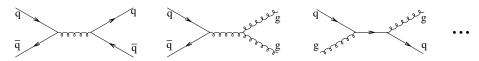
Infrared safe definition of jet flavour

Gavin P. Salam (in collaboration with Andrea Banfi & Giulia Zanderighi)

LPTHE, Universities of Paris VI and VII and CNRS

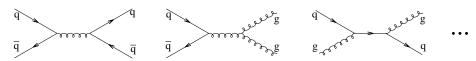
DIS 2006, Tsukuba, Japan 20 April 2006

QCD processes at hadron colliders involve many possible subprocesses. E.g. dijet production:



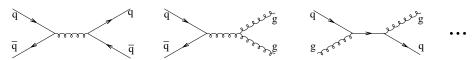
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 e.g. which subprocesses get largest corrections
- To know relative numbers of quark v. gluon jets
 e.g. for multiplicity studies, Monte Carlo tuning
- When matching multi-leg calculations with Monte Carlo showering
 e.g. CKKW, Nagy-Soper NLO+showers
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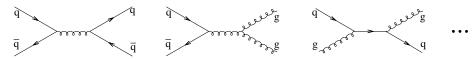
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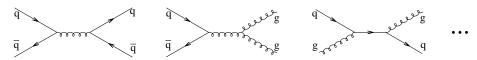
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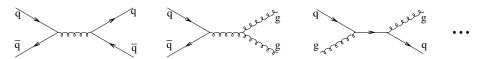
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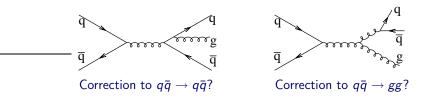


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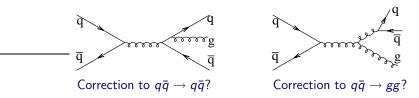


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Need a convention to define channel beyond LO:

Cluster event into jets, channel defined according to number of jets with 'quark-flavour' v. 'gluon-flavour'

e.g. as done in CKKW

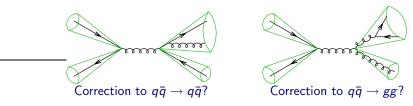


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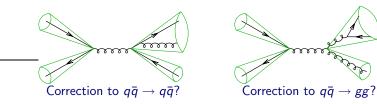
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376 papers with 'quark/gluon jet' in title

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Jet flavour and infrared safety

Physical meaning of quark or gluon jet (jet *flavour*) is "obvious".

[one initiated by a hard quark resp. gluon]

But with normal jet algorithms (k_t , cone), sum of flavours of partons in jet is *infrared unsafe*:

 Soft gluon → large angle qq̄ is clustered into different jets and contaminates jet flavour.

Can the jet flavour be made infrared safe?

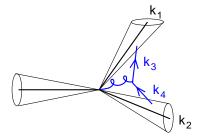
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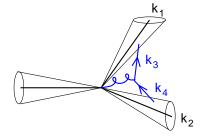
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Logic behind k_t clustering

 k_t algorithm clusters closest pair of particles, next closest pair, etc.

Key issue is distance measure:

$$d_{ij}^{(k_t)} = 2\min(E_i^2, E_j^2) \left(1 - \cos \theta_{ij}\right),\,$$

This is a logical generic choice because of structure of divergences in gluon emission:

$$[dk_j]|M_{g\to g_ig_j}^2(k_j)|\simeq \frac{\alpha_s\,C_A}{\pi}\frac{dE_j}{\min(E_i,E_i)}\frac{d\theta_{ij}^2}{\theta_{ii}^2}\,,\qquad (E_j\ll E_i\,,\,\,\theta_{ij}\ll 1)\,.$$

For each divergent limit, $E_j \to 0$, $\theta_{ij} \to 0$, distance vanishes $(y_{ij} \to 0)$.



Quark production only has collinear divergence, but no soft divergence

$$[dk_j]|M_{g\to q_i\bar{q}_j}^2(k_j)|\simeq \frac{\alpha_s T_R}{2\pi}\frac{dE_j}{\mathsf{max}(E_i,E_j)}\frac{d\theta_{ij}^2}{\theta_{ij}^2},\qquad (E_j\ll E_i\,,\,\,\theta_{ij}\ll 1)\,,$$

- \bullet k_t distance does not match divergence structure for quark emission
- fatal for jet flavour studies because soft large-angle q, \bar{q} from soft gluon are deemed similarly close to all particles in event

Solution: modify distance measure for quarks to reflect divergences [Banfi, GPS & Zanderighi, hep-ph/0601139]

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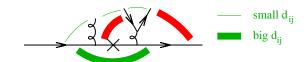
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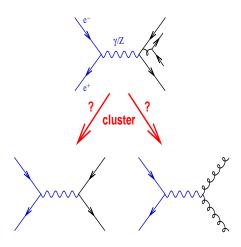


Analytical demonstration of IR safety is straightforward.

Can also illustrate it numerically:

- Take $e^+e^- \rightarrow 2$ jets (has known flavour structure)
- Calculate 3 and 4-parton configurations (with EVENT2)
- Cluster to 2 jets
- As function of y_3 (measure of event hardness) examine σ for events with mis-flavoured jets (gluonic, multi-flavoured)

NB: \exists class of flavour algos. That shown earlier is $\alpha = 2$



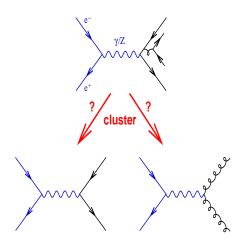
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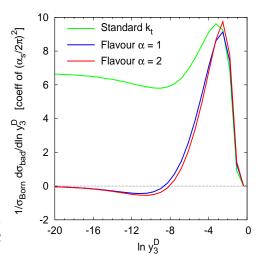
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Jet flavour at hadron colliders

Extension from e^+e^- to hadron-collisions requires extra ingredient: beam hardness $k_{tB}(\eta) \equiv$ estimate of DGLAP evolution scale at a given rapidity.

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- NLO progs for DIS and pp do not provide flavour info
 - A great shame...
- Instead, stress-test algo. with parton-shower events
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 ⇔ different scalings with y₃.
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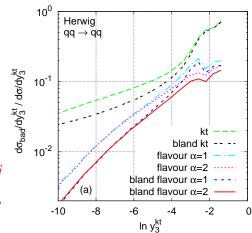
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- Key new idea is different clustering for quarks and gluons
 Can it be done more simply? (Jade?)
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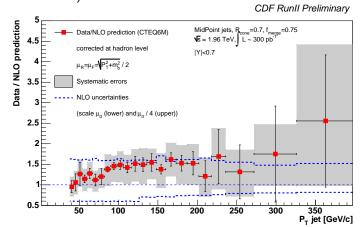
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An important motivation for studying *b*-jets was to reduce theory uncertainties.

Frixione & Mangano '96

But in practice NLO uncertainties are very large, $\sim 40-60\%$ (10-20% is more usual for NLO).



Must identify all b-hadrons in event — feasible, cf. CDF '04

- Gives physical definition of various b-production channels (flavour excitation, flavour creation, . . .) *i.e.* measurable in data, calculable at NLO
- ullet flavour b-jet cross sections are free of any $\ln E_{\perp}/m_b$ enhancements except those resummed in b PDF

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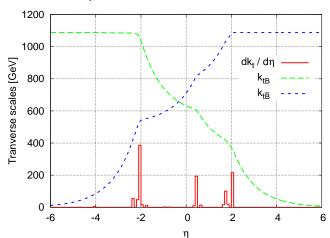
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b-production sub-processes (preliminary)

