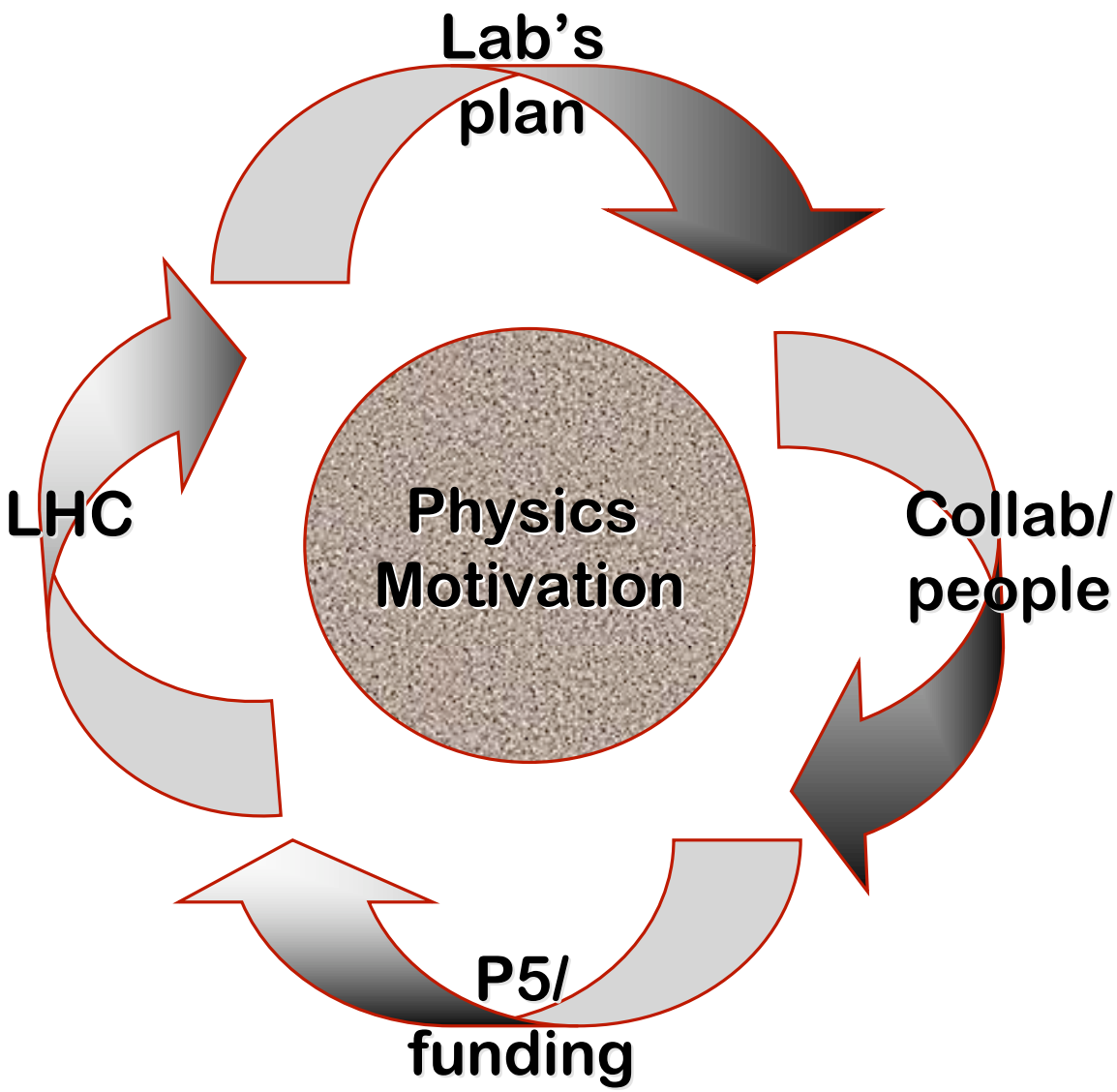
CDF - 2010

P5 review, Sept 24th

Jacobo Konigsberg & Robert Roser
CDF spokespeople
Doug Glenzinski - Phys. Coord.

Running in 2010 and beyond

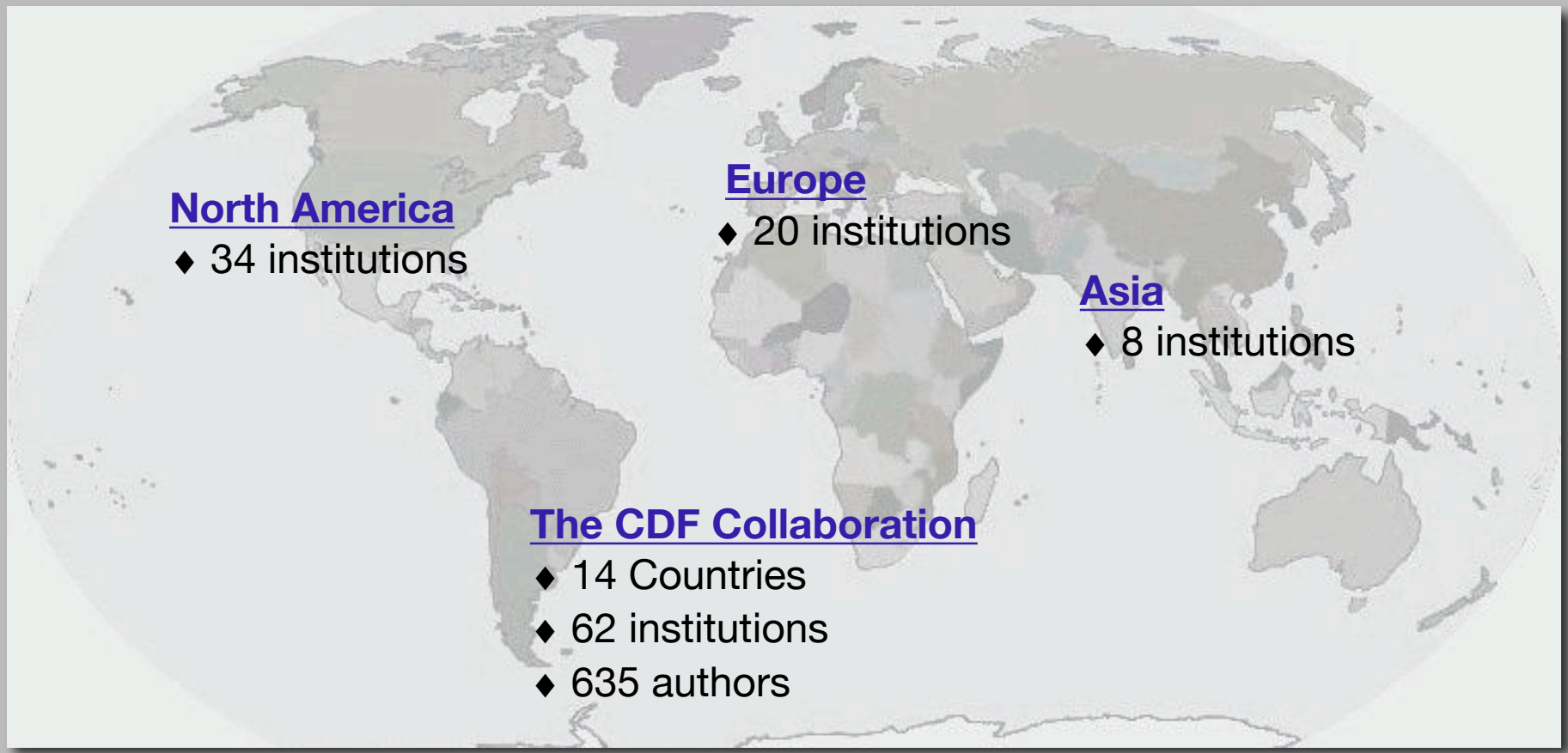


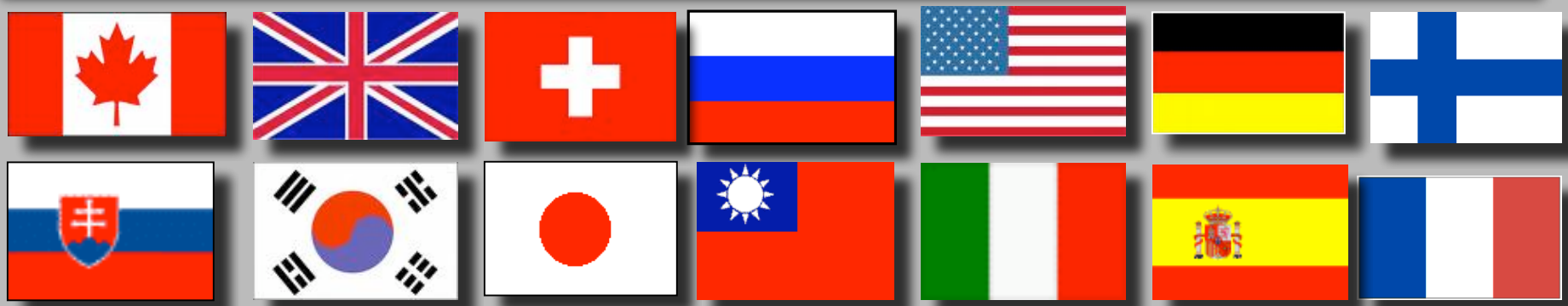
Outline

- Perspective
- Process
- Progression
- Possibilities
- Path

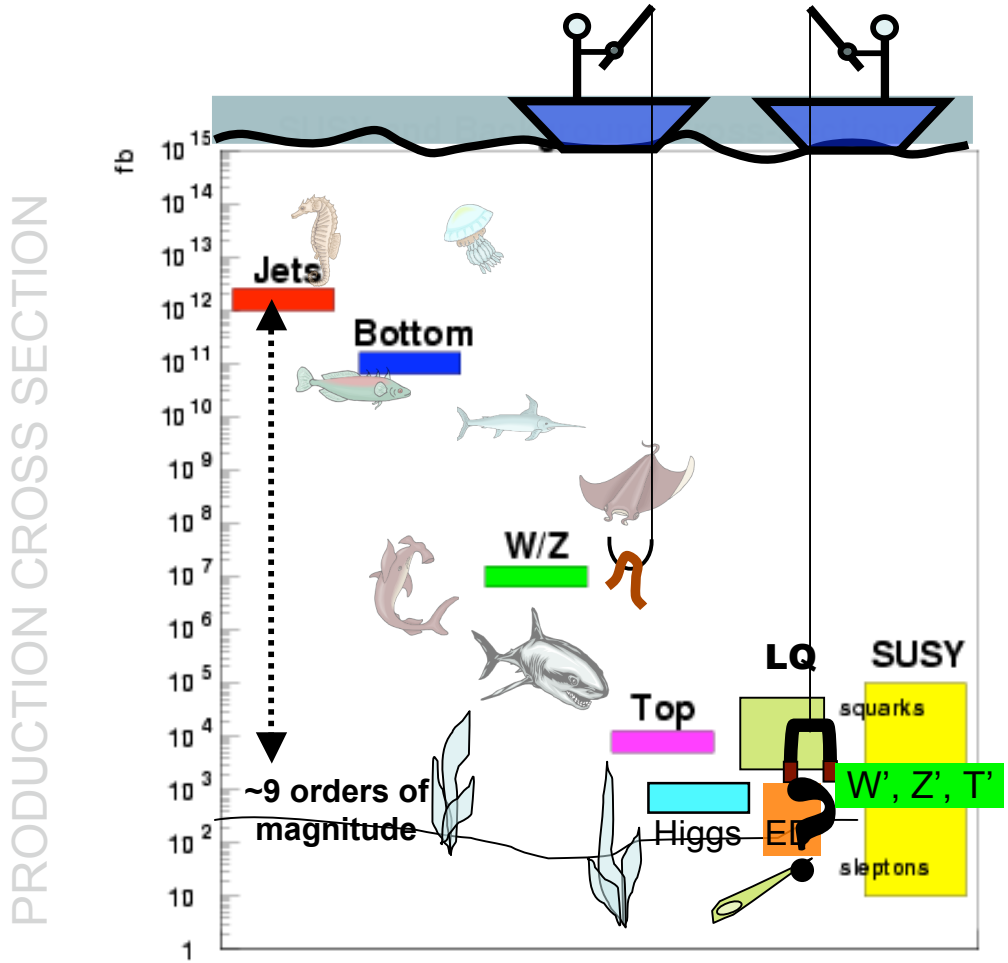
Perspective

The CDF Collaboration





Broad and deep physics program



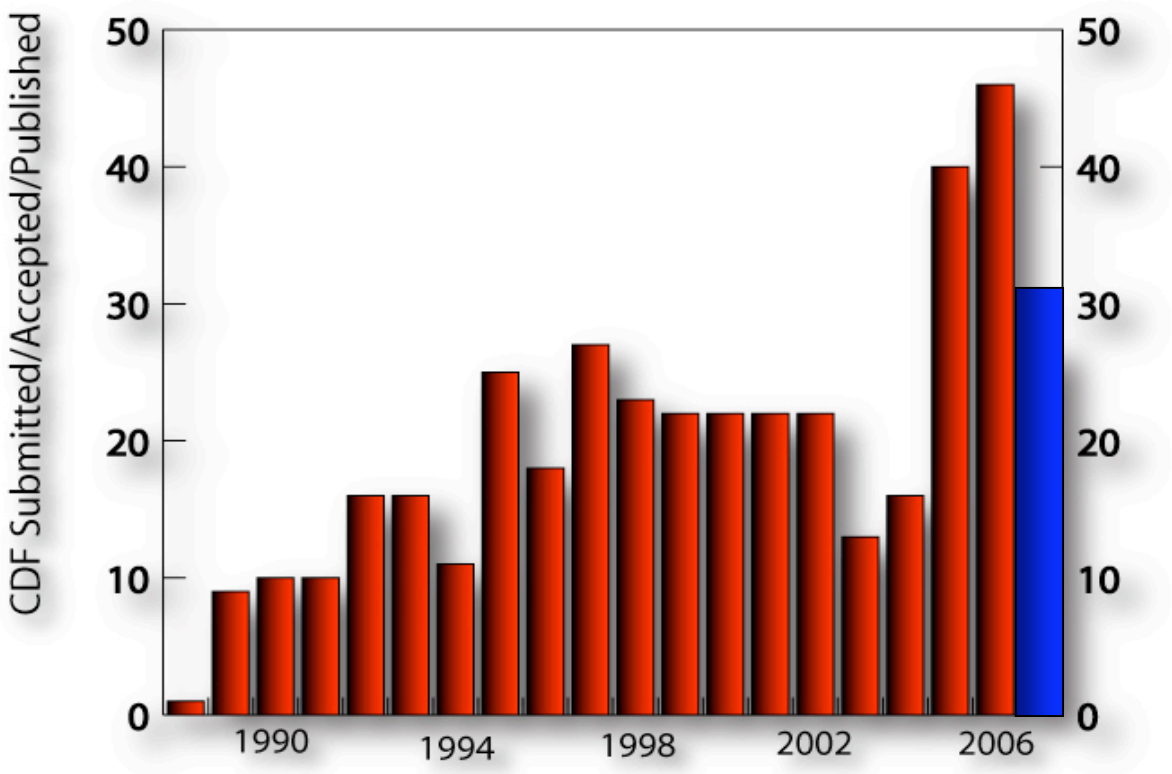
Some CDF Run 2 Physics Highlights

- ✓ Observation of Bs-mixing
  - Δm_s = 17.77 +- 0.10 (stat) +- 0.07(sys)
- ✓ Observation of new baryon states
  - Σ_b and Ξ_b
- ✓ Observation of new charmless B=>hh states
- ✓ Evidence for D^o-D^obar mixing
- ✓ Precision W mass measurement
  - Mw = 80.413 GeV (48 MeV)
- ✓ Precision Top mass measurement
  - Mtop = 170.5 (2.2) GeV
- ✓ W-width measurement
  - 2.032 (.071) GeV
- ✓ WZ observation (6-sigma)
  - Measured cross section 5.0 (1.7) pb
- ✓ ZZ evidence
  - 3-sigma
- ✓ Single top evidence(3-sigma) with 1.5 fb^{-1}
  - Measured cross section = 3.0 (1.2) pb
  - $|V_{tb}|$= 1.02 ± 0.18 (exp.) ± 0.07 (th.)
- ✓ Significant exclusions/reach on many BSM models
- ✓ Constant improvement in Higgs Sensitivity

Most are world's best results !

CDF Publication History

- **Publications submitted+accepted+published**
  - 137 Run 2 publications and 17 papers submitted but not published
  - We also have >50 additional papers under internal review !
  - On track for >40 publications in 2007



We are publishing our results as we go !

New results at Lepton-Photon 2007

- http://www-cdf.fnal.gov/internal/physics/joint_physics/S07CDFResults.html
- ~ 50 new results since April '07
- ~ 30 use the full available dataset

B Group

Analysis	Luminosity
Observation of $B_c \rightarrow J\pi$ and Precision Mass Determination	2.2 fb^{-1}
Observation of the $Cascade_b$	1.9 fb^{-1}
Measurement of $\Delta\Gamma_s/\Gamma_s$ and φ_s using $B_s \rightarrow J\varphi$	1.9 fb^{-1}
Search for FCNC $B_{s(d)} \rightarrow \mu^+ \mu^-$ Decays	1.9 fb^{-1}
Orbitally Excited B mesons (B^{**})	1.7 fb^{-1}
Observation of $B_s \rightarrow D_s K$	1.2 fb^{-1}
Evidence for D^0-D^0bar Mixing	1 fb^{-1}
Measurement of the CP Asymmetry in $B^0 \rightarrow JK^*$ Decays	1.7 fb^{-1}

Electroweak Group

Analysis	Luminosity
Anomalous Coupling Limits from WZ events	1.9 fb^{-1}
Evidence for ZZ Production	1.5 fb^{-1}
Measurement of $d\sigma (Z/\gamma^* \rightarrow e^+e^-)/dy$	1.1 fb^{-1}
Measurement of the W-Charge Asymmetry	1 fb^{-1}
Direct Measurement of the Z-Boson Invisible Width	1 fb^{-1}
Anomalous Coupling Limits from ZZ events	1.9 fb^{-1}

New results at Lepton-Photon 2007

Exotics Group

Analysis	Luminosity
Search for Anomalous Production of $\gamma\gamma\tau$	2 fb^{-1}
Search for Direct Production of Squarks and Gluinos	1.4 fb^{-1}
Search for Heavy Quarks in Dileptons+X	1.2 fb^{-1}
Global Search for New Physics at High-p_T	1 fb^{-1}
Search for Large Extra Dimensions using MET+1 Jet Events	1 fb^{-1}
Search for high mass resonance decaying to e^+e^-	1 fb^{-1}

Higgs Group

Analysis	Luminosity
Search for $H \rightarrow W^+W^-$ Events	1.9 fb^{-1}
Search for $WH \rightarrow l\nu\, bb$ Events	1.7 fb^{-1}
Search for $ZH \rightarrow \nu\nu\, bb$ Events	1.7 fb^{-1}
Search for hbb in Events with at least 3 B-tags	1 fb^{-1}
Updated CDF SM Higgs Combination	1-2 fb^{-1}
Updated CDF+D0 SM Higgs Combination	1-2 fb^{-1}

QCD Group

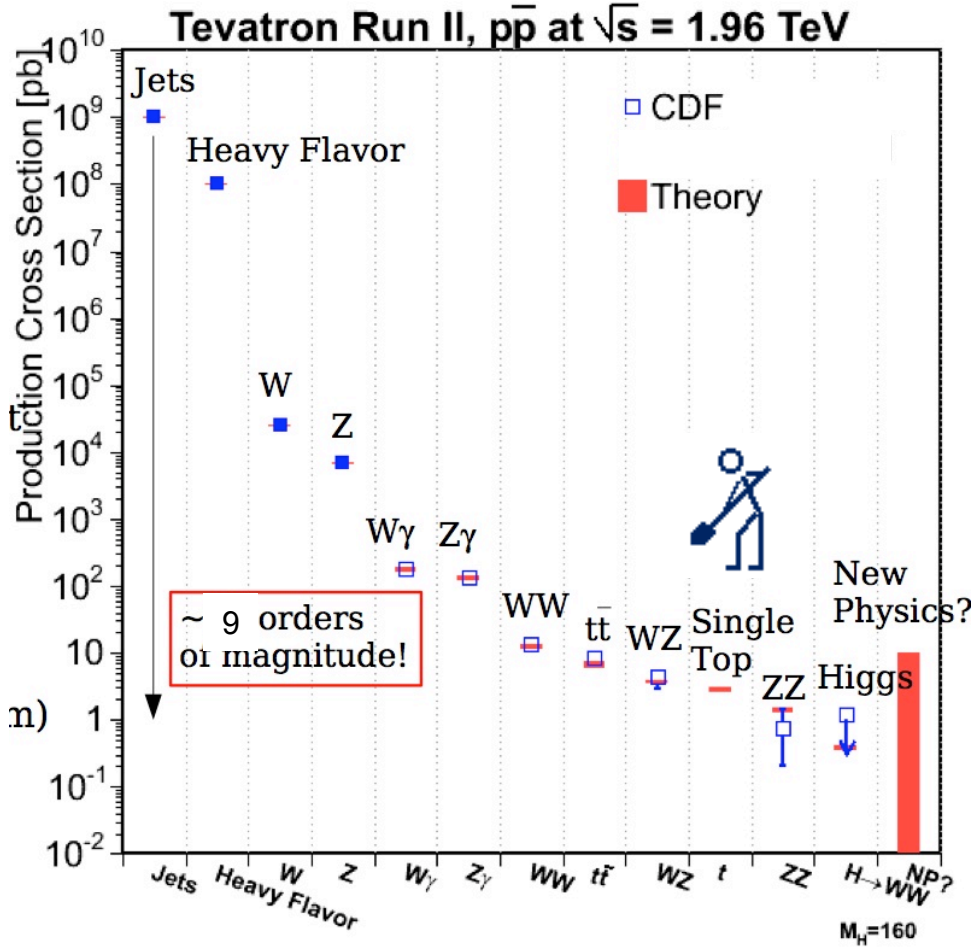
Analysis	Luminosity
Inclusive Z+Jets Cross Section	1.7 fb^{-1}
Measurement of the Inclusive Z+bjet Cross Section	1.5 fb^{-1}
Inclusive Jet Cross Section using MidPoint Algorithm	1 fb^{-1}
Measurement of b-bbar Differential Cross Sections	0.26 fb^{-1}

New results at Lepton-Photon 2007

Top Group

Analysis	Luminosity
Search for Single-Top Production using ME Discriminant	1.7 fb^{-1}
Search for Single-Top Production using Likelihood Discriminant	1.7 fb^{-1}
Measurement of M_t in Lepton plus Jets events using KDE	1.7 fb^{-1}
Measurement of M_t in Dilepton events using ME	1.9 fb^{-1}
Measurement of M_t in Dilepton events using Templates	1.9 fb^{-1}
Measurement of M_t in Dilepton events using KDE	1.9 fb^{-1}
Measurement of M_t using lepton-p_T	1.9 fb^{-1}
First Measurement of W+c Cross Section	1.7 fb^{-1}
Measurement of W-Helicity Fractions in ttbar decays	1.7 fb^{-1}
Measurement of A_{FB} in ttbar events	1.7 fb^{-1}
Measurement of the Charge of the top-quark	1.5 fb^{-1}
Measurement of top-quark Width and Lifetime	1 fb^{-1}
ttbar Cross Section using lepton plus jets events with a Btag	1.1 fb^{-1}
ttbar Cross Section using ee, μμ, eμ Dilepton events	1.2 fb^{-1}
ttbar Cross Section using e/μ plus track events	1.1 fb^{-1}
ttbar Cross Section using e/μ plus track plus Btag events	1.1 fb^{-1}
Measurement of the fraction of gg→ ttbar events using low p_T tracks	1 fb^{-1}
Measurement of the fraction of gg→ ttbar events using NN Discriminant	1 fb^{-1}
Search for the FCNC Decays $t \rightarrow Zq$	1.1 fb^{-1}
Search for $W' \rightarrow tb$ Events	1 fb^{-1}
ttbar Cross Section using ee, μμ, eμ Dilepton events	1.9 fb^{-1}

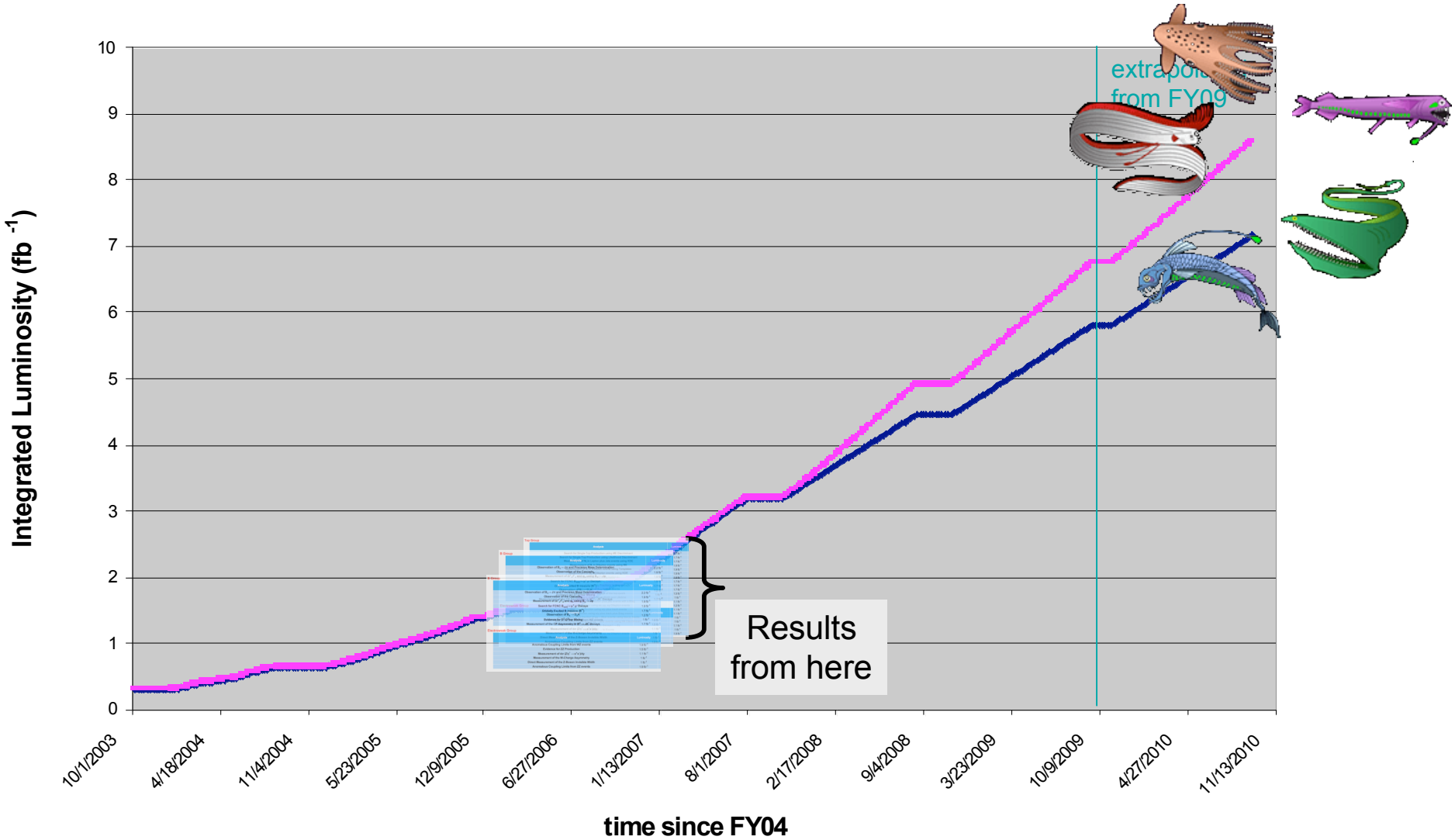
Evolution of CDF's Physics Program



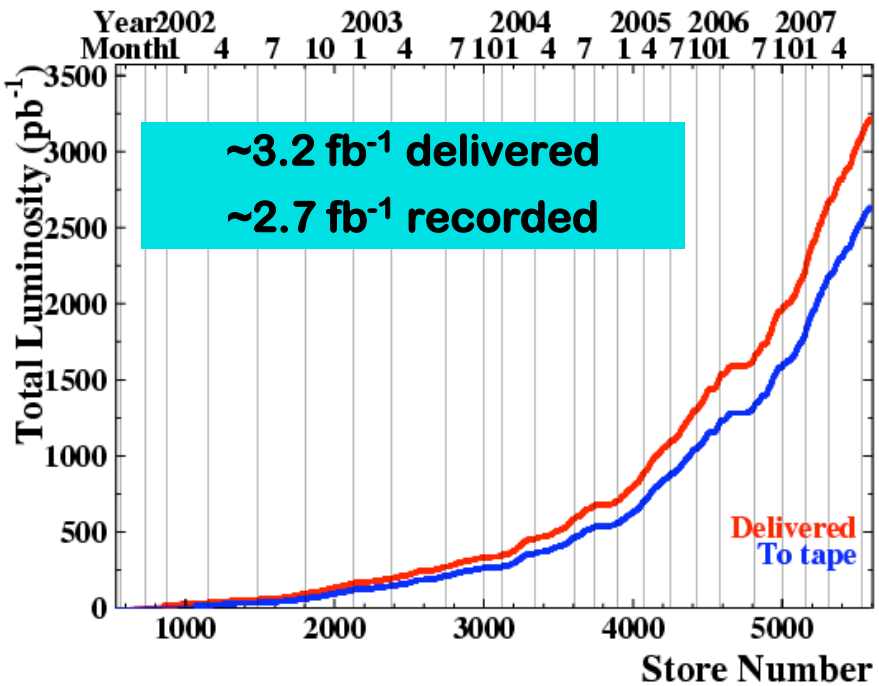
- **1st Physics [few 100 pb^{-1}]**
  - Heavy flavor physics, inclusive W/Z, re-establish top
- **Now [1-2 fb^{-1}]**
  - Precision Mt, Bs-Mixing, Top properties, Observation of rare processes
- **Looking Ahead [several fb^{-1}]**
  - Even rarer processes, New Physics searches, Higgs

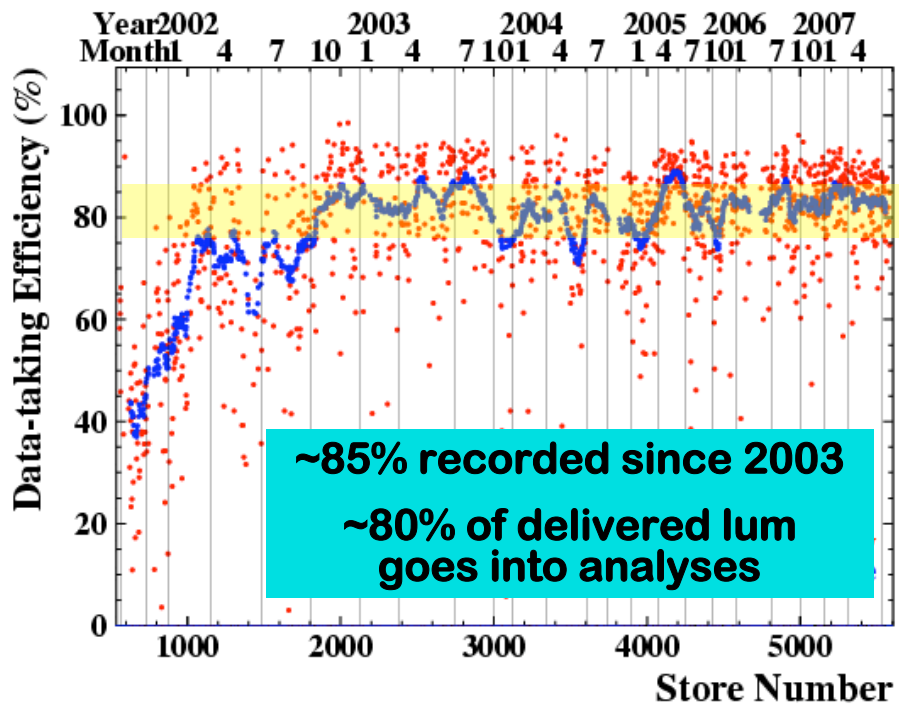
We'll continue to push on all fronts, but the focus now is to uncover the Unknown.

We are just getting started



Collecting data - happily…





- Luminosity records:
  - Highest initial inst. lum
    - ~2.92e32
  - Integrated lum/week
    - 45 pb^{-1}
  - Integrated lum/month
    - 165 pb^{-1}
  - Stacking rate
    - 23.1 mA/hr

Great success

- Sources of inefficiency include:
  - Trigger dead time and readout ~ 5%
    - Intentional - to maximize physics to tape - also studies
  - Start and end of stores ~5%
  - Problems (detector, DAQ) ~5%

Stable

Detector Status - Executive Summary

- Calorimetry and Muon systems working well
- Tracking chamber (COT)
  - Aging not a problem, will be ok through 2010
- Silicon longevity
  - Expect silicon detector to last beyond 2010
    - Radiation not expected to be a problem
    - ISL cooling leak FIXED
- High Luminosity running
  - Inst. Lum expectations are now clear < 300-350 e^{32}
    - Trigger
      - Recently completed upgrade on tracking and calorimeter
      - We are collecting high-Pt data with high efficiency up to $3e^{32}$
    - DAQ
      - Built more bandwidth
    - Physics
      - No significant effect up to 3e32

No showstopper foreseen through FY10

Update on ISL cooling leak

- We formed a task force with the following objectives:
  - Determine a safe short term operating configuration
  - Determine probable cause of leak and repair it
  - Study other potential vulnerabilities in system

- Results:
  - Leak caused by a breakdown of Glycol into formic acid which attacked weld joints
  - Turned off East half of the ISL and L00 for last 300 pb^{-1} of FY07 until current shutdown.
  - Recently completed in situ repair and preventive maintenance
    - We are now flowing water through these lines
  - New instrumentation and procedures to better keep and monitor the system
  - Damage was limited to weld joints

FIXED => Expect ISL+L00 to be OK for the remainder of Run 2

Physics Impact

- Task force to assess impact on physics while ISL/L00 off
  - Collected 300 pb^{-1} (10% of total data set to date) with east half of ISL+L00 Off while investigating causes and developing repairs.
- Conclusions:
  - Efficiency for adding silicon hits to COT tracks and impact parameter resolution both only moderately affected
  - Forward electron ID down by ~3%
  - B-tagging
    - Efficiency down by ~7% per jet
    - Mis-tag rate also down by ~7%
    - Re-optimization could mitigate efficiency loss somewhat
  - Higgs
    - Total lepton acceptance falls by <5%
    - Acceptance for Events with ==1 Btag falls by ~3%
    - Acceptance for Events with ==2 Btags falls by ~10%

The "OFF" data will be used in all analyses - properly calibrated
Will affect our physics sensitivity minimally

People: Summary

- People are migrating to the LHC [and other experiments]
  - This is not new, started a long time ago
- We've taken many measures to mitigate the impact on the experiment
  - We have stabilized, streamlined and automated many tasks in operations and in physics analysis
  - We spend considerable effort retaining, recruiting and planning ahead
- But very importantly:
  - Luminosity increase has made a tremendous difference
  - The experiment is running very well
  - Very rich and exciting physics program
  - LHC delays have also made a difference
  - Many opportunities for people to make a mark here: physics and leadership
  - The collaboration age profile is ==> young, yet excellent
  - Try to keep senior people engaged at all levels
  - We have focused our physics program through Higgs

Enough people to run the experiment in FY09 and accomplish the physics

Postdocs joining CDF last ~1.5 yrs

- Examples [many were students at CDF that stayed on CDF]
  - Enrique Palencia: Cantabria ==> FNAL
  - Fabrizio Margaroli: Bologna ==> Purdue
  - Anadi Canepa: Purdue ==> Penn
  - Olga Norniella: Barcelona ==> UIUC
  - Craig Group: Florida ==> FNAL
  - Valentin Necula: Florida ==> Duke
  - Nathan Goldschmidt: Wisconsin ==> Florida
  - Alison Lister: Geneva ==> UC Davis
  - Jen Pursley: Hopkins ==> Wisconsin
  - Bo Jayatilaka: Michigan ==> Duke
  - Dan Krop ==> U. Chicago
  - Shang-Yuu Tsai: Academia Sinica, Taiwan
  - Sergo Jindariani: Florida ==> FNAL
  - Susan Burke: Arizona ==> FNAL
  - Manoj Kumar Jha: Delhi ==> Bologna
  - Diego Tonelli: Pisa ==> FNAL
  - Hyunsu Lee: Korea ==> U. Chicago
  - Tom Schwarz: Michigain ==> UC Davis
  - And others…

~ 20 new postdocs

PhD's from last ~1.5 yrs

- Ch. Dorr — Karlsruhe University
- K. Gibson — CMU
- A. Holloway — Harvard University
- V. Necula — University of Florida
- M. Rossi — University of Udine
- S. Sabik — University of Toronto
- T. Schwarz — University of Michigan
- A. Canepa — Purdue University
- B. Cooper — UCL
- N. Leonardo — MIT
- A. Loginov — ITEP, Moscow
- G. Salamanna — University of Roma
- P. Catastini — University of Pisa
- P. Squillacioti — University of Pisa
- D. Tonelli — University of Pisa
- I. Vollrath — University of Toronto
- A. Attal — UCLA,
- S. Baroiant — UCDavis
- S. Bolshov — MIT
- S.-H. Chuang — University of Wisconsin
- S. Forrester — UC Davis
- M. Griffiths — University of Liverpool
- C. Group — University of Florida
- B. Jayatilaka — University of Michigan
- J. Kraus — University of Illinois
- S. Lai — University of Toronto
- M. Soderberg — University of Michigan
- T. Akimoto — University of Tsukuba
- O. Norniella — Barcelona
- E. Palencia — University of Cantabria
- X. Portell — Barcelona
- K. Copic — University of Michigan
- S. Harper — Oxford University
- J. Lee — University of Rochester
- V. Rekovic — University of New Mexico
- H. Sun — Tufts University
- V. Tiwari — CMU
- B. Mohr — UCLA
- G. Lungu — U. of Florida

~ 40 and ~40 more expected this year

Perspective

- Very productive physics program
- The CDF detector expected to perform well through 2010
- Strong collaboration in place through 2009
- Productive career start for postodcs and students

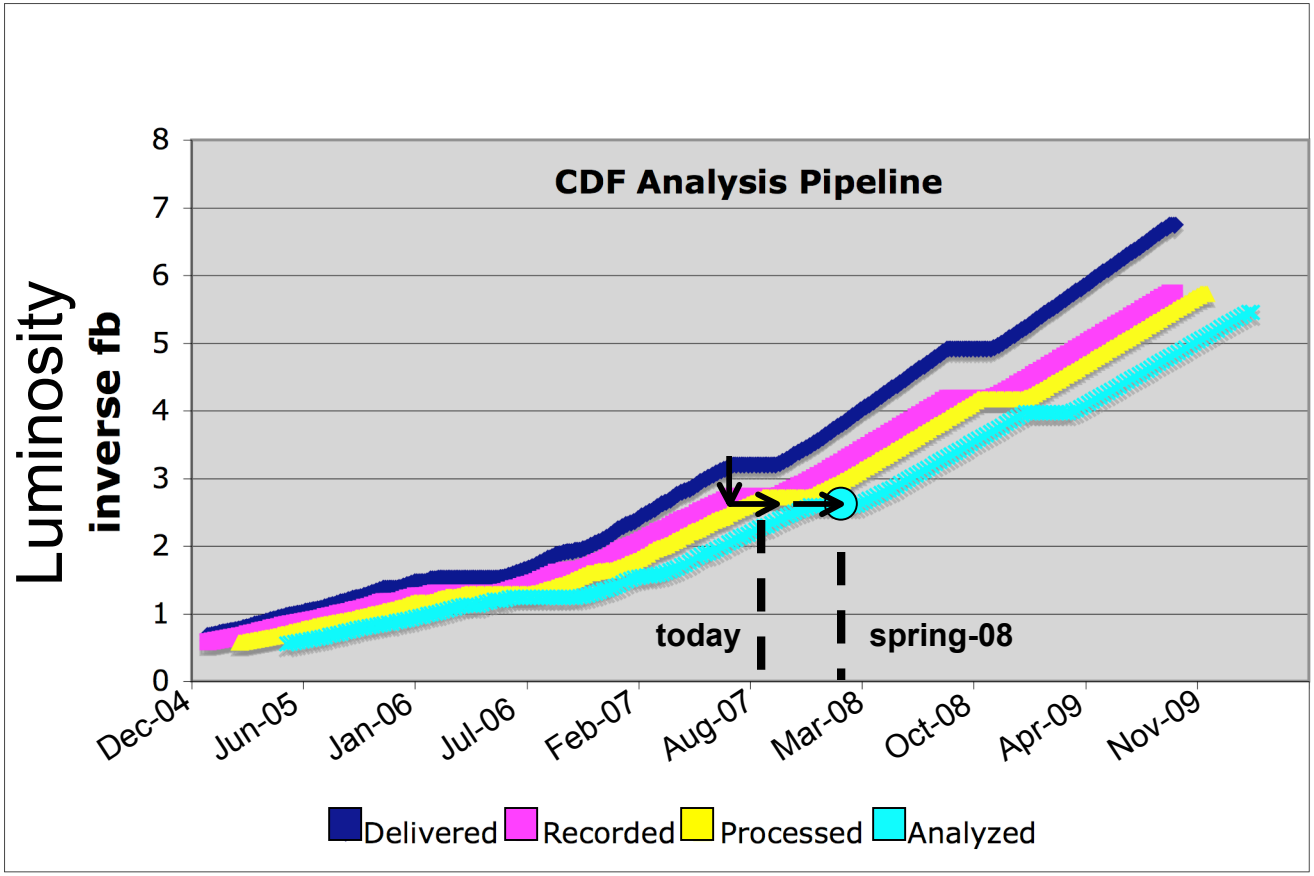
Process

Process: from data to a physics result

- **Q: What is the typical time between taking data and it making it into a public result ?**

- **A: There is no typical**
  - There is a minimum time for each new data period [~ 200 pb^{-1}]
    - Need to process, calibrate, align, ntuplize, validate, run existing analysis, update MC, present internally & make public
      - This is done in a few months
  - Usual additions to the minimum:
    - Wait for sufficient more data to get better stats/syst and then just repeat existing analysis
    - Wait for more data .and. improve analysis
    - Wait for new Offline code releases w/ improvements
      - Close to a final release
    - Turnover of analysis teams: students and postdocs move on
    - Wait for other analyses/tools that affect this one
  - Conference schedules modulate all this

What to expect in Spring 08



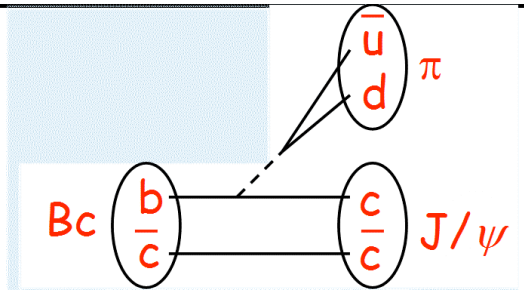
- **By Spring 08 we will not have much more data analyzed than what we already have**

Process and people

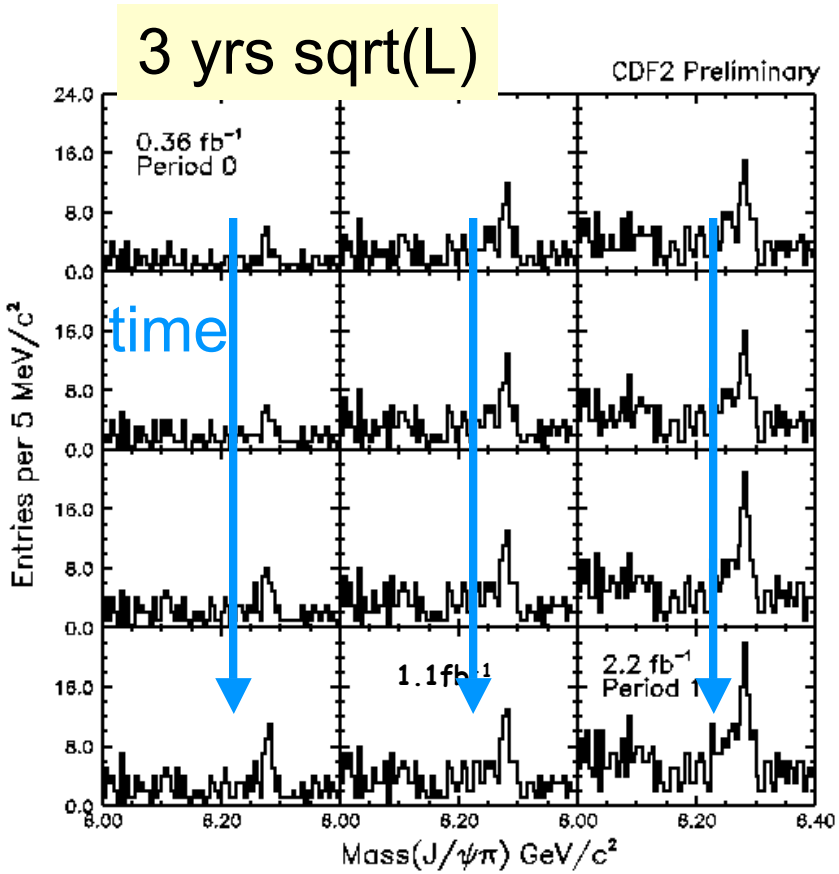
- Program driven by intellectual curiosity and the thrill of possibility
- People tend to go after the physics that are accessible to them first
  - Pragmatic and sociological reasons
- Then they push and innovate
- Especially when they see the possibilities
  - And things start to come together
- It is engrained in us to want to make progress
- We get creative, adaptive and adoptive and, most importantly: we learn from the data all the time
- One cannot fully lay out a roadmap and know where every measurement or search will end up, given time and more data
- Sqrt(L) is a myth in hadron collider physics, except at the very very end, when there is nothing left to do but to surrender
- A few examples of this on the next slides

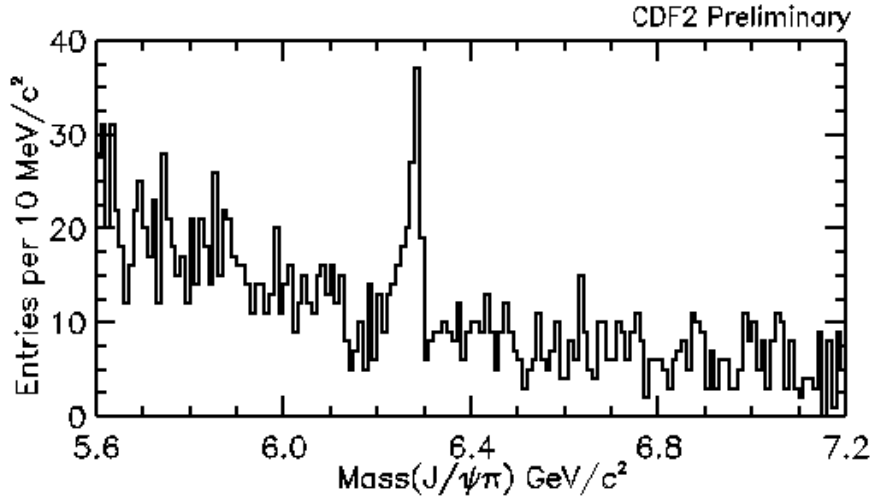
Progression

Bc => J/ψ π with 2.2 fb^{-1}



- Bc is a unique system of two distinct heavy quarks and is not produced at B factories. Full reconstruction allows for a mass measurement.
- The analysis was tuned on Bu==>J/ψK at 360pb^{-1} before "opening the box"
- The data has just grown to become <3σ, then 6σ, and now 8σ

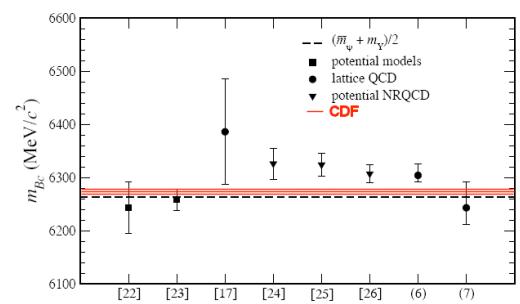




$M(Bc)_{CDF}$ = 6274.1 +/- 3.2 +/- 2.6 MeV/c^2

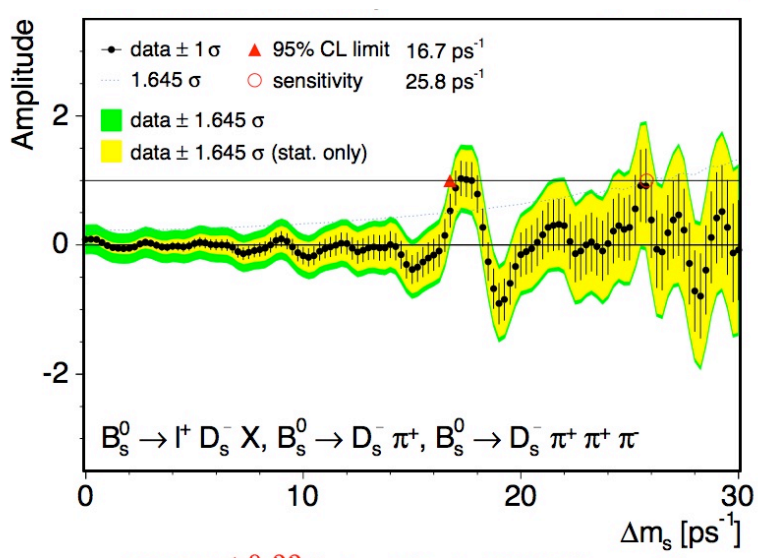
$M(Bc)_{LATTICE}$ = 6304 +/- 12 $^{+18}_{-0}$

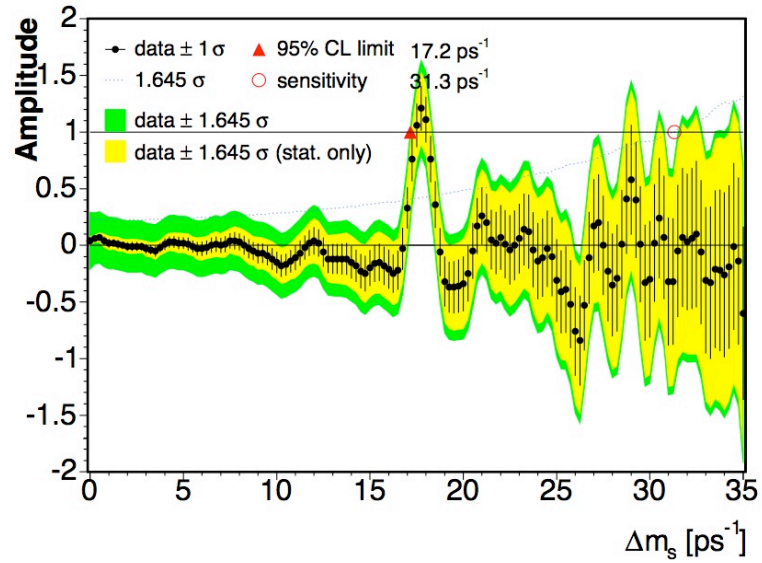
Δ ~ 30 MeV/c^2



Bs-mixing: from evidence to discovery

1 fb^{-1} in March 2006 → 1 fb^{-1} in July 2006





$$\Delta m_s = 17.31^{+0.33}_{-0.18}(stat.) \pm 0.07(syst.)\ \text{ps}^{-1}$$

Probability of background fluctuation: $0.2\% \sim 3.1\sigma$ → **8 x 10^{-8} (> 5σ) prob. background fluctuation**

$$\Delta m_s = 17.77 \pm 0.10(stat.) \pm 0.07(syst.)\ \text{ps}^{-1}$$

$$\Longrightarrow |V_{td}|/|V_{ts}| = 0.2061 \pm 0.0007(exp.)\ ^{+0.0081}_{-0.0060}(th.)$$

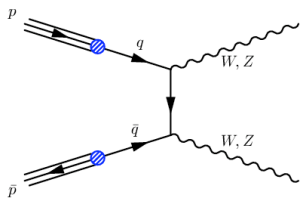
No longer limited by experimental precision

Significant improvements on same dataset

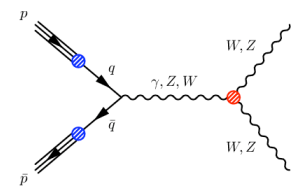
- **Neural Nets for event selection & to combine opposite-side flavor tagging**
- **Better particle ID**
- **Inclusion of partially reconstructed decays**
- **New trigger paths**

- **+ Group focus, the "I can almost taste it" effect**

Observation of WZ Production

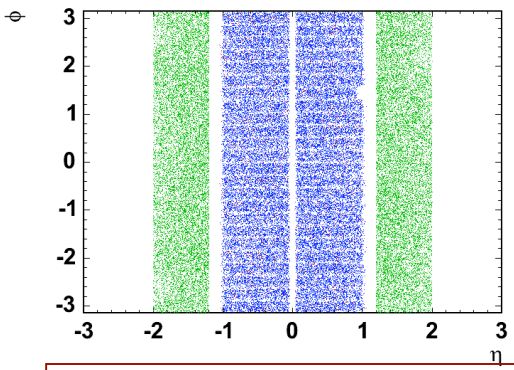


NLO cross section: 3.7 ± 0.1 pb

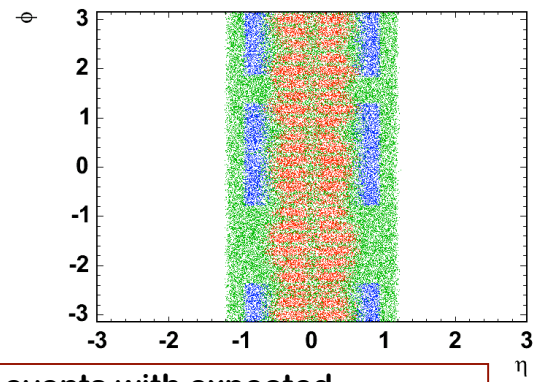


3 leptons + MET
1.1 fb-1

electrons



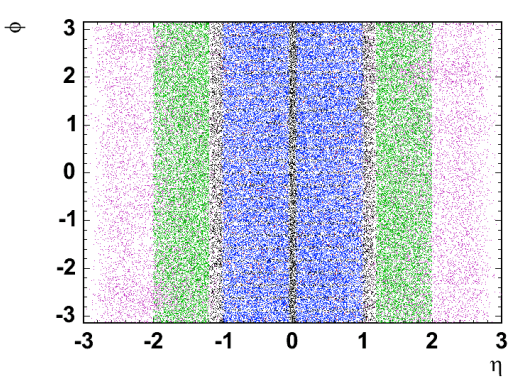
muons

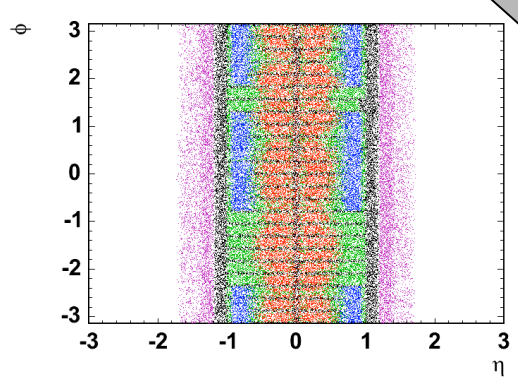


1st pass: observed 2 events with expected background of 0.9 ± 0.2 and expected signal of 3.7 ± 0.3

Increased acceptance by adding plug calorimeter and tracks pointing to cracks: 16 obs vs 3 bcknd

Same data





From ~nothing to observation
- same data-

+ new lepton types
+ more triggers
+ better analysis

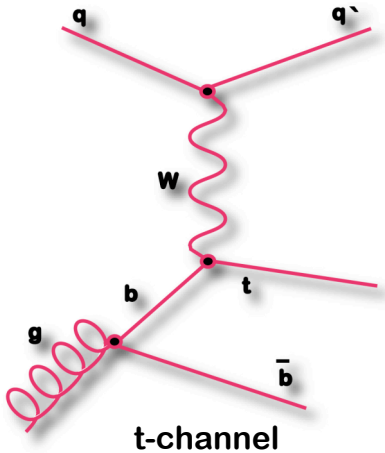
Much of this being used in H=> WW

Prob(background only) < 1.5×10^{-7} (5.1σ)

2 MET bins:
Prob(background only) < 2×10^{-9} (5.9σ)

$\sigma(WZ)=5.0^{+1.8}_{-1.6}$(stat.+syst.) pb

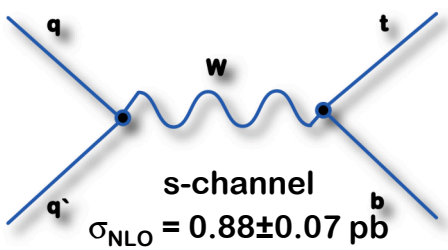
Single Top Quark Production



t-channel

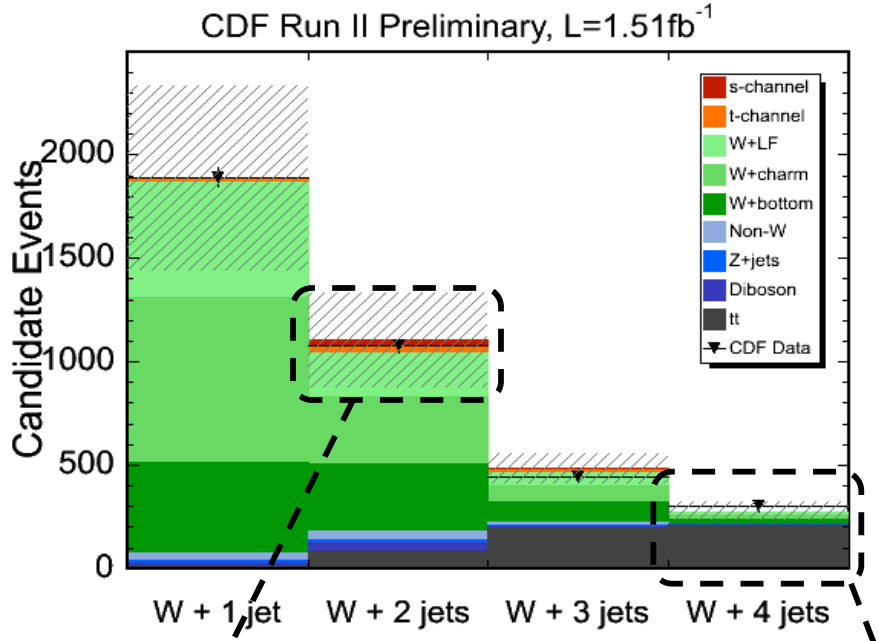
σ_{NLO} = 1.98±0.21 pb

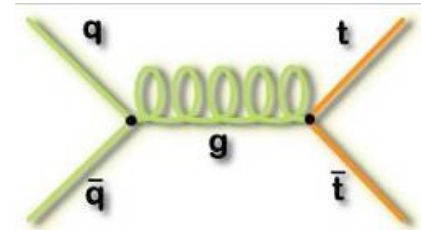
M_t=175 GeV/c^2



s-channel

σ_{NLO} = 0.88±0.07 pb





σ_{NLO} = 6.7 ± 1.0 pb

M_t=175 GeV/c^2

Single top swamped by large backgrounds and hidden behind background uncertainty!

→ Makes counting experiment impossible!

→ Need to use more event information

→Higgs searches (WH) face similar challenge

Top-pair production has much better s/b and very distinct final state signature!

→ Counting experiment after b-quark tagging 'fairly easy'

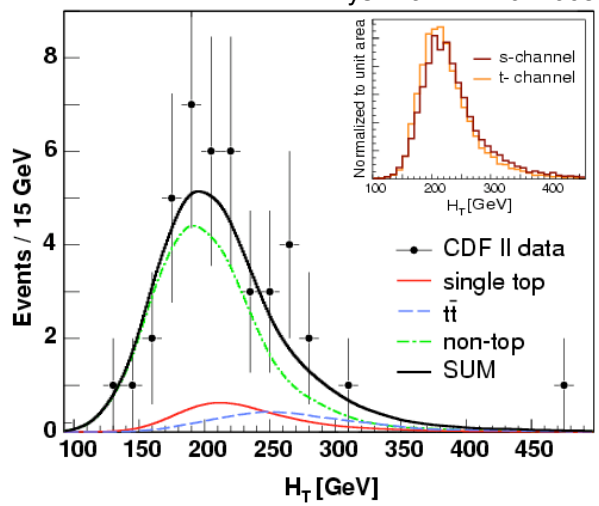
Single Top History

2004: Simple analysis while refining Monte Carlo samples and analysis tools

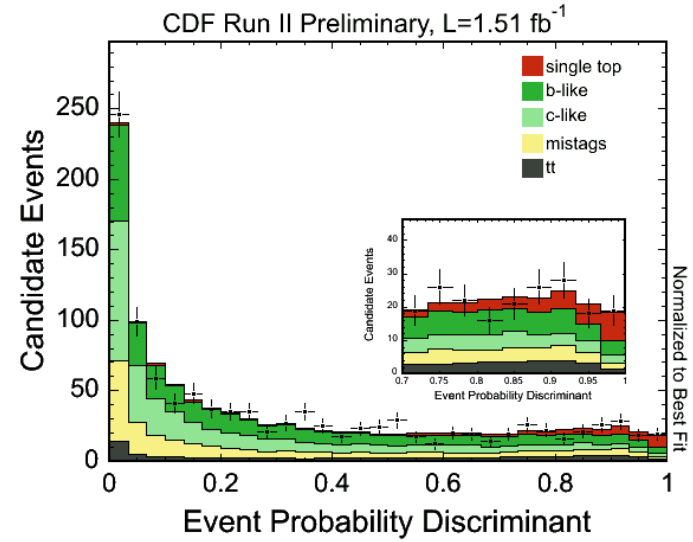
2 years

2006: Established sophisticated analyses Check robustness in data control samples

Phys. Rev. D71 012005

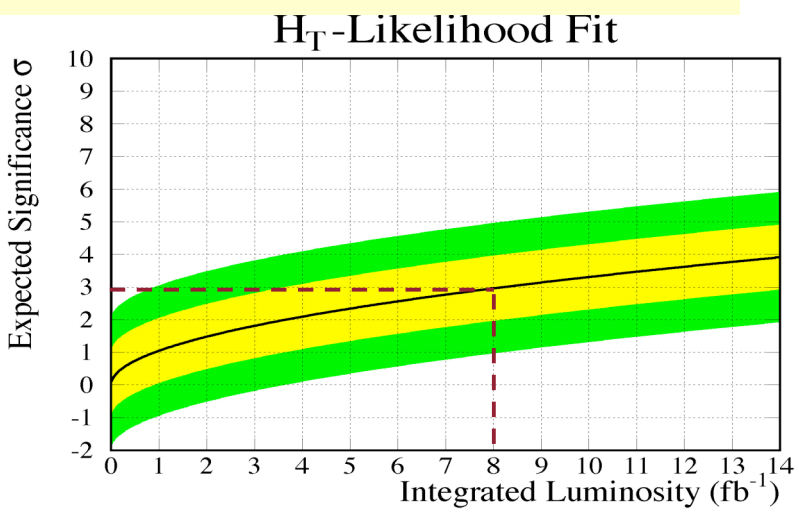


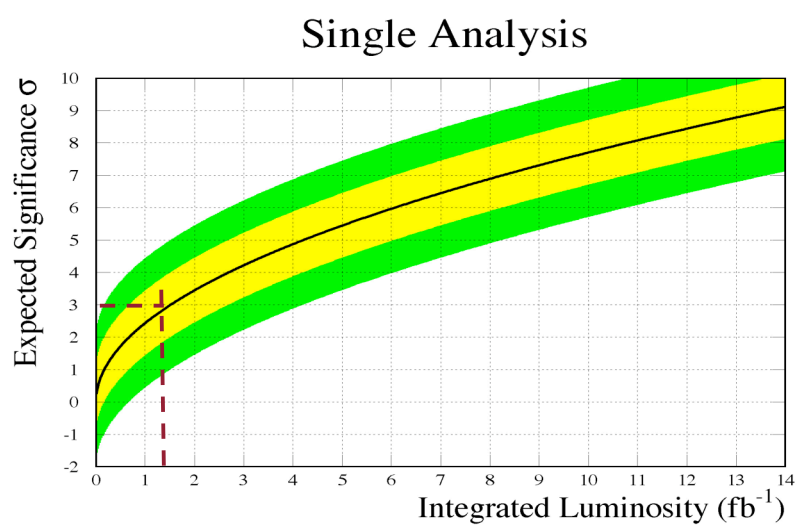
- *Development of powerful analysis techniques (Matrix Element, NN, Likelihood Discriminant)*
- *NN Jet-Flavor Separator to purify sample*
- *Refined background estimates and modeling*
- *Increase acceptance (forward electrons)*
- *10x more data*



First Tevatron Run II result using 162 pb^{-1}
$\sigma_{\text{single top}}$ < 17.5 pb at 95 % C.L.

2007: 3-σ evidence for single top quark production using 1.5 fb^{-1}



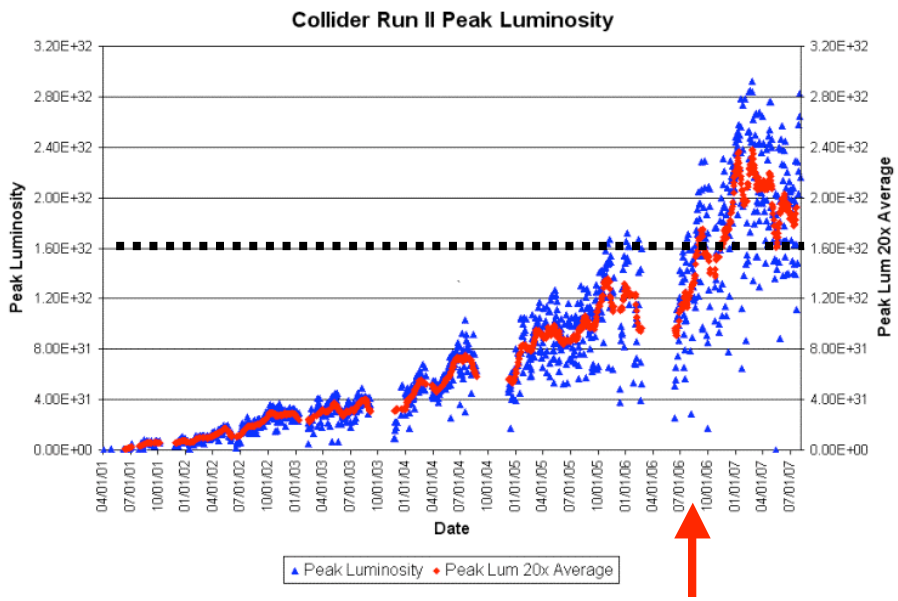


Towards the Higgs

- We have shown some examples where we utilized more data, added additional triggers, added new channels, and developed tools and analysis techniques to drastically improve the analysis
  - Much of this is making its way into Higgs analyses

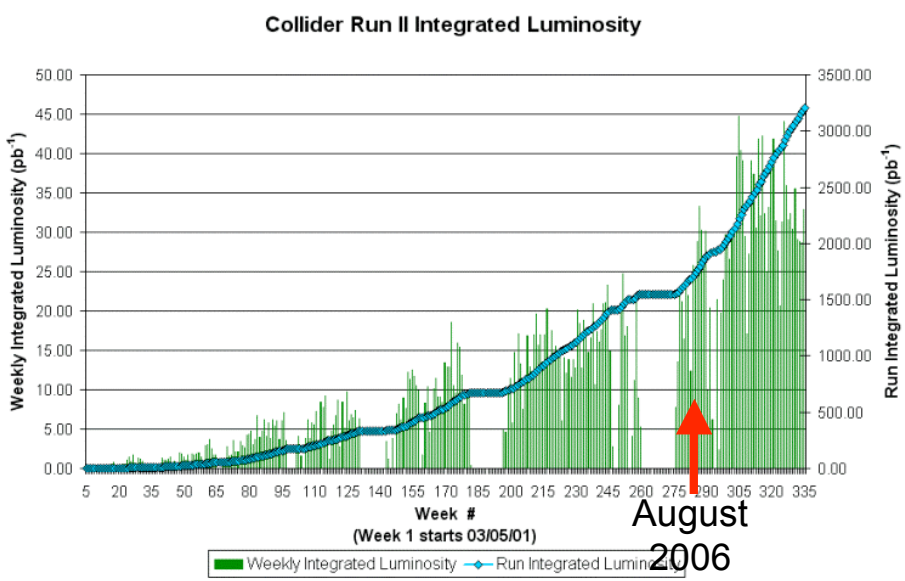
- So what about the Higgs?
  - Smaller cross section… very challenging, needs all channels, need CDF+D0, and *needs lots of data*

Higgs Effort at CDF

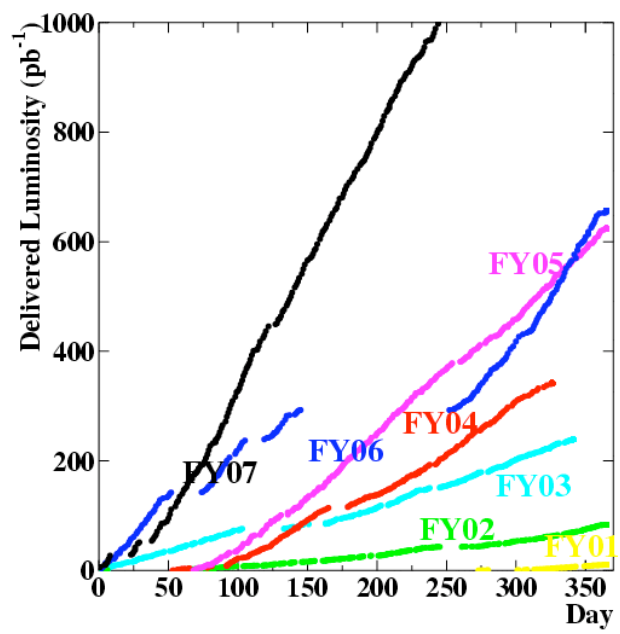


Before Summer 06
it did not seem that we would
integrate enough luminosity
to reach Higgs territory

Then things changed !

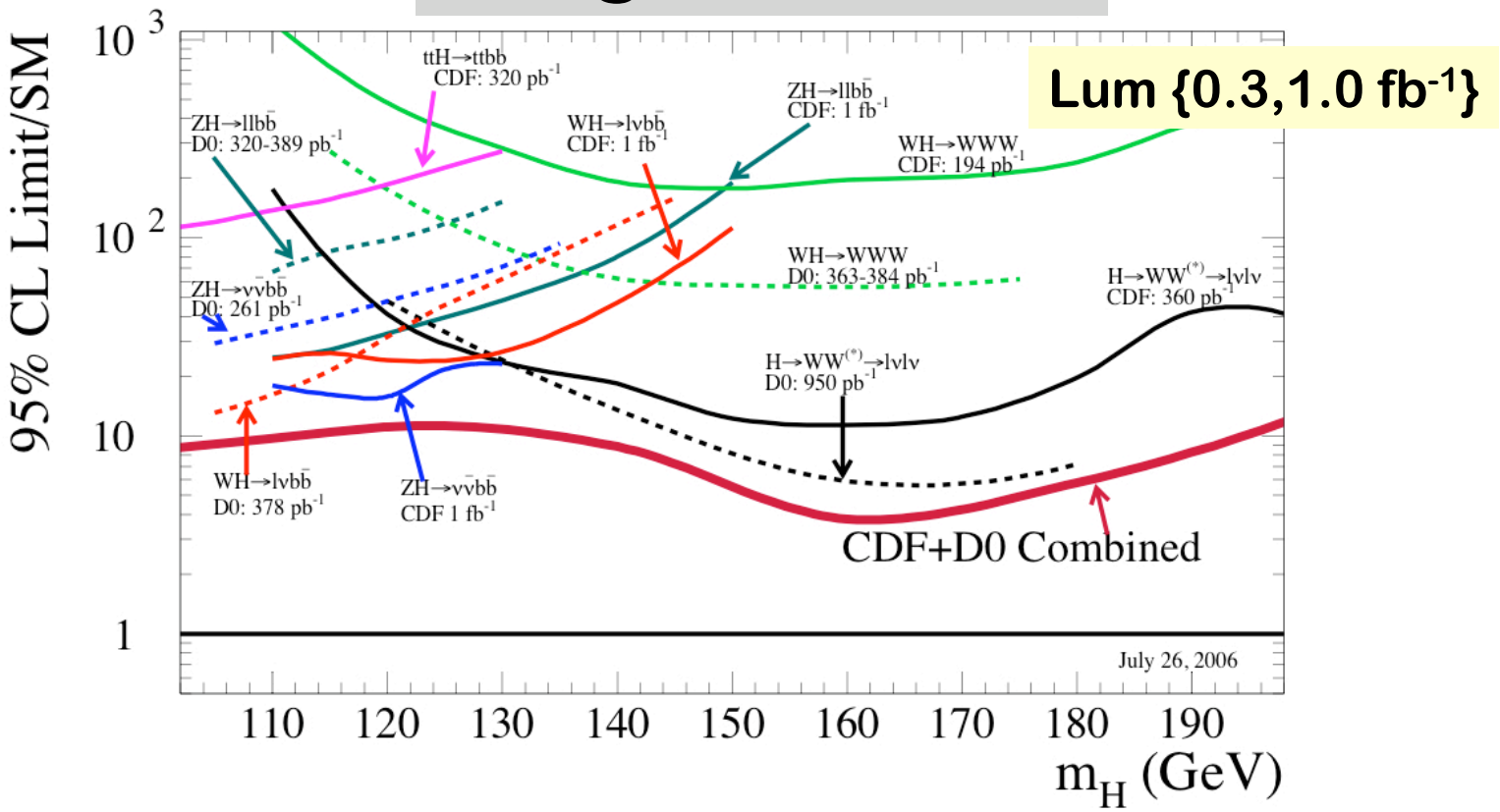


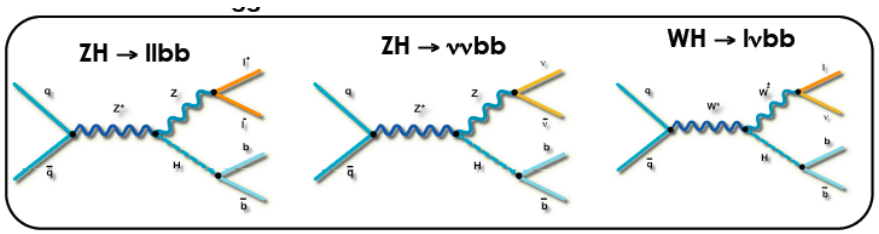
August
2006

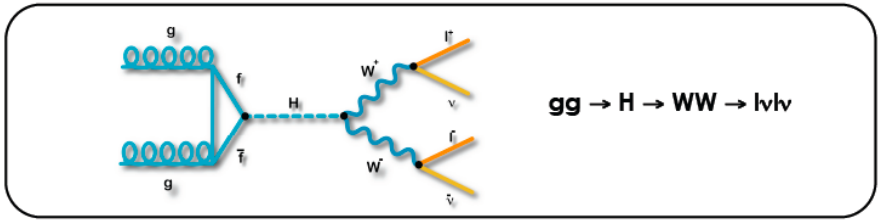


Status circa Summer'06

@ 115 ~10x SM
@ 160 ~4x SM







CDF Higgs Effort

- **Since Fall 2006, the Higgs effort at CDF intensified**
  - Revisited the entire trigger table to maximize our Higgs acceptance [“Higgs Trigger Task Force”]
  - Launched an additional trigger upgrade to significantly improve acceptance to Higgs in missing energy channels [“L2 Calorimetry Upgrade”]
  - Established a new Physics analysis group, dedicated to the Higgs [“Higgs Discovery Group”]
  - Established several working groups to develop algorithmic improvements to further increase our sensitivity
  - Techniques from other measurements started to be adopted

- **Over the last year there’s been a dramatic infusion of people, effort and ideas, aimed at finding the Higgs**

CDF Higgs Trigger Task Force

To open the trigger maximally for Higgs

Report of the Higgs Trigger Task Force

S. Amerio, A. Anastassov, A. Annovi, A. Apresyan, V. Boisvert, A. Buzatu, S. Camarda, F. Canelli, A. Canepa, E. Cartman, B. Casal, M. Casarsa, G. Chiarelli, G. Cortiana, G. De Lorenzo, J. Donini, S. Donati, R. Erbacher, C. Ferrazza, G. Flanagan, R. Forrest, I. Furic, J. Garcia, O. Gonzalez, C. Group, A. Heijboer, B. Heinemann, M. Herndon, A. Ivanov, E. James, T. Junk, B. Kilminster, N. Krumnack, M. Kruse, K. Lannon, S. Leone, J. Lewis, A. Lister, T. Liu, R.-S. Lu, D. Lucchesi, T. Maruyama, A. Mitra, O. Norniella, C. Neu, E. Nurse, S. Pagan Griso, E. Pianori, K. Pitts, L. Ristori, V. Rusu, R. St.Denis, L. Sartori, F. Sforza, A. Sidoti, A. Soha, A. Taffard, S. Torre, P. Totaro, V. Veszpremi, S.-M. Wang, A. Warburton, D. Waters, P. Wilson, T. Wright, A.M. Zanetti, X. Zhang

Abstract

This report outlines a strategy on how to trigger on the Higgs boson in the most optimal way for the remainder of CDF Run II. Taking advantage of the CDF Run 2b trigger and data acquisition upgrades, we find that we can improve the purity of our triggers and significantly improve our acceptance for the Higgs.

From HTTF Report

mode	current acceptance	proposed acceptance
$WH \to e\nu_e bb$	45%	89%
$WH \to \mu\nu_m ub\bar{b}$	42%	88%
$ZH \to e^+e^-b\bar{b}$	71%	90%
$ZH \to \mu^+\mu^-b\bar{b}$	60%	96%
$ZH \to \nu\bar{\nu}b\bar{b}$	74%	96%
$H \to l\nu l\nu$	66%	82%

Existing Triggers "data in the bag"

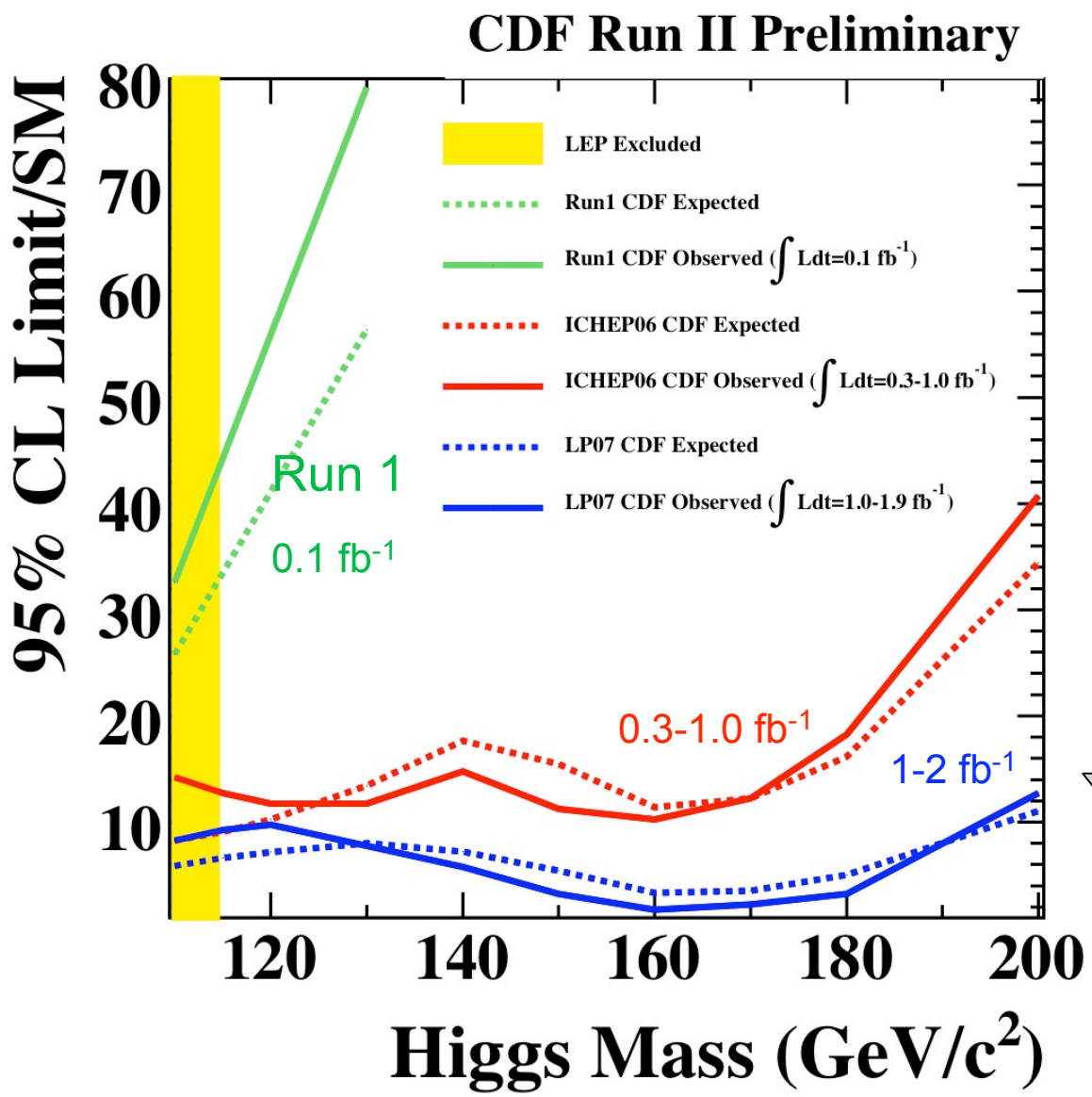
trigger path	cross section (nb) at $3 \times 10^{32}\text{cm}^{-2}\text{s}^{-1}$
new ELECTRON_CENTRAL_18	100
new MET_PEM	20
MET45	80
new Z_NOTRACK	50
new MET28_JET24	120
new MUON_CMUP18	100
new MUON_CMX18	150
MUON_BMU_JET	40
total	< 660

More triggers being implemented

From existing triggers and new ones

Expected increase in Higgs events ~ x2

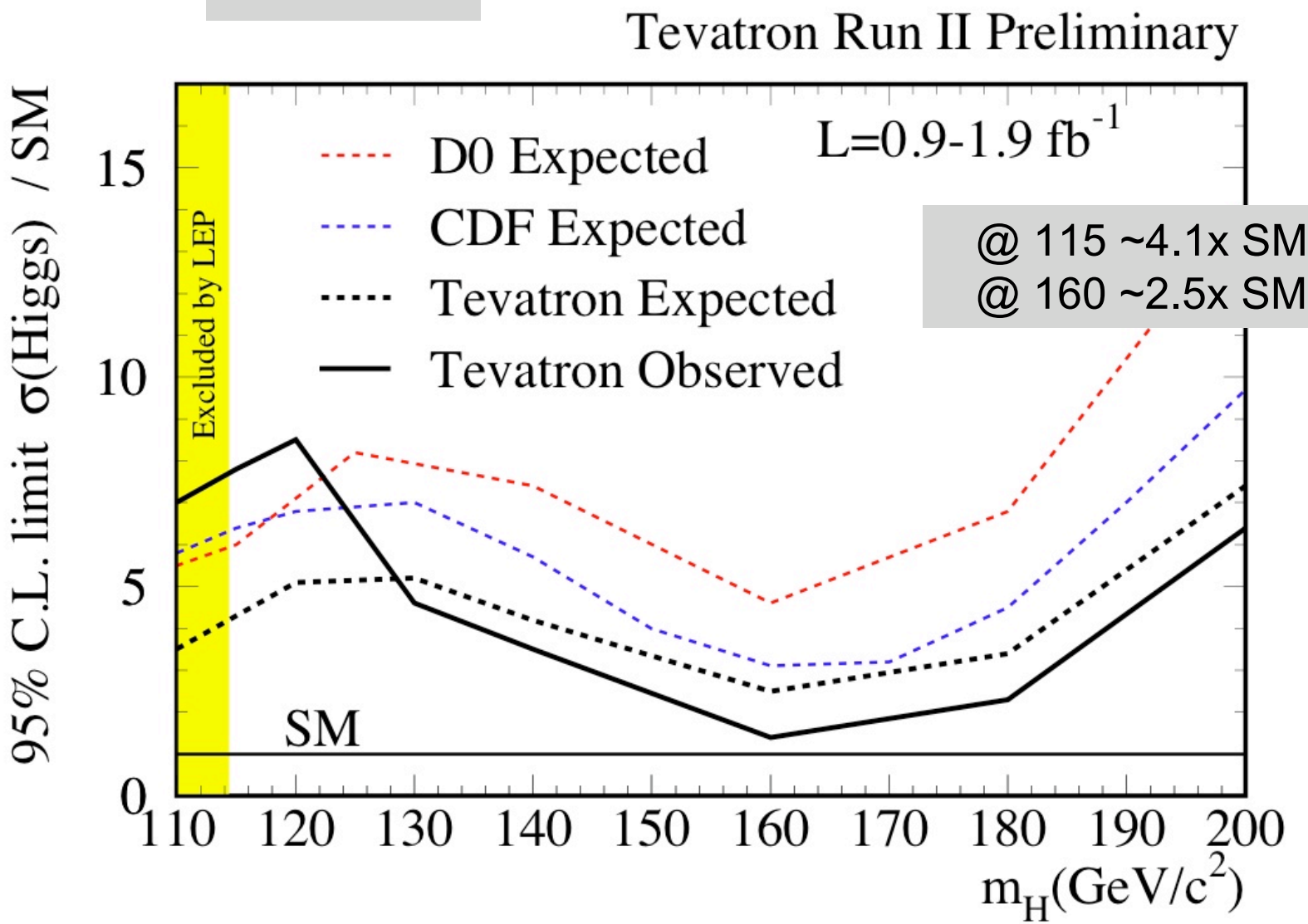
CDF alone, in perspective…



1 yr
Lum+effort

Summer 2007 (Lepton-Photon)

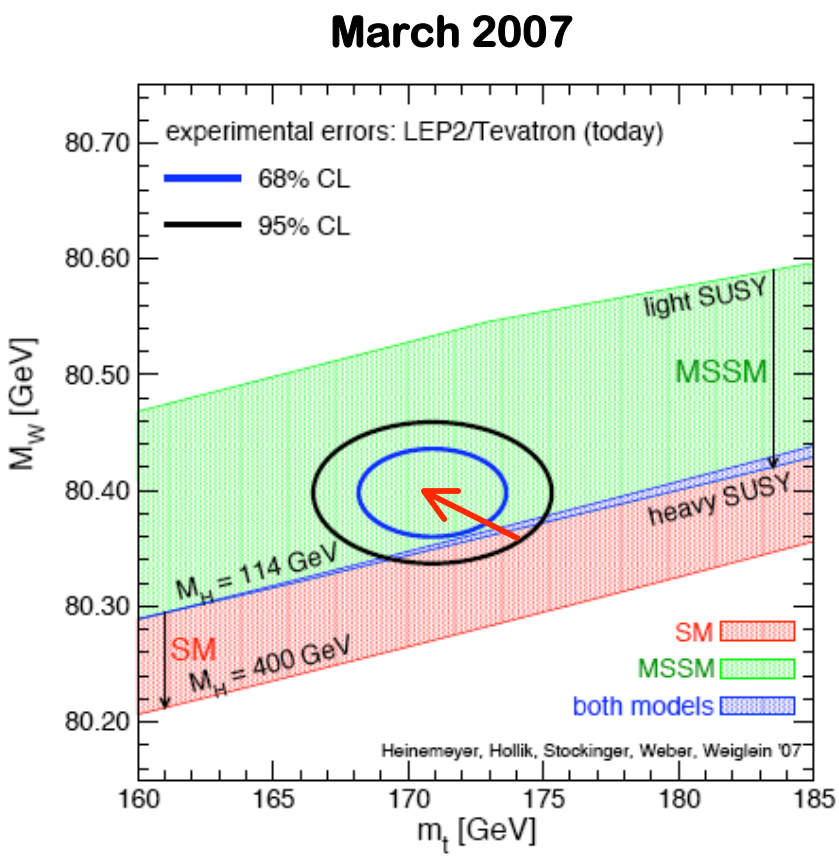
CDF & D0

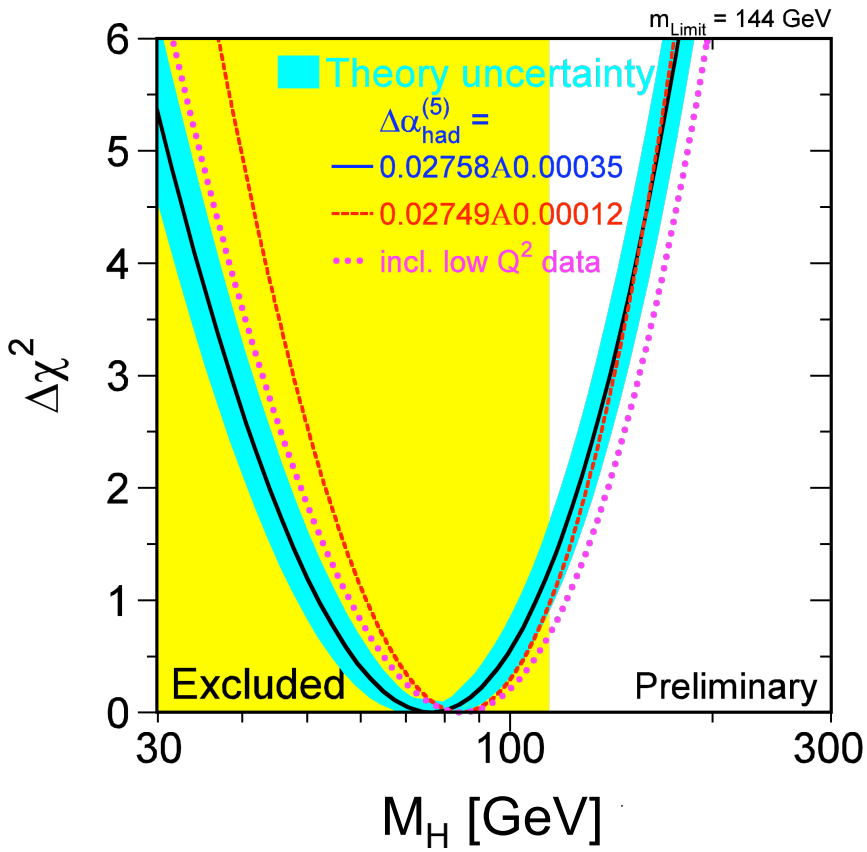


@ 115 ~4.1x SM
@ 160 ~2.5x SM

Possibility

Higgs: where [who] are you?





Preferred value: m_H = 76 GeV at minimum

Upper limit: m_H < 144 GeV @ 95% C.L.

Our M_{top} and M_W results are having an important effect

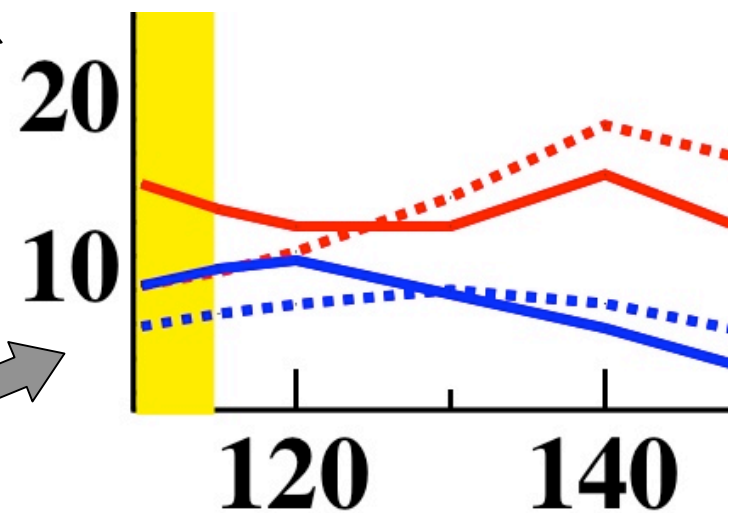
Recent Projections in sensitivity increase

- **Low Mass Higgs (~ 115 GeV)**

%'s are in sensitivity

Minimum Achievable Improvements

- 25% b tagging (improved usage of existing taggers)
  - Into ZH=>llbb and VH=>MET+bb
    - Implemented in WH=>lnubb Summer'07
- 25% trigger acceptance (pre-existing triggers)
  - Into ZH/WH => llbb, lnubb
    - Completed S vs B studies
- 20% from advanced analysis techniques studies & better usage of MET
  - Into MET+bb and lnubb
    - Implemented in ZH=>llbb Summer'07



x1.5 avg. sensitivity improvement for all analysis

All improvements validated on analysis/studies with real data/tools

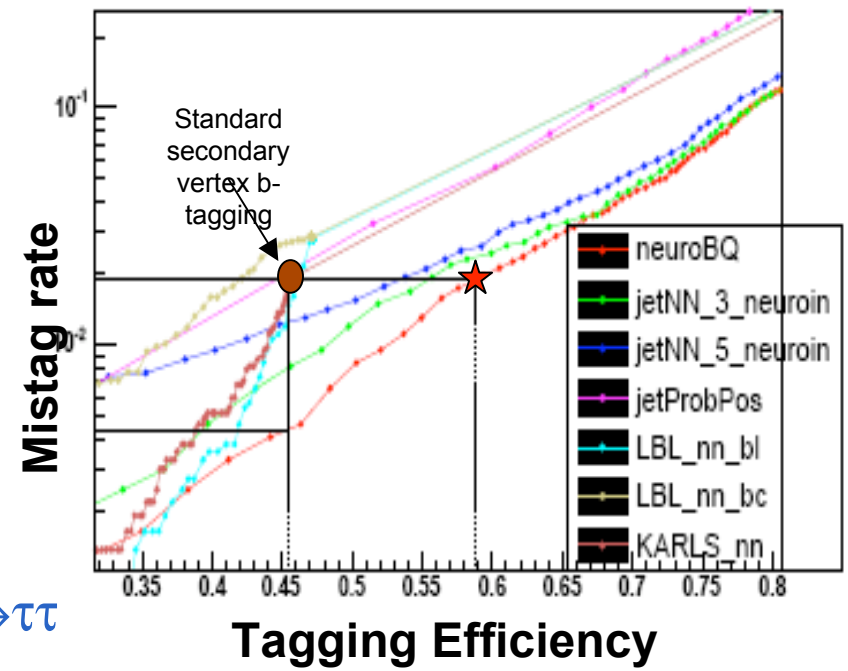
Recent Projections in sensitivity increase

%'s are in sensitivity

- **Low mass Higgs(~115 GeV)**

  Further Achievable Improvements

  - 25% b tagging (NN-based)
    - All channels
      - Tagger in advanced stage
      - Efficiency studied
  - 25% trigger acceptance
    - More pre-existing triggers
      - Based on HTTF studies
  - 10% Tau channels (hadronic)
    - τ Id well understood from $H \rightarrow \tau\tau$ analysis



Additional x1.5 avg. sensitivity improvement for all analysis

All improvements validated on analysis/studies with real data/tools

Recent Projections in sensitivity increase

%'s are in sensitivity

- **High mass Higgs (~160 GeV): WW**

Range of achievable improvements

- 10-20% (from ME+NN)
  - Ongoing studies
- 10-20% from hadronic taus in W decay (including+better id)
  - Ongoing studies
- 25-40% VH=>VWW and VBF (jj in final state)
  - Expect good S/B
  - Ongoing studies
- 10-15% more triggers (existing triggers)+ more leptons

Improvements from x1.7 to x2.3 in sensitivity

All improvements validated on analysis/studies with real data/tools

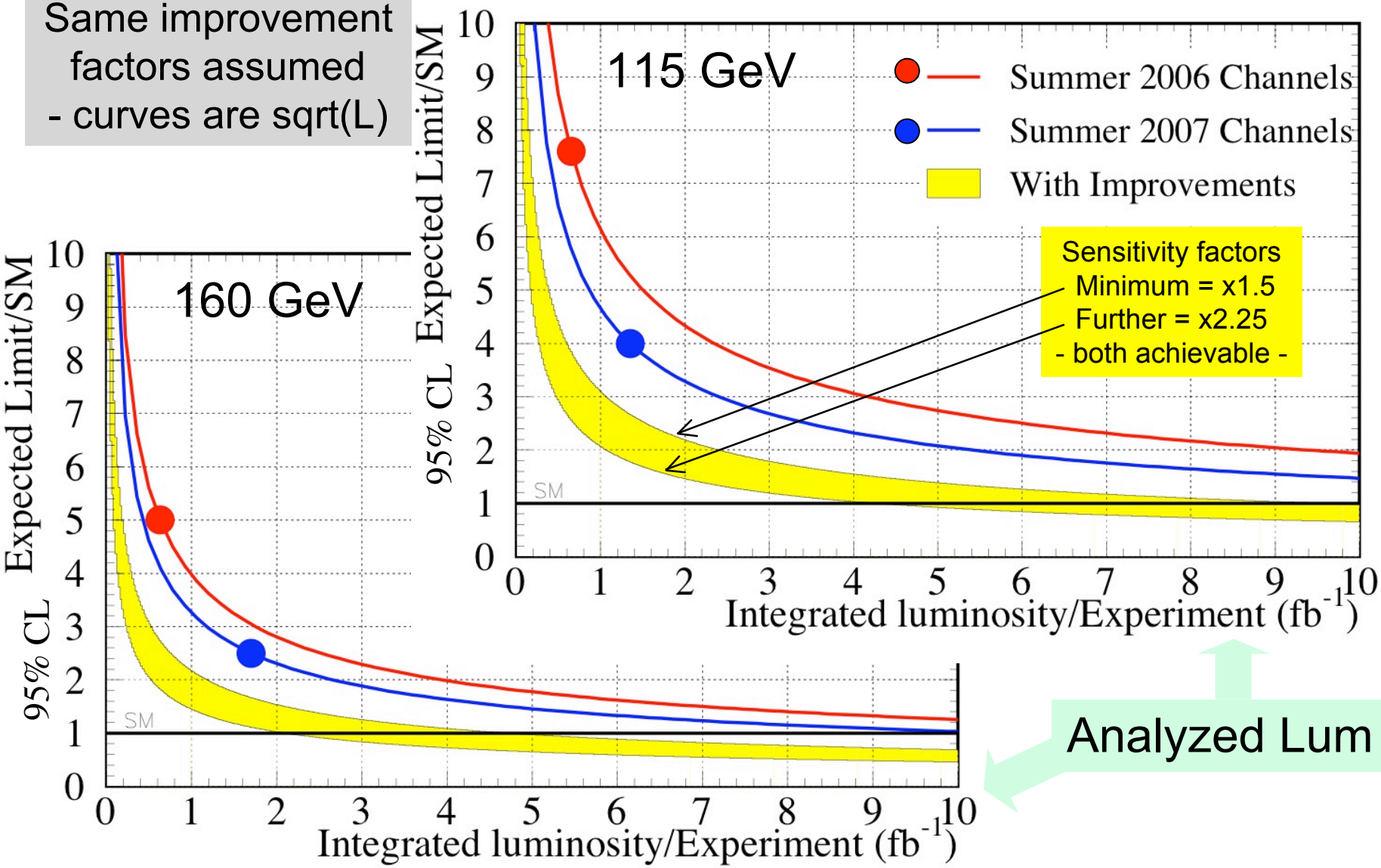
Other work in progress

- New triggers from L2 Cal upgrades and new paths from HTTF
  - In the works: sharp MET efficiency turn-on
- Forward tracking and forward b-tagging
  - Tracking is advanced, b-tagging is not yet
- High-pt b-tagging triggers
  - A team working on it
- Improve bb mass resolution
  - Task force with HDG
- WZ/WH channels with W,Z=> jets
  - New people started to look
- Other ideas we have
- Other ideas that we'll have

None of this is included in the "minimum" [1.5]
to "further" [1.5x1.5 = 2.25] achievable improvement factors

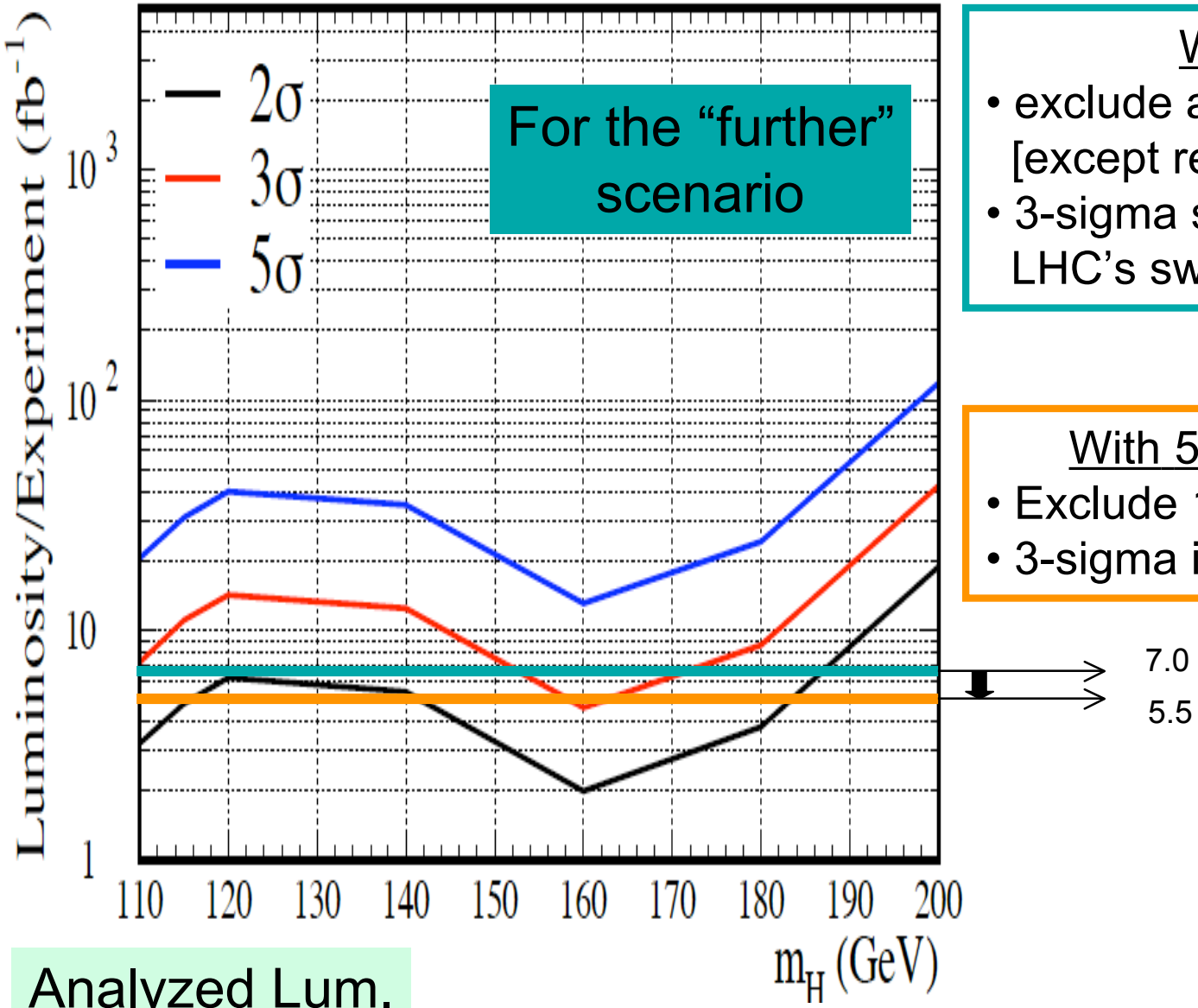
Achievable Sensitivity

CDF+D0 combined
Same improvement factors assumed
- curves are sqrt(L)



Analyzed Lum

An exclusion region growing



With 7 fb^{-1}

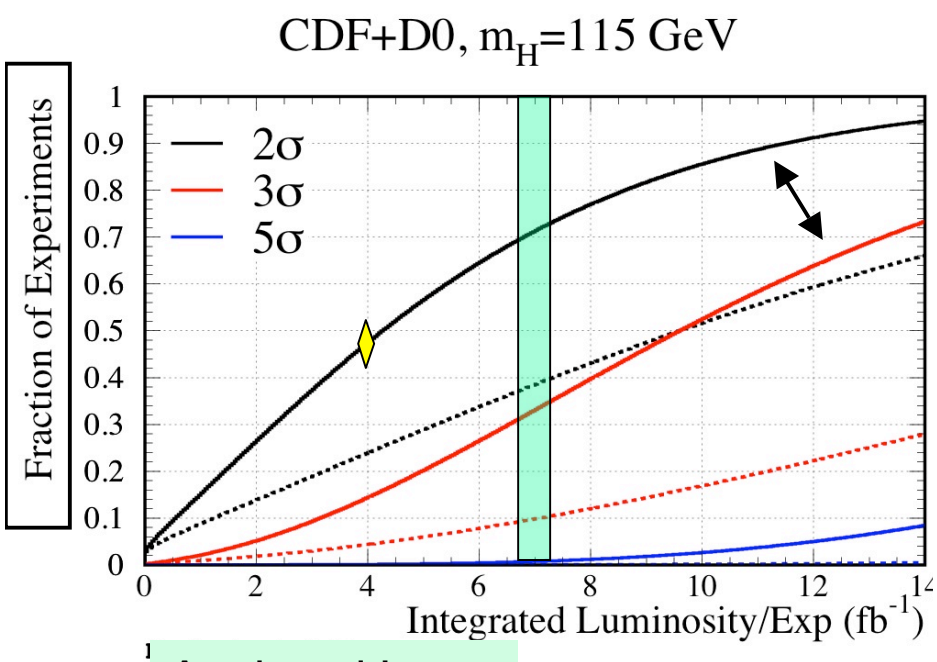
- exclude all masses !!! [except real mass]
- 3-sigma sensitivity 150:170 LHC's sweet spot

With 5.5 fb^{-1} tougher:

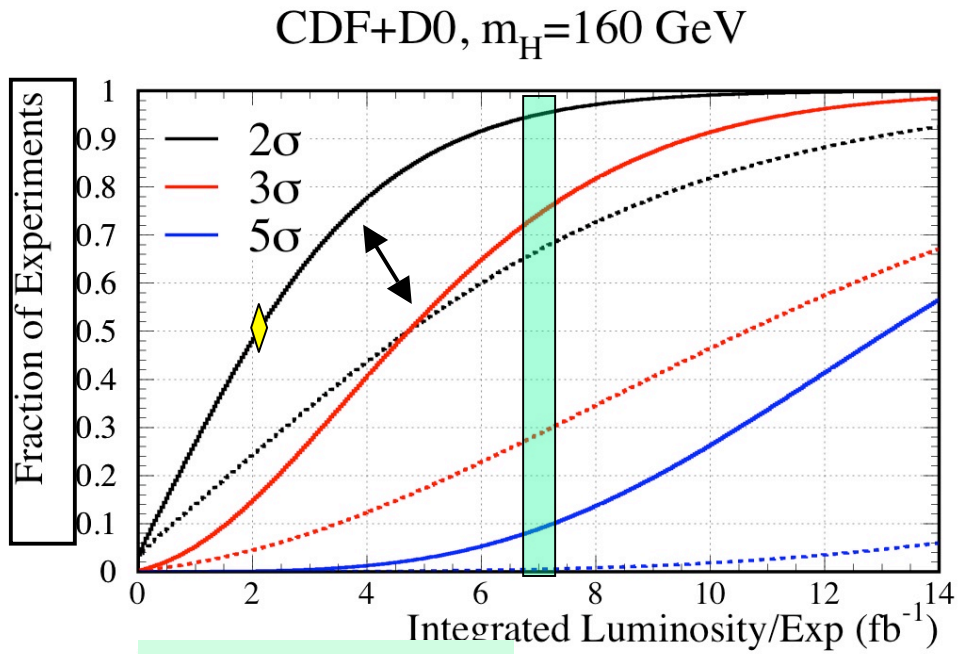
- Exclude 140:180 range
- 3-sigma in one point: 160

Analyzed Lum.

On any given roll of the dice



Analyzed Lum.



Analyzed Lum.

Solid lines = 2.25 improvement
Dash lines = 1.50 improvement

"further" @ 115 GeV

7 fb^{-1} => 70% experiments w/2σ
30% experiments w/3σ

"further" @ 160 GeV

7 fb^{-1} => 95% experiments w/2σ
75% experiments w/ 3σ

Higgs Summary

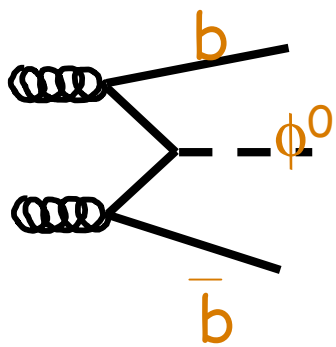
- This is very exciting
- We are sweeping down in sensitivity towards an exclusion/evidence region
- At the Higgs Horizon the more luminosity the better
  - one more year certainly helps
- The bands of possibility shown here are based on studies with real data and existing tools => achievable factors
  - Still, it is the state-of-the-art TODAY
- Psychology changes when you get closer and closer
  - Loose ends get dealt with, 10% effects matter most, no stone is left unturned - WZ, Bs-mix. and single top are good examples

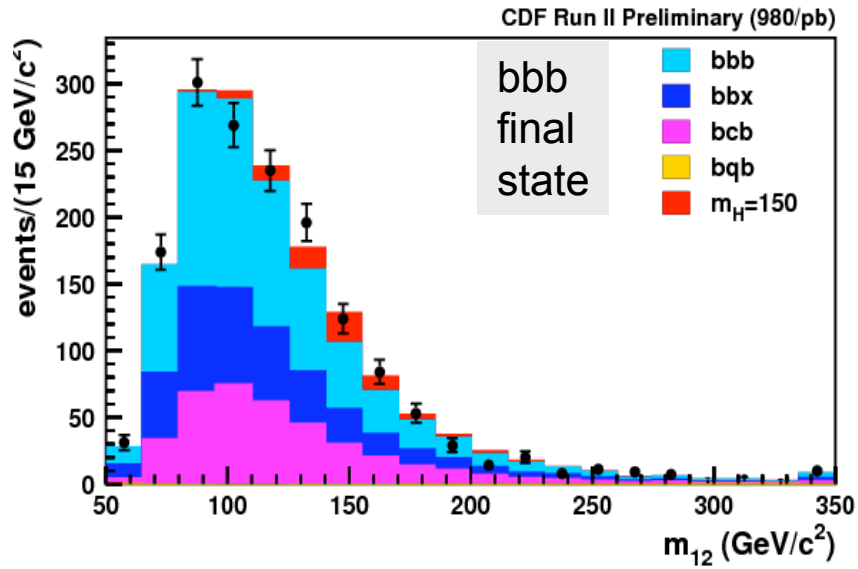
More possibility

"…. LHC comes, but I find the reality of our data, with all of its bumps and wiggles, to be irresistible.
Keep me posted."

- a senior member of CDF

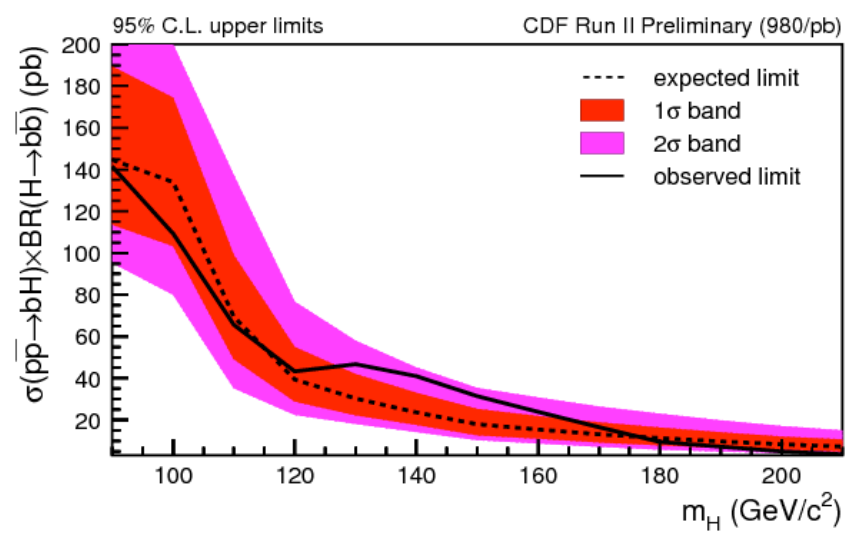
Supersymetric Higgs





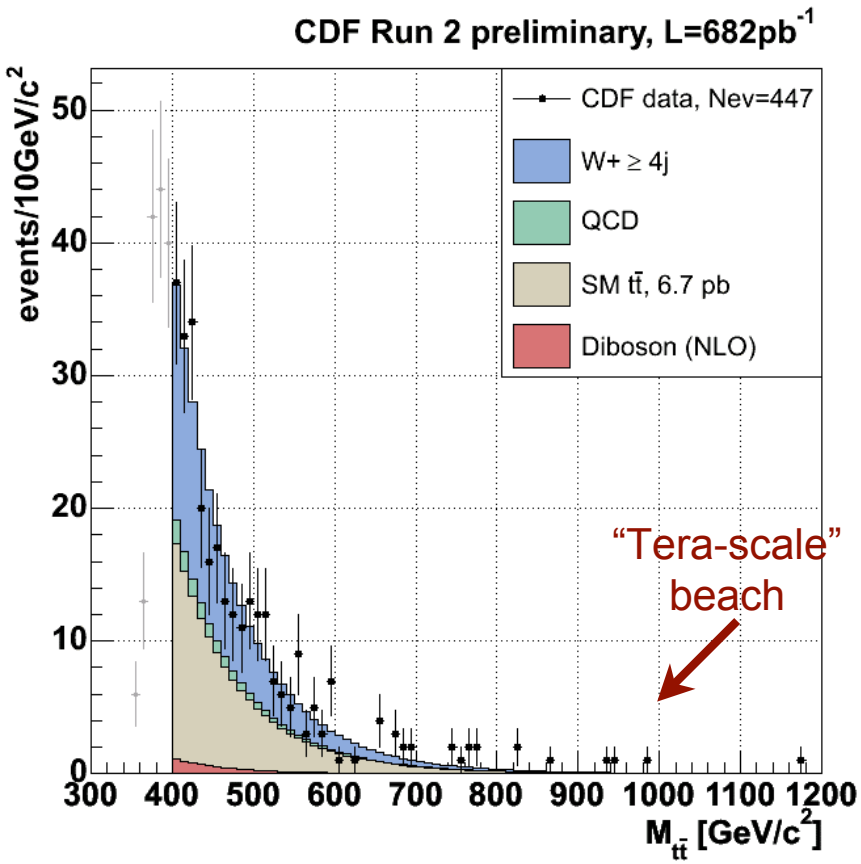
- Searching for Higgs production in association with b quarks
- Tiny cross section in SM, but enhanced by ~$\tan^2\beta$ in MSSM
- At high $\tan\beta$, degeneracy between

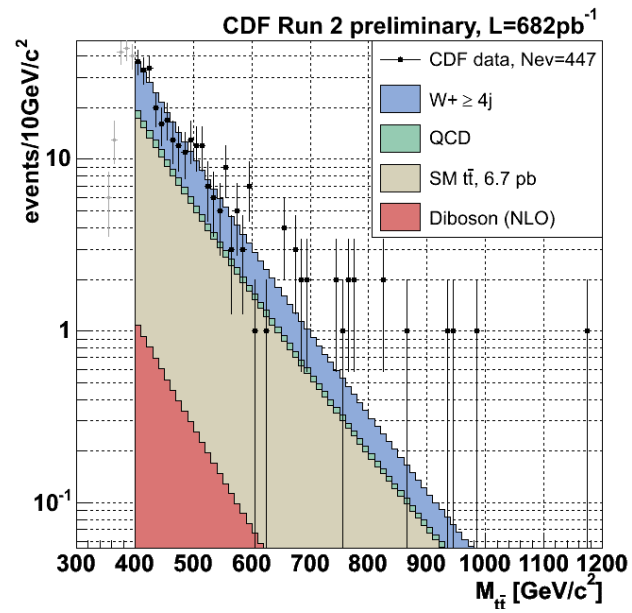
M_{12} = inv. mass of 2 highest Et jets

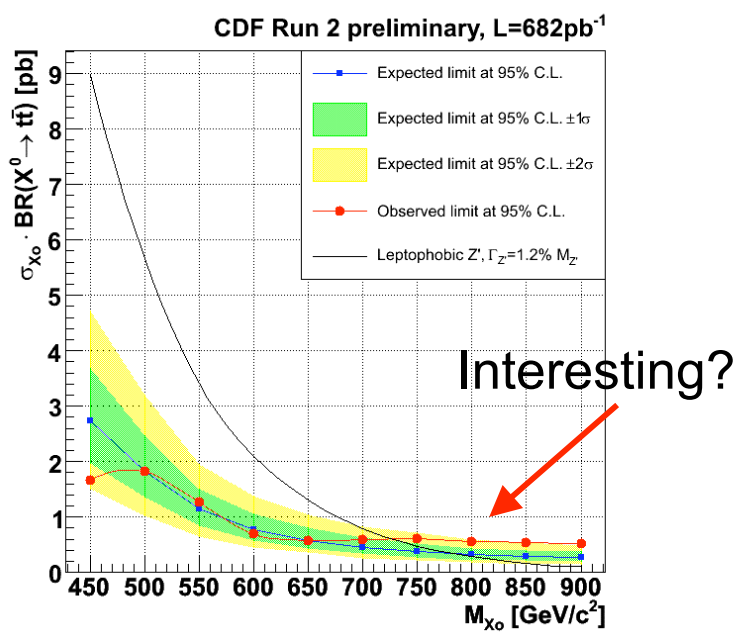


Resonances in ttbar production

CDF data

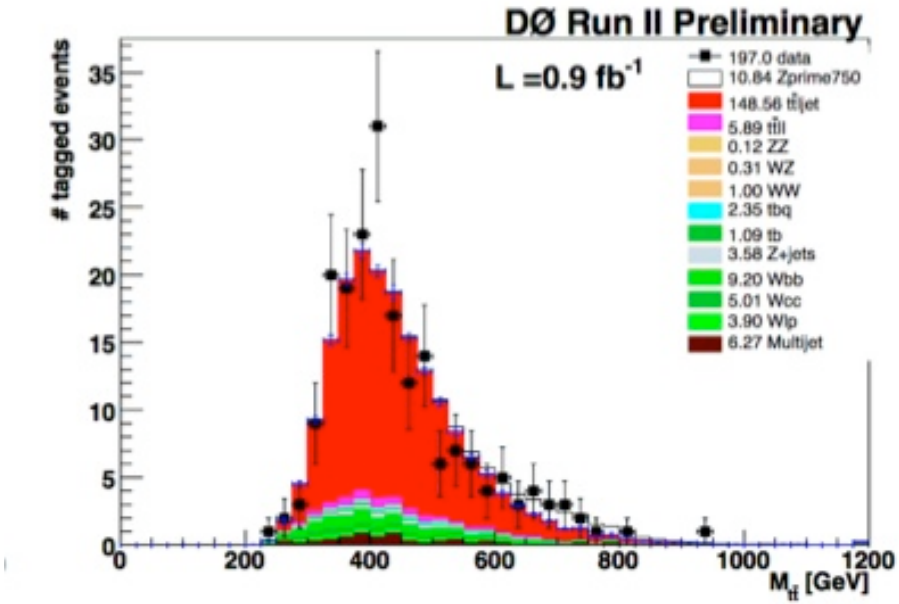




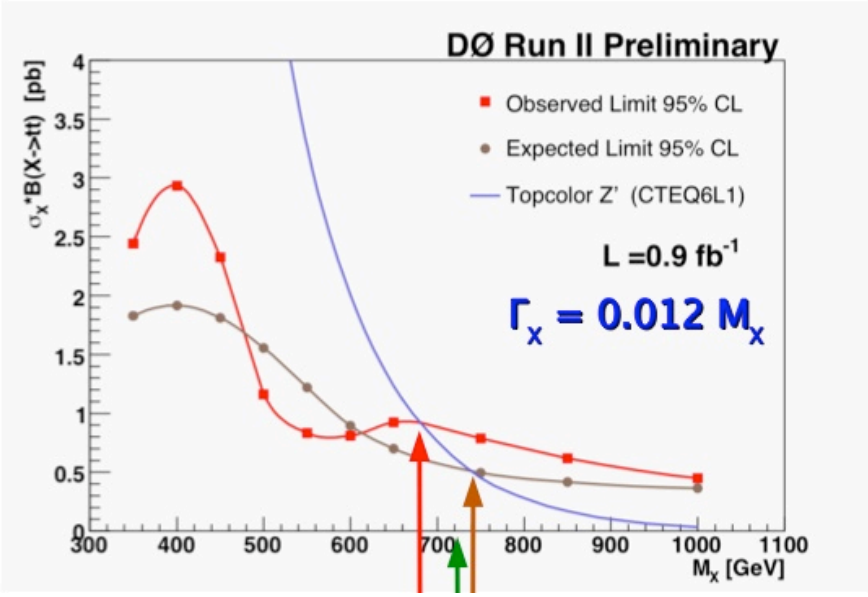


Note to self: test this distribution with as much data as possible !

Resonances in ttbar production



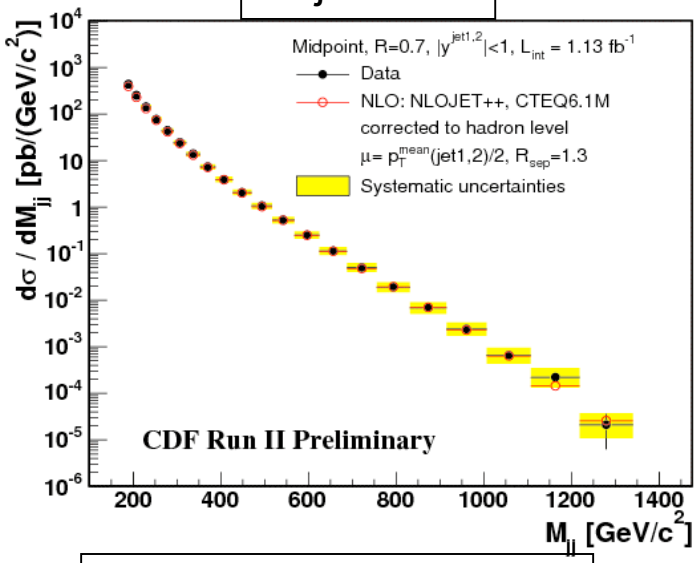
D-zero data



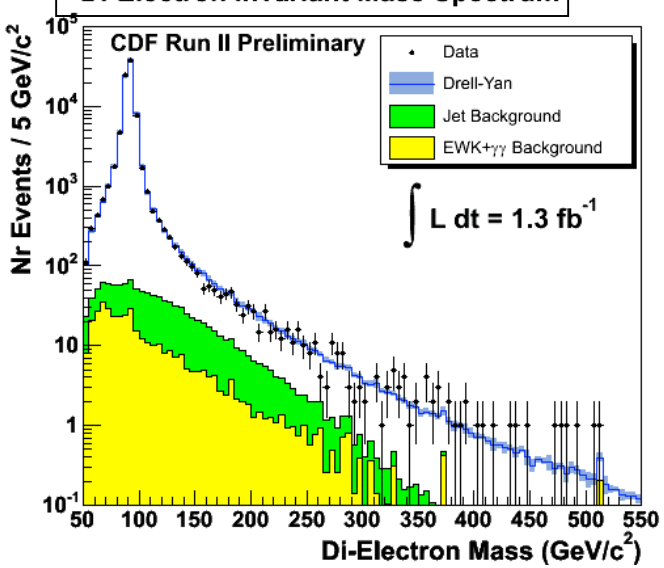
Interesting?

Más Resonances: dijets, diphotons, dileptons

Di-jet mass

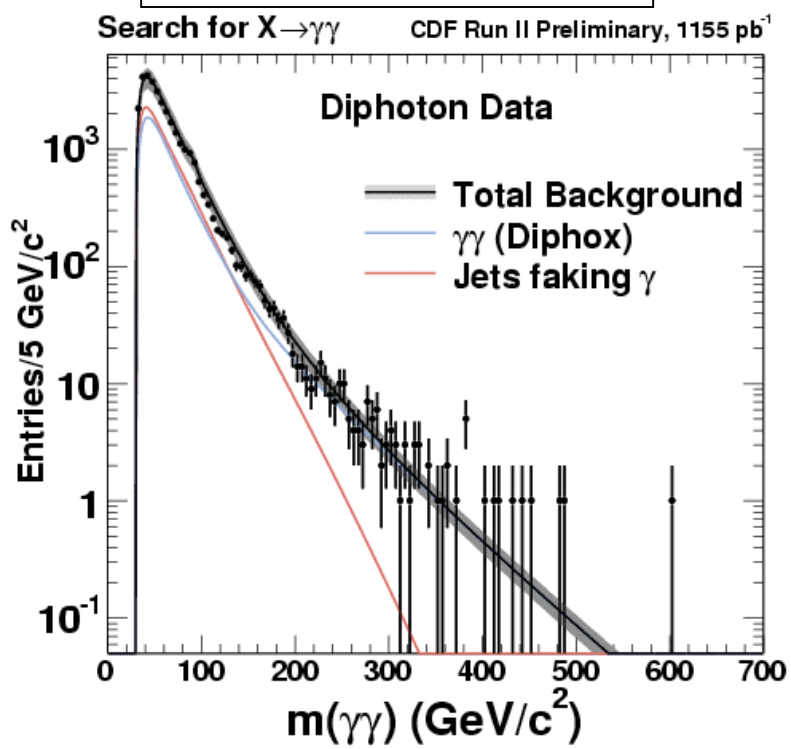


Di-Electron Invariant Mass Spectrum



- **Compositness, technicolor, extra-dimension gravitons, bosophilic/leptophobic higgs, new heavy gauge bosons, anything ! - just keep looking**

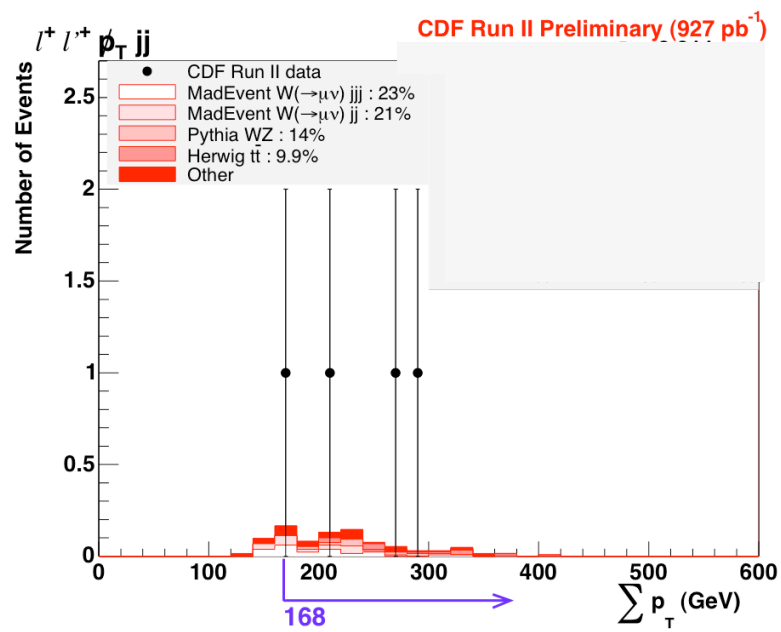
Di-photon mass



Broad program with more Lum

- Precision program opens up, of course - not discussed here
- Sensitivity reach on all specialized searches improves, not just SM Higgs - which is a target with well-identified x-section
- We also look broadly -model independent way- at the data for excesses in many high-pt signatures
  [with different combinations of final state objects]
  - Identify significant excess ? => investigate further
- It takes just one true outlier

Same-sign dileptons
Data=4 SM=0.7
Lum = 0.9 fb^{-1}



Notes on possibility

- We already have "fluctuations" in the data
- Which one is from a real new physics source?
- The top discovery experience at CDF:
  - 19 pb-1 ~3-sigma EVIDENCE with 13 l+j evts, 2 dileptons
  - 19-40 ~ nothing exciting
  - 40-67 a lot more… DISCOVERY
    - On which third are we today?
- Some existing new physics sources could have not yet revealed themselves yet- and we could still have sufficient # of events for a discovery before the end of Run 2
- Some may already be there
- Who knows for sure today? => we keep "experimenting"

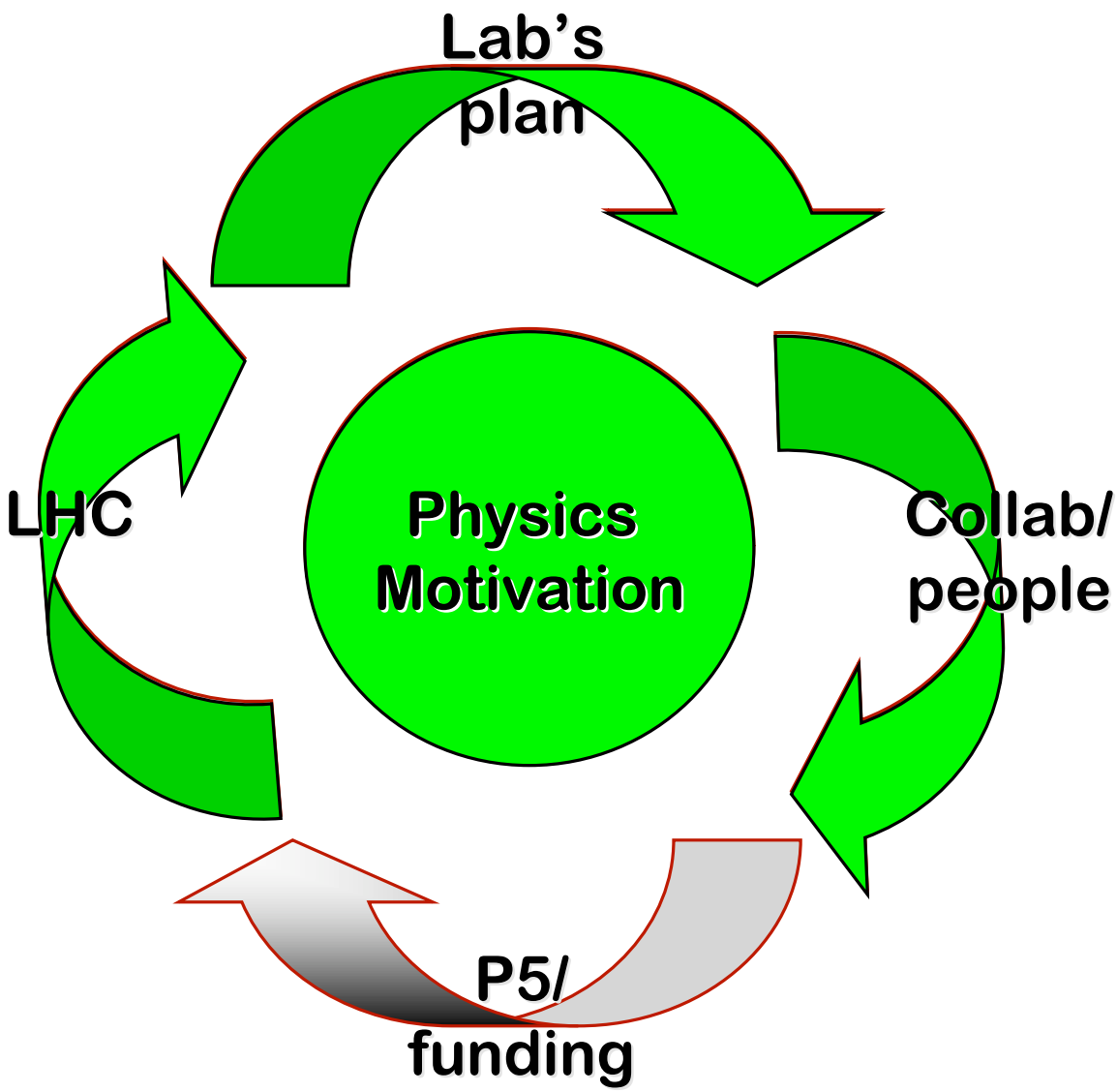
Path

Executive Summary

- Very exciting and rich physics program
  - Many parts benefit from "as large a dataset as possible"
  - Higgs search needs that + a large effort
    - We have a chance of saying something very important
  - There is discovery potential -in general- as we gather more data
  - Improvements are continuously coming into the game
- The CDF detector will operate well through FY10
  - No problems and no critical vulnerabilities identified [see review report]
- Collaboration committed through FY09
  - The recent decision to run helped consolidate this
- No new physics information in Spring 2008
  - Only a little more luminosity analyzed due to Summer shutdown
- Lab's commitment to run in FY10 is critical
  - it has resonated through the collaboration

We want to run CDF through FY10

Closing remarks

- We think we -the HEP community- are not in a position now to decide to end the program after FY09. Not much change by Spring'08
  - Amazingly rich physics program
  - Higgs looks [realistically] promising
  - @ 2 fb^{-1} not enough information to know what we may find with 7-8 fb^{-1}
- It would be a shame to have missed a discovery, or an important piece of physics, that could have been within our reach, but we prematurely decided to stop
- To help facilitate securing the resources needed to run in 2010 we need an early recommendation to run
  - The longer we wait the harder it'll be to make it happen

Running in 2010 and beyond