

Progress in SCET on b-jet substructure

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Energy Correlation Functions

- IRC safe observables and excellent discriminators for light quarks and gluon initiated jets. (**Moult, Necib, Thaler (2016)**)

$$\begin{aligned} U_1^\alpha &= \sum_{i,j} z_i z_j \theta_{ij}^\alpha \\ U_2^\alpha &= \sum_{i,j,k} z_i z_j z_k \min(\theta_{ij}, \theta_{jk}, \theta_{ik})^\alpha \end{aligned} \tag{1}$$

- Jets groomed with soft drop algorithm which gets rid of wide angle soft radiation.

$$\min(z_i, z_j) > z_{cut} \theta_{ij}^\beta \tag{2}$$

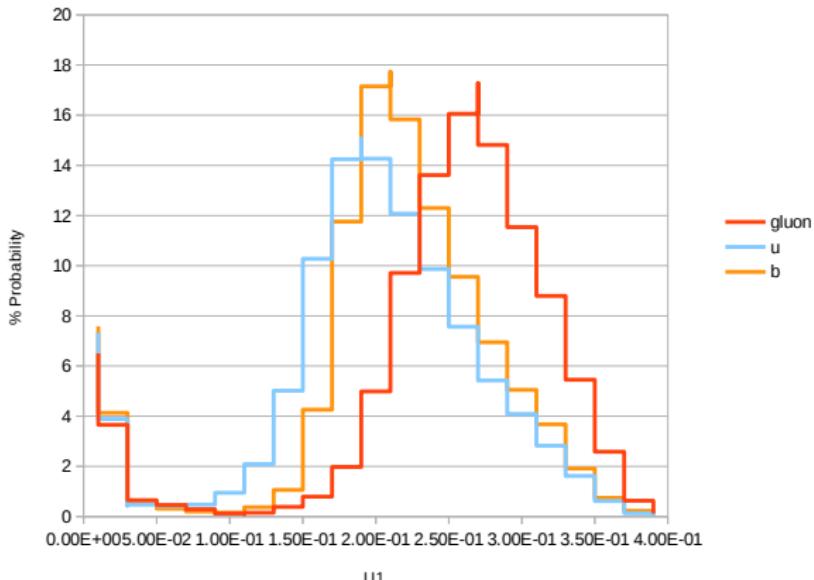
- Last time we discussed comparison of different U 's for light and heavy quark jet discrimination using MC simulations. We find the best discriminator to be groomed U_1 .

U1 for Ungroomed Jets

U1

Ungroomed Jets

$pT > 500 \text{ GeV}, R=0.6, \alpha=0.2$

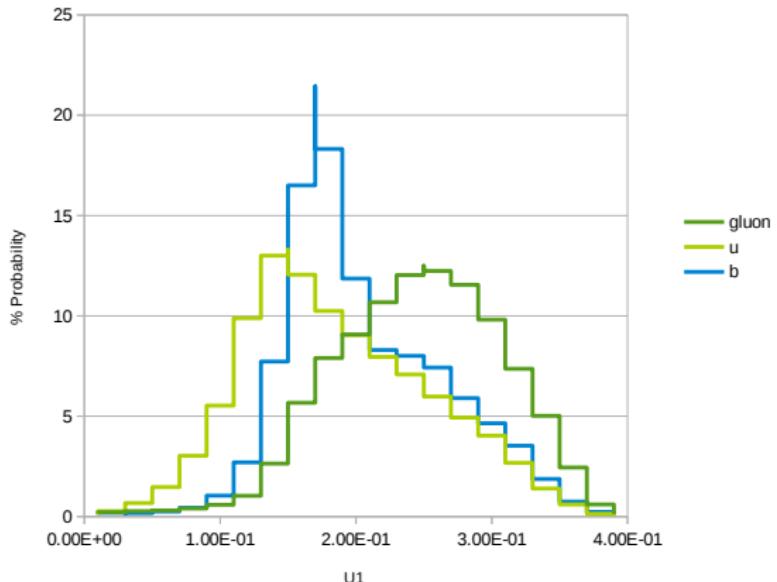


U1 for Groomed Jets

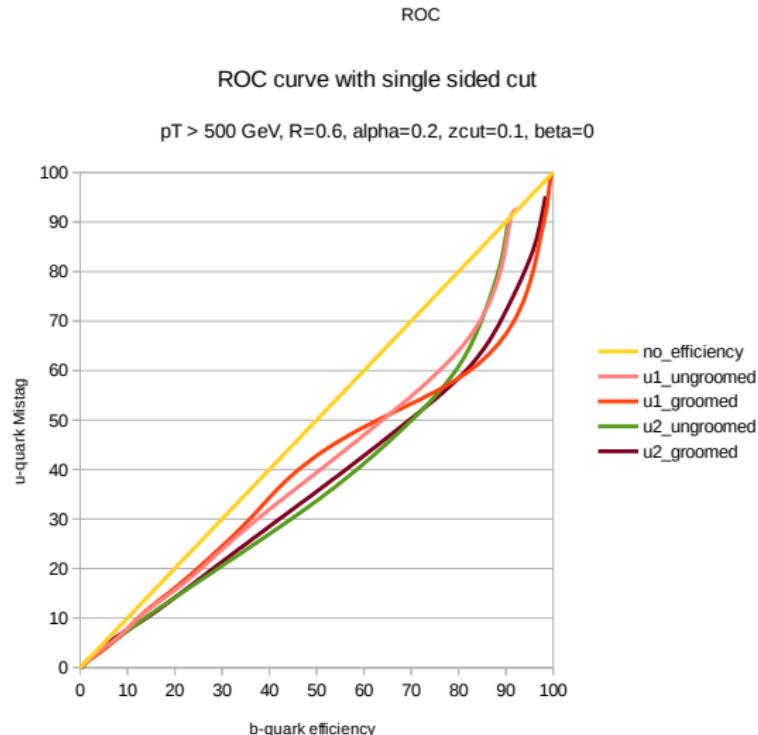
U1

Groomed Jets

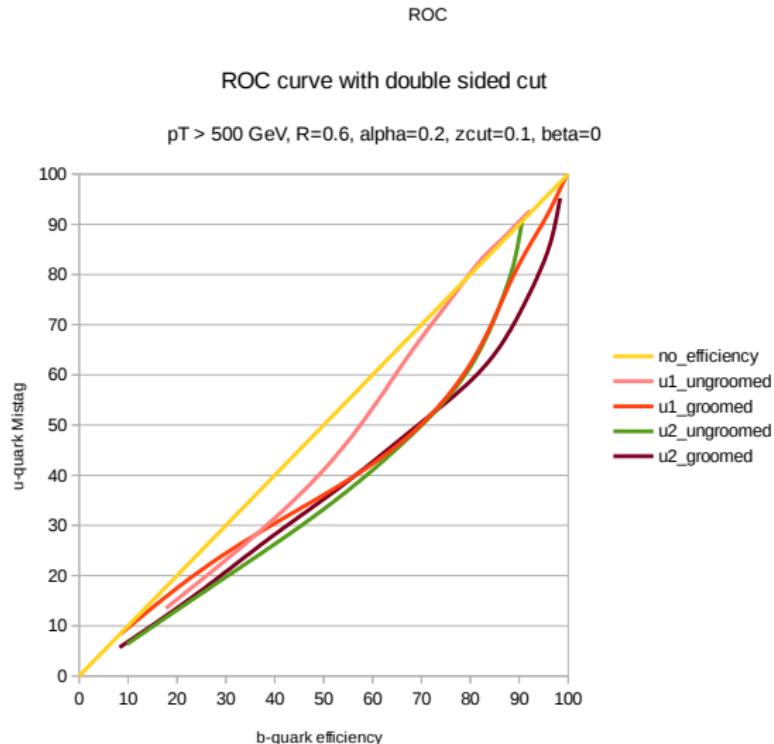
$pT > 500 \text{ GeV}, R=0.6, \alpha=0.2, z\text{cut}=0.1, \beta=0$



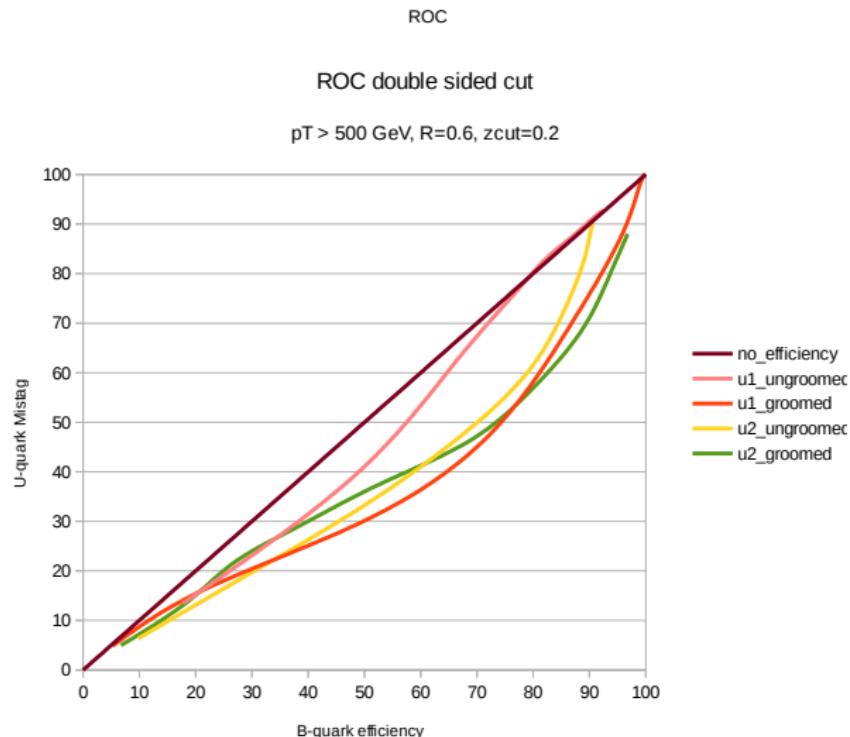
ROC curves for U1 vs U2



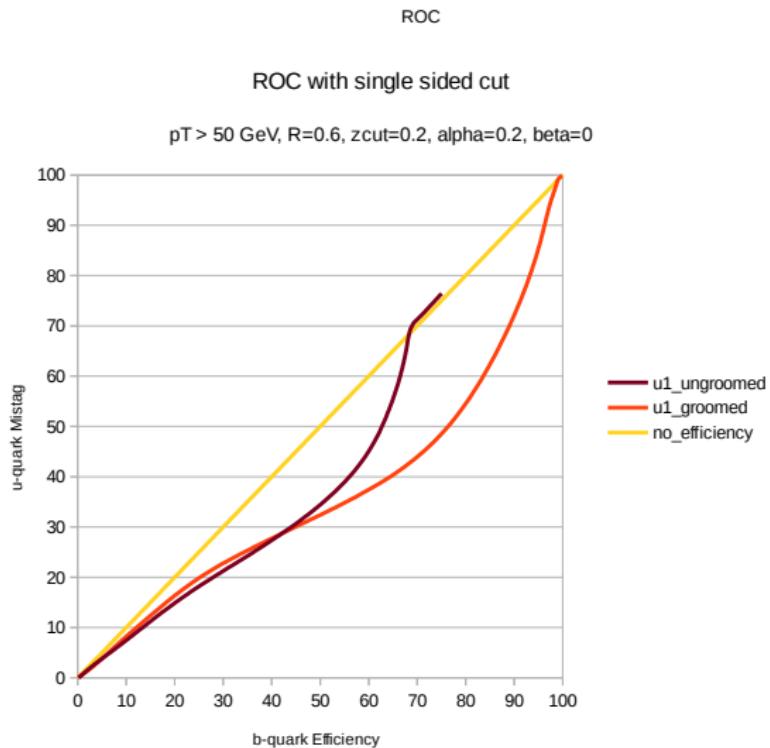
ROC curves for U1 vs U2



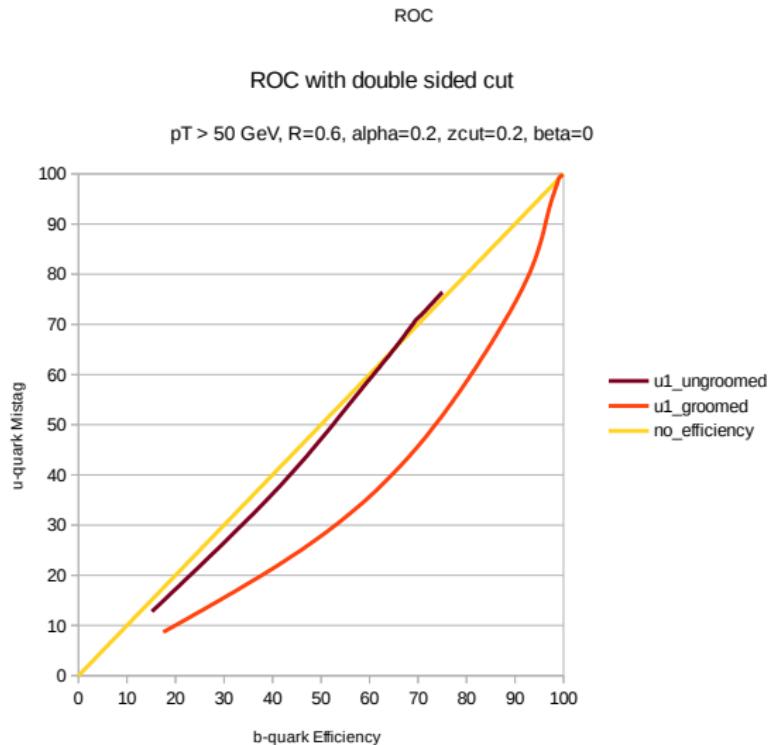
ROC curves for U1 vs U2 at $z_{cut} = 0.2$



ROC curves for low p_T jets

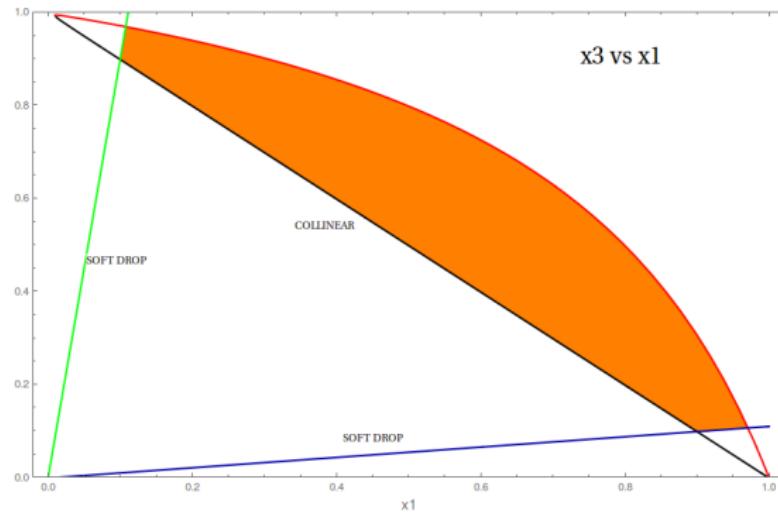


ROC curves for low p_T jets



Analytic Calculations

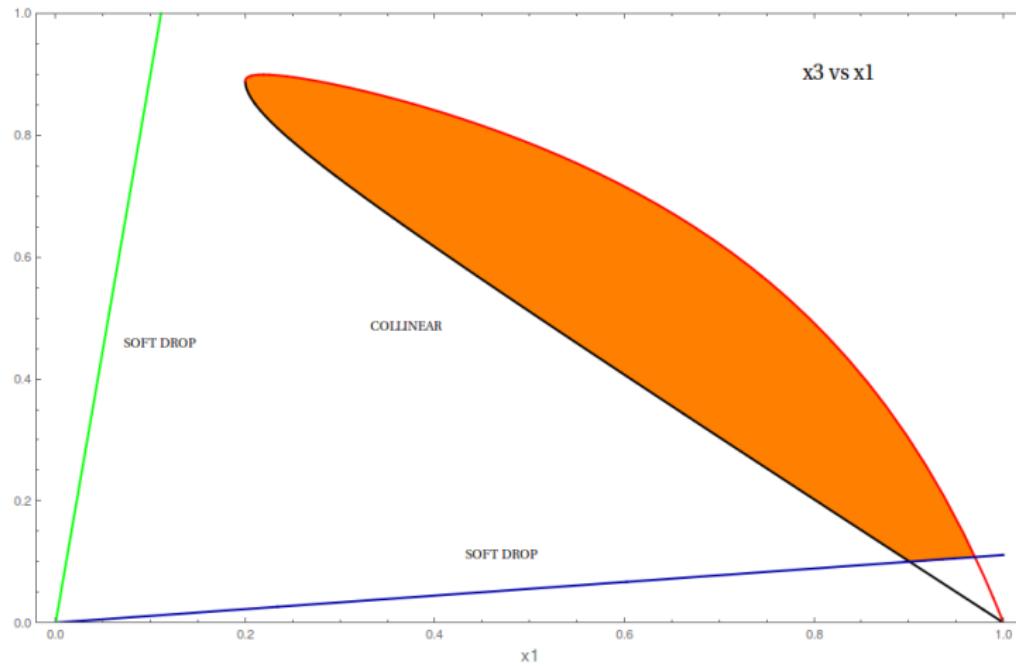
- So far we have completed calculations in full QCD for groomed U1 in $e^+e^- \rightarrow b\bar{b}g$.



- $x_i = \frac{E_i}{E_{cm}}$ is the ratio of energy of particles in CM frame. $E_{cm} = 1$ TeV

Analytic Calculations

- $E_{cm} = 50 \text{ GeV}$



Analytic Calculations

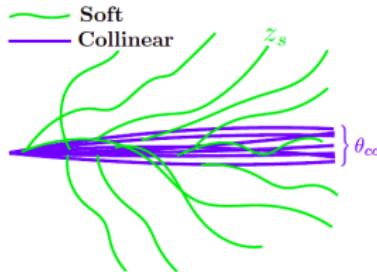
- The difference between heavy and light jets shows up as a log of mass of the heavy quark.
- Light quark jets in Laplace space for $U_1^\alpha \rightarrow \nu$, (**Frye, Larkoski, Schwartz, Yan (2016)**)

$$\frac{2}{\alpha} \left(\frac{3}{2} + \ln(z_{cut}) \right) \ln(\nu) \quad (3)$$

- while for b-jets

$$\frac{2}{\alpha} \left(\frac{3}{2} + \ln(z_{cut}) \right) \ln(m_b^2 \nu / s) \quad (4)$$

SCET Factorization



- Modes identified in SCET factorization are soft, collinear and collinear-soft. Hierarchy of modes depends on value of α .

$$\begin{aligned} p_s &\sim z_{cut} Q(1, 1, 1) \\ p_c &\sim Q \left(1, (U_1^\alpha)^{2/\alpha}, (U_1^\alpha)^{1/\alpha} \right) \\ p_{cs} &\sim z_{cut} Q \left(1, \left(\frac{U_1^\alpha}{z_{cut}} \right)^{2/\alpha}, \left(\frac{U_1^\alpha}{z_{cut}} \right)^{1/\alpha} \right) \end{aligned} \quad (5)$$

- Leading Log resummation in SCET and results for $pp \rightarrow Zb$. (in progress)