Parton shower Sudakov $\Delta_a(\mu_h, \mu_s)$

Check in PYTHIA8 (reproduce results Nagy and Soper, *arXiv:2002.04125*).
No-emission probability:

$$\Pi(\mu_s^2, \mu_h^2, x) = \exp\left\{ -\int_{\mu_s^2}^{\mu_h^2} \frac{d\mu^2}{\mu^2} \int \frac{dz}{z} \frac{\alpha_s(\mu^2)}{2\pi} \hat{P}(z) \frac{f(x/z, \mu^2)}{f(x, \mu^2)} \right\} \tag{1}$$

The perturbative no-emission probability:

$$\Pi_{pert}(\mu_s^2, \mu_h^2, x) = \exp\left\{ -\int_{\mu_s^2}^{\mu_h^2} \frac{d\mu^2}{\mu^2} \int dz \frac{\alpha_s(\mu^2)}{2\pi} \hat{P}(z) \right\}, \tag{2}$$

Their relation is:

$$\Pi_{pert}(\mu_s^2, \mu_h^2, x) = \frac{f(x, \mu_s^2)}{f(x, \mu_h^2)} \Pi(\mu_s^2, \mu_h^2, x) \tag{3}$$

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PDF property:

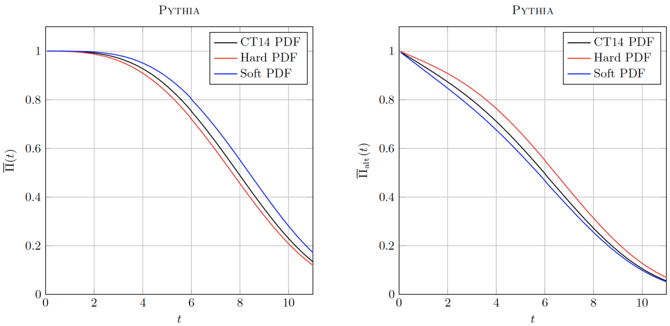
$$\Pi_{alt}(\mu_s^2, \mu_h^2, x) = \frac{f(x,\mu_h^2)}{f(x,\mu_s^2)} \Pi(\mu_s^2, \mu_h^2, x) \quad (4)$$

$$\stackrel{?}{=} \exp\left\{ - \int_{\mu_s^2}^{\mu_h^2} \frac{d\mu^2}{\mu^2} \int dz \frac{\alpha_s(\mu^2)}{2\pi} \hat{P}(z) \right\} \quad (5)$$

$$\stackrel{?}{=} \Delta_a(\mu_h^2, \mu_s^2) \quad (6)$$

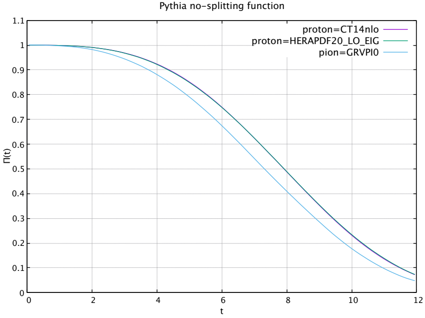
- The alternative no-emission probability should not depend on the PDFs to reproduce the correct Sudakov.
- Procdure:
  - Determine scale of 1st emission in the backward shower
  - Fill histograms for Π and Π_{alt}

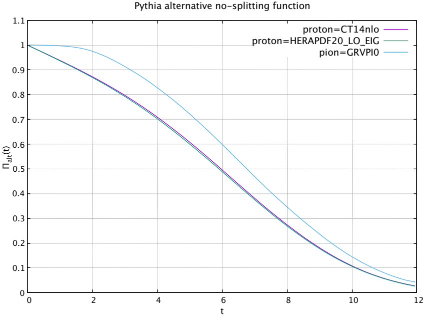
Evolution of parton showers and parton distribution functions, Z. Nagy and D.E. Soper, arXiv:2002.04125 [hep-ph]



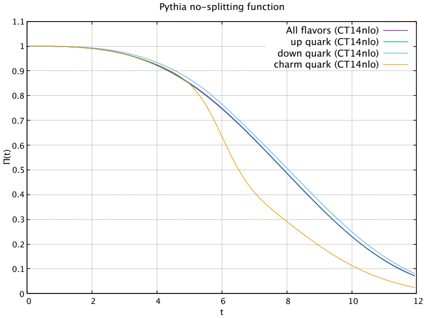
Conclusion: "Differences in the alternative no-emission probability (right) are not much smaller than the differences in the no-emission probability (left)."
$\Rightarrow$ PDF property does not hold.

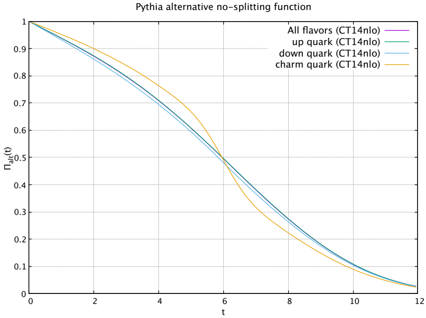
Test with proton and pion PDFs





Test with all flavours and single flavour selection





Generate Drell-Yan events using PYTHIA8 with an e^+e^- mass range of: 2500 GeV $< \mu_h <$ 2700 GeV.

- Starting scale of the shower is μ_h
- Scale of the first splitting μ_s
- 'Shower time':

$$t = \ln(\mu_h^2/\mu_s^2)$$

PYTHIA:

- determine the t of the first splitting in an event
- calculate the following quantities of the shower:
  - Probability for first splitting at t: $\rho(t)$
  - No-emission probability: $\Pi(t) = \int_\tau^\infty d\tau \rho(\tau)$
  - Alternative probability function: $\Pi_{alt}(t) = \frac{f(x,\mu_h^2)}{f(x,\mu_s^2)} \Pi(t)$