Leading Hadronisation Corrections

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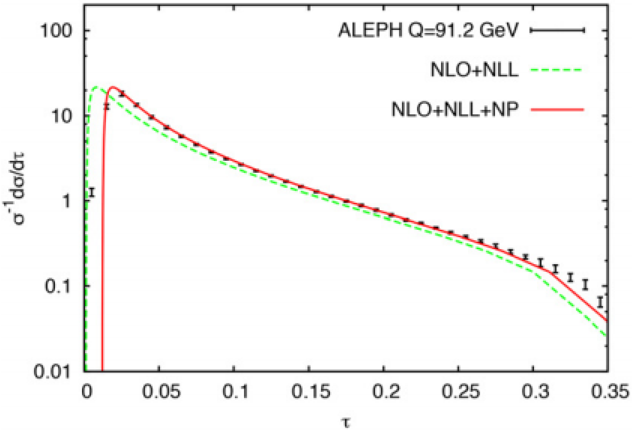
Aim:

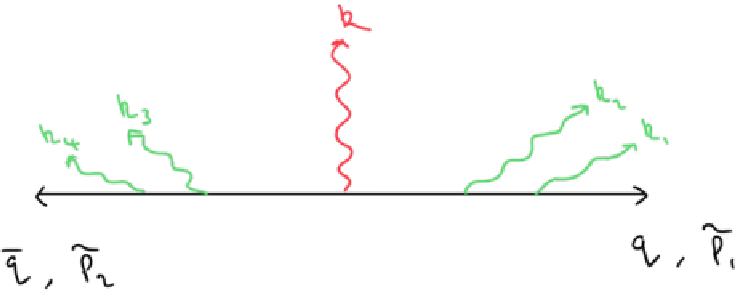
Introduce a new method to compute leading hadronisation corrections to two-jet event shapes in e^+e^- annihilation.

Hadronisation provides a shift in perturbative event-shape distributions:



Ansatz:

The leading hardonisation corrections are due to the emission of a non-perturbative gluon with momentum k:



For a general final-state observable, V, in in e^+e^- annihilation, the full integrated cross-section is given by:

$$\Sigma(v) = \Sigma_{\mathrm{PT}}(v) + \delta\Sigma_{\mathrm{NP}}(v)$$

where:

$$\Sigma_{\mathrm{PT}}(v) = \int d\mathcal{Z}\left[\{\tilde{p}\}, \{k_i\}\right] \Theta\left(v - V\left(\{\tilde{p}\}, \{k_i\}\right)\right)$$

and:

$$\delta\Sigma_{\mathrm{NP}} = \int d\mathcal{Z}\left[\{\tilde{p}\}, \{k_i\}\right] \int [dk] M^2_{\mathrm{NP}}(k)$$
$$\times \left[\Theta\left(v - V\left(\{\tilde{p}\}, k, \{k_i\}\right)\right) - \Theta\left(v - V\left(\{\tilde{p}\}, \{k_i\}\right)\right)\right]$$

We find that:

$$\delta\Sigma_{\rm NP} = -\int d\mathcal{Z}\left[\{\tilde{p}\},\{k_i\}\right]\int [dk] M^2_{\rm NP}(k)\,\delta V_{\rm NP}\left(\{\tilde{p}\},k,\{k_i\}\right)\delta(v - V\left(\{\tilde{p}\},\{k_i\}\right)$$
$$= -\left\langle \delta V_{\rm NP}\right\rangle \frac{d\Sigma_{\rm PT}}{dv}$$

with:

$$\delta V_{\rm NP}\left(\{\tilde{p}\},k,\{k_i\}\right) \equiv V\left(\{\tilde{p}\},k,\{k_i\}\right) - V\left(\{\tilde{p}\},\{k_i\}\right)$$

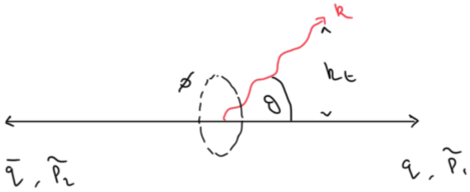
and:

$$\left\langle \delta V_{\rm NP}\right\rangle \equiv \frac{\int [dk] M^2_{\rm NP}(k) \int d\mathcal{Z}\left[\{\tilde{p}\},\{k_i\}\right]\,\delta V_{\rm NP}\left(\{\tilde{p}\},k,\{k_i\}\right)\delta(v - V\left(\{\tilde{p}\},\{k_i\}\right)}{\int d\mathcal{Z}\left[\{\tilde{p}\},\{k_i\}\right]\delta(v - V\left(\{\tilde{p}\},\{k_i\}\right)}$$

Therefore:

$$\Sigma(v) = \Sigma_{\rm PT}(v) - \left\langle \delta V_{\rm NP}\right\rangle \frac{d\Sigma_{\rm PT}}{dv}$$
$$= \Sigma_{\rm PT}\left(v - \left\langle \delta V_{\rm NP}\right\rangle\right)$$

We are able to make use of 2 key points:



Soft and Collinear Emissions:

$$\delta V_{\mathrm{NP}}\left(\{\tilde{p}\}, k, \{k_i\}\right) = \frac{k_t}{Q} f_{\mathrm{V}}\left(\eta, \phi, \{k_i\}\right)$$

Local Parton Hadron Duality:

$$[dk]\, M^2_{\mathrm{NP}}(k) \sim \frac{dk_t}{k_t} M^2_{\mathrm{NP}}(k_t) d\eta \frac{d\phi}{2\pi}$$

We therefore find that:

$$\langle \delta V_{\mathrm{NP}} \rangle = \frac{\langle k_t \rangle_{\mathrm{NP}}}{Q} c_V$$

where:

$$\langle k_t \rangle_{\mathrm{NP}} = \int dk_t \, M^2_{\mathrm{NP}}(k_t)$$

and:

$$\boxed{c_V \equiv \frac{\int d\eta \frac{d\phi}{2\pi} \int d\mathcal{Z}_{\mathrm{sc}} \left[\{\tilde{p}\}, \{k_i\}\right] f_{\mathrm{V}}\left(\eta, \phi, \{k_i\}\right) \delta\left(1 - \frac{V_{\mathrm{sc}}(\{\tilde{p}\},\{k_i\})}{v}\right)}{\int d\mathcal{Z}_{\mathrm{sc}} \left[\{\tilde{p}\}, \{k_i\}\right] \delta\left(1 - \frac{V_{\mathrm{sc}}(\{\tilde{p}\},\{k_i\})}{v}\right)}}$$

with:

$$\int d\mathcal{Z}_{\mathrm{sc}}[\{\tilde{p}\}, \{k_i\}] \, G(\{k_i\}) = e^{-\int [dk] M^2(k)} \sum_n \prod_{i=1}^{n} \int [dk_i] M^2(k_i) G(k_1, \ldots, k_n)$$