Problems in resumming interjet $E_t$ flows with $k_t$ clustering.

Mrinal Dasgupta

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Definitions used in gaps between jets studies at HERA.
- Resummation and non-global logarithms.
- Reducing the non-global component via $k_t$ clustering.
- Recently uncovered problems in theoretical predictions.
- Impact of new findings, other variables affected, conclusion.
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Definitions

One way of quantitatively describing gaps between hard jets is in terms of $E_t$ flow into the gap. Thus we study the differential distribution

$$\frac{1}{\sigma} \frac{d\sigma}{dQ_\Omega}.$$

$Q_\Omega$ is sum over $E_t$ of emissions inside the gap:

$$Q_\Omega = \sum_{i \in \Omega} E_{t,i}.$$

Here the sum can refer to either a sum over hadrons or a sum over minijets in the gap. Minijets are soft jets obtained after running a jet algorithm e.g. $k_t$ clustering. Commonly used definition experimentally (H1, ZEUS).
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Problem with theoretical description of such observables uncovered some years ago. They are non-global in nature. M. Dasgupta and G.P. Salam, 2002

If $Q_\Omega$ is defined in terms of the hadronic energies in the gap rather than minijet energies result is

$$\frac{d\sigma}{dQ_\Omega} = \frac{d}{dQ_\Omega} \left[ e^{-R(Q/Q_\Omega)} S \left( \frac{Q}{Q_\Omega} \right) \right]$$

$R$ independent-emission piece, exponentiates one gluon result. $S$ represents effects of correlated soft emission, only numerical results for two/(1+1) jets, in large $N_c$ limit exist.

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\( k_t \) clustering reduces the magnitude of the non-global component.

R.B. Appleby and M.H. Seymour 2003

Clustering algorithm pulls soft hadrons in the gap outside by clustering with harder emissions.

- Some configurations escape clustering, contribute to NG component. NG piece non-zero but significantly smaller.
- Appleby and Seymour’s result: after \( k_t \) clustering the distribution takes the form \( e^{-R}\cdot S \). \( S \) reduced by clustering and the independent emission \( e^{-R} \) is unchanged.
- Reduction of \( S \) shd reduce theoretical uncertainty.
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AS extended this ansatz to dijets in photoproduction.

Computed just primary emission piece (analogous to $e^{-R}$) exactly. More complicated colour structure with colour anomalous dimension matrices.

Approximated NG component, arguing that it’s small. Agreement within theoretical uncertainty with HERA data.

However there’s more to the story!

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There are algorithm dependent single-log pieces in addition to $e^{-R S}$.

Discovered while studying jets e.g. azimuthal correlations between dijets near $\phi = \pi$.

Origin: Incomplete real-virtual cancellations outside the gap.
New terms due to clustering

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![Diagram](a)
Take $2/(1+1)$ jet-case. The energy-ordered independent emission prob. for 2 gluons $k_1$ and $k_2$:

$$M^2 = C_F^2 \alpha_s^2 W_{ab}(k_1) W_{ab}(k_2)$$

while the one-real one-virtual term reads

$$M^2 = -C_F^2 \alpha_s^2 W_{ab}(k_1) W_{ab}(k_2)$$

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Algorithm dependent corrections

Leading $O(\alpha_s^2)$ correction thus obtained:

$$C_2^{\text{indep.}} = \frac{16}{3\pi} C_F^2 \left( \alpha_s^2 L^2 \right) r^3, \Delta \eta \geq r.$$ 

Need to integrate the real-virtual piece over region where pure real emission are clustered away. Not accounted for by $e^{-RS}$ form.
Comparisons with EVENT2

\[ \left( \frac{\alpha_s}{2\pi} \right)^2 C_F^2 \text{ piece} \]

L = ln(Q_\Omega/Q) \left( \frac{\alpha_s}{2\pi} \right)^2 \pi \frac{2}{S} \left( \frac{dL}{\sigma_d} \right) \left[ \text{EVENT2-resummed} \right]

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Straightforward numerically in the 2 jet or 1+1 jet (DIS) cases. Replace $C_A/2$ by $C_F$ and turn-off correlated emission in MC developed to treat NG logs.
Another finding: NG logs may be reduced even further by clustering than found by AS. This would mean the effect here is the main complication.

Need to understand its computation in cases with more complicated colour structure e.g. photoproduction and dijets in pp collisions.

Work on this is in progress through dijet resummations in DIS and pp collisions A. Banfi, G. Corcella, MD '05 and in progress.

Need to consider this wherever one tries to resum soft emissions that are affected by defining a jet, even with cone algorithms.
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