The STAR forward upgrade

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STAR has proposed to add a Forward Upgrade during the next few years to enable several critical measurements of proton structure at both high- and low-x. These include explorations of the Collins and Sivers effects in the range $0.3 < x < 0.5$ and gluon polarization down to $x \sim 2 \times 10^{-3}$. Overall, it will enable a suite of measurements in pp and p+A collisions that, when combined with future measurements at the future Electron-Ion Collider, will provide precise tests of the validity – and limits – of factorization and universality. This is essential to separate the effects related to the intrinsic properties of the hadrons under study from interaction-dependent dynamics. For a broad overview of the science of the STAR Forward Upgrade, see the 2016 RHIC Cold QCD Plan [1].

The Forward Upgrade will consist of a Forward Tracking System (FTS), followed by a Forward Calorimeter System (FCS). The FTS will consist of three layers of Si detectors within the STAR magnet, followed by four layers of small thin-gap chambers (sTGCs) in the pole-tip region. The FTS will provide vertex and charge-sign determinations for charged tracks, together with momentum measurements for tracks with $p_T <\sim 2$ GeV/c. The FCS will consist of a pre-shower detector, an electromagnetic calorimeter, and a compact hadronic calorimeter. The FCS will provide triggering, together with neutral particle, charged hadron, and jet measurements.

Our group at Texas A&M has been involved in STAR's planning for the Forward Upgrade since it was first conceived. During this past year, we were among 10 STAR institutions who submitted a consortium development MRI proposal to the NSF to obtain the funds necessary to construct the FCS. The schedule calls for the Forward Upgrade to be completed in time for a planned RHIC 500 GeV pp run in late 2021 or early 2022.

Texas A&M and BNL are jointly responsible for the FCS trigger system. Texas A&M has the responsibility to develop the trigger algorithms, then we will work together with BNL collaborators to implement them. This past year, we developed and simulated the full trigger logic scheme for the FCS, consisting of DEP/ADC boards, which will digitize the analog signals from the Pre-shower, ECal, and HCal and generate logic primitives, followed by DEP/IO boards, which will combine the logic primitives to yield efficient and selective electron, photon, charged hadron, jet, di-electron, and di-jet triggers. DEP/ADC boards are new cost-effective, 32-channel, 12-bit wavelength digitizers operating at 75 MHz (8 times the RHIC bunch-crossing frequency) that also include a powerful FPGA that can perform detailed logic calculations, together with high-speed optical and copper-wire outputs. DEP/IO boards replace the ADC front-ends with 32 high-speed line receivers that feed the identical FPGA and back-end electronics. Both boards have been designed at BNL. Four DEP/ADC boards are now in operation at STAR.

Texas A&M is also responsible for developing calorimeter clustering algorithms. Given the limited momentum resolution of the FTS for energetic charged hadrons, several of the planned Forward Upgrade measurements, including both the planned Collins and Sivers effect measurements, will need to combine track directional information from the FTS with calorimeter cluster energies from the FCS to

infer hadron momenta. This will be our major contribution to the Forward Upgrade during the coming year.

[1] E.-C. Aschenauer *et al*., arXiv:1602.03922.