Model Independent Search at the D0 experiment

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We present a review of global searches at the Tevatron with D0 detector. The strategy involves splitting the data from the Tevatron into many final states and looking for signs of new physics in the high $p_T$ tails of various distributions using SLEUTH algorithm. We analyzed 117 D0 final states and 5543 D0 distributions. No evidence of new physics is found. The two discrepant final states arise from detector modeling issues.

I. INTRODUCTION

The standard model of particle physics has been remarkably successful: all fundamental particles predicted by this model have been discovered, with the exception of the Higgs boson. Despite its success, there are strong motivations from the theory to expect new physics at energies at or just above the electroweak scale. Generally, beyond standard model theories do not give precise energy and phase space regions to search for new physics. Motivated by this, D0\cite{1} collaboration performed a scan over many channels to look for significant deviations from the standard model in events containing objects of high transverse momentum. In this searches, we widen the scope of considered final states compared to the dedicated analyses. At the same time, a sensitivity for each final state is generally worse than one for the dedicated analyses.

II. RESULTS

We analyze 1 fb$^{-1}$ of the Tevatron data. We generate the corresponding Monte Carlo for various processes including $Z$ and $W$ boson production, diboson and $t\bar{t}$ production. We use data to simulate the QCD processes, and performs a fit to obtain various Scale Factors assigned to each process. We then define exclusive final states by considering objects such as isolated electrons, muons, taus, photons, jets, missing transverse energy and taking various combinations of those( for example electron + muon $+ 2$ jets $+$ missing transverse energy). We impose some transverse momentum and pseudorapidity cuts on the selected objects. We consider only final states with at least one lepton to avoid dealing with QCD processes that are hard to simulate. We then perform two sorts of checks called VISTA in the bulk of various distributions on those exclusive final states. First, we perform a check on the number of events in each exclusive state; the goodness of fit is calculated by Poisson probabilities. Second, we perform a shape-only analysis of histograms within a state by calculating a Kolmogorov-Smirnov probability for the consistency of the shape with the predicted Standard Model backgrounds. Both of these numbers require additional interpretation, because of the number of trials involved. When observing many final states or many histograms, some disagreement is expected due to statistical fluctuations in the data. Thus the Poisson probability used in determining event count agreement is corrected to reflect this multiple testing. The final state probabilities converted into standard deviations before adding the trials factor correction are shown in Fig. 1. We examines 117 final states and 5543 distributions and find 2 discrepant final states and 16 shape discrepancies - all of them seem to be discrepant due to difficulties in modeling of our detectors.

The discrepancy for the $\mu^+\mu^- + E_T$ final state shows the greatest difference from the SM prediction in the modeling of jet distributions. There is a significant excess in the number of jets at high pseudorapidities, which points to likely problems with modeling ISR/FSR jets in the forward region, as can be seen in Fig. 2h. This difference is also observed in dedicated analyses.

The $\mu^+\mu^-$ discrepancy can be attributed to difficulties modeling the muon momentum distribution for high $p_T$ muons. The muon smearing modeling is based on muons from $Z$ and $J/\psi$ decays, dominated by muons below 60 GeV, and is not as reliable at high $p_T$ . The prime signature of poorly simulated high $p_T$ muons is an excess of $E_T$ because of the mismodeling of the resolution of the mismeasured track. The $\Delta\phi$ between the positive muon and $E_T$ in the $\mu^+\mu^- + E_T$ final state is shown in Fig. 2h, where the excess tends to be for events where the $E_T$ is collinear with a muon.

We then use SLEUTH algorithm in an attempt to systematically search for new physics as an excess in the tails of high $p_T$ distributions. We use a variable that adds the absolute values of the $p_T$ of each object in the event to the $E_T$. We cut on the value of this variable that gives the least probability $P$ for the Monte Carlo to be consistent with data. We declare the state to be discrepant after trials if this probability crosses the threshold of $10^{-3}$. The SLEUTH algorithm is often described as being quasi-model independent, where "quasi" refers
to the assumption that the first new physics will appear as an excess of events with high-$p_T$ objects. Thus, SLEUTH would be expected to be most sensitive to high-mass objects decaying into relatively few final state particles. Before we proceed, we test the SLEUTH algorithm. The question we want to answer is will we be able to re-discover the top pairs had they not been discovered. For that, we remove the $t\bar{t}$ processes from our generation, and run SLEUTH. The results are presented on Fig. 3. The probability that the Monte Carlo after trial factors agrees with data is much smaller than the $10^{-3}$ - the threshold to claim discovery.

We then run the SLEUTH on data. The most discrepant final states are given in Tab. I. No final states in addition to ones discrepant at VISTA level surpass the discovery threshold. Fig. 4 shows

| Final state         | p - value |
|---------------------|-----------|
| $l^+l^- + E_T$      | < 0.001   |
| $l^\pm + 2Jet + E_T$| < 0.001   |
| $l^\pm + \tau^\mp + E_T$| 0.0050   |
| $l^\pm + 1Jet + E_T$ | 0.019     |
| $e^\pm\mu^\mp + 2b + E_T$ | 0.12      |
| $l^\pm + 2b + E_T$ | 0.12      |
| $l^\pm + 2b + 2Jet + E_T$ | 0.3      |
| $e^\pm\mu^\mp + 2b + E_T$ | 0.31      |
| $l^\pm + \tau^\mp$ | 0.91      |
| $l^\pm + 2b + 2Jet + E_T$ | 0.98      |

TABLE I: The list of the most discrepant SLEUTH final states with the p-value after correction for trials.
Performing global searches with SLEUTH, we did not find any hint of new physics in the D0 data, more data has already been recorded by the experiment. If we incorporate this data set into our analysis and continue implementing improvements to our correction model, we will become much more sensitive to possible new physics.

III. CONCLUSION

Performing global searches with SLEUTH, we did not find any hint of new physics in the D0 data, more data has already been recorded by the experiment. If we incorporate this data set into our analysis and continue implementing improvements to our correction model, we will become much more sensitive to possible new physics.

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