How does the hadronization process depend on the properties of the hadronizing system?

Following any high-energy interaction involving hadrons, all partons will undergo the phenomenon known as hadronization, ensuring that only colorless hadrons are observed in the final state. However, the conditions immediately preceding hadronization may be significantly different across collision systems.

In proton-proton collisions, the general expectation has been that the hadronizing partons mainly reflect the initial partonic scatterings (including initial and final state radiation), with little or no additional final state interactions before hadronization. Color flow in the parton system is important. This picture has led to very successful descriptions of hadron and jet production in pp collisions.
Conversely, the extreme conditions in ultra-relativistic heavy-ion collisions are expected to produce a state of matter in which quarks and gluons are deconfined and in local thermal equilibrium, the quark-gluon plasma (QGP). Color seems randomized and statistical principles apply. This picture has led to a very successful description of particle ratios based on statistical thermal models. It has also seen great success in describing low momentum hadrons with fluid dynamics and intermediate momentum hadrons with quark recombination.

In recent years, intriguing new experimental data has provided new insights from comparing results on hadrochemistry (spectral shapes and yields), anisotropic multi-particle correlations and other observables across collision systems for varying beam energies. These results have challenged many popular assumptions about how the hadronization process can be understood, and how it can be modeled effectively in Monte Carlo simulations. Many of these challenges come from the soft sector of collisions and are often found in systems with a large densities of particles. On the other hand, experimental and theoretical advances in jet substructure provide additional material for study.

We are presented with two exciting opportunities: As hadronization models are challenged and new data becomes available a great deal could be learned about the hadronization process itself, with profound connections to QCD confinement. On the other hand, as our understanding of hadronization grows we might be able to peel back this layer to learn about partons and their dynamics “before” hadronization.

At this workshop, we would like to discuss several interesting questions related to hadronization. We would like to identify concrete experimental measurements and new theoretical tools that have the potential to lead to substantial progress. We pose the following questions to start the discussion:

- Are the phenomenological models consistent with constraints from first principles QCD and/or lattice QCD calculations? Can we make such statements in kinetic equilibrium? Away from equilibrium?
- In what way is hadronization sensitive to the pre-hadronic degrees of freedoms? What are the experimental constraints on the underlying degrees of freedom?
- To what extent are new ideas in hadronization consistent with existing and well tested models (e.g. Lund strings, cluster hadronization, statistical hadronization models)? Are there observables (correlations, hadron chemistry, forward-backward correlations, etc) that can tell us about their validity and mutual relations? Can we further exploit particle correlation studies to constrain effects such as recombination, color reconnection and ropes and others?
- Many theoretical models such as EPOS and Statistical Hadronization Models operate with volume/density effects. Can we observe phase space limitation phenomena such as canonical suppression or core-corona separation in a more direct manner?
- Is there any way to differentiate hydrodynamic collectivity from mechanisms such as color reconnection and or initial state flow? Can we use hadronization to further constrain the origin of collectivity in the various collision systems where it has been observed?