Motivation

- Precision calculations of jet substructure moments like the jet mass are difficult since they are sensitive to soft and wide-angle radiation
- Systematically removing this radiation with the soft drop grooming algorithm can allow for precision calculations as well as improved experimental resolution
- Probing QCD beyond the parton shower accuracy, starting new era of precision JSS

Jet Reconstruction with Soft Drop

- Create R=0.8 anti-k jets, and recluster their constituents with the Cambridge/Aachen algorithm
- Starting from the last branch of the clustering history, check if
  \[ \min(p_T^{1,1}, p_T^{2,2}) > z_{cut} \frac{\Delta R_{1,2}}{R} \]
  - If this condition is not satisfied, the softer branch is removed. Once this condition is satisfied, the algorithm terminates
- \( z_{cut} \) sets the scale of energy removal
  - Use \( z_{cut} = 0.1 \)
- \( \beta \) determines the sensitivity to wide-angle radiation
  - Measure \( \beta = 0.1, 1, 2 \)

Event Selection and Unfolding

- \( p_T^{lead} > 600 \text{ GeV} \), to be fully efficient for the lowest unrescaled trigger
- Apply dijet selection: \( p_T^{lead} < 1.5 * p_T^{sublead} \)
- Measure as a function of \( \rho = \log_{10}(\text{[Rsoftdrop} / p_T^{ungroomed}])^2 \). \( \rho \) depends logarithmically on \( p_T \), so final result are binned inclusively in \( p_T \)
- Simultaneously unfold in \( p_T \) and \( \rho \), and normalize each \( p_T \) bin between -3 and -1 in \( \rho \)
  (the resummation region)

Uncertainties

Cluster Energy Scale Shift
- Data/MC difference in the E/p ratio used to determine a shift for clusters

Cluster Energy Scale Smearing
- Data/MC difference in E/p ratio used to determine a smearing in the energy scale of clusters

Cluster Angular Resolution:
- Use the distribution of deltaR(track,cluster) to determine an angular smearing of cluster of 5 mrad
- Dominated by modeling uncertainties at low mass, with cluster energy scale uncertainties also very important at moderate and high mass

Results

- Measured the soft drop jet mass and compared to two QCD predictions with accuracy beyond LL
- Three main regimes:
  - \( p < -3 \): Nonperturbative regime
  - \(-3 < p < -1 \): Resummation regime
  - \( p > -1 \): Fixed order regime
- Resummation regime should be most accurate for MC and LO+NNLL, while fixed order regime should be most accurate for NLO+NNLL
- Predictions agree with measurement in regions where non-perturbative effects are small
- Less good agreement with predictions and measurement at small \( p \), particularly for higher \( \beta \)
- Pythia, Sherpa, and Herwig++ all do an excellent job of describing the data over the entire mass range