Since the last time we met…

Robert Roser
Fermilab

For Dmitri Denisov, Stefan Soldner and Giovanni Punzi

August 27, 2010

Outline of Tevatron Presentations

1. Progress of the Tevatron experiments since June PAC meeting - Rob Roser

2. DZero detector radiation aging and collaboration manpower through 2014 - Stefan Soldner

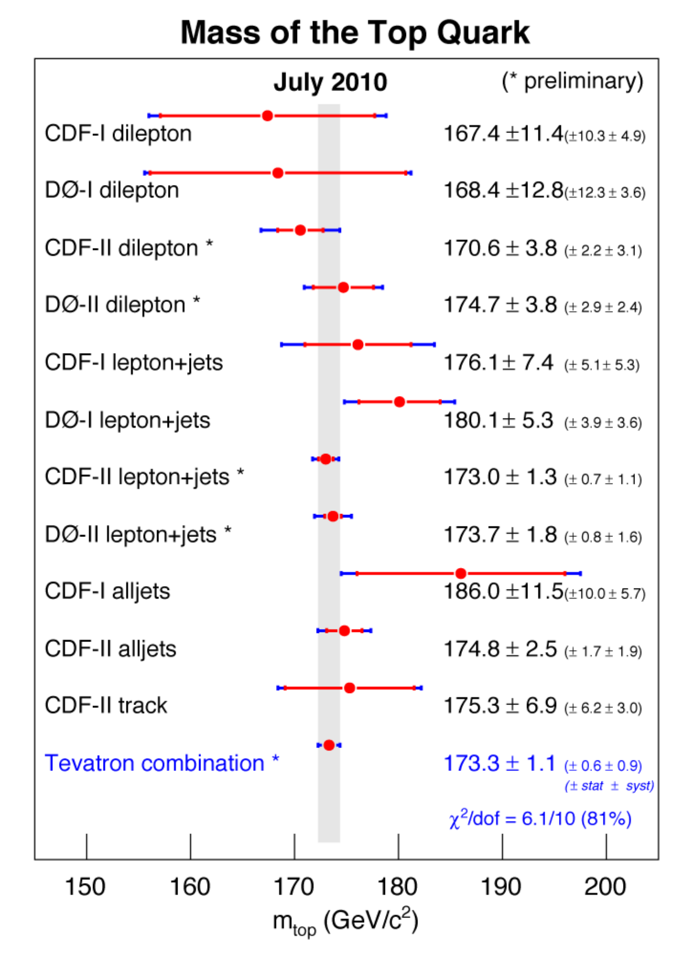
3. CDF detector radiation aging and collaboration manpower through 2014 - Giovanni Punzi

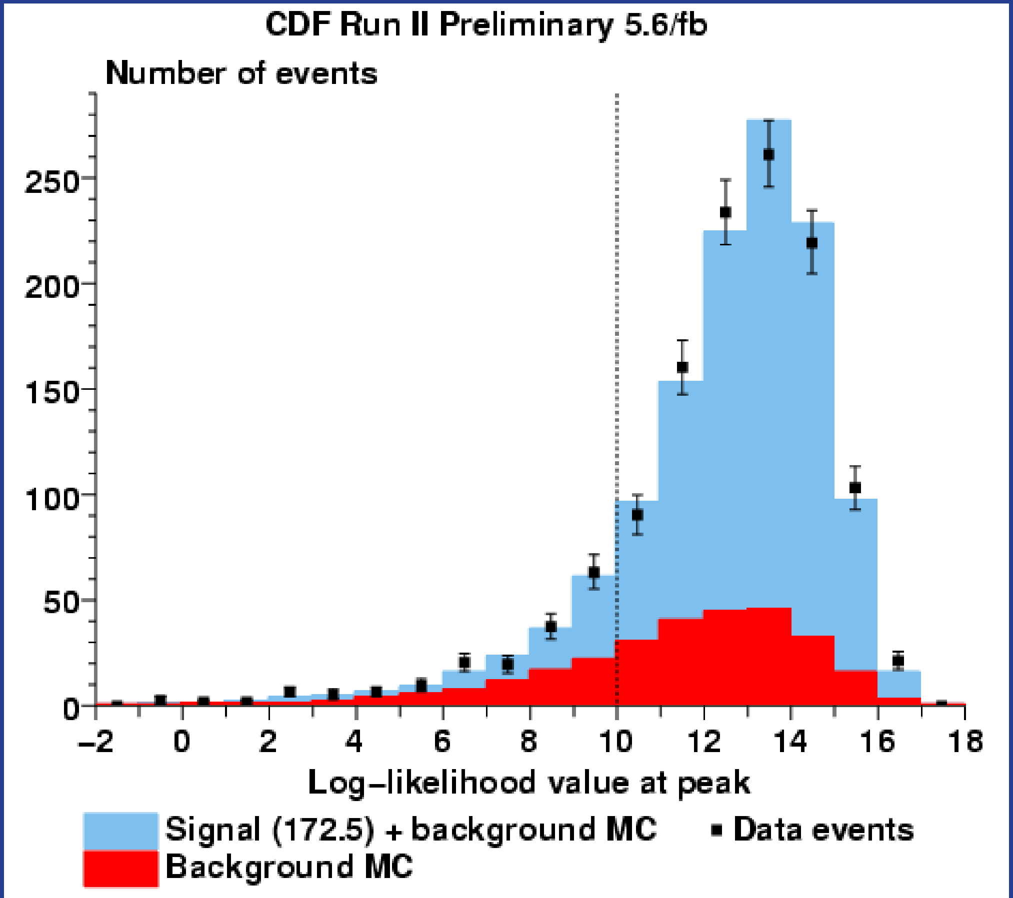
4. Answers on PAC questions about Higgs sensitivity and mass resolution – Dmitri Denisov

The Brief Scorecard….

- ~100 New Tevatron Results presented in Paris at ICHEP 2010
- Web pages with the details for D0 and CDF listed here.
  - http://www-d0.fnal.gov/Run2Physics/D0ICHEP2010.html
  - http://www-cdf.fnal.gov/physics/S10CDFResults.html
- Most of these results use ~6 fb-1 of data!
- 10 papers published in PRD/PRL
- A large number of articles in the scientific press regarding Higgs Results and Run III

Future Legacy: Precision Top Mass





$m_t = 173.0 \pm 0.7_{stat} \pm 0.6_{JES} \pm 0.9_{syst}$ GeV/c^2 = 173.0 ± 1.2 GeV/c^2

current Tevatron precision: 0.7%

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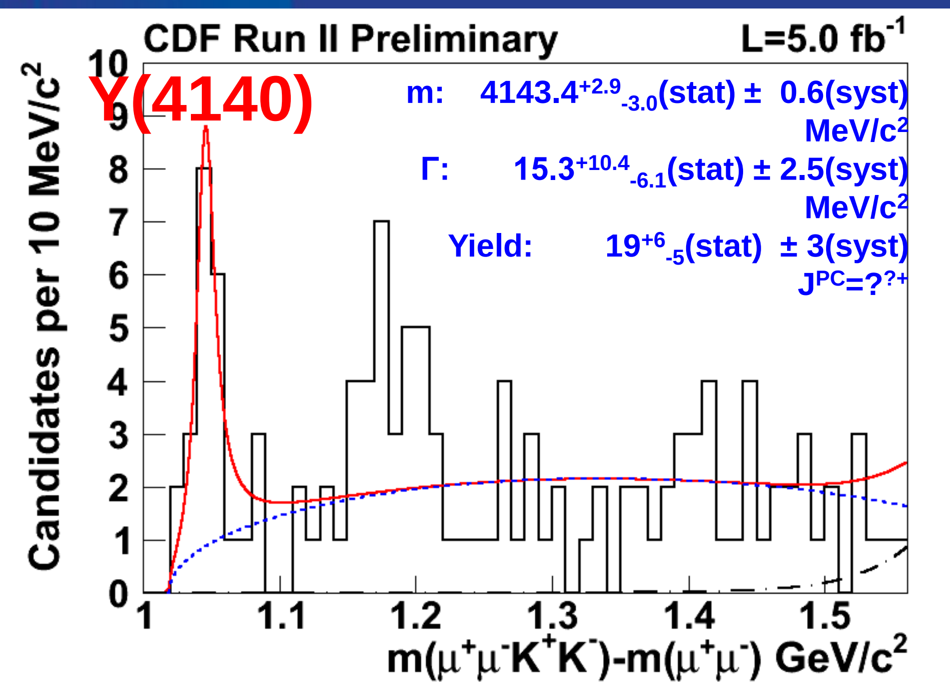
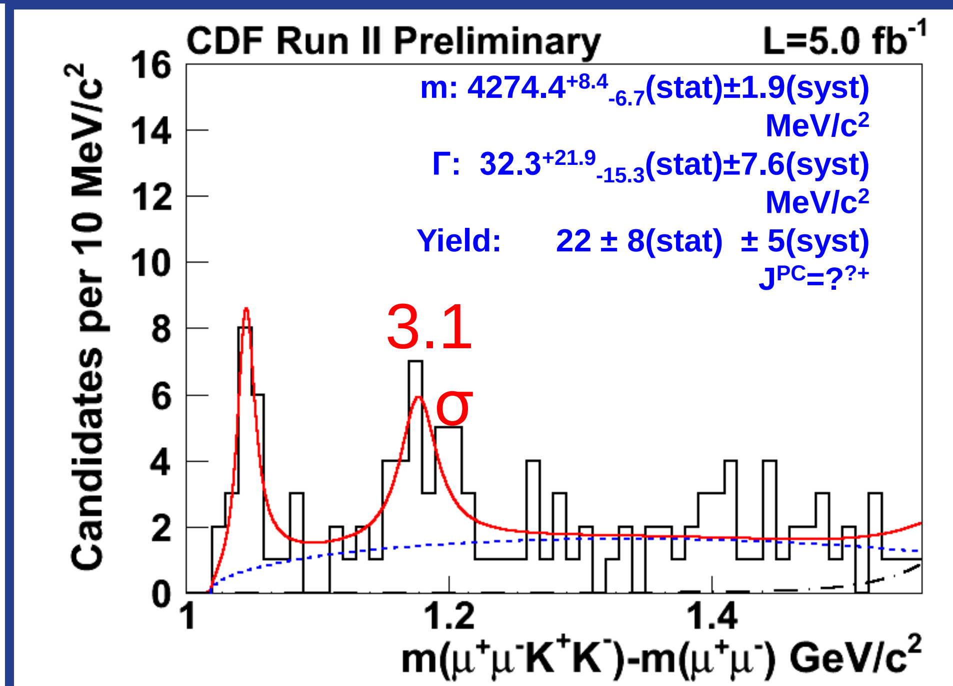
Observation of Y(4140)

- Y(4140) → J/yf through exclusive $B^+ \to Y(4140)K^+$ decay (PRL 102, 242002)
- Y(4140) significance >5σ with the same cuts as before using 5.0fb^{-1} data
- Suggestive evidence emerging for another structure at 4270 MeV/c^2

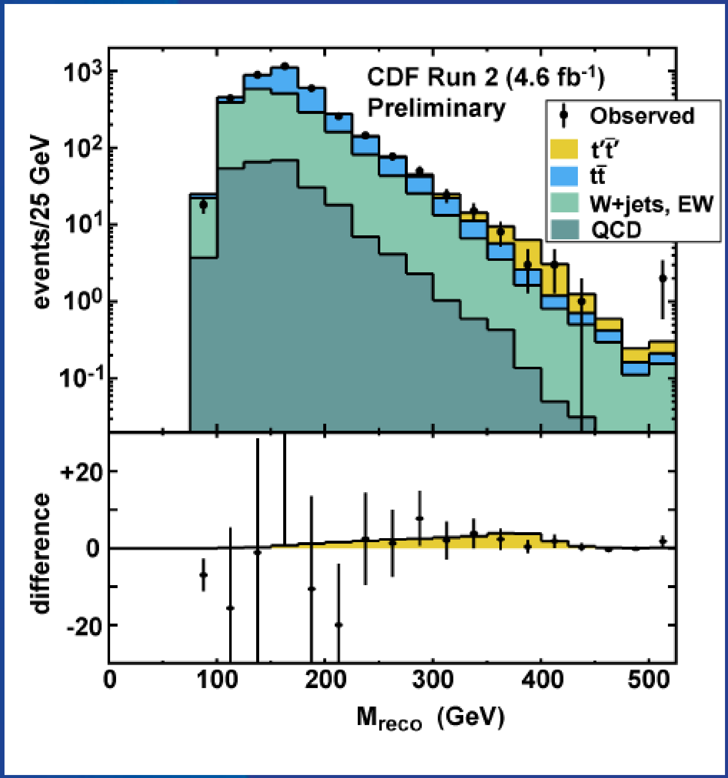


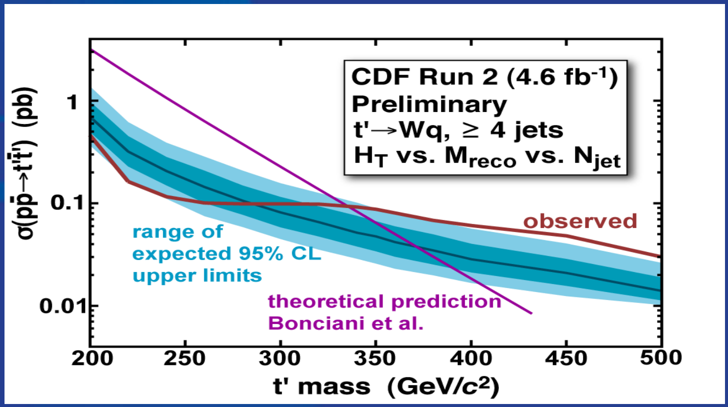


Relative BF: $$\frac{\mathcal{B}(B^+ \to Y(4140)K^+, Y(4140) \to J/\psi\phi)}{\mathcal{B}(B^+ \to J/\psi\phi K^+)} = 0.149 \pm 0.039(\mathrm{stat}) \pm 0.034(\mathrm{syst})$$

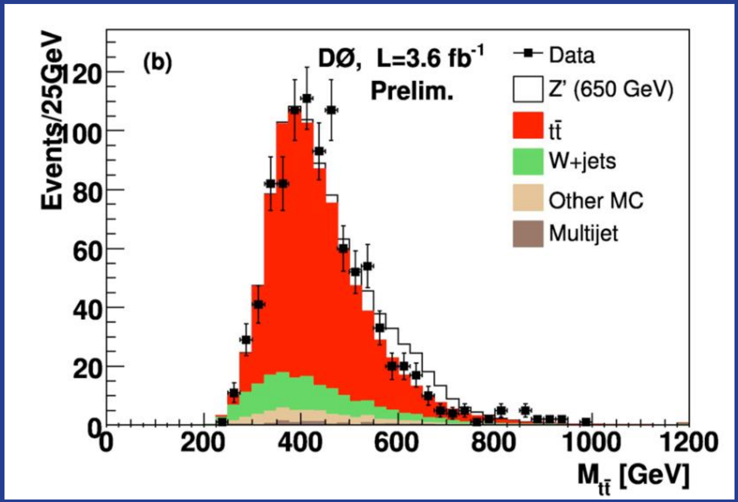
Hints and Excesses

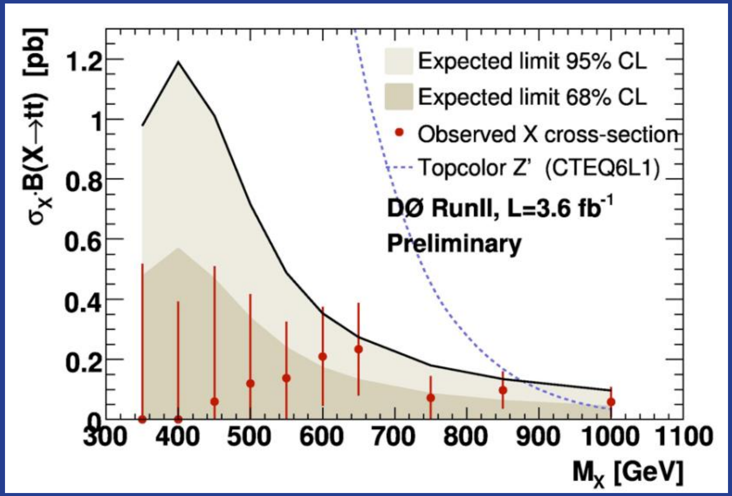
search for t' quarks





search for ttbar resonances





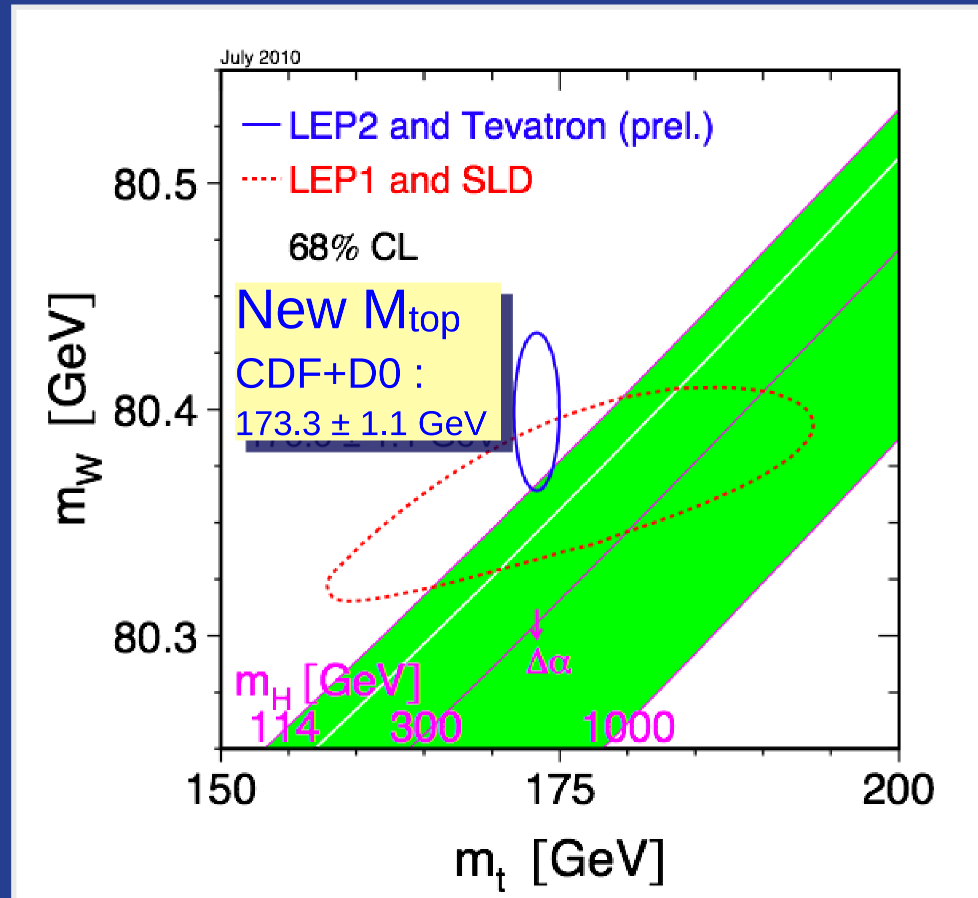
Constraints on Higgs mass

- Electroweak constraints

  $\ln M_H \propto \Delta M_W \propto M_t^2$

  - Other precision electroweak observables
- LEP direct searches
  - $m_H > 114.4$ GeV @ 95% CL
- Tevatron direct searches

...

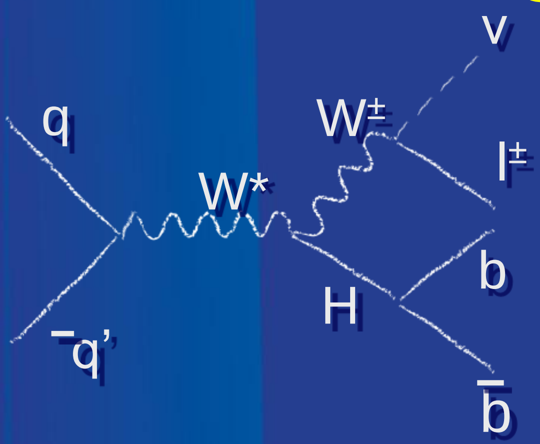


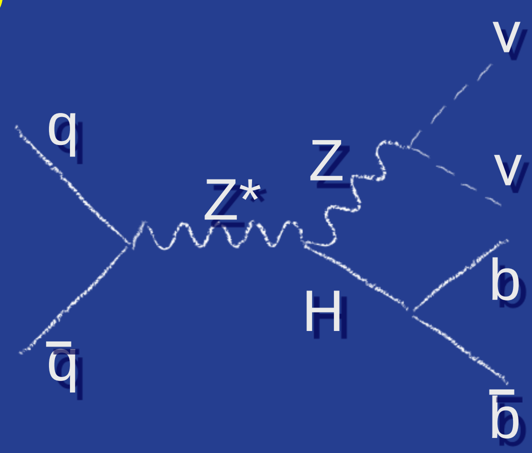
Precision Fit finds

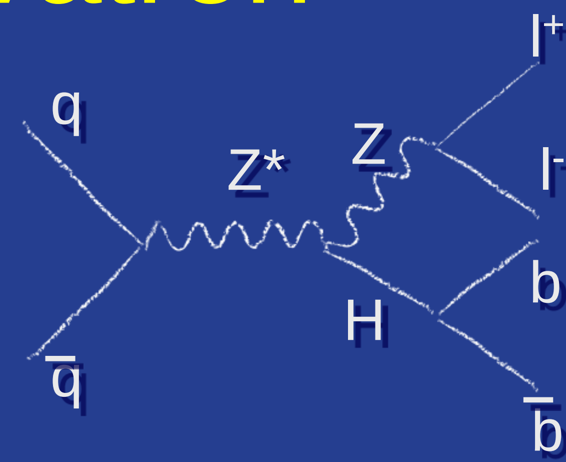
$m_H = 89.0\ ^{+35}_{-26}$ GeV

$m_H < 158$ GeV @ 95% CL

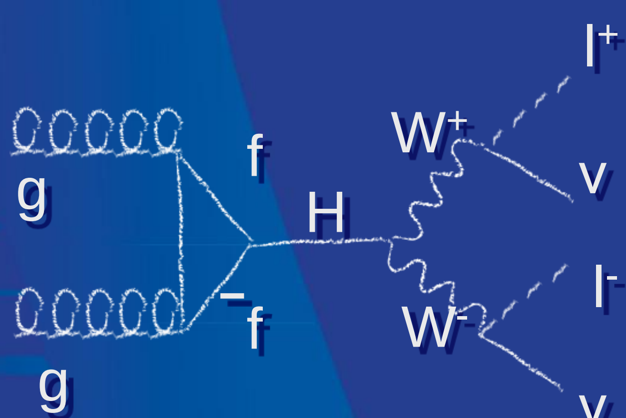
SM Higgs at the Tevatron

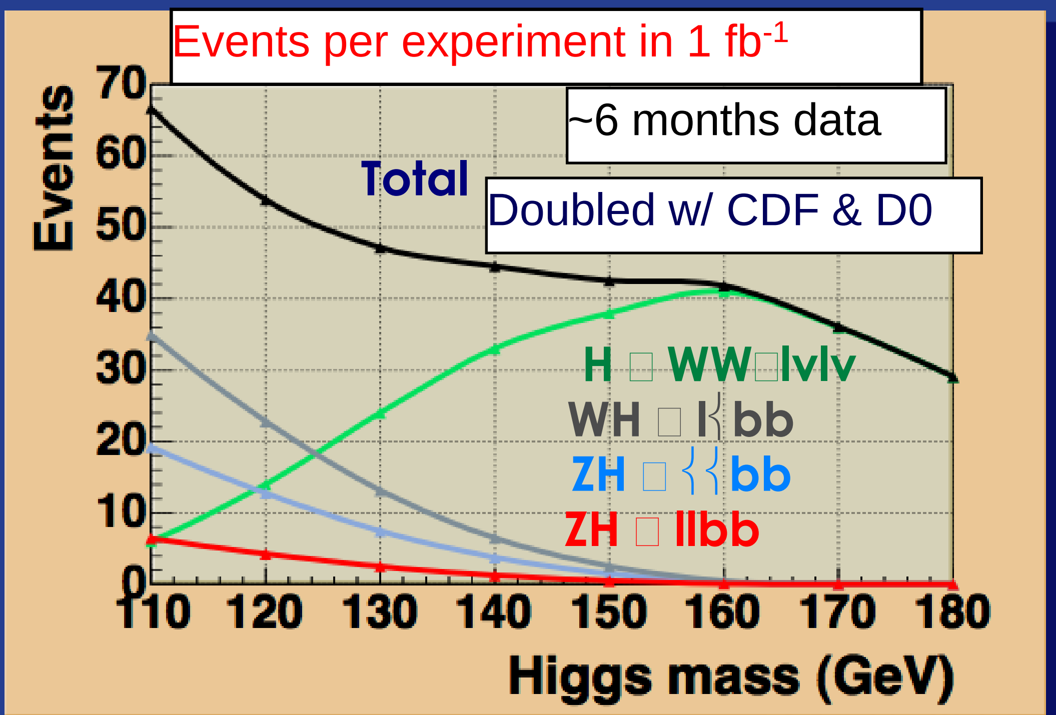






Main decay modes





Tevatron Higgs storyline (Reminder)

- How to build an advanced Higgs analysis program
  - Start with basic analysis for particular channel
  - Bootstrap special techniques to gain sensitivity
    - Improve acceptance
      - Loosen lepton ID & b-tag requirements
      - Add backup triggers
      - Relax kinematic selection
    - But...backgrounds increase & become difficult to model
      - Incorporate specialized background rejection techniques
      - Don't cut, separate events into categories with alike S/sqrt(B)
        - High S/sqrt(B) gives best signal sensitivity
        - Low S/sqrt(B) gives best background constraints
      - Use multivariate techniques to distinguish signal from bkgd
      - Background modeling checks ! Data must stay well modeled !
- Repeat for each Higgs topology per grad student
- Combine modes taking into account uncertainties correlated between backgrounds

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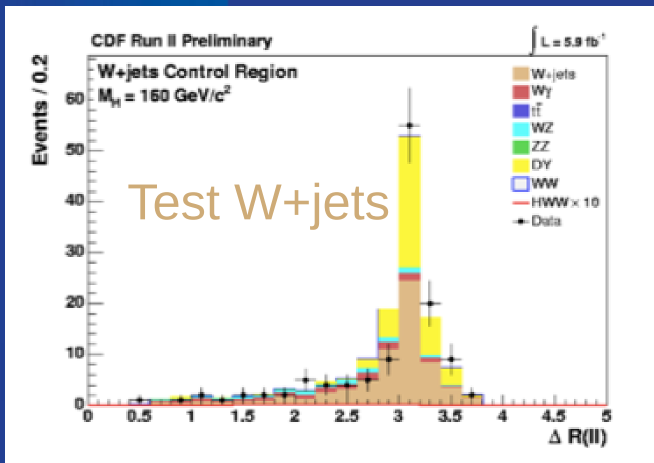
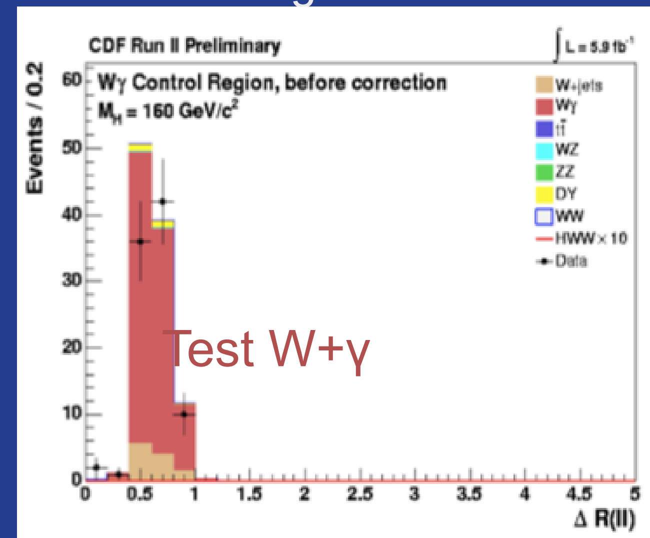
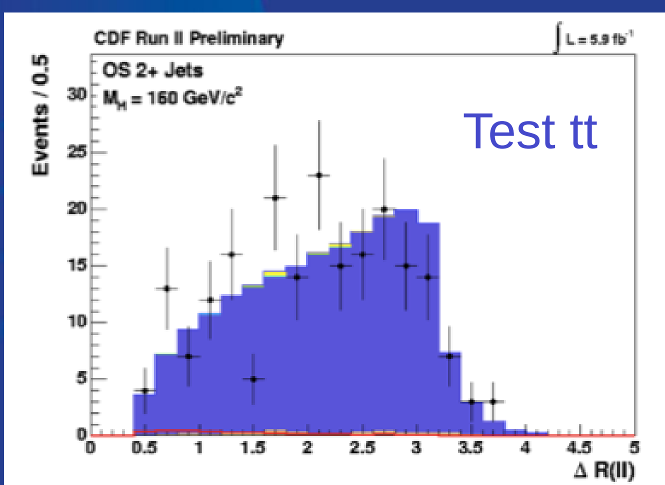
Validating background models

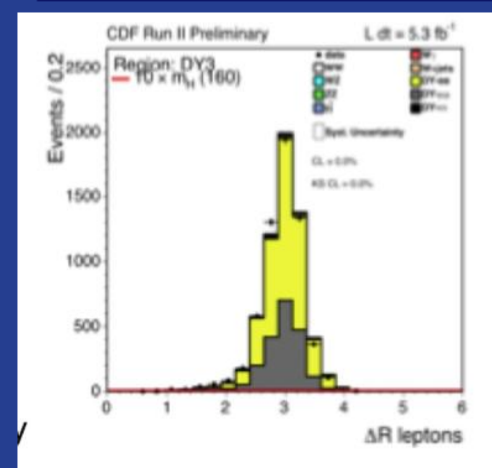
- H→WW topologies have different main backgrounds:
  - Isolate control regions to test rate & shape of dominant backgrounds





Most sensitive kinematic variable $dR(l_1,l_2)$





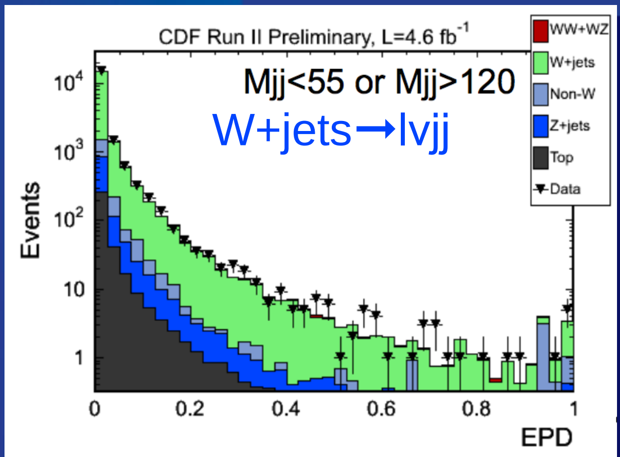
Test Drell-Yan

Gaining faith in multivariate methods

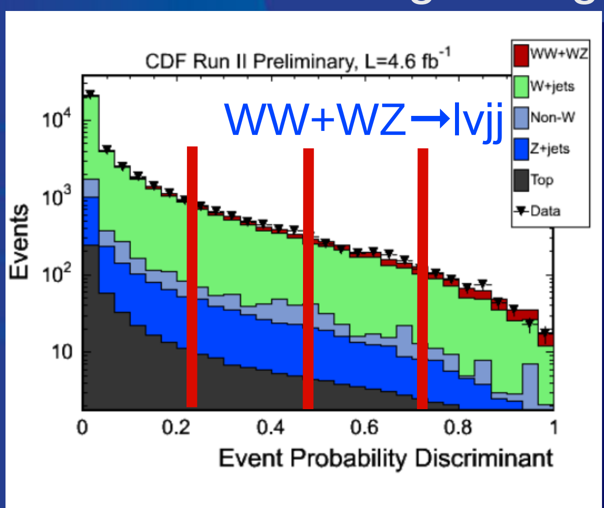
Diboson search : WW + WZ → lνjj

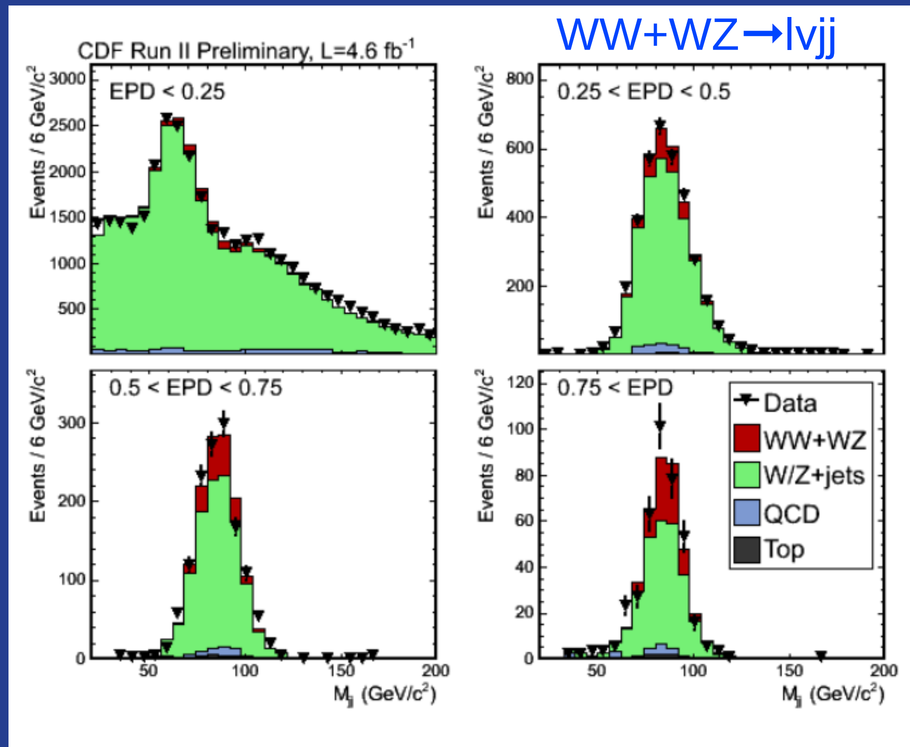
- Same topology as WH → lνbb
  - We can validate multivariate analysis techniques used in WH search by making measurement instead of a search

Control region



Signal region





M_{jj}

Measured σ(WW+WZ) = 16.6 $^{+3.5}_{-3.0}$ pb

[Standard Model σ = 15.1 ± 0.8 pb]

Summary of low & high mass results

Channel	Expt	Dataset now	Increase since Nov. 2009 combination
$H \to WW$	D0	6.7	24%
$H \to WW$	CDF	5.9	23%
$WH \to l\nu bb$	CDF	5.7	30%
$WH \to l\nu bb$	D0	5.3	6%
$ZH/WH \to METbb$	CDF	5.7	60%
$ZH/WH \to METbb$	D0	6.4	23%
$ZH \to llbb$	CDF	5.7	40%
$ZH \to llbb$	D0	6.2	45%
$H \to \gamma\gamma$	CDF	5.4	New!
$H \to \gamma\gamma$	D0	4.2	0%
$H \to \tau\tau$	CDF	2.3	15%
$H \to \tau\tau$	D0	4.9	0%
$ZH/WH \to qqbb$	CDF	4	100%
ttH	D0	2.1	0%

Each channel represents several "sub-channels"

$H \to WW$ Sub-channels
opposite sign leptons + 0-jets
opposite sign leptons + 1-jets
opposite sign leptons + 2-jets
opposite sign leptons , low M_{ll}
same sign leptons
trileptons, no Z candidate
trileptons, Z candidate, 1-jet
trileptons, Z candidate, 2-jet
electron + hadronic tau
muon + hadronic tau
leptons + jets

New

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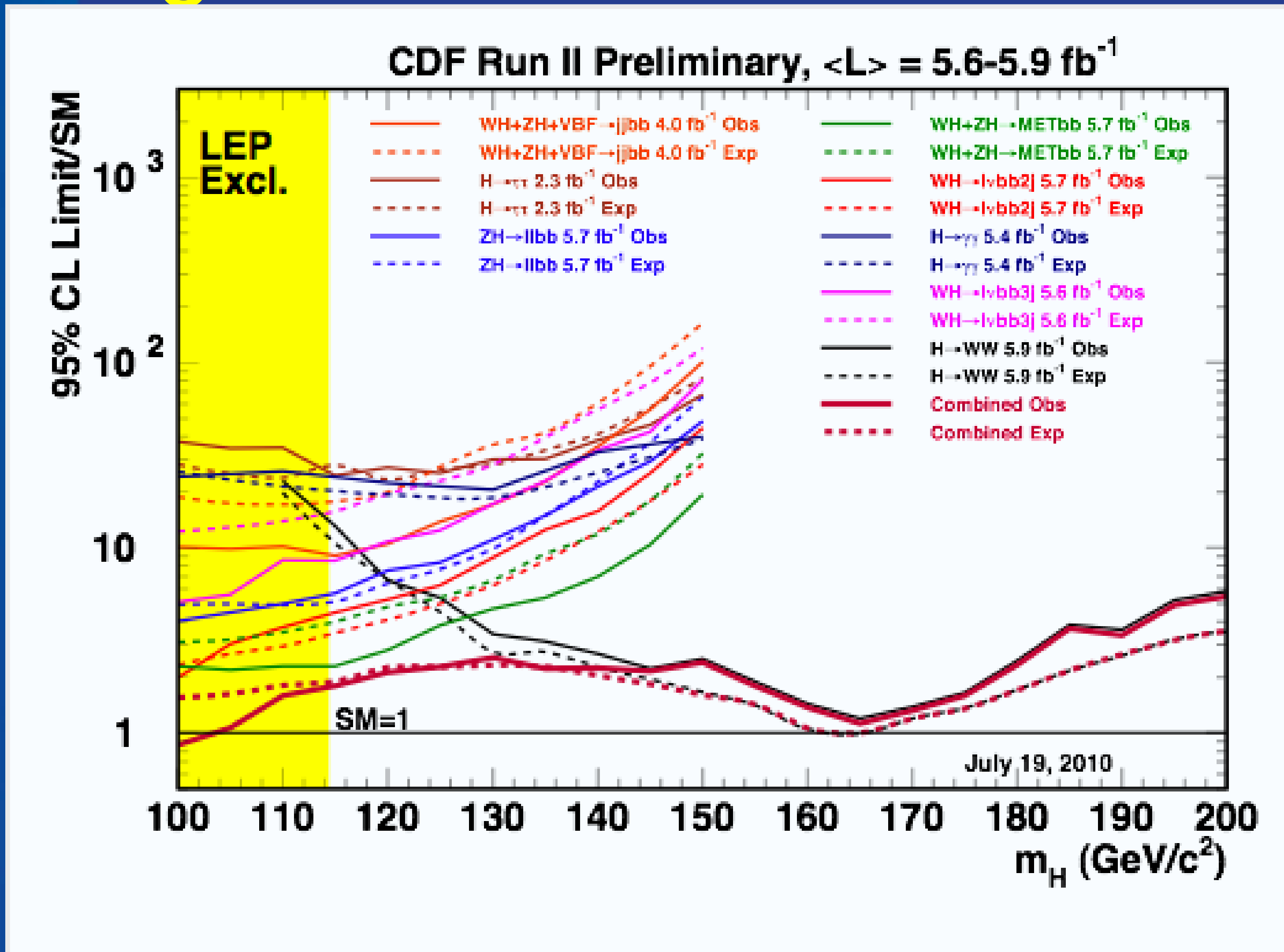
What goes into the combination?



Example CDF – Ditto for D0

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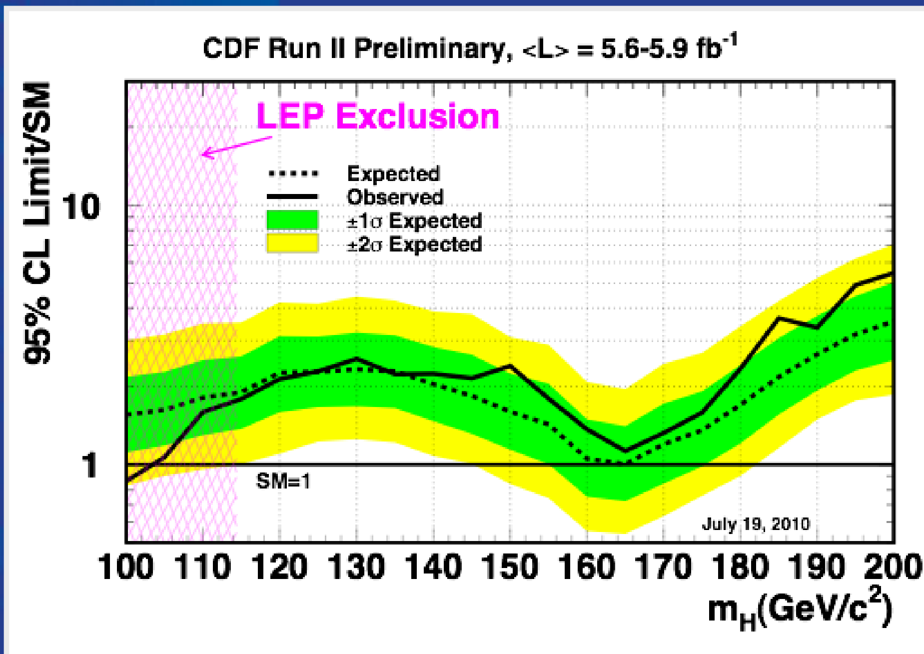
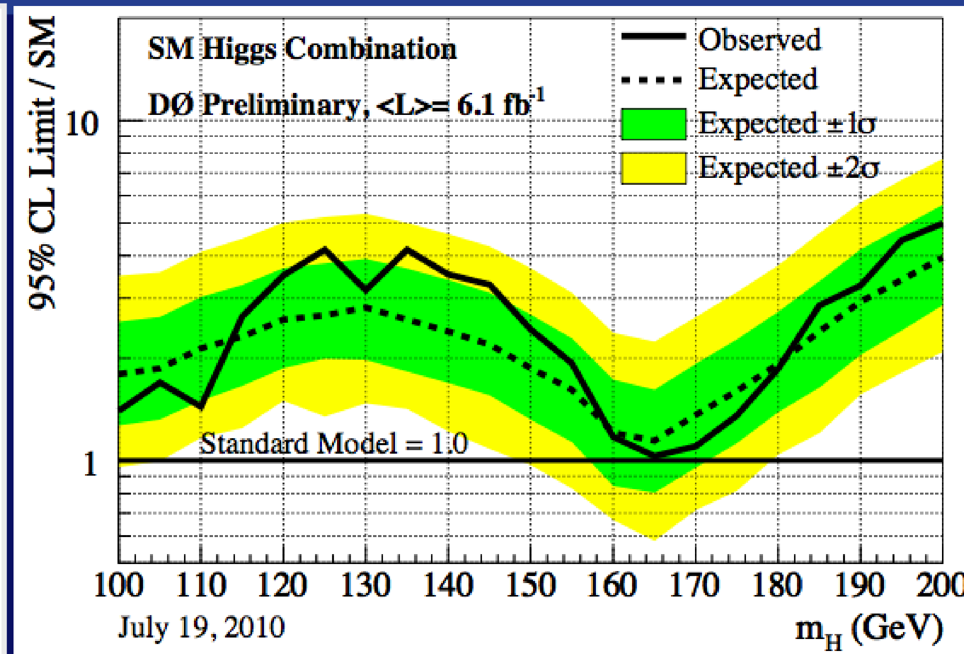
CDF & D0 Individual Combinations

- CDF's limits

D0's limits





CDF achieves expected exclusion at 165 GeV

D0 almost achieves observed exclusion at 165 GeV

@ m_H = 100 GeV, both set observed limits below expected

Closing in on low mass LEP exclusion

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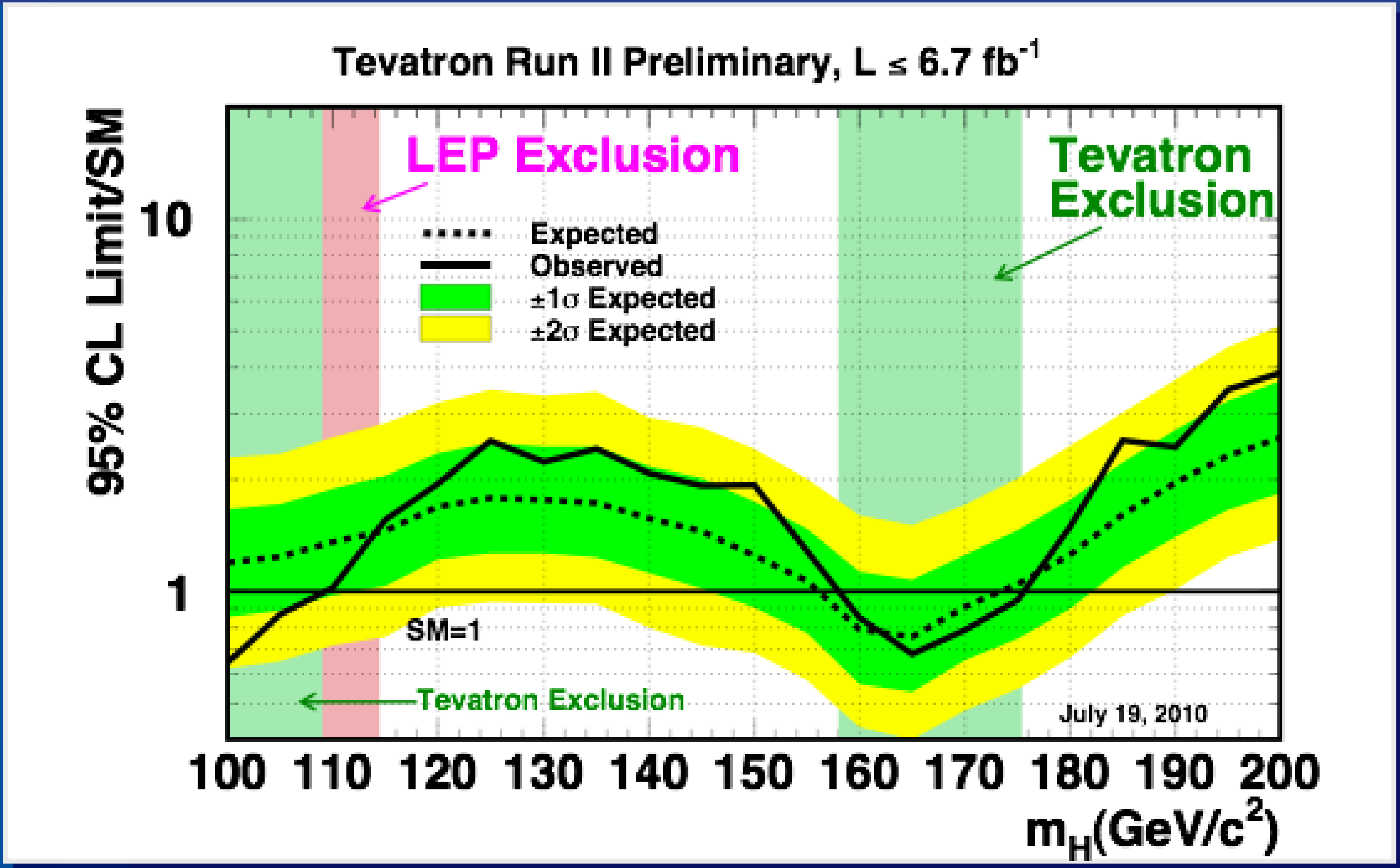
Tevatron combination

“Expected sensitivity”



- Low mass sensitivity approaching LEP exclusion :
  - Expected 1.45*SM @ 115 GeV
  - Expected 1.24*SM @ 105 GeV
- High mass 95% CL exclusion :
- $158 < m_H < 175$ GeV
  - 4 times previous (162 - 166 GeV)
  - Expected ($156 < m_H < 175$ GeV)

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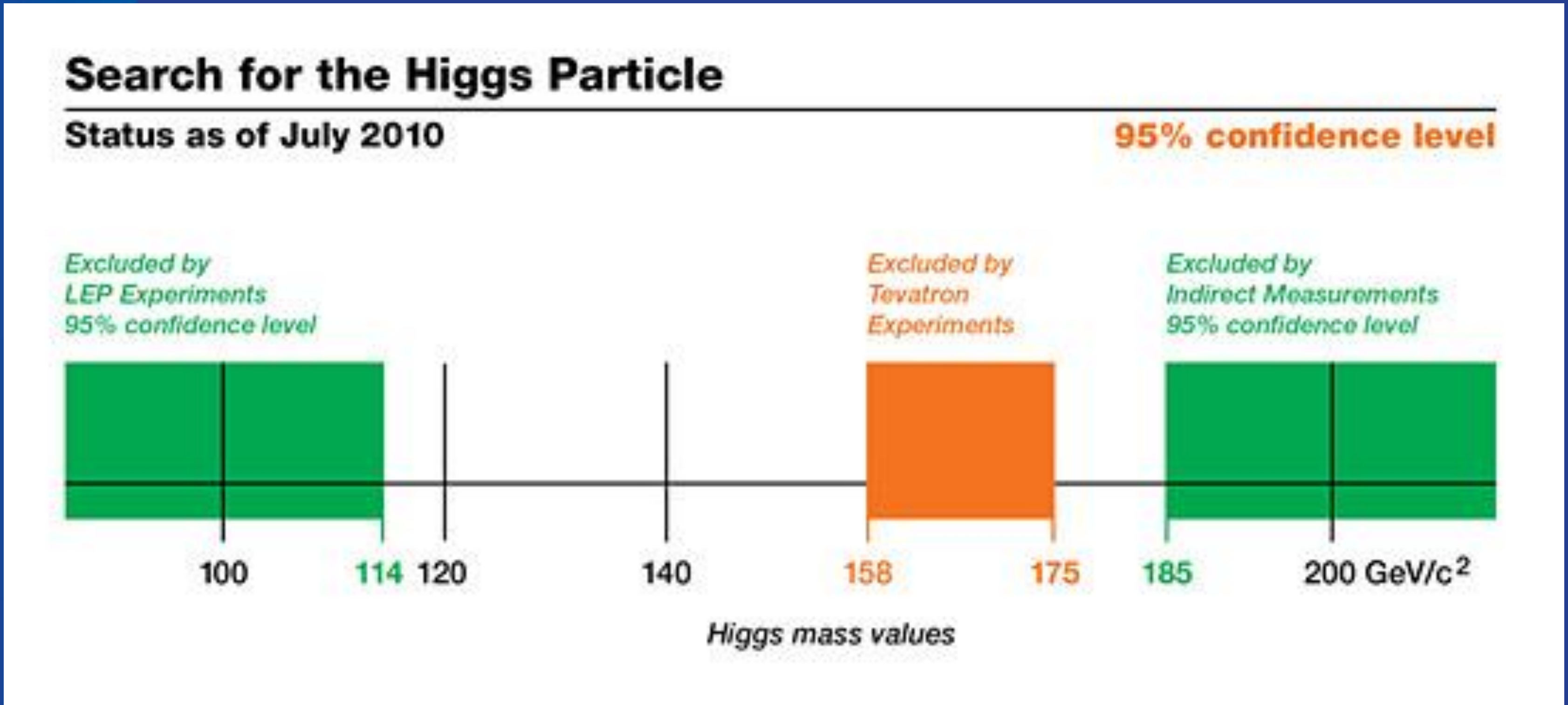
No Words Needed



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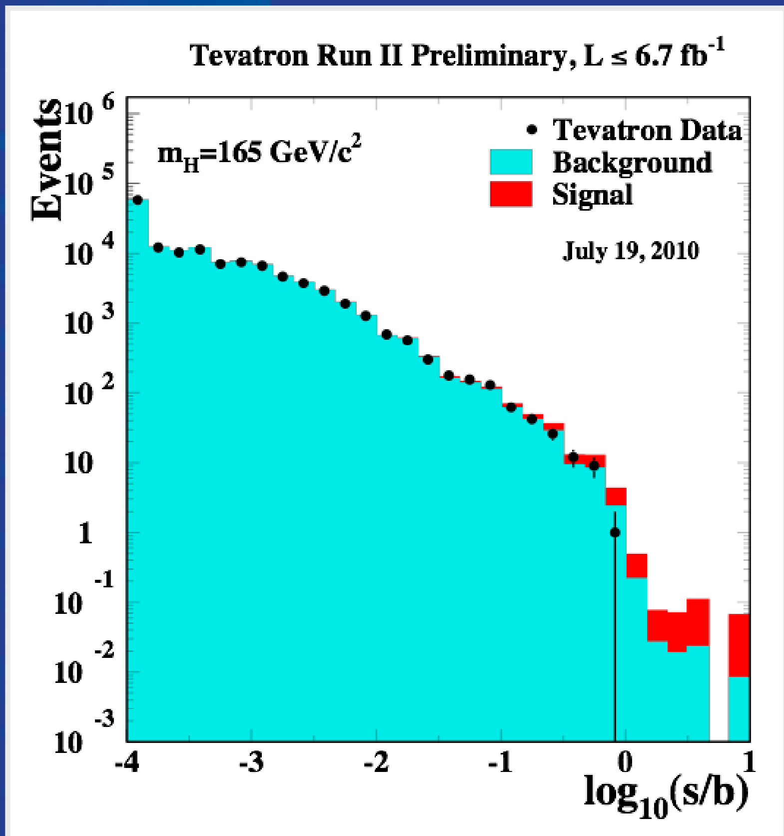
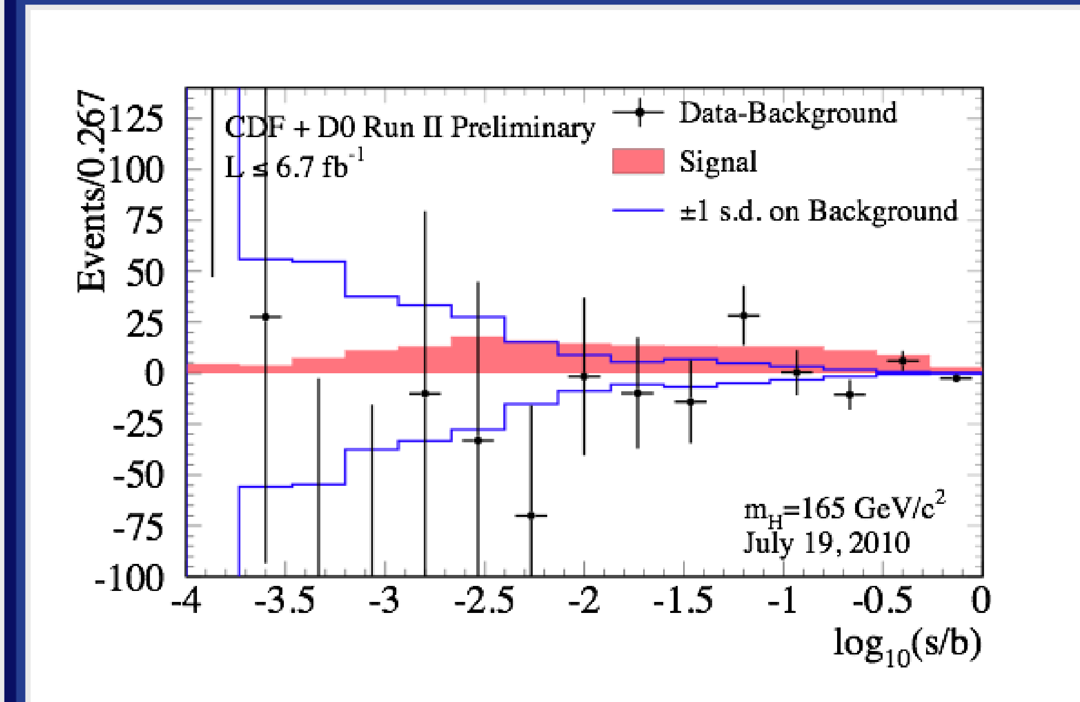
Hypothesis : m_H = 165 GeV





Data - Background shown compared to signal in red

Excellent modeling, consistent with no signal :

Exclusion at 165 GeV

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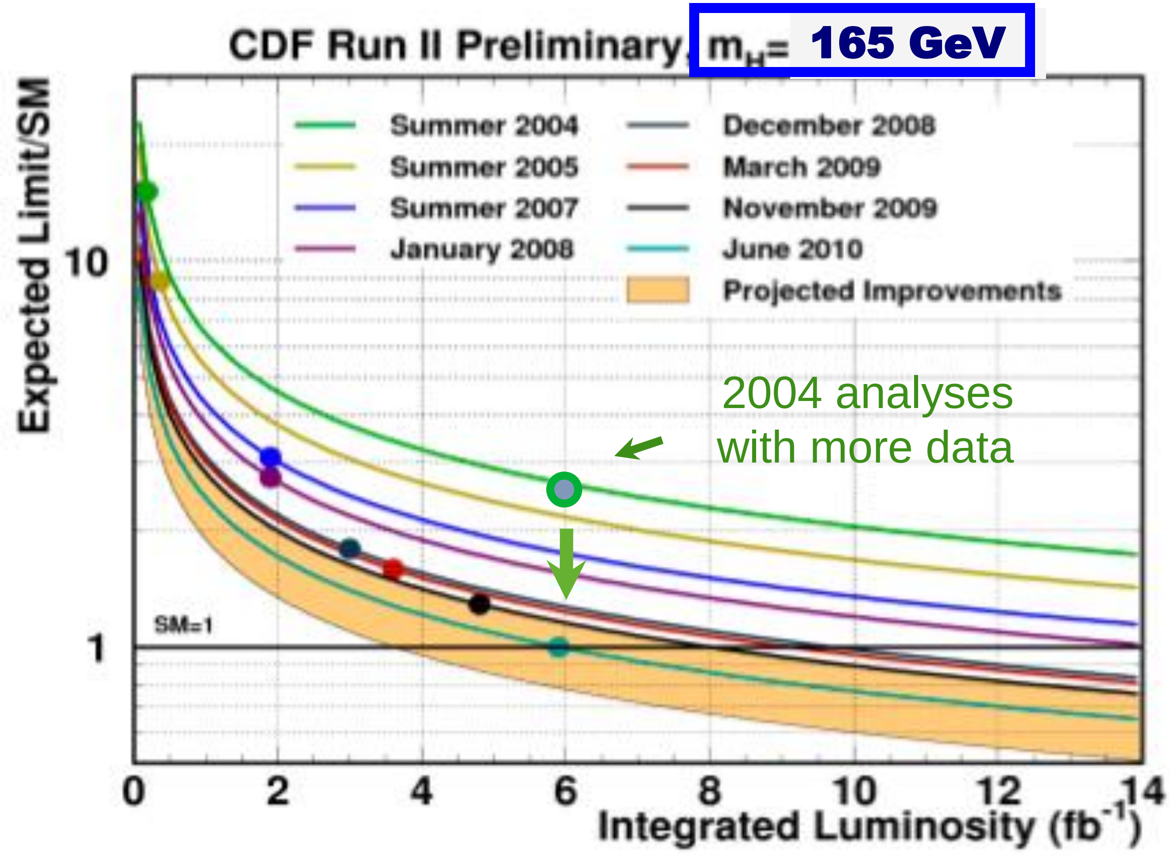
How Have We done on Improvements over Time



High mass : Summer 2010 limits already well into yellow band

Approaching target sensitivity

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Why Extend the Tevatron Run ?

Why 3 years (2012-2014)

- Tevatron has been running year-by-year since 2007.

- We need a sizeable commitment in terms of run-duration in order to "reload" with new students and post doc's who have a career path on the Tevatron

- 3 more years = ~16 fb-1 of data per experiment; this enables us to get $>3\sigma$ expected sensitivity across the entire interesting mass region (114 – 185).

- LHC, with their current predicted performance will not surpass the Tevatron on many physics measurements including low mass Higgs with planned 7 TeV Run

Prospects for Higgs Evidence

~16 fb^{-1} :

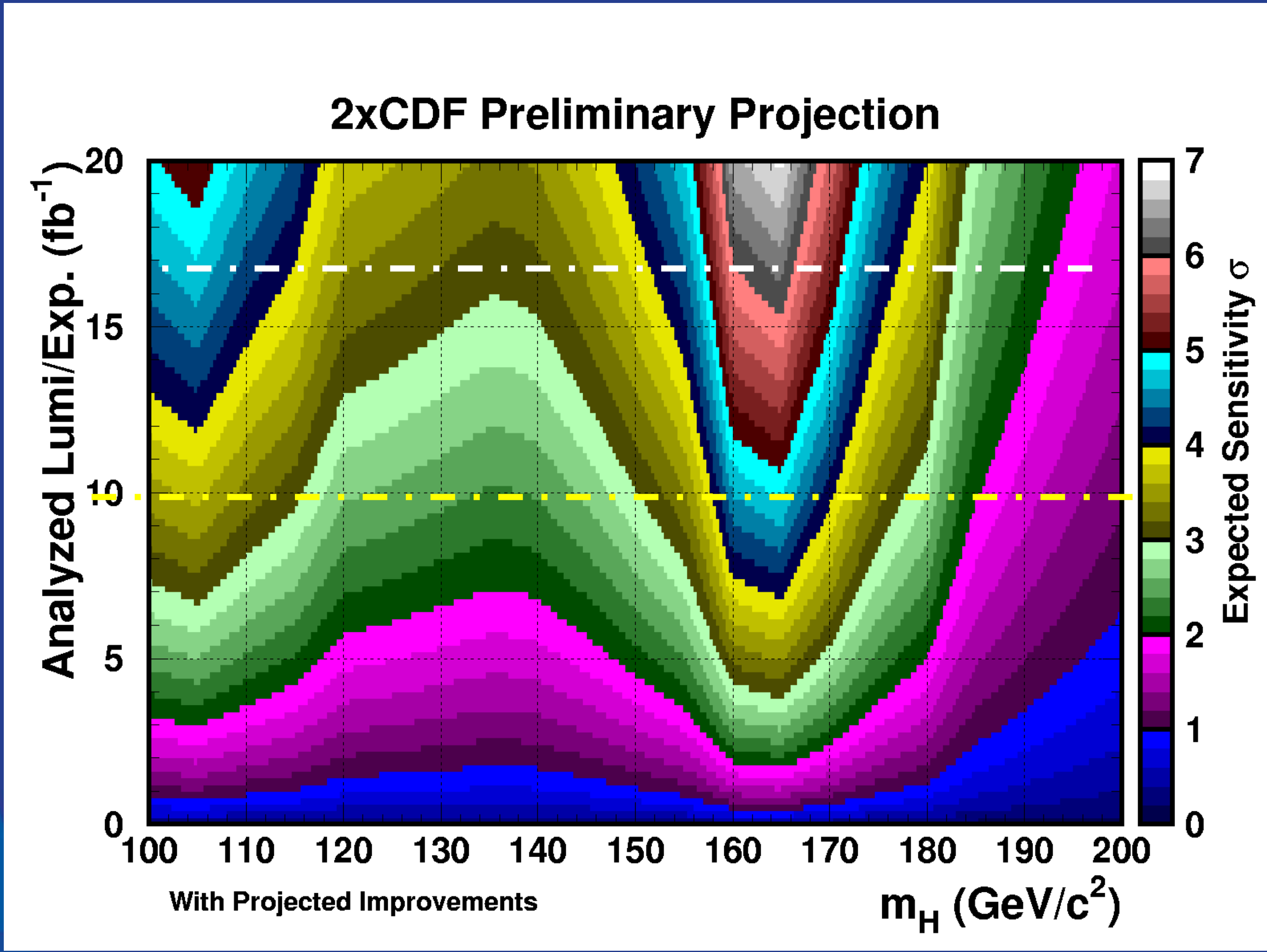
> 3 σ expected sensitivity from 100 – 180 GeV

>4 σ @ 115 GeV

>6 σ @ 165 GeV

End of 2011:

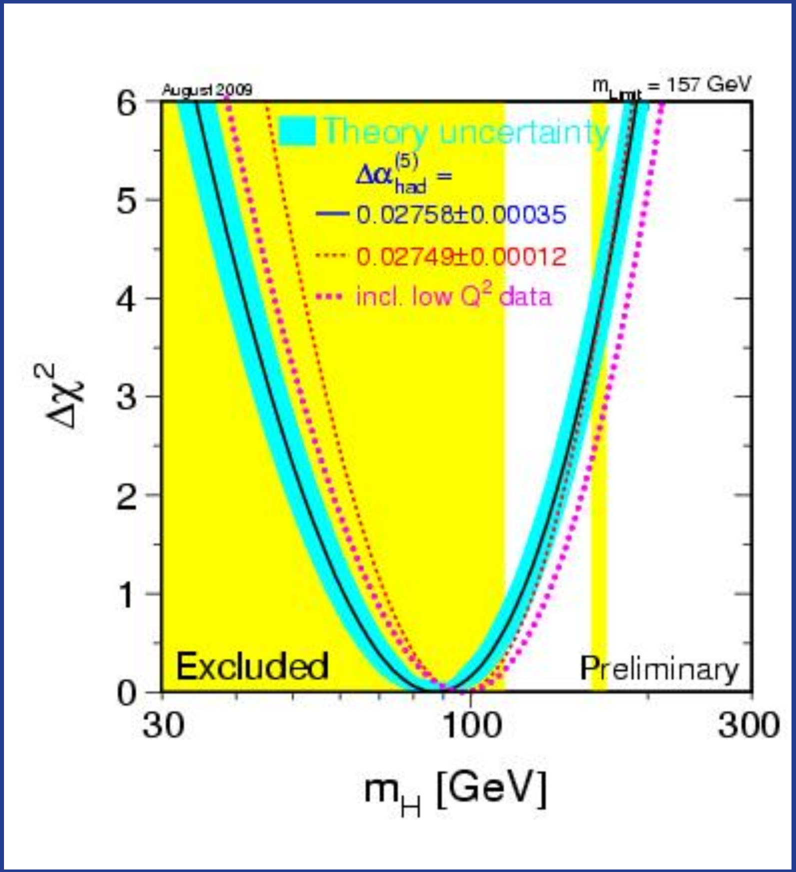
> 2.4 σ expected sensitivity across mass range



"Biggest No-Brainer in the History of Earth!!!"

You can't lose….

- EWK fits all point to a low mass Higgs – we have to look there no matter what is found at much higher mass!
- You either find it…
  - OR
- Not seeing a low mass Higgs guarantee's that there is new physics waiting to be found

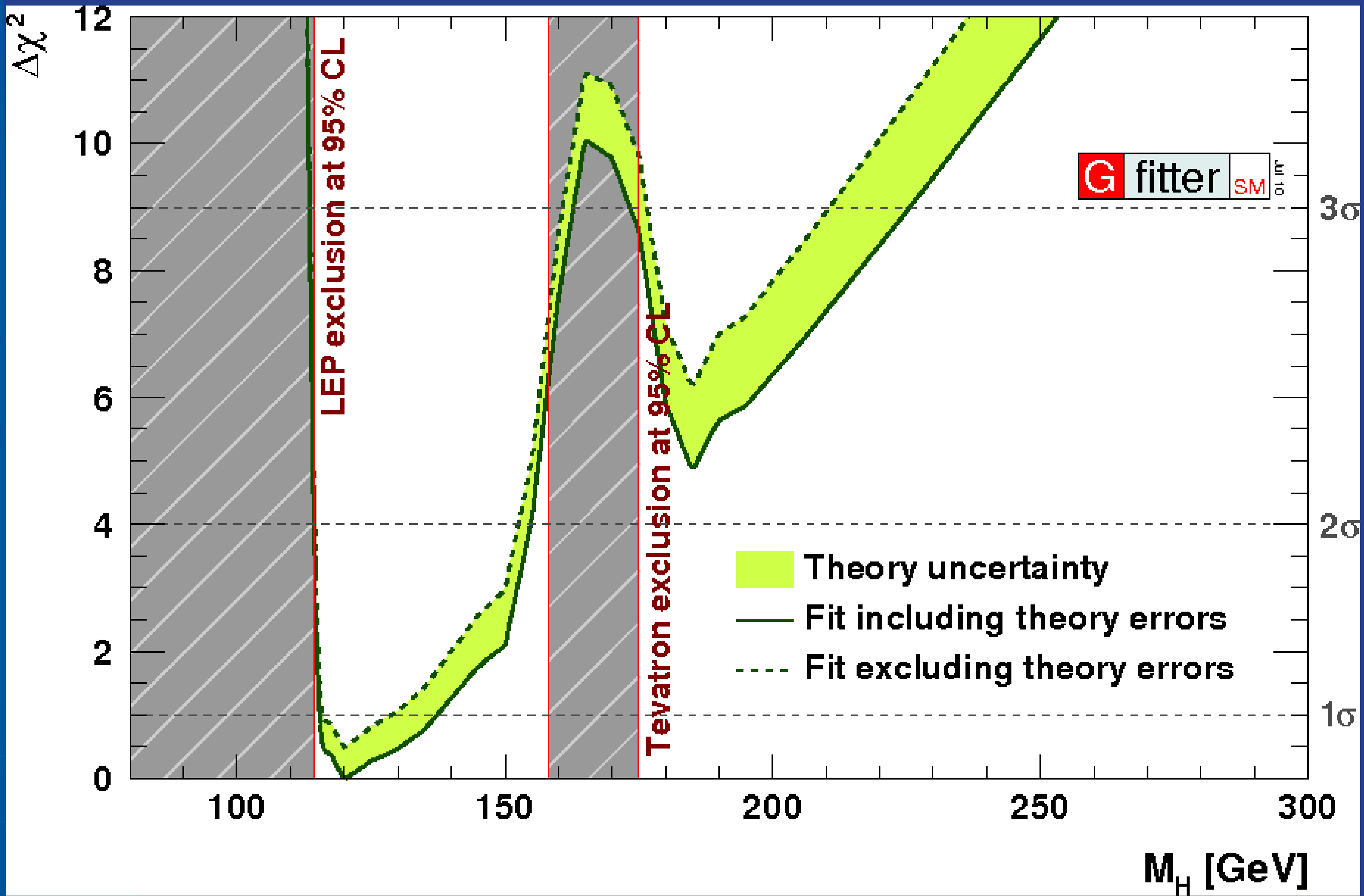


Precision Fit finds

$m_H = 89.0^{+35}_{-26}$ GeV

$m_H < 158$ GeV @ 95% CL

What do we know?



The most probable Higgs Mass is 120 GeV

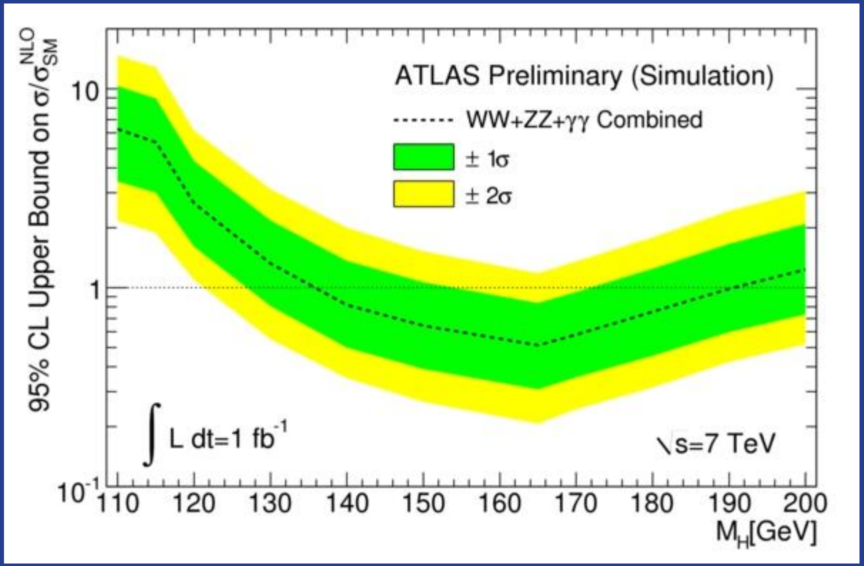
What Are the Latest LHC Expectations?

Assumes 7 TeV on 7, 1 fb-1

Plots and numbers from ICHEP2010 Talks

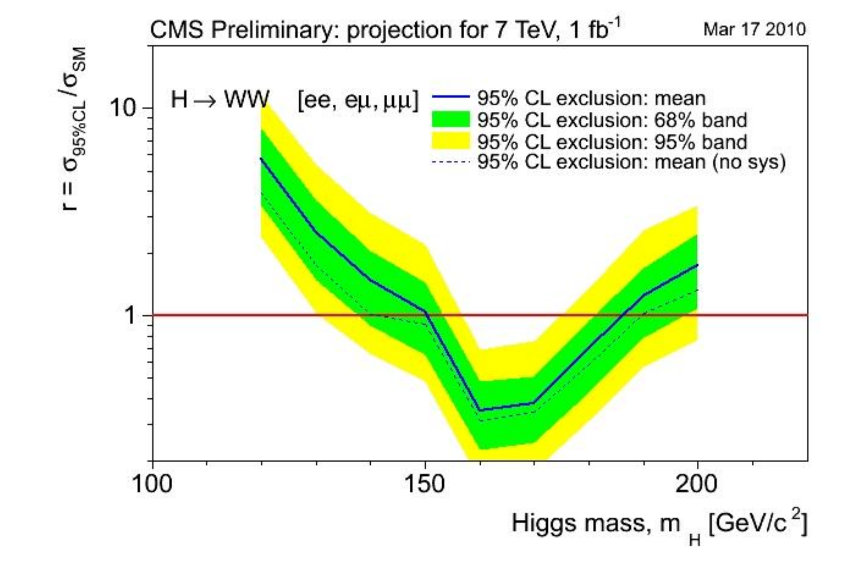
Atlas

WW+ZZ+ γ γ can exclude (136,190) GeV



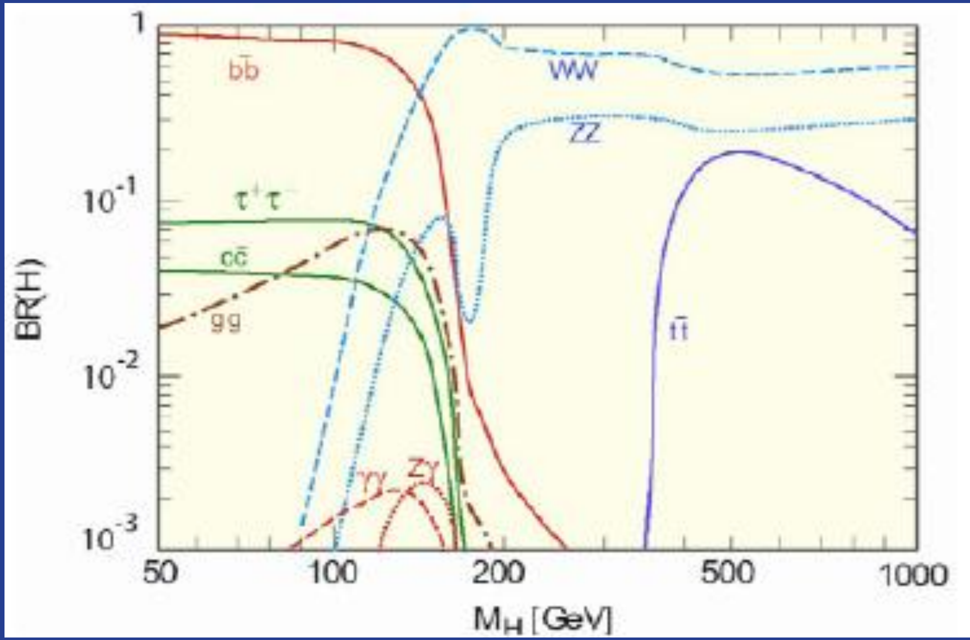
CMS

WW+ZZ+ γ γ can exclude (145,190) GeV



Complimentarity of Tevatron and LHC

- To Understand EWSB, one wants to observe Higgs decaying into b-jets
- However, Low Mass Higgs searches at the LHC rely on $H \rightarrow \gamma\gamma$ and $H \rightarrow \tau\tau$



Some Final Thoughts on Run III

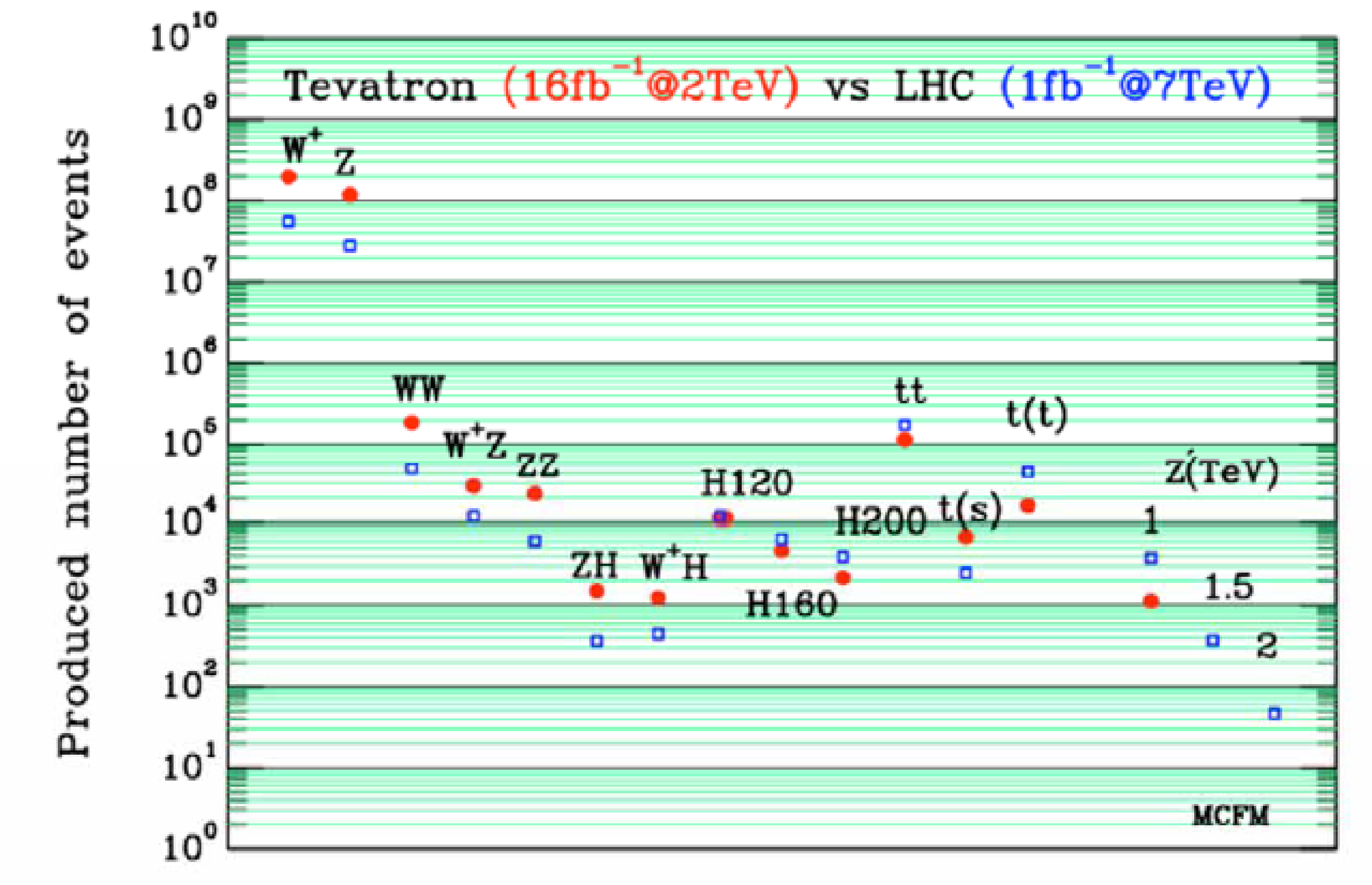
- Science is about making progress now
- Tevatron has a track record – it is straight forward to extrapolate from where we are now to 2014
- It makes sense to run both programs until the Tevatron physics program is clearly surpassed.

Conclusions

- The experiments continue to make great progress in producing a wide range of interesting and important physics results
- The Higgs exclusion has grown to $158<M_H<175$ GeV with 6 1/fb of data.
- With 3 additional years of running, the Tevatron can reach $>3\sigma$ expected sensitivity across the entire interesting mass range (114-185) for SM Higgs
- Finding evidence for a low mass Higgs boson in b-decays is essential to understanding EWSB in the SM – a unique capability of Fermilab's program

Backup

Event Yields



Comparing Tevatron at 2014 with LHC at 2012/13