Thermodynamical string fragmentation and QGP-like effects in jets

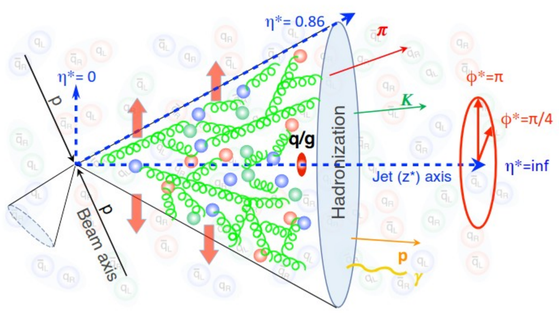
1) HUN-REN Wigner Research Centre for Physics, Budapest, Hungary

Róbert Vértesi[1,*] vertesi.robert@wigner.hu

Antonio Ortiz[1,2] antonio.ortiz@nucleares.unam.mx

2) Universidad Nacional Autónoma de México, Mexico City, Mexico

Motivation

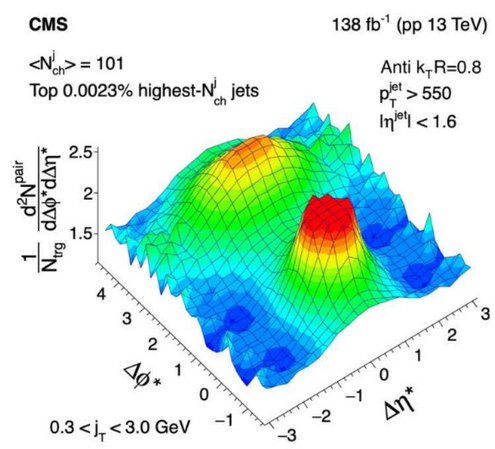


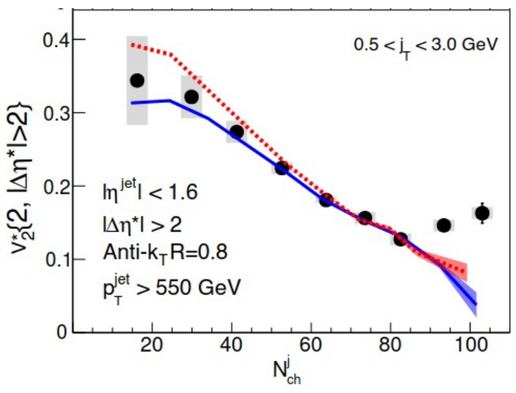
- Small collision systems exhibit collectivity
- Is there similar collectivity in a single jet?
  - Idea: in the jet frame (j_T,Φ*,η*) the particle shower is similar to bulk physics

A. Baty et al., Phys.Rev.C 107 (2023) 6, 064908

- CMS measured angular correlations, to deduce intra-jet azimuthal anisotropy (v_2*, elliptic flow)

CMS, Phys.Rev.Lett.133(2024)14,142301

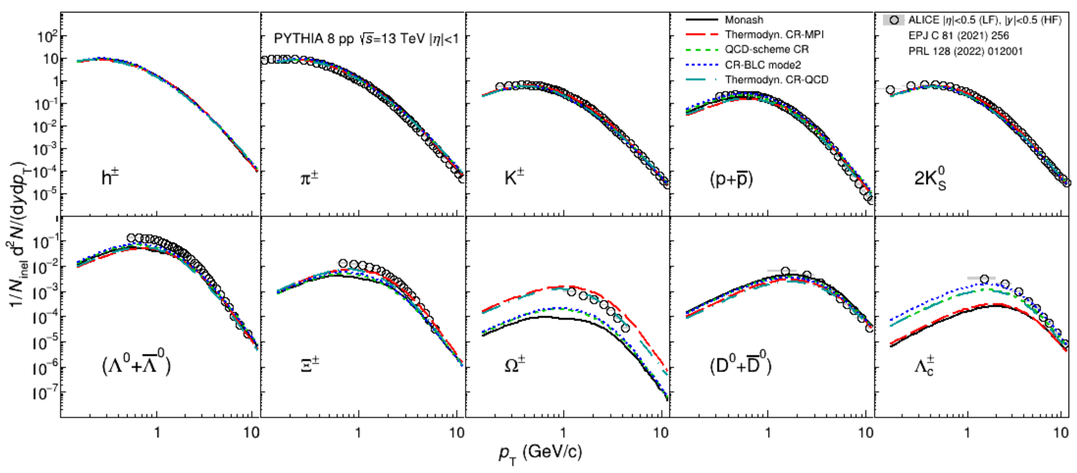




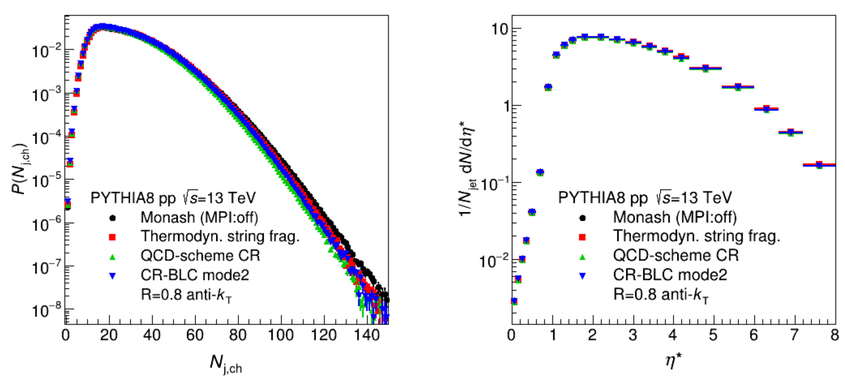
- Substantial v_2* is seen
- For low and medium jet multiplicity (N^j_{ch}), the trend is well understood by models
- A high-N^j_{ch} increase is present compared to predictions

Simulations

- PYTHIA 8 was used to explore further signiatures of collectivity
- Several models were explored
  - Monash: tuned to early LHC data, capable of succesfully describing many observables, includes Lund fragmentation
  - QCD-scheme color reconnection with default settings (CR-QCD), as well as CR-BLC mode 2 that is tuned to describe heavy-flavor baryon sector: allow for color string junctions
  - Thermodynamical string fragmentation with close packing: thermodynamics-motivated alternative to Lund fragmentation

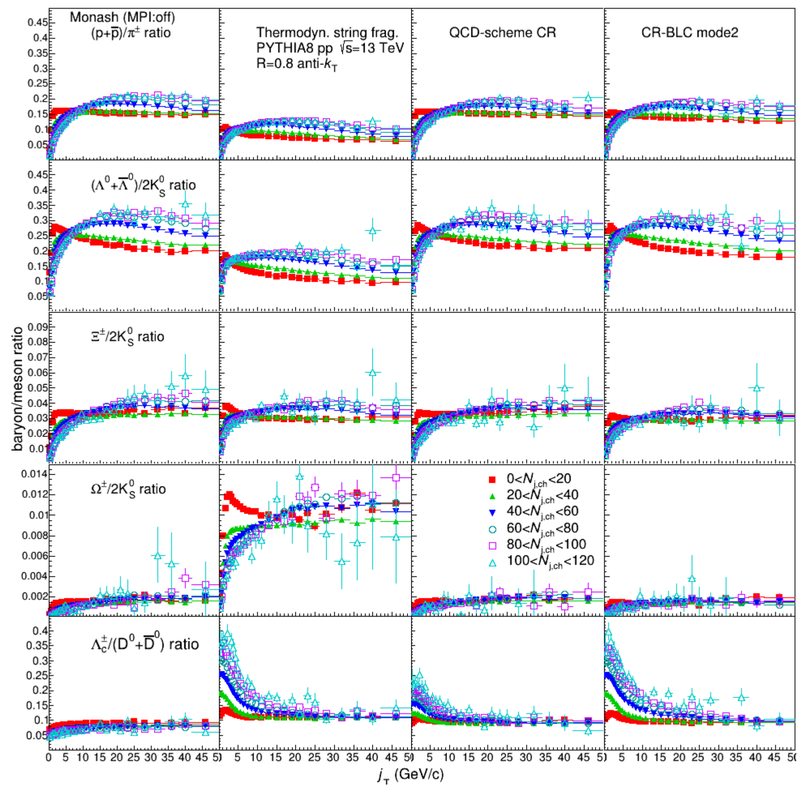


- Validation on bulk data:
  - Light particle yields are generally well-described by Monash
  - Strange baryons are better described by thermodinamical fragmentation with CR-QCD
  - Charmed hadrons are best described by the CR-BLC tune



- Jets are reconstructed using the anti-k_T algorithm and R=0.8
  - Jet multiplicities and η* distributions are relatively uneffected by the choice of model

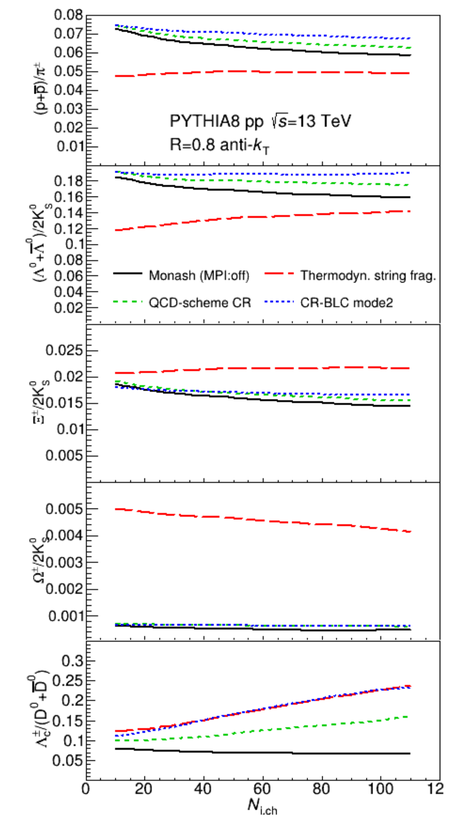
Results



- Baryon-meson ratios as a function of j_T, different N^j_{ch} ranges
  - In the light-flavor sector, trends are similar for all models
  - Λ^0/K_S^0: grouping into low-N^j_{ch} and high-N^j_{ch} curves
  - Λ_c^+/D^0: if color junctions are allowed, a characteristic low-j_T enhancement is present that gets stronger with multiplicity; this is similar to p_T-dependent enhancement of charmed baryons in the bulk

ALICE, Phys. Rev. C 107, 064901

- j_T-integrated baryon-to-meson ratios as a function of N^j_{ch} for different models
  - Thermodynamical string fragmentation presents a rising trend, contrary to Lund fragmentation results: indicates a relative baryon enhancement with increasing N^j_{ch}
  - For Ω±, there is a fivefold increase in Thermodynamical string fragmentation compared to other models
  - Models including color junctions show a constant rising of the Λ_c^+/D^0 ratio with N^j_{ch}



Conclusions

- The N^j_{ch} and η* distributions are only slightly or not affected by the choice of the PYTHIA 8 settings.
- The proton-to-pion and the Λ^0/K_S^0 ratios show low-high multiplicity grouping trend for j_T>5 GeV/c, possibly reflecting the flavor of the jet-initiating parton.
- The Λ^0/K_S^0 and $\Xi^\pm/K_S^0$ ratios show a bump structure reminiscent of the radial flow-like effects observed in the p_T spectra as a function of the inclusive charged particle multiplicity
- The thermodynamical string fragmentation model shows a strong enhancement of the $\Omega^\pm/K_S^0$ compared to other models
- Λ_c^+/D^0 shows an increase at low j_T with increasing N^j_{ch} for the Lund string fragmentation model with the QCD-scheme CR models. This effect is similar to the multiplicity-dependent Λ_c^+/D^0 as a function p_T reported by ALICE.
- Thermodynamical string fragmentation predicts a continuous increase of the p/π, Λ^0/K_S^0 and Ξ/K_S^0 ratios with increasing N^j_{ch}. However, the strength of the enhancement gets reduced with the increase of the s-quark content, probably because of phase-space constraints

This work was supported by the Hungarian National Research, Development and Innovation Office (NKFIH) under the contract numbers OTKA FK131979 and 2021-4.1.2-NEMZ_KI-2022-00034. Support for this work has been received from CONAHCyT under the Grant CF No. 2042; PAPIIT-UNAM under the project IG100524