Kinematics of SIDIS

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Source of Errors?

Unpolarized SIDIS cross section (current region)

$$\frac{d\sigma^{\ell+p\to\ell' hX}}{dx_B\, dQ^2\, dz_h\, dP_T^2} \propto \sum_q \mathcal{H}_q \ \text{F.T.} \left\{ \tilde{D}_{h/q}(z, z\,\boldsymbol{b}_\perp; Q)\ \tilde{f}_{q/P}(x, \boldsymbol{b}_\perp; Q) \right\}$$

$$+ \text{ large } q_T \text{ corrections} + \text{power suppressed terms}$$

Perturbation Theory **Factorization**

(Re)Calculation of large qT SIDIS cross section at $O(\alpha_s^2)$

Work in progress:

B. Wang, N. Sato, T. Rogers, J.O.G.H.

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Perturbation Theory

Kinematics of TMD regime

Mixing with other physics?

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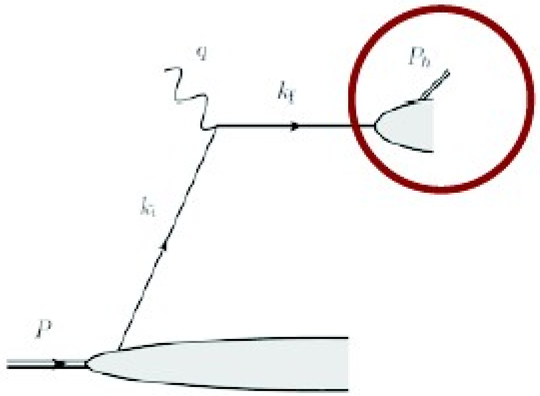
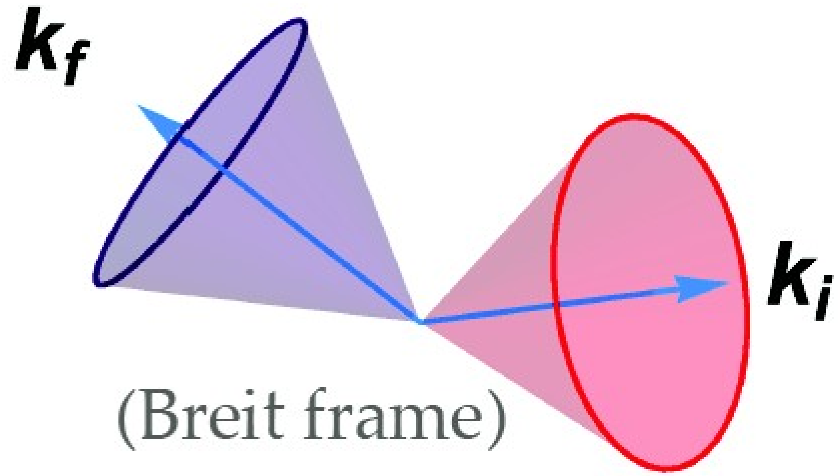
$$+ \text{ large } q_T \text{ corrections} + \boxed{\text{power suppressed terms}}$$

Factorization

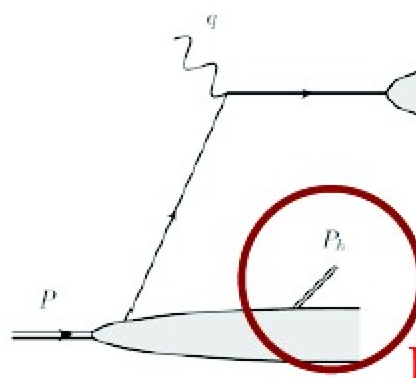
Which Region?



TMDs



factorization theorems for different leading regions



Fracture Functions

Historical note

ANL-HEP-CP-87-45
April 30, 1987

$$y_h = \frac{1}{2} \ln \left[\frac{E_h + p_{h,L}}{E_h - p_{h,L}} \right],$$

where $E_h, p_{h,L}$ are the energy and longitudinal component of momentum of hadron h. (Longitudinal is defined by the direction of the momentum **q**.) The full range of y_h allowed kinematically is $Y = \ln W_X^2 = \ln(Q^2(1-x)/x)$; W_X is the invariant mass of the system X in the fully inclusive $eA \to e'X$.

It has been established[13] experimentally that the typical hadronic correlation length in rapidity is $\Delta y_h \simeq 2$. Therefore, if the dynamics of quark fragmentation is to be studied independently of "contamination" from target fragmentation, it is necessary that $Y \gtrsim 4$, or, equivalently, that

$$W_X = \left[\frac{Q^2(1-x)}{x} \right]^{1/2} \gtrsim 7.4\text{GeV}. \qquad (17)$$

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$$W_X = \left[\frac{Q^2(1-x)}{x} \right]^{1/2} \gtrsim 7.4\text{GeV}. \qquad (17)$$

If the inequality Eq. (17) is satisfied, it should be possible to measure fragmentation functions $D(z, Q^2)$ over essentially the full range of z, $0 < z < 1$. Somewhat smaller values of W_X may be adequate if attention is restricted to the large z region. As Y is increased

More recently

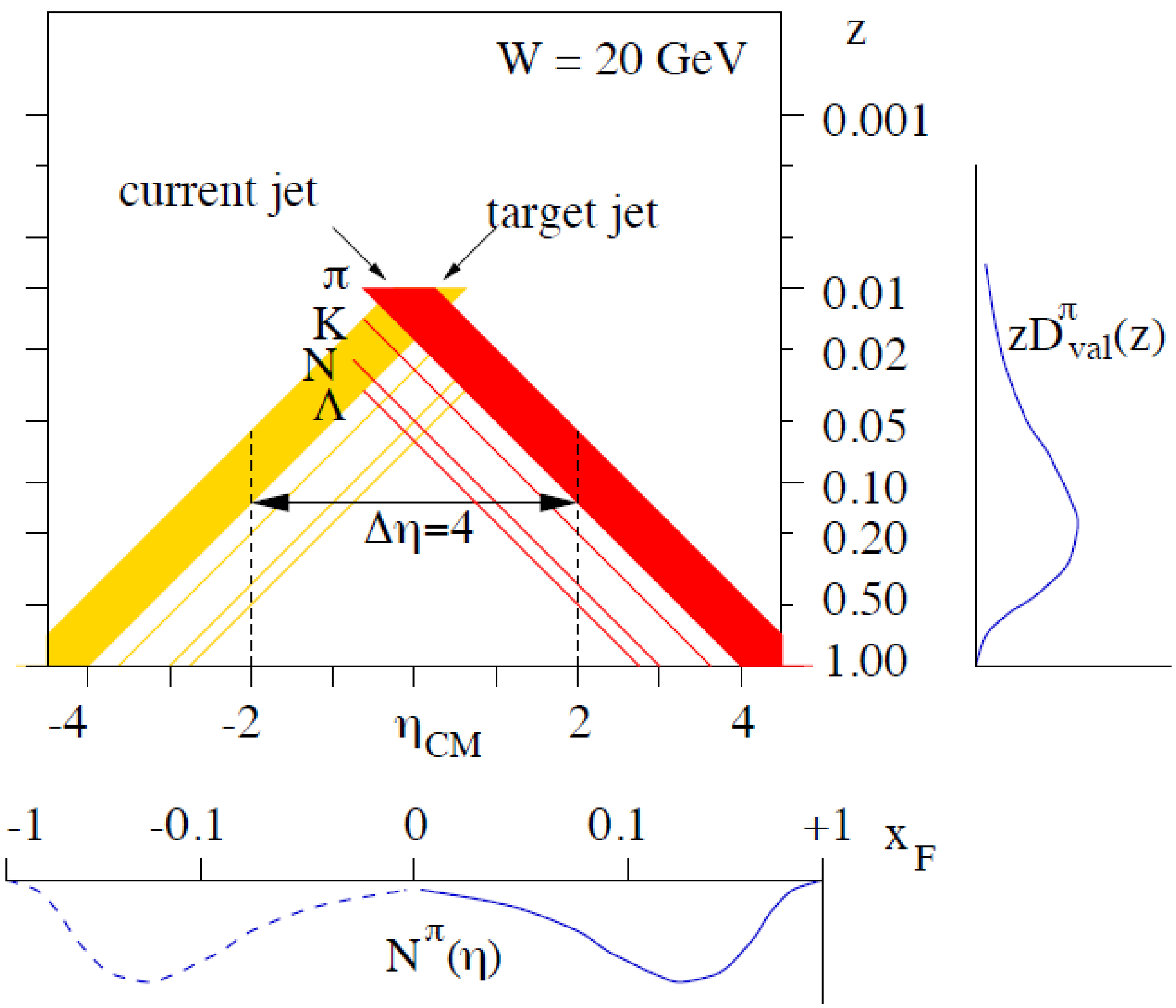
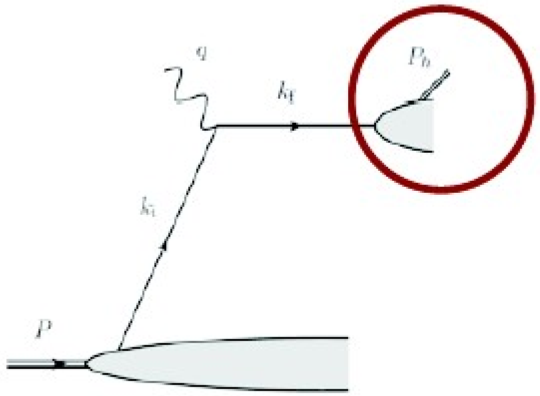


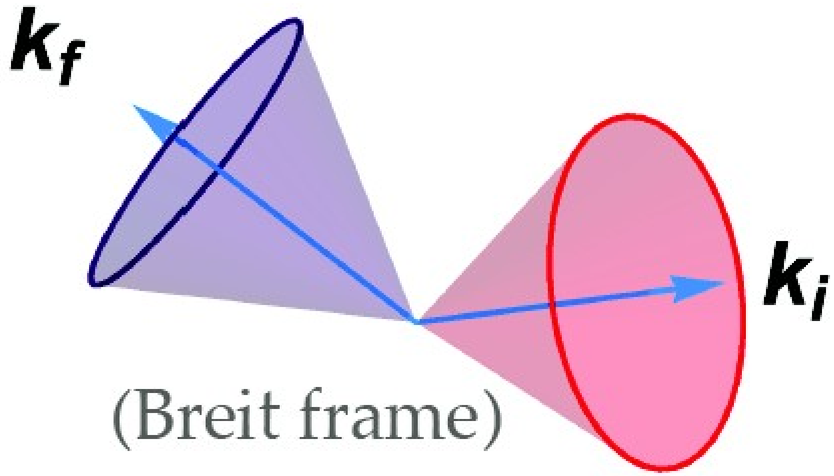
FIGURE 3. Relation between $z-values$ in fragmentation and CM rapidity for $W = 20$ GeV.

P.J. Mulders AIP Conf.Proc. 588 (2001) 75-88

Even More recently



TMDs



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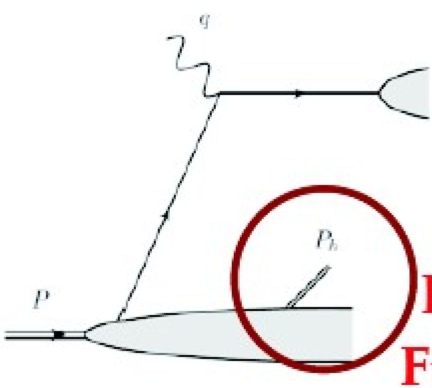
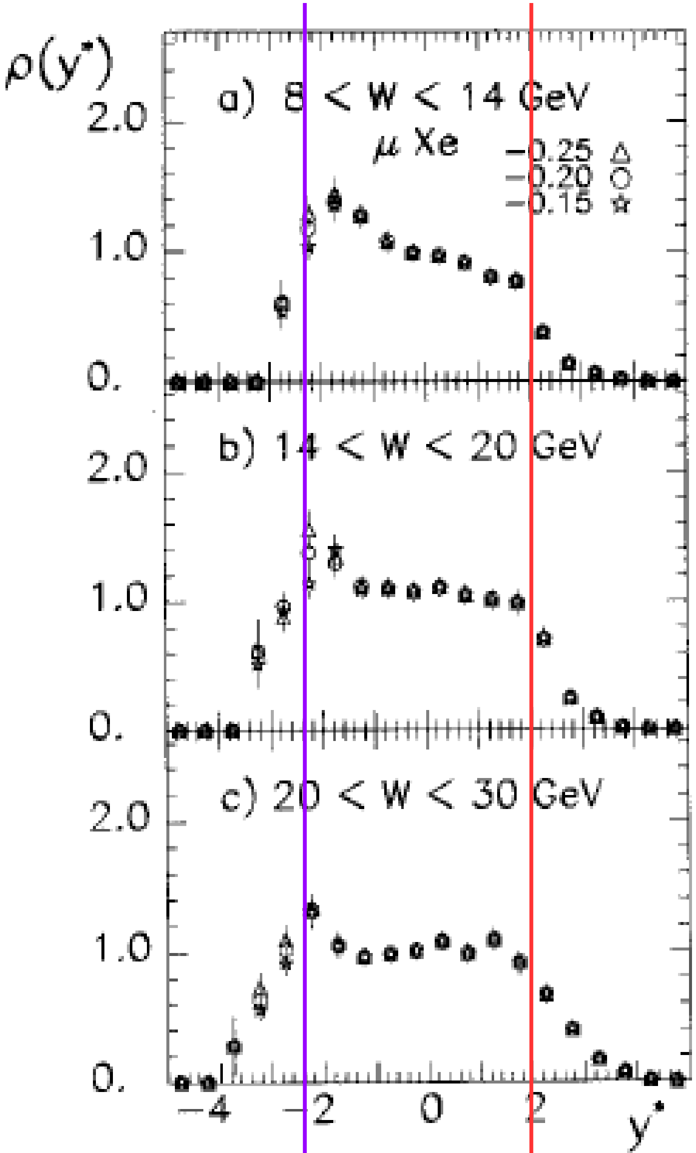


Fracture Functions

M. Boglione, J. Collins, L. Gamberg, JOGH, T. C. Rogers, and N. Sato,Phys. Lett.B766, 245 (2017),1611.10329.



A real-life example

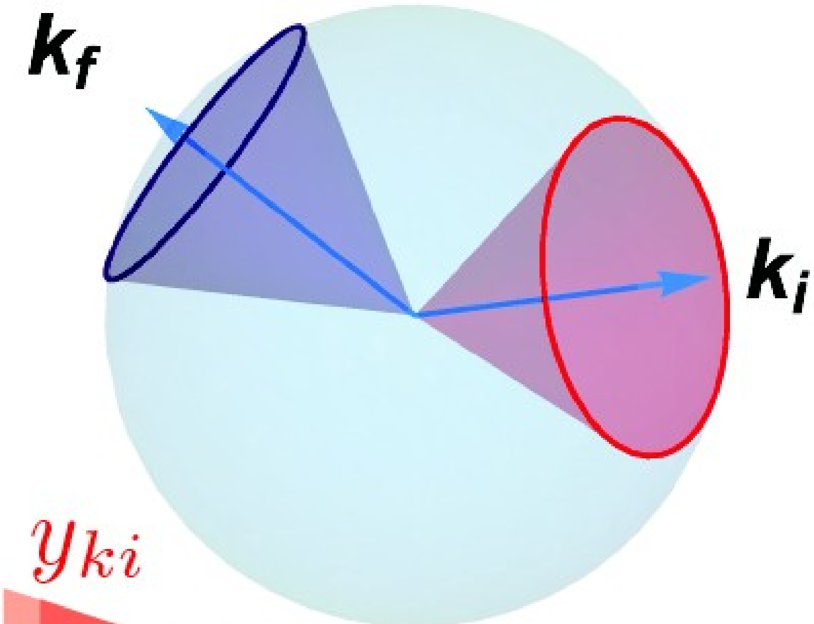
Z. Phys. C 61, 179–198 (1994)

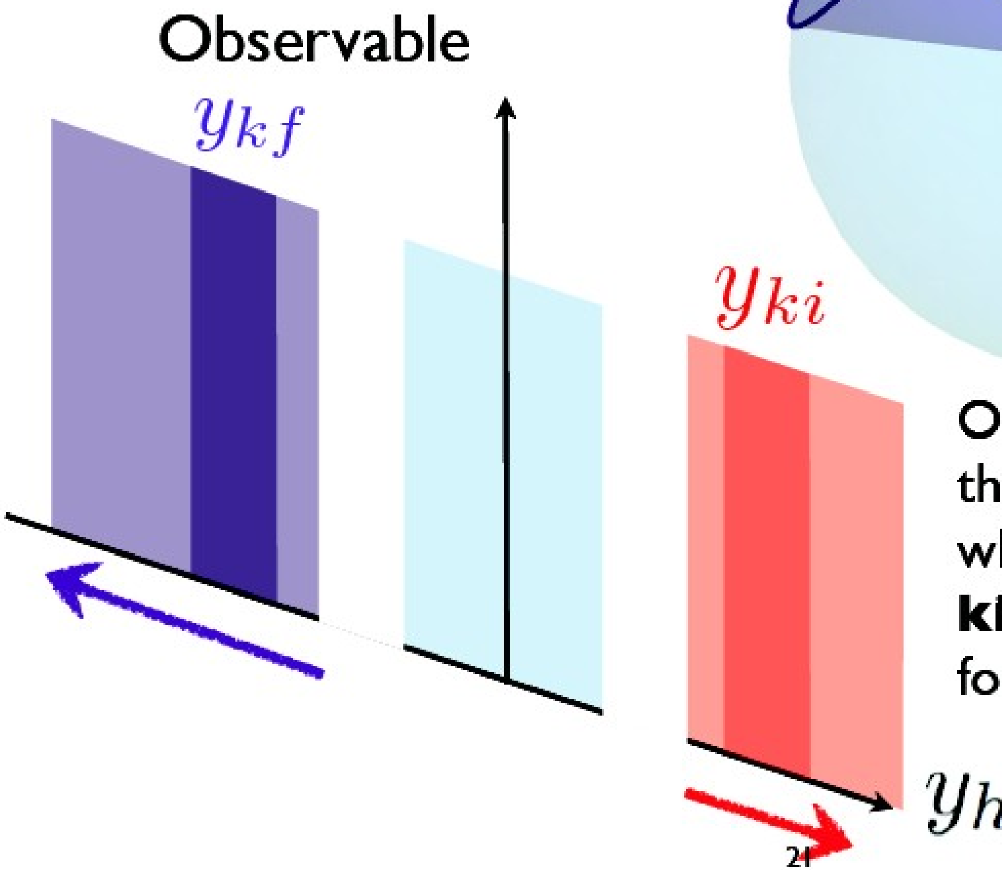
E665 Collaboration

Fig. 23a–c. Normalized cms-rapidity distribution of positive hadrons in μXe scattering, in three bins of W, for three variants of the particle identification procedure (see Sect. 3.1): assignment of the proton mass if x_F (m_π) is < -0.15 (stars), or if x_F (m_π) is < -0.20 (circles), or if x_F (m_π) is < -0.25 (triangles)

Breit frame

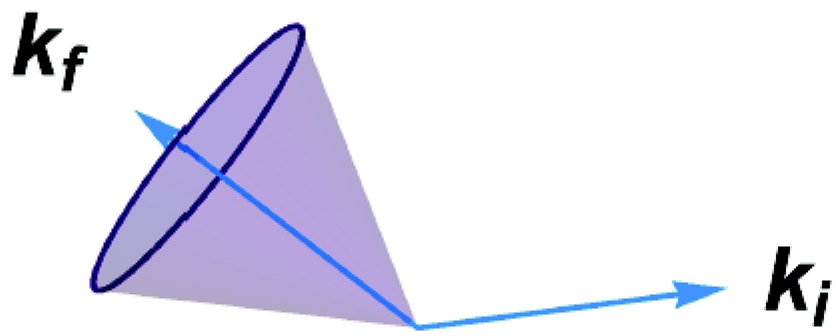
$$y_h \equiv \frac{1}{2} \log \frac{P_h^+}{P_h^-}$$





One may take this into account, at least when defining **kinematic limits** for current/target region

Power counting and kinematics of the current region



current region

small masses

$$P_h \cdot k_\mathrm{f} = O\left(m^2\right)$$

$$P_h \cdot k_\mathrm{i} = O\left(Q^2\right)$$

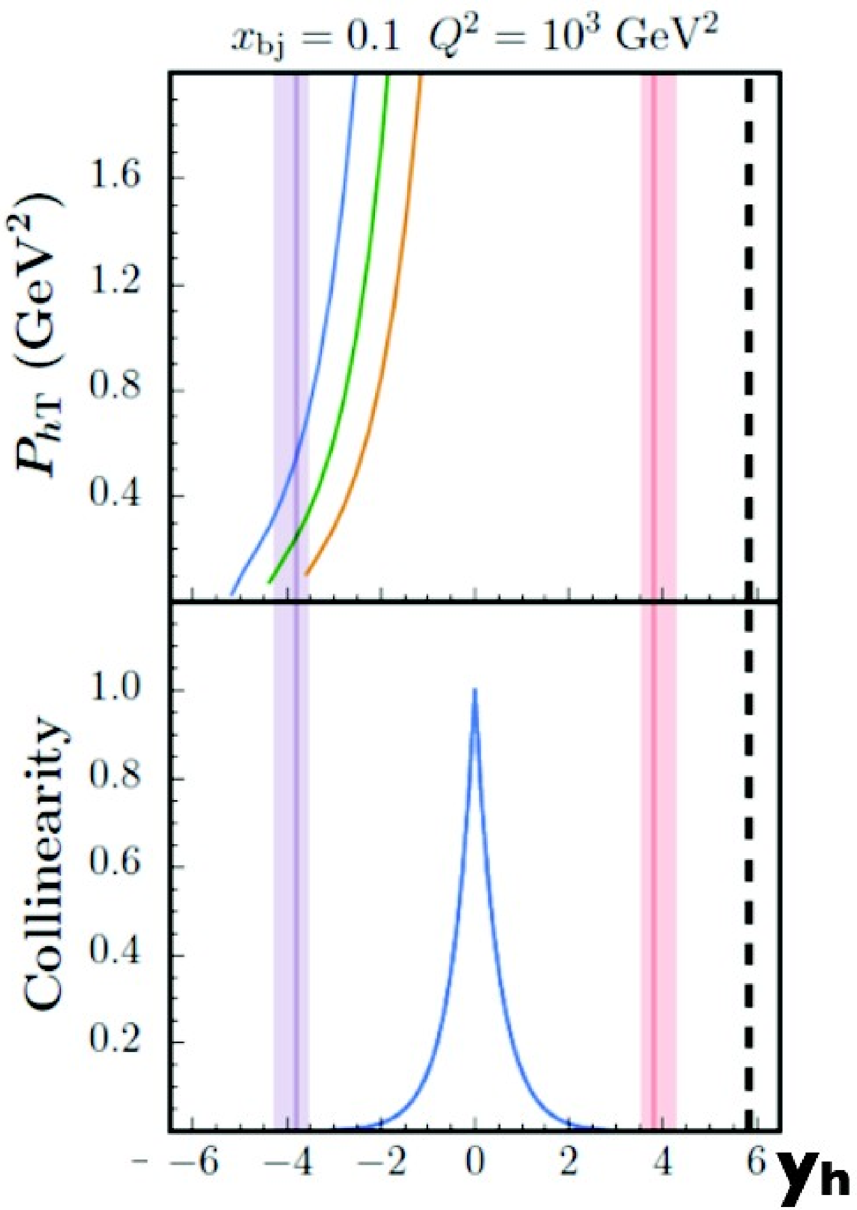
hard scale

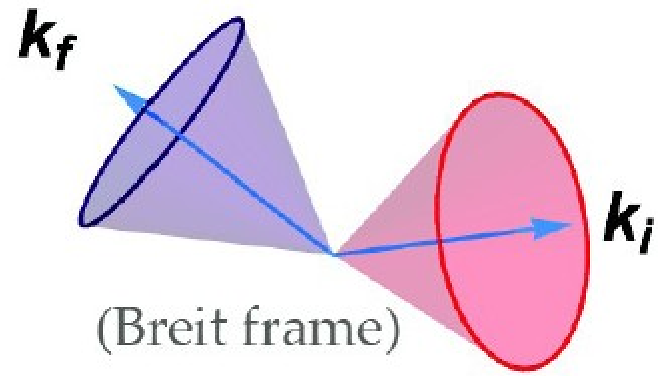
require small values for

$$R \equiv \frac{P_h \cdot k_\mathrm{f}}{P_h \cdot k_\mathrm{i}}$$

notice quark momenta have to be estimated

M. Boglione, J. Collins, L. Gamberg, JOGH, T. C. Rogers, and N. Sato,Phys. Lett.B766, 245 (2017),1611.10329.

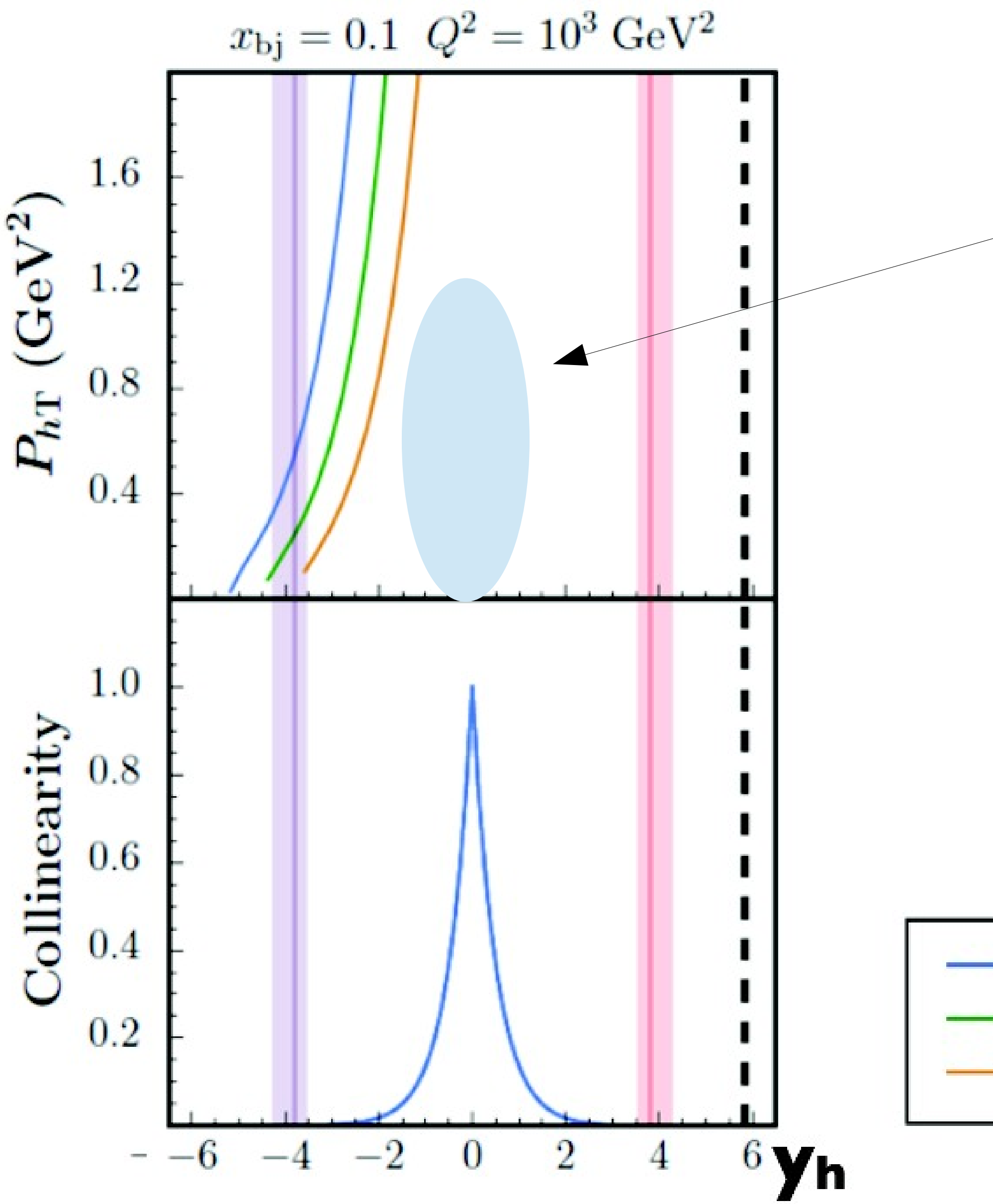




$$R \equiv \frac{P_h \cdot k_{\rm f}}{P_h \cdot k_{\rm i}}$$

TMD:Current Region **Target Fragmentation**

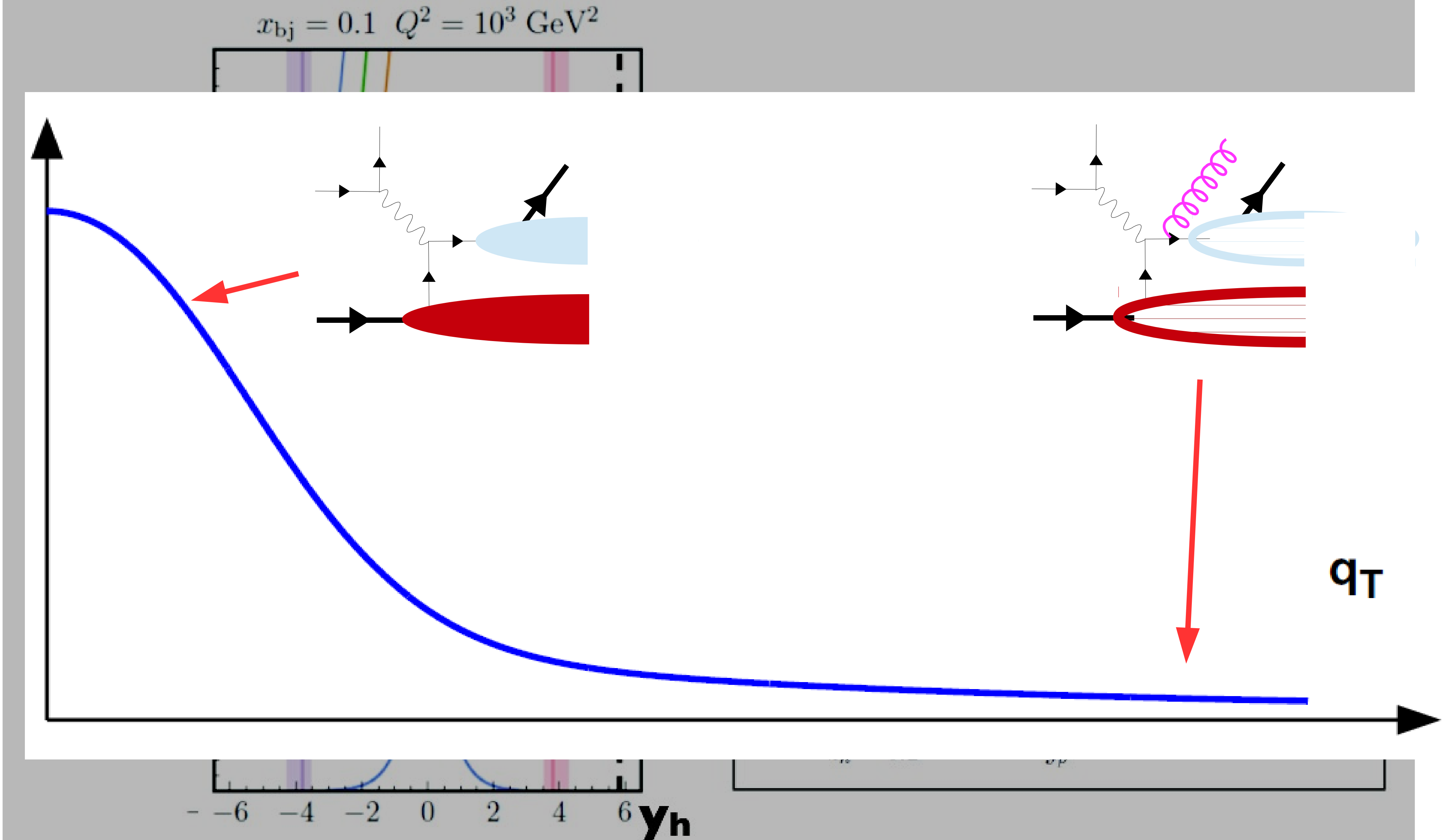
M. Boglione, J. Collins, L. Gamberg, JOGH, T. C. Rogers, and N. Sato,Phys. Lett.B766, 245 (2017),1611.10329.



Avoid region of central rapidity, soft non-TMD effects

$$R \equiv \frac{P_h \cdot k_{\rm f}}{P_h \cdot k_{\rm i}}$$

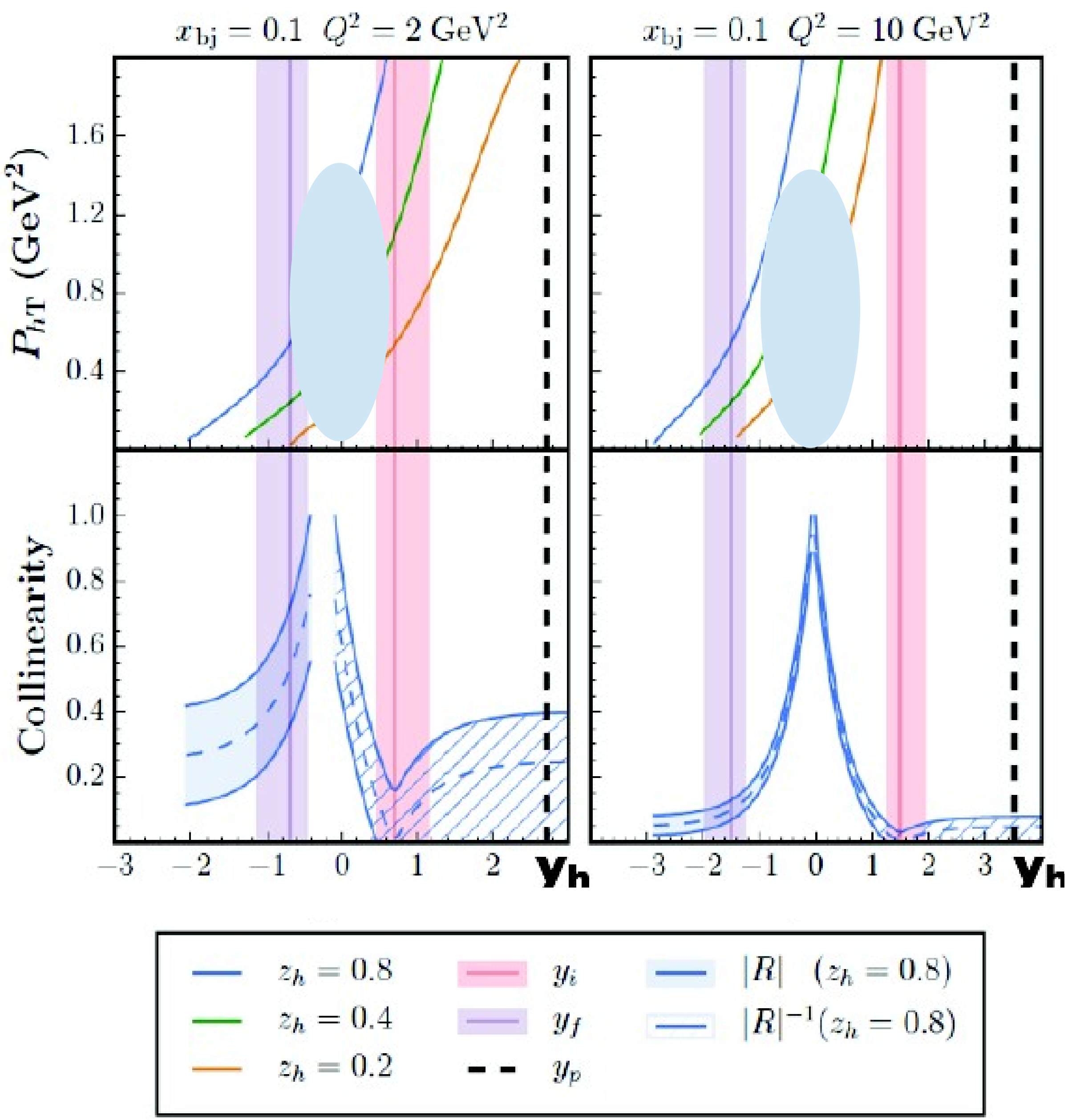
TMD:Current Region **Target Fragmentation**



TMD:Current Region **Target Fragmentation**

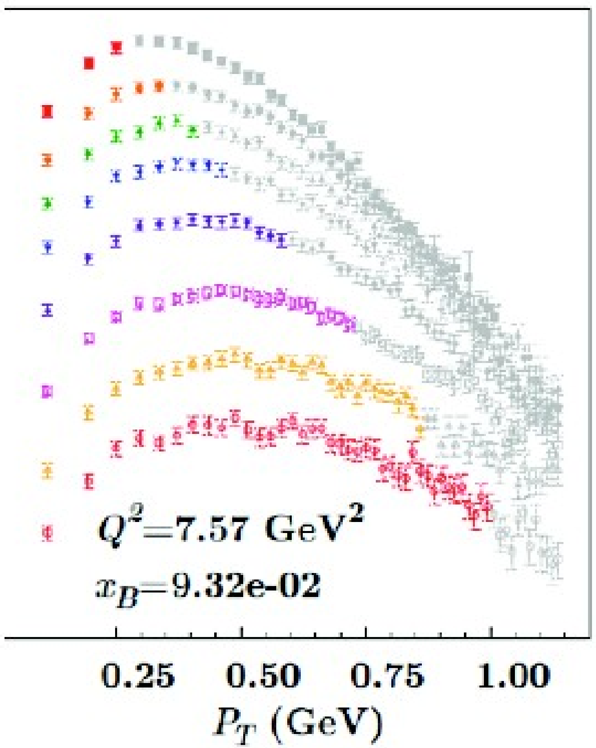
M. Boglione, J. Collins, L. Gamberg, JOGH, T. C. Rogers, and N. Sato,Phys. Lett.B766, 245 (2017),1611.10329.

Available data is likely to receive contributions from non-TMD physics.



$$R \equiv \frac{P_h \cdot k_f}{P_h \cdot k_i}$$

M. Boglione, J. Collins, L. Gamberg, JOGH, T. C. Rogers,
and N. Sato,Phys. Lett.B766, 245 (2017),1611.10329.



precise implementation of the R criterion on data is work in progress

a better set of variables?

$\{Q^2, x_B, P_{hT}, z_h\}$

$q_T = P_{hT} / z_h$ $\quad y_h$

***ONLY AN EXAMPLE**

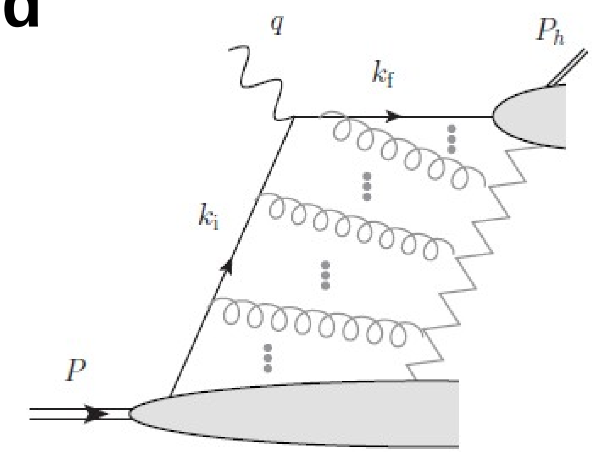
Final Remarks

better set of variables?

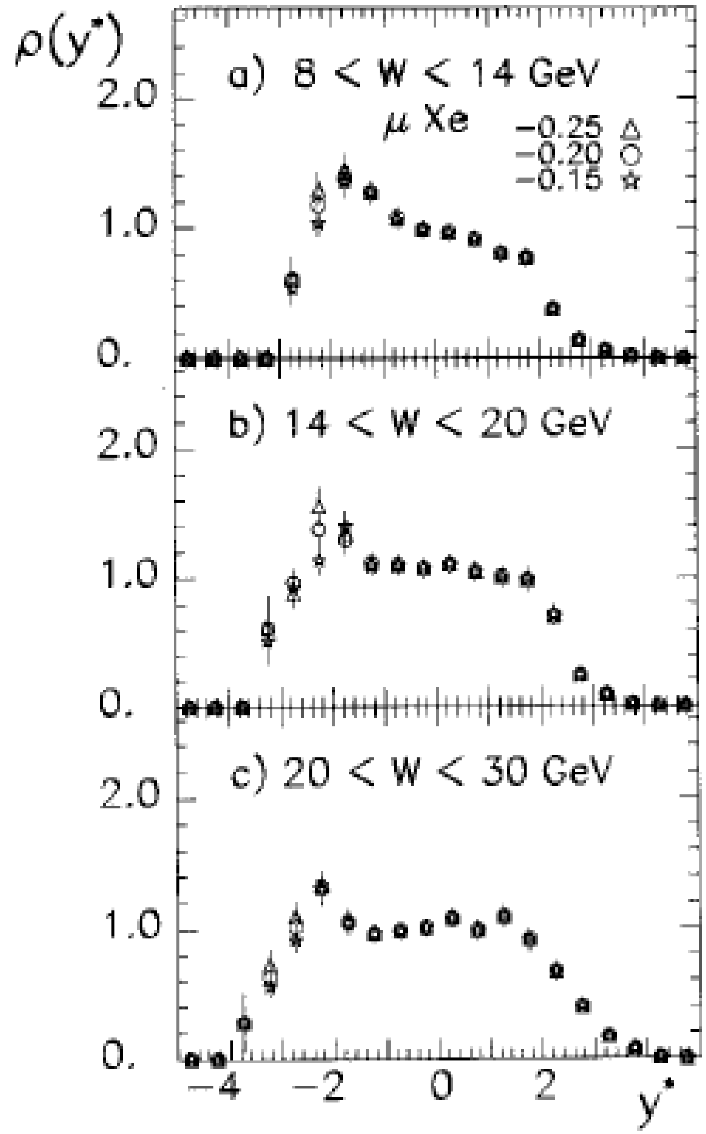
$\{Q^2, x_B, P_{hT}, z_h\}$

$q_T = P_{hT} / z_h$ $\quad y_h$

Warning: at low kinematics the simple Parton picture does not hold



(a)



Thank you.