Higgs physics at the Tevatron

Fabrizio Margaroli
Sapienza U. & INFN

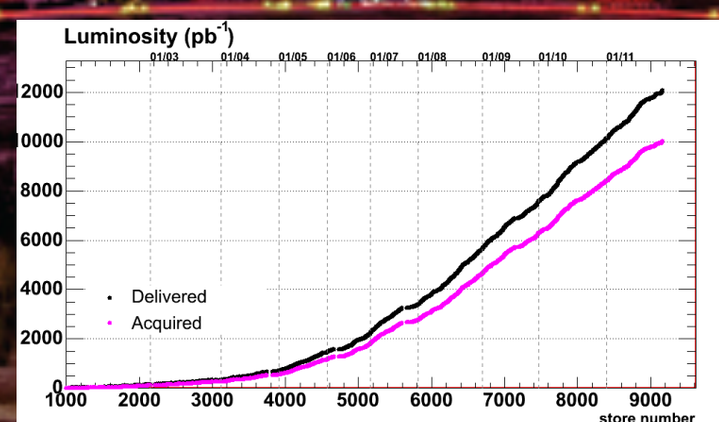
Tevatron

See monday's talk by Paul Grannis

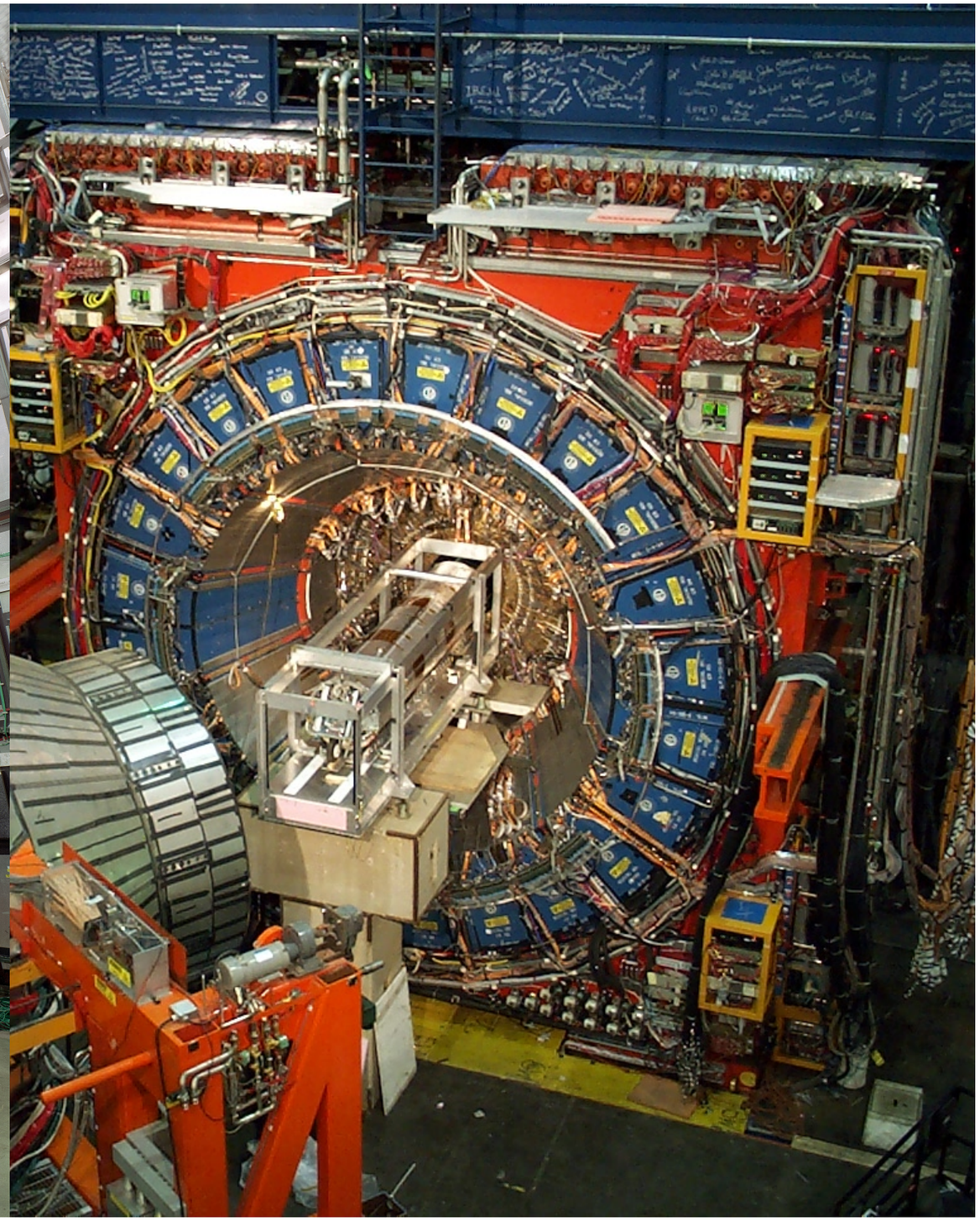
Tevatron

See monday's talk by Paul Grannis

Tevatron



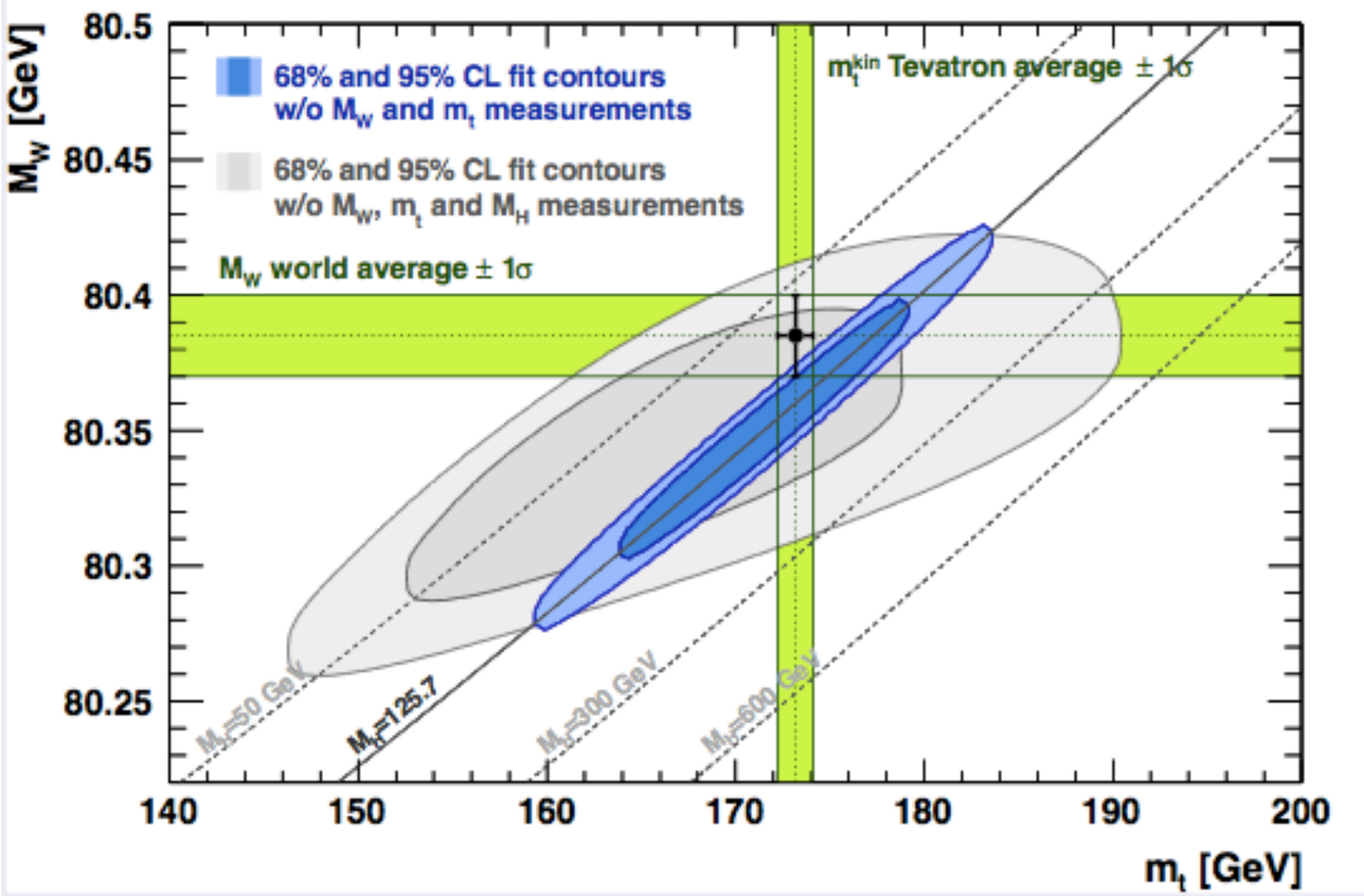
ITS DETECTORS



TeV role in SM self-consistency

- Measuring the W mass (a "non-resonance") or the top quark mass (a colored object) is a pretty complex business.
- A complex business that has been tackled with unexpected precision by the Tevatron experiments

EPJ C72 2205



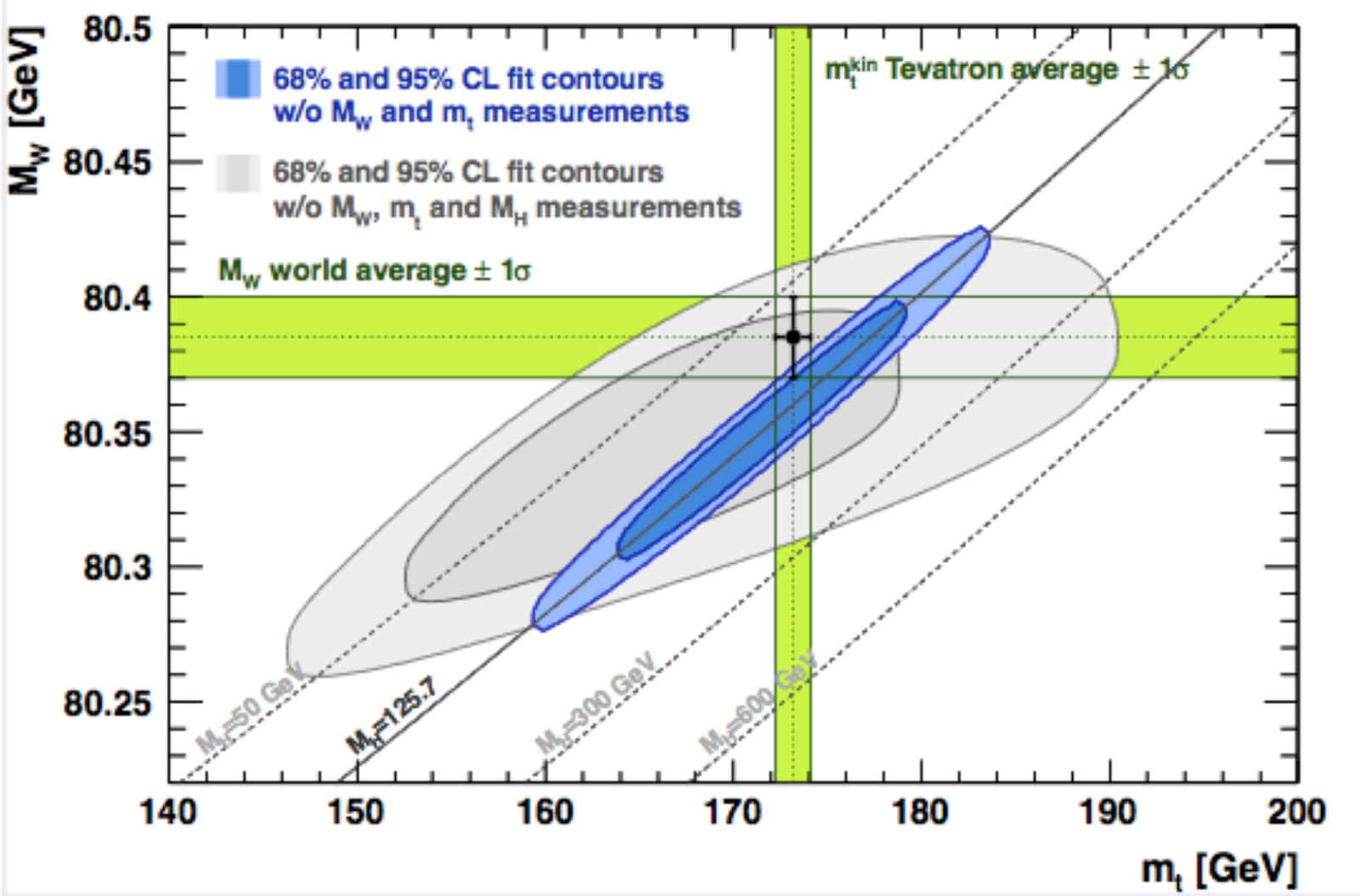
Predicted Higgs boson to be within 1sigma to where we found it!

Knowledge of Higgs mass allows prediction of Mtop to 1.4% level: Mtop=175.8±2.5GeV

TeV role in SM self-consistency

- Measuring the W mass (a "non-resonance") or the top quark mass (a colored object) is a pretty complex business.
- A complex business that has been tackled with unexpected precision by the Tevatron experiments

EPJ C72 2205



Predicted Higgs boson to be within 1sigma to where we found it!

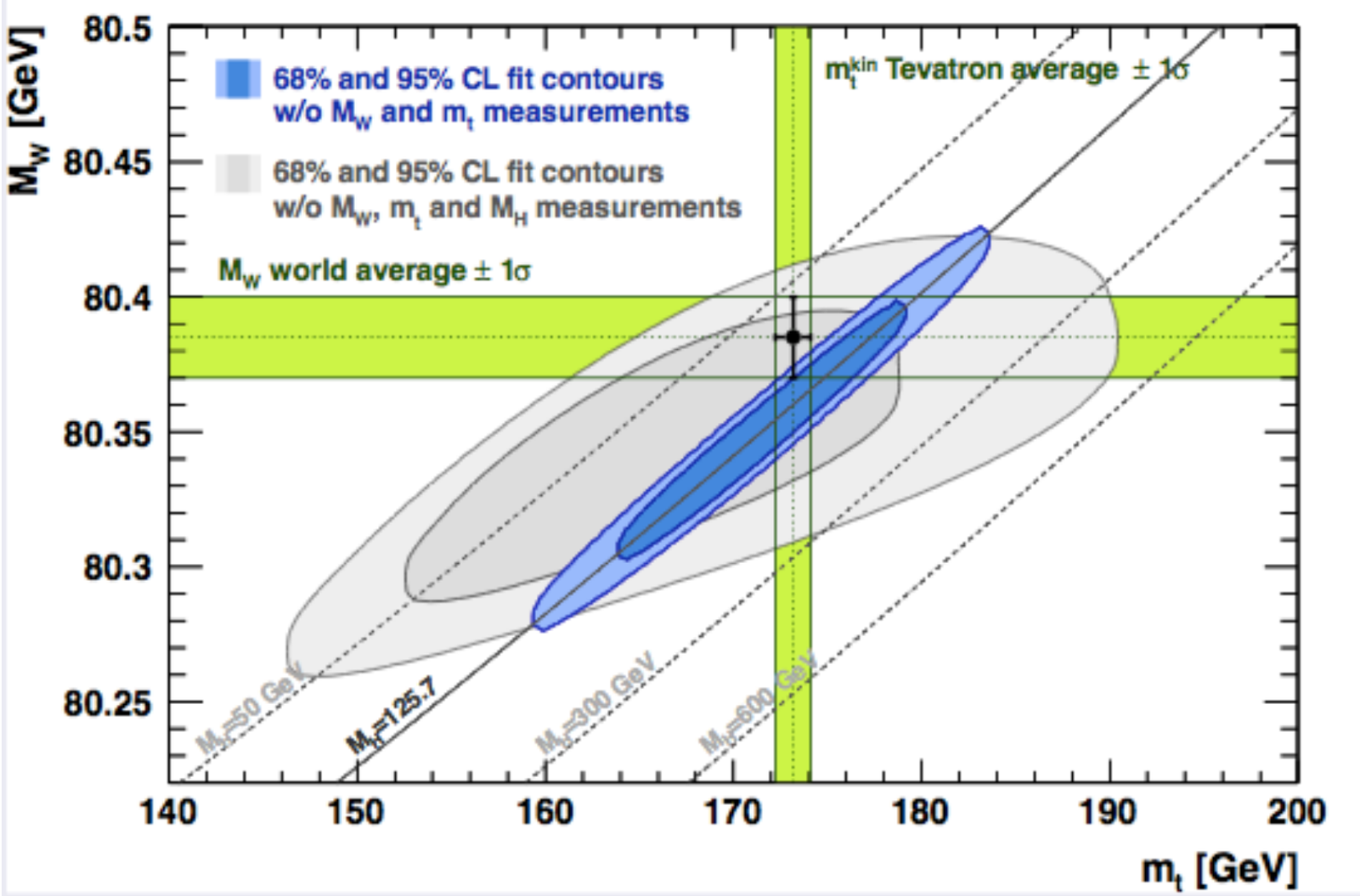
Knowledge of Higgs mass allows prediction of Mtop to 1.4% level: Mtop=175.8±2.5GeV

Latest D0 result moves in that direction

TeV role in SM self-consistency

- Measuring the W mass (a "non-resonance") or the top quark mass (a colored object) is a pretty complex business.
- A complex business that has been tackled with unexpected precision by the Tevatron experiments

EPJ C72 2205



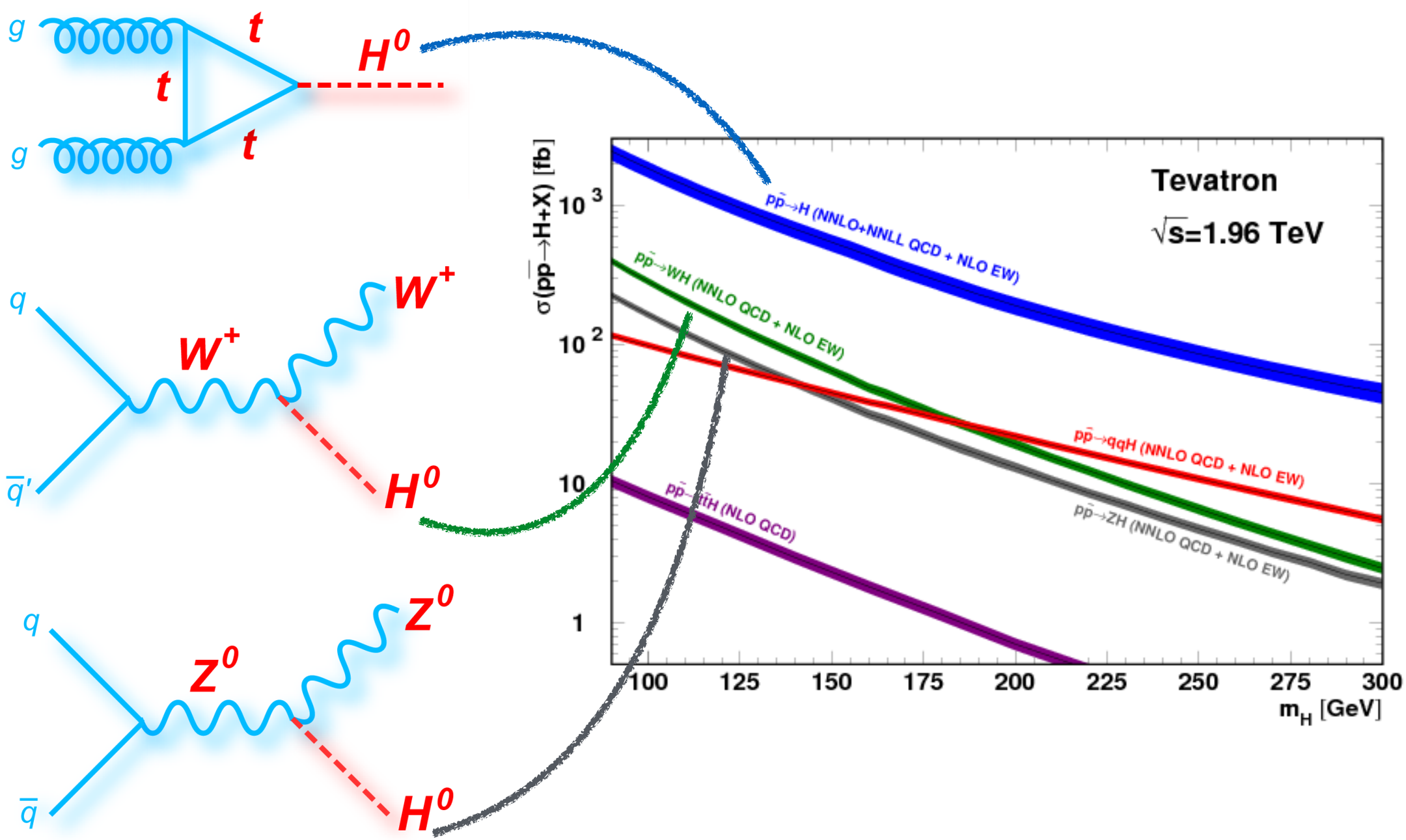
Predicted Higgs boson to be within 1sigma to where we found it!

Knowledge of Higgs mass allows prediction of Mtop to 1.4% level: Mtop=175.8±2.5GeV

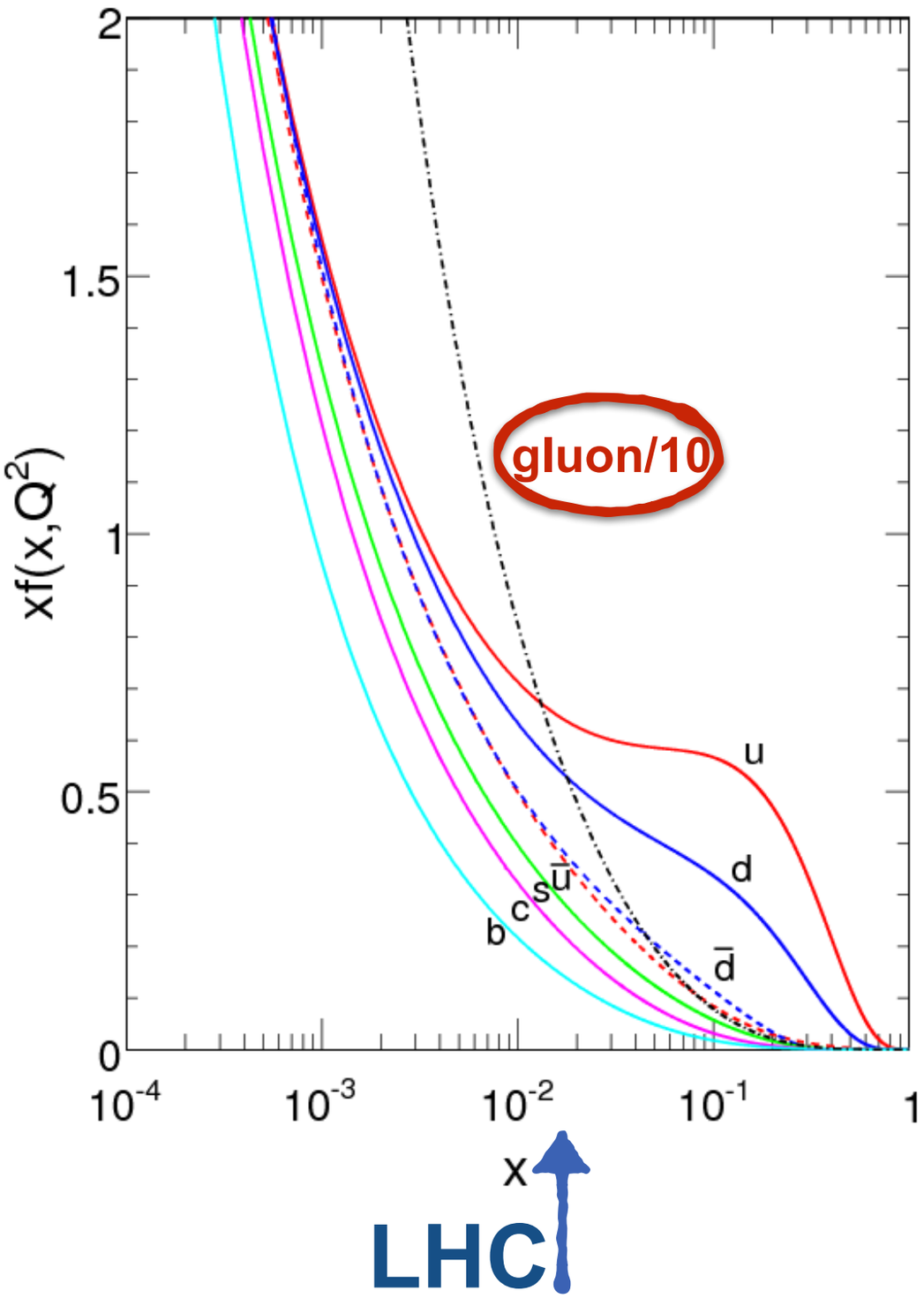
Latest D

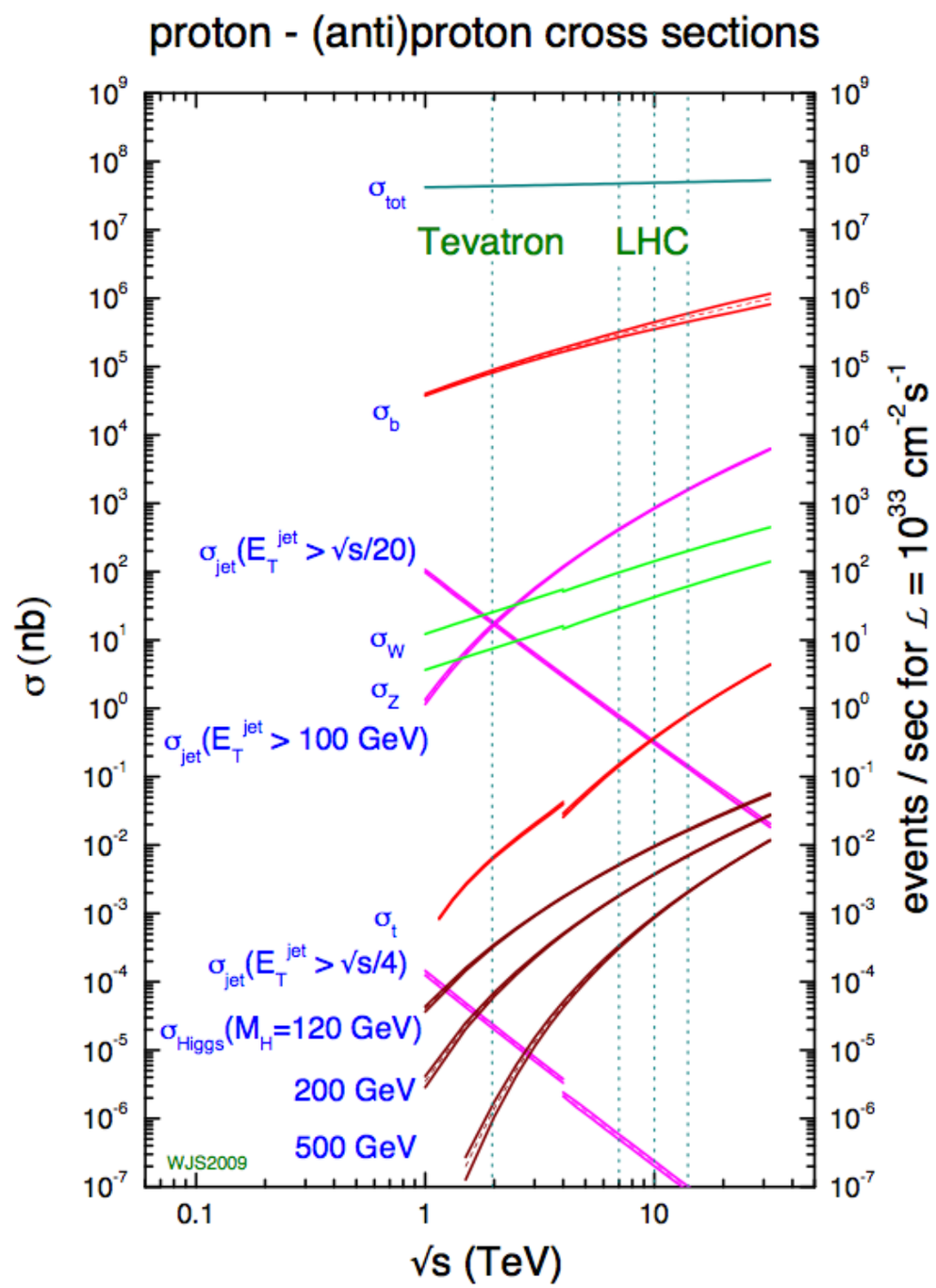
See tomorrow's talk by G.Petrillo

Higgs production at the Tevatron

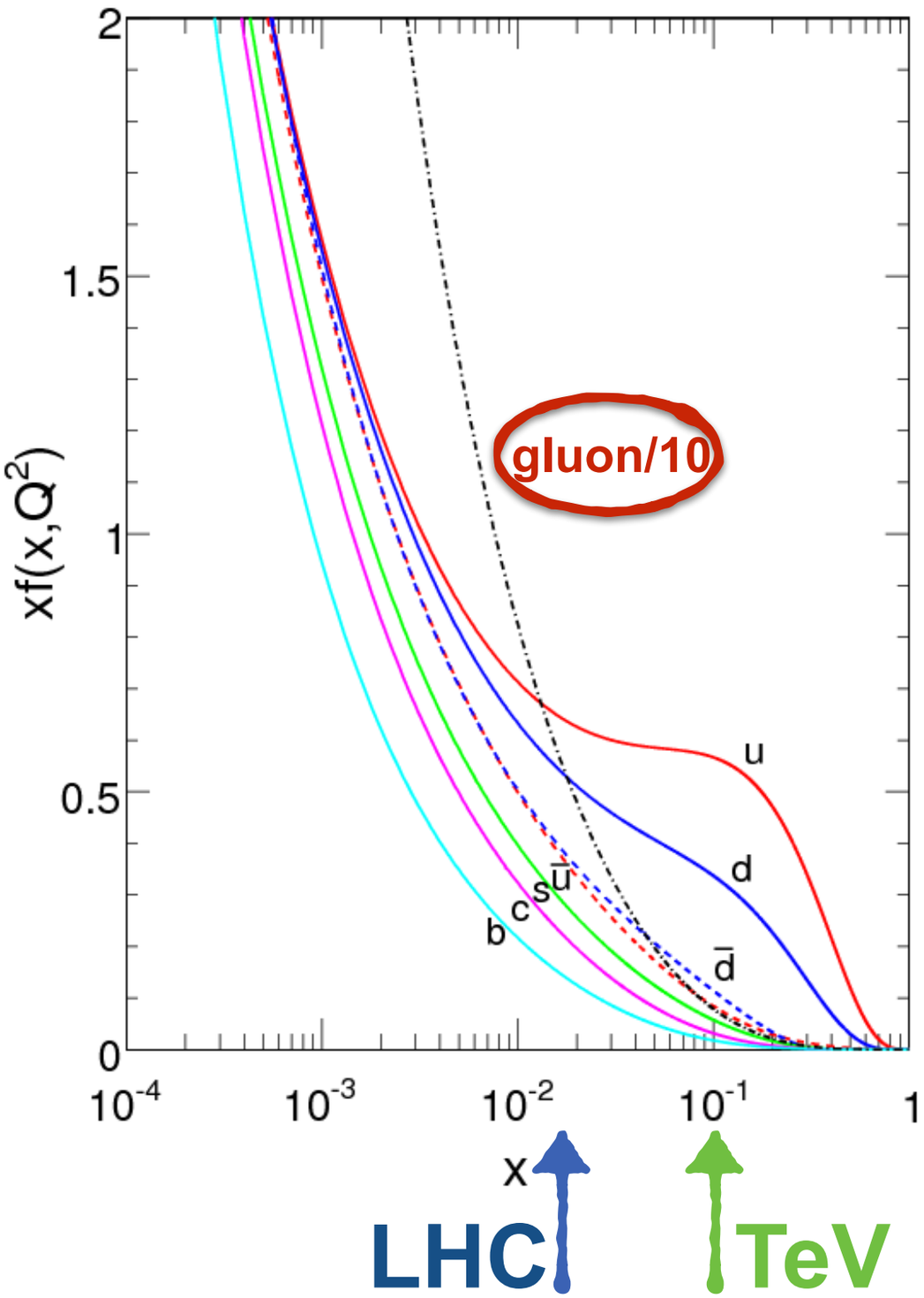


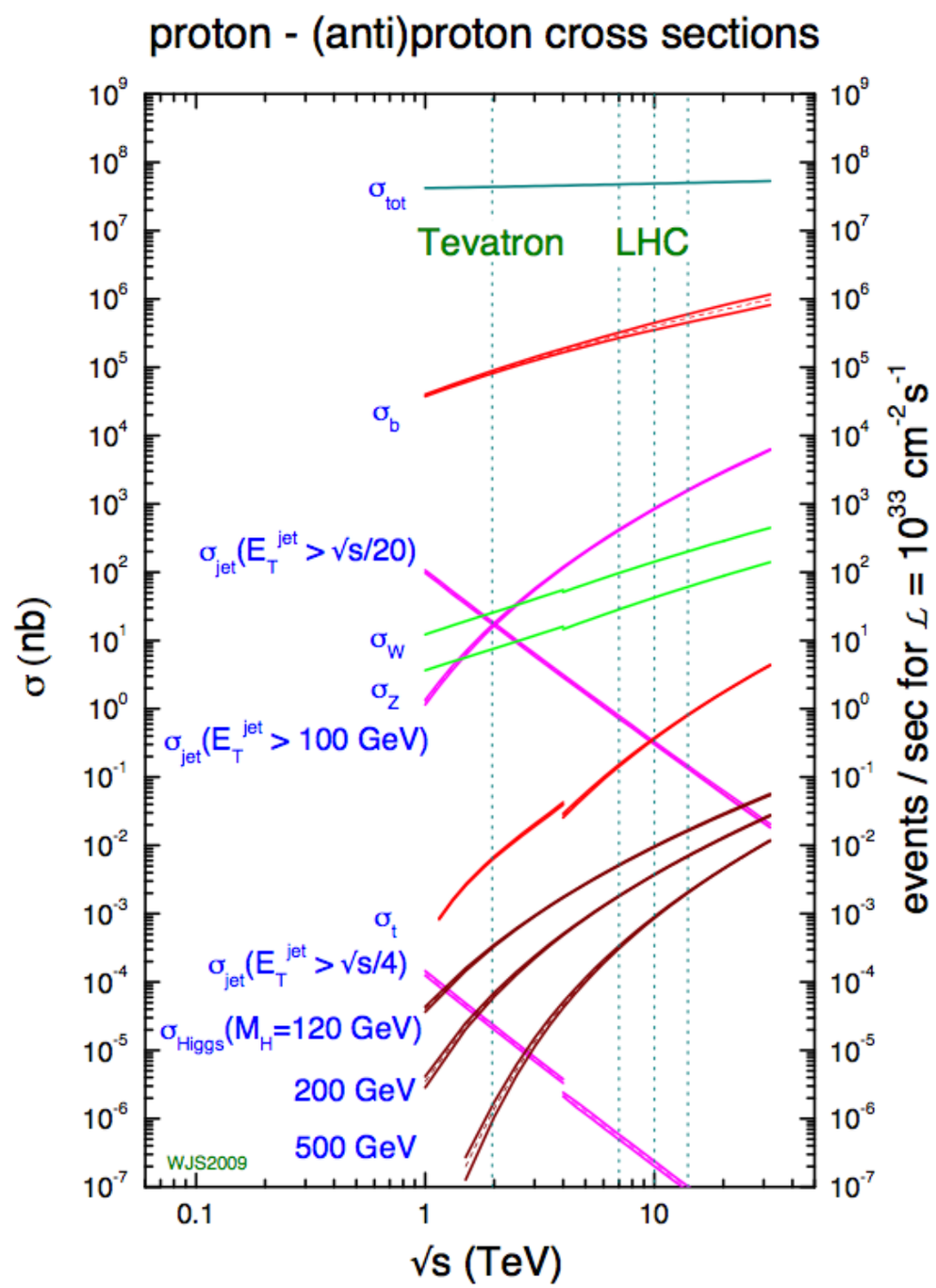
DIFFERENCES BETWEEN TEV AND LHC



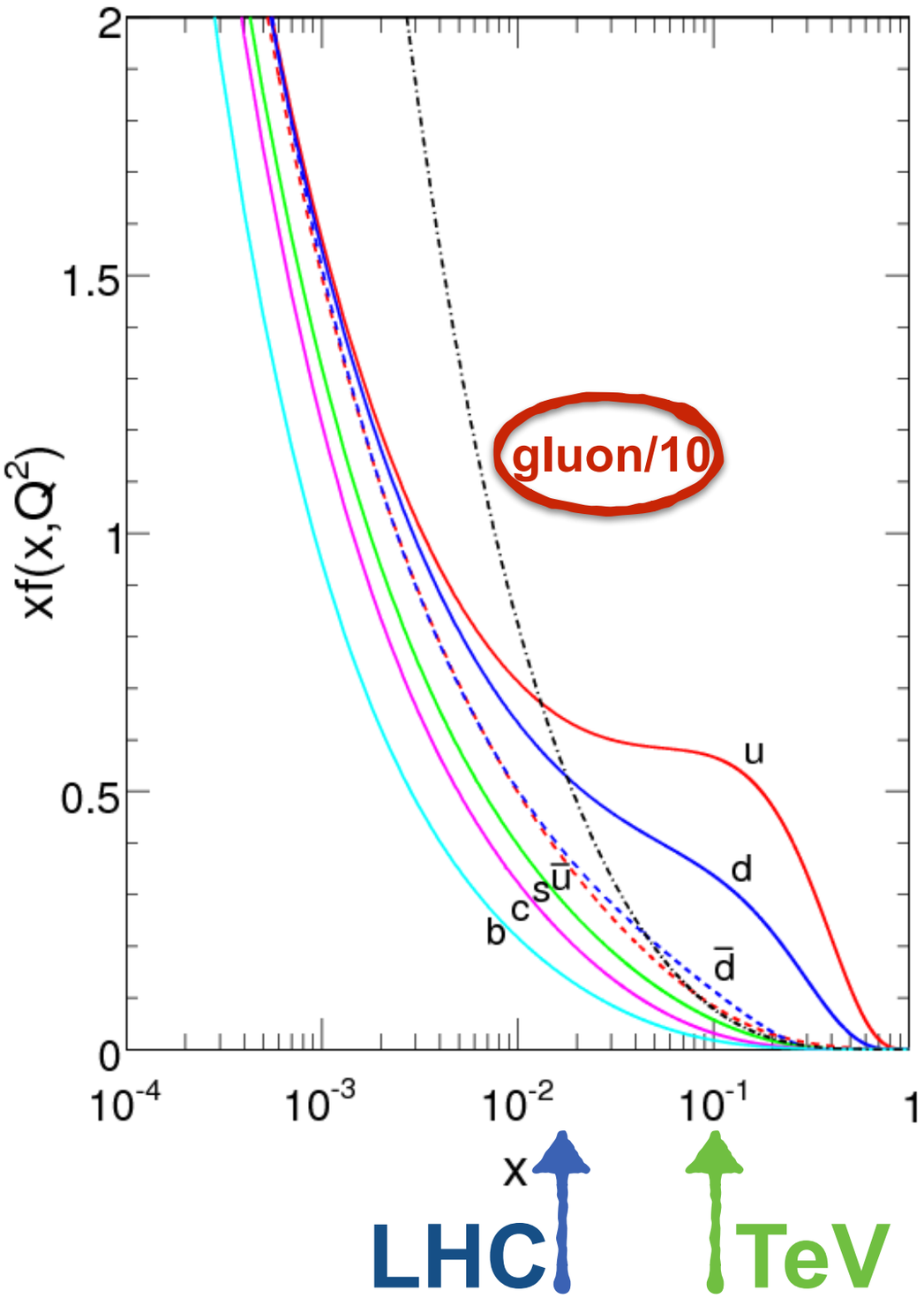


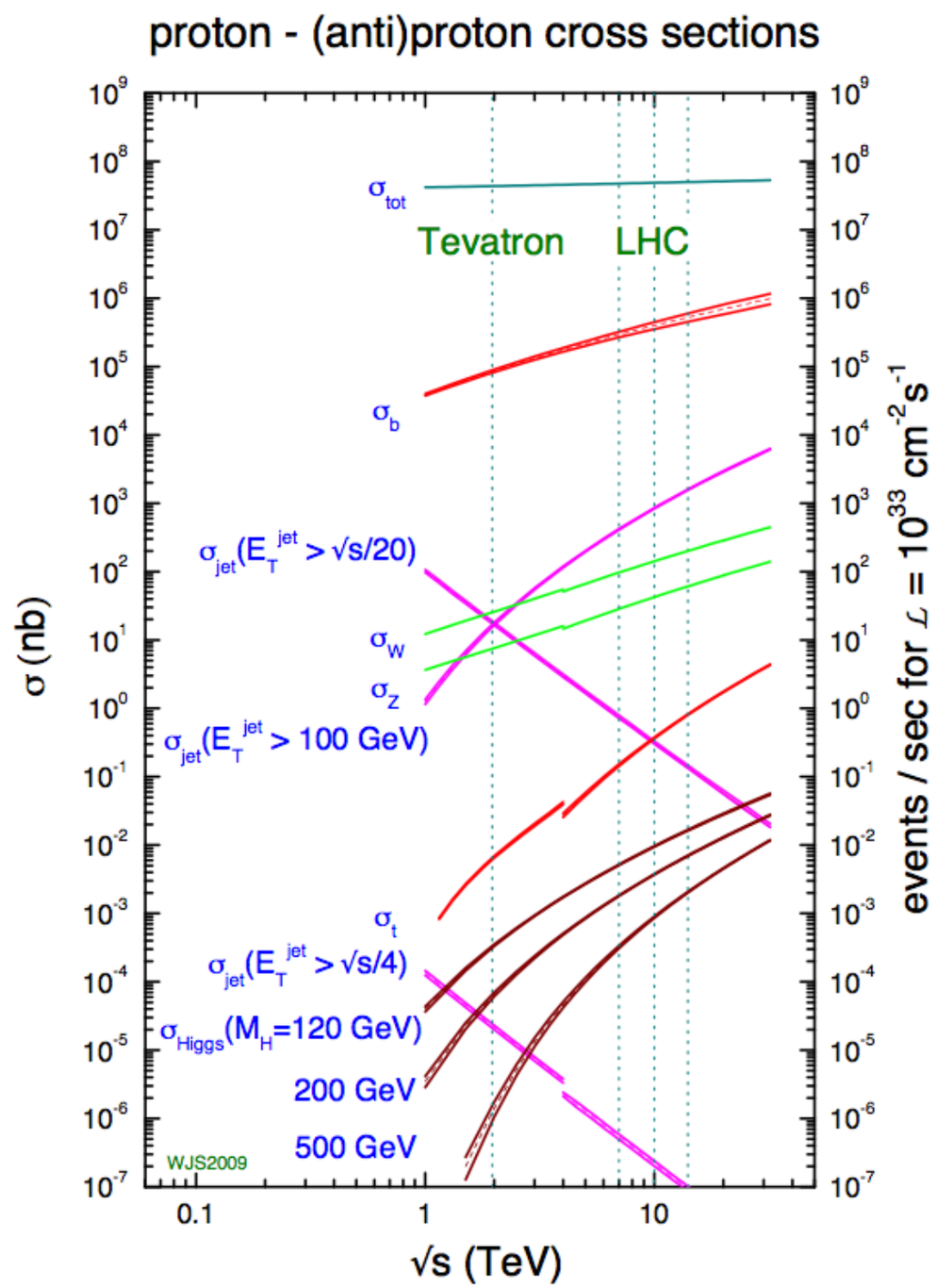
DIFFERENCES BETWEEN TEV AND LHC





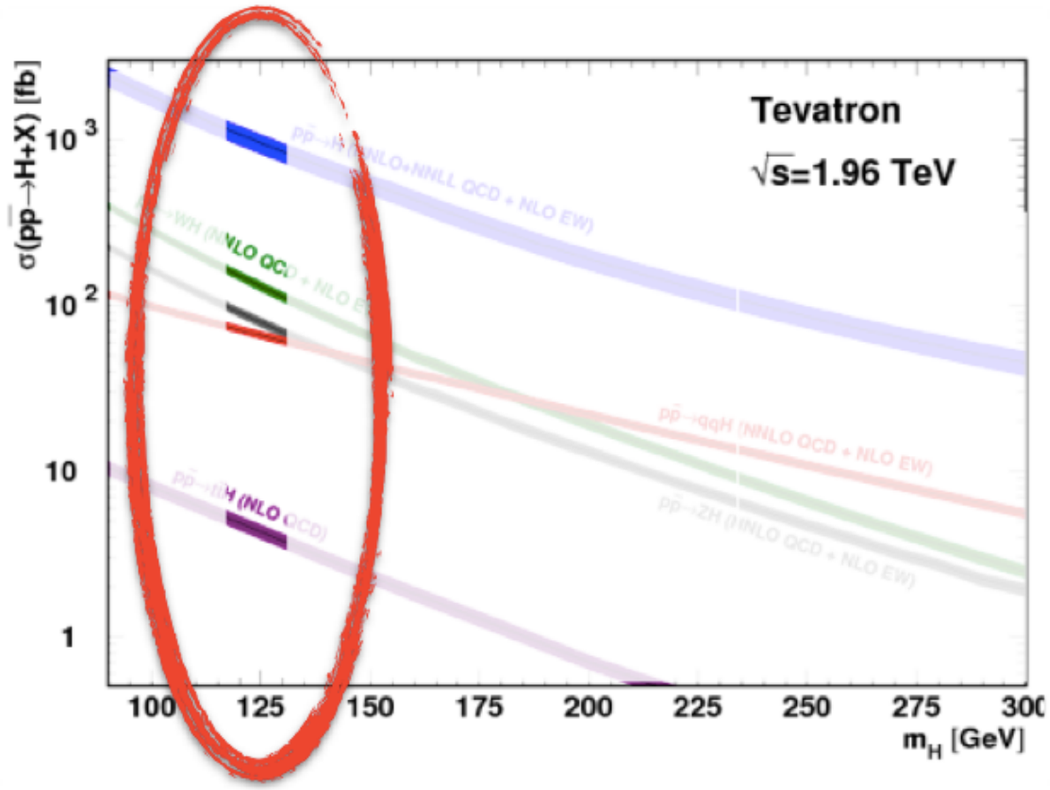
Differences between TeV and LHC

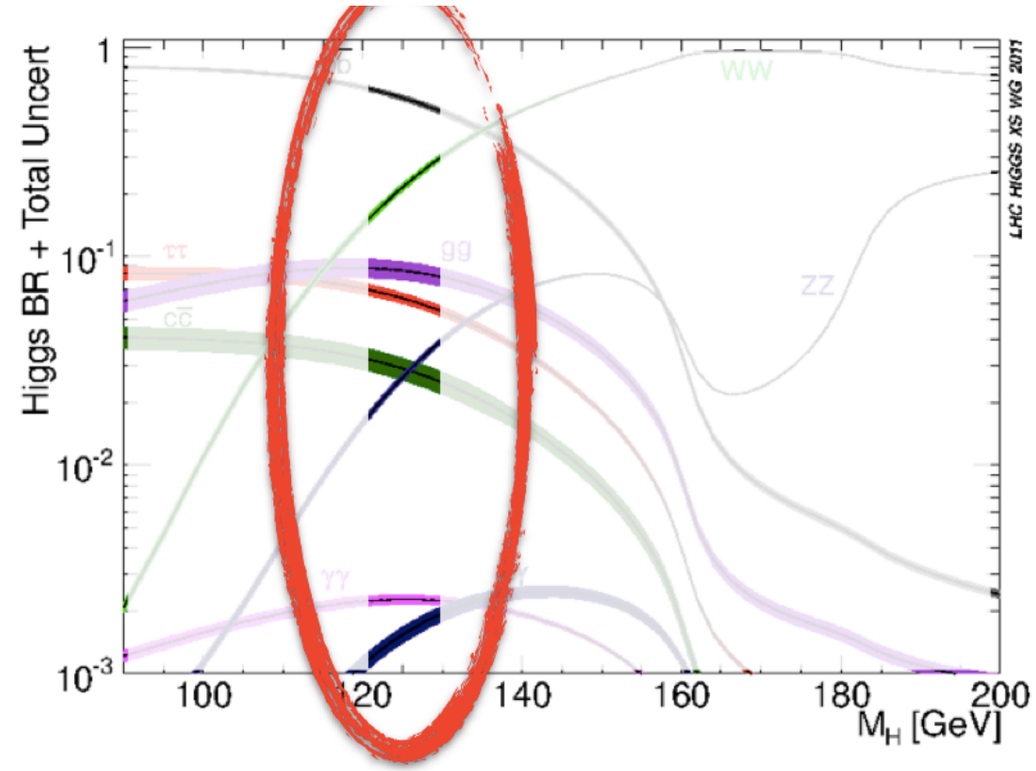


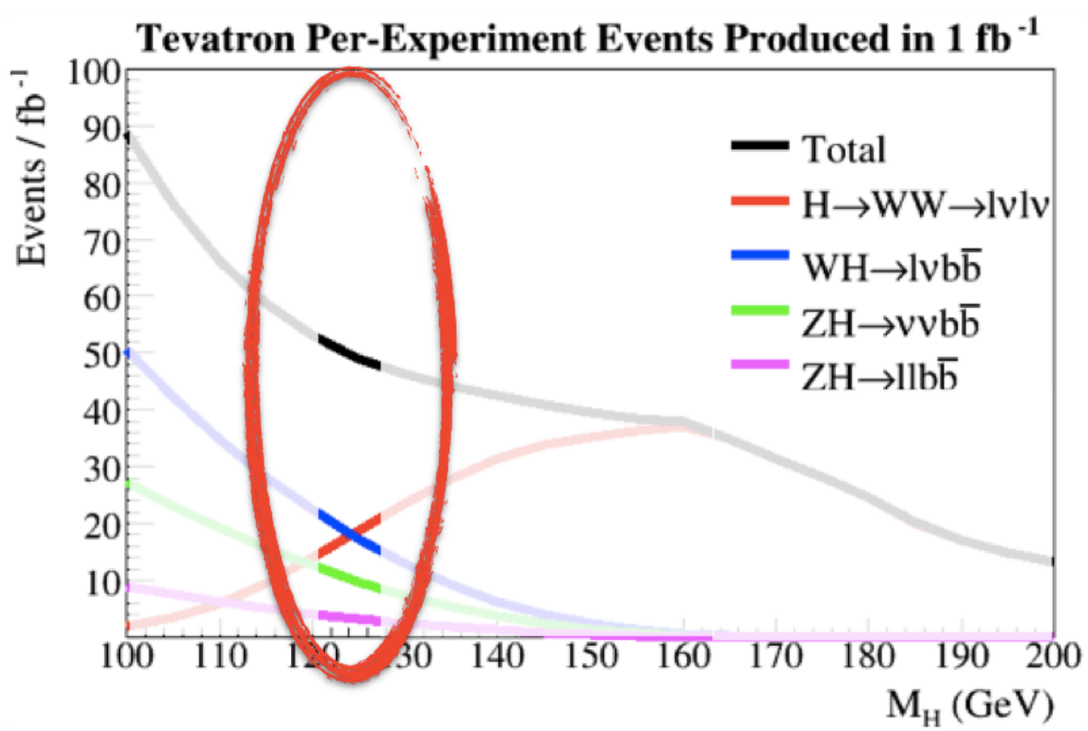


Tevatron is a quark collider

THE STRATEGY AT THE TEVATRON

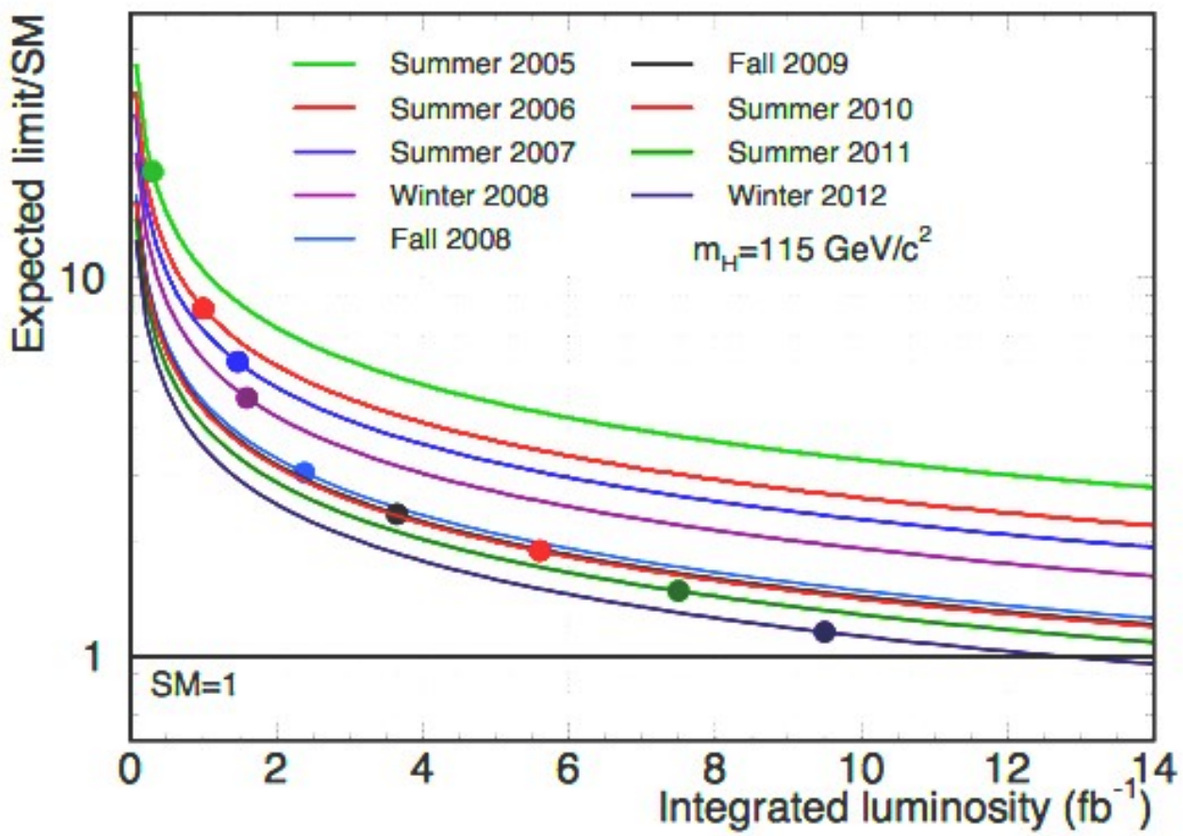


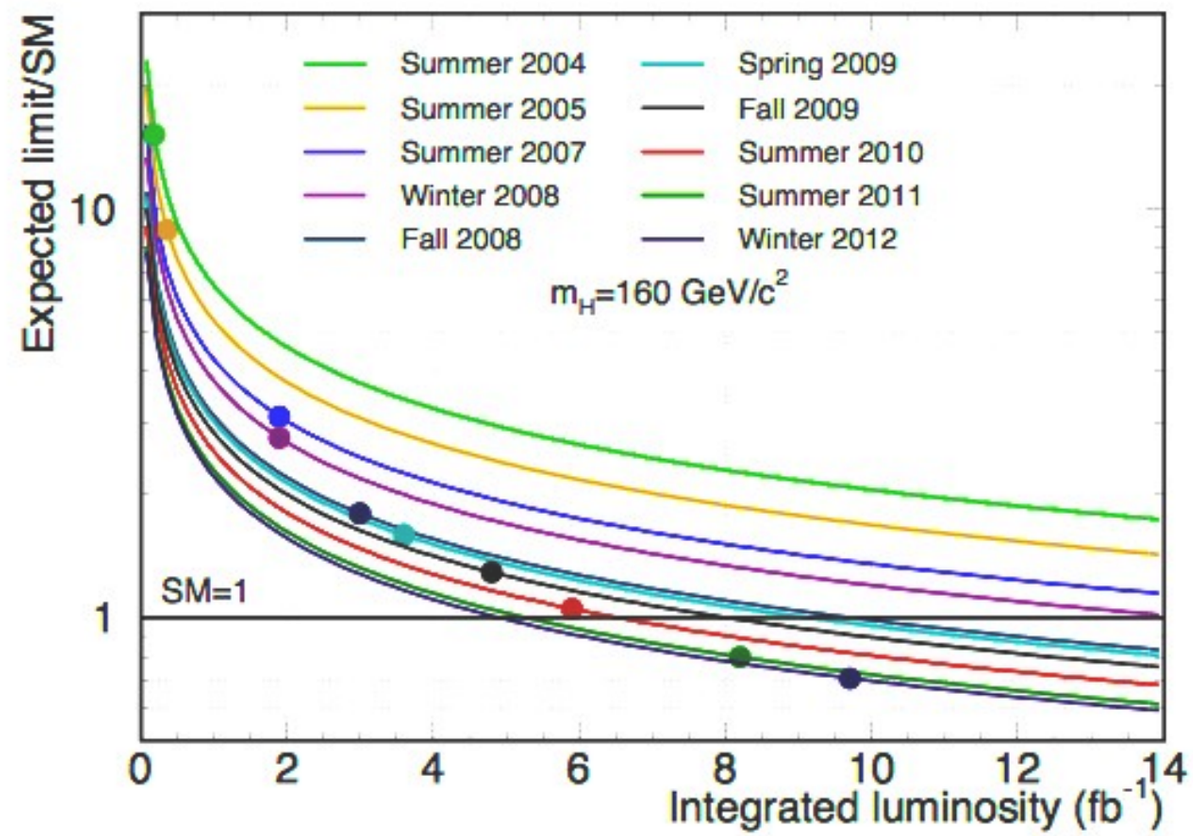




See also monday's talk by W.Fisher

CHALLENGES

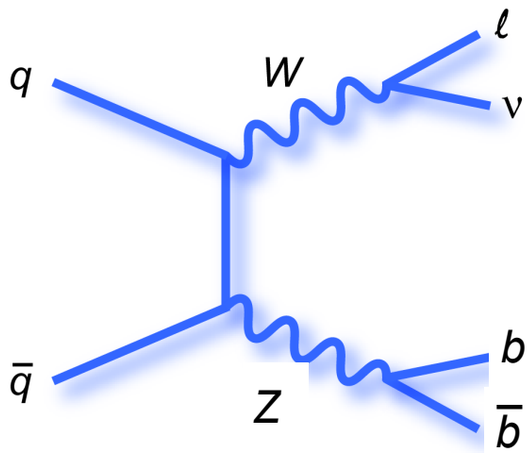

Expected limit/SM
Summer 2005
Summer 2006
Summer 2007
Winter 2008
Fall 2008
Fall 2009
Summer 2010
Summer 2011
Winter 2012
m_H=115 GeV/c^2
SM=1
10
1
0
2
4
6
8
10
12
14
Integrated luminosity (fb^{-1})


Expected limit/SM
Summer 2004
Summer 2005
Summer 2007
Winter 2008
Fall 2008
Spring 2009
Fall 2009
Summer 2010
Summer 2011
Winter 2012
m_H=160 GeV/c^2
SM=1
10
1
0
2
4
6
8
10
12
14
Integrated luminosity (fb^{-1})

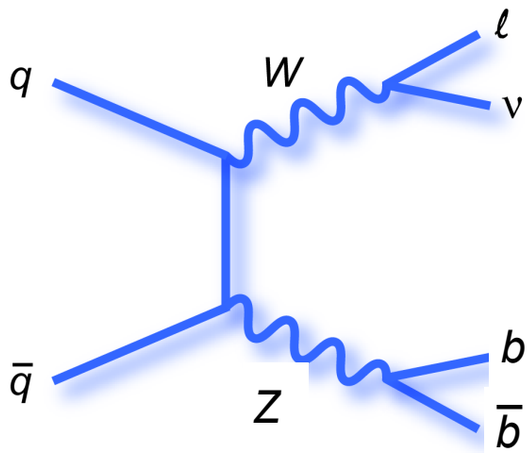
CHALLENGES

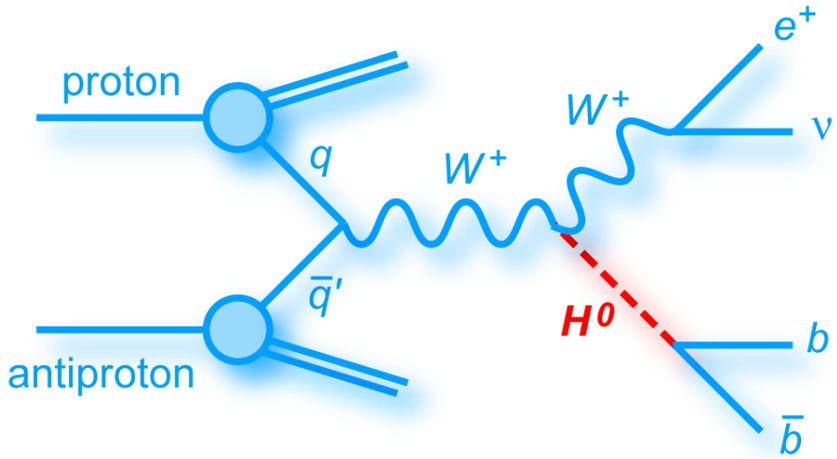
- A large number of challenges had to worked out to achieve sensitivity to Higgs boson
- Get enough luminosity - thanks to the excellent job by the FNAL Accelerator Division!
- Make most of this data available
  - monitor existing triggers, develop new
  - use all available triggers, even the dirtiest
- Improve object ID performance
  - b-tagging received a tremendous boost from Higgs searches
  - improve dijet mass resolution
- Improve understanding of the backgrounds
  - best theory-driven tools when possible
  - data-driven techniques whenever needed
- Adopt multivariate approach at every step of the analyses
- ***Put the hard-learned lessons to use to maximize the physics output***

VALIDATION OF LOW-MASS SEARCHES(1)

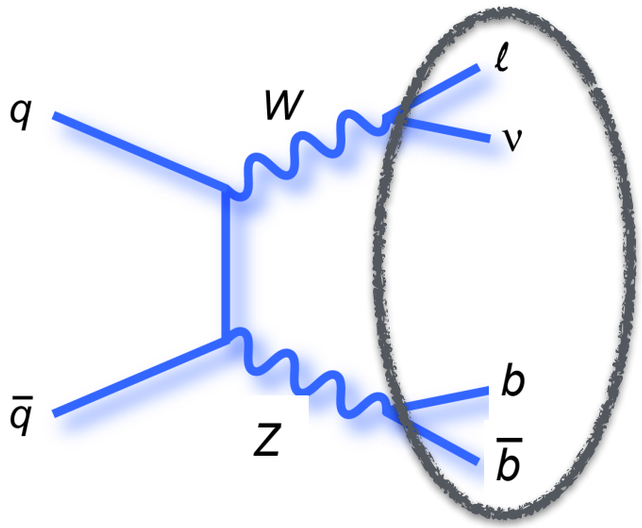


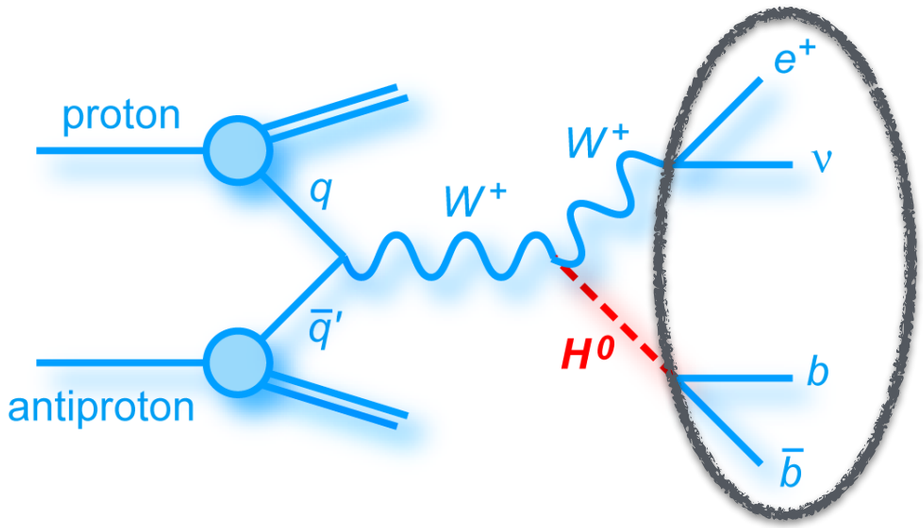
VALIDATION OF LOW-MASS SEARCHES(1)



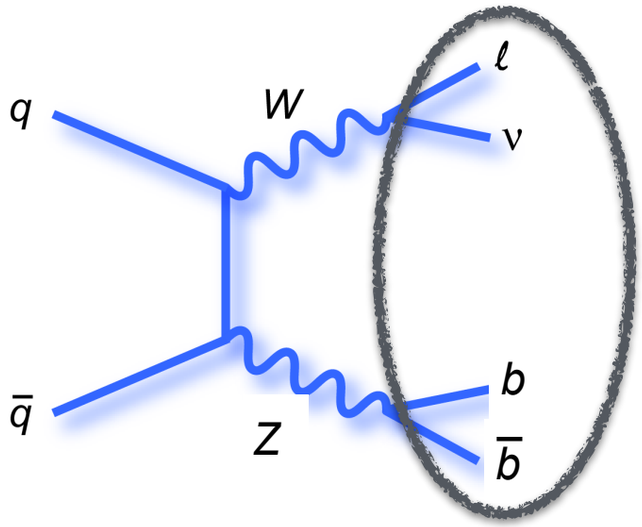


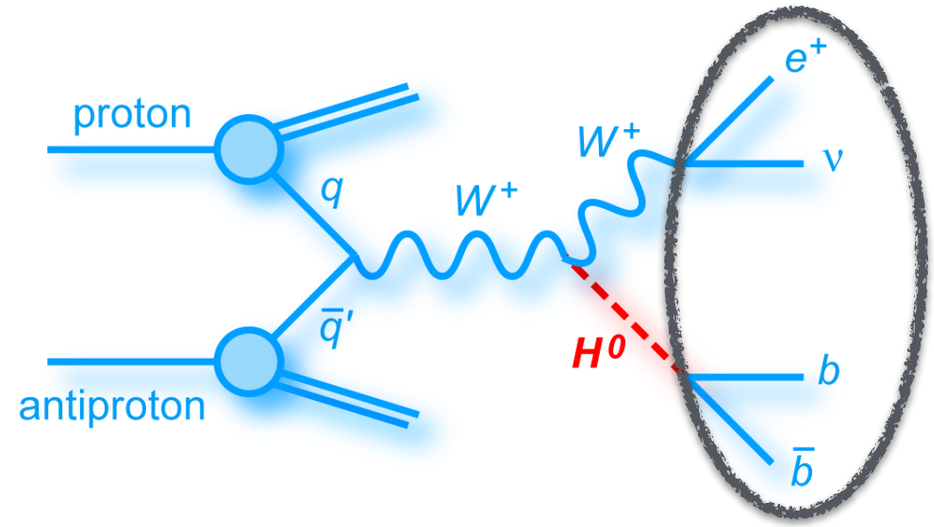
VALIDATION OF LOW-MASS SEARCHES(1)



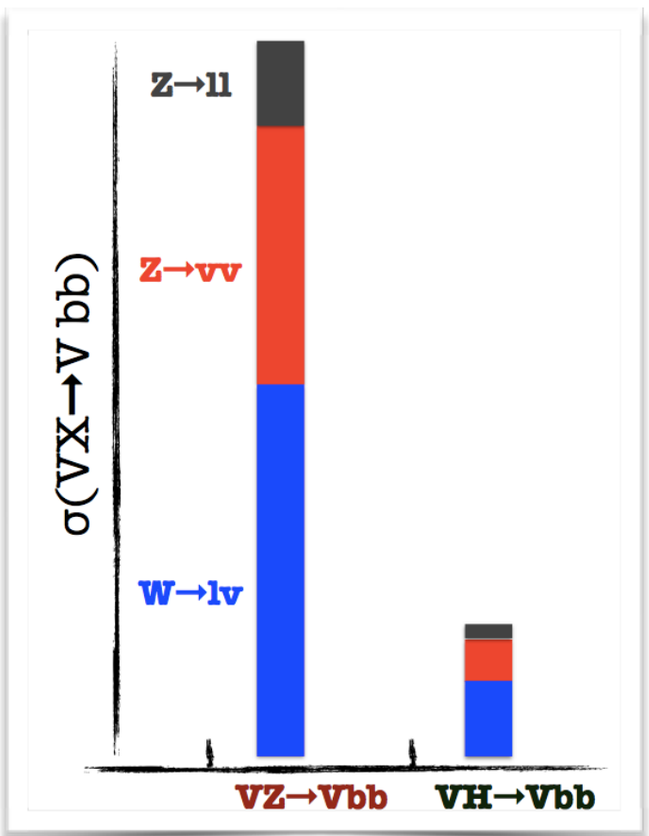


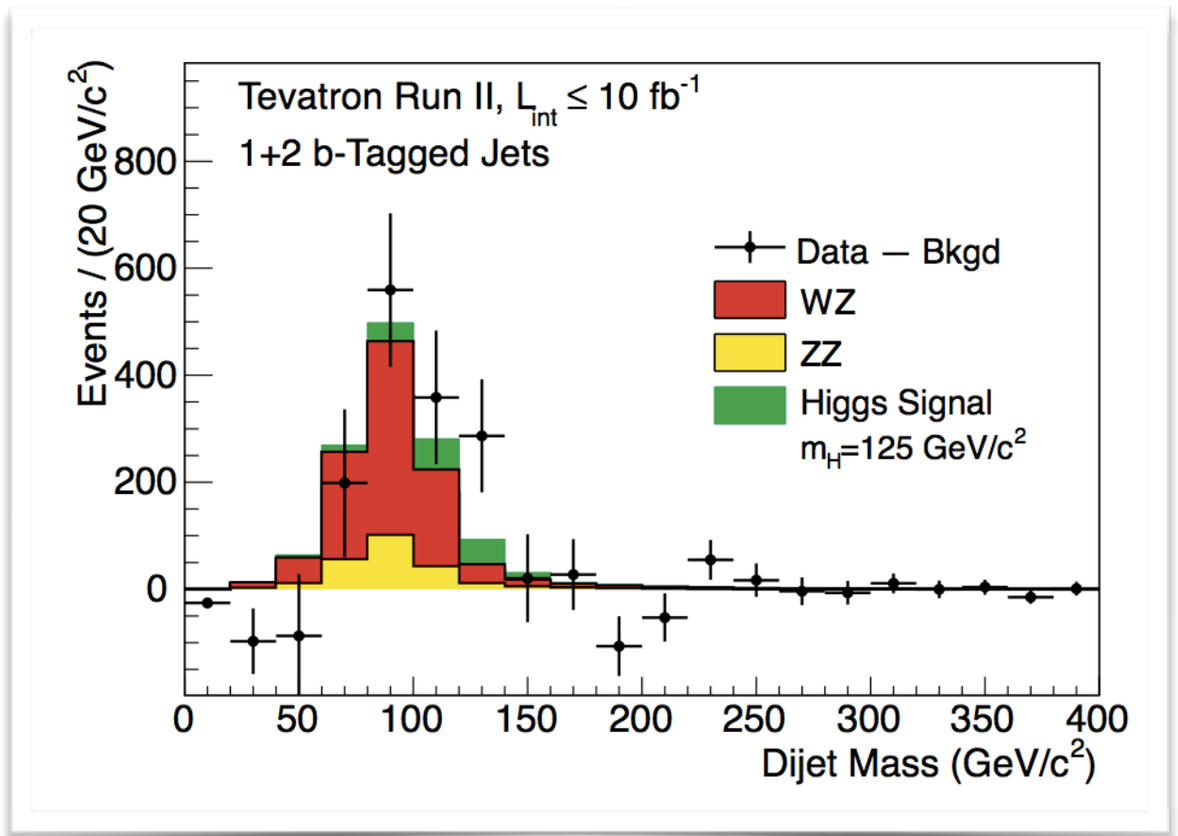
VALIDATION OF LOW-MASS SEARCHES(1)





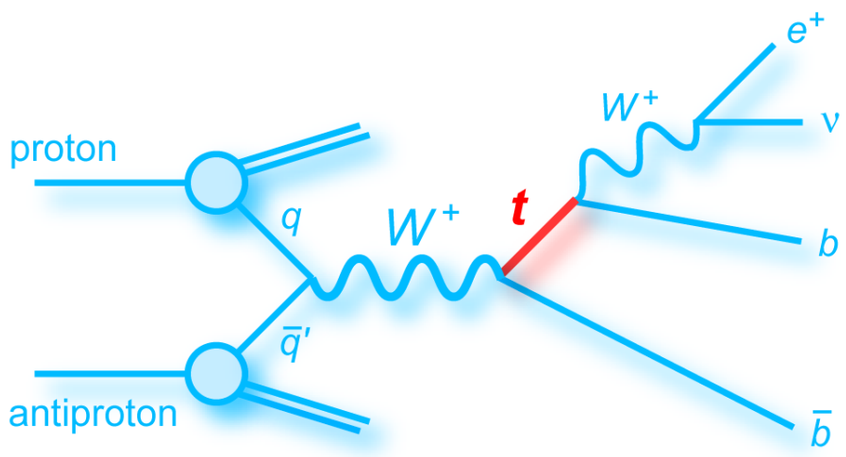
- VZ→Vbb cros sectionXBR is 6 times VH→Vbb but with less striking kinematic



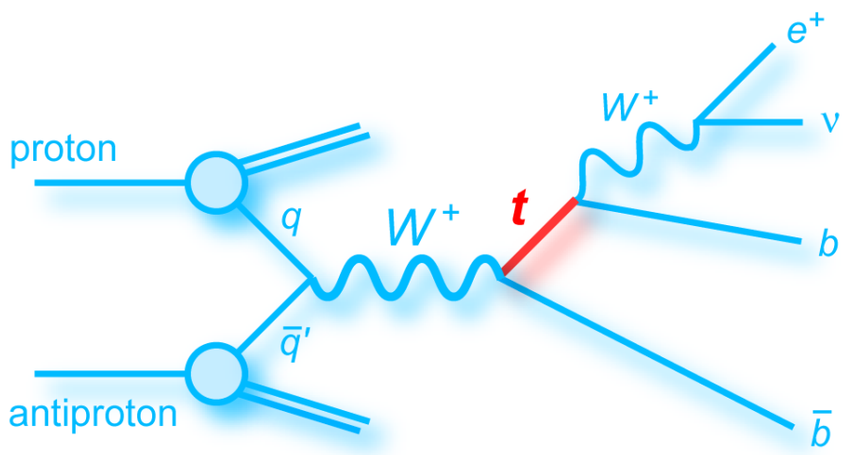


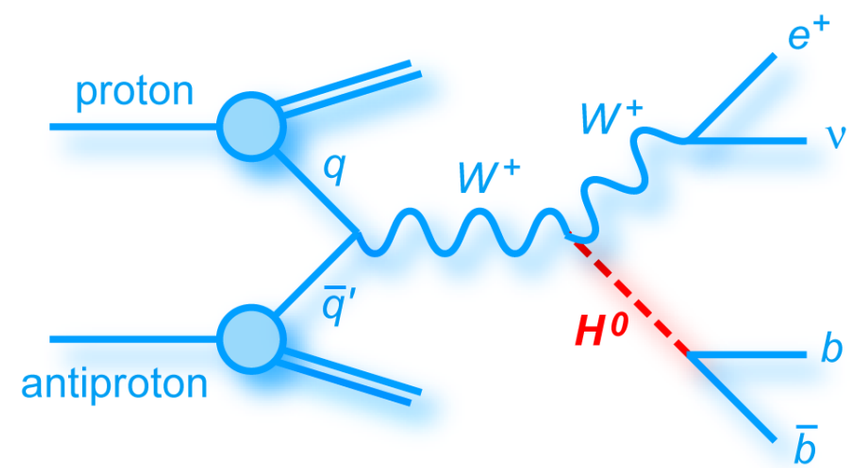
- The measured cross section using MVAs for VZ production is 3.0±0.9pb (4.4pb SM)

VALIDATION OF LOW-MASS SEARCHES(2)

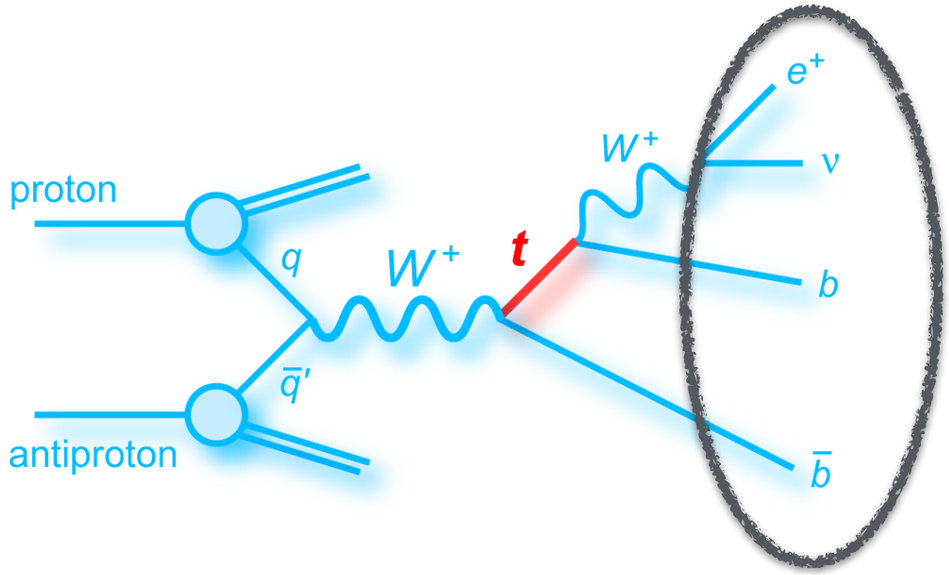


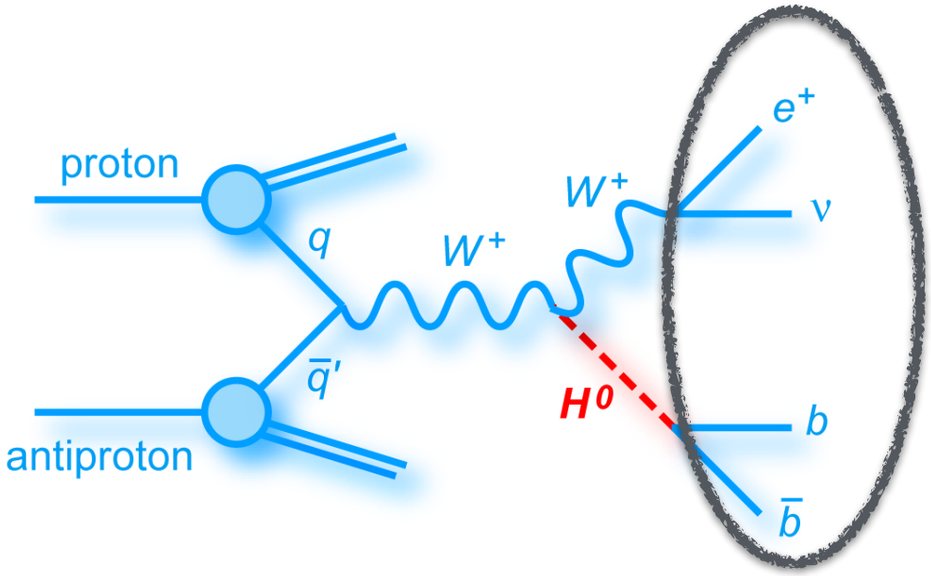
VALIDATION OF LOW-MASS SEARCHES(2)



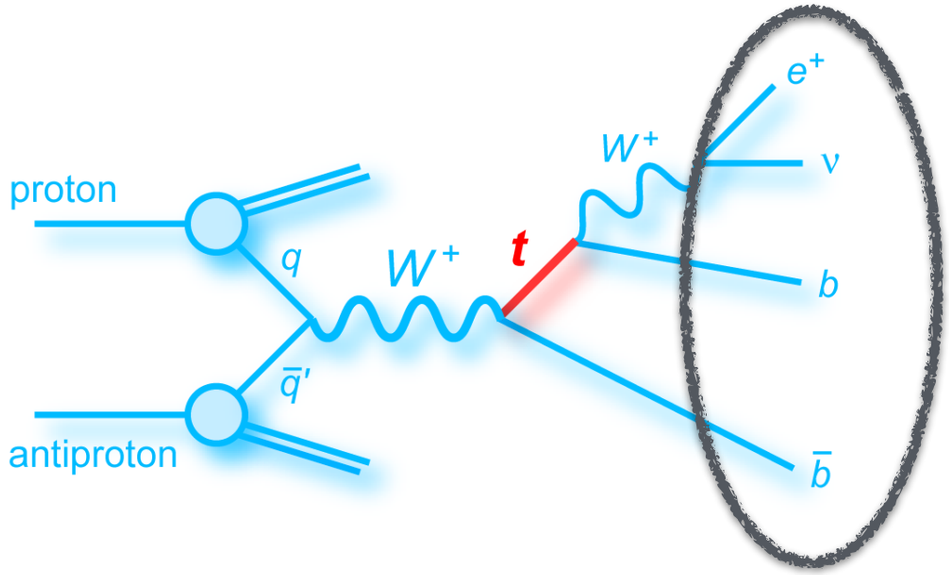


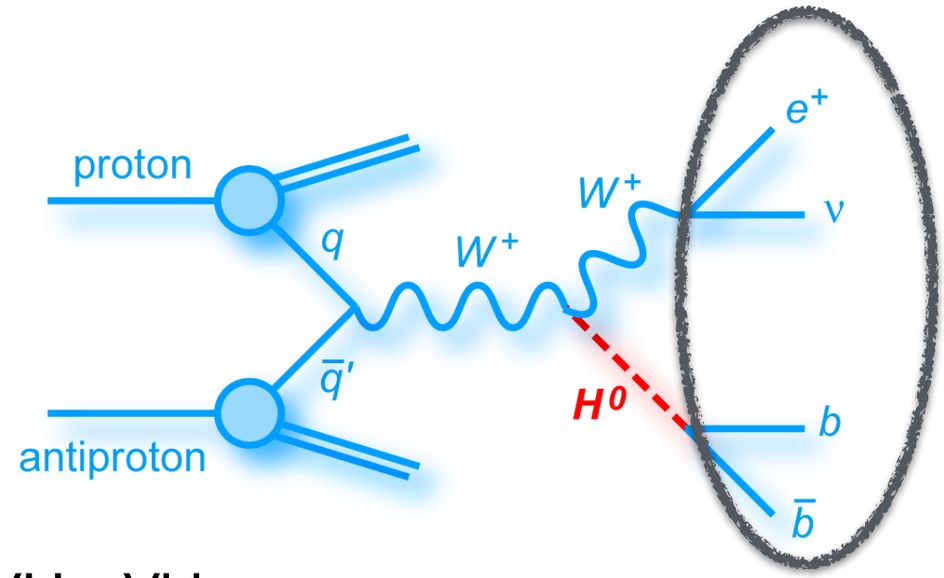
VALIDATION OF LOW-MASS SEARCHES(2)



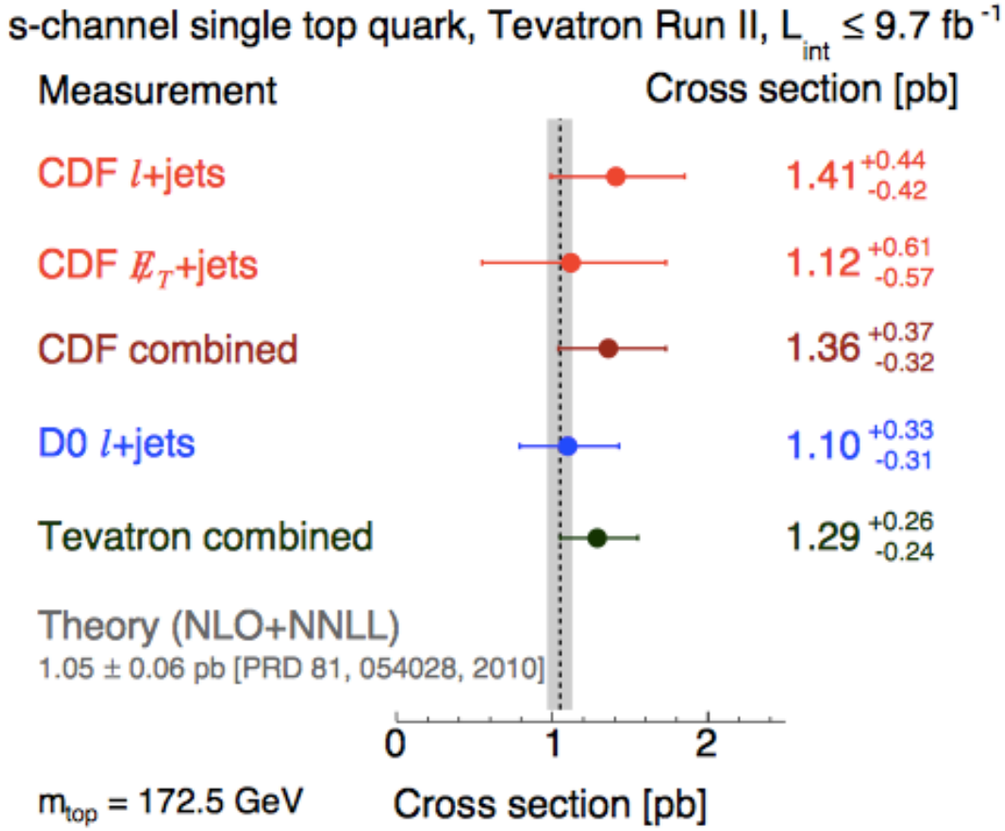


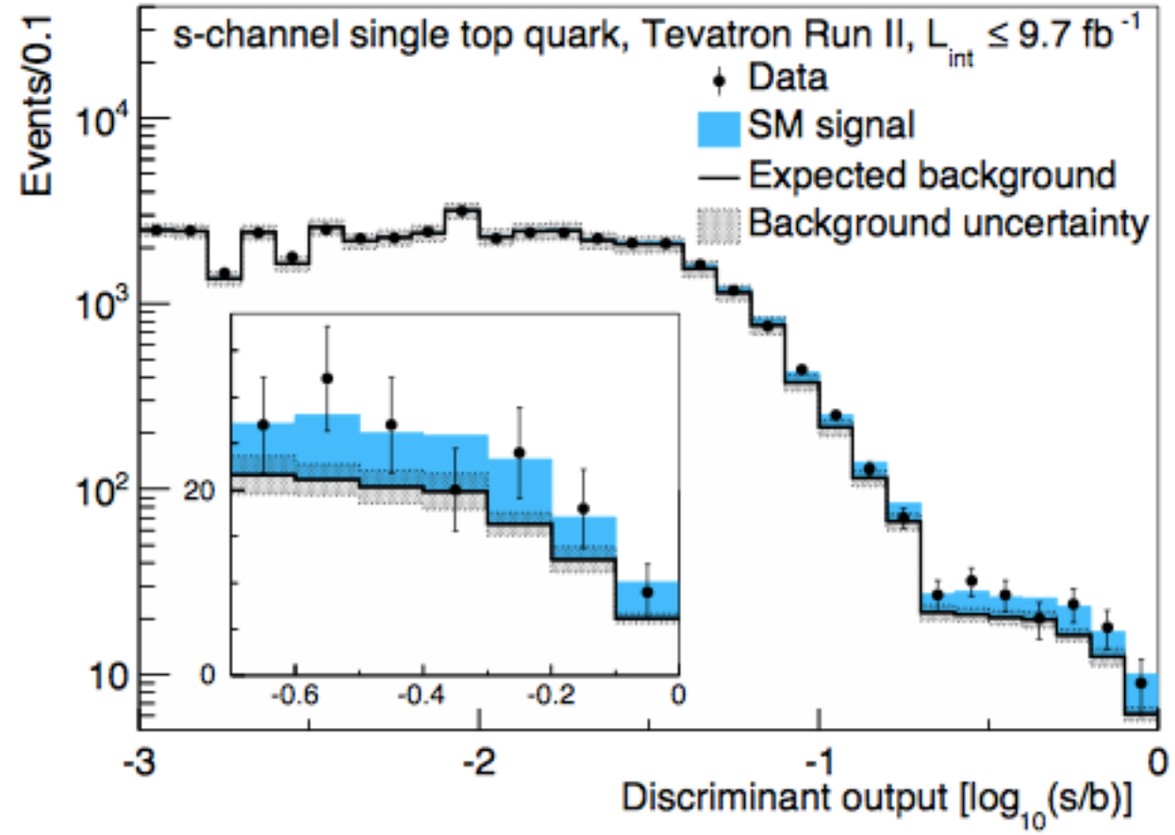
VALIDATION OF LOW-MASS SEARCHES(2)





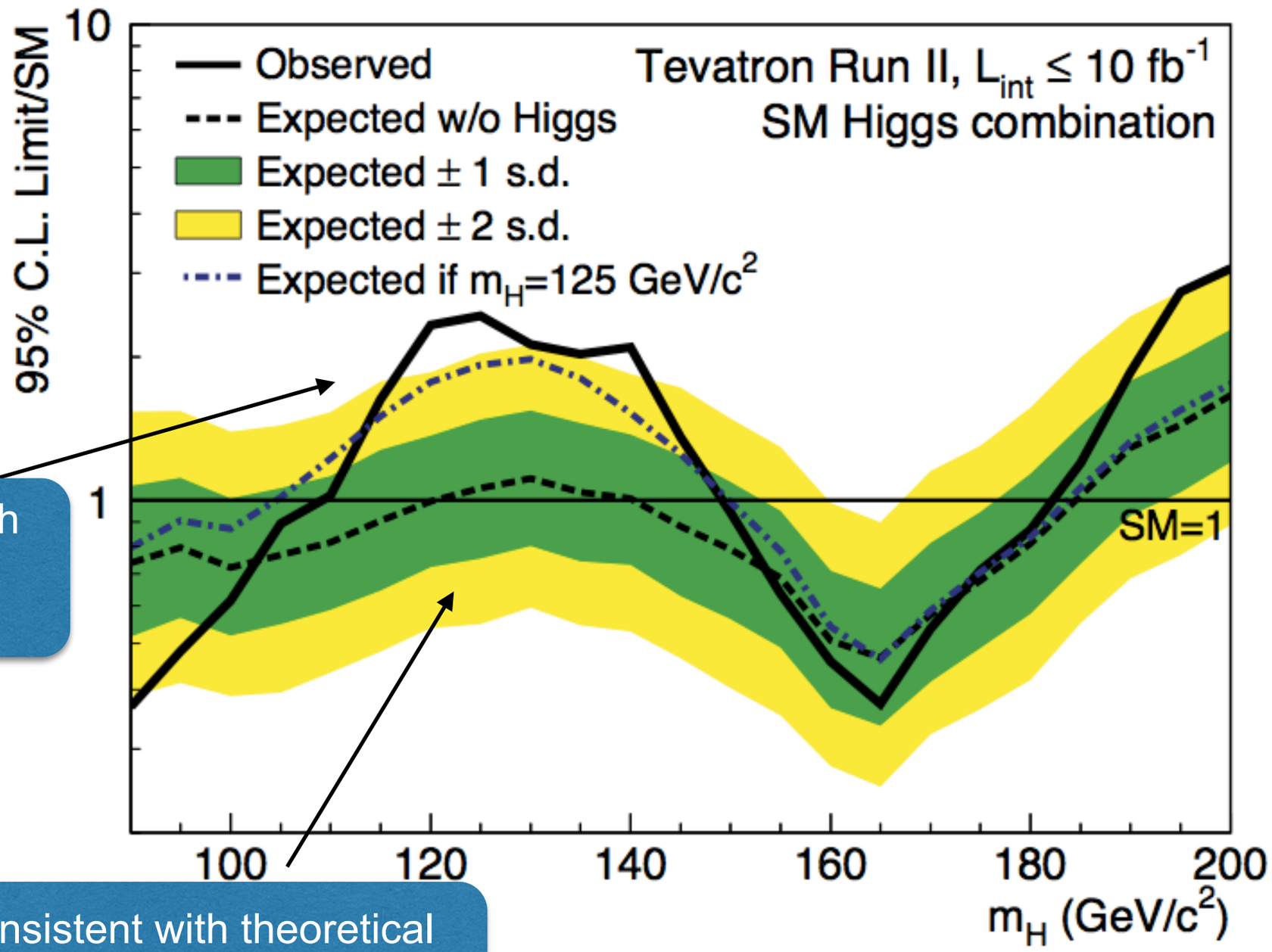
- Single top s-channel cross section X BR is ~9 times VH→Vbb





- The measured cross section using MVAs for production is σ=1.29±0.25 pb (6.3 s.d.)

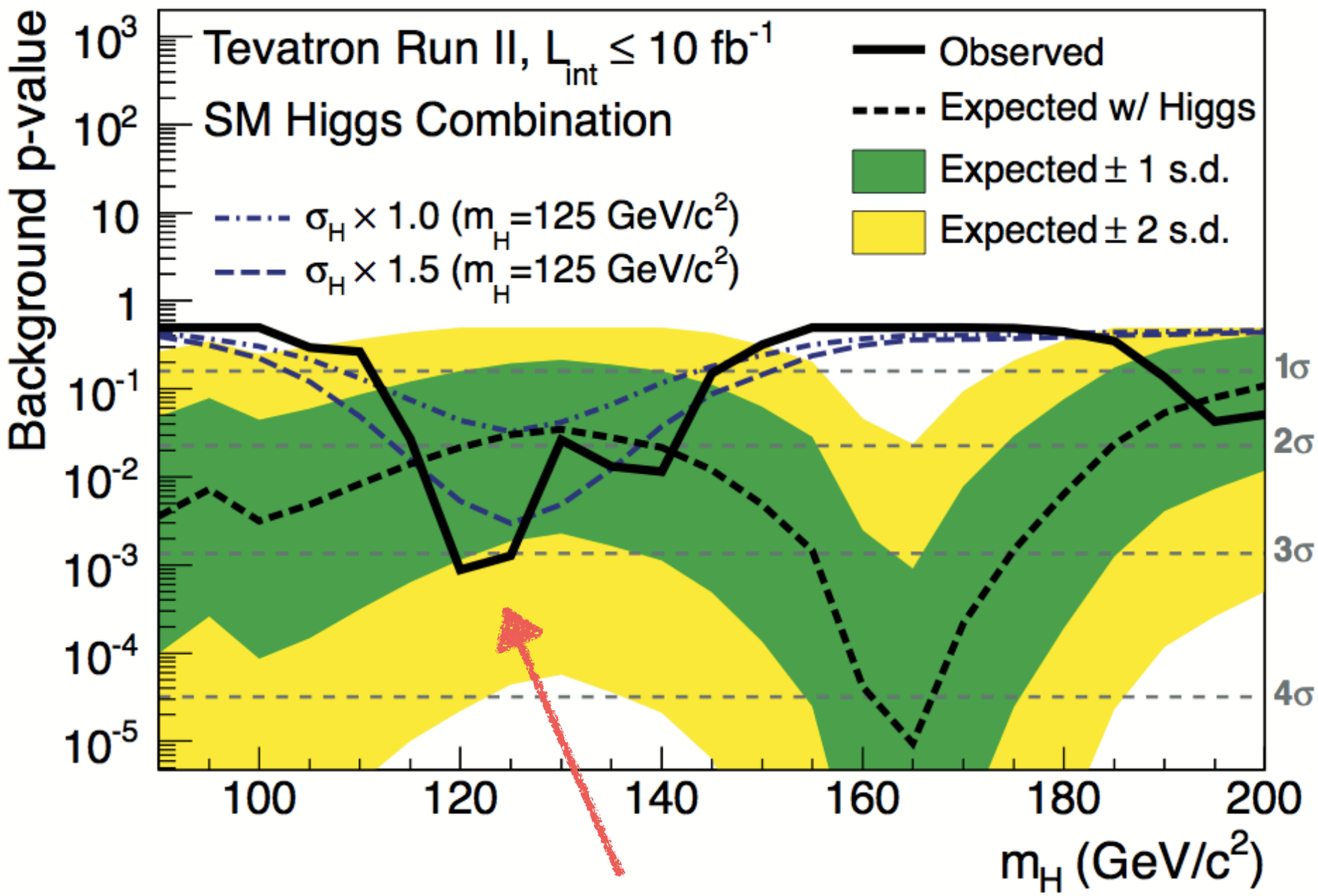
SENSITIVITY



Consistent with experimental resolution

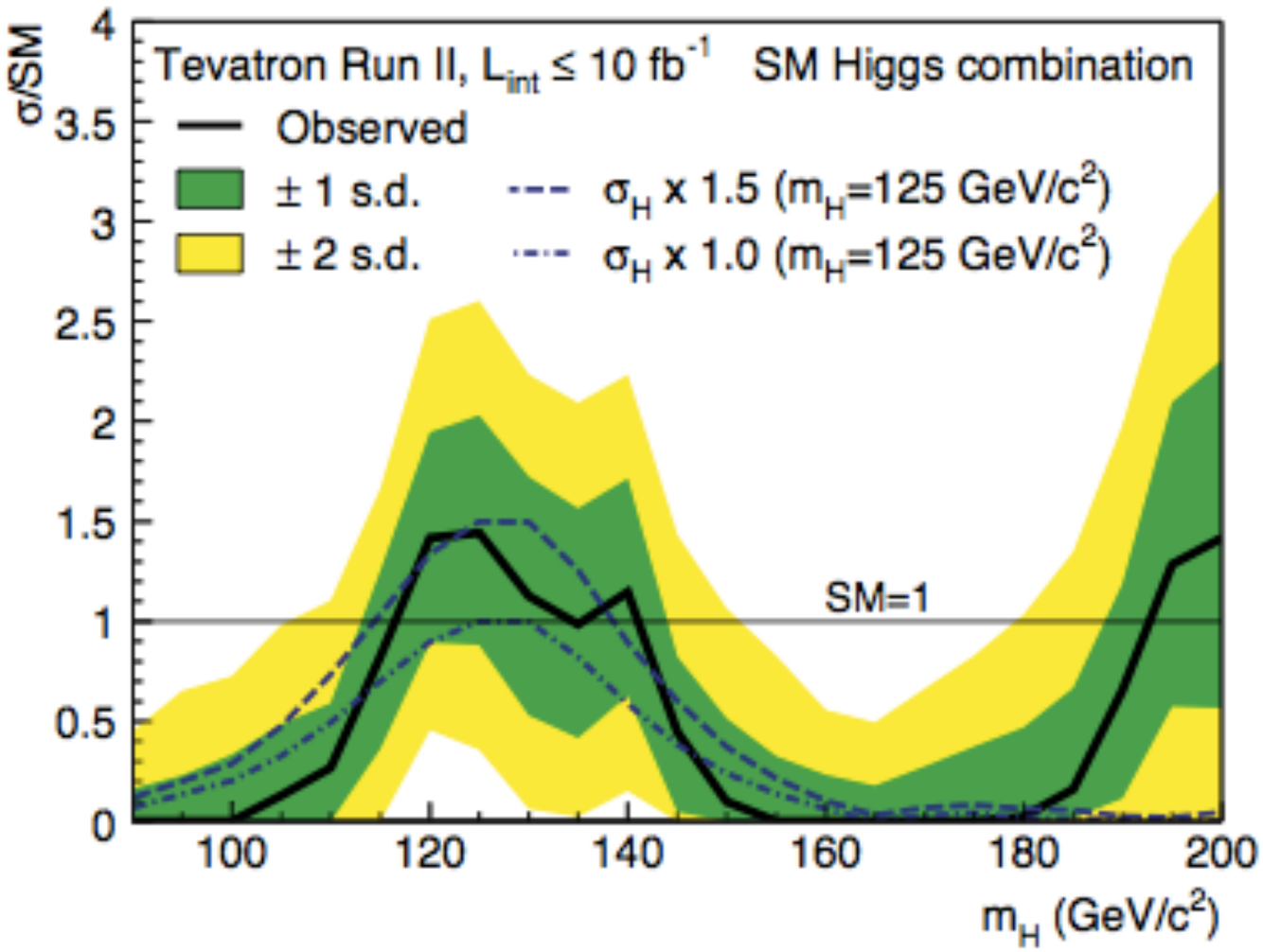
Consistent with theoretical predictions and experimental constraints on the width

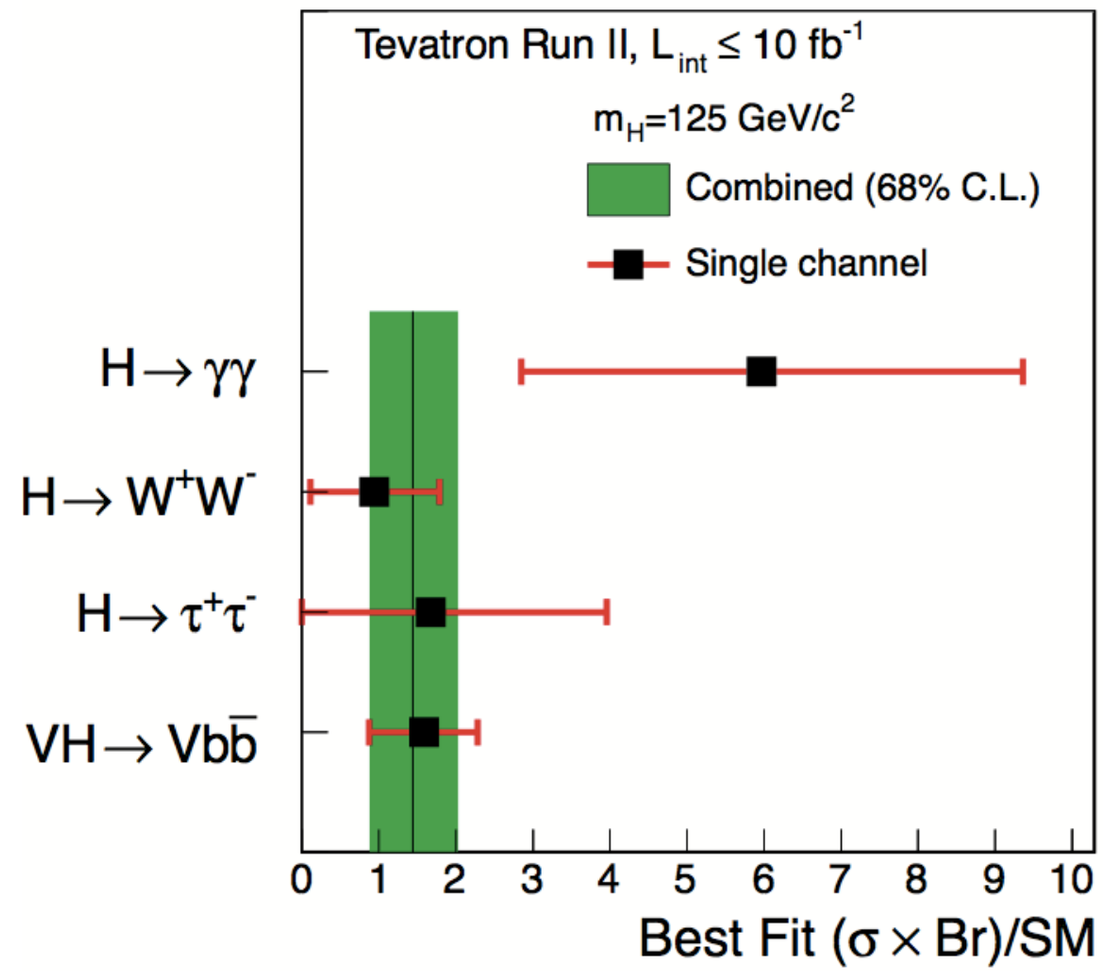
OTHER MEASURE OF SENSITIVITY



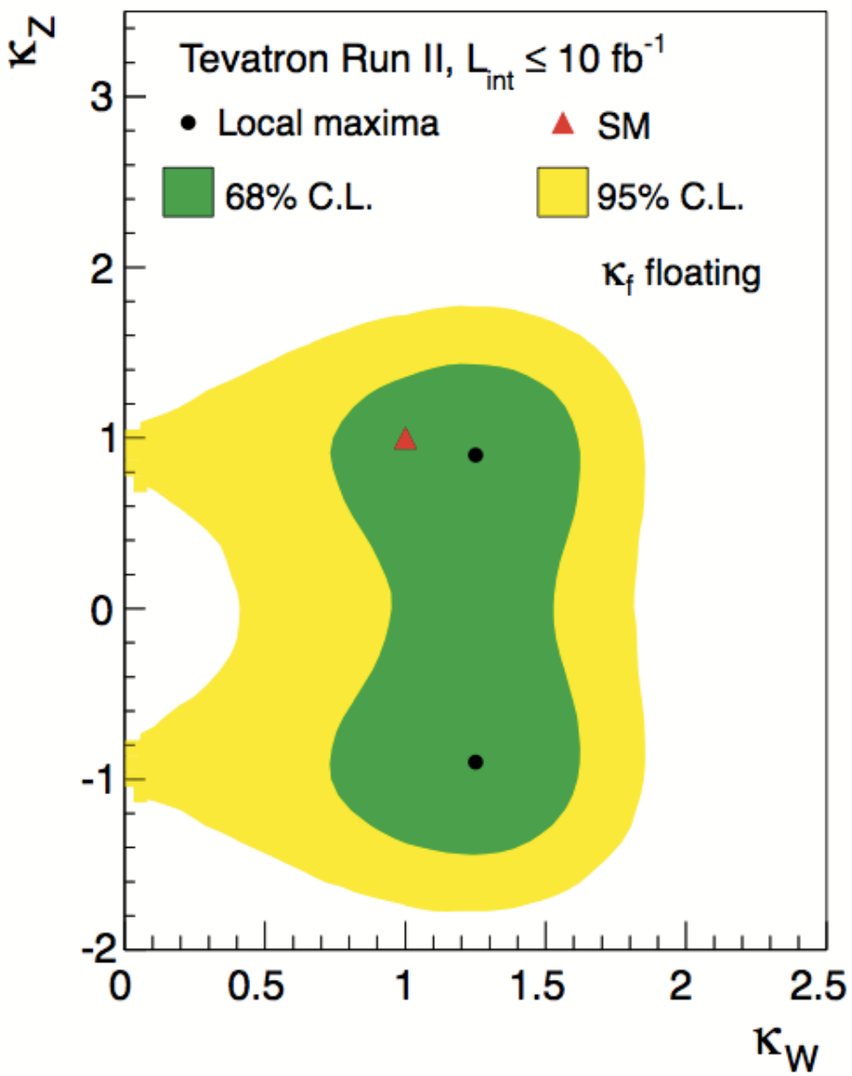
FROM SENSITIVITY TO MEASUREMENT

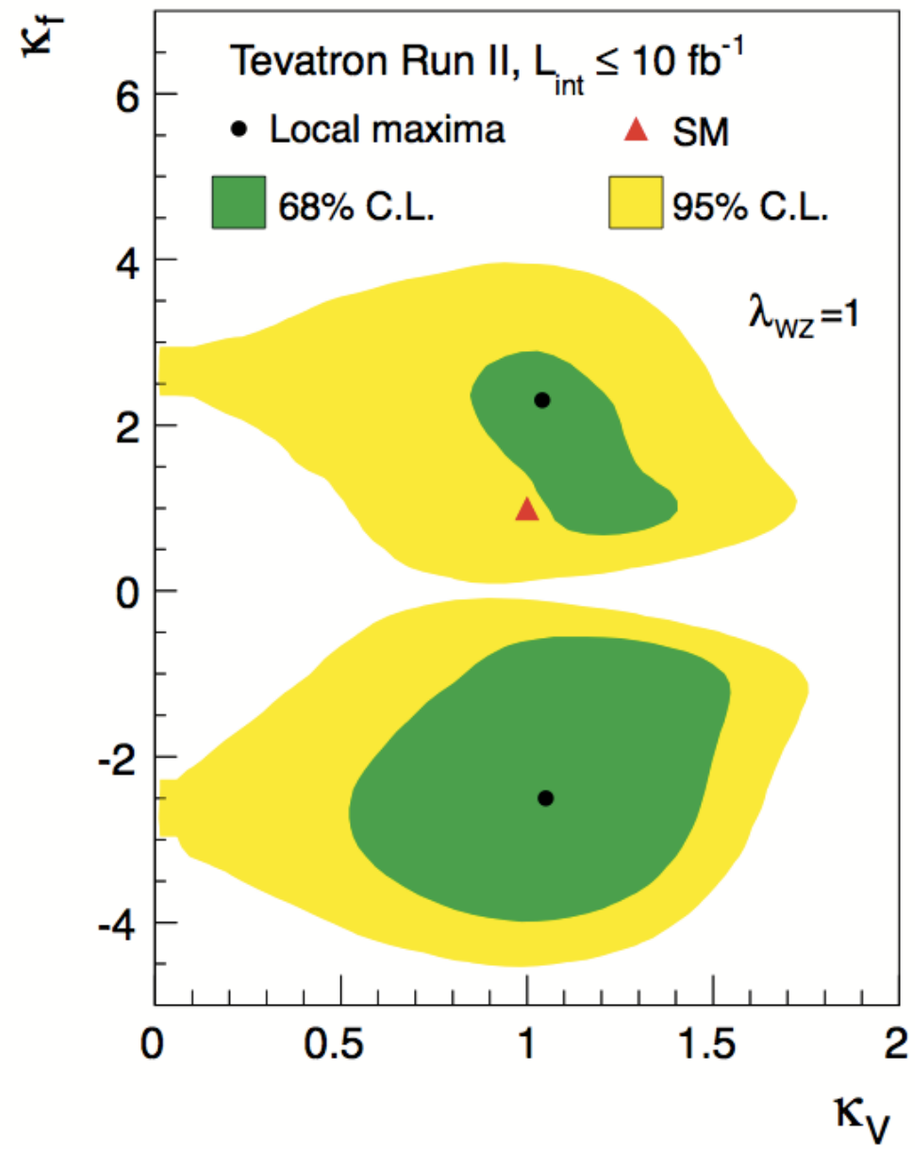
- Now consider the hypothesis a signal is present, and extract relevant physics



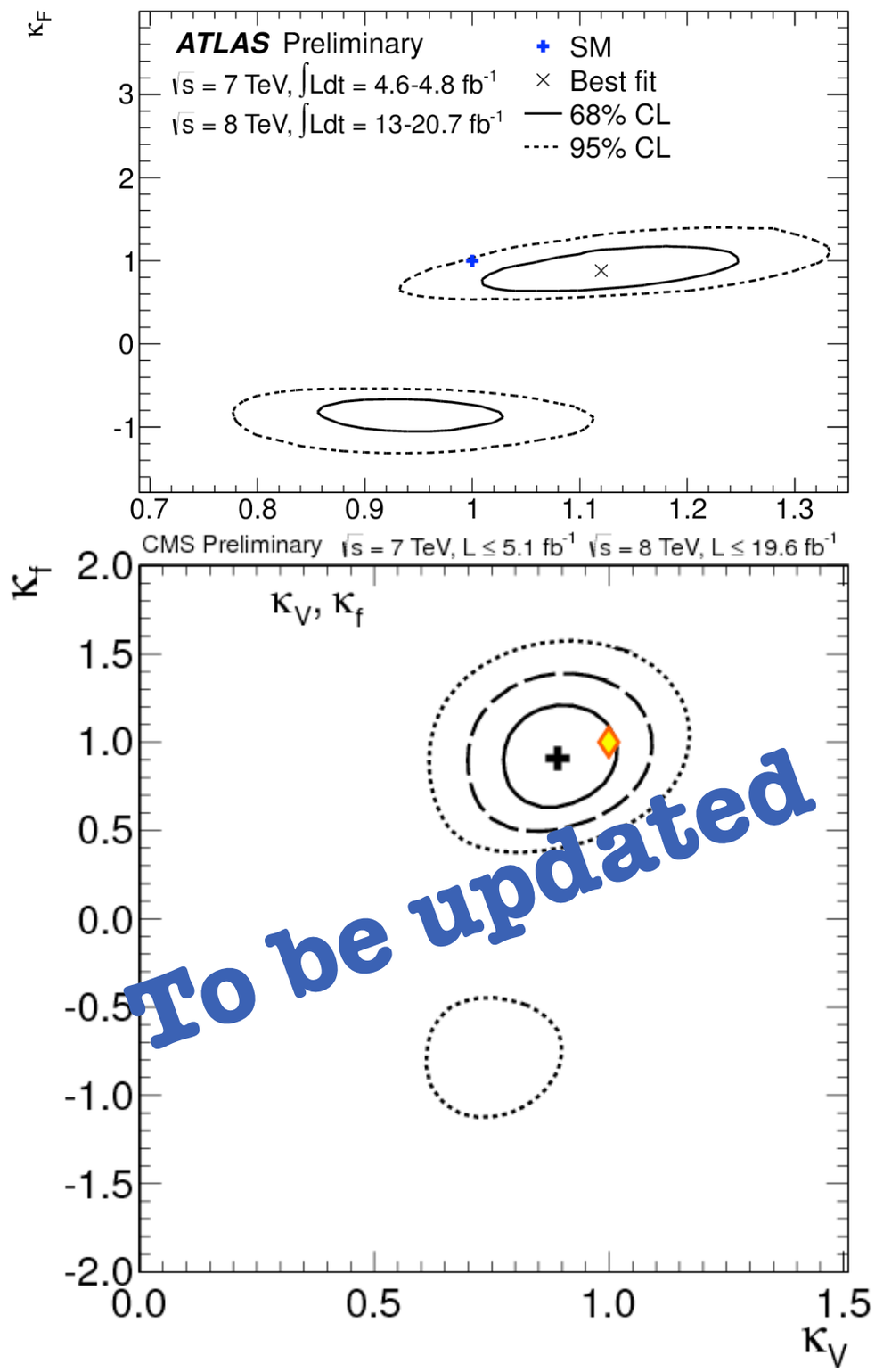


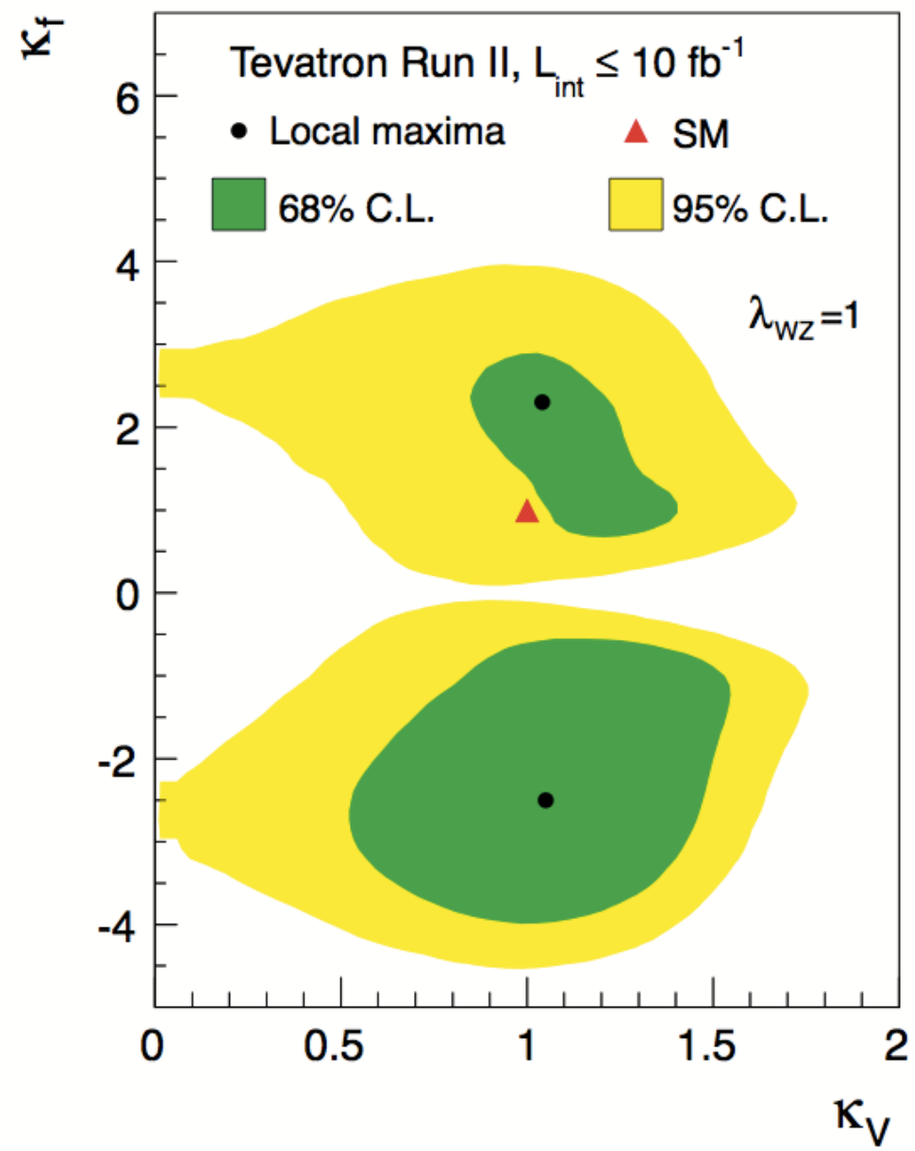
TEVATRON HIGGS COUPLINGS





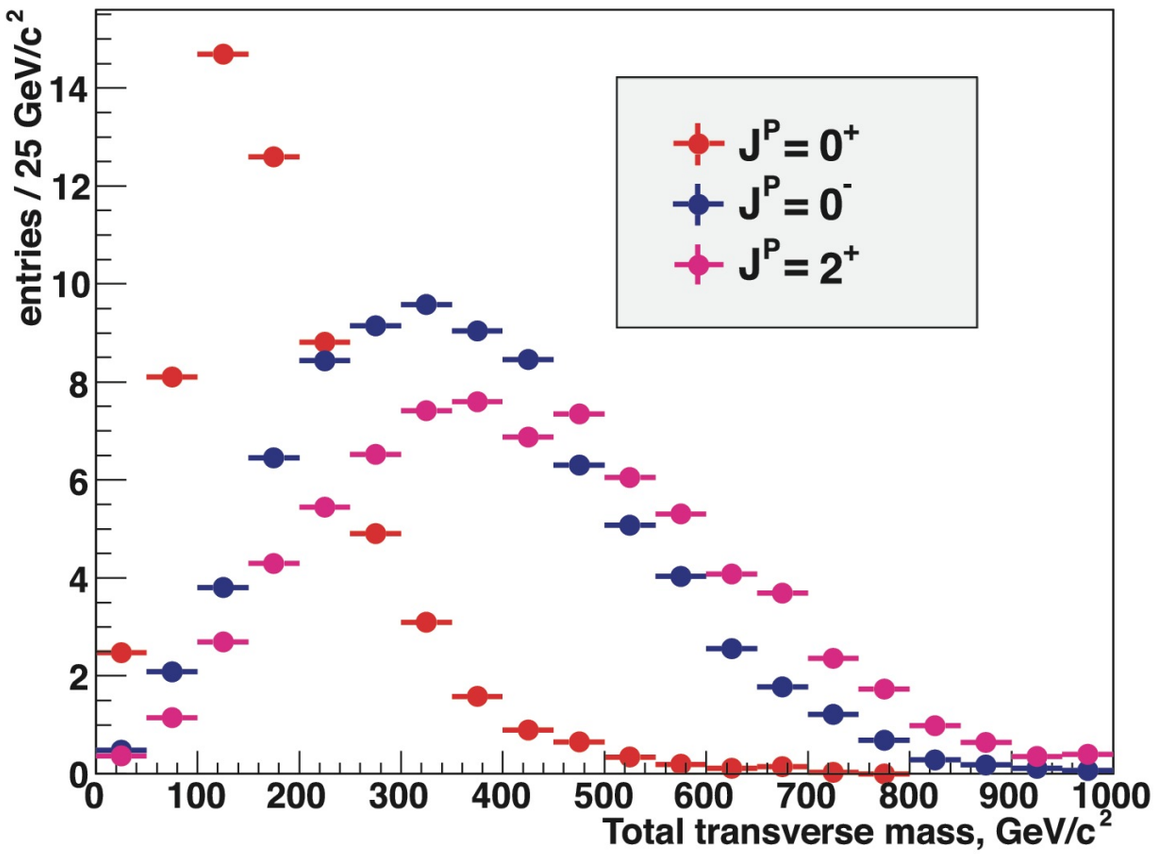
Global Higgs couplings

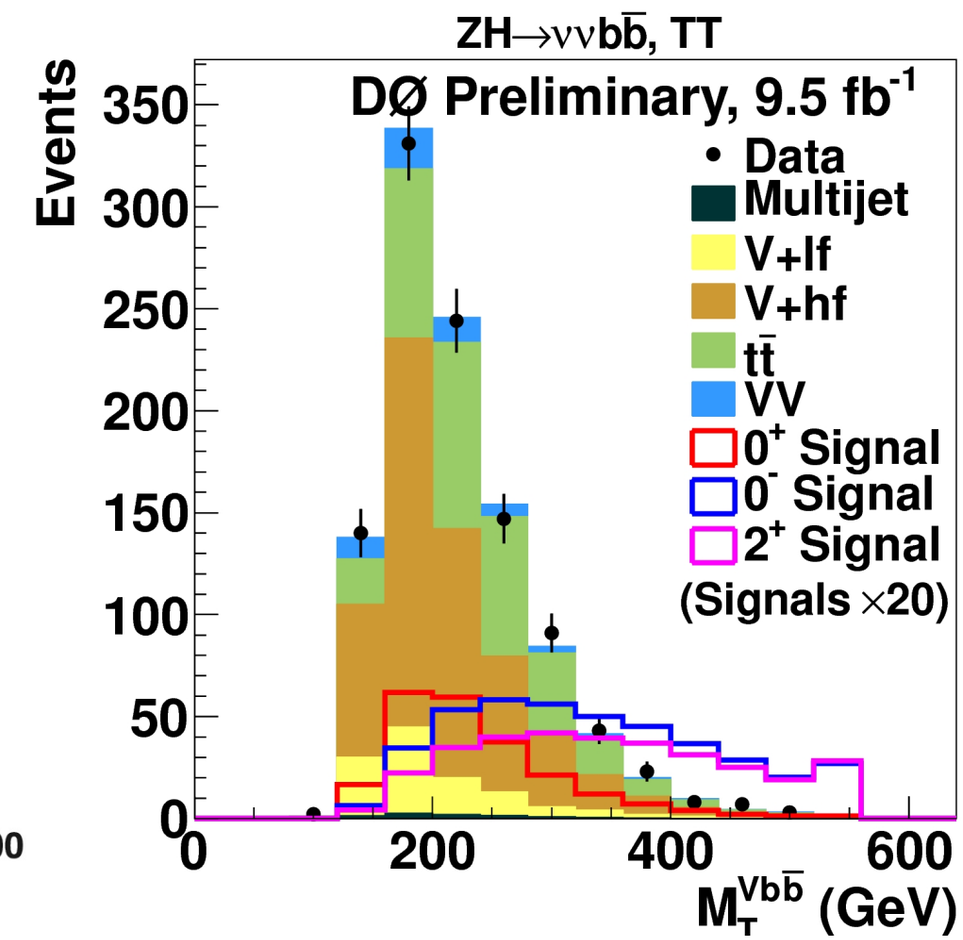




Measuring Spin and Parity

- Assume SM Higgs production cross section for new physics
- simulate new physics using MC, utilize all D0 channels aiming at VH production

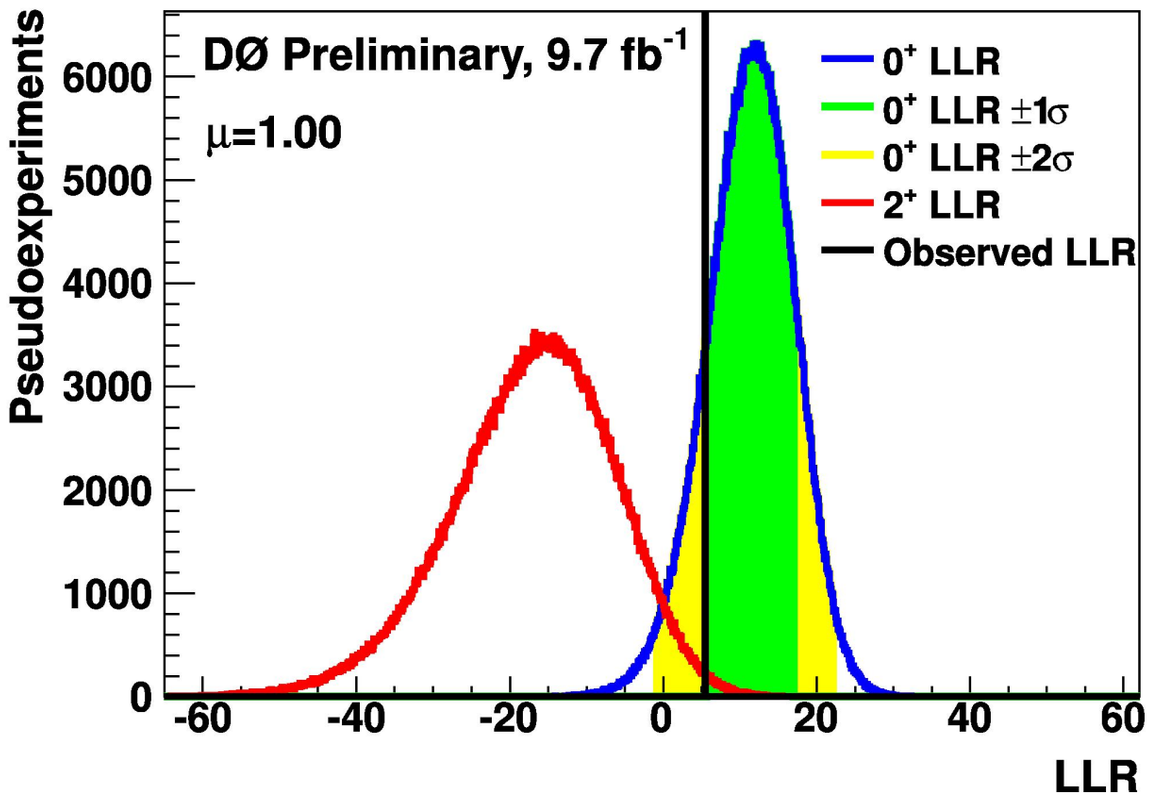


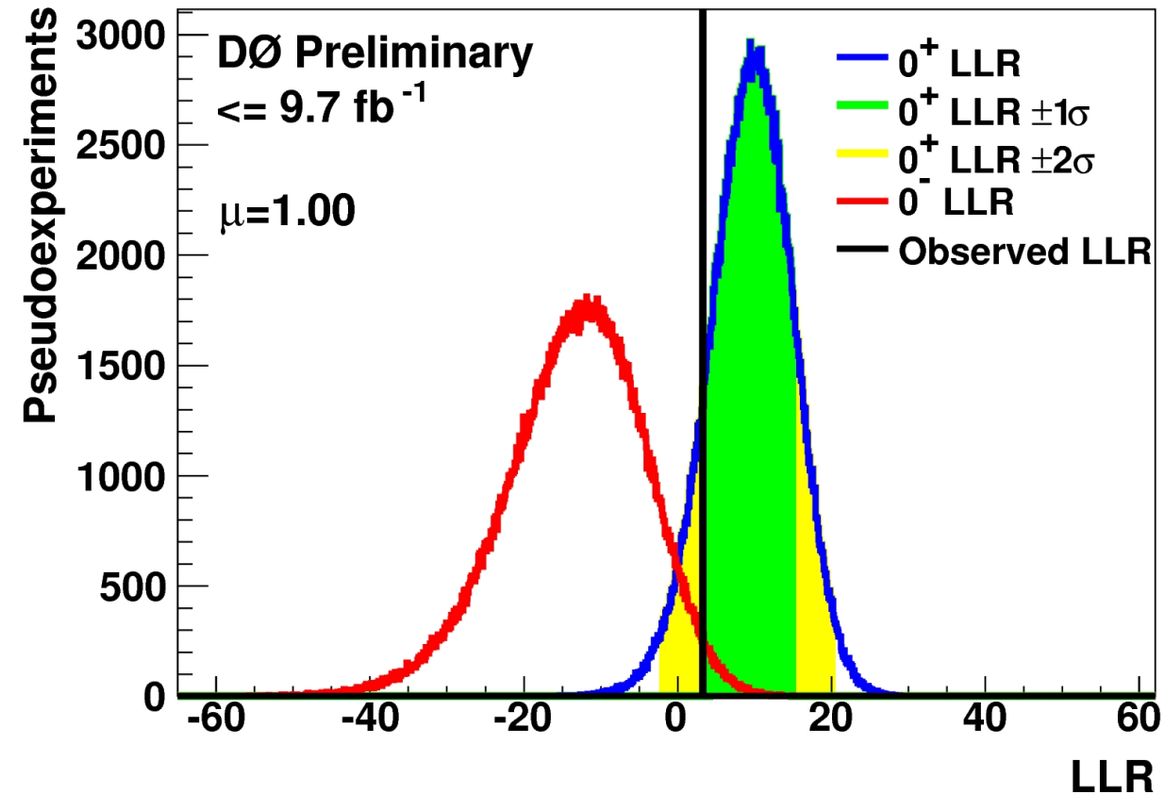


- test different JP hypothesis by looking at the effect on thresholds

SPIN AND PARITY

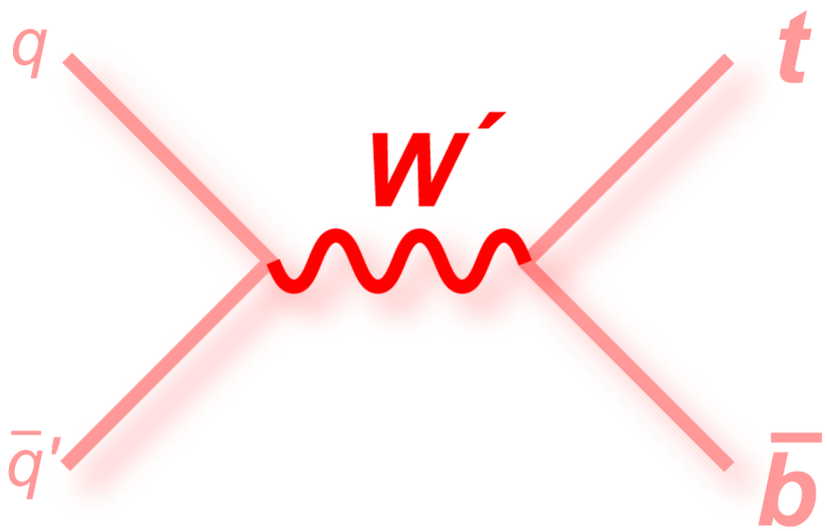
- Translate distributions into numbers



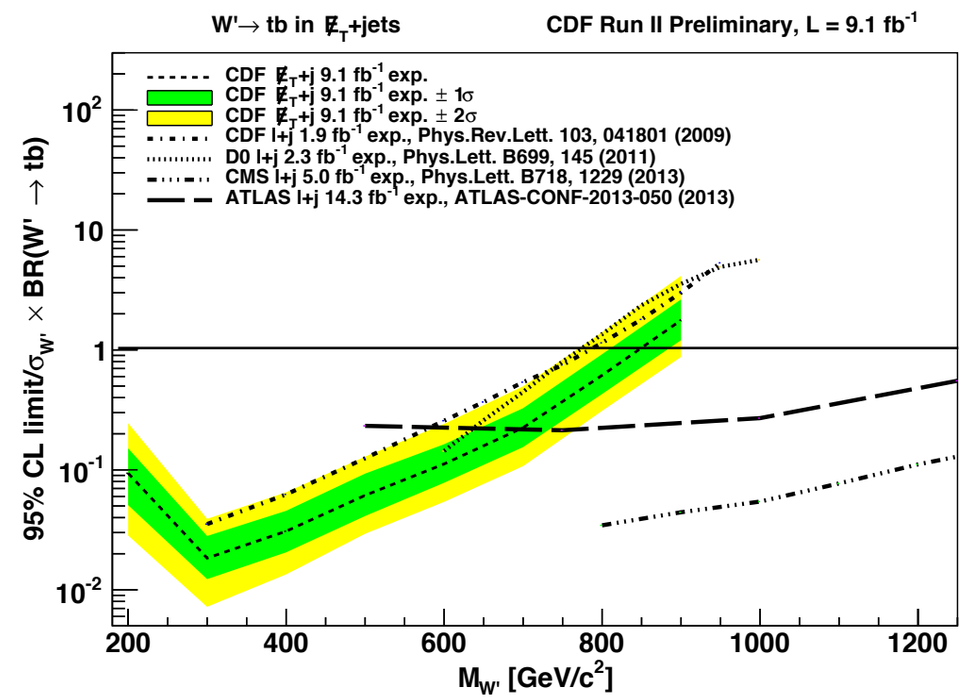


- For the μ = 1.0 case exclude the JP = 2+ hypothesis at the 99.2% C.L.
- For the μ = 1.0 case reject the JP = 0− hypothesis at the 97.9% C.L.
- Both expected result at μ = 1.0 and μ = 1.23 (as seen in the data) lie in the 3s.d. region

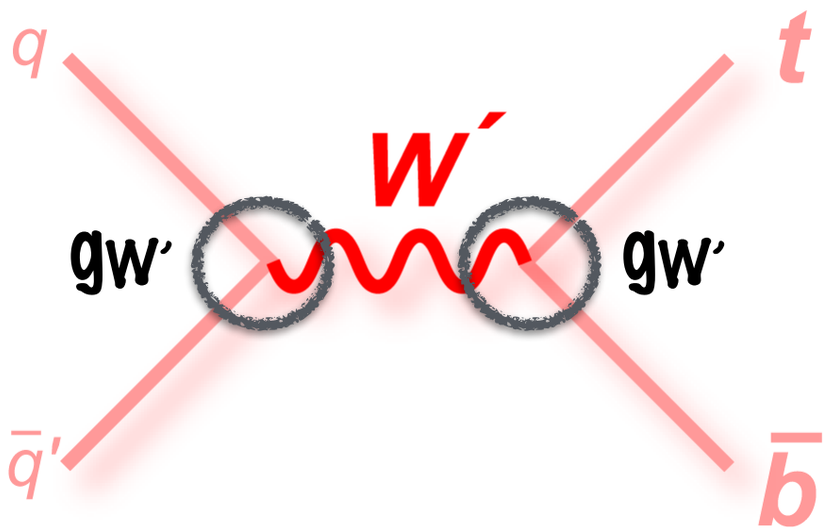
ELECTROWEAK NP: "LOW MASS" W' AND Z'



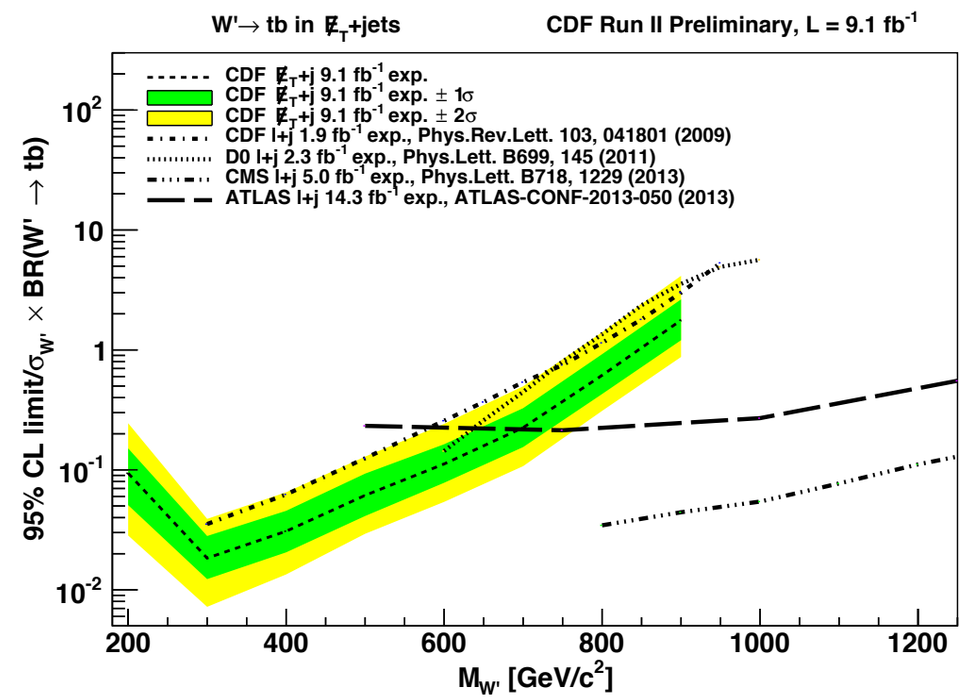
Conf. Note 11079



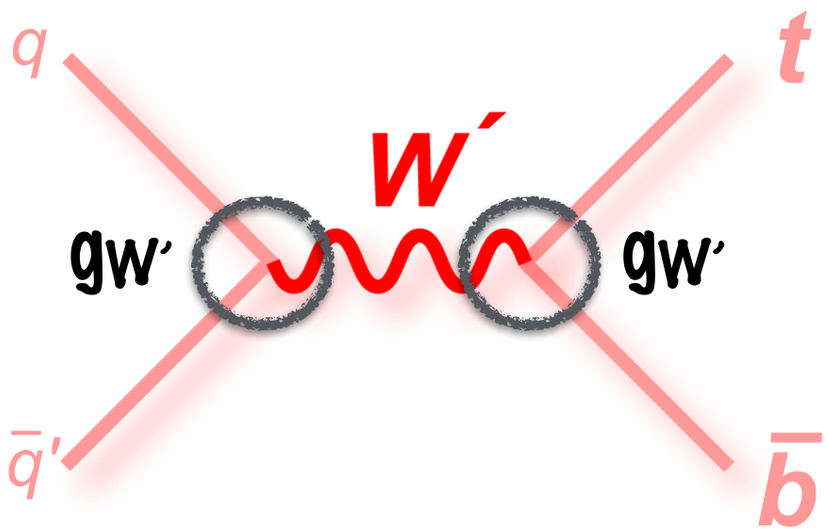
ELECTROWEAK NP: "LOW MASS" W' AND Z'



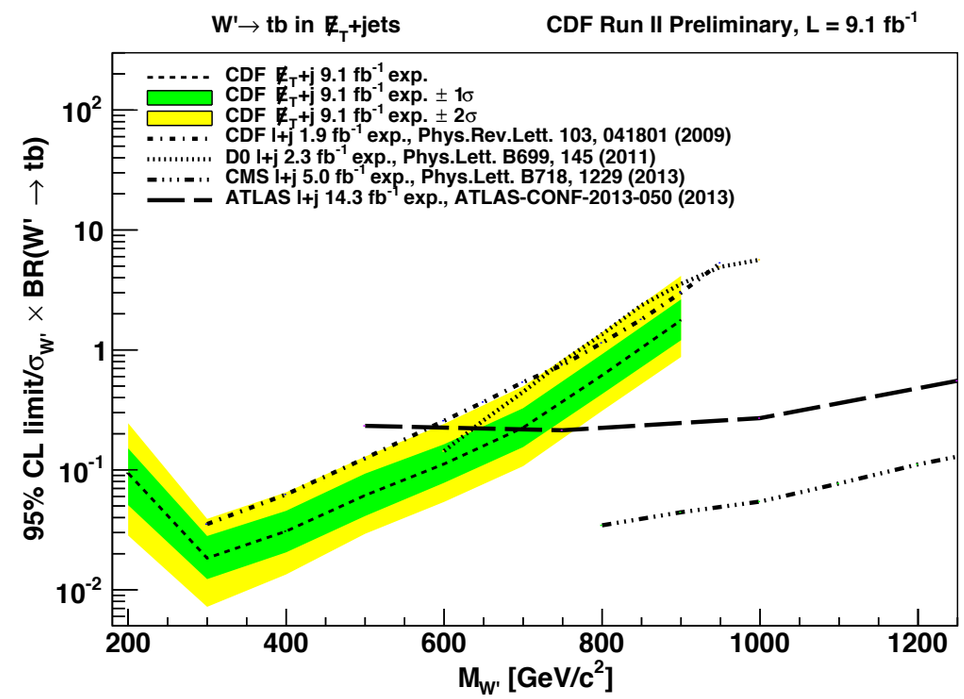
Conf. Note 11079

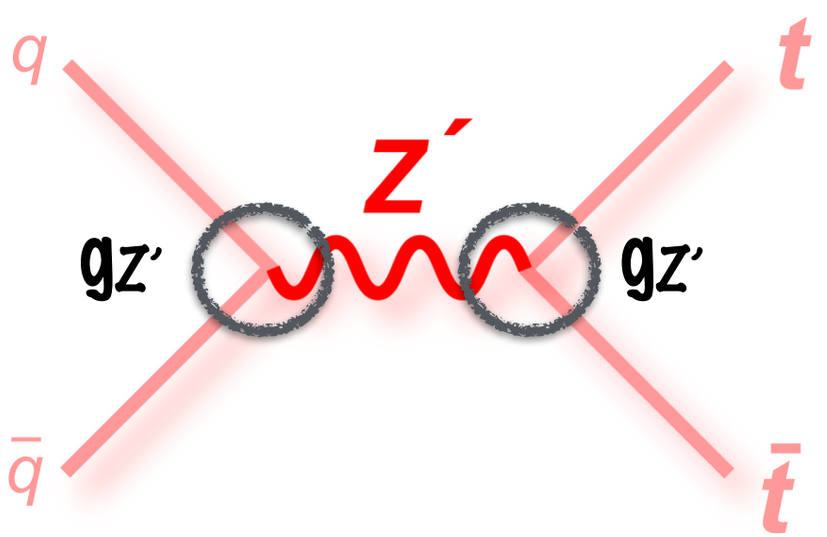


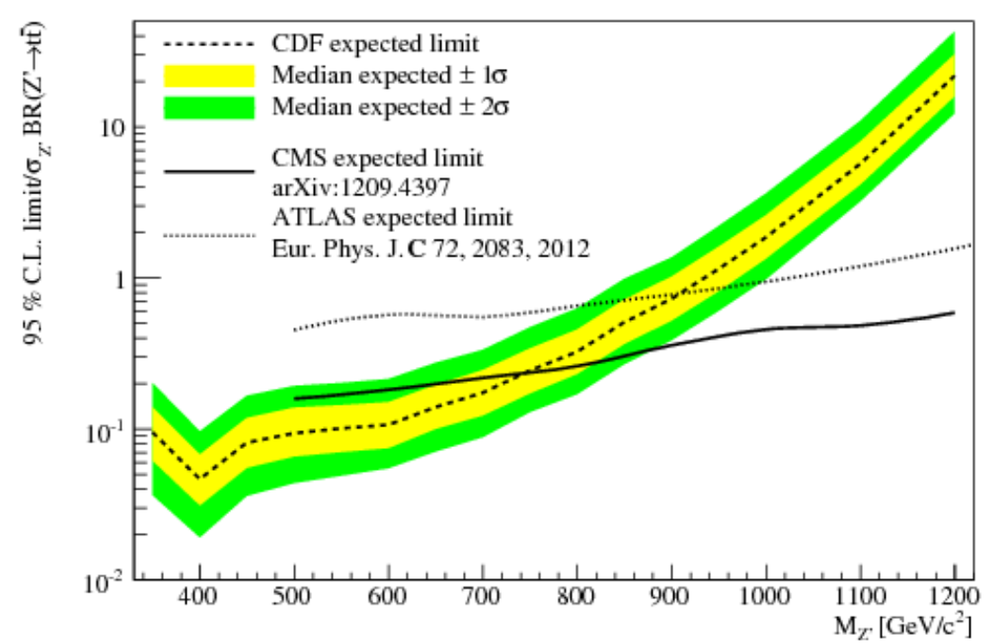
ELECTROWEAK NP: "LOW MASS" W' AND Z'



Conf. Note 11079







PhysRevLett 110 121802

Conclusions

Tevatron $p\bar{p}$ collider gave the first evidence of a new particle interacting with fermions

- ★ Provided valuable information about Yukawa structure
- ★ Probing scalar nature of the new boson in fermionic final states
- ★ Great place to explore EWK physics at O(100)GeV scale

Conclusions

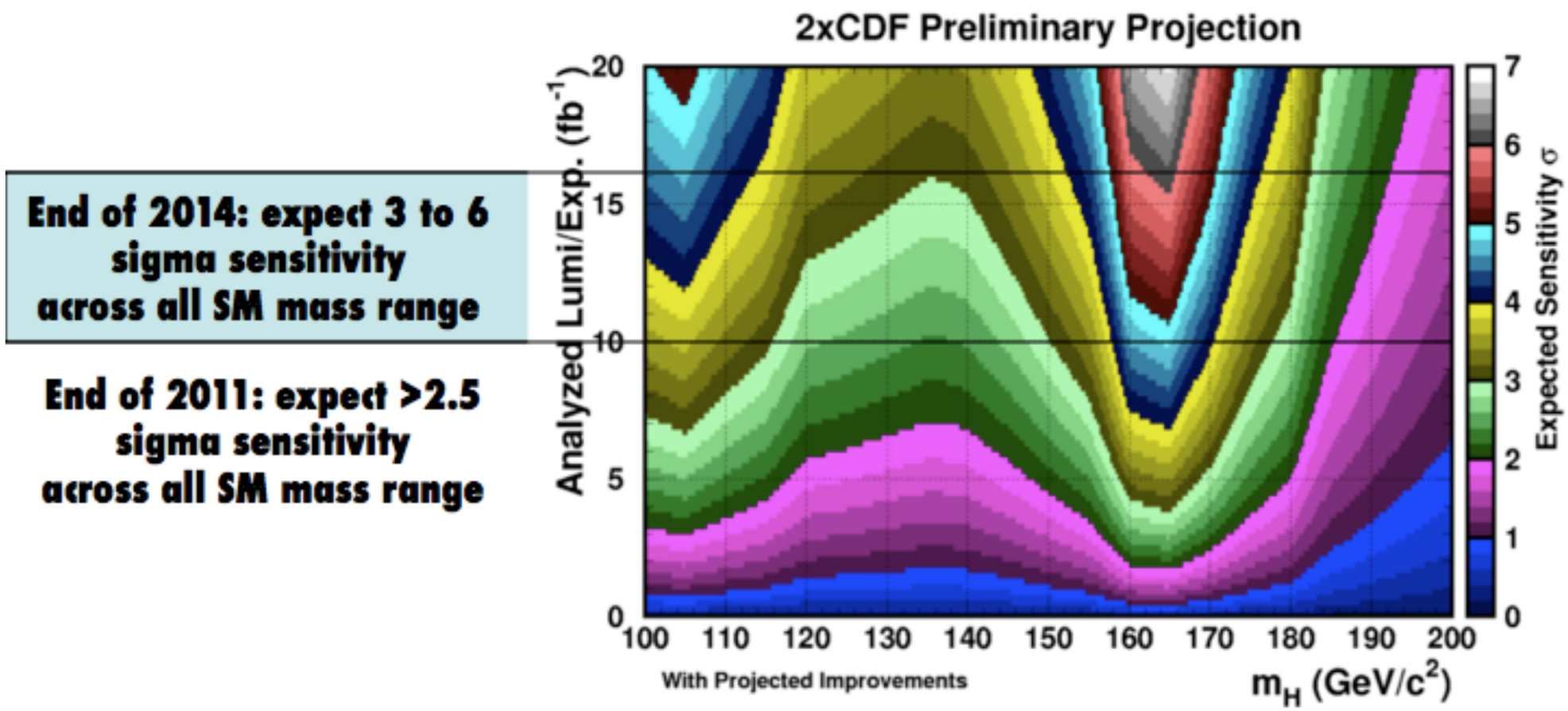
Tevatron $p\bar{p}$ collider gave the first evidence of a new particle interacting with fermions

- ★ Provided valuable information about Yukawa structure
- ★ Probing scalar nature of the new boson in fermionic final states
- ★ Great place to explore EWK physics at O(100)GeV scale

Thanks

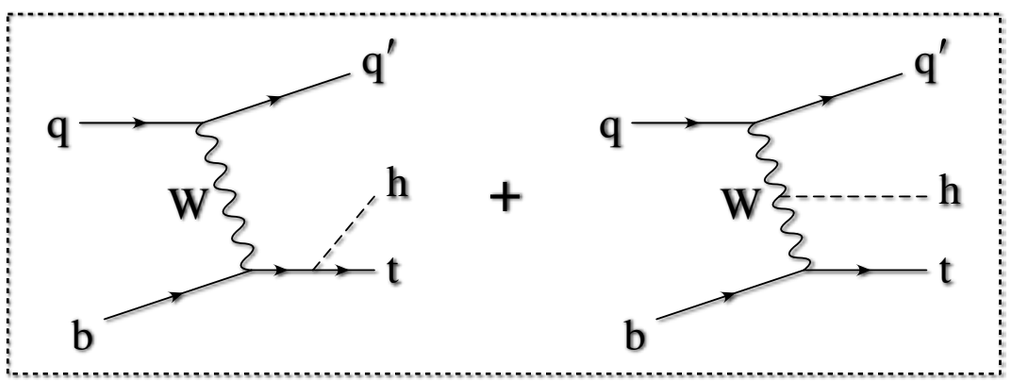
BACKUP

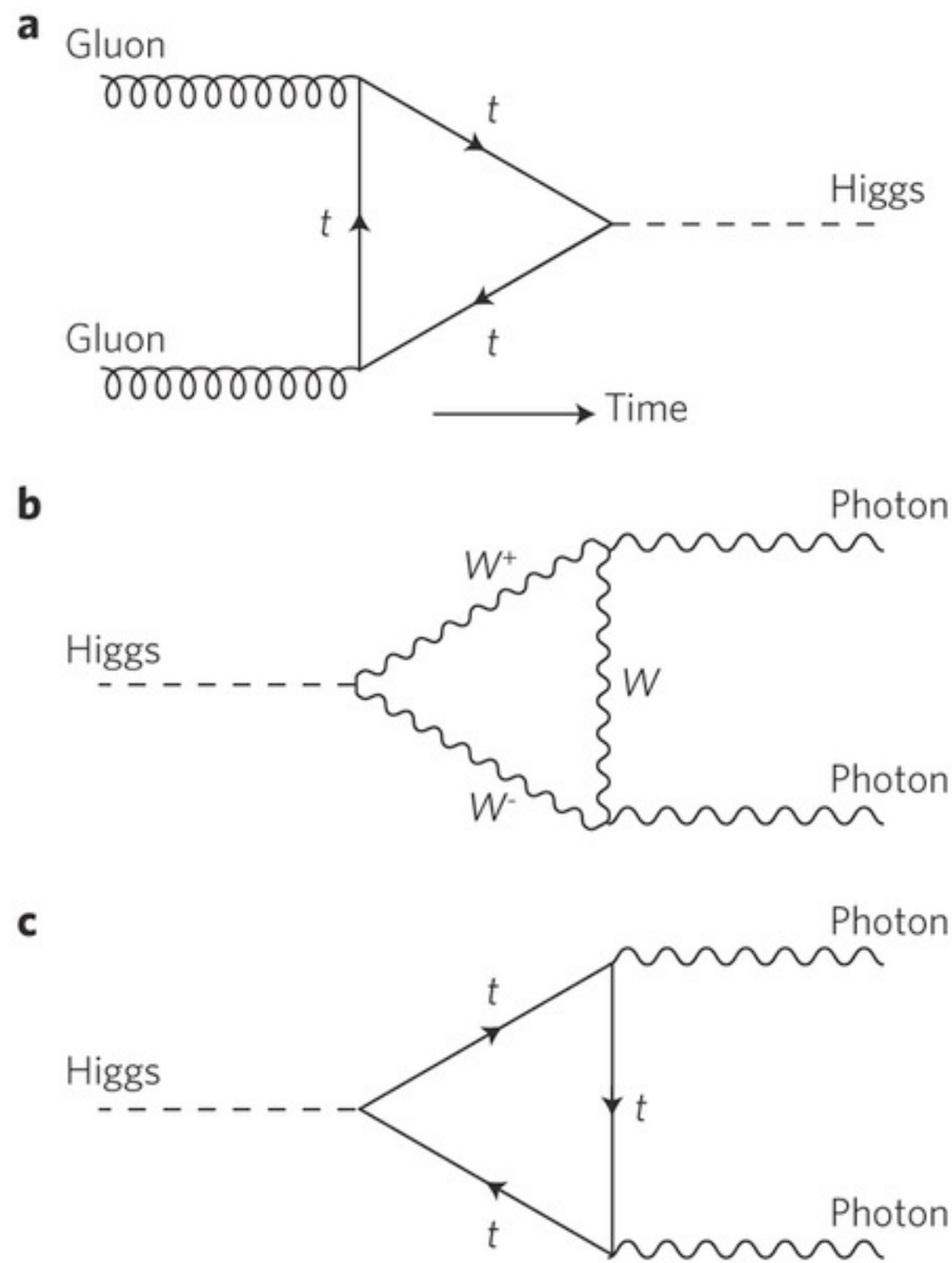
THE COLLIDER THAT COULD



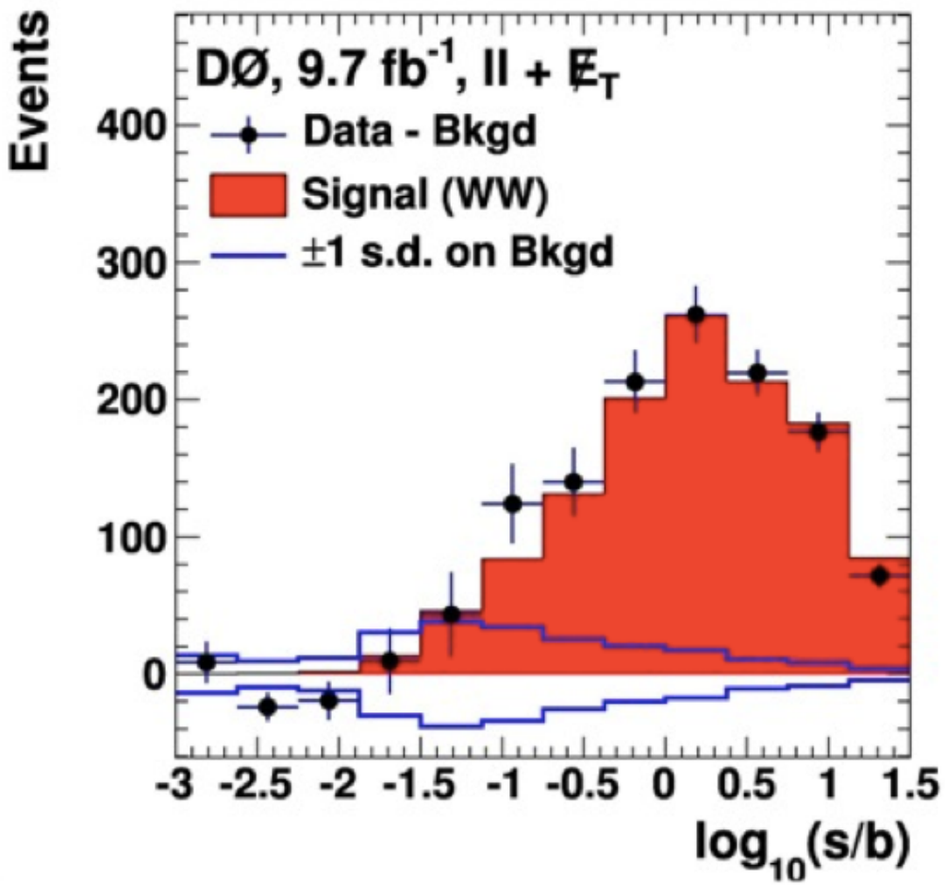
HIGGS AND FERMIONS

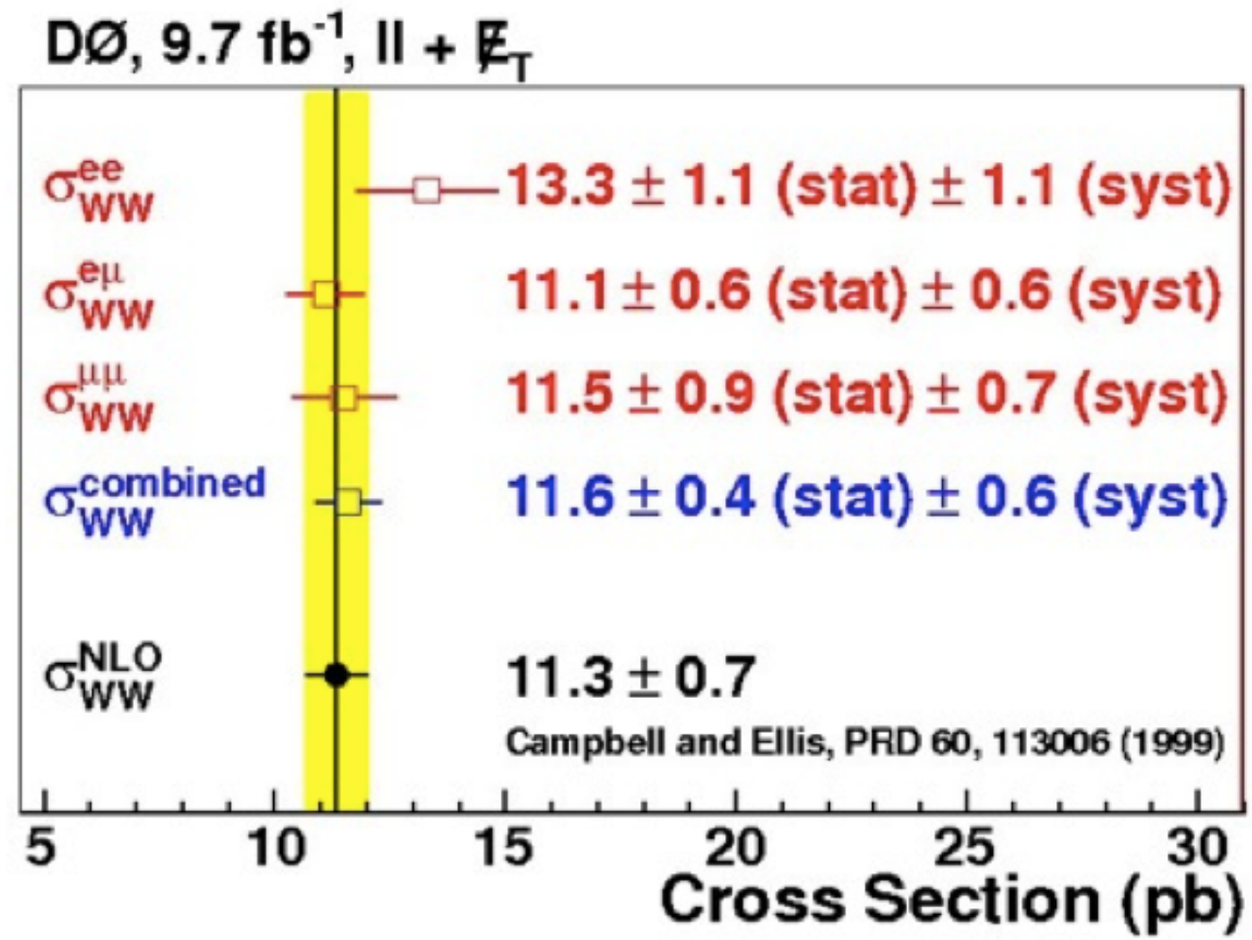
- We know there is a Higgs boson in LHC data
- it first appeared decaying into two bosons
- the big picture is still far from clear, as there are a multitude of loops where new physics might be hiding
- not to mention interference between diagrams...



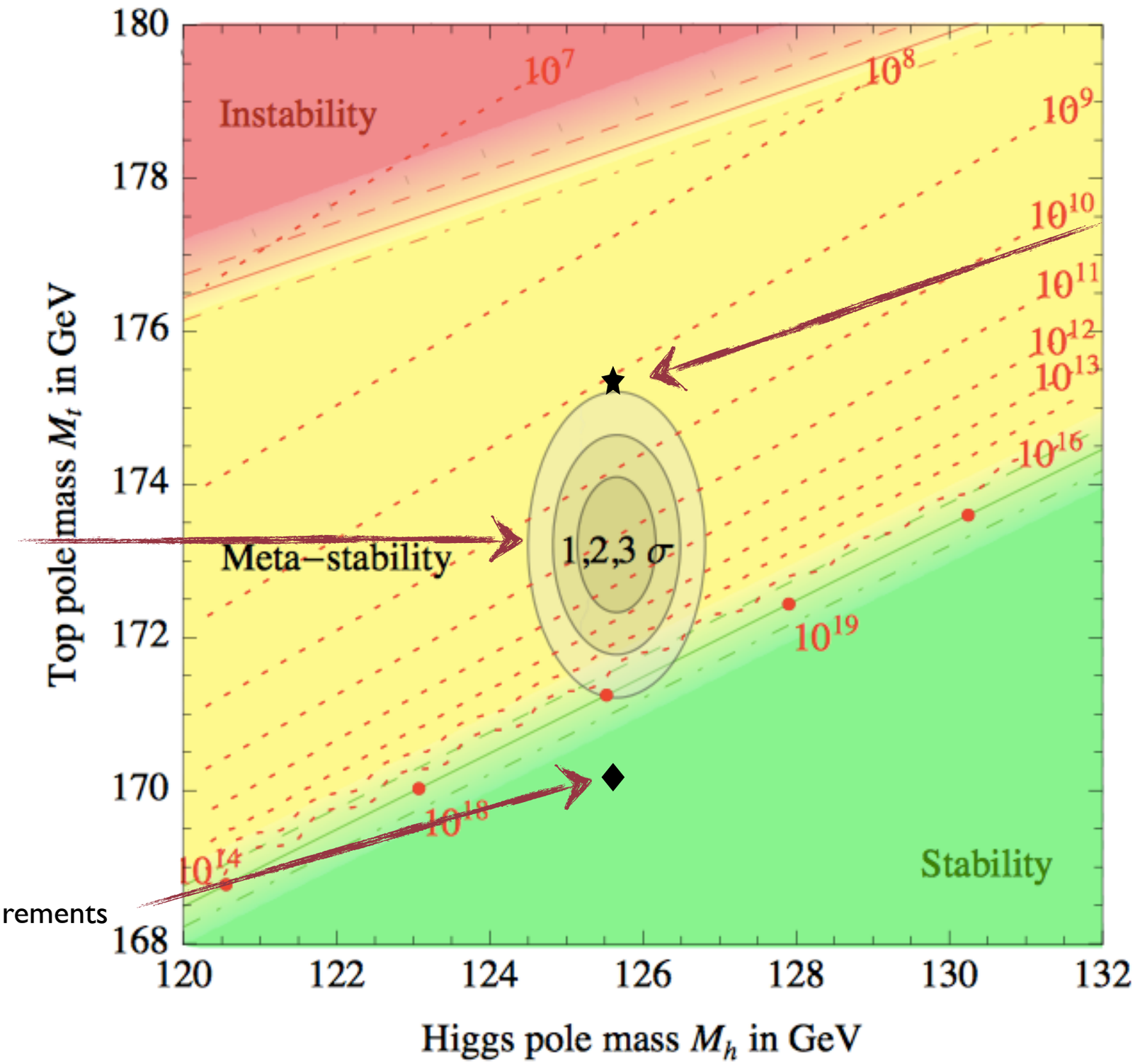


VALIDATION OF THE HIGH-MASS SEARCHES





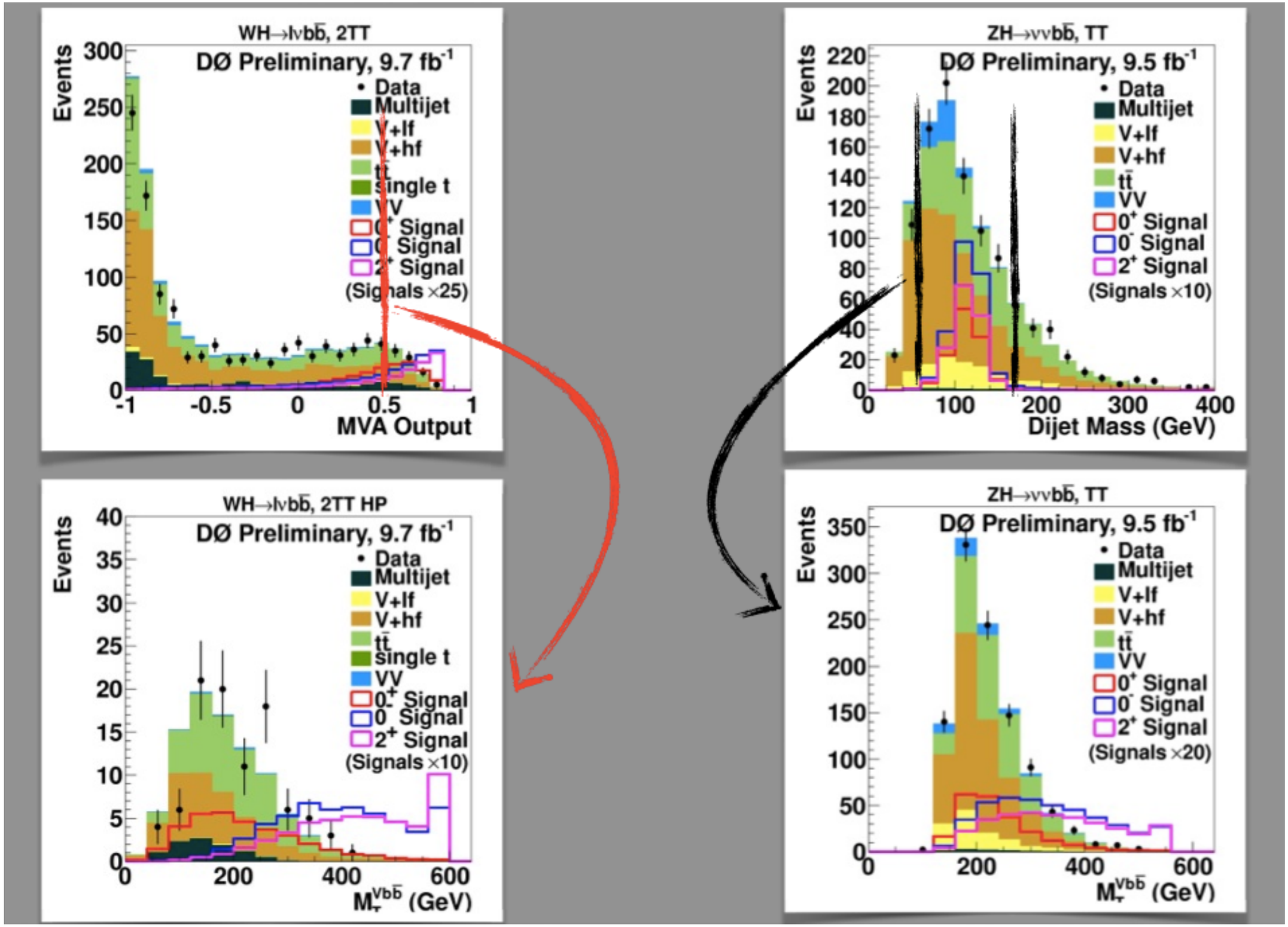
Top, Higgs, and all of us



From EWK fits including Higgs mass

Mtop from direct measurements

From indirect measurements (until recently)

JHEP 1312 (2013) 089

Spin and Parity