Measurement of the b-jet cross section at Vs=1.96 TeV

Peters, O.

Citation for published version (APA):
Peters, O. (2003). Measurement of the b-jet cross section at Vs=1.96 TeV
Summary

This thesis describes the measurement of the differential $b$-jet production cross section using a muon tag, at a center of mass energy of 1.96 TeV. This cross section has been previously measured at 1.8 TeV using the DØ detector in Run I, and shown to be around a factor two higher than theoretical predictions. This analysis confirms that result.

The current state of the theoretical calculation includes a next to leading order calculation of the $b$-jet cross section. Using $b$-jets instead of $b$-quarks has the benefit that fragmentation effects are included in the jet algorithm. The dominant error on the theoretical cross section is coming from the renormalization and factorization scales, and to a lesser extent from the uncertainty on the mass of the $b$-quark.

Measuring the $b$-jet cross section in $\bar{p}p$ collisions requires an intricate system of accelerators and detectors. The Tevatron at Fermilab accelerates protons and anti-protons to an energy of 980 GeV, resulting in a center of mass energy of 1.96 TeV available for the collisions. The DØ detector uses a multitude of components to detect these collisions, of which especially the muon system and the calorimeter system are the most important for this analysis.

Due to the high rate of the collisions at the center of the detector, a complex trigger system is used to filter out the interesting events. Three levels of triggers are designed, but only the first level trigger, one that requires the presence of a muon and a jet, is used for this analysis.

Each recorded event needs to be reconstructed to get the real physics objects as they were produced in the collision, such as muons and jets. The jets are reconstructed with a 100% efficiency above 20 GeV, but with an energy resolution that is not well described by the Monte Carlo simulation. The muons are reconstructed using the central muon system only, without using the central tracker. Even though the reconstruction efficiency of the muons is comparable to that predicted by the Monte Carlo simulation, the simulation does not describe the data well in terms of the direction and momentum resolution of the muon. This deficiency of the Monte Carlo is addressed in the analysis by adding additional smearing at the appropriate places.

To measure the $b$-jet cross section in the data, a data sample is used that is taken with the DØ detector in the period February 26$^{th}$ until May 10$^{th}$, 2002. It corresponds
to a total integrated luminosity of 3.4 pb$^{-1}$ and contains 361,037 events. From this data sample, the differential $\mu$+jet cross section as a function of the jet $E_T$ is extracted first. Then, the relative momentum of the muon with respect to the combined $\mu$+jet axis, a variable called $P^\text{Rel}_T$, is used to determine the relative amount of $b$-jets that are present in the sample. Folding the $\mu$+jet differential cross section with the relative $b$-jet content results in the $b$-jet cross section, measured as a function of jet transverse energy as it is measured in the calorimeter.

To be able to compare this cross section to the theoretical predictions, it needs to undergo a number of corrections. The major corrections are for the resolution of the calorimeter and the energy carried away by the muon and neutrino in the $b \rightarrow \mu + \nu$ decay. Taking these corrections into account results in the $b$-jet cross section measured as a function of the true $b$-jet $E_T$, which is a quantity which can be compared directly to the theory.

The measured data points are a factor 1.7 to 2.2 higher than the central prediction of the calculation. A $\chi^2$ comparison with the theory results in a $\chi^2$ value, per degree of freedom, of 1.31 for the central prediction, corresponding to a probability of 15.0%. The data points are more compatible with the upper band of the prediction, resulting in a $\chi^2$ per degree of freedom of 0.61, corresponding to a probability of 33.5%.