Searches for light $H^{\pm}$ decaying to a hadronic tau in the one lepton mode with ATLAS

Thies Ehrich for the ATLAS collaboration

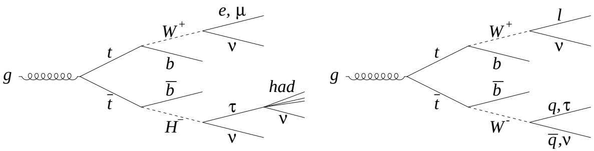
Max-Planck-Institut für Physik
(Werner Heisenberg Institut)
Munich

cHarged 2008
18-Sep-2008

Signal and $t\bar{t}$ Background

Signal

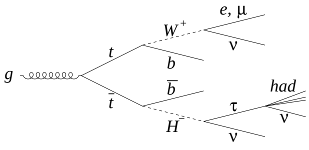
Main Background ($t\bar{t}$)



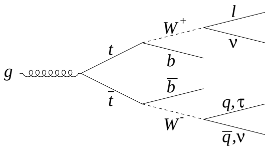
- here:
  - $m_{H^{\pm}} < m_{top}$
  - $t\bar{t} \rightarrow (Wb)(H^{\pm}b)$ [main production mode]
  - $H^{\pm} \rightarrow \tau\nu \rightarrow \tau$-jet $\nu\nu$ [BR($H^{\pm} \rightarrow \tau\nu$) ∼100%]
  - $W \rightarrow l\nu$
- no full event reconstruction possible (3 ν; both sides)
- Signal would be observed as an excess of events over SM $t\bar{t}$
- same signature, but not covered in the signal:
  - $W \rightarrow \tau\nu$
  - single top events

Backgrounds

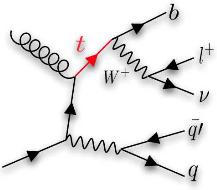
Signal, 62 pb^{-1}



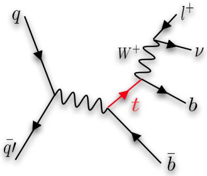
$t\bar{t}$ Background, 833 pb^{-1}



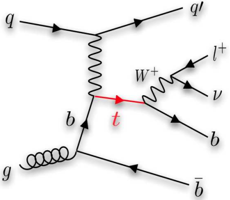
Wt, 66 pb^{-1}



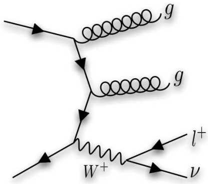
s-chan, 11 pb^{-1}



t-chan, 247 pb^{-1}



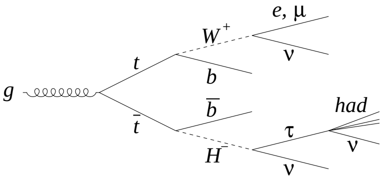
W+jets, 912 pb^{-1}



- all cross-sections are inclusive
- except: W+Jets: 3 Jet filter, W→e$/\mu/\tau+\nu$

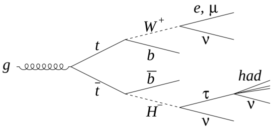
Trigger Selection

see talk from M. Flechl for description of the ATLAS detector



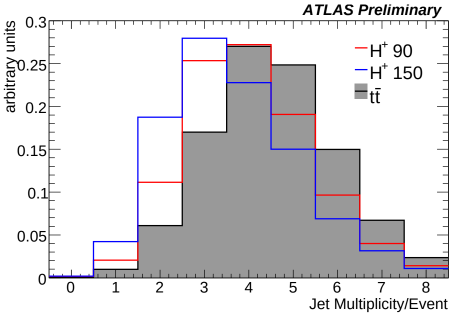
- Trigger (see talk from C. Potter)
  - isolated electron, $p_T > 25$ GeV+$E_T^{miss} > 30$ GeV
  - isolated muon, $p_T > 20$ GeV+$E_T^{miss} > 30$ GeV
  - isolated τ-jet, $p_T > 35$ GeV+$E_T^{miss} > 40$ GeV+3 jets (20 GeV)
  - isolated τ-jet, $p_T > 35$ GeV+$E_T^{miss} > 50$ GeV

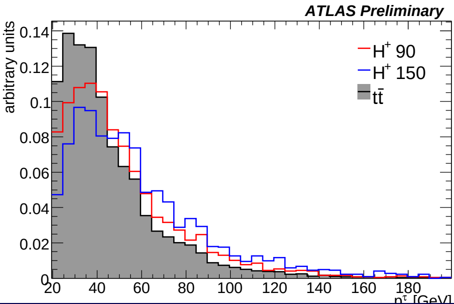
Event Selection



- $N_{e,\mu} \geq 1$
  - $p_T > 25$ (e), 20 (μ) GeV
  - $|\eta| < 2.5$ (e, μ, τ, b), 5 (jets)
  - isolation required
- $N_{jets} (= N_{light\ jets} + N_{b\text{-}jets} + N_{\tau\text{-jets}}) \geq 3$
  - $p_T > 20$ GeV
- $N_{\tau\text{-jet}} \geq 1$ (see talk from A. Saavedra)
  - $p_T^{\tau} > 40$ GeV
  - refinement of τ selection by: $\frac{E_T^{had}}{p^{\tau}_{T,lead.\ track}} > 0.1$
- $N_{b\text{-jet}} \geq 1$ (see talk from G. Piacquadio)
- charge(τ)=-charge(ℓ)
- $E_T^{miss} > 175$ GeV

Jets





- for high $H^{\pm}$ mass $m_{H^{\pm}} \sim 150$ GeV:
  - b-jet associated to $H^{\pm}$ is very soft $p_T \sim 20$ GeV
  - often not even reconstructed
    $\Rightarrow$ require only one b-tag

- τ-jets more energetic due to $m_{H^{\pm}} > m_W$ and different polarizations

Cutflow (m_h-max Scenario, $\tan\beta$=20)

cross-sections [fb] and rel. cut efficiencies (ATLAS Preliminary)

Channel		All ev.	Trigger	$\geq$1 e,μ	$\geq$3 jets	$\geq 1\tau$	$\geq$1 b	τ p_T	$\sum$ q	E_T^{miss}
$H^{\pm}$ (110 GeV)	[fb]	8570	4510	3534	2986	772	650	439	431	30
	[/]		*0.53*	*0.78*	*0.84*	*0.26*	*0.84*	*0.67*	*0.98*	*0.07*
$t\bar{t}$ (1 lep)	[fb]	452000	169612	137928	122547	4760	4006	1915	1730	78
	[/]		*0.37*	*0.81*	*0.89*	*0.04*	*0.84*	*0.48*	*0.90*	*0.04*
single top	[fb]	112500	30180	25065	18081	271	168	47	38	-
	[/]		*0.27*	*0.83*	*0.72*	*0.02*	*0.61*	*0.28*	*0.81*	-
$W\rightarrow l\nu$+jets	[fb]	769547	216556	166598	101473	1549	180	92	58	-
	[/]		*0.28*	*0.77*	*0.61*	*0.02*	*0.12*	*0.51*	*0.63*	-

- most significant $t\bar{t}$ reduction by τ tagging
- p_T^{τ} and E_T^{miss} cut values optimized taking into account a systematic uncertainty on the background of 10%
- after all cuts (at $\mathcal{L}$=1 fb^{-1}):
  - 30 $H^{\pm}$ events
  - 78 (72) $t\bar{t}$ events in the case of SM (MSSM)

Systematic Uncertainties

Dominating experimental uncertainties

- jet energy scale (E_T^{miss}): $\sim 30 - 40\%$
- τ-jet energy scale: $\sim 10\%$
- τ-jet energy resolution: $\sim 10\%$

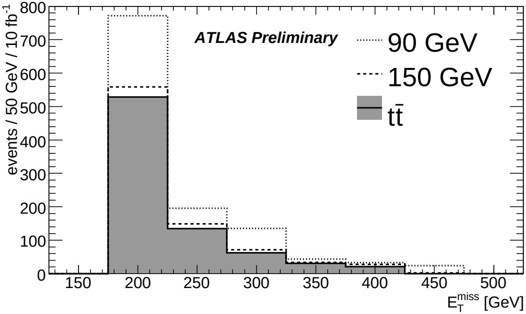
Theoretical uncertainties

- cross-section $t\bar{t}$ background: 12%
- branching ratio $t \rightarrow H^{\pm}b$: $< 10\%$
- branching ratio $H^{\pm} \rightarrow \tau\nu$: $< 5\%$

A method to estimate the $t\bar{t}$ background from data has been developed (see talk from T. Vickey).
$\Rightarrow$ estimated uncertainty of $t\bar{t}$: $\mathcal{O}(10\%)$

- Excess of events visible, especially for small masses (numbers are normalized to $\mathcal{L}$=10 fb^{-1}).

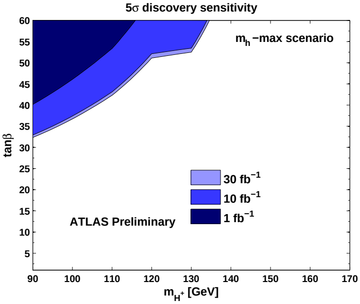
tanβ=20

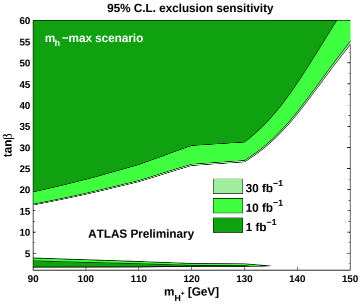


Missing Energy (Signal+Background) after all cuts

Discovery and Exclusion Limits (m_h-max)

- results calculated using a profile likelihood method (see talk by O. Vitells)
- assumed systematic background uncertainty: 10% signal systematic uncertainty: 40%
- statistical uncertainties of MC taken into account





Conclusions

- The main keys towards a $H^{\pm}$ discovery are:
  - good understanding of the $t\bar{t}$ background down to $\sim 10\%$
  - powerful τ-identification
  - small uncertainty on E_T^{miss}
- Discovery of light $H^{\pm}$ bosons challenging for $\mathcal{L}$=10 fb^{-1}.
- Exclusion possible over a wide tanβ range, but intermediate region remains uncovered.