Energy Frontier Topical Group 5 (EF05)

Conveners: Michael Begel, Stefan Hoeche, Michael Schmitt

General scope: Physics with jets and jet substructure, higher-order calculations and their impact on precision QCD physics, measurements of the strong coupling constant and its running, measurements of quark masses, PDF fits and PDF-sensitive measurements, W/Z(+jets) boson production, MC event generators, ...

Many overlaps with EF01, 03, 04, 06, 07 and TF and CompF topical groups

Website: https://snowmass21.org/energy/qcd

Indico category: https://indico.fnal.gov/category/1139/

Group meetings on Mondays, 9am CDT/10 am EDT/4pm CERN

Major topics

- Measurements of α_S
- Parton Distribution Functions (with EF06)
- Connections between the LHC and the EIC (with EF07)
- Jet substructure
- Theoretical calculations: fixed-order pQCD and resummation
- Non-perturbative aspects of QCD
- MC Event Generators
- Theory predictions for Higgs boson, top quark production, etc.
- Lattice QCD
- Connections to machine learning
- Spin observables
- Precision physics at small x (with EF06)

Focus Questions

- What precision in α_S can be reached by each future machine/experiment?
- The HEP and EIC communities should develop some joint benchmarks for PDFs. (EIC accesses high x_{Bj})
- What is the evolution of jets as a function of energy at the EIC and at hadron colliders? What can EIC jet studies learn from techniques developed at the LHC?
- Are jets universal? How can we tell? If not, how do we deal with non-universality in our hadronization models?
- How can we get more precise and robust systematic uncertainties? How do experimental and theoretical uncertainties mix?
- What is a theoretical uncertainty (e.g. renormalization and factorization scales)? How can “theoretical” uncertainties reported by experimentalists be decorrelated so that they can properly be taken into account?
- It is important to explore PDFs coming from lattice calculations. Does the traditional PDF community need to provide guidance?

Focus Questions

- We need a “Les Houches” accord on a realistic assessment of parton shower uncertainties (and correlations). There are new ideas from the theory community about how to formulate these uncertainties.
- How do we keep separate tuning of ostensibly non-perturbative parameters such as h_{damp} from perturbative physics which should be essentially parameter-free?
- What can we learn about non-perturbative physics using minimum-bias events at the LHC?
- How can we promote the analysis of Belle data to provide crucial information on non-perturbative QCD?
- What information (if any) can be extracted from neutrino data - i.e., data used to calibrate beam fluxes?
- Which spectra and measurements are most useful for constraining non-perturbative effects?
- What is a better way to analyze and study multiple-parton interactions (and the underlying event)?
- Can the community provide an assessment of MC event generators?

Many interesting LOIs (primary EF05, ↗️ https://snowmass21.org/loi)

- Perspectives for high-precision $\alpha_S(m^2_Z)$ determinations from future e^+e^- measurements at the FCC-ee (200)
- Precision measurements of α_S and its running at future colliders (217)
- Recommendations for more precise and robust assessment of experimental and systematic QCD uncertainties (219)
- Are Jets Universal? (220)
- Recommendations for better measurements of multi-parton interactions and the underlying event (212)
- Recommended benchmark measurements of hadron spectra, etc., to constrain non-perturbative QCD physics (213)
- An assessment of the strengths and weakness of existing MC event generators (214)
- Assessment of what can be learned from neutrino scattering data for non-perturbative physics (215)
- Uncertainties in perturbative QCD calculations and Monte-Carlo simulations (231)
- Uncertainties in simulations of non-perturbative QCD effects (232)
- Lattice-QCD Determinations of Quark Masses and theStrong Coupling α_s(257)
- High-precision $\alpha_S(m^2_Z)$ determinations from future FCC-ee $e^+e^-\rightarrow$hadrons data below the Z peak(208)
- A Very Forward Hadron Spectrometer for the LHC (087)
- Gluon Saturation at the Electron Ion Collider (168)
- Higher twist effects in inclusive and diffractive nuclear structure functions (076)
- New frontiers in PDF analyses in the HL-LHC era (146)
- Snowmass LOI Les Houches Wishlist: placeholder (206))
- Exclusive Z decays (091)
- Jets and Jet Substructure at Future Colliders (140)
- EW and BSM physics at EIC (210)
- Forward jets and dense systems (025)

Many interesting LOIs (secondary EF05, ↗️ https://snowmass21.org/loi)

- Toward the N3LO accuracy of parton distribution functions (268)
- Jets and jet substructure in heavy-ion collisions (195)
- Forward Physics Facility (193)
- Numerical Lattice Gauge Theory (017)
- Emerging Computational Techniques for Jet Physics (046)
- Precise predictions for Higgs pair hadroproduction (127)
- Generative, Explainable Artificial Intelligence for Nuclear Physics and HEP (189)
- Letter of Intent: A Forward Calorimeter at the LHC (148)
- Measurement of the W mass and width at FCC-ee (166)
- Unitarity of CKM Matrix,|Vud|, Radiative Corrections and Semi-leptonic Form Factors (249)
- Probing Scalar and Tensor Interactions at the TeV Scale (192)
- EFT Analysis of the VVV process:a Letter of Interest for Snowmass 2021 (233)
- xFitter: An Open Source QCD Analysis Framework (040)
- The Femtography Project (159)
- Discovery potential of all-hadronic searches for vector-like quarks at future colliders (186)
- Probing High Scale Physics via Standard Model Parameters (012)
- Cold QCD Matter at High Densities (225)
- Constraining Physics Beyond the Standard Model using Electric Dipole Moments (230)
- Precision Lattice QCD in Support of BSM Searches (047)
- Using lattice QCD for the hadronic contributions to themuong−2 (103)
- Bottom quark mass (262)
- Particle production and correlations in dilute-dense collisions in the CGC framework: finite-width target effects (270)
- Origin of Nuclear Shadowing and Antishadowing (267)

Thank you for participating in the EF activities!

We look forward to your ideas and contributions.
We are especially glad to work with such a vibrant and enthusiastic group.
Please send us suggestions, comments, expressions of interest, etc.

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