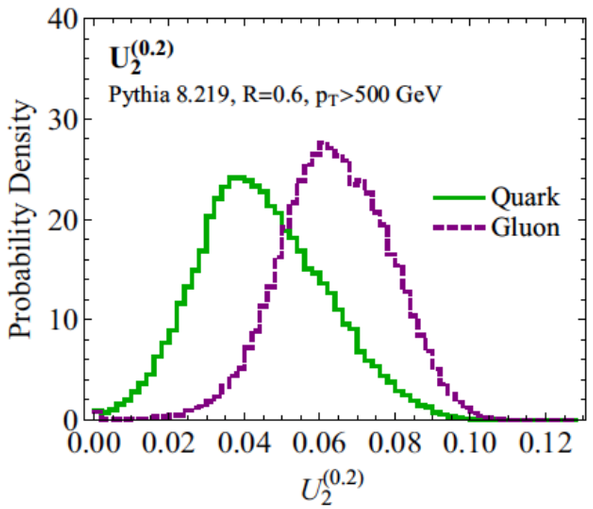
Goals: SCET for precision b-jet substructure

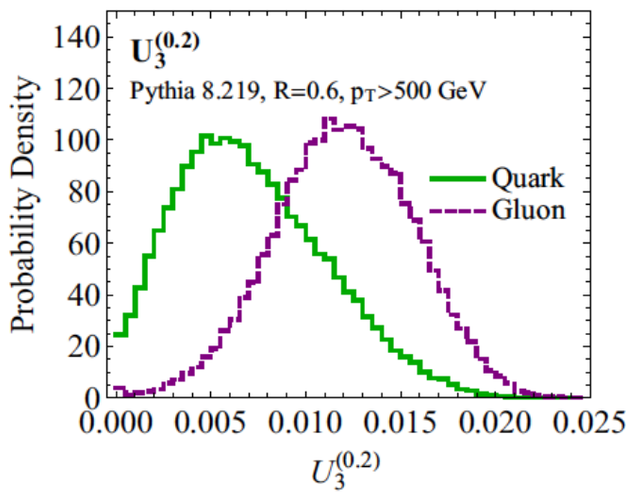
- This LDRD supported PhD student **Prashant Shrivastava** (Carnegie Mellon), who visited Jun-Aug 2017 and continues his collaboration with us.
- Collaborating also with DOE EC-funded postdoc **Varun Vaidya**

- We are applying two recent theoretical ideas in jet physics:
- *Generalized Energy Correlation Functions*
  - e.g. $U_1^{(\beta)} = \sum_{1 \le i < j \le n_J} z_i z_j \theta_{ij}^{\beta}$ Moult, Necib, Thaler (2016)

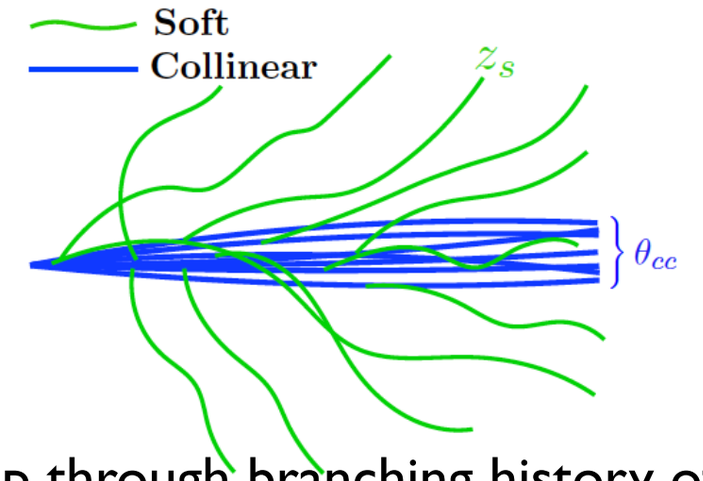
$$U_2^{(\beta)} = \sum_{1 \le i < j < k \le n_J} z_i z_j z_k \min\{\theta_{ij}^{\beta}, \theta_{ik}^{\beta}, \theta_{jk}^{\beta}\}$$

  - U_i variables shown to be excellent light *q*-*g* discriminants; we are extending their study to massive quark jets





- *Jet Grooming:*
  - **Soft Drop:** Larkoski, Marzani, Soyez, Thaler (2014)



Step through branching history of reclustered jet.

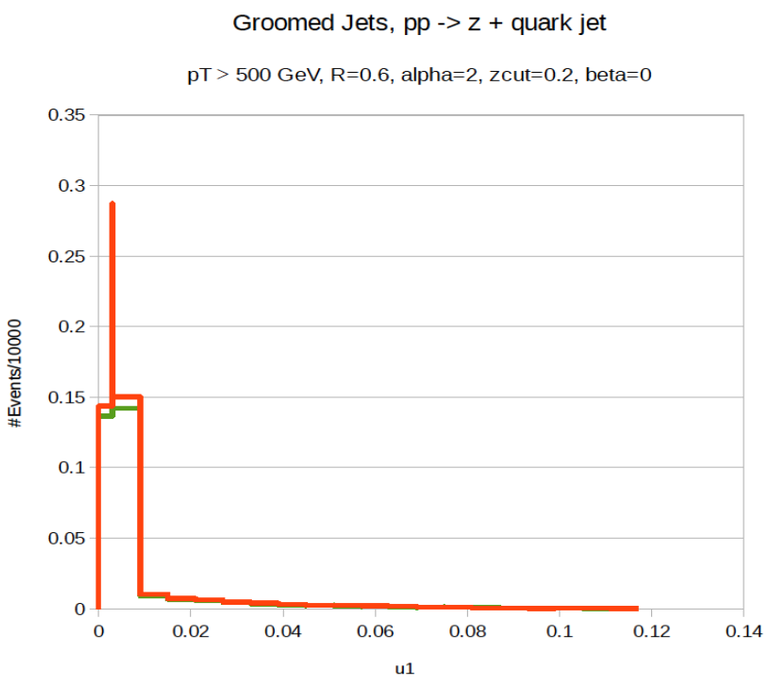
Remove branches failing **soft drop** condition:

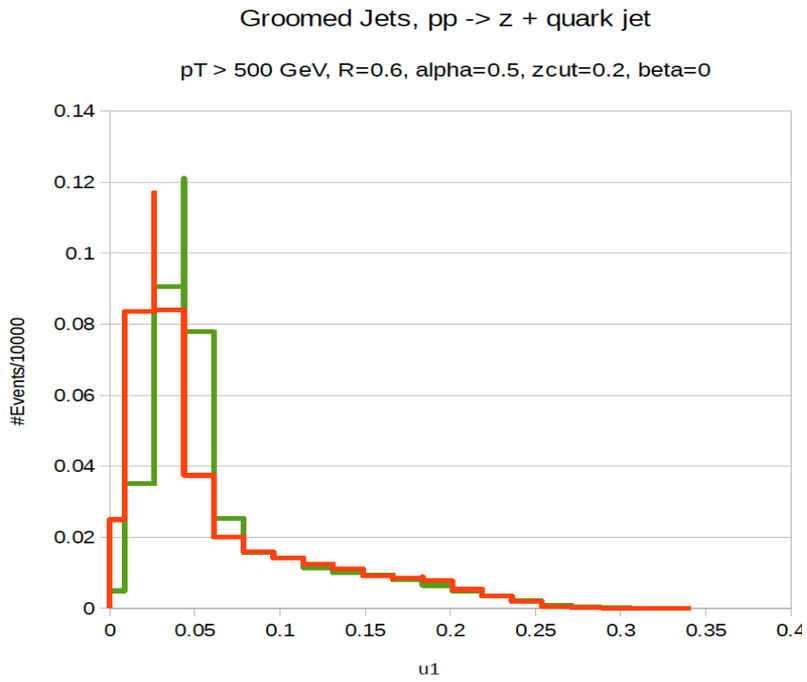
$$\frac{\min[p_{Ti}, p_{Tj}]}{p_{Ti} + p_{Tj}} > z_{\text{cut}}$$

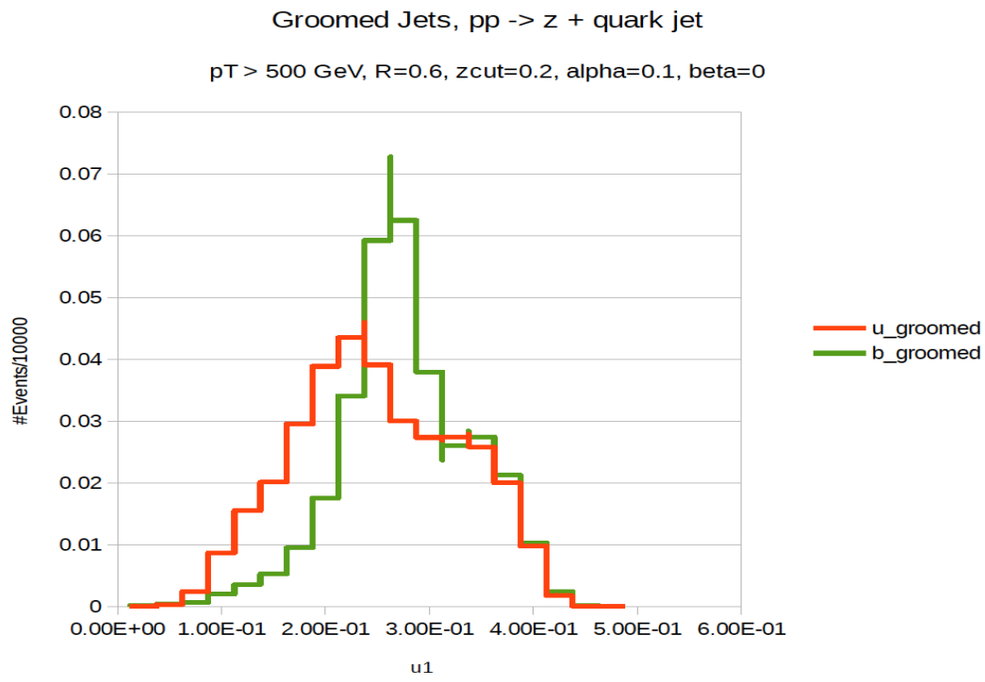
Vary angular exponent to enhance discriminating power

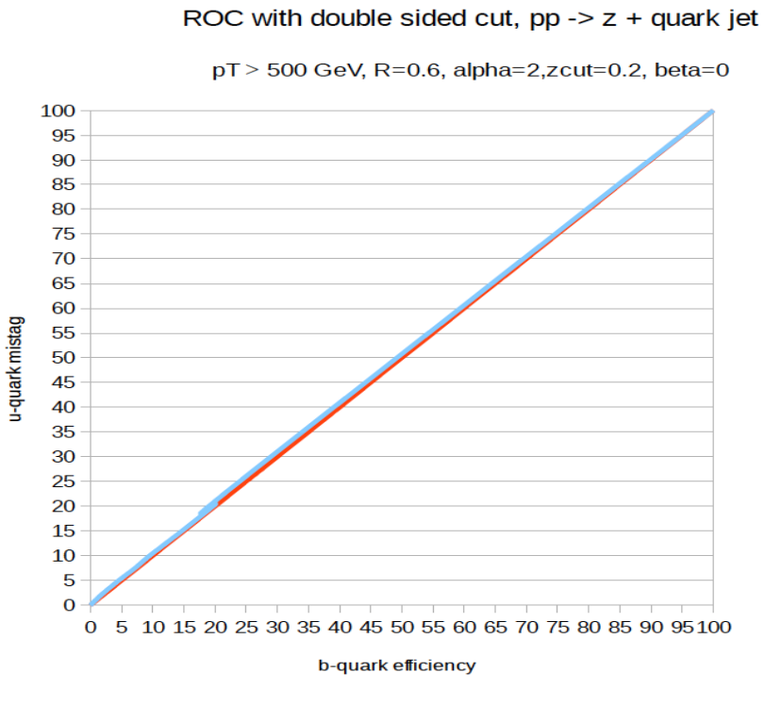
$$U_1^{(\alpha)} = \sum_{1 \le i < j \le n_J} z_i z_j \theta_{ij}^{\alpha}$$

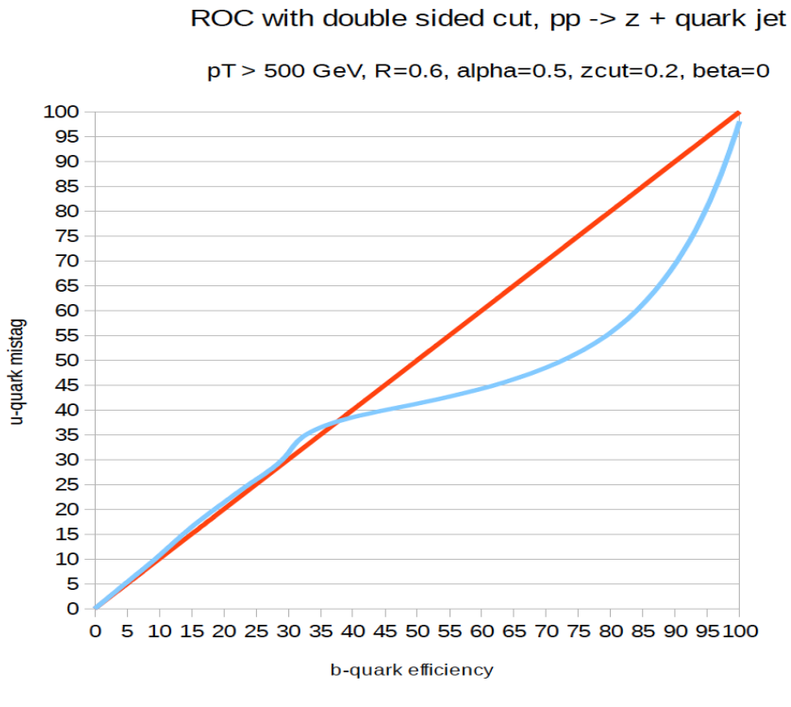
Lee, Shrivastava, Vaidya (in progress)

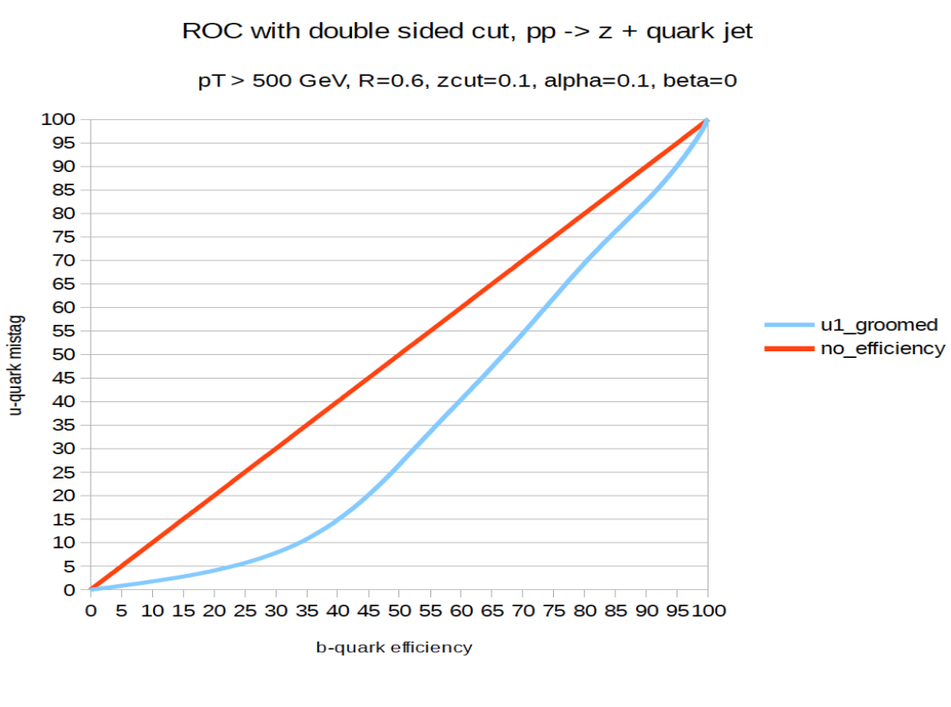












Factorization in SCET

$$e_2^{(\alpha)} = \sum_{i,j} z_i z_j \theta^\alpha$$ **with α << 1**

$$p_c \sim Q\left(1, (e_2^{(\alpha)})^{2/\alpha}, (e_2^{(\alpha)})^{1/\alpha}\right) \qquad p_{cs} \sim z_{cut} Q\left(1, \left(\frac{e_2^{(\alpha)}}{z_{cut}}\right)^{2/\alpha}, \left(\frac{e_2^{(\alpha)}}{z_{cut}}\right)^{1/\alpha}\right)$$

$$\mathbf{E_J}$$

$$\mathbf{z_{cut} E_J}\ ,\ \mathbf{\Delta^{\alpha/2} E_J}$$

$$\mathbf{e_2^{(\alpha)} E_J}$$

$$\frac{d\sigma}{de_2} = \sigma(z_{cut}, E_J) S_c(z_{cut}, e_2^{(\alpha)}) \otimes J(e_2^{(\alpha)}, \Delta^{\alpha/2})$$

Collinear Soft Jet function

$$\Delta = m_b^2 / E_J^2$$

- **Resum logs of $e_2^{(\alpha)}$**
- **Match the resummed result to the fixed order cross section**

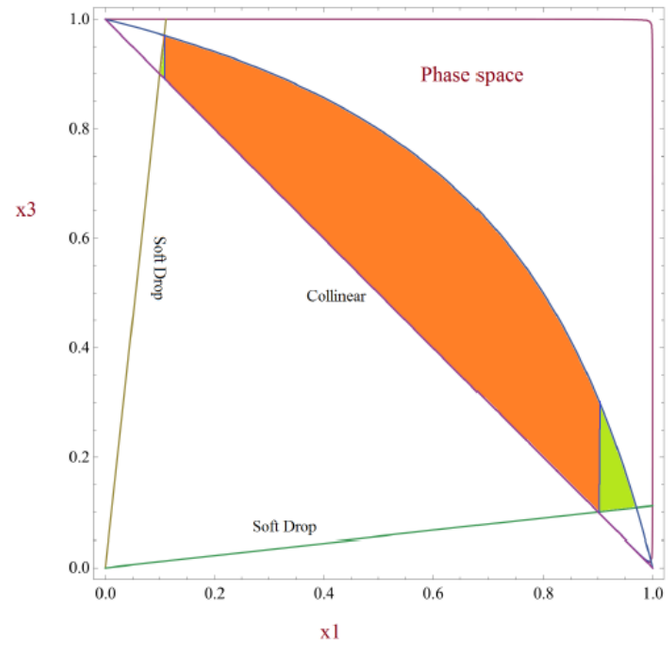


Figure 1. phase space for integration

Next steps in FY18

- Complete full QCD fixed-order calculation of groomed and ungroomed U_1 distributions for light parton and heavy quark jets
- Complete SCET factorized and resummed calculations of groomed and ungroomed U_1 distributions
- Compute α enhanced terms dependent on m_b
- Obtain *analytic* prediction for m_b dependent cross section and discriminating power