Are charmed mesons thermalized in heavy ion collisions at RHIC and LHC?

I.P. Lokhtin[1], A.V. Belyaev[1], G.Kh. Eyyubova[1,2], G. Ponimatkin[3] and E.Yu. Pronina[1]

[1] *Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia*
[2] *FNSPE, Czech Technical University in Prague, Czech Republic*
[3] *Ostrov Industrial High School, Ostrov, Karlovy Vary District, Czech Republic*

H Y D J E T + +

event generator to simulate heavy ion event as merging of two independent components (**soft** hydro-type part + **hard** multi-partonic state); http://cern.ch/lokhtin/hydjet++

I.Lokhtin, L.Malinina, S.Petrushanko, A.Snigirev, I.Arsene, K.Tywoniuk, Comp.Phys.Comm. 180 (2009) 779

Soft ("thermal")

The "thermal" hadronic state generated on the chemical and thermal freeze-out hypersurfaces obtained from the parametrization of relativistic hydrodynamics with preset freeze-out conditions (the adapted generator FAST MC).

Hard ("non-thermal")

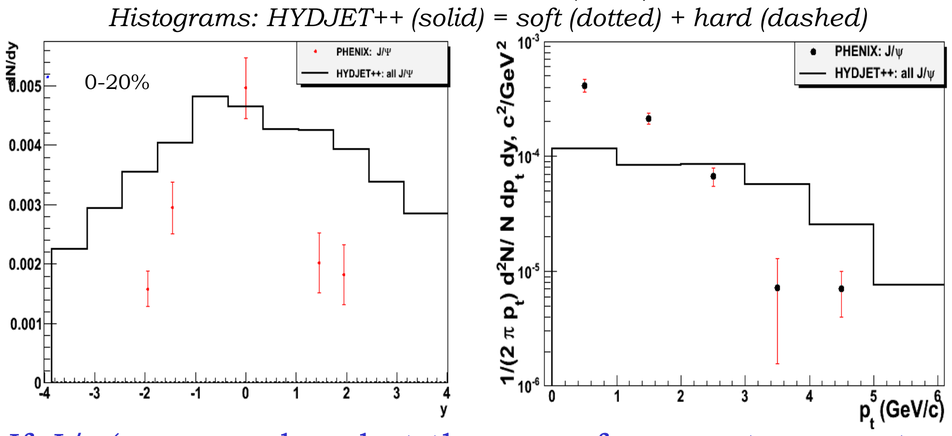
Fragmentation of medium-modified PYTHIA partonic state taking into account nuclear shadowing, multiple scattering, radiative and collisional energy loss of hard partons in expanding quark-gluon plasma (based on PYQUEN model).

The RHIC and LHC data on various characteristics of charmed hadrons (J/ψ and D mesons) are analyzed and interpreted within two-component HYDJET++ model

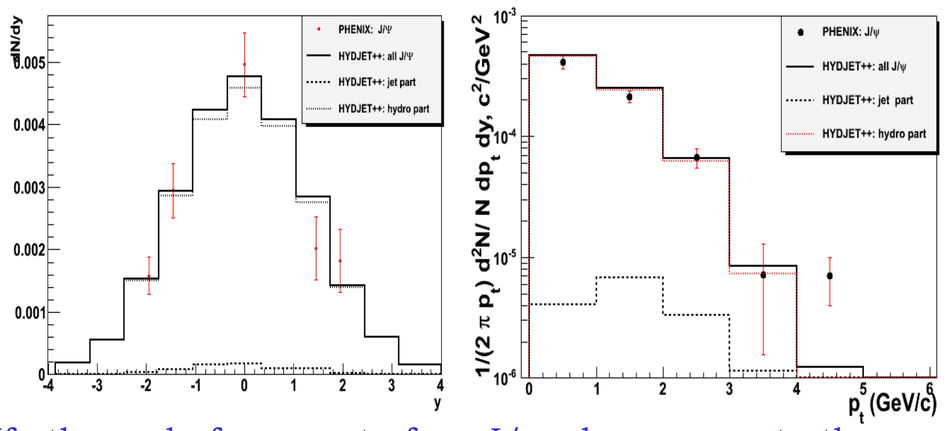
RHIC, AuAu @ $\sqrt{s_{NN}}$=200 GeV

J/ψ-mesons (y- and p_T-spectra)

Points: PHENIX data PRL 98 (2007) 232301;
Histograms: HYDJET++ (solid) = soft (dotted) + hard (dashed)



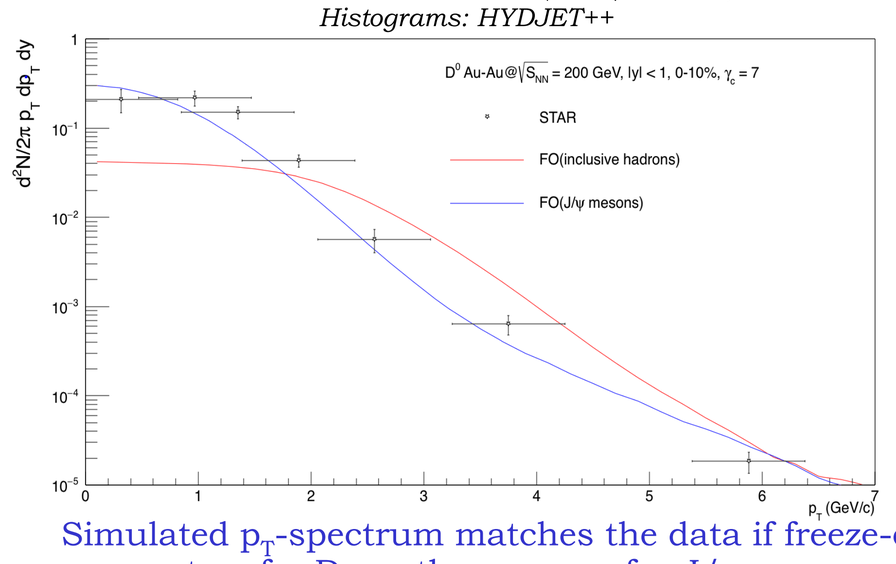
If J/ψ's are produced at the same freeze-out parameters as for inclusive (light) hadrons, then simulated spectra are much wider than the data.



If thermal freeze-out for J/ψ happens at the same temperature as chemical freeze-out (with reduced collective velocities), then simulated spectra match the data.

D-mesons (p_T-spectrum)

Points: STAR data PRL 113 (2014) 142301;
Histograms: HYDJET++



Simulated p_T-spectrum matches the data if freeze-out parameters for D are the same as for J/ψ.

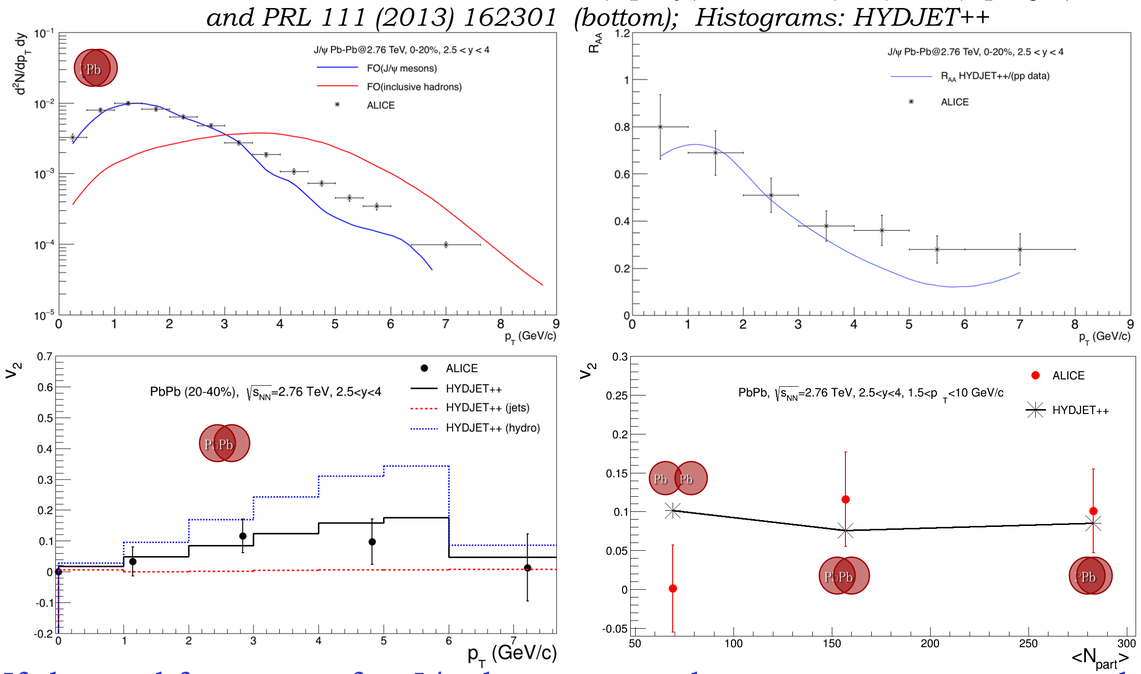
Charmed mesons at RHIC (summary)

Momentum spectra of D and J/ψ mesons in most central AuAu collisions may be reproduced (with the same freeze-out parameters) by two-component model including thermal (soft) and non-thermal (hard) components. Thermal freeze-out of charmed mesons happens before thermal freeze-out of light hadrons, presumably at chemical freeze-out (with reduced radial and longitudinal collective velocities**). Thus D and J/ψ mesons seem not to be in a kinetic equilibrium with the medium.**

LHC, PbPb @ $\sqrt{s_{NN}}$=2.76 TeV

J/ψ-mesons (p_T-spectrum, R_{AA} and v_2)

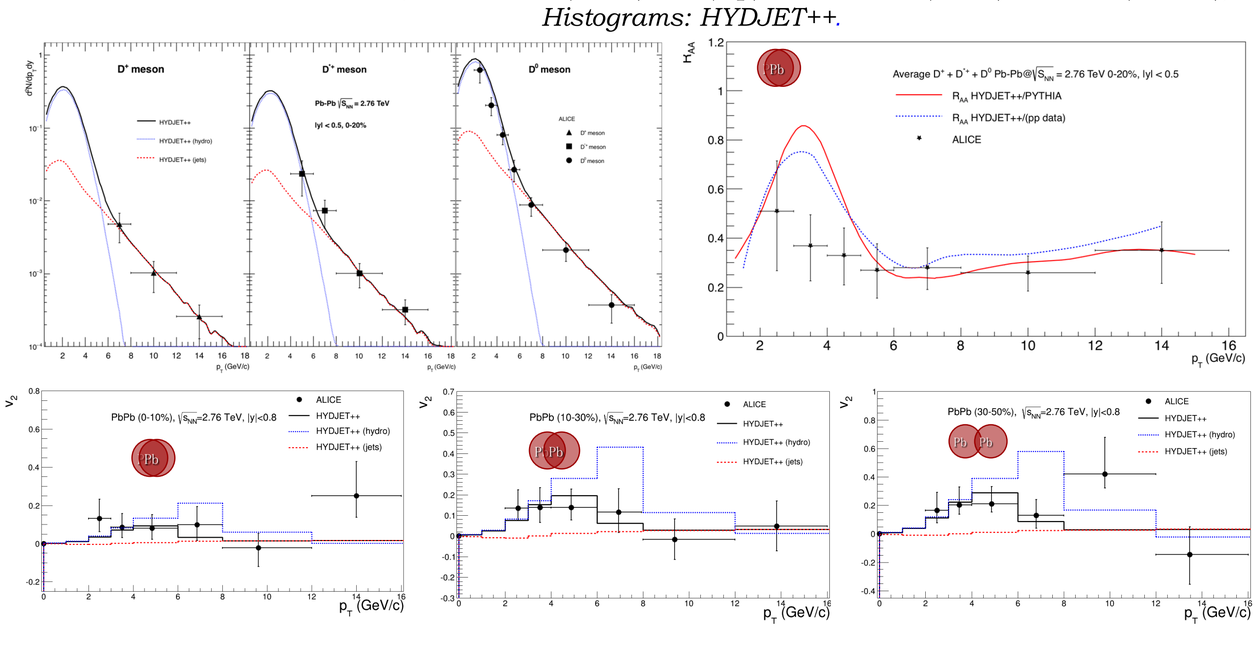
Points: ALLICE data, arXiv:1506.08804 (top left), PLB 734 (214) 314 (top right) , and PRL 111 (2013) 162301 (bottom); Histograms: HYDJET++



If thermal freeze-out for J/ψ happens at the same temperature as chemical freeze-out (with reduced collective velocities), then simulated spectra match the data up to p_T~3 GeV/c. Elliptic flow v_2 (p_T, N_{part}) is reproduced well.

D-mesons (p_T-spectrum, R_{AA} and v_2)

Points: ALLICE data, JHEP 1209 (2012) 112 (top) and PRC 90 (2014) 134904 (bottom); Histograms: HYDJET++.



The simulated p_T-spectra and elliptic flow v_2 (p_T) of D with the same freeze-out parameters as for inclusive (light) hadrons match the data. Nuclear modification factor $R_{AA}(p_T)$ is reproduced at high p_T.

Charmed mesons at LHC (summary)

Momentum spectra and elliptic flow of D and J/ψ mesons in PbPb collisions may be reproduced by two-component model including thermal (soft) and non-thermal (hard) components. Thermal freeze-out of D-mesons happens simultaneously with thermal freeze-out of light hadrons; thermal freeze-out of J/ψ-mesons happens appreciably before, presumably at chemical freeze-out (with reduced radial and longitudinal collective velocities). **Thus the significant part of D mesons (up to p_T~4 GeV/c) seems to be in a kinetic equilibrium with the medium, while J/ψ mesons – not.** Non-thermal charm production mechanism and in-medium heavy quark energy loss are important at high p_T.