Novel sub-jet observables for quenched jets

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Which jet is quenched which one is not?
How different MC models modify the jet structure? How to tell them apart?
"Easy-to-measure" and experimentally robust observables?
AND theoretically rigorous / well defined observables?

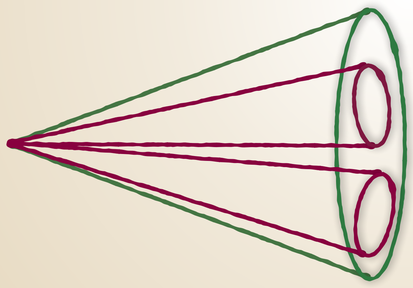
A direction matching all criteria: colinear and infrared safe observables with strong sensitivity to the jet structure - SUB-JETS.

Setup

Jet finder: anti-kT, R=0.4

Observables: multiplicity, leading and sub-leading sub-jets with r < R reconstructed with k_T and anti-k_T algorithms

Event generators:
- MC PYTHIA[1] (used as a reference - vacuum jets)
- Q-PYTHIA[3] and JEWEL[4] (in-medium modified jets)



Leading Jet:
- ✦anti-k_T algorithm;
- ✦Et > 120 GeV;
- ✦R = 0.4.

Leading and Sub-leading Sub-jet:
- ✦anti-k_T and k_T algorithm;
- ✦R = 0.1.

Jet Quenching Models

Q-PYTHIA:
- ✦ Medium-modified version of PYTHIA 6;
- ✦ Radiative energy loss of type BDMPS-Z;
  - ✦ Modification of the vacuum splitting functions:

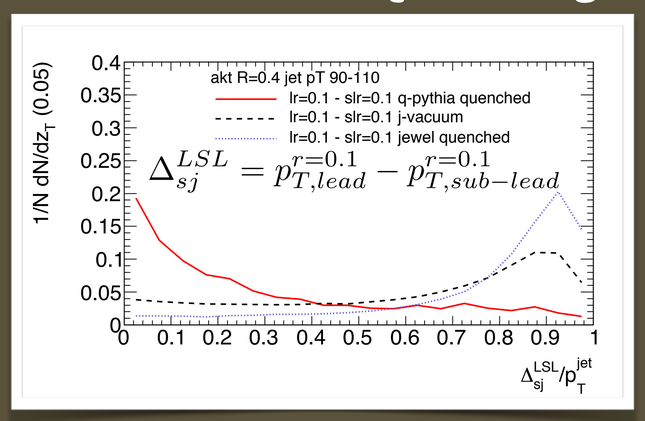
$$P_{tot}(z) = P_{vac}(z) \rightarrow P_{tot}(z) + \Delta P(z,t,\hat{q},L,E)$$

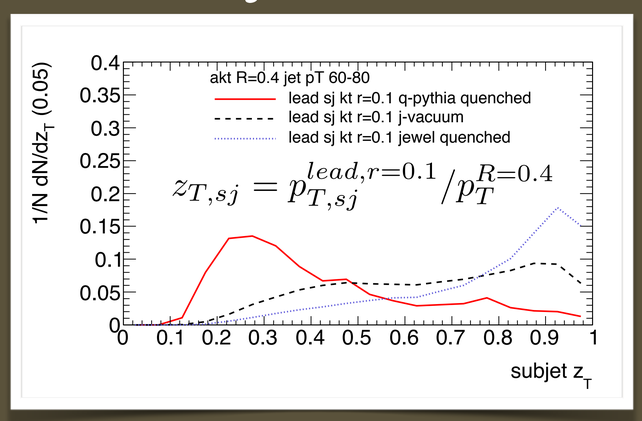
$$\Delta P(z,t,\hat{q},L,E) \simeq \frac{2\pi t}{\alpha_s}\frac{dI^{med}}{dzdt}$$

- ✦ Quenching parameter: transport coefficient (average of squared transverse momentum acquired by the particle, k_T^2, per mean free path: $\hat{q} = \frac{k_\perp^2}{\lambda}$

JEWEL:
- ✦ Medium-modified version of PYTHIA 8;
- ✦ Contains both elastic and radiative energy loss (does not make distinction between the two):
  - ✦ All medium interactions described at leading order by 2-->2 QCD matrix elements;
- ✦ Implemented the Landau-Pomeranchuck-Migdal effect

Different quenching - different sub-jet structure

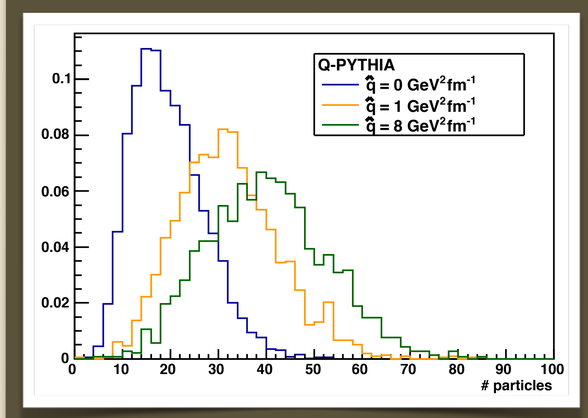




Jets with the same energy have a very different substructure.

Strong sensitivity to the details of modeling: the fraction of energy carried by the leading sub-jets.
New directions - more definitions possible - search for novel, robust, experimentally "preffered" observables...

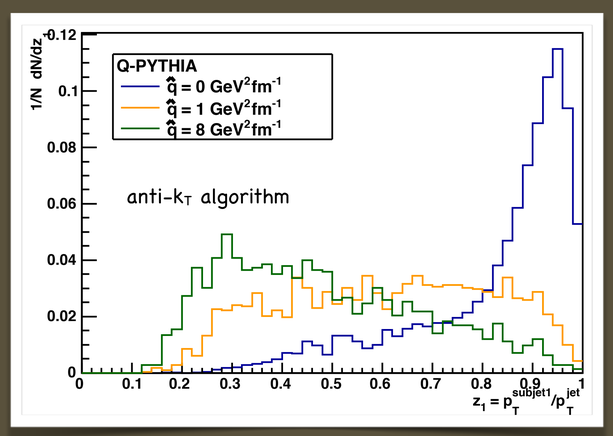
Select samples of quenched jets

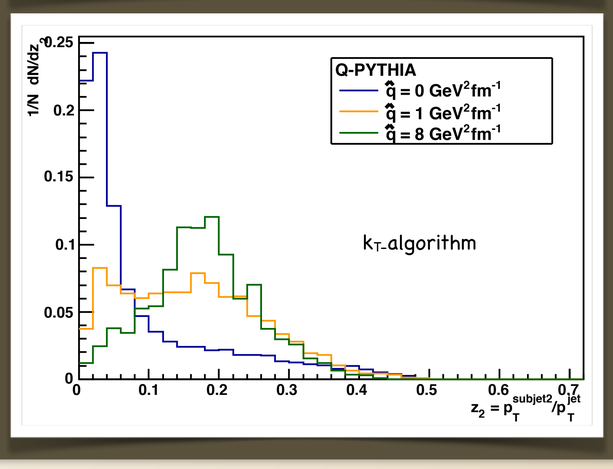


Jet multiplicity is sensitive to quenching strength (qhat). Promising tool for distinguishing quenched from un-quenched jets?

Sensitivity to the "strength" of jet quenching

Combined information of leading and sub-leading sub-jet:
- ✦ strong constraints to quenching modeling - qhat
- ✦ expectation: differential observables - outlook for measurements robust against backgrounds in AA collisions





Future work

- ✦ Improve/develop observables with different jet quenching models;
- ✦ Detail studies with heavy-ion underlying event backgrounds & include experimental effects

1. T. Sjostrand, S. Mrenna, and P. Skands, **PYTHIA 6.4 Physics and Manual**, JHEP 0605 (2006) 026.
2. To reconstruct the jets we use: M. Cacciari, G. P. Salam, G. Soyez, **FastJet User Manual**, Eur.Phys.J. C72 (2012) 1896.
3. N. Armesto, L. Cunqueiro and C. A. Salgado, Q-PYTHIA: **A Medium-modified implementation of final state radiation**, Eur.Phys.J. C63 (2009) 679-690.
4. K. C. Zapp, F. Krauss and U. Wiedemann, **A perturbative framework for jet quenching,** JHEP 1303 **(2013) 080.**