Physics potential of an extended Tevatron run

Fermi National Accelerator Laboratory

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Toronto
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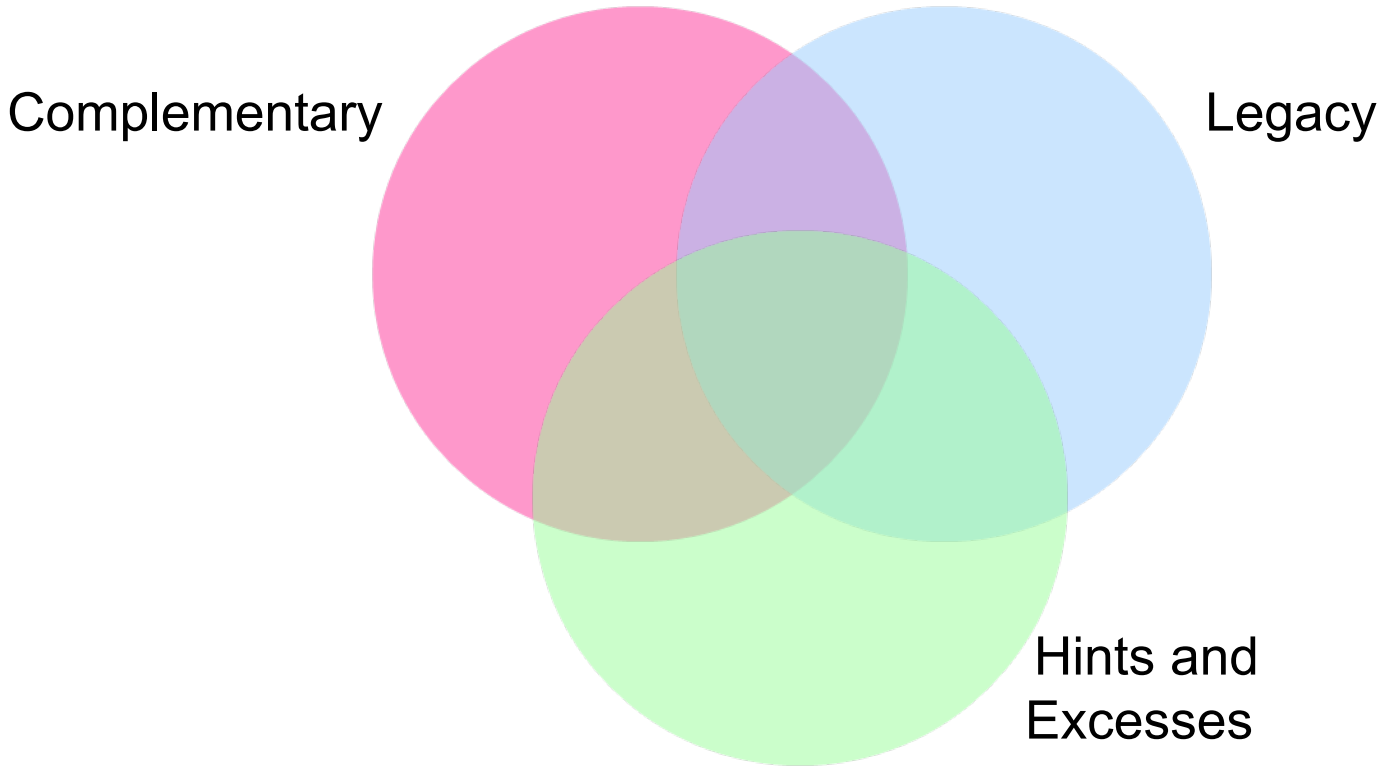
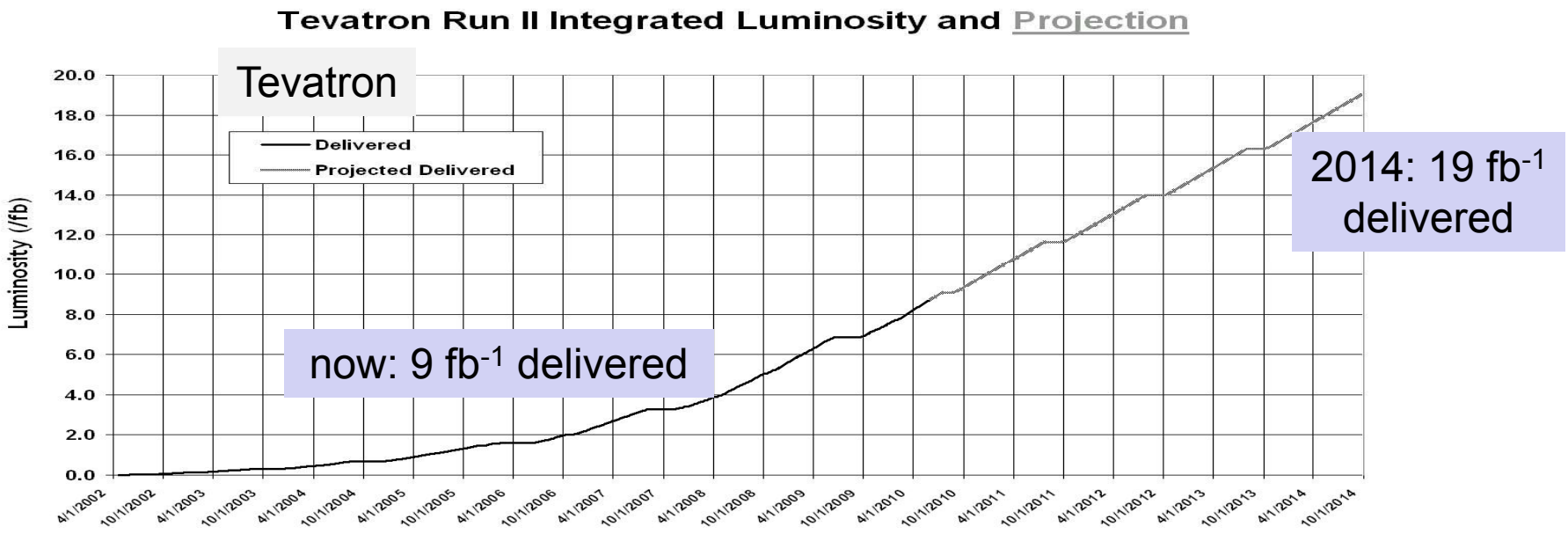
Overview

- The Context: Tevatron, CDF & Dzero, LHC
- Physics opportunities
  - Unique to the Tevatron or complementary to the LHC
  - Legacy measurements
  - Higgs and other opportunities for discovery

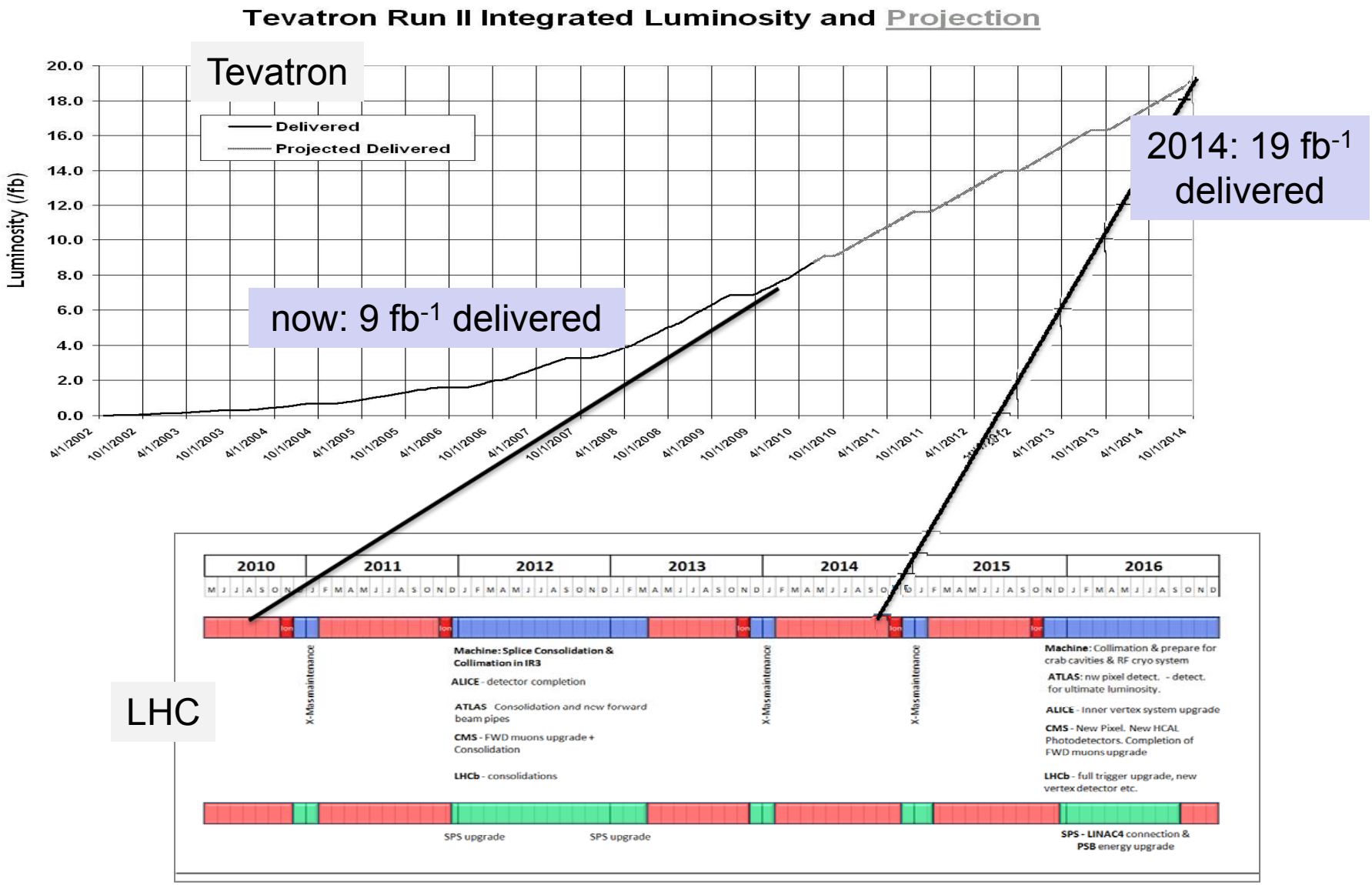


Integrated Luminosity and Schedule



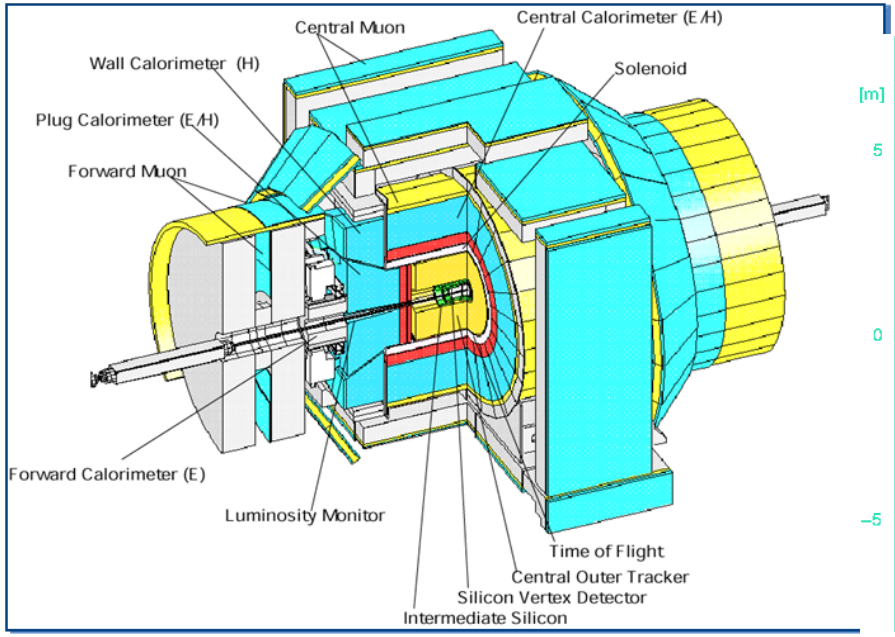
- No major upgrades to accelerator
  - Only short shutdowns for maintainance
  - Projection: about 2.5 fb^{-1} delivered per year
- Double present integrated luminosity by Oct 2014
  - 19 fb^{-1} delivered
  - 16 fb^{-1} in final analyses

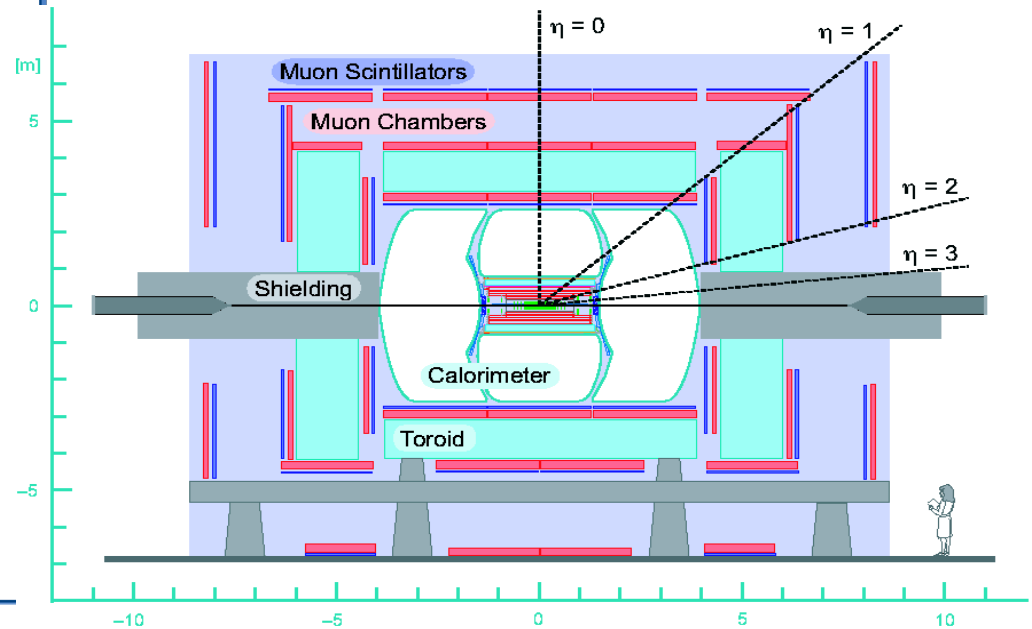
Integrated Luminosity and Schedule



CDF and Dzero Detectors

- Detectors operating stably for many years
  - Existing 9 fb^{-1} of luminosity has been used to track ageing effects
- Main attention is focused on aging of tracking detectors
  - Fermilab review in June 2010





CDF and Dzero Detectors

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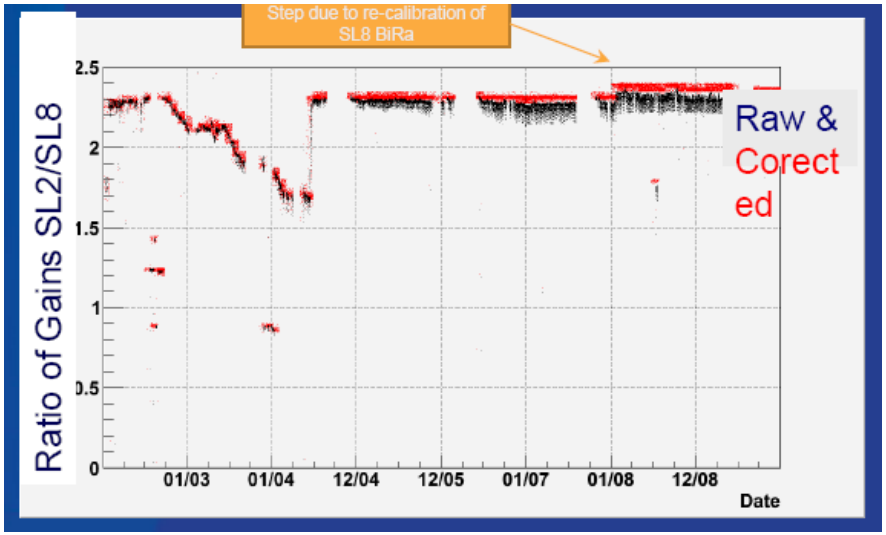
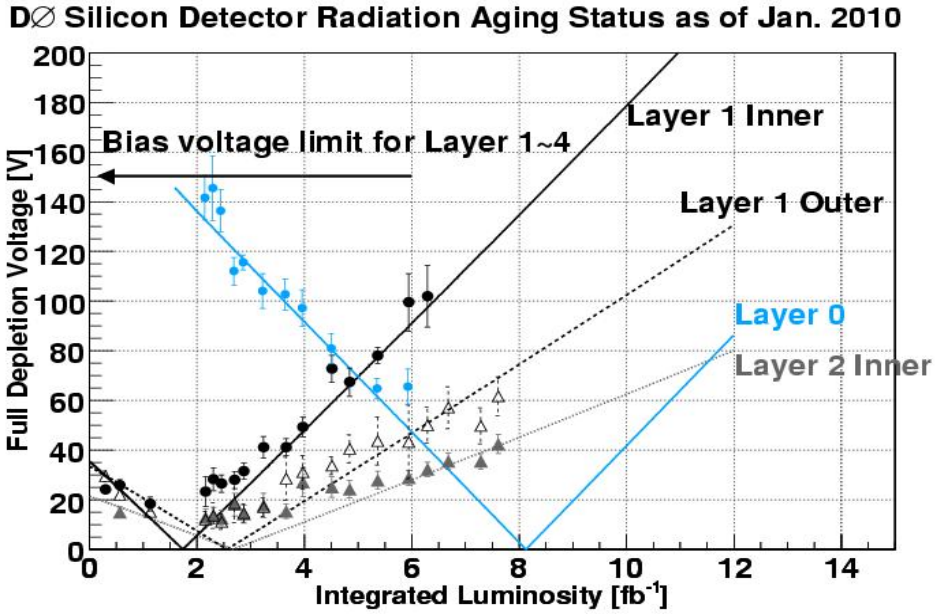
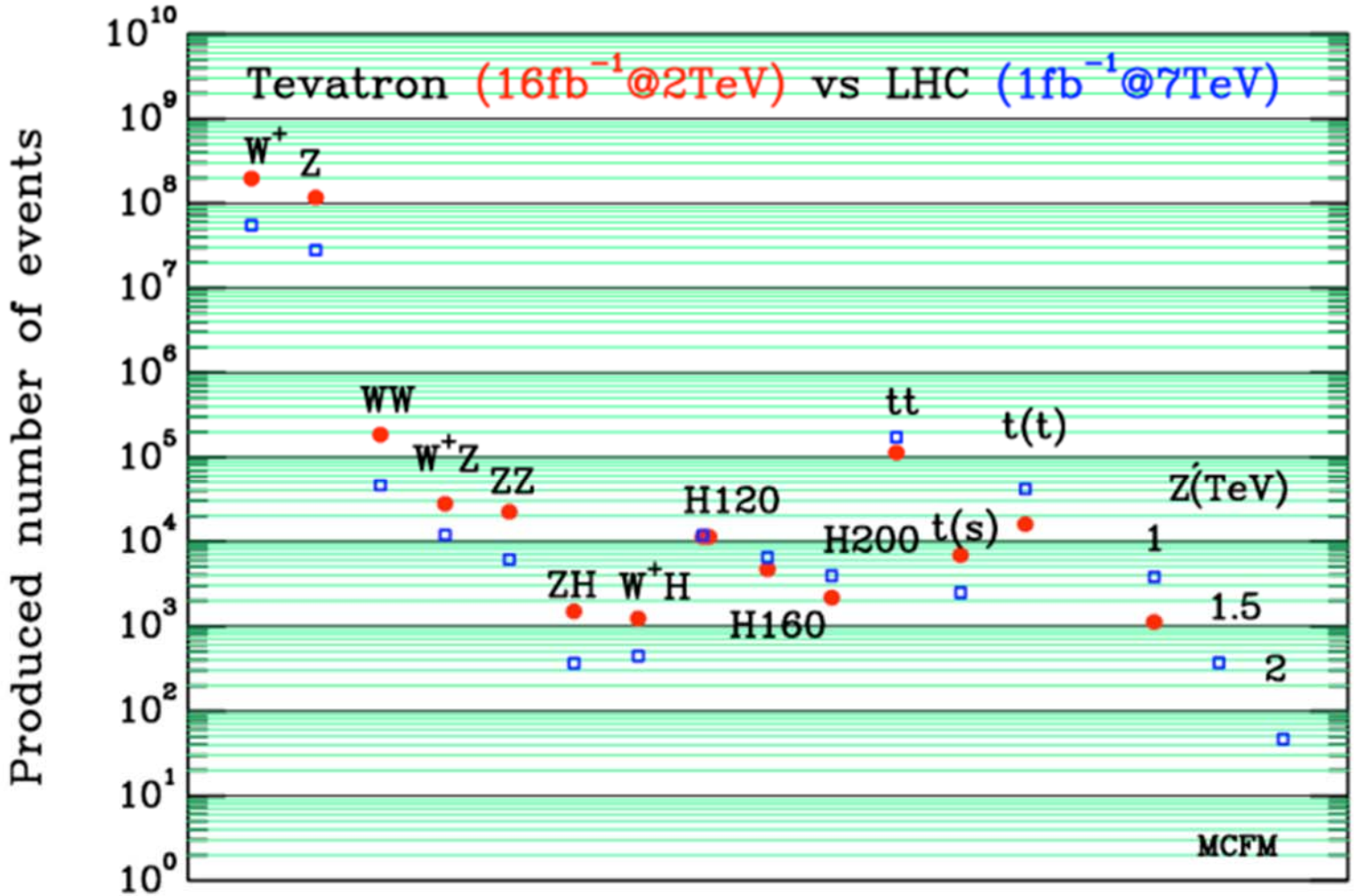
Example: CDF Central Outer Tracker (drift chamber)



Example: Dzero Silicon Microstrip Detector

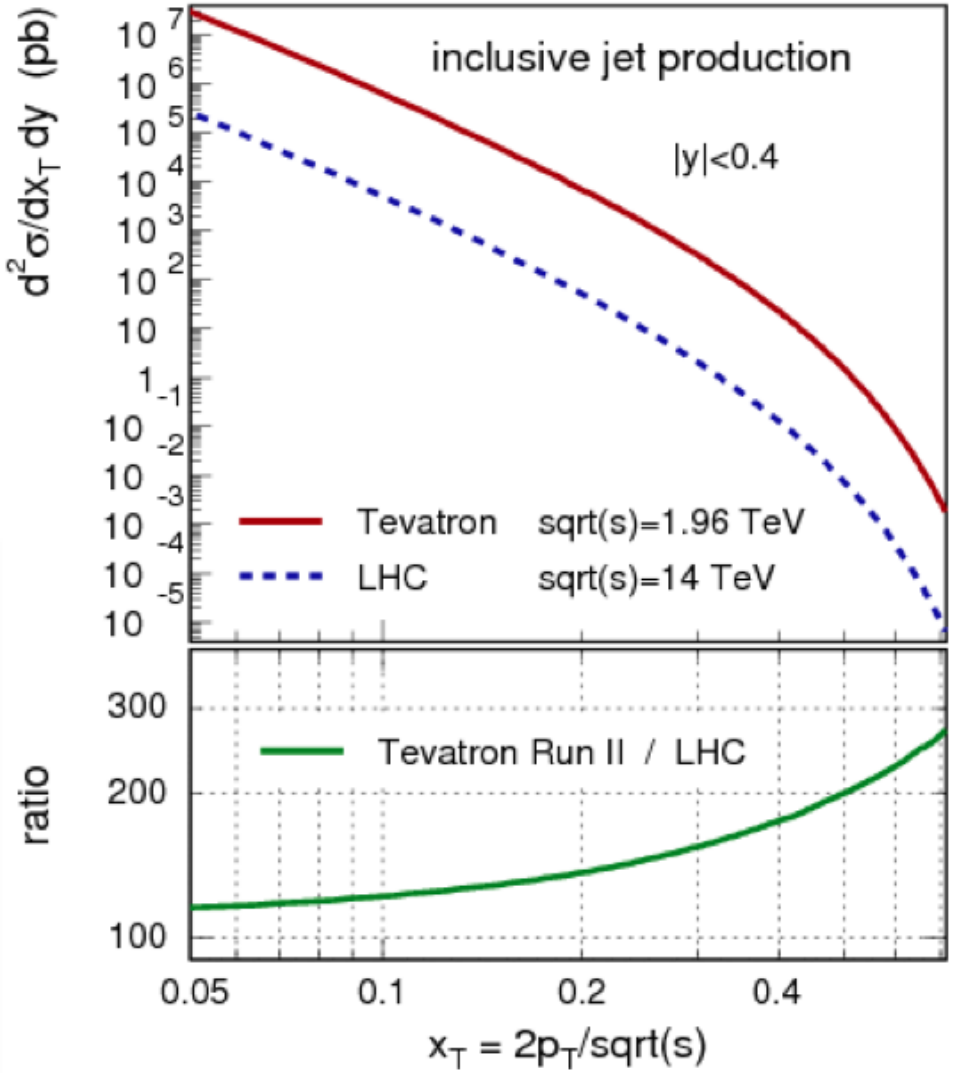


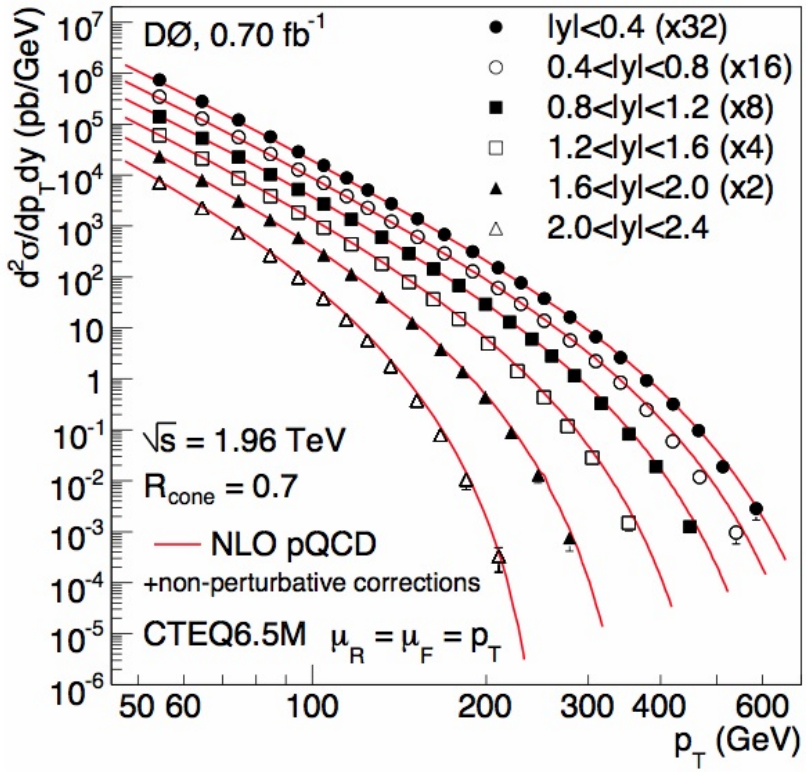
Reference event yields: Tevatron and LHC



(Caution: compares 2014 Tevatron data set with 2012 LHC data set)

Complementary: high-x gluons at Tevatron





gluon distribution at high x_T>0.5:

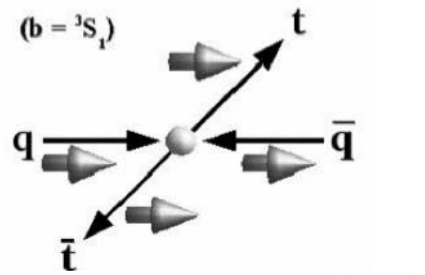
LHC needs 200 times more luminosity than Tevatron to reach the same sensitivity on PDFs

measurement still statistically limited

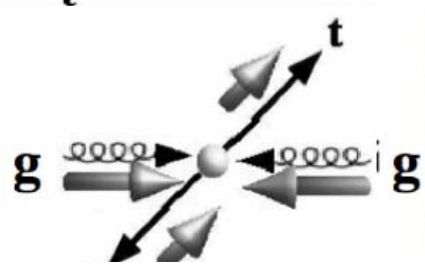
Complementary: Tevatron is a proton-antiproton collider

Example: spin correlations in t-tbar production

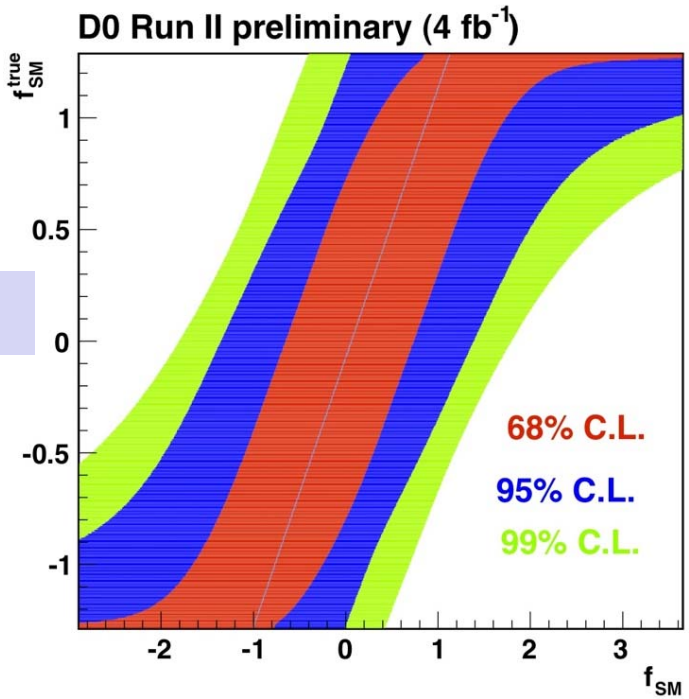
Tevatron

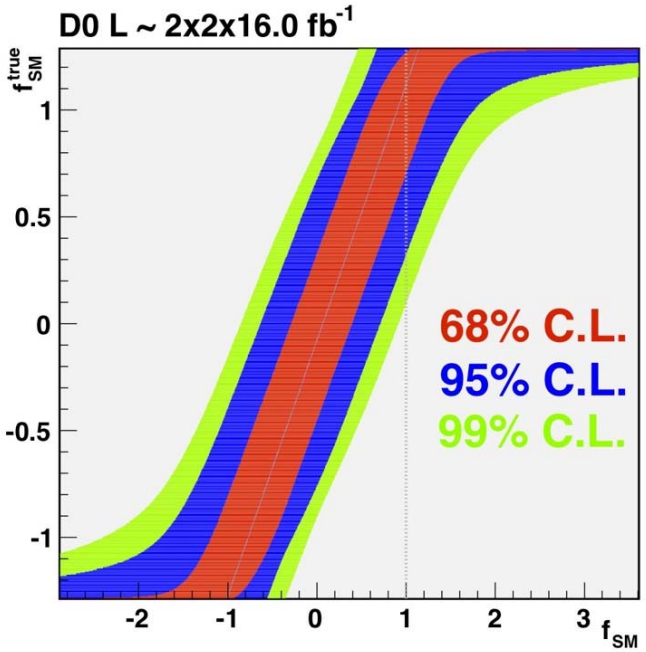


LHC



Now

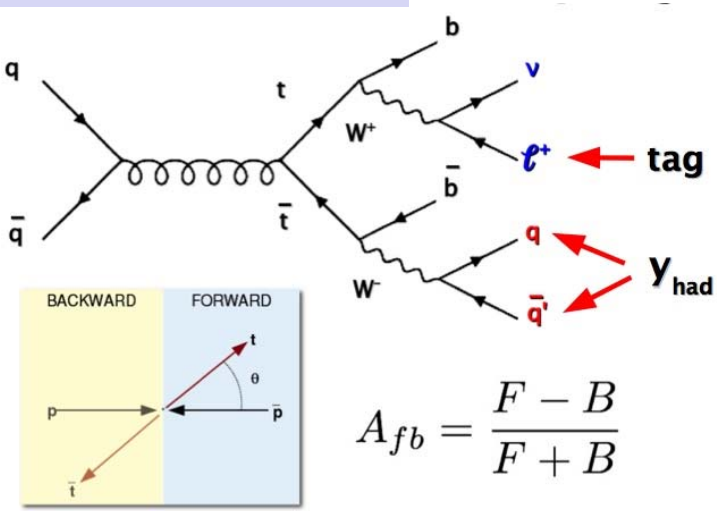




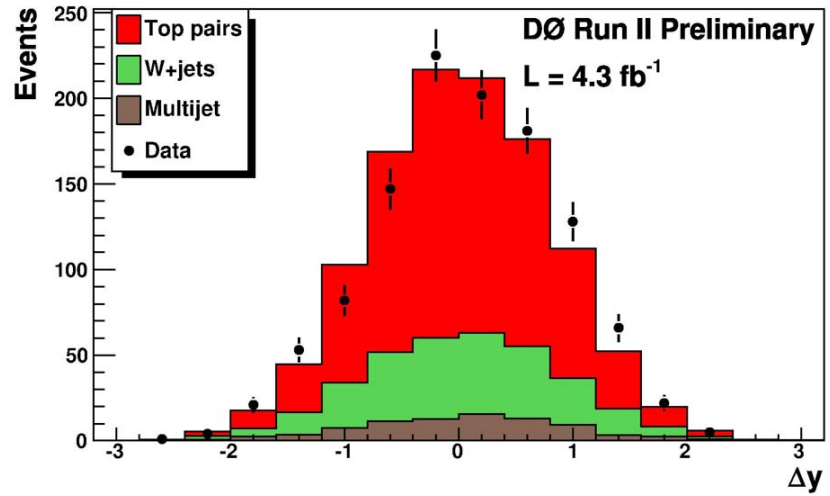
Projected sensitivity

More proton-antiproton features

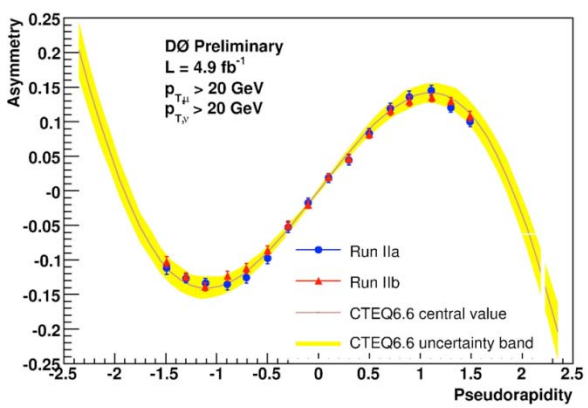
t-tbar asymmetry:

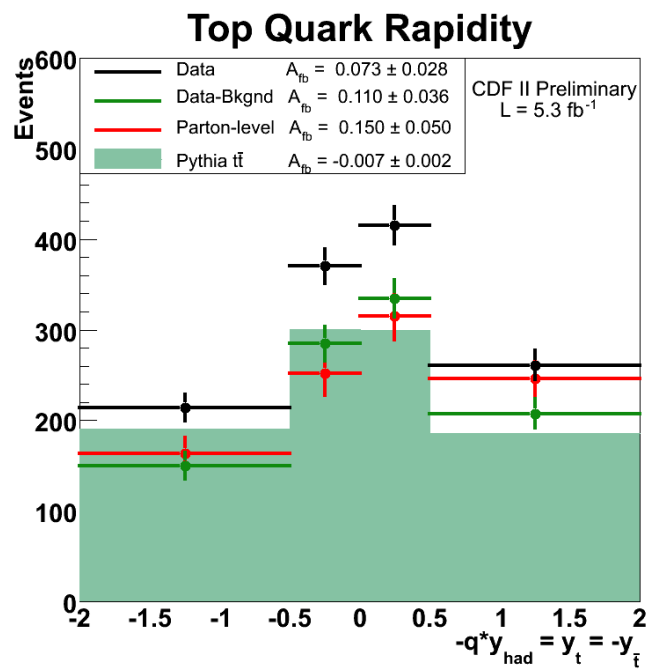


$$A_{fb} = \frac{F - B}{F + B}$$

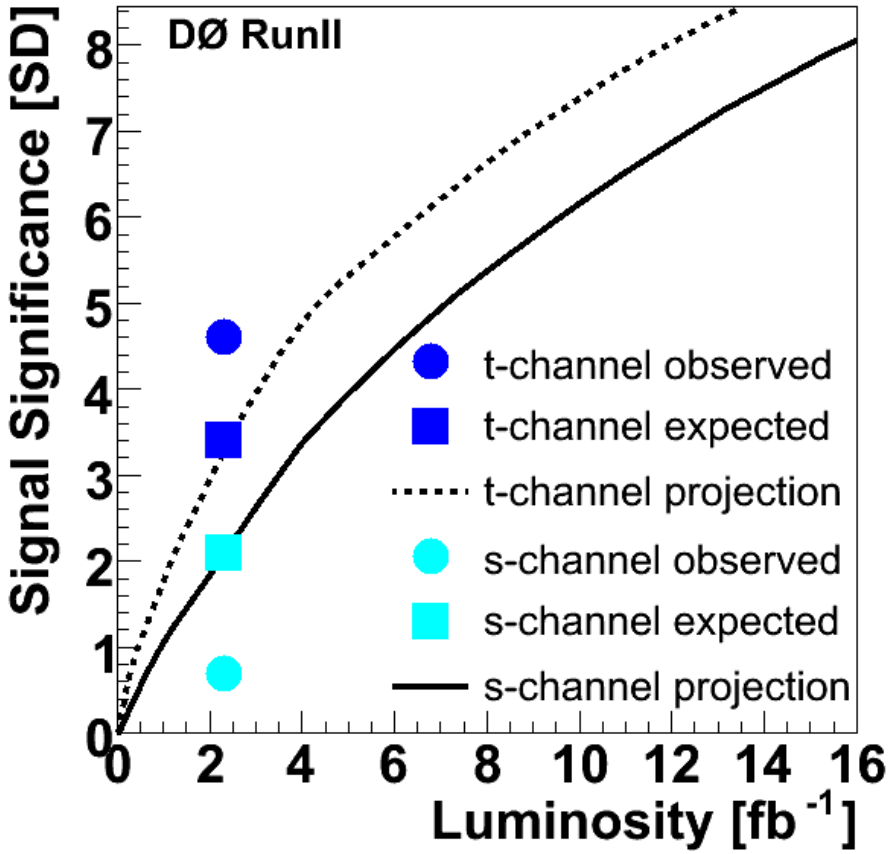


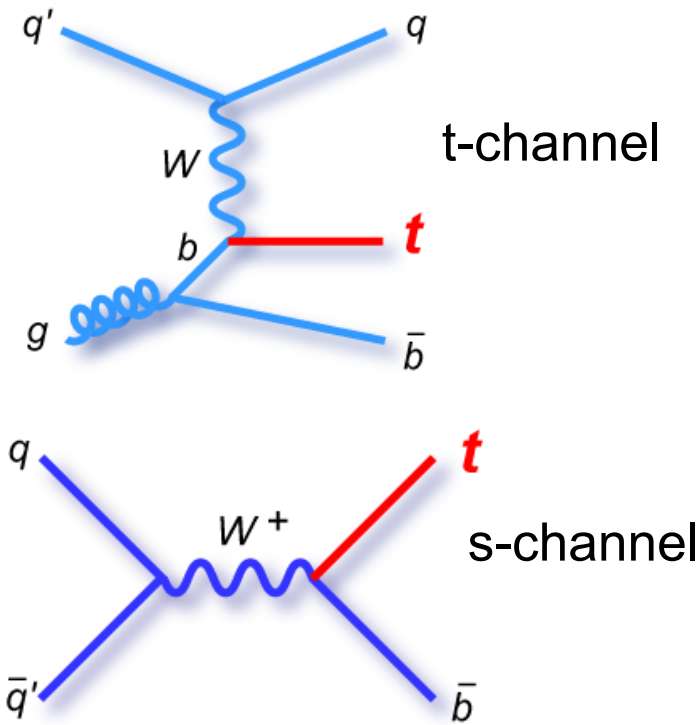
W→μν asymmetry:





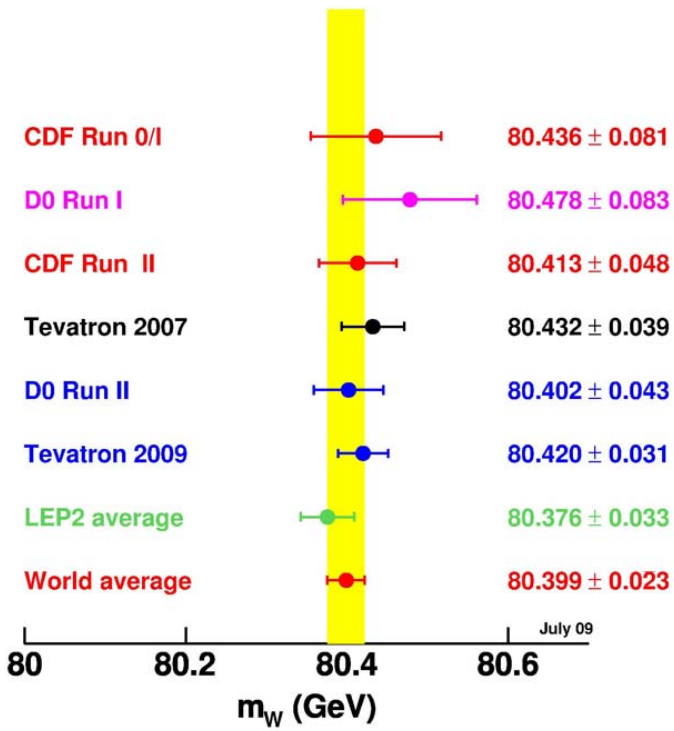
Complementary/Legacy: Single top (s-channel)



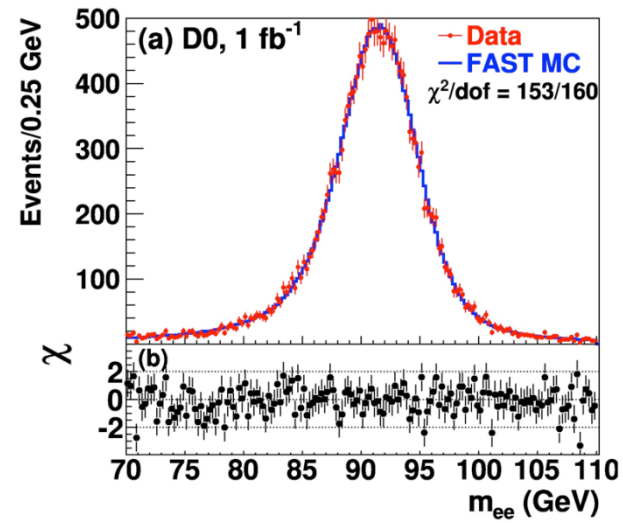


LHC estimation: 10-30 fb-1 at √s=14 TeV for 3-sigma excess in s-channel

Future Legacy: W mass

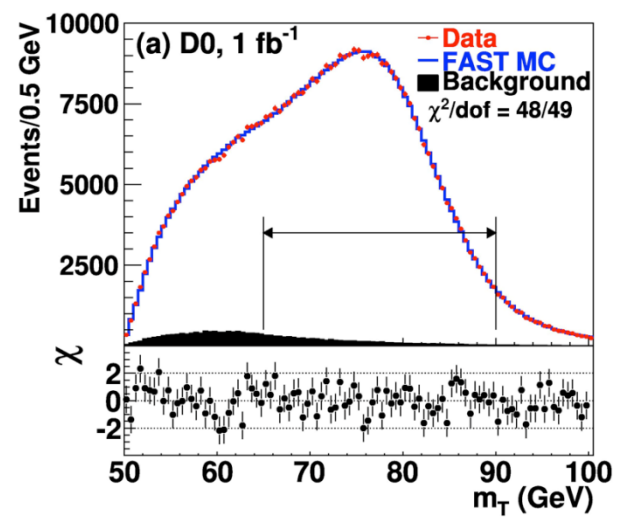


calibration



~18k events in 1 fb^{-1}

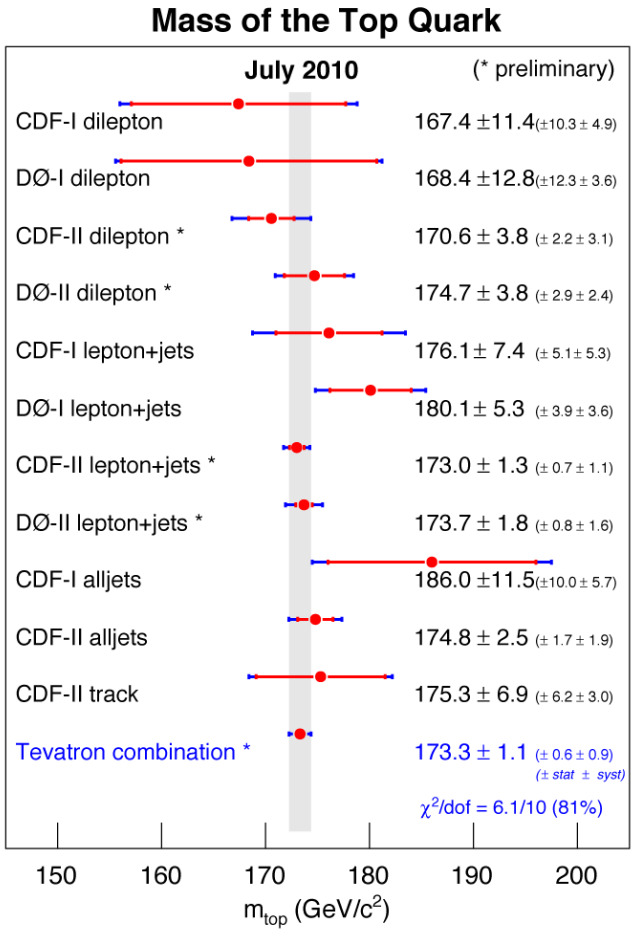
signal

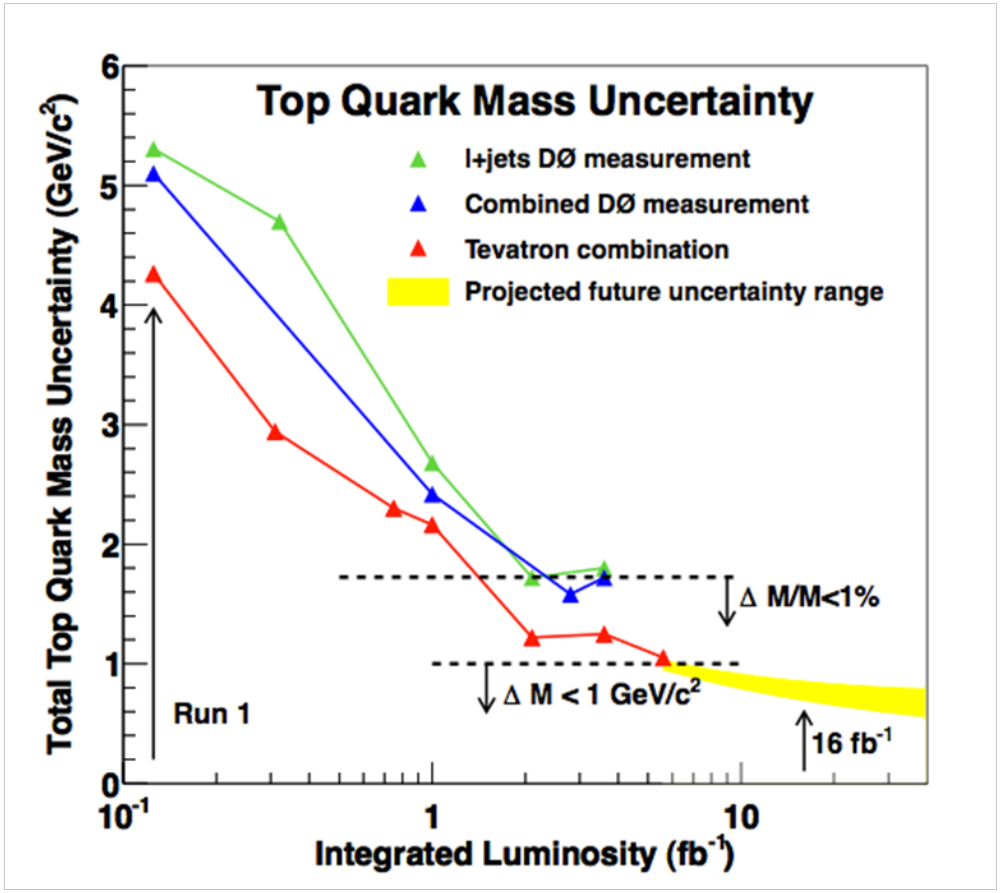


~485k events in 1 fb^{-1}

current Tevatron precision: 0.04%
→ expect improvements (statistics+systematics) with larger data sets

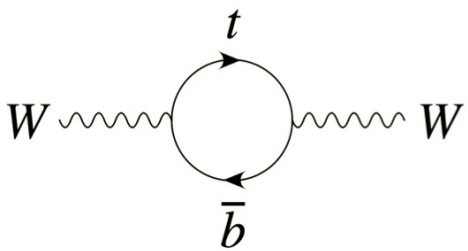
Future Legacy: Top Mass

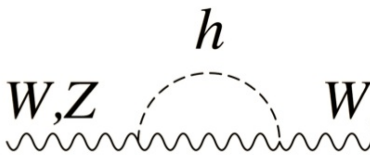




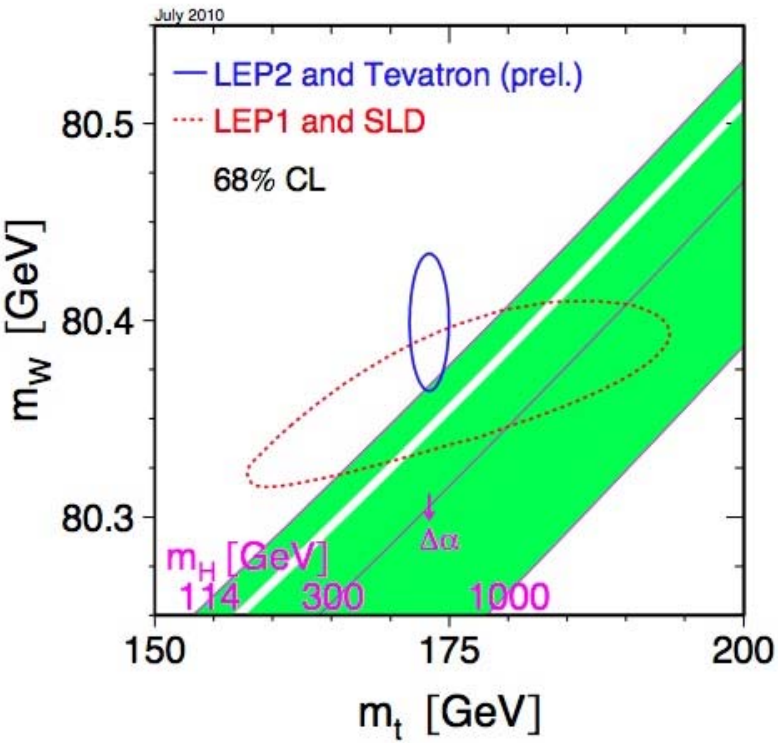
current Tevatron precision: 0.7%

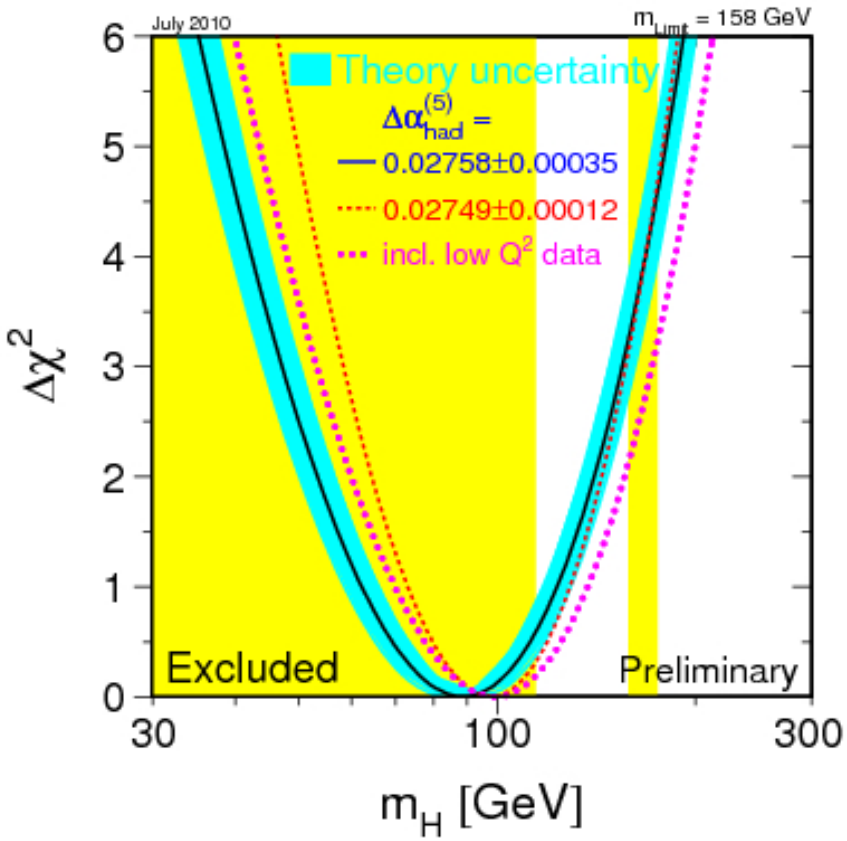
Self-consistency of the SM





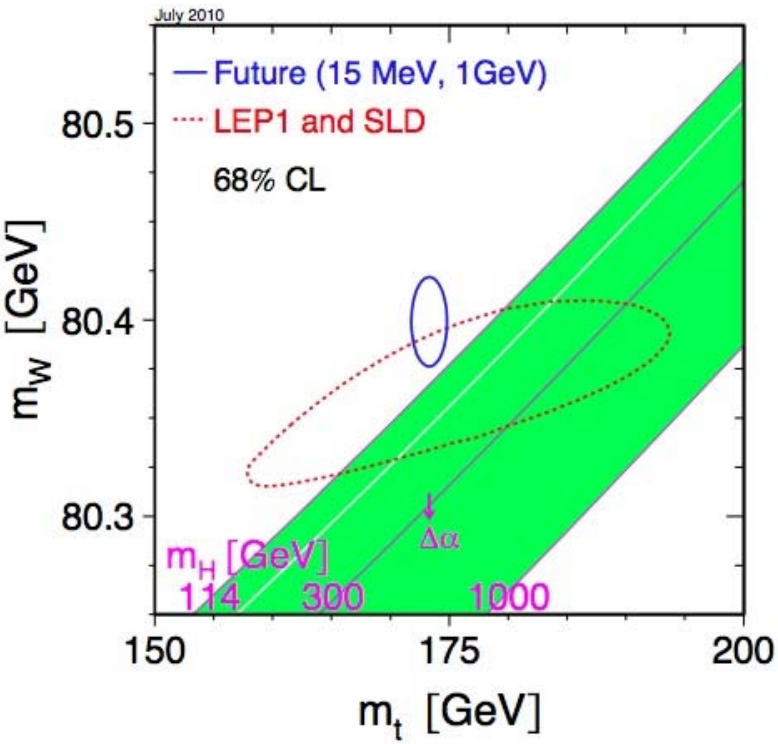
Current





Self-consistency of the SM

Projections

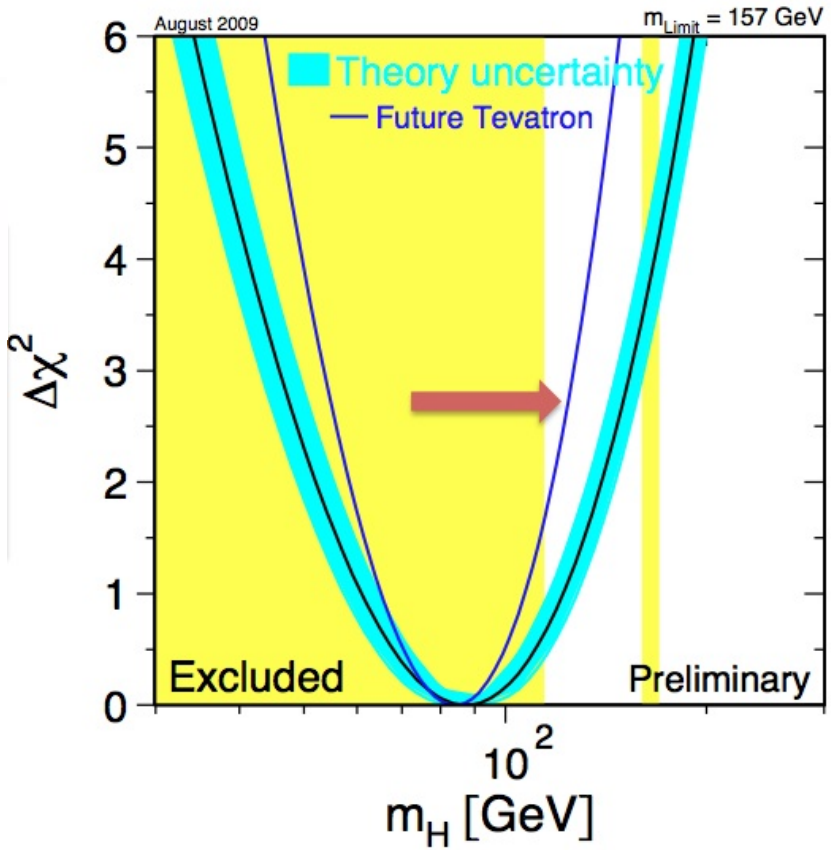


Improved W mass measurement is critical

Assume:

top mass uncertainty = 1 GeV

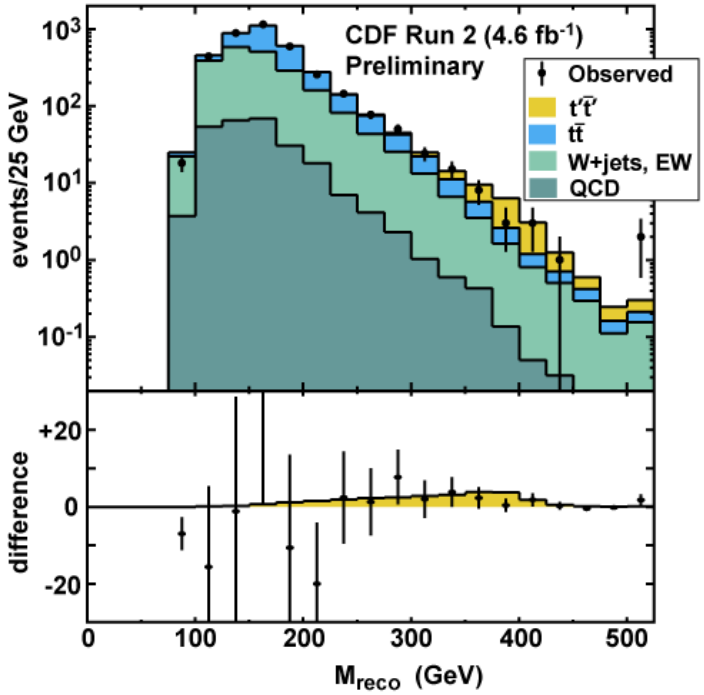
W mass uncertainty = 15 MeV

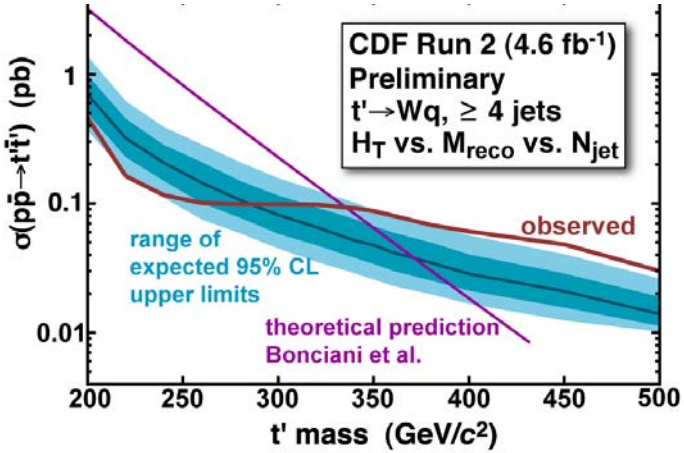


m_H < 117 GeV at 95% CL at current minimum

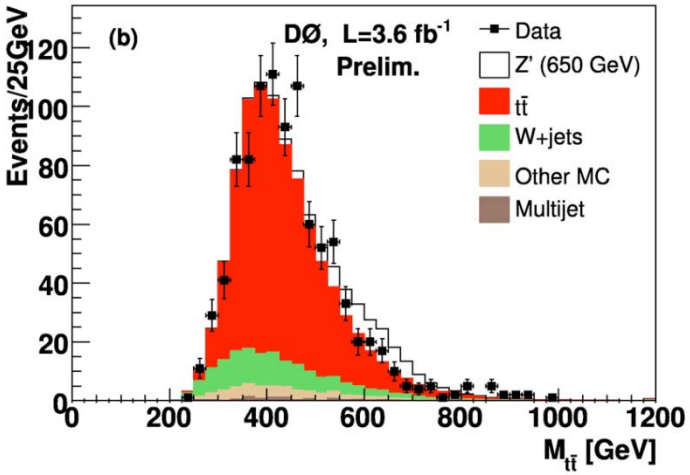
Hints and Excesses

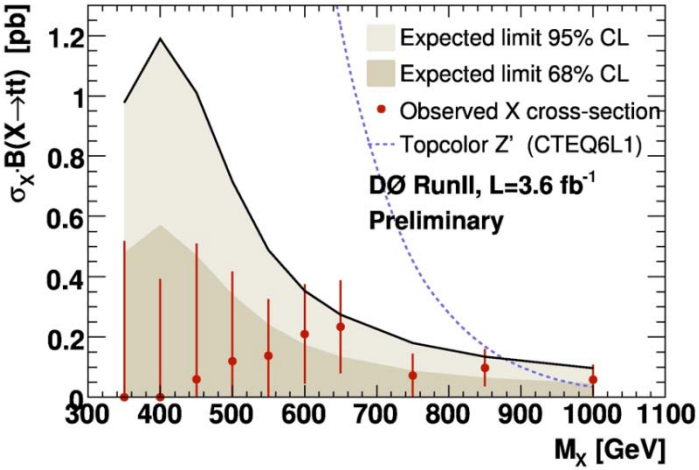
search for t' quarks





search for ttbar resonances

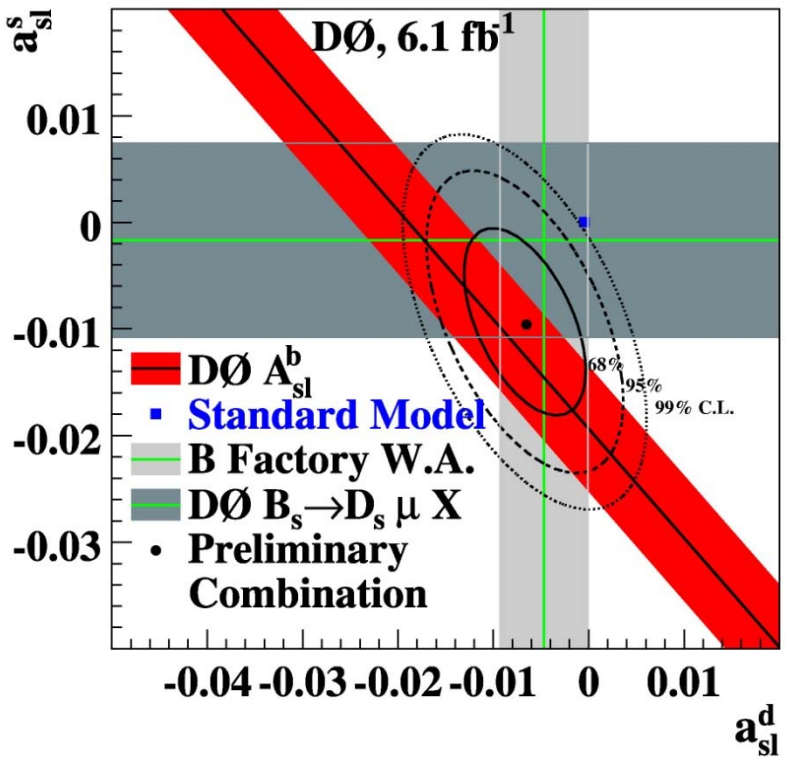




Hints and excesses: dimuon asymmetry and a_{sl}

$$a_{sl}^{q} \equiv \frac{\Gamma(\overline{B}_q^0 \to \mu^+ X) - \Gamma(B_q^0 \to \mu^- X)}{\Gamma(\overline{B}_q^0 \to \mu^+ X) + \Gamma(B_q^0 \to \mu^- X)}; \quad q = d, s$$

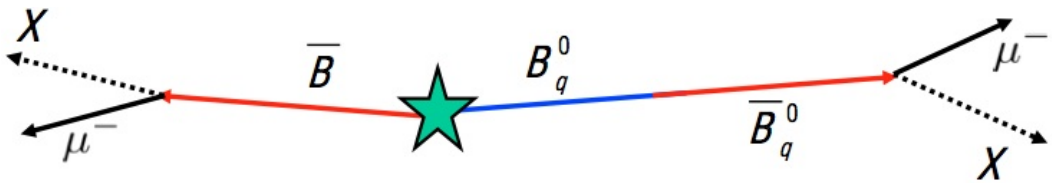
Given relative abundances of B_d and B_s, measured asymmetry A^b_{sl} gives linear combination of a^b_{sl} and a^d_{sl}



arXiv.org:1005.2757

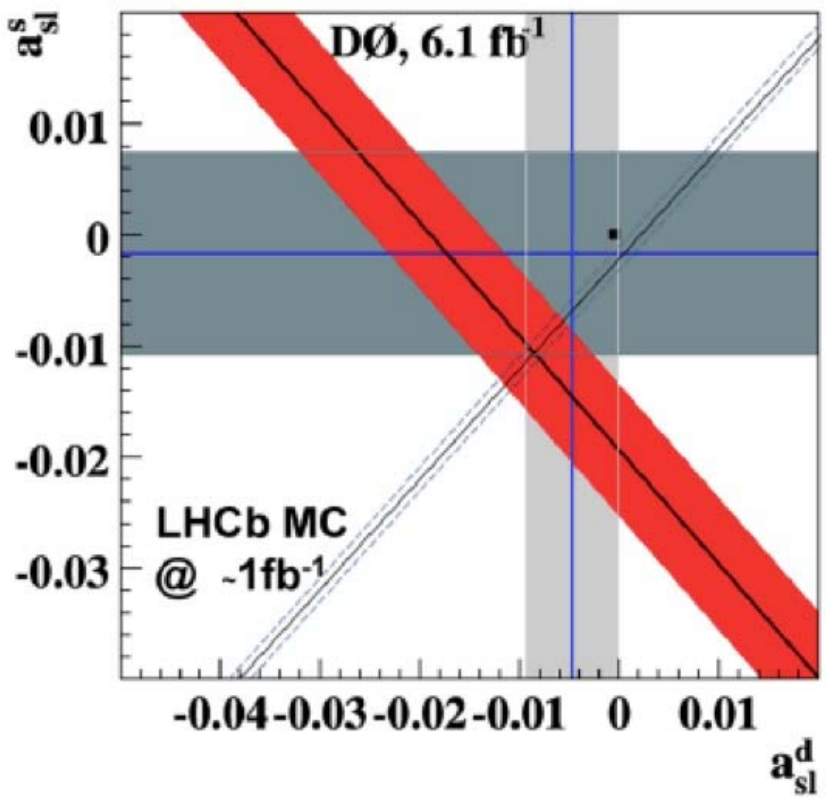
3.2 σ deviation from SM

Complementary: Di-muon Asymmetry



$$A_{sl}^b \equiv \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}}$$

N_b^{++} (N_b^{--}) – number of same-sign $\mu^+\mu^+$ ($\mu^-\mu^-$) events from $B \to \mu X$ decay



semileptonic decays:

$B_{s,d} \to D\mu\nu$ at the LHCb

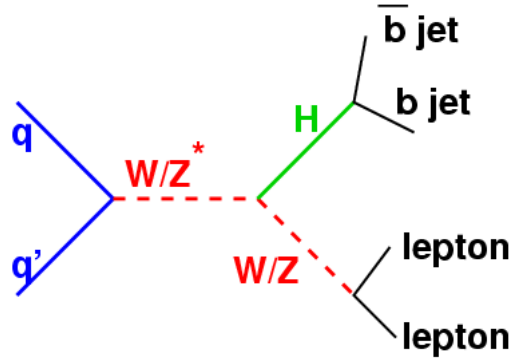
HIGGS

SM Higgs search at the Tevatron

Low mass (m_H <~135 GeV):
dominant decay:

$$H \to b\bar{b}$$

Use associated production modes to get better signal/background



$$q\bar{q}' \to WH \to \ell\nu b\bar{b}$$

$$q\bar{q} \to ZH \to \ell^+\ell^- b\bar{b}$$

$$q\bar{q} \to ZH \to \nu\bar{\nu} b\bar{b}$$

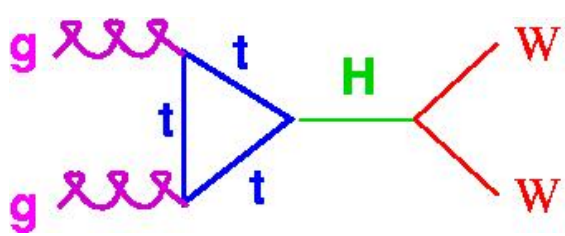
Intermediate mass:

$$q\bar{q} \to WH \to WWW^{(*)}$$

$$gg \to H \to \gamma\gamma$$

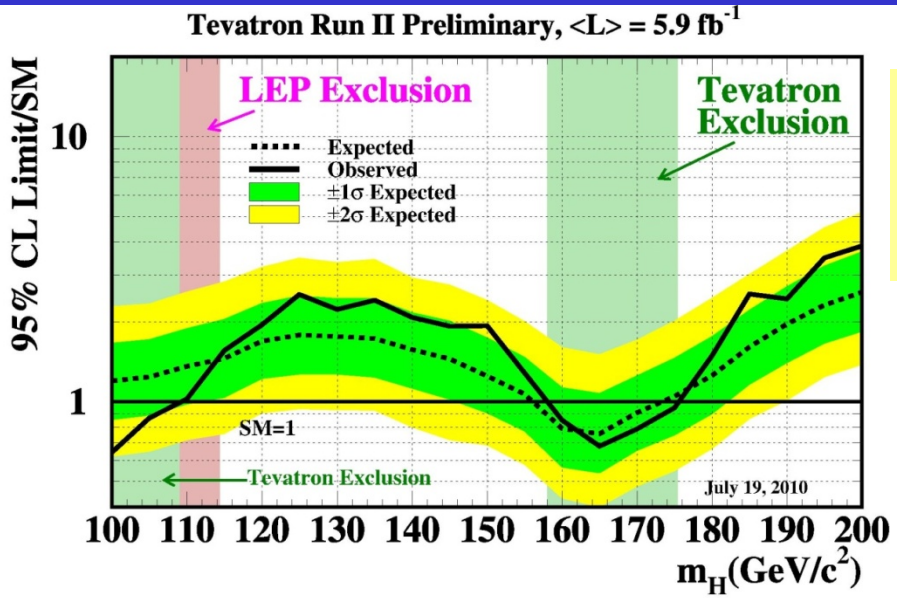
High mass (m_H>~135 GeV):
dominant decay:

$$H \to WW^{(*)}$$



$$gg \to H \to WW \to \ell\nu\ell'\nu'$$

SM Higgs limits from all modes/channels

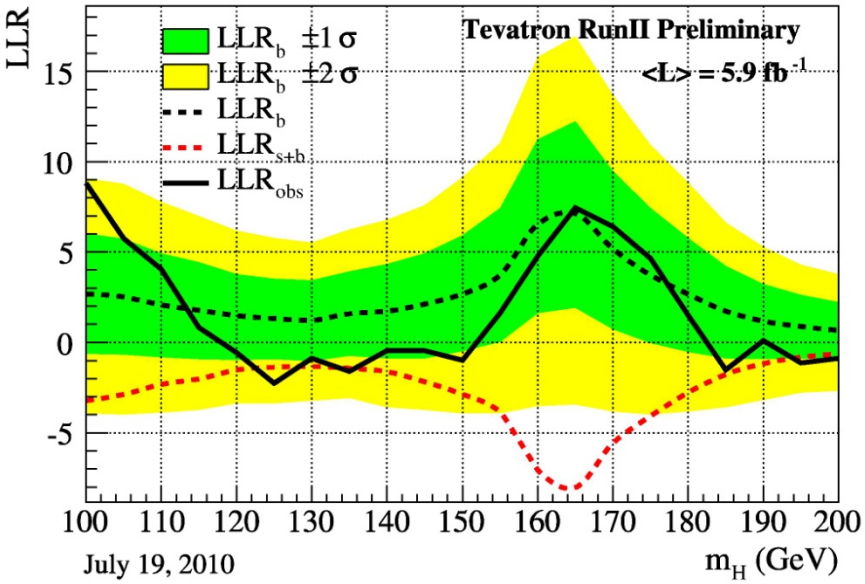


Last preliminary combination: July-2010
Up to6.7 fb^{-1} of luminosity Fermilab-Conf-10-257-E

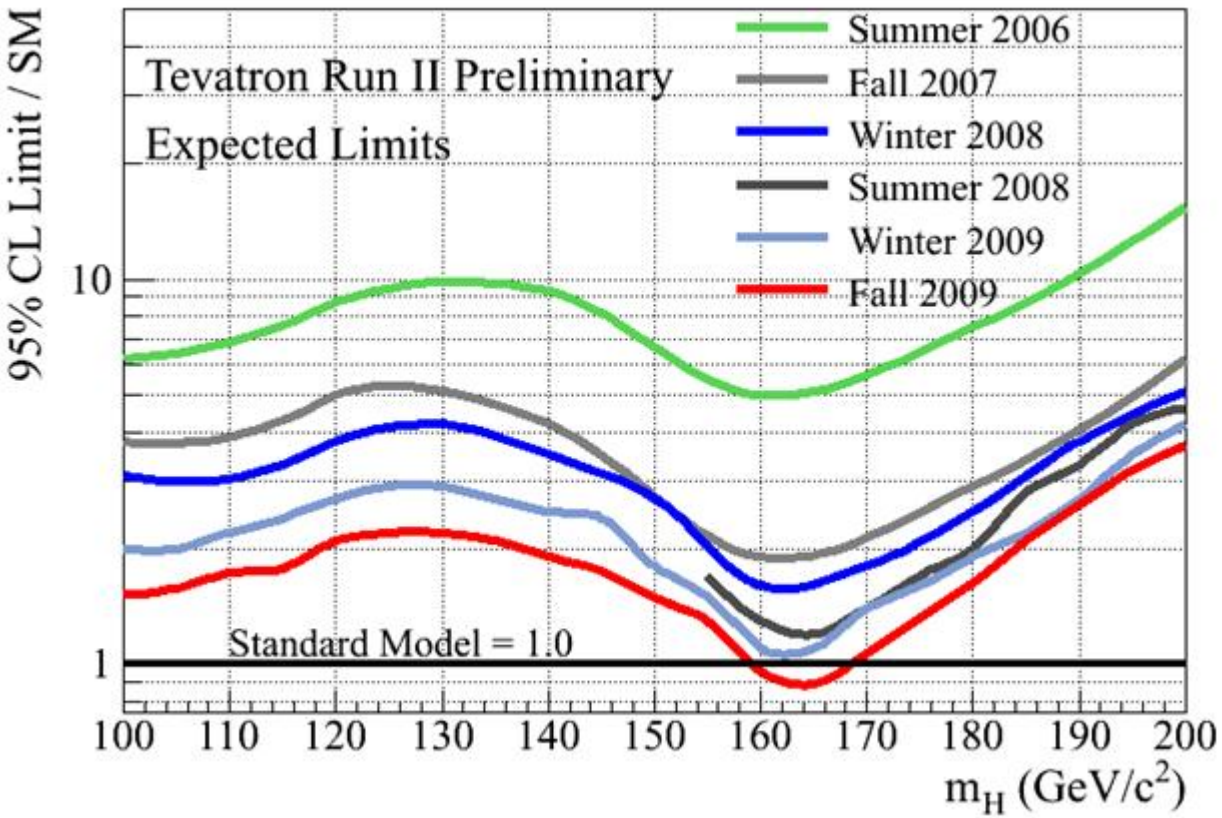
Cross section limit
(relative to SM xsec)

Log-Likelihood ratio plot:

- source of xsec limit
- contains more information



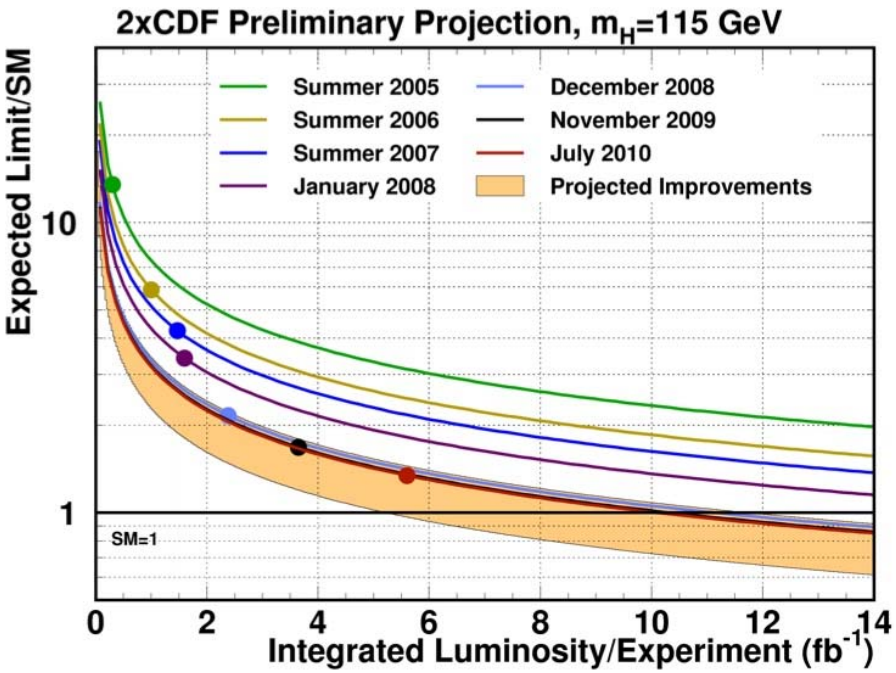
Historic Progress

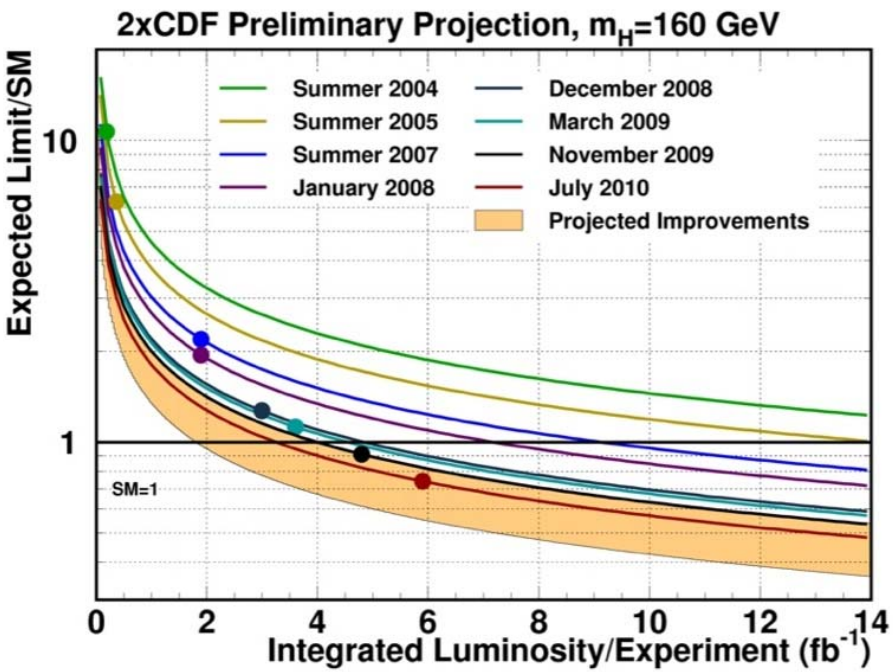


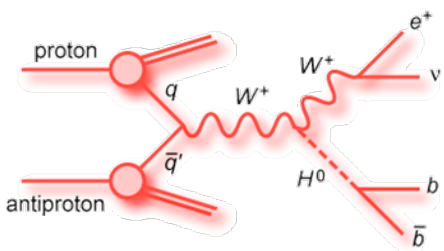
- Expected limits are the measure of experimental sensitivity

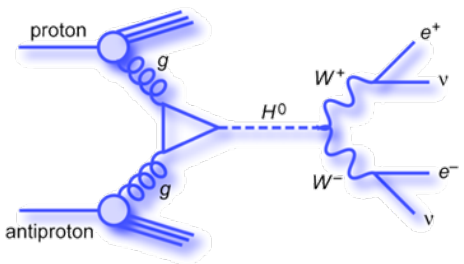
- The Tevatron expected limits have made impressive progress since 2006

Improvements

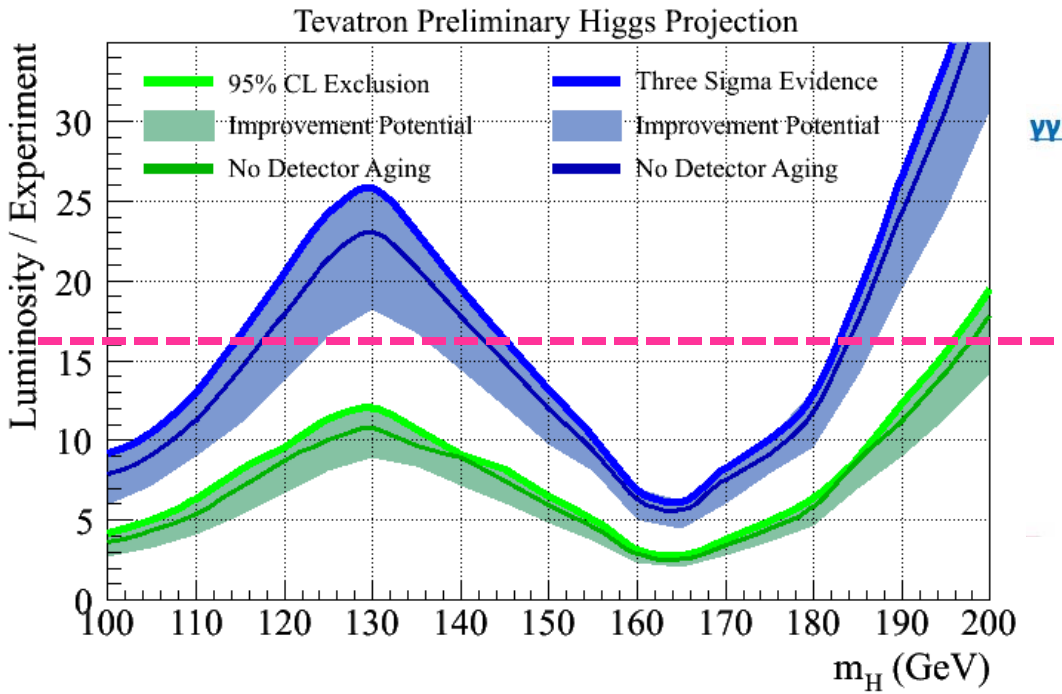


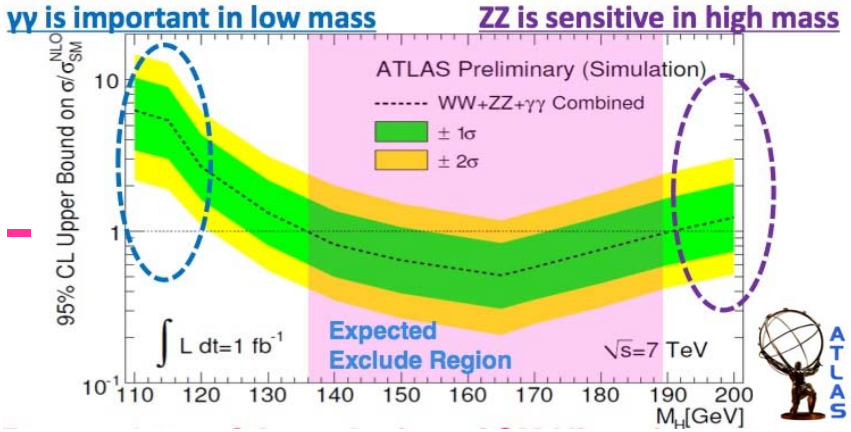


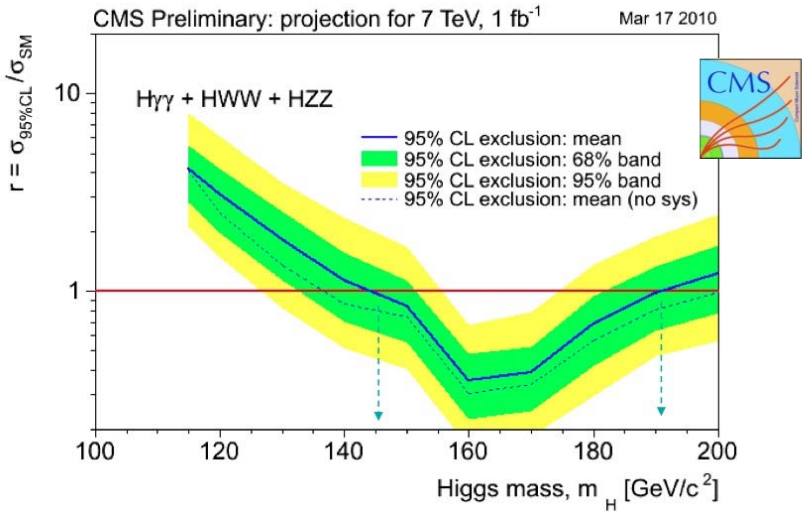




Higgs projection





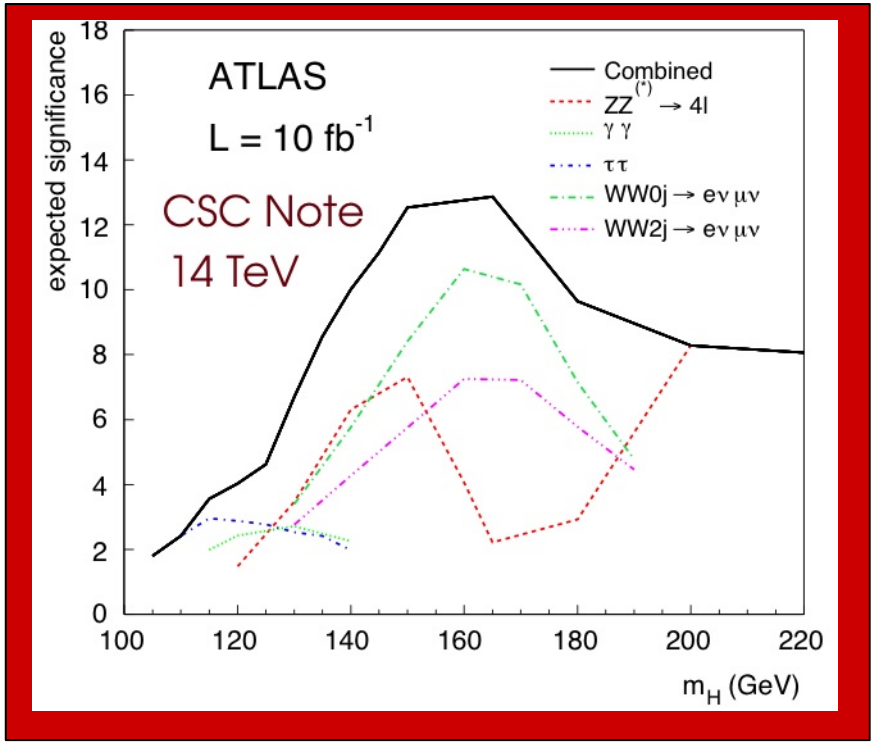


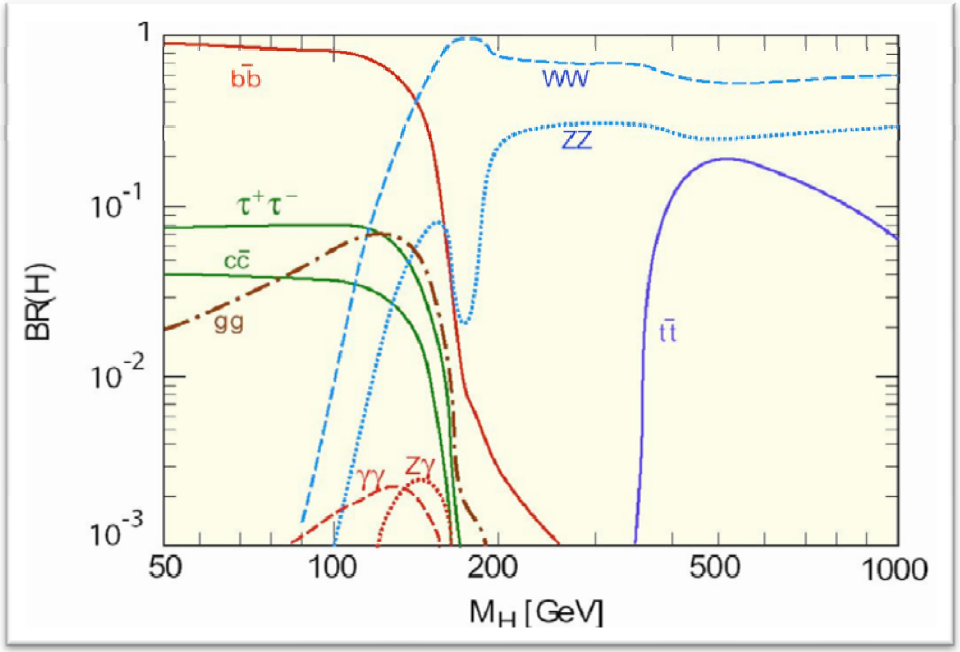
With 16 fb-1 at the Tevatron, expect:

- 95% CL exclusion (and stronger) over whole range m_H<190 GeV
- 3σ evidence, in 100 < m_H < 180 GeV, except maybe for m_H around 130 GeV
- 4σ evidence for m_H=115 GeV

Beyond discovery: probing the Nature of the SM Higgs

Low mass Higgs search at the LHC relies on $H \rightarrow \gamma\gamma$ and $H \rightarrow \tau\tau$





To understand EWSB, one wants direct observation of Higgs decays into b jets

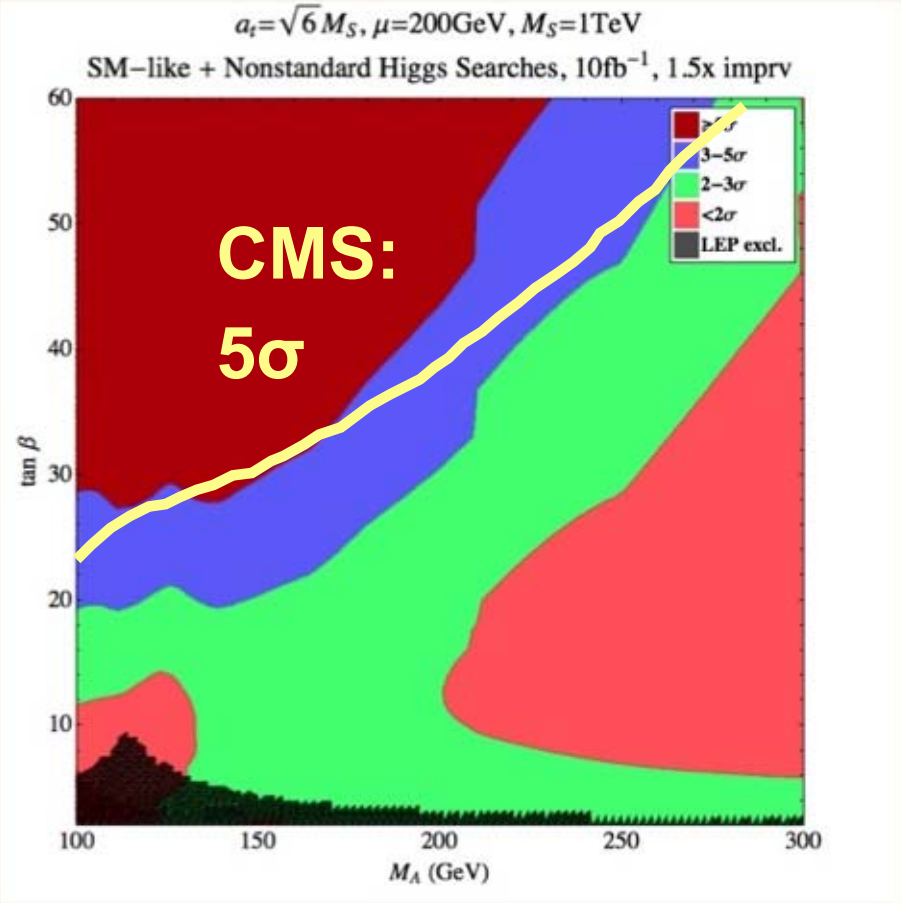
Complementary

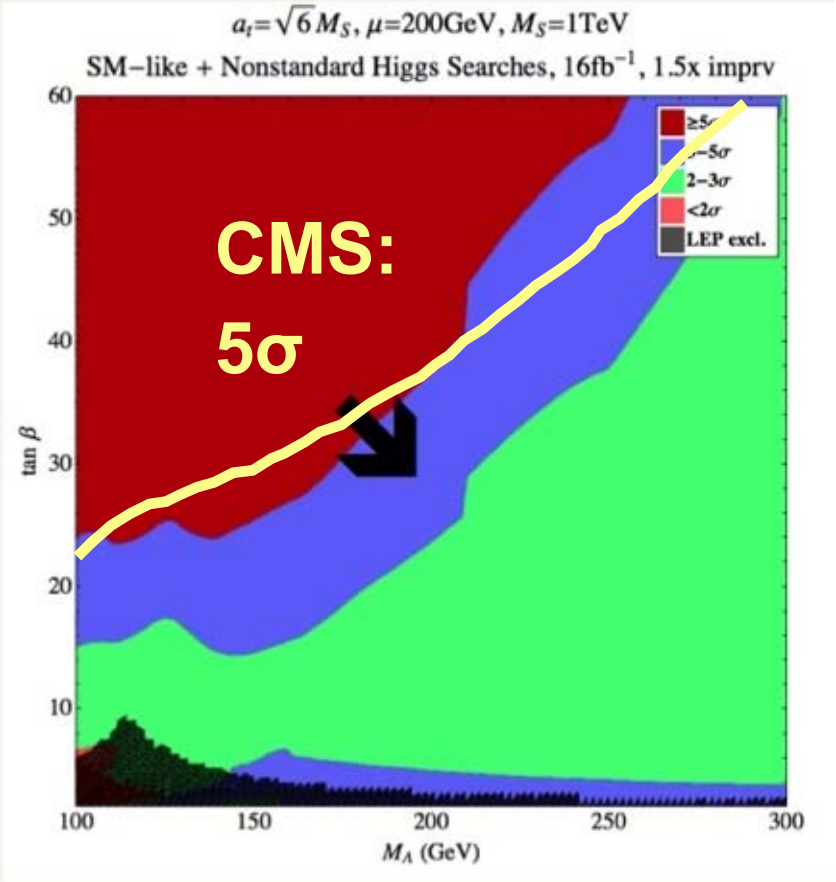
MSSM+SM Neutral Higgs

Maximal Mixing Scenario

10 fb^{-1}

16 fb^{-1}

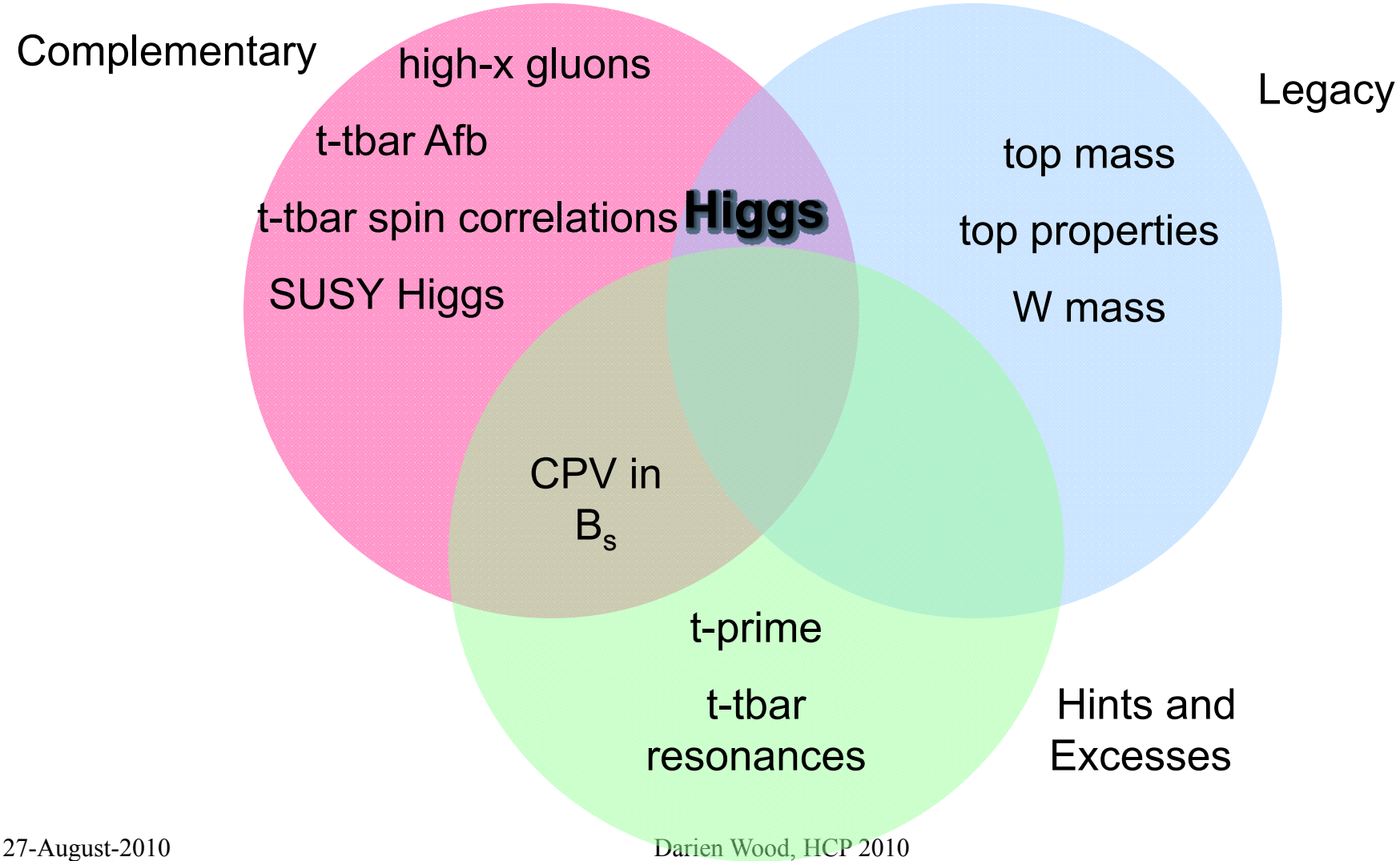




Draper, Liu, Wagner

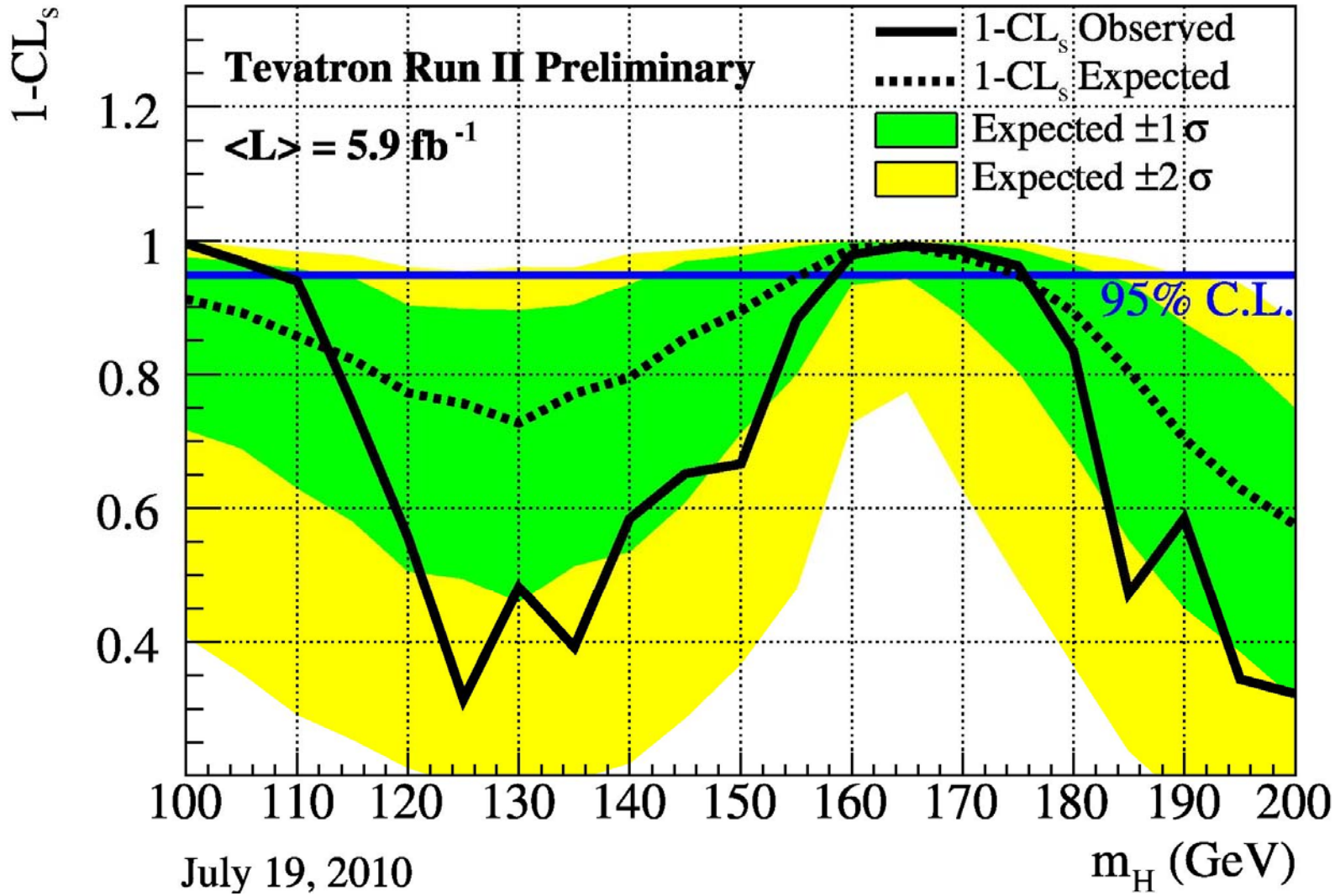
Summary

- Tevatron acceleartor and the CDF and Dzero detectors are prepared to take advantage of a unique opportunity in the next few years

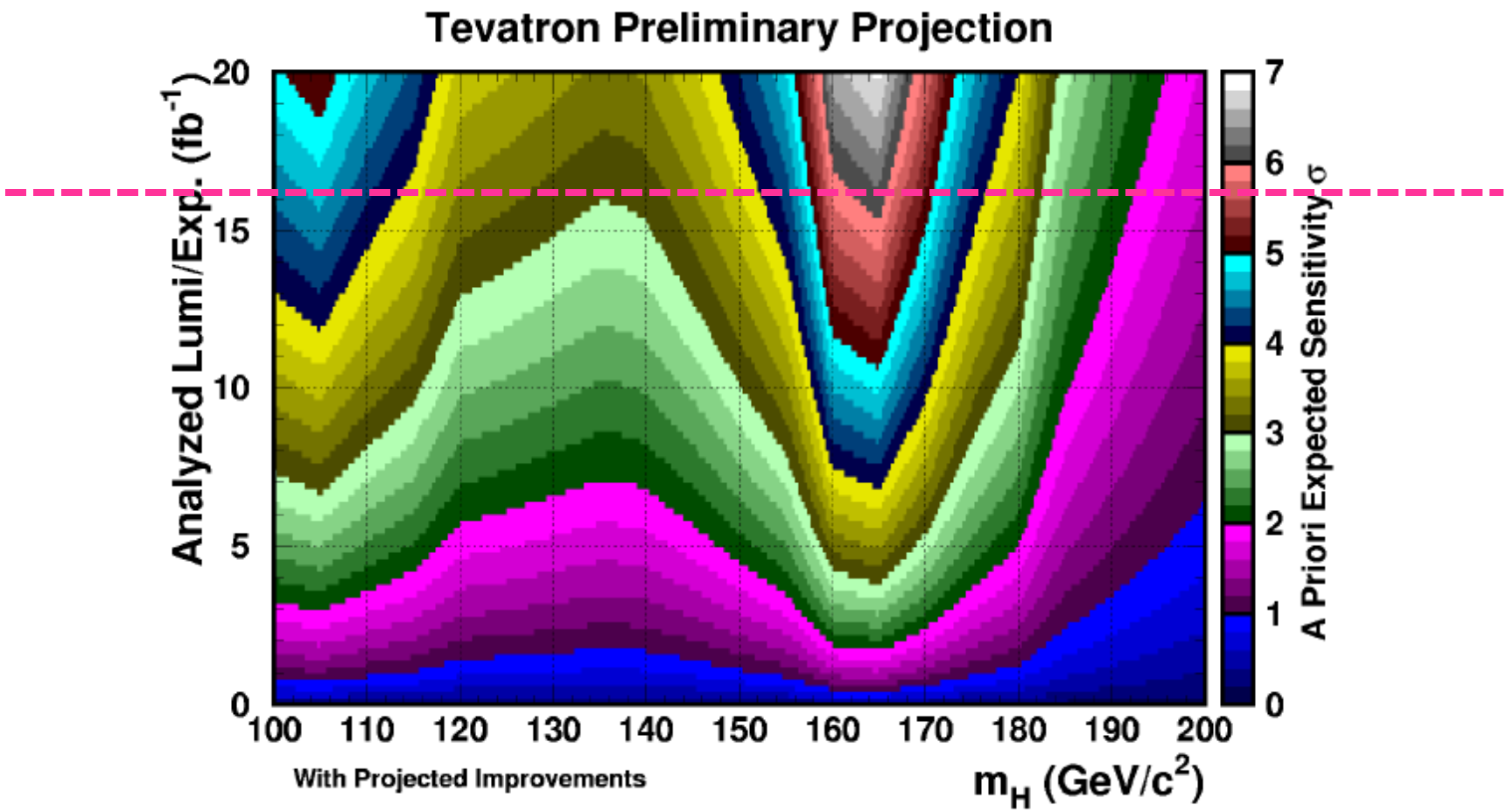


BACKUP SLIDES

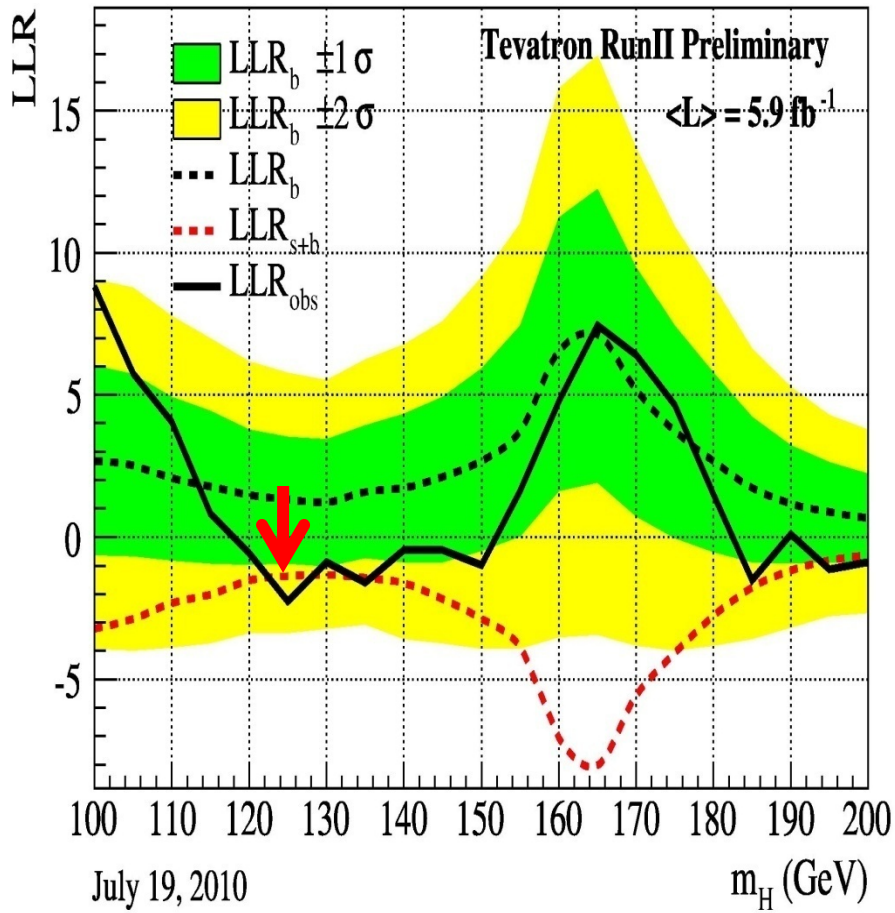
CL vs. m_H (July 2010)

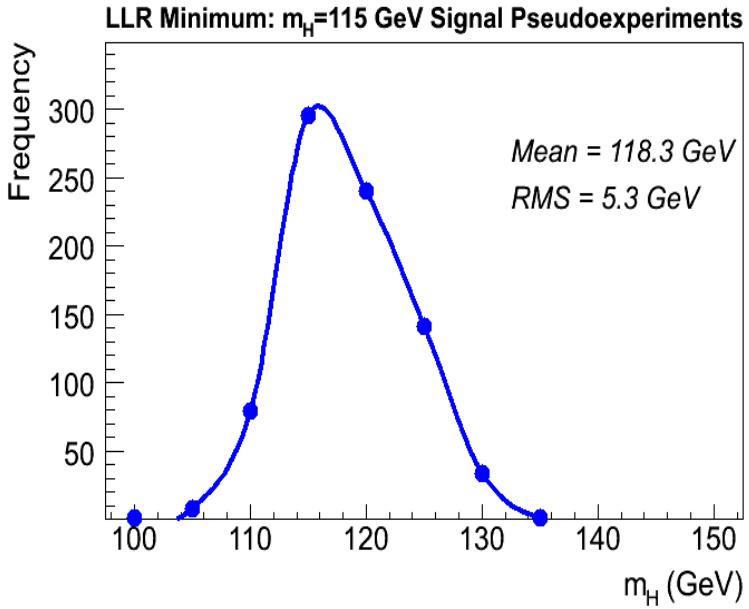


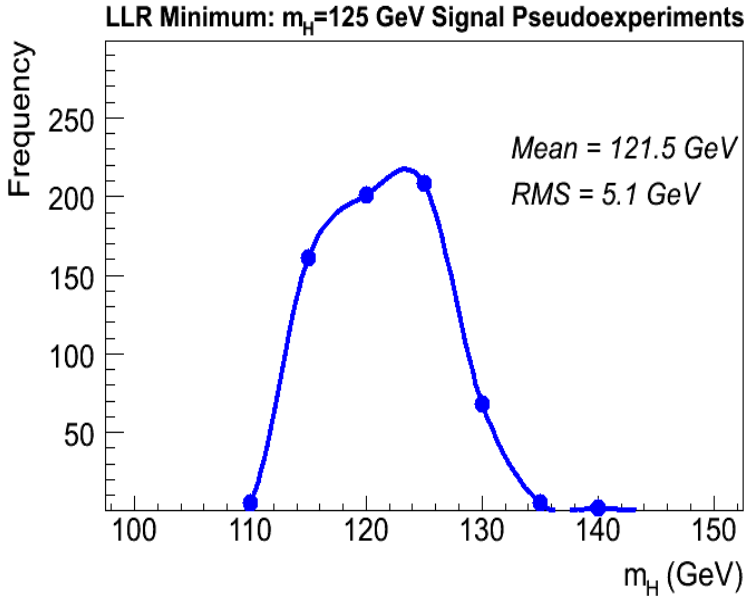
Projected Higgs signficance vs. mass and luminosity



Higgs Mass Pseudo Experiments







- Perform 800 injection pseudo-experiments