CDF and D0 Higgs results with the full Tevatron dataset

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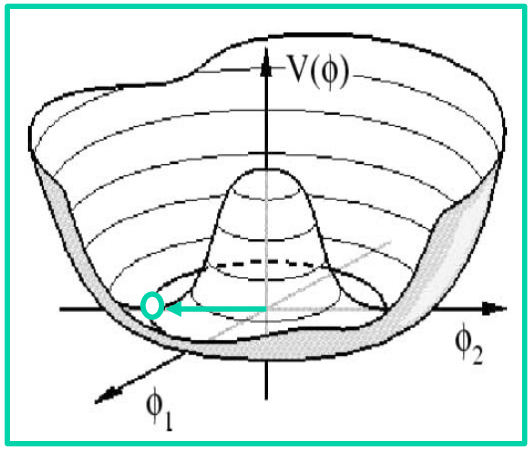
on behalf of the CDF and D0 collaborations

July 2nd, 2012
Tevatron Higgs Seminar

Higgs in Standard Model

- The standard model mechanism for electroweak symmetry breaking was first proposed forty-eight years ago
- Theory still awaits validation through the discovery of predicted Higgs boson
- This is likely to be the week when either evidence for the Higgs boson is reported or it is excluded over the entire mass range consistent within the standard model



Today's Presentations

- On Wednesday, the LHC experiments are expected to present their first Higgs search results based on ~5 fb^{-1} of additional data collected at $\sqrt{s}$ = 8 TeV
- Tevatron presented first results based on full datasets this past spring
- Since then additional analysis improvements, made to the D0 searches in particular, have been implemented leading to an increase in the combined sensitivity of Tevatron searches
- Today's talks :

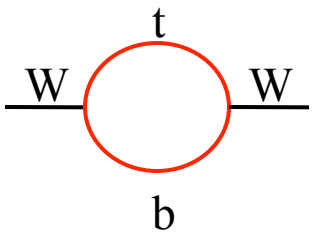
  Part I - Overview of Higgs search channels and review of CDF results

  Part II – Updates to D0 search results and Tevatron combination

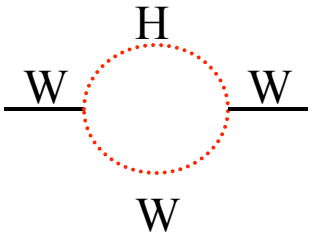
Indirect SM Higgs Mass Constraints

- SM Higgs boson mass is a free parameter of the theory
- Constrained indirectly through precision measurements
- In particular, self-energy corrections to the W mass depend on the mass of the top quark and Higgs boson

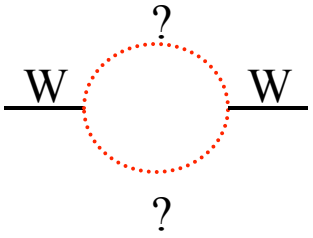
$\Delta M_W \propto M^2_{top}$



$\Delta M_W \propto \ln M_H$



New Physics



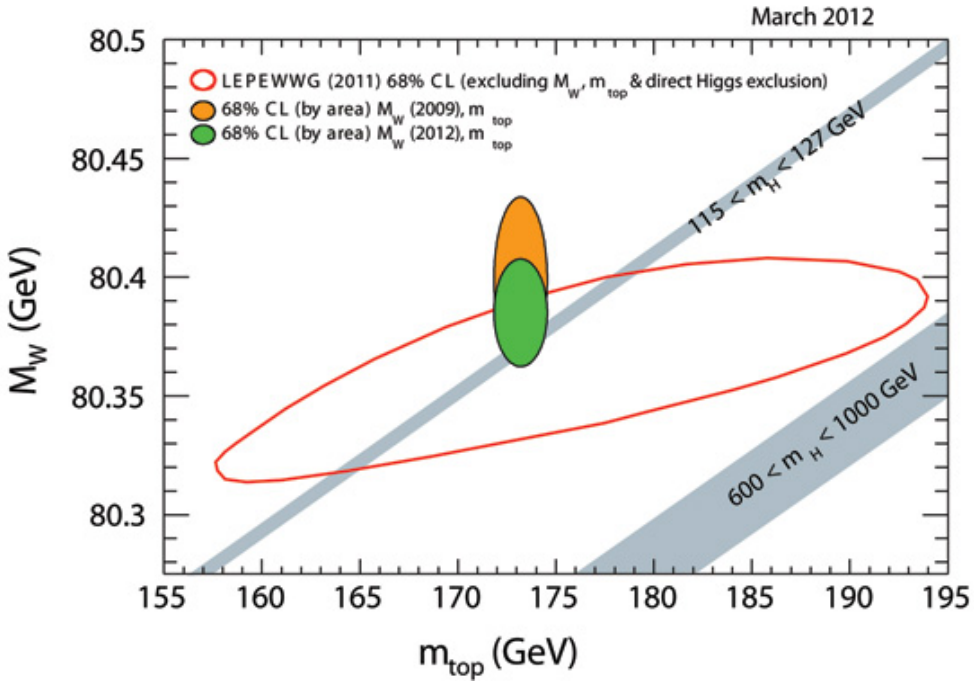
Indirect SM Higgs Mass Constraints

- Recently updated top quark and W boson mass measurements from the Tevatron

$m_W = 80385 \pm 15$ MeV

$m_t = 173.2 \pm 0.9$ GeV

- If Higgs boson is found, next question to be answered is its compatibility with the standard model



$m_H < 152$ GeV at 95% C.L.

Indirect SM Higgs Mass Constraints

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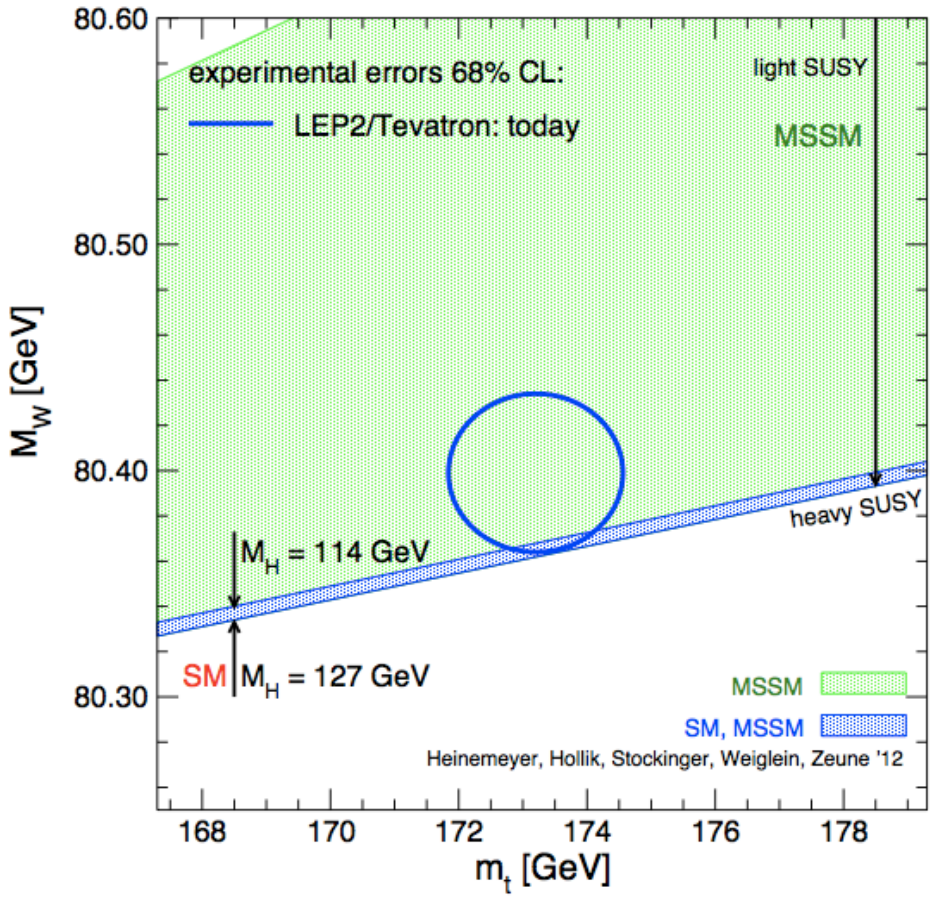
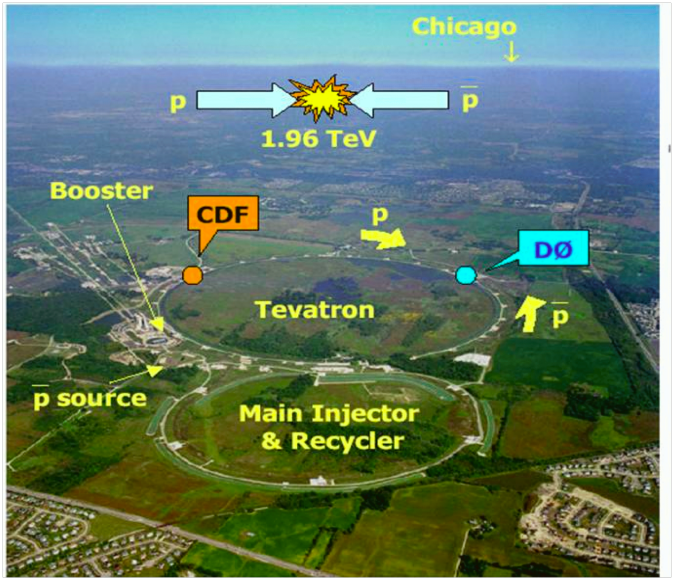
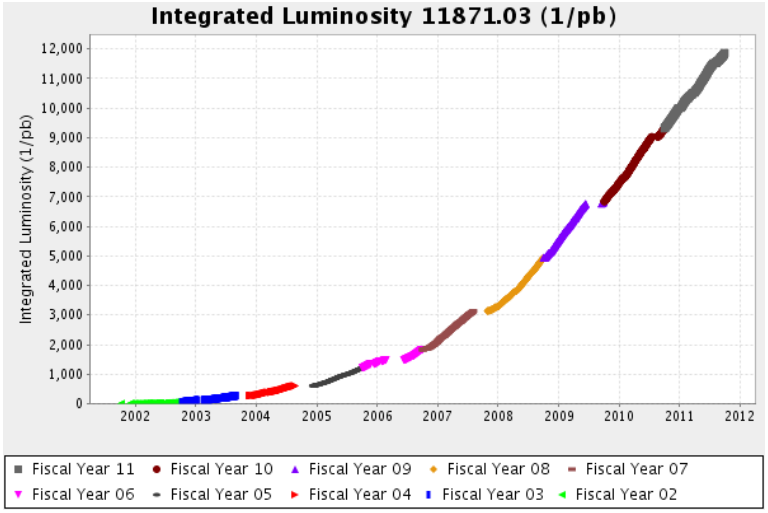


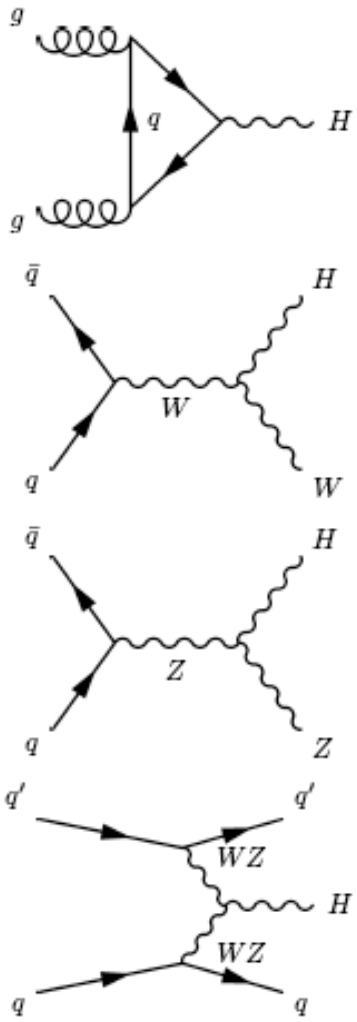
Tevatron

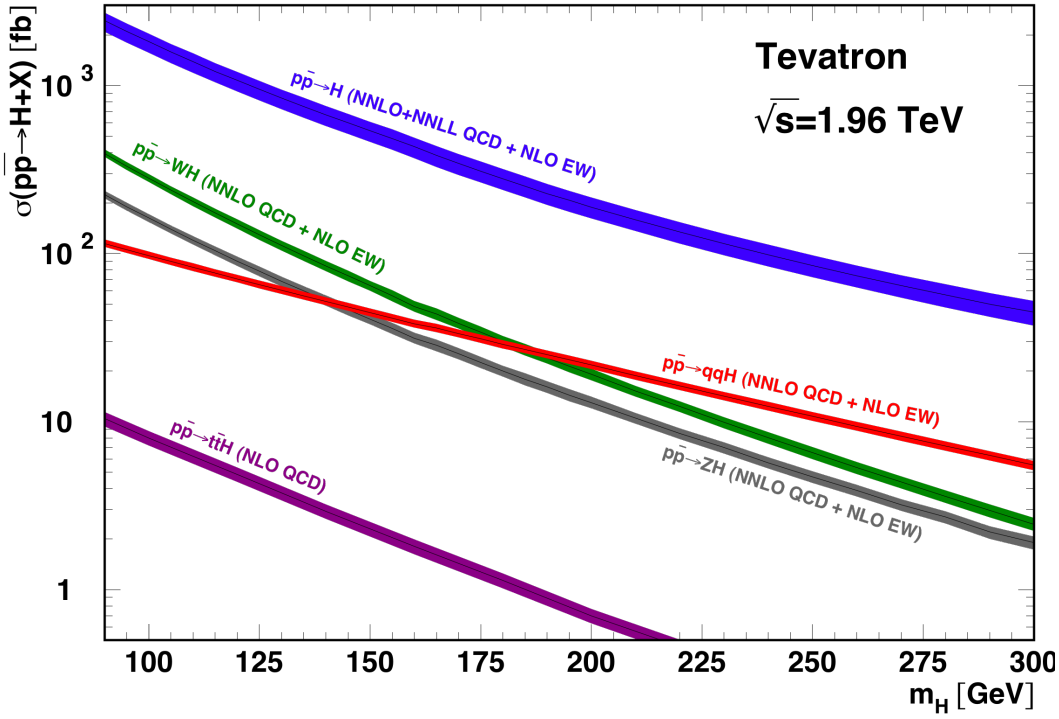
- Run II : 2001-2011
- Over 12 fb^{-1} delivered and 10fb^{-1} recorded with the CDF and D0 detectors
- Initial luminosity record of 4.31 x 10^{32} $cm^{-2}s^{-1}$
- Thanks once again to all the people who contributed to the production of these datasets





SM Higgs Production





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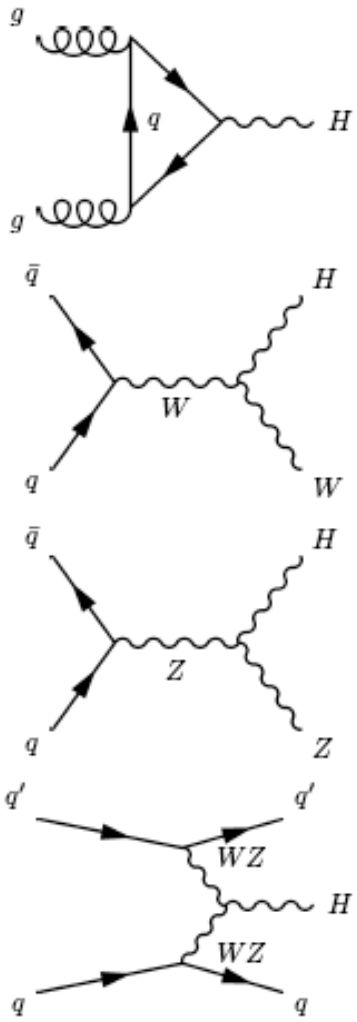
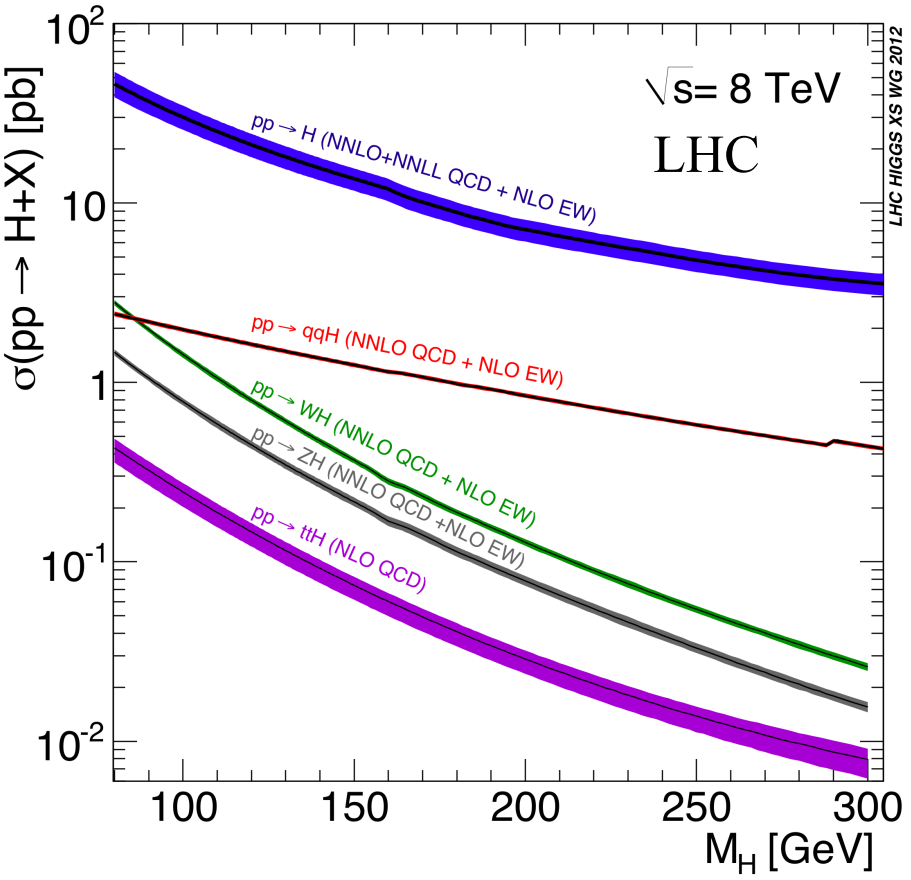
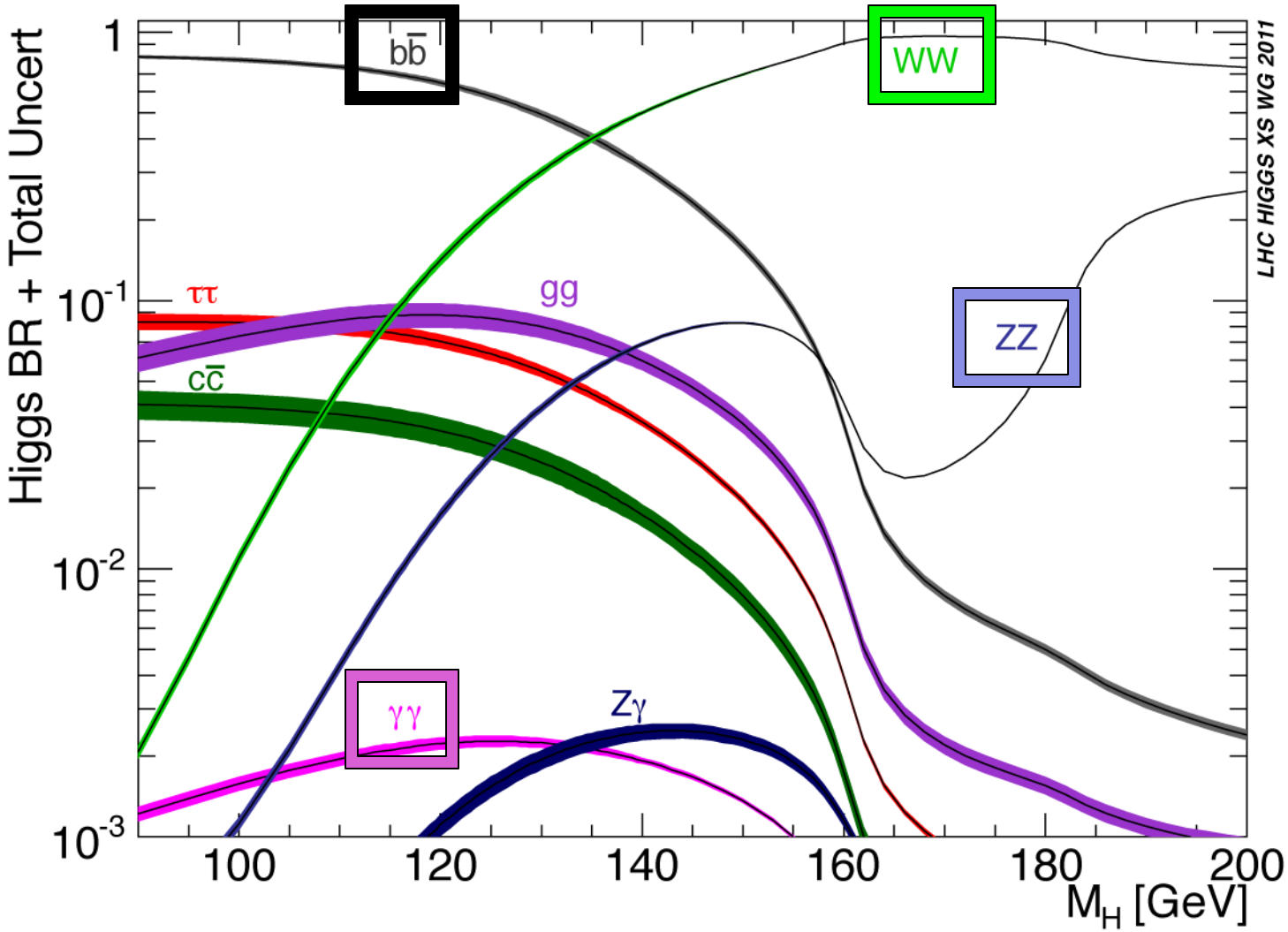


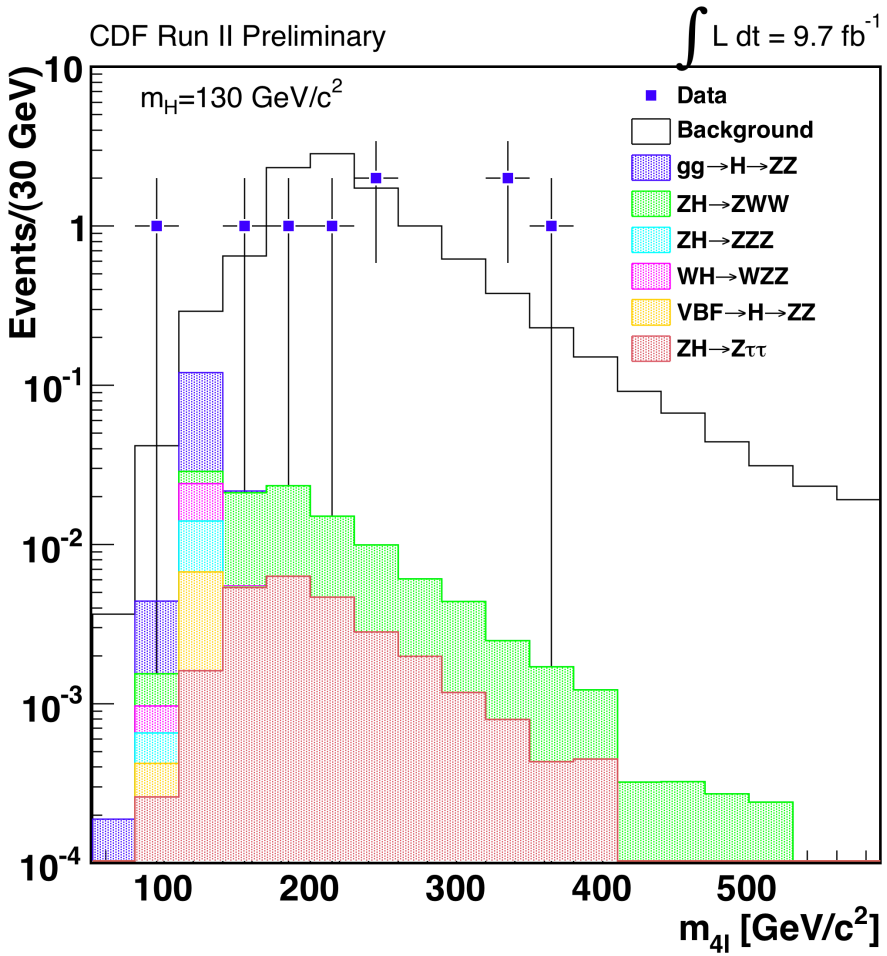


SM Higgs Decay



H→ZZ→4 leptons

- Small expected signal rates
- Low SM backgrounds
- Narrow Higgs boson mass resonance easy to separate from non-resonant background contributions



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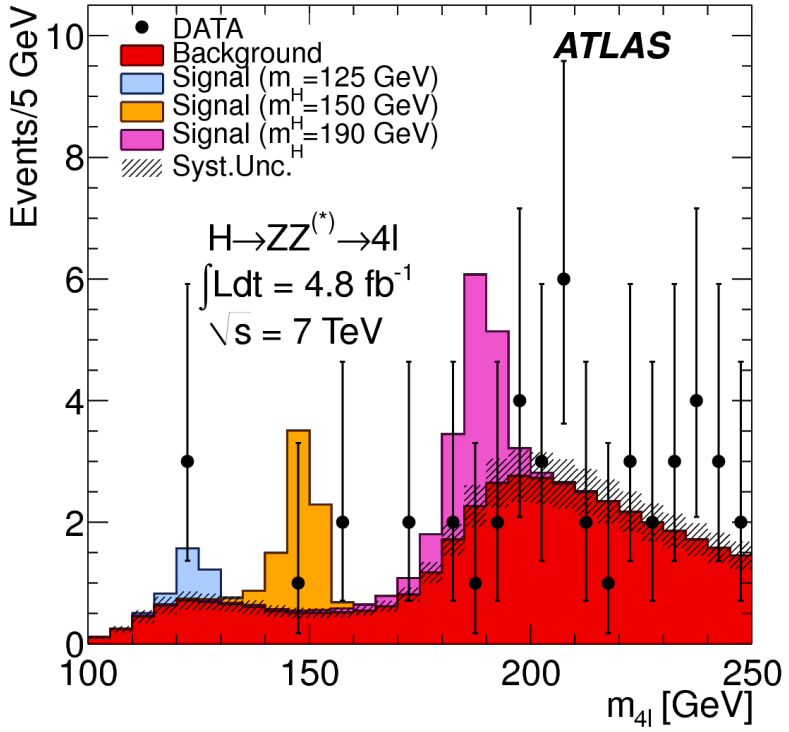
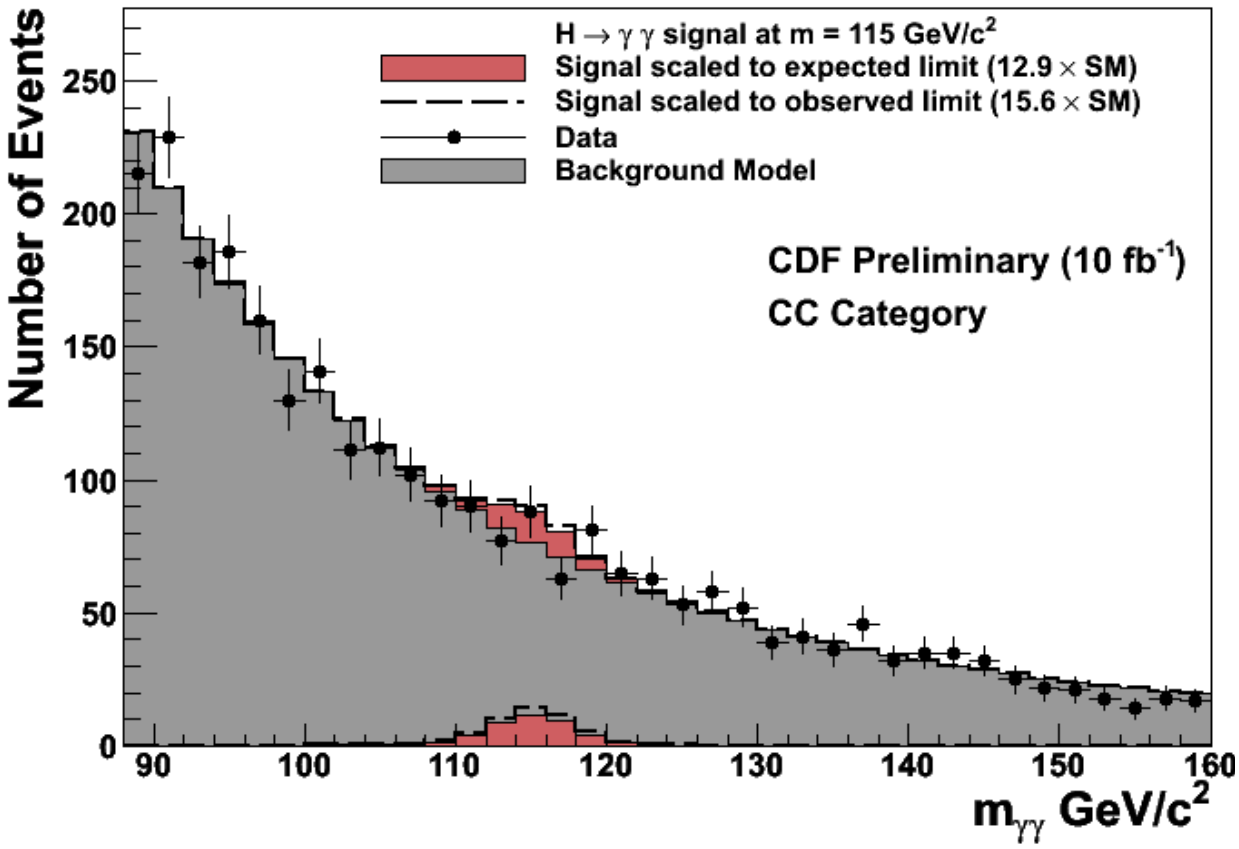


Sqrt(s)	2 TeV	7 TeV	8 TeV
Luminosity	10 fb-1	5 fb-1	5 fb-1
Signal Events	2.1	16	20
Detector	CDF	ATLAS	ATLAS
Signal Yield	0.2	2.7	?
Sensitivity	18xSM	1.5xSM	?

$m_H = 130$ GeV

H→γγ

- Slightly larger expected signal rates
- Larger non-resonant SM backgrounds
- Signal appears as narrow mass resonance on top of falling background spectrum



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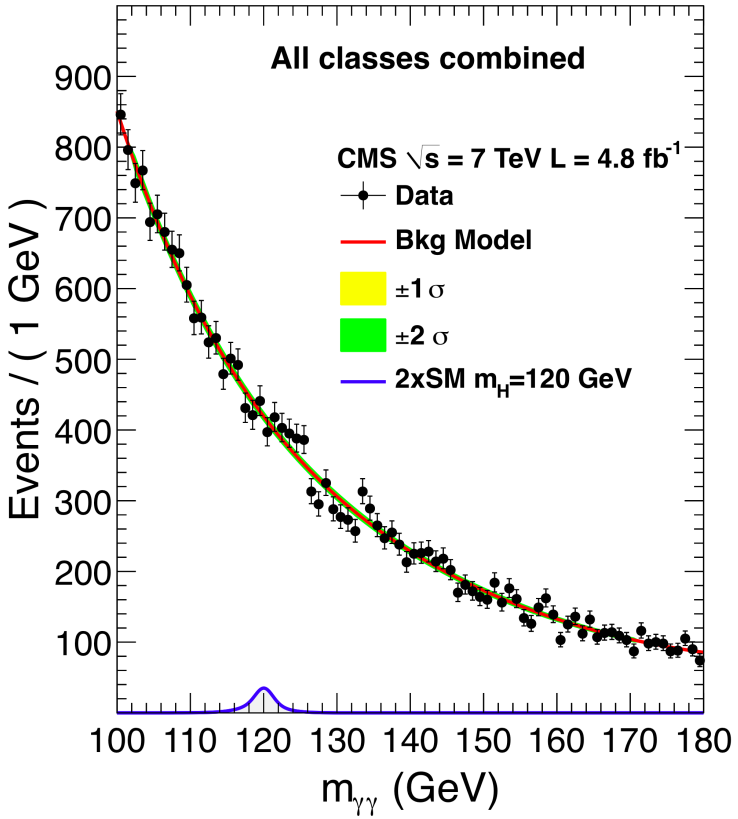
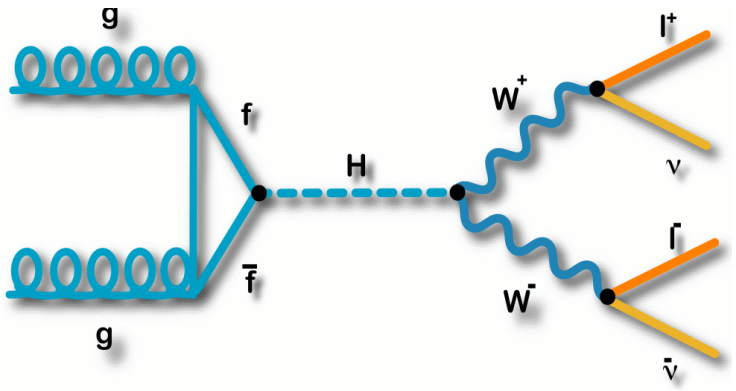


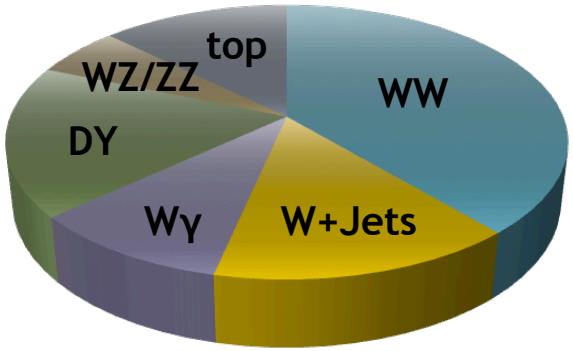
Sqrt(s)	2 TeV	7 TeV	8 TeV
Luminosity	10 fb-1	5 fb-1	5 fb-1
Signal Events	28	200	255
Detector	CDF	CMS	CMS
Signal Yield	7	75	?
Sensitivity	11xSM	1.4xSM	?

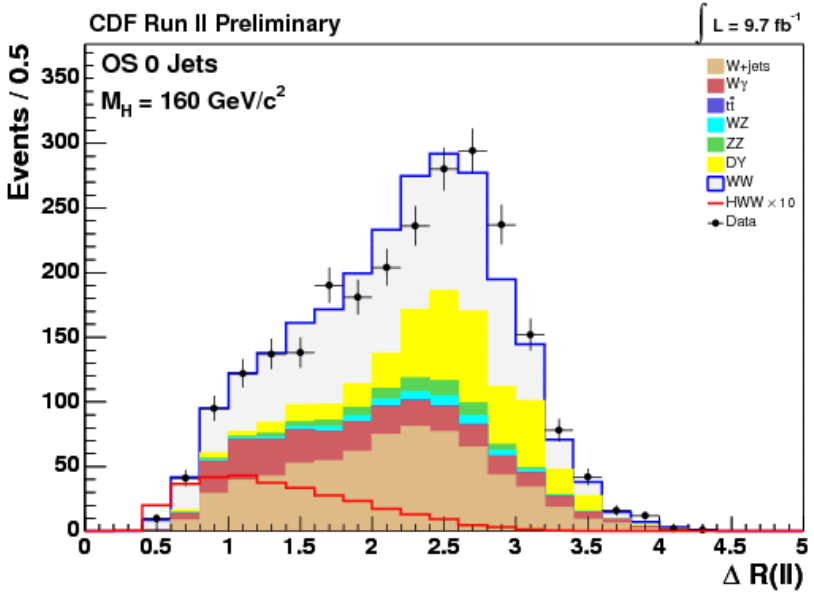
m_H = 125 GeV

H→WW→lνlν

- Basic event selection is two reconstructed leptons and missing E_T
- Presence of two neutrinos in final state prevents complete Higgs mass reconstruction
- Separate potential signal from large backgrounds using kinematic event information

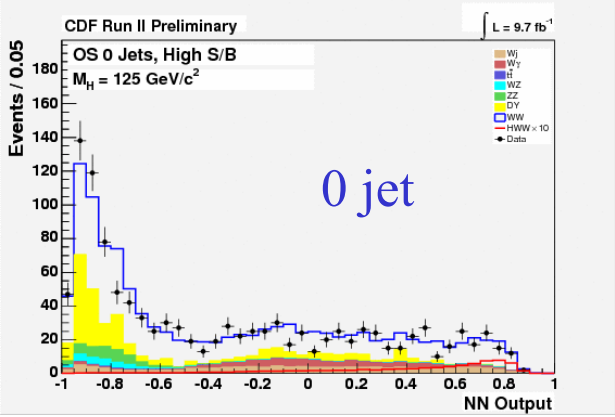


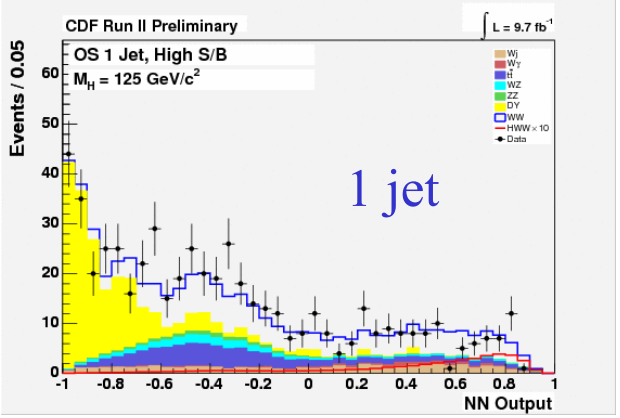


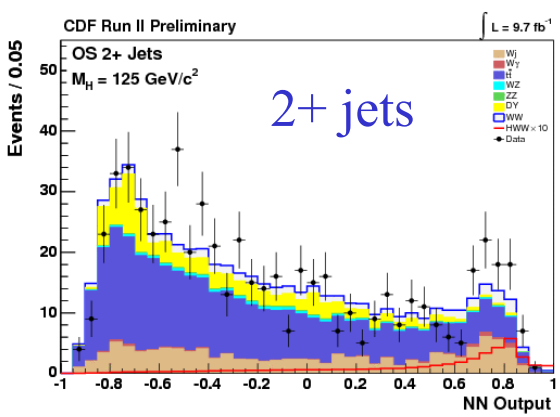


H→WW→lνlν

- Multi-variate techniques are used to exploit as much kinematic event information as possible
- Data are separated into multiple search samples to isolate contributions from specific signal and background processes

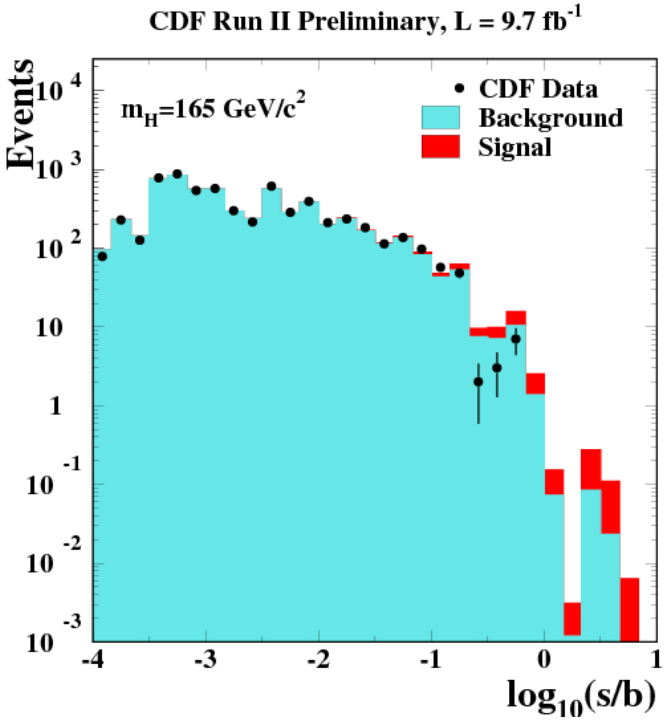


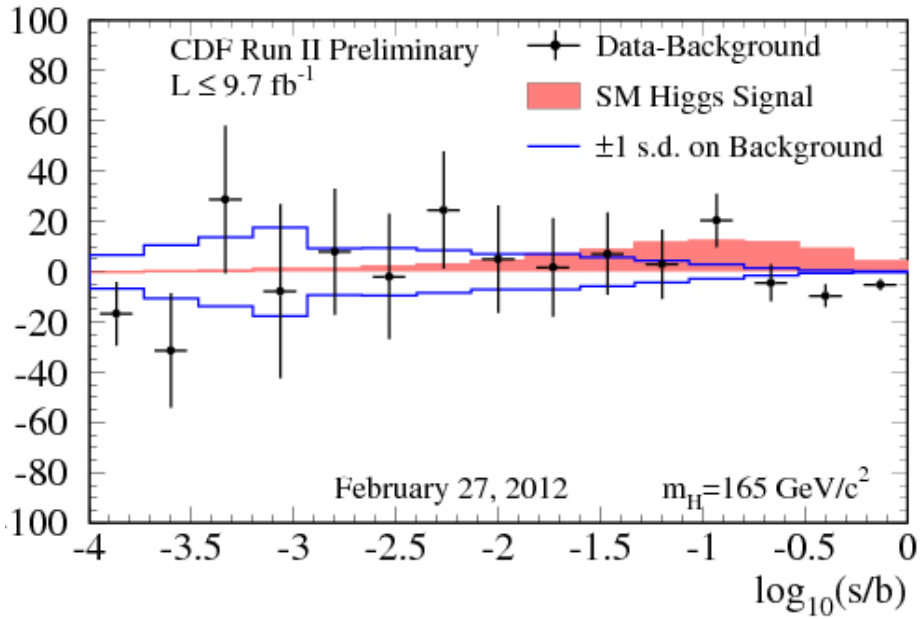




H→WW→lνlν

- Results from thirteen independent search samples are combined to obtain the best possible sensitivity
- No significant, observed excesses in data above predicted SM background contributions





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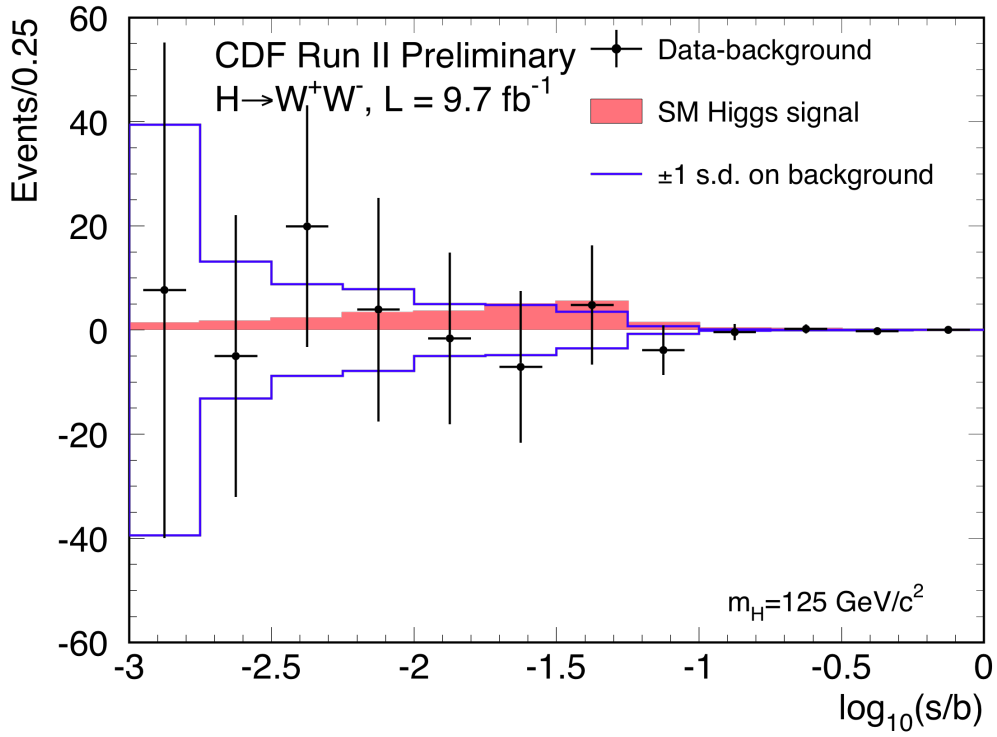

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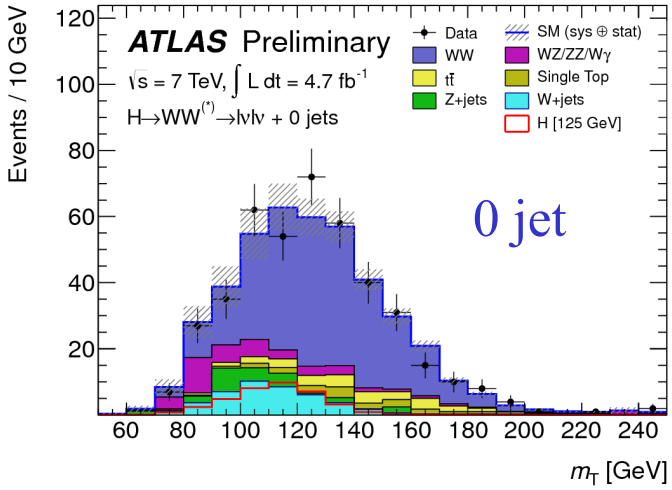
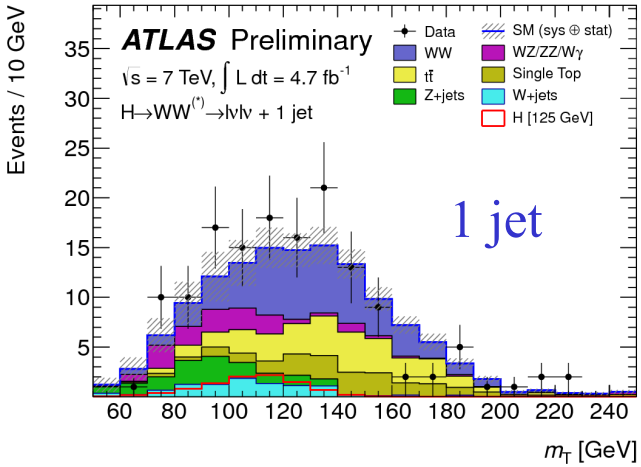


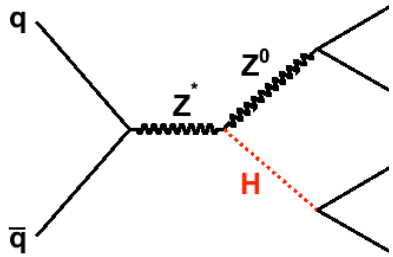


Sqrt(s)	2 TeV	7 TeV	8 TeV
Luminosity	10 fb-1	5 fb-1	5 fb-1
Signal Events	170	1215	1550
Detector	CDF	ATLAS	ATLAS
High S/B Signal Yield	7	32	?
Sensitivity	3.1xSM	1.2xSM	?

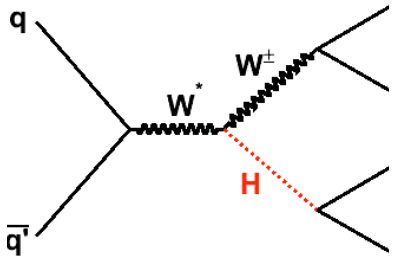
$m_H = 125$ GeV

H→bb

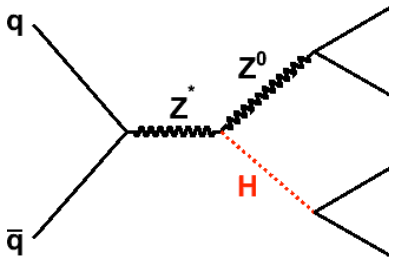
- Tevatron searches in this decay mode are still the world's most sensitive
- Basic event selection is 0, 1, or 2 leptons and/or missing E_T plus two high E_T jets
- Challenge is separating the small number of potential signal events from the much larger SM background contributions



ZH→ννbb



WH→lνbb



ZH→llbb

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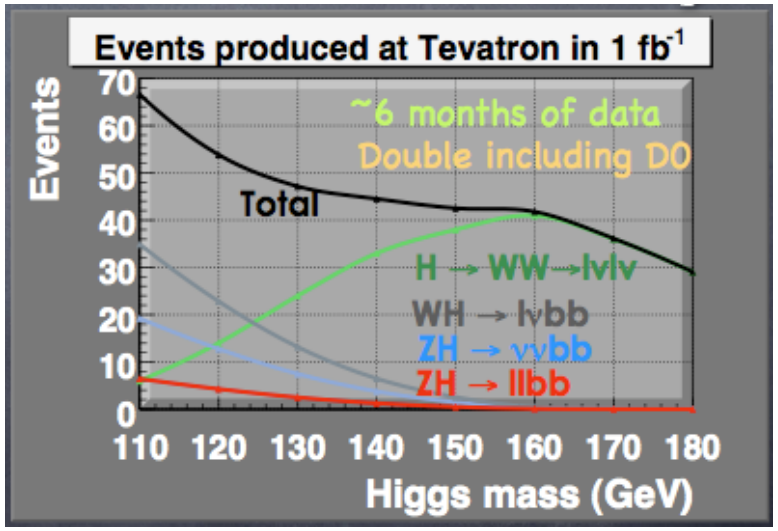
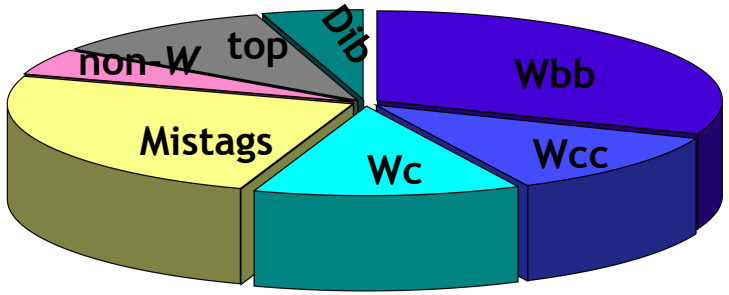
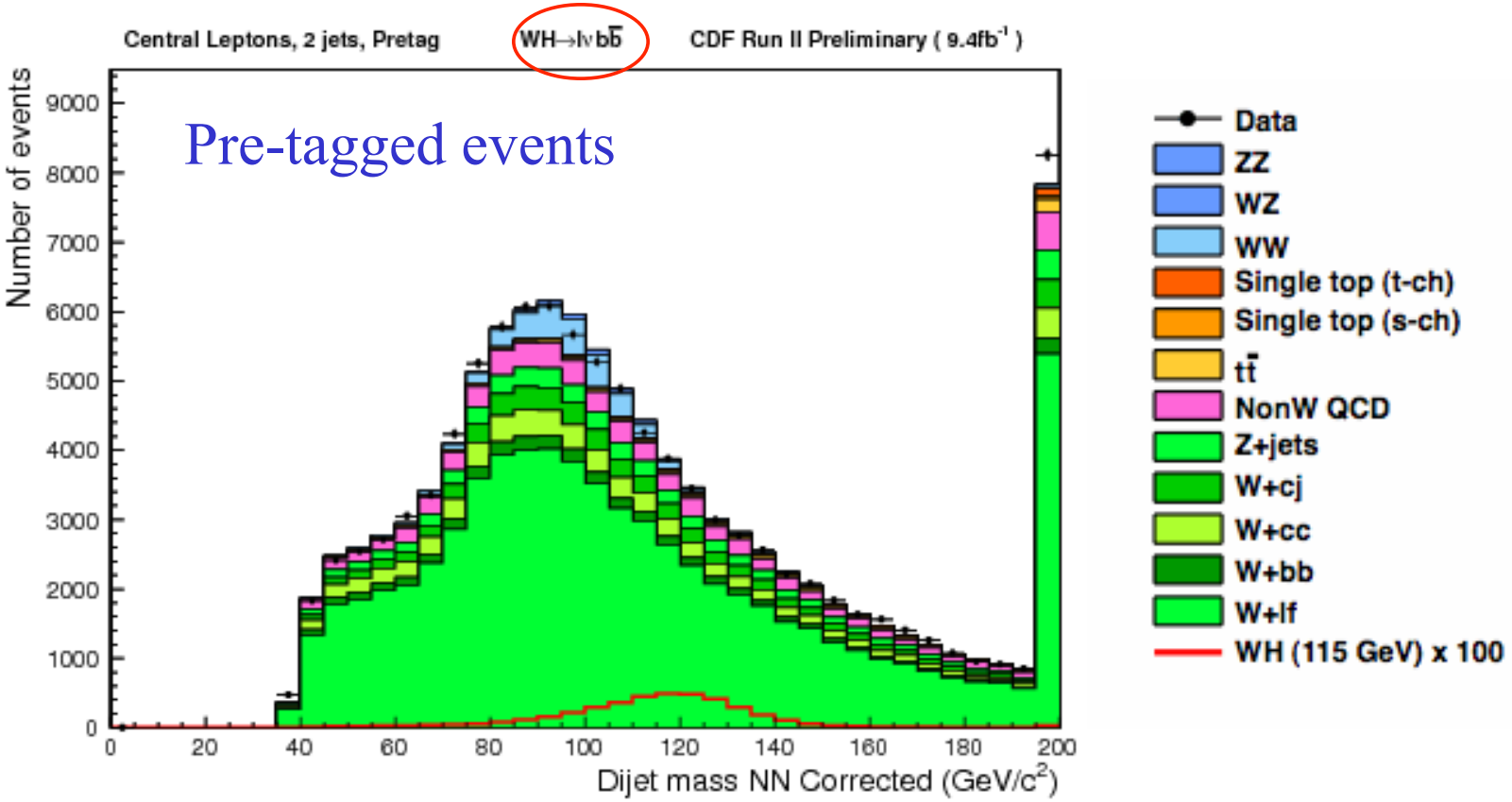




H→bb



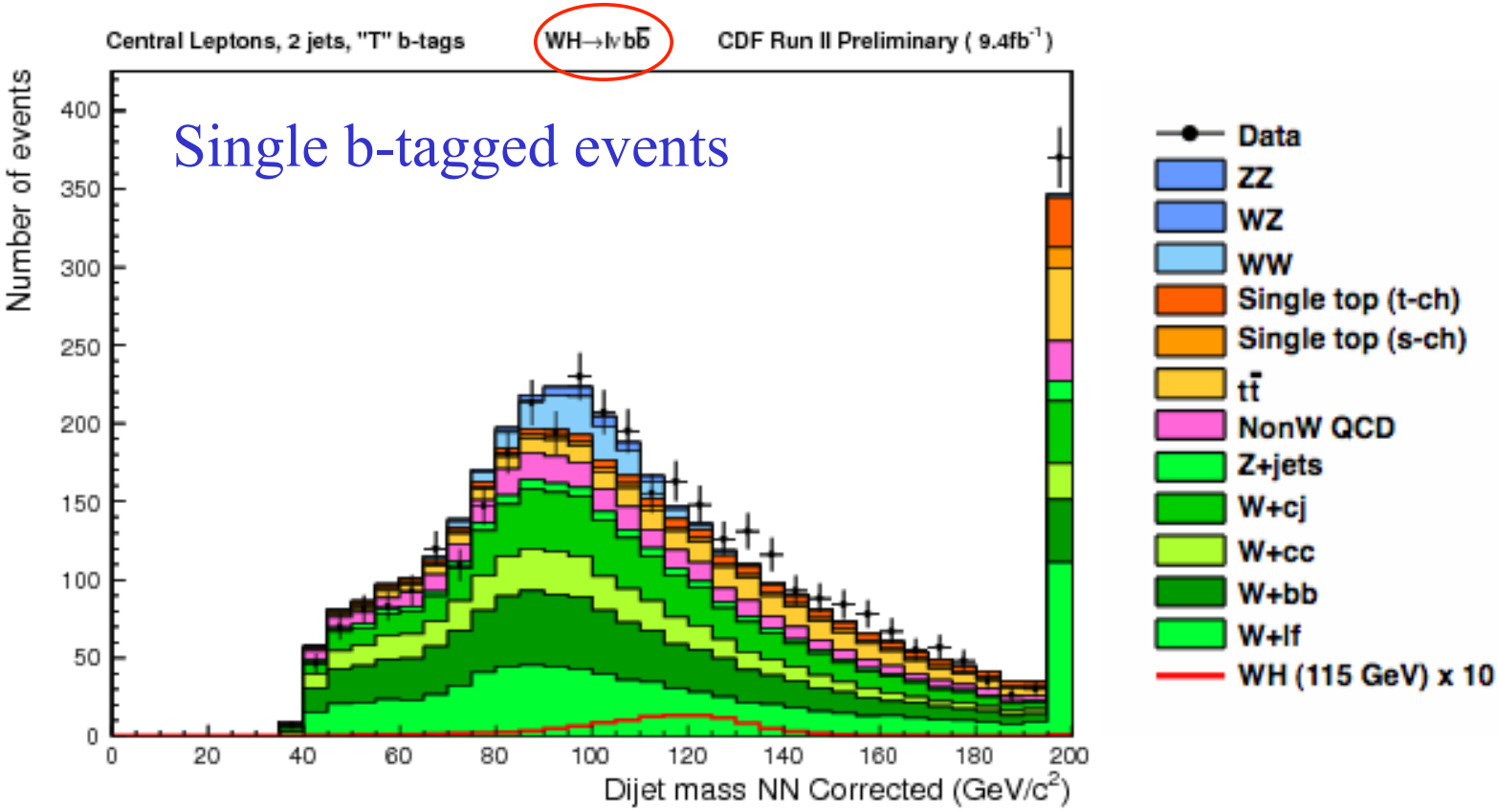
Focus on

Increasing lepton reconstruction and selection efficiencies

Improving the efficiency for tagging bottom quark jets

Optimizing dijet mass resolution

H→bb



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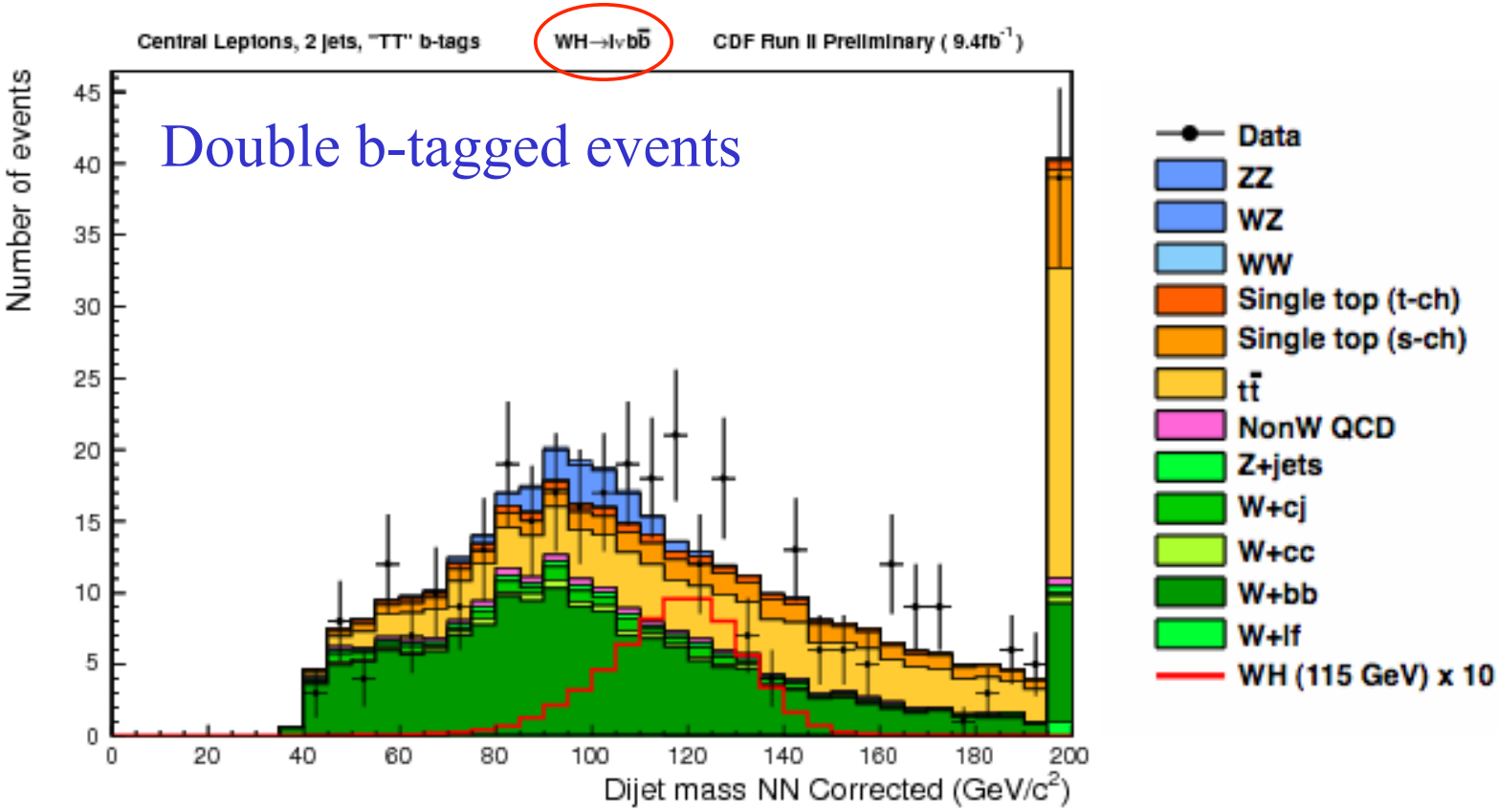


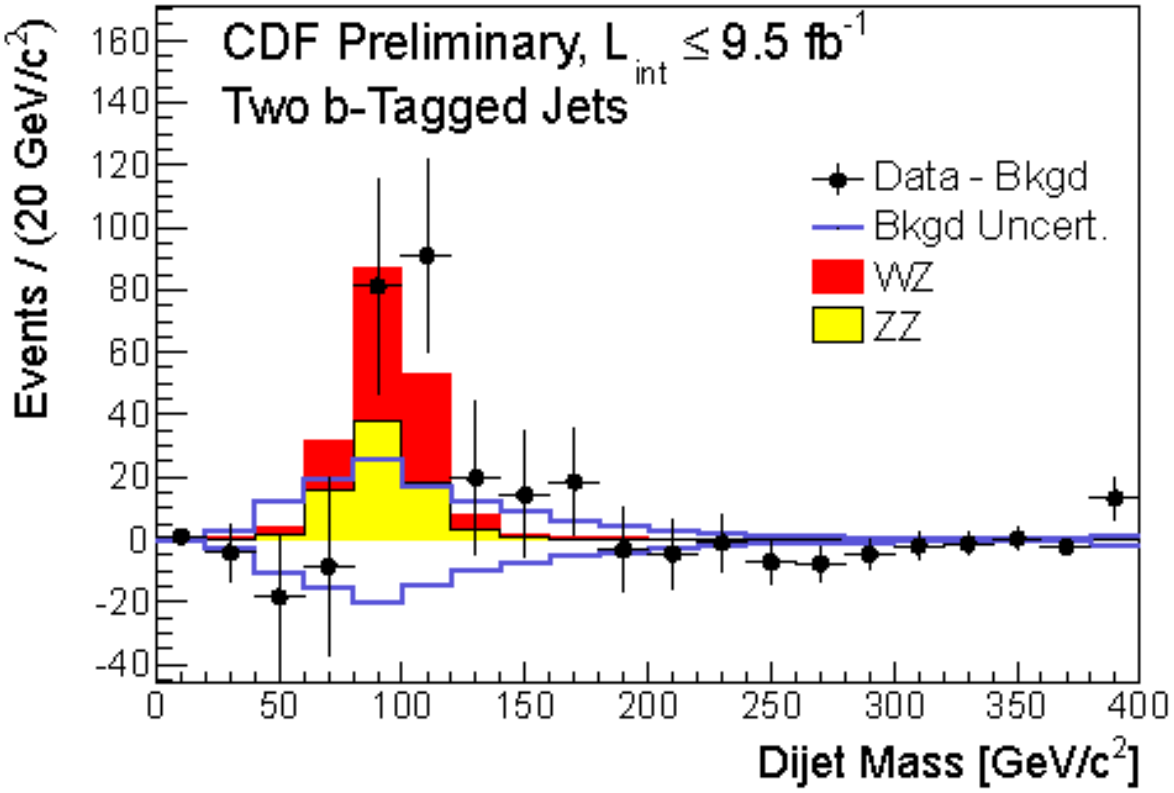
Double b-tagged events

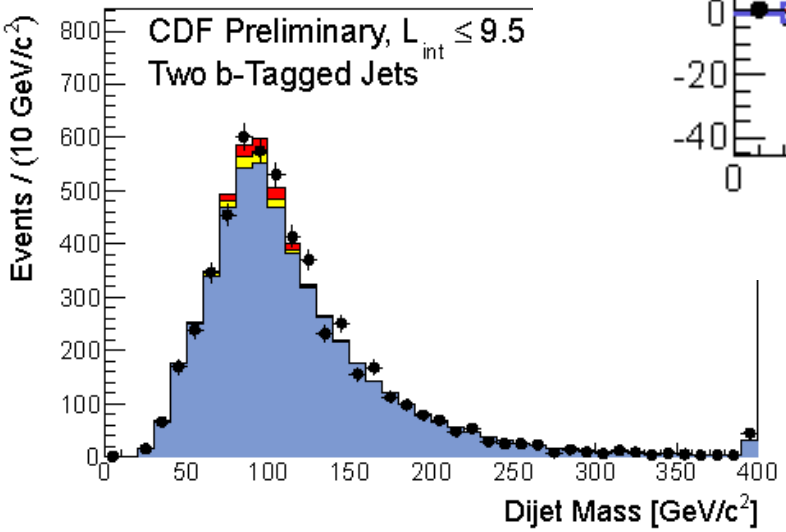
Focus on

- Increasing lepton reconstruction and selection efficiencies
- Improving the efficiency for tagging bottom quark jets
- Optimizing dijet mass resolution

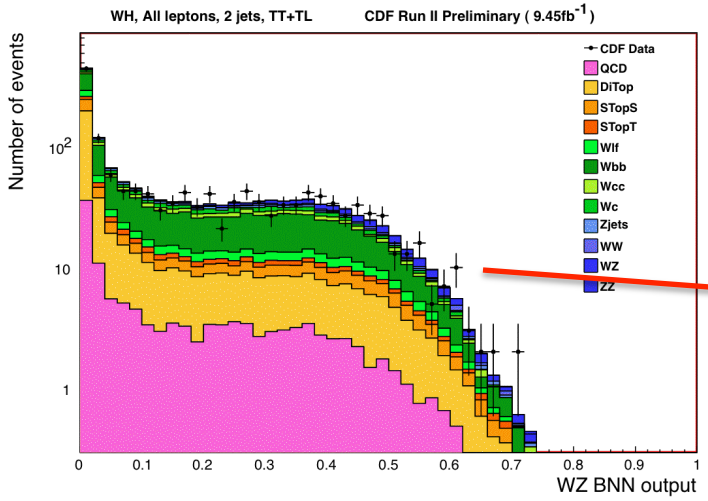
Validation of H→bb

- Background model validation
- Measure WZ/ZZ with Z→bb



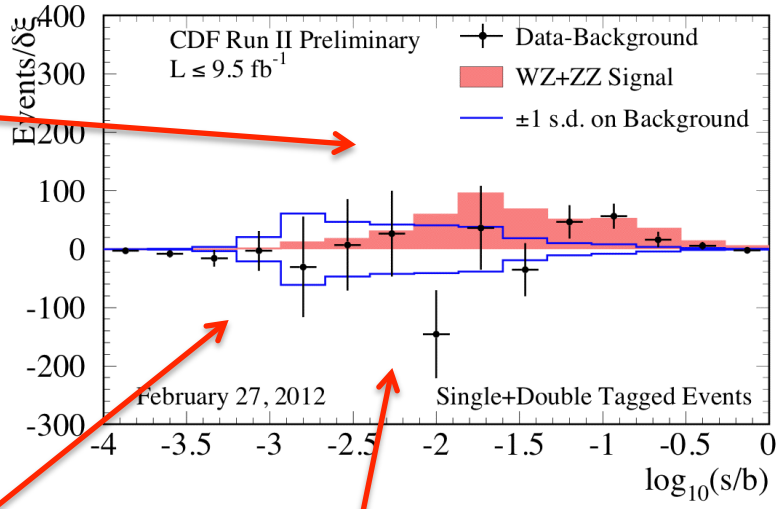


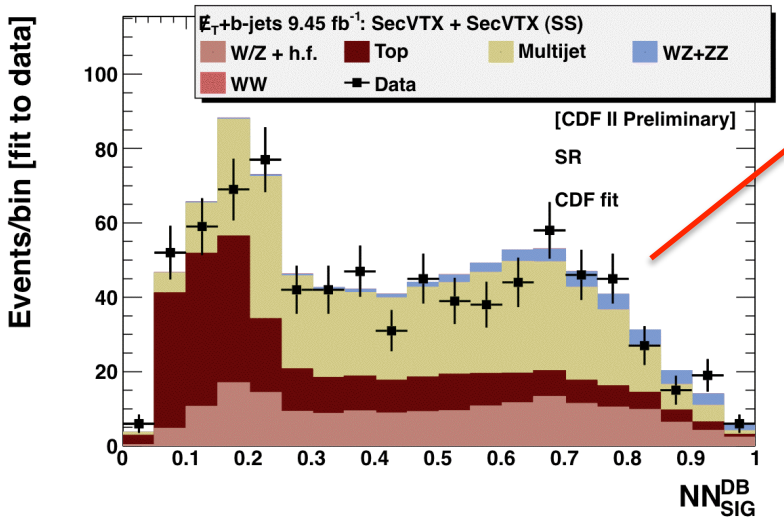
Validation of H→bb

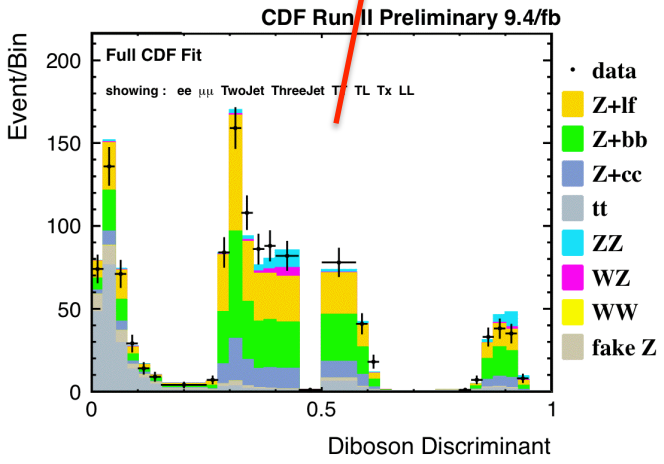


σ(WZ+ZZ)= 4.08 +/- 1.32 pb (SM: 4.4 +/- 0.3 pb)

Sig. ~ 3.2σ

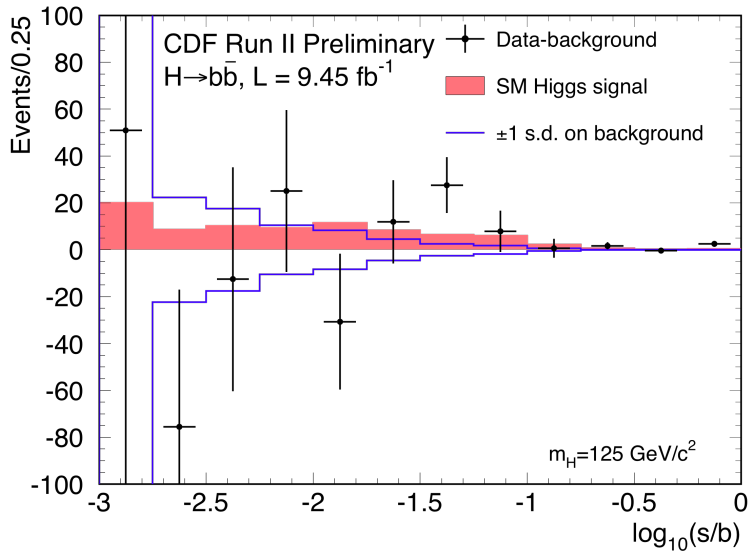


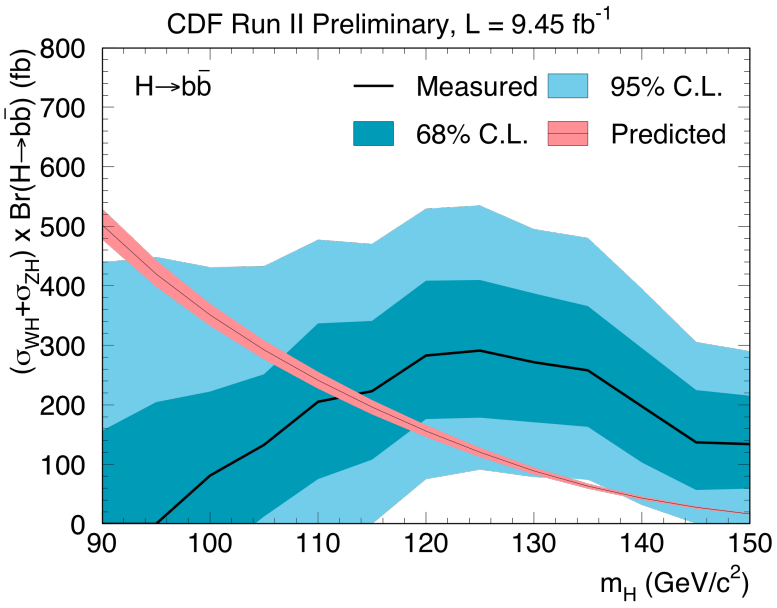




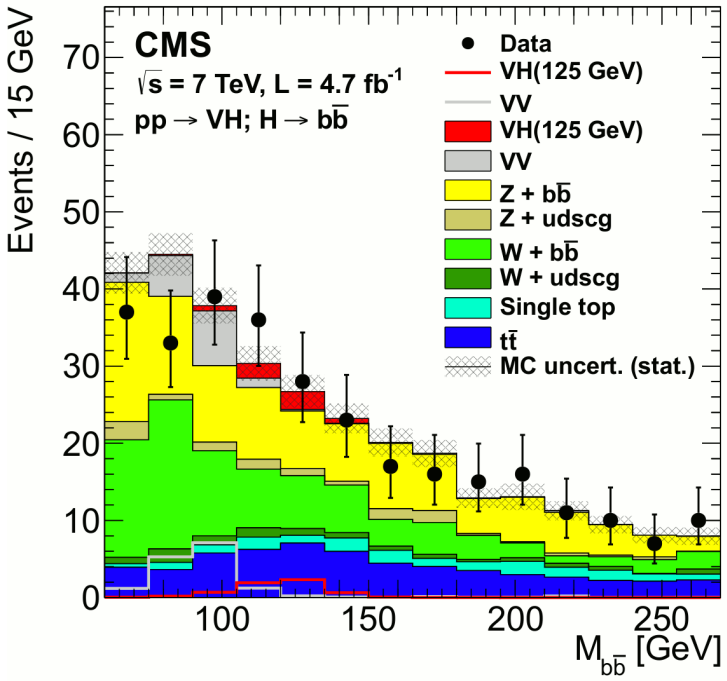
H→bb

- Data excess above the predicted SM background contributions in the highest S/B discriminant bins
- Fitted Higgs cross section is about 2x SM expectation at m_H = 125 GeV (and also consistent with SM at ~1.5σ)
- Maximum local p-value associated with excess is 2.7σ corresponding to global p-value of 2.5σ





H→bb



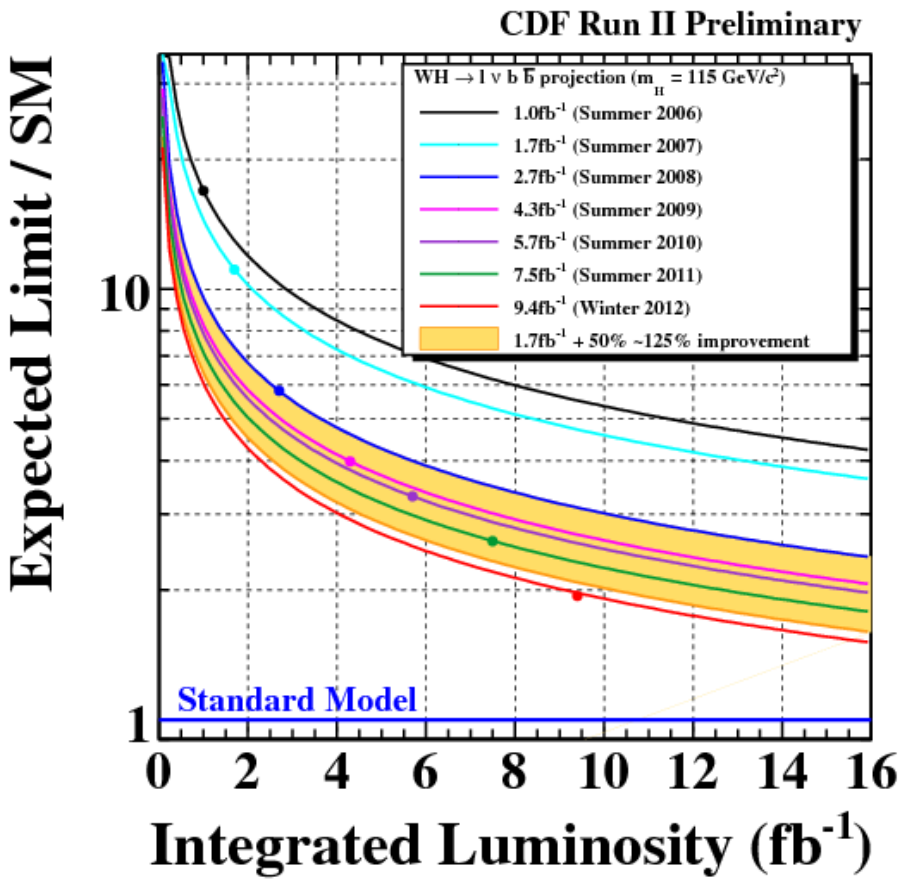
Sqrt(s)	2 TeV	7 TeV	8 TeV
Luminosity	10 fb-1	5 fb-1	5 fb-1
Signal Events	315	670	820
Detector	CDF	CMS	CMS
High S/B Signal Yield	13.7	5	?
Sensitivity	1.7xSM	4.3xSM	?

$m_H = 125$ GeV

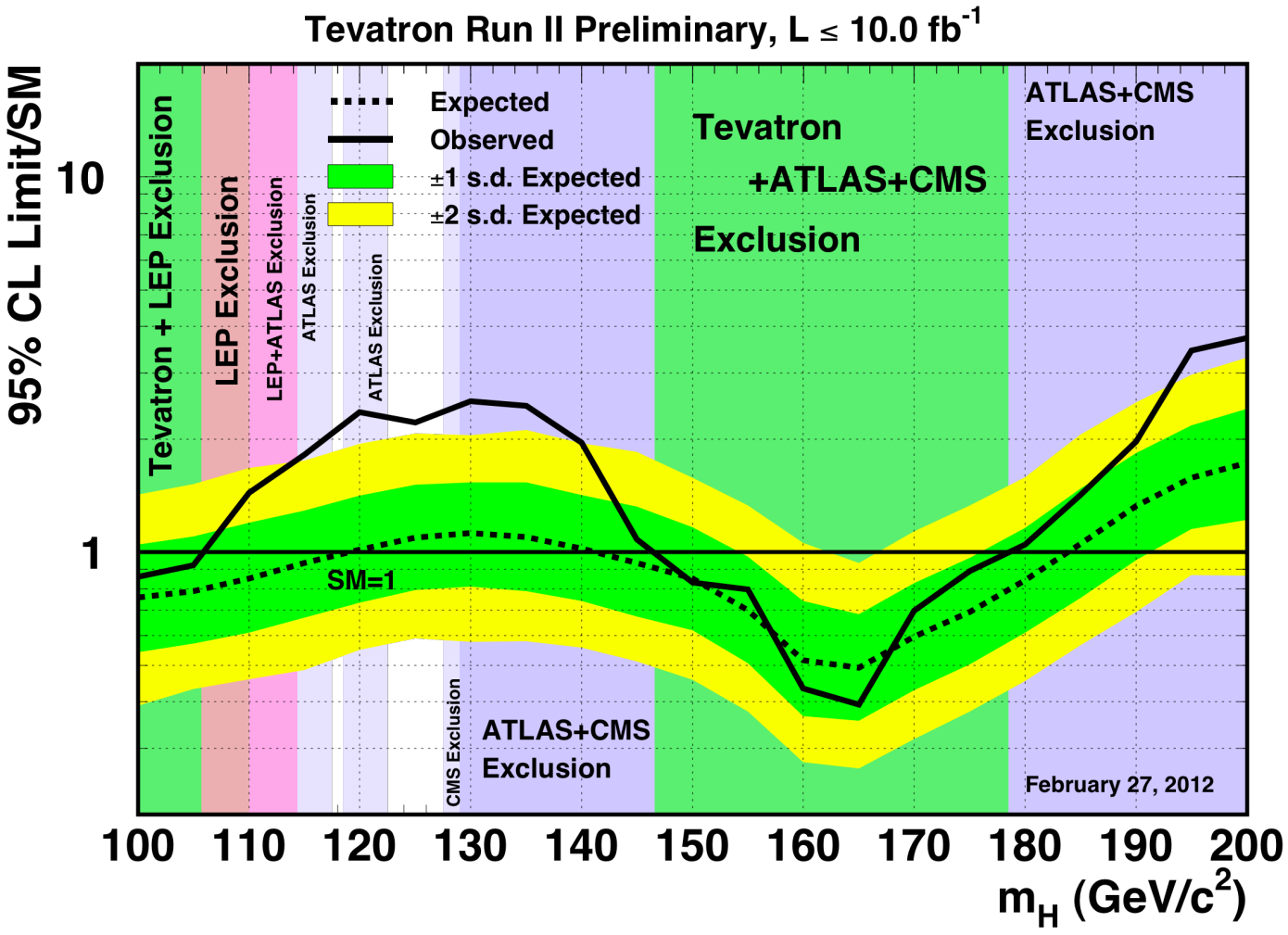
Summarizing CDF searches

- CDF Higgs searches have exceeded our most optimistic sensitivity projections from five years ago
- Work still in progress to incorporate neural network bottom quark tagging in ZH→ννbb search
- If a Higgs boson is found, goal moving forward will be best possible measurement of

  σ(WH+ZH) x Br(H→bb)



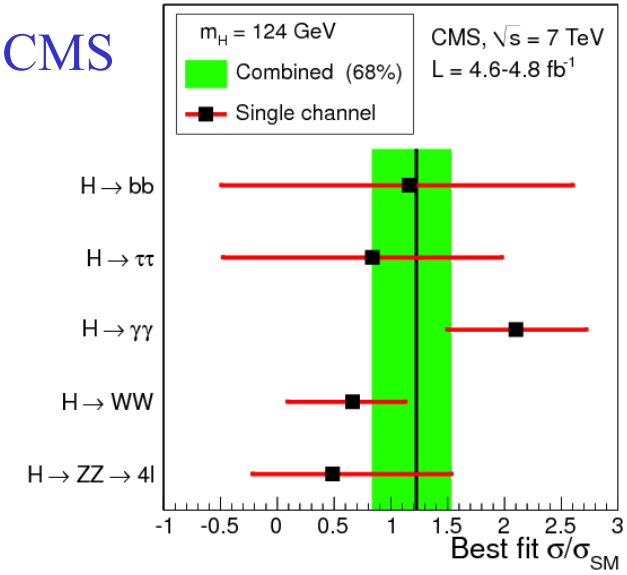
Current Landscape



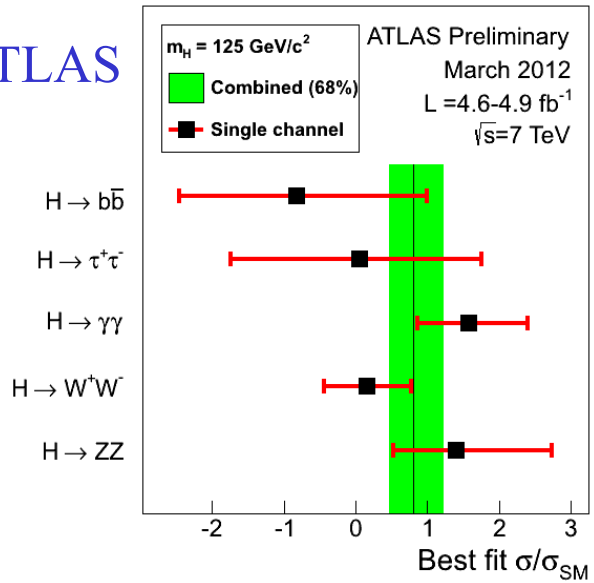
Spring 2012 Results

Current Landscape

CMS

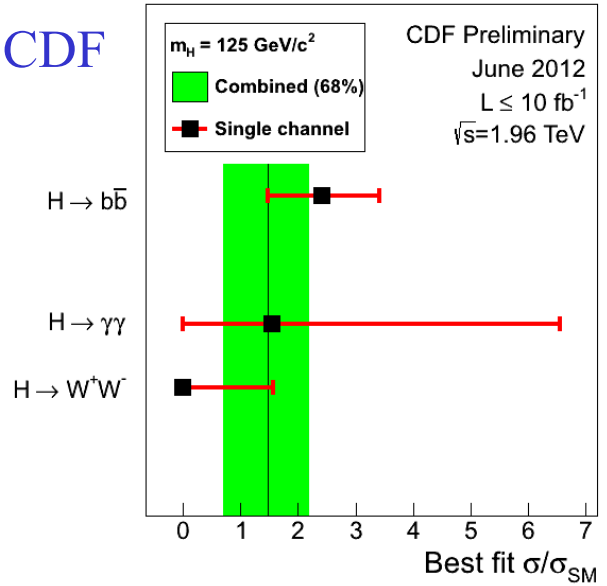


ATLAS

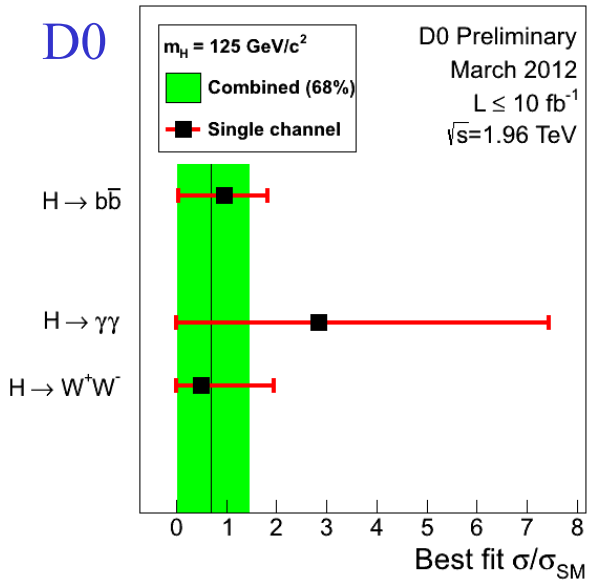


Spring 2012 Results

CDF



D0



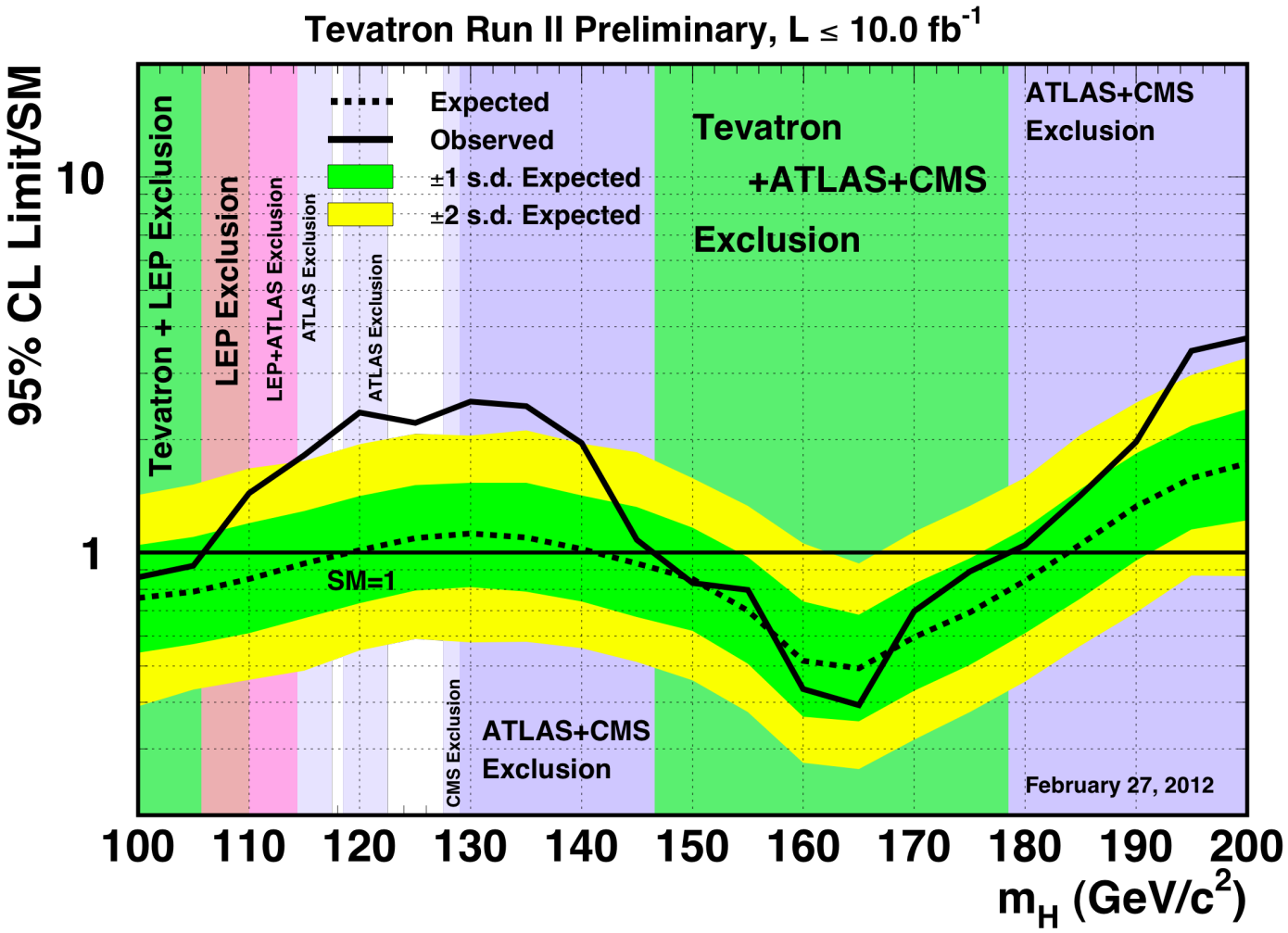
Current Landscape

SM Higgs Searches		
Experiment	Local P-value	Global P-value
CDF+D0	2.8σ	2.2σ
ATLAS	2.9σ	1.6σ
CMS	3.1σ	2.1σ

Spring 2012 Results

Single Channel Searches			
Experiment	Channel	Local P-value	Global P-value
CDF	H->bb	2.7σ	2.5σ
ATLAS	H->γγ	2.8σ	1.5σ
CMS	H->γγ	3.1σ	1.8σ

Summer 2012



And now to new results …