Rare Particle Searches using STAR

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High energy nucleus-nucleus collisions at RHIC may provide an environment favorable for the production of certain novel particles that have not been observed in other environments. It is hoped that RHIC collisions will produce a deconfined state of quarks and gluons. Since this state may be a necessary pre-condition for the production of certain exotic particles, existing limits from other collision systems may not apply. This working group was formed with the intent of identifying exotic particles that may be of interest at RHIC and assessing the STAR capabilities for finding such particles.

QCD, the fundamental theory of the strong interaction, tells us that all observed hadrons are composite particles made from fractionally charged quarks. Although it is widely believed that quark confinement is a fundamental property of QCD, confinement has not been analytically proven within the framework of QCD. In previous accelerator based quark searches, confinement was probed at the scale of 1 fm. At RHIC, the quasi-free quarks will extend over a larger region ($\approx$ 10 fm). At such distance scales, it is possible that some quarks cannot find their partners and emerge as fractionally charged particles that are observable in the STAR detector. In addition, the Quark-Gluon plasma may lead to the production of strangelets and anti-nuclei.

We hope to identify these particles through a measurement of mass and charge. The STAR TPC can provide such a measurement. The energy loss per unit length (dE/dx) of a charged particle depends on the charge, momentum, and velocity of the particle via the well known Bethe-Bloch formula. By plotting the dE/dx measured in the STAR TPC versus the rigidity (obtained from the curvature of the track), one can look for bands corresponding to particles with a unique charge and/or mass. An example is shown in Fig. 1.

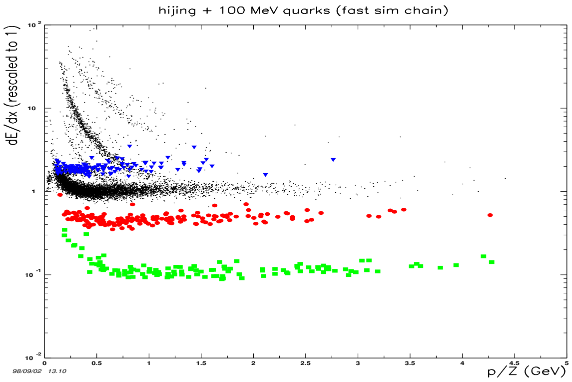

Figure 1: Simulated dE/dx vs rigidity ($|p/Z|$) for $|Z| = 1/3$ (green squares), $|Z| = 2/3$ (red circles), and $|Z| = 4/3$ (blue triangles), along with the background from known particle species.

Our group activities in the past year have focussed on preparing to perform such searches using the STAR detector. We have performed extensive simulations to confirm that STAR is sensitive to fractionally charged particles at a level of less than 1 particle/event.

To examine the sensitivity of the STAR TPC to particles with $|Z| < 1$, we took data during the October TPC cosmic-ray testing with reduced gain in the TPC. These tests indicate that we should have no problems identifying $|Z| = 2/3$ tracks, while $|Z| = 1/3$ tracks will be very difficult to reconstruct using the nominal STAR gains. These $|Z| = 1/3$ tracks, however, can be identified in special runs with increased gain.

We have also defined an analysis procedure and have requested modifications to the STAR DST to assist our analysis. During DST production, candidate tracks will be tagged. For these tracks, the raw TPC pixel data in and around the track will be placed in a special DST structure and stored for later detailed analysis.