PARTON SHOWER EVOLUTION
AT THE AMPLITUDE LEVEL

Fernando Torre González
Supervised by Jeff Forshaw and Simon Plätzer
Parton showers model the cascade of QCD radiation that occurs from coloured high-energy particles

- Angular ordered shower: up to NLL accuracy of global, two-jet observables but it fails beyond the two-jet limit or for non-global observables.

- Dipole shower: accurate for global and non-global observables, only up to LL and LC
Real emissions and virtual exchanges factorise in the soft kinematic limit

\[ |H\rangle \]

\[ D^\mu |H\rangle \]

\[ D_i^\mu = \sum_j t_j E_i \frac{p_j^\mu}{p_j \cdot q_i} \]

\[ \Gamma |H\rangle \]

\[ \Gamma = \frac{\alpha_s}{\pi} \sum_{i<j} (-T_i \cdot T_j) \left\{ \int \frac{d\Omega_k}{4\pi} \omega_{ij}(k) - i\pi \delta_{ij} \right\} \]
Real emissions and virtual exchanges factorise in the soft kinematic limit

\[ |H\rangle \]

\[ \mathbf{D}^\mu |H\rangle \]

\[ \mathbf{D}_i^\mu = \sum_j T_j E_i \frac{p_j^\mu}{p_j \cdot q_i} \]

\[ \Gamma |H\rangle \]

\[ \Gamma = \frac{\alpha_s}{\pi} \sum_{i<j} (-\mathbf{T}_i \cdot \mathbf{T}_j) \left\{ \int \frac{d\Omega_k}{4\pi} \omega_{ij}(k) - i\pi \delta_{ij} \right\} \]

Gell-Mann basis

\[
\lambda_1 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \lambda_2 = \begin{pmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \lambda_3 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{pmatrix}, \quad \lambda_4 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}, \quad \lambda_5 = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}, \quad \lambda_6 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \sqrt{3} & 0 \\ 0 & 0 & 0 \end{pmatrix}
\]

Colour Flow Basis
Colour evolution: real emissions

\[ T_i = \lambda_i t_{c_i} + \bar{\lambda}_i \bar{t}_{c_i} - \frac{1}{N_c} (\lambda_i - \bar{\lambda}_i) s \]

\[ t_{c_i} \text{ or } t_{\sigma(c_i)} \]

(A)

(B)
An example of colour evolution

1. [ρ]
2. [ρ D τ]
3. [τ V σ]
4. [σ H ̄σ]
5. ⟨σ V† τ⟩
6. ⟨τ D† ̄ρ⟩
7. ̄ρ

(A) Breakdown of the jet veto cross section by multiplicity and colour order, for the process singlet $\rightarrow q\bar{q}$.

(B) Breakdown of the jet veto cross section by multiplicity and colour order, for the process singlet $\rightarrow gg$.

Figures from Matthew de Angelis’ doctoral thesis at UoM