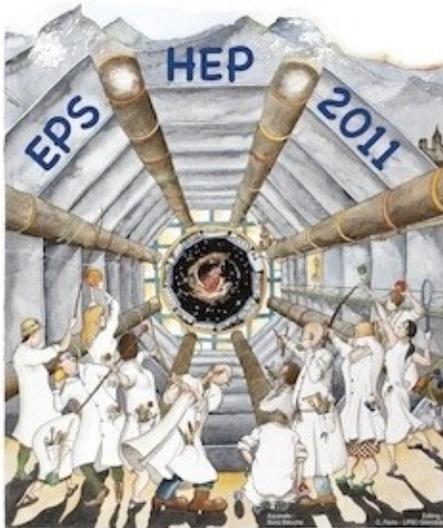


DØ Results for Summer 2011

Fermilab Joint Experimental-Theoretical Seminar
22 July 2011

Marco Verzocchi

 Fermi National Accelerator Laboratory



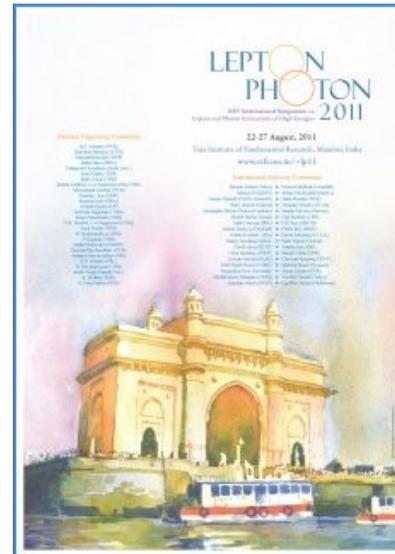
**Meeting of the Division of Particles & Fields
of the American Physical Society**
August 9-13, 2011, Providence, RI
at Brown University & Rhode Island Convention Center
<http://www.brown.edu/dfp2011>

CP Violation
BSM Physics
Fields & String Theory
High Energy Gamma-ray and Neutrino Astrophysics
Early Universe & Cosmology
Astroparticle Physics and Cosmology
Dark Matter Searches
Hadron Spectroscopy
Perturbative and non-Perturbative QCD
Heavy Ion Physics
Neutrinos
Heavy Flavor Physics
Top Quark Physics
Electroweak Physics
Higgs Physics
Detector R&D
LHC Collider Physics

Local Organizing Committee
David Cutts (co-chair)
Ulrich Heinz (co-chair)
Ian Duff-Anderson
Richard Gaietta
Gerard Gounik
Anat Jevicki
Srinivas Koushappas
Greg Landsberg
Robert Lanoce
David Lowe
Masaaki Mura
Thomas Spree
Mehmet Sponholz
Chang-Ji Tan
Gregory Tarter
Anastasia Volovich

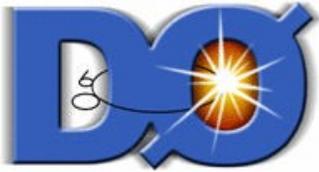
Scientific Organizing Committee
Masaaki Mura (chair)
Chip Block
Claudio Campagnari
David Cutts
David Demme
Ulrich Heinz
Kara Hoffman
Anat Jevicki
Boris Knieper
Greg Landsberg
Pamela McBride
Alexey Petrov
Jim Richter
Steve Ritz
Kate Scholberg



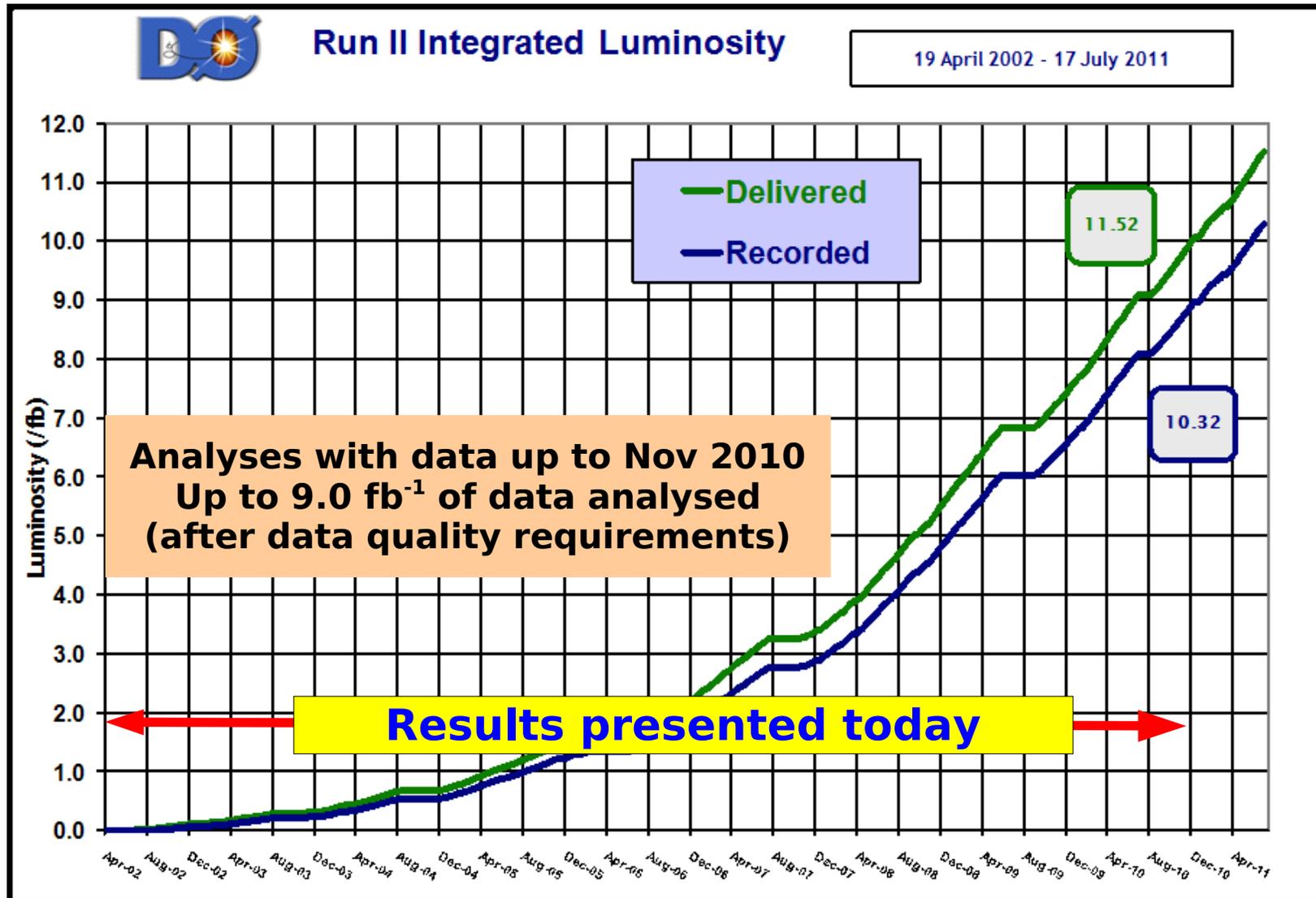


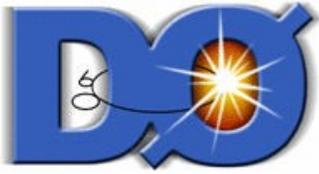


460 Collaborators in 80 Institutions from 20 Countries
Many thanks to all of them for the results presented today

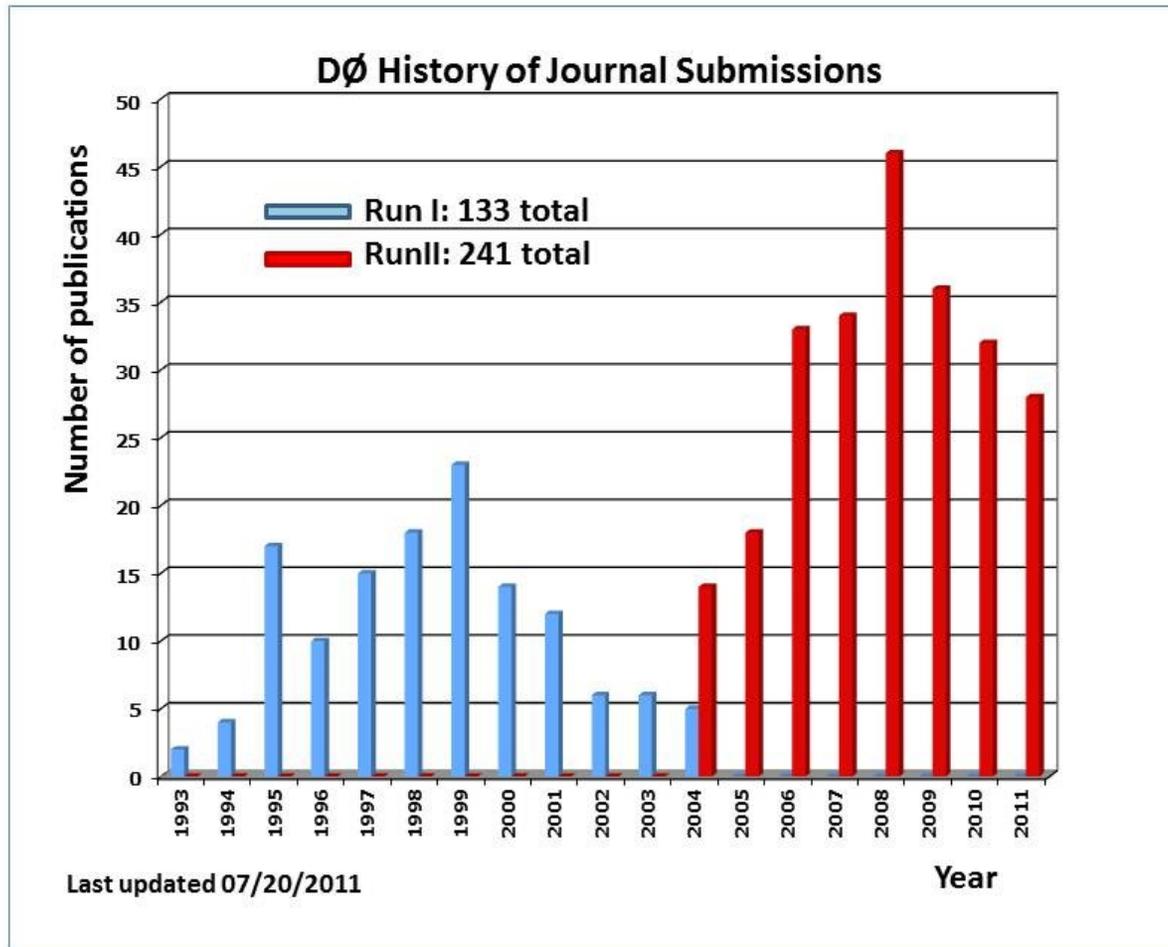


Thanks to the Accelerator Division

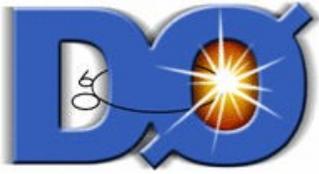




Publication Summary



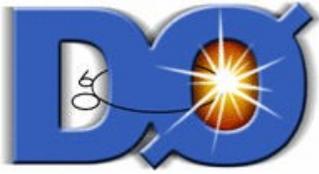
**28 new journal submissions (so far) in 2011
4 per month on average**



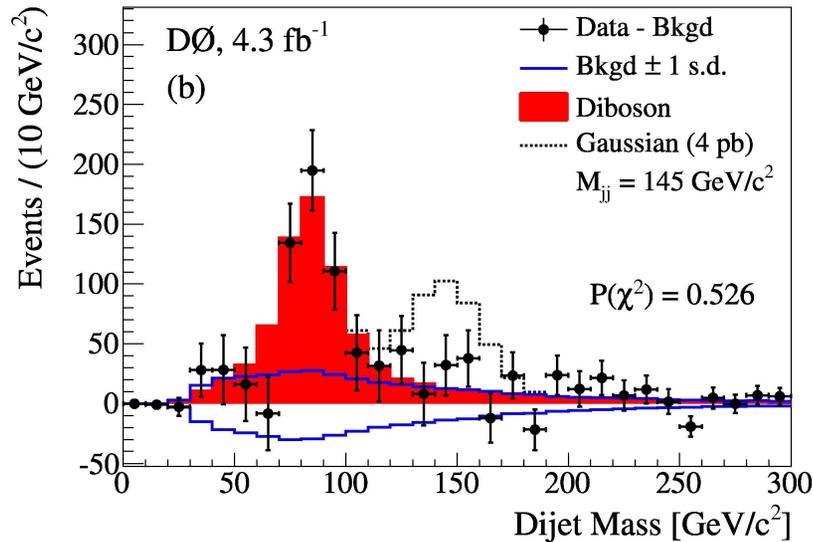
DØ Wine&Cheese Seminars

- **11 February - S. Jabeen**
 - Top physics: mass from cross section, spin correlations, FCNC in $t\bar{t}$ events
- **11 March - C. Schwanenberger**
 - New results for Winter Conferences (Higgs, $A_{fb}(e^+e^-), \dots$)
- **10 June - J. Haley**
 - Dijet invariant mass spectrum in $W+2$ jets events
- **30 June - B. Hoeneisen**
 - Likesign dimuon asymmetry

- **This coming Monday 25 July (2:30pm)**
 - **Doug Orbaker**
 - **Forward-backward asymmetry in top quark-antiquark production in proton-antiproton collisions at DØ**
 - Result not covered today



Reminder: W+2 jets

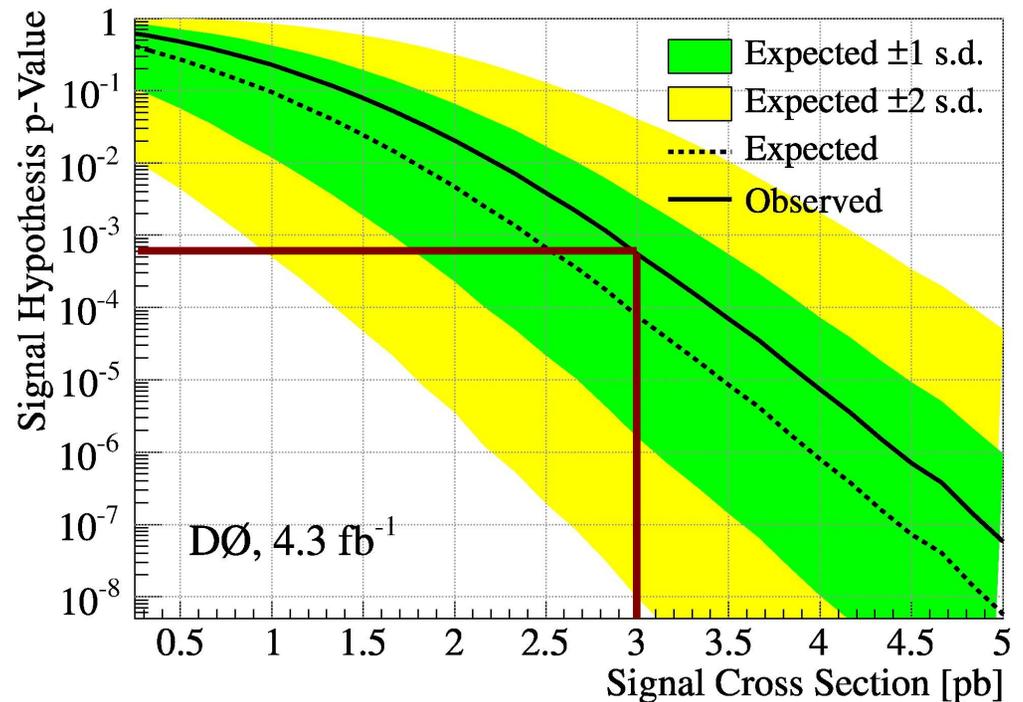


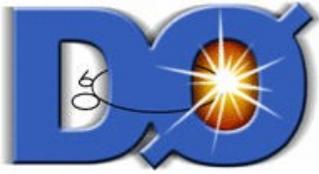
DØ does not confirm the excess observed at CDF

Pick a cross section, read the exclusion level....

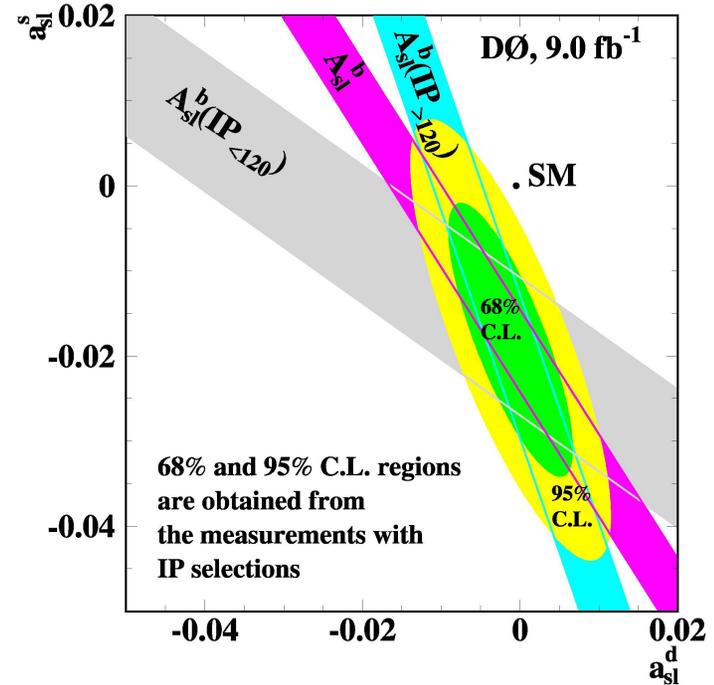
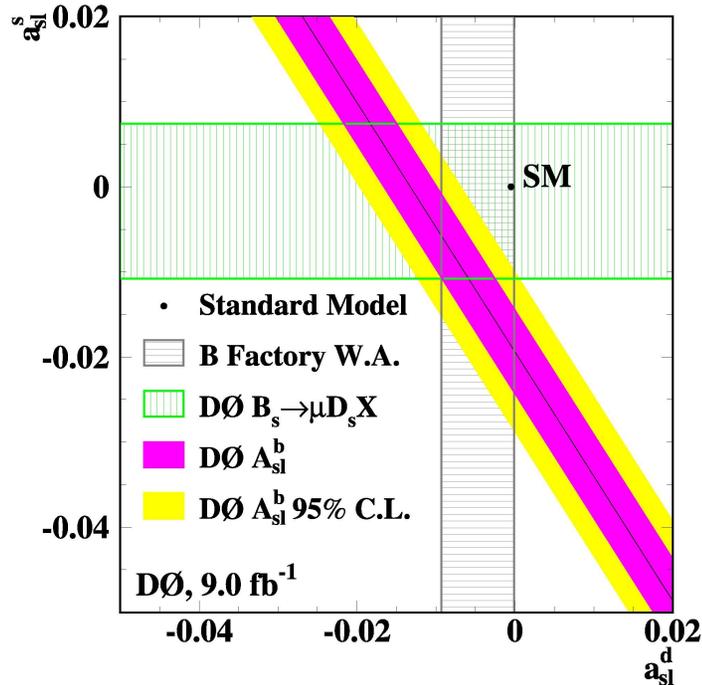
Repeated the analysis with selection and analysis procedure as close as possible to CDF

PRL 107, 011804 (2011)





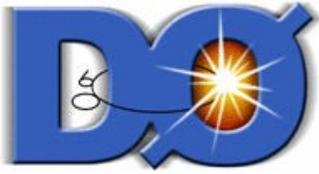
Reminder: like-sign 2μ asymmetry



$$A_{sl}^b = (-0.787 \pm 0.172(\text{stat}) \pm 0.093(\text{syst}))\%$$

3.9 standard deviations away from SM predictions

arXiv.org:1106.6308



Outline

- **New physics beyond the SM**

- **1st generation leptoquarks, stable charged particles**

- **B-physics**

- **Rare decays, CP violation in $B_s \rightarrow J/\psi\phi$**

- **Top quark physics**

- **Cross sections, Rb, mass, spin correlations, single top**

- **QCD and Electroweak**

- **W+jets differential cross sections, 3 jets, $A_{fb}(e^+e^-)$ and $\sin^2\theta_w$**

- **Higgs**

- **Updated SM and BSM searches, DØ combination**



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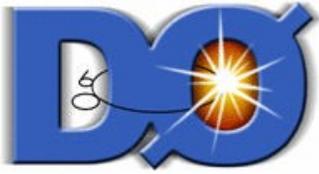
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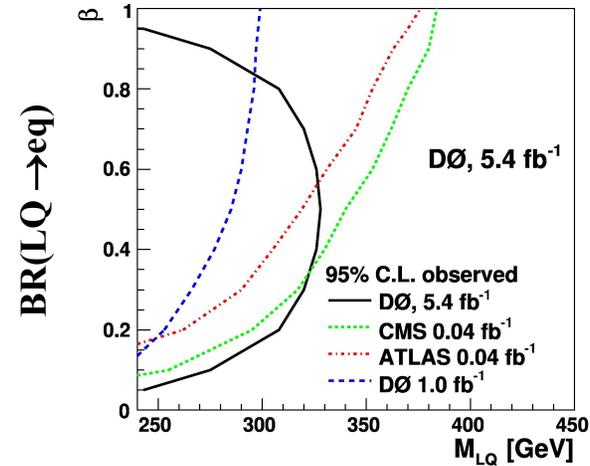
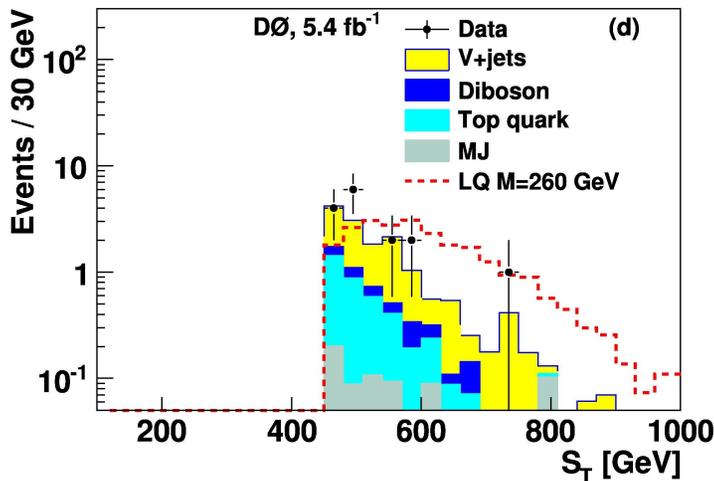
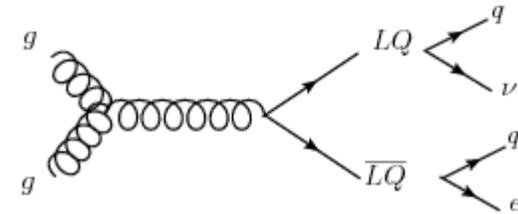
- Updated SM and BSM searches, DØ combination



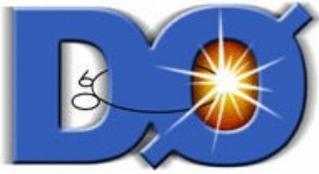
NP Searches (I) - Leptoquarks

Search for 1st generation leptoquarks in $e\nu qq'$ final state

Report limits in plane of LQ mass and branching ratio $LQ \rightarrow e q$



arXiv.org:1107.1849

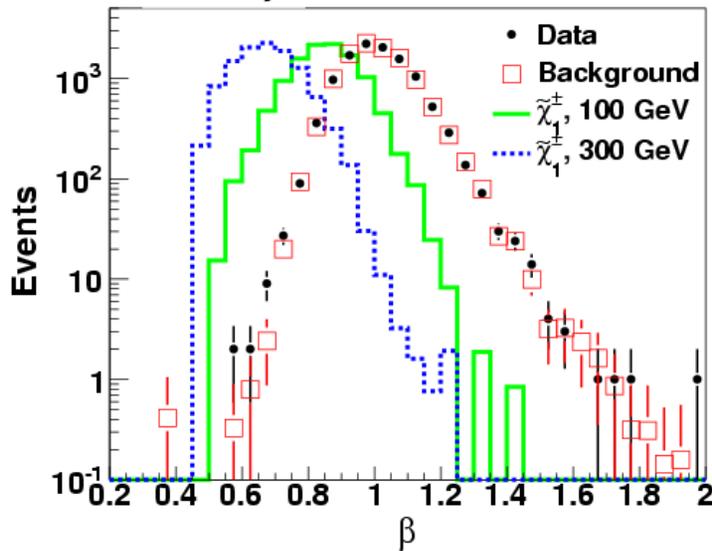


NP Searches (II) - Long Lived Particles

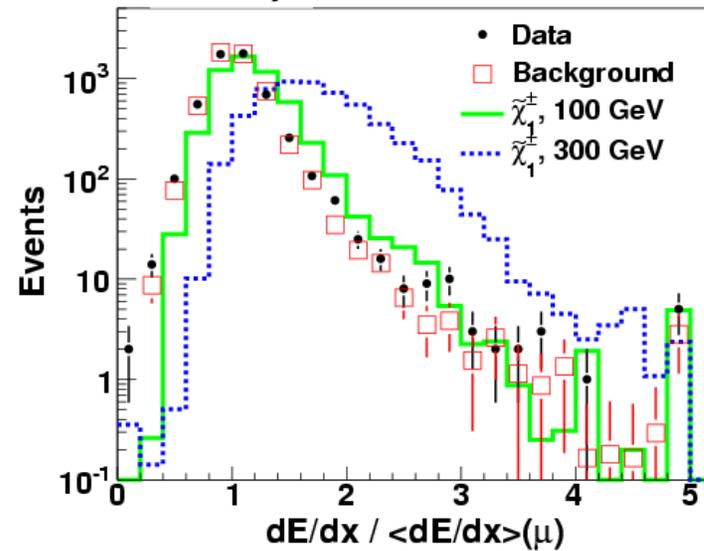
Search for charged massive long lived particles (charginos, staus, stops) using speed and dE/dx information

Exclude higgsino-like (gaugino-like) charginos
with $m_{\chi} < 230$ (251) GeV at 95% CL

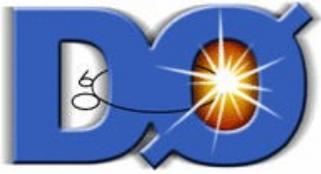
(a) $D\bar{D}$ Preliminary 5.2 fb⁻¹



(b) $D\bar{D}$ Preliminary 5.2 fb⁻¹

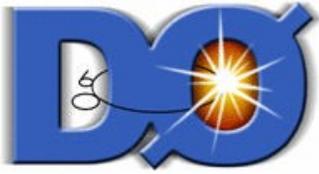


New at EPS, to be submitted soon



Outline

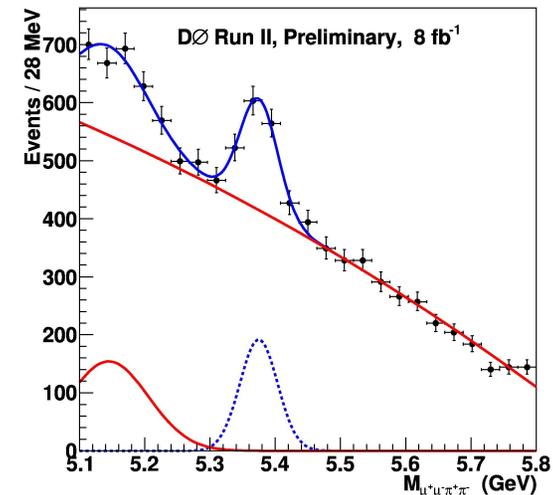
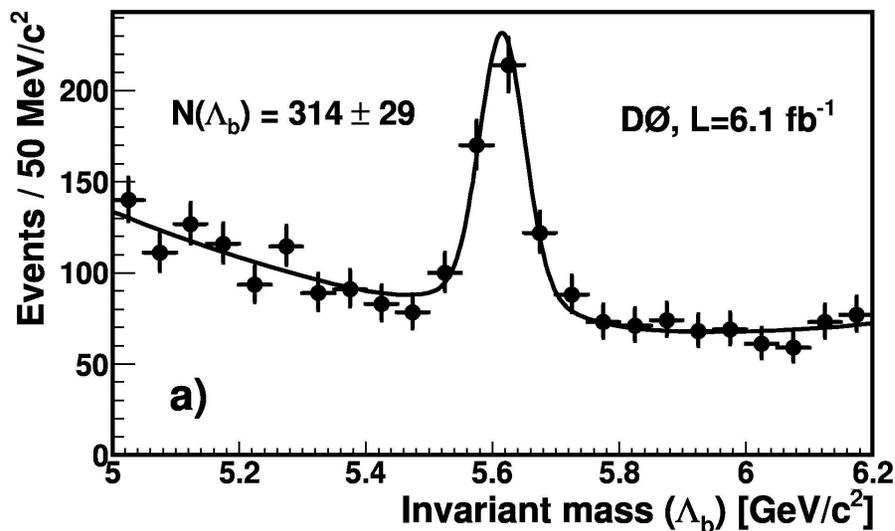
- New physics beyond the SM
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B-physics (I)- rare decays

Measured branching ratios

- $f(b \rightarrow \Lambda_b) * B(\Lambda_b \rightarrow J/\psi \Lambda) = (6.01 \pm 0.61(\text{stat}) \pm 0.58(\text{syst}) \pm 0.28(\text{PDG})) * 10^{-5}$
- $B(B_s \rightarrow J/\psi f_0) / B(B_s \rightarrow J/\psi \phi) = (0.210 \pm 0.032(\text{stat}) \pm 0.036(\text{syst}))$



arXiv.org:1107.1849

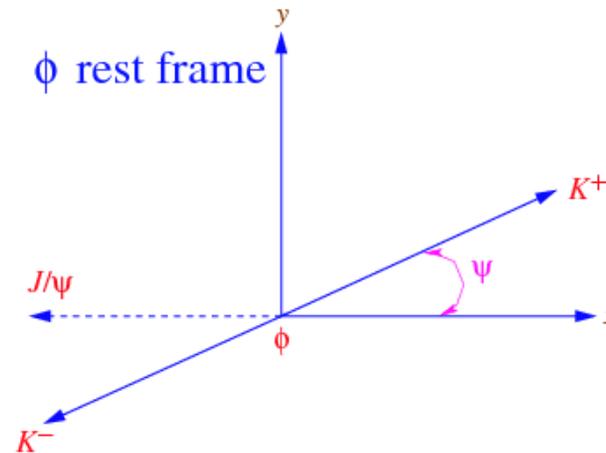
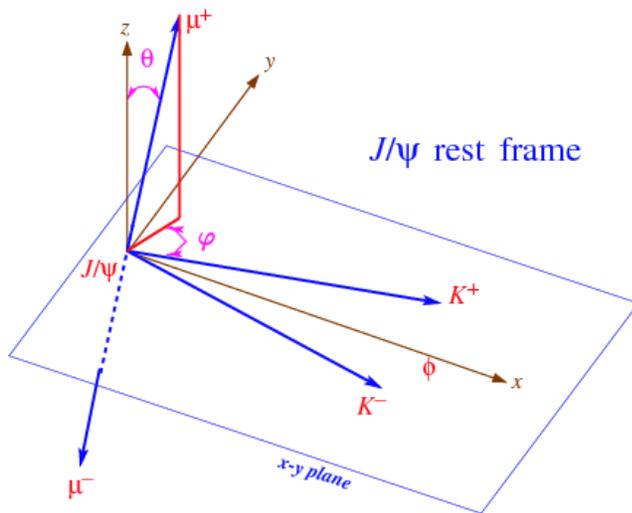
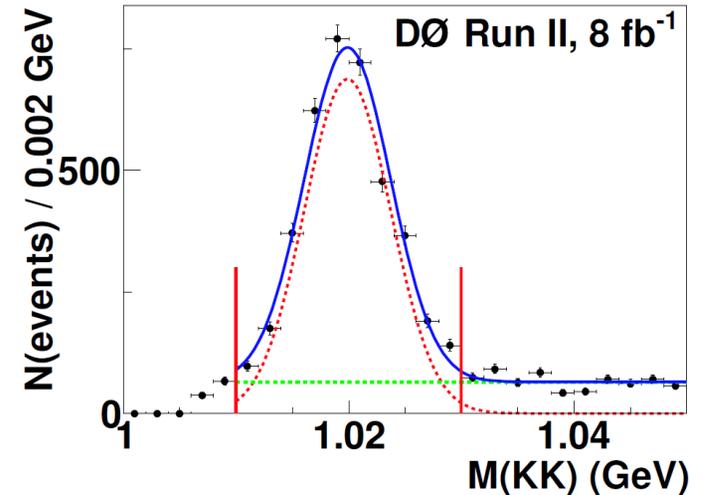
<http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/B/B62/>



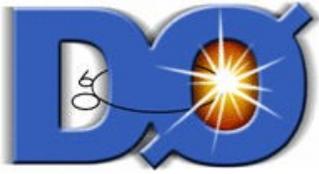
B-physics (II)- CP violation

Updated measurement of CP violation in $B_s \rightarrow J/\psi \phi$ flavor tagged decay

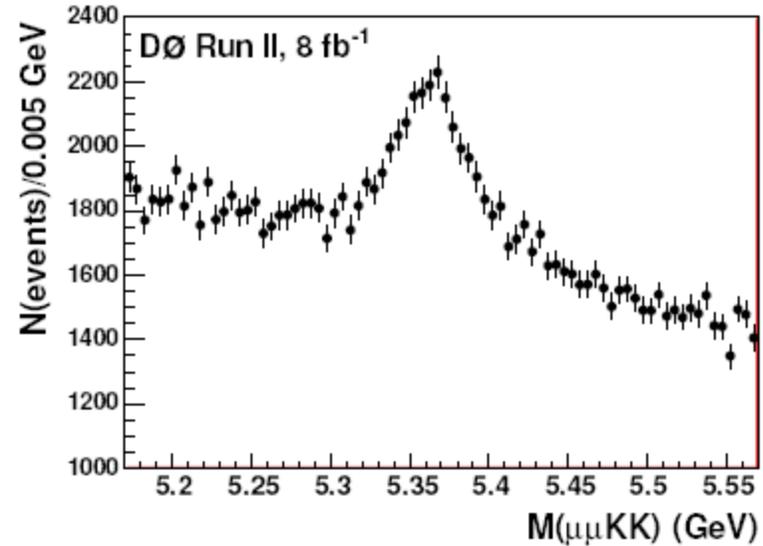
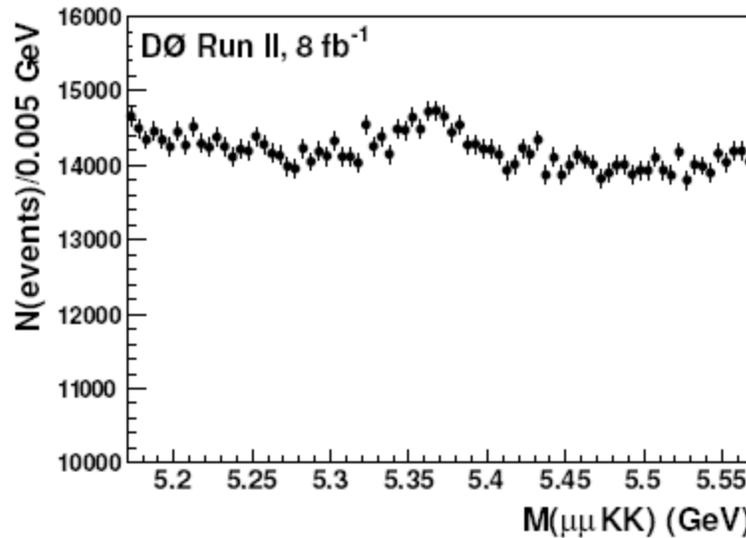
- Polarization of decay products
- Include s-wave contribution
- Signal selection (BDT)
- Flavor tagging
- Time dependence (oscillations)



New at EPS, to be submitted soon



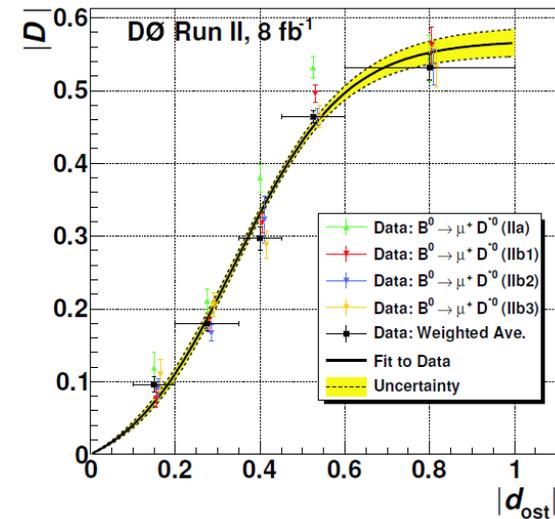
B-physics (III)- CP violation



(a)

Updated measurement of CP violation in $B_s \rightarrow J/\psi \phi$ flavor tagged decay

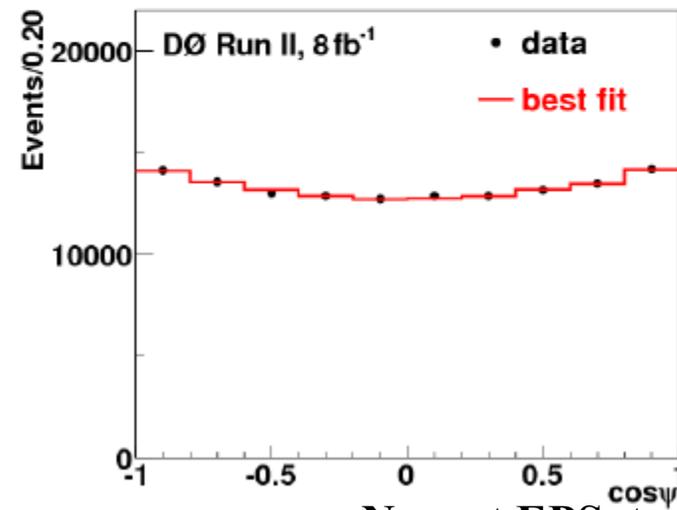
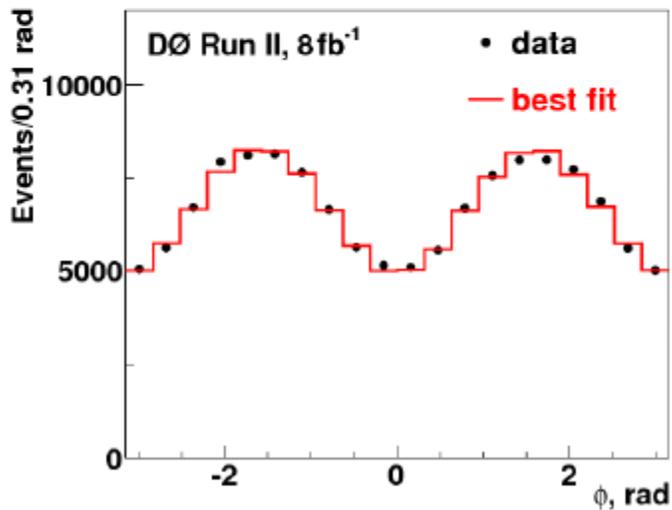
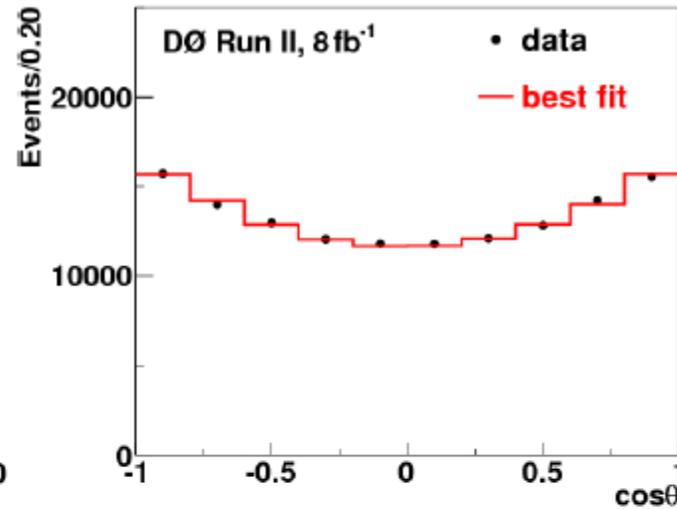
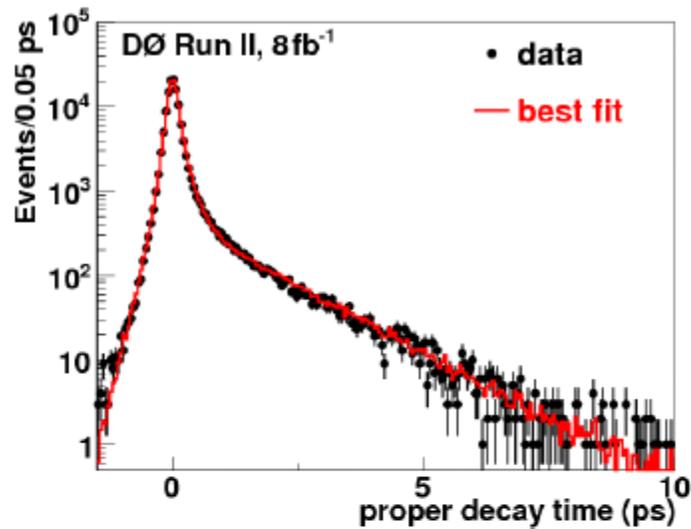
- Polarization of decay products
- Include s-wave contribution
- Signal selection (BDT)
- Flavor tagging
- Time dependence (next slide)



New at EPS, to be submitted soon



B-physics (IV)- CP violation



New at EPS, to be submitted soon



B-physics (V)- CP violation

$$\bar{\tau}_s = 1.443_{-0.035}^{+0.038} \text{ ps},$$

$$\Delta\Gamma_s = 0.163_{-0.064}^{+0.065} \text{ ps}^{-1},$$

$$\phi_s^{J/\psi\phi} = -0.55_{-0.36}^{+0.38},$$

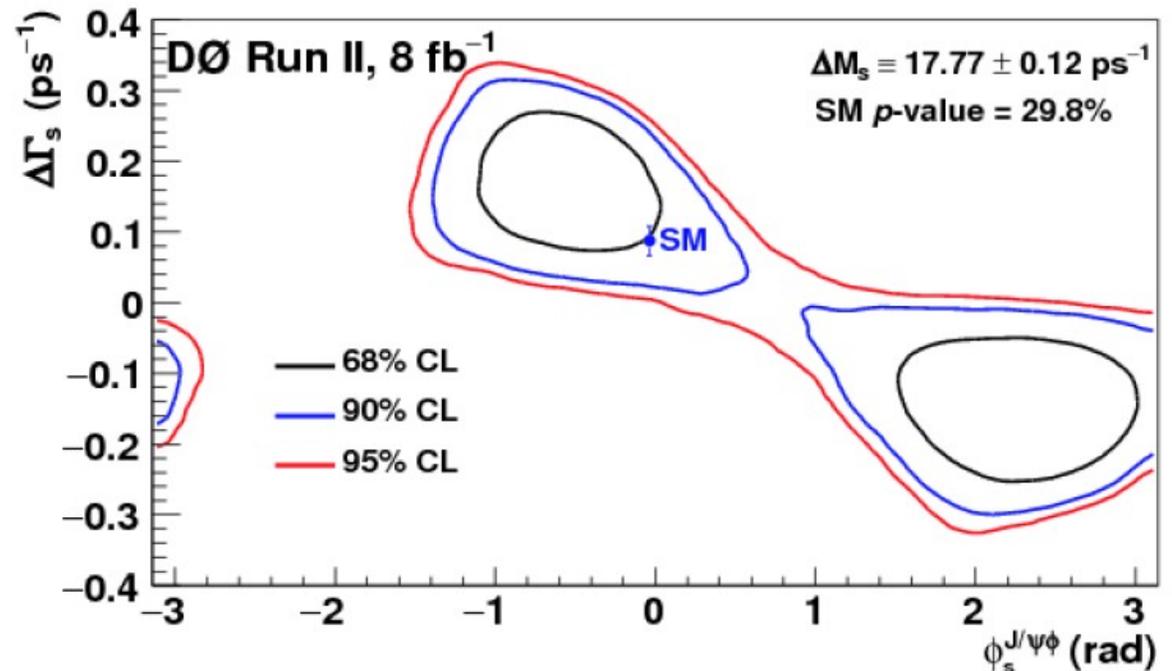
$$|A_0|^2 = 0.558_{-0.019}^{+0.017},$$

$$|A_{||}|^2 = 0.231_{-0.030}^{+0.024},$$

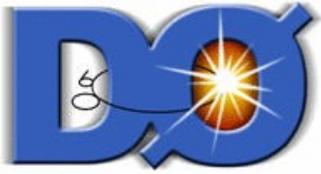
$$F_S = 0.173 \pm 0.036,$$

$$\delta_{||} = 3.15 \pm 0.22,$$

$$\cos(\delta_{\perp} - \delta_s) = -0.11_{-0.25}^{+0.27}.$$

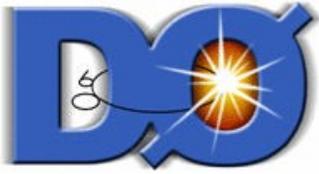


New at EPS, to be submitted soon



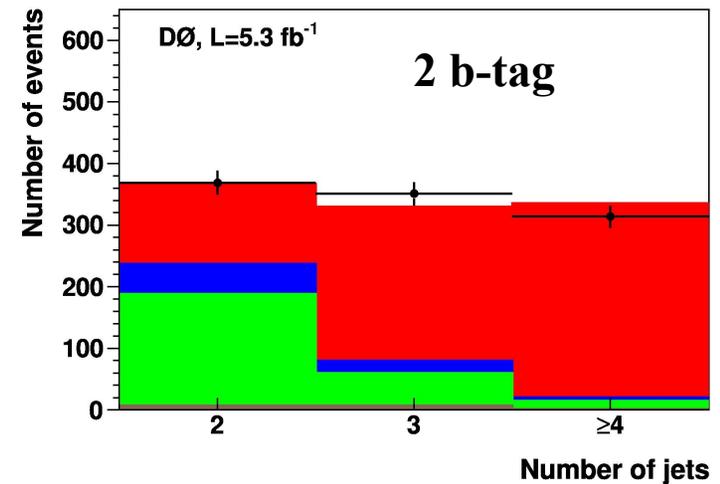
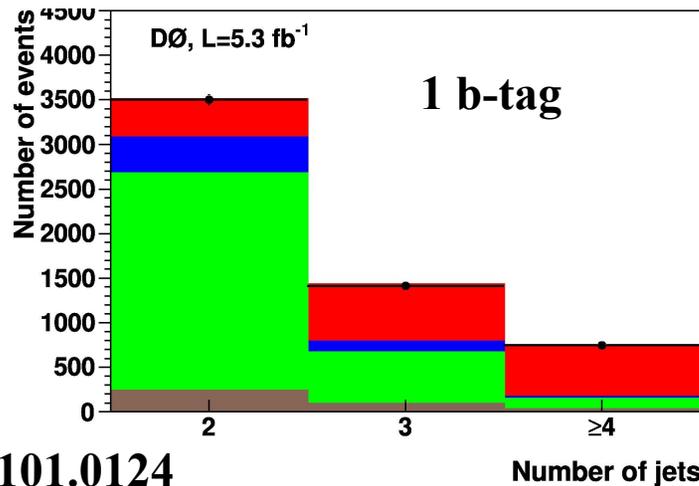
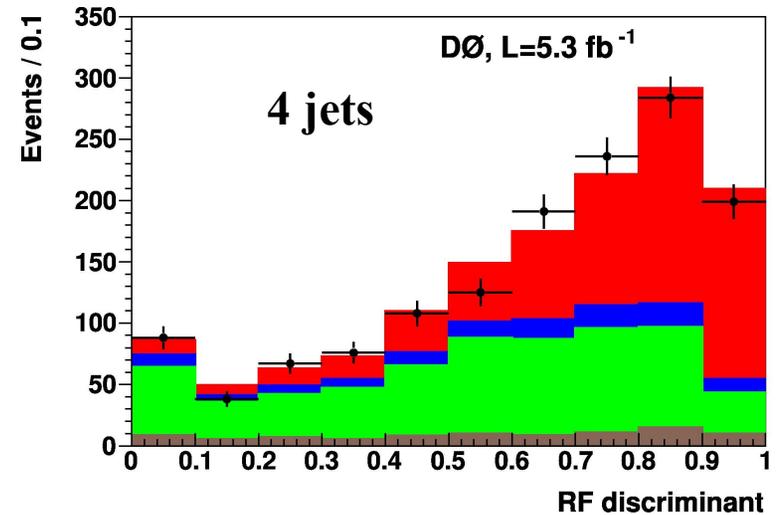
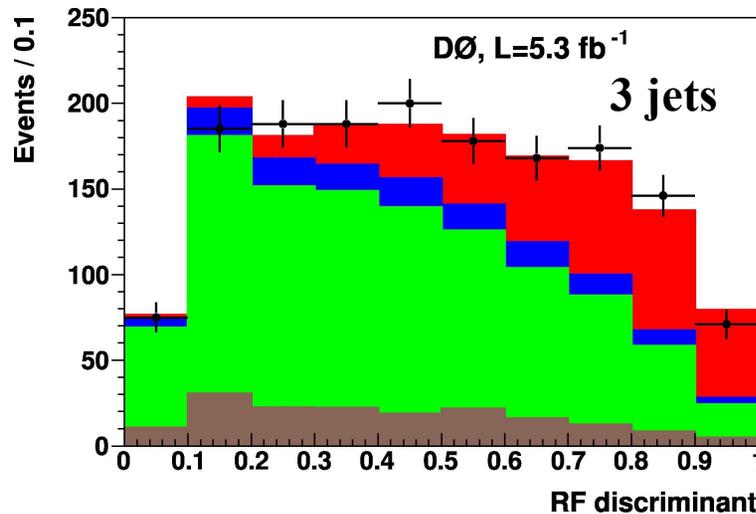
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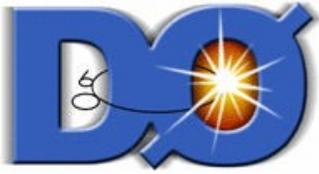


Top physics (I) - Cross Sections

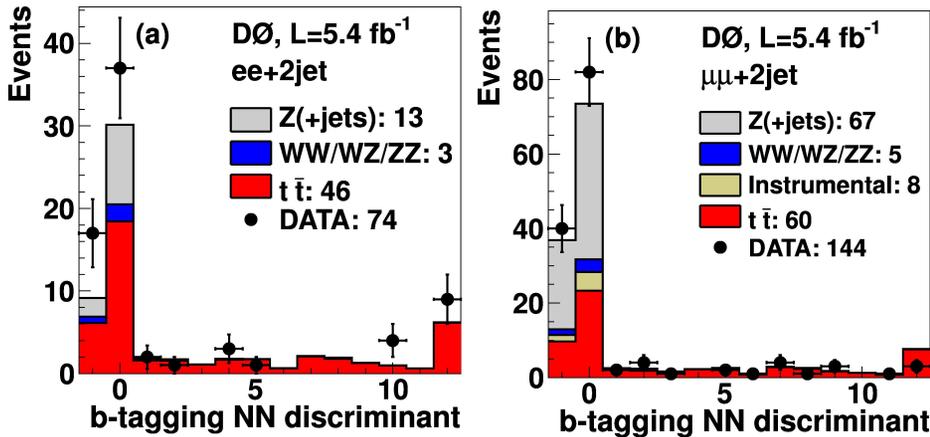
Selection: lepton+jets channel - use kinematics and b-tagging



arXiv.org:1101.0124



Top physics (II) - Cross Sections



Selection: dilepton channel - use b-tagging

Combine results to obtain

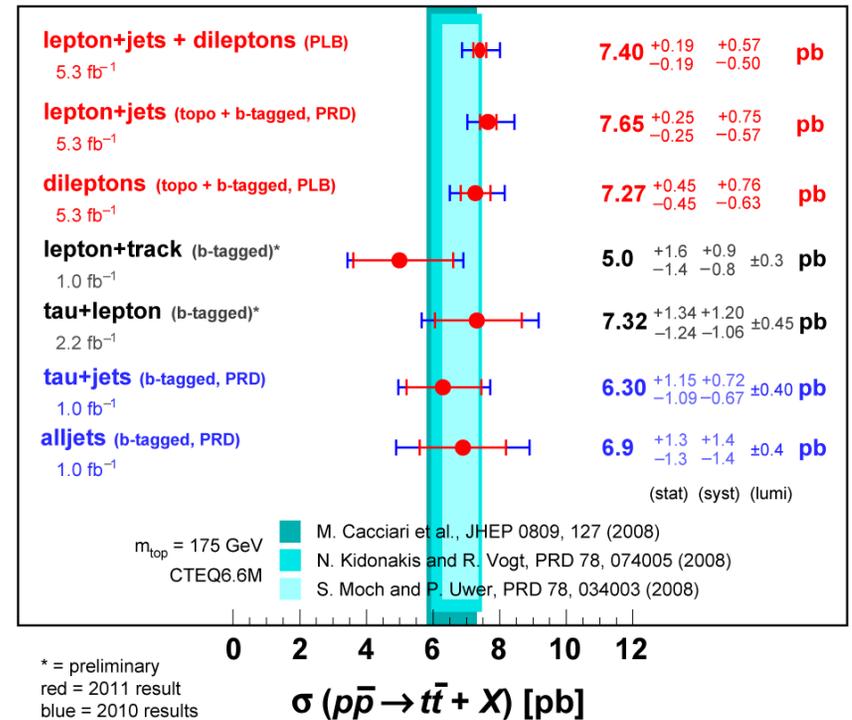
$$\sigma_{t\bar{t}} = (7.56 + 0.63 - 0.56) \text{ pb (8\% precision)}$$

Systematics dominated by luminosity uncertainty

Precision similar to theoretical calculations

DØ Run II

July 2011



arXiv.org:1105.5384



Top physics (III) - Mass measurements

Top mass measured with matrix element technique in l+jets/dilepton channels

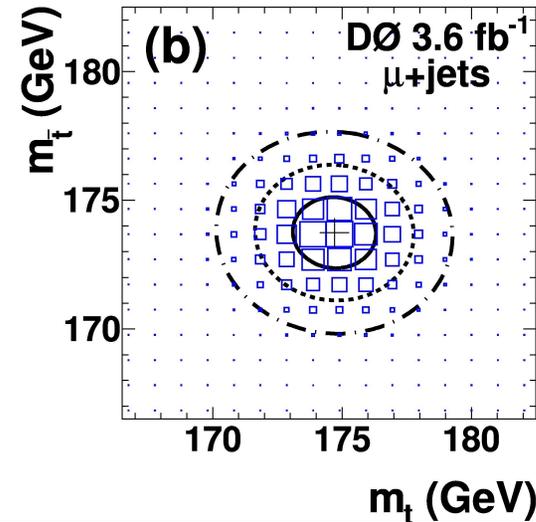
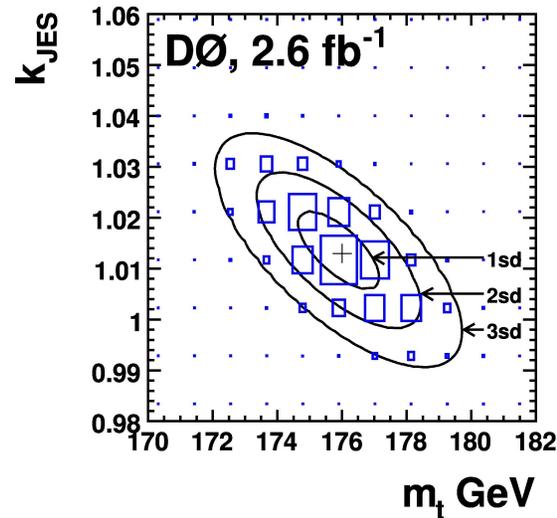
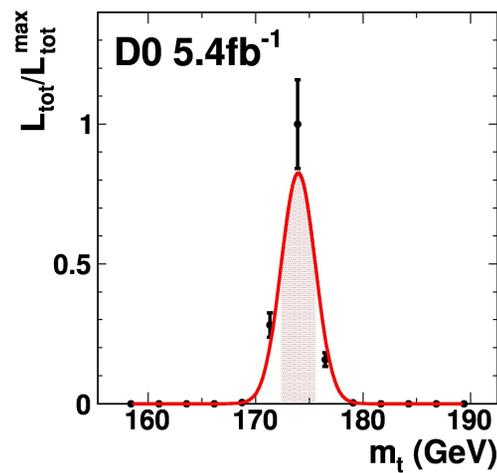
Improved treatment of systematics and heavy/light quark JES differences

**Also measured Δm_{top}
 $= (0.8 \pm 1.8 \pm 0.5) \text{ GeV}$**

arXiv.org:1105.6287

arXiv.org:1106.2063

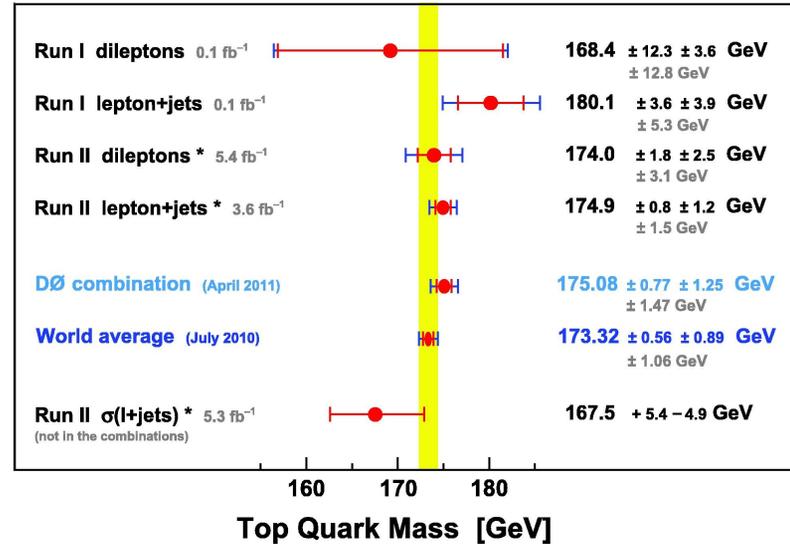
arXiv.org:1105.0320

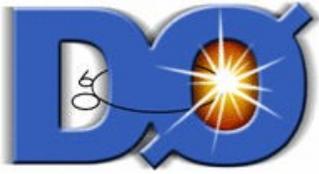


DØ

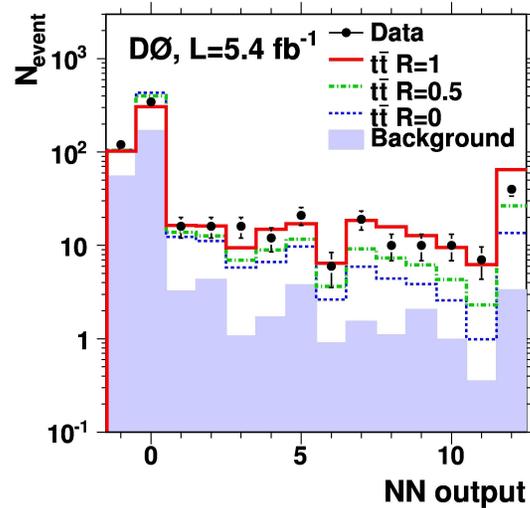
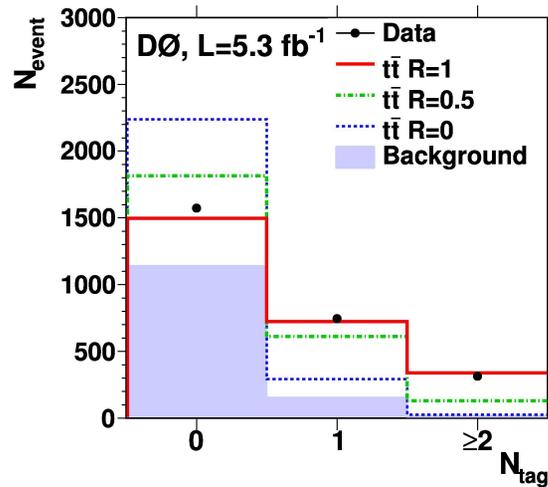
* = preliminary

April 2011





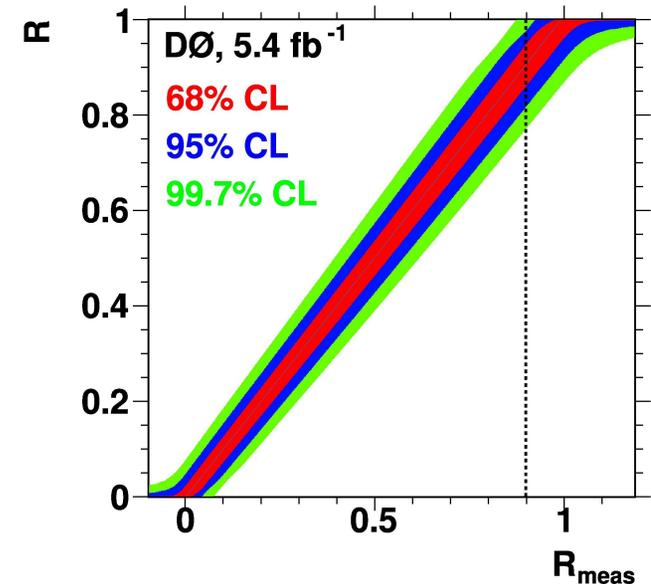
Top physics (IV) - $B(W \rightarrow tb)/B(W \rightarrow qb)$



Compare number of b-tags with templates for different values of $R=B(W \rightarrow tb)/B(W \rightarrow qb)$

• $R=(0.90 \pm 0.04)$

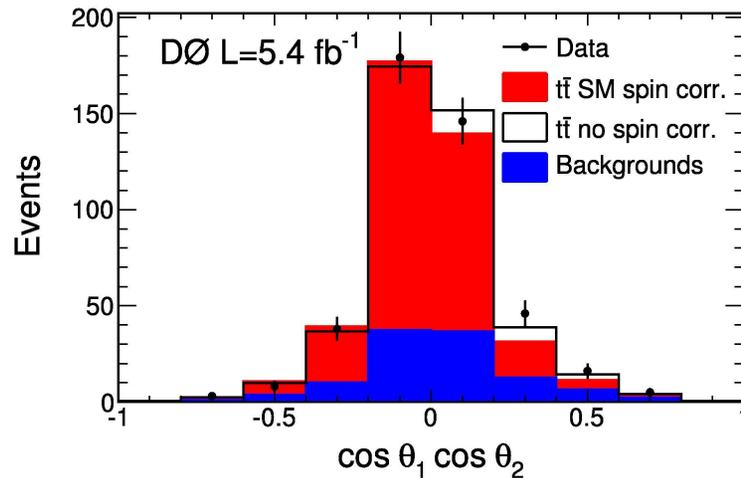
• $|V_{tb}|=0.95 \pm 0.02$



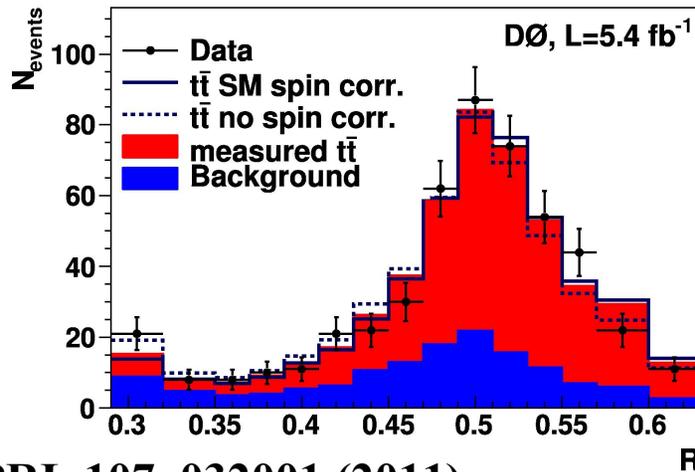
arXiv.org:1106.5436



Top physics (V) - Spin correlations



arXiv.org:1103.1871



PRL 107, 032001 (2011)

Measure strength of correlation C between top quark spins, via template fit to angular distribution:

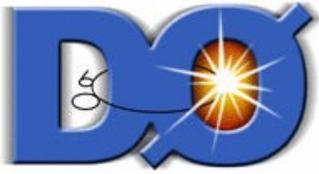
$$\frac{1}{\sigma} \frac{d^2\sigma}{d \cos \theta_1 d \cos \theta_2} = \frac{1}{4} (1 - C \cos \theta_1 \cos \theta_2)$$

Obtain $C=0.10 \pm 0.45$ (SM 0.78),
Exclude $C < -0.06$ @ 95% CL

Use full decay information in matrix element method (compare correlation/no-correlation hypotheses)

Exclude no correlation hypothesis at 97.7% CL

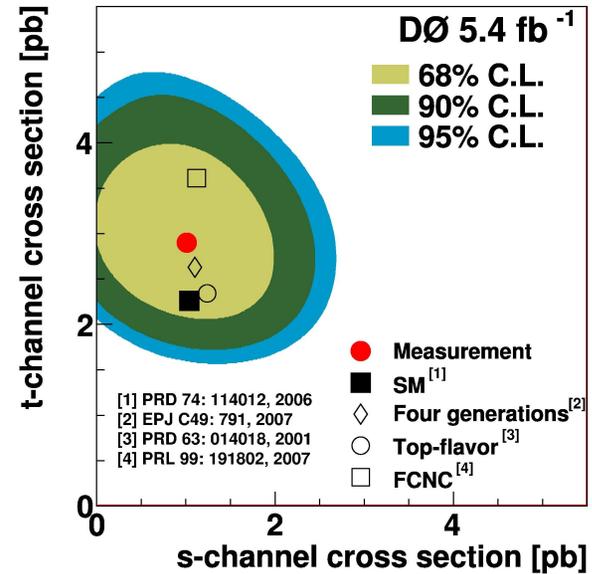
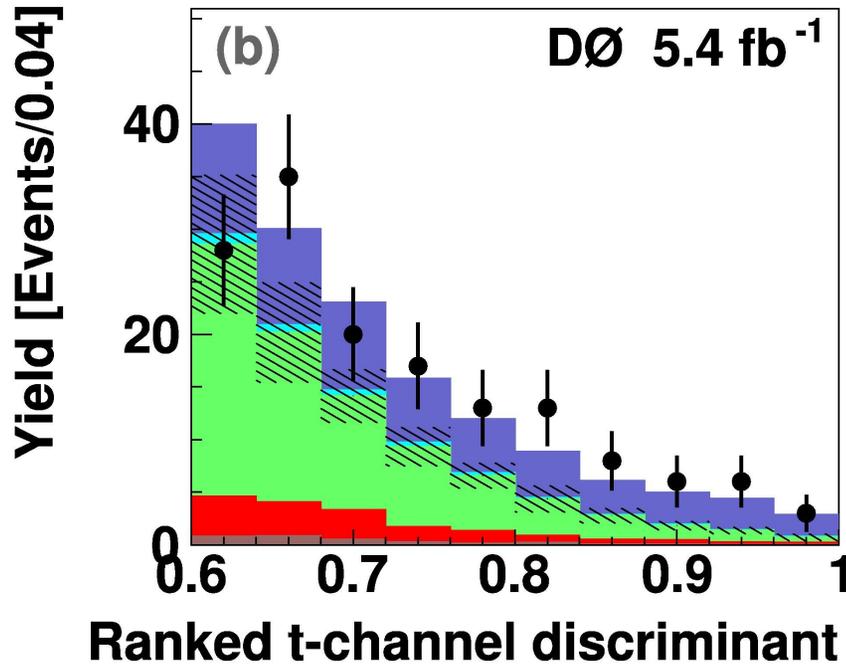
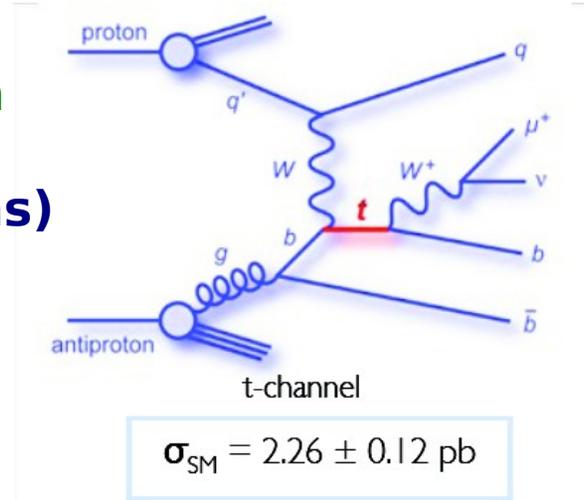
Obtain $C=0.57 \pm 0.31$ (SM 0.78)



Top physics (VI) - Single top

Observation of single top t-channel production

$$\sigma(\text{tqb}) = (2.90 \pm 0.56) \text{ pb} \quad (5.5 \text{ standard deviations})$$

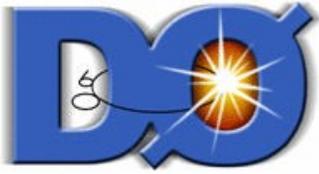


arXiv.org:1105.2788



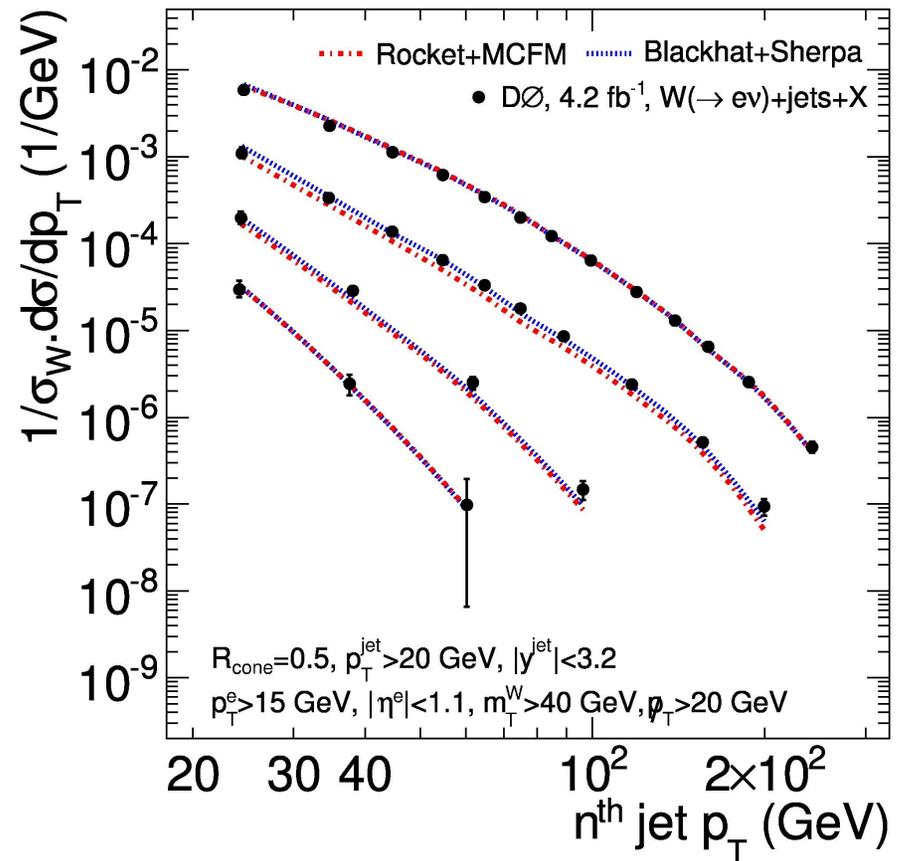
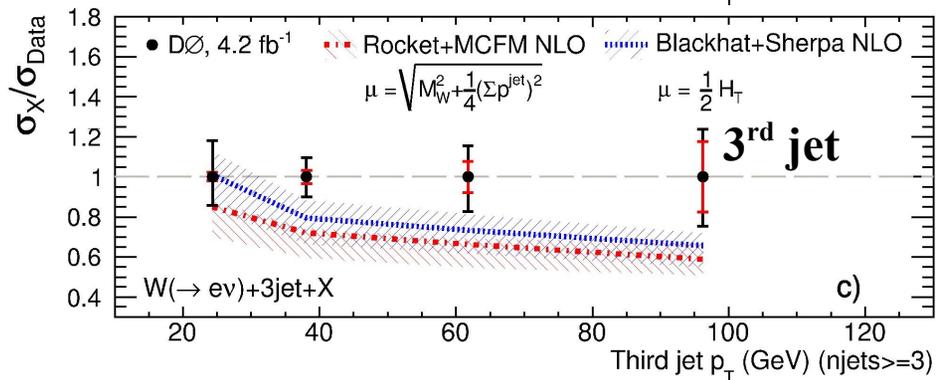
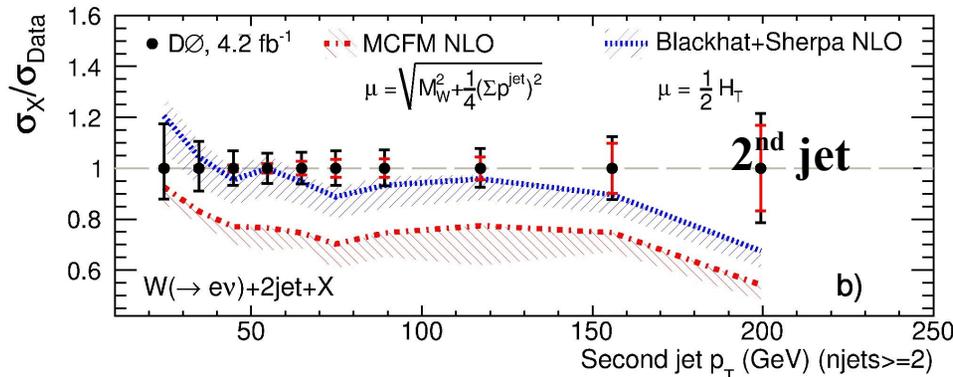
Outline

- New physics beyond the SM
 - 1st generation leptoquarks, stable charged particles
- B-physics
 - Likesign dimuons, rare decays, CP violation in $B_s \rightarrow J/\psi\phi$
- Top quark physics
 - Cross sections, Rb, mass, spin correlations, single top
- **QCD and Electroweak**
 - **W+jets differential cross sections, 3 jets, $A_{fb}(e^+e^-)$ and $\sin^2\theta_w$**
- Higgs
 - Updated SM and BSM searches, DØ combination

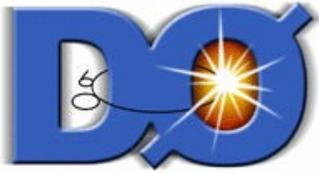


QCD (I) - W+jets differential X-sect

Measure W+jets differential cross section as function of jet p_T (for n^{th} jet in event), compare to NLO calculations



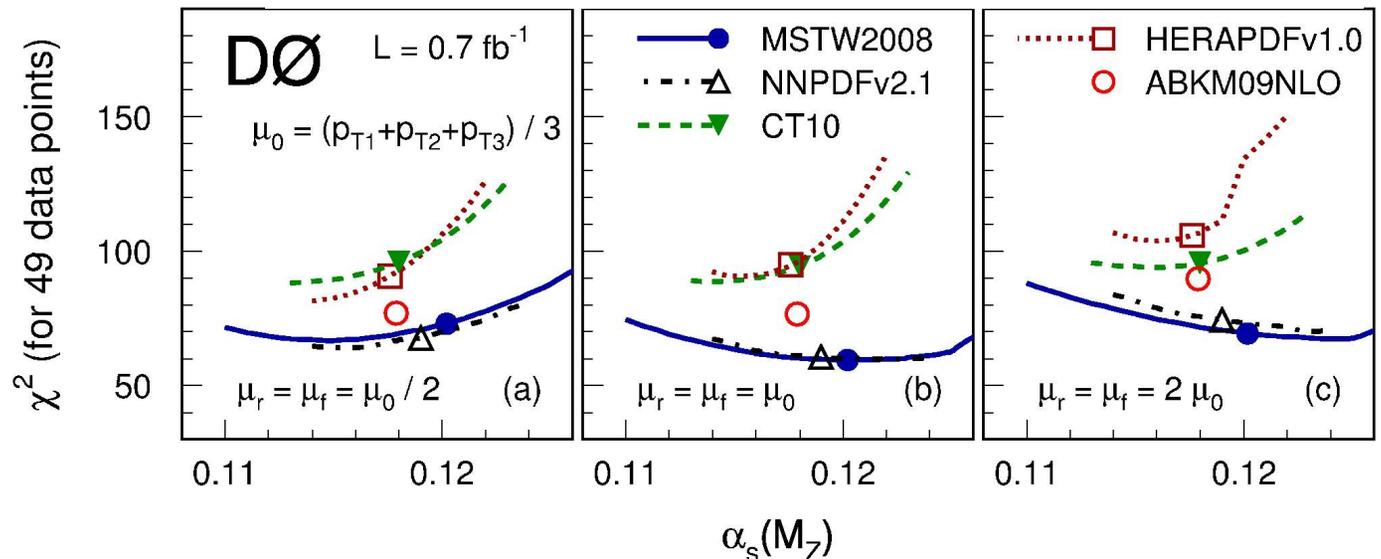
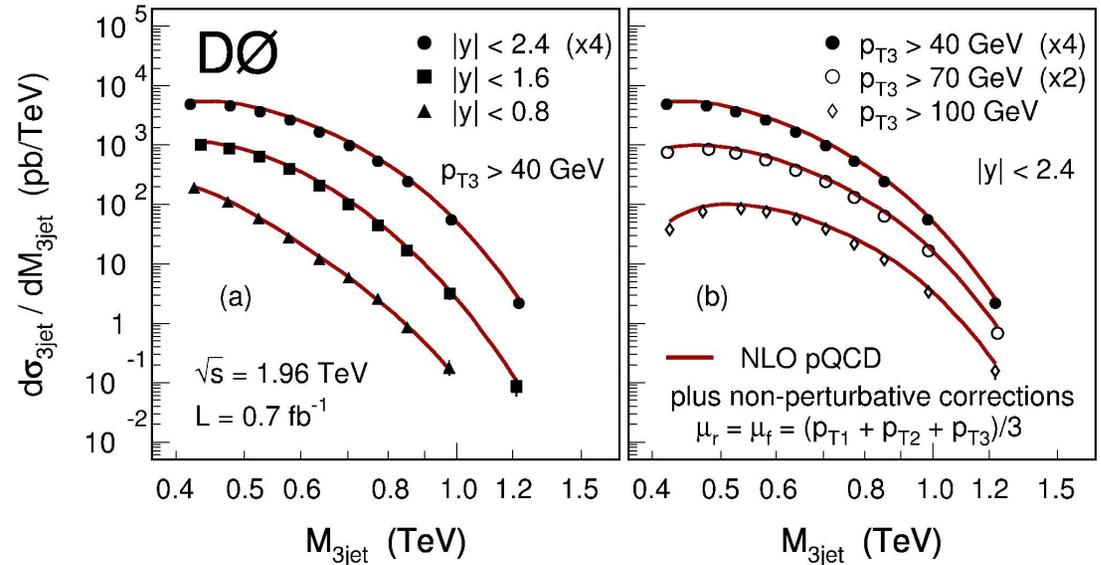
arXiv.org:1106.1457



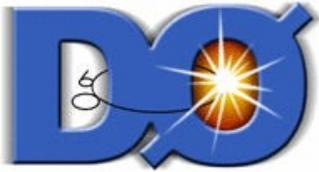
QCD (II) - 3 jets cross sections

Measure 3-jets differential cross section vs M_{3jet} in bins of p_T /rapidity

Calculate consistency with different PDF sets as function of α_s



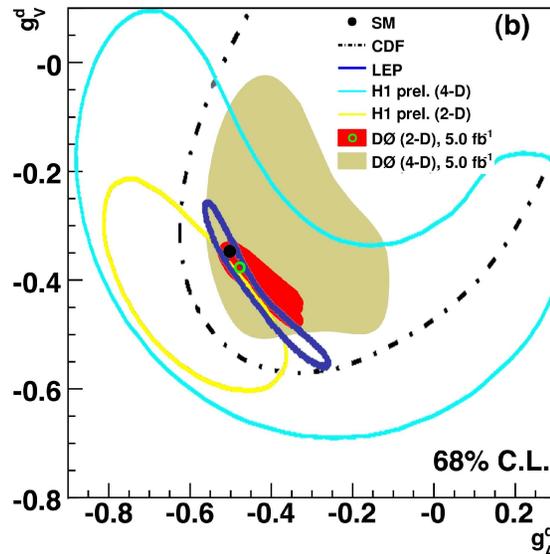
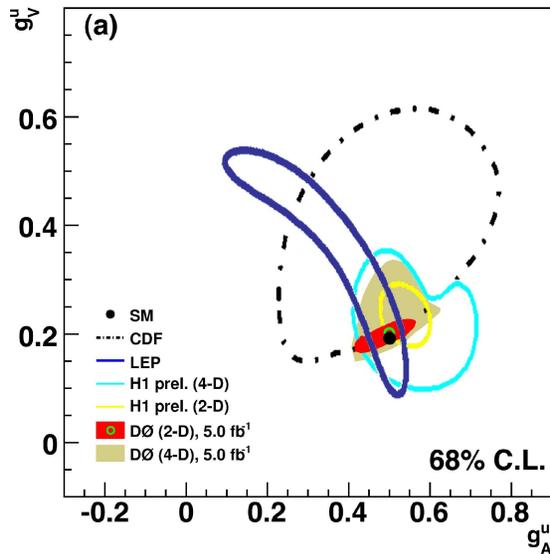
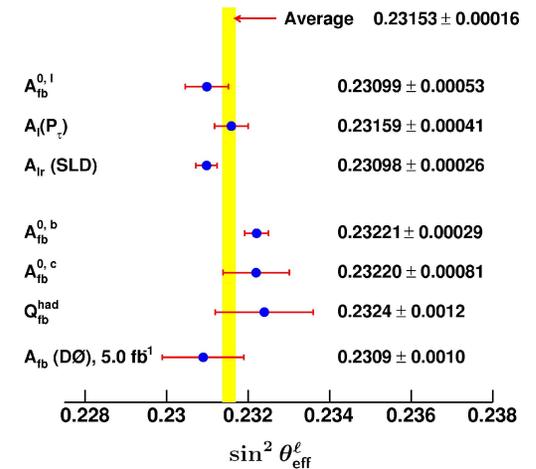
arXiv.org:1104.1986



Electroweak - $A_{fb}(e^+e^-)$ and $\sin^2\theta_w$

Measure forward-backward asymmetry in Drell Yan events vs Mee

Extract $\sin^2\theta_w$ and Z-light quark couplings

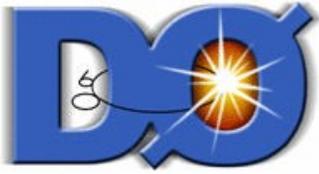


arXiv.org:1104.4590



Outline

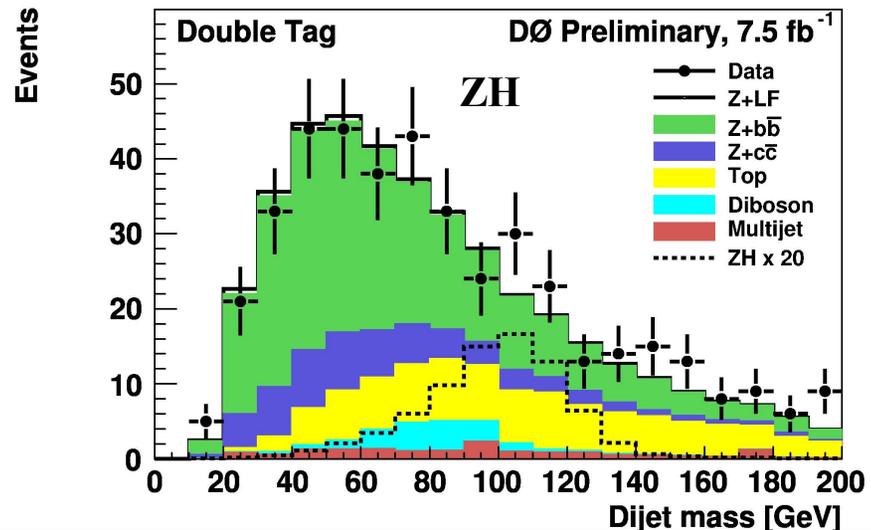
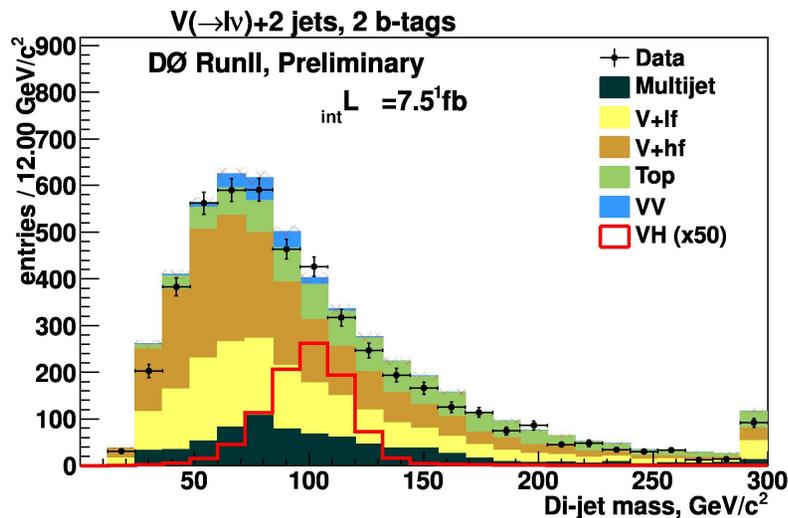
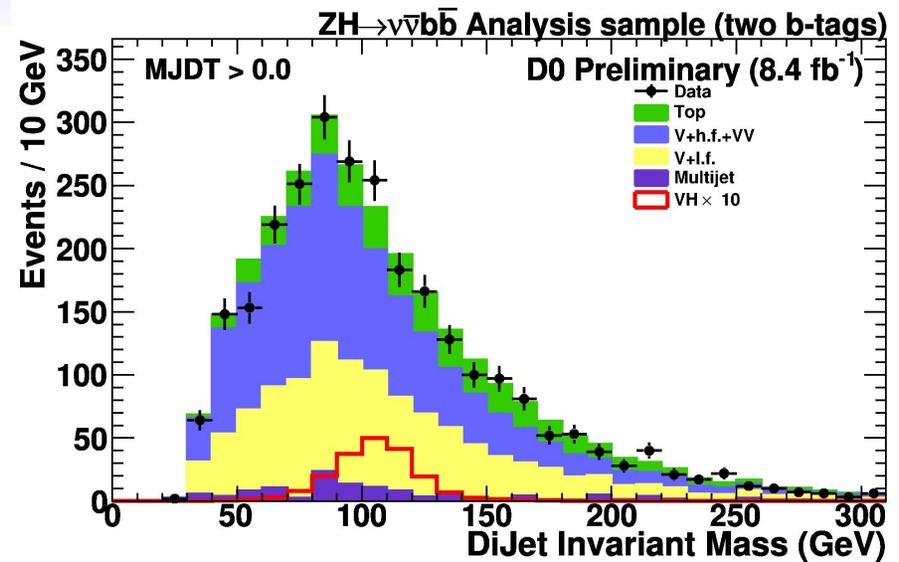
- New physics beyond the SM
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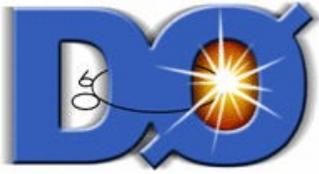


Higgs (I)- Low M_H

Search for WH/ZH associated production:

Bump in dijet invariant mass spectrum with 2 b-tags



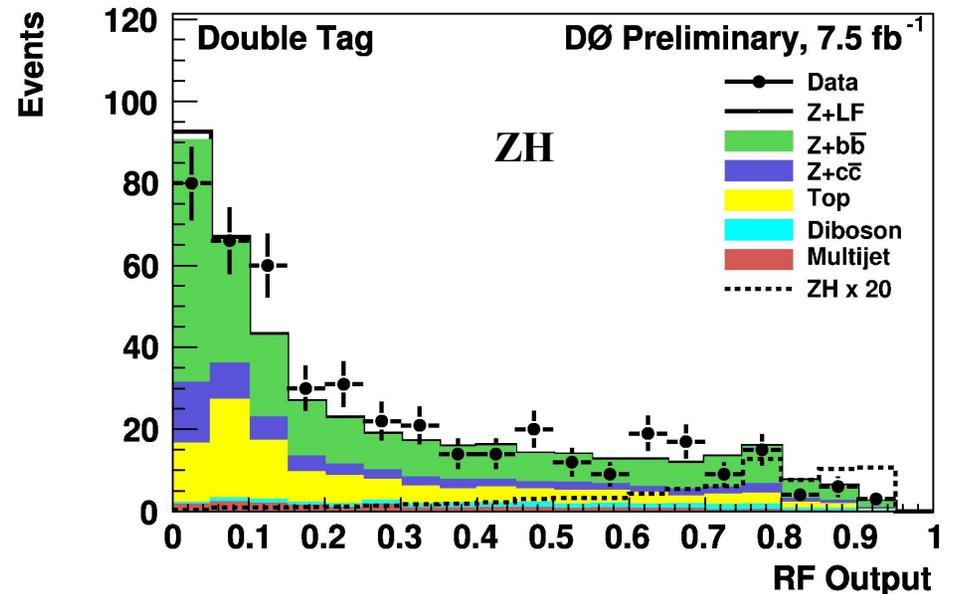
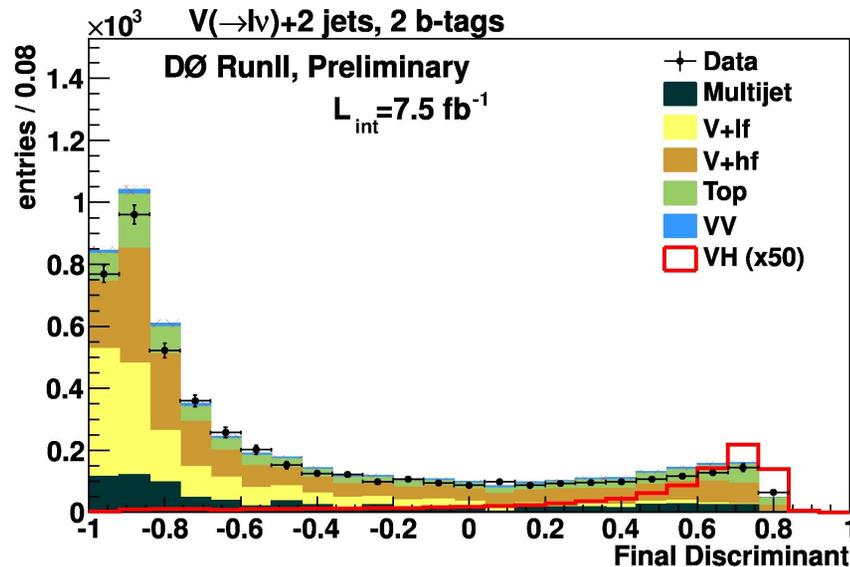


Higgs (II)-Low M_H

Increase size of dataset (up to 8.6 fb^{-1})

Improvements in analysis technique (use full b-tagging information from 2 jets in ZH channels)

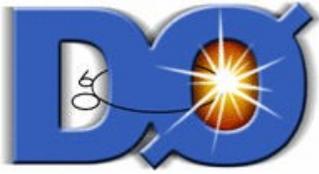
Multivariate discriminants



WH: <http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H108/>

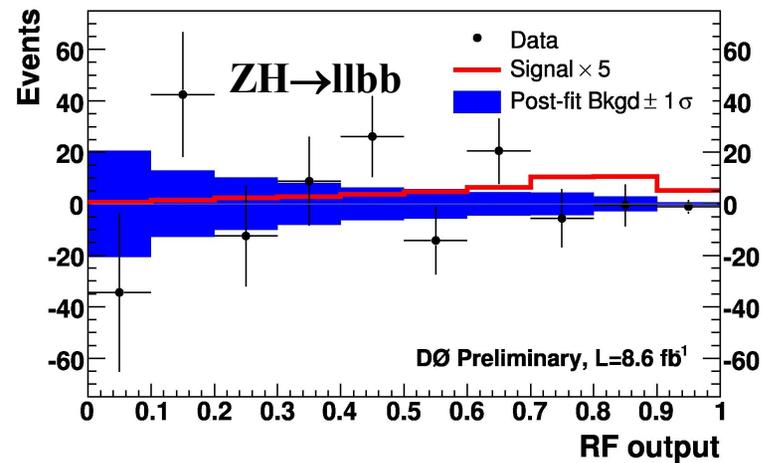
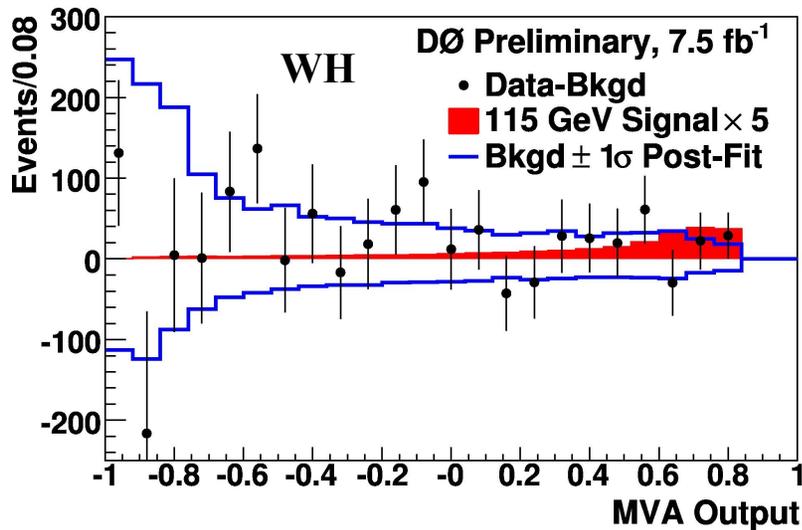
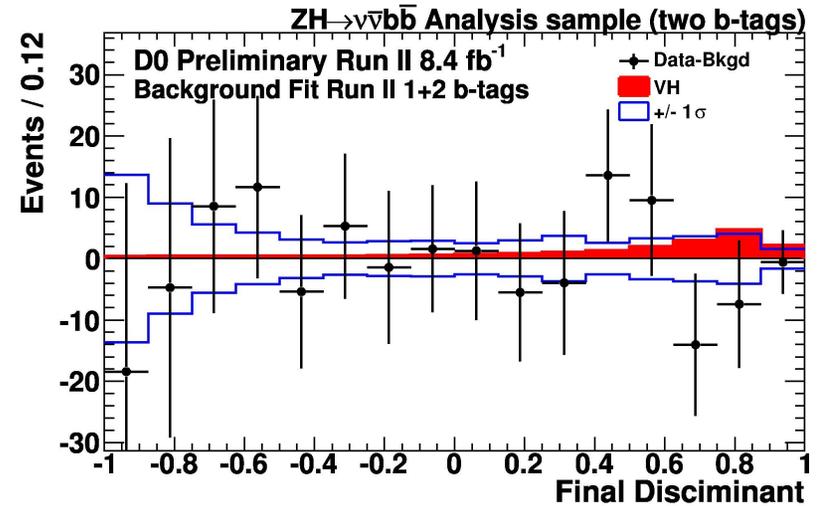
ZH: <http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H109/>

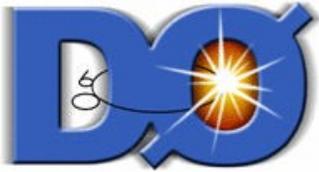
vvbb: <http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H110/>



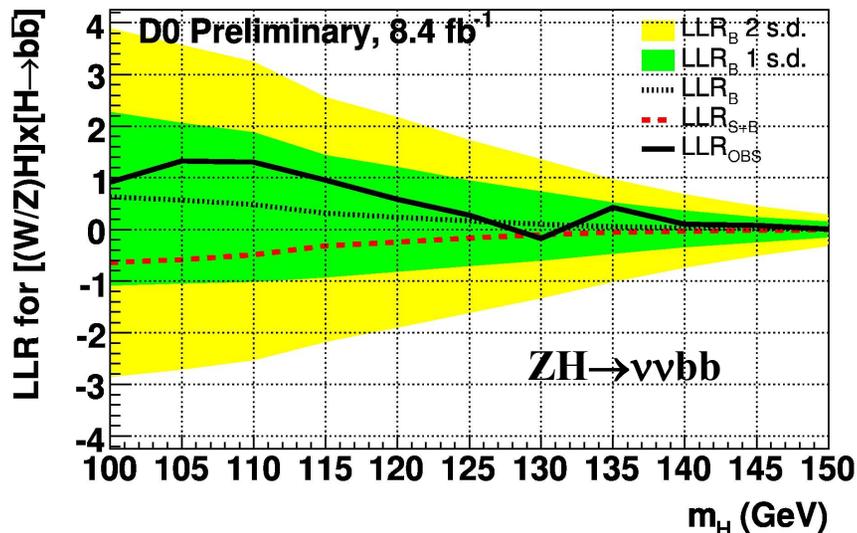
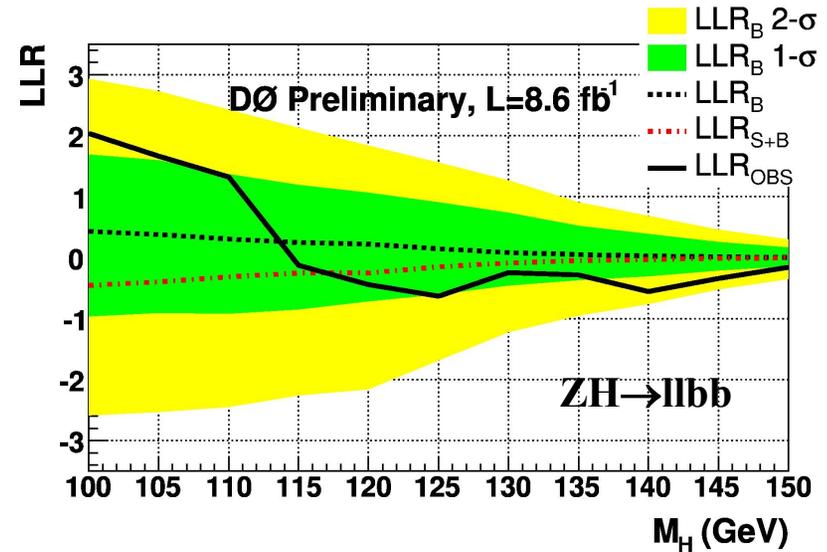
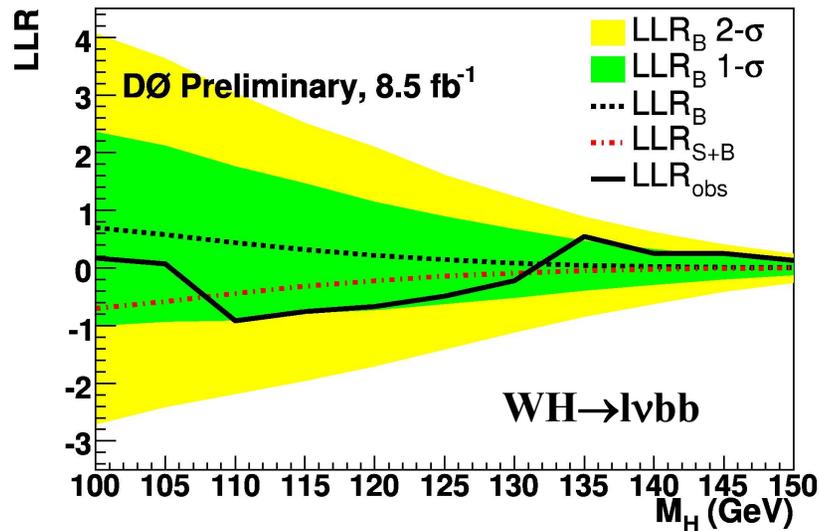
Higgs (III)-Low M_H

Data-MC comparisons after background subtraction and final fit to nuisance parameters for systematics



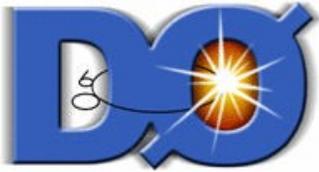


Higgs (IV)-Low M_H



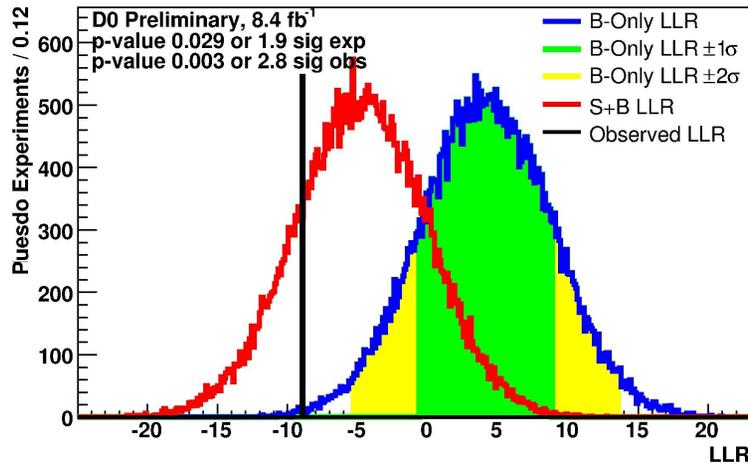
Sensitivities at 115 GeV:

- WH \rightarrow lvbb: 3.5*SM**
- ZH \rightarrow vvbb: 4.0*SM**
- ZH \rightarrow llbb: 4.8*SM**



Higgs (V)-VZ with $Z \rightarrow b\bar{b}$

VZ $\rightarrow \nu\bar{\nu}b\bar{b}$ Analysis

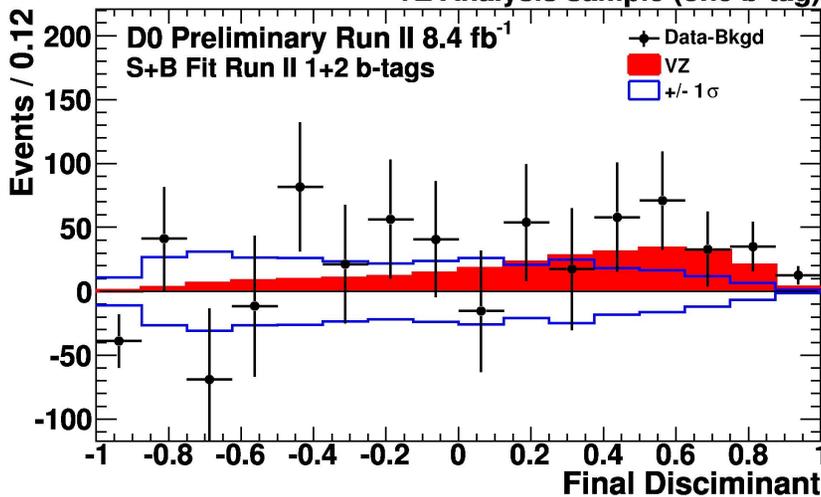


Study WZ/ZZ production with $Z \rightarrow b\bar{b}$ in the $\nu\bar{\nu}b\bar{b}$ final state

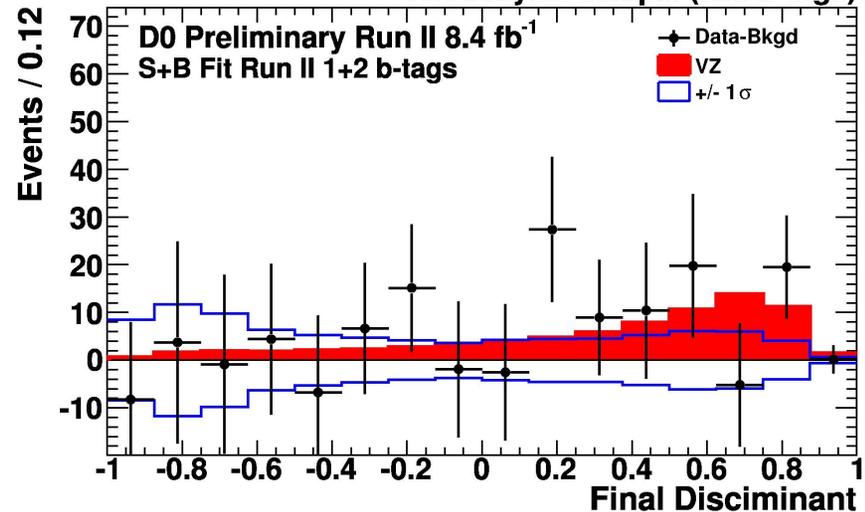
Measure $\sigma = (6.9 \pm 1.3 \pm 1.8) \text{ pb}$
(SM 4.6 pb)

Observed significance 2.8 s.d.
(expect 1.9 s.d.)

VZ Analysis sample (one b-tag)



VZ Analysis sample (two b-tags)



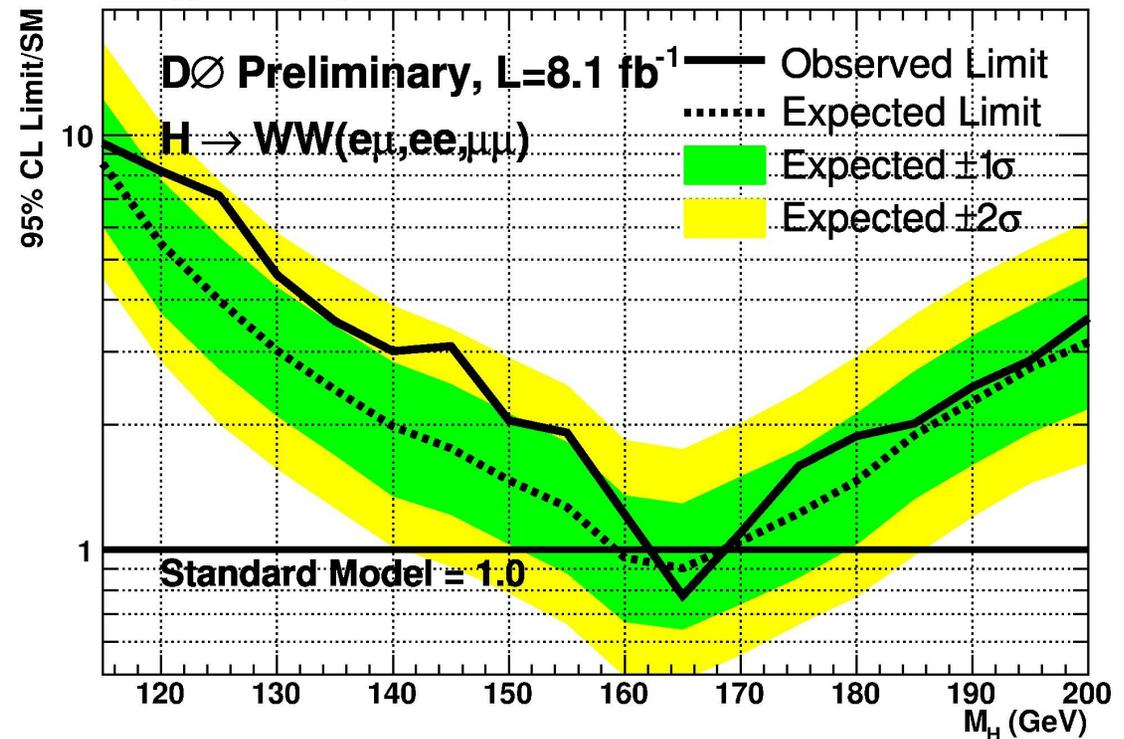


Higgs (VI)- $H \rightarrow WW$

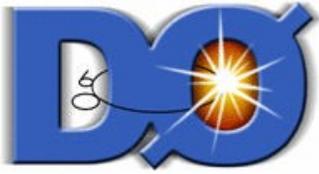
Updated theoretical predictions, improved understanding of systematic uncertainties

Improvement in background model for $e\mu$ channel

Full combination includes also $lvjj$ and $\mu\tau$ final states



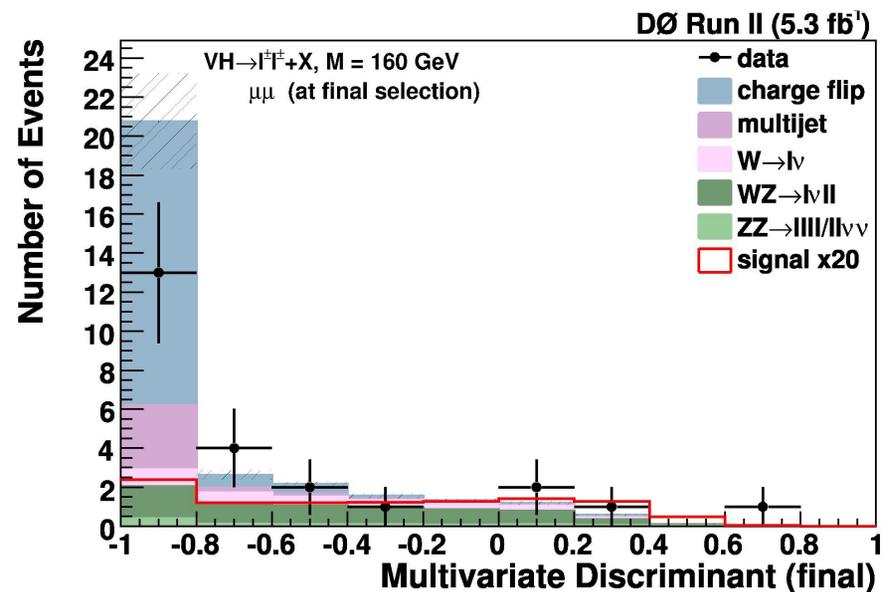
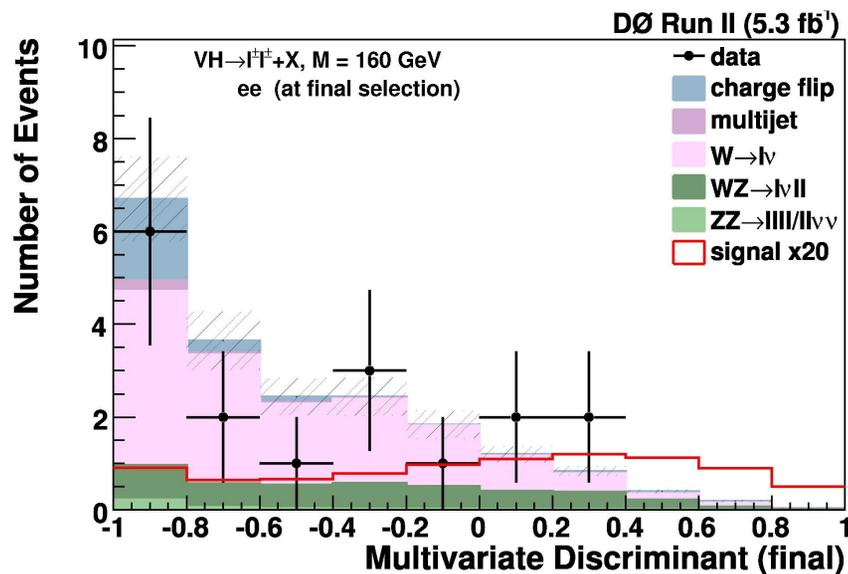
<http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H111/>



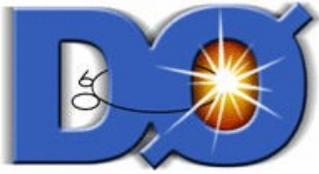
Higgs (VII)-likesign dileptons

Sensitivity to associate WH/ZH production with H WW decays via likesign dilepton final state

Backgrounds: misidentified leptons / charge flips estimated from data



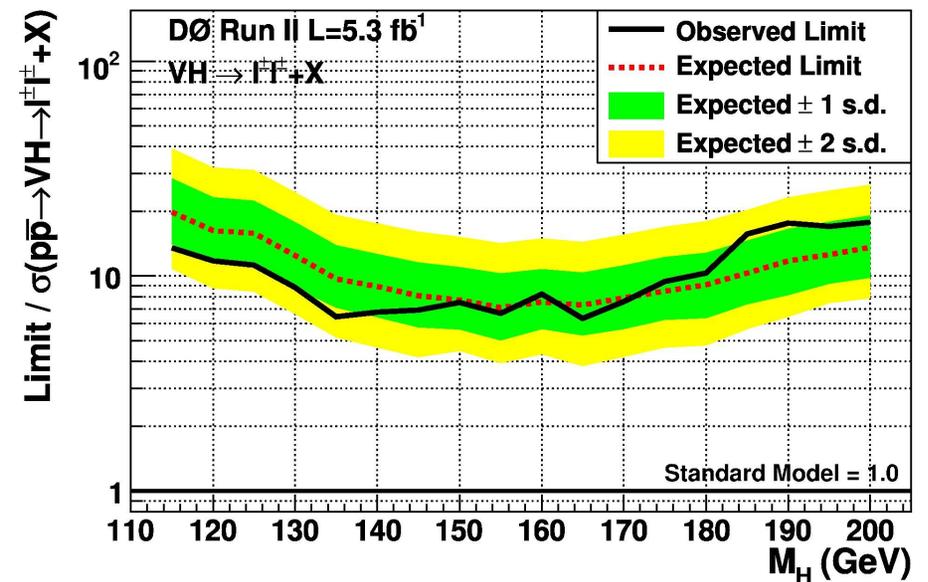
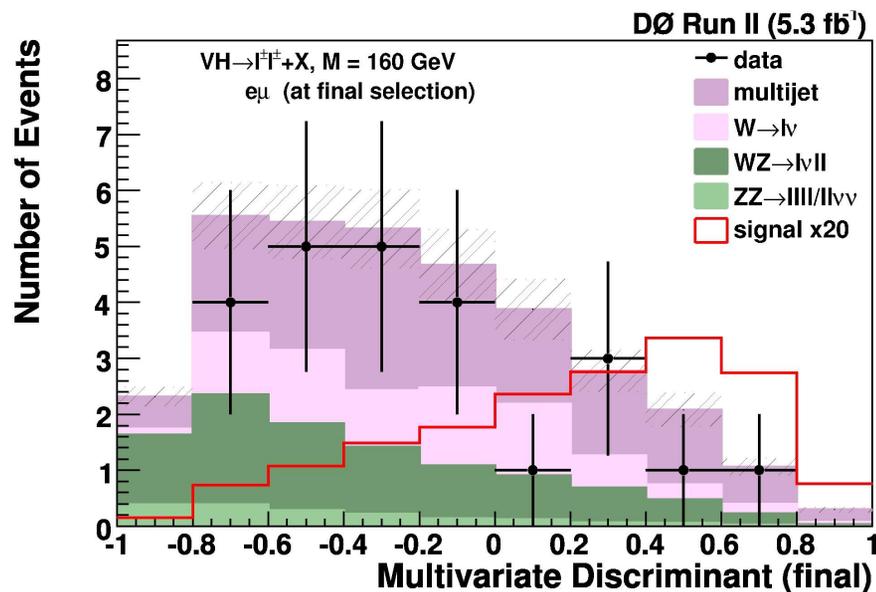
arXiv.org:1107.1268



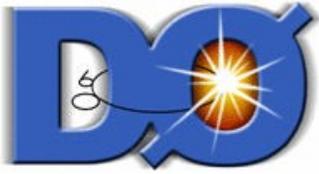
Higgs (VIII)-likesign dileptons

Sensitivity to associate WH/ZH production with H WW decays via likesign dilepton final state

Backgrounds: misidentified leptons / charge flips estimated from data

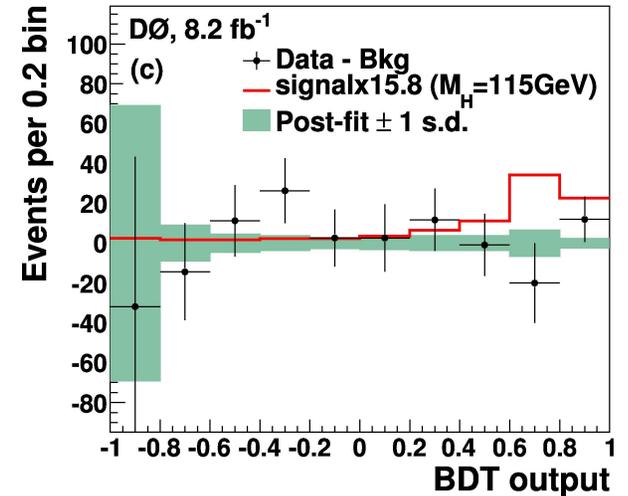
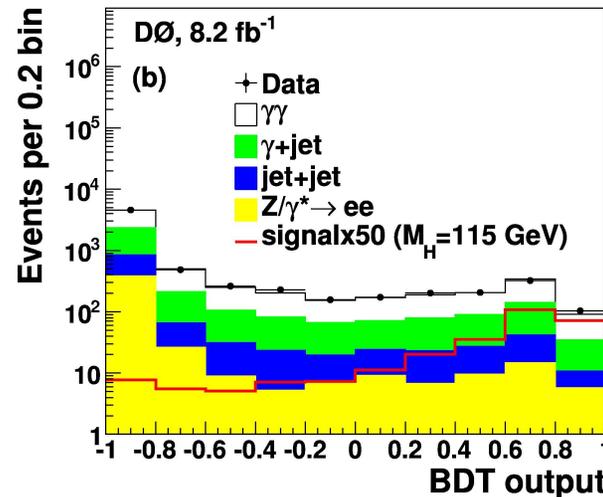
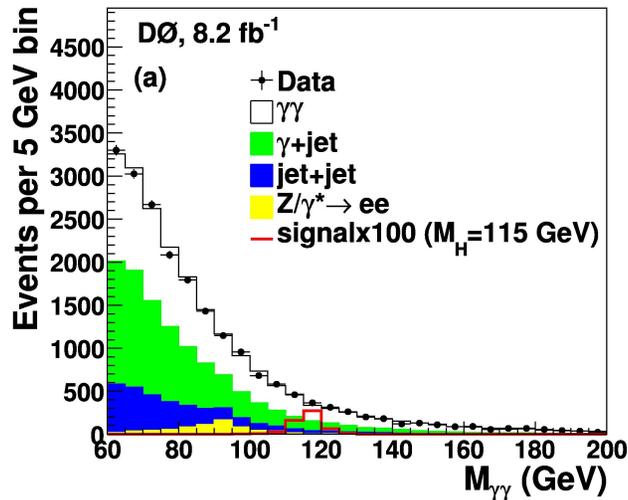
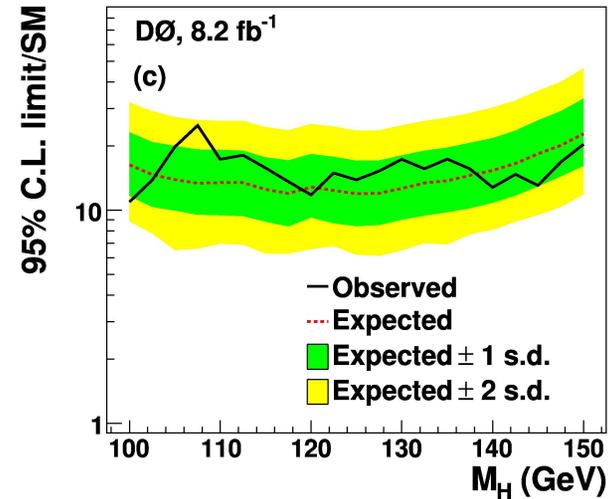


arXiv.org:1107.1268

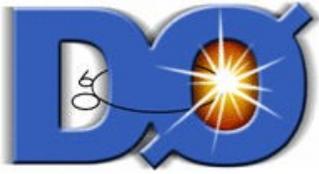


Higgs (IX) - $H \rightarrow \gamma\gamma$

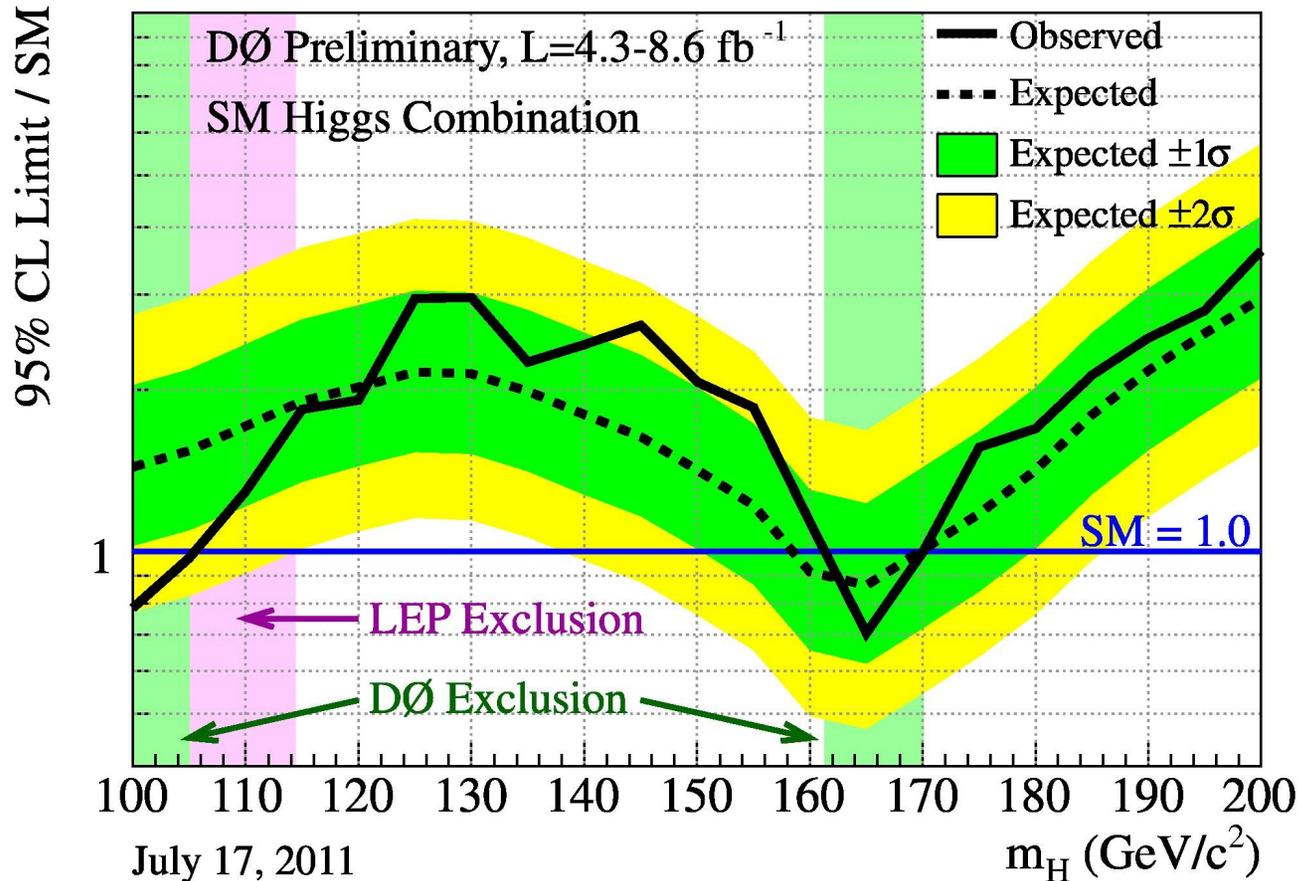
- Increased dataset
- Use additional kinematic information in discriminant (BDT)
- SM/fermiophobic Higgs interpretation



Submitted today to arXiv/PRL



Higgs (X)- Limits



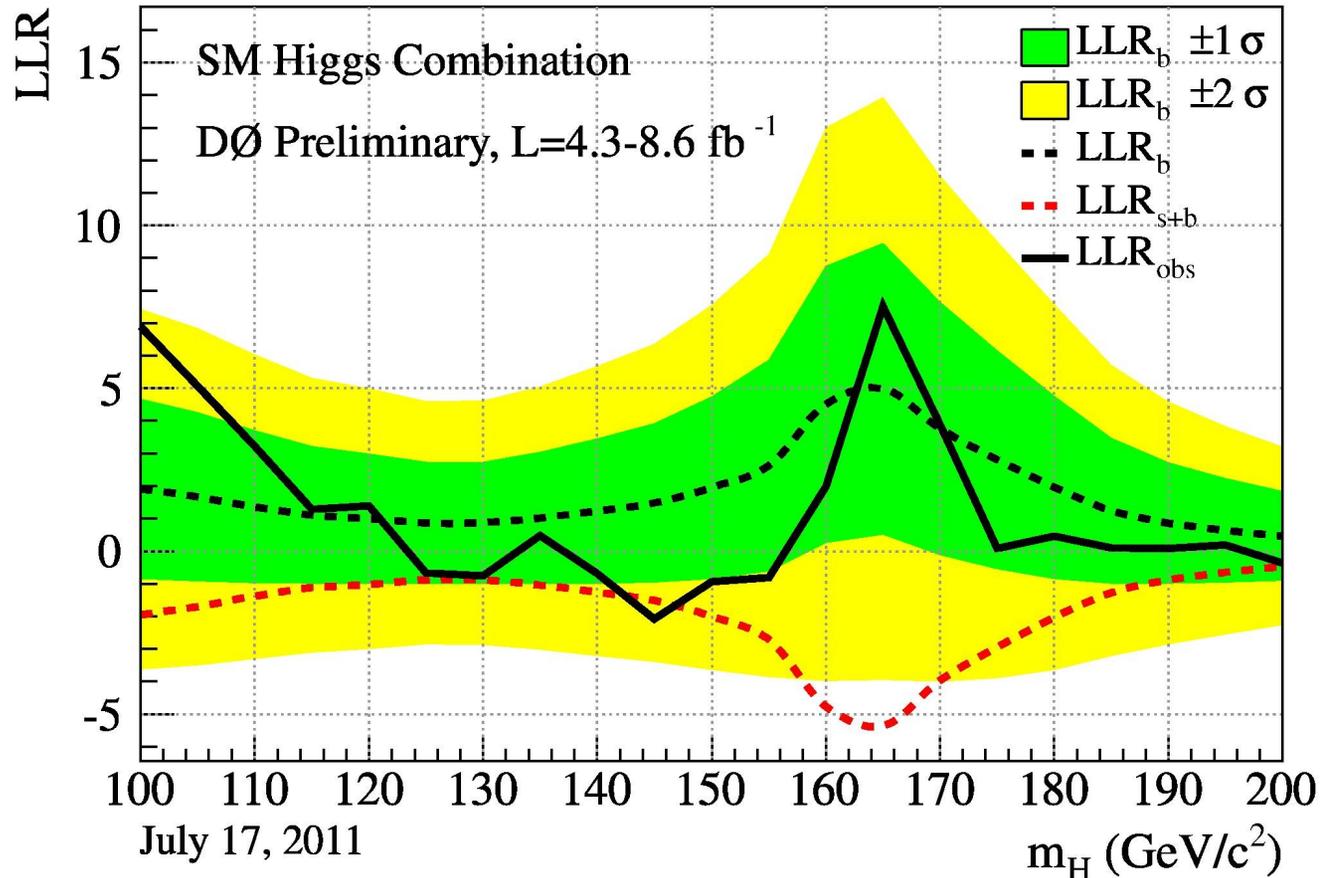
Exclude @ 95%CL: $M_H < 105 \text{ GeV}$ and $M_H \in [161-170] \text{ GeV}$

Expected exclusion: $M_H \in [159-170] \text{ GeV}$

<http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H112/>

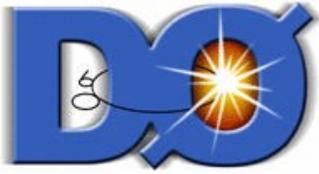


Higgs (XI)- Sensitivity



**Achieved 1 standard deviation sensitivity
over the entire mass range**

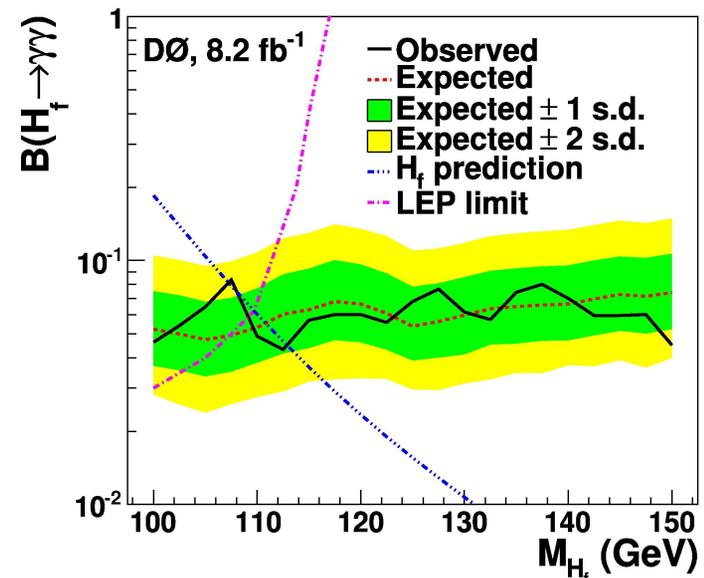
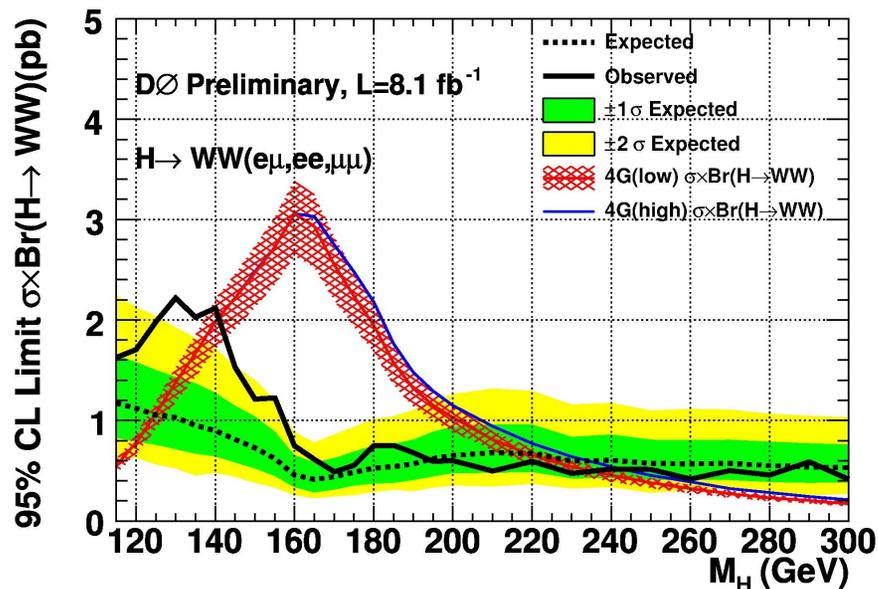
<http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H112/>



Higgs (XII)- Exotic Models

In 4th generation model enhanced production cross section $gg \rightarrow H$, interpret $H \rightarrow WW$ search: exclude $M_H \in [140-240]$ GeV

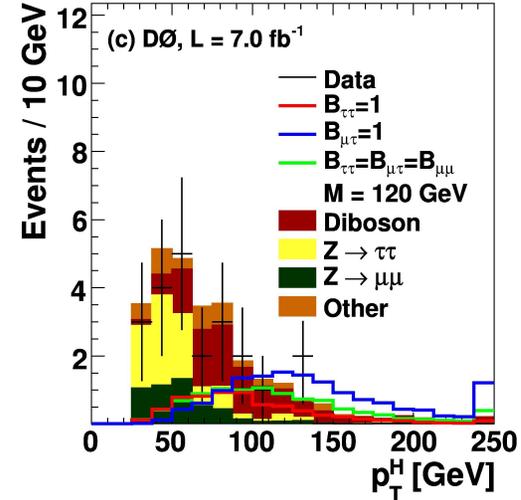
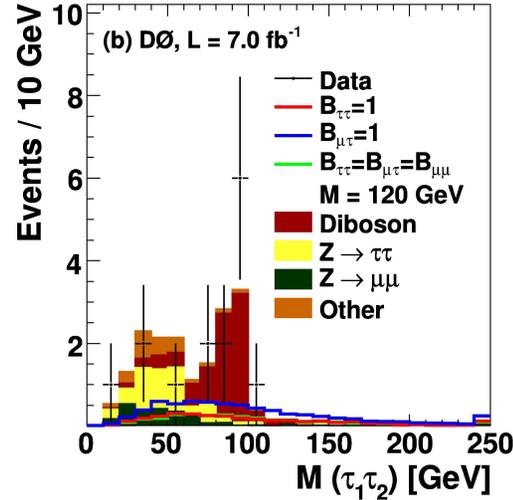
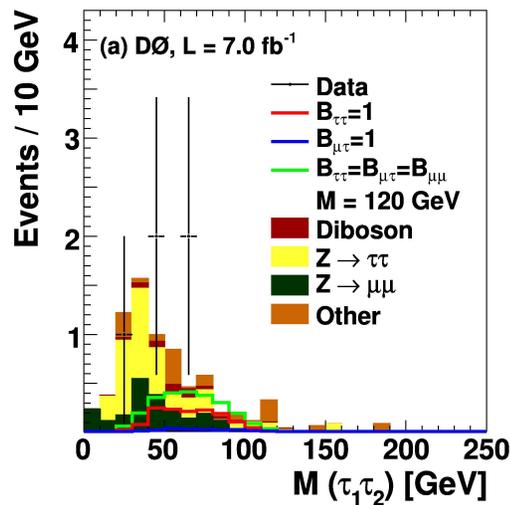
In fermiophobic models use $H \rightarrow \gamma\gamma$ exclude $M_H < 112.9$ GeV @ 95% CL



<http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H111>



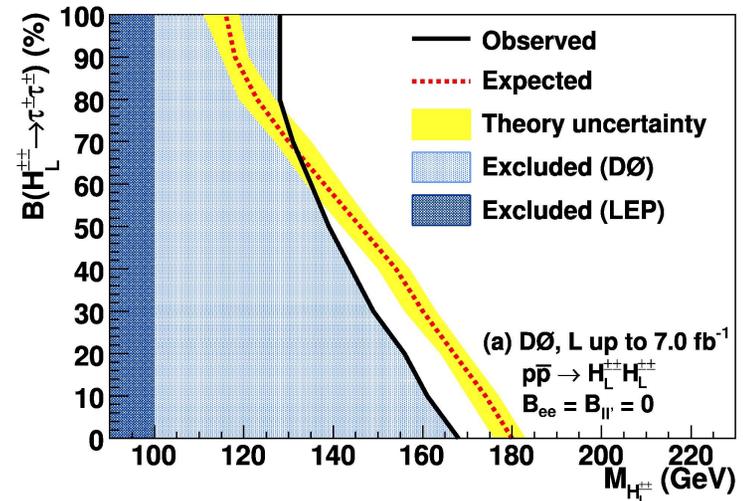
Higgs (XIII)- Doubly charged H



Search for $H^{\pm\pm}$ decaying to μ/τ

First time τ channel considered
Consider also mixed decay channels

arXiv.org:1104.4250





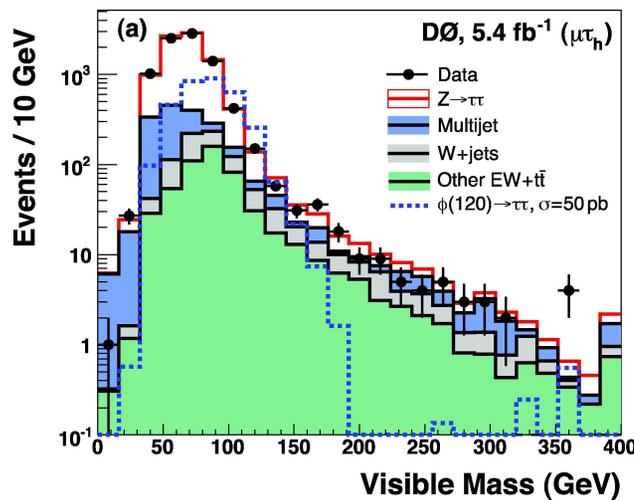
Higgs (XIV)- $H \rightarrow \tau\tau$

Two searches for $H \rightarrow \tau\tau$ decays:

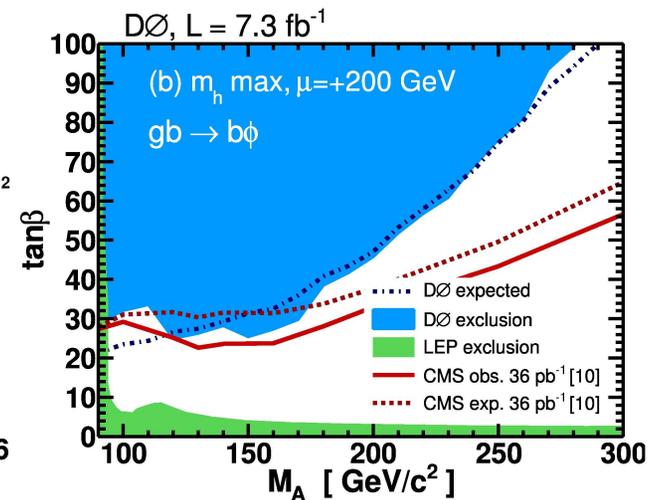
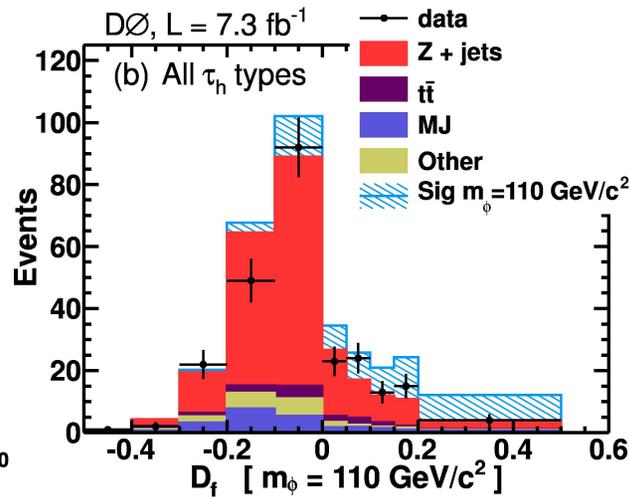
- Gluon fusion production ($e+\mu$ and $\mu+\tau$ final states)
- Associated production $bH \rightarrow b\tau\tau$ ($\mu+\tau$ final states)

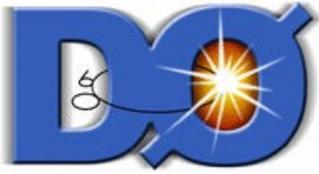
Set limits on $M_A/\tan\beta$ plane

arXiv.org:1106.4555

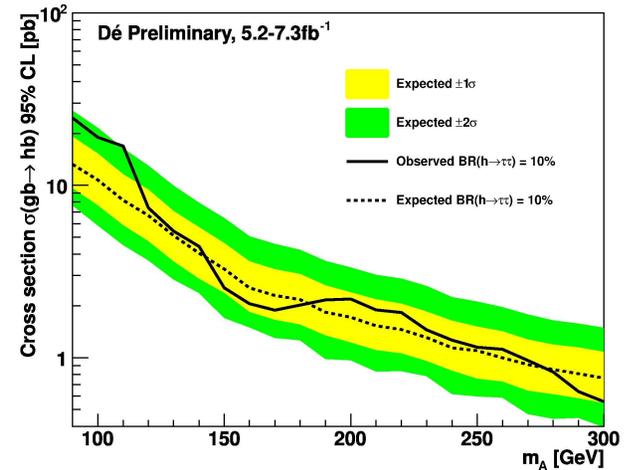
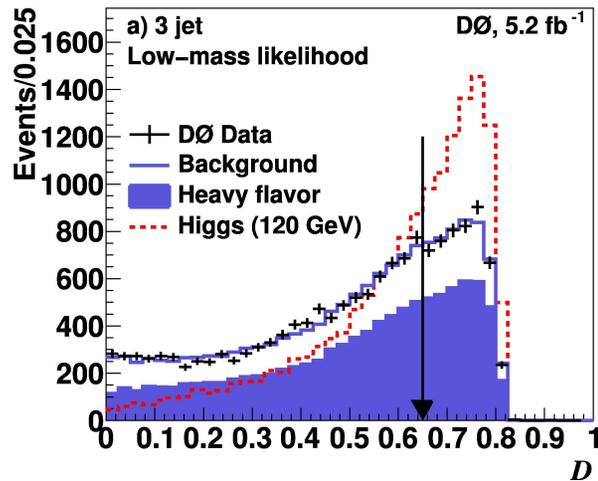


arXiv.org:1106.4855





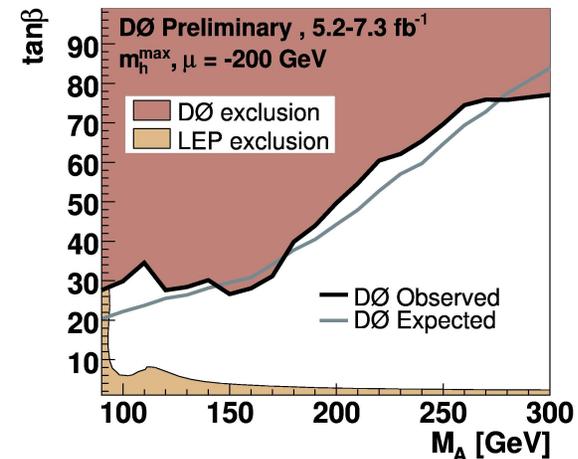
Higgs (XV)- SUSY Higgs



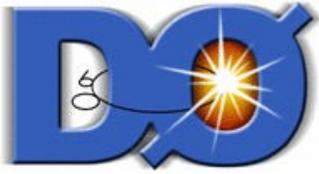
Combine the result of the $b\tau\tau$ search with the bbb search

Best limits from the Tevatron on SUSY Higgs

bbb channel remain exclusive domain of Tevatron experiments



<http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/HIGGS/H113/>



Conclusions

Many new results for EPS/DPF/LP

DØ on track for publishing a record number of papers in 2011

Direct and indirect searches at Tevatron and the LHC strongly favour a low mass Higgs boson in the range ~120-150 GeV

Tevatron is unique due to its sensitivity to the $H \rightarrow b\bar{b}$ decay mode

Thanks to all DØ colleagues who have contributed to these results

Public web pages for DØ results for Summer 2011:

<http://www-d0.fnal.gov/Run2Physics/D0Summer2011.html>