# CKKW-L merging in Pythia: Status report


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# General procedure for CKKW-L merging

- From the ME input, find all possible shower histories
- Pick one history according to the probability with which the shower would have produced it. Here, we try to stay as close as possible to Pythia.
- Generate the Sudakov factor by trial showering, reweight with $\alpha_s$ factors and PDF factors
- Combine reweighted histograms for all ME multiplicities to get distributions for ME+PS merging.

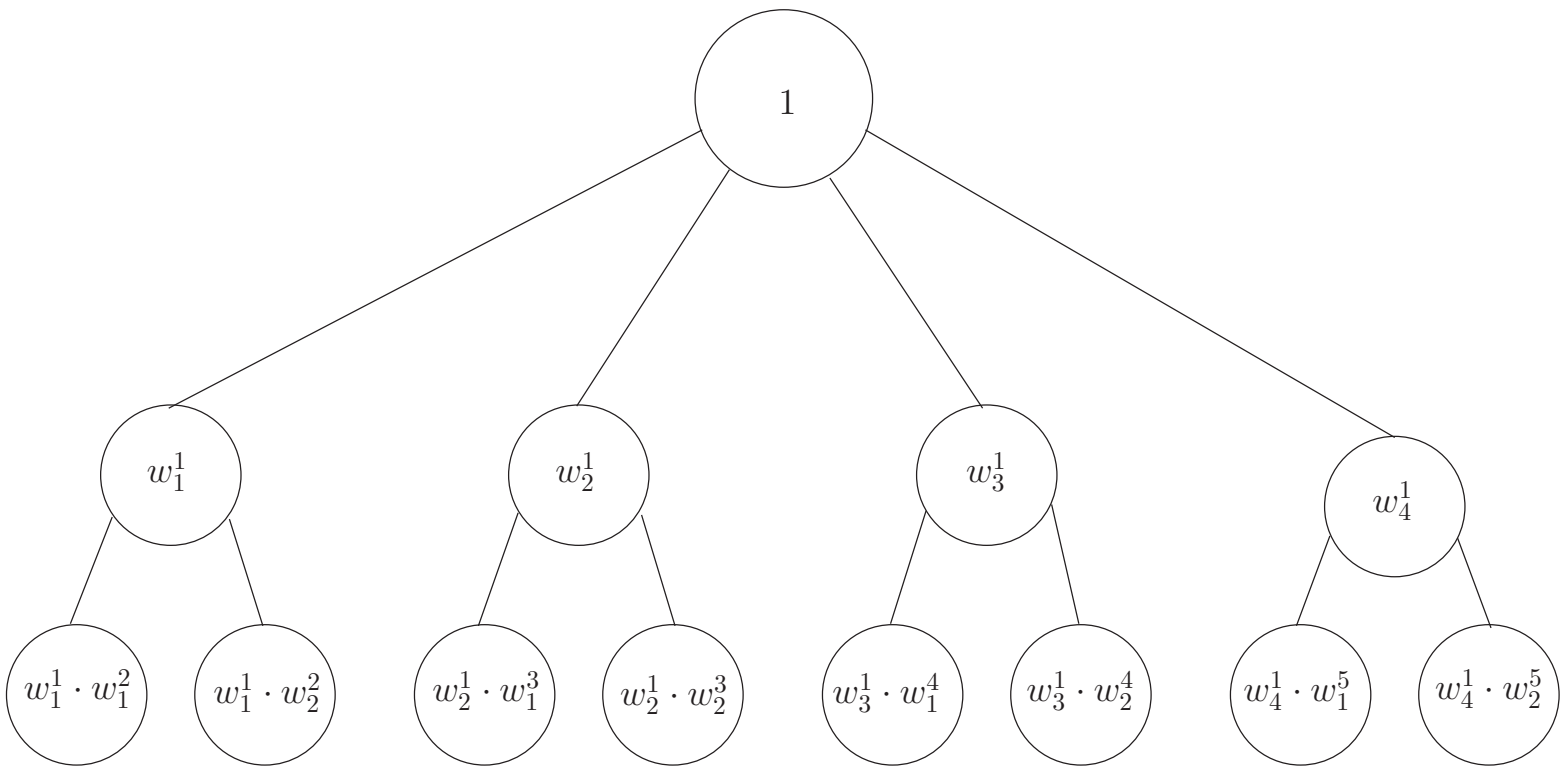
# How to choose a history?

What we don't have:

A shower history is basically a Feynman diagram $\Rightarrow$ For a certain event, choose the most probable diagram as history.

What we have:

We can assign each splitting a shower splitting probability and use the product of of splitting probabilities to guide us.



# Clustering final-final dipoles

For a final state dipole, a splitting happens with probability:

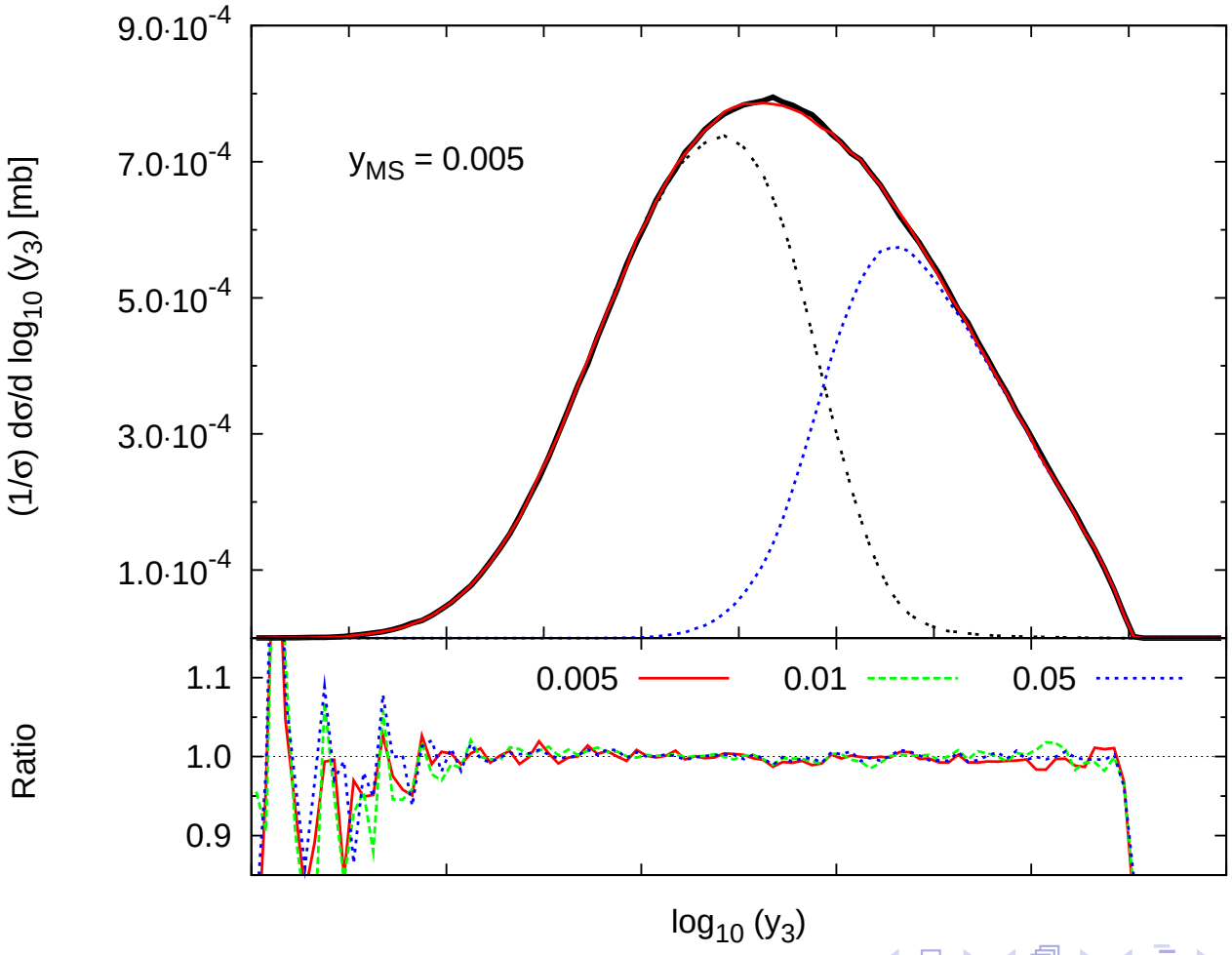
$$
\begin{aligned}
P_{\text{shower}} &= P_1(z_1)\,\frac{dp^2_{T,1}}{p^2_{T,1}}\,dz_1 \;+\; P_2(z_2)\,\frac{dp^2_{T,2}}{p^2_{T,2}}\,dz_2 \\
&= \left\{ \frac{N_1(z_1)}{Q_1^2}\cdot\frac{m^4_{Dip}}{Q_1^2+Q_2^2} + \frac{N_2(z_2)}{Q_2^2}\cdot\frac{m^4_{Dip}}{Q_1^2+Q_2^2} \right\} dx_1\,dx_2 \\
&\left( N_i(z_i) = P_i(z_i)\cdot(1-z_i) \right)
\end{aligned}
$$

where $x_1(x_2)$ is the three-particle energy fraction of the emittor (recoiler) after the branching. Thus if we compare FSR-type histories to FSR-type histories, it is fine to index histories with weights

$$w_{1,2} = \frac{N_1(z_{1,2})}{Q^2_{1,2}}.$$

# $e^+e^- \longrightarrow$ jets merging results

$e^+e^- \longrightarrow$ jets merging is implemented and working. Three jet distributions can be checked against Pythia, since the first emission is correct there:



# $pp \longrightarrow W+$jets merging at LO

What is done so far

- Find all histories of reclusterings of final-final, final-initial and initial-initial dipole splittings
- Trial shower (= multiplying with no-emission probability)
- $\alpha_s$ reweighting

Still to do

- PDF ratio reweighting

# Clustering final-final and final-initial dipoles

A few slides ago, we found the probability weights for FSR-like clusterings

$$w_{1,2}^{\mathrm{FSR}} = \frac{N_1(z_{1,2})}{Q_{1,2}^2} \cdot \frac{m_{Dip}^4}{Q_1^2 + Q_2^2}$$

so that for comparing histories of FSR-like splittings, we could write

$$w_{1,2} = \frac{N_1(z_{1,2})}{Q_{1,2}^2}.$$

# Clustering initial-initial dipoles

For a initial state dipole, an ISR splitting happens with probability:

$$
\begin{aligned}
P_{\text{shower}} &= \frac{x_1' f(x_1', Q_1^2)}{x_1 f(x_1, Q_1^2)} P_1(z_1)\ \frac{dp_{T,1}^2}{p_{T,1}^2}\ dz_1 + \frac{x_2' f(x_2', Q_2^2)}{x_2 f(x_2, Q_2^2)} P_2(z_2)\ \frac{dp_{T,2}^2}{p_{T,2}^2}\ dz_2 \\
&= \left[ \frac{x_1' f(x_1', Q_1^2)}{x_1 f(x_1, Q_1^2)} \frac{N_1(z)}{Q_1^2}\ \frac{\hat{s}}{2} + \frac{x_2' f(x_2', Q_2^2)}{x_2 f(x_2, Q_2^2)} \frac{N_2(z)}{Q_2^2}\ \frac{\hat{s}}{2} \right] d|\cos\theta| dz \\
\Rightarrow \qquad w_{1,2}^{\text{ISR}} &= \frac{x_{1,2}' f(x_{1,2}', Q_{1,2}^2)}{x_{1,2} f(x_{1,2}, Q_{1,2}^2)} \frac{N_{1,2}(z)}{Q_{1,2}^2}\ \frac{\hat{s}}{2}
\end{aligned}
$$

where $\theta$ is the angle between emittor and radiated particle (in emittor+"recoiler" CM frame). Comparing ISR- to ISR-type histories, it is fine to index histories with weights

$$
w_{1,2} = \frac{x_{1,2}' f(x_{1,2}', Q_{1,2}^2)}{x_{1,2} f(x_{1,2}, Q_{1,2}^2)} \frac{N_1(z_{1,2})}{Q_{1,2}^2}.
$$

# Comparing probability weights of FSR to ISR clusterings

Need to compare apples and apples: Normalization of probability weights important $\Rightarrow$ Use

$$w_{1,2}^{\text{FSR}} = \frac{N_{1,2}(z_{1,2})}{Q_{1,2}^2} \cdot \frac{m_{Dip}^4}{Q_1^2 + Q_2^2} \quad , w_{1,2}^{\text{ISR}} = \frac{x'_{1,2} f(x'_{1,2}, Q_{1,2}^2)}{x_{1,2} f(x_{1,2}, Q_{1,2}^2)} \frac{N_{1,2}(z)}{Q_{1,2}^2} \frac{\hat{s}}{2}$$

to index a clustering in the history tree.
Before, we used

$$w_{1,2}^{\text{FSR, old}} = \frac{P_{1,2}(z_{1,2})}{Q_{1,2}^2} \quad , w_{1,2}^{\text{ISR, old}} = \frac{x'_{1,2} f(x'_{1,2}, Q_{1,2}^2)}{x_{1,2} f(x_{1,2}, Q_{1,2}^2)} \frac{P_{1,2}(z)}{Q_{1,2}^2},$$

which gave good results, since how to choose a shower history is a subleading effect. We'll investigate the impact of different presciptions.

# Conclusions: Status of CKKW-L merging in Pythia

- $e^+e^- \longrightarrow$ jets merging completed
- $pp \longrightarrow W+$jets merging at LO nearly done
- Next step: $pp \longrightarrow W+$jets merging at NLO

Thank you for your attention