New Variables for Parton Shower

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Kinematics to allow better treatment of heavy particles, avoiding overlapping regions in phase space and dead cones.

We choose $\tilde{q}^2$ as new evolution variable,

$$\tilde{q}^2 = \frac{\boldsymbol{p}^2}{z^2(1-z)^2} + \frac{m^2}{z^2}$$

with the agument of running α_S chosen according to

$$\alpha_S(z^2(1-z)^2\tilde{q}^2)$$

angular ordering

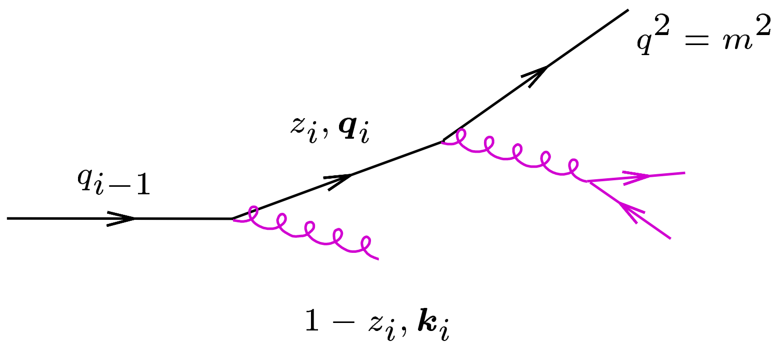
$$\tilde{q}_{i+1} < z_i\tilde{q}_i \qquad \tilde{k}_{i+1} < (1-z_i)\tilde{q}_i$$

Technically: *reinterpretation* of known evolution variables, i.e. the branching probability for $a \to bc$ still is

$$dP(a \to bc) = \frac{d\tilde{q}^2}{\tilde{q}^2}\frac{C_i\alpha_S}{2\pi}P_{bc}(z)\,dz$$

$\longrightarrow$ Sudakov's etc. technically remain the same!

Kinematics



Sudakov basis p, n with $p^2 = m^2$, $n^2 = 0$,

$$q_i = \alpha_i p + \beta_i n + \boldsymbol{q}_i$$

Longitudinal splitting

$$\alpha_i = z_i \alpha_{i-1}$$

transverse momenta reconstructed from $\boldsymbol{p}_i$,

$$\boldsymbol{q}_i = \boldsymbol{p}_i + z_i \boldsymbol{q}_{i-1} \qquad \boldsymbol{k}_i = -\boldsymbol{p}_i + (1 - z_i)\boldsymbol{q}_{i-1}$$

Azimuthal angle φ still chosen randomly or as a result of *azimuthal spin correlations* (planned) β_i from virtuality q_i

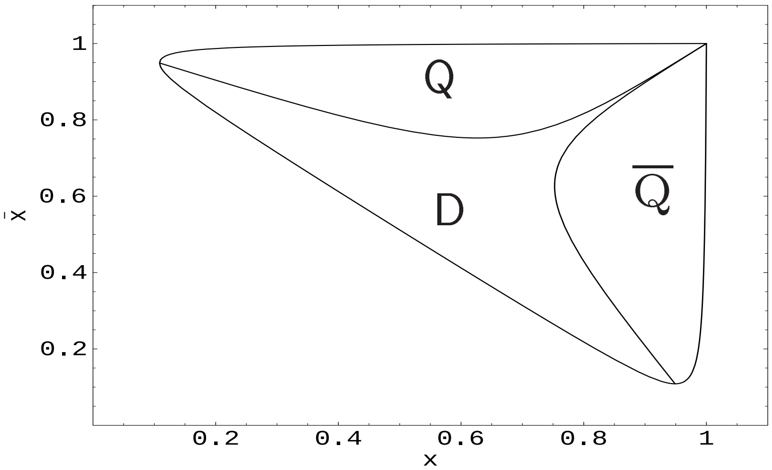
$$\beta_i = \frac{\boldsymbol{q}_i^2 + q_i^2 - \alpha_i^2 m^2}{2p \cdot n \alpha_i}$$

with recursive reconstruction of virtualities from

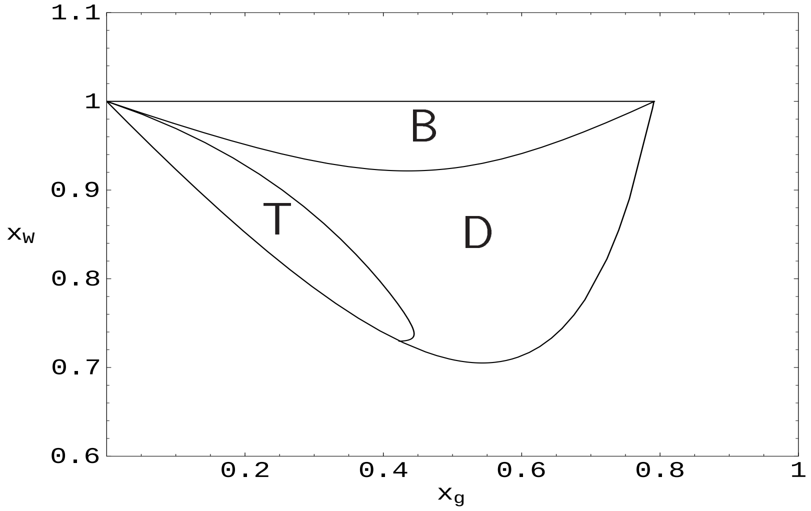
$$q_{i-1}^2 = \frac{q_i^2}{z_i} + \frac{k_i^2}{1 - z_i} + \frac{\boldsymbol{p}_i^2}{z_i(1 - z_i)}$$

Phase space coverage

$e^+e^- \to q\bar{q}g$



$t \to Wbg$



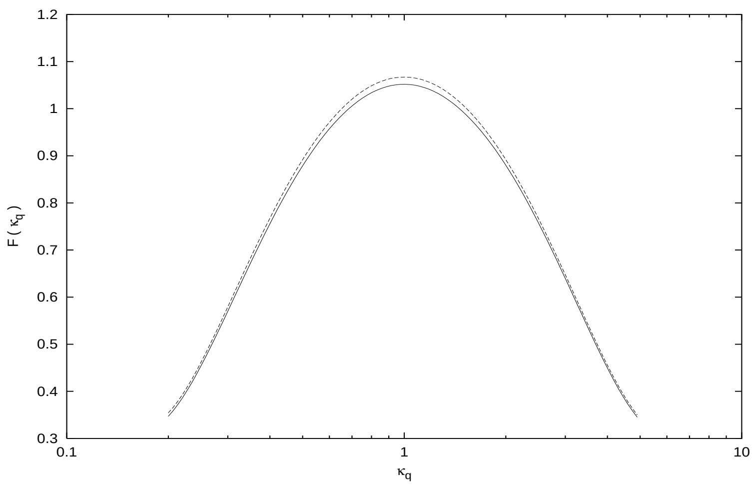
- smooth coverage of the soft region is achieved by choosing appropriate limiting values for the parton shower
- soft ME correction can be applied without double counting (N.B. tricky for radiation from b in t-decay)

Dead Region Contribution

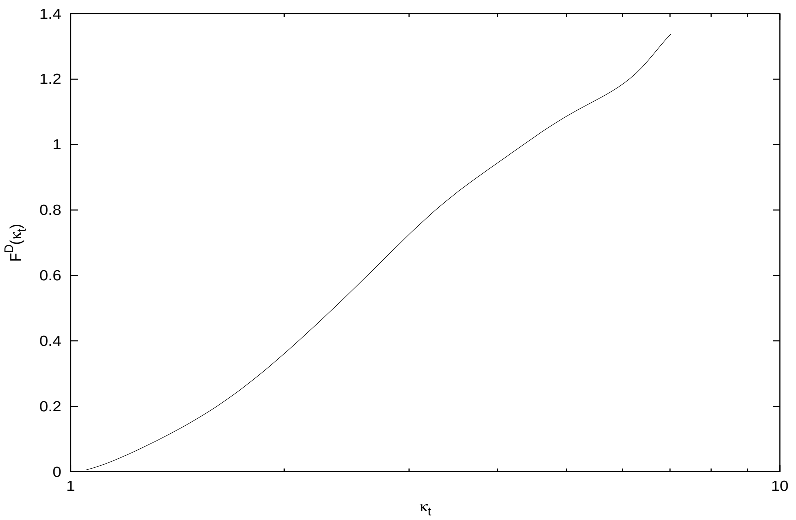
We need to check that the dead region integral is finite (eg. the soft and collinear divergences are handled). We have

$$\int_D d^2(ME) \equiv \frac{\alpha_s}{2\pi} C_F F_V^D(\tilde{\kappa})$$

$e^+e^- \to q\bar{q}g$



$t \to Wbg$

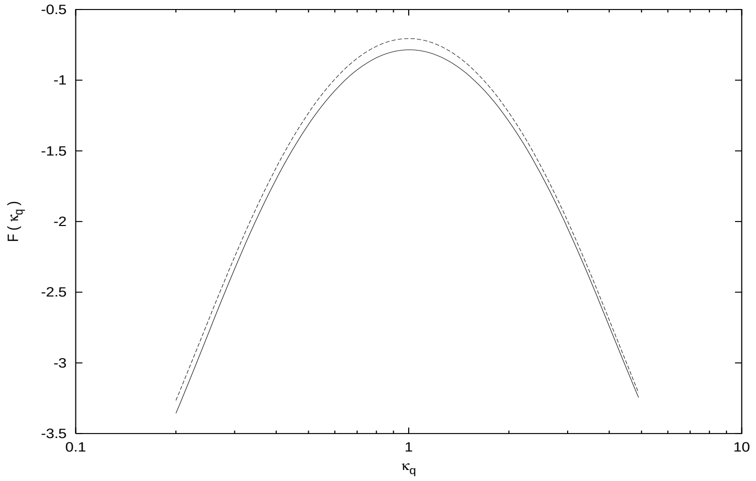


Discrepency between Matrix Element and Parton Shower

The parton shower approximation must cover the divergences and overestimates the matrix element.

$$\int_{\mathrm{Jets+D}} d^2(ME) - \int_{\mathrm{Jets}} d^2(PS) \equiv \frac{\alpha_s}{2\pi} C_F F_V(\tilde{\kappa})$$

$e^+e^- \to q\bar{q}g$



$t \to Wbg$