The 22nd International Conference on
Strangeness in Quark Matter
22-27 March, 2026, Los Angeles, CA

Contribution ID: **8** Type: **Poster Presentation**

Strangeness Production from Color Field Overlap: Comparing Rope Hadronization and Hydrodynamics

Tuesday, 24 March 2026 18:18 (1 minute)

Strangeness production is a key signature of the formation of a hot and dense medium in heavy-ion collisions. Hybrid approaches combining transport theory and hydrodynamics within the core–corona framework have been successful in describing this enhancement.

At the same time, collective behavior and strangeness enhancement have also been observed in small systems such as proton–proton collisions, suggesting that some of the phenomena associated with QGP formation may already emerge from the coherent superposition of multiple nucleon–nucleon interactions.

One approach is provided by Pythia/Angantyr, where overlapping color flux tubes increase the effective color field strength through color field overlap (color ropes). The enhanced string tension boosts strange-quark production and transverse momentum through the Schwinger mechanism. Although Angantyr is not intended as a QGP model, a dense network of overlapping strings can be interpreted as the earliest stage of QGP formation, a non-thermal precursor that transitions into a deconfined medium as the string tension melts during thermalization.

We implement a rope-based mechanism in the SMASH transport framework using the Pythia/Angantyr rope hadronization approach. By comparing this mechanism to a hydrodynamical evolution using SMASH+vHLLE, we identify where each description succeeds or fails and explore potential transition regions between rope-dominated dynamics and hydrodynamic behavior.

The study focuses on Pb+Pb collisions at 158 A GeV and 40 A GeV, confronting both scenarios with NA49 data on strange mid-rapidity yields and average transverse mass as a function of participating nucleons. This allows us to establish a quantitative baseline for strangeness production and to explore the connection between strong color fields and QGP-like behavior.

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Session Classification: Poster Session