DØ: Operations, Physics Results and Analysis Plans

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Fermilab Institutional Review

June 6-9, 2011

U.S. DEPARTMENT OF ENERGY

Fermilab

Outline

- Operations (data taking, detector status, computing, plans)
- Physics results since Summer 2010
- Analysis plans for 2011/2012 ……
- Conclusions

The DØ Collaboration (2011)

80 Institutions

- 36 US, 44 non-US

20 Countries (+1)

460 Collaborators (-7%)

- About 150 students / postdocs
- 25 new members since Summer 2010

Fermilab Role in DØ

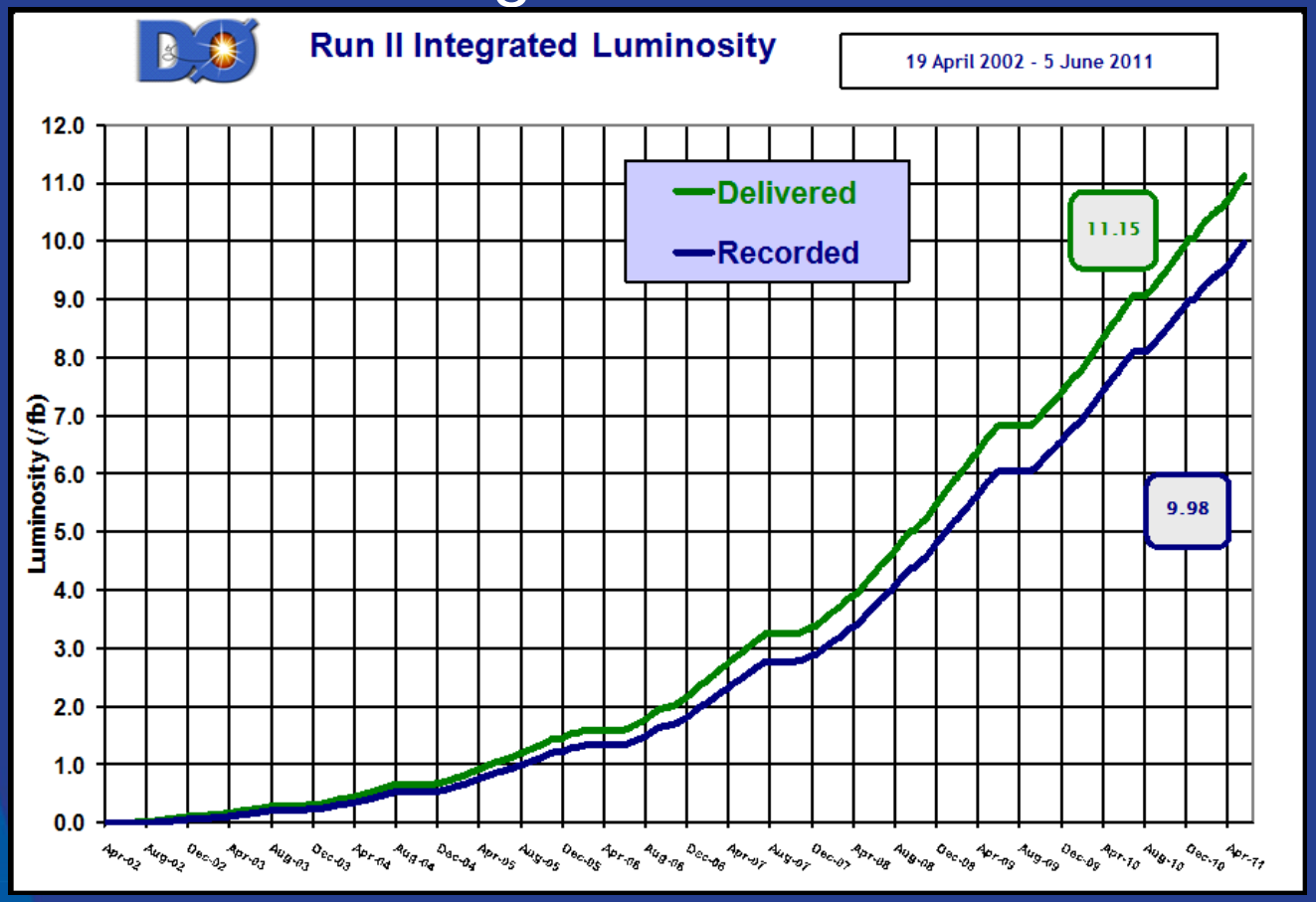
Roles covered by Fermilab group members (past 12 months)

- 1 of 2 spokespersons (Dmitri Denisov)
- 1 of 2 physics analysis coordinators (Marco Verzocchi)
- Technical coordinator (George Ginther)
- 1 of 2 offline / algorithms coordinators (Qizhong Li)
- 2 of 2 Run Coordinators (Bill Lee, Stefan Grünendahl)
- Many leadership positions on detectors and algorithms
- Principal author(s) on 10% of new publications in last year (25% on preliminary results, names mentioned later in the slides)
- Participate in all physics group

Host laboratory support and impact of Visitor's budget

- Mechanical, electrical and computing and infrastructure support
- 6 International Fellows (2 physics group conveners, Yvonne Peters & Mark Williams)
- 38 FTEs supported by visitor's budget
- Crucial for successful detector operation (many individuals)
- Critical impact on algorithms development and analysis effort
- Will be crucial for timely publication of final analyses results in next 12-18 months

DØ Data Taking



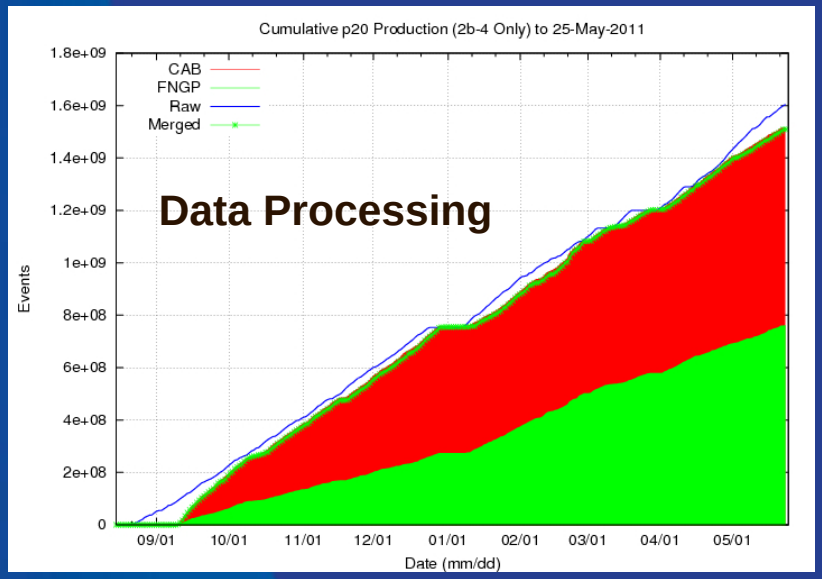
Data taking efficiency ~ 90%

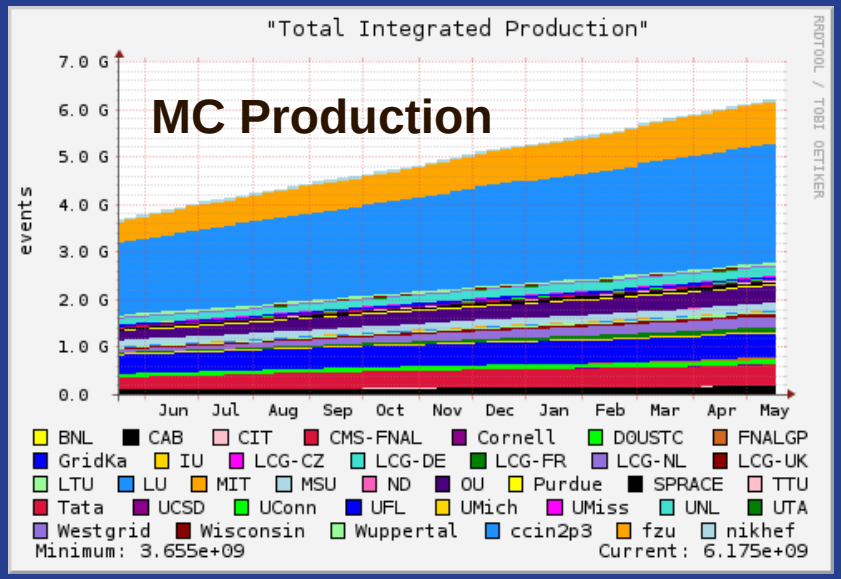
Expect final dataset (after data quality requirements) to be ~ 10 fb^{-1}

Data Processing

Flexibility in allocating resources between reconstruction / MC generation / user analysis

- Data usually available for analysis with delay < few weeks
- MC production performed remotely and at Fermilab
- Allocate more resources for analysis when necessary
- Importance of continued replacement of CPUs / disk servers @ end of maintenance contracts





Operations after September 2011

Intend to operate detector (cosmics, calibrations and studies) after the end of the Tevatron run

- Requires availability of detector support personnel and facilities until end 2011 (cooling, power, consumables and online computing)

Complete data reconstruction / data quality assessment / data preparation for analysis by end October 2011

- Publication of final results in Summer 2012 for most analyses

Complete generation of MC samples tuned to data collected in FY 2011 by March 2012

- Followed by reprocessing of older MC samples (with improvements) as needed

Continued support of analysis computing (dedicated analysis facility, disks, tapes) crucial for success of physics program

Data Reprocessing

Reprocessing: benefit from improvements in algorithms (mostly tracking)

Time estimate for full reprocessing of Run II dataset

- Access to raw data: 6 months
- Full reprocessing with current computing resources: 5 years

Can achieve physics goals with partial reprocessing (2 options):

1) Full reprocessing from raw data

- Allows for improvements in tracking
- Reprocess only events which are interesting for targeted searches
- Benefit from improvements in alignment, calibration, algorithms
- Algorithm improvements result mostly from studies for run extension
- Further developments being tested now
- Will perform a test of reprocessing this Summer to understand gain in physics
- Goal is to complete reprocessing in time for Higgs publications in Summer 2012

2) Partial reprocessing from output of 1st pass reconstruction

- Faster, but more limited scope (no tracking)

DØ Physics Results

Journal submission continuing at constant rate

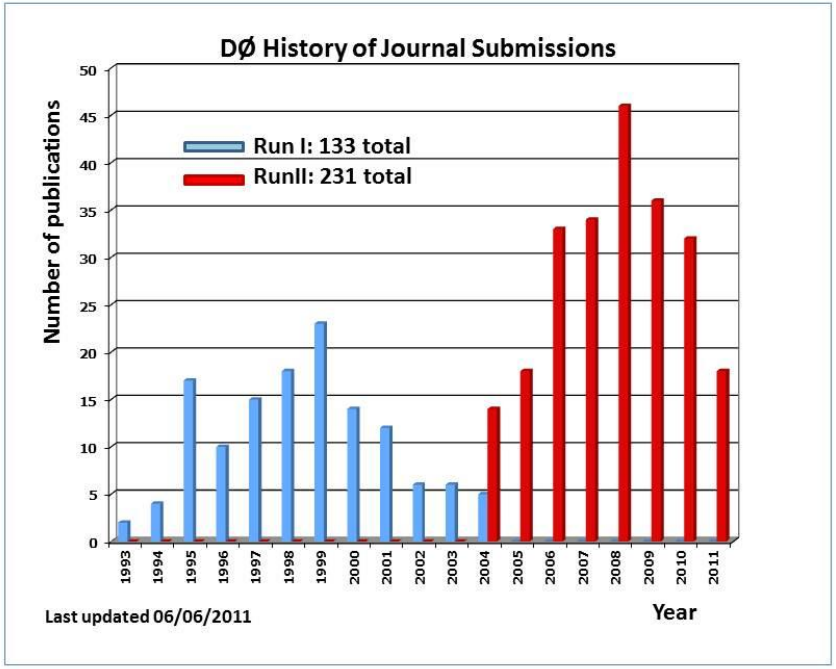
- 18 articles submitted so far in 2011
- 12 more in very advanced stage (collaboration review ended for 11)
- expect to publish ~ 80 more physics papers with DØ data

Submitted > 70 abstracts for Summer 2011 conferences

Theses

- 2009: 34 Ph.D.
- 2010: 27 Ph.D.
- 2011: 5 Ph. D. so far

Expect ~60 more Ph.D. on DØ data



Analysis Plans (2011 and Beyond)

Some guidance

- UA2: Last SPS run in Fall 1990, published 10+2+2 articles in 91-93
- D0 Run I: Continued to publish until 2004
- Opal @ LEP: Run ended in 2000, flat rate @ 60% for 3 years, long tail
- HERA: Run ended in 2007, still publishing many results

Expect >40 journal submissions in 2011, >30 in 2012

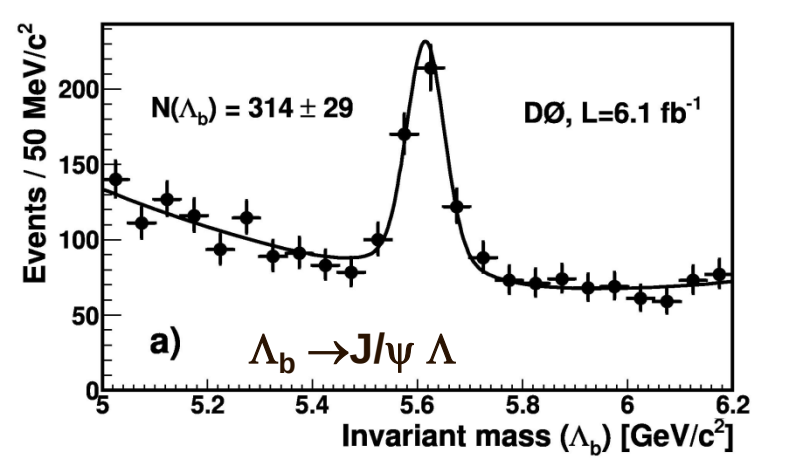
Performing personpower survey (requested by PAC, will be presented in Aspen), in the past always underestimated actual involvement in the experiment

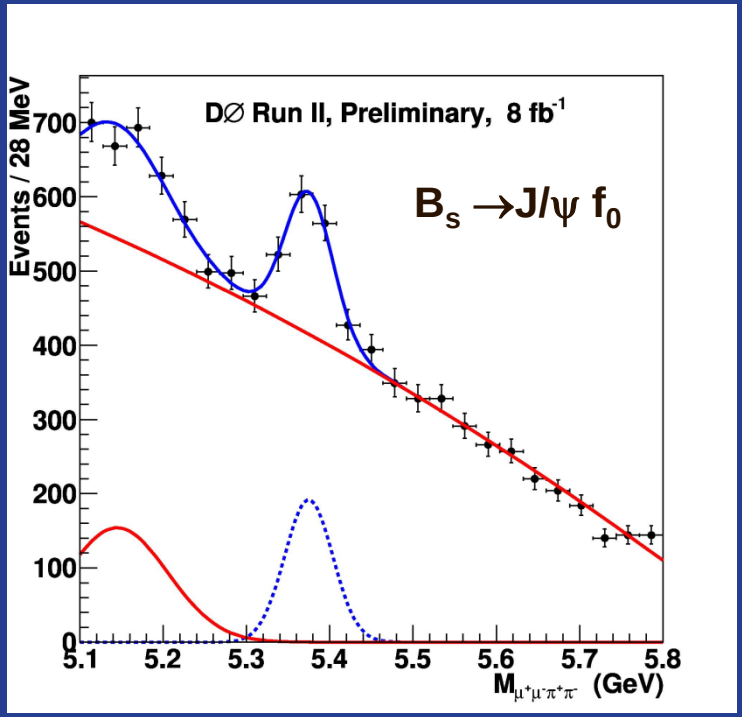
Details for each analysis group discussed in the following, after brief summary of recent results

Heavy Flavor Physics

Most precise measurement of $\Lambda_b \rightarrow J/\psi\ \Lambda$ branching ratio:

- $f(b \rightarrow \Lambda_b) * BR(\Lambda_b \rightarrow J/\psi\ \Lambda) = (6.01 \pm 0.60(stat) \pm 0.58(syst) \pm 0.28(PDG)) * 10^{-5}$





Observation of $B_s \rightarrow J/\psi\ f_0$

- $BR(B_s \rightarrow J/\psi\ f_0) / BR(B_s \rightarrow J/\psi\ \varphi) = 0.210 \pm 0.032(stat) \pm 0.036\ (syst)$

Heavy Flavor Physics: Plans

Likesign dimuon asymmetry:

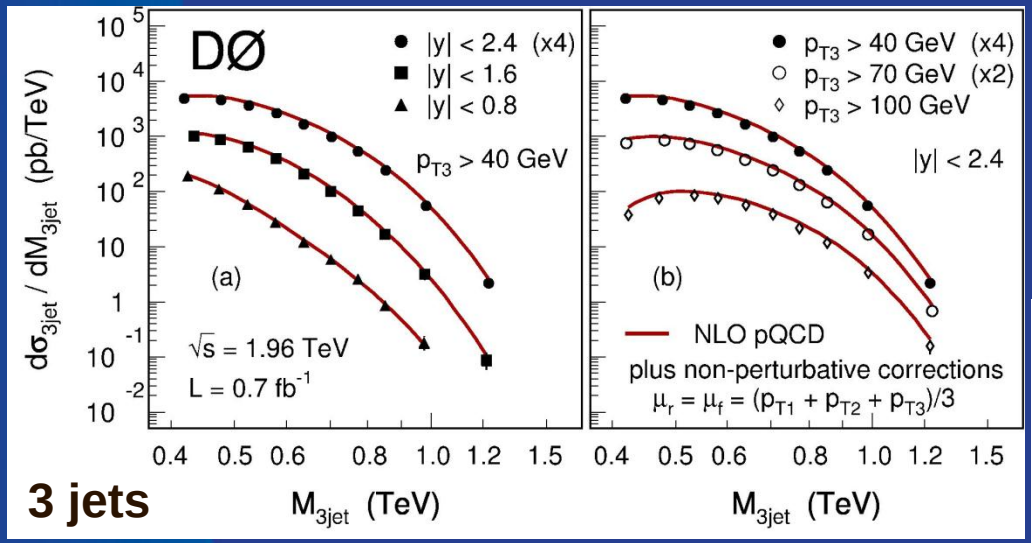
- Update result with 9 fb^{-1} for the Summer conferences
- Improved analysis technique (add impact parameter information)
- Improve constraint on flavor specific asymmetry (tagged B^0_d decays)
- Expect LHCb to provide additional constraints by end 2011
- Will repeat analysis with full dataset

CP violation $B_s \rightarrow J/\psi\ \phi$

- Analysis on 8 fb^{-1} for the Summer conferences
- Removed theoretical constraints on hadronic phases in final state
- Allow for s-wave background
- Combination with CDF
- Expect result with similar sensitivity from LHCb on same timescale

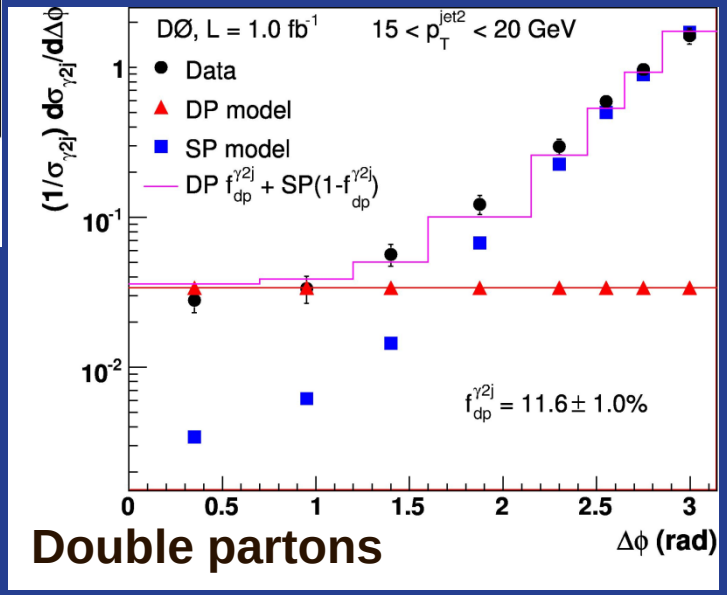
QCD

Measurement of the three jet invariant mass differential cross section:



Double parton interactions in γ+2/3 jets

- Extend previous studies to γ+2 jets
- Measure function of DP interactions vs p_T^{jet}
- Comparisons with MC models



QCD: Plans

Jet based analyses performed on 0.7 fb^{-1}

Very precise measurement of jet energy scale available September 2011

Expect to repeat inclusive jet measurements on 7 fb^{-1} dataset by Summer 2012 (triple differential cross section)

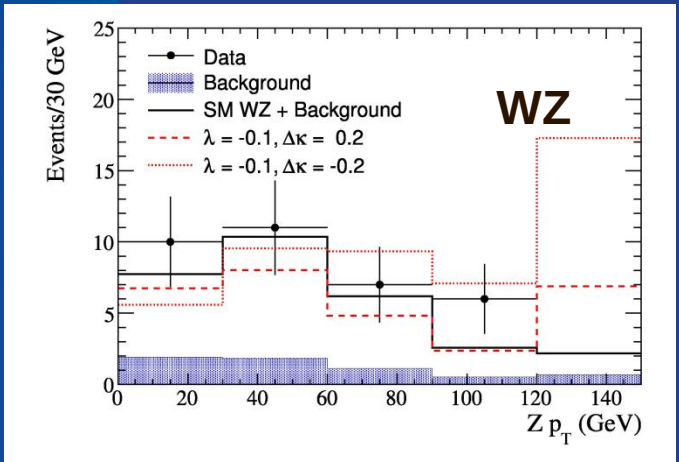
Running of strong coupling constant up to 500 GeV

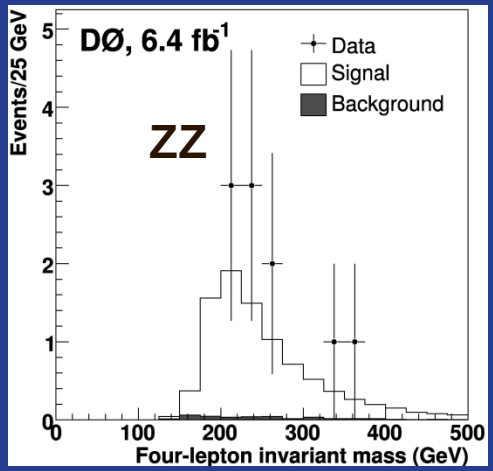
Continue studies of γ/W/Z + jets production (heavy flavour jets)

Electroweak Physics: Dibosons

Updated measurements of WZ, ZZ and Wγ production cross sections:

- σ(Wγ)= (15.2±1.6) pb [QCD: (16.0±0.4) pb] X. Bu (Fermilab RA)
- σ(WZ)= (3.89±1.07/0.90) pb [QCD: (3.25±0.19) pb]
- σ(ZZ)= (1.26±0.49/0.40) pb [QCD: (1.4±0.1) pb]





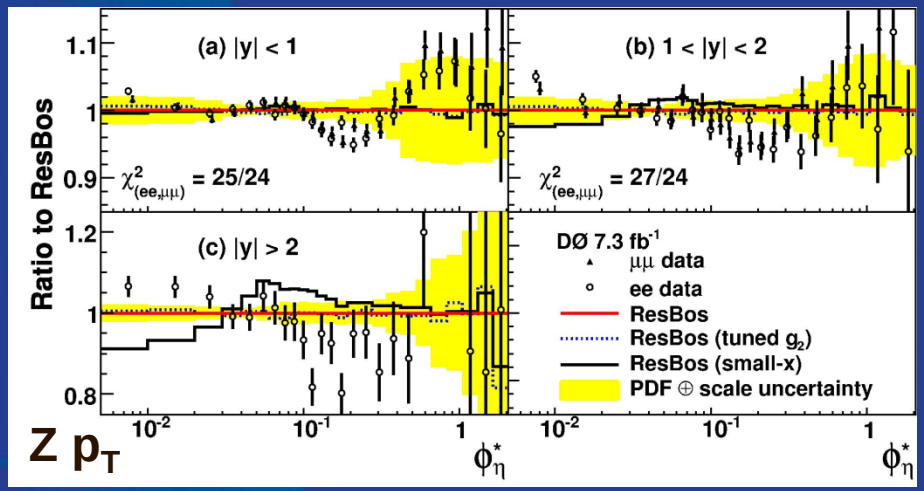
Extraction of limits on anomalous couplings in triple gauge boson vertices

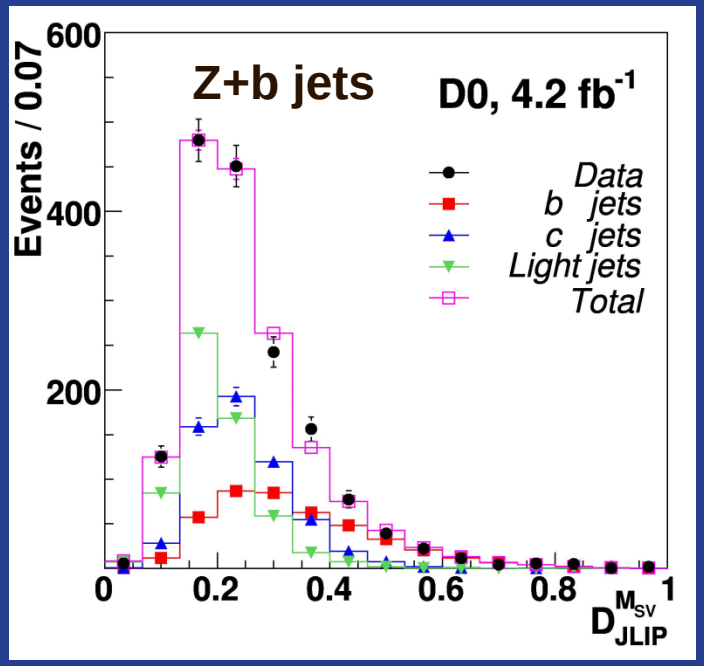
- Most precise constraints on WWZ couplings

Electroweak Physics: Z Production

Precise measurement of Z p_T distribution via new observable:

- Exclude low-x broadening of p_T distribution
- Details of p_T/rapidity dependence not described by models
- Important ingredient in W mass measurement





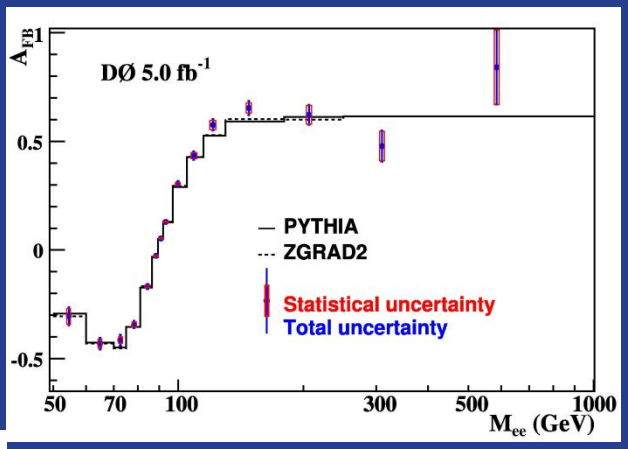
Ratio σ(Z+b-jets)/σ(Z+jets):

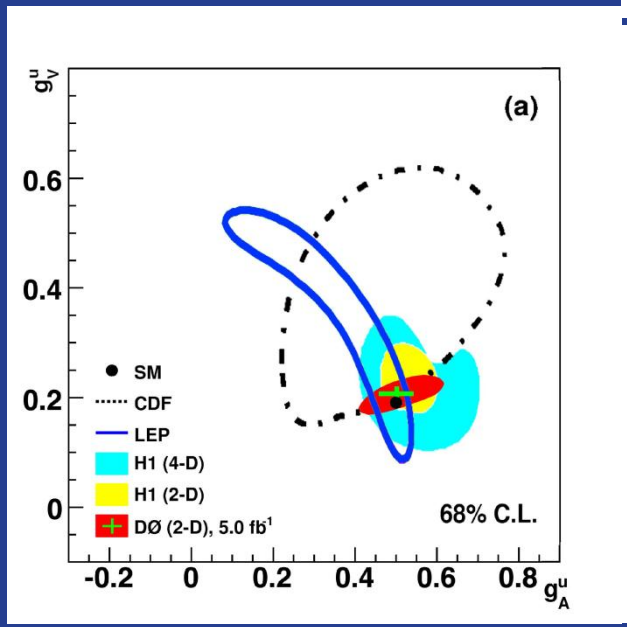
- Important input in Higgs searches
- R=0.0193±0.0027, consistent with QCD

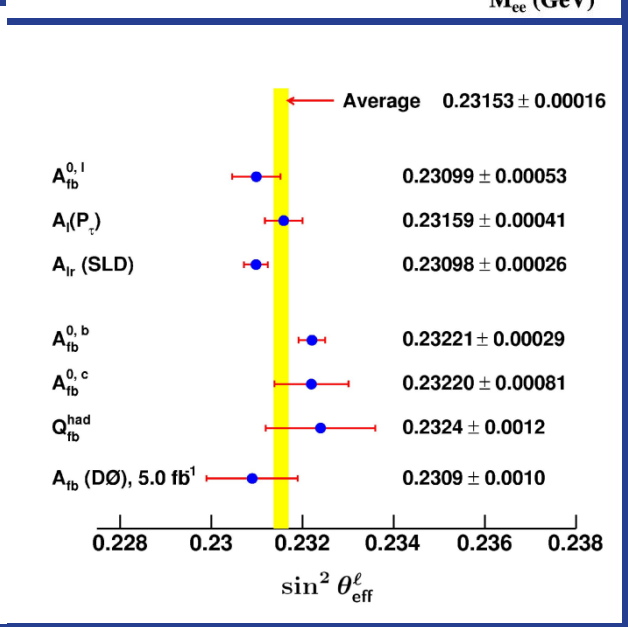
Electroweak Physics: $\sin^2\theta_W$

Measurement of forward-backward asymmetry for e^+e^- production vs M_{ee}:

- Sensitivity to $\sin^2\theta_W$ in region around Z pole
- Extract $\sin^2\theta_W$ = 0.2309±0.0010
- Extract g_V, g_A for u/d quarks
- Most precise measurement at hadron colliders







H.Yin (Fermilab RA)

Electroweak Physics: Plans

W boson mass: expect result in Summer 2011 (5 fb^{-1})

- <25 MeV precision

Repeat analysis on full dataset, will include forward electrons (reduce uncertainty related to PDFs), likely to be ready in 2013

- <15 MeV precision

Constraints on PDFs: W charge asymmetry (Summer 2012)

- Will also benefit from LHC inputs

Diboson production and triple gauge couplings:

- publish by End 2011, 5-7 fb^{-1}, anomalous couplings

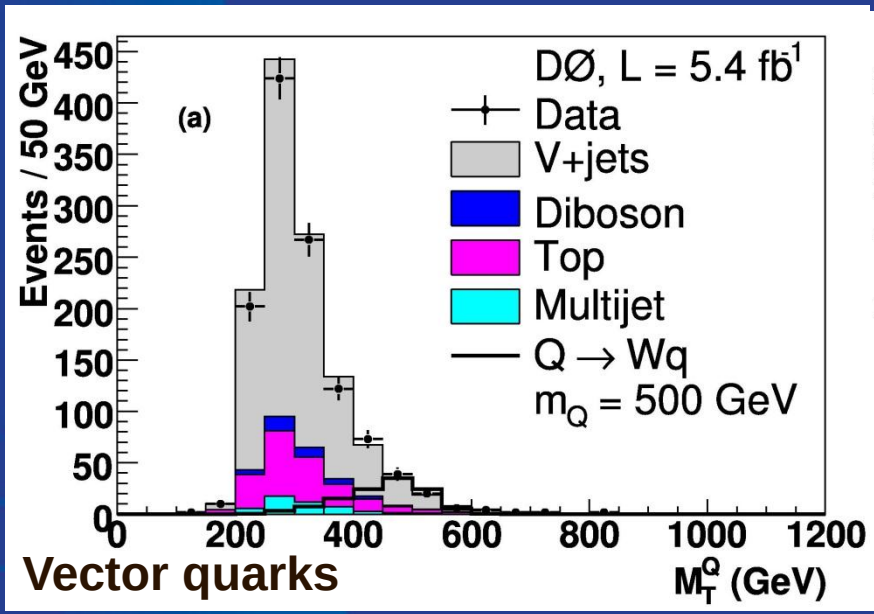
$\sin^2\theta_W$: aim for complete analysis by Summer 2013

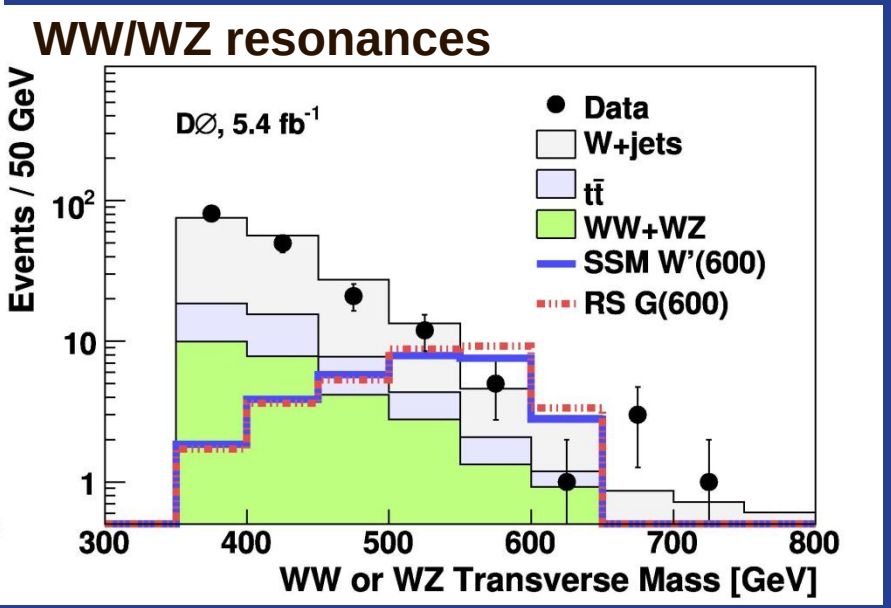
- In combination with CDF achieve precision similar to best LEP/SLC measurements

New Physics (I)

Extend D0 searches to new models / signatures and develop new techniques:

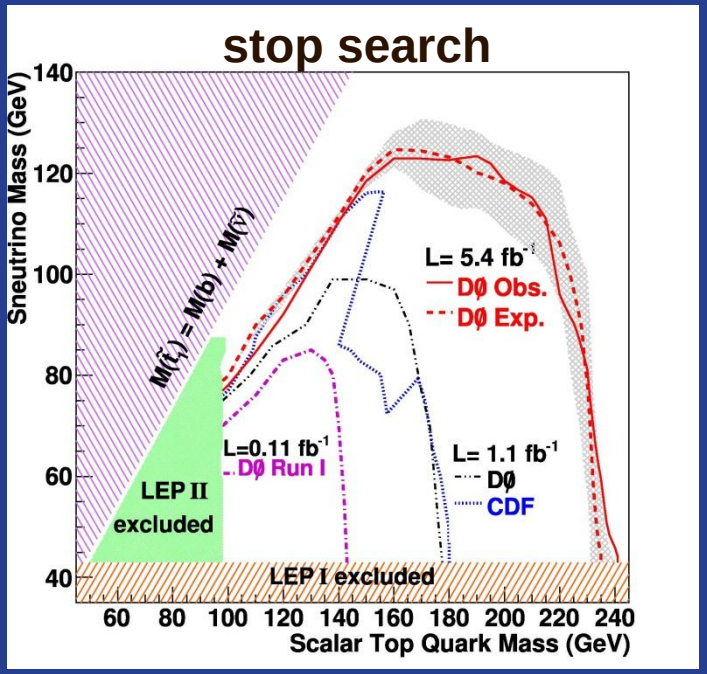
- Single production of vector quarks (Wj/Zj resonances)
- Search for WW/WZ resonances using high mass jets (boosted jets)



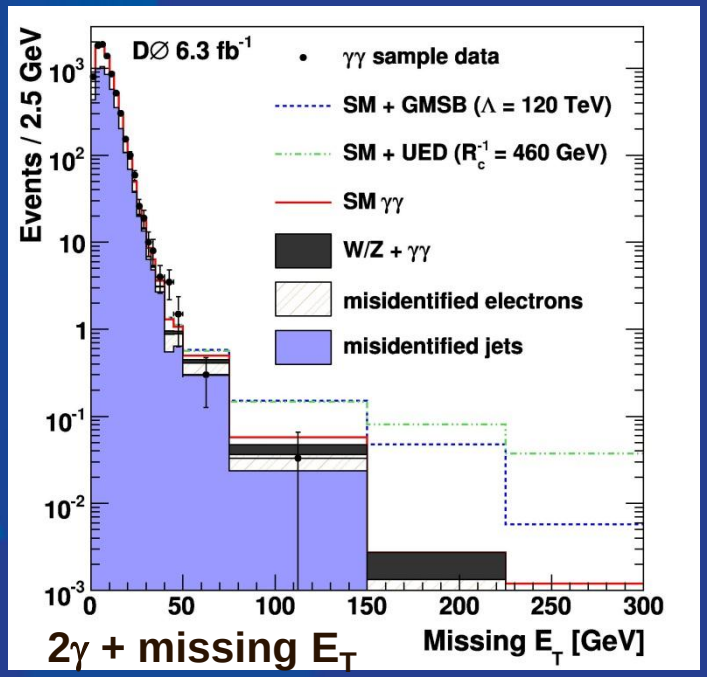


New Physics (II)

Search for stop decays in e+μ final states



Search for gauge mediated SUSY / universal Extra dimensions in 2γ+missing E_T final states

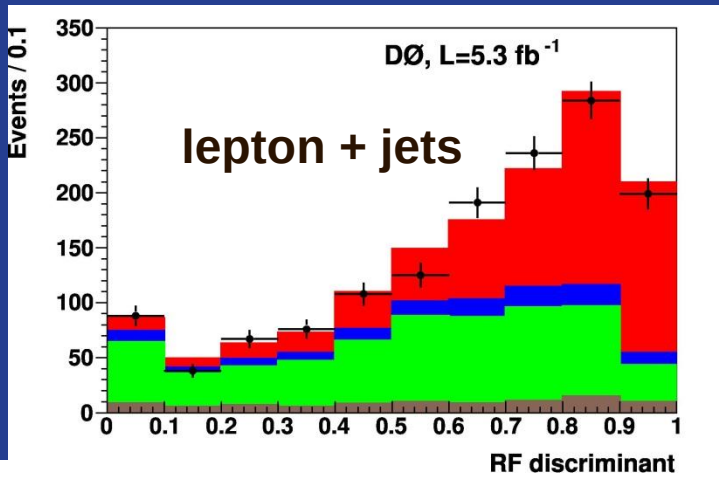


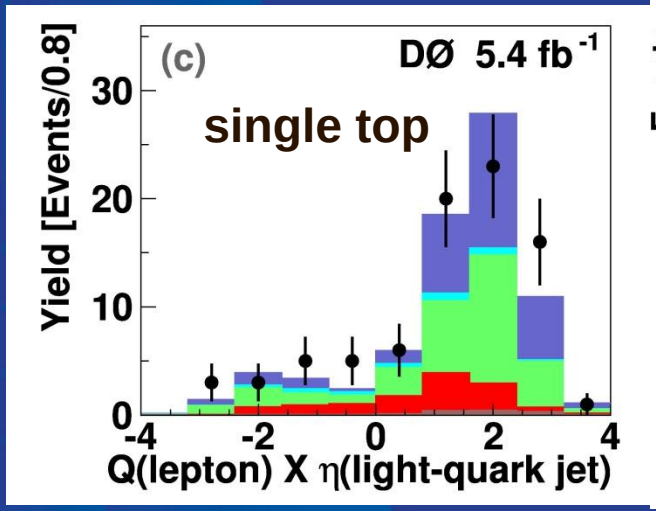
- 9 new phenomena searches articles submitted since July 2010
- 5 more in the pipeline
- Prepare to react to future LHC discoveries

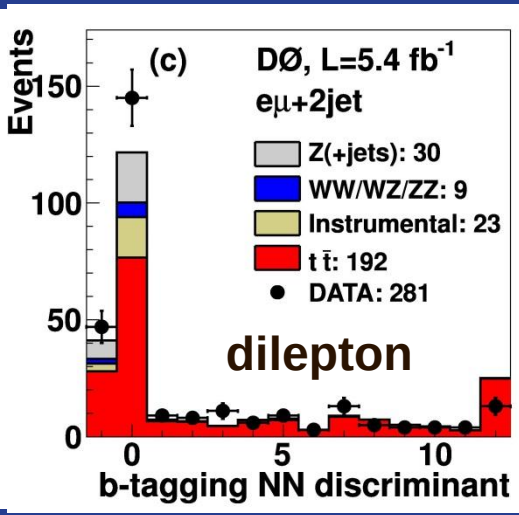
Top Physics: Production Cross Sections

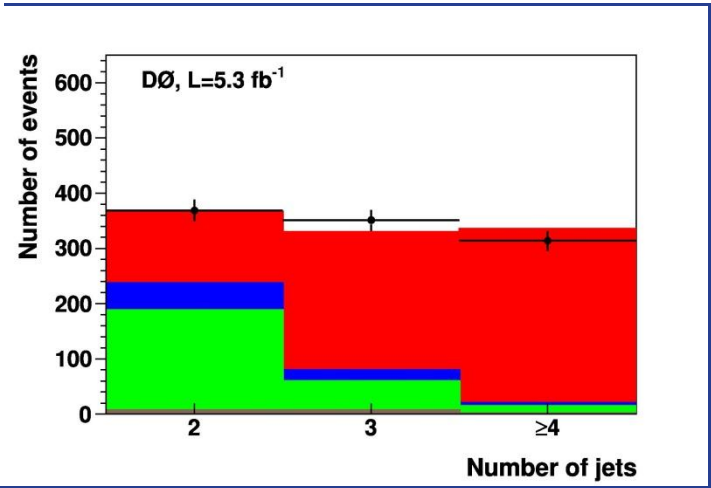
Measurement top production cross section:

- Top pair production: σ = (7.6 ± 0.6) pb
- Electroweak production (single top)
  - t-channel σ = (2.9 ± 0.6) pb
  - 5.5 standard deviations (1st observation)
- Update limit on s-channel single top production









Y. Peters (International Fellow)

Top Physics: Spin Correlations & W Helicity

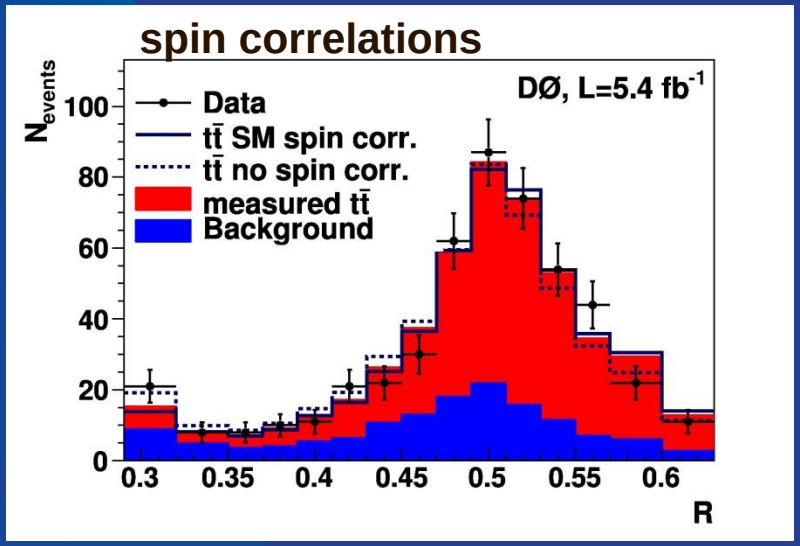
Measurement of spin correlation in tt events

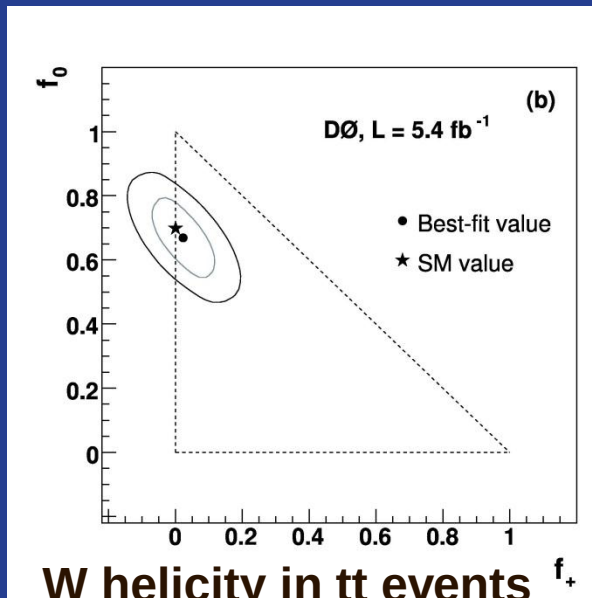
- Exclude absence of spin correlations at 99.7%
- Measurement unique to Tevatron

Improved measurement of W helicity in top decays

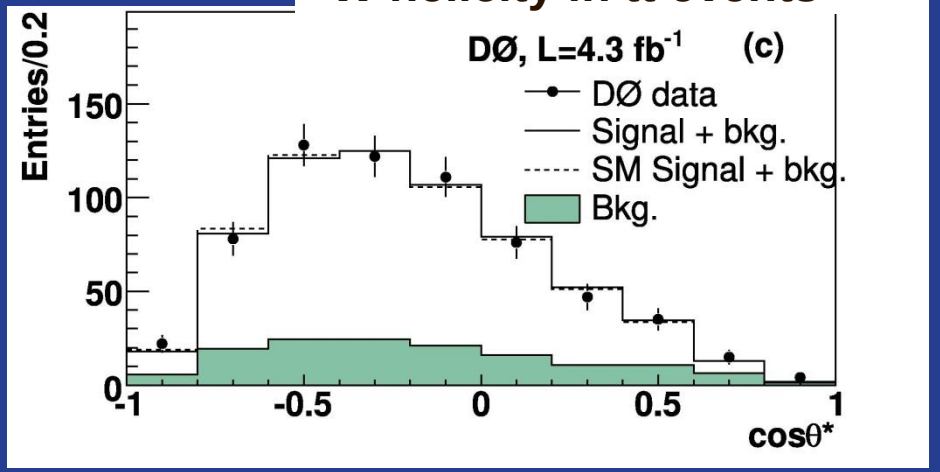
- Fit to angular distribution of top decay products
- W bosons predominantly left-handed polarization

Y. Peters

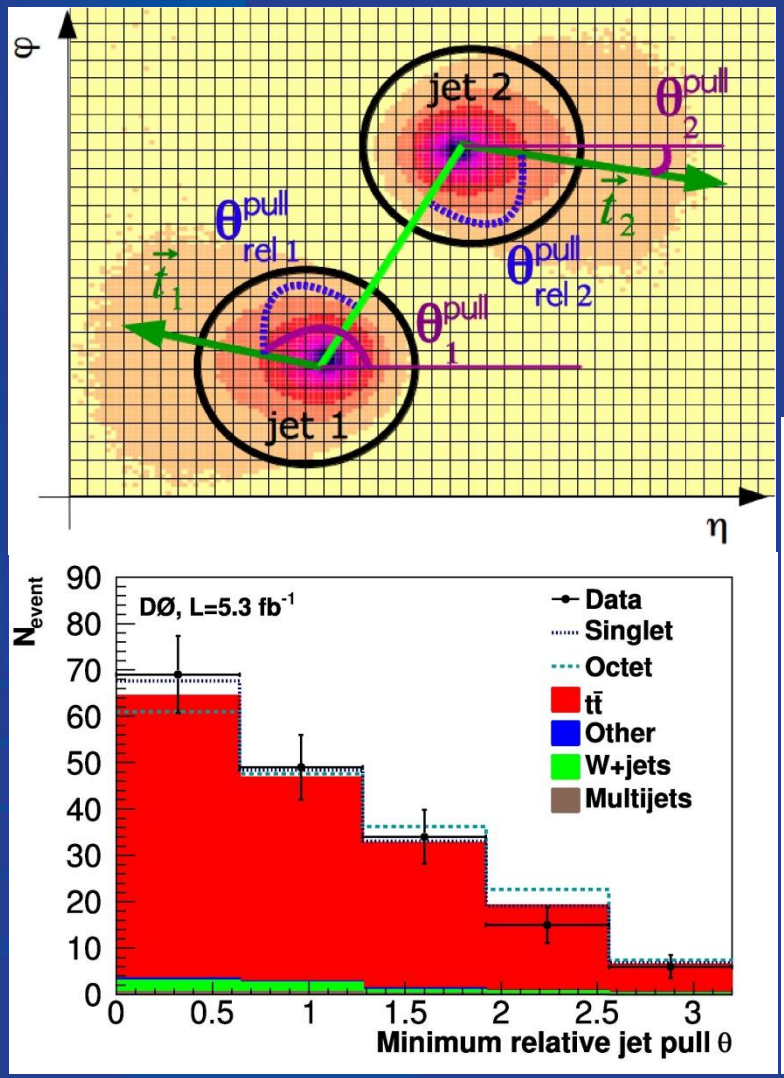




W helicity in tt events

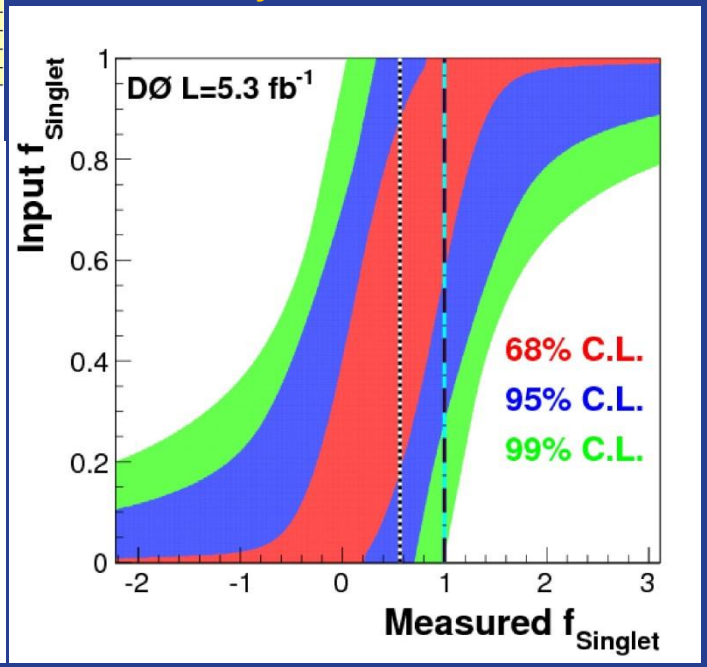


Top Physics: Color Flow



First study of color flow in tt events

- New variable sensitive to inter-jet radiation between object from same color string
- Useful discriminant for future searches (Higgs, LHC)
- Exclude possibility that W boson in top decay is in octet state at 2 s.d.

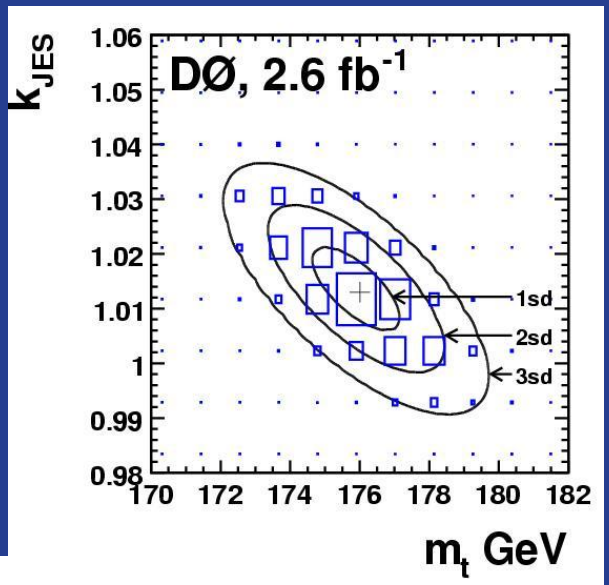


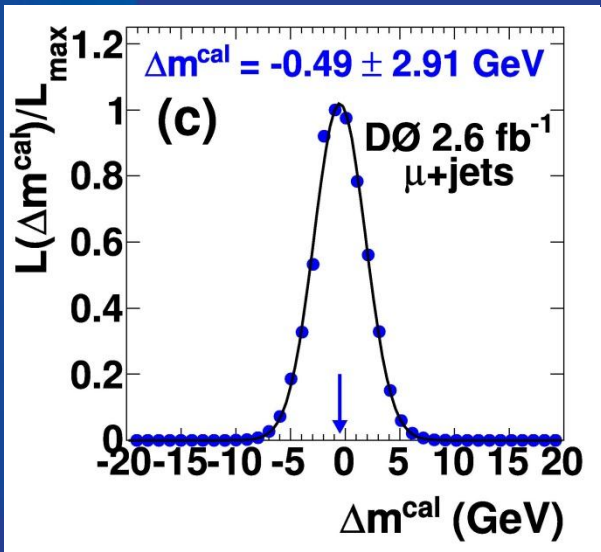
Y. Peters

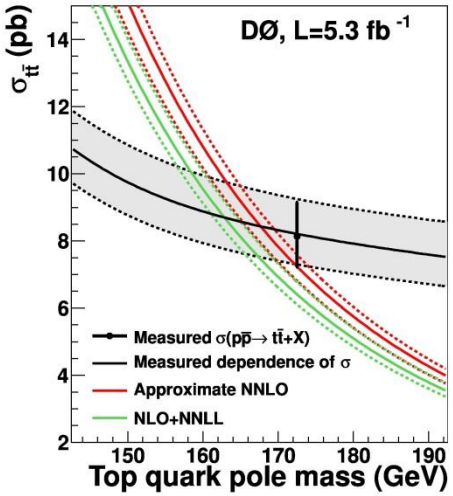
Top Physics: Mass / Width Measurements

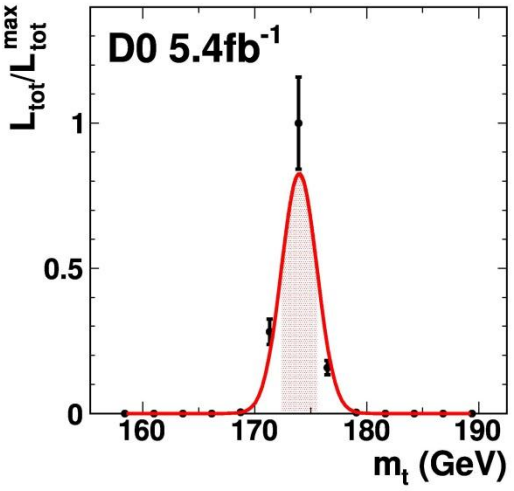
Updated measurements of top mass/width

- M_{top} = (175.08±1.47) GeV (Z. Ye, Fermilab RA)
- Benefit from improved flavor dependent JES
- Width determination from t-channel single top σ, R_b
- Γ_{top} = (2.0±0.6) GeV
- Extract M_{top} from cross section
- Study difference between pole and MSbar mass
- ttbar mass difference DM = (0.8±1.8) GeV





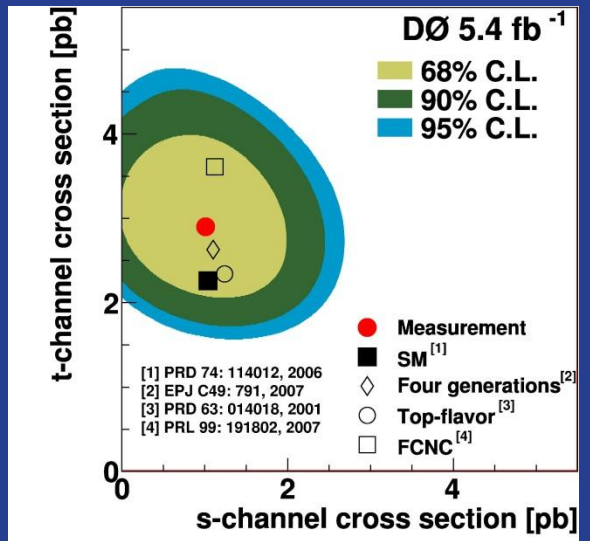


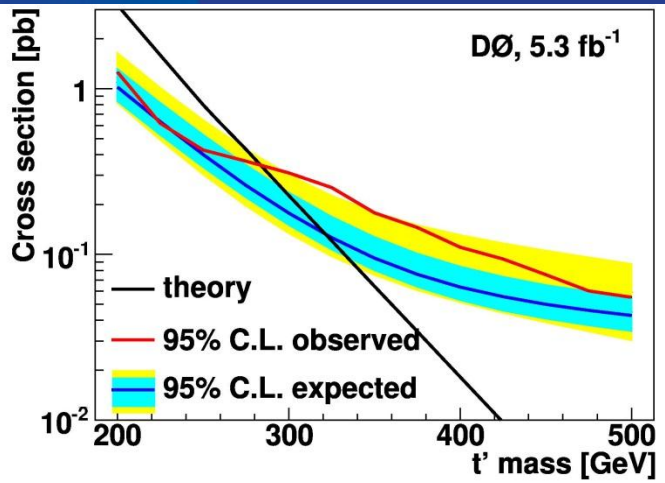


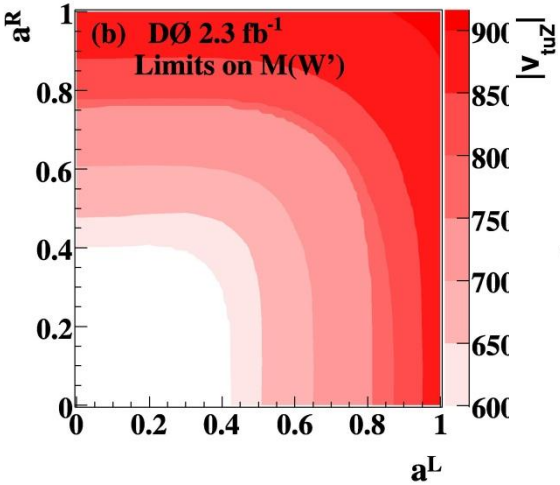
New Physics in Top Final States

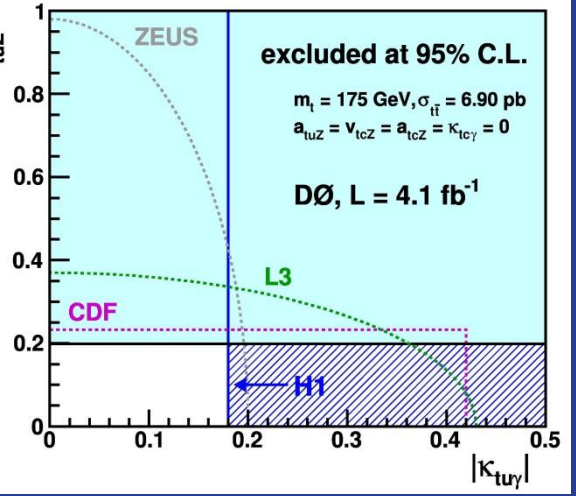
Many searches in top related final states:

- Anomalous couplings in single top production
- Limits on flavor changing neutral currents in top decays
- Search for W' resonances in tb final states
- Search for 4th generation t' quark ($m_{t'} > 285$ GeV)









Top physics: Plans

Mass – systematics limited, total error below 1 GeV (target end 2012)

- Finishing reanalysis of JES scale (including flavor dependence)
- Add all hadronic channel

Single top – s-channel

- Need full dataset to reach 3 σ sensitivity

Spin correlations – statistically limited, complementary to LHC

- Demonstrated new techniques
- Extend to lepton+jets channel

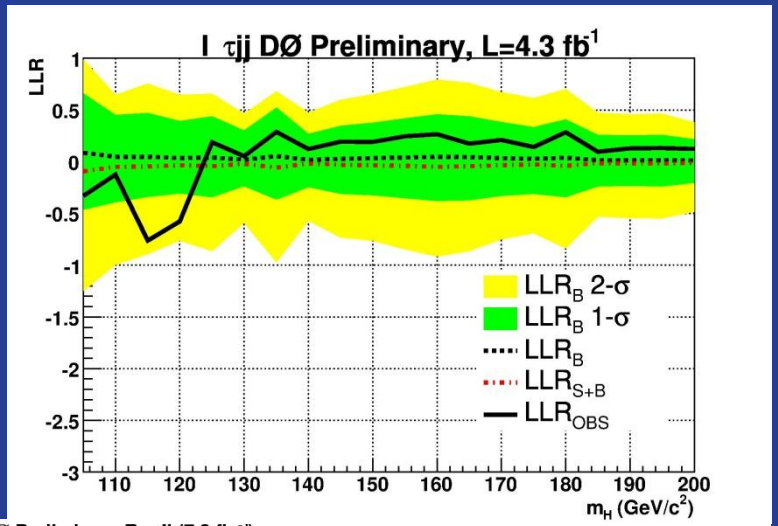
$A_{fb}(tt)$ – interesting CDF result, DØ result out soon

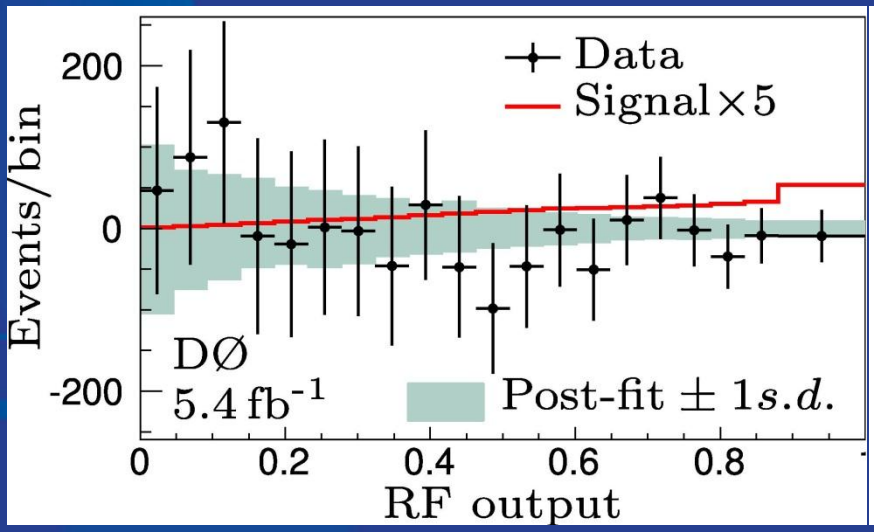
Differential cross sections

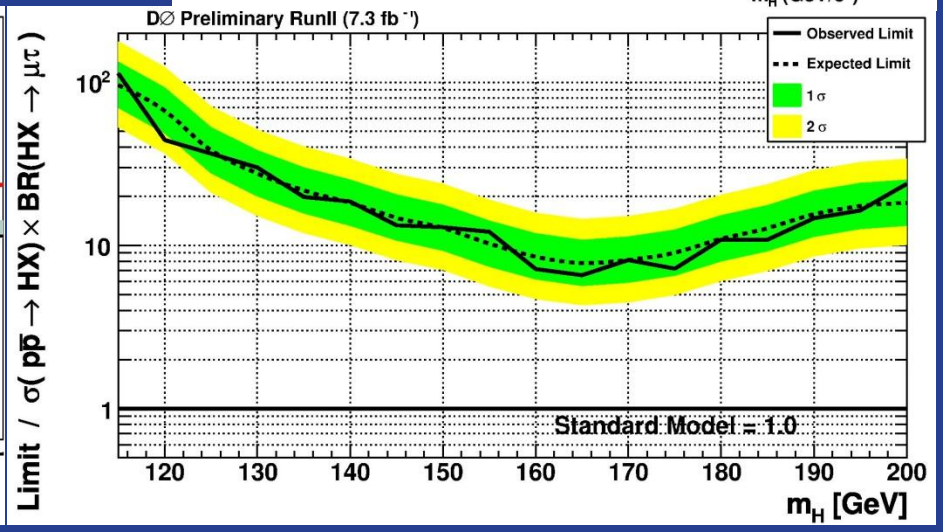
Higgs (I)

Increase sensitivity through inclusion of new final states

- H search in $\tau\tau$jj final states (sensitivity to multiple production mechanisms)
- H $\rightarrow$WW $\rightarrow \mu\tau$ / H $\rightarrow$ WW $\rightarrow$ lνjj (increase number of WW decay channels used in analysis)







Higgs (II)

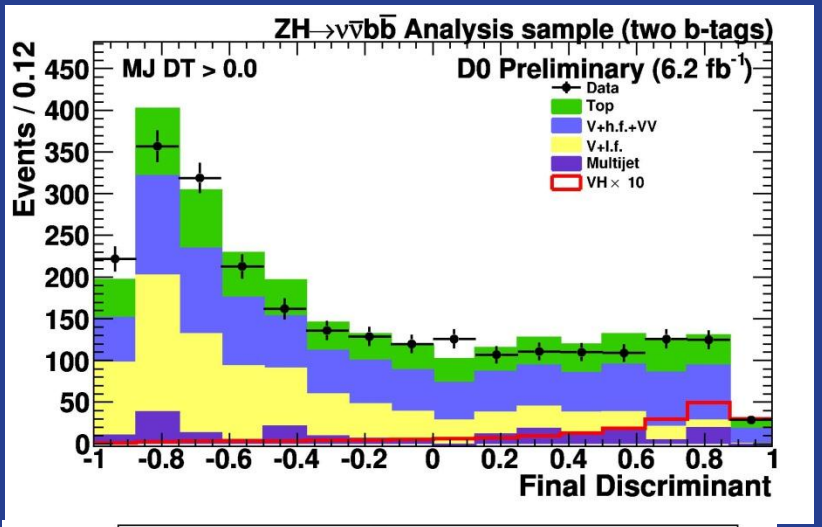
Standard Model searches in low mass range (H→bb decay)

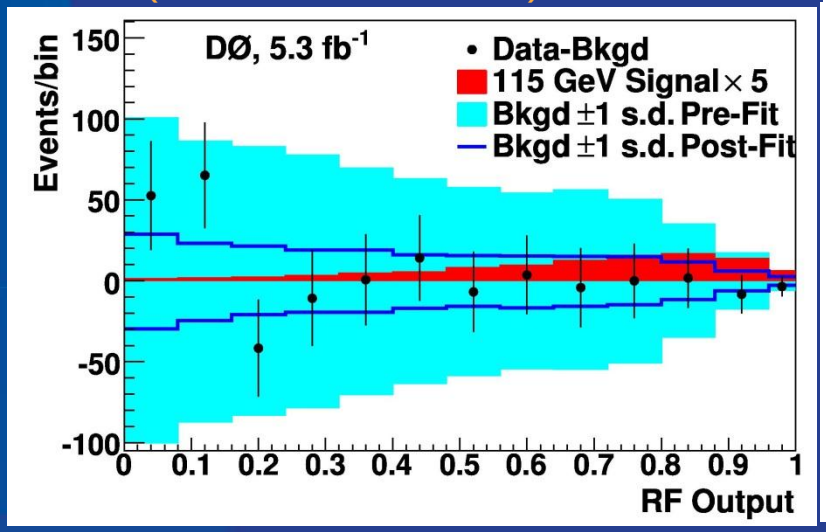
- Improved/published all WH/ZH channels, benefit from b-tagging / tracking developments
- H → γγ

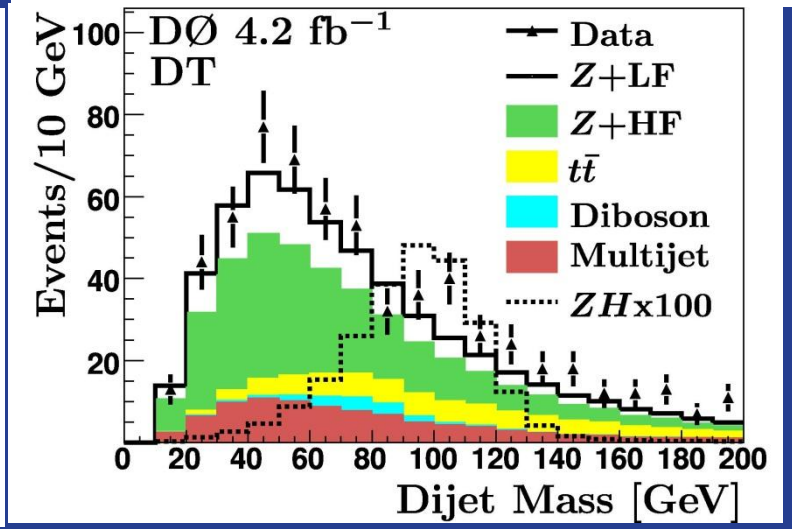
M. Cooke, S. Desai, X. Bu (Fermilab RA)

B. Penning (Lederman Fellow)

T. Scanlon (International Fellow)



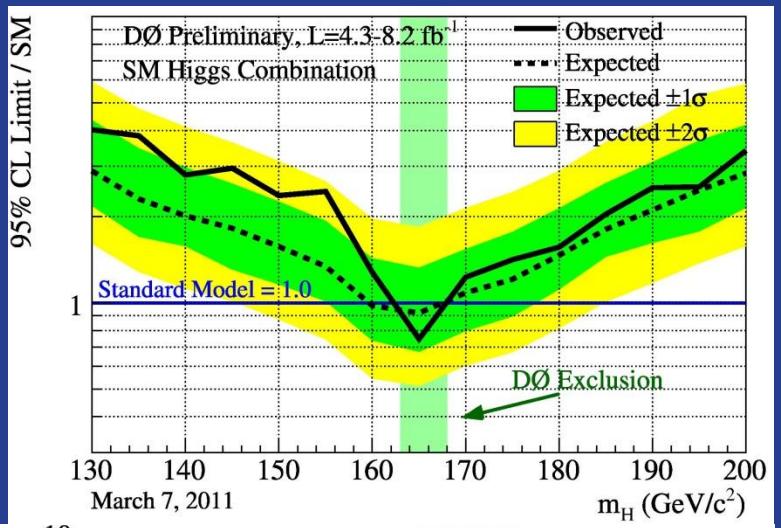


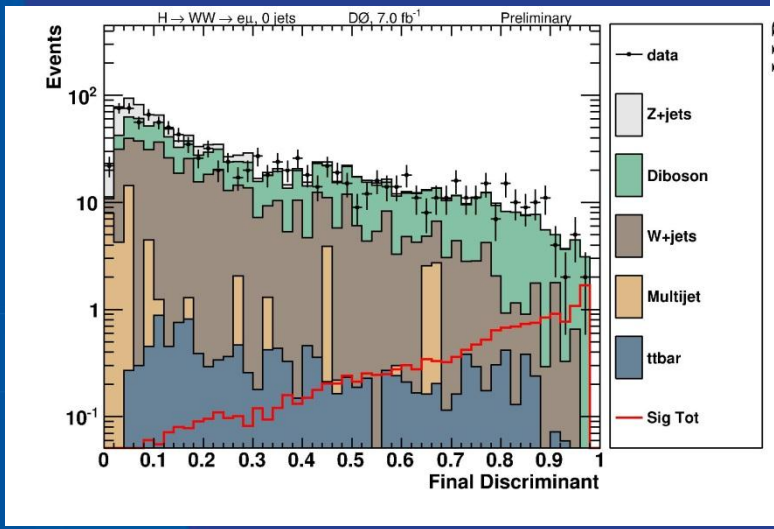


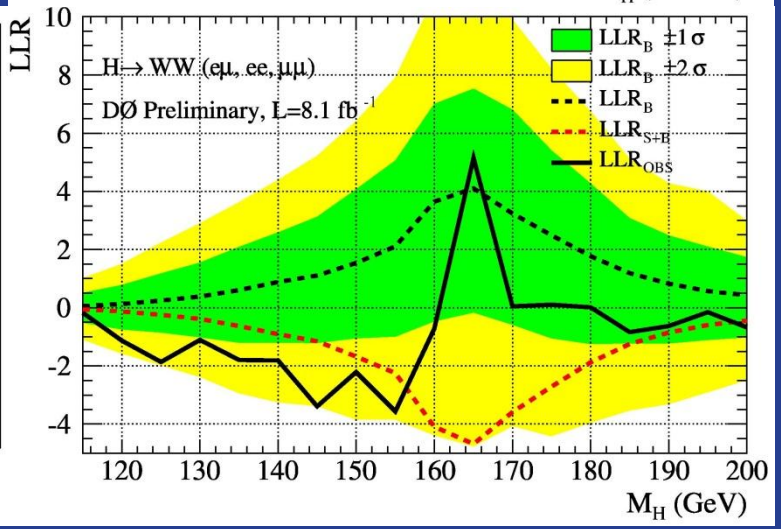
Higgs (III)

High mass Standard Model searches

- Sensitivity improvements
- Additional channels
- Reached SM sensitivity around 160 GeV
- Exclude SM Higgs boson in [163-168] GeV range (expected [160-168] GeV)







Higgs (IV)

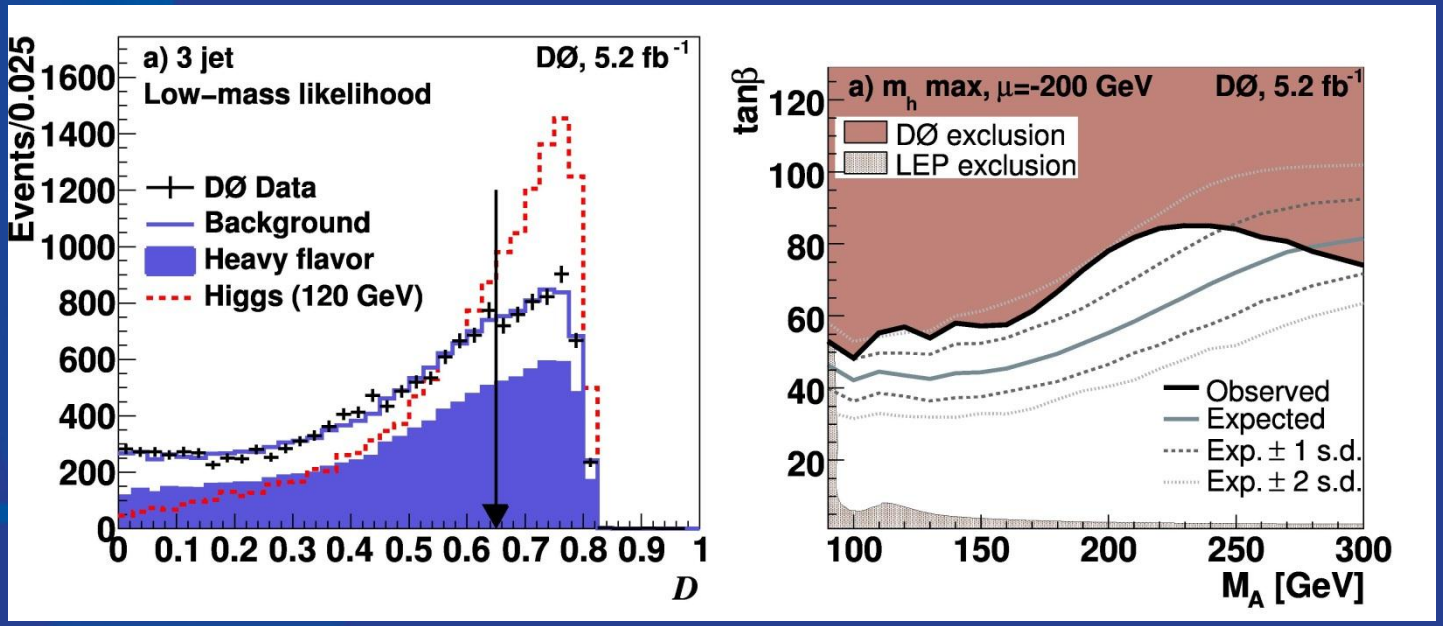
SUSY Higgs

- Published result of $b\phi \rightarrow bbb$ search (channel unique to Tevatron)
- Work in progress on $b\phi \rightarrow b\tau\tau$ and $H \rightarrow \tau\tau$ (publications this week)

Fermiophobic Higgs

- $H \rightarrow \gamma\gamma$ X. Bu (Fermilab RA)

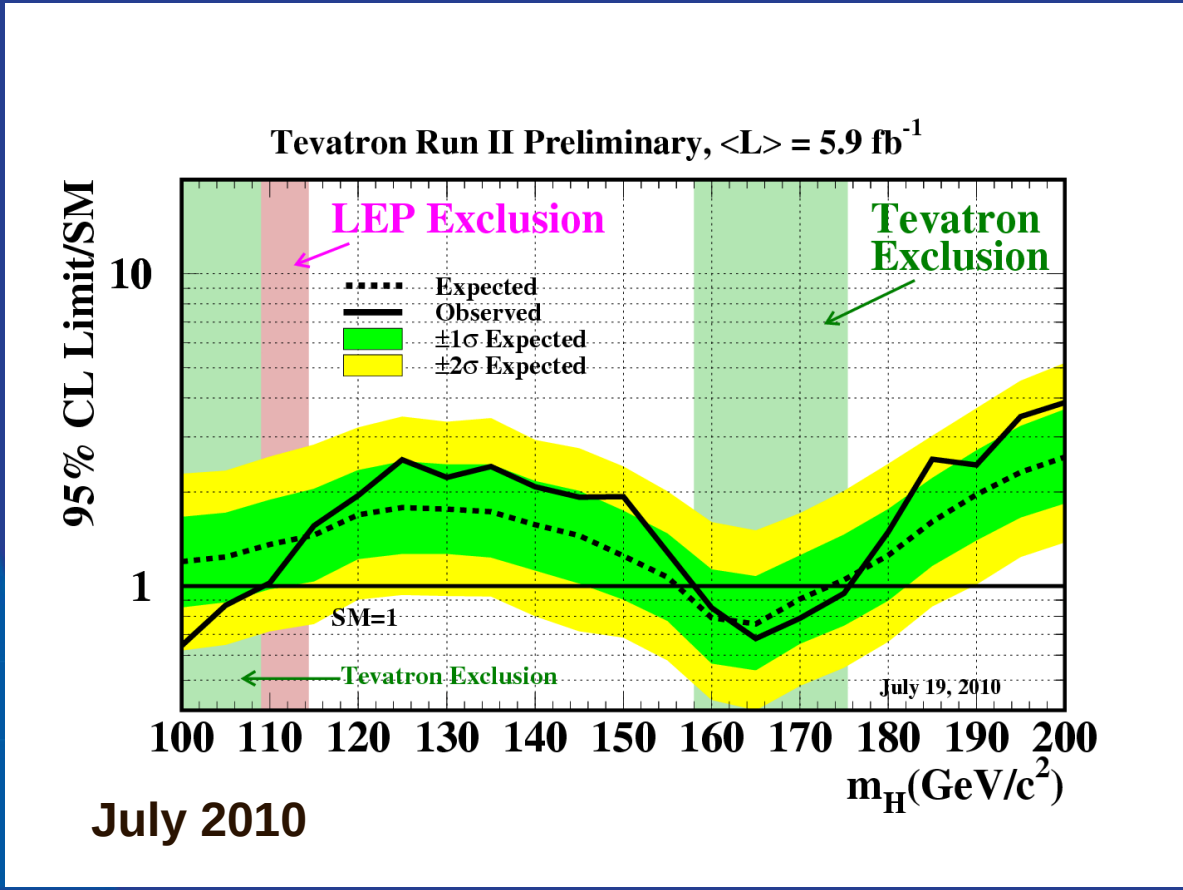
4^{th} generation interpretation of $H \rightarrow WW$



Higgs (V)

CDF-DØ Combinations

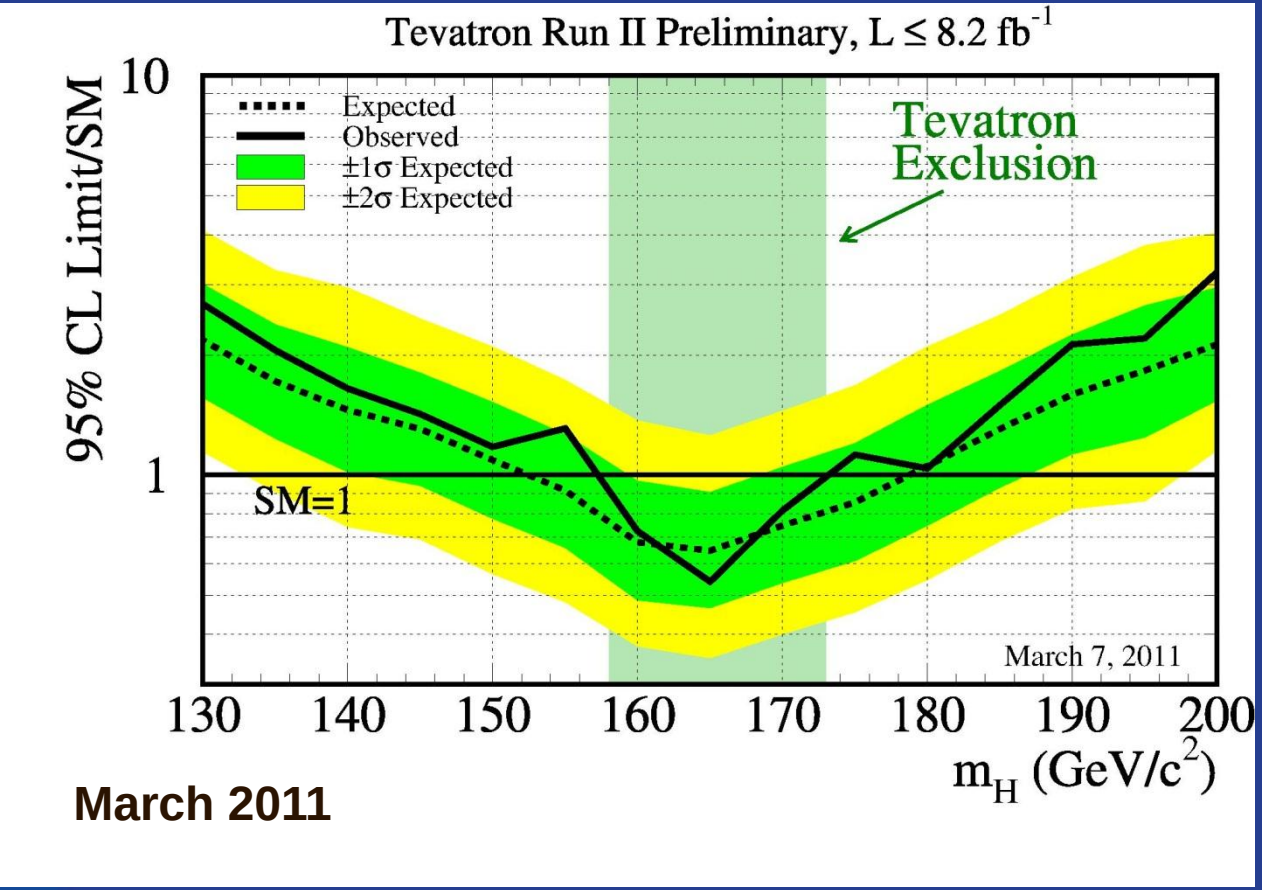
- Full mass range: Summer 2010: within 2*SM for all masses below 190 GeV



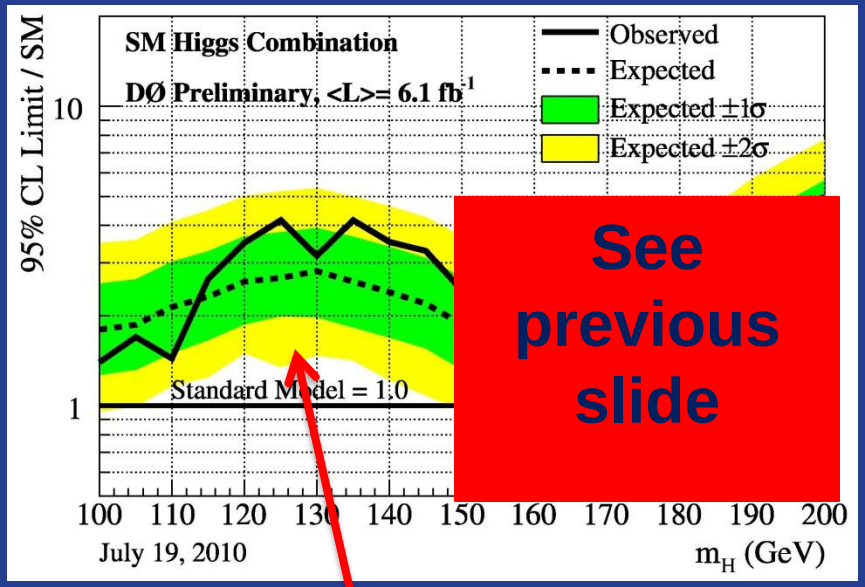
Higgs (VI)

CDF-DØ Combinations

- High mass: updated Winter 2011: exclude [158-173] GeV range (exp. [153-179] GeV)



Higgs: Plans



SM Higgs: all channels, focus on sensitivity at low mass

- 8 fb^{-1} combination at low mass for Summer 2011
- Demonstrate sensitivity to WZ with $Z \rightarrow bb$

Expect further improvements on b-tagging, dijet mass resolution

Complementarity between LHC and Tevatron on low mass Higgs ($H \rightarrow bb$ @ LHC requires several 10 fb^{-1})

SUSY Higgs: bbb final state unique at Tevatron, LHC will soon dominate $\tau\tau$

Conclusions

DØ continues producing interesting physics results

Use 10 fb^{-1} of data for final analyses

In the next few weeks

- Dijet invariant mass spectrum in W+2 jets (CDF bump)
- Update of the likesign dimuon asymmetry analysis
- Forward-backward asymmetry in top pairs
- Full combination of MSSM Higgs results
- Update of SM Higgs searches

Expect >40 journal submissions in 2011 (18 up to today, collaboration review already completed for 11 more), >30 in 2012

- Many new results expected for summer conferences

Strong commitment from Collaboration on Higgs analyses and legacy measurements