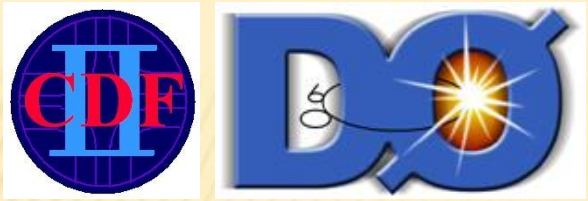
Jon Hays on behalf of the CDF and DØ collaborations

BEYOND STANDARD MODEL SEARCHES FOR HIGGS BOSONS AT THE TEVATRON

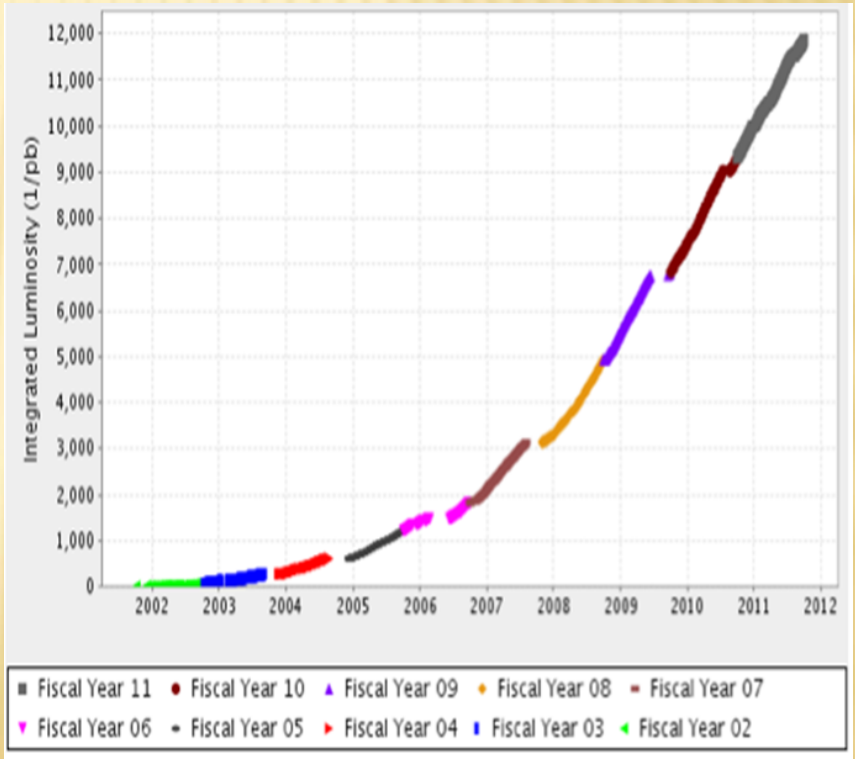


OUTLINE

- Introduction
- 4th Generation and fermiophobic scenarios
- Scalar bosons in cascade decays
- Neutral bosons inspired by MSSM
- Overview and Conclusions

INTRODUCTION

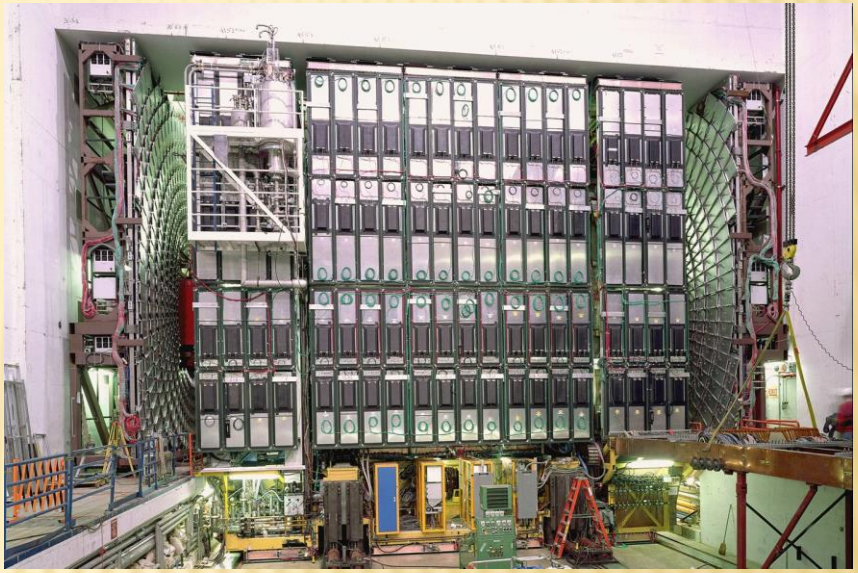
Ten year RunII ended
30th September 2011

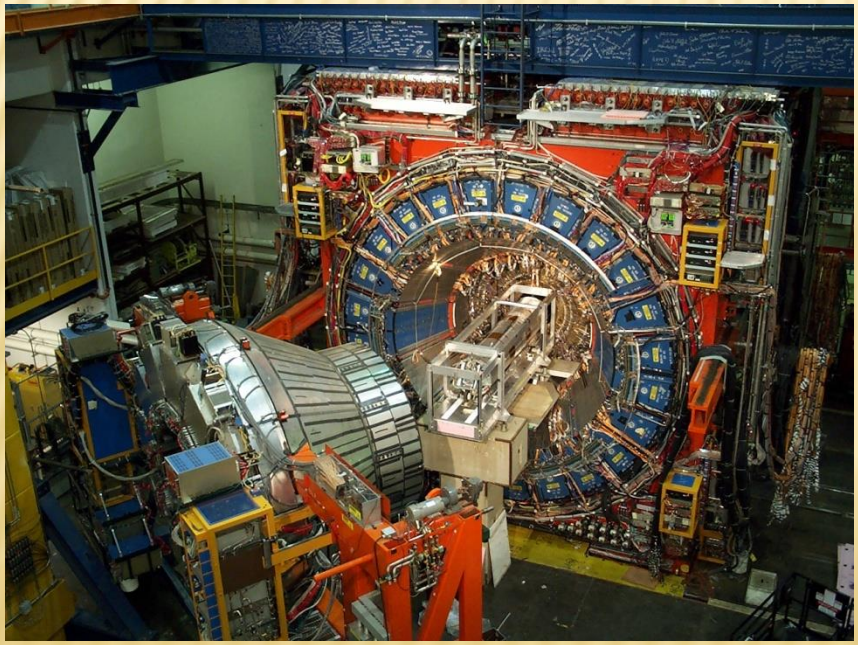


~12 fb^{-1} delivered
~10 fb^{-1} recorded for analysis

INTRODUCTION

Broadly similar general purpose detectors
With differing strengths





CDF: excellent central tracking with large lever arm

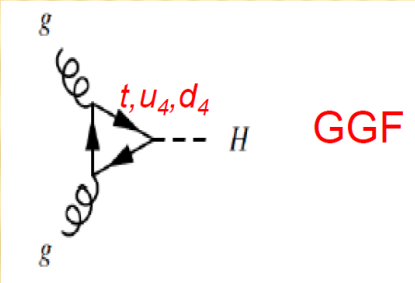
D0: Hermetic calorimeter and large muon acceptance

4TH GENERATION FERMIONS

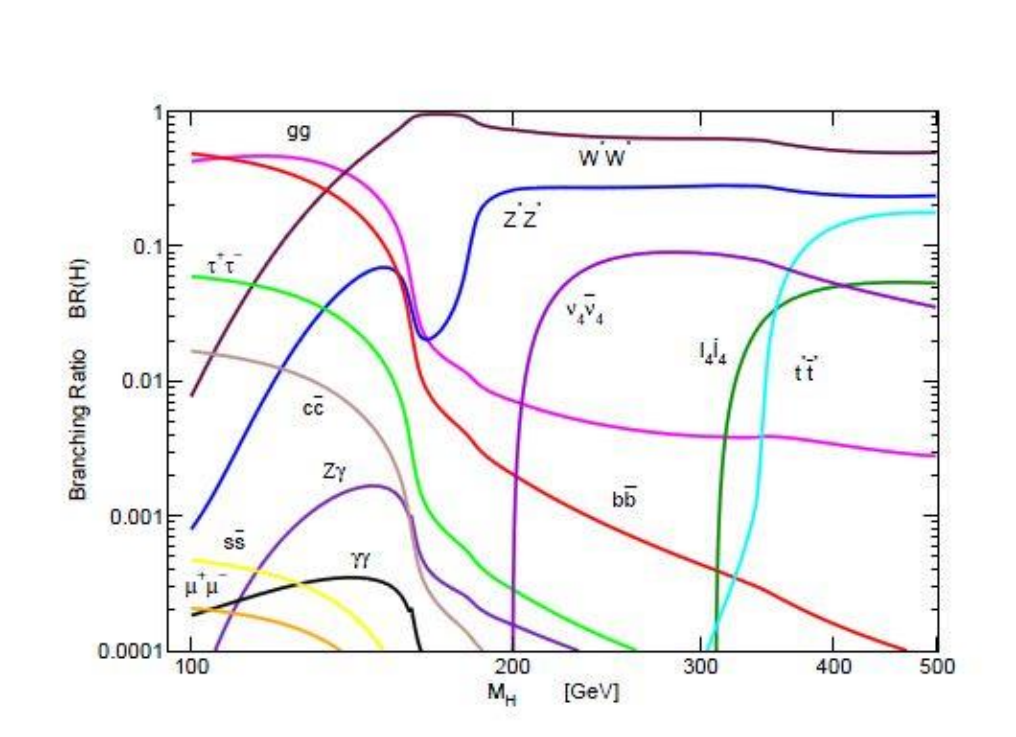
Extension of SM – add an extra generation of fermions

Extra quarks:
gluon-gluon fusion dominates production overwhelmingly

modifies low mass BRs



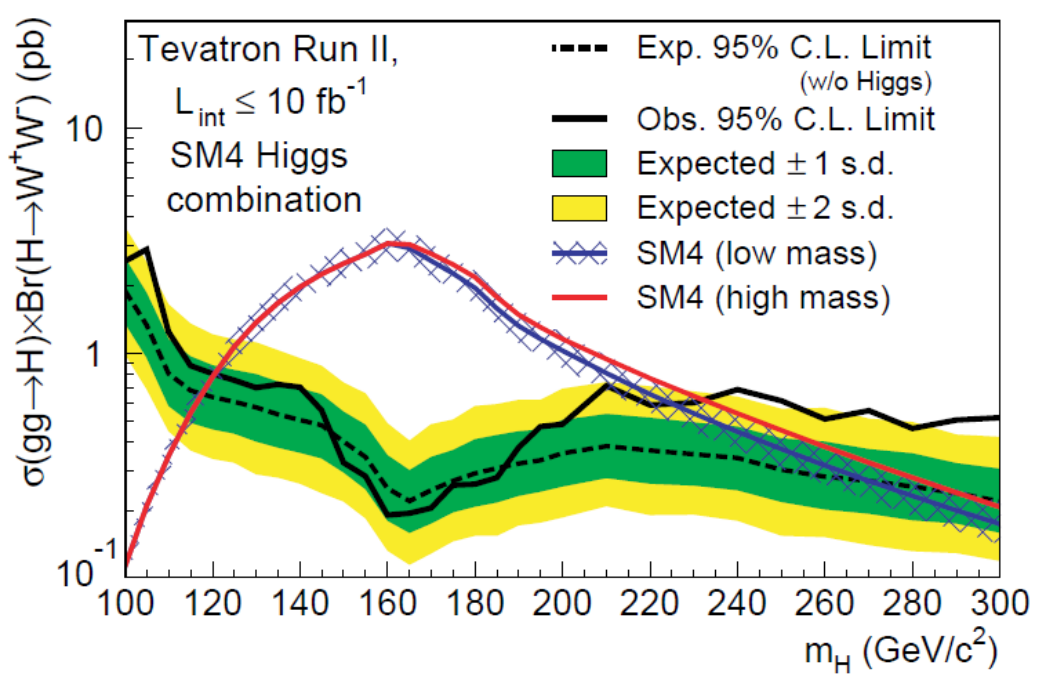
Extra leptons:
possibly modified high mass BRs depending on masses



G.D.Kribs, T.Plehn, M.Spannowsky, T.M.P. Tait arXiv:0706.3718v1

4TH GENERATION FERMIONS

Reanalysis of SM search in WW and ZZ with only ggF signal – selection re-optimised



95% CL in two scenarios:

Low mass:
m_{l4} = 100 GeV $m_{\nu 4}$ = 80 GeV
m_{u4} = 450 Gev m_{d4} = 400 GeV

121 – 225 GeV (observed)
118 – 270 GeV (expected)

High mass:
m_{l4} = $m_{\nu 4}$ = 1000 GeV
m_{u4} = 450 Gev m_{d4} = 400 GeV

121 – 232 GeV (observed)
118 – 290 GeV (expected)

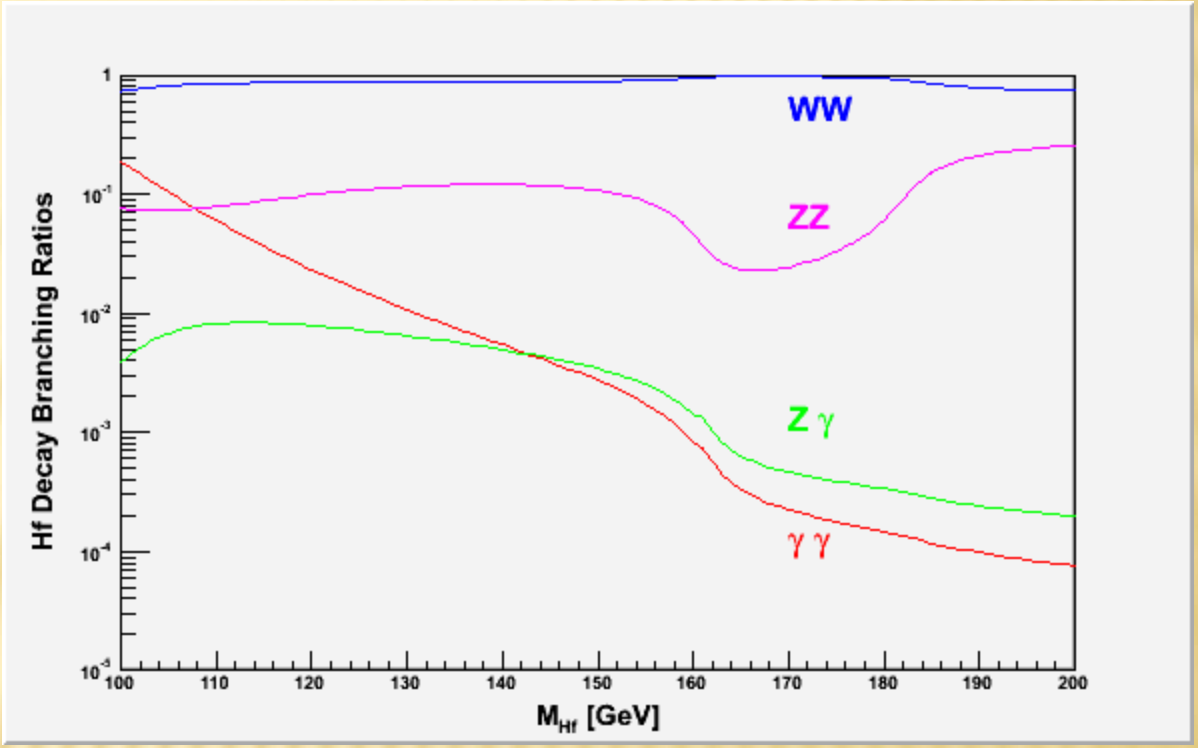
Accepted PRD: arXiv:1303.6346

FERMIOPHOBIC

Assume scalar boson couplings to fermions vanish but otherwise SM-like

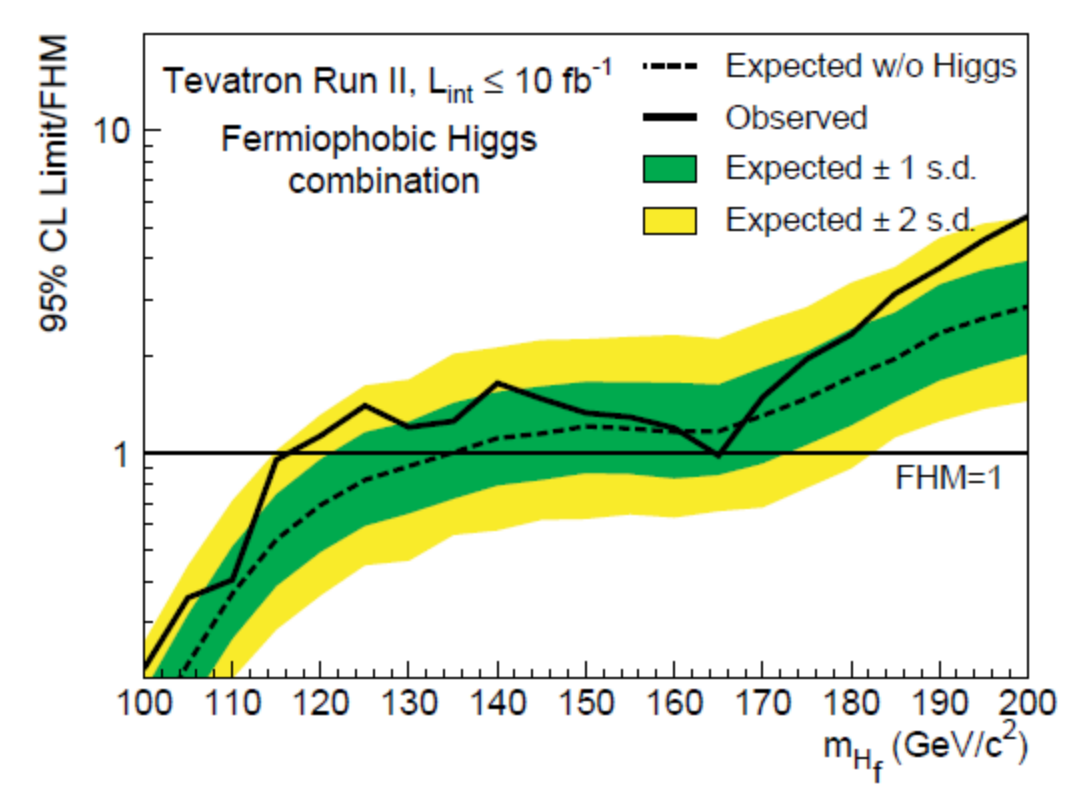
Only VH and VBF production contribute

WW decay dominates
But enhancement of γγ contributes most sensitivity at low mass



FERMIOPHOBIC

Reanalysis of SM searches –
combination of WW, ZZ and γγ with only VH and VBF signals



95% CL exclusions:

$100 < M_{Hf} < 116$ GeV (observed)
$100 < M_{Hf} < 135$ GeV (expected)

Accepted PRD: arXiv:1303.6346

(See also, coupling fits in Gavin's talk on Friday afternoon)

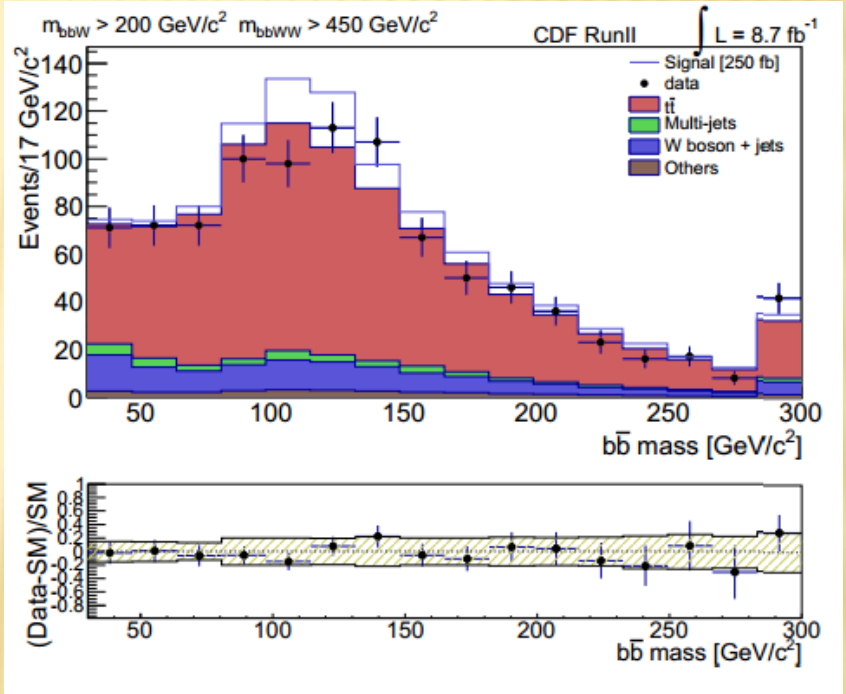
CASCADE DECAYS

Considers decay chain with heavy scalar H^0, assuming $h^0(126)$:

$H^0 \rightarrow H^{\pm} + W \rightarrow W + h^0 + W \rightarrow W + bb + W$

Simplified 2HDM model

Event selection similar to top-pair production, lepton+jets analyses:
- 1 electron or muon,
- 4 or more jets,
- >0 b-tags
- significant missing ET

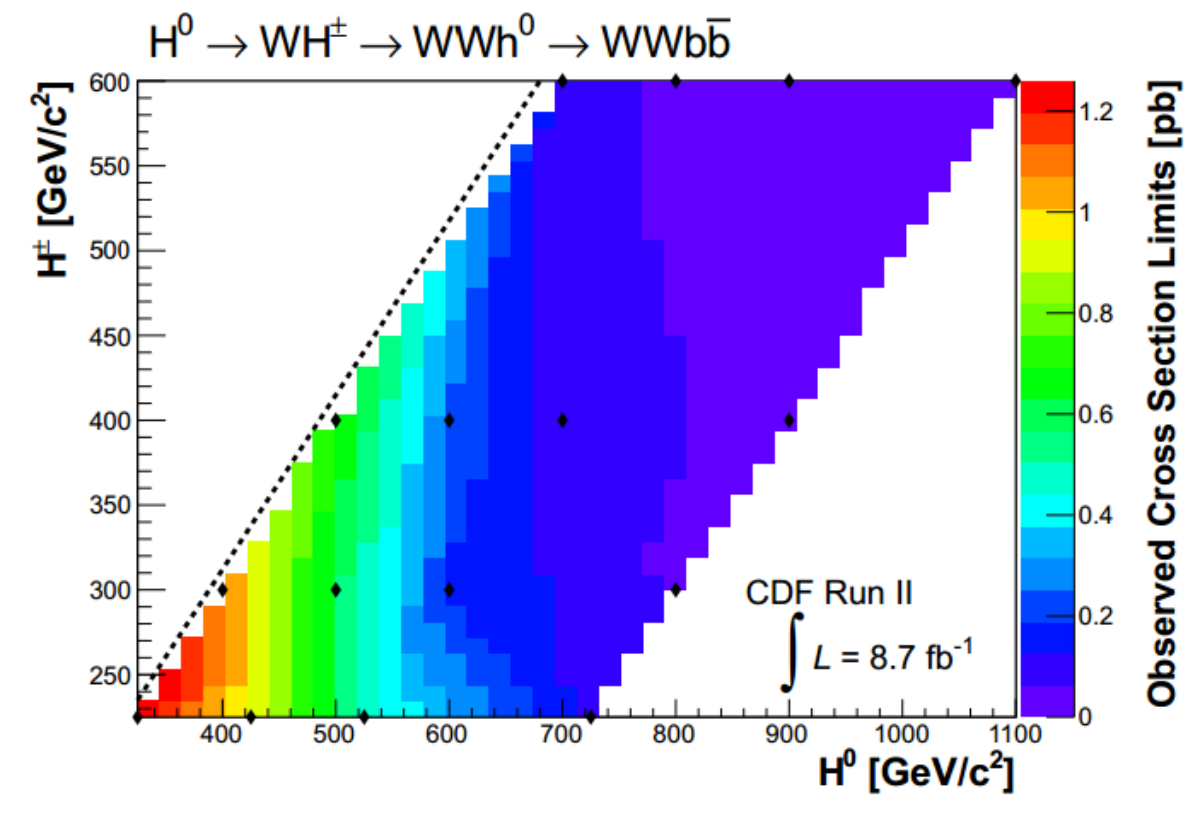


Signal:
Madgraph+PYTHIA

Background:
top and W/Z+jet ALPGEN+PYTHIA
multijet – data driven control region

Select events with $M_{jj} \sim M_W$
Search in M_{bb}

CASCADE DECAYS



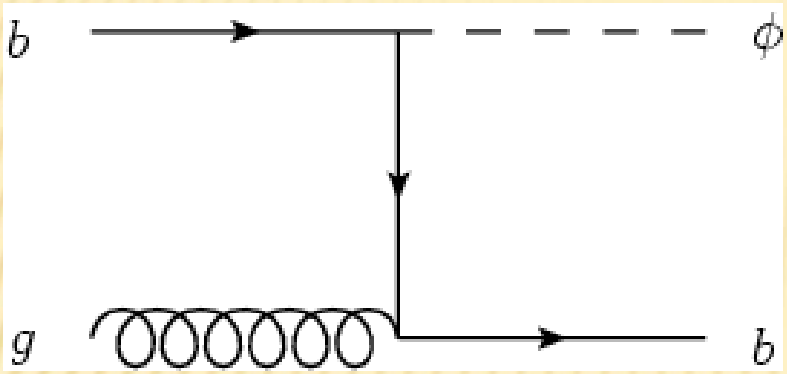
Cross section limits derived in 2D space: $M_{H\pm}$ vs M_{H0}

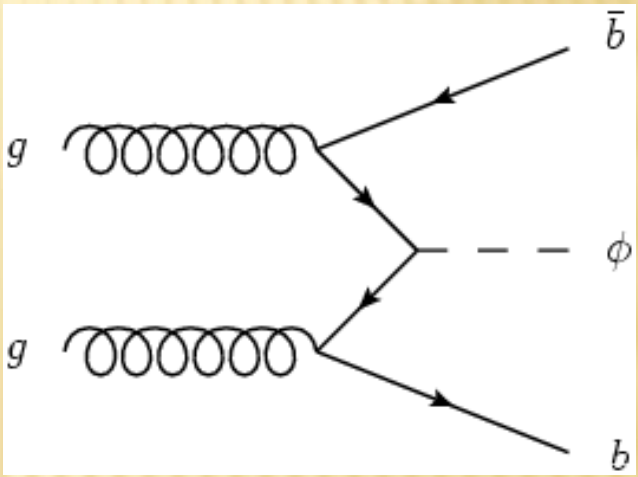
Vary between 1300 to 15 fb, no theoretical exclusion

Phys. Rev. Lett. 110, 121801 (2013)

MSSM-LIKE NEUTRAL BOSON

Tevatron combination of searches with b-quark final states



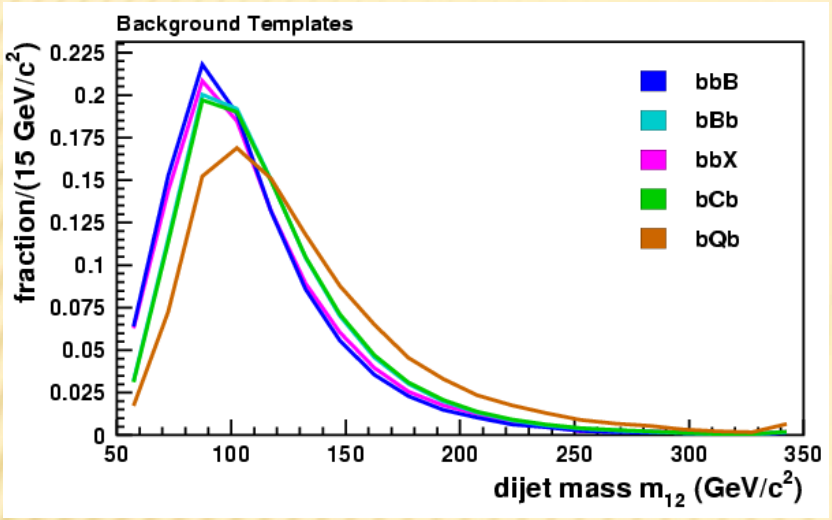


3 or 4 b-quarks in the final state

Single boson production inspired by MSSM with enhanced bbφ couplings for tanβ>1

Avoid too much model dependence – could be sensitive to other new physics

MSSM-LIKE NEUTRAL BOSON



CDF:

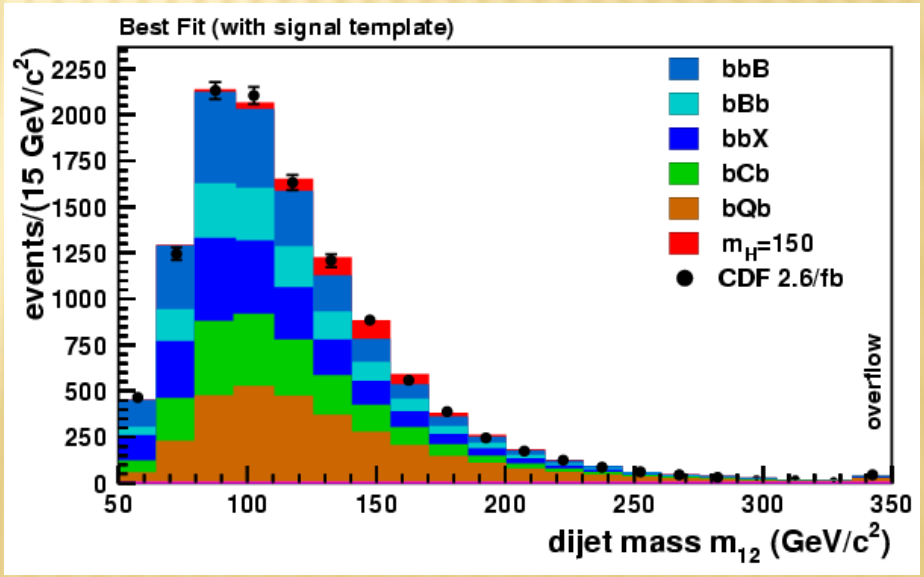
2.6 fb^{-1}

b-jet triggers, 3 jet selection with secondary vertex b-tagging

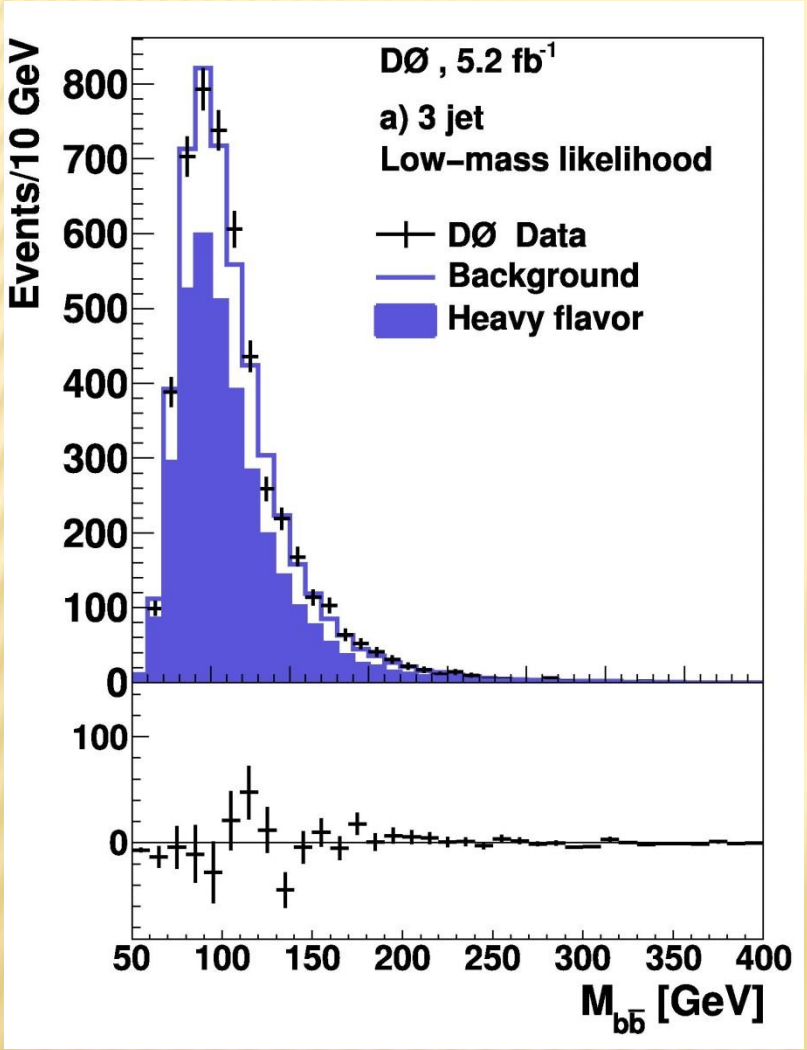
Require 3-bjets ~ 11.5k events

Data driven background templates

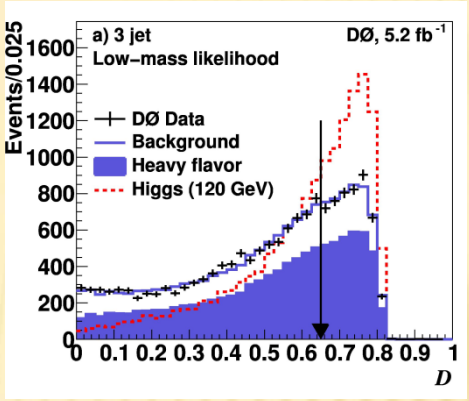
Signal: PYTHIA reweighted to MCFM cross section versus pt

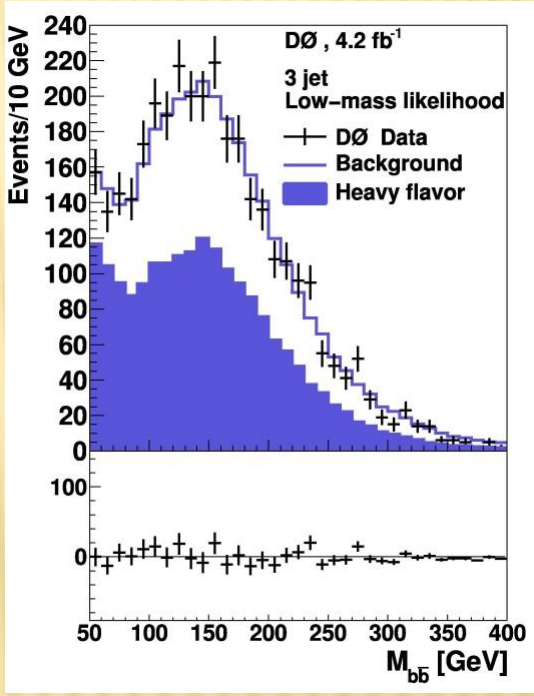


MSSM-LIKE NEUTRAL BOSON



Signal PYTHIA reweighted to MCFM





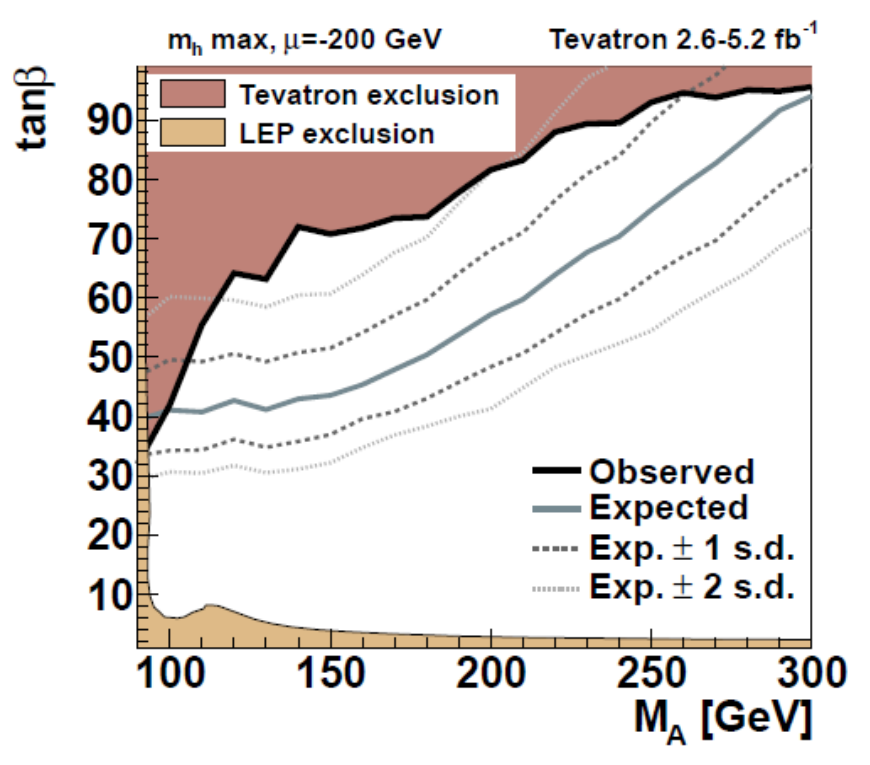
D0:
5.2 fb^{-1}
b-jet triggers,
3 jet selection with NN b-tagging

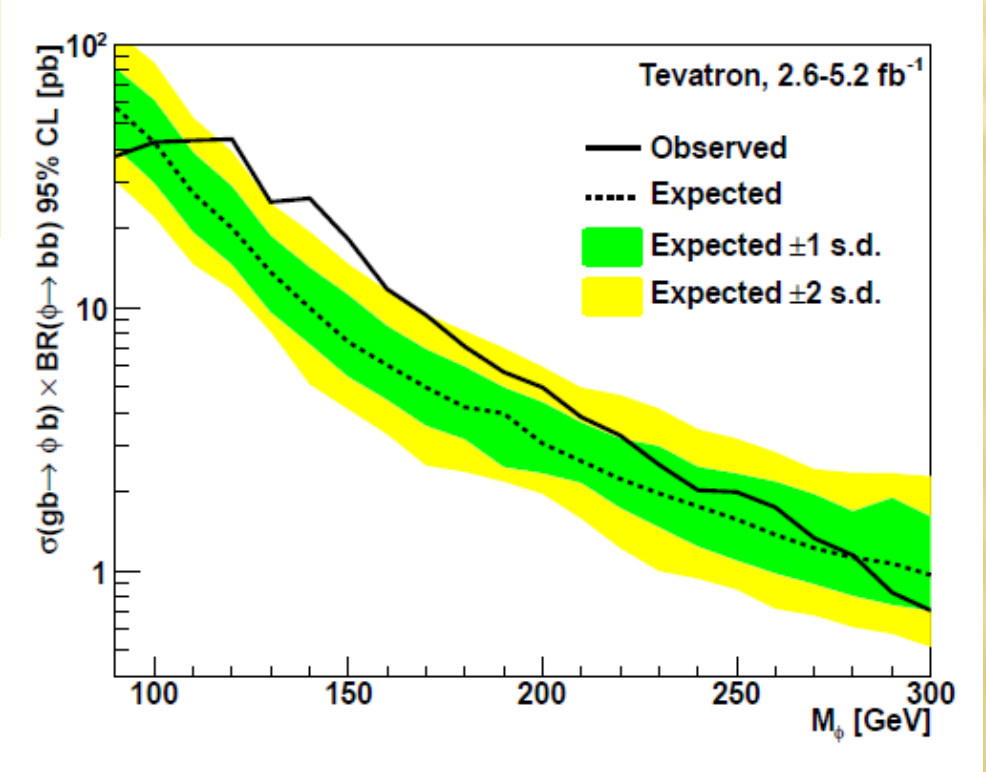
Require 3/4-bjets ~ 15k / 12k events

Backgrounds:
Ratio of MC templates used to reweight data with 2 b-tags

MSSM-LIKE NEUTRAL BOSON

Model independent limit
assumes narrow state
pt > 12 GeV on associated b-jet





Model dependent MSSM scenario –
full width simulation

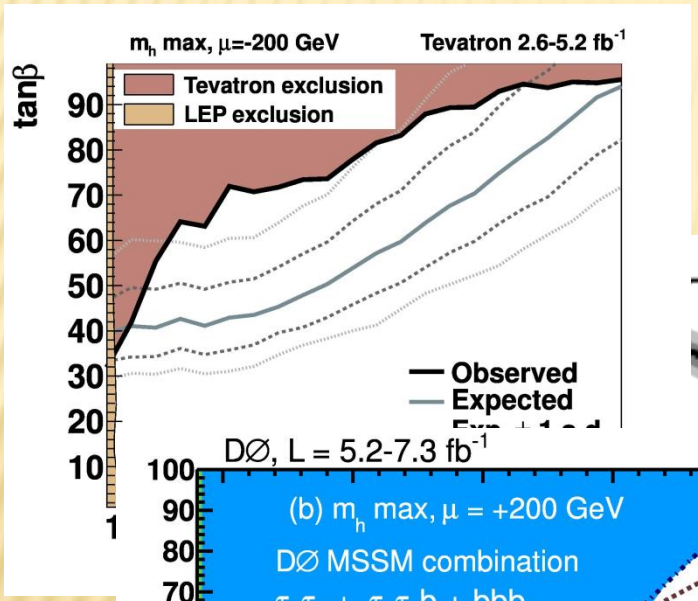
Excess about 2 s.d. after trials factor

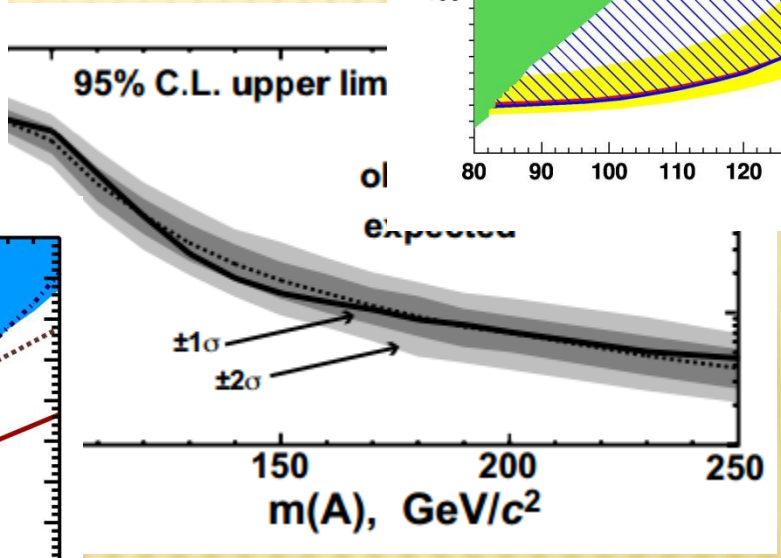
Phys. Rev. D 86, 091101(R), (2012)

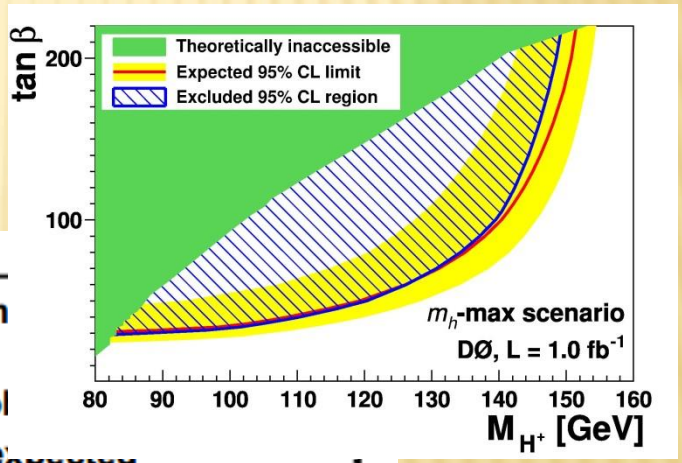
BSM HIGGS AT THE TEVATRON

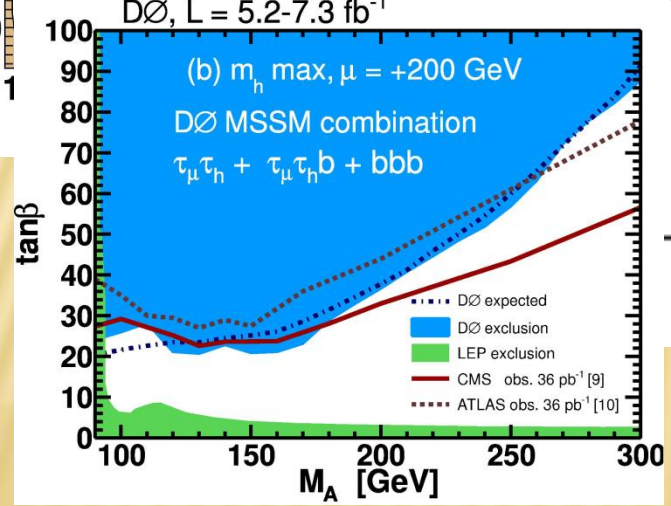
Many different searches over the years:

MSSM inspired searches for neutral and charged bosons









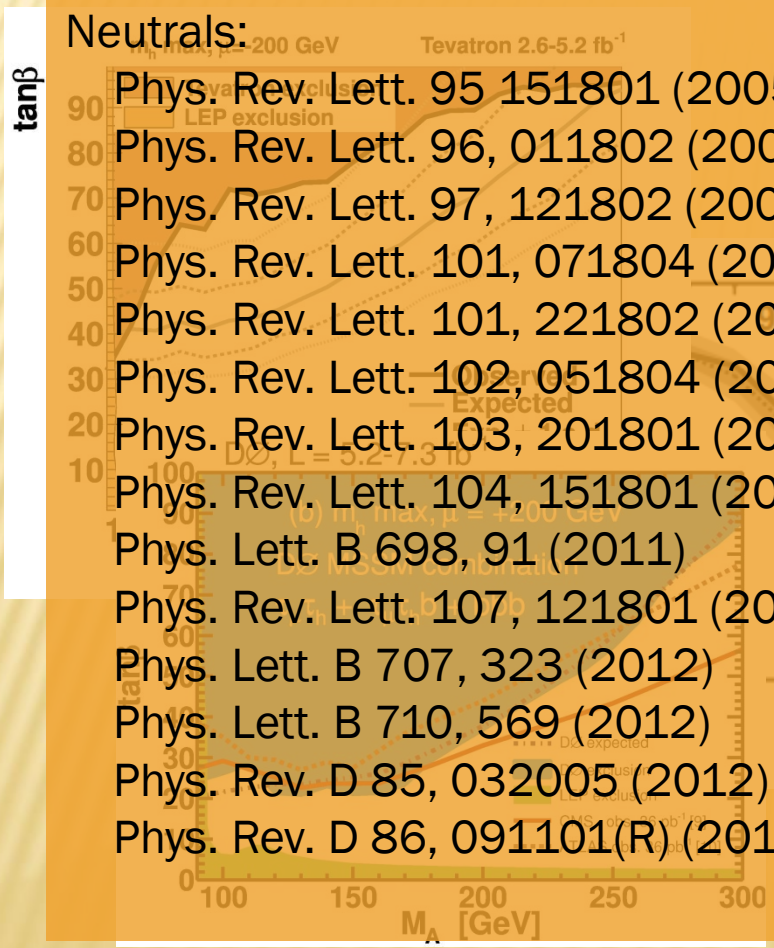
BSM HIGGS AT THE TEVATRON

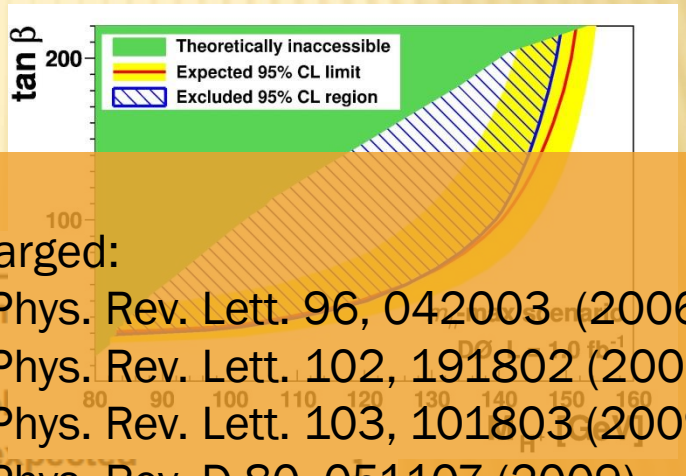
Many different searches over the years:

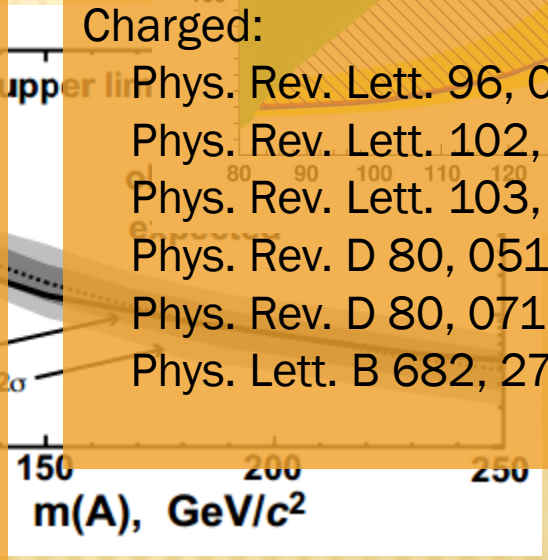
MSSM inspired searches for neutral and charged bosons

Neutrals:

- Phys. Rev. Lett. 95 151801 (2005)
- Phys. Rev. Lett. 96, 011802 (2006)
- Phys. Rev. Lett. 97, 121802 (2006)
- Phys. Rev. Lett. 101, 071804 (2008)
- Phys. Rev. Lett. 101, 221802 (2008)
- Phys. Rev. Lett. 102, 051804 (2009)
- Phys. Rev. Lett. 103, 201801 (2009)
- Phys. Rev. Lett. 104, 151801 (2010)
- Phys. Lett. B 698, 91 (2011)
- Phys. Rev. Lett. 107, 121801 (2011)
- Phys. Lett. B 707, 323 (2012)
- Phys. Lett. B 710, 569 (2012)
- Phys. Rev. D 85, 032005 (2012)
- Phys. Rev. D 86, 091101(R) (2012)





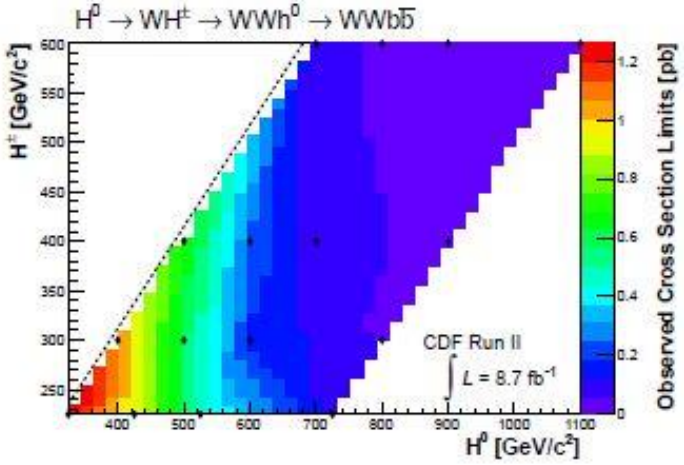


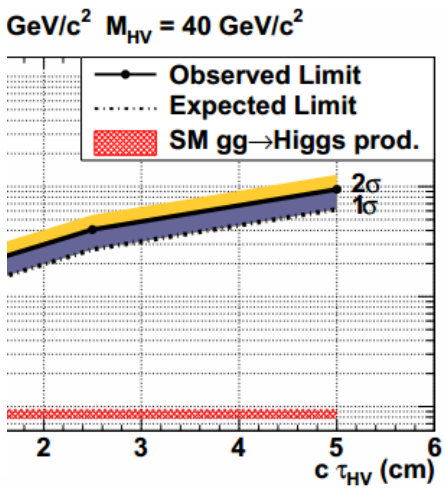
Charged:

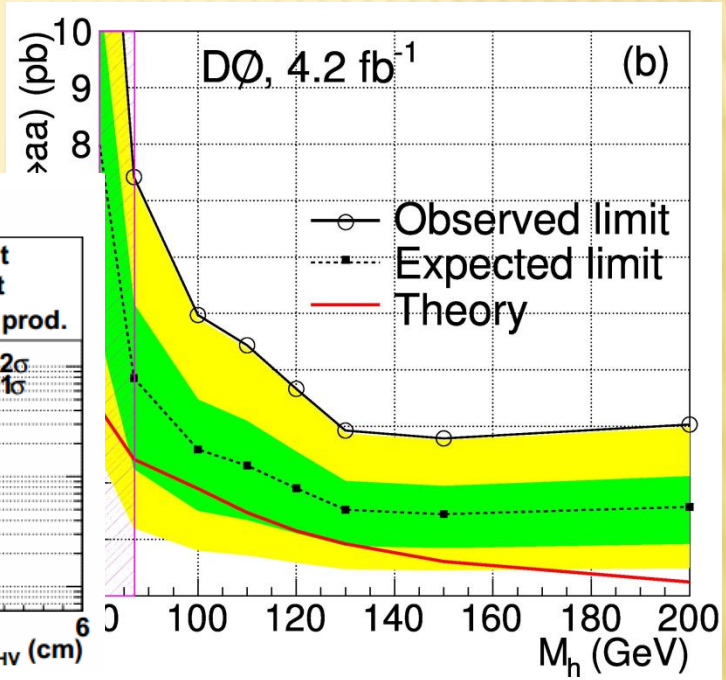
- Phys. Rev. Lett. 96, 042003 (2006)
- Phys. Rev. Lett. 102, 191802 (2009)
- Phys. Rev. Lett. 103, 101803 (2009)
- Phys. Rev. D 80, 051107 (2009)
- Phys. Rev. D 80, 071102 (2009)
- Phys. Lett. B 682, 278 (2009)

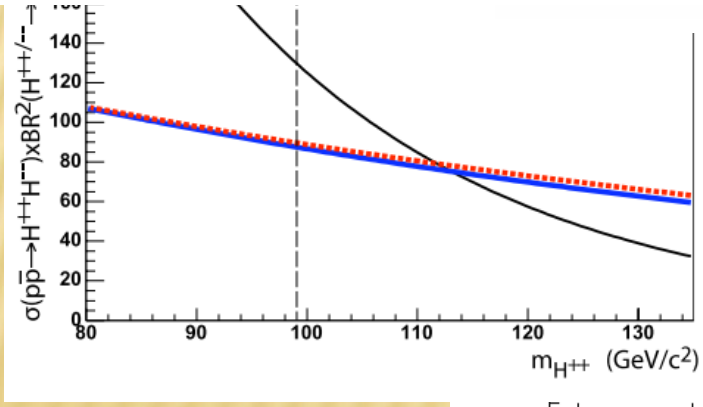
BSM HIGGS AT THE TEVATRON

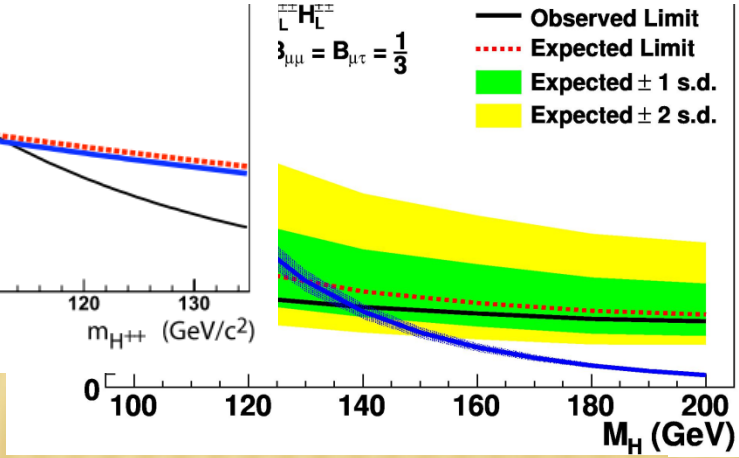
Many different searches over the years:
nMSSM, double charged bosons, long lived states, heavy states, Hidden valley scenarios

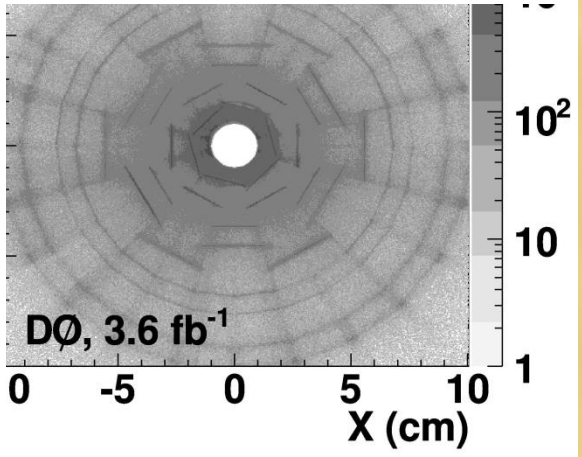












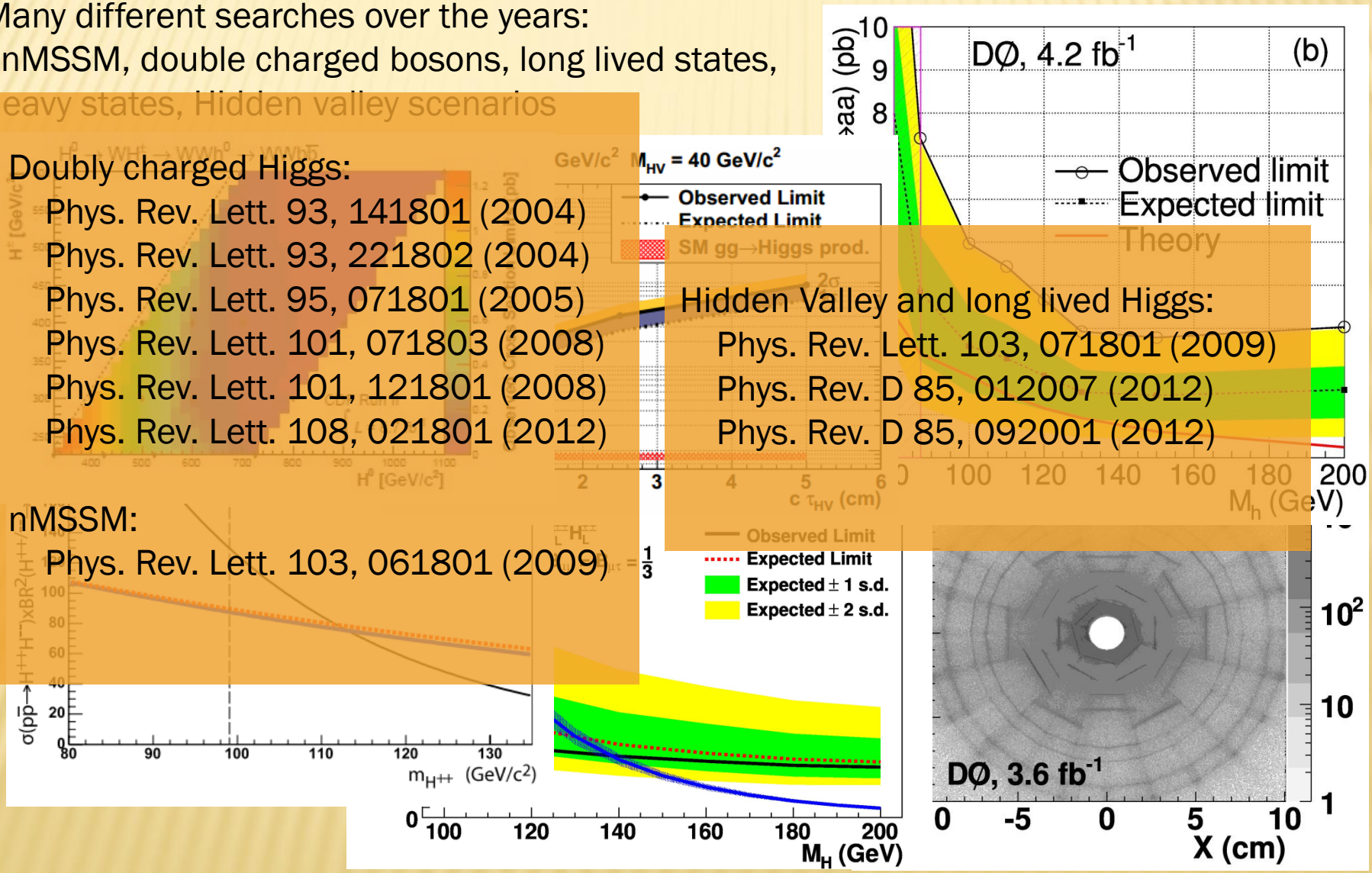
BSM HIGGS AT THE TEVATRON

Many different searches over the years:
nMSSM, double charged bosons, long lived states, heavy states, Hidden valley scenarios

Doubly charged Higgs:
- Phys. Rev. Lett. 93, 141801 (2004)
- Phys. Rev. Lett. 93, 221802 (2004)
- Phys. Rev. Lett. 95, 071801 (2005)
- Phys. Rev. Lett. 101, 071803 (2008)
- Phys. Rev. Lett. 101, 121801 (2008)
- Phys. Rev. Lett. 108, 021801 (2012)

nMSSM:
- Phys. Rev. Lett. 103, 061801 (2009)

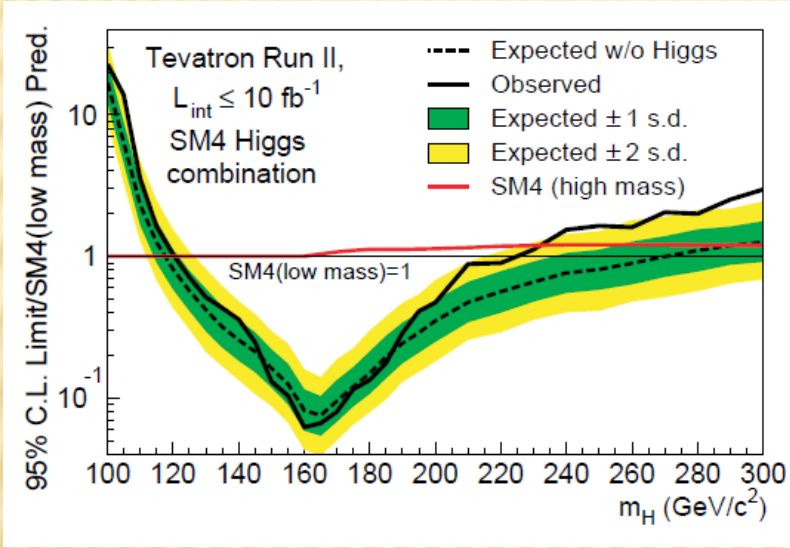
Hidden Valley and long lived Higgs:
- Phys. Rev. Lett. 103, 071801 (2009)
- Phys. Rev. D 85, 012007 (2012)
- Phys. Rev. D 85, 092001 (2012)

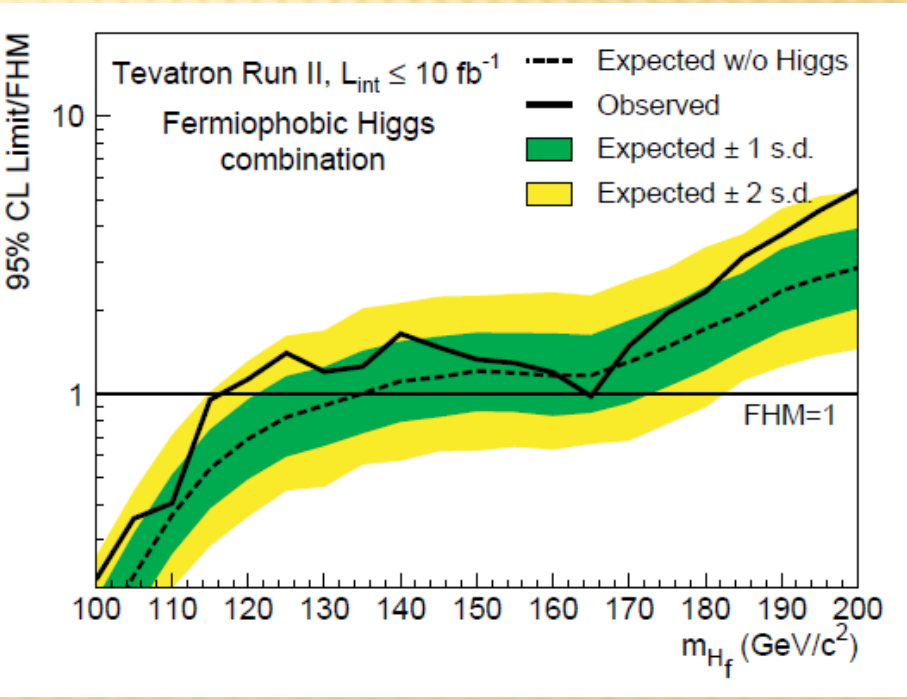


BSM HIGGS AT THE TEVATRON

Many different searches over the years:

Fermiophobic and 4th generation fermion scenarios



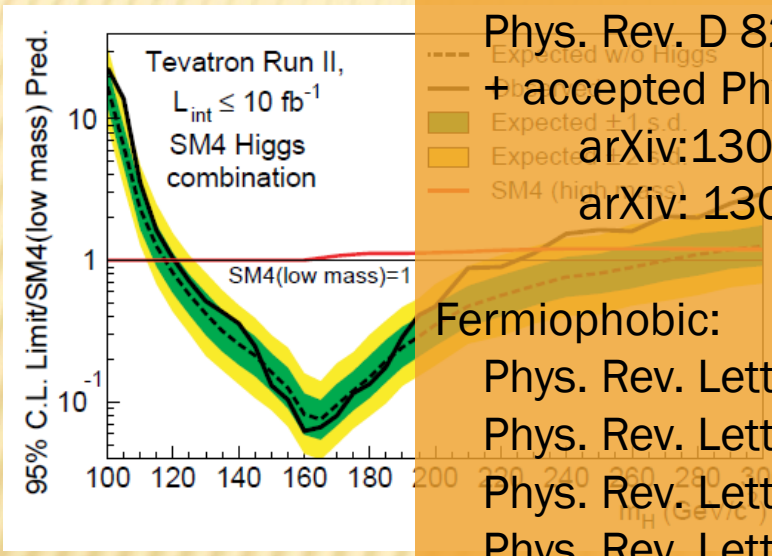


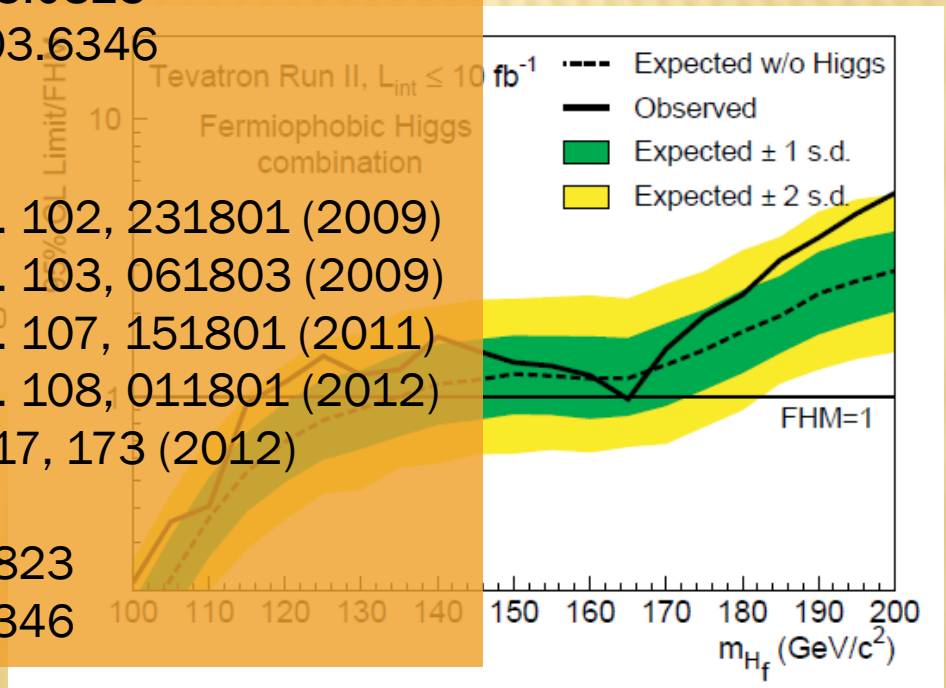
BSM HIGGS AT THE TEVATRON

Many different searches over the years:
Fermiophobic and 4th generation fermion scenarios

4th Generation Searches:
Phys. Rev. Lett. 96, 011801 (2006)
Phys. Rev. D 82, 011102 (2010)
+ accepted Phys. Rev. D:
arXiv:1303.0823
arXiv: 1303.6346

Fermiophobic:
Phys. Rev. Lett. 102, 231801 (2009)
Phys. Rev. Lett. 103, 061803 (2009)
Phys. Rev. Lett. 107, 151801 (2011)
Phys. Rev. Lett. 108, 011801 (2012)
Phys. Lett. B 717, 173 (2012)
Also in:
arXiv:1303.0823
arXiv:1303.6346



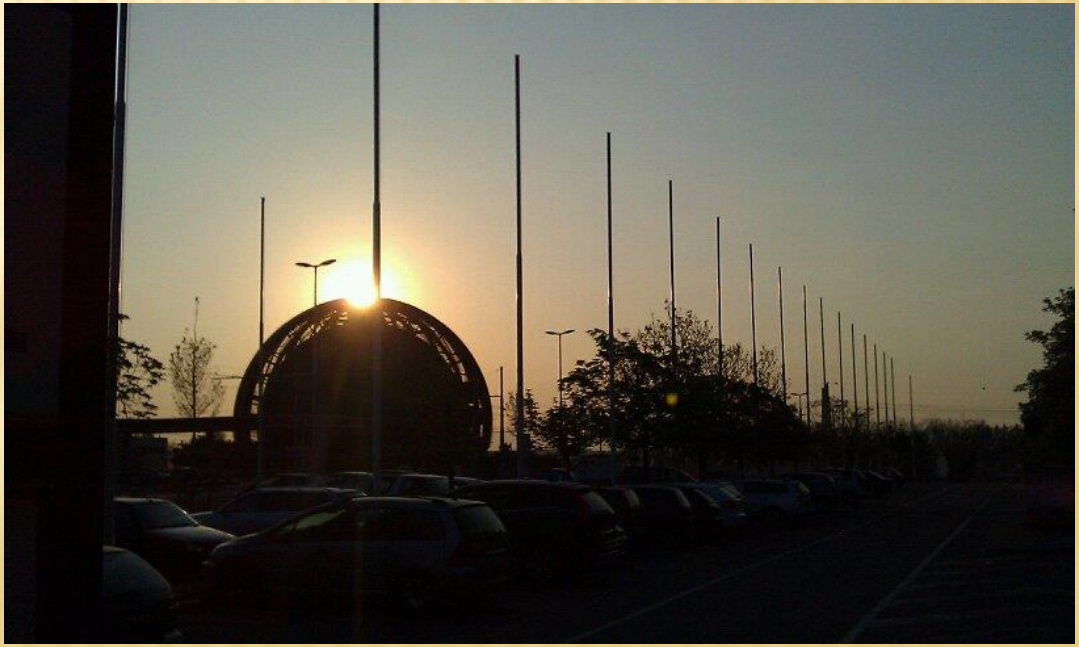


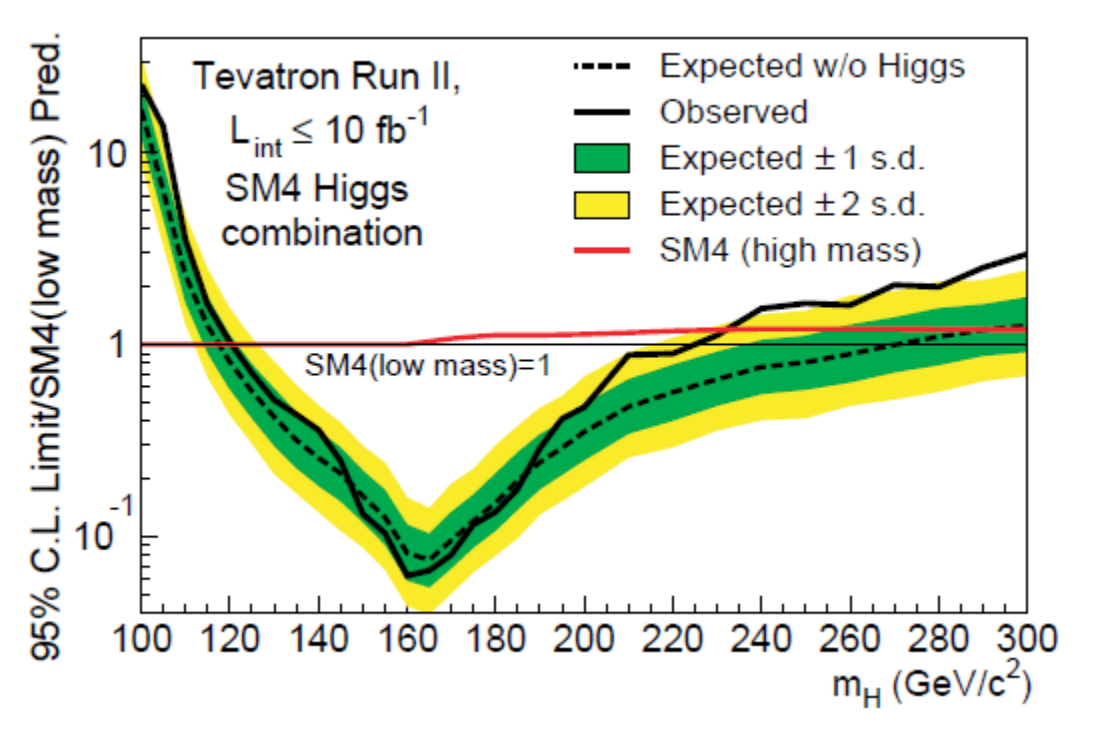
SUMMARY

Huge programme of research covering many areas of BSM Higgs physics

Over 40 publications in Run II ☺

No sign of physics beyond the SM ☹




Tevatron Run II,
$L_{int} \leq 10$ fb^{-1}
SM4 Higgs combination
Expected w/o Higgs
Observed
Expected ±1 s.d.
Expected ±2 s.d.
SM4 (high mass)
SM4(low mass)=1
95% C.L. Limit/SM4(low mass) Pred.
10
1
10^{-1}
100 120 140 160 180 200 220 240 260 280 300
m_H (GeV/c^2)