2008 International Linear Collider Workshop (LCWS08)
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Recent Results and Prospects from the Tevatron

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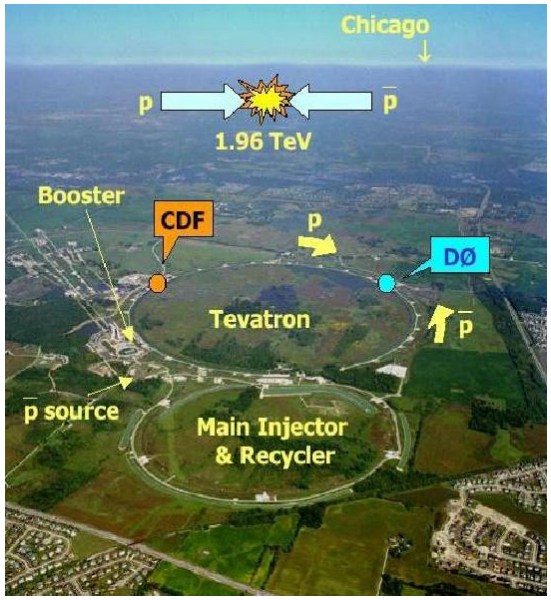
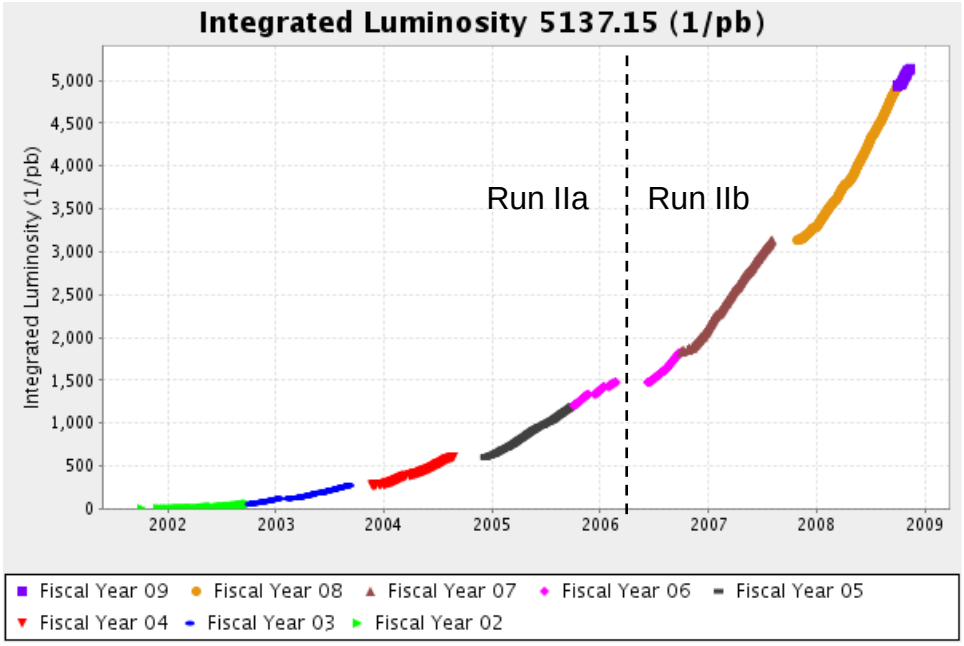
For the CDF and DØ Collaborations

Tevatron Accelerator

	Run I	Run IIa	**Run IIb**
Bunches in Turn	6 × 6	36 × 36	**36 × 36**
√s (TeV)	1.8	1.96	**1.96**
Typical L ($cm^{-2}s^{-1}$)	1.6×10^{30}	$1x10^{32}$	**2.8×10^{32}**
∫ Ldt (pb^{-1}/week)	3	15-20	**50-60**
Bunch crossing (ns)	3500	396	**396**
Interactions/ crossing	2.5	2.5	**7.0**





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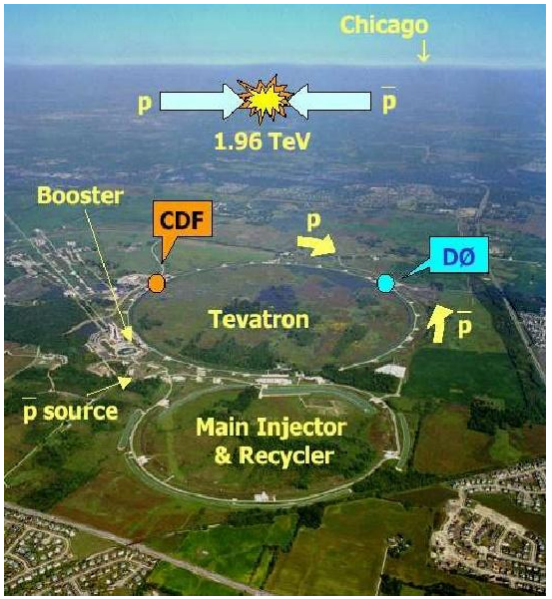

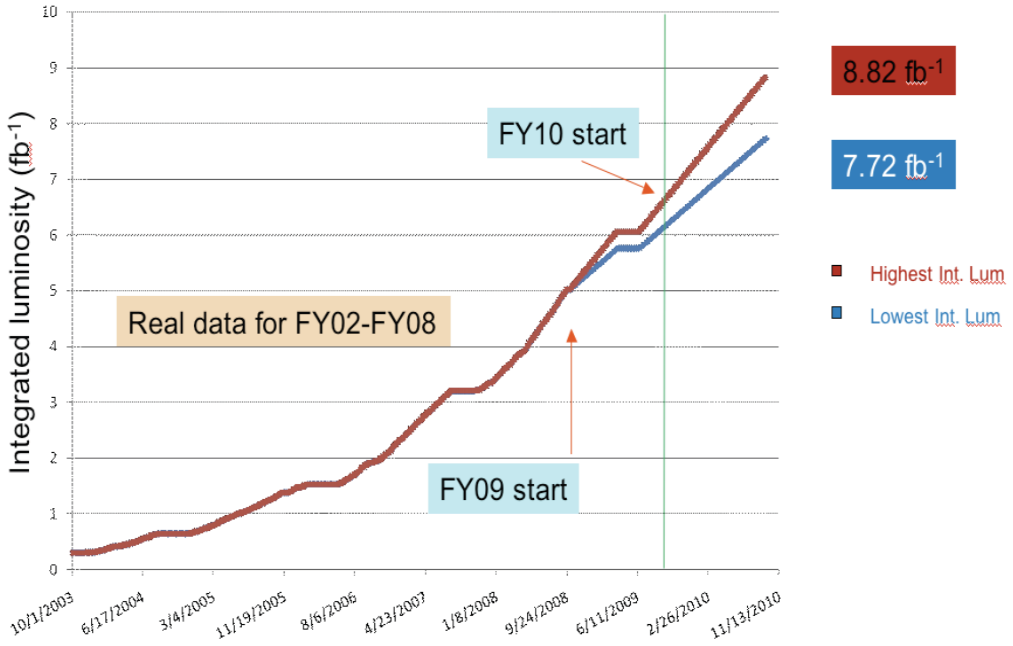

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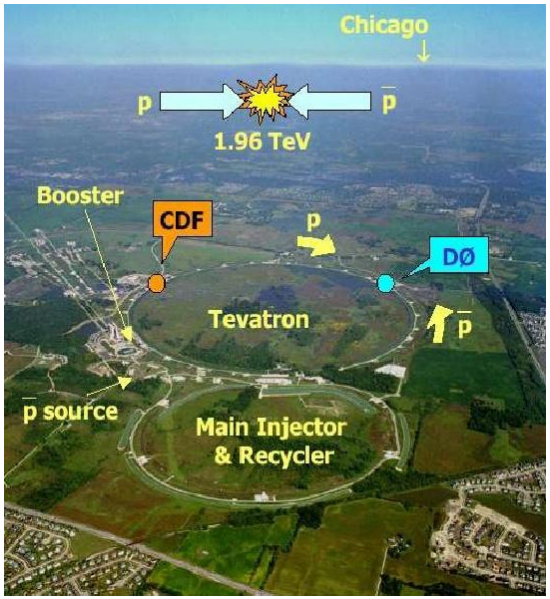

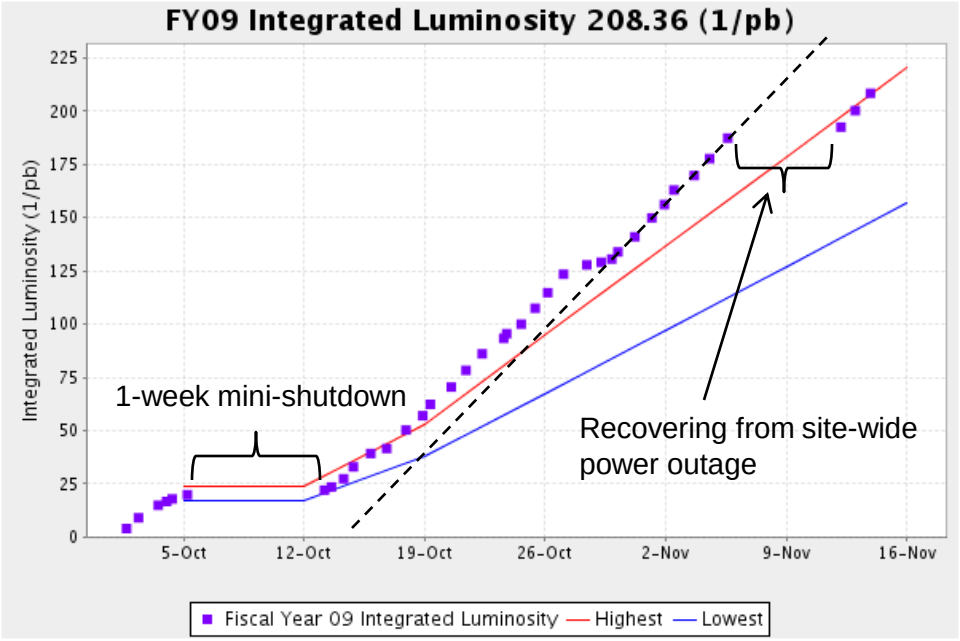

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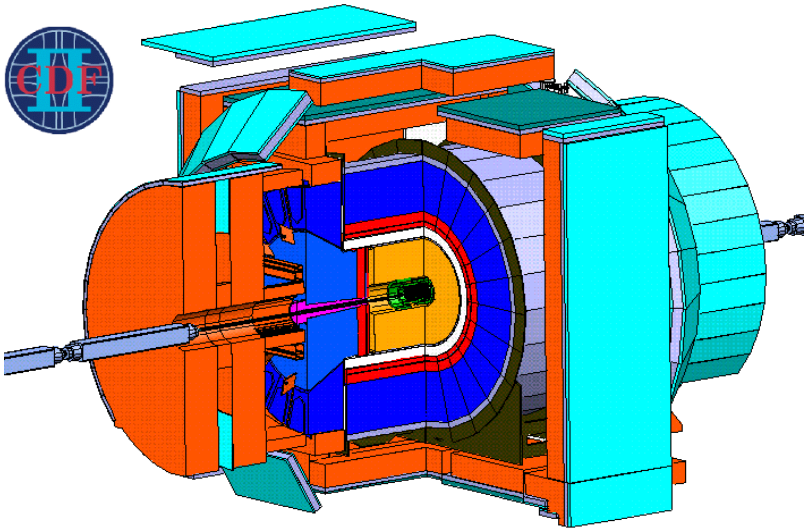
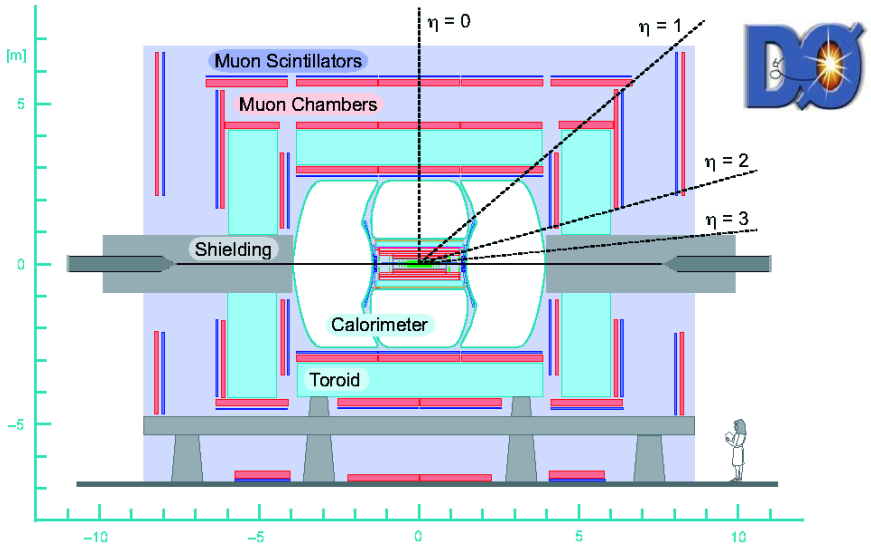
- Project ~7.7-8.8 fb^{-1} by end of FY10.
- But in end of FY08 and beginning of FY09 better slope than “Highest Lum” projection!

CDF and DØ Detectors



63 institutions (15 countries)
589 physicists



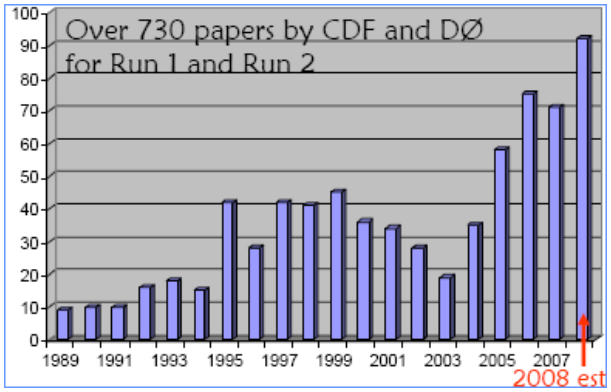
90 institutions (18 countries)
554 physicists

- Multipurpose detectors:
  - Central tracking system embedded in a solenoidal magnetic field:
    - Silicon vertex detector
    - Tracking chamber(CDF)/fiber tracker(DØ)
  - Preshowers
  - Electromagnetic and hadronic calorimeters
  - Muon system

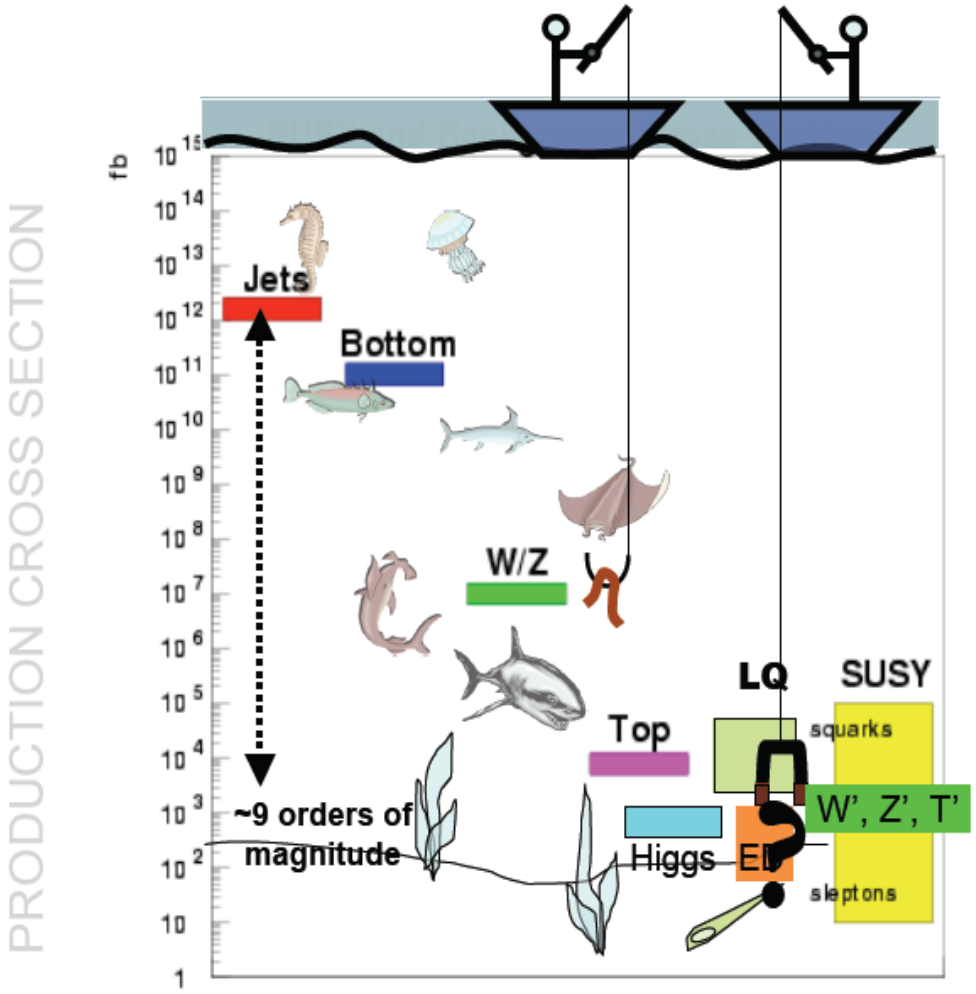
- All detector subsystems expected to survive till the end of the run.
  No further upgrades, stable triggers.
- Data taking efficiency: ≥85%

Physics Program at the Tevatron

- Broad and deep program being fully exploited.



- Recorded luminosity to date: ~4.5 fb^{-1}
- Physics analyses to date typically use ~1-3 fb^{-1}, so final results with the full dataset will have ~2.5-7 times more statistics.
- This talk will only cover a subset of recent results spanning the whole physics program.

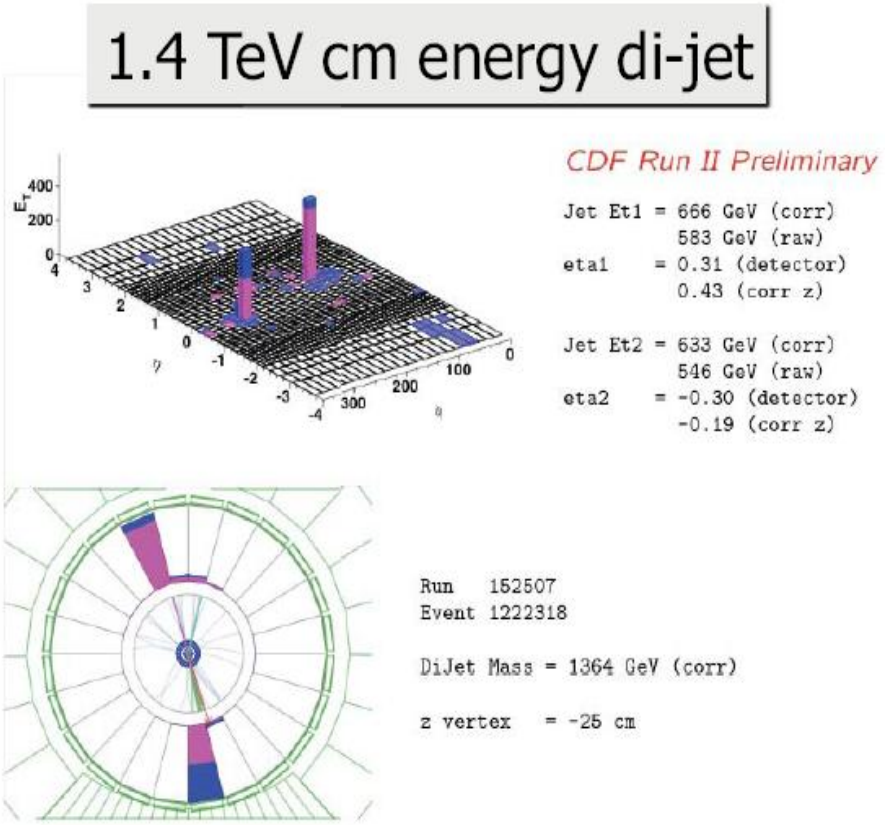


QCD Program

- Physics at a hadron collider (Tevatron, LHC) requires precise understanding of QCD:
  - Hard interactions of 2 partons, PDFs
  - Multi-parton interactions (underlying event)
  - Soft/hard initial/final state radiation
  - Hadronization/fragmentation

Full program of measurements:

- Jet production
  - Inclusive jet p_T, dijet mass, dijet angular distributions,…
  - Vector boson + jets
- Photon production
  - Diphoton
  - Photon + X
- Heavy-flavor production
  - Inclusive
  - Associated with vector bosons
- Underlying event, jet fragmentation
- Diffractive program

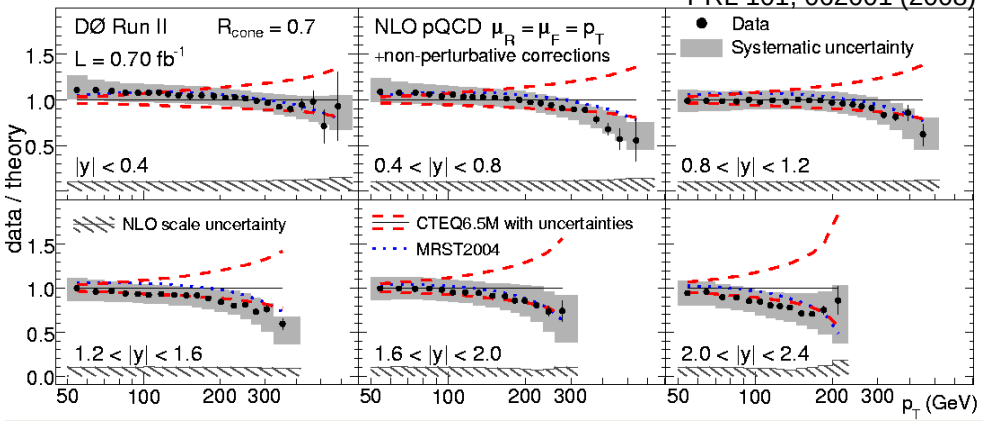


Jet Production

Inclusive jet cross section

- Stringent probe of pQCD over 8 orders of magnitude!
- Forward jets: sensitive probe of gluon PDF at high x.
- Central jets at high p_T: sensitive probe of New Physics.
- After years of work, achieved jet energy calibration ~1-2%.

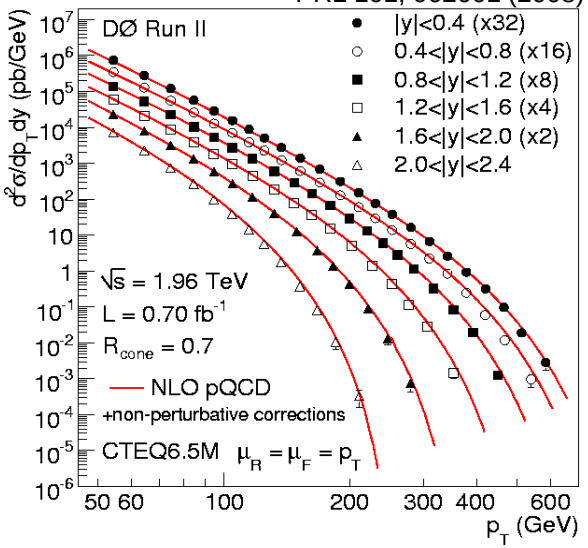
PRL 101, 062001 (2008)

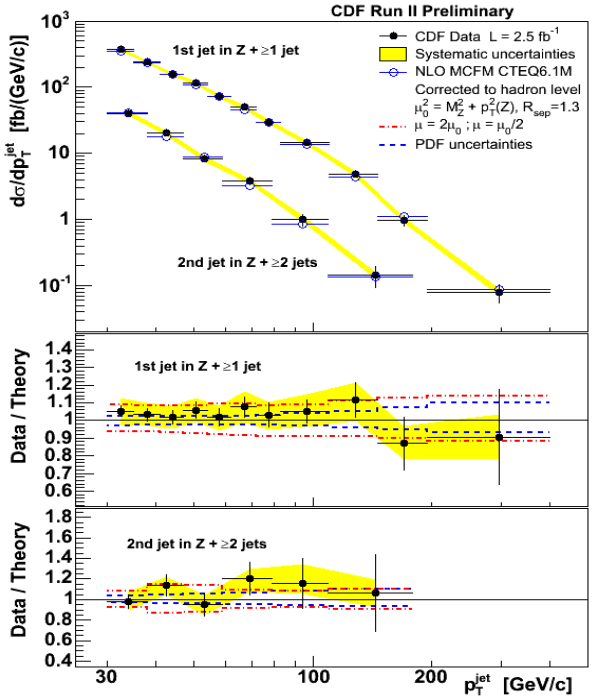


Significant constraints to the gluon PDF.

Extremely useful input for the LHC.

PRL 101, 062001 (2008)



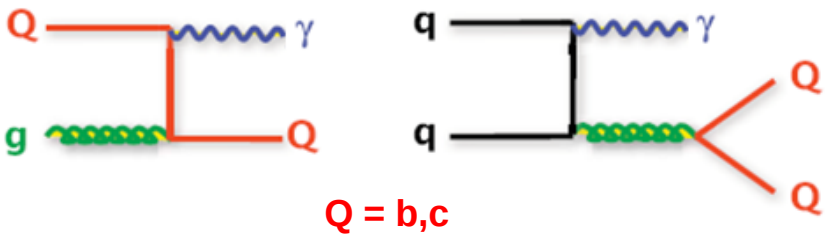


W/Z+jets total/differential cross sections

- Test of pQCD predictions at high momentum transfers.
- Main backgrounds to top, Higgs, New Phenomena searches ⇒ critical to validate theoretical calculations and Monte Carlo event generators.

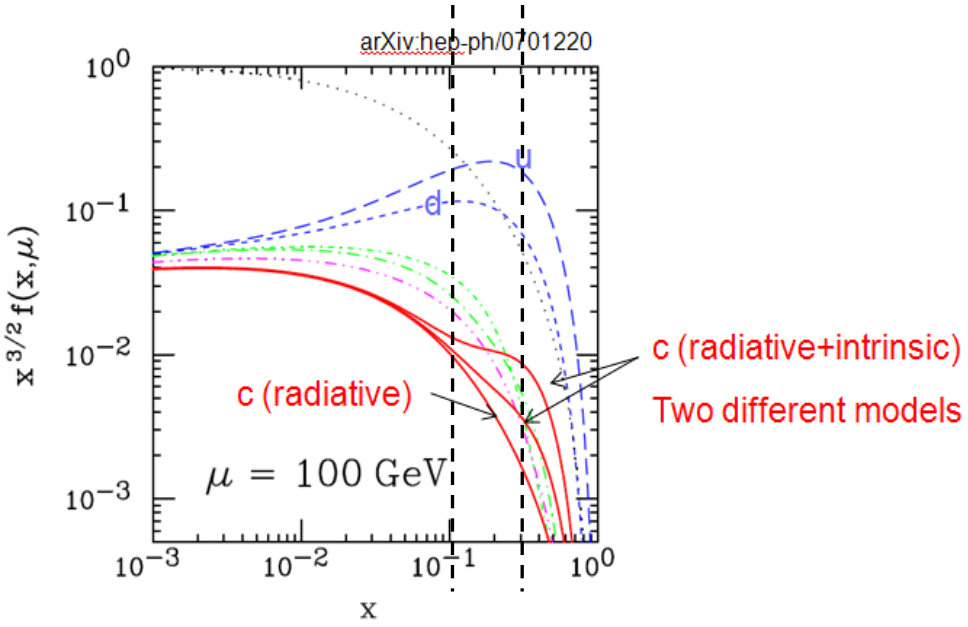
Vector Boson + Heavy Flavor Jets

- Sensitive to production mechanism and the heavy quark content of the proton. Also probes fragmentation into heavy quarks.

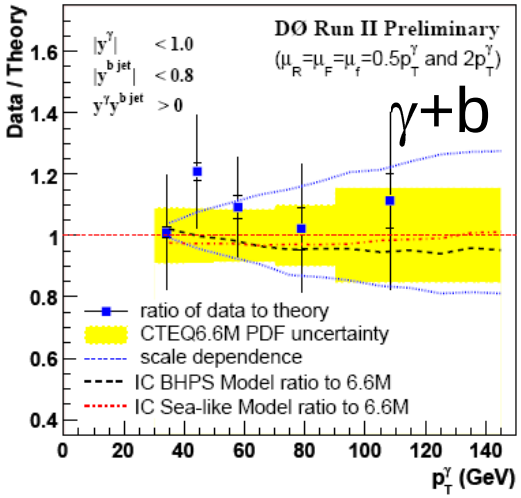


Q = b,c

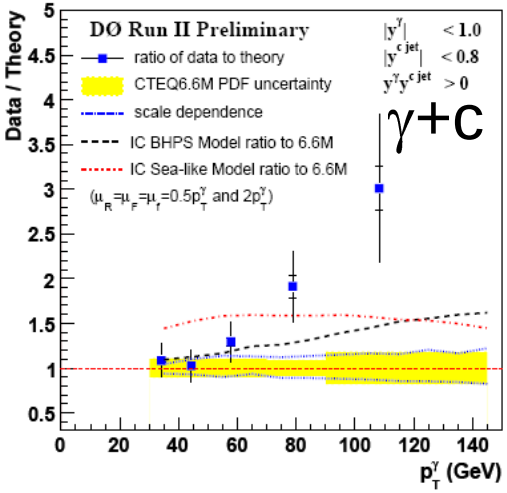
- Is there an "intrinsic charm" (non-perturbative) component of the proton?



Region probed: $0.1<x<0.3$, $0.9\times10^{3}<Q^{2}<2\times10^{4}$ GeV^2



γ+b in agreement with NLO QCD



Large discrepancy for γ+c at high p_T^{γ}

Non-intrinsic charm?

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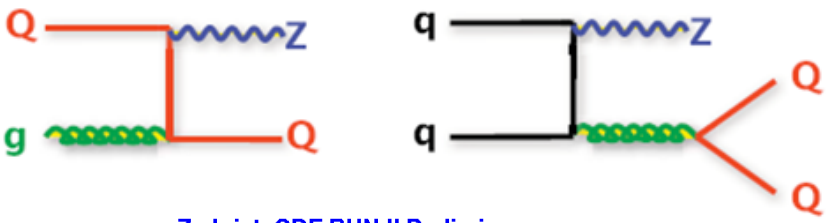
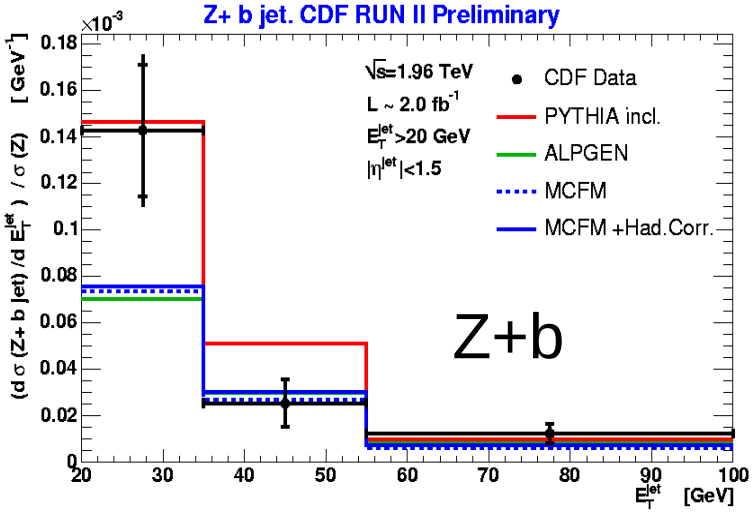
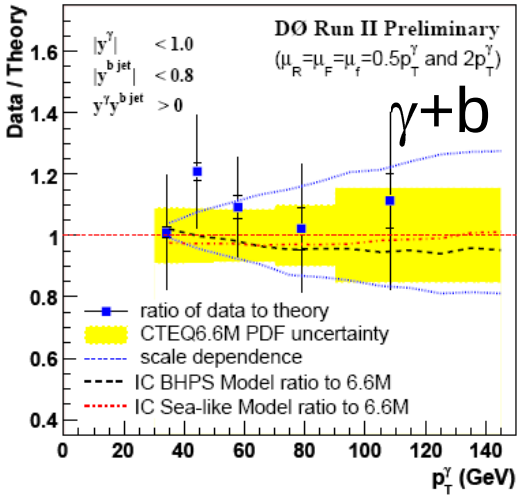




σ(Z+b-jet) = 0.86 ± 0.14(stat) ± 0.12(syst) pb

NLO prediction: 0.53 ± 0.08 (scale+PDF) pb

First differential distributions available.
Higher statistics needed for more
stringent tests of theoretical predictions.



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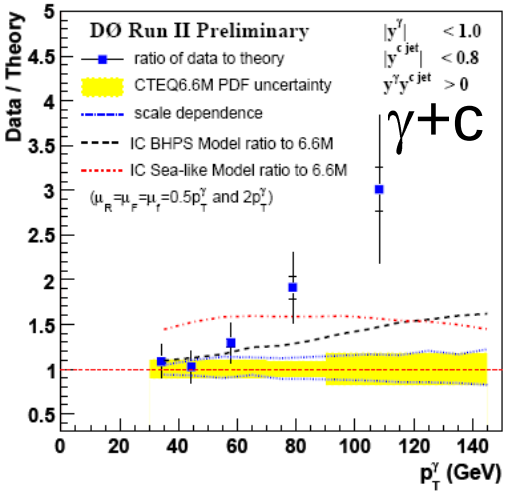

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Heavy Flavor Program

- Large production cross section (~0.1 mb).
- Many b,c species are produced at the Tevatron:

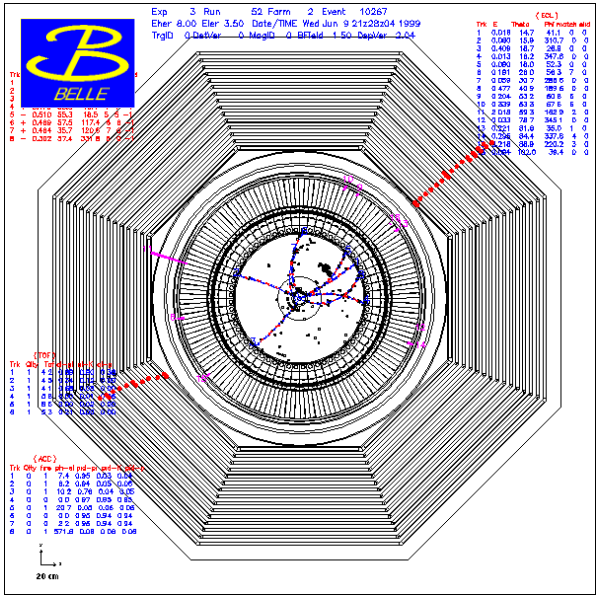
$$\bar{B}^0 = |b\,\bar{d}\rangle,\ B^- = |b\,\bar{u}\rangle \quad \Lambda_b^0 = |b\,d\,u\rangle,\ \Sigma_b^- = |b\,d\,d\rangle$$
$$\bar{B}_S^0 = |b\,\bar{s}\rangle,\ B_c^- = |b\,\bar{c}\rangle \quad \Xi_b^- = |b\,d\,s\rangle \quad \ldots$$

  many of which are inaccessible at the B factories.

- Low p_T lepton (CDF+DØ) and displaced track (CDF) triggers allow for rich samples of semileptonic and hadronic decay modes.

- Hadron collider environment challenging but sufficient statistics and detector capabilities allow for an extremely rich program:
  - Precise cross section, mass & lifetime measurements
  - Exclusive decays, branching fractions & rare decays
  - Mixing and CP violation
  - Spectroscopy & decay properties
  - Discovery of new states

"Typical" event display at the B-factories:



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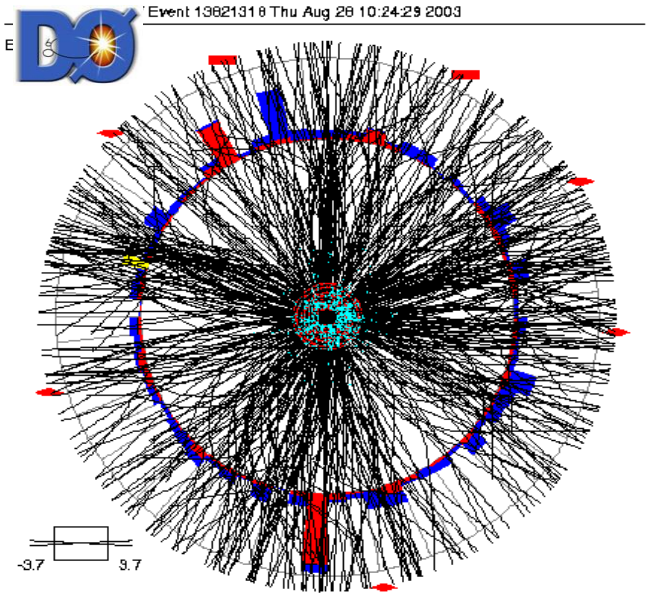
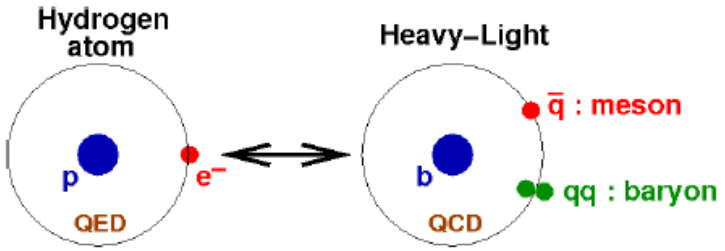


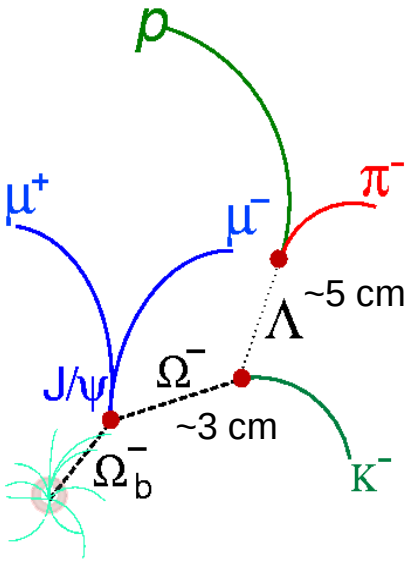
Study of New Heavy b-Baryons

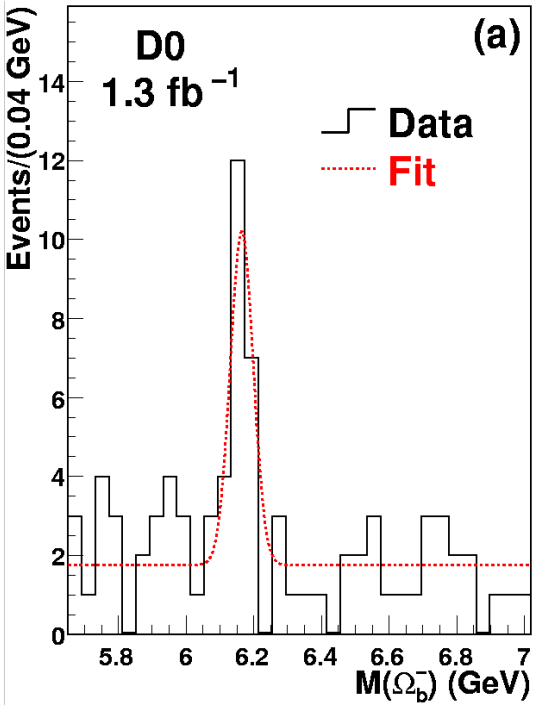
- Heavy quark hadrons are the "hydrogen atom" of QCD and b hadrons offer the heavier quarks in bound systems
  ➔ Very sensitive tests of potential models, HQET, lattice gauge calculations…
- Have added to Λ_b(udb) (seen in UA1):
  $\Sigma_b^{\pm}$, $\Sigma_b^{*\pm}$(uub,ddb), Ξ_b^-(dsb), Ω_b^-(ssb).



Observation of the Ω_b^-

arXiv:0808.4142 [hep-ex]





17.8 ± 4.9 (stat) ± 0.8 (syst) events

Mass: 6.165 ± 0.010(stat) ± 0.013(syst) GeV

Significance: 5.4σ

$$\frac{f(b\to\Omega_b^-)Br(\Omega_b^-\to J/\psi\,\Omega^-)}{f(b\to\Xi_b^-)Br(\Xi_b^-\to J/\psi\,\Xi^-)} = 0.80\pm0.32(stat)^{+0.14}_{-0.22}(syst)$$

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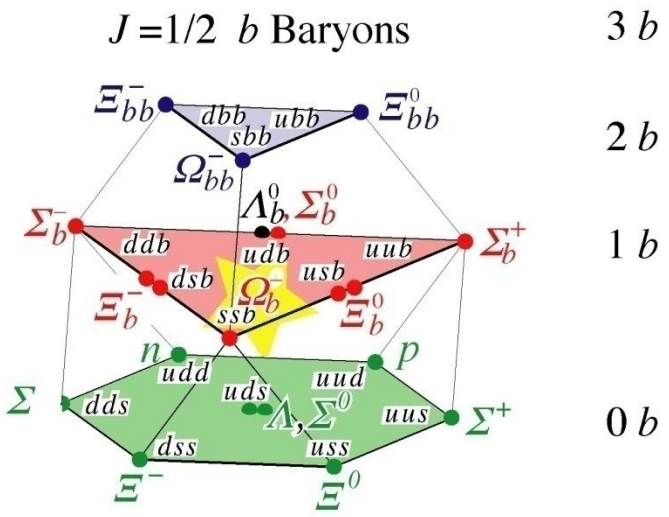

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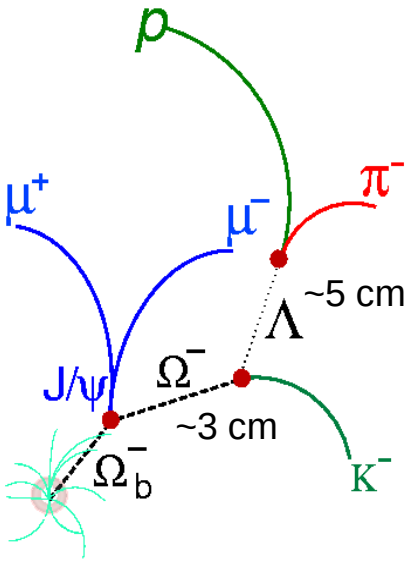

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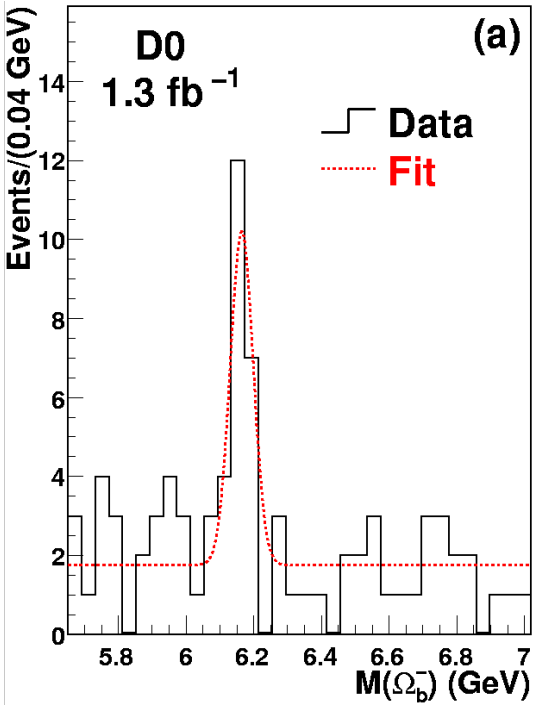

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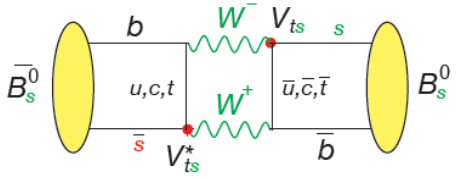
CP Violation in B_s Decays

$B_s^0 - \bar{B}_s^0$ mixing



Weak eigenstates:

$$i\frac{d}{dt}\begin{pmatrix} B_s^0 \\ \bar{B}_s^0 \end{pmatrix} = \begin{pmatrix} M - \frac{i\Gamma}{2} & M_{12} - \frac{i\Gamma_{12}}{2} \\ M_{12}^* - \frac{i\Gamma_{12}^*}{2} & M - \frac{i\Gamma}{2} \end{pmatrix}\begin{pmatrix} B_s^0 \\ \bar{B}_s^0 \end{pmatrix}$$

Mass eigenstates:

$$|B_s^H\rangle = p|B_s^0\rangle + q|\bar{B}_s^0\rangle \quad |B_s^L\rangle = p|B_s^0\rangle - q|\bar{B}_s^0\rangle$$

B_s meson allows to probe the entire matrix:

$\Delta m_s = M_H - M_L \sim 2|M_{12}|$ Sensitive to New Physics

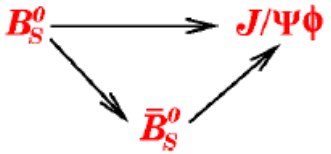
$\Delta\Gamma_s^{CP} = \Gamma_{even} - \Gamma_{odd} \sim 2|\Gamma_{12}|$ Not sensitive to New Physics

$\Delta\Gamma_s = \Gamma_L - \Gamma_H \sim 2|\Gamma_{12}|\cos\phi_s$ VERY sensitive to New Physics

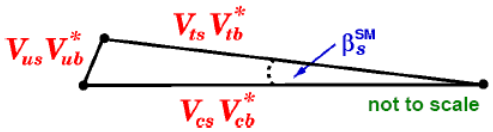
$$\phi_s^{SM} = \arg[-M_{12}/\Gamma_{12}] \rightarrow \phi_s^{SM} + \phi_s^{NP}$$

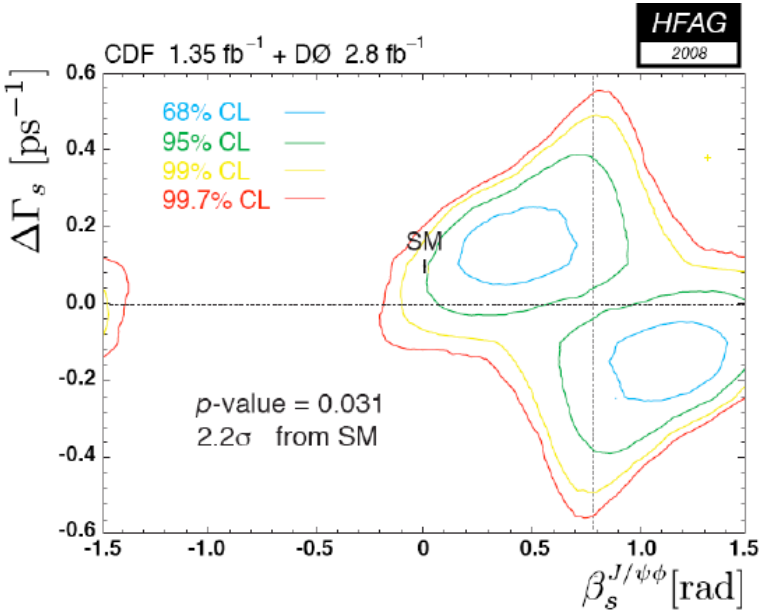
~0.004

Time-dependent angular analysis in flavor-tagged $B_s \rightarrow J/\psi\phi$ decays:



$\Rightarrow \sin 2\beta_s^{SM}$





Combination of CDF and DØ measurements w/o assumptions on strong phases yields 2.2σ deviation from the SM (p-value=3.1%).

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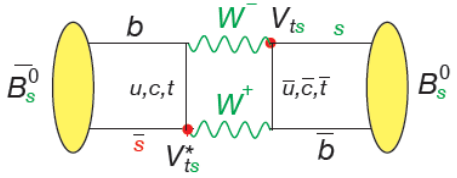

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B_s meson allows to probe the entire matrix:

$\Delta m_s = M_H - M_L \sim 2|M_{12}|$ Sensitive to New Physics

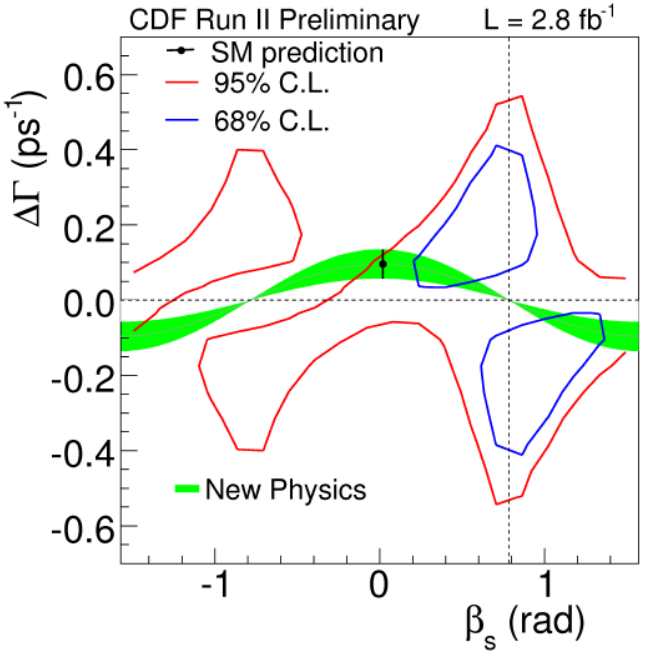
$\Delta\Gamma_s^{CP} = \Gamma_{even} - \Gamma_{odd} \sim 2|\Gamma_{12}|$ Not sensitive to New Physics

$\Delta\Gamma_s = \Gamma_L - \Gamma_H \sim 2|\Gamma_{12}|\cos\phi_s$ VERY sensitive to New Physics

$$\phi_s^{SM} = \arg[-M_{12}/\Gamma_{12}] \rightarrow \phi_s^{SM} + \phi_s^{NP}$$

~0.004

Updated CDF result with 2.8 fb^{-1}: consistency with the SM further decreased (p-value= 0.15 → 0.08).



Very exciting prospects in the near future:

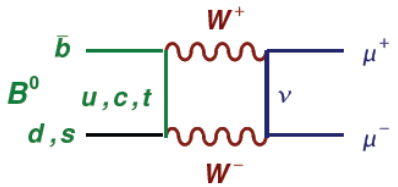
- Updates with 4 fb^{-1} by Moriond'09.
- Additional measurements (charge asymmetries) underway.

Rare Decays

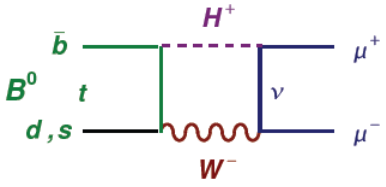
- Rare decays very sensitive to New Physics. Large b production rate and high luminosity open a window of opportunity at the Tevatron.

- **FCNC $B_{s/d}$ decays**:

SM



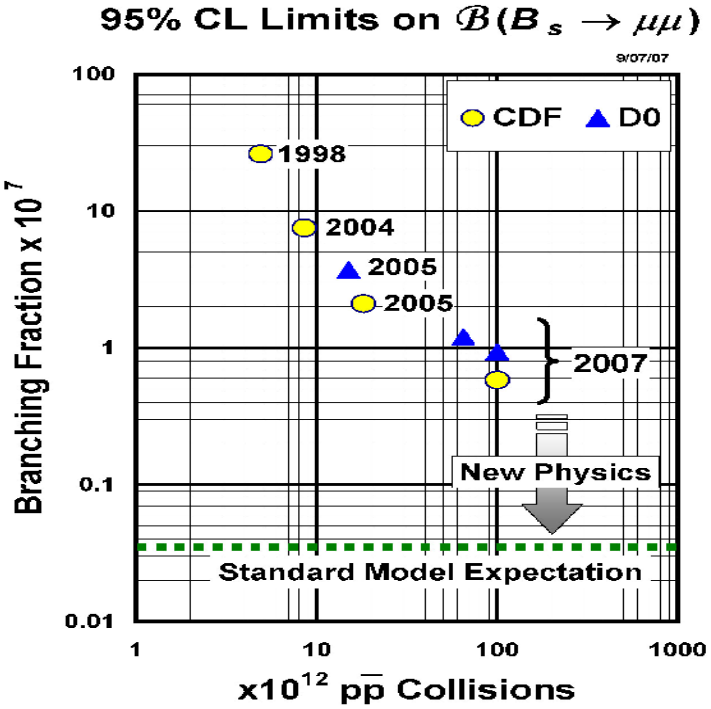
NP



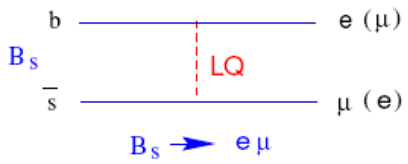
SM: BR($B_s \to \mu\mu$) ~3.8×10^{-9}

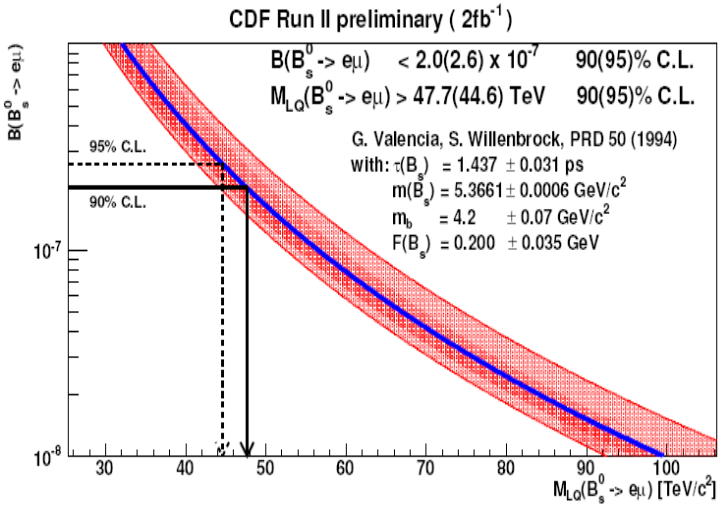
MSSM/2HDM: SM x $\tan^N\beta$ (N=6,4)!!

CDF (2 fb^{-1}): <5.8×10^{-8} (~15xSM) @ 95% CL



- **Flavor-violating $B_s \to e\mu$ decays:**
  - Forbidden in the SM.
  - Sensitivity to very large mass scales.





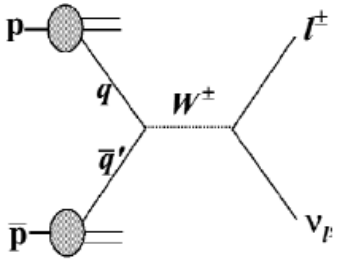
Limits on B_d competitive with B factories.

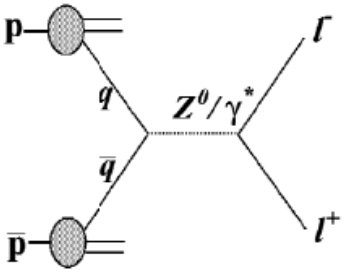
Unique limits on B_s.

Electroweak Program

- Single W($\rightarrow l\nu$)/Z($\rightarrow l^+l^-$) production occurs at high rate: O(100k-10k)/week!!
- Provide “standard candles”: lepton ID/trigger efficiencies vs. time, integrated luminosity verification, electron energy scale, etc.
- Inclusive production cross section in good agreement with theoretical prediction.

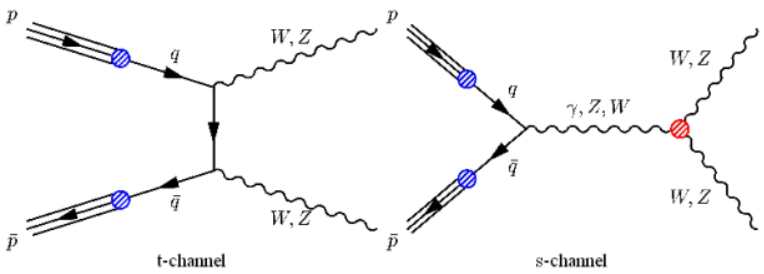
  ➔ could be used to overcome ~6% luminosity uncertainty in many measurements.





Extensive and very competitive program:

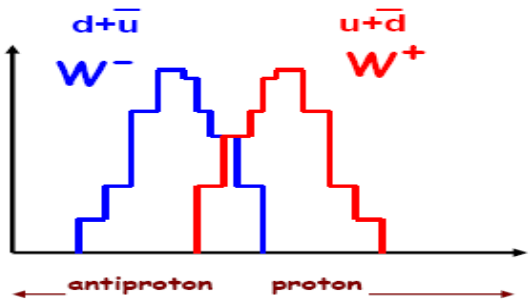
- W/Z production cross sections and differential distributions
- Precision measurements: M_W, Γ_W, $\sin^2\theta_w$,…
- Diboson physics



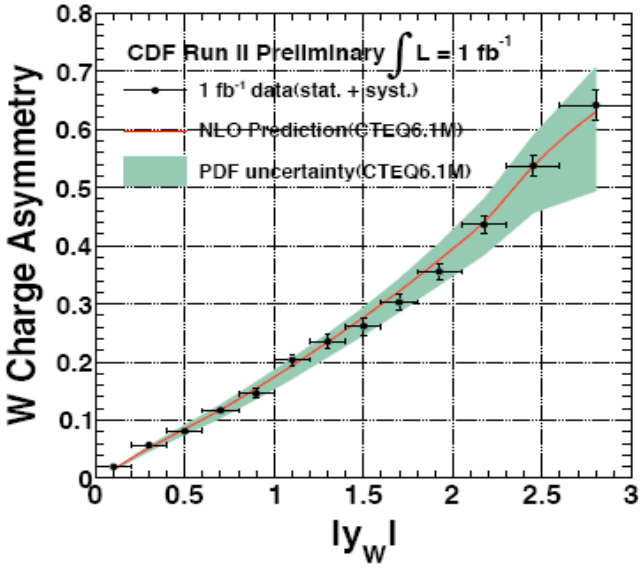
W/Z Asymmetries

- Differential distributions provide important information on production mechanism.

W charge asymmetry



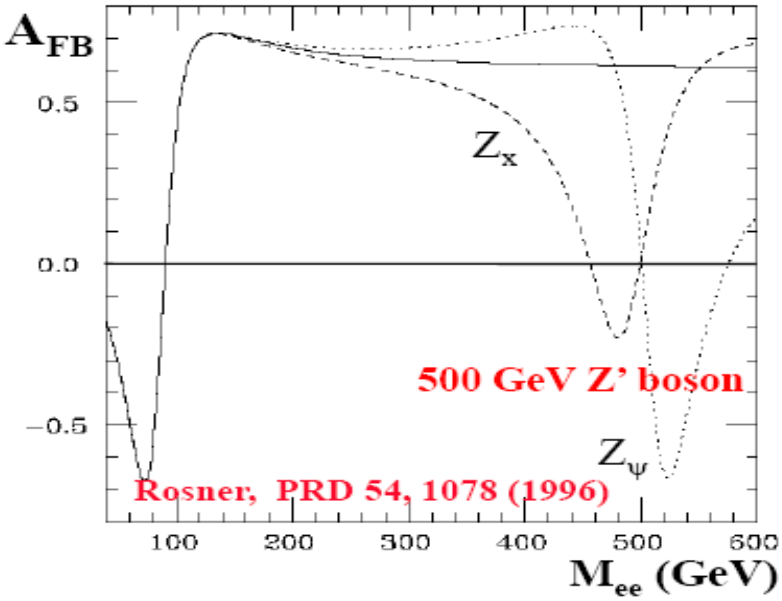
$$A(y) = \frac{d\sigma(W^+)/dy - d\sigma(W^-)/dy}{d\sigma(W^+)/dy + d\sigma(W^-)/dy}$$



Significant constraints on PDFs!

Forward-backward asymmetry in $Z/\gamma^* \rightarrow e^+e^-$

- Measurement of A_{FB} as a function of M_{ee}.
- Sensitive to New Physics effects at high M_{ee} (extend region probed by LEP2).
- Measurement of $\sin^2\theta_w$.
- Measurement of Z-u-u and Z-d-d couplings.



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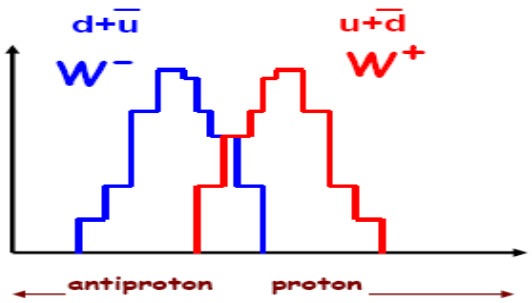

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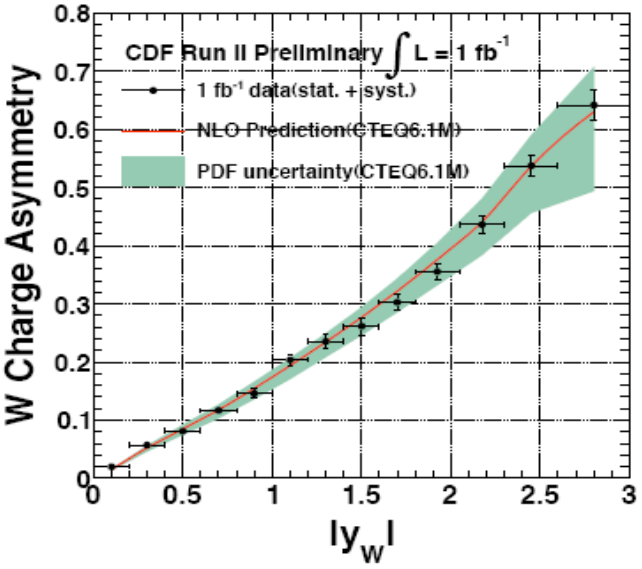

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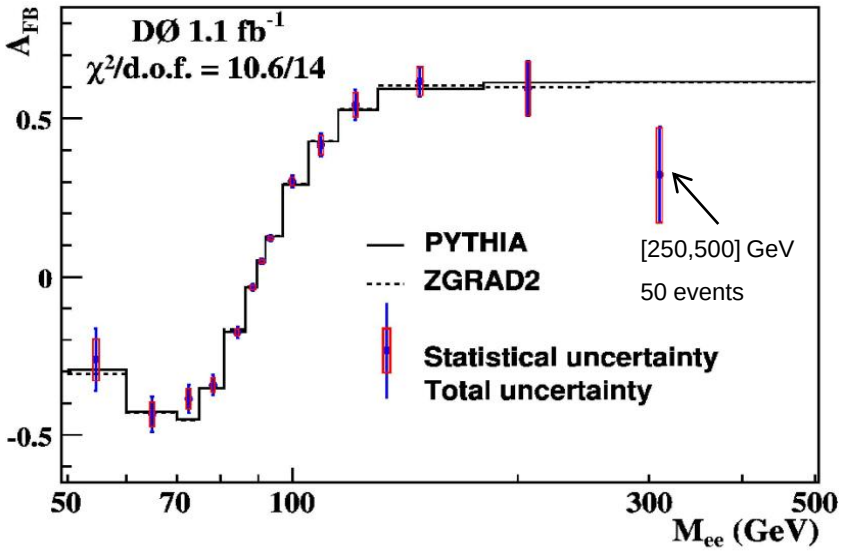
PRL 101, 191801 (2008)



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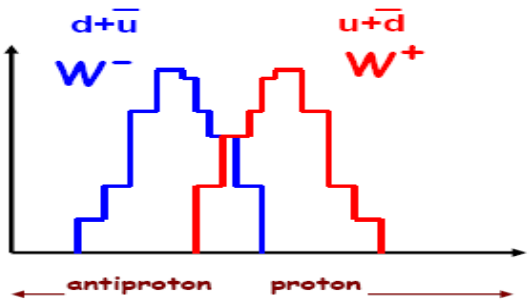

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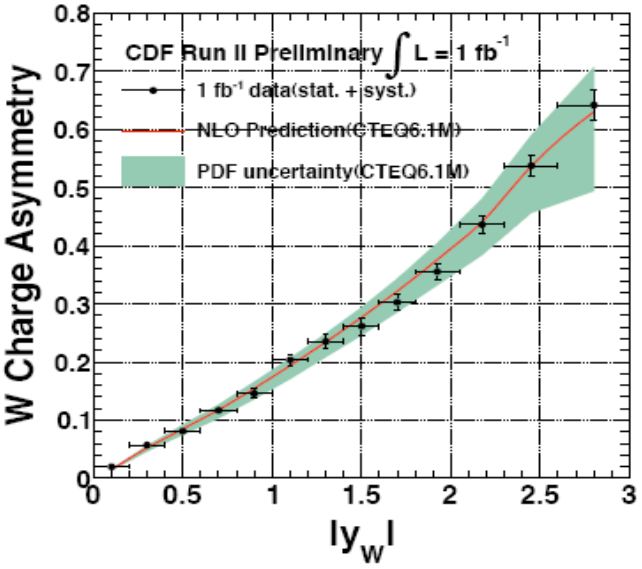

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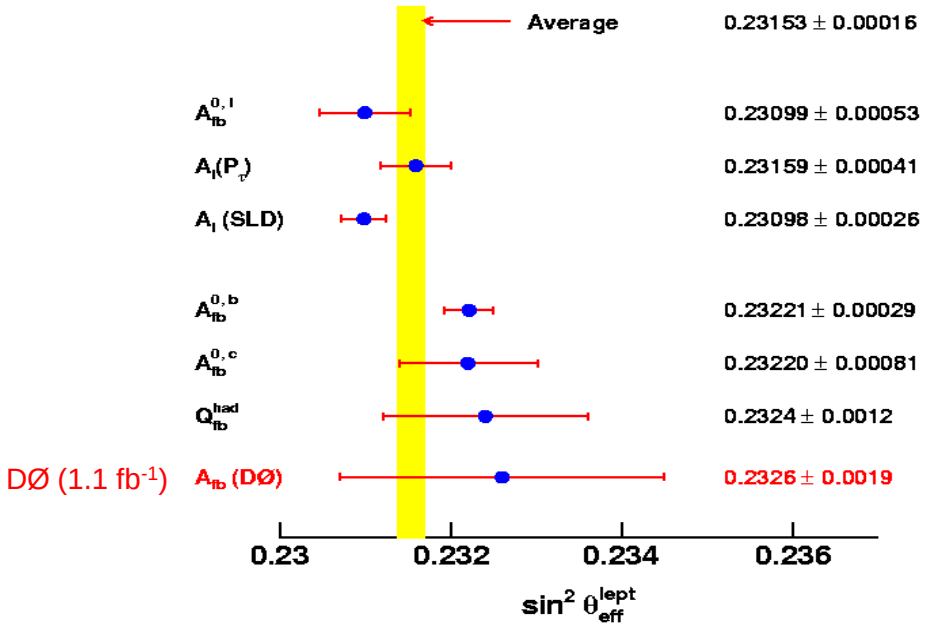

Very competitive measurement with full dataset and CDF+DØ.

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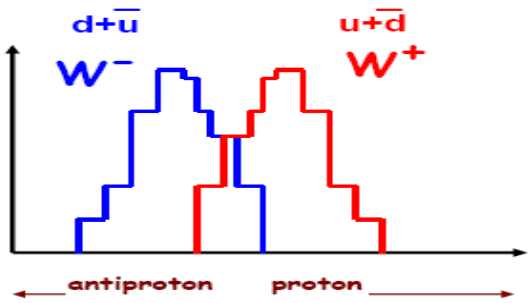

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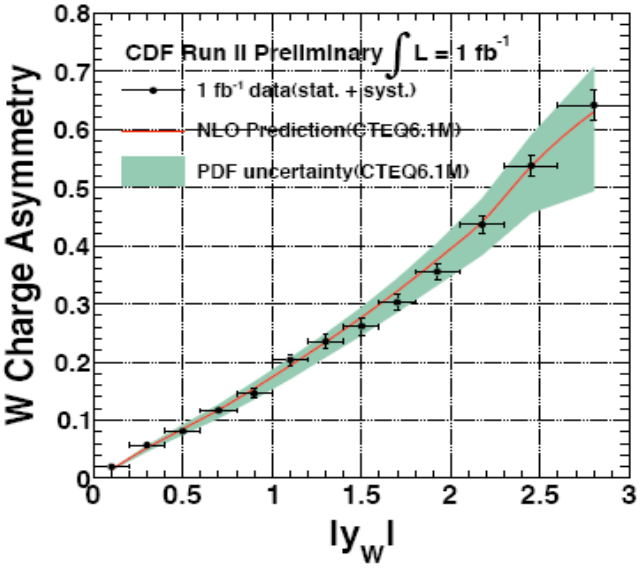

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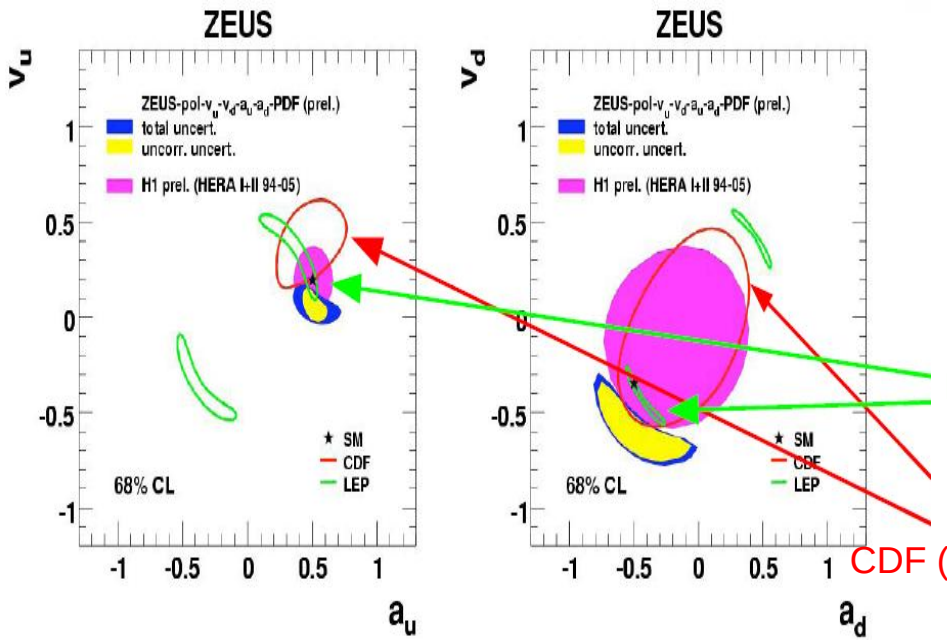


Uncertainties will shrink by ~x10!

W Boson Mass

- Constraint on SM Higgs mass is now dominated by the W mass uncertainty:

  Δm_t = 1.2 GeV ➔ ΔM_H = +9/-8 GeV

  ΔM_W = 25 MeV ➔ ΔM_H = +17/-13 GeV

- Measured from template fits to W transverse mass, lepton p_T and MET distributions.

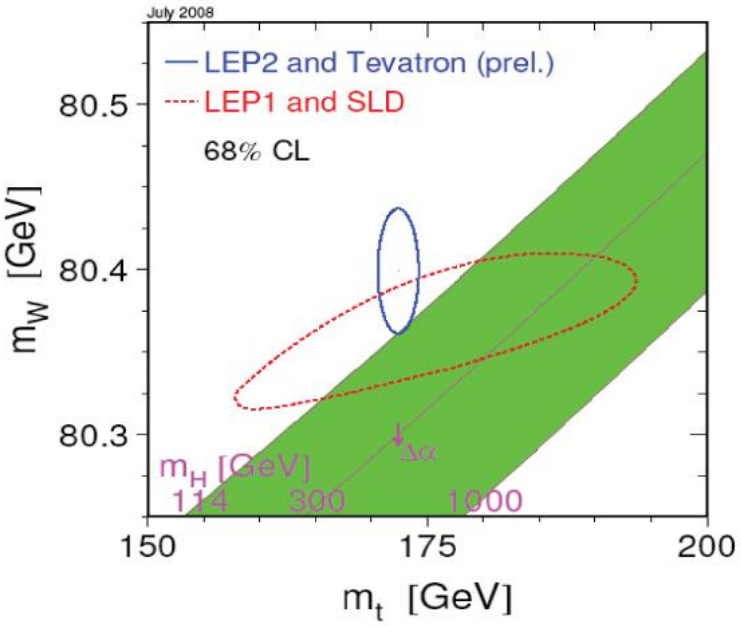
- Exquisite understanding of the detector response, noise and pileup required:

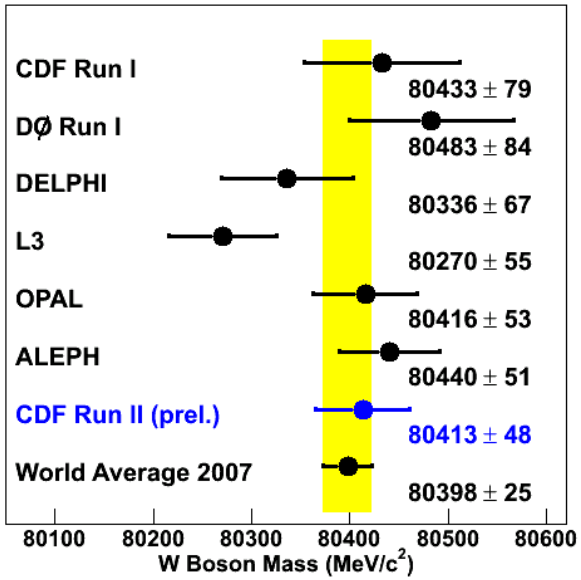
  ~ few MeV for quantities ~40 GeV!

- Uncertainty currently dominated by statistics of Z sample used for calibration.

  Theoretical uncertainties ~10-15 MeV.

- New results expected soon!
  - CDF working on 2.4 fb-1 measurement
  - DØ working on 1 fb-1 measurement





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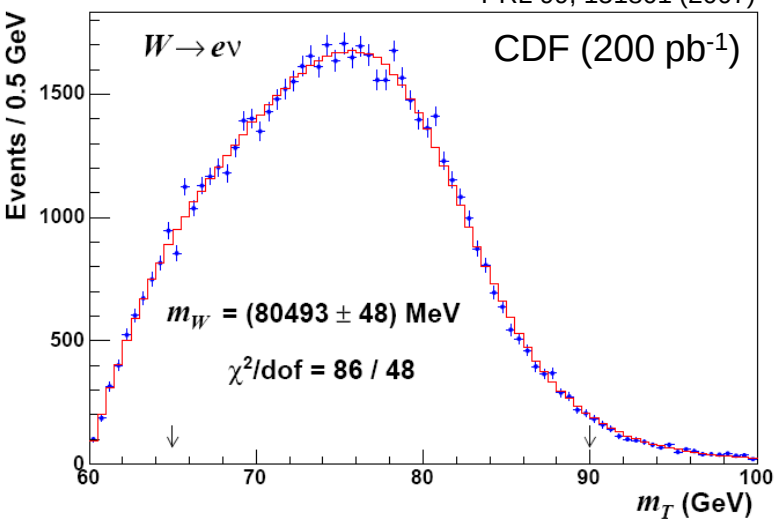
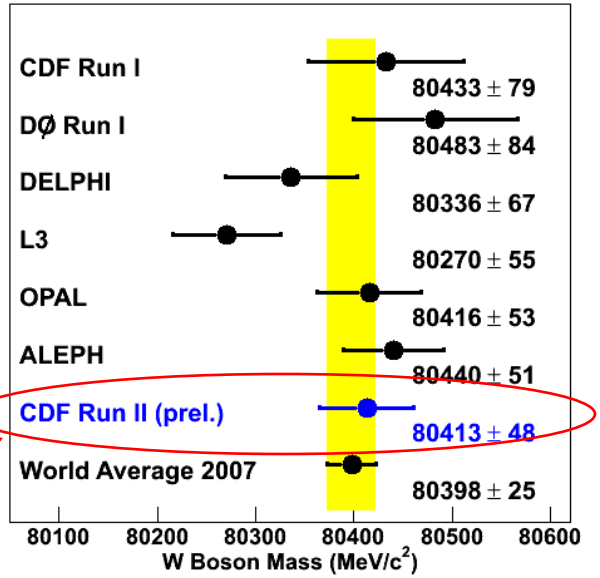
PRL 99, 151801 (2007)





CDF (200 pb^{-1})

Best single measurement

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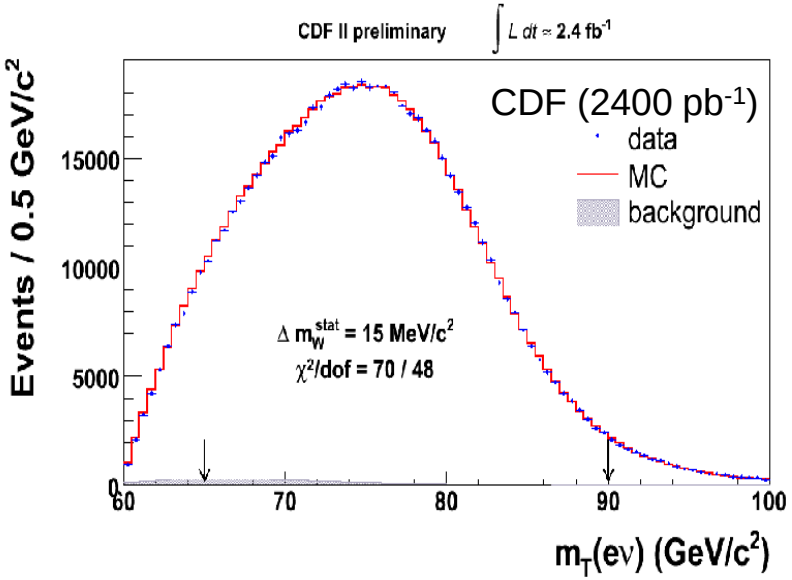
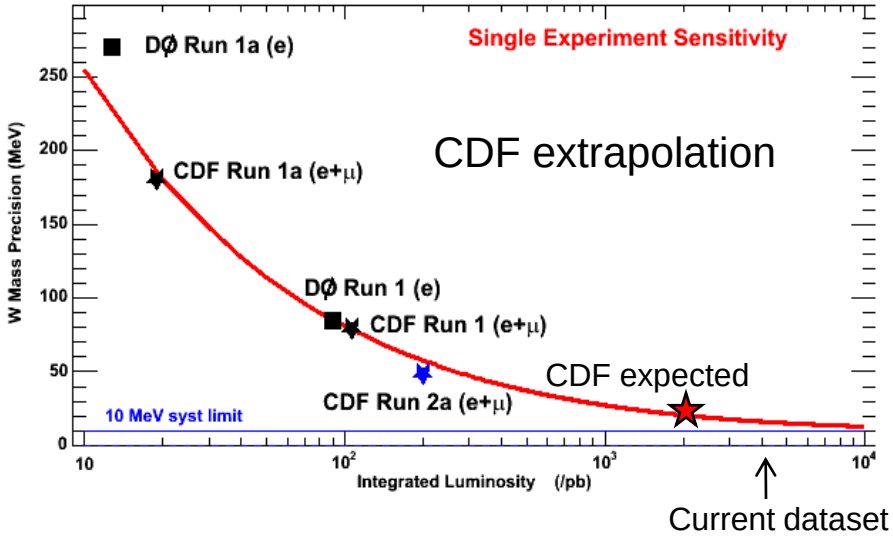
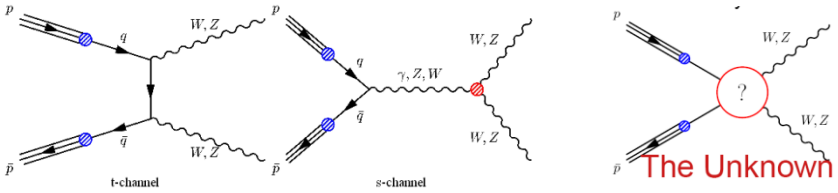
With full data sample expect CDF+DØ combined uncertainty of ~15-20 MeV.

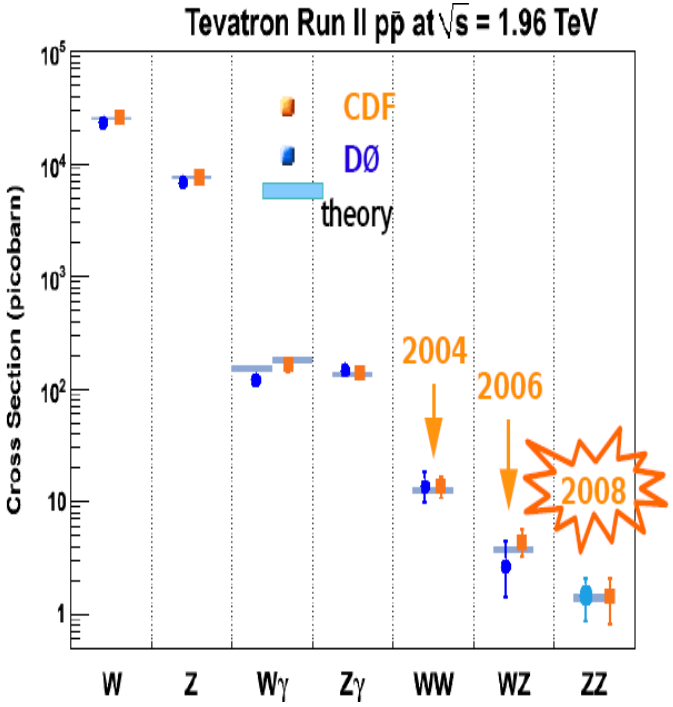




Diboson Production

- Probe of non-abelian structure of SM and sensitive to New Physics.





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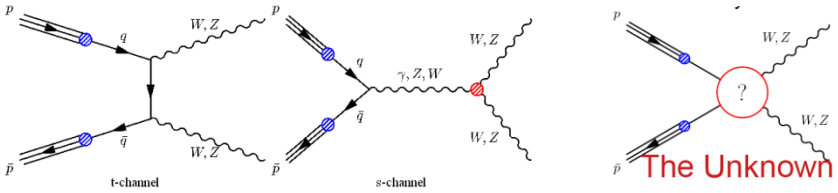

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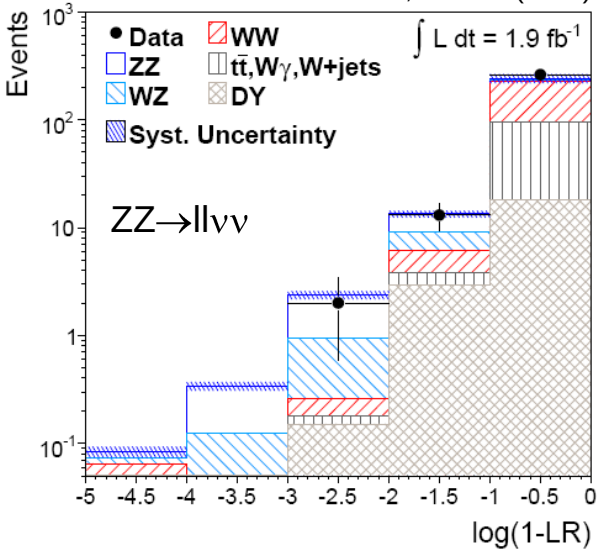
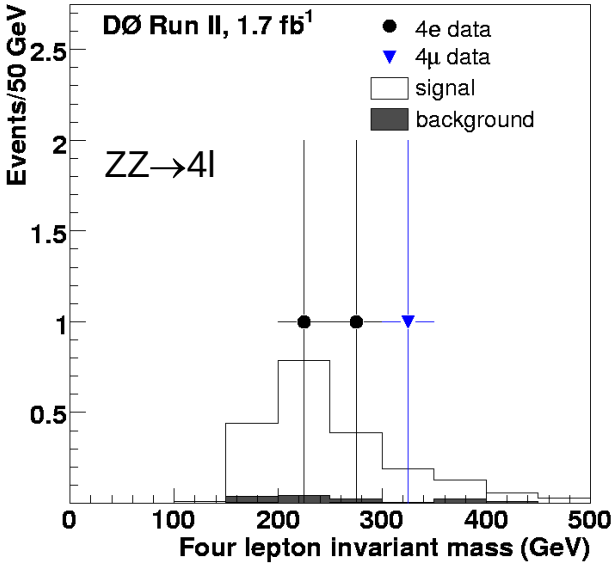
PRL 100, 201801 (2008)



PRL 101, 171803 (2008)



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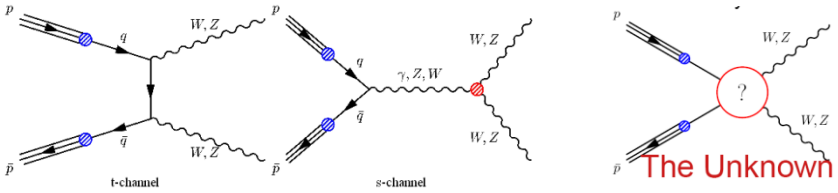

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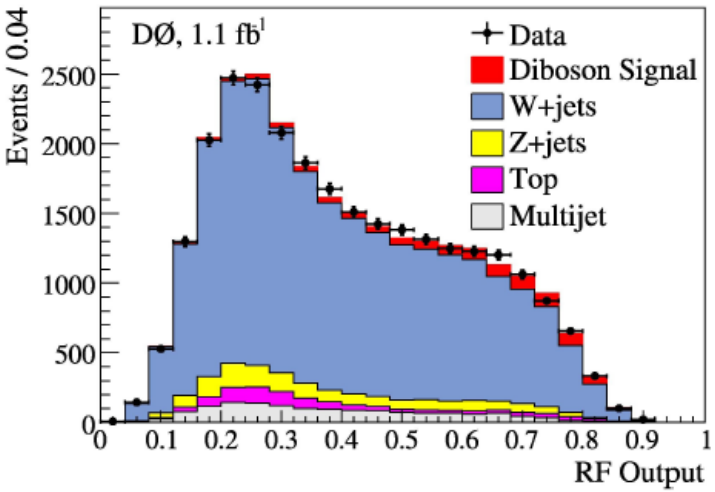
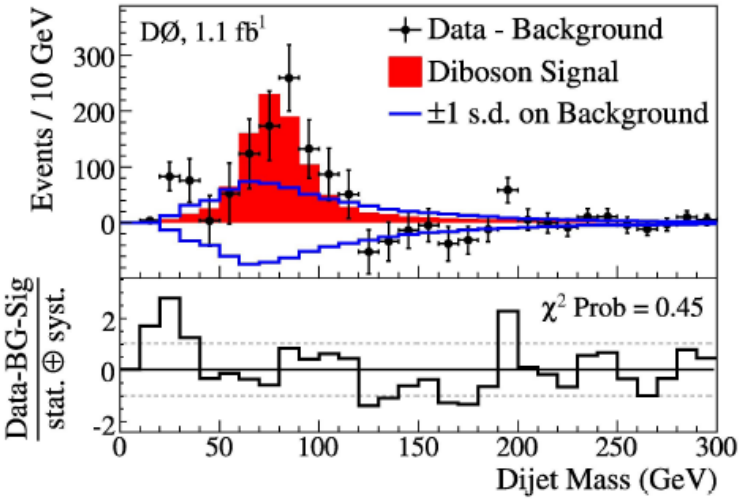
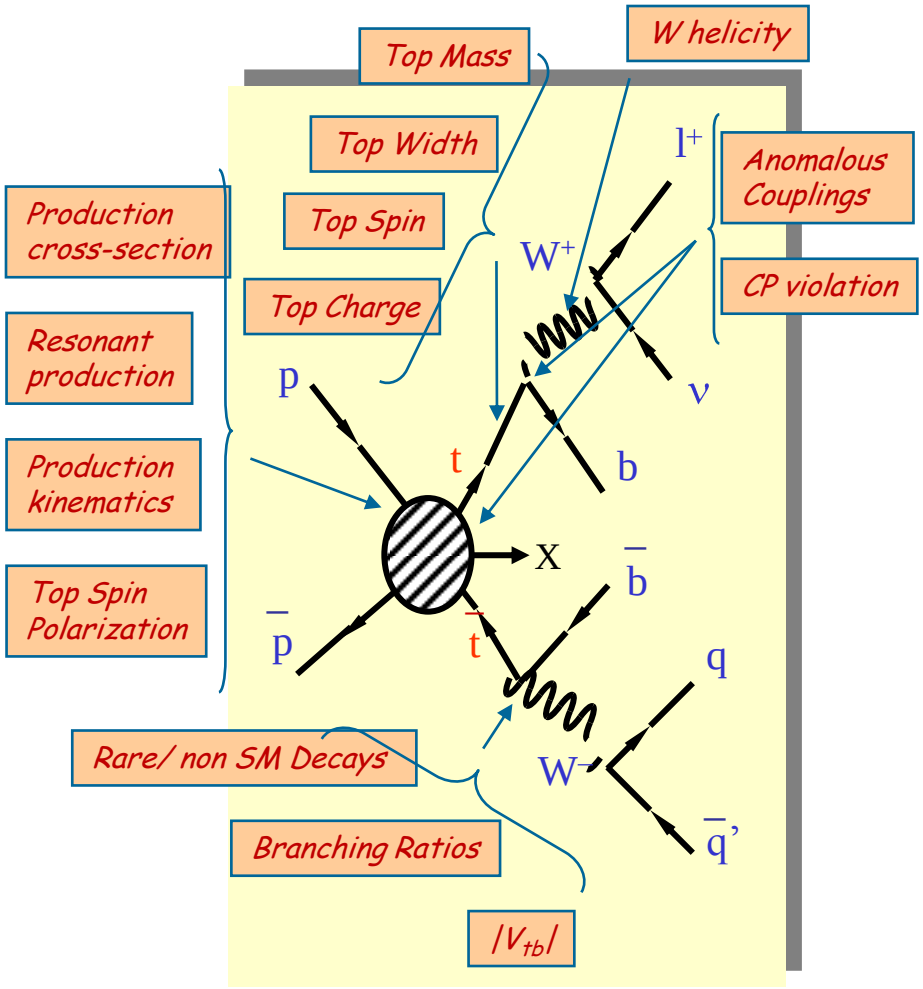
WW/WZ→lνjj arXiv:0810.3873 [hep-ex]





Top Physics Program

- Precision measurements of top quark properties crucial in order to unveil its true nature: $\lambda_t = \sqrt{2}\, m_t/v = 0.991 \pm 0.007$!!!
- Extremely rich program of measurements.
- Large top samples in Tevatron Run II have allowed to make the transition from the discovery phase to a phase of precision measurements of top quark properties.



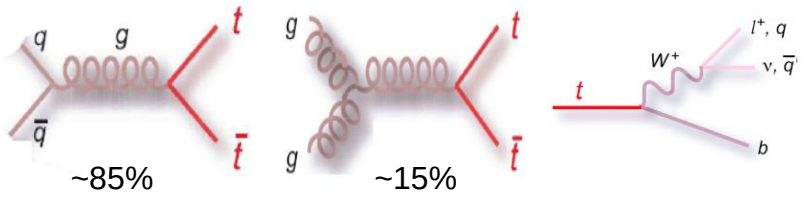
Top Quark Production and Decay

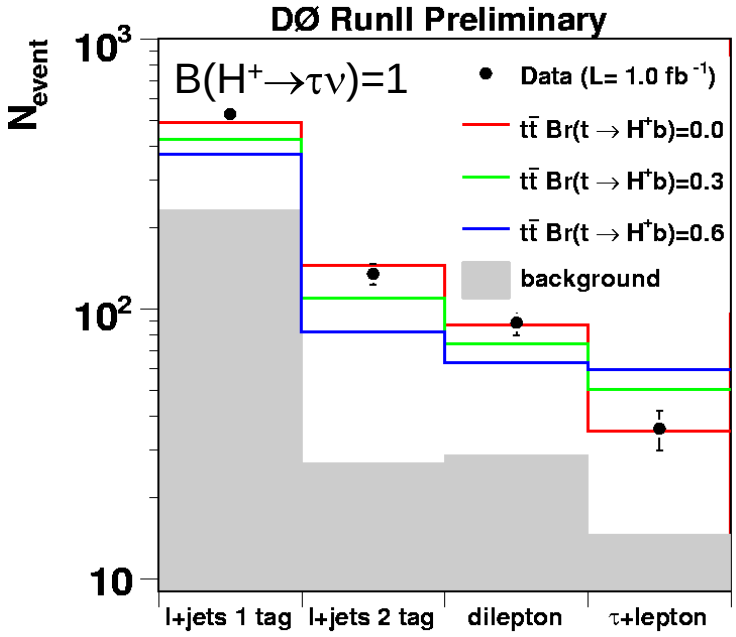
- Top quarks dominantly produced in pairs via the strong interaction.
- Measured cross sections in agreement with SM.

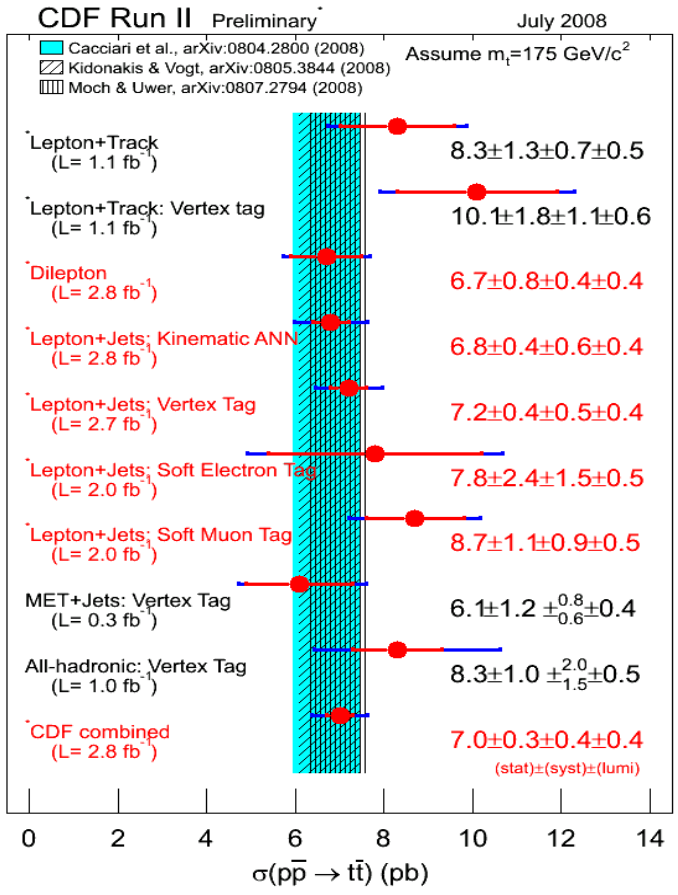
  Experimental precision from combination of channels (~9%) comparable to theoretical error.

- Precise measurements in different channels allows to place constraints on New Physics.

  E.g. $t \to H^+ b$: channels affected differently depending on H^+ decay modes.







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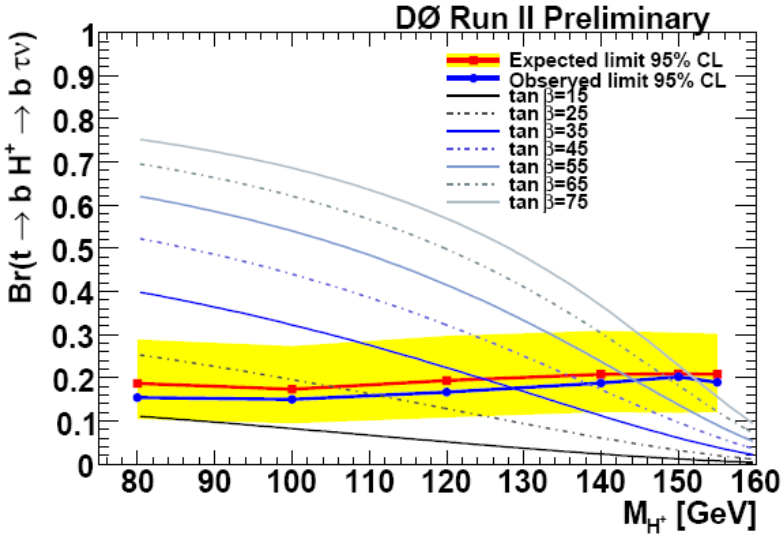
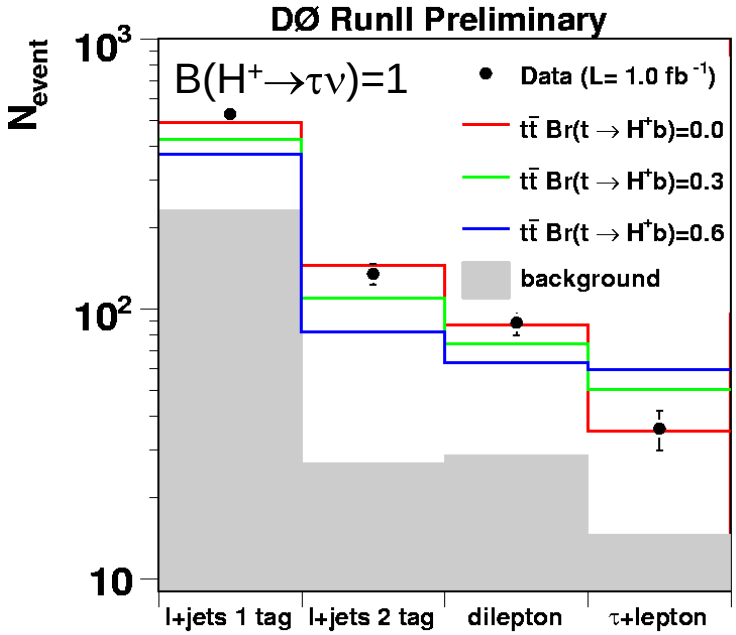
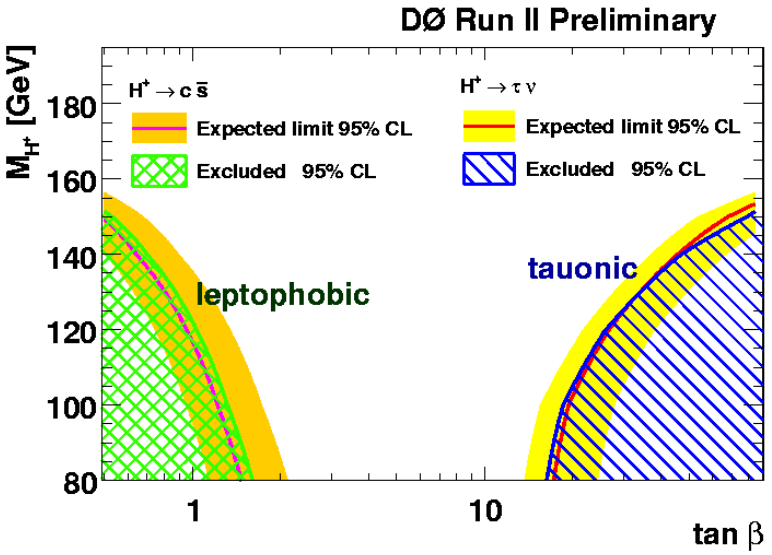






Top Quark Production and Decay

- Top quarks dominantly produced in pairs via the strong interaction.
- Measured cross sections in agreement with SM.

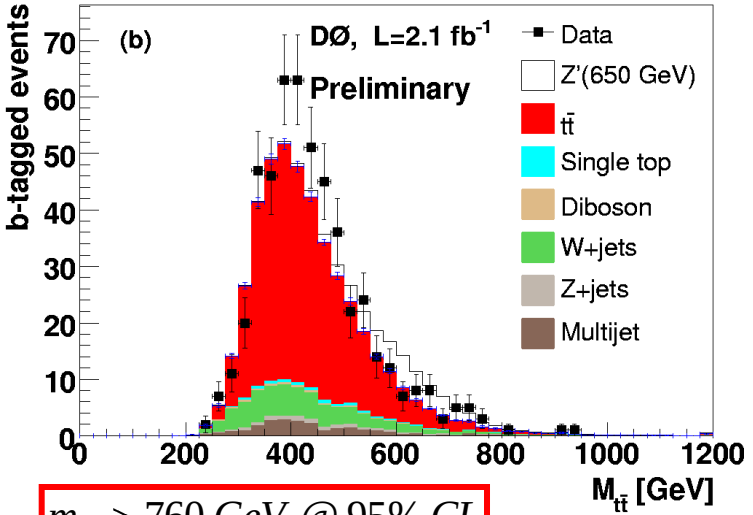
  Experimental precision from combination of channels ~9% (comparable to theoretical error).

- Precise measurements in different channels allows to place constraints on New Physics.

  E.g. $t \to H^+ b$: channels affected differently depending on H^+ decay modes.

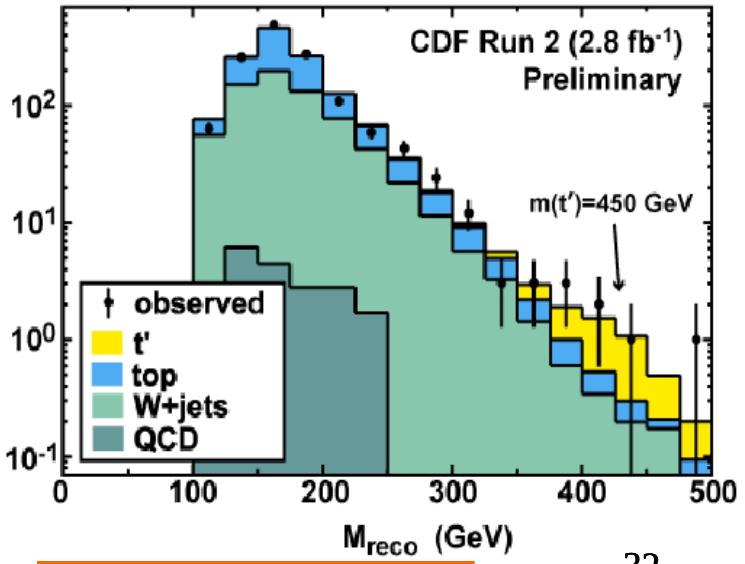
- Also probing for non-SM production mechanisms (e.g. $Z' \to tt$) or New Physics contamination in the top samples (e.g. $t't' \to WqWq$).

Using top as a tool to look for New Physics



$m_{Z'} > 760\ GeV\ @\ 95\%\ CL$

(leptophobic Z' with Γ/M=1.2%)

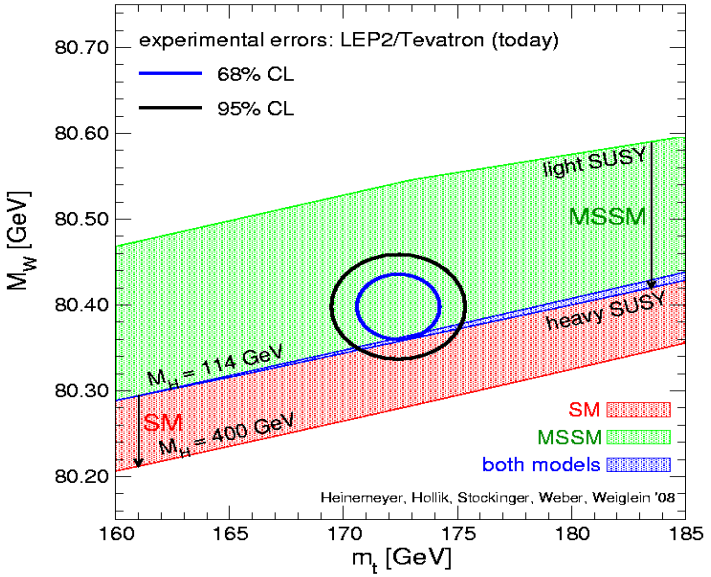


$m_{t'} > 311\ GeV\ @\ 95\%\ CL$

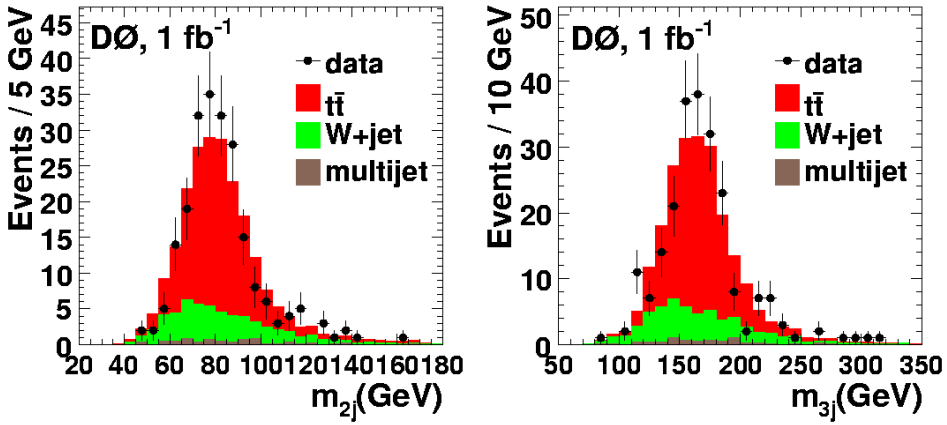
Top Quark Mass

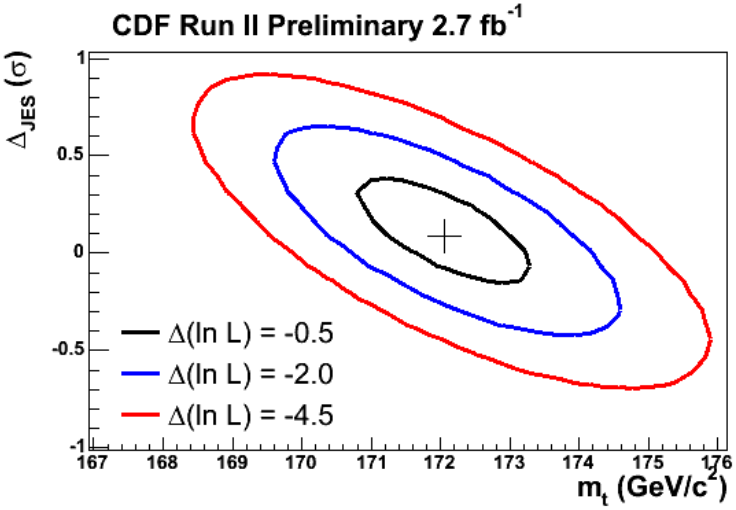
- Fundamental parameter of the Standard Model.
- Important ingredient for EW precision analyses at the quantum level.
  - ⇒ incisive consistency checks
  - ⇒ constrain/rule out models of New Physics
  - ⇒ provide valuable information on the parameters of the Lagrangian

- Sophisticated techniques to minimize statistical and dominant systematic uncertainties (JES via in-situ calibration to M_W in lepton+jets).



PRL 101, 182001 (2008)





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  - $\Rightarrow$ provide valuable information on the parameters of the Lagrangian

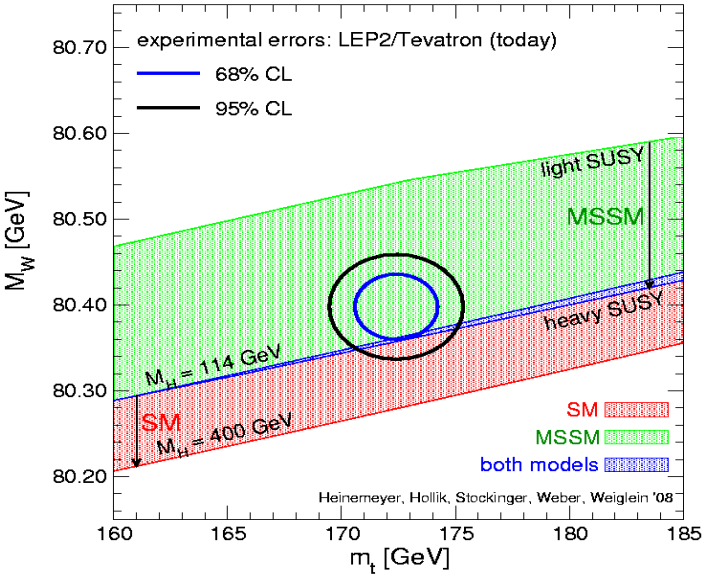
- Sophisticated techniques to minimize statistical and dominant systematic uncertainties (JES via in-situ calibration to M_W in lepton+jets).

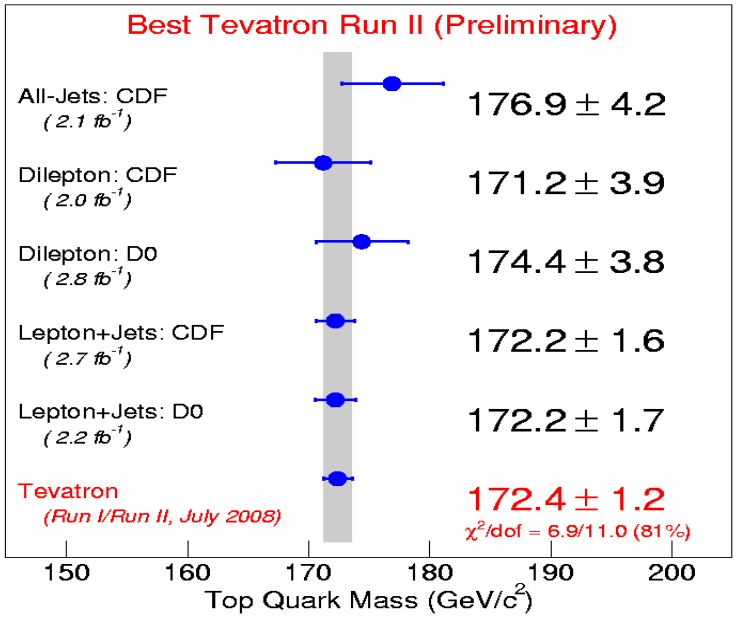
- Current world-average (most sensitive channels use up to 2.7 fb^{-1}):

$$m_t = 172.4 \pm 0.7 \pm 1.0\ GeV$$

Measurement will be limited by systematic uncertainties (signal modeling, b-jet response), some of which can be constrained by data.

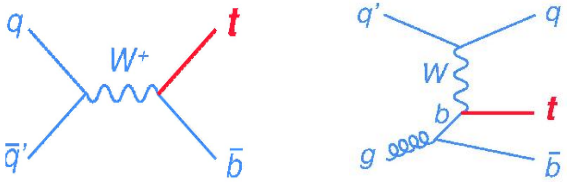
Estimate ultimate precision ≤1 GeV



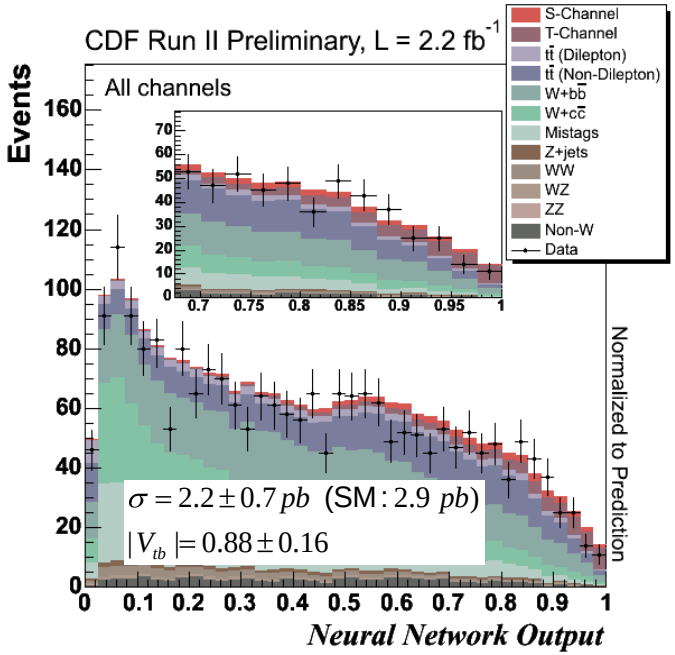


Probing the *tbW* Interaction

Electroweak single top production

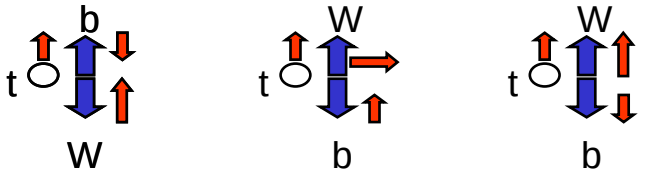


- Cross section proportional to *tbW* strength
- Rate ~1/2 tt but very large W+jets background
- Both experiments have evidence for single top via sophisticated multivariate techniques to extract the signal.



Expect observation with ~3 fb^{-1}

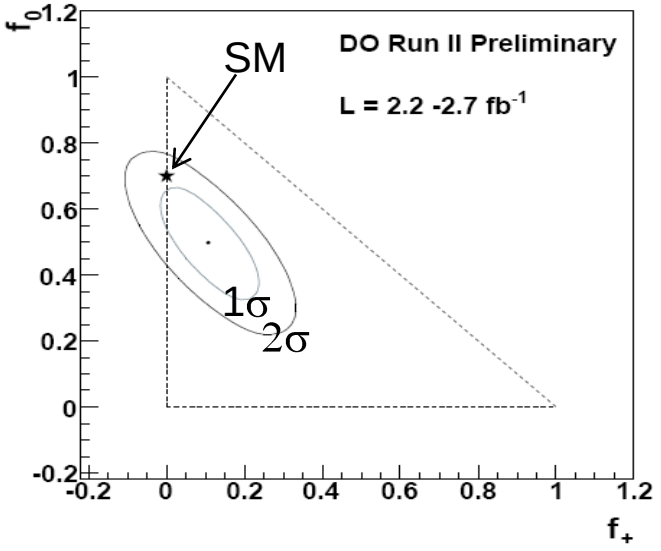
W helicity in top quark decays



$\lambda_W = -1$ $\lambda_W = 0$ $\lambda_W = +1$

SM: $F_- \approx \frac{2M_W^2}{m_t^2 + 2M_W^2} = 0.30$ $F_0 \approx \frac{m_t^2}{m_t^2 + 2M_W^2} = 0.70$ $F_+ = 0$

- Reconstruct helicity angle of lepton in top quark pair events.



Sensitive to ratio of anomalous couplings

Probing the *tbW* Interaction

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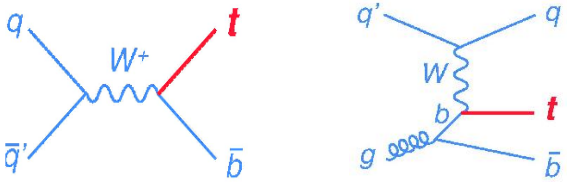
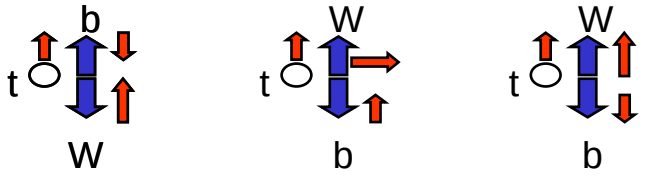


- Cross section proportional to *tbW* strength
- Rate ~1/2 tt but very large W+jets background
- Both experiments have evidence for single top via sophisticated multivariate techniques to extract the signal.

- With full dataset:
  - $\Delta V_{tb}/V_{tb}$~8%
  - Simultaneous measurement of s- and t-channel cross sections.
  - Model-independent measurement of *tbW* couplings.
  - Searches for anomalous production (W', H^+, FCNC)

Results available on all these topics with <2 fb^{-1}

W helicity in top quark decays



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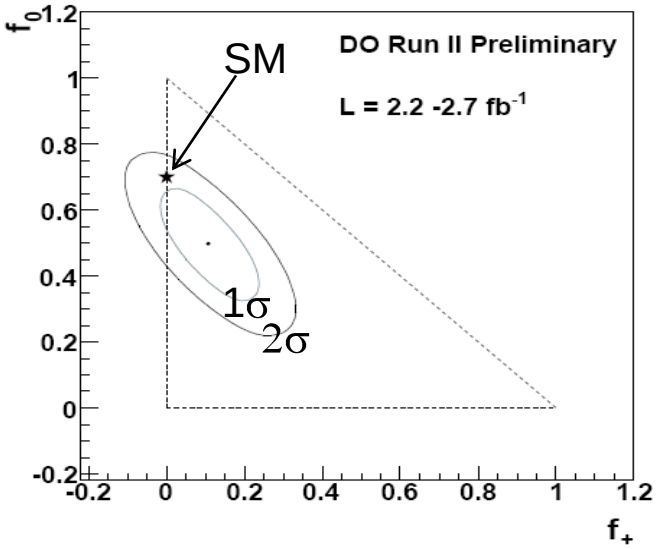


Sensitive to ratio of anomalous couplings

New Phenomena Searches

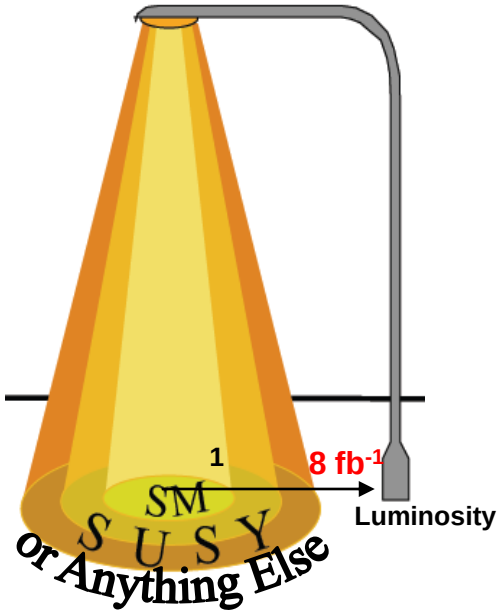
Model-inspired searches: theory-driven

➔ optimized analyses to extract well-defined signals.

- SUSY: (heavy-quark)jets + MET, multi-leptons + MET, multi-photons+MET, long-lived massive particles, rare B decays, etc
- Extra Dimensions: mono-jets, di-lepton/di-photon resonances
- Extra gauge bosons: W', Z'
- Leptoquarks
- Compositeness: excited leptons,..
- …

Signature-based searches: final-state driven

➔ Looking for deviations from the SM anywhere.

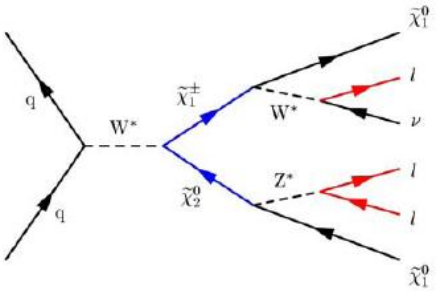


Prospects for discoveries remain open:

1. Tevatron is still the energy frontier.
2. High luminosity: significant signals may quickly develop as luminosity grows and analyses mature.
3. Well understood detector, refined experimental techniques and experienced collaborations. Data makes you smarter…

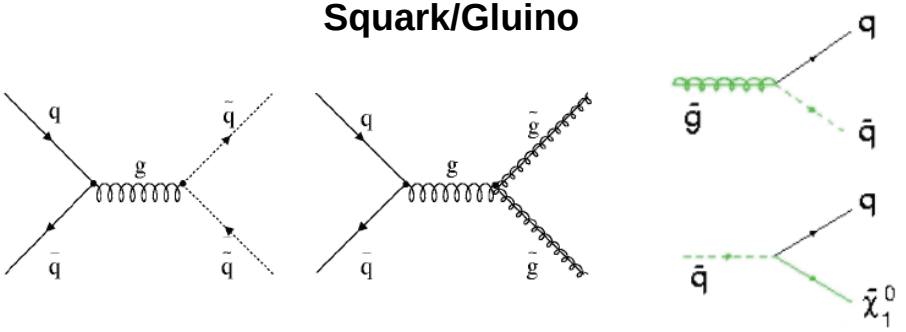
SUSY Searches

Chargino/Neutralino

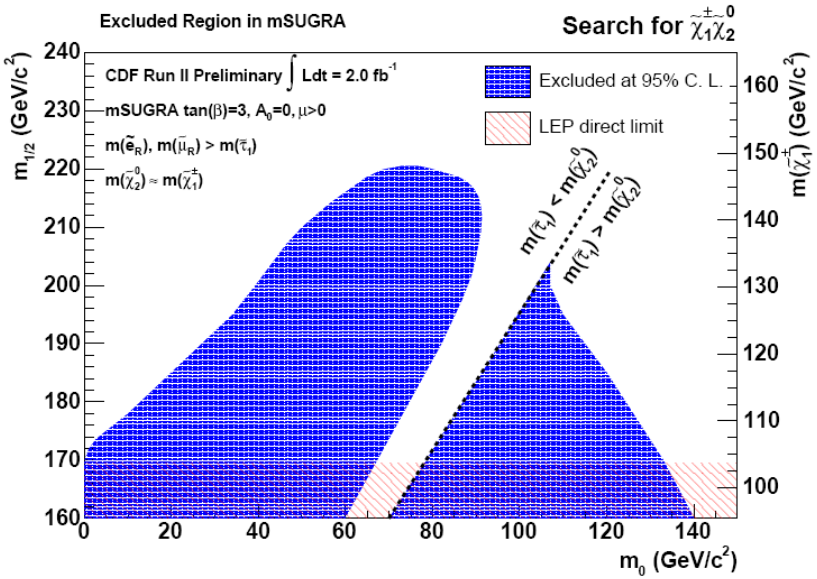


- Clean multi-lepton+MET signature, but:
  - low σxBR (<0.1 pb)
  - low p_T leptons (<10 GeV)
- Challenges: lepton ID at low p_T

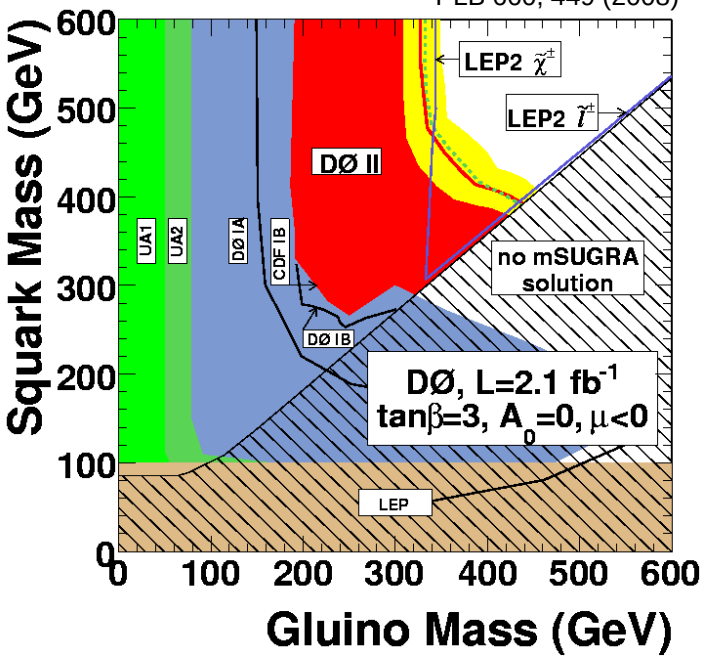
Squark/Gluino



- Pair production of q̃,g̃ with decays involving multi-jets + MET.
- Critical to understand tail of MET distribution.



PLB 660, 449 (2008)



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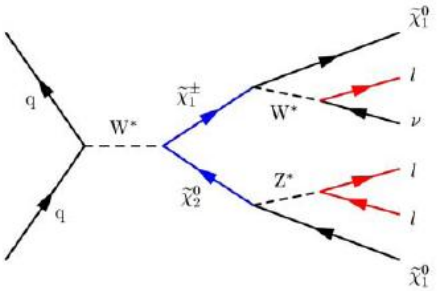

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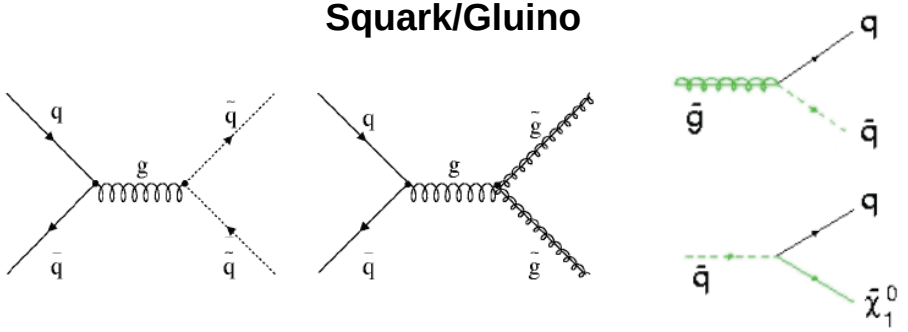
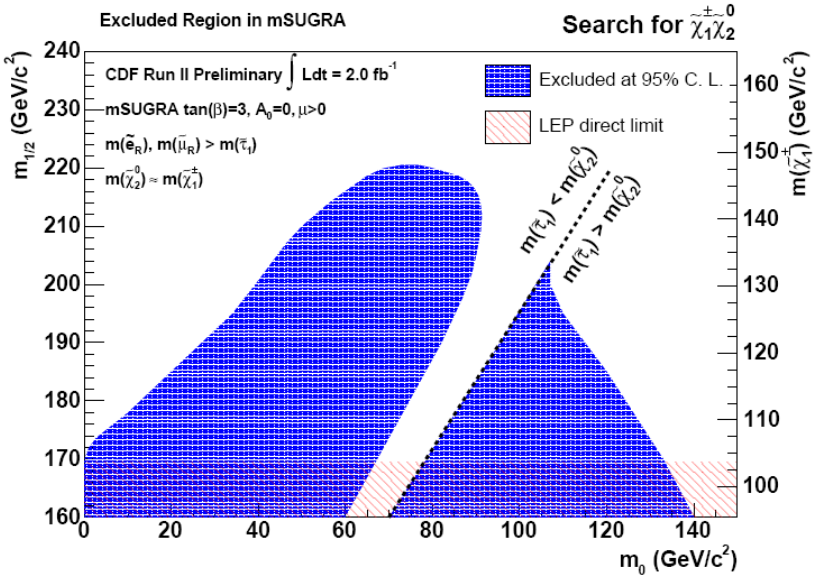
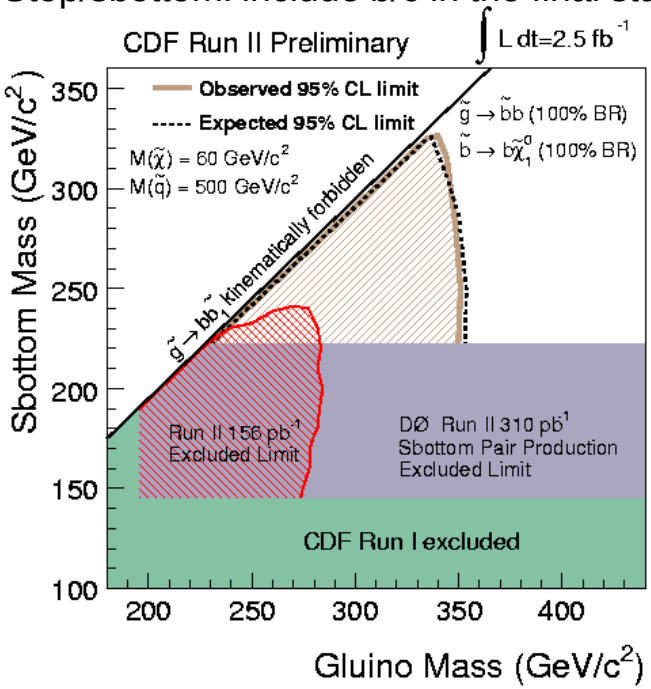


- Pair production of q̃,g̃ with decays involving multi-jets + MET.
- Critical to understand tail of MET distribution.
- Stop/sbottom: include b/c in the final state.

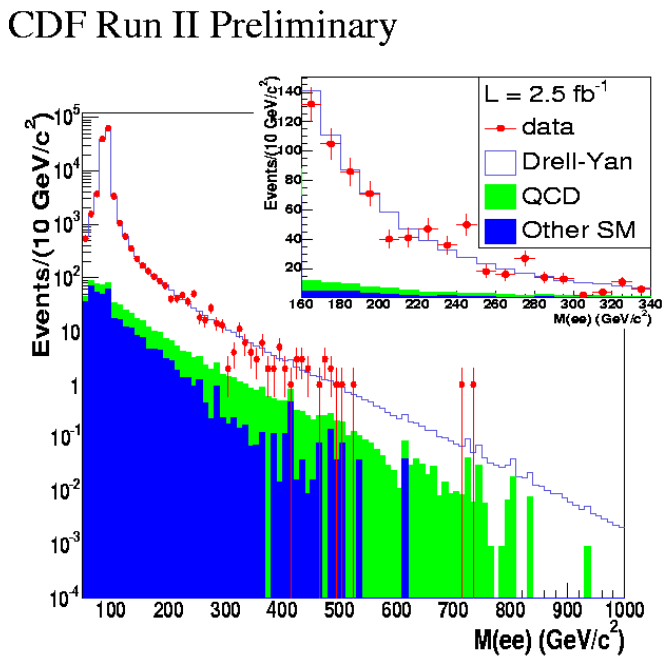




Non-SUSY Searches

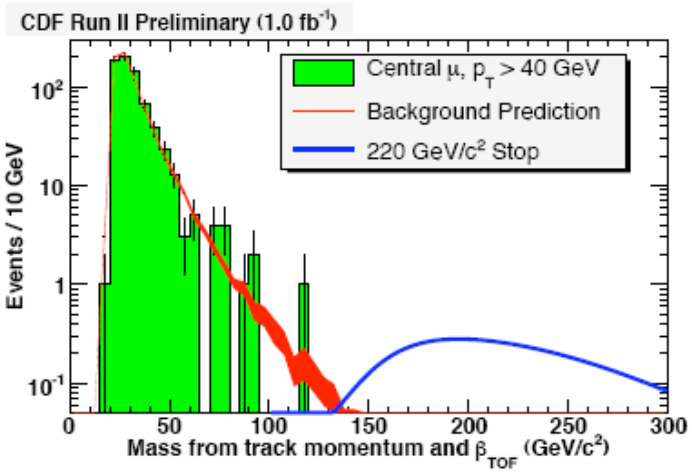
Di-lepton invariant mass distributions probes:

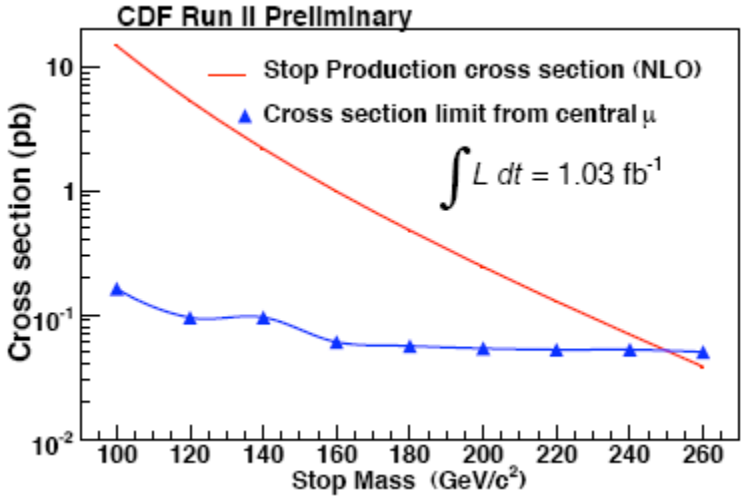
- New Z' gauge bosons: expected in many beyond-SM scenarios (GUTs, etc).
- Extra-dimensions (large, Randall-Sundrum gravitons, etc)



- Most significant excess at M(ee)~240 GeV (3.8σ). Probability for fluctuation in 150-1000 GeV range 0.6% (2.5σ).
- Observed limits ~840-966 GeV depending on Z' model.

- Quasi-model independent searches for long-lived or "stable" particles:
  - Using Time-of-Flight system (CDF) or muon timing (DØ).





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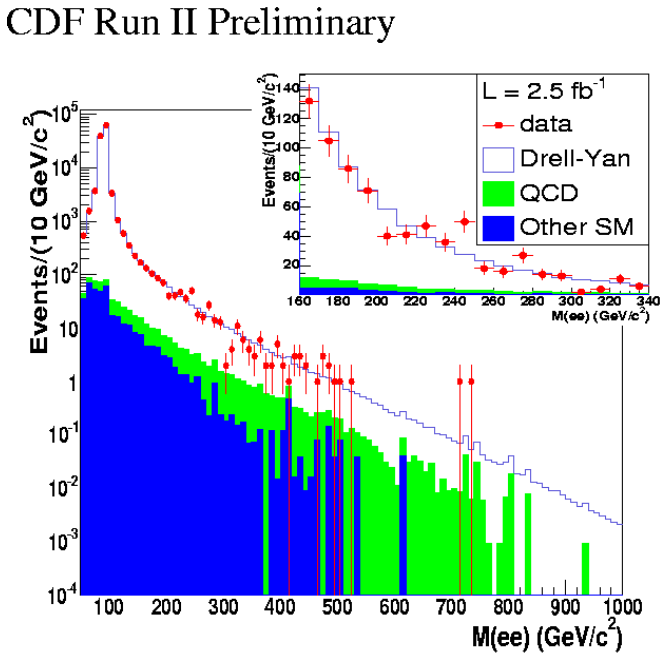

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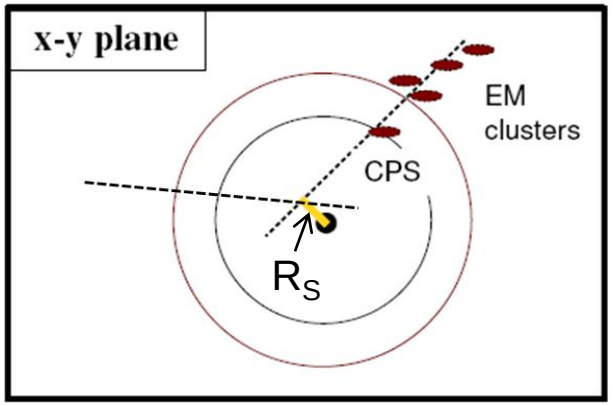
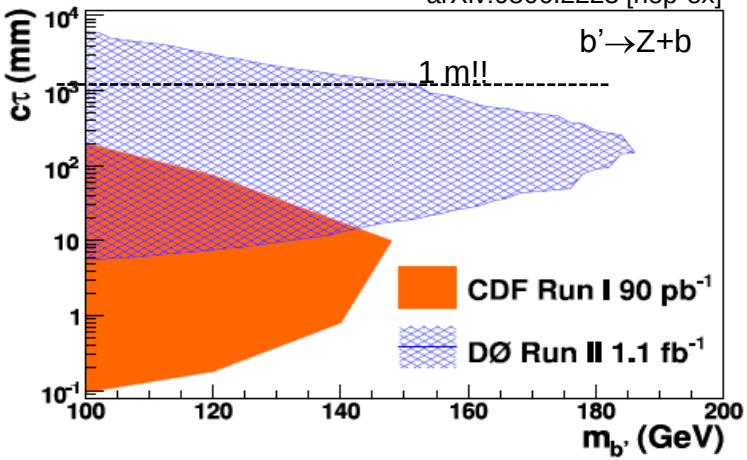
  - Reconstructing displaced vertices with the tracking system (CDF) or the calorimeter and preshower (DØ).

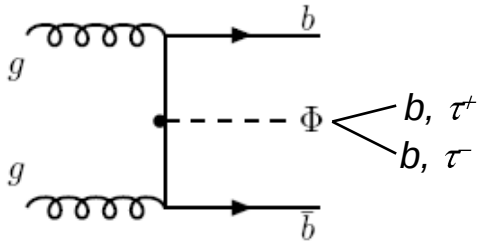


arXiv:0806.2223 [hep-ex]



SUSY Higgs

- MSSM at large tanβ:
  - $\Phi^0=\{h^0/H^0,A^0\}$ nearly degenerated in mass
  - Coupling to b, τ enhanced ($\propto$tanβ) ➔ $\sigma_{\Phi+X} \propto 2 \times \tan^2\beta$
  - BR($\Phi^0 \to bb$)~90%, BR($\Phi^0 \to \tau^+\tau^-$)~10%



- Three complementary channels:
  - b(b)+$\Phi^0 \to$bbb(b)
  - b(b)+$\Phi^0 \to \tau^+\tau^-$ b(b) (require one $\tau \to e,\mu$)
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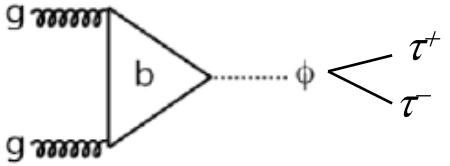

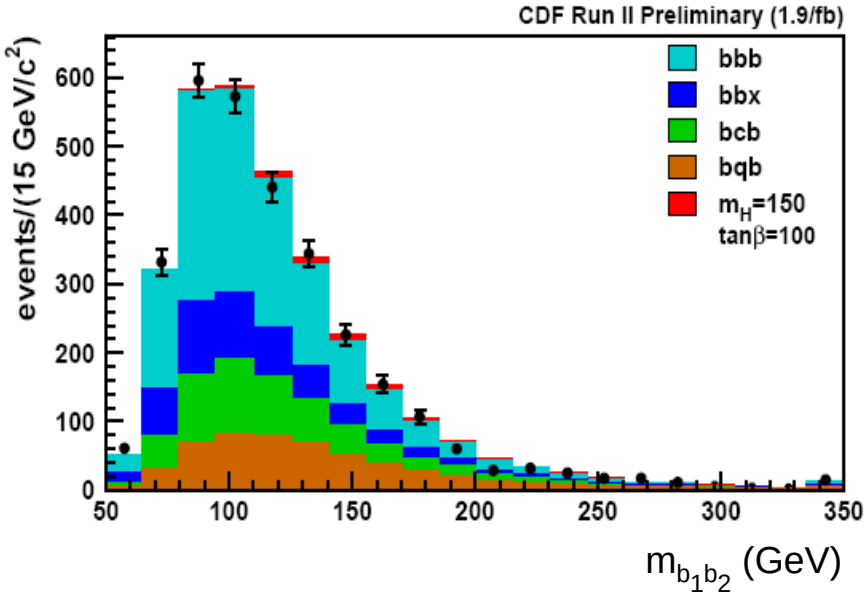

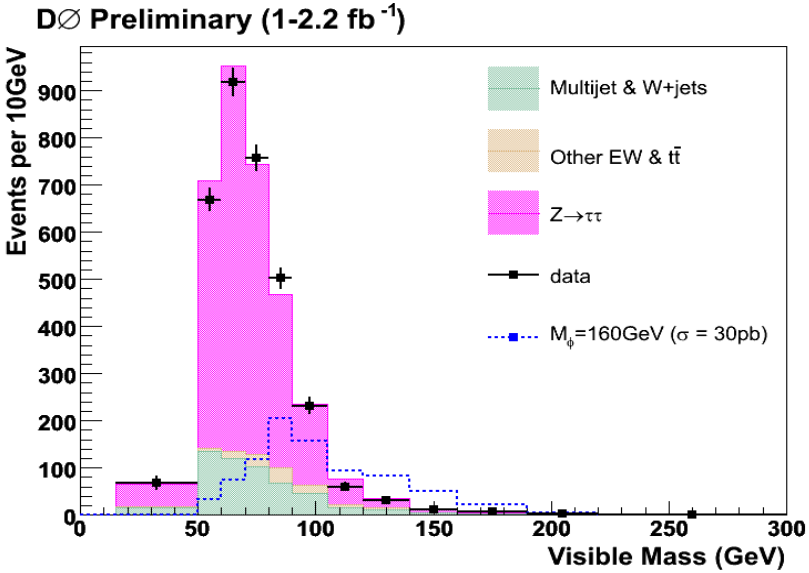

$$M^{vis} = \sqrt{\left(p_\ell^\mu + p_\tau^\mu + p_T^\mu\right)^2}$$

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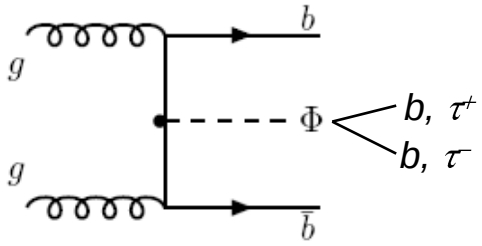

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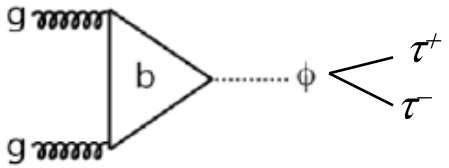
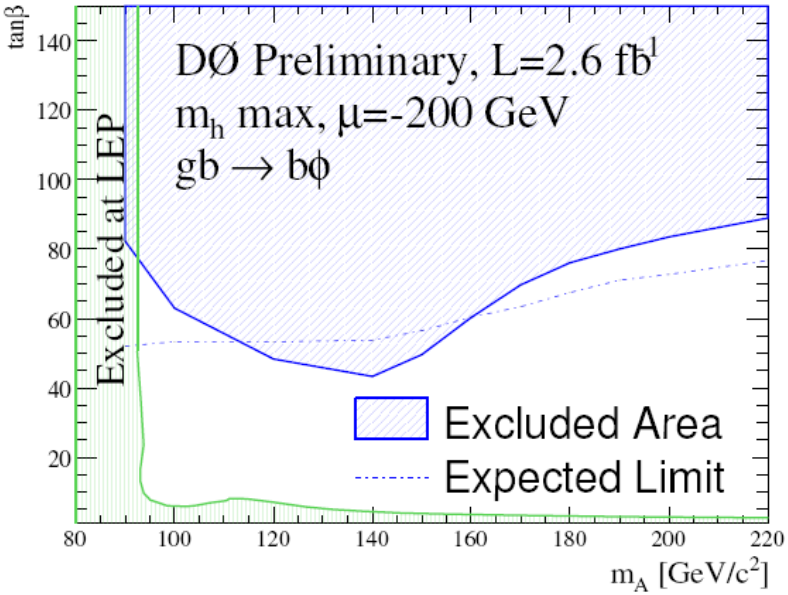
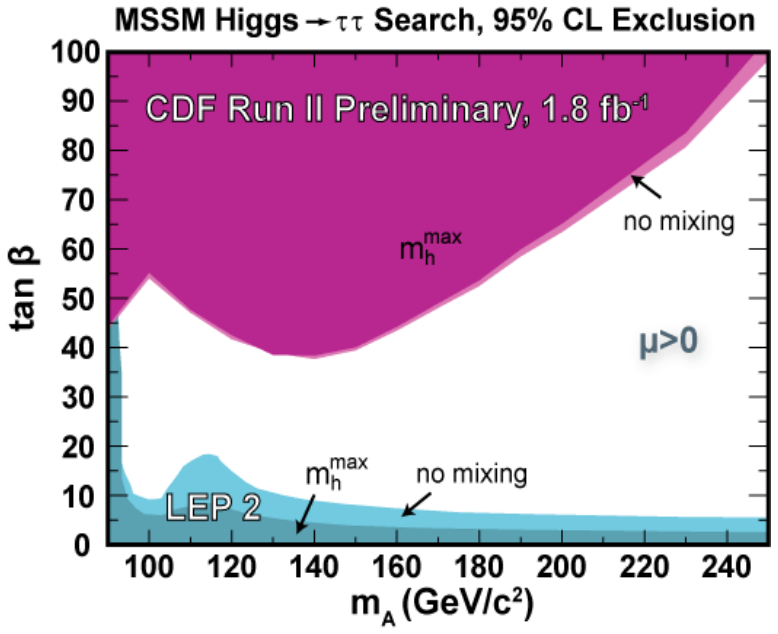






Individual searches approaching "interesting" range tanβ < m_t/m_b~35.
Combination underway.

SM Higgs at the Tevatron

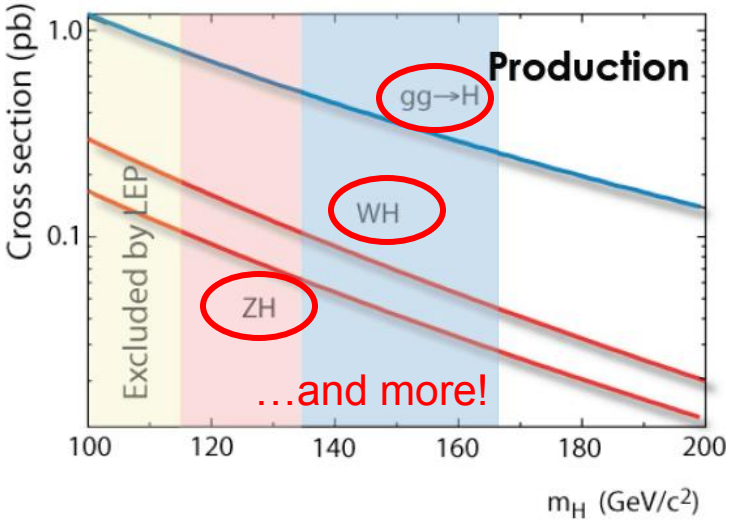
- Current experimental information (limits @ 95% CL):
  - SM LEP direct search: m_H>114 GeV
  - SM indirect constraint: m_H<154 GeV
    + LEP direct search: m_H<185 GeV

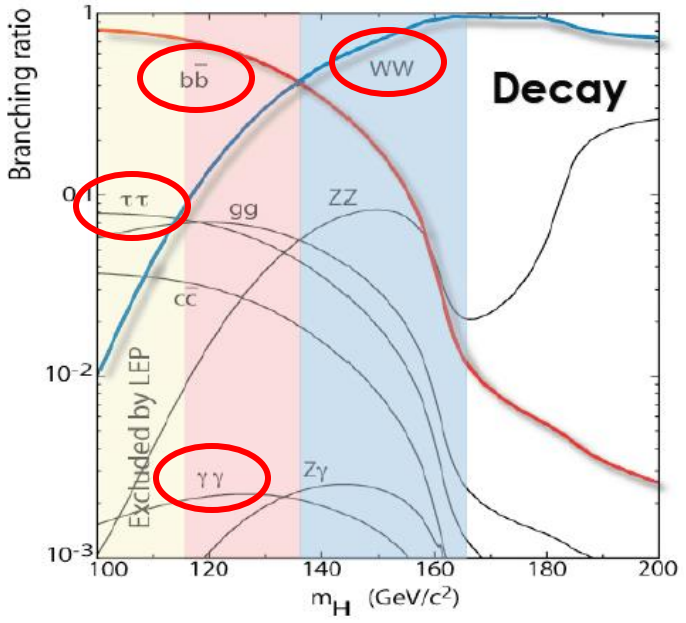
➔ Tevatron is sensitive over whole "interesting" mass range.

- Main production mechanisms (115<m_H<180 GeV):
  - Gluon fusion (gg→H): σ~0.8-0.2 pb
  - Associated production (VH, V=W,Z): σ~0.2-0.03 pb

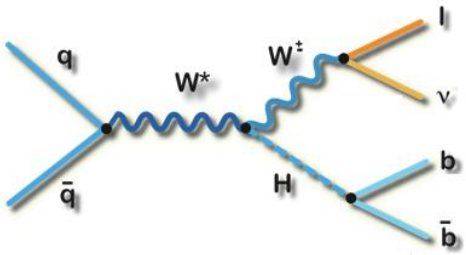
- Dominant decay channels:
  - m_H<135 GeV: H→bb
  - m_H>135 GeV: H→WW$^{(*)}$

- Search strategy:
  - Low mass region:
    dominated by WH→lνbb, ZH →l^+l^-bb, ZH→ννbb
  - High mass region:
    dominated by gg→H→WW$^{(*)}$→ $l^+νl'^-ν$
  - Complement with many other channels:
    VBF production, VH→qqbb, H→ττ(with 2jets), H→γγ, WH->WWW, ttH,…





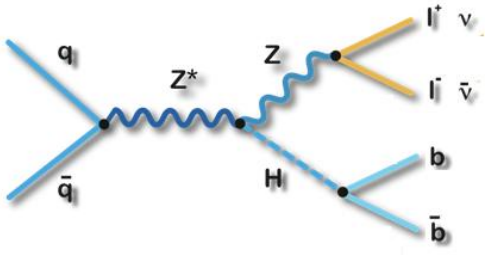
SM Low Mass Higgs



1 high p_T lepton

MET

2 b-jets



2 high p_T leptons

2 b-jets

High MET

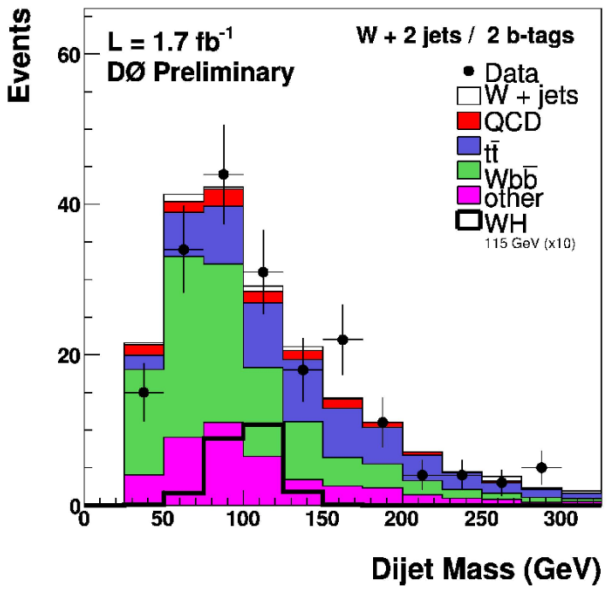
2 b-jets

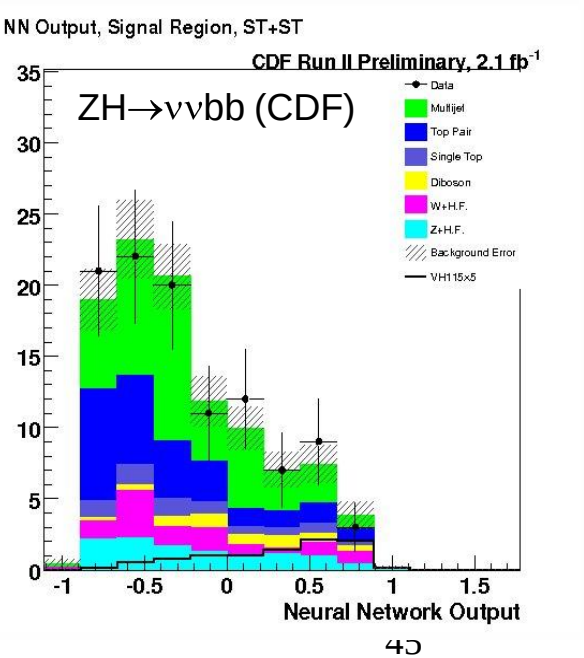
Key issues:

- Lepton identification
- B-tagging performance
- Dijet mass resolution
- Background modeling
  - W/Z+heavy-flavor jets
  - Multijets (ZH→ννbb)
- All analyses use multivariate techniques for signal-to-bckg discrimination.

95%CL Limits at m_H = 115 GeV

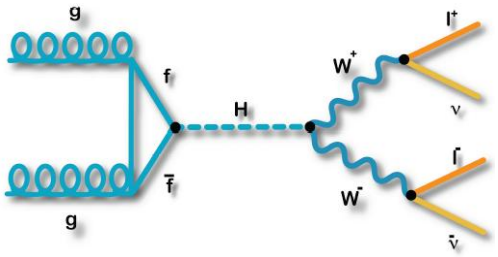
Analysis	Lum (fb^{-1})	Limit (σ/SM)	
		Exp.	Obs.
WH→lνbb (CDF)	2.7	5.6	5.7
WH→lνbb (DØ)	1.7	8.5	9.3
ZH→ννbb (CDF)	2.1	6.3	7.9
ZH→ννbb (DØ)	2.1	8.4	7.5
ZH→l^+l^-bb (CDF)	2.4	11.8	11.6
ZH→l^+l^-bb (DØ)	2.3	12.3	11.0





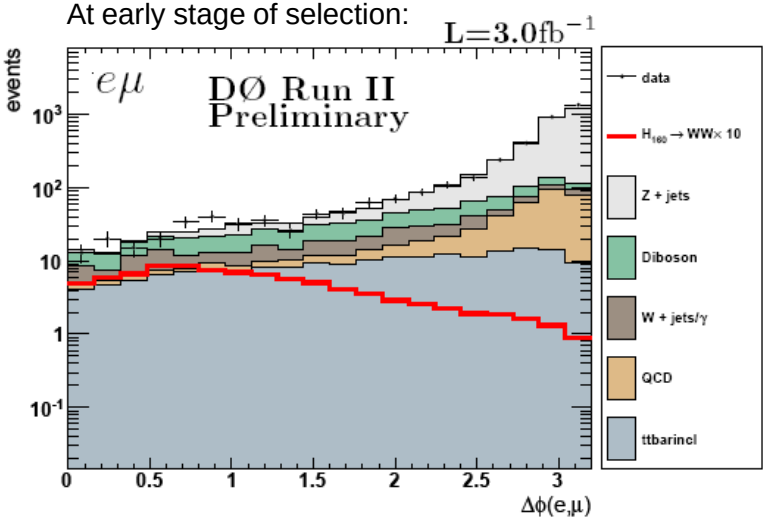
Best individual channels have expected limits ~6xSM

SM High Mass Higgs



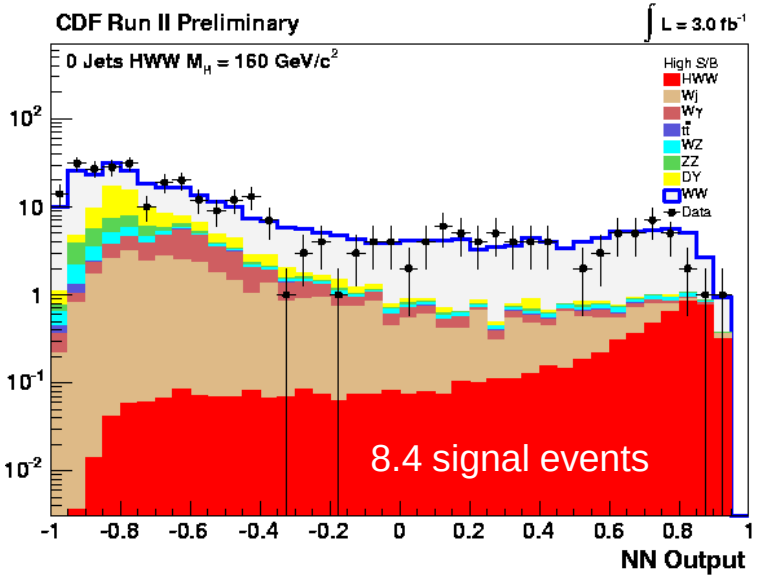
ee, μμ, eμ

At early stage of selection:



- Highest sensitivity channel for m_H>130 GeV.
- Main backgrounds:
  - m_H~160 GeV: WW
  - m_H~130 GeV: W+jets
- Low $\Delta\phi$(l,l) because of spin-0 Higgs.
- Capitalize on improvements in lepton identification and multivariate techniques.

After full selection:

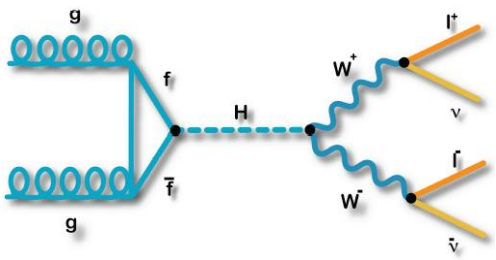


95%CL Limits at m_H = 165 GeV

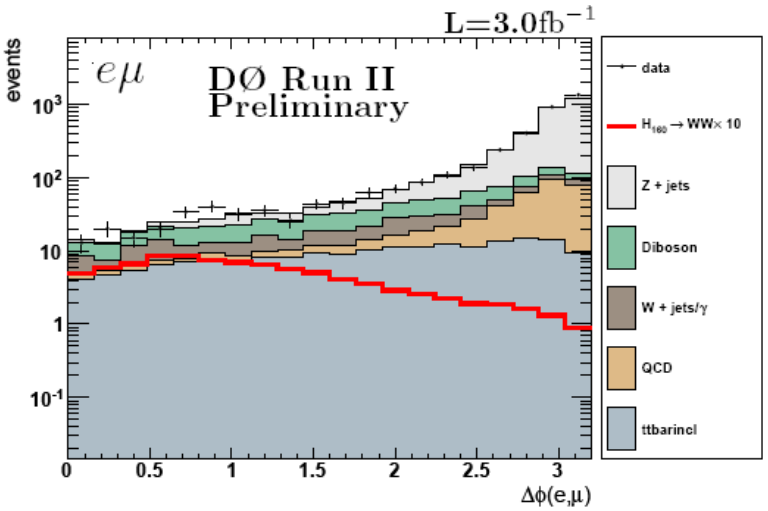
Analysis	Lum (fb^{-1})	Higgs Events	Limit (σ/SM)	
			Exp.	Obs.
CDF	3.0	17.2	1.6	1.6
DØ	3.0	15.6	1.9	2.0

Both experiments approaching SM sensitivity!

SM High Mass Higgs



ee, μμ, eμ



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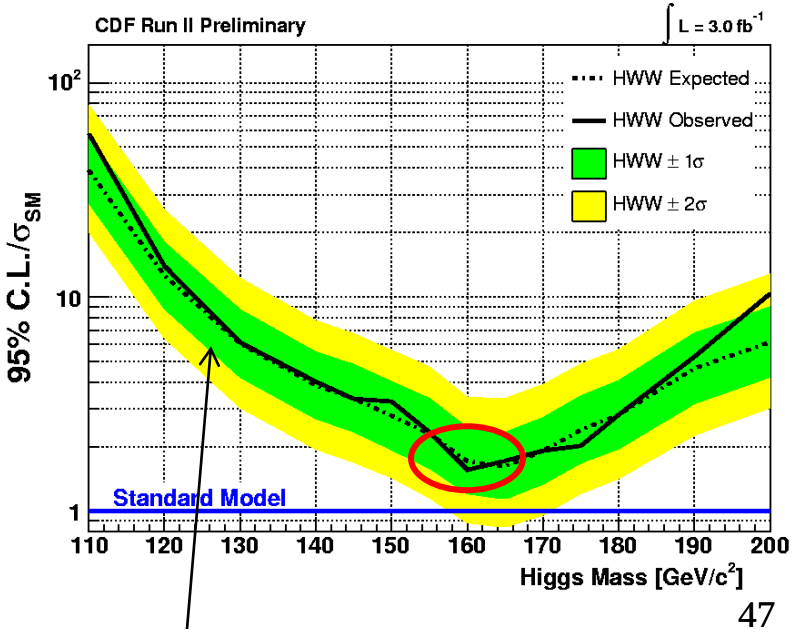
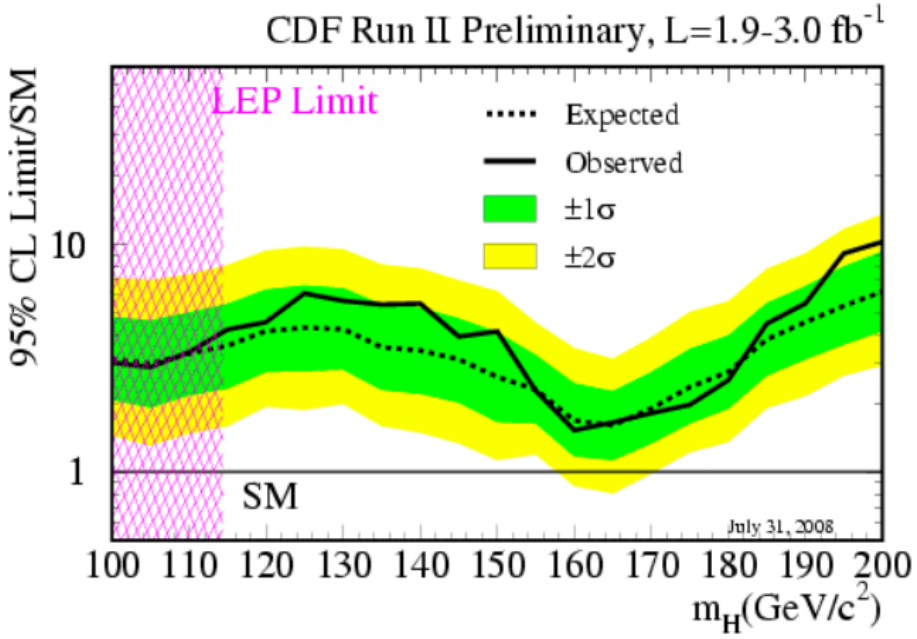
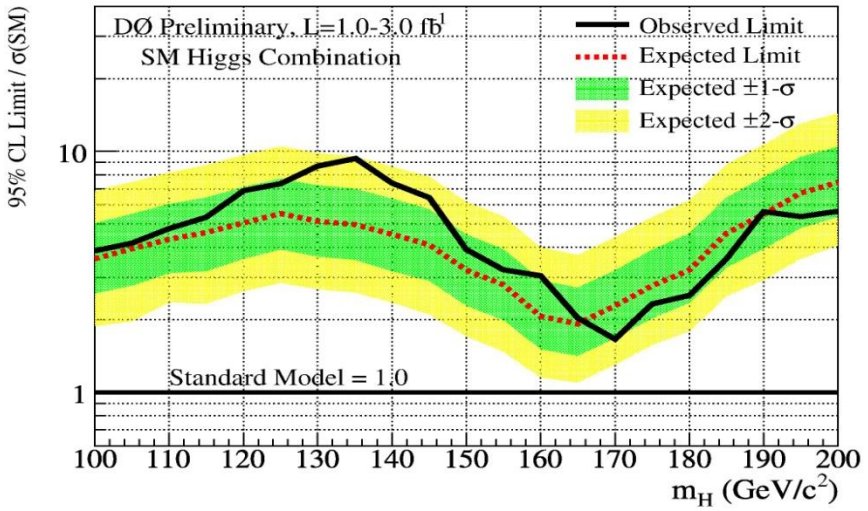


Significant sensitivity at low mass as well!

SM Higgs Combined Limits

- Calculation of limits and combination:
  - Using Bayesian and CLs approaches.
  - Incorporate systematic uncertainties (including correlations) using pseudo-experiments.
  - Some uncertainties are effectively constrained by data.





At m_H = 115 GeV:

Exp. limit: 3.6 x SM
Obs. limit: 4.2 x SM

At m_H = 165 GeV:

Exp. limit: 1.6 x SM
Obs. limit: 1.6 x SM

At m_H = 115 GeV:

Exp. limit: 4.6 x SM
Obs. limit: 5.3 x SM

At m_H = 165 GeV:

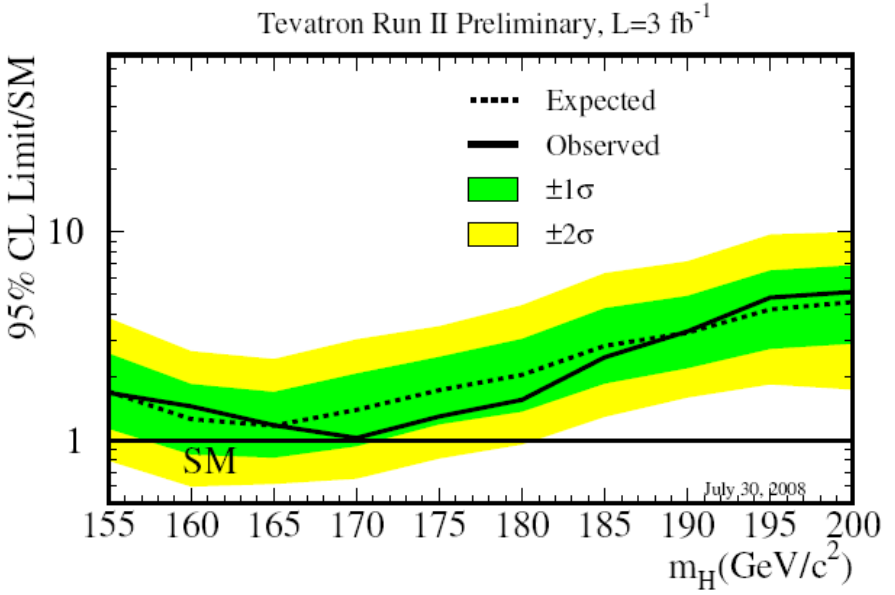
Exp. limit: 1.9 x SM
Obs. limit: 2.0 x SM

Tevatron SM Higgs Combination

Excluded m_H = 170 GeV @ 95% CL

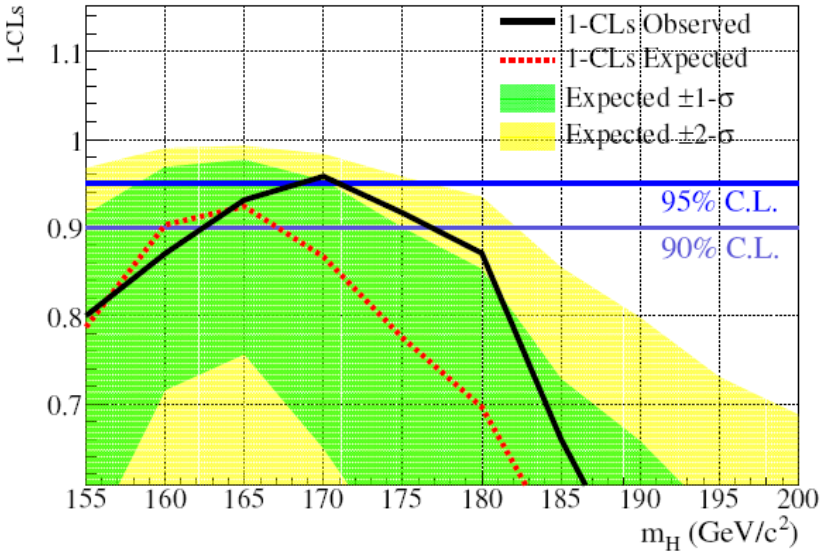
95%CL Limits/SM

M_Higgs(GeV)	160	165	**170**	175
Method 1: Exp	1.3	1.2	1.4	1.7
Method 1: Obs	1.4	1.2	**1.0**	1.3
Method 2: Exp	1.2	1.1	1.3	1.7
Method 2: Obs	1.3	1.1	**0.95**	1.2



arXiv:0808.0534 [hep-ex]

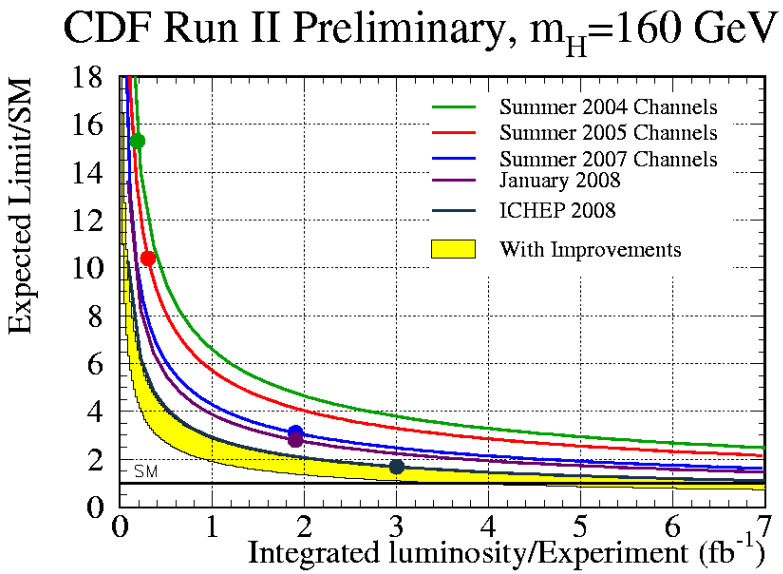
- First direct exclusion since LEP II.
- Verified using two independent methods (CLs, Bayesian).
- Expect to exclude wide mass range by Moriond'09.



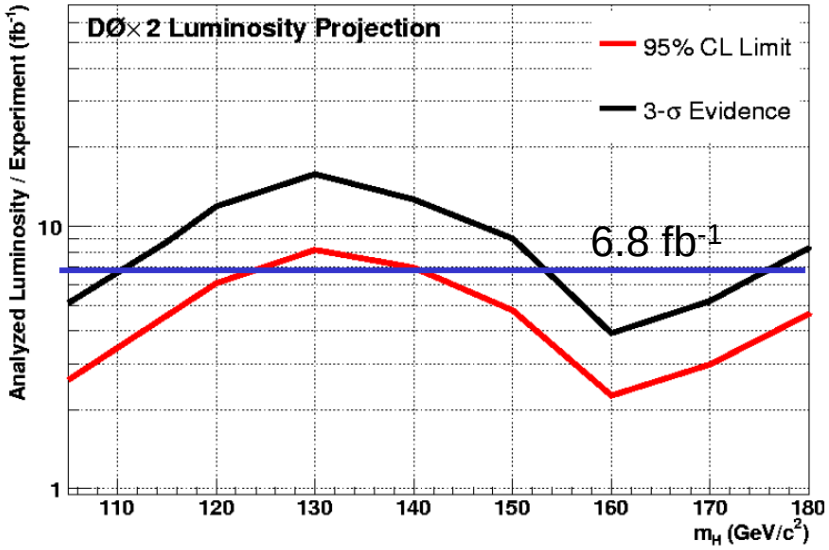
- Low mass Tevatron combination not available yet.
  - Challenging owing to the large number of channels (~70).
  - Expected sensitivity (as of ICHEP'08):
    < 3.0xSM @ m_H=115 GeV.

SM Higgs Prospects

- Limits have improved faster than $1/\sqrt{L}$ due to analysis improvements.
- Major effort underway to continue to improve sensitivity:
  - Optimized object identification/resolution
  - Optimized selections and signal-to-bckg discrimination
  - Reduced systematic uncertainties
  - Adding new channels
  - Adding more data!



- Median projected reach with 8.5 fb^{-1} delivered (6.8 fb^{-1} used in analysis):
  - Exclude at 95% CL over full mass range.
  - Evidence at low and high mass.
  - There is a band of possibilities around these lines.
- Tevatron complements LHC at low mass.

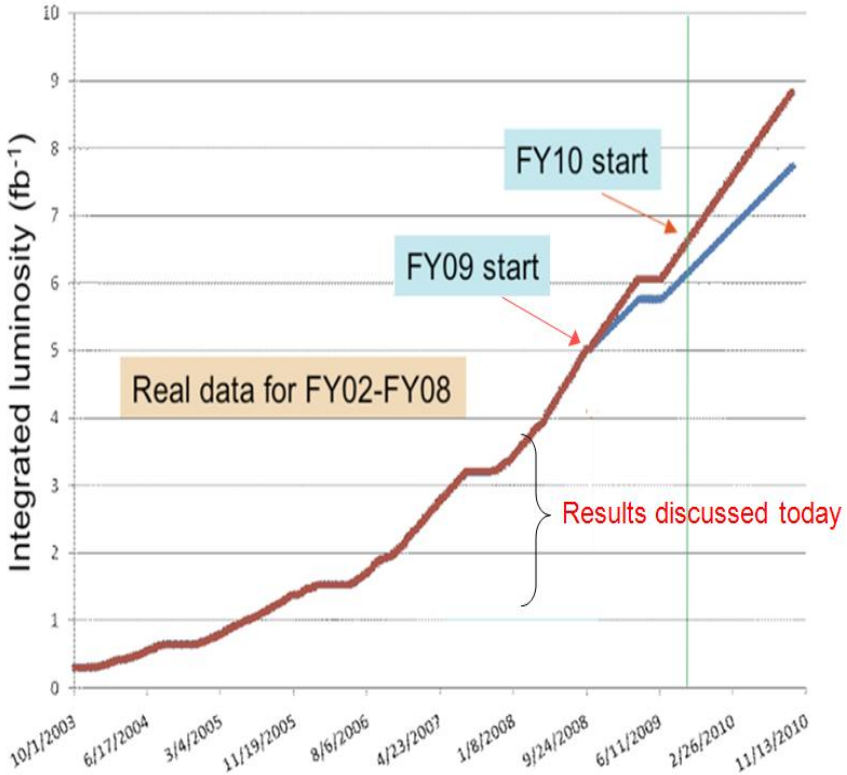


Conclusions

- Run II physics program in full swing.
- Excellent performance of the accelerator and CDF and DØ detectors. Collaboration strengths sufficient to carry out program.
- Expect >8 fb^{-1} by the end of the run. Analyzed luminosity will increase by a factor of ~2.5-7.
- Physics reach further expanded by analysis improvements.
- Expect significant statements from the Tevatron on precision measurements and the Higgs search.

  Prospects for discoveries remain open.
- Continue to establish benchmarks in analysis techniques for the LHC era.
- Exciting prospects for concurrent analysis of Tevatron and LHC data!

In a way we are "just getting started"…



For more information:

http://www-cdf.fnal.gov/physics/physics.html

http://www-d0.fnal.gov/Run2Physics/WWW/results.htm

Backup

Multi-Muon Events at CDF

- Observe a larger-than-expected yield of muons with large impact parameter (outside the 1.5 cm radius beam pipe) in a sample collected with a dimuon trigger.
- These events are referred to as “ghost events”, and disappear when making tight requirements on silicon tracking.
- Only ~50% of events can be explained based on standard sources (long-lived particles, punch-through, in-flight decays, interactions with material, etc).
- A significant fraction of “ghost events” contain more additional muons (and tracks) in a cone around the trigger muon than predicted:
  - Impact parameter of muons consistent with originating from decay of a particle with τ~20 ps.
  - Also different kinematic properties than expected from standard sources.

- The source of this excess is currently not understood.

FERMILAB-PUB-08-046-E

Study of multi-muon events produced in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV

T. Aaltonen,[21] J. Adelman,[11] B. Álvarez González,[9] S. Amerio[x],[35] D. Amidei,[28] A. Anastassov,[31] J. Antos,[12] G. Apollinari,[15] A. Apresyan,[39] T. Arisawa,[44] A. Artikov,[13] W. Ashmanskas,[15] P. Azzurri[aa],[37] W. Badgett,[15] B.A. Barnett,[23] V. Bartsch,[25] D. Beecher,[25] S. Behari,[23] G. Bellettini[y],[37] D. Benjamin,[14] I. Bizjak[dd],[25] C. Blocker,[6] B. Blumenfeld,[23] A. Bocci,[14] V. Boisvert,[40] G. Bolla,[39] D. Bortoletto,[39] J. Boudreau,[38] A. Bridgeman,[22] L. Brigliadori,[35] C. Bromberg,[29] E. Brubaker,[11] J. Budagov,[13] H.S. Budd,[40] S. Budd,[22] S. Burke,[15] K. Burkett,[15] G. Busetto[z],[35] P. Bussey[k],[19] K. L. Byrum,[2] S. Cabrera[u],[14] C. Calancha,[26] M. Campanelli,[29] F. Canelli,[15] B. Carls,[22] R. Carosi,[37] S. Carrillo[m],[16] B. Casal,[9] M. Casarsa,[15] A. Castro[w],[5] P. Catastini[z],[37] D. Cauz[cc],[42] V. Cavaliere[z],[37] S.H. Chang,[24] Y.C. Chen,[1] M. Chertok,[7] G. Chiarelli,[37] G. Chlachidze,[15] K. Cho,[24] D. Chokheli,[13] J.P. Chou,[20] K. Chung,[10] Y.S. Chung,[40] C.I. Ciobanu,[36] M.A. Ciocci[z],[37] A. Clark,[18] D. Clark,[6] G. Compostella,[35] M.E. Convery,[15] J. Conway,[7] M. Cordelli,[17] G. Cortiana[z],[35] C.A. Cox,[7] D.J. Cox,[7] F. Crescioli[y],[37] C. Cuenca Almenar[u],[7] J. Cuevas[r],[9] J.C. Cully,[28] D. Dagenhart,[15] M. Datta,[15] T. Davies,[19] P. de Barbaro,[40] M. Dell'Orso[y],[37] L. Demortier,[41] J. Deng,[14] M. Deninno,[5] G.P. di Giovanni,[36] B. Di Ruzza[cc],[42] J.R. Dittmann,[4] S. Donati[y],[37] J. Donini,[35] T. Dorigo,[35] J. Efron,[32] R. Erbacher,[7] D. Errede,[22] S. Errede,[22] R. Eusebi,[15] W.T. Fedorko,[11] J.P. Fernandez,[26] R. Field,[16] G. Flanagan,[39] R. Forrest,[7] M.J. Frank,[4] M. Franklin,[20] J.C. Freeman,[15] I. Furic,[16] M. Gallinaro,[41]

- Investigations continue at CDF.
- DØ is planning to check this result.