NEW SIGNATURES FOR TOP IN HADRON COLLIDER

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1. Motivation.

2. New Interations to Top and Bottom

heavy vector resonance V

heavy scalar resonance S

3. New Signatures at Hadron Collider.

Tao Han, G. Valencia and Yili Wang, hep-ph/0405055,
PRD accept (in Press)

Motivation

In SM, mass generation are from scalar doublet (Higgs).

No explanation on higgs-fermion Yukawa couplings.

No experimental data to find light Higgs.

One possibility: no light Higgs,

at TeV scale, longitudinal vector boson *W*, *Z*

interactions are strong, need new physics to modify it.

New Interations to Top and Bottom

New heavy resonances:

heavy vector resonance V

heavy scalar resonance S (like heavy Higgs).

Top $\Rightarrow$ Main goal of Tevatron and LHC

Strong interactions to top and bottom

Weak couplings to first two generations

Ignore couplings with W, Z:

NP B593,415(2001), PRD 68,15003(2003).

(Prof. Han and Valencia)

Heavy vector V

Coupling strongly to *t* and *b*

No mixing with *W* and *Z*

Framework of effective Lagrangian.

No specific model.

(Prof. X. He and G. Valencia)
PRD 66,13004(2002); 68, 33011(2003)

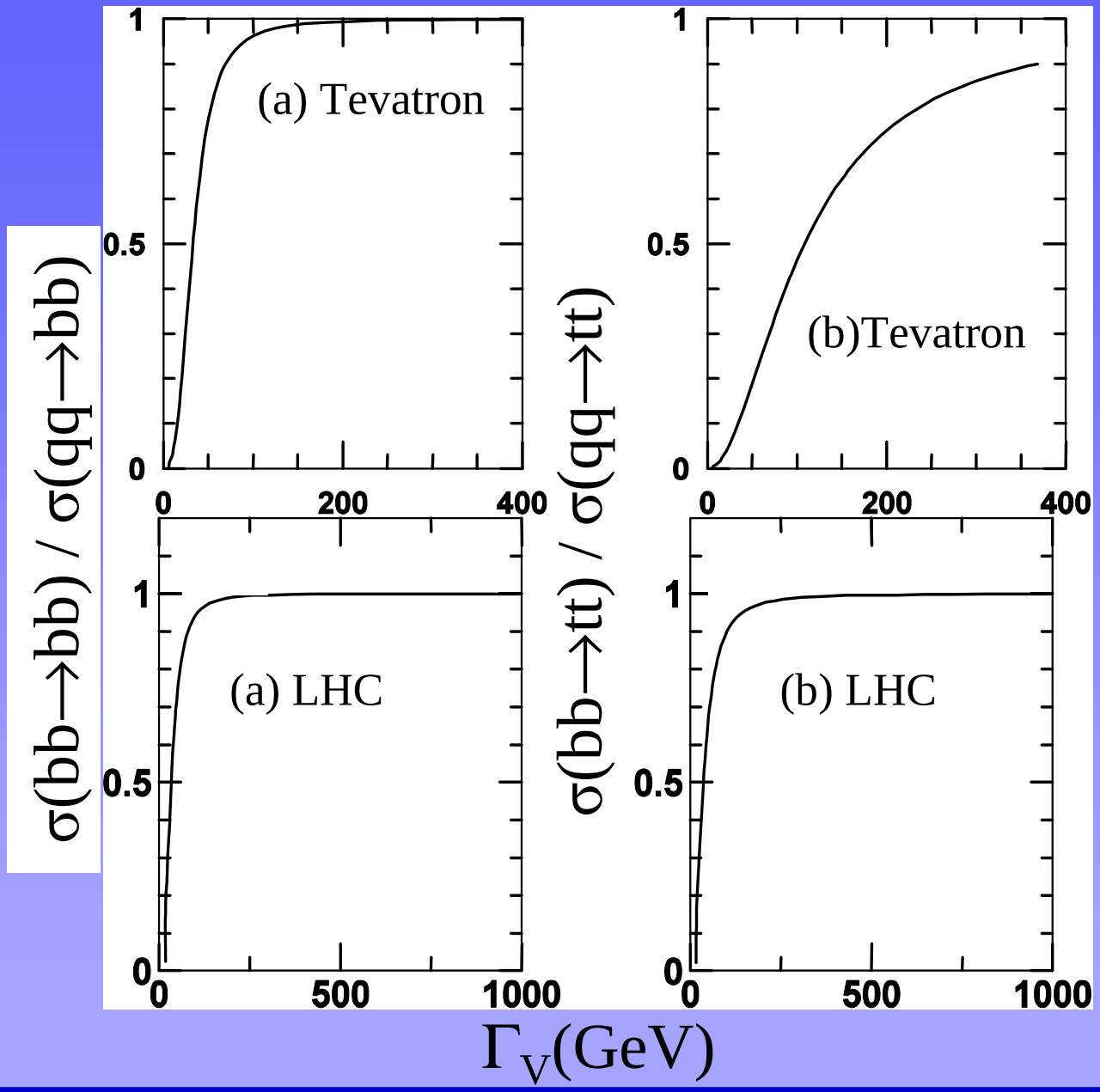
No V-Z mixing, right handed

$$L = \frac{g}{2}\tan\theta_W \tan\theta_R\left(\frac{1}{3}\bar{q}_L \gamma^\mu q_L + \frac{4}{3}\bar{u}_{Ri} \gamma^\mu u_{Ri} - \frac{2}{3}\bar{d}_{Ri} \gamma^\mu d_{Ri}\right)V_\mu$$

$$-\frac{g}{2}\tan\theta_W\left(\tan\theta_R + \cot\theta_R\right)\left(\bar{t}_R \gamma^\mu t_R - \bar{b}_R \gamma^\mu b_R\right)V_\mu$$

$$g_A = g_V = \frac{g}{4}\tan\theta_W \cot\theta_R$$

$$\Gamma(V \to f\bar{f}) = \frac{M_V}{2\pi} g_V^2 \left(1-4\frac{m_f^2}{M_V^2}\right)^{1/2}\left(1-\frac{m_f^2}{M_V^2}\right)$$


(a) Tevatron
(b)Tevatron
(a) LHC
(b) LHC
σ(bb→bb) / σ(qq→bb)
σ(bb→tt) / σ(qq→tt)
Γ_V(GeV)
0
0.5
1
200
400
500
1000

Theoretical constraint:

$$g_V < 1.8 \qquad \cot\theta_R < 20$$

$$g_V = 0.63 \quad \Leftrightarrow \quad \cot\theta_R = 7$$

$$Tevatron: \quad M_V = 400 \ GeV$$

$$\Gamma_V = 47 \ GeV$$

$$LHC: \quad M_V = 1 \ TeV$$

$$\Gamma_V = 127 \ GeV$$

Heavy scalar resonance S

$$L = -\frac{m_t}{v} S\left(k_b \bar{b} b + k_t \bar{t} t \right)$$

Coupling to *b* or *t* or both.

Width mainly from *b* and *t*.

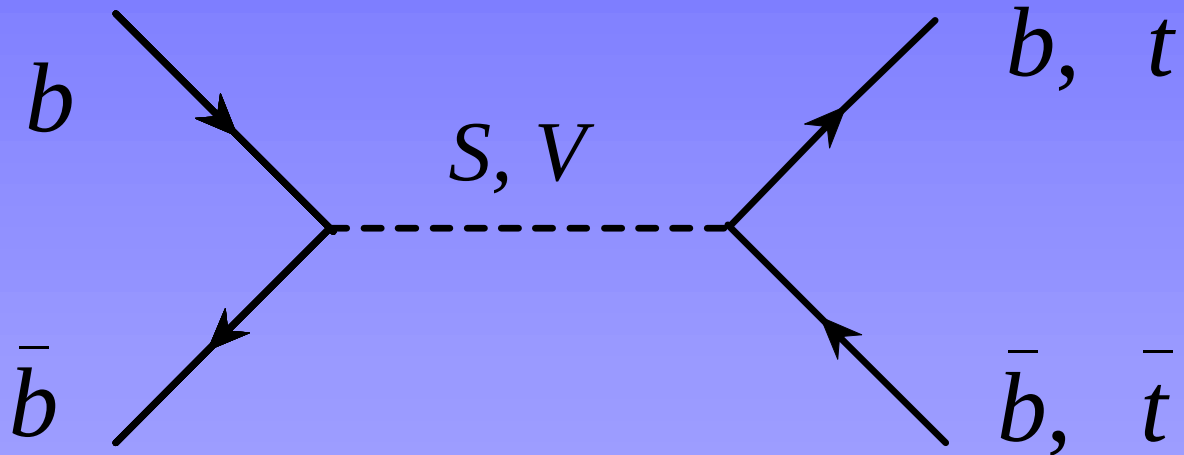
W and *Z* ignored

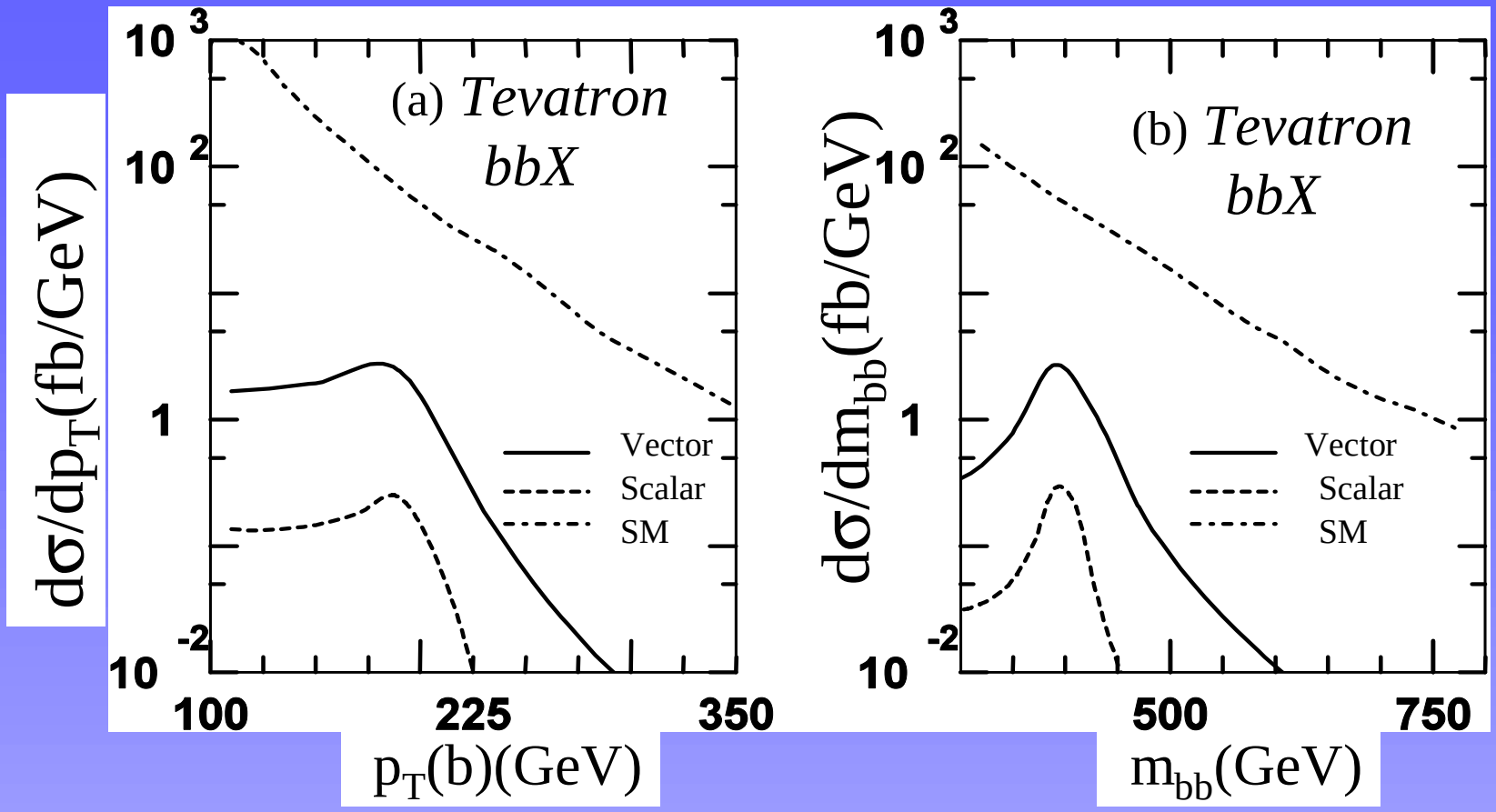
Theoretical constraint: $k_{b,\,t} \leq 3$

$$k_b = 1\,, \qquad k_t = 1$$

New Signatures at Hadron Collider

A. $b\bar{b}X$ *and* $t\bar{t}X$ *processes*

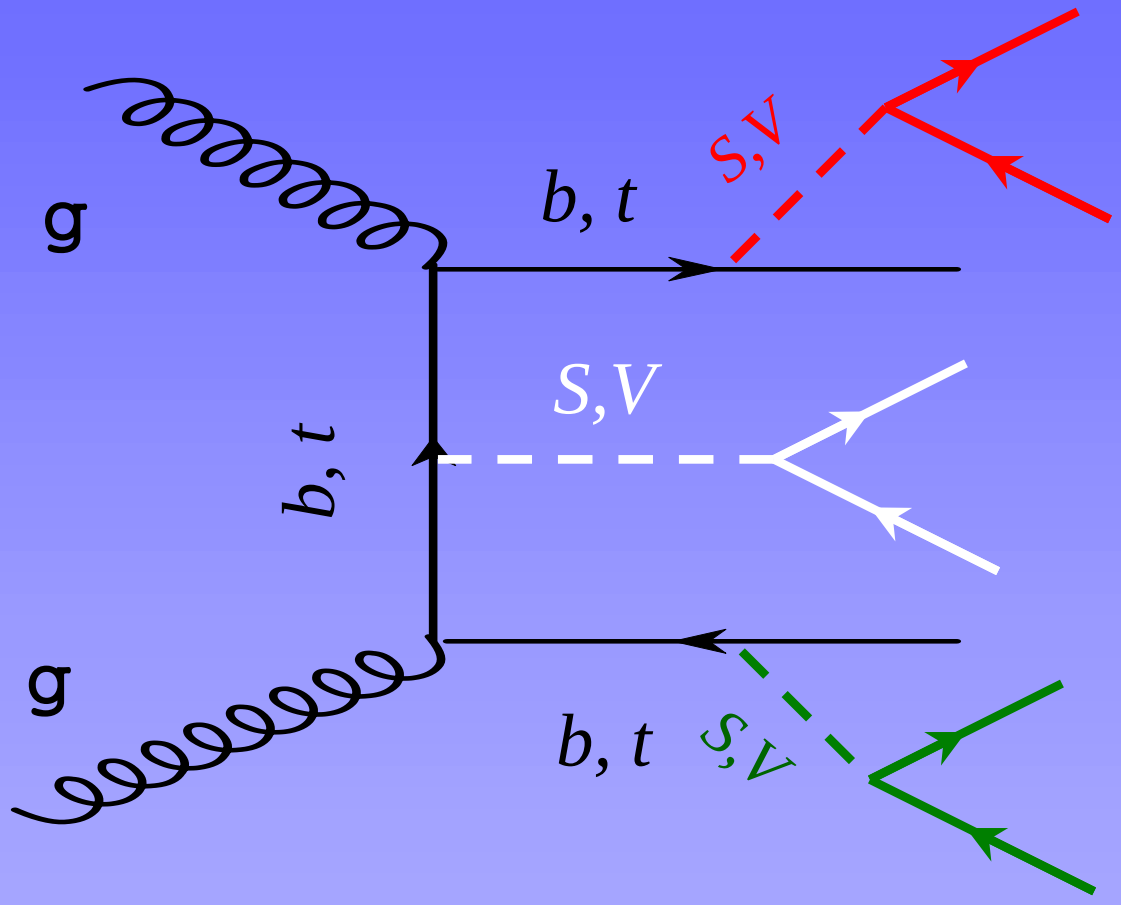




$$|y_{b,t}| < 2 \quad p_T(b,t) > 100\ GeV$$

$$M_{S,V} - 2\,\Gamma_{S,V} < m_{bb,tt} < M_{S,V} + 2\,\Gamma_{S,V}$$

B. $b\bar{b}t\bar{t}X$ and $t\bar{t}t\bar{t}X$ processes



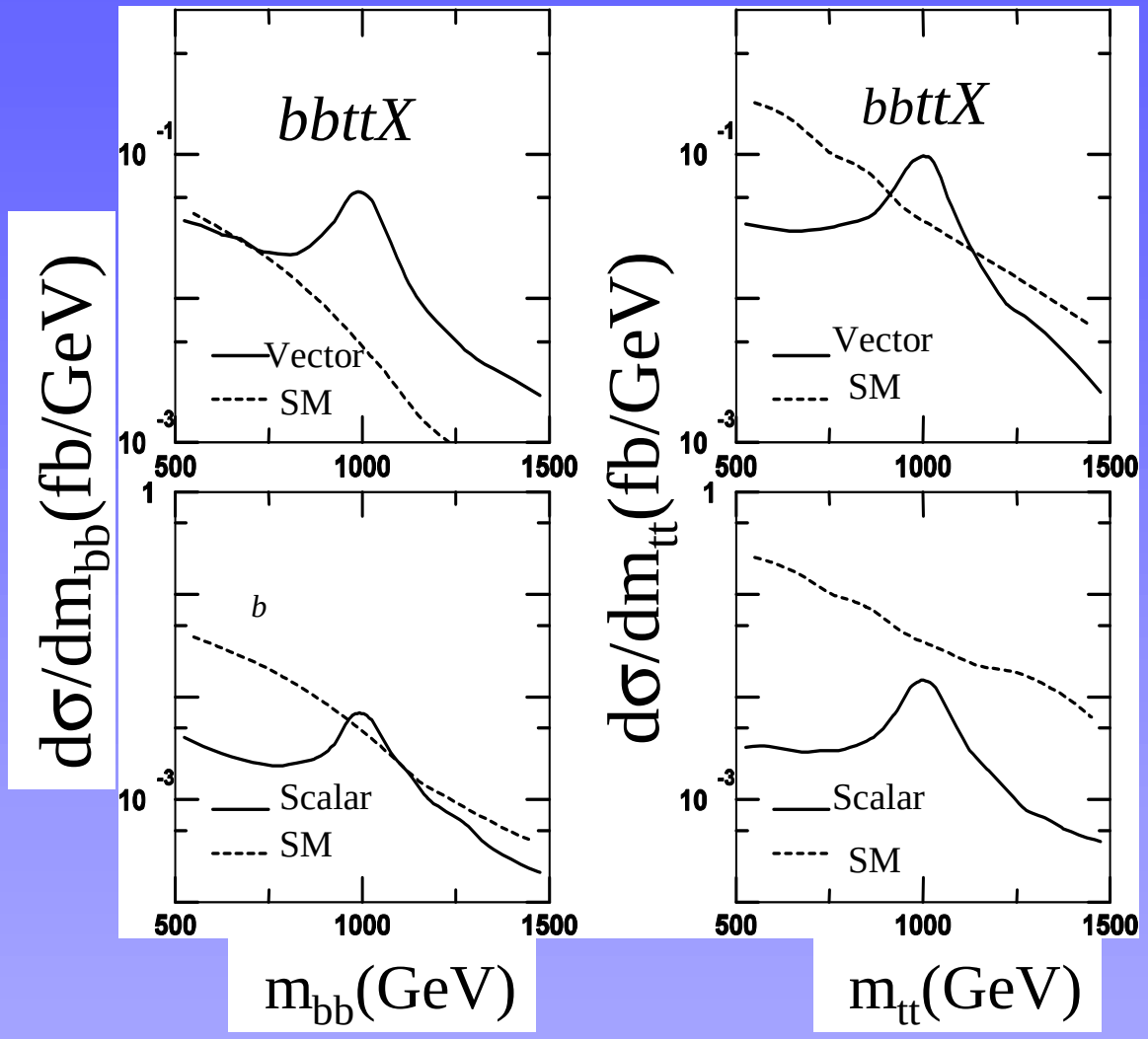
$|y_{b,t}| < 2$

$p_T(b) > 100\ GeV$

$p_T(t) > 50\ GeV$

two b tagged: 70%

two top 16%

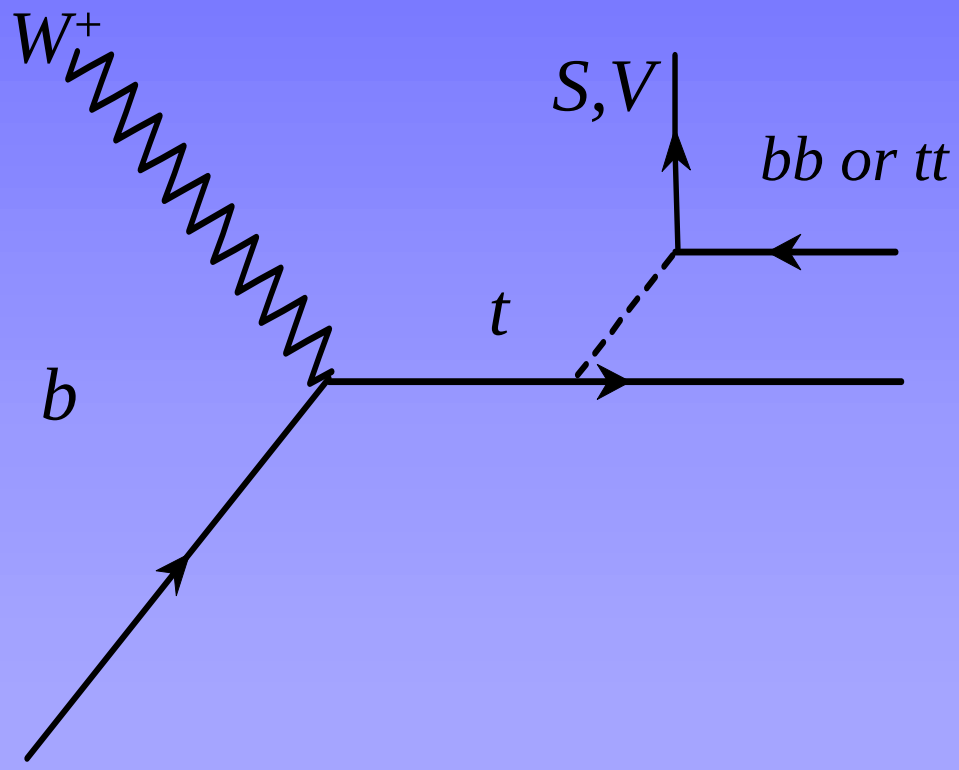


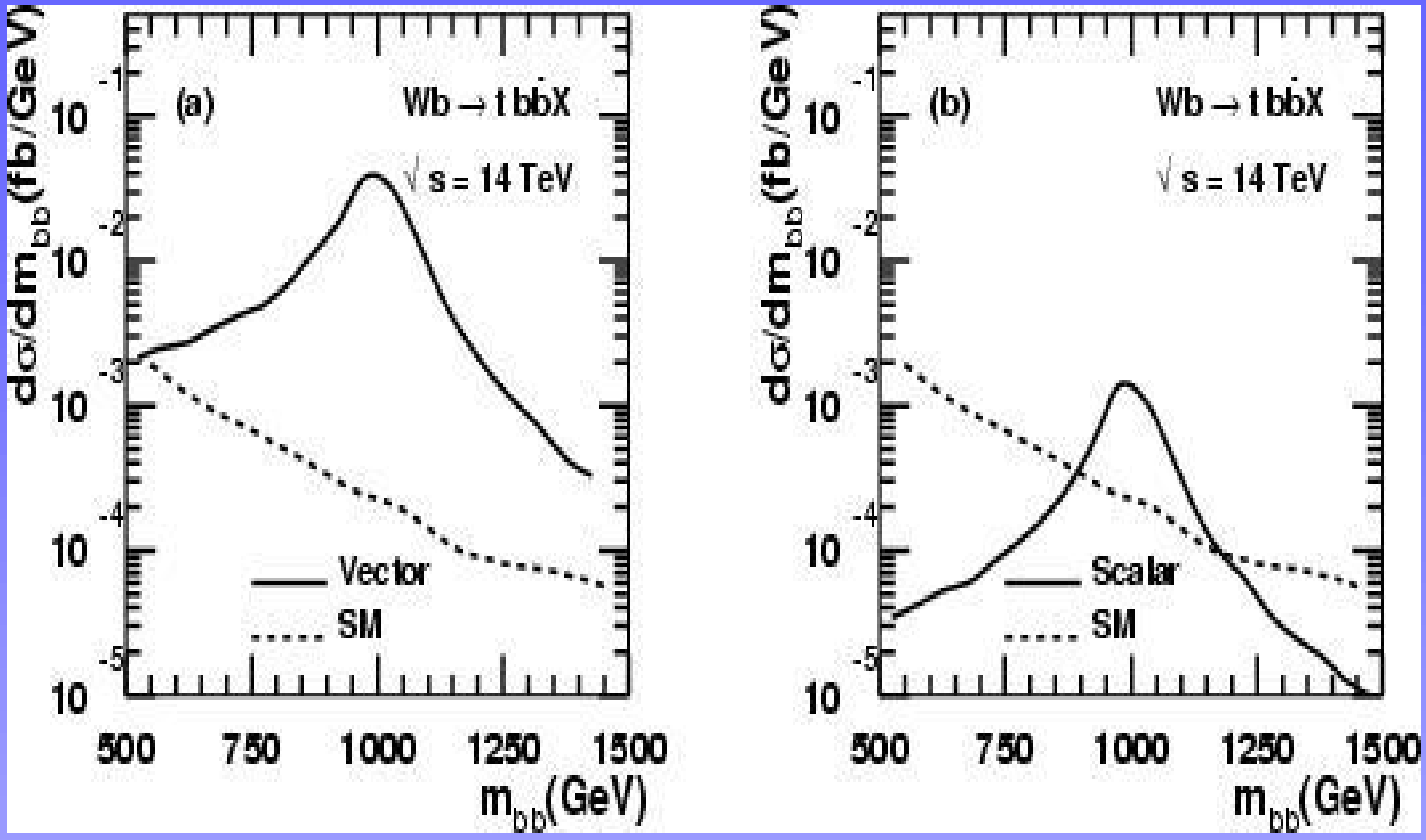
$M_{S,V} - 4\ \Gamma_{S,V} < m_{bbtt} < M_{S,V} + 4\ \Gamma_{S,V}$

LHC

C. Single Top Processes

$$Wb \to tR \quad \to \quad t, b\bar{b} \quad and \quad t, t\bar{t}$$

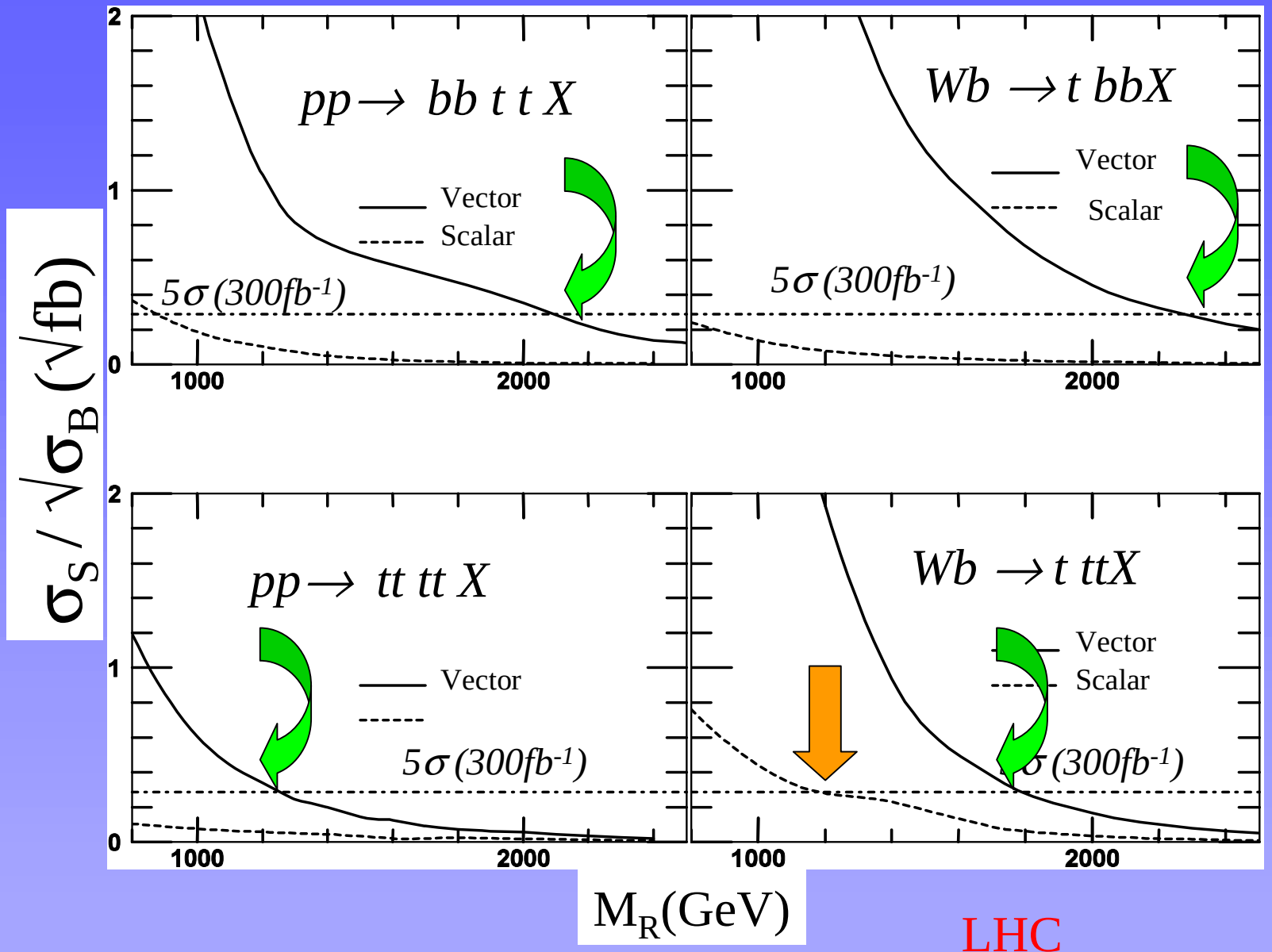




LHC

$$M_{S,V} - 4\,\Gamma_{S,V} < m_{bb,tt} < M_{S,V} + 4\,\Gamma_{S,V}$$

$$|y_{b,t}| < 2, \quad p_T(b) > 100\ GeV, \quad p_T(t) > 50\ GeV$$


$pp \to bb\,t\,t\,X$
$Wb \to t\,bbX$
$pp \to tt\,tt\,X$
$Wb \to t\,ttX$
Vector
Scalar
$5\sigma(300fb^{-1})$
$\sigma_S / \sqrt{\sigma_B}(\sqrt{fb})$
M_R(GeV)
LHC

Summary:

Tevatron: almost no reach

LHC can probe new couplings

LHC: bb t t X or tt tt X;

Wb $\rightarrow$t bb;t tt

$M_V \sim 2$ TeV, $M_S \sim 1.2$ TeV