Understanding boosted top tagging with N-subjettiness and Prong Finding

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Work in progress

BOOST
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Introduction

- Tagging hadronically decaying top quarks, reconstructed as a single jet.
- Grooming, prong finding and jet shapes used in combination ((ATLAS 2016, CMS 2016))
- Understand what drives this type of tagging procedure
- Focus on Y_m-Splitter (M Dasgupta, M Guzzi, J Rawling, G Soyez, 2018) with a cut on the N-subjettiness ratio τ_{32} (J. Thaler, K, Tilburg 2011), and grooming with mMDT/ Soft drop (M. Dasgupta, A Fregoso, S Marzani, G Salam, 2013) (A. Larkoski, S Marzani, G Soyez, J. Thaler, 2014)
- Additional step of requiring jets to be within mass window 160 GeV $< m_{\text{jet}} < 225$ GeV

figure adapted from arXiv:1909.12285FERMILAB-PUB-19-492-CMS-E

Study the performance and impact of NP effects and UE

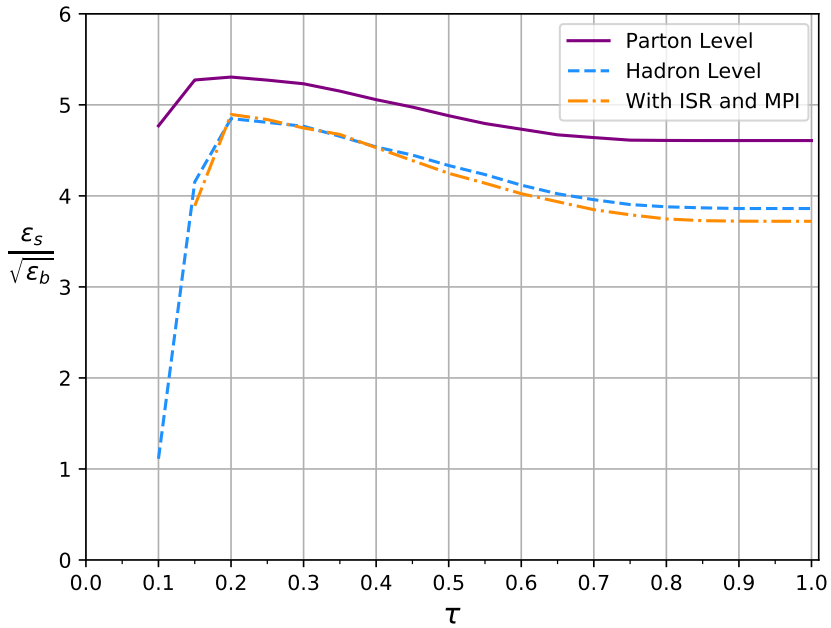
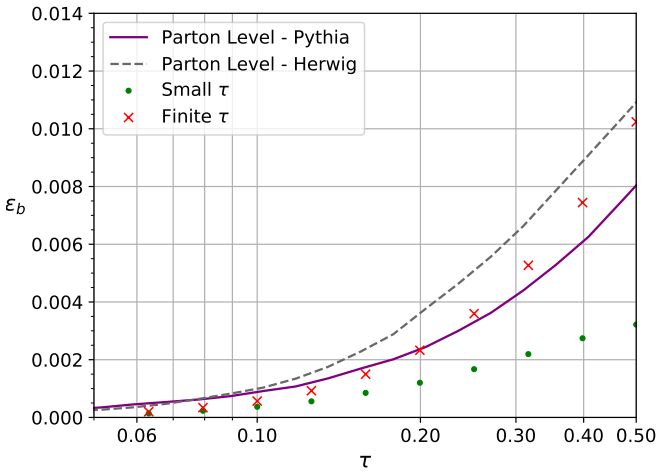


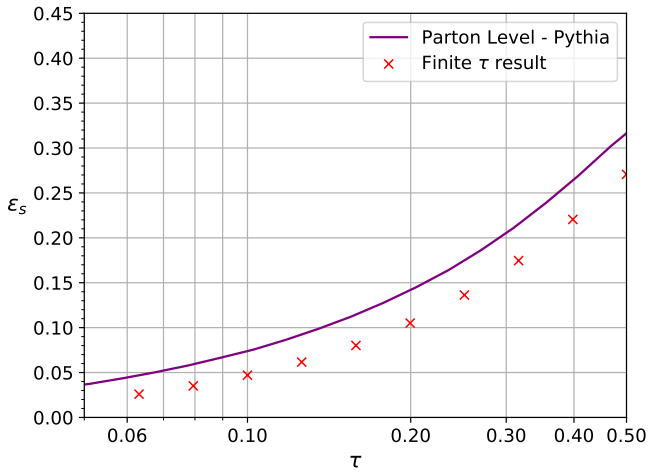
Figure 2: mMDT + Y_m-Splitter+ τ_{32}

- All three steps contribute to the performance
- Grooming and prong finding both necessary to reduce impact of NP effects and UE.

Analytic calculations for signal and background, accounting for finite τ effects.



Background: No Grooming.



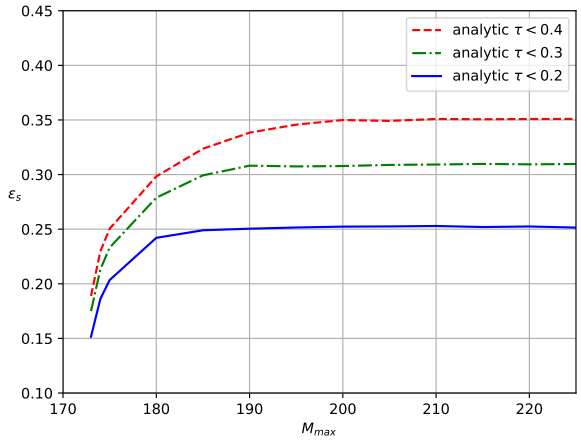
Signal: No Grooming

$$\text{Background} \propto \exp\left[-\frac{C_F\alpha_s}{2\pi}\ln^2\left(\rho_b\frac{\tau}{1-\tau}\right)\right]$$

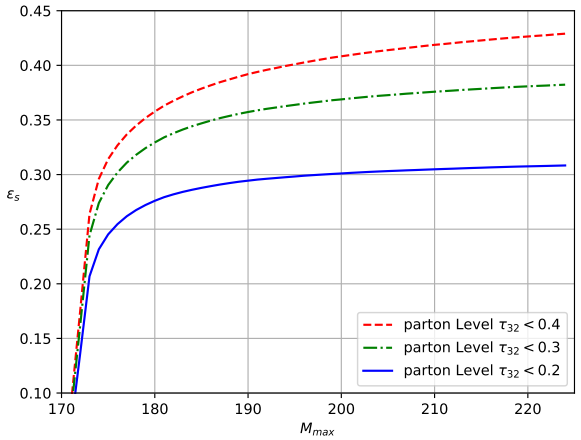
$$\text{Signal} \propto \exp\left[-\frac{C_F\alpha_s}{2\pi}\ln^2\left(\min(\rho_b\frac{\tau}{1-\tau}, \rho_{\text{max}}-\rho_{\text{top}})\right)\right]$$

Making the most of the jet mass

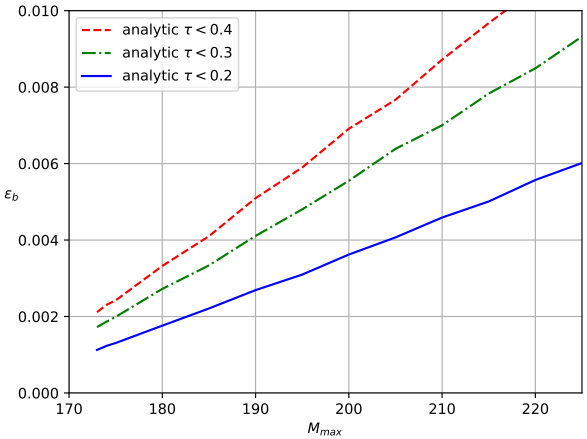
- Reducing M_{max} suppresses the background with very little effect on the signal



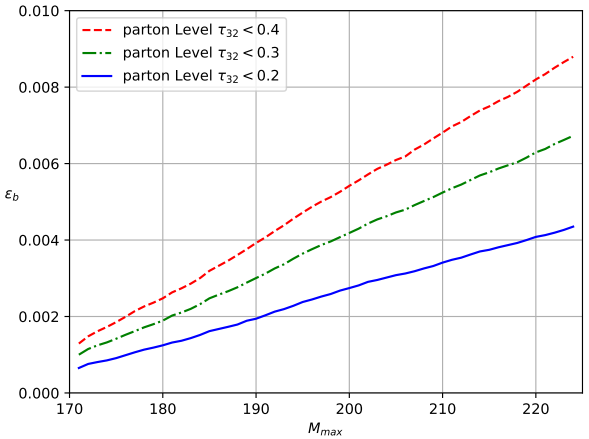
Top jets - Analytic



Top Jets - Pythia



Light quark jets - Analytic

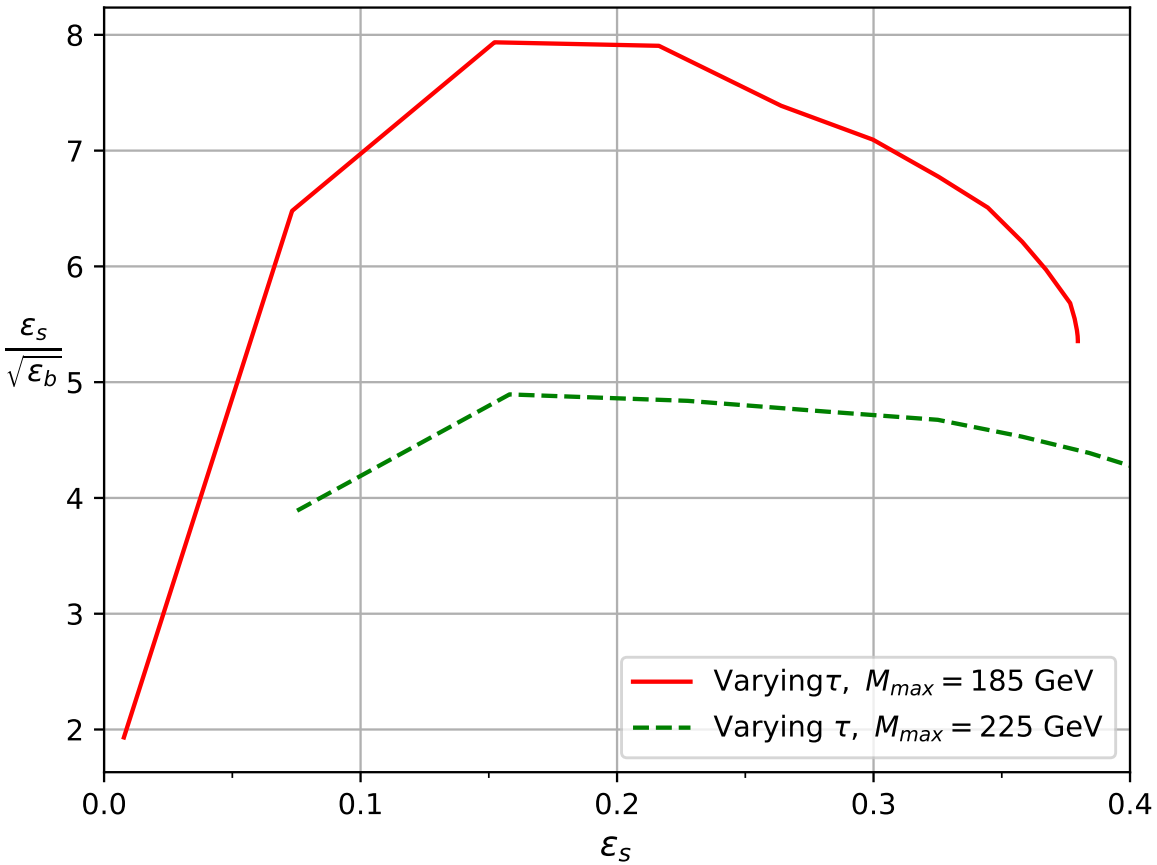


Light quark jets - Pythia

Jets Pre-groomed with mMDT.

Making the most of the jet mass

- This holds up at hadron level, leading to gains in signal significance.
- Hadronisation corrections $< 15\%$ for $M_{\text{max}} = 185$ GeV and $\tau = 0.4$.



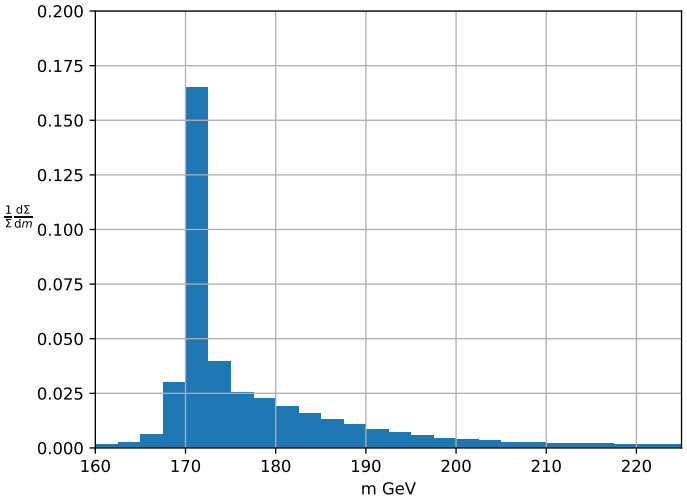
Hadron level jets with UE from Pythia, pre-groomed with mMDT, tagged with Y_m-Splitter and a cut on τ_{32}

Summary

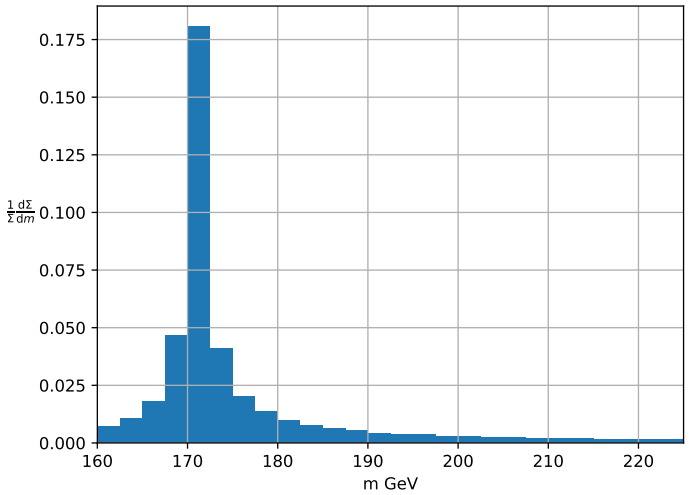
- mMDT + Y_m-Splitter + τ_{32} is an effective top-tagger and resilient to non-perturbative effects.
- Performed analytic calculations for both signal and background distributions
- Understood the interplay between mass and τ_{32} cuts allowed us to use the mass cut to greatest effect.

Backup Slides

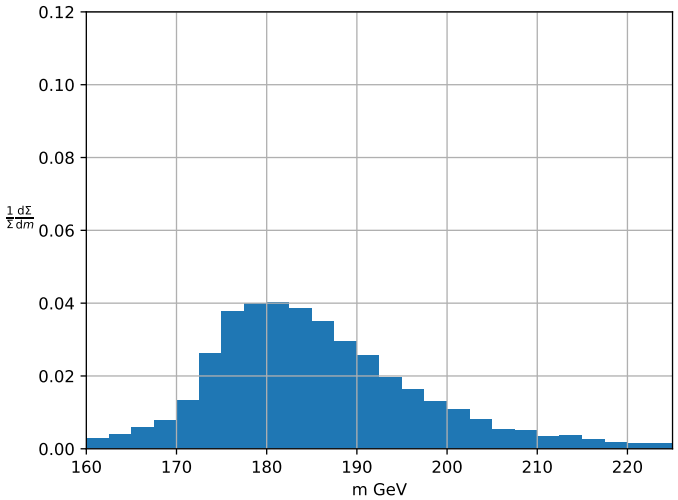
Top Mass Distribution



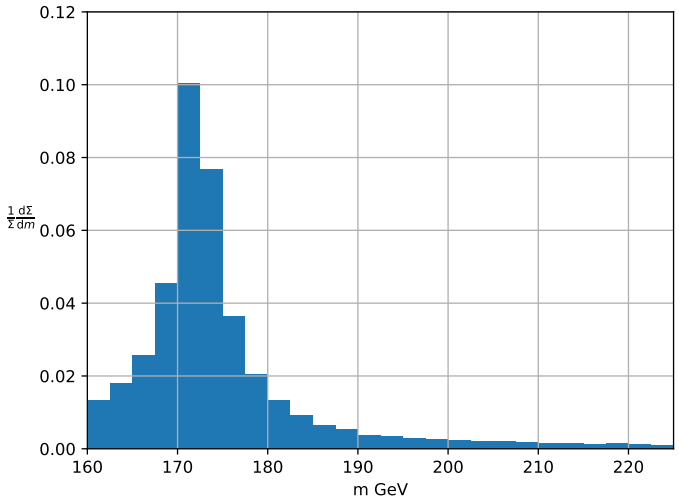
Parton Level, No ISR or MPI, Un-Groomed



Parton Level, No ISR or MPI, Groomed

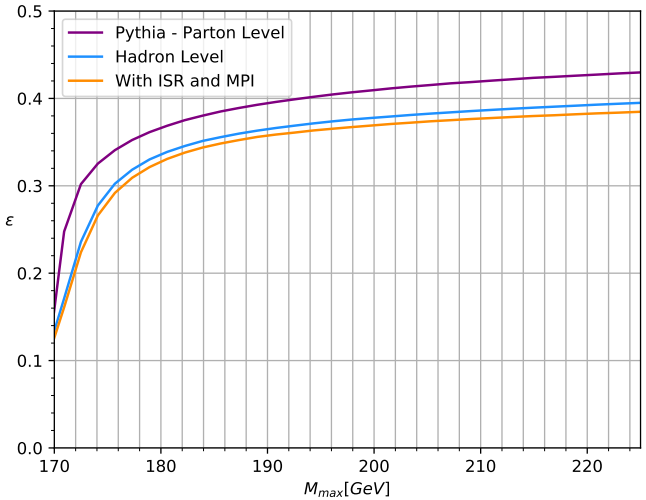


Hadron Level, with ISR and MPI, Un-Groomed

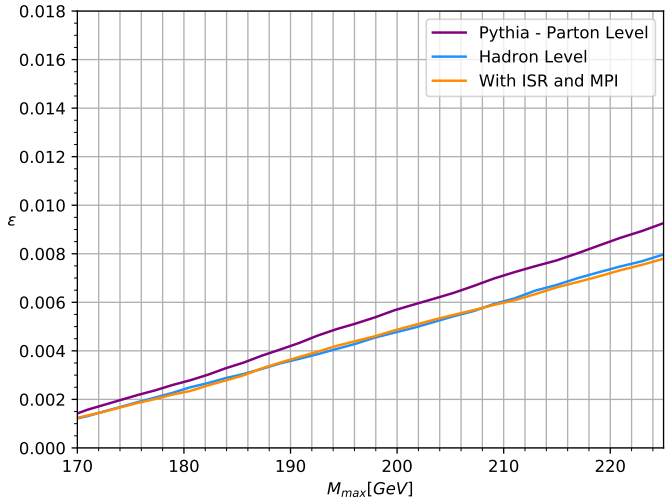


Hadron Level, with ISR and MPI, Groomed

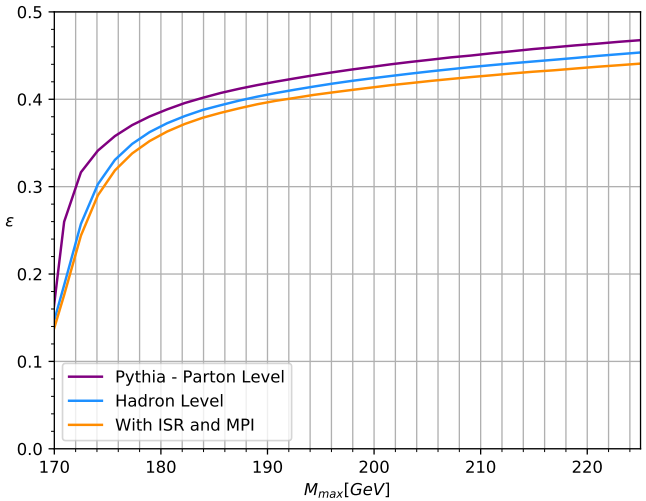
Hadronisation Corrections



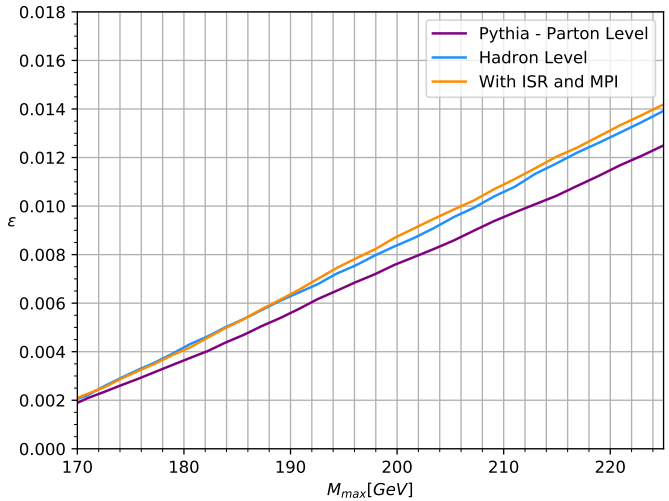
Top jets $\tau_{32} < 0.4$.



Light quark jets $\tau_{32} < 0.4$.



Top jets $\tau_{32} < 1$.



Light quark jets $\tau_{32} < 1$.