SEARCH FOR AN INVISIBLE HIGGS IN $t\bar{t}h$ EVENTS

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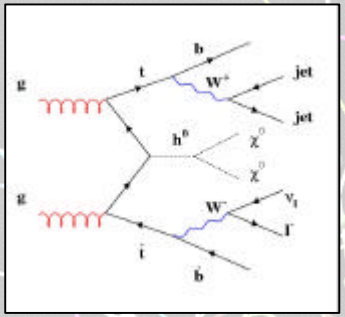
Motivation

The search for the Higgs boson is a window on physics beyond the Standard Model (SM). Some scenarios predict a Higgs boson which decays to stable invisible particles. In general Supersymmetry (SUSY) models with R-parity conservation a SM-like Higgs could decay to light neutralinos (c^0) that would escape detection. We are developing a search strategy for the invisible Higgs produced in tth events in the ATLAS experiment. One point in the SUSY parameter space has been selected:

$M_h = 121$ GeV, $M_\chi = 35.5$ GeV, $BR(h \to \chi^0 \chi^0) = 1$

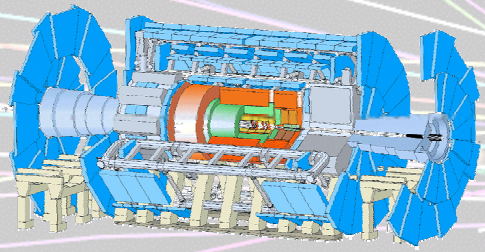


Search strategy

The Higgs boson can be produced in several processes. We concentrate on associated production of $t\bar{t}h$ (diagram on the left) decaying according to:

$$tth \to (bjj)(bl\nu)(c^0c^0)$$

Both the neutrino (ν) and the neutralinos (c^0) leave the experiment undetected. The signal events are selected by requiring a large missing transverse energy, together with two jets originating from the ***b*** quarks (tagged), one isolated lepton, and two or more extra jets (**jj**).



Process	σ×BR
tth	330 fb
tt	490 000 fb
bbW, W → lν	73 000 fb
bbZ, Z → l^+l^-	61 400 fb
ttW, W → lν	420 fb
ttZ, Z → ν	190 fb

Signal and backgrounds

The expected background is much larger than the signal (table on the left). An excellent background rejection will be necessary. So far only the ***tt*** background was explored.

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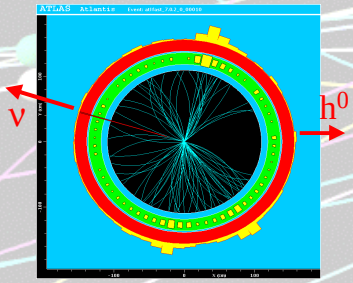
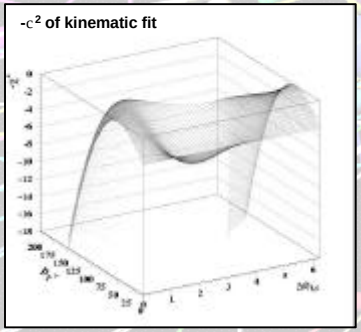
Event reconstruction I - $t \to bjj$

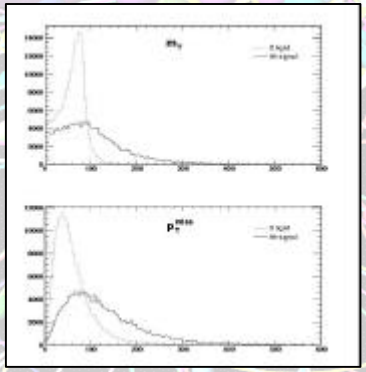
The momentum of the hadronically-decaying top quark can be found by searching for combinations of jets compatible with the masses of the $W^\pm$ and the top quark:

$$|m_{jj} - m_W| < 25 \text{ GeV}, |m_{bjj} - m_t| < 25 \text{ GeV}$$

The missing transverse momentum (p_T^{miss}) and the ***transverse mass*** (m_T) can be used to discriminate against background (figures and table below). Using appropriate cuts on m_T and p_T^{miss}, around 118 signal events can be expected after an integrated luminosity of **100 fb^{-1}** collected in ATLAS (one year at design luminosity). These events should be observable over around 1107 background events.







$$m_T = \sqrt{\left(E_T^{miss} + E_T^{lepton}\right)^2 + \left(\vec{p}_T^{\,miss} + \vec{p}_T^{\,lepton}\right)^2}$$

100 fb^{-1}	N_{signal}	$N_{background}$	signal/vback
t→bjj reconstr.	621±4	(810±2)x10^3	0.689
m_T>100 GeV	270±3	34010±410	1.46
p_T^{miss}>150 GeV	118±2	1107±74	3.36

Event reconstruction II - kinematic fit to $t \to bl\nu$

The neutrino in the decay to $t \to bl\nu$ contributes to the overall missing transverse momentum:

$$\vec{p}_T^{\,miss} = \vec{p}_T^{\,h^0} + \vec{p}_T^{\,n}$$

The momentum of the neutrino can be inferred from that of the lepton and from the invariant masses of the $W^\pm$ (m_W) and the top quark (m_t) through a **kinematic fit**. Assuming values of p_T of the neutrino (p_T^n) and the azimuthal angle between lepton and neutrino ($\Delta\phi_{ln}$), the longitudinal momentum of the neutrino can be obtained from the constraints on m_W and m_t (see figures above). Using the momentum of the neutrino, the transverse momentum of the invisible Higgs boson can be obtained from the equation above.

Event reconstruction II - jets

A discrepancy was noticed between the average number of jets in the signal compared to background events. The cone-jet algorithm used in finding jets is being investigated. The figure on the right shows the average number of jets for different values of the cone radius in the algorithm. Other observables such as the angular separation between jets may also be useful in selecting signal events and rejecting background. This is under investigation.