Analyzing performance of the STAR detector during the 2017 510 GeV proton-proton run

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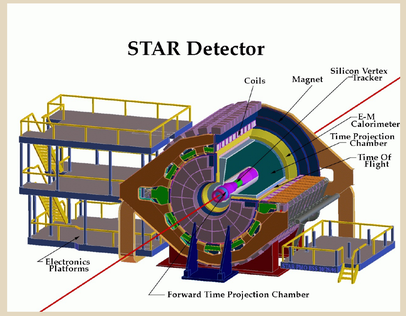
Abstract

In 2017, the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) collected a high-statistics dataset from transversely polarized proton proton collisions at the center-of-mass energy of 510 GeV. An important first step in the analysis of the 2017 data is assessing the quality of the data, in particular, through studying the stability of several sub-systems throughout the duration of the RHIC run. By tracking detector-level information for each run, STAR can identify a list of high-quality runs for physics analyses.



STAR Detectors: EMCs, TPC, and TOF

• The Time Projection Chamber (TPC) provides 3D "pictures" of charged particle trajectories. The TPC volume is filled with a gas mixture (10% methane and 90% argon). Charged particles moving through the detector ionize the gas, leaving electrons to drift in an electric field to the readout endcaps. This information is then used to reconstruct the paths of the charged particles through the TPC.

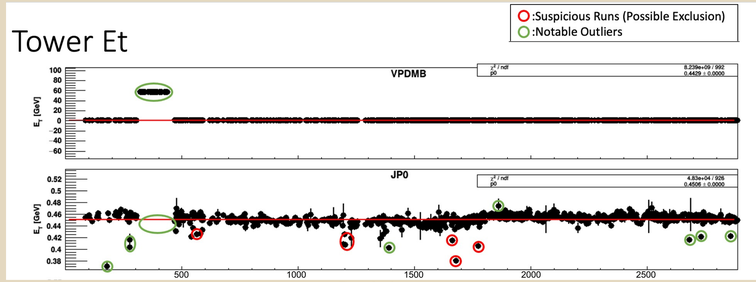
• The Endcap ElectroMagnetic Calorimeter (EEMC) and the Barrel ElectroMagnetic Calorimeter (BEMC) measure photon and electron energies.

• The Time of Flight (TOF) system is used to identify charged particle species. The TOF measures the time needed for the particle to travel through STAR. This information, combined with the particle track length and momentum from the TPC, gives the mass of the particle.

STAR Data-taking and Analysis

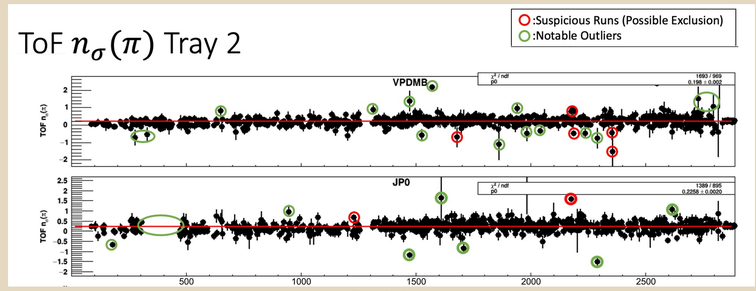
Through these detectors, STAR collects data in approximately 30 minute "runs" of the data acquisition system. The raw data are then processed into "micro-DST" files with a ROOT-tree structure. Then, we write code using C++ to extract the relevant information from these files. Our analysis takes a closer look at the run-averaged values for quantities from each detector that are especially relevant for jet analyses. This makes it easier to find "outlier" runs where there may have been an issue with a specific detector, making it necessary to drop that run from the first round of analysis. For this study, we define notable outliers outlined in green to be $\geq 3\sigma$ from the mean. Suspicious runs outlined in red meet the same criteria as the notable outliers, and also contain notes in the shift log, documenting detector issues for those runs.

Tower E_T

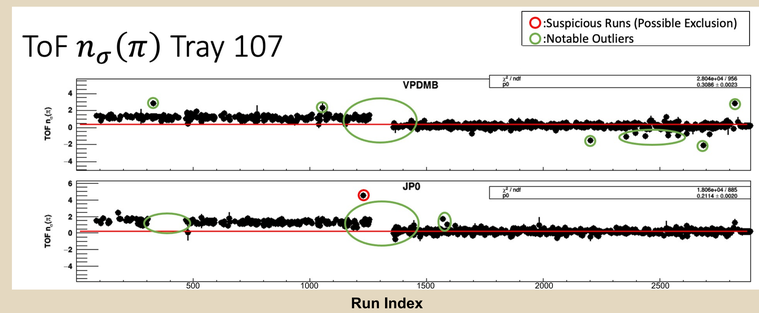


The average tower energy from the BEMC is plotted run by run, with the red circles indicating suspicious runs marked for possible round 1 exclusion and green circles indicating notable outliers requiring further investigation. The top row are a relatively unbiased data sample ("minimum bias"), while the bottom row are data triggered by a large patch of energy in the BEMC ("jet patch"). The significant gap in data around run index 400 arises from the jet patch trigger being disabled during data taking due to a problematic tower in the BEMC.

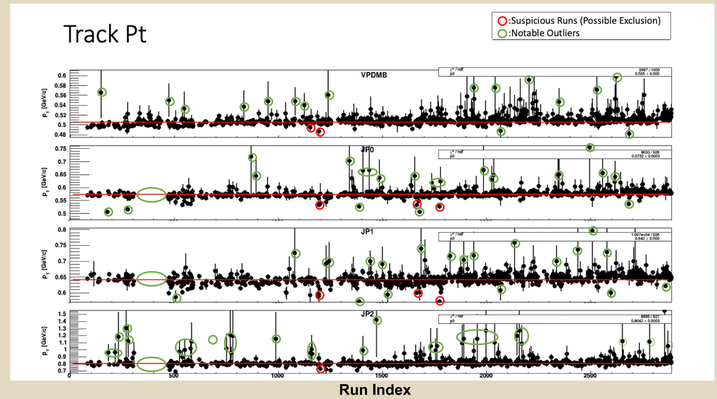
TOF $n_\sigma(\pi)$



$n_\sigma(\pi)$, a measurement of how likely the particle is to be a pion, is shown for two of 120 TOF trays. Tray 2 pictured above shows a more typical plot, again with the gap around run index 400 and another gap around 1250 where TOF data are not available for any trays. Tray 107 below shows a drop in $n_\sigma(\pi)$ after this gap, and round 2 analysis will investigate causes for the shift and whether calibrations or corrections are needed.



Track P_T



The average track momentum from the TPC is plotted. The JP triggers cut out in the same region as both the tower energy and $n_\sigma(\pi)$ plots. There are also other notable outliers, such as the the red circles at run index 1201 for all four panels.

Results/Future Analysis

We now have a list of potential round 1 exclusions due to issues spanning from blown fuses to power dips to dead triggers. These issues are identified by looking at notes in the shift log documented by detector experts or shift crew. Most of these outliers are the points circled in red in the plots shown, and the next step in analysis is a second round of further investigation of notable outliers circled in green.

Run Id:	Detector
18073029	Trigger Rate
18073034	Trigger Rate
18073043	Towers above threshold/track eta/zvtx/vpd hit ratio
18073046	Towers above threshold/tower et/tower eta/zvtx
18091004	Track pt/tower et/t zero/t zero can diff/ vpd hits ratio
18072007	Trigger rate/ track pt
18092014	Trigger rate/track pt/ tower et
18105024	Towers above threshold/trigger rate/track pt/ tower et/tower eta/ tower phi
18105042	Towers above threshold/trigger rate/track phi/tower eta
18107040	Towers above threshold/track eta/ t zero/vpd hits ratio
18108083	Tower phi
18109001	Towers above threshold/trigger rate/track pt/tower et/ tower eta/ tower phi
18109053	Towers above threshold
18109057	Towers above threshold
18110005	Towers above threshold
18116006	T zero/ vpd hits ratio
18126007	T zero/ t can diff/ t zero can ratio/ t zero can diff/ vpd hits ratio
18127030	Towers above threshold/ t zero/ t zero can diff/ vpd hits ratio
18127039	Towers above threshold/ track eta/ t zero/ t zero can diff/ vpd hits ratio
18127065	Towers above threshold/ track phi/ t zero/t zero can diff/ vpd hits ratio
18127066	Towers above threshold/track eta/ t zero/ t zero can diff/ vpd hits ratio
18132059	Towers above threshold/ tow eta/ t can diff
18132064	Towers above threshold/trigger rate/ tower eta/ tower phi/ vpd hits diff
18132065	Towers above threshold/trigger rate/ tower eta/ tower phi/ t can diff/vpd hits diff

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