The JETSCAPE collaboration: Hybrid hadronization updates and studies of hadronic rescattering

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In previous versions of this report we have discussed the continuing work of the JETSCAPE collaboration. JETSCAPE is a multi-disciplinary collaboration, supported by NSF, which is tasked to develop a software framework for simulations of high energy nucleus-nucleus and other collisions. In this reporting period, both products of the JETSCAPE collaboration, the JETSCAPE framework and the XSCAPE framework, underwent major updates with members of the Texas A&M group playing an outsize role [1]. The largest change included in the updates to JETSCAPE 3.6 and XSCAPE 1.1, respectively, concern the Hybrid Hadronization model which was developed at Texas A&M. With the help of members of Hannah Elfner's group in Frankfurt, in particular through the efforts of Hendrik Roch, significant improvements to Hybrid Hadronization were made.

These improvements include: increased stability, in particular by processing string configurations which are too complex for PYTHIA 8 to fragment; precise net baryon number conservation by eliminating several bugs in the handling of string junctions; better treatment of beam partons; for the first time, the possibility to hadronize parton "holes" in quark gluon plasma that are tracked by some shower Monte Carlo codes; stricter enforcement of energy and momentum conservation; more precise determination of the final positions of hadrons from string fragmentation; a more complete spectrum of excited meson states that partons can recombine into, including all quark model states from the particle data book; compatibility of output with the hadronic transport model SMASH.

The last improvement unlocks a new ability for the JETSCAPE and XSCAPE frameworks. Hadrons from hard processes can now be fed into SMASH to compute hadronic final state interactions for jets both in vacuum and in a medium. SMASH had previously only been used as an afterburner for output from fluid dynamic simulations, i.e. in the soft sector of high energy nuclear collisions. Preliminary studies were carried out to test the new functionality, and a systematic study of the effects of hadronic final state rescattering in the vacuum was begun.

Fig. 1 shows preliminary results from simulations of electron-position collisions at the Z-pole energy of 91.2 GeV. This collision system is the experimentally and theoretically cleanest test of our understanding of jet physics. Interestingly, we see significant (up to 15%) percent effects on hadron spectra. Hadronic rescattering seems to lead to some kind of self-quenching in which the higher momentum hadrons are slightly depleted and the fraction of very low momentum hadrons increases. This preliminary result provides ample motivation to study these effects carefully even for vacuum systems. We expect the hadronic rescattering to be even more impactful in nucleus-nucleus collisions, where the system is surrounded by a thick "corona" of hot hadron matter which can be simulated by SMASH.

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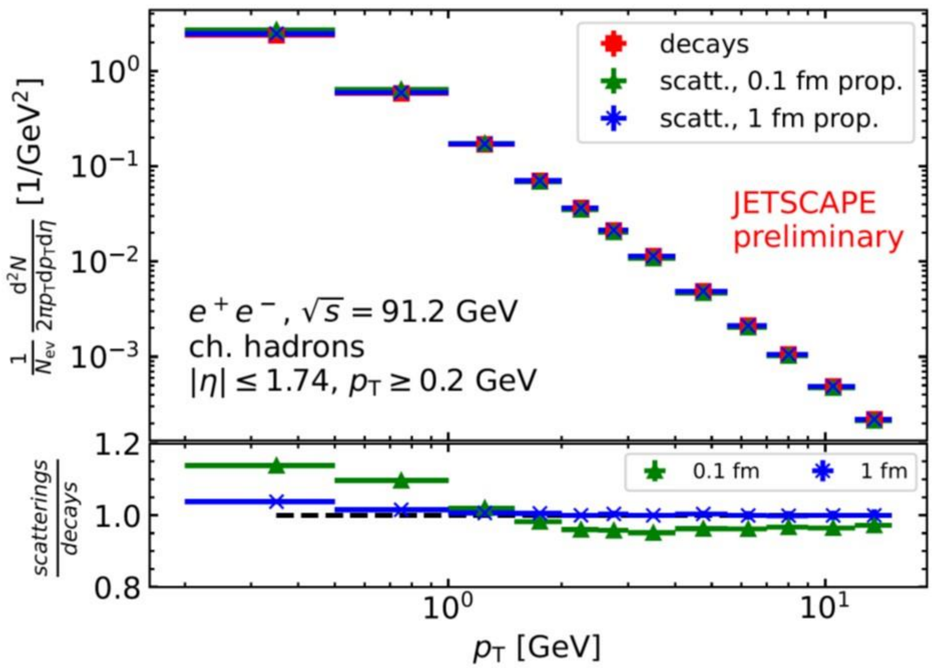

FIG. 1. The spectrum of charged hadrons in e+e- collisions at an energy of 91.2 GeV. Results are shown for hadron decays only in SMASH, and two scenarios with hadronic rescattering in SMASH with hadrons propagating for a proper time of 0.1 or 1 fm/c, respectively. The bottom panel shows the ratio of the latter two result with the decays only case. Hadronic rescattering has an effect even in this very dilute system.

[1] The JETSCAPE 3.6x and XSCAPE 1.1.x packages, https://github.com/JETSCAPE