JEWEL Model for Jet Quenching

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The MC model of Jet Quenching

The model for Jet Quenching takes into account different types of phenomena:

- Parton showers;
- Elastic scattering with the medium;
- LPM effect;

Parton showers

The parton showers is treated by making use of factorization in such a way that, given that the parton has gone through *n* branching processes, the differential cross-section of emitting an extra radiation is given by:

$$\mathrm{d}\sigma_{n+1} = \sigma_n \frac{\mathrm{d}t\mathrm{d}z}{t} \frac{\alpha_{\mathrm{s}}(\mu^2)}{2\pi} \hat{P}_{ba}(z)$$

Parton showers

The scale at wich the coupling constant is evaluated is given by the virtuality of the parton *t.* The pole is avoided by inserting a *infra-red cutoff* t_c. This also set minimal and maximum values for *z* wich avoid the poles on the kernel *P(z).*

Parton showers

The angular ordering of emissions can be applied through the requirement that:

$$t_0 > t_1 > t_2 > \ldots > t_c$$

Elastic Scattering with The Medium

The medium on JEWEL is characterized as a collection of scattering centers with a Debye mass μ_D=3T, where T is the temperature of the medium. This identification yields a cross-section on the form:

$$\sigma_i(E,T) = \int_0^{|\hat{t}|_{\max}(E,T)} \mathrm{d}|\hat{t}| \int_{x_{\min}(|\hat{t}|)}^{x_{\max}(|\hat{t}|)} \mathrm{d}x \sum_{j\in\{\mathrm{q},\bar{\mathrm{q}},\mathrm{g}\}} f_j^i(x,\hat{t}) \frac{\mathrm{d}\hat{\sigma}_j}{\mathrm{d}\hat{t}}(x\hat{s},|\hat{t}|)$$

The PDFs are calculated through integration of DGLAP equation.

Elastic Scattering with the Medium

The differential part of the cross-section will be given by:

$$\frac{\mathrm{d}\hat{\sigma}}{\mathrm{d}\hat{t}}(\hat{s},|\hat{t}|) = C_{\mathrm{R}}\frac{\pi}{\hat{s}^2}\alpha_{\mathrm{s}}^2(|\hat{t}|+\mu_{\mathrm{D}}^2)\frac{\hat{s}^2+(\hat{s}-|\hat{t}|)^2}{(|\hat{t}|+\mu_{\mathrm{D}}^2)^2} \longrightarrow C_{\mathrm{R}}2\pi\alpha_{\mathrm{s}}^2(|\hat{t}|+\mu_{\mathrm{D}}^2)\frac{1}{(|\hat{t}|+\mu_{\mathrm{D}}^2)^2}$$

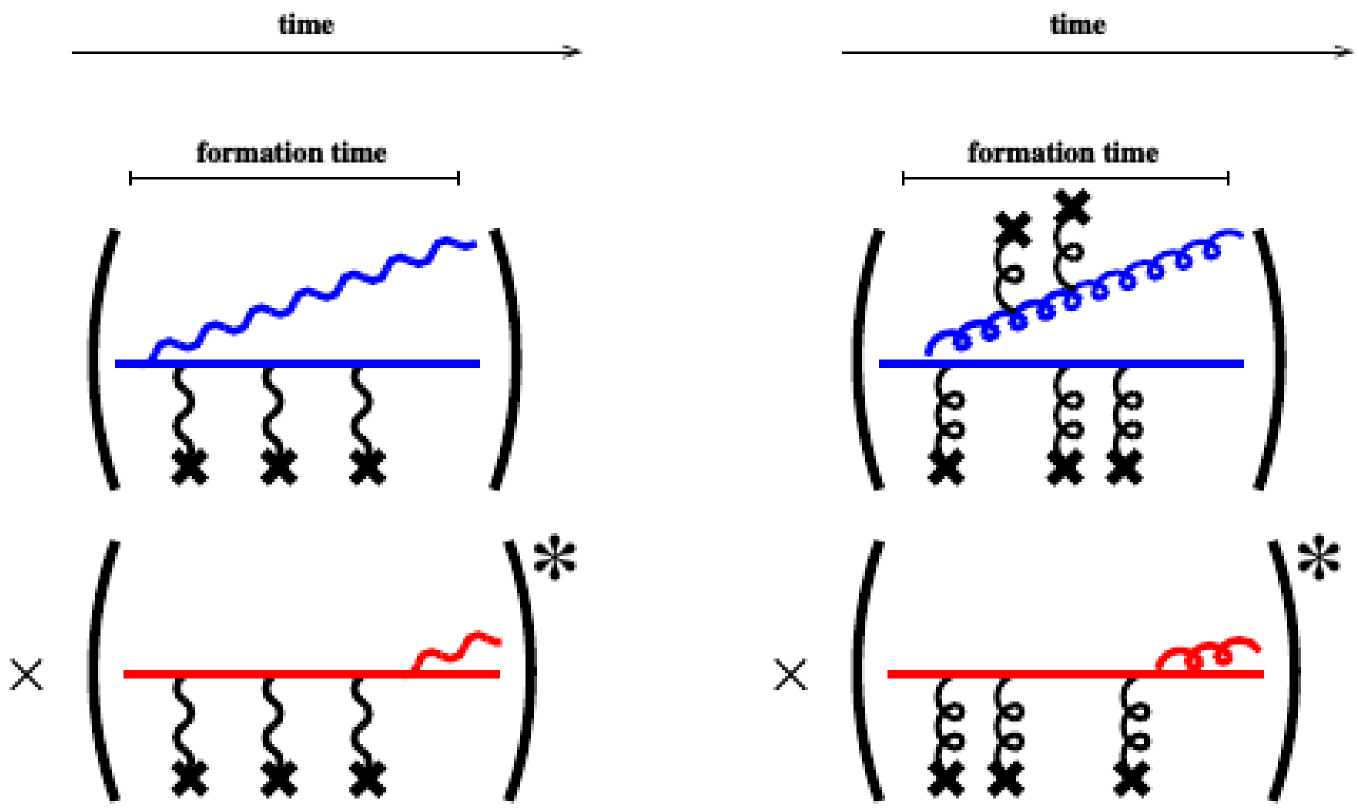
Thus, the medium is completely characterized by a density of scattering centers and its temperature profile. It is worth remarking that the inclusion of mass effects will only alter the virtuality calculations.

LPM effect

The LPM effect is the name of a destructive interference phenomena that happens when the gluon formation time on *bremsstrahlung* processes overlap with multiple scattering collisions.

LPM effect

It can be pictorially viewed on the following Feynman diagrams:



Medium Model

In the results that will be presented, the medium used for the parton propagation is built from a Glauber model initial conditions, alongside an ideal expansion, in such a way that the expansion is parametrically given by:

$$\epsilon(x, y, b, \tau) = \epsilon(x, y, b, \tau_{\mathrm{i}}) \left(\frac{\tau}{\tau_{\mathrm{i}}} \right)^{-4/3}$$

Medium model

The temperature profile, in turn, will be given by:

$$T(x,y,b,\tau) \propto \epsilon^{1/4}(x,y,b,\tau_{\mathrm{i}}) \left(\frac{\tau}{\tau_{\mathrm{i}}}\right)^{-1/3}$$

Medium model

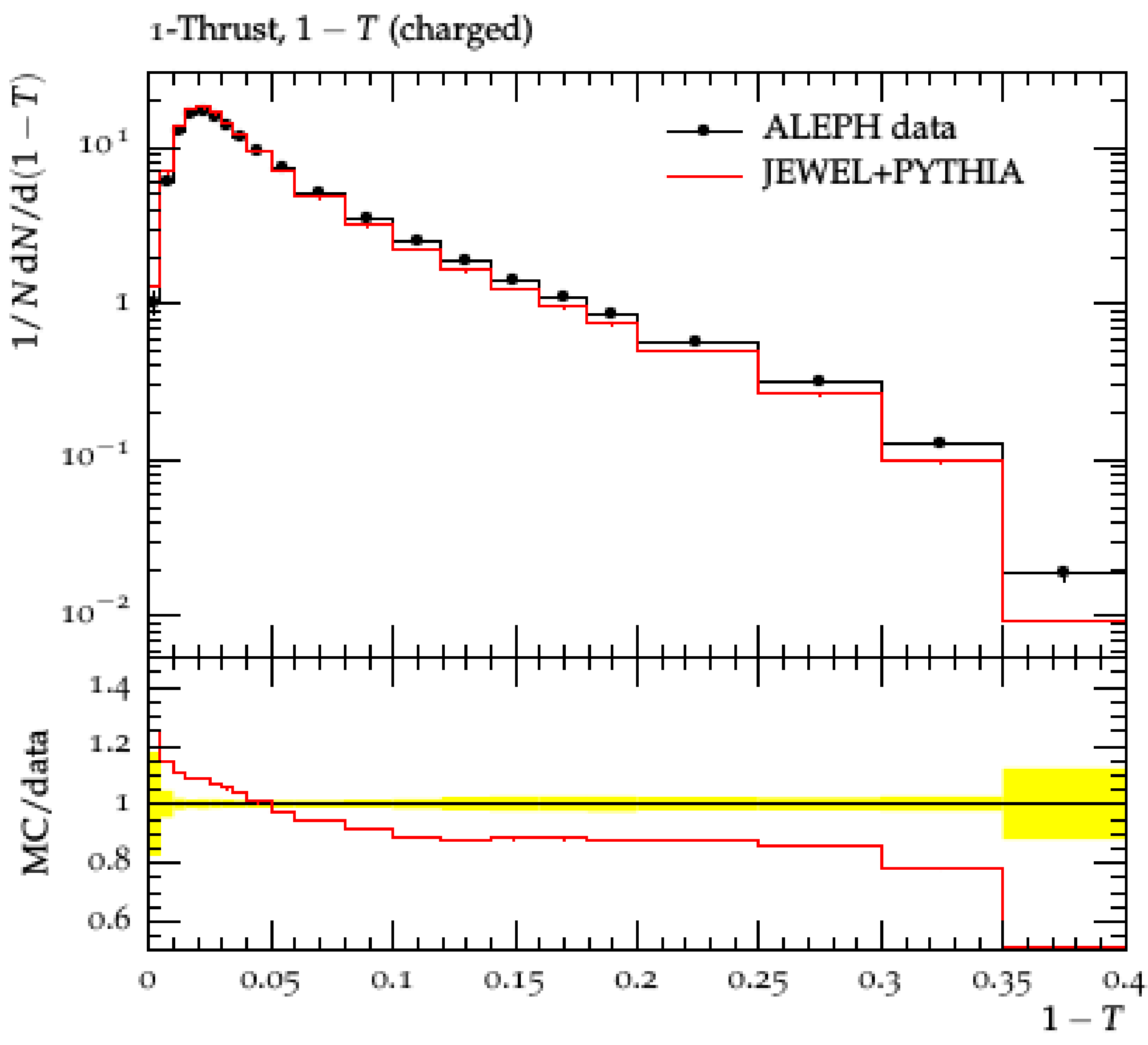
The particle density, that gives the density of scattering centers, goes as:

$$n(x, y, b, \tau) \propto T^3(x, y, b, \tau)$$

JEWEL validation

On the absence of medium, the JEWEL reduces to PYTHIA, and the data is validated against data from LEP and $p+p$ collisions at LHC.

JEWEL validation



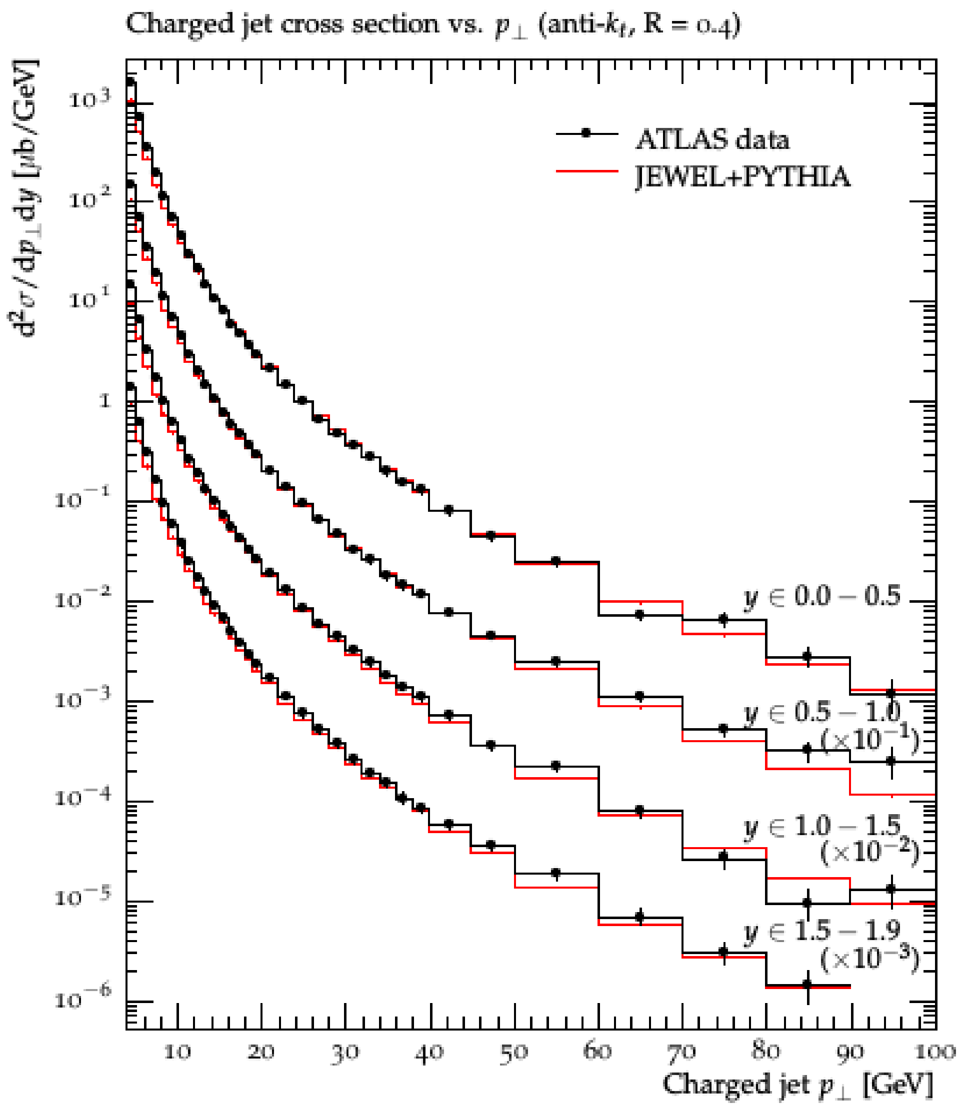
JEWEL validation

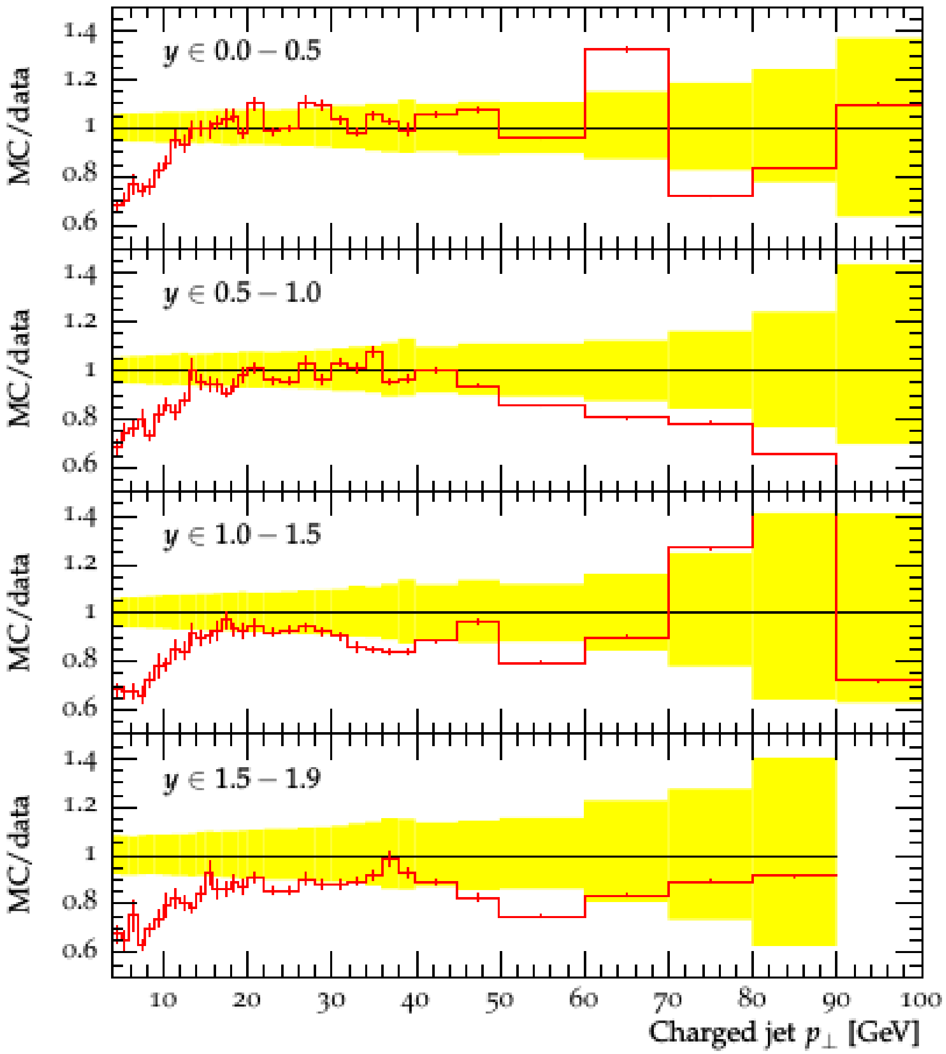
The variable thrust is defined as:

$$T \equiv \max_{\boldsymbol{n}_T} \frac{\sum_i |\boldsymbol{p}_i \cdot \boldsymbol{n}_T|}{\sum_i |\boldsymbol{p}_i|}$$

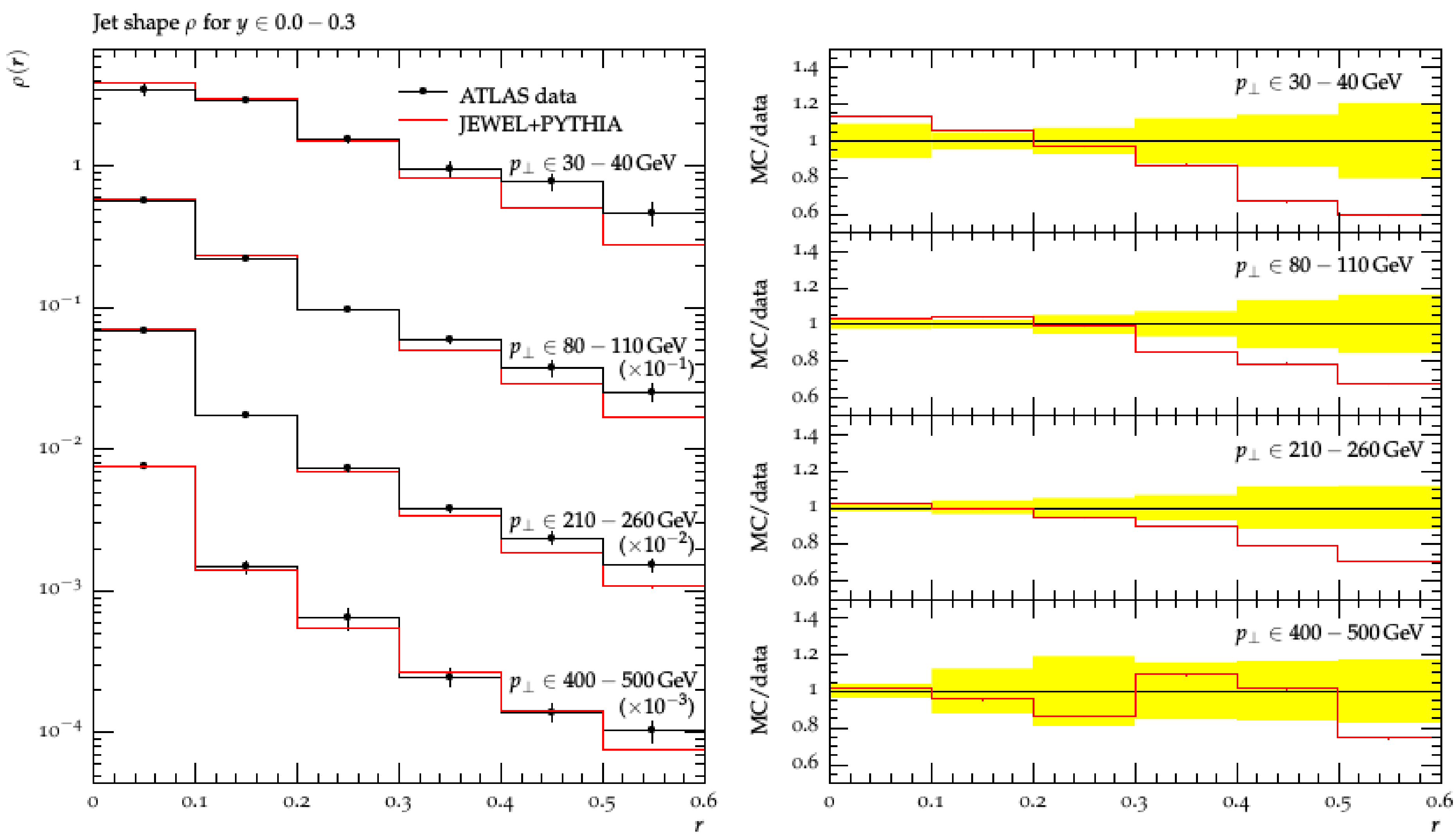
The value *T=.5* is equivalent to a spherical distribution.

JEWEL validation

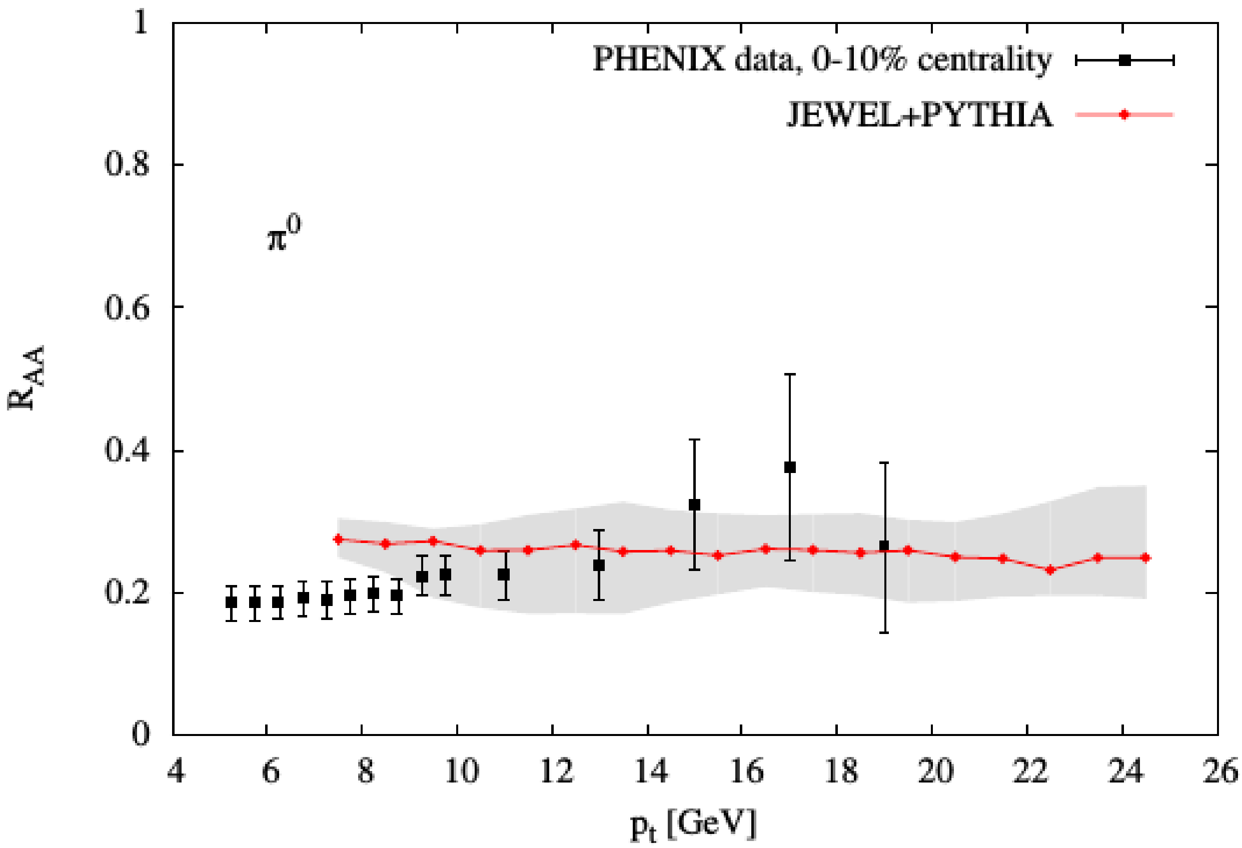




JEWEL validation

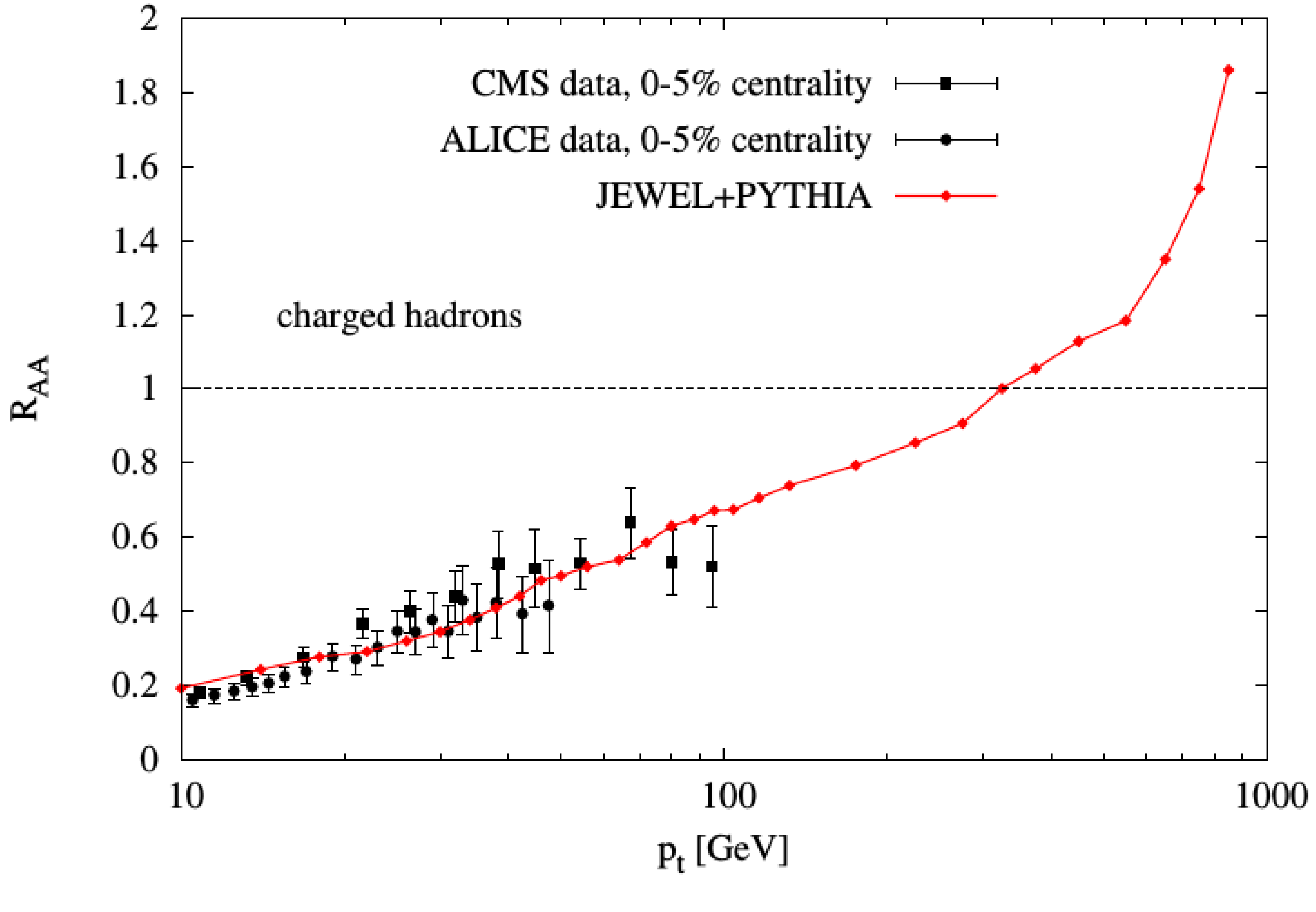


JEWEL validation

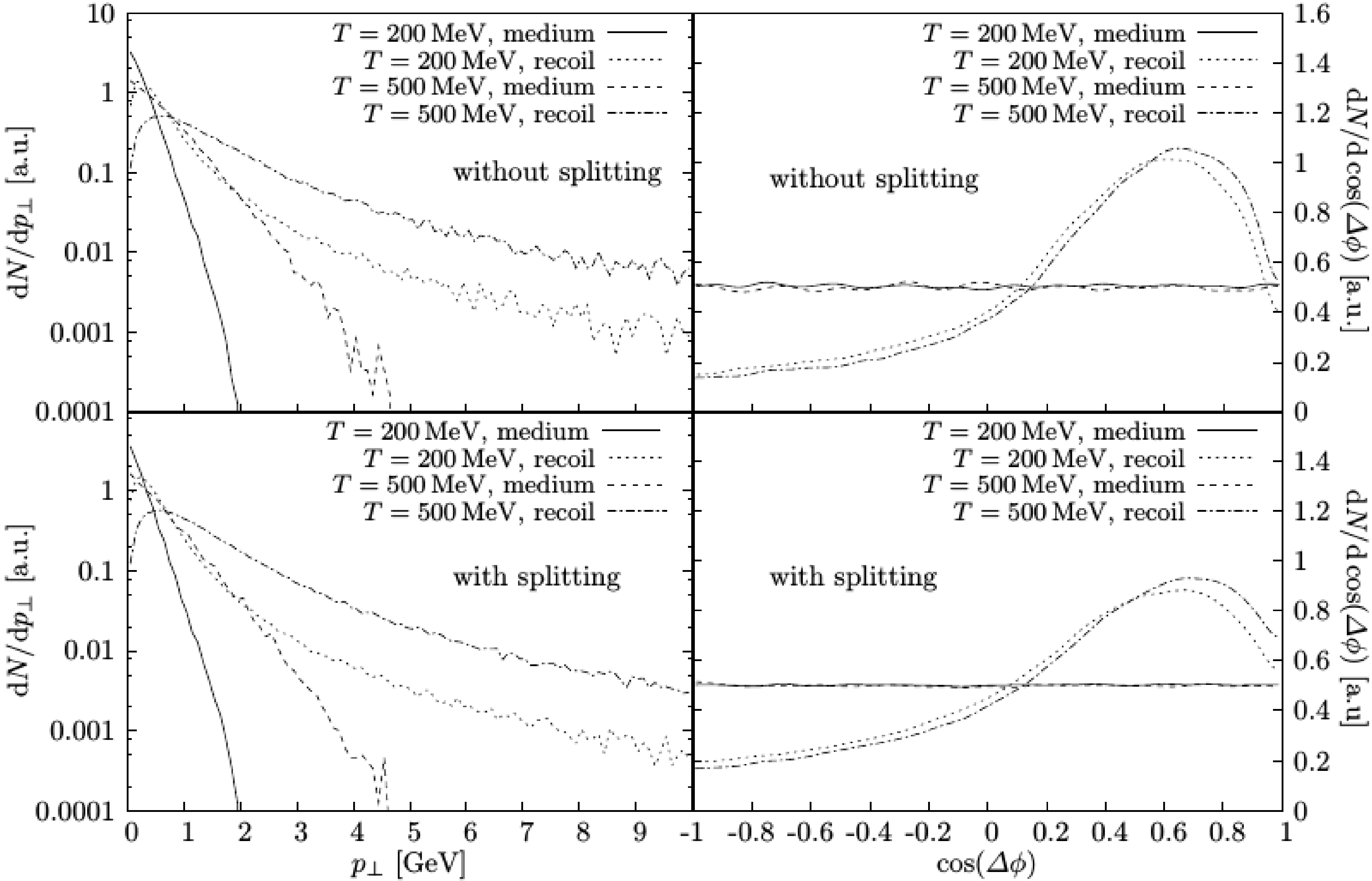


Here, the shaded region represents a variation of about 10% on the Debye mass, wich illustrates the sensitivity of data to temperature.

JEWEL validation

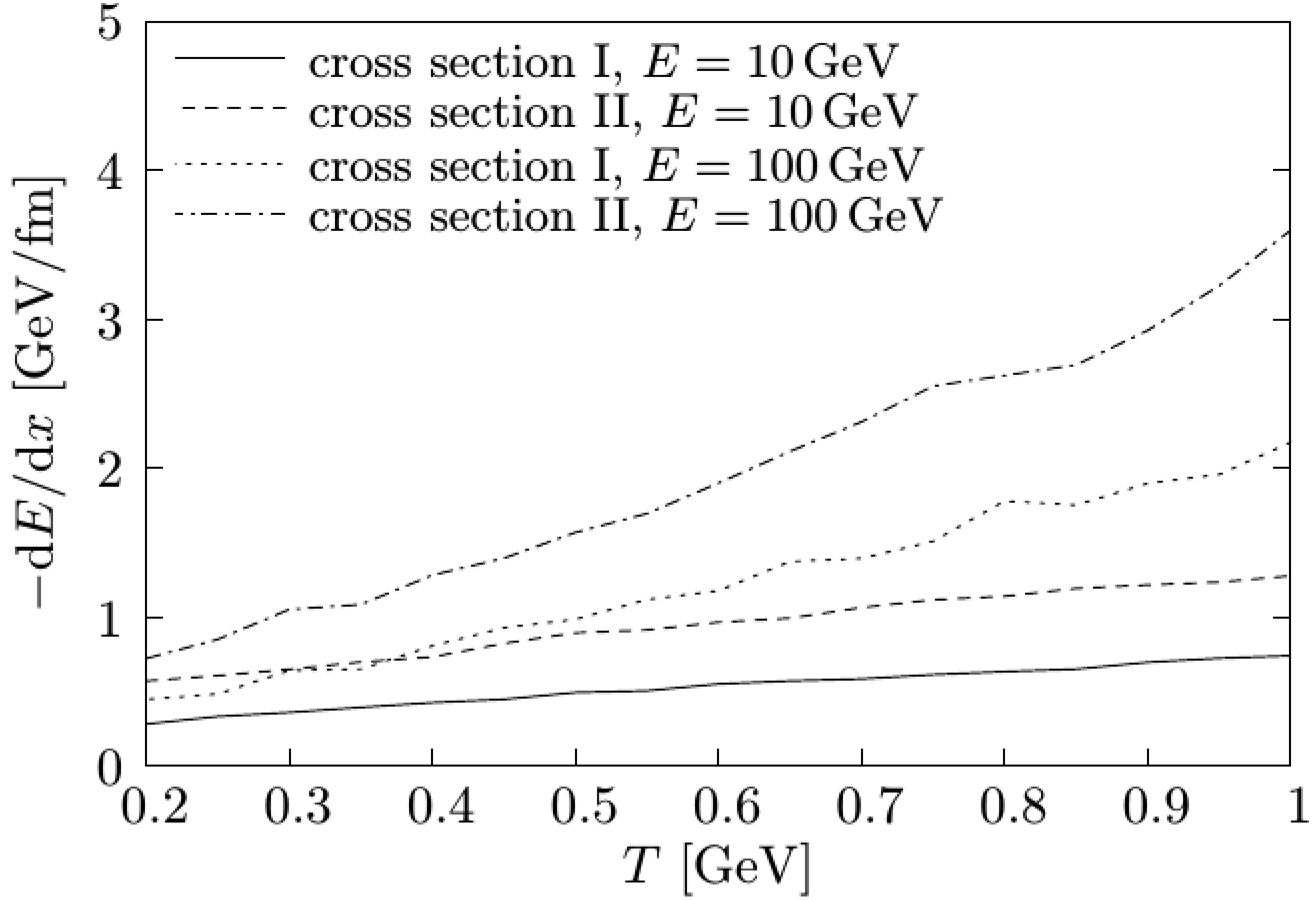


JEWEL response to medium



JEWEL response to medium

The energy loss temperature dependence on JEWEL:



Conclusion

Due to agreement with previous experimental data and high sensitive to temperature profiles, JEWEL provides a well suited model for testing more realistic hydrodynamic evolution and initial conditions models on future research.

Bibliography

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- Zapp, Korinna, Gunnar Ingelman, Johan Rathsman, Johanna Stachel, and Urs Achim Wiedemann. “A Monte Carlo Model for ‘Jet Quenching.’” The European Physical Journal C 60, no. 4 (April 2009): 617–32. https://doi.org/10.1140/epjc/s10052-009-0941-2.