Search for charged Higgs boson at the Tevatron

Brigitte Vachon
Canada Research Chair
McGill University, Montréal

On behalf of the CDF and DØ collaborations

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Outline

- Theoretical background
- Search for singly charged Higgs ($H^{\pm}$)
- Search for doubly charged Higgs ($H^{\pm\pm}$)
- Summary

Charged Higgs production in $p\bar{p}$ collisions

Extensions of Standard Model Higgs sector leads to many physical Higgs bosons

Singly charged Higgs (H^+):

- Arise in models with two Higgs doublets such as SUSY and some GUT
- Different 2HDM depending on strategy used to avoid FCNC (Type-I, Type-II, Type-III)
- Models typically depend on M_{H+} and $\tan\beta = v_1/v_2$

top quark decays: $p\,\bar{p} \rightarrow t\,\bar{t} \rightarrow \left(H^+ b\right)\left(W^- \bar{b}\right)$

direct production: $p\,\bar{p} \rightarrow H^+ \rightarrow t\,\bar{b}$

Doubly charged Higgs (H^{++}):

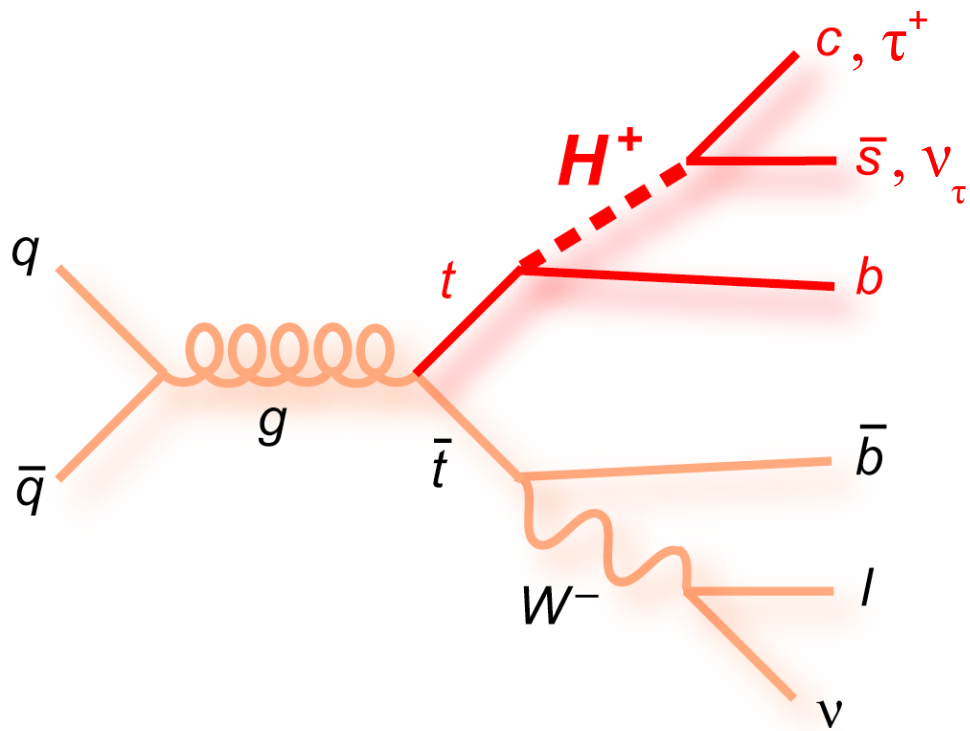
- Exotic extensions of the Higgs sector involving higher isospin multiplets (ex. Left/Right symmetric models, Higgs triplet, Little Higgs)
- Models depend on M_{H++} and Higgs couplings

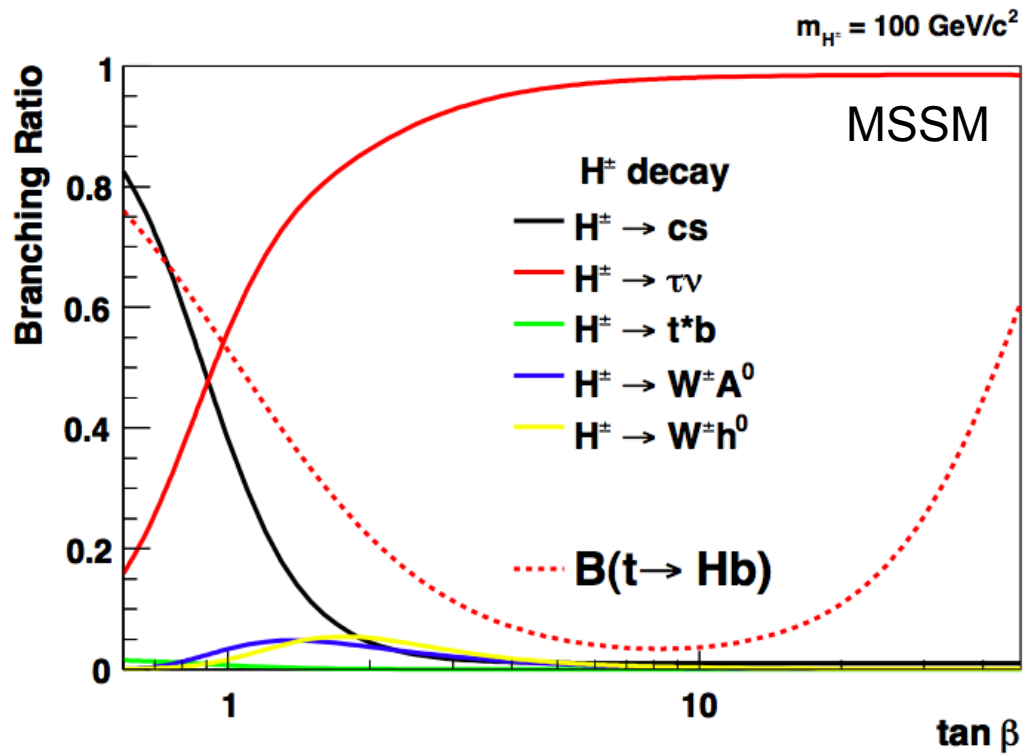
direct production: $p\,\bar{p} \rightarrow H^{++} H^{--} \rightarrow l^+ l^+ l^- l^-$

Discovery of charged Higgs is unambiguous evidence for new physics

Charged Higgs in top decay: $t \rightarrow H^+ b$

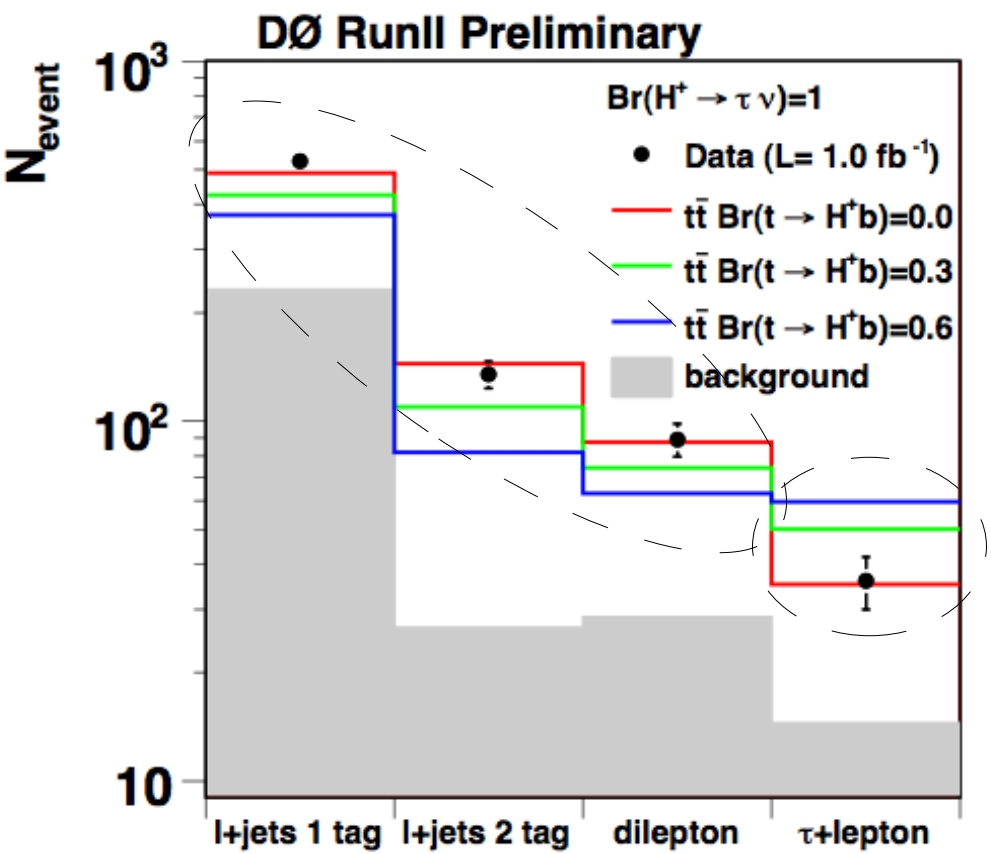
Assume $M_{H+} < M_{top}$

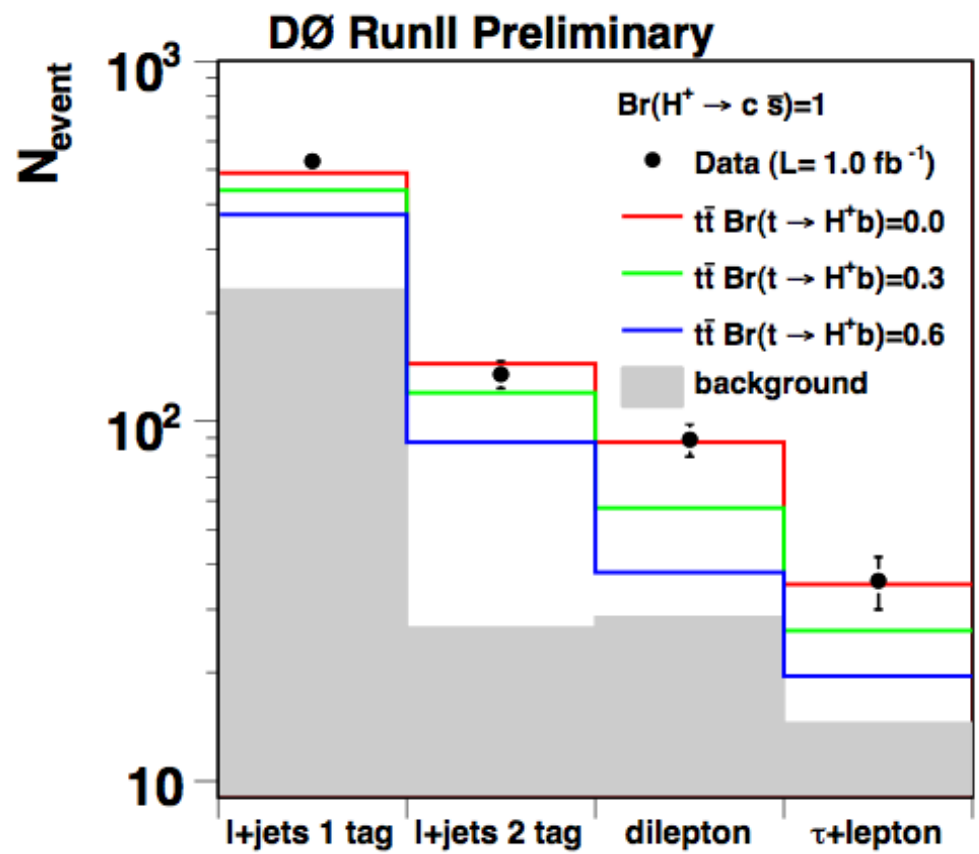




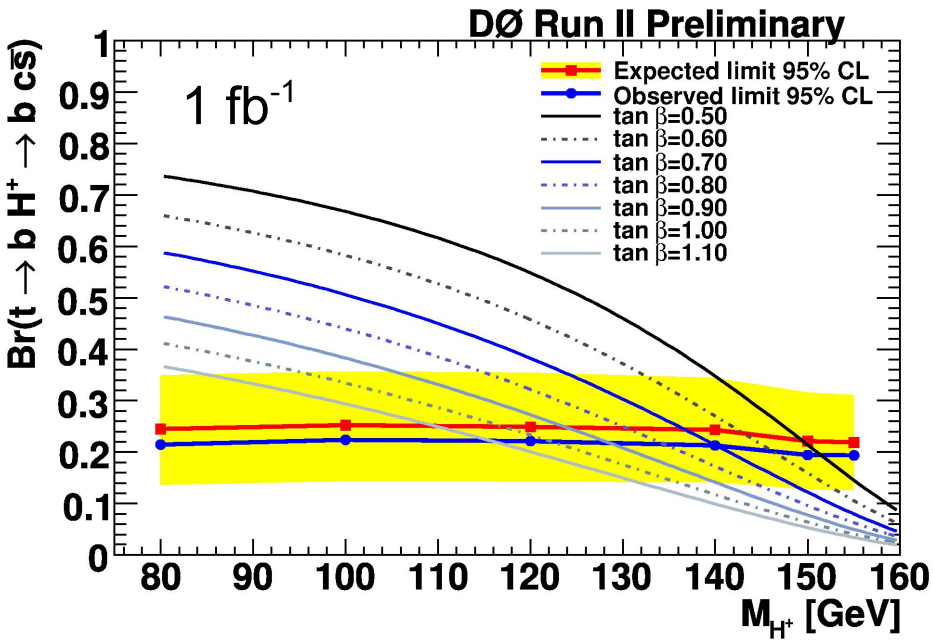
Charged Higgs in top decay: $t \rightarrow H^+ b$

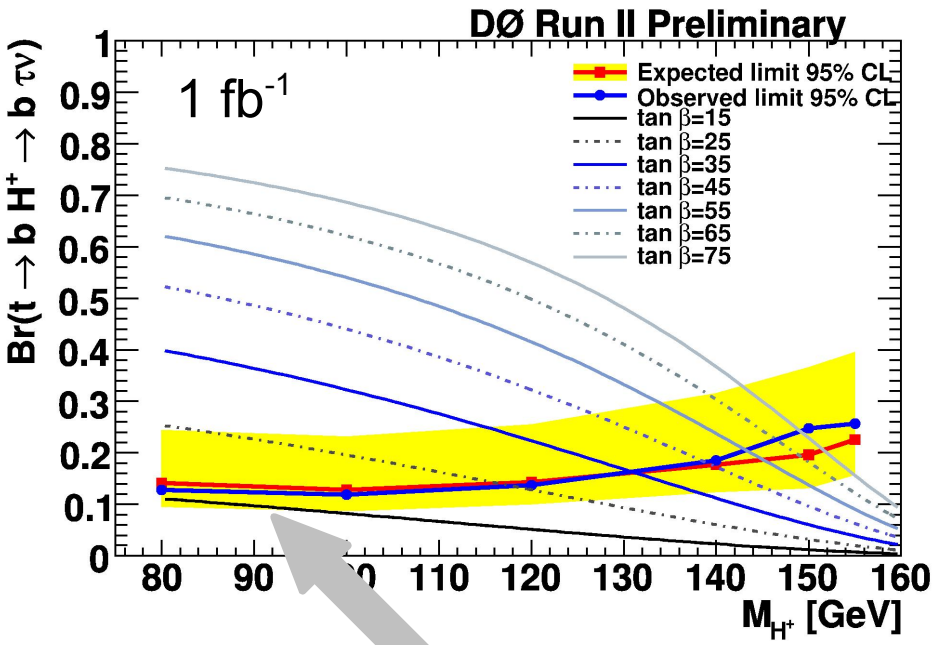
- Search for H^+ using top pair production cross-section measurements in different final states (di-lepton, tau+ℓ, ℓ+jets)
- Consider purely tauonic decay ($H^+ \rightarrow \tau^+ \nu_\tau$) and leptophobic decay ($H^+ \rightarrow c\,\bar{s}$)
- Maximum likelihood fit to the number of events. Set limits using likelihood ordering principle of Feldman and Cousins

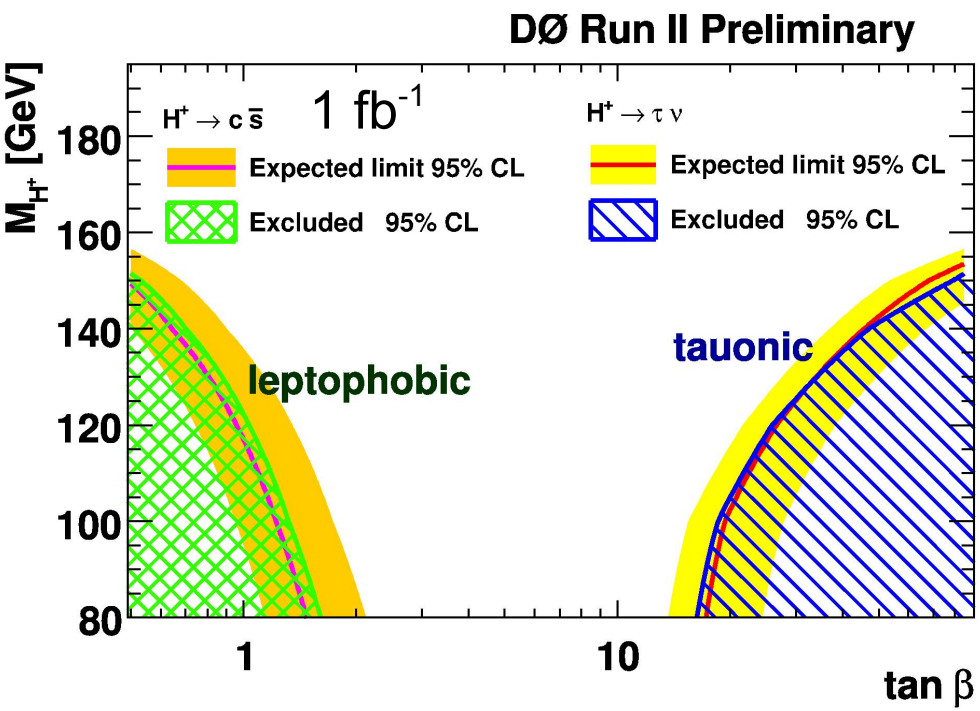




Charged Higgs in top decay: $t \rightarrow H^+ b$



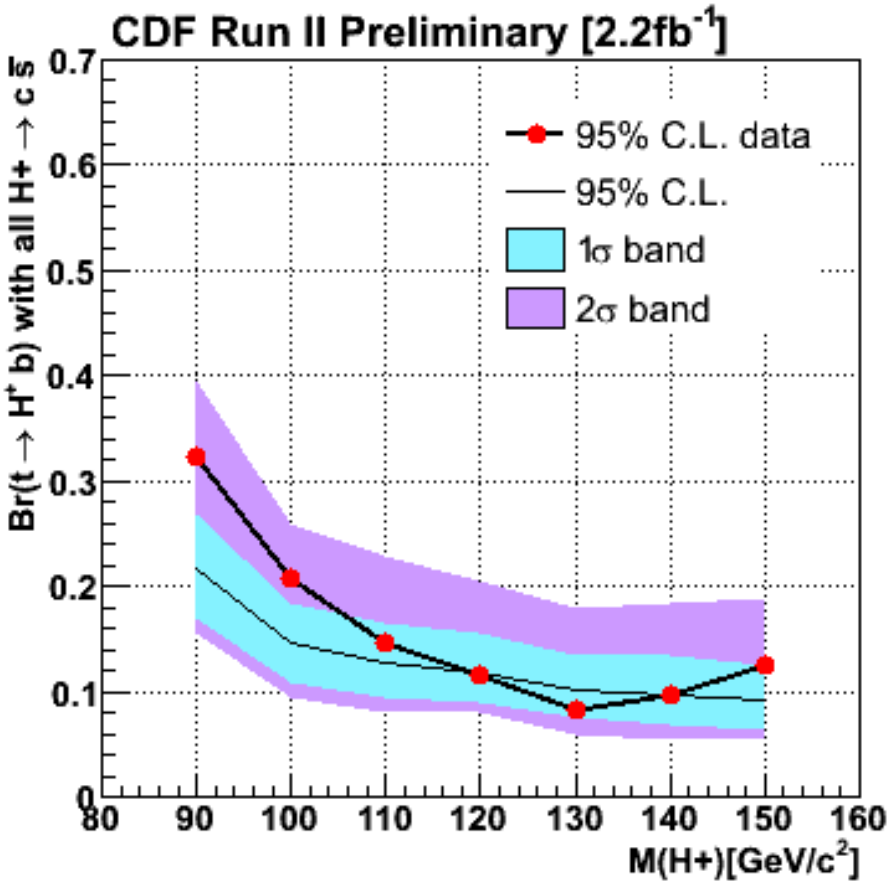


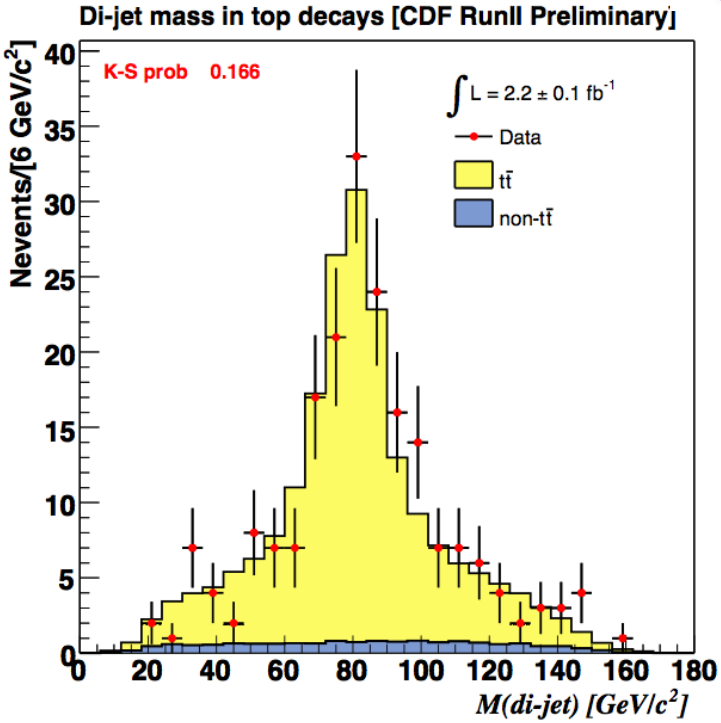


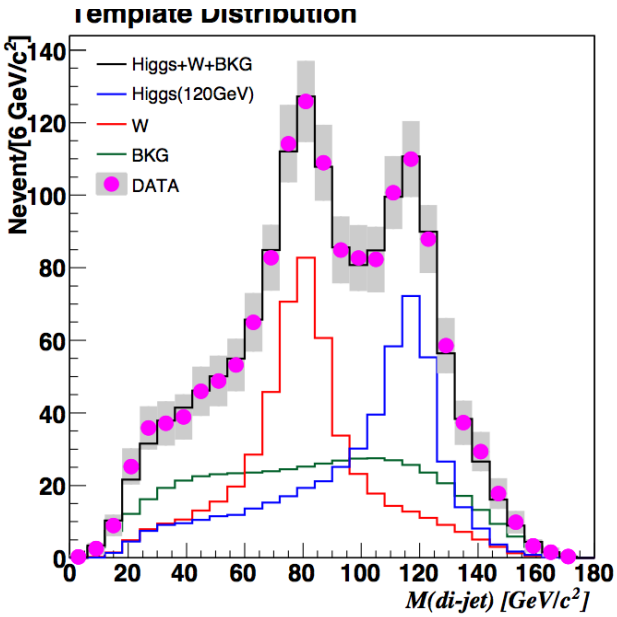
Simultaneous fit to σ_{tt} and $Br(t \rightarrow H^+ b)$ improves sensitivity by ~ 30%

Charged Higgs in top decay: $t \rightarrow H^+ b$

- Search for leptophobic decay ($H^+ \rightarrow c\bar{s}$)
- Perform template fit of reconstructed di-jet invariant mass in ℓ+jets events using binned maximum likelihood



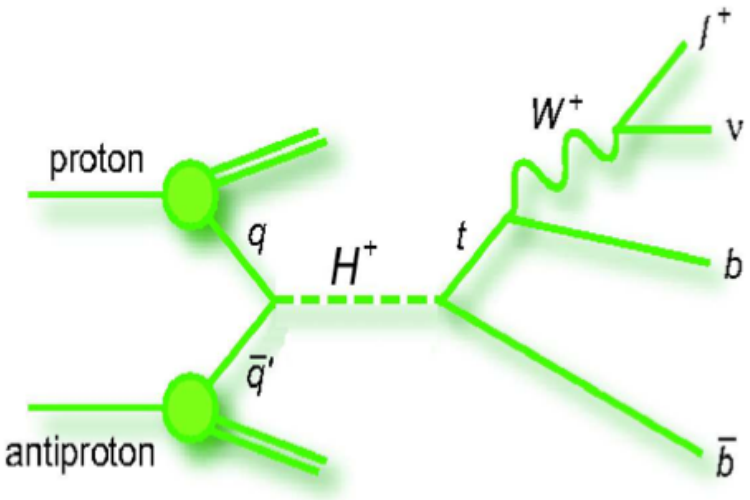


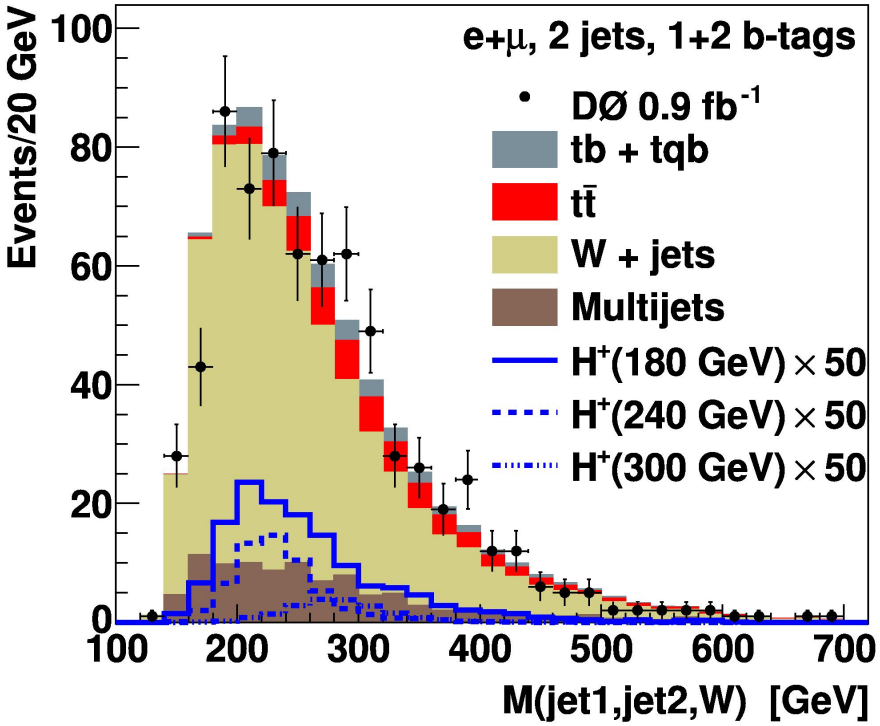


Direct production of charged Higgs

Assume $M_{H+} > M_{top}$

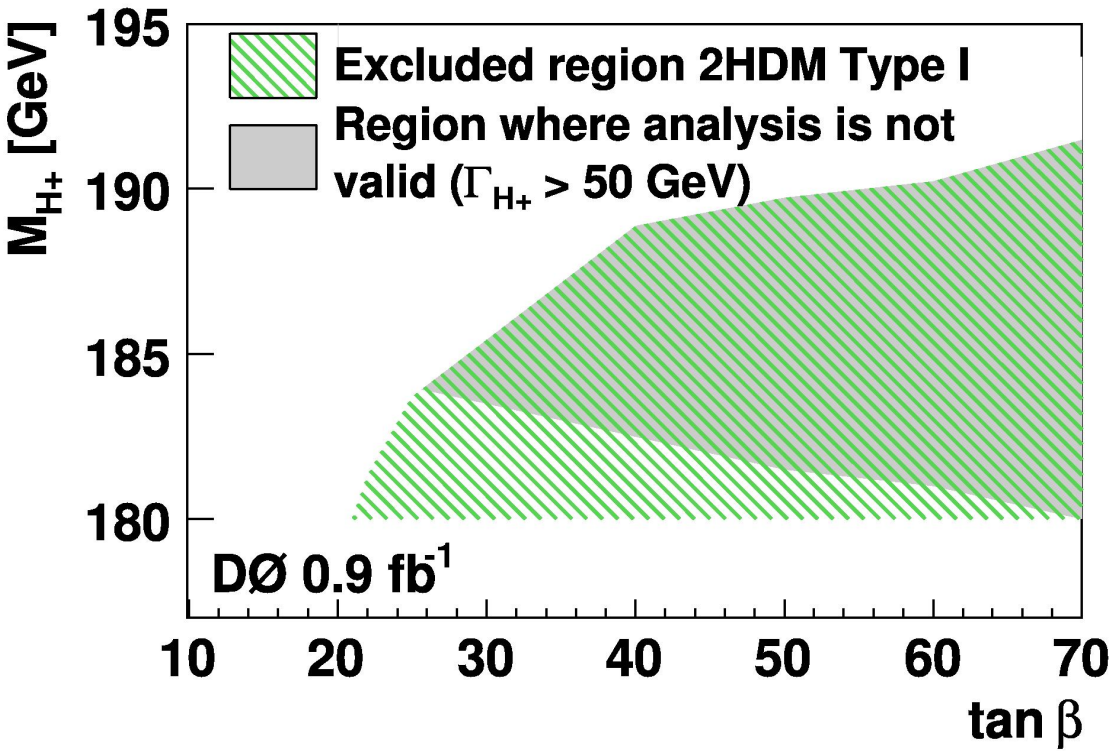
- First search for H^+ production via quark fusion
- Use single top quark event selection
- Use reconstructed invariant mass as discriminating variable
- Perform binned likelihood using Bayesian method to calculate cross-section limits
- Simulate different 2HDM by combining in different proportions purely left and right-handed signal samples

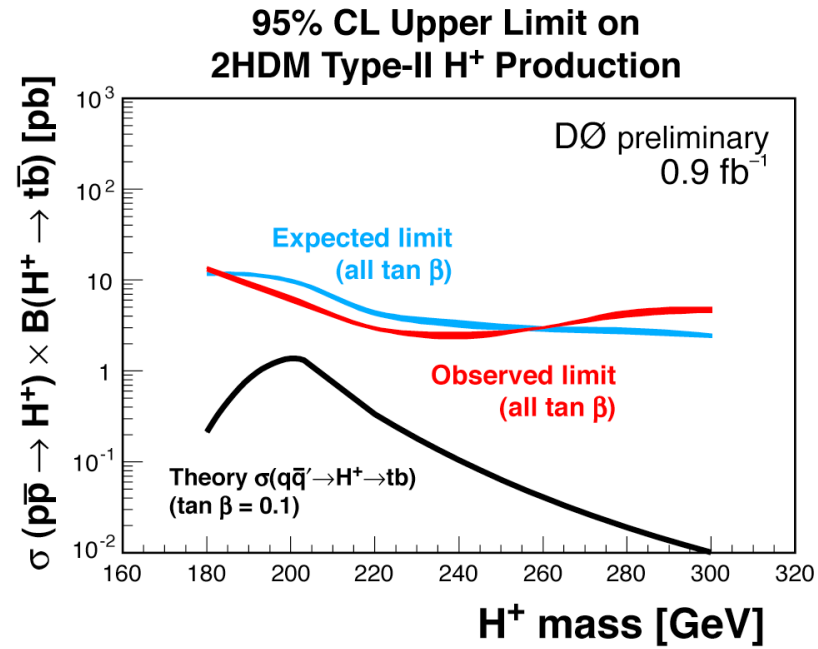


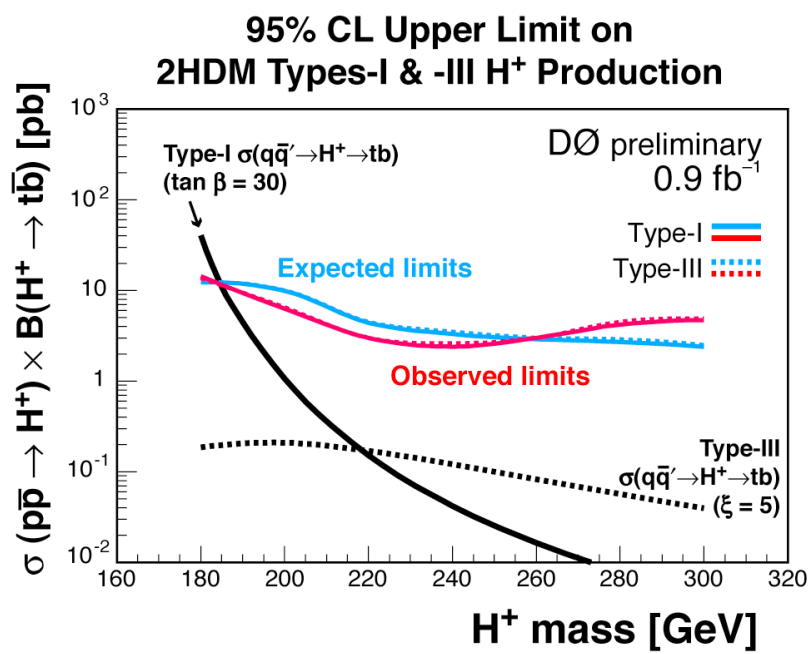


Direct production of charged Higgs

- Calculate production cross-section limits for 2HDM Type-I, Type-II and Type-III
- Exclude region of parameter space in 2HDM Type-I

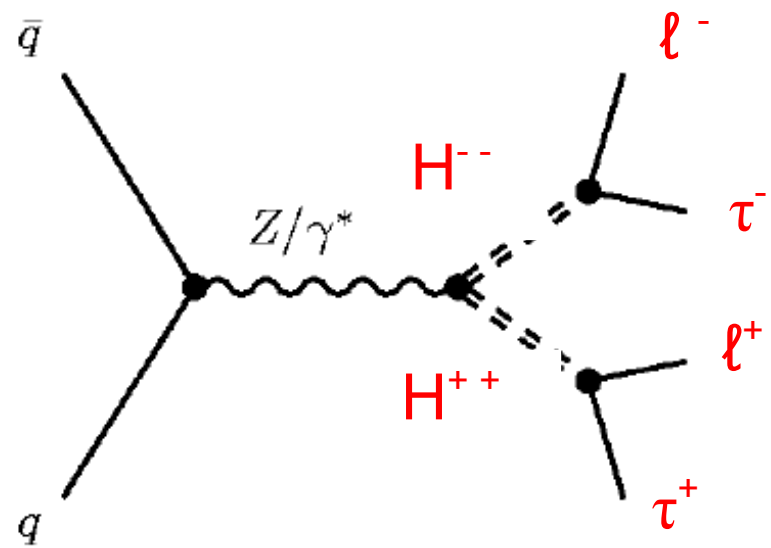






Search for doubly charged Higgs (H^{++})

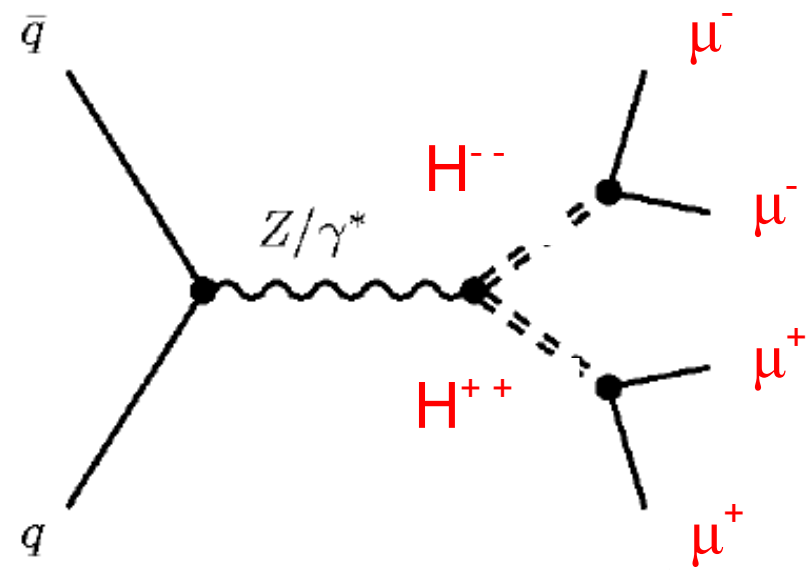
Search for lepton flavour violating decay modes



- 3 or 4 leptons events
- remove $Z \rightarrow \ell^+\ell^-$ background
- further reduce background using H_T cut

Signal efficiency
~ 8% at $M(H^{++})$= 85 GeV
~ 14% for $M(H^{++})$ = 135 GeV

Search for muon decay mode



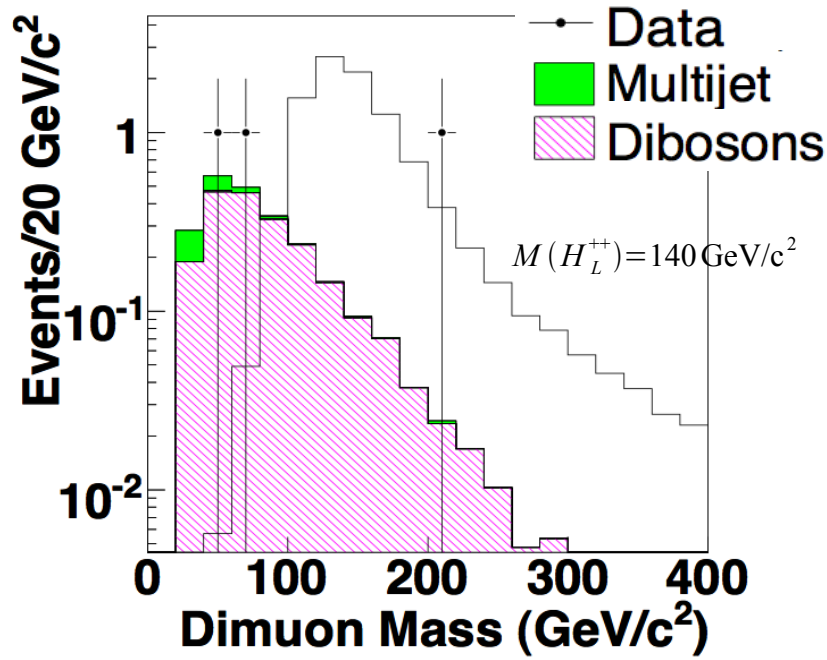
- 2 like-sign muons
- presence of third muon
- $\Delta\varphi$ requirement to reduce $Z \rightarrow \mu^+\mu^-$ background

Signal efficiency nearly independent of mass ~ 32-34%

Search for doubly charged Higgs (H^{++})

	3-lepton		4-lepton	
	$e\tau$	$\mu\tau$	$e\tau$	$\mu\tau$
Bkg	0.24 ± 0.27	0.27 ± 0.13	0.04 ± 0.05	0.14 ± 0.05
Data	0	0	0	0

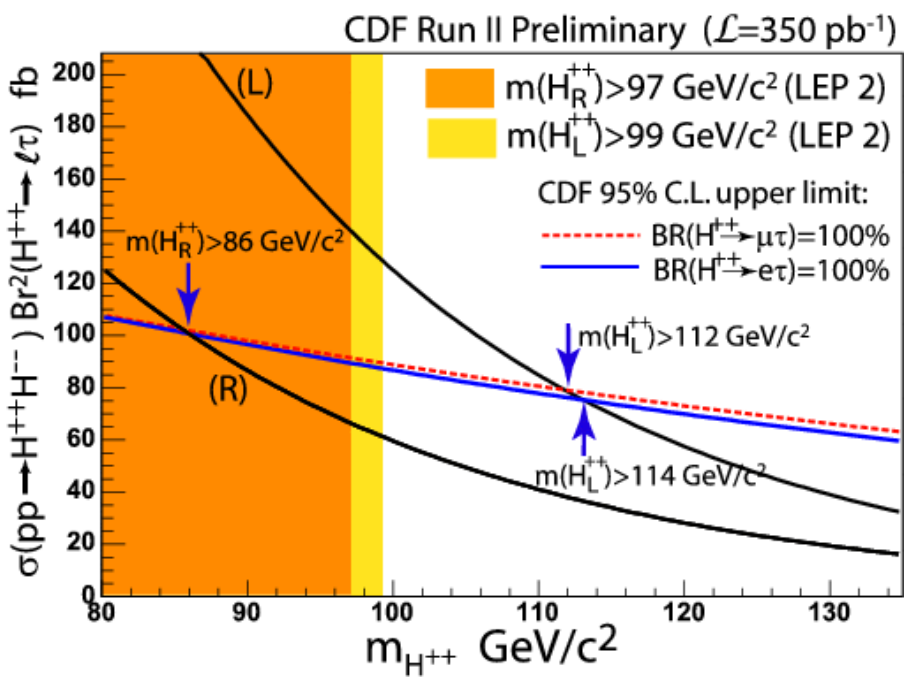
$Z/\gamma^* \rightarrow \mu^+\mu^-$	< 0.01
Multijet	0.2 ± 0.1
$Z/\gamma^* \rightarrow \tau^+\tau^-$	< 0.01
tt	< 0.01
WW	< 0.01
WZ	1.62 ± 0.11
ZZ	0.47 ± 0.03
Total background	2.3 ± 0.2
Data	3



Search for doubly charged Higgs (H^{++})

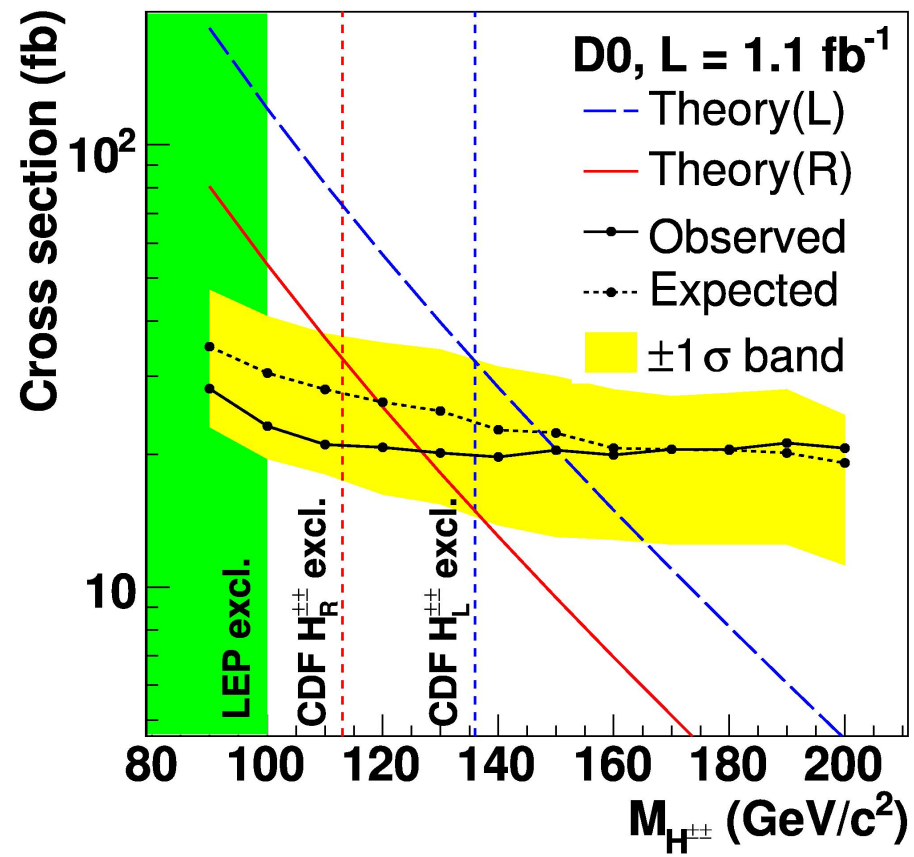
- Use Bayesian method
- Assume exclusive decay to e+tau or mu+tau

$$M(H_L^{++}) > 114\,GeV/c^2 \quad (e\tau)$$
$$> 112\,GeV/c^2 \quad (\mu\tau)$$



- Use CL_s method
- Assume exclusive decay to muons

$$M(H_L^{++}) > 150\,GeV/c^2 \quad (\mu\mu)$$
$$M(H_R^{++}) > 127\,GeV/c^2 \quad (\mu\mu)$$



Summary

- Evidence for charged Higgs boson would be unambiguous sign of new physics
- Search for singly and doubly charged Higgs performed at Tevatron
- No evidence for the existence of charged Higgs boson is found
- Constraints on different model parameters have been calculated