Nuclear matter production

- At the high energies reached in proton-proton (pp), proton-lead (p-Pb) and lead-lead (Pb-Pb) collisions at the LHC, a significant production of light (anti-)nuclei, such as (anti-)deuterons, is observed.
- Two different theoretical models are available to describe the production mechanism of light (anti-)nuclei:
  - Statistical-thermal model
    - The yield of the hadronic species dN/dy is fixed at chemical freeze-out and it depends on the freeze-out temperature T_F and on the mass of the hadron: \( \frac{dN}{dy} \propto \exp \left( \frac{-m}{T_F} \right) \)
    - Since the mass of the nucleus is high, small variations in T_F drastically change the yield of nuclei.
  - Coalescence model
    - The baryons that are close in phase-space at the kinetic freeze-out can coalesce to form (anti-)nuclei.
    - The probability of producing a nucleus by coalescence can be expressed through the coalescence parameter B_m: \( B_m = \frac{E_0^2}{E_{lab}^2} \frac{dN}{dy} \)

Mean transverse momentum

- The mean transverse momentum \( \langle p_T \rangle \) has been evaluated from the Levy-Tsallis distribution, a simple coalescence model describes the results obtained in pp collisions better than the Blast Wave model.

Analysis strategy

- 9 multiplicity classes + integrated multiplicity
- Particle Identification
  - Signal extracted from:
    - TOF squared mass distribution
    - TPC number of sigma distribution
- Corrections
  - efficiency x acceptance
  - rejection of secondaries
- Systematic Uncertainties
  - Many sources (track selection, signal extraction, rejection of secondaries, material budget, TPC-TOF matching efficiency)

Results

- Transverse momentum spectra vs multiplicity
  - The transverse momentum (p_T) spectra have been measured for (anti-)deuterons.
  - The p_T spectra are fitted using a Levy-Tsallis distribution:
    \[ f(p_T) = p_T^\alpha \frac{dN}{dp_T} \exp \left( \frac{-m}{T_F} \right) \left[ 1 + \left( \frac{p_T}{m} \right)^2 \right]^{-\frac{\alpha}{2}} \]
    \( \alpha = 1.875 \) free parameters
    - The fit to the production spectra is aimed to:
      - extrapolate the spectra in the unmeasured p_T region
      - evaluate the p_T integrated yield dN/dy and mean transverse momentum \( \langle p_T \rangle \)

References