

# Charming Top Decays with a Flavor Changing Neutral Higgs Boson at Hadron Colliders

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# Theoretical Values for FCNC Top Decays

ATLAS-PHYS-PUB-2013-012

Process	SM	QS	2HDM-III	FC-2HDM	MSSM
$t \rightarrow u\gamma$	$3.7 \cdot 10^{-16}$	$7.5 \cdot 10^{-9}$	—	—	$2 \cdot 10^{-6}$
$t \rightarrow uZ$	$8 \cdot 10^{-17}$	$1.1 \cdot 10^{-4}$	—	—	$2 \cdot 10^{-6}$
$t \rightarrow uH$	$2 \cdot 10^{-17}$	$4.1 \cdot 10^{-5}$	$5.5 \cdot 10^{-6}$	—	$10^{-5}$
$t \rightarrow c\gamma$	$4.6 \cdot 10^{-14}$	$7.5 \cdot 10^{-9}$	$\sim 10^{-6}$	$\sim 10^{-9}$	$2 \cdot 10^{-6}$
$t \rightarrow cZ$	$1 \cdot 10^{-14}$	$1.1 \cdot 10^{-4}$	$\sim 10^{-7}$	$\sim 10^{-10}$	$2 \cdot 10^{-6}$
$t \rightarrow cH$	$3 \cdot 10^{-15}$	$4.1 \cdot 10^{-5}$	$1.5 \cdot 10^{-3}$	$\sim 10^{-5}$	$10^{-5}$

# Introduction and Motivation

Das and Kao (1996)

- A special two Higgs doublet model explains why top quark is the most massive elementary particle by suggesting that it is the only fermion that couples to a Higgs doublet ( $\phi_2$ ) with a much larger VEV ( $v_2 \gg v_1$ ).
- This model leads to flavor changing neutral Higgs (FCNH) interactions and CP violation.
- Most LHC data are consistent with the Standard Model. FCNH interactions might lead to new physics beyond SM.

# A Special Higgs Model for the Top Quark

## 1 Introduction

In the Standard Model (SM) of electroweak interactions:

1. There is one Higgs doublet to generate mass for gauge bosons as well as for fermions. A neutral Higgs scalar ( $H^0$ ) remains after spontaneous symmetry breaking.
2. The top quark has a large mass because its Yukawa coupling with the  $H^0$  is large.<sup>†</sup>

In a special two Higgs doublet model, the top quark is much heavier than the other quarks and the leptons, because it is the only elementary fermion getting a mass from a much larger vacuum expectation value (VEV) of a second Higgs doublet.

This model has a few interesting features:

1. The ratio of the Higgs VEVs,  $\tan \beta \equiv |v_2|/|v_1|$ , is chosen to be large.
2. The Yukawa couplings of the lighter fermions are highly enhanced.
3. There are flavor changing neutral Higgs interactions.

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<sup>†</sup>The mass of a fermion is equal to its Yukawa coupling with the  $H^0$  times the vacuum expectation value of the Higgs field,  $m = \lambda(v/\sqrt{2})$ .

Introducing a transformation, which takes the Higgs doublets to their Higgs eigenstates ( $\Phi_1$  and  $\Phi_2$ ), we have

$$\begin{aligned} \begin{pmatrix} \Phi_1 \\ \Phi_2 \end{pmatrix} &= \begin{pmatrix} \cos \beta & \sin \beta e^{-i\theta} \\ -\sin \beta & \cos \beta e^{-i\theta} \end{pmatrix} \begin{pmatrix} \phi_1 \\ \phi_2 \end{pmatrix}, \\ \Phi_1 &= \begin{pmatrix} G^+ \\ \frac{v+H_1+iG^0}{\sqrt{2}} \end{pmatrix}, \\ \Phi_2 &= \begin{pmatrix} H^+ \\ \frac{H_2+iA}{\sqrt{2}} \end{pmatrix}, \end{aligned} \tag{3}$$

where  $v = \sqrt{|v_1|^2 + |v_2|^2}$ , and

1.  $G^\pm$  and  $G^0$  are Goldstone bosons,
2.  $H^\pm$  are singly charged Higgs bosons,
3.  $H_1$  and  $H_2$  are CP-even scalars, and
4.  $A$  is a CP-odd pseudoscalar.

Without loss of generality, we will take  $v_1, v_2 \in \mathcal{R}$ , and

$$\langle \phi_1 \rangle = \frac{v_1}{\sqrt{2}}, \quad \langle \phi_2 \rangle = \frac{v_2 e^{i\theta}}{\sqrt{2}}.$$

In the Higgs eigenstates, the Higgs potential becomes

$$\begin{aligned}
 V[\Phi_1, \Phi_2] &= \frac{1}{2}\lambda_1(\Phi_1^\dagger\Phi_1 - \frac{v^2}{2})^2 + \frac{1}{2}\lambda_2(\Phi_2^\dagger\Phi_2)^2 \\
 &+ \lambda_3(\Phi_1^\dagger\Phi_1 - \frac{v^2}{2})\Phi_2^\dagger\Phi_2 + \lambda_4(\Phi_1^\dagger\Phi_2)(\Phi_2^\dagger\Phi_1) \\
 &+ \lambda_5(\Phi_1^\dagger\Phi_1 + \Phi_2^\dagger\Phi_2 - \frac{v^2}{2})(\Phi_1^\dagger\Phi_2 + \Phi_2^\dagger\Phi_1) \\
 &+ (\lambda_6\Phi_1^\dagger\Phi_2 + \lambda_6^*\Phi_2^\dagger\Phi_1)(\Phi_1^\dagger\Phi_1 - \Phi_2^\dagger\Phi_2 - \frac{v^2}{2}) \\
 &+ \frac{1}{2}\lambda_7(\Phi_1^\dagger\Phi_2)^2 + \frac{1}{2}\lambda_7^*(\Phi_2^\dagger\Phi_1)^2 \\
 &+ \rho(\Phi_2^\dagger\Phi_2), \tag{4}
 \end{aligned}$$

where the parameters  $\rho$ ,  $v$  and  $\lambda_i$ ,  $i = 1$  through 5, are all real;  $\lambda_6$  and  $\lambda_7$  can be complex.

CP is violated if the imaginary part of  $\lambda_6$  or  $\lambda_7$  is nonvanishing.

There are two sources of CP violation in the Higgs potential:

1. the mixing of the  $A$  with the  $H_1$  and the  $H_2$ , and
2. the CP violating interaction of  $AH^+H^-$ .

### 3 Special Yukawa Interactions

We choose the Lagrangian density of Yukawa interactions to be of the following form

$$\begin{aligned} \mathcal{L}_Y = & - \sum_{m,n=1}^3 \bar{L}_L^m \phi_1 E_{mn} l_R^n - \sum_{m,n=1}^3 \bar{Q}_L^m \phi_1 F_{mn} d_R^n \\ & - \sum_{\alpha=1}^2 \sum_{m=1}^3 \bar{Q}_L^m \tilde{\phi}_1 G_{m\alpha} u_R^\alpha - \sum_{m=1}^3 \bar{Q}_L^m \tilde{\phi}_2 G_{m3} u_R^3 + \text{H.c.}, \end{aligned}$$

where

$$\phi_\alpha = \begin{pmatrix} \phi_\alpha^+ \\ \frac{v_\alpha + \phi_\alpha^0}{\sqrt{2}} \end{pmatrix}, \quad \tilde{\phi}_\alpha = \begin{pmatrix} \frac{v_\alpha^* + \phi_\alpha^{0*}}{\sqrt{2}} \\ -\phi_\alpha^- \end{pmatrix}, \quad \phi_\alpha^- = \phi_\alpha^{+*}, \quad \alpha = 1, 2, \quad \text{and (5)}$$

$$L_L^m = \begin{pmatrix} \nu_l \\ l \end{pmatrix}_L^m, \quad Q_L^m = \begin{pmatrix} u \\ d \end{pmatrix}_L^m, \quad m = 1, 2, 3, \quad (6)$$

$l^m$ ,  $d^m$ , and  $u^m$  are the gauge eigenstates.

This Lagrangian respects a discrete symmetry,

$$\begin{aligned} \phi_1 & \rightarrow -\phi_1, \quad \phi_2 \rightarrow +\phi_2, \\ l_R^m & \rightarrow -l_R^m, \quad d_R^m \rightarrow -d_R^m, \quad u_R^\alpha \rightarrow -u_R^\alpha, \\ L_L^m & \rightarrow +L_L^m, \quad Q_L^m \rightarrow +Q_L^m, \quad u_R^3 \rightarrow +u_R^3. \end{aligned} \quad (7)$$

## 4 Flavor Changing Neutral Higgs Interactions

The Yukawa interactions of the quarks with neutral Higgs bosons now become

$$\begin{aligned}
 \mathcal{L}_Y^N &= - \sum_{d=d,s,b} \frac{m_d}{v} \bar{d}d(H_1 - \tan \beta H_2) \\
 &\quad - i \sum_{d=d,s,b} \frac{m_d}{v} \bar{d}\gamma_5 d(G^0 - \tan \beta A) \\
 &\quad - \sum_{u=u,c} \frac{m_u}{v} \bar{u}u[H_1 - \tan \beta H_2] \\
 &\quad + i \sum_{u=u,c} \frac{m_u}{v} \bar{u}\gamma_5 u[G^0 - \tan \beta A] \\
 &\quad - \frac{m_t}{v} \bar{t}t[H_1 + \cot \beta H_2] + i \frac{m_t}{v} \bar{t}\gamma_5 t[G^0 + \cot \beta A] + \mathcal{L}_{\text{FCNH}}, \\
 \mathcal{L}_{\text{FCNH}} &= \left\{ -\epsilon_1^* \epsilon_2 \bar{u}c[(m_u + m_c)H_2 + i(m_c - m_u)A] \right. \\
 &\quad - \epsilon_1^* \bar{u}t[(m_u + m_t)H_2 + i(m_t - m_u)A] \\
 &\quad - \epsilon_2^* \bar{c}t[(m_c + m_t)H_2 + i(m_t - m_c)A] \\
 &\quad + \epsilon_1^* \epsilon_2 \bar{u}\gamma_5 c[(m_c - m_u)H_2 + i(m_u + m_c)A] \\
 &\quad + \epsilon_1^* \bar{u}\gamma_5 t[(m_t - m_u)H_2 + i(m_u + m_t)A] \\
 &\quad \left. + \epsilon_2^* \bar{c}\gamma_5 t[(m_t - m_c)H_2 + i(m_c + m_t)A] \right\} \times \left( \frac{1}{v \sin 2\beta} \right) + \text{H.c.}
 \end{aligned}$$

# The Higgs Basis

In the Higgs basis, the Higgs potential becomes

$$\begin{aligned} V[\Phi_1, \Phi_2] = & \frac{1}{2}\lambda_1(\Phi_1^\dagger\Phi_1 - \frac{v^2}{2})^2 + \frac{1}{2}\lambda_2(\Phi_2^\dagger\Phi_2)^2 \\ & + \lambda_3(\Phi_1^\dagger\Phi_1 - \frac{v^2}{2})\Phi_2^\dagger\Phi_2 + \lambda_4(\Phi_1^\dagger\Phi_2)(\Phi_2^\dagger\Phi_1) \\ & + \lambda_5(\Phi_1^\dagger\Phi_1 + \Phi_2^\dagger\Phi_2 - \frac{v^2}{2})(\Phi_1^\dagger\Phi_2 + \Phi_2^\dagger\Phi_1) \\ & + (\lambda_6\Phi_1^\dagger\Phi_2 + \lambda_6^*\Phi_2^\dagger\Phi_1)(\Phi_1^\dagger\Phi_1 - \Phi_2^\dagger\Phi_2 - \frac{v^2}{2}) \\ & + \frac{1}{2}\lambda_7(\Phi_1^\dagger\Phi_2)^2 + \frac{1}{2}\lambda_7^*(\Phi_2^\dagger\Phi_1)^2 \\ & + \rho(\Phi_2^\dagger\Phi_2). \end{aligned}$$

Where the parameters  $\rho$ ,  $v$  and  $\lambda_i$ ,  $i = 1$  through  $5$ , are all real;  $\lambda_6$  and  $\lambda_7$  can be complex. CP is violated if the imaginary part of  $\lambda_6$  or  $\lambda_7$  is nonvanishing.

In this parameterization,  $\tan \beta$  can be written as

$$\tan \beta = \frac{\lambda_1 - \lambda_2}{\lambda_5} + \sqrt{1 + \frac{(\lambda_1 - \lambda_2)^2}{\lambda_5^2}}.$$

# Special Models for the Top Quark

- A Two Higgs doublet model for the top quark,  
Das and Kao (1996)
- Neutrino masses, mixing and leptogenesis in a two Higgs doublet model 'for the third generation',  
Atwood, Bar-Shalom, and Soni (2005)
- Flavor-Changing Neutral-Current Decays in Top-Specific Variant Axion Model,  
Chiang, Fukuda, Takeuchi, and Yanagida, (2015)

# A General Two Higgs Doublet Model

Mahmoudi and Stal (2009)

- ▶ Let us express the general Yukawa interaction Lagrangian for neutral Higgs bosons as

$$\begin{aligned} \sqrt{2} \mathcal{L}_I^N = & \bar{U} [-\kappa^U s_{\beta-\alpha} - \rho^U c_{\beta-\alpha}] U h^0 + \bar{D} [-\kappa^D s_{\beta-\alpha} - \rho^D c_{\beta-\alpha}] D h^0 \\ & + \bar{U} [-\kappa^U c_{\beta-\alpha} + \rho^U s_{\beta-\alpha}] U H^0 + \bar{D} [-\kappa^D c_{\beta-\alpha} + \rho^D s_{\beta-\alpha}] D H^0 \\ & + \bar{U} [+i\gamma_5 \rho^U] U A^0 + \bar{D} [-i\gamma_5 \rho^D] D A^0 \end{aligned}$$

where  $\kappa^f = \frac{\sqrt{2} m_f}{v}$ ,  $\tan \beta \equiv v_2/v_1$ , and  $v = \sqrt{v_1^2 + v_2^2}$ .

- ▶ There are 4 flavor conserving models with  $Z_2$  symmetries, such that  $\rho$ 's are related to  $\kappa$ 's in the following form [Barger, Hewett and Phillips, PRD 41 (1990) 3421.]:

	Type			
	I	II	III	IV
$\rho^D$	$\kappa^D \cot \beta$	$-\kappa^D \tan \beta$	$-\kappa^D \tan \beta$	$\kappa^D \cot \beta$
$\rho^U$	$\kappa^U \cot \beta$	$\kappa^U \cot \beta$	$\kappa^U \cot \beta$	$\kappa^U \cot \beta$
$\rho^E$	$\kappa^E \cot \beta$	$-\kappa^E \tan \beta$	$\kappa^E \cot \beta$	$-\kappa^E \tan \beta$

- ▶ In a general model without  $Z_2$  symmetries,  $\rho$  matrices are free.

# The Decoupling Limit of 2HDM

Gunion and Haber (2003)

- In the decoupling limit of 2HDM, we expect
  - ▶  $M_h = O(v)$
  - ▶  $M_H, M_A, M_{H^\pm} = M_S + O(v^2/M_S)$
  - ▶  $|\cos(\beta-\alpha)| = O(v^2/M_S^2)$
  - ▶ If  $\cos(\beta-\alpha) = 0$ ,  $h^0$  becomes the SM Higgs boson.
- Recently, there has been interests in the 2HDM parameter space where the alignment is obtained without decoupling and without fine tuning where  $H^0$  and  $A^0$  can be light and  $h^0$  is like SM Higgs.  
Craig, Galloway, Thomas (2013); Carena et al. (2014)

# When the Higgs Meets the Top

- The Higgs boson is the mass giver, while the top quark is the most massive particle. Their interactions might give us guidance to search for new physics beyond the Standard Model.
- The LHC has become a top factory.
- We might be able to observe  $t \rightarrow ch^0$  if  $\lambda_{ct} = \rho_{ct} \cos(\beta-\alpha)$  can lead to observable signal.
- Or we might discover  $H^0, A^0 \rightarrow t\bar{c} + \bar{t}c$  in the decoupling limit with  $\lambda_{tc} = \rho_{tc} \sin(\beta-\alpha)$ .

# Top Decay Width

Hou (1991)

- The FCNH top decay width is

$$\Gamma(t \rightarrow c\phi^0) = \frac{|\lambda_{tc}|^2}{16\pi} \times (m_t) \times [(1 \pm \rho_c)^2 - \rho_\phi^2] \\ \times \sqrt{1 - (\rho_\phi + \rho_c)^2} \sqrt{1 - (\rho_\phi - \rho_c)^2}$$

$\rho_c = m_c/m_t$ ,  $\rho_H = M_H/m_t$ , + for  $H^0$  and - for  $A^0$ .

- The total width is

$$\Gamma_t = \Gamma(t \rightarrow bW) + \Gamma(t \rightarrow c\phi^0)$$

# Constraints on FCNH Couplings

- ATLAS data (2018) have placed tight constraints on  $\lambda_{tc}$  and  $\lambda_{ct}$  with  $t \rightarrow ch^0 \rightarrow c\gamma\gamma$ 
  - ▶ the top decay should have  $B(t \rightarrow ch^0) < 0.16\%$ ,
  - ▶ or  $\lambda_{tch} < 0.077$ , with  $\lambda_{tch} = \rho_{tc} \cos(\beta-\alpha)$ ,
  - ▶ That leads to  $\lambda_{tch} \simeq 1.92 \times \sqrt{B(t \rightarrow ch^0)}$
- If we choose  $\rho$ -matrix to be Hermitian, then  $b \rightarrow s\gamma$  and  $B - \bar{B}$  mixing imply  $|\rho_{ct}| < 0.1$ .
- Thus we choose  $|\rho_{ct}| < 0.1$ , while  $|\rho_{tc}| < 1$ .

# Future ATLAS Expectations

- At the LHC with collider energy of 8 TeV and an integrated luminosity  $L \sim 25 \text{ fb}^{-1}$ , ATLAS set a limit for the branching fraction

$$B(t \rightarrow ch^0) < 0.83\% \text{ or } \rho_{tc} \cos(\beta - \alpha) < 0.174$$

- At the LHC with collider energy of 14 TeV and an integrated luminosity  $L = 3000 \text{ fb}^{-1}$ , ATLAS expects to set a limit for the branching fraction

$$B(t \rightarrow ch^0) < 1.5 \times 10^{-4} \text{ or } \rho_{tc} \cos(\beta - \alpha) < 0.0234$$

$$pp \rightarrow tch^0 \rightarrow tcbb + X$$

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## Top decays with flavor changing neutral Higgs interactions at the LHC

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ARTICLE INFO

ABSTRACT

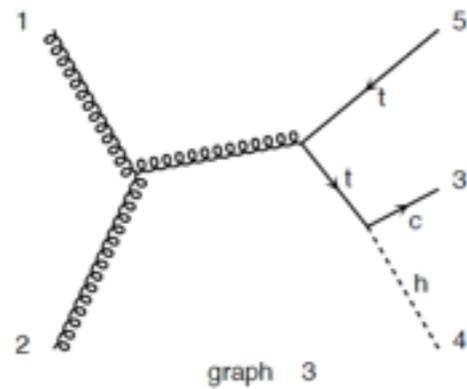
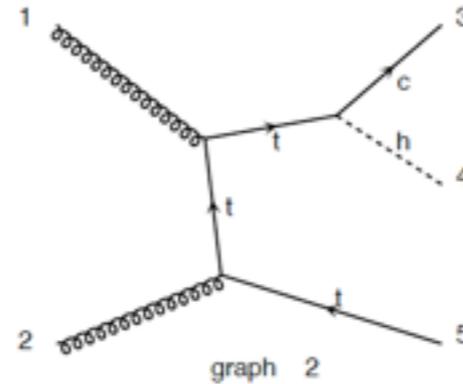
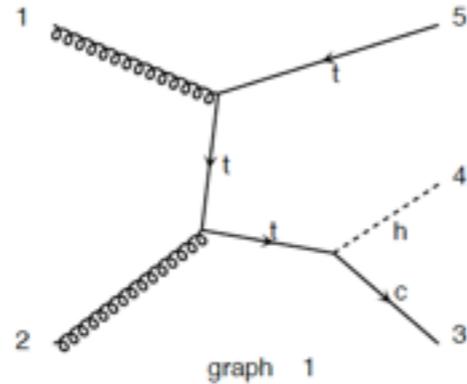
# FCNH Top Decays at the LHC

Hou (1991); Hall and Weinberg (1993);

Aguilar-Saavedra and Branco (2000);

Kao, Cheng, Hou, and Sayre (2012);

Chen, Hou, Kao, and Kohda (2013).



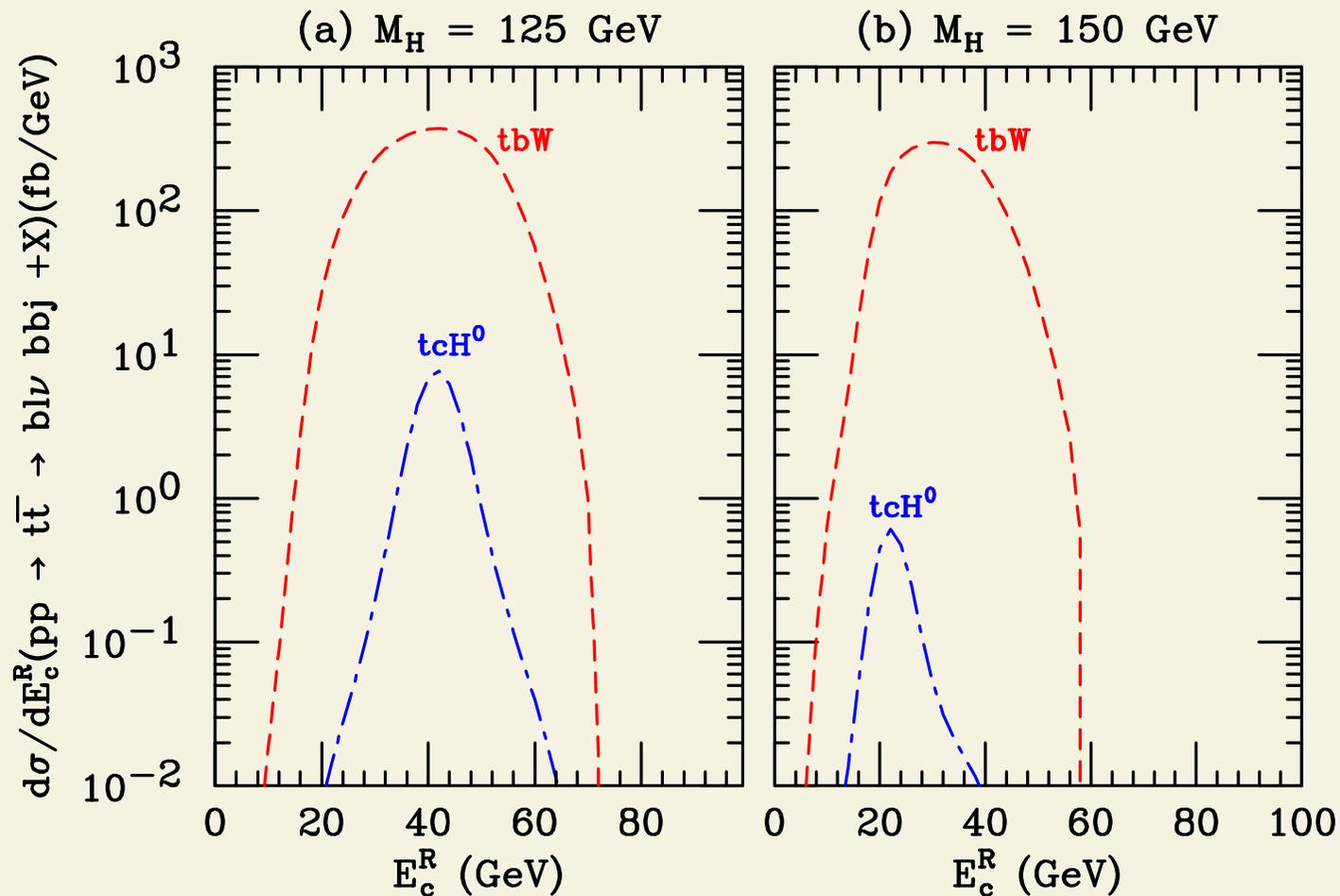
$$g_{htc}(\text{CS}) = \frac{\sqrt{m_t m_c}}{v} \sim 0.06$$

$$\lambda_{htc}(\text{HW}) = \epsilon_{Q3} \epsilon_{U2} \sim 0.2$$

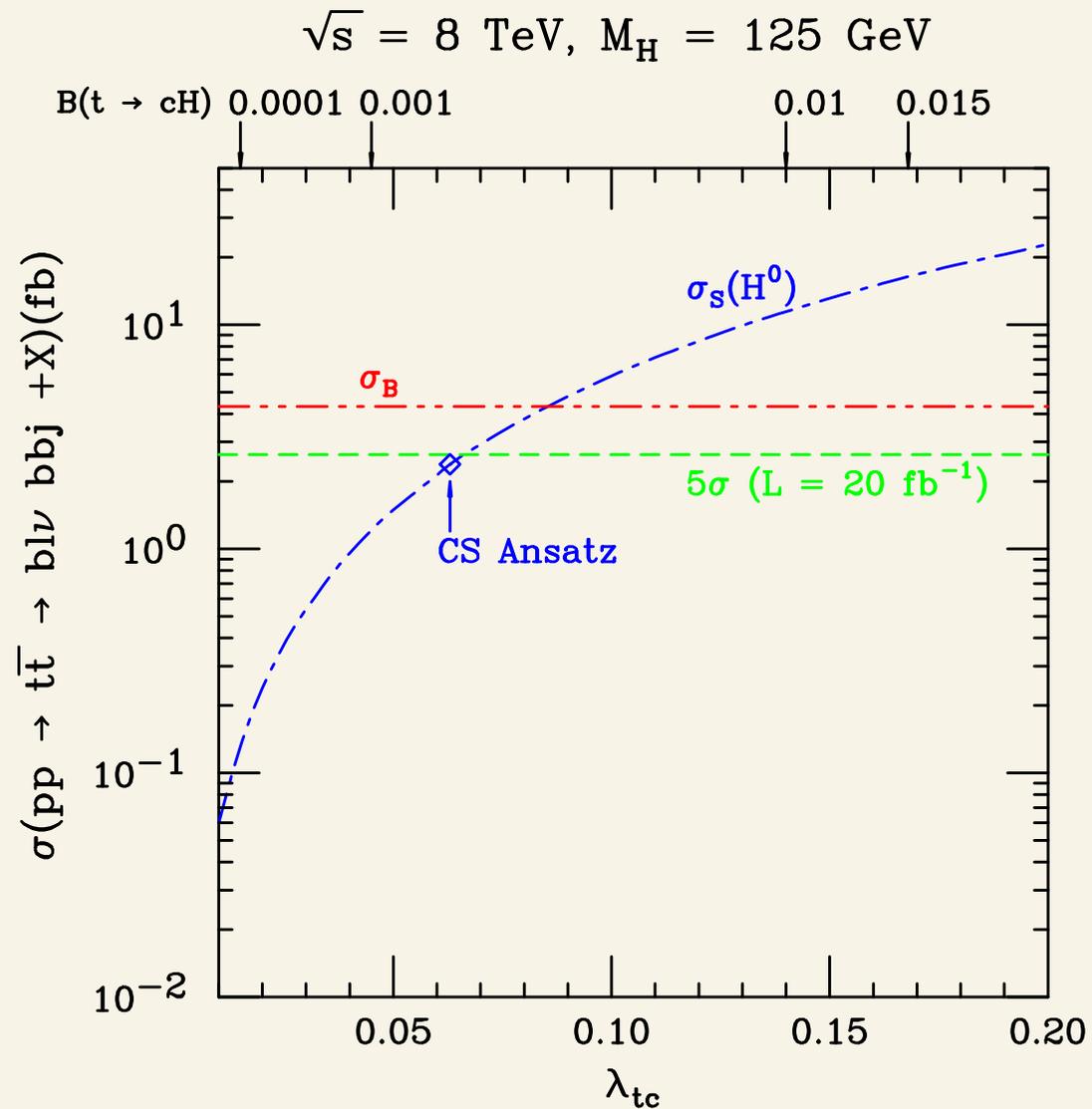
# Reconstructed $E_{\text{charm}}$

Han, Jiang, and Sher (2001)

$\sqrt{s} = 14 \text{ TeV}$

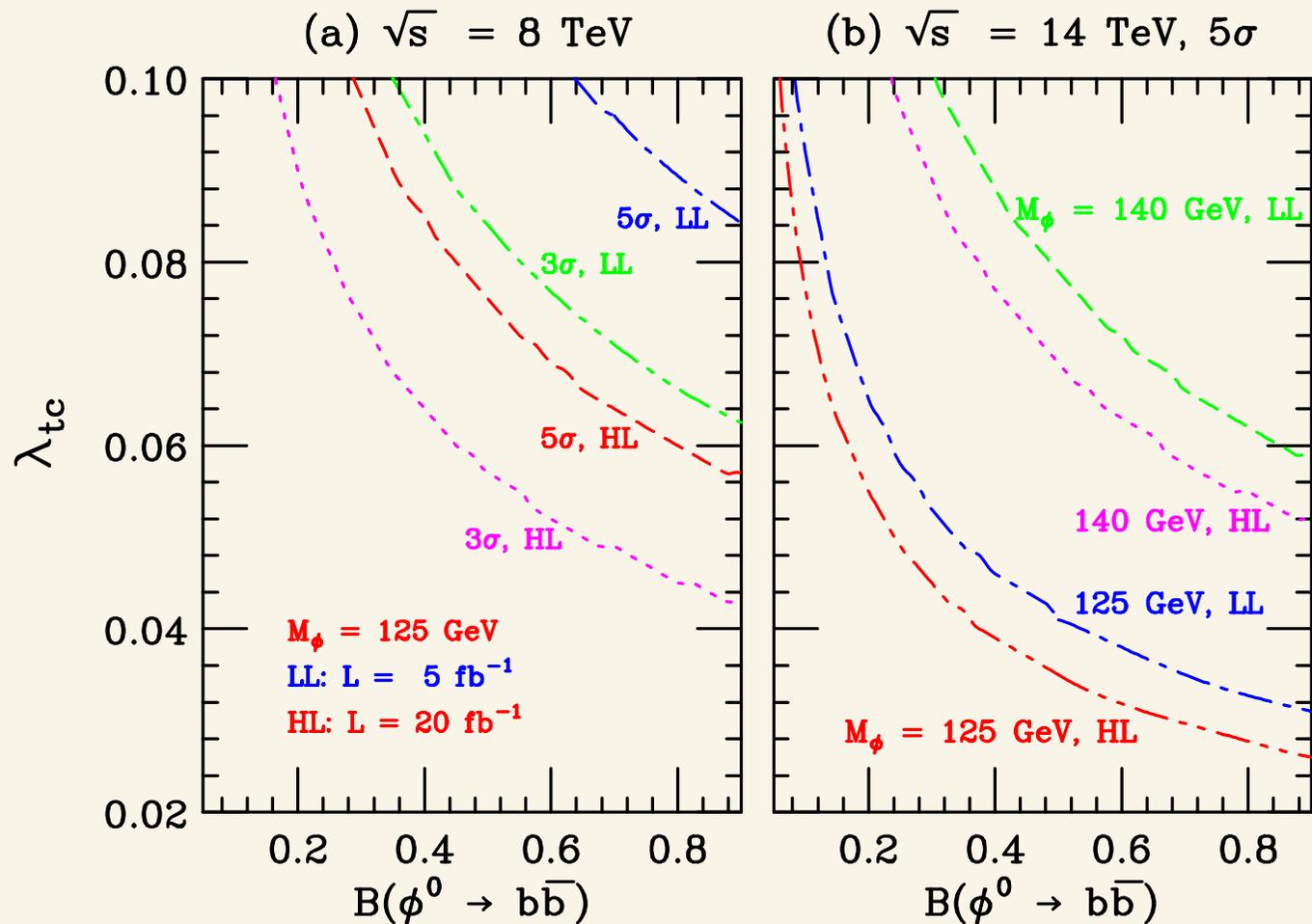


# Discovery Potential with 8 TeV



# Discovery Contours

$L = 20 \text{ fb}^{-1}$  at 8 TeV;  $30 \text{ fb}^{-1}$  at 14 TeV



$$pp \rightarrow tch^0 \rightarrow tcZZ^* + X$$

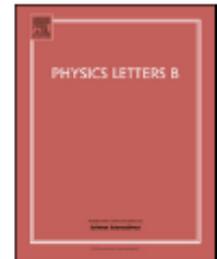
Physics Letters B 725 (2013) 378–381



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When the Higgs meets the top: Search for  $t \rightarrow ch^0$  at the LHC



Kai-Feng Chen<sup>a</sup>, Wei-Shu Hou<sup>a,\*</sup>, Chung Kao<sup>a,b</sup>, Masaya Kohda<sup>a</sup>

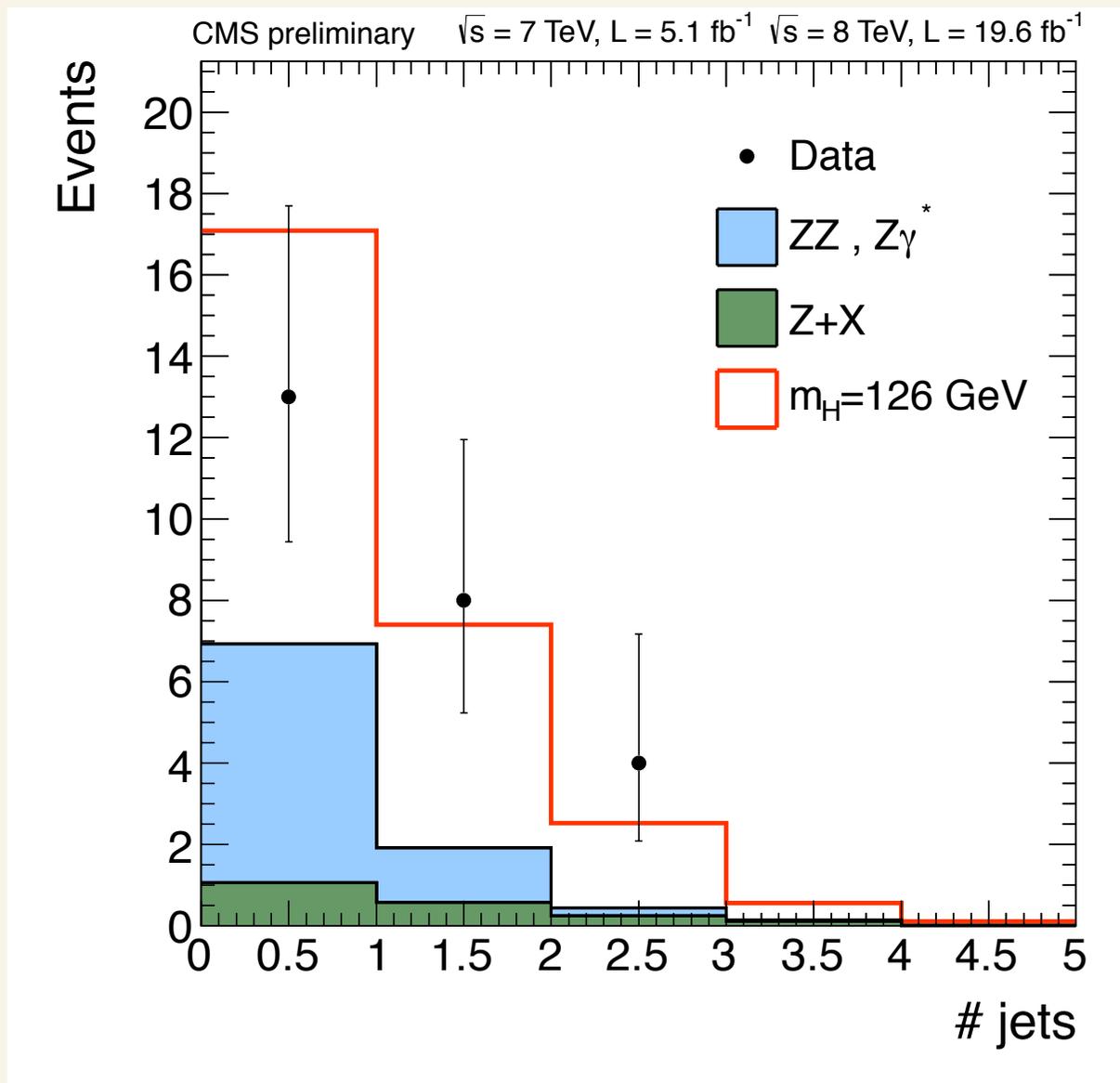
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ARTICLE INFO

ABSTRACT

# The Golden Mode for Higgs Discovery



# Constraint from the Golden Mode for Higgs Discovery

- The CMS preliminary result with full 7 and 8 TeV data shows 13, 8, and 4 events with 0, 1, and 2 jets, respectively, after selecting events with  $121.5 \text{ GeV} < M_{4l} < 130.5 \text{ GeV}$ .
- The resulting 95% confidence level limit on the relative signal strength between  $t$  to  $ch^0$  and inclusive Higgs production is around 31%,
- That can be converted to a limit of 6.5 pb on the effective cross section of  $t$  to  $ch^0$  at 8 TeV, or a branching ratio limit around 1.5%.

$$pp \rightarrow tch^0 \rightarrow tcWW^* + X$$

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## Charming top decays with a flavor changing neutral Higgs boson and $WW$ at hadron colliders

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We investigate the prospects for discovering a top quark decaying into one light Higgs boson ( $h^0$ ) along with a charm quark ( $c$ ) in top-quark pair production at the CERN LHC and future hadron colliders. A general two Higgs doublet model is adopted to study the signature of flavor changing neutral Higgs interactions with  $t \rightarrow ch^0$ , followed by  $h^0 \rightarrow WW^* \rightarrow \ell^+\ell^- + \cancel{E}_T$ , where  $h^0$  is the  $CP$ -even Higgs boson and  $\cancel{E}_T$  stands for missing transverse energy from neutrinos. We study the discovery potential for this flavor changing neutral Higgs signal and physics background from dominant processes with realistic acceptance cuts as well as tagging and mistagging efficiencies. Promising results are found for the LHC running at 13 and 14 TeV center-of-mass energy as well as future pp colliders at 27 and 100 TeV.

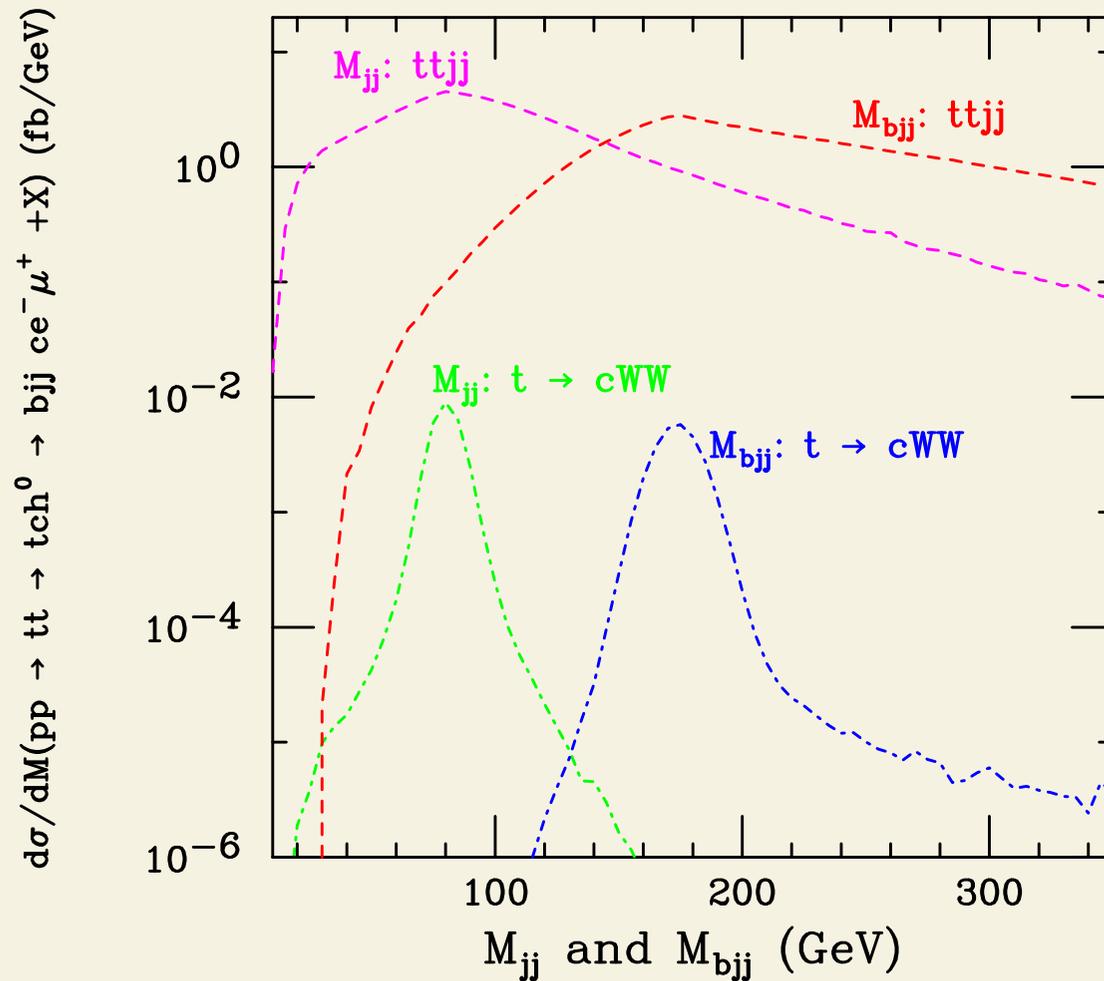
DOI: [10.1103/PhysRevD.99.055036](https://doi.org/10.1103/PhysRevD.99.055036)

# Discovery Potential of t to ch with h to WW Jain and Kao (2018)

- h to WW has the second largest BF.
- We study WW to ll +MET.
- The cluster traverse mass of ll offers good approximation to reconstruction the Higgs mass (ll) and the top quark mass (c ll).

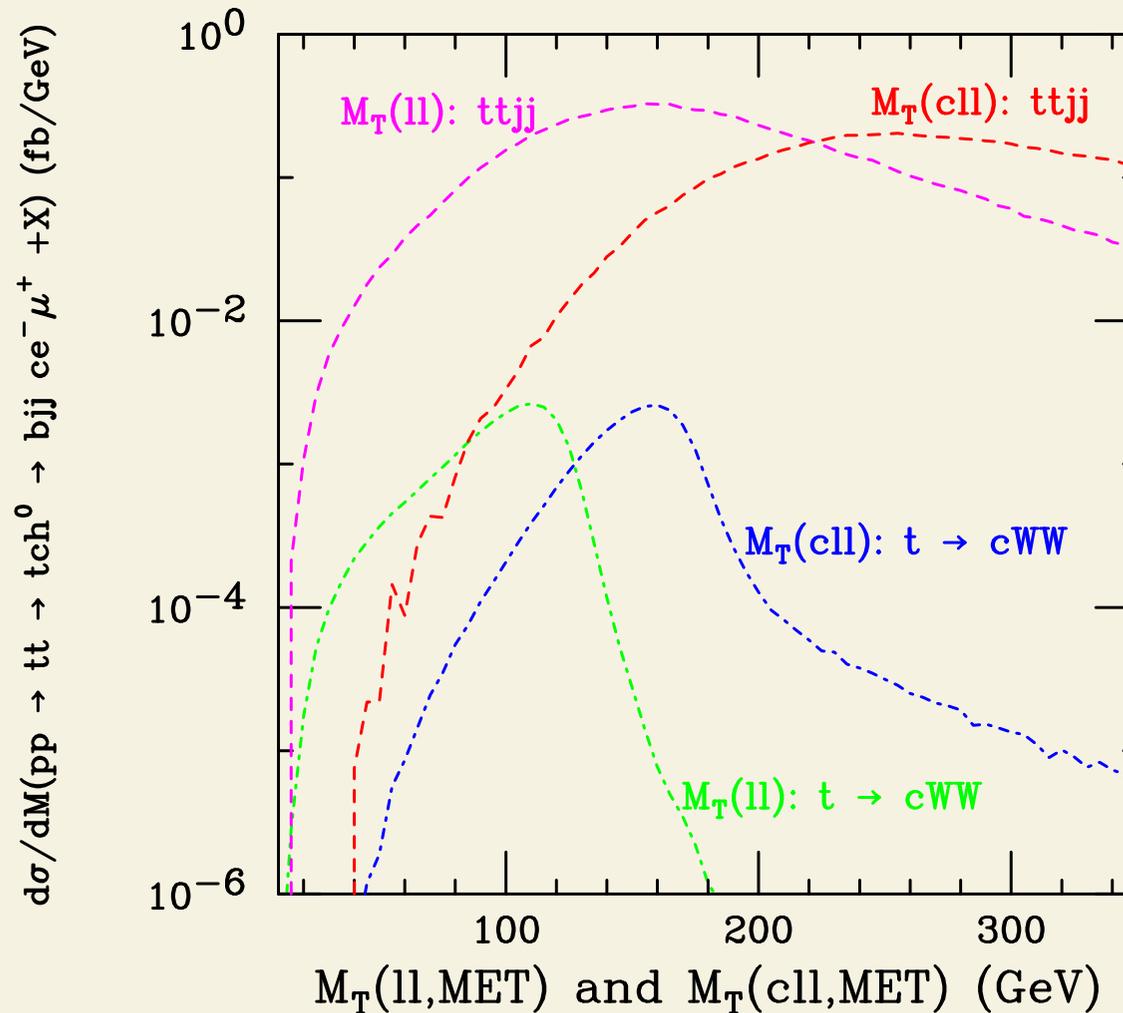
# Invariant Mass Distributions

$$\sqrt{s} = 14 \text{ TeV}$$

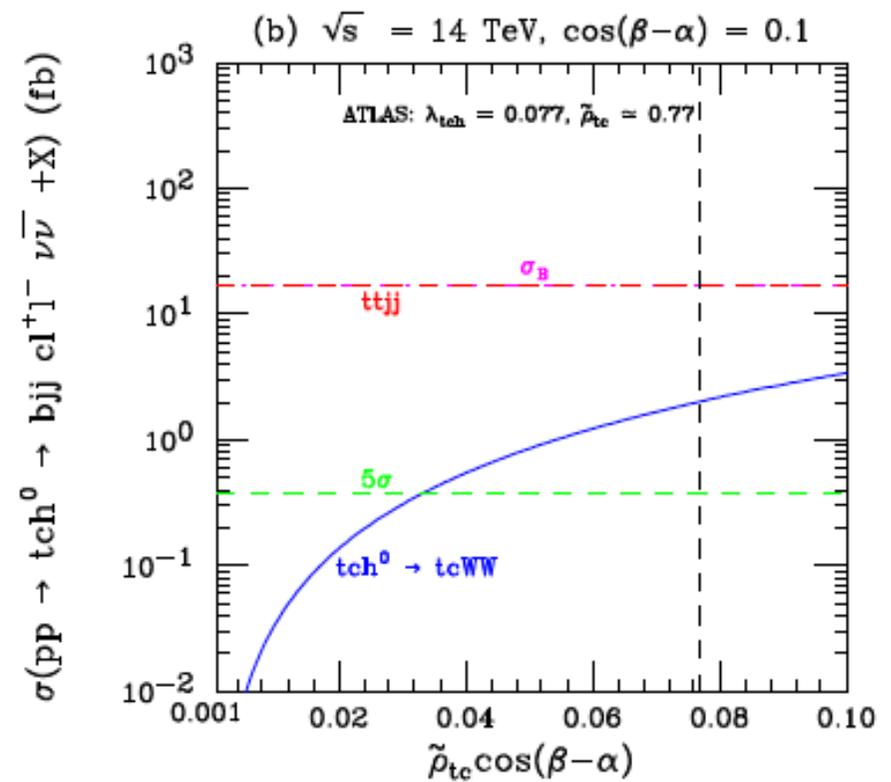
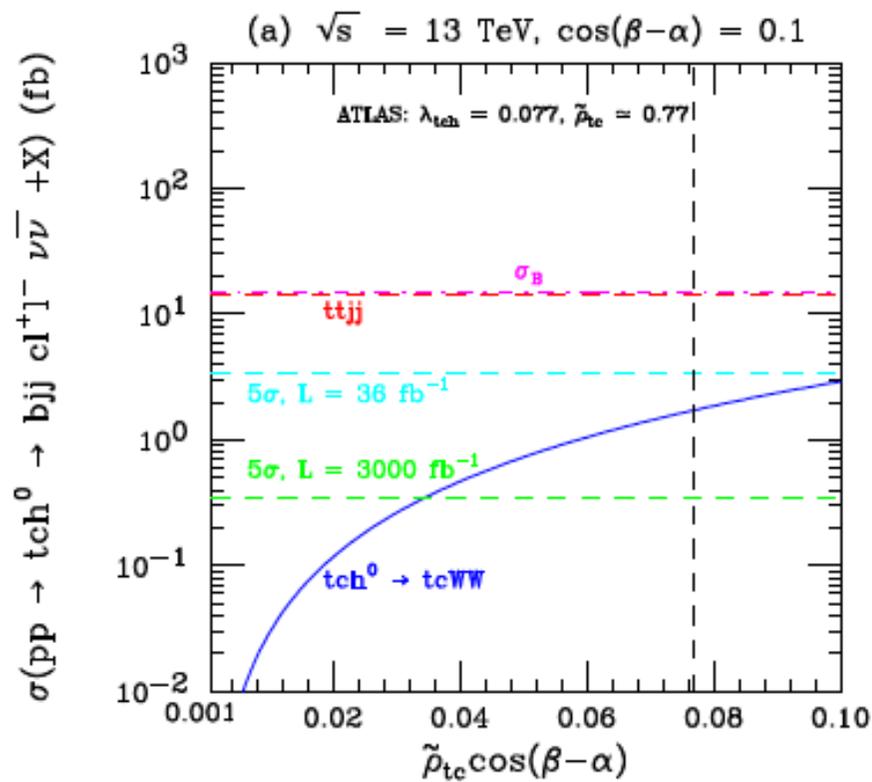


# Transverse Mass Distributions

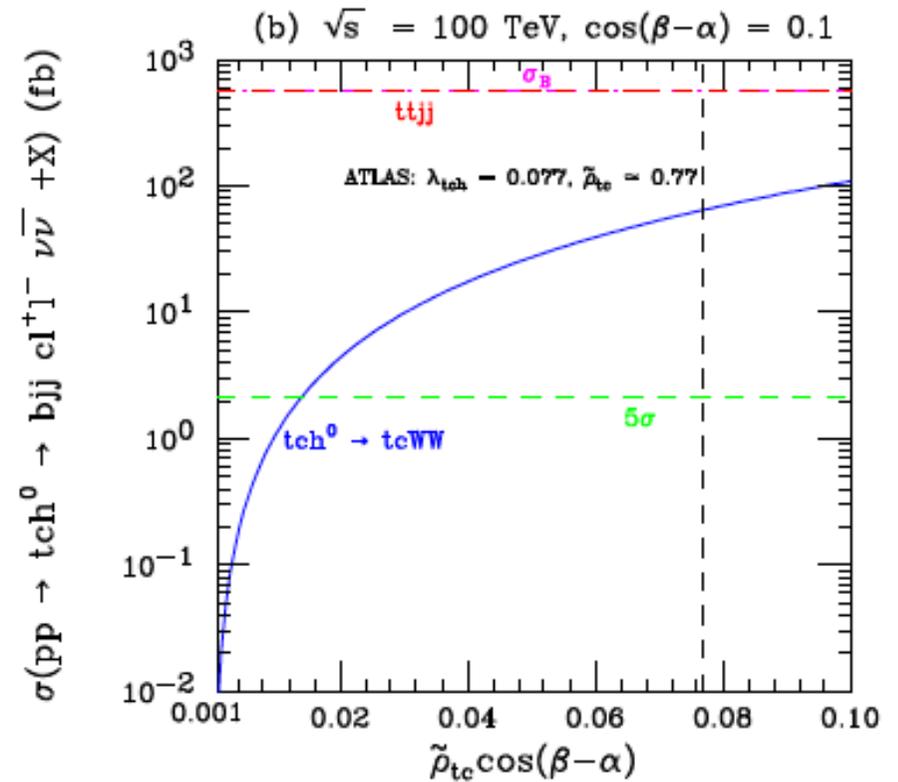
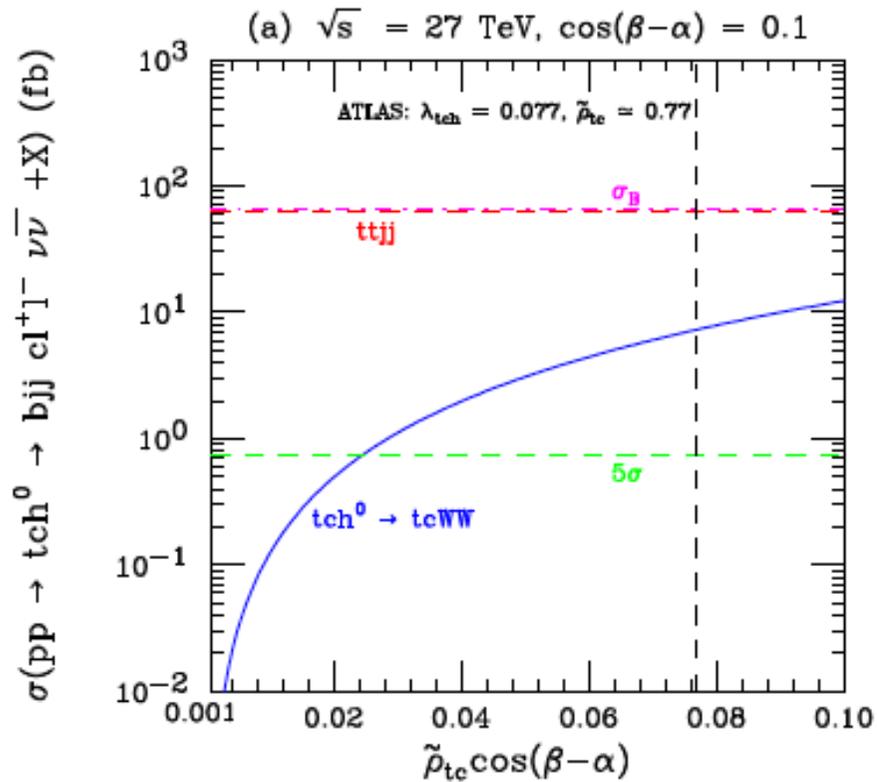
$$\sqrt{s} = 14 \text{ TeV}$$



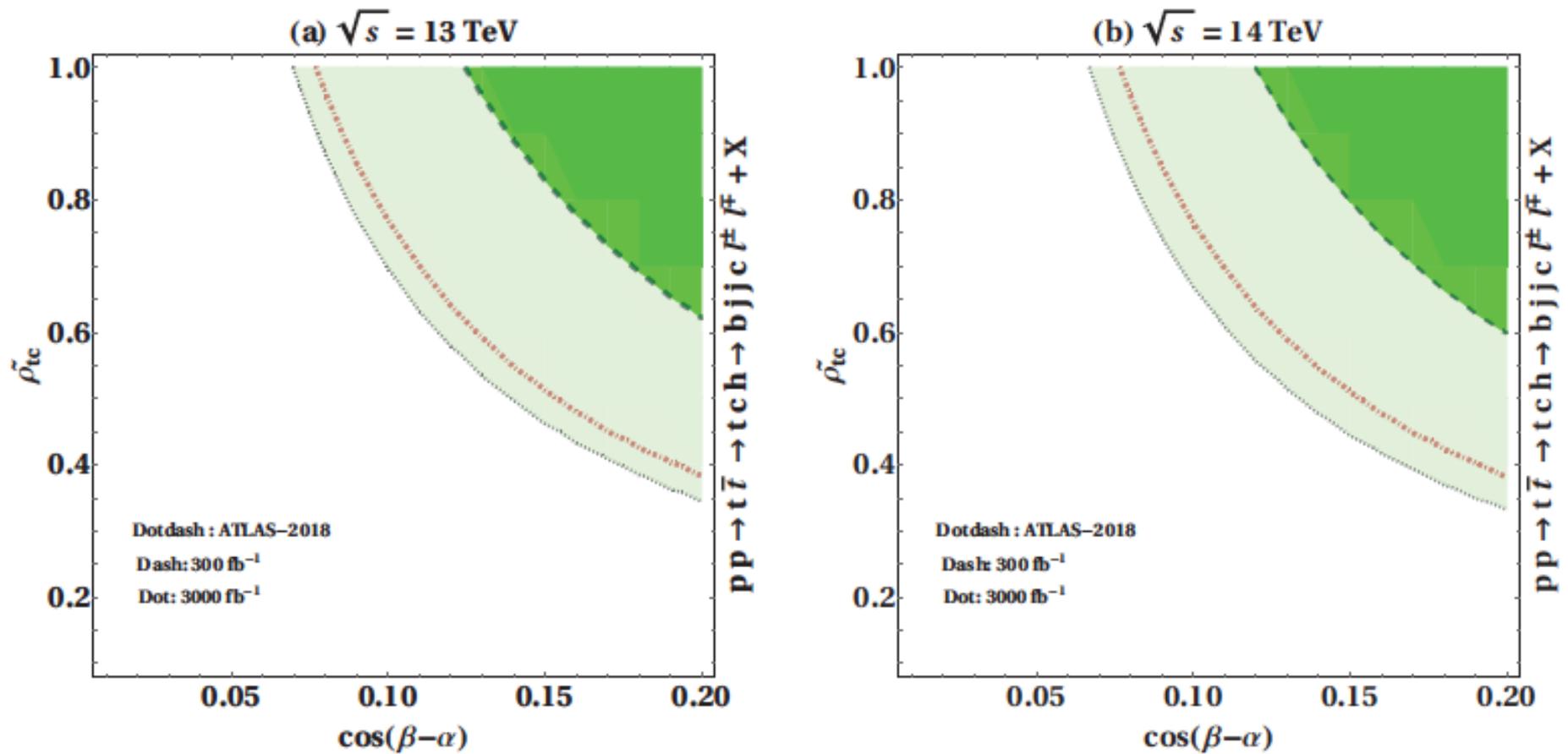
# Cross Section of Signal and Background



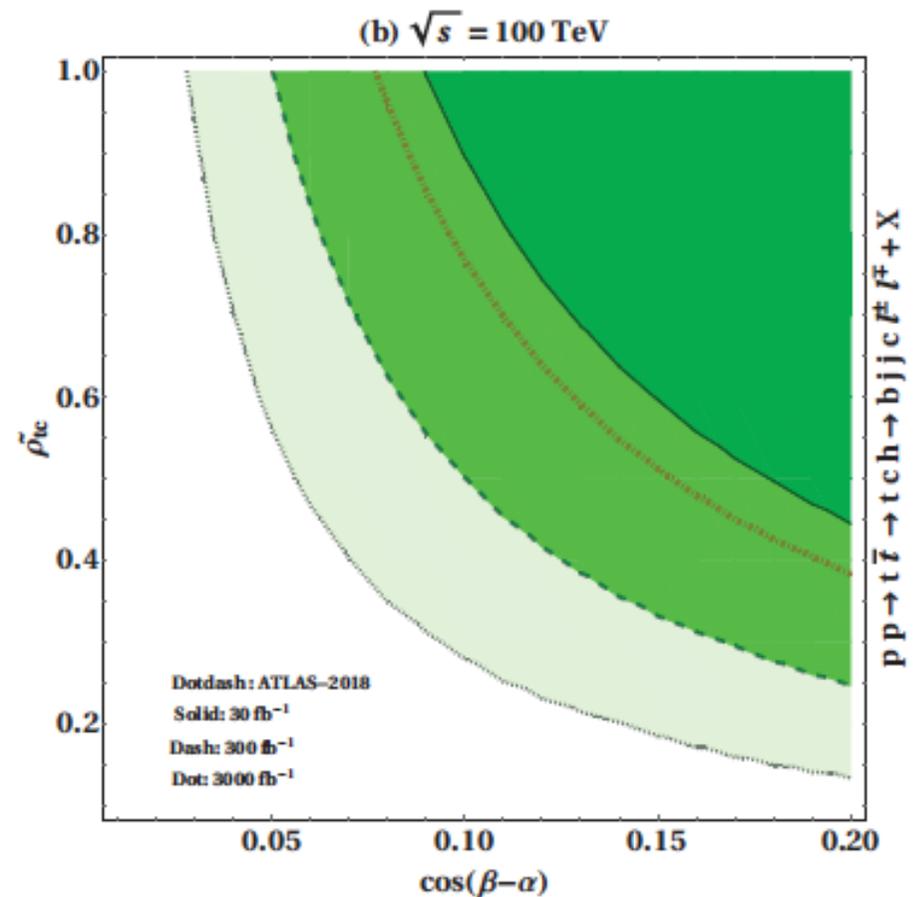
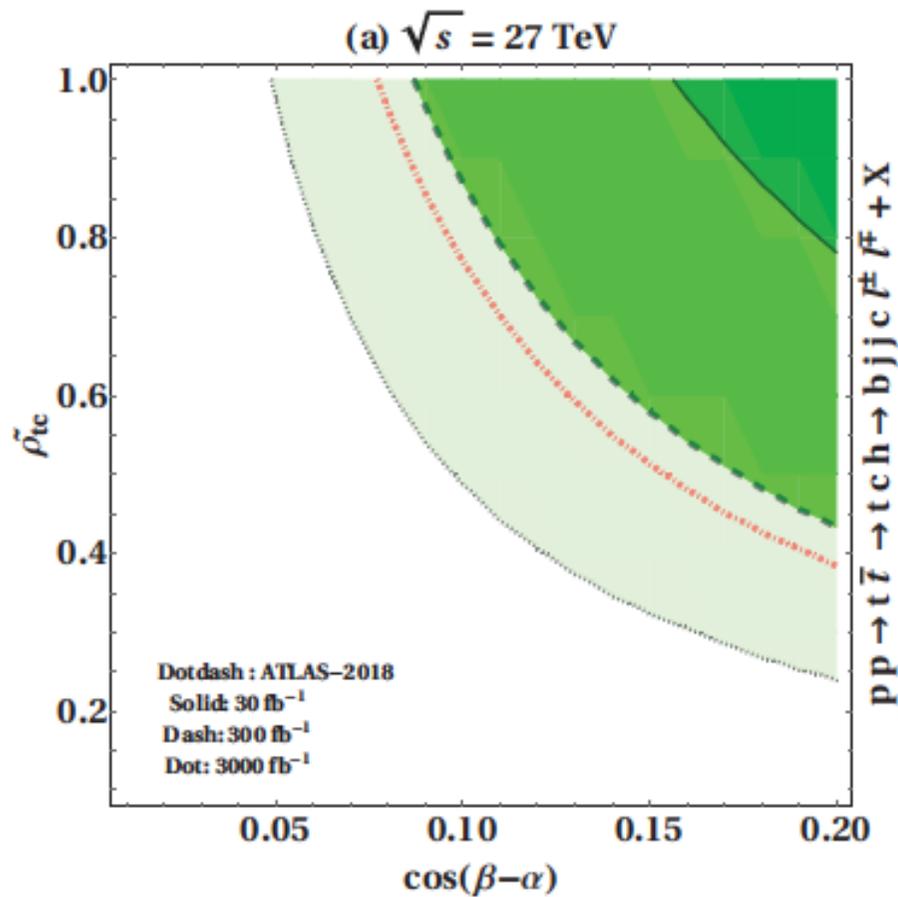
# Cross Section of Signal and Background



# Discovery Potential



# Discovery Potential



# Transverse Mass

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For both the  $N_{\text{jet}} = 0$  and  $N_{\text{jet}} = 1$  ggF SRs, eight regions, later used for the fit, are defined by subdividing in  $m_{\ell\ell}$  at  $m_{\ell\ell} < 30$  GeV and  $m_{\ell\ell} \geq 30$  GeV, in  $p_{\text{T}}$  of the subleading lepton at  $p_{\text{T}}^{\text{sublead}} < 20$  GeV and  $p_{\text{T}}^{\text{sublead}} \geq 20$  GeV, and by the flavour of the subleading lepton. For the categories with zero jets and with exactly one jet, the discriminating variable between signal and SM background processes is the dilepton transverse mass, defined as  $m_{\text{T}} = \sqrt{(E_{\text{T}}^{\ell\ell} + E_{\text{T}}^{\text{miss}})^2 - |\mathbf{p}_{\text{T}}^{\ell\ell} + \mathbf{E}_{\text{T}}^{\text{miss}}|^2}$  where  $E_{\text{T}}^{\ell\ell} = \sqrt{|\mathbf{p}_{\text{T}}^{\ell\ell}|^2 + m_{\ell\ell}^2}$  and  $\mathbf{p}_{\text{T}}^{\ell\ell}$

# Cluster Mass

## Collider Physics by Barger and Phillips

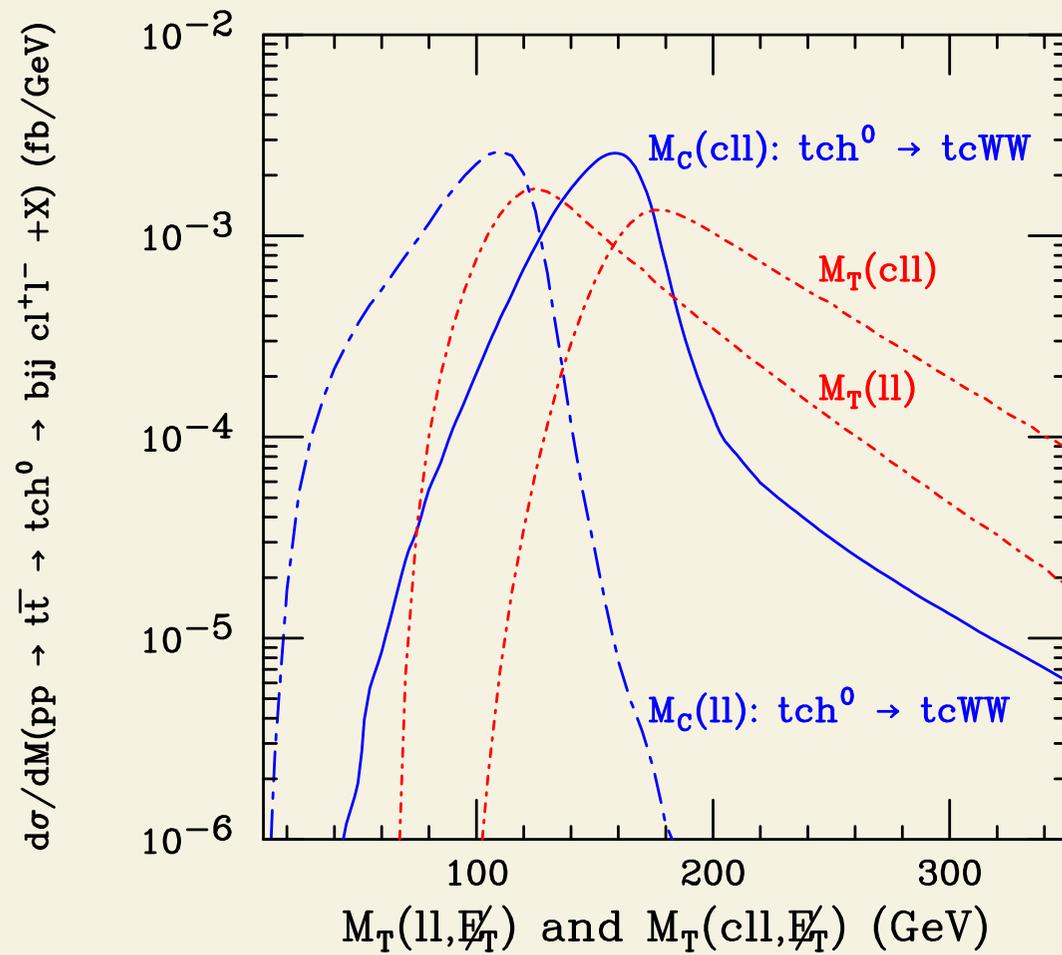
$$M_T^2(\ell\ell, \cancel{E}_T) = \left( \sqrt{p_T^2(\ell\ell) + M_{\ell\ell}^2} + \cancel{E}_T \right)^2 - (\vec{p}_T(\ell\ell) + \vec{\cancel{E}}_T)^2, \quad (23)$$

and

$$M_T^2(c\ell\ell, \cancel{E}_T) = \left( \sqrt{p_T^2(c\ell\ell) + M_{c\ell\ell}^2} + \cancel{E}_T \right)^2 - (\vec{p}_T(c\ell\ell) + \vec{\cancel{E}}_T)^2, \quad (24)$$

# $M_C$ versus $M_T$

$\sqrt{s} = 14 \text{ TeV}$



# Summary for FCNH top Decay

- It is of great interest to search for the link between the top quark ( $t$ ) and the Higgs bosons ( $H^0, h^0, A^0$ ).
- A discovery of  $t \rightarrow ch^0$  would suggest the existence of an extended Higgs sector beyond the usual 2HDM-II and MSSM.
- Experimental studies of  $h^0$  to  $bb, WW^*, ZZ^*, \tau^+\tau^-$  and  $\gamma\gamma$  modes will provide important information for FCNH interactions.