

MCEG for TMD physics: the quest to characterize perturbative and non perturbative QCD phenomena

(On behalf of Jefferson Lab TMD LDRD)

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Motivations

■ Main objectives:

- Urgent requirement: MCEG for TMD physics
- Language dictionary between in NP and HEP
- Improve the theoretical framework for TMDs

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- Use Pythia8+DIRE as a starting point
- Use QCD factorization theorems as a guidance

LDRD personnel

JLab

Pythia

Other



Experimentalists



+ Jake Ethier
+ Eric Moffat
+ Andrea Signori

Theorists



Progress

- **Validation of Pythia8+DIRE against HERA data**
 - Implementation of DIS in pythia8 via DIRE parton shower
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 - FFs in pythia
 - Validation of DGLAP formalism against parton shower+Lund string model
 - Pythia8+DIRE vs world e^+e^- data

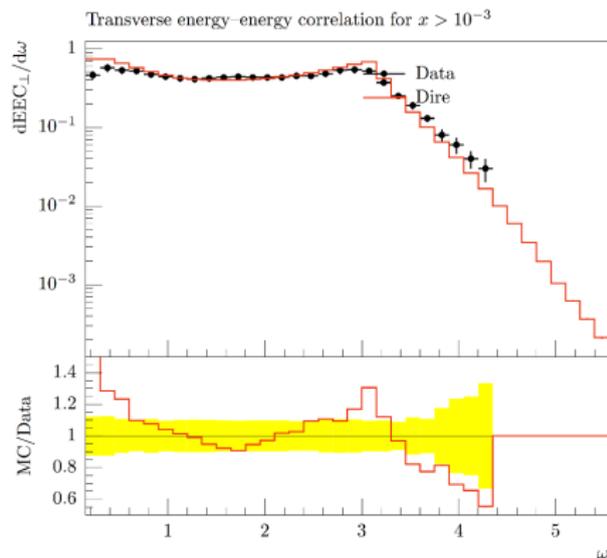
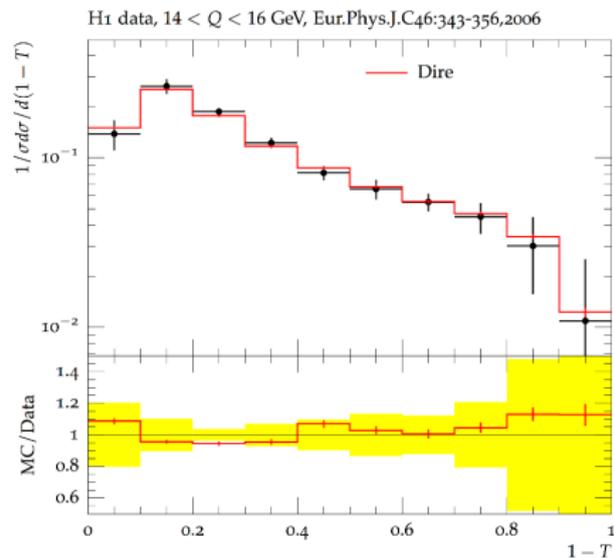
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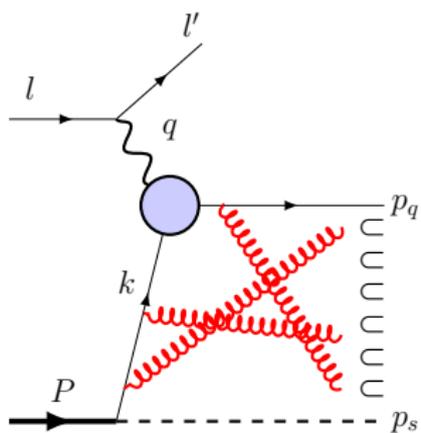
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- **Extensions of the CSS formalism**
 - Inclusion of string effects in QCD factorization

Validation of Pythia8+DIRE against HERA data

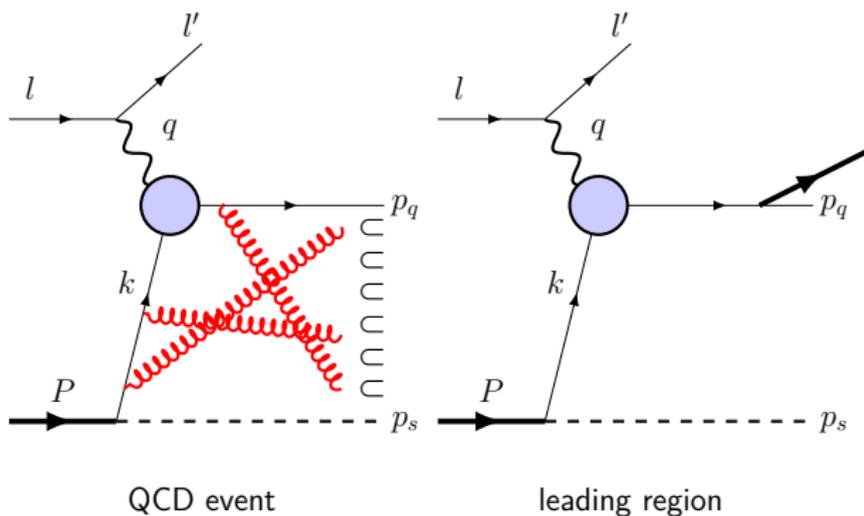


Factorization in SIDIS

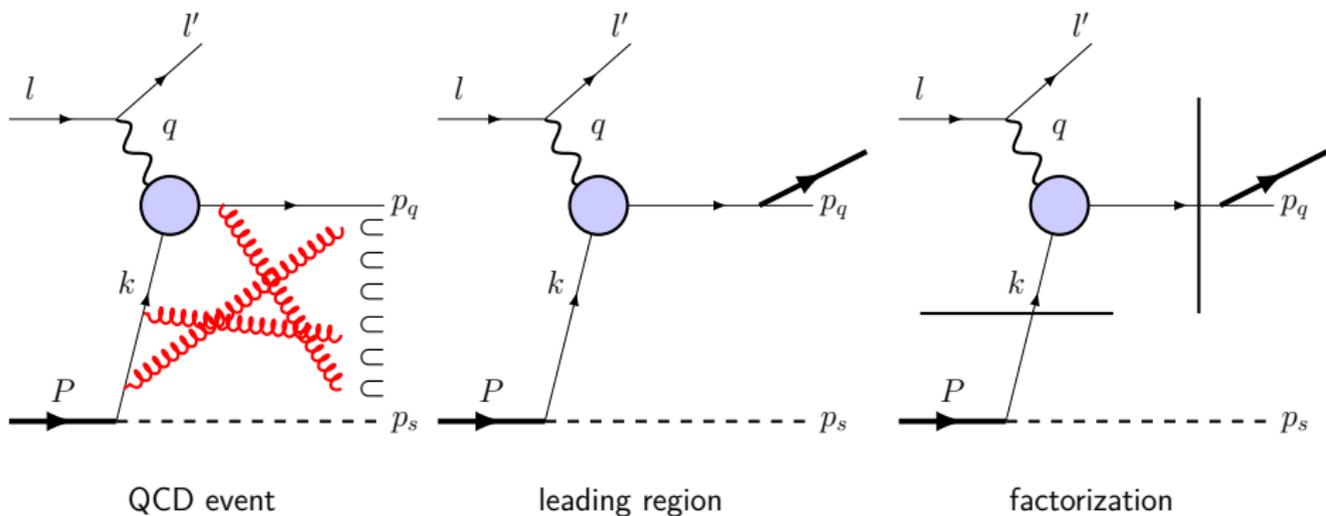


QCD event

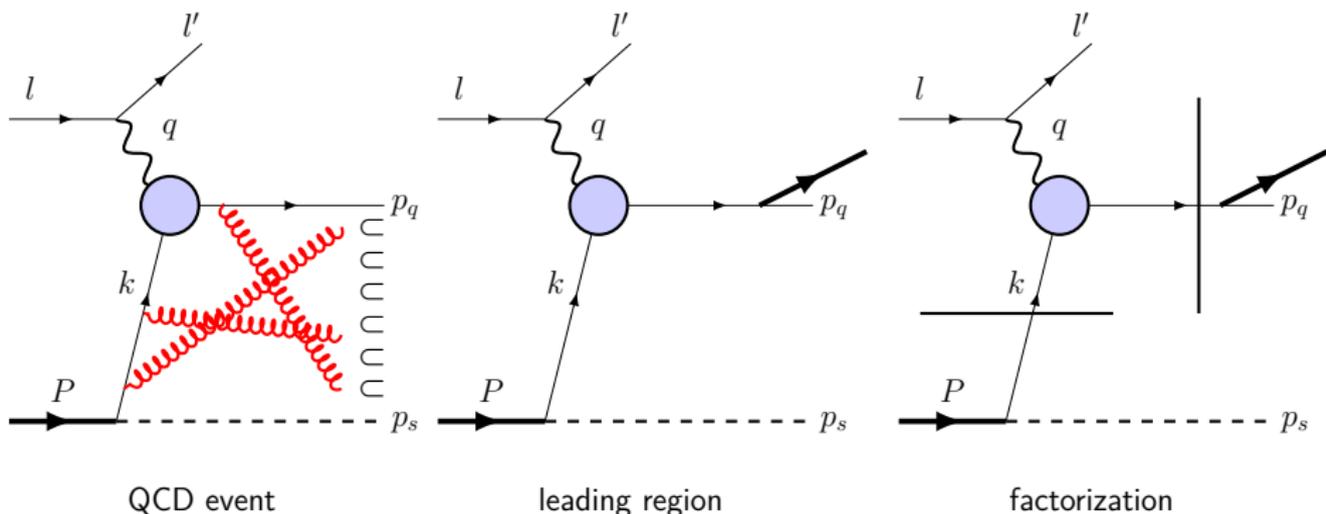
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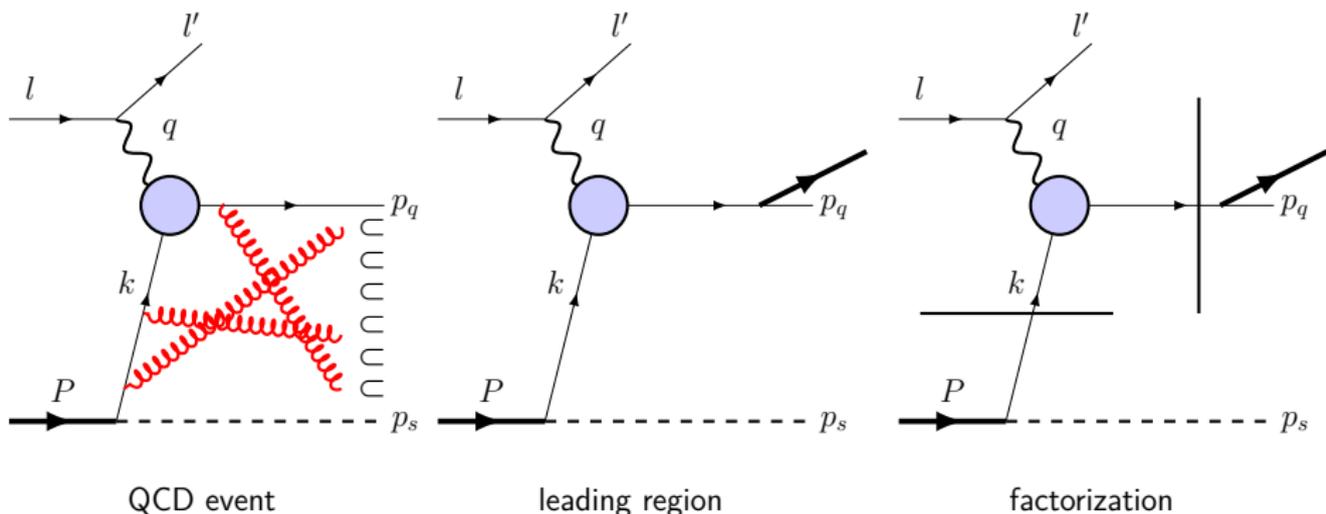
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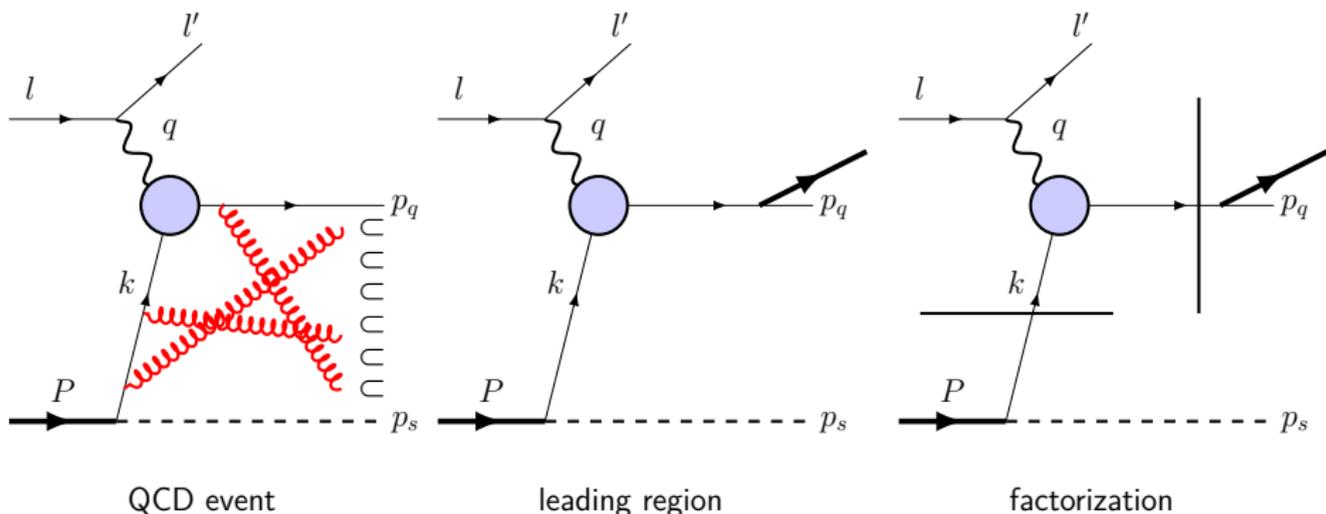
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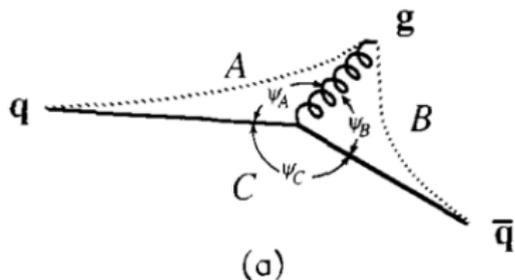
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see discussion by J. Collins arXiv:1610.09994

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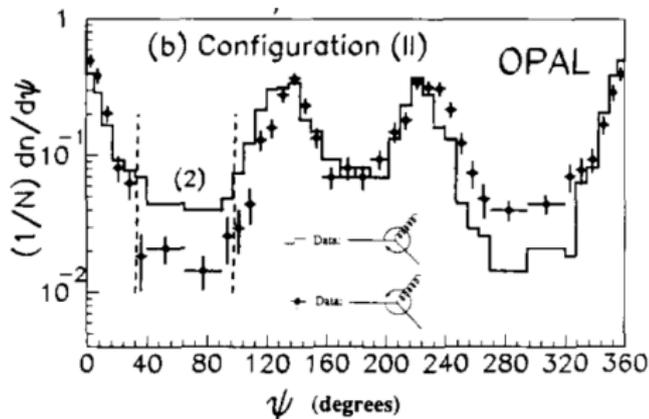
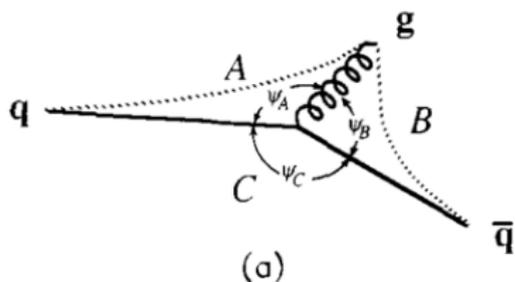
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- String type effects are potentially important

String effects: PLB261 (1991) (OPAL Collaboration)



- 3 Jets events: $Q\bar{Q}$ and gluon jets. Jets are projected into a plane
- ψ : angle of a given particle relative to the quark jet with the highest energy
- ψ_A : angle between highest energetic jet and gluon jet
- ψ_C : angle between quark jets
- Only events with $\psi_A = \psi_C$ are kept

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- **Particle flow asymmetry is observed** \rightarrow **evidence of string effects**

Study of FFs in pythia8+DIRE

Technical details

- Simulate e^+e^- at $Q = 30, 91.2, 1000$ GeV flavor by flavor

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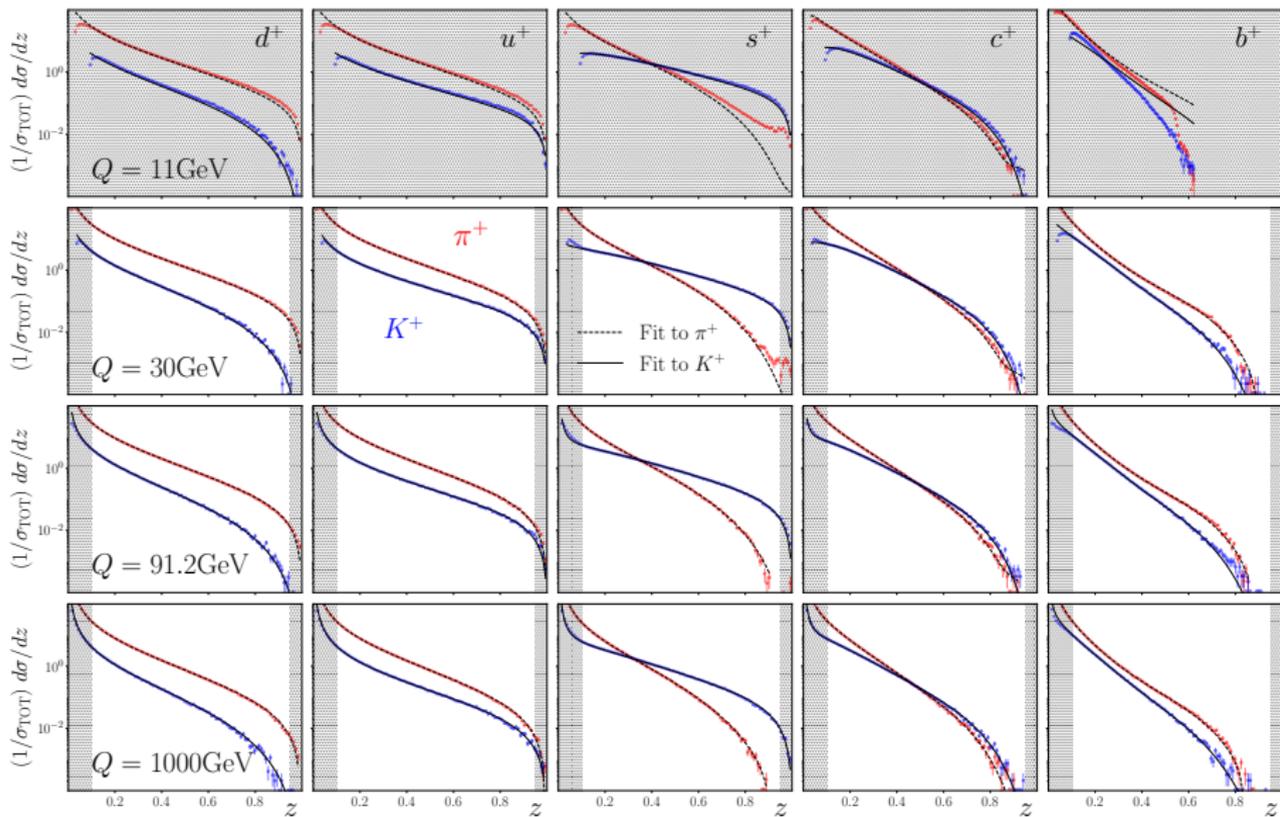
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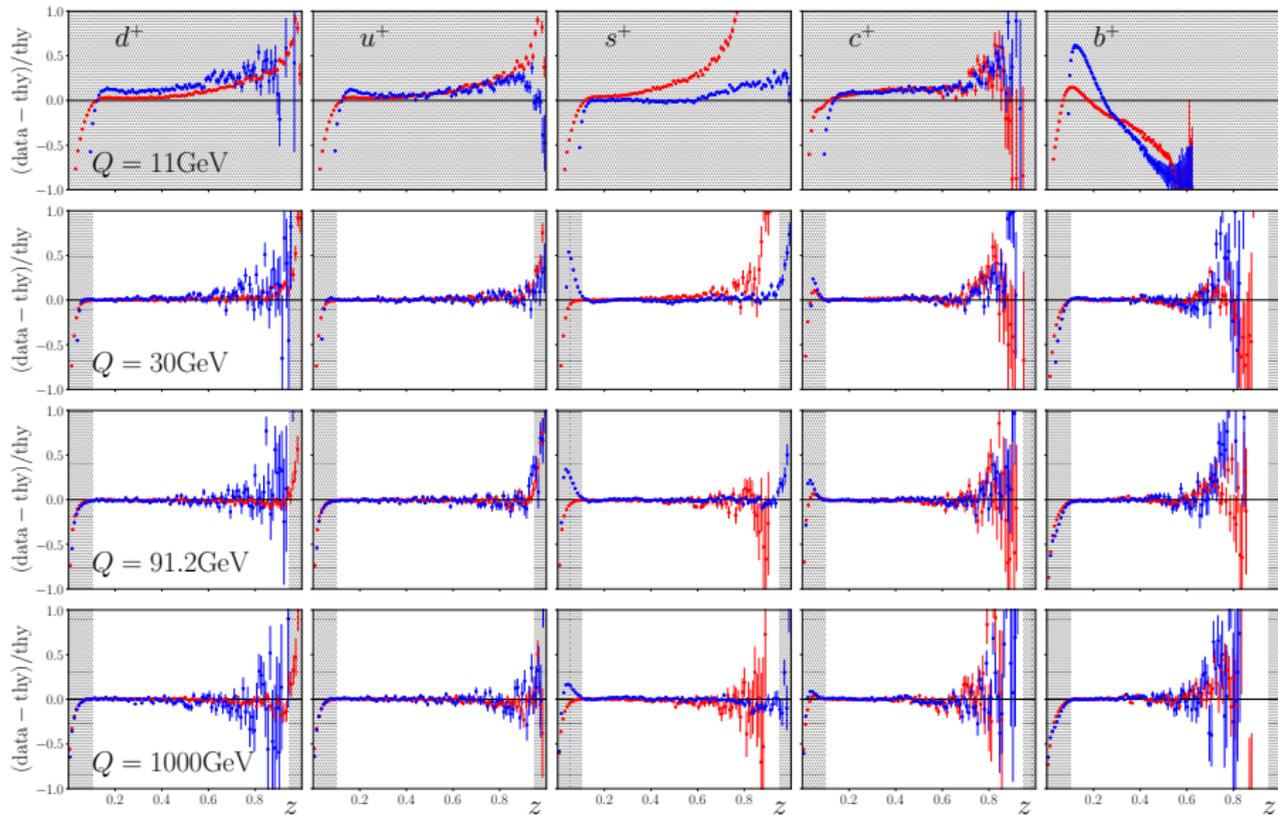
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- Parametrization: $D_{q^+}(z) = Nz^\alpha(1-z)^\beta(1+c_1z+c_2z^2+\dots)$

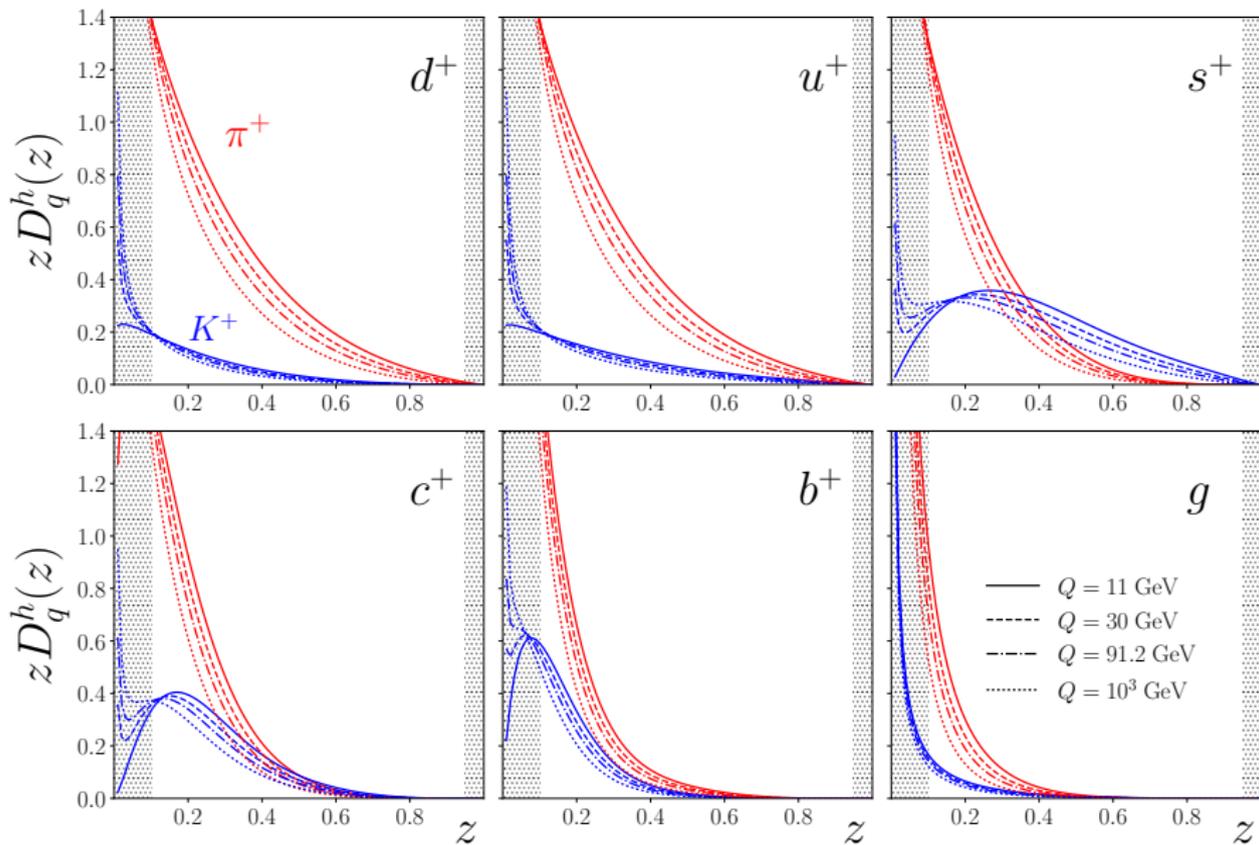
Pythia8 vs. collinear factorization (preliminary)



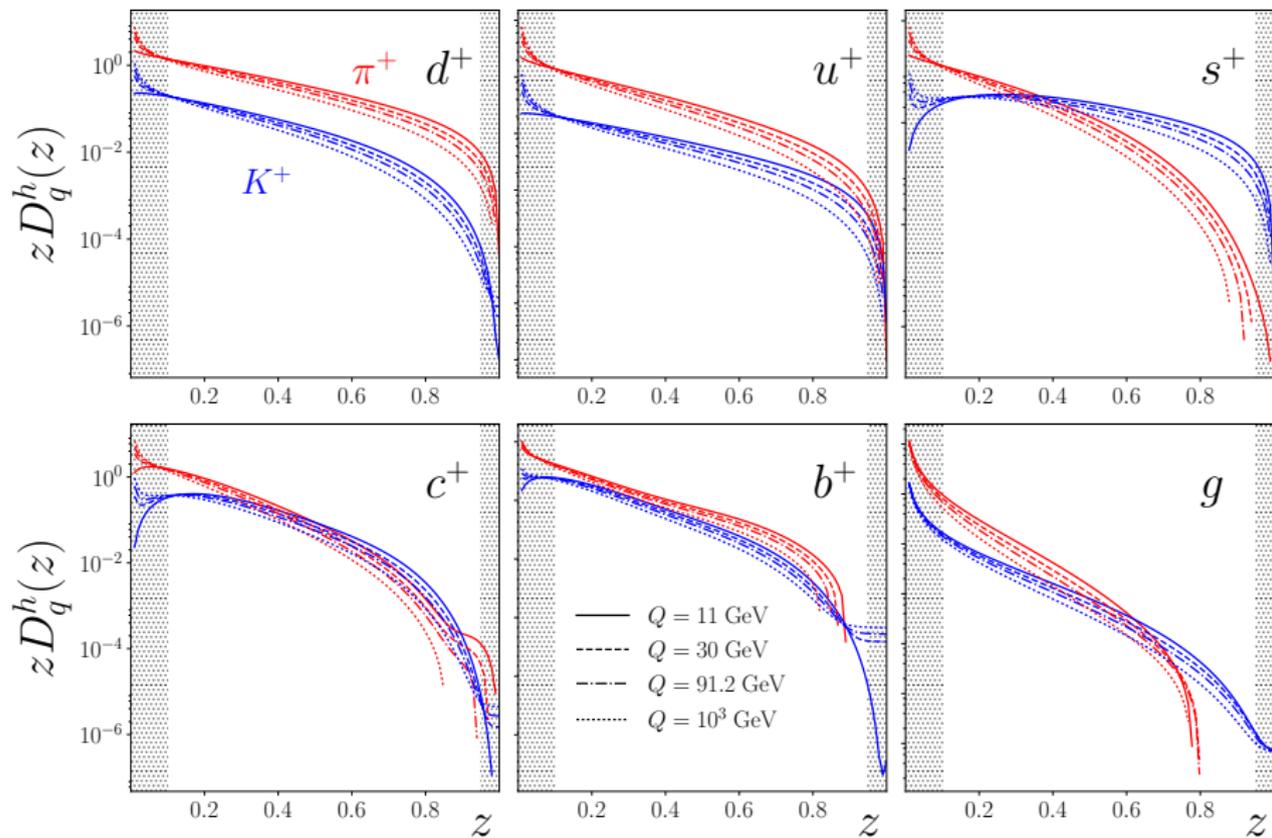
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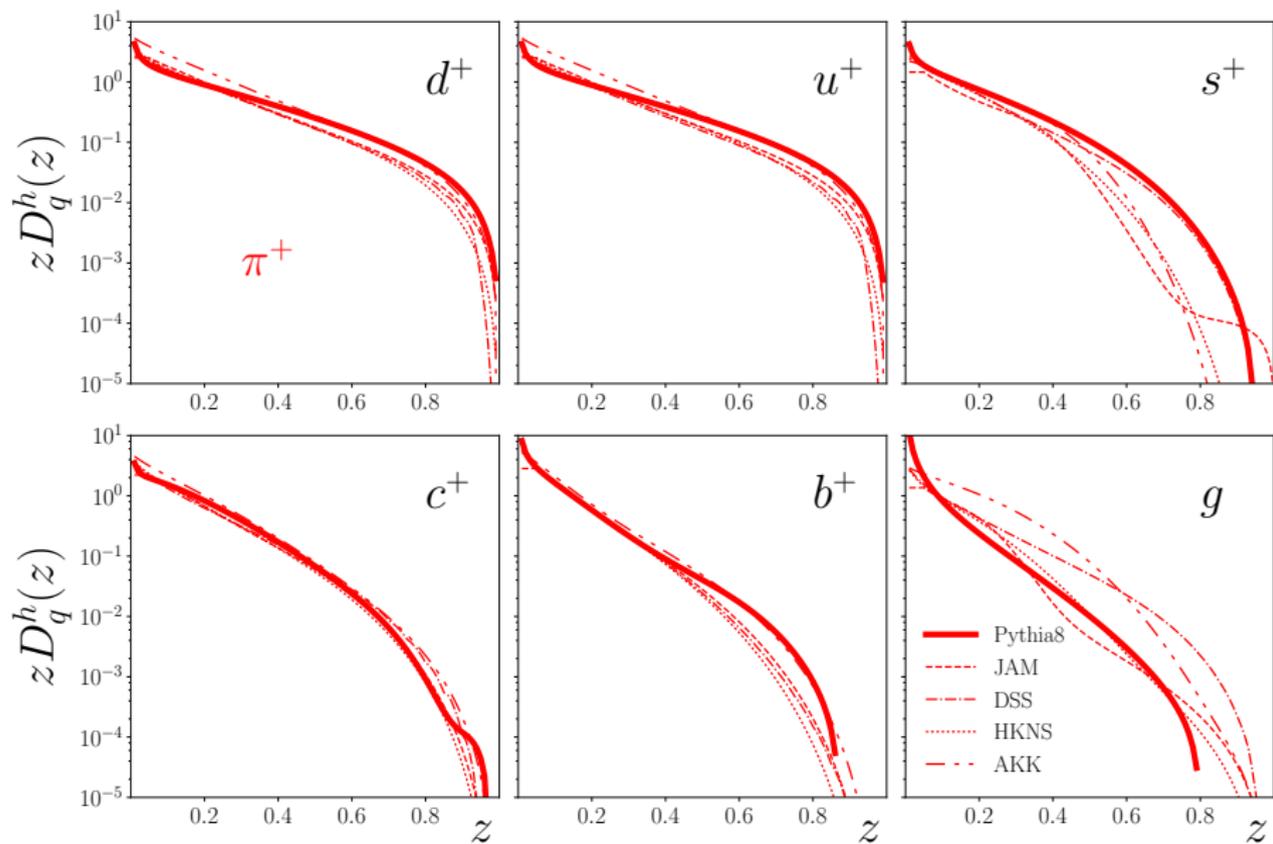
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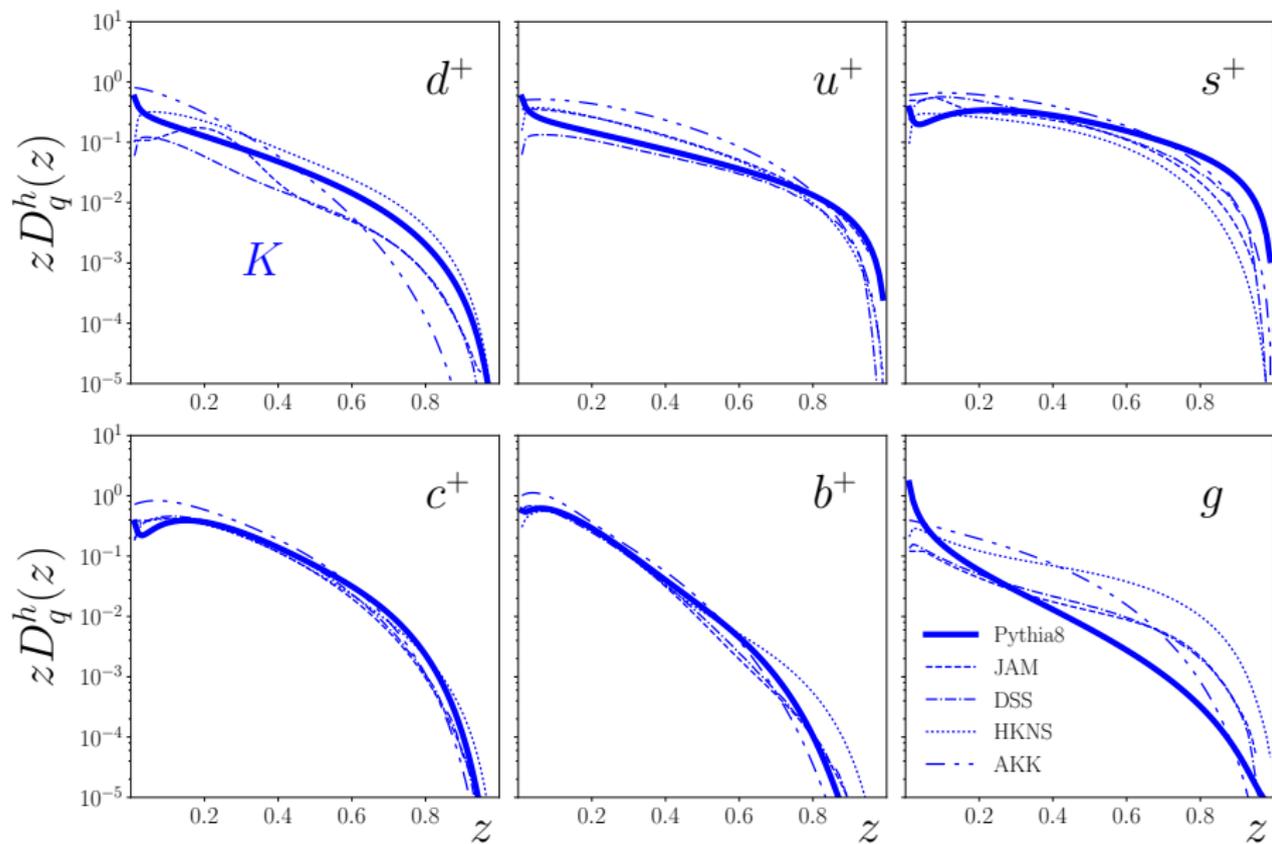
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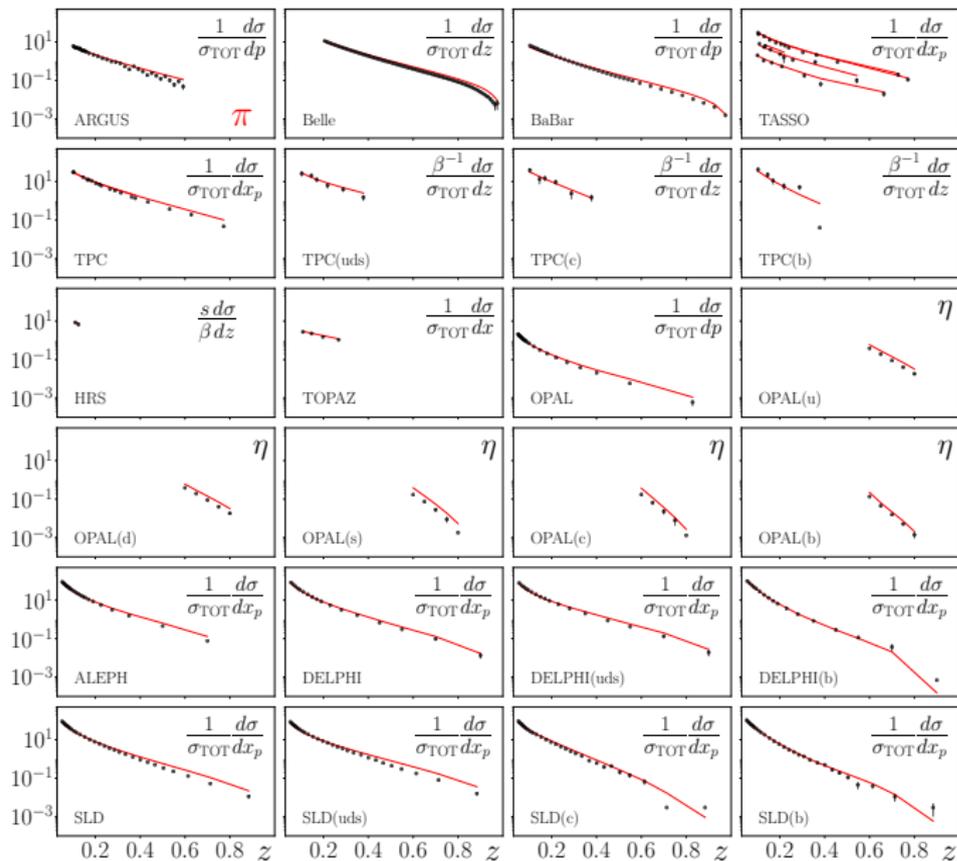
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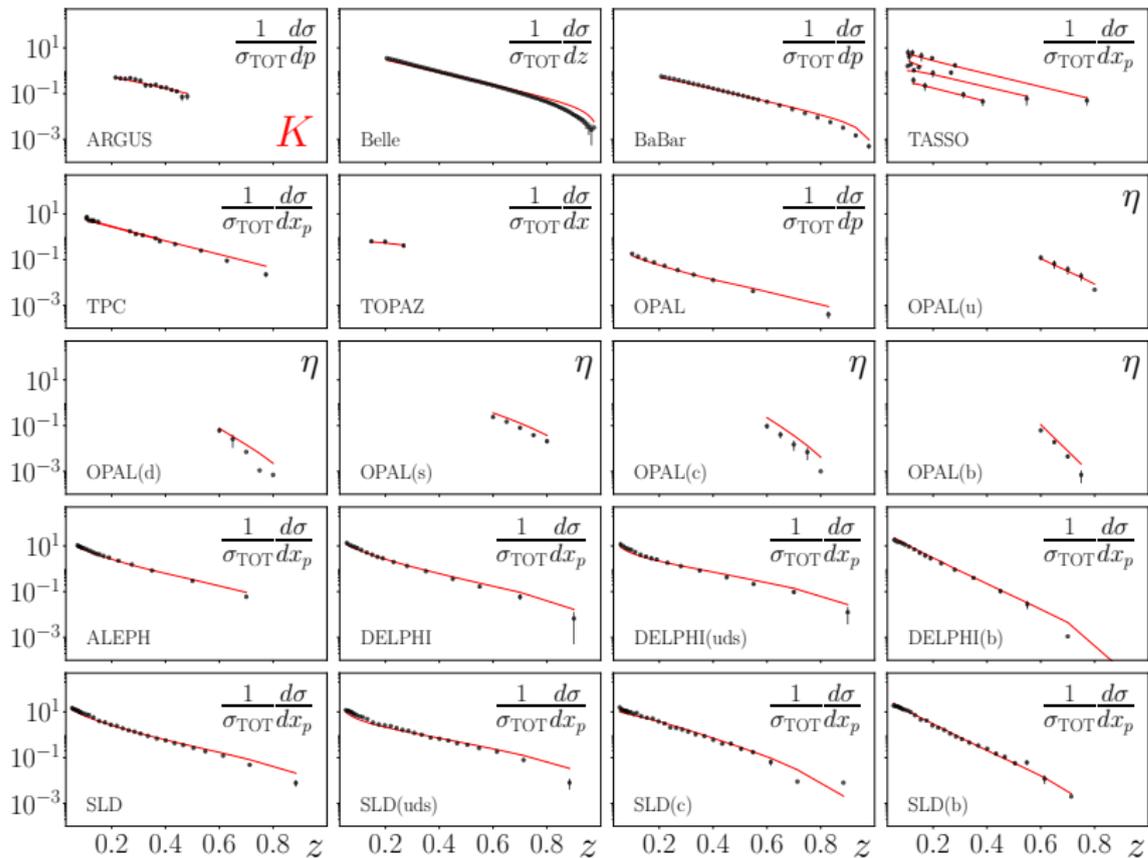
Pythia8+DIRE K FFs and other global analyses



Pythia8+DIRE vs global $e^+e^- \rightarrow \pi + X$



Pythia8+DIRE vs global $e^+e^- \rightarrow K + X$



Summary of FF studies

■ So far...

- DGLAP formalism seems to work in Pythia8+DIRE from $Q > 30\text{GeV}$
- Difficulties in describing Pythia8's sample at $Q = 11\text{GeV}$
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- Extract FFs from Pythia8's SIDIS at low energies
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■ Ongoing studies of SIDIS and MCEG-theory mismatches