Search for the Standard Model Higgs Boson in the Decay Channel H→WW* →$\mu\nu_\mu$+jj at the DØ Experiment

A. Grohsjean , O. Biebel , M. Binder , T. Christiansen , J. Elmsheuser , M. Erlebach , F. Fiedler , P. Haefner , B. Tiller , T. Nunnemann , D. Schaile , P. Schieferdecker , and R. Ströhmer

The Standard Model (SM) Higgs boson provides a possible answer to the mass generating mechanism for weak gauge bosons and fermions and its experimental detection would represent an essential proof of the electroweak theory.
At the DØ experiment a search for the Higgs boson in the decay channel H→WW*→lν_l + lν_l where both W bosons decay leptonically has been performed previously [1].
This study investigates the possibility of searching for the Higgs boson with a mass of around 120 GeV in the H→WW*→$\mu\nu_\mu$+jj channel. The DØ experiment is located at the Tevatron collider, a p$\bar{\text{p}}$ collider with a center of mass energy of $\sqrt{s}$ = 1.96 TeV. The SM Higgs boson is expected to be produced mainly via gluon gluon fusion with a production cross section of 0.69 pb for m_H=120 GeV. For this Higgs mass the decay branching ratio BR(H→WW*) is predicted to be 0.13.
The signature of this process is characterized by two jets from the hadronic W boson decay, as well as an isolated muon and missing transverse energy from the leptonic W. Background processes with similar topology are W+jj, WW and WZ events where W+jj is the dominant process. Table 1 gives an overview of the signal and the main physics background processes together with their cross section times branching ratio, $\sigma\times$BR, and the Monte Carlo simulation program used to generate events for studying these processes. Background with non-isolated or fake muons has not been considered so far. All processes were studied using the full detector simulation.

event	$\sigma\times$BR[pb]	MC
H→WW*→ $\mu\nu_\mu$+jj	0.013	Pythia
W+jj→ $\mu\nu_\mu$+jj	220	Alpgen
W+jj→ $\tau\nu_\tau$+jj → $\mu\nu_\mu$+jj	38.2	Alpgen
WW → $\mu\nu_\mu$+jj	1.65	Pythia
WZ → $\mu\nu_\mu$+jj	0.26	Pythia

Table 1: Generated signal for an assumed Higgs mass of 120 GeV and background processes, $\sigma\times$BR [pb], MC Generator.W+jj events have been generated requiring a minimum jet transverse momentum at parton level of 8 GeV.

Table 1 shows the dominance of background over signal events. To reduce the number of background events the following preselection cuts are applied. One of the jets has to have a transverse momentum, p_T, higher than 15 GeV, the second a p_T higher than 12 GeV. In addition there must be more than 10 GeV missing transverse energy in the event, as well as an isolated muon with $p_T \geq 10$ GeV. There are two isolation requirements. The sum of the transverse momenta of all tracks excluding the muon track that are found in a cone around the muon direction with cone radius 0.5, dR = $\sqrt{d\phi^2 + d\eta^2} \leq 0.5$, has to be less than 4 GeV; η and ϕ are the pseudorapidity and the azimuthal angle respectively. Furthermore the energy deposited in the calorimeter around the muon direction in $0.15 \leq dR \leq 0.4$ has to be less than 2.5 GeV.

To discriminate against the W+jj background the special kinematics of the signal process is exploited. In signal events with an assumed Higgs mass of m_H = 120 GeV one of the two W bosons is not on its mass shell, see figure 1. To reconstruct the event one can now apply a kinematic fit where the mass of the hadronically decaying W boson has to be 80 GeV and the Higgs mass 120 GeV. The lepton momentum as well as the jet directions are assumed to be perfectly measured.

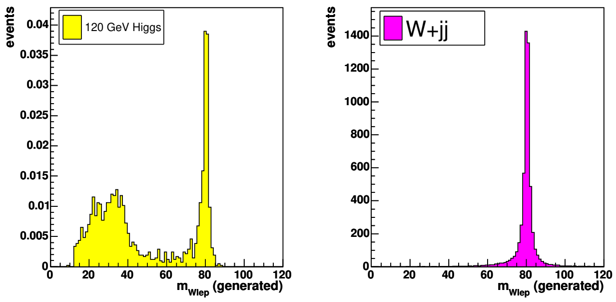

Fig. 1: Invariant mass of the leptonically decaying W boson from generated Monte Carlo for signal (left) and W+jj Background (right).

The kinematic fit itself represents a powerful way of discriminating the signal from the main background and improves the energy resolution of both jets. Table 2 shows the number of events passing the preselection and with a real kinematic solution for $p_z(\nu)$ for an assumed integrated luminosity of around 147pb^{-1}, as well as the efficiency of the kinematic reconstruction. The selection efficiency for signal events is very high considering that the on-shell W boson decays hadronically in only 50 percent of the cases.

events	presel.	real $p_z(\nu)$	eff.[%]
120 GeV Higgs	0.39	0.18	46
W+jj	5374	268	5
W+jj with $\tau \to \mu$ decay	57	11	20
WW	99	5	5
WZ	16	0.64	4

Table 2: Number of events after preselection, after kinematic fit and the efficiency of the kinematic reconstructon for an assumed integrated luminosity of around 147pb^{-1}.

Information from kinematical variables has been combined into a neural network to discriminate between signal and background. With a cut on the neural network output, a signal to background ratio of around 1/500 is expected for a 120 GeV Standard Model Higgs. This is comparable with the results from the traditional analysis in the dimuon final state for a 120 GeV Higgs boson [1], but with a selected event sample about 20 times larger.

In the future, this analysis will be refined and applied to DØ data.

References

[1] J. Elmsheuser *et al.*, this report, p.35