Introduction:
- The Standard Model (SM) predicts a neutral massive gauge boson (the Higgs boson).
- Beyond the SM, two-Higgs-doublet models (2HDM) such as the Minimal Supersymmetric Standard Model (MSSM) predict four physical Higgs bosons: \(H^0, A^0, H^+, H^-\).
- The SM gives rise to a unique Higgs boson.
- Any evidence of \(H^0\) is an evidence of new physics beyond the SM.
- LEP excluded any charged Higgs boson up to 80 GeV.
- The discovery of a neutral Higgs boson is predicted by many extensions of the SM.

The Analysis in Brief:
- Search for charged Higgs bosons (\(H^\pm\)) from top-quark decays where \(H^\pm\) decays to \(t\bar{t}\) producing two jets in the detector.
- Complementary to the \(t\bar{t}\) channel which is dominated by SM processes.
- Select same-sign lepton events: use high \(p_T\) lepton (e or \(\mu\)), large \(E_T\) (\(> 100 \text{ GeV}\)).
- Fully reconstruct the \(t\bar{t}\) events using kinematical jets: fit the di-jet mass and determine \(H^\pm\) background separation power.

Event Selection, Reconstruction and the Fitter:
- Use MC samples for signal and background.
- The \(H^\pm\) signal: 90, 100, 110, 120, 130, 140, 150 GeV mass points.
- Major backgrounds include: SM \(t\bar{t}\), Single Top, \(W+\) jets (light or heavy), di-boson and QCD.
- Apply a cut on optimized event selection cuts.
- Selected events are used as an input to the kinematical \(f_0\) fit.

In the Fitter:
- Constraints the values of the leptonic \(W\) boson mass and the top pair masses to be their PDG values.
- Allows the measured \(p_T\) values to vary within their uncertainties.
- Use information to provide a consistency solution and correct jet combination.
- Allow combinations where the 5th jet swaps the 3rd or 4th jet (if not b-tagged).

From the Fitter:
- Removes badly reconstructed di-jet events using a cut on the \(f_0\) value.
- Significantly reduces the background events.
- Provides a stringent resolving power between \(H^\pm\) and SM signal MC.

The \(f_0\) function:
- First term is to allow the \(p_T\) of the jets and leptons to be changed within their uncertainties.
- Second term allows the rescaling of the sum of extra jets energy (SEJ) (defined as a quantity absorbing all jet E\(_T\), not associated with the lepton or the four leading jets) and is used to re-calibrate the \(E_T\) to the data.
- Third term constrains the masses of the top pair to \(M_{t\bar{t}} = 172.5\) GeV.
- Fourth term constrains the mass of the leptonic \(W\) to \(M_W = 80.42\) GeV.

Analysis with 35pb\(^{-1}\) of ATLAS Data (\(\geq 1\) b-tag):
- In 2010 ATLAS recorded more than 35pb\(^{-1}\) of physics data.
- Use \(\geq 7\) b-tag and impose 2 jet cut to enhance signal.
- Total data events (323) agree with the SM expectation within error.
- This expected number of SM other, non-SM background and the case of \(m_{H^\pm} = 110\) GeV signal with \(BR > 10\%\) are shown in the following table.
- Expected and observed limits are compatible with the Tevatron limits with a factor of 3 to 6 less luminosity.

Data-MC Comparison:
- Dijet mass distributions of the data is compared with the SM expectation (MC) (left) with \(BR = 0.30\) for \(m_{H^\pm} = 90\) GeV (right) with \(BR = 0.18\) for \(m_{H^\pm} = 110\) GeV.

Analysis with 35pb\(^{-1}\) of ATLAS Data (2 b-tag):
- The efficiency of the 2-tag cut is about 30\% for both channels.
- Total data events 92.
- Good discriminating power for some backgrounds (single top, \(W +\) jets).
- Good agreement between data and SM expectation in both channels (electron left and muon right).
- Statistically limited.

Prospects of Analysis with 4.7fb\(^{-1}\) of ATLAS Data:
- Sufficiently high statistics to apply 2-tag and a tighter \(q_2^2 < 10\) cut to reduce the background rate and improve signal-background separation power (expect 14K events).
- However, the effect of systematic uncertainties becomes dominant.
- Many sources of systematic uncertainties that affect the signal acceptance and/or the shape of the reconstructed di-jet mass.
- Use different techniques to estimate the effect of these uncertainties.
- The expected limits will be between several percent to 1\% depending on the \(H^\pm\) mass.
- Results are in the collaboration review and will be public within a month.