Identify charged Higgs boson in $W^{\pm}H^{\mp}$ associated production at the LHC

鲍守山

山东大学物理学院

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H.L.Li, S.Y.Li, Z.G.Si, Y.L.Wu, Phys. Rev. D83:075006, D85 075005

Contents:

New Charged Bosons BSM

NP With New Charged Bosons

- $H^{\pm}$: New Doublet, THDM(MSSM). SM has no Charged Scalar
- $W'^{\pm}$: New Gauge Interaction, ED, LR

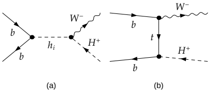
LHC–Searching Higgs ISM and NP BSM

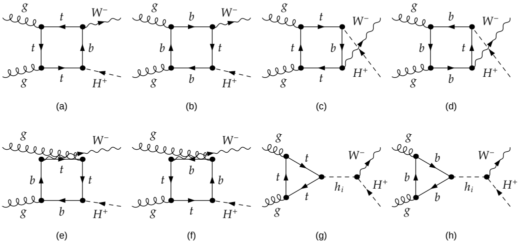
$pp \to WX$ is interesting to search Higgs ISM and NP BSM

- In addition to the Golden Channels, the $pp \to W^{\mp}H(2b_j)$ is another promising discovery channel for a SM Higgs particle with mass below about 135GeV.
- In addition to $gb \to H^{-}t$ and $gg \to H^{-}t\bar{b}$, another interesting channel is to produce the $H^{\pm}$ in association with W bosons, and the leptonic decays of the W-boson can serve as a trigger for the $H^{\pm}$ boson search.

$H^{\pm}$ Production at LHC

At hadron colliders, the dominant mechanisms for $W^{\pm}H^{\mp}$ associated production are $b\bar{b}$ annihilation at tree level and gluon-gluon fusion at one-loop level.





$b\bar{b}$ annihilation strongly depends on y_b;

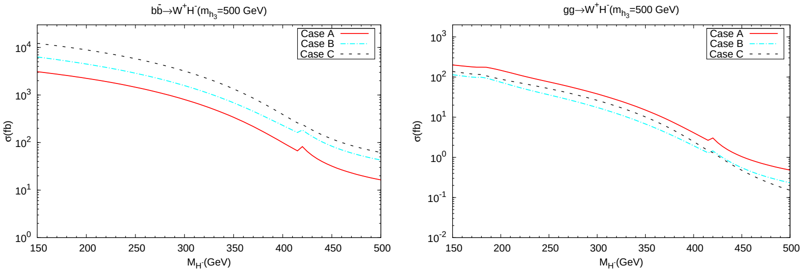
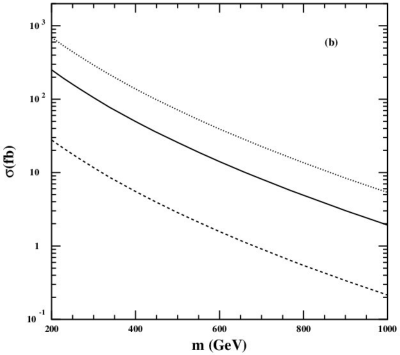


Figure: (y_t, y_b)=A: 0.2,0.5; B: 0.1, 0.8; C: 0.01, 1.0

Result

- $\sigma(b\bar{b})/\sigma(gg) \sim 10^2$
- smaller y_b, larger y_t: $b\bar{b}$ smaller, gg larger;
- In Type II or MSSM, the $b\bar{b}$ is dominant for large $\tan\beta$.
- The Cross-section In MSSM is smaller by 2 order.



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$W^{\mp}X^{\pm}$ at LHC

$pp \to W^{\mp}H^{\pm}$

- $H^{\pm} \to cs$, $W + 2j$.
- $H^{\pm} \to \tau\nu$;
- $H^{\pm} \to tb$, $b\bar{b}jj$

- $M_{H^{\pm}} < m_t + m_b$;
- small $\tan\beta$ in MSSM;
- $W'^{\pm} \to cs$

$W^{\mp}X^{\pm}$ at LHC

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- Larger $\tan\beta$, especially for $M_{H^{\pm}} < m_t + m_b$;
- $M_{H^{\pm}}$ from p_T distribution of τ-jet;
- $W'^{\pm} \to \tau\nu$

$W^{\mp}X^{\pm}$ at LHC

$pp \to W^{\mp}H^{\pm}$

- $H^{\pm} \to cs$, $W + 2j$.
- $H^{\pm} \to \tau\nu$;
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- $M_{H^{\pm}} > m_t + m_b$;
- $t \to bW(l\nu)$
- $W'^{\pm} \to tb$

Backgrounds

Bacground		$m_{H^\pm}$	
$t\bar{t}$	5.38×10^5	300	105
$t\bar{t}W$	5.22×10^2	400	49.7
$t\bar{t}Z$	6.85×10^2	500	25.7
$WZjj$	3.90×10^4	600	14.1
$WWjj$	6.88×10^4	800	4.90
$Wjjjj$	2.55×10^7	1000	1.93

Table: the cross section of the SM backgrounds, unit of fb.

$pp \to W^\mp H^\pm \to l + \not{E}_T + b\bar{b}jj$

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$|M_{jjj} - m_t| \leq 20GeV;$

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$|M_{jjj} - m_t| \leq 20GeV$;b-taggering; $|M_{jjjj} - m_{H^{\pm}}| \leq 30GeV$;

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$pp \to W^{\mp}H^{\pm} \to \boxed{l + \not{E}_T + b}\ \boxed{\bar{b}jj}$

$|M_{jjj} - m_t| \leq 20GeV$;b-taggering; $|M_{jjjj} - m_{H^\pm}| \leq 30GeV$;
$|M_{jl\nu} - m_t| > 20GeV, M_{jl} > 1.5m_{H^\pm}$

$pp \to W^{\mp}H^{\pm} \to l + \not{E}_T + b\bar{b}jj$

$m_{H^\pm}$ (GeV)	No cuts	Cut I	Cut I+II	Cut I+II+III
300	105	6.37	3.33	1.43
400	49.7	4.41	2.05	1.11
500	25.7	2.83	1.20	0.72
600	14.1	1.81	0.70	0.45
800	4.90	0.77	0.26	0.18
1000	1.93	0.35	0.10	0.07

S/B	0.01	0.03	0.31	0.57	>9	>3.5
$S/\sqrt{B}$	2.27	3.42	8.15	8.77	>22	>8.57

The $S/\sqrt{B}$ is improved to 8 for $m_{H^\pm} = 500\text{GeV}$, so that the reconstruction of $H^\pm$ through tb final states is possible.

$H^{\pm}$ at LHC–$H^{\pm}$ vs $W'^{\pm}$

$\boxed{pp \to W^{\mp}H^{\pm} \to l + \not{E}_T + b\bar{b}jj}$ vs $\boxed{pp \to W^{\mp}W'^{\pm} \to l + \not{E}_T + b\bar{b}jj}$

- $H^{\pm} \to t\bar{b}(\bar{t}b) \sim p_t \cdot p_b$: **Isotropic** in $H^{\pm}$ rest frame
- $W'^{\pm} \to t\bar{b}(\bar{t}b) \sim p_b \cdot \epsilon$: **Not Isotropic** in W' rest frame

$H^{\pm}$ at LHC–$H^{\pm}$ vs $W'^{\pm}$

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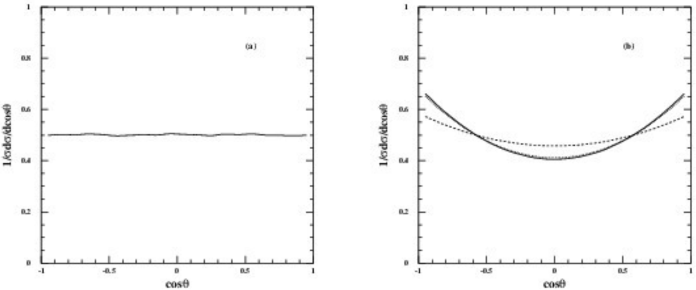
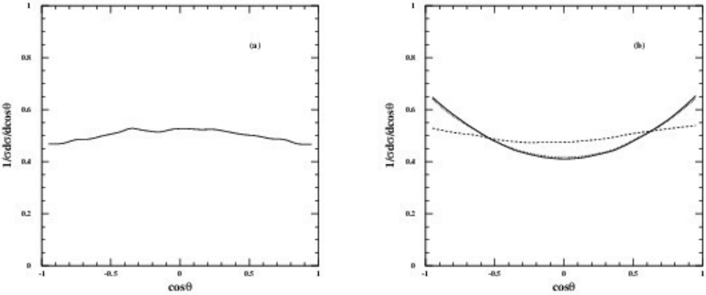


$\sim 1 + A\cos^2\theta$

	$H^{\pm}$	$W'^{\pm}_L$	$W'^{\pm}_R$	$W'^{\pm}_V$
No cuts	0	0.69	0.28	0.65

$H^\pm$ at LHC–$H^\pm$ vs $W'^\pm$

$pp \to W^\mp H^\pm \to l + \not{E}_T + b\bar{b}jj$ vs $pp \to W^\mp W'^\pm \to l + \not{E}_T + b\bar{b}jj$



$\sim 1 + A\cos^2\theta$

	$H^\pm$	$W_L'^\pm$	$W_R'^\pm$	$W_V'^\pm$
No cuts	0	0.69	0.28	0.65
Cuts	-0.13	0.66	0.14	0.60

Summary

- $\sigma(W^{\pm}H^{\mp})$ is model-dependent. $(\sigma = 0.72) \times (\mathcal{L} = 300) \sim 200$ for $m_{H^{\pm}} = 500GeV$.
- The distribution of the final states can be used to distinguish $H^{\pm}$ and $W'^{\pm}$. $A_{H^{\pm}} < 0$, $A_{W'} > 0$

Thank You!

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