Soft gluon effects for selected event shape distributions

Lorenzo Magnea

CERN – Department of Physics – Theory Division

Università di Torino – INFN, Sezione di Torino

CERN – 10/12/04

Outline

1404 - 2004
Alma Universitas Taurinensis

Event shapes in e^+e^- annihilation

Picturing the final state of high-energy collisions

- Event shape distributions probe QCD at *all scales* from the perturbative to the non-perturbative regime.

  finite order $\longrightarrow$ resummation $\longrightarrow$ power corrections

- They provide a *global picture* of final state of hard collisions.

  energy flow $\longleftrightarrow$ hadronization $\longleftrightarrow$ mass effects

- A large amount of data is *available* (LEP, HERA ...)

  better theory $\longleftrightarrow$ more analysis ?

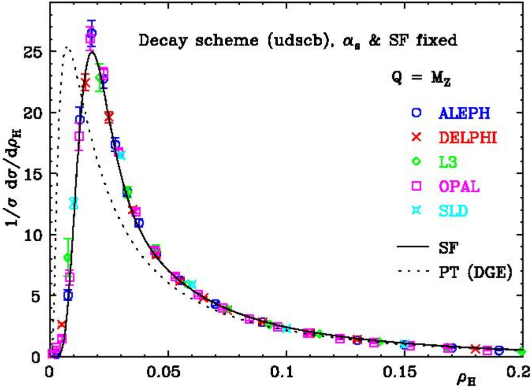
- Studies are emerging for *hadron-hadron* collisions

  impact at LHC ?

1404-2004 ALMA UNIVERSITAS TAURINENSIS

A striking example

Fit of LEP data for *heavy jet mass* distribution (Gardi, Rathsman).



Note: “parameterless”, however *small* α_s.

Event shapes in e^+e^- annihilation

Examples

- Thrust: $T = \frac{\sum_i |\vec{p}_i \cdot \hat{n}|}{Q}$; $\tau = 1 - T$.

  $\longrightarrow$ $\hat{n}$ is used to define several other shape variables.

- C-parameter: $C = 3 - \frac{3}{2} \sum_{i,j} \frac{(p_i \cdot p_j)^2}{(p_i \cdot q)\,(p_j \cdot q)}$.

  $\longrightarrow$ does not require maximization procedures.

- Angularity: $\tau_a = \frac{1}{Q} \sum_i (p_\perp)_i \mathrm{e}^{-|\eta_i|(1-a)}$.

  $\longrightarrow$ recently introduced (Berger, Sterman)

- Transverse Thrust: $T_\perp = \frac{\sum_i |\vec{p}_{\perp i} \cdot \hat{n}_\perp|}{\sum_i \vec{p}_{\perp i}}$; $\tau_\perp = 1 - T_\perp$.

  $\longrightarrow$ defined for *hadron-hadron* collisions

Resummation of Sudakov logarithms

Infrared and collinear emission dominates the two-jet limit

- Large *double* logarithms of the variable vanishing in the two-jet limit $(L = \log t\ ; L = \log C\ ; \ldots)$ enhance finite orders $\rightarrow$ *need to resum*.
- A pattern of *exponentiation* emerges

$$\sum_k \alpha_s^k \sum_p^{2k} c_{kp} L^p \rightarrow \exp\left[L g_1(\alpha_s L) + g_2(\alpha_s L) + \alpha_s g_3(\alpha_s L) + \ldots \right]$$

- In general the *Laplace transform* exponentiates

$$\int_0^\infty d\tau e^{-\nu\tau} \frac{1}{\sigma}\frac{d\sigma}{d\tau} = \exp\left[\int_0^1 \frac{du}{u} \left(e^{-u\nu} - 1\right) \left(B\left(\alpha_s\left(uQ^2\right)\right) + \int_{u^2Q^2}^{uQ^2} \frac{dq^2}{q^2} A\left(\alpha_s(q^2)\right) \right) \right].$$

ALMA UNIVERSITAS TAURINENSIS 1404-2004

Resummation of Sudakov logarithms

Infrared and collinear emission dominates the two-jet limit

- Large *double* logarithms of the variable vanishing in the two-jet limit $(L = \log t \; ; L = \log C \; ; \ldots)$ enhance finite orders $\rightarrow$ *need to resum*.
- A pattern of *exponentiation* emerges

$$\sum_k \alpha_s^k \sum_p^{2k} c_{kp} L^p \rightarrow \exp \left[L g_1(\alpha_s L) + g_2(\alpha_s L) + \alpha_s g_3(\alpha_s L) + \ldots \right]$$

- In general the *Laplace transform* exponentiates

$$\int_0^\infty d\tau e^{-\nu\tau} \frac{1}{\sigma} \frac{d\sigma}{d\tau} = \exp \left[\int_0^1 \frac{du}{u} \left(e^{-u\nu} - 1 \right) \left(B\left(\alpha_s\left(uQ^2\right)\right) + \int_{u^2Q^2}^{uQ^2} \frac{dq^2}{q^2} A\left(\alpha_s(q^2)\right) \right) \right] .$$

1404-2004 ALMA UNIVERSITAS TAURINENSIS

Resummation of Sudakov logarithms

Infrared and collinear emission dominates the two-jet limit

- Large *double* logarithms of the variable vanishing in the two-jet limit $(L = \log t \; ; L = \log C \; ; \ldots)$ enhance finite orders $\longrightarrow$ *need to resum*.
- A pattern of *exponentiation* emerges

$$\sum_k \alpha_s^k \sum_p^{2k} c_{kp} L^p \longrightarrow \exp\left[L g_1(\alpha_s L) + g_2(\alpha_s L) + \alpha_s g_3(\alpha_s L) + \ldots\right]$$

- In general the *Laplace transform* exponentiates

$$\int_0^\infty d\tau \, \mathrm{e}^{-\nu\tau} \frac{1}{\sigma}\frac{d\sigma}{d\tau} = \exp\left[\int_0^1 \frac{du}{u}\left(\mathrm{e}^{-u\nu} - 1\right)\left(B\left(\alpha_s\left(uQ^2\right)\right) + \int_{u^2Q^2}^{uQ^2} \frac{dq^2}{q^2} A\left(\alpha_s(q^2)\right)\right)\right].$$

1404-2004 ALMA UNIVERSITAS TAURINENSIS

Resummation of Sudakov logarithms

Exponentiating power corrections

- The exponent is *ill-defined* because of the *Landau pole*

  regularization ⟶ ambiguity ⟶ power corrections

- Focus on *small* τ, *large* ν, set IR factorization scale μ, expand in powers of ν/Q (soft), *neglecting* ν/Q^2 (collinear).

$$S_{\rm NP}(\nu/Q,\mu) = \int_0^{\mu^2} \frac{dq^2}{q^2} A\left(\alpha_s(q^2)\right) \int_{q^2/Q^2}^{q/Q} \frac{du}{u}\left({\rm e}^{-u\nu} - 1\right) \simeq \sum_{n=1}^{\infty} \frac{1}{n!}\left(\frac{\nu}{Q}\right)^n \lambda_n(\mu^2)\,,$$

- *Non-perturbative* parameters

$$\lambda_n(\mu^2) = \frac{1}{n}\int_0^{\mu^2} dq^2\, q^{n-2} A\left(\alpha_s(q^2)\right)\,.$$

Resummation of Sudakov logarithms

Exponentiating power corrections

- The exponent is *ill-defined* because of the *Landau pole*

  regularization ⟶ ambiguity ⟶ power corrections

- Focus on *small* τ, *large* ν, set IR factorization scale μ, expand in powers of ν/Q (soft), *neglecting* ν/Q^2 (collinear).

$$
\begin{aligned}
S_{\rm NP}(\nu/Q,\mu) &= \int_0^{\mu^2} \frac{dq^2}{q^2} A\left(\alpha_s(q^2)\right) \int_{q^2/Q^2}^{q/Q} \frac{du}{u}\left({\rm e}^{-u\nu}-1\right) \\
&\simeq \sum_{n=1}^{\infty} \frac{1}{n!}\left(\frac{\nu}{Q}\right)^n \lambda_n(\mu^2)\ ,
\end{aligned}
$$

- *Non-perturbative* parameters

$$
\lambda_n(\mu^2) = \frac{1}{n}\int_0^{\mu^2} dq^2\, q^{n-2} A\left(\alpha_s(q^2)\right)\ .
$$

Resummation of Sudakov logarithms

Shape functions

- The parameters $\lambda_n(\mu^2)$ build up a *shape function*

$$\exp\left[S_{\rm NP}(\nu/Q,\mu)\right] \equiv \int_0^\infty d\epsilon\, {\rm e}^{-\nu\,\epsilon/Q}\, f_\tau(\epsilon,\mu)\ .$$

- The physical *distribution* is recovered via inverse transform

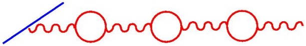
$$\sigma(\tau) \sim \int_0^{\tau Q} d\epsilon\, f_\tau(\epsilon,\mu)\,\sigma_{\rm PT}\left(\tau - \epsilon/Q\right)\ .$$

- One recovers the *perturbative* result *shifted* by the soft energy flow, and *smeared* by the shape function.
- *Universality* of power corrections is in general *lost*, however *specific* observables still *related* ($1-T$, ρ_J, C, $\ldots$).
- *Assumption*: smooth transition to *nonperturbative* regime.

Dressed gluon exponentiation

It is possible to combine *renormalon* methods and *Sudakov resummation* to construct models of power corrections. One method is *dressed gluon exponentiation* (Gardi).

- *Step 1:* compute *characteristic function* $\mathcal{F}(k^2)$ of the dispersive method in the *Sudakov limit* (resum *"bubble graphs"*).



- *Step 2:* use dressed gluon distribution as *kernel of exponentiation*.

$$\ln\left(\frac{d\tilde{\sigma}}{d\nu}\Big|_{DGE}\right) = \int_0^\infty d\tau\ \frac{d\sigma}{d\tau}\Big|_{SDG}\left(1 - e^{-\nu\tau}\right) .$$

- *Step 3: Borel representation* of the exponent suggests pattern of *power corrections.*

Dressed gluon exponentiation

It is possible to combine *renormalon* methods and *Sudakov resummation* to construct models of power corrections. One method is *dressed gluon exponentiation* (Gardi).

- *Step 1:* compute *characteristic function* $\mathcal{F}(k^2)$ of the dispersive method in the *Sudakov limit* (resum *"bubble graphs"*).

- *Step 2:* use dressed gluon distribution as *kernel of exponentiation*.

$$\ln\left(\frac{d\tilde{\sigma}}{d\nu}\bigg|_{DGE}\right) = \int_0^\infty d\tau \, \frac{d\sigma}{d\tau}\bigg|_{SDG} \left(1 - e^{-\nu\tau}\right) \; .$$

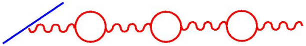
- *Step 3: Borel representation* of the exponent suggests pattern of *power corrections*.

Alma Universitas Taurinensis 1404-2004

Dressed gluon exponentiation

It is possible to combine *renormalon* methods and *Sudakov resummation* to construct models of power corrections. One method is *dressed gluon exponentiation* (Gardi).

- *Step 1:* compute *characteristic function* $\mathcal{F}(k^2)$ of the dispersive method in the *Sudakov limit* (resum *"bubble graphs"*).



- *Step 2:* use dressed gluon distribution as *kernel of exponentiation*.

$$\ln\left(\frac{d\tilde{\sigma}}{d\nu}\Big|_{DGE}\right) = \int_0^\infty d\tau\, \frac{d\sigma}{d\tau}\Big|_{SDG}\left(1 - e^{-\nu\tau}\right) \quad .$$

- *Step 3: Borel representation* of the exponent suggests pattern of *power corrections*.

Dressed gluon exponentiation

Features of DGE

- *NLL* Sudakov resummation *reproduced* by using *"gluon bremsstrahlung"* definition of running coupling. *All* subleading logs computed in the "large n_f" limit.
- *Factorial growth* of subleading logs detected: a *handle* on the range of applicability of N^pLL resummation.
- *Definite prescription* for merging resummed PT with power corrections.
- *Phenomenology* of thrust, jet masses; models of power corrections in the Sudakov region for DIS, Drell-Yan, fragmentation.

The C parameter

Virtual gluon emission at one loop

Renormalon effects in the *inclusive approximation* can be extracted from the distribution computed with a *"massive" gluon*.

- *Define* the event shape with a gluon virtuality $\xi = k^2/Q^2$.

$$\mathbf{c}(x_1, x_2, \xi) \equiv \frac{C}{6} = \frac{(1-x_1)(1-x_2)(1-x_3+2\xi)-\xi^2}{x_1 x_2 x_3} \,.$$

- One-loop *matrix element* for virtual gluon emission

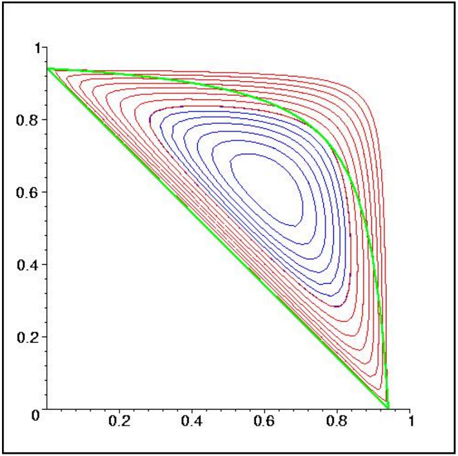
$$\mathcal{M}(x_1, x_2, \xi) = \frac{(x_1+\xi)^2+(x_2+\xi)^2}{(1-x_1)(1-x_2)} - \frac{\xi}{(1-x_1)^2} - \frac{\xi}{(1-x_2)^2} \,.$$

- *Characteristic function*

$$\mathcal{F}(\xi, c) = \int dx_1 dx_2 \, \mathcal{M}(x_1, x_2, \xi) \, \delta\left(\mathbf{c}(x_1, x_2, \xi) - c\right) \,.$$

1404-2004 ALMA UNIVERSITAS TAURINENSIS

Phase space with a 'massive' gluon



Phase space (green) and fixed c contours for $\xi = 0.06$

- Collinear limit: $x_{1,2} = 1 - \xi$
- Soft limit: $x_1 = x_2 = 1 - \sqrt{\xi}$
- $c_{\rm soft} = \xi / x_3$
- *Soft region* $\frac{\xi}{1+\xi} < c < \frac{\sqrt{\xi}}{2}$
- *Hard region* $\frac{\sqrt{\xi}}{2} < c < c_{\max}$.

1404-2004 Alma Universitas Taurinensis

Constructing the Sudakov exponent

The single dressed gluon cross section

$\mathcal{F}(\xi, c)$ can be computed in closed form in terms of elliptic integrals (Gardi, LM). To perform *DGE* one must then

- *Extract* terms responsible for Sudakov logs

$$\mathcal{F}_l(\xi, c) = \frac{1}{c}\left[-4\ln\left(\frac{\xi}{c}\right) - 3 + 2\left(\frac{\xi}{c}\right) + \left(\frac{\xi}{c}\right)^2 - 8\ln\left(\frac{1}{2}\left(1+\sqrt{1-4c^2/\xi}\right)\right)\right].$$

- *Compute* the dispersive integral

$$\frac{1}{\sigma}\frac{d\sigma}{dc}(c, Q^2) = -\frac{C_F}{2\beta_0}\int_0^1 d\xi\, \frac{d\mathcal{F}(\xi,c)}{d\xi}\, A(\xi Q^2)\ .$$

- *Use* the Borel representation for the coupling

$$A(\xi Q^2) = \int_0^\infty du\, \left(Q^2/\Lambda^2\right)^{-u} \frac{\sin \pi u}{\pi u}\, \mathrm{e}^{\kappa u}\, \xi^{-u}\ .$$

Note: κ defines the *renormalization* scheme.

Constructing the Sudakov exponent

Exponentiating the dressed gluon

- *Define* the Borel representation of the *SDG* cross section.

$$\frac{1}{\sigma}\,\frac{d\sigma}{dc}\Big|_{\rm SDG} = \frac{C_F}{2\beta_0}\int_0^\infty du\,\left(Q^2/\Lambda^2\right)^{-u}\,B(c,u)\,.$$

  Note: the Borel integral is always left unperformed

- *Exponentiate* in Laplace space.

$$\frac{1}{\sigma}\,\frac{d\sigma}{dc}\Big|_{\rm DGE} = \int_{k-{\rm i}\infty}^{k+{\rm i}\infty}\frac{d\nu}{2\pi{\rm i}}\,{\rm e}^{\nu c}\,\exp\left[S\left(\nu,Q^2\right)\right]\,,$$

  using the *single gluon* result as kernel

$$S\left(\nu,Q^2\right) = \int_0^\infty dc\,\frac{1}{\sigma}\frac{d\sigma}{dc}\Big|_{\rm SDG}\left({\rm e}^{-\nu c}-1\right)\,.$$

- *Results* are summarized by the Borel exponent.

$$S\left(\nu,Q^2\right) = \frac{C_F}{2\beta_0}\int_0^\infty du\,\left(Q^2/\Lambda^2\right)^{-u}\,B_c(\nu,u)\,.$$

The Borel exponent

Although the *single gluon* result $B(c,u)$ has *no renormalons*, upgrading to *multi-gluon* emission via exponentiation generates *towers* of renormalon poles in $B_c(\nu,u)$.

- For the *C-parameter*

$$B_c(\nu,u) = 2\,e^{5u/3}\,\frac{\sin\pi u}{\pi u}\left[\Gamma(-2u)\left(\nu^{2u}-1\right)2^{1-2u}\frac{\sqrt{\pi}\,\Gamma(u)}{\Gamma(\frac{1}{2}+u)} - \Gamma(-u)\left(\nu^{u}-1\right)\left(\frac{2}{u}+\frac{1}{1-u}+\frac{1}{2-u}\right)\right].$$

- Compare with the *thrust*

$$B_\tau(\nu,u) = 2\,e^{5u/3}\,\frac{\sin\pi u}{\pi u}\left[\Gamma(-2u)\left(\nu^{2u}-1\right)\frac{2}{u} - \Gamma(-u)\left(\nu^{u}-1\right)\left(\frac{2}{u}+\frac{1}{1-u}+\frac{1}{2-u}\right)\right].$$

1404-2004 Alma Universitas Taurinensis

Towards phenomenology

Borel functions contains *perturbative* and *non-perturbative* informations (in part *common* to t and C).

- Coefficients of subleading logarithms (in the large n_f limit): expand in powers of u, with $u^n \to n!(b_0 \alpha_s/\pi)^{n+1}$.
- *IR safety* is expressed by cancellation of singularities at $u = 0$.
- Renormalons of *collinear* origin at $u = 1, 2$, corresponding to power corrections of the form $(\nu/Q^2)^p, \ p = 1, 2$.
  NOTE: only relevant at $\tau, C \sim \Lambda^2/Q^2$, may depend on massive definition of observable.
- Renormalons from *wide angle soft* radiation $u = m/2, \, m \, \mathrm{odd}$, corresponding to leading power corrections $(\nu/Q)^m$.
  NOTE: Even powers absent in the large n_f inclusive approximation.

1404-2004 Alma Universitas Taurinensis

Towards phenomenology

Thrust and *C-parameter* have common features and differences.

- Sudakov logarithms *coincide* up to NLL (Catani, Webber), but *differ* beyond, due to soft emission.
  $\Rightarrow$ Numerical growth of coefficients *milder* for C.
- Similar *pattern* of corrections: *only odd* powers of ν/Q.
  $\Rightarrow$ May *explain* success of *shifting* perturbative distribution.
  $\Rightarrow$ However: *smaller residues* of renormalon poles for C.
- *Origin* of differences: scale of soft emission is $2Qc$ for $c = C/6$, while it is $Q\tau$ for $\tau = 1 - T$.
- *Consequences*: resummed *perturbative* prediction, and approximation of shape function by *shift* expected to *work better* for c than for τ.

1404-2004
ALMA UNIVERSITAS TAURINENSIS

Angularities

- *Definition:* $\tau_a = \frac{1}{Q} \sum_i (p_\perp)_i \mathrm{e}^{-|\eta_i|(1-a)}$.

  Also: $\tau_a = \frac{1}{Q} \sum_i \omega_i (\sin\theta_i)^a (1 - |\cos\theta_i|)^{1-a}$,
- *Some properties*
  - $\tau_0 = 1 - T$; $\tau_1 = B$.
  - $a \leq 2$ for IR safety.
  - $a \leq 1$ for feasibility of resummation.
- For *negative* a, high rapidity particles (*w.r.t.* the thrust axis) are weighted less: *better* collinear behavior.
- At *one loop*, with the thrust axis given by particle i,

$$\tau_a = \frac{(1-x_i)^{1-a/2}}{x_i} \left[(1-x_j)^{1-a/2} (1-x_k)^{a/2} + (j \leftrightarrow k) \right] .$$

Resummation for angularities

Berger, Kucs, Sterman, hep-ph/0303051

- Sudakov logs at one loop have *simple scaling* with a.

$$\frac{d\sigma}{d\tau_a}\bigg|_{\log}^{(1)} = \frac{2}{2-a}\frac{2}{\tau_a}C_F\frac{\alpha_s}{\pi}\ln\left(\frac{1}{\tau_a}\right) = \frac{2}{2-a}\,\frac{d\sigma}{d\tau}\bigg|_{\log}^{(1)}.$$

- Resummation is *intricate*.

$$\ln\left[\tilde{\sigma_{\mathrm{LL}}}(\nu,a)\right] = 2\int_0^1\frac{du}{u}\left[\int_{u^2Q^2}^{uQ^2}\frac{dp_T^2}{p_T^2}A\left(\alpha_s(p_T)\right)\left(\mathrm{e}^{-u^{1-a}\nu\left(\frac{p_T}{Q}\right)^a}-1\right)\right].$$

- General a-dependence of Sudakov logs is *nontrivial*.

$$g_1(x,a) = -\frac{4}{\beta_0}\frac{1}{1-a}\frac{A^{(1)}}{x}\left[\left(\frac{1}{2-a}-x\right)\ln\left(1-(2-a)x\right)\right.$$
$$\left. -(1-x)\ln(1-x)\right].$$

Scaling of power corrections

An analysis of power corrections for angularities has been carried out using *resummation* (Berger, Sterman) *and* using *DGE* (Berger, LM). Remarkably

- A *simple scaling* holds. DGE yields

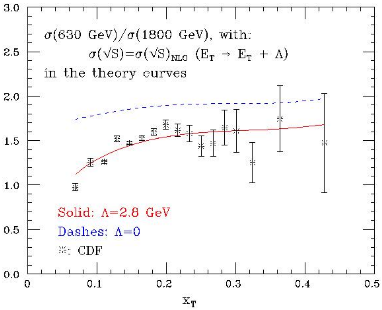
$$B_a^{\rm soft}(\nu,u) = \frac{1}{1-a}\left[2\,{\rm e}^{5u/3}\,\frac{\sin\pi u}{\pi u}\,\Gamma(-2u)\left(\nu^{2u}-1\right)\frac{2}{u}\right]$$

- *Collinear* contribution shows an *intricate* structure of *fractional* power corrections in DGE, but they are suppressed by either ν/Q^{2-a} or ν^b/Q^2 with $0 < b < 1$.
- In the *shape function* language

$$S_{\rm NP}^{(a)}(\nu/Q,\mu) = \frac{1}{1-a}\,S_{\rm NP}^{(0)}(\nu/Q,\mu)\ ,$$

  a *testable prediction*.

What impact at Tevatron/LHC?



Fit of CDF data with NLO QCD assuming E_T-independent shift Λ in jet energy (Mangano, hep-ph/9911256).

- Cross section ratio should *scale* up to *PDF* ad α_s effects.
- Data can be fitted with *shift* in distribution.
- *Small* Λ has impact at *high* E_T.
- $\sigma(E_T) \sim E_T^{-n} \to \frac{\delta\sigma}{\sigma} \sim -n\delta E_T$
- *Several* sources of energy flow *in* and *out* of jets.

1404-2004
ALMA
UNIVERSITAS TAURINENSIS

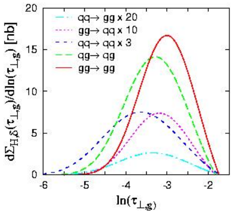
Power corrections and other problems ...

- *Sources* of power corrections
  - Soft radiation from *hard antenna* ⇒ *resummation*.
    - ∗ *Calculable* in perturbative QCD.
    - ∗ Partly *localized* in phase space.
  - Soft radiation from *underlying event* ⇒ *models*.
    - ∗ *Not calculable* in perturbative QCD.
    - ∗ *Fills* phase space (*minijets?*)
- Experimental *issues*.
  - Detector *coverage* and event *cuts* ⇒ *constraints* on global event shapes.
  - *Observable-specific* problems ⇒ *jet* algorithms, *non-global* logarithms.
- Need *discriminating* observables ...

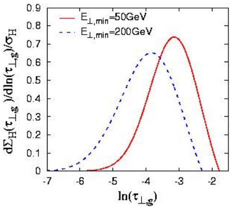
1404-2004 Alma Universitas Taurinensis

An example: the transverse thrust

A. Banfi et al. hep-ph/0407287



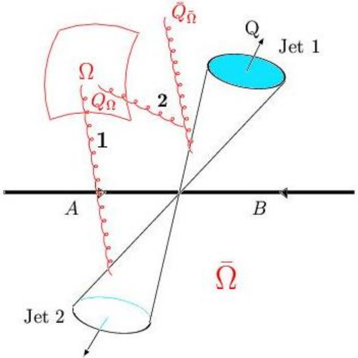
$\tau_\perp$ distribution separated into different hard scattering channels.



$\tau_\perp$ distribution summed over channels for different $E_{\perp,\min}$ cuts.

- Numerically *resummable* with CAESAR. Resummation applicable to $\log \tau_\perp \sim \eta_{\max}$.
- *Discriminates* parton channels.
- Underlying event modeled by *shift*.

Event shape/energy flow correlations



Energy flow into Ω and origin of nonglobal logs

- Gluon 1: $\log(Q_\Omega/Q)$.
- Gluon 2: $\log(Q_\Omega/Q_{\bar{\Omega}})$.
- *Resummation* of nonglobal logs *under study*.
- Non-global → Non-Sudakov → Non-linear.
- Can one *suppress* them?
- Study soft radiation *without* hard antenna?

Event shape/energy flow correlations

- In e^+e^- annihilation *suppress* nonglobal logs via

$$\sigma\left(\epsilon_1,\epsilon_2\right) = \frac{1}{2s}\sum_N \overline{|M(N)|^2}\,\delta(\epsilon_1 - f_\Omega(N))\,\delta(\epsilon_2 - \tau_a^{(1)}(N) - \tau_a^{(2)}(N))$$

with $f_\Omega(N) = \left(\sum_{i\in\Omega}\omega_i\right)/s$ and $\tau_a^{(n)}$ the angularity of jet n.

- At small ϵ_1, ϵ_2, with $\epsilon_1 \sim \epsilon_2$ radiation into $\bar{\Omega}$ is forced to the *two-jet limit*.
- Possible *generalization* to hadron-hadron collisions: introduce ϵ_3 for beam jets. $\{\epsilon_i, a\}$ serve as *handles* to *tune* soft radiation.
  - $\epsilon_i \ll 1$, $a > 0$: narrow jets, wide-angle radiation suppressed.
  - $\epsilon_i \ll 1$, $a < 0$: inclusive on soft radiation.
  - $\epsilon_3 \sim 1$, $a < 0$: suppress high rapidity.

Perspective

- *Event shape distributions* map the transition between perturbative and non-perturbative QCD (also in *DIS* ...)
- *Theoretical advances* lead to testable QCD-motivated models of power corrections (*shape functions*).
- *DGE* combines resummation with renormalon calculus.
  - All available perturbative information is retained.
  - A well-defined matching betwen PT and NP is provided.
  - Models for shape functions yield testable predictions: *C-parameter*, *angularities ...*
- Detailed *phenomenology* awaits destiny of data
- Extension to *hadron collisions* desirable, *flexible* observables required.

1404-2004 Alma Universitas Taurinensis