Decoding nuclei production mechanism at the LHC through deuteron-nucleon correlation studies

LUND UNIVERSITY

Funded by the European Union

Sushanta Tripathy*, Peter Christiansen

Division of Particle and Nuclear Physics, Department of Physics, Lund University, Lund, 22364, Sweden

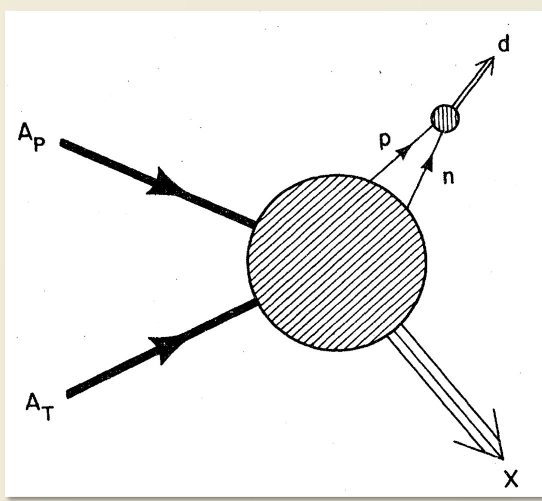
*email: sushanta.tripathy@cern.ch

Based on arXiv:2509.03195

Introduction and motivation

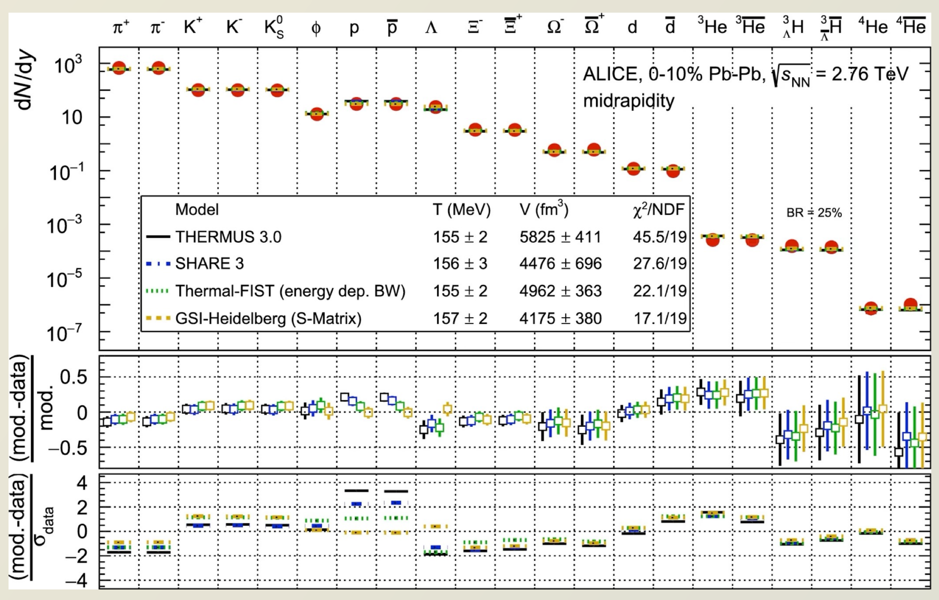
Nuclei with very low binding energies are not expected to survive the dense and hot final state environment in ultra-relativistic nuclear collisions

J. Kapusta, Phys. Rev. C 21 (1980) 1301



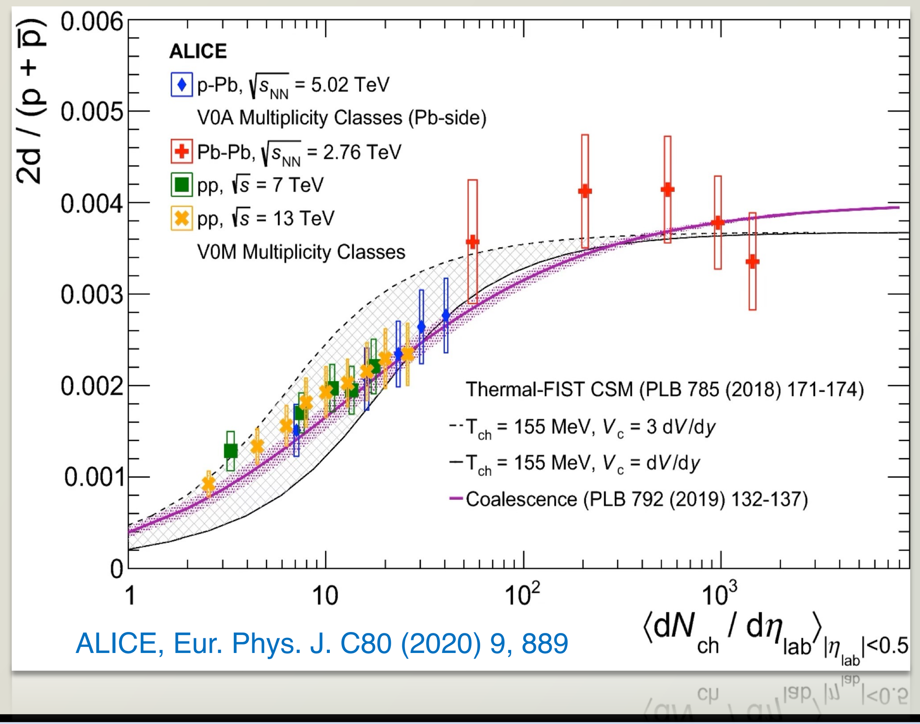
The traditional view has therefore been that nuclei form via **coalescence** after the hot environment has dissipated

ALICE, Eur. Phys. J. C 84 (2024) 813



Statistical thermal models, can describe the relative abundances of light nuclei in pp and heavy-ion collisions at the LHC equally well.

Good description of the deuteron production by both the models

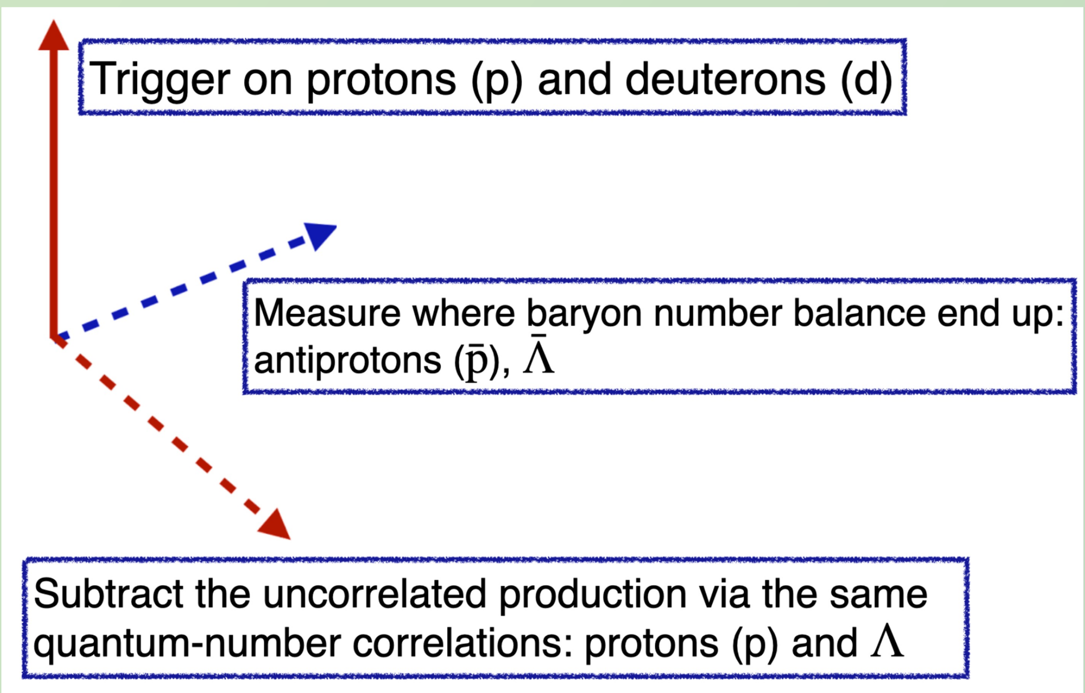


ALICE, Eur. Phys. J. C80 (2020) 9, 889

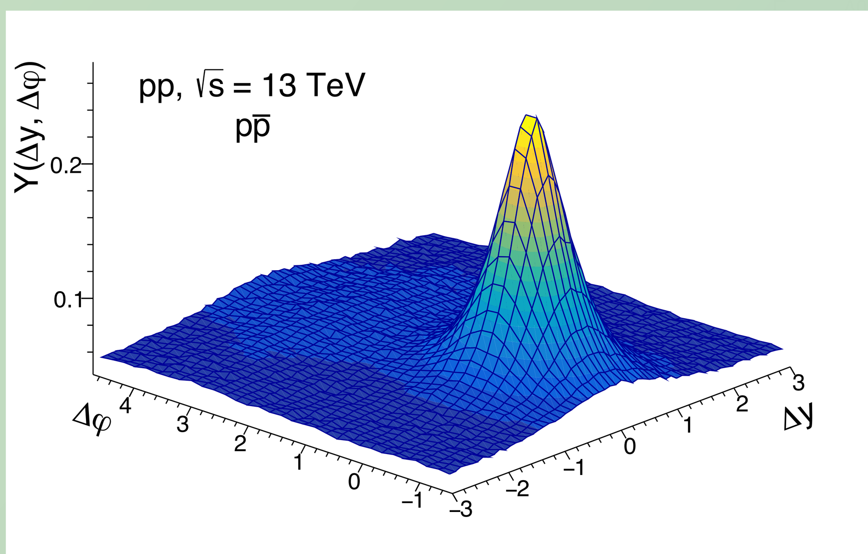
How to distinguish between the models?

An observable with discriminating power is needed!

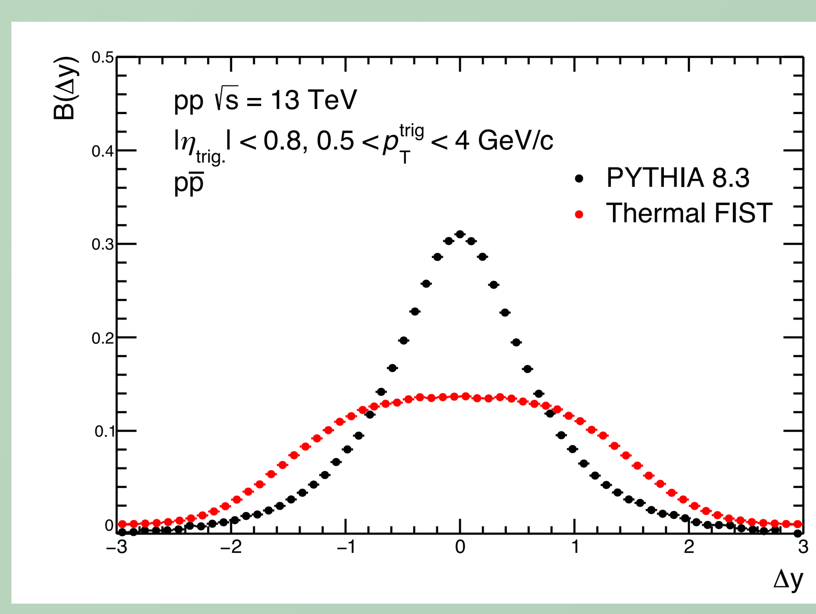
Methodology



$$Y(\Delta y, \Delta\varphi) = \frac{1}{N_{\rm trig}} \frac{d^2 N_{\rm pairs}}{d\Delta y\, d\Delta\varphi}$$



Cuts on **trigger** : |η| < 0.8,
d: 1 < p_T < 8 GeV/c, p: 0.5 < p_T < 4 GeV/c
No kinematic cuts on associated particles to recover the complete balance!



Results and discussion

Cuts on **trigger** : |η| < 0.8,
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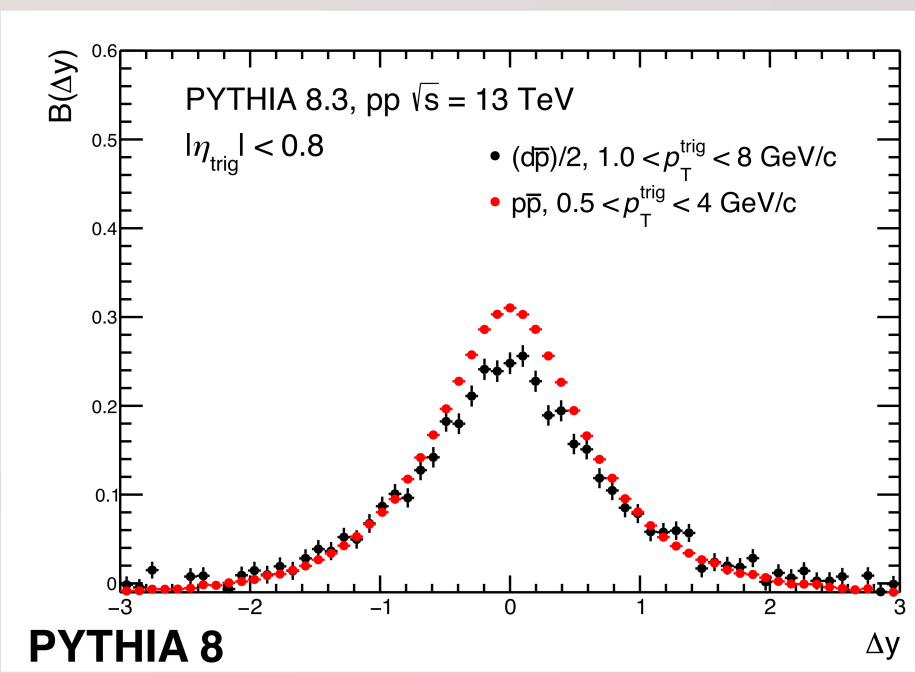
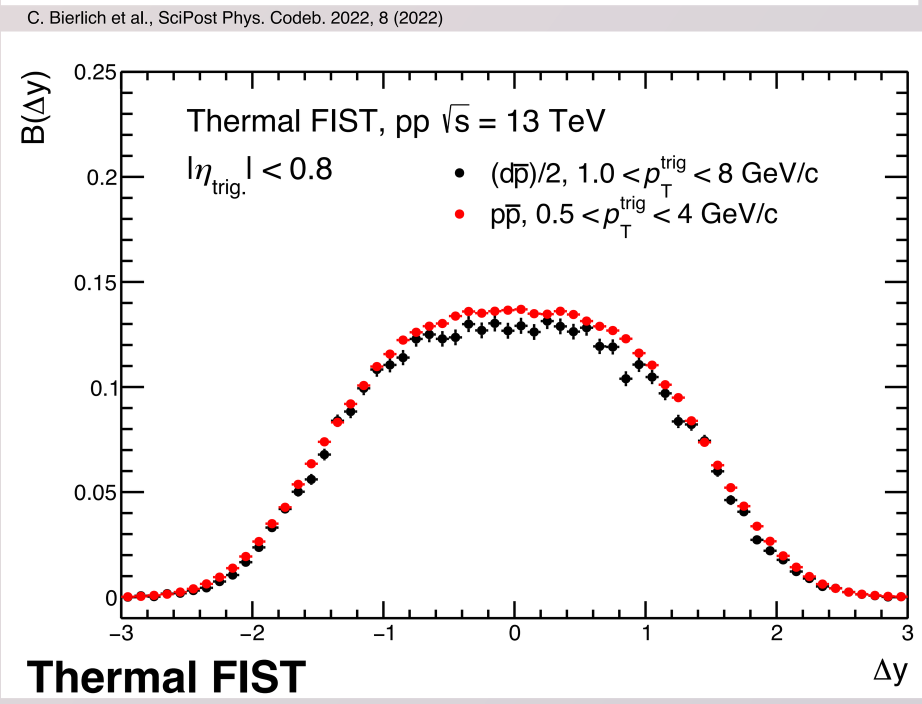


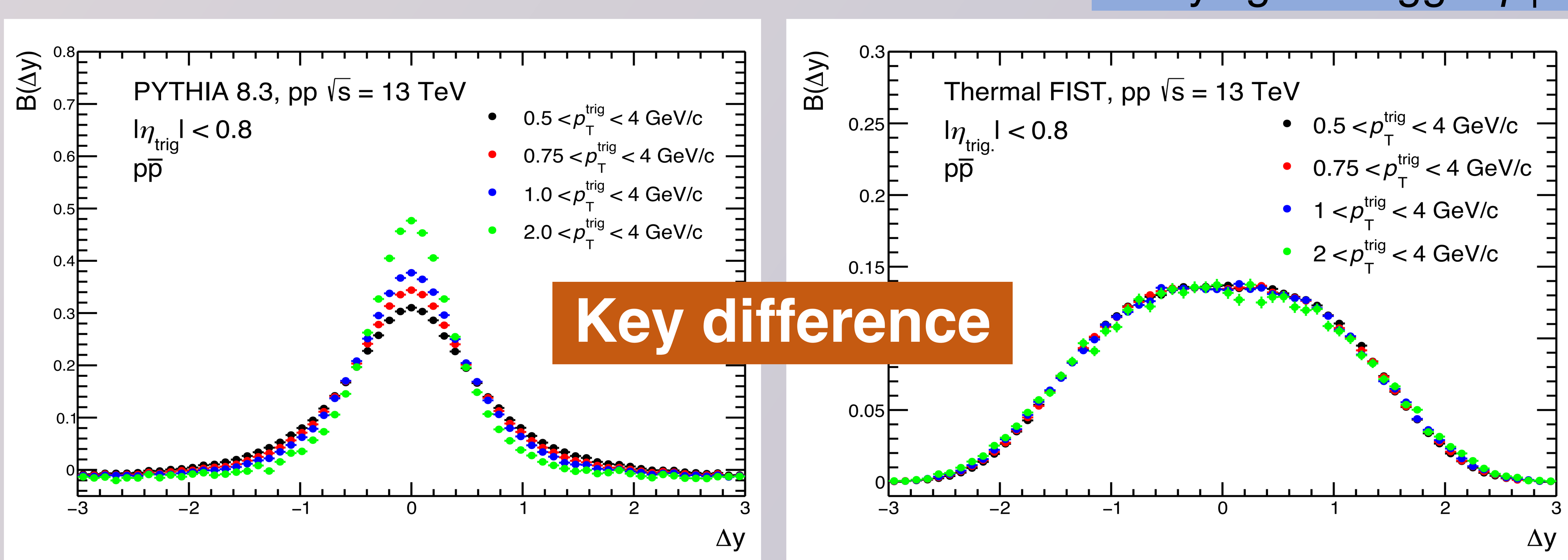
C. Bierlich et al., SciPost Phys. Codeb. 2022, 8 (2022)



V. Vovchenko and H. Stoecker, Comput. Phys. Commun.244, 295 (2019)

- Studied for **PYTHIA 8** after switching the deuteron production and **Thermal-FIST**
- Since a deuteron consists of two nucleons, **balance function is expected to be approximately twice that of a proton**. Both **models confirm** this behavior

Varying the trigger p_T



- **Expected narrowing in PYTHIA**: the antibaryon that balances a proton is produced on the same string as the proton
- **No dependence in Thermal FIST**: quantum number conservation is only imposed globally on the final state
- Such a measurement in experiments could serve as **discriminator** of models

Conclusion

- A **striking difference** seen in the transverse momentum dependence of the balance functions: PYTHIA exhibits a clear narrowing with increasing trigger p_T, whereas Thermal-FIST shows no such dependence
- This observable offers a **promising discriminator** between the two production mechanisms and motivates using the data already collected during Run 3 of the LHC.

Acknowledgements: The authors acknowledge the funding received from the European Union's Horizon Europe research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 101149298.