Hadron transverse momentum distribution in $pp \to Z + \text{jet}(h)$

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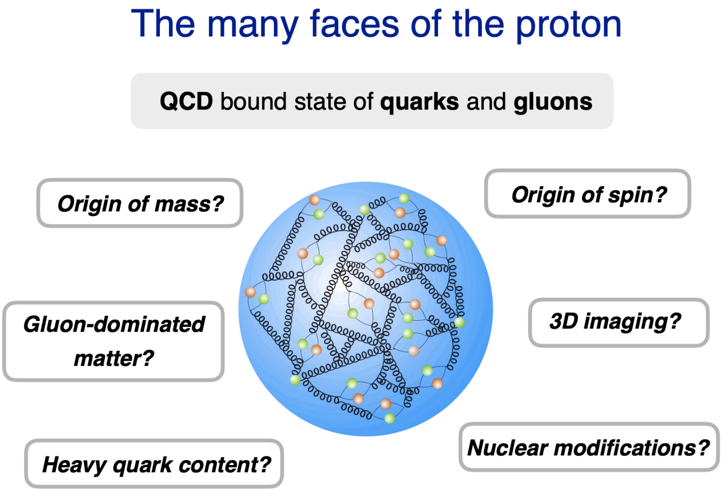
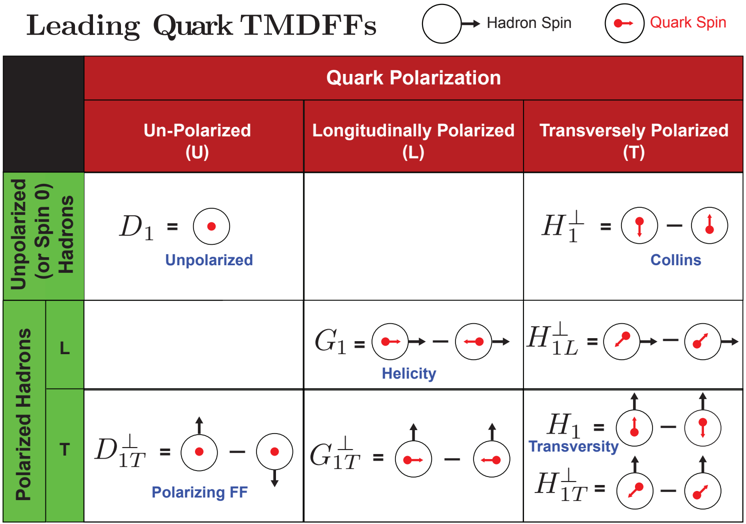
Purpose of study



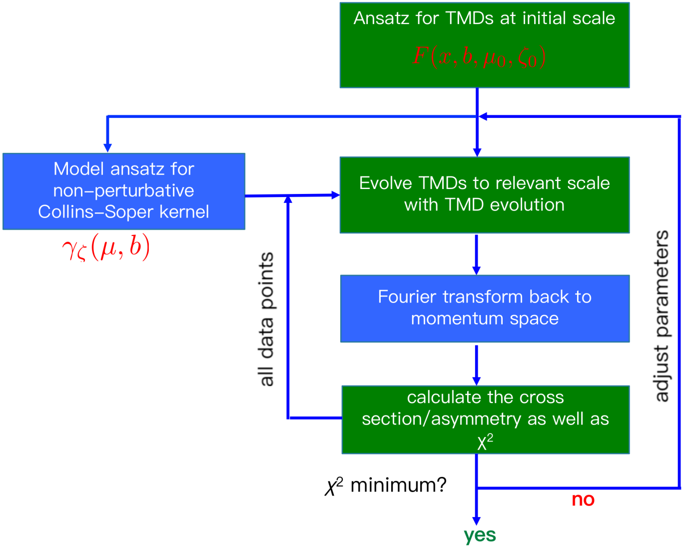
Picture from Zhongbo Kang's talk.

TMD PDFs



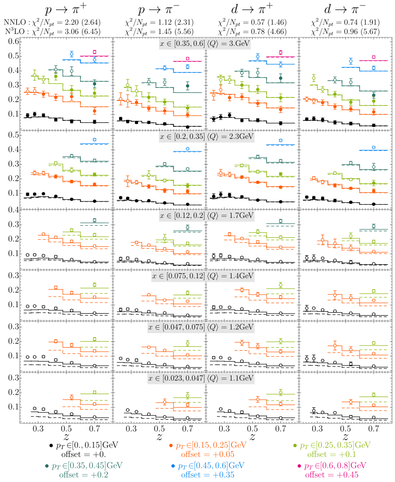
Leading quark TMD PDFs, [TMD Handbook, 2023]

TMD global analysis

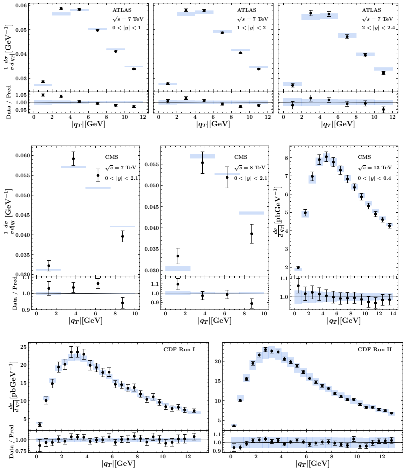


Picture from Zhongbo Kang's talk.

TMD global analysis

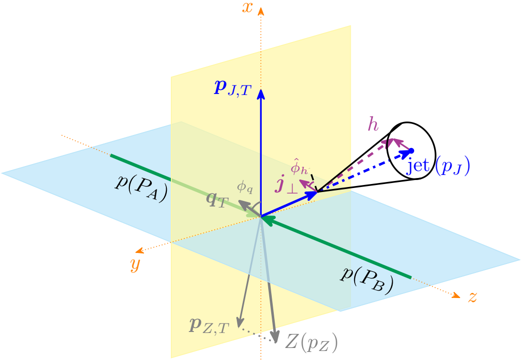


Fit to SIDIS data, [Scimemi and Vladimirov, 2019].



Fit to DY data, [MAP, 2022].

- p_J and $\boldsymbol{p}_{J,T}$: jet momentum and transverse momentum,
- $\boldsymbol{q}_T$: transverse momentum imbalance, $\boldsymbol{q}_T = \boldsymbol{p}_{Z,T} + \boldsymbol{p}_{J,T}$,
- ϕ_{q_T} and ϕ_J: azimuthal angle of $\boldsymbol{q}_T$ and jet.



TMD factorization

In small q_T, *i.e.*, back-to-back limit, TMD factorization [Kang, Lee, Terry and Xing, 2019] gives:

$$\frac{\mathrm{d}\sigma^{p+p\to Z+\mathrm{jet}(h)+X}}{\mathrm{d}\mathcal{PS}\,\mathrm{d}z_h\,\mathrm{d}^2\boldsymbol{j}_T} = \sum_{a,b,c}\int \mathrm{d}\phi_J \int \prod_{i=1}^{4} \mathrm{d}^2\boldsymbol{k}_{iT}\,\delta^2\left(\boldsymbol{q}_T - \sum_{i=1}^{4}\boldsymbol{k}_{iT}\right) \\ \times f_a\left(x_a, k_{1T}^2, \mu, \nu\right) f_b\left(x_b, k_{2T}^2, \mu, \nu\right) \\ \times S_{\mathrm{global}}(\boldsymbol{k}_{3T}, \mu, \nu) S_{cs}(\boldsymbol{k}_{4T}, R, \mu) \\ \times H_{ab\to cZ}(p_T, m_Z, \mu)\mathcal{D}_{1,c}^{h}(z_h, \boldsymbol{j}_T, p_T R, \mu),$$

where $\mathrm{d}\mathcal{PS} \equiv \mathrm{d}\eta_J\,\mathrm{d}\eta_Z\,\mathrm{d}p_T\,\mathrm{d}^2\boldsymbol{q}_T$, ϕ_J is the azimuthal angle of the jet, $\mathcal{D}_{1,c}^{h}$ are the TMD fragmenting jet functions (FJFs).

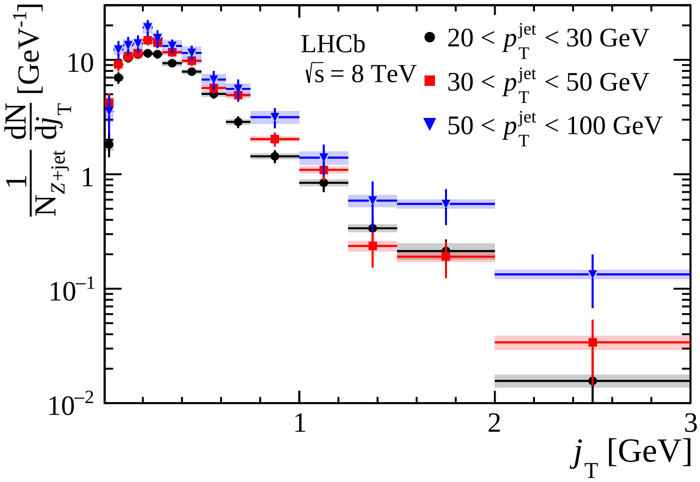
Difficulty in comparing to measurements

The TMD FJFs is factorized as TMD FFs convoluted with soft functions:

$$\mathcal{D}_{1,c}^{h}(z_h, \boldsymbol{j}_T, p_T R, \mu) = \int \frac{\mathrm{d}^2\boldsymbol{b}}{(2\pi)^2} e^{\imath \boldsymbol{j}_T \cdot \boldsymbol{b}/z_h} D_{h/i}(z_h, \boldsymbol{b}, \mu, \nu) S_i(\boldsymbol{b}, \mu, \nu R),$$

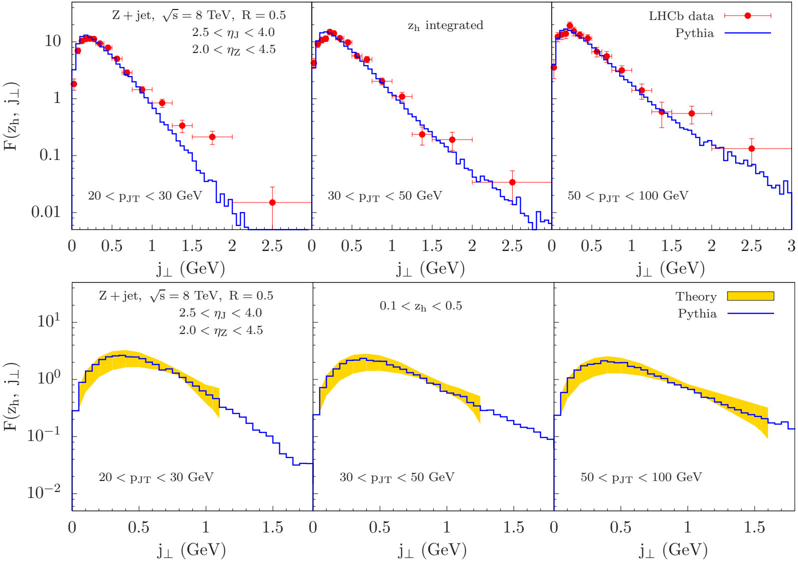
where $D_{h/i}$ are the TMD FFs, which can be further matched onto collinear FFs, and they are only well constrained at $z_h \gtrsim 0.05$.

Previous j_T-dependent measurements

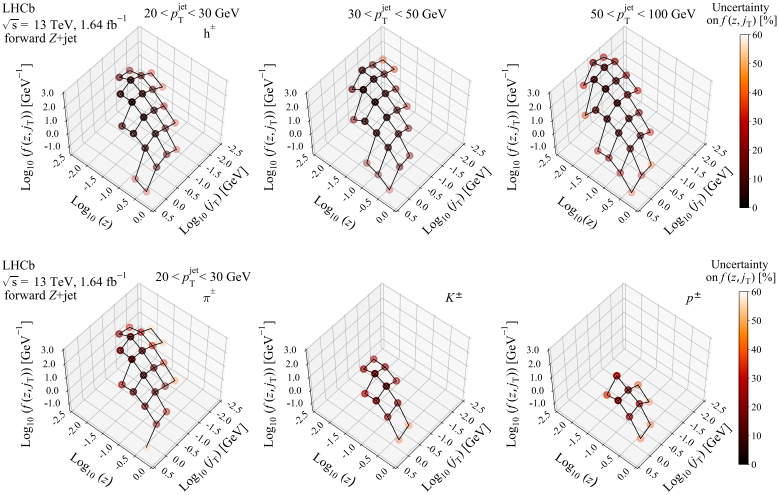


Distributions of the transverse momentum j_T of charged hadrons with respect to the jet axis in three bins of jet p_T, [LHCb, 2019]

Comparison to previous measurements

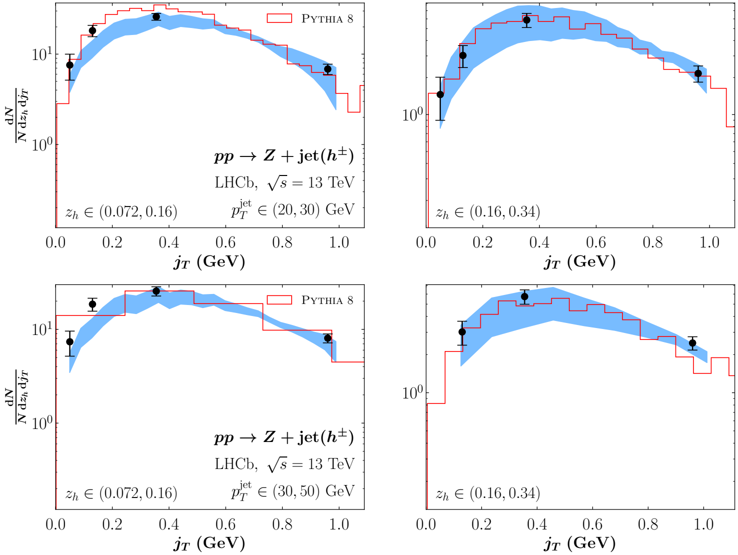


Comparison is only feasible with Pythia simulation, [Kang, Lee, Terry and Xing, 2019]



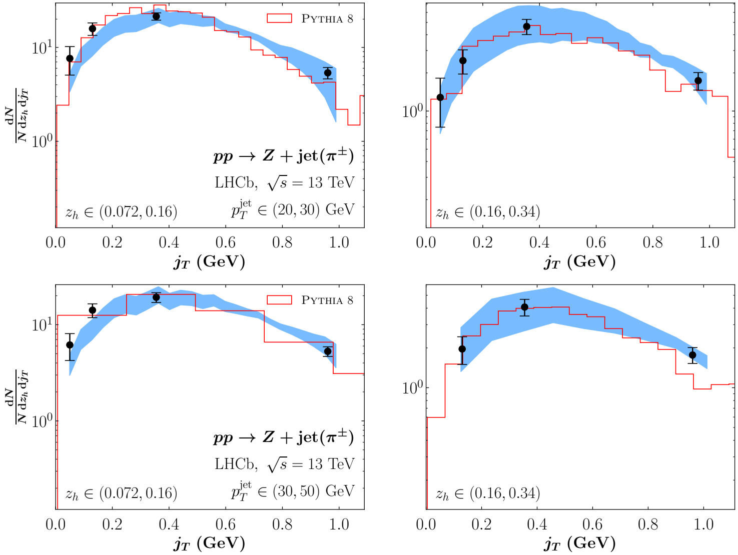
Distributions of the longitudinal momentum fraction z_h as well as transverse momentum $\boldsymbol{j}_T$ of charged hadrons, $\pi^{\pm}$, $K^{\pm}$ and $p/\overline{p}$ with respect to the jet axis in three bins of jet p_T, [LHCb, 2022]

Comparison to new data: charged hadrons



Jet $p_T \in (20, 30)$ GeV and $(30, 50)$ GeV, collinear FFs are from [DSS, 2022].

Comparison to new data: $\pi^{\pm}$

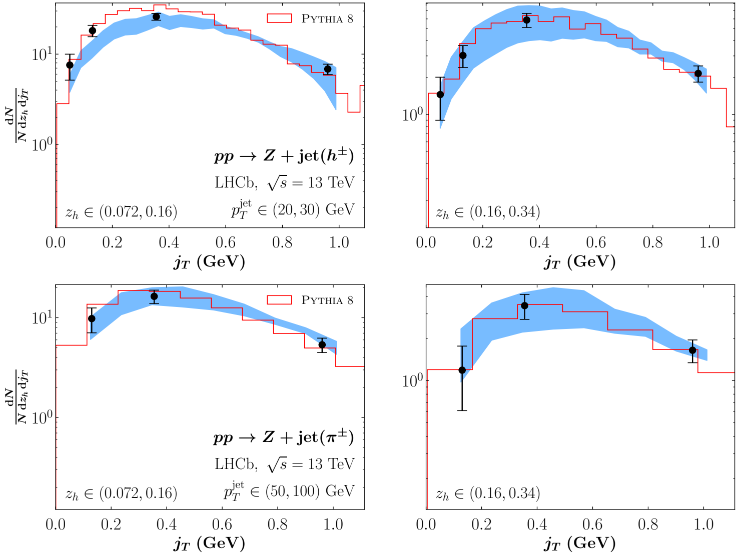


Jet $p_T \in (20, 30)$ GeV and $(30, 50)$ GeV, collinear FFs are from [DSS, 2022].

Future

- Work on improving the prediction to $Z + \text{jet}(K^{\pm})$ production.
- Make predictions to $pA \to Z + \text{jet}$ and $pA \to Z + \text{jet}(h)$ processes.

Comparison to new data



Charged hadron (upper) or $\pi^{\pm}$ (lower) production, with jet $p_T \in (50, 100)$ GeV.