

Exercises “Physics at LHC” (sheet 2)

Event shapes:

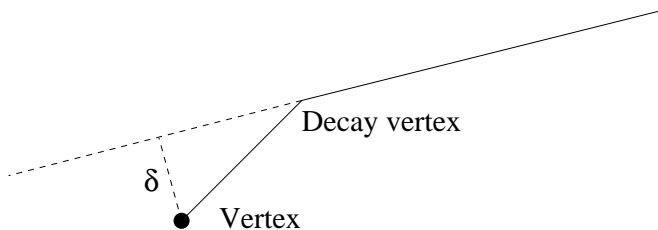
In the e^+e^- rest frame thrust and sphericity are given by

$$T = \max_{\vec{n}_T} \frac{\sum_i |\vec{p}_i \cdot \vec{n}_T|}{\sum_i |\vec{p}_i|} \quad S = \frac{3}{2} \min_{\vec{n}_S} \frac{\sum_i |\vec{p}_i \times \vec{n}_S|^2}{\sum_i |\vec{p}_i|^2}$$

where \vec{n}_T and \vec{n}_S are unit vectors

1. Show that $S = \frac{3}{2}(\lambda_2 + \lambda_3)$ where $\lambda_1 \geq \lambda_2 \geq \lambda_3$ are the eigenvalues of the matrix $S^{\alpha\beta} = \frac{\sum_i p_i^\alpha p_i^\beta}{\sum_i |\vec{p}_i|^2}$.
2. Are T,S infrared and collinear safe?
3. Show that $T = 1, S = 0$ for $e^+e^- \rightarrow q\bar{q}$, $T = \frac{2}{3}, S = \frac{3}{4}$ for $e^+e^- \rightarrow q\bar{q}g$ with $|p_q| = |p_{\bar{q}}| = |p_g|$, $T = \frac{1}{2}, S = 1$ for isotropic $e^+e^- \rightarrow q\bar{q}gg\dots$

Impact parameter:



The impact parameter is defined as the distance of the (extrapolated) track parameter to the primary vertex.

1. A particle has a mass m , an energy E and a lifetime τ . What is its mean decay length?
2. Show that under the assumption $\beta = 1$ the impact parameter is of order $\delta \sim c\tau$ independent of the particle energy. (Assume e.g. that the particle undergoes a symmetric decay into two massless particles)