Hadron production in the Relativistic Diffusion Model

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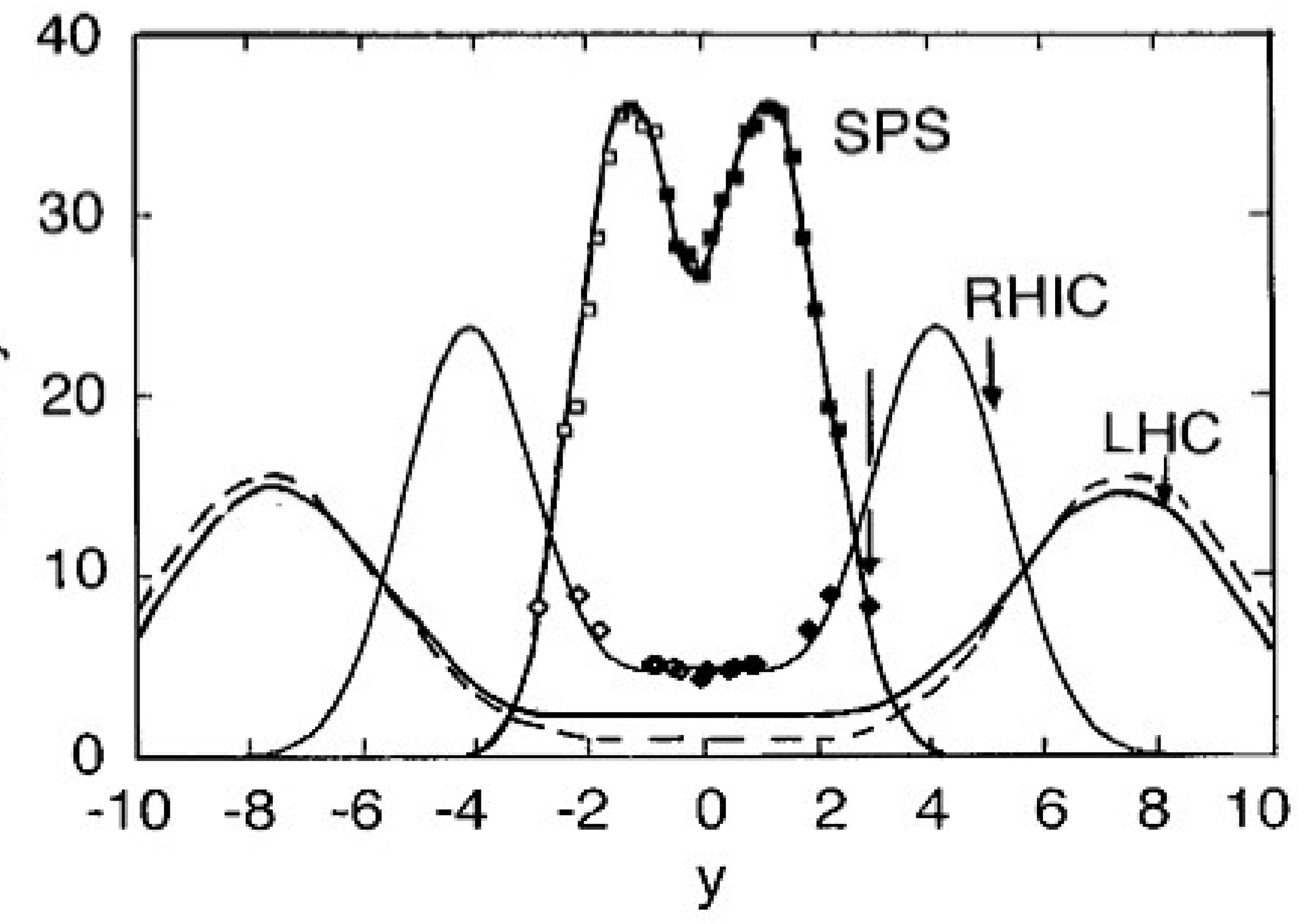
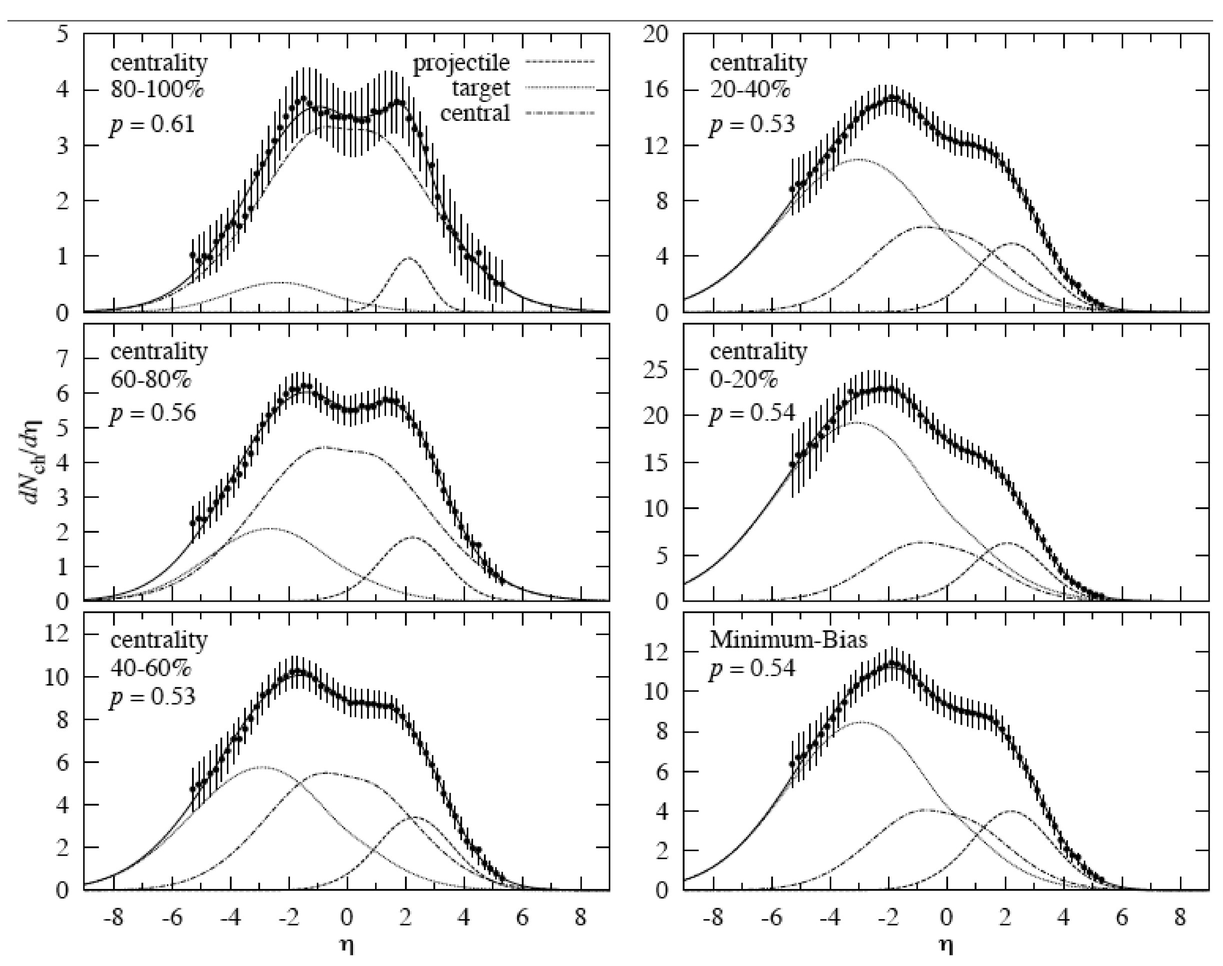
Net proton rapidity distributions: SPS to LHC



Net-proton rapidity spectra in the Relativistic Diffusion Model (RDM), solid curves: transition from the double-humped shape at SPS energies of $\sqrt{s_{NN}}$=17.3 GeV to a broad midrapidity valley at RHIC (200 GeV) and LHC (5.52 TeV). See [5] for details; Data are from NA49 and BRAHMS.

Produced charged hadrons in d+Au at RHIC



Pseudorapidity distributions of charged hadrons in d + Au collisions at $\sqrt{s_{NN}}$ =200 GeV for five different collision centralities, and minimum-bias in comparison with PHOBOS data [2]. The analytical RDM-solutions are optimized in a fit to the data. Au-like, d-like, and central partial distributions are shown for each centrality. Only the midrapidity part comes close to local equilibrium. From [4].

Relativistic Diffusion Model

A Relativistic Diffusion Model (RDM) for high-energy heavy-ion collisions is outlined and used to investigate stopping and particle production. With three sources for particle production, the energy- and centrality dependence of rapidity distributions for net protons, and pseudorapidity distributions of charged hadrons in heavy systems at RHIC energies are precisely reproduced in the analytical model. The gradual approach to local thermal equilibrium is discussed for both symmetric and asymmetric (d + Au) systems.

In the RDM, the net-baryon rapidity distribution at RHIC energies emerges from a superposition of the beam-like nonequilibrium components that are broadened in rapidity space through diffusion due to soft collisions and particle creations, and from a near-equilibrium (thermal) component at midrapidity that may indicate local quark–gluon plasma (QGP) formation. The time evolution of the distribution functions in the three sources is governed by a Fokker–Planck equation (FPE) in rapidity space [1,3–5]

$$\frac{\partial}{\partial t}[R(y,t)]^{\mu} = -\frac{\partial}{\partial y}\left[J(y)[R(y,t)]^{\mu}\right] + D_y \frac{\partial^2}{\partial y^2}[R(y,t)]^{\nu}$$

with the rapidity y = 0.5 ln[(E+p)/(E-p)]. The rapidity diffusion coefficient D_y that contains the microscopic physics accounts for the broadening of the rapidity distributions due to interactions and particle creations, and it is related to the drift term J(y) by means of a dissipation–fluctuation theorem (Einstein relation). In this work a linear drift function is used. Results with an extrapolation to LHC energies of $\sqrt{s_{NN}}$ = 5.52 TeV are shown in the left figure.

The Relativistic Diffusion Model [1] in its linear form ($\mu=\nu=1$) with explicit treatment of the collective expansion [5], or in its nonlinear version with implicit consideration of the collective effects, is also suitable for the description and prediction of the rapidity distributions of produced charged hadrons in symmetric [3,5] and asymmetric [4] systems.

If particle identification is not available, one has to convert the results to pseudorapidity space, $\eta=-\ln[\tan(\theta/2)]$ with the scattering angle θ.
The conversion from y− to η−space of the rapidity density is performed through the Jacobian

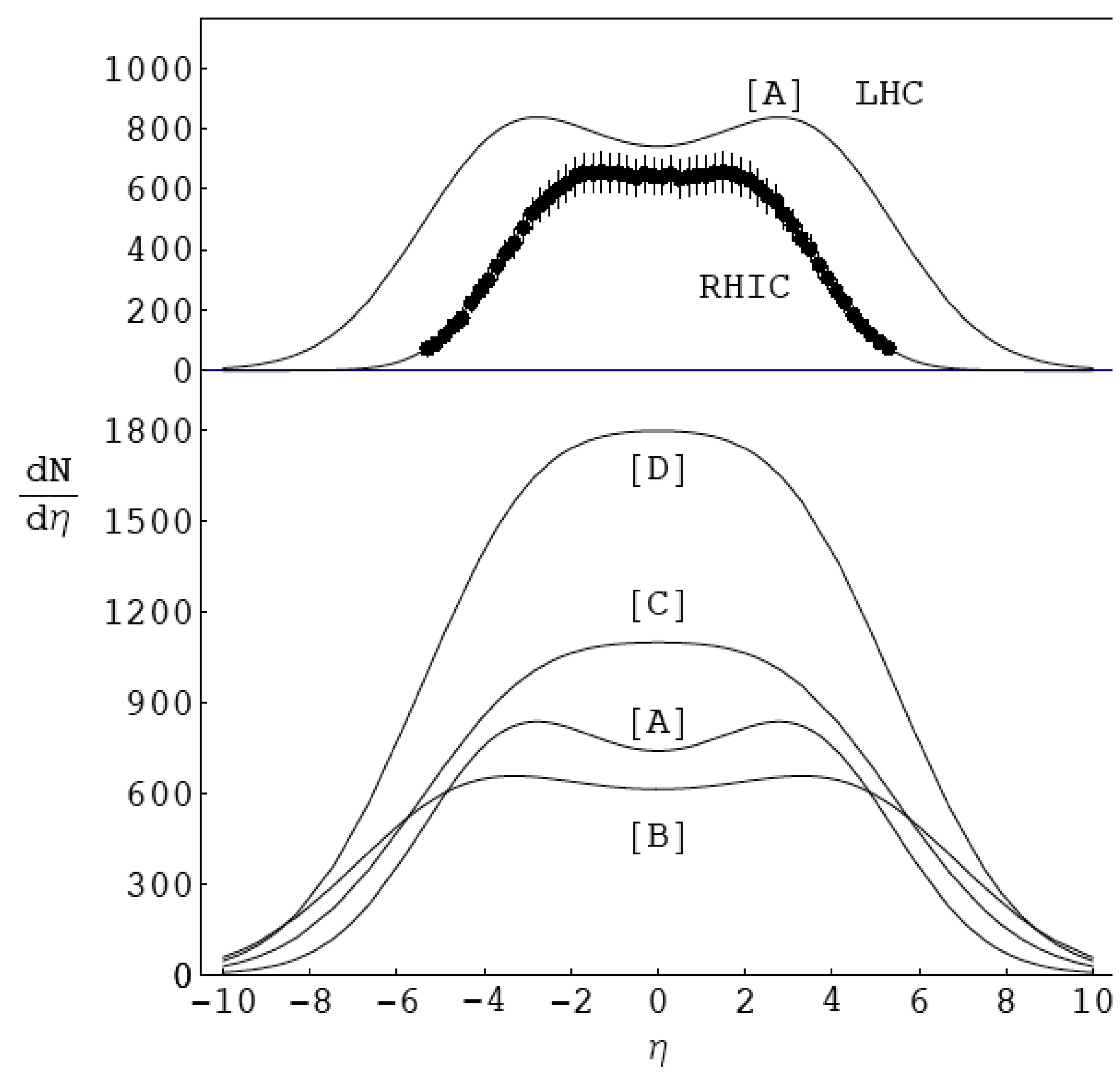
$$J(\eta, \langle m\rangle/\langle p_T\rangle) = \cosh(\eta)\cdot[1+(\langle m\rangle/\langle p_T\rangle)^2+\sinh^2(\eta)]^{-1/2}.$$

The average mass <m> of the produced charged hadrons in the central region is approximated by the pion mass, and a mean transverse momentum of 0.4 GeV/c is used at the highest RHIC energy. Results for d+Au are at the left, for Au+Au below.

Produced charged hadrons at the Large Hadron Collider (LHC)

We have extrapolated the transport coefficients for produced charged hadrons from Au+Au at RHIC energies ($\sqrt{s_{NN}}$= 19.6 – 200 GeV) to Pb+Pb at LHC energies of $\sqrt{s_{NN}}$= 5.52 TeV. Results of the curves [A] to [D] are discussed in [5].

Produced charged hadrons at the Large Hadron Collider (LHC)



Produced charged hadrons for central Au + Au collisions at RHIC in the 3-sources diffusion model compared with 200 A GeV PHOBOS data [2], and diffusion-model extrapolation to Pb + Pb at LHC energies of 5520 A GeV. See [5] for curves [A] to [D] at LHC energies.

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