Viscosity:

The important discovery that the hot matter created at RHIC flows with less viscosity than any other known fluid poses a new challenge: to measure and calculate the actual (small) value of the shear and/or bulk viscosity coefficients for the quark-gluon plasma. Intellectually this is an exciting problem since the physics of strongly coupled plasmas and the question how to describe them theoretically transcends traditional disciplinary boundaries. The phase structure of strongly coupled many-body systems is an important issue also for very dense electrodynamic plasmas, both in the laboratory and in astrophysical environments, it plays a key role in understanding the BEC-BCS crossover in systems of cold trapped fermionic atoms, and it has found the interest of particle theorists who discovered that the tools of superstring theory can be successfully applied to the calculation of transport coefficients in systems with asymptotically large (infinite) coupling strength. Based on these calculations, one now expects that there exists a universal lower limit for the ratio of shear viscosity to entropy density, η/s, and that the QGP viscosity may even approach this lower limit.

An experiment-driven approach to extracting the viscosity of the fireball matter at RHIC requires a detailed comparison of measured collective flow patterns (radial, directed and elliptic flow at all rapidities in collisions between equal nuclei, v_1 and v_3 at midrapidity in collisions between unequal nuclei) with a viscous relativistic hydrodynamic framework which is presently being developed. Direct comparisons between data and microscopic transport simulations, followed by a theoretical extraction of the viscosity coefficients from the latter, will be helpful, too. In order to fully constrain the hydrodynamic model and to separate viscous effects from those generated by variations of the initial state and the Equation of State, a complete flow analysis of all hadrons as well as direct photons must be performed, for several (symmetric and asymmetric) collision systems at various collision energies. This requires high-statistics transverse momentum spectra up to p_T = 2−3 GeV/c for a large number of identified hadrons with different masses and quark contents, including rare multi-strange baryons and mesons such as the Ω, Ξ, and φ, and charmed hadrons. Hence, for every combination of collision system and beam energy data of statistical quality similar to Run 4 must be collected. This can only be realized in an acceptable time period once the upgraded capabilities at RHIC II, both in collider luminosity and increased data acquisition rate, become available.