Quarks and gluons in the Lund plane

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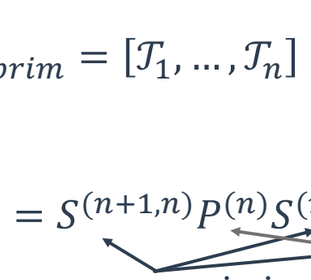
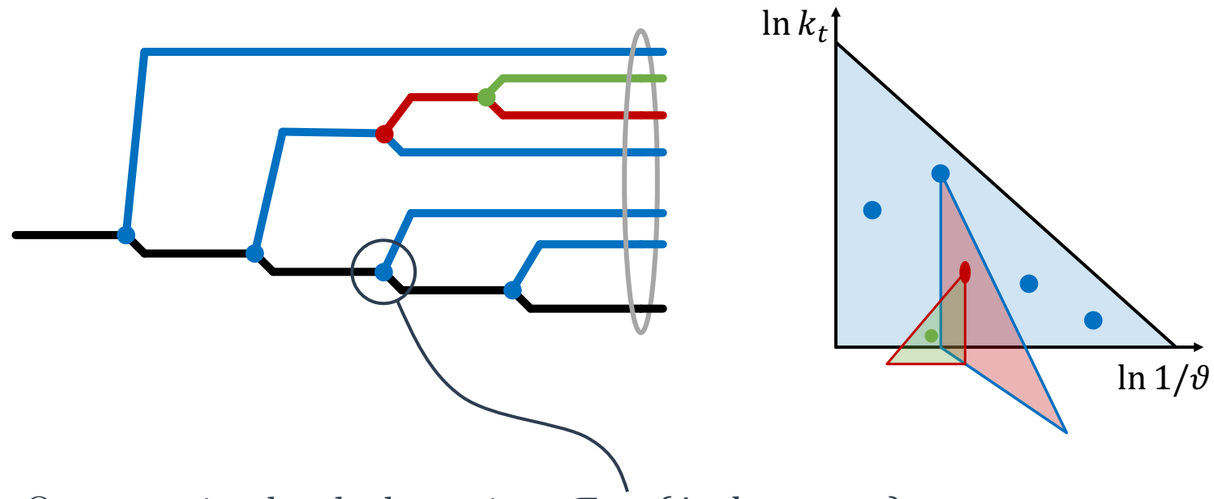
Based on arXiv:2112.09140



The jet Lund plane

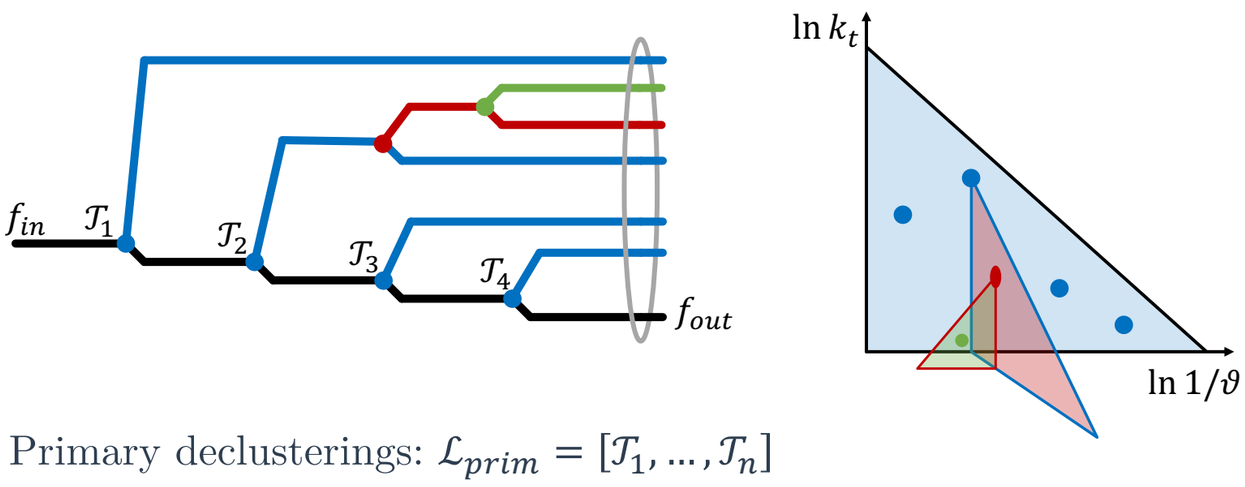
[F.Dreyer,G.Salam,G.Soyez, arXiv:1807.04758]

Cambridge/Aachen reclustering (angular ordering)



One step in the declustering: $\mathcal{T}_i = \{\Delta_i, k_{t,i}, z_i, \dots\}$

Primary Lund declusterings



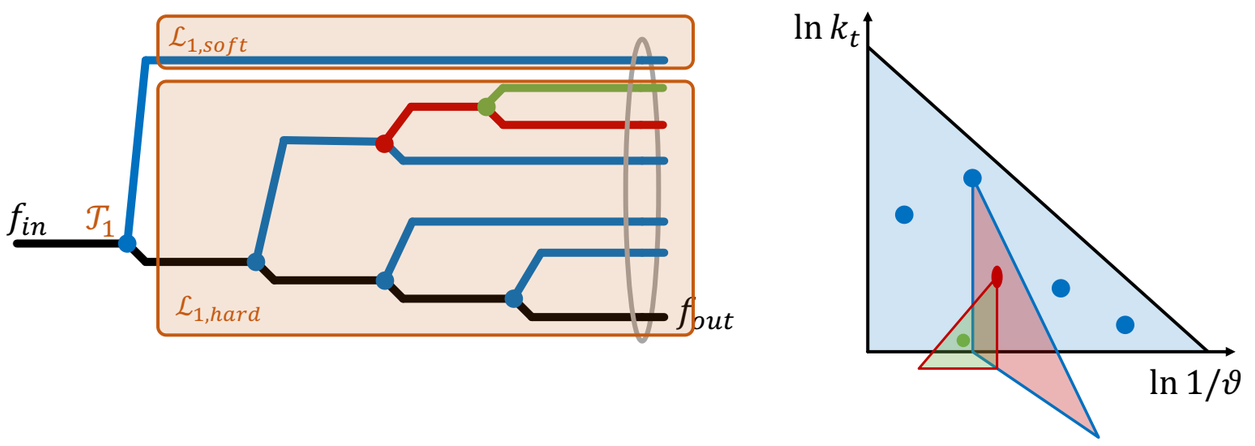
Primary declusterings: $\mathcal{L}_{prim} = [\mathcal{T}_1, \dots, \mathcal{T}_n]$

Probability of $\mathcal{L}_{prim}$:

$$p(\mathcal{L}_{prim}, f_{out}|f_{in}) = S^{(n+1,n)} P^{(n)} S^{(n,n-1)} \dots P^{(1)} S^{(1,0)}$$

no emission splitting

The Lund tree



Full tree (recursively):

$$\mathcal{L}_{tree}(j) = [\mathcal{T}_j, \mathcal{L}_{j,hard}, \mathcal{L}_{j,soft}]$$

The likelihood ratio

Optimal discriminants at NLL:

$$\mathbb{L}_{prim} = \frac{p_q(\mathcal{L}_{prim})}{p_g(\mathcal{L}_{prim})}$$

$$\mathbb{L}_{tree} = \frac{p_q(\mathcal{L}_{tree})}{p_g(\mathcal{L}_{tree})}$$

Ingredients to NLL:

- changing flavor
- collinear-hard emissions
- running coupling
- commensurate angle emissions

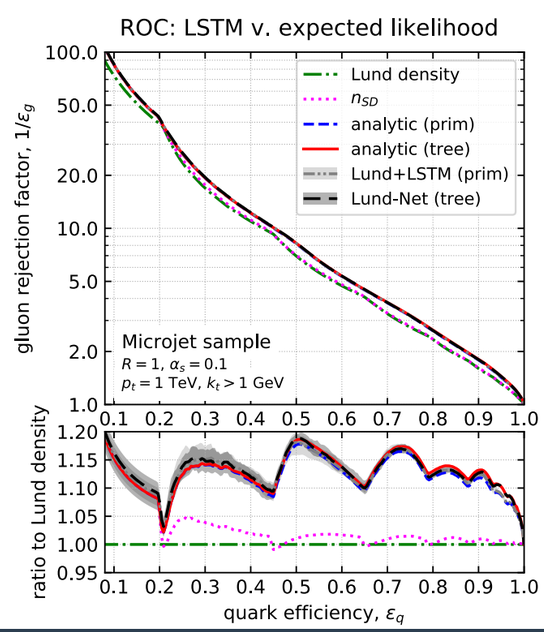
[A.Lifson,G.Salam,G.Soyez,2007.06578]

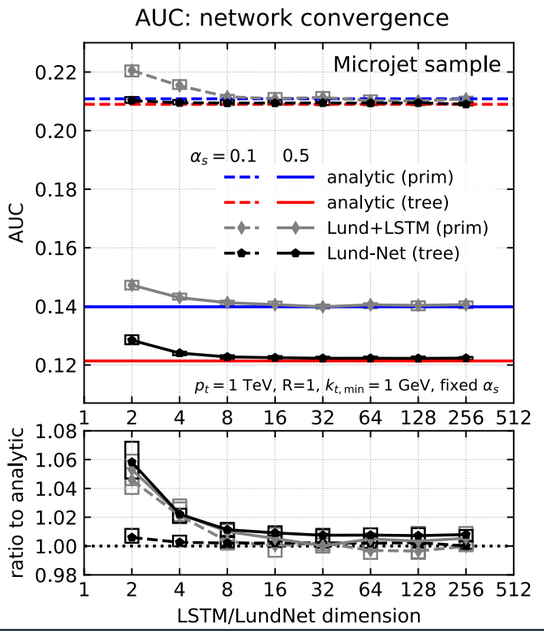
Machine Learning techniques:

1. LTSM network ($\mathcal{L}_{prim}$) [F.Dreyer,G.Salam,G.Soyez,1807.04758]
2. Lund-net graph network ($\mathcal{L}_{tree}$) [F.Dreyer,H.Qu,2012.08526]

Equivalence of ML and analytic

Collinear limit ⟶ ML = analytic!

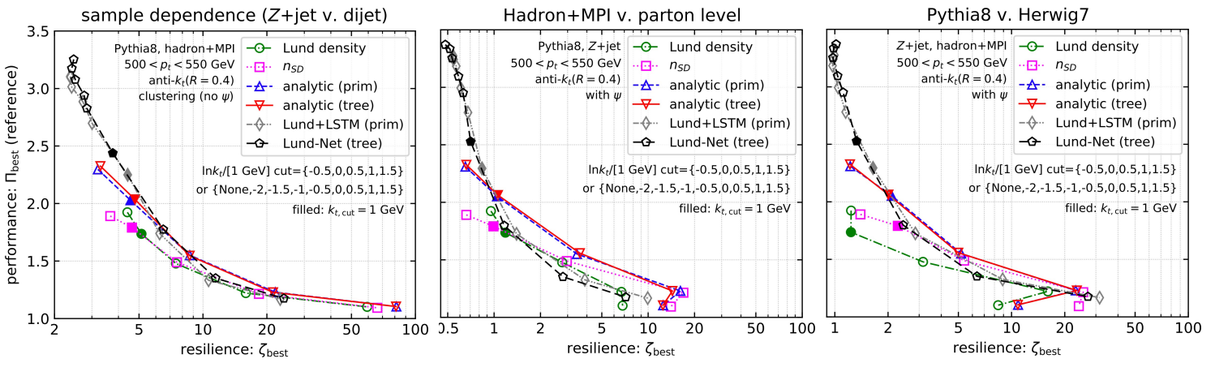




Equivalence of ML and NLL

Studies:

- sensitivity to the parton shower (Pythia8 vs. Herwig7)
- sensitivity to the hard process (dijet vs. Z+jet)
- sensitivity to non-perturbative effects (MPI, hadronization)

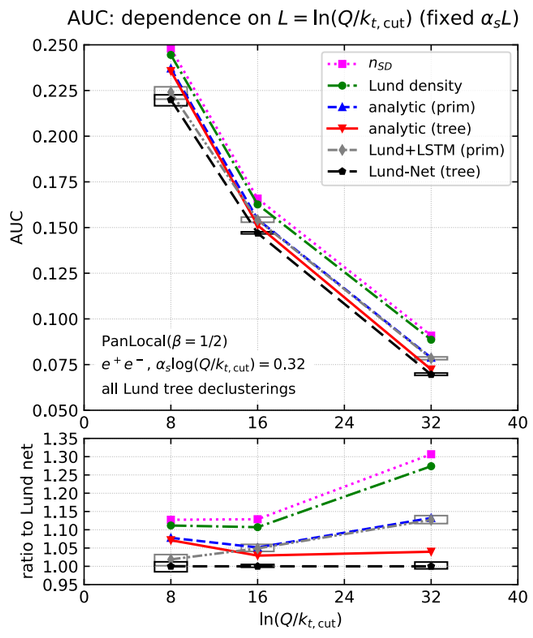


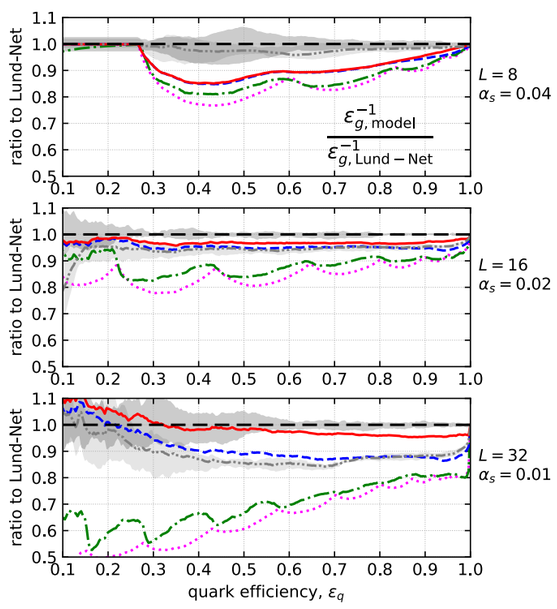
Lund-ML > Lund analytic > ISD

tree > primary > ISD

Equivalence of ML and NLL

PanScales NLL parton shower: ML ⟶ NLL [2002.11114]





Adam Takacs LHCP 2022 (online)