Inclusive hadronic distributions in jets in the vacuum and in the medium

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Outline

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- Conclusions

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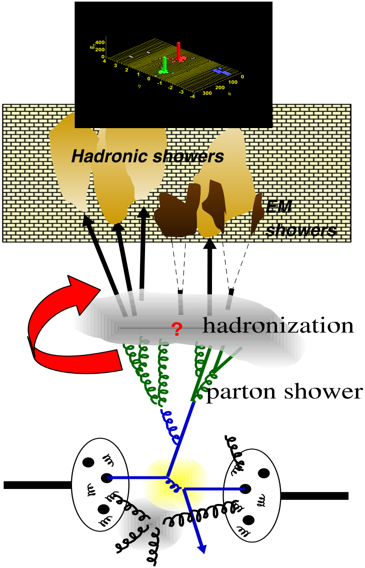

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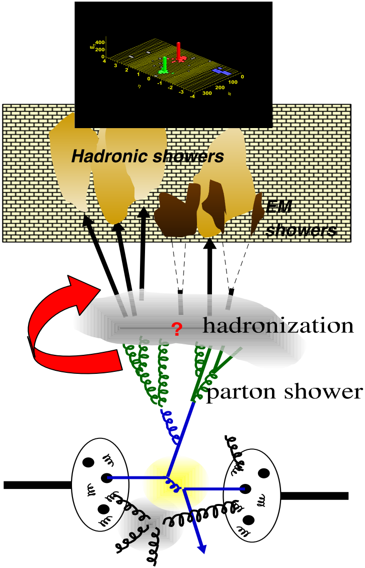

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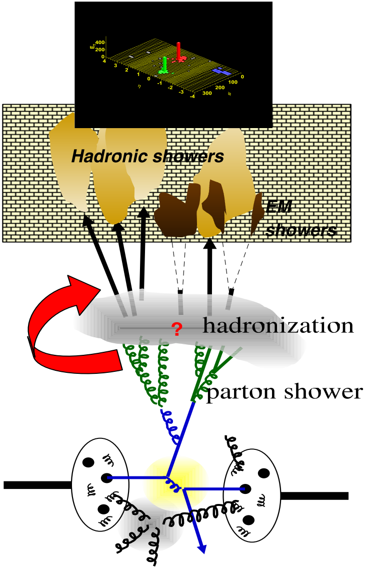
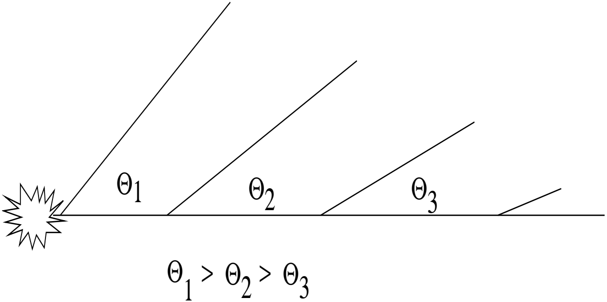


- Partonic cascade: traited in pQCD
  - planar gauge: tree amplitudes ⇒ parton shower picture (probabilistic interpretation)
- Hadronization: advocates for Local Parton Hadron Duality Hypothesis (LPHD)
  - partonic distributions ≃ hadronic distributions: factor $\mathcal{K}^{ch}$
  - "limiting spectrum:" $Q_0 \sim \Lambda_{QCD}$

Angular Ordering



- necessary condition to the construction of QCD evolution equations $\Leftrightarrow$ to the $k_\perp$-ordering of Dokshitzer-Gribov-Lipatov-Altereli-Parisi (DGLAP) evolution equations in the DIS

Resummation schemes

- DLA: $\alpha_s \log(1/x) \log\Theta$ ($\alpha_s \log^2 \sim 1 \Rightarrow \log \sim \alpha_s^{-1/2}$): resummation of soft and collinear gluons
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- MLLA: $\underbrace{\alpha_s \log\log}_{\mathcal{O}(1)} + \underbrace{\alpha_s \log}_{\mathcal{O}(\sqrt{\alpha_s})}$: the SL corrections to DLA
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- Next-to-MLLA: $\underbrace{\alpha_s \log\log}_{\mathcal{O}(1)} + \underbrace{\alpha_s \log}_{\mathcal{O}(\sqrt{\alpha_s})} + \underbrace{\alpha_s \log\log^{-1}}_{\mathcal{O}(\alpha_s)}$
  - improve the restoration of the energie balance
  - and allow to increase the range in "x" ($k_\perp \approx x E_{jet} \Theta$)

For instance: ((N)MLLA ev. eq., gluon and quark jets)

$$\underbrace{\tilde{D}_g^h(\ell, y)}_{gluon\ jet} = \delta(\ell) + \int_0^{\ell} d\ell' \int_0^{y} dy' \gamma_0^2(\ell' + y') \Big[\underbrace{1}_{DLA} - (a_1 + a_2\, \psi_\ell(\ell', y'))\, \delta(\ell' - \ell) \Big]$$

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- Logic of Low-Barnet-Kroll theorem:
- DLA (LO) term: $\propto \mathcal{O}(1)$
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- $\tilde{D}_g^h = (\ell + y) \iint \frac{d\omega d\nu}{(2\pi i)^2} e^{\omega \ell} e^{\nu y} \int_0^\infty \frac{\mathrm{d}s}{\nu + s} \left(\frac{\omega(\nu+s)}{(\omega+s)\nu}\right)^{\sigma_0} \left(\frac{\nu}{\nu+s}\right)^{\sigma_1+\sigma_2} e^{-\sigma_3\, s}$
  - $\sigma_0 = \frac{1}{\beta_0(\omega-\nu)}$, $\quad \sigma_1 = \frac{a_1}{\beta_0}$, $\quad \sigma_2 = -\frac{a_2}{\beta_0}(\omega - \nu)$, $\quad \sigma_3 = -\frac{a_2}{\beta_0} + \lambda$
- $\tilde{D}_q^h \simeq \frac{C_F}{N_c} \left(1 + r_1\sqrt{\alpha_s} + r_2\alpha_s\right) \tilde{D}_g^h$

Reminder: Dokshitzer et al.

Hump-backed plateau: $\tilde{D}^h \equiv \mathcal{K}^{ch} \times \frac{1}{\sigma}\frac{d\sigma}{d\ln(1/x)}$ at Z^0 peak, $Q = 91.2$ GeV

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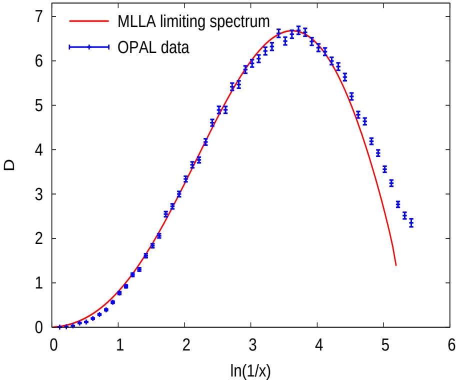
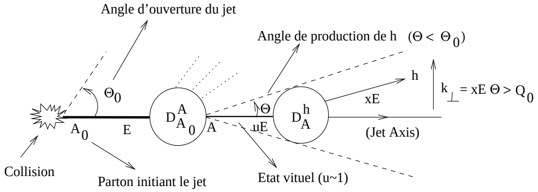


$Q \gg Q_0 \sim \Lambda_{QCD} \approx m(\pi^{\pm}) = 230$ MeV, $\gamma_0 \approx 0.5$, good agreement though!

Inclusive $k_\perp$-one particle distribution $\frac{d\sigma}{d\ln k_\perp}$

- Inclusive one particle $\frac{d\sigma}{d\ln k_\perp}$: obtained from the correlation between one particle and the energy flux (jet axis)



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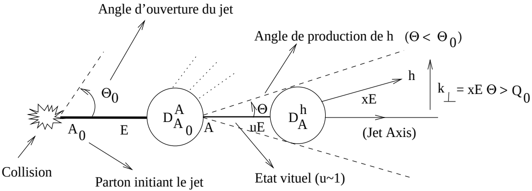

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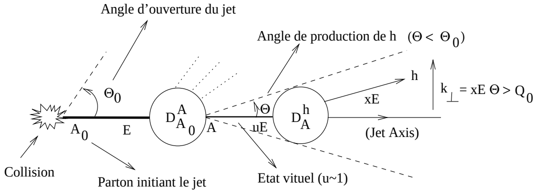

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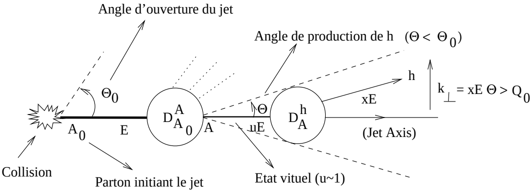

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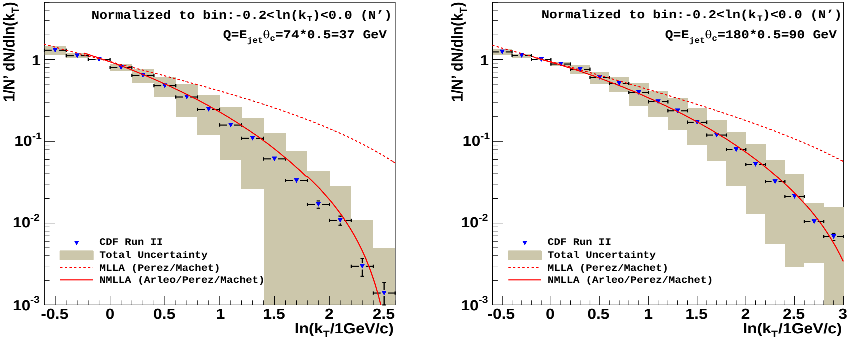
- Tested for the MLLA and NMLLA validity regions (from small to larger $k_\perp$)

Comparison with CDF data for $\frac{d\sigma}{d\ln k_\perp}$ at the Tevatron



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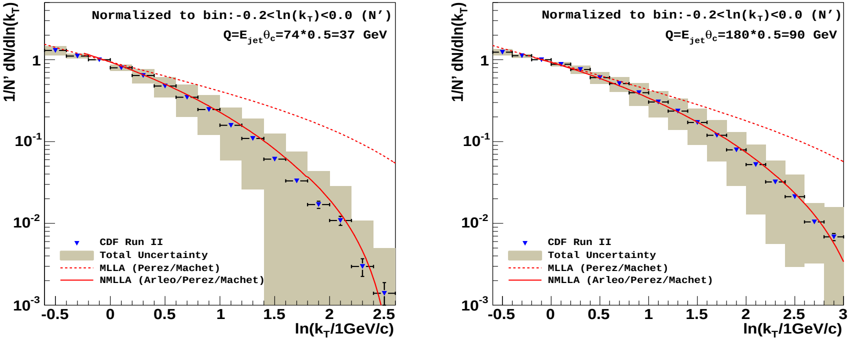

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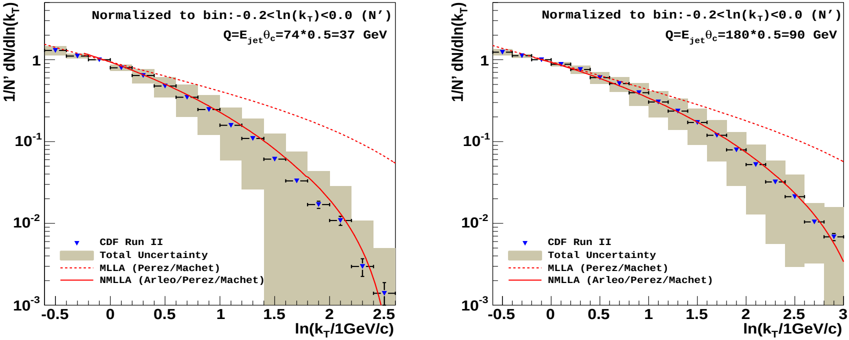
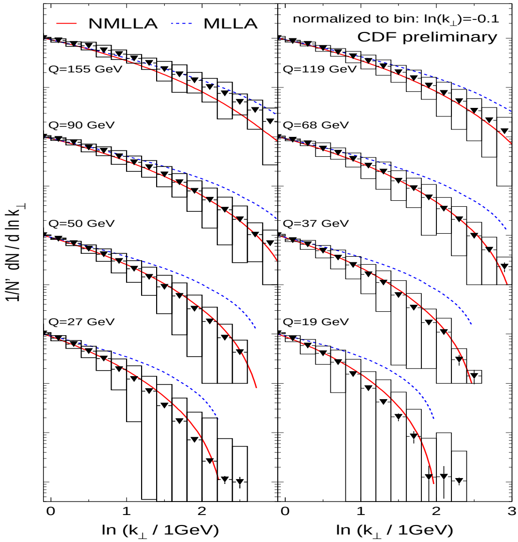


- CDF data in very good agreement with NMLLA expectations
- range of validity enlarged at NMLLA

Reference:

Aaltonen et al., CDF Collab; Phys. Rev. Lett. **102** (2009) 232002



Reference:

Arleo, Perez-Ramos, Machet; Phys. Rev. Lett. **100** (2008) 052002

Energy loss from Borghini-Wiedemann model

- Energy loss: Borghini-Wiedemann model, hep-ph/0506218

$$d\sigma_q^q \propto \frac{\alpha_s(k_\perp^2)}{4\pi} P_q^q(x) \frac{dx}{x}\frac{dk_\perp^2}{k_\perp^2}, \quad P_q^q(x) = C_F\left(\frac{2N_s}{(1-x)_+} - (1-x)\right)$$

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  - Medium-modified multiplicity N_A^h, ratio $r = \frac{N_G^h}{N_Q^h}$, multiplicity correlators $\frac{\langle N_A^h(N_A^h-1)\rangle}{N_A^2}$ as function of the nuclear parameter N_s; Pérez-Ramos, Eur.Phys.J. C 62 (2009) 541, J.Phys. G 36 (2009) 105006
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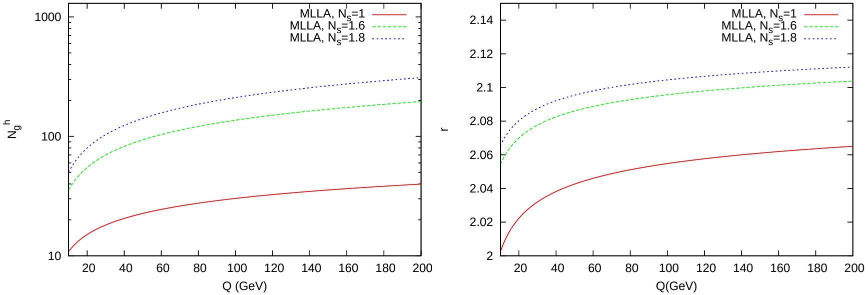
- Collimation of multiplicity in jets in the vacuum and in the medium, Arleo, Pérez-Ramos, Phys.Lett. B 682 (2009) 50

Multiplicity and mult. ratio in vacuum vs. medium

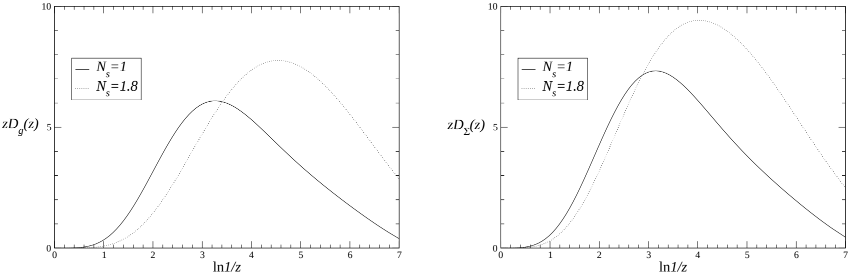


$$N_g^h(Q) \simeq \left(\ln\frac{Q}{\Lambda}\right)^{-\frac{\sigma_1}{\beta_0}} \exp\sqrt{\frac{4N_s}{\beta_0}\ln\frac{Q}{\Lambda}}, \qquad r(Q) \equiv \frac{N_g^h}{N_q^h} = \frac{N_c}{C_F}\left(1 - r\sqrt{\frac{\alpha_s}{N_s}}\right)$$

References:

R. Pérez-Ramos, Eur. Phys. J. C 62 (2009) 541, J. Phys. G: Nucl. Part. Phys. 36 (2009) 105006

Fragmentation functions vacuum vs. medium



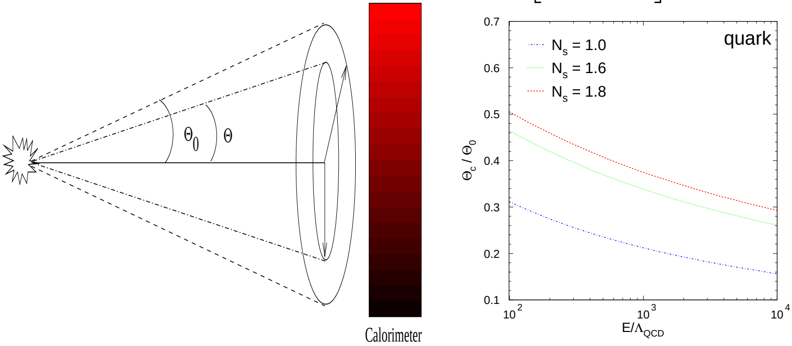
• From DGLAP (large z) and DLA evolution equations (soft gluon logarithms, small z) as a fonction of the nuclear parameter N_s.

Reference:

S. Albino, B.A. Kniehl and R. Pérez-Ramos, Nucl. Phys. B 19 (2009) 306

Collimation of average multiplicity in jets

$$N^h(\Theta, E) = \delta \times N^h(\Theta_0, E) \Longrightarrow \Theta/\Theta_0 \sim \left[N^h(E/\Lambda)\right]^{-\frac{1}{2N_s}\beta_0 \ln\frac{1}{\delta}}$$



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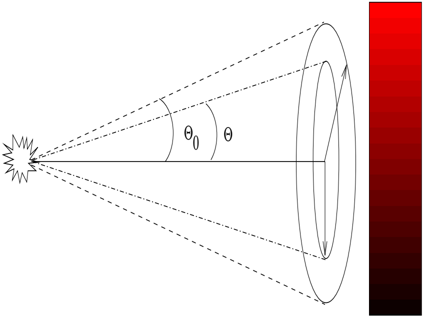

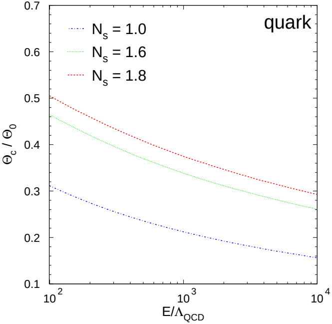

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- evidence for a "broadening" of jets in nuclear media.

References:

F. Arleo, R. Pérez-Ramos, Phys. Lett. B 682 (2009) 50

Conclusion

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- Limiting spectrum proves once again to be the most successful to describing the data
- Increase of average multiplicity in medium-modified jets at small x and suppression of hard corrections (factor $1/\sqrt{N_s}$)
- Suppression of FFs at large x
- Broadening of jets in the medium as compared to those in the vacuum (for same energy of the leadin parton)