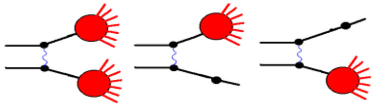
Coalescence in the FTF model

V. Uzhinsky, 29 Oct. 2019

Changes in FTF model:



G4DiffractiveExcitation.cc -- **De-excitation of exc. Hadrons is allowed. It is very old problem of Fritiof.**

G4ElasticHNScattering.cc -- **More simple and more correct algorithm. It makes proton spectra symmetric in CMS.**

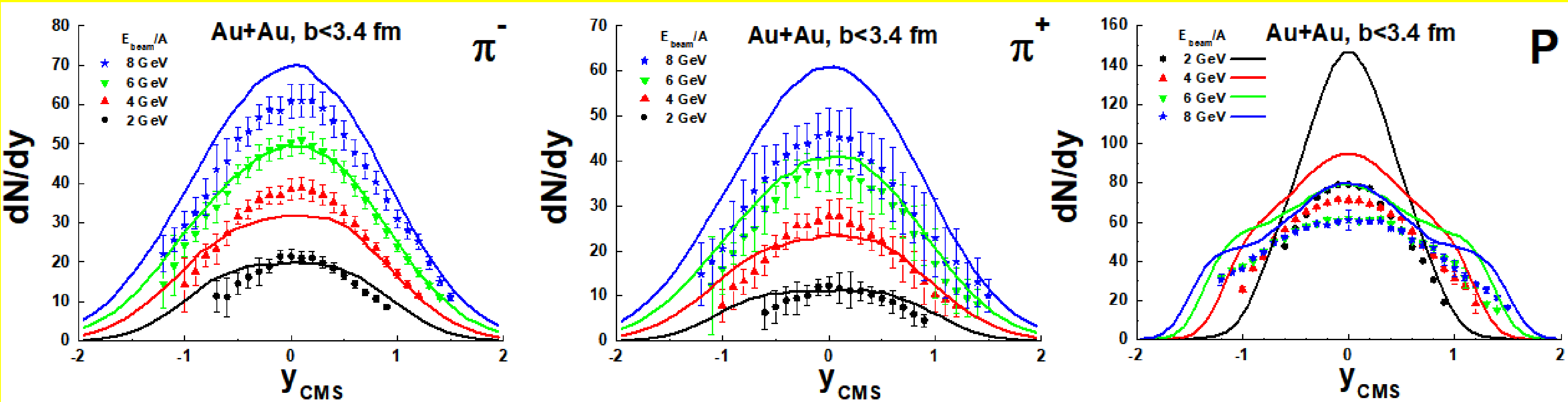
G4FTFParticipants.cc -- **Sampling of impact parameter in pre-defined range is allowed (temporary) for simulations with various centralities.**

G4FTFParameters.cc -- **E* = 0 to protect crush in G4ExcitatioHandler. I believe it is happened due to huge E*. It is needed to improve the calculation of E*.**

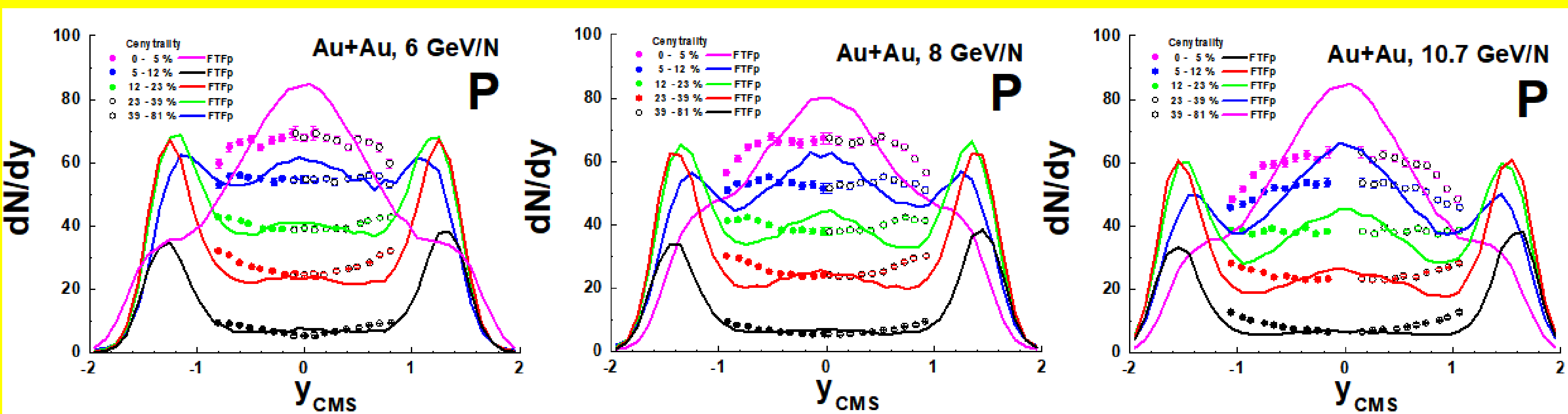
Coalescence is added. It allows to decrease proton yield and light nucleus production in the central region.

How does FTF (G4.10.5ref06) work? E895 and E917 Exp.

J. L. Klay et al., Phys. Rev C 68, 054905 (2003), Charged pion production in 2A to 8A GeV central Au+Au Collisions,
J. L. Klay et al., E895 Collaboration, Phys. Rev. Lett. 88, 102301 (2002)



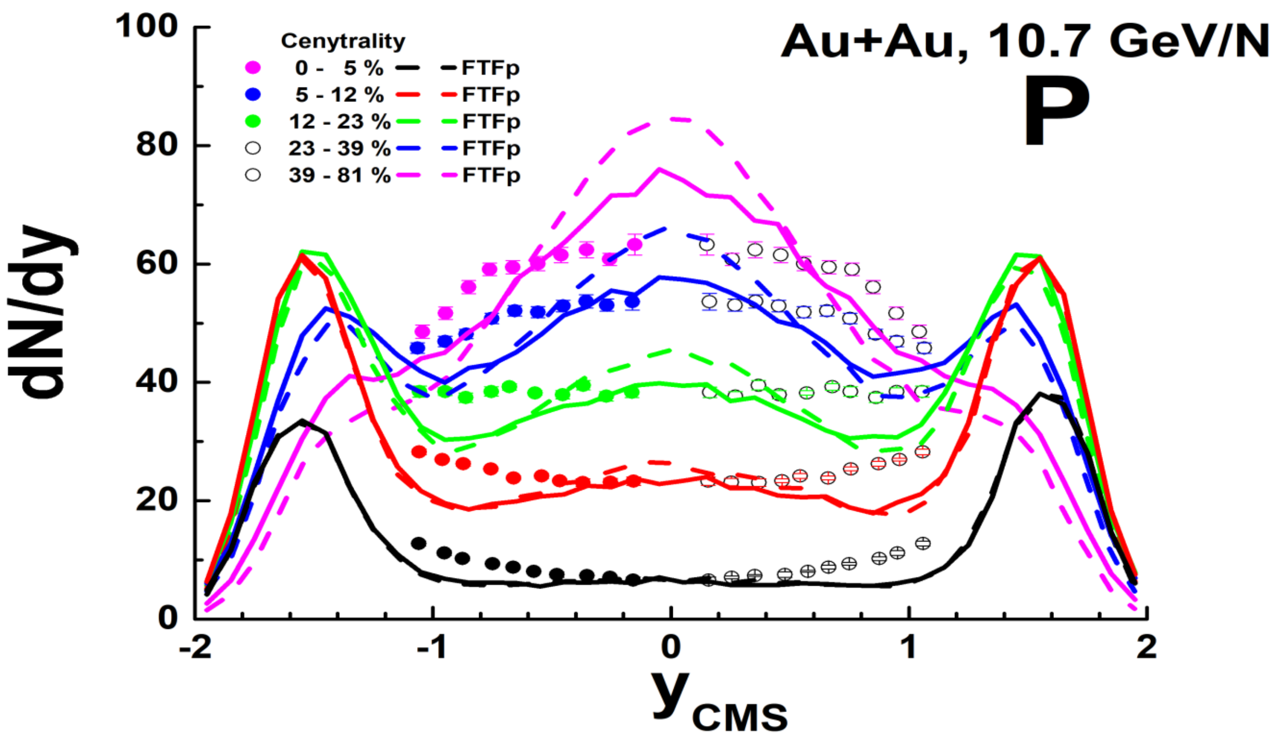
Proton emission in Au+Au collisions at 6-GeV/nucleon, 8-GeV/nucleon, and 10.8-GeV/nucleon, PRC66 , 05490 (2002), E917 Collab. (B.B. Back et al.)



Problems: Overestimation of Pi+/- mesons at highest energies and bad spectra of protons.

Results of the improvements for E917 exp.

Proton emission in Au+Au collisions at 6-GeV/nucleon, 8-GeV/nucleon, and 10.8-GeV/nucleon, PRC66 , 05490 (2002), E917 Collab. (B.B. Back et al.)



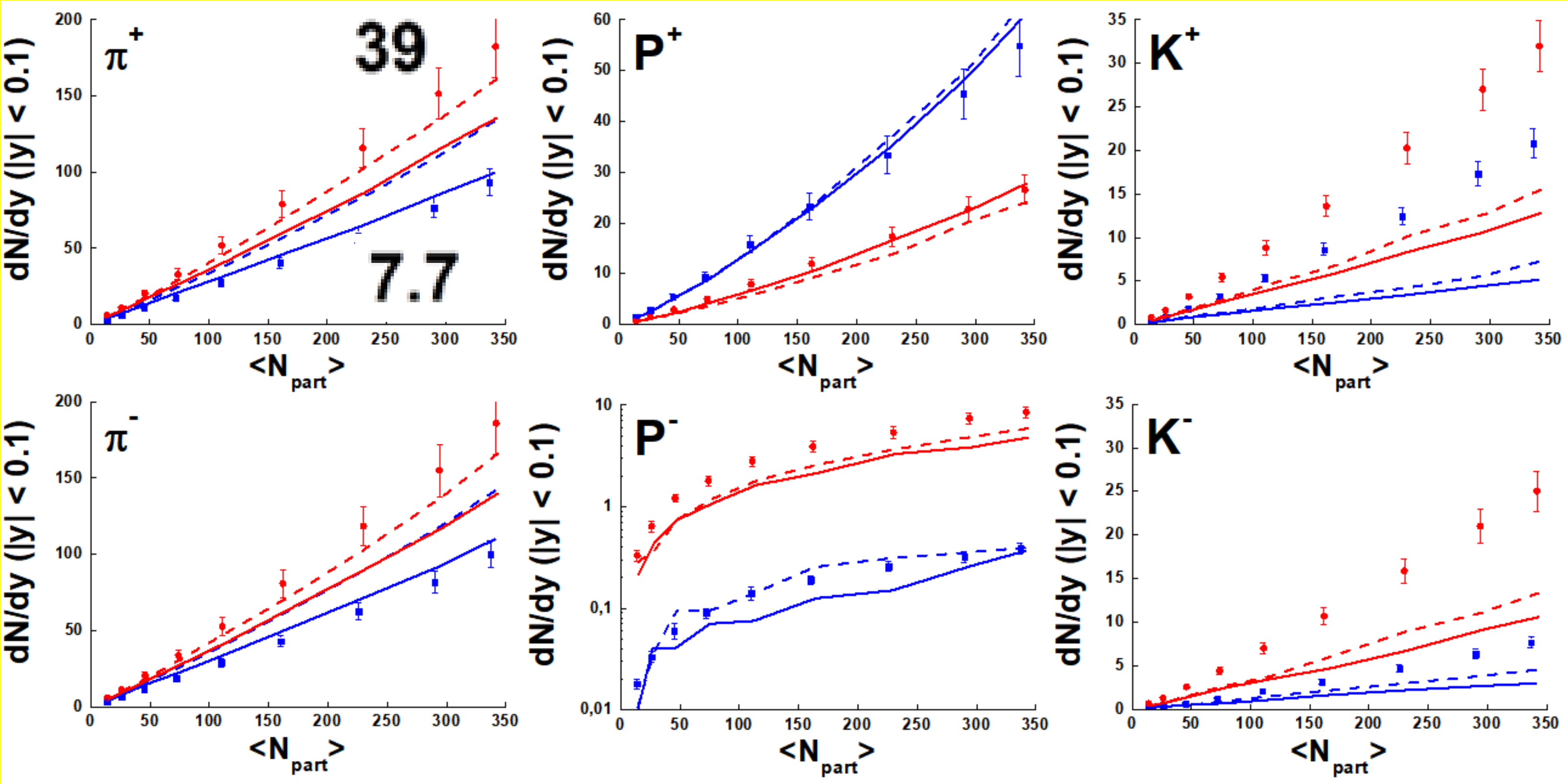
Dashed lines are previous calculations, solid ones – current results.

There is a problem for most central interactions.
A source of the disagreement at |y| ~ 0.5 – 1 is unknown!

Results of the improvements for BES of RHIC

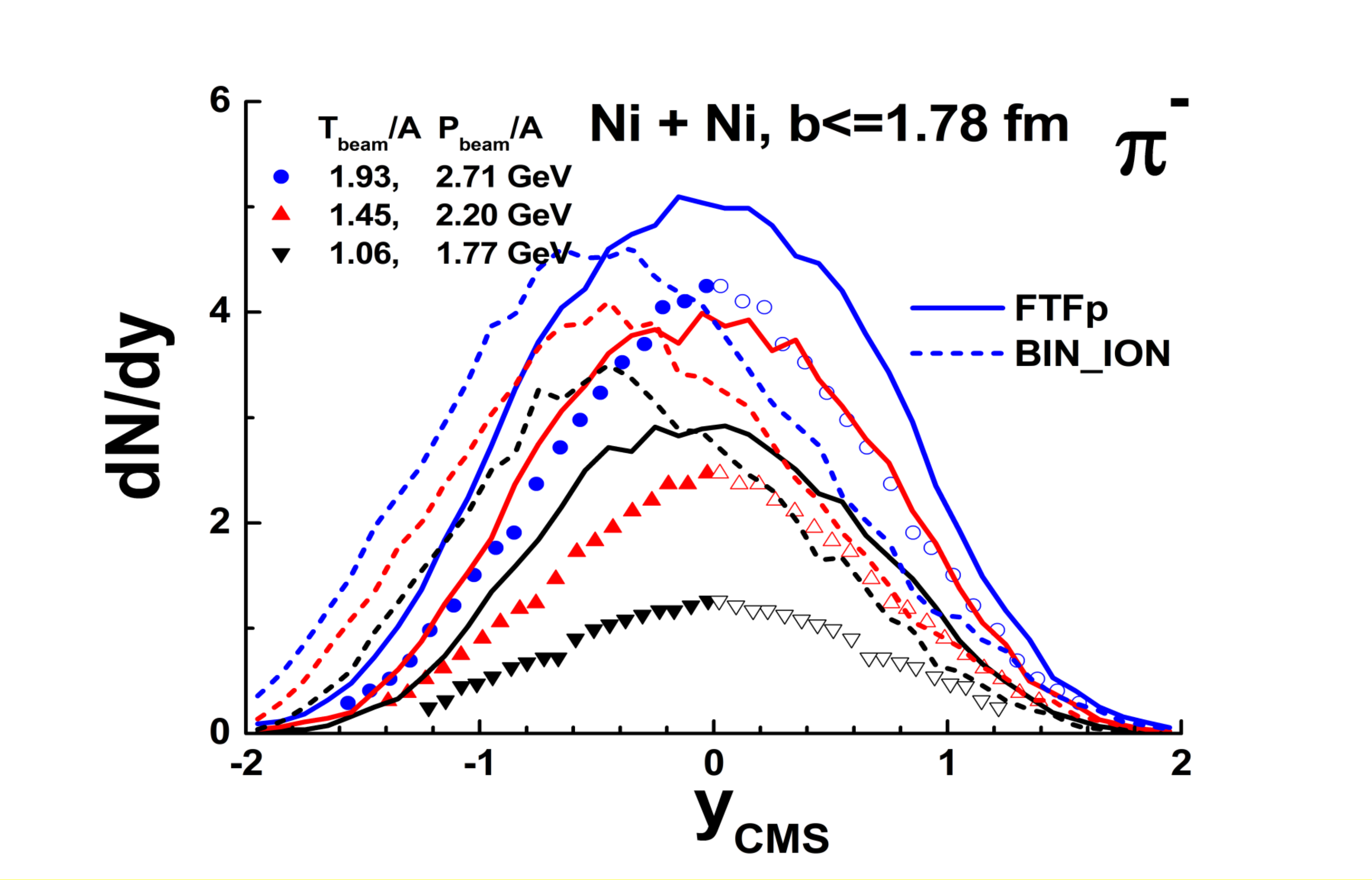
Bulk properties of the medium produced in relativistic heavy-ion collisions from the beam energy scan program, PRC **96**, 044904 (2017)

STAR Collaboration (L. Adamczyk et al.) Ecms= 7.7, 11.5, 19.6, 27, and 39 GeV

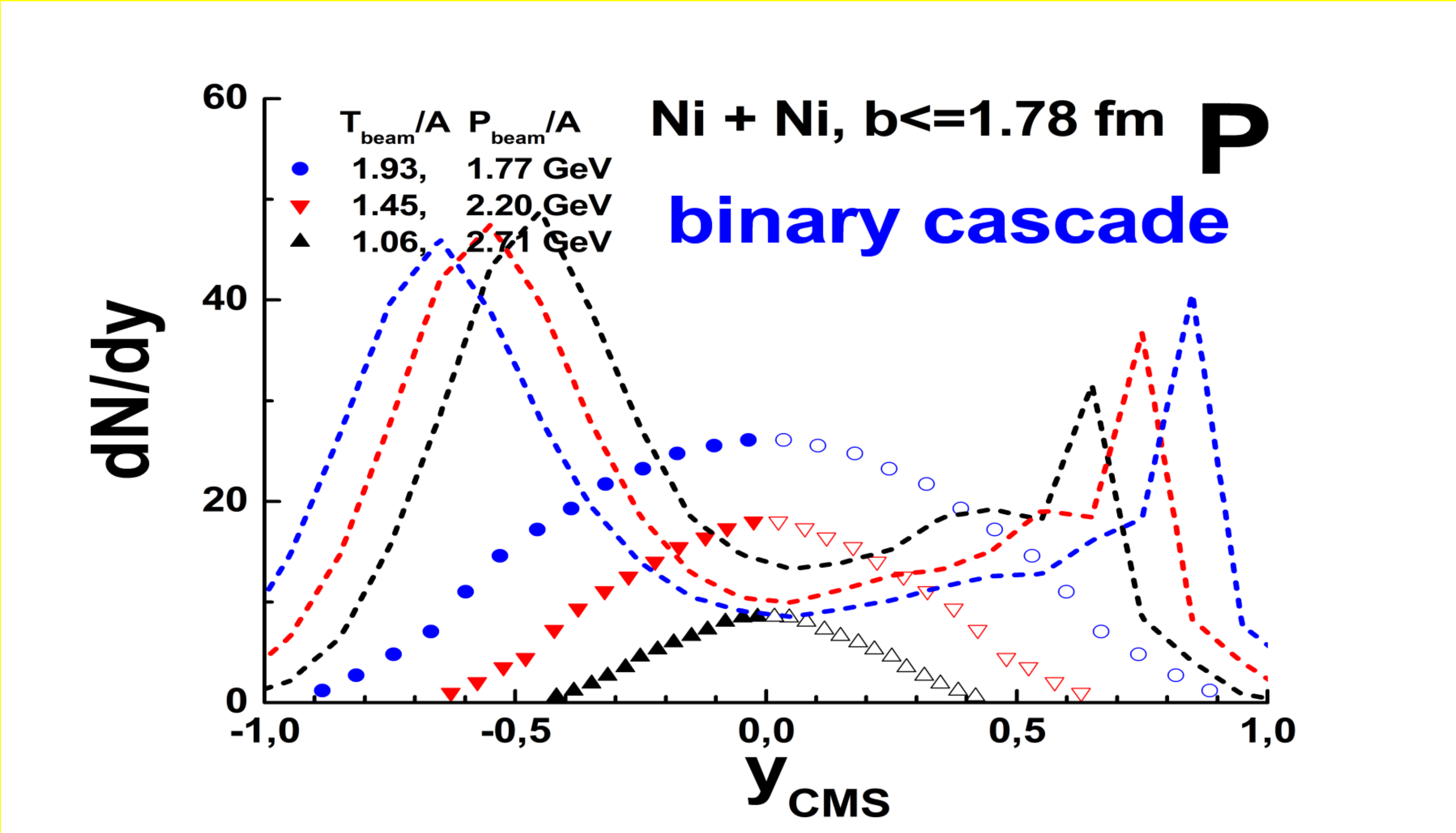


New FTF: Pi+, Pi-, P – OK at 7.7 GeV; Pi+ and Pi- underestimated at 39 GeV. Old FTF: Pi+ and Pi- overestimated at 7.7 GeV; OK at 39 GeV.

Binary cascade model and FTF for Ni+Ni

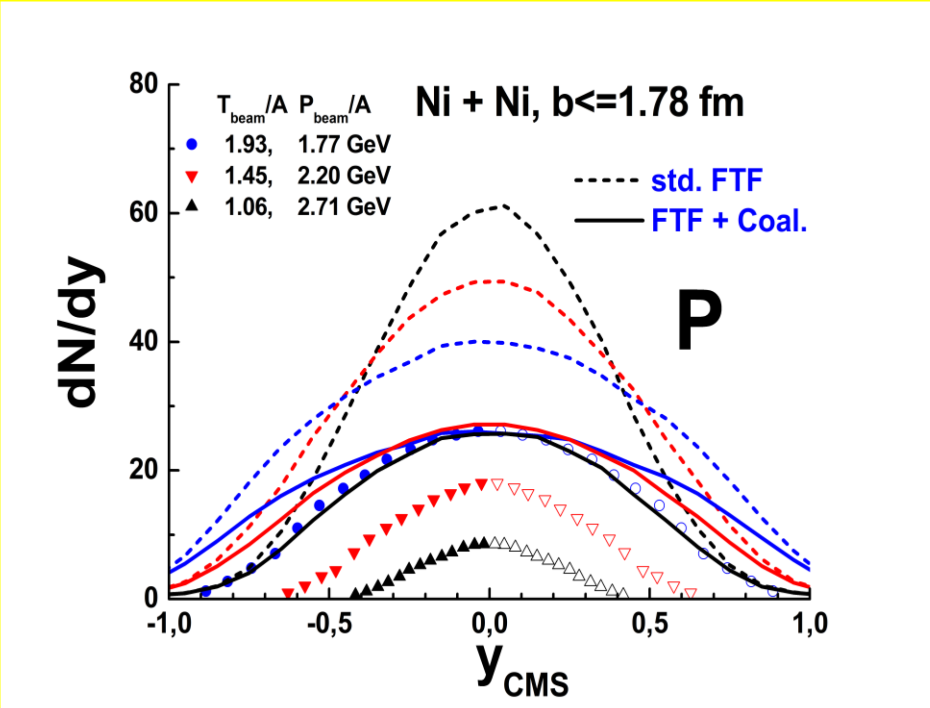


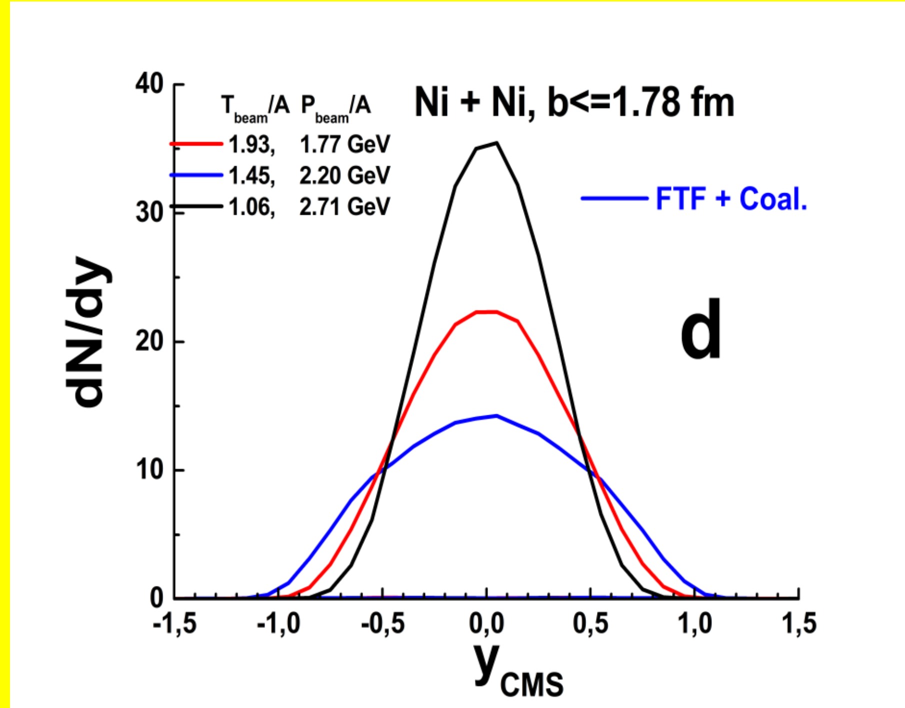
Binary cascade model and FTF for Ni+Ni



BIC is used very old idea about independent cascading of projectile nucleons in target nucleus.

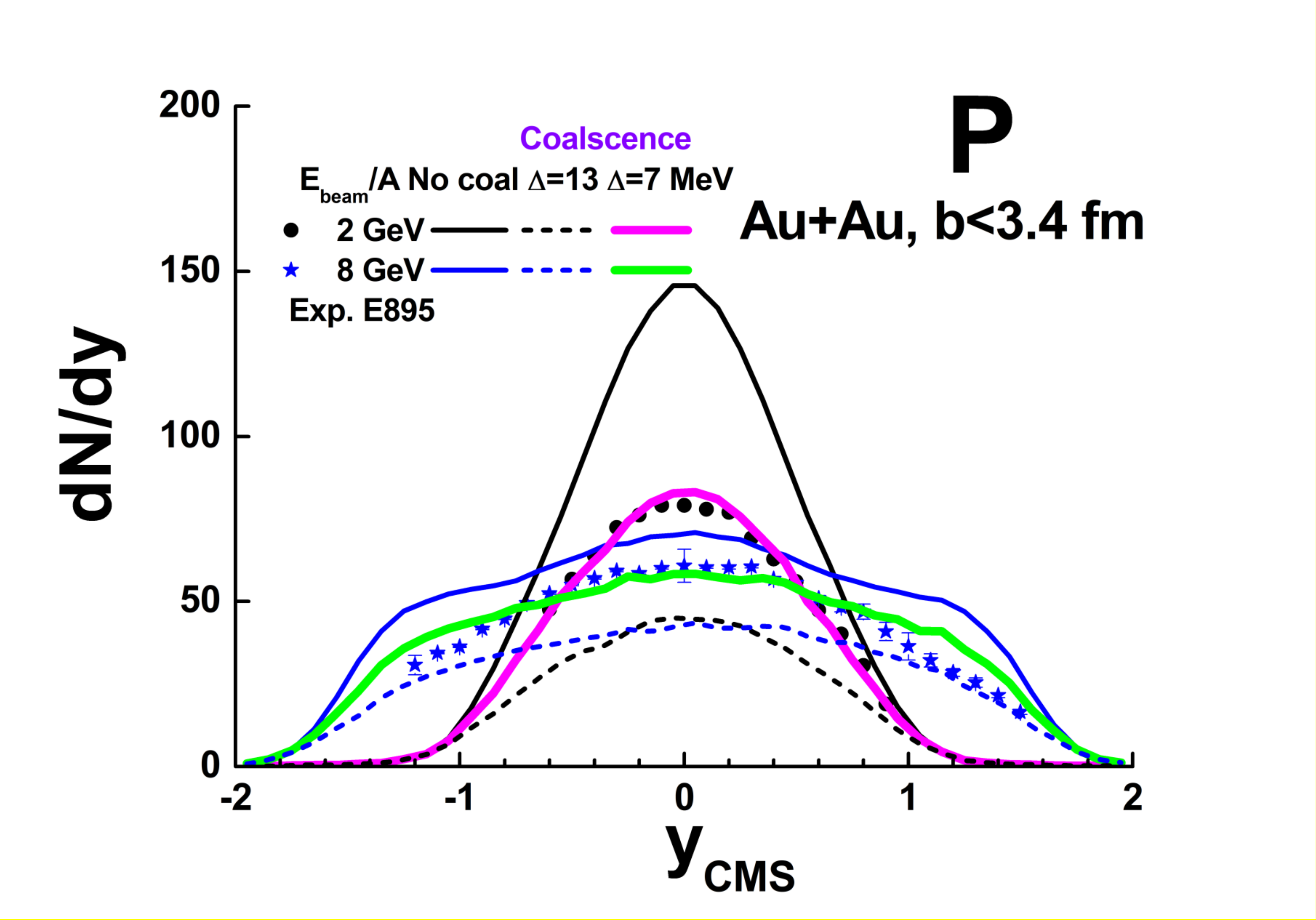
FTF + Coalescence for Ni+Ni





Adjustment of the coalescence radii allows to decrease proton yield and increase light nucleus production.

FTF + Coalescence for Ni+Ni



Conclusion

Draft implementation of the coalescence is done in binary cascade
G4GeneratorPrecompoundInterface.cc

It allows to decrease proton yield at low energies and produce light nuclei in the central region.
Further tuning of the parameters is needed.

It would be well to improve the binary cascade model for low energy nucleus-nucleus reactions.
It can be useful for medical applications.

Some related materials

High Energy Hadron Production, Self-Organized Criticality and Absorbing State Phase Transition
Paolo Castorina and Helmut Satz
arXiv.org 1910.09029

P. Bak, C. Tang and K. Wiesenfeld,
Self-organized criticality: An Explanation of 1/f noise
Phys. Rev. Lett. 59 (1987) 381

H. J. Jensen, **Self-Organized Criticality**,
Cambridge University Press, Cambridge University Press, 1998

H.Hinrichsen, **Non Equilibrium Critical Phenomena and Phase Transitions into Absorbing States**,
arXiv:0001070.

In other words, in our case there is no hot (or a very short-live) interacting hadron gas.

No equilibrium thermal system of any kind is assumed.

No hot hadronic gas after QGP freezeout!

Some related materials

High Energy Hadron Production, Self-Organized Criticality and Absorbing State Phase Transition

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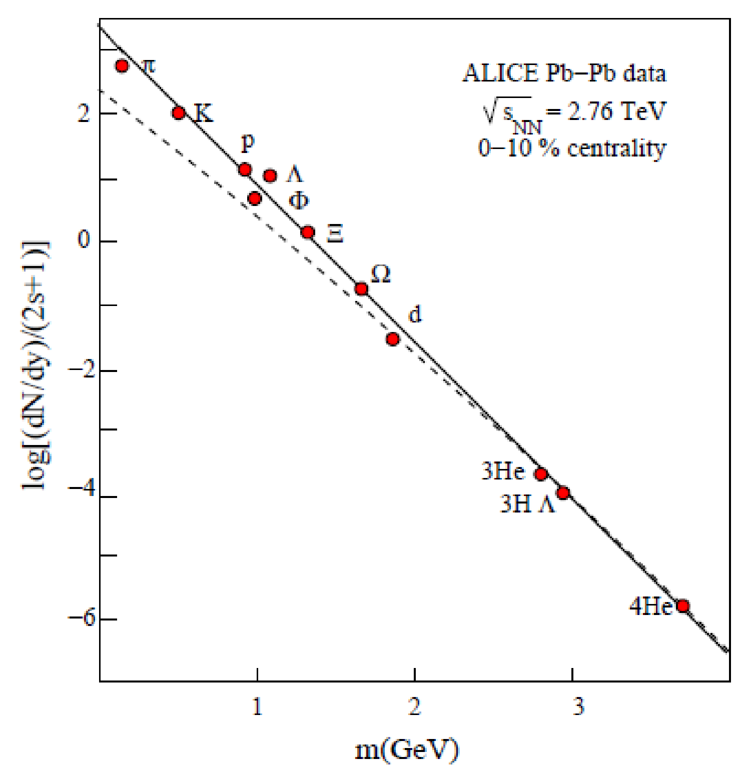


$$N(m) = \alpha[\rho(m)]^{-p}$$

$$\log[(dN/dy)/(2s+1)] \simeq -m\left(\frac{0.43\,p}{T_H}\right) + A,$$

Yield rates of species at central rapidity vs. their mass m [1–3]. The solid line corresponds to Eq. (7), the dashed line to Eq. (8).

ALICE exp. data

Some related materials

Deuteron and antideuteron production simulation in cosmic-ray interactions

Diego-Mauricio Gomez-Coral,* Arturo Menchaca Rocha, and Varlen Grabski, Amaresh Datta, Philip von Doetinchem, and Anirvan Shukla

PHYSICAL REVIEW D 98, 023012 (2018)

In this work, deuteron and antideuteron production from 20 to 2.6 × 10^7 GeV beam energy in p + p and p + A collisions were simulated using EPOS-LHC and Geant4's FTFP-BERT Monte Carlo models by adding an event-by-event coalescence model afterburner.

To generate (anti)deuterons emulating the coalescence process, an afterburner [52] was created to be coupled to the MC generators **EPOS-LHC and FTFP-BERT**. The
afterburner performed an iterative operation for every event, by identifying all proton-neutron and antiproton-antineutron pairs from the stack of particles created by the generator and calculating the difference in momenta of each pair in their center-of-mass frame. $\Delta k\, j = |k_p - k_n| < p_0$.

Some related materials

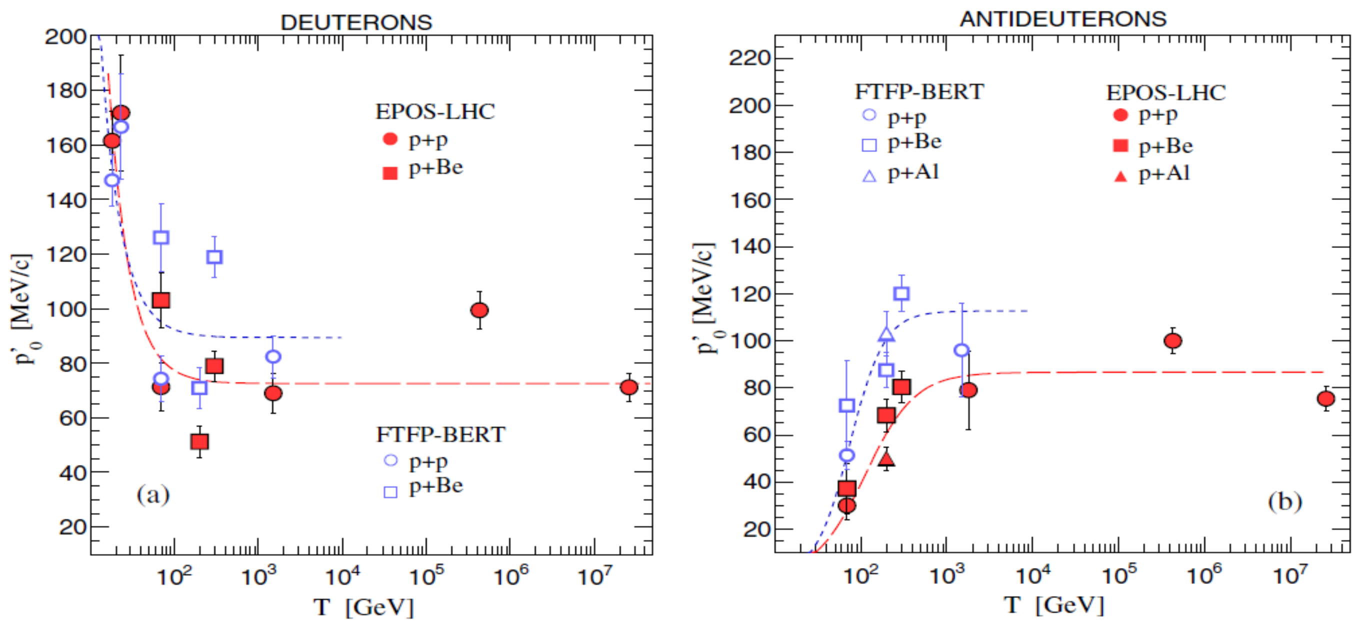
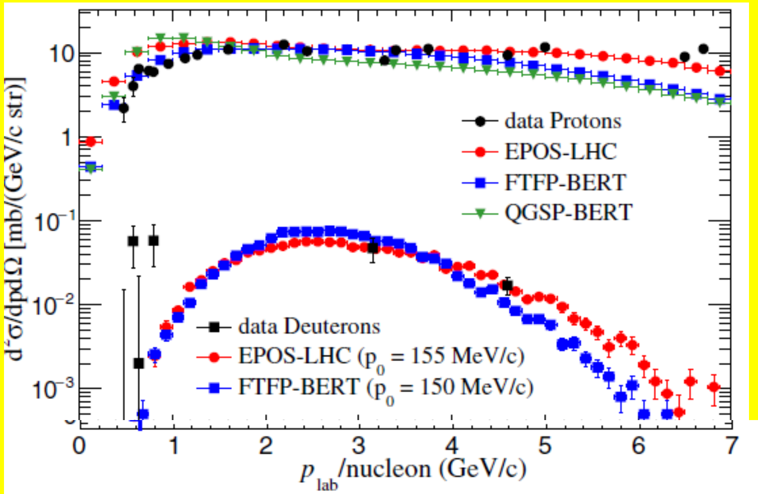


FIG. 29. Extracted coalescence momentum p'_0 (symbols) for deuterons (a) and antideuterons (b) as a function of the collision kinetic energy (T). Fit functions [Eqs. (4) and (5)] for EPOS-LHC (long-dashed red line) and FTFP-BERT (dashed blue line) are shown.



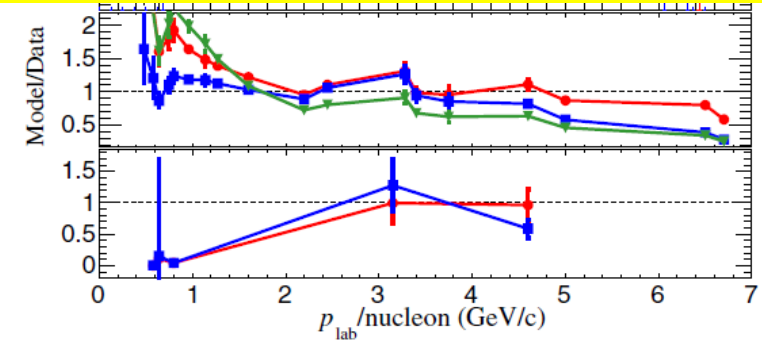


FIG. 11. Double differential cross sections from MC models compared to data of protons and deuterons produced in p + p collisions at 19 GeV/c [36].