A Novel SM Higgs search channel at the LHC

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Based on:

A.M. and Zack Sullivan arXiv:0105.XXXX

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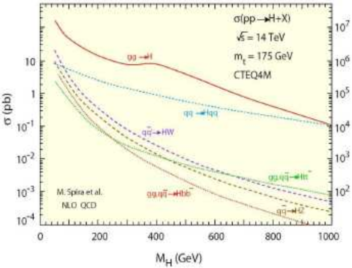
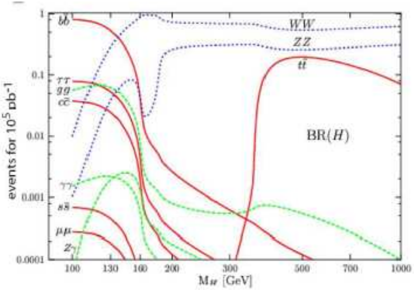
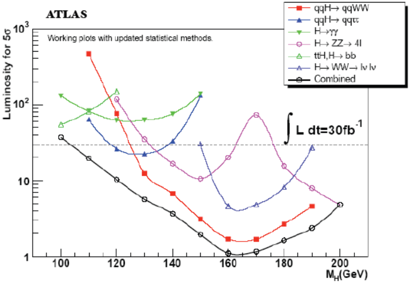
Higgs Production and Branching Ratios

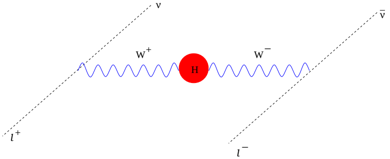




- Gluon Fusion is the dominant production mechanism
- For $m_h \geq 140$ GeV, $h \to W^+W^-$ is the dominant decay mode.

$h \to WW$ in the leptonic mode





- Projected 5 σ significance with a luminosity of $4 - 5$ fb^{-1} for $m_h = 160$ GeV.
- However uncertainties in heavy flavor background. See Zack's talk.
- $V - A$ structure of the W couplings imply spin-correlations between between leptons.

What about the semi-leptonic channel?

$h \rightarrow WW$ in the semi-leptonic mode

- Large cross-section, but also larger background $\Rightarrow 3\ \sigma$ significance with 30 fb^{-1} luminosity at the Tevatron.

  Han and Zhang 1998

- For the $h \rightarrow jjl\nu$ mode angular variables θ_l^0, φ_l and θ_j^0 have been found.

  Dobrescue and Lykken 2009

- Main backgrounds to this process Wjj, $t\bar{t}$, WZ and WW.

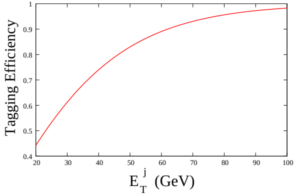
- Largest background is due to Wjj.

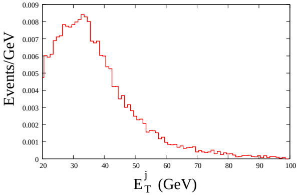
Can we make it competitive with the leptonic channel?

A way forward: Charm Tagging

- Advantages of charm tagging:

1. Reduces the Wjj background substantially.
2. Can use many more spin correlations than are present in the leptonic channels.
3. Can reconstruct the Higgs Mass.





- Using a heavy flavor tagging efficiency $\sim 60 - 70\%$ in the relevant kinematic region of $E_T^c = 30 - 40$ GeV.

Signal and Backgrounds

Signal: 2 or 3 jets, 1 tagged jet, 1 lepton + MET

$Wcj/Wc\bar{c}$: Dominant background and scales with charm tagging efficiency.

Wjj: Next largest background, is sub-dominant due to charm tagging.

$Wbj/Wb\bar{b}$: Largest background that does not scale with charm tagging efficiency.

$t\bar{t}$: Large cross-section is reduced by requiring low multiplicity of jets.

WW & Single Top: Reduced by appropriate angular cuts.

Simulation

- Generated signal and background events for $\sqrt{s} = 14$ TeV with Madgraph.

- Showered events with Pythia.

- Used PGS as the detector simulation.

- Used jet cone algorithm with cone-size 0.4.

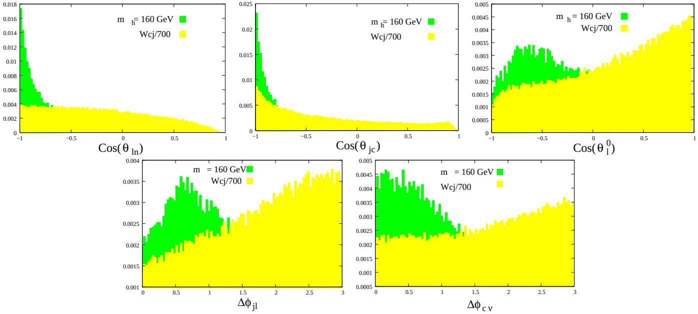
- Assumed b-tagging efficiency of 60%

- Assumed light jet mis-tag rate of 1%.

- Basis cuts:

1. $E_T^j > 20$ GeV
2. $p_T^l > 20$ GeV
3. $\eta_{j(l)} < 2.5$

Angular Cuts



• θ_{ij} angle between the ith and jth particle in the rest frame of the Higgs.

• θ_l^0 angle between the lepton in the rest frame of the $l\nu$ system and the direction of the W boost in the rest frame of the Higgs boson.

Dobrescue and Lykken

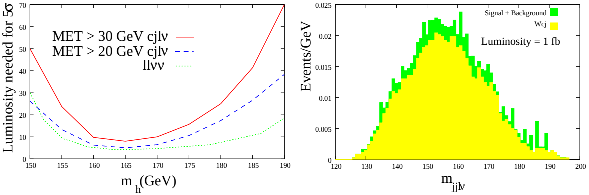
Signal Significance

Number of Events per fb

Cuts	Signal	Wcj	WW	$t\bar{t}$	Wbj	Single Top	$Wc\bar{c}$	$Wb\bar{b}$	Wjj
2 or 3 j, 1 tag, 1 l	282	183988	2585	25472	10492	9027	4722	2670	92936
MET $>$ 30.0	189	111380	1818	20507	6838	7142	3059	1822	72863
p_T^l ¡ 60.0	185	83027	1546	12937	5757	5271	2531	1504	51127
$\Delta\eta_{lc} < 2.0$	152	49281	1246	7972	3824	2689	1718	1125	26320
$\Delta\phi_{\nu c} < 1.5$	120	17003	192	2595	1436	764	387	323	7790
$\Delta\phi_{lj} < 2.0$	107	14193	161	1803	1200	591	344	275	5063
$\cos(\theta_{jb}) < -0.6$	85	6650	59	937	418	324	131	122	2127
$\cos(\theta_{ln}) < -0.8$	62	2671	31	214	178	65	66	59	524
$\cos\theta_l^0 < 0.2$	55	1950	24	193	149	56	46	45	270
$45 < M_{jc} < 85$ GeV	48	905	20	16	79	9	27	29	125
$140 < m_h < 170$ GeV	43	649	18	4	57	6	18	19	90

- For $m_h = 160$ GeV, significance of 1.5σ in 1 fb^{-1}.
- If MET cut reduced to 20 GeV significance can be improved to $2\ \sigma$ with 1 fb^{-1}.
- Changes in the charm-tagging efficiency affects only the signal, Wcj and $Wc\bar{c}$.

Comparison of leptonic and semi-leptonic modes



- With 60% charm tagging efficiency and minimum MET cut of 30 GeV a 5 σ significance is possible with 10 fb^{-1}.

- The significance is independent of the b-tagging efficiency, but needs a small mistag rate of light jets.

- Improvements in the MET measurement can further enhance the significance.

Conclusions

- The semi-leptonic mode of the $gg \to h \to W^+W^-$ channel can be made competative with the leptonic mode with charm tagging, independent of b-tagging efficiency.

- Can independently measure the Higgs mass in this mode, unlike the leptonic mode.

- Improvements in MET measurement can further boost the significance in this channel.