MAPPING PROTON QUARK STRUCTURE: LOOKING INSIDE THE PROTON—HOW DO QUARKS SPIN?

The team used Blue Waters (BW) for four major tasks: experimental data production to convert raw data into a format for physics-level analysis; extraction of detector efficiency maps from raw data as input to realistic simulations; Monte–Carlo simulations; and physics-level analysis. The various work flows are sketched in Fig. 1.

Three petabytes of raw COMPASS data collected at CERN were transferred to BW using the File Transfer System FTS3 [3], a bulk data mover created to globally distribute CERN–LHC data. The data were packed into tar files of 100 GB on BW Lustre and then stored on BW tape. Upon production request by the COMPASS analysis coordinator, they were then retrieved from tape.

For each triggered event in COMPASS, the information of the detectors was recorded by the Data Acquisition (DAQ) system. The COMPASS Reconstruction Analysis Library (CORAL) software performed the conversion of raw data information to physical quantities. CORAL’s function was to reconstruct particle trajectories and momenta, and the position of vertices. The reconstructed information was stored in the form of Data Summary Trees (DSTs), which were read and analyzed using the COMPASS Physics Analysis Software Tools (PHAST). CORAL and PHAST jobs were submitted to the BW nodes using the production framework ESCALADE, which allows for a detailed bookkeeping of job status, failure, and output. Detector efficiencies were extracted from a sampled fraction of the experimental data. They required separate submissions to the BW grid for each of the 240 detector planes, which made the efficiency maps about a factor of seven more CPU-expensive compared to the standard data productions.

The production of Monte–Carlo data began with the generation of signal and background events with event generator packages. For the simulation of the detector response to the physics event, a GEANT4 [4] toolkit was then used based on the description of the COMPASS apparatus. Lastly, simulated hits were subject to the same reconstruction CORSAL and PHAST codes as experimental data.

METHODS & CODES

Blue Waters allowed the research team to analyze the physics results of the 2018 COMPASS run with the nuclear physics community about one year earlier than usual. This fast turnaround time for the analysis was unprecedented.

RESULTS & IMPACT

Blue Waters enabled the research team to share the first physics results of the 2018 COMPASS run with the nuclear physics community about one year earlier than usual. This fast turnaround time for the analysis was unprecedented.

PHYSICS ANALYSIS SOFTWARE TOOLS (PHAST)

Blue Waters enabled the research team to share the physics results of the 2018 COMPASS run with the nuclear physics community about one year earlier than usual. This fast turnaround time for the analysis was unprecedented.

PUBLICATIONS & DATA SETS


Figure 1: Work flows for COMPASS experimental data productions (top), Monte–Carlo simulations (bottom), and physics-level analysis (right). (Courtesy R. Longo.)

Figure 2: The Sivers amplitude (qT-weighted) extracted from COMPASS Drell–Yan data. The green curve represents a projection assuming the sign change. The data are consistent with the predicted sign of the Sivers function.