The JETSCAPE collaboration: X-scape and a year of first physics result

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In previous versions of this report we have discussed the inception and successful launch of the JETSCAPE collaboration and their product, a flexible and modular event generator that simulates collisions of nuclei at very high energies [1]. JETSCAPE stands for *Jet Energy-loss Tomography with a Statistically and Computationally Advanced Program Envelope*. Its initial funding consisted of $3.6M from the *Software Infrastructure for Sustained Innovation* (SI2) program of the U.S. National Science Foundation. The collaboration involves theoretical and experimental physicists, computer scientists, and statisticians at various institutions around the U.S. R. J. Fries has been a PI on this project from the first minute.

We are happy to report that in 2020 the NSF has approved the *X-Scape* project as the follow-up project for the JETSCAPE collaboration. Funded with $4M, the X-Scape project will build on the existing software framework and make it more comprehensive and powerful. The new project will allow users to simulate lower energy nuclear collisions as well as proton-nucleus and electron-nucleus collisions. Thus X-Scape will offer much needed capabilities to support experiments at the Electron-Ion Collider, the next-generation nuclear physics experiment planned by D.o.E. at Brookhaven National Laboratory for 2030 and beyond. The new project has also added more institutions and PIs to the project. Fig. 1 shows a schematic flow diagram for the X-Scape framework.

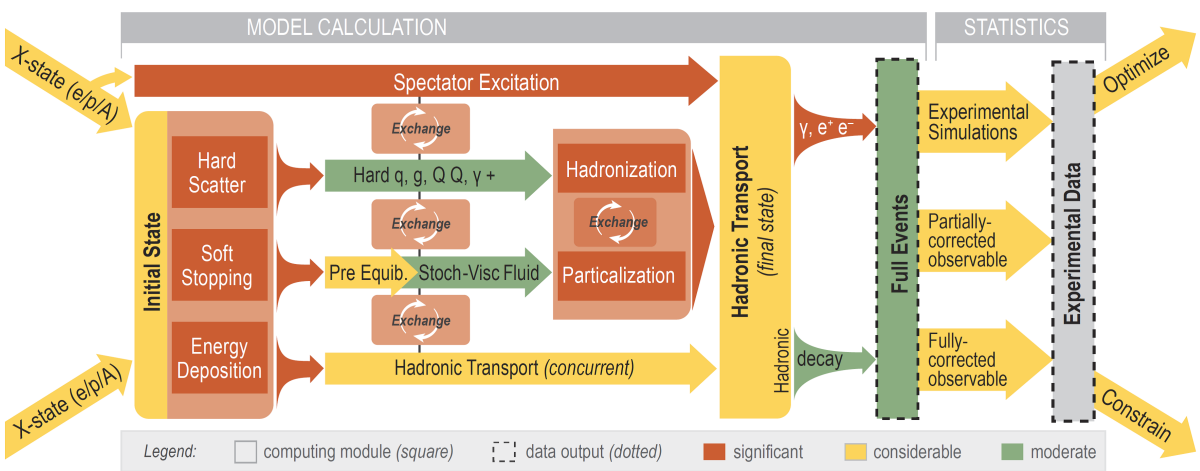

Fig. 1. Schematic Flow Diagram of the X-Scape event generator that will be able to simulate p+p, p+A, A+A, e+p and e+A collisions at high energies.

The current reporting year was also the first year where several science studies were successfully carried out by the JETSCAPE collaboration using the finished JETSCAPE framework. A comprehensive study of jets and hadrons at high momenta in p+p collisions was the first science paper published by JETSCAPE, and significant contributions were made by members of the Texas A&M group. The results have been published in 2020 [2]. Subsequently, two papers were published by JETSCAPE in Phys. Rev.

C and Phys. Rev. Lett. carrying out the most sophisticated study to date to extract parameters of the quark gluon plasma formed in high energy nuclear collisions from low-momentum experimental data, in particular the shear and bulk viscosities of quark gluon plasma [3,34. The analysis uses advanced statistical tools and also includes an estimate of uncertainties from modelling unknown details of the physical processes. Finally, JETSCAPE also published a paper with a Bayesian analysis of the jet transport parameter $\hat{q}$ [5]. This parameter determines the quenching of jet and high momentum particles in quark gluon plasma and is a major focus point of the nuclear physics programs at both the Large Hadron Collider (LHC) and the Relativistic Heavy Ion Collider (RHIC).

[1] The JETSCAPE 3.0 package, https://github.com/JETSCAPE.
[2] A. Kumar *et al.* (JETSCAPE Collaboration), Phys. Rev. C **102**, 054906 (2020).
[3] D. Everett *et al.* (JETSCAPE Collaboration), Phys. Rev. Lett. **12**6, 242301 (2021).
[4] D. Everett et al. (JETSCAPE Collaboration, Phys. Rev. C **103**, 054904 (2021).
[5] S. Cao *et al.* (JETSCAPE Collaborationi, arXiv: 2102.11337 [nucl-th]; Phys. Rev. C (accepted).