Systematics of strangeness production in p+p, p+Pb and Pb+Pb collisions at 158 *A*GeV/c

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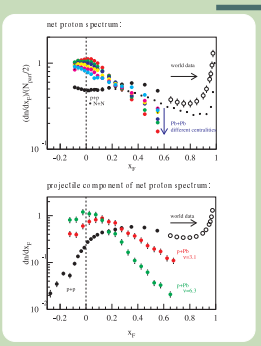
Motivation



A smooth evolution in the degree of stopping is observed when going from average p+p collisions to - centrality selected - p+Pb and Pb+Pb interactions (NA49 data). The increasing energy lost by the projectile nucleons is available for particle production as seen from the rise in pion multiplicity.

In this contribution we investigate to which extent the amount of stopping determines the particle production, e.g. pion multiplicity and also strangeness content, independently of the collision system.

The Feynman-x of the net protons is used to quantify the energy loss, the average number of ϕ-mesons serves as a measure of strangeness production.

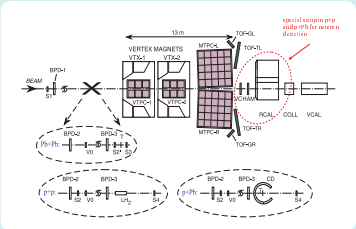
Already in p+p collisions there is a variation of "stopping". The observed dependence of $\langle\pi\rangle$ and $\langle\phi\rangle/\langle\pi\rangle$ on the Feynman-x of the leading proton is used to estimate the "trivial" contribution to the enhancement of these variables in p+Pb and Pb+Pb.

Experiment

The experiment NA49 at the CERN SPS consists of a large-acceptance hadron spectrometer, charged particles are tracked through a magnetic field using four large-volume TPCs.

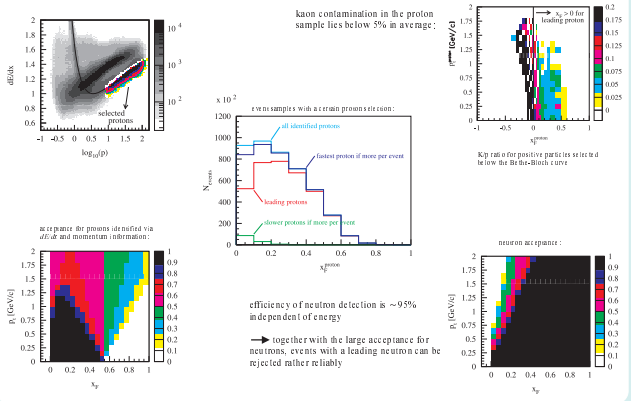
The particles are identified by means of the momentum and *dE/dx* information and within a certain acceptance by the additional time-of-flight measurement of four scintillator walls. ϕ-mesons are reconstructed via the invariant mass of their charged decay kaons.

In p+p and p+Pb collisions neutral hadrons can be detected by the condition of having an energy deposited in the hadronic part of the ring calorimeter (RCAL) and at the same time no signal in the proportional chambers (VCHAM) in front of the ring calorimeter.



Data analysis

selection of the leading proton
- as protons all forward going, positive particles below the Bethe-Bloch curve but within a 3σ distance are taken
- keep only the fastest proton if there are more than one in an event
- reject events from the sample where a neutron faster than the proton is detected



→ together with the large acceptance for neutrons, events with a leading neutron can be rejected rather reliably

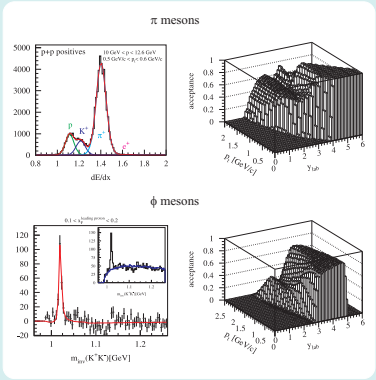
characterize the degree of stopping in p+p collisions by the Feynman-x of the leading proton

measure the correlation of observables in p+p collisions with the Feynman-x of the leading proton

convolution of these correlations with the Feyman-x distributions of
- the net protons
- the projectile net protons

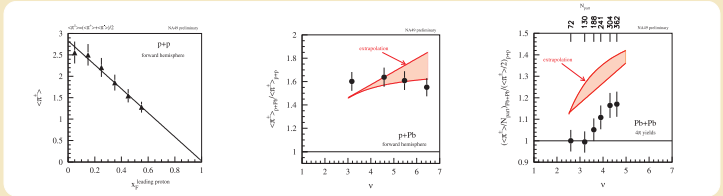
in p+Pb and Pb+Pb collisions at various centralities

extrapolation of these observables to p+Pb and Pb+Pb interactions



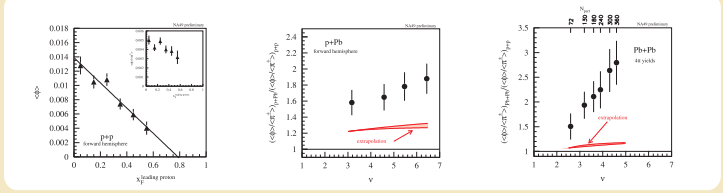
Results

π production



- Already in p+p collisions an increase of pion multiplicity with "stopping" of the proton is seen.
- Extrapolated to p+Pb and Pb+Pb interactions this yields a slight overestimation of the experimental data.
- Concerning the interpretation of the results in p+Pb collisions it is important to consider, that the asymmetry of the reaction results in larger uncertainties of the extrapolation than in Pb+Pb interactions and that pion production in the forward hemisphere includes several

ϕ production



- Also a rise of $\langle\phi\rangle$ and even $\langle\phi\rangle/\langle\pi\rangle$ in p+p collisions with the increased "stopping" of the proton is seen.
- Extrapolated to p+Pb and Pb+Pb interactions this yields a clear underestimation of the experimentally observed enhancement.

Summary

- In p+p collisions an increase of particle yields with proton stopping is observed
  - $\langle\pi\rangle$ rise by a factor of 1.9
  - $\langle\phi\rangle$ rise by a factor of 2.7
  - → $\langle\phi\rangle/\langle\pi\rangle$ increase by a factor of 1.4

  from Feynman-x of 0.5 to 0 of the leading proton.

  → p+p minimum bias data might not be always the right reference for comparison

- Using this result and taking the increased energy loss of the projectile nucleons in p+Pb and Pb+Pb interactions into account, as "trivial" contribution to particle production it is expected that
  - $\langle\pi\rangle$ increase by a factor of 1.4 … 1.7 in p+Pb
    1.1 … 1.35 in Pb+Pb
  - $\langle\phi\rangle/\langle\pi\rangle$ increase by a factor of 1.2 … 1.3 in p+Pb
    1.05 … 1.15 in Pb+Pb

  relative to p+p minimum bias data.

  → The extrapolation in fact gives qualitatively the right behavior of rising yields compared to p+p minimum bias collisions, but the experiment shows that
  - the $\langle\pi\rangle$ enhancement is slightly overestimated
  - the $\langle\phi\rangle/\langle\pi\rangle$ enhancement is strongly underestimated.

* supported by the Bundesministerium für Bildung und Forschung, Germany