles can be used to discriminate 2- or 3-prong topologies from those of light jets produced in QCD processes. Machine learning techniques are utilized to build discriminants capable of simultaneously separating and classifying the particle species. This approach adds additional information relative to existing techniques, thereby improving sensitivities of analyses dependent on such heavy-object tagging tools. We demonstrate the performance of this tagging method and provide a proof-of-principle application to a simple analysis scenario.

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W Tag Scale Factor With Fully-Merged Tops

Corresponding Author(s): ash.marie.parker@gmail.com

Algorithms / 31

W/H tagging in CMS

Corresponding Author(s): thea.aarrestad@cern.ch

The case of CMS "two prong" tagging algorithms are presented, specifically detailing the cases of W and H boson tagging. This talk will focus on the most recent algorithms used in LHC Run II analyses and their validation in data.

Algorithms / 32

W/Top/H tagging in ATLAS

Corresponding Author(s): nurfikri.bin.norjoharuddeen@cern.ch

We present updates of W, Top and Higgs tagging studies with the ATLAS detector. The performance of 2 variable taggers, HEPTopTagger and shower deconstruction are compared in Monte Carlo simulations. To asses the modelling of the taggers' performance, the tagging efficiencies are measured, with the full 2015+2016 dataset, in semi-leptonic top quark pair events and the background rejections are measured in dijet and photon+jet topologies. Recent developments in subjet reconstruction techniques for high transverse momentum Higgs->bb tagging are also presented.

Poster Session / 68

Weakly Supervised Classifiers in High Energy Physics

Francesco Rubbo[1] ; Ben Nachman[2] ; Ariel Gustavo Schwartzman[3] ; Lucio Dery[4]

[1] *SLAC National Accelerator Laboratory (US)*

[2] *Lawrence Berkeley National Lab. (US)*

[3] *SLAC National Accelerator Laboratory (US)*

[4] *Stanford University*

Corresponding Author(s): ldery@stanford.edu, ariel.gustavo.schwartzman@cern.ch, francesco.rubbo@cern.ch, benjamin.philip.nachman@cern.ch

As machine learning algorithms become increasingly sophisticated to exploit subtle features of the data, they often become more dependent on simulations. This paper presents a new approach called weakly supervised classification in which class proportions are the only input into the machine learning algorithm. Using one of the most challenging binary classification tasks in high energy physics - quark versus gluon tagging - we show that weakly supervised classification can match the performance of fully supervised algorithms. Furthermore, by design, the new algorithm is insensitive to any mis-modeling of discriminating features in the data by the simulation. Weakly supervised classification is a general procedure that can be applied to a wide variety of learning problems to boost performance and robustness when detailed simulations are not reliable or not available.